Using Pulse Cal tones for Calibration

- A (very brief) overview of some exploration I've done in using pcal tones for calibrating an L-band VLBA dataset with lots for RFI
- Reminder that arbitrary length FFTs are now supported in DiFX (though not widely tested yet)
- If any of this piques your interest, feel free to contact me to discuss further

Pulse cal tone extraction in DiFX

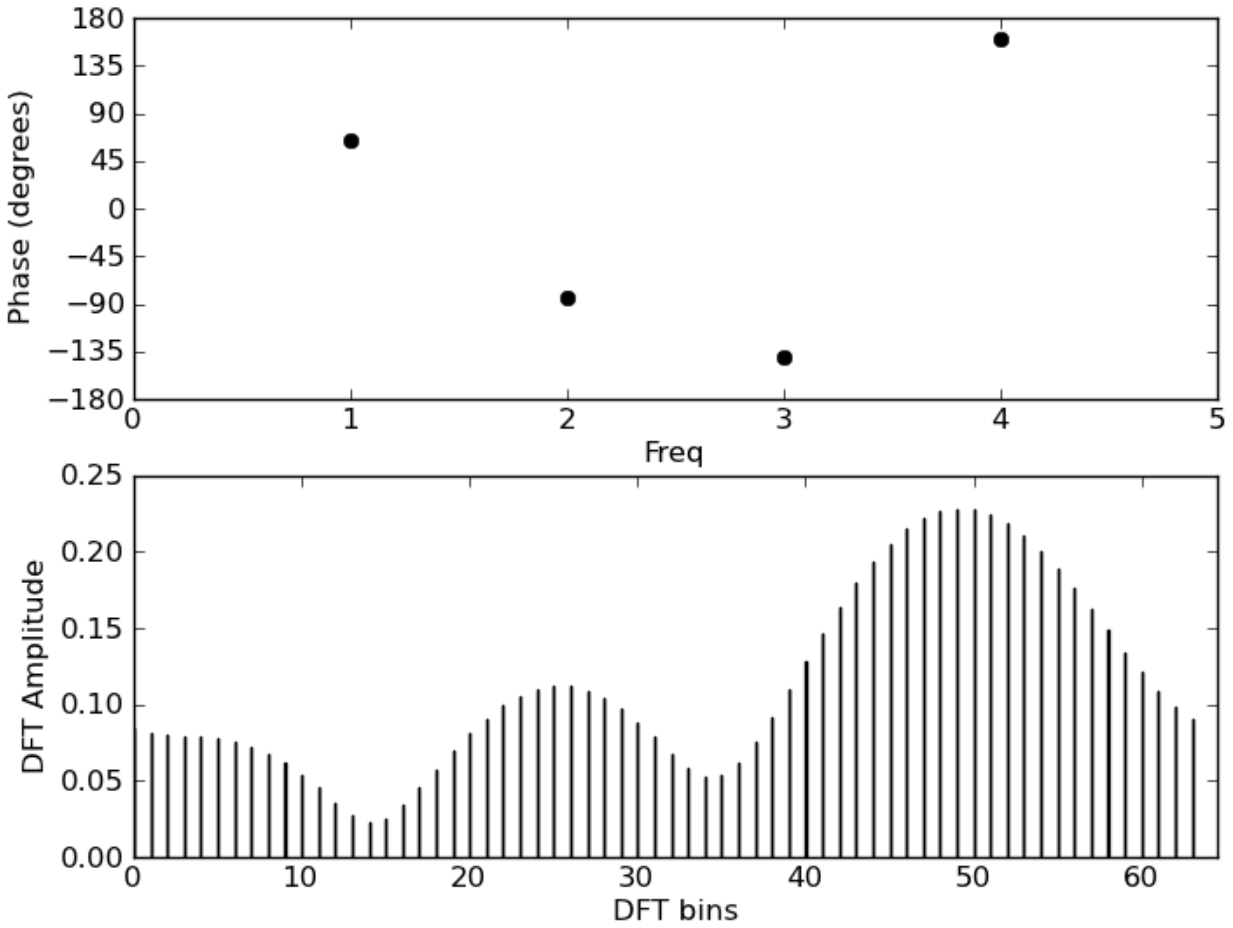
- This is working more or less reliably now

- For critical applications (e.g. geodesy) we recommend archiving the .difx/ output
  - since almost all bugs discovered are in difx2fits/difx2mark4

