SPIRE Spectrometer Data Reduction: Special Cases

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Topics to Cover

- Data reprocessing --- Do you generally need to reprocess FTS data yourself (for example, to use more up-to-date calibration tables)?
- Special cases that may call for additional data processing with available scripts/tasks in HIPE.

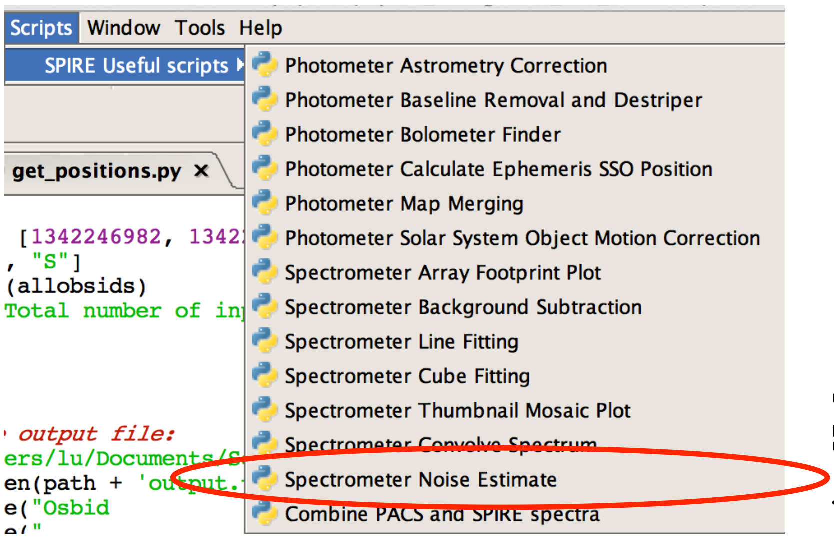
  Examples:
  - Spectral line fluxes: unresolved vs. partially resolved
  - Continuum of faint sources
  - Point source vs. semi-extended sources

Do you need to reprocess your FTS data?

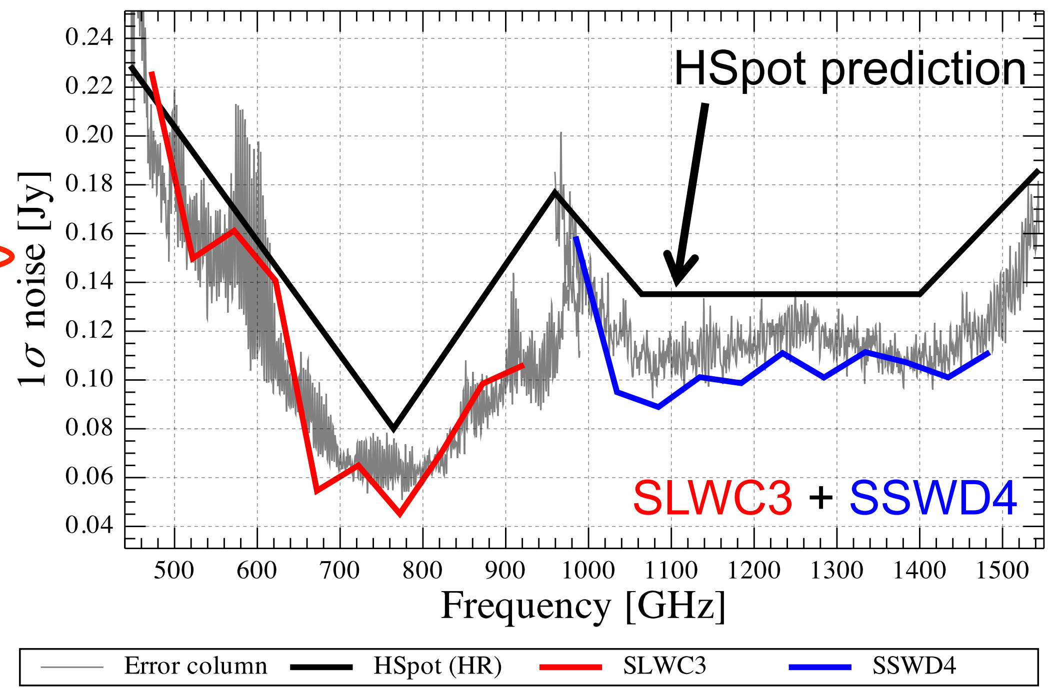
Normally, the answer is NO if you have data from HIPE 11 and onward. However,

- Both calibration and pipeline are still being improved at this point. If you particular data might benefit from reprocessing with the latest calibration tree available, please feel free to contact NHSC helpdesk. We usually respond nicely and very promptly.

Quick Noise Assessment May be Useful



- Red and blue: Total rms noise (systematic + random)
- Gray spectrum: randon noise only
- Black curve: HSpot predicted total noise



Useful to see if your observation performed as or better than expected.

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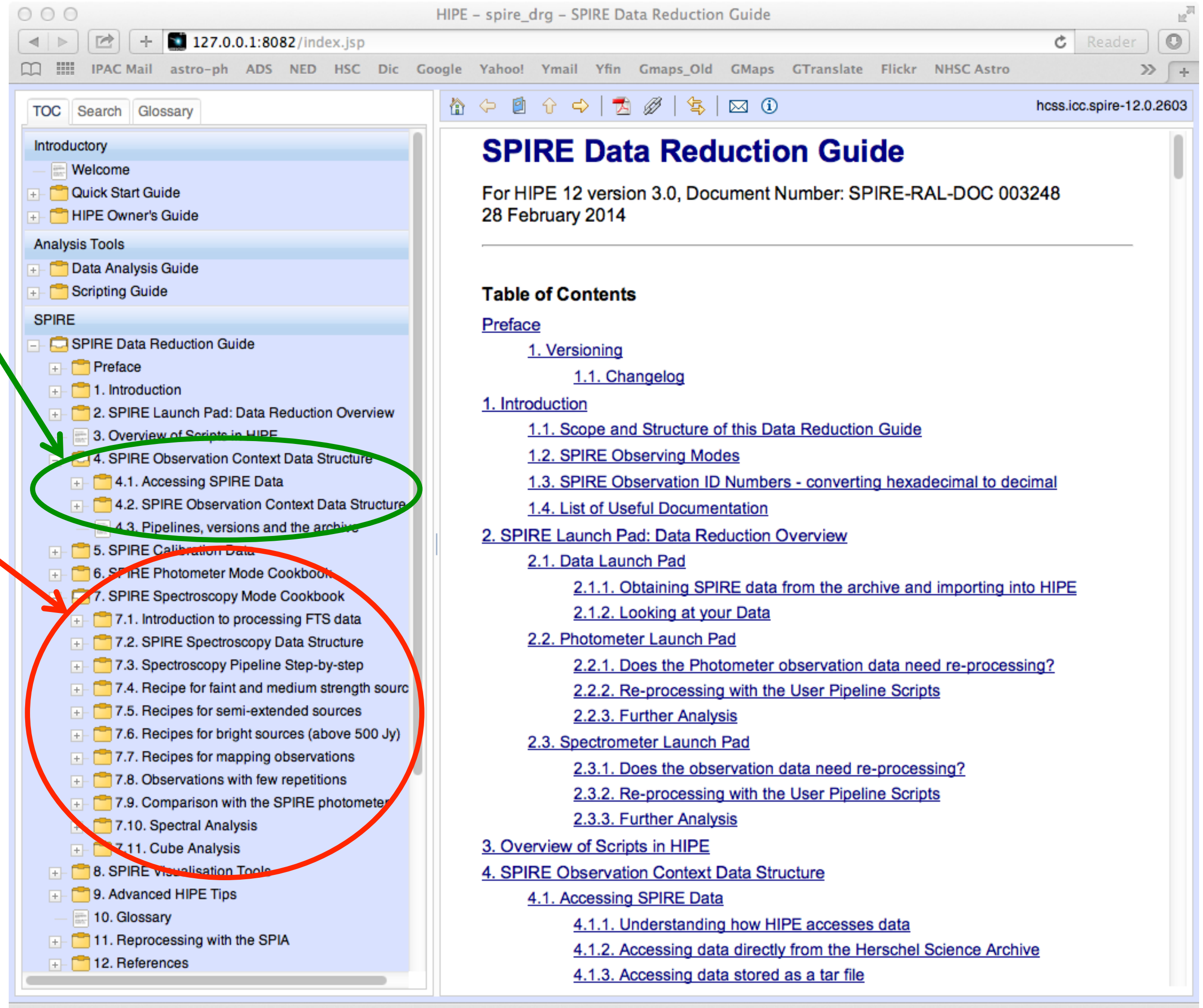
SPIRE Data Reduction Guide (DRG)

General SPIRE data info

SPIRE/FTS data structure and processing, and data analysis receipes



Spectrometer Useful Scripts

- Array Footprint Plot
- Background Subtraction
- Line Fitting
- Thumbnail Mosaic Plot
- Convolve Spectrum
- Noise Estimate
- Cube Fitting
- Combining PACS and SPIRE spectra

Available in HIPE!

