

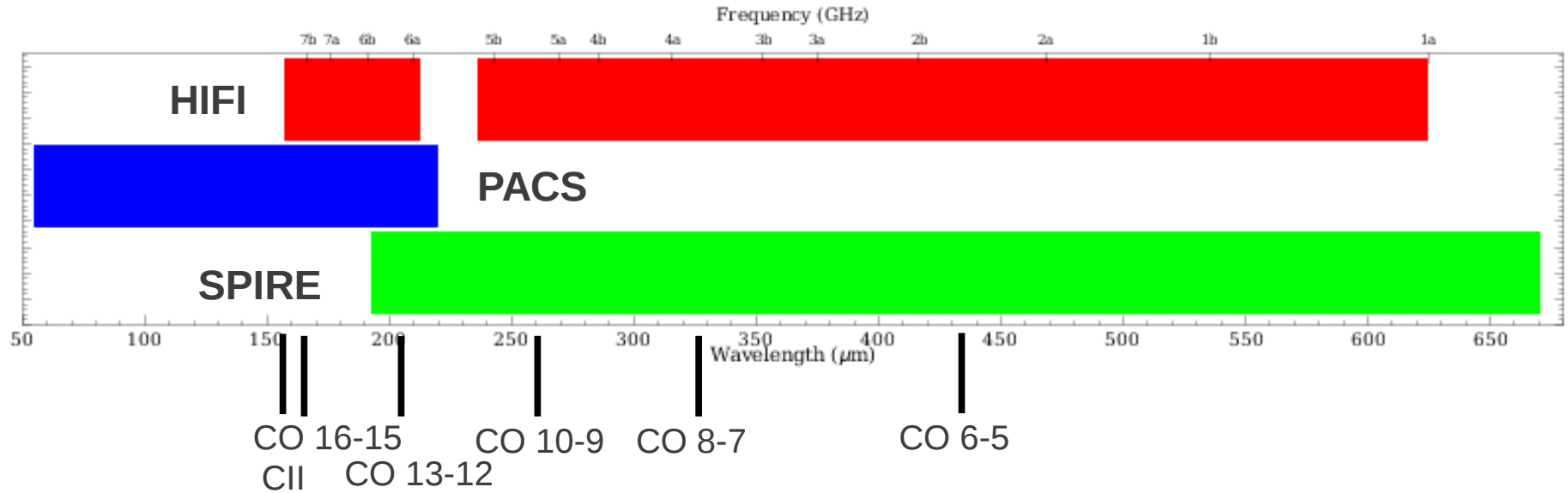


Herschel Spectrometer Cross-Calibration Update

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HSC Instrument Calibration Team



Herschel Spectrometers Cross Calibration



- This is wavelength/frequency accessibility, not necessarily coverage.
- HIFI spectral resolution is a factor 1000 higher than PACS and SPIRE. Lines fluxes obtained by fitting a model or speintegrating.
- PACS Red Leak stops for now comparisons between 190-220 microns, although shown

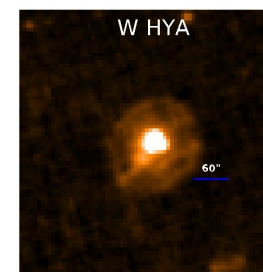
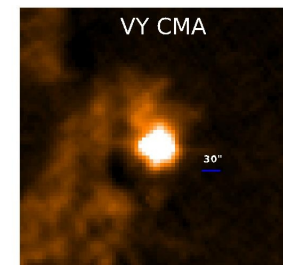
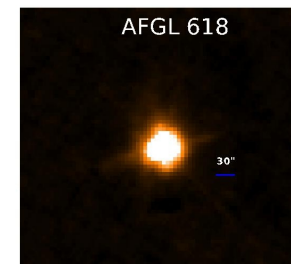
Spectrometers Cross Calibration use cases:

- I. Line Source Cross-comparisons
- II. Continuum Source Cross-comparison
- III. Extended Source Cross-comparison

Line Sources

- Source Sample: Started from HIFI routine calibration plan
- XCal proposal: coordinated observations within a cycle by the three instruments since ~OD850
- We make use of both science and calibration observations

Source Name	Type	Nr Coordinated obs.
CRL 618	Point	3/3
AFGL 2688	Compact	2/3
NGC 6302	Compact	3/3+1
NGC 7027	Compact	2/3
AFGL 4106	Point	Only SPIRE and HIFI
IRC+10216	Compact/Ext	2/3
VY CMa	Compact	HIFI & PACS not anymore
IK Tau	Point	
R Dor	Point	2/3
o Cet	Point	2/3 HIFI and PACS
W Hya	Compact	





