CSO Observing Manual

January 18, 2002

Acknowledgment

This revision of the CSO Observing Manual has been long in the making. Since the last edition (July 1997), CSO has gone through a number of significant changes in hardware (new antenna computer, etc.) and associated with them new ways of communicating and working with these new hardware. Some of the common use computers have also been upgraded, and some died of old age. All in all, a significant part of the last observing manual has become obsolete, and at places misleading.

In making this revision, I have incorporated most of the user comments jotted down on the copy of the manual placed in the control room, and also attempted to update information wherever I see relevant. Structure-wise, it largely follows the last edition. But I also include a section on making continuum observations with SHARC, which I know will become obsolete when SHARCII comes on-line.

Some of the contents are pirated from certain web sites(SHARC), or user manuals (CAMERA, BADRS) with some or little editing. Respective authors will see their hands in this manual. To them, and to numerous users who commented on the old observing manual, I extend my thanks. This observing manual reflects the collective wisdom and experience of the CSO staff and visitors.

Hopefully, you'll find this revision an improvement over the last. I certainly welcome your suggestions, comments, and criticism.

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Chapter 1

The Observatory

1.1 Introduction

The Caltech Submillimeter Observatory is a 10.4 meter submillimeter antenna at 13,300 feet on Mauna Kea in Hawaii. The telescope is an alt-az f 0.4 dish, with positions for receivers at both the Cassegrain focus, and in the sidecab, which is effectively a rotating (with zenith) Nasmyth focus. We are able to observe from 0.5 to 88.5 degrees zenith angle, except in certain areas where we are restricted by local obstructions: mountains, JCMT, etc. The telescope is contained within a very compact, rotating dome structure, which has 2 large shutters which open to allow observing.

The classical Mauna Kea night will allow observing from around sunset till sometime after dawn. There are 4 constraining features on this. Firstly, it is not permitted to get sunlight on the dish surface, secondary and its support legs, backing structure, or Teepee (see Figure 1.1). This may restrict

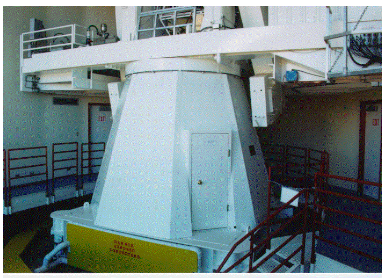

Figure 1.1: *This is the TeePee. It is the base of the telescope. The antenna motor controllers, the Hand Paddle, the cable wrap, and much of the limit switch logic is housed in here. The door is interlocked with the limit switch system, because if the door is ajar it is possible for it to foul the telescope backup structure. So the door must be closed if you wish to move the telescope.*

you a little in getting started, though obviously not much if your sources are in the east. It is possible to observe until ˜10 AM in the morning, if one carefully chooses sources in the west, and closes the shutter partially to shield the dish. There are a couple of reasons for keeping the sun off the dish. Being a submillimeter dish it is very sensitive to thermal gradients in the structure. These will probably affect you anyway during the first hour after sunset - we are currently investigating them and hope we may be able to model the effect. Also, the dish surface is more than good enough to focus the suns rays, even at an oblique angle, and this can do a great deal of damage to cables, equipment and people. Secondly, the inversion layer. This needs to fall below the summit for good submillimeter observing, and this usually happens sometime near sunset. Its return over the summit is a little less predictable, but is usually soon after sunrise, though occasionally it is possible to continue observation nearly all day if suitable sources (i.e., far from the sun) can be found.

The third reason is simply one of sleep - single shift operations at these frequencies (and at this altitude) make for tiring observing sessions. The fourth involves the need for our day-crew and engineers to have some access to the telescope for maintenance, though this can be negotiated for special cases.

1.2 Our Cozy Dome

The usable space in the dome of the CSO is a 3 story structure, shaped rather like a horseshoe. The first floor (see Figure 1.2) contains a galley,

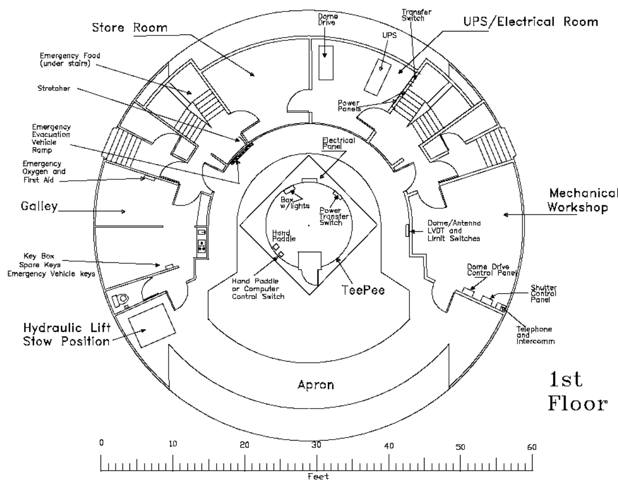

Figure 1.2:

toilet, storage rooms, the Uninterruptable Power Supply, and the mechanical workshop. The base of the stairwell between the Galley and store room also contains the emergency food, water, heating and lighting supplies. The second floor (see Figure 1.3) contains a lounge room and bathroom, storage

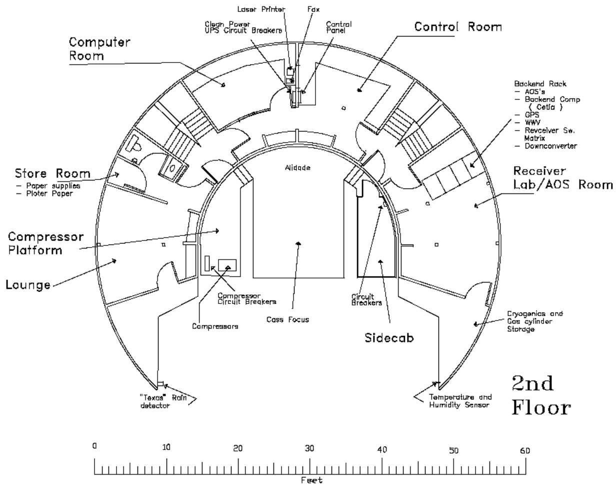

Figure 1.3:

closet, the computer room, Control Room, Electronics Lab, a cryogenics storage area, and access to the antenna alidade platform and sidecab. Much of your time whilst observing will be spent on this floor. The third floor (see Figure 1.4) contains a receiver/electronics lab, and another storage room.

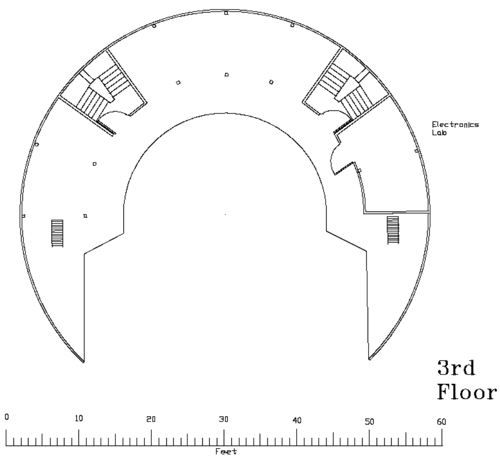

Figure 1.4:

The galley contains the important equipment: a microwave oven, hot-plates, sink, hot-air popcorn popper, fridge etc. The only other room on this floor (see Figure 1.2) you are likely to use is the mechanical workshop, which also contains the main control panels (see Figure 1.5) for the Dome Drives and Shutter Drives, which you are unlikely to need except when there is a problem, as these are usually controlled from the Control Room.

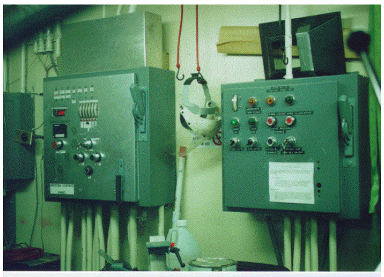

Figure 1.5: *These two control panels, located in the Mechanical Workshop (Figure 1.2)control the two independent dome hydraulic systems. Normally, observers don't need to interact with these boxes. The box on the left controls the shutter hydraulic system. Normally, this system is controlled in the Control Room (Figure 1.3), but this panel allows the system to be controlled more flexibly. The box on the right controls the dome drive hydraulic system. This system provides hydraulic pressure to push the four dome drive wheels against the rail.*

On the second floor (Figure 1.3), the Electronics lab also doubles as the backend room. It contains the Accousto-Optic Spectrometers, their related IF conversion units and the Backend Computer. There are four AOSes - two

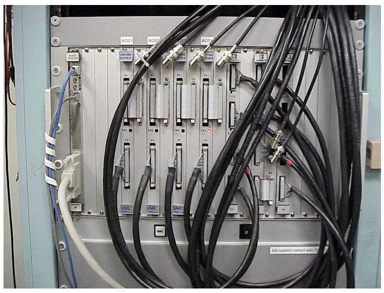

Figure 1.6: *This is the backend computer, a PowerPC based VMEbus machine running LynxOS. It is located in the Receiver Lab/AOS Room (Figure 1.3), on the same rack as the antenna computer (Figure 2.1).*

are 1024 channel, 500 MHz bandwidth units, one 1024 channel, 50 MHz high resolution unit and a 2048 channel 1.5 GHz model. The four can be run simultaneously or in any combination, and the position of the 50 MHz AOS within the 500 MHz bandwidth of the IF can be adjusted. The two 500 MHz AOSes can be overlapped fully or partially, within the 1 GHz bandwidth offered by the heterodyne receivers.

The main room here is, of course, the Control room, and it is quite likely that you may find yourselves rarely leaving it (apart from your frequent trips outside to check the weather!). From here, you have complete control over all aspects of the observatory, apart from receiver tuning. Note that the storage closet (between the lounge and the bathroom) is were we keep most consumable stores such as paper, pads, pens, printer cartridges etc.

Note that the observatory also has an intercom system. It is entirely separate to the phone system, and a special phone in each room is attached to it. This allows you to talk to people in any room, or to page someone by dialing 30. The ordinary phone system has 2 lines, and is available in the galley, control room, computer room, receiver lab, electronics lab and mechanical workshop. It is not an exchange system - just dial 1, then the area code etc.

As you may have noticed, the entire dome structure rotates. This means that we have to have a supply of fresh water contained within the dome, plus a holding tank for waste water (including the sewer). These are each of the order of 400 gallons. Please be sparing in your use of fresh water - it is quite a job to fill the tank, and drain the waste tank. Thank you. This rotation also means that your vehicle may not be where you think you left relative to the doors – this is not an affect of the altitude.

Each room is fitted with 2 heating systems - a fan/heater unit, plus radiant panels in the ceilings. These should always be turned off in any room which is not occupied for long periods of time, as electricity up here is very expensive. You will also find 2 water jugs. These are meant as not-so-subtle hints. The altitude has a number of affects on your body which you should be aware of. Firstly, it is (hopefully) extremely dry up here, so you will dehydrate very easily. This is not helped by the body's reaction to low oxygen levels - unfortunately, the kidneys react by preferentially retaining salts and dumping water. Actually, this is part of a process of thickening the blood as a means of increasing the blood oxygen content. Thus, it is recommended that you drink AT LEAST one large glass of water (or equivalent) an hour. If you don't, you'll be sorry – severe headaches are caused by dehydration at least as often as directly by oxygen deprivation. If you are not aware of the various problems with working at high altitude, please ask us for a copy of a report on this.

Please also note that static electricity is a very big problem up here, mainly due to the dry atmosphere. PLEASE be sure to ground yourself before touching any sensitive equipment, particularly receivers. You will also note that the wall plugs come in 2 colors - white and orange. This is because we have 2 separate ground systems, a 'dirty' (white) ground and a 'clean' (orange) ground. Be careful not to attach any equipment to clean power which may be inherently dirty, or which may provide some shorting path to the dirty ground, such as via the chassis. If in doubt, please ask a staff member.

The Observatory has three components to its power supply. Firstly, as of October 1988 we transferred from local, mountaintop generated power to Hawaiian Electric Company power. This is something of a mixed blessing and hence, we now have a small backup generator (the second component) which can provide power for emergency functions, such as closing the shutter and operation of the CTI compressors for maintaining the receivers. Eventually this probably will be wired so as to allow observing to continue during a protracted power outage, though initially it will only be for emergency use. The third component is the Uninterruptable Power Supply, which is a standard AC/DC battery/AC system which can supply the computers and certain aspects of the receiver chain for short periods.

If the main power is down for a protracted period, it will be necessary to shut down certain equipment to ensure this system can maintain the vital items. See the relevant Emergency procedures manual for more information on this. There are copies of it in the Control Room, the UPS room and with the LPG cylinders for the generator.

1.3 Starting the Control System

When you first arrive in the observatory each evening, you are required to do a 'walkabout'. This is to check for anything that has been left in a dangerous position for observing. Large items, such as the crane, and many doors which may foul the dish have interlocks on them to prevent the antenna driving if they are in an unsafe position. However, it is always possible that some piece of equipment may have been left out in such a way that it could hit the dish, or may fall when it is moved. Though all staff will always make sure not to leave anything in a dangerous position, it is naturally the responsibility of the person about to drive the telescope/dome system to ensure that it is safe to do so. A walk around the front of the dish on the first floor (see Figure 1.2) (commonly called the apron), followed by a check of the alidade platform, sidecab, and third floor should be sufficient, and only take a few minutes. It can easily be done in a fraction of the time the shutter doors take to open. Newcomers to the observatory will be shown this as part of their introductory tour. Look for things like ladders left against the wall in the sidecab etc - anything that may foul the telescopes movement, particularly in zenith. See the section on Antenna Motion Limits for information on limit and interlock switches.

In the control room, near the phone, there is a box housing several rows of colored lights. This is the Control Panel (see Figure 1.7). If any of the red lights are on, you should not try to move the antenna or dome. If you happen to try to move the dome while one of these lights (apart from the Emergency Stop lights) is illuminated, you will probably cause a fault to occur, by driving the antenna into the dome. The computer does know when an Emergency Stop button is pressed. So the basic aim before starting observing is to ensure there are no red or orange LEDs illuminated, and that

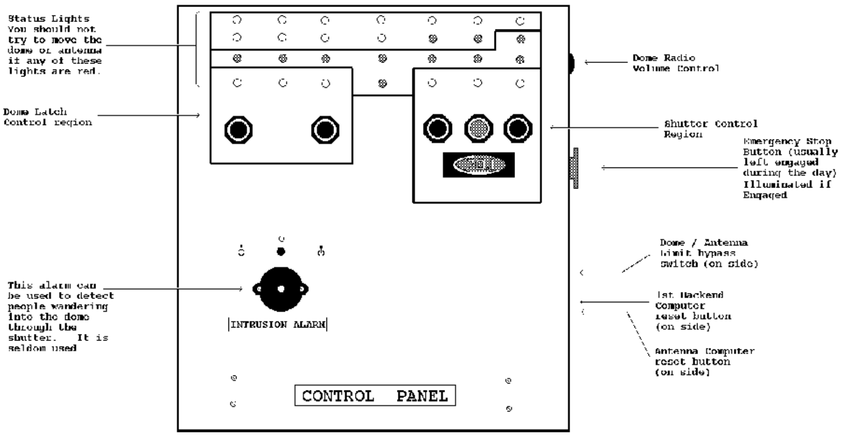

Figure 1.7:

the three green LEDs for the Dome Drive system are illuminated. When you have this state, you can start to slew the dome/antenna system to your source. If you do hit one of the dome/antenna limits, you will need to follow the procedure in Chapter 6 to enable movement again.

The dome and antenna are normally powered down when observing is not taking place. The following steps will power them up. The observatory is usually left disabled by the use of the Control Room Emergency Stop Button. This is pushed to disable the antenna, dome and shutter. Note that this currently only disables the Azimuth, Zenith angle, dome and shutter motors. It does not disable the chopping or focusing motors of the secondary mirror, nor any other motors relating to the fourth and fifth mirrors, or the chopper wheel. When an Emergency Stop button is pushed, its internal light is extinguished and a red led on the Control Panel (see Figure 1.7) is illuminated to indicate which button is pressed, disabling motion. If you find that an Emergency Stop Button has been engaged, you must check with any other persons in the dome before disengaging it. If you engage an Emergency Stop Button for safety reasons (for instance, if you are working on the telescope structure, or on a ladder etc.) you should place a note on the engaged button stating that you should be consulted before the button is disengaged.

The main controls relevant to the general movement of the telescope/dome system are in the Workshop (room 106) on the first floor (see Figure 1.2), though these are not used as much now we have control from the Control Room. The only aspect of the drive system which is occasionally of concern to observers is the dome drive motors, which must be forced against the azimuth rail to drive the dome. Pressurizing the drive hydraulics is performed from the comfort of the Control Room. On the lower left-hand side of the Control Panel (see Figure 1.7) you will find two buttons and three lights. Basically, the left-hand button enables the Dome Drive Motors, and the right-hand button disables the drives. If any of the three LEDs is red, or unilluminated, the dome drive is disabled (and physically disengaged). Press the left-hand button: the three LEDs will (within a couple of minutes) turn green. You must NOT try to drive the antenna/dome system in Azimuth from the computer until these three are green. Pressing the right-hand button will reverse this procedure.

Apart from enabling the telescope/dome system, you will also need to open the Shutter. This is also performed from the Control Panel (see Figure 1.7) in the Control Room, via the 3 buttons immediately to the right of the Dome Drive Controls. Note that you will have to have released the Emergency Stop button before you can open (or close) the shutter. The left hand button initiates the opening sequence - whilst it is flashing green, the shutter is in the process of opening - when it turns a solid green, it has finished. The percentage open is shown by the LCD display, 0 being closed and 99 being fully open. Do not worry about small deviations from these numbers at the extremes: any hieroglyphics are due to oxygen deprivation. To close the shutter, simply press the Close button - it will stop automatically when it is fully closed. You do NOT need to press the Stop button - this applies to both opening and closing. Again, the same philosophy applies to the LEDs. Note: if you wish to reverse direction (ie change from opening to closing during the actual opening process, or vice versa), you MUST press the Stop button (center of the three) before starting the other cycle.

1.4 Shutting Down the Observatory

When leaving each morning, the observatory should be shut down as follows. The shutter takes a while to close, so you should first start it closing by pressing the Shutter Close button on the Control Panel (see Figure 1.7) in the Control Room. The Antenna should be stowed using the `STOW` command to UIP, or by sending it to an azimuth of between 80 and 100, and a zenith angle of 15 degrees. Note that the STOW command will arbitrarily select an azimuth near were the Sun will rise. This is to prevent us from continually parking in the same place, and therefore minimizes wear on the slip rings. **If you are stowing the telescope after sunrise, be sure that you do not slew the telescope through the Sun's azimuth!** After the antenna has driven to the correct position and the shutter is closed, the Emergency Stop button in the control room should be pushed in.

If you have been using the SIS receivers, please make sure you have turned off the magnets.

The shutter doors **MUST** be closed before you leave the observatory.

Be sure the secondary mirror is not chopping.

All of the blower/heater units should be turned off. All lights should be turned off, and the side doors should be locked.

1.5 Antenna Motion Limits

The dome can rotate around and around and never break any wires. It has slip rings. The antenna, however, has a cable wrap, and it cannot rotate forever. The antenna can rotate through 444 degrees, starting at an azimuth of -92 degrees (west) passing through north at az=0 and continuing clockwise to 352 (almost north again). This range allows the tracking of most objects without any interruptions to allow the wrap to unwind. These limiting azimuths are enforced by two levels of limit switches. Upon hitting the first limit switch, motion in the current direction will be disabled, but you can still drive off the limit switch under either computer or hand paddle (see Figure 1.8) control. It you somehow hit the second limit switch, all motion of the antenna will be disabled, and you will have to jumper out the limit switch to move. The limit switches are mechanical, and they are hard to position precisely, so the above quoted limit positions may be off by one or two degrees.

The zenith angle motion is limited too, of course. The telescope cannot be sent to a position lower than about 88.5 degrees. It can be sent slightly past the zenith, to about -2 degrees, though in fact we rarely go past 2 degrees. Each of these limits has a pair of limit switches like the azimuth ones. The capability to go to slightly negative zenith angles is not currently used to track celestial objects. In fact, it can be difficult to track objects within about 1.5 degrees of the zenith, as the 'OFF' position used in spectral OO scans is often in azimuth, and you may not be physically able to move the beam on the sky that far.

There are a number of other limit switches and interlocks in the observatory. These are mainly to prevent various objects from fouling the antenna. They all have indicators on the Control Panel (see Figure 1.7) in the Control Room. The large overhead crane has a limit switch to stop the antenna moving if the crane is not in its fully stowed position, which is up against the side of the dome. The portable hydraulics lift for accessing the secondary must also be stowed next to the Galley door (see Figure 1.2). The TeePee (see Figure 1.1) door and the door on the rear of the sidecab must also be closed, as they can interfere with the antenna at certain zenith angles. Also, the railing next to the front door to the sidecab must be in its 'rearward' position i.e., it must be in the pair of holes nearest the sidecab, not the pair about 4 inches further towards the Control Room (see Figure 1.3). There is

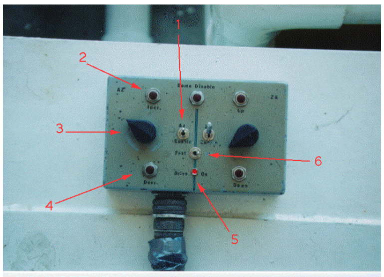

Figure 1.8: *This is the antenna Hand Paddle, which allows manual (non-computerized) control of the telescope position. It normally can be found inside of the TeePee (see Figure 1.1). The cable is long enough to reach the Control Room. In order to activate the Hand Paddle, you must switch the transfer switch (see Figure 1.9) in the TeePee from Computer control to Hand Paddle control. If the Hand Paddle doesn't work, it is likely that its internal batteries are dead or have fallen out of their holder.*
Description of Controls:
1 - **Azimuth Enable Switch** *This switch enables the azimuth motor controllers. You should not leave them enabled if you are not actively using the Hand Paddle, because the telescope will drift in azimuth if your do. There is an analogous switch for zenith angle.*
2 - **Increment Button** *Pressing this button causes the telescope move clockwise.*
3 - **Rate Control** *This knob controls the rate at which the telescope will move. Rotating it clockwise increases the speed.*
4 - **Decrement Button** *Pressing this button will make the telescope move counterclockwise.*
5 - **Drive On Indicator** *This LED is illuminated if the Hand Paddle is active. If it is not illuminated, try switching the Computer control/Hand Paddle control transfer switch (see Figure 1.9).*
6 - **Fast/Slow Switch** *This switch is like a gear shift for the antenna. In slow mode, the telescope will move very slowly, to allow accurate positioning. This switch affects both azimuth and zenith angle.*

also an interlock on the hoist to the cryogenics platform.

1.6 Using the Hand Paddles

It is sometimes necessary or convenient to move the antenna or dome manually. There are two 'hand paddles' to allow this. These are the only form of manual control of the antenna/dome structure which we have, and their use is very rare. Before explaining the hand paddles it should be noted that normally the antenna and dome cannot be moved independently in azimuth. They can differ in relative position by about two degrees, after that there would be a collision. If the antenna were to push the dome, you would hear an unpleasant noise as the clutch slips. If the dome were to push the antenna, the antenna would be back driven. The antenna shouldn't be back driven except in an emergency. Only CSO staff members should use the dome hand paddle.

The most commonly used hand paddle is the antenna hand paddle (see Figure 1.8). It is located in the TeePee (see Figure 1.1) and is normally plugged in to the left side of the Antenna Control Limit Box (the box in the TeePee with the LEDs on the top). To use this hand paddle, first idle the antenna computer (using the UIP's `IDLE` command). The antenna computer should be idled so that it will not move the dome as you move the antenna. Now proceed to the TeePee and find the hand paddle. You probably should disable both directions (azimuth and zenith angle) using the toggle switches on the hand paddle. If you do not, the motions may slowly drift even if you are not pressing either of the motion push buttons. Now use the toggle switch (see Figure 1.9) on top of the box just inside the TeePee door to switch to

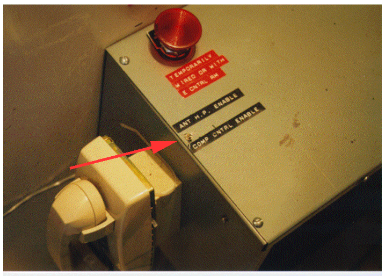

Figure 1.9: *The red arrow in the photograph above shows the location of the switch. In the setting "ANT H.P. ENABLE", the Hand Paddle (see Figure 1.8) controls the motion of the telescope. In the "COMP CNTRL ENABLE" setting, the antenna computer controls the telescope motion. This switch is located inside the Tee Pee (see Figure 1.1), near the door.*

hand paddle control rather than Computer control. A red light should be illuminated on the hand paddle. Now enable the motion on the axis you wish to drive, and use the push buttons to send a drive voltage.

In some cases it is desirable to drive the antenna in azimuth with the hand paddle, while having computer move the dome to keep the dome and antenna from colliding. To do this, the antenna computer must be running its normal program, and the antenna should *not* be idle. When the antenna is idle, the dome and antenna motors are turned off by the antenna computer. If the antenna is idle, the best way to get it out of that condition is to enter

```
UIP> ALTAZ
UIP> TRACK
```

under UIP. The antenna should be accelerated slowly with the handle paddle, since the dome servo was not designed for this mode of operation. The dome will seem sluggish.

The dome has a hand paddle too, but it is used even less often. It is located inside the dome motor controller box (see Figure 1.10) (The big grey box behind the UPS batteries in the in the UPS/Electrical Room (see

Figure 1.10: *This big box in the UPS/Electrical Room (see Figure 1.2) houses the dome motor controllers, which power the four motors that rotate the dome.*

Figure 1.2), room 108, immediately beneath the Control Room on top of the RFI shielding). It must be plugged into a cable that is normally plugged into a socket located in the upper left hand corner of the box, outside of the RFI shielding. **The limit switches on antenna–dome relative position are BYPASSED when this hand paddle is used**. This means you can easily run the dome into the antenna and cause the antenna to be back driven.

Both of these hand paddles have a problem. The drive voltages are supplied by internal batteries, which often go dead or fall out of their internal battery holder. If the hand paddle doesn't work, check the batteries.

The only likely circumstance for using the antenna hand paddle is when the dome and antenna get so far out of alignment that they cannot be driven by computer control. This requires you to maneuver the antenna so it is aligned with the dome in an azimuthal sense. To do this, drag the hand paddle from the Teepee to the area next to the workshop where you will find the LVDT (see Figure 1.11), limit switches and mechanical buffers which

Figure 1.11: *This is the LVDT (Linear Voltage Displacement Transducer) which measures the position of the dome relative to the antenna. This is the way we know were the dome is. This transducer is located under the sidecab, and can be seen easily from the first floor. If you ever have to move the antenna off of a dome-telescope limit switch, using the hand paddle, then you'll want to place this transducer in the center of its travel.*

all relate to the dome/antenna azimuth relationship. Look up - you will eventually realize that the mechanism from the antenna between the two sets of limit switches is not centrally located - and it should be. Carefully, enable the azimuth control, slow rate on the hand paddle, and try moving the antenna in one direction. Simply move it so it is as nearly centered as you can get it. Stow the hand paddle, remembering to disable both axes on it, and return control to the computer by toggling the switch inside the Teepee door to the left from Hand Paddle back to Computer Control.

1.7 Focus Control

Computer control of the secondary focus is handled from the UIP command FOCUS, which allows you to send the secondary to a specific position, or to have the secondary follow the preprogrammed focus curve. The focus position is shown on the bottom left corner of the antenna status display. The units displayed, and the units used in the focus command, are millimeters at the secondary encoders, except for the theta (rotation) position, which is displayed in degrees.

There are two modes for having the secondary follow the focus curve. In continuous update mode, the secondary will be moved anytime the antenna computer decides it should be – regardless of whether an integration is taking place. The other mode, stealthy mode, allows the secondary to move only when the antenna is changing positions on the sky. The secondary will remain fixed during an integration. Stealthy mode is the default.

The FOCUS command allows you to specify an offset that will be added to the value from the focus curve.

Since moving the secondary has an effect on pointing, the antenna computer attempts to compensate. Small offsets (TAZO and TZAO shown on page 1 of the antenna status display) are recalculated each time the secondary is moved. If for some reason you wish to disable the pointing adjustments, issues the UIP command

```
UIP> TOA DON'T_FOCUS_COMP
```

this is done automatically if you specify optical pointing. To re-enable the adjustments, type

```
UIP> TOA DO_FOCUS_COMP
```

It is a game observer who will fiddle with such things however.

The X_POSITION, Y_POSITION and THETA_POSITION commands work just like the FOCUS command described above, but they act upon the X (left–right), Y (up–down), and theta (rotation) motions of the secondary.

Chapter 2

The Computers

2.1 Summit Computer System: Overview

The CSO summit computer system is based on a loosely coupled network of workstations and micro computers. The philosophy behind this is now quite common amongst observatories. The basic aim is to minimize inter-processor communications, particularly any which need to be high speed, as intra-processor communications (between different tasks for example) are much easier to synchronize and manage than inter-processor communications. The result is that tasks are allocated to individual computers based on a combination of their real-time, electro-mechanical and functional relationships to each other. This produces an extremely simple system, with clear cut task allocation between the different computers.

In functional groups, there are three Digital workstations running OpenVMS, two SUN Ultra workstations running Solaris, two PowerPCs running LynxOS, a Macintosh computer named sharc running an instrument of its namesake, and a host of Linux and Window PCs.

The VMS machines consist of a VAXstation, called poliahu, two identical DEC Alpha workstations, alpha1 and alpha2. The three machines run in a cluster which enables sharing of their CPU as well as disk resources. They also share user account information and the user directories which are on a pair of SCSI disks constantly mirroring each other, providing a higher level of protection for disk failures. The three machines form a stable cluster in that we can afford to have any one of them hung without impacting on the operation of the remaining two, ensuring the least amount of interruption to observations due to computer failures.

The primary observer interface for antenna and instrument controls, the UIP (User Interface Program) software package, has moved from poliahu to the faster and more capable alpha1 (and soon alpha2 too). The UIP controls almost all aspects of the observing chain, from antenna and backend spectrometer control, to setting up command files (or scripts) for extended observing. It interprets commands from the observer, and passes them on as suitable to the various microcomputers. This includes such things as finding sources in catalogs, and requesting the Antenna computer to drive the antenna to position and track the source, setup the backend (AOS or SHARC) system with correct integration time and switching format, and to actually perform the integrations, and transfer data (be it spectra or continuum) from backend to user directory on alpha1 for further processing, as well as prepare the data file to be uploaded by one of the Solaris machines for archiving into the Sybase database at the end of the day. The two alphas are truly sharing their CPU resources: any task that runs on alpha1 can be run on alpha2, including a java-enabled Netscape and a whole host of Unix-like utilities (such as xv, zip, tar, etc.). The venerable poliahu, aside from providing a critical quorum for the cluster, is tied to the receiver computer at its boot time. It also runs a small number of "legacy" user applications for data processing that have yet to be ported to the SUN workstations or the alphas. Data reduction programs, such as CLASS, CAMERA, BADRS, run on poliahu, so is CLASS on alpha1, though newer versions of these programs are no longer ported to VMS machines.

The SUN workstations include two SUN Ultra 1 workstations (hapuna and kilauea). An NIS is running between the two, so a user account on one is as good as on any other. Needless to say the user disk is shared, so are the mails and most of the user utilities. These machines are to provide some homely comfort to observers from a SUN Solaris world. They also do a fair amount of heavy-lifting for the observatory too: kilauea runs Sybase servers for data achieving and Apache web servers to answer queries on CSO database searches (with links from the main CSO webpage). It also doubles as a caching domain name server for the local domain and a secondary network time server. Hapuna serves user disk and application disk to other SUN workstation. It also runs the anonymous ftp server (aliased to ftp.cso.caltech.edu). The machine has proved to be the most preferred console by observers in the control room. Most of the data reduction, the whole suite of GAG package (CLASS, Greg, Gildas, etc.), Camera, SAOImage, SuperMongo, to name a few, can be done on any of the SUN workstations. Observers home directories on alpha1 (where data is being acquired) are accessible at `/user_vax/acct_name`. As we tighten up network security for the Observatory, these machines also serve as gateways for accessing observatory computers from off-site locations via Secure Shell (ssh).

The PowerPCs perform real-time or time-critical tasks. They are VME-bus based with a PowerPC CPU module and other off-the-shelf commercial modules. One is the antenna computer, named hau(see figure 2.1). It controls the telescope axes, secondary mirror focus and beam switch, Sidecab

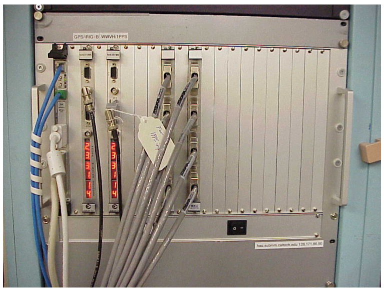

Figure 2.1: *This is the antenna computer, a PowerPC based VMEbus machine running LynxOS. It is located in the Receiver Lab/AOS Room (Figure 1.3), on the same rack as the backend computer (Figure 1.6). Note the two VME cards on the antenna computer interfacing to the GPS and WWV clocks. The times show should be identical, or you will not be able to point on anything.*

receiver optics and local phase locks, Cassegrain instrument rotators, and status monitors. In addition, it is a NTP server for the observatory, using a local GPS and/or WWV clock as reference. The other is the backend computer(see figure 1.6), and it runs the four Accousto Optic Spectrographs (AOSes). Both are mounted on the same rack in the Receiver Lab/AOS Room(see figure 1.3). SHARC is run by a Macintosh computer in the control room. During normal operation, the various computers talk to each other primarily over ethernet. The only exceptions to this are a few bits of time-critical information (phase lock loop and source acquisition status, for example) which are bussed around the observatory on TTL lines.

The unassuming Linux box, puuoo, a mere Pentium 120 machine, carries alot of weight. It serves the Observatory's webpage (aliased to www.cso.caltech.edu), and is the default Xwindow AOS display for the backend computer. It also doubles as the print server for the summit computers. It is constantly busy number crunching in the background to serve up the tau plots popular in the summit community. Puuoo will soon be upgraded to a relative "modern" dual-processor Linux PC rack-mounted along with the CISCO router and switch on the corridor outside of the computer room.

Pika, the Window box currently sitting next to puuoo, is provided for your web surfing pleasure (when things are slow...). Indeed, web surfing is now an integral part of observing at CSO, as you check on the weather (see http://www.cso.caltech.edu/weather.html), look at the tau plots (see http://www.cso.caltech.edu/tau_plot.html), or help yourself diagnosing problems with the trouble shooting guide (http://www.cso.caltech.edu/docs/troubleshooting.html). It also manages AutoCAD drawings for the observatory engineering crews. One other useful feature of pika is that via a XReflection link you can turn the console into that of a host of other machines (hapuna, kilauea, alpha1, and poliahu) you are logging in as if you were on that machine's console.

You can even set up keyboard to stimulate that of the target machine.

Another Window box, ahi, in the computer room, serves the similar purposes.

We also maintain two PCs in our Hale Pohaku office. One is a late model Linux box called ono. The other one is a window95 box called puka for those who wish to have brought along Window based laptop. Ono is loaded with a full array of data reduction packages, if that is how you choose to spend your time there. And of course, there is Netscape on both machines.

You are welcome to bring along your laptop when you come to observe at CSO. Instructions on getting on-line are posted on the chalk board in our Hale Pohaku office as well as in the control room on the Summit. This "on-line service" can be arranged too at our Hilo office if you plan to spend some time there.

2.2 Message Passing Between Computers

Many different pieces of software in the alpha1 will want to talk to one of the microcomputers, more or less at the same time. This creates a potential problem because the responses from the microcomputers must be sent back to the appropriate process. Also certain operations, such as sending a spectrum from the backend computer to alpha1 must execute uninterrupted until completion. The way access to the antenna computer is synchronized is by giving a special process exclusive control over the access to its ethernet port, and having it route the messages to and from other processes. This process is called ANT_MCP.

Things are a bit more complicated for the backend computer. The observer tells the backend computer which AOSes are to be active by issuing the `AOS` command with the proper qualifiers. Each active AOS has its own process running in the backend computer. The AOS process is started by a "Client" process on alpha1. The name of the Client process will be AOS #n Client, where n is the number of the AOS. This client process controls access to the TCP/IP link to the backend computer over which commands are sent. Each active AOS also creates four additional TCP/IP links between the backend computer and alpha1. These links are used to report error conditions, to set VMS event flags, to transfer spectra and to send periodic messages verifying that the system is okay. There is a more detailed description of these processes in section 2.7. If you get a message such as

"Timeout of 50 MHz AOS EKG channel - the backend computer may have died."

that means that the process controlling AOS 2 in the backend computer is no longer exchanging "I'm alive" messages with alpha1. It often means that the backend computer has crashed.

The communication protocol between alpha1 and SHARC's Macintosh is nearly the same as for alpha1 and the backend computer. The UIP's `SHARC` command starts a client process on alpha1, which then sets up a TCP/IP link to the Mac. On the Mac end, Labview software is started by this first TCP/IP link, and the Labview software then creates several more TCP/IP links to alpha1, which are serviced by server processes on alpha1.

It is possible to write code for alpha1 that allows you to communicate directly with the microcomputers, without invoking the UIP at all. This is what is done by the holography software (the authors of which hated the UIP). Doing this is fairly easy. First you must obtain an exclusive VMS lock on the name of the microcomputer process you wish to communicate with. For example, to send a message to the antenna computer, you must get an exclusive lock on the resource called ANT. Then you write your message to a mailbox – in the case of the antenna computer this mailbox is called TO_ANT. Next you should read all messages that return over the corresponding "FROM" mailbox – FROM_ANT in the case of the antenna computer. The last message will be a special End-Of-File message. Finally you must release the exclusive VMS lock so that other programs may communicate with the micro.

2.3 Antenna Computer Display

Here (Figure 2.2) is what you should see (approximately) on the antenna computer display screen. The antenna computer can display several "pages" of information on this screen. This is Page 1, the default display. Observers will almost never need to look at any other page. The UIP's `PAGE` command allows you to select the active page. See the UIP's online help for the `PAGE` command for a description of the available pages.

Date
This is the date (well duh!).

DOY - Day of Year
Day number of the current UT date.

MJD - Modified Julian Date
This is the current Julian date minus 2400000.5 in days.

UTC - Coordinated Universal Time
This is the current Coordinated Universal Time. If this time is not updating, the antenna computer is definitely not running.

DAT
This is the difference between TAI (International Atomic Time) and UTC in seconds.

```
DATE    JAN/21/2000  DOY  21 MJD  51564  AAZ       +53.5232  AZA       +32.5611
UTC      04:54:45.1  DAT  32 DUT +0.341  RAZ       +53.5231  RZA       +32.5611
LST      02:32:21.3                      EAZ(")        +0.1  EZA(")        -0.1

RAO            +0.0  DECO          +0.0  SOURCE      CRL618  EPOCH       2000.0
GLO            +0.0  GBO           +0.0  RAEP   04:42:53.56  DECEP  +36:06:53.6
AZO            +0.0  ZAO           +0.0  RA     04:42:53.99  DEC    +36:06:52.5
FAZO          -61.2  FZAO         -14.7  HA    -02:10:32.69  P ANGLE  -110.8217
TAZO           -1.0  TZAO         -49.6  TRACKING       ACQ  CELES
POINTING  345_SIDE  REFRAC         26.6

LINE       343000U  F REST  343.000000                       BAROM        620.5
SIDEBAND     UPPER  MUL/IF  4 / 1.5000                       TEMP          -1.5
V OFFSET     +0.00  F OFFSET   +0.0000                       HUMID         64.5
V LSR       -21.30  F LOCK     85.3730                       TAU 225      0.192
V RADIAL    +28.23  PLL  GUNN UNLOCKED                         AT    04:52:00.0
X POS       -10.40  THETA       +90.00                       WIND PK       17.7
Y POS       +10.32  FOCUS        -4.72  FOC MODE  STEALTHY     AT    22:07:30.0
Y OFFSET     +0.35  FOC OFFS     -0.25  BSW   NOT CHOPPING   TLENGTH     -0.001
_______________________________________________________________________________
Jan 20 12:20:16 localhost obsd[62]: Focus monitor enabled, 5 sec interval
Jan 20 12:20:19 localhost obsd[62]: Rotator monitor enabled, 10 sec interval
Jan 20 12:20:21 localhost acqd[73]: Version 1.0.1 (Jan 11 2000) started
```

Figure 2.2:

DUT

This is the difference between UT1 (Earth rotation time) and UTC in seconds.

LST - Local Sidereal Time

This is the current hour angle of the vernal equinox. You'd better know stuff like this!

AAZ - Actual Azimuth

This is the current azimuth, in decimal degrees, of the telescope.

AZA - Actual Zenith Angle

This is the current zenith angle, in decimal degrees, of the telescope. We should really be using elevation...

RAZ - Requested Azimuth

This is the azimuth, in decimal degrees, that the telescope *should* have. It is the position the servo system is trying to acquire.

RZA - Requested Zenith Angle

This is the zenith angle, in decimal degrees, that the telescope *should* have. It is the position the servo system is trying to acquire.

EAZ - Azimuth Error

This is the difference, in arc seconds, between the telescope's current azimuth, and the azimuth the telescope *should* have.

EZA - Zenith Angle Error

This is the difference, in arc seconds, between the telescope's current zenith angle, and the zenith angle the telescope *should* have.

