Tracing the magnetic connectivity between the solar surface, corona and inner heliosphere using combined X-ray and radio observations

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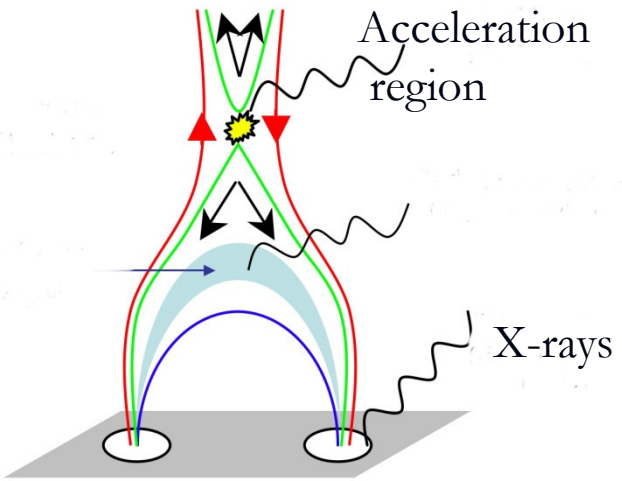
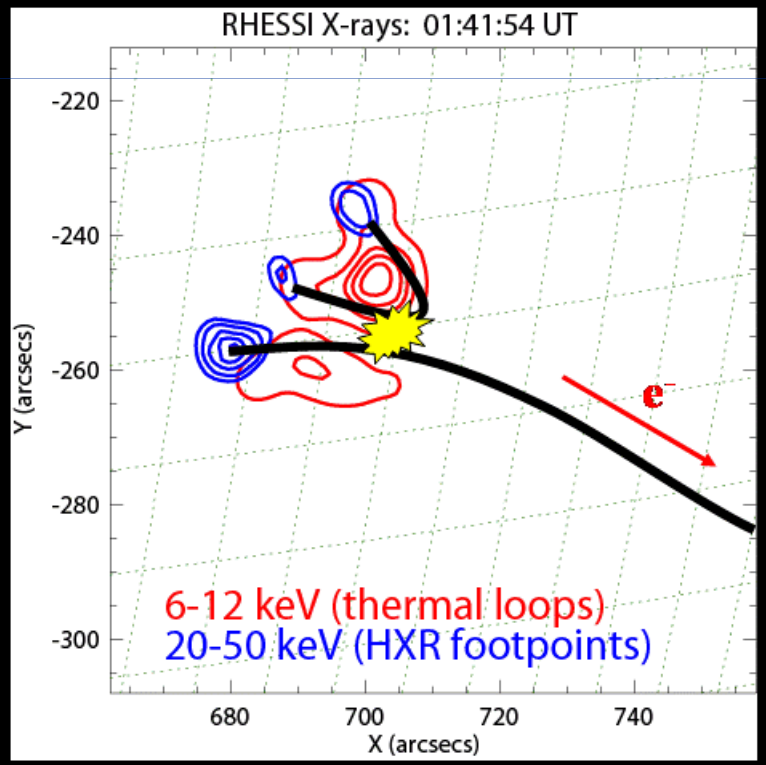
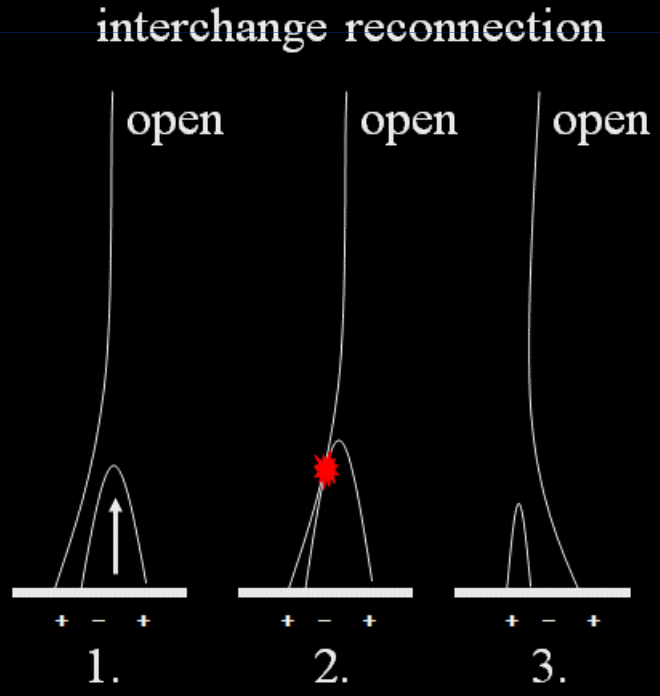




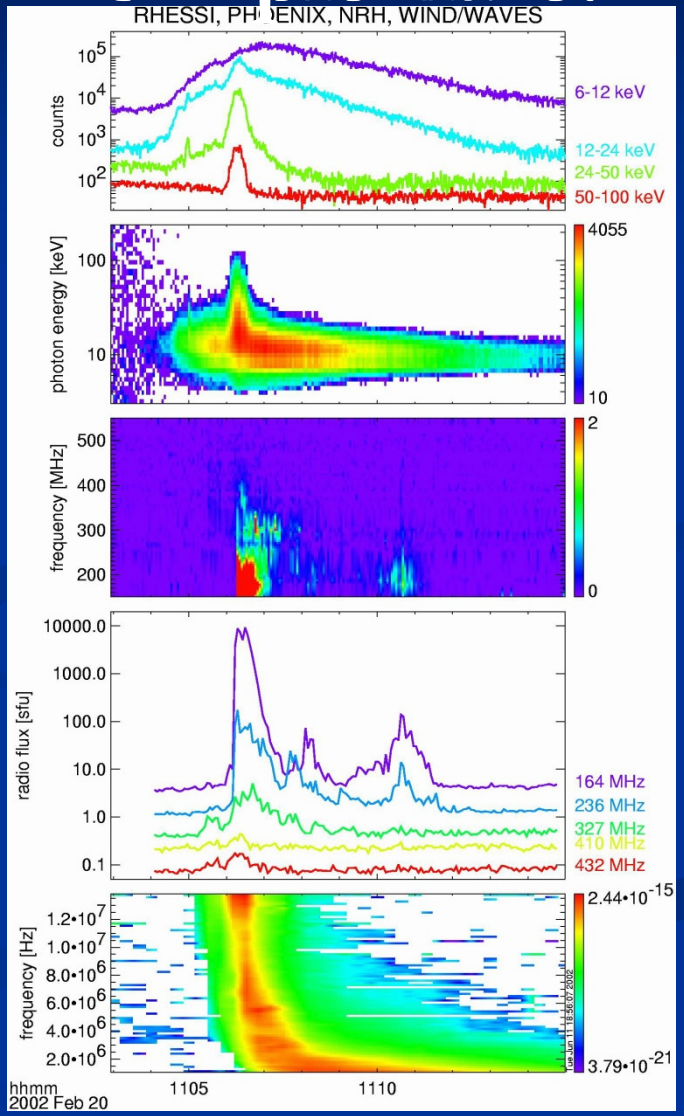


From Krucker

Electron acceleration associated with magnetic reconnection ? A simple flare.

