

Planetary Models updates

Raphaël Moreno

Observatoire de Paris-Meudon (LESIA)

- HIFI cross-calibration measurements: Uranus & Neptune
- Neptune/CO (SPIRE)
- TITAN

Planet splinter summary (Dec. 2010)

Herschel observations: cross-calibration

Comparison between HIFI/SPIRE of Neptune/Uranus at the same period (Oct-Dec 2011).

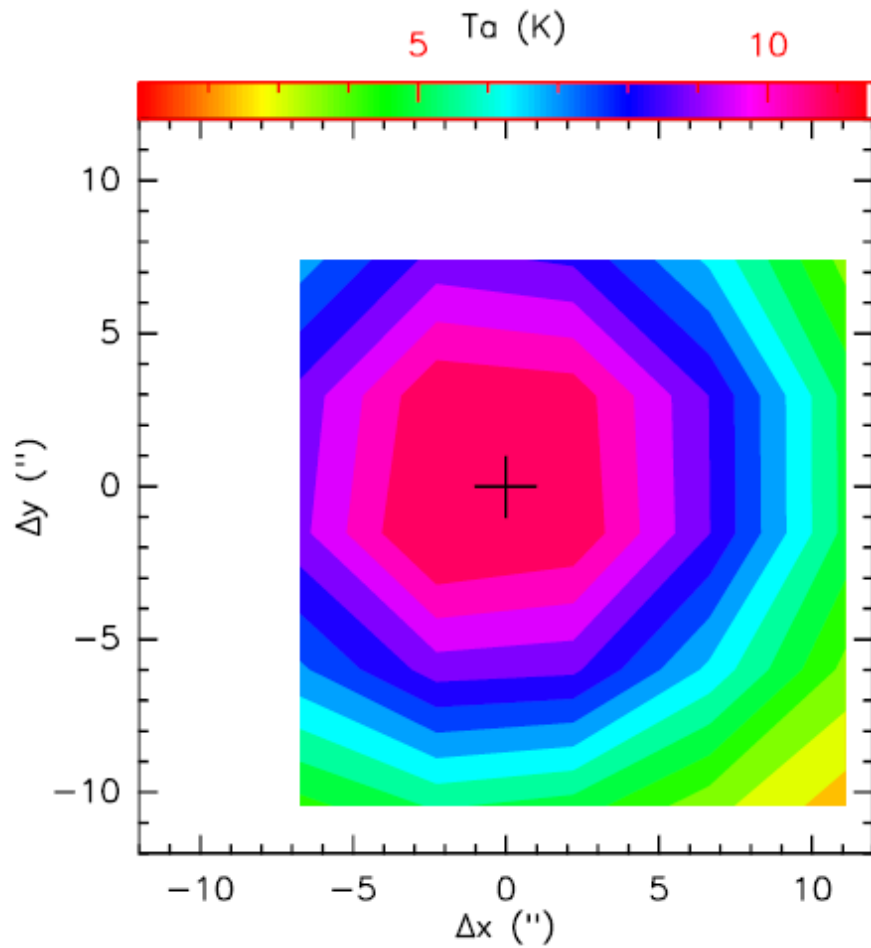
Idea: Compare/transfer the Mars absolute calibration of HIFI to SPIRE using Uranus/Neptune observations.

Uranus and Neptune maps with HIFI at 648 and 1012 GHz (band 2a and 4a) and also Mars in the same period (7.5'' on the 8/9 Dec. 2011)

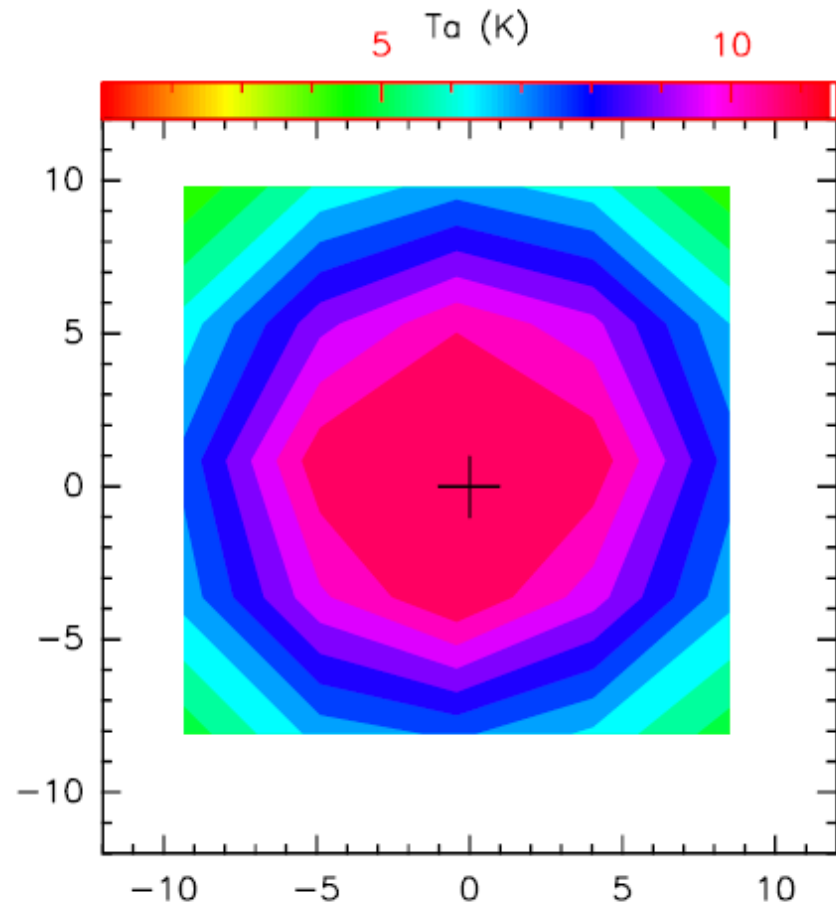
Map of 5x5 points with step of HPBW/4 for a total of ~18 H

