

Legacy Calibration: HUG#8

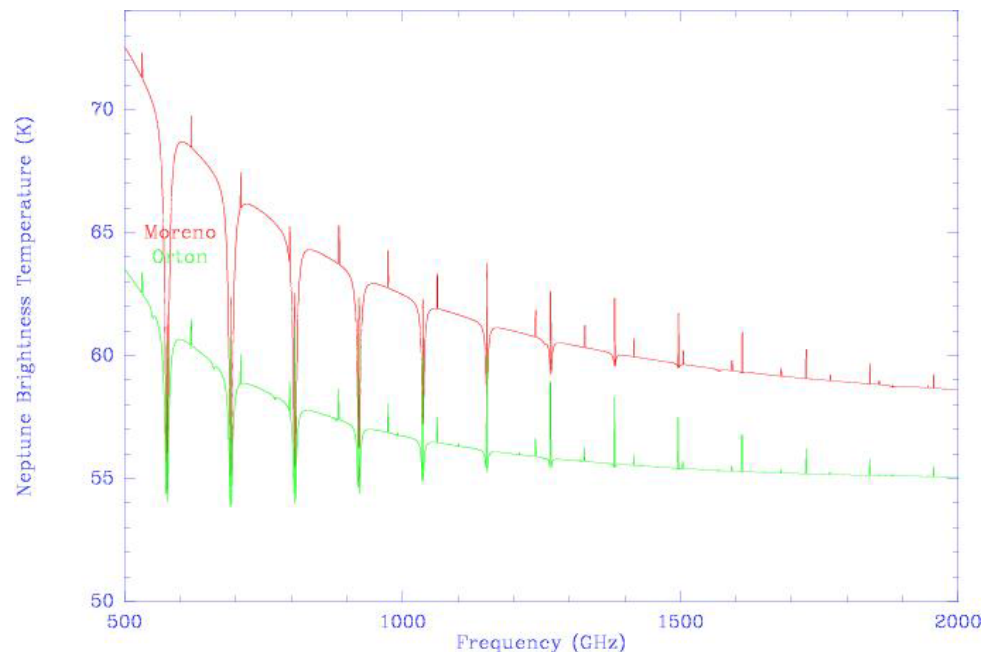
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22-23 May 2014

- Completion of Experimental Astronomy issue. Should be out in 1-2 months. 18 articles. Many more in A&A and other publications (>30!).
- Three calibrator types. Absolute flux calibration done against these.
 - Stellar G/K star models for 8 objects. Unchanged since launch (Decin et al)
 - Planetary models – mainly Uranus and Neptune, but also Mars (Moreno & Orton)
 - Asteroids (Mueller).
- Where we are, where we are going and likely completion
 - HIFI
 - PACS
 - SPIRE
 - Cross-calibration
 - Pointing
 - Final documentation and archive contexts

- Based on MARCS models of stellar atmospheres.
- Now projected out to $\lambda = 7\text{mm}$
- Normalisation requires very accurate K band magnitudes.
- Sizes:
 - Could be adjusted in the cases where interferometer measurements.
 - Known variation with λ not included in model (1-3% systematic).
- No plans to rerun MARCS models (grant application, Leen Decin, not funded).
- Future?

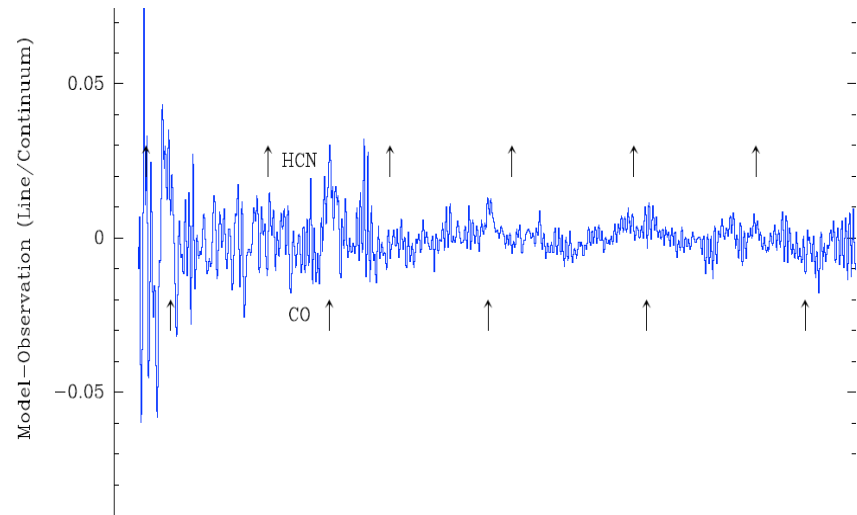
- In early days of HCalSG – several years pre-launch – no consensus and atmospheric models of gas giants could differ by as much as 30%.