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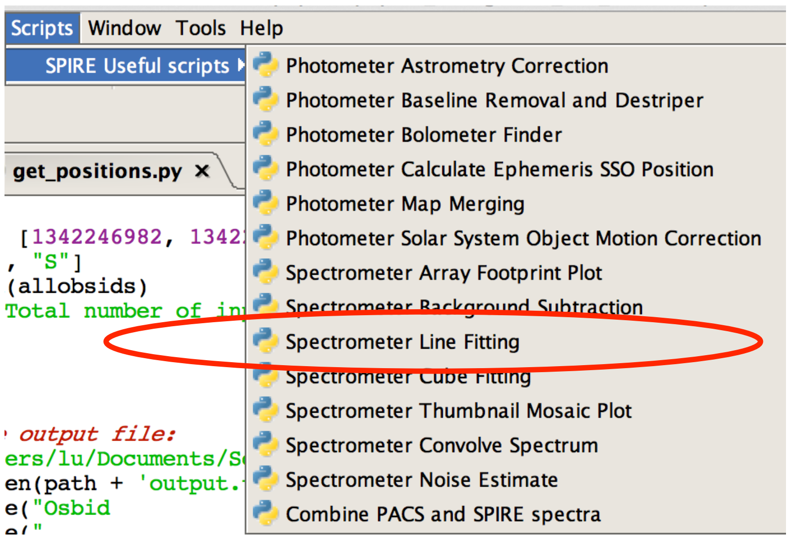
Spectral Line Fluxes

Hands-on exercise 1

- Line fitting script (for unresolved lines)



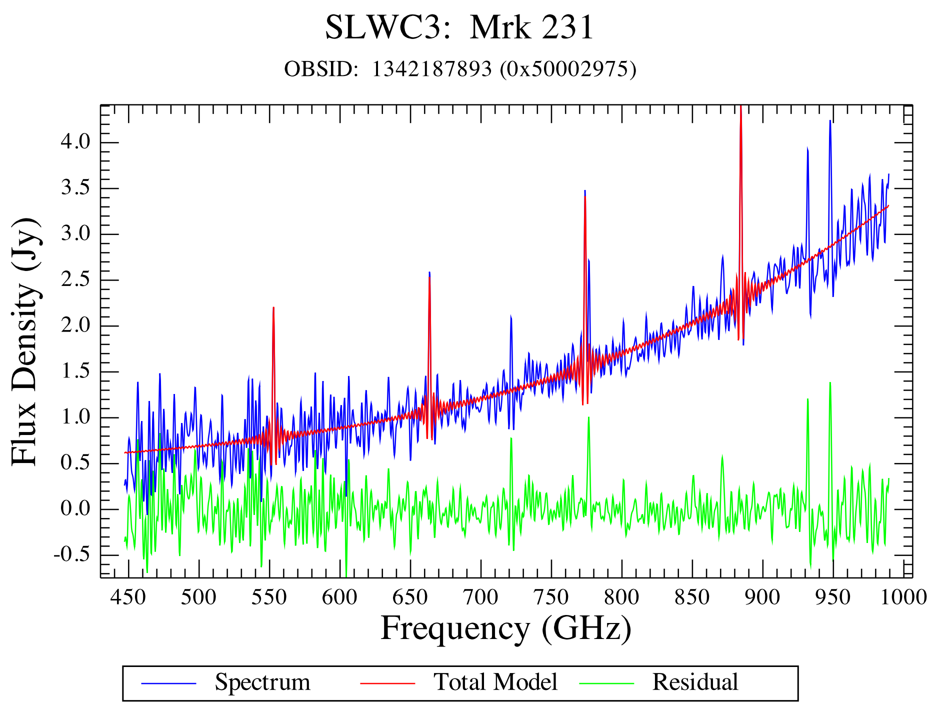
- Fit continuum and lines simultaneously
- SINC profiles for lines
- Polynomial for continum

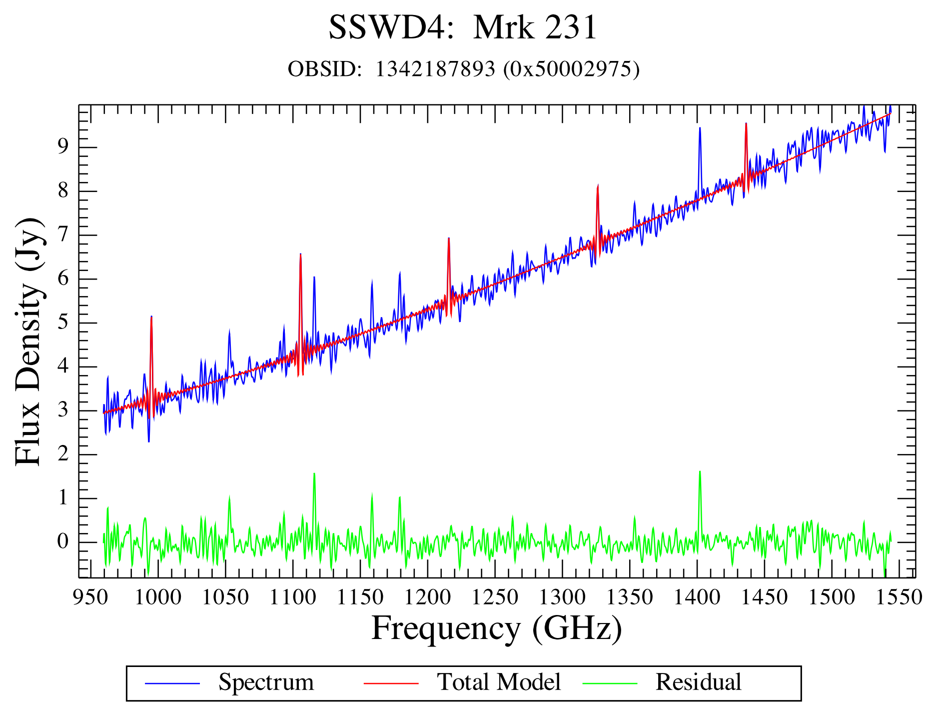
- Interactive line fitting (both unresolved & partially resolved lines)
- Cube fitting script (to fit one or more lines in a cube)

See a demo on Thursday!

Line Fitting (for Unresolved Lines)

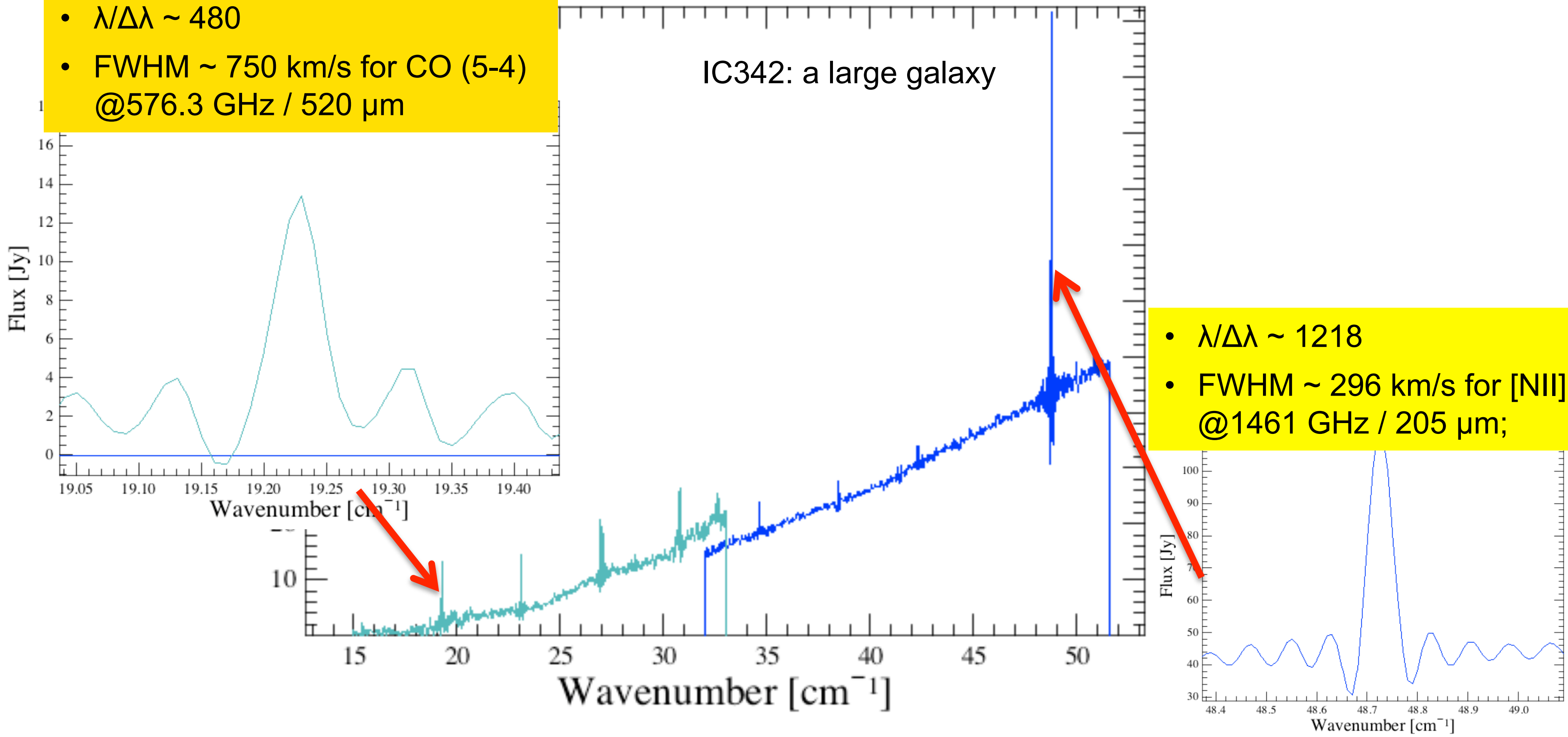
HIPE SPIRE useful script: **Spectrometer line fitting**





