Clipping Correction Task Performance

Ed Polehampton, August 2011

Before launch, Dominique did a study into the effectiveness of the clipping correction task (see the Phase 2 FTS Scientific Validation Report, SPIRE-RAL-DOC-003216, Feb 2009). The recommendation from that report that has been propagated to the Pipeline Description Document (SPIRE-BSS-DOC-002966) was:

"*Ground based tests from the PFM4 test campaign have shown that a clipped signal of 40% of the theoretical peak (i.e. 60% of signal amplitude is left over) corresponds to four clipped samples (at ZPD) and to eight clipped samples (for secondary peaks) per scan. In this case, the restored signal has an RMS error of 2%-3% of signal amplitude at ZPD. That corresponds to less than 1% RMS error on the final reconstructed spectrum continuum. The same tests showed that a clipped signal that results in an 80% reduction of the ZPD amplitude results in an RMS error of up to 6% on the reconstructed interferogram signal.*"

and in the SPIRE Data Reduction Guide:

"*The clipping correction task has been shown to work well reconstructing these clipped samples when the number of consecutive samples is less than 3. The error introduced to the reconstructed interferogram in this case (for 2-3 consecutive clipped points) is ~2%. These errors affect the total power and overall shape of the spectrum. If more than 3 consecutive samples are clipped, the data should be treated with caution, and possibly excluded from the final map. More than 3 consecutive clipped samples should only happen for the brightest sources (e.g. sources of 100s-1000s Jy observed in the nominal mode), but is more likely in jiggled observations for the reasons described above.*"

The following code example from the DRG determines the number of consecutive clipped samples from an SDI product:

```
for scan in sdi.scanNames:
     for detector in sdi[scan].channelNames:
        clippedSamples = sdi[scan][detector]['mask'].data\
                              .where(SpireMask.TRUNCATED).toInt1d()
        clippedSamples.append(0)
        diff = (clippedSamples.where(\
                          clippedSamples-SHIFT(clippedSamples,1) != 1)).toInt1d()
        consecutiveSamples = (diff-SHIFT(diff,1))[1:]
```

Effect of Clipping on the Final Spectrum

In order to check the effect of the clipping reconstruction on the final spectrum, an unclipped set of scans from one of the Orion Bar mapping observations was used. The observation was 0x50003A2D. The fourth scanning building block (0xa1060004) was used as the centre detectors were not already clipped.

In order to simulate clipping, the level-0.5 data were manually truncated at ZPD and the mask bit set to show that those samples were truncated. Different levels of truncation were applied and the pipeline was run with and without the clipping correction task to see the effect on the final spectrum.

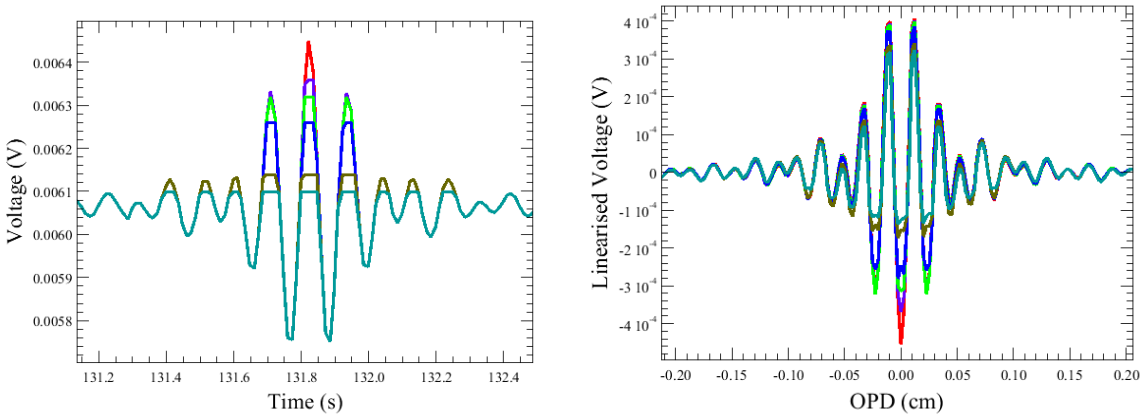

Figure 1: SSWD4 detector timeline showing the clipping, and uncorrected Interferogram after the createInterferogram task.

