RHESSI and NoRH Observations of the 3 July 2002 Flare

X1.5

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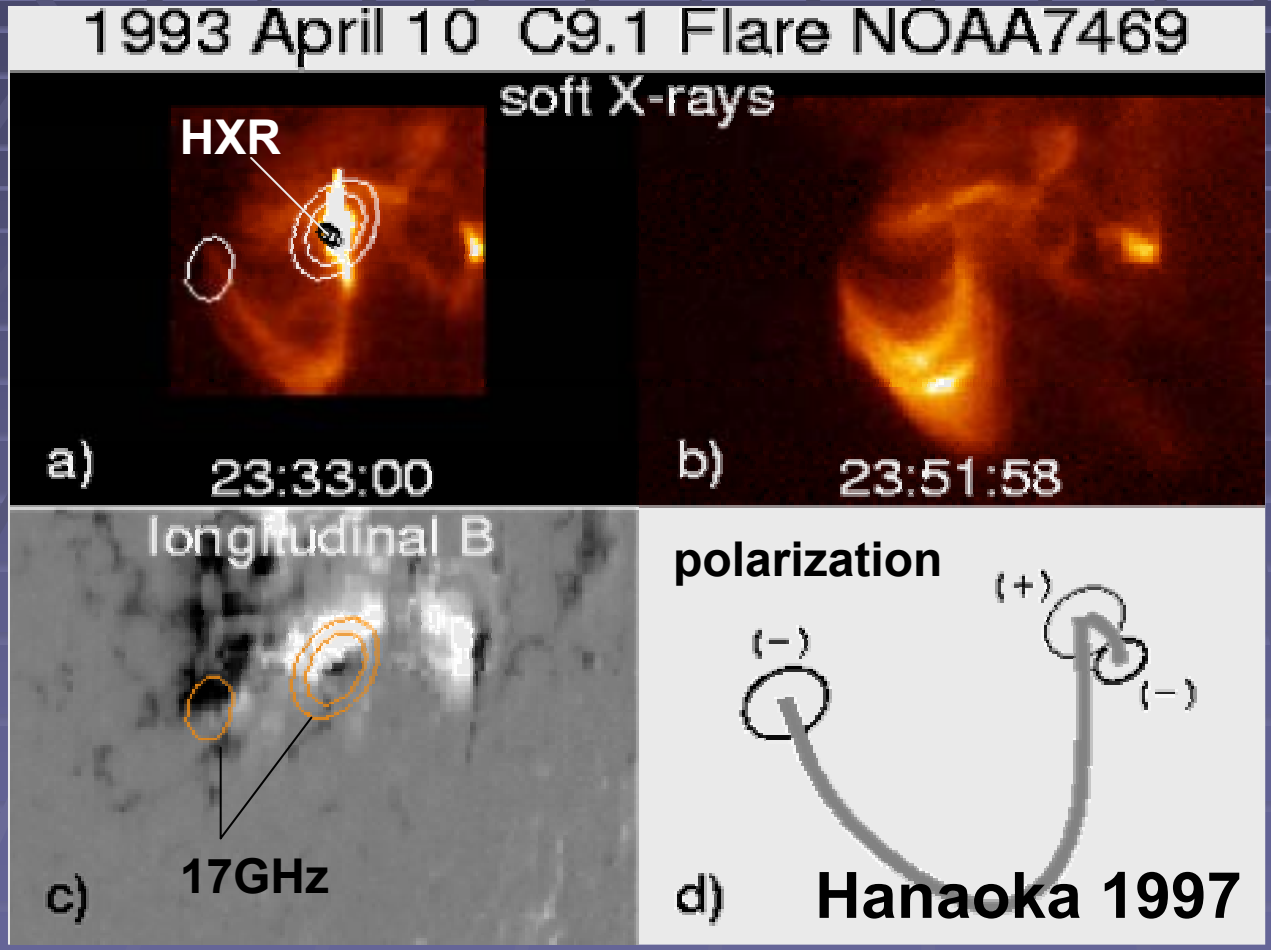
Acknowledgement
This study is a result of the NRO data analysis workshop held in 2002 August at Nobeyama.

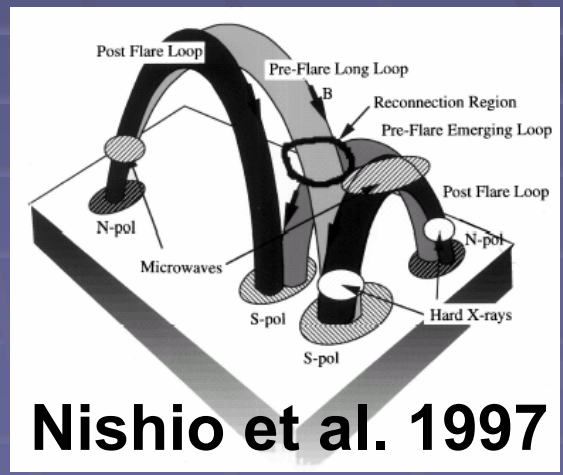
1. Introduction

Hanaoka-Nishio type flare

Two loops with three legs

⇒ Interaction between a pre-existing loop and an EMF

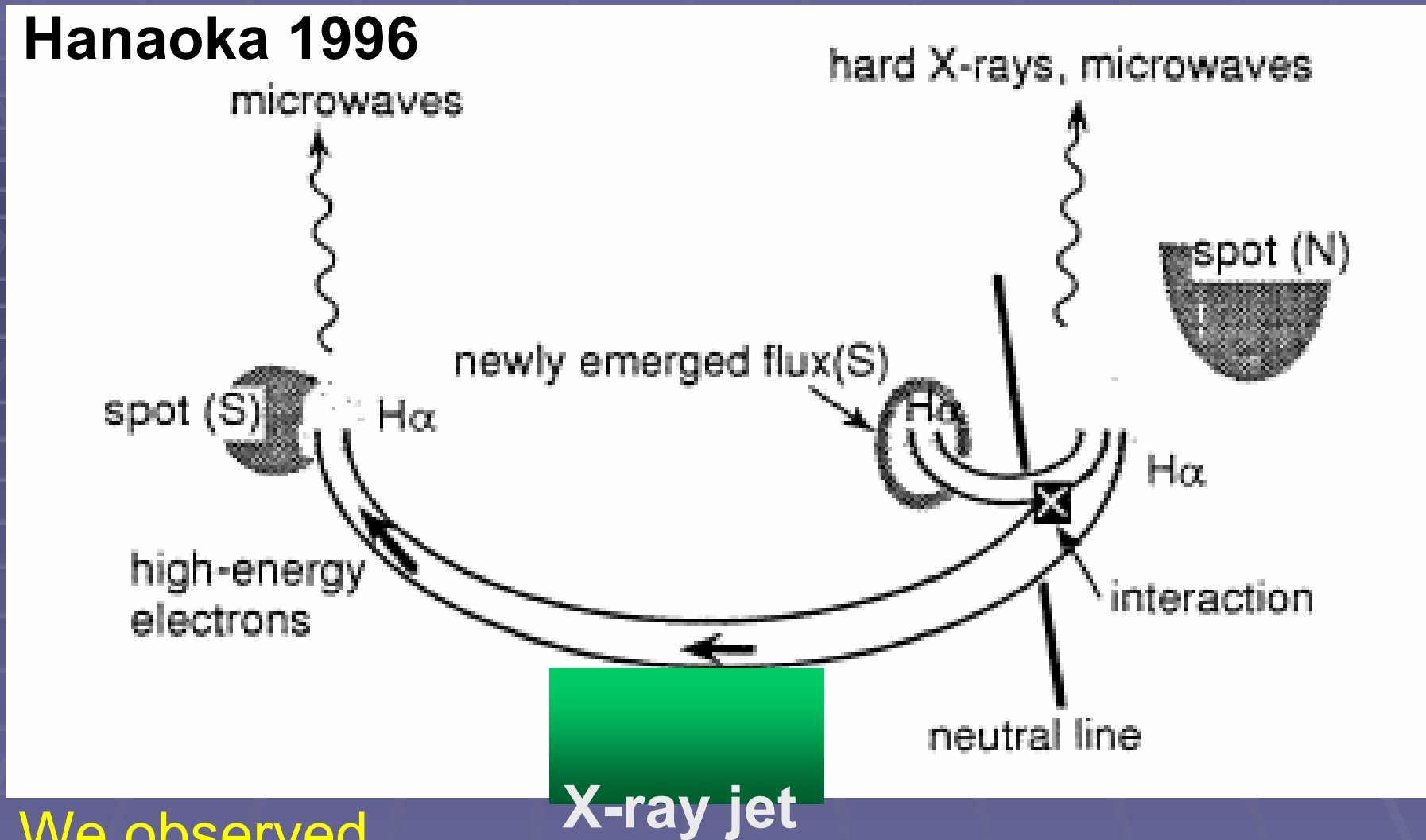




Only footpoints brighten at 23-33 keV

⇒ Thick target emission

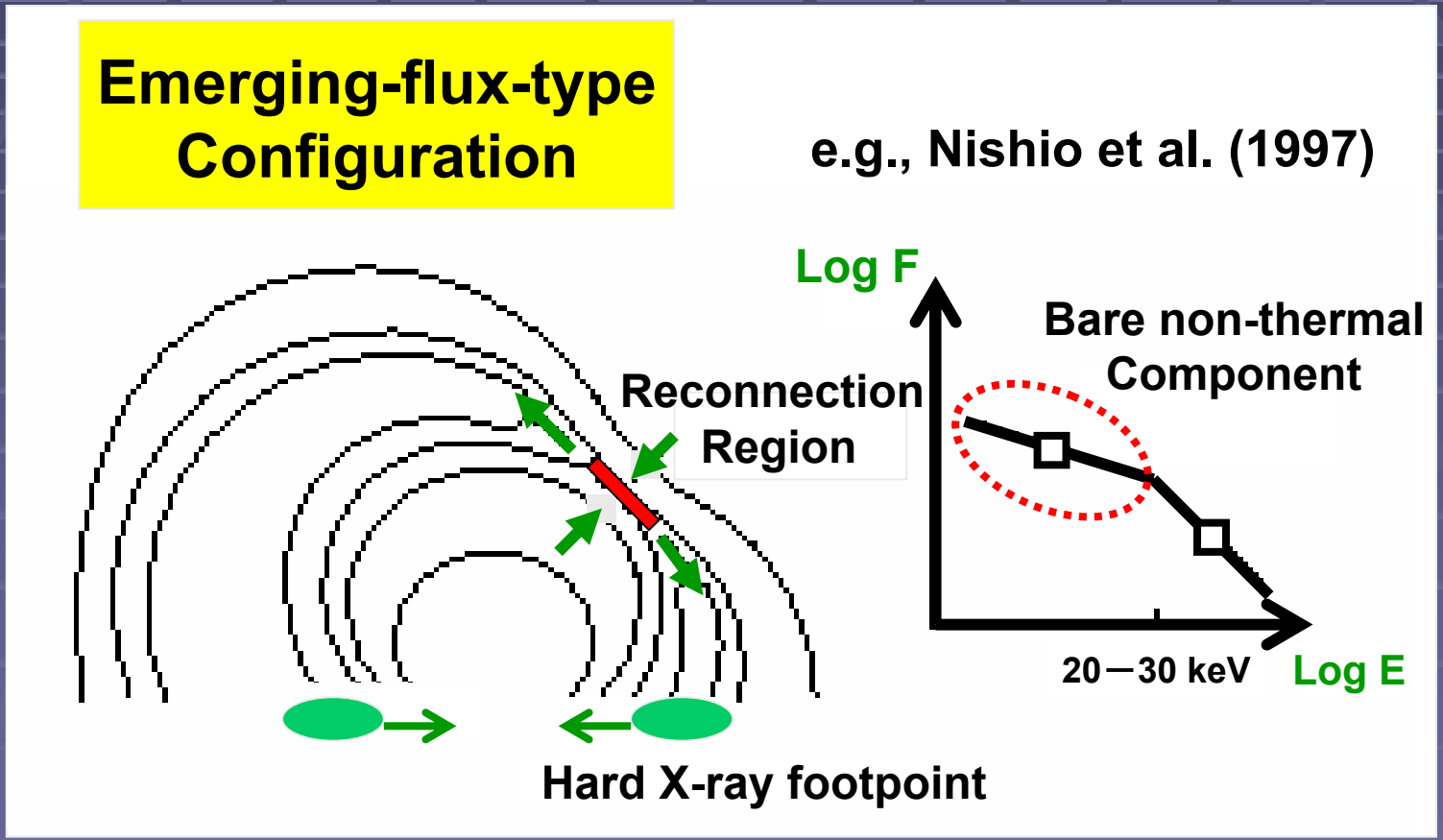
Hanaoka 1996



We observed

- **Plasma Flow with≦4000 km/s（NoRH　17 GHz）**
- **The longer loop filled with 10 - 50keV plasma (RHESSI)**