RAO - Right Ascension Offset

This is an offset in arc seconds in Right Ascension, on the sky. It is corrected for the variation with declination of the size of an R.A. step. Although you are welcome to use this offset (you can set it with the UIP's `RAO` command), this offset is used by the computer in OTF mapping, and also if you specify a "Designated Offset". Usually it is better to use the "Mapping" offsets to map a source (with `RAO/map` command, or use the "Field" offset to offset entire OTF maps (with `RAO/FIELD` command).

DECO - Declination Offset
This is an offset in arc secondsn Declination, on the sky. Although you are welcome to use this offset (you can set it with the UIP's `DECO` command), this offset is used by the computer in OTF mapping, and also if you specify a "Designated Offset". Usually it is better to use the "Mapping" offsets to map a source (with `DECO/map` command, or use the "Field" offset to offset entire OTF maps (with `DECO/FIELD` command).

AZO - Azimuth Offset
This is an offset in arc seconds in Azimuth Angle, on the sky. It is corrected for the variation with zenith angle of the size of an azimuth step. Although you are welcome to use this offset (you can set it with the UIP's `AZO` command), this offset is used by the computer when `CALIBRATION` and `CHOP_SLEWY` scans are taken, so your value is apt to be overwritten. Usually it is better to use the "Mapping" offsets to map a source.

ZAO - Zenith Angle Offset
This is an offset in arc seconds in Zenith Angle, on the sky. You may change the value of this offset using the UIP's `ZAO` command.

GLO - Galactic Longitude Offset
This is an offset in arc seconds, on the sky. It is corrected for the variation with galactic latitude of the size of a galactic longitude step. You may change this offset using the UIP's `GLO` command.

The Galactic coordinates in the antenna computer are not very accurate. They **Should not** be used for mapping!

GBO - Galactic Latitude Offset
This is an offset in arc seconds, on the sky. You may change this offset using the UIP's `GBO` command.

The Galactic coordinates in the antenna computer are not very accurate. They **Should not** be used for mapping!

FAZO - Fixed Azimuth Offset
This is an offset in arc seconds, on the sky. It is corrected for the variation with zenith angle of the size of an azimuth step. The "Fixed Offsets" are used to correct for the receivers' small collimation errors. They should be changed only when pointing. Default values are loaded by the UIP's `POINTING_FILE` command. You can change them manually using the UIP's `FAZO` command.

FZAO - Fixed Zenith Angle Offset
This is an offset in arc seconds, on the sky. The "Fixed Offsets" are used to

correct for the receivers' small collimation errors. They should be changed only when pointing. Default values are loaded by the UIP's `POINTING_FILE` command. You can change them manually using the UIP's `FZAO` command.

TAZO - Tracking Azimuth Offset
This is an offset in arc seconds, on the sky. It is corrected for the variation with zenith angle of the size of an azimuth step. This offset is internally generated in the antenna computer, to compensate for pointing changes caused by moving the secondary (to follow the focus curve). You can not change this offset, and it probably shouldn't even be displayed on the default page.

TZAO - Tracking Zenith Angle Offset
This is an offset in arc seconds, on the sky. This offset is internally generated in the antenna computer, to compensate for pointing changes caused by moving the secondary (to follow the focus curve). You can not change this offset, and it probably shouldn't even be displayed on the default page.

POINTING - Pointing Constants File
This is the name of the last pointing file specified with the UIP's `POINTING` command. When you issue the `POINTING` command, the computer loads in the default "Fixed" offsets for the specified receiver, and the secondary mirror focus offsets, if any. It also tells the computer were to log any pointing results.

The pointing files are located in the directory PNT_DIR: on the VAX and Alpha, and they all have the extension .POINTING_SETUP. The UIP command `POINTING *` will list all the known pointing setups.

Refrac - Refraction Correction
This is the refraction correction, in arc seconds. It is obviously applied to the zenith angle, and always moves the telescope away from the horizon. Unless the pointing setup is "optical", the refraction is calculated based on the radio refraction model given by Berman et al. (1975) in JPL tech report 32-1601.

Source - Source Name
This is the source name from your source catalog. It is the name you gave when you issued the UIP's `OBSERVE` command (truncated to eight characters for display purposes).

Epoch - Coordinate Epoch
This is the epoch of the coordinates of the current object. Currently, the antenna computer can handle both J2000 and B1950, and has a clear preference to J2000 (as shown here). But for historical reasons all the sources entered into catalog under UIP are stored in B1950 system, even you can enter the source in B1950 or J2000, or some other equatorial/Galactic systems.

RAEP - Catalog Right Ascension
This is the object's J2000 coordinate.

DECEP - Catalog Declination
This is the object's J2000 coordinate.

RA - Current Right Ascension
This is the object's position at this moment, corrected for precession, nutation, aberration etc.
DEC - Current Declination
This is the object's position at this moment, corrected for precession, nutation, aberration etc.
HA - Hour Angle
This tells you how far your source is from (when negative) or after (when positive) transit in hour:min:sec.
P Angle - Parallactic Angle
This is the angle between local zenith and the North Pole, spanned from the source. It measure the source orientation on the sky.
Tracking - Telescope Status
The current telescope status shows up here. The possible values are `IDLE` (not trying to move or even servo to the current position), `TRACKING` (trying to servo to the requested azimuth and zenith angle) and `STOWED` (essentially identical to `IDLE`).
Acq - Tracking Status
This field displays `Acq` if you are within the Acquire Limits of the requested position, and `Not Acq` otherwise. You can change the acquire limits using the UIP's `ACQUIRE_LIMITS` command.
Celes - Tracking Mode
This field displays the current tracking mode, which is the method by which new requested azimuth and zenith angle values are being derived. Possible values for this field are `Celes`, `Planet` and `Altaz`.
Stop Button Indicator
This indicates that one or more of the big red "Stop Buttons" is engaged. When this indicator is present, you cannot move the telescope, dome, or shutter. You should be able to locate the active Stop Button by examining the Control Panel.

If a Stop Button somewhere other than the control room is engaged, you should try to find out who pushed it and why, before disengaging it. This is particularly true during the daytime, when people might be working in dangerous places (under the dome, etc.).

It is sometimes useful to fool the antenna computer into thinking that a Stop Button has been pushed, even when it hasn't. This will disable telescope and dome motion via software. The command to do that is

`UIP> TOA ALWAYS_PANIC 1SET.`

To undo the above, issue the command

`UIP> TOA ALWAYS_PANIC 0SET`

Line - Spectral Line Name
This is the name of the spectral line being observed. It is specified when

you enter the UIP's LO command. Information about spectral lines is stored in spectral line catalogs. There is a system-wide default catalog, and users may have their own line catalogs. A list of the currently open line catalogs can be obtained with the UIP command CATALOG/LINE. New spectral lines maybe added to the user's default line catalog (private_catalog.line_cat under your home directory) with the UIP's LINE command. If you would like to add a new spectral line to a catalog other than your default catalog, say diatomic.line_cat, you can use LINE/catalog=cat# where cat# is the number associated with diatomic.line_cat in the directory listing when you do CATALOG/LINE.

F rest - Rest Frequency
This is the Rest Frequency, or laboratory frequency, of the spectral line, in GHz. It is obtained from the line catalog, when you issue the UIP's LO command.

Sideband
Our heterodyne receivers all operate in the "double sideband" mode, which means that two sky frequencies, separated by an interval equal to twice the IF frequency, are mapped to each frequency in the IF bandpass. This sideband indicator specifies whether the line will appear in the lower or upper (higher) frequency sideband. By default, the sideband information is obtained from the line catalog, but you may override that when you issue the LO command by including either the /LOWER or /UPPER qualifier.

It is important to choose the correct sideband, because you might have an accidental overlap with another line if you choose incorrectly. On the other hand, sometimes choosing the sideband carefully will allow you to observe two lines simultaneously (for example CS(7-6) in the lower sideband, and CO(3-2) in the upper one). The LINECAT program on poliahu has a graphic mode which will display where all well-known lines will fall in the IF bandpass, for any particular setup.

Another reason you should select your sideband carefully is that noise enters the system through both sidebands. So if you are not trying to observe lines in both sidebands simultaneously, you should put the unused ("image") sideband at the frequency where the atmospheric opacity is lowest. Often a quick look on where your program line is on the atmospheric transmission curve over Mauna Kea would suffice to decide which sideband the line should be in. On the other hand, you may want to use the DSB program, again on poliahu, to help you to do that.

MUL/IF - Harmonics and Intermediate Frequency
MUL is the harmonic number that the multiplier in the receiver's LO chain is configured to produce. In other words, the Gunn oscillator's frequency is multiplied by this number. By default, this number is obtained from the line catalog when you give the LO command, but you can override the default

value by using the `/MULTIPLIER` qualifier on the `LO` command.
IF shows the IF frequency, in GHz. Normally we use an IF of 1.5 GHz, but this can be changed in the range of 1.2 – 1.8 GHz using the `/IF=` qualifier on the UIP's `LO` command.

If you change the IF frequency with the `LO` command, you will normally want to change the center frequency of the AOSes too (although it is not required by the software). For example, if you were using AOS #1, and you wished to observe normally with an IF of 1.4 GHz, you'd need to issue the following commands

```
UIP> LO/IF=1.4
UIP> AOS/AOS1=1.4
```

Be careful though to reset the IF to 1.5 GHz when you're done, as it would otherwise stay on and you will find out you no longer see the line you saw before fiddling with the IF.

V offset - Velocity Offset
This is an offset (in km/sec) that is applied when the antenna computer calculates the Doppler corrected frequency to send to the Phase Lock Loop. The line should appear shifted from the bandpass center by this amount in the final spectrum. This offset is entered by using the `/V_OFFSET=` qualifier on the UIP's `LO` command.

F offset - Frequency Offset
This is an offset (in GHz) that is applied when the antenna computer calculates the Doppler corrected frequency to send to the Phase Lock Loop. The line should appear shifted from the bandpass center by this amount in the final spectrum. This offset is entered by using the `/F_OFFSET=` qualifier on the UIP's `LO` command.

V LSR - Local Standard of Rest Velocity
The LSR velocity (in km/sec) is obtained from the source catalog. It cannot be overridden. If you need to change it, you must edit the source information, which can be done with the UIP's `VERIFY/EDIT sourcename` command. Currently we can only use LSR or simple radial velocities. We can't use heliocentric velocities, or Z, etc.

F LOCK - Lock Frequency
This is the frequency, in GHz, that the Gunn oscillator should be tuned to. The Gunn oscillator is the uppermost component of the LO chain on the receiver. Observers must tune the Gunn any time the frequency is changed appreciably. There are tuning charts for each Gunn just inside the sidecab, taped to the wall.

V radial - Radial Velocity
This velocity, displayed in km/sec, is normally calculated by the antenna computer. Normally observers don't directly change this number. However, if you wish to, you can directly specify the radial velocity to be used

in the Doppler shift calculation, by using the UIP's `LO/RADIAL_VELOCITY=` command. If you directly specify the radial velocity, keep in mind that the antenna computer will use it directly, and not apply any corrections for the earth's rotation, etc.

PLL - Phase Lock Loop
It shows the phase lock status, which can be simply `LOCKED`, or `GUNN UNLOCKED`, or `YIG UNLOCKED`, depending on the status of the Gunn Oscillator's Phase Lock Loop. If the antenna computer cannot talk to the Phase Lock Loop system (because it is dead, or unplugged) a blinking error message will appear here.

X POS - Secondary Mirror X Position
This is the secondary Mirror's X position in millimeters. If the telescope is tipped to the horizon, X is the direction parallel to the horizon and perpendicular to the telescope's optical axis. Positive motion is towards the compressor platform, and away from the sidecab. Normally, this value never changes.

Y POS - Secondary Mirror Y Position
This is the secondary Mirror's Y position in millimeters. If the telescope is tipped to the horizon, Y is the direction is vertical. Positive motion is downward at the horizon. This value will normally change slowly as you track a source – it is part of the "focus curve". The UIP's `FOCUS` command allows you to specify at what times the computer will be allowed to update the secondary's position. See the UIP's online help for `FOCUS` to get a description of the various updating modes that are available.

THETA - Secondary Mirror Theta Position
For the secondary mirror, theta is rotation about the optical axis. It is measured in degrees. The chop angle follows this rotation - it should always remain at 90 degrees to produce an azimuth chop. You may change this angle with the UIP's `THETA` command, but if you do so, the telescope's efficiency may drop.

FOCUS - Secondary Mirror Focus (Z) Position
This is the motion of the secondary mirror along the optical axis, which is normally called focus. It is displayed in mm units. This value will normally change slowly as you track a source - it is part of the "focus curve". The UIP's `FOCUS` command allows you to specify at what times the computer will be allowed to update the secondary's position. See the UIP's online help for `FOCUS` to get a description of the various updating modes that are available.

Y OFFSET - Secondary Mirror Y Position Offset
This is the distance, in millimeters, that the secondary should be offset from the focus curve, in the Y direction. Default values for this offset are loaded with the UIP's `POINTING` command, along with the "Fixed Offsets". This value can be set manually with the UIP's `Y_POSITION/OFF=` command. Note

that setting the offset with the `Y_POSITION/OFF=` command does not result in the secondary mirror immediately moving. A `FOCUS` command must be issued to actually move the mirror.

FOC OFFS - Secondary Mirror Focus Offset

This is the distance, in millimeters, that the secondary should be offset from the focus curve, in the focus, or Z, direction. Default values for this offset are loaded with the UIP's `POINTING` command, along with the "Fixed Offsets". This value can be set manually with the UIP's `FOCUS/OFF=` command. Note that setting the offset with the `FOCUS/OFF=` command does not result in the secondary mirror immediately moving. A second `FOCUS` command must be issued to actually move the mirror.

FOC MODE - Focus Update Mode

This field tells you when the secondary mirror will be adjusted to follow its focus curve. The default is `STEALTHY`, which means that the secondary will be adjusted only when the alpha tells the antenna computer to adjust it. That will happen after each OO_SCAN or CHOP_SLEWY cycle is completed. See the online help for the UIP's `FOCUS` command for a description of the available focusing modes.

BSW - Beam Switching Mode

This field shows you the current beam switching mode, which can be `CHOPPING` if you are chopping the secondary mirror, or `NOT CHOPPING` if you are in regular position on/off mode.

Barom - Barometric Pressure

This is the current air pressure, in millibars. It is measured at a little weather station in the dome, near the shutter. This value is updated every 10 seconds, and is used in calculating the refraction correction.

Temp - Celsius Temperature

This is the current air temperature in degrees C. It is measured at a little weather station in the dome, near the shutter. This value is updated every 10 seconds, and is used in calculating the refraction correction.

Humid - Relative Humidity

This is the current relative humidity, in percent. It is measured at a little weather station in the dome, near the shutter. This value is updated every 10 seconds, and is used in calculating the refraction correction.

If this number is blinking, if means that the humidity is so high, water may start condensing on the telescope. You should frequently check to see if this is happening - once the telescope gets wet, the telescope's efficiency drops rapidly and it is almost impossible to dry the thing off until the dome warms up in the daytime. Close the dome if water starts to condense on the telescope. The humidity reading saturates at about 115 $\rightarrow$ 117%. If it gets that high you should close the dome immediately whether or not you can detect condensation.

Tau 225 - 225 GHz Tau Measurement
This is the opacity at 225 GHz. It is measured at roughly 10 minute intervals by a dedicated radiometer located on the roof of the shed. In very poor weather, the radiometer occasionally gives junk readings equal to, or less than zero. Such readings are not shown on the antenna display, so the display might not be updated at regular intervals during poor weather, or in the afternoons.

A more elaborate display of atmospheric opacity at both 225 GHz and 350 μm is available on our web-site (http://www.cso.caltech.edu).
AT - Tau Time
This is the Universal Time at which the currently displayed 225 GHz opacity was measured.
WIND PK - Peak Wind Speed
This is the maximum wind speed (in mph) measured during the last 15 minutes at the JCMT. If this value exceeds 50 mph, **you MUST close the shutter!**
AT - Wind Speed Timestamp
This is the time at which the peak wind speed was logged. The peak listed is the peak within a 15 minute window, so the time displayed here is not the exact time when the maximum speed gust occurred, but rather the time at which the 15 minute window started.
TLENGTH - Dome/Telescope Relative Position
This field displays the value of the LVDT (see Figure 1.11) that measures the position of the dome relative to the antenna. It is normalized so the the full travel of the LVDT is -1.0 to 1.0. If this value approaches 1, the antenna computer will idle itself, and you won't be able to move the telescope or dome. You will need to re-align the dome and telescope before you can observe. See dome/shutter related section in the CSO trouble shooting Guide on our web for detailed instructions.

2.4 Backend Display

The program in the backend computer (see Figure 1.6) which runs the AOS produces a real-time display of the AOS data. By default, this display appears on puuoo's monitor in the control room (see Figure 1.3), but it can be re-directed to another X window display either on the summit or elsewhere (see the online help for the `AOS` command's `/DISPLAY=` qualifier). Examples of the types of display that will appear are shown in this section.

This display is produced when a temperature calibration scan is taken (see Figure 2.3). The Tsys value is calculated using the data from such a scan, and

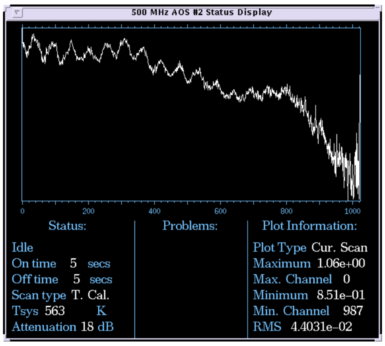

Figure 2.3:

is updated on this display. The "Problems:" region of this display is blank in this example. Any "Problems" that appear in amber are informational messages, and don't indicate anything serious. Any "Problems" that appear in red indicate conditions that will either corrupt the data, or prevent data from being taken at all.

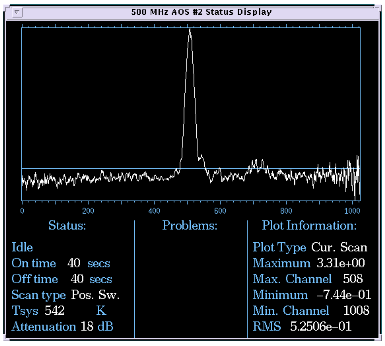

Figure 2.4:

This display shows the output of an `OO_SCAN` scan (see Figure 2.4). The display will be updated as integration takes place. When the scan is complete this display will show a spectrum which is identical to the one stored in the CLASS data file.

The attenuation reported is the setting of the AOS's programmable attenuator. If the value is 0 or 31, that indicates that the IF power level is either too low or too high for the AOS to handle.

The Maximum, Minimum and RMS are all in temperature units (T_A^*) unless no valid calibration scan is available (in which case the message "No valid Cal. scan" will appear in place of the system temperature. When no baseline is active (as in this display), the RMS is calculated over all channels, even if there is a signal present (as there is here between channels 480 and 560). The only exception to this is the display for the 1.5 GHz

AOS. Currently the Observatory's IF bandwidth is 1 GHz, so the edge of a spectrum from the 1.5 GHz AOS contains only noise. These noise channels are neither displayed nor used in the RMS calculation.

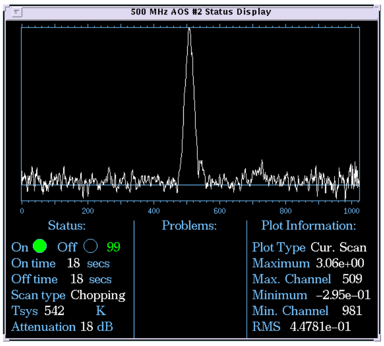

Figure 2.5:

This display was produced during a CHOP_SLEWY scan (see Figure 2.5). In most ways it is identical to the OO_SCAN display. However little green circles turn on and off as the secondary mirror chops. You should not be concerned if the little green circles do not appear and disappear with perfect regularity, or if the green dots do not appear and disappear simultaneously in several AOS windows which are simultaneously integrating. This display is produced in an X window, and it is not possible to control precisely when a feature will appear or disappear in an X window.

The green "99" is a measurement of the chop duty cycle. More precisely, it is the percentage of AOS data that is flagged as good by the Programmable Window Comparator. If it drops below 50, it will turn red, and you should try to do something to improve the chop duty cycle. Things you can try include:better tuning of the chopper; chopping at a lower frequency; reducing the chopper throw; increasing the positional tolerance level.

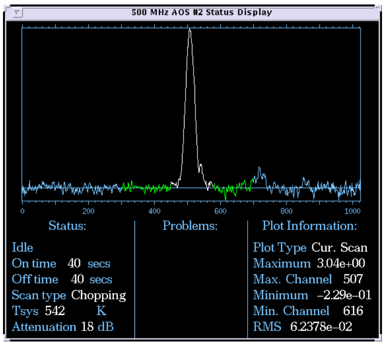

Figure 2.6:

This display was also produced during a CHOP_SLEWY scan (see Figure 2.6).

In this case an AOS baseline window was active. These windows are usually introduced to allow pointing using a spectral line. The linear baseline is fitted to the channels shown in green. By default, the `FIVE_POINT` command will integrate all the white channels (all channels between the baselines), but this behavior can be overridden by qualifiers to the `FIVE_POINT` command. When a baseline is active, the RMS is calculated only over the green channels. The baseline shown in the display was specified by the command

```
UIP> AOS 10 300 450 580 700
```

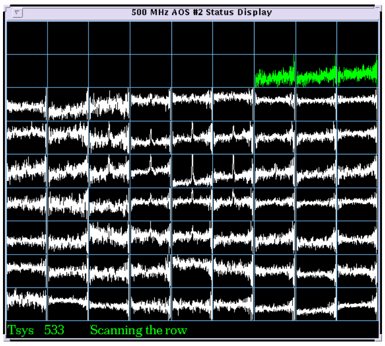

Figure 2.7:

This display was produced during an `OTF_MAP` (see Figure 2.7). Each map cell is displayed individually. The cells displayed in white have spectra produced using two OFF integrations - they are identical to the spectra stored in the data file. The green spectra are from the row currently being scanned. The will be re-drawn in white, and stored in the data file after the OFF integration is taken at the end of the row.

Note that the vertical scale in each cell is independent of all other cells, and calculated to just fit the spectrum's data range. One side effect of this is that the cells with no signal appear to be noisier than those in which a signal appears. This is normal, and unavoidable, behavior.

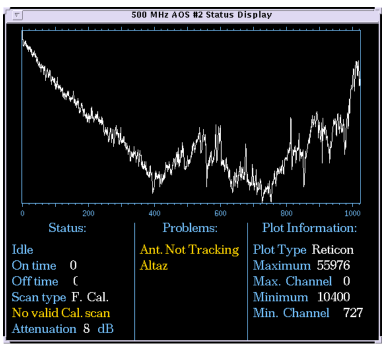

Figure 2.8:

This plot shows a "Reticon" display (see Figure 2.8). It is simply a plot of the raw data from the AOS's reticon detector. The scale is inverted - low abscissa values correspond to high power. This display is sometimes useful for diagnostic purposes, or just to examine the shape of the IF bandpass. This display is turned on with the UIP command

`UIP> RETICON`.

It may be turned off by issuing the command

`UIP> NO_RETICON`.

One other useful program that used to run on the backend computer is orrery (see Figure 2.9) , which shows the real time (±20 min) sky positions

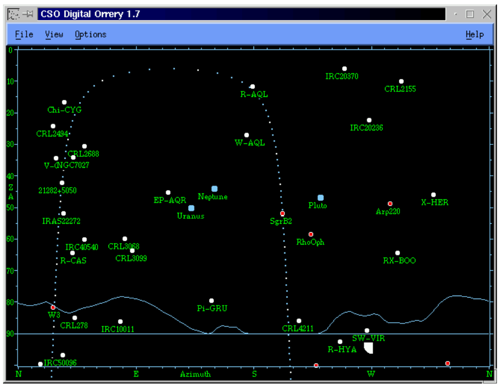

Figure 2.9:

of your program source, available planets, CO pointing stars, other known continuum sources, Galactic plane, etc. Pull-down menu on the display allows you to configure what you want to display, and by clicking on a source a drop-out window will tell you what we know of the source, it's size, flux densities, and spectral line temperatures measured at CSO. Now the program is run from hapuan or kilauea. You can start the orrery on the Solaris boxes UIP by

hapuna% orrery -display puuoo:0.

2.5 Where Is That File?

The VMS operating system supports tree structured file directories. This means that important files can be hard to find. Here are where some of the important ones are located. Don't mess with any of these files without talking to Richard Chamberlin first. This information is included for completeness rather than that you will need it.

- The UIP
The default UIP is located in CSO_SYS:[UIP] (aka UIP:). Sources for the commands are in CSO_SYS:[UIP.SRC.COMMANDS]. Include files, which describe how the data files are laid out among other things, are in CSO_SYS:[UIP.INCLUDES]. However, to run UIP, you merely need to type `UIP` - it is an installed program.

- Catalogs
The standard source and line catalogs are in CSO_SYS:[CAT_DIR] (aka CAT_DIR:). In addition to the default source and line catalogs, the Palomar, bright star, and CO point star catalogs are here. These catalogs are not in a printable format. The UIP's `VERIFY` command must be used to snoop through them.

- Log files
If your UIP log file is opened automatically by the UIP, it will be placed in CSO_SYS:[LOG_DIR] (aka LOG_DIR:).

- Pointing
The OVRO pointing constant reduction program is in USER:[TDG.POINT] and is called POINT. Individual pointing constant files, such as those called up by the UIP's `POINTING` command, are in CSO_SYS:[PNT_DIR] (aka PNT_DIR:). Don't mess with any of the files in PNT_DIR: without checking with Richard Chamberlin.

- IRAM GAG Suite
The codes for the ASTRO, CLASS, GREG, GRAPHIC, VECTOR program, along with documentation and utility programs, are located in a series of subdirectories rooted by the logical name GAG_ROOT:. Documentations are in GAGROOT:[DOC]. The executable images for CLASS, GREG, etc. are in GAG_UTIL, which is GAG_ROOT:[BIN]. You may wish to run the GAG suite (CLASS, etc.) off our summit Solaris machines, as newer versions of GAG have only been ported to UNIX systems. The version of GAG run on Alpha1 dated Fall 1996, and the one on Poliahu is even earlier (February 1994).

- TeX
Files for TeX are located in a series of subdirectories rooted by the logical name TEX_ROOT: on Poliahu. TeX resides in TEX_ROOT:[PROGRAMS]. The files describing standard formats for such things as a memo with the Caltech letterhead are stored in TEX_ROOT:[LOCAL.INPUTS]. Again, you may wish to process your TeX files on the Solaris machines, from which you can readily access your VMS directory (at /user_vax/usrname).

- DVIPS
  DVIPS resides in the directory pointed to by DVIPS$ on Poliahu. As with TeX, the same utility is available on the Solaris machines.

- Forth Files
  The assembly language sources to CSO Forth is in CSO_SYS:[FORTH]. The standard vocabulary is in CSO_SYS:[FORTH.COMMON] and the antenna microcomputer's Forth code is in CSO_SYS:[FORTH.ANTENNA] (aka FORTH_ANT:). These are only of historical value now since the antenna is now controlled by a modern power PC running Lynx OS.

2.6 Taking Your Data Home

There are a variety of ways you can take your data home. We have three DAT magtape drives one each on Alpha1, Poliahu, and Hapuna, respectively). Also, our internet connection is usually fast enough to transfer a full night's worth of data in a few minutes. Please do not remove your data files from alpha1 after you have sent them home. You are encouraged to remove any files of temporary nature though. After you leave the observatory, your data will remain on the VMS machines for quite some times (up to one year), depending on the demand on disk space but also on the size of your data file(s). The data is archived to tapes on a regular basis, and is being mirrored constantly between two identical SCSI drives on Alpha1. When files are removed from your home directory, they are placed under BIGDISK:[tmp.usrname] for some extended period and eventually deleted.

Spectral Line data are also archived in a SYBASE database. If all copies of an original data file have been lost (a very unlikely event), the data can be retrieved from this database. But that's a big hassle.

2.6.1 Transferring Data Over the Internet

This is the most sensible way to transport data home, for most observers. The standard method of transferring data over internet is using `FTP`. Let's assume that your data file is called `[SMITH]25DEC94.DAT` , and you wish to transfer your data to a computer whose internet address is `jach.hawaii.edu`. The following dialog shows how the file can be transferred. Comments are preceded by an exclamation point.

```
$ FTP jach.hawaii.edu
JACH.HAWAII.EDU>login
Username:  smith
Password:  ! Your password is not echoed
JACH.HAWAII.EDU>bin ! Transported in "binary" mode
```

```
Type: Image, Structure: File, Mode: Stream
JACH.HAWAII.EDU>put 25dec94.dat 25dec94.dat
JACH.HAWAII.EDU>quit
```

If the target machine (jach.hawaii.edu in this case) happens to insist on communicating with remote hosts through secure shell (**ssh**) by refusing remote ftp and telnet requests, you would need to do the data transfer on one of our Solaris hosts, say Hapuna:

```
hapuna% cd /user_vax/smith
hapuna% scp 25dec94.dat smith@jach.hawaii.edu:/home/smith
```

2.6.2 Putting Data on Tape

If you really wish to go home with your data on a DAT tape, you can do that on the Alpha1 or Poliahu if you have a VMS machine back home to read the tape, or on Hapuna for UNIX hosts. Currently the name you should use for the tape drive is MKB300: on Poliahu or MKA100 on Alpha1.

On Alpha1 or Poliahu (your account is shared among the VMS hosts, which currently include one VAX (Poliahu) and two Alpha's (Alpha1 and Alpha2)), you would want to make a "BACKUP Saveset". This format has lots of redundancy, so a small number of tape errors will probably not corrupt your data. The Saveset is written with the VMS `BACKUP` command, and there is online help available for the command. Also, help can be found in volume 4A of the big orange VMS manuals in the computer room. The following example illustrates how to write several files to a Saveset.

First, insert a blank tape in the DAT drive

```
$ init mkb300: tape !  This wipes out anything on the tape.
$ mount/for mkb300:
$ backup/ignore=label *DEC94.DAT MKB300:DEC94.BCK/SAVE
$ dismount mkb300:
```

The above backup command puts all files ending in `DEC94.DAT` into a saveset called `DEC94.BCK` on the tape.

There may be cases when you have data (or other files you would like to take with you) in more than one directory or even on more than one disk. In this case the easiest way to back them up is to write yourself a command file like the one below (but you can type this in too if you want, the syntax is the same):

```
$BACKUP/LOG/VERIFY/IGNORE=LABEL -
/LIST=BACKUP.LIST USER:[RTM.MAR94]*.*.*,-
USER:[DBENFORD...]*.*.*,-
USER2:[DBENFORD...]*.*.*,-
USER2:[HUNTER...]*.*.*,-
LOG_DIR:*.*.* -
```

```
MKB300:DATA.BCK/SAVE
```

This procedure backs up data from the USER and USER2 disks as well as from the LOG_DIR directory, including complete directory trees. It takes all versions of all files in the directories, to get only the latest version use *.*; in the file specification. It produces a listing file called BACKUP.LIST in the directory where you started it from and writes a saveset called DATA.BCK on a DAT tape. The /VERIFY qualifier causes it to read back the data written to the tape and compare with the files on disk after it is finished writing.

On Hapuna, the DAT tape drive is at /dev/nrst4. To back up your data files to tape:

```
hapuna% cd /user_vax/smith
hapuna% mount /dev/nrst5
hapuna% tar cvf /dev/nrst5 *dec94.dat
```

2.6.3 Writing a FITS File

Our data reduction software comes from the Groupe d'Astrophysique de Grenoble (hereafter GAG). One of the programs in this suite, CFITS converts CLASS format files into FITS. Start the program by

```
$ CFITS
```

Read in you data file(s) in the normal CLASS way, with FILE IN and FIND/ALL (assuming you want all the scans). Insert a tape into the tape drive. Type

```
CFITS> MOUNT MKB300:
```

change the tape device name to /dev/nrst4 if you are on hapuna. After several seconds it should say it has done so successfully.

```
CFITS> WRITE *
```

- this will write out all the scans read in.

2.6.4 Dumping the Data as ASCII Text

It is also possible to write your data out from CLASS in ASCII format using the DUMP command. This is really an act of desperation, but we've had observers do it... There is help on the DUMP command within the CLASS manual.

2.7 Background Processes on Alpha1

There are several processes run on alpha1 that are not attached to any terminal. They are started when the the antenna computer is restarted, or when SHARC or an AOS is the active backend. Normally they operate without any user intervention. These processes are the background processes. If things have just stopped working, the chances are good that one of these processes is messed up.

The process `ANT_MCP` is the process which handles communication between alpha1 and the antenna computer. It makes sure that only one process can be sending commands to the antenna computer at any given moment, and it routes messages from the antenna back to the appropriate job. If an unsolicited message comes from the antenna computer, it will be printed on the terminal running the UIP (hereafter called the system console). If a job sends a message to the antenna computer that results in the antenna computer sending a response more than five seconds later, the response will be considered unsolicited, and will be routed to the system console (if there is one), not the appropriate job. (Messages logged on the system console are also saved in the operator log located in `SYS$MANAGER`. However, there is no system console on alpha1 and the existence of operator logs is somewhat unpredictable at best).

`Dwncvtr Client` is the process that accepts commands from the UIP, and sends them to the Downconverter, which is controlled by the backend computer.

`AOS #n Client` accepts commands from the UIP, and sends them to the nth AOS. <`AOS n EKG`> exchanges a message with `AOS n` every 5 seconds, to check if the AOS process on in the backend computer is still alive. If <`AOS n EKG`> detects that the `AOS n`is dead, it kills all other processes on alpha1 which are associated with the AOS, and sends a swan song to the system console. <`AOS n Errors`> is used by the backend computer to report any error conditions existing in the `AOS n` to the system console. <`AOS n E. Flag`> sets the appropriate event flag when `AOS n` completes an integration phase. <`AOS n Scans`> accepts the scan data from the `AOS n`, and writes to a data file. Most of these processes have SHARC mode analogs, with `SHARC` substituted for `AOS n` in the process name.

2.8 Printers

In the computer room (see Figure 1.3) there are two printers (HP Laserjet and HP color Inkjet) served out of puuoo. Printer queues are set up on various computers to access these two printers on Summit. On the Unix machines (hapuna, kilauea, and puuoo),

```
lpr filename
```

sends the file to the laser printer while

```
lpr -Pdj filename
```

points to the color inkjet. On the VMS machines (alpha1, alpha2, and poliau),

```
print/que=lw filename
```
sends the file to the laser printer while
```
print/que=lwc filename
```
sends the file to the color inkjet printer.

In the CSO office at Hale Pohaku, there are also two printers (HP laserjet and HP color inkjet) served by the Linux workstation ono. Again, the laser printer is the default ("lp") and "dj" points to the color inkjet. These two are accessible from any of the Summit machines with queue names of "onolp" and "onodj" respectively. Similarly, the two printers at our Hilo office are accessible from any of the Summit machines vis queue names "hilolp" and "hilodj".

Chapter 3

The Fabulous User Interface Program (UIP)

3.1 Introduction

The UIP is the program that takes commands from the observer. It allows control over almost all aspects of telescope motion and data acquisition, plus things like catalog access, data reduction access, log files etc. Observations are taken from UIP automatically with schedules (similar to command procedures), or via commands entered at the keyboard.

To invoke the UIP simply type `UIP` after logging in to alpha1. You will be asked whether you wish to open your last log file - answer as you think fit. The log files are very useful - they record all important events (any command you issue, errors, results returned etc, all with a date and time stamp). You may want to send this file home along with your data at the end of your run. Please do not move the log file from LOG_DIR.

Once in the UIP you can see the available commands by typing `HELP`. Help for individual command is available by typing `HELP command`. Typing `command?` will list the parameters and qualifiers for the `command`. A command can be specified by the minimum number of characters needed to uniquely distinguish it (guaranteed to be less than five, and usually less than 4). For example `ANTENNA` can be abbreviated `ANT`. Note however that macro names, source names and line names *cannot* be abbreviated. If you enter a line which does not begin with a UIP command, it will be passed to DCL (the VMS command line interpreter), as a subprocess. This allows you to edit files, mount tapes etc. without constantly hopping in and out of the UIP. If you need to type several lines of DCL, but still don't want to leave the UIP (for instance if you have a command file executing in the background) typing $ (carriage return) or `DCL` will spawn a subprocess that will remain until you explicitly log it out. It is important to remember that commands that affect the context of the subprocess do not affect the context of the parent process running the UIP. For example, if you type the command

`ASSIGN MY_DATA.DAT FOR030`

within the UIP, a subprocess will be spawned and the logical name will be assigned as expected. However this logical name will then immediately disappear when the subprocess terminates and control is returned to the UIP. So the command will not really have any effect at all (this would not be the case if you had defined a system or group logical name). Another limitation is that a subprocess cannot give itself privileges that the parent process does not have, even if the parent process is authorized to give itself those privileges.

While a subprocess does not normally inherit any of the parent process' open files, a UIP subprocess will automatically open any catalogs that have been opened by the parent process. The opening of these files only occurs if the UIP subprocess executes a command that references the catalogs, such as `OBSERVE`.

A complete listing of `UIP` commands and their functions and usages is in Appendix C. It is intended to provide a quick reference for experenced users and a point to start learning `UIP` for first time users. We encourage you to use the `HELP` facility under `UIP` to get the upto-date information for the commands while you are running `UIP`.

3.2 UIP Subprocesses

Subprocesses do not inherit any macros you have created using the `DEFINE` command. Note the difference between subprocesses and macros: subprocesses are usually long command files which perform tasks such as mapping and they do not tie up the terminal while being executed. Macros are typically shorter, and are defined by the `DEFINE` command (usually in the user's UIP.INI file). They perform simple tasks which are just short lists of common UIP commands that a user frequently requires. Macros do tie up the terminal for further input until they are completed.

3.3 The Parser

The UIP uses the DCL command parser (the standard VMS parser), so the syntactic rules for UIP commands are the same as those for DCL commands. Parameters must be entered in the proper order, after the command, and separated by a space. Qualifiers can be entered anywhere after the command. Both parameters and qualifiers are used to pass values to the UIP commands. Parameters are used for commands where it is very likely that many of the values will have to be passed each time the command is executed. For instance the `SOURCE` command has the format

`UIP> SOURCE NAME\QUAL RA DEC [velocity] [PM_RA] [PM_Dec].`

It is unlikely that you would ever want to use the `SOURCE` command and not specify at least the name, right ascension and declination. Since the `SOURCE` command uses parameter passing for these values, the order of entry specifies which parameter is which. On the other hand, some commands have many possible modes requiring a single value to be passed, and it would be tedious to have to specify a value for all the irrelevant parameters just to space yourself to the parameter of interest. For these commands, values are passed with qualifiers. Using a qualifier requires you to identify the value you are passing, but it relieves you of having to type place holding values. For qualifiers whose values are binary, simply specifying the qualifier or its negation will suffice (for instance `/PRINT` or `/NOPRINT`). Qualifier names are "minmatched" just like the command names, so usually only the first one or two characters of the name are needed. You will be prompted for any required parameters that you haven't entered. If a qualifier requires a value, you must use the format `/QUALIFIER=VALUE`. For example, to specify that AOS 2 should be used in a `FIVE_POINT` command, one would say

`UIP> FIVE/AOS=2`

You can see a list of all the parameters and qualifiers for a UIP command by typing the command name followed by a question mark.

The use of the DCL parser has its disadvantages. Certain characters (for instance /, + and !) are interpreted by the parser before the parameters are handed to the command. This means that source names such a 1758+37 must be entered as "`1758+37`", with the quotes keeping the parser from interpreting the "+" character.

3.4 Aborting Commands

All UIP operations that take any significant amount of time, such as `OO_SCAN`, `FIVE_POINT`, `VERIFY` (with wild cards), `ANWAIT`, etc. can be aborted safely by typing control C (`^C`). You don't have to wait for the current integration to complete. In rare instances the `^C` may be ignored, so you may have to type `^C` twice. There is no danger in doing this, since you can no longer exit the UIP by typing `^C`. You can still exit the program by typing `^Y`, but this is not recommended. In some cases, `^C` will result in "cleanup" procedures being executed, before control is returned to your terminal. These procedures do things such as moving the hot load out of the beam, if you interrupted a calibration.

^C will also abort the execution of macros defined with the DEFINE command. But it does not effect subprocesses running command files. These can be stopped with the KILL command.

3.5 Defining Macros

The basic UIP vocabulary can be augmented by defining new words in terms of old words. The DEFINE command allows this to be done. These new words are called "macros". Macros may be added interactively from the keyboard, or they may be INTERPRETed from a command file. Macros may be nested to any depth, and because they are reinterpreted upon each execution, changes made in early definitions will effect macros that were defined later. Macros are forgotten as soon as the UIP is exited, so if you wish to have one of your macros always available, put the definition in the UIP.INI file in your home directory (user:[smith]) by using the editor. If you have a macro that you would like to be available to all users, it should be put in the file CANONICAL:UIP.INI - examine this file to see how typical macros are defined. All the macros that have been DEFINEd may be listed by typing the UIP command DEFINE/LIST.

Macros may be passed parameters. See the description of the DEFINE command to see how to do this. The HELP command does not operate on macros, so any documentation must be in the form of comments placed in the definition of the macro. Comments should be preceded by a "C" if the entire line is a comment, or by a "!" if only the remainder of a line should be considered a comment.

DEFINEing a new word is often more efficient than writing a small command file to be EXECUTEd, because no subprocess is spawned. Spawning subprocesses in VMS is slow and always will be.

3.6 Useful Macros Globally Available

The following commands are defined in CANONICAL:UIP.INI and thus are available to all users.

IAZ and IZA	These commands are identical to AZ and ZA, except they wait for the antenna to reach the requested position, and then idle the antenna.
FCAL	Requests a frequency calibration comb from the AOS. The integration will last for about 1 second, and the comb spectrum will be saved in the currently active data file. The derived channel-to-frequency conversion function is applied automatically to all subsequent scans when stored.

