SPIRE Spectrometer Observations of Faint Point Sources: Data Reduction Improvements over the Pipeline

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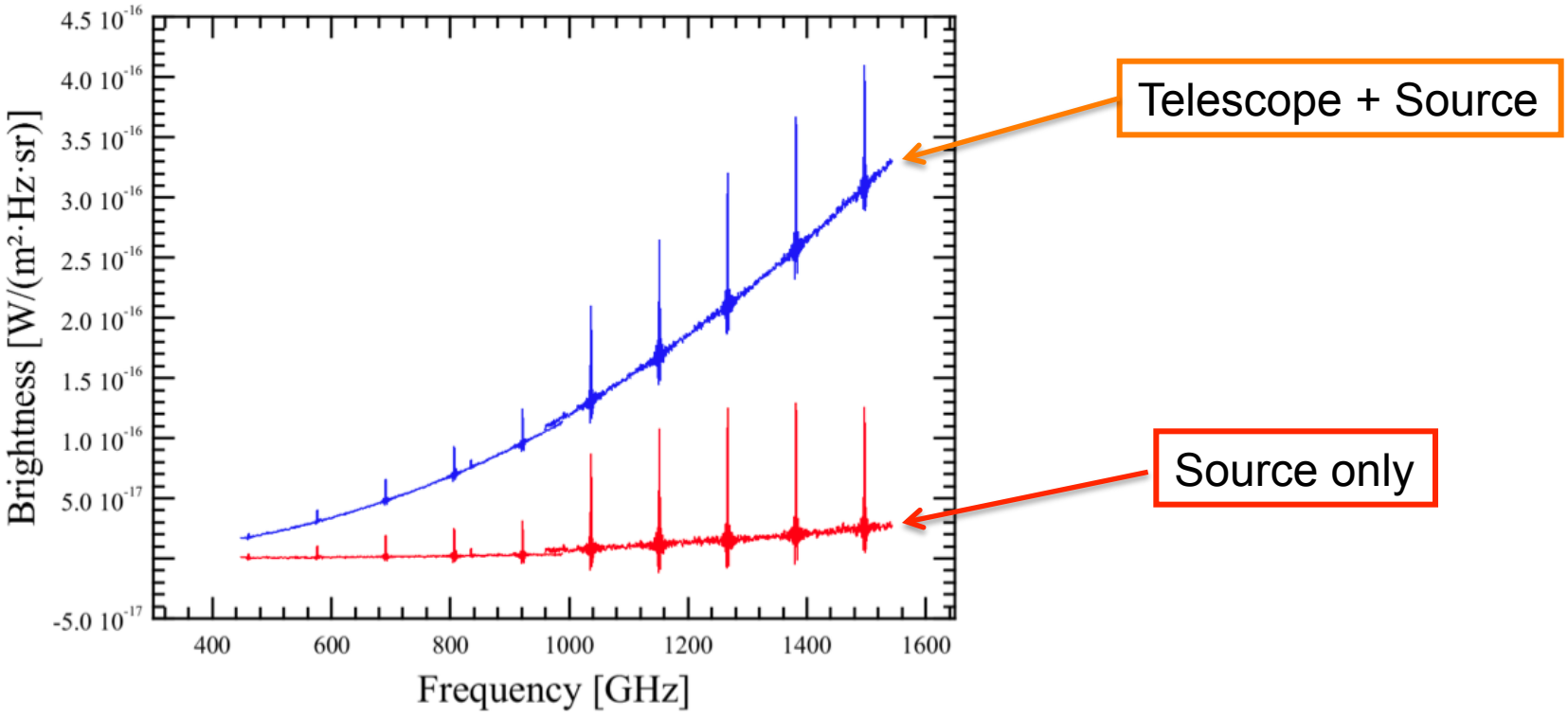
Goals

- Discussion of systematic effects and errors pertinent to faint point-source observations (< 10 Jy).
  - Continuum flux calibration uncertainty.
  - Noise in spectra.
- Post-pipeline improvements to data reduction:
  - Improving continuum flux accuracy.
  - Check and possibly reduce the noise in your spectrum.

