SPIRE Spectrometer Data: Calibration Updates, User Data Reprocessing, and Other Issues

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(On behalf of the SPIRE ICC)

Outline

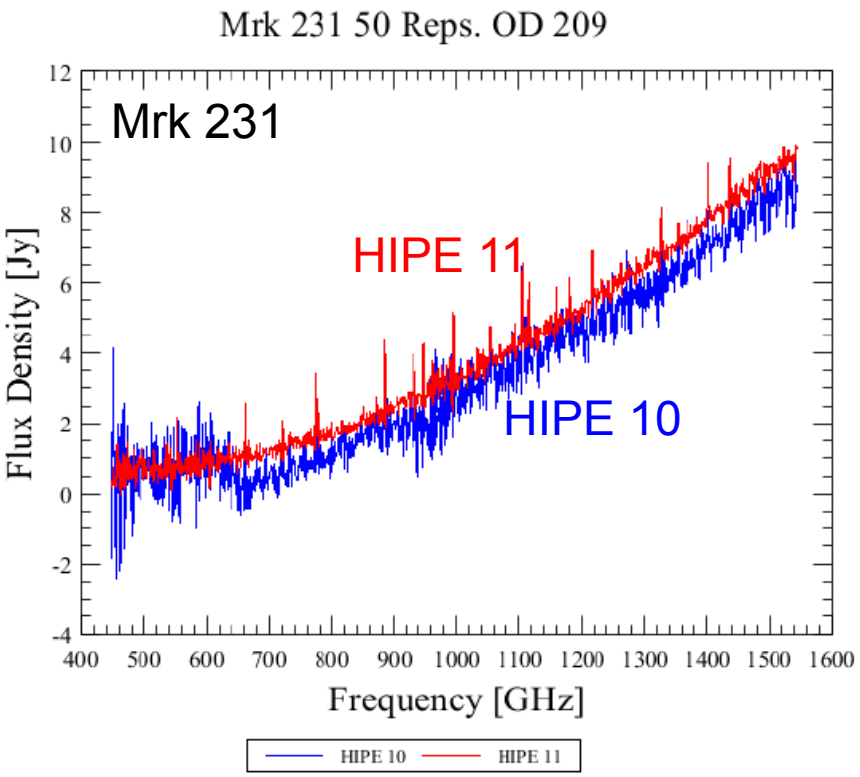
- Calibration updates.
- User data reprocessing.
- Issues that may impact your data and how to deal with them:
  - Continuum offset
  - Fringe problem?
  - Partially resolved lines
  - Semi-extended sources, pointing offset
  - Cooler cycles
  - LR mode

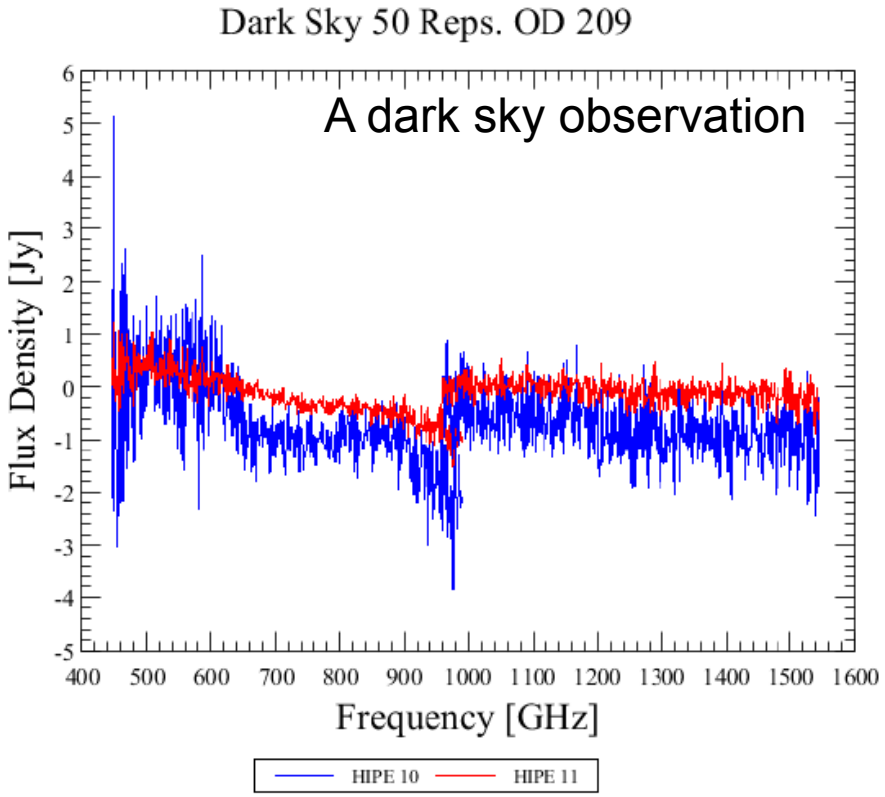
Why Might You Want to Reprocess Your FTS Observations?

Two Main Reasons:

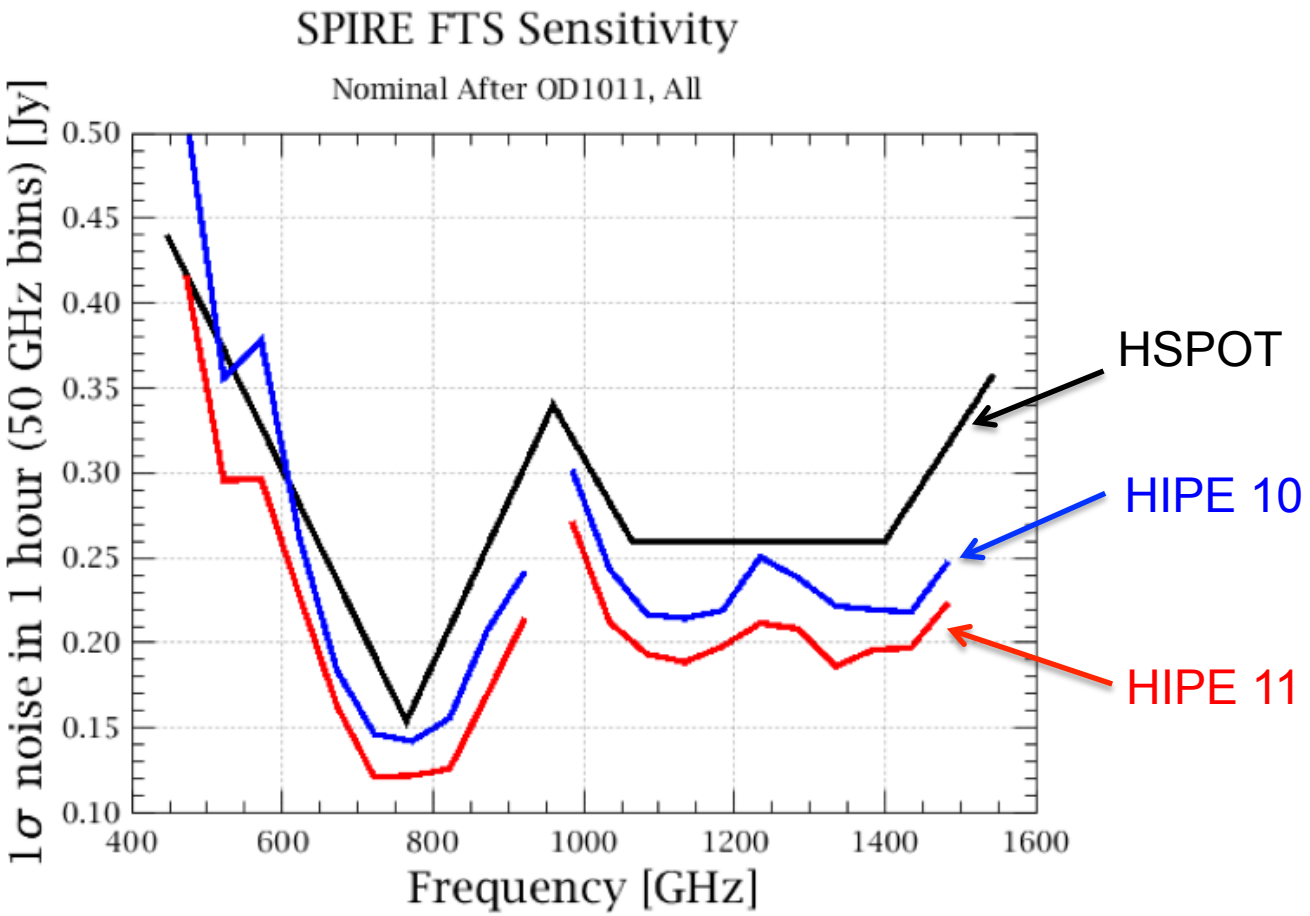
- Both calibration and pipeline are still being improved at this point. You might want to process your data with the latest calibration files (i.e., spire_cal_11_0).
- Depending on your particular observation, you may want to explore possible improvements to the standard data reduction pipeline, especially if your targets are faint (i.e., of a few Jy). We discuss a few “issues” that may affect your observations, and how you can deal with them.

