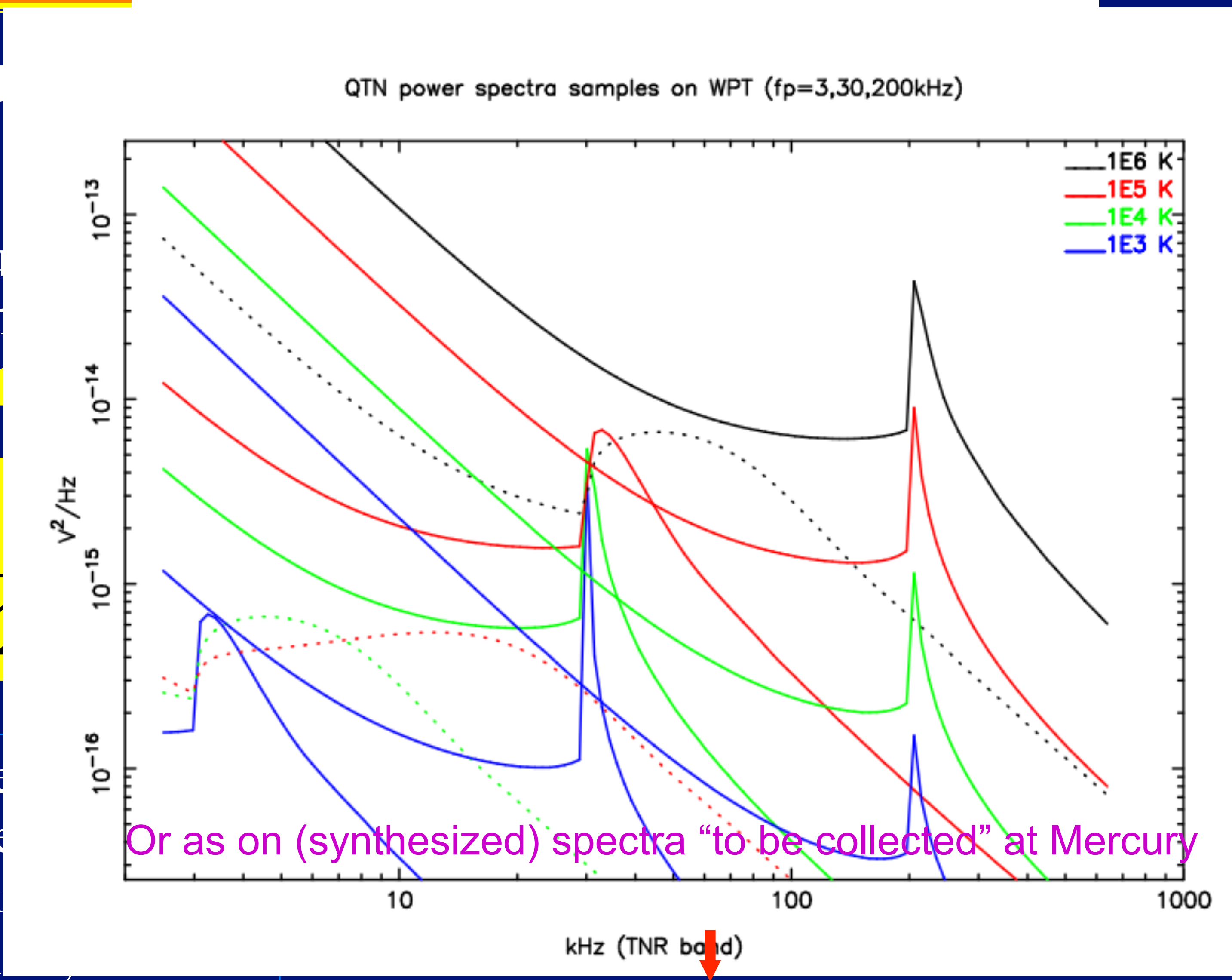
Global studies: Waves and electric fields