HIFI Cross-calibration measurements – 1012 GHz

Mars – 1012 GHz – Pol=H

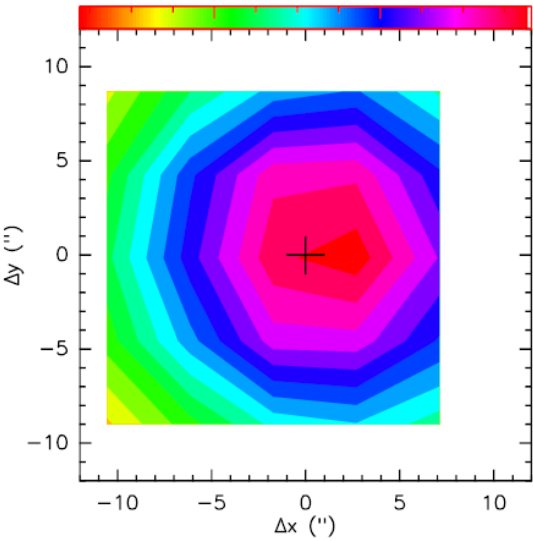


Mars – 1012 GHz – Pol=V



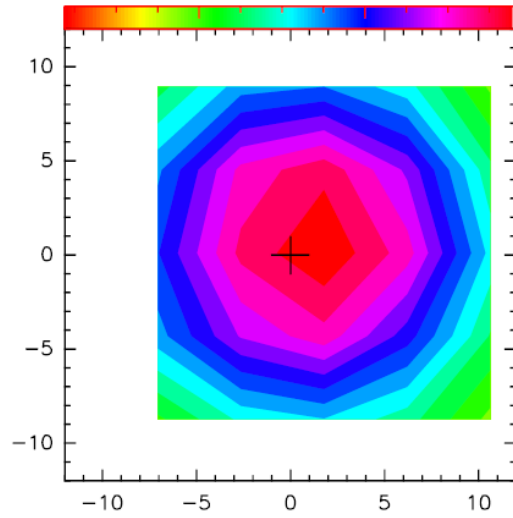
Uranus - 1012 GHz - Pol=H

0.2 Ta (K) 0.4



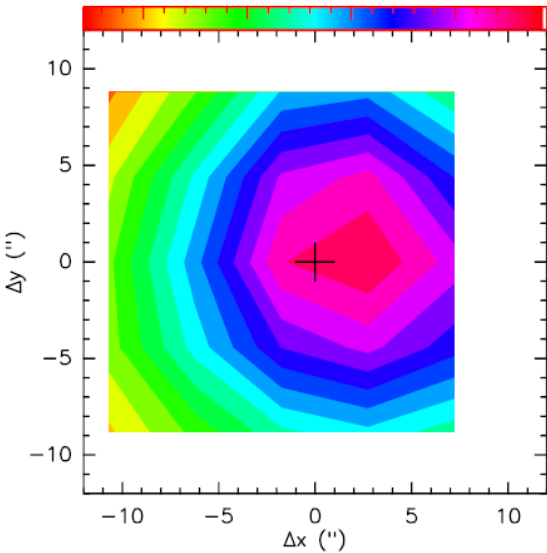
Uranus - 1012 GHz - Pol=V

0.2 Ta (K) 0.4



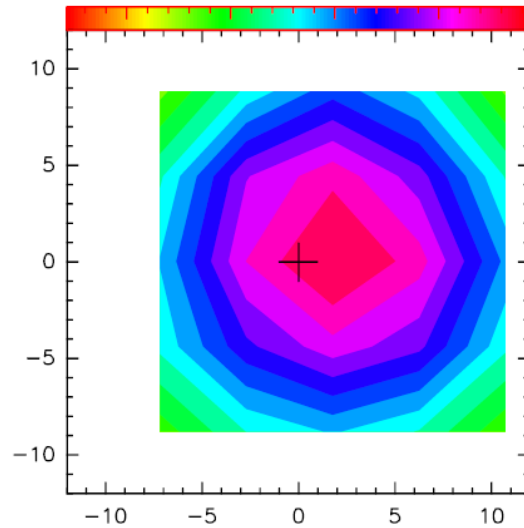
Neptune - 1012 GHz - Pol=H

0.05 0.1 Ta (K) 0.15 0.2



Neptune - 1012 GHz - Pol=V

0.05 0.1 Ta (K) 0.15 0.2



Reduced with HIPE 8.0

HPBW = $20.3'' \pm 0.13''$

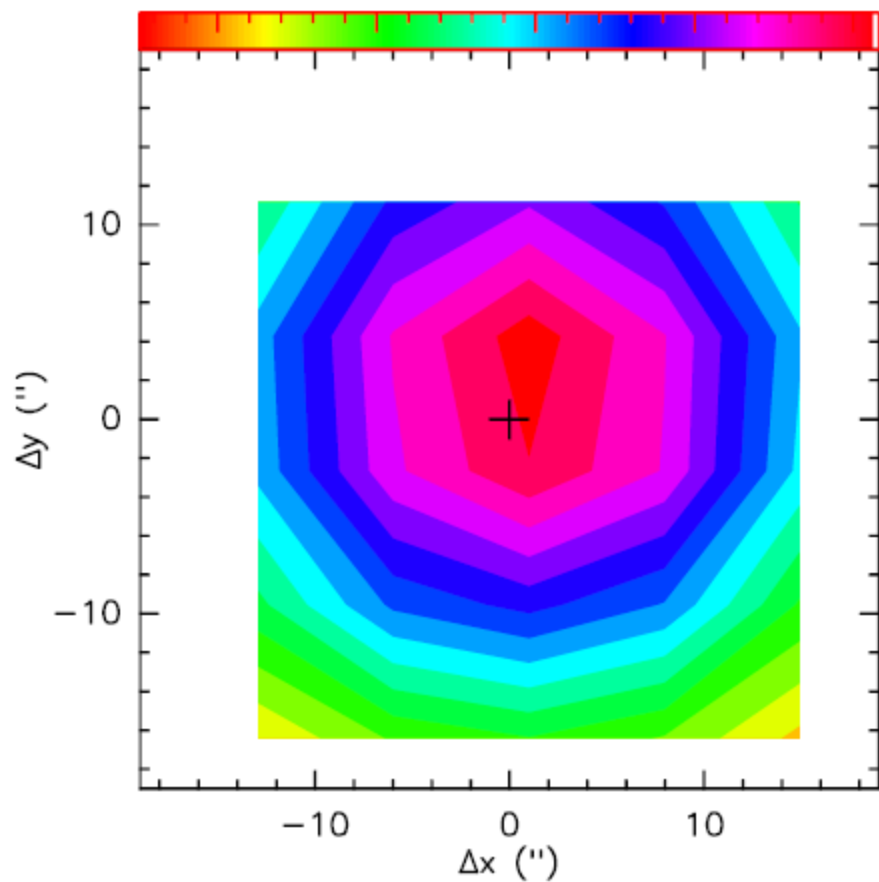
Gaussian FIT :
SNR ~ 100

HIFI Cross-calibration measurements – 648 GHz

Mars - 648 GHz - Pol=H

Ta (K)

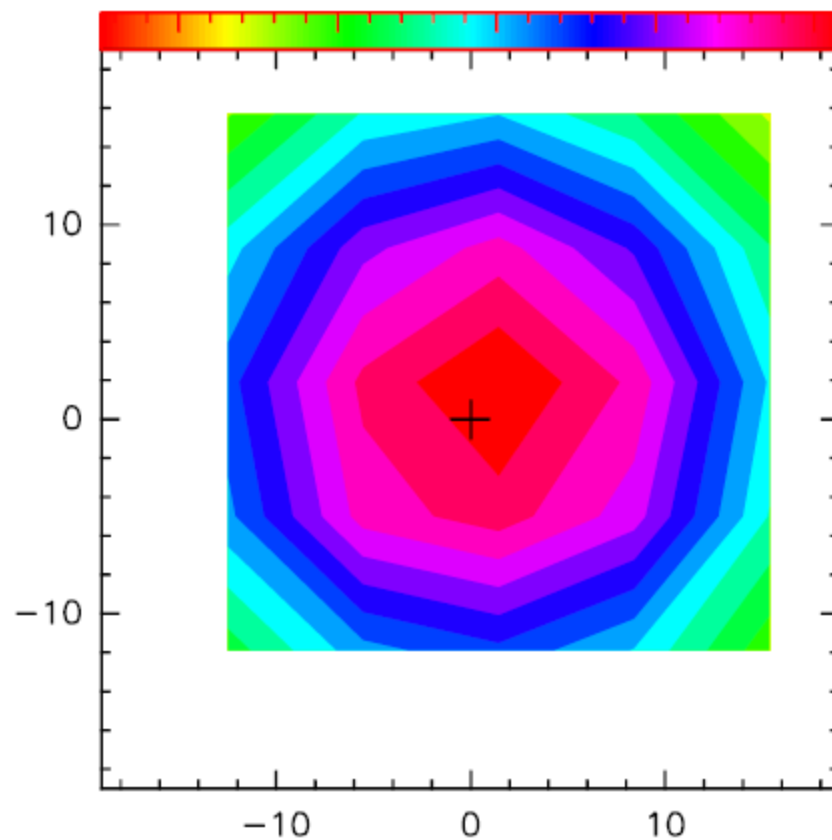
1 2 3 4 5



Mars - 648 GHz - Pol=V

Ta (K)

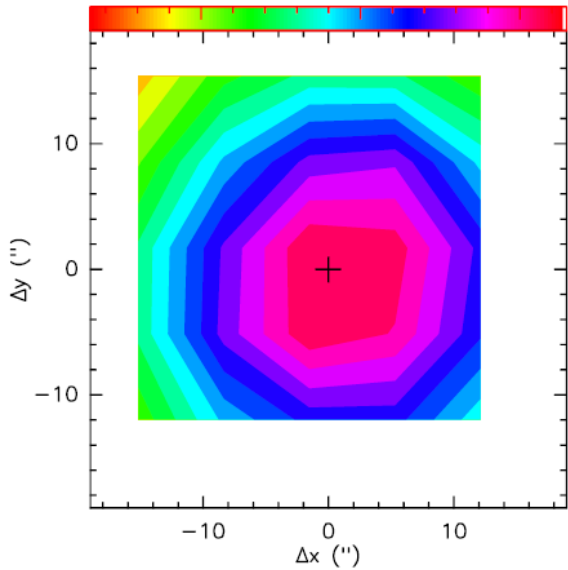
1 2 3 4 5



Uranus - 648 GHz - Pol=H

Ta (K)

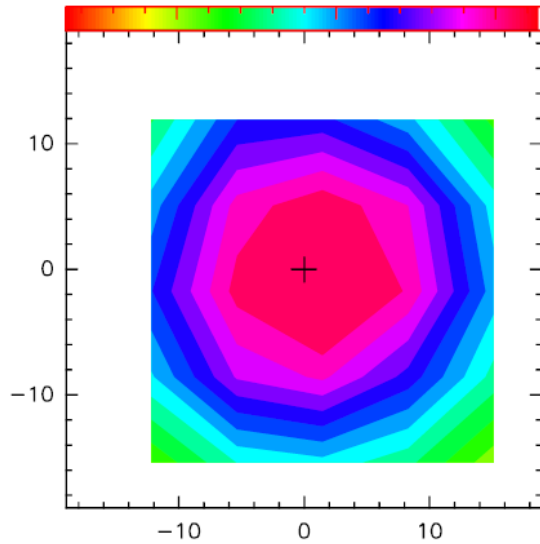
0.1 0.2 0.3



Uranus - 648 GHz - Pol=V

Ta (K)

