Measurements of type III decay times in the frequency range 3-12 MHz

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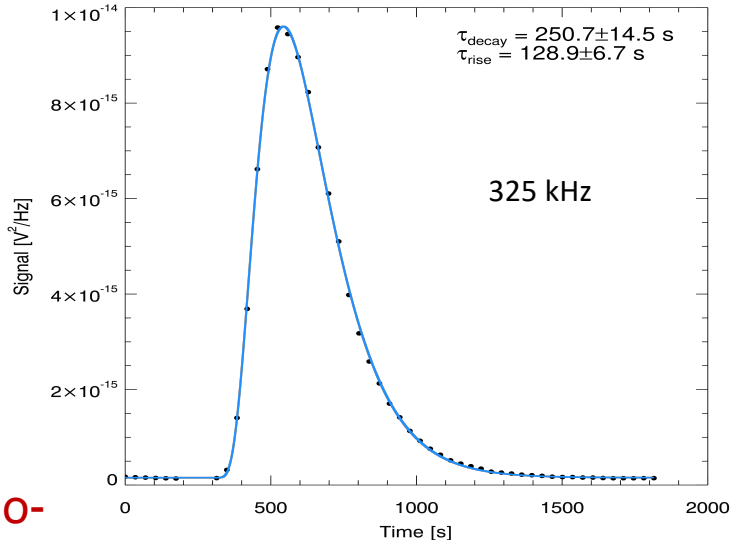
Background

- Density fluctuations affect the propagation and the properties of the detected type III bursts. Scattering of radio waves on density irregularities is crucial for interpreting radio source sizes, positions, directivity and intensity-time profiles.

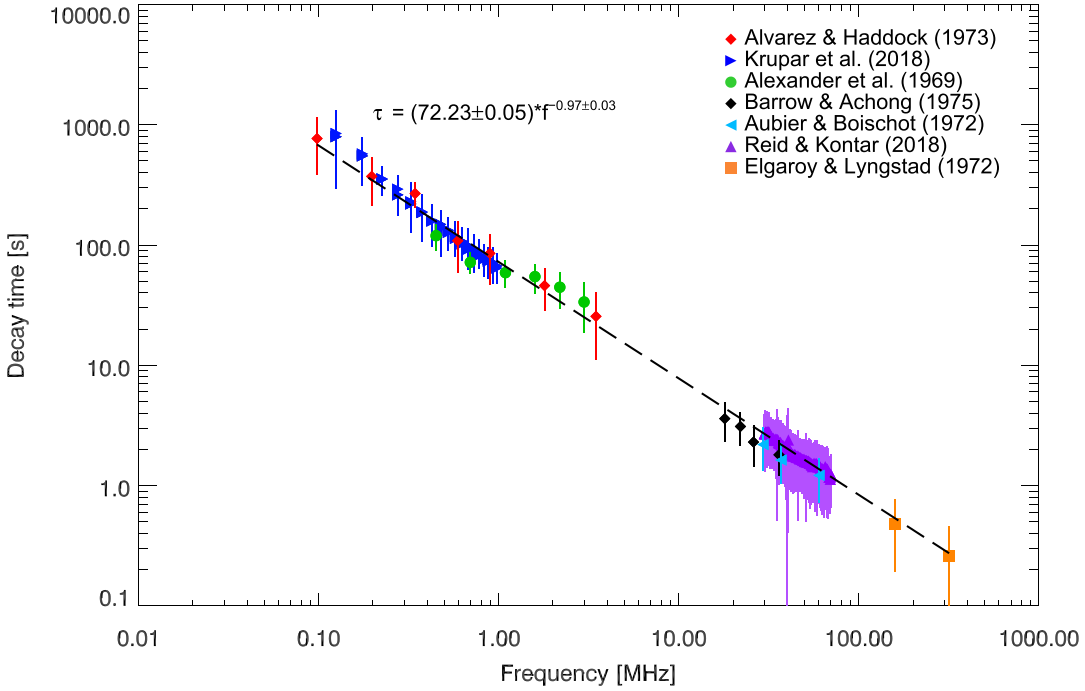
- the intensity-time profiles for a fixed frequency (”light curves”) characterized by a rise and decay phase with an approximately exponential behavior.



- Decay times τ are directly related to the radio-wave scattering → useful information about the strength and anisotropy of the scattering and levels of density fluctuations

Background

Kontar et al. (2019)



- The best-fit of the decay time τ as a function of frequency f, assuming a power-law dependence is:

$$\tau = (72.2 \pm 0.3) f^{(-0.97 \pm 0.003)}$$

- A clear data gap is present between 3 and 15 MHz due to the lack of data.

