Spatially resolved observations of a band-splitted coronal type II radio burst.

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Workshop- Glasgow
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- Two questions:
- Origin of type II radio bursts?: Blast wave or piston driven?
- Nature of band-splitting?

- Very few spatially –resolved observations of type II bursts at high frequencies, close enough to flare sites and onsets of eruptive features

(Zimovets et al., A&A in revision)

A piston driven coronal shock (with type II emission)

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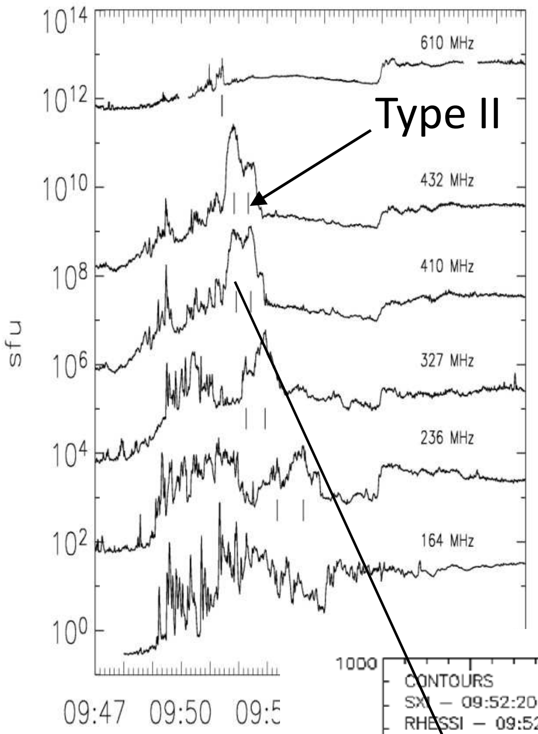
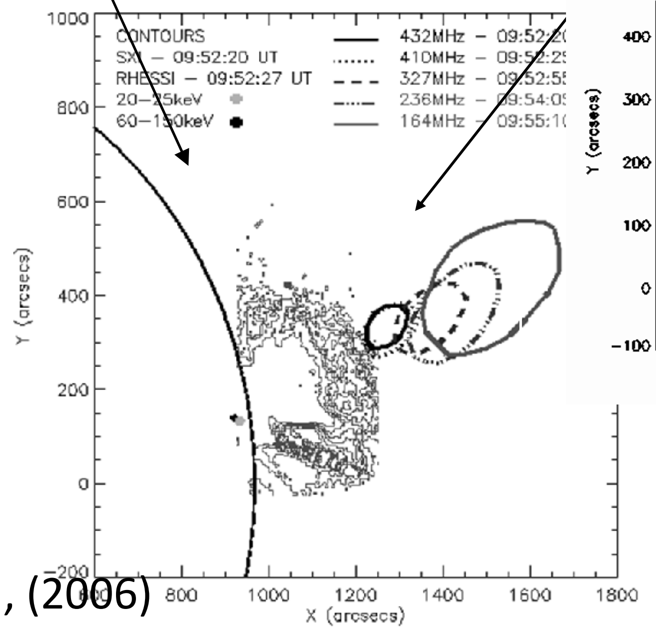
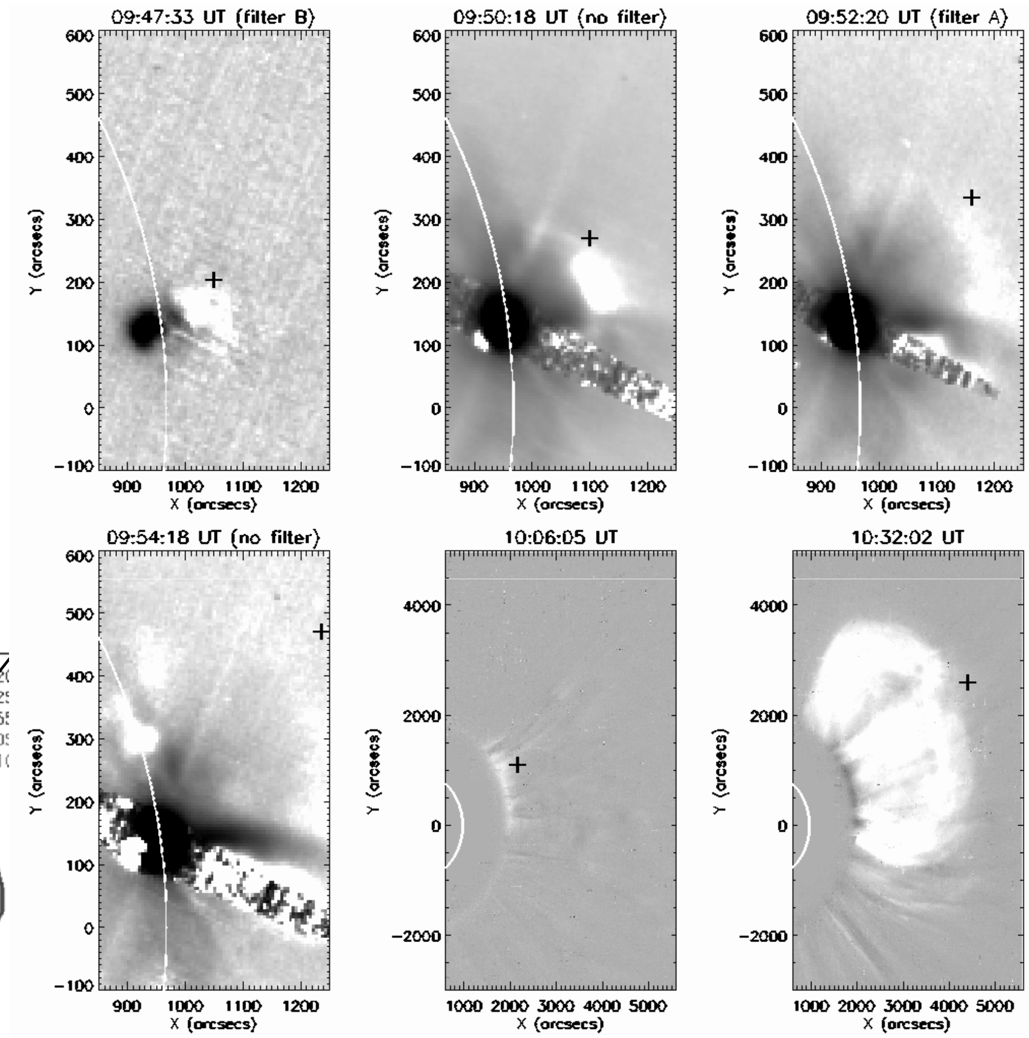


