

Preliminary comparison of some radio type III bursts (RPW) and STIX flares

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RPW Science Meeting
30/11-02/12 2021
Meudon



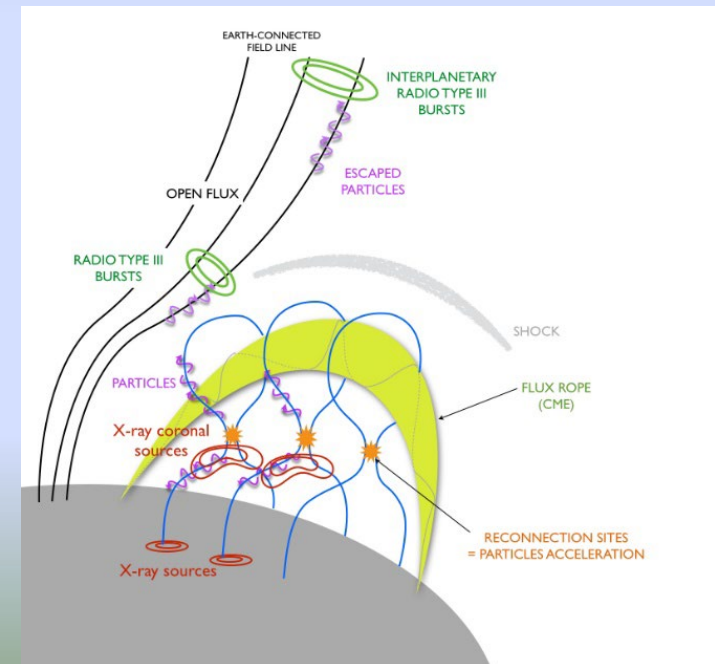
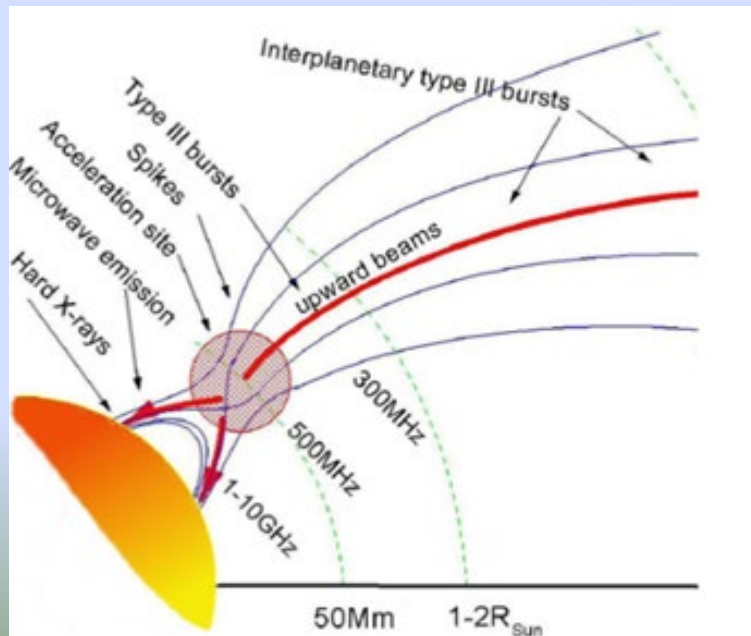
Energetic particles in the solar atmosphere?

What are the acceleration mechanisms? Where are the acceleration sites? How do energetic particles propagate from the corona in the interplanetary medium?

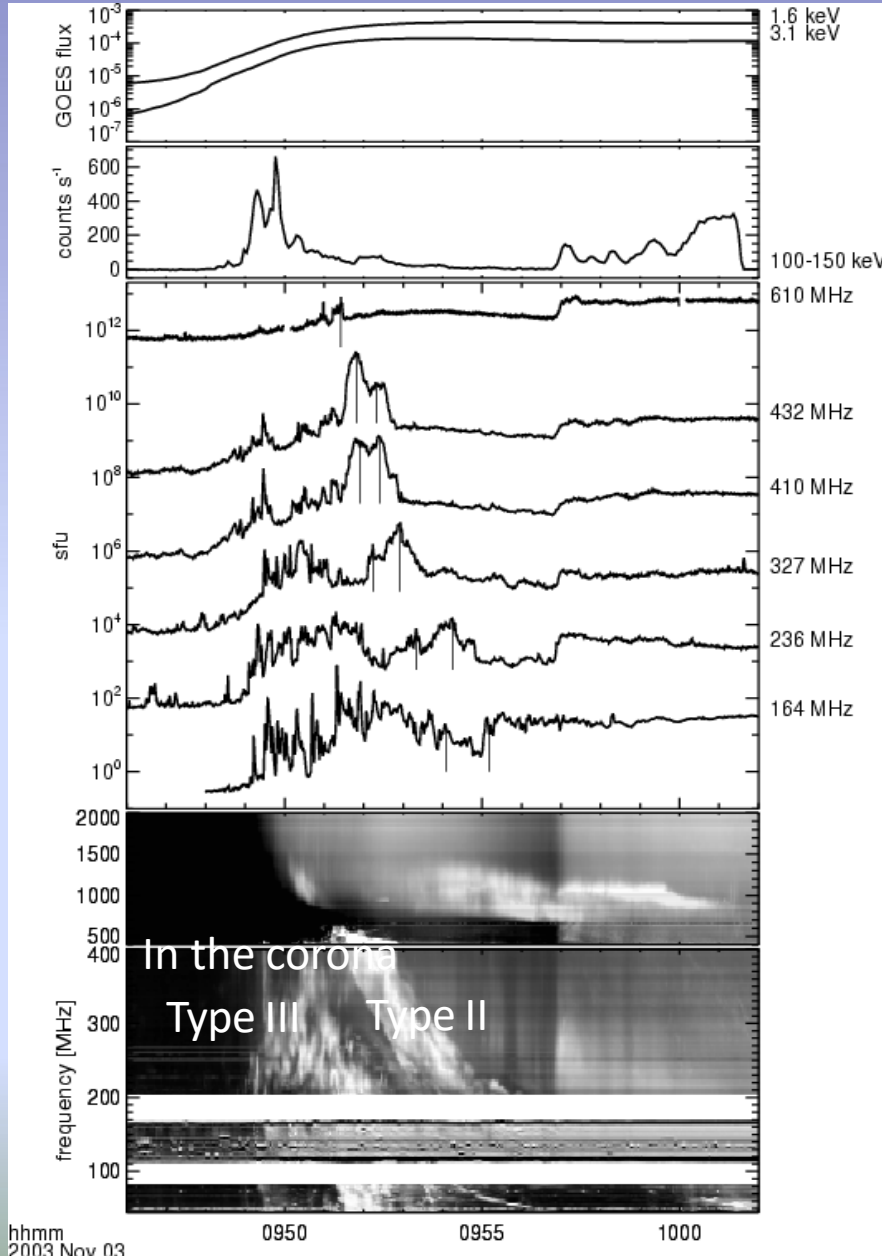
What is the link between particles interacting at the Sun (i.e. HXR producing energetic electrons) and particles propagating to the interplanetary medium (producing e.g. type III emissions?)

What is the link between energetic particles at the Sun and in the interplanetary medium??

one of the key questions for Solar Orbiter and Parker Solar Probe missions

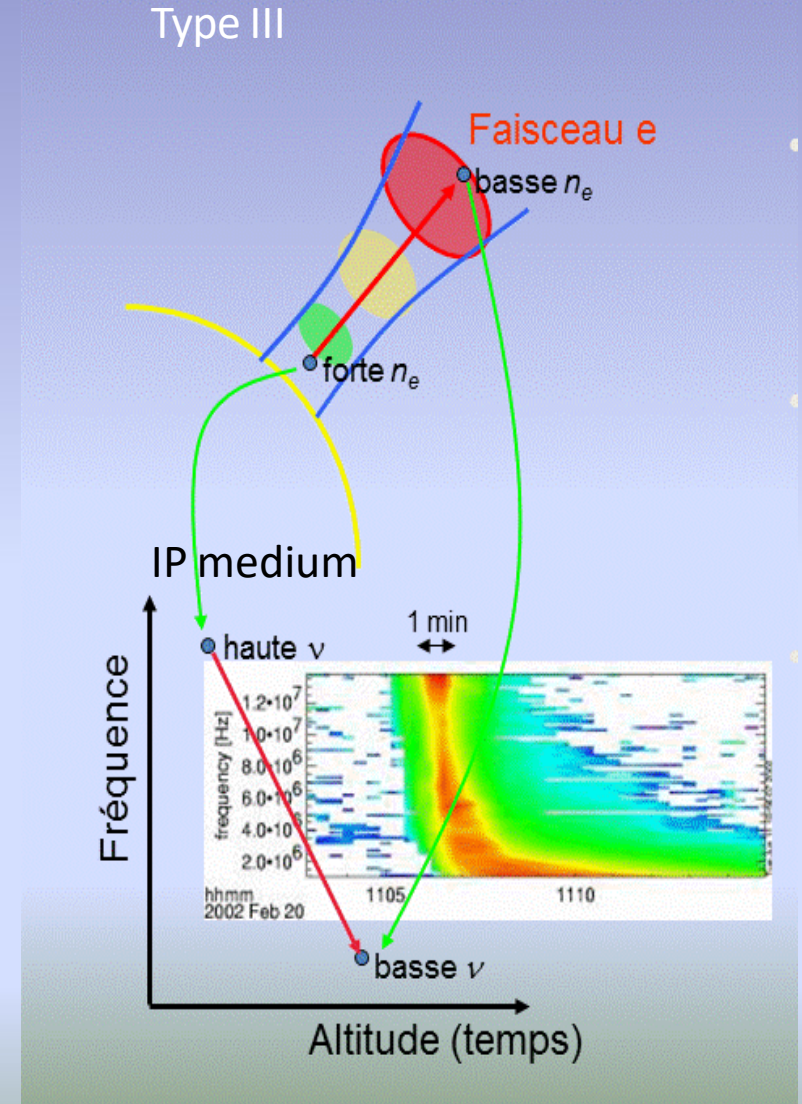


Electromagnetic radiation from energetic electrons



Energetic electrons from solar flares produce X-ray emissions in a wide energy band and Plasma radio emissions in a large frequency band : 600 MHz to 30 MHz (present example)