Bridging the gap –> - confirm the expected trend and to
- characterize the scattering in 2 - 7 $R_\odot$ range currently unexplored.

Background

From the instrumental point of view, this kind of measurement is quite challenging

- they can only be made from space
- high temporal resolution is needed to properly sample signals in which the expected τ is of the order of 1 – 10 s.

A dedicated configuration, peculiar to this study is necessary.

This is not always easy to achieve since instruments on spacecraft currently flying are exploited for the widest variety of studies and more general configurations, allowing broad spectrum measurements, are generally preferred.

Our approach

HFR nominal configuration 50 frequency bins.
Nominal burst mode → time sampling of each individual HFR spectrum of about 8s

Not ENOUGH to carry out the analysis an ad hoc configuration is needed

Starting from December 20th2022 HFR configured:

- to acquire on five frequency bins : [3.225, 5.225, 6.875, 10.125, 12.225] MHz for five times followed by a sweep on 50 frequency bins on the full HFR band between 0.425 and 16.325 MHz
- average on the lowest possible number of spectra (16),
- time resolution of 0.07 s for five times followed by an acquisition after ~ 1 s seconds due to the long sweep.

Our approach

- 9 month of data: 20 December 2022- 31 August 2023
- L2 HFR data calibrated in V^2/Hz (at the receiver level) have been used

Semi-automated type III identification:

- Data available on daily base
- the occurrence of a type III burst is manually checked in the light curves at the lowest frequency, 3.225 MHz.
- the same burst is automatically sought at the other four frequencies in a time window of ~ 30 s, encompassing the type III maximum at 3.225 MHz.

Results

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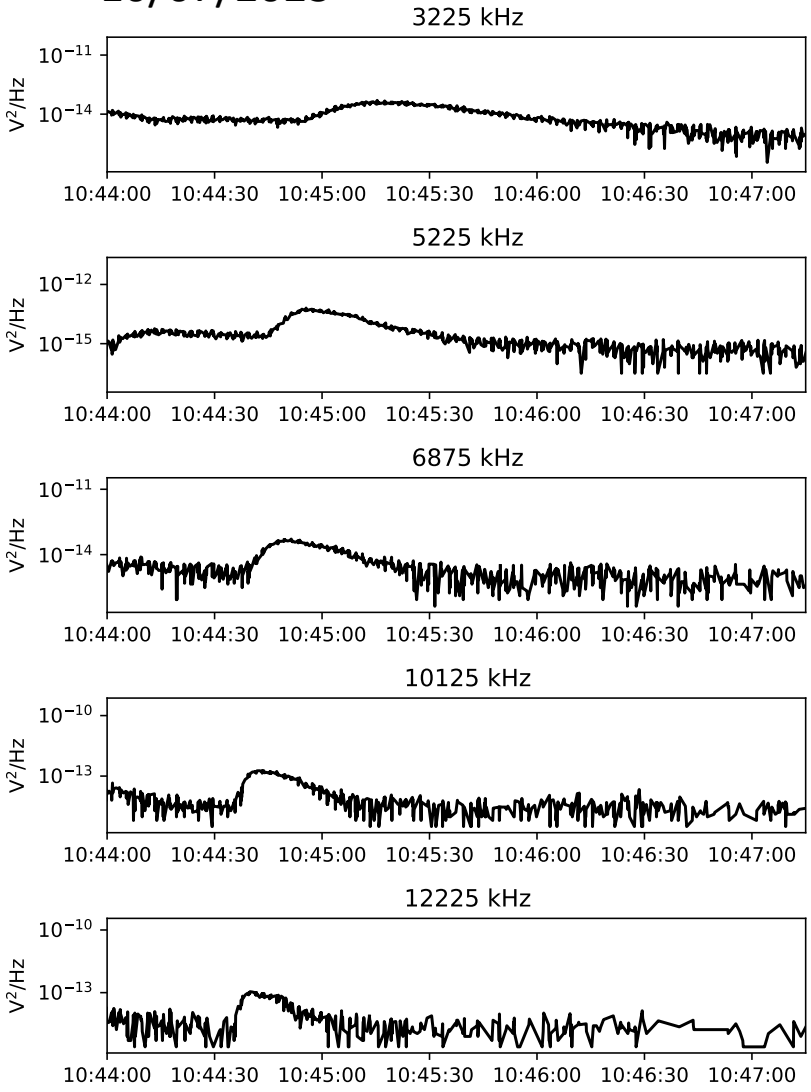