- Moreno and Orton worked hard to get models to within few percent of each other for Uranus and Neptune by launch (based on flyby, infrared ground and space-based observations and atmospheric modeling).

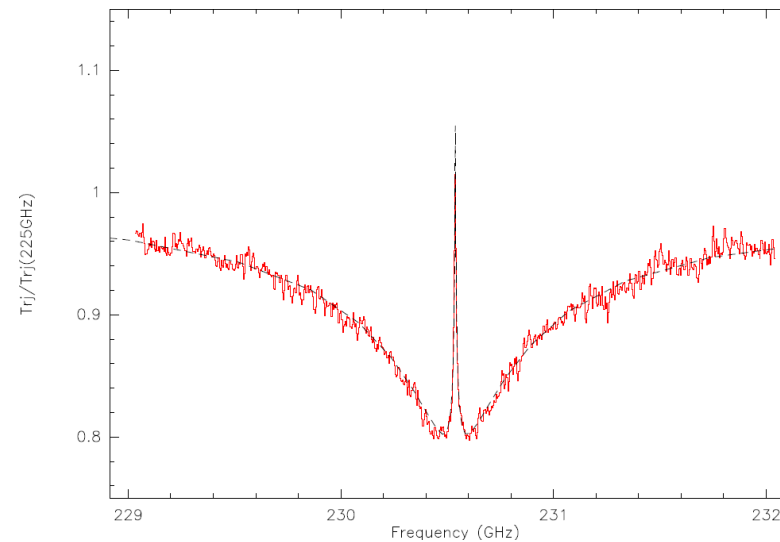
- Feedback from Herschel observations has enabled further tuning (e.g. SPIRE/PACS spectral lines).
- Best models (e.g. just presented ESA5 model) now put systematic error from **models as 5% (99% confidence) for latest Neptune model (ESA5)** – SPIRE photometric standard. Slightly worse probably for Uranus model (ESA4) – SPIRE spectroscopic standard.
- **Done with models. Will need to incorporate Neptune ESA5 model in SPIRE calibration tree (minimal differences).**

Neptune ESA5 model versus observations (DONE)



Model (Neptune)
versus SPIRE
spectra (calibrated
using Uranus).

Includes fixing to
other telescopic data
– IRAM CO 2-1 line.



- Thomas Mueller provided models for dozens of asteroids prior to the beginning of the mission with predetermined brightnesses for PACS/SPIRE for each day of the projected mission.
- Able to be used to predict best observing setup for known asteroids.
- However, able to run TPM for specific time of each observation made. So every calibration obsid has an associated model for time/date of observation.
- Able to also use for PACS non-linearity checks as covering the full flux range of the non-linearity above 20 or so Jy in PACS photometer.
- Completely consistent with stellar models. Feedback from Herschel observations.
- Able to move some objects to the position of prime calibrators with < 5% systematic uncertainties. In Experimental Astronomy paper
 - Ceres, Pallas, Vesta, Lutetia.

