

SPIRE FTS Calibration Update

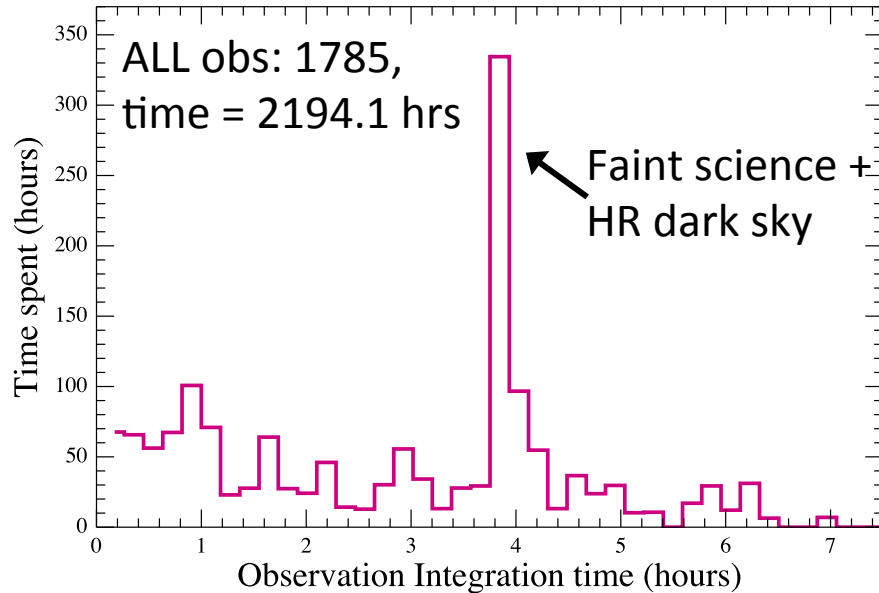
Cross calibration meeting ESAC March 2013

SPIRE FTS Calibration Update:

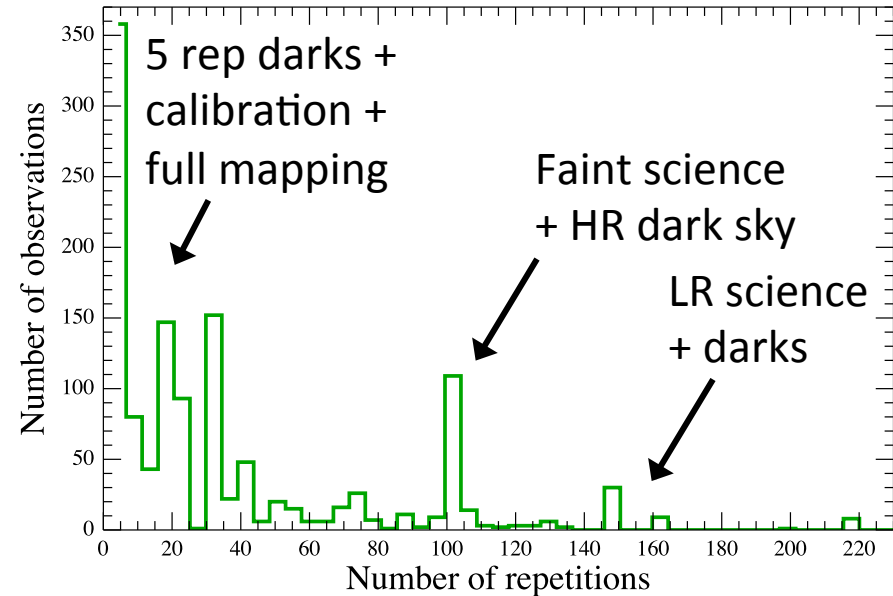
FTS mission stats

2

Integration time



Number of reps



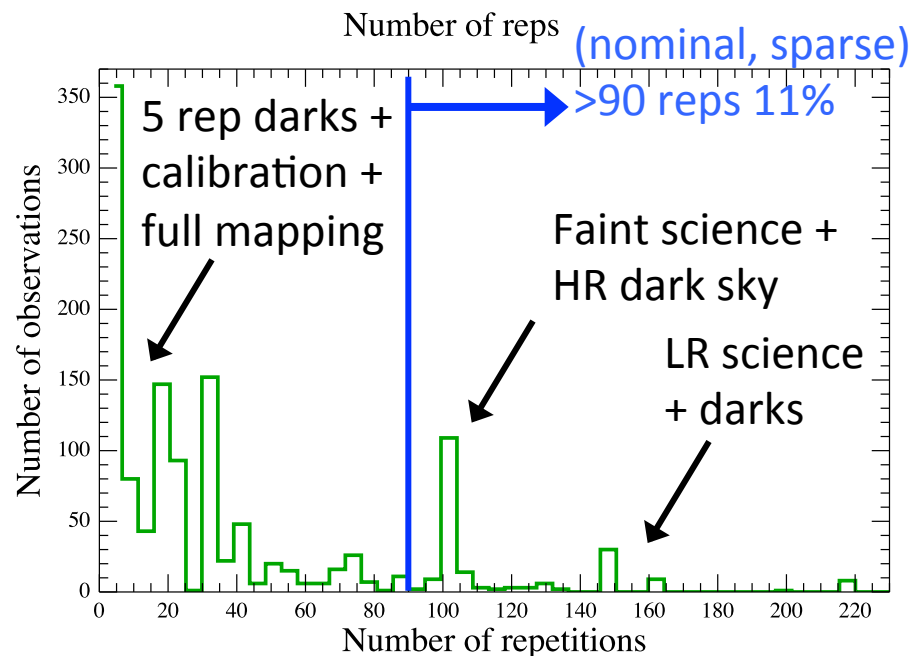
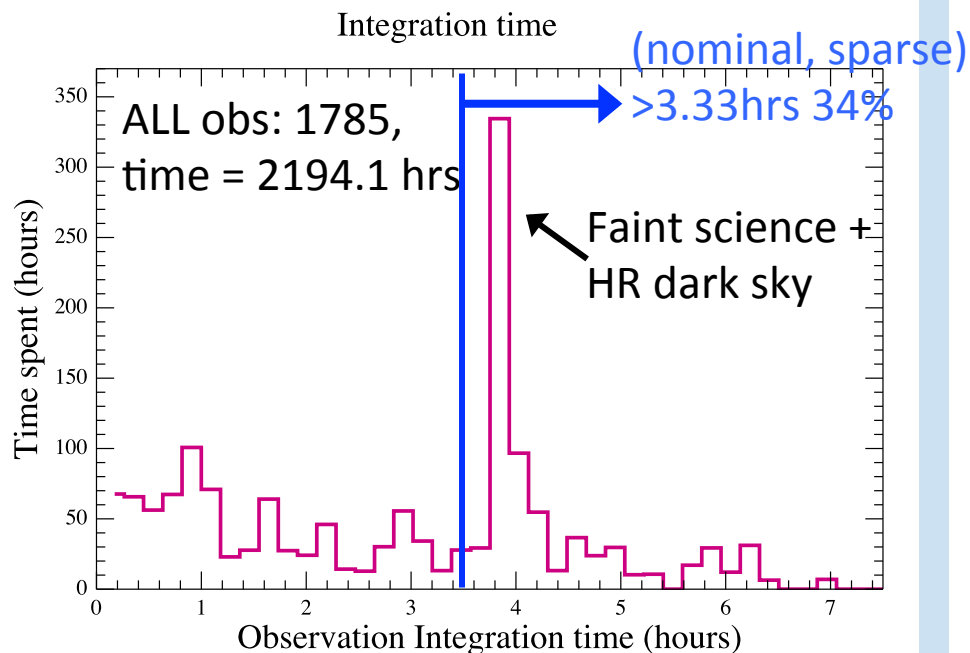
Nominal: 97% of total time (2132.6 hrs), 91% of all observations

Spatial sampling	% time (hrs)	% num reps
Sparse	73 (1590.3)	75
Intermediate	17 (366.2)	9
Full	8 (176.1)	7

SPIRE FTS Calibration Update:

FTS mission stats

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Nominal sparse obs	% time (hrs)	% num reps
Calibration	7 (153.9)	22
Dark sky	12 (254.4)	9
High Res	68 (1489.2)	56
Low Res	4 (79.3)	16
High + Low Res	1 (17.0)	2

SPIRE FTS Calibration Update: V&V overview

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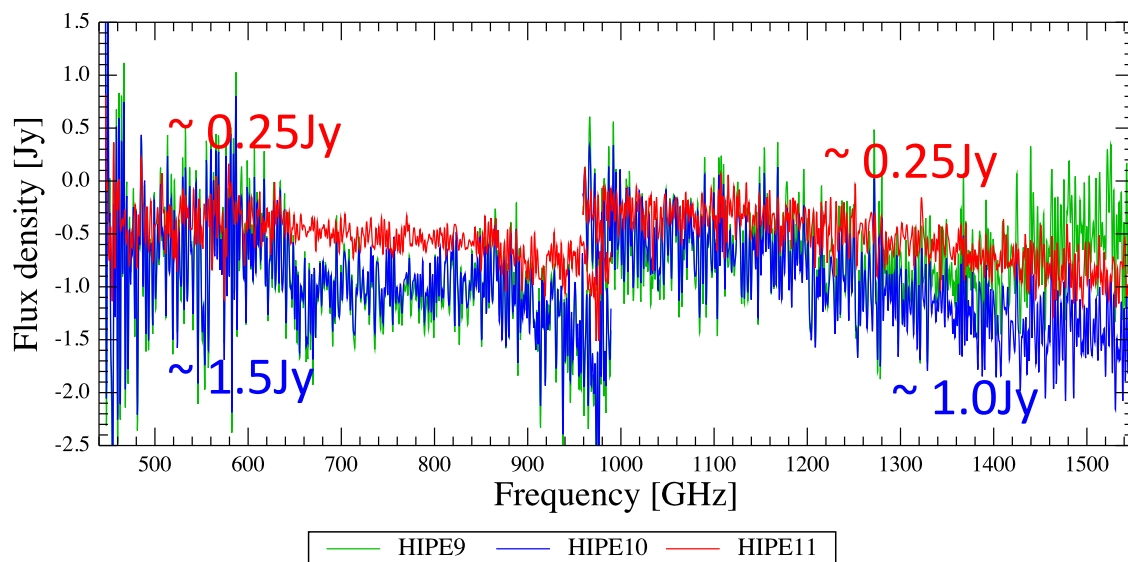
- Sensitivity
- Offset
- Repeatability
- Absolute flux calibration

SPIRE FTS Calibration Update: Sensitivity

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METRIC:

- Used to assess the total observed noise levels achieved against HSpot
- Observations included: Dark sky and featureless SSO
- Estimated from the average noise over all observations (92)
- Average sensitivity = median of the sensitivity per detector
- Significant improvement with implementation of a mean telescope RSRF, but see poster by Fulton et al. for HIPE11 update
- Systematic noise is particularly significant for 'bad days' e.g.



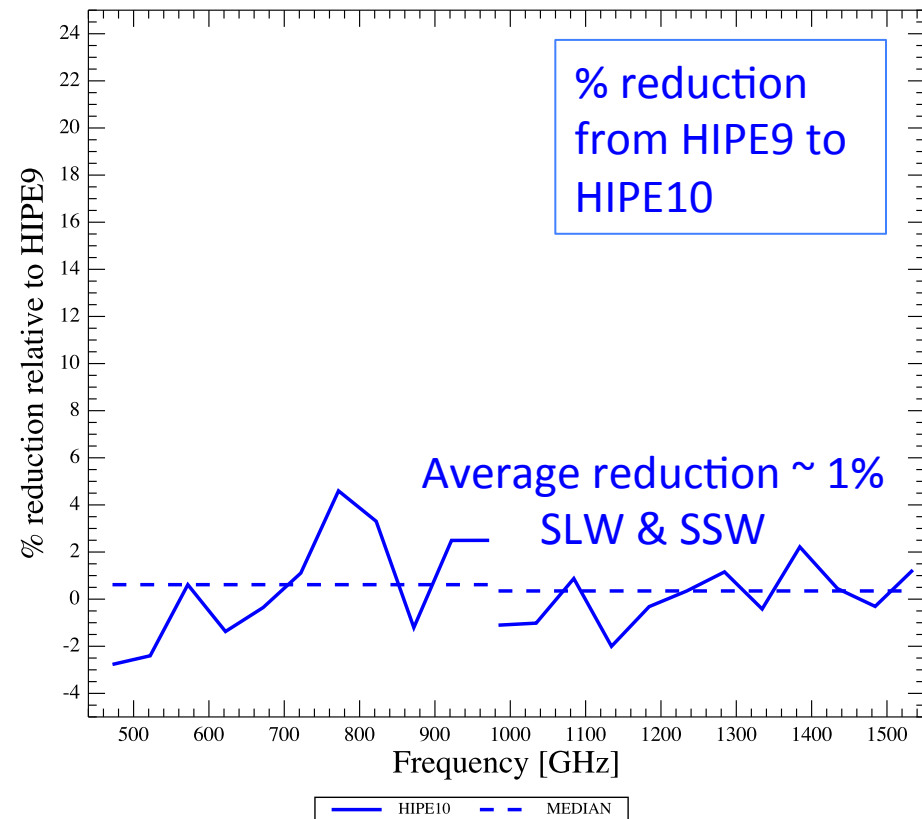
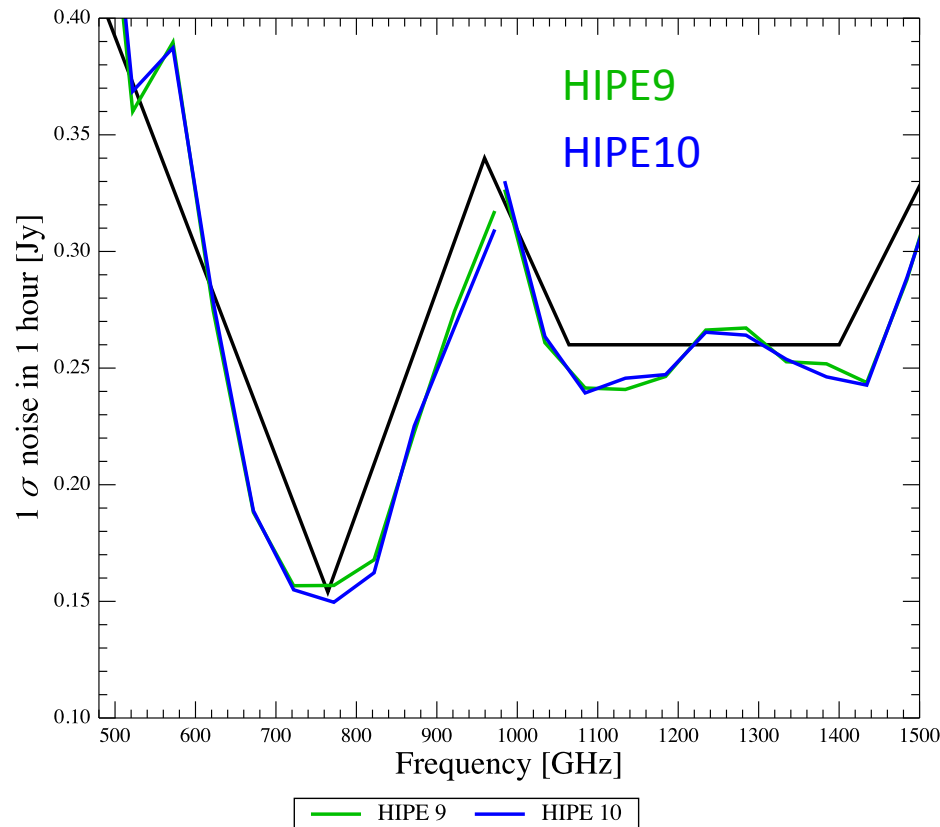
Very faint science
target from OD
1032 (continuum
< 300 mJy)

HIPE9
HIPE11
HIPE10

SPIRE FTS Calibration Update: Sensitivity

6

Used to assess the total observed noise levels achieved against HSpot

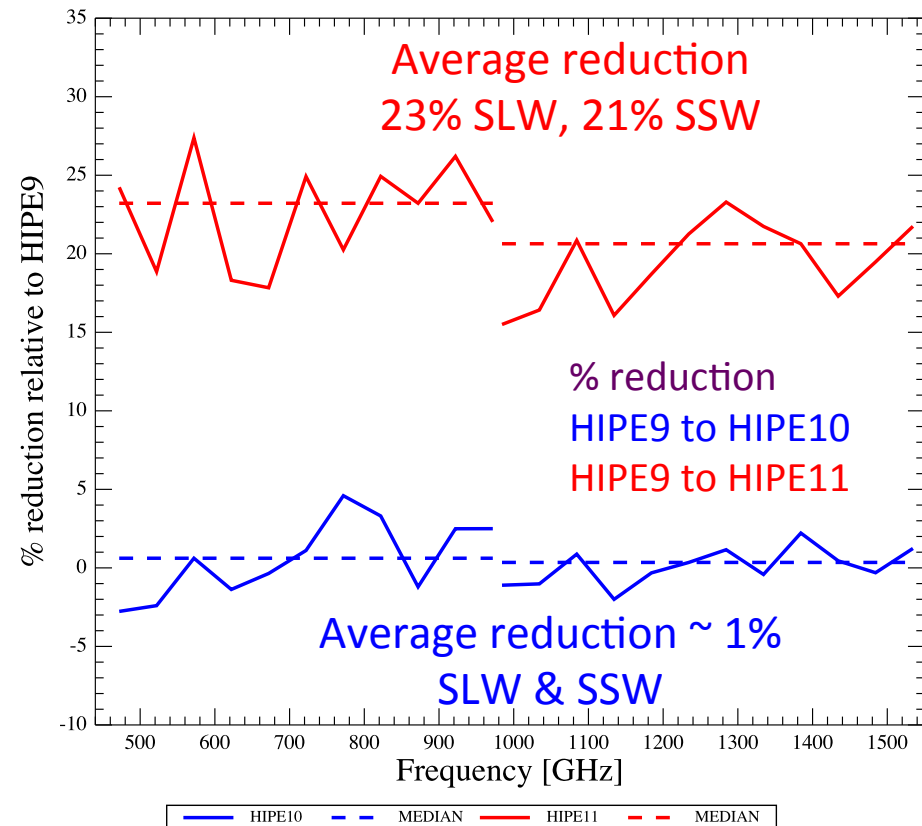
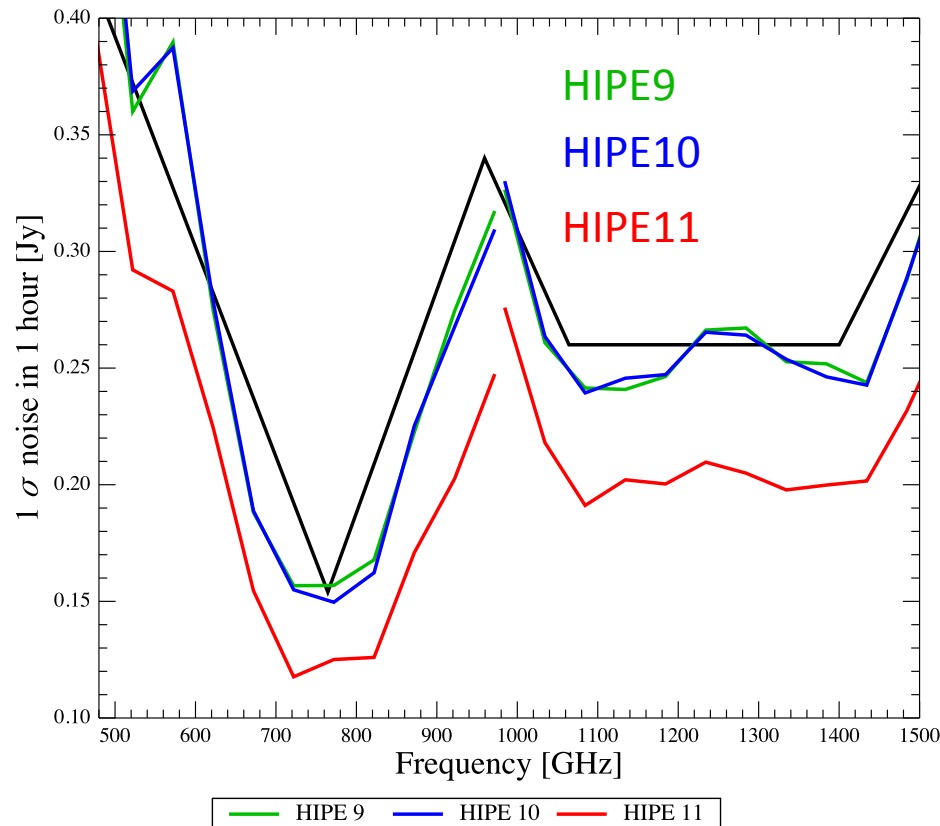