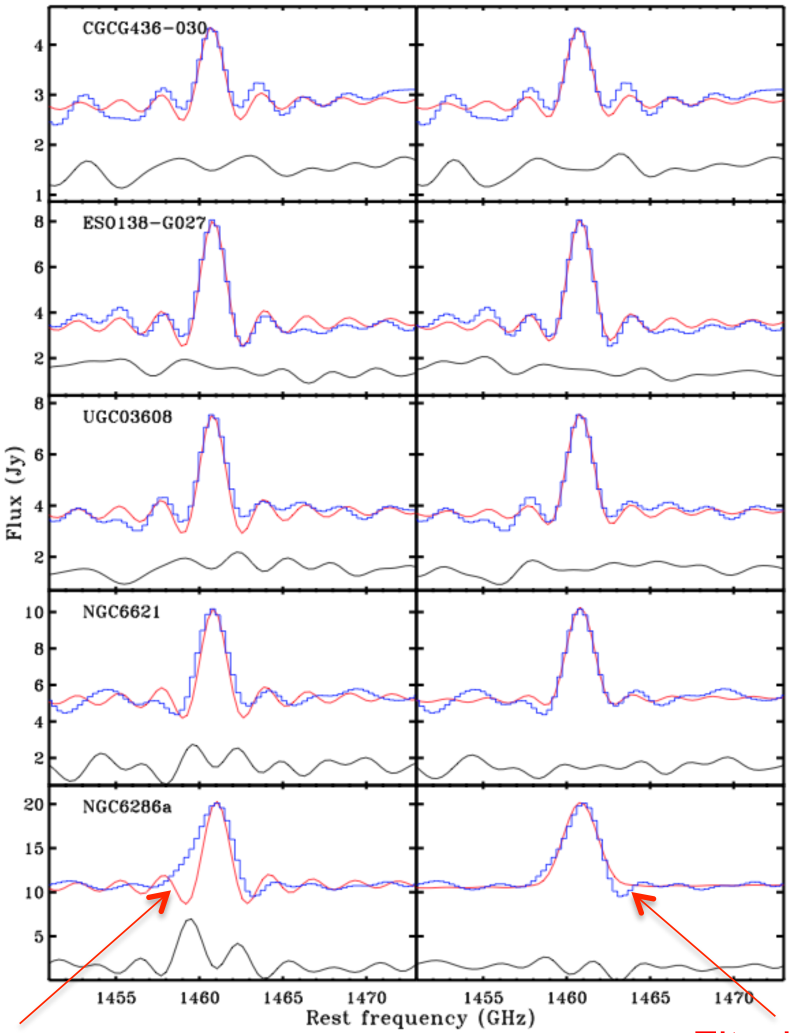
Spectral Resolving Power Depends on Wavelength

- $\lambda/\Delta\lambda \sim 480$
- FWHM ~ 750 km/s for CO (5-4) @576.3 GHz / 520 μm



- $\lambda/\Delta\lambda \sim 1218$
- FWHM ~ 296 km/s for [NII] @1461 GHz / 205 μm;

Partailly Resolved Lines

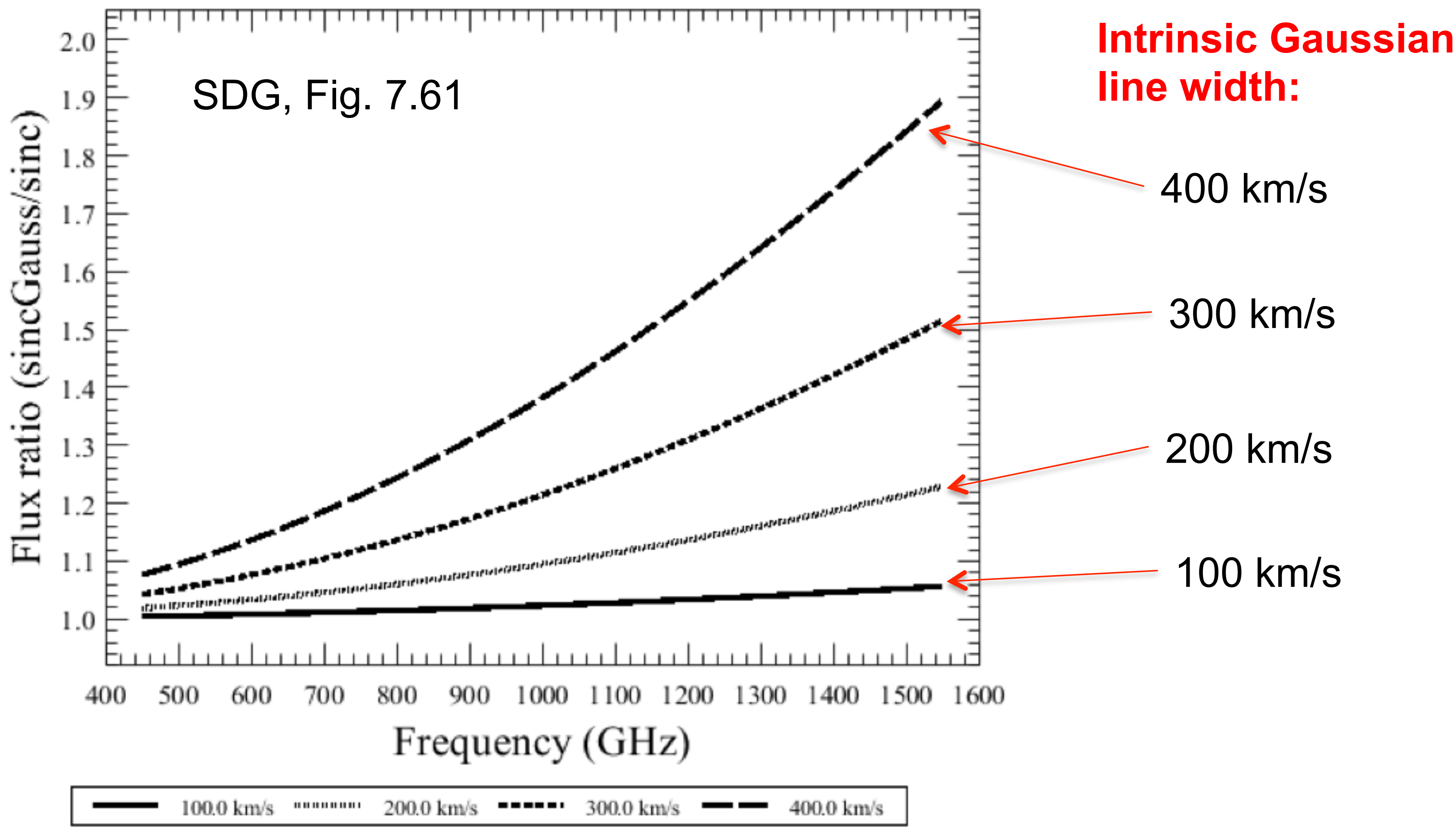


Fit with SINC only

Fit with SINC convolved with Gaussian (SincGauss model)

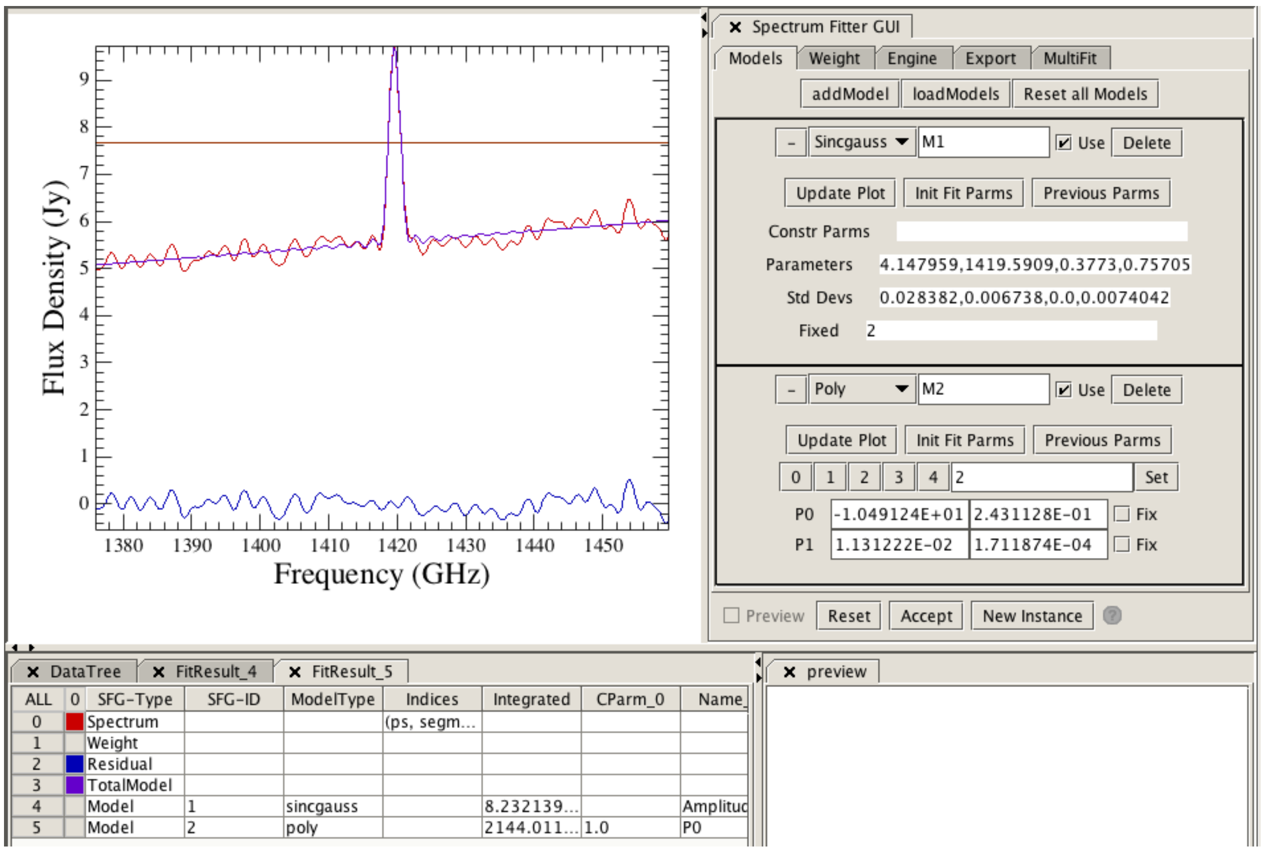
- The [NII] 205 μm line might become resolved if its intrinsic velocity is large enough (e.g., > 300 km/s)
- In this case, either use a SincGauss model to fit the line (best if S/N is high), or apply a correction factor to compensate for the flux underestimate assuming an intrinsic line width (best if S/N is poor)