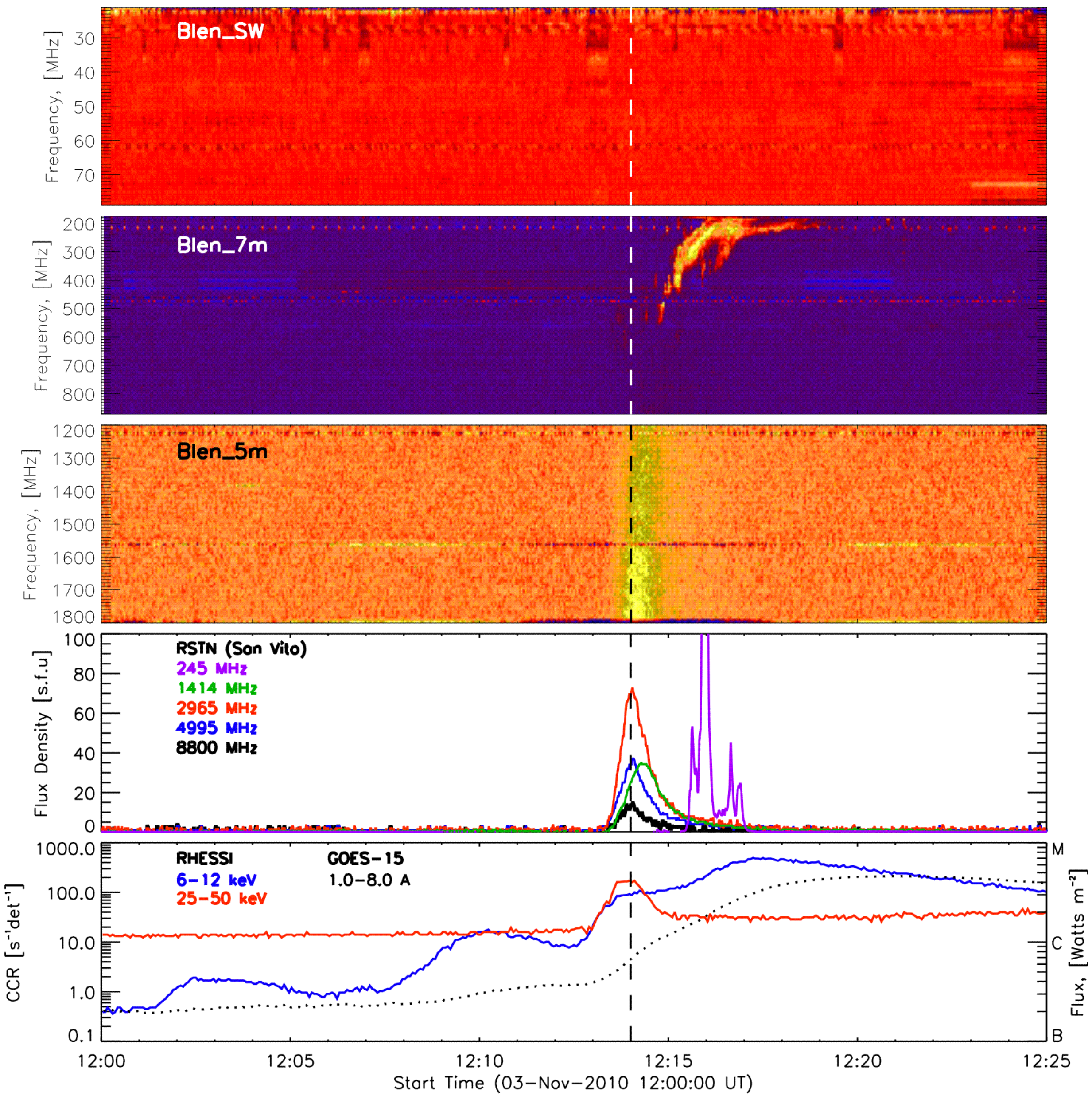
SXI
09:52:20 UT
NRH (432)
09:52:20 UT



Dauphin et al., (2006)



Detection of a rising SXR loop
GOES/SXI linked to the CME
(Dauphin et al, 2006)
Shock wave associated with the rising loop



