



# 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.



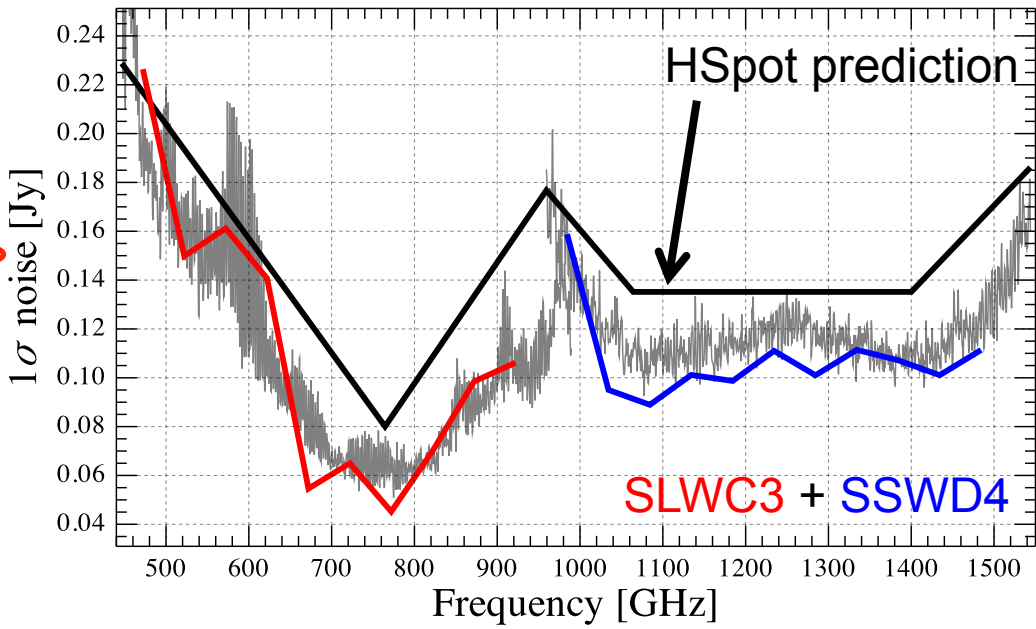
# Quick Noise Assessment May be Useful

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

```

Scripts Window Tools Help
SPIRE Useful scripts
  Photometer Astrometry Correction
  Photometer Baseline Removal and Destriper
  Photometer Bolometer Finder
  Photometer Calculate Ephemeris SSO Position
  Photometer Map Merging
  Photometer Solar System Object Motion Correction
  Spectrometer Array Footprint Plot
  Spectrometer Background Subtraction
  Spectrometer Line Fitting
  Spectrometer Cube Fitting
  Spectrometer Thumbnail Mosaic Plot
  Spectrometer Convolve Spectrum
  Spectrometer Noise Estimate
  Combine PACS and SPIRE spectra

get_positions.py x
[1342246982, 1342
, "S"]
(allobsids)
Total number of in
' output file:
ers/lu/Documents/s
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```



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

— Error column    — HSpot (HR)    — SLWC3    — SSWD4



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- Data reprocessing --- Do you generally need to reprocess FTS data yourself?



Additional data processing with available scripts/tasks in HIPE: some special cases to consider