BLADEIN and BLADEOUT	These two commands simply move the chopper blade in and out of the beam respectively. Useful for skydips.
1M, 1.5M, etc.	Moves the antenna to a Zenith Angle corresponding to the specified airmasses. 1.5M moves you to 1.5 airmasses. Handy for skydips.
GUNN_ON and GUNN_OFF	Allows the Gunn oscillator to be turned on and off
LIM and NOLIM	Enables and disables the software limits for the dome/antenna relative position. Useful for getting out of limit switches.

3.7 Log Files

When the UIP starts up, it opens a log file. If the log file you last used is still on the system, and not in use by anyone else, you will be asked if you wish to reopen it. Otherwise a new log file will be opened.

Everything you type into the UIP, plus the responses, are written into the log file. The only exceptions are help messages, and the output of DCL subprocesses. I/O from command files executing as subprocesses is logged. The active log file can be viewed by typing the VIEW_LOG command. A copy of the log file will be thrown into the EDT editor. Your commands are logged with a time stamp (the date and time they were entered), along with other status information such as the data file name, etc. Scan numbers are (conspicuously) not logged in the log file. If you were trouble shooting, you can pursue the log file for events occurred around a bad scan by relating the time stamps in the log file and the system time stored in the scan header (viewed simply by displaying the scan with CLASS).

Commands that involve the log file:

LOGON	Used to open a new log file
NOLOG	Closes a log file
LOG	Explicitly logs a string in the log file, with a time stamp if desired
VIEW_LOG	Calls up the EDT editor with a copy of the current log file
STATUS	Will tell you the name of the active log file

3.8 Schedules/Command Files/Scripts

Normal observation is frequently performed using a schedule (which may just as well be called a command procedure or a script, depending on which world of computing you are from), particularly if you are mapping. It is simply a file of UIP commands, frequently little more than OO_SCANS and mapping offsets. It can be prepared with the VMS editor, as with any text file, or via the MAPPER command (type HELP MAPPER under UIP to see its usage).

To execute a schedule, use the EXECUTE command. Schedules may be executed synchronously, or asynchronously (depending on the /WAIT qualifier). Schedules are executed as subprocesses, and may be nested to any depth (you will eventually run into some limitations by the VMS system parameters or or user privilege). The second parameter in the EXECUTE command is the number of times the schedule should be executed with a default of 1. If the file name in the EXECUTE command is preceded by a dollar sign, the directory pointed to by the logical name CANONICAL will be searched for the file.

```
UIP> EXECUTE $MAP_VENUS
```

is equivalent to

```
UIP> EXECUTE CANONICAL:MAP_VENUS
```

Note that any of the commands below (KILL, STATUS, etc.) will only effect schedules that are running from the terminal you are using. Each terminal, running a separate copy of the UIP, can have its own schedule running and knows nothing about any schedule running on a different terminal. You can't, for instance, walk over to an idle terminal and kill a schedule running somewhere else. If you have managed to get a schedule running and cannot kill it, you'll need to perform a SHOW SYSTEM, followed by SET PROC/PRIV=ALL, and STOP/ID=xxxx where xxxx is the PID number of the relevant subprocess (usually your login name appended with an "_1" or similar) from the show system command.

Commands that Involve Schedules:

EXECUTE	Begins the execution of a schedule
KILL	Terminates, forever, the execution of a schedule
HOLD	Stops the execution of a schedule – may be resumed later
RESUME	Restarts a schedule suspended by HOLD
LAST	Sets the execution repeat count to 1
STATUS	Tells you the name of the schedule currently running, if any. It also shows the current line of the schedule and how may times it will be executed.

Parameters may be passed to the subprocess executing a schedule, as illustrated by the following command procedure, AOS_ON_OFF.COM:

```
c This is a general routine for taking simple (on-off)/off scans
c with the AOS. It requires two parameters as follows:
c     STEP           The size of the off position step in arc min
c     STEP_TYPE      The type of step (i.e.  AZO, RAO etc)
   ON_POSITION /CLEAR
   TAKE_DATA /LEAVE
   BEWAIT
   {STEP_TYPE} {STEP}
   OFF_POSITION /CLEAR
   ANWAIT
```

```
TAKE_DATA
BEWAIT
{STEP_TYPE} 0
```

Notice the words STEP and STEP_TYPE in curly braces. They tell the UIP that these words are parameters which must be translated. To execute this command file with a 5 arc minute offset step in declination, the following UIP statement should be given:

```
UIP> EXECUTE AOS_ON_OFF STEP=5 STEP_TYPE=DECO
```

The equal signs must be there, and no spaces are permitted on either side of the equals sign. Parameters are stored in global DCL symbols. As a result the parameters are sticky, so the next time this command file is executed, with perhaps a 10 minute offset, still in declination, the command

```
UIP> EXECUTE AOS_ON_OFF STEP=10
```

would suffice. Note that this schedule is in fact nothing more than the OO_SCAN command. Many of the UIP commands are just subroutines containing other UIP commands.

There is a very crude conditional test capability during schedule execution. The UIP commands IF_S and GOTO_S allow DCL symbols to be compared with other symbols or constants to control branching within a schedule. Currently only forward branching is allowed, but if reverse branching is ever useful, it can easily be added. It's not clear this feature is useful at all, so not much work has been put into it. If other control features would be useful to you, please mention them to the CSO staff and they will be added.

Schedules can also be INTERPRETed. This means the commands in the schedule file are executed without spawning a subprocess. The file UIP.INI under your home directory is always interpreted when the UIP is started, if it exists. This is intended to allow an observer to have a standard setup file, and avoid having to retype the same commands many times.

3.9 Source Catalogs

The source catalogs that the UIP can manipulate are not simple ASCII text files. They are sorted, random access files for reasons of efficiency. As a result, creating, modifying, and inspecting source files **must** be done from within the UIP. The UIP can have up to 10 source files opened at once. The most recently opened catalog will be searched first to find an object. Upon entering the UIP, two source catalogs are opened automatically, the DEFAULT_CATALOG.CAT located in CAT_DIR:, the PRIVATE_CATALOG.CAT located in your home directory. The default catalog contains some well known and commonly observed sources, and is read-only. By default any object you enter via the SOURCE command will be stored in your PRIVATE_CATALOG.CAT.

You could load someone else's catalog using the `CATALOG` command (not that we encourage that!). You can also create new catalogs of your own with the `CATALOG` command, if you prefer not to write a new source into your existing `PRIVATE_CATALOG.CAT`. You would have to use the `/CAT=cat#` qualifier with the `SOURCE` command to have the new source go into the new catalog you opened. Also you need to load the the catalog every time you start up UIP in order to access the sources in the catalog.

Commands that Involve Catalogs:

`CATALOG`	Opens/closes existing catalogs and creates new ones
`FORGET`	Deletes a source from a catalog
`OBSERVE`	Finds a source in a catalog and sends antenna (and you too!) to the source position
`SOURCE`	Adds a source to your private catalog. Sources may be entered using B1950, J2000, or galactic coordinates.
`VERIFY`	Shows the position of a source. Also allows editing of source parameters as well as wild card searches. Will calculate the source's current ALTAZ coordinates. Can display either RA-Dec or Galactic coordinates.

3.10 Velocity Convention

The CSO calculates the sky frequency in nonrelativistic regime using the "radio" definition. This differs from the "optical" definition as

$$z_{radio} = \frac{\nu_0 - \nu}{\nu_0} = \frac{v_{lsr}}{c}$$

while

$$z_{optical} = \frac{\lambda - \lambda_0}{\lambda_0} = \frac{v_{optical}}{c}.$$

These lead to

$$\frac{1}{v_{lsr}} - \frac{1}{v_{optical}} = \frac{1}{c}$$

or

$$\frac{1}{z_{radio}} - \frac{1}{z_{optical}} = 1.$$

3.11 Galactic Coordinates

An object can be entered into your source catalog in its galactic coordinates if you use the `GALACTIC` qualifier with the `SOURCE` command. The position you give will be interpreted as being l and b, rather than RA and Dec. These coordinates will be converted into RA and Dec in B1950 epoch, and stored that way in your catalog. If you wish to see the galactic coordinates of any source in a catalog, use the `VERIFY` command with the `/GALACTIC` qualifier.

3.12 Spectral Line Catalogs

In addition to the source catalogs, which hold positions and velocities of objects, there is a line catalog, which stores information about spectral lines. Similar to the source catalogs, there is an observatory-wide default line catalog (`CAT_DIR:DEFAULT_CATALOG.LINE_CAT`), and each user automatically has a private line catalog (`PRIVATE_CATALOG.LINE_CAT` in your home directory). Each entry in the line catalog contains an alphanumeric name for the line, the rest frequency of the line, the sideband the line will be seen in, and the multiplier value to produce the LO. New entries to your private line catalog are made by command `LINE`. Information from the line catalog, as well as the source catalog, is used to calculate the required lock frequency. The `LO` command sends the relevant information to the antenna computer, which will calculate the lock frequency. Normally, to set the lock frequency correctly, the `OBSERVE` command must be given before the `LO` command, because the `OBSERVE` command supplies the source position as well as the source velocity. The `DOPSET` command can be used to look at LO parameters for hypothetical observations.

Commands that involve the line catalog:

`FORGET`	Deletes entries in the line catalog
`LINE`	Allows you to insert new entries into the line catalog
`LO`	Sends the line parameters to the antenna computer to set up the Phase Lock Loop (PLL). Allows the default parameters to be overridden and will also report the current LO parameters.
`VERIFY`	As is the case with source catalog entries, this command allows you to inspect entries in the line file, using wildcards, if desired. The `/EDIT` qualifier allows you to modify catalog entries. The `/LINE` qualifier must be used to work with line catalog entries.
`DOPSET`	Calculates velocities, lock frequencies, etc. for hypothetical observations using the venerable NRAO DOPSET program. Does not affect the antenna computer or Phase Lock Loop in any way.

3.13 Observing Planets and Comets

Files containing planetary ephemeris are used to track planets, asteroids and comets. These files reside in the directory CAT_DIR, and are named JUPITER.DAT etc. A sample of MARS.DAT is shown below

```
183943.568 -235708.41 2.421520488 49353.0000 !  MARS 01JAN94000000 UT
```

```
184303.259 -235418.19 2.420230210 49354.0000 !  MARS 02JAN94000000 UT
184622.985 -235111.93 2.418920378 49355.0000 !  MARS 03JAN94000000 UT
184942.732 -234749.62 2.417591065 49356.0000 !  MARS 04JAN94000000 UT
185302.487 -234411.28 2.416242300 49357.0000 !  MARS 05JAN94000000 UT
185622.238 -234016.93 2.414874085 49358.0000 !  MARS 06JAN94000000 UT
185941.970 -233606.61 2.413486427 49359.0000 !  MARS 07JAN94000000 UT
190301.667 -233140.37 2.412079352 49360.0000 !  MARS 08JAN94000000 UT
190621.314 -232658.26 2.410652931 49361.0000 !  MARS 09JAN94000000 UT
```

The first two columns are the right ascension and declination of the planet as seen from the center of the earth (geocentric). The third column is the geocentric distance of the object in AU (this is used to calculate the parallax correction). The forth column is the truncated Julian date, specifying the time for which the preceding coordinates are valid. The Julian dates need not be integral, so ephemeris entries may be spaced as closely in time as is desirable. The text following the "!" is treated as a comment. Note that this same format may be used for asteroids or comets.

When you execute the UIP's `PLANET` command, the UIP selects three lines from the ephemeris file: the most recent past entry, and the two nearest future entries. These data are then sent to the antenna computer which performs a cubic interpolation between the three sets of ephemeris data. New RA and Dec values are calculated by the antenna computer every 10 seconds. Note that new ephemeris data will *not* be automatically fed to the antenna computer when initial data become obsolete. So if your ephemeris file contains one entry per hour, you should re-issue the `PLANET` command at least once per hour.

3.14 Pointing Files

The computer keeps several sets of pointing offsets on disk. If, from inside the UIP, you type

```
UIP> POINTING 345_SIDE
```

the offsets for the 345 GHz receiver in the sidecab will be loaded. There are a variety of other canned pointing setups - for the 230 GHz sidecab receiver (`230_SIDE`), as well as for `OPTICAL`. There is no canned set of offsets for the old single channel bolometer since its position on the sky depends upon the chopper swing, but `SHARC` does have a pointing file. The names of these pointing files eg `345_SIDE` and `OPTICAL` etc. cannot be abbreviated.

In addition to holding the "fixed" azimuth and zenith angle offsets for each receiver, the pointing files also hold the focus offsets for the secondary mirror.

Don't mess with any of the pointing files in PNT_DIR. They are maintained by designated CSO staff members.

Chapter 4

Heterodyne Observations Using AOS

4.1 Pointing

Pointing of the antenna is an important aspect of an observing session. Ideally, the pointing file one loads up with the `pointing` command would take care of the antenna pointing. But there are residuals (with a rms of $2'' \sim 3''$) for a given pointing model, and more importantly, things change between pointing model updates. It is therefore often the first thing an observer would check before going on his/her program source. During a normal observing session, one would want to check the pointing on a regular basis, say, every $2 \sim 3$ hours. There are two commands under UIP you can use to check pointing: `JOY_STICK` and `FIVE_POINT`.

4.1.1 "`JOY_STICK`" Pointing

If you have a very strong source, such as a planet, you can use the UIP's `JOY_STICK` command, which allows you to move the telescope by pressing the arrow keys on the terminal keyboard. The half power points can be determined by examining the receiver's total power output on a multimeter or the strip chart recorder. The cumulative offsets will be displayed on the antenna status monitor. Once you've pointed up, these offsets should be added to the fixed offsets (FAZO and FZAO) to make them quasi-permanent. This command is not used much these days, and when one does use it, it is often to establish a rough pointing (say, within $10''$), upon which one uses the `FIVE_POINT` command to improve the pointing.

4.1.2 `Five_Point` Pointing

The `FIVE_POINT` command drives the antenna to four offset positions, two each in azimuth and zenith angle respectively, that form a cross centered on your source. Observer specifies the size of the offset, which is usually one half of the beam width. The command derives the peak position by fitting a 3-parameter Gaussian to the measurements taken at the middle, plus-offset, and minus-offset positions in azimuth and zenith angle respectively. The position of the "real" peak, relative to the current source position, is calculated as

$$\Delta \mathrm{Az} = \frac{-\mathrm{offset} * [ln(\mathrm{plus\_flux}) - ln(\mathrm{minus\_flux})]}{2[ln(\mathrm{plus\_flux}) - 2\ln(\mathrm{midlle\_flux}) + ln(\mathrm{minus\_flux})]}$$

An alternative (with the `/NOGAUSS` qualifier) is to use a more conservative, centroiding calculation to interpolate the peak position, which is derived as

$$\Delta \mathrm{Az} = \frac{\mathrm{offset} * [\mathrm{plus\_flux} - \mathrm{minus\_flux}]}{\mathrm{plus\_flux} + \mathrm{midlle\_flux} + \mathrm{minus\_flux}}$$

This centroiding approach is useful if the receiver is giving fluxes with positive and significant negative values, because a Gaussian can never be negative. Gaussian fitting is the default. Note that the default gaussian method of calculating offsets generally overestimates the required correction if the source is extended.

The `FIVE_POINT` routine can be used to point on planets in a pseudo-continuum mode. One does this by

```
UIP> AOS/DEBASE 5
UIP> FIVE_POINT 15
```

The first command tells the backend computer not remove baseline and to integrate for 5 second on each position of the on/off pair; the second command specifies the step size of the offset for the four offset positions is 15″. This way the "flux" at each position is derived by summing up all the channels on the first active AOS. Often you would want to exclude the edge channels, by specifying a halfwidth of 400 or so:

```
UIP> FIVE_POINT 15 400
```

When sky conditions are good, you may wish to have all the five positions share a common off position when doing five_point pointing. This is done by the `/ONE` qualifier of the `FIVE_POINT` command. On the other hand, when sky conditions are not very good (when you see some negative "flux" at some positions while doing five_point pointing in position switch mode), you would be better off using the chopper instead:

```
UIP> SECONDARY 90 1.123
UIP> AOS/DEBASE 2
```

UIP> FIVE_POINT 15 400

The SECONDARY command starts the chopper at a frequency of 1.123 Hz with a chopper throw of 90″. Up on starting up the chopper, you may need to tune up the chopper so a reasonable duty cycle (≥80%) can be achieved. This entails setting the four parameters, P, D, I, and G on the chopper control box in the sidecab to values specified in a table posted on the sidecab wall. The only drawback in doing five_point pointing with chopper is that it takes longer to complete, as a CHOP_SLEWY scan is often done symmetrically on both sides of the source (see Section 4.3.2 for more details). The amount of integration of for each of the on/off pair is reduced accordingly in to the AOS command.

If your object has a strong spectral line (∼1.0 K or better), you can quickly point up on it using the UIP's FIVE_POINT command. This is the so called "spectral line pointing". Here's how it works. You tell the backend computer to sum the values of all the channels that span your spectral line, after subtracting a baseline specified in the AOS command. It will take data and calculate this line integral for five sky positions, and derive new values for the fixed azimuth and zenith angle offsets.

Chances are though that you will have to use one of the "CO pointing stars" instead your object to check the antenna pointing. These are sources of reasonably strong CO emission (mostly at J=2→1 transition at 230 GHz, and some at J=3→2 transition at 345 GHz), and of which we know their positions to a good precision and their sizes. They are stored in CAT_DIR:CO_POINT_STAR.CAT, and ones that are above horizon at any given moment are displayed by orrery (see Figure 2.9). To point on a CO pointing star, you need to load the catalog first by

UIP> CAT CO_POINT_STAR.

You would also need to do a quick scan on the source to determine the baseline, and set the baseline by

UIP> AOS 10 425 475 550 600

where the first number is the integration time and the following two pairs of numbers define the baseline window. It often works out better if you only include a small number of channels on either side of the line profile to define the baseline. In this particular example, the line is centered on channel 512 with a half width of 40 channels, and we are using 50 channels on either side of the line to specify the baseline windows. To use FIVE_POINT command to point on this source with a 15″ offset:

UIP> FIVE_POINT/CEN=512 15 40

The /CENTER= qualifier specifies the line center, which defaults to whatever the last FCAL command has determined (usually close to 512) if this qualifier is not used. If the second parameter (line half width) is not specified, then FIVE_POINT will integrate all channels in between the two baseline windows specified by the AOS command; if no Note that the baseline window will stay in effect until you redefine them or delete them all together with

UIP> AOS/DEBASE.

In position ON/OFF mode, you may use the /ONE qualifier in the above FIVE_POINT command to have all the five positions share the same off-position. If you are using chopper, the above commands will do just fine except that you will want to reduce the integration on on the AOS command somewhat. See the UIP's online help for a description of the parameters and qualifiers for the FIVE_POINT command.

4.2 Calibration, Secondary and AOS Control

4.2.1 Temperature and Frequency Calibration

Calibration of AOS spectra to temperature units is performed using a chopper wheel which can insert a hot load (at ambient temperature) into the telescope's beam at a point between the secondary and tertiary mirrors. When the computer is instructed to perform calibration automatically, the following steps take place. First the telescope is stepped off the source. The hot load is switched into the beam. The programmable attenuator on the AOS is adjusted to keep the hot load power from saturating the AOS. Data are taken. Next the hot load is switched out, and sky data are taken. Finally the antenna moves back to the source position and the programmable attenuator is readjusted. The backend computer calculates a (HOT-SKY)/SKY spectrum and all source spectra will be divided by this calibration spectrum, and multiplied by an assumed ambient temperature. This will convert the returned source spectra will be in temperature units. By default, a calibration spectrum is taken at the beginning of each OO_SCAN or CHOP_SLEWY scan if either the source or line frequency has changed.

A frequency calibration comb is taken automatically every time you start or restart AOS. It is also performed during long slews. You can take a frequency calibration scan directly by invoking the FCAL macro which is defined globally. During an FCAL, the AOS's Bragg cells are thermally loaded. So it is recommended that you wait 1 minute after an FCAL before continuing observing. The frequency calibration comb is important, because it will allow you to precisely determine the AOS's center channel, total frequency coverage, and spectral resolution. For the 500 MHz AOSes, the comb consists of five spikes. The middle spike denotes the center of the bandpass. The spikes are separated by 100 MHz. The comb for the 50 MHz usually shows only 4 spikes (sometimes there's a fifth spike at the edge of the bandpass) and the center of the bandpass is in between the two most central spikes.

The sky position for the calibration scan is the positive off position for the OO_SCAN. This offset is needed keep source features out of the calibration spectrum. Both the calibration scan and frequency calibration comb are stored in the your data file as separate scans. Taking a temperature calibration scan adds about 10-30 seconds to each OO_SCAN. The exact time depends on the calibration integration time (see below) , the distance to the off position, and how long you wish to pause between the calibration scan and the data scan (the default is 20 seconds). The taking of a calibration scan at the beginning of each OO_SCAN can be disabled by the /NOCAL qualifier. The backend computer will then use the last calibration scan for that object to calibrate the data - quite acceptable if conditions are good. In most cases, there is really no good reason to take a calibration scan for every or every few OO_SCANs. But you should perform a calibration scan at every 20 minutes or so. Note that after a number of OO_SCANs with no calibration scan, you would need to use the /CAL qualifier to have a calibration scan done at the next OO_SCAN.

If you wish to take a calibration scan directly, without using the OO_SCAN command, you can use the UIP's CALIBRATE command. This command also allows you to change the assumed ambient temperature, and the calibration scan's integration time. This time does not effect the integration time for source integrations. If you use the CALIBRATE command to take your calibration spectra, you must give an offset to the source position at which the sky integration should take place. The assumed ambient temperature is not recorded anywhere in the data file, so be careful about messing around with it. Note that the Double Sideband System Temperature is displayed on the Backend computer AOS display screen, and CLASS scan header. CLASS (our main data reduction program) will use this temperature for weighting when adding scans.

The AOS command tells you some calibration related information, including the calibration integration time, the assumed ambient temperature, and whether automatic calibration is enabled. Automatic calibration can be disabled with the /NOAUTO qualifier of the AOS command - this will prevent the calibration of the data, so your scans will come back in raw AOS Reticon units.

The backend display will display a warning if you haven't taken a calibration scan. The stored calibration scan is invalidated when you change sources (using the OBSERVE or PLANET commands). The backend will not calibrate sources with an invalid calibration spectrum.

4.2.2 The SECONDARY Command

For heterodyne observing, the `SECONDARY` command controls the chopping characteristics of the secondary mirror. In SHARC mode, the `SECONDARY` command is also used to specify some of the chopping parameters, but the actual control of the chop is somewhat more complicated, and requires some manual adjustment of the chop electronics. A chopping secondary mirror offers a much better match of sky backgrounds at ON- and OFF- beam than traditional ON/OFF scans do. The resultant spectra generally have better baseline. If your object is not as extended ($\geq 5' - 6'$), you should try to use the chopper.

Currently we can only chop in azimuth.

The `SECONDARY` command takes 4 parameters, all of which have default values. The first parameter specifies the amplitude of the chop (also known as the chop throw), in arc seconds. The default is 120". The maximum permissable value is 540". Obviously you'll get a better duty-cycle if you use a smaller chop.

The second parameter is the chopping frequency, in Hz. For heterodyne observing, there appears to be little or nothing gained by chopping faster than about 1/3 Hz. You should keep the chop frequency as low as possible, the duty cycle drops dramatically as the frequency increases. You should choose a chop frequency that does not have an integral harmonic at 60 Hz, in order to minimize 60 cycle pick-up (and cold head noise). The default is 0.321 Hz. Note that in SHARC mode we can only chop at certain specific frequencies. See the SHARC documentation for details.

The third parameter specifies how close the secondary mirror must be to the correct position before integration is allowed to take place in the ON buffer. This parameter has no effect at all in SHARC mode. This parameter is a source of great confusion in heterodyne mode. Ideally, we would like the azimuth offset of the secondary mirror to look like a perfect square-wave. Obviously, that is not going to happen in reality. There will always be some slew time between chop positions, and perhaps some overshoot and ringing. The position is monitored by a hardware box called the Programmable Window Comparator located on the sidecab rack near the top. This box decides when the secondary mirror is close enough to the correct position that the AOS should be allowed to take data. This third parameter to the `SECONDARY` command specifies what "close enough" is for the ON buffer. The units are arc seconds. The default is 1/4 of the beam size. This default will lead to very poor duty cycles at high frequencies (and hence the smaller beams). In these cases, you might want to try something closer to $5''$.

The fourth parameter is the same as the third parameter, but for the OFF buffer. The default behavior is for the OFF window to have the same width as the ON behavior. You should use this default. Don't specify this parameter.

To stop the secondary mirror, use the `/STOP` qualifier on the `SECONDARY` command.

4.2.3 Moving the AOSes Within the IF Bandpass

For many years, the CSO had a total IF bandwidth of 1 GHz without having a spectrometer that could cover that entire frequency range. The largest AOS had a 500 MHz bandwidth. However we did have two such AOSes, so hardware was constructed to allow these 500 MHz AOSes (and the 50 MHz too) to be moved around within the total IF bandwidth. This allowed the entire IF bandwidth to be covered. Now that we have a 1.5 GHz AOS, the capability of moving the narrower AOSes is used much less frequently, but it still may be occasionally useful, so it will be described here.

The positioning of the AOSes within the IF bandpass is handled by the Downconverter (see Figure 4.1) in the Receiver Lab/AOS Room (see Fig-

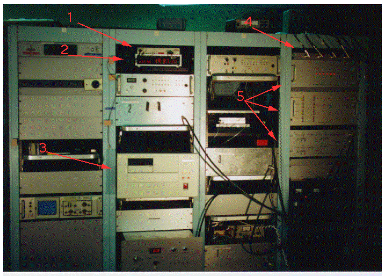

Figure 4.1: *This photograph shows various equipment on the 19 inch racks in the Electronics Room. Points of Interest:*
1 - **GPS CLOCK** - *By default, this is the Observatory's time standard.*
2 - **WWV Clock** - *The WWV Clock can also be used as the observatory time standard, if the GPS system fails for some reason. The UIP's* `CLOCK` *command allows you to switch between the two standard clocks.*
3 - **BACKEND COMPUTER** - *This computer controls the AOSes*
4 - **IF CABLES** - *These cables bring the IF signal from the sidecab to the Downconverter.*
5 - **DOWNCONVERTER** - *This set of boxes selects which AOSes will receive the signal, and heterodynes the IF signal a second time, in order to match the input requirements of the AOSes.*

ure 1.3). The 1st 500 MHz AOS can be moved around in the lower half of the 1 GHz bandpass, and the 2nd 500 MHz AOS can move around within the upper half. The 50 MHz AOS piggy-back rides along with the 1st 500 MHz AOS, but it can be moved around within the portion of the bandpass covered by the 1st 500 MHz AOS. Because the 1.5 GHz AOS covers the entire IF bandpass, no provisions have been made to move that AOS in frequency space.

The AOSes are positioned using qualifiers to the UIP's `AOS` command. They are moved from their nominal position (at the center of the IF bandpass) by specifying a different IF frequency. For example, if you issue the command

`UIP> AOS/AOS1`,
the 1st 500 MHz AOS will be activated, and placed at the center of the 1 GHz IF bandpass. The Observatory's default IF frequency is 1.5 GHz, so the above command is exactly equivalent to the command

`UIP> AOS/AOS1=1.5`.
In this configuration the 1st 500 MHz AOS would cover the frequency range between 250 MHz and 750 MHz within the 1 GHz IF bandpass. If you wanted to move this AOS 100 MHz lower in the IF bandpass, to cover the frequencies from 150 to 650 GHz, you would issue the command

`UIP> AOS/AOS1=1.4`.

Note that changing this "IF Frequency" *does not* change the IF frequency of the receiver! That's a common source of confusion. You *can* change the Observatory's IF frequency, to avoid unfortunate spectral line coincidences for example, but this is not the way to do it. Use the `/IF=` qualifier to the `LO` command, if you want to change the receiver's IF frequency.

Here's another example. Let's say you wanted to use the two 500 MHz AOSes to cover the entire 1 GHz bandpass. Then you would issue the command

`UIP> AOS/AOS1=1.250/AOS3=1.750`
This command tells the Downconverter to have the 1st 500 MHz AOS cover the lower 500 MHz of the IF bandpass, and the 2nd 500 MHz AOS cover the upper 500 MHz chunk. Confused yet? Just wait.

By default, the center channel of the 50 MHz AOS corresponds to the same frequency within the IF bandpass as does the center channel of the 1st 500 MHz AOS. So the command

`UIP> AOS/AOS1=1.4/AOS2`
would result in the 50 MHz AOS covering the frequencies from 375 MHz to 425 MHz within the 1 GHz IF bandpass. However the 50 MHz AOS can also be offset, but its offset is relative to the 1st 500 MHz AOS. So, for example, if you wanted to offset the 1st 500 MHz by 150 MHz from the center of the IF bandpass, but you wanted the 50 MHz AOS to remain centered within the IF bandpass, you would issue the command

`UIP> AOS/AOS1=1.35/AOS2=0.135`.
Remember that all UIP commands want to have frequencies specified in GHz.

4.3 Spectral Scans

Spectral scans can be taken in different way, with the traditional position ON/OFF mode, using the chopper, or in frequency switching mode if you are up for some excitement and disappointment. The following three UIP commands accomplish the spectral scan taking in these three modes: `OO_SCAN`, `CHOP_SLOWY`, and `FSWITCH`.

4.3.1 The `OO_SCAN` Command

The `OO_SCAN` command is the basic command used in heterodyne observing when you don't intend to use the chopping capability of the secondary mirror. We'll call this mode of observing "Beam Switching". The `OO_SCAN` command allows the observer to take beam switched scans using a variety of switching patterns.

The `OO_SCAN` command can take sets of ON and OFF integrations of arbitrary length. The ONs and OFFs will be summed into two buffers in the AOS. Any mixture of the (ON-OFF)/OFF, ON or OFF buffers may be sent to alpha1 but the individual integrations are lost if they are not returned.

For spectral line observing, the most common use of `OO_SCAN` will be for taking symmetric ON/OFF patterns. The basic symmetric pattern is

ON −OFF +OFF ON

if you give a cycle count of 2, the command

`UIP> OO_SCAN 2/STEP=120`

will result in an integration with the pattern

ON −OFF +OFF ON ON −OFF +OFF ON

with the OFF positions separated from the position by 120″ in azimuth.

`OO_SCAN` takes certain actions automatically unless you explicitly tell it not to, by using qualifiers. At the beginning of the first integration, the programmable attenuator will be set to a setting below saturation. It will not be changed for the remainder of the `OO_SCAN` execution. By default the secondary mirror is also adjusted in focus and tilt at the beginning of an `OO_SCAN`. If either the source or the spectral line has been changed since the last temperature calibration scan was taken, a `CALIBRATION` scan will be taken by default before the `OO_SCAN` command begins. At the end of execution, `OO_SCAN` tells the antenna computer to recalculate the LO frequency to Doppler track the object.

Parameters and qualifiers for the `OO_SCAN` command are sticky. This means that they are remembered indefinitely once you have specified them. So once you have taken an `OO_SCAN`, you can take additional identical scans by merely typing "`OO`". These parameters and qualifiers are inherited by any subprocesses. They revert to the default parameters once you exit the UIP.

If you have been taking OO_SCANs with the /RAO and /DECO offsets, and you wish to revert to some other type of offsets, you must specify /NORAO and /NODECO. This is also true for galactic offsets.

Sometimes, when observing an object in a region of the sky with lots of line emission, it is necessary to go to an explicit clean position on the sky for OFF integrations. OO_SCAN can do this. You must place the OFF position in the source catalog, using the same name as the source, but with a qualifier of \OFFPOSITION as part of the source name. The VERIFY command will report if a designated OFF position is known for the source. If an OFF position is available, and if you use the /DESIGNATED_OFF qualifier for the OO_SCAN command, an asymmetric pattern moving between the ON and designated OFF positions will be executed. Note that the antenna computer moves the antenna to the OFF position via RA and Dec offsets, so the OFF position will not appear in the RA and Dec coordinates on the antenna status display. The offsets will appear, however. Since the switching offsets are used to go to the OFF position, if you are mapping you will need to use the mapping offsets.

4.3.2 The CHOP_SLEWY Command

The CHOP_SLEWY command is the basic command used in heterodyne observing when you intend to use the chopping capability of the secondary mirror, which you must first set up the chopping parameters using the SECONDARY command (see Section 4.2.2).

The one and only parameter for the CHOP_SLEWY command is the number of "cycles". When chopping, the telescope effectively has two beams on the sky - let's call them the + and − beams. A cycle begins by putting the source into the + beam and integrating long enough for both the ON and OFF buffers in the AOS program to accumulate one "integration time" of data in each. This integration time is specified by the AOS command, just as with an OO_SCAN. Next, the source is placed in the − beam, and the telescope integrates for *twice* the "integration time". Finally, the source is placed in the + beam again, and a final integration is taken. Those **four** integrations constitute a single CHOP_SLEWY cycle. The parameter passed to CHOP_SLEWY specifies the number of these cycles that should be strung together back-to-back, to produce a single scan.

As you integrate, you'll notice a percentage appearing near the blinking green dots on the AOS display (see Figure 2.5). This is your integration duty cycle. It will turn red if it falls below 50%. Usually a value below 50% indicates a bad 3rd parameter has been specified for the SECONDARY command (see Section 4.2.2), or the chopper is not properly tuned.

As CHOP_SLEWY executes, you'll notice that the source is moved from the

+ beam to the − beam using the azimuth offsets which appear on the antenna computer's display. The offsets that appear will be ±1/2 the chopper throw, and occasionally that causes some confusion, particularly at 14,000 feet. These offsets are correct, because an offset of 0 places the source in between the two beams.

Although `CHOP_SLEWY` has only one parameter, it has four qualifiers analogous to the `OO_SCAN` command (`/CALIBRATE_AT_START`, `/FOCUS_ADJUST`, `/LO_ADJUST` and `/ATTENUATOR_ADJUST`) which behave like their `OO_SCAN` counterparts.

4.3.3 The FSWITCH Command

The `FSWITCH` command allows you to take Frequency Switched (FS) scans. It takes two parameters: separation of the two line images (in GHz) and the switching rate (in Hz). The switching rate will be default to 8.6 Hz if you don't specify it. So the following command

```
UIP> FSWITCH 0.01 5
```

will switch the frequency with a step of ±5 MHz at a rate close to 5 Hz. See the on-line help for this command for other qualifiers and usage in details.

There are a number of limitations to this capability though. First, you can only use the 50 MHz AOS with this command. This in most cases makes sense as you wouldn't want to do frequency switching anyway if the spectral line is too wide (say, ≥10 km/s).

Second, even with a very small step (∼1 MHz) the current IF chain hardware produces huge, ugly baseline features, which have an amplitude of many tens of degrees. The "solution" to this problem is to take an FS scan of a blank area on the sky (a "Bandpass" scan), and use it to correct the on-source spectrum. That seems to work pretty well. An `FSWITCH` scan taken with the `/BANDPASS` qualifier will be used by the AOS program to correct subsequent `FSWITCH` scans automatically. The catch, of course, is that you must spend as much time integrating on the Bandpass scan as you do on the on-source scan. So much of the advantage of frequency switching is lost. However a single Bandpass scan may be used to correct the on-source scans taken in the subsequent 10-15 minutes or so. Occasionally, a bad match between the on-source scan and the bandpass scan would still occur. The source of this error is not presently clear.

Third, the frequency switch section of the scan header is not being updated with proper information of the FS scans settings. As a result, you can not readily "fold" a FS scan using CLASS. You need to do the following under CLASS:

```
LAS\ MODIFY SWITCH_MODE frequency 2 5 5 1 -5 5 -1
```

to change the scan header of the current scan, and then you'll be able to fold the scan. In the above CLASS command, the first three numbers following the number "2" (for two phases) describe the frequency offset, integration time, and weight for the first phase, respectively. The following three numbers are for the second phase. So this particular FS scan was taken with a 10 MHz separation and a total integration time of 10 seconds. You may need to experiment with the sign of the weight assigned to each phase to get the spectral line folded correctly.

We hope to fix up this header problem eventually. It entails to an overhaul of a number of UIP commands, the SCOREBOARD, and the SCAN_WRITER server. Nevertheless, FSWITCH can be used in some mapping situations. It may also be useful for verifying that an OFF position is truly free of emission.

4.4 Spectral Line Mapping

Mapping an area in emission or absorption of a spectral line is accomplished by taking a spectral scan at each point on a grid that covers the area. You would use OO_SCAN, or CHOP_SLEWY, or FSWITCH command at each grid point specified by RAO/MAP and DECO/MAP commands to build up the coverage. This sounded tedious, especially if you are mapping a large area ($\geq 5' \times 5'$). Help is available under UIP to make life a little easier. If the spectral line is strong (that a reasonable signal-to-noise ratio can be achieved with a few seconds of integration), you can use the OTF_MAP command or the newer, more feature rich XOTF_MAP command to do On-The-Fly mapping. Failing that, you can use the MAPPER command to produce a command file. Executing the resultant command file is all you need to do to map the area point by point.

4.4.1 Point-By-Point Mapping

The MAPPER command produces a command file for Point-By-Point mapping. The observer can execute this command file using the UIP's EXECUTE command. The command file MAPPER produces simply moves the antenna to each point in a raster map, and when the antenna reaches that point another command file is executed. The name of this second command file is specified by MAPPER's "work file" parameter. Typically this work file will simply contain a single OO_SCAN, a CHOP_SLEWY, or a FSWITCH command, but it can contain any number of UIP or VMS commands. You may also give the MAPPER command an optional "end of row" file. This file will be executed at the end of each row of the map. This allows calibration scans to be taken at regular intervals.

The terminal on which the command file is being executed is not locked while execution takes place. A separate subprocess is created to handle the command file, so even though the commands being sent by the command file show up on the terminal, the terminal is idle and available for use. This is very handy. For instance it is often desirable to suspend execution of the command file temporarily, to take a calibration scan or perform some other activity. To do this type

UIP> HOLD

This will halt the execution of the command file, without killing the sub-process. Note that this *MUST* be typed on the terminal that started the execution of the command file. All other terminals running the UIP have no control whatsoever. Now you can type any series of command you wish. When you wish to resume executing the command file, type

UIP> RESUME

and the command file will resume executing at the next line. Note that any integration that was taking place when the HOLD command is given will be completed normally (it won't be suspended), so you should wait for the scan to be stored on alpha1 before initiating another data taking command (such as CALIBRATE). You should avoid executing the STATUS command when a command file has been halted with the HOLD command.

By default, the file MAPPER produces has an ANWAIT command between the commands setting up each new position, and the command executing your "work file". This ANWAIT halts the execution of the command file until the antenna has acquired the new position. Since the backend computer will normally refuse to integrate if the antenna is not on source, the ANWAIT is usually not needed, and wastes a few seconds per point. If you use the /NOANTENNA_WAIT qualifier with the MAPPER command, these ANWAITs will not be generated. This will save you a little time at each point, but it relies on the backend computer receiving a signal from the antenna computer when the object is acquired. This should normally be ok. You should *NOT* try this if your work file contains either a CALIBRATE command, an OO_SCAN/CALIBRATE or a CHOP_SLEWY/CALIBRATE.

4.4.2 On-The-Fly Mapping

In addition to the Point-By-Point (PBP) mapping using the OO_SCAN, FSWITCH, or CHOP_SLEWY commands with offsets, maps can be made by continuously scanning across the source. This is called On-The-Fly (OTF) mapping. OTF mapping is possible in both continuum and spectral line modes, and it is worthwhile only if you are making a fairly big map ($\geq 5' \times 5'$). The main advantage of OTF mapping is that it is several times faster than PBP mapping, because the telescope does not have to acquire each position individually; it remains acquired at all times. The UIP command which produces an OTF map is OTF_MAP.

There is an additional advantage to OTF mapping if you are observing in spectral line mode. First, all on-source positions in a given row can use the same off-source data as a reference. For large maps, this significantly reduces the amount of time you must spend on the reference position. There is a minor disadvantage to this; if you later decide to average together n spectra from different regions of your map, you will find that the noise will not diminish by root n, because the noise in the spectra will not be independent. You can, however, choose the OFF-position integration time to be long enough to allow pixels to be averaged, and still produce the signal-to-noise ratio you would have obtained with PBP mapping.

There are currently two ways that you can take OFF data. These are azimuth switching, and using a "Designated Off" (see the description of the `OO_SCAN` command in Section 4.3.1. In either mode, the telescope will take off-source data at the beginning and end of each row. The end-of-row OFF data for one row is the beginning-of-row OFF data for the next, so for a map with n rows the telescope will go to the reference position $n + 1$ times (and once for each Cal. scan). Because the OFF data will be subtracted from many map positions, it makes sense to spend a little more time integrating at the reference position than one spends on an individual map pixel. A fair rule of thumb is that if a row of your map has m pixels, you should spend root m times as long integrating on the reference position as you spend integrating on each map position. The length of the reference integration is set by the `AOS` command, while the `OTF_MAP` command controls the integration time for the map pixels.

By default, the `OTF_MAP` routine will produce temperature calibrated (ON - OFF) / OFF spectral. It will also display them in real-time on the AOS display. You'll notice that each pixel is drawn twice. The first time it is drawn as the row is scanned (in green). These spectra only use one OFF position (because the second OFF position is taken at the end of the row). After the second OFF integration is taken, all the row's pixels are re-drawn (in white) using a pseudo-OFF interpolated from the two real OFF integrations. The pixels shown in this white display are the ones actually stored in the CLASS file.