Creative use of pcal tones 1: Multiple tones

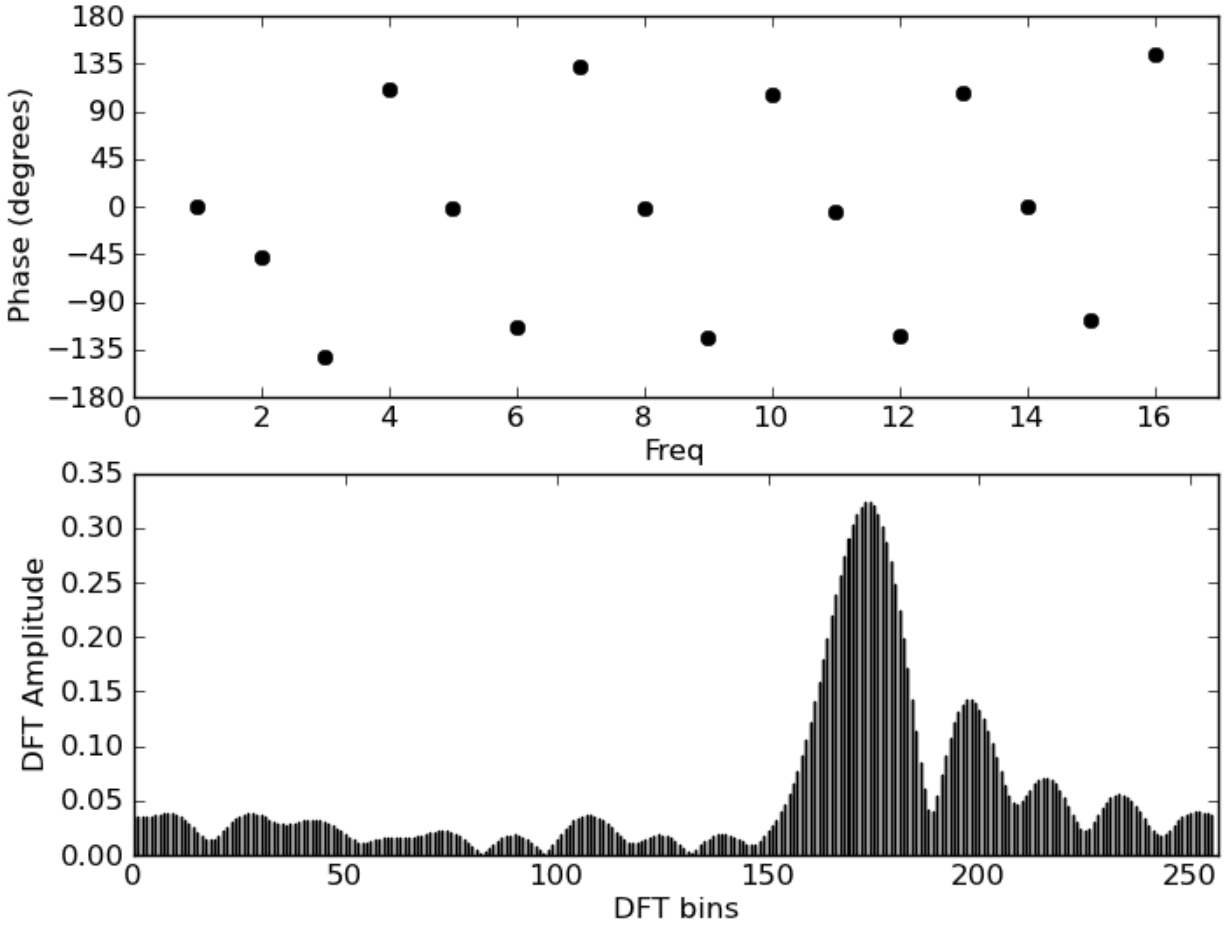
- DiFX extracts tones right across the bandpass
- Using all (i.e. more than two) of these tones has two advantages
  - Resolves ambiguities to the 1us level (for 1MHz tone spacing)
    - Good enough to resolve ambiguities between sub-bands on every dataset I've tested on.
  - Higher signal to noise
    - Allows very short integration time where necessary

