This document describes the proceedure for bootstrapping RCW38 and IRAS12073-6233 calibrations from the Mars raster scan.

Contents

1 Motivation

During the May 2008 APEX-SZ observing run Mars, our primary calibrator, set 8:00pm local time. This did not provide us with a guarenteed calibrator each night. We decided to use stable HII regions as our calibrators for this run. This required us to perform a raster scan on Mars followed by a raster on both RCW38 and IRAS12073-6233 on at least one night. We did this on the 24^{th} of May.

2 Bootstrapping

We calculate the calibration parameters from the original Mars scan. This uses the both the brightness temperature and radius of Mars measured at 150GHz *http://www.jach.hawaii.edu/jac-bin/planetflux.pl*. The ratio between the expected sky power and the amplitude of the measured signal from the calibrator source gives the sky power to adc count conversion. The expected sky power is the difference between the total source power and the power emitted from the CMB, adjusted by an integration factor which accounts for the radial size of the source compared to our gaussian beams.

Using the calibrations from Mars, we can measure a secondary source calibrator temperature. Assuming the radial profile of the secondary calibration source is does not change, we set the radial size integration factor to 1 for each channel (essentially assumes that the source is much larger than our beams). This bootstrapped temperature and radial size integration factor for the secondary source calibrators can be used for later calibrations.

2.1 Amplitude Fitting

Our two secondary calibrator sources are both extended, significantly dimmer than Mars, and have a non-gaussian radial profile. The signal from these sources have amplitudes comparible in size to glitches, which appear randomly in the data. Proper processing must be applied to the timestreams to select the true signal amplitude necessary for the source temperature calculation and subsequent calibration conversions. We acheive this by loading the most recent Mars beam parameter data, flagging optically dead and railed channels, then flagging a 3' region, centred on the source coordinates. We then filter the timestream data by removing a flagged second order polynomial and a first order spatial template. Any data outside the flagged region is then set to zero to reduce the probably of large amplitude glitches in the data. A gaussian is fit to the maximum point in the timestream and the resulting amplitude is set as the beam amplitude.
The non gaussian profile of the calibrator can effect the fit, so we've implemented a recursive fitting method which will calculate the reduced chi square of the gaussian fit. If the reduced chi square is above some threshold, the region in which the gauss function is fit is reduced and a new fit is made. After ten iterations, if the reduced chi square threshold is not reached, the signal amplitude is set to 'not a number' and no calibration conversions are calculated for this channel.

3 Stability of Beam Sizes

This bootstrapping method for the temperature calibration is unable to measure beam parameters, other than amplitude. To gain beam information, such as offsets, and beam full-width-half-maximums, we use the beam parameters measured for the most recent mars calibration. This is acceptable if we know that the beam parameters do not change much over time. To check this, we look at beam parameters measured from four different Mars raster scans, each from a different observing run. Scan 5656 was chosen for the April 2007 observing run, scan 28940 from the August 2007 run, scan 52500 from the December run, and scan 17680 from the May 2008 observing run. Quantitativly we can see that the measured FWHM of the beams as a function of distance from the centre of the focal plane remain similar throughout each observing run. Focusing on the reference channel, the x and y offsets are stable within 6 arcseconds and the FWHM are both stable within 3 arcsecs

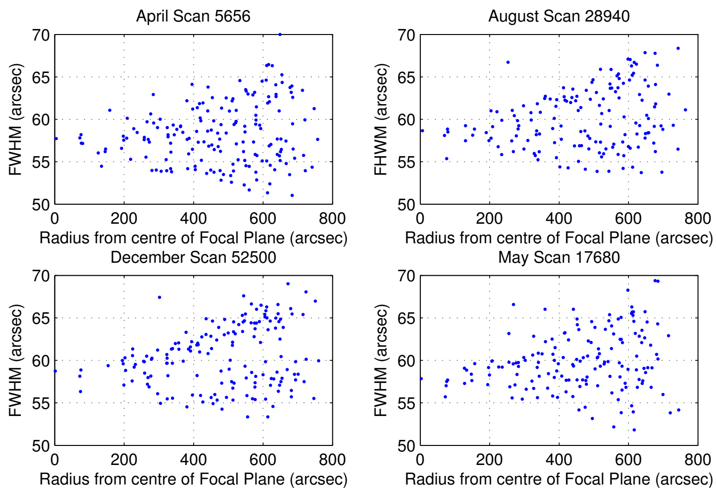

Figure 1: The measured FWHM as a function for radial distance from the focal plane centre.