HIPE 11: Reduced Noise & Finges

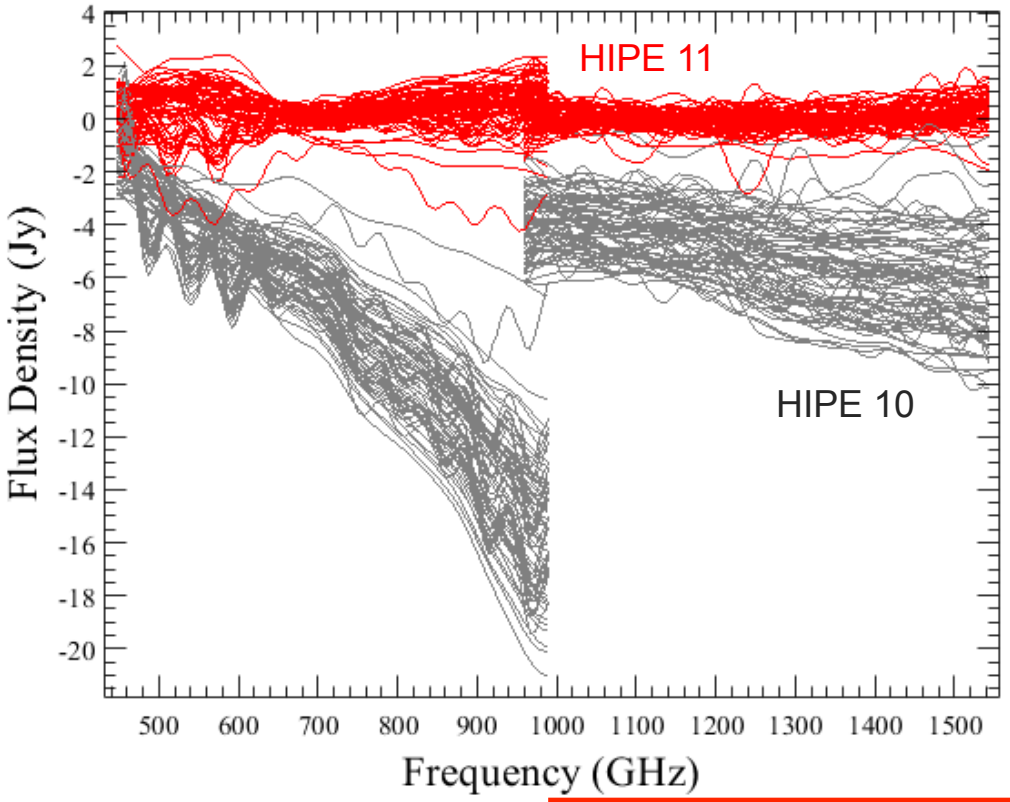




HIPE 11: Better RSRFs ➔ Better Sensitivity



HIPE 11: Much Better Results for the Bright Source Mode



- HIPE 11 gives much better results on dark observations than HIPE 10.

NOTE: Ideally we want a flat spectrum at 0 Jy for these (telescope background-subtracted) spectra of dark sky.

How to Do a User Data Reprocessing?

- You can load the spectrometer data reprocessing script within your HIPE session:
  - ➔ HIPE -> Pipelines -> SPIRE -> Spectrometer single pointing user pipeline.
- As an example, at the end of this session, I will show how to run this script to reprocess an observation from HIPE 10 to 11:
  - ➔ Obsid = 1342230419
  - ➔ Target = ESO099-G004
  - ➔ HR, 40 FTS repeats, sparse sampling, with nominal detector setting.

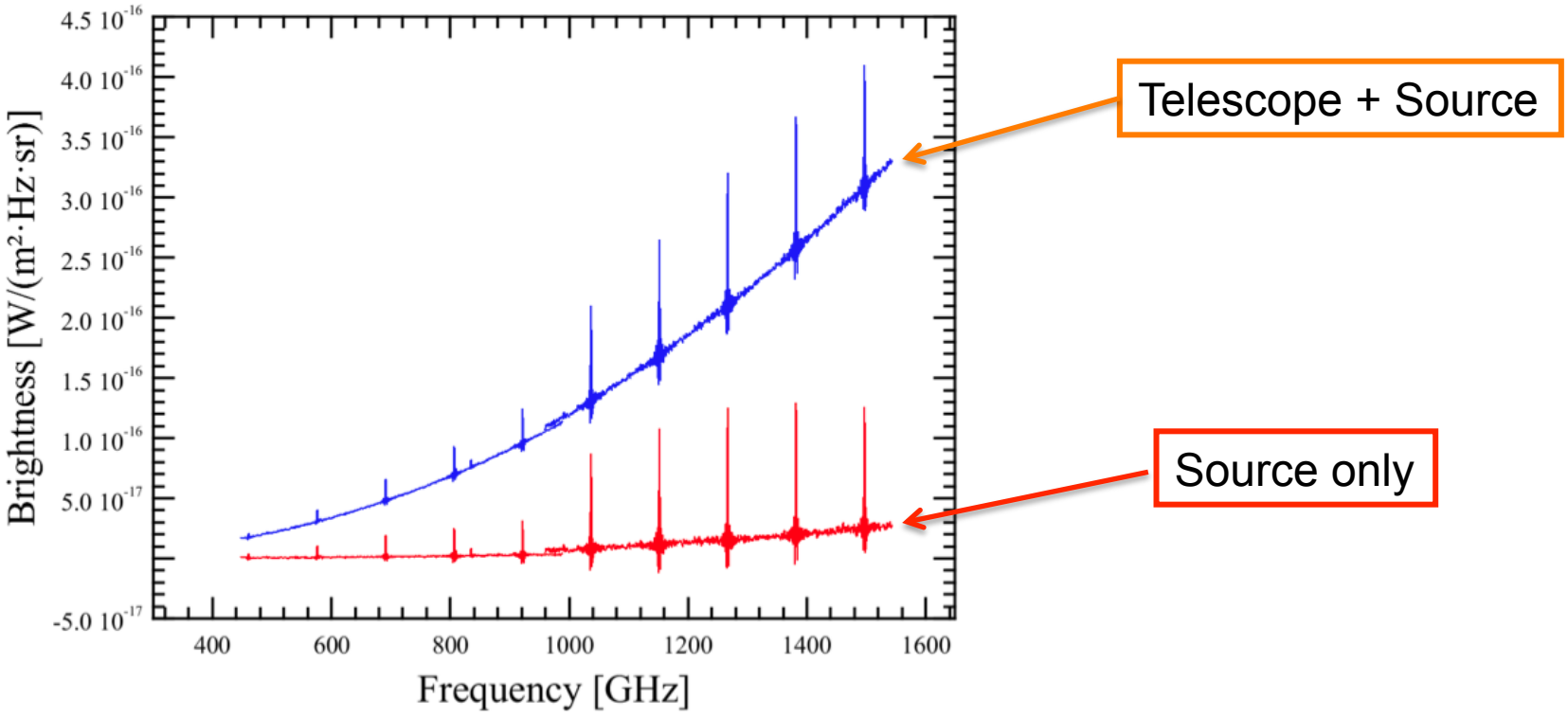
  (Note: This is one of the sample observations for the workshop.
- Then during the last SPIRE session this afternoon, you can do an exercise to compare the spectral noise between HIPE 10 and 11 results on this particular observation.

Potential Issues

- Issues that may impact your data and how to deal with them:
  - I. Continuum offset.
  - II. Fringes, and how to remove them.
  - III. Partially resolved lines.
  - IV. Semi-extended sources (or pointing offset).
  - V. Impact from the cooler cycles.
  - VI. Long expoures in the LR mode.

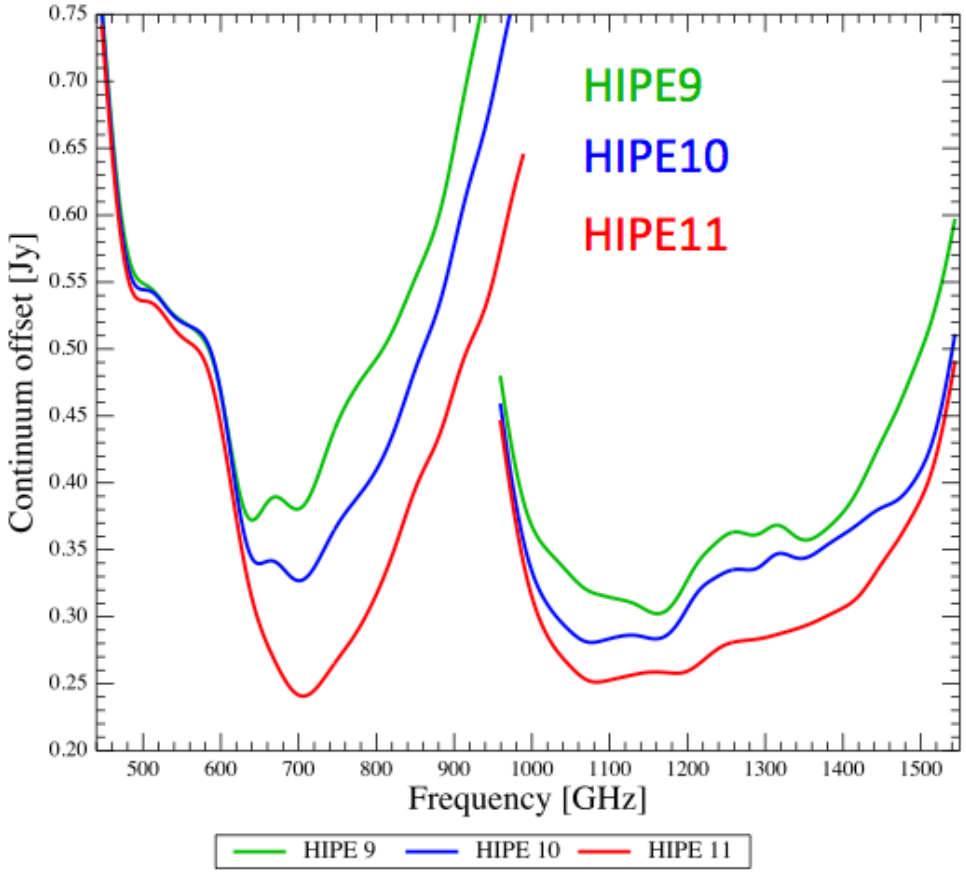
I. Continuum Flux Systematics

Telescope Emission Dominates Most Observations!