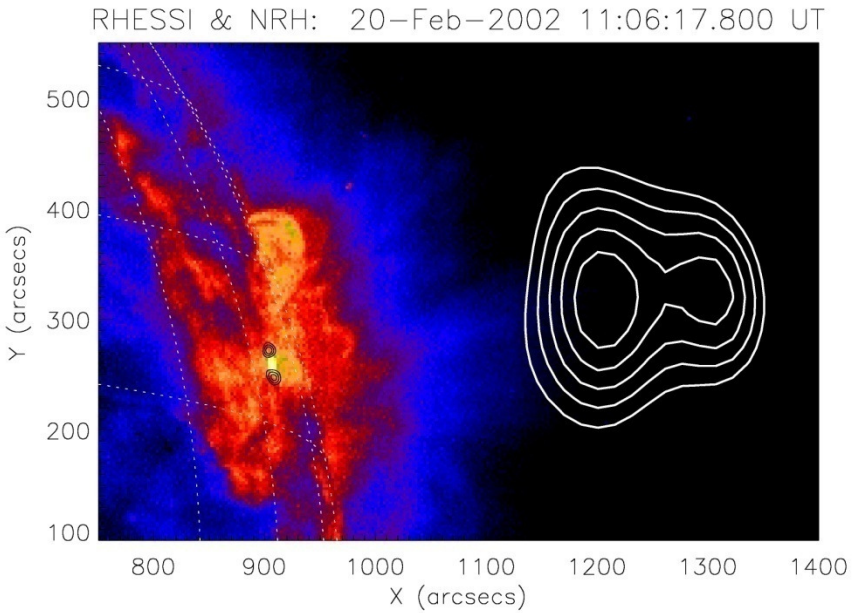
- HXR from the low atmosphere (chromosphere) - *e* precipitated downward to $n_e > 10^{12}$ cm^{-3}, bremsstrahlung with ambient *p*, $h\nu$<*energy(e)*
- Radio emission (type III) from outward propagating *e* beams, $\nu = 2\nu_{pe} \propto \sqrt{n_e}$, start < 400 MHz : $n_e < 10^9$ cm^{-3}, energy some keV

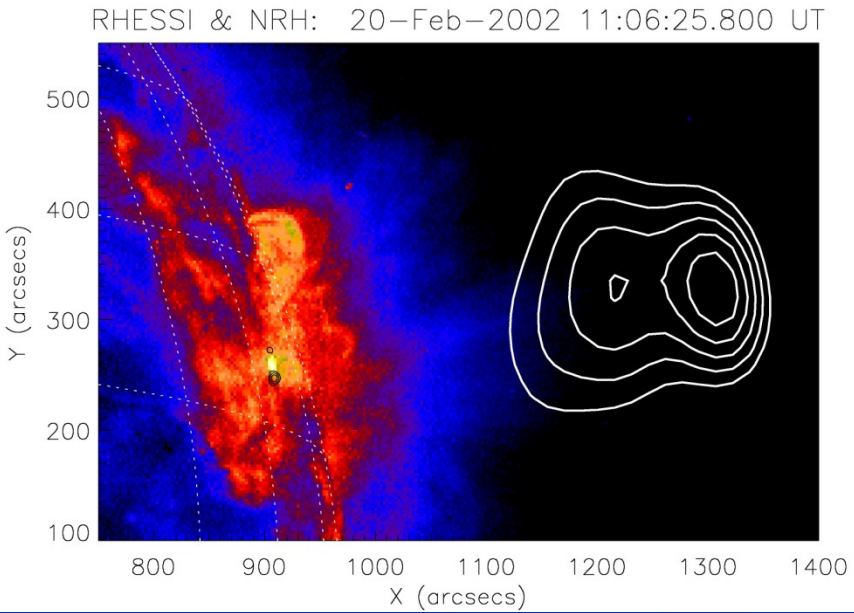
⇒ Acceleration region in the corona, injects particles downward (chromosphere) & upward (high corona, IP space)



Vilmer et al., 2002 Solar Phy

Electron acceleration associated with magnetic reconnection ? A simple flare.





- Comparison of images at ≠ times at decimetric wavelengths (NRH) and above 30 keV over EIT

Vilmer & Krucker & Lin & RHESSI Team (2002)

Images at highest frequencies??
Closest to the X-ray sites??

Electron acceleration and injection in the interplanetary medium? A more complex flare.