SincGaussan to Sinc Flux Ratio



Interacvtive Line Fitting: SincGauss Profile

See demo on Thursday morning



- 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 SPIRE DRG Sect. 7.10.7 for more info).

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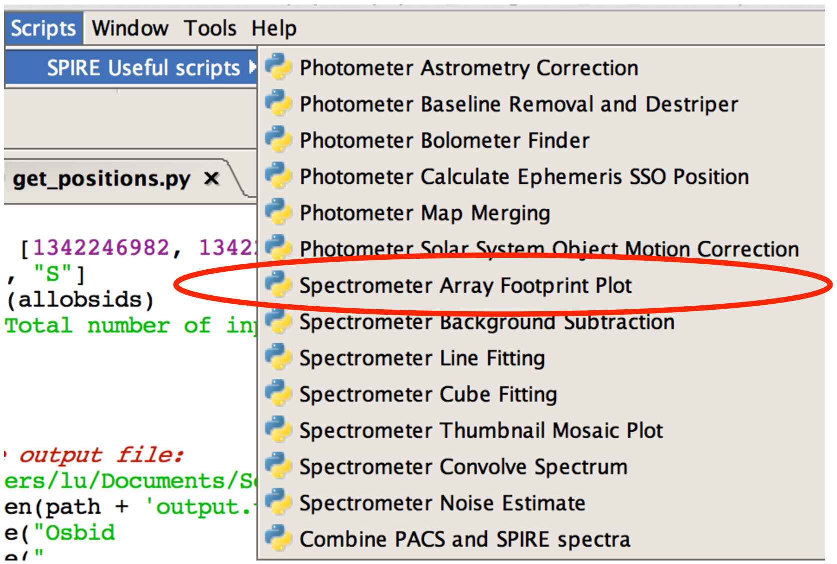
Faint Point-like Targets

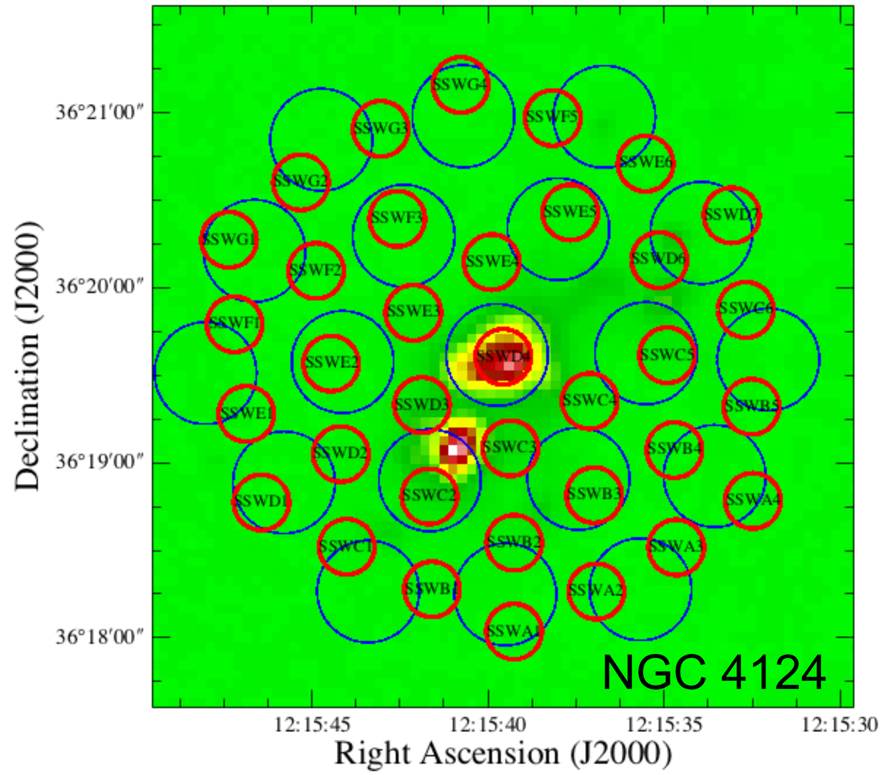
Faint sources:	a few to < ~10 Jy;
Medium sources:	~10 to < ~100 Jy.

- Checking the source extent
  - To make sure it is a point source
- Further background subtraction
- Comparing with the photometer

Detector Footprint on Sky



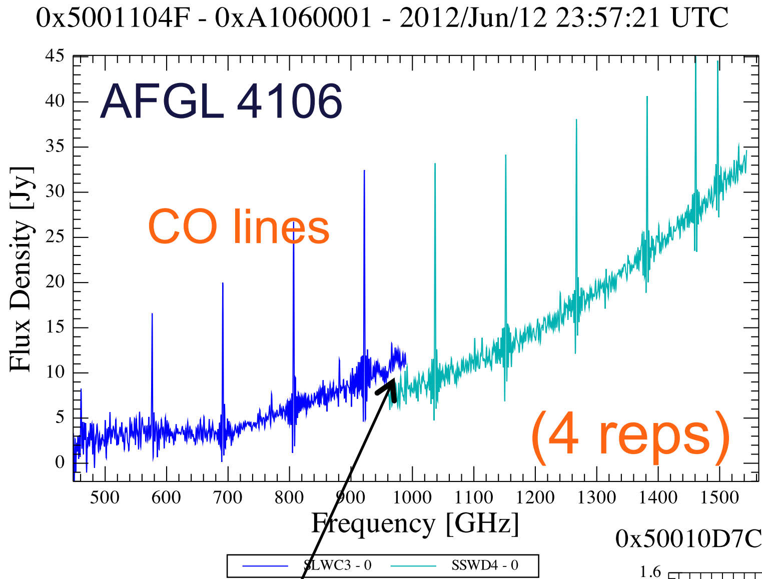
FTS footprint on PACS 70um image



Useful for visualization of the extent and relative location of the target w.r.t. the detector array.

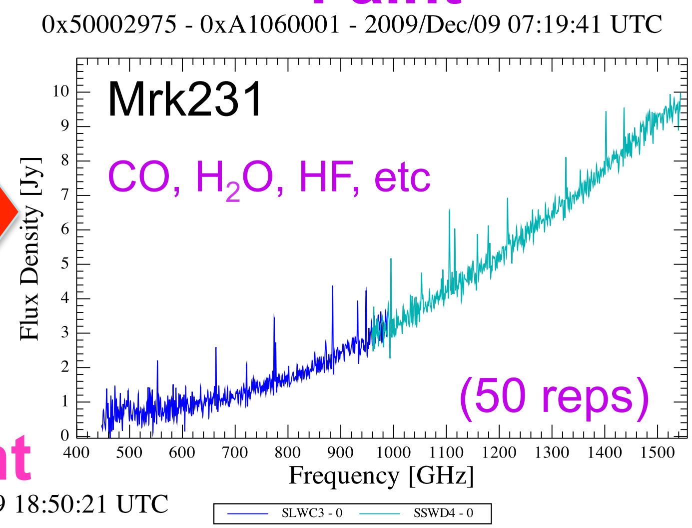
Examples of Point-source Spectra

Medium source

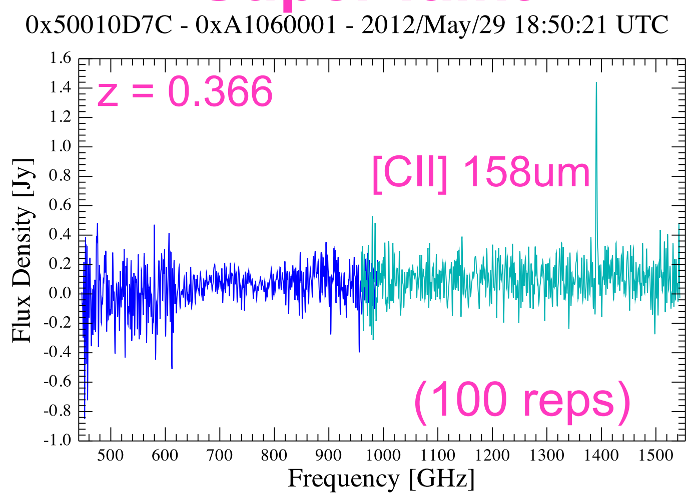


Gap: may indicate some residual telescope background, which can be further removed.