Uncertainty from Telescope Emission Removal

Standard deviation of > 5000 dark sky scans reduced using the standard pipeline:



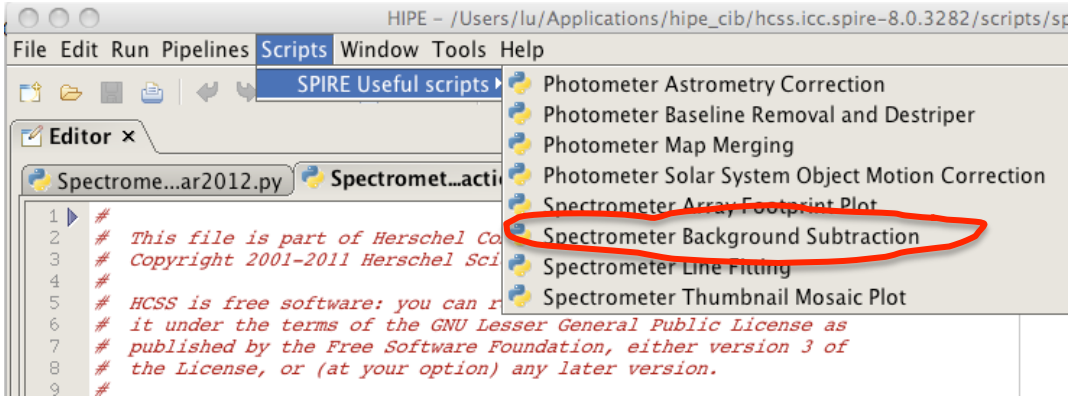
- Continuum flux calibration accuracy in HIPE 11 is on the order of ~ 0.3-0.6 Jy for SLW and ~ 0.3-0.4 Jy for SSW.
- Further improvement may be done using the background subtraction script.

How to Remove Residual Telescope Emission?

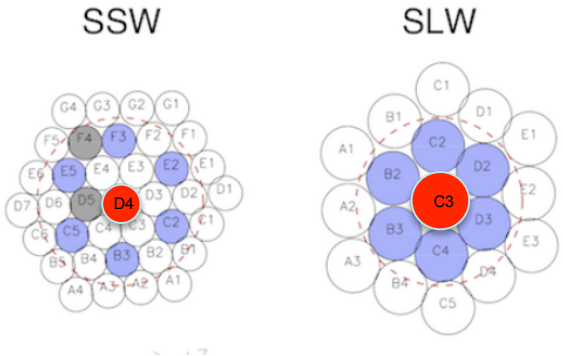
- Two practical ways:
  - Subtract an observed **Dark Sky** from the same observational day, as close in time to your observation as possible, which is processed in the same way as your own observation.
    - A list of dark observations can be found at:

    http://herschel.esac.esa.int/twiki/bin/view/Public/SpireDailyDarkObservations
  - Subtract a 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.

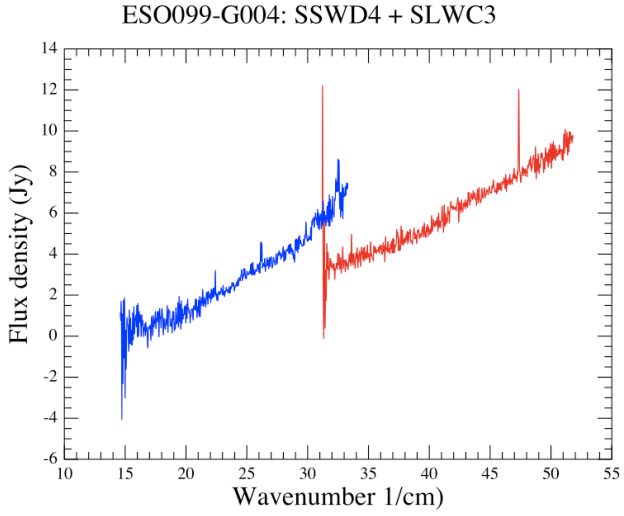
A script for doing both these corrections is available inside HIPE:

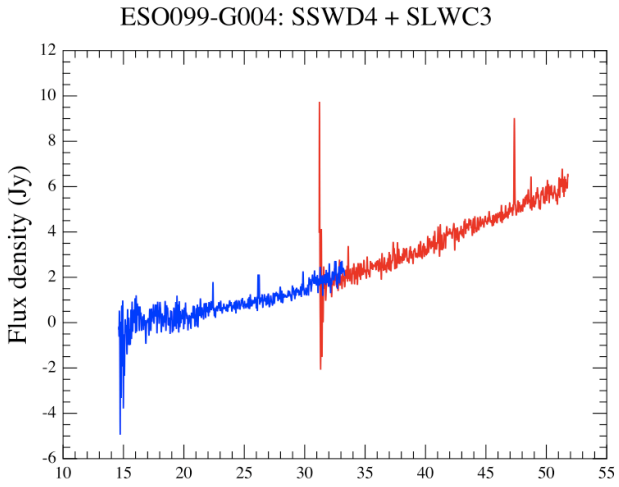


Residual Telescope Emission Removal: Using Surrounding Channels

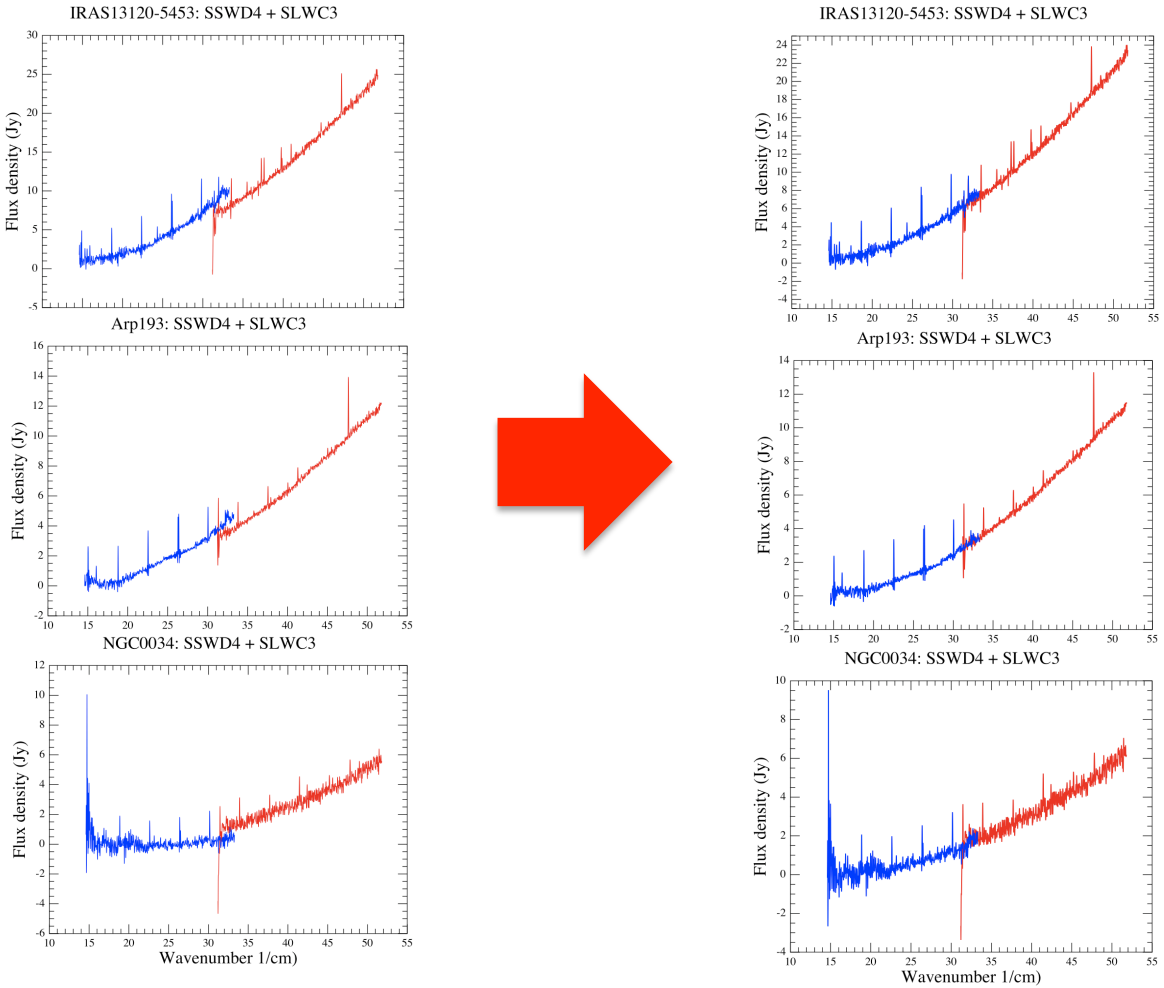


- Using a median spectrum from the co-aligned detectors as the residual telescope spectrum.
- This (or a polynominal fit to it) is then subtracted from the spectrum of the central detectors.