- Spectral line fluxes: unresolved vs. partially resolved
- Continuum of faint sources
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# SPIRE Data Reduction Guide (DRG)

General SPIRE data info

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

HIPE - spire\_drg - SPIRE Data Reduction Guide

127.0.0.1:8082/index.jsp

hcss.icc.spire-12.0.2603

## SPIRE Data Reduction Guide

For HIPE 12 version 3.0, Document Number: SPIRE-RAL-DOC 003248  
28 February 2014

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# 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!



## Topics to Cover

- Data reprocessing --- Do you generally need to reprocess FTS data yourself?
- Additional data processing with available scripts/tasks in HIPE: some special cases to consider



- Spectral line fluxes: unresolved vs. partially resolved
- Continuum of faint sources
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# Spectral Line Fluxes

Hands-on exercise 1

- Line fitting script (for unresolved lines)

```
Scripts Window Tools Help
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  Combine PACS and SPIRE spectra

get_positions.py x
[1342246982, 1342
, "S"]
(allobsids)
Total number of in

output file:
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e("Osbid
e"
```

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

- 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!

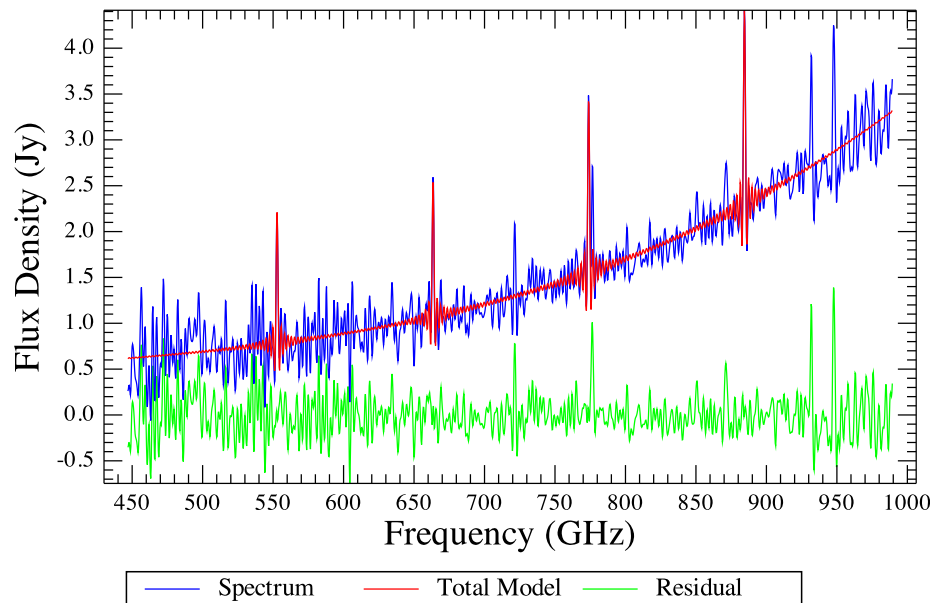


# Line Fitting (for Unresolved Lines)

## HIPE SPIRE useful script: Spectrometer line fitting

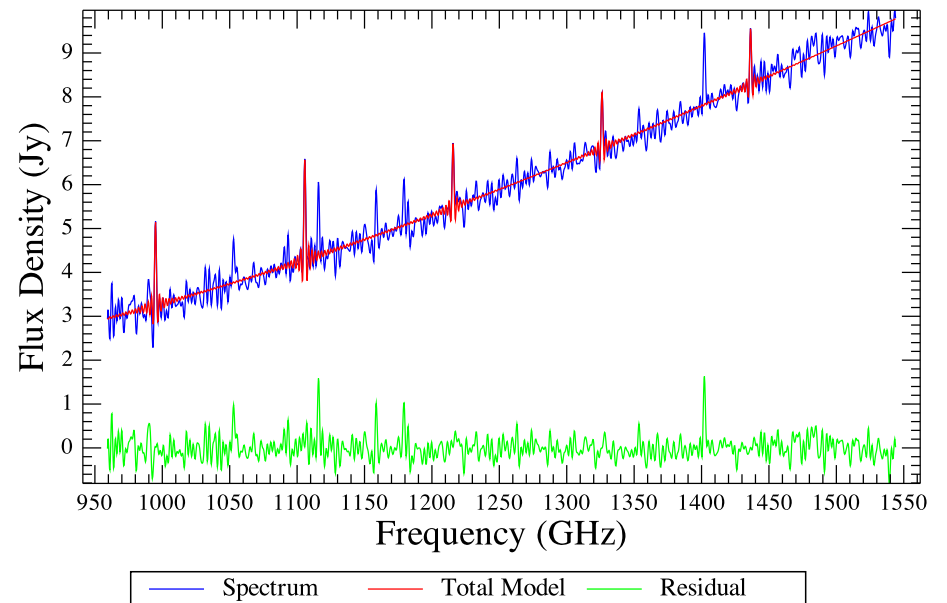
SLWC3: Mrk 231

OBSID: 1342187893 (0x50002975)



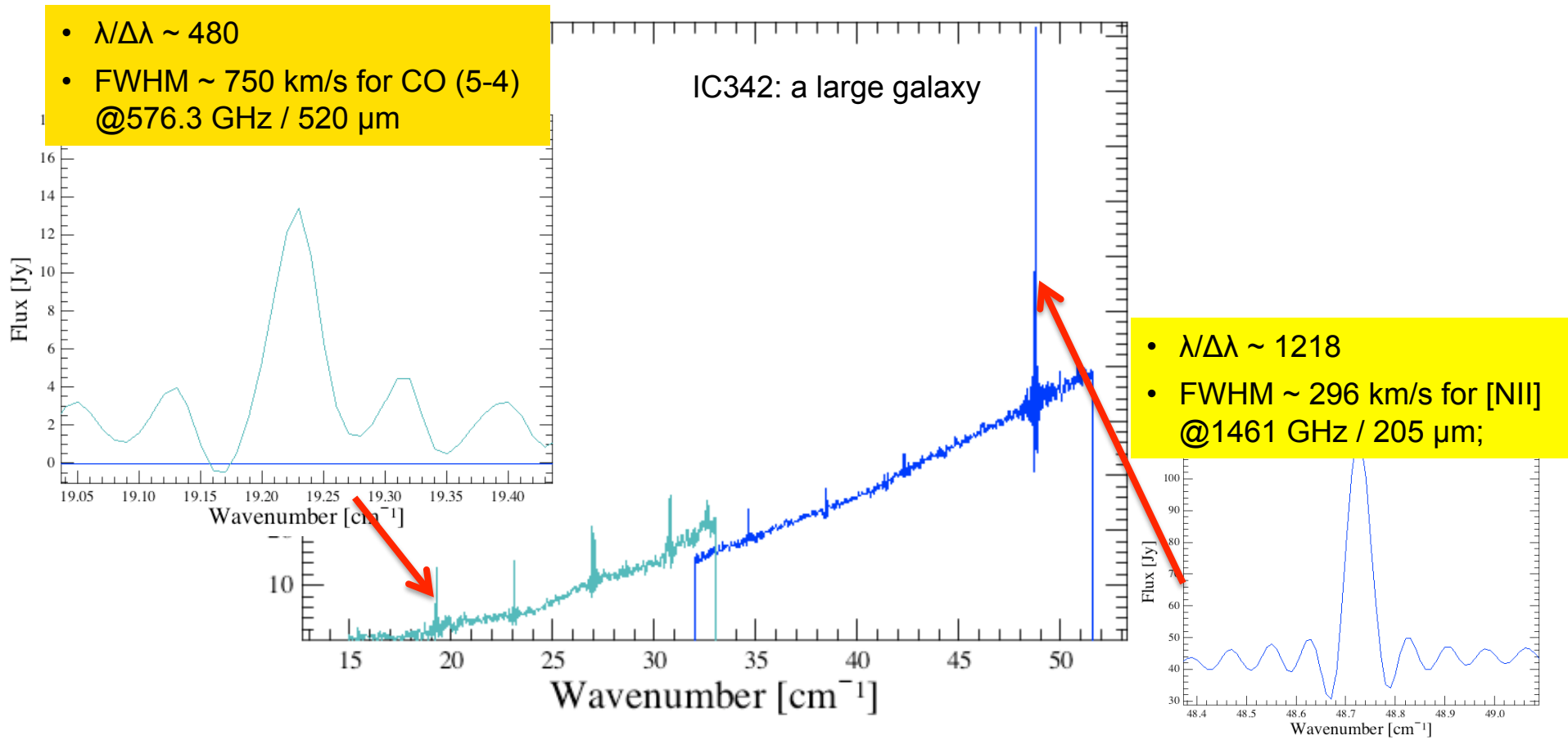
SSWD4: Mrk 231

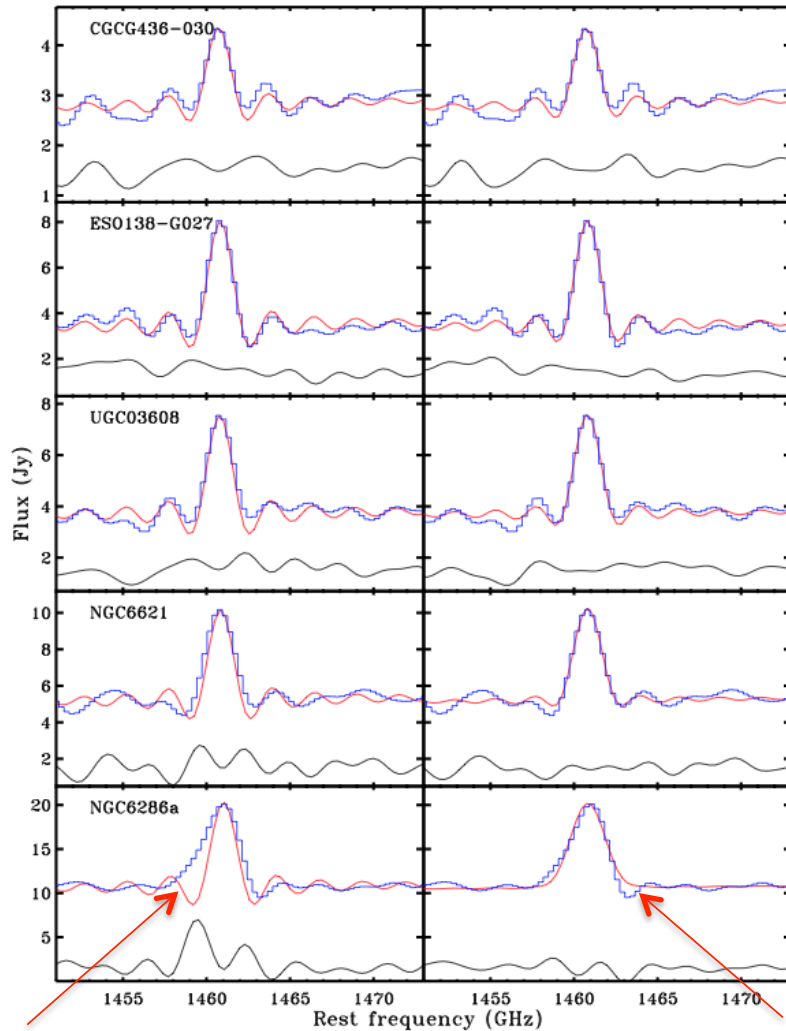
OBSID: 1342187893 (0x50002975)





# Spectral Resolving Power Depends on Wavelength





## Partially Resolved Lines

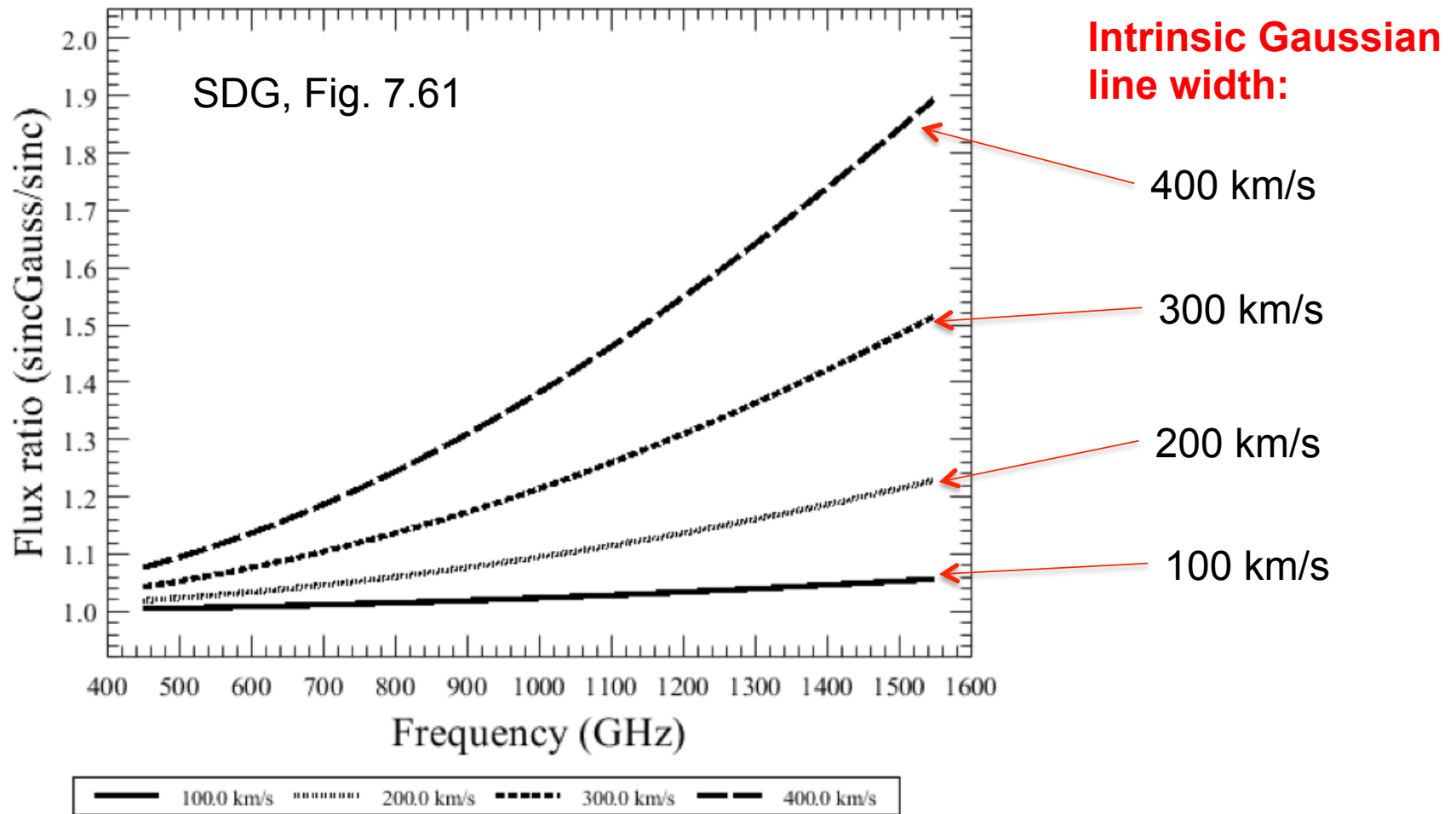
- The [NII] 205  $\mu\text{m}$  line might become resolved if its intrinsic velocity is large enough (e.g.,  $> 300 \text{ km/s}$ )
- In this case, either use a SincGauss model to fit the line (best if S/N is high), or apply a correction factor to compensate for the flux underestimate assuming an intrinsic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

Fit with SINC only

Fit with SINC convolved with Gaussian (SincGauss model)



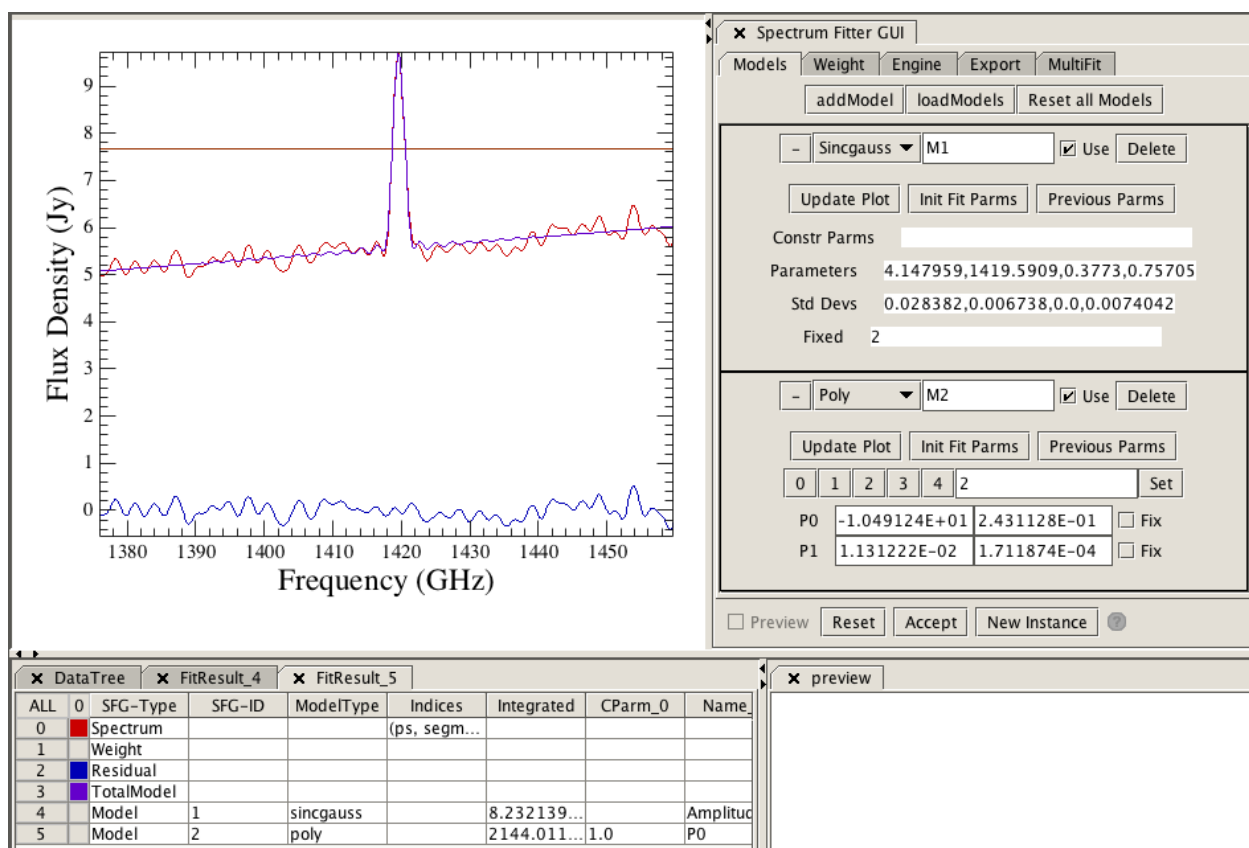
# SincGaussian to Sinc Flux Ratio