Faint

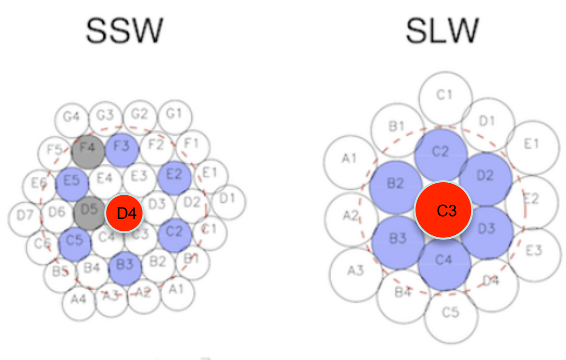


Super faint

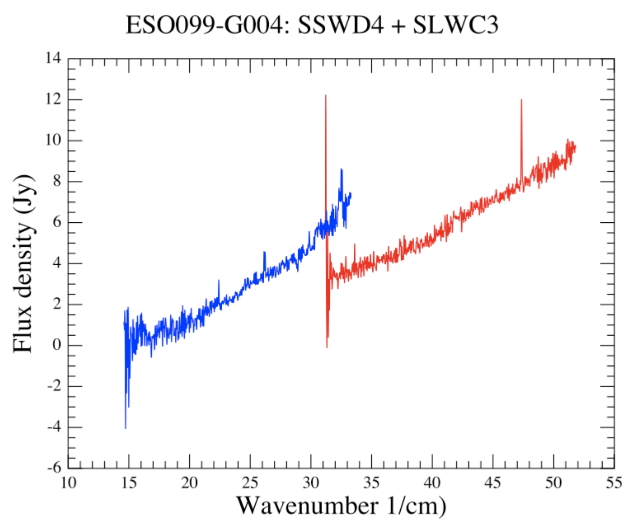


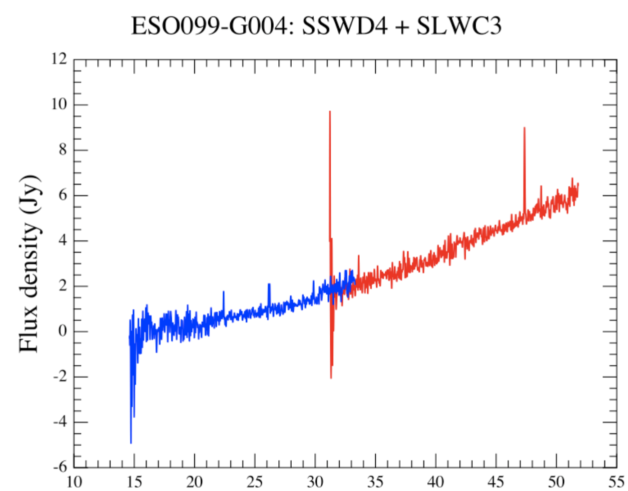
Level 2 pipeline products

Residual Telescope Emission Removal: Using Surrounding Channels

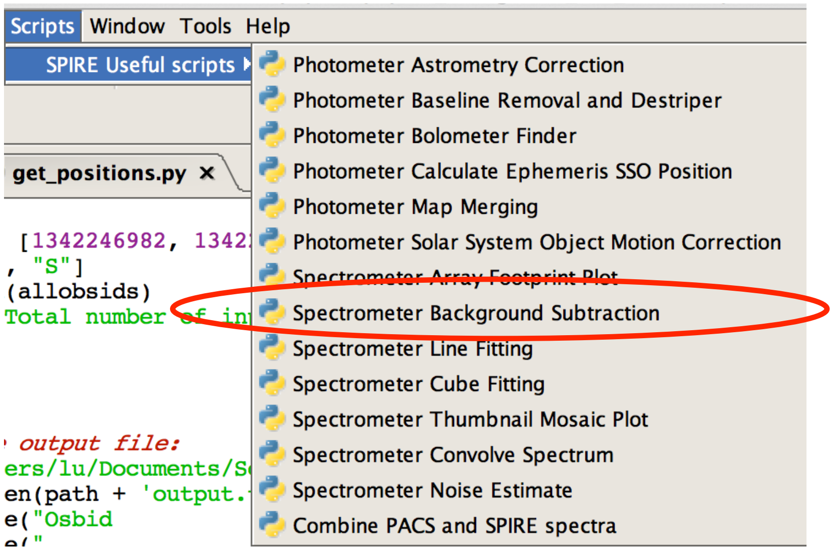


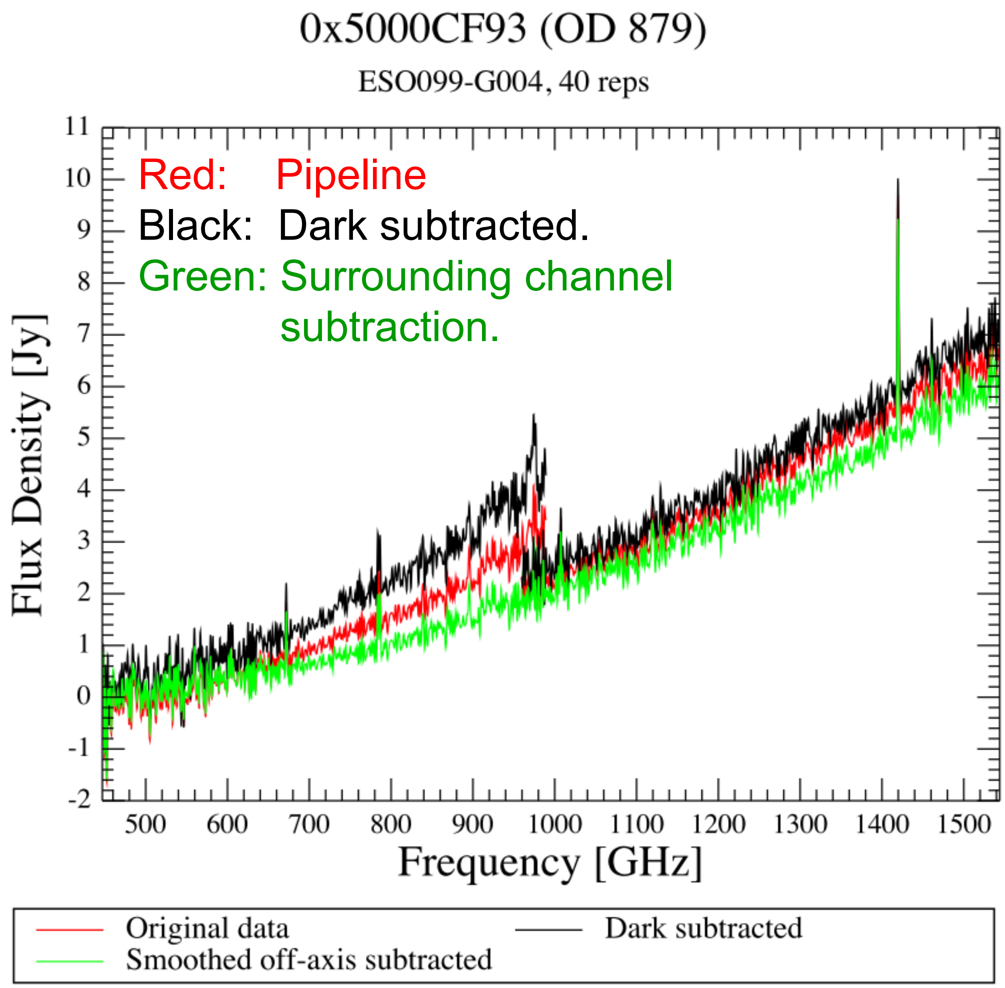
- Using a median spectrum from the co-aligned detectors as the residual telescope spectrum.
- This (or a polynominal fit to it) is then subtracted from the spectrum of the central detectors.