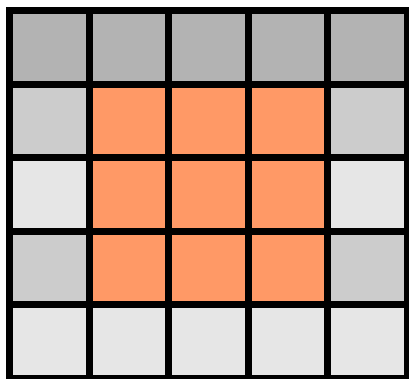
- Observations up to ~OD 1085
- Extension of comparison over more lines (CO lines, CII)
- No correction regarding extent, but identification of “point” sources and “compact” sources + from PACS and SPIRE photometry maps.
- No mispointing corrections applied
- Line flux is calculated at native spectral resolution
- The uncertainties quoted do not include the absolute flux calibration uncertainties yet.



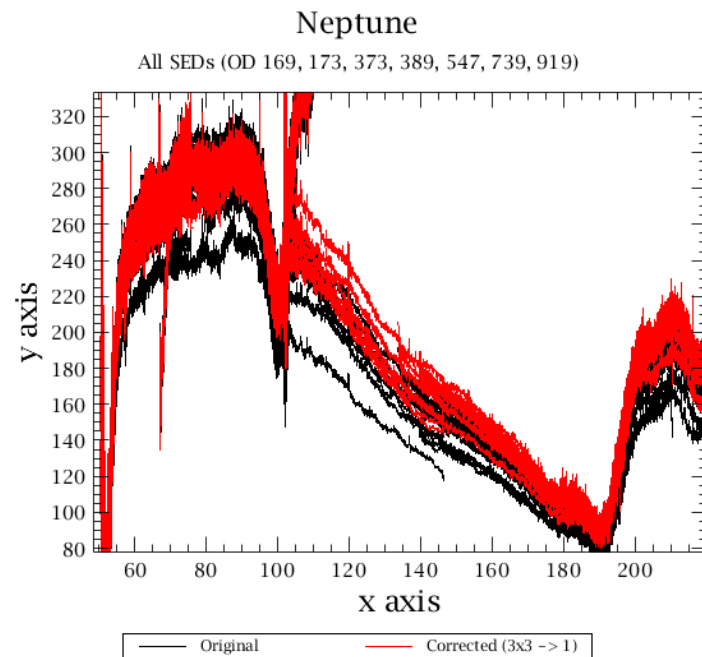
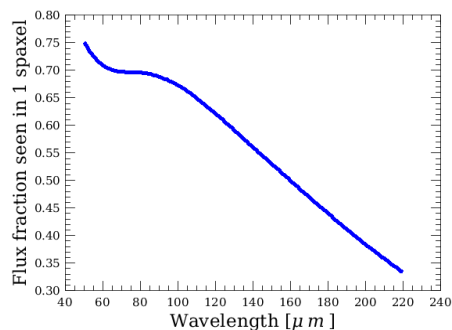
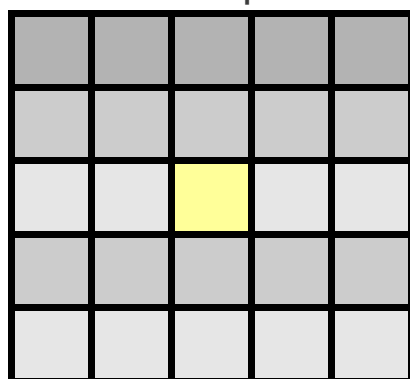
PACS: 3x3 to central mispointing correction for point sources

- Final step correction in the rebinned cube released to users in HIPE 9.0.
- Ratio between the spectrum of the central spaxel and that of the central 3x3 is compared to the same ratio for a perfectly pointed source (Averaged or wavelength dependent).
- Correction applied to the central spaxel spectrum. Then, point source loss correction from the central spaxel to the entire beam.

3x3 central spaxels



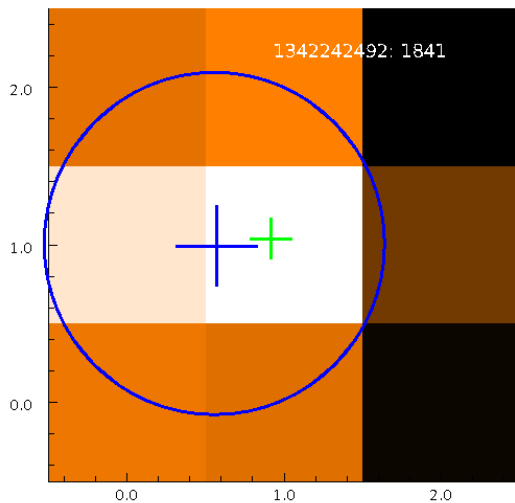
central spaxel





HIFI: 2D Gaussian fit in 3x3 raster maps

- Gaussian 2D fit on the line integrated intensity raster map (Nyquist Sampled)