# Interactive 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).



## Topics to Cover

- Data reprocessing --- Do you generally need to reprocess FTS data yourself?
- Additional data processing with available scripts/tasks in HIPE: some special cases to consider
  - Spectral line fluxes: unresolved vs. partially resolved
  - ➔ – Continuum fluxes of faint sources
  - Point source vs. semi-extended sources



# Faint Point-like Targets

Faint sources: a few to  $< \sim 10$  Jy;  
Medium sources:  $\sim 10$  to  $< \sim 100$  Jy.

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





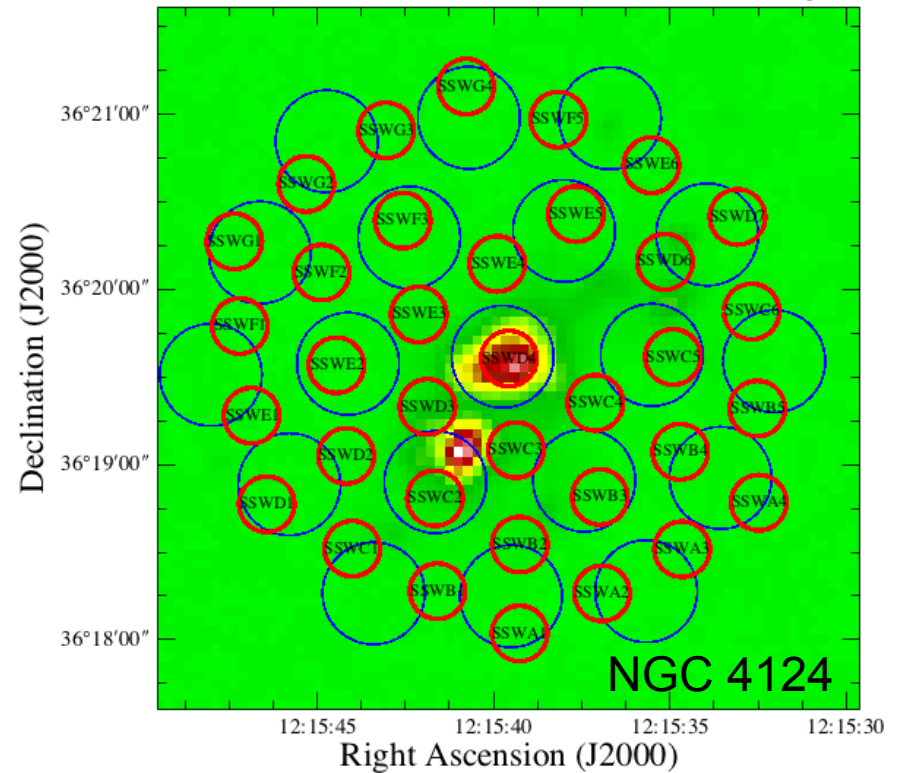
# Detector Footprint on Sky

```
Scripts Window Tools Help
SPIRE Useful scripts
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  Photometer Baseline Removal and Destriper
  Photometer Bolometer Finder
  Photometer Calculate Ephemeris SSO Position
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get_positions.py x
[1342246982, 1342
, "S"]
(allobsids)
Total number of in

output file:
ers/lu/Documents/S
en(path + 'output.
e("Osbid
e/'
```

FTS footprint on PACS 70um image



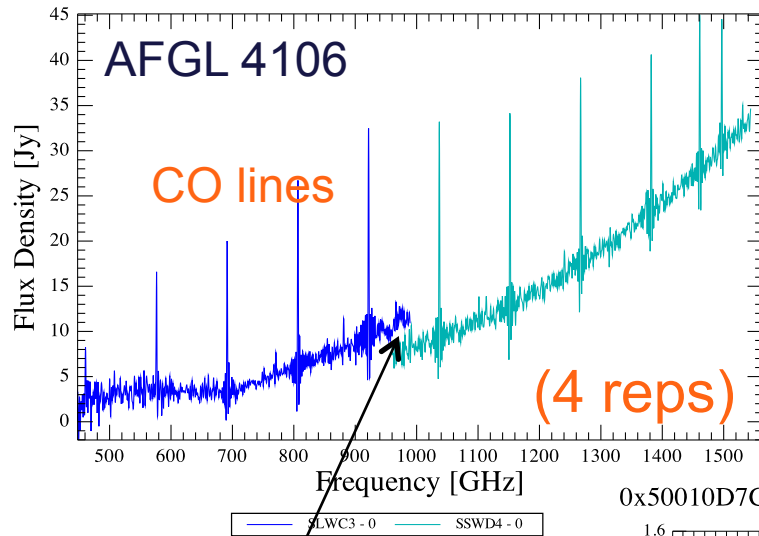
Useful for visualization of the extent and relative location of the target w.r.t. the detector array.