HIPE10 sensitivity $\approx$ HIPE9 sensitivity

SPIRE FTS Calibration Update: Sensitivity

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Used to assess the total observed noise levels achieved against HSpot



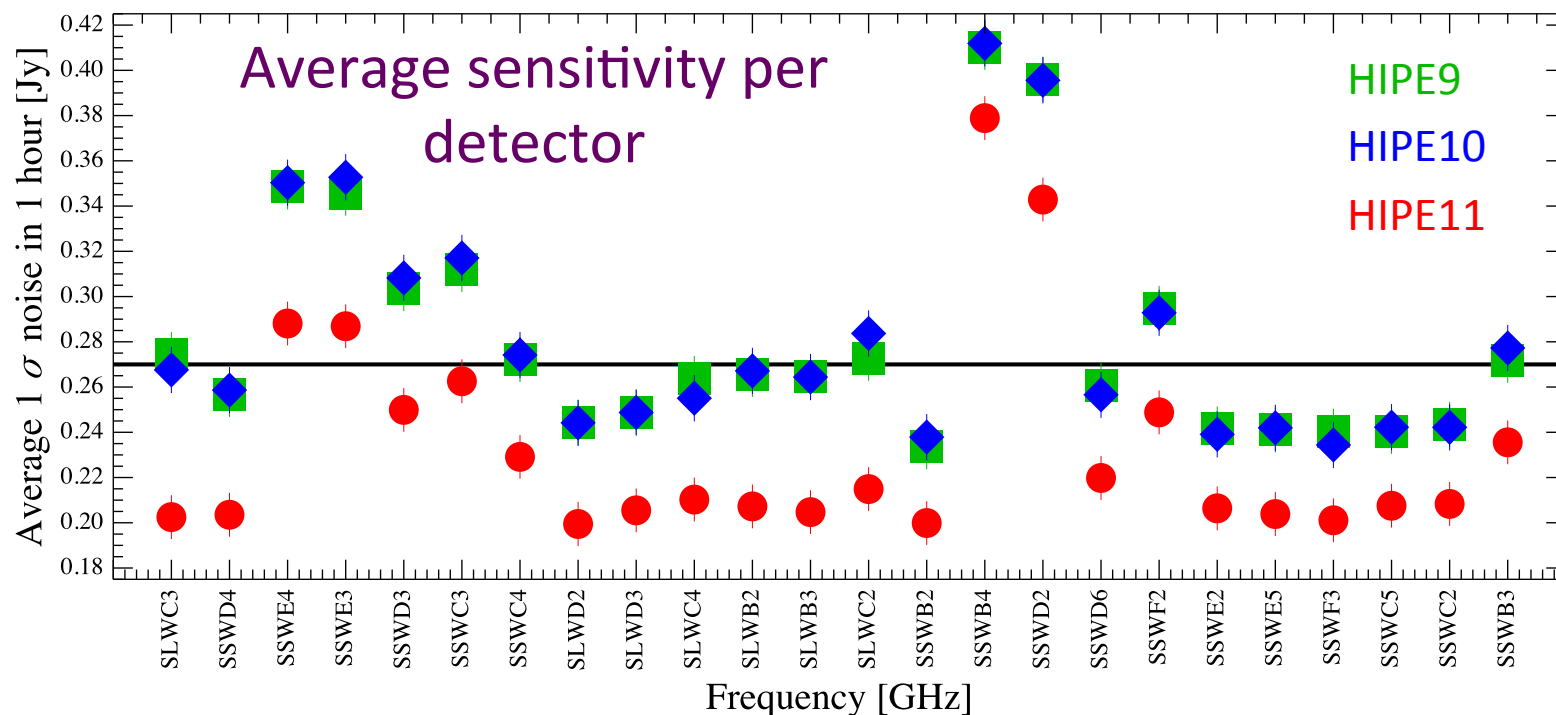
HIPE11 will bring a significant sensitivity improvement

SPIRE FTS Calibration Update:

Sensitivity: all detectors

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Improvement: ~ 0% HIPE9 -> HIPE10
~ 16% HIPE9 -> HIPE11



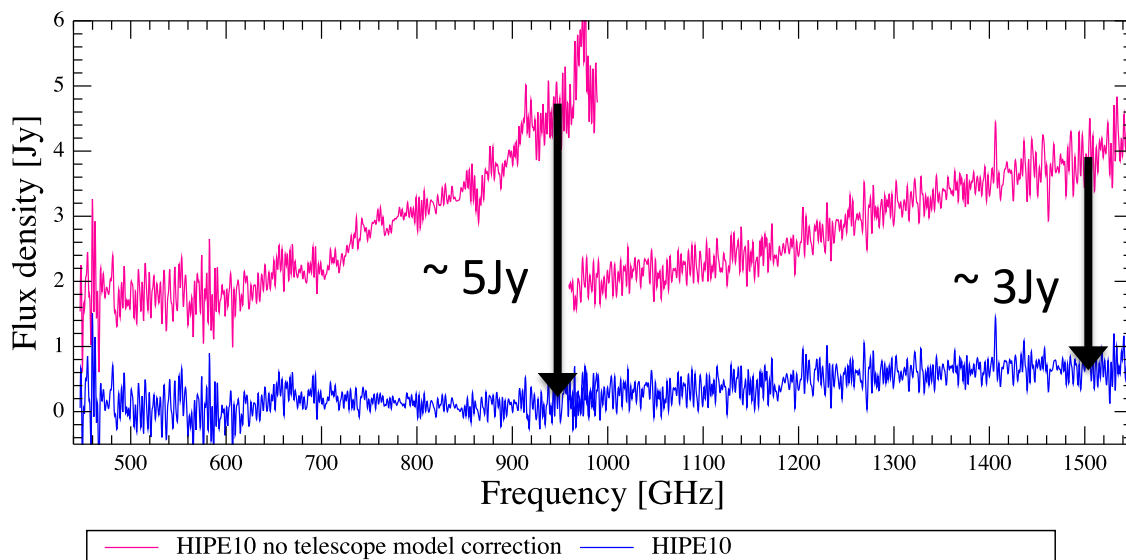
SPIRE FTS Calibration Update: Continuum offset

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METRIC:

- Used to assess the additive error on continuum flux density
- Observations included: Dark sky only
- Estimated from the 'spread' (standard deviation) over all scans (> 5000)
- Average offset error = median of the spread per detector
- Hugely improved with the telescope model correction (see poster by Hopwood et al.)
- Particularly ugly looking for faint sources e.g.:

Very faint science
target from OD
1130 (continuum
50-500 mJy)



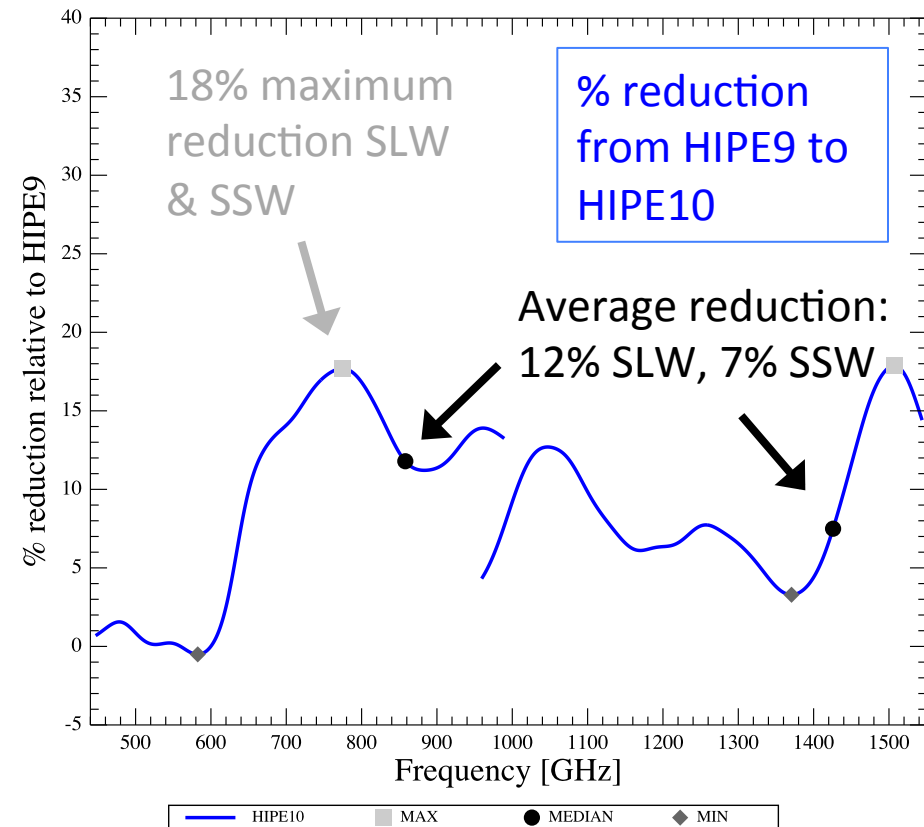
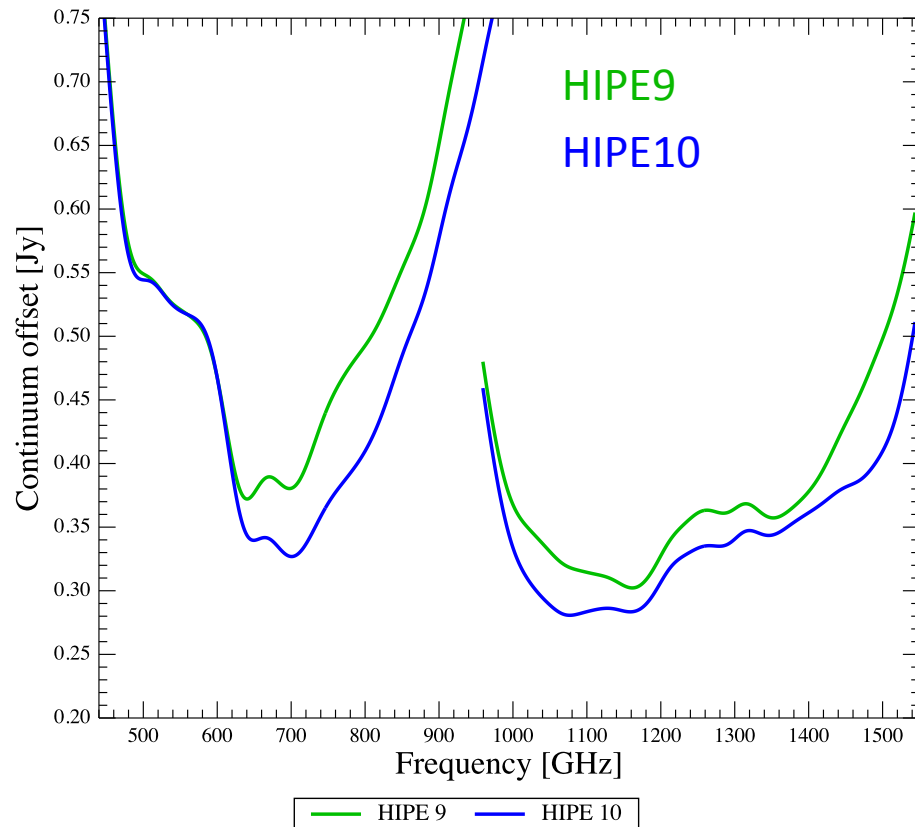
HIPE10 without
telescope
model
correction

HIPE10 with
telescope
model
correction

SPIRE FTS Calibration Update: Continuum offset

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Used to assess the additive error on continuum flux density



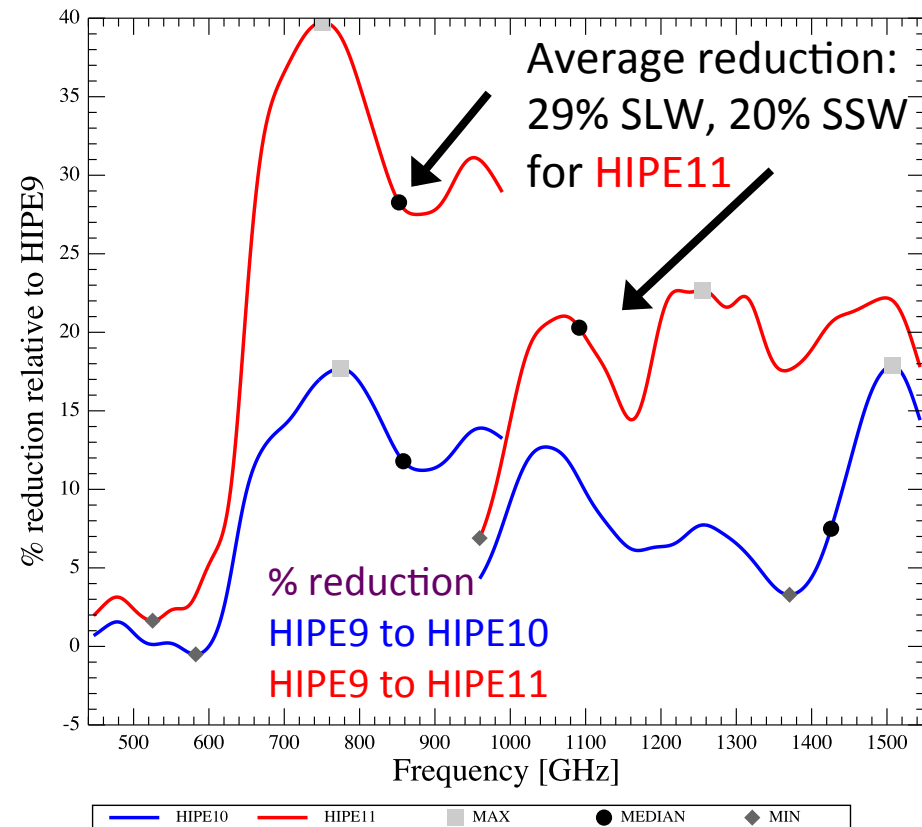
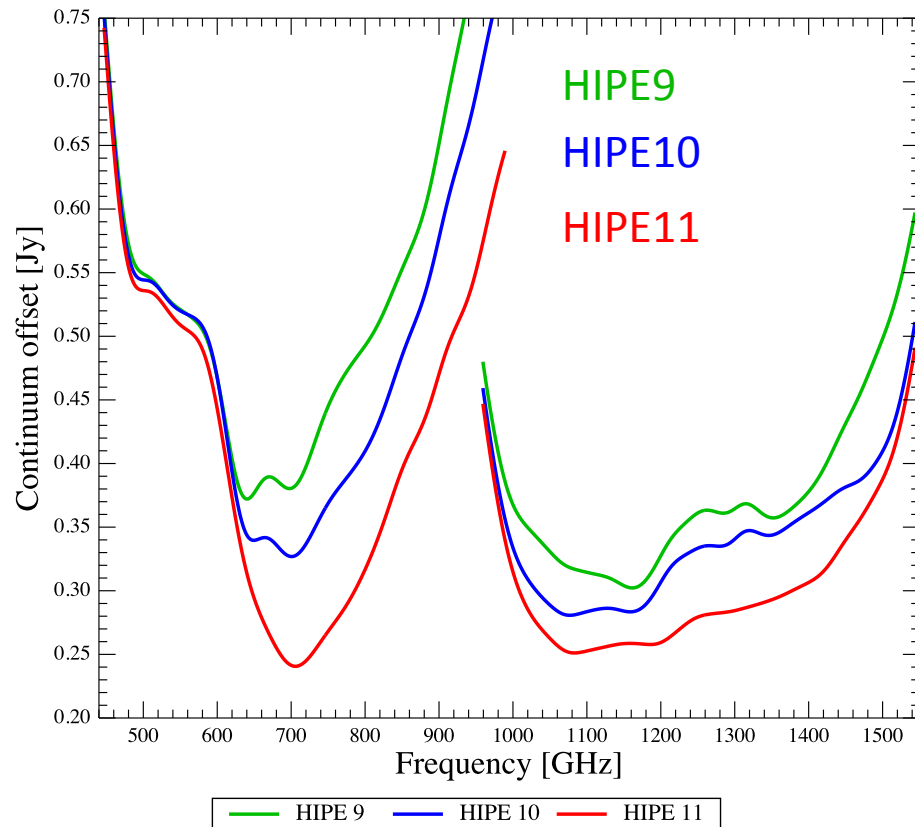
HIPE10 sensitivity reduces the offset > 600GHz

SPIRE FTS Calibration Update: Continuum offset

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Used to assess the additive error on continuum flux density

