LOFAR observations of Saturn's atmosphere

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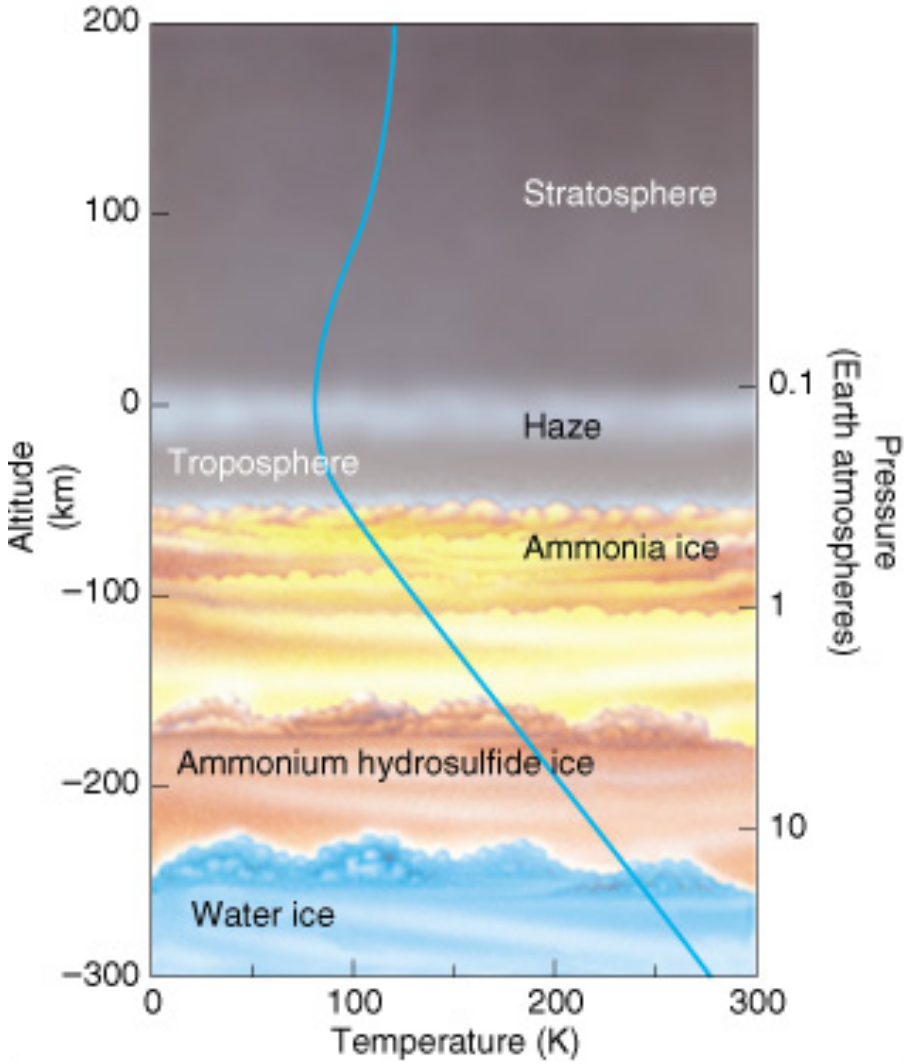
Science objectives

- Determine the deep atmospheric water vapor abundance, hence the O/H ratio in Saturn's interior
- Obtain better constraints for interior models of Saturn, *i.e.* the contribution of H_2O to the heavy-element component (z)
- Check the prediction of a negligible level of synchrotron radiation
- Assess the existence of a weakly-ionized region below 30 kbar

