The Dynamic Spectrum of Interplanetary Scintillation

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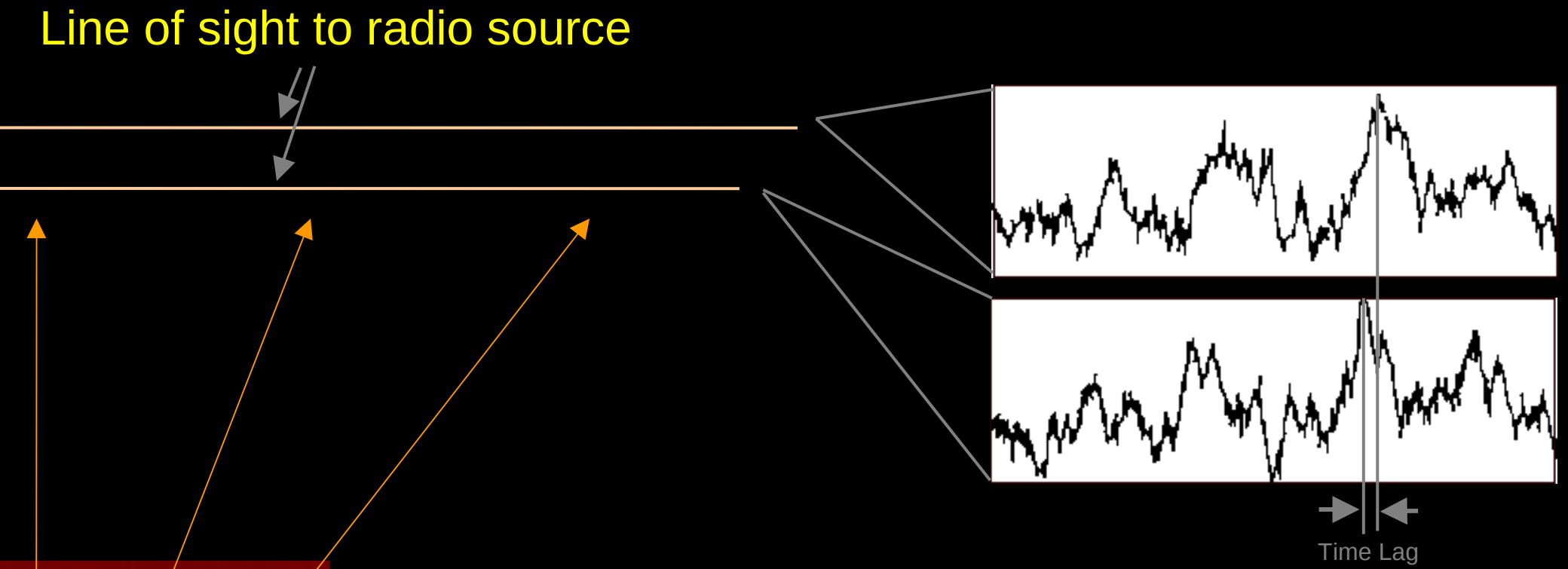
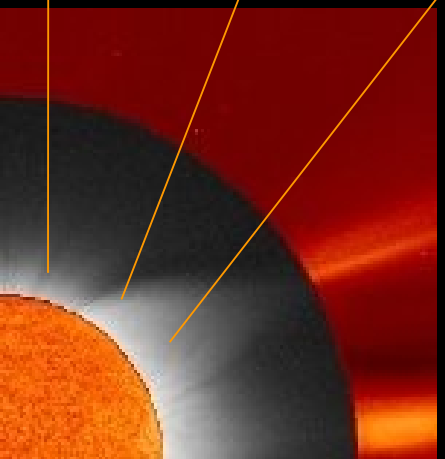
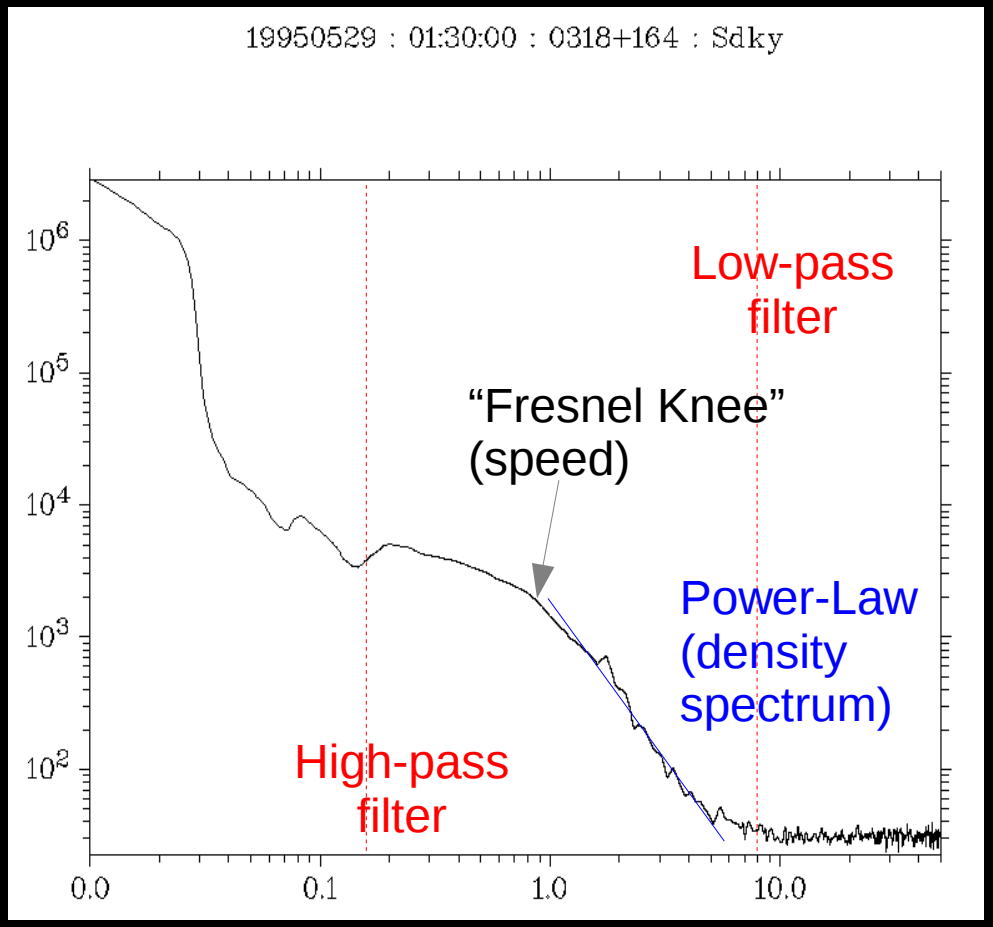
Overview of Interplanetary Scintillation