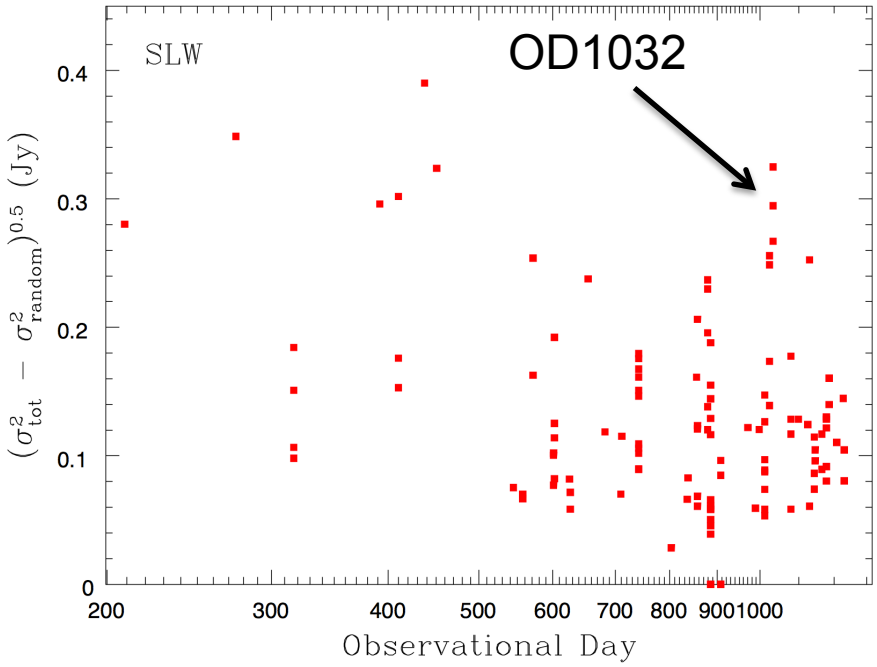


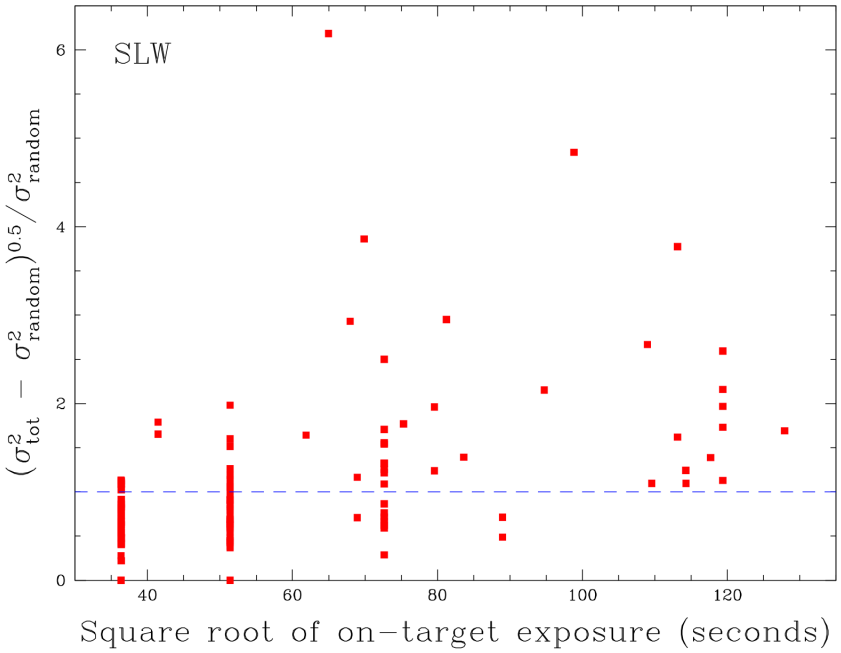
Residual Telescope Emission Removal: More Examples



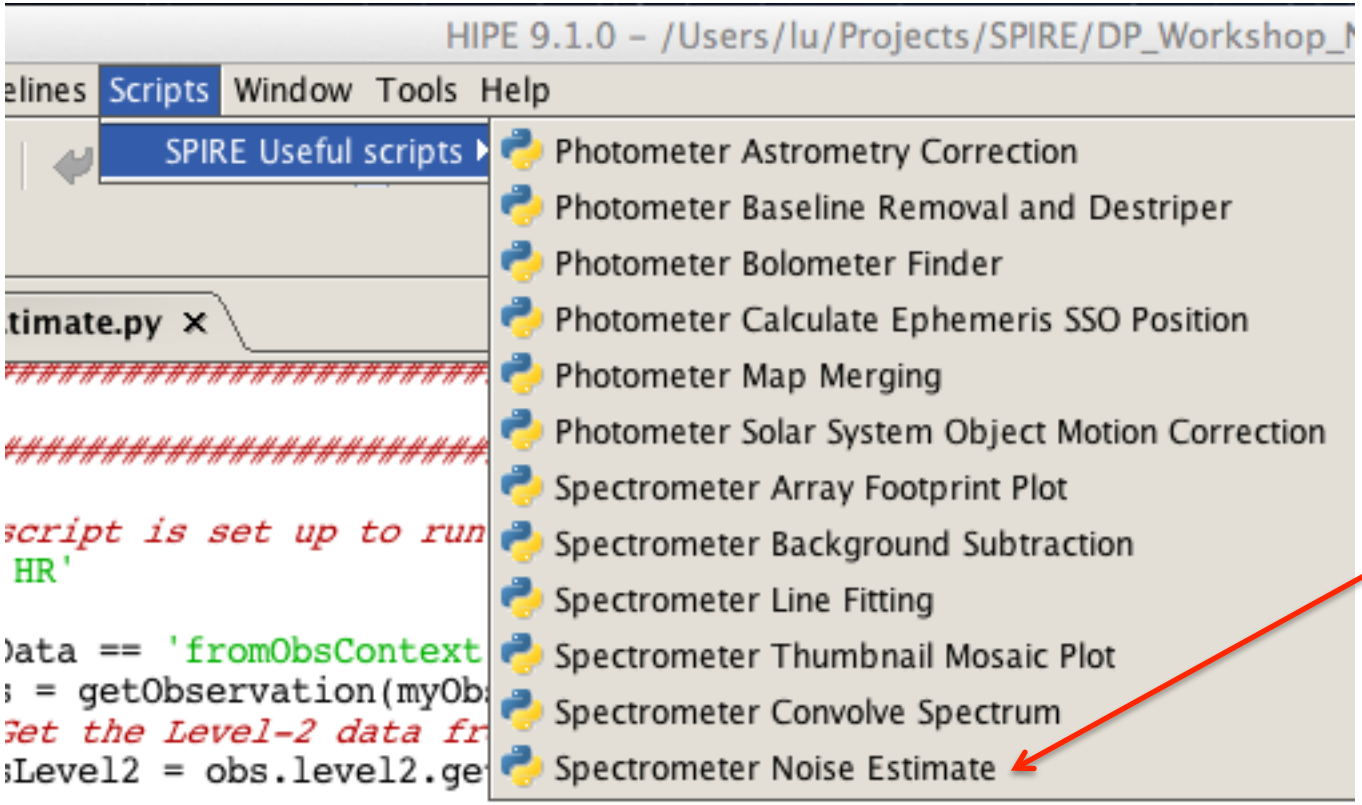
See a demo on this in this afternoon

Systematic Noise Over the Mission
(NOTE: HIPE 10 Results)





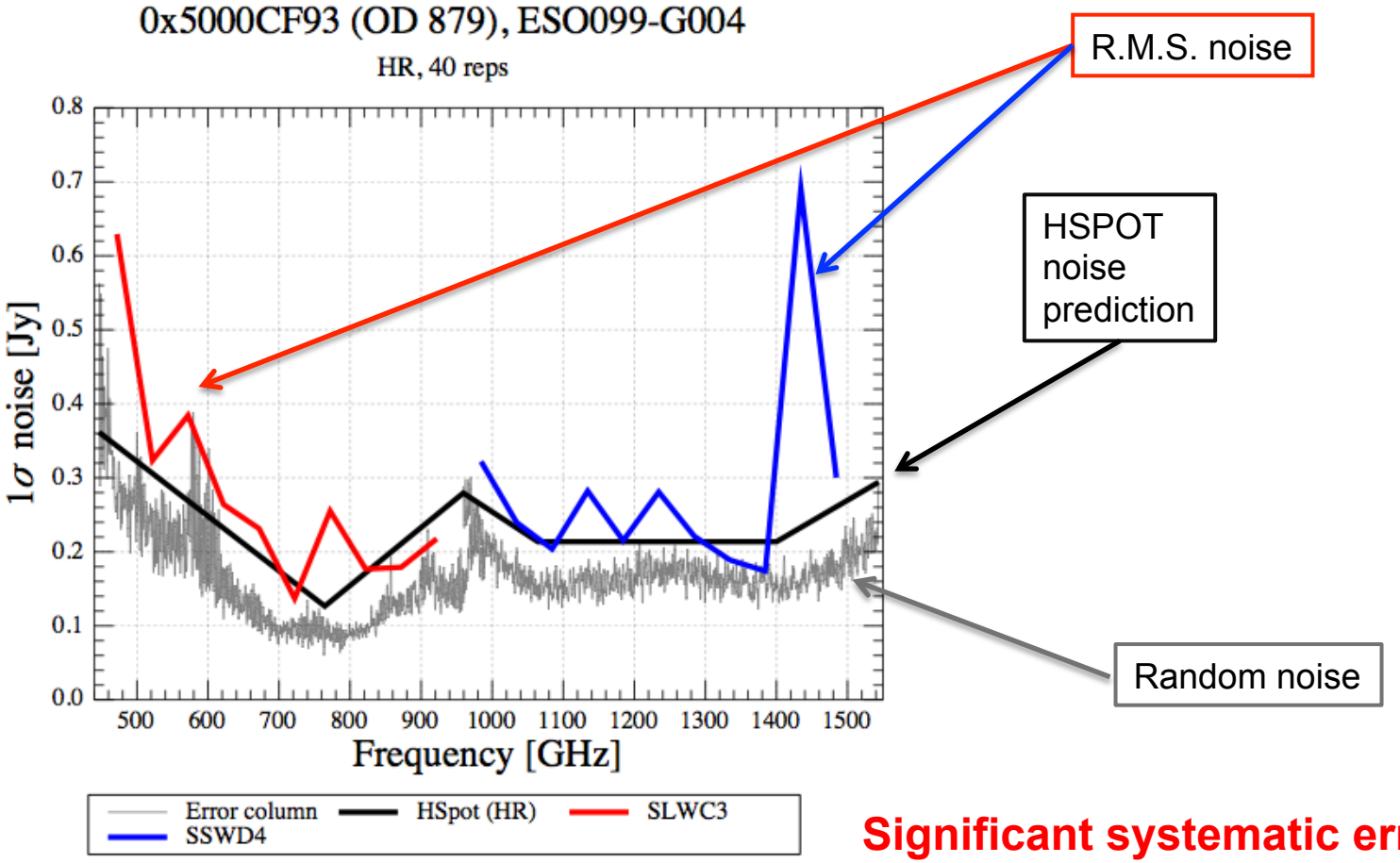
II. Any Significant Systematic Noise?