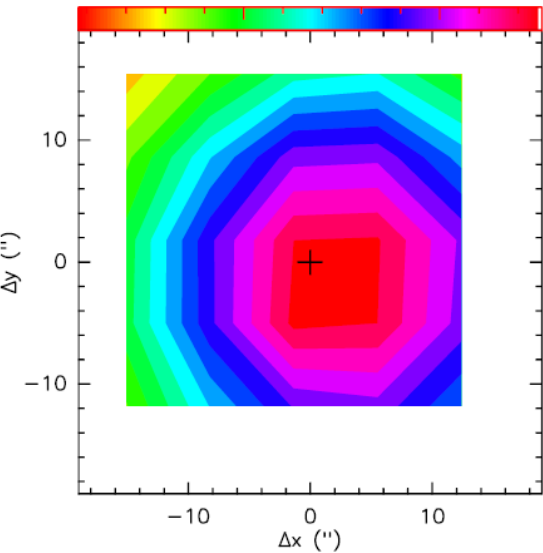
0.1 0.2 0.3



Neptune - 648 GHz - Pol=H

Ta (K)

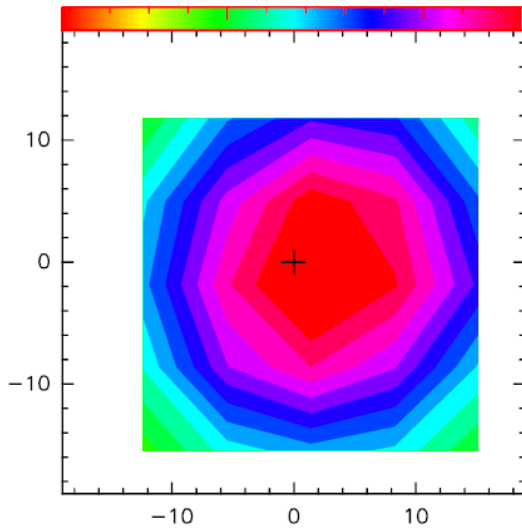
0.05 0.1



Neptune - 648 GHz - Pol=V

Ta (K)

0.05 0.1



Reduced with HIPE 8.0

Manual correction of the
DSB image_gain
(0.51-0.55) at 648 GHz

HPBW = $31.8'' \pm 0.27''$

Gaussian FIT :
SNR ~ 100

Method

Peak Antenna Temperature derived from a 2D gaussian fit

Use a relative Calibration of Mars (Lellouch's model) to derive the Brightness Temperature of Uranus and Neptune.

Beam efficiency (B_{eff}) and HPBW also derived on Mars (~ 7% less than in Roelfsema etal 2012)

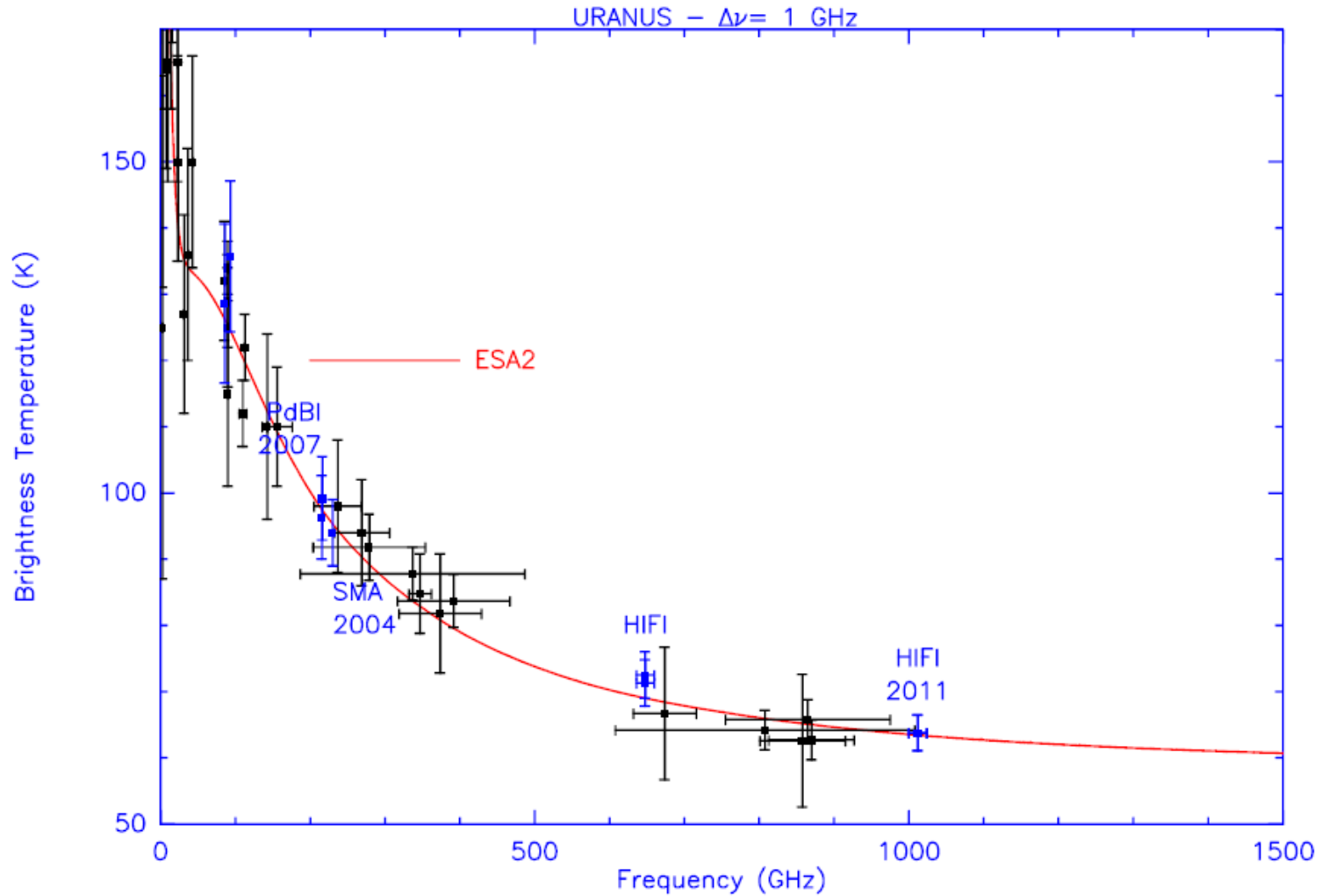
Freq (GHz)	Polarization	B _{eff}	HPBW(“)
648	H	0.681	31.8
“	V	0.695	31.8
1012	H	0.697	20.3
“	V	0.710	20.3

Results

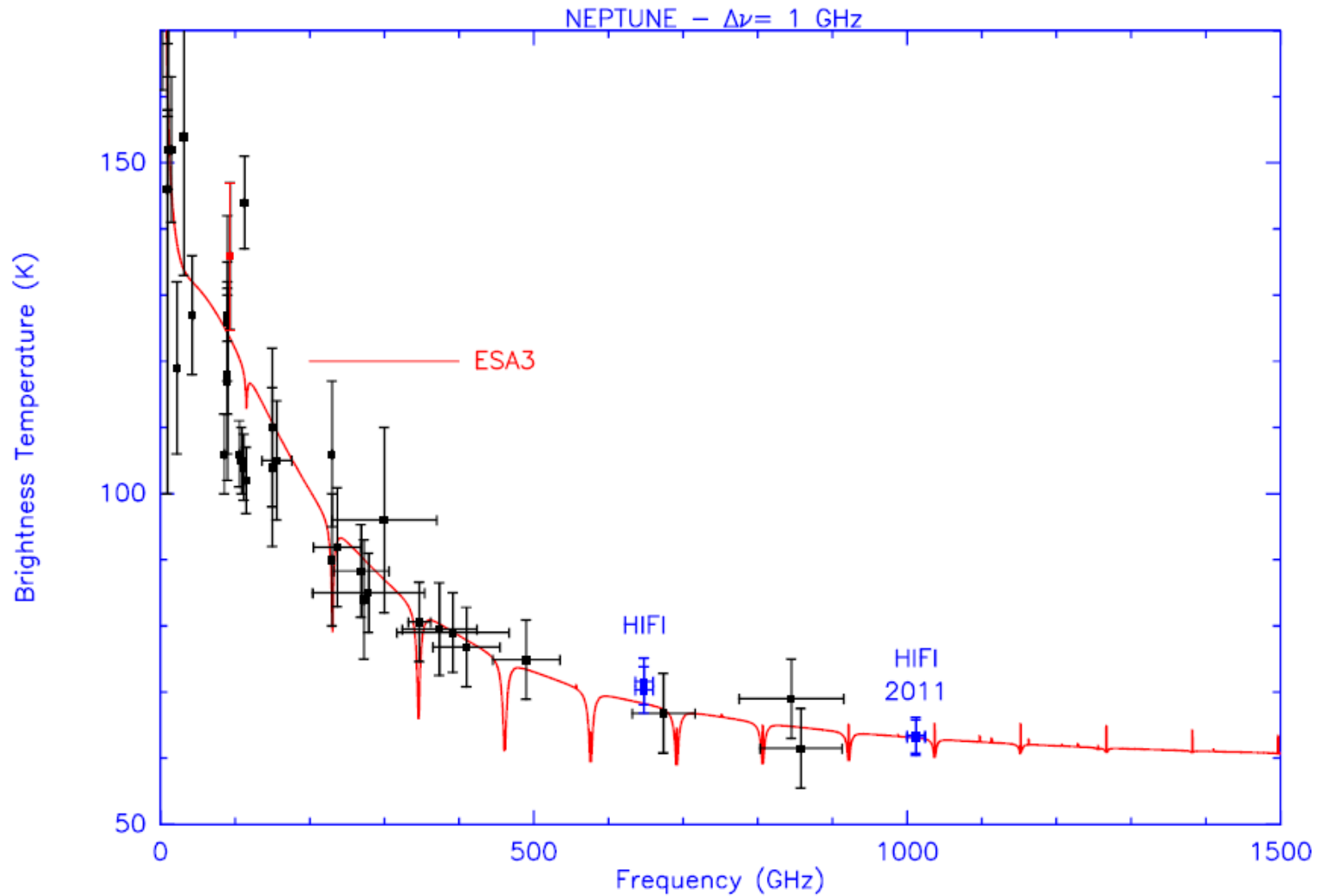
Planet	Freq.	Polar.	Tb (K)	dTb (K)	dTb_Mars (K)
Uranus	648	H	71.305	0.5	2.5
“	“	V	72.535	0.5	2.5
“	1012	H	63.751	0.5	2.5
“	“	V	63.795	0.5	2.5
Neptune	648	H	70.318	0.6	2.5
“	“	V	71.620	0.6	2.5
“	1012	H	63.461	0.5	2.5
“	“	V	63.133	0.5	2.5

