Models of the Giant Planets

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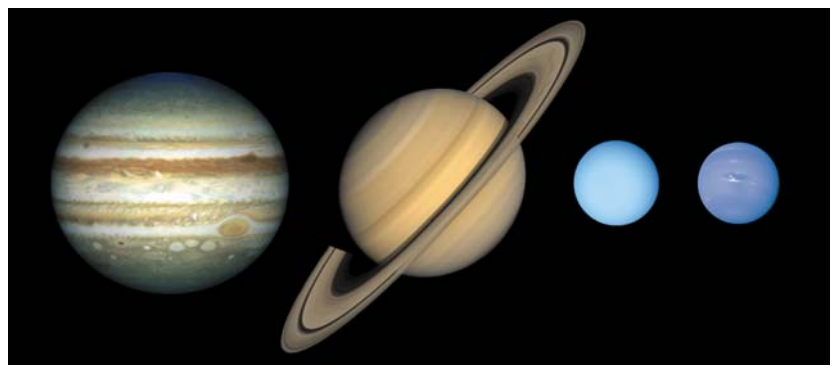


- Knowledge of giant planets
- Modelling
- Giant planets submm spectrum

Thermal Structure of Giant Planets

- **Thermal Profiles : P(T)**

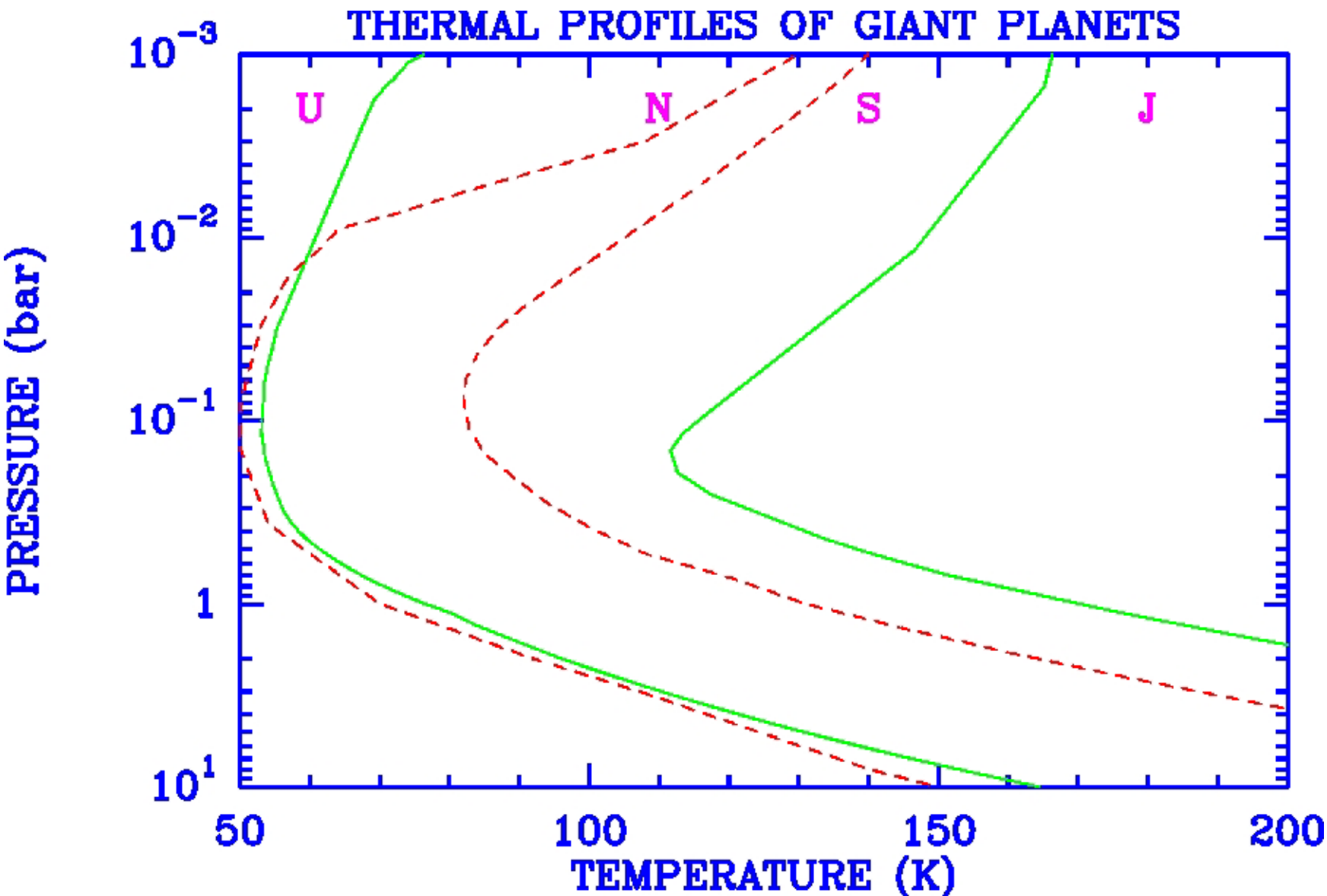
  Troposphere : From Voyager radio-occultation

  Stratosphere : From IR continuum and Line

- **Trospospheric Variations with latitudes:**

  $\Delta T/T < 2\%$

Thermal Profiles



Composition of Giant Planets

Species	Solar (X/H_2)	Jupiter (⊙)	Saturne (⊙)	Uranus (⊙)	Neptune (⊙)
He	0.16	1	0.25	0.83	1.5
H_2O	1.5×10^{-3}	≥ 0.4	-	-	-
CH_4	7.8×10^{-4}	2.5	5.8	30	25
NH_3	2.0×10^{-4}	1-4	2-3	0.25-1*	0.25-1*
H_2S	3.7×10^{-5}	2.1	10*	1-10*	1-10*
PH_3	6.2×10^{-7}	1.0	4.8	-	-

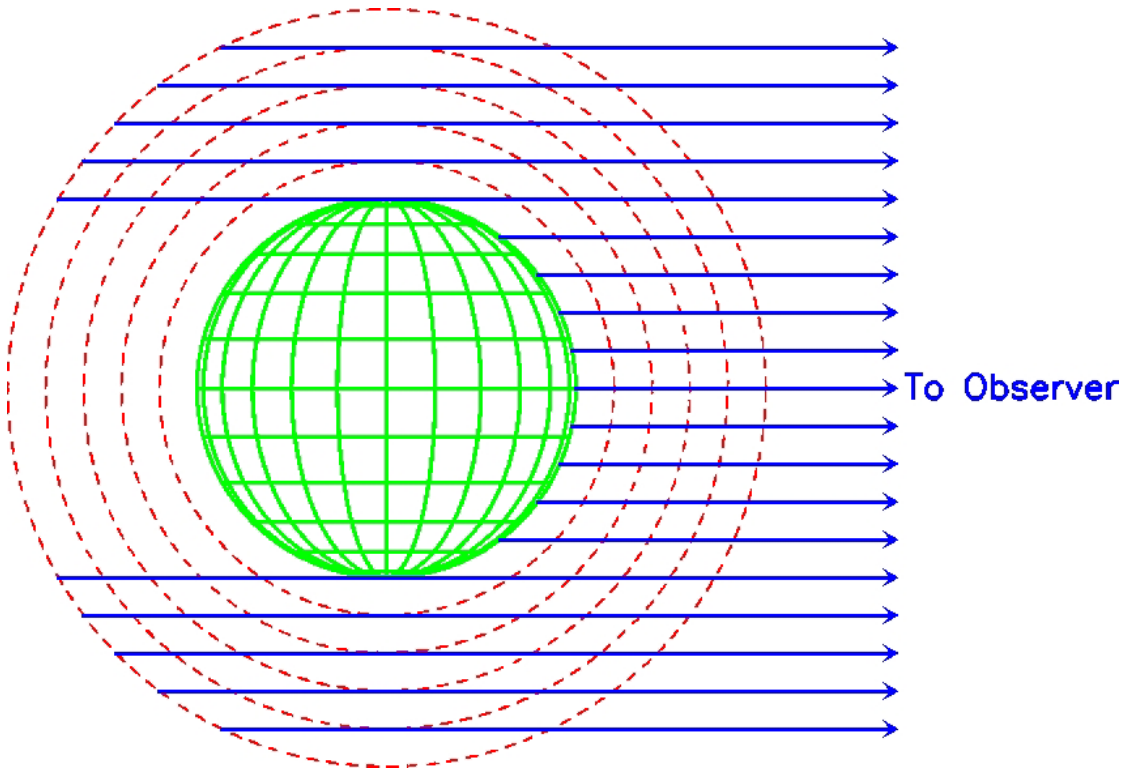
- Cloud Chemistry: $NH_3(g) + H_2S(g) \leftrightarrow NH_4SH(s)$

Modelling

- Radiative Transfert

$$J_{tot}(\nu) = J_S(\nu)\exp^{-\tau_m} + \int \tau_m S(\nu) \exp^{-\tau} d\tau$$

- Spherical geometry



Modelling (II)

- Collision induced opacity : H_2- H_2; H_2- H_e ; H_2- CH_4

- Molecular Opacity : NH_3 ; PH_3 ; H_2S ; CH_4

-- Absorption Coefficient (JPL Catalog)