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

Spectral Noise: An Example

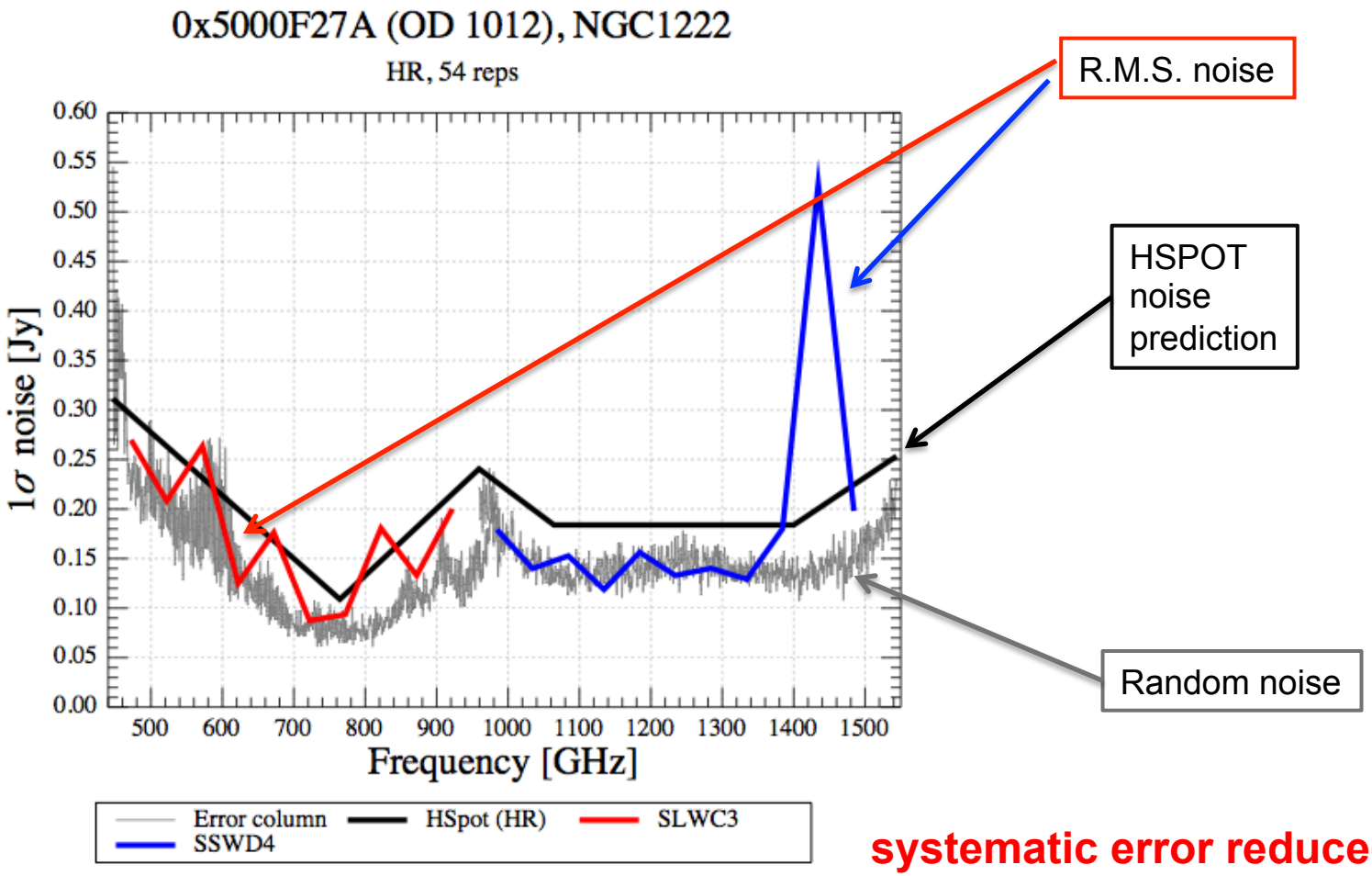
(HIPE 10 result)



Significant systematic error!

Spectral Noise: An Example

(HIPE 11 result)



systematic error reduced!

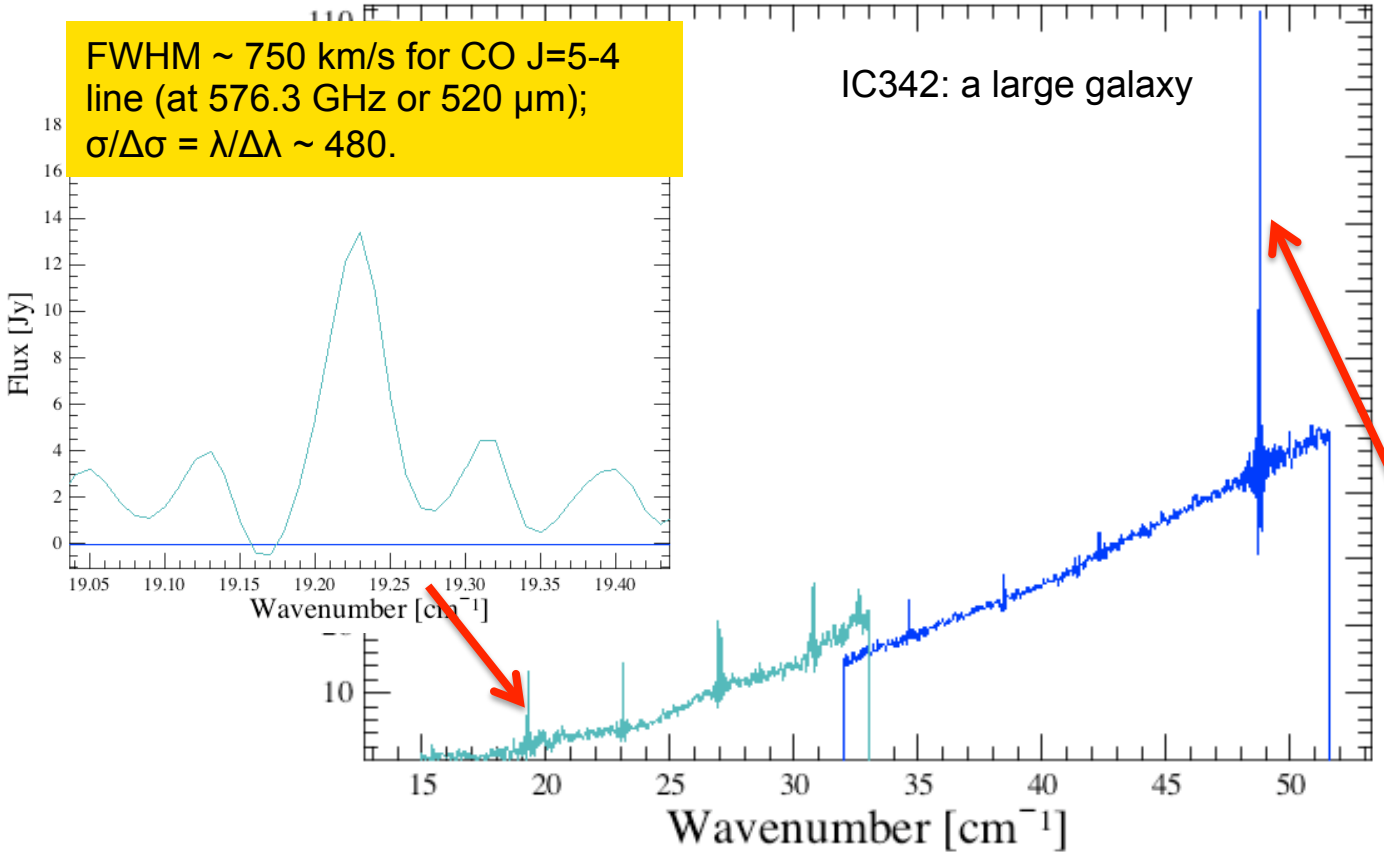
How to Beat Down Systematic Noise

- ***First anf foremost, use or reprocess your data to HIPE 11 results.***
- If there is still significant sytematic noise (or fringes), there are ways to reduce it:
  - **Direct dark subtraction**: Subtract from your observation a long dark observation taken in the same OD. (This may not work for early ODs, i.e., prior to OD1079, 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.)
    - See http://herschel.esac.esa.int/CalibrationWorkshop5/Posters/11_NanyaoLu.pdf)
    - A user script for this is available unpon requesting.