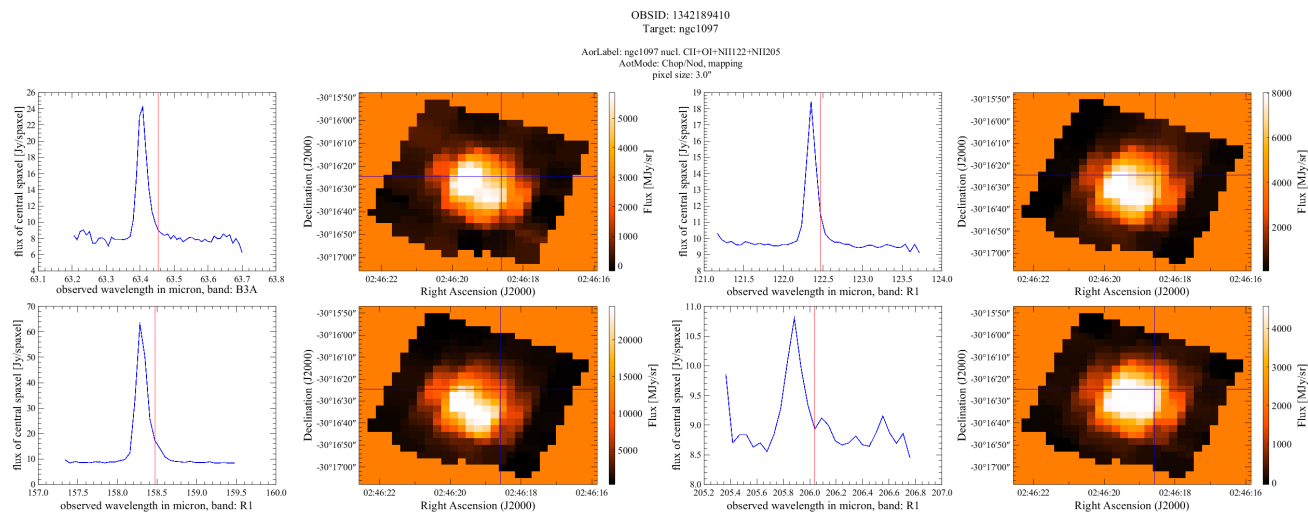
- Legacy passed on to other observatories.
- No further modeling expected – already uses best shape models, information on rotation, flyby information and IRAS, MSX, Spitzer, Herschel, WISE, AKARI and ground-based N-/Q- data.
- **Looking for further cross-calibration confirmation with Planck data.**

ARCHIVING:

- Main item is best way to present in archive. Hundreds of specific models for specific obsids when each asteroid observed during Herschel mission.
 - Link in archive? Exactly how? FITS table?
 - HPDP of full model set?

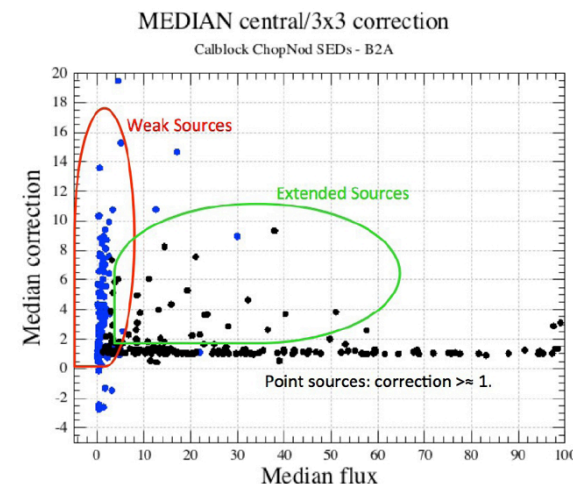
➤ Overall:

- Pipelines for P now have MADmap working with better performance and speed. Jscanam main mapper. UNIMAP in HCSS 13. Still some final tests/decisions before HCSS 12.1 bulk reprocessing.
- New browse/standalone products for P and S.
- To include gyro pointing corrections in HCSS 13. Testing of jitter reduction getting more promising – useful recent Pointing WG.
- PACS-P $\sim 1\%$ repeatability and PACS-S $\sim 4\%$ RMS.