Absolute uncertainty depend mainly on Mars' model :
<5% in flux

Uranus model comparison



Neptune model comparison



HIFI- cross-calibration measurement Summary

Planete	Freq (GHz)	HIFI/Esa2 (flux)	HIFI/Esa3 (flux)
Neptune	648	1.055	1.048
“	1012	1.025	1.005
Uranus	648	1.036	
	1012	1.007	

•In general agreement within
5 % at 648 GHz and ~ 0.6 % at 1012 GHz

More measurements needed at 648 and 1012 GHz to confirm this
tendency (instead of 648 GHz, at 491 GHz seems better
with image gain of 0.5)

HIFI-SPIRE cross-calibration observability period

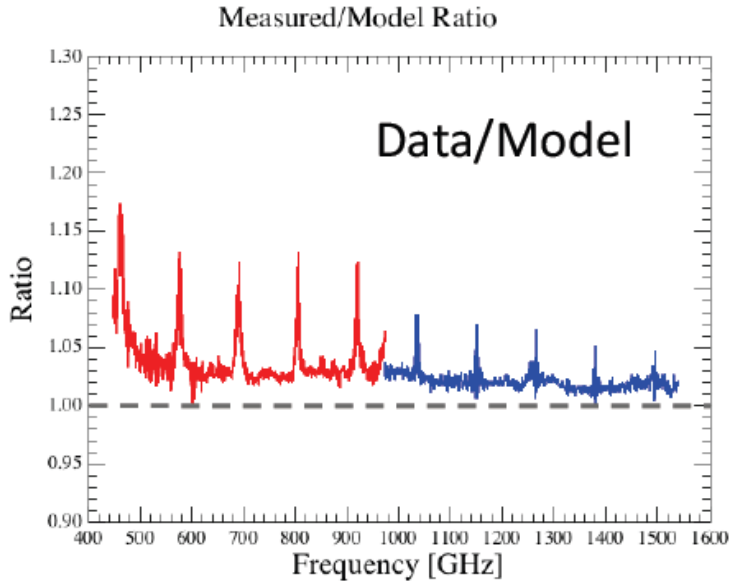
Planet	Start	End	Diameter	Ra/Dec
Mars	2012-May-06	2012-Aug-17	9.5'' → 5.4''	10 → 13h / +9 → -10
Uranus	2012-May-29	2012-Jul-20	3.5''	00h / +02
Neptune	2012-Apr-23	2012-Jun-13	2.3''	22h / -11

Optimal epoch : 2012-May-29 – 2012-Jun-13
(Mars Diameter : 8.0'' → 7.3'')

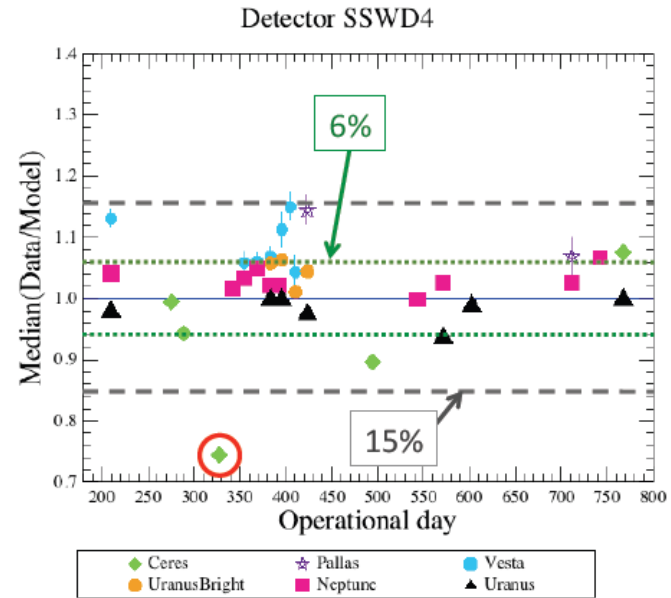
In order to check the measurements reproducibility/stability with
time at 1012 and 648 GHz (or ~491 GHz)

Last observability period (short window)

HIFI-SPIRE comparison



SPIRE (from
Hopwood's Talk)

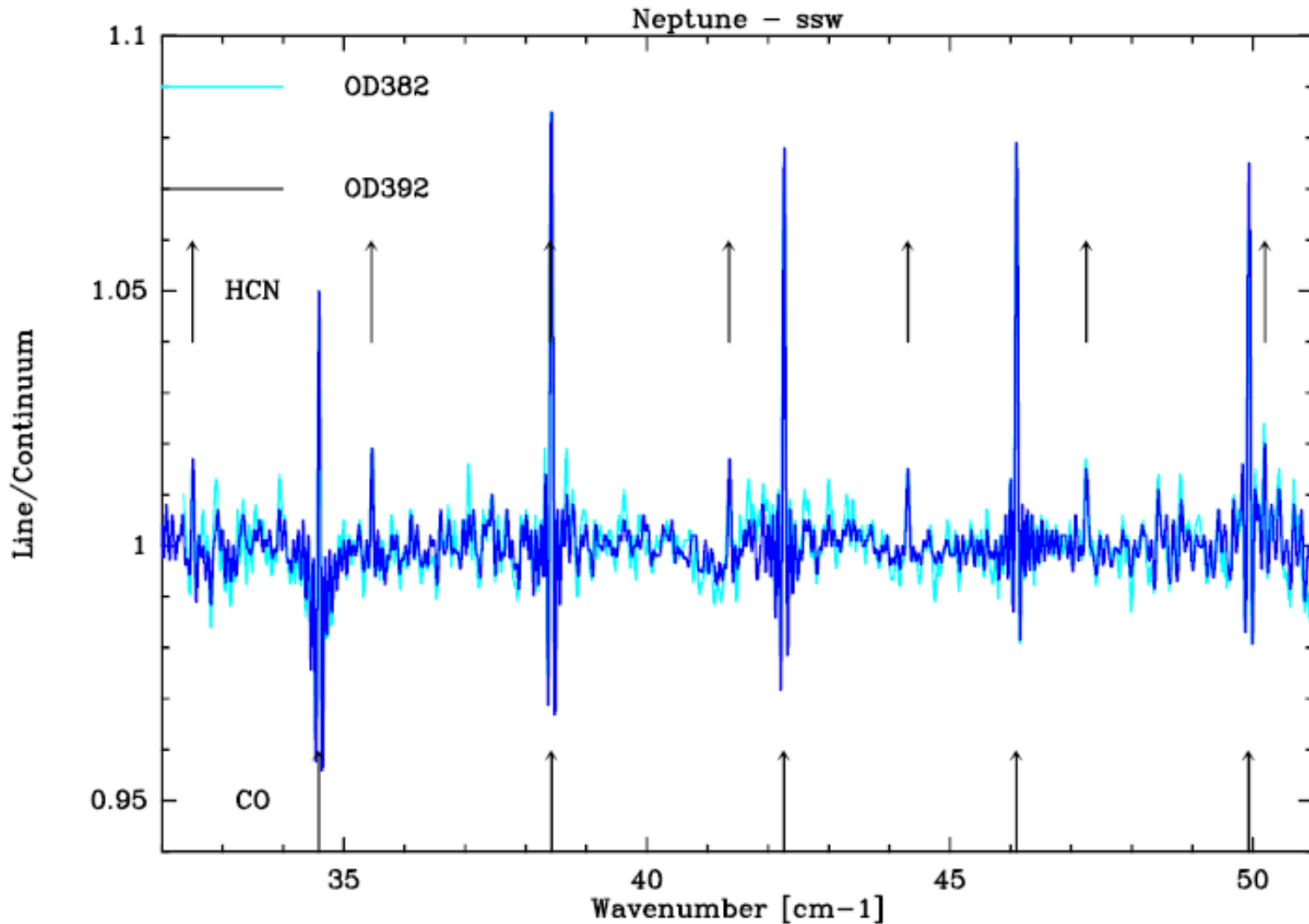


$$\text{Neptune [HIFI/Esa2]} / \text{Uranus [HIFI/Esa2]} = 1.018$$

This is comparable with the SPIRE results of 2-3 %
(~ stable with time)