-- Pressure broadening coefficient

-- Lineshape: Ben-Reuven, Van-Vleck & Weisskopf,

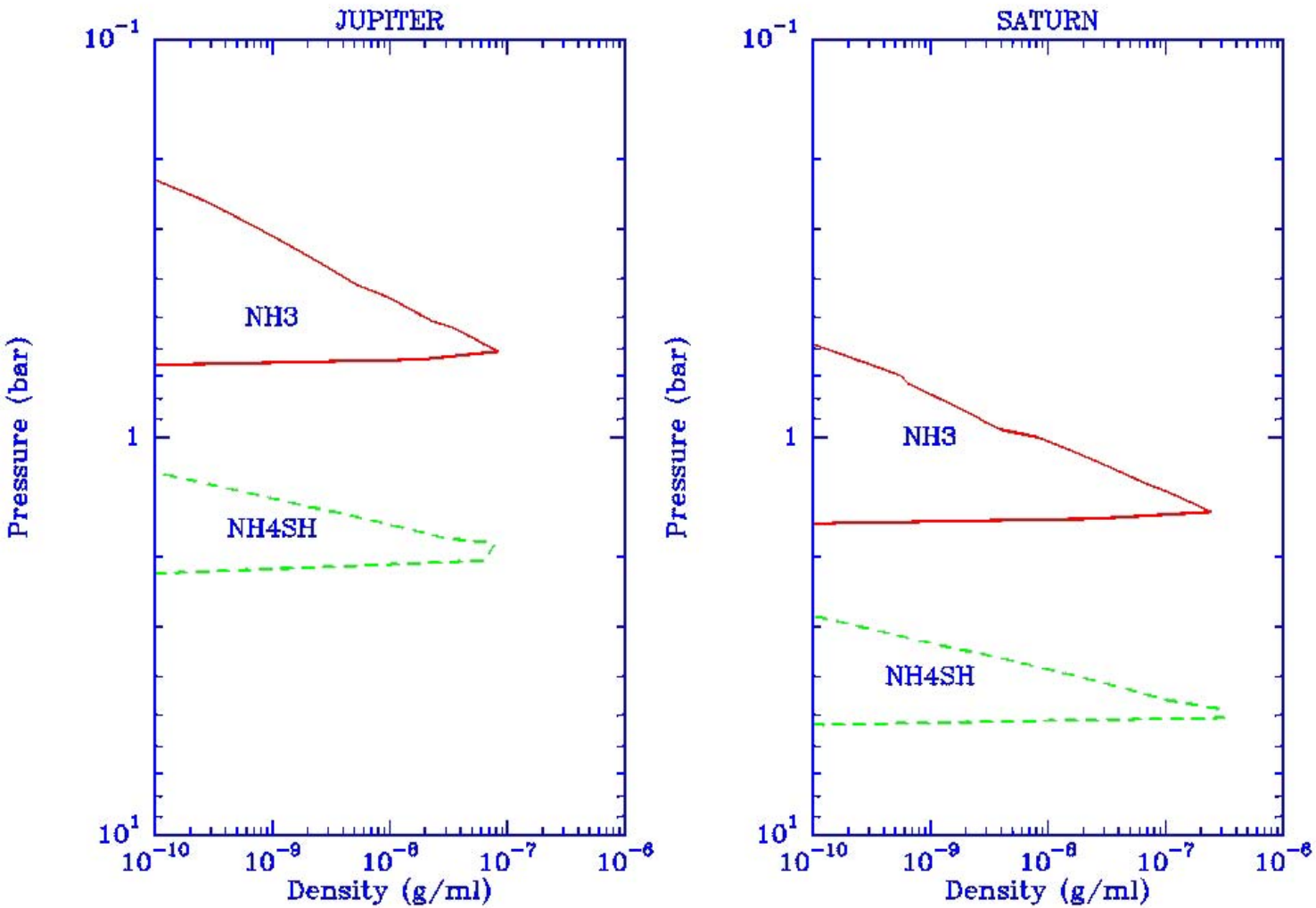
Lorentz, Voigt, Doppler

Modelling (III)

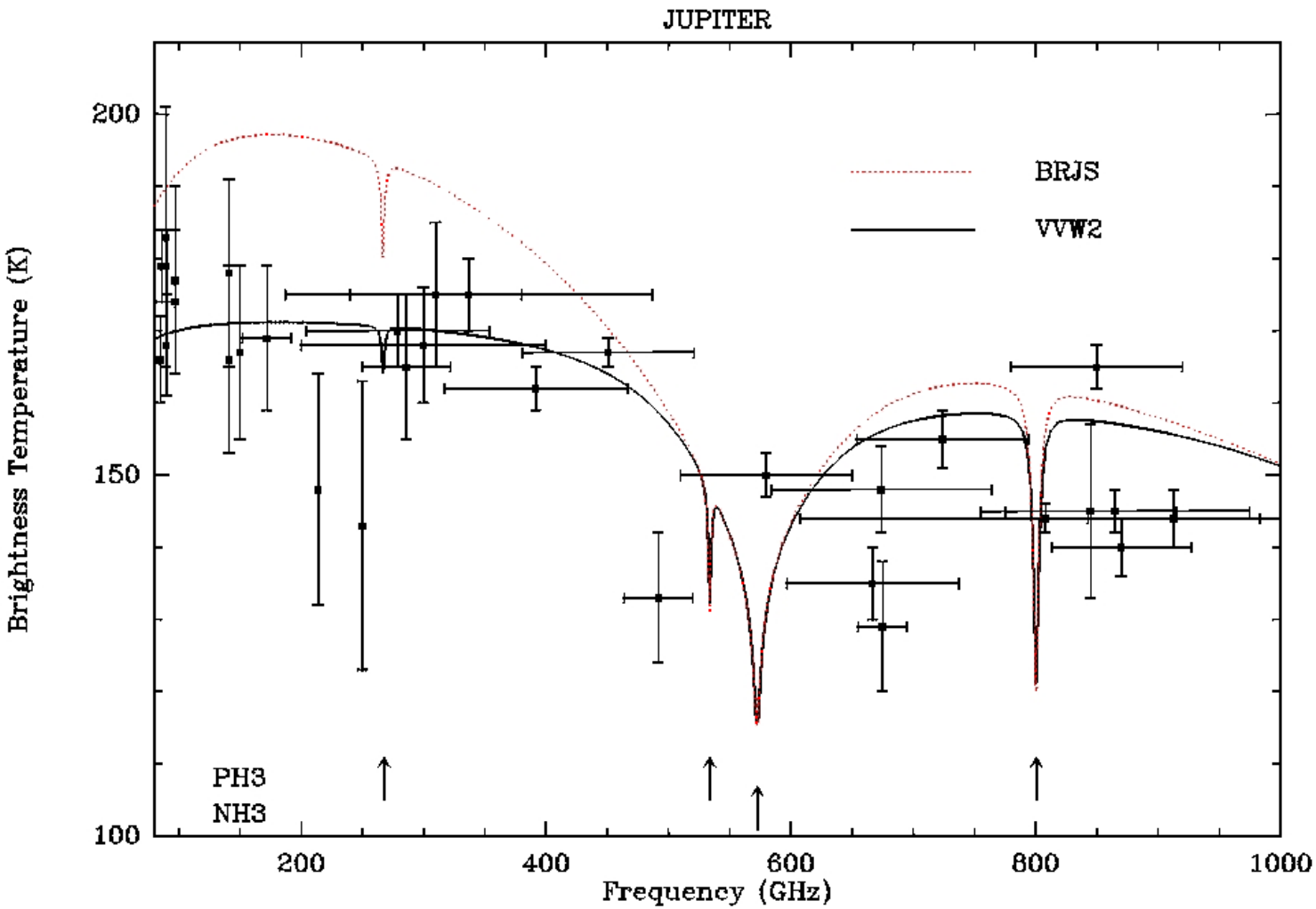
Physical parameters Inputs :