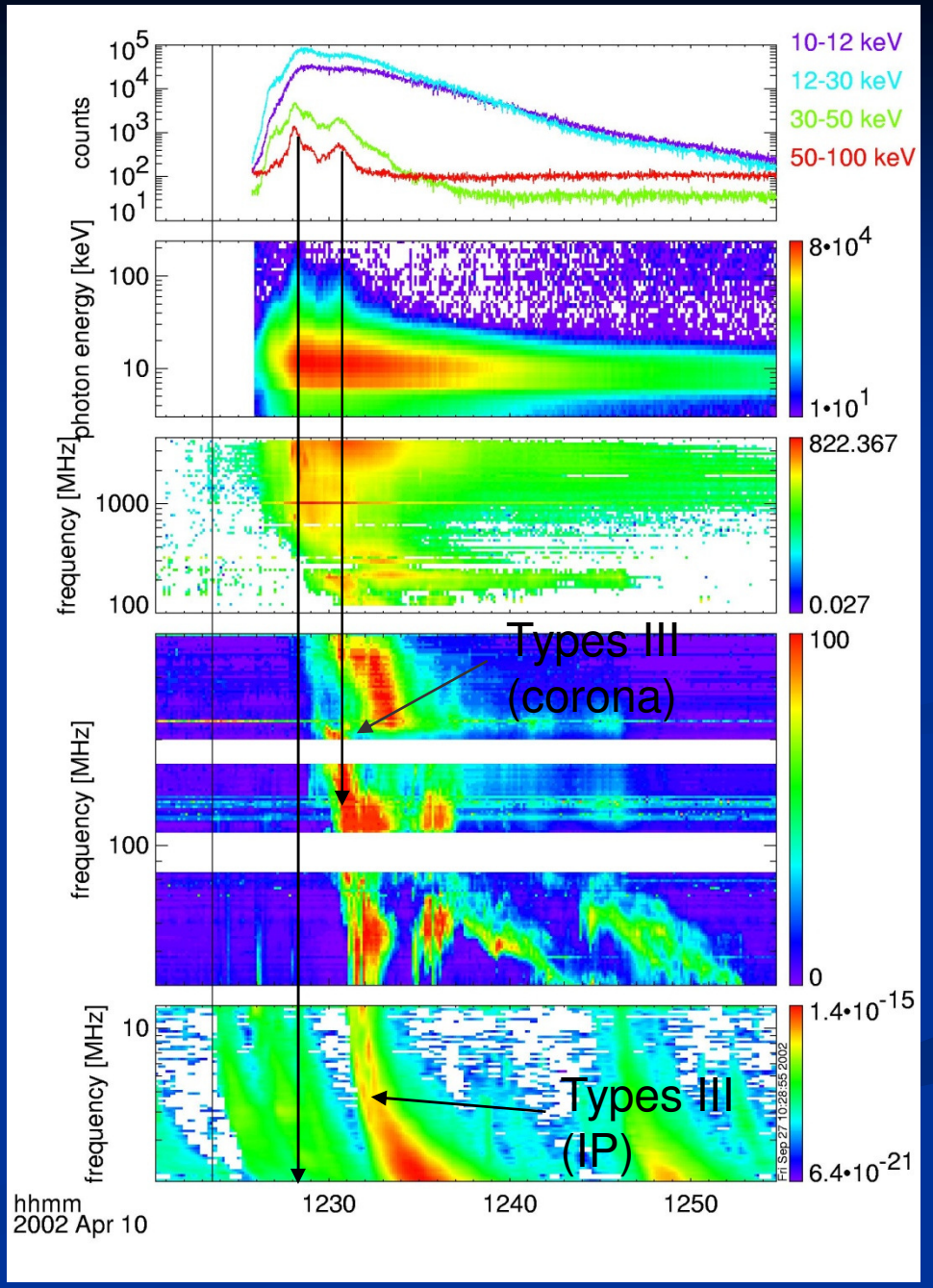
HXR from the low atmosphere (chromosphere) - *e* precipitated downward to *ne* > 1012 cm-3,

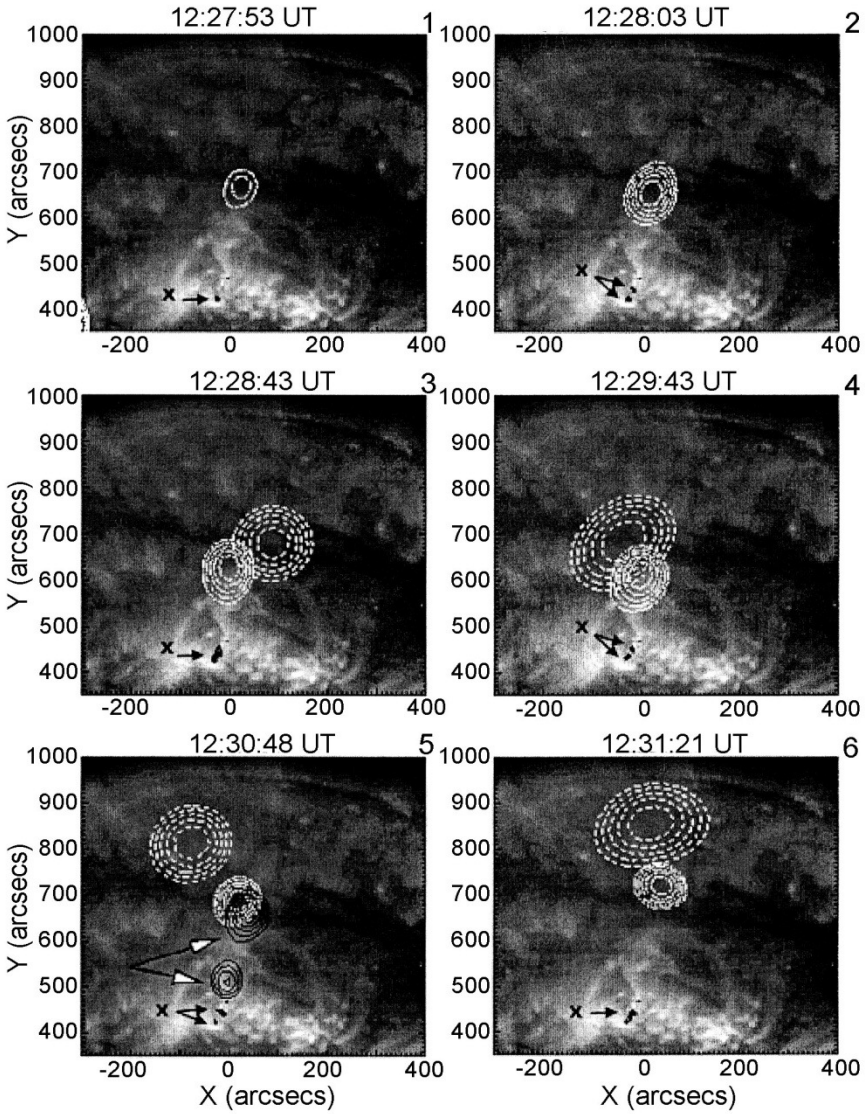
Radio emission (type III) from outward propagating *e* beams,

Radio composite spectra
3 GHz to 1 MHz

Acceleration region in the corona, injects particles downward & upward but several sites for the high corona or IP space