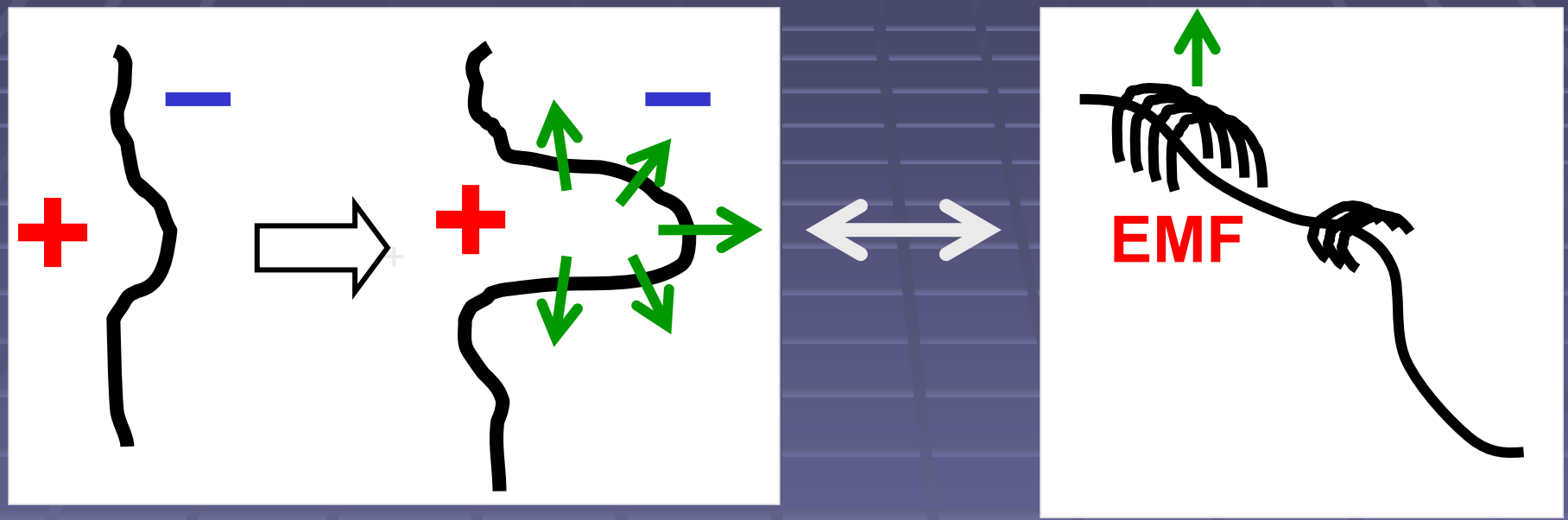
Relationship between magnetic field configuration & hard X-ray spectra



Sakao et al. 1999

Evolution of the magnetic neutral line

Saita 1998; Saita et al.1999

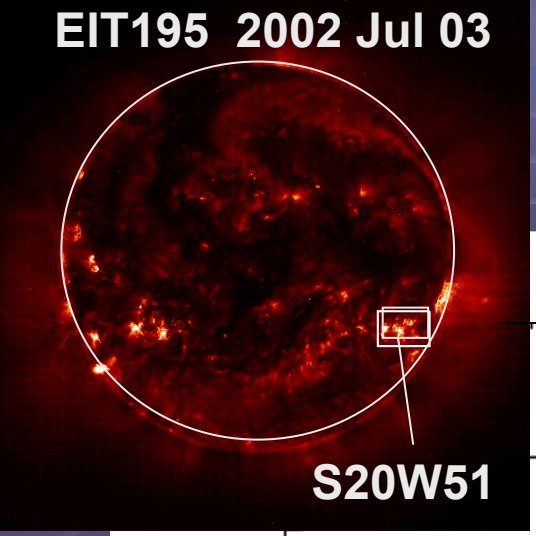


Post flare : **Increase** of magnetic shear

At the flare peak time: $\gamma_{M1/L} \leqq 4$ (E≦20-30 keV)

2. Observation

The Long-term Evolution of AR10017



Flare activity at AR10017

GOES X-ray Flux

X1.5, III

M1.5

M5.3

M3.2,III,V,II,IV

CME

M1.1, III

Watts m^{-2}

10^{-4}

10^{-5}

10^{-6}

10^{-7}

10^{-8}

10^{-9}

X

M

C

B

A

2002 Jul 2

Jul 3

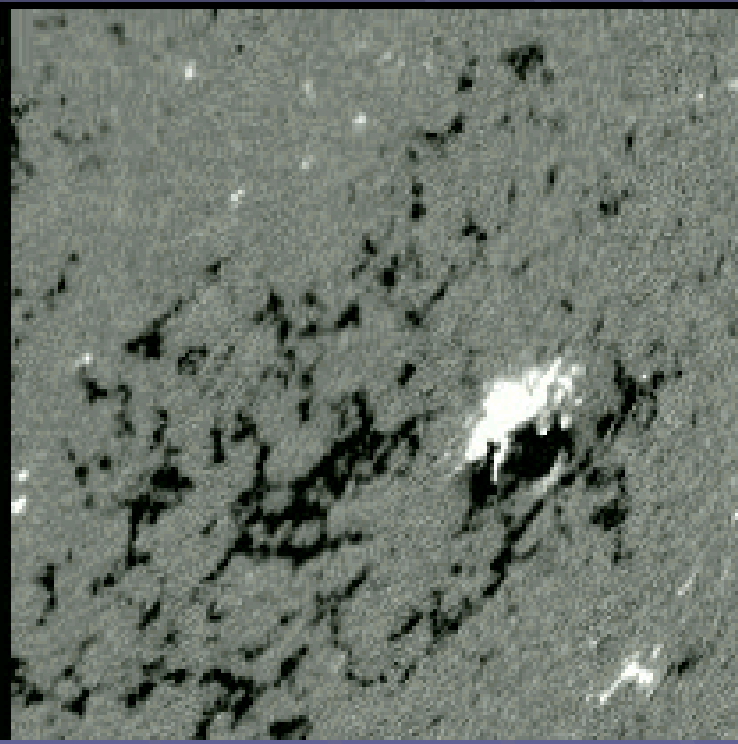
Jul 4

Jul 5

Magnetic Evolution

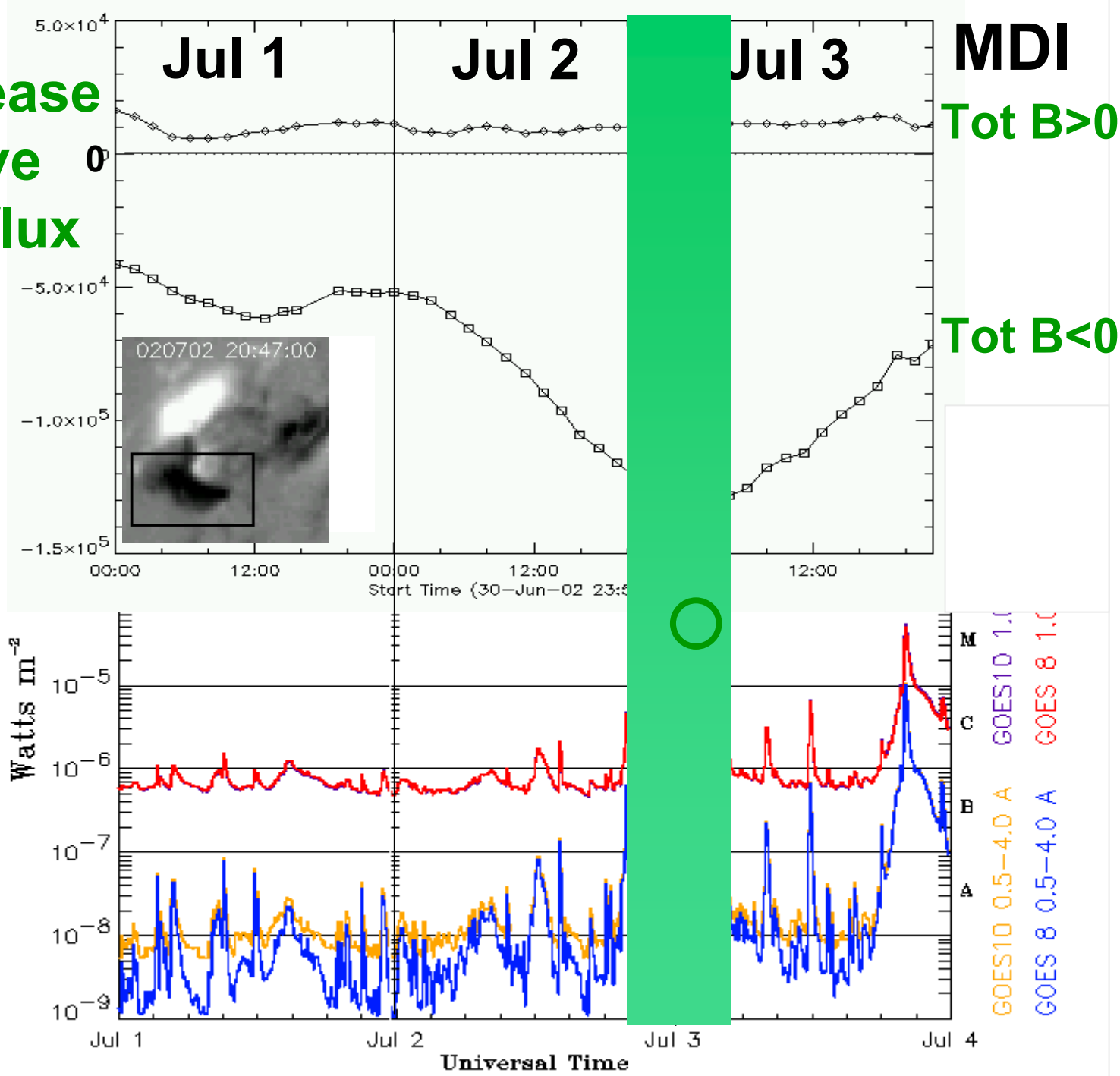
SOHO/MDI

Rotation corrected



(±100Gauss)