- Thermal Structure
- He/H_2
- Vertical distribution of minor species

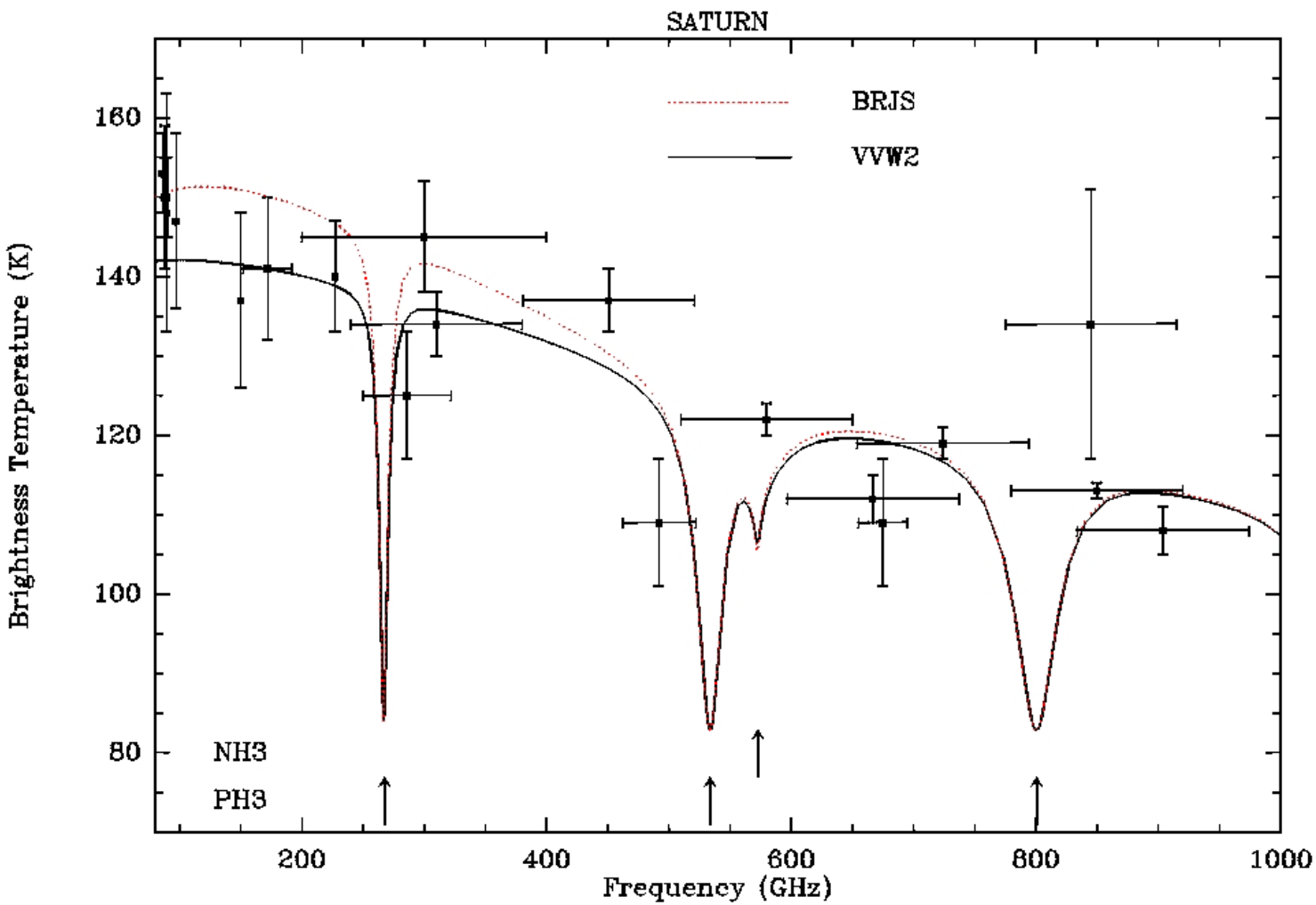
Jupiter and Saturn Clouds



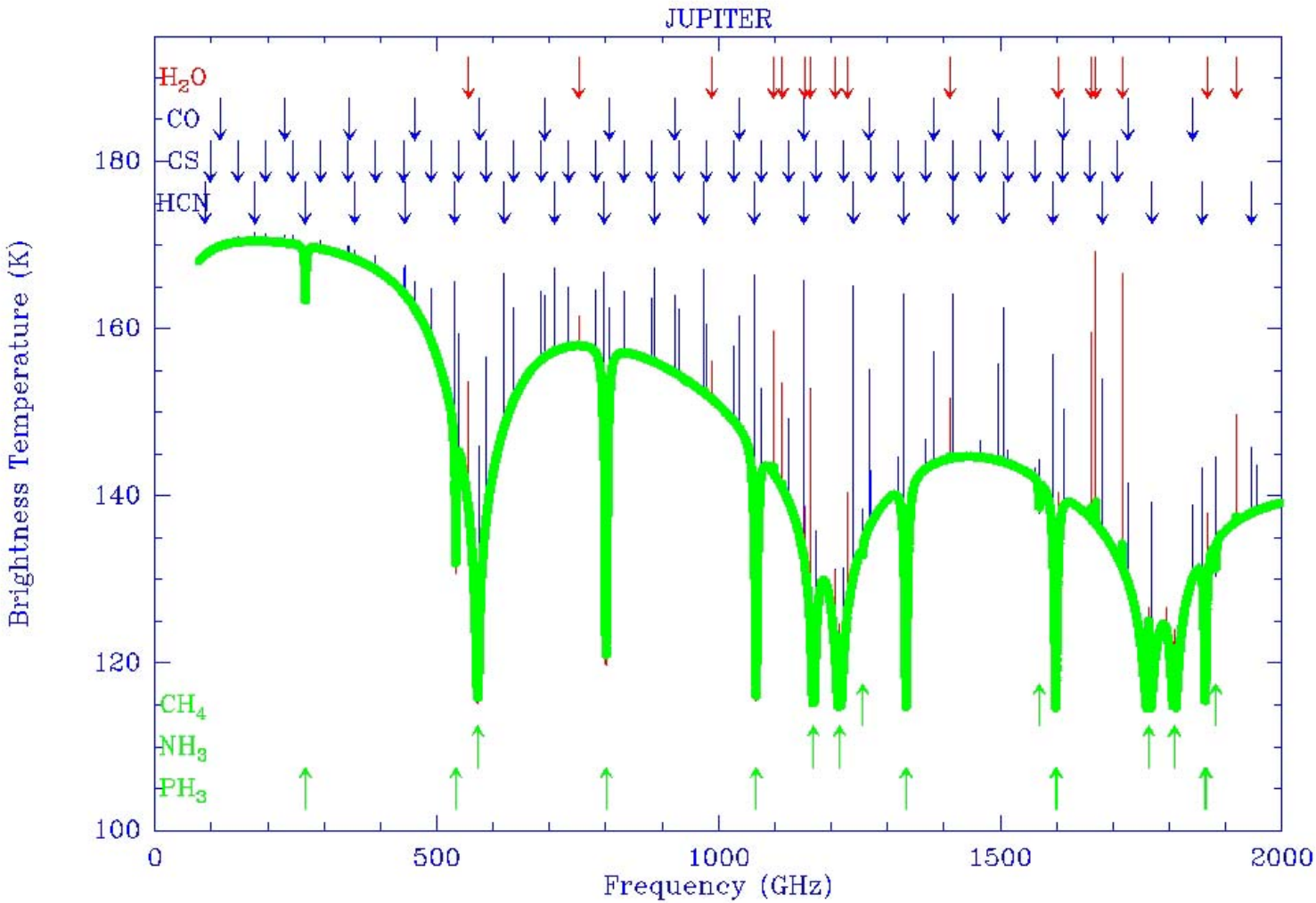
Jupiter mm spectrum



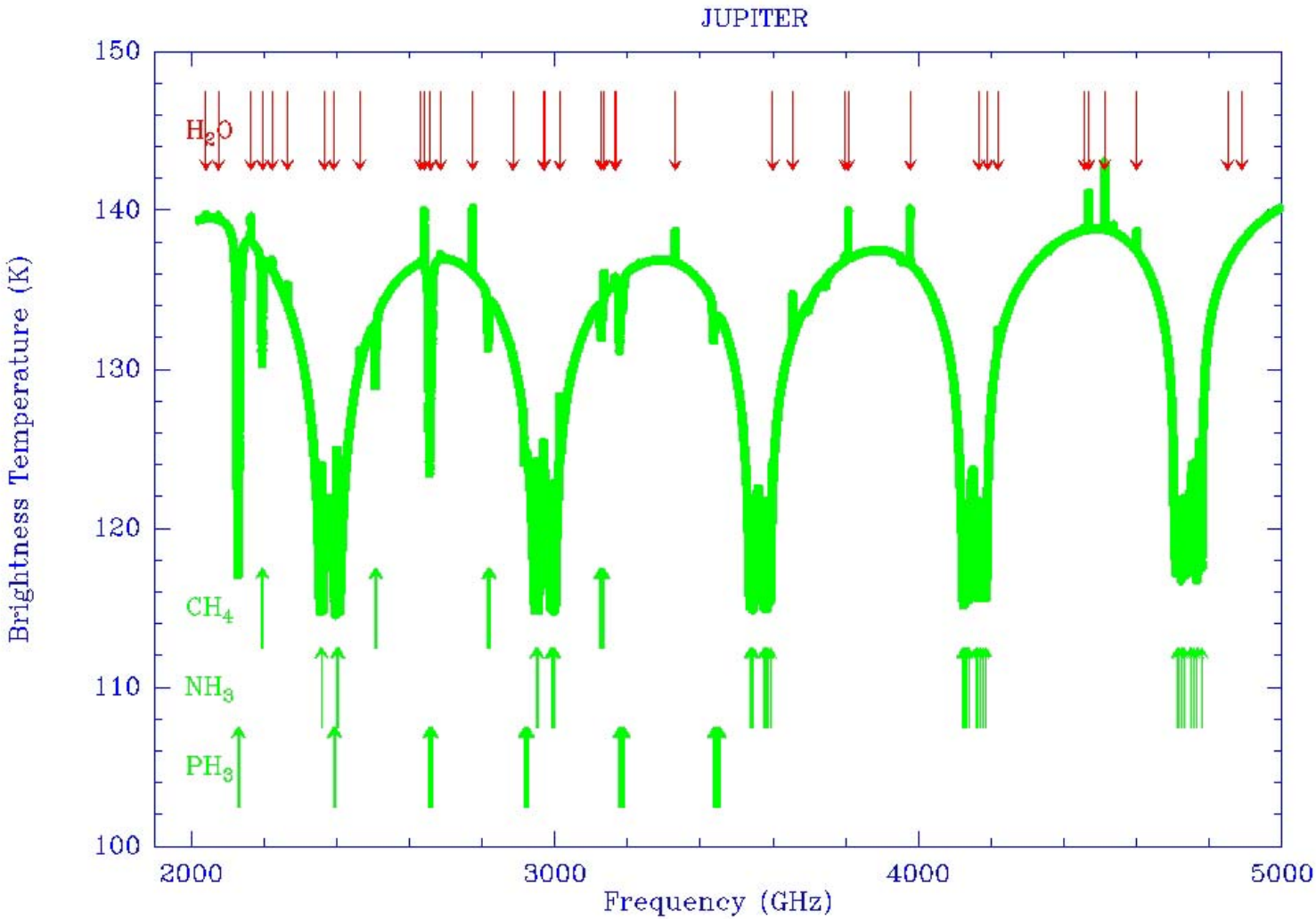