Dauphin, Vilmer, Krucker, 2006



RADIO and X-RAY EMITTING ELECTRONS

One of the cartoon

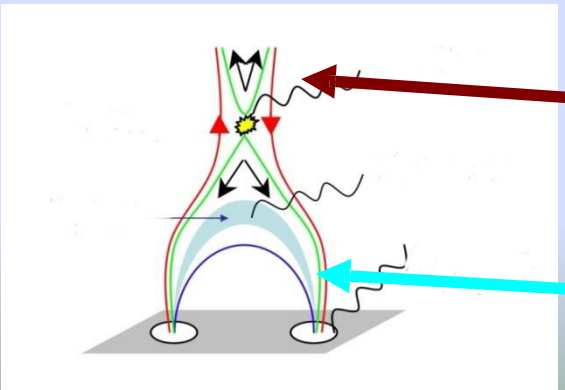
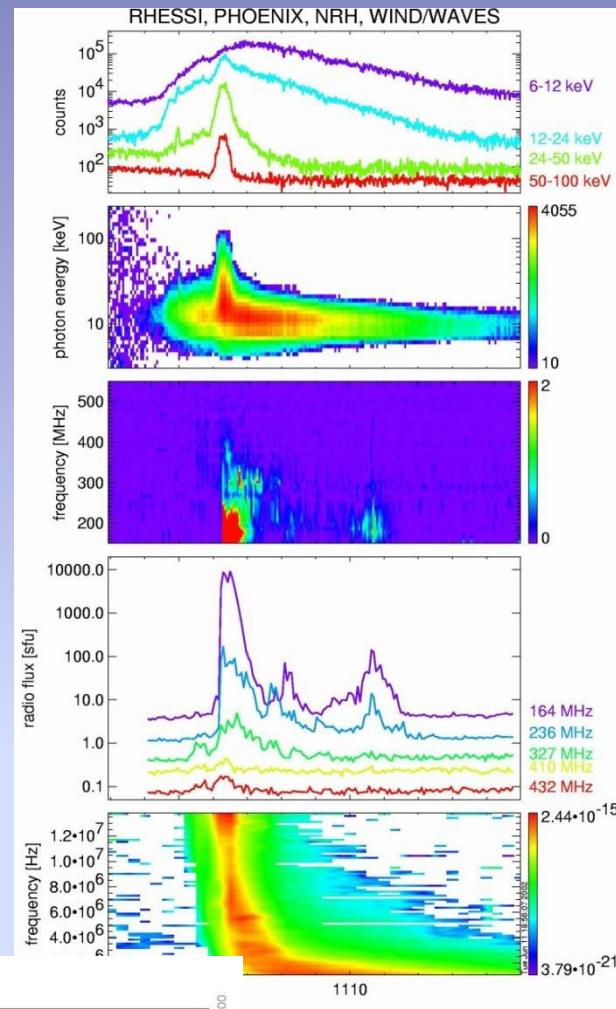
Electrons travelling downwards into the chromosphere radiate X-rays in dense ($n_e=10^{12} \text{ cm}^{-3}$) plasma via Bremsstrahlung.

Detected X-rays are usually in the 6-100 keV energy range
 Electrons travelling upwards can induce Langmuir waves which in turn produce coherent radio emission (type III) in the rarefied ($n_e < 10^9 \text{ cm}^{-3}$) coronal and interplanetary plasma.

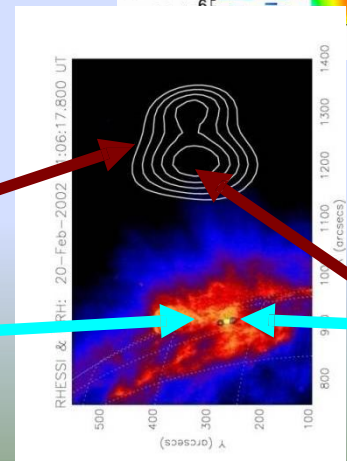
Detected radio frequencies are from around 400 MHz down to 2 MHz

X-RAYS

RADIO



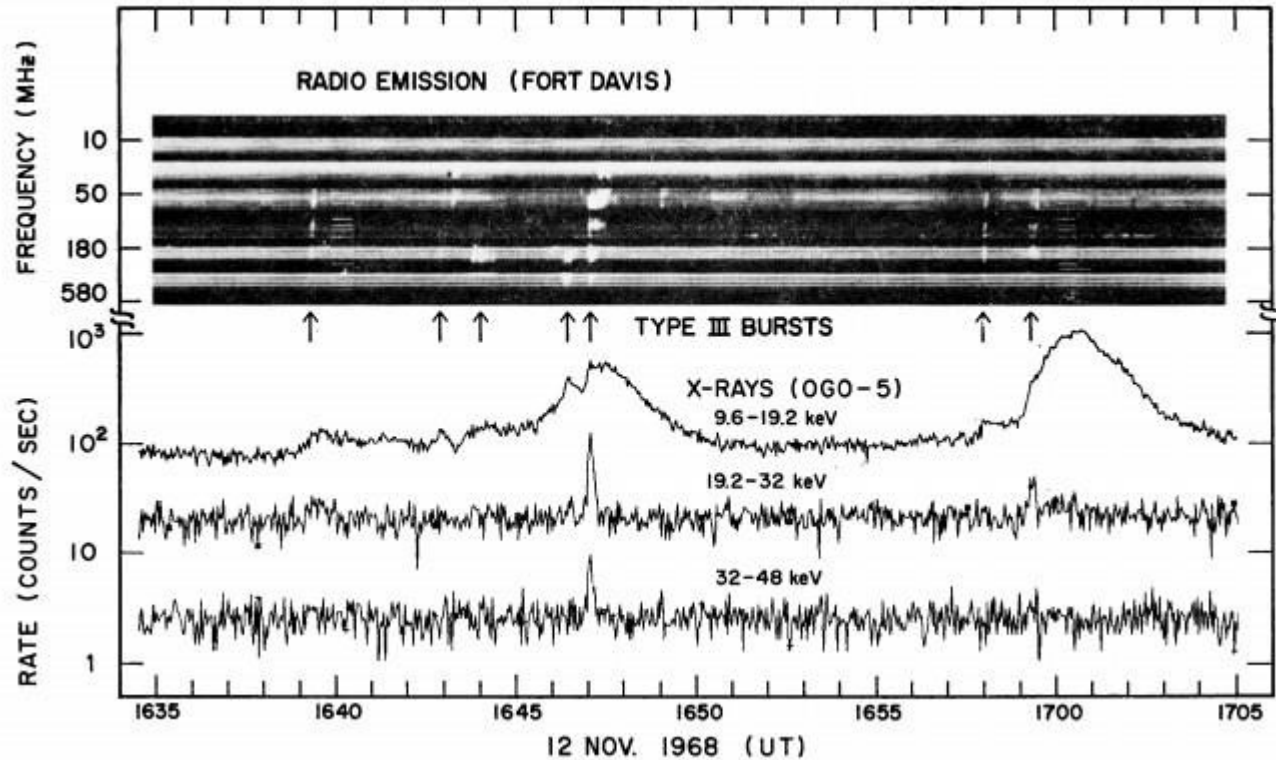
Standard picture ?
 Electron acceleration in the corona
 Propagation both upwards and downwards.



Vilmer et al. 2002

NRH and RHESSI observations

HXR – Type III Statistical Connection



Kane, (1972)

First studies by Kane (1972): good association between some HXR and type III radio emission, suggesting electrons originate from a common acceleration site.

First statistical study of HXR and Type III emission (Kane, 1981)

- 20% of the impulsive HXR bursts correlated with coronal metric type III radio bursts
- 3% of type III emission at metric wavelengths associated with HXR

The more intense the type III burst, the more likely it would be associated with a HXR flare. The harder the X-ray spectral index, the more likely it is associated with a type III radio burst.

Events which have associated HXR and Type III radio emission tended to have higher radio starting frequencies.

Relation between coronal and interplanetary type III bursts

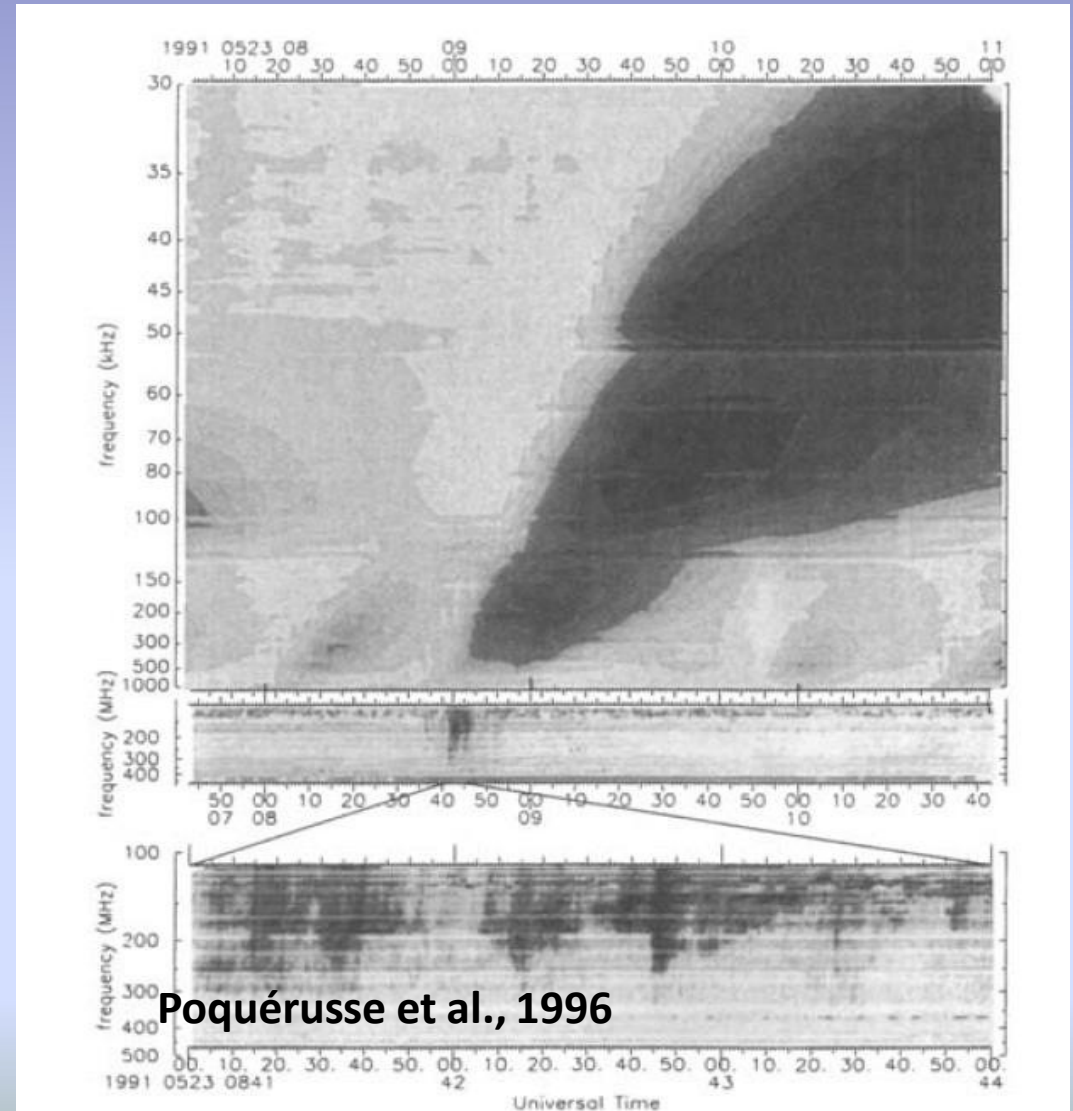
Association between type III groups (ARTEMIS spectrograph (100-500 MHz)) and URAP/Ulysses (1-940 kHz).

If associated, one single type III burst at low frequencies usually comes from a group of 10 to 100 type III bursts at higher frequencies.

50% of the events (200 events) produced both strong coronal and interplanetary type III emissions.

Not every coronal type III burst (even if strong) produces an IP type III burst.

(Poquérousse et al., 1996)



Electron beams in the corona to the IP medium

Long standing questions:

What kind of correlation between X-ray and radio intensities?