Also studied by Bain, Krucker , ApJ 2012
RHESSI nuggett

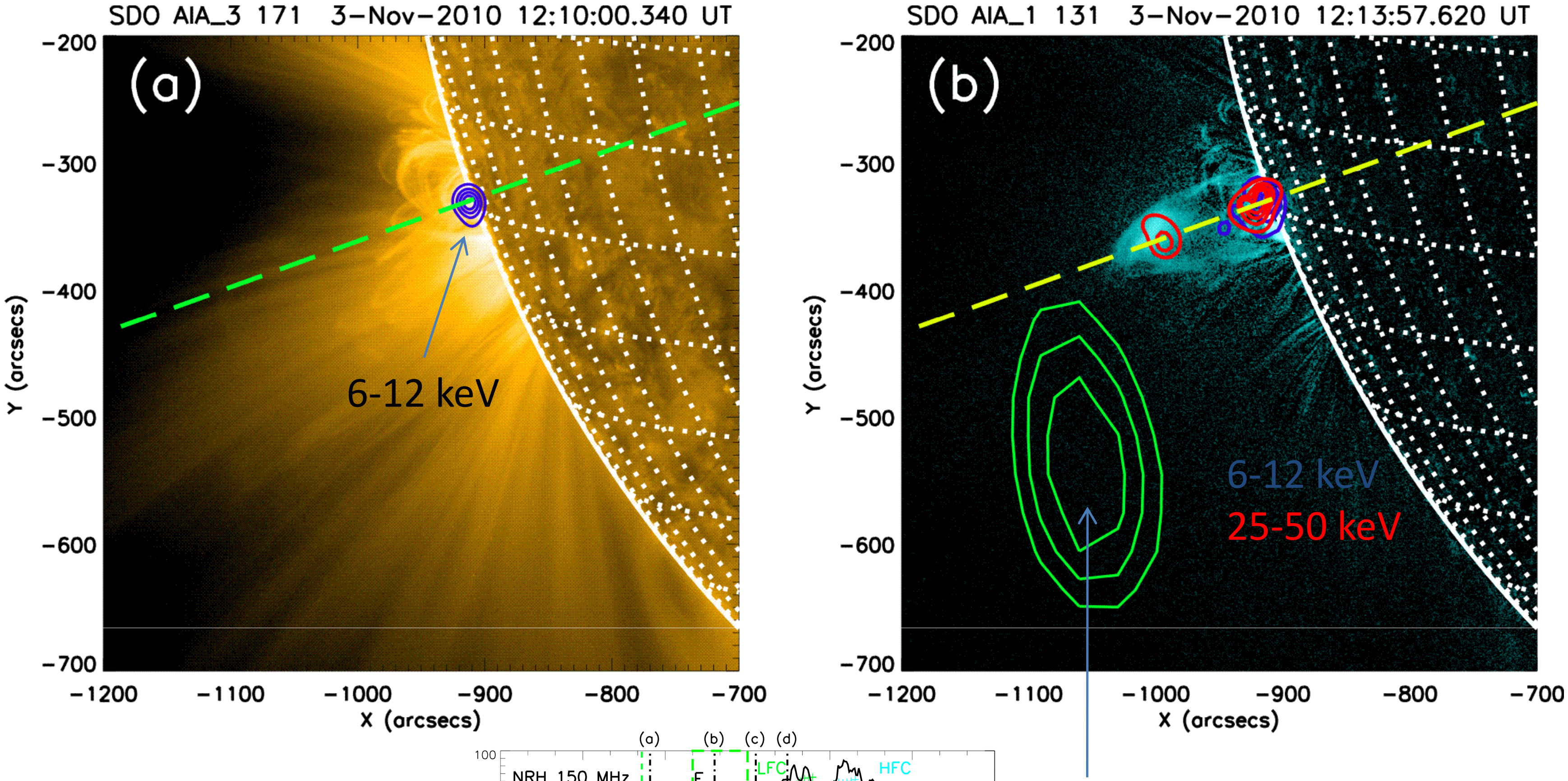
7 years later!!
3 November 2010

Type II burst

Radio

X-rays
Flare S20 E97

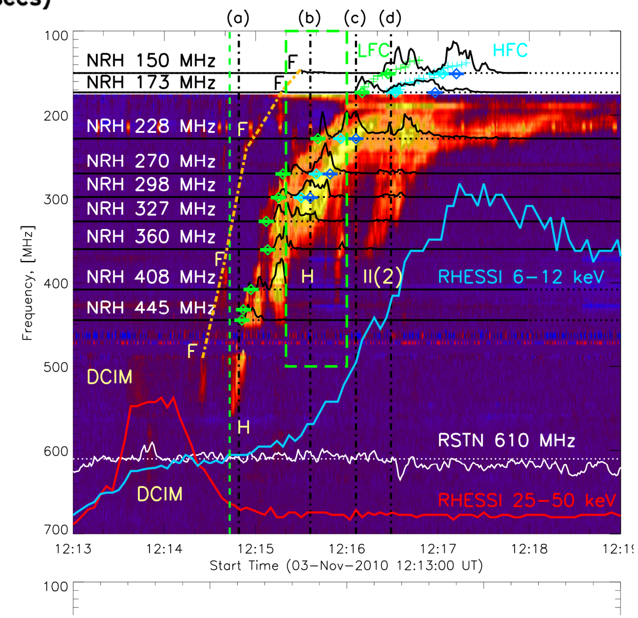
Narrow and slow