Background Subtraction => Better Continuum

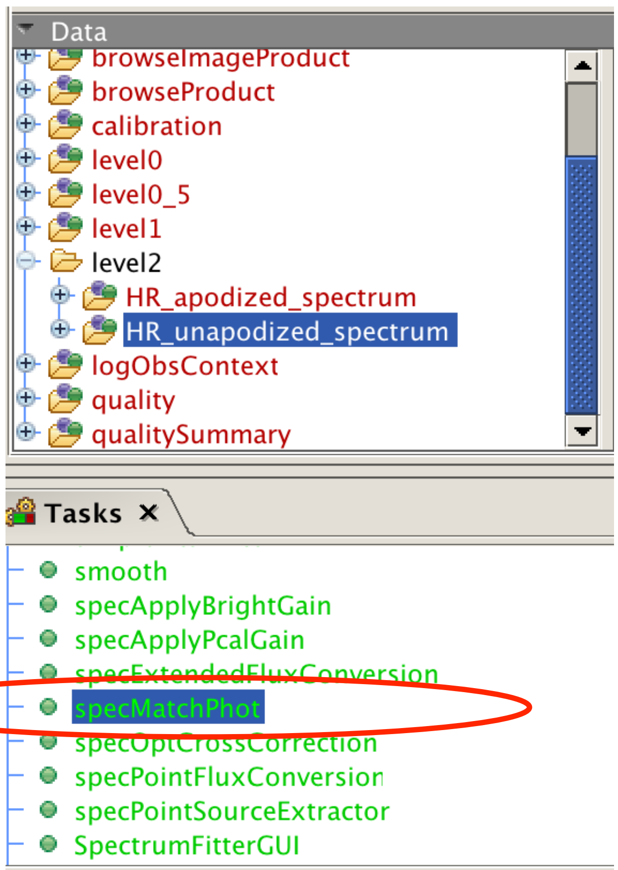


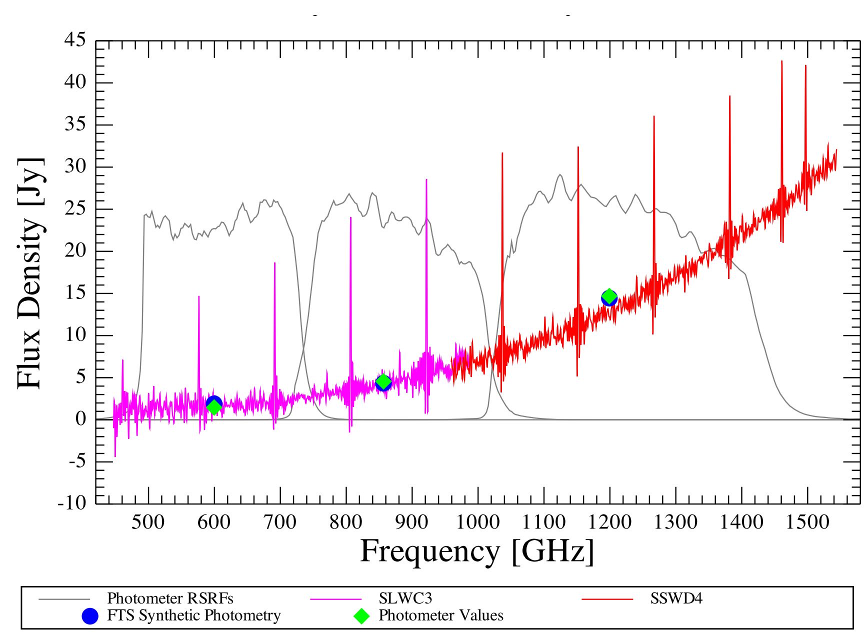


➡ Improves the continuum flux of a faint, point-like target.

Comparing with SPIRE photometer

HIPE task **SpecMatchPhot**





Synthetic photometry also output in a table:

Synthetic photometry results

Meta Data

None

Table Data

Index	names []	spec250 [Jy]	spec350 [Jy]	spec500 [Jy]	phot250 [Jy/beam]	phot350 [Jy/beam]	phot500 [Jy/beam]
0	SLWB2	0.5524880934532026	2.2750690830393063	NaN	1.4595235477934987	4.5625949527907	14.688015400555697
1	SLWB3	1.7079940700571916	2.900204401489005	NaN	1.4595235477934987	4.5625949527907	14.688015400555697
2	SLWC2	0.7795710130592949	2.4846351262954545	NaN	1.4595235477934987	4.5625949527907	14.688015400555697
3	SLWC3	3.5301211206430834	7.208739635225893	NaN	1.4595235477934987	4.5625949527907	14.688015400555697
4	SLWC4	2.271641002463886	3.1913230785009703	NaN	1.4595235477934987	4.5625949527907	14.688015400555697
5	SLWD2	1.910852171027807	3.147223386802127	NaN	1.4595235477934987	4.5625949527907	14.688015400555697
6	SLWD3	2.4930847414696724	3.41185471573297	NaN	1.4595235477934987	4.5625949527907	14.688015400555697
7	SSWB2	NaN	NaN	1.7915315388884716	1.4595235477934987	4.5625949527907	14.688015400555697
8	SSWB3	NaN	NaN	1.5853857093619672	1.4595235477934987	4.5625949527907	14.688015400555697

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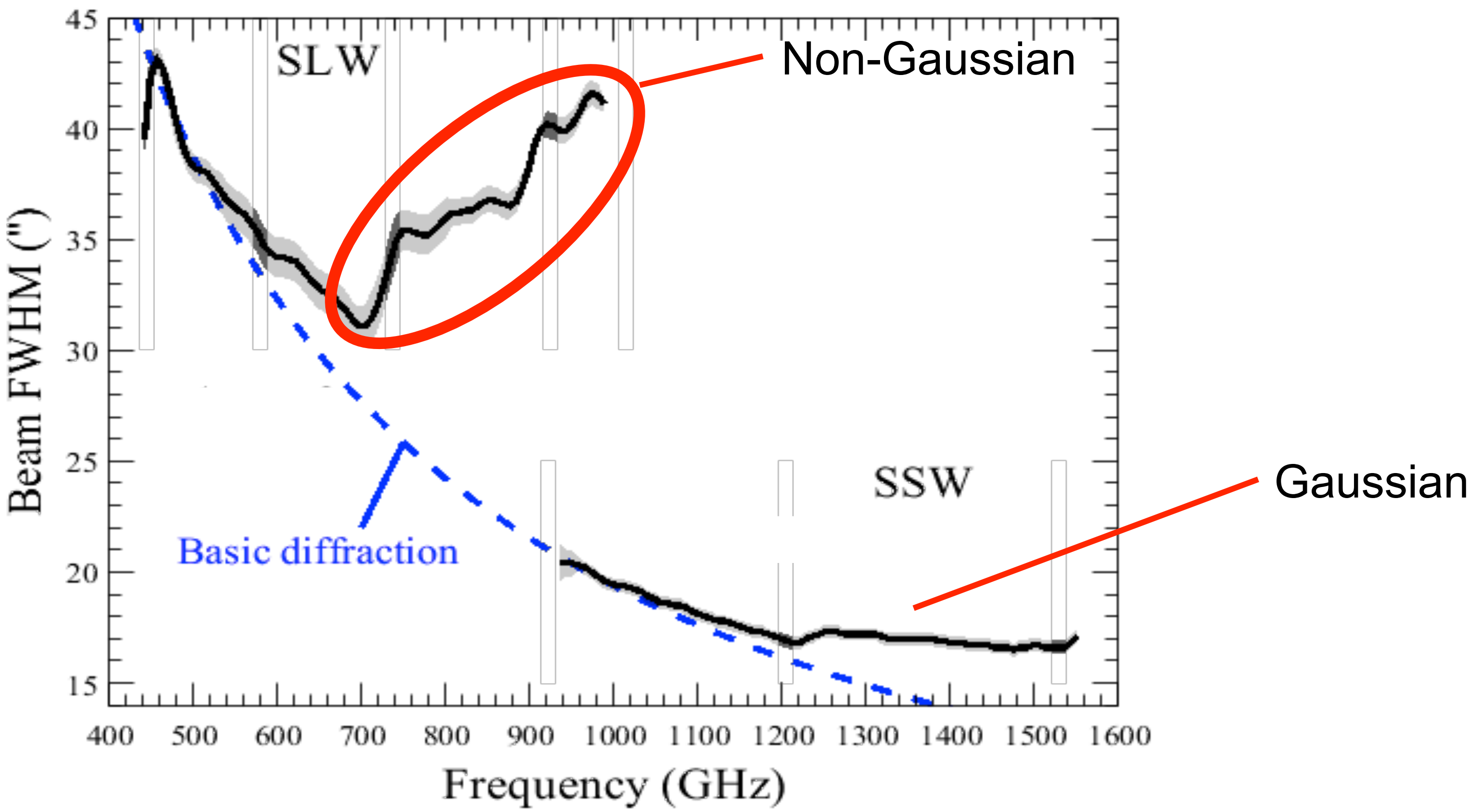
Partially Extended Sources

- Effect of a semi-extended source
- What correction is needed?