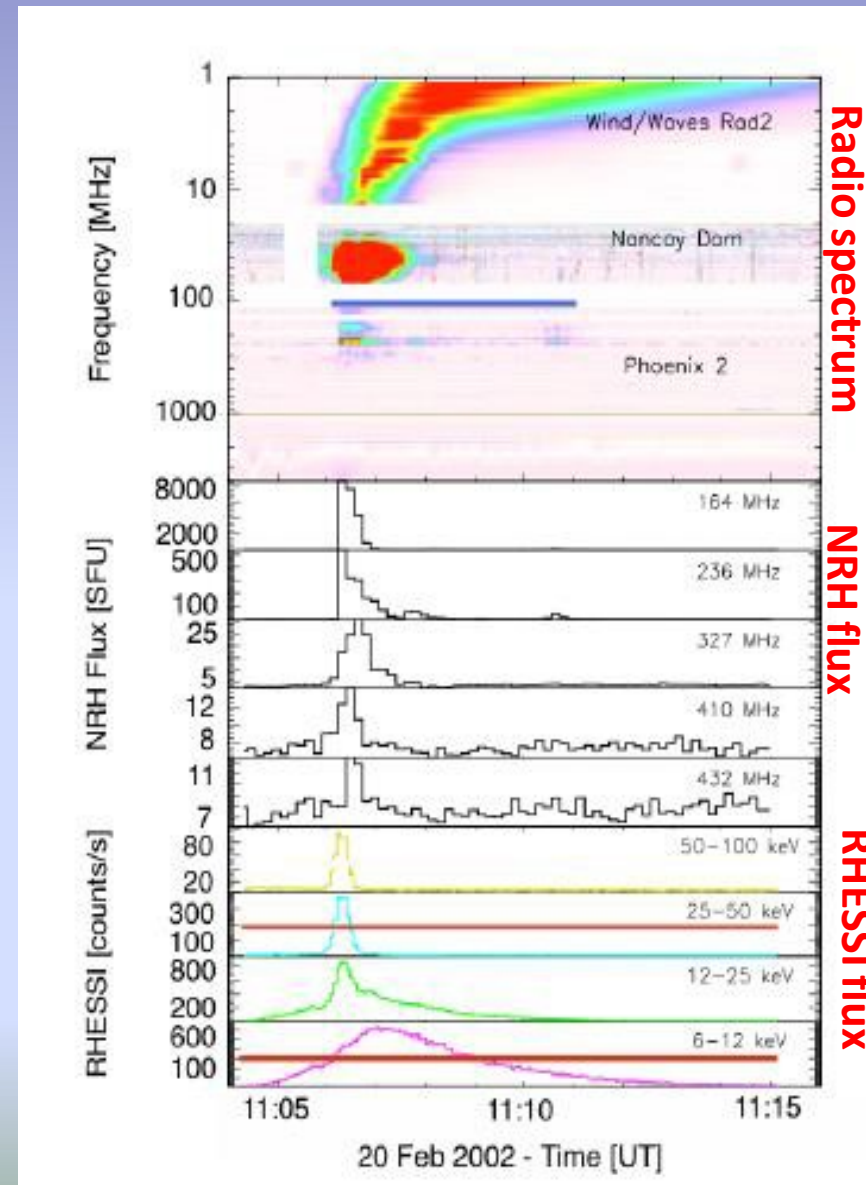
Do all coronal type III bursts have an interplanetary counterpart?

Study based on >1000 coronal type III bursts over 10 years of data (2002-2011)

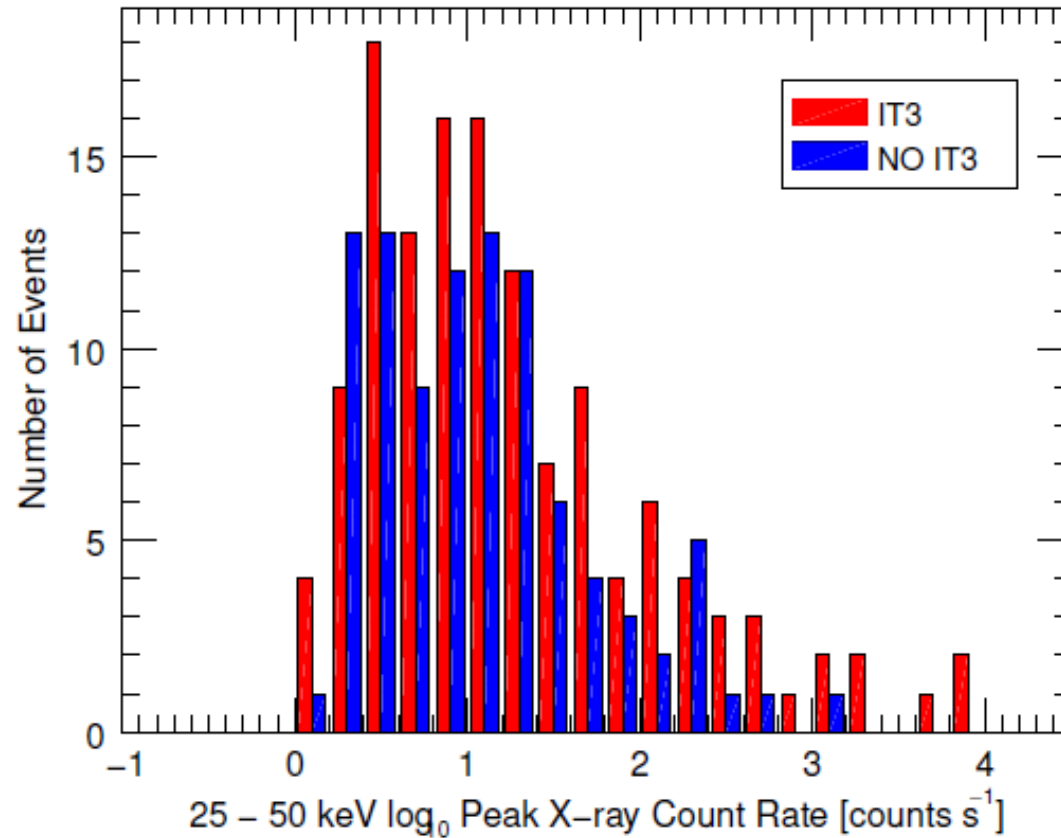
28% association rate between the groups of type III bursts and X-ray flares.

54% of the coronal type III bursts have IP counterparts

Reid & Vilmer, 2017

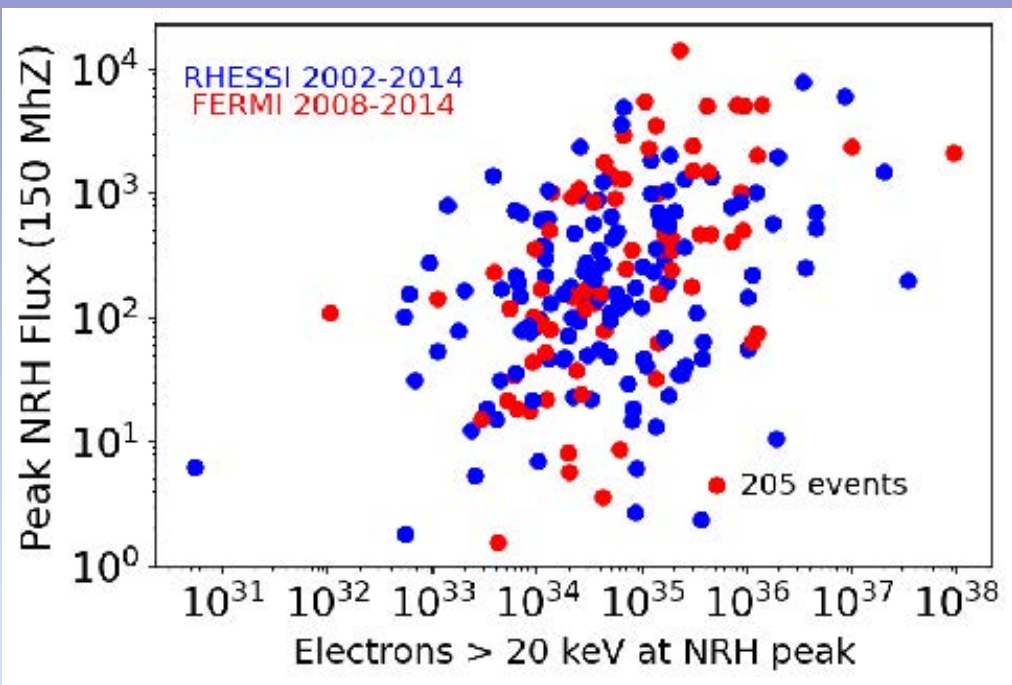
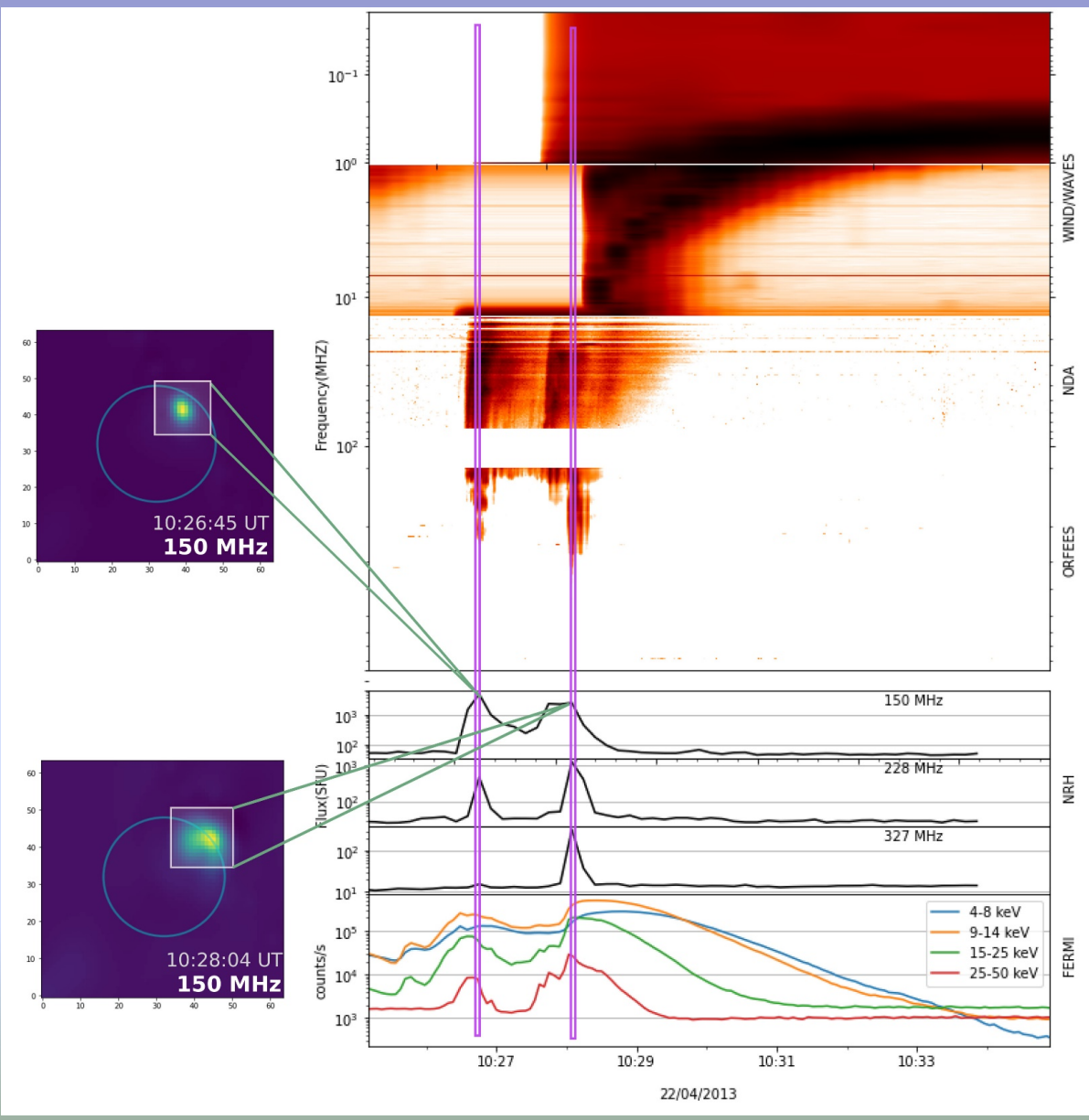