In order to und
important

✓ such a measu
electron den
The q

$$V_{\omega}^{2} = \frac{}{(2}$$

Antenna response
electrostatic wave
depends on anten
antenna direction



Measurement of n_e and T_e

Global studies: Waves and electric fields

•**Passive el**

• **Method**

• Very **acc**

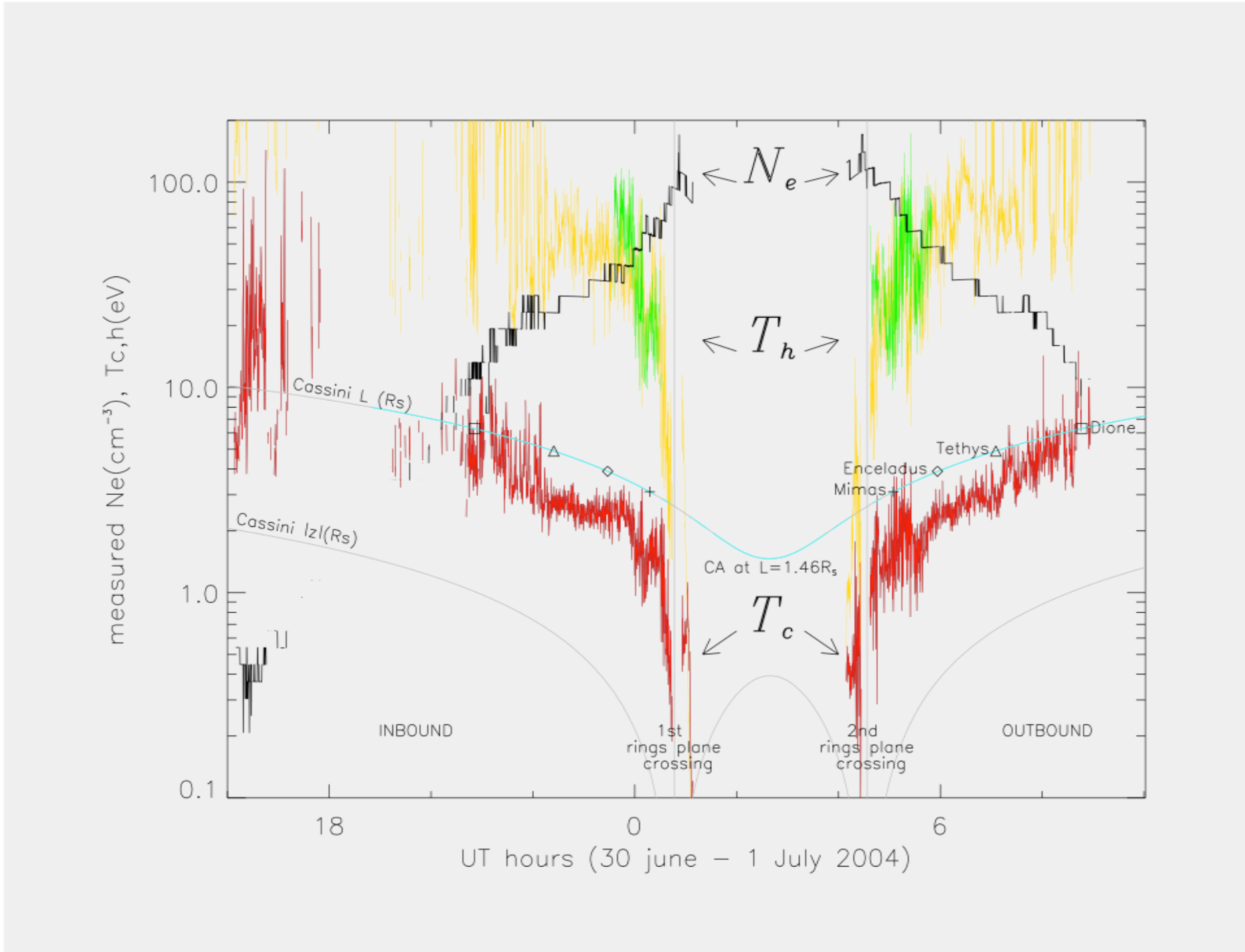
r

wind (Ulys s

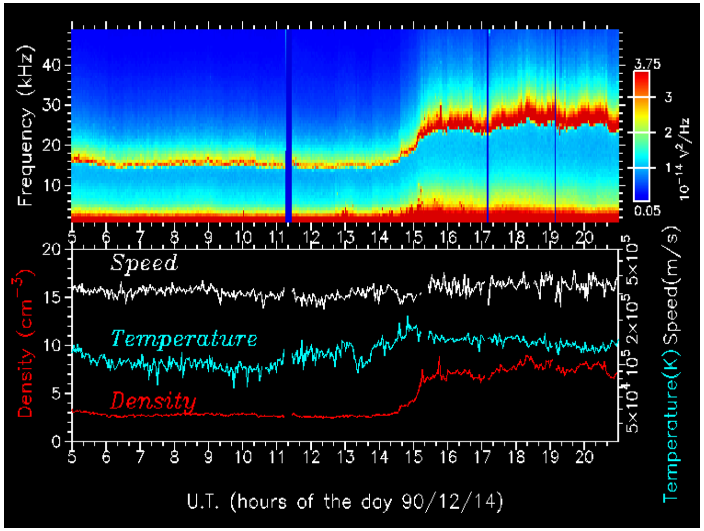
Ionosphere e

(Wind, Ima s

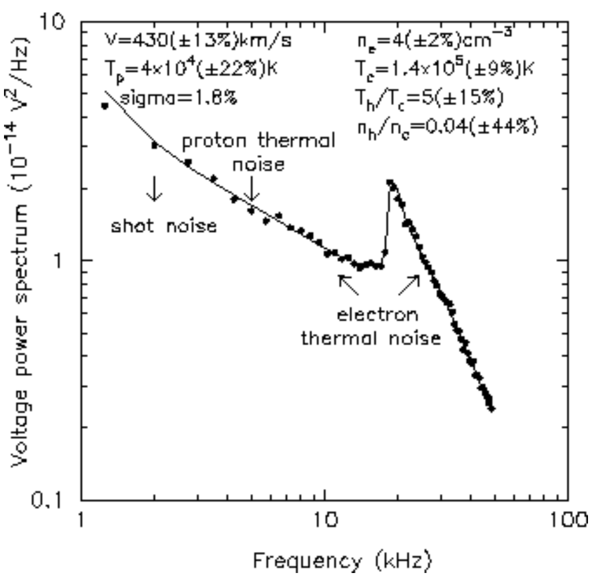
torus (Cassi

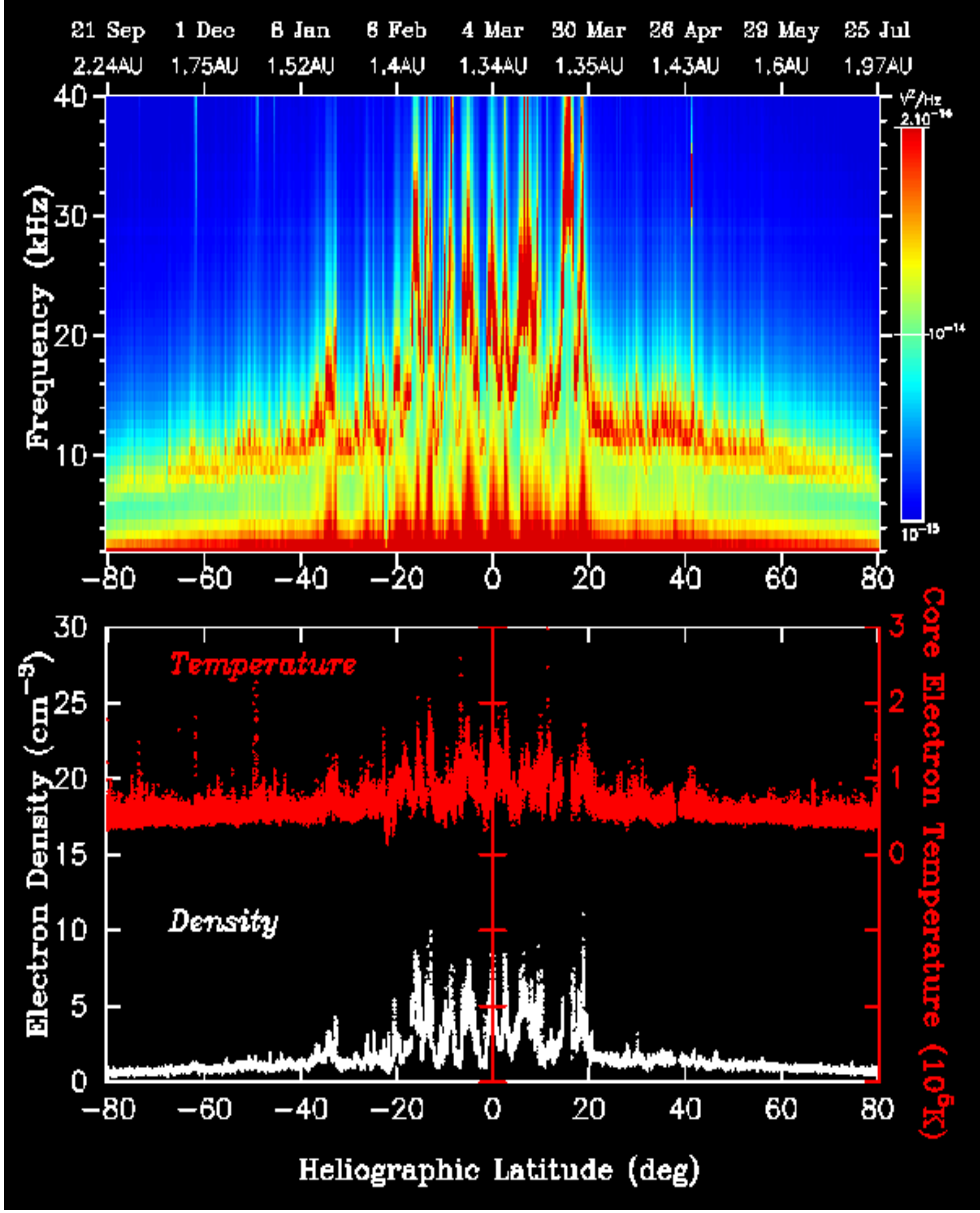


From M. Moncuquet et al,, *GRL*, *VOL. 32, L20S02, 2005*



From the Ulysses spectra
to solar wind plasma parameters





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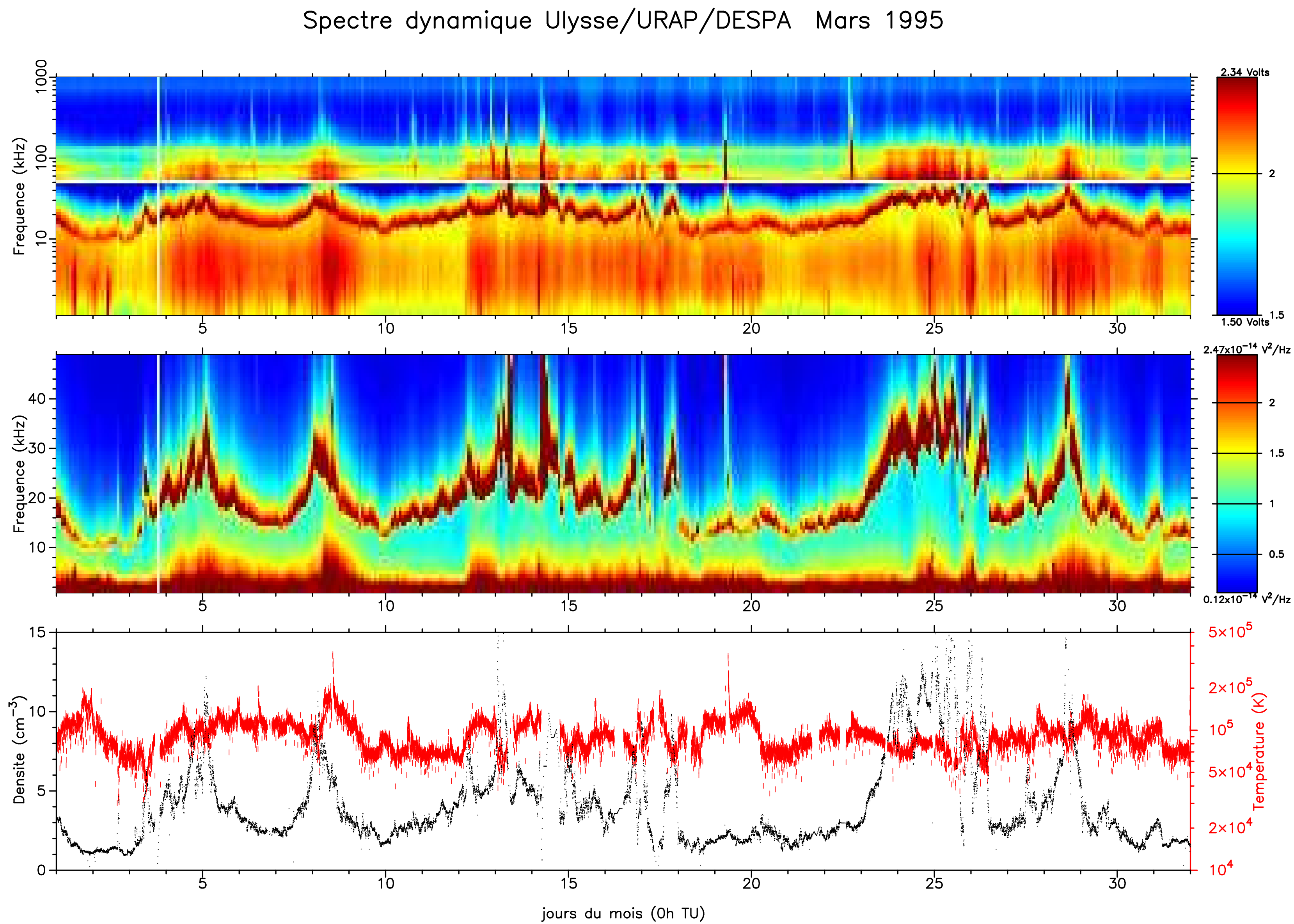