4 tones, 1 second integration



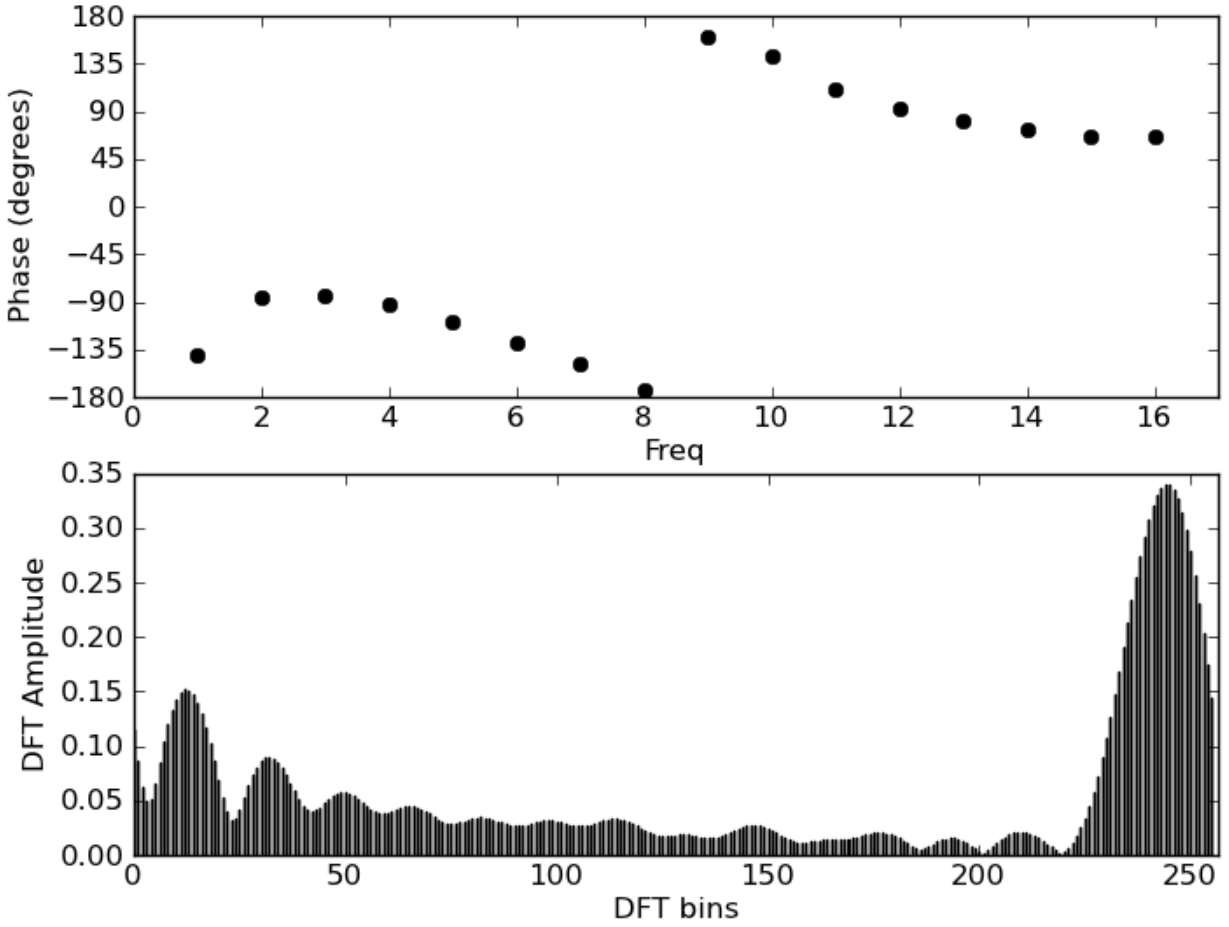
Good solution with just 4 tones (1s integration)

16 tones 0.05 s integration!



Using the two outer tones is clearly not the best strategy!

Pcal for Bandpass



2nd order phase effects clearly visible.