# Examples of Point-source Spectra

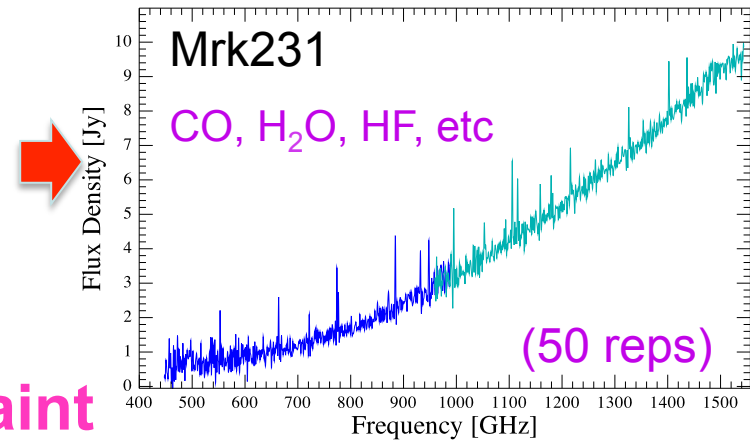
## Medium source

0x5001104F - 0xA1060001 - 2012/Jun/12 23:57:21 UTC



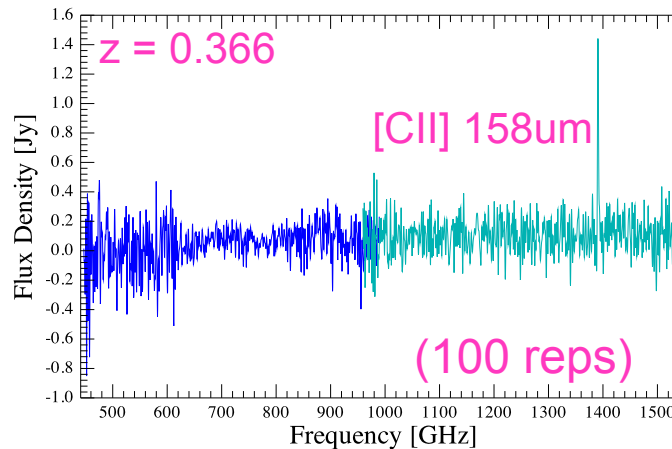
## Faint

0x50002975 - 0xA1060001 - 2009/Dec/09 07:19:41 UTC



## Super faint

0x50010D7C - 0xA1060001 - 2012/May/29 18:50:21 UTC



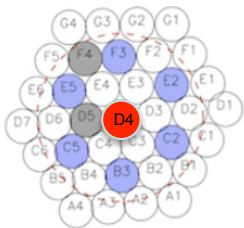
Level 2  
pipeline  
products

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

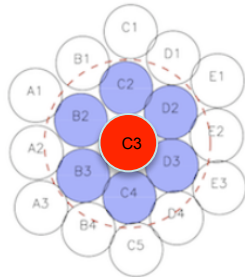


# Residual Telescope Emission Removal: Using Surrounding Channels

SSW

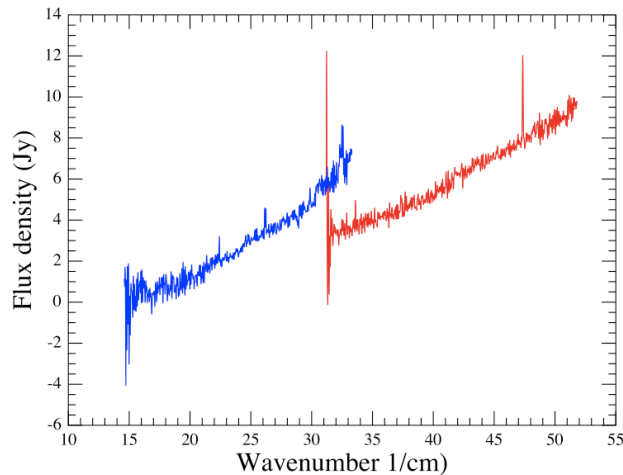


SLW

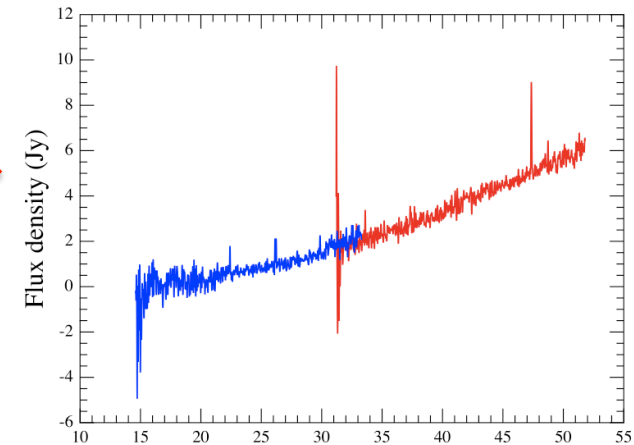


- Using a median spectrum from the **co-aligned detectors** as the residual telescope spectrum.
- This (or a polynomial fit to it) is then subtracted from the spectrum of the **central detectors**.

ESO099-G004: SSWD4 + SLWC3

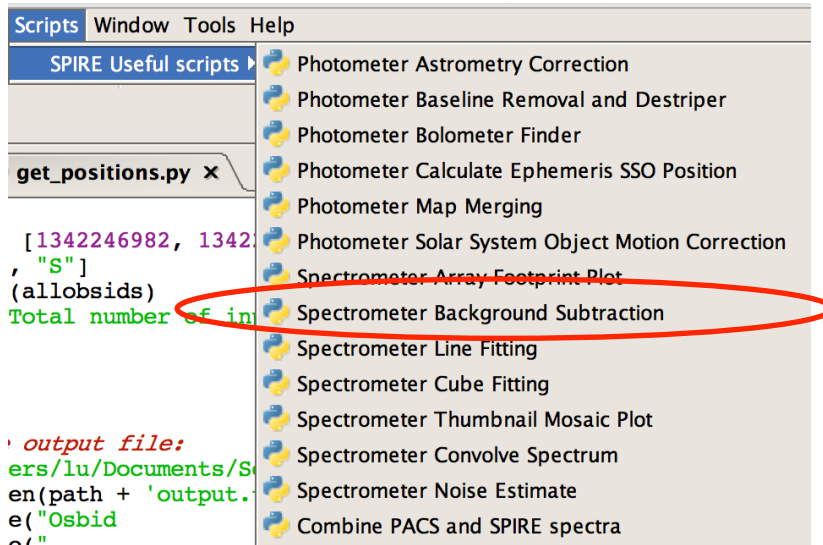