Saturn mm spectrum



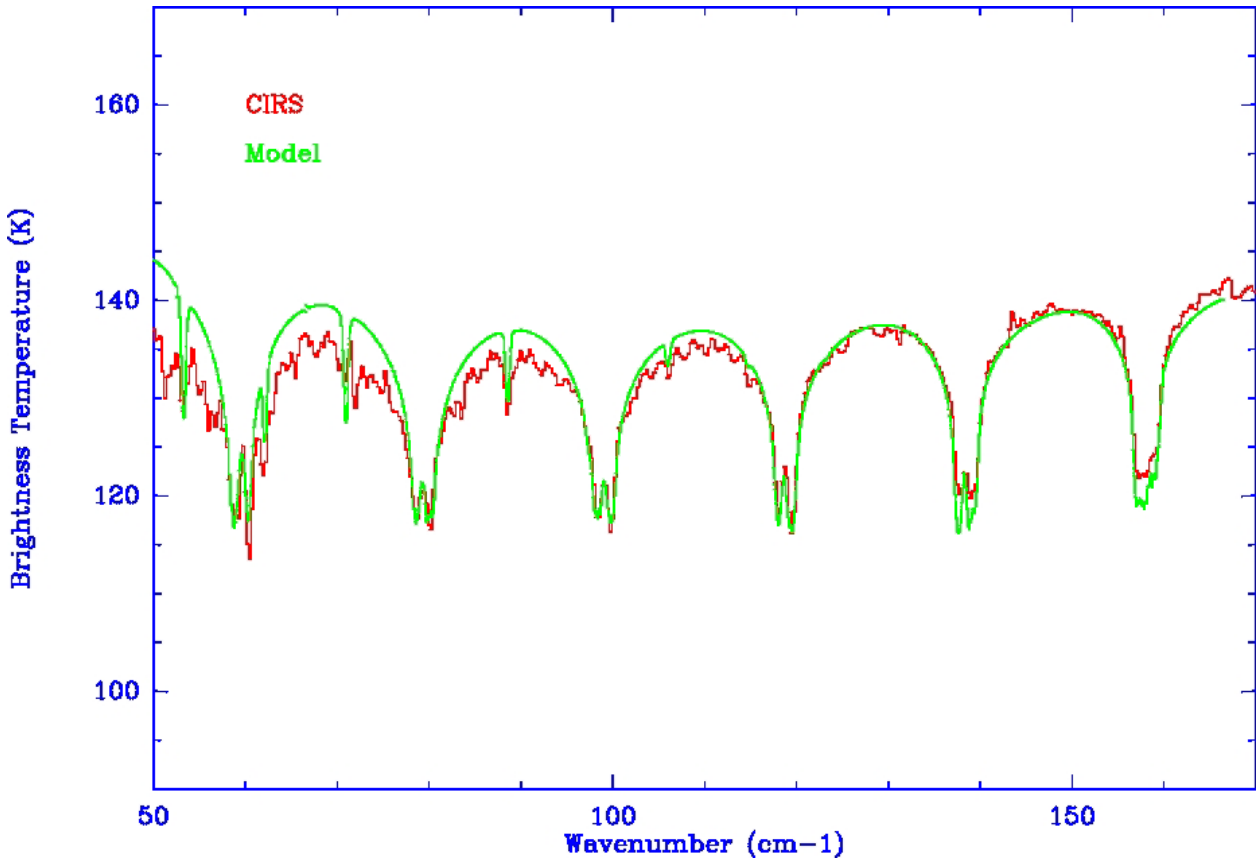
Jupiter submm spectrum



Jupiter FIR spectrum

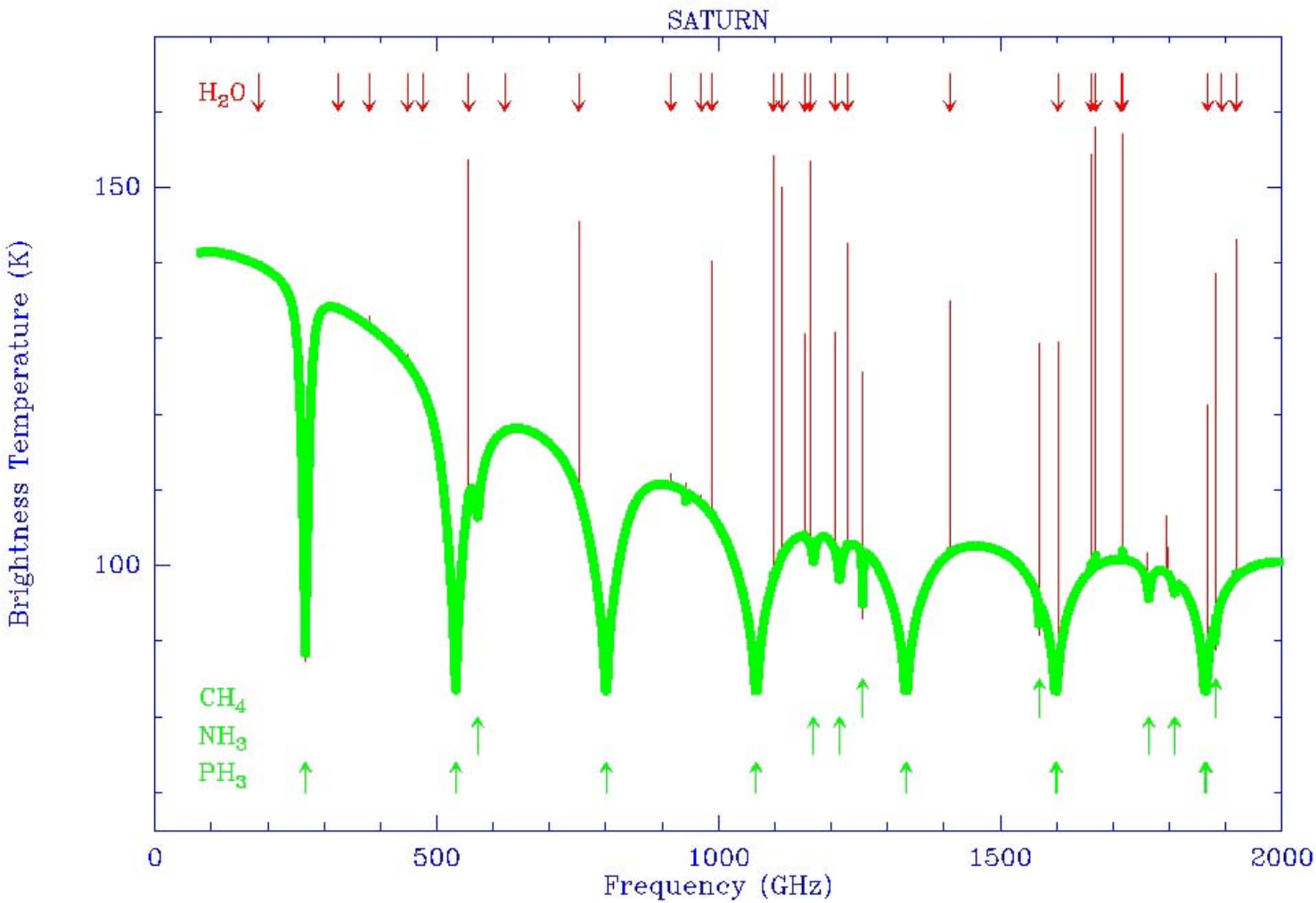


CIRS spectrum of Jupiter

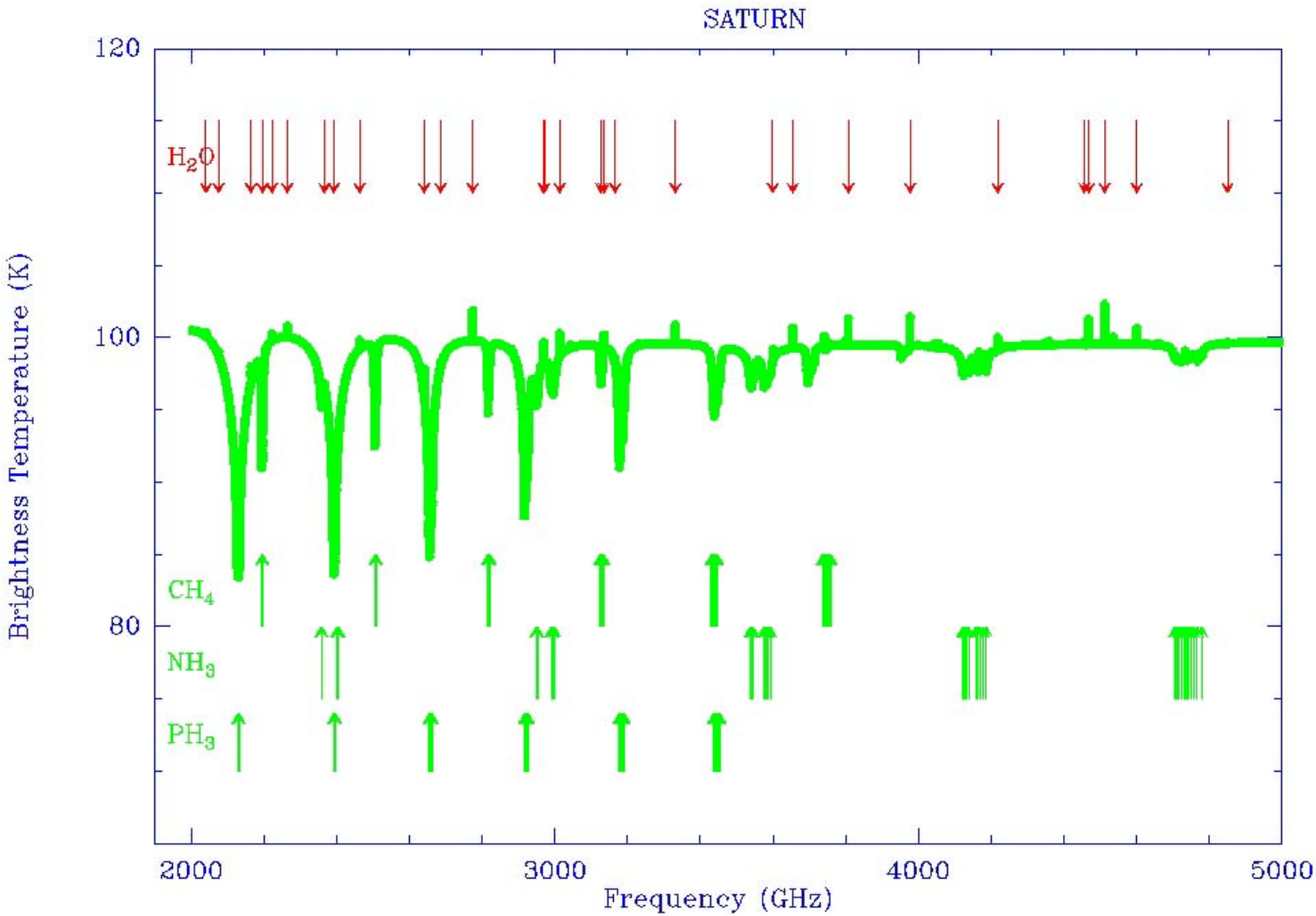