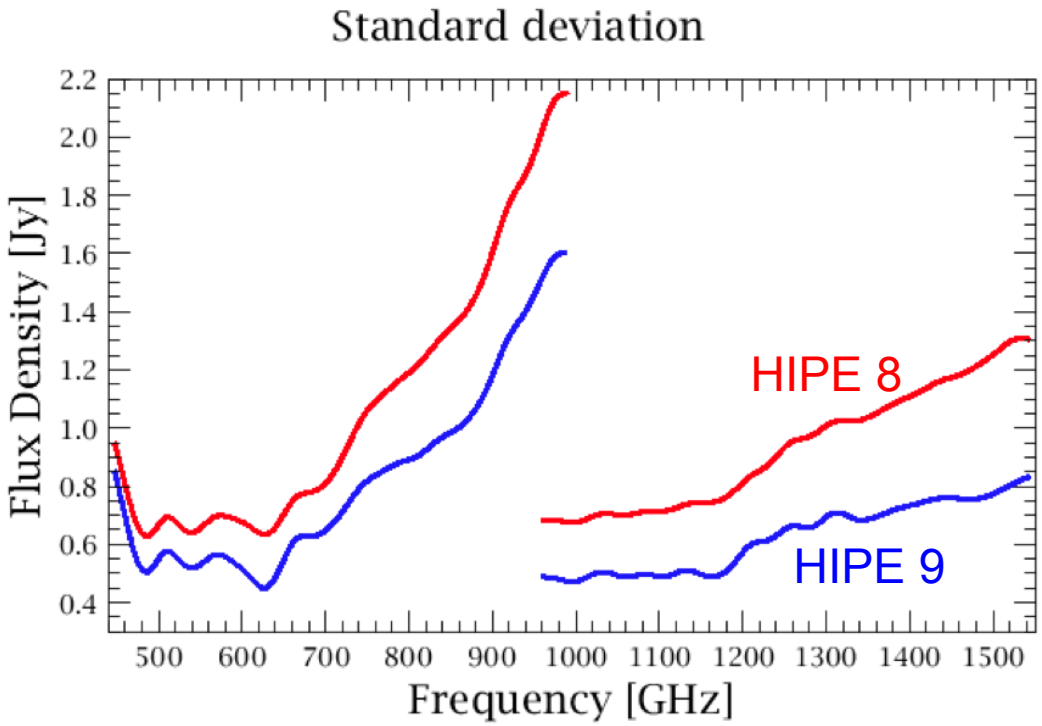
I. Improving Continuum Flux

Telescope Emission Dominates Most Observations!



Uncertainty from Telescope Emission Removal

Standard deviation of many Dark Sky observations reduced using the standard pipeline:



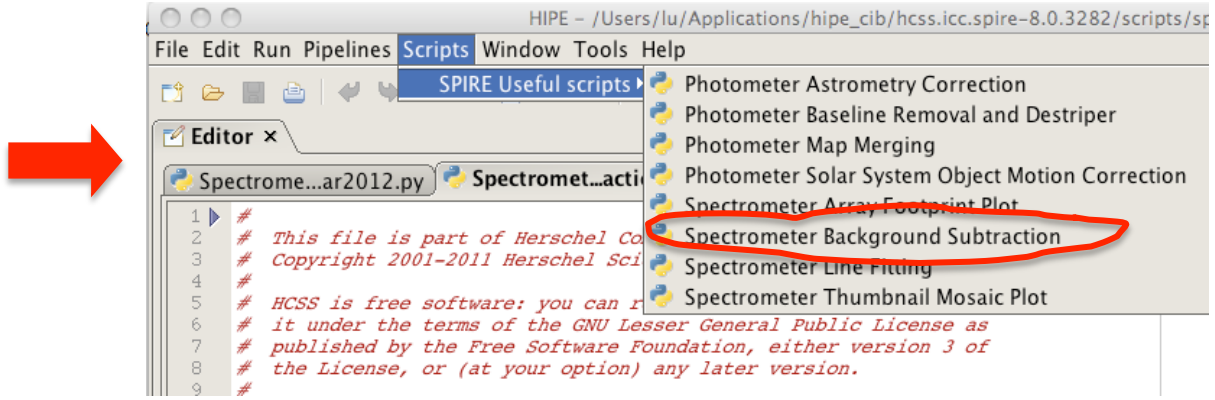
- Telescope model is good to 1 – 2 Jy in continuum flux uncertainty in HIPE 8.
- This has been improved to 0.5 – 1 Jy in HIPE 9.

How to Remove Residual Telescope Emission

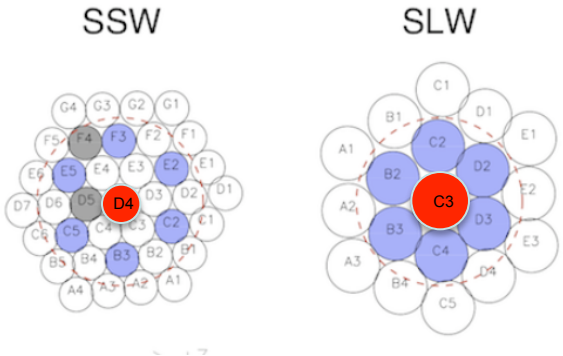
- Two practical ways:
  - Subtract an observed **Dark Sky** from the same observational day, as close in time to your observation as possible, which is processed in the same way as your own observation.
    - A list of dark observations can be found at:

      http://herschel.esac.esa.int/twiki/bin/view/Public/SpireDailyDarkObservations
  - Subtract a mean or median spectrum from surrounding detectors in case of a point source observation:
    - We will demo how to do this using a simple script in the end of the session.