Interplanetary type IIIs and X-ray count rates



Reid and Vilmer, 2017

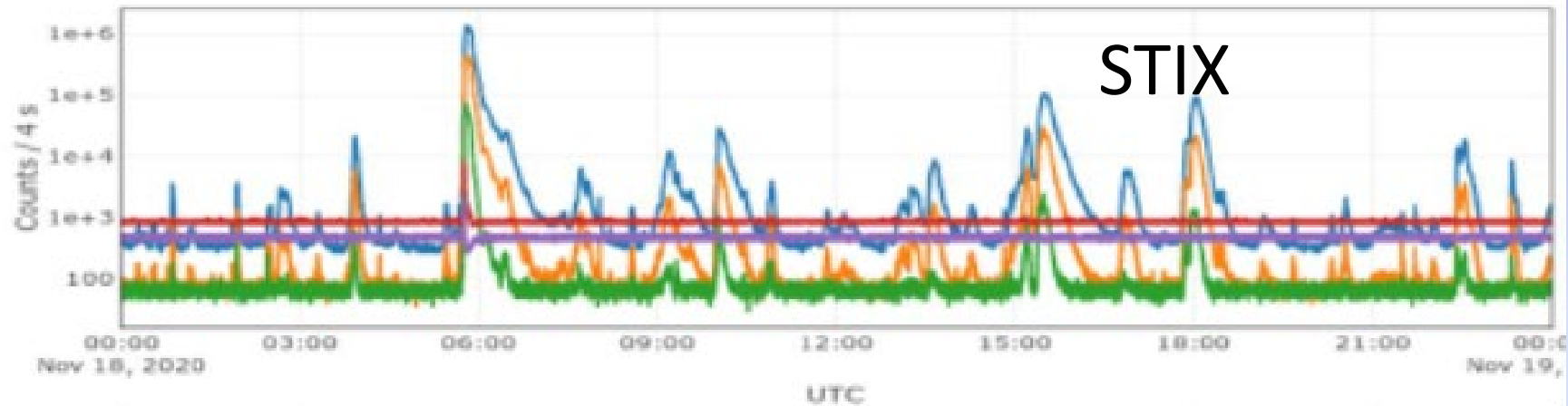
Is the X-ray count rate related to the likelihood of having an associated IP type III radio burst? No strong link BUT events with high count rates tend to be associated with IP type III bursts (Stronger electron beam (see Reid and Kontar (2015) on type III stopping frequencies))



James and Vilmer, in preparation

First preliminary comparisons STIX –RPW

2020/11/18 00:00 - 23:59

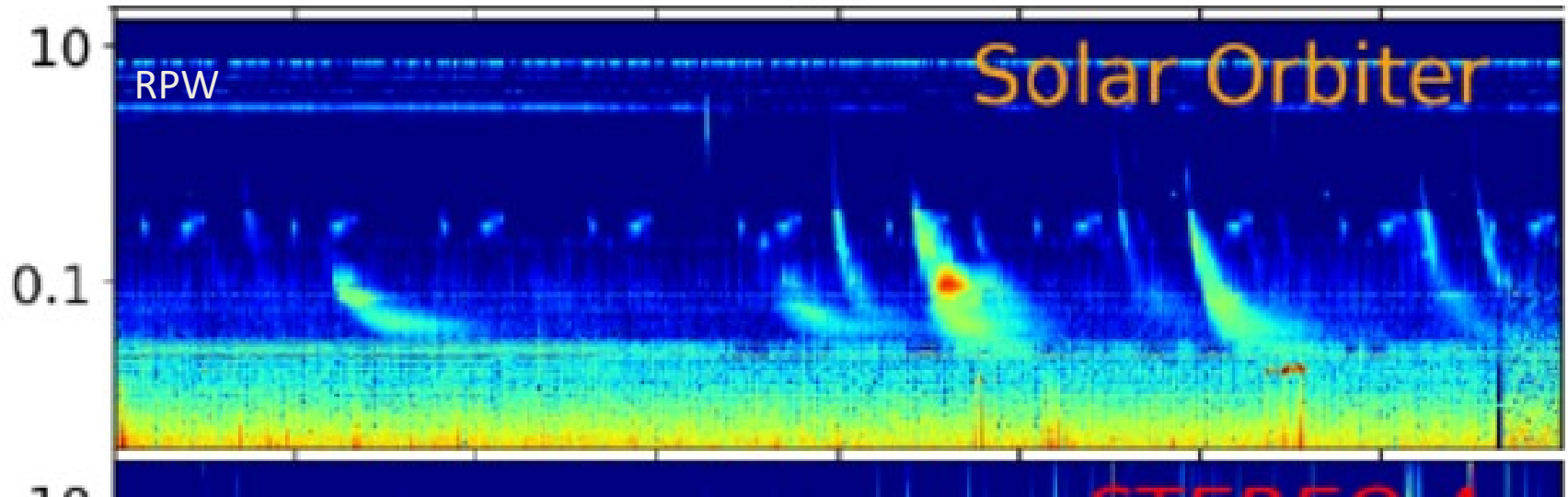


Large X-ray flares and no radio

Strong type III , weak X-rays

Same AR on the SUN?

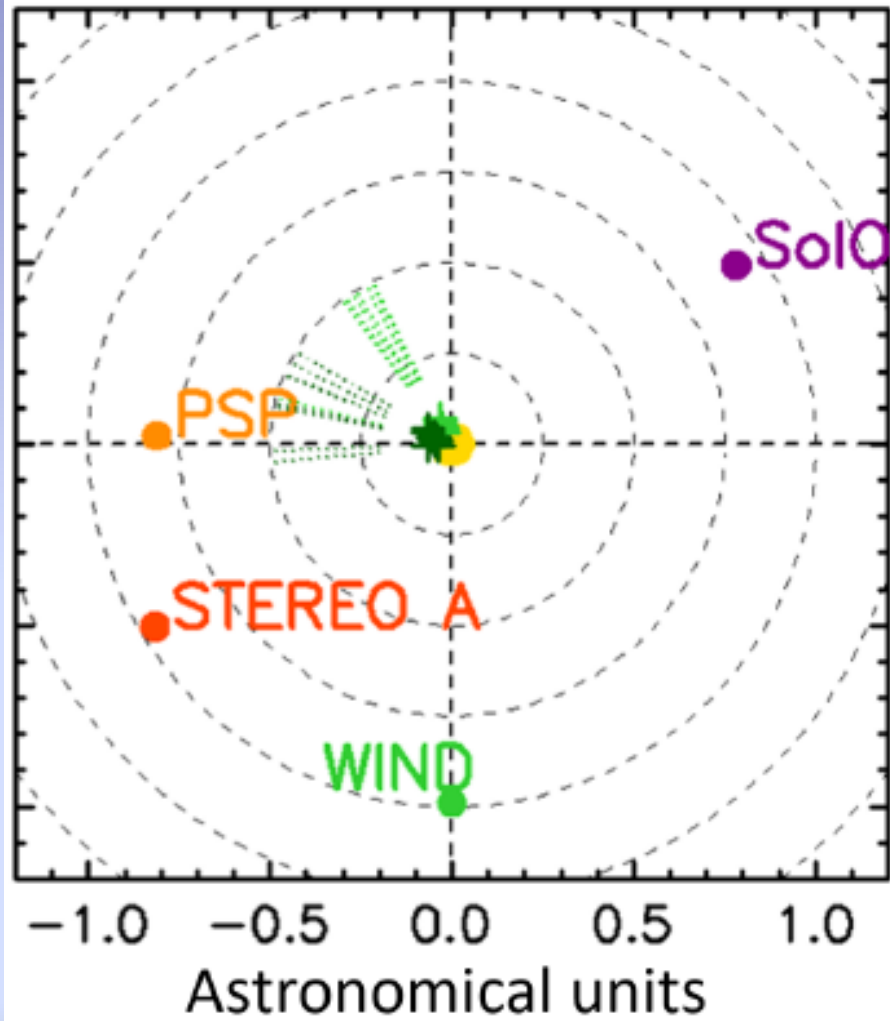
Connectivity?



Thermal or non –thermal X-ray flares?