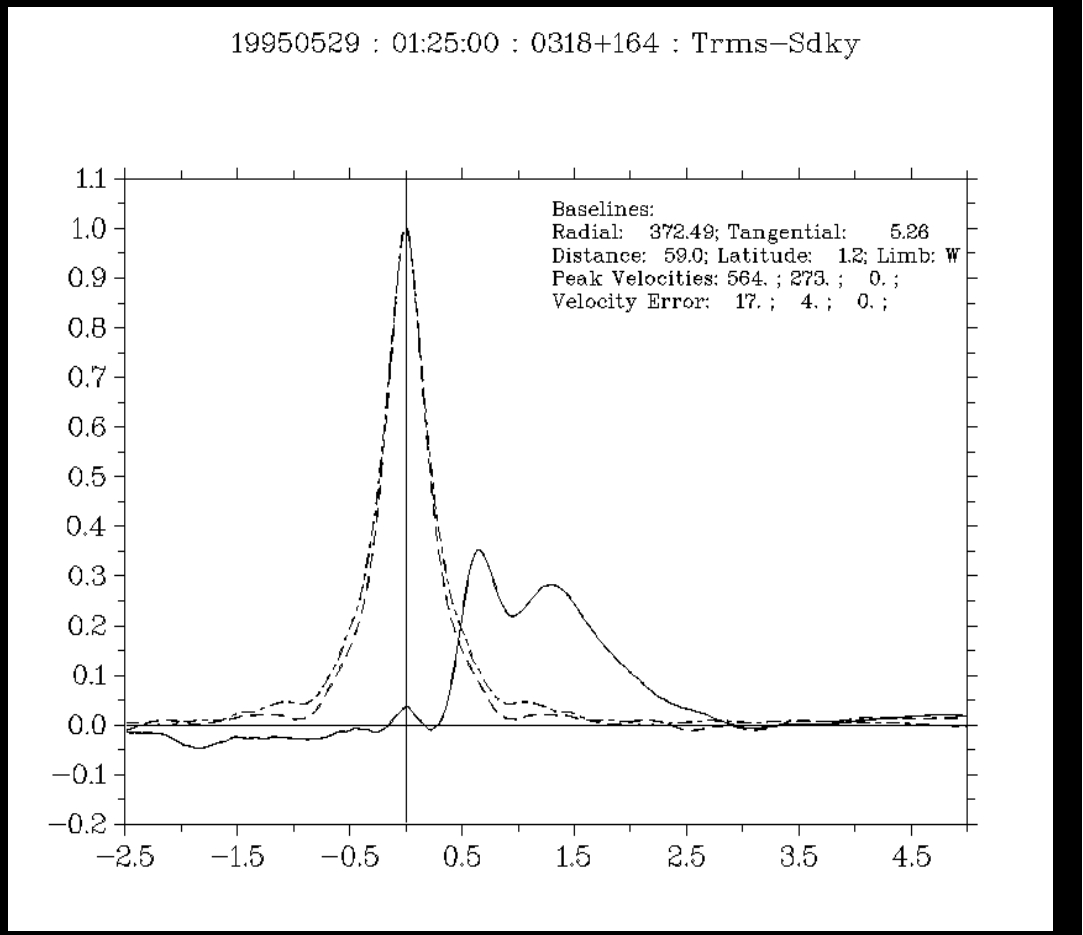




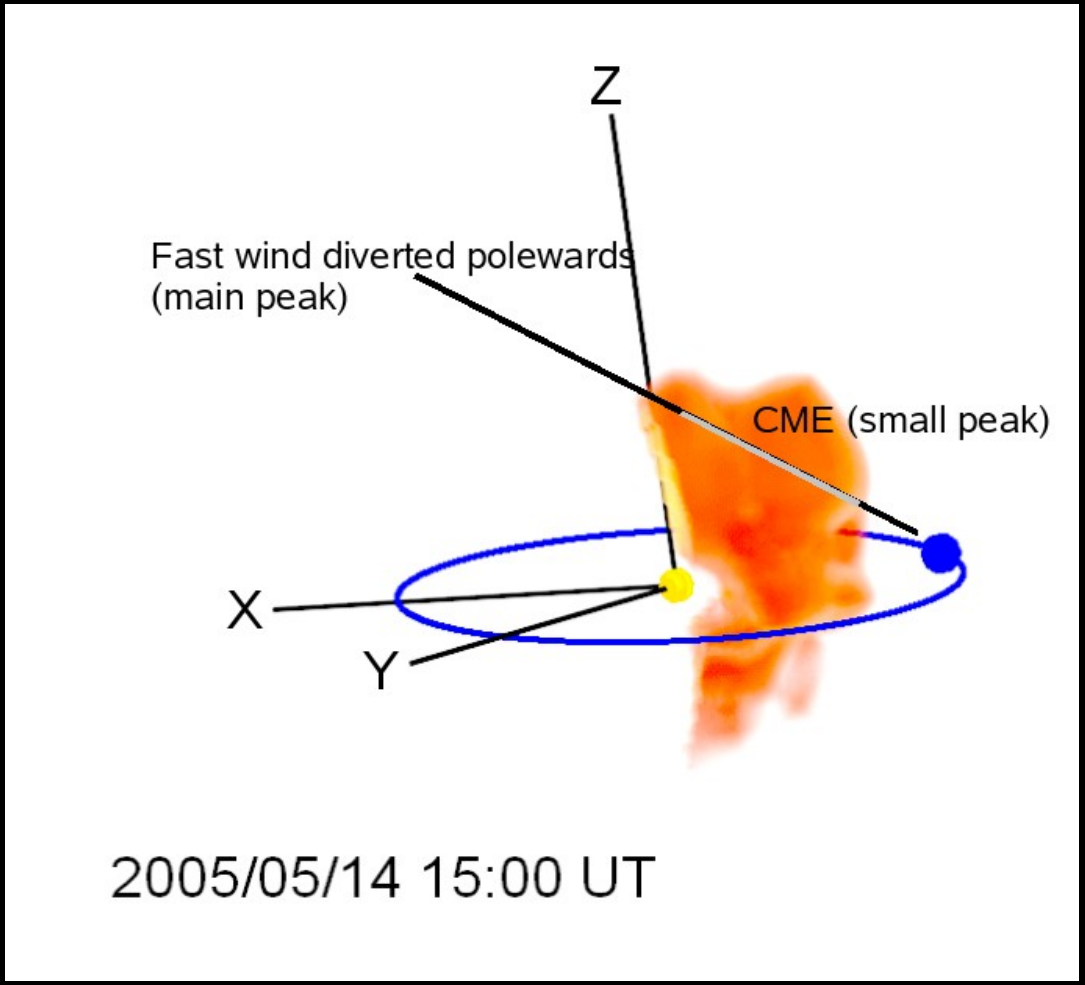
- Simultaneous measurements by two stations show similar patterns of scintillation.
- Time-lag for maximum cross-correlation gives estimate of solar wind outflow speed.

IPS Power Spectrum and Cross-Correlation





Tomography



- Many IPS measurements taken over several days can be used to build up a tomographic image.
- Here, we used the tomographic image to help constrain the analysis of a single, independent IPS observation.

IPS from LOFAR

- Aim is to create power spectrum (and cross-correlation):
  - Use coherent stokes I and fly's-eye mode to obtain separate files of beam-form data from each station.
  - Test observations also using the Superterp for greater sensitivity and narrower beam.
  - Mostly HBA-high at present, but expect to use lower frequencies also.
- Need dynamic spectrum for RFI identification
  - Initial dynamic spectrum pipeline under construction.
  - Dynamic spectrum of IPS may produce useful science.