Rapid increase of negative Magnetic flux

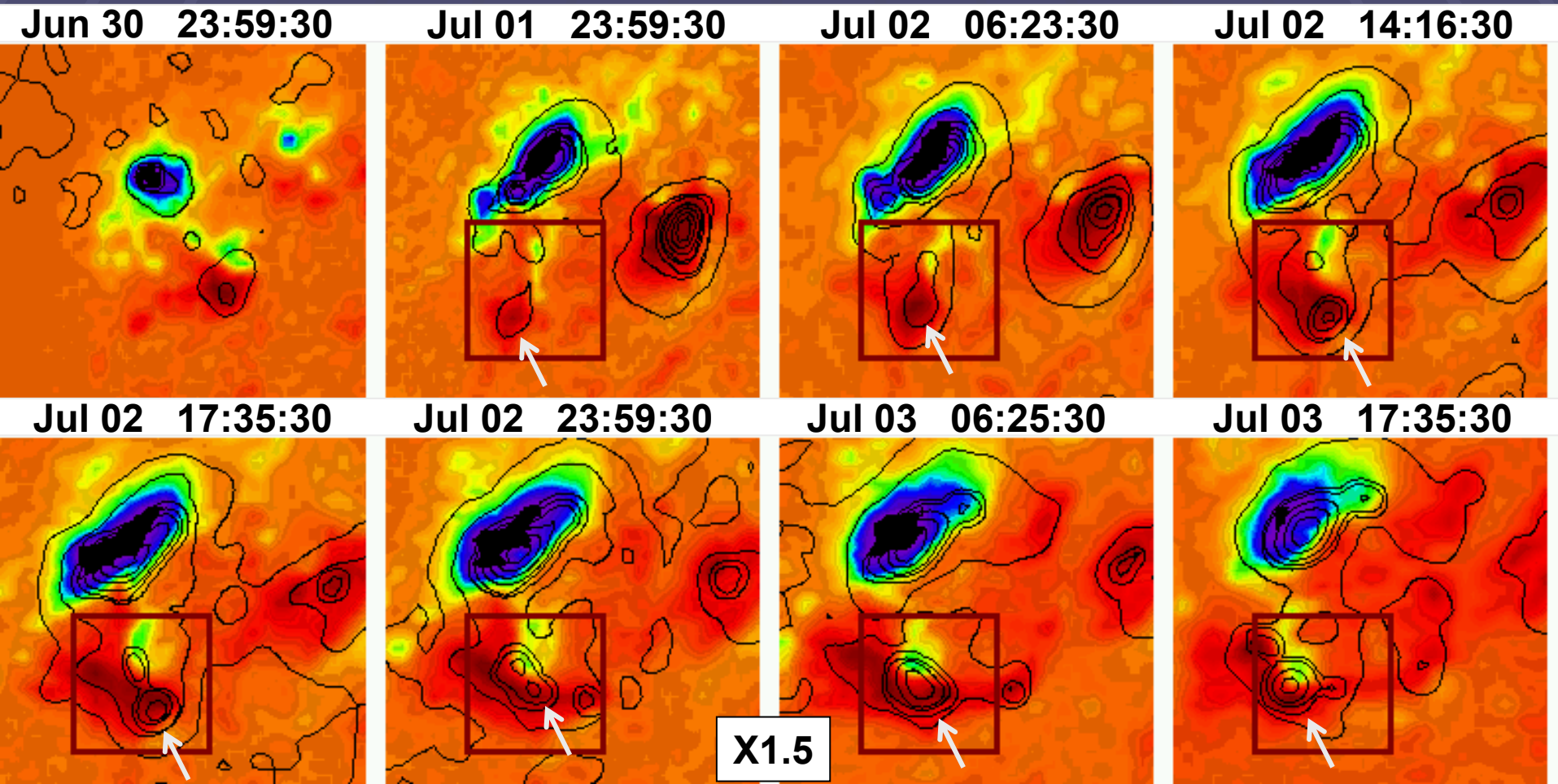


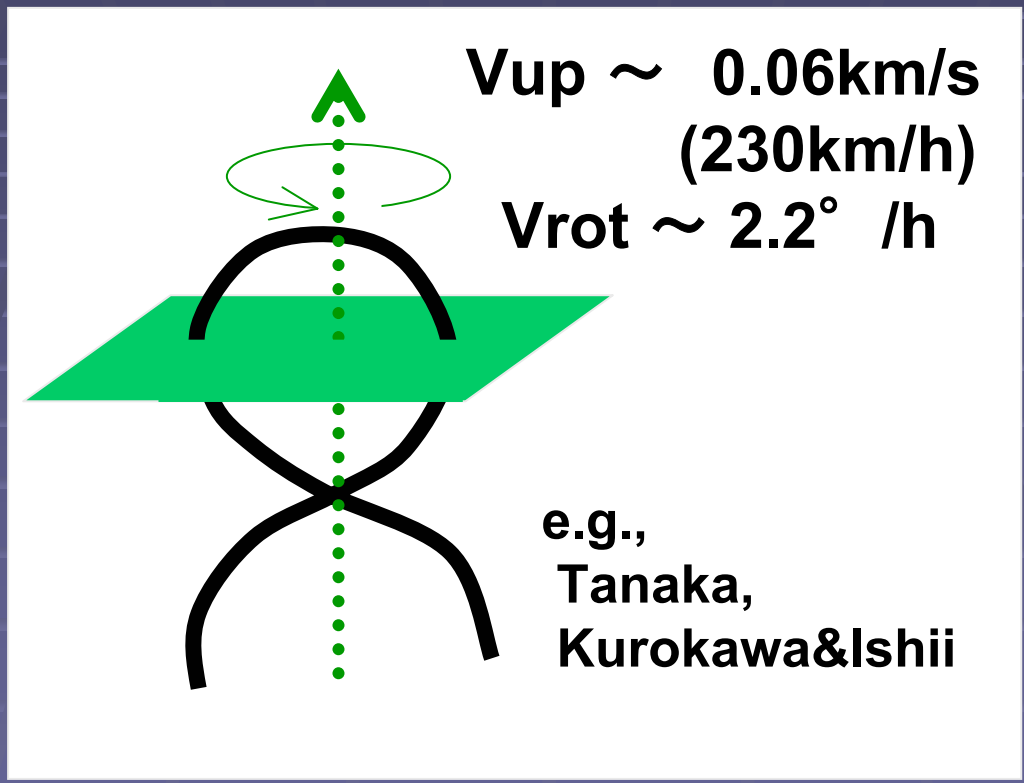
Emergence of a twisted dipole

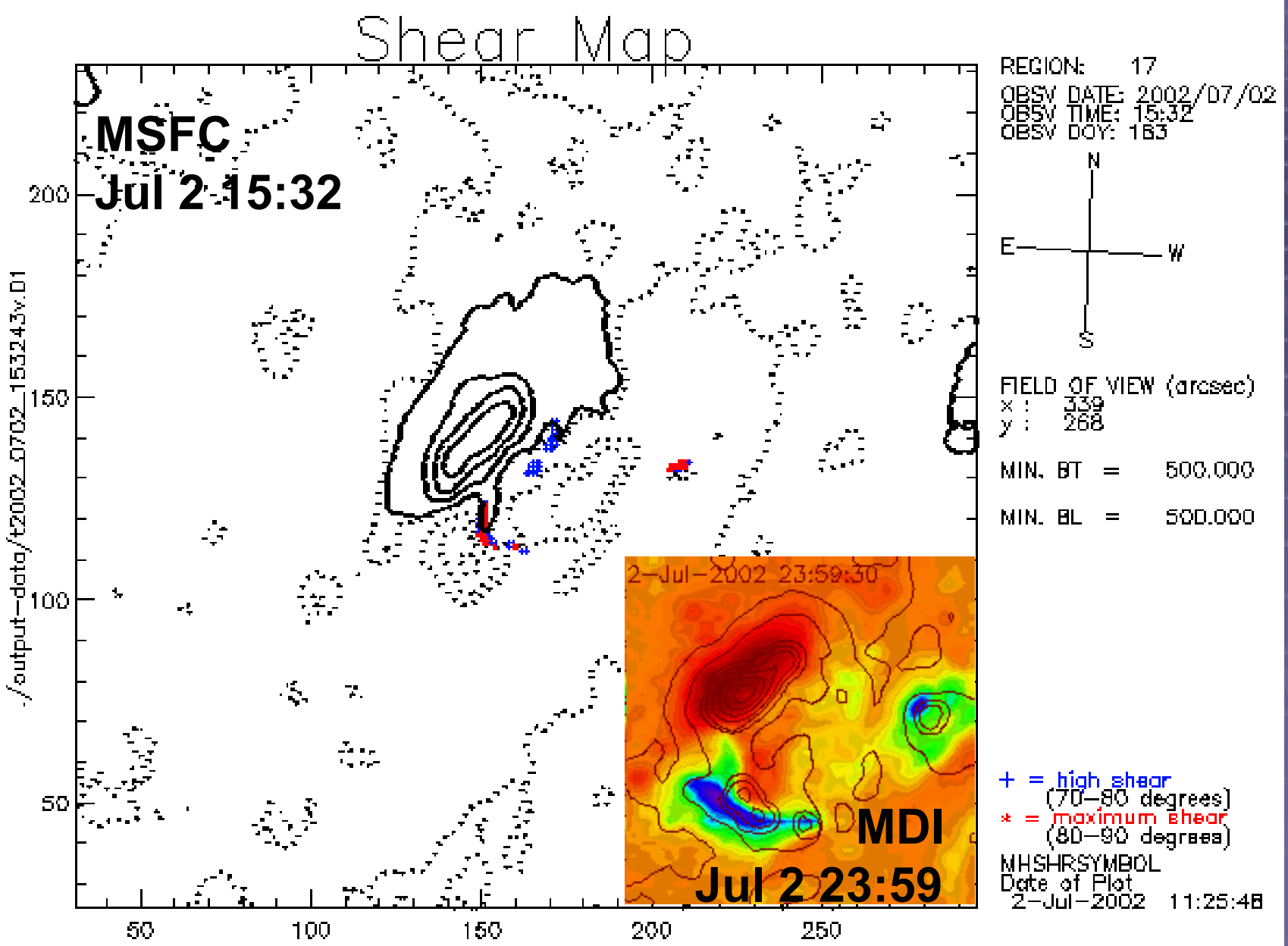
SOHO/MDI (98”x98”) -900G +900G

Contour: whitelight (20,40,60,80% of 8200)

N W



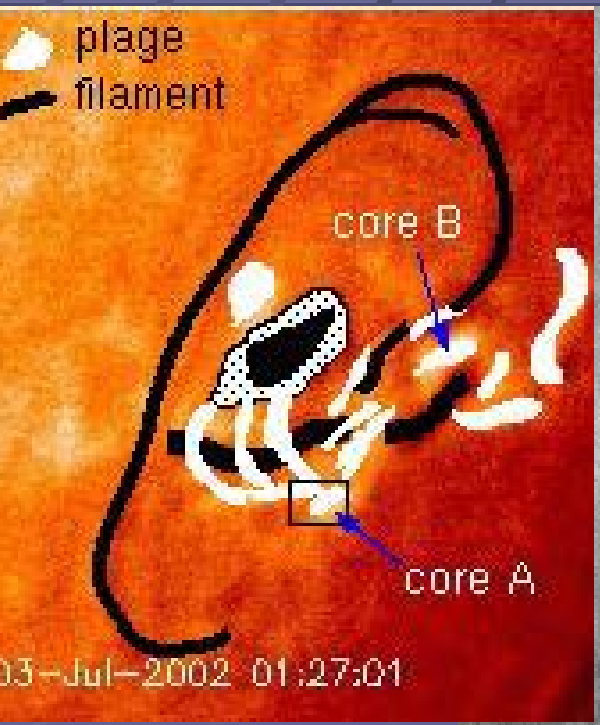

Vup ~ 0.06km/s
(230km/h)
Vrot ~ 2.2° /h
e.g.,
Tanaka,
Kurokawa&Ishii

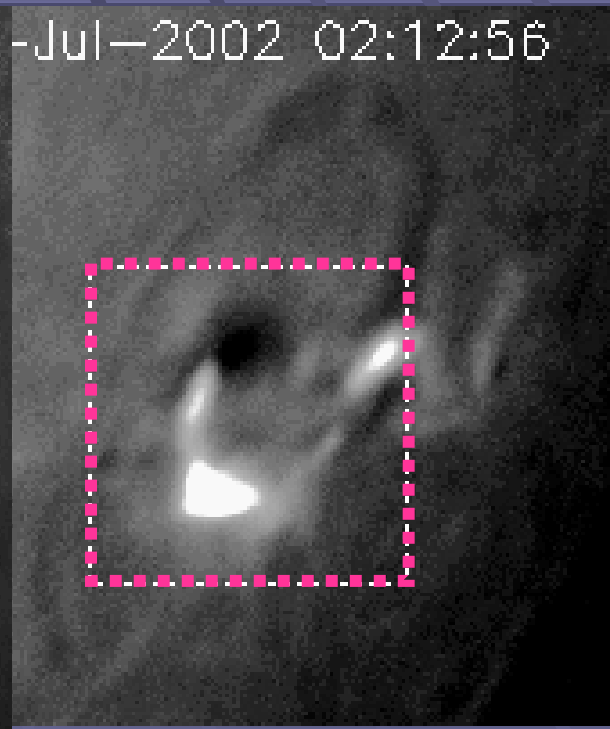

Shear Map
MSFC
Jul 2 15:32
/output-data/t2002_0702_153243w.01
REGION: 17
OBSV DATE: 2002/07/02
OBSV TIME: 15:32
OBSV DOY: 163
N
E
W
S
FIELD OF VIEW (arcsec)
x : 339
y : 268
MIN. BT = 500.000
MIN. BL = 500.000
2-Jul-2002 23:59:30
MDI
Jul 2 23:59
+ = high shear
(70-80 degrees)
* = maximum shear
(80-90 degrees)
MHSHRSYMBOL
Date of Plot
2-Jul-2002 11:25:48
50
100
150
200
250

Flare site

X1.5 (02:08 - 02:13 - 02:16)

Hα snapshots (Sartorius)

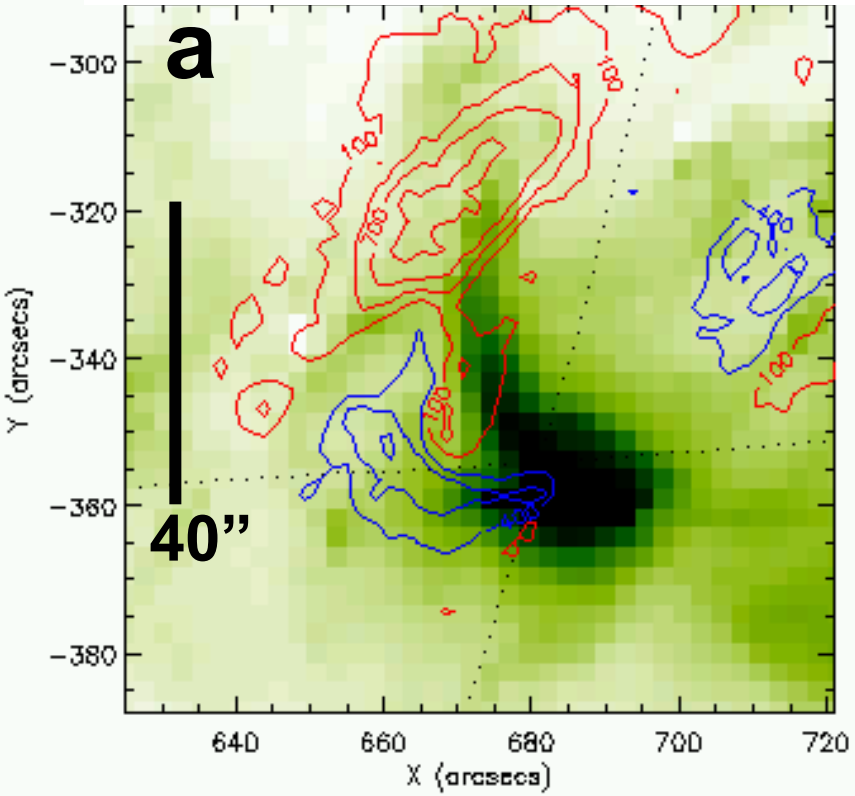




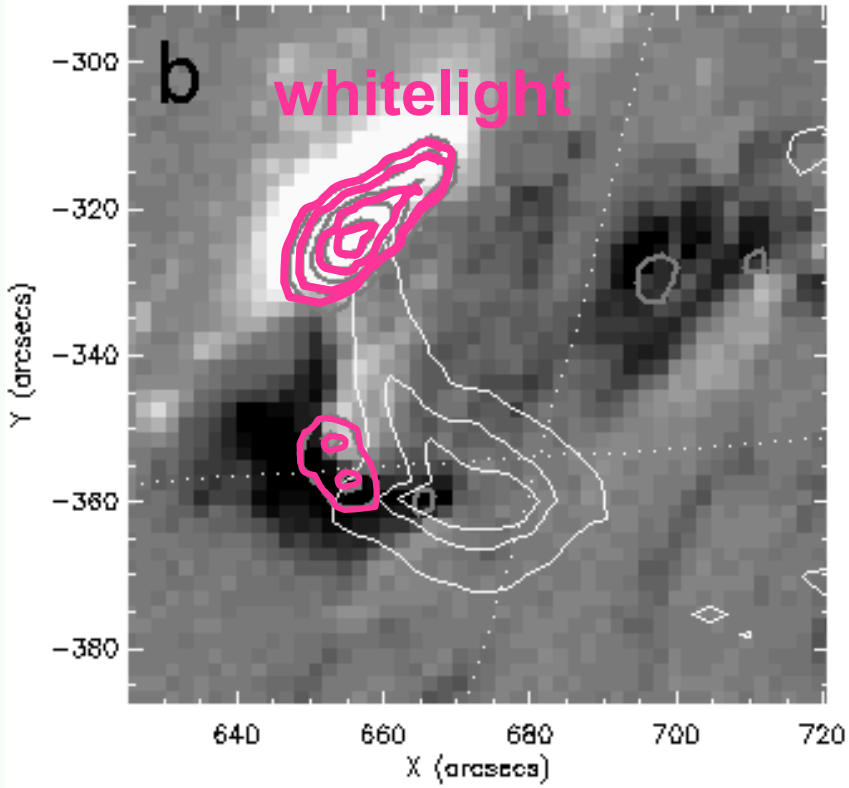
Flare site

X1.5 (02:08 - 02:13 - 02:16)