- Gaussian sigma is $HPBW(\nu)/2.4$, left as free parameter to fit
- Cube is only used for visualization, fit is done on the htp raster in WCS coordinates (non-regularly sampled grid).
- Applied both for point and compact sources

RANominal, DecNominal
RAPeak, DecPeak



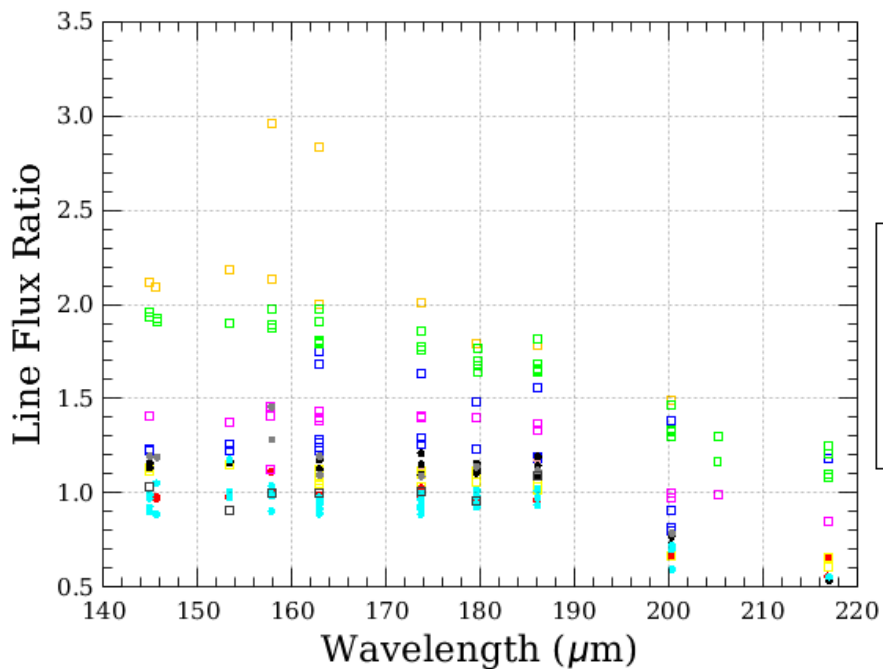
Correction for mispointed observations