SSWD4

Colour in plots	Clipping voltage	Consecutive points clipped	Clip corrected		Not clip corrected	
			% out of band power	Ratio with unclipped spectrum	% out of band power	Ratio with unclipped spectrum
Red	none	[0]	4.6	1.000	4.6	1.0
Purple	0.00636	[2]	4.6	1.000	20.8	0.83
Green	0.00626	[1,2,1]	4.6	1.000	27.7	0.69
Blue	0.00614	[2,3,2]	4.6	0.998	39.5	0.32
Brown	0.00610	[4,4,4]	4.8	0.979	71.6	-0.70
Turquoise	0.00607	[2,3,3,4,4,4,2,3,3]	5.1	0.972	82.4	-1.15

SLWC3

Colour in plots	Clipping voltage	Consecutive points clipped	Clip corrected		Not clip corrected	
			% out of band power	Ratio with unclipped spectrum	% out of band power	Ratio with unclipped spectrum
Red	none	[0]	2.4	1.000	2.4	1.0
Purple	0.00579	[2]	2.4	1.000	5.7	0.92
Green	0.00594	[2,5,1]	2.4	0.998	29.6	0.30
Blue	0.00600	[4,5,3]	2.4	0.998	41.2	0.09
Brown	0.00612	[6,7,6]	2.4	0.985	57.7	-1.03
Turquoise	0.00616	[4,6,7,6,3]	2.4	0.984	67.9	-1.37

The percentage out-of-band power was calculated from the QC parameter which records the ratio of the mean signal out-of-band to in-band. These ratios were multiplied by the ratio of the bandwidths to convert to power, and added together for below and above the band.

The ratio with the unclipped spectrum was calculated by taking the sum over the whole band.

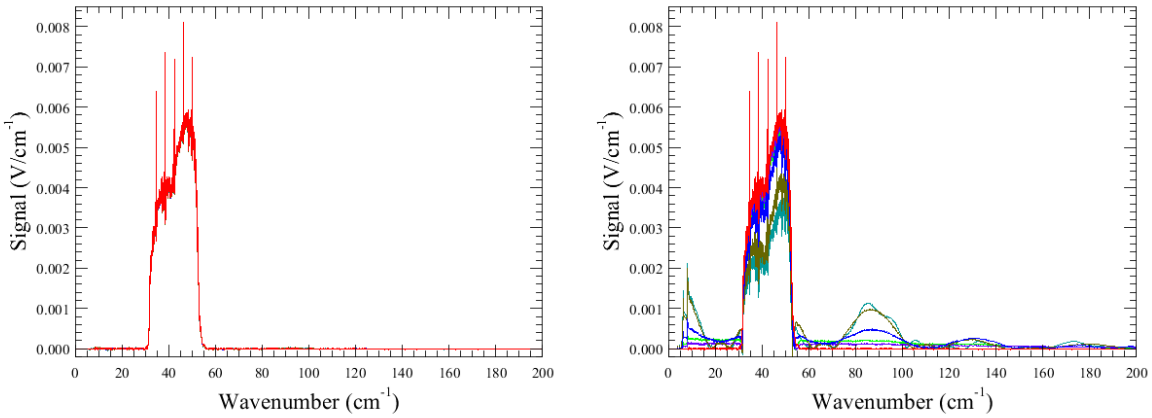

Figure 2: SSWD4 spectrum over the full range showing out of band signal, corrected with the clipping task (left) and uncorrected (right).