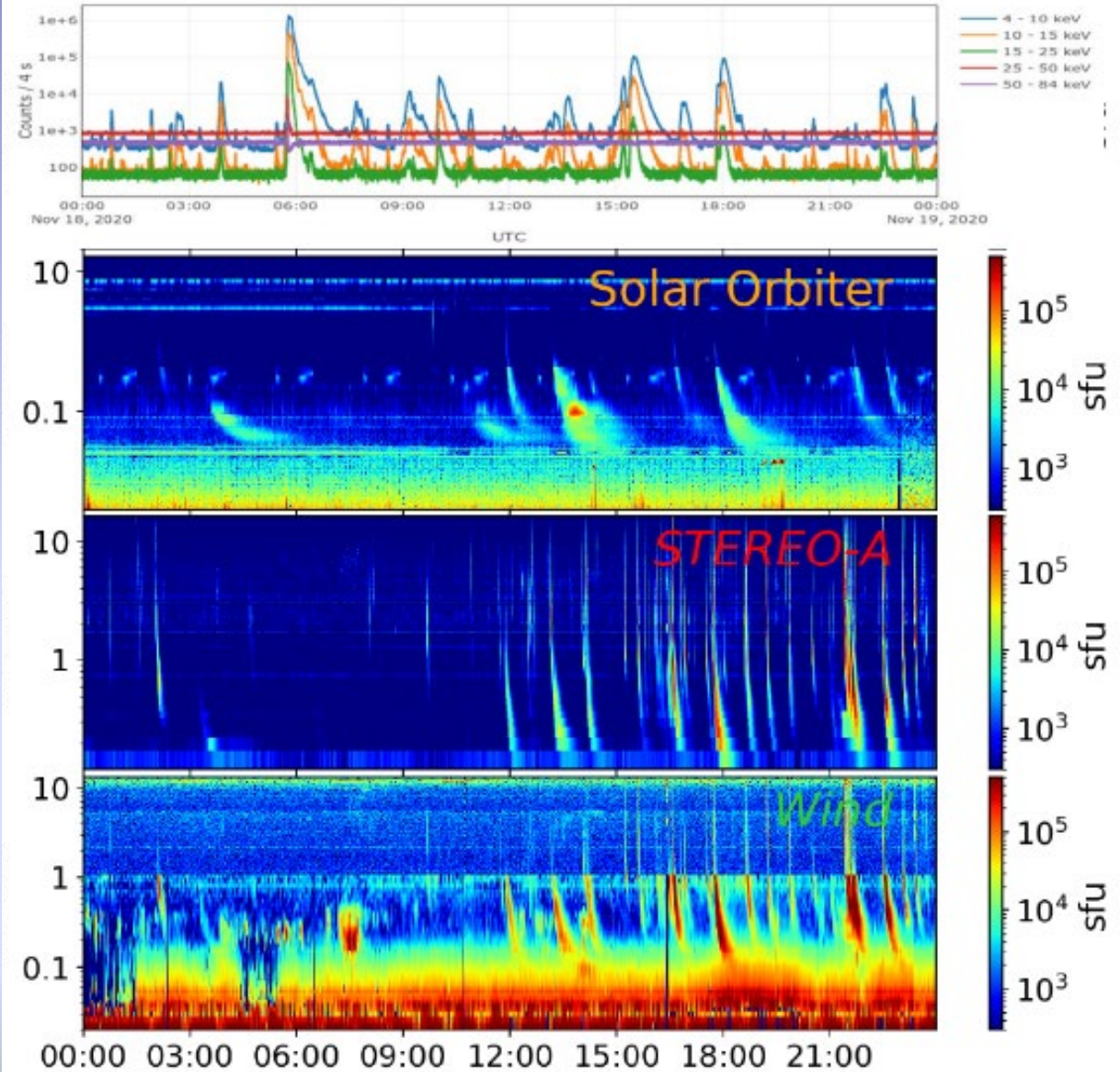
Courtesy STIX, RPW teams
Courtesy V. Krupar

2020/11/18 02:00

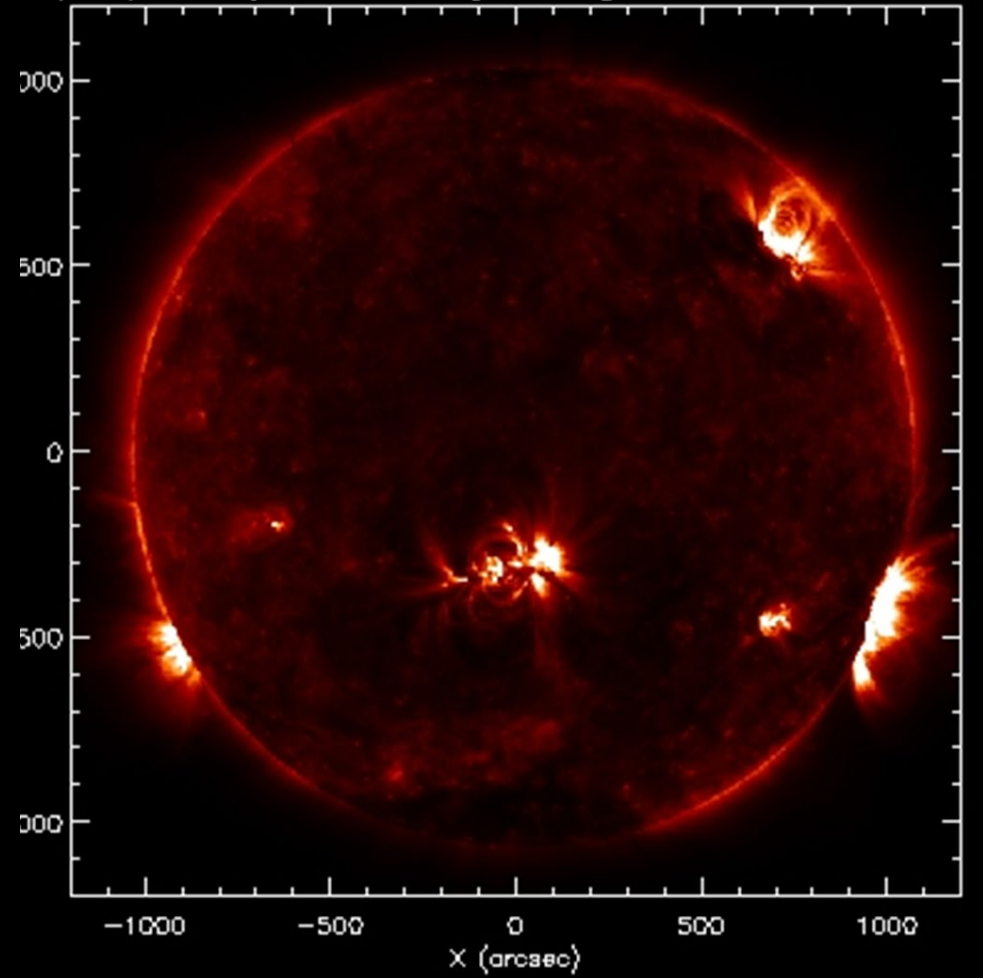


Musset et al., 2021

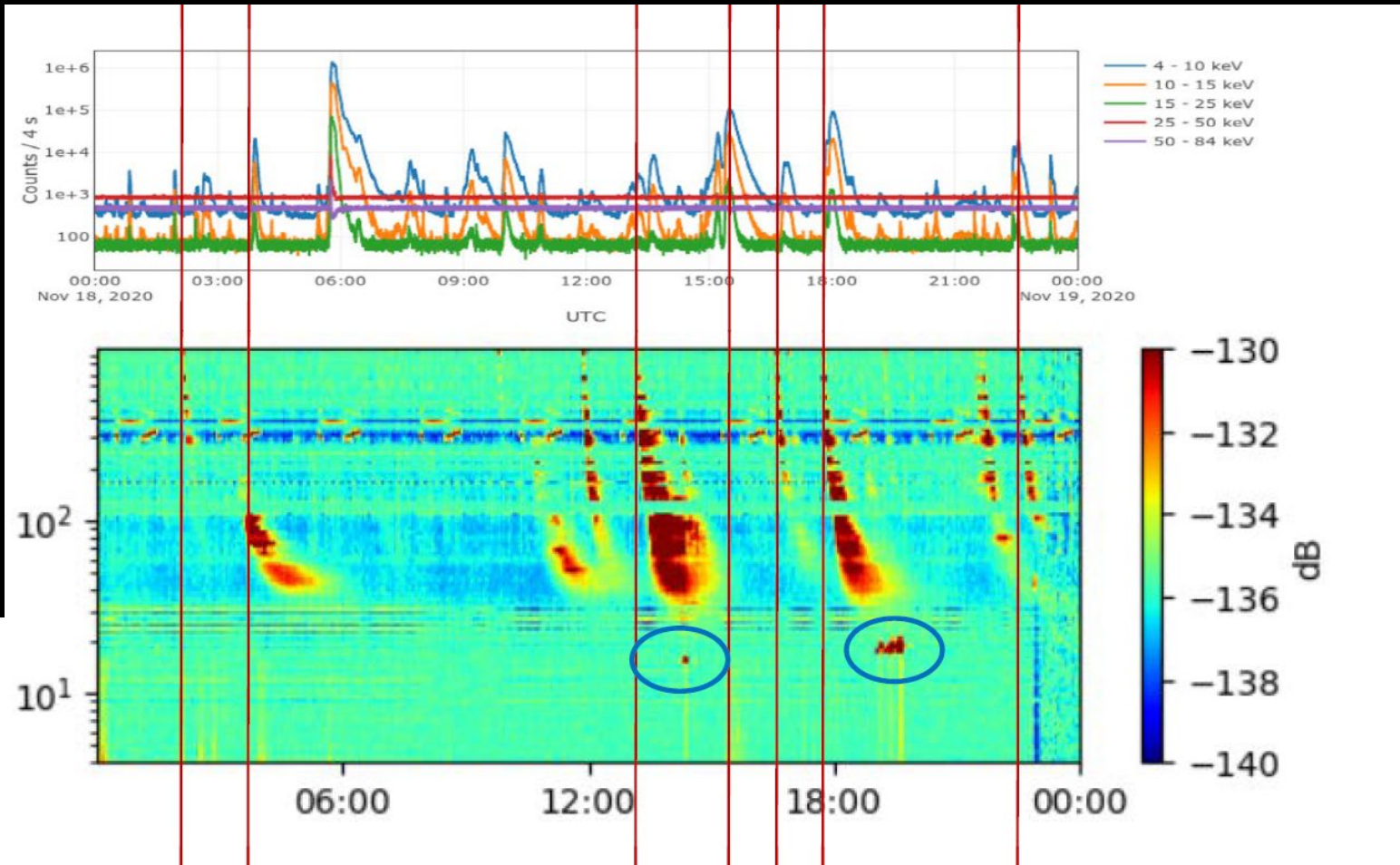
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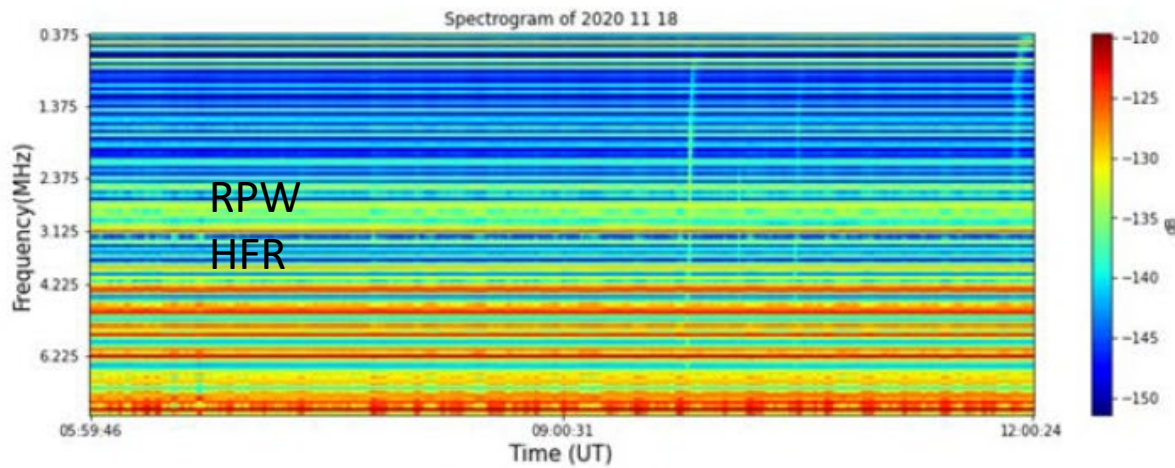