➔ Relative calibration between Uranus and Neptune are
In very good agreement between HIFI and SPIRE

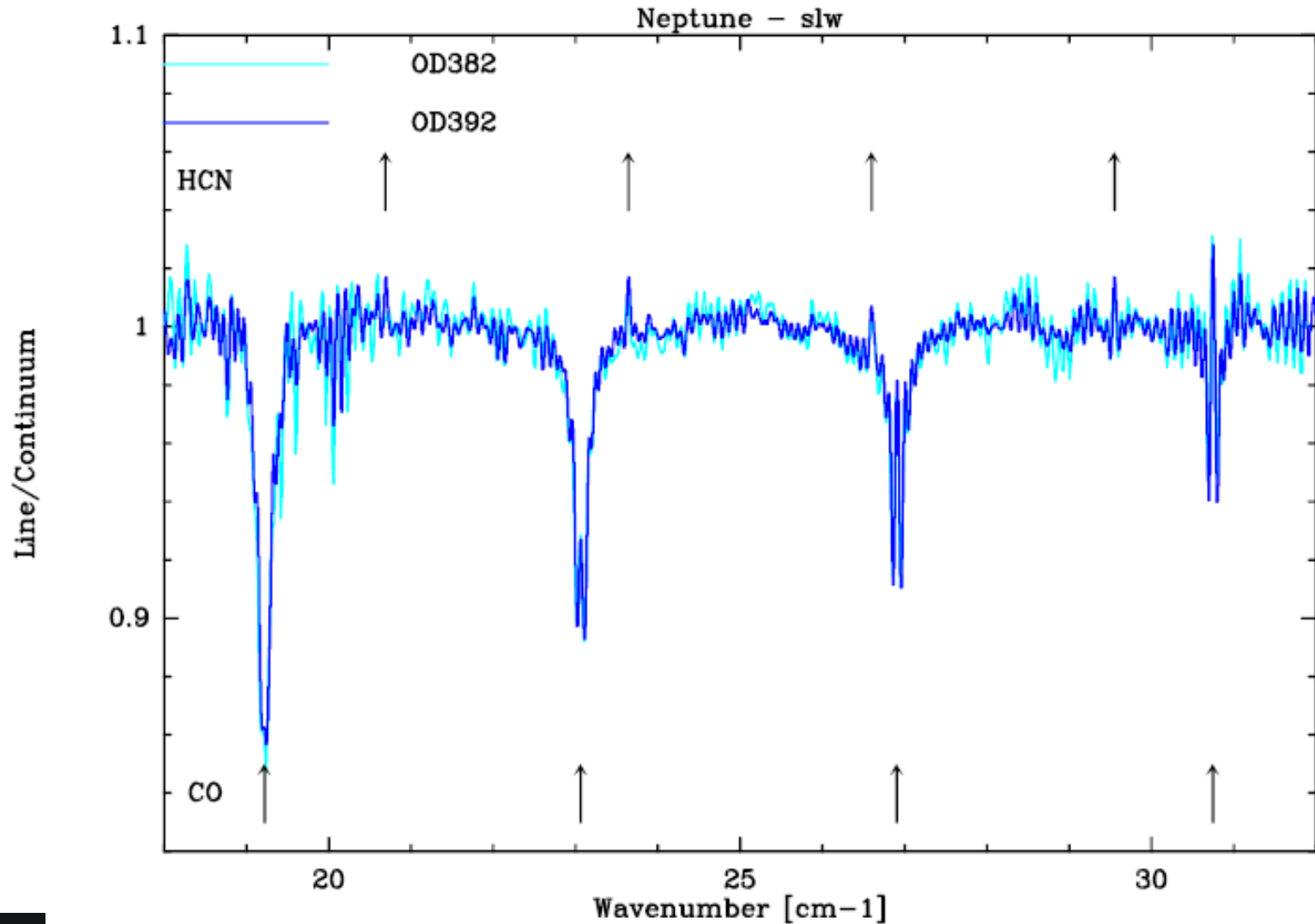
Comparison with Neptune/CO



High level of reproducibility



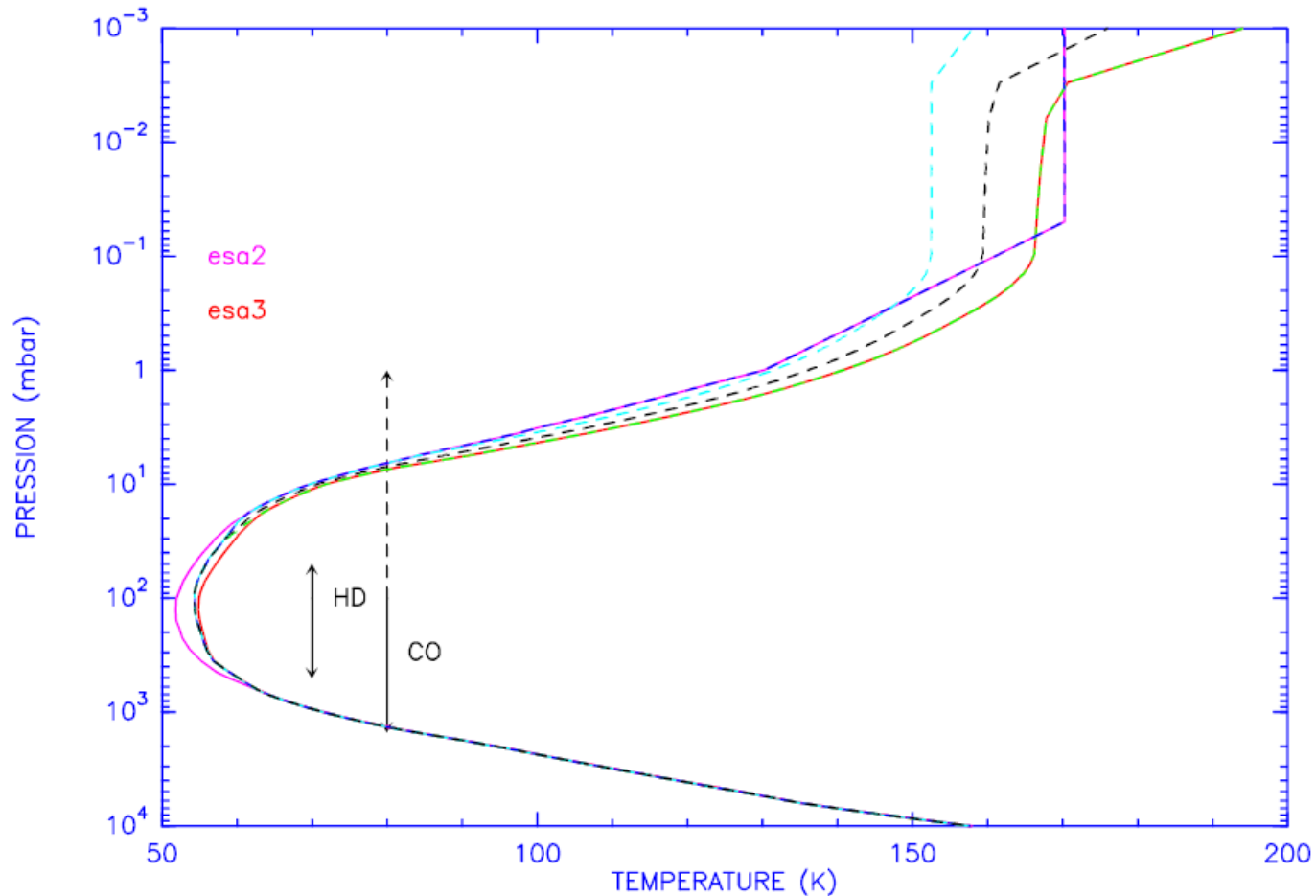
Unapodized Spectra (long- λ)