- Keyword information drastically improved in FITS products for advanced searches in the Herschel Archive
- Important update in the telescope background normalization calibration (TBN) scheme.
 - Empirical description of telescope emissivity model
 - Spectral shape dramatically improved ($\sim 10\%$ SED wide)
 - Fully consistent with calibration block + RSRF scheme. Absolute flux calibration accuracy: rms $\sim 4\%$, peak-to-peak 15% in all bands
 - TBN recommended for chopNod observations
- Roll-out of correction tool for PACS-S semi-extended sources
- I-pipe script for flux correction based on pointing drift fitting for bright sources (> 50 Jy) is now public, while in validation.

Determination of continuum flux low limit for applicability of the central to 3x3 correction (5-10 Jy)



➤ Still to do:

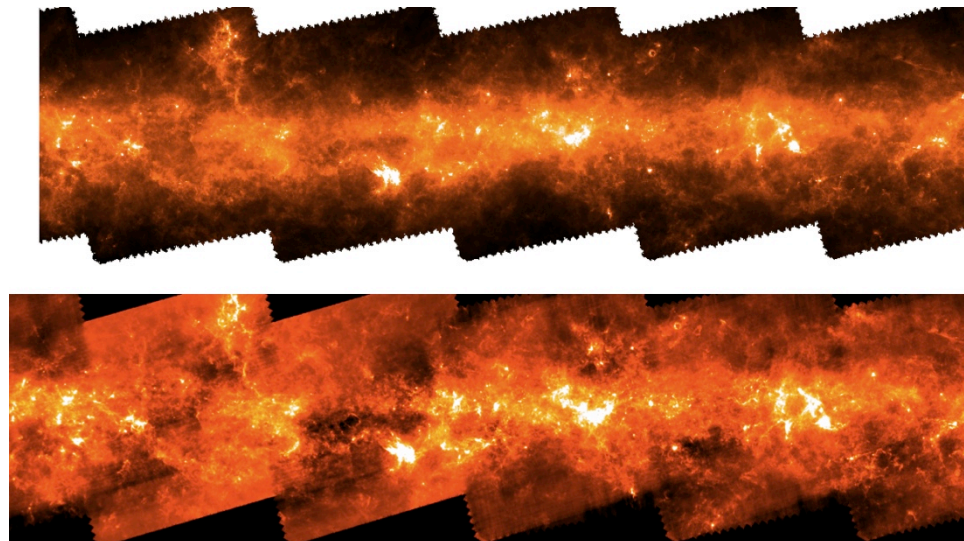
- Need tests of mappers and flux – finalize selection for 12.1 BKRP and plan for HCSS 13.
- add gyro pointing drift correction in SPG (**13**)
- Improvements for unchopped spectroscopy. Calibrate response drifts and transient modelling.
- Investigate recovery of extended emission in PACS-P.
- Inclusion of full jitter correction → PACS-S flux correction.
- Outline and definition of Standalone Legacy Products for PACS
- Point Source Catalog – PACS implementation plan imminent.

➤ Target completion:

- Major release of HCSS 13. Although implications of jitter correction will go beyond this release or bulk reprocessing release HCSS 13.1

➤ Overall:

- Excellent repeatability/overall SPIRE-P $\sim 2\%$. Biggest overall flux calibration problem is reducing the error associated with models (absolute error).
- Much work on repeatability and use of various point source extractors – in association with point source catalog setup. Improvements on use of software with SPIRE P data.
- SPIRE-P pipeline improvements:
 - Cooler burp removal, use of Planck zero point correction gives extended emission maps, multi-pass pipeline