CME



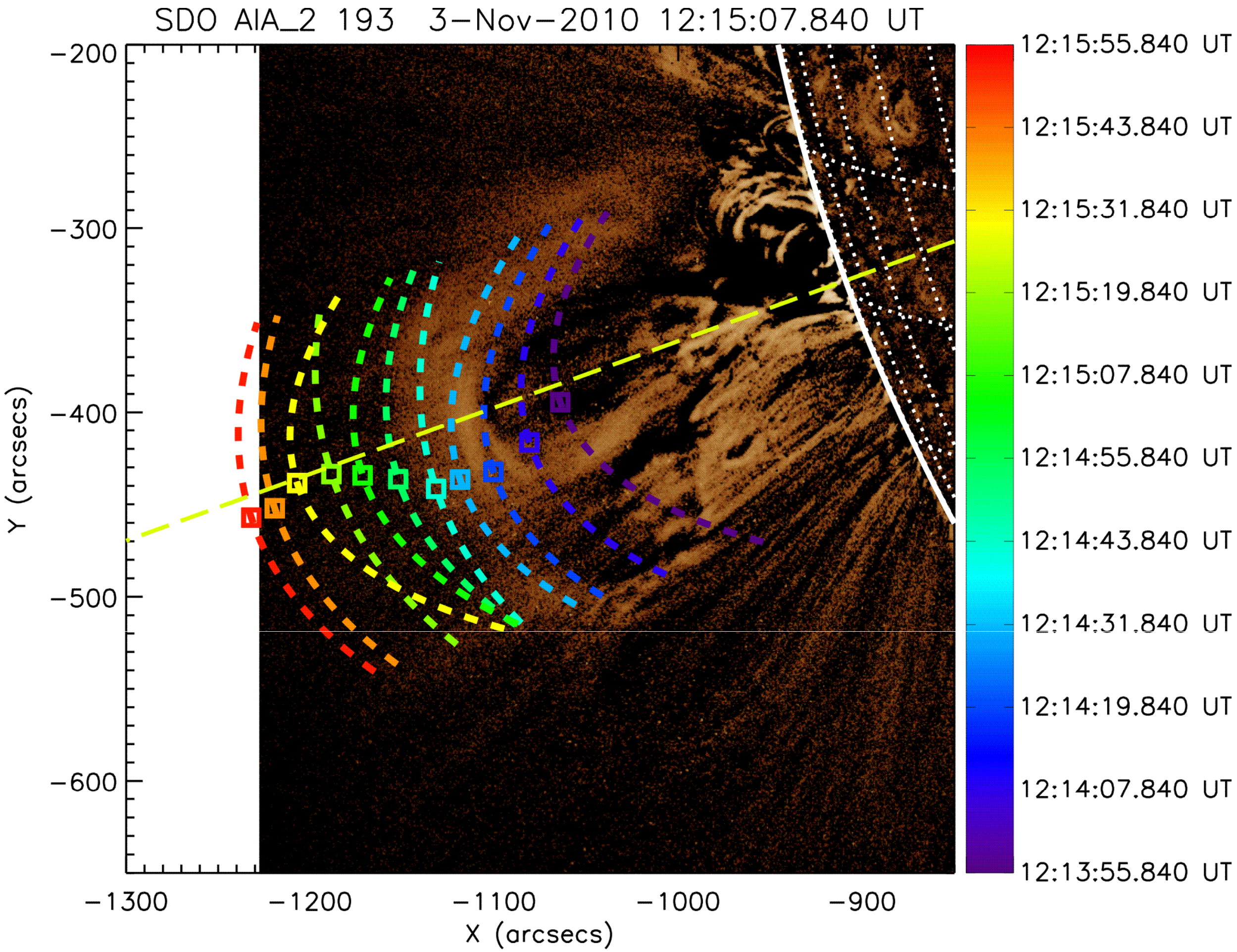
NRH 445 MHz DCIM

Pre-impulsive phase

AIA -171 Warm
0.5-2 MK



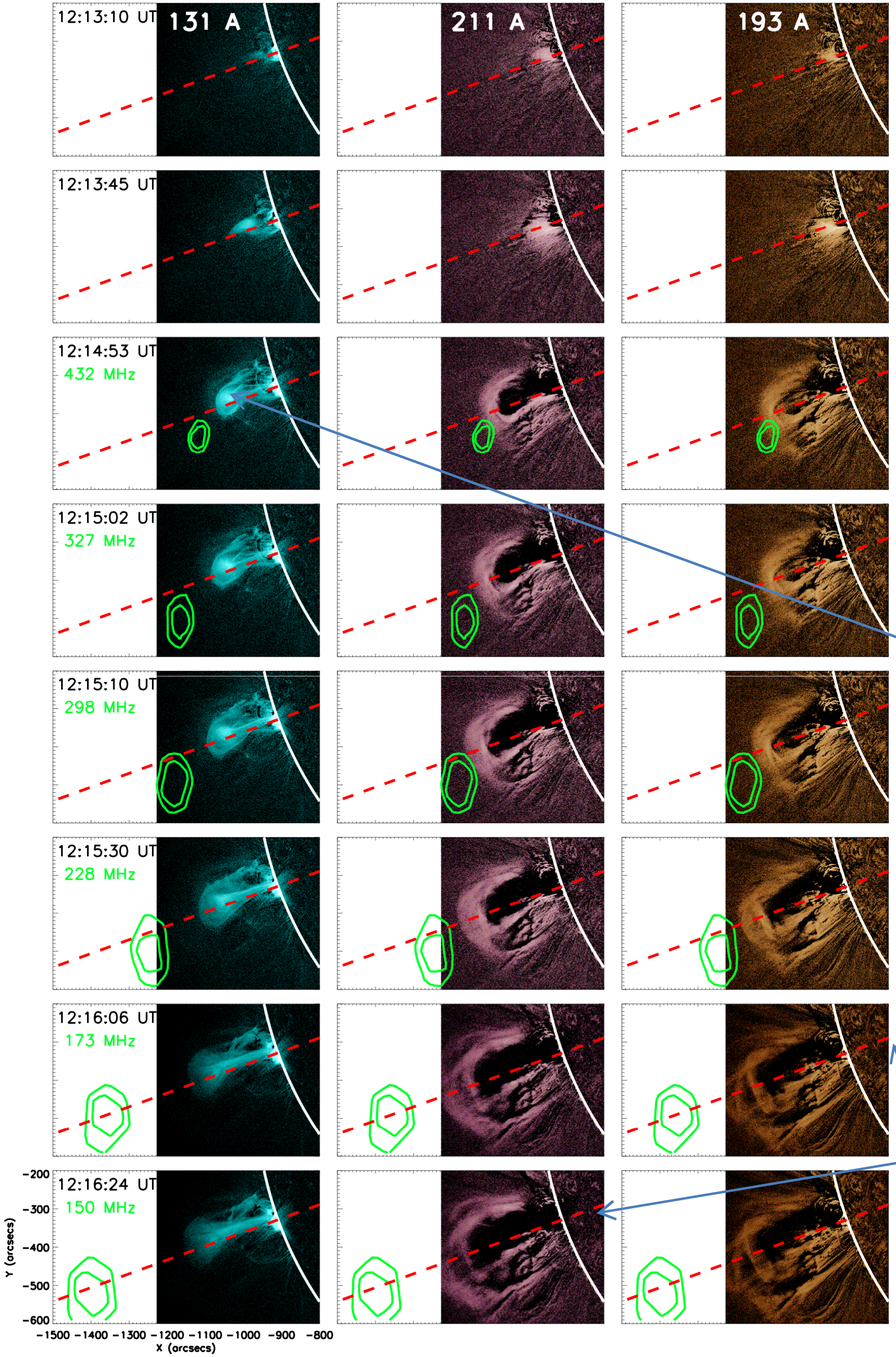
AIA-131 Hot
7 -11 MK
Start of ascent of hot plasma blob
12:13 UT