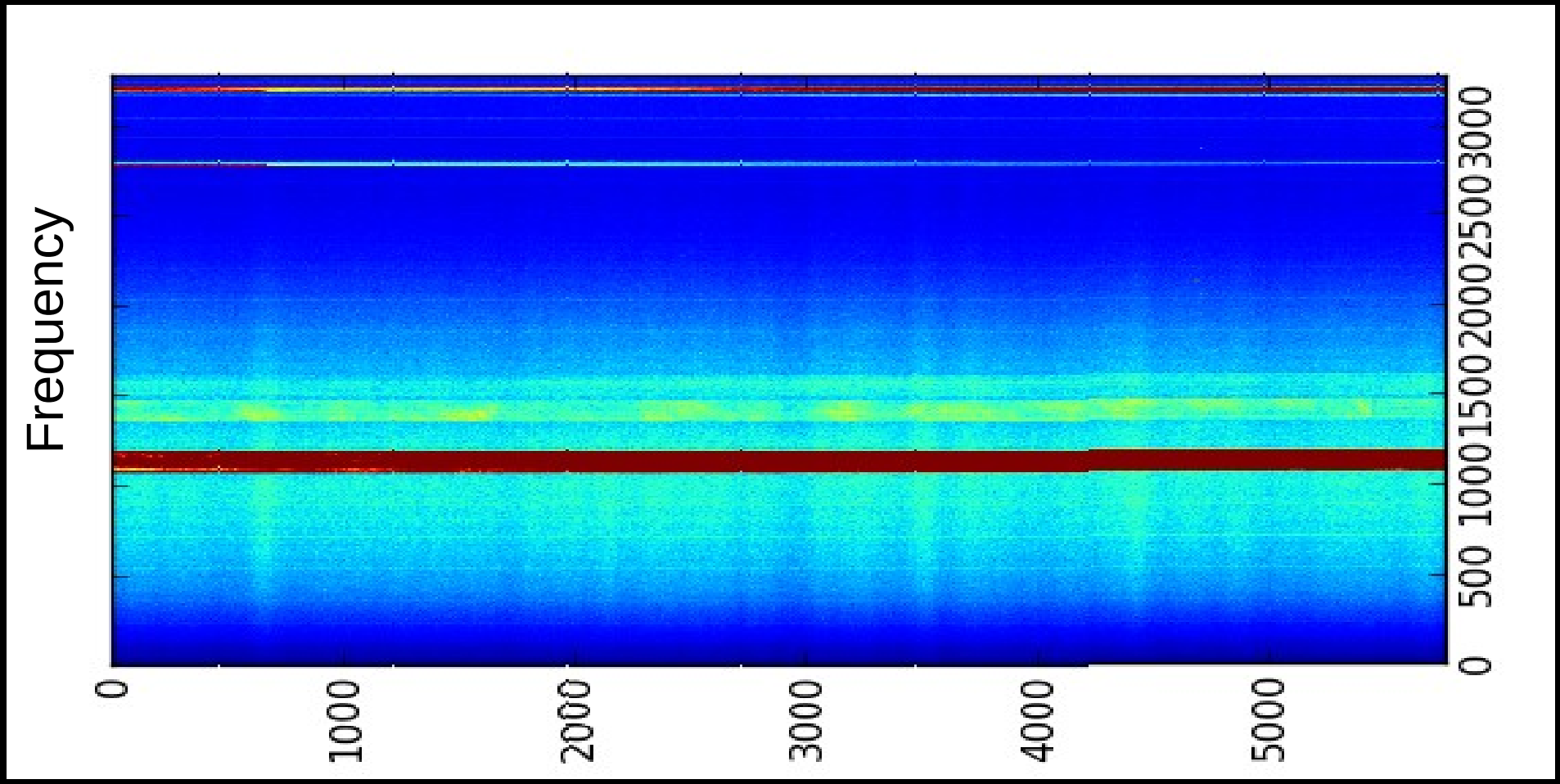
Dynamic Spectrum Pipeline

- Certain channels in each sub-band are junk:
  - Currently, these are averaged over in the frequency dimension using data in channels either side.
- The data need to be corrected for the antenna response across the pass-band:
  - No response curves, so estimate created from first block of data (iterative procedure involving removal of contaminated channels, curve fitting and smoothing).
- RFI is identified in “flattened” data:
  - Spikes in data taken to be RFI