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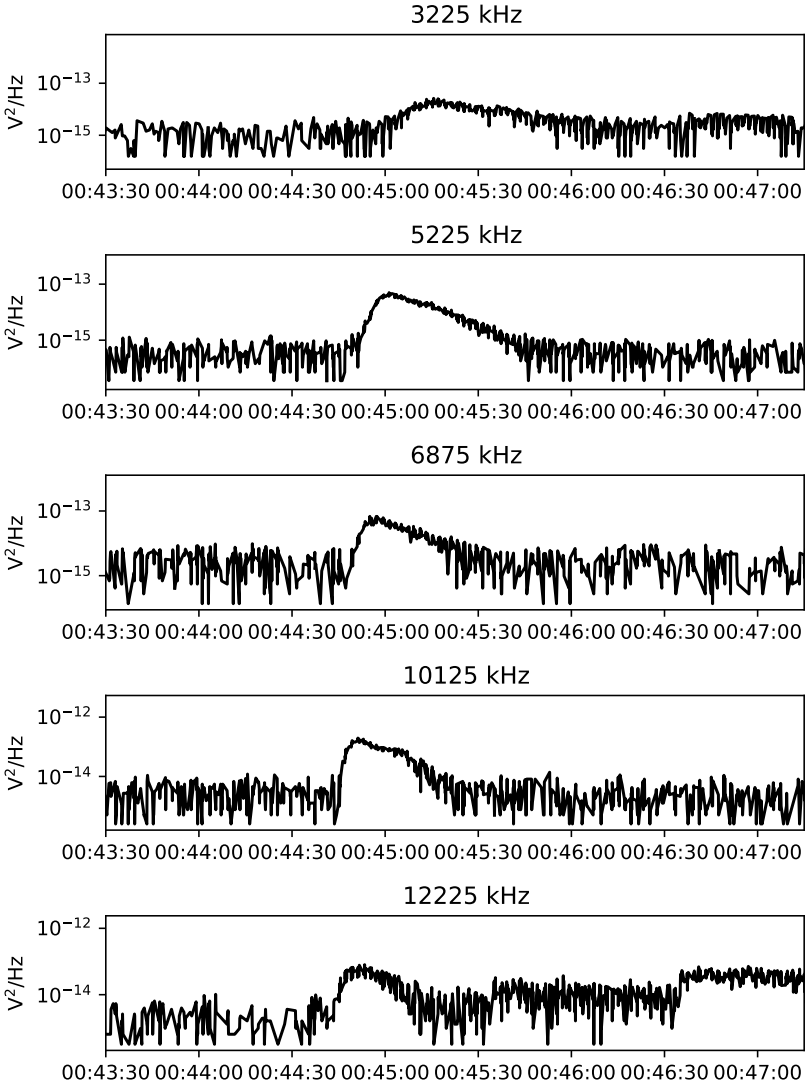

Results

The decay time τ is obtained for each frequency by fitting the data points through an exponential function

$$S(t) = S_{peak} \exp\left(\frac{t_{peak} - t}{\tau}\right) .$$

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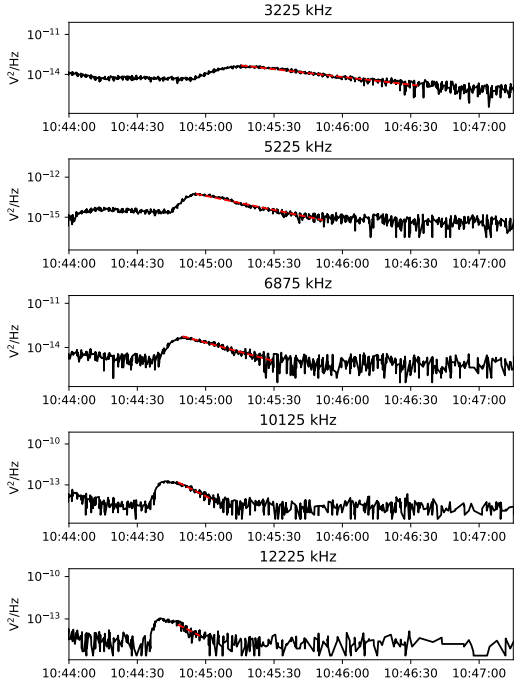