Vilmer et al. 2003





Vilmer et al., 2003

•RHESSI 40-65 keV and

432 (black), 327 and 164 MHz contours on EIT images

First, electron acceleration and injection in low corona (Xray and 432 MHz radio emissions)

•Later on electron production higher in the corona in connection with type III in the interplanetary medium and electron injection in the corona

•-Interest of large band radio imaging spectroscopy to follow electron paths towards the IP

•*Tracing the magnetic connectivity between the solar surface, corona and IP with combined X-ray and Radio observations*

(one of the key question of Solar Orbiter)

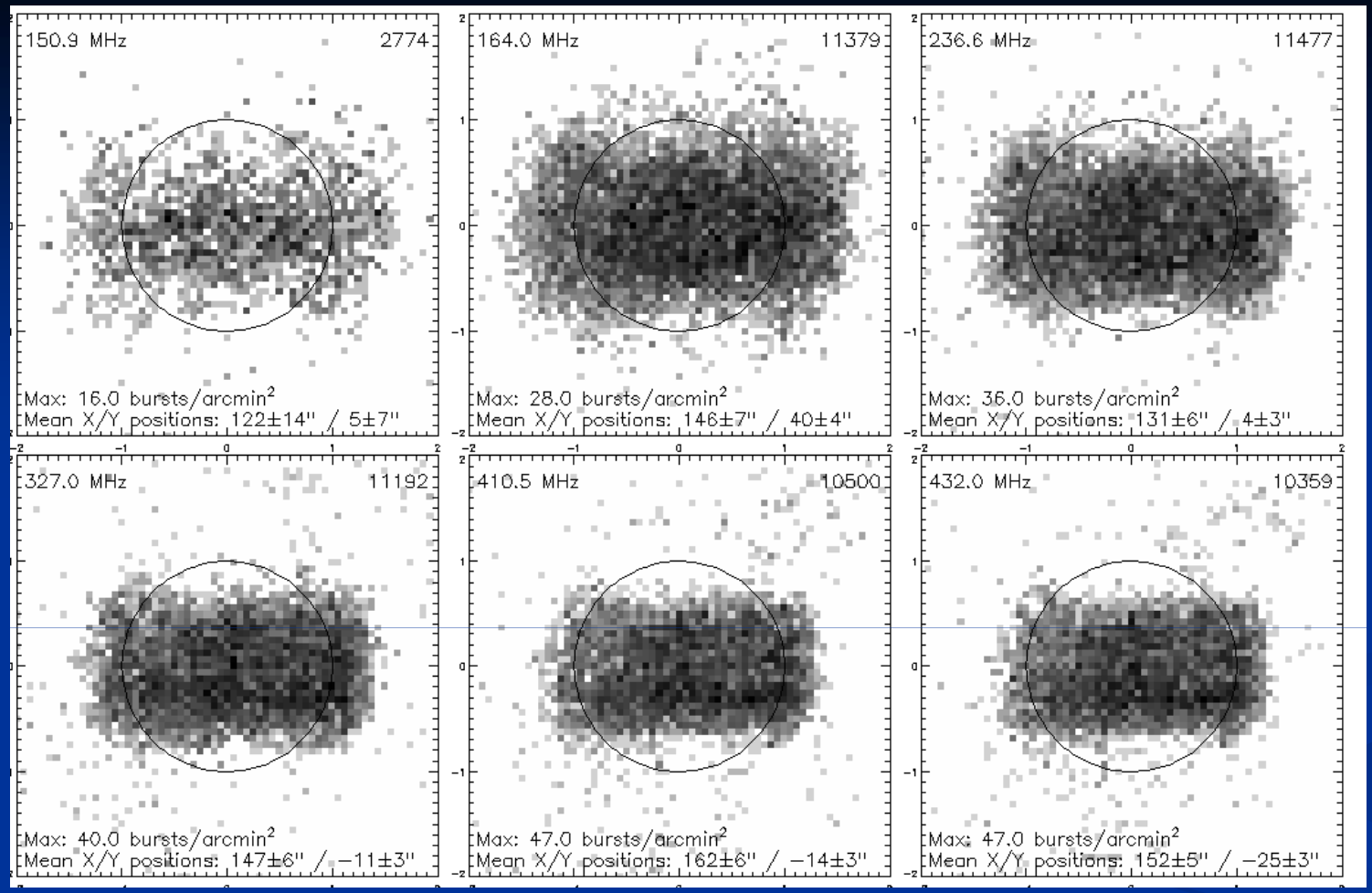
A Systematic Work in Progress:

- Start from the list of solar radio bursts from NOAA

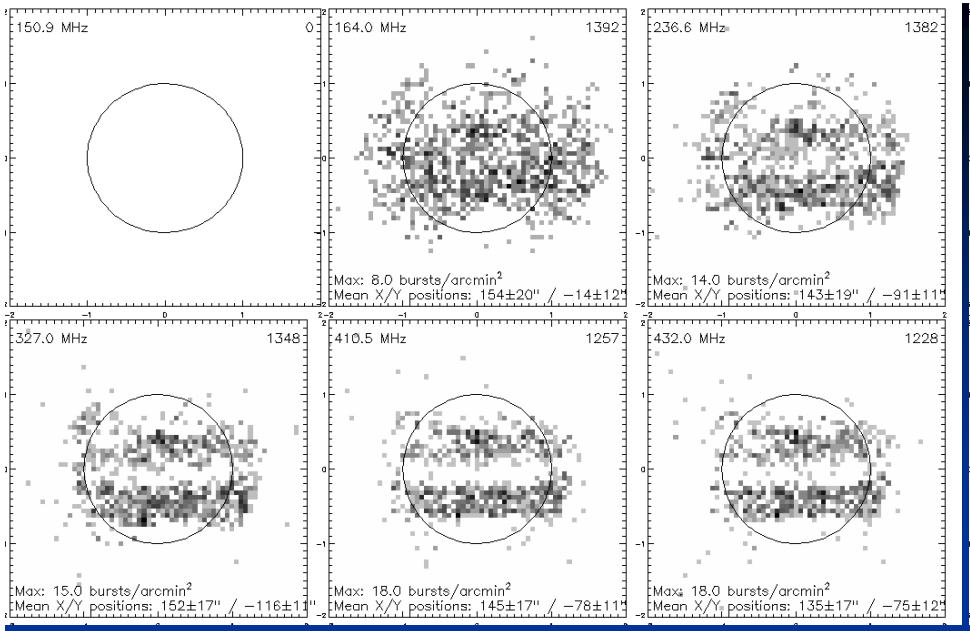
  Select events between 08:30 and 15h30 UT and in the 150-432 MHz range (i.e. observed by the NRH). Removal of events reported by several observatories.