Saturn's observable atmosphere from the UV to the microwave domains



Radiative transfer in Saturn's atmosphere

•LOFAR measures the brightness temperature $T_b(\nu)$ at low frequency

•T_b is equal to the integral over altitude of the product of the local kinetic temperature by the so-called weighting function (or contribution function):

$$T_b = \int_z T(z') \times wf(z')\, dz'$$

with $wf(z') = e^{-\tau} \times \delta\tau/\delta z'$

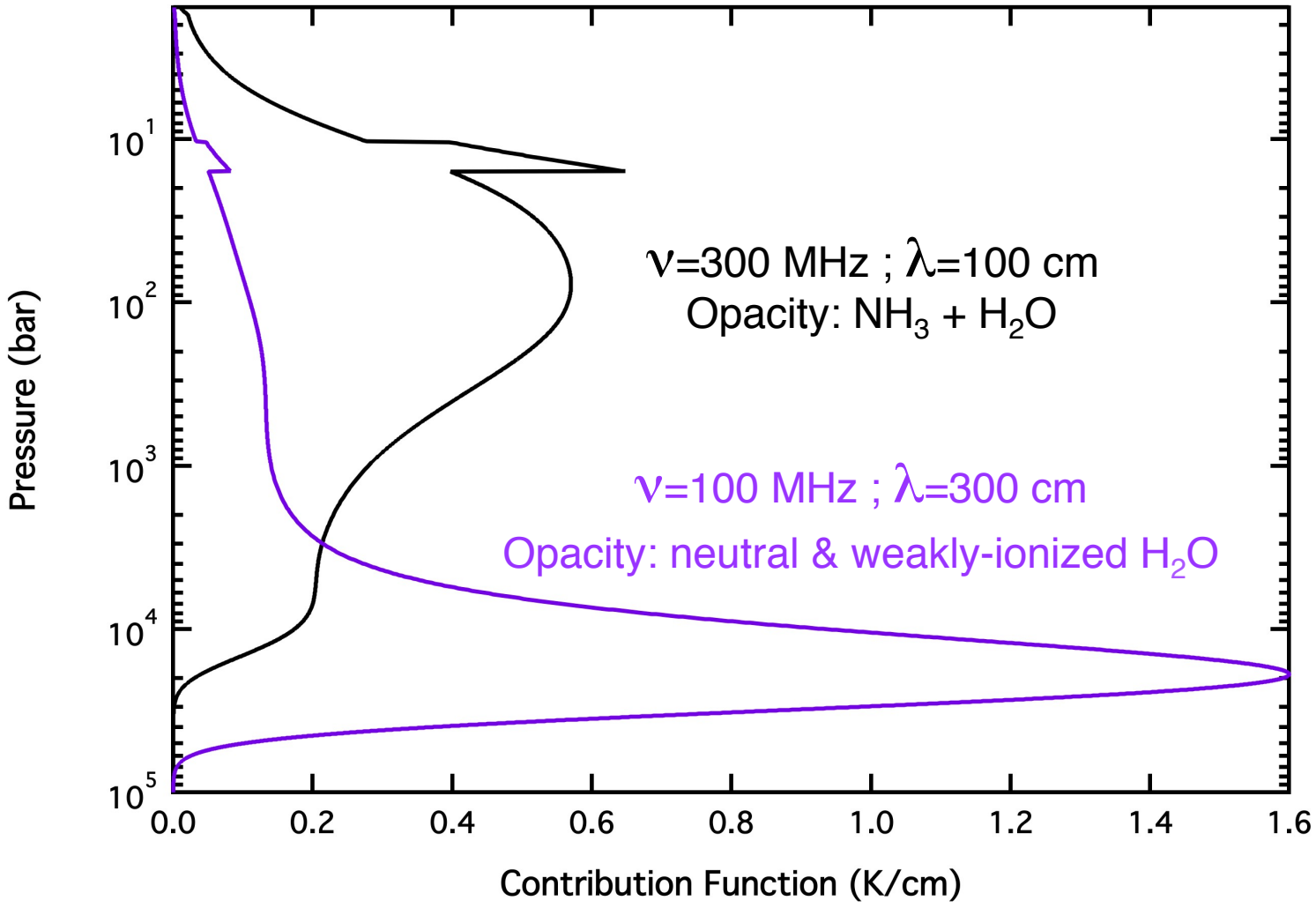
and $\tau = \int_z \alpha(z')\, dz'$

where τ is the optical depth and α is the radiative absorption coefficient

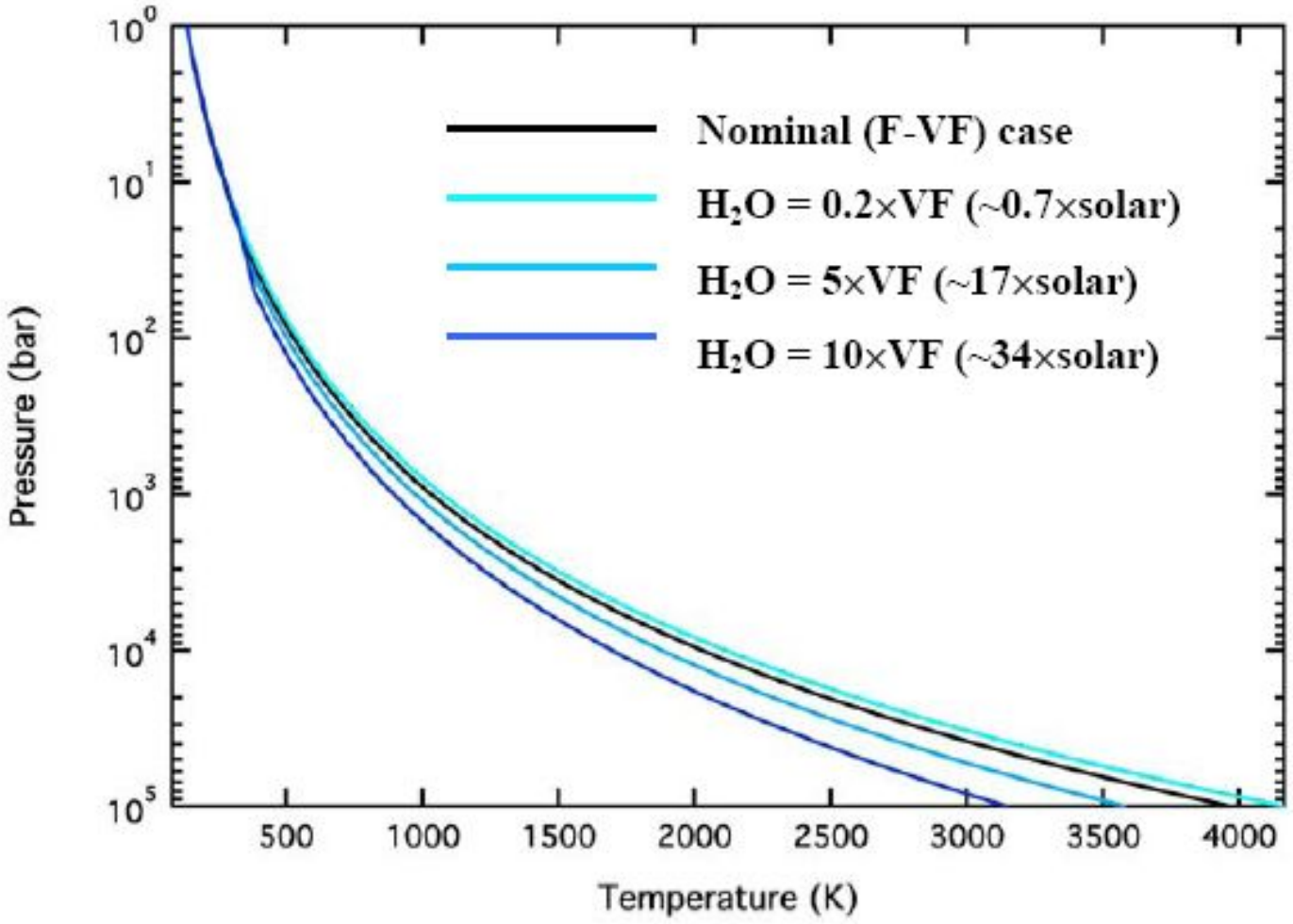
Barbier-Eddington approximation: $T_b(\nu) = T(\tau(\nu)=1)$