EIT195 2002 July 3 02:23:63



MDI 2002 July 2 23:59:00

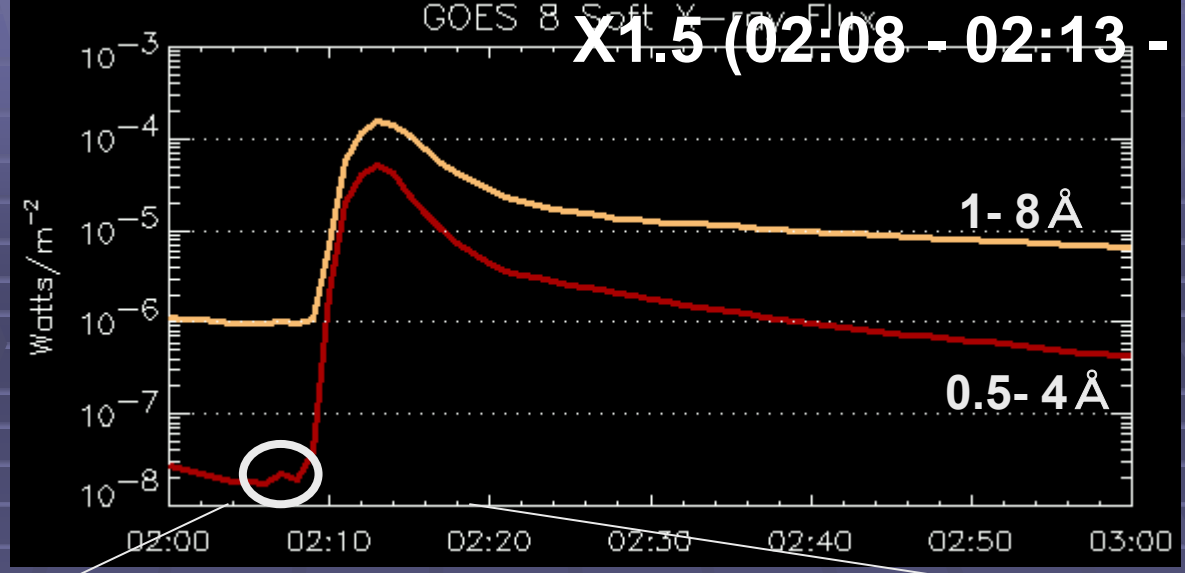


Loop-loop interaction event

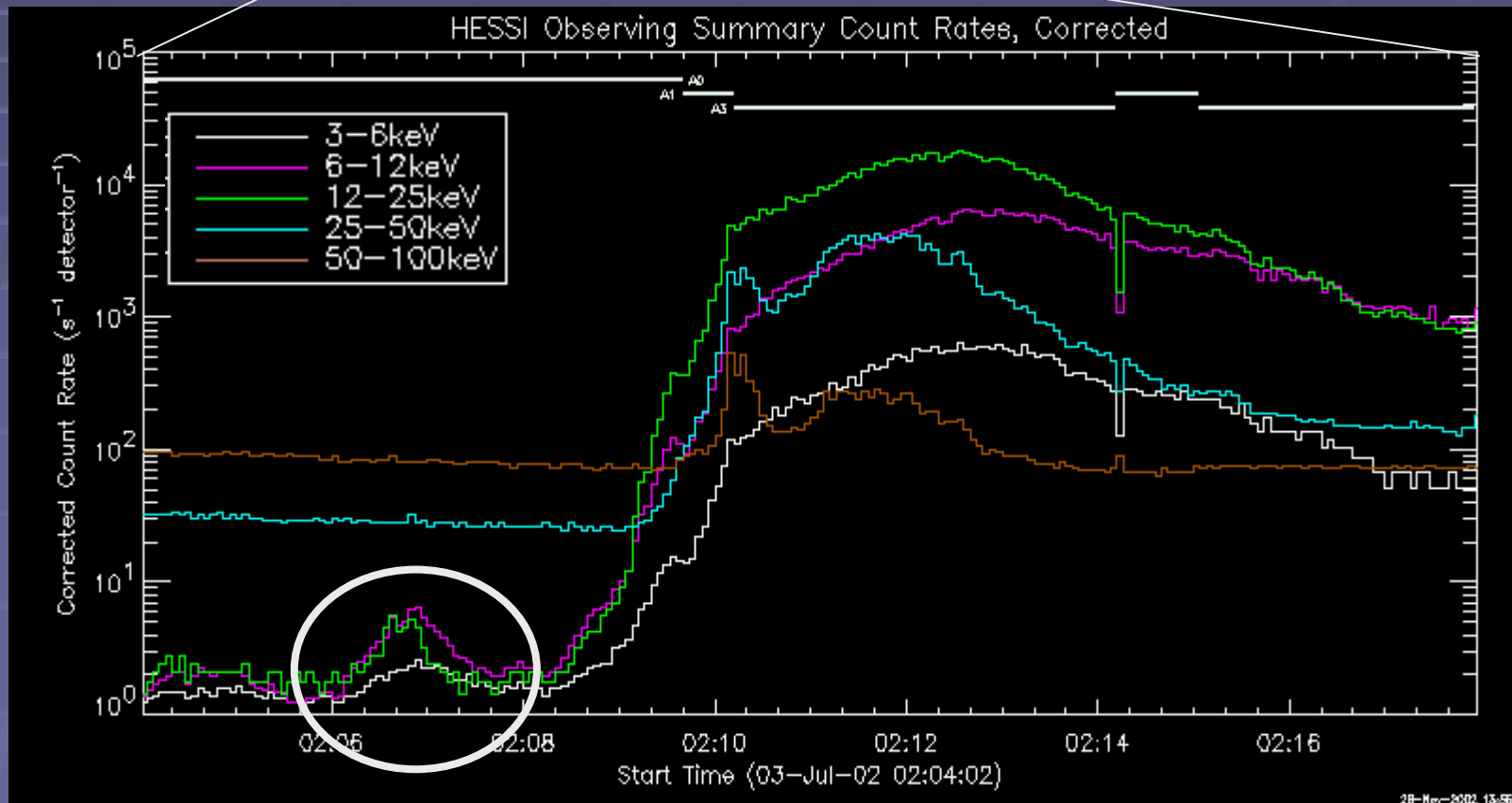
Time profiles of the event

GOES

X1.5 (02:08 - 02:13 - 02:16)



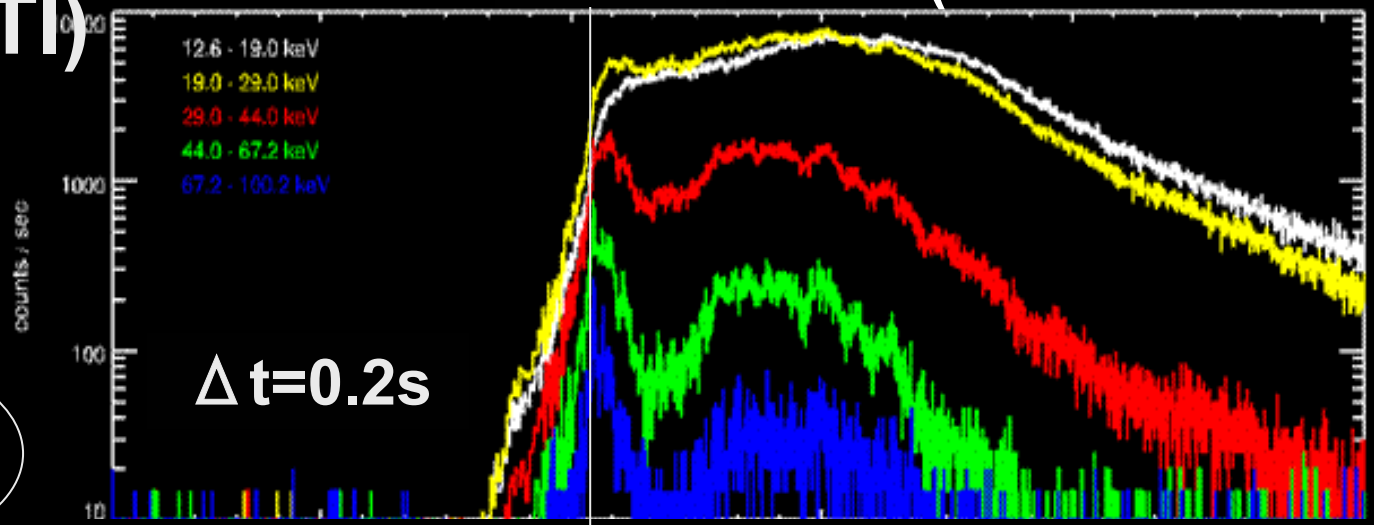
RHESSI

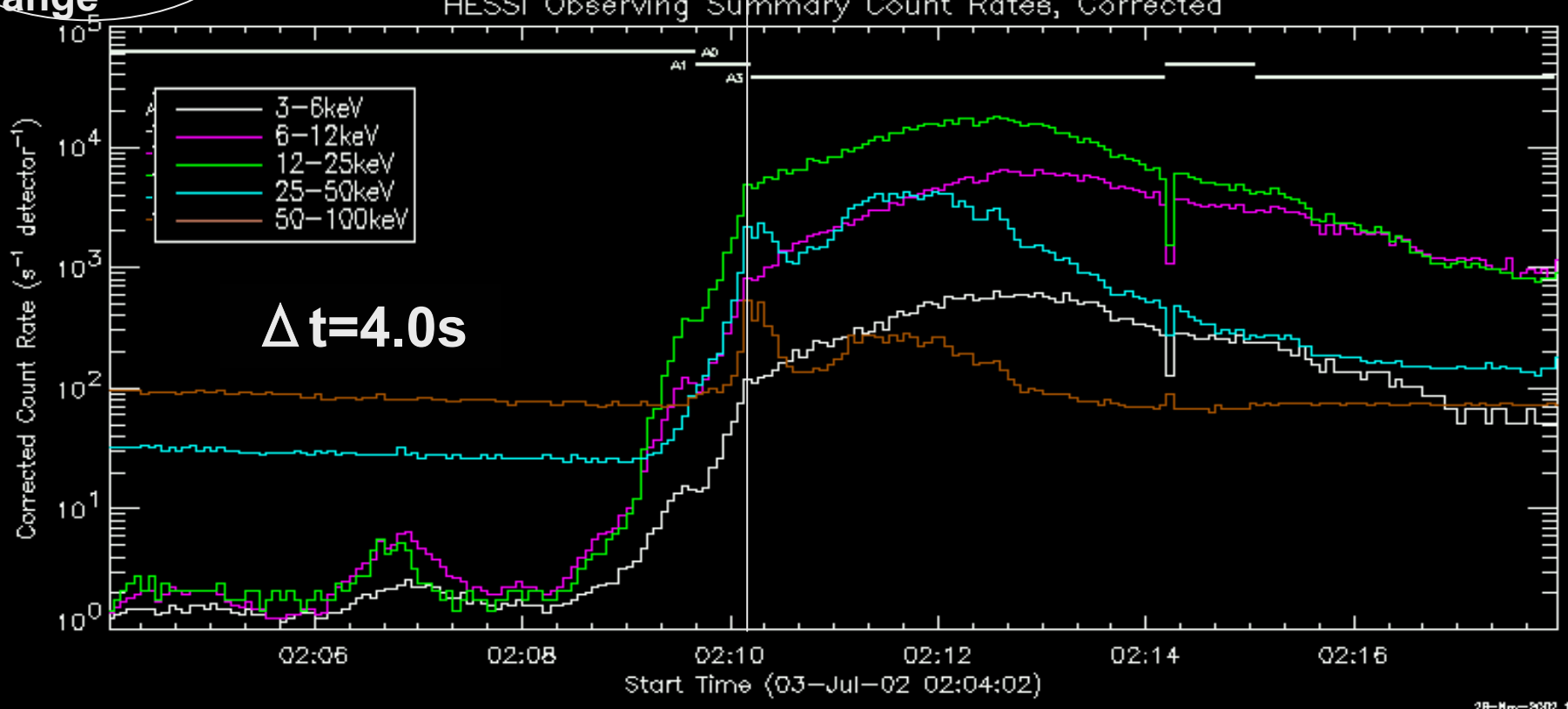


HXRS(MTI) vs RHESSI

Has better dynamic range

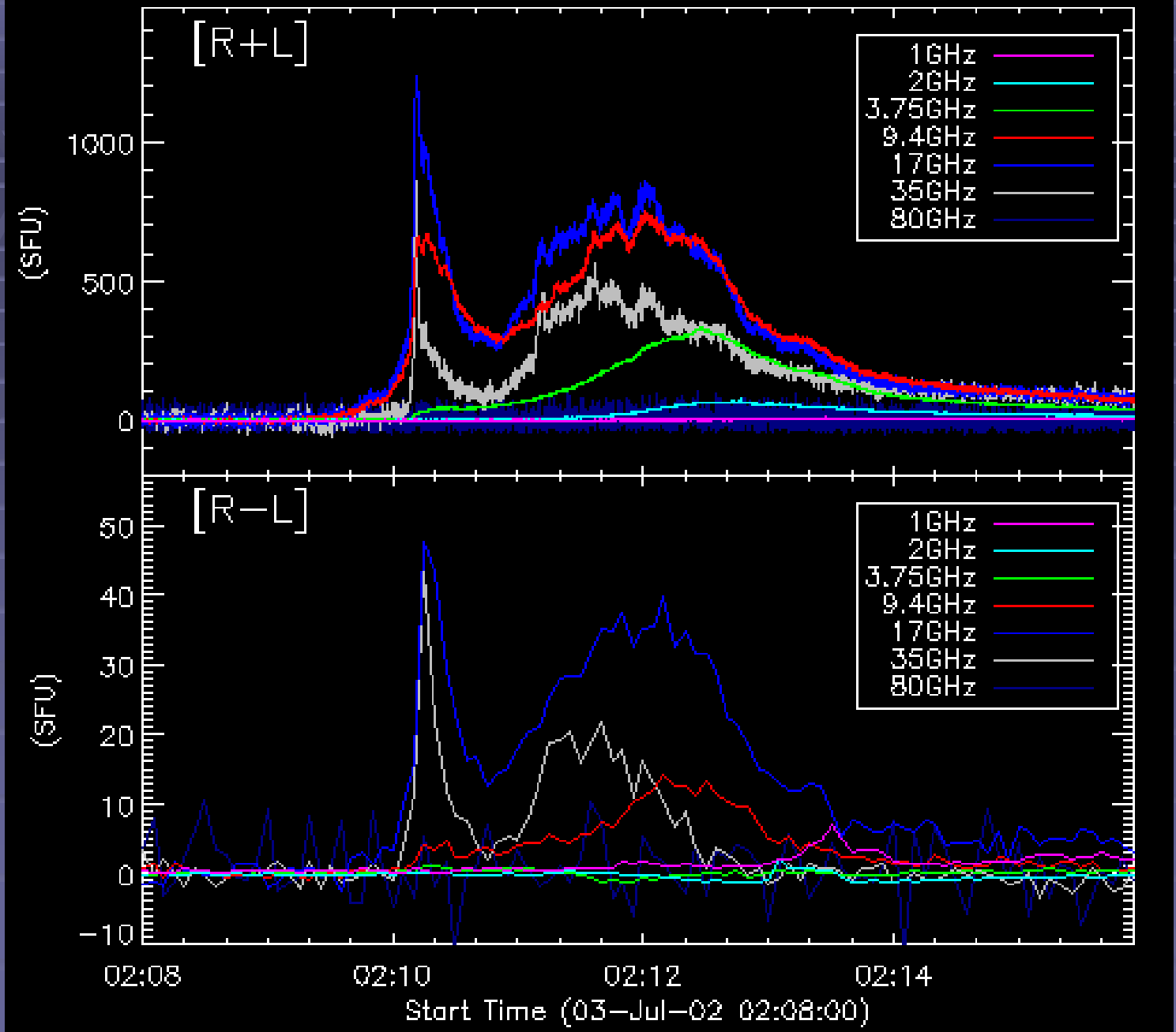
02:10:10 / HXRS X1.5 (02:08 - 02:13 - 02:16