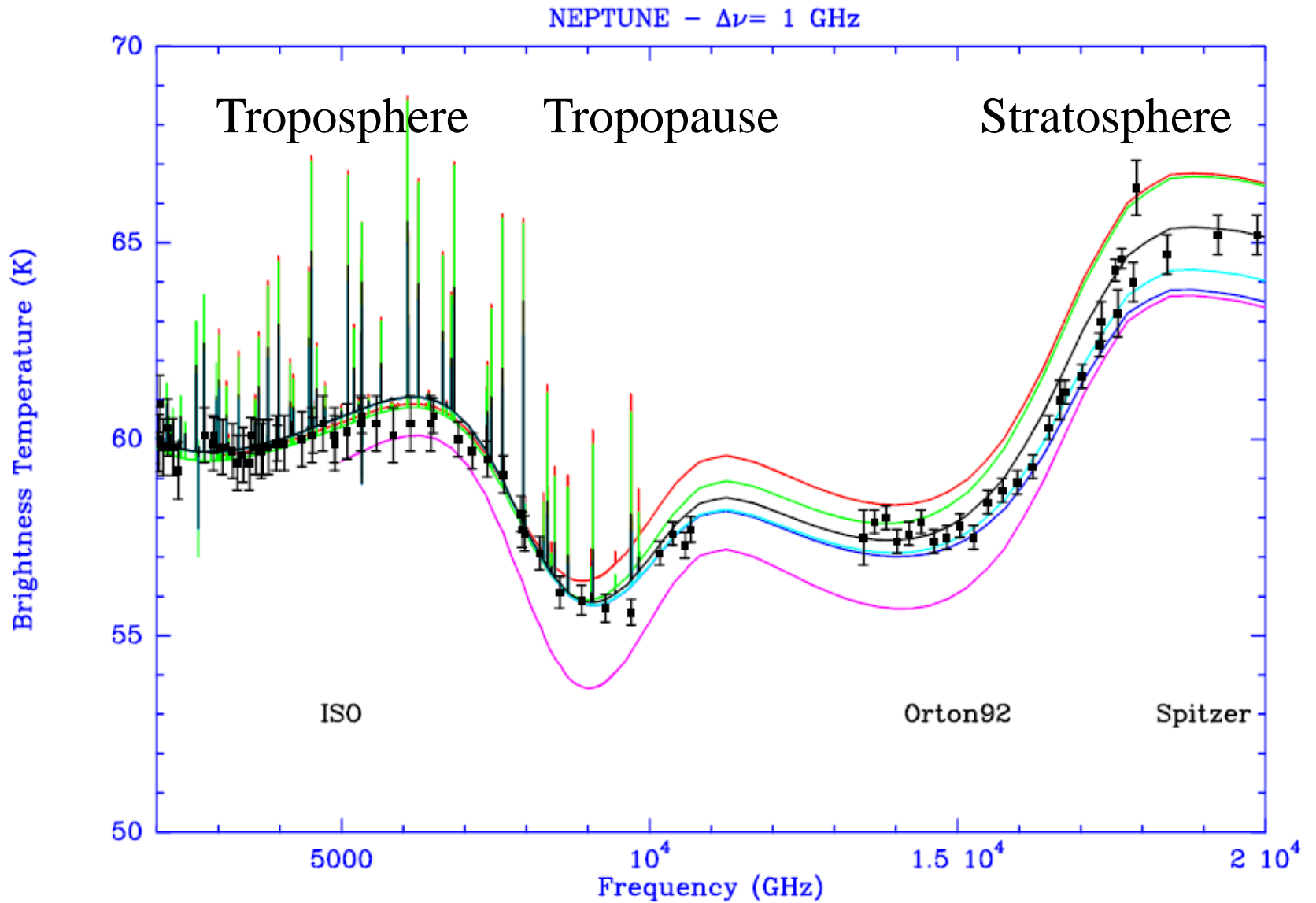
The noise increases at the band edges



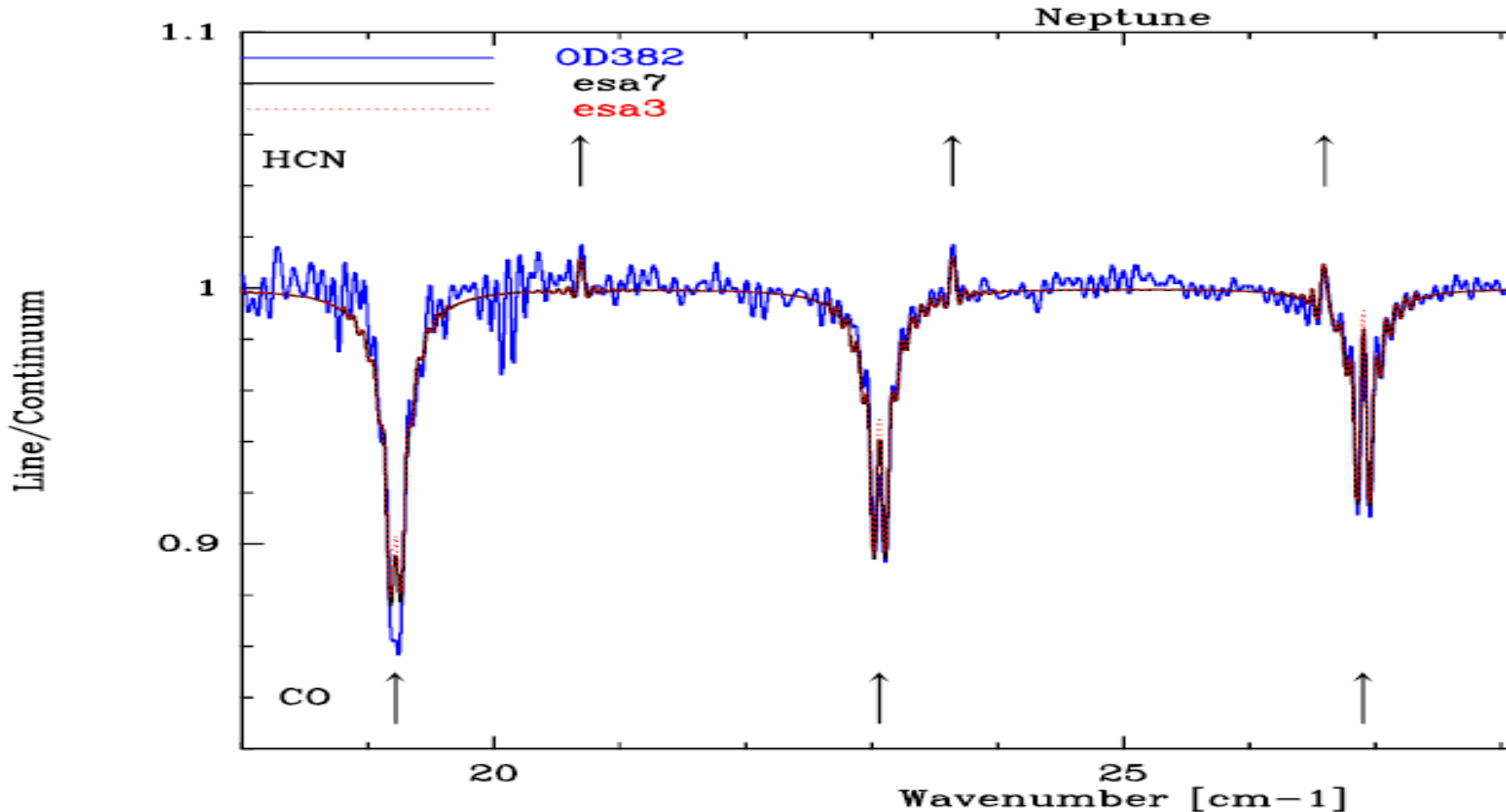
Neptune's Thermal Structure study



FIR-continuum simulations



Neptune/CO - SPIRE



Need to modify the deeper tropospheric temperature to better fit the CO lines (on going work) – SPIRE probe deeper than PACS