The `OTF_MAP` routine is fairly complex, and still contains bugs. Many combinations of parameters and qualifiers, which logically should work, have not been tested and may fail totally. Ideally, you should try to figure out how you want to make you map in advance of your observing run, and discuss it with the CSO staff. If the mode you want isn't known to work, then it can be tested and fixed if need be.

The quality of ON - OFF subtraction in OTF maps is inferior to that of PBP maps. OTF mapping is not recommended for spectral lines located in difficult portions of the atmospheric windows, such as the 492 GHz neutral carbon line. It is most useful for making large maps of reasonably strong

($> 0.1K$) lines. One should pay attention to the length of time that each row requires. This determines the interval between OFF integrations, and this interval should not be allowed to significantly exceed 1 minute, unless you are mapping an extremely strong line. In general it is better to make several maps quickly and combine the data later, rather than one slowly scanned map.

If you want to do OTF map along a specific position angle, or a skewed map, or you want the telescope to move in a zigzag fashion on successive scan lines, check out the `XOTF_MAP` command.

OTF maps chew up disk space quickly. Keep an eye on it with the DCL command

```
$ SHOW DEVICE /MOUNT
```

where the available disk space is shown in 512-byte blocks. Look for the `DSA0:` entry. Alternatively, you can do this on the SUN boxes as

```
hapuna% df -alk
```

where the available disk space is shown in kilo-byte. Look for the `/user_vax` entry. Also, make sure you only fire up the AOSes that you intend to use.

4.5 Inspecting and Reducing Spectral Data

The spectral scans are written into your data file in CLASS format. So if you want to do anything more than just looking at the scans as they are being integrated with the data, you will have to use CLASS. Here we provide some basics with using CLASS. Proficient CLASS users can simply skip this section.

4.5.1 Basics of Using CLASS

CLASS is a single dish line data reduction program, as a part of the GILDAS image processing package. It was written by the Groupe d'Astrophysique in Grenoble and used at IRAM and a number of other fine institutions. As with most of the astronomy applications, newer versions of GILDAS have only been ported to UNIX platforms. So even though CLASS and some other GILDAS programs still run on the VMS machines, we encourage observers to run them instead from the SUN Solaris boxes (hapuna and kilauea). You would first move to your data directory by

```
hapuna% cd /user_vax/smith/nov96
```

then simply type

```
hapuna% class
```

to start CLASS. There is on-line help integrated with the CLASS program, and there is a hardcopy of the user manual at our Hale Pohaku office and in the control room on the summit.

To plot a spectrum on the terminal, you must set up the display, open the data file, read in the relevant scans, select the scan you want and tell the program to plot it. These are acomplished by the following CLASS commands:

```
LAS> dev xl black
LAS> file in nov96.dat
LAS> find/all
LAS> list
LAS> get 1309
LAS> plot
```

The "`dev`" command spawns up an balck X-window in lanscape format; the "`file`" and "`find/all`" command open the input data file, and search for all relevant scans (all scans if no selection criteria are set - see below); the "`list`" command lists all the scans found; the "`get`" command gets a specific scan and the "`plot`" command plots the scan in the X-window. To inspect new scans as soon as they are stored in the file:

```
LAS> new
LAS> find/all
LAS> get last
LAS> plot.
```

CLASS (and the closely related GREG and other GILDAS programs) is very powerful and can perform a wide variety of functions for data reduction and display. However, it is not always obvious from the manual how to do many things. Some of the most trivial which you will want to perform are listed below (remember - CLASS also uses minmatch, so two to three letters are often enough). Make sure you read up other options eachof these commands may have using the on-line help for CLASS.

`LAS> dev xl bl`	Open an X window for display.
`LAS> set plot hist`	Set the plot mode to histogram.
`LAS> set form long`	Print a full header on your plots.
`LAS> set align v`	Align scans in velocity rather than channel number or frequency when summed or averaged.
`LAS> set cursor on`	Turn the cursor on to mark the line windows.
`LAS> set unit c`	Set the X axis to plot in channel instead of velocity.
`LAS> set window`	Set the line windows to avoid when fitting a baseline to the spectrum. Move the cursor with mouse; press "n" to mark the position of each edge of a window; press "e" to exit. If using the `/nocursor` qualifier, line windows can be entered on the command line.
`LAS> show window`	Show the currently defined line windows.

`LAS> base n`	Determine a baseline fit of order `n`. Produce rms for sections of the spectrum used for fitting. Handy with `n`=1 to see if you are integrating down correctly with time. It uses windows previously defined. Don't be overtly creative when fitting baselines.
`LAS> smooth h`	Perform a Hanning smooth.
`LAS> sum`	Average scans in the current `find` index.
`LAS> header`	Dump the header of the current scan
`LAS> hard/plot`	Print a hard copy of the scan you last plotted on the default printer (the HP LaserJet printer).
`LAS> set mode x x1 x2`	Set the x plot range to be from `x1` to `x2` in current x unit.
`LAS> set mode x aut`	Autoscale the x axis.
`LAS> clear a`	Clear the alphanumeric part of the screen.
`LAS> clear p`	Clear the plot.

CLASS has a variety of criteria you can use to discriminate among scans. One often sets up these selection criteria to narrow down the list of scans a "`find/all`" will produce, or to find relevant scans from different areas of a data file to be added. After setting any of these selection criteria, you will need to execute the "`find/all`" command to implement them.

`LAS> set num n1 n2`	Restrict the scan number range from `n1` to `n2`.
`LAS> set telescope "CSO 500MHz"`	Set the telescope name to CSO 500MHz, which selects scans from the first 500MHz AOS only.
`LAS> set source name`	Select scans with that source name.
`LAS> set line name`	Select scans with that line name.
`LAS> set match x`	Select the position-matching tolerance for scans to `x`″.
`LAS> set off x y`	Select scans that fall within the tolerance (set by `set match`) of an offset (`x′, y′`).
`LAS> set range x1 x2 y1 y2`	Select scans with offsets falling within the tolerance of the area defined by `(x1, y1)` as the southwest corner and `(x2, y2)` as the northeast corner. Offsets are in arcmin.

It is also possible to set the above selection criteria using qualifiers on the `find` command itself. But the command line can get rather clattered, and you may soon loose track of what were set.

It's convenient to enter into a file the CLASS commands you often issue as soon as you fire up CLASS, so they will be executed as part of the CLASS initialization. The file is called `class.init` and is often located in your home directory (`/home/hapuna/smith`). A typical `class.init` often contains the following:

```
dev xl bl
set form long
set plot histo
set align v
set cursor on
```

You can add to this file any CLASS commands you see fit, some selection criteria, for example.

4.5.2 Making Contour Plots

It is very easy to make contour plots of maps using CLASS and GREG. Let's say, for example, that you wish to make a contour map of the entire flux in a line that extends from a VLSR of -40 to -20 km/sec. In CLASS fill the index with all the scans you wish to have included in your contour map (using `set number`, `set offset` etc. along with `find/all`). Then execute the command

```
LAS> print area -40 -20 /out mymap.greg
```

which produces an ASCII file called `mymap.greg`, which has four columns of data. The first column contains the the scan number for the scan on that particular offset. The second column has the first offset (usually RA). The third column the second offset (usually Dec). The fourth and last column contains the integrated line strength.

Now exit CLASS and fire up GREG (by typing `greg`). Type the following commands:

`GREG> dev xl bl`	Set up X diaplay
`GREG> col x 2 y 3 z 4 /file mymap.greg`	Read in the data
`GREG> random 100 100 /blank -10`	Interpolate the data onto a 100×100 grid with banking at -10
`GREG> limit /reverse x`	Calculate plot limits - RA should be flipped
`GREG> levels 10 20 30 40 50 60 0 80 90`	Contour levels in percent
`GREG> rgmap/per 1`	Plot the map
`GREG> box`	Draw the box
`GREG> label ‘‘RA Offset’’ /x`	Label the x axis
`GREG> label ‘‘Dec Offset’’ /y`	Label the y axis
`GREG> hard/plot`	Make a hard copy if desired

Another perhaps a little more elegant way of making contour maps is using the tdv function of the `cube` command under CLASS. Be sure you read up on these commands and ones listed above using the on-line help.

4.6 Heterodyne Cookbook

Typical spectral line observing is hard to define, but the following will give you a guide, especially for new users to understand some of the basic commands and get started a little quicker.

- Firstly, log into alpha1. You may wish to set up a subdirectory to contain all the data and intermediate files you may generate for the run. This is done by
`$ CREAT/DIR [.NOV96]`
`$ CD [.NOV96]`.

- Start UIP by typing
`$ UIP`
the computer will respond with one or two questions on log files and data file. If unsure, carriage returns will perform safe default operations. Your personal catalog will automatically be opened when you start UIP, but other catalogs can be opened with the `CATALOG` command - for example
`UIP> CAT GALAXIES`
will open the catalog galaxies.cat in your current default directory.

- If you are the current observer, and just wish to check the status of various things, type
`UIP> STATUS`,
which will tell you the currently active log, data and pointing files. Also
`UIP> AOS`
will tell you the current configuration of the AOS processes on the Backend Computer (see Figure 1.6).

- To set up the AOS parameters:
`UIP> AOS/NOAOS1/AOS2/AOS3/NOAOS4 10`.
This will activate the 2nd and 3rd AOSes (the 50 MHz and the 2nd 500 MHz AOS), and each integration will be 10 seconds (resulting in 20 seconds of "ON" time and 20 seconds of "OFF" time per `OO_SCAN` cycle, or 40 second "ON" and 40 seconds "OFF" per `CHOP_SLEWY` cycle). 10 seconds is the shortest time we usually use for normal observations, and up to 60 seconds can be used under extremely good conditions but 30 seconds is the usual maximum. When pointing on a planet, 5 seconds integration would often suffice.

- Now open a data file:
`UIP> DATA 26NOV96.DAT 1001`

will open a new IRAM format data file in your current directory, and initialize the scan number to 1001.

- Next, load the relevant pointing file. For example:
  `UIP> POINT 345_SIDE`
  will load the 345 GHz Receiver pointing parameters. Other options are `230_SIDE, 492_SIDE, 650_SIDE`, and `850_CASS`, depending on the receiver you plan to use. You might want to compare the values of `FAZO` and `FZAO` shown on the status display monitor with recent values logged in the Pointing Log book. If they disagree, the log book values are a better bet.

- Now set up up the correct local oscillator (LO) frequency for receiver tuning by
  `UIP> OBSERVE M82`
  `UIP> LO 12CO3-2-4`
  The first command (`OBSERVE`) loads up the correct velocities for your source (`M82` in this case) into the Antenna computer and drives the antenna to the source. Make sure the the Emergency Stop is pressed before issuing this command if you do not wish the antenna to actually move to your source yet. The second command (`LO`) selects the spectral line you want to observe (the ^{12}CO $3 \rightarrow 2$ transition at 345 GHz in this case). You can view the commonly observed lines by
  `VERIFY/LINE *`
  If the line you wish to observe is not among them, you will need to set it up using the `LINE` command. The Antenna computer will now determine the exact frequency for the Gunn oscillator using this frequency and the relevant velocities.

- Tune the receiver.

- Check the pointing — see the Section 4.1.

- Check the sky position of your source:
  `UIP> VERIFY/ALT MY_SOURCE`
  it will tell you the RA, Dec, Hour Angle and current Azimuth and Zenith of your source. By using the `/ZA=XX` qualifier it will tell you the rise and set times (in UT) of your source for the zenith angle `XX`.

- To start observing,
  `UIP> OBS MY_SOURCE`
  unless you are observing a planet or a comet, in which case use
  `UIP> PLANET JUPITER`

- Calibrate your spectra.
  There are two ways of calibrating your data: either by taking calibration scans manually with the `CAL` command, or letting `OO_SCAN`, `CHOP_SLEWY` or `OTF_MAP` take them for you. If you wish to take them manually, simply type
  `UIP> CAL`
  It will use the relevant parameters from `OO_SCAN` for the OFF position. To disable the taking of a calibration scan by the `OO_SCAN` command, use the qualifier `/NOCAL` on your `OO_SCAN` command). By default, you will get the resulting HOT-SKY/SKY returned to your data file. To examine the parameters for the actual `OO_SCAN`, type
  `UIP> OO/LIS`
  this will merely list the current settings for the myriad of qualifiers and parameters on `OO_SCAN`. Note that they are all "sticky". This means that if you change any of them, the next time you execute `OO_SCAN`, you only need type the `OO` itself - it remembers your parameters and qualifiers. You can also set the parameters and not have it execute an `OO_SCAN` by typing (for example)
  `UIP> OO/JUST/STEP=300/LIS 4`
  This will just set the offset for the off position to 300 arcseconds, the number of cycles to 4, and will then display all the current parameters and qualifiers.

  Note that data will be returned to alpha1 automatically calibrated into temperature units. This can be turned off with the `/NOAUTO` qualifier on the `OO_SCAN`. You may also wish to keep the ON and OFF scans, as well as the calibrated ON-OFF/OFF : this can be achieved by
  `UIP> AOS/ON/OFF`

- To actually start an integration, type
  `UIP> OO X`
  or
  `UIP> CHOP X`
  where `X` is the number of cycles you want. For an `OO_SCAN`, a cycle is a set of 2 ONs and 2 OFFs (symmetric or asymmetric as requested). We do not recommend performing more than 15 minutes integration in one `OO` command - a crash of the Backend computer during the integration will probably cause the loss of the whole integration. See Section 4.3 for details of using these commands.

- To start mapping an area, type
  `UIP> EXEC MY_SCHEDULE.CLASS`
  where `MY_SCHEDULE.CLASS` is the schedule (or command procedure, or

script) you set up beforehand manually or with the `MAPPER` command for Point-By-Point mapping (see Section 4.4.1). To make OTF maps (see section 4.4.2), simply issue the `OTF` command with appropriate parameters. For example,
`UIP> OTF 75 75 0.5 0.5 15 15 /AZO=120`
Make sure you only fire up the AOSes you intend to use as data rate is a lot higher in OTF mode. You could quickly run up 40-50 MB of data with one AOS in one night. Files of these sizes put alot of pressure on the data archiving process run on kilauea. This could come back and haunt you: you may see the OTF process waits for the scans to be added slowly to the data file at end of each row. We have also seen cases of scan header mixups and scans not written at all under these circumstance.

- Remember to check the pointing every few hours.

Other useful commands:
`UIP> ACQUIRE 3 15`
will adjust the limits on the acquires status. If your OFF position is known to be spatially isolated and free of contamination, this will allow the computer to start integrating before the antenna is exactly on the Off position, which can save substantial amounts of time. In this example, the slop on the ON position is set to 3 arcseconds, and on the OFF position to 15 arcsecs.

To add sources to your catalog:
`UIP> SOURCE`
This will prompt you for all relevant information: RA, Dec, velocity and proper motions. NOTE: if the declination is positive, do NOT enter it with a "+" sign — this will fail. By default, new sources will go into your personal catalog, which is called `PRIVATE_CATALOG.CAT`.

To add lines to the line catalog, use the `LINE` command. It is very similar to the `SOURCE` command.

Chapter 5

Continuum Observations Using SHARC

Continuum observations are made at the CSO with the Sub-millimeter High Angular Resolution Camera (SHARC). The camera is a linear array of 20 bolometers (out of the 24 originally designed), and operates in three broad atmospheric windows centered at 870 μm, 450 μm, and 350 μm, respectively. It can be used in imaging mode to map reasonably strong objects or in pointed observation mode to detect faint continuum emission in these bands. In the following sections, we describe the general procedures of operating SHARC, and offer instructions on reducing SHARC data taken in imaging and pointed observation mode. For technical information, latest tips and instructions on using the SHARC, we refer users to the SHARC page on our web site(http://www.submm.caltech.edu/cso/sharc/cso_sharc.html).

5.1 Overview of SHARC Operations

Submillimeter continuum observations at the CSO are made in beam switching mode, in which the output represents the difference in signal between two positions on the sky. With SHARC, the beam is switched using the chopping secondary. To achieve the best sky subtraction, the two beams must be at the same airmass, which implies that the chopper throw is in azimuth.

SHARC server, residing on a Macintosh computer in the control room, interfaces with the instrument usually mounted on the right rotator (looking out to the alidade from the control room) of the Cassegrain relay optics platform. It also coordinates with UIP through a SHARC client run alpha1 to control data acquisition. The server automatically flags out data taken with the four cells (pixel 1, 5, 15, and 16). Once started observations are conducted under UIP with the `OTF` or `CHOP_SLEWY` command.

The standard observing mode with SHARC is on-the-fly (OTF) mapping. In this mode, the telescope moves in azimuth at a fixed rate while the bolometer array, which is usually aligned North-South, scans across the object being imaged. The resulting map is a differential image of the object which has to be restored and regridded onto a regular grid in the equatorial coordinate system. This is done using a program called "camera" (see Section 5.3), which uses NOD-2 subroutines initially developed at the Effelsberg 100-m Telescope for image restoration.

SHARC can also be used in pointed observation mode to take CHOP_SLEWY scans on an object. The scans would represent the continuum emission profile of the object along a cut projected by the bolometer array on the object. This mode is often used to detect faint continuum emission from various types of objects ranging from proto-stellar cores to distant galaxies. You may rotate SHARC to align the array to a particular position angle as the object moves across the sky. The SHARC scans are viewed and further processed by "badrs" (see Section 5.4), which treats the SHARC scans the similar way CLASS treats spectral scans.

It is almost essential to have available some bright continuum sources during your observing sessions, as checking antenna pointing, calibrating relative gains for each element of the bolometer array, and initial focus adjustment all need to be performed on a bright continuum source. Planets, such as Venus, Mars, Jupiter, Saturn, and Uranus, often make good objects for such tasks. Other sources, such as IRC10216, M42, G34.3, IRAS16293, SgrB2, etc., can also be used in desperation. Try to plan your observing sessions (if you have any choice at all) to have some exposure to at least one bright continuum source.

5.2 SHARC Cookbook

We will describe in the following sections the procedures that you need to go through every night of SHARC run, and those additional tasks you need to perform on the first night of the run.

5.2.1 Typical Procedures

- Check to make sure the equipment is ready.
  - Reading on the Lakeshore (usually sitting on the alidade floor) should be >5000kOhms, which indicates that SHARC is at operating temperature. Disconnect the Lakeshore cable and the FET thermometer cable from the dewar. Else, check laminated sheet (in control room) for instructions on finishing the cycle.

  - Check the panel on the SHARC power control box (mounted alongside the staircase as you enter the alidade from the side-cab side). The box should be on, and the heater switch in "FET Heater" position. Pre-amp and A/D switches should be "ON". The corresponding LEDs should be lit.
  - Check if filter wheel is at correct position. The counter on top of SHARC dewar should read 7500 for the 350 μm filter, 5000 for the 450 μm filter, and 2500 for the 870 μm filter.
  - Check Pre-amp and Gain setting. On the small aluminum box attached to the dewar, check if switch is on the "ON" position, and gain is set to the higher level (8000).
  - Check A/D box (at the base of the dewar) and see if the power switch is "ON". It will not hurt to press the 'RESET' button once to ensure it's not stuck in some funny state.
  - Check the tertiary mirror position. If you can see the secondary mirror through the beam path, you should be fine. otherwise the tertiary mirror is in place to divert the beam to the sidecab. Unscrew, and flip the mirror out of the beam, then tape it to the side.
  - Remove mirror covers (Plexi-glass cover on the flat mirror, foam cover on the ellipsoid under SHARC). You may also wipe the SHARC window (bottom of dewar) if there is apparent condensation.

- Start up SHARC server and client.
  To start the SHARC server on the Macintosh computer, click on the "SHARC Server" icon in the top right corner of the Mac window. To start the SHARC client on alpha1, use the `SHARC` command under UIP, for example

  UIP> `SHARC/WAVE=350/FREQ=4.123/REF=12/SOUND/LOAD/RESTART`
  will tell SHARC server that you intend to operate the SHARC at 350 μm, to chop the secondary mirror at 4.123 Hz, and to use the 12th pixel on the bolometer array as the reference pixel. You also want the wonderful sound features associated with certain SHARC operations, and you want the server to load the last phases measured for each pixel at this particular chopper frequency (see Section 5.2.2). While under UIP, you should also load the appropriate pointing file for SHARC:

  UIP> `POINTING SHARC`.

- Start the chopper.
  With the chopper frequency you specified above in the `SHARC` command

and a chopper throw (typically 60″ or less), you start the chopper under UIP by

`UIP> SECONDARY 60 4.123`

for example. UIP will tell you the offset and peak voltage the chopper waveforms should have. You need these two numbers to set the chopper throw, as part of the chopper tuning.

- Tune up the chopper.
  This is done in the sidecab, on the chopper control box in conjunction with a HP oscilloscope mounted on the sidewall. The chopper control box is on the equipment rack right above the tool drawer.
  - Make sure the leftmost toggle switch on the chopper control box is on "TTL" mode, instead of "Analog" mode used for heterodyne observations. If the red LED is lit, press the black button to its immediate right to start the chopper.
  - Make sure one of the BNCs going to the oscilloscope is connected to "TTL monitor" (via a T-splitter), not to the 'Analog monitor' port. On the oscilloscope CH1 (and CH2) will have the chopper position, and the TTL control signals. You may need to adjust the trigger level to get updates.
  - Look up the settings appropriate to your desired chopper from the table taped to the sidewall, and set them accordingly using the turn knobs P, G, I, and D on the chopper control box.
  - Set the oscilloscope cursors to the correct levels that UIP's `SECONDARY` command told you. Now adjust the offset and gain knobs on the left side of the chopper control box to make the chopper signal fit between the cursor lines.
  - Fine tune the chopper by playing with the P, G, I, and D knobs on the chopper control box to make the chopper signal as close to the TTL signal as possible. Don't waste too much time on this though.

- Align the bolometer array to north-south. This is done under UIP by

  `UIP> ROTATOR/RIGHT -10`

  which command the right rotator the SHARC dewar is mounted to go to move to a positional angle of -10 degrees, a number which is deemed appropriate after taking into account various offsets introduced by the design of the instrument, the mounting plate, and the relay optics.

- Check antenna pointing.

- Go to a bright continuum source, a planet preferably, by

  `UIP> OBSERVE BRIGHT_SOURCE` or

  `UIP> PLANET SATURN`

- Open a data file

  `UIP> DATA SATURN_350.MAP1`
  Since you will be making a single row OTF map of Saturn, you should specify that the file is in map format when prompted by the `DATA` command. This is important as `OTF` files and `CHOP_SLEWY` files have different format under SHARC mode.

- Make a quick map to point on the source.
  With a chopper throw of 60″, the following `OTF` command

  `UIP> OTF 180 0 4 4 4 4`
  would produce a 2′ wide single scan map of your source at a speed of 4″ per second. Some of the parameters in the above `OTF` command, azimuth size (in arcsecond), elevation size (in arcsecond), speed, ramp time, azimuth resolution (in arcsecond), and elevation resolution (in arcsecond), respectively, mean somewhat differently than in the heterodyne mode. The azimuth size is not the size of the final reconstructed map; it is larger by one chop throw.

- Analyze the data with CAMERA.
  On one of the Solaris boxes, change directory to where the data file is by

  `hapuna% cd /user_vax/smith/nov98`
  and start up CAMERA by

  `camera`
  Open the data file "SATURN_350.MAP1" and select pointing mode (p). The program will plot the dual beam image of the source and leave you in cursor mode. If the data are noisy, hit "s" to smooth the data in the direction of the scan (the data are usually highly oversampled in this direction by default). Place the cursor on the peak (or geometric center) of the positive beam and hit the spacebar. The location of the cursor (Az-El offsets) will be written in the terminal window. Place the cursor on the negative beam and hit the spacebar. The difference between the "azoff" values for the two cursor positions is the chopper throw. Hit "e" to exit from cursor mode. Restore the image using the value of the chopper throw that you have just measured. Set the second parameter (L-to-R amplitude) to -1 if the negative beam is on the left, otherwise set it to 1. The restored image will appear in the graphics window and you will be placed again in the cursor mode.

Place the cursor on the peak in the restored image and hit "p". New values of the fixed pointing offsets (FAZO and FZAO) will be given in the terminal window. Apply these values in the UIP:
UIP> FAZO xxx
UIP> FZAO xxx

  - Start another OTF scan of the pointing source and repeat the procedure several times until you reach convergence. Record the elevation and peak voltage. You will want to point on the source at a few other elevations during the night, so you can determine the atmospheric opacity at the particular wavelength you are observing. This is done by

    ALPHA1::smith> SHARCTAU
    on alpha1, alpha2, or poliahu, and inputing the airmass (=1/cos(EL)) and the peak voltage in pairs. You will need the opacity when reducing your data with CAMERA or BADRS.

- Imaging with SHARC.
  If you intend to map your source, open a data file in map format with the DATA command under UIP, and then issue the appropriate OTF command. You may want to run the SHARCOTF command on alpha1, alpha2, or poliahu and answer a few questions regarding the image you want to make. The program will produce an OTF command that fits your needs and tells you approximately how long the map will take.

  Make a map of the source using the OTF command, e.g.

  UIP> OTF 270 240 5 5 5 4/ALT
  When choosing the length of the scan, make sure there is some baseline at both ends. Otherwise you will not be able to restore the data properly. Always add the chopper throw to the length of the scan you have determined based on the extent of your source (i.e. with a $30''$ chopper throw, you have to set the scan length to $270''$ to get a restored map of $240''$ in size). Beware that the noise in the restored image increases roughly as the square root of the scan length divided by the chopper throw. Definitely something to keep in mind when yon make long scans with a small chopper throw.

- Pointed observation with SHARC.
  If you intend to make deep integration on your source, open a data file in point format with the DATA command under UIP, and use the CHOP_SLEWY command to start integration. You may want to set up the characteristics of each "scan" such as

  UIP> SHARC/CHOP=4/INT=8

Each "scan" will contain four CHOP_SLEWY cycles and each of the four segments of one CHOP_SLEWY cycle will last 8 seconds. So each "scan" will have 64 seconds of on-source integration. To get one such scan, simply

```
UIP> CHOP 1
```

To make 10 such scans,

```
UIP> REPEAT 10 CHOP 1.
```

If you want the bolometer array to align to a particular position angle on your source during the whole observing session, issue a ROTATOR command

```
UIP> ROTATOR/RIGHT/STEALTHY/OFFSET=xx
```

before you start integrating with the CHOP_SLEWY command. This will rotate the SHARC dewar to the current parallactic angle plus the offset (your preferred position angle) at a time the antenna computer deems convenient.

Since the SHARC dewar can only rotate in a limited angular range (due to other external constraints, such cables, etc.), the requested angle may fall outside of the legal angular range at some point if you are tracking a source from rise to set, and you cannot keep tracking the position angle with the bolometer array. You may, however, continue to observe by allowing the array to flip 180 degrees. The only catch is that the "scans" taken from this point onward will have to be processed separately as the correspondence between the bolometer cell and the source position is also flipped.

5.2.2 Additional Tasks For the First Night

There are a few other tasks typically to be performed on the first night of a SHARC run: adjusting the focus, phasing the pixel, and calibrating pixel gains.

- Focus adjustment
  The nominal focus of the bolometer array (+0.25) is stored in the SHARC pointing file. The peak intensity of the images is fairly insensitive to focus changes of ± 0.25, but the shape of the image does change considerably over such a range due to aberrations. So focus adjustment is to optimize the focus for the roundest, smallest (hence the best beam shape), and brightest image of a planet (except perhaps Jupiter) or other suitably strong and point-like objects. You would do this after you have first pointed on the source. The procedure is similar to that of pointing. You would make a quick OTF map of the source,

and note the peak intensity and the shape of the source. Then you adjust the focus offset in small steps by

UIP> FOCUS/OFFSET=0.15
UIP> FOCUS
Note that the second FOCUS command is needed to commit the change. You would make another quick OTF map of the source, and compare the peak intensity and source shape to those under the previous focus setting. Repeating the process till you find the "sweet spot".

- Phasing the pixel
  This is the process whereby each bolometer pixel establishes its own phase, which SHARC server uses to decide how long after the chopper control signal (TTL) transition should the bolometer be read out, and hence to achieve the best possible efficiency. The phases are therefore specific to the chop frequency, and this process needs to be done every time you change the chop frequency. In reality, there is little chance one would want to change the chop frequency in the middle of a SHARC run. So this procedure is often performed on the first night and the chosen chop frequency will be used throughout the whole observation run.

  You would want to do this while tracking a bright object (such as planets, M42, G34.3, IRAS16293, SGRB2 etc.). To phase, type

  UIP> AZO xx/CHOP
  UIP> PHASE_yy
  where xx in the first command is one half of the chopper throw you measured while doing pointing. This command will place the source in one of the chopper beam. yy in the second command is your choice of the reference pixel, which is often the center pixel of the array (12) for large scale mapping. Watch the display on the Macintosh for the pixel phases as they are measured. Except the bad pixels (1, 5, 15, 16) all phases should be within a few degrees of each other (in the range of 260–280 degrees). If unsure, repeat the phasing until a good set of phases is obtained. Type

  UIP> SHARC/SAVE_PHASE
  to save the phases on the Macintosh disk. If for some reason you need to restart the SHARC server and client, simply type

  UIP> SHARC/LOAD_PHASE
  to load the last saved phases.

- Pixel gain calibration.
  This process is often referred as flat-fielding. It is used to determine

relative pixel gains and is done by moving a bright point source along the bolometer array. Practically only Venus, Mars, Jupiter, and Saturn (plus a few very bright Galactic sources, such as G34.3) are really suitable for this purpose. Do not despair if you cannot do this on the first night. Doing it at any point during the run is useful, so long as you have a set of measurements. In the worst case, you can use with confidence gains from recent SHARC runs. To flat-field, type

`UIP> FF_SHARC`

while tracking on a planet or other bright object. The command will place the source in both the 'on' and 'off' beams of the chopper, and move it across all pixels. Two entries (on and off beam) are written to your opened data file (in map format). You can inspect the gains by choosing the "gain" mode under `CAMERA`. This will generate the gain files (gains_1.dat and gains_2.dat), which you will need to reconstruct the images of your program source.

5.3 Reducing SHARC Maps with CAMERA

5.3.1 General concepts

There are two ways you can make a two dimensional map out of the SHARC OTF data. The samples taken by the different pixels of the array in a given azimuth scan will form a map in Az-El coordinates. Alternatively, the samples taken with a single array pixel over a range of scans in an OTF map will also make a two dimensional map in Az-El coordinates. CAMERA will let you look at you data in both ways. The first mode, called scan mode, is used primarily for pointing, focusing and deriving gains for different pixels in the array. This mode was described in considerable detail in Sec 5.2. The second mode is typically used in the final data reduction. In the following sections we describe how to properly reduce a SHARC image.

5.3.2 Reducing Maps

To reduce the `OTF` maps, run `camera` and reduce the data in `map` mode. You will have an option to de-spike and de-stripe the data. These functions are described below. Most of the time you want to choose automatic processing mode. You will be asked a number of questions during reduction of the map taken with the first pixel of the array. Parameters given will be applied to processing of subsequent maps.

You can safely look at the first few scans while a large map is still running. If any of the camera pixels are noisier than the remaining pixels you can blank them and exclude them from the data reduction. This can be done using `camera.dat` file which has to be placed in the directory from which you run `camera` (see below).

At the end you will be prompted again for the next filename. If you reply `radec`, the program will add all the maps, re-grid them onto a regular grid in the equatorial coordinate system and display the final image on the screen. This is a rough version of your final map which is written in FITS format to the file `filename_ext.fits`, where 'filename.ext' is the name of the data file you are working on. The reduced data is written to the file `camera.radec`. When you exit `camera` properly using the `quit` command this file is renamed to `filename_ext.radec`. You should thus quit `camera` after reducing each data file.

5.3.3 De-Spiking

A simple de-spiking algorithm is implemented in `CAMERA`. If you choose to de-spike your data, the program will calculate the mean and the rms for the samples taken in a given scan with a given pixel of the array. It will the search for data points which satisfy the condition

```
(data-mean)/rms > ncut
```

where ncut is a user specified cutoff and will replace these points with the average of four neighboring points in the same scan. If you have a compact source in the map, you can specify an avoidance region. Only points outside of the avoidance region will be included in calculations of the mean and the rms. Note that this procedure will not work if there is a strong source in the map.

5.3.4 De-Striping

In windy conditions you often see a lot of correlated noise in the data. You can try to remove this correlated noise using a simple de-spiking algorithm built into `CAMERA`. For each integration, the program will calculate an average signal for all pixels of the array and it will subtract the average from all the pixels. If you have a compact source in the map, you can specify an avoidance region. This algorithm will not work for extended sources.

5.3.5 `CAMERA.DAT`

There are several bad pixels in the array. The information about which pixels are bad is stored in the header and the data taken with this pixels will not be processed. In addition, on occasions some pixels (in particular pixels 17 and 18) may become much noisier than the remaining pixels. If you want to exclude any additional pixels from from the data reduction, copy the file /home/hapuna/dcl/bin/camera.dat to your current directory. Edit this file and change the second column from 1 to -1 for the pixels you want to exclude.

5.3.6 Adding Maps

You will use a program called `regrid` to produce a final map in the equatorial coordinate system. An example input file for `regrid` can be found in `/home/hapuna/dcl/bin/regrid.inp`. Here is the list of parameters you will have to specify on successive lines in the command file:

- RA and Dec for the center of the final map.
- Limits of the final map in arcsec (+rao, -rao, -deco, +deco).
- Pixel size of the final map in arcsec (RA and Dec). Typically 5 arcsec is a good number. Pixels don't have to be square.
- Minimum number of data points required per pixel of the final map.
- Cutoff limit for weights of maps to be included. You should run the command file for the first time with this parameter set to zero. Weights of the maps will be printed at the end along with the average, min and max values. If all the weights are within a factor of a few, you probably want to leave this parameter at zero. If one or more maps have weights significantly lower than the remaining maps, you may want to exclude them from the final average. To do it, set the cutoff above the weight of the maps you want to exclude and run the command file again.
- Data file name. This is the `.radec` file created by `camera`.
- Range of maps to be read from the data file.
- Pointing corrections in RA and Dec in arcsec. Normally these are set to zero. You can correct pointing errors in `camera` before transforming the data to the equatorial coordinate system.
- Scaling factor from mV to Jy (i.e. Jy/mV).
- The following lines include the gains for different pixels of the array. You can include here the file `gains_ave.dat` (see above) and delete the lines corresponding to pixels which were blanked. The bad pixels will have a gain of -1 in `gains_ave.dat`, but you also have to delete lines corresponding to any additional pixels you might have excluded in `CAMERA.DAT`.

If you want to average several maps, repeat last five items for all the maps you want to include. Otherwise type quit on the following line. Leave the following three lines as they are in the example command file. The final result of the command file is a FITS image `regrid.fits`. You will have to rename after running the command file, so that it doesn't not get overwritten.

5.4 Reducing SHARC Scans with BADRS

5.4.1 Introduction

The less "glamorous" side of observing with SHARC is perhaps the deep integrations taken with the `CHOP_SLEWY` command. Here one uses the SHARC bolometer array to observe the flux density along a $2'X10''$ cut on the source, with each pixel analogous to a spectral channel. Indeed, the way `BADRS` (pronounced BAD-RISS) handles SHARC `CHOP_SLEWY` scans bears more than a touch of similarity to that of `CLASS` and AOS spectral scans. As you can see from next section, `BADRS` implements many of the basic commands of `CLASS`. Fire up `BADRS` on one of the SUN Ultra boxes or on poliahu (for a older version) by simply typing `badrs`, and you can carry on pretty much as in you are using `CLASS`. There are of course commands specific to `BADRS`, and even for the ones that appear common to both there may be important differences (`FILE OUT`, for example). So patiently read the next section before you boldly march into `BADRS`.

5.4.2 `BADRS` Commands

For completeness, we simply copy the `BADRS` help file which lists implemented commands, each with a short explanation.

- BADRS
  BADRS is the CSO SHARC Bolometer Array Data Reduction Software. It is used to analyze and reduce the scans produced by `CHOP_SLEWY`, which are used to integrate on a line $2'X10''$ with 24 bolometer pixels. BADRS is pronounced BAD-RISS, and is currently in version 3.0 (98/10/08). For more information, contact Dominic Benford (dbenford@tacos.caltech.edu).

- BASE
  Removes a linear fit from the current scan. `BASE 0` removes a 0-th order baseline, `BASE 1` a 1st order. The fit only looks at good pixels excluding the window (`SET WINDOW`).

  – ALL: removes a linear fit from each scan in the list of found scans.

- CALIBRATE
  This will run through the list of currently selected scans, applying a multiplicative correction factor exp(-tau*(airmass-airmassref)). Then each scan is correctly calibrated for coadding.
  - TAU
    `/TAU=1.5` will set the in-band tau value to 1.5; otherwise it is set to 25*Tau_225GHz.
  - AIRMASS
    `/AIRMASS=0` will correct the flux to above the atmosphere. By default, it is 1.
- DEBUG
  This is a switch which turns debugging mode off and on. It prints BADRS internal variables. Watch out if you open a file with this turned on.
- DESPIKE
  Runs a simple despiking algorithm, removing all spikes greater than some multiple of the scan sigma. I.E. `DESPIKE 3` will remove any spike greater than 3 sigma. This is applied to all scans in the found list; use `NEW` to undo. Minimum DESPIKE is 2sigma. The algorithm uses the nearest neighbors to determine the new value.
- DEVICE
  Creates a graphics output. If you do not specify a graphics device, it will ask you. Typical ones are /X11 (XWindows), /VT125, and /GF.
- DIRECTORY
  Typing `DIRECTORY` will give you a listing of the current directory. `DIRECTORY 'directory'` gives you a listing of the directory pointed to by 'directory'.
- DRAW
  Used to add items to the graphics display.
  - IDENTITY: puts a little ID string (your name and the date) on the plot.
  - TEXT: allows you to draw text on the plot.
    `DRAW TEXT xpos ypos text angle`
  - CLEAR: clears the plot
  - FONT: `DRAW FONT 'font'` changes the font. Options are SIMPLEX and DUPLEX.

  - SIZE: `DRAW SIZE 'size'` changes to new size. 0.65 is default.
  - COLOR: changes the pen color.
  - LINE_STYLE: changes the line style between solid and dots.
  - WIDTH: changes the line width. Default is 1.

- DROP
  Allows you to drop a single scan from the list of found scans (see FIND). Example: `DROP 17` will drop scan # 17. Using `FIND` will bring it back.

- EXIT: EXITs the program, returning to the DCL command prompt.

- FILE
  `FILE` is used to input or output files to the disk. BADRS can read only SHARC `CHOP_SLEWY` data files, so don't bother trying to reduce anything else. The output file format is also CHOP_SLEWY data, so you can read files back in. If you want a (slightly) more portable format, use `PRINT` or `CLASS`.

  - IN
    Used for input: `FILE IN filename`
    This command loads into memory the desired filename. Therefore it removes any file currently in memory.
  - OUT
    This opens an output file for writing. `FILE OUT` will always create a new file, writing the file header to it and closing. To add scans to the file, use the `WRITE` command.

    Special thanks to Todd Hunter for developing the SHARC scan writing routines!

- FIND
  Performs a search on the current input file, extracting the scans you specify by `SET NUMBER`. This enables you to work with a subset of the whole data file.

  - /ALL: finds everything, regardless of specifications.

- FLIP
  Multiplies all found scans by -1. Used if you accidentally observed in the negative beam. Because one rarely swaps beams, this command cannot be used on the current scan in memory.

- GAUSS
  Fits a gaussian to the current scan. It is a pretty robust method, so it doesn't need any input parameters. Use `PLOT/GAUSS` to view.

- GET
  Get a scan number from the file into current scan memory. Use `GET i` to get scan number i; use `GET NEXT` to get i+1. Use `GET FIRST` to get the first scan in the index, and `GET LAST` to get the last scan in the index.

- HELP
  Typing `HELP` yields the standard HELP screen. `HELP 'command'` will give you help on the specified command. It's pretty straight forward.

- HEADER
  Lists information about the current scan in memory.
  - /FULL: lists everything.
  - /FILE: lists the file header information only.
  - /SCAN: lists the header for the indicated scan.

- INTERPOLATE
  The current scan will be fit by a CURRENT_PIXELS/2 polynomial, and any bad pixels will be filled in by the interpolated values. After this, use `SET BAD NONE` to turn on all pixels. Actually, this lovely polynomial method has problems. For the time being, INTERPOLATE is just going to use the nearest neighbors.

- LIST
  Lists the contents of the file currently in memory. By default, provides a short listing of the scans in the current found list.
  - /ALL: lists all scans, not just those in the found list.
  - /FULL: lists the contents in a longer format.
  - /SCAN: lists everything stored in a single scan. You must supply the scan number: `LIST /SCAN=2`

- NEW
  Reopens the file, getting any new scans. All modifications made to the file (BASE, FLIP, DESPIKE, etc.) will be undone! Note that for data files being written to (i.e. in the process of observing into them), the most recent scan will probably be junk.

- PLOT
  Displays a scan on the graphics output. If no number is specified, it will plot the scan in current scan memory. Otherwise, `PLOT number` will plot that scan number. By default, the PLOT command only prints the in_phase data.