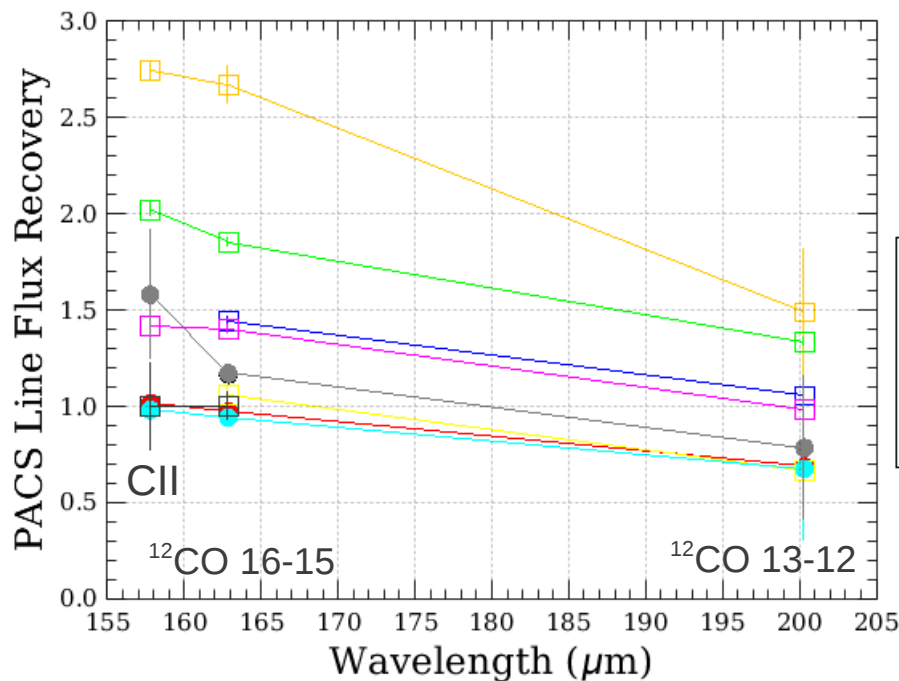
PACS 3x3 to central

PACS XCal Observations OD1085

3x3 to central Mispointing correction



Observations up to OD1085





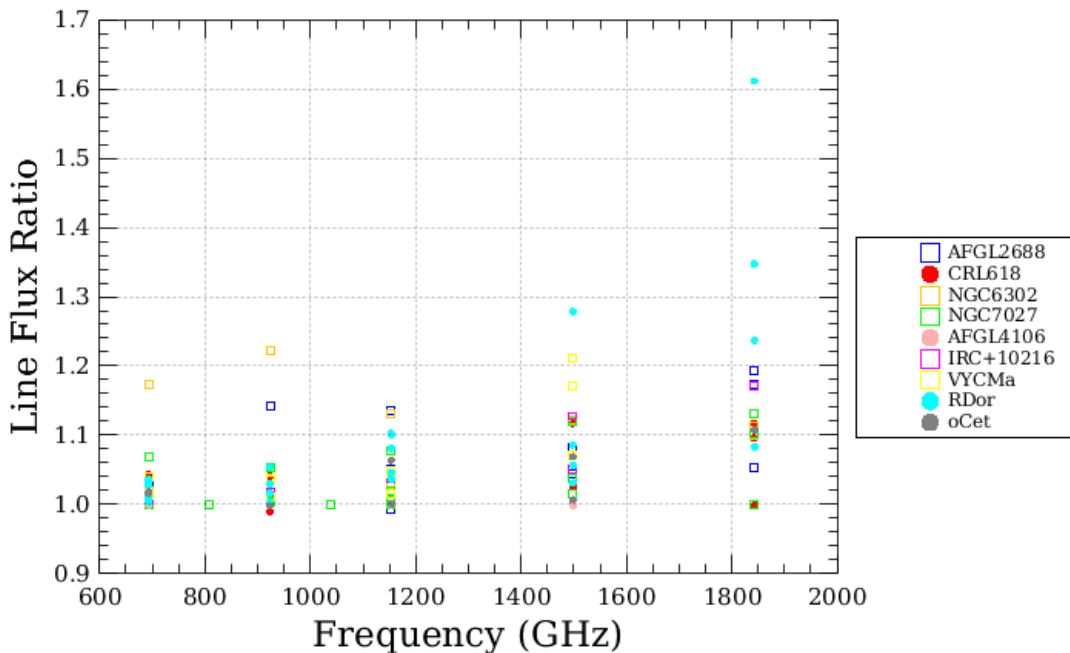
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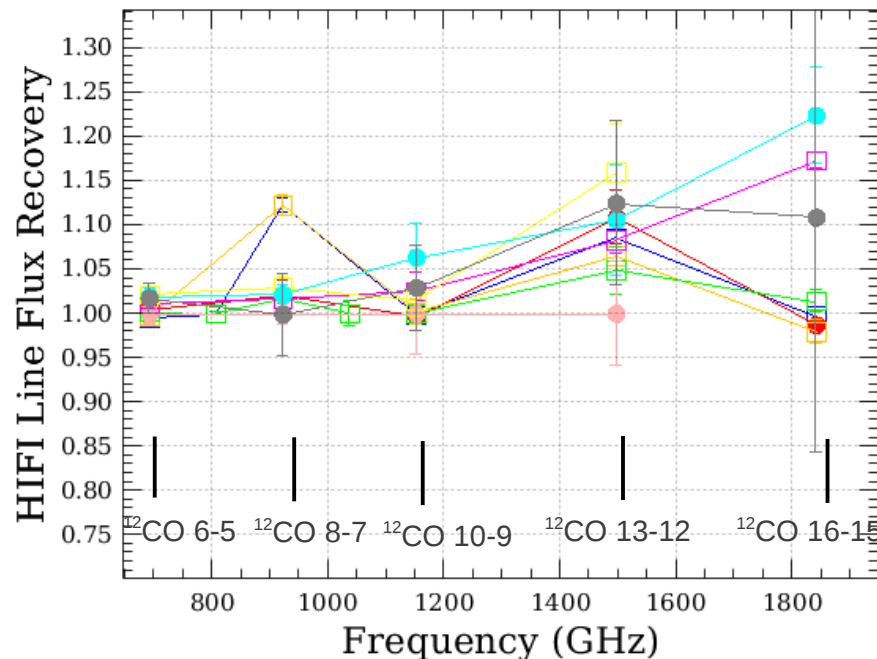
HIFI 2D Gaussian fit to 3x3 raster maps