T_b is thus the mathematical image of the atmospheric temperature

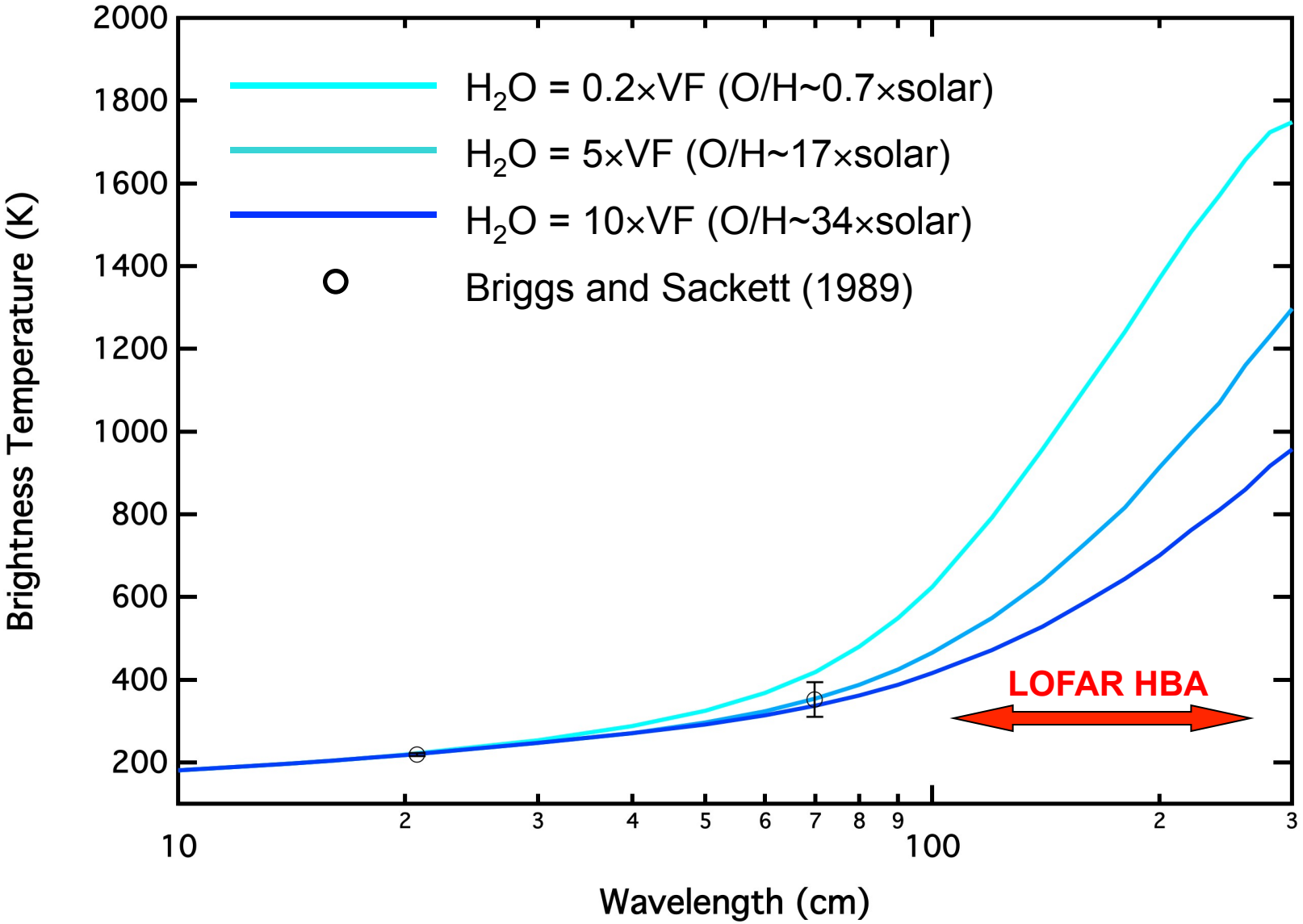
LOFAR is expected to probe much deeper in Saturn's atmosphere down to pressures of a few kbar