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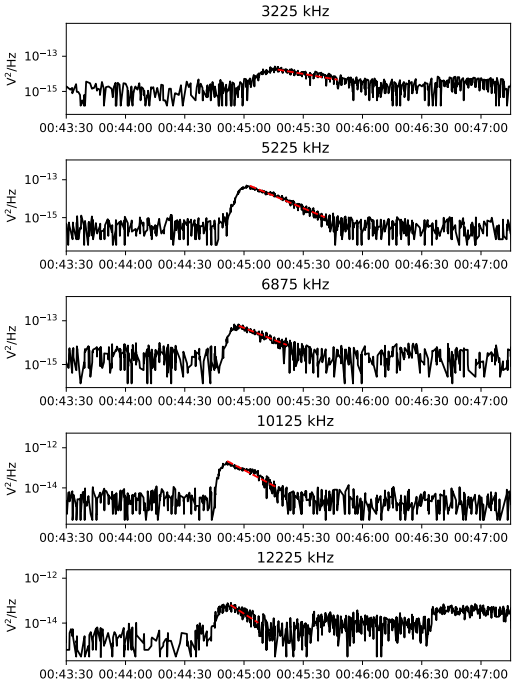
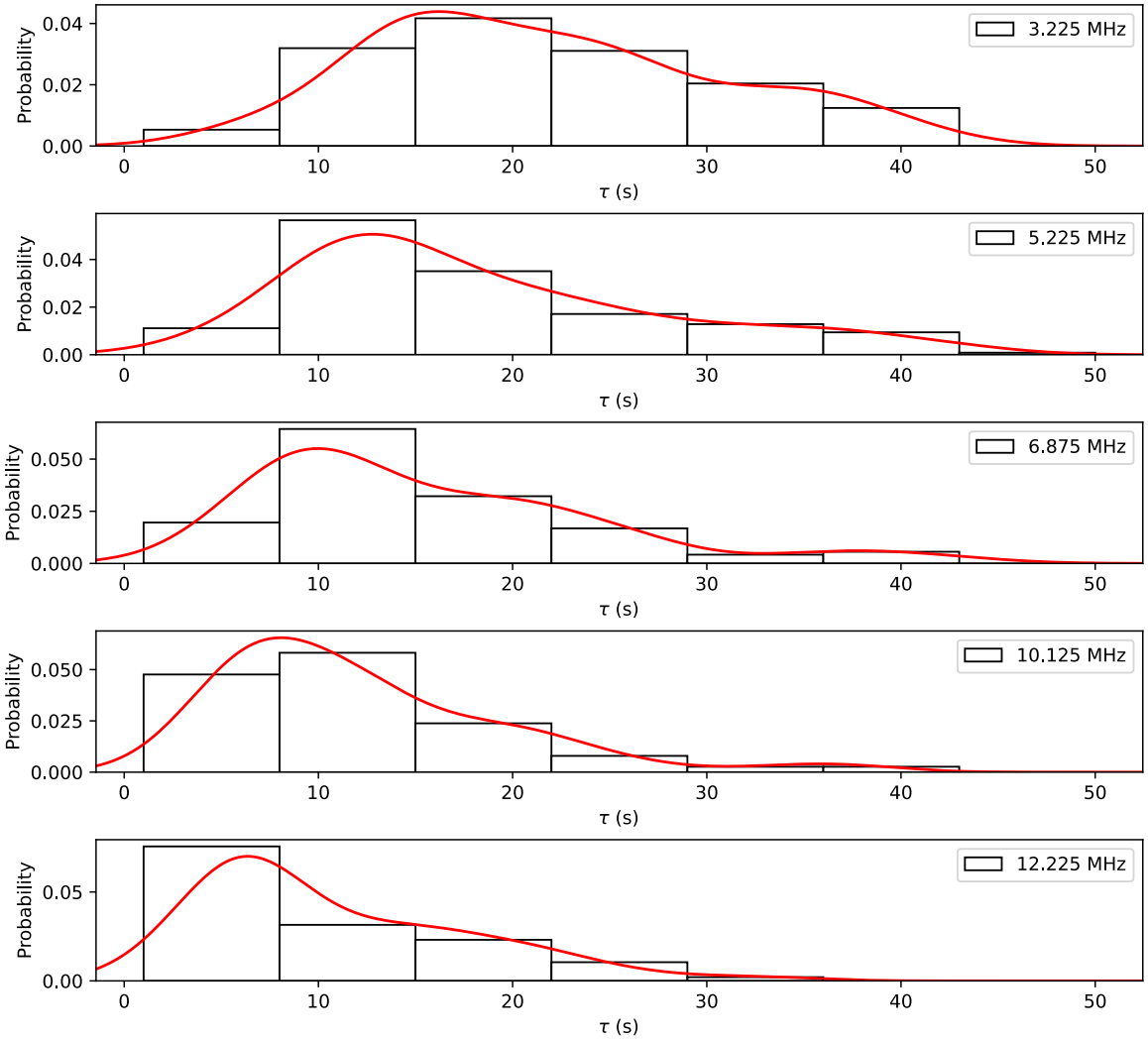


The left and right limits of the fitting interval are chosen as the point corresponding to the 0.95 of the maximum and the last value above the background.

