

Notes on the pickup noise that appeared in Bolocam starting in summer 2010

Jack Sayers
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1 Overview

In summer 2010, sometime between the June 1 mm run and the September 1 mm run, several narrow pickup lines in the Bolocam data streams became significantly enhanced during Bolocam observations. The result was a factor of a few increase in the RMS of the raw data streams (25 Hz bandwidth), which can be seen in Figure 1. The worst pickup line, by far, is located at $\simeq 4$ Hz and is therefore present in the downsampled data (5 Hz bandwidth). In general, all of the lines have always been present in Bolocam data, but at much lower amplitudes.

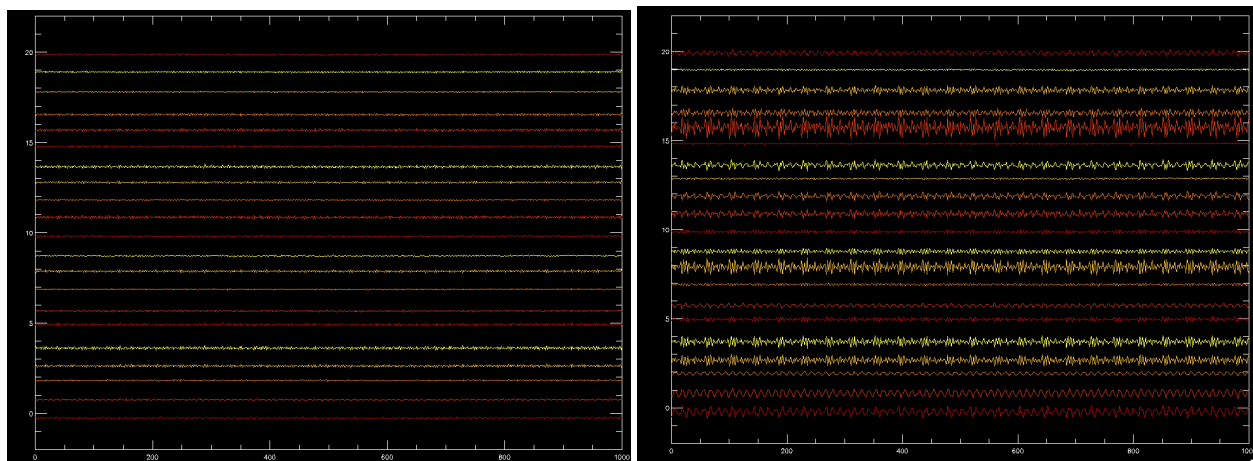


Figure 1: Left: Bolocam traces for 20 different bolometers taken from all 6 hexants in Feb. 2010. Right: the same bolometers in Oct. 2010.

2 October 2010 tests

JS and the CSO day crew performed a large number of tests in October 2010 when Bolocam was on the telescope for a 2 mm observing run. We were able to determine that the noise scales linearly with the bolometer resistance, and therefore is likely being sourced at the bolometer (see Figure 2). Additionally, we verified that there was no pickup noise on the bias monitors, eliminating the bias board as the source. We tried several things to eliminate this pickup noise (turning off all non-essential electronics, plugging all the electronics into a different UPS, ungrounding/regrounding electronics, turning off and unplugging various hexants, turning off the rotator motor, turning off the vac. pump, covering the receiver cabin opening with ecosorb, and probably some more things that I can't remember), but none had any effect on the noise.

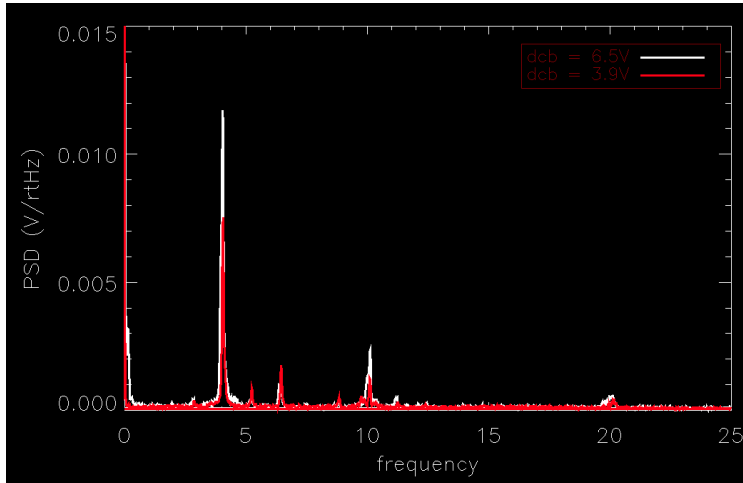


Figure 2: Timestream PSD for bolometer A18, which has a particularly strong 4 Hz pickup line. The white PSD is for data taken while looking at the sky with a DC bolometer voltage of 6.5 V, and the red PSD is for data taken while looking at the dome with a DC bolometer voltage of 3.9 V. Note that the overall scale of the PSD is wrong, and is off by a factor of a few.