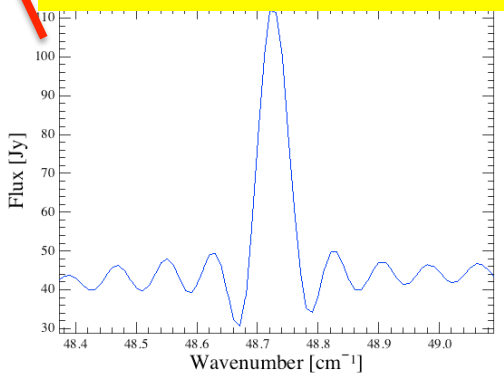
III. Spectral Resolving Power Depends on Wavelength

FWHM ~ 750 km/s for CO J=5-4 line (at 576.3 GHz or 520 μm);
σ/Δσ = λ/Δλ ~ 480.

IC342: a large galaxy



FWHM ~ 296 km/s for [NII] 205um (at 1461 GHz or 205 μm);
σ/Δσ = λ/Δλ ~ 1218.



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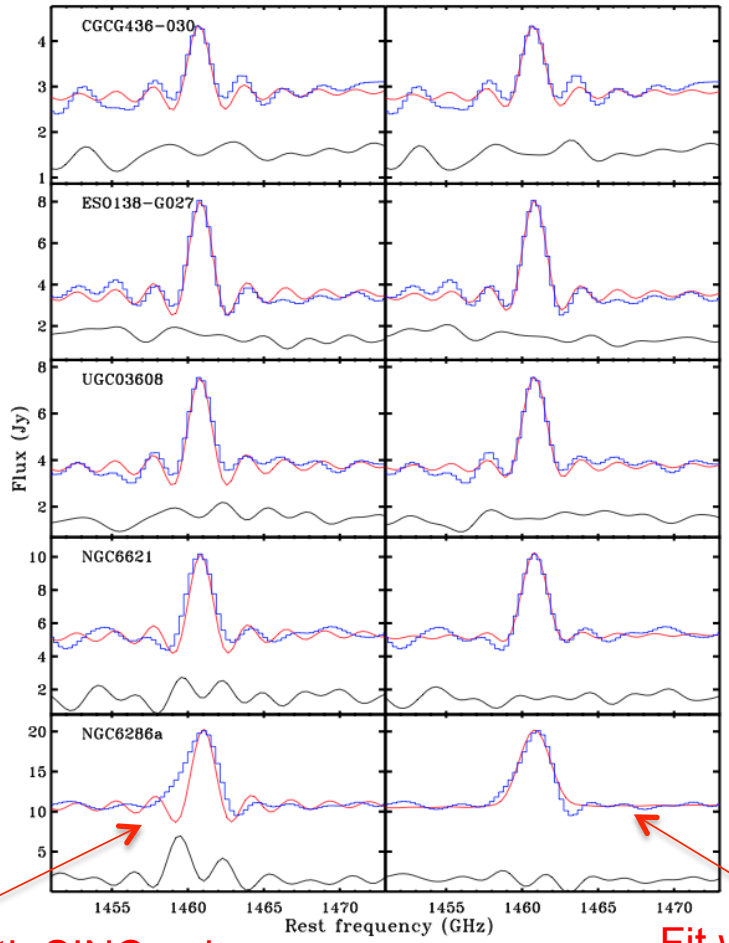
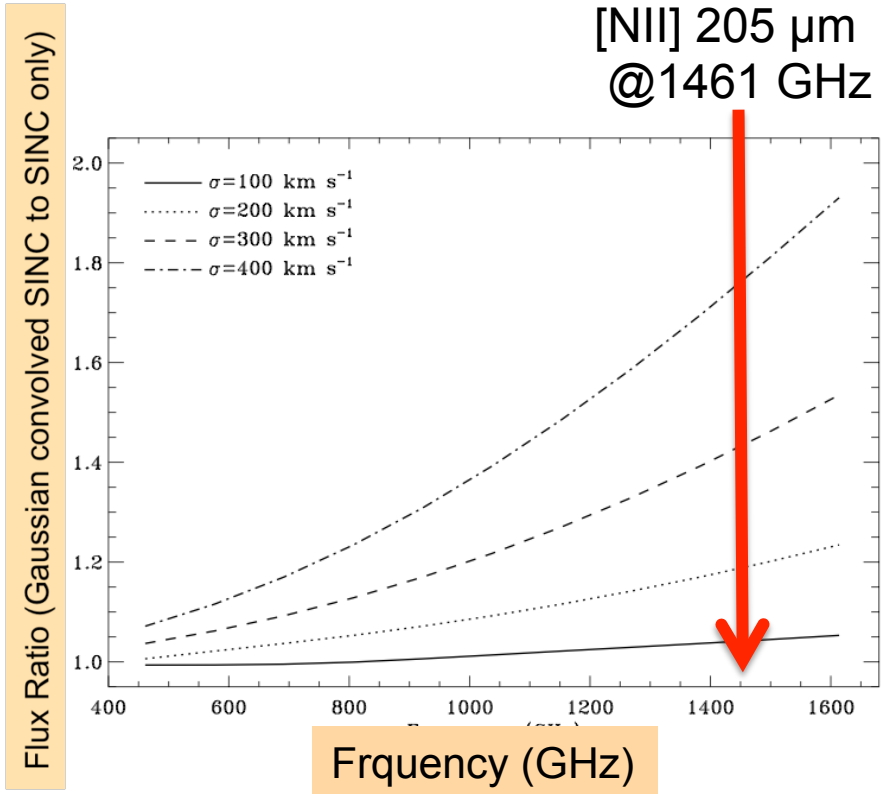
[NII] 205 um Lines May be Partially Resolved