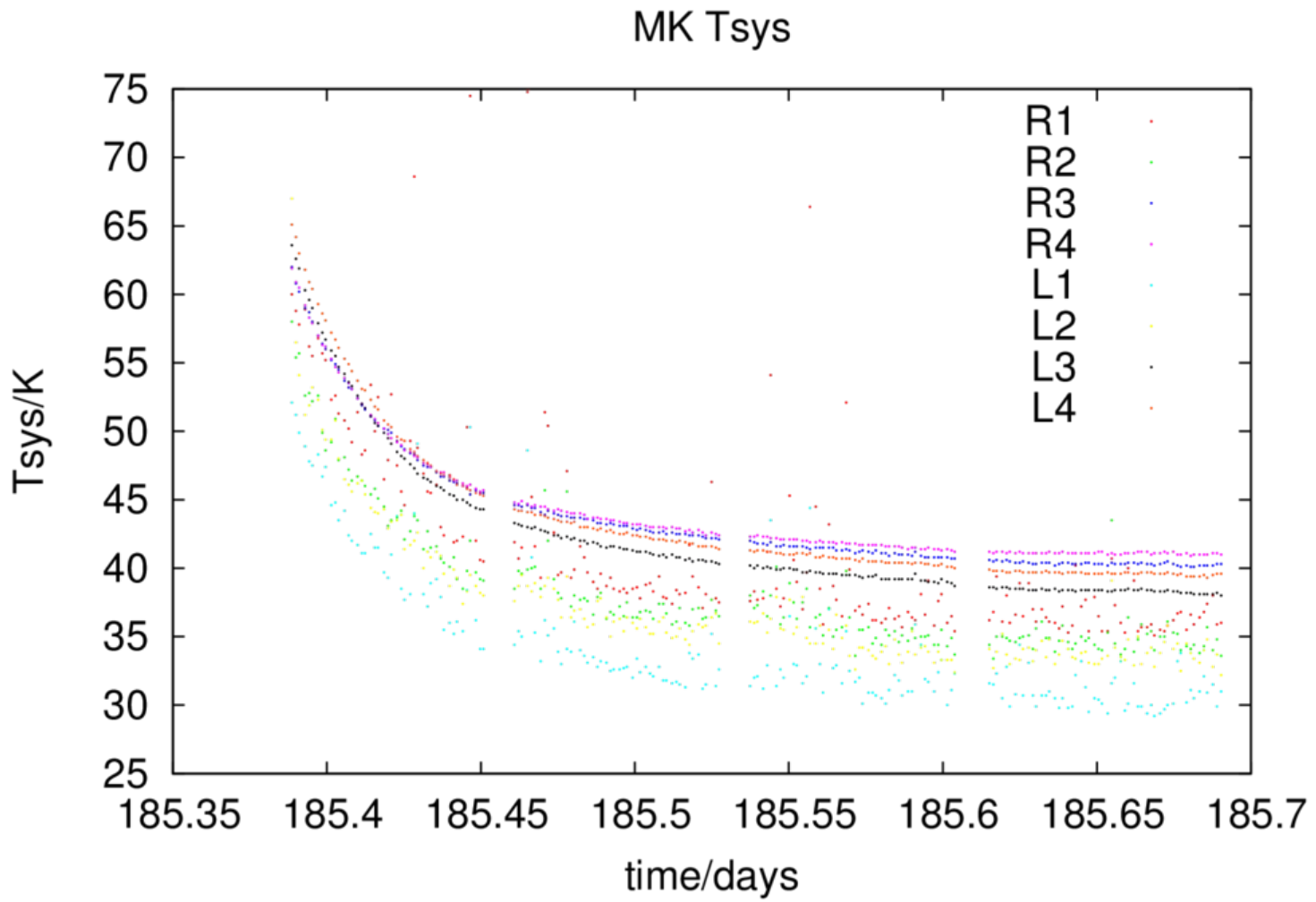
Multiple Tones

- I have a student working on extracting delay and phase calibration from raw data in .difx files
- We'll hopefully have something working by the end of the year.

Creative use of pcal tones 2: High time resolution Tsys.

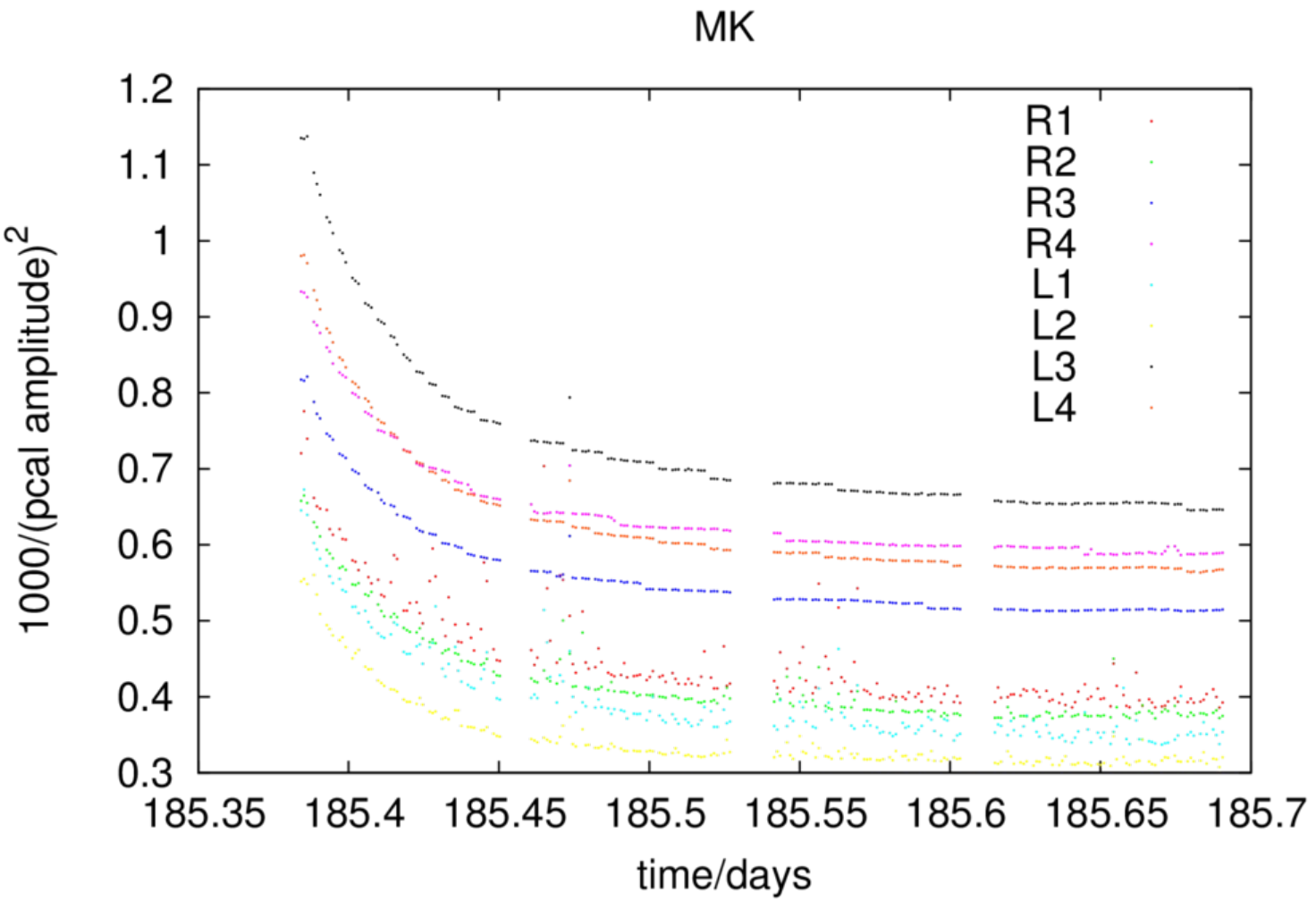
- Tsys is proportional to 1/(pcal amplitude)^2
- Add all tone amplitudes in a sub-band together.
- Normalise *for each individual sub-band of each antenna* using Tsys derived by other means.