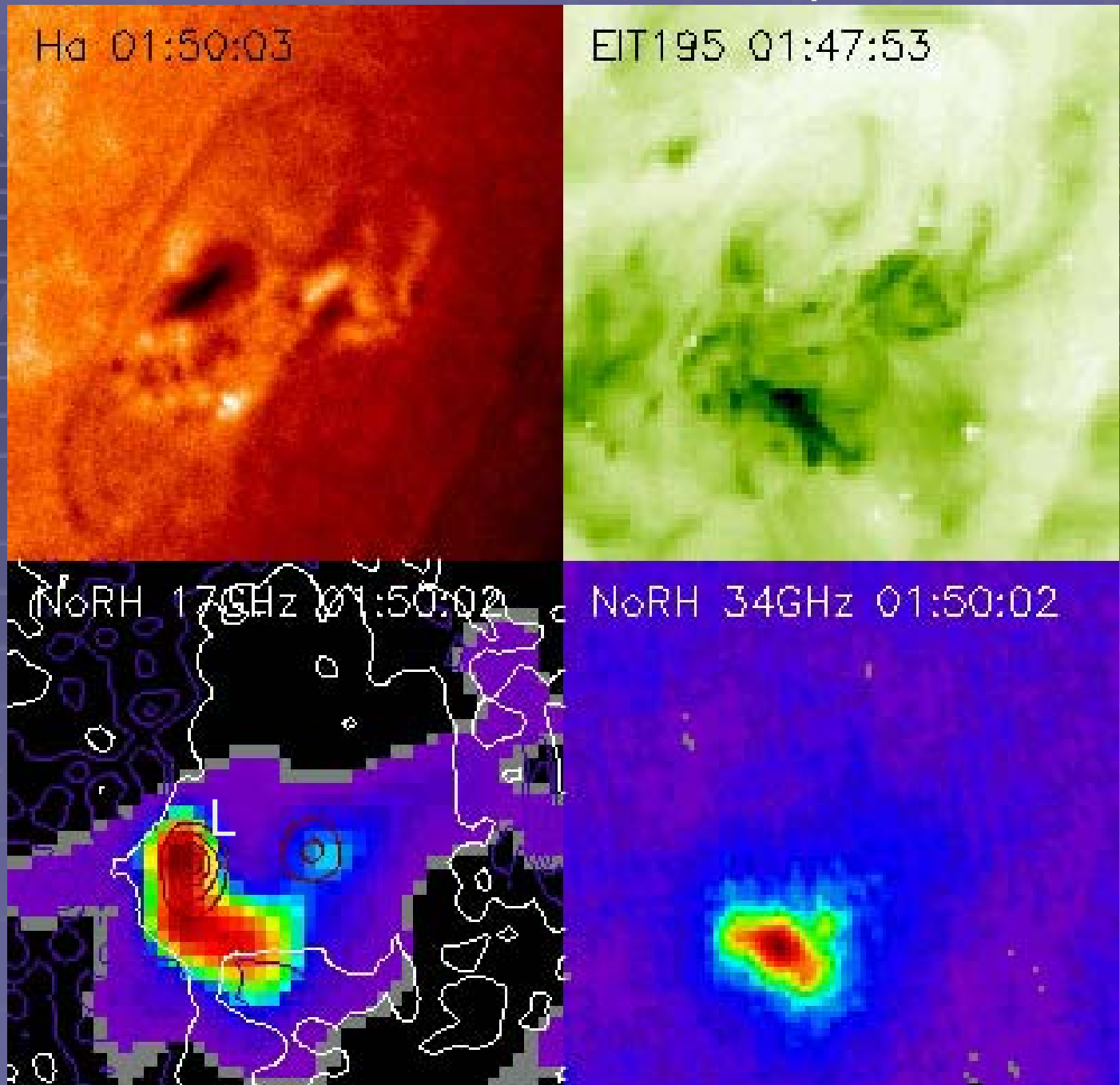
Nobeyama Radio Polarimeter

X1.5 (02:08 - 02:13 - 02:16)

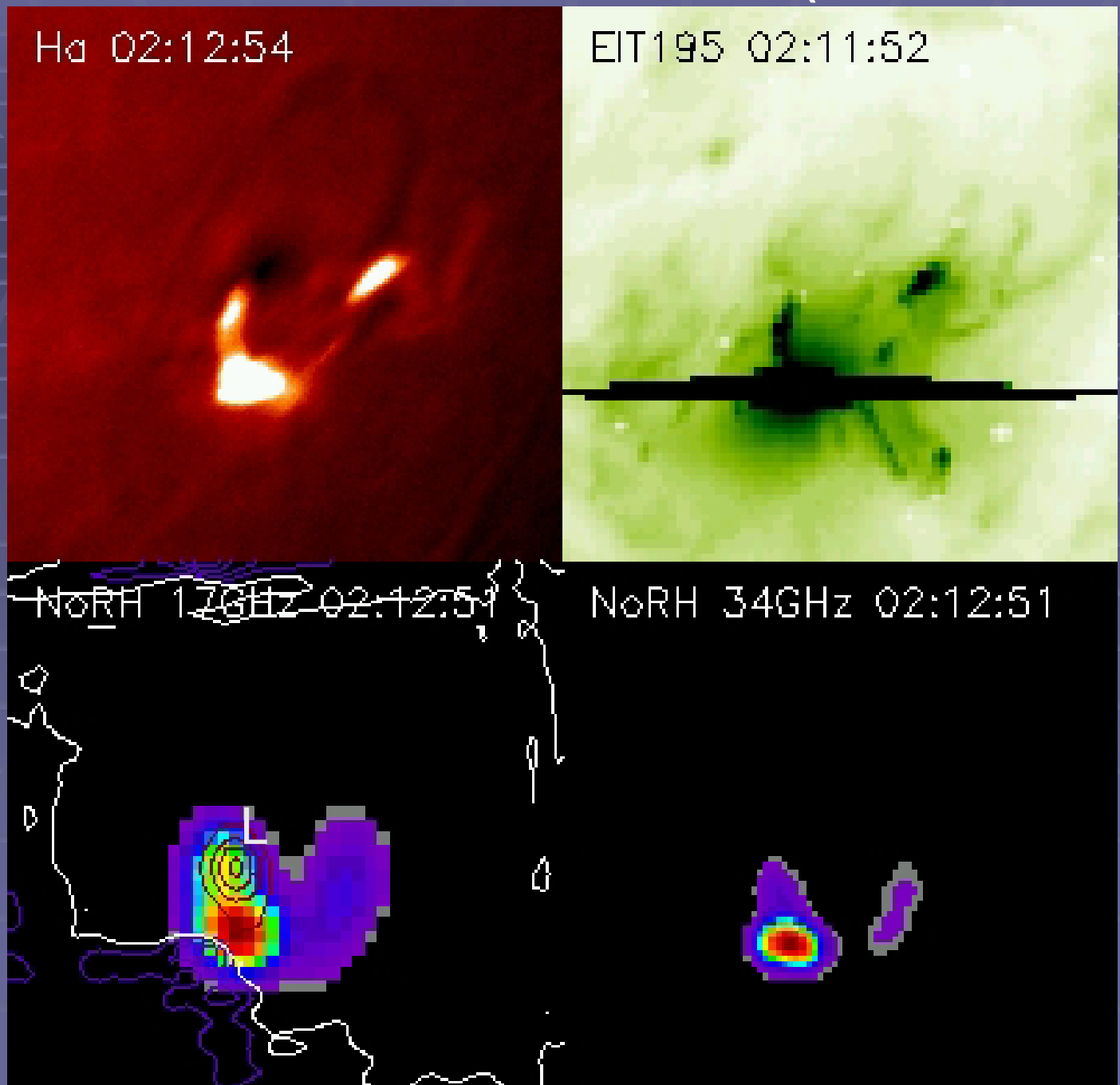


Flare images

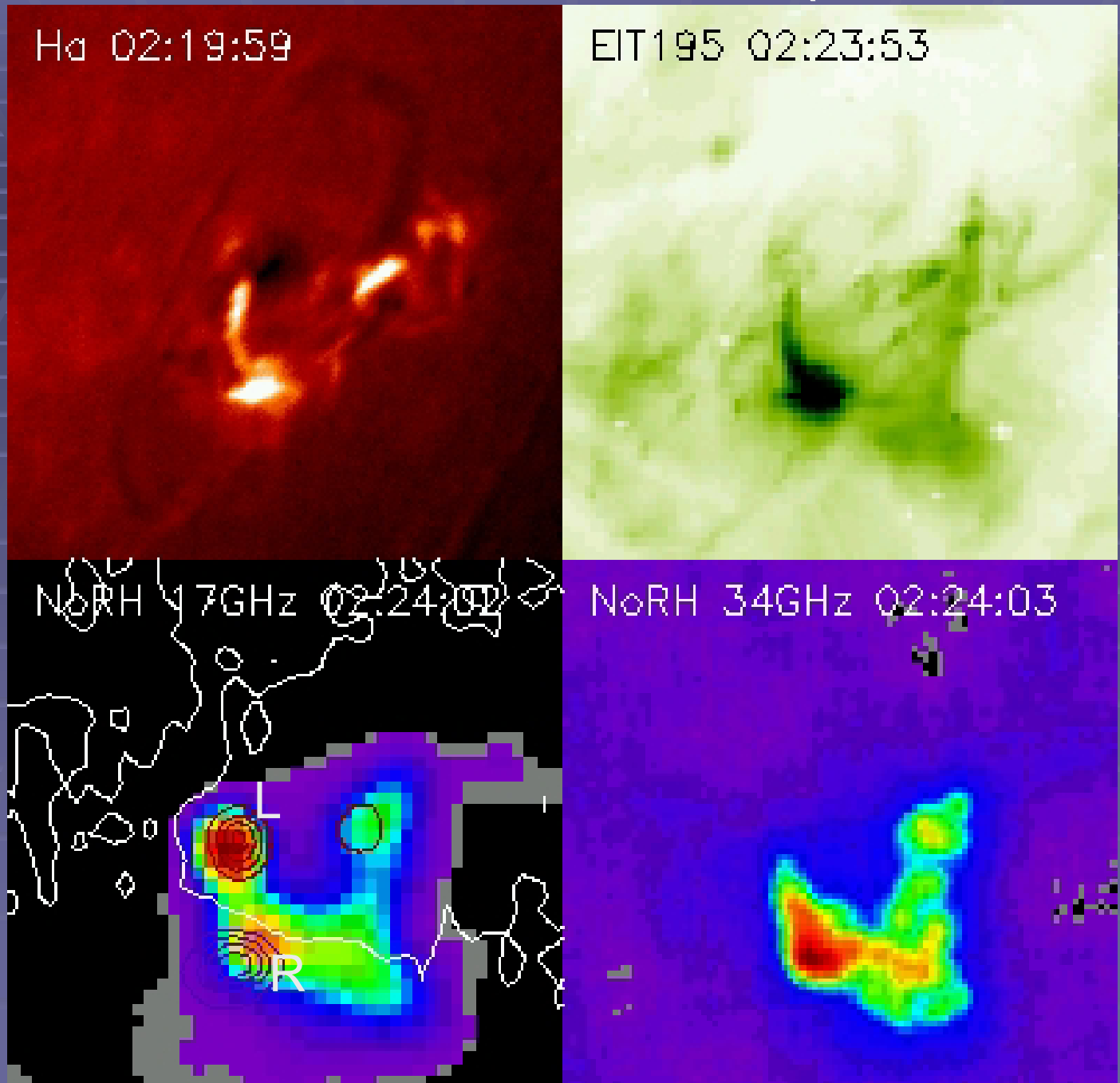
X1.5 (02:08 - 02:13 - 02:16)