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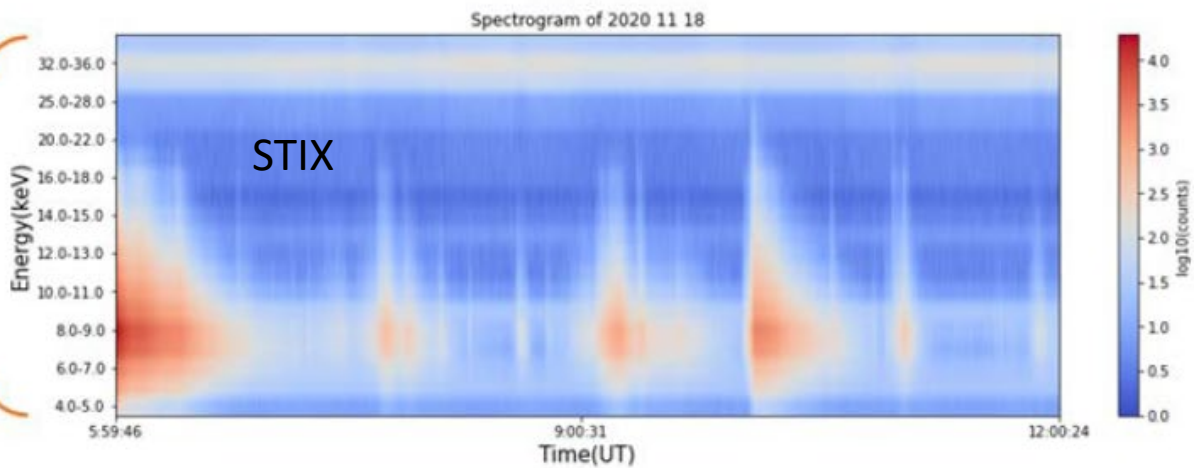


Courtesy STIX, RPW EUI (SOLO)
Thanks to V. Krupar

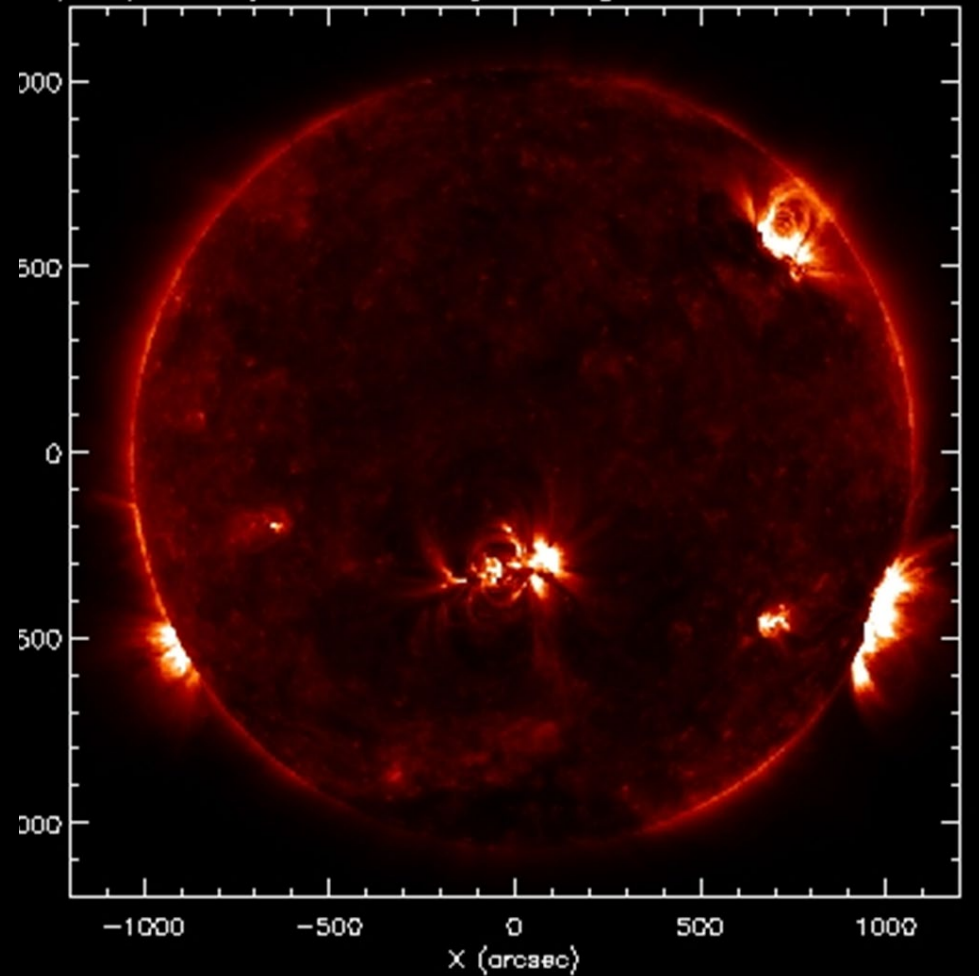




Region A
(limb)

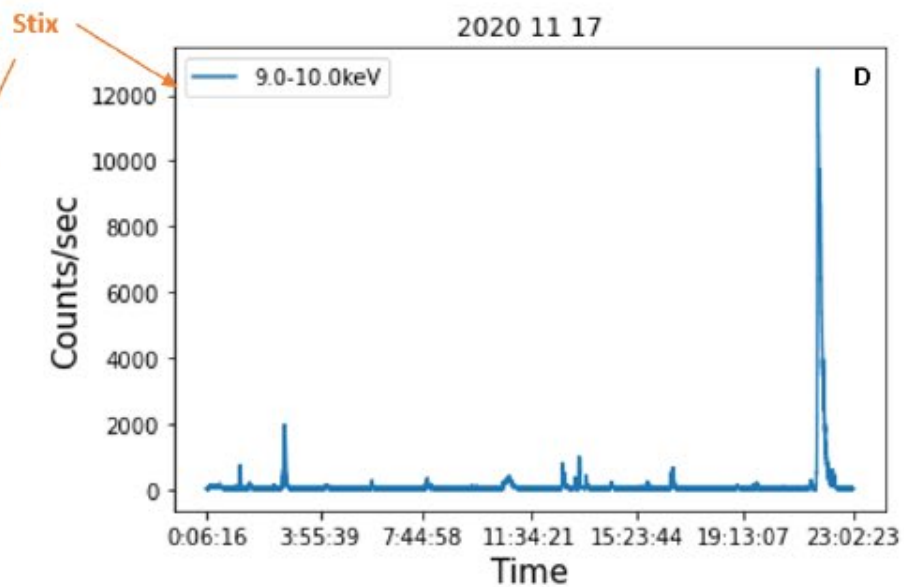
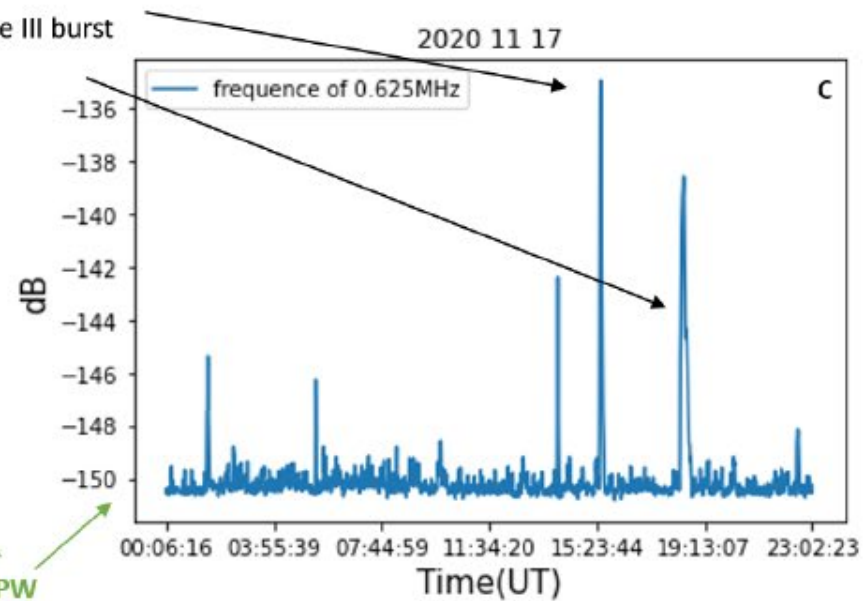
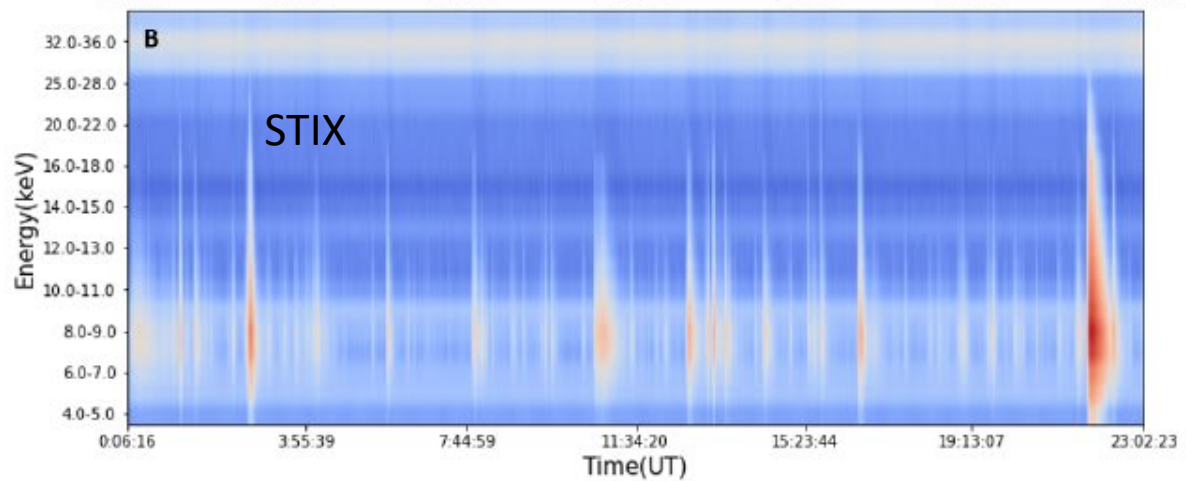
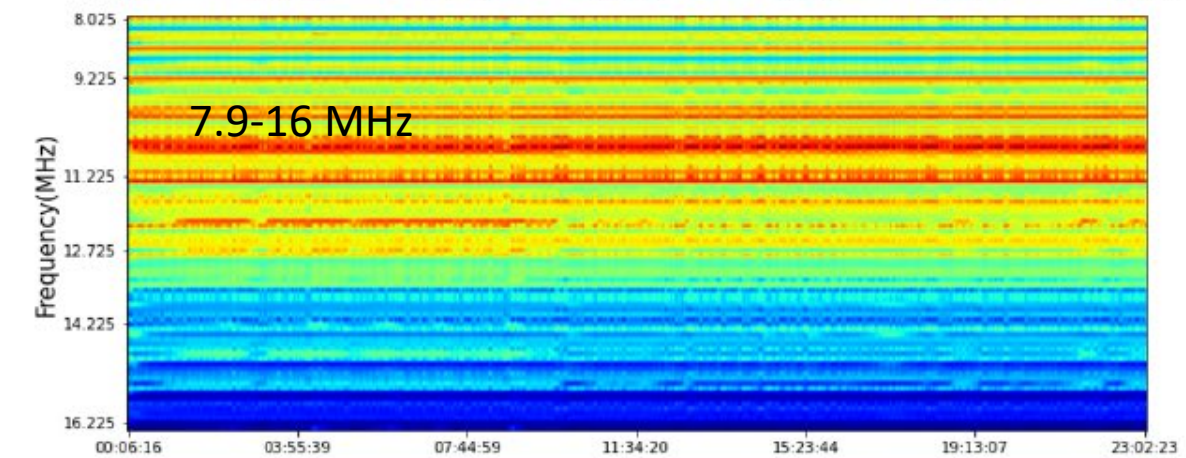
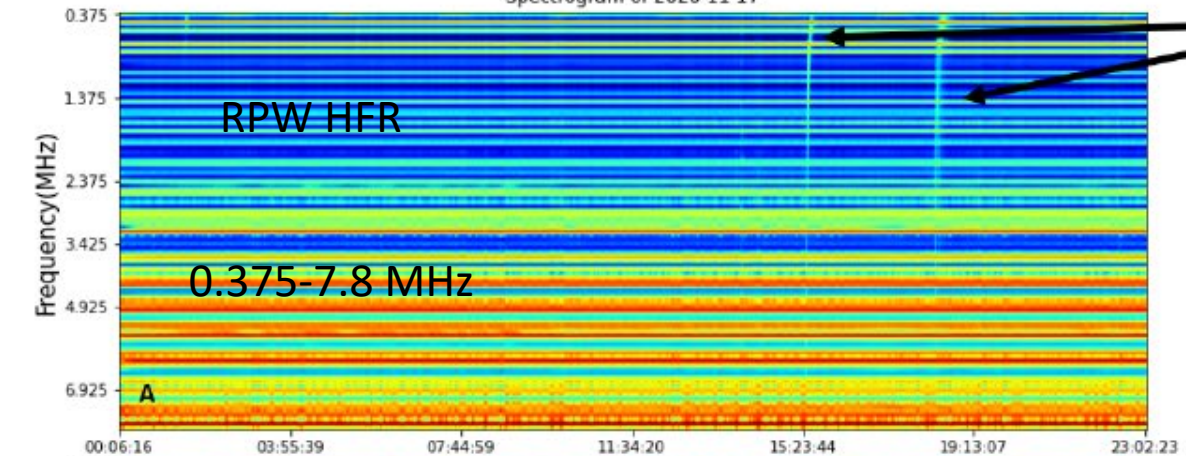