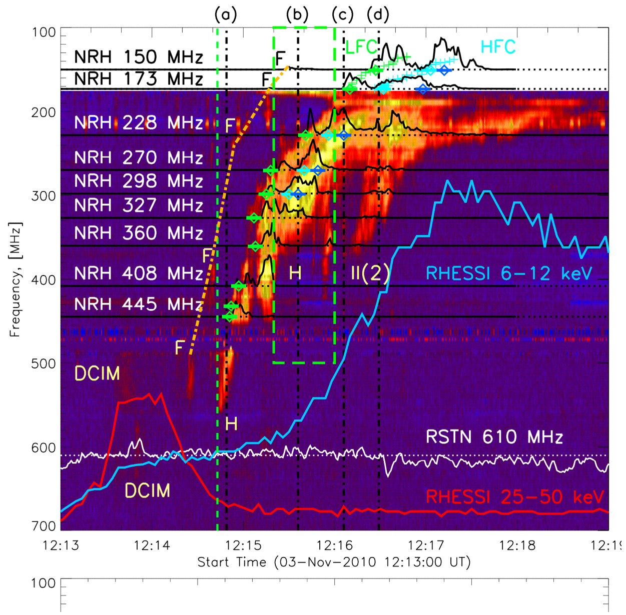


Wraping of the hot plasma by colder material

Leading edge of the « warm » eruptive plasma as a function of time

From 12:13 to 12: 16 UT



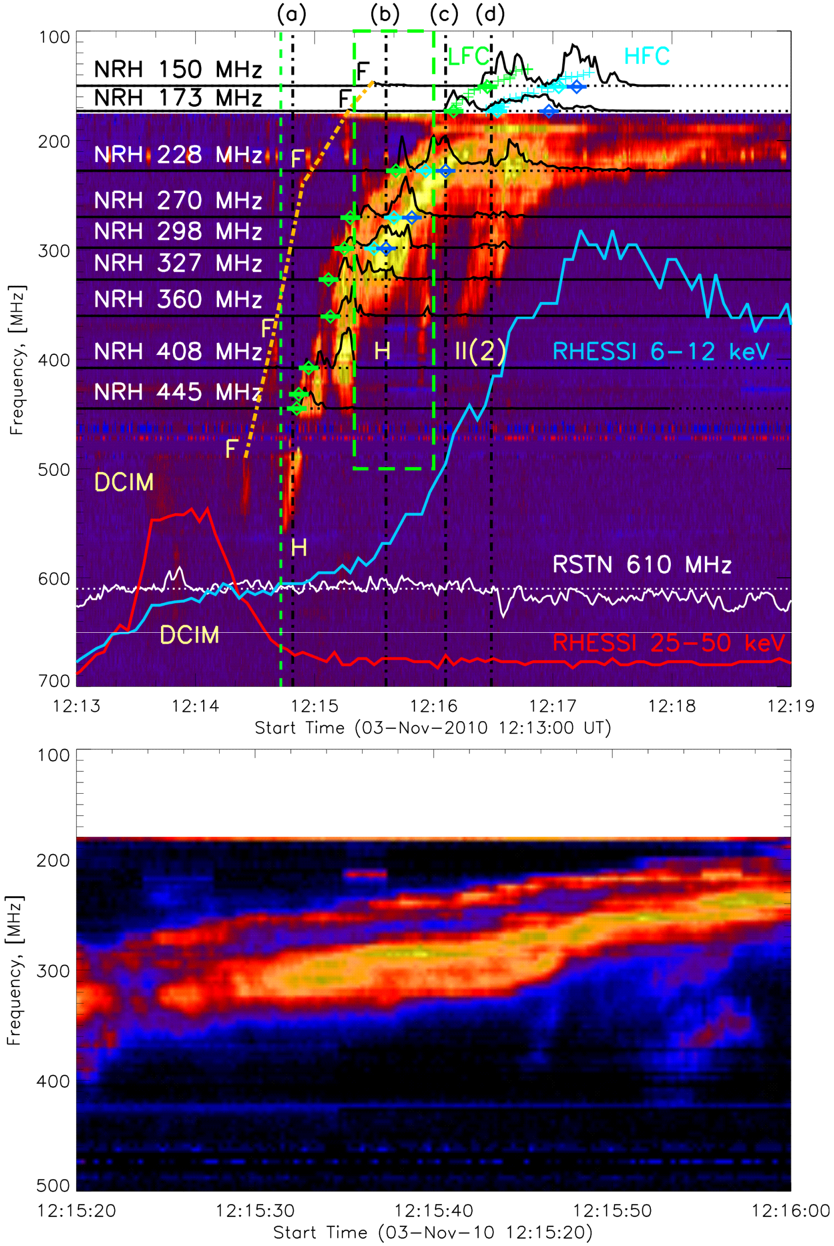


7 -11 MK

Positions of the type II burst when it first appeared at a given frequency above the leading edge of the « warm » plasma