  (see Saint-Hilaire, Vilmer and Kerdraon in preparation)

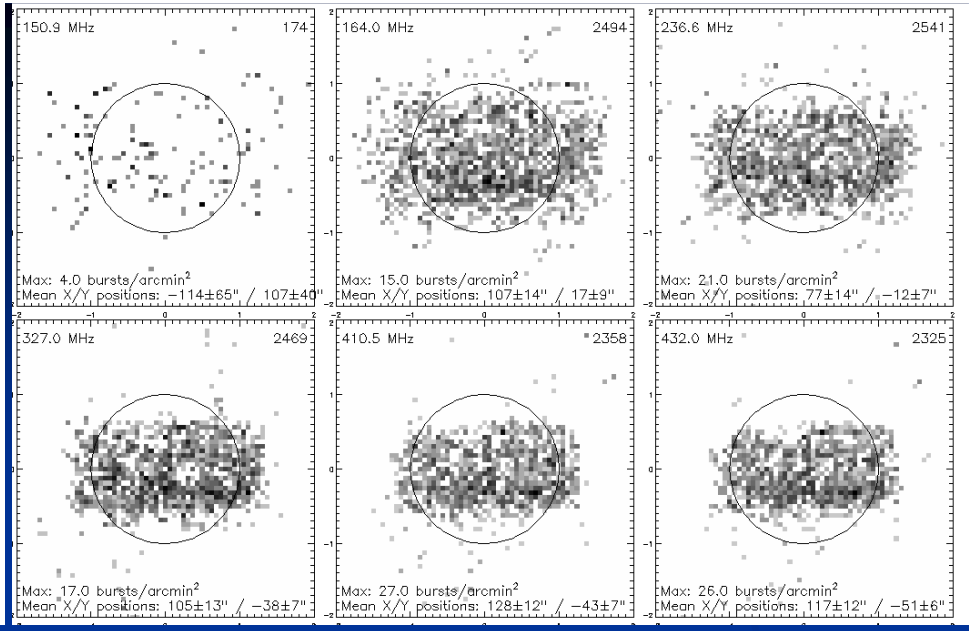
Select events observed by RHESSI and WIND/WAVES using the RHESSI quick look site (http://sprg.ssl.berkeley.edu) and the Radio Monitoring Survey at LESIA (http://secchirh.obspm.fr)



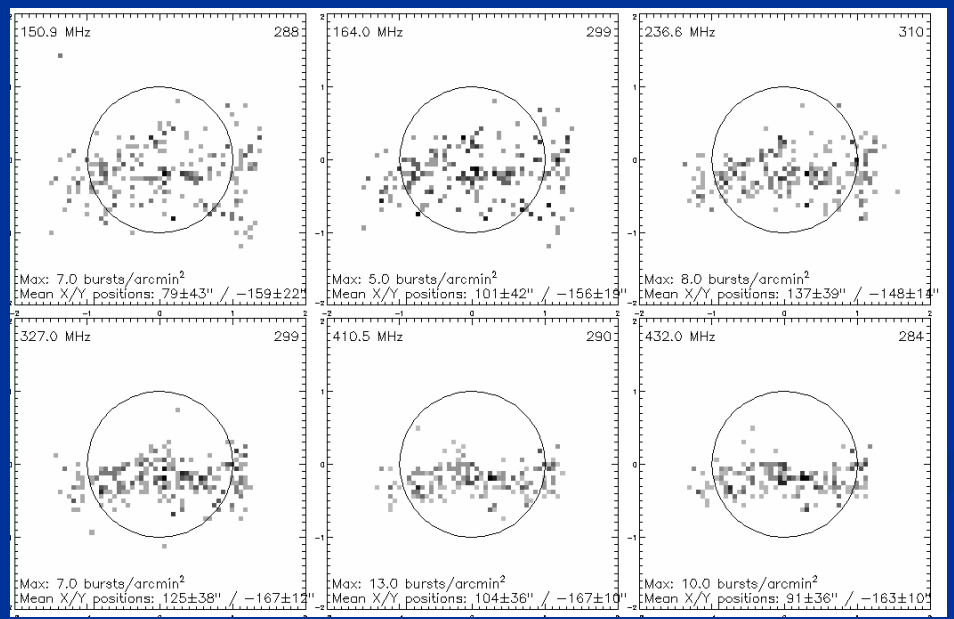
Distribution of radio bursts from 1998 to 2008



1998



2002



2006

Some statistics:
-From 14 February 2002 to 30 September 2002:

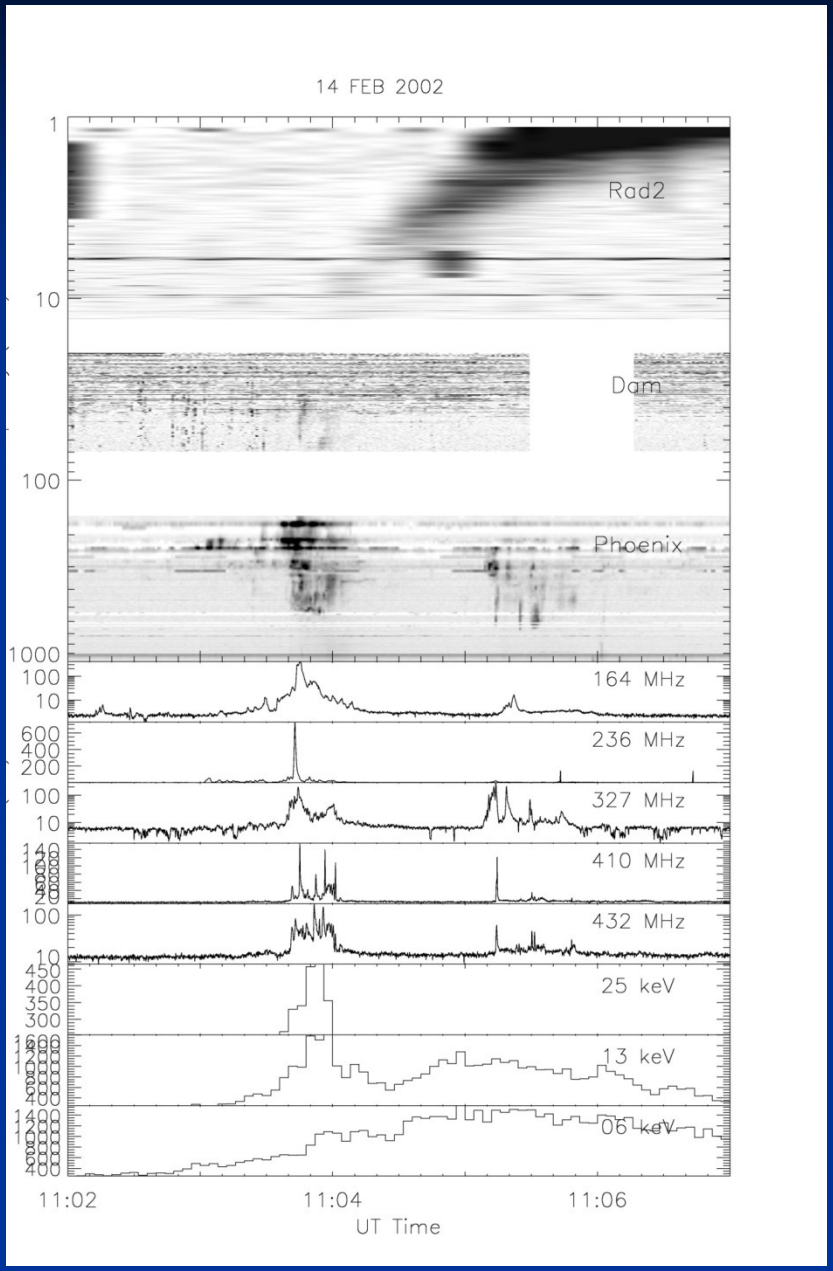
1080 events in the list (i.e. bursts reported by NOAA and observed with the Nançay Radioheliograph)

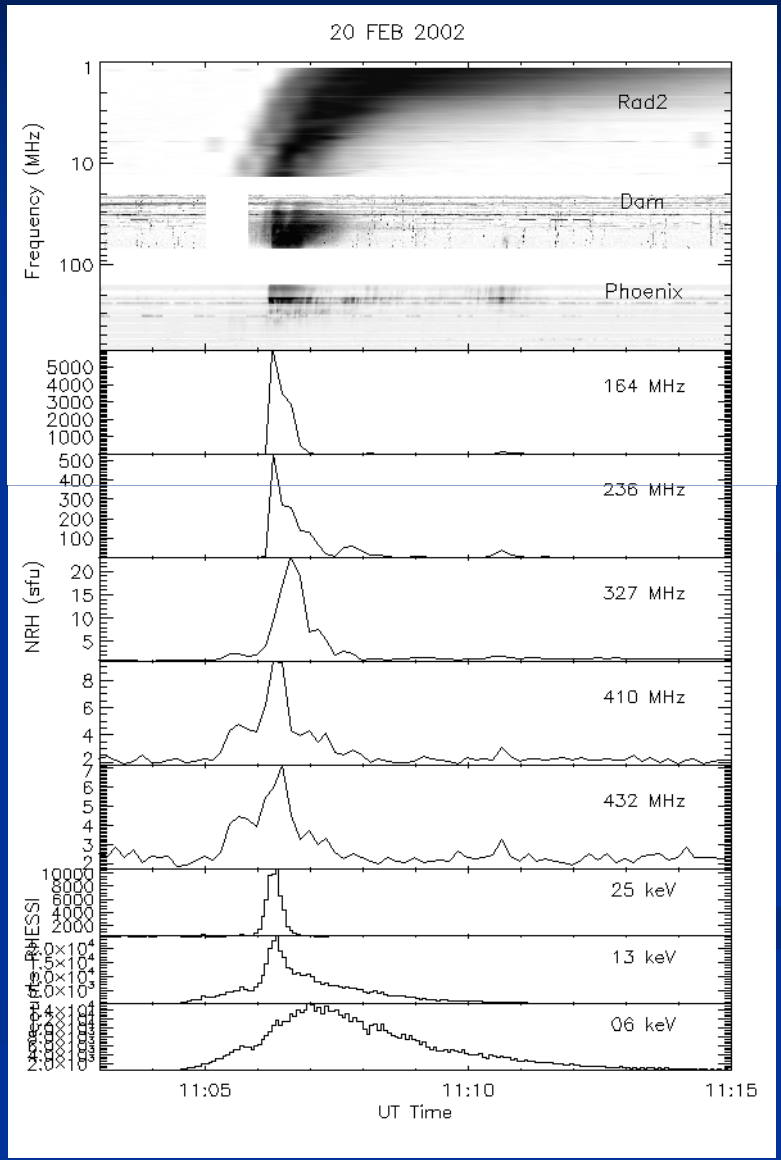
596 events (55%) have a signature in WIND/WAVES (i.e. at frequencies below 12 MHz)