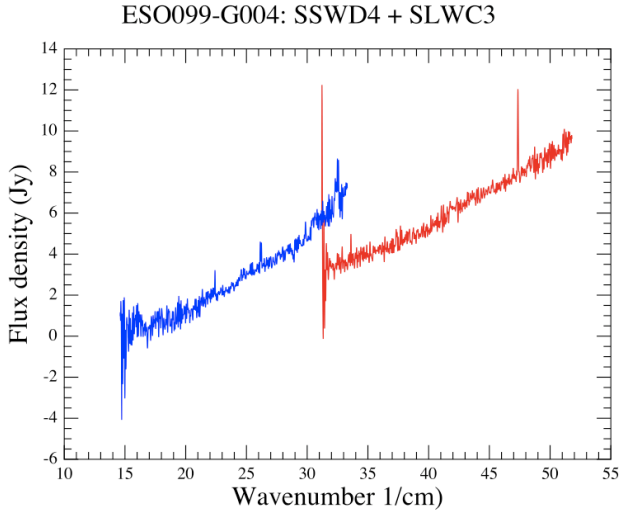
A script for doing both these corrections is available inside HIPE:

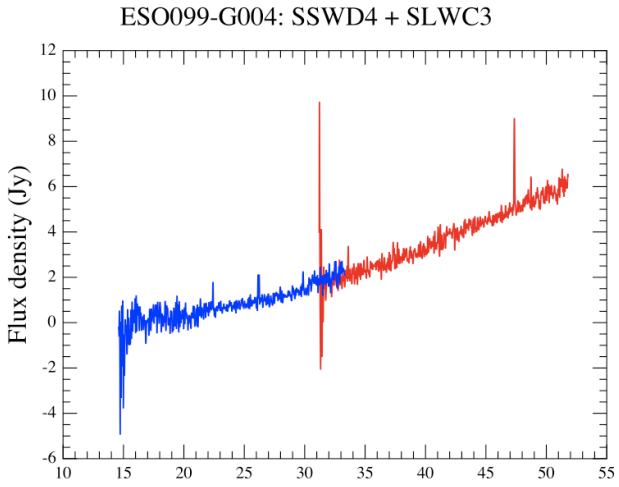


Residual Telescope Emission Removal: Using Surrounding Channels

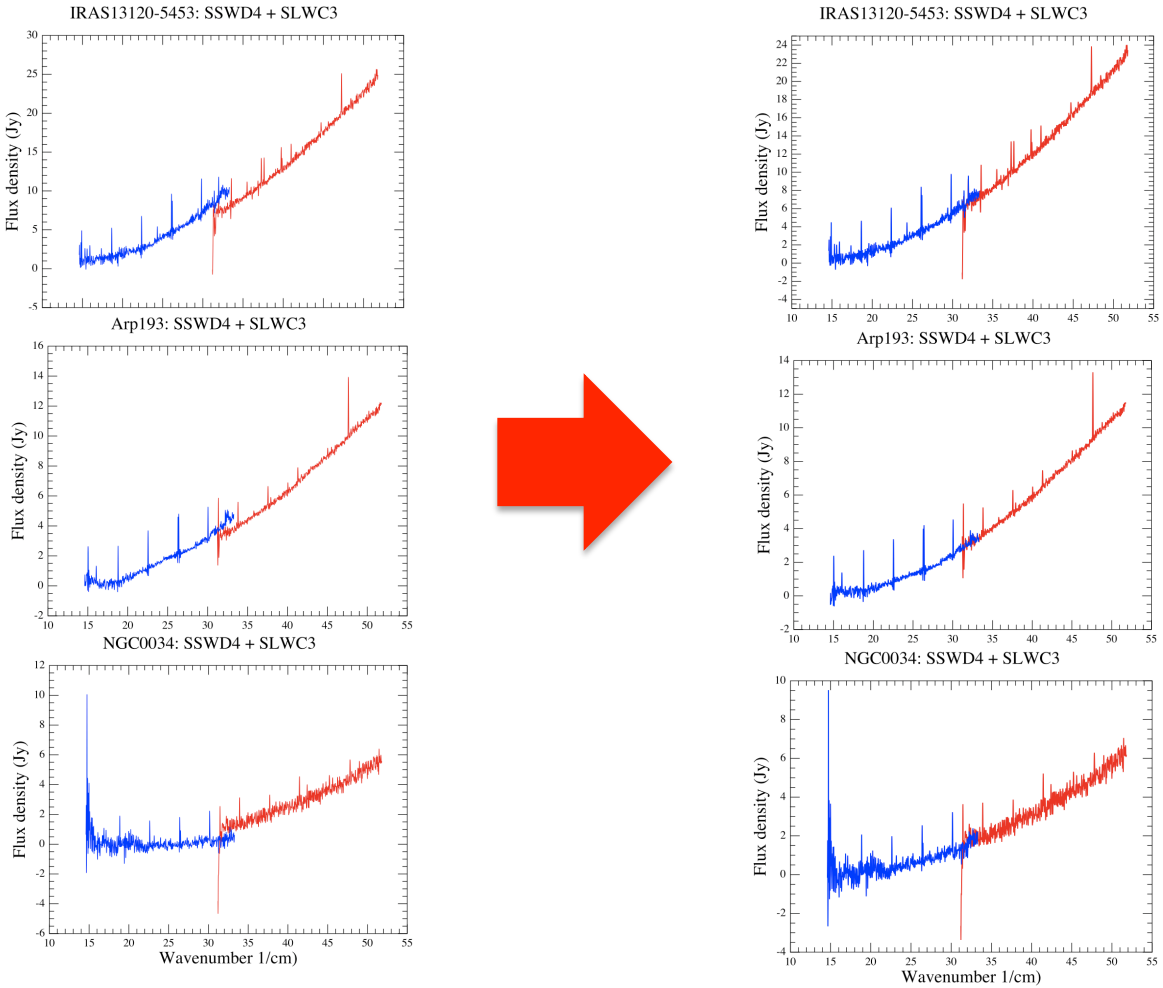


- Using a median spectrum from the co-aligned detectors as the residual telescope spectrum.
- This (or a polynominal fit to it) is then subtracted from the spectrum of the central detectors.