  - number
    This number is the counter, usually 1 to n, of the data set. This is NOT the "scan number" written by Alpha1. Why? Because it is theoretically possible to have a file with 100 scans, all with the same "scan number". The BADRS counter is therefore used, because it is guaranteed to be unique. By the way, `PLOT 1` just **displays** scan 1, it doesn't `GET 1` first. This means that you cannot do `PLOT 1/GAUSS`, because you won't have found a Gaussian fit to a scan you haven't GOT.
  - /HARD: sends a hardcopy to the printer.
  - /SPEC: prints only the spectrum, not the box.
  - /GOOD_ONLY: leaves off the bad channels.
  - /TITLE: prints a title on: `PLOT /TITLE=''Scan name''`.
  - /TOTAL_POWER: plots total power as opposed to in_phase.
  - /QUADRATURE: plots the quadrature (out of phase) data as opposed to the in_phase.
  - /IN_PHASE: plots the in_phase data. This is the default.
  - /GAUSS_FIT: displays the gaussian fit found using GAUSS.
  - /ARCSECONDS: displays the X axis in arcseconds (default is in pixel number).
  - /BLANK_BAD
    By default, dots are placed to mark where the bad pixels' values would be. Blanking them removes this, which is probably better for presentation quality plots. As though anyone will ever present this stuff.

- PRINT
  Prints an ascii table of the current scan. Prompts for an output filename if one is not supplied on the command line.

  - /ALL
    Prints each scan in the current index (i.e. those found by the most recent `FIND` command) into separate files including header information and the scan data averages. The file names take on the following format: CURRENT_INFILE.SCANn. This feature is useful for porting the data to other packages such as CLASS.

- WRITE_SCAN
  Writes the CURRENT scan in memory to the file on disk specified by the FILE OUT command. Note that summed scans don't yet have

meaningful on/off data, only the final averages. The on/off data is blank, and there is only one scan. Because SUM adds together averages, only the averages are written.

- SET
  This command is used to set a BADRS parameter.
  - NUMBER
    Sets the number range for selection using `FIND`. Format is `SET NUMBER low_end high_end`. Using an asterisk (*) as a wildcard allows you to choose variable ranges. I.E. `SET NUMBER 10 *` will select everything from 10 on up; `SET NUMBER * *` takes everything.
  - WEIGHT
    Sets the weighting for summation. Can be TIME (longer scans get more weight) or SIGMA (noisier scans get less weight). SIGMA uses the scan sigma, not the channel sigma (see `SET SIGMA` for more information).
  - CALIBRATION
    Set the conversion factor for mV to Jy, as determined by `SET UNIT`. This is not a permanent feature of a scan - when you write out a scan, `MULTIPLY` it by the calibration factor first.
  - UNIT
    Determines whether the unit is mV or Jy. BADRS automatically converts into mJy or microV when the source is sufficiently weak.
  - WINDOW
    This specifies an area of pixels to avoid including in `BASE` fits or in the calculation of sigma. It is inclusive, so `SET WINDOW 10 14` ignores all 5 pixels between 10 and 14.
  - SOURCE: specifies a source name to be found when using `FIND`.
  - BAD
    Allows you to flag bad pixels. It works as a switch. `SET BAD 11` will first turn off pixel 11 (assuming it was good to begin with), then `SET BAD 11` a second time will turn it back on. `SET BAD NONE` turns on all pixels, `SET BAD ALL` turns 'em all off.
  - MATCH
    This allows you to turn on and off (NOMATCH) position matching for SUM. What this actually does is track the rotation of the array on the sky (well, really just the PA of the source- assuming no dewar rotation) and checks to see if the outlying pixels are

overlapping. It will `SET BAD` all those pixels that have slewed away from themselves due to sky rotation.

  - SIGMA
    Not to be confused with `SET WEIGHT`, this switch determines how sigma is measured. The usual way is to measure the sigma in the scan (i.e. 24 pixels are used to determine the RMS in the 24 pixels). This is `SET SIGMA SCAN`. The other way is `SET SIGMA CHANNEL`. This will calculate, during a SUM, the RMS in each channel from the set of scans used to build up the sum.

- SHOW: shows the value of a BADRS parameter. See `SET`.

- SPAWN
  Use this to send a command to DCL. If you do not specify a command, a subprocess is spawned. An easy way to do things is to put a command in quotes, i.e. `SPAWN ''DELETE /NOCONFIRM JUNK.TXT;*''`.

- SUM
  Adds the current scan list (created by `FIND`). The weighting for summation is derived from `SET WEIGHT TIME` (in which those scans with more time are given more weight) or from `SET WEIGHT SIGMA` (in which those scans with the lowest sigma are more heavily weighted). The sigma used here is always the scan sigma, not the channel sigma (see `SET SIGMA` for more help).

- IGNORE
  Like `DROP, IGNORE` removes a scan number from the current found list. Unlike i`DROP, FIND` won't bring it back, but `FIND/ALL` will.

- MULTIPLY
  This allows you to multiply the current scan by a number (for instance, the Jy/mV conversion factor). This is useful for writing out the scan to a new file, since you'll want to retain correct calibration for each scan in the new (reduced) data file, even if they have different conversion factors themselves.

- COMMENT
  Can be abbreviated C or even ! if you like that sort of thing. This is a robust 3-D N-body Simulated Annealing commenting routine. Use it with care.

- CLASS
  Generates an ASCII file listing of each scan in the specified data file (preceeded by header variables) suitable to be read into CLASS.

- SHIFT
  Allows you to move the scan to the left or right by 1 pixel, thereby taking out some amount of pointing/ref_pixel drifts. Use the required parameter `LEFT` or `RIGHT` to indicate direction.

- SIGMA
  Calculates the values of SIGMA for each pixel. When used with `SET SIGMA CHANNEL, SIGMA` will estimate the value of the sigma of each channel at a given point in time based on the variance of the nearest several points.

Chapter 6

In Case of Trouble

As CSO is a hands-on observatory, where visiting astronomers do their own observing, we do expect from observers a certain level of familiarity of CSO's hardware and software environments, which we hope this manual would help to achieve. And of course thing do go wrong, occasionally. For these occasions, we have two levels of help in place.

The first level of help is really self help, with assistance of a on-line trouble shooting guide (http://www.cso.caltech.edu/docs/troubleshooting.html). This guide categorizes problem broadly into Dome/Shutter related, AOS related, antenna computer related, tuning related, and pointing related. For each symptom, we try to exhaust all likely causes with each cause leading to a solution. The list of problems are pretty extensive, covering most often seen problems. And we do try to keep the guide up to date.

The second level of help is the CSO staff person on call for the week. This person carries the pager. So simply dial up the pager will often result in a prompt call back shortly. We do encourage you to first pursue the on-line trouble shooting guide and see if you can solve the problem yourself. But don't hesitate to call if it's something you can't deal with.

We also encourage you to make use of other on-line resources on our website (http://www.cso.caltech.edu), which is alot more than the pretty tau_plots one often sees. For example, the mini how-to page (http://www.cso.caltech.edu/docs/howto.html) shows you some of the VMS and `UIP` related tasks you wish you had remembered; the useful utility page (http://www.cso.caltech.edu/docs/utility.html) shows some of utilities on our summit computers you might not know to exist. Of course, there is the all important emergency procedure (http://www.cso.caltech.edu/docs/pf/pf.html) which would not doubt be very handy during a power outage. We do have a printed copy of this emergency procedure on the shelf in the control room.

With these two levels of help, we hope most of the problems can be fixed promptly. In an effort to help us keeping the on-line resources (trouble shooting, etc.), please send me (at peng@submm.caltech.edu) comments, suggestions for new additions, and simply anything you see lacking in these guides and pages. Thanks!

Appendix A

Calibration at the CSO

This appendix describes the theory and practice of calibration at the CSO. It was last updated in November 1996. Several authors (Tom Phillips, Taco, and Todd Groesbeck) were involved in creating these "classical" texts at the early years of the CSO life. These are the principals and practices we still hold near and dear today. But as to the actual numbers regarding beam efficiency, etc., one may find the latest measurements on our web site(http://www.submm.caltech.edu/cso/receivers/beams.html).

A.1 Temperature Calibration

The method of calibration employed at the CSO is known as "chopper-calibration" and was first discussed for millimeter astronomy by Penzias and Burrus (Ann. Rev. A. & A., 1973). In this method, an ambient temperature absorber is switched into the beam at a point between the receiver and the secondary mirror. As will be shown below, this completely determines the corrections necessary to produce a value of T_A^*, the temperature of the source corrected for atmospheric effects and telescope losses due to ambient temperature effects, including spillover and blockage. A further correction is necessary for cold spillover and beam coupling to the source.

At the moment, the calibration can be carried out automatically on command by the computer, at the start of each scan, or, if preferred for some technical reason, by hand using the "hot" and "sky" commands. In each case the computer will automatically apply the T_A^* calibration by using the previous appropriate cal scan (if available). Values for correction factors to apply to T_A^* are given at the end of this section.

A.1.1 The Theory

Let us define the following quantities:

α	=	hot spillover efficiency
	=	$1-$ (fraction of power falling on ground etc..)
β	=	cold spillover efficiency
	=	$1-$ (fraction of power falling on sky, but not forming part of the beam)
γ	=	source coupling efficiency
T_{RX}	=	receiver noise temperature (DSB)
T_h	=	hot load temperature = ground temp = air temp
T_c	=	cold load temperature
T_s	=	source temperature
V_h	=	voltage looking at hot load
V_c	=	voltage looking at cold load
V_{sky}	=	voltage looking at sky (off position)
V_s	=	voltage looking at source (on position)
G	=	system temperature to voltage conversion factor
τ	=	atmospheric opacity at a given zenith angle

We will need to make several assumptions. The major ones are:

a) All temperatures are large compared to the operating frequency; i.e. $T >> \frac{h\nu}{k}$. The lowest temperature is likely to be T_c which is about 70 K. Therefore we can use the Rayleigh-Jeans assumption over most of the submillimeter range.

b) $T_h = T_{ground} = T_{air}$. Often T_{air} may be less than T_h by about 20 K, but this is not too important.

c) The receiver side-band ratios are equal.

We now wish to write down the expressions for the voltages under various conditions:

$$
\begin{aligned}
V_h &= G[T_{RX} + T_h] \\
V_c &= G[T_{RX} + T_c]
\end{aligned}
$$

The voltages looking at the sky (off) and the source (on) have contributions from the atmosphere, the ground (hot) spillover, the sky (cold) spillover, the receiver and the source.

$$
V_{sky} = G[\underbrace{\alpha\beta(1-e^{-\tau})T_h}_{\text{atmosphere}} \underbrace{+(1-\alpha)T_h}_{\text{hot spillover}} \underbrace{+\alpha(1-\beta)(1-e^{-\tau})T_h}_{\text{cold spillover}} \underbrace{+T_{RX}}_{\text{receiver}}]
$$

or

$$V_{sky} = G[T_{RX} + (1 - \alpha e^{-\tau})T_h],$$

and

$$V_s = G[T_{RX} + (1 - \alpha e^{-\tau})T_h + \underbrace{\alpha\beta\gamma T_s e^{-\tau}}_{\text{source}}].$$

Now the computer takes the data through the `OO_SCAN` routine which calculates $\frac{V_s - V_{sky}}{V_{sky}}$, and calibrates through the `CAL` routine which calculates $\frac{V_h - V_{sky}}{V_{sky}}$. So

$$OO\_SCAN = \frac{V_s - V_{sky}}{V_{sky}} = \frac{G\alpha\beta\gamma T_s e^{-\tau}}{V_{sky}}$$

and,

$$Cal = \frac{V_h - V_{sky}}{V_{sky}} = \frac{G\alpha T_h e^{-\tau}}{V_{sky}}.$$

The ratio of these quantities eliminates G, α and τ:

$$\frac{OO\_SCAN}{Cal} = \frac{\alpha\beta\gamma T_s e^{-\tau}}{\alpha T_h e^{-\tau}} = \frac{\beta\gamma T_s}{T_h}$$

or

$$T_s = \frac{T_h}{\beta\gamma} \times \frac{OO\_SCAN}{Cal}, \text{for double side-band data} \quad (A.1)$$

$$T_s = \frac{2T_h}{\beta\gamma} \times \frac{OO\_SCAN}{Cal}, \text{for single side-band data} \quad (A.2)$$

What the computer will plot (as a function of velocity, channel # or frequency) is the quantity

$$T_A^* = 2T_h \times \frac{OO\_SCAN}{Cal} \quad (A.3)$$

i.e. the source temperature corrected for the atmosphere and hot spillover. However, we also need to know the value of $\beta\gamma$, the product of the cold spillover and source coupling efficiencies, to get

$$T_s = \frac{T_A^*}{\beta\gamma}. \quad (A.4)$$

The actual value of T_s, and what you may wish to call it, will depend on the size of the source. There are three typical cases: sources large, similar or small compared to the beam.

a) Large sources, i.e. a few times the beam size, can be calibrated by determining $\beta\gamma$ from the full moon temperature as measured by the chopper-cal method. Then

$$\beta\gamma(Moon) = \frac{T_A{}^*(Moon)}{T_{Moon}}. \tag{A.5}$$

Probably you will want to call these temperatures $T_A{}^*$ still, but note that they are calibrated with respect to the Moon.

b) Sources comparable to the beam can be calibrated by determining $\beta\gamma$ from the $T_A{}^*$ of a planet of size comparable to the beam. Usually these temperatures are called main beam, T_{mb}. For a planet of uniform temperature, we can calculate $\beta\gamma$ from:

$$\beta\gamma(Main\ beam) = \frac{T_A{}^*(Planet)}{T_{Planet}} \times \left[1 - exp\left(\frac{-D^2}{\theta^2} ln2\right)\right]^{-1} \tag{A.6}$$

where D is the planet diameter and θ the half power full beamwidth. This assumes that the main beam is gaussian. The best planets for this are Jupiter and Mars, with Venus probably OK. The trouble here is that the planet temperature may be a function of frequency if it has an atmosphere. Mars is the most reliable since it has very little atmosphere.

c) Small sources can be calibrated by the main beam efficiency or more traditionally from the aperture efficiency, which is very similar except that it is assumed that the beam is the diffraction function of a uniformly illuminated, perfect telescope, rather than a gaussian. In that case, slightly higher temperatures will be obtained and the result is called brightness temperature, T_b. This is not a good unit because, in its original definition, it requires a correction for the Planck factor also. This makes sense for very hot radio sources, but not for low temperature molecular sources. To avoid this difficulty, we should either invent yet another temperature unit or use Janskys. I suggest you use Janskys.

Another quantity that the computer will give you is the system temperature, T_{sys}. This is the system noise in temperature units, at some zenith angle, divided by the loss factor for a source. It is used for weighting scans.

$$T_{sys} = \frac{T_{RX} + (1 - \alpha e^{-\tau})T_h}{\alpha\beta\gamma e^{-\tau}}. \tag{A.7}$$

But

$$Cal = \frac{\alpha e^{-\tau} T_h}{T_{RX} + (1 - \alpha e^{-\tau})T_h},$$

So,

$$T_{sys} = \frac{T_h}{Cal \times \beta\gamma}. \tag{A.8}$$

Actually, since the computer doesn't know $\beta\gamma$ and the weights only require relative T_{sys} values, you will get from the computer, simply

$$T_{sys} = \frac{T_h}{Cal}. \tag{A.9}$$

A.1.2 The Numbers

For spectral line data we have, from equations A.3, A.4, A.5 and A.6:

$$\begin{aligned} T_A^* &= 2T_h \times \frac{OO\_SCAN}{Cal}, && \text{computer output} \\ T_A^*(\text{Moon-corrected}) &= \frac{T_A^*}{\beta\gamma(Moon)}, && \text{large source} \\ T_{MB} &= \frac{T_A^*}{\beta\gamma(Main\ Beam)}. && \text{smallish source} \end{aligned}$$

The $\beta\gamma$ correction factors vary with the receiver and, strictly speaking, with frequency for each receiver. Current known values are:

Receiver	230 GHz	345 GHz	492 GHz	650 GHz
$\beta\gamma$(Main beam)	0.76	0.65	0.53	0.32 ??

Every observer should report in the log book at the CSO any new measurements of $\beta\gamma$. Please make sure that your pointing, focus, Y-tilt and side-band ratios are adjusted properly before making the measurement. Note - the above numbers have changed recently due to the presence of the autocal chopper in the beam edges.

A.2 Skydip Measurements

A.2.1 The Theory

We will use many of the same quantities and some of the results of the previous section. In addition, let us define the following quantities:

$$\begin{aligned}
T_{spillover} &= \text{spillover temperature} \equiv (1-\eta_{hot}) * T_h \\
\tau_z &= \text{atmospheric opacity at zenith} \\
M &= \text{airmass at a given zenith angle} = 1/cos(ZA) \\
&\quad \text{(assuming a plane-parallel atmosphere)} \\
Y &= V_h/V_c = \text{“Receiver Y-factor”}
\end{aligned}$$

As noted, we assume a plane-parallel model for the atmosphere, so for a given zenith angle we have

$$\tau = \tau_z M.$$

We will be comparing measurements at different zenith angles rather than on- and off-source measurements. The entire passband of the receiver is treated as a single channel (the total power output is used), and we assume that the contribution of any source to the total power is negligible in comparison with the contributions of the receiver, spillover, and the atmosphere.

From Sec. A.1.1, we have

$$\begin{aligned}
V_h &= G[T_{RX} + T_h] \\
V_c &= G[T_{RX} + T_c]
\end{aligned}$$

and

$$V_{sky} = G[T_{RX} + (1 - \eta_{hot} e^{-\tau})T_h].$$

If we now form the quantity

$$\begin{aligned}
A &= \ln\left(\frac{V_h - V_c}{V_h - V_{sky}}\right) \\
&= \ln\left(\frac{T_h - T_c}{\eta_{hot}\ e^{-\tau}\ T_h}\right) \\
&= \tau + \ln\left(\frac{T_h - T_c}{\eta_{hot}\ T_h}\right) \\
&= \tau_z M + \ln\left(\frac{T_h - T_c}{\eta_{hot}\ T_h}\right)
\end{aligned}$$

we see that A is a linear function of airmass with slope τ_z. With T_h and T_c known, η_{hot} can be found from the intercept as

$$\eta_{hot} = (1 - \frac{T_h}{T_c})e^{-(intercept)}.$$

$T_{spillover}$ can then be calculated from its definition. Note that for any measurement of V_{sky} we may define a T_{equiv} by requiring

$$V_{sky} = G[T_{RX} + T_{equiv}].$$

$T_{spillover}$ can then also be thought of as the T_{equiv} that would be measured for an airmass of zero.

If V_c (or T_c) is unknown, τ_z can be found by defining

$$\begin{aligned} A' &= \ln\left(\frac{V_h}{V_h - V_{sky}}\right) \\ &= \ln\left(\frac{T_h + T_{RX}}{\eta_{hot}\ e^{-\tau}\ T_h}\right) \\ &= \tau_z M + \ln\left(\frac{T_h + T_{RX}}{\eta_{hot}\ T_h}\right) \end{aligned}$$

where now A' is linear in airmass with a slope of τ_z. If T_{RX} is known, this intercept can be used to find η_{hot}. However, it is more likely that T_{RX} will be determined from measurements of V_h and V_c at known temperatures as follows:

$$\begin{aligned} Y &= \frac{V_h}{V_c} \\ &= \frac{T_{RX} + T_h}{T_{RX} + T_c} \end{aligned}$$

and

$$T_{RX} = \frac{T_h - YT_c}{1 - Y}.$$

(This is of course unrelated to doing a skydip except insofar as measurements are typically made of V_h and V_c.)

Whether A or A' is used, it is necessary to make more than one measurement in order to find the slope and the intercept. The usual way of doing this is outlined below.

A.2.2 The Practice

A skydip is usually performed at the CSO using the `1M`, `1.5M`, etc. macros under the `UIP`. Issuing one of these macros causes the telescope to go to the corresponding zenith angle for 1, 1.5, 2, 3, 4, or 5 airmasses. The total power must be recorded at each of these positions (some day it may be automated, but not yet) and for the hot and cold loads.

A utility program called TAUPLOT exists at the CSO which will do all of the necessary calculations and produce pretty plots (see Figure A.1). This may be run by simply typing `tauplot` at either the `UIP>` prompt or the $

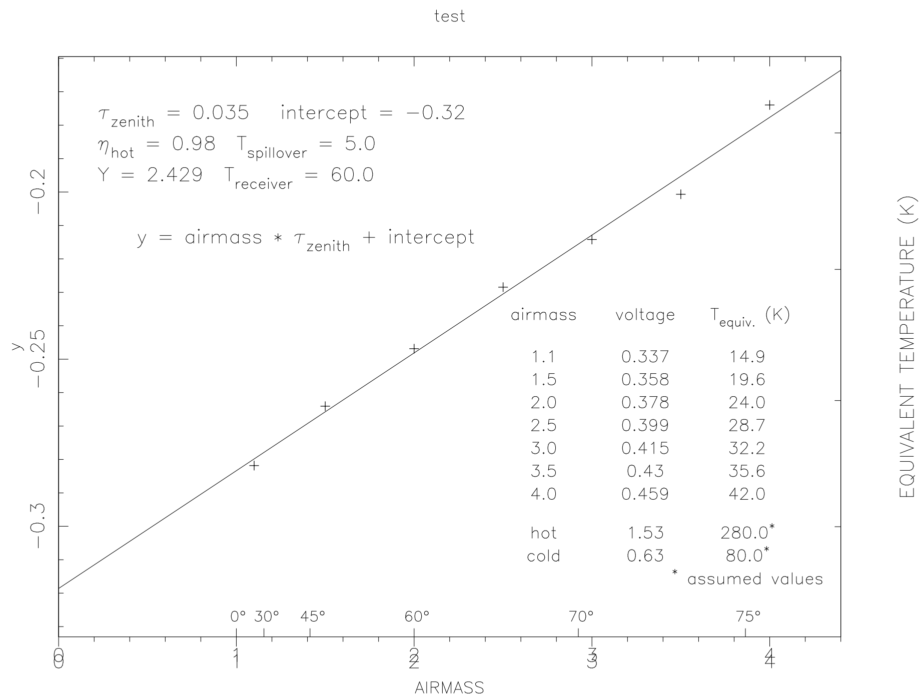

Figure A.1: *A sample plot produced by the TAUPLOT program.*

prompt. The program will then prompt you for an airmass and voltage, and will repeat the prompt after the values are entered. A simple carriage return will cause the program to go on, and you are prompted for V_h and then V_c. Default values for T_h and T_c will be used unless other values are specified at the next prompt.

IMPORTANT NOTE – The program is set up under the assumption that G is positive (it checks that V_{sky} is always less than V_h). This means that although the total power voltage may be displayed as negative, the absolute value of this should be used. Furthermore, it is often more convenient to use integral values though this is not necessary. Thus, if the meter reads -0.142, a value of 142 should be entered.

Once the data entry is complete, the program calculates τ_z, the intercept, $\eta_{hot}, T_{spillover}, Y$, and T_{RX}, as well as equivalent temperatures T_{equiv} for all of the measured V_{sky}. These are displayed on the screen, and you are asked if you wish to plot the results. The default is to produce first a screen plot and then hardcopy, but you may specify otherwise if you desire. All of the calculated values are also displayed on the plot.

If for some reason, V_c is not measured, the program may be run using the A' formalism outlined above by not entering a value at the V_c prompt. In this case, τ_z is the only value calculated and is displayed with a message to that effect.

A.3 Frequency Calibration

Frequency calibration of the AOS backends at the CSO is done using a multiplied crystal oscillator to generate a comb with peaks separated by 100 MHz for the 500 MHz AOS or 10 MHz for the 50 MHz AOS. These allow one to determine the relationship between the IF frequency ν_{IF} and channel number of the AOS. (This relationship is assumed to be linear and experience shows this to be so.)

When the `LO` command is issued, the LO frequency ν_{LO} is set so that the desired line frequency will correspond to the center of the passband, or approximately channel 512. This will take into account velocity and frequency offsets as well as the correct ν_{IF}. A default relationship between channel number and frequency is then written into the observation headers. However, because the AOS exhibits some variation in response to temperature changes, the calibration comb should be used to determine the precise relationship as follows:

- Start by using the FCAL macro to record a scan showing the response of the AOS to the comb. Then use CLASS to look at this scan using units of channel numbers.

  Determine the channel numbers corresponding to the peaks of the comb. As a peak may cover more than one channel, it may be necessary to estimate where the center of the peak occurs. Note that as displayed in `CLASS`, channel N extends from $N - 0.5$ to $N + 0.5$, and that for the purposes of these calculations, non-integral channel numbers should be used, *e.g.* a peak may occur at channel number 308.7.

- Next use the number of channels separating the peaks to find the width of each channel in MHz. These values should be roughly the total backend width (500 MHz or 50 MHz) divided by the total number of channels (1024), or about .49 MHz or .049 MHz. The channel width in velocity is determined from the channel width in frequency and is calculated for the desired line frequency.

- Finally determine the channel number which actually corresponds to the desired line frequency. For the 500 MHz AOS, this is the channel location of the central peak. For the 50 MHz AOS, this is the channel location halfway between the two central peaks. This should not vary by more than a few channels from the default channel location of 511.5 for both of the backends.

If after determining the correct values for the reference channel number (corresponding to the desired line frequency) and the width of the channels you desire to change from the default values to the correct values, you can do this within CLASS for data taken in the IRAM format. At the present time, there is no provision made for changing the default values that will be written as you observe, so corrections must be made after the fact. As you will want to write out the scans after they have been corrected, this means you must first open a new data file for writing. See the CLASS manual for a description of the `FILE OPEN` command if you are not sure how to do this.

Variables exist corresponding to the reference channel location and the channel spacing in both frequency and velocity which are used by CLASS in plotting, etc. The names of these variables are `REFERENCE`, `FREQ_STEP`, and `VELO_STEP`. The command `EXAMINE variable_name` can be used to display the current values, while the command `LET variable_name = value` can be used to change the values. Unfortunately, these new values do not become effective until the scan is written out to a data file and the new scan then read back in. Alternatively, the command `MODIFY` can be used (with conveniently different variable names, of course). To change the reference channel, type `MODIFY RECENTER value`; to change the channel frequency spacing, type `MODIFY WIDTH value`. Using `MODIFY` has some advantages: the values become effective immediately, and changing the frequency spacing automatically causes the velocity spacing to be changed correctly. However, with either `LET` or `MODIFY` **the scan must be written to a data file or the changes will be lost**. This can be done using either `WRITE` or `UPDATE`. Again, see the CLASS manual for more details on these commands.

Some conditions for which having the correct values is essential would include: adding together spectra where a line has been observed in different parts of the passband; observing weak or narrow lines which might be lost if any smearing were to occur because of AOS drifts; observing lines near the edge of the passband, or very wide lines. Note that because all values are calculated from the reference channel at ~ 512, errors in the channel width value become progressively more important as you move toward the edge of the passband.

At the present time, the frequency calibration comb is switched in only upon the user's request (or if the antenna is sent on a very long slew). The `FCAL` macro in the UIP program does this; to do this in a command file you must give the actual series of commands which correspond to the `FCAL` macro. Type `DEFINE/LIST FCAL` to see this series of commands.

REMEMBER – Only you can prevent data corruption. You must decide how important the calibration is to you and how to deal with it.

Appendix B

The Shadow Program

Editor's Note:
The `SHADOW` program and this accompanying memo was written by Maren H. Purves in December 1991.

Observing must stop if the Sun hits the telescope. That's an actual CSO rule. It is often possible to begin observing well before sunset, and extend it well after sunrise if you choose your sources carefully, and keep the shutter closed as much as possible. The SHADOW program helps you do this.

B.1 Introduction

The dome shadow program is a utility program to calculate whether the sun shines on any part of the dish at the current telescope position at the present time or whether the sun would shine on the dish if you slewed the telescope to a certain new position.

It is meant to facilitate some daytime observing without getting the sun on any part of the telescope (in normal observing conditions this would usually be the back of the secondary mirror assembly). Unless you are already observing and know that you are at a point where the sun doesn't shine on the antenna structure, run it up before you open the shutters! It will tell you how far you can safely open the shutters for the position you are currently pointing at. The dome shadow program will always provide you with the percentage you have to open the shutter to in order that the dish is fully illuminated by the source if that is possible for the current position (or source you want to observe). It will also inform you how far you can open the shutter so that the sun doesn't shine on the secondary, the front or the back of the dish and the front of the teepee.

The program does **not** control either the dome shutters or the antenna. It does **not** prevent you from pointing the telescope into the sun either. It is your responsibility not to get the sun on the telescope structure, the dome shadow program is there to help you (only!). The only communication with the antenna computer is in reading the time and telescope position out of it.

B.2 How To Use It

The program can be called by typing `SHADOW` from the DCL or UIP prompt. It will initially inform you where you are pointed and how far you can open the shutter and then ask you whether you would like RA/Dec or Altaz coordinate systems for the user input and then leaves you with a command prompt after listing its (one-letter, but not case sensitive) commands:

[c] – new **c**oordinate system (AZ or RA)

[d] – percentage you can open the **d**ome to for the current position of the telescope

[m] – set flag for **m**iddle illumination only, for Texas focal reducer (it is not necessary to illuminate the whole disk, only the panel used)

[n] – **n**ew source (in the coordinate system set up)

[p] – **p**redict, i.e. the program will prompt you not only for the source coordinates but also for the time and date you want to check its observability for

[q] – **q**uit

[r] – **r**epeat current telescope position. Hit <CR> does the same

[s] – repeat **s**ource already specified (if no source was specified, it will use 0.0 0.0 in the chosen coordinate system)

[t] – **t**rack source (prompts for coordinates but not coordinate system)

[x] – e**x**periment, shutter only, specify position, useful for daytime operations where you don't care whether the dish is fully illuminated but would like to open the shutter to a certain percentage

Tracking can be interrupted with control-C and will be interrupted by the program when the source sets, the sun starts shining on the telescope at the source position or the sun sets.

B.3 Constraints and Deficiencies

- The dome shadow program will not work when the antenna computer is not running. However, it will not warn you if the antenna computer doesn't provide "reasonable" output, e.g. if it isn't running.
- It will throw you out when the sun sets (or when it thinks the sun sets).
- To ensure some level of accuracy it is necessary that the time in the VAX is fairly accurate (close to the time in the antenna computer). The shadow program uses the time in the VAX, not the time in the antenna computer.
- Coordinates have to be typed in, they cannot be input from source catalogs.
- Coordinate systems are restrained to altaz and RA/DEC.
- Not all input is trapped for input errors.
- The coordinates for the sun are taken from the usual sun-ephemeris file in `CAT_DIR` and interpolated linear between the preceding and following day (i.e. only two values are used). For this reason the position you get from the shadow program will be slightly different than the position you get from the UIP using `VER/ALTAZ SUN`.

Again: The program has no control of the dome shutters or of the telescope to prevent you from pointing it into the sun.

Appendix C

The UIP Commands

This appendix explains the functions of the `UIP` commands. This information is readily available under `UIP` by typing `HELP`. Here we list the commands and their functions for your convenience of quick reference or learning `UIP` before coming to the CSO. We encourage you to use the `HELP` utility to get the upto date information for each commands (functions and usage of some commands did change in the past few years!).

- **ACQUIRE_LIMITS**

  This command allows you to set, independently, the acquisition limits for the ON and OFF positions. The smaller these values are, the longer it will take the antenna to decide it has acquired the source, and the slower your data taking will be.

  Typing this command with no parameters will result in the current values being typed on the terminal.

  - ON: The acquisition limit for ON scans, in arc seconds.
  - OFF: The acquisition limit for OFF scans, in arc seconds.

- **ADJUST_ATTN**

  `ADJUST_ATTN` tells the backend to automatically set its attenuator at this time. It only sets it once per invocation, no automatic updating is done. This command currently only works if the AOS is the backend.

- **ALTAZ**

  `ALTAZ` tells the antenna computer to switch to altazimuth pointing mode. The values given with the AZ and ZA commands are used. The telescope will not be idle, and it will continuously try to stay at the requested position.

- **ANTENNA**
  The command is used to restart various processes running on the antenna computer as well as some client processes on VAX/ALPHA which are needed for proper operation of the telescope.

  Syntax
  `ANTENNA [/[NO]RESTART[=<level>]] [/[NO]SYNCHRONIZE] [/REBOOT]`

  – /RESTART
    If /RESTART is specified, client processes on VAX/ALPHA (ANT_MCP2 and ACQ_CLIENT), and servers and other processes on the antenna computer will be restarted in an appropriate order. If this qualifier is given in a negated form as /NORESTART, those processes will be stopped, but not restarted.

    An optional value given as /(NO)RESTART=XXX specifies the restart (or stop) level. /(NO)RESTART=ALL or /(NO)RESTART=1 will restart (or stop) everything. The default is /RESTART or /RESTART=4. Restart (and stop) levels are defined as follows:

    4: Restart/stop top half of TCS and server processes for UIP

    3: Restart/stop status monitor processes

    2: Restart/stop bottom half of TCS and refresh/remove shared memory

    1: Refresh/remove TCS semaphores and mutexes

  – /SYNCHRONIZE
    If /NOSYNCHRONIZE is specified, no messages will be sent to the AOS backend computer. This will prevent the ANTENNA command from hanging when the AOS related processes are not running on the backend computer. The default is /SYNCHRONIZE.

  – /REBOOT: If specified, the antenna computer will be rebooted.

- **ANWAIT**
  `ANWAIT` causes the UIP to pause until the antenna computer has acquired the source it is trying to track. It is primarily of use in synchronizing command file (schedule) execution.

  If this command is executed interactively, it can be aborted via Ĉ. This is also true if the `ANWAIT` command appears in a DEFINEd macro, such as IAZ or IZA. Note that canceling `ANWAIT` in this manner will also force any other process to continue if it was waiting for the antenna to acquire the requested position.

• AOS

`AOS` allows you to change the integration time of the AOS backends, and to change certain other AOS parameters. It also informs the UIP that you will be observing in spectroscopy mode (as opposed to bolometer mode). Typing `AOS` without any parameters results in the current parameters being displayed. All parameters, except the baseline parameters, are sticky.

The `AOS` command also allows you to specify which AOSs are active and to position the three of the AOSs (all except the 1.5 GHz) within the 1 GHz IF bandpass.

- INTEGRATION_TIME
  This parameter specifies how long the AOS should integrate, in seconds. It may not be possible to integrate for precisely the time you request since the true integration time must be a multiple of the reticon readout time.
- W1L
  The low channel number for the first window of an optional baseline. This linear baseline only effects the AOS display, and the line integrals calculated by the `FIVE_POINT` routine. The data sent to the VMS machine are not affected. Note that four channels, specifying two windows, must be given for line windows to be activated.
- W1H: The high channel number for the first baseline window.
- W2L: The low channel number for the second baseline window.
- W2H: The high channel number for the second baseline window.
- /SECOND
  This qualifier tells the computer to modify or display the values for the second (50 MHz) AOS. It is synonymous with /50.
- /50
  This qualifier tells the computer to modify or display the values for the second (50 MHz) AOS. It is synonymous with /SECOND.
- /ON
  /ON specifies that the ON position scan should be sent to the VAX after an integration. /ON can be specified along with any of the other qualifiers below.
- /OFF
  /OFF specifies that the OFF position scan should be sent to the VAX after an integration. /OFF can be specified along with any of the other qualifiers.

- /DARK
  /DARK specifies that the DARK data should be sent to the VAX after an integration. /DARK can be specified along with any of the other qualifiers.
- /LOCK_IGNORE
  /LOCK_IGNORE tells the backend computer to ignore the LO lock signal sent to it by the antenna computer. This might be useful if you are locking the LO manually.
- /ACQUIRE_IGNORE
  /ACQUIRE_IGNORE tells the backend computer to ignore the acquired signal from the antenna computer.
- /IDLE_IGNORE
  /IDLE_IGNORE tells the backend computer to integrate if the antenna is idle. This is useful when you are running tests. The default action is to not integrate when the antenna is idle. You must use /IDLE_IGNORE to disable this.
- /AUTO_CALIBRATE
  /AUTO_CALIBRATE tells the backend computer to convert the (ON-OFF)/OFF scans to temperature units by using a calibration scan and an assumed hot load temperature. This calibration is enabled by default. /NOAUTO_CALIBRATE disables calibration. The ON and OFF scans are never calibrated.
- /DEBASE
  /DEBASE turns off the optional baseline feature. This baseline is the one that effects the AOS display and the `FIVE_POINT` routine. It has no effect on the data sent back to the VAX. The baseline is automatically erased when you change sources.
- /SHELF_LIFE_OF_CAL_SCAN
  /SHELF_LIFE_OF_CAL_SCAN, which can of course be abbreviated to something reasonable like /SHELF, specifies the length of time, in minutes, that a calibration scan should be considered valid. Once this time limit runs out, the backend computer will refuse to use the CAL scan. The default action of `OO_SCAN` is to check for the existence of a valid CAL scan, and to take one if none is available. A CAL scan will never be declared invalid while an OO_SCAN is being taken, but if you are taking AOS data via some set of commands other than OO_SCAN, the CAL scan may be declared illegal while you are taking a single scan, so this feature should be disabled. This feature may be disabled by giving a value of 0 for this qualifier, which corresponds to an infinite CAL

scan shelf-life. By default this feature is disabled.

- /SHUT_UP
  By default, the AOS will send a message to the VAX if integration is interrupted due to a phase lock drop-out, or the antenna going idle. These messages will be printed on the system console, and on any terminal enabled to receive operator messages. /SHUT_UP allows you to tell the backend computer to quit sending these messages.
- /FCAL_AUTO
  /FCAL_AUTO, which is the default, causes a frequency calibration scan to be taken any time the AOS CLIENT process is restarted, or an active backend computer is reloaded, or the `AOS /BANDWIDTH` qualifier is specified or a long slew occurs. This should only be disabled if the AOS hardware is broken, and the FCAL scans are all defective.
- /PRINT
  By default, the current AOS parameters are printed when the `AOS` command is executed. Specifying /NOPRINT suppresses these messages.
- /AOS1
  Specifying /AOS1 tells the system that the 1st 500 MHz AOS should be active.

  Specifying /AOS1=n tells the computer to configure the 1st 500 MHz AOS for an IF of n. The legal values are 1.2 - 1.5 GHz. 1.5 GHz corresponds to the center of the receivers' bandpass.
- /AOS2
  Specifying /AOS2 tells the system that the 50 MHz AOS should be active.

  Specifying /AOS2=n tells the computer to configure the 50 MHz AOS for an offset of n GHz relative to the 1st 500 MHz AOS. The legal range is -0.250 to +0.250, allowing you to park the 50 MHz AOS anywhere within the 1st 500 MHz AOS's bandpass.
- /AOS3
  Specifying /AOS3 tells the system that the 2nd 500 MHz AOS should be active.

  Specifying /AOS3=n tells the computer to configure the 2nd 500 MHz AOS for an IF of n. The legal values are 1.5 - 1.8 GHz. 1.5 GHz corresponds to the center of the receivers' bandpass.
- /AOS4
  Specifying /AOS4 tells the system that the 1.5 GHz AOS should

be active. Unlike the /AOS1, /AOS2 and /AOS3 qualifiers, this qualifier does not take a parameter, because the 1.5 GHz AOS cannot be moved within the IF bandpass.

– /DISPLAY
The DISPLAY qualifier allows you to redirect the real-time display produced by the backend computer, which displays the current integration. This qualifier must be given a value, and the legal values are PUUOO, ALPHA, VAX, HAPUNA or the IP number of an X11 server, followed by a colon and the display number (which is usually 0) - for example 128.171.85.10:0 .

  NEW FEATURE - specifying `/DISPLAY=VNC` tells the backend computer to use a virtual display server. You can have multiple windows for each AOS by starting viewer applications manually on any one of the UNIX and Windows computers on the summit. Default viewers should be running on puuoo. If not, single-click the AOS1, AOS2, AOS3 or AOS4 icon on the task bar.

– /DARK_DATA
Specifying `/DARK_DATA=nnn` tells all active backend computers to take nnn frames as "dark data" (a flat-field for the RETICON) after each integration. nnn must be a positive integer (zero is a valid value). If nnn is non-zero, the "dark data" will be scaled and subtracted from the "light data". Note that the RF power is not applied to the Bragg cell when "dark data" are collected, so the temperature of the Bragg cell may change enough to adversely affect the data. By default, 12 frames of "dark data" (about 0.27 seconds) are taken.

– /DEAD500
Now here's a kludge for you. This qualifier, when used with the /AOS1=xxx qualifier, tells the computer to issue all the commands required to offset the 500 MHz AOS #1, but not to actually activate that AOS. Why would anyone want to do that? Because the 50 MHz AOS rides along on the back of the 500 MHz AOS, and this command will allow you to shift the 50 MHz even if the 500 MHz AOS happens to be dead.

– /RESTART
/RESTART will kill all the active AOSs and then restart them. This is sometimes useful if the AOS processes in the backend computer have become messed up.

• ATLST

`ATLST` halts execution until the specified local sidereal time. It is used to control the execution of schedules.

- LST: in the format hh:mm:ss, or hhmmss. Unlike ATUT, cannot specify date.
- SLACK
  If the specified LST is earlier than the current LST, but not by more than SLACK minutes, execution continues without halting. For instance if ATLST 12:00:00 is executed at LST 12:05:00, and SLACK=60, then execution will continue. However if SLACK=1 in the example above, then execution would have halted until the next day. SLACK must be an integer. **NOT IMPLEMENTED**.
- /TTL: if specified, the TTL acquired signal will follow the status of the LST timeout. Otherwise it will follow the acquire status.

• ATUT

`ATUT` halts execution until the specified universal time. It is used to control the execution of schedules.

- UT
  The time in the format dd-mmm-yyyy:hh:mm:ss. The date part is optional. Valid UTs are 12-APR-1987:12:34:56, or 12:00:12, etc.

• AZ

This routine sends a new azimuth angle to the antenna computer. The command `AZ` automatically selects ALTAZ coordinates.

- AZ: the new azimuth angle to be sent to the antenna computer.

• AZO

This routine sends a new azimuth offset to the antenna computer. It should be used rather than directly setting the offset (via `TOANTENNA`), since it also updates the status information in the VAX, so that the correct offsets can be written into the scan header.