Workshop QTN 7-8
March 2014

M. Moncuquet

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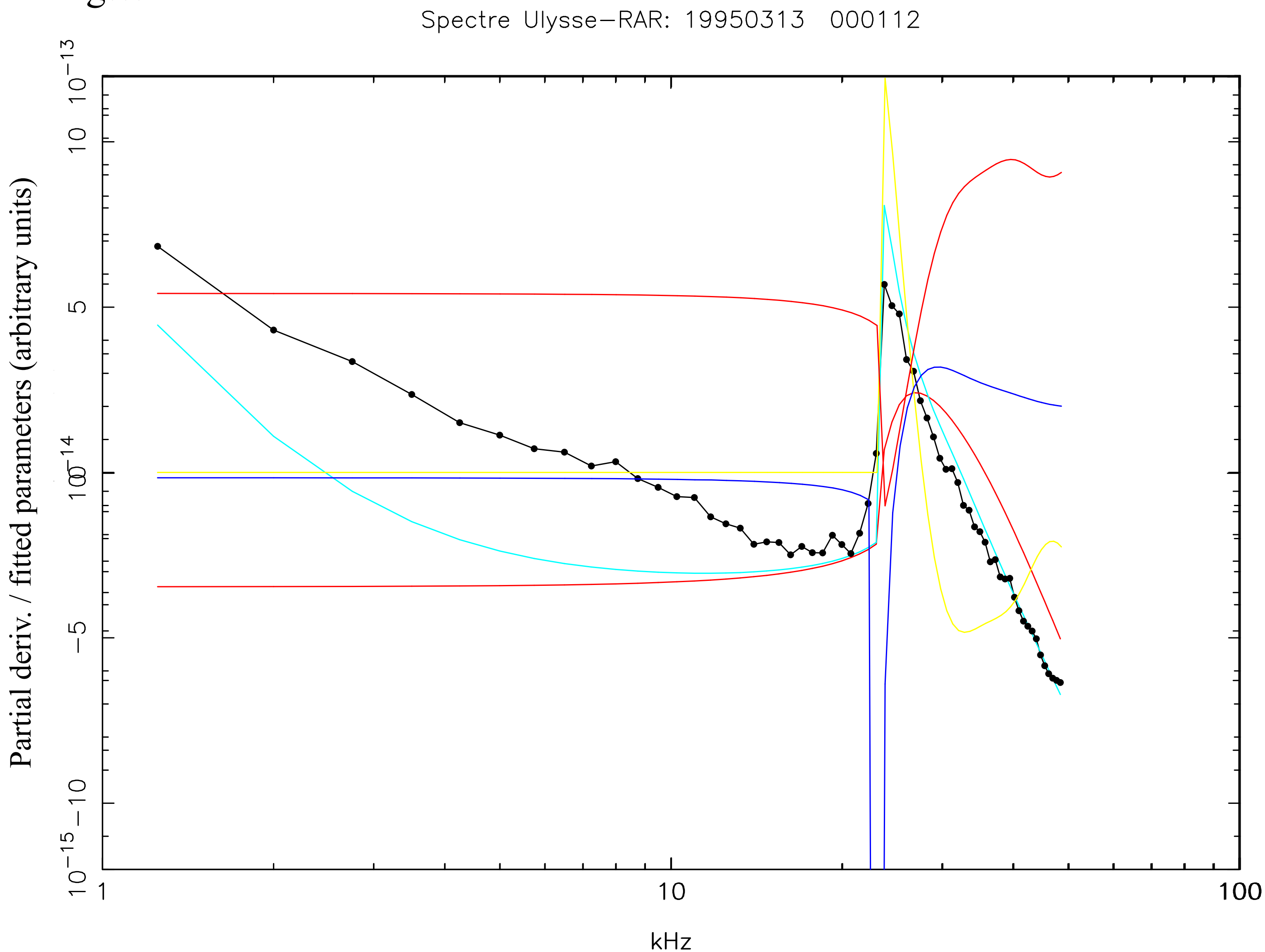
About fitting…



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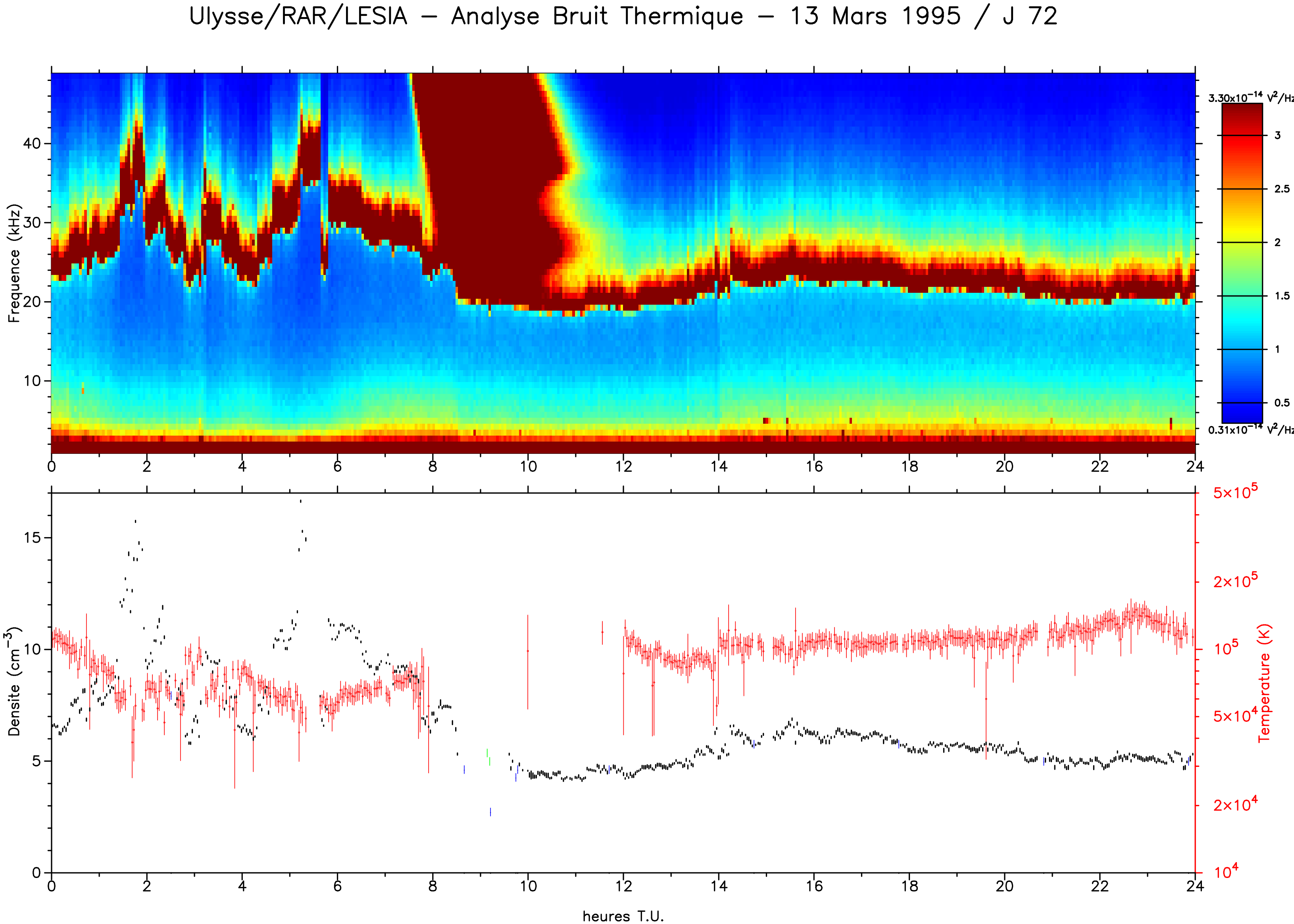
About onboard QTN diagnostic …