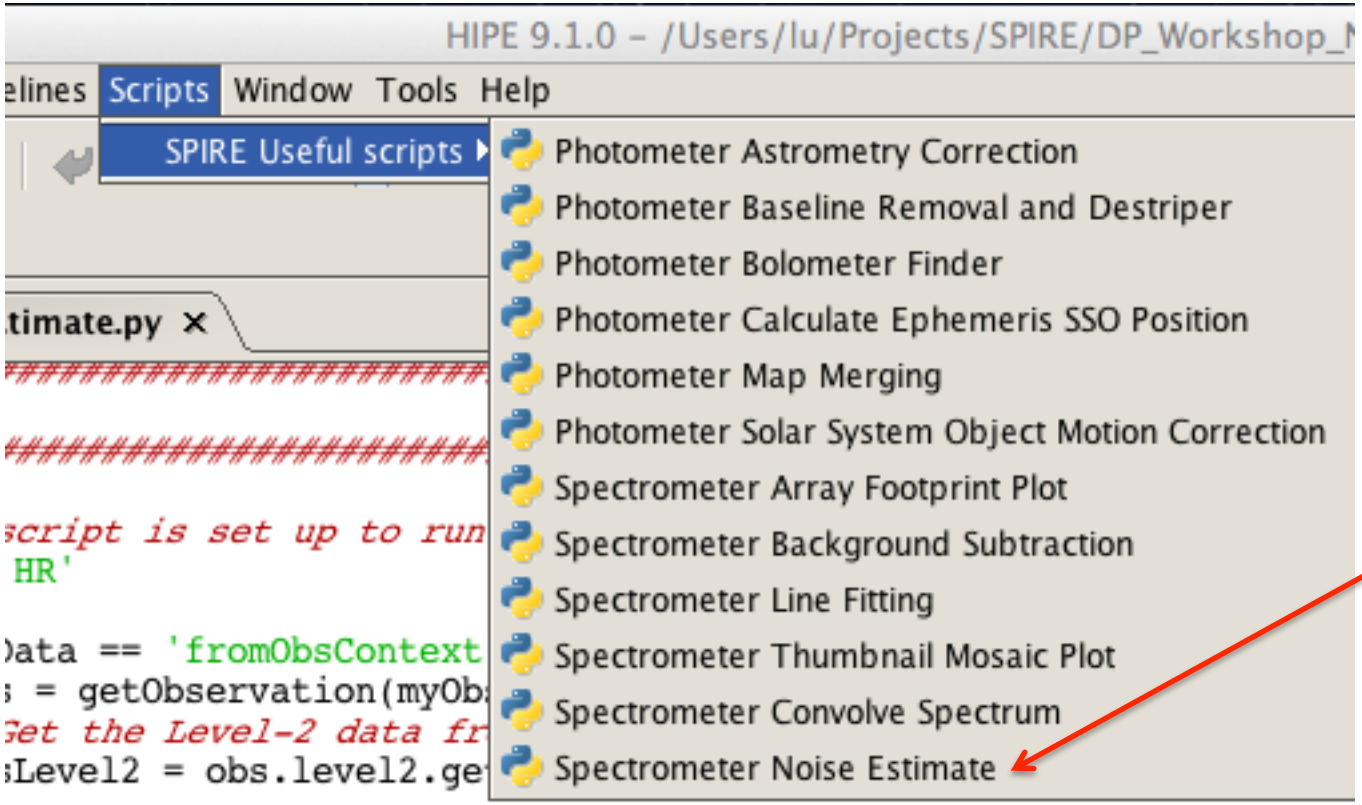




Residual Telescope Emission Removal: More Examples

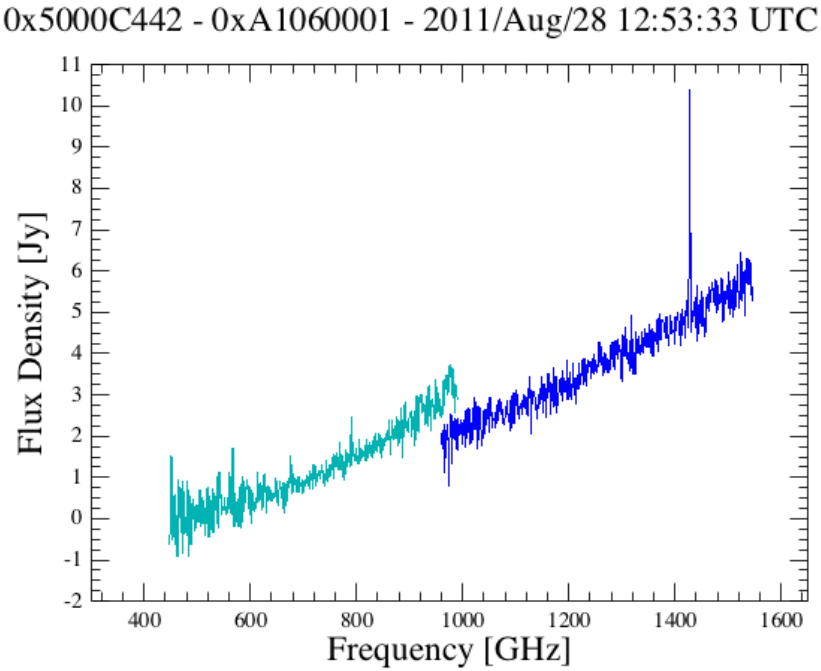