Increase of the distance between warm plasma and radio source

0.5-2 MK

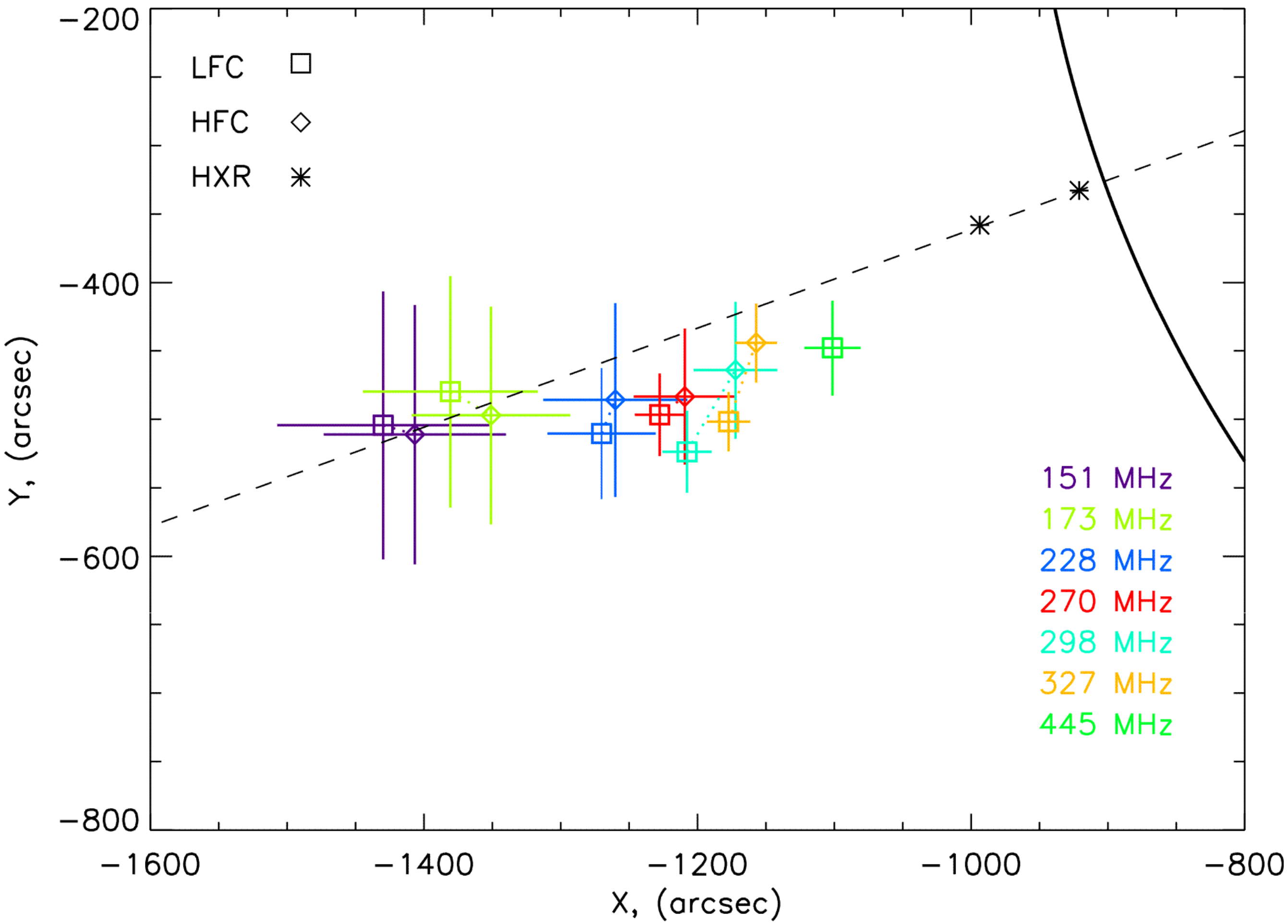


Band splitting of the harmonic component (LHC and HFC)

Δf/f= 0.16±0.02 ‘consistent with earlier Observations) (Mann, 1995)

Drift rate: 1-9 MHz/s (unusually high)

