

20 Meter Calibration

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Python programs were utilized to calibrate the 20 meter telescope at NRAO's Green Bank, WV site. Located in the 20mops user account on pork, the following programs and files are used:

20mcalnew.py	Executable program used to calibrate each scan
cal_functions.py	Source of functions for 20mcalnew
Cal_OnOff_log.txt	Output of 20mcalnew.py
Cal_freqrange.txt	Text file of output for ranging frequencies
LCP_calibration.txt	Lab data for left polarization
RCP_calibration.txt	Lab data for right polarization

All calibration scans were performed as track scans ranging from 60-90 seconds.

[Latest Skynet Data: 19h02m44s](#)

[2D](#) - [3D](#) - [L](#) - [R](#) - [Ascii](#) - [FITS L](#) - [FITS R](#) - [Latest](#) - [Log](#)

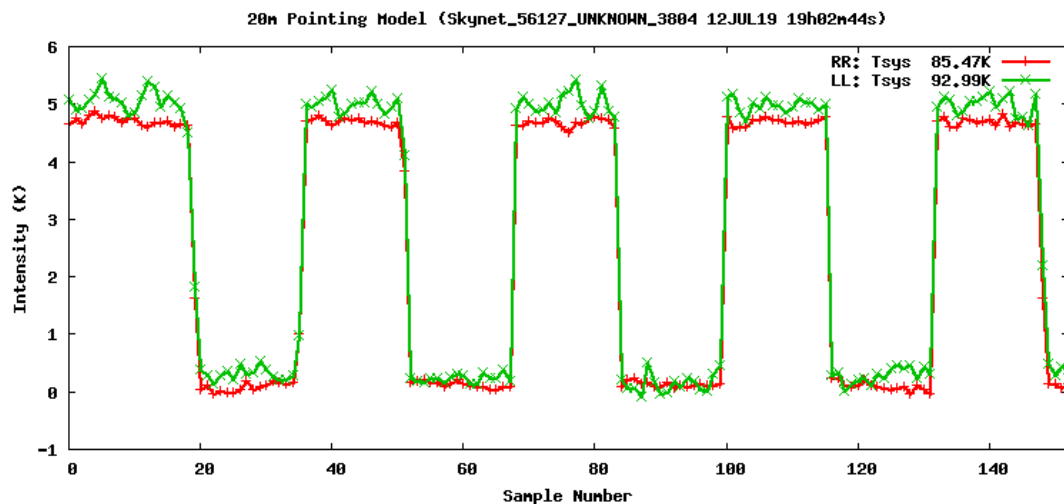


Figure 1: Example Calibration Scan.

There are multiple ways to initiate a calibration scan.

- Command line: In pork, type:
CyborgSignals #
Where # corresponds to the number of seconds the cal signal is on or off.

- Skynet Radio Client Interface (Manual Control): This requires the use of the scripting tab.


```
## For taking a single calibration scan
cyborg.centerFrequency=9000.
cyborg.callInterval = 4.
cyborg.targetName ="CalOnOff"
az = 180. #Azimuth in decimal hours
el = 88. #El in decimal degrees
Zenith = Location(CoordType.AZ_EL, az, el)
scanDuration=90
```
- Skynet Website:
 - User has option to change the sky frequency at Step 4 of 'Add Observation'

Calibration Method

It was desired to convert the input of counts into Kelvins and/or Janskys. For this purpose, the Lab Data were taken in the range of 8000 – 10000 MHz under the following conditions:

"Receiver is cold and mounted in the outdoor test building. Weather: Clear
 Used 300K absorber in roof, and 8K cold sky
 Uses older cryo amp (S/N 15), with input LNA
 Measurement uses receiver, optical links, downconverter box, with pwr meter on output of down converter"- Steve White. March 13th, 2012

The data processing was performed in approximately 3 steps:

1- Initial Estimates- The data was first sorted according to numerical value. The top tolerance level and the bottom tolerance level were excluded from the data set for further processing. The default tolerance level is 5% but can be easily changed. Removing the 10% of data effectively removes outlying points and helps achieve a greater accuracy. A rough average of the high values and the low values were obtained to get an approximate height (sometimes called a jump or step) of the calibration signal. This was done separately for each polarization. Take Figure 1 as an example. The estimated height for this is ~4.8.

2-Step by Step- The next part of the program contains a loop that looks for a difference of at least 85% of the initial estimate from one data point (i) to the fourth next (i+4) data point. This does a good job of extracting all the steps within the data as long as the data is not overwhelmingly noisy or against a very steep baseline. The program uses the locations of the steps to split the data into many smaller arrays to average over.