  - Can be zeroed but other methods of replacement being investigated.

Test Observations

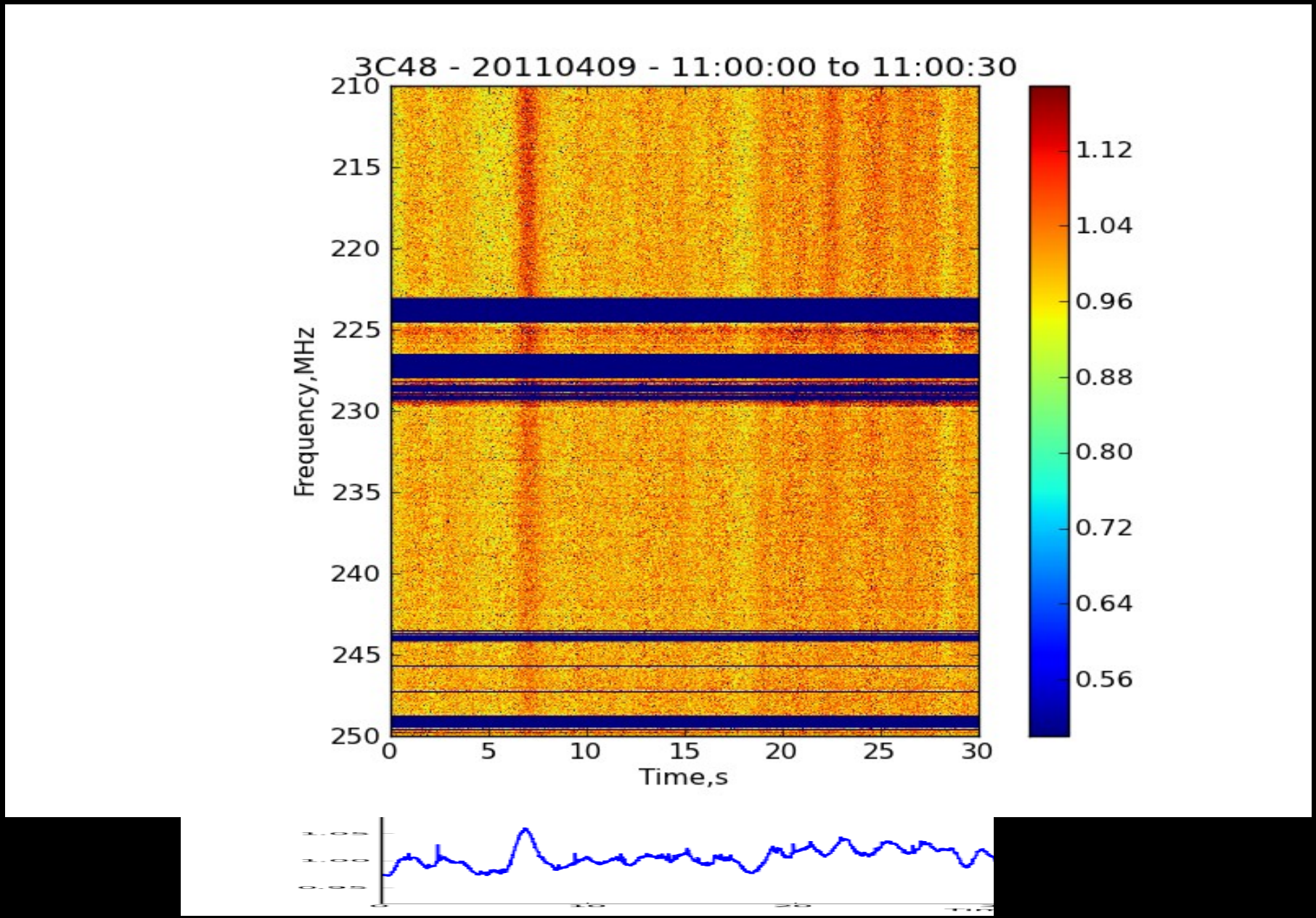
- Several observations have been taken:
- Two of these are the main targets for pipeline testing:
  - 1. Observation of 3C48 taken on 9th April 2011
  - 2. Observation of 3C84 taken on 7th May 2011
- Simultaneous observations of the second case taken with the EISCAT Svalbard Radar (northern Scandinavia).
  - Data also taken on the same source that day with other systems.