- OFFSET: The new azimuth offset in arc seconds.
- /FIXED: If specified, the fixed azimuth offset (FAZO) will be modified.
- /MAPPING: If specified, the mapping offset will be modified.
- /CHOPPING
  If /CHOPPING is specified, then the chopping azimuth offset (CAZO) will be modified. This offset is intended primarily for use in bolometer mode, and is used by `CHOP_SLEWY`. **NOTE THAT**

THIS OFFSET IS NOT RECORDED IN SPECTRAL LINE DATA FILES.

- /TEXAS
  If /TEXAS is specified, then the Texas switching mode is activated (that moves the telescope ON and OFF source based on a digital input signal to the antenna computer), and the offset is stored in the Texas switching offset.
- /ON_BEAM
  This will modify the chopping azimuth offset (CAZO) such that the ON beam is pointed toward the source. This is to be used in bolometer mode for SHARC/PHASE, SHARC gain scans and the like.
- /OFF_BEAM
  This will modify the chopping azimuth offset (CAZO) such that the OFF beam is pointed toward the source. This is to be used in bolometer mode for SHARC/PHASE, SHARC gain scans and the like.

• BEEP

This command causes the terminal to beep. That's it. Not every program can be an n-dimensional maximum entropy deconvolution. This command is useful in command files and macros (made via DEFINE).

The qualifiers on this command allow you to turn on and off the automatic beeps at the end of scans and at the completion of command file execution.

- COUNT: The number of times the terminal should beep.
- MESSAGE: The message you want typed out after the beep(s).
- /SCAN_BEEP: the control terminal will beep each time a scan is completed.
- /FILE_BEEP
  Specifying /FILE_BEEP will result in the control terminal beeping each time a command file being EXECUTEd finishes.
- /WARNING_BEEP
  Specifying /WARNING_BEEP will result in a warning beep being sent to the control terminal any time a scan is started when warning conditions are in effect.

• BEWAIT

`BEWAIT` causes the UIP to pause until the backend computer has finished its current integration. It is primarily of use in synchronizing command file (schedule) execution.

If this command is executed interactively, it can be aborted via ^C. This is also true if the `BEWAIT` command appears in a DEFINEd macro. Note that canceling `BEWAIT` in this manner will also force any other process to continue if it was waiting for an integration to complete.

- **BOLOMETER**

The `BOLOMETER` command allows you to change the bolometer setup. Parameters such as sample rate or integration time can be changed. This command also has the effect of telling the computer that you are going to observe with the bolometer, rather than the AOS or whatever, so it must be executed at least once.

Typing `BOLOMETER` with no parameters will result in the current bolometer parameters being typed on your terminal.

All bolometer parameters and qualifiers are sticky.

  - INT_TIME
    INT_TIME specifies the number of seconds to integrate per point. It must be an integer. This parameter has no effect on drift and On The Fly scans.
  - SAMPLE_TIME: milliseconds to wait between samples.
  - ARRAY_SIZE
    This parameter is the number of samples the backend computer will take before they are transferred back to the VAX. Valid values are integers from 1 to 8192. This parameter is only used for drift and On The Fly scans.
  - /PRIVATE_BACKEND
    /PRIVATE_BACKEND tells the computer that the CSO backend computer is not going to be used for data-taking. No commands will be sent to the CSO backend computer until a CSO backend is selected.
  - /DRIFT
    /DRIFT specifies that drift scans should be taken, rather that the default ON / OFF switching type of observing.
  - /OTF
    /OTF specifies On The Fly mapping will be taking place. OTF scans are identical from the backend computer's point of view, however using this qualifier causes extra information concerning the OTF scan direction and speed to be stored.

- /SCALE: the conversion constant for millivolts to pseudo-Janskys.
- /FREQUENCY
  The frequency at which the bolometer's response is centered. You may use /WAVELENGTH instead, if you wish. The units are GHz.
- /WAVELENGTH
  The wavelength at which the bolometer's response is centered. You may use /FREQUENCY instead, if you wish. The units are microns.
- /BEAM_SIZE
  The /BEAM_SIZE=x qualifier allows you to specify the size of the beam, which may differ from the telescope's diffraction limited beam size, depending upon the feedhorn used in the bolometer. The size should be specified in arc seconds.
- /LOCK_IGNORE
  /LOCK_IGNORE tells the backend computer to ignore the LO lock signal sent to it by the antenna computer. This might be useful if you are using the total power channel of a heterodyne receiver as a pseudo- bolometer, and are locking the LO manually.
- /ACQUIRE_IGNORE
  /ACQUIRE_IGNORE tells the backend computer to ignore the acquired signal from the antenna computer.
- /IDLE_IGNORE
  /IDLE_IGNORE tells the backend computer to integrate if the antenna is idle. This is useful when you are running tests. The default action is not to integrate when the antenna is idle. **THIS SHOULD NOT BE USED WHEN DRIFT OR ON THE FLY SCANS ARE BEING TAKEN.**
- /SHUT_UP
  /SHUT_UP allows you to tell the backend computer to quit sending certain messages.

• CALIBRATE

`CALIBRATE` tells the computer to take calibration data with the chopper. It has no effect at all unless you are observing in AOS spectrometer mode. Issuing this command results in a new (HOT-SKY)/SKY being taken, and by default it will be used to calibrate each spectrum before it is stored on disk. This default may be overridden by the /NOAUTO_CAL qualifier of the AOS command. Typing the `AOS` command with no parameters will show you the current settings relating to calibration spectra.

If the antenna is slewing, `CALIBRATE` will wait until the source is acquired before taking the hot load data. Otherwise the hot load data are taken while the antenna is moving to the off position to save time.

The `CALIBRATE` command can be aborted via ^C, if it is being executed interactively. The chopper will be moved out of the beam. If `CALIBRATE` is aborted in a subprocess, via `KILL`, the chopper hot load may be left in the beam.

- /INTEGRATION_TIME
  The integration time is the time, in seconds, that the AOS will integrate for both the HOT and SKY spectra. It does not affect the length of source integrations. The default is 5 seconds, and it is sticky.
- /HOT_TEMPERATURE
  If the AOS is AUTO_CALing the spectra, which is done by default, the individual scans will be divided by (HOT-SKY)/SKY and multiplied by this temperature. The default is 560.0 which corresponds to a hot load temperature of 280.0 K with a double sideband receiver.
- /OFFSET
  This qualifier allows you to specify how many arc seconds to step off the source before taking the calibration scan. The default is 300 arc seconds.
- /COORDINATE
  This qualifier allows you to specify the coordinate direction in which to step off the source. The legal values are AZO, ZAO, RAO, DECO, GLO and GBO. The default is AZO.
- /SAVE_SCANS
  Specifying /SAVE_SCANS will cause the calibration scans to be stored in the data file. This is the default action.
- /MOVE_OFF
  Specifying /NOMOVE_OFF indicates that the telescope is already OFF the source. This qualifier can not be used with /OFFSET, /COORDINATE, or /DESIGNATED_OFF. (It is used internally by `OTF_MAP`.)
- /STAY_OFF
  When the calibration scan is taken, the antenna must move off source, to avoid getting source features in the calibration scan. By default, the antenna will be moved back on source at the end of the calibration. Sometimes that is not what you want. And

here at the CSO we think the observer is king. So specifying /STAY_OFF will keep the antenna at the off source position.

- /FREQUENCY_CALIBRATION
  Specifying /FREQUENCY_CALIBRATION will cause a frequency calibration comb to be taken instead of a temperature calibration.
- /ATTENUATOR
  This qualifier, which is selected by default, causes the backend computer to adjust the AOS's programmable attenuator in order to prevent saturation of the analog to digital converter. For frequency calibrations (`CALIBRATE/FREQUENCY`), the attenuator will **ALWAYS** be auto-adjusted before data are taken. If /NOATTENUATOR is not specified, the programmable attenuator will be adjusted after a frequency calibration.
- /3DB
  Specifying /3DB causes the current programmable attenuator setting to be incremented by 3 before the hot load is inserted. This new value remains in place until the calibration scan is completed, at which time the attenuator is returned to its original state.
- /DESIGNATED_OFF
  The /DESIGNATED_OFF qualifier tells `CALIBRATE` to search the open source catalogs for a designated off position for the object being observed. Such off positions must have the source's name, and a qualifier of OFFPOSITION. The `VERIFY` command will show you any available off position for a given source.
- /IN_BLADE
  If /IN_BLADE is specified, then the only action taken is to move the calibration blade into the beam. No data are taken.
- /OUT_BLADE
  If /OUT_BLADE is specified, then the only action taken is to remove the calibration blade from the beam. No data are taken.
- /SPIN_BLADE
  If /SPIN_BLADE is specified, then the only action taken is to spin the calibration blade. No data are taken. /NOSPIN_BLADE or /STOP_BLADE will stop the blade.
- /STOP_BLADE
  If /STOP_BLADE is specified, then then the only action taken is to stop the calibration blade. No data are taken.
- /MANUAL
  If /MANUAL is specified, no commands will be sent to the chop-

per wheel. Instead, the user will be prompted to insert and remove the hot load himself. This qualifier is sticky.

- /OTF
  This qualifier is not really useful for interactive use. It is used internally by `OTF_MAP`, to keep the OTF map grid from being erased when a temperature calibration scan is taken.

• CATALOG

`CATALOG` opens (or closes) a file for use as a source catalog. As many as 10 catalogs may be open at once, and they are searched in the order opposite the order in which the were opened. The catalog `CAT_DIR:DEFAULT_CATALOG.CAT` is always open, and is searched last. In addition, each user automatically has a private catalog into which new sources will be entered by default (`SYS$LOGIN:PRIVATE_CATALOG.CAT`).

The `CATALOG` command can also be used to make a new catalog file. Entering `CATALOG` without any parameters results in the listing of all the currently open catalogs. Entries can be inserted into the most recently opened catalog using the `SOURCE` command. They may be removed using the `FORGET` command.

If you do not specify the directory in which the catalog resides, the program will search for the catalog by searching first the default directory, then `SYS$LOGIN`, and finally `CAT_DIR`. If no file extension is given, .CAT is assumed.

- FILE_NAME: the name of the catalog.
- /CLOSE: Closes the last catalog file opened.
- /LINE: a line catalog is to be opened, closed or displayed.

• CELES

`CELES` tells the antenna computer to switch to celestial pointing mode. The most recently supplied RA and DEC positions will be used.

• CHICAGO

The `CHICAGO` command enables the Chicago array bolometer to control the telescope position by switching between two azimuth offset positions according to pulses received at analog inputs 3 and 4. Positive-going pulse of at least 20 ms at input 3 will cause the antenna to move to the offset AZOFF1, while a similar pulse at input 4 will cause a move to AZOFF2.

- AZOFF1: the first azimuth offset position, in arc seconds.
- AZOFF2: the second azimuth offset position, in arc seconds.

- /STOP: disables the Chicago control of position switching.
- /DESIGNATED_OFF
  This qualifier was put in for the Texans. Specifying it sends the designated OFF offset to the antenna computer. The antenna computer will also be instructed to switch to these offsets if digital input #1 on the CIC is TTL low. If the input is TTL high, the offsets will be removed. Thus designated OFF switching can be controlled by a TTL line.
- /AZ
  This qualifier was put in for the Texans. Specifying it sends parameter 1 to the antenna computer, for an AZ offset. The antenna computer will also be instructed to switch to these offsets if digital input #1 on the CIC is TTL low. If the input is TTL high, the offsets will be removed. Thus designated OFF switching can be controlled by a TTL line.

- ## CHOP_SLEWY

`CHOP_SLEWY` is the data taking command for observing with the chopping secondary. `CHOP_SLEWY` commands the antenna and backend computers to take on-off data in one of three patterns: by default, it performs a symmetric set of measurements with the pattern + - - + ... + - - +. Using the /ASYMMETRIC qualifier, you can get + + (/ON_BEAM, default) or - - (/OFF_BEAM).

- CYCLES
  The basic CHOP_SLEWY pattern is + - - +. This parameter controls how many times this pattern is repeated.
- /CALIBRATE_AT_START
  If /CALIBRATE_AT_START is given, then a calibration scan will be taken before taking any source data. The default action is to calibrate at the start only if no valid calibrator scan is already available. If a designated off position has been given, it will also be used for the calibration scan.
- /FOCUS_ADJUST
  /FOCUS_ADJUST is the default behavior of CHOP_SLEWY, and it tells the antenna to adjust the focus after each cycle. You can disable this feature with /NOFOCUS_ADJUST.
- /LO_ADJUST
  /LO_ADJUST is the default behavior of CHOP_SLEWY, and it tells the antenna to adjust the LO after each cycle. You can disable this feature with /NOLO_ADJUST. This qualifier obviously

only matters when you are observing with one of the heterodyne receivers.

- /ATTENUATOR_ADJUST
  By default, if the backend is an AOS, then the programmable attenuator is automatically adjusted at the beginning of a scan. /NOATTENUATOR_ADJUST prevents that adjustment from occurring.
- /ASYMMETRIC
  The /ASYMMETRIC qualifier commands CHOP_SLEWY to take data using a + + or - - motion on the sky. By default, + + is used unless the /OFF_BEAM qualifier is specified.
- /ON_BEAM
  This specifies that the CHOP_SLEWY motion will be + +, which is the default; this qualifier only works in /ASYMMETRIC mode.
- /OFF_BEAM
  This specifies that the CHOP_SLEWY motion will be - - rather than + +; this qualifier only works in /ASYMMETRIC mode.

• CLOCK

`CLOCK` allows you to specify which observatory clock should be used as the time standard. The current choices are WWV and GPS. Note that the `CLOCK` command only selects the standard to use - it does not itself reset the time in any computer. To actually reset the time based on the chosen standard, you should use the `FIX_TIME` command. Issuing this command without any parameter will cause the computer to report which clock is currently being used.

- NAME
  The name of the clock to use. The only accepted values are WWV and GPS. Abbreviations are not allowed.

• DATA_FILE

`DATA_FILE` opens a data file into which the scans will be written. It can open a spectrometer file (SPA or IRAM format), a bolometer file, a SHARC file or an FTS file. Before executing this command you must give an `AOS, BOLOMETER, SHARC` or `FTS` command to let the VAX know what type of file to create. If a file with the specified name exists, it is reopened otherwise a new file is created. Scan numbers for SPA format files should be in the range 1001-31999.

- FILE_NAME: the name of the new file.
- FIRST_SCAN: the number of the first scan in the file.

- FIRST_OBS: the number of the first observation (default = 1).
- /ARCHIVE
  /ARCHIVE (the default behavior) causes the data to be written to the observatory's SYBASE database. If you specify /NOARCHIVE the data will only be written to your private data file. Observers should not specify /NOARCHIVE - it is intended to be used only when engineering scans are being taken.
- /SIDEBAND_CALIBRATE
  If /SIDEBAND_CALIBRATE is specified (it is the default), the sideband calibration correction will be written into the scan headers if you are taking data in CLASS format. This correction does not correct for the receiver's sideband ratio, but rather for the error introduced by using a calibration scan that was taken in both sidebands at once. If /SIDEBAND_CALIBRATE is used, there will be a delay of a few seconds before the first scan is stored, and every time the observing frequency changes by a substantial amount. Data for calculating the correction is being cashed during this time. /NOSIDEBAND_CALIBRATE allows you to avoid this short delay.

• DB

`DB` sets the attenuator in the currently active backend to a new value. This command currently only works with the AOS backend, and only when manual attenuation is disabled on the front panel.

- DB
  An number specifying how many db to insert. Valid values are integers between 0 and 31 for AOS1, AOS2 and AOS3, and floating-point values between 0.0 and 47.625 for AOS4.
- /ADD
  Specifying /ADD causes the parameter DB to be added to the current attenuation.
- /SUBTRACT
  Specifying /SUBTRACT causes the parameter DB to be subtracted from the current attenuation.
- /AOS1
  Specifying /AOS1 causes the attenuator in the first wideband AOS (the first 500 MHz AOS) to be set, regardless of which AOS is currently active.
- /AOS2
  Specifying /AOS2 causes the attenuator in the high resolution

AOS (the 50 MHz AOS) to be set, regardless of which AOS is currently active.

- /AOS3
  Specifying /AOS3 causes the attenuator in the second wideband AOS (the second 500 MHz AOS) to be set, regardless of which AOS is currently active.
- /AOS4
  Specifying /AOS4 causes the attenuator in the ultra wideband AOS (the 1.5 GHz AOS) to be set, regardless of which AOS is currently active.
- /FIRST: same as the /AOS1 and /500.
- /SECOND: same as the /AOS2 and /50.
- /THIRD: same as the /AOS3.
- /FOURTH: same as the /AOS4.
- /500: same as the /AOS1 and /FIRST.
- /50: same as the /AOS2 and /SECOND.
- /QUERY: current attenuator settings will be printed on the terminal.

• DCL

`DCL` is a completely unnecessary command. If you type DCL with no parameters, the effect is exactly the same as typing a $, a sub-process will be spawned. If you type `DCL` with one or more parameters, the effect will be exactly as if you typed those parameters by themselves. Why does this command exist? It exists to provide compatibility with CLASS, GREG and GILDAS which use the command `DCL` to access the VMS command line interpreter.

• DEBUG

DEBUG turns on certain debugging features that will be of very little use to observers.

- /NAME_CHANGE: tells the UIP to change its name to reflect what command is executing.
- /VERBOSE: turns verbose debugging statements on.
- /ALL_OFF: turns off all debugging features.

• DEC2

This routine sends a new declination position to the antenna computer. The command `DEC2` automatically selects CELES coordinates.

- DEC: the new declination position to be sent.
- PM_DEC: the new proper motion in declination.
- EPOCH: the date for which the declination is accurate, e.g. 2000.0.

- **DECLINATION**
  This routine sends a new declination position to the antenna computer. The command `DECLINATION` automatically selects CELES coordinates.
  - DEC: the new declination position to be sent.
  - EPOCH: the date for which the declination is accurate, e.g. 1950.0.

- **DECO**
  This routine sends a new declination offset to the antenna computer. It should be used rather than directly setting the offset (via `TOANTENNA`), since it also updates the status information in the VAX, so that the correct offsets can be written into the scan header.
  - OFFSET: the new declination offset in arc seconds.
  - /MAPPING: If specified, the mapping offset will be modified.
  - /FIELD: If specified, the field offset will be modified.
  - /TEXAS
    If /TEXAS is specified, then the Texas switching mode is activated (that moves the telescope ON and OFF source based on a digital input signal to the antenna computer), and the offset is stored in the Texas switching offset.

- **DEFINE**
  This routine allows you to add a command to the UIP defined in terms of other known UIP commands. When `DEFINE` is invoked you are thrown into the VMS editor where you can type in lines of `UIP` commands (including other commands added with `DEFINE`). After you exit the editor, the lines will be read and the command will be added. Some simple error checking is done, and if an error is found, it will be reported and you will be returned to the editor where corrections may be made.

  `DEFINE` cannot be executed in a command file, but it can be executed in files being INTERPRETed. Adding DEFINE commands to `SYS$LOGIN:UIP.INI` will result in your private commands being added each time you run the `UIP`. In files being INTERPRETed, the following format is used:
  `DEFINE northstow`

```
AZ 0
ZA 0
END_DEFINE
```

the above line adds the new command `northstow`.

At execution time any words typed after the name of the DEFINEd word will be equivalenced to symbols p1, p2, etc. Inside the DEFINEd word these symbols may be accessed through the use of curly braces.

- NAME
  The name of the new command. Must be less than 80 characters. This parameter must be specified unless you are using the /LIST qualifier. Go ahead, redefine existing commands, create infinite loops, see if I care.
- /LIST
  /LIST causes to command specified to be listed on the terminal. If no NAME is given, all definitions will be listed by name only.
- /EDIT
  /EDIT puts you in the VMS editor with a copy of the command definition. Upon exiting the editor, the command will be redefined using the modified text.
- /FORGET: tells the `UIP` to remove the specified command.

- ## DOPSET

`DOPSET` runs the dopset program and sends the results to your terminal. It is included as a UIP command just for convenience, so that you (yes YOU) don't have to remember or look up the screwy format the dopset program requires. It can read parameters from both line and source catalogs, so you may run this command for different objects and lines than you are observing at. Note that dopset doesn't have provisions for accepting proper motion, so the source position it calculates may not agree with the position calculated by the antenna computer.

- NAME
  The name of the object. Must be less than or equal to 20 characters, but can also have a (upto) 20 character qualifier separated by a backslash '\'.
- LINE
  This is the name of the line in the line catalog. If not given you must explicitly give the frequency, multiplier and sideband using the qualifiers.

- /FREQUENCY
  This is the lab frequency of your line, for instance 230.538 GHz for the CO J=2-1 line. If given it overrides any frequency from the line catalog.
- /VELOCITY
  Doppler shift velocity from LSR in km/sec, if any. If given it overrides the velocity given in the source catalog.
- /MULTIPLIER
  An integer specifying which harmonic of the Gunn oscillator's frequency is used as the LO. If given it will override any multiplier obtained from the line catalog.
- /FIRST_IF
  The frequency in MHz of the first IF. If not given, the current IF for the observatory is used.
- /UPPER
  This qualifier specifies that the UPPER sideband will be used. It overrides the default sideband in the line catalog.
- /LOWER
  This qualifier specifies that the LOWER sideband will be used. It overrides the default sideband in the line catalog.
- /RANGE
  The number of hours on each side of the source's transit for which the calculation should be performed. If not specified, only the values for transit will be calculated.
- /INCREMENT
  If an hour angle RANGE is specified, then you may also specify an increment. This increment is the number of minutes to skip between calculations.
- /UTDAY
  If you wish the calculation to be done for some day other than today, the UTDAY parameter must be given. It also must be given if the antenna computer is down.
- /PRINT
  If /PRINT is specified, the output is sent to the laser printer rather than your terminal.

• DRIFT_SCAN

`DRIFT_SCAN` performs drift scans. In this observing mode, the telescope azimuth and altitude are fixed wrt the local horizontal coordinates of date. Celestial objects thus *drift* across the telescope beam by the Earth rotation, and result in scans along a constant apparent right ascension at the sidereal rate. This command is primarily intended for BOLOCAM and SHARC II.

- SCAN_LENGTH
  SCAN_LENGTH specifies the length of each scan in seconds of arc. This must be a non-negative number.
- NUMBER_OF_SCANS
  NUMBER_OF_SCANS specifies the total number of scans to be taken. This must be a positive number. The default is 1.
- /STEP_SIZE
  /STEP_SIZE=XXX specifies the separation in apparent declination, in seconds of arc, between two adjacent scans. The default is 0, i.e., all scans (amount specified by NUMBER_OF_SCANS) will be repeated at the same apparent declination.
- /OFFSET
  Initial scan offsets in seconds of arc. Both the offset in apparent right ascension (i.e., the offset along the scan direction) and the offset in apparent declination, or only the apparent right ascension offset can be specified as /OFFSET=(XXX,YYY), or as /OFFSET=XXX, respectively. The first scan will be taken from (XXX", YYY") off the source. The default for the apparent right ascension offset is (- SCAN_LENGTH / 2) and the default for the apparent declination offset is

  - STEP_SIZE x (NUMBER_OF_SCANS - 1) / 2.
- /SETTLING_TIME
  /SETTLING_TIME=XXX specifies the settling time in seconds, which is equivalent to the ramp up time for OTF_MAP. The default is 10 seconds.
- /FOCUS_ADJUST
  If /NOFOCUS_ADJUST is specified, XRASTER_SCAN will not adjust the secondary mirror focus position. By default, the secondary mirror focus is adjusted at the beginning of each scan.
- /ROTATOR_ADJUST
  If /NOROTATOR_ADJUST is specified, XRASTER_SCAN will not adjust the instrument rotator position. By default, the instrument rotator is adjusted at the beginning of each scan based on the parallactic angle.
- /CANCEL: cancel DRIFT_SCAN.

- **EL**
This routine sends a new elevation angle to the antenna computer. The command `EL` automatically selects ALTAZ coordinates.
  - EL: the new elevation angle to be sent.

- **ELO**
This routine sends a new elevation angle offset to the antenna computer. It should be used rather than directly setting the offset (via `TOANTENNA`), since it also updates the status information in the VAX, so that the correct offsets can be written into the scan header.
  - OFFSET: the new elevation angle offset in arc seconds.
  - /FIXED: If specified, the fixed zenith angle offset (FZAO) will be modified.
  - /MAPPING: If specified, then the mapping offset will be modified.

- **EXECUTE**
This routine executes a command file. A sub-process running the UIP program is spawned, and it takes its commands from the specified file.
  - FILE
    The name of the VMS text file that contains the commands to be executed. If a dollar sign precedes the file name, the directory pointed to by the logical name `CANONICAL` will be searched for the file.
  - REPEAT_COUNT: the number of times the file should be executed.
  - ABORT_TIME
    ABORT_TIME specifies a time at which the execution of the command file should be halted, if it has not already terminated. By default the time is assumed to be LST, but UT can be specified using the /UT qualifier.
  - /WAIT
    If this qualifier is specified, the parent process will wait until the child process terminates before continuing execution. If /WAIT is not specified, the two processes will execute in parallel.
  - /UT
    /UT tells the program that the time specified as the ABORT_TIME is UT, the default interpretation is LST. UT must be specified in the clumsy VMS time specification, in quotes. For example: `--`

20:30:10 would specify 20:30:10 UT today. See VMS help under HELP SPECIFY DATE for more information.

- **EXIT**

  EXIT stops execution of the UIP program and exits to DCL level or parent process. Any sub-processes, either detached or running a command file, will be killed.

  - STATUS: value to be passed to the next higher level. By convention odd values indicate success, even values indicate failure.

- **FAST_TRACK**

  FAST_TRACK allows you to examine and modify the variables used in the FAST_TRACK scan mode. In the FAST_TRACK scan mode, the antenna is told to track at some multiple of the sidereal rate. Data are then taken as if a drift scan had been requested. This allows scanning a source in constant declination strips at a faster rate than would be possible with drift scans. Scans are initiated with the command TAKE_DATA /FAST_TRACK (or just TAKE /FAST).

  Typing this command with no parameters will result in the current parameter values being typed on the terminal.

  - SPEEDUP
    This multiple of the sidereal rate will be added to the LST. A speedup factor of 0 results in the normal tracking rate. If you want to scan over the source at 5 times the sidereal rate, you can use a speedup factor of 5 (for an east to west scan) or -5 (for a west to east scan). A speedup factor of -1 will freeze the antenna's position, and allow the sky to drift by.
  - LENGTH
    The length of the scan, in arc seconds. Once the antenna has moved by this amount from the position at which the scan started, the antenna will revert to the normal sidereal rate, and re-acquire the initial position.

- **FIVE_POINT**

  FIVE_POINT will help you check the pointing on a strong line or continuum source. It will command the antenna to the source's nominal position, and to four surrounding positions in the AZ and ZA directions. Data will be taken at each position, and the line will be integrated. Finally, the integrated line strengths will be displayed, along with new suggested pointing offsets.

You must supply an offset step size and a line half-width over which to integrate. The width must be given in channels. Here is an example:

`FIVE_POINT 30 25` ! Step around by 30 arcsecond steps

The individual integrations are performed by the `OO_SCAN` command, so you should set up sensible OO_SCAN parameters before executing `FIVE_POINT`. In chopping mode, `FIVE_POINT` uses `CHOP_SLEWY`. In heterodyne chopping mode, `FIVE_POINT` will measure the throw also.

A linear baseline can be removed in the backend computer prior to calculating the line integral. The `AOS` command allows you to set the windows for this baseline. `FIVE_POINT` requires pretty good baselines to give good results.

The corrections are calculated in one of two ways. In most cases, fitting a three parameter Gaussian is appropriate (one for AZ and one for ZA). In this case, for ZA

$$\Delta\mathrm{ZA} = \frac{-\mathrm{offset} * [ln(\mathrm{plus\_flux}) - ln(\mathrm{minus\_flux})]}{2 * [ln(\mathrm{plus\_flux}) - 2ln(\mathrm{middle\_flux}) + ln(\mathrm{minus\_flux})]}$$

where plus_flux, minus_flux and middle_flux are the measurements from positive, negative and zero offset points respectively.

If /NOGAUSS is selected, then a more conservative, centroiding calculation is used to calculate the offsets. The formula in this case is

$$\Delta\mathrm{ZA} = \frac{\mathrm{offset} * (\mathrm{plus\_flux} - \mathrm{minus\_flux})}{\mathrm{plus\_flux} + \mathrm{middle\_flux} + \mathrm{minus\_flux}}$$

This approach is useful if for some reason the receiver is giving fluxes with both positive and (significant) negative values, because a Gaussian is never negative.

Gaussian fitting is the default. With either type of fitting, the routine will refuse, politely, to suggest any pointing corrections unless the center position is the strongest.

The results will be logged in a file PNT_DIR:<yymmmdd>.<pointing_setup> together with the pointing constants, T terms, refraction and weather parameters in use. The first two lines of the pointing log follow the format required by the OVRO pointing program, they basically contain some parameters required for fitting pointing constants; the third line logs the T term coefficients in use; after that there are 3 lines for each `FIVE_POINT` executed:
1: source name, time, day of year, AZ, ZA, offset in AZ, offset in ZA
2: pointing constants C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11

3: old FAZO, old FZAO, TAZO, TZAO, temperature, barometric pressure, humidity, refraction, tau_225

- OFFSET: the size of the steps to be taken, in arc seconds.
- HALF_WIDTH
  The number of channels, on either side of the center channel, over which integration should be performed. If this parameter is not specified, then integration will take place over all the channels between the high limit of the low baseline window and the low limit of the high baseline window. For instance if you specified the baseline windows by issuing the command
  `AOS 10 400 500 520 620`
  and you did not pass a second parameter to `FIVE_POINT`, then channels 501 through 519 will be summed to produce the line integral.

  If no baseline window has been given, then a warning will be printed, and ALL channels will be summed to form the integral.
- FILE_NAME
  The name of an optional file into which the final tweaked up values can be written. The format of this file is the same as the format for files produced by `JOY_STICK`, except that the word 'RADIO' is written in the first line instead of 'OPTICAL'.
- /AOS
  This qualifier allows you to specify which AOS is to be used for pointing (only one can be used at a time). By default, the lowest numbered active AOS is used. Specifying /AOS=2 results in the 50 MHz AOS being used. /AOS=3 tells the UIP to use the 2nd 500 MHz AOS.
- /CENTER
  This qualifier, which requires a value, allows you to tell the backend computer to center the integration over a specific channel.

  By default, the integration is centered on the center channel found when the last frequency calibration scan (FCAL) was processed. If no information is available from an FCAL, a warning message will be issued, and channel 512 will be used.
- /ONE_OFF
  If /ONE_OFF is specified, then only one OO_SCAN will be executed, for the first point. The other four ON points will use the OFF position data taken by the initial OO_SCAN. This procedure will save something like a factor of 2 in time, at the expense of poorer baselines.

If you decide to use this option, use the AOS command to specify the total integration time, and set up OO_SCAN as usual. The `OO_SCAN` will be executed as if you had entered
`OO_SCAN 1 /ASYMMETRIC/REVERSE/NOALTERNATE`
However these parameters will not change the sticky OO_SCAN parameters.

- /SAVE_SCANS
  Specifying /SAVE_SCANS will cause all five scans taken to be stored in the current data file. You do not really want them, do you? /SAVE_SCANS=CENTER tells `FIVE_POINT` to just save the central position scan, the other four will be chucked.
- /QUERY
  If /QUERY is specified, you will be asked if you want the calculated FAZO and FZAO to be sent to the antenna computer. /QUERY is selected by default.
- /STUFF_IT
  Specifying /STUFF_IT will cause the newly calculated FAZO and FZAO to be sent to the antenna computer. You will probably regret it in the morning.
- /CYCLES
  /CYCLES is used in bolometer mode observing, to specify how many CHOP_SLEWY cycles should be executed.
- /GAUSS
  /GAUSS finds the offset by fitting a Gaussian function to the fluxes. The Gaussian is fitted to the absolute values of the fluxes, since a Gaussian can never give a negative value. If your receiver somehow gives negative readings which are significant, do not use this qualifier. /GAUSS is selected by default.

- **FIX_TIME**
  This routine resets the time in either the antenna computer (default) or the VAX should it become corrupted. `FIX_TIME` does this by reading the active observatory time standard (either the WWV or GPS clock).

  - /VAX: If specified, the time in the VAX is reset instead, antenna computer's time is fixed.

- **FLSIGNAL**
  `FLSIGNAL` - preset/set/reset TTL flags.

- **FLWAIT**
  FLWAIT - wait for TTL flags.

• FOCUS

The FOCUS command allows the user to control the focusing of the secondary mirror. One can set the mirror at a fixed point, or enable auto-focusing via a focus curve. If auto-focusing is chosen, an offset may be applied, and the timing of the focus changes may be controlled.

If FOCUS is entered without any parameters or qualifiers, and if the antenna is in STEALTHY mode, the antenna will be instructed to adjust the focus and Y tilt based on its pointing curve. Note that this is done automatically at the beginning of an OO_SCAN, OBSERVE or PLANET command.

- POSITION
  If this optional parameter is specified, it will be sent to the antenna computer and used as a fixed focus position. The antenna computer will not update the position.
- /OFFSET
  This qualifier allows you to specify a fixed offset which will be added to the value from the focus curve when the antenna computer updates the secondary position.
- /CONSTANT_UPDATES
  Specifying CONSTANT_UPDATES tells the antenna computer to update the position of the secondary whenever the position should be changed. In this mode, the secondary might be moved when an integration is taking place.
- /STEALTHY_UPDATES
  This qualifier tells the antenna computer to update the position of the secondary only when data is not being taken, so that during a given integration the focus will be constant.
- /SET_OFFSET
  This qualifier, which should be used alone, is used to calculate the offset which should be applied to the focus curve. First one should find the best focus position, using the FOCUS command to send the secondary to specific positions. Then when the focus is good, invoke FOCUS with this qualifier, and the offset will be calculated. Then invoke FOCUS with either the /STEALTHY_UPDATES or the /CONSTANT_UPDATES qualifier to tell the antenna to use the focus curve.
- /POINTING_UPDATE
  This qualifier, which is not selected by default, tells the computer to adjust the TAZO and TZAO to where they should be at the

present zenith angle. Not that when the antenna is in /CONSTANT_UPDATES or /STEALTHY_UPDATES mode, these constants will be updated automatically every time the focus position is changed.

- ## FORGET

  `FORGET` removes an entry from either the spectral line catalog or the source catalog.

  - NAME
    The name of the object. Must be less than or equal to 20 characters, but can also have a 20 character qualifier separated by a backslash ''
  - /LINE
    Specifying /LINE tells the program that the NAME parameter refers to a spectral line, not a source.
  - /CATALOG
    The number of the catalog from which the entry should be removed. Use the `CATALOG` command to find out what number corresponds to the catalog of interest. If this qualifier is not specified, then the entire list of catalogs will be searched, in numerical order, until the first occurrence of the name is found. The search terminates after that entry is deleted.
  - /QUIET
    If /QUIET is not specified, the catalog in which the object was found will be reported.

- ## FSWITCH

  `FSWITCH` takes a frequency switched scan. The actual frequency change takes place in the RF downconverter (in the backend room).

  This command is just now being implemented - check with the CSO staff before you use this command.

  - SEPARATION
    This parameter specifies the size of the frequency step used in frequency switching. The two line images will be separated by this amount, symmetrically offset from 0. Note that the units are GHz! This is not the most convenient unit, of course, but ALL frequency units in the `UIP` are specified in GHz, to make things easier to remember.
  - RATE
    This parameter specifies the rate, in Hz, at which the frequency

should be switched. Note that the rate you specify will not necessarily be the rate you will get; the rate will be modified to correspond to an even integral number of AOS readout frames per cycle.

- /BANDPASS
  This qualifier tells the AOS processes that the current scan should be used as a bandpass calibrator.
- /FOCUS_ADJUST
  /FOCUS_ADJUST is the default behavior of `FSWITCH`, and it tells the antenna to adjust the focus after each cycle. You can disable this feature with /NOFOCUS_ADJUST.
- /LO_ADJUST
  /LO_ADJUST is the default behavior of `FSWITCH`, and it tells the antenna to adjust the LO before taking data. You can disable this feature with /NOLO_ADJUST.
- /ATTEN_ADJUST
  /ATTEN_ADJUST is the default behavior of `FSWITCH`, and it tells the antenna to adjust the programmable attenuator before taking data. You can disable this feature with /NOATTEN_ADJUST.
- /KM_SEC
  If this qualifier is specified, then the units of the SEPARATION parameter are taken to be km/sec, rather than GHz.

• FTS

The FTS command tells the system that you will be taking data with the FTS spectrometer either for spectroscopy or holography.

- /HOLOGRAPHY: signals that you will be taking holography data.
- /LOAD_MICROS: Obsolete.

• GB

The command sends a new Galactic latitude to the antenna computer.

- LATITUDE: The new Galactic latitude ([-]ddmmss.s).

• GBO

This routine, along with GLO, allows you to step off your source position in galactic coordinates. GL and GB commands can be used to send the telescope to a position in absolute galactic coordinates. The /GALACTIC qualifier of the `SOURCE` command does allow you to enter sources using galactic coordinates, but they are converted to equatorial coordinates before being sent to the telescope.

***** CAUTION ***** These offsets are not very accurate. They should not be used for offsets greater than about 10 arc minutes if exact positioning is required. Do **NOT** go mapping all around the galactic plane with these (l and b) offsets. Use RAO and DECO instead.

- OFFSET: The new galactic latitude offset in arc seconds.
- /MAPPING: If specified, the mapping offset will be modified.

- **GL**

The command sends a new Galactic longitude to the antenna computer.

- LONGITUDE: the new Galactic longitude (dddmmss.s).

- **GLO**

This routine, along with `GBO`, allows you to step off your source position in galactic coordinates. `GL` and `GB` commands can be used to send the telescope to a position in absolute galactic coordinates. The /GALACTIC qualifier of the `SOURCE` command does allow you to enter sources using galactic coordinates, but they are converted to equatorial coordinates before being sent to the telescope.

***** CAUTION ***** These offsets are not very accurate. They should not be used for offsets greater than about 10 arc minutes if exact positioning is required. Do **NOT** go mapping all around the galactic plane with these (l and b) offsets. Use RAO and DECO instead.

- OFFSET: the new galactic longitude offset in arc seconds.
- /MAPPING: If specified, the mapping offset will be modified.

- **GOTO_S**

`GOTO_S` performs an unconditional jump within a schedule. It has the form

`GOTO label`
where label is a line containing only a label. Labels are just words and they must be preceded by an underscore on the labeled line.

- LABEL: the label to branch to.

- **GUIDE_STAR_CAT**

The `GUIDE_STAR_CAT` command is used to enter the coordinates and velocity as well as visual magnitude and proper motion to the guide_star catalog. (Last adapted from source.pas on August 22, 1998)

The usage is almost the same as `SOURCE` command, except that it accepts an additional parameter, vmag, for star's visual magnitude. And it does not search for a tracking star to match each entry, but use itself as guiding star instead. This command is therefore not aimed for general observers, but specifically for those who maintain CSO's optical pointing star catalogs. One other minor difference to the `SOURCE` command is that the new entries are written into the last opened catalog, rather than the user's private catalog. So the right procedure to update/create a optical star catalog is to open the desired catalog upon invoking `UIP`, execute the UIP command script which repeat the `GUIDE_STAR_CAT` command for each new star.
Syntax

```
GUIDE_STAR_CAT [ qualifiers ] NAME RA DECLINATION
    VELOCITY PM_RA PM_DEC EPOCH VMAG
```

- NAME
  The name of the source. An optional qualifier can be added following the backslash character '∖' The name and qualifier can each be as long as 20 characters.
- RA
  The right ascension of the source in the form hhmmss.sss, or the Galactic longitude in the form of dddmmss.ss if the /GALACTIC qualifier is specified.
- DECLINATION
  The declination of the source in the form [-]ddmmss.ss, or the Galactic latitude in the form of [-]ddmmss.ss if the /GALACTIC qualifier is specified.
- VELOCITY
  The radial velocity of the source. Can be specified as LSR velocity, (km/sec), heliocentric velocity (km/sec), or red shift. LSR velocity is the default. See also the qualifiers /LSR, /HELIOCENTRIC, and /Z for details.
- PM_RA
  The proper motion in right ascension of the source (sec/year). If the original value is expressed in unit of arcsec/year, you probably need to convert it as follows:

$$\text{PM\_RA}[sec/yr] = \frac{15}{cos(DEC)}\text{PM\_RA}[arcsec/yr].$$

  Do not enter non-zero value with the /GALACTIC qualifier.