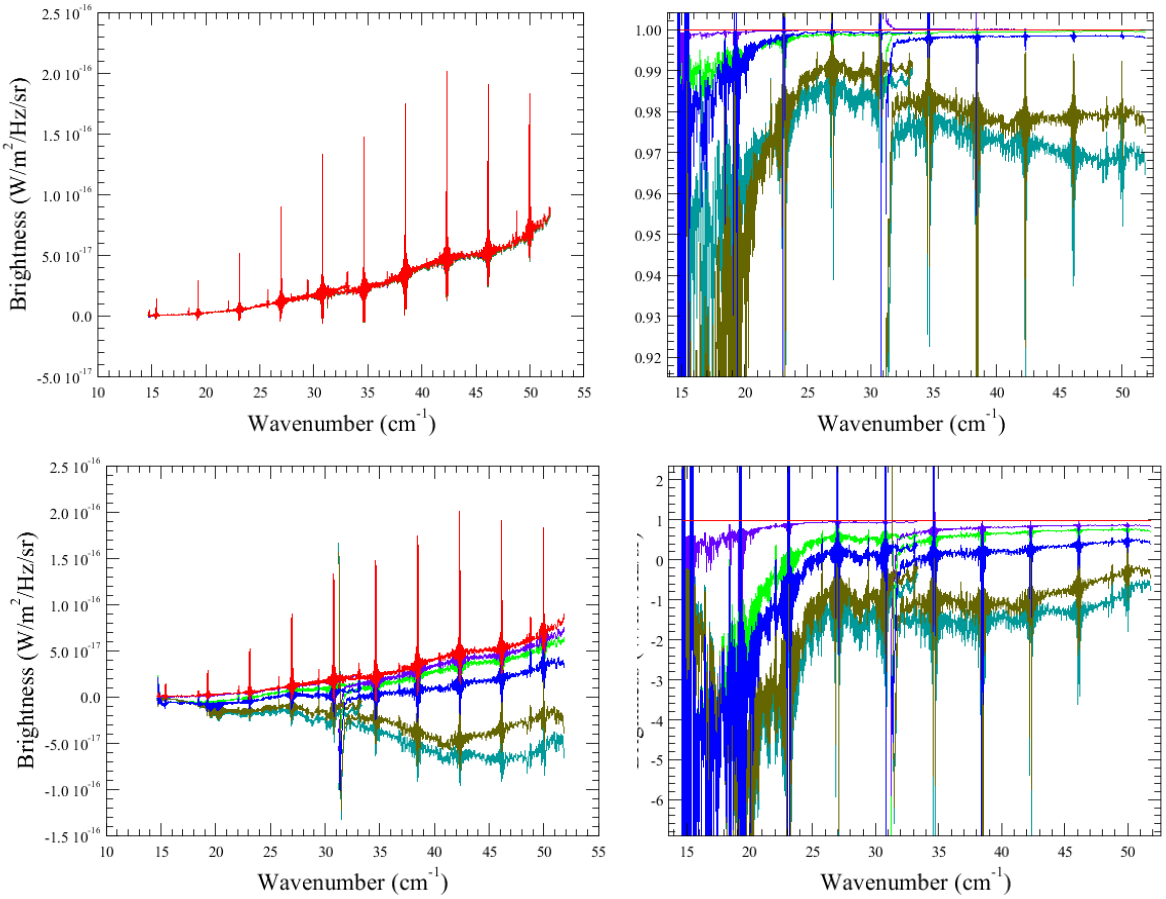

Figure 3: Spectrum corrected with the clipping task (above) and without correction for clipping (below). The plots on the right show the ratio with the unclipped spectrum.

The results show that the clipping correction task is doing a very good job at reconstructing the interferogram, even up to quite severe truncation levels. When only the central lobe at ZPD is clipped, and a few points of the first sidelobes, the spectrum only changes by much less than 1% (except at low wavenumbers in SLW where the signal is very low). Severe clipping of the two adjacent sidelobes can still be corrected to ~3% in the final spectrum.