Results

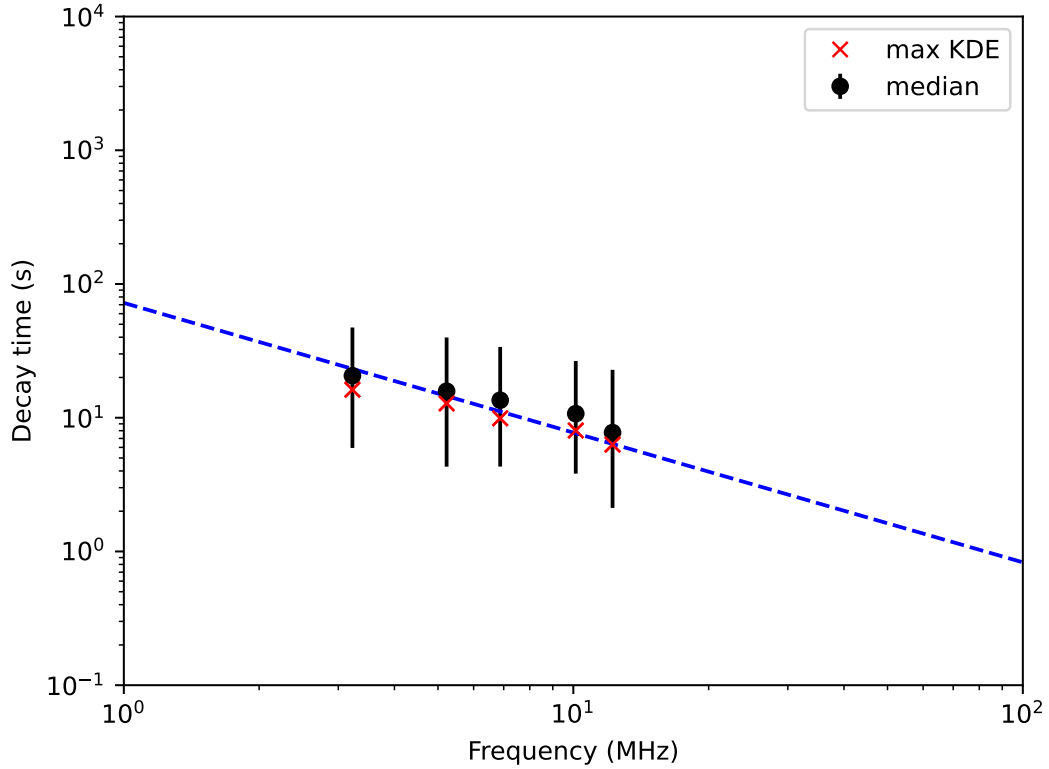
τ values from fitting that converge and with $R^2 > 0.7$



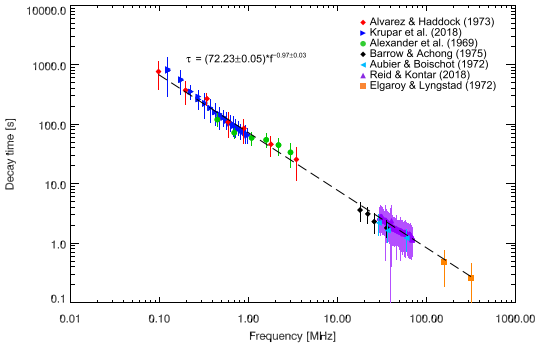
- τ increase with decreasing frequency
- skewed distributions
- Kernel densty estimator (KDE)