HIFI XCal Observations OD1085

GaussFit to 3x3 raster maps



Observations up to OD1085

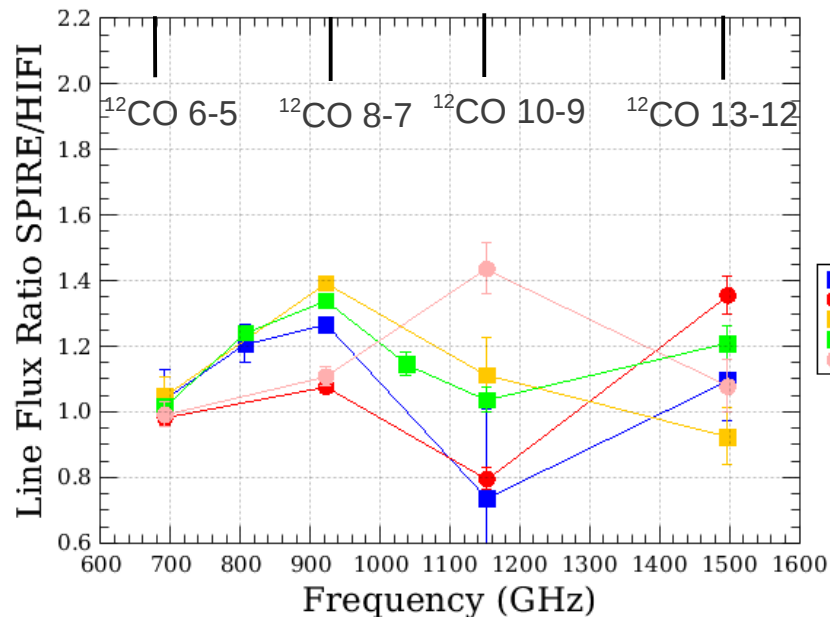




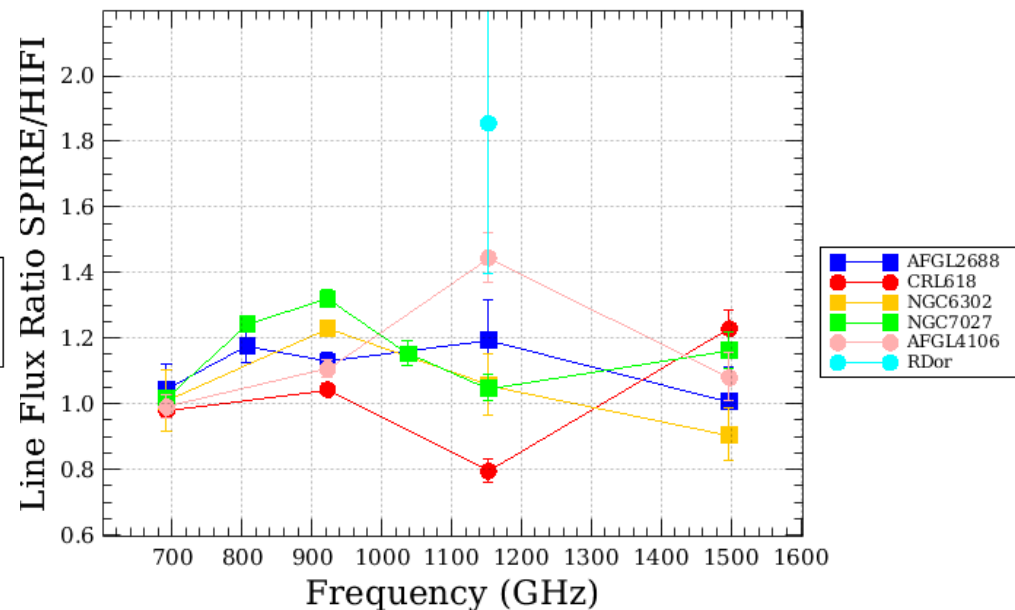
Correction for mispointed observations



Observations up to OD1085/1032



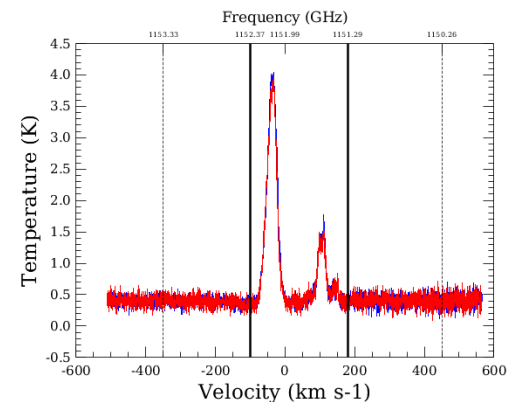
Observations up to OD1222/1208



Iteration 2

Iteration 2.