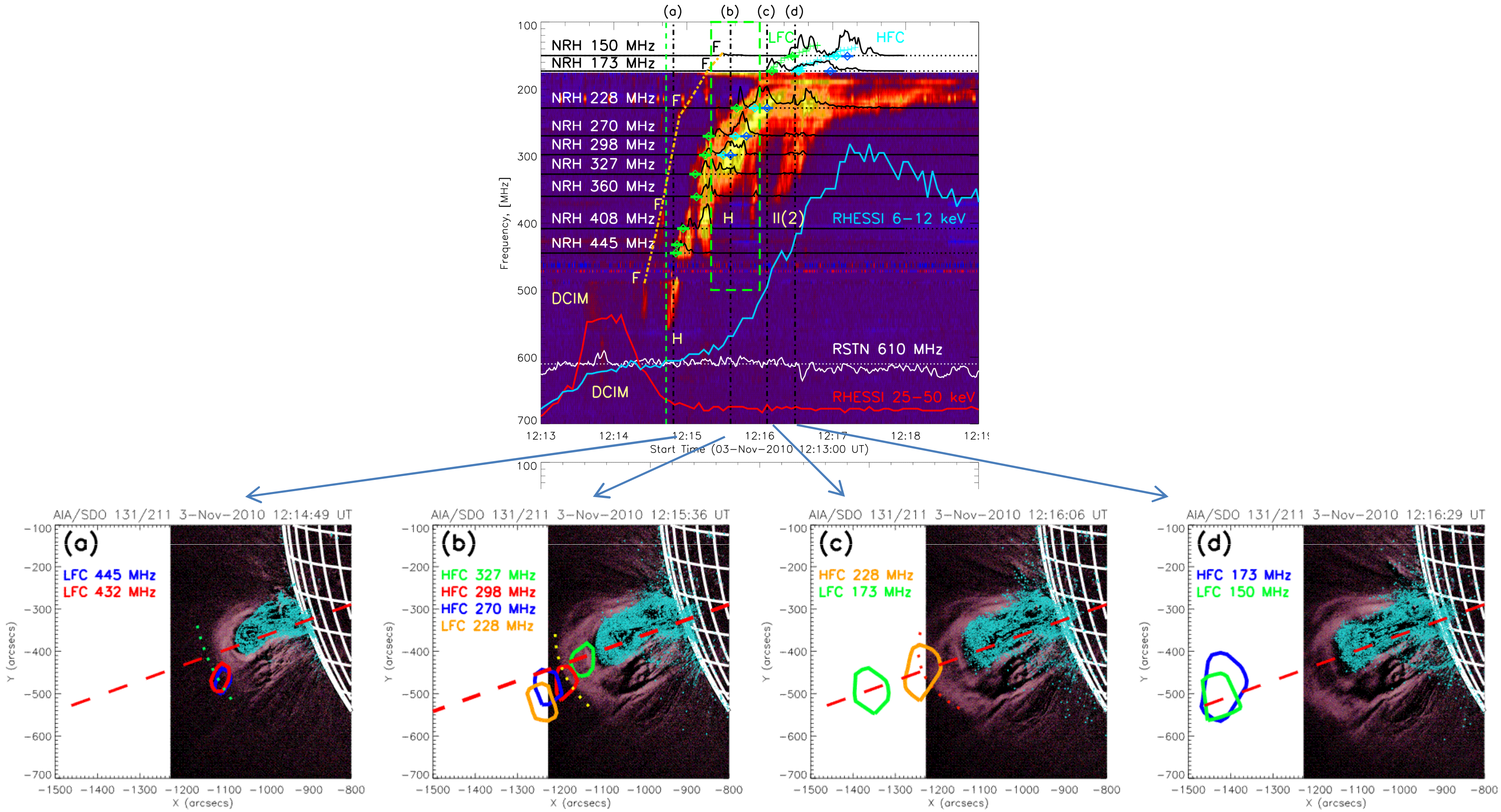
But already observed for dm type II burst with high starting frequencies



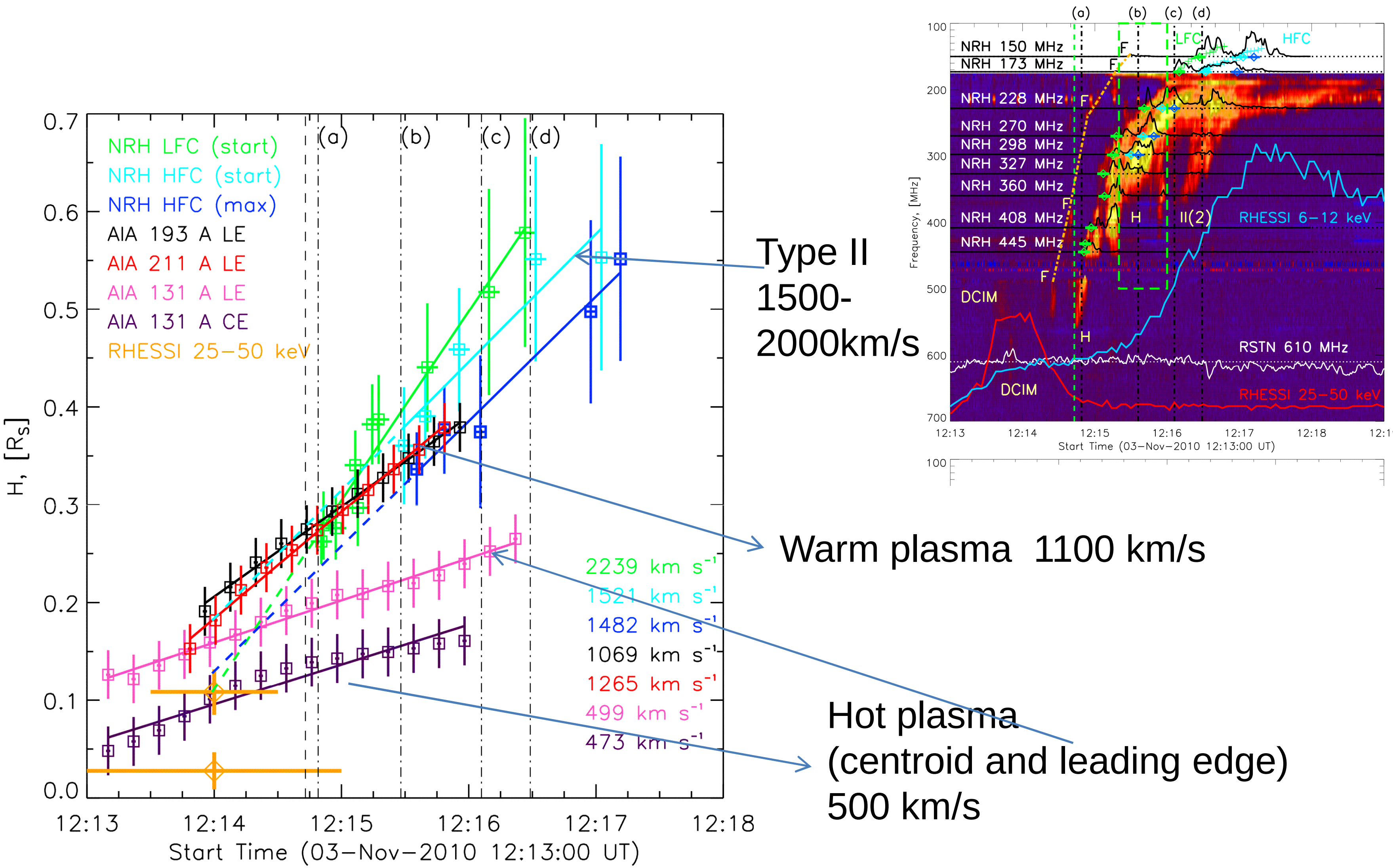
Relative positions of the LFC and HFC at several frequencies and of the HXR sources (average and scatter of the centroid positions)