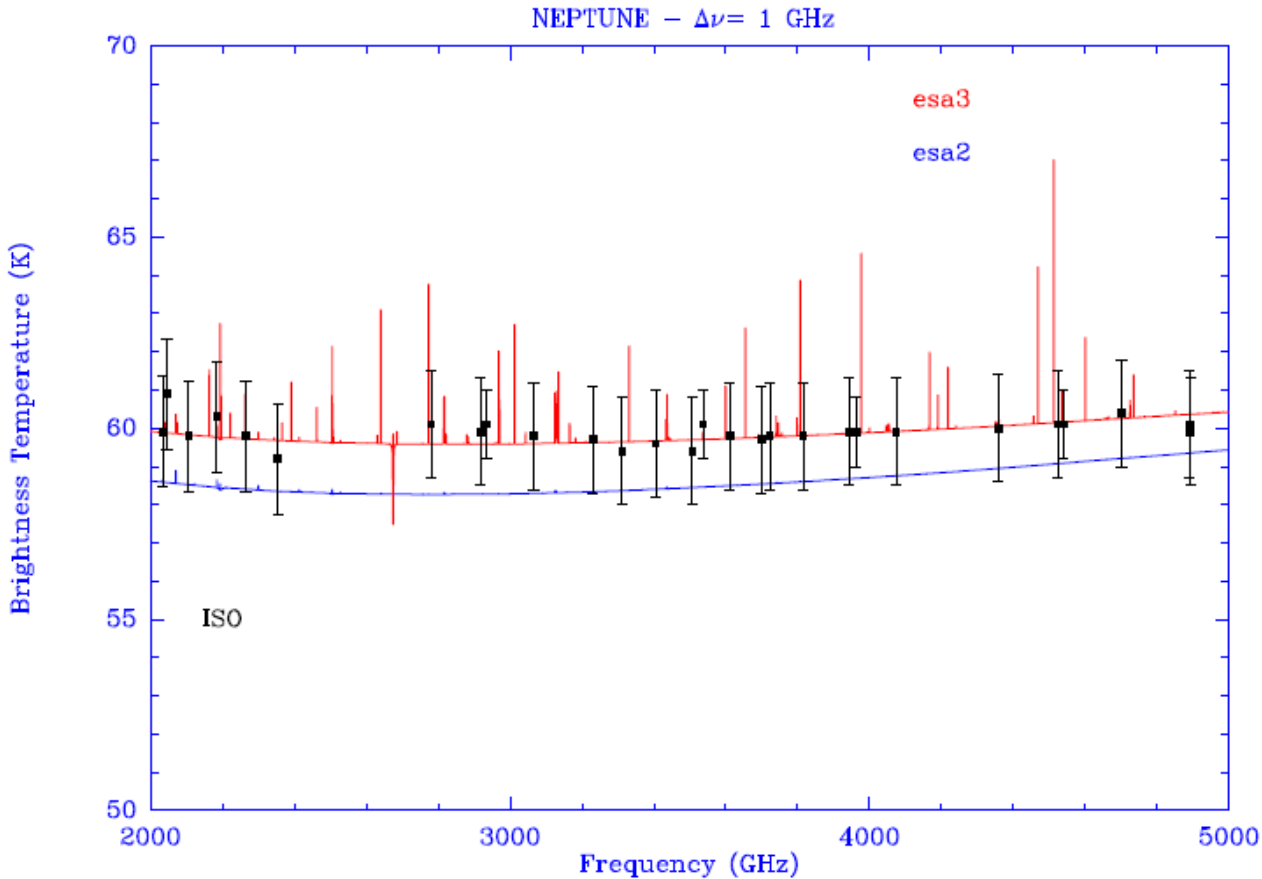


Neptune/CO Summary

The spectra obtained on Neptune with SPIRE/Herschel allowed us to measure many lines of CO and HCN and to constrain :

- Thermal structure study of the stratosphere ($P < 100$ mb)
- ➔ fit almost the measurements from 2-20 THz (150-15 μm)
- **TBD**: Improve $P(T)$ in the stratosphere ($P < 100$ mb)
- **Study $P(T)$ in the troposphere ($P > 100$ mb) with SPIRE/Neptune**
- Coupled study with other measurements (HIFI,IRAM,PACS)
- Similar study on Uranus
- ➔ Expect to Constraint Neptune's continuum $< 3\%$ (ESA4 ...)

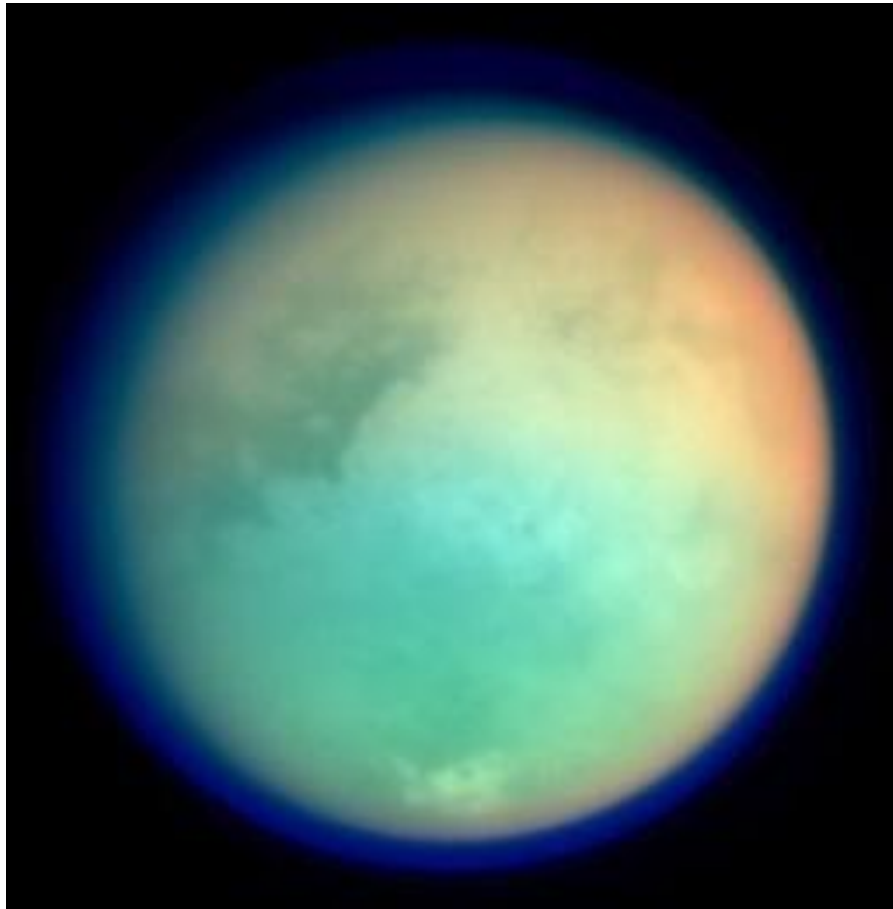
Neptune's continuum (PACS)

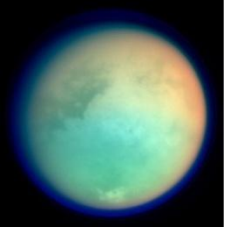


Neptune ISO calibrated versus Uranus

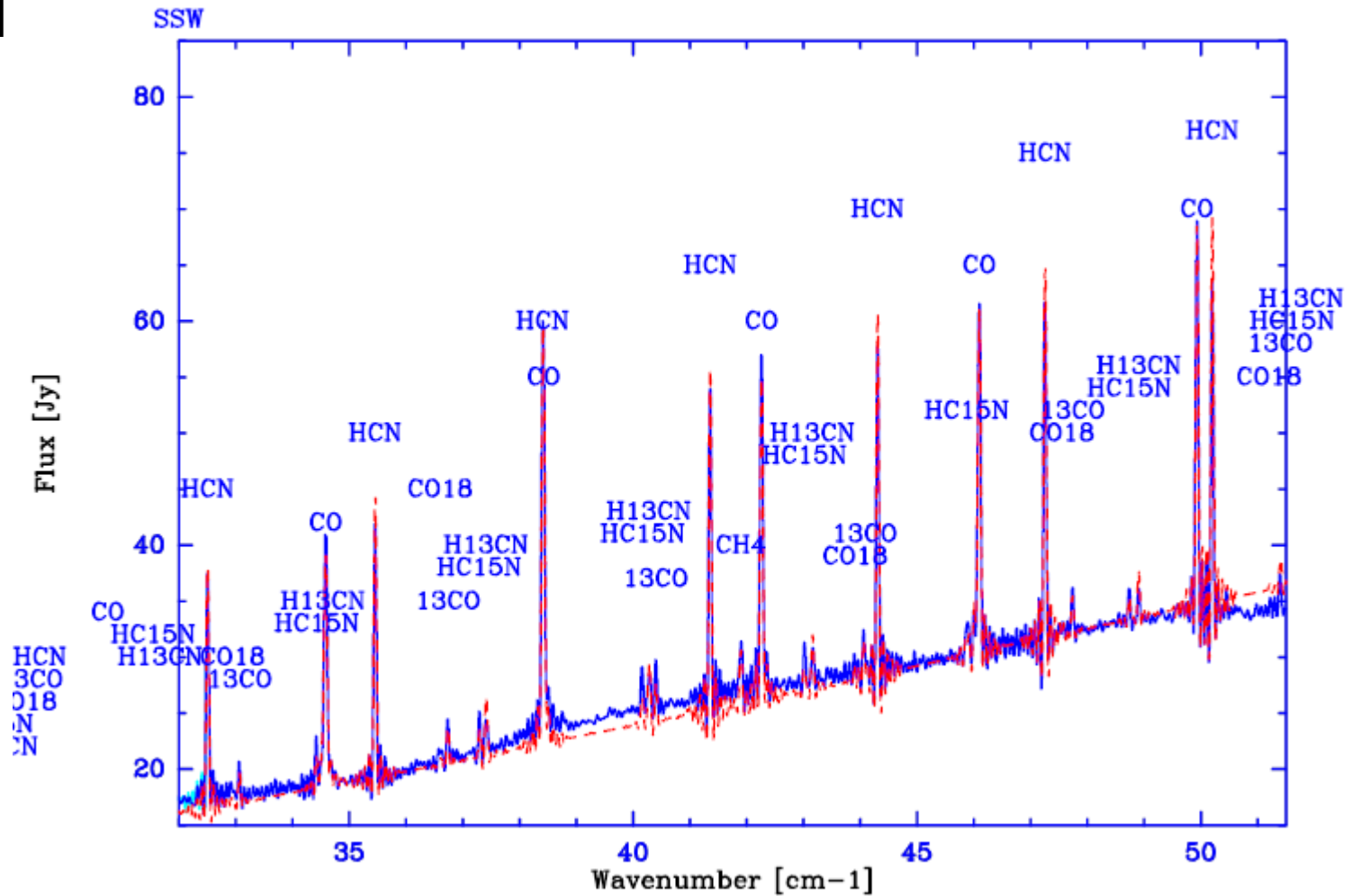
PACS-Photometry calibration : agreement with ESA3 within 2 %
(see M. Nielbock's talk with Fiducial stars as reference)