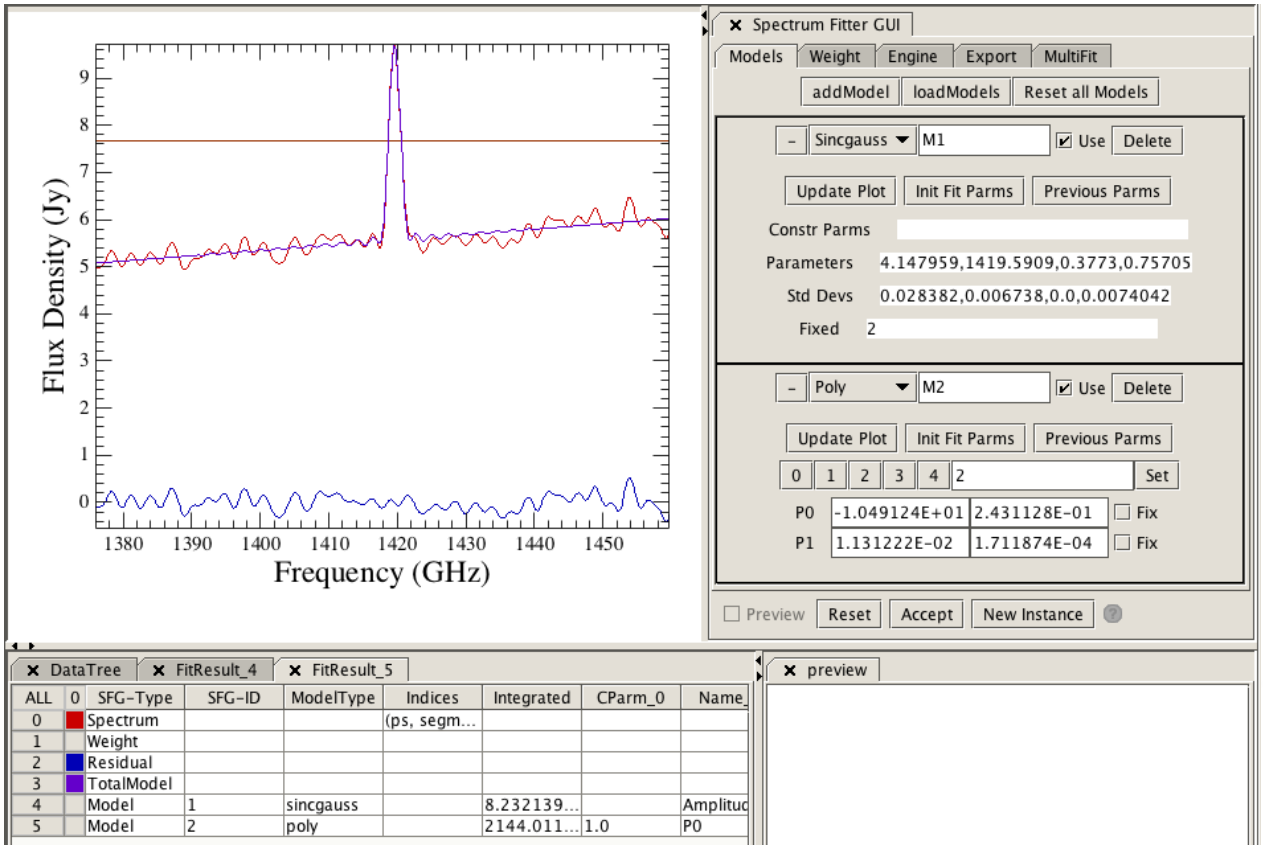




Fit with SINC only

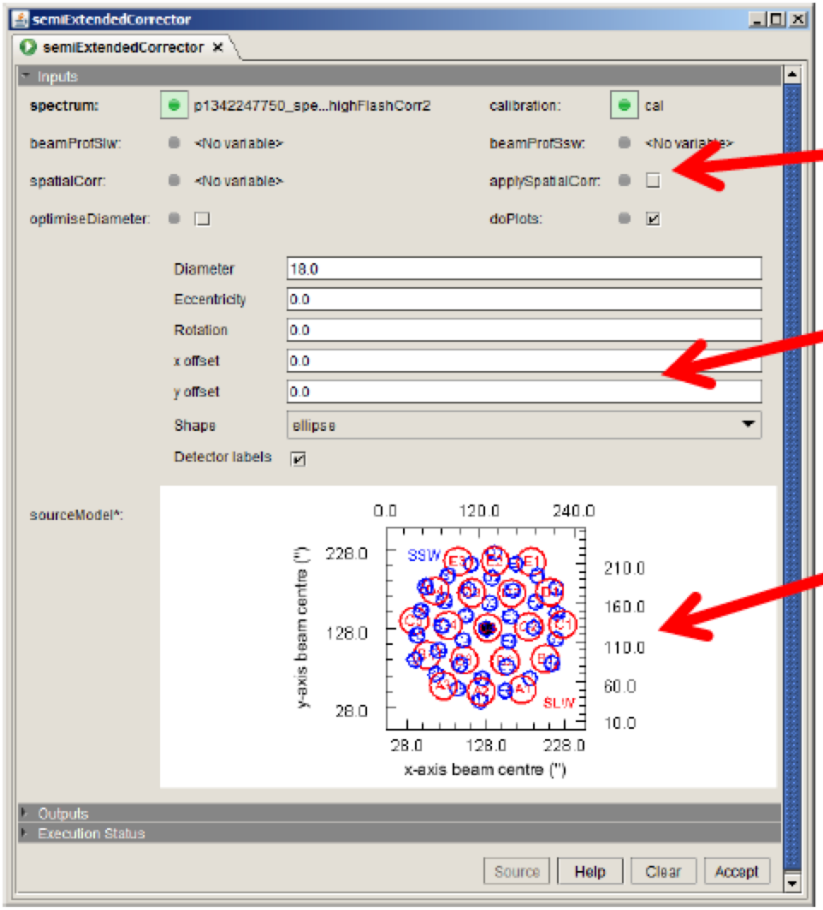
Fit with SINC convolved with Gaussian (SincGauss model)

Line Fitting with SincGauss Profile in HIPE



- Works best when S/N is high.
- For fainter lines, it might be better to use a SINC profile for fitting, and then correct the resulting flux for an estimated velocity width.
- See SDRG, sect. 6.9.10 on how to use SincGauss line profile in script.

IV. Semi-extended Source Correction Tool



Task name: semiExtendedCorrector

Input the Point-source calibrated Level-2 product and calibration tree

Enter the details of the source model

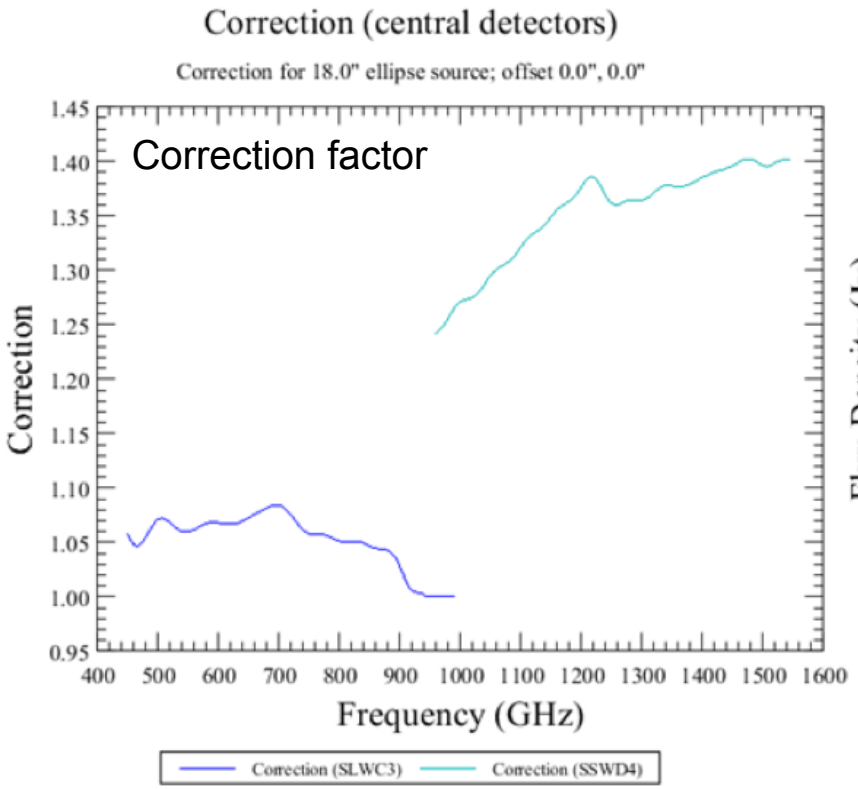
Source model visualised with footprint

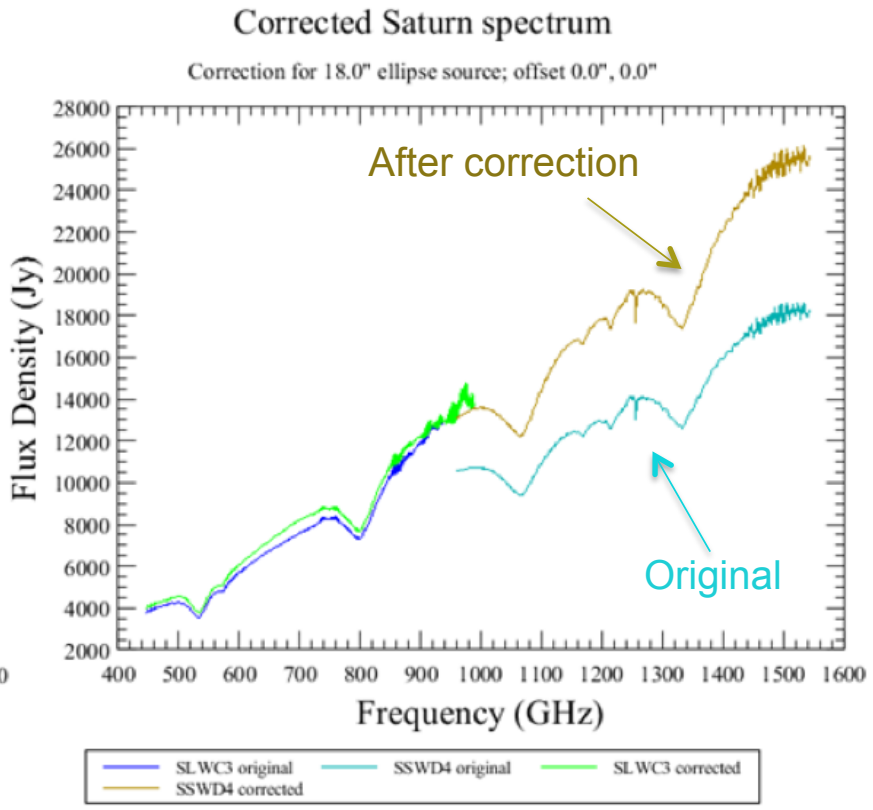
Applicable to centre detectors:

Ellipse
Gaussian

(For more information. see: Wu et al 2013 --- http://arxiv.org/abs/1306.5780)