Latest Skynet Data: 19h02m44s

2D - 3D - L - R - Ascii - FITS L - FITS R - Latest - Log

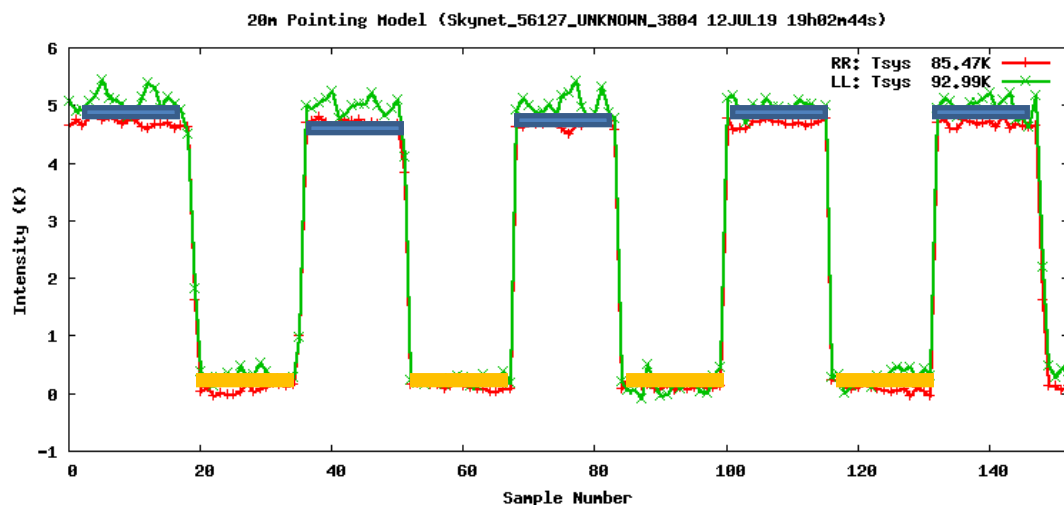


Figure 2: Calibration scan from Figure 1. The blue lines represent the smaller arrays that are averaged to find all the 'high' and 'low' values.

After the average value was found for each of the smaller arrays, each step's height was calculated. In the above figure 7 steps were found. The value of the i^{th} step was calculated according to the following equations.

$$\text{Jump Height} = \frac{Up(i) + Up(i + 1)}{2} - Down(i)$$

$$\text{Next Jump Height} = Up(i) - \frac{Down(i) + Down(i + 1)}{2}$$

Where 'Up' refers to the value of the median of the cal on signal (blue lines in Fig. 2) and 'Down' refers to the value of the median of the call off signal (orange lines in Fig. 2). This method effectively accounts for any slanted baseline in a calibration scan.

Latest Skynet Data: 18h21m41s

2D - 3D - L - R - Ascii - Latest - Log

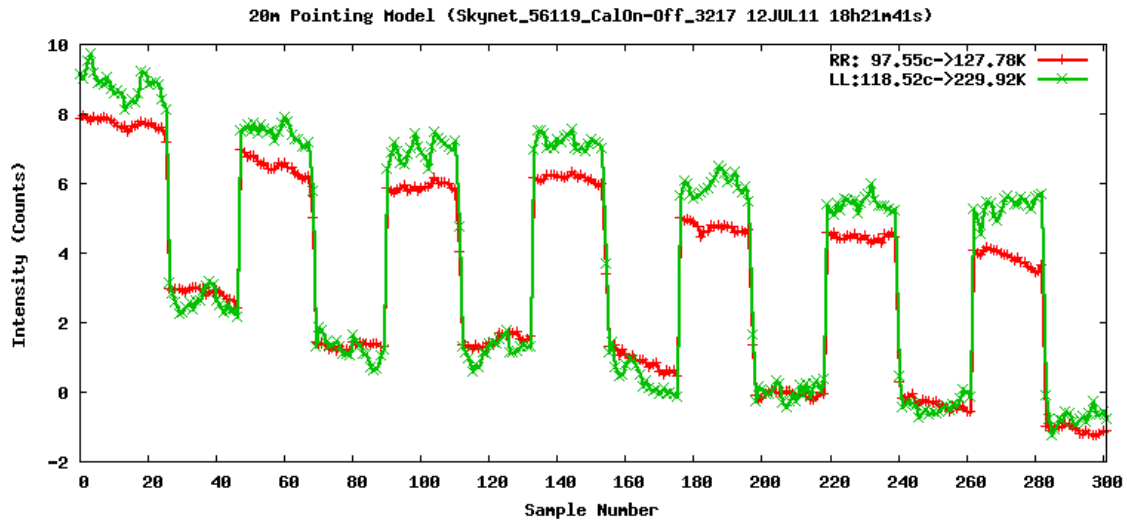


Figure 3: Example calibration scan with slanted baseline

3-Comparing lab data- The observing frequency is found in the header. The file searches for lab data at that frequency and returns the Kelvin value. If the frequency is between 8000 and 10000 MHz but not an exact lab match the Kelvin value gets interpolated from the two nearest points. If the scan is below 8000 MHz, or above 10000 MHz the lab data for 8000 or 10000 is used. That is, there is currently no extrapolation of the lab data.

Output- The format of the output is as follows:

```
10000 56134 20804 0213 108.0 86.71 0.839 0.112 0.840 0.055 0.836 0.019 0.835 0.022
```

Observing Frequency, 5 digit date ID, UTC time, scan ID number, Left System Temperature, Right System Temperature, initial guesses: Left Kelvin/count, Left std. dev. ,Right K/count, Right std.dev., 'Best cal values:' Left K/c, Left std., Right K/c, Right std.

The last four numbers reported after "initial guesses:" refer to the initial jump height estimates used to get the newer values.

Data Processing

In order to calibrate an astronomical object, a program called "GLEN I DON'T KNOW" searches for the most recent calibration values at the same frequency. The calibration is performed automatically and the data is displayed on the 20m website here: <http://www.gb.nrao.edu/20m/peak/latest/>.

Note: the temperature displayed on this graph is not meant to reflect actual temperature of the source. It is merely the temperature gain experienced by the telescope when viewing that location in the sky.