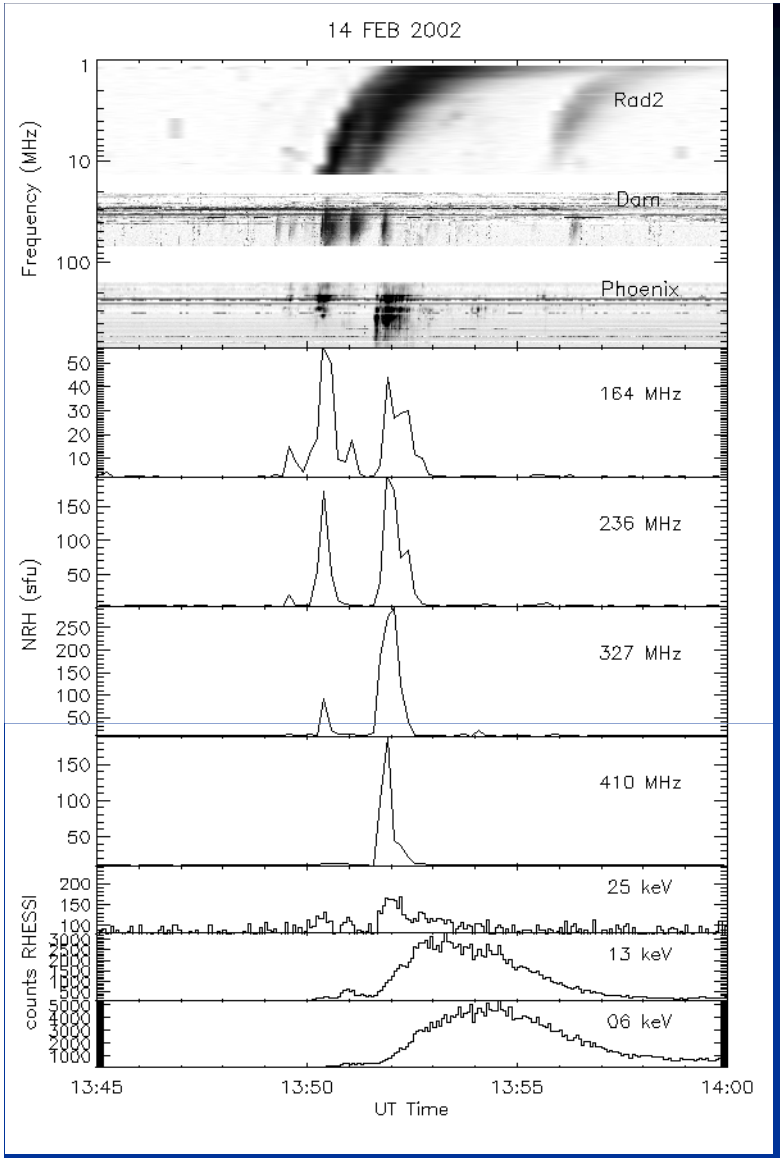
357 events for which the RHESSI spacecraft is in the night.
181 events for which the RHESSI spacecraft is in the SAA (no solar observations)

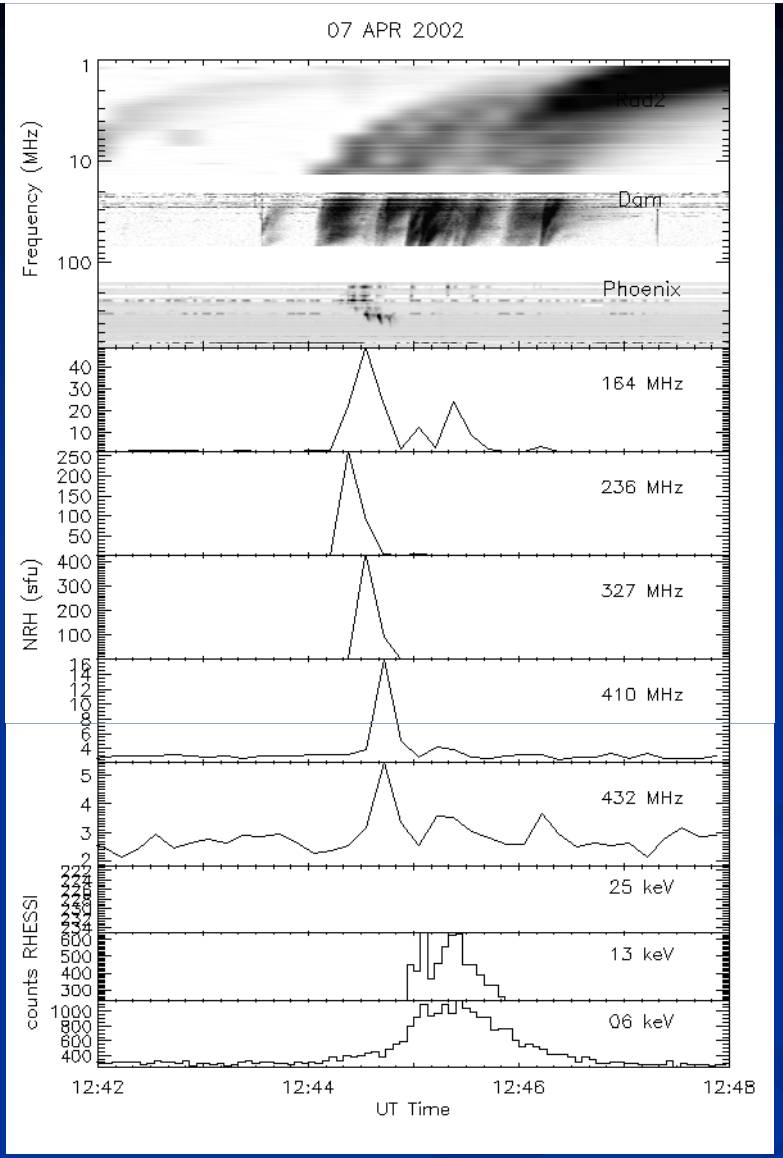
Among the 542 events with RHESSI observations at the time of the radio burst
224 events with a X-ray signature with RHESSI (41%)
163 events with both X-ray signature with RHESSI and a signature in WIND/WAVES (30%)

Quasisimultaneous observations of the hardest X-ray emission and decimetric to hectometric type III bursts