- PM_DEC
  The proper motion in declination of the source (arcsec/year). Do not enter non-zero value with the /GALACTIC qualifier.
- EPOCH
  The epoch of the source coordinates. For the equatorial coordinates, the standard epoch is either 1950.0 (B1950.0) or 2000.0 (J2000.0). When none of the equatorial coordinates qualifiers (/OLD_EQUATORIAL, /NEW_EQUATORIAL) is specified, the coordinates system is defaulted as follows:

Epoch	Coordinates
2000.0	FK5 system at J2000.0
1950.0	FK4 system at B1950.0
default	FK4 system at B1950.0
others	Not allowed (ambiguous)

  See the qualifiers /OLD_EQUATORIAL and /NEW_EQUATORIAL for details. For the Galactic coordinates, see the qualifier /GALACTIC.
- VMAG: Visual magnitude of the source (mag).
- /CATALOG
  The source catalog number into which the entry should be placed. Use the `CATALOG` command to find out what number corresponds to the catalog of interest. If this qualifier is not specified, the entry will be placed in the last opened catalog.
- /COMPAT
  Specifying /COMPAT indicates that input coordinates should be converted to 1950 coordinates before they are stored in a source catalog. Specifying /NOCOMPAT disables the 2000 to 1950 conversion. Note that Galactic coordinates are still converted to equatorial coordinates. /COMPAT is the default.
- /OLD_EQUATORIAL
  Specifying /OLD_EQUATORIAL indicates that the input coordinates are referred to the old (pre-IAU 1976) equatorial reference system (FK4). This is the default coordinates system. Optionally, you can specify the equinox (i.e. the epoch of the mean equator and equinox of the equatorial coordinates system to which the source coordinates values are referred) as /OLD[=equinox]. If the equinox is not specified, the standard epoch B1950.0 is assumed.
- /NEW_EQUATORIAL
  Specifying /NEW_EQUATORIAL indicates that the input coordinates are referred to the new (post-IAU 1976) equatorial reference

system (FK5). Optionally, you can specify the equinox (i.e. the epoch of the mean equator and equinox of the equatorial coordinates system to which the source coordinates values are referred) as /NEW[=equinox]. If the equinox is not specified, the standard epoch J2000.0 is assumed.

Since the current telescope control system can handle only the old equatorial coordinates, and since it is difficult to accommodate the coordinates system information into the current source catalogs without modifying a number of UIP commands, new equatorial coordinates of any arbitrary equinox and epoch will be converted to the FK5 coordinates at J2000.0, then converted to the FK4 coordinates at B1950.0. The conversion method and matrix explained in the 'Explanatory Supplement to The Astronomical Almanac' are used.

- /GALACTIC
  The antenna computer can only handle the equatorial (R.A. and Dec.) coordinates. However, you can enter Galactic coordinates, instead of R.A. and Dec., if you use this qualifier. The Galactic coordinates will be converted to R.A. and Dec., and stored in the catalog. If you wish to inspect the coordinates as Galactic coordinates, then use the `VERIFY/GALACTIC` command.
- /LSR
  Specifying /LSR indicates that radial velocity of the source is referenced to the local standard of rest (LSR). This is the default when the radial velocity of the source is specified but no velocity qualifier is given.
- /HELIOCENTRIC
  Specifying /HELIOCENTRIC indicates that radial velocity of the source is referenced to the heliocenter. Note: the antenna computer can't handle heliocentric velocities yet, so this option is effectively not implemented.
- /Z
  Specifying /Z indicates that radial velocity of the source is entered as red shift. Note: the antenna computer can't handle velocities given as red shift yet, so this option is effectively not implemented.

• HELP

Help is available on any of the following UIP commands. Normal VAX/VMS help syntax is used. For a brief listing of parameters and qualifiers, type `COMMAND?`

- VERB: the command to be helped with. Typing `VERB?` is easier.

- **HOLD**
  This routine stops the execution of the command file currently running. It does this by putting the sub-process executing the command file in a suspended state. The function `RESUME` restarts the sub-process.

- **IDLE**
  `IDLE` stops the drive motors and applies the brakes. This is the state when the computer is first turned on. The status display shows 'IDLE'. To observe a source, you must type `TRACK`. Note that `IDLE` stops the servo loop entirely, and applies the brakes when the telescope comes to rest. The telescope will not necessarily come to rest at the point it was tracking. To stop the telescope at the current position, e.g., to do a drift scan, switch from celestial coordinates to altazimuthal coordinates by typing `ALTAZ`.

- **IF_S**
  `IF_S` performs a conditional test in a schedule. It has no effect when typed in by hand. The general form of the test is
  `IF item1 .EQS. item2 GOTO label`
  Only equality can be tested and the test is a literal string test. Symbols contained in curly brackets will be expanded before the test is performed.

  - EXPRESSION: The conditional test to be performed.

- **INSTRUMENT**
  `INSTRUMENT` - select PI instrument to use.

  - NAME: the PI instrument to use (CHAMP, SuZIE, BOLOCAM or FIBRE).

- **INTERPRET**
  `INTERPRET` redirects the input to the UIP program. This allows files of UIP commands to be executed. It differs from `EXECUTE` in that no subprocess is spawned. When the `UIP` is first invoked, the file `CANONICAL:UIP.INI` is automatically interpreted, followed by `UIP.INI` in your home directory if it exists.

  - FILE: name of the VMS text file containing the commands to be interpreted.
  - /SHOW: the read from the command file are echoed on the terminal (and in the log file in verbose mode).

- **JOY_STICK**

  JOY_STICK is intended to aid in the manual tweaking of the telescope offsets. It allows you to change the offsets by using the arrow keys on the terminal, rather than explicitly typing in the offsets. Optionally, a special logging file can be opened to log final values for later analysis. The following keys have special functions when you are executing this routine:

E	Exits this routine
H	Prints this help message
L	Logs the current values in file
O	Allows a new source to be selected
R	Resets the offsets to their original values
S	Changes the step size
V	Verifies the position of a source
Z	Zeros the offsets in play
<arrow keys>	Changes the offsets

  - STEP_SIZE
    STEP_SIZE specifies how large a step is to be taken each time an arrow key is hit. The units are arc seconds.
  - FILE_NAME
    The name of an optional file into which the final tweaked up values can be written. If this file is not specified, logging will be done in the regular UIP log file. Having this separate file is intended primarily for use in optical pointing.
  - /RA_DEC
    /RA_DEC causes the arrow keys to effect the RA and DEC offsets, rather than the AZ and ZA offsets which are changed by default.
  - /FIXED
    /FIXED causes the arrow keys to effect the fixed offsets.
  - /OPTICAL
    /OPTICAL is intended to help you check the pointing near your source. It is particularly helpful when you are tuned to some obscure frequency, and you can't point on any line via FIVE_POINT. When /OPTICAL is specified, the antenna is moved to the location of a nearby star bright enough to be seen with the PaigeAtron. The pointing is changed to optical, and you may center the star in the PaigeAtron cross-hairs using the arrow keys. When you finish, the antenna will move back to your source, and radio pointing will be enabled again. Any corrections you made by adjusting the AZO and ZAO will be added to the fixed offsets (FAZO and FZAO).

- /PAIGEATRON
  /PaigeAtron allows you to move the cross-hairs on the PaigeAtron monitor. When this qualifier is used, the STEP_SIZE parameter is truncated to an integer, and corresponds to the number of pixels the cross-hair pattern should move each time an arrow key is pressed. The changes made in this way are not permanent, and will be lost the next time a `POINTING` command is executed (this happens implicitly when `JOY_STICK/OPTICAL` is used). To permanently change the cross-hairs' position in a standard pointing setup, the pointing file must be updated.

• KILL_SUBPROCESS

This routine stops the execution of the command file currently running. It cannot be restarted.

• LAST_EXECUTION

Frequently one wants to execute a simple command procedure many times, in order to integrate continuously until the signal to noise ratio is acceptable. One can do this by executing a command file with a large repeat count (see `HELP EXECUTE`). The `LAST_EXECUTION` command tells the VAX to stop executing the file after the current integration.

• LINE

`LINE` inserts information about spectral lines into the line catalog. The syntax of the command is
`LINE NAME FREQUENCY SIDEBAND MULTIPLIER`
For example:
`LINE 12co2-1 230.53797 upper 2`

- NAME
  The name of the line. It may be as long as 20 characters. Certain characters, such as '+', '-' and '/', should be avoided, since the parser will interpret them. If these characters must be used, the entire name must be enclosed in quotation marks.
- FREQUENCY
  The laboratory frequency of the line in gigahertz.
- SIDEBAND
  The default sideband. May be specified as UPPER or LOWER, or any truncated version of these words.
- MULTIPLIER
  The default value for the multiplier in the LO chain. Must be an integer.

- /CATALOG
  By default, the new line entry will be placed in users private catalog. You can override this by specifying /CATALOG=n which tells the program to place the entry in the nth open catalog. You can get a numerical listing of the catalogs by issuing the command `CATALOG/LINE`.

- **LO**

The `LO` command sends information to the antenna computer that is needed to calculate the phase lock loop frequency. It can be used to center the bandpass on a line from the line catalog, or with an arbitrary frequency. Default values for such things as sideband may be overridden with qualifiers. If `LO` is executed with no parameters or qualifiers, the antenna computer is instructed to recalculate the phase lock frequency.

This command is executed automatically when the `OBSERVE` command is given. Whenever the `LO` characteristics are changed, the new values are logged in the log file.

- NAME
  The name of the spectral line you wish the bandpass to be centered on. It must be a line in the catalog (these may be added with the `LINE` command).
- RECEIVER
  The number of the receiver you are using. If not specified, the computer will select a receiver automatically, based on the following assumed receiver coverage:

  Receiver 1 = 300 GHz and below
  Receiver 2 = 300 – 400 GHz
  Receiver 3 = 400 – 600 GHz
  Receiver 4 = 600 GHz and above
- /FREQUENCY
  This qualifier may be used with or without the NAME parameter above, to load in a specific frequency. It takes a value, which is the desired frequency in GHz. If this qualifier is used without the NAME parameter, the line name will be changed to 'POT_LUCK'.
- /UPPER
  /UPPER specifies upper sideband. This will override any default value found in the line catalog.
- /LOWER
  /LOWER specifies lower sideband. This will override any default value found in the line catalog.

- /BOTH
  /BOTH specifies that both sidebands will contribute to the resulting spectra.
- /MULTIPLIER
  This qualifier takes a parameter which is an integer specifying what harmonic of the Gunn oscillator output is to be used as the first LO.
- /F_OFFSET
  This qualifier allows a frequency offset to be sent to the antenna computer. It is specified in GHz.
- /V_OFFSET
  This qualifier allows a velocity offset to be sent to the antenna computer. It is specified in km/sec.
- /IF_FREQUENCY
  This qualifier allows you to specify a different intermediate frequency (IF). The unit is GHz. The legal values are between 1.2–1.5 with default to 1.5. This qualifier is sticky! Make sure you reset it to default with /IF=1.5 when you change to a different line with the `LO` command.
- /50_F_OFFSET
  This qualifier allows you to offset the 50MHz AOS from the center of the 500 MHz AOS. You must supply a value, which should be in MHz.
- /50_V_OFFSET
  This qualifier allows you to offset the 50MHz AOS from the center of the 500 MHz AOS. You must supply a value, which should be in km/sec.
- /LOCK_LOOP
  This qualifier, which is sticky, allows you to specify which method you are using to phase lock the LO system. The only valid values are 'EIP', 'OLD_PLL' (John Maute's PLL), 'MPI' (Bundeslock) and 'NEW_PLL' (John Carlstrom's PLL). EIP specifies that the locking will be done by the EIP counter, and xxx_PLL tells the computer that you will be using a home brew phase lock loop system. MPI tells the antenna to simply calculate the lock frequency. The VAX will grab this information and transmit it to a serial line pointed to by the logical name MPI_LINK.
- /RADIAL_VELOCITY
  This qualifier allows you to specify a radial velocity that you have

calculated yourself. It disables the radial velocity calculation that the antenna computer normally performs, and substitutes for it the value you specify with this qualifier. Automatic radial calculation will be suspended until you issue an `LO` command with the /NORADIAL_VELOCITY qualifier. The unit is km/sec, and a negative value indicates approach. The `OBSERVE` command implicitly executes an `LO /NORADIAL_VELOCITY` command unless the /NOLO qualifier is used.

– /FORCE_RX_CHANGE
  By default the computer will not attempt to reprogram the LO Matrix Box if it does not think it needs to. This qualifier allows you to force the computer to reprogram the box. It is primarily for use by other UIP commands, but it will certainly work if given manually. The computer will also inquire whether or not you want to move the sidecab mirrors, unless the /FORCE=NOMIRRORS qualifier is used.

– /ANTENNA_ONLY
  If /ANTENNA_ONLY is specified, commands will be sent only to the antenna computer. No messages will be sent to the backend computers. Note that this means the IF downconverter will not be configured, so there is a very good chance that if you use this qualifier, the IF will not be plumbed to the AOSs correctly.

– /LOG
  This qualifier causes the current `LO` parameters to be printed on the terminal. All the other parameters and qualifiers will be ignored.

– /GUNN_ON
  If /GUNN_ON is specified, the antenna computer will be instructed to turn on the Gunn oscillator. /NOGUNN_ON will turn the Gunn off. If either of these actions is specified, no other action (such as recalculating the sky frequency) will be taken.

– /LOOP_N
  This qualifier allows you to specify the harmonic number for the Gunn PLL. The Gunn oscillator is locked to a certain harmonic (+ 20 MHz) of the reference signal generated by the YIG oscillator. By default the antenna computer chooses an appropriate harmonic number as follows:

$$\mathrm{LOOP\_N} = \mathrm{INT}\left[\frac{\mathrm{F\_Gunn} - 20\mathrm{MHz}}{5.990\mathrm{GHz}} + 0.5\right]$$

  where 5.990 GHz is the nominal YIG frequency. This happens when a new line name, line frequency, intermediate frequency, sideband, multiplier harmonic number, frequency offset, or velocity offset is sent by the `LO` command.

- **LOG**

This routine writes the rest of the line to the current log file.

  – MESSAGE: the text to be written.

  – /STAMP: If specified, a time stamp is written into the file before the text.

- **LOGON**

`LOGON` opens a new log file and records the time and date. While the log file is open, significant events, such as source changes, are recorded in this file. The file is closed using the `NOLOG` command.

  – FILE_NAME
  The name of the file. The default is LOG_DIR:NAME_DATE.TIME, for instance `LOG_DIR:RTM_13FEB85.231216`.

  – /PATRONIZE
  /NOPATRONIZE turns off all the little chatty messages that tell you what the computer is doing. You can put `LOGON/NOPATRONIZE` in your `UIP.INI` file, and get rid of these messages forever.

  – /VERBOSE
  Specifying /VERBOSE results in all of the dialog to and from the UIP program being saved in the log file.

  – /SCAN_BEEP
  Specifying /SCAN_BEEP will result in the control terminal beeping each time a scan is completed.

  – /FILE_BEEP
  Specifying /FILE_BEEP will result in the control terminal beeping each time a command file being EXECUTEd finishes.

  – /WARNING_BEEP
  Specifying /WARNING_BEEP will result in a warning beep being sent to the control terminal any time a scan is started when warning conditions are in effect.

- **MAPPER**

Mapper is a first try at implementing a automated mapping. It produces a command file which the observer can execute to raster an area of the sky. The default coordinate system is RA-Dec.

- FILE_NAME
  The name of the command file to be produced. There is no default.
- LONGITUDE_STEP
  Size, in arc seconds, of the steps of the longitude like coordinate in whatever coordinate system you have chosen. Possibilities are right ascension, azimuth, or galactic longitude.
- N_LONGITUDE_STEPS
  Number of steps to take, in each direction about the center, for the longitude like coordinate. So for a 9 by X map, this parameter should be 4.
- LATITUDE_STEP
  Size, in arc seconds, of the steps of the latitude like coordinate in whatever coordinate system you have chosen. Possibilities are declination, zenith angle, or galactic latitude.
- N_LATITUDE_STEPS
  Number of steps to take, in each direction about the center, for the latitude like coordinate. For an X by 11 map, this parameter should be 5.
- WORK_FILE
  Name of a file that should be executed at each point. `MAPPER` generates EXECUTE/WAIT WORK_FILE after each position change.
- END_OF_ROW_FILE
  Optional name of a file that should be executed after each row is completed. `MAPPER` generates `EXECUTE/WAIT END_OF_ROW_FILE` after each row.
- /ALTAZ: causes the generation of altitude azimuth offsets.
- /GALACTIC: causes the generation of l, b offsets.
- /MAPPING_OFFSETS
  /MAPPING_OFFSETS specifies that the mapping offsets, rather than the switching offsets, should be used. This is the default for spectral line observations, but not for continuum observations.
- /ANTENNA_WAIT
  /ANTENNA_WAIT, which is the default, causes an `ANWAIT` command to be executed at each position before integration begins. This is not really needed if you are observing with the AOS, because the backend computer will not start an integration until the source has been acquired. Specifying /NOANTENNA_WAIT will save a few seconds per integration if you are using the AOS.

- **NOLOG**

  `NOLOG` closes the current log file. No other log file is automatically opened, so unless a `LOGON` command is given, events will not be logged.

- **OBSERVE**

  `OBSERVE` looks up the coordinates of an object, and sends them to the antenna computer. The currently open source catalogs are searched in the reverse of the order in which they where opened. If the object is found, its name and coordinates will be sent to the antenna computer. A suitable guide star will be chosen, and its position stored for use with `JOY/OPTICAL`.

  – NAME: the name of the object, no more than 20 characters.

  – /LO
    This qualifier is selected by default. If /NOLO is NOT specified, the LO frequency will be updated after the new source position has been entered. This qualifier has no effect if you are not observing in spectral line mode.

  – /FCAL
    This qualifier, which is selected by default, tells the backend to take a frequency calibration comb if you are going to slew more than 40 degrees in azimuth. This has no effect if you are observing in bolometer mode. A calibration comb will not be taken if the `OBSERVE` command is executed in a command file.

  – /TIME
    This qualifier, which is selected by default, causes the antenna computer's time to be reset. If there is something wrong with the observatory clock (WWV or GPS), then specifying /NOTIME will keep the system from sending an erroneous time to the antenna computer.

  – /OPTICAL_POINTING
    This qualifier is used for optical pointing. The telescope will be moved to the specified source (presumably a star), and an exposure will be taken with the CCD camera on the fabulous PaigeAtron (the Keck prototype). The PaigeAtron's PC will fit a gaussian profile to the star's image, and report the star's position offsets to the VAX which will print the results on the terminal, and write it to a pointing file. A value must be given to this qualifier, the number of milliseconds for the CCD exposure.

  – /X_GUESS
    This qualifier is only used in optical pointing mode. It is the guess

to be given to the CCD camera for the X position of the star in the CCD frame.

- /Y_GUESS
  This qualifier is only used in optical pointing mode. It is the guess to be given to the CCD camera for the Y position of the star in the CCD frame.
- /REPEAT_COUNT
  This qualifier, which requires a value, specifies how many optical images should be taken and gauss-fitted. It has no effect if /OPTICAL_POINTING is not specified.

• OFF_POSITION

`OFF_POSITION` tells the backend computer that we are off the source position, and that the next integration should take place in the OFF buffer.

- /CLEAR: tells the backend computer to clear the buffer before integrating, as would be appropriate for a new source.

• ON_POSITION

ON_POSITION tells the backend computer that we are on the source position, and that the next integration should take place in the ON buffer.

- /CLEAR: tells the backend computer to clear the buffer before integrating, as would be appropriate for a new source.
- /ONLY_ON
  /ONLY_ON tells the backend computer to *only* clear the ON buffer. By default both the ON and the OFF are cleared when /CLEAR is specified.

• OO_SCAN

`OO_SCAN` allows you to take ON/OFF data in a variety of predefined patterns, without executing a command file. You may execute either a symmetric or an asymmetric pattern. You may also specify how many cycles should be performed.

Unless explicitly commanded not to, the `OO_SCAN` command will take a calibration scan, with the chopper, before taking source data. The calibration scan will be taken at the OFF position.

Unlike most UIP commands, `OO_SCAN` parameters and qualifiers are sticky. This means that if you wish to take a second `OO_SCAN` with the same parameters, you need only type `OO`. Only the parameters you wish to change ever need to be specified.

Typing `^C` (control C) will abort this routine gracefully, but only if you are executing it interactively. Use `KILL` to terminate a subprocess running a command file.

- CYCLES
  This parameter specifies how many times the basic ON/OFF pattern should be executed.
- /SYMMETRIC
  /SYMMETRIC specifies that a symmetric ON/OFF pattern should be used. This is the default pattern. The basic symmetric pattern is: +OFF ON ON -OFF.

  If the parameter CYCLES is set to 2, the actual pattern will be +OFF ON ON -OFF -OFF ON ON +OFF.

  The OFF position must be specified with the /STEP and /COORDINATE qualifiers. /SYMMETRIC is chosen by default if no other pattern is given.
- /ASYMMETRIC
  /ASYMMETRIC specifies that only one OFF position should be used. The pattern is just: ON OFF.

  If the parameter CYCLES is set to 2, the actual pattern will be ON OFF OFF ON.

  The OFF position may be specified with the /STEP and /COORDINATE qualifiers, or an explicit OFF position may be given with the /RAO and /DECO or /GLO and /GBO qualifiers.
- /DESIGNATED_OFF
  The /DESIGNATED_OFF qualifier tells `OO_SCAN` to search the open source catalogs for a designated OFF position for the object being observed. Such OFF positions must have the source's name, and a qualifier of OFFPOSITION. An asymmetric pattern will be executed. If this qualifier is selected, then the /SYMMETRIC, /ASYMMETRIC, /STEP, /COORDINATE, /RAO, /DECO, /GLO, /GBO and /REVERSE qualifiers are ignored. The `VERIFY` command will show you any available OFF position for a given source.
- /STEP
  The /STEP qualifier allows you to specify the size of the step to get to the OFF position. This qualifier is normally used with the /COORDINATE qualifier (see below). If no /COORDINATE

qualifier is given, the offset is assumed to be in azimuth. The units are seconds of arc.

- /COORDINATE
  The /COORDINATE qualifier is used in conjunction with the /STEP qualifier to specify the direction to step to get to the OFF position. The only legal values are AZO, ZAO, RAO, DECO, GLO and GBO.
- /RAO
  /RAO is used for asymmetric switching in which you wish to specify an explicit sky position as the OFF position. The units are seconds of arc. If this qualifier is used, /DECO must be specified too.
- /DECO
  /DECO is used for asymmetric switching in which you wish to specify an explicit sky position as the OFF position. The units are seconds of arc. If this qualifier is used, /RAO must be specified too.
- /GLO: identical to /RAO except the offset is in Galactic longitude.
- /GBO: is identical to /DECO except the offset is in Galactic latitude.
- /REVERSE
  If /REVERSE is specified, then the order in which ONs and OFFs are taken is reversed. So the basic asymmetric pattern becomes OFF ON, and the basic symmetric pattern becomes
  ON +OFF +OFF ON ON -OFF -OFF ON (cycles = 2).

  Note that the number of cycles must be even in the symmetric case, or you will have uneven numbers of +OFF and -OFF integrations.
- /ALTERNATE
  If /ALTERNATE is specified, then every other `OO_SCAN` will be taken /REVERSE. This is **NO LONGER** the default behavior.
- /ATTENUATOR
  If /NOATTENUATOR is not specified, then the backend (if it is the AOS) will be instructed to adjust its programmable attenuator to avoid overflow before data is taken.
- /LO
  If /LO is specified, then the phase lock frequency will be adjusted at the end of the set of ON-OFF pairs, to allow for Doppler tracking. This adjustment is done by default if the Phase Lock Loop is being used (instead of the EIP counter).

- /FOCUS_ADJUST
  If /NOFOCUS_ADJUST is not given, then the secondary focus and Y tilt will be adjusted before the first integration takes place.
- /CALIBRATE_AT_START
  If /CALIBRATE_AT_START is given, then a calibration scan will be taken before taking any source data. The default action is to calibrate at the start only if no valid calibration scan is already available. If a designated OFF position has been given, it will also be used for the calibration scan.
- /PAUSE_AFTER_CAL
  /PAUSE allows the observer to specify an integer number of seconds to wait after the calibration scan, before taking the scan's data. This is desirable if the thermal load of the calibration wheel seems to affect the receiver's performance for some period after taking a calibration scan. For example, /PAUSE=5 will result in a 5 second pause between calibration and data taking. This qualifier is selected by default, and the default time is 20 seconds.
- /SAVE_CAL_SCANS
  This qualifier, which is selected by default, tells the computer to store the temperature and frequency calibration scans in your data file. Specifying /NOSAVE_CAL_SCANS will disable the storage of these scans.
- /JUST_PARAMS
  Specifying /JUST_PARAMS keeps the OO_SCAN command from actually doing anything. Only the parameters will be changed. This option is available to allow you to change the sticky OO_SCAN parameters, without actually taking data or moving the telescope. This should be useful in files being INTERPRETed.
- /LIST: lists current values for all parameters and qualifiers that are sticky.
- /RESET
  /RESET sets all the million of OO_SCAN parameters, qualifiers and hangers-on back to the default values that nature intended them to have. This qualifier's action takes place before any others, so if you specify other options on the same command line, they will NOT be canceled by /RESET.

- **OTF_MAP**

  `OTF_MAP` maps an area surrounding the source position. Data are taken continuously while the telescope is scanning the source (OTF_MAP ⟹

On The Fly Map), rather than acquiring individual offset positions. In some cases this can result in a factor of 2 or more increase in the observing duty-cycle.

The considerations involved in using `OTF_MAP` are fairly complex, particularly for spectral line work. You should consult with a CSO staff member before using this mapping mode. SHARC users may wish to use the `SHARCOTF` program for some help.

It is now possible to do OTF mapping with any combination of AOSs active.

Also see the "new generation" `OTF_MAP, XOTF_MAP` for some advanced features of making OTF maps, such as skewed map, zigzag scan lines, etc. Some of the features, such as mapping along a specific positional angle, `XOTF_MAP` does it correctly.

- LONGITUDE_SIZE
  The size of the map in the longitude-like coordinate (right ascension, azimuth or Galactic longitude) in arc seconds.
- LATITUDE_SIZE
  The size of the map in the latitude-like coordinate (declination, zenith angle or Galactic latitude) in arc seconds.
- SPEED
  This parameter sets the speed at which the telescope should move across the sky, in arc seconds per second of time. The default is LONG_RES per second. The scan proceeds from negative values of the longitude- like coordinate towards positive. This parameter must be positive.
- RAMP_TIME
  The time in seconds to wait for the antenna computer to acquire the new moving position. Data will not be taken during this time. The default RAMP_TIME is 10 seconds, which is adequate for speeds of up to several times the sidereal rate. For speeds below about 5 seconds of arc per second, substantially smaller values of RAMP_TIME may be used. At very slow speeds (about 1 arc second per second), RAMP_TIME may be set to 0.
- LONG_RES
  The step size in the longitude-like coordinate, in arc seconds. This parameter is optional, if not specified, 1/2 the beam width, rounded to the nearest arc second, will be used. This parameter must be positive. In SHARC mode, this parameter is ignored and

the step size is computed and set as follows:

$$\text{LONG\_RES} = \frac{\text{SPEED} * \text{CHOPS\_PER\_INT}}{\text{FREQ\_CHOP}}.$$

- LAT_RES
  The step size in the latitude-like coordinate, in arc seconds. This parameter is optional, if not specified, the value of the parameter LONG_RES will be used. This parameter can be either positive or negative. If the parameter is positive, the map is started at the bottom (negative Dec, ZA or whatever).

- /POSITION_ANGLE
  If /POSITION_ANGLE=XXX is specified, then the scans will be taken along a position angle of XXX degrees, measured from north through east. For example if XXX = 0, south to north scans will be taken. If XXX = 45, scans will go from south-east to north-west. If no position angle is given, the source is scanned from west to east, which is equivalent to a position angle of 270. This qualifier cannot be used with /ALTAZ or /GALACTIC.

- /CALIBRATE
  This qualifier only has an effect when observing in spectral line mode. By default, a calibration scan will be taken before the map is started. If /NOCALIBRATE is specified, then no cal. scan will be taken. If /CALIBRATE=N is specified, then a cal. scan will be taken at the beginning, and also before every Nth row.

- /PAUSE_AFTER_CAL
  /PAUSE allows the observer to specify an integer number of seconds to wait after the calibration scan, before taking the scan's data. This is desirable since the thermal load of the calibrator wheel seems to affect the receiver's performance for some period after taking a calibration scan. For example, /PAUSE=5 will result in a 5 second pause between calibration and data taking. This qualifier is selected by default, and the default time is 20 seconds.

- /SKIP
  We all know that the backend computer never crashes. But in the purely hypothetical event that it did so during an OTF_MAP, you might want to restart your map, skip down to the row where the ##%#! thing crashed, and start from there. This qualifier would allow you to do that. /SKIP=N tells `OTF_MAP` to skip the first N rows of your map.

- /FOCUS_ADJUST
  If /NOFOCUS_ADJUST is not given, then the secondary focus and Y tilt will be adjusted before the first integration takes place.
- /ALTAZ
  /ALTAZ causes the map area to be scanned in Alt-Az coordinates. The default is RA & Dec, except in SHARC mode where Alt-Az scans are performed regardless of whether or not the /ALTAZ qualifier is specified. This is because the chopping secondary can only chop in azimuth and SHARC OTF scans must be performed along the chopping direction.
- /SIDEWAYS
  /SIDEWAYS, which can only be used with the /ALTAZ qualifier, causes the map to be scanned in Zenith Angle, rather than azimuth. In SHARC mode, /ALTAZ need not be specified because it is default.
- /GALACTIC: causes the map area to be scanned in Galactic coordinates. The default is RA & Dec.
- /AZO
  If /AZO=XXX is specified, the OFF position data will be taken XXX arc seconds from the center of the row being scanned. The duration of the OFF integration will be whatever integration time was specified in the most recent `AOS` command. Cal. scans will be taken with this same azimuth offset, relative to the center of the map. This qualifier may not be used with /DESIGNATED_OFF.
- /DESIGNATED_OFF
  If /DESIGNATED_OFF is specified, data will be taken at a designated off position after each row has been scanned. This is useful if no region of the area you are mapping is free of signal, and you know of a particular position which is clean. See `OO_SCAN` for more information on how to set up a designated off position in the source catalog. The duration of the OFF integration will be whatever integration time was specified in the `AOS` command. Any cal. scans requested with the map will be taken at the designated off position, and an extra OFF integration will be taken after each cal. scan. This qualifier may not be used with /AZO.
- /MOVE_ONLY
  When /MOVE_ONLY is specified, the antenna will perform the rastering movements, but no data will be taken. This can be helpful for determining what amount of time is needed for ramping up (see RAMP_TIME). It can also be handy when you scan an

area to find your beam on the strip-chart recorder.

- /SHUTUP_ALREADY
  If /SHUTUP_ALREADY is not specified, the arrival of individual scans will be announced on the terminal which issued the `OTF_MAP` command.
- /DEBUG
  If /DEBUG is specified, the program will print out many, many diagnostic messages. These are intended to help locate the many outstanding bugs in this routine.

• PAGE

This routine commands the microcomputer in the antenna to change the contents of its status display. The following displays have been implemented:

Page 1: Standard display	Page 2: Pointing
Page 3: Tracking	Page 4: Space invaders style tracking
Page 5: Optical tracker	Page 6: GPIB status
Page 7: Holography Setup	

A word of caution: leaving the display on page 6 indefinately could result in rare glitches in GPIB operations.

- PAGE_NUMBER: the page to be displayed

• PAUSE

This routine is intended for use only within a command file. It has no effect if it is executed interactively. `PAUSE` places the current process in a suspended state. This allows a command file to halt itself at a specific point. The command file's execution is resumed when the user executes a `RESUME` command.

• PLANET

`PLANET` looks up the coordinates of an object in the ephemeris file called `CAT_DIR:NAME.DAT`, where NAME is the name of the object, and passes three consecutive lines of information to the antenna computer. The three lines are those closest to the current time and are used by the antenna computer for a quadratic fit to compute the actual position of the object. Each line of the file should contain the following four quantities, in free format: right ascension, declination, range (distance) in AU, and UTC epoch in MJD. An optional range rate (radial velocity) in km/s can be given after these quantities, following the keyword 'vrad ='. Right ascension, declination, range, and range rate should be geocentric. For example:

```
092000.07 -013102.2 0.8536949382 51525 ! 12/13/1999 vrad = -21.92113
092120.10 -014213.3 0.8410722778 51526 ! 12/14/1999 vrad = -21.78948
092239.58 -015321.4 0.8285261389 51527 ! 12/15/1999 vrad = -21.65616
```

The lines should be in chronological order.

- NAME: the name of the object, no more than 20 characters.
- /DOPPLER
  /DOPPLER causes the antenna computer to Doppler track the object using the radial velocity information in the ephemeris file. The default is /NODOPPLER.
- /LO
  If /LO is specified, the LO frequency will be updated after the new source position has been entered. This qualifier has no effect if you are not observing in spectral line mode.

• POINTING

`POINTING` loads a file of pointing constants into the antenna computer, to facilitate changing pointing modes. For instance
`POINTING optical`
will load in the most recent pointing constants for optical pointing.
`POINTING 345_SIDE`
will load in the most recent parameters for the 345 GHz SIS receiver in the sidecab.

- NAME
  The name of the pointing setup such as OPTICAL or BOLOMETER. Can be a file name if /FILE is specified (see below). Typing * for this parameter will result in a list of the known pointing setups being printed.
- /CHECK
  Specifying /CHECK tells the program to try to check the pointing with the PaigeAtron optical telescope. The program will search for a suitable guide star. If there is no guide star within the field of view of the optical telescope (about $22' \times 22'$), the (radio) telescope will be moved a bit to acquire a nearby star. Once a star has been selected, the optical telescope will be commanded to take an exposure. The optical telescope will then take an exposure, and find the star within the frame. The offsets will then be reported, and the observer will be given the option of applying them to the current pointing model.
- /FILE: to load constants from your own private file, specified in the NAME parameter.

- /NAME_CHANGE
  /NAME_CHANGE, which is the default, tells the computer to change the name of the pointing file displayed on the antenna display, and stored in the SCORE_BOARD. The name stored in SCORE_BOARD is used when the antenna computer is reloaded, to determine what pointing constants to default to.
- /AZIMUTH
  /AZIMUTH=x allows you to enter an azimuth value for a star for optical pointing. A star will be chosen near this azimuth. If /AZIMUTH is specified, /ZA, /REPEAT_COUNT and /EXPOSURE must also be specified.
- /ZA
  /ZA=x allows you to enter an zenith distance for a star for optical pointing. A star will be chosen near this angle. If /ZA is specified, /AZIMUTH, /REPEAT_COUNT and /EXPOSURE must also be specified.
- /REPEAT_COUNT
  /REPEAT_COUNT=n allows you to specify how many exposures and fits should be taken when doing an optical pointing. If /REPEAT_COUNT is specified, /ZA, /AZIMUTH and /EXPOSURE must also be specified.
- /EXPOSURE
  /EXPOSURE=n allows you to specify the duration (in msec) of exposures taken for optical pointing. If /EXPOSURE is specified, /ZA, /AZIMUTH and /REPEAT_COUNT must also be specified.

- ## PUNDIT

  By default, only one process running the UIP can issue commands which effect the observatory's operation. If another terminal is running the UIP, you will not be allowed to issue any command which communicates with the antenna or backend microcomputers, or changes the data acquisition setup. However, the `PUNDIT` command allows you to override this feature. Typing `PUNDIT TRUE` will tell the UIP to allow your terminal to issue all UIP commands. `PUNDIT FALSE` disables this feature. Typing `PUNDIT` by itself will tell you whether you are a pundit or a pleb.

  If you wish to be a permapundit, just place `PUNDIT TRUE` in your `SYS$LOGIN:UIP.INI` file.

  - STATUS: A TRUE (T) or FALSE (F) response.

- ## RA

  This routine sends a new right ascension position to the antenna computer. The command `RA` automatically selects CELES coordinates.

  - RA: the new Right Ascension position to be sent.
  - EPOCH: the date for which the right ascension is accurate, for example 1950.0.

- ## RA2

  This routine sends a new Right Ascension position to the antenna computer. The command `RA2` automatically selects CELES coordinates.

  - RA: the new Right Ascension position to be sent.
  - PM_RA: the new proper motion in Right Ascension.
  - EPOCH: the date for which the right ascension is accurate, for example 2000.0.

- ## RAO

  This routine sends a new Right Ascension offset to the antenna computer. It should be used rather than directly setting the offset (via `TOANTENNA`), since it also updates the status information in the VAX, so that the correct offsets can be written into the scan header.

  - OFFSET: the new Right Ascension offset in arc seconds.
  - /MAPPING: if specified, the mapping offset will be modified.
  - /FIELD: if specified, the field offset will be modified.
  - /TEXAS
    If /TEXAS is specified, then the Texas switching mode is activated (that moves the telescope ON and OFF source based on a digital input signal to the antenna computer), and the offset is stored in the Texas switching offset.

- ## RASTER_SCAN

  `RASTER_SCAN` is used by CHAMP and BOLOCAM to perform raster scans.

  - X_OFFSET: initial offset along the x (longitude) axis in arcsec.
  - Y_OFFSET: initial offset along the y (latitudee) axis in arcsec.
  - X_VELOCITY: scan velocity along the x axis in arcsec/s.
  - Y_VELOCITY: scan velocity along the y axis in arcsec/s.
  - SCAN_TIME: scan time in seconds.

- REPEAT_COUNT: number of raster scans to be performed (default=1).
- /SETTLING_TIME: settling time in seconds (default=10 seconds).
- /OVERSCAN_TIME: overscan time in seconds (default=0 second).
- /ALTAZIMUTHAL: selects the altazimuthal coordinate system for scan offsets and velocities.
- /EQUATORIAL: selects the apparent equatorial coordinate system for scan offsets and velocities.
- /GALACTIC: selects the Galactic coordinate system for scan offsets and velocities.
- /FOCUS_ADJUST
  If /NOFOCUS_ADJUST is specified, RASTER_SCAN will not change the secondary mirror focus position. By default, the secondary mirror focus is adjusted at the beginning of each scan.
- /ROTATOR_ADJUST
  If /NOROTATOR_ADJUST is specified, `RASTER_SCAN` will not change the instrument rotator position. By default, the instrument rotator is adjusted at the beginning of each scan based on the parallactic angle.
- /CANCEL: cancel raster scan.
- /DEBUG
  If /DEBUG is specified, command strings to be sent to the antenna computer, as well as other verbose messages, will be printed on the terminal, but no real action will be taken.

- ## RECALL

  `RECALL` is intended to be a faithful reproduction of the DCL command line editing feature. The only difference is that in the UIP, `RECALL` will remember all the commands that have been entered, not just the last 20 as in DCL. There are some optional enhancements which can be turned on via qualifiers.

  - MATCH_LINE
    The line to be recalled. If it is a number N, then the Nth line will be recalled. Otherwise the last line which matches will be recalled.
  - /ALL: to display the last 20 lines you have typed.

- /SPACE_EQUALS_RECALL
  If you type RECALL/SPACE_EQUALS_RECALL, or put this in your initialization file, then the following feature will be turned on. If you type a space as the first character of a line, it will be converted into the string RECALL. This is intended to make it easier to recall old command (i.e., fewer keystrokes).

- # REPEAT_COMMAND

`REPEAT_COMMAND` will allow you to repeat a command several times. For example: `REPEAT 5 CHOP 2` will perform `CHOP_SLEWY 2` five times.

  - NUM_ITERATIONS: the number of times to repeat the command.
  - COMMAND_LINE: one line of text comprising a standard `UIP` command.
  - /BEEP_AT_END: will beep 3 times when finished.

- # RESUME

This routine restarts the execution of a schedule that has been halted via the `HOLD` command.

- # ROTATOR

The `ROTATOR` command allows the user to control the motion of the Cassegrain instrument rotators. One can set the rotator at a fixed angle, or enable auto adjustment to follow the parallactic angle. If auto adjustment is selected, an offset may be applied, and the timing of the focus changes may be controlled.

If `ROTATOR` is entered without any parameters or qualifiers, and if the antenna is in STEALTHY mode, the antenna will be instructed to adjust the rotator based on the parallactic angle. Note that this is done automatically at the beginning of `OO_SCAN, OBSERVE` or `PLANET` command.

  - POSITION
    If this optional parameter is specified, it will be sent to the antenna computer and used as a fixed rotator position.
  - /LEFT
    Specifying /LEFT activates the left (as seen from the control room) rotator. Only one rotator can be active at a time.
  - /RIGHT
    Specifying /RIGHT activates the right (as seen from the control room) rotator. Only one rotator can be active at a time.

- /NONE: deactivates the any active rotator.
- /OFFSET
  This qualifier allows you to specify a fixed offset which will be added to the parallactic angle when the antenna computer updates the rotator position.
- /CONSTANT_UPDATES
  Specifying CONSTANT_UPDATES tells the antenna computer to update the position of the rotator whenever the position should be changed. In this mode, the rotator might be moved when an integration is taking place.
- /STEALTHY_UPDATES
  This qualifier tells the antenna computer to update the rotator's position only when data is not being taken, so that during a given integration the rotator will remain fixed.

- **SBUPDATE**
  `SBUPDATE` updates scoreboard variables. The variables being updated are: `SB_AZS`, `SB_ELS`, `SB_FOCUS`, `SB_FOCUS_OFFSET`, `SB_LOCK_FREQ`, `SB_LSTRAD`, `SB_TEMP`, `SB_TILT`, `SB_TILT_OFFSET`, and `SB_UT_DATA`.

- **SECONDARY**
  The `SECONDARY` command controls the chopping secondary mirror. It allows the chop throw and frequency to be specified, as well as where in the chop cycle the system will acquire data.

  - THROW
    This parameter specifies the separation of the beams on the sky, in arc seconds. The default is 120″. Note that in SHARC mode, this value is used only to calculate positions for `OTF` maps and `CHOP_SLEWY` scans - the actual motion of the mirror is determined by adjusting the controls on Martin's Chopper Box in the sidecab. Maximum throw is 540″.
  - FREQUENCY
    This parameter controls the chopping frequency. In SHARC mode, this is set by the SHARC computer output, set by `SHARC/FREQUENCY=XXX`.
  - ON_TOLERANCE: default is forced to be 10 arc seconds.
  - OFF_TOLERANCE
    This parameter has the same effect as ON_TOLERANCE, but for the off- source beam. The default value for this parameter is equal to the ON_TOLERANCE value.