LFC always above HFC

HFC component always a bit closer to the flare site



Relative positions of the LFC and HFC components at diff. frequencies observed at a specific time



NRH LFC (start)
NRH HFC (start)
NRH HFC (max)
AIA 193 A LE
AIA 211 A LE
AIA 131 A LE
AIA 131 A CE
RHESSI 25–50 keV
(a)
(b)
(c)
(d)
2239 km s⁻¹
1521 km s⁻¹
1482 km s⁻¹
1069 km s⁻¹
1265 km s⁻¹
499 km s⁻¹
473 km s⁻¹
H, [R_S]
Start Time (03–Nov–2010 12:13:00 UT)
NRH 150 MHz
NRH 173 MHz
NRH 228 MHz
NRH 270 MHz
NRH 298 MHz
NRH 327 MHz
NRH 360 MHz
NRH 408 MHz
NRH 445 MHz
LFC
HFC
DCIM
RSTN 610 MHz
RHESSI 6–12 keV
RHESSI 25–50 keV
II(2)
Frequency, [MHz]
Type II 1500-2000km/s
Warm plasma 1100 km/s
Hot plasma (centroid and leading edge) 500 km/s

- -Characteristic velocity of hot plasma: 500 km/s
- - Characteristic velocity of the LE of surrounding warm plasma: 1100 km/s
- - LFC type II emission just above the warm eruptive plasma but characteristic velocity of the LFC type II source 2200 km/s
- - LFC and HFC sources launched from the vicinity of the HXR source

but positions closely related to the position of the LE of the erupting plasma

- *Blast wave or piston driven?*
- **two strong evidences in favour of the piston-driven shock wave scenario:**

location of the type-II burst sources above the apex of the eruptive plasma leading edge

same propagation direction of the type-II burst sources and the erupting plasma apex

But: how to explain the difference between the velocity of LE and the velocity of the shock?

Propagation of a shock wave in a non uniform, stratified corona, including dense loops

- See numerical simulation by *Pohjolainen et al. (2008); Pomoell* et al. (2008, 2009):

the shock wave can propagate faster through the corona than its driver .

- The shock front is strongest near the leading edge of the erupting plasma.

Nature of the band-splitting?

- *Scenario 1:*

- Coherent radio emission simultaneously generated ahead and behind the shock front (upstream and downstream regions)
- (Smerd, 1974)

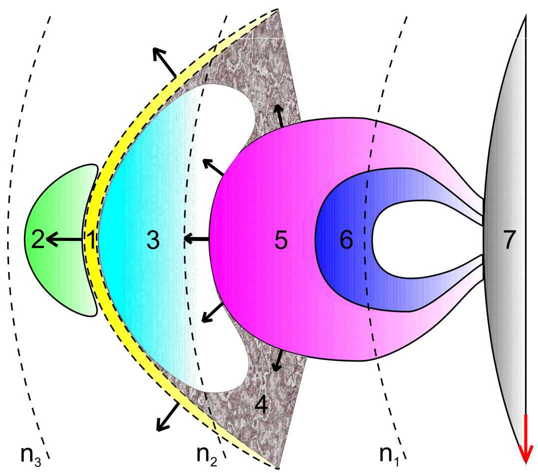
- *Scenario 2:*

Different parts of the shock wave front simultaneously

encounter coronal structures of different physical properties (McLean, 1967)

Nature of the band-splitting?

- *In the present case, the observations rather support scenario 1:*
- *(LFC) source is located above (HFC) one,*
- *HFC source fills almost all the space between the LFCsource and the leading edge of eruptive plasmas*

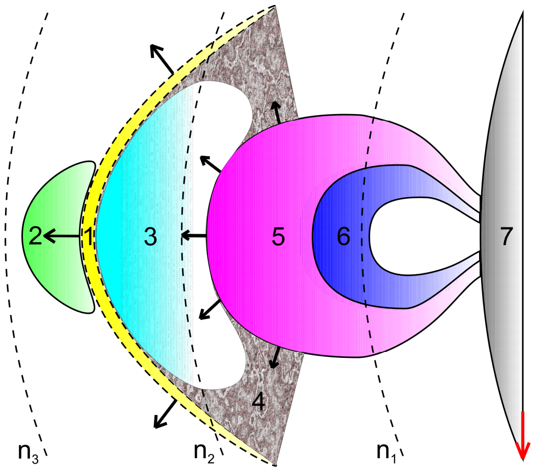


View from the north pole

((1)) shock wave, (2) LFC source (3) HFC source, (4) turbulent magnetosheath, (5) warm (*T ≈ 1 − 2 MK) plasma rim (6) its leading edge, (7) hot* (*T 10 MK) erupting flux rope*

Nature of the band splitting

- *Upstream and down stream radio sources*
- How to generate plasma waves in the downstream region? Usually not observed in in situ measurements (Bale et al…)
- Still some observations of radio emissions downstream of interplanetary shocks (Hoang et al; Moullard et al.)
- In the downstream region, potential electron acceleration in the magnetosheath behind the shock



Other observations?

Simulations of electron acceleration in the downstream region?