➔Improvement of Jupiter spectrum in the submm/FIR

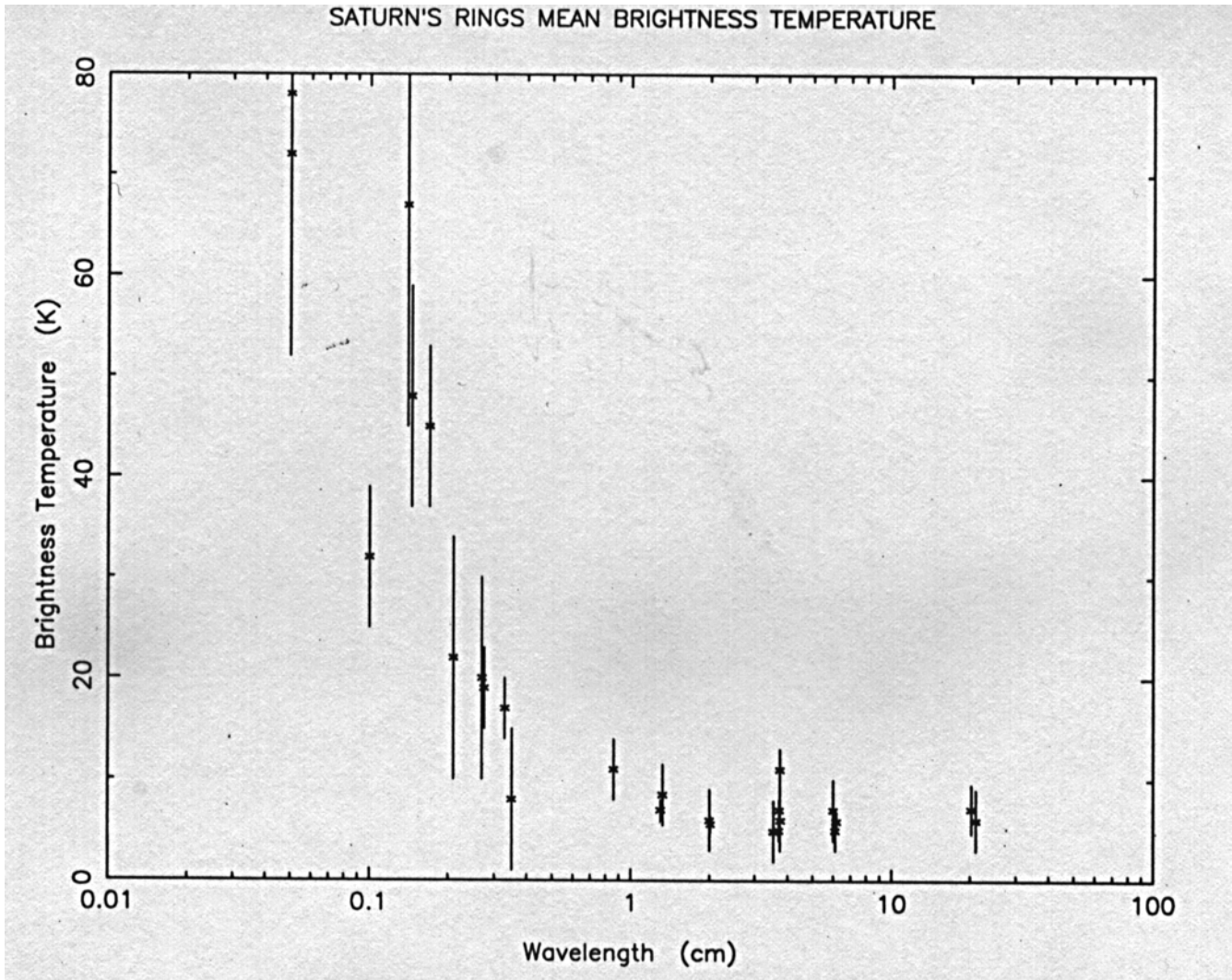
Saturn submm spectrum



Saturn FIR spectrum



Saturn's ring brightness in the submm



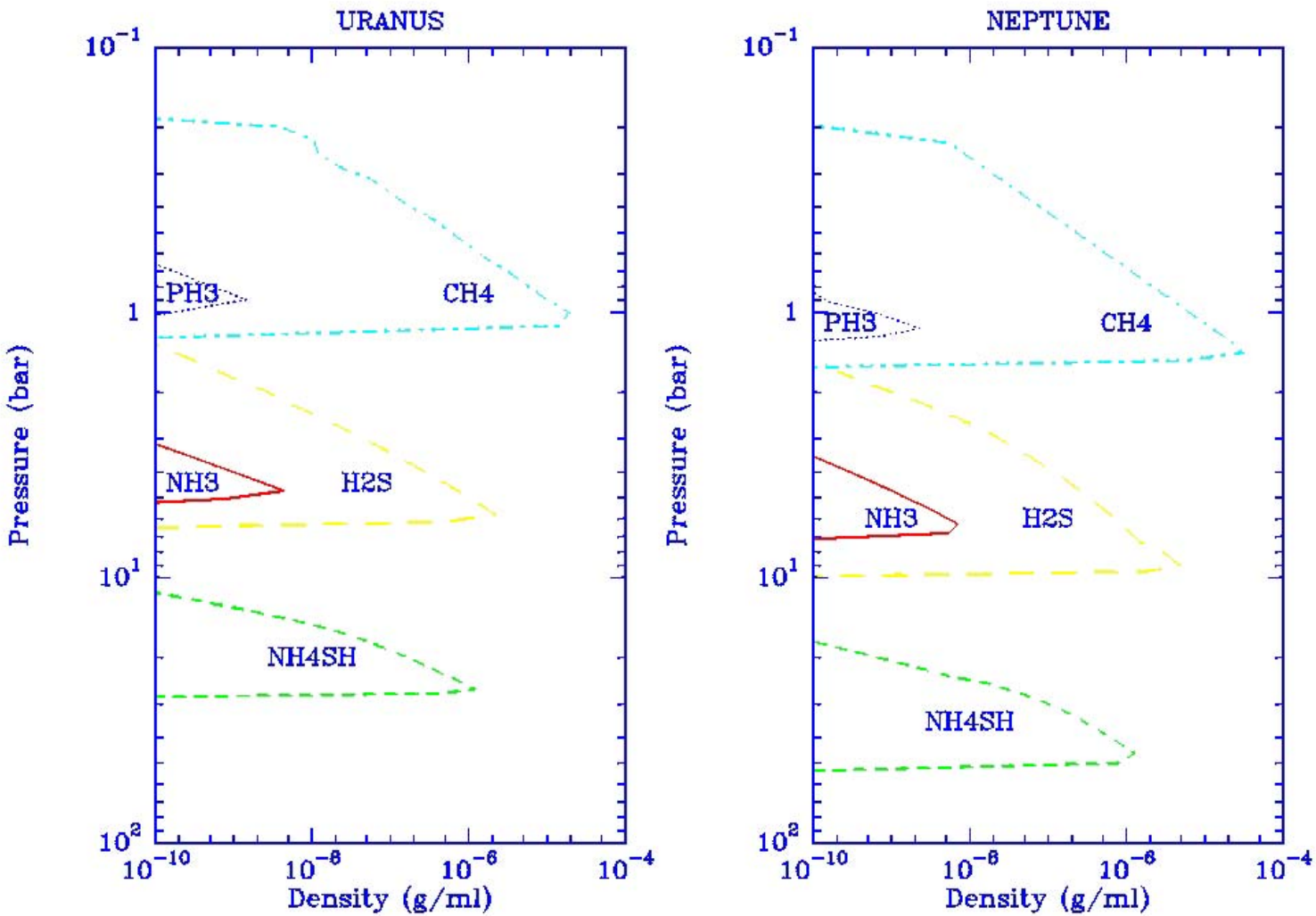
From De Pater 89