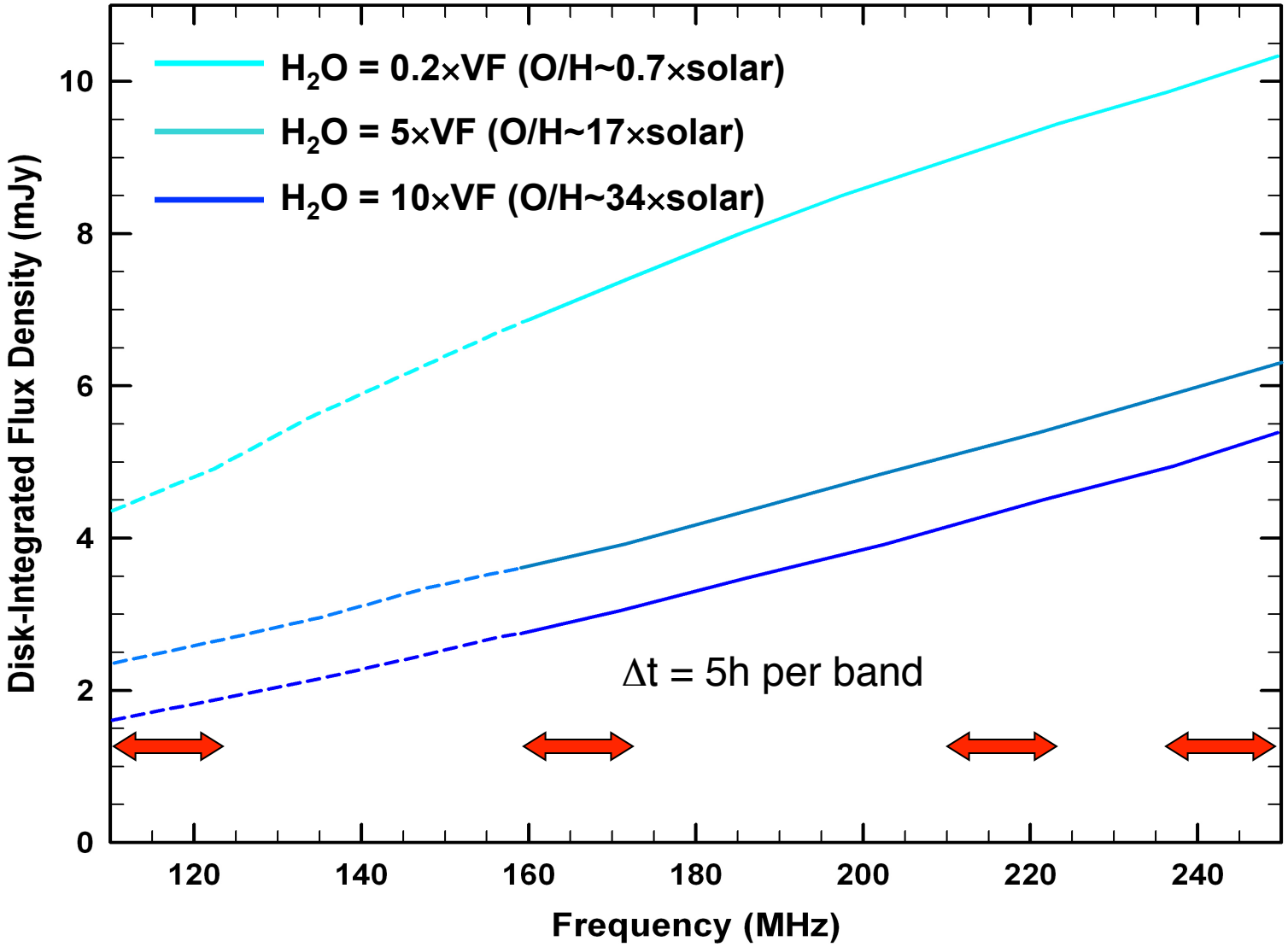
Saturn's temperature profile as a function of the H_2O abundance