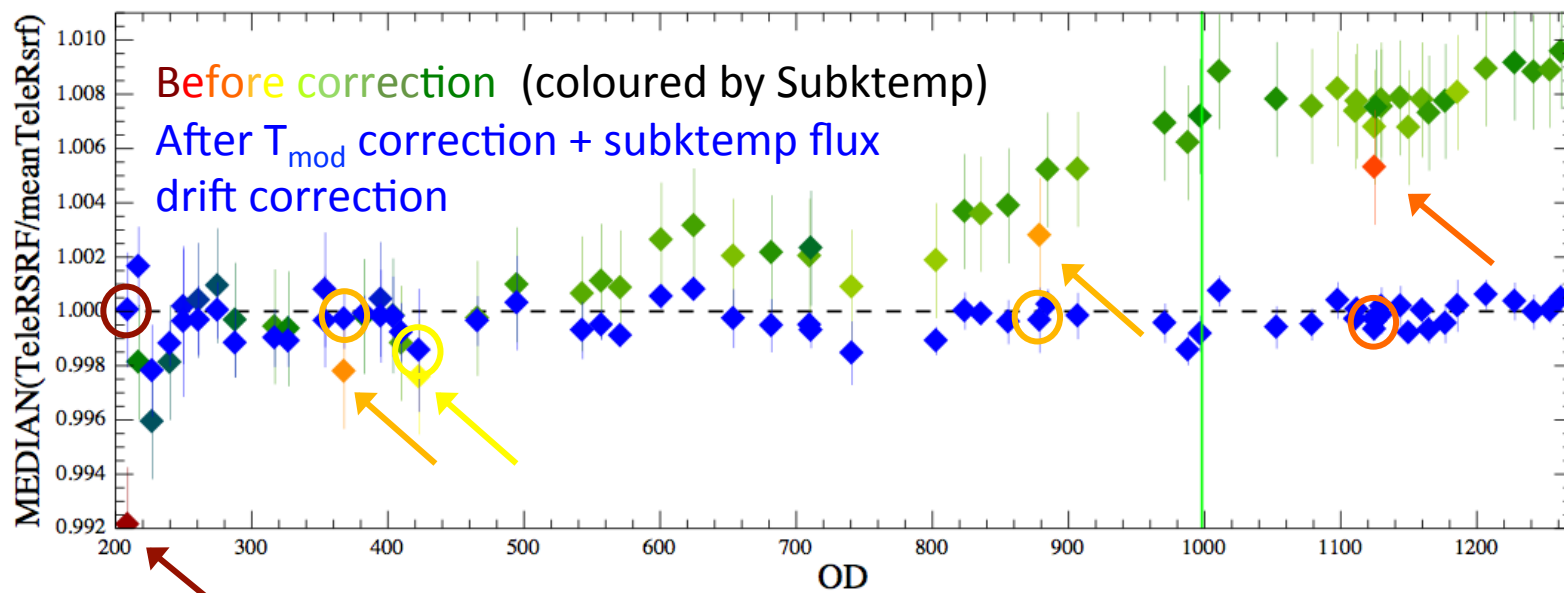
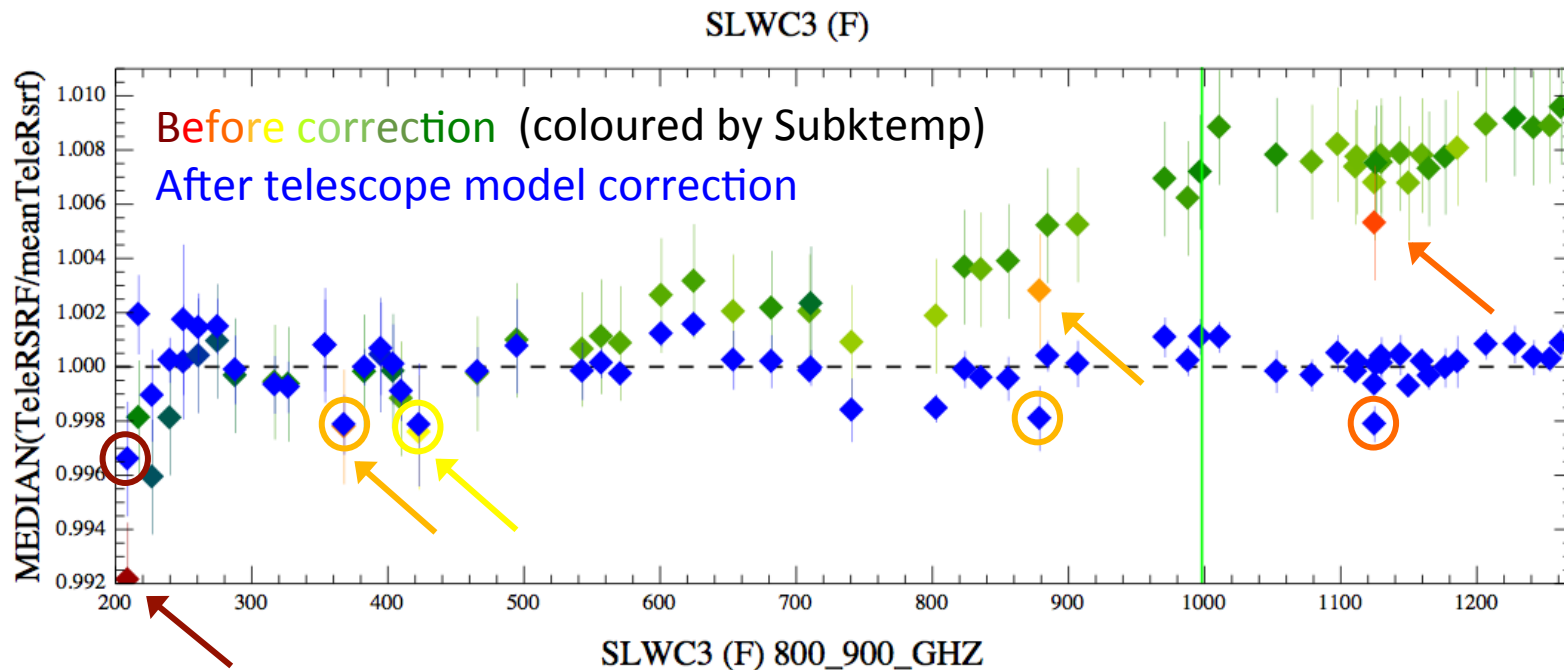
40% maximum
reduction SSW
for HIPE11



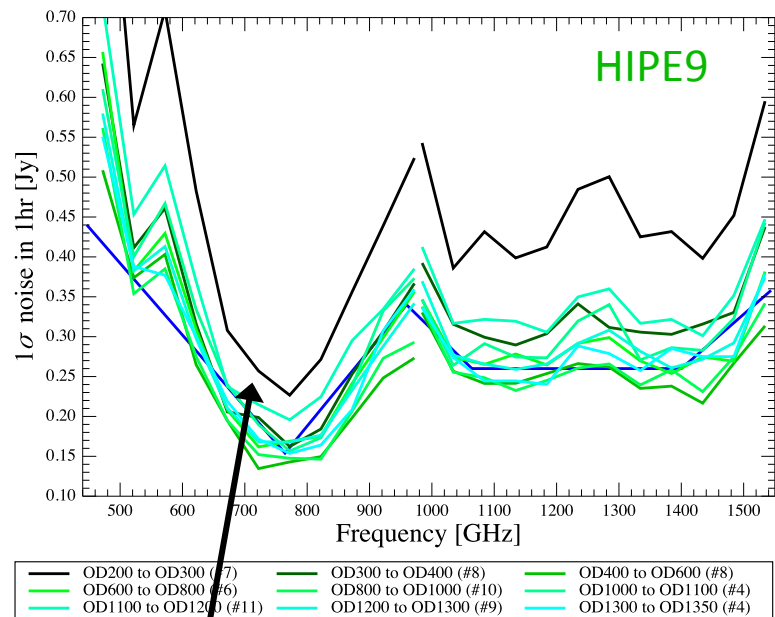
HIPE11 sensitivity reduces even further the offset

SPIRE FTS Calibration Update: Future work

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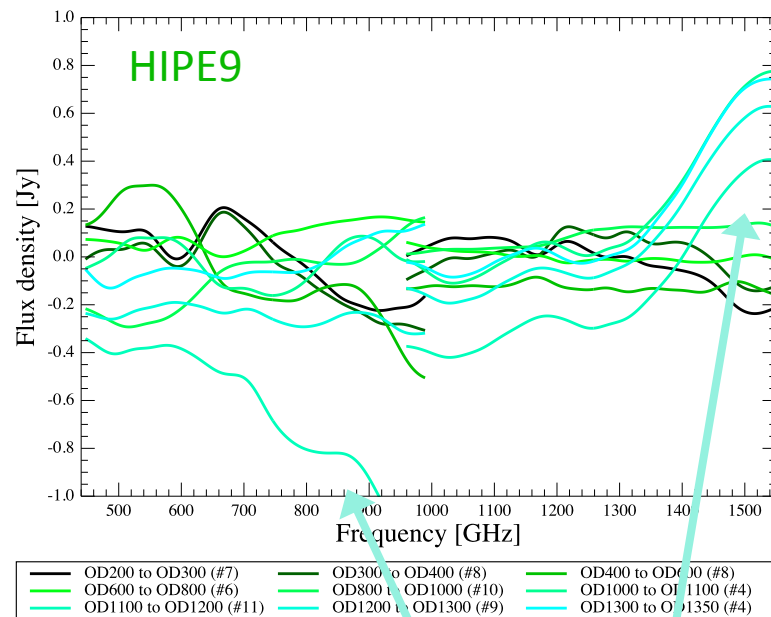


Noise



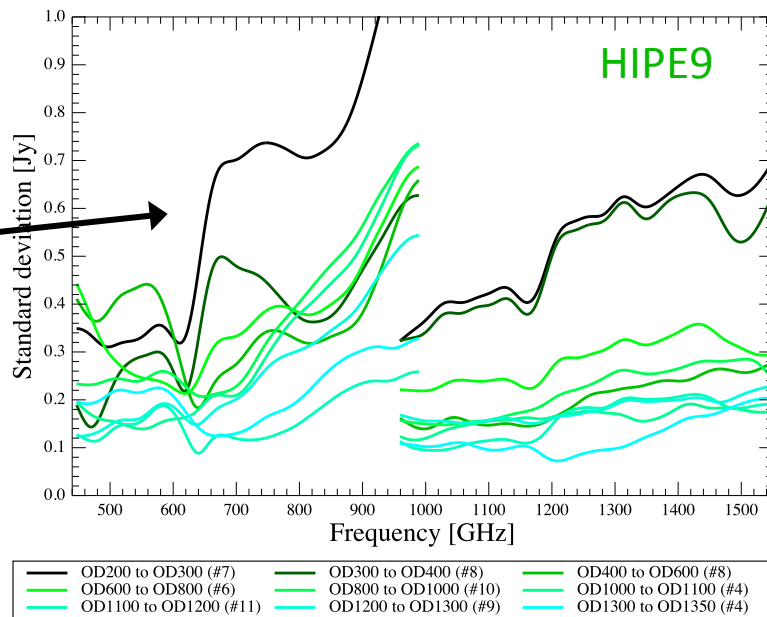
Early ODs are noisy with a large spread

Shape

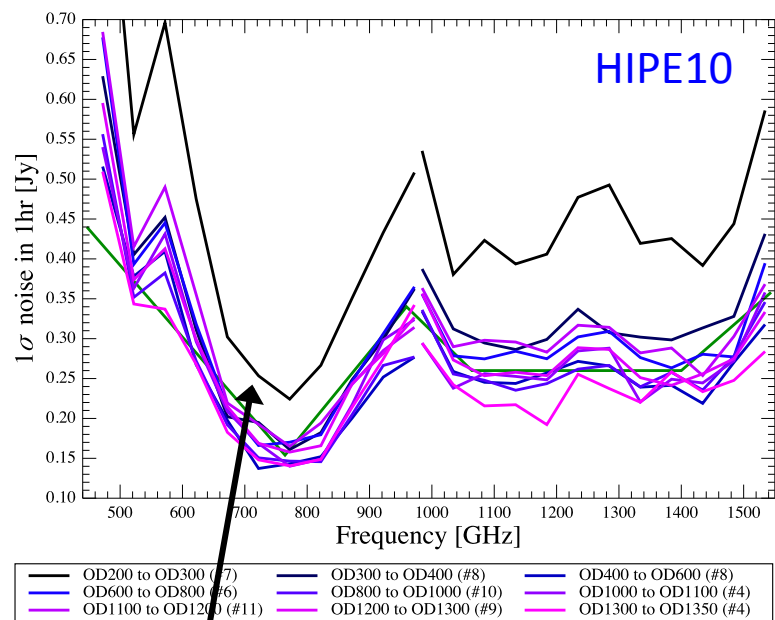


Poor shape for 'after' observations (> OD998) due to BSM correction

Spread

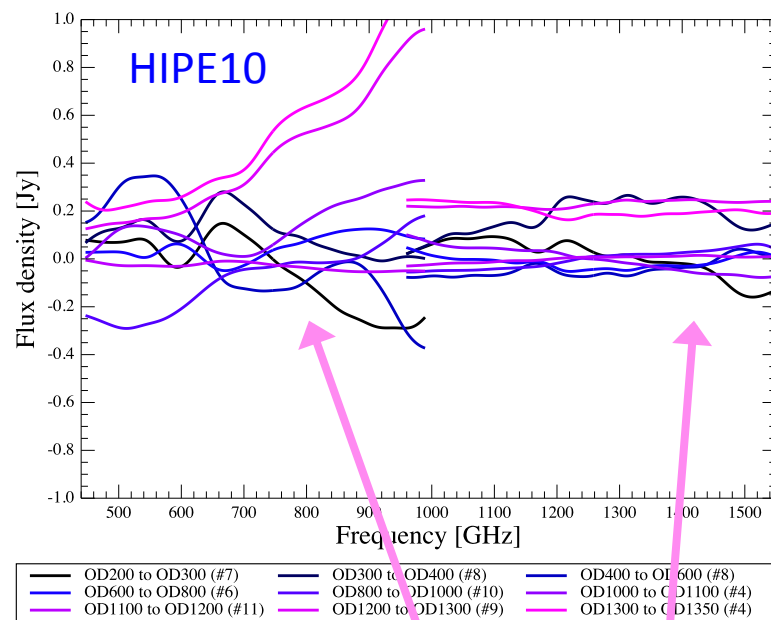


Noise

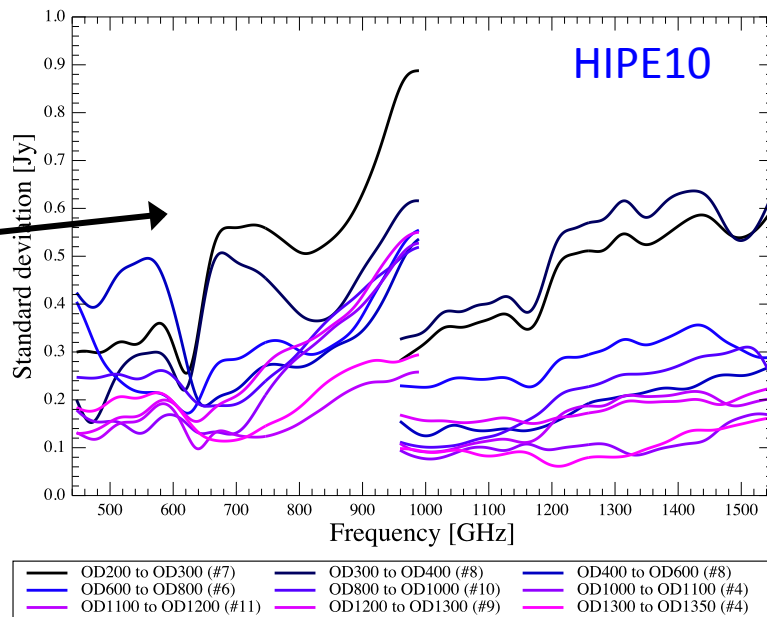


Early ODs still
noisy with a
large spread

Shape



Spread

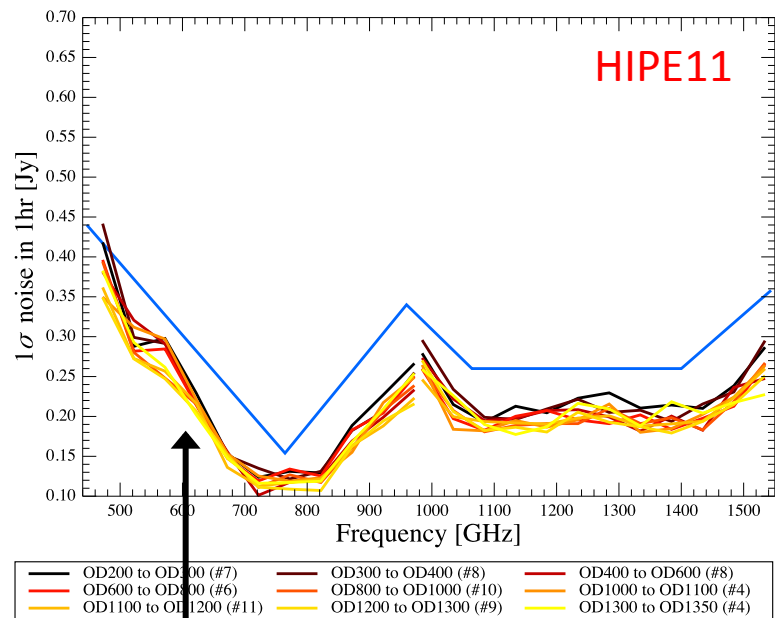


Poor shape for
'after' observations
(> OD998) well
corrected in SSW
(and up to 1200 for
SLW)