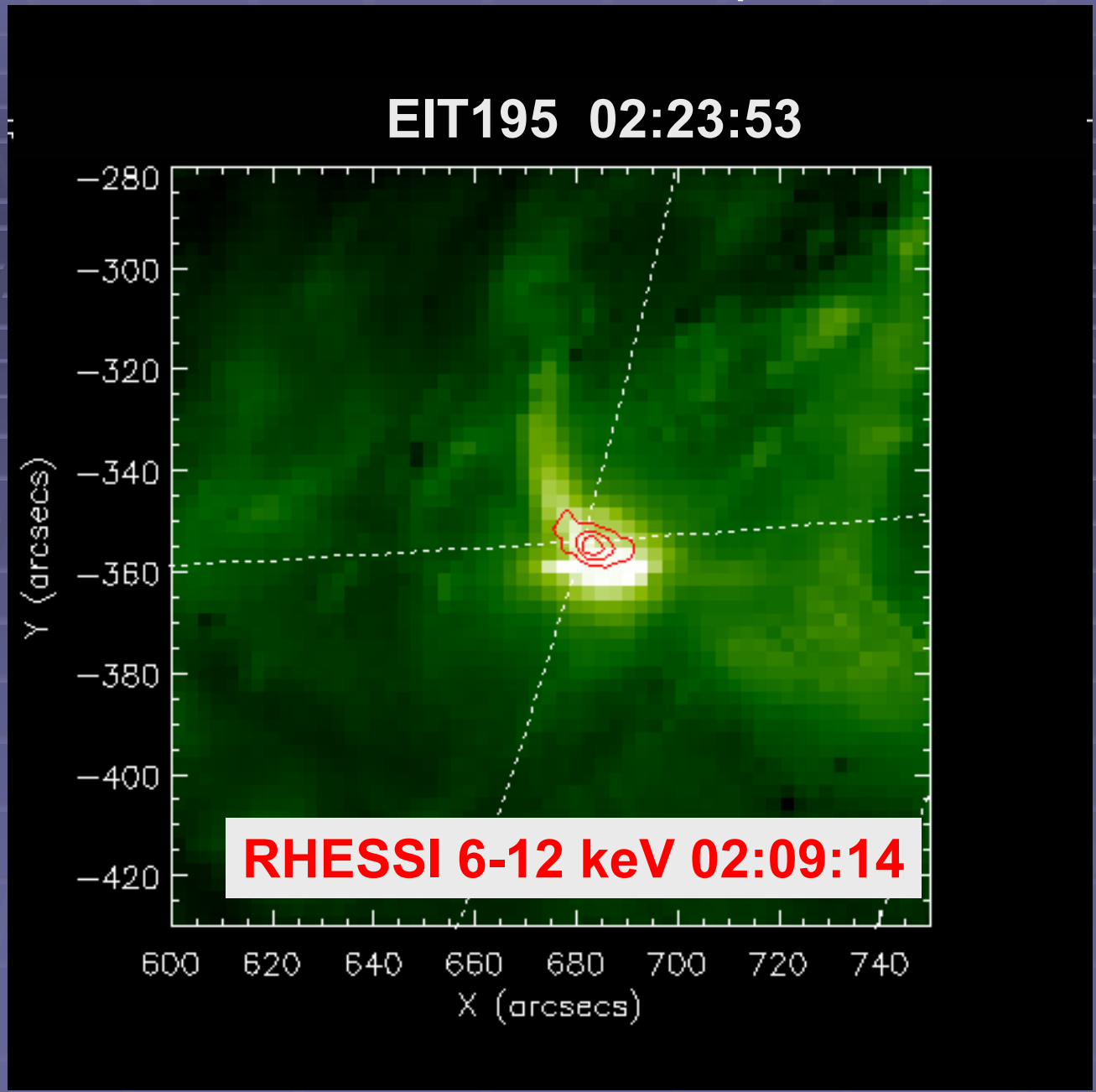
X1.5 (02:08 - 02:13 - 02:16)



X1.5 (02:08 - 02:13 - 02:16)

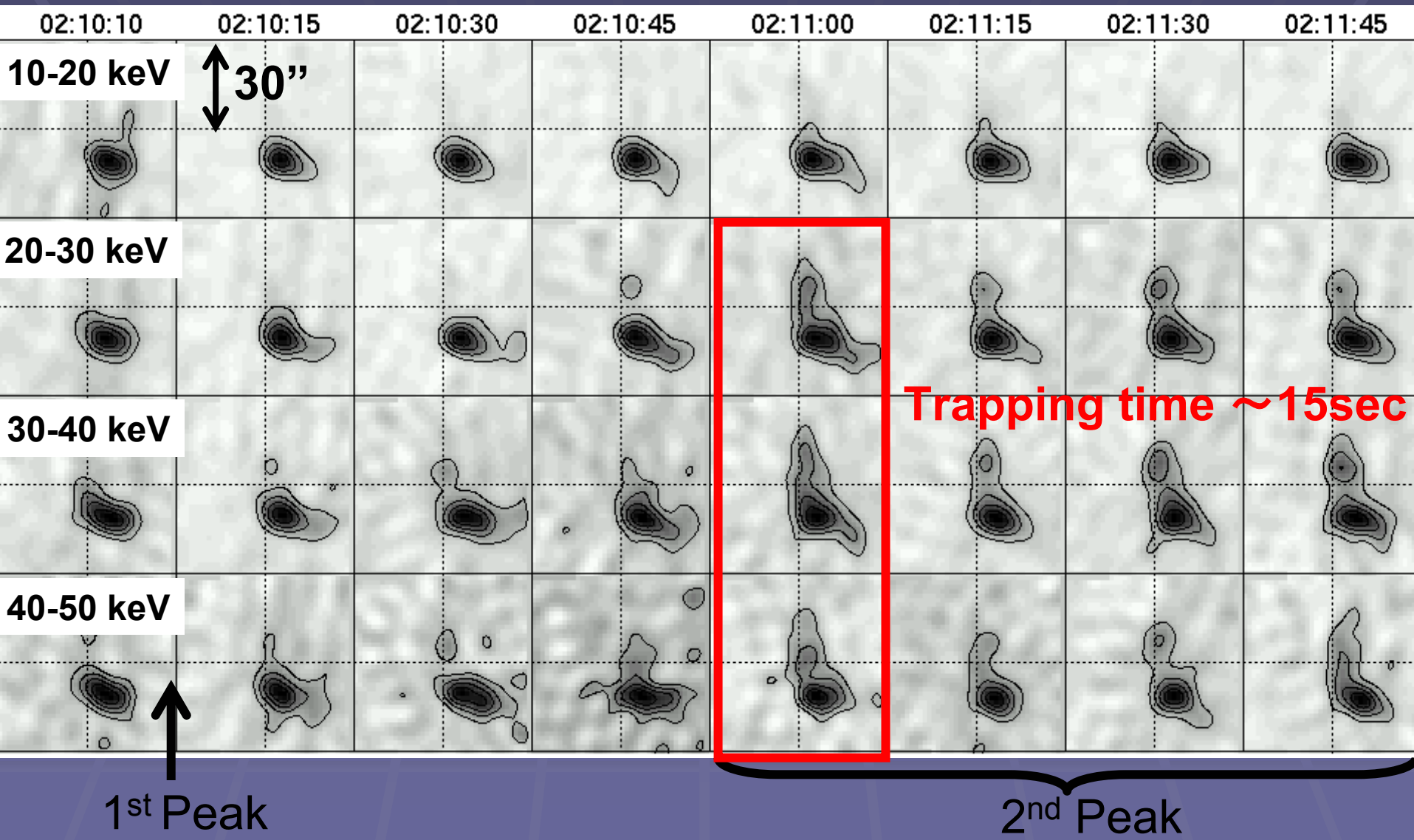


X1.5 (02:08 - 02:13 - 02:16)



X1.5 (02:08 - 02:13 - 02:16)

The loop was filled with electrons with energies up to 50keV.



X1.5 (02:08 - 02:13 - 02:16)

The loop was filled with electrons with energies up to 50keV.

N
W

Electron trapping time

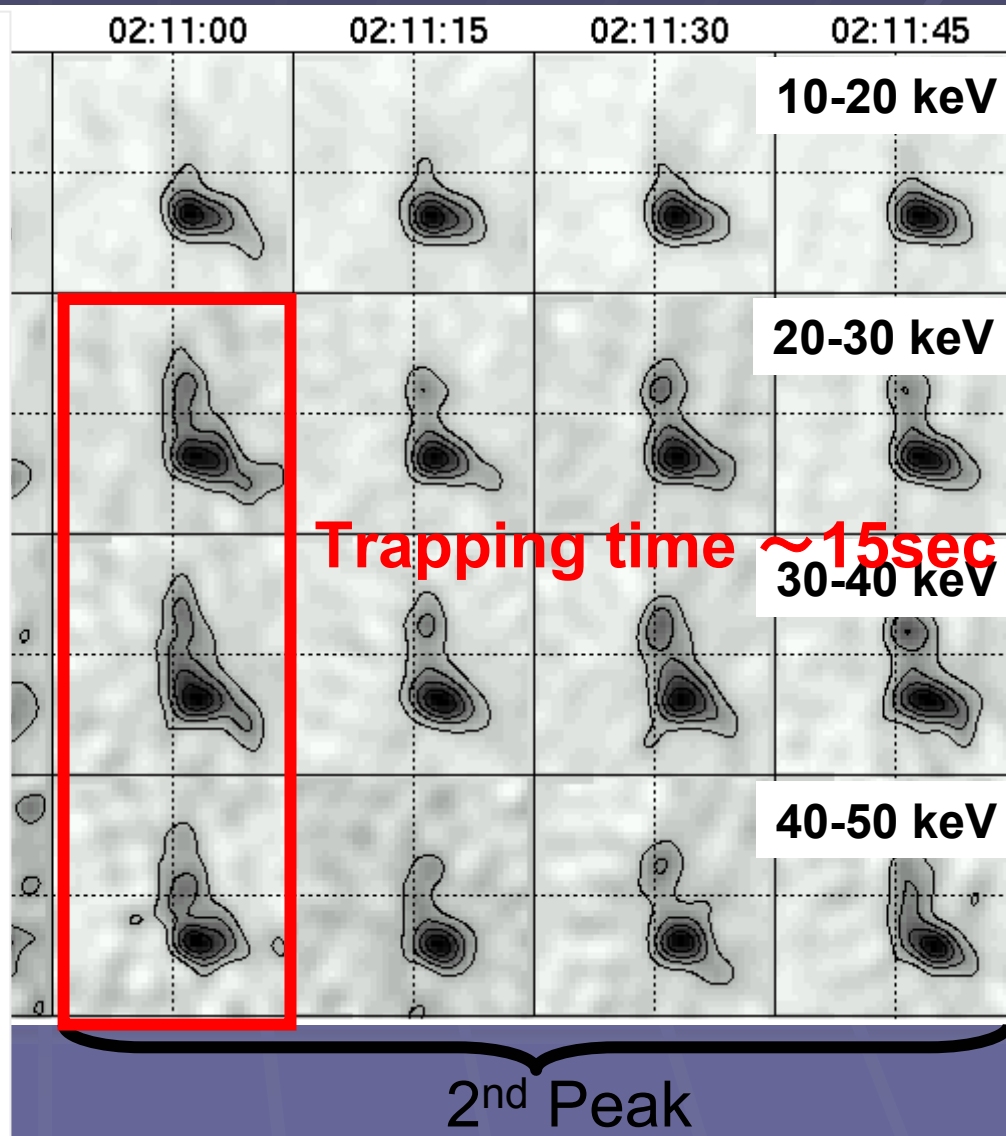
Assuming Coulomb Collision
(Trubnikov 1965; Spitzer 1967;
Schmidt 1979)