ESO099-G004: SSWD4 + SLWC3



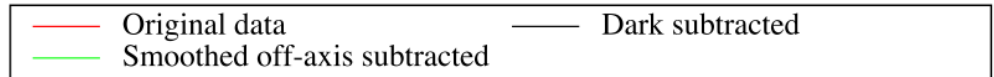
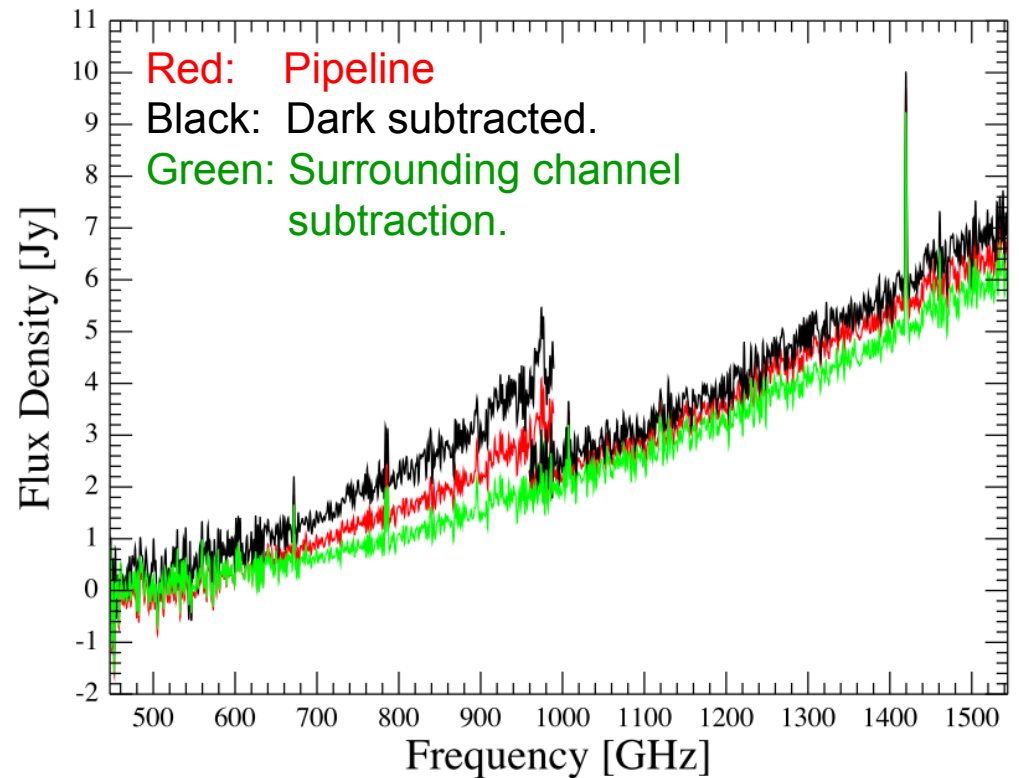


# Background Subtraction => Better Continuum



0x5000CF93 (OD 879)

ESO099-G004, 40 reps

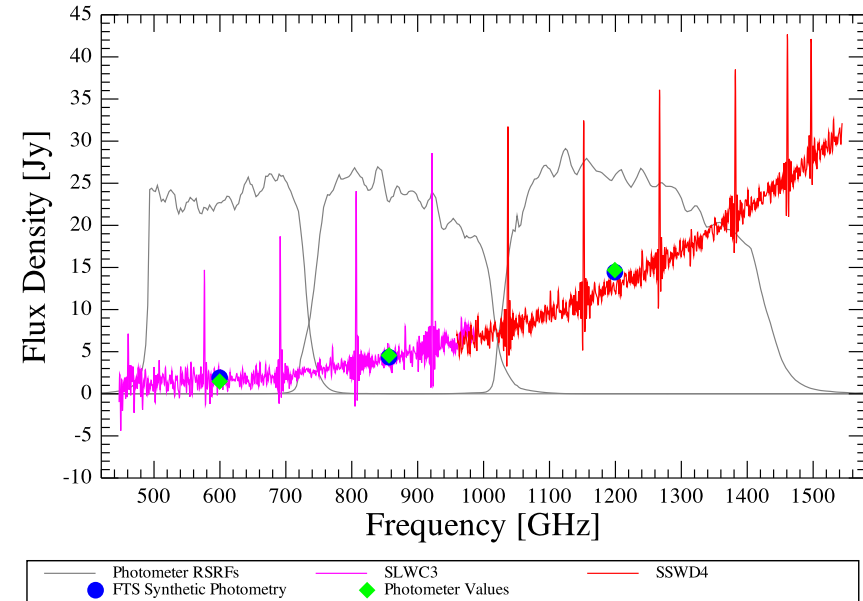
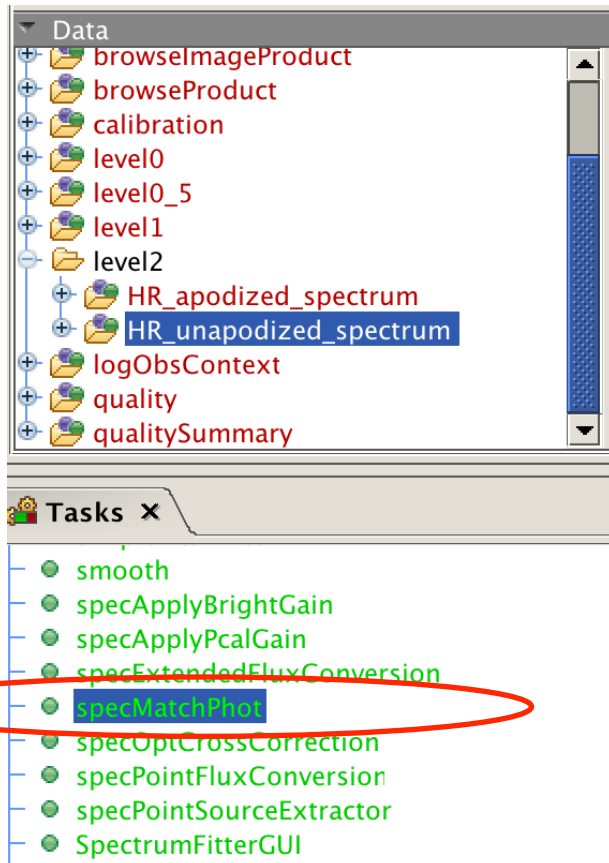


➔ Improves the continuum flux of a faint, point-like target.



# 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



## Topics to Cover

- Data reprocessing --- Do you generally need to reprocess FTS data yourself?
- Additional data processing with available scripts/tasks in HIPE: some special cases to consider
  - Spectral line fluxes: unresolved vs. partially resolved
  - Continuum fluxes of faint sources
  - ➔ Point source vs. semi-extended sources

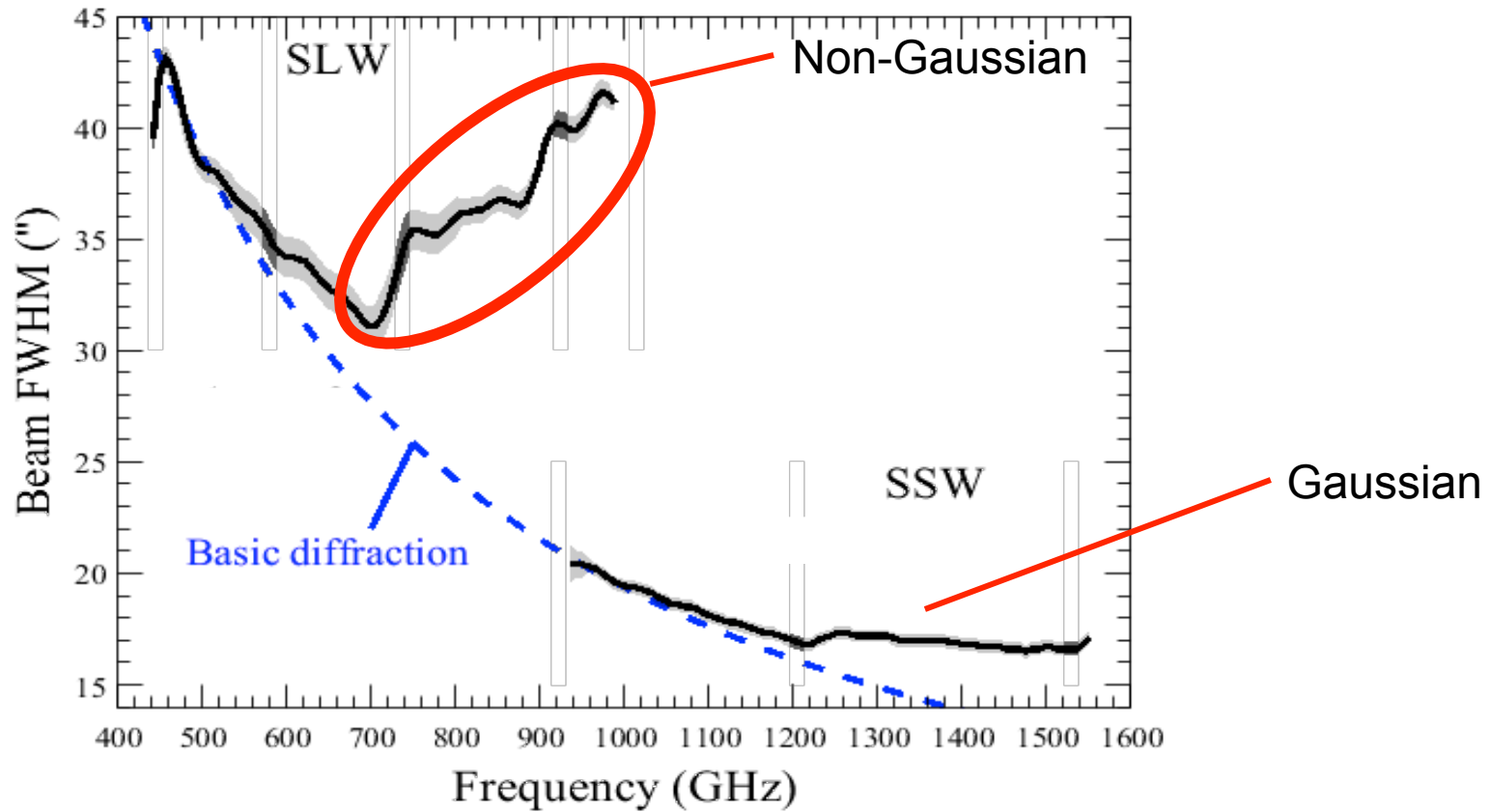


# Partially Extended Sources

- Effect of a semi-extended source
- What correction is needed?