SPIRE FTS Calibration Update: Stats in OD bins

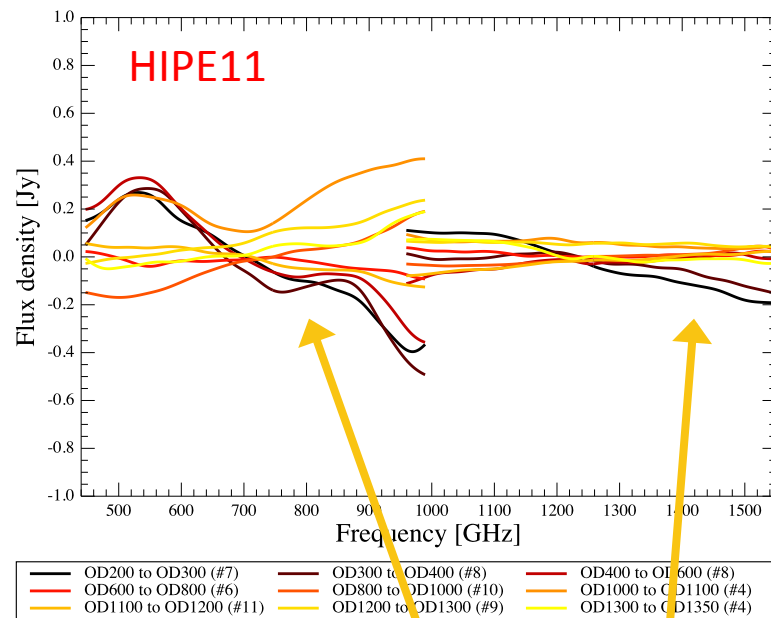
15

Noise



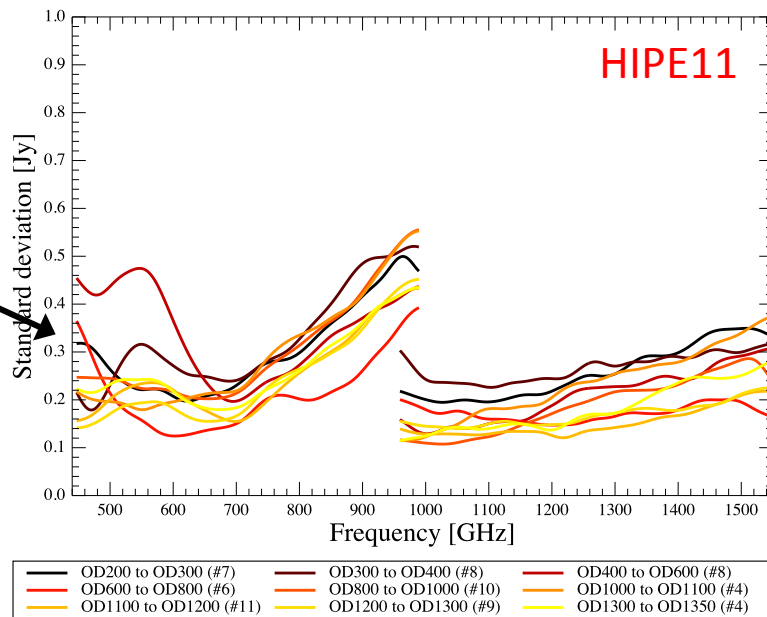
Noise and shape
is fixed for Early
Ods

Shape



Poor shape is
corrected over all
OD bins

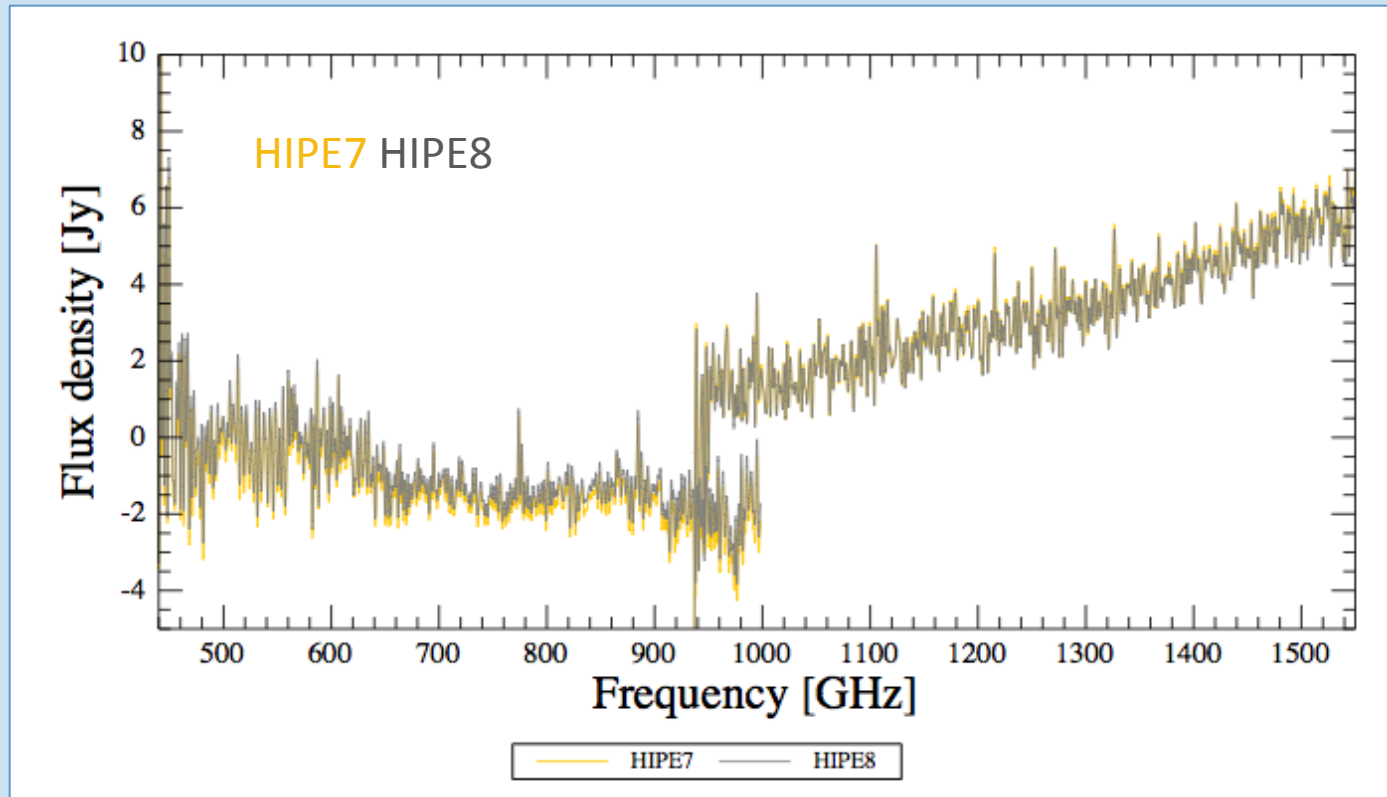
Spread



SPIRE FTS Calibration Update: Improvements for science

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Mrk 231 OD209: a 'bad day', awful shape, horrible noise

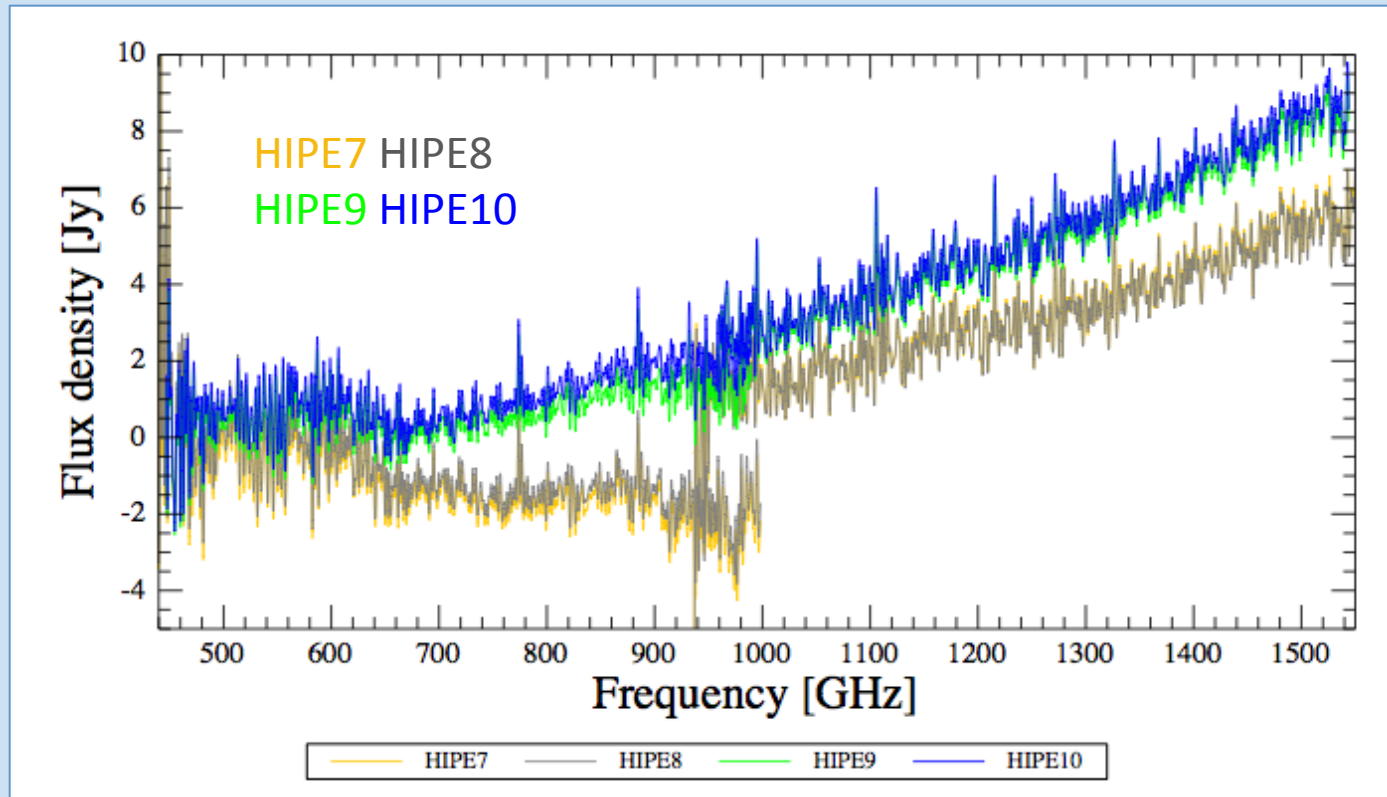


Standard SPG level-2 output

SPIRE FTS Calibration Update: Improvements for science

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Mrk 231 OD209: a 'bad day', ~~awful shape~~, horrible noise

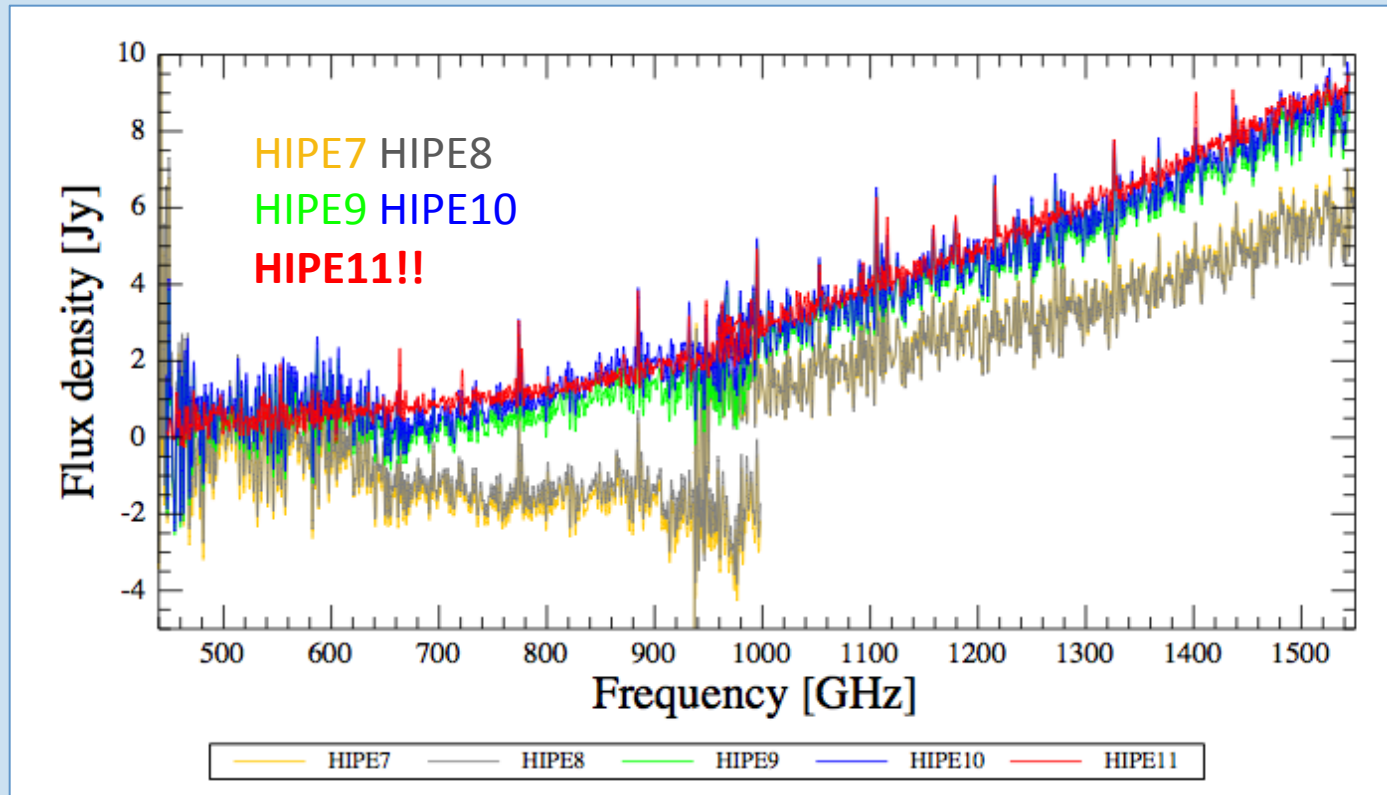


Standard SPG level-2 output

SPIRE FTS Calibration Update: Improvements for science

a 'good day'!

Mrk 231 OD209: ^va 'bad day', awful shape, horrible noise



Standard SPG level-2 output

HIPE7 HIPE8
HIPE9 HIPE10
HIPE11

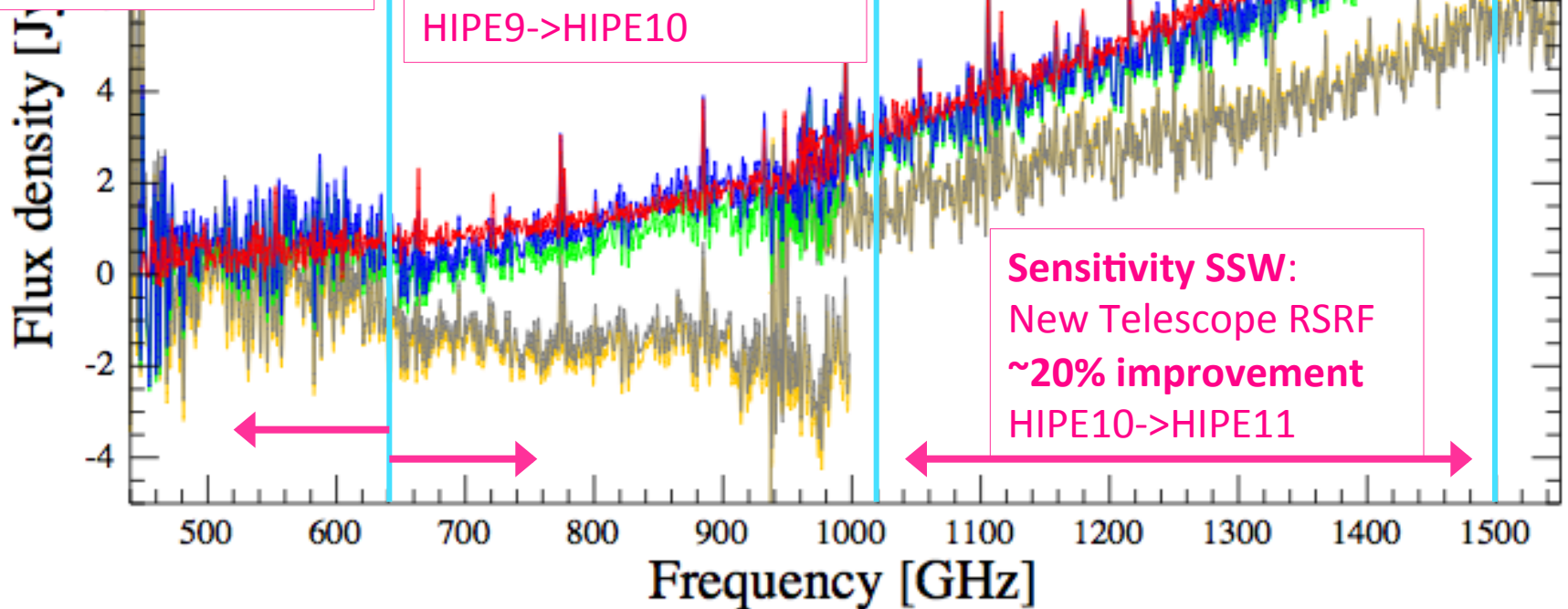
SPIRE FTS Calibration Update: Improvements for science

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Mrk 231 OD209 (50 reps)