Tsys extracted online at the station approx 90s integration time



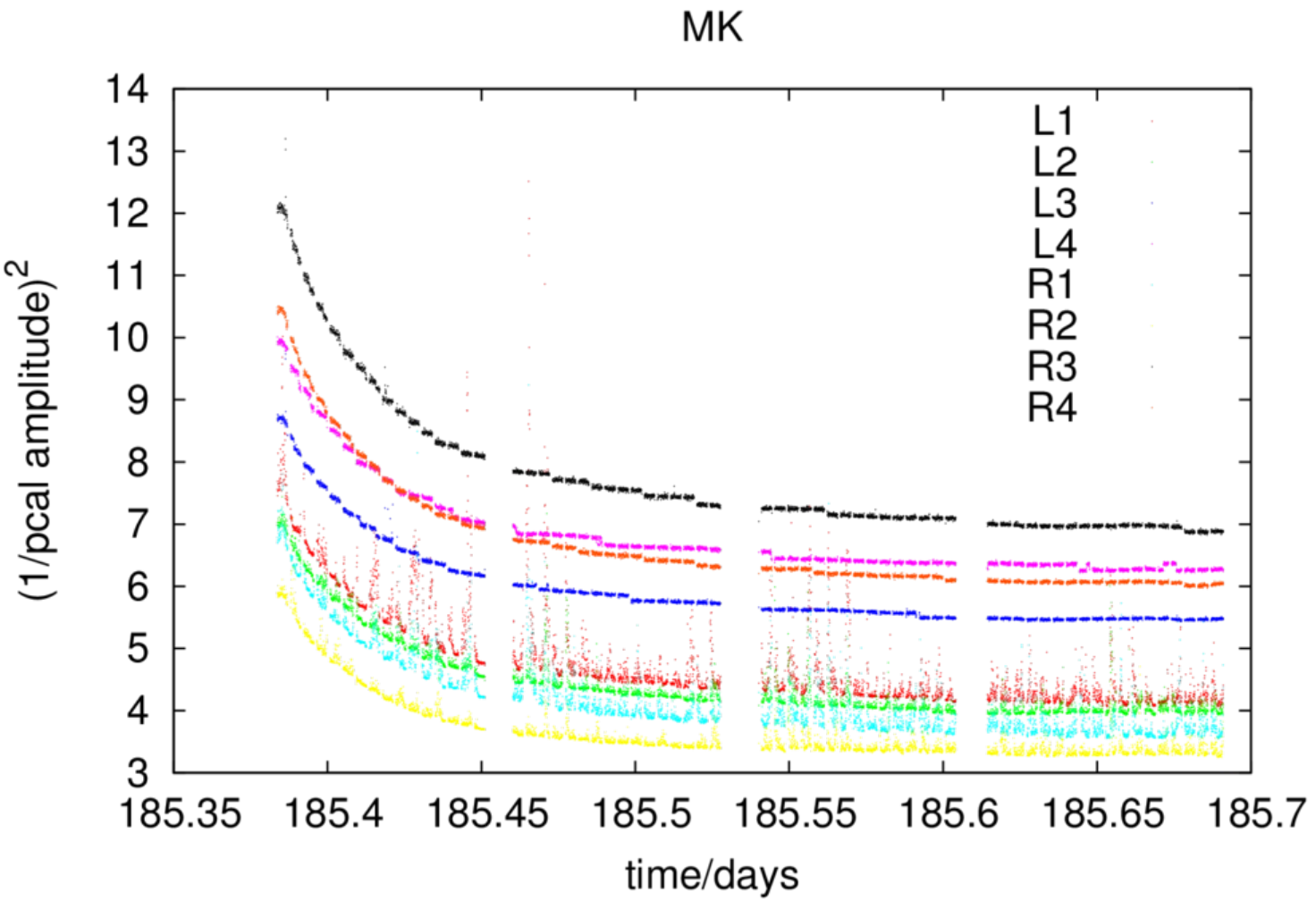
Spikes in Tsys almost certainly due to RFI

Tsys derived from pcal tones (90s integration time)