JS developed a cleaning module, `pickup_noisefilt_module.pro`, to help filter this new pickup noise from the data. Currently, the module applies a fairly sharp low-pass filter to the data at 3.33 Hz, although JS plans to perform tests to further optimize this module. The module is not yet a part of the svn archive, but is located in the svn tree on kilauea. The filter is effective at removing the new pickup noise; we obtained typical sensitivities of 250 – 300 mJy- \sqrt{s} after application of this filter, compared to our historical average of $\simeq 200$ mJy- \sqrt{s} .

3 December 2010 tests

JS and SG went to the CSO in December 2010 to further debug this pickup problem immediately prior to the start of a 1 mm observing run. We first looked for the noise when Bolocam was in the Genie lift on the third floor of the CSO, using a single cable for hexant A from the e-box to the lockins (the other 5 hexants were not connected from the e-box to the lockins). The digitized traces on Andante showed no evidence of the enhanced pickup noise. Note that the DC bolometer voltage was $\simeq 1.5$ V with Bolocam looking at a mirror, and therefore the pickup noise should have been lower compared to the previous 2 mm data, but still easily measurable.

We then mounted the cryostat on the optics box, ensuring that the electrical connection between the cryostat on the telescope was an “open line” prior to connecting any cables. We then cabled the cryostat identically to how it was cabled on the third floor. Once Bolocam was mounted on the optics box, the pickup lines returned to the data with the expected amplitude based on the October 2010 measurements, indicating that something is fundamentally different with the environment at the back of the telescope compared to the third floor. We then set the bias amplitude to 0 V and recorded bolometer data pre-lockin using a spectrum analyzer (see Table 1). We found strong pickup lines at/near 120 Hz and at/near 240 Hz, which we assume are sourced by rectified 60 Hz (UPSs?). In particular,

frequency	amplitude	frequency	amplitude
60.0 Hz	38 $\mu\text{V}/\sqrt{\text{Hz}}$	121.1 Hz	750 $\mu\text{V}/\sqrt{\text{Hz}}$
102.0 Hz	25 $\mu\text{V}/\sqrt{\text{Hz}}$	122.3 Hz	65 $\mu\text{V}/\sqrt{\text{Hz}}$
108.0 Hz	22 $\mu\text{V}/\sqrt{\text{Hz}}$	123.5 Hz	325 $\mu\text{V}/\sqrt{\text{Hz}}$
109.2 Hz	25 $\mu\text{V}/\sqrt{\text{Hz}}$	124.7 Hz	90 $\mu\text{V}/\sqrt{\text{Hz}}$
110.4 Hz	40 $\mu\text{V}/\sqrt{\text{Hz}}$	126.0 Hz	75 $\mu\text{V}/\sqrt{\text{Hz}}$
110.9 Hz	25 $\mu\text{V}/\sqrt{\text{Hz}}$	128.3 Hz	30 $\mu\text{V}/\sqrt{\text{Hz}}$
111.6 Hz	75 $\mu\text{V}/\sqrt{\text{Hz}}$	179.9 Hz	52 $\mu\text{V}/\sqrt{\text{Hz}}$
112.0 Hz	110 $\mu\text{V}/\sqrt{\text{Hz}}$	233.9 Hz	25 $\mu\text{V}/\sqrt{\text{Hz}}$
113.7 Hz	38 $\mu\text{V}/\sqrt{\text{Hz}}$	235.1 Hz	17 $\mu\text{V}/\sqrt{\text{Hz}}$
114.0 Hz	31 $\mu\text{V}/\sqrt{\text{Hz}}$	236.3 Hz	15 $\mu\text{V}/\sqrt{\text{Hz}}$
116.3 Hz	90 $\mu\text{V}/\sqrt{\text{Hz}}$	238.7 Hz	280 $\mu\text{V}/\sqrt{\text{Hz}}$
117.5 Hz	40 $\mu\text{V}/\sqrt{\text{Hz}}$	239.9 Hz	120 $\mu\text{V}/\sqrt{\text{Hz}}$
118.7 Hz	190 $\mu\text{V}/\sqrt{\text{Hz}}$	241.1 Hz	15 $\mu\text{V}/\sqrt{\text{Hz}}$
120.0 Hz	450 $\mu\text{V}/\sqrt{\text{Hz}}$	300.3 Hz	20 $\mu\text{V}/\sqrt{\text{Hz}}$

Table 1: Measured spectral lines for bolometer A18 pre-lockin. The white noise level on the sky is approximately $5 - 10 \mu\text{V}/\sqrt{\text{Hz}}$.

the pickup lines just above 120 Hz appeared to be the source of the noise in our bolometer data. To confirm this assumption, we changed our bias frequency from 130 Hz to 140 Hz and digitized more data on Andante. All of the lines moved by 10 Hz, and the digitized band from 0 – 10 Hz was completely free from lines, confirming that the noise source is the lines just above 120 Hz.

4 Planned solution

As a long term solution, we plan to change the Bolocam bias frequency from 130 to 140 Hz. This change will involve not only adjusting the bias frequency, but also adjusting two band-pass filters on the bias board. JS and SG did not make this change in December 2010 due to: 1) limited time available to change the band-pass filters, 2) the effectiveness of the digital filtering developed by JS, and 3) the fact that neither JS nor SG would be available to closely inspect the subsequent 1 mm data. JS will make the change prior to the next 2 mm Bolocam run, when he will be present to closely inspect the incoming data (and revert to 130 Hz if there are any major problems).