  
- Semi-extended (flux) correction tool (SECT) in HIPE



# FTS beam profile



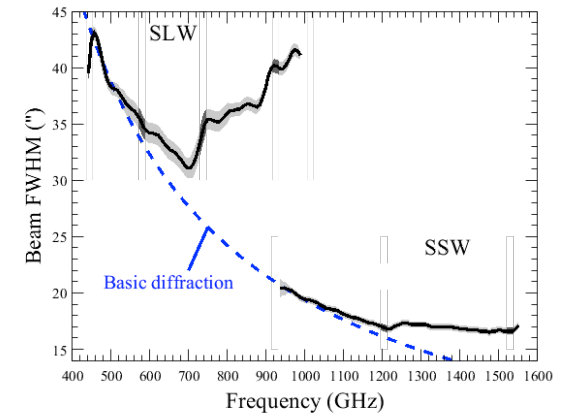
See [Makiwa et al. 2013, Applied Optics, 52, 3864](#)





# Identifying Possible Partially Extended Sources

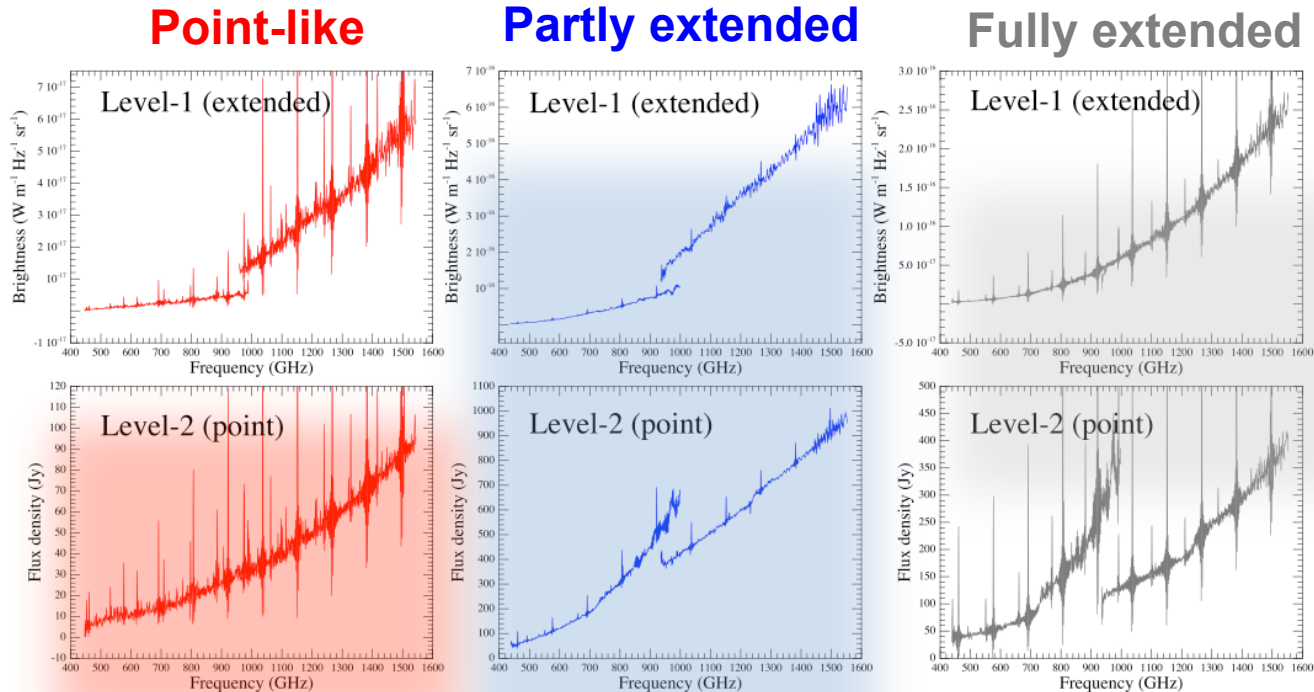
- The spectrum shows kinks and discontinuities where the beam size changes



Extended calibration

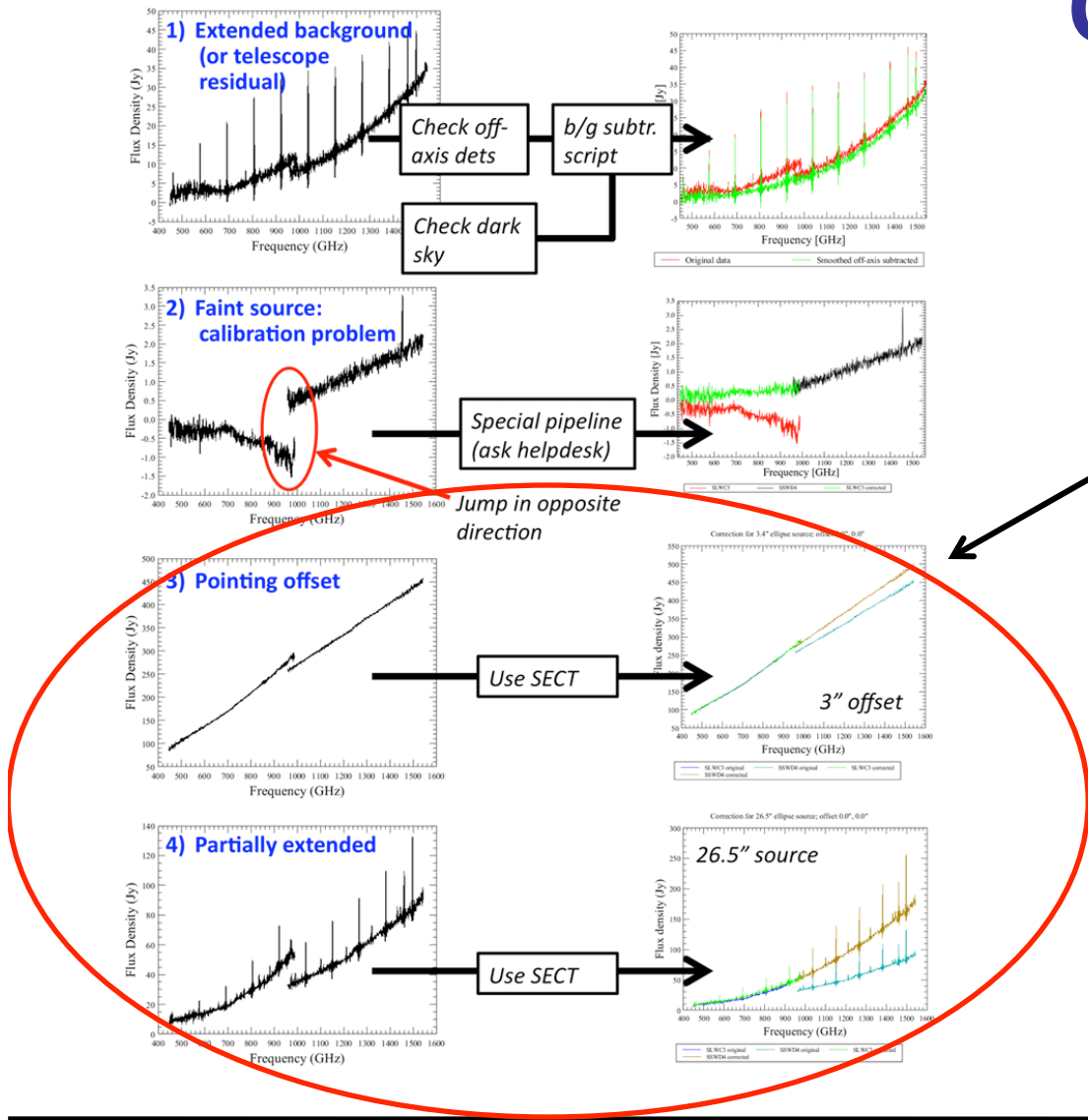


Point-source calibration





# Other possible causes for a spectral gap



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