Results

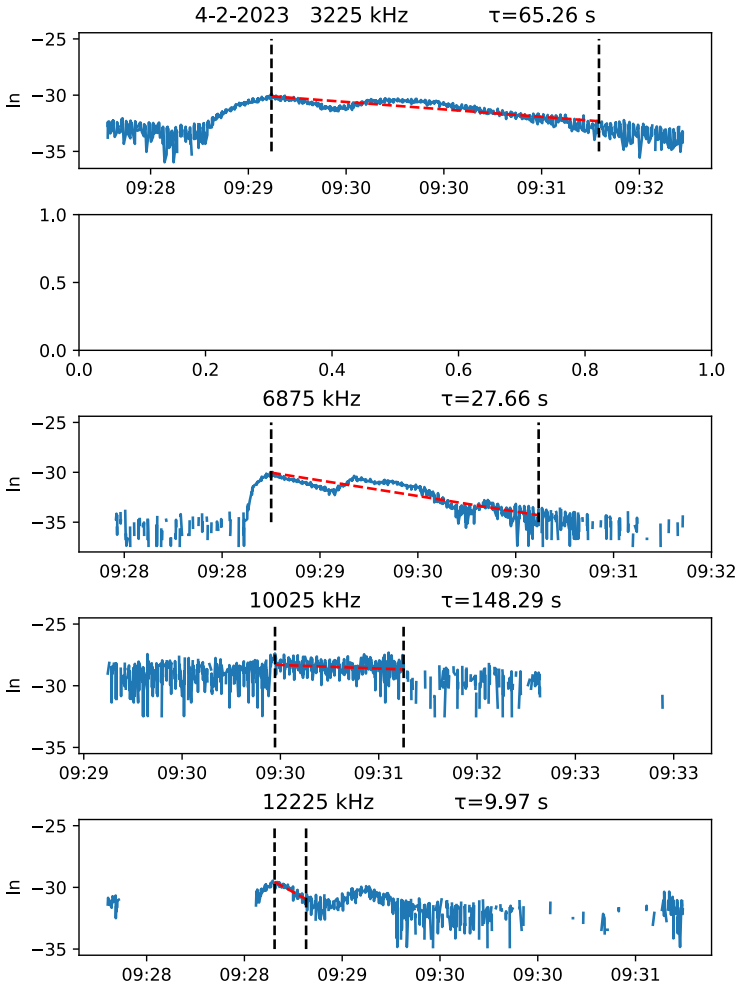
frequency (MHz)	total number of $\tau(s)$	$med(\tau)(s)$	$\Delta\tau(s)$	$\tau_{KDE}(s)$
3.225	167	20.62	$[14.67, 26.67]$	16.2
5.225	167	15.79	$[11.49, 24.04]$	12.8
6.875	102	13.52	$[9.21, 20.33]$	9.9
10.125	108	10.73	$[6.91, 15.85]$	8.0
12.225	68	7.75	$[5.63, 15.07]$	6.3