4 Example: RCW38

The RCW38 scan 17687 and beam parameters from measured from the Mars raster scan 17680 are used to calculate a temperature for RCW38. The adc_pw_sky conversion calculation is

$$skypower/adc = RSF * (P_\nu(\nu_o, T_{source}) - P_\nu(\nu_o, T_{cmb})) * \Delta\nu/amp \tag{1}$$

Where $P_n u = 2 * h * \nu/(exp^{h\nu/kT} - 1)$ and is the power density per mode per hertz. The RSF is the radial size integration factor, $\Delta\nu = 30GHz$ is the bandwidth, $\nu = 150GHz$ is the observing frequency and amp is the source signal amplitude. This is rearranged to calculate the source power density per mode per hertz

$$P_\nu(\nu, T_{source}) = (skypower/adc) * amp/(\Delta\nu * RSF) + P_\nu(\nu_o, T_{cmb}) \tag{2}$$

From which the effective source temperature can be calculated. This temperature is calculated for each non-flagged channel. To reduce the effect of

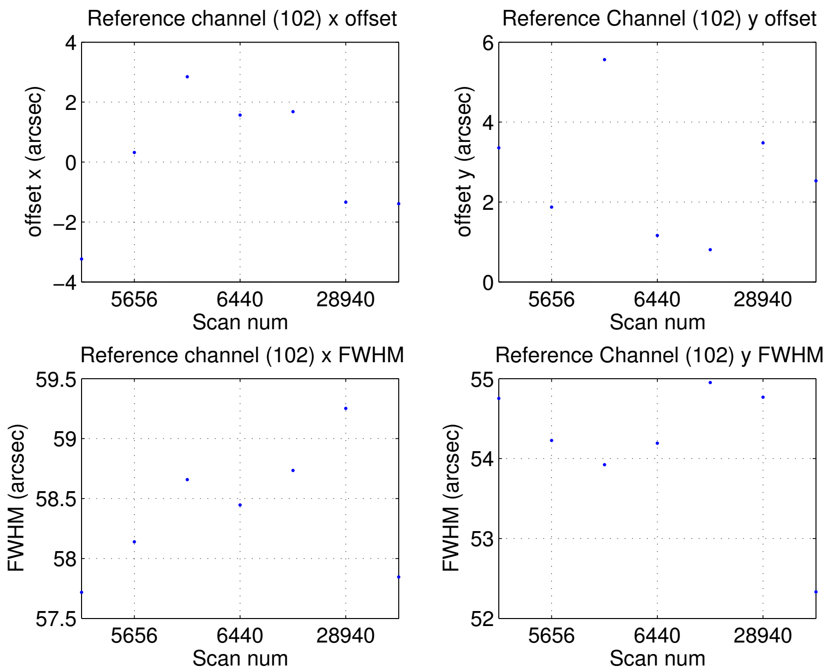

Figure 2: The measured beam parameters for reference channel 102.