$T_{trap} = 0.95 \times 10^{8} (E^{3/2}/n_e) \times (20/\ln \Lambda)$

~ 15 sec

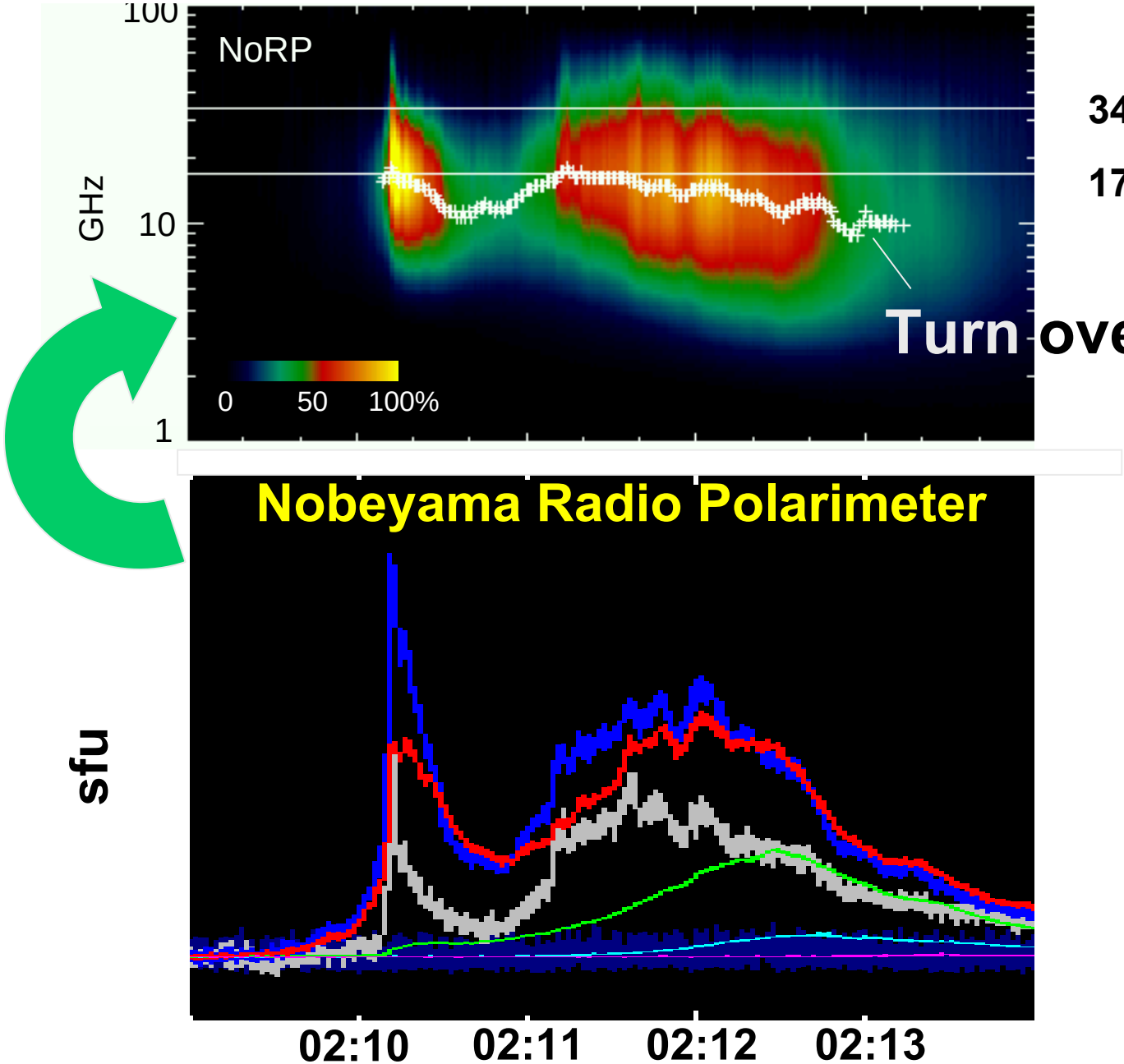
For 30 keV

$\Rightarrow$ $n_e \sim 10^{9}$ cm^{-3}



Radio Spectra

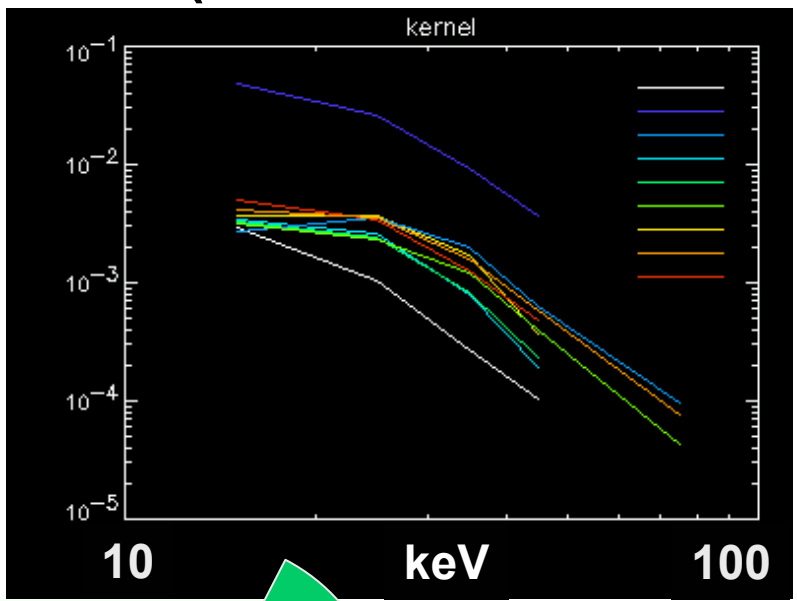
X1.5 (02:08 - 02:13 - 02:16)

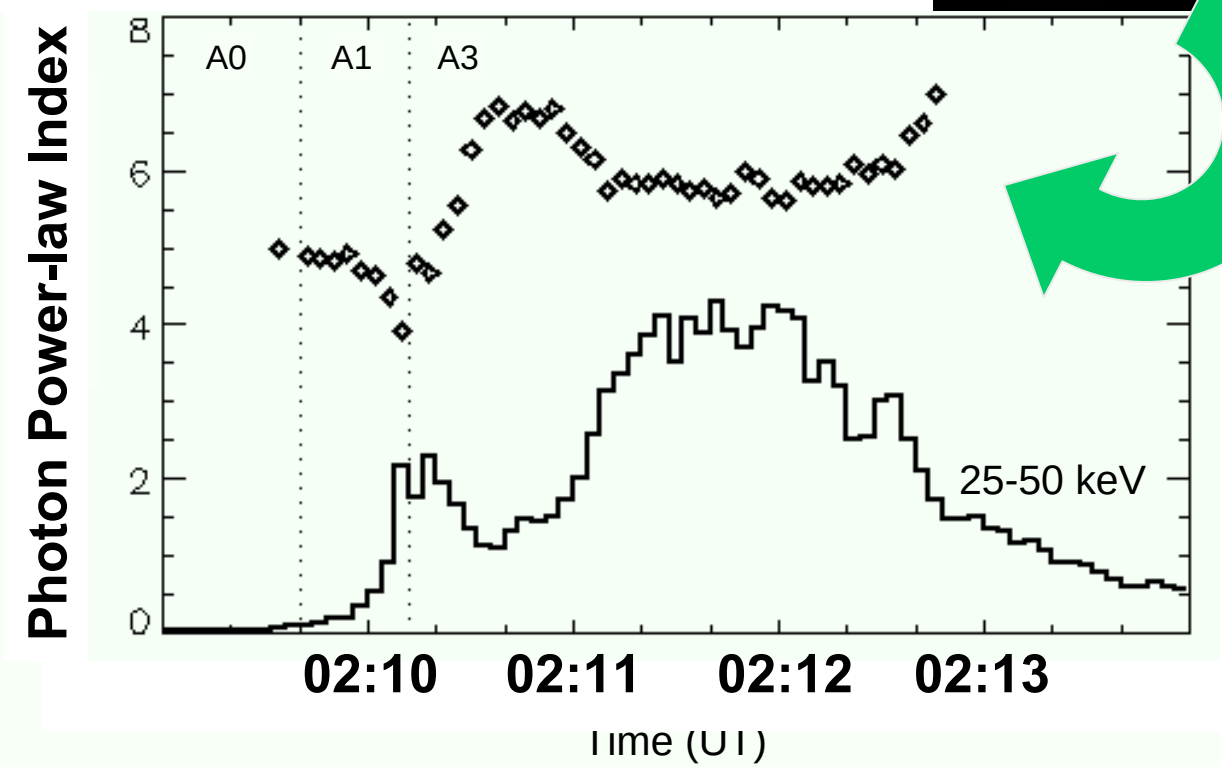


X1.5 (02:08 - 02:13 - 02:16)

Hard X-ray Spectra

RHESSI



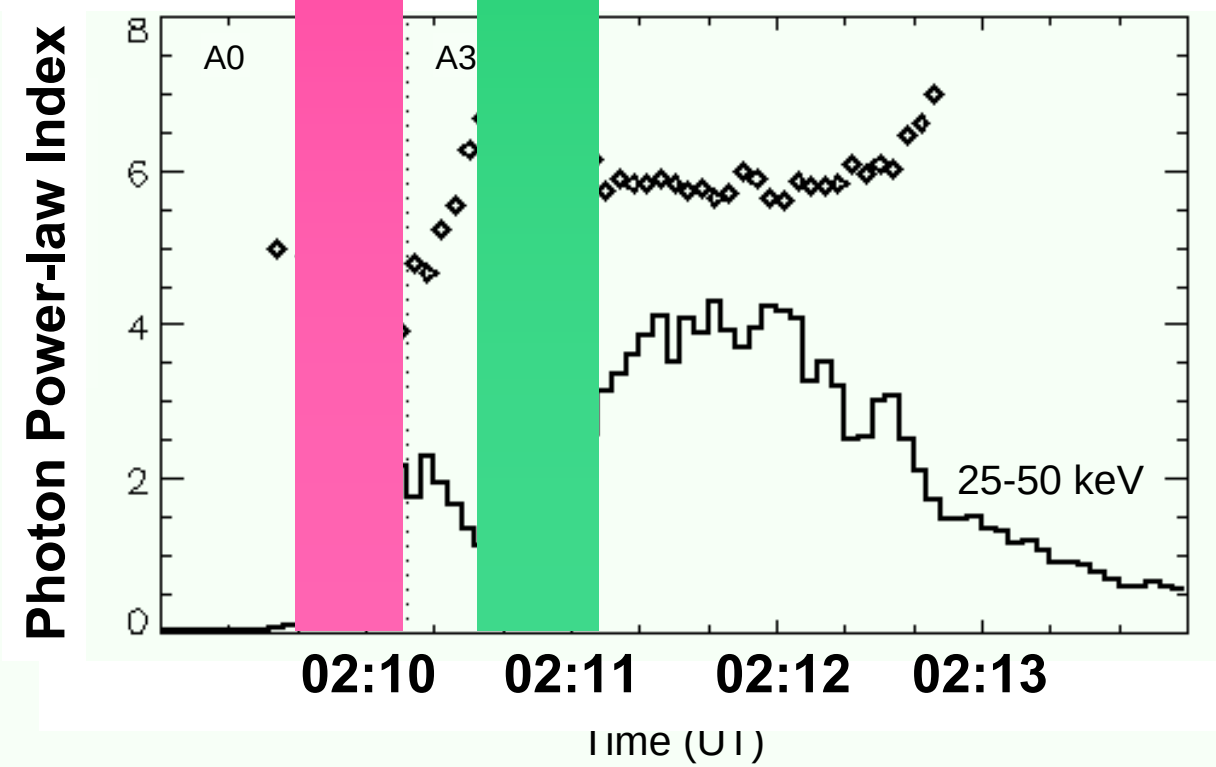


X1.5 (02:08 - 02:13 - 02:16)

Hard X-ray Spectra

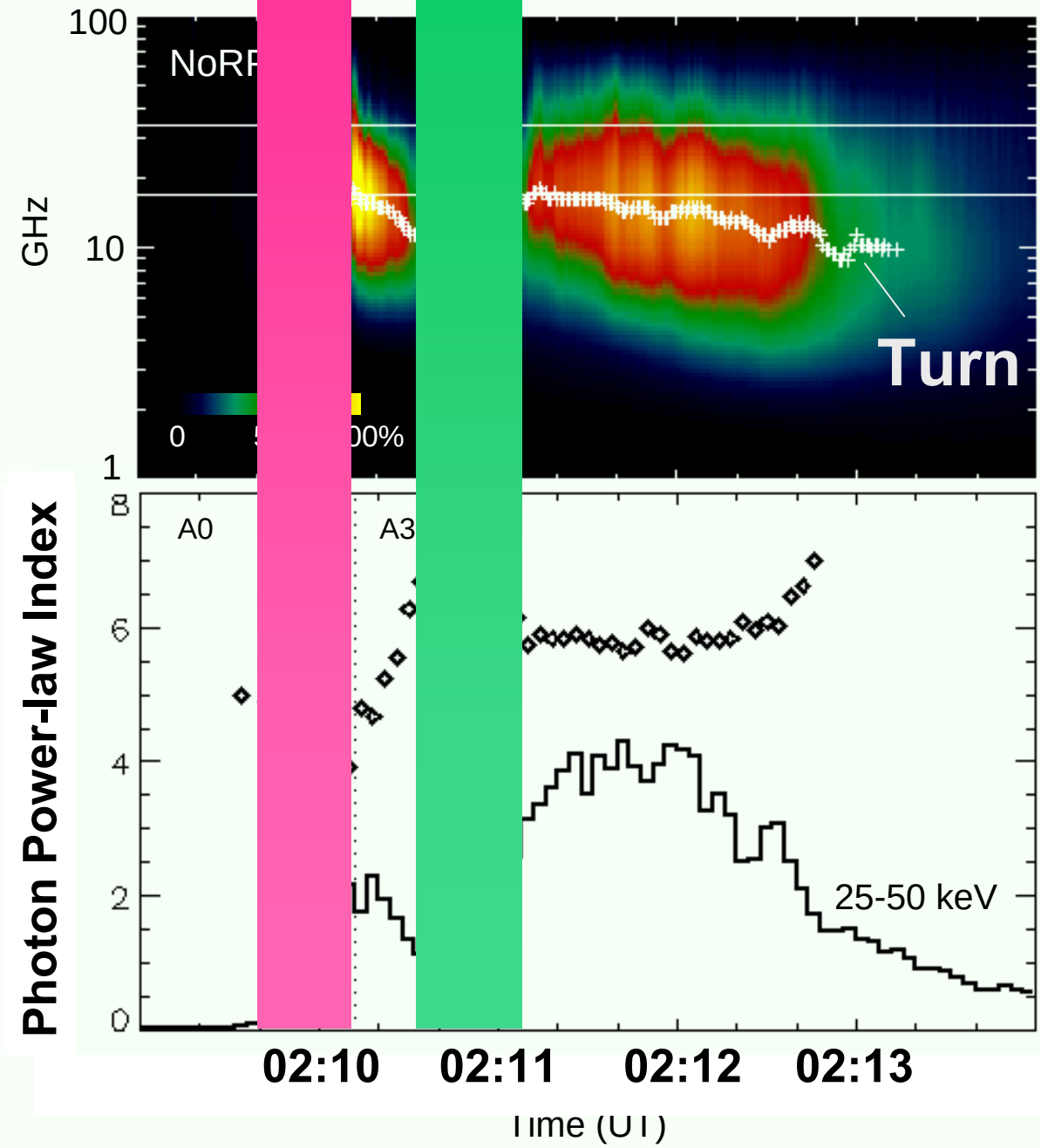
RHESS

Hardning



Soft-hard-soft
⇒ Type B
(Tanaka 1983)

X1.5 (02:08 - 02:13 - 02:16)