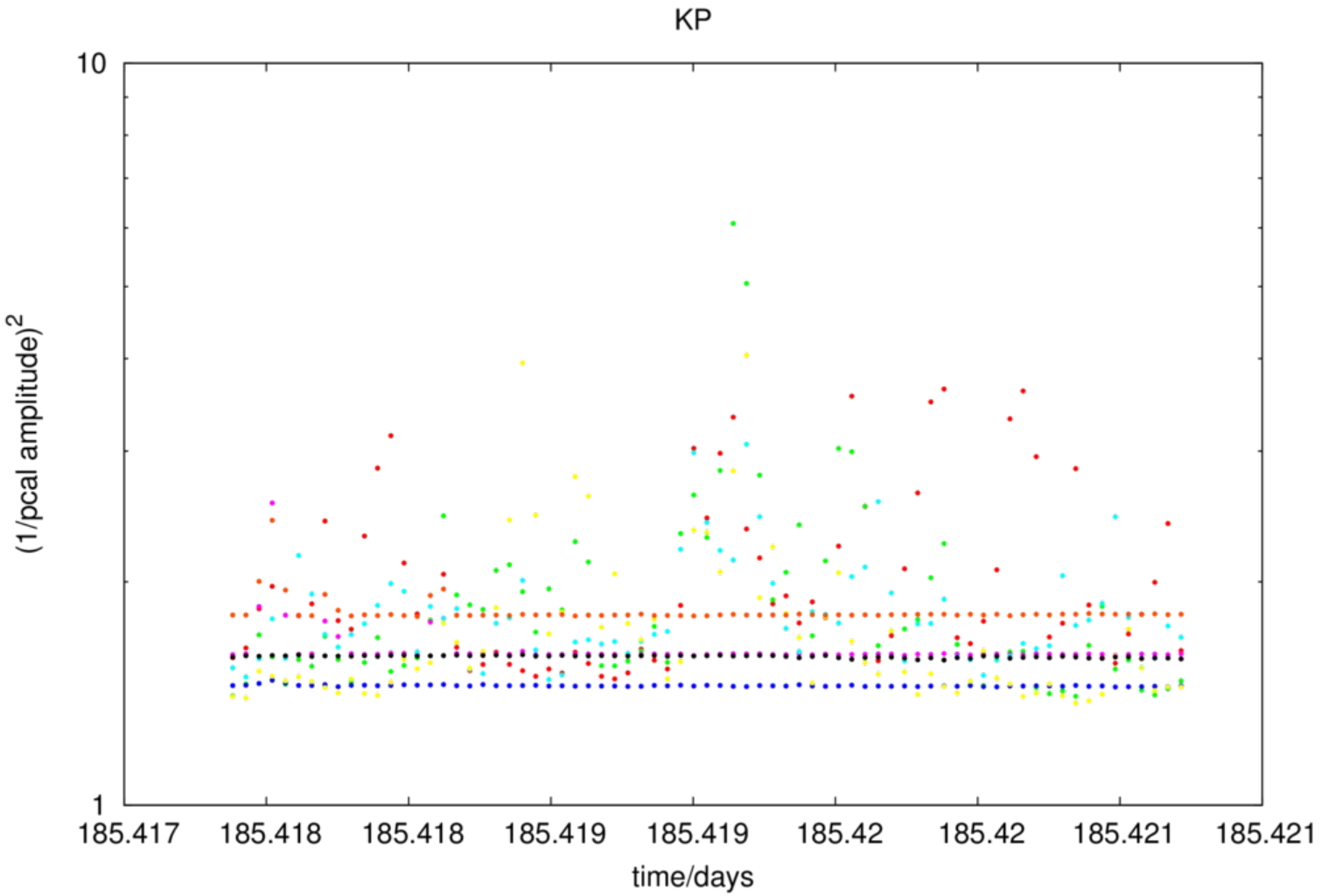
General shape clearly matches

Tsys derived from pcal tones (4s integration time)



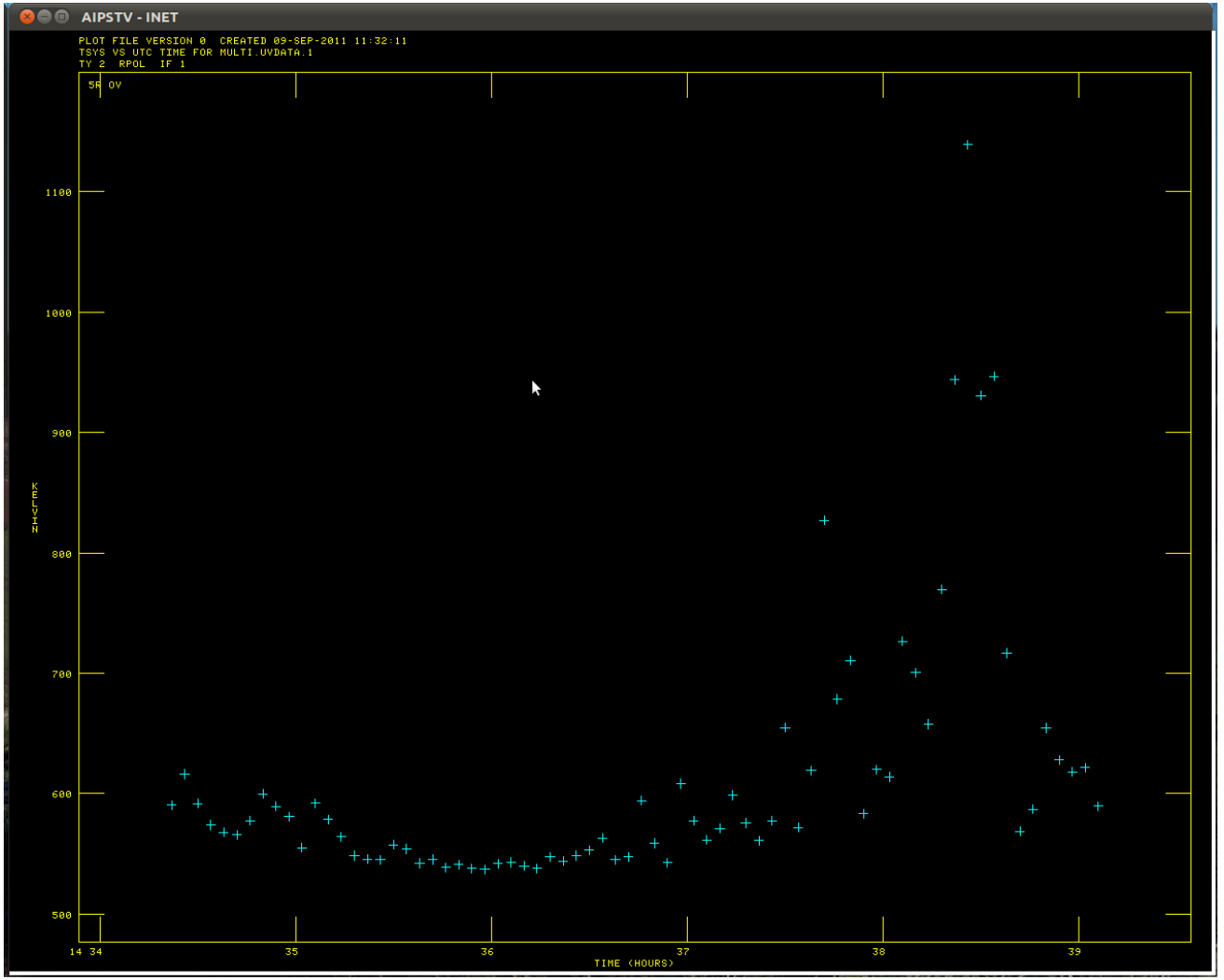
Tsys varies rapidly in the presence of RFI