CIRS Spectrum of Saturn

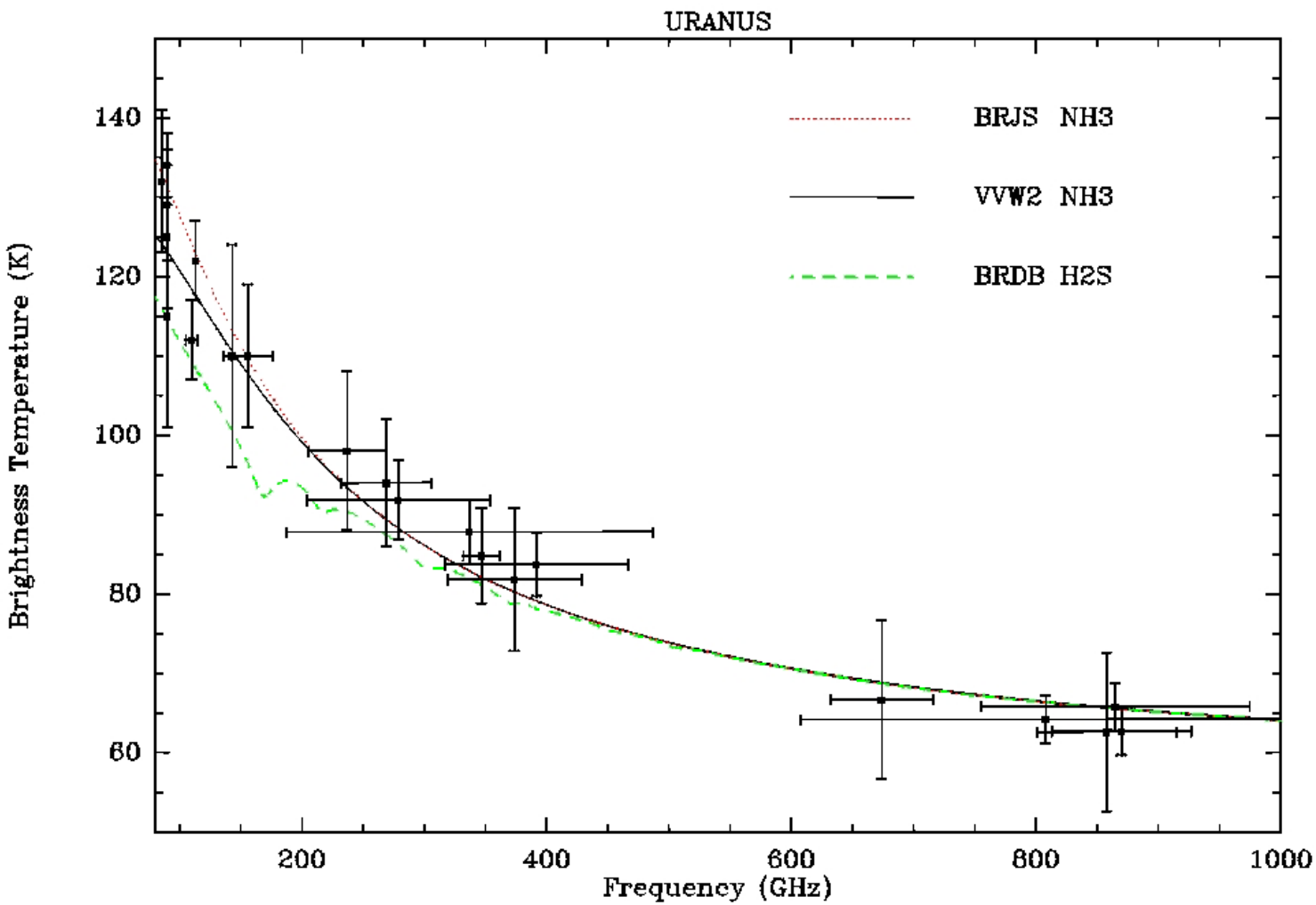
- Still not fully available/calibrated
- Work in progress by the Cassini/CIRS team
- Expected final calibration < 2 %
- Can be a very good reference spectrum