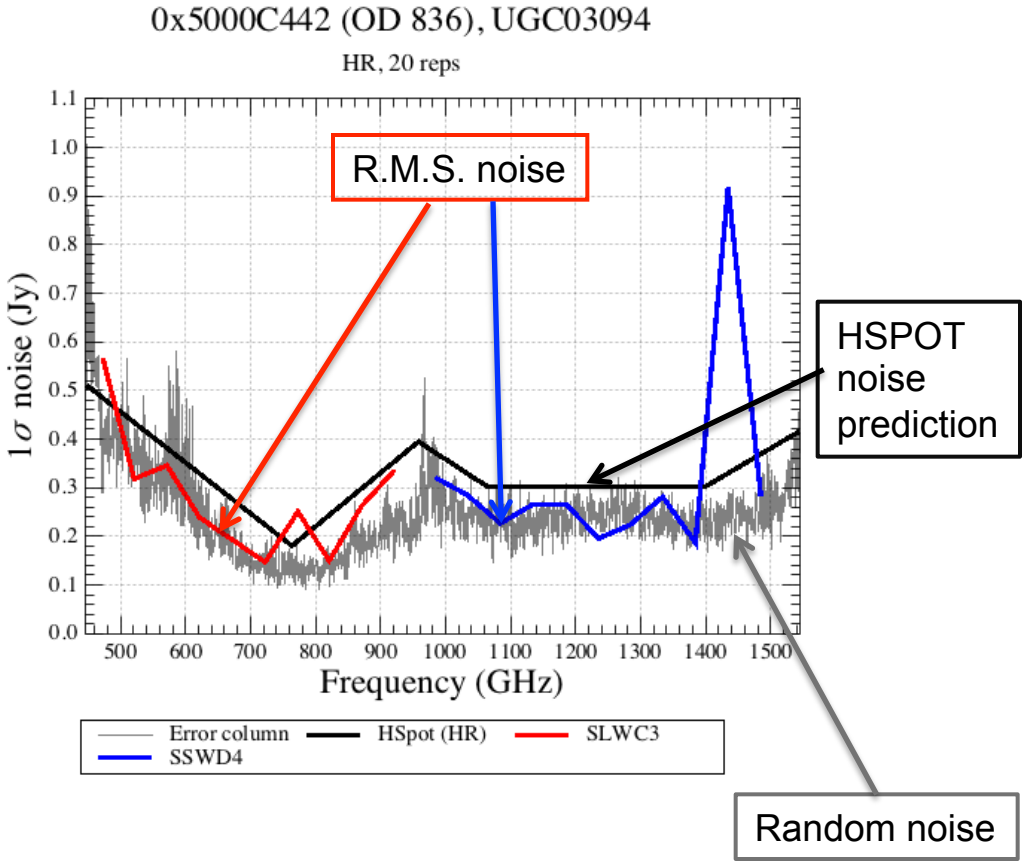
II. Spectral Noise



Script does a quick calculation of r.m.s. noise in your spectrum.