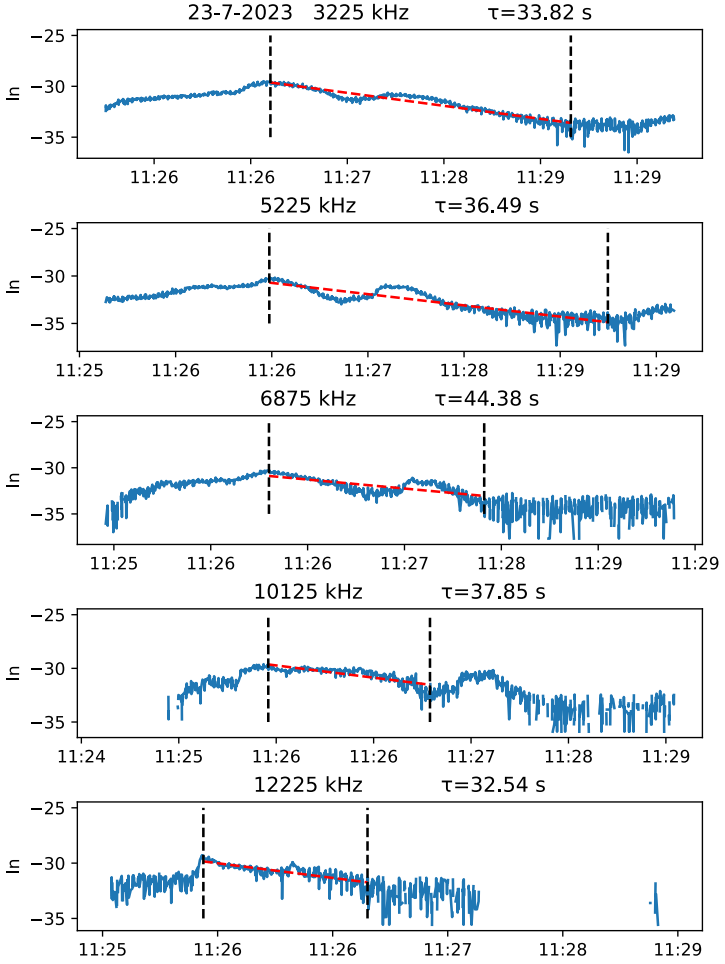


median values (25%–75% interval) and the peak value of the $P_{emp}(\tau)$



Future developments



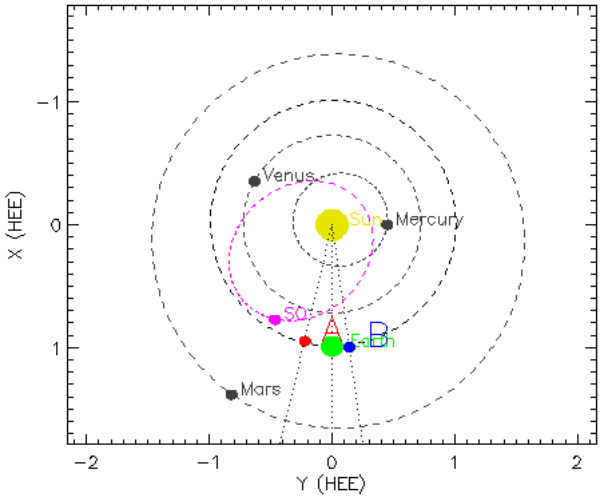


Almost 50 events identified

Double maxima → fundamental-harmonic pairs ?????

Future developments

Comparison with ground based data (DAM)



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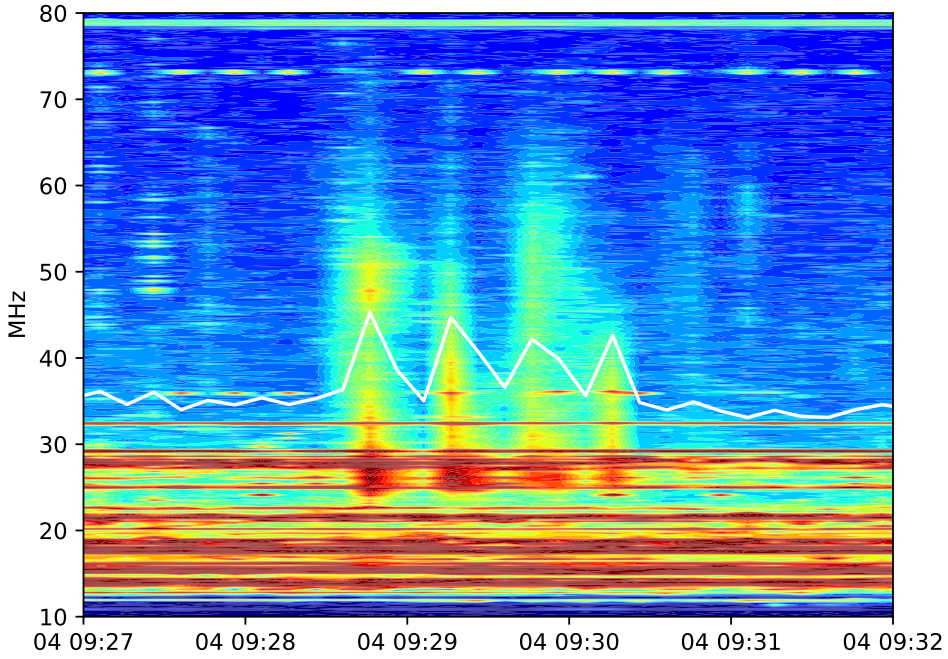