Semi-extended Source Correction Tool



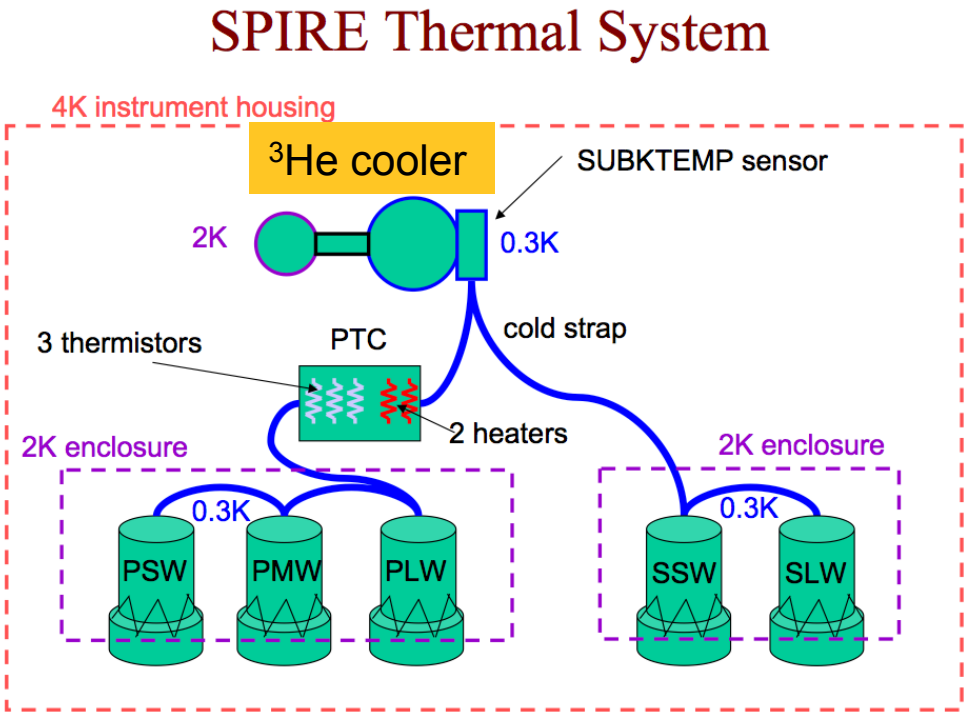


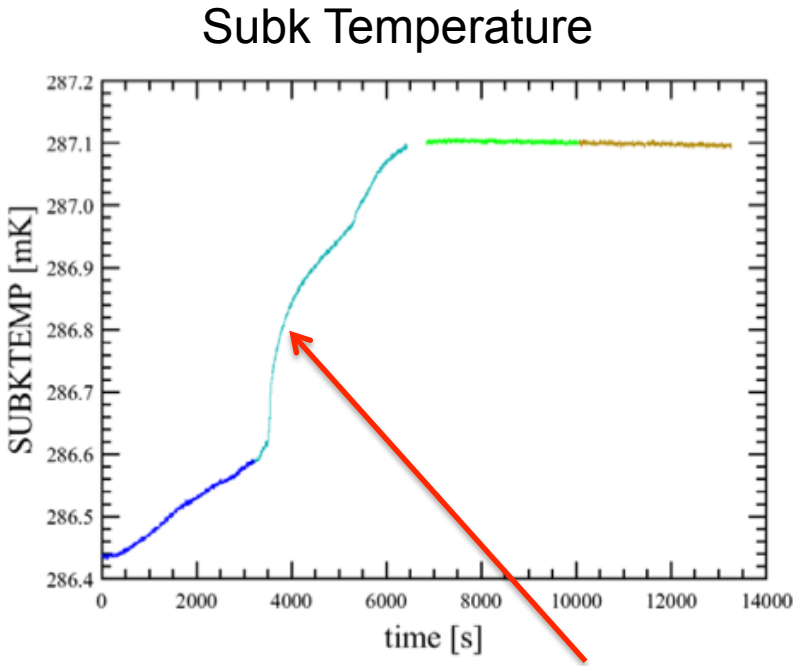
Semi-extended Source Correction Tool

Some remarks on using this tool:

- Works best on bright objects.
- For faint objects, the continuum suffers an (additive) uncertainty on the order of 0.4 Jy. *It might be a good idea to try to reduce/remove this continuum offset using surrounding channels before applying the semi extended correction tool to your data.*
- For galaxies, it is likely that the warm CO lines come from a more compact region than the (cold) dust continuum. Thus, if your interest is in CO lines, it might be better not to apply this correction to your spectrum.

V. Impact from Cooler Cycles

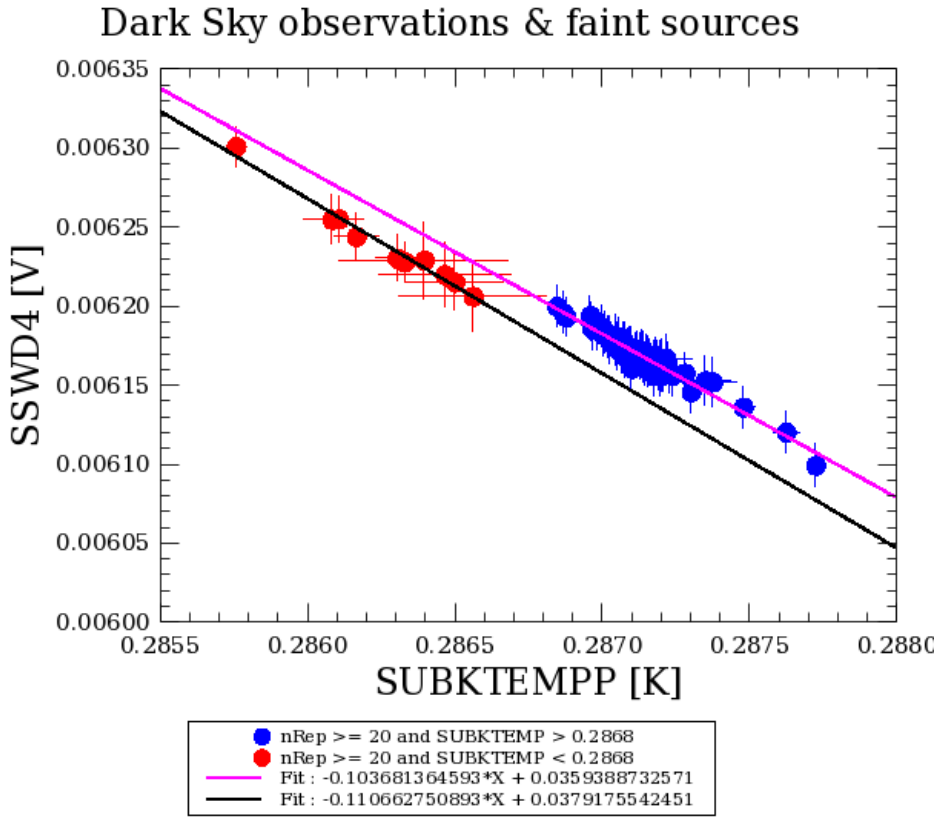




Fridge hold time ~ 45 hrs. n

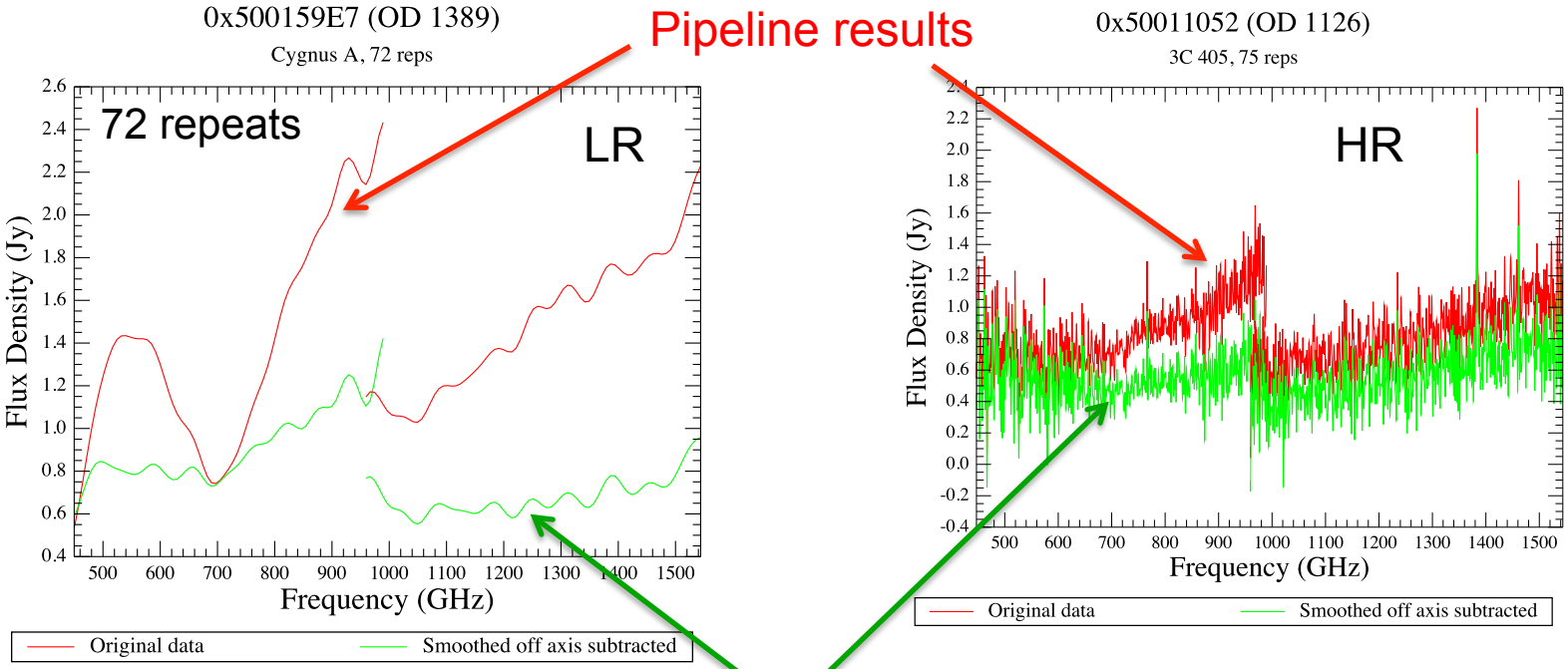
Unstable initial part
("cooler burp")

Impact from Cooler Cycles



- Red data points are taken when SubK temp. still increases rapidly during the initial phase of a cooler cycle.
- If not corrected for, it leads to a flux over- (under-) estimate at the high (low) end of a spectrum.
- This can be empirically corrected. Investigation is still underway.

VI. Caution on Low-resolution (LR) Data (with Long Integration)



Still under investigation!

Summary on Potential Issues

I. Continuum offset.
- Subtraction of a dark obs from the same observational day.
- Surrounding channel background subtraction.

II. Fringes and how to remove them.
- Check HIPE 11 results first, for the least possible fringes.
- Subtraction of an HR dark from same day (available after OD1079)
- Noise template method (for ODs prior to OD1079 or any OD).

III. Partially resolved lines.
- Gaussain-SINC profile fitting (but generally requiring a higher S/N).

IV. Semi-extended sources (or pointing offset).
- Correction tool available. But be aware of the continuum uncertainty in faint sources and of the fact that lines may originate from a more compact region than the continuum.

V. Impact from cooler cycles (under investigation).

VI. Long exposures in the LR mode (under further investigation).

Demo on Data Reprocessing

- I will use the script:
  - ➔ HIPE -> Pipelines -> SPIRE -> Spectrometer single pointing user pipeline.
- I will featch the HIEP 10 results of the following observation from Herschel archive and reprocess it to HIPE 11:
  - ➔ Obsid = 1342230419
  - ➔ Target = ESO099-G004
  - ➔ HR, 40 FTS repeats, sparse sampling, with nominal detector setting.

  (Note: This is one of the sample observations for the workshop.
- We will let the script run during the coffee break. And we will come back in the last SPIRE session today compare the spectral noise between HIPE 10 and 11 results on this particular observation.