- The dispersion in CO8-7 is dominated by the compact sources
- Some line contamination is corrected readjusting the CO10-9 line integration limits, but not all is gone
- Scatter reduces for the CO13-12 line significantly

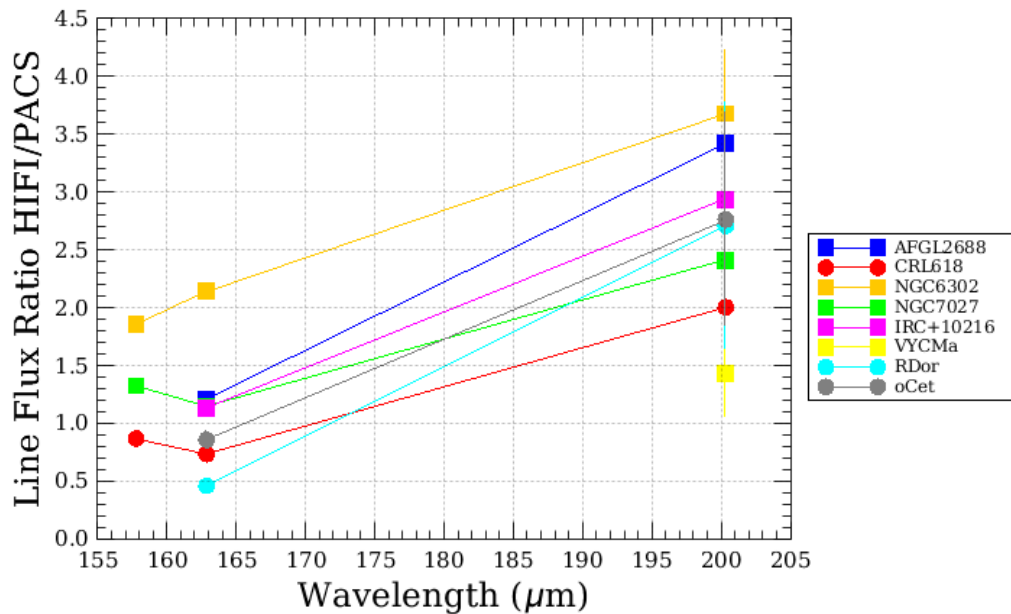




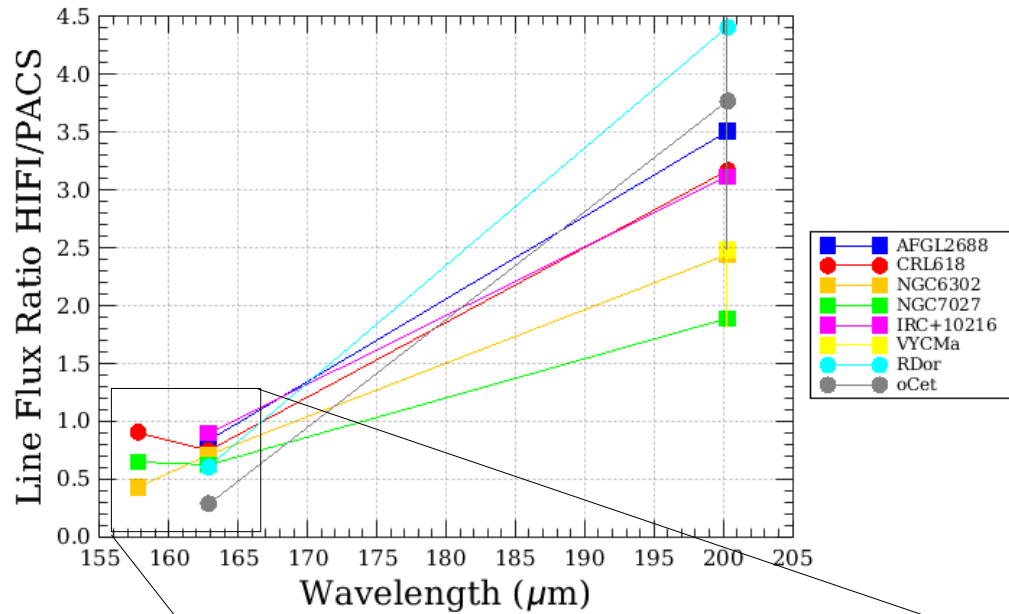
Correction for mispointed observations



Observations up to OD1085



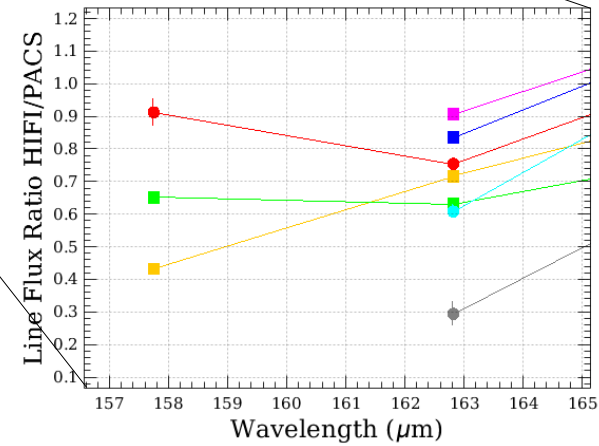
Observations up to OD1222



Iteration 2

Scatter is apparently reduced but PACS seems to extract a larger flux.

Iteration 2.





Next Steps in Line Source Comparisons



- Focus on the Point Sources, to try explain the present results.