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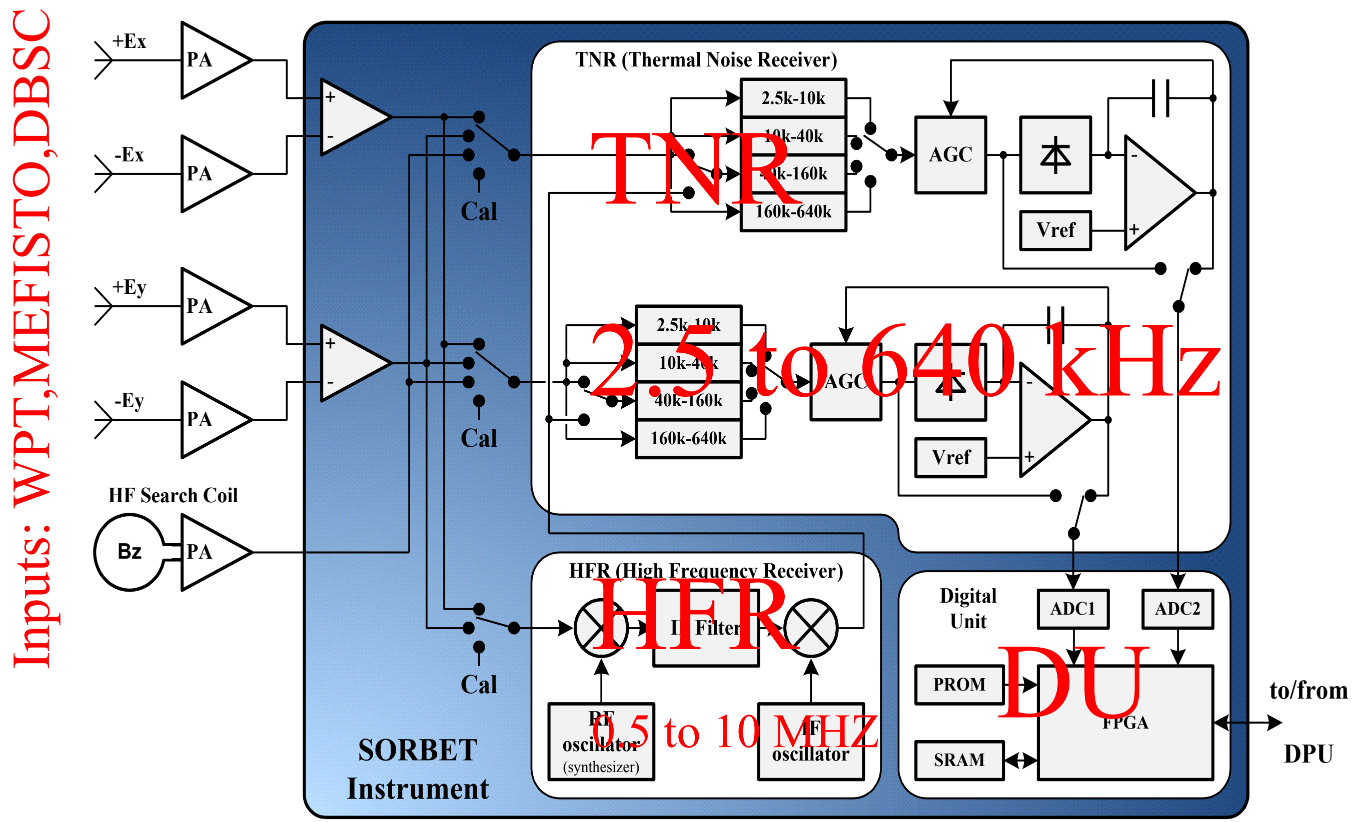
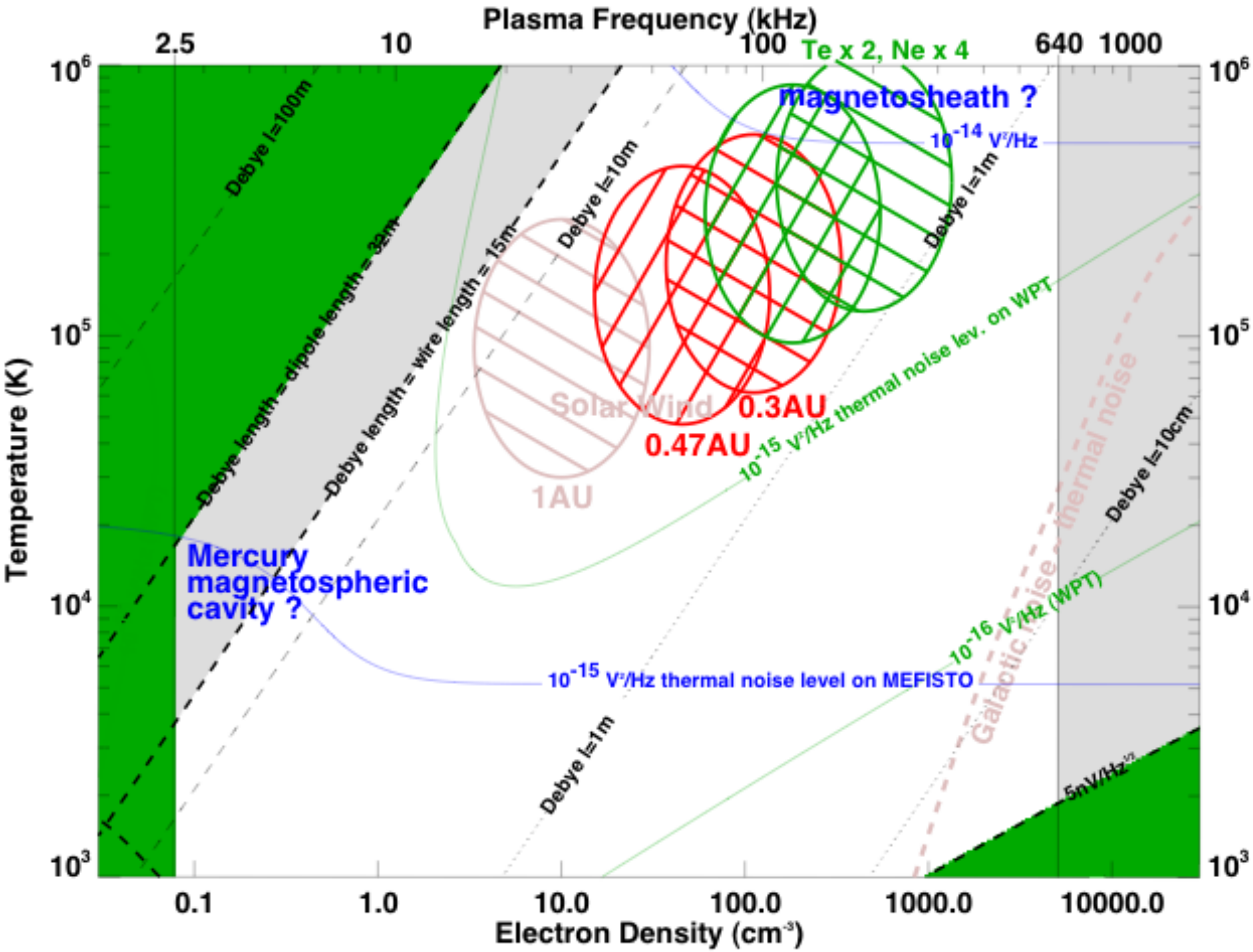
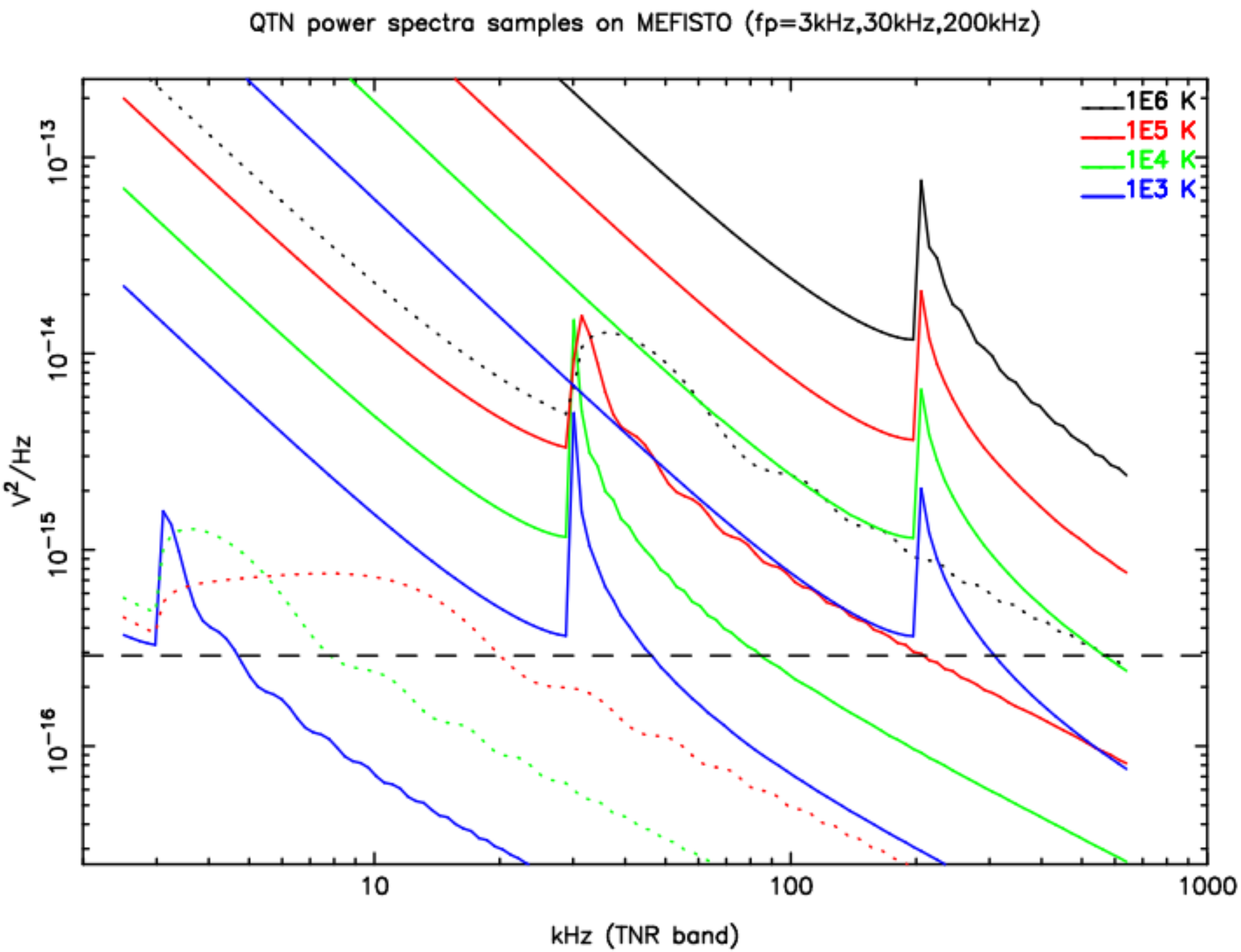
Now, few words about QTN plan on BepiColombo

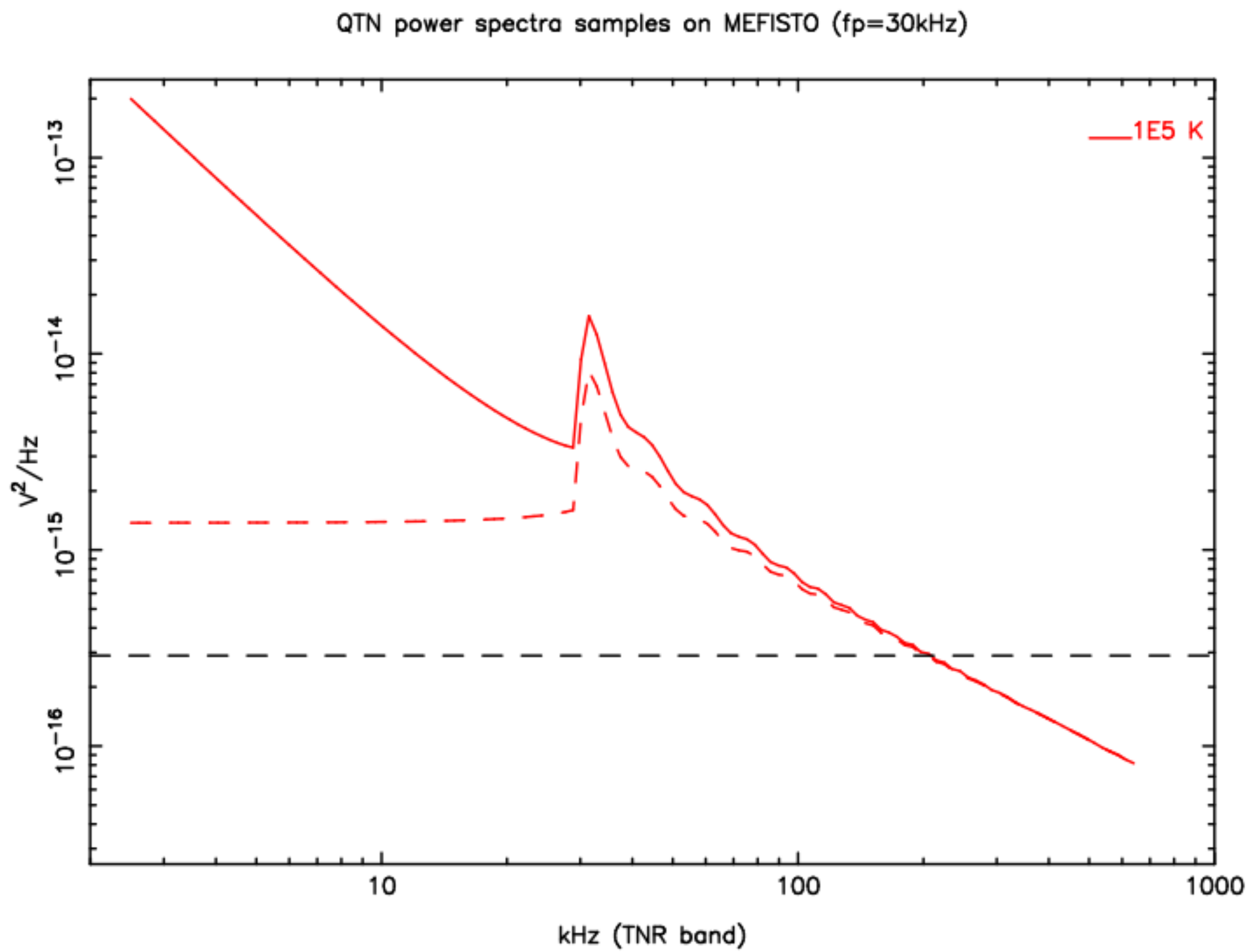
Sorbet is a medium and high frequency spectrometer in the range 2.5kHz to ~10 MHz

with 4 bands of 32 freq from 2.5 to 640 kHz and two channels operable simultaneously