A single 3-minute scan (4s accumulation period)



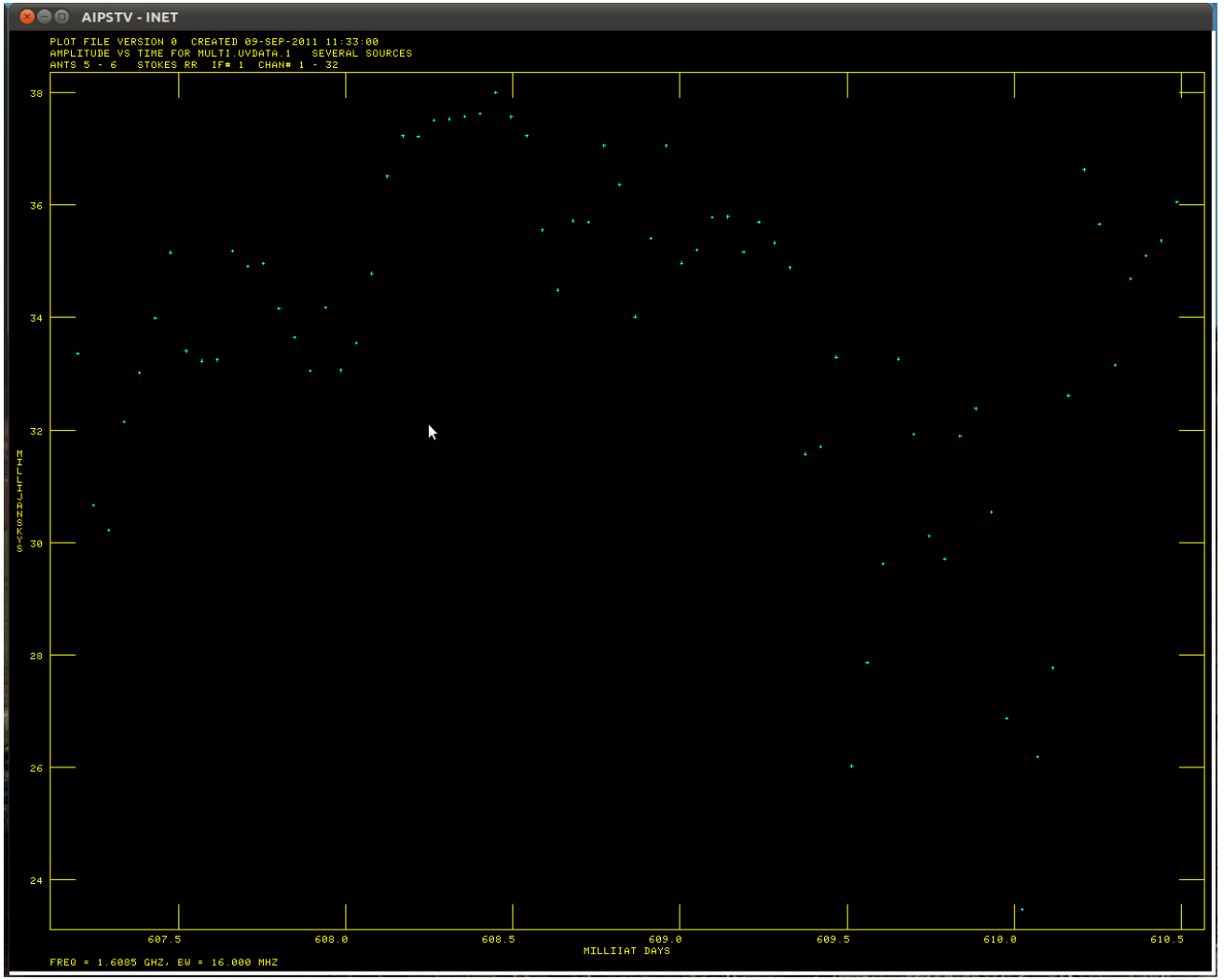
Tsys varies rapidly in the presence of RFI