3C48 on 20110409 - Superterp

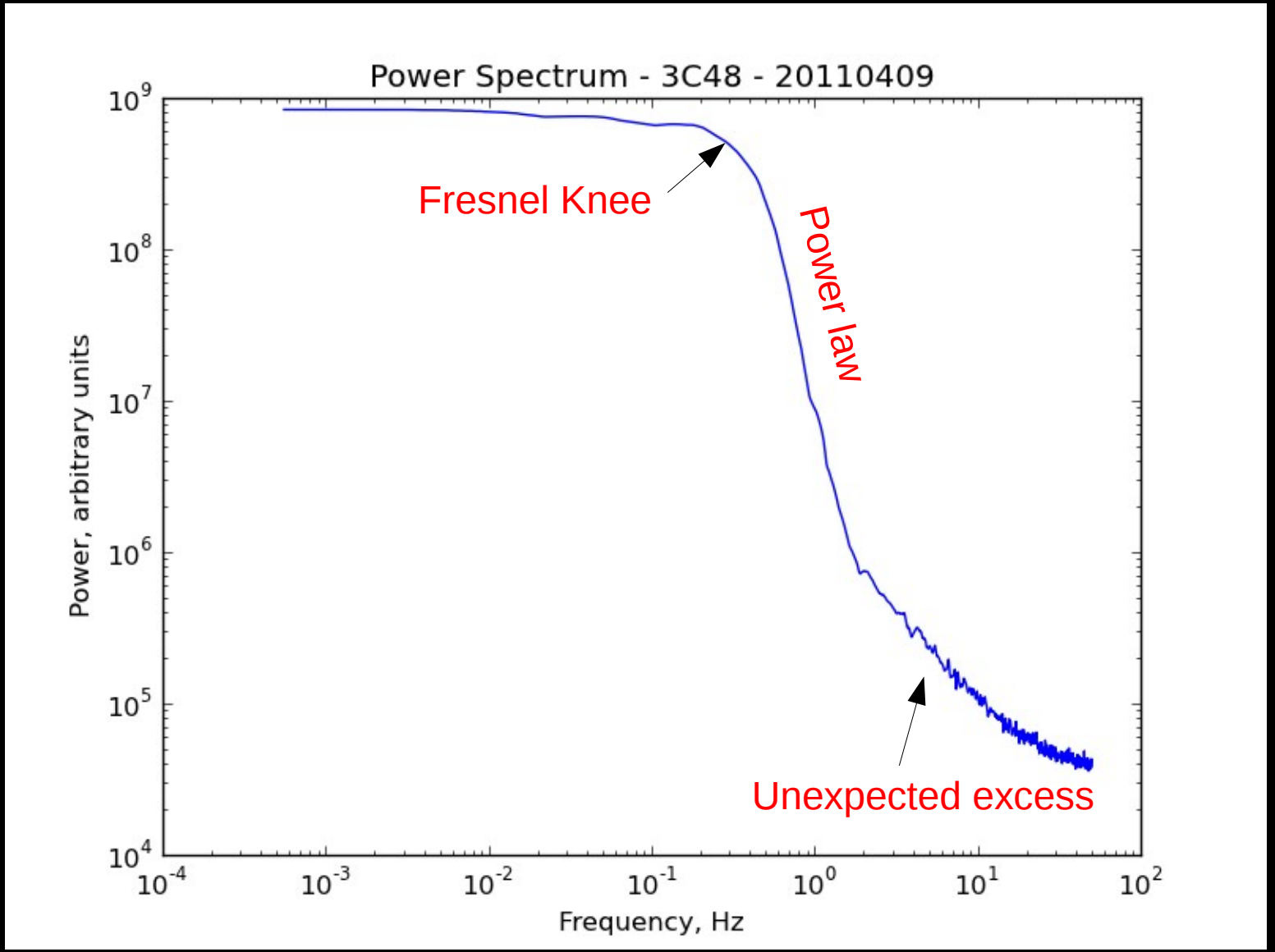


Raw dynamic spectrum plot (arbitrary axes, 1 minute)