- Semi-extended (flux) correction tool (SECT) in HIPE

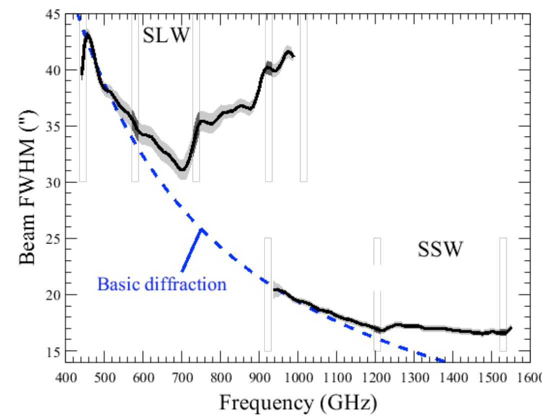
FTS beam profile



See Makiwa et al. 2013, Applied Optics, 52, 3864

Identifying Possible Partially Extended Sources

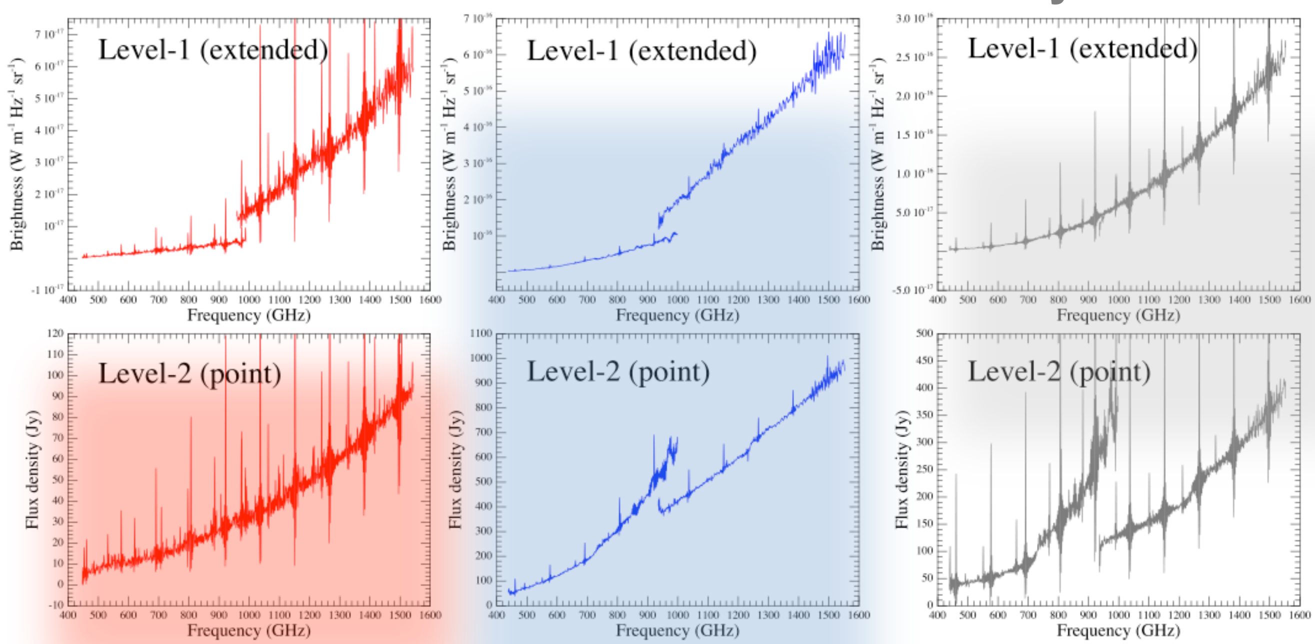
- The spectrum shows kinks and discontinuities where the beam size changes



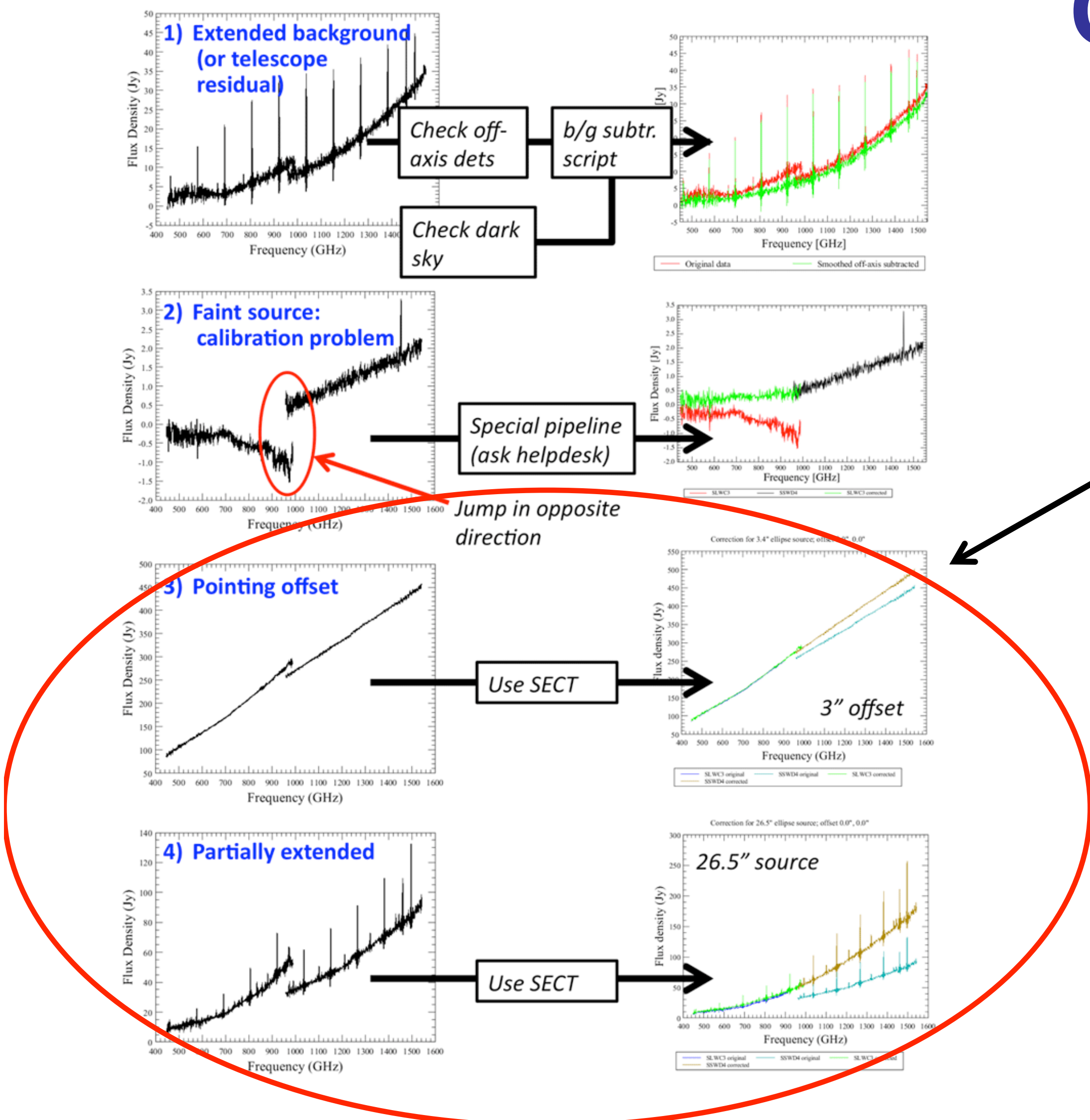
Point-like | **Partly extended** | **Fully extended**

Extended calibration →

Point-source calibration →



Other possible causes for a spectral gap

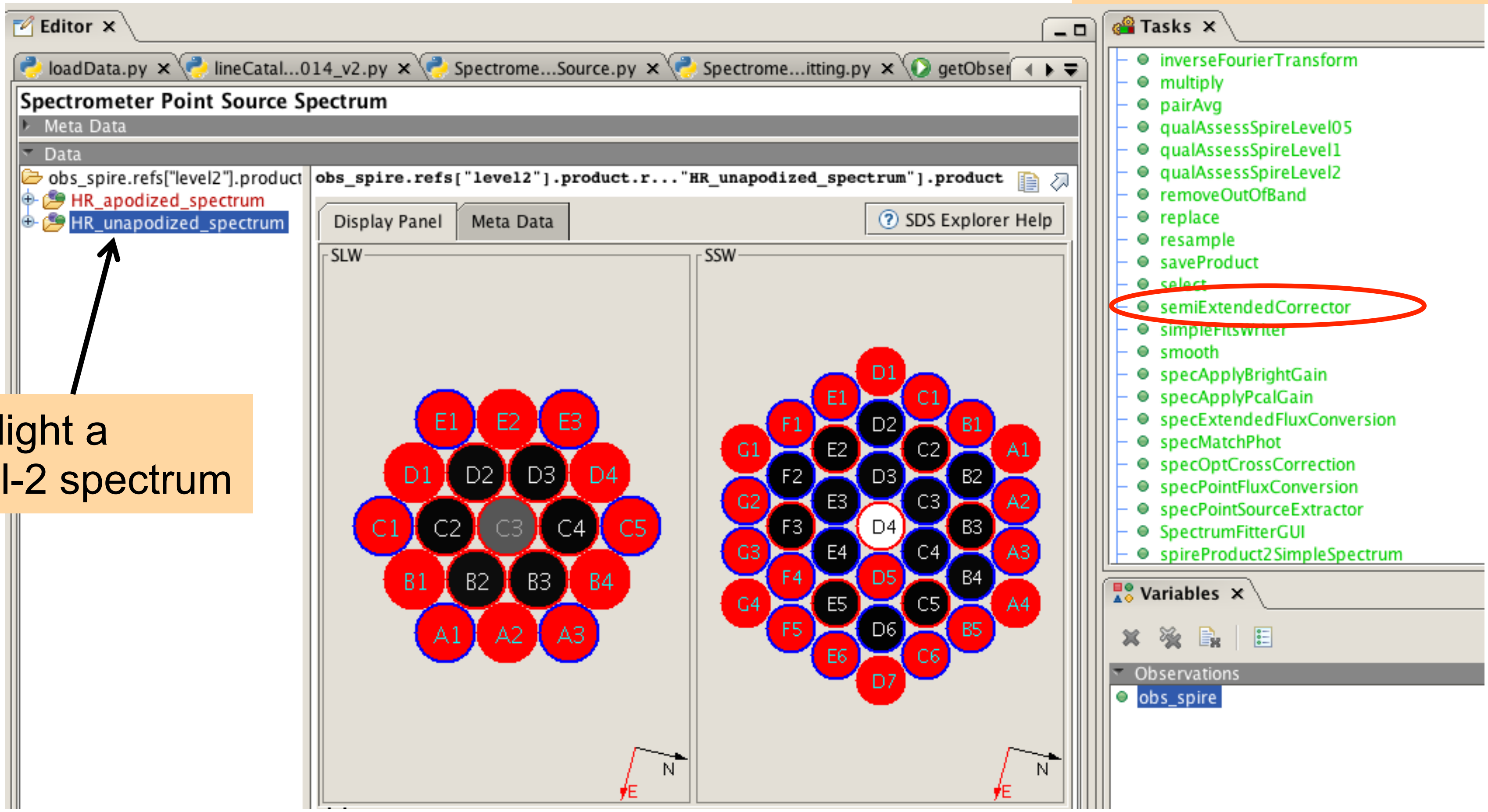


Cases appropriate for using SECT (the semi-extended source fluc correction tool) in HIPE.