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



# Task semiExtendedCorrector

Under applicable tasks:

obs\_spire.refs["level2"].product  
obs\_spire.refs["level2"].product.r... "HR\_unapodized\_spectrum".product

Display Panel Meta Data SDS Explorer Help

SLW SSW

semiExtendedCorrector

obs\_spire

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:

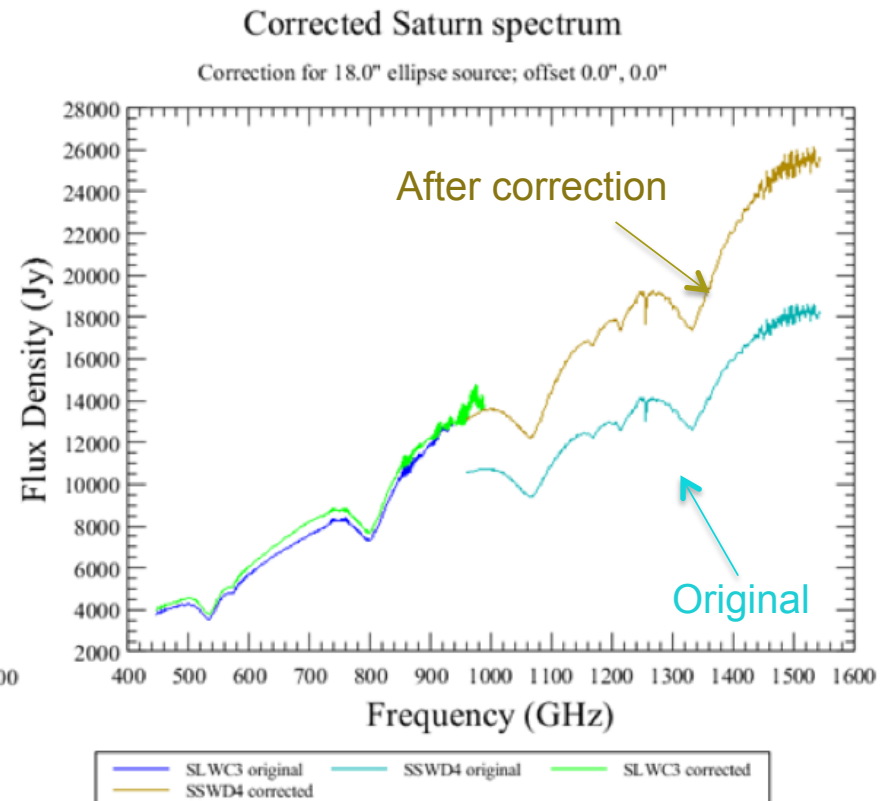
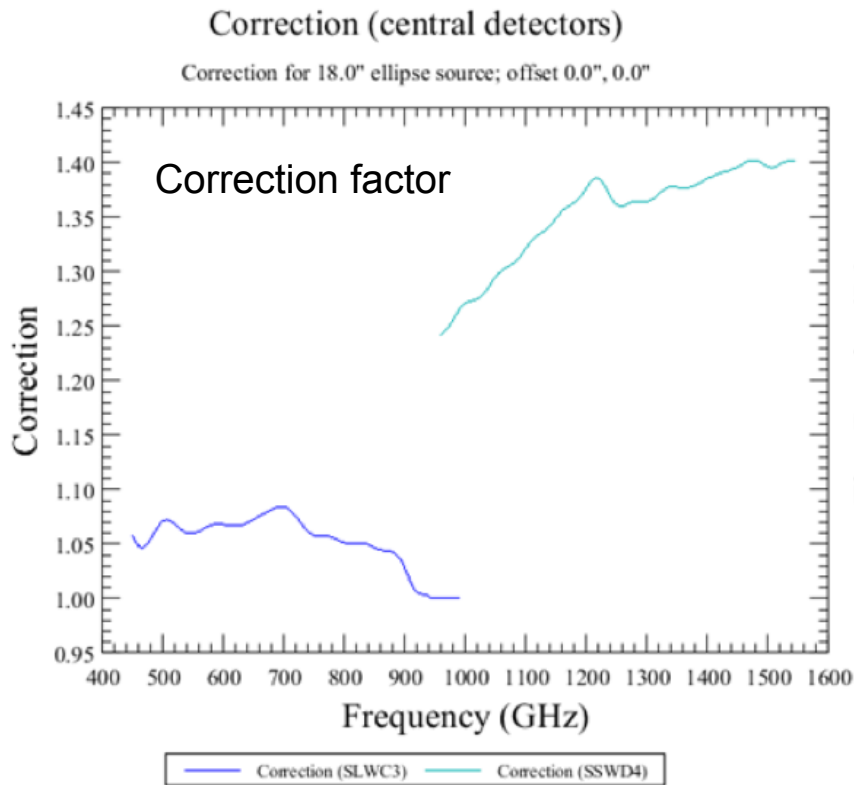
- Gaussian
- Top hat
- Sersic

Source model visualized 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