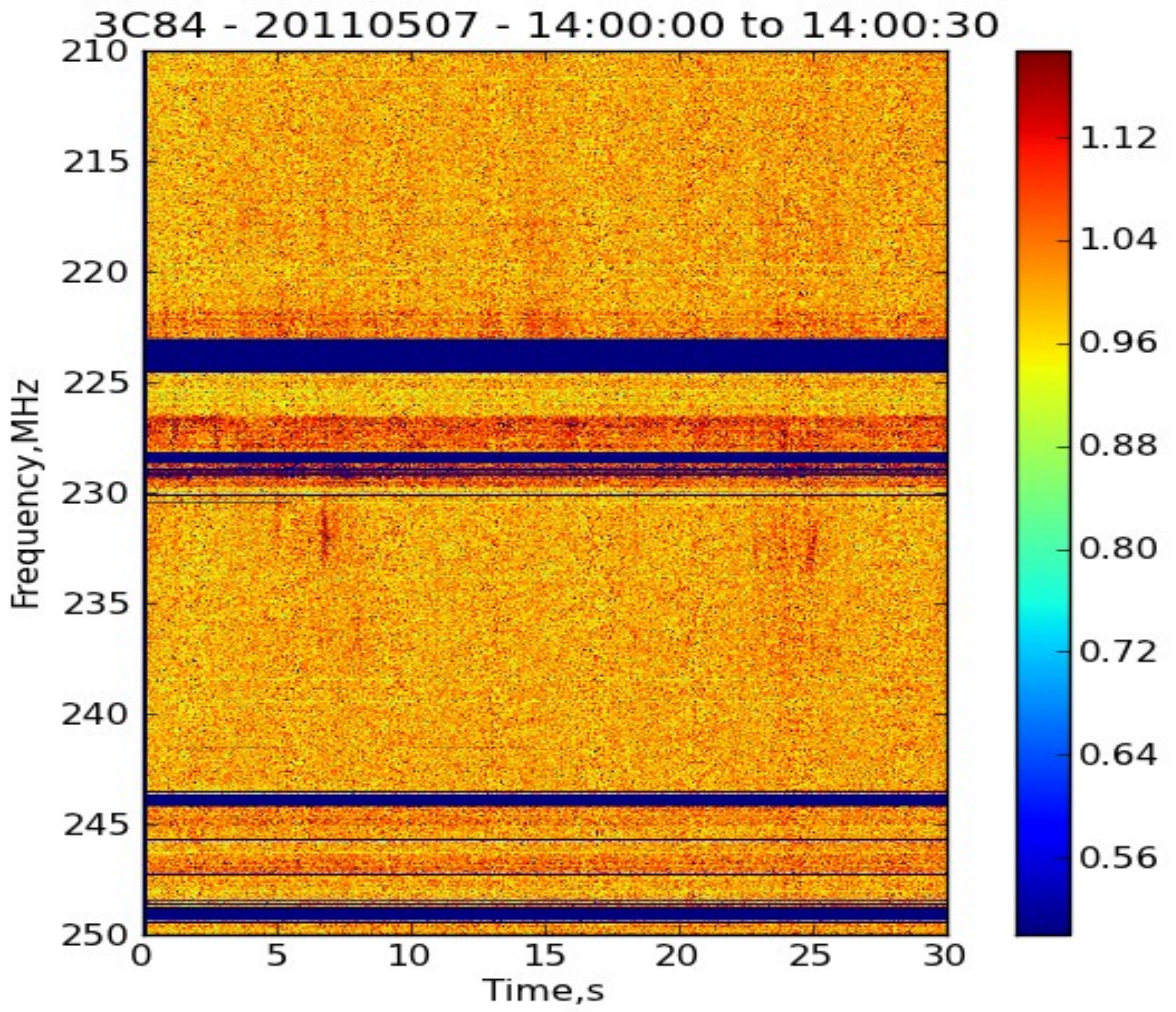
3C48 on 20110409 - Superterp



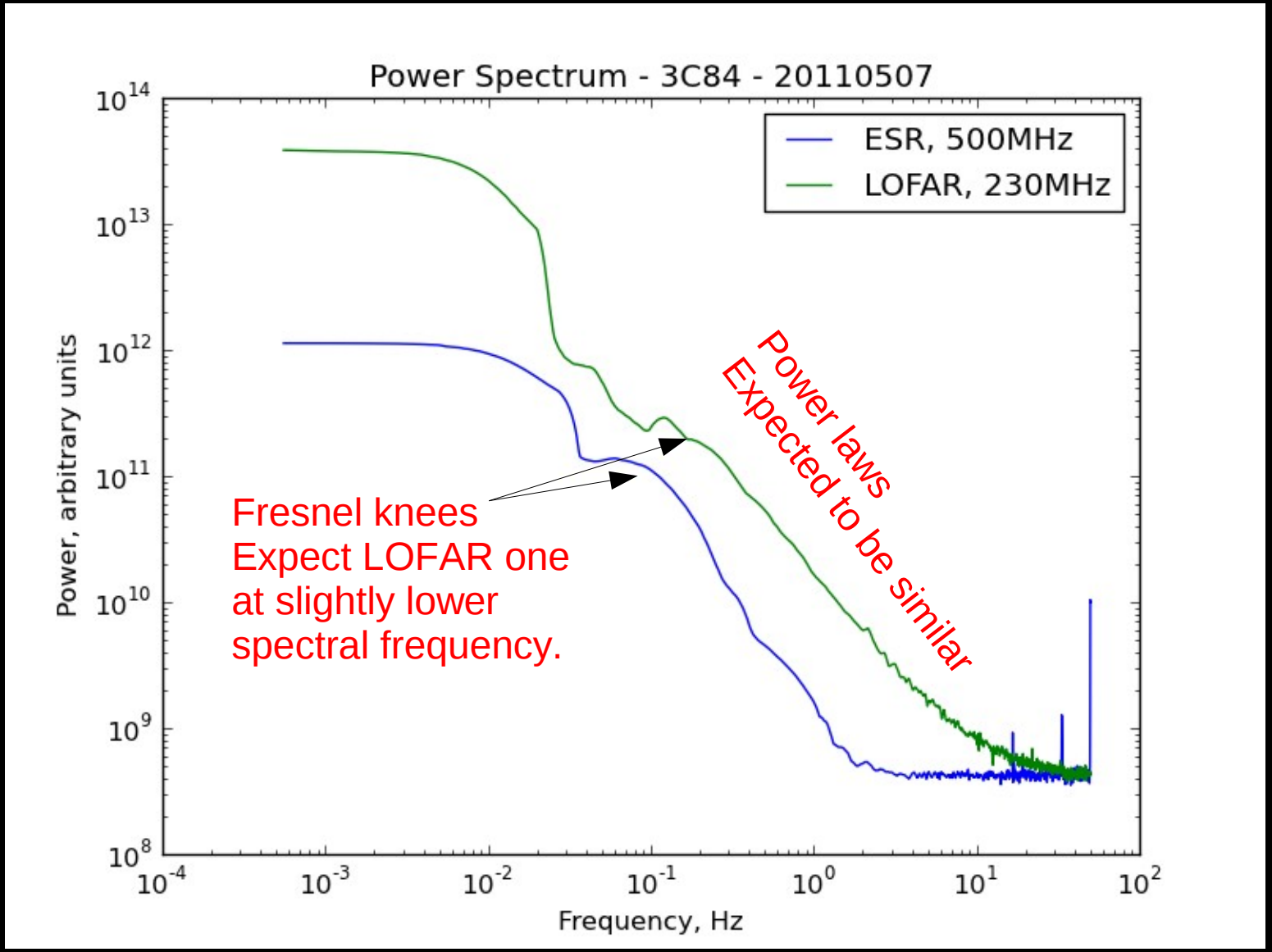
3C48 on 20110409 - Superterp



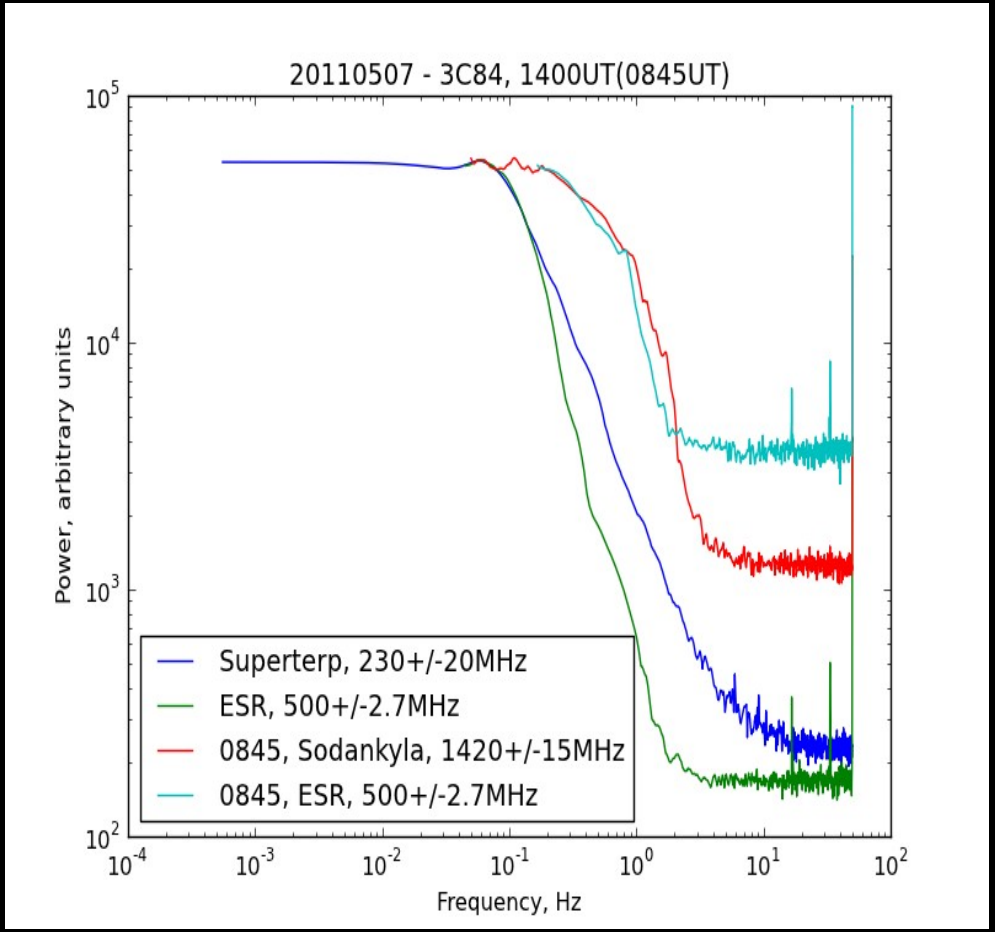
3C84 on 20110507 - Superterp

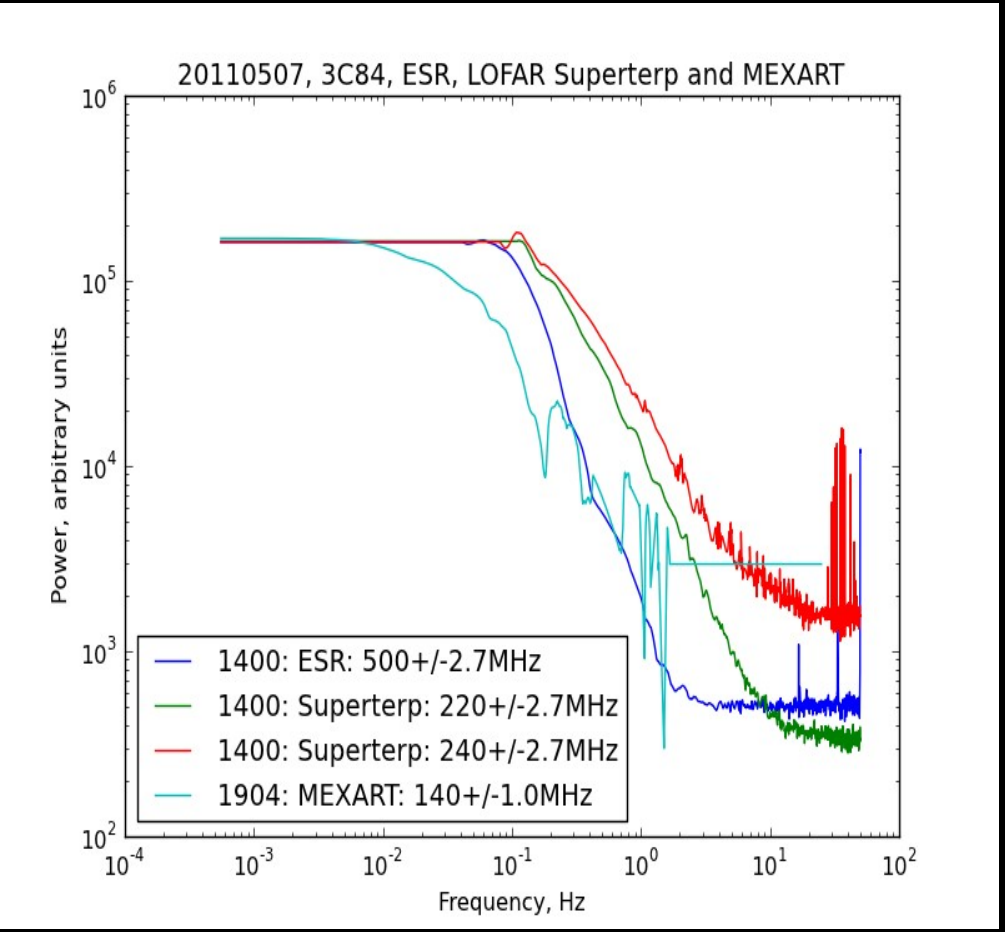


3C84 on 20110507 - Superterp

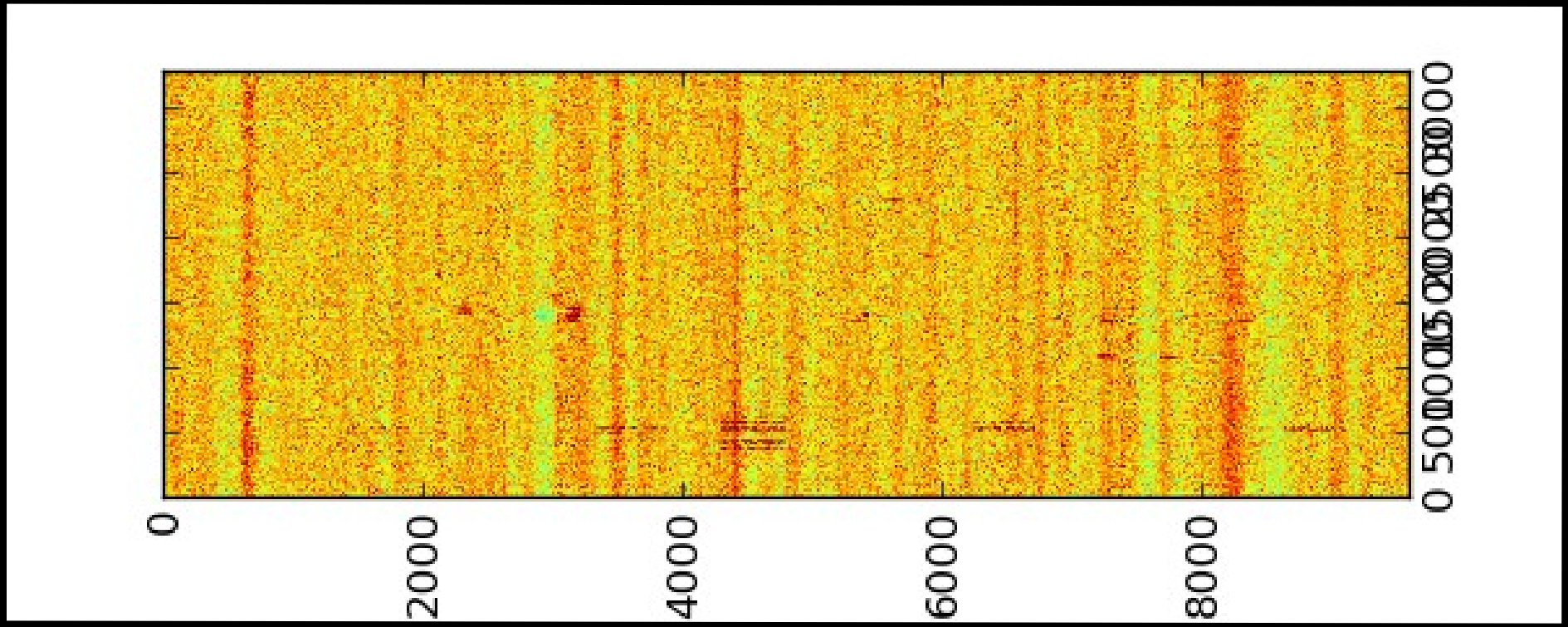


Mass Comparison Plots





RFI Cleaning Experiments



Instead of zeroing contaminated data points, trying replacement:

- Bad point replaced with random good point selected from bounded area in frequency dimension
- Looks good, but will introduce noise overall
- Probably various other issues.

Summary

- Dynamic spectrum pipeline under construction
- Encouraging results but obvious issues:
  - Need proper antenna response curves
  - RFI identification could probably be improved
- Results suggest that interplanetary scintillation definitely being seen, but power spectra not yet reliable.
- Dynamic spectrum of interplanetary scintillation not studied in detail before:
  - Showing promise of offering new insights into solar wind micro-structure.