Convert to SN table and apply to data in AIPS



Tsys (derived from pcals)

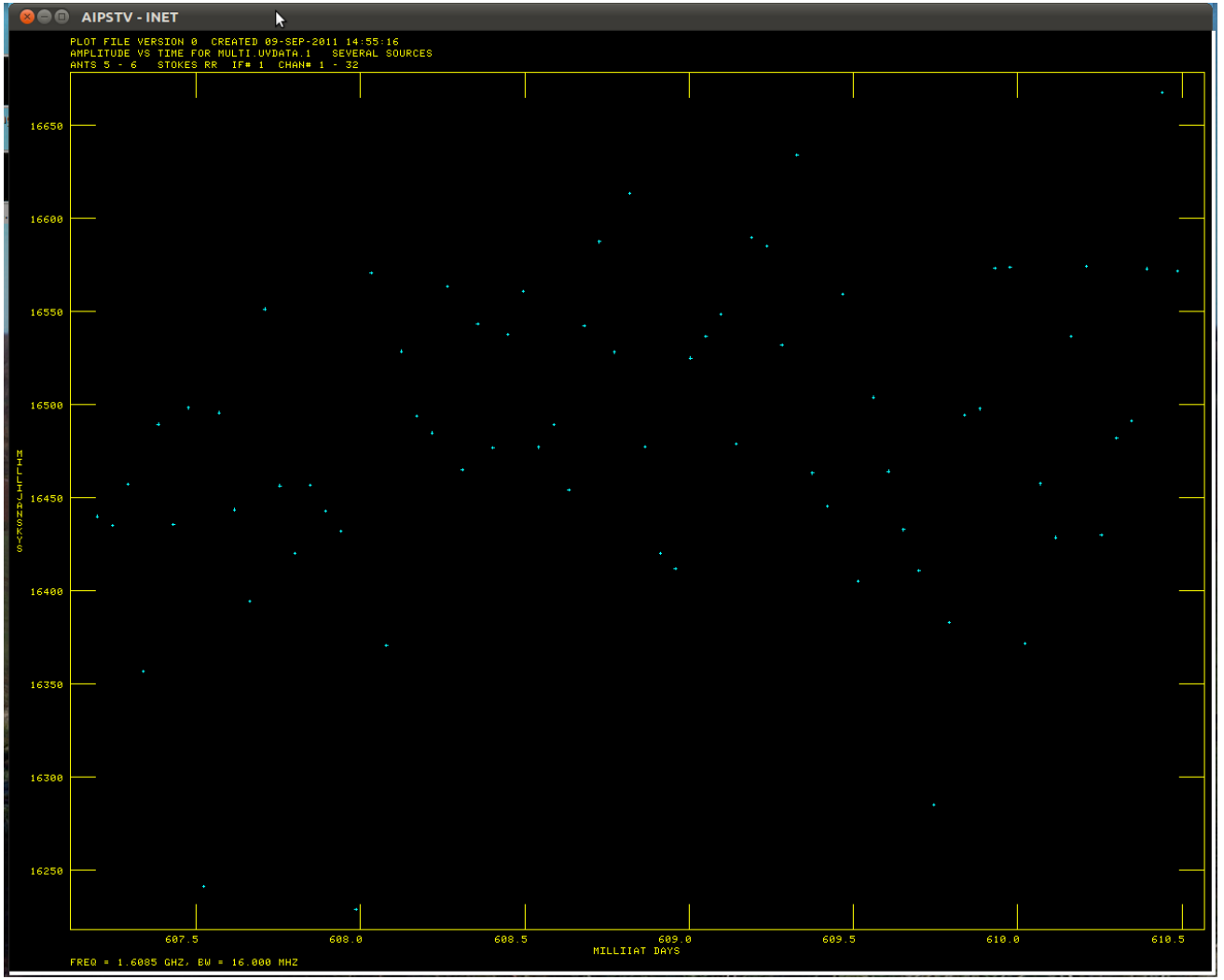
Strong source (3C84) with high SNR even for a single visibility



Single baseline, Single sub-band, all spectral channels averaged

Calibrate visibilities with pcal Tsys

16.65 Jy



16.25 Jy

Higher resolution Tsys

- Very preliminary results indicate increase of ~5% increase in dynamic range in clean image of a weak source
  - For a visibility dataset which had already been extensively flagged
- Comparison with a high-resolution dataset derived from noise diode not yet done
- Ultimately having a single test signal in the dataset reduces spurious noise (and processing power required at the correlator to extract the signal)

Arbitrary-length FFT

- IPP has a (rather arbitrary?) separation between FFT routines (which only work on a power-of-2 length) and 'DFT' routines which work on an arbitrary length
- Allowing non-power-of-two length FFTs in DiFX improves band-matching capability (e.g. correlate 125MHz bandwidth against 128MHz