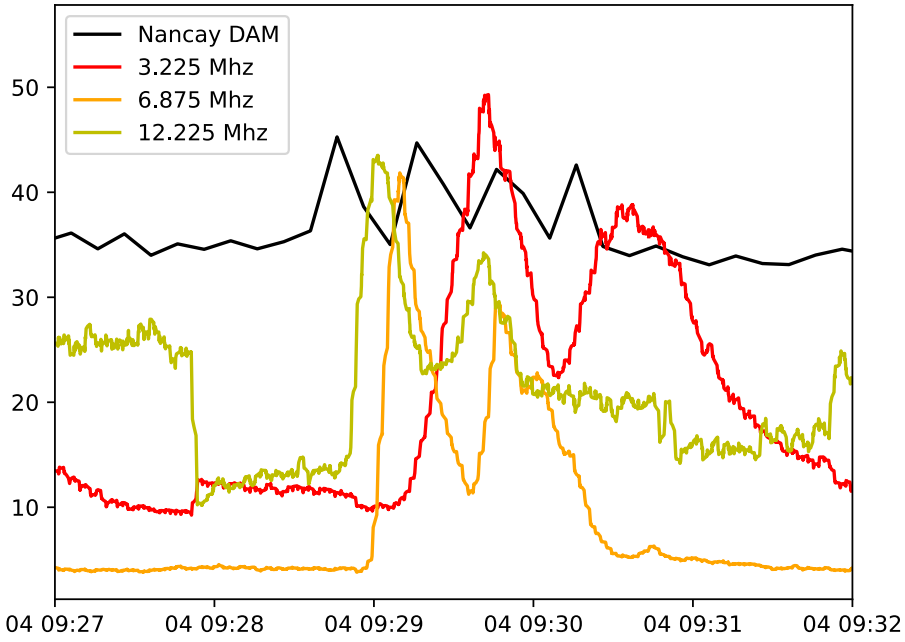

Future developments

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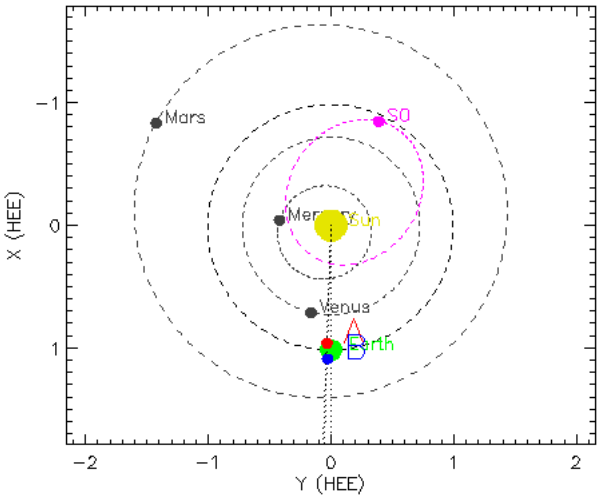

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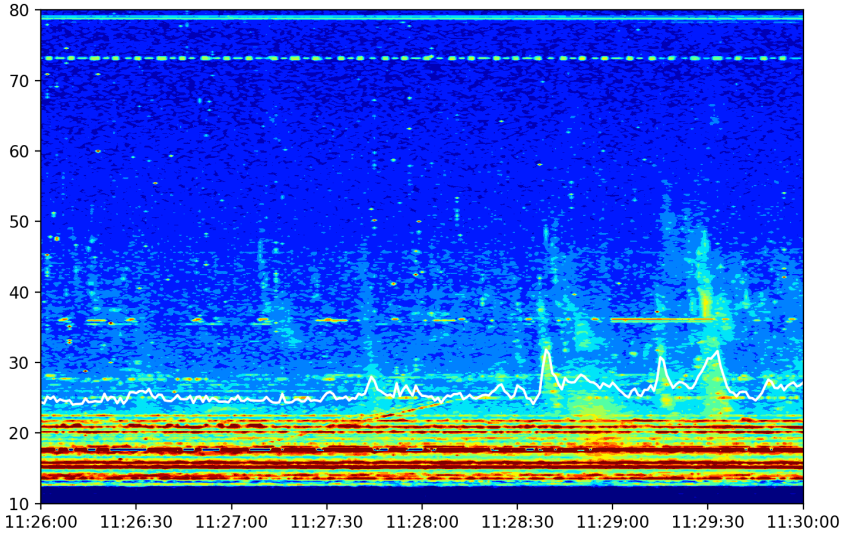

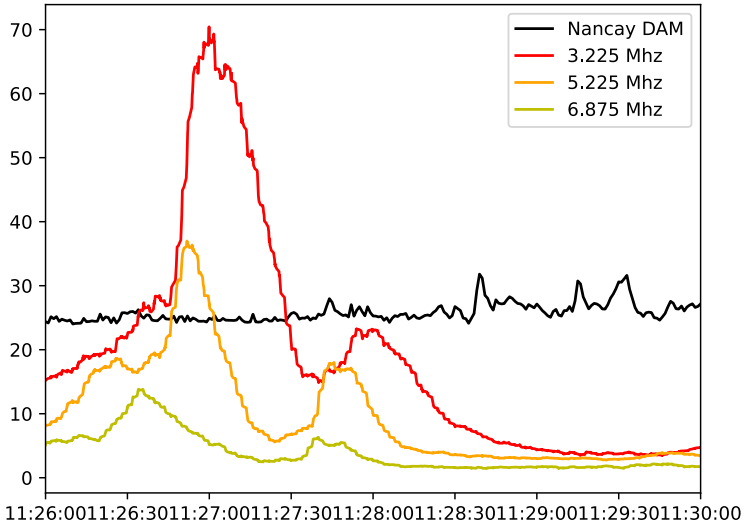

Future developments

Calculating the expected deltat between F and H components:

- Estimate the speed of the exciter from the type III dynamic spectrum
- Using a radial model for the density (e.g. Leblanc et al.,1998) to derive the heliocentric radial distances