- Line contamination.
- Proper treatment for compact or semi-extended sources
- Reprocessing with de-leaked RSRFs to correct from PACS red leak
- Corrections for Mispointed observations for point sources at the time resolution of a single frame PACS.
- Use of improved pointing products for HIFI 3x3 raster maps.



Treatment of Compact Sources



$$S[Jy] = \frac{2 \cdot k_B}{A_{geom} \cdot \eta_A} \cdot \left(\frac{1}{K}\right) \cdot T_A' [K]$$

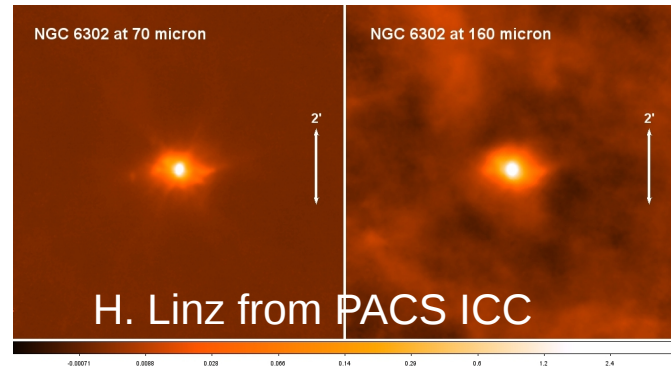
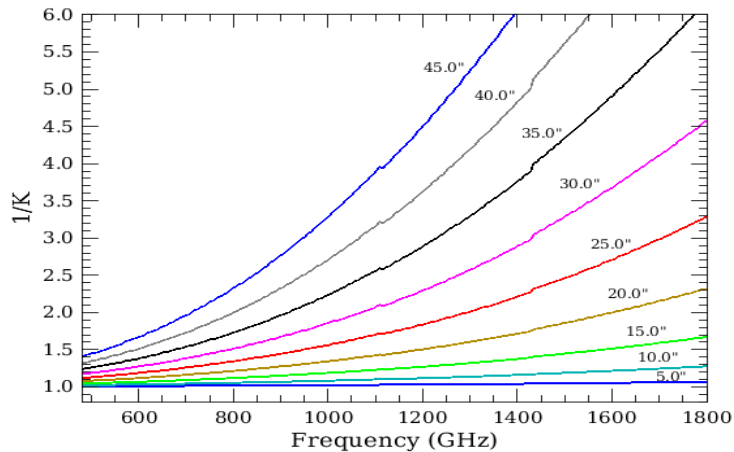
Coefficient for a reduction in antenna temperature when observing a source of non-negligible diameter

