KFPA IDL Prototype Pipeline Description

Joe Masters

April 21, 2010

Abstract

The purpose of this document is to describe the IDL KFPA Pipeline code provided by Glen Langston for the purpose of calibration and imaging multi-beam, K-band datasets from the Green Bank Telescope.

In particular, this description applies to github commit #a26a9777b9, which is installed in /home/sandboxes/kfpa_pipeline (since 2010-04-14), but it also applies to the original pipeline code supplied by Glen.

All descriptions below apply to a single spectral band (IF), feed and polarization. The pipeline, however will process all bands, feeds and polarizations in an map.

A map consists of a reference scan, followed by one or more mapping scans, followed by a second reference scan.

1 Avegerage elevation and system temps for reference scans

For each reference scan we:

1. Average the CALON and CALOFF integrations as:

$$CAL_{ave} = (CALON_{ave} + CALOFF_{ave})/2 \quad (1)$$

where $CALON_{ave} = (\sum_{i=0}^{n} i_{CALON})/n$ and $CALOFF_{ave} = (\sum_{i=0}^{n} i_{CALOFF})/n$.

2. Average the elevation for all CALON integrations.
3. Compute the total exposure time for all CALON integrations.
4. Compute T_{sys} as:

$$T_{sys} = avg(CAL_{ave}[80]/(CAL_{diff})[80]) * TCAL_{mean} \quad (2)$$

where [80] represents the center 80% of the bandpass and $TCAL_{mean}$ is the average off all CALOFF TCAL values for the scan.

2 Average cals over all map scans

For the full block of map scans we difference the CALON and CALOFF integrations as:

$$CAL_{diff} = CALON_{ave} - CALOFF_{ave} \quad (3)$$

3 Compute zenith opacity tau (τ)

Next we retrieve the archived τ prediction for date and frequency using Ron Maddalena's *getForecastValues* script, installed only in his home directory in Green Bank.

4 Smooth and remove T_{sky} from refs and map CAL_{diff}

Smoothing of the averaged spectra and the averaged map block spectra are performed as follows:

1. Smoothing the averaged difference of CAL states (CAL_{diff}):

   (a) median smoothing applied to remove narrow band RFI, with a filter of size **5** channels.

   $$CAL_{ave\_median} = median(CAL_{ave}, 5) \quad (4)$$

   (b) Savitzky-Golay smoothing is further applied.

   $$CAL_{ave\_savgol} = savgol(CAL_{ave\_median}) \quad (5)$$

   (c) Convert to units of K/Count:

   $$cal_{k/count} = TCAL_{mean}/(CAL_{diff})[80] \quad (6)$$

(d) Savitzky-Golay smoothing with different parameters is again applied to band edges.

$$CAL^*_{ave\_savgol} = CAL_{ave\_savgol} * cal_{k/count} \tag{7}$$

(e) Boxcar smoothing is applied to the spectrum to reduce effects of joining previous two Sav-Gol filters.

where [80] represents the center 80% of the bandpass and $TCAL_{mean}$ is the average off all CALOFF TCAL values for the scan.

2. Smoothing the average of CAL states (CAL_{ave}):

   (a) median smoothing applied to average of reference spectrum integrations to remove narrow band RFI, with a filter of size **5** channels as in equation (4).

   (b) Savitzky-Golay smoothing is further applied as in equation (5).

3. Convert smoothed CAL_{ave_savgol} to K/count units as in equations (6) and (7).

4. Determine sky temperature contribution to spectrum (T_{sky}). This is dependent upon the observed frequencies and date of observation.

5. Subtract T_{sky} contibution from CAL_{ave_savgol} and median smooth (cell size **11**).

$$CAL^*_{ave\_savgol} = median(CAL_{ave\_savgol} - T_{sky}, 11) \tag{8}$$

5 Apply gain correction to all map integrations

1. Gather UTC times from reference scans to later be used for interpolation.

2. For each scan and each integration:

   (a) Get the frequency range of each channel.

$$freq_{start} = CALON.observed_frequency + ((0 - refChan) * delChan) * 1.E{-}6 \tag{9}$$

$$freq_{end} = CALON.observed_frequency + ((nChan - refChan) * delChan) * 1.E-6 \quad (10)$$

(b) Get opacity tau (τ)

(c) Determine sky temperature contribution to integration (T_{sky}).

(d) Correct for opacity per channel

(e) Average CALON and CALOFF (CALONOFF)

(f) Compute and interpolated reference from the two reference scans and also interpolate T_{sys}. ($ref_{interp.}$)

(g) Update inegration spectra.

$$CALON(\nu) = opacity(\nu) * ((CALONOFF * CAL_{diff}) - (T_{sky}(\nu) + ref_{interp.})) \quad (11)$$

(h) Update T_{sys}

$$CALON(\nu).tsys = CALON[80] + T_{sky}[mid] + CAL_{diff}.tsys \quad (12)$$

3. Convert to AIPS friendly format (idlToSdfits) and image.