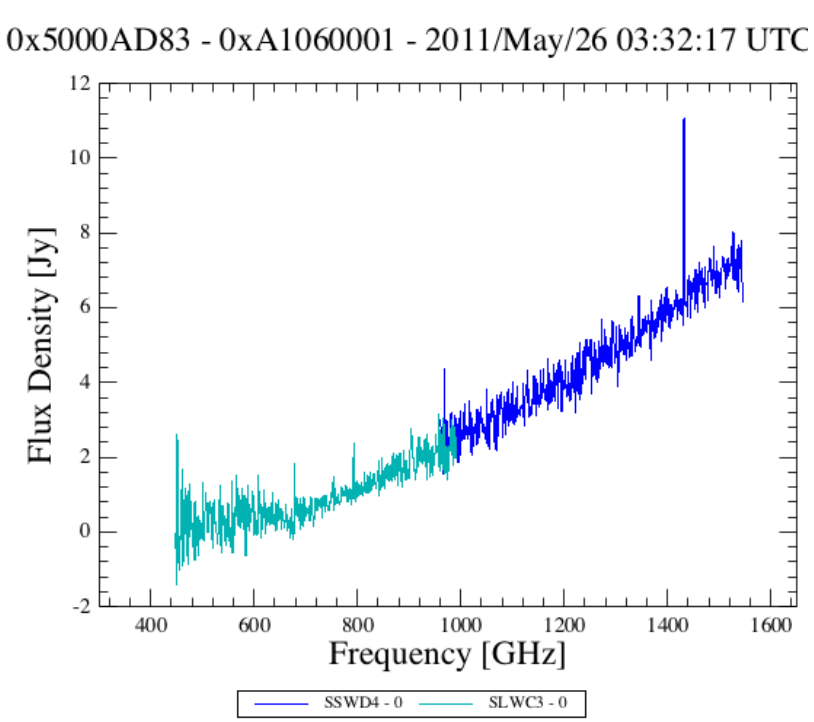
Spectral Noise: An Example

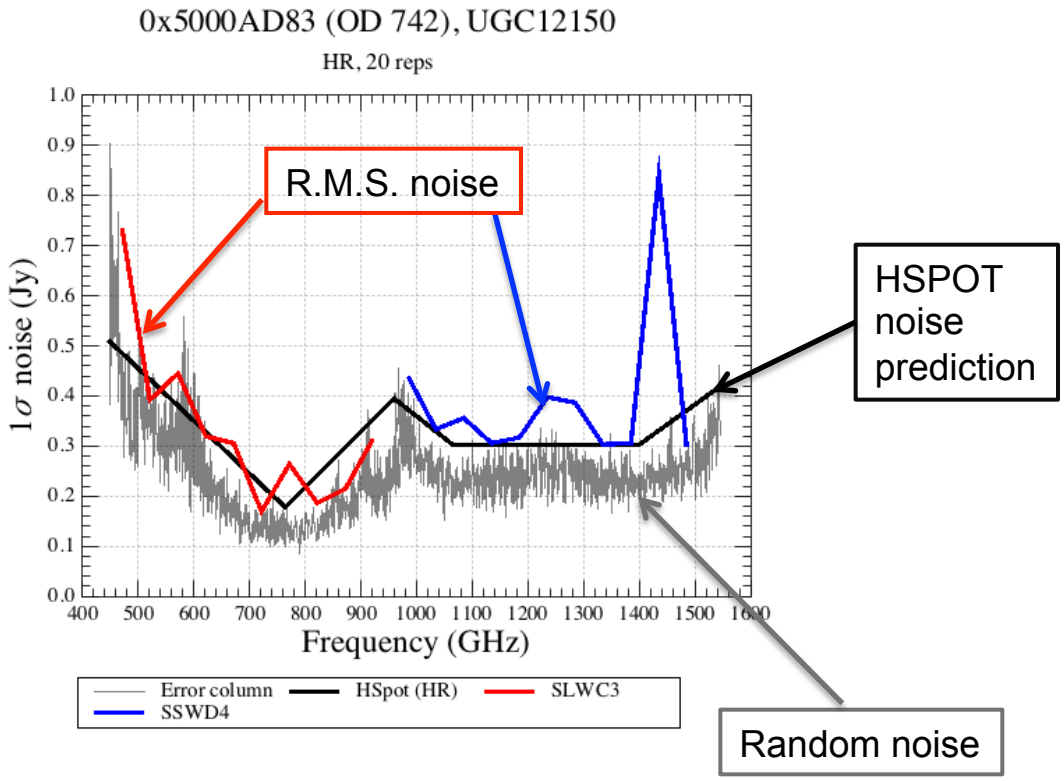




The total R.M.S. noise is quite close to the random noise in this case!