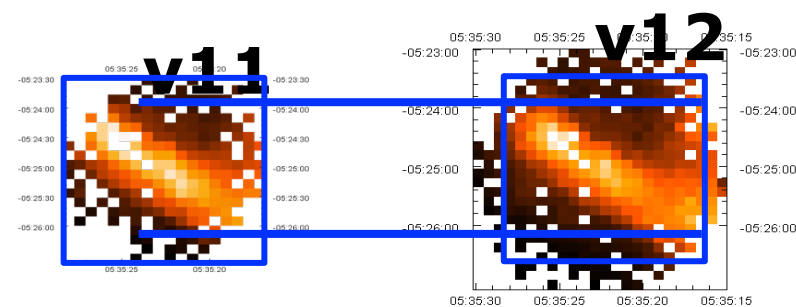
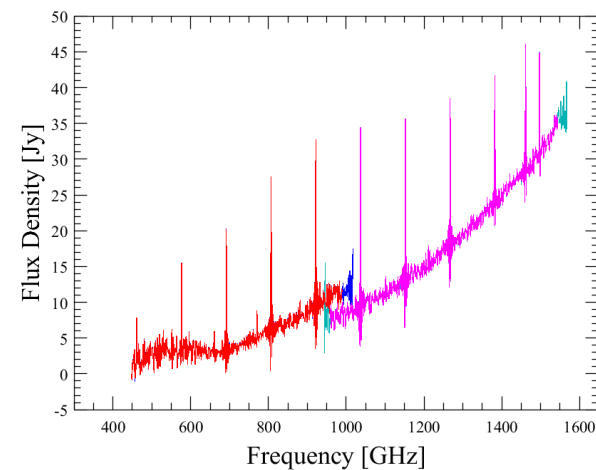
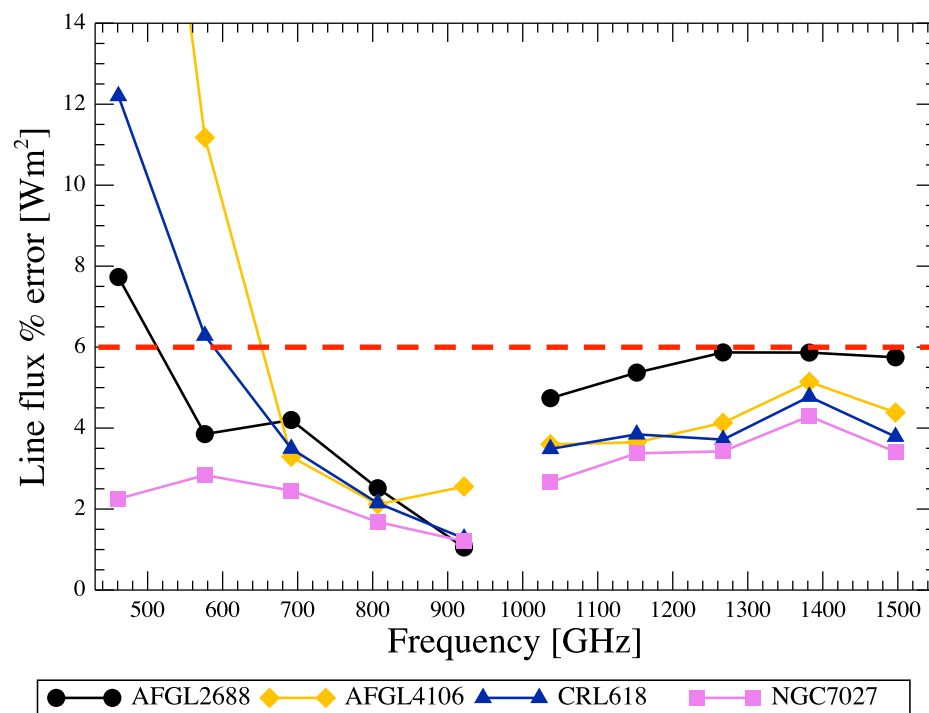


SPIRE-S Improvements



➤ SPIRE-S:

- Extended in wavelength band edges of modules
- Repeatability of $\sim 6\%$
- Included vignettted pixels



- Still to come for SPIRE-S:
 - Convolution mapper archive product
 - New nonlinearity correction
 - Improve obs context logical structure allowing better archival search capabilities.

- Updates pending for SPIRE-P
 - Point Source Catalog implementation plan in place (feasibility etc.). Approx. 2 million sources expected above and below galactic plane.
 - Planck HFI calibration updates and data release will update the flux background offset for SPIRE maps.