Titan



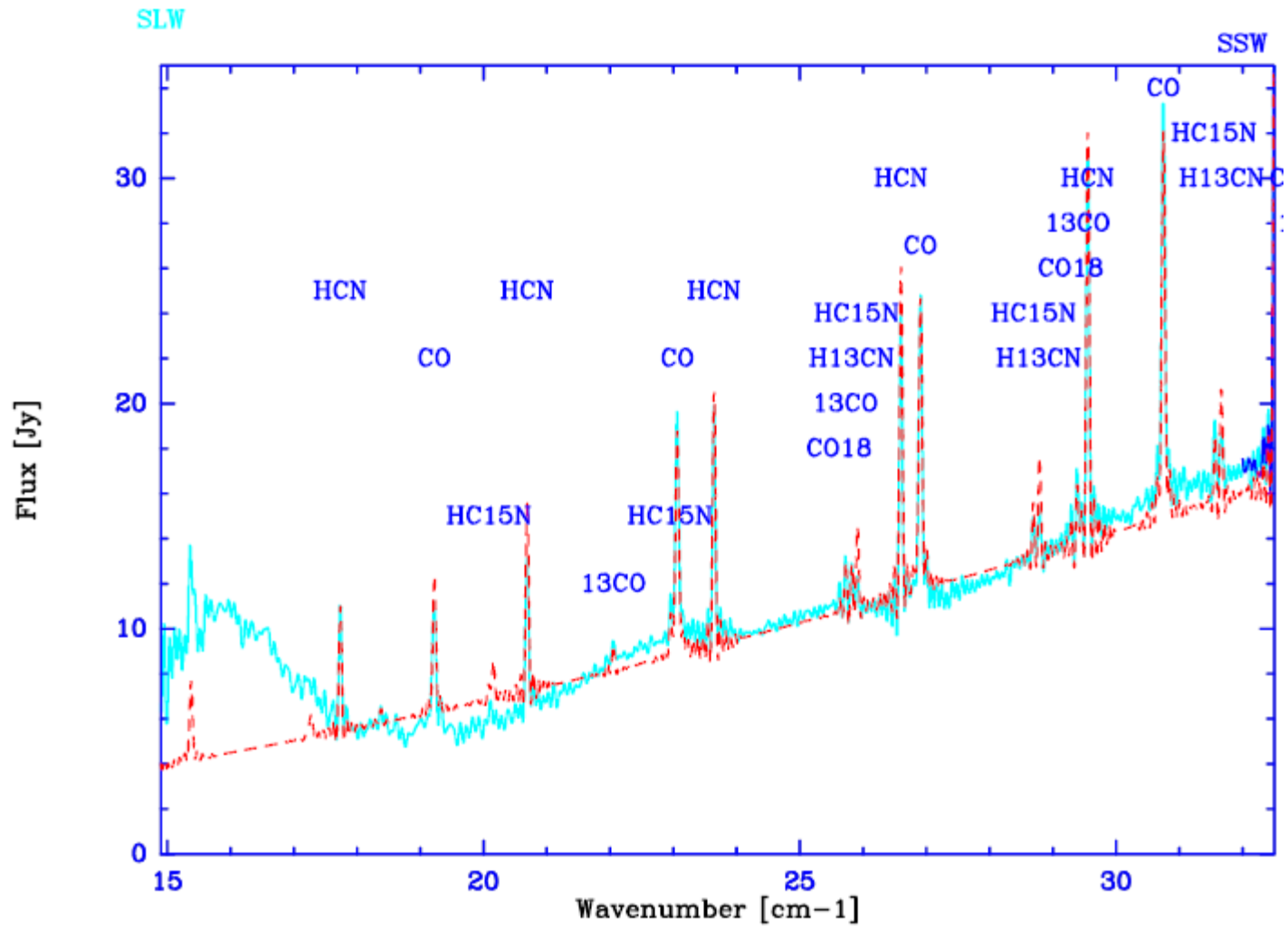


Titan/Spire (ssw)



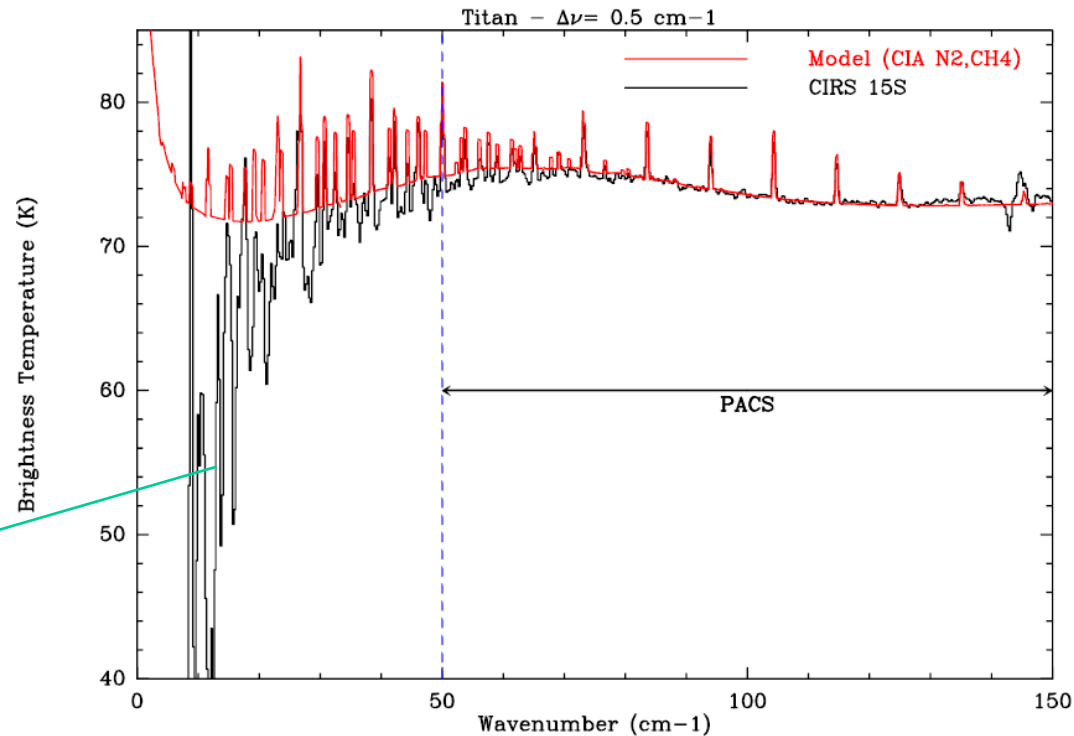
Calibrated versus Uranus

Titan/Spire (slw)



Contamination from Saturn < 18-20 cm⁻¹

Titan Model versus CASSINI-CIRS



Loss of sensitivity

Modeled continuum in perfect agreement (1-2% in flux) with CIRS in the PACS range, and probably also in the SPIRE range.

CIRS absolute calibration is of 1%.

Calibration with Titan

SPIRE calibration can be check in Titan continuum.
Cross- calibration Titan/Uranus for SSW : $\pm 2-4 \%$ - SLW : $\pm 5-10 \%$
Well known modeled and measured continuum.

The accurate PACS PHOTOMETRY could also be cross-calibrated on Titan .

For cross-calibration : Scan map should be measured on Titan
(next window in June 2012)

Conclusions

- HIFI cross-calibration measurement at 648 and 1012 GHz shows that the Relative calibration of Neptune/Uranus are
In very good agreement between HIFI and SPIRE
- Working to obtain Neptune & Uranus ESA4 model (accuracy <3%)
- Still Need a joint analysis of HIFI, SPIRE, PACS and mm/submm ground-based telescope (continuum and CO lines)
- Need more HIFI measurements to confirm the 648/1012 GHz measurements on Uranus and Neptune (last observability period in June 2012)
- Titan (accuracy ~1%) should be included in the PACS/SPIRE cross-calibration scheme.
→ Need PACS-Photometry observations to be performed.