(with or without) rings

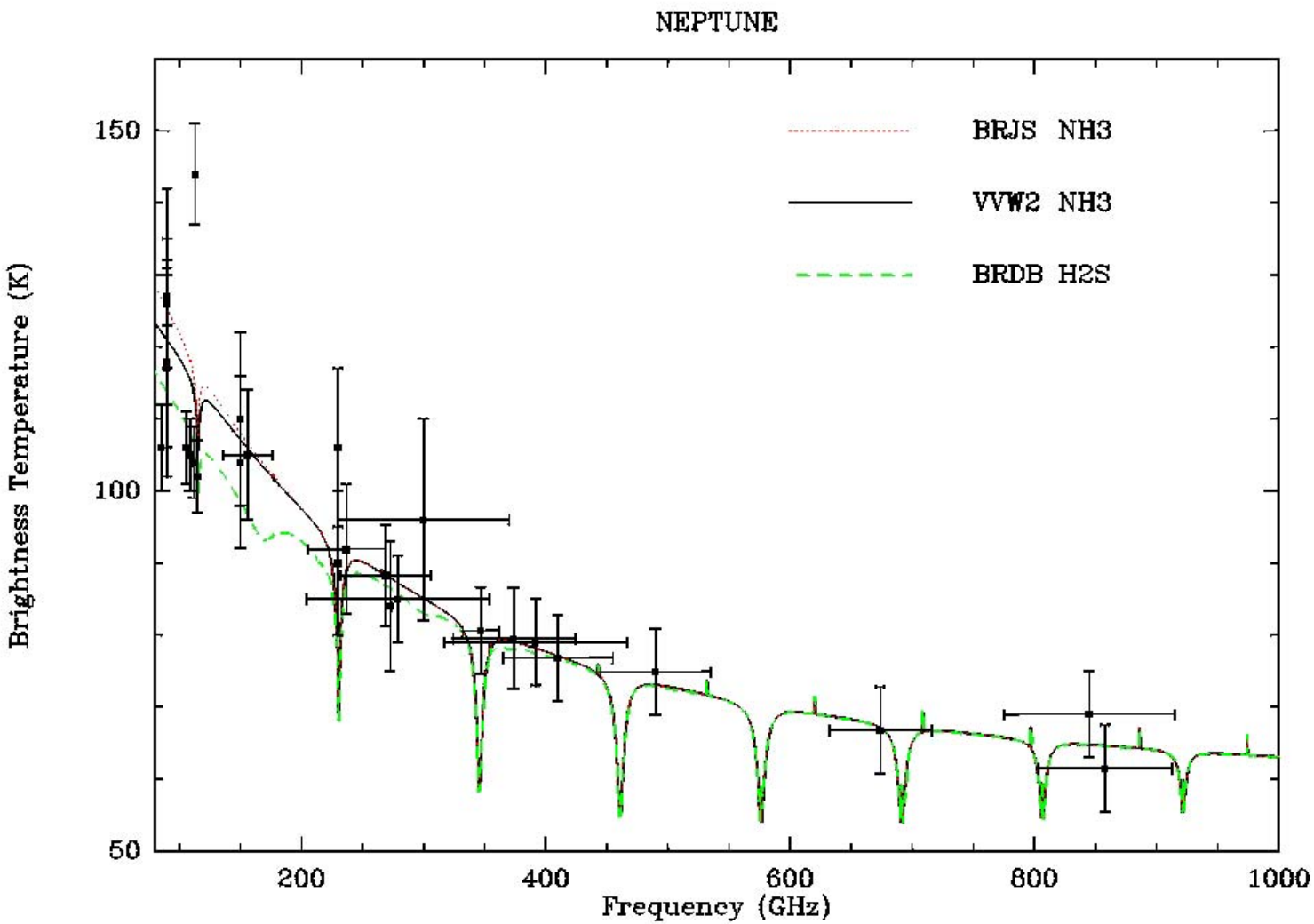
Uranus and Neptune Clouds



Uranus mm spectrum



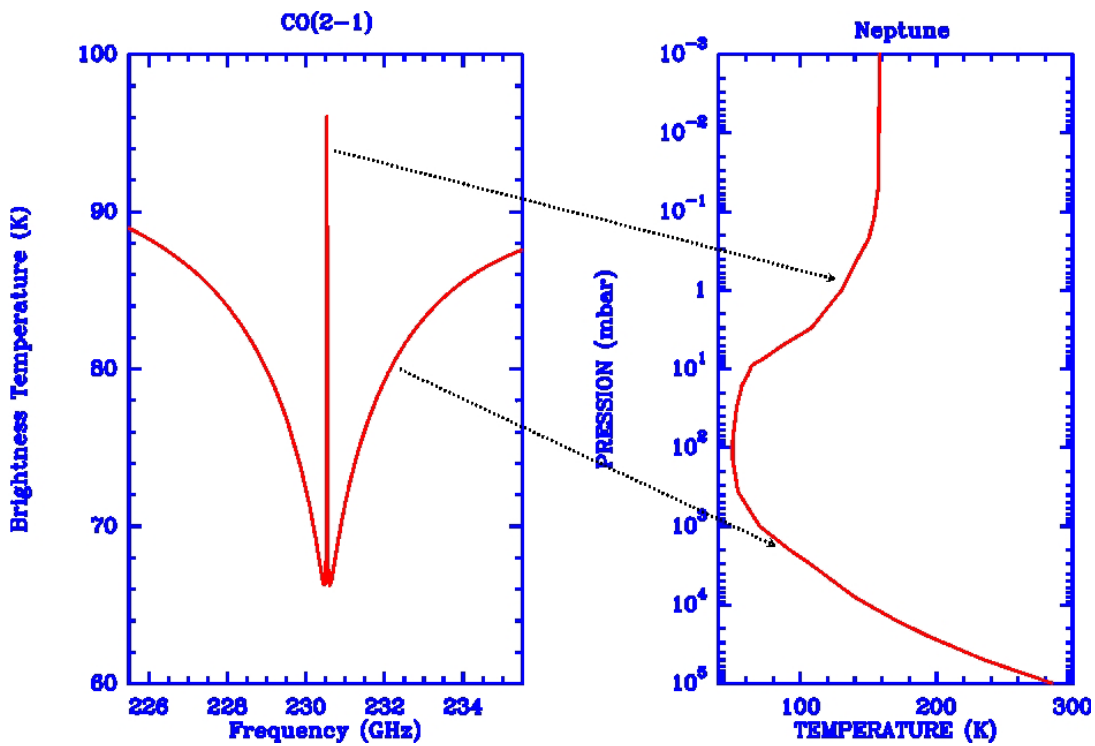
Neptune mm spectrum



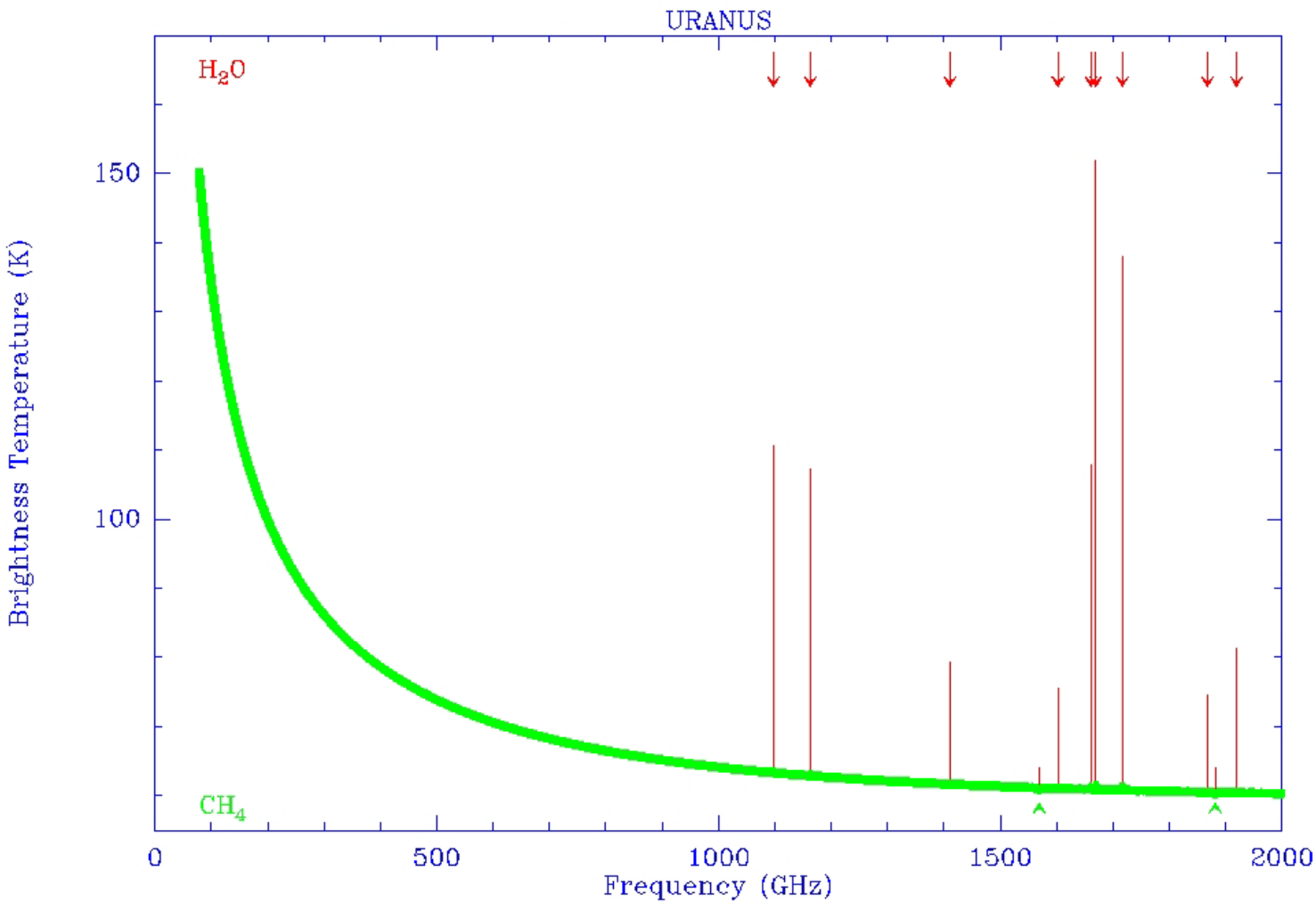
CO on Neptune

- Recently new observations of CO absorption lines at 230 and 350 GHz

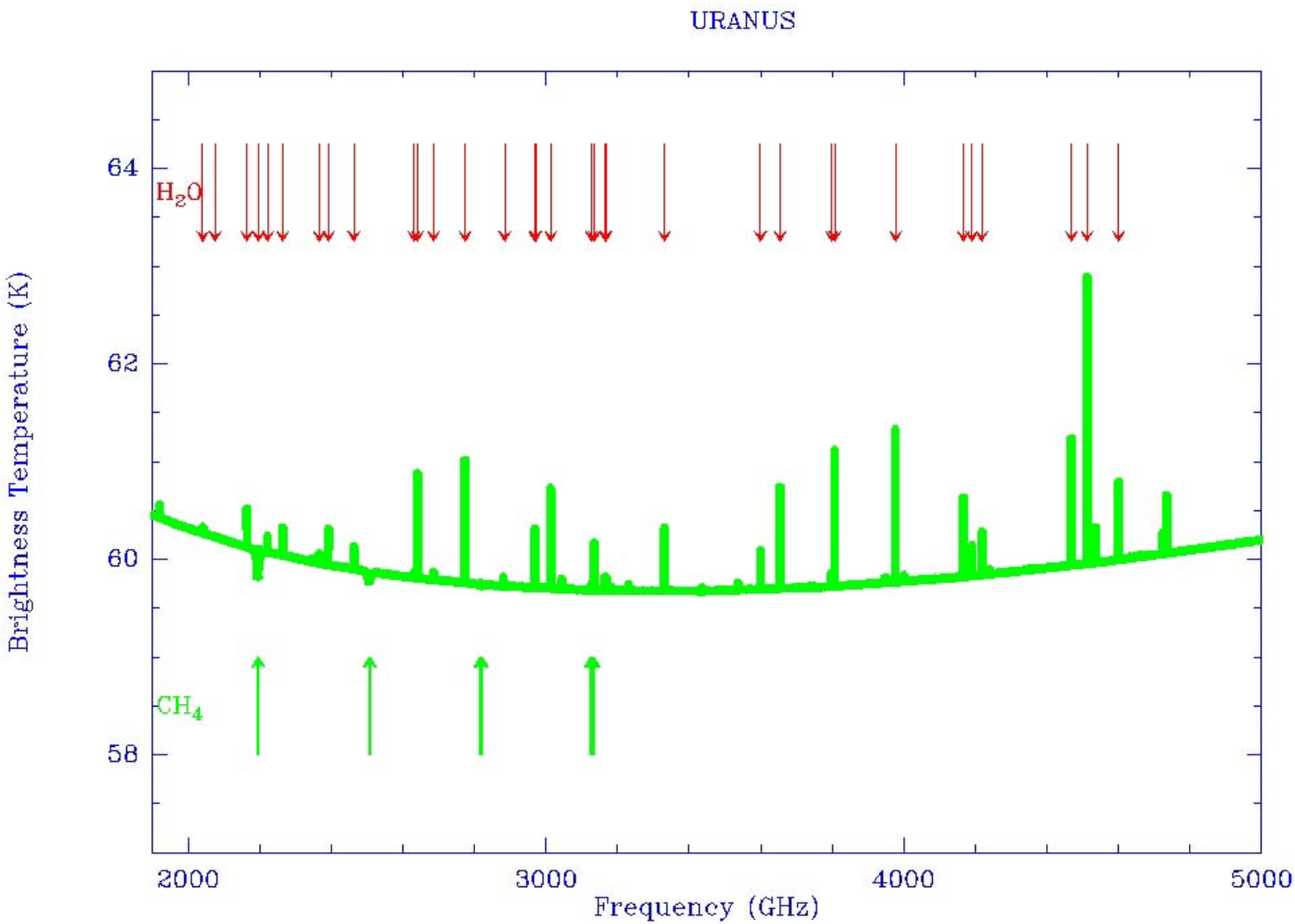
➔ Constraints on tropospheric CO and Thermal structure