Sensitivity < 600 GHz:
New instrument RSRF
~25% improvement
HIPE10->HIPE11

SLW offset > 600 GHz:
Telescope model corr.
Up to 40%
improvement
HIPE9->HIPE10



Sensitivity SSW:
New Telescope RSRF
~20% improvement
HIPE10->HIPE11

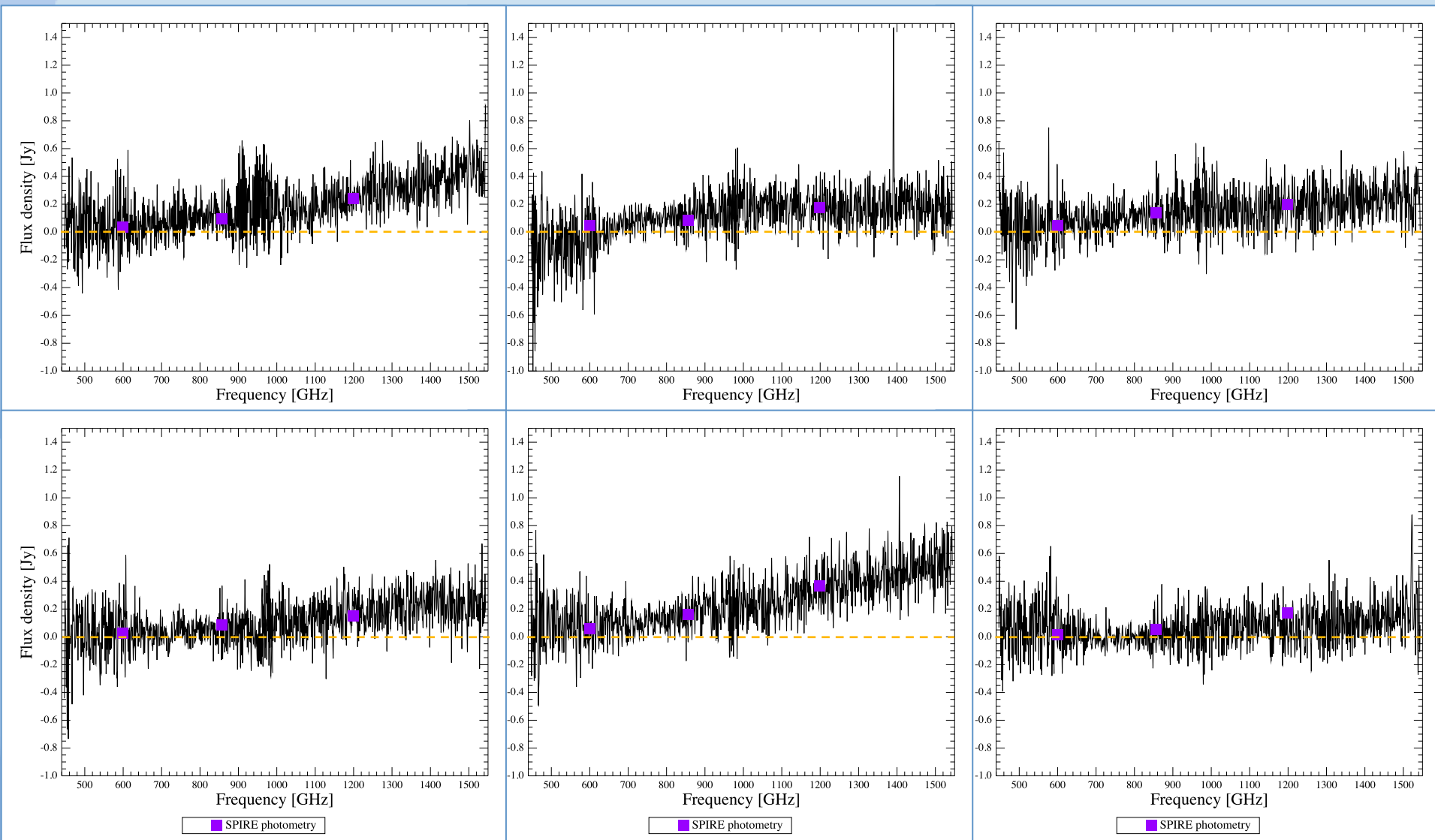
— HIPE7 — HIPE8 — HIPE9 — HIPE10 — HIPE11

SPIRE FTS Calibration Update: Photometer comparison

< 100 mJy 500 μm

< 200 mJy 350 μm

< 300 mJy 250 μm

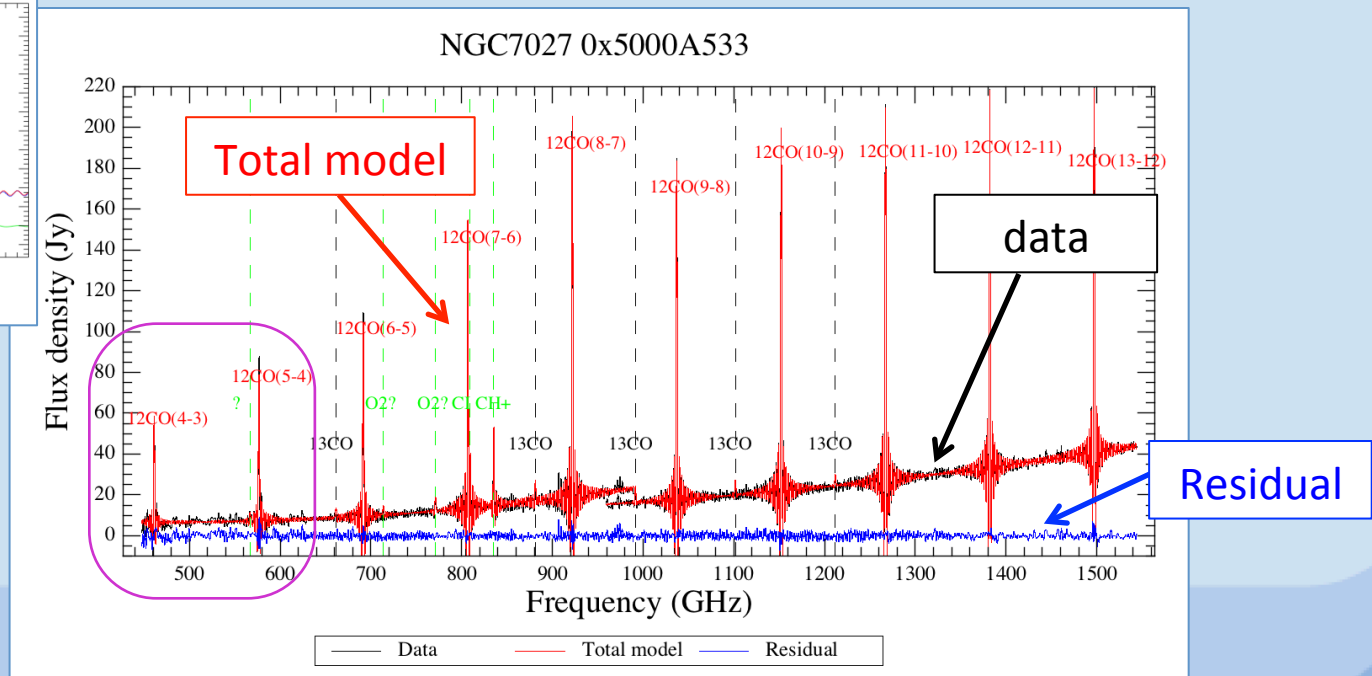
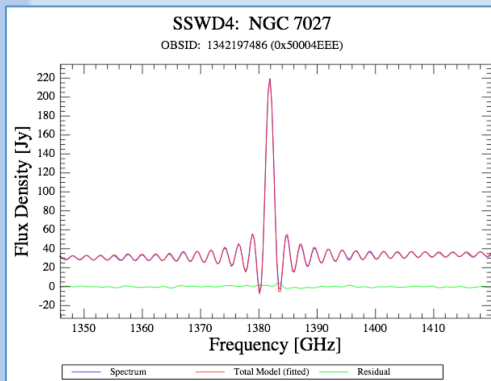


SPIRE FTS Calibration Update: Repeatability

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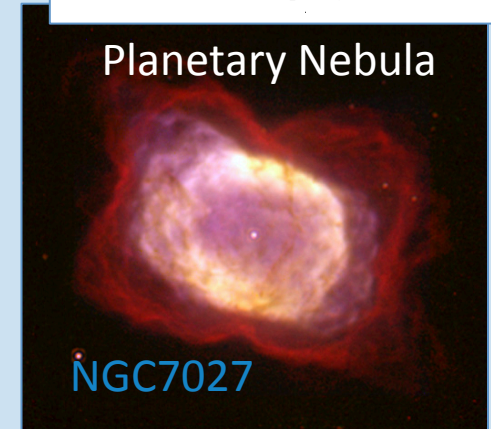
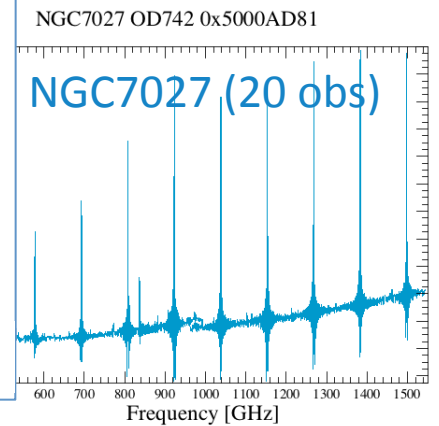
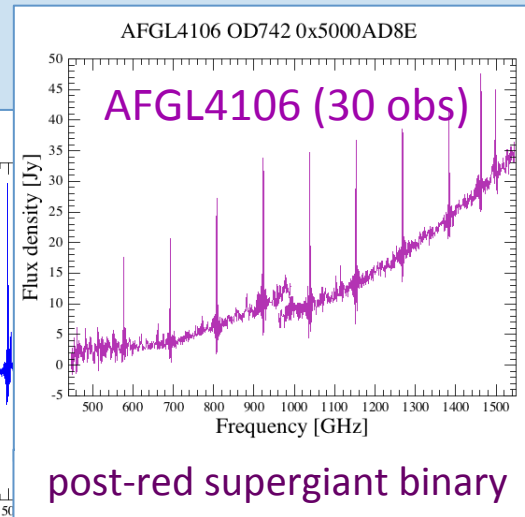
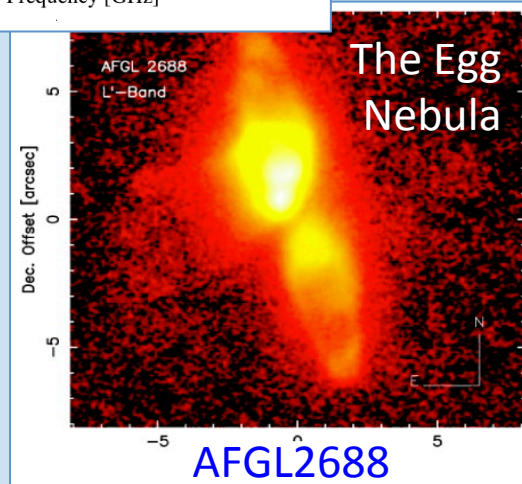
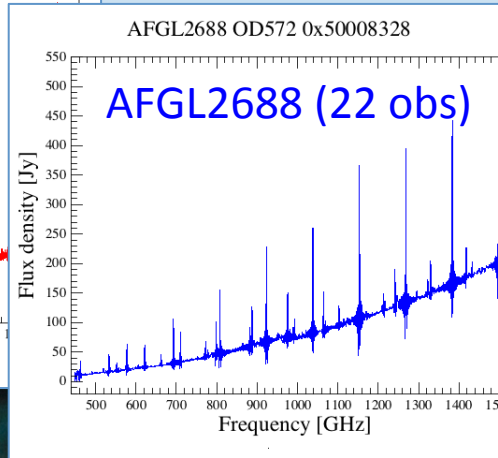
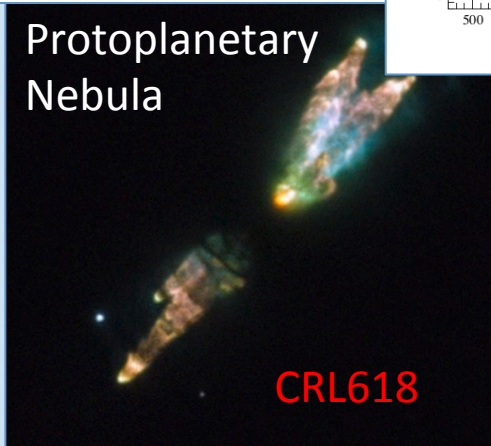
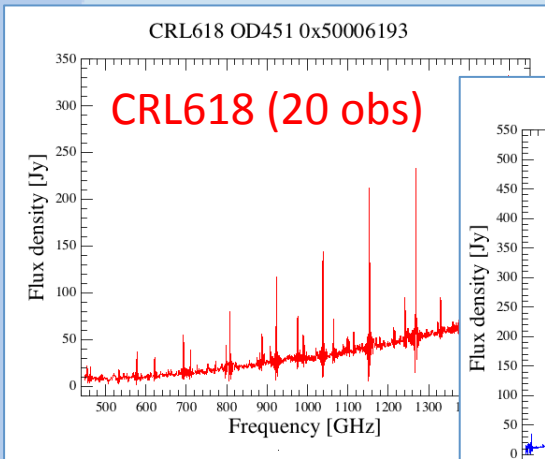
METRIC:

- Used to assess consistency across the mission for repeated observations
- Line sources
- Measurements taken: line flux, line velocity
- Lines and continuum fitted simultaneously in HIPE
- e.g. **NGC7027**



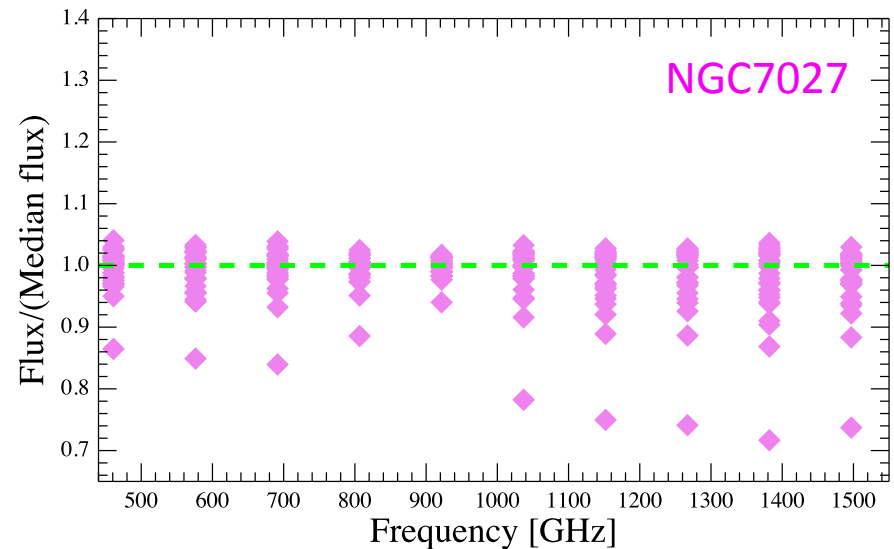
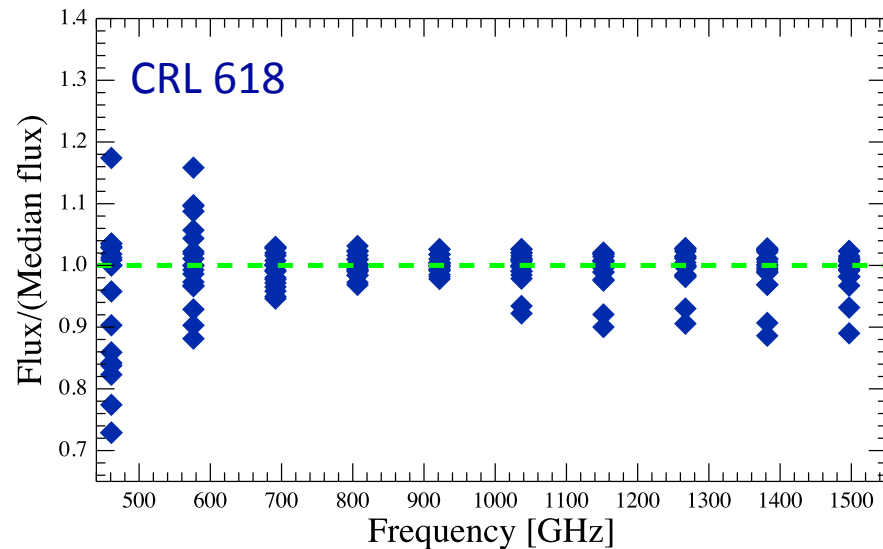
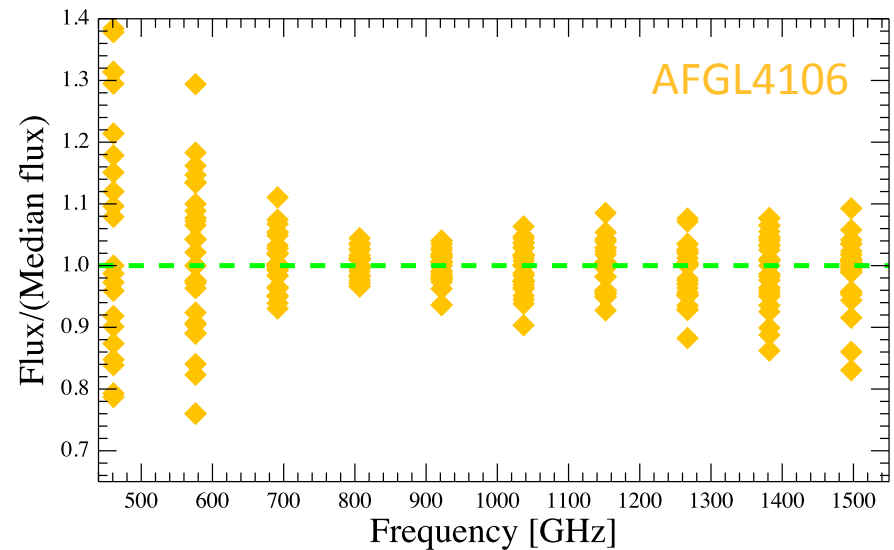
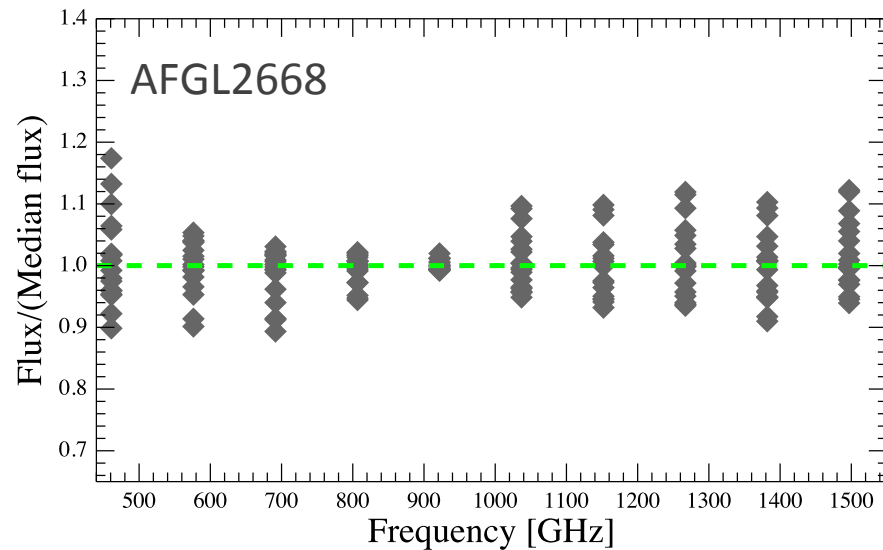
SPIRE FTS Calibration Update: Line sources