Spectral Noise: Another Example



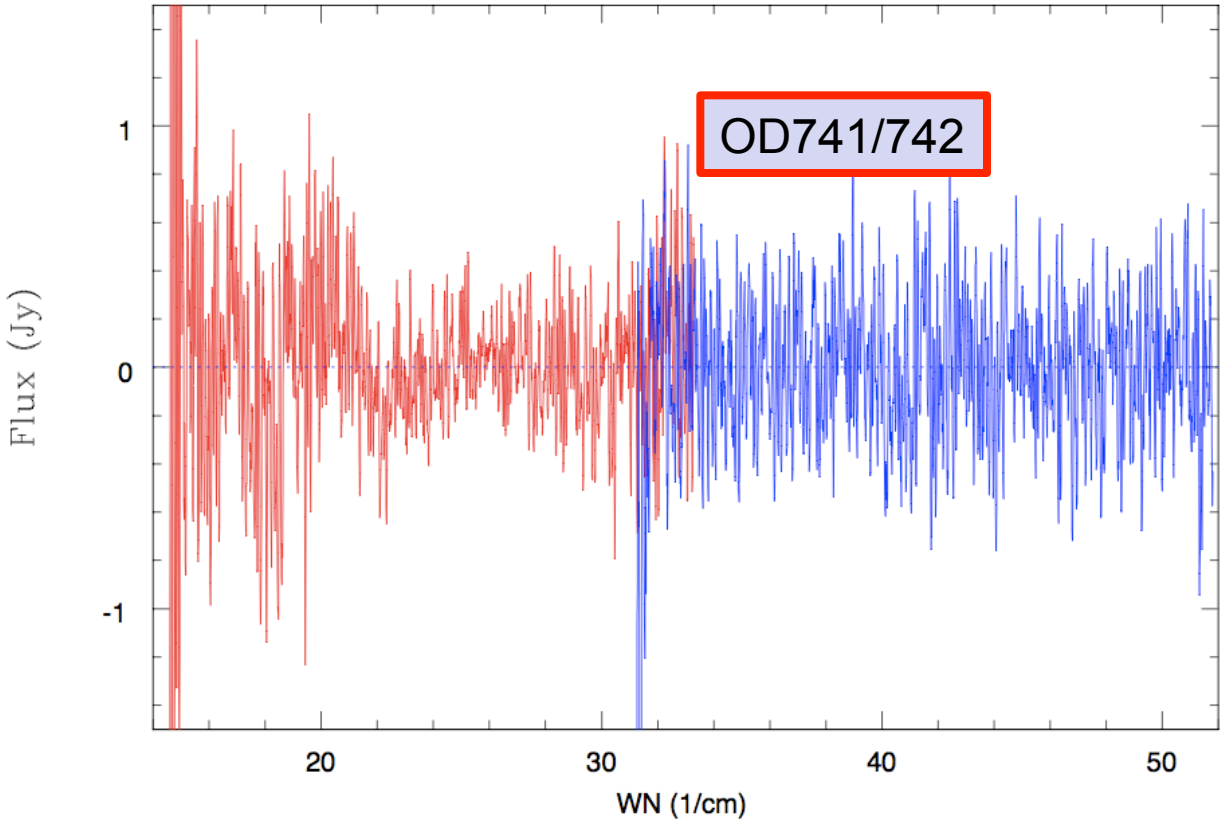


The total R.M.S. noise is significantly greater than the random noise in tis case!
→ Suggesting that there presents some significant systematic noise.