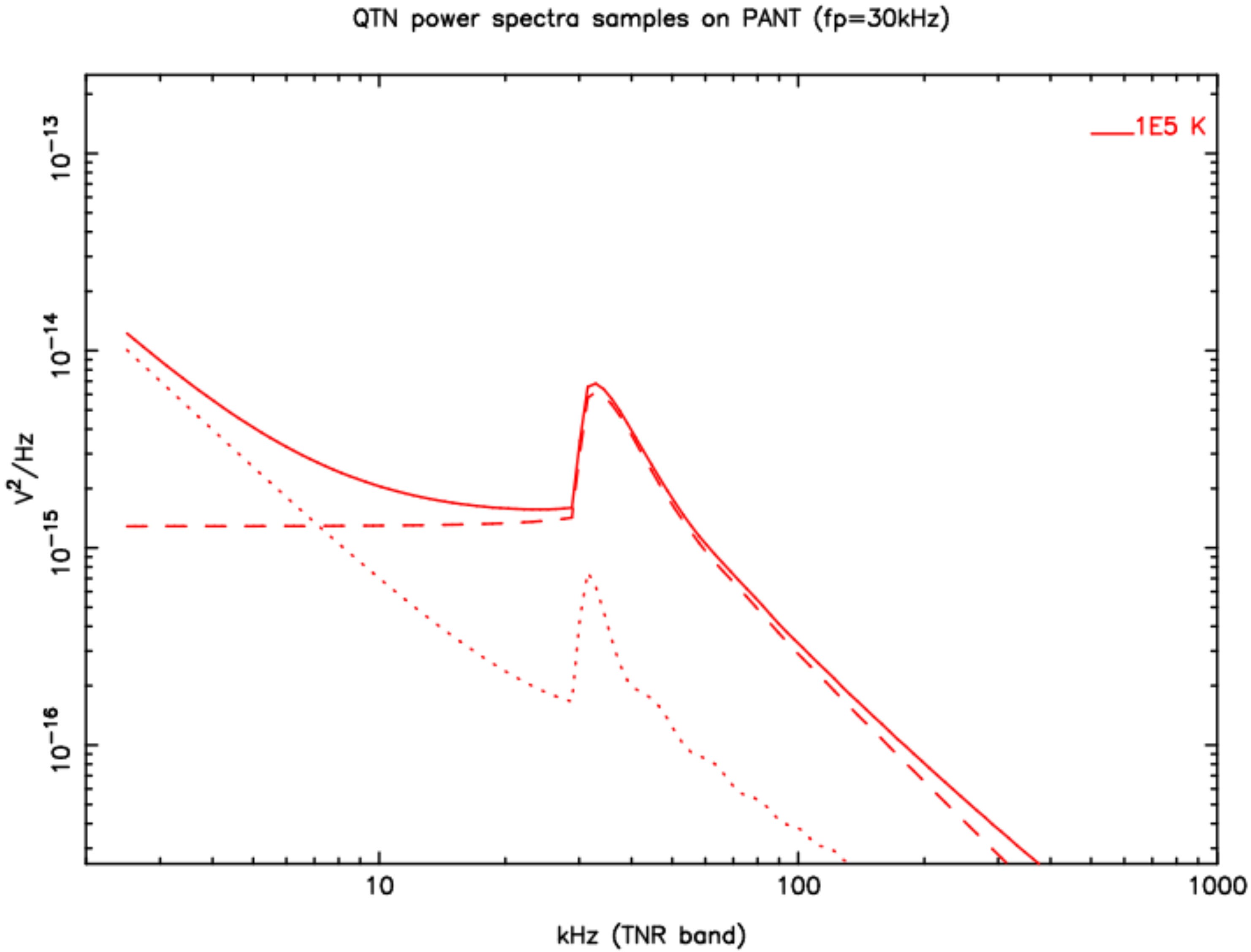


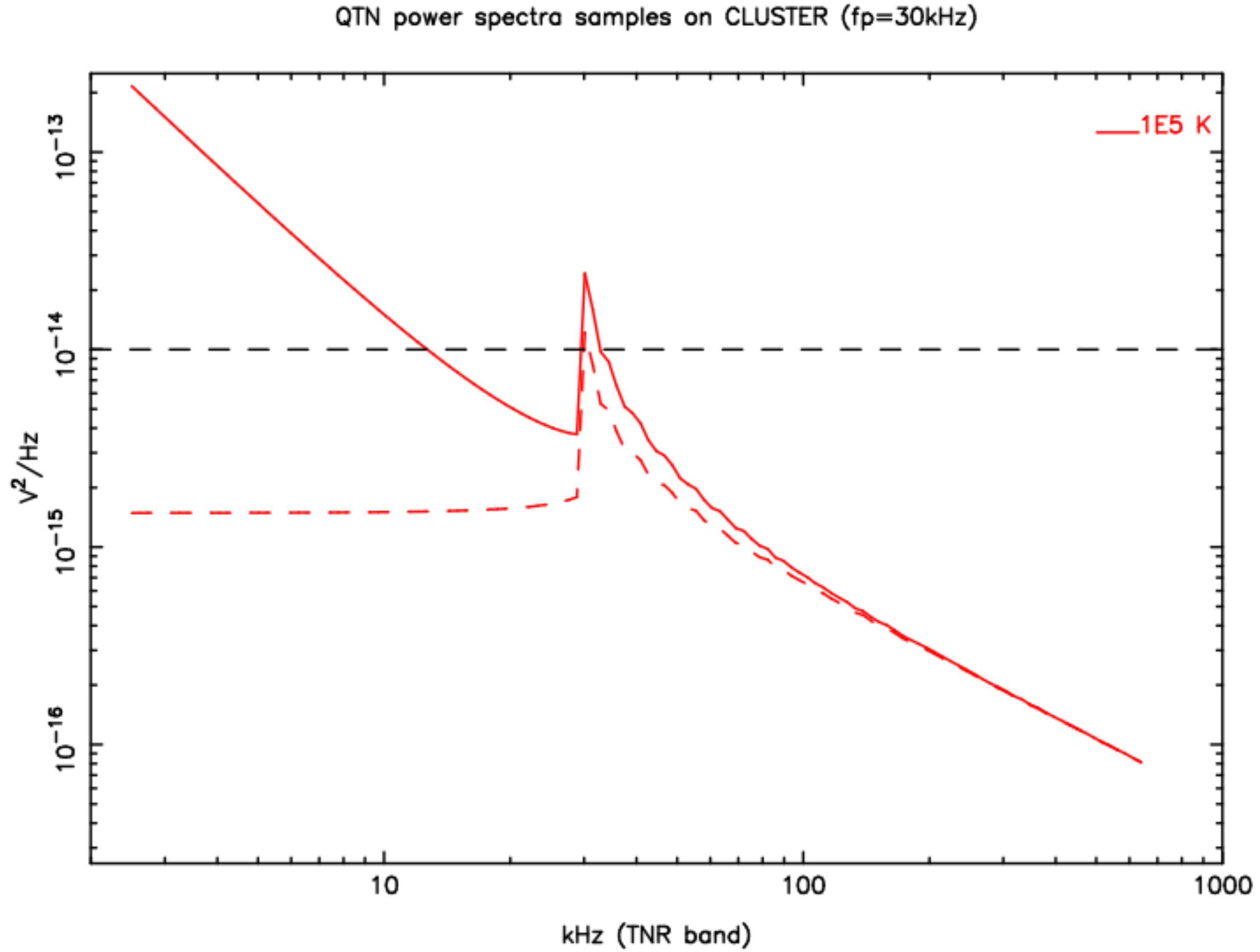

Plasma Frequency (kHz)
2.5
10
100
640
1000
Te x 2, Ne x 4
magnetosheath ?
10^{-14} V²/Hz
Debye l=100m
Debye l=10m
Debye l=1m
Debye length = dipole length = 32m
Debye length = wire length = 15m
Solar Wind
0.3AU
0.47AU
1AU
10^{-15} V²/Hz thermal noise lev. on WPT
Galactic noise - thermal noise
Debye l=10cm
Mercury magnetospheric cavity ?
10^{-16} V²/Hz (WPT)
10^{-15} V²/Hz thermal noise level on MEFISTO
Debye l=1m
5nV/Hz$^{1/2}$
Temperature (K)
10^6
10^5
10^4
10^3
0.1
1.0
10.0
100.0
1000.0
10000.0
Electron Density (cm^{-3})


QTN power spectra samples on MEFISTO (fp=3kHz,30kHz,200kHz)
1E6 K
1E5 K
1E4 K
1E3 K
V²/Hz
10⁻¹³
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10
100
1000
kHz (TNR band)



QTN power spectra samples on MEFISTO (fp=30kHz)
1E5 K
10^{-13}
10^{-14}
10^{-15}
10^{-16}
V^2/Hz
10
100
1000
kHz (TNR band)