- /STOP
  Specifying /STOP stops the secondary from chopping, and positions it at the neutral position.
- /DEBUG: prints out some debugging information.
- /RELOAD
  This will query the antenna computer for values for the chopper throw and frequency. Assuming you have put them in right before (i.e., before a backend crash), `SEC/RELOAD` will bring them back.

- ## SERVICE

  `SERVICE` puts the antenna and dome in the position necessary to allow portable and waste water to be added and removed (respectively, I hope). The antenna is driven to a ZA of 0 for no good reason, and the brakes are applied.

- ## SHARC

  Before issuing this command, be sure the SHARC Server program is running on the Mac. (It can be started by clicking on the SHARC Server icon near the top righthand corner of the desktop.) The `SHARC` command allows you to change the chopping frequency, the number of chop cycles per integration, as well as most other important SHARC parameters. It also informs the antenna computer that you will be observing in continuum mode (as opposed to spectroscopy mode). Typing `SHARC` without any parameters results in the current parameters being displayed. All parameters are sticky, with 2 exceptions: 1) the SETUP_DISPLAY will be turned off if it is running at the start of an integration. 2) FLUSH_BUFFER will be set true regardless of the input if the CHOPS_PER_INT or FREQ_CHOP qualifiers are present.

  - /CHOPS_PER_INT
    The value of this qualifier specifies how many secondary chop cycles over which the Quadra will accumulate the bolometer signal during each integration. The value must be a positive integer.
  - /INTEGRATIONS_PER_SEGMENT
    The value of this qualifier specifies how many integrations the Quadra will take during each of the 4 segments of each `CHOP_SLEWY` cycle of the telescope. The default value is 1, and in the case of `OTF_MAP`, the value 1 will be used automatically by the Quadra regardless of the input or current value.
  - /FREQ_CHOP
    The frequency at which to move the chopping secondary. Only quantized values are allowed–those which satisfy the relation:

freq = 500/N where N = 1..256
Any real number entered shall be rounded to the closest available frequency whose value shall then be set and reported. The default is 4.09 Hz.

- /DELAY_CHOP
  The delay to be applied to the bolometer signal before the lock-in is performed. The default value is 18.0 msec and should not be changed unless you really know what you are doing.
- /WAVELENGTH
  Specifying /wavelength=n tells the computer which filter is being used and thus which wavelength (in microns) to write to the header. Note that you must manually turn the filter wheel to change filters. The default is 350.0 microns.
- /REFERENCE_PIXEL
  The number of the reference pixel from which angular offsets on the sky are calculated. This can be set either from the UIP or directly on the Mac. Either way, the UIP will read back the current setting after each SHARC command. This is the pixel that is pointed on.
- /SUMRS
  The number of bits to shift the DSP data values; that is, the DSP signal is divided by 2^{sumrs} before being reported. The default is 6 and should not need to be changed.
- /ANGLE_PARALLACTIC
  The parallactic angle of the array mapped onto the sky. It is zero (I think) if the array is aligned in elevation. This feature has not been implemented yet. Someday we will read the rotation stage encoders.
- /QUADRATURE
  This qualifier tells the computer to store quadrature data in addition to the normal in-phase data. /NOQUADRATURE turns off this storage. It is good idea to keep the quadrature data.
- /FLUSH_BUFFER
  /FLUSH_BUFFER specifies that the DSP buffer inside the Quadra 950 should be flushed before any new data is taken. Flushing is automatically done whenever FREQ_CHOP or CHOPS_PER_INTEGRATION is changed. /NOFLUSH_BUFFER will prevent flushing from occurring in other cases, but this is not recommended.
- /PHASE_ARRAY
  /PHASE_ARRAY causes the Macintosh to immediately compute

the current phase in the specified pixel (based on a computation of the arctangent of the next integration of in-phase and quadrature data collected by the DSP) and set this value as the phase to be used subsequently by the DSP processor in its lock-in computation. If no pixel number is specified or pixel phases are computed. Be warned that specifying /PHASE_ARRAY=0 **WILL NOT WORK PROPERLY** if you are **NOT** looking at a source that fills the entire array (i.e. chopping on/off the lunar limb). In order to phase the array on a point source (i.e. a planet), you can use appropriate UIP macro for the current reference pixel, e.g. with reference=12:

```
UIP> EXE USER:[HUNTER.NEWUIP]PHASE_12.COM
```

NOTE: These macro files assume that the array is aligned in elevation with pixel 1 having the highest elevation.

- /SAVE_PHASE
  This qualifier writes the current phases to a standard file on the Mac. It overwrites whatever was there before, so be sure your phases are good before issuing this command. In case of a Mac crash, these phases can be restored with the LOAD_PHASE qualifier. Note that when you compute new phases with the `PHASE_*.COM` command file or the `SHARC/PHASE=*` command, these phases are used for all future data. Saving the phases to disk simply insures against losing the phase information if the Mac crashes (which is very rare!).
- /LOAD_PHASE
  Loads the stored pixel phases from disk on the Mac. This should only be done if you have suffered a Mac reboot and lost the phase information. Of course it is always safer to rephase on a real bright source, if one is available.
- /ACQUIRE_IGNORE
  /ACQUIRE_IGNORE tells the Quadra to ignore the acquired signal from the antenna computer and thus, to take data and save it even if the antenna is idle. This is useful when you are running tests. The default action is to not integrate when the antenna is idle. You must use /NOACQUIRE_IGNORE to disable this.
- /IDLE_IGNORE
  /IDLE_IGNORE tells the Quadra to ignore the idle signal from the antenna computer and thus, to take data and save it even if the antenna is idle. This is useful when you are running tests.

The default action is to not integrate when the antenna is idle. You must use /NOIDLE_IGNORE to disable this.

- /SETUP_DISPLAY
  /SETUP_DISPLAY tells the Quadra to open the Labview VI display on its monitor and start displaying data. This is useful to see how the signals look before starting an integration. /NOSETUP_DISPLAY will kill this window. If it is still running when a real integration is called for, it will be killed automatically.
- /SHUT_UP
  /SHUT_UP allows you to tell the backend computer to quit sending certain messages.
- /PRINT
  By default, the current SHARC parameters are printed when the `SHARC` command is executed. A query is made to the Quadra for the current settings of CHOPS_PER_INT and CHOP_FREQ. Specifying /NOPRINT suppresses these messages.
- /SOUNDS
  Specifying /SOUNDS will turn on the audio soundtrack on the Mac to make observing more fun. /NOSOUNDS disables the audio.
- /RESTART
  Forces the current SHARC Client to be killed and a new one created. This qualifier fixes the situation when the SHARC Server on the Mac has just been restarted but the old SHARC Client is still running on the VAX.
- /DIE: tells the Labview process on the Quadra to die.
- /AZIMUTH_ALIGNED
  Tells the SHARC Macintosh that the cryostat is aligned in azimuth; i.e. parallel to the horizon (this is not the optimal configuration for the optics!). It will load the corresponding fixed pixel offsets for this configuration into subsequent new data files.
- /ELEVATION_ALIGNED
  Tells SHARC that the cryostat is aligned in elevation; i.e. perpendicular to the horizon (optimal Strehl ratio). It will load the corresponding fixed pixel offsets for this configuration into subsequent new data files.

• SOUND

`SOUND` allows the UIP to request the Macintosh to play one of the many digitally-sampled sounds in its library. Currently, the library consists of mostly Star Trek snippets but we will take requests. Before issuing this command, the SOUND server on the Mac must be started (if it is not already running, e.g. via the Startup Folder) by clicking on the Sound Server icon near the top righthand corner of the desktop. The Mac sound can be output to the control room stereo. To do this, be sure that the 1/8-inch audio jack is plugged into the lowest connector port on the back of the Mac. Then set the stereo to VCR input and turn the volume up to about 4.

– /BYTE
  The value of /BYTE determines which soundbyte is played. The current available sounds are listed below along with their future surround-sound associations:

  MAC standard sounds:

3 = Simple Beep	4 = Quack	5 = Droplet
6 = Indigo	7 = Wild Eep	8 = Sosumi

  Star Trek sounds:

9	=	Auto-destruct order (rebooting the antenna)
12	=	McCoy: Spock, do something! (TLENGTH unsafe)
13	=	Data: That was NOT manual override (A+D-/A-D+)
14	=	Picard: Make it so! (OBSERVE command)
15	=	Picard: Fire! (when facing AZ 302)
16	=	Picard: Red alert! (rain alarm)
20	=	Picard: Tea, Earl Grey, Hot (every hour on the hour)
21	=	Picard: Engage! (opening the dome)
22	=	Destruct button (closing the dome)
23	=	Warp drive in trouble (OTF crash)
24	=	Warp drive acceleration (slewing)
25	=	Tribble coo (successful Cetia reboot)
26	=	Transporter activation (Orrery display)
27	=	Spock's viewer (Netscape activation)
28	=	Red alert klaxon (the dome alert/the rain alarm)
29	=	Phaser hit to the hull (running into the latches)
30	=	Phaser hit on deflectors (a backend crash)
31	=	Intercom whistle (VAX crash)
32	=	Enterprise main view screen (AOS display)
33	=	Garbled radio signal (data scan arrival)
34	=	Bridge doors (opening control room door)
35	=	Ben Finney's heartbeat (SIS I/V sweep)
36	=	Buttons on the Bridge (the LO command)
37	=	Communicator activation (unexpected message from backend)
40	=	Photon torpedo (FCAL scan arrival)

41 = Stratos torture device (Loss of LO lock)
42 = Food synthesizer (CAL scan arrival)
43 = Spock: I do not think you realize the gravity of your situation
44 = McCoy: I'm a Doctor, not an Engineer!
45 = Computer: Unable to comply (Ultimate limit)
46 = Scotty: Aye, and if my grandmother had wheels she'd be a wagon.
47 = Scotty: ...stop up the drain. (Ethernet reboot failure)
48 = McCoy: It won't die! (multi-AOS processes on Cetia)
49 = Picard: What the hell are you still doing here. (STOW)
50 = Spock: Fascinating
51 = Locutus: Resistance is futile
52 = Kirk: This is damn peculiar
53 = Spock: Illogical
54 = Scotty: Up your shaft

Babylon 5 sounds:

55 = Theme music bumper
56 = Chime 1
57 = Chime 2 (doorbell)
58 = Computer: Confirmed (VERIFY command)
59 = Computer: Files accessed (DATA_FILE, CATALOG commands)
60 = Computer: 1 non-human lifeform detected
61 = Computer: Enter Password
62 = Ivanova: Priority 1 Alert
63 = Computer: Scanning listed data (VERIFY * command)
64 = Ivanova: Signal coming in
65 = Computer: Standby
66 = Ivanova: Stop program (IDLE)
67 = Computer: Unable to respond
68 = Sheridan: computer virus defense
69 = Computer: Files transferred
70 = Sinclair: Fatal error

Three Stooges sounds:

73 = Moe: If I want anything done around here...
74 = Moe: Quiet, birdbrain! (AOS/SHUTUP)
75 = Curly: Nyuk, nyuk, nyuk
76 = Moe: This is all your fault, you
77 = Curly: Woo Woo Woo
78 = Curly: I'm a victim of soicimstance!
79 = Moe: Wake up and go to sleep
80 = Curly: Soitenly!
81 = Nose hit
82 = Curly: Nyahhh, nyahhh

83 = Moe: You idiot

Local sounds:	**Miscellaneous sounds**:
38 = Dom: Steege!	10 = I am Immortal (from Highlander)
39 = Dom: Steege (brief)	11 = Bill & Ted: Bogus!
71 = Dom: Pogs!	17 = Bill & Ted: Excellent Friends
84 = Mac: Let's Go Home	18 = Excellent! (antenna restarts properly)
85 = Ant: Get a Life	19 = Excellent-n-music (AOS restarts properly)

– /DIE: stops the sound server on the Mac.

• SOURCE

The `SOURCE` command is used to enter the source coordinates and velocity into the source catalog. (Last modified August 12, 1998)

NOTE: THE J2000.0 COORDINATES WILL BE CONVERTED TO THE B1950.0 COORDINATES AND STORED IN THE SPECIFIED SOURCE CATALOG.

Syntax

```
SOURCE [ qualifiers ] name ra declination
   [ velocity [ pm_ra [ pm_dec [ epoch ] ] ] ]
```

– NAME
The name of the source. An optional qualifier can be added following the backslash character '\'. The name and qualifier can each be as long as 20 characters.

– RA
The right ascension of the source in the form hhmmss.sss, or the Galactic longitude in the form of dddmmss.ss if the /GALACTIC qualifier is specified.

– DECLINATION
The declination of the source in the form [-]ddmmss.ss, or the Galactic latitude in the form of [-]ddmmss.ss if the /GALACTIC qualifier is specified.

– VELOCITY
The radial velocity of the source. Can be specified as LSR velocity, (km/sec), heliocentric velocity (km/sec), or red shift. LSR velocity is the default. See also the qualifiers /LSR, /HELIOCENTRIC, and /Z for details.

– PM_RA
The proper motion in right ascension of the source (sec/year). If the original value is expressed in unit of arcsec/year, you probably

need to convert it as follows:

$$\text{PM\_RA}[sec/yr] = \frac{15}{cos(\text{DEC})}\text{PM\_RA}[arcsec/yr].$$

Do not enter non-zero value with the /GALACTIC qualifier.

- PM_DEC
  The proper motion in declination of the source (arcsec/year). Do not enter non-zero value with the /GALACTIC qualifier.
- EPOCH
  The epoch of the source coordinates. For the equatorial coordinates, the standard epoch is either 1950.0 (B1950.0) or 2000.0 (J2000.0). When none of the equatorial coordinates qualifiers (/OLD_EQUATORIAL, /NEW_EQUATORIAL) is specified, the coordinates system is defaulted as follows:

Epoch	Coordinates
2000.0	FK5 system at J2000.0
1950.0	FK4 system at B1950.0
default	FK4 system at B1950.0
others	Not allowed (ambiguous)

  See the qualifiers /OLD_EQUATORIAL and /NEW_EQUATORIAL for details. For the Galactic coordinates, see the qualifier /GALACTIC.
- /CATALOG
  The source catalog number into which the entry should be placed. Use the CATALOG command to find out what number corresponds to the catalog of interest. If this qualifier is not specified, the entry will be placed in your private catalog.
- /COMPAT
  Specifying /COMPAT indicates that input coordinates should be converted to 1950 coordinates before they are stored in a source catalog. Specifying /NOCOMPAT disables the 2000 to 1950 conversion. Note that Galactic coordinates are still converted to equatorial coordinates. /COMPAT is the default.
- /MAS_PER_YEAR
  /MAS_PER_YEAR indicates that the proper motions are given in mas/yr, instead of s/yr for right ascension and "/yr for declination. It also indicates that the proper motion in right ascension given has already been multiplied by cosine of declination.
- /OLD_EQUATORIAL
  Specifying /OLD_EQUATORIAL indicates that the input coordinates are referred to the old (pre-IAU 1976) equatorial reference

system (FK4). This is the default coordinates system. Optionally, you can specify the equinox (i.e. the epoch of the mean equator and equinox of the equatorial coordinates system to which the source coordinates values are referred) as /OLD[=equinox]. If the equinox is not specified, the standard epoch B1950.0 is assumed.

– /NEW_EQUATORIAL

  Specifying /NEW_EQUATORIAL indicates that the input coordinates are referred to the new (post-IAU 1976) equatorial reference system (FK5). Optionally, you can specify the equinox (i.e. the epoch of the mean equator and equinox of the equatorial coordinates system to which the source coordinates values are referred) as /NEW[=equinox]. If the equinox is not specified, the standard epoch J2000.0 is assumed.

  Since the current telescope control system can handle only the old equatorial coordinates, and since it is difficult to accommodate the coordinates system information into the current source catalogs without modifying number of UIP commands, new equatorial coordinates of any arbitrary equinox and epoch will be converted to the FK5 coordinates at J2000.0, then converted to the FK4 coordinates at B1950.0. The conversion method and matrix explained in the 'Explanatory Supplement to The Astronomical Almanac' are used.

– /GALACTIC

  The antenna computer can only handle the equatorial (R.A. and Dec.) coordinates. However, you can enter Galactic coordinates, instead of R.A. and Dec., if you use this qualifier. The Galactic coordinates will be converted to R.A. and Dec., and stored in the catalog. If you wish to inspect the coordinates as Galactic coordinates, then use `VERIFY/GALACTIC` command.

– /LSR

  Specifying /LSR indicates that radial velocity of the source is referenced to the local standard of rest (LSR). This is the default when the radial velocity of the source is specified but no velocity qualifier is given.

– /HELIOCENTRIC

  Specifying /HELIOCENTRIC indicates that radial velocity of the source is referenced to the heliocenter. Note: the antenna computer can't handle heliocentric velocities yet, so this option is effectively not implemented.

– /Z

  Specifying /Z indicates that radial velocity of the source is entered as red shift. Note: the antenna computer can't handle velocities given as red shift yet, so this option is effectively not implemented.

– Examples

(1) 'B1950.0' coordinates

```
SOURCE name ra declination
   [ velocity [ pm_ra [ pm_dec [ 1950.0 ] ] ] ]
```

Ex. B1950.0 coordinates and LSR velocity of Ori IRC 2:

```
SOURCE oriirc2 053247.00 -052424.0 9.0
```

(2) 'J2000.0' coordinates

```
SOURCE /NEW_EQUATORIAL name ra declination
   [ velocity [ pm_ra [ pm_dec [ 2000.0 ] ] ] ]
```

Ex. J2000.0 coordinates and redshift of 3C 273 (IAU 1226+023) taken from the 1998 edition of 'The Astronomical Almanac':

```
SOURCE /Z /NEW 3c273 122906.69971 020308.59 0.1584
SOURCE /Z 3c273 122906.69971 020308.59 0.1584 0 0 2000.0
```

(3) Non-standard equinox (and epoch)

```
SOURCE /OLD_EQUATORIAL=equinox name ra declination
   [ velocity [ pm_ra [ pm_dec [ epoch ] ] ] ]
SOURCE /NEW_EQUATORIAL=equinox name ra declination
   [ velocity [ pm_ra [ pm_dec [ epoch ] ] ] ]
```

Ex. J1998.5 coordinates of Alpha Tau (Aldebaran) taken from the 1998 edition of 'The Astronomical Almanac':

```
SOURCE /NEW=1998.5 aldebaran 043550.1 163023
```

Note: The coordinates shown in the above example are referred to the mean equator and equinox of J1998.5. The `SOURCE` command will do the following:

a Move the coordinates from J1998.5 to J2000.0 - no effect since the proper motions are not given

b Precess the coordinates system from J1998.5 to J2000.0

c Convert the J2000.0 coordinates (at epoch J2000.0) to the B1950.0 coordinates (at epoch B1950.0) by the conversion matrices and formulae given in the 'Explanatory Supplement to the Astronomical Almanac'

(4) Non-standard equinox and epoch, when equinox != epoch

```
SOURCE /OLD_EQUATORIAL=equinox name ra declination
   velocity pm_ra pm_dec epoch
SOURCE /NEW_EQUATORIAL=equinox name ra declination
```

```
velocity pm_ra pm_dec epoch
```

Ex. ICRS coordinates and proper motions, at epoch J1991.25, of the first source listed in 'The Hipparcos Main Catalogue':

```
SOURCE /NEW=2000.0 hipp 000000.22 010520.4 0 -0.0003 -0.002
1991.25
```

Note: The coordinates and the proper motions in 'The Hipparcos Main Catalogue' are referred to the ICRS (International Celestial Reference System), which is consistent with J2000.0, but the epoch is J1991.25. The SOURCE command, shown in the above example, will do the following:

a Move the coordinates from J1991.25 to J2000.0, using the proper motions given

b Convert the J2000.0 coordinates and proper motions at J2000.0 to the B1950.0 coordinates and proper motions at B1950.0 by the conversion matrices and fomulae given in the 'Explanatory Supplement to the Astronomical Almanac'

– Changes
The following features have been added:

a `SOURCE` accepts the new (post-IAU 1976) equatorial coordinates, converts to the old (pre-IAU 1976) equatorial coordinates, and stores them in the source catalog.

b `SOURCE` accepts the equatorial coordinates at any epoch referred to any equinox.

The following bugs have been fixed:

a `SOURCE` could not handle the Galactic coordinates correctly when G.L. $>$ 359 degree and $|$ G.B. $|>$ 89 degree.

b Description of the proper motion in right ascension was incorrect. The unit should read (sec/year).

c User entries of new sources now go to user's private catalog by default, instead of last opened catalog. If you mean to write to a catalog other than your private catalog, use the /CATALOG qualifier (see help on the qualifier).

- **STARE**

`STARE` blocks execution for specified number of seconds. It is equivalent to DCL's `WAIT`.

– DURATION: DURATION in seconds.

- **STATUS**
  STATUS prints the current values of certain system parameters relating to logging, command and data file status.

- **STOW**
  STOW causes the antenna to be driven to a random azimuth in a roughly eastern direction. The reason is that if the dome is parked at a fixed azimuth every day, the electrical slip rings, powering the dome, will wear unevenly. The antenna is driven to a zenith angle of 15, and the antenna is idled.

  If the file UIP_INFO:STOW.ZA exists, then the first line will be read. If the first line contains a valid zenith angle, the antenna will be stowed at that zenith angle.

  - /ZENITH: if specified, the antenna is driven to 0 ZA.
  - /SHARC
    If /SHARC is specified, then the telescope will be stowed at 50 degrees to minimize the boil off of SHARC cryogenics. If the current pointing file is SHARC, then the telescope will be stowed at ZA = 50 unless /NOSHARC is specified.
  - /CHAMP: If specified, the telescope will be parked at AZ $\sim$ -20.

- **TAKE_DATA**
  TAKE_DATA causes the backend to integrate. A message will be returned when the scan is complete, and the scan will be logged. This command will work for both spectroscopy and continuum receivers.

  - /LEAVE_IT: tells the backend computer not to send the scan back to the VAX.
  - /SHUTUP_ALREADY: disables the reporting of scan completion.
  - /IDLE: tells the backend computer to idle the antenna at the same time as data taking starts.
  - /FAST_TRACK
    /FAST_TRACK tells the antenna computer to begin tracking at some multiple of the sidereal rate (specified with the FAST_TRACK command). The backend computer is then signaled to take data as if a drift scan were occurring. /FAST_TRACK cannot be used with /LEAVE_IT.

- **THETA_POSITION**
  The THETA_POSITION command allows the user to control the rotation

of the secondary mirror. If an absolute position is specified, then autofocusing is disabled. An offset can also be specified to be added to the stored focus curve.

– POSITION
  If this optional parameter is specified, it will be sent to the antenna computer and used as a fixed THETA position. The antenna computer will not update the position.

– /OFFSET
  This qualifier allows you to specify a fixed offset which will be added to the value from the focus curve when the antenna computer updates the secondary position.

– /SET_OFFSET
  This qualifier, which should be used alone, is used to calculate the offset which should be applied to the focus curve. First one should find the best THETA position, using the `THETA_POSITION` command to send the secondary to specific positions. Then when the focus is good, invoke `THETA_POSITION` with this qualifier, and the offset will be calculated. Then invoke `FOCUS` with either the /STEALTHY_UPDATES or the /CONSTANT_UPDATES qualifier to tell the antenna to use the focus curve.

• TILT_CURVE

`TILT_CURVE` takes the dome for a spin, and reads the tilt meters, generating a curve of tilt vs azimuth. New tilt meter zeros are determined and sent to the antenna. Since the forth text files are not automatically changed, the updated pointing constants will disappear with the next reload unless the text files are manually changed.

– STEP_SIZE
  How many degrees the dome and antenna are stepped between tilt meter readings. Must be an integer.

– SETTLE_TIME
  The values brought back from the antenna are smoothed values. This necessitates waiting at each point to allow the average to drift to its proper value. This parameter is that time, in integer seconds.

– FILE_NAME
  In addition to plotting the data, `TILT_CURVE` writes the data into a text file for later perusal. This parameter names that file.

- /RETROGRADE
  Normally the curve is taken going from AZ 0 to AZ 360. /RETROGRATE causes the curve to be taken in the reverse direction.
- /VIDEO
  The tilt meter curve will normally be plotted on the lineprinter. Specifying /VIDEO redirects the output to the user's CRT.

• **TO_AOS**
This routine sends a string to the AOS process in the backend computer. It is automatically converted to uppercase, except for any portion that is enclosed in quotation marks.

- MESSAGE: the text to be sent.
- /ALL: causes the command to be sent to all active AOS processes.
- /BOTH: a synonym for /ALL. See help for /ALL.
- /FIRST
  Specifies that the message is to be sent to the first AOS process, which runs the first 500 MHz AOS.
- /SECOND
  Specifies that the message is to be sent to the second AOS process, which runs the 50 MHz AOS.
- /THIRD
  Specifies that the message is to be sent to the third AOS process, which runs the second 500 MHz AOS.
- /FOURTH
  Specifies that the message is to be sent to the fourth AOS process, which runs the 1.5 GHz AOS.
- /500
  /500 has exactly the same effect as /FIRST, the message is sent to the first AOS process, which runs the first 500 MHz AOS.
- /50
  /50 has exactly the same effect as /SECOND, the message is sent to the second AOS process, which runs the 50 MHz AOS.

• **TOANTENNA**
This routine sends a string to the antenna microcomputer. It is automatically converted to uppercase, except for any portion that is enclosed in quotation marks.

- MESSAGE: the text to be sent.

• TRACK

TRACK causes the telescope to slew to the requested position and then track that position, adjusting the pointing of the telescope as necessary.

• VERIFY

VERIFY allows you to inspect entries in either the spectral line catalog, or one of the source catalogs. For sources, catalogs are searched in the reverse of the order in which they where opened. Wildcards may be used for both the name and qualifier. For example:
`VERIFY 3C*\data`
will type out all of the known 3C sources with data as the qualifier.

VERIFY will also work on planets, by performing a cubic interpolation on the data in the ephemeris catalog. This is the same method the antenna computer uses. Planet names must be entered without a qualifier. If you use the VERIFY/EDIT command on a planet, you'll get no sympathy from me.

VERIFY can take a long time to run, if you are using wildcards. ˆC will abort it's execution, if it is being executed interactively.

(Last modified January 12, 1998)

The following feature has been added:
VERIFY can convert the old (pre-IAU 1976) equatorial coordinates in the source catalog to the new (post-IAU 1976) equatorial coordinates.

The following defect has been fixed:
VERIFY could not handle the galactic coordinates correctly when G.L. $>$ 359 degree and $|$ G.B. $|>$ 89 degree.

- NAME: the name of the object or line, no more than 20 characters.
- /ZA
  If this optional parameter is specified, VERIFY will calculate the UT at which the object will rise to this zenith angle, and when it will set below this angle. Specify the angle in degrees. This parameter is ignored if wildcards or /PITHY are specified.
- /LINE
  Specifying /LINE tells the program to look in the spectral line catalog, rather than the source catalog, to find the entry named by the NAME parameter.
- /EDIT
  /EDIT allows you to change source parameters without deleting the source and reentering it. It does not currently work with wildcards. When you use this feature, you are thrown into the

VAX editor, and are presented with a line formatted properly to reenter the source with it's current parameter values. After you have changed the values and exited the editor, the source is removed and reentered with the new parameters.

- /TRACKING_STAR
  If this qualifier is specified, then information about the star chosen for pointing is printed on the terminal, and in the log file.
- /ALTAZ
  If ALTAZ is specified, `VERIFY` will display the altitude and azimuth of the object. The object's position will not be precessed before the calculation, so the position will be approximate. The hour angle and parallactic angle are also displayed.
- /PARALLACTIC_ANGLE
  If this optional parameter is specified, `VERIFY` will calculate the UT at which the object will rise to this parallactic angle, and when it will set below this angle. The formulas currently work for angles between -90 and +90, and that's probably all you'll need. (Though we can't help but try to get it to work for sources that never rise above Mauna Loa!) Specify the angle in degrees. This parameter is ignored if wildcards or /PITHY are specified.
- /PITHY
  /PITHY selects the short form of output. It will not work with /ALTAZ or /TRACKING_STAR. /PITHY is automatically selected when wildcards are used.
- /PRINT: sends the output to the line printer.
- /ASCII_FILE: sends the output to a text file. You must supply a name for the file.
- /DEFAULT
  This parameter is only useful in it's negated form. Specifying /NODEFAULT tells `VERIFY` not to search the default catalog. This is particularly useful if you want to get a listing of your personal file, without a copy of the default catalog appended to the end.
- /GALACTIC
  If /GALACTIC is specified, the coordinates of the object will be l and b, rather than RA and Dec.
- /NEW_EQUATORIAL
  If the /NEW_EQUATORIAL qualifier is specified, the source coordinates will be converted to the new (post-IAU 1976) equatorial coordinates.

– /OLD_EQUATORIAL
If the /OLD_EQUATORIAL qualifier is specified, the source coordinates displayed will be referred to the old (pre-IAU 1976) equatorial coordinates system. Since the source coordinates in the source catalog are already referred to the old equatorial coordinates system, this is the default and no conversion will be made.

- ## VIEW_LOG

Due to the way log files are opened in the UIP, the current log file cannot be examined directly (e.g., via the VMS TYPE command). This command attempts to make up for that shortcoming. It throws a copy of the current log file into the editor. Upon exiting the editor, the copied file is deleted.

– /PRINT: if specified, then whatever is left of the file in the editor when you exit is printed before deletion.

- ## WEATHER

This routine enables the user to send weather parameters to the antenna computer, so that the refraction corrections can be made accurately.

– TEMPERATURE: ambient temperature in degrees.

– HUMIDITY: relative humidity in percent.

– PRESSURE: Barometric pressure in millibars. The default is usually OK.

– /AUTOMATIC
If /NOAUTOMATIC is specified, then the antenna computer will NOT automatically update the weather using values from the weather station.

– /FAHRENHEIT
If /FAHRENHEIT is specified, the temperature is taken to be in degrees Fahrenheit, otherwise Centigrade is assumed.

- ## X_POSITION

The `X_POSITION` command allows the user to control the focusing of the secondary mirror, by moving it perpendicular to the optic axis. If an absolute position is specified, then auto-focusing is disabled. An offset can also be specified to be added to the stored focus curve.

– POSITION
If this optional parameter is specified, it will be sent to the antenna

computer and used as a fixed X position. The antenna computer will not update the position.

- /OFFSET
  This qualifier allows you to specify a fixed offset which will be added to the value from the focus curve when the antenna computer updates the secondary position.
- /SET_OFFSET
  This qualifier, which should be used alone, is used to calculate the offset which should be applied to the focus curve. First one should find the best X position, using the `X_POSITION` command to send the secondary to specific positions. Then when the focus is good, invoke `X_POSITION` with this qualifier, and the offset will be calculated. Then invoke `FOCUS` with either the /STEALTHY_UPDATES or the /CONSTANT_UPDATES qualifier to tell the antenna to use the focus curve.

• XOTF_MAP

`XOTF_MAP` maps an area surrounding the source position. This routine is very much like `OTF_MAP`, but it has some advanced features, such as moving the antenna in a zigzag fashion on successive scan lines, doing a skewed map, etc. It'll take care of the case when the number of "cells" on each scan line is even.

The considerations involved in using OTF_MAP are fairly complex, particularly for spectral line work. You should consult with a CSO staff member before using this mapping mode. SHARC users may wish to use the `SHARCOTF` program for some help.

- LONGITUDE_SIZE
  The size of the map in the longitude-like coordinate (right ascension, azimuth or Galactic longitude) in arc seconds.
- LATITUDE_SIZE
  The size of the map in the latitude-like coordinate (declination, zenith angle or Galactic latitude) in arc seconds.
- SPEED
  This parameter sets the speed at which the telescope should move across the sky, in arc seconds per second of time. In heterodyne receiver mode, the SPEED and LONGITUDE_RES parameters determine the integration time for each cell:
  INTEGRATION_TIME = LONGITUDE_RES / SPEED.
  The default is LONGITUDE_RES per second. The scan proceeds

from negative values of the longitude-like coordinate towards positive. This parameter must be positive.

- RAMP_TIME
  The time in seconds to wait for the antenna computer to acquire the new moving position. Data will not be taken during this time. The default RAMP_TIME is 10 seconds, which is adequate for speeds of up to several times the sidereal rate. For speeds below about 5 seconds of arc per second, substantially smaller values of RAMP_TIME may be used. At very slow speeds (about 1 arc second per second), RAMP_TIME may be set to 0.
- LONGITUDE_RES
  The step size in the longitude-like coordinate, in arc seconds. This parameter is optional, if not specified, 1/2 the beam width, rounded to the nearest arc second, will be used. This parameter must be positive. In SHARC mode, this parameter is ignored and the step size is computed and set as follows:

  LONGITUDE_RES = SPEED * CHOPS_PER_INT / FREQ_CHOP.
- LATITUDE_RES
  The step size in the latitude-like coordinate, in arc seconds. This parameter is optional, if not specified, the value of the parameter LONGITUDE_RES will be used. This parameter can be either positive or negative. If the parameter is positive, the map is started at the bottom (negative Dec, ZA or whatever).
- /POSITION_ANGLE If /POSITION_ANGLE=XXX is specified, then scans will be taken along a position angle (PA) of XXX degrees, which is measured from north through east. If the PA is 0, for example, south to north scans will be taken. If the PA is 45, scans will go from south- west to north-east. If no position angle is given, the source is scanned from west to east, which is equivalent to a position angle of 90.

  NOTE: A position angle is conventionally measured from north through east. The original `OTF_MAP` command, however, measured it from north through west.
- /SIDEWAYS
  /SIDEWAYS, which can only be used with the /ALTAZ qualifier, causes the map to be scanned in Zenith Angle, rather than azimuth. In SHARC mode, /ALTAZIMUTHAL need not be specified because it is default.
- /SKEW If /SKEW=XXX is specified, each row will be offset by XXX arc seconds from the previous row. This will result in a

parallelogram-shaped map. The default is, of course, /SKEW=0.

- /ZIGZAG If /ZIGZAG is specified, OTF_MAP will alternate a scan direction by reversing the position angle for even number rows. For example, rows 2, 4, 6, 8, ... will be taken from east to west instead of from west to east when the position angle is 270 degrees.
- /SKIP
  We all know that the backend computer never crashes. But in the purely hypothetical event that it did so during an `OTF_MAP`, you might want to restart your map, skip down to the row where the ##%#! thing crashed, and start from there. This qualifier would allow you to do that. /SKIP=N tells `OTF_MAP` to skip the first N rows of your map.
- /ALTAZIMUTHAL
  /ALTAZIMUTHAL causes the map area to be scanned in Alt-Az coordinates. The default is RA-Dec, except in SHARC mode where Alt-Az scans are performed regardless of whether or not the /ALTAZIMUTHAL qualifier is specified. This is because the chopping secondary can only chop in azimuth and SHARC OTF scans must be performed along the chopping direction.
- /EQUATORIAL
  /EQUATORIAL causes the map area to be scanned in apparent equatorial coordinates of date (Ra-Dec). This is the default.
- /GALACTIC
  /GALACTIC causes the map area to be scanned in Galactic coordinates. The default is RA-Dec.
- /FOCUS_ADJUST
  If /NOFOCUS_ADJUST is not given, then the secondary focus and Y tilt will be adjusted before the first integration takes place.
- /ROTATOR_ADJUST
- /CALIBRATE
  This qualifier only has an effect when observing in spectral line mode. By default, a calibration scan will be taken before the map is started. If /NOCALIBRATE is specified, then no calibration scan will be taken. If /CALIBRATE=N is specified, then a calibration scan will be taken at the beginning, and also before every Nth row.
- /PAUSE_AFTER_CAL
  /PAUSE_AFTER_CAL allows the observer to specify an integer

number of seconds to wait after the calibration scan, before taking the scan's data. This is desirable since the thermal load of the calibrator wheel seems to affect the receiver's performance for some period after taking a calibration scan. For example, /PAUSE=5 will result in a 5 second pause between calibration and data taking. This qualifier is selected by default, and the default time is 20 seconds.

- /OFFSET
  /OFFSET=(XXX,YYY) or /OFFSET=XXX - this qualifier allows you to specify the OFF position by offset(s) in arc seconds from the map center in the local (mapping) coordinates system, whose orientation is defined by the position angle. /OFFSET=XXX is equivalent to /OFFSET=(XXX,0).
- /AZO
  If /AZO=XXX is specified, the OFF position data will be taken XXX arc seconds from the center of the row being scanned. The duration of the OFF integration will be whatever integration time was specified in the most recent AOS command. Calibration scans will be taken with this same azimuth offset, relative to the center of the map. This qualifier may not be used with /DESIGNATED_OFF.
- /DESIGNATED_OFF
  If /DESIGNATED_OFF is specified, data will be taken at a designated off position after each row has been scanned. This is useful if no region of the area you are mapping is free of signal, and you know of a particular position which is clean. See OO_SCAN for more information on how to set up a designated off position in the source catalog. The duration of the off integration will be whatever integration time was specified in the AOS command. Any calibration scans requested with the map will be taken at the designated off position, and an extra off integration will be taken after each calibration scan. This qualifier may not be used with /AZO.
- /MOVE_ONLY
  When /MOVE_ONLY is specified, the antenna will perform the rastering movements, but no data will be taken. This can be helpful for determining what amount of time is needed for ramping up (see RAMP_TIME). It can also be handy when you scan an area to find your beam on the strip-chart recorder.
- /DEBUG

If /DEBUG is specified, `OTF_MAP` will print out many, many diagnostic messages.

- **XRASTER_SCAN**
  `XRASTER_SCAN` performs raster scans, i.e., on-the-fly (OTF) scans. This command is primarily intended for CHAMP, BOLOCAM and SHARC II.

  - SCAN_VELOCITY
    SCAN_VELOCITY specifies the scan velocity in seconds of arc per second. This must be a positive number.
  - SCAN_LENGTH
    SCAN_LENGTH specifies the length of each scan in seconds of arc. This must be a non-negative number.
  - NUMBER_OF_SCANS
    NUMBER_OF_SCANS specifies the total number of scans to be taken. This must be a positive number. The default is 1.
  - /STEP_SIZE
    /STEP_SIZE=XXX specifies the latitudinal separation, in seconds of arc, between two adjacent scans. The default is 0, i.e., all scans (amount specified by NUMBER_OF_SCANS) will be repeated at the same latitude.
  - /OFFSET
    Initial scan offsets in seconds of arc. Both the longitudinal offset (i.e., the offset along the scan direction) and the latitudinal offset, or only the longitudinal offset can be specified as /OFFSET=(XXX,YYY), or as /OFFSET=XXX, respectively. The first scan will be taken from (XXX", YYY") off the source. The default for the longitudinal offset is (- SCAN_LENGTH / 2) and the default for the latitudinal offset is (- STEP_SIZE x (NUMBER_OF_SCANS - 1) / 2).
  - /POSITION_ANGLE If /POSITION_ANGLE=XXX is specified, scans will be taken along a position angle of XXX degrees, which is by convention measured from north through east. The default is 90 degrees, i.e., scans will be taken from west to east.
  - /ALTERNATE_DIRECTION
    If /ALTERNATE_DIRECTION is specified, every other scan will be taken in reverse.
  - /ALTAZIMUTHAL
    If /ALTAZIMUTHAL is specified, the altazimuthal coordinates will be used for scans. This is the default.

- /EQUATORIAL
  If /EQUATORIAL is specified, the apparent equatorial coordinates will be used for scans.
- /GALACTIC
  If /GALACTIC is specified, the Galactic coordinates will be used for scans.
- /SETTLING_TIME
  /SETTLING_TIME=XXX specifies the settling time in seconds, which is equivalent to the ramp up time for `OTF_MAP`. This can be shortened if the scan velocity (specified by SCAN_VELOCITY) is slow. The default is 10 seconds.
- /FOCUS_ADJUST
  If /NOFOCUS_ADJUST is specified, `XRASTER_SCAN` will not adjust the secondary mirror focus position. By default, the secondary mirror focus is adjusted at the beginning of each scan.
- /ROTATOR_ADJUST
  If /NOROTATOR_ADJUST is specified, `XRASTER_SCAN` will not adjust the instrument rotator position. By default, the instrument rotator is adjusted at the beginning of each scan based on the parallactic angle.
- /CANCEL: cancel XRASTER_SCAN.

• Y_POSITION

The `Y_POSITION` command allows the user to control the focusing of the secondary mirror, by moving it perpendicular to the optic axis. If an absolute position is specified, then auto-focusing is disabled. An offset can also be specified to be added to the stored focus curve.

- POSITION
  If this optional parameter is specified, it will be sent to the antenna computer and used as a fixed Y position. The antenna computer will not update the position.
- /OFFSET
  This qualifier allows you to specify a fixed offset which will be added to the value from the focus curve when the antenna computer updates the secondary position.
- /SET_OFFSET
  This qualifier, which should be used alone, is used to calculate the offset which should be applied to the focus curve. First one should find the best Y position, using the `Y_POSITION` command to send

the secondary to specific positions. Then when the focus is good, invoke `Y_POSITION` with this qualifier, and the offset will be calculated. Then invoke `FOCUS` with either the /STEALTHY_UPDATES or the /CONSTANT_UPDATES qualifier to tell the antenna to use the focus curve.

- **ZA**

  This routine sends a new zenith angle to the antenna computer. The command `ZA` automatically selects ALTAZ coordinates.

  – ZA: the new zenith angle to be sent to the antenna computer.

- **ZAO**

  This routine sends a new zenith angle offset to the antenna computer. It should be used rather than directly setting the offset (via `TOANTENNA`), since it also updates the status information in the VAX, so that the correct offsets can be written into the scan header.

  – OFFSET: the new zenith angle offset in arc seconds.

  – /FIXED: if specified, the fixed zenith angle offset (FZAO) will be modified.

  – /MAPPING: if specified, the mapping offset will be modified.

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