(Caution: the CO lines, from warm/dense molecular gas, may arise from a more compact region than the cold dust contiuum.)

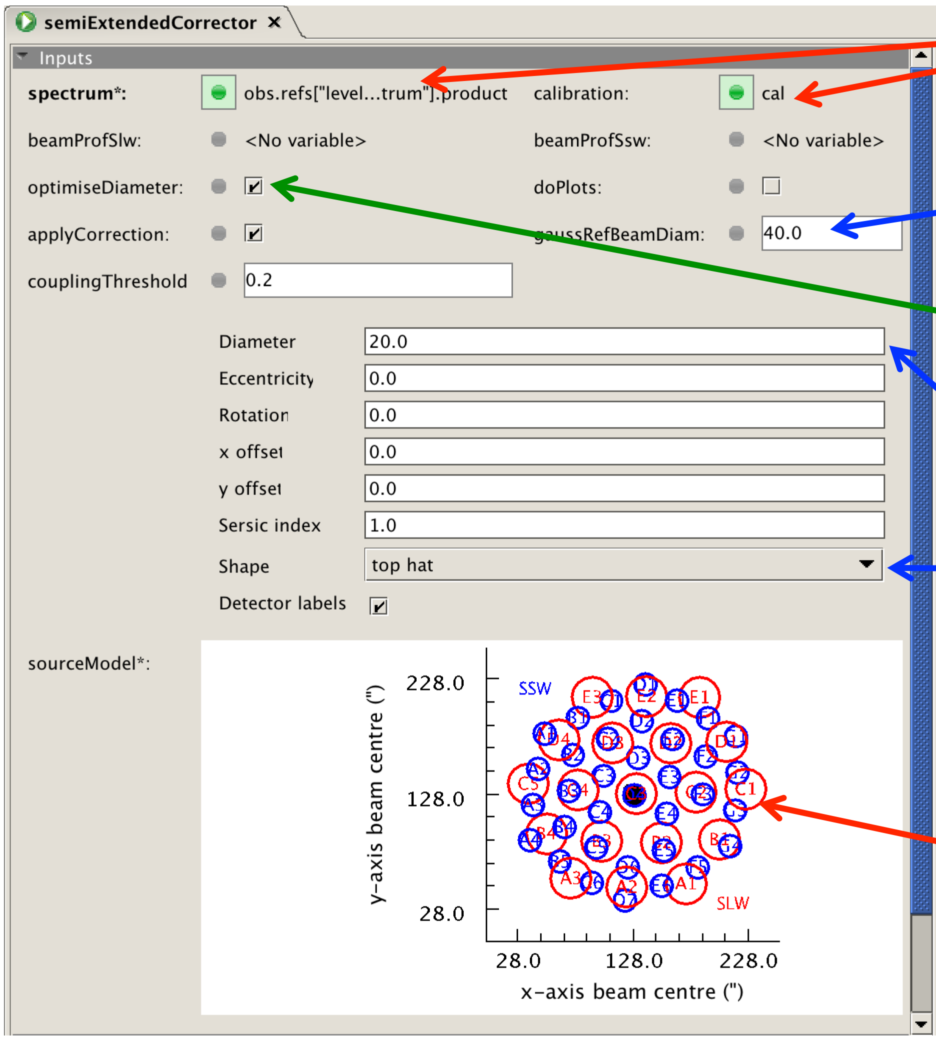
Task semiExtendedCorrector

Under applicable tasks:



Highlight a Level-2 spectrum

Task semiExtendedCorrector



Load a Level-2 spectrum and the calibration tree

Reference beam for the final spectrum extraction

If elected, iterate to find the best source diameter by minimizing the SSW/SLW gap

Enter details of the source surface brightness model:

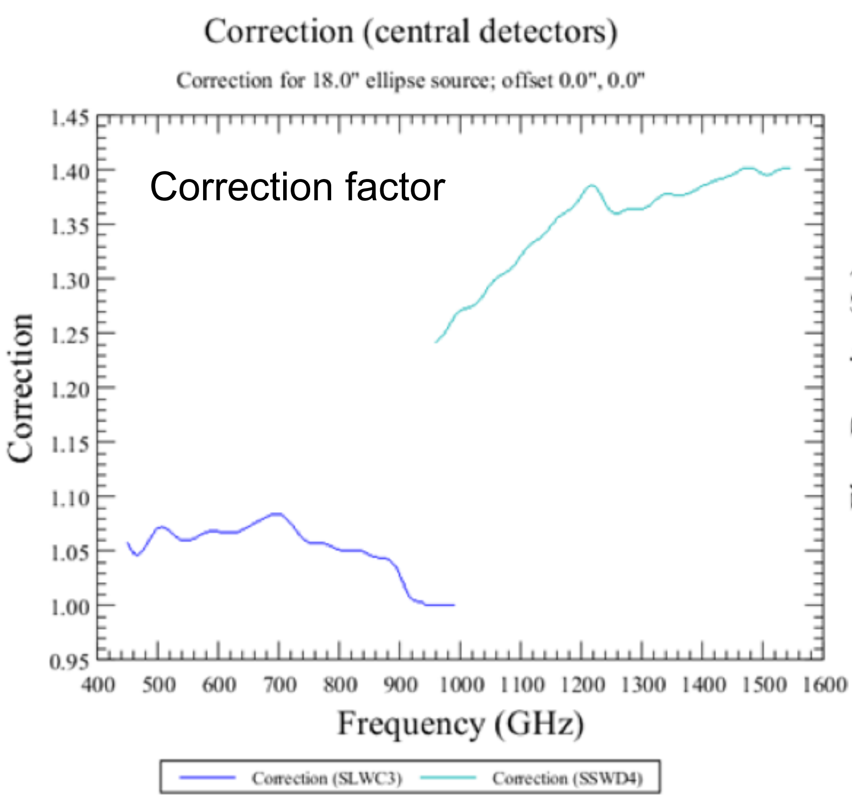
- Gaussian
- Top hat
- Sersic

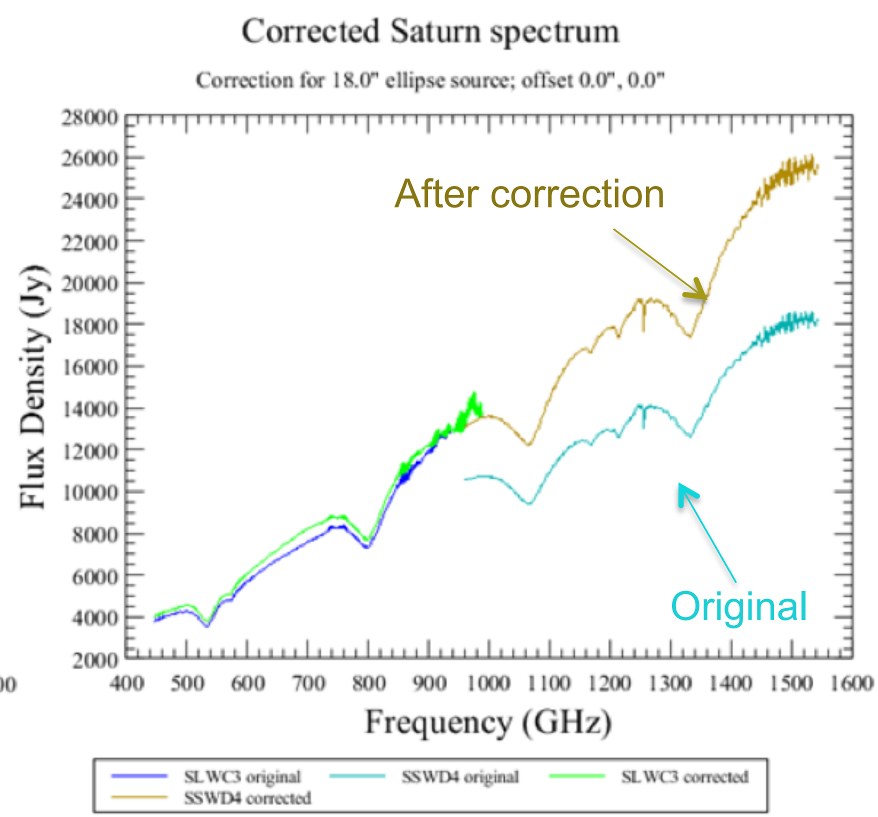
:

Source model visalized with detector footprint

(Based on ***Wu et al. 2013, A&A, 556, 116***)

Semi-extended Source Correction Tool





Units of the output spectrum are Jy "in the reference beam"

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 warm CO lines come from a more compact region than (cold) dust continuum. Thus, if your interest is in CO lines, it is not always better to apply this correction tool to your spectrum