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First comparisons STIX/RPW (master degree A. Simonnin)

Origin of the X-ray flare from the Coarse Flare Locator



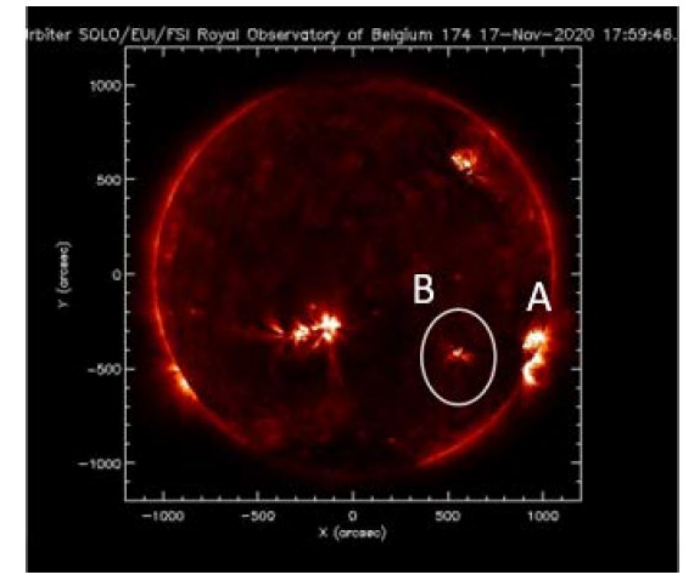
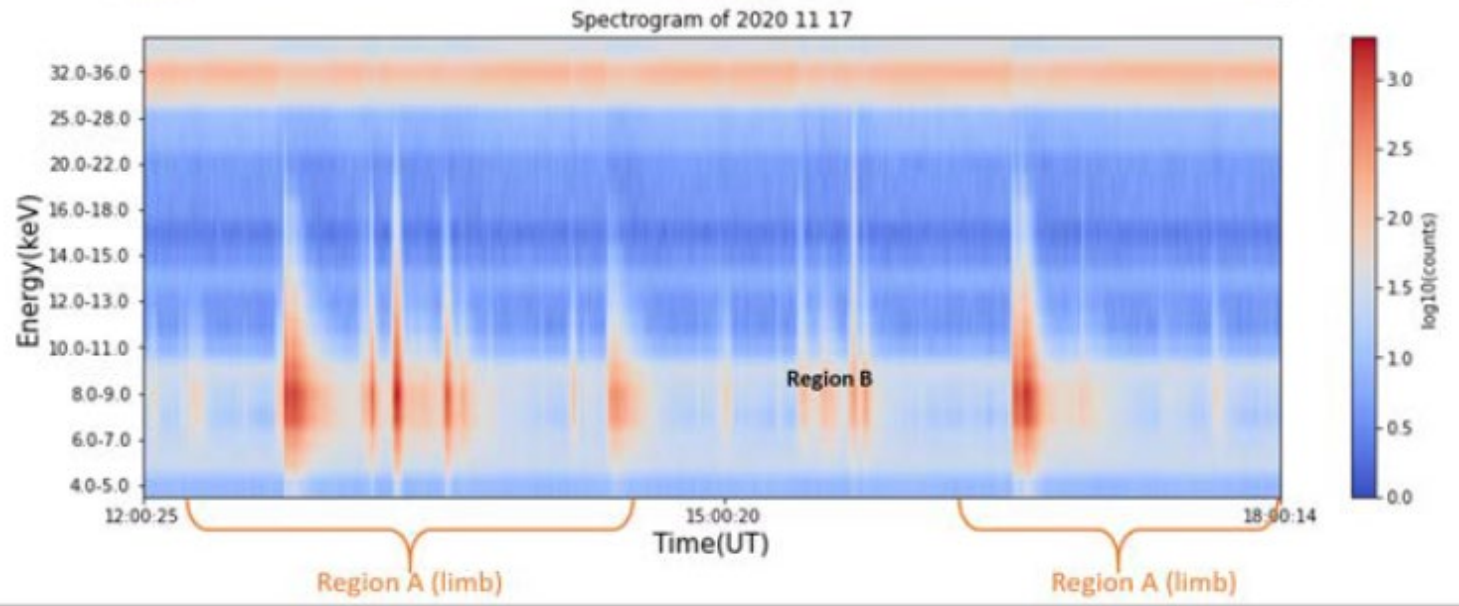
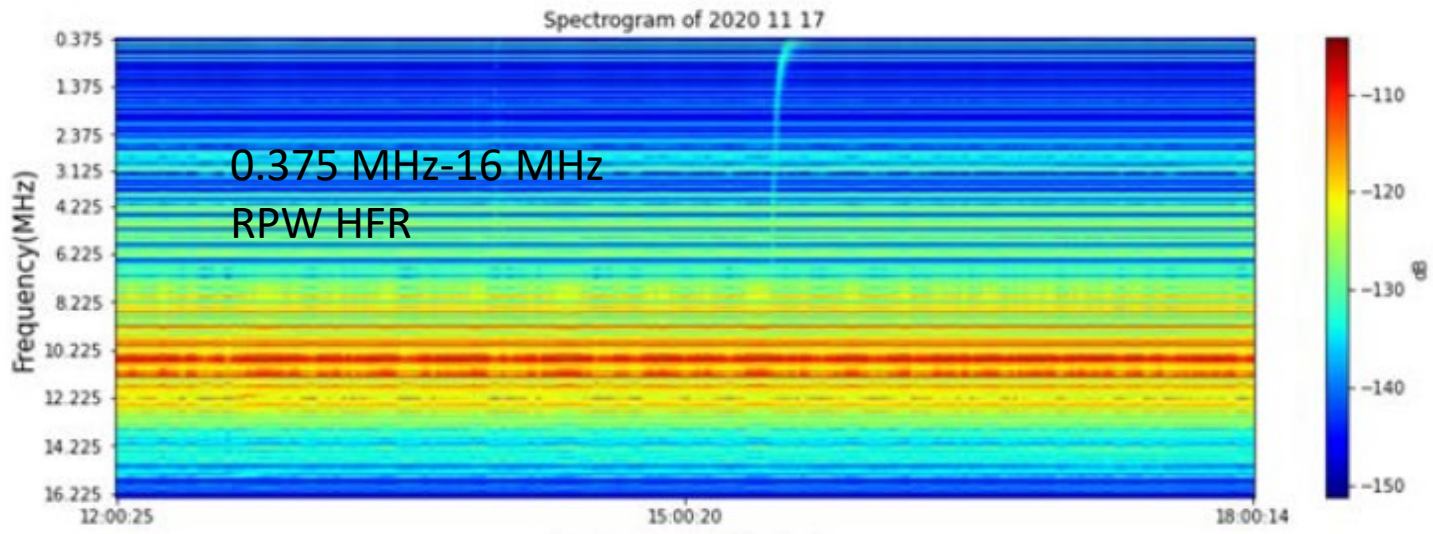
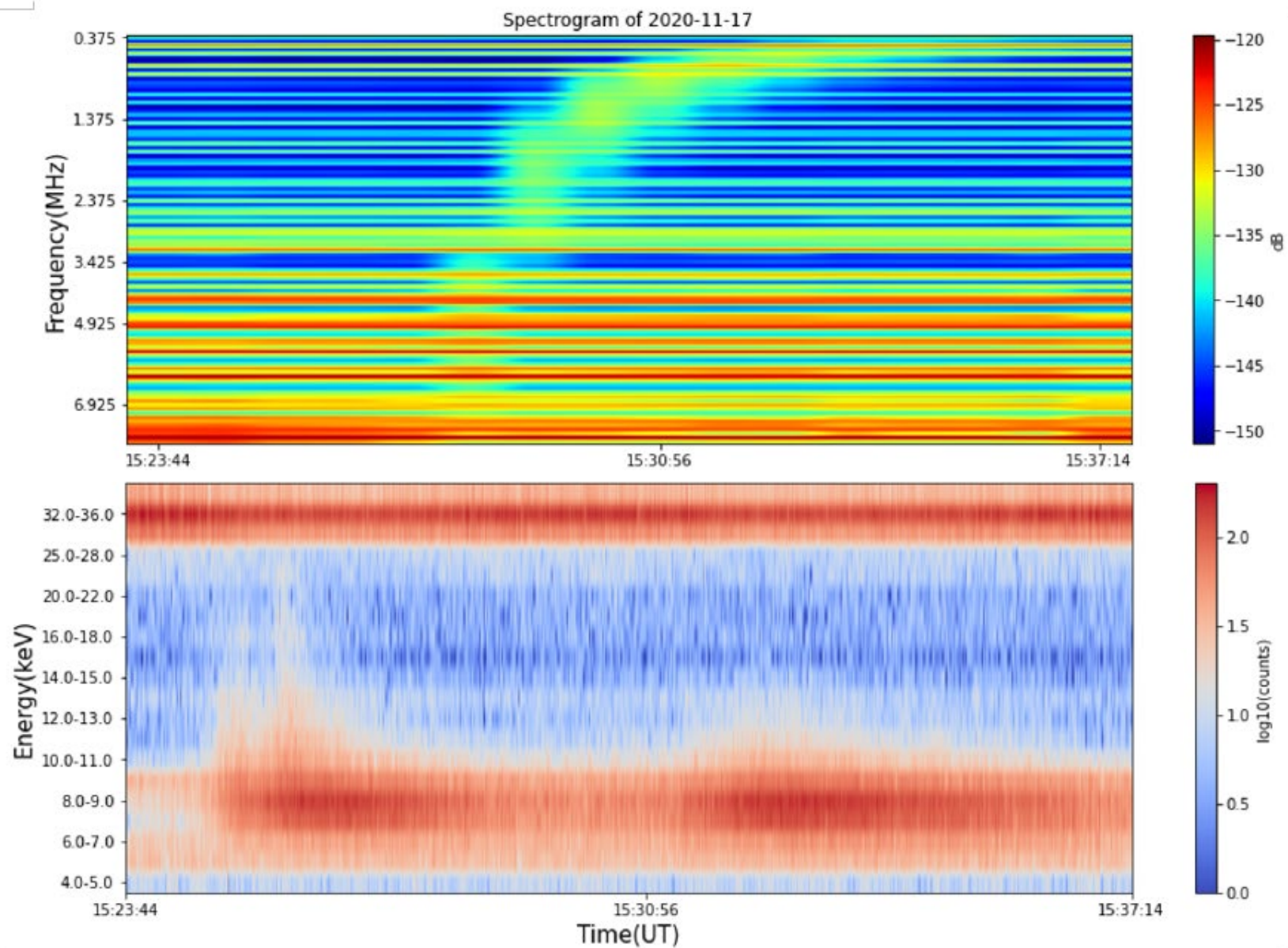
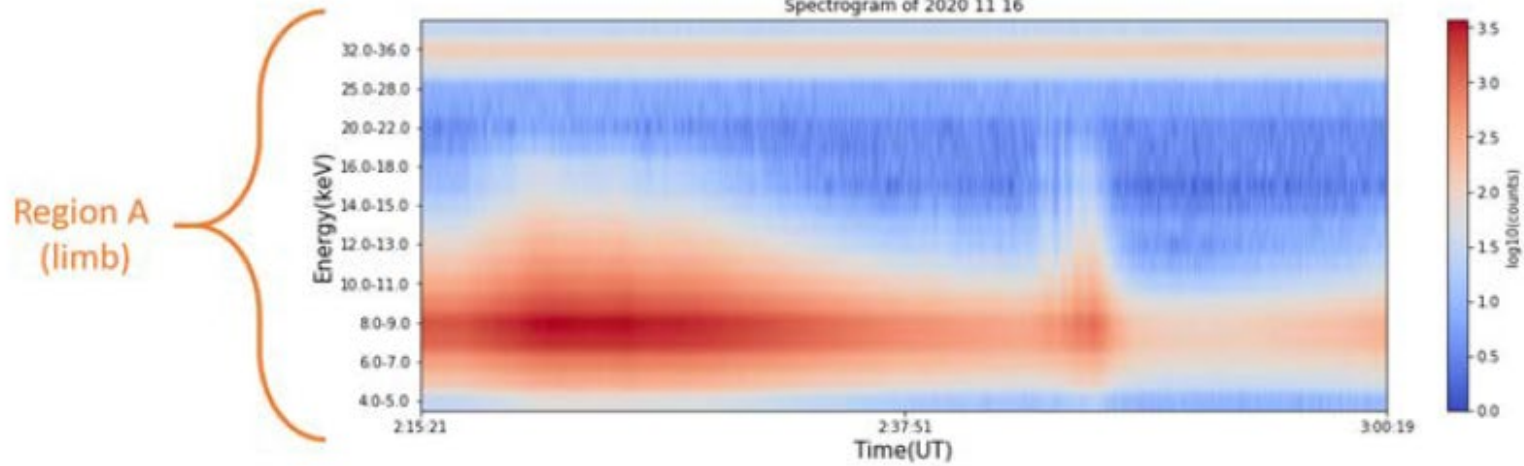
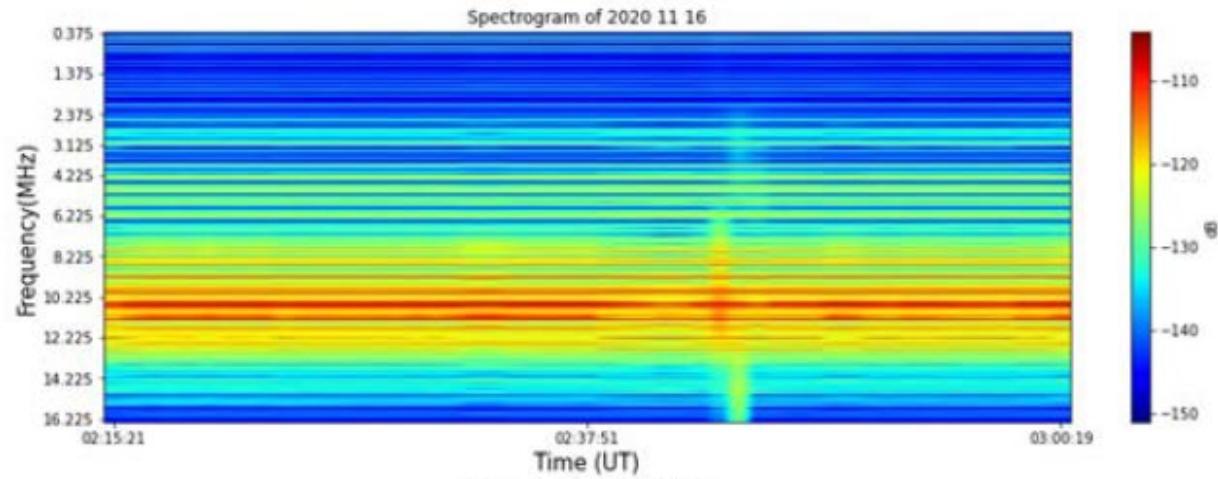
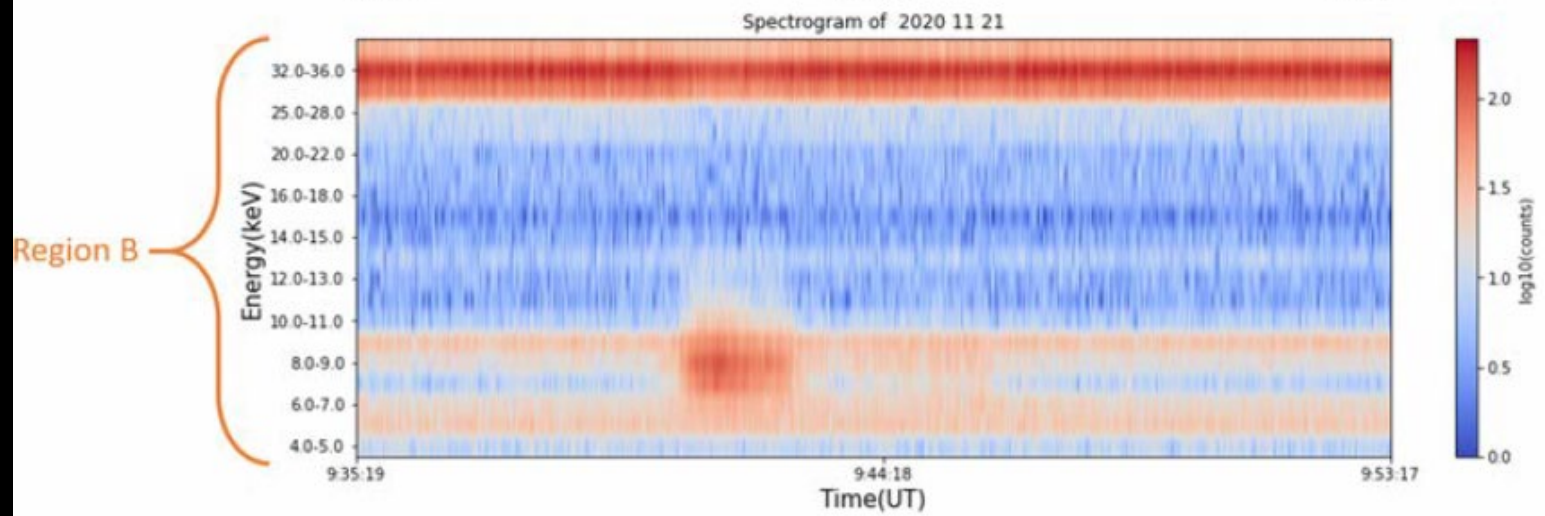
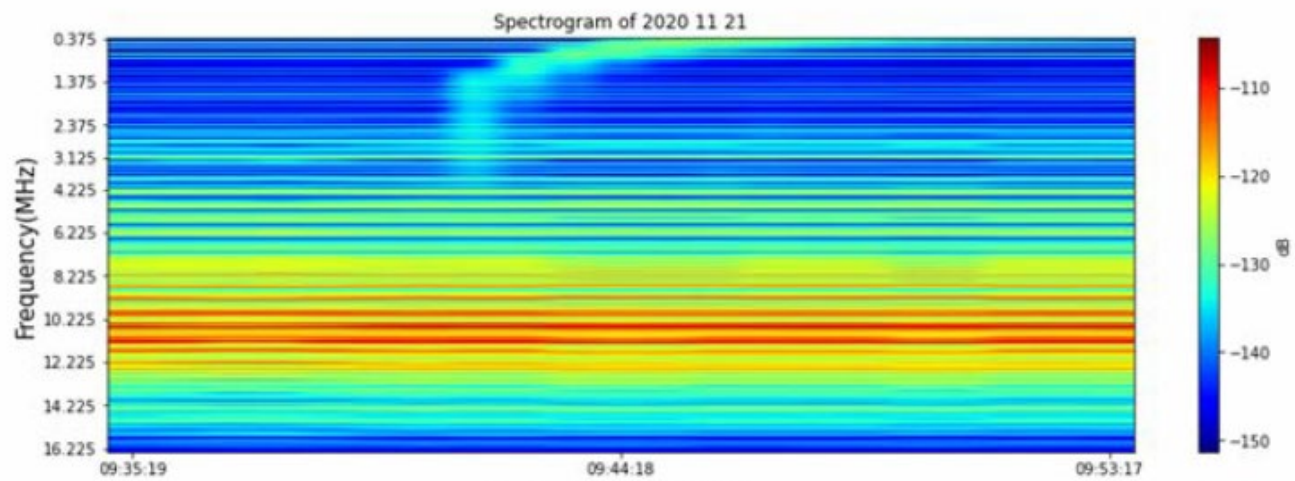


Figure 1: SOHO/EUI/FSI image of the Sun showing the solar disk. The x and y axes are in arcseconds. Two regions are labeled: Region A on the right limb and Region B on the inner disk. A white circle highlights Region B.



ZOOM EVENEMENT 16/11 A 3H





- Very preliminary comparisons between STIX and RPW
- (the code exists and has been developed in Python by A. Simonnin

- What to next?
- Filter RPW spectra
- Do a more detailed analysis of the location of the X-ray source seen by STIX with respect to the AR seen in EUV
- Analyse X-ray spectra: respective contribution of thermal and non-thermal components of the X-ray burst associated with radio or not
- Starting frequency of RPW type III burst and X-ray position
-
- And also probably a lot of other STIX/RPW observations in 2021!!!