Beating Down Systematic Noise

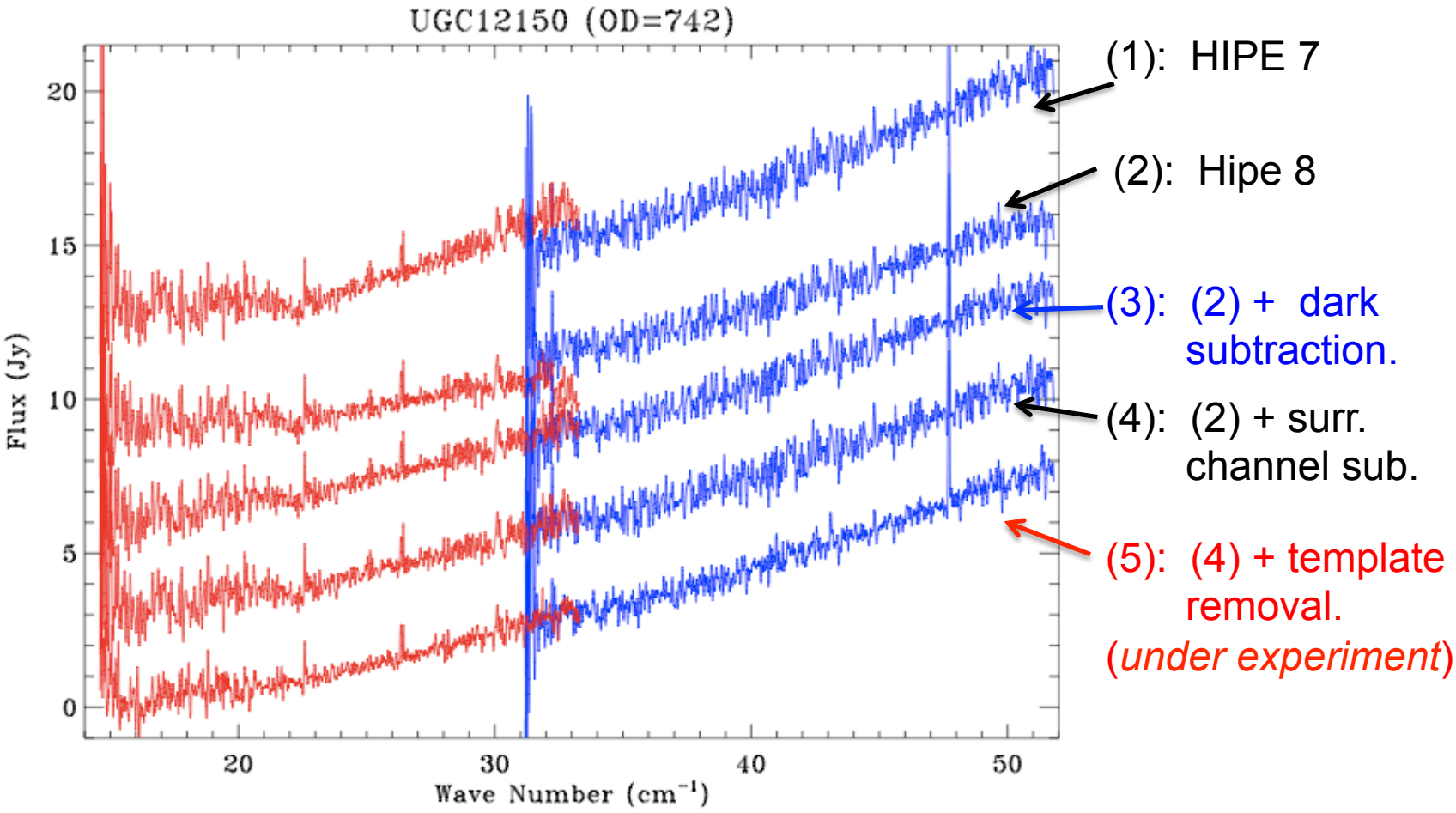
- In some observational days (ODs), there appears to have significant systematic noise that persists throughout the OD. This "correlated noise" may be removed in a number ways:
  - **Direct dark subtraction**: Subtract from your observation a long dark observation taken in the same OD. (This may not work for early ODs as dark observations were take in a different mode, i.e., CR instead of HR.)
  - **Noise Template Method**: Create a correlated-noise template by median filtering observations of galaxies at different redshifts. Then this template spectrum could be subtracted from your own spectrum to remove much of the systematic noise. (This method always works. But you need to have and access to other observations on the same OD.)

Example of a Template of Significant Systematic Noise



Based on 18 independent observations

Spectrum Examples



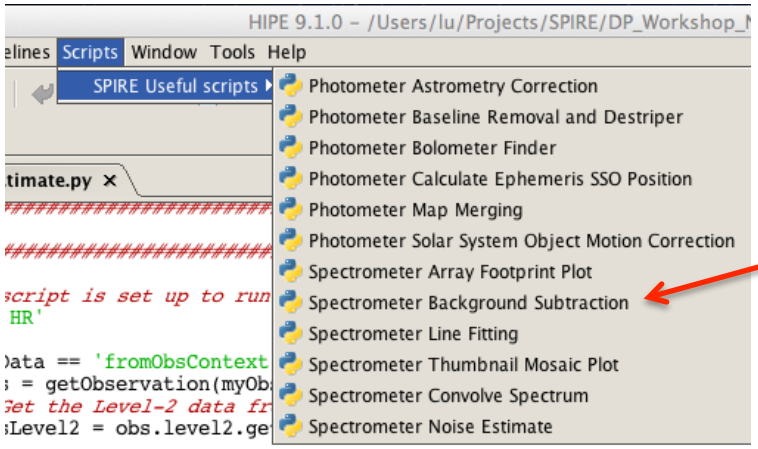
Summary

- Faint point-source spectra from standard pipeline may suffer a continuum flux uncertainty of 0.5-1 Jy (as of HIPE 9.1). In most cases, this can be easily corrected for by subtracting a residual sky spectrum from a dark observation or surrounding detectors. *Simple scripts for these corrections are available with HIPE 9.1.*
- On some ODs, spectral noise is significantly larger than the random noise implying some *systematic (or correlated) noise,* which varies from one FTS cycle to another. There are ways to possibly remove or reduce this systematic noise, including (a) direct subtraction of a dark observation, and (b) subtraction of a correlated-noise template.

Demo on Improving Continuum Flux

- You can download the script from:
  https://nhscsci.ipac.caltech.edu/sc/index.php/SPIRE/September2012

  Note: this is a simplified version of the user script available in HIPE 9.1:



The original script

- The sample observation we will use is of the galaxy UGC03094 from program "OT1_nlu_1." This is one of the sample data for this workshop.

Surrounding Channel Subtraction on UGC 3094