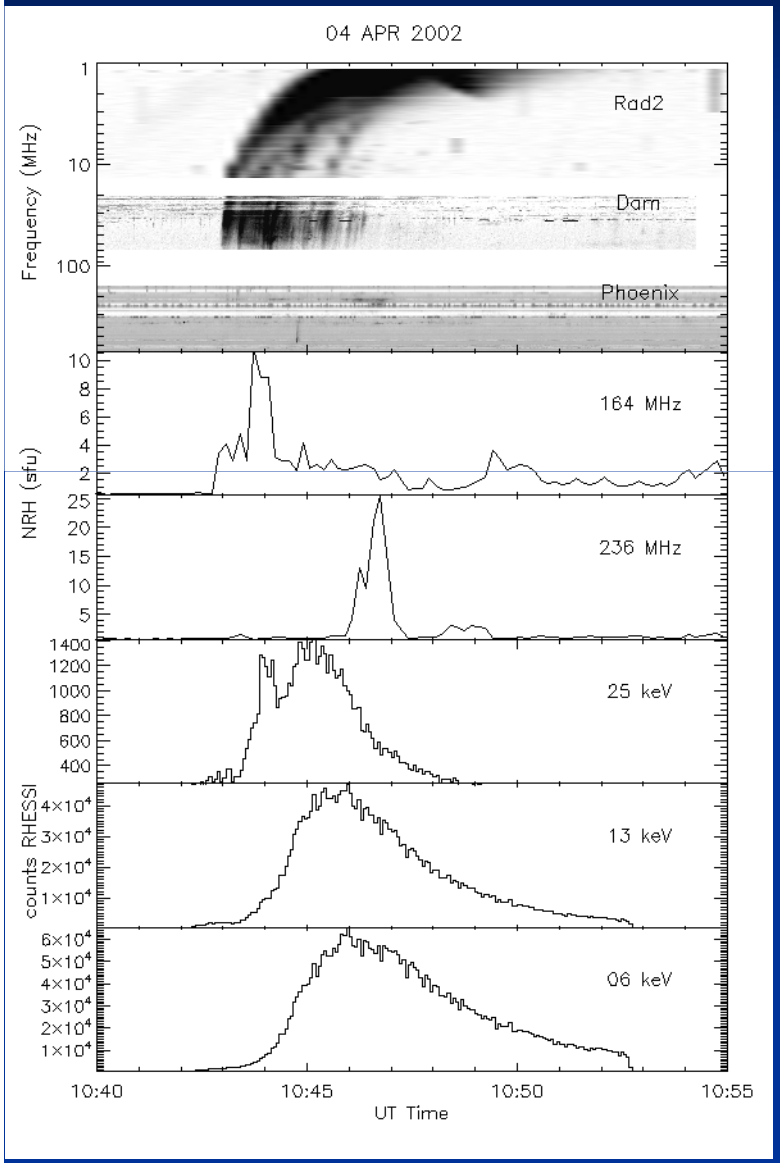




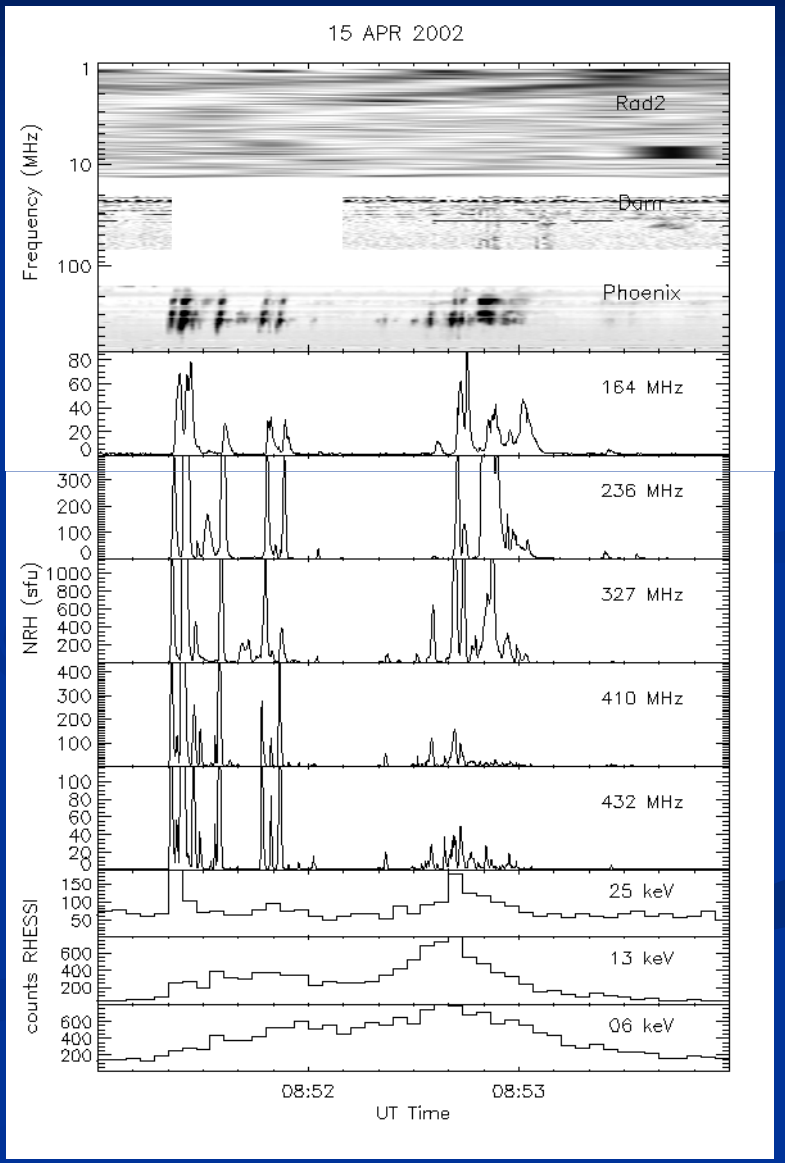


Metric to hectometric emissions first!

Faint metric/decimetric emissions



No emission below 100 MHz!



Preliminary conclusions:

The relationship between HXR emissions and radio emissions from beams propagating in the corona and in the interplanetary medium is not always as simple as expected from simple scenarios:

Our preliminary results based on 8 months of observations suggest that:

Only around 50% of the bursts observed by the NRH in the 450-150 MHz range are detected below 10 MHz by WIND/WAVES

-Only around 30% of events can be clearly followed from the HXR domain to the radio domain below 10 MHz

-For these events, the link between all emissions is not simple, varies from flare to flare and even in the course of flares.

Possible interpretations:

-Magnetic field connections from the flare site to the corona ?

Need to study the spatial configurations of HXR emissions and of radio emissions at different heights(frequencies) provided by RHESSI and the Nançay Radioheliograph observations to understand the connectivity and changes in connectivity.

-Variations of the properties of the electron beams
of the acceleration heights, sites

Characteristics of electrons deduced from RHESSI observations
Numerical simulations of electron beam propagation and production of Langmuir waves (see e.g. Reid, Vilmer, Kontar)

All these questions will be addressed in the context of the preparation of the combined observations of X-ray and radio bursts with STIX and RPW on Solar Orbiter