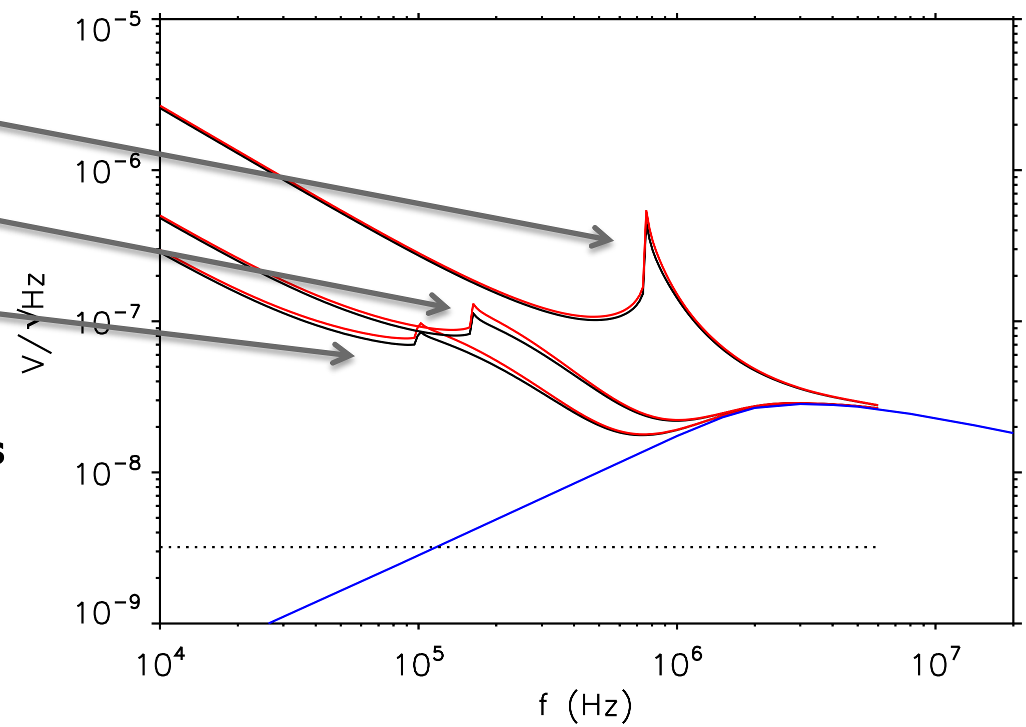

QTN power spectra samples on PANT (fp=30kHz)
1E5 K
10^{-13}
10^{-14}
10^{-15}
10^{-16}
V^2/Hz
10
100
1000
kHz (TNR band)


QTN power spectra samples on CLUSTER (fp=30kHz)
1E5 K
10^{-13}
10^{-14}
10^{-15}
10^{-16}
V^2/Hz
10
100
1000
kHz (TNR band)

2. "Determine the structure and dynamics of the plasma and magnetic fields at the sources of the solar wind"

FIELDS will measure:

- The plasma density to ~1-2% accuracy over the science orbit
- The core electron temperature to ~5-10% accuracy over the science orbit



Quasi-thermal noise **measurements of plasma parameters**
- **antenna geometry is critical**
- **no s/c potential effects. This is good!**

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***Quasi-thermal noise* measurements of plasma parameters**
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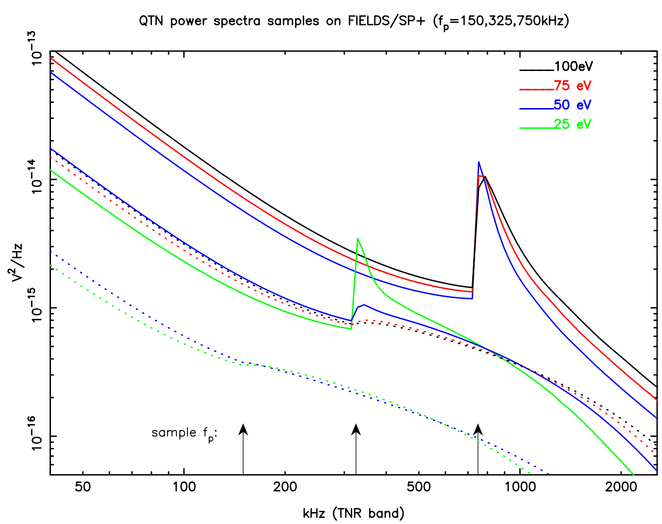

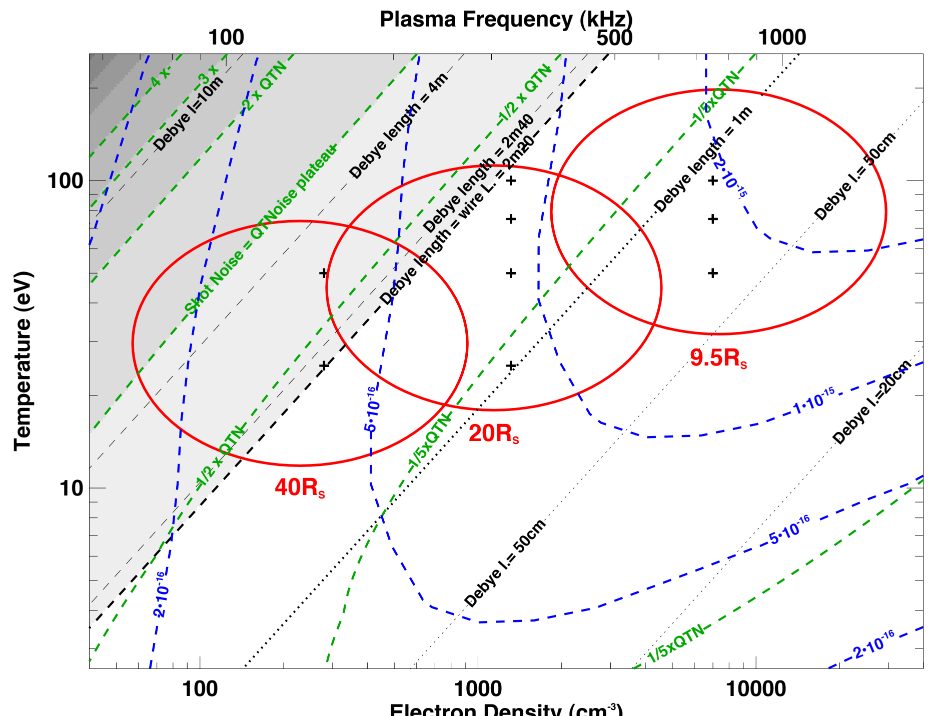

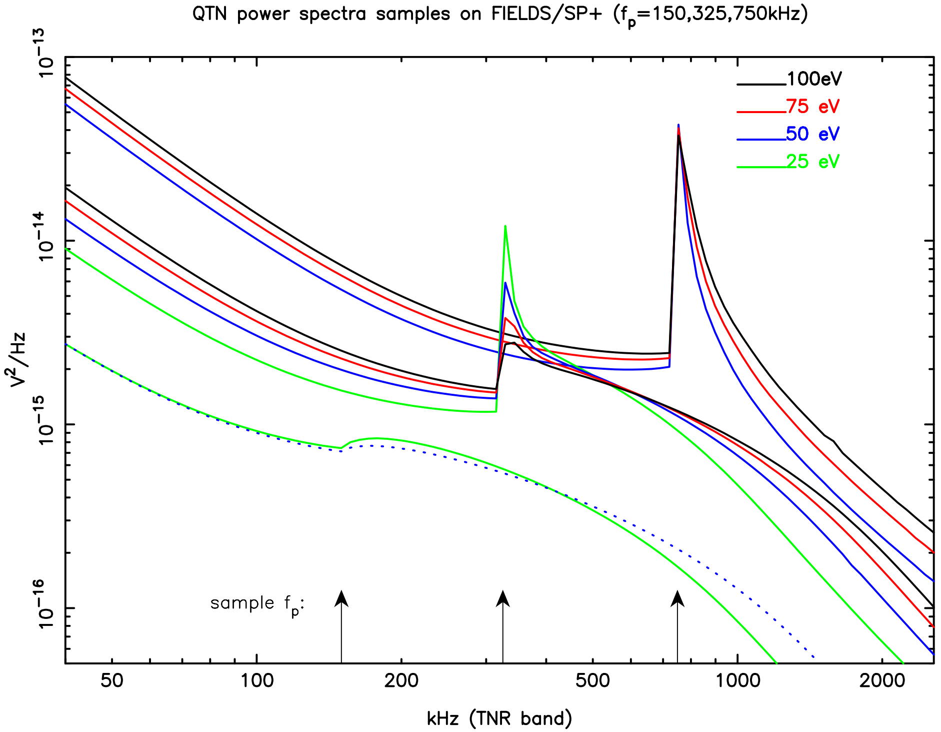

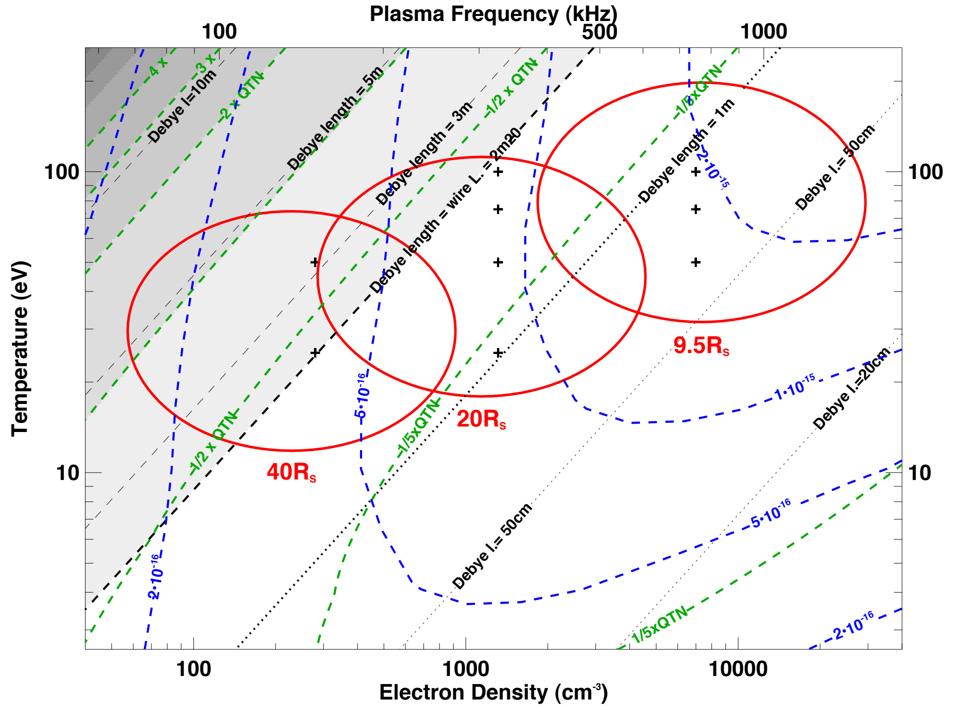

from Fields proposal (2010)