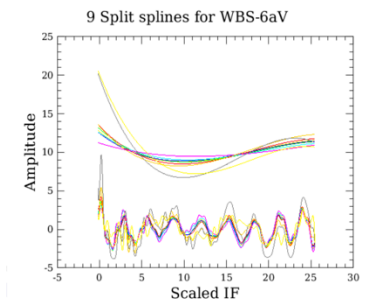
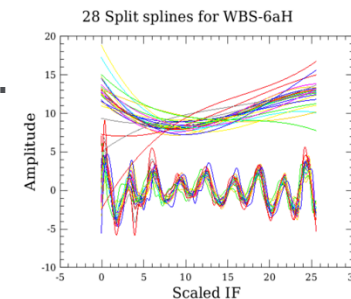
- Target Completion
 - HCSS 13. Point Source Catalog will be beyond this.

➤ Overall:

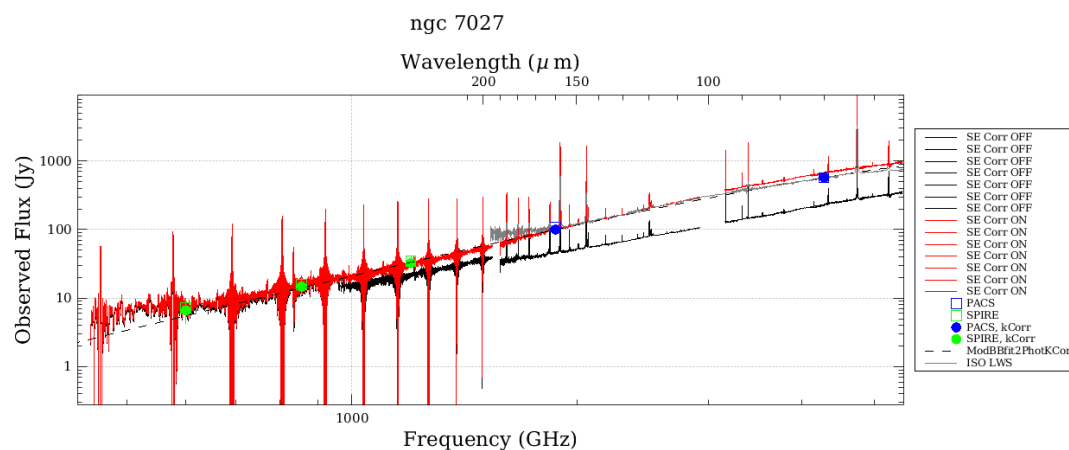
- Beam information coming to a conclusion. Some simplistic assumptions now replaced by detailed beam modelling. Some large changes to efficiency parameters coming.
- HEB wave correction in HCSS 13 now being tested.
- Improved spur detection

➤ Still to do:

- Complete sideband investigations
- Include HIFI beam information (not many tasks will use it) at least on website/Twiki
- Sideband ratio – gas cell data from ground tests to be placed into the archive (HSA) later this year. SBR running to a conclusion on all bands.
- HPDP: spectral scans and maps. Not too many of these – could be done by hand within ICC.



- Spectral cross-calibration paper to be written this summer
 - Much improved understanding on the details of how to get accurate flux measurements.