$$K = \frac{1 - e^{-x^2}}{x^2}$$

$$x = \sqrt{(\ln 2)} \cdot \frac{\theta_s}{\theta_B}$$

$$\theta_B = \sqrt{\frac{4 \cdot \ln 2}{\pi}} \cdot \Omega_{MB}$$

$$\Omega_{MB} = \frac{\eta_B \cdot \lambda^2}{\eta_A \cdot A_{geom}}$$

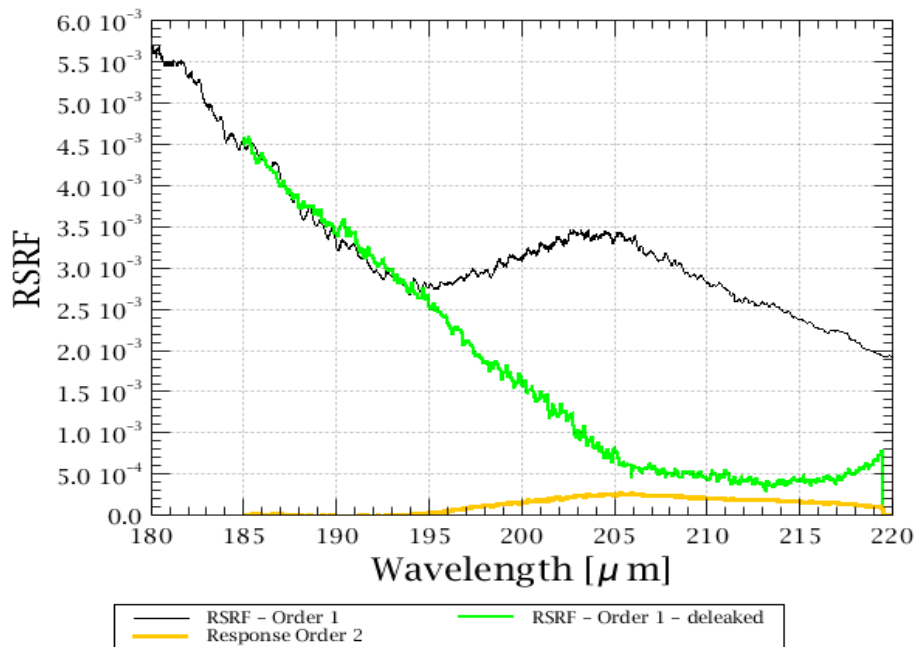


Initial spatial model

SPIRE Semi-extended Tool to refine source parameters

HIFI: convertKtoJy task

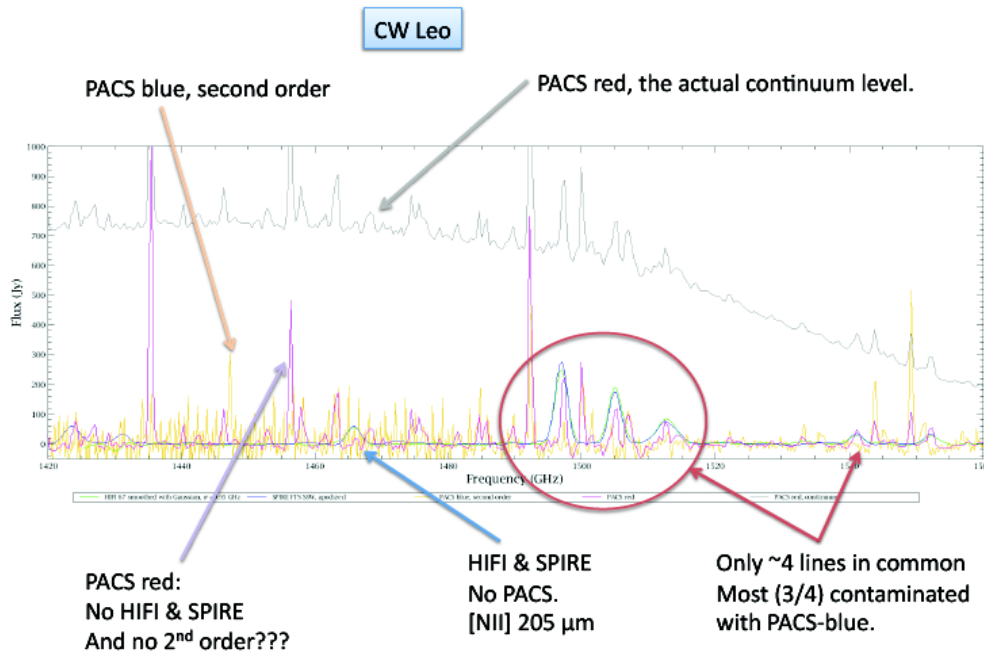
PACS: TBC



- Production of the RSRF in PACS Red Leak region is ongoing
- FM-ILT, ground based measurements of the RSRFs for each order
- Use of other SPIRE&HIFI data to confirm line fluxes.



- Convolution plays a major role due to difference in spectral resolution between HIFI and PACS/SPIRE
- IRC+10216: Exercise by I. Valtchanov presented in the XCal Workshop
- Neptune: Coordinated observations by PACS/SPIRE OD1118/1125





- CASSIS has line identification capabilities via CASSIS plugin. Is this easy to use within HIPE scripts?



- Line Flux unit conversion: discussion is going on in the Cube toolbox group.
- Dedicated integrator for HIFI timeline product?
- Inter Image/Cube WCS match visualization capabilities in Spectrum Explorer.
- Bilinear interpolator from irregular to regularly sampled grid (HCSS-15574)
- Beams available for the three instruments. Convolution and deconvolution tool with spatial and spectral kernels with comparison capabilities.