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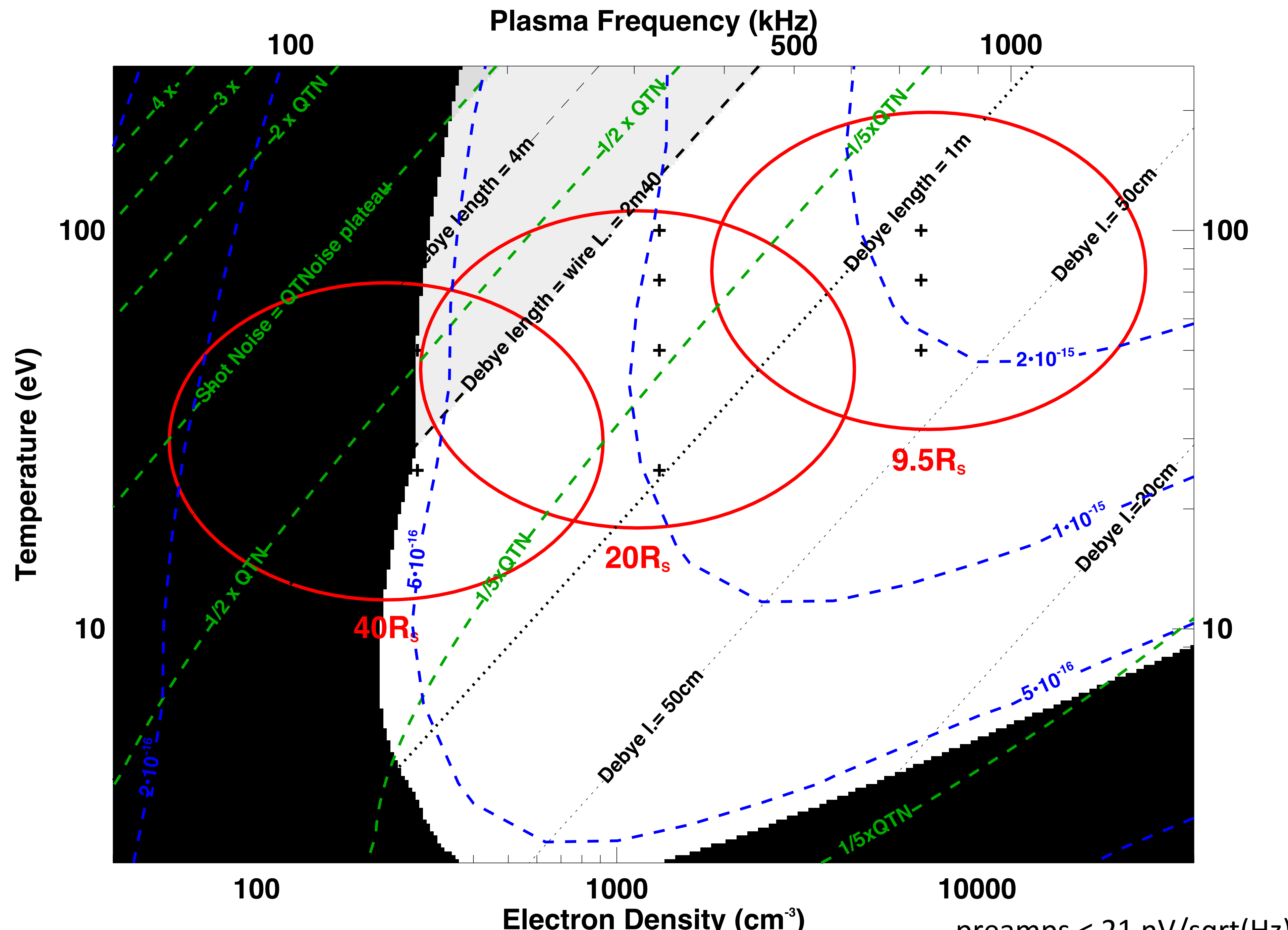


preamps < 21 nV/sqrt(Hz)

Final remarks and summary

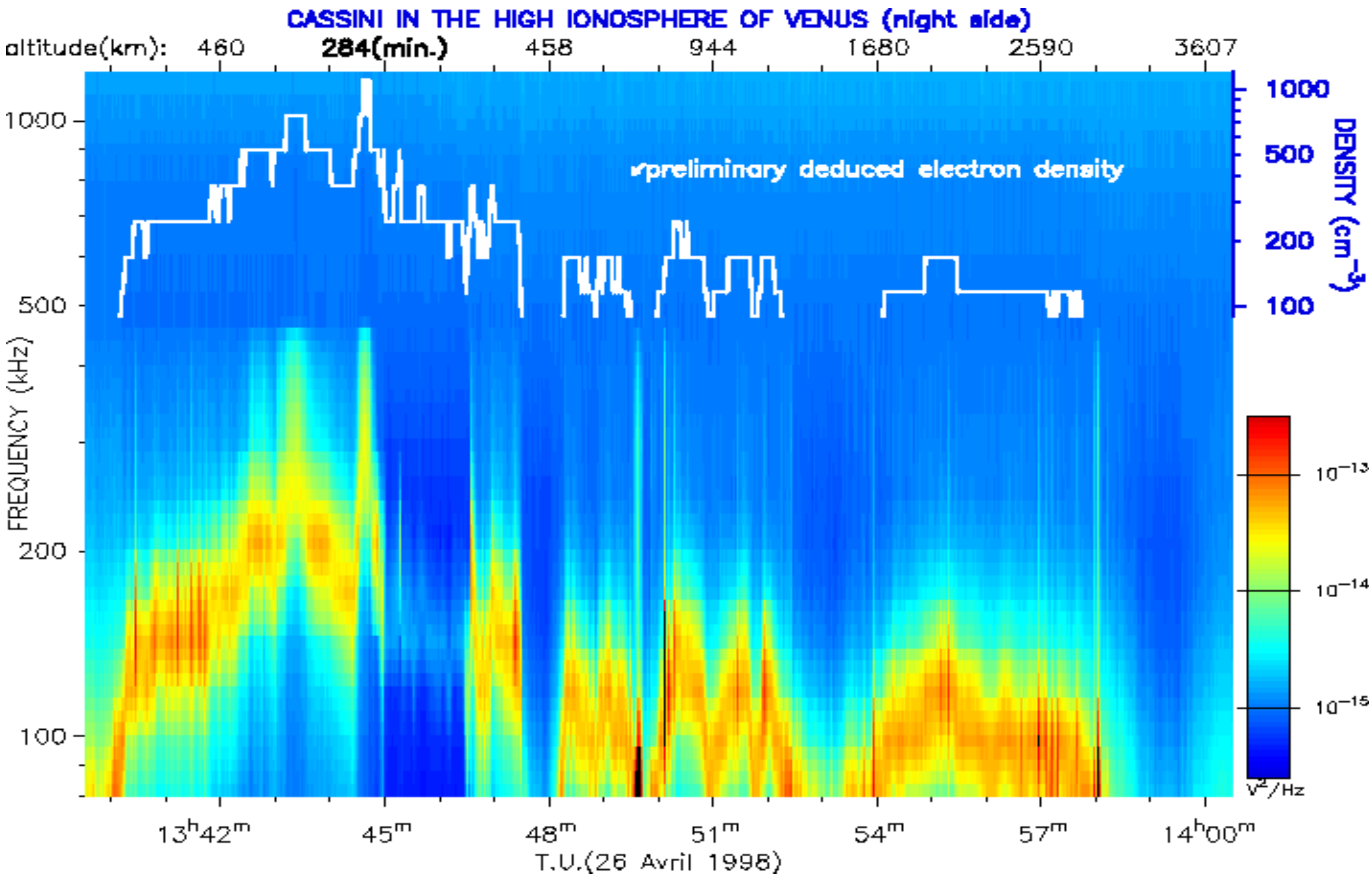
- In QTN spectroscopy, high spectral resolution is good for all fitted parameters of the given distribution, and especially the density, and absolute calibration (in V^2/Hz) is critical to determine the temperatureS and especially the core temperature (or something equivalent).
- It is also critical to design the antenna in order to minimize the shot noise near the plasma peak and get a part of the spectrum really independent of the floating potential. Of course this constraint can be released in case of very stable potential or very reliable potential measurement (I did not met that a lot).
- On Bepi, we have improved the spectral resolution (we doubled from STEREO or WIND) and we made a special effort to well calibrate with the AGC (that's was not a pb on Ulysses and of course no more for SP+).
- The noise of the preamp (and of course of the receiver) has to be low: 6nV for the preamps on SP+ is good. The base capacitance of the mounting structure has also to be as low as possible compared with the antenna capacitance: it is generally known during AIT, but better determined on flight by using well known HF sources or an other instrument.