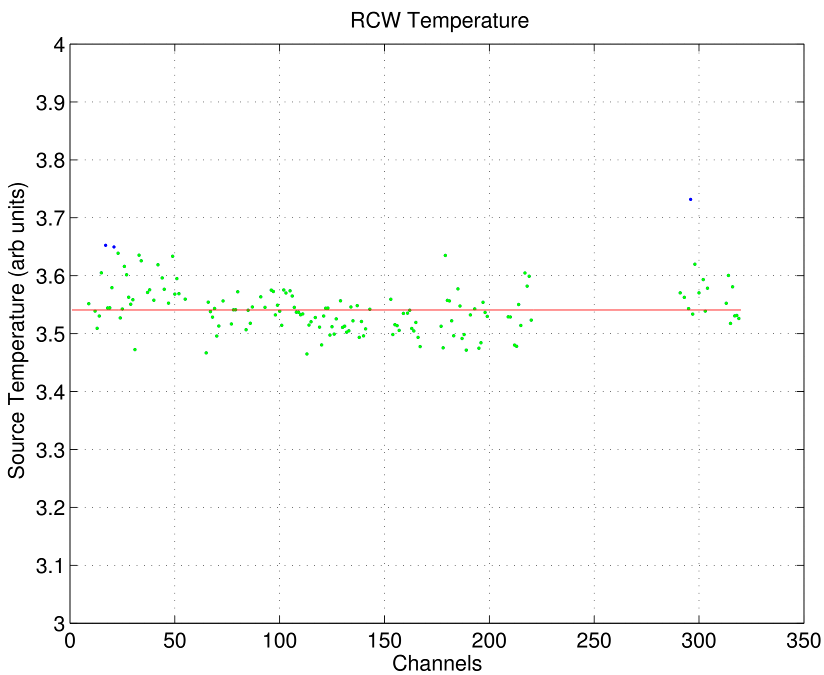

Figure 3: The bootstrapped source temperature for each good channel.

outliers on final source temperature, the values within one standard deviation of the mean are averaged. The measured temperature is 3.541K

To test this bootstraping method, we have calculated calibration conversion factors using the bootstrapped RCW38 temperature from May 24^{th} and a source radius of -1 which indicates that the radial size is larger than the beam size. We've used a secondary_source_calibration function which applies the special filtering described above on a raster scan of RCW38 taken on April 6^{th} 2007 and compared the results with the measured calibration conversion factors from the Mars scan taken on the same day. The adc to temperature conversions are plotted with the original Mars calibration adc to temperature conversions. The relative error is calculated for each channel. This method reproduces the Mars calibration conversions to less than 5% error.

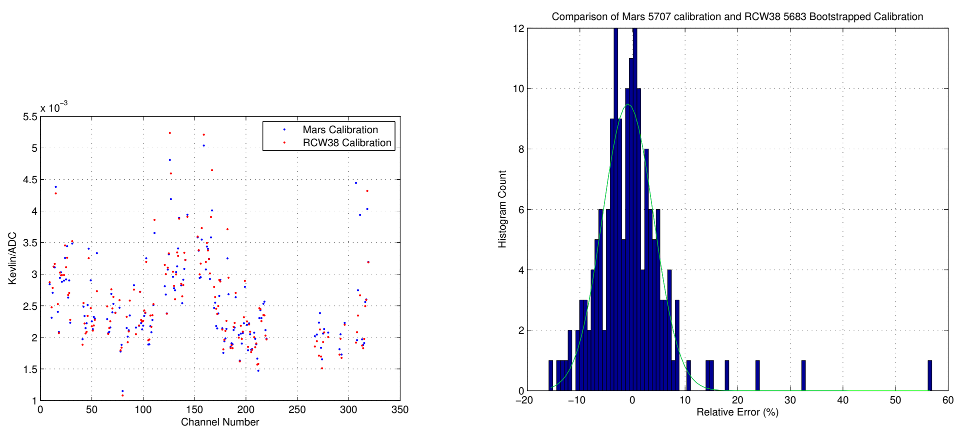

Figure 4: Left: The channel-by-channel Kelvin per adc count conversion factors, measured using Mars and RCW38. Right: A histogram of the channel-by-channel relative differences. The green line is a gaussian with sigma = 4.8

5 Implementation into the Pipeline

The discussed method of bootstrapping can be implemented into the pipeline with little disturbance to the common user.

The bootstrapped temperatures for the secondary calibrators can be written into a source parameter file like what we have for Mars. The angular size column can be set to -1 indicating that the radial source is much larger than the beam size.

A new fuction secondary_calibrator_sourcecal.m has been written to load in the previous day's beam parameters, filter the timestreams, and perform the beam amplitude fitting. The szd structure is then passed to the gauss-beamcal to measure the flux parameters.

the secondary_calibrator_sourcecal function can be added to our top-level sourcecal function which writes the beam and flux parameters to a .dat file.