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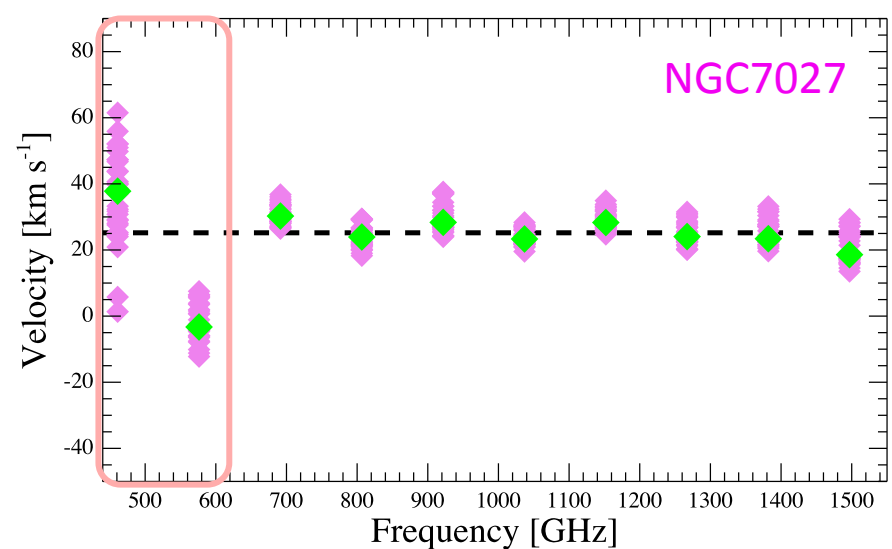
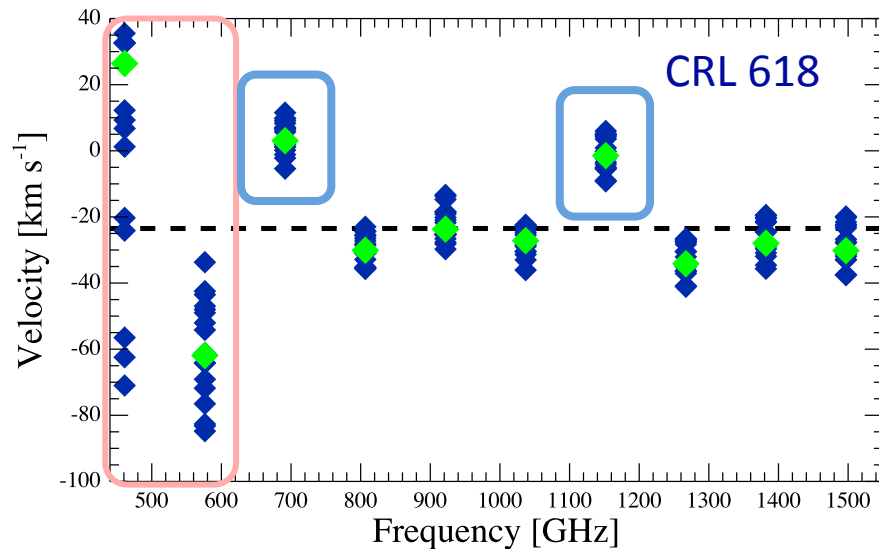
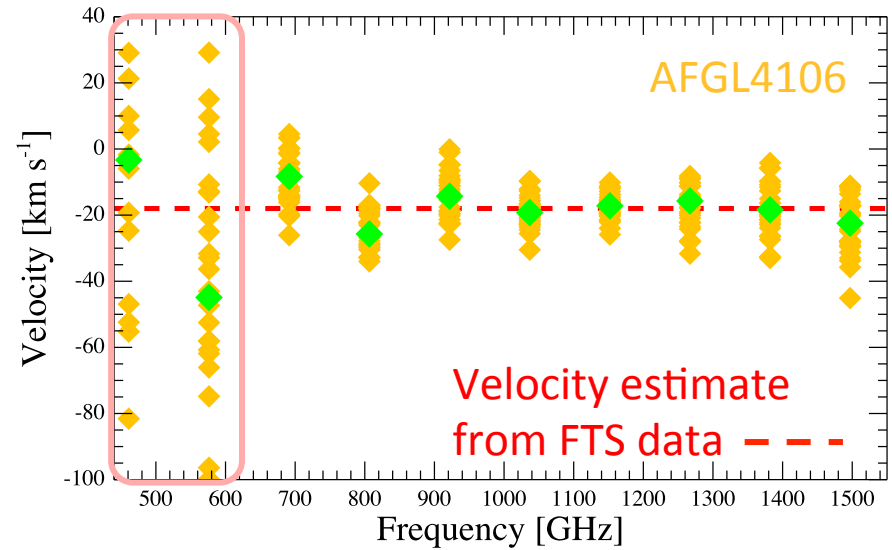
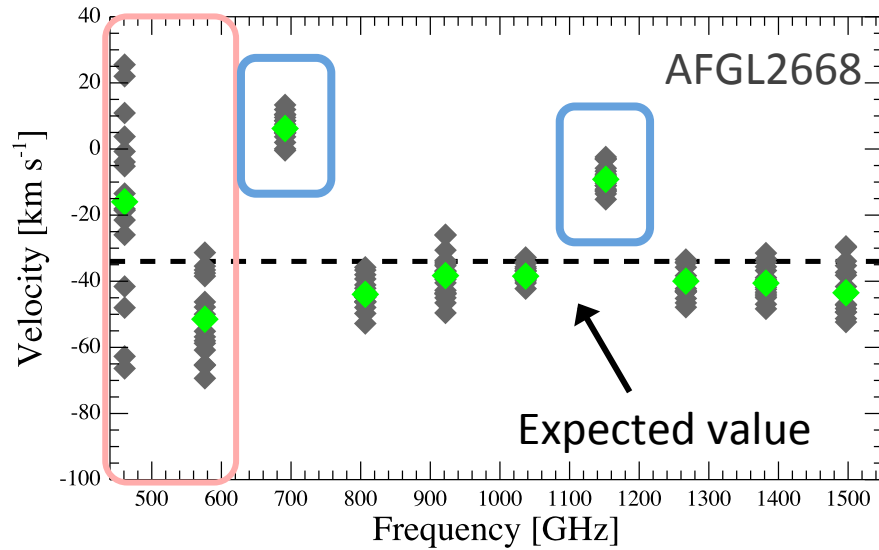
SPIRE FTS Calibration Update: (Line flux)/(Average line flux)

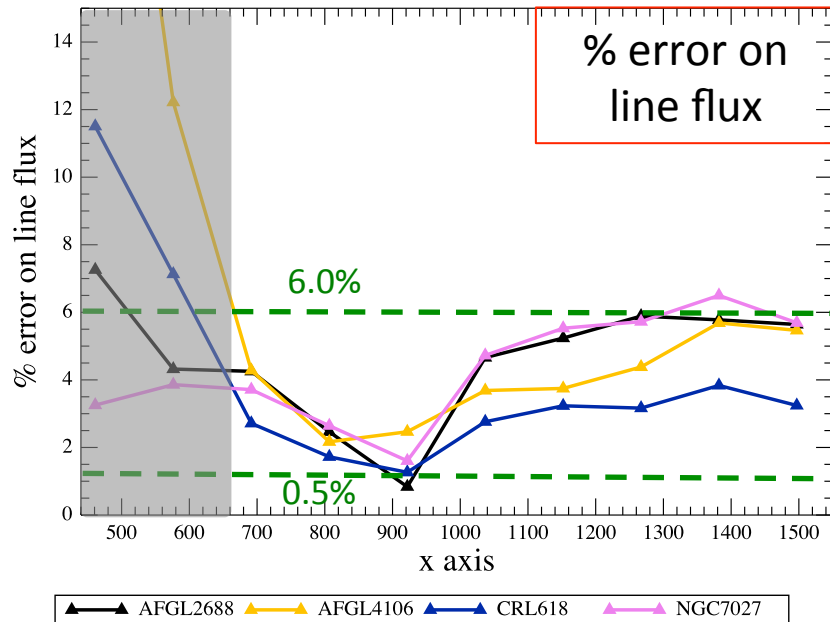
23



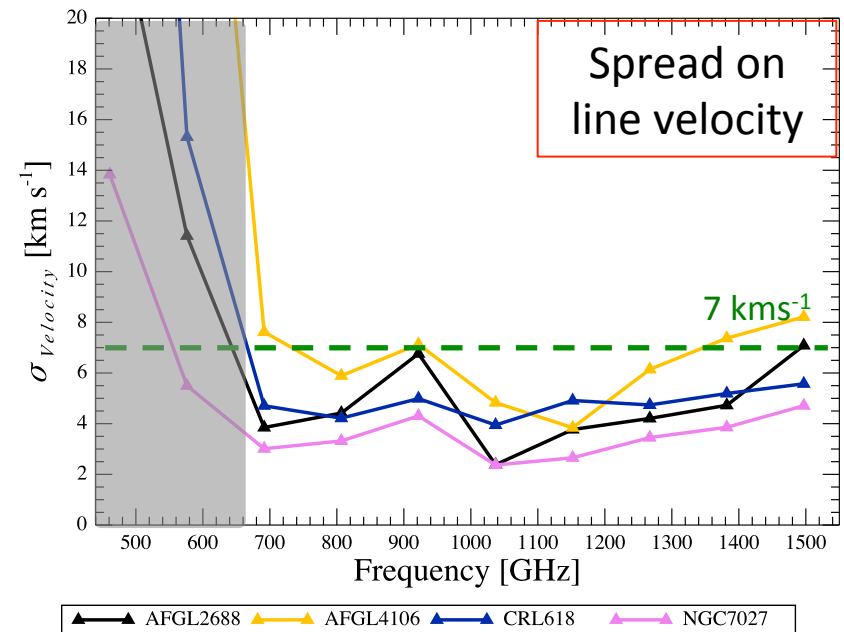
SPIRE FTS Calibration Update: Line velocity

◆ Mean
velocity





Error on line flux 0.5-6.0%



Spread on line velocity < 7 km s^{-1}

SPIRE FTS Calibration Update:

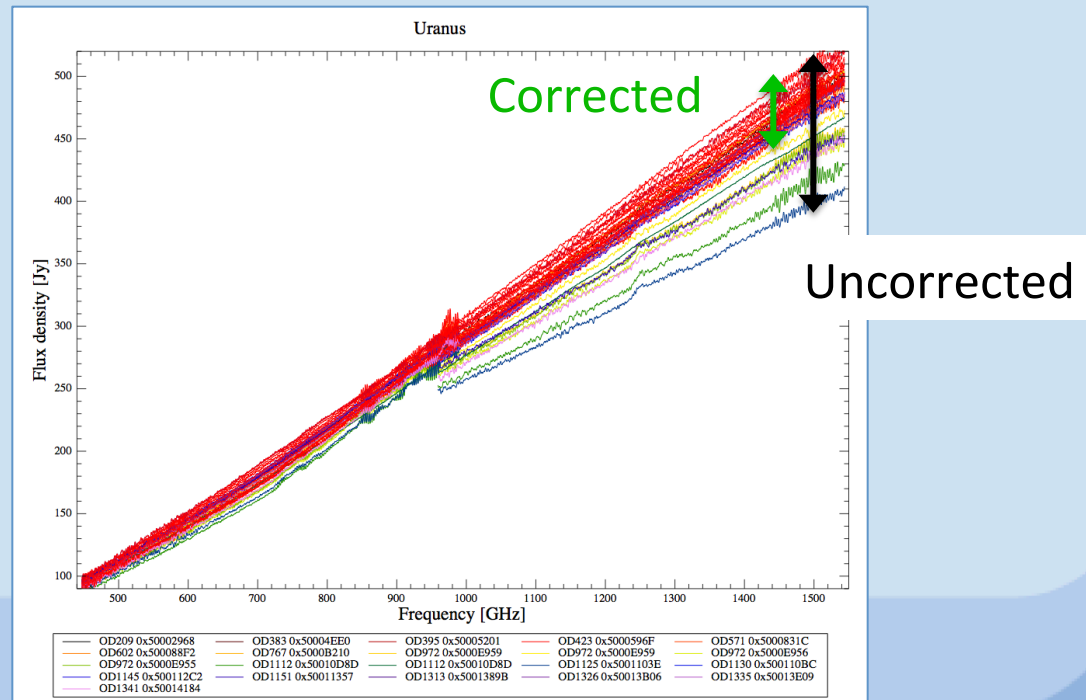
Absolute flux

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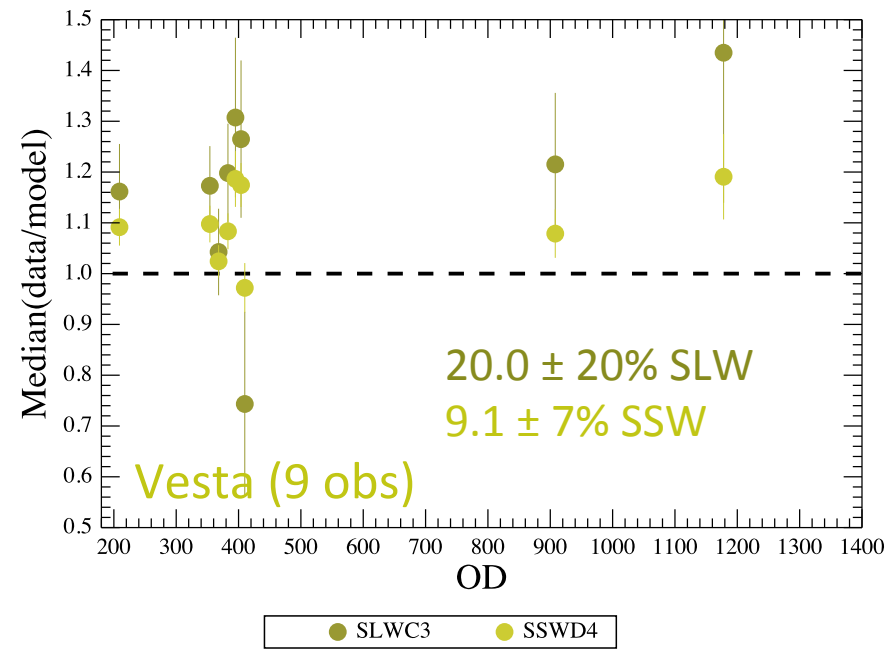
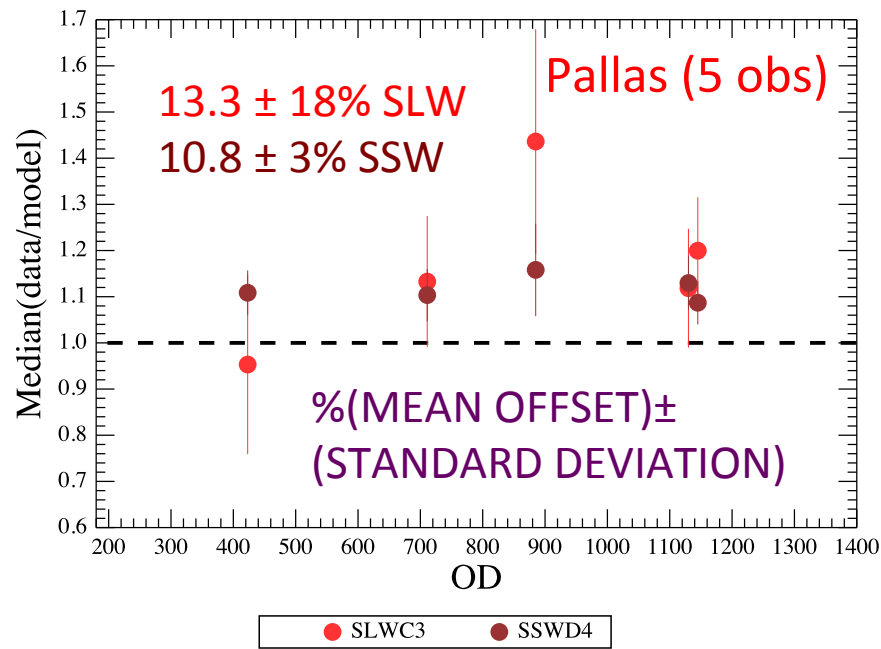
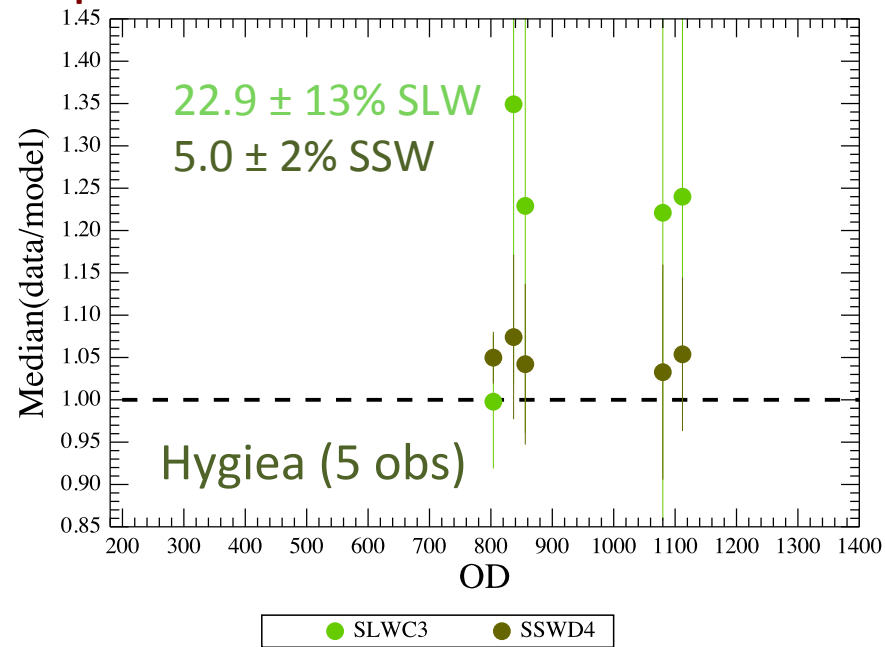
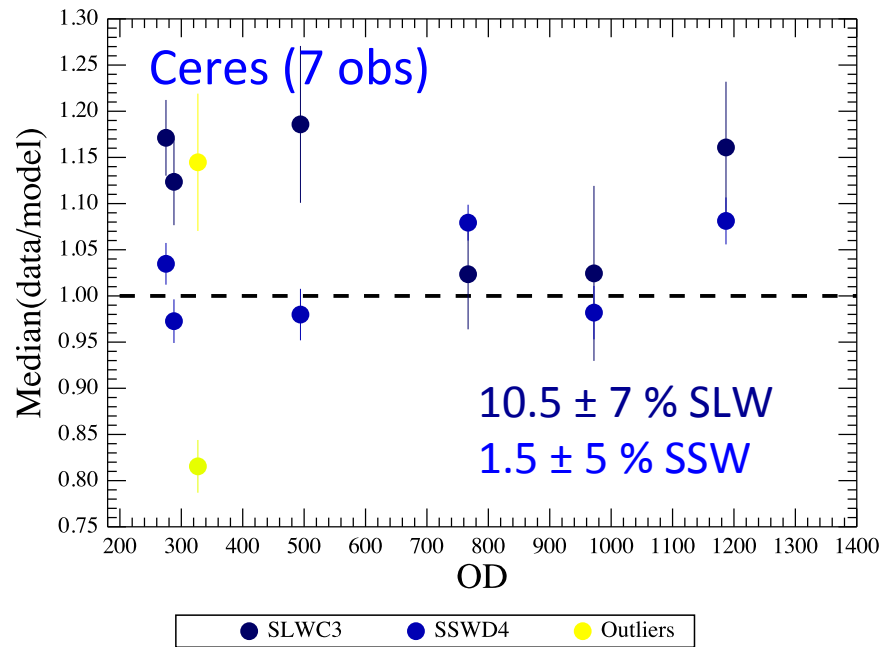
METRIC:

- Used to assess point source flux calibration
- Planets and asteroids with associated models available
- Measurements taken: ratio of data to model
- Currently a single observation of Uranus is used for point source calibration but future versions may incorporate more after pointing correction (see poster by Valtchanov et al.)
- e.g. pointing correction of **Uranus** observations

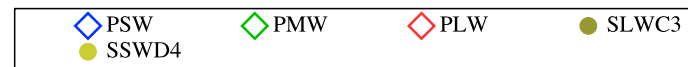
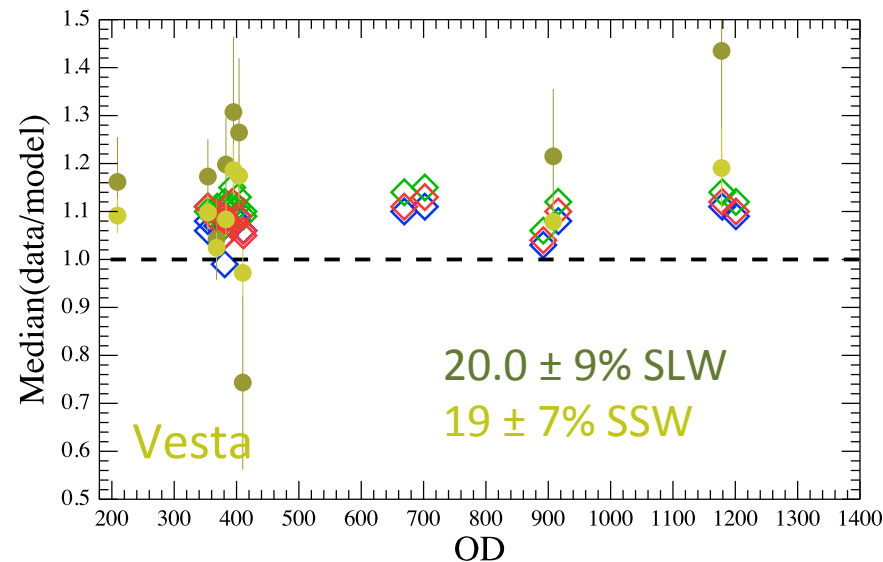
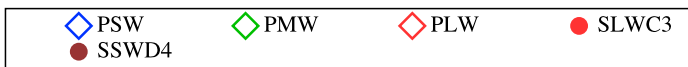
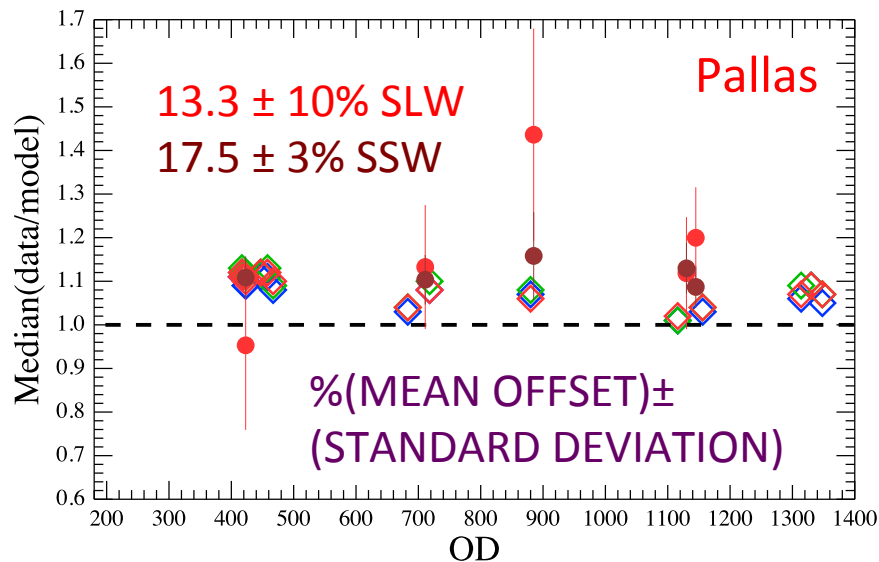
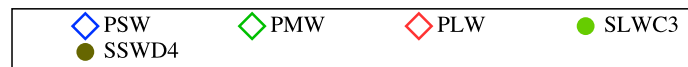
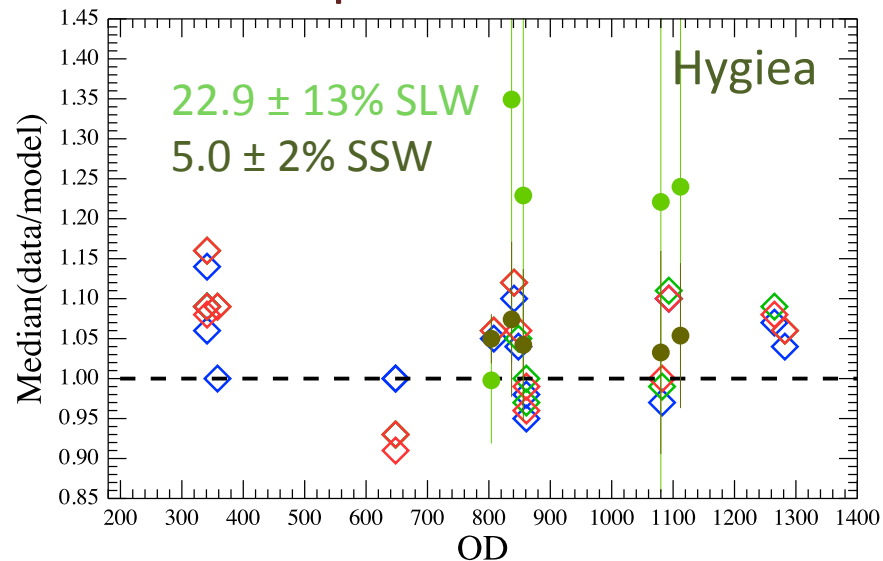
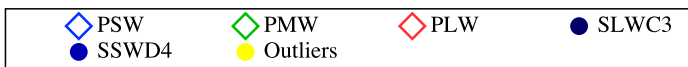
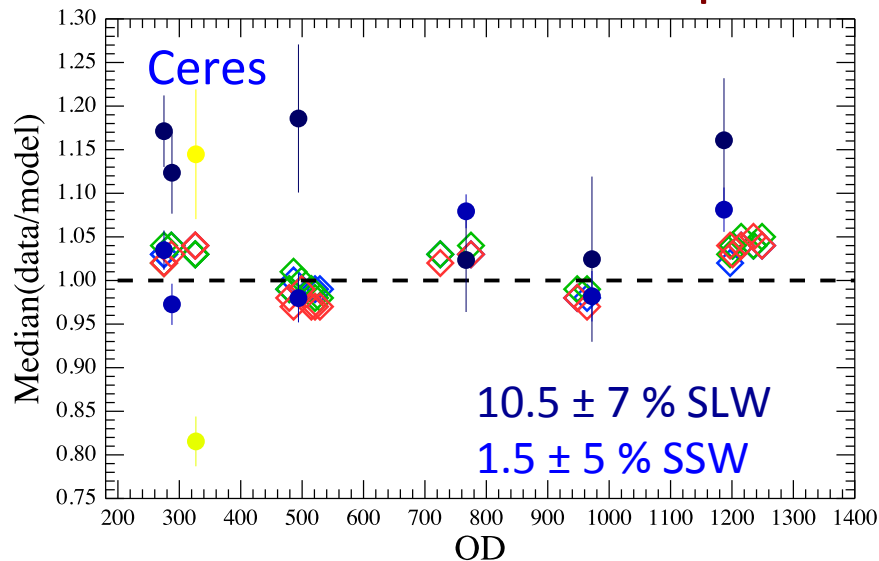
Models used:
Uranus - ESA4
Neptune - ESA3
Asteroids - Thomas Muller



SPIRE FTS Calibration Update: Asteroids



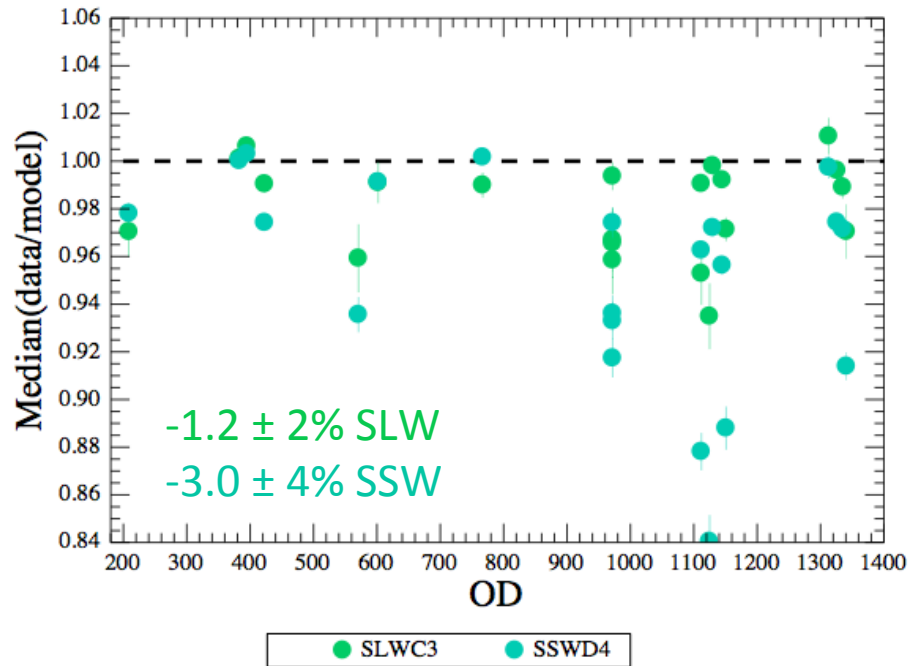
SPIRE FTS Calibration Update: Asteroids with photometer ratios



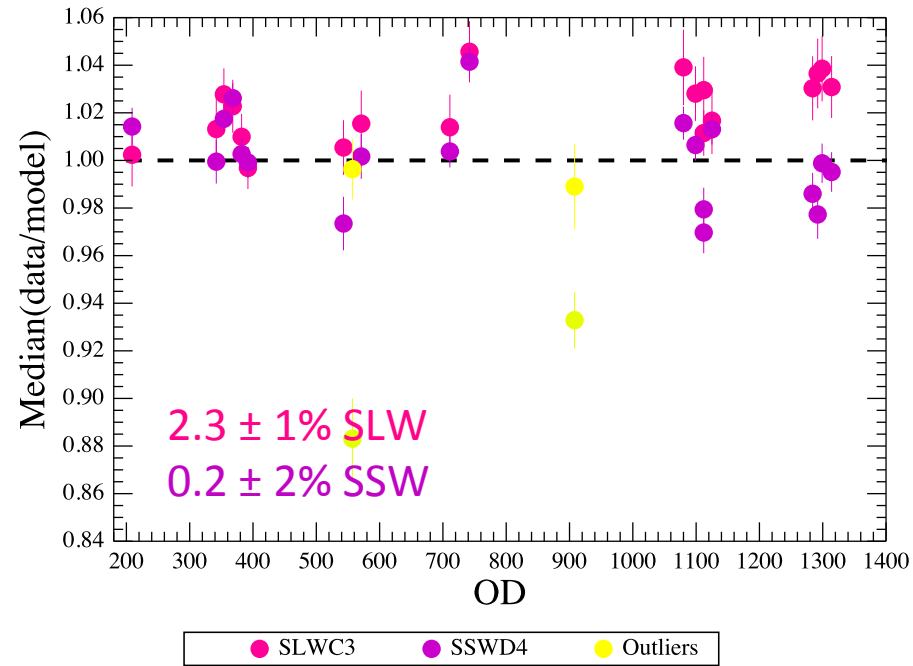
SPIRE FTS Calibration Update: Absolute flux: Planets

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Uranus

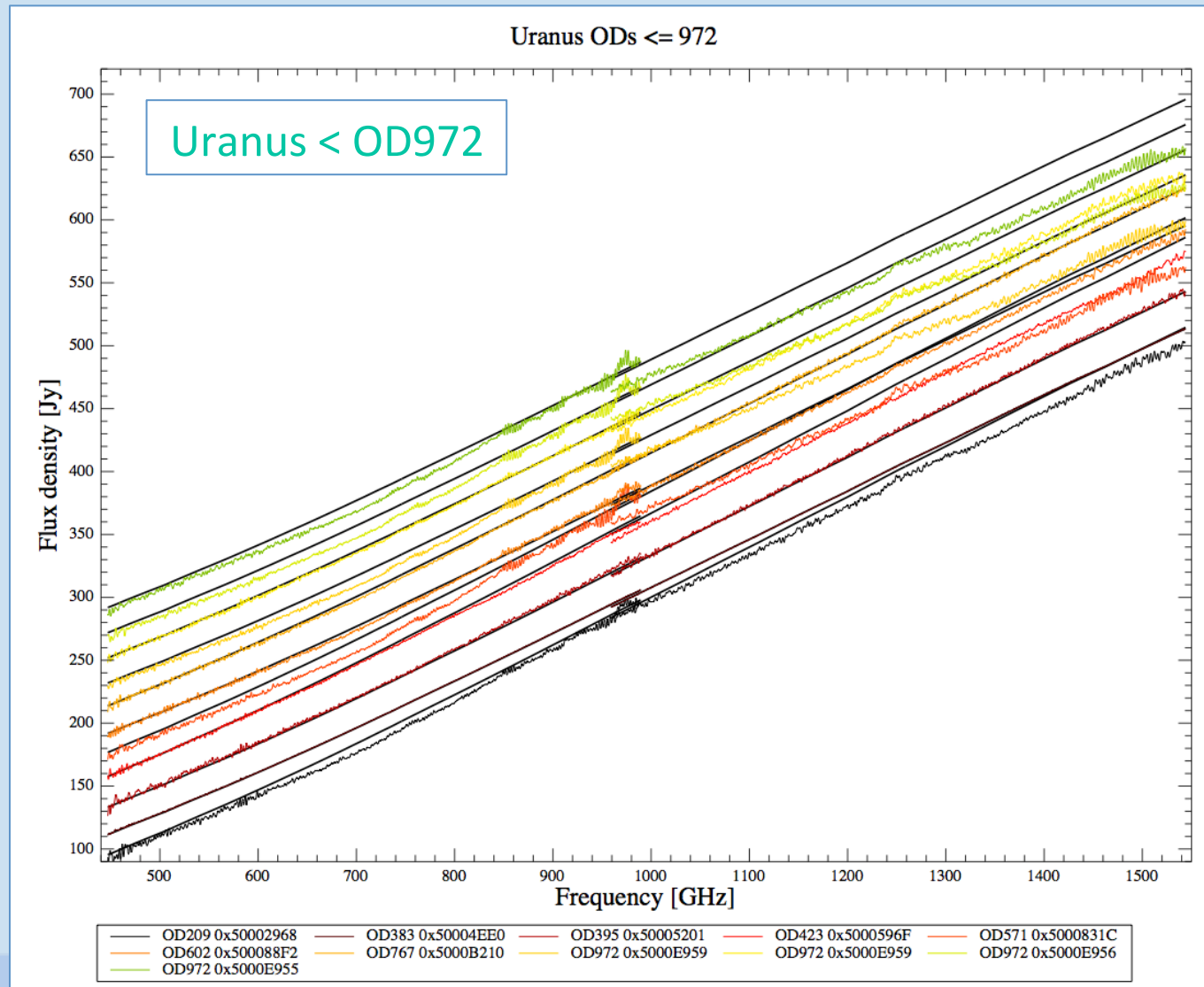


Neptune



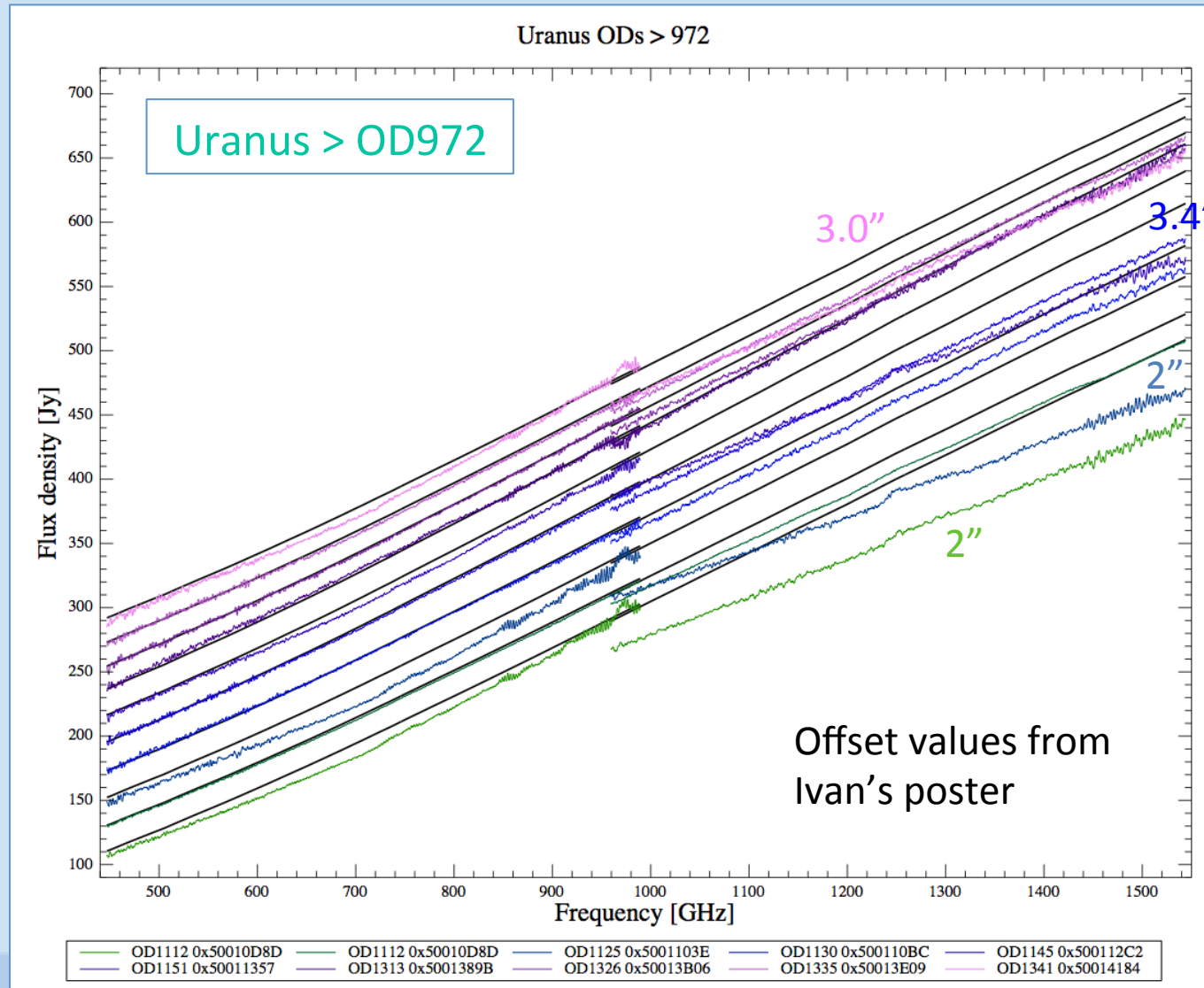
SPIRE FTS Calibration Update:

Absolute flux: Planets pointing offset



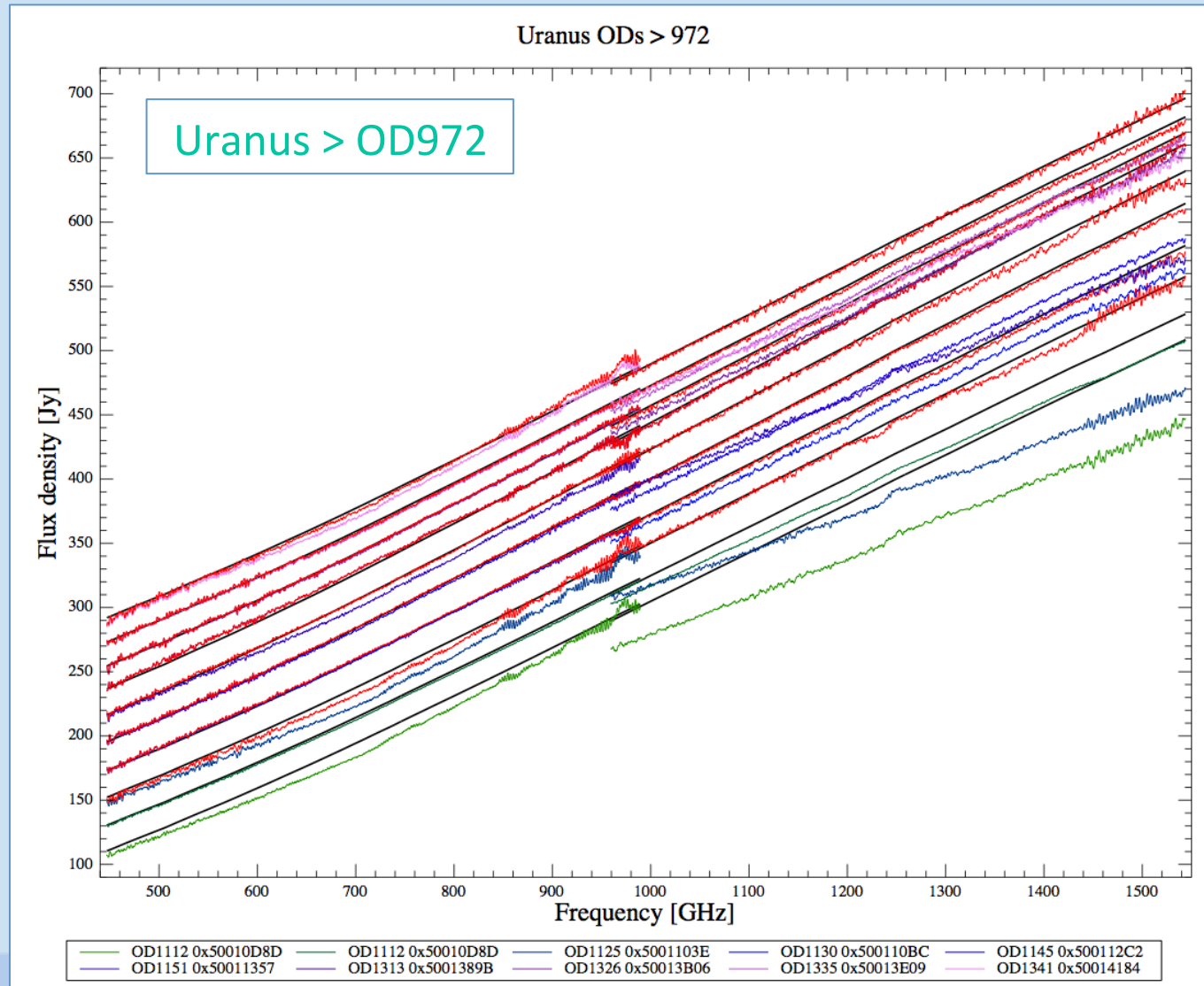
SPIRE FTS Calibration Update:

Absolute flux: Planets pointing offset



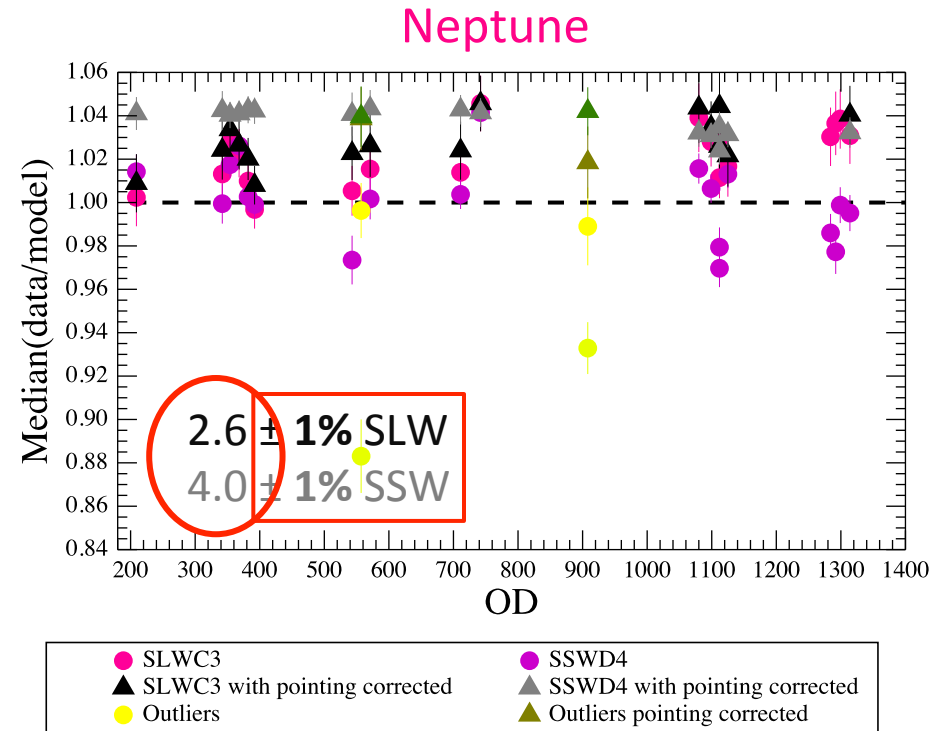
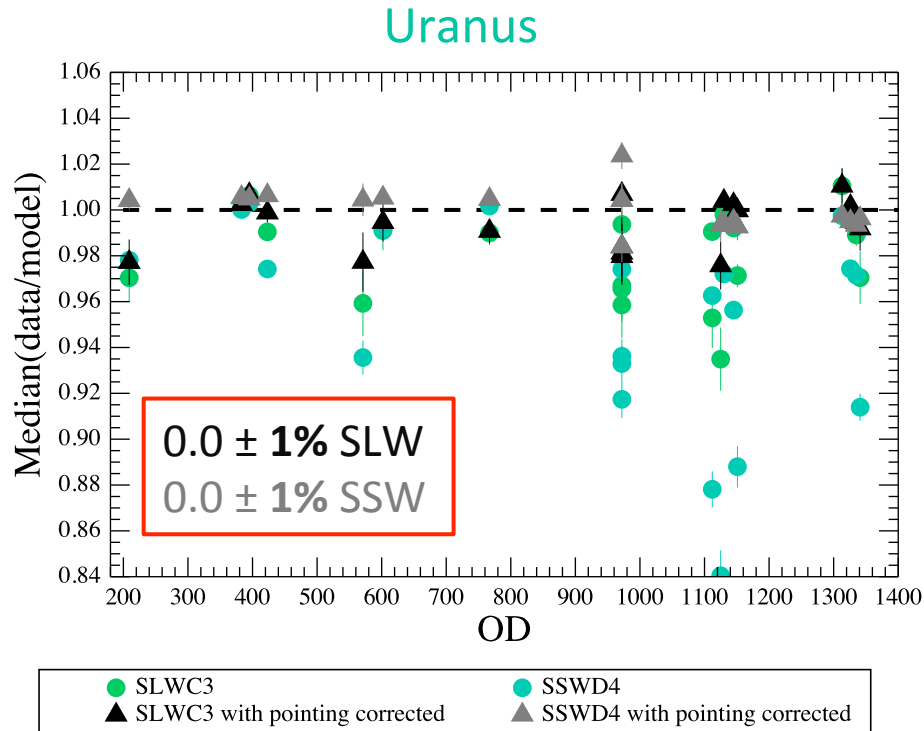
SPIRE FTS Calibration Update:

Absolute flux: Planets pointing offset



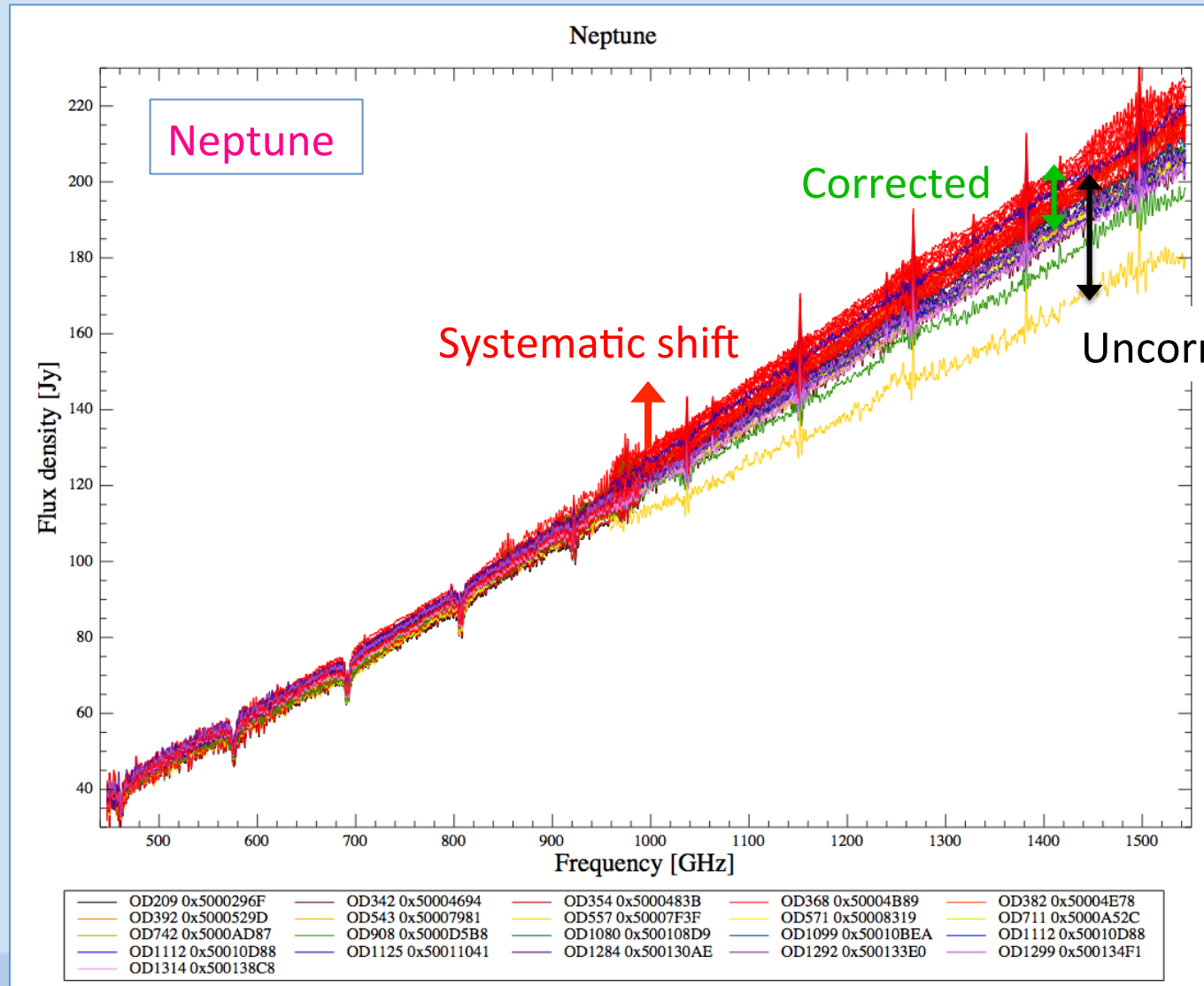
SPIRE FTS Calibration Update: Absolute flux: Planets

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SPIRE FTS Calibration Update:

Absolute flux: Planets pointing offset



SPIRE FTS Calibration Update:

Summary

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Continuum offset error improves by:

11% SLW, 8% SSW HIPE10 29% SLW, 20% SSW HIPE11

Sensitivity improves by:

1% SLW, 0.5% SSW HIPE10 23% SLW, 21% SSW HIPE11

Systematic shape, spread issues not resolved in HIPE10 are mainly resolved in HIPE11

Infamous bad days resolved

Line sources:

Error on line flux < 6.0%

Spread on line velocity < 7 kms⁻¹

Absolute flux calibration assessment is hampered by pointing offset

For observations with low pointing offset, agreement with the model is 1%

Pointing corrected data:

Uranus: $\mu = 1.0 \pm 0.01$ Neptune: $\mu = 2.3 \pm 0.01$ SLW & 1.0 ± 0.02 SSW

Future work: Fabulous new RSRFs into HIPE11

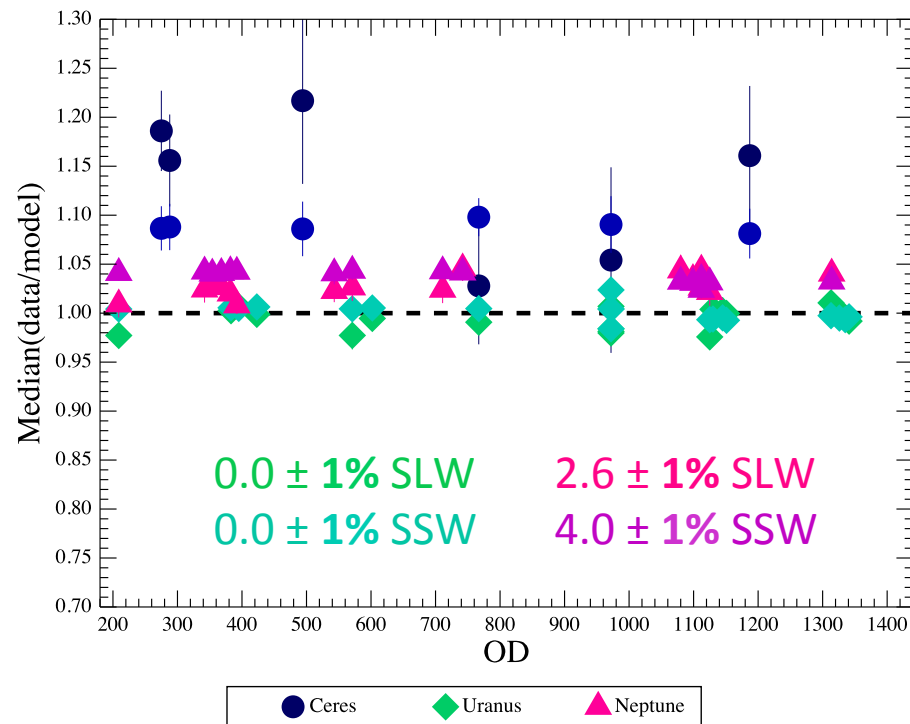
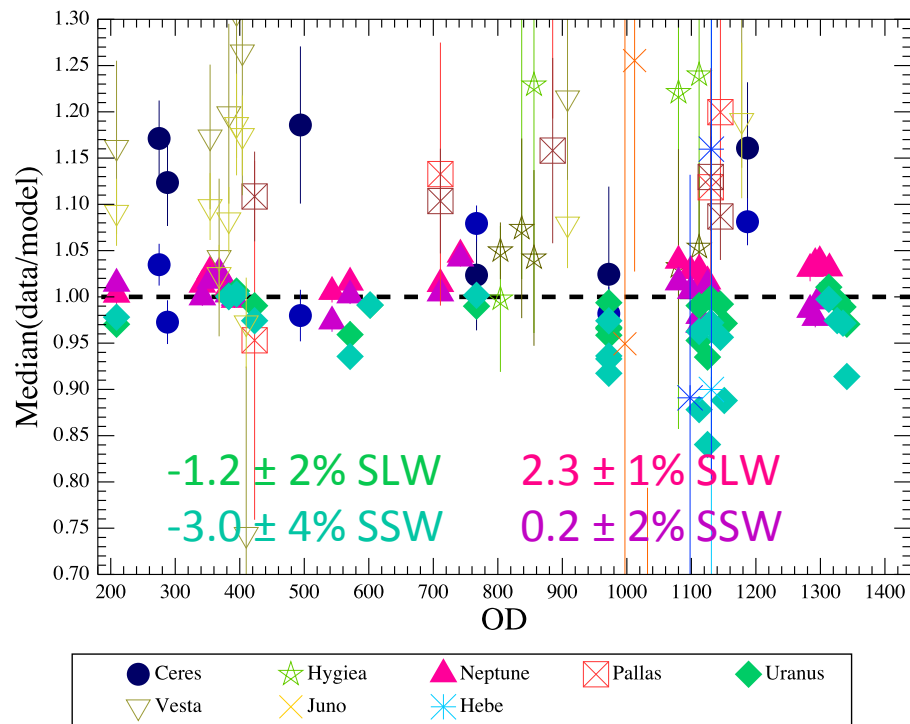
Pointing offset correction & temperature based flux correction into HIPE12

Off-axis detectors & mapping

SPIRE FTS Calibration Update:

Absolute flux: Summary

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Agreement with Uranus model
within 1%

Agreement with Neptune
model within 2%