Final remarks and summary II

- The method of fitting we used on Ulysses, Wind and shall use on Bepi is to search the minimum chi-square of data/model by using the Levenberg-Marquard sheme (that may be quickly described as both an hessian method and a steepest descent method, depending on an adaptable parameter). I don't recommend using the L-M from IDL as a blackbox. The main advantage of the method is to provide the covariance matrix and so reliable errors on each fitted parameters, if the error bars on the signal has been correctly implemented. Because the method needs computation of partial derivatives for each parameters of the distribution, it has a serious cost in process time (especially with kappa). The method to compute a grid of models and to interpolate by cubic spline has been successful with the Ulysses spectra: it will be implemented on Bepi for production of plasma parameters (core +halo or kappa distribution) on a daily basis (with at least one month delay from real time telemetry). However, it is working on fixed frequencies spectra, and I don't know if it is adapted for RFS-SP+.
- For quick-view data production on Bepi, we have implemented the detection of the plasma peak, as well as the telemetry level of the thermal plateau, in our FPGA (the best we can do as embarked intelligence, the FPGA being almost full): it is transmitted with HK to Earth and allows the production of a preliminary QTN diagnostic on real time. I suggest RFS-Fields to do so because you have the info onboard (and a larger FPGA).

Final remark (really)

- Regarding the detection of the strahl using QTN with the two orthogonal dipoles : I have some suggestions (I had no time to prepare further, sorry). Let's say I am confident that we may detect QTN differences on each dipoles if the angle between a privileged direction (I mean B) and each dipole is different, but I doubt it's possible to clearly distinguish, with only QTN, for example a temperature anisotropy (Tpara/Tperp) in the halo from the presence of a strahl (but I did not make any computation yet…)



The first Cassini flyby of Venus

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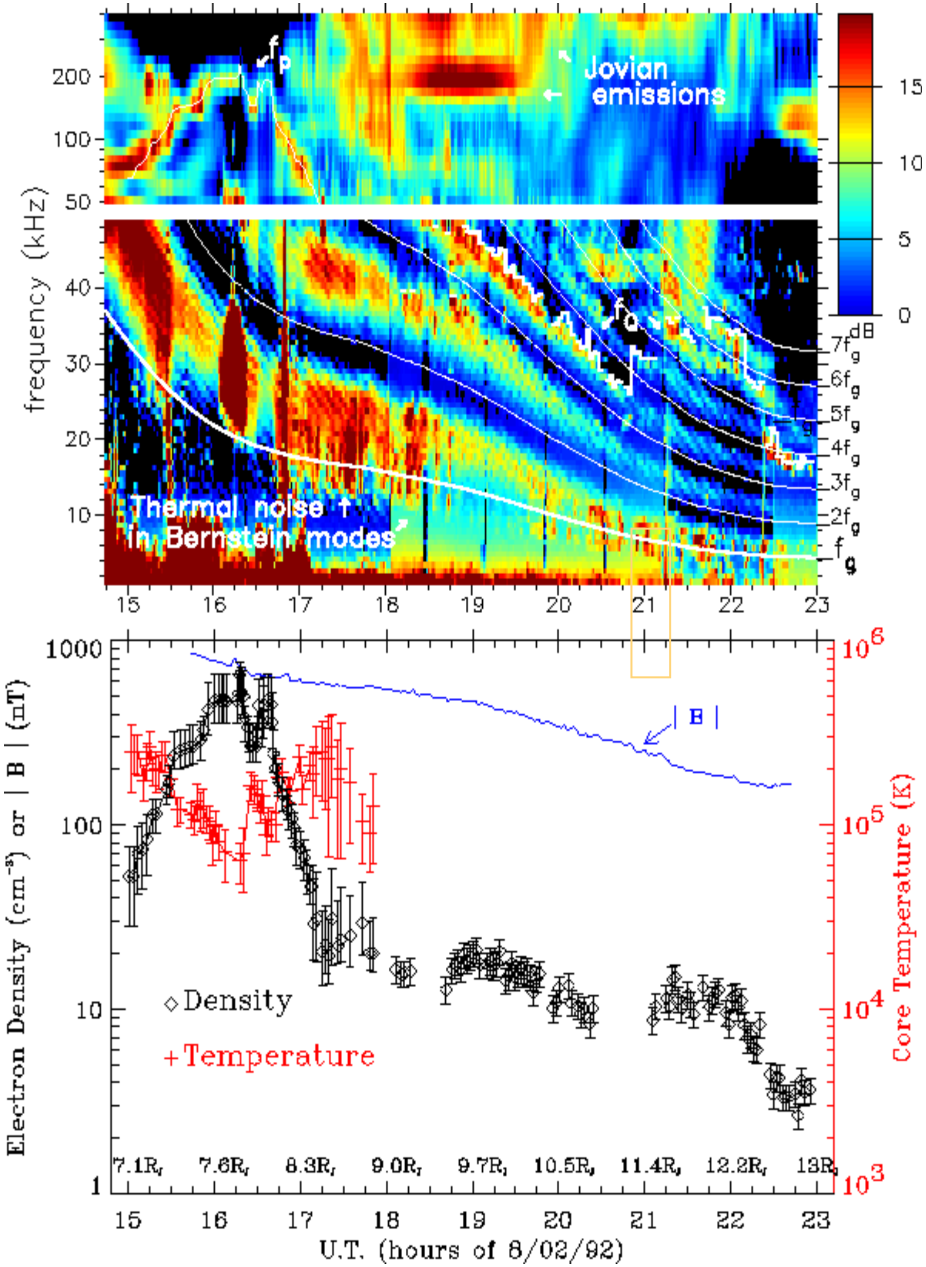
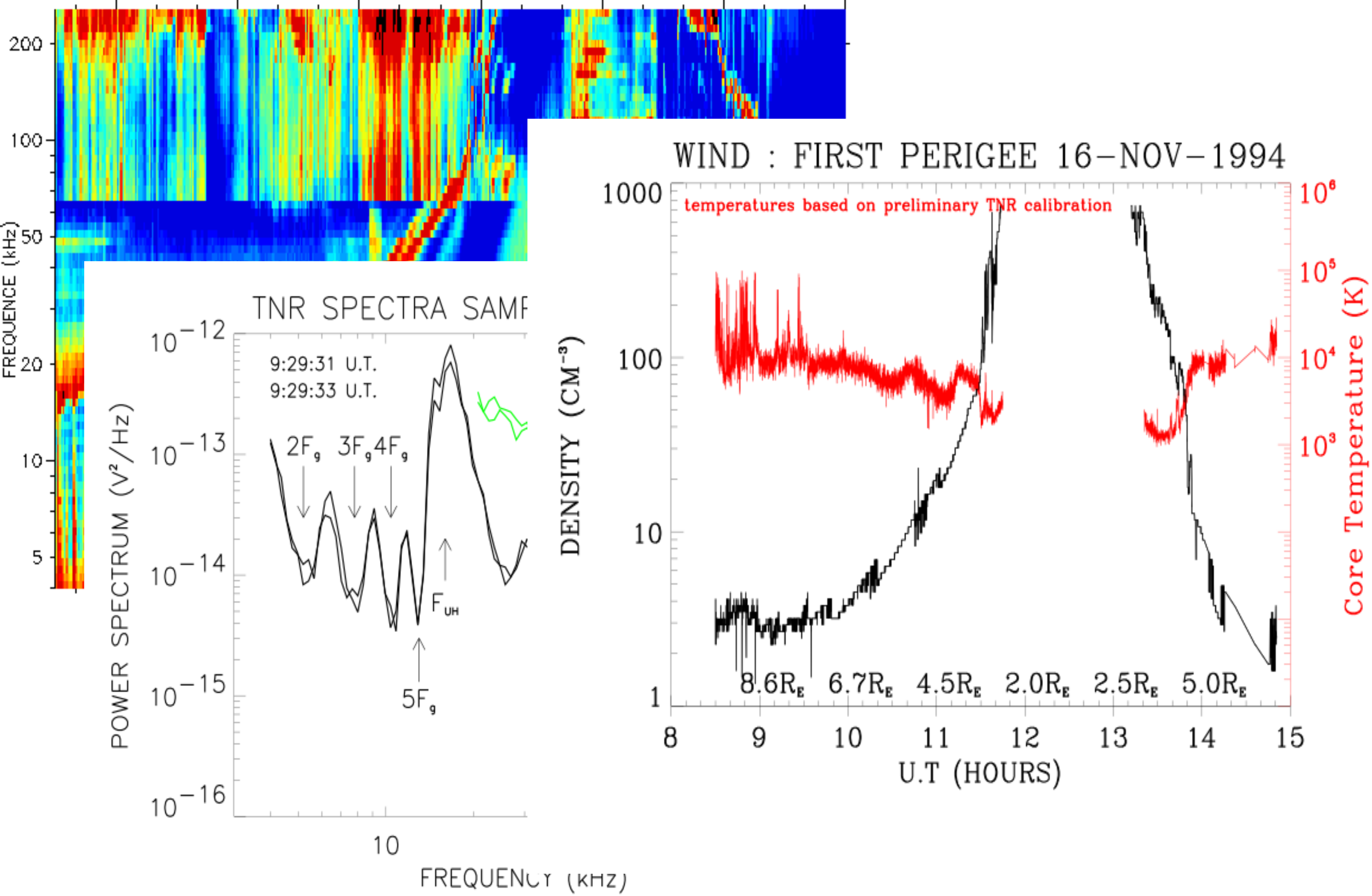


Ulysses QTN measurements (in Bernstein modes)

through the Io plasma torus


FREQUENCE (kHz)
200
100
50
20
10
5
TNR SPECTRA SAMP
9:29:31 U.T.
9:29:33 U.T.
2Fg
3Fg
4Fg
5Fg
FUH
POWER SPECTRUM (V²/Hz)
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10
FREQUENCY (kHz)
WIND : FIRST PERIGEE 16-NOV-1994
temperatures based on preliminary TNR calibration
DENSITY (CM⁻³)
1000
100
10
1
Core Temperature (K)
10⁶
10⁵
10⁴
10³
8.6RE
6.7RE
4.5RE
2.0RE
2.5RE
5.0RE
8
9
10
11
12
13
14
15
U.T (HOURS)