Saturn's brightness temperature spectrum between 10 cm and 300 cm

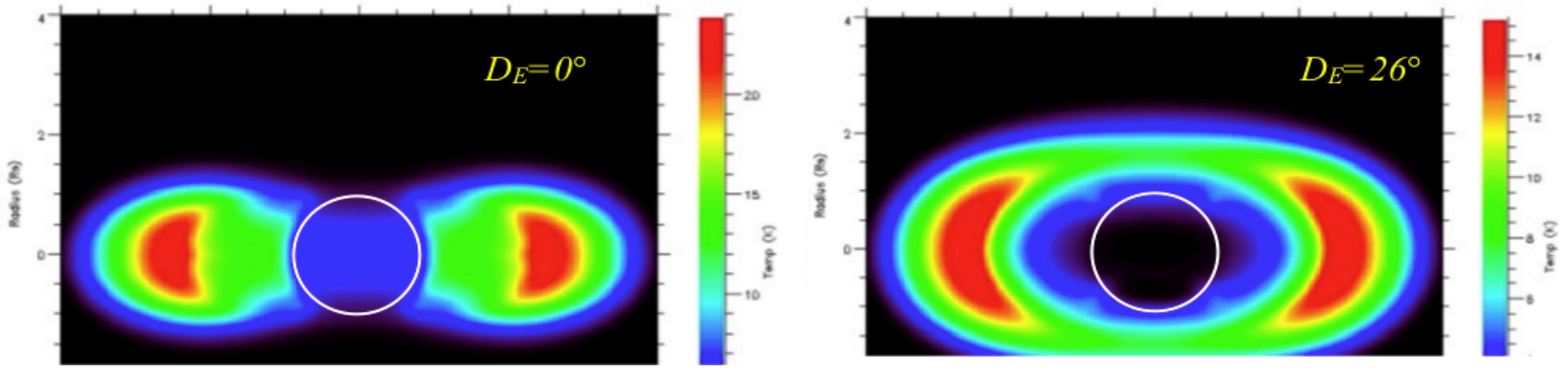


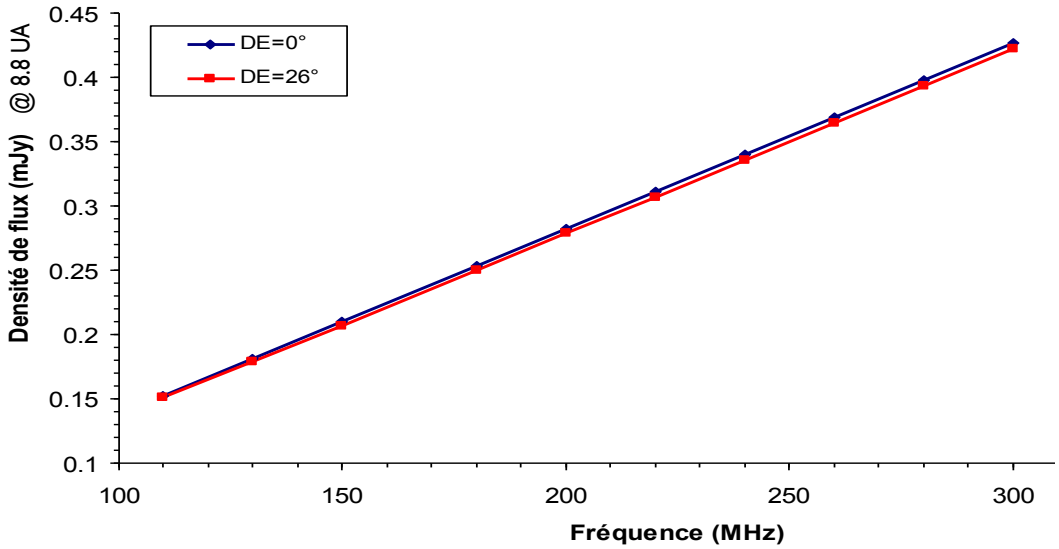
Saturn's disk-integrated flux density in the LOFAR HBA range



Modeled synchrotron radiation in the LOFAR HBA range

- Cassini particle measurements → ONERA code Salammbô-3D
  → particle fluxes around Saturn
  → predicted distribution & spectrum of synchrotron radiation





Conclusions

- good signal-to-noise is expected at least in 3 of the bands above 160 MHz (160-172 + 210-222 + 238-250 MHz)

- a 10% accuracy should allow us to discriminate between "under-solar" and "over-solar" H_2O distributions

- the accuracy of the O/H determination will strongly depend on the quality of the imaging processing and calibration

LOFAR Proposal

A determination of the abundance of water in Saturn's deep atmosphere with LOFAR

Observation request of the Planets-Exoplanets Working Group (PEWG) on behalf of LOFAR's Transients Key Project (TKP), under the umbrella of the LRA12A004 Transients proposal

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Team Members' Specialties

Saturn's Atmosphere & Interior / LOFAR Imaging / Saturn's Synchrotron Radiation