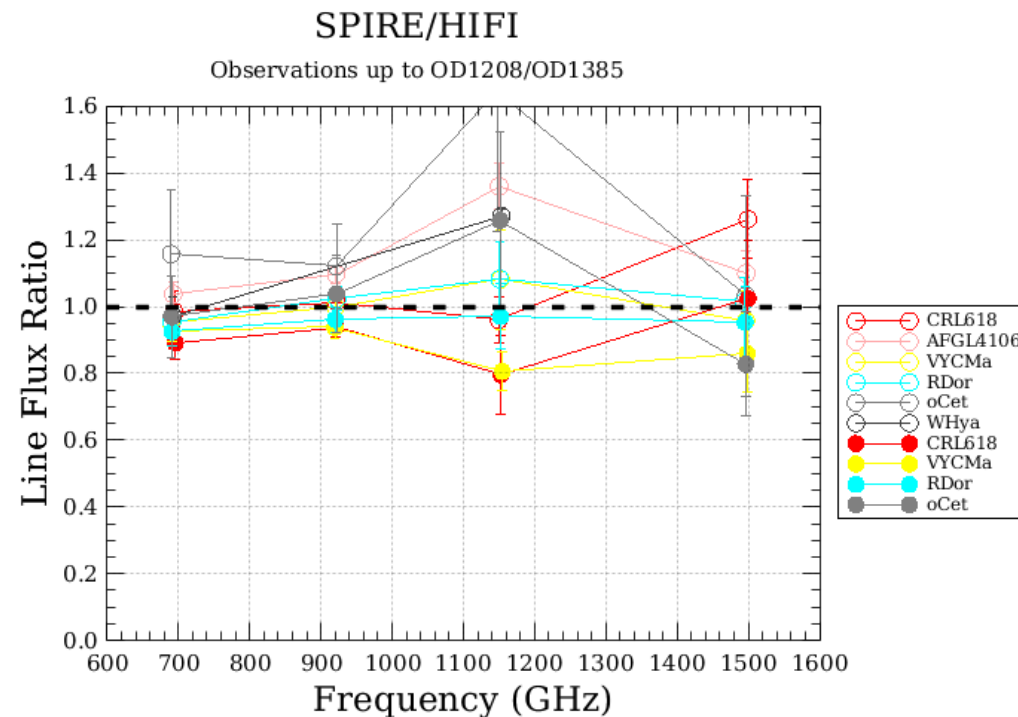


- *Need to understand K corrections for semi-extended sources offset from beam centres.*
- Photometry (SPIRE/PACS) xcal to be completed. Much information and clearly no problems. But should have a paper on this.
- Cross-calibration with Planck:
 - Very consistent overall calibration (gain)
 - Used in SPIRE maps to adjust backgrounds to the correct level.
 - Will need an update when updated Planck calibration is in place.

Spectral Line Comparisons



➤ E.g. CO line comparisons.



To do: Implementation of HIFI semi-extended source correction (only one pending in line flux extraction cross-calibration scripts).

- Information has been passed on with Herschel Explanatory Supplement.
- There are >30 calibration papers in press or published.
 - Likely to be placed in projected Herschel Explanatory Library.
- Need to work with calibration products to place in archives in most appropriate way. Proposal to come from APM.
 - Set of products like those provided KPs?
 - Link specific obsids to specific calibration models? Perhaps include in overall observation context?

- Currently in archive.
 - Bulk reprocessing of using version 11.1 – now have STR distortions corrected (at least in part) for the whole of the mission. Overall $\sim 1.''4$ pointing 1-sigma.
 - Towards the end of the mission – onboard pointing (not adjusted on the ground) was closer to $1''$.
 - So may be able to improve a little more on STR distortions.
- To come.
 - Working with PACS on the final code for handling jitter as well. Various issues seen in testing. Improvements suggested/being included at HSC – very promising.
 - Can potentially reduce jitter (including larger ones at ends of scan legs) to a third of original value.
 - Still would like to change pointing products for ALL the mission within HCSS 13.1 bulk reprocessing. WILL NEED LOTS OF TESTING.
- Further in the future.
 - Looking into reducing effects of STR heating – especially at solar aspect angles that led to some direct sunlight on STR optics.

- **All teams looking to state of final products and final calibrations (including calibration tables).** Standalone legacy products being fully defined (to allow better archive data mining)
- Pointing affects all observations:
 - Should be at 1" or so for full mission (1-sigma APE)
 - We may do better with better accuracy on scan map paths
 - Has already helped to improve knowledge of timing offsets seen in scan maps since the beginning of the mission.
- **Basic idea is that the most important items are identified and encapsulated (as much as possible) for work done within the HCSS 13 and 13.1 timeframe.** And the deadline is not that far away.
- Only some items (icing on the cake) identified as beyond HCSS 13 (e.g. pointing correction for STR heating).
- **All calibration modelling work done.** Only one small concern – we know we could have slightly better stellar models.
- **Legacy calibration – work used by ALMA, Planck, SOFIA (so far).**