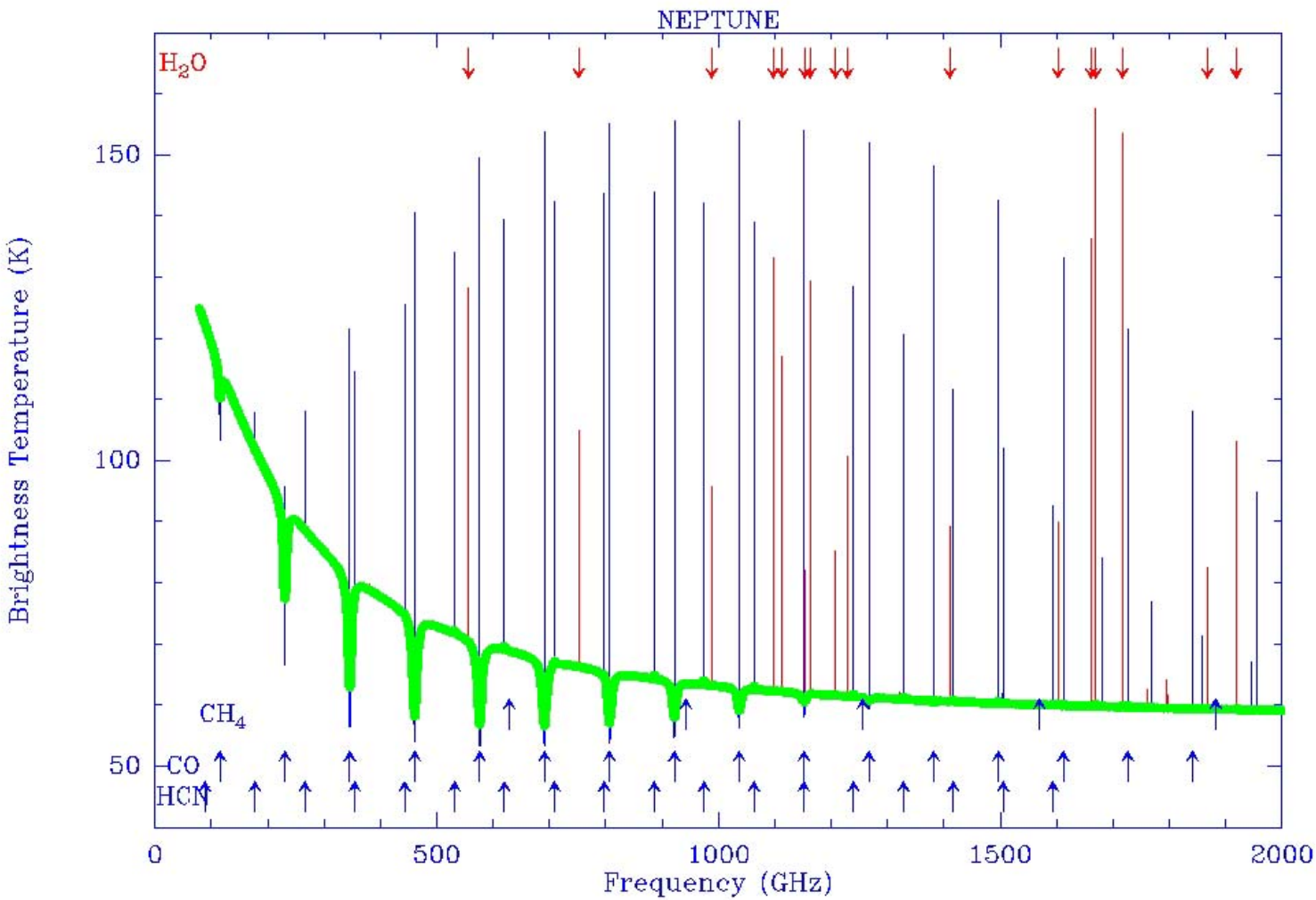
Uranus submm spectrum



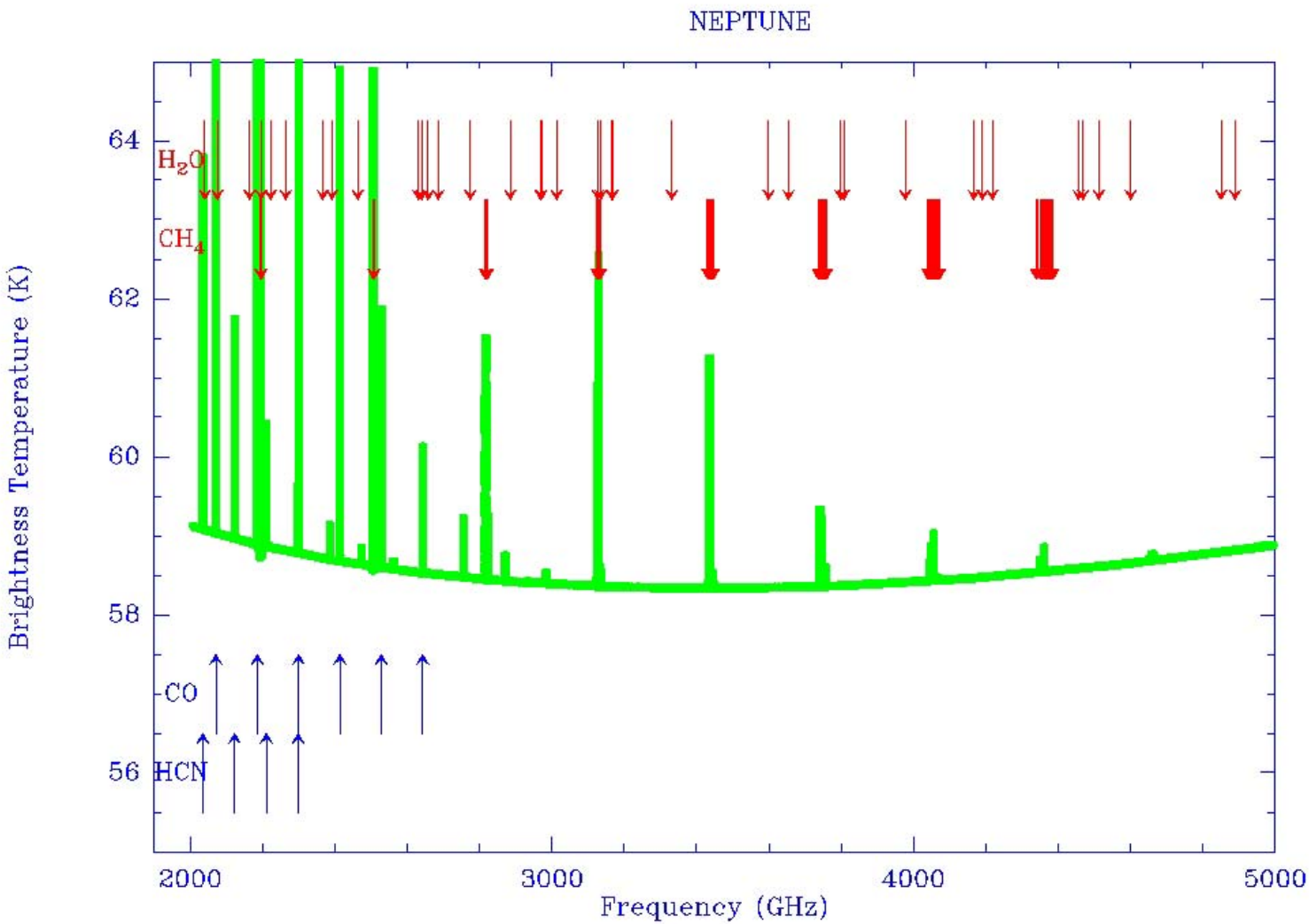
Uranus FIR spectrum



Neptune submm spectrum



Neptune FIR spectrum



Uranus-Neptune Model's Improvement

- ISO LWS and SWS spectra

➔Constraints on the Thermal structure and composition in the stratosphere

However data are Cross-calibrated :

LWS Flux Reference on Uranus: (Orton's Model)

- Accurate CO measurements on Neptune and CH_4 Observations with HERSCHEL

➔Constraints on tropospheric CO and CH_4 and Thermal structure

Conclusions

- Planets are well known/modelled in the submm/FIR

➔ Good Calibrators (uncertainties 5%)

- Improvement : Better knowledge of

-Thermal structure & Composition

-Cloud absorption in the submm/FIR (NH_3,CH_4,H_2S,PH_3)

- Measurement of the full submm/FIR spectum of Giant Planets (Herschel/Cassini) and Cross-calibration with Mars