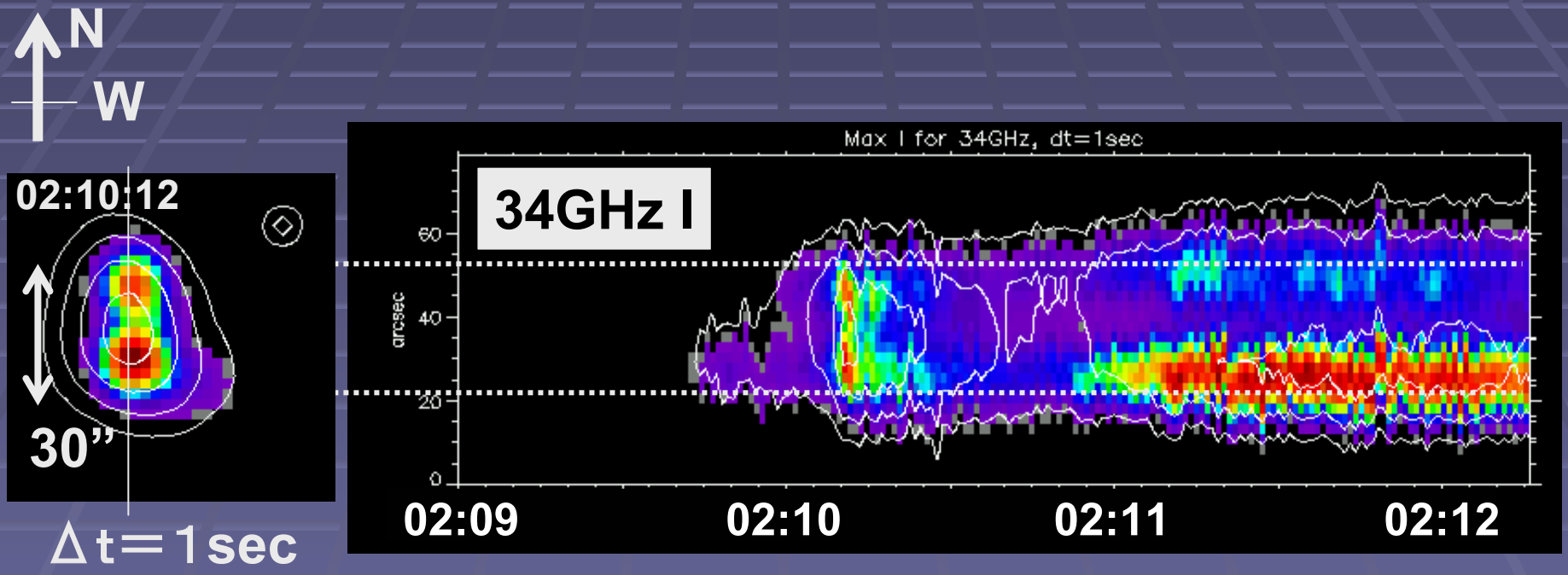


34 GHz
17 GHz
Optical thin

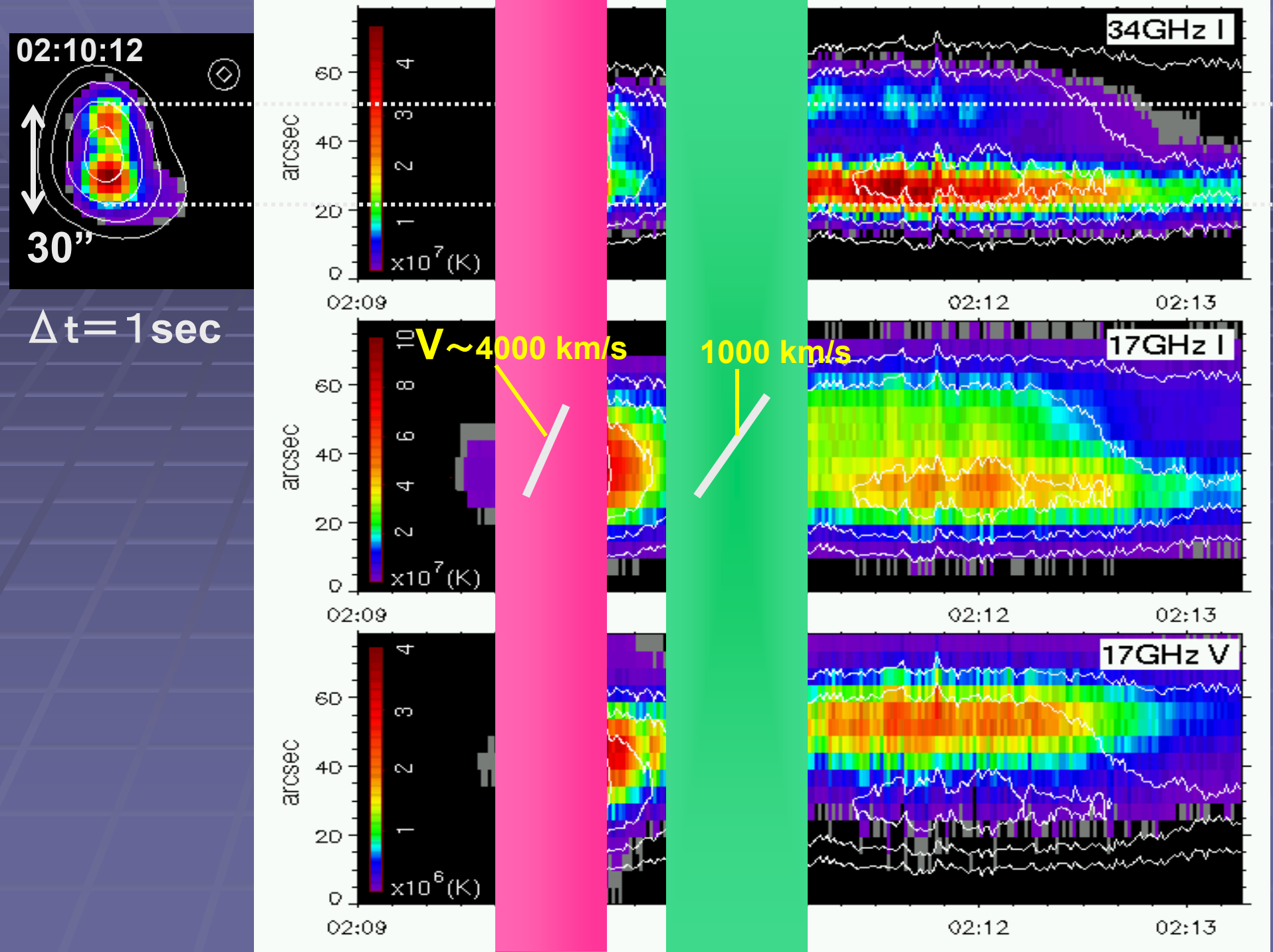
Turn over frequency

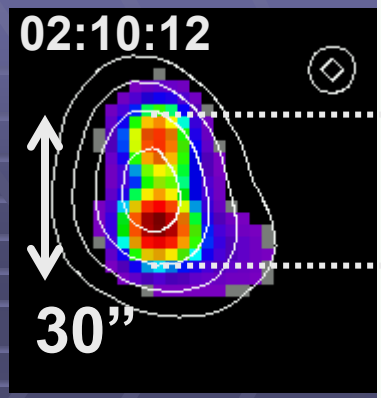
Soft-hard-soft
⇒ Type B
(Tanaka 1983)

Time slice of NoRH images

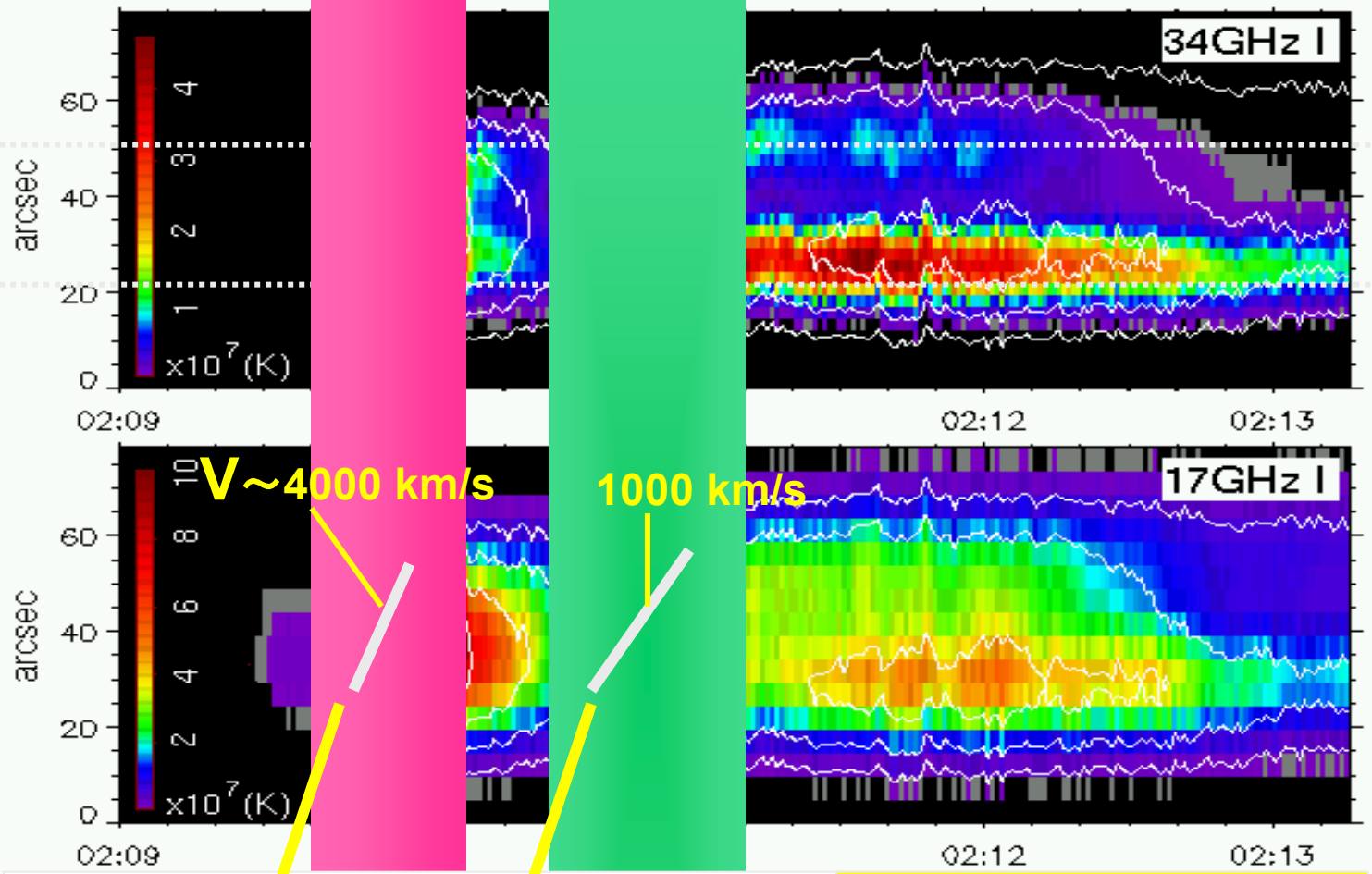


Color : brightness temperature (K)


02:10:12
30”
Δt=1sec
34GHz I
17GHz I
17GHz V
arcsec
x10^7(K)
x10^6(K)
V~4000 km/s
1000 km/s
02:09
02:12
02:13



Δt=1sec



HXR emission from trapped electrons

$n_e \sim 10^9$ cm^{-3}

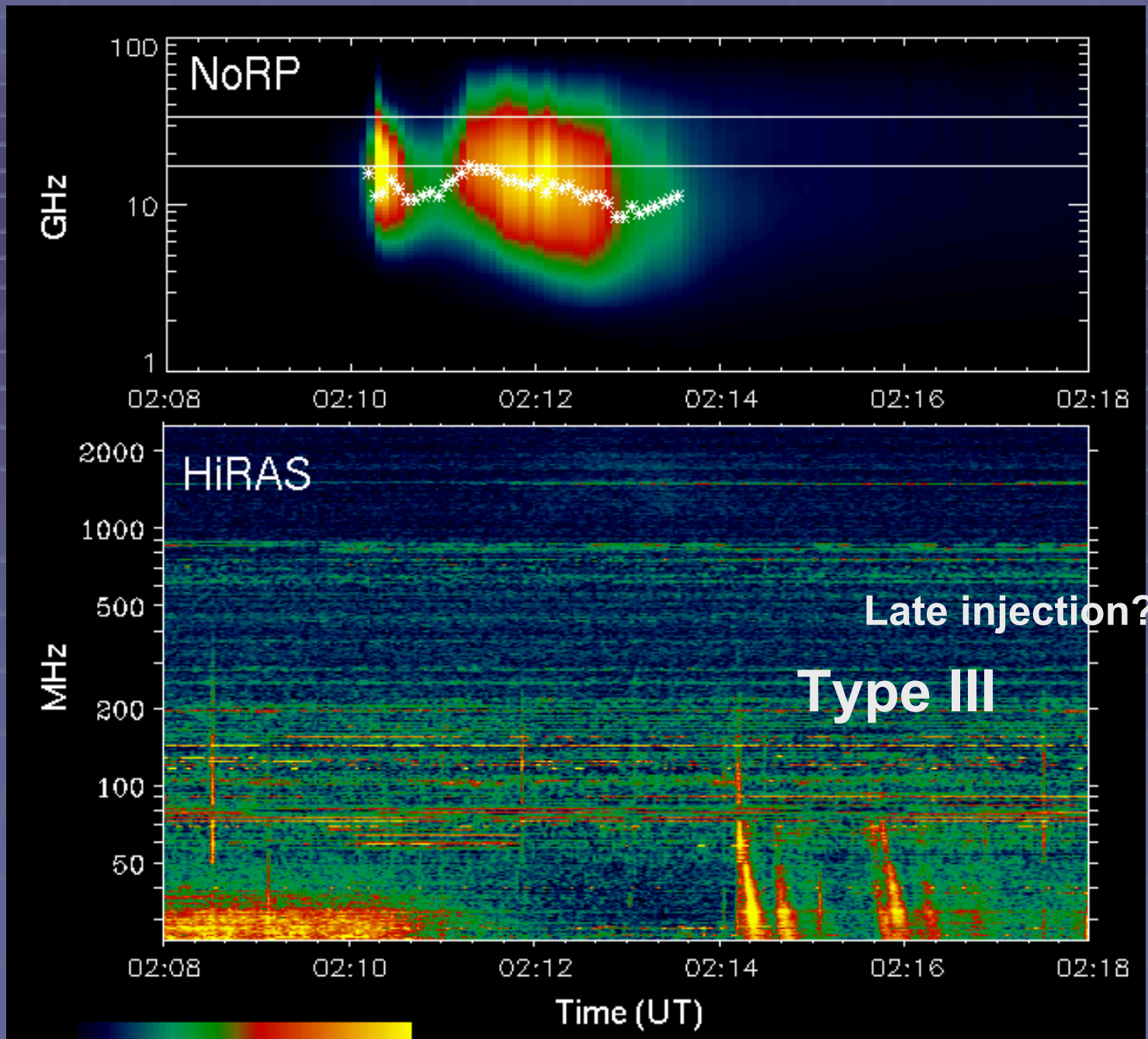
If $V=V_A$ & B~100 Gauss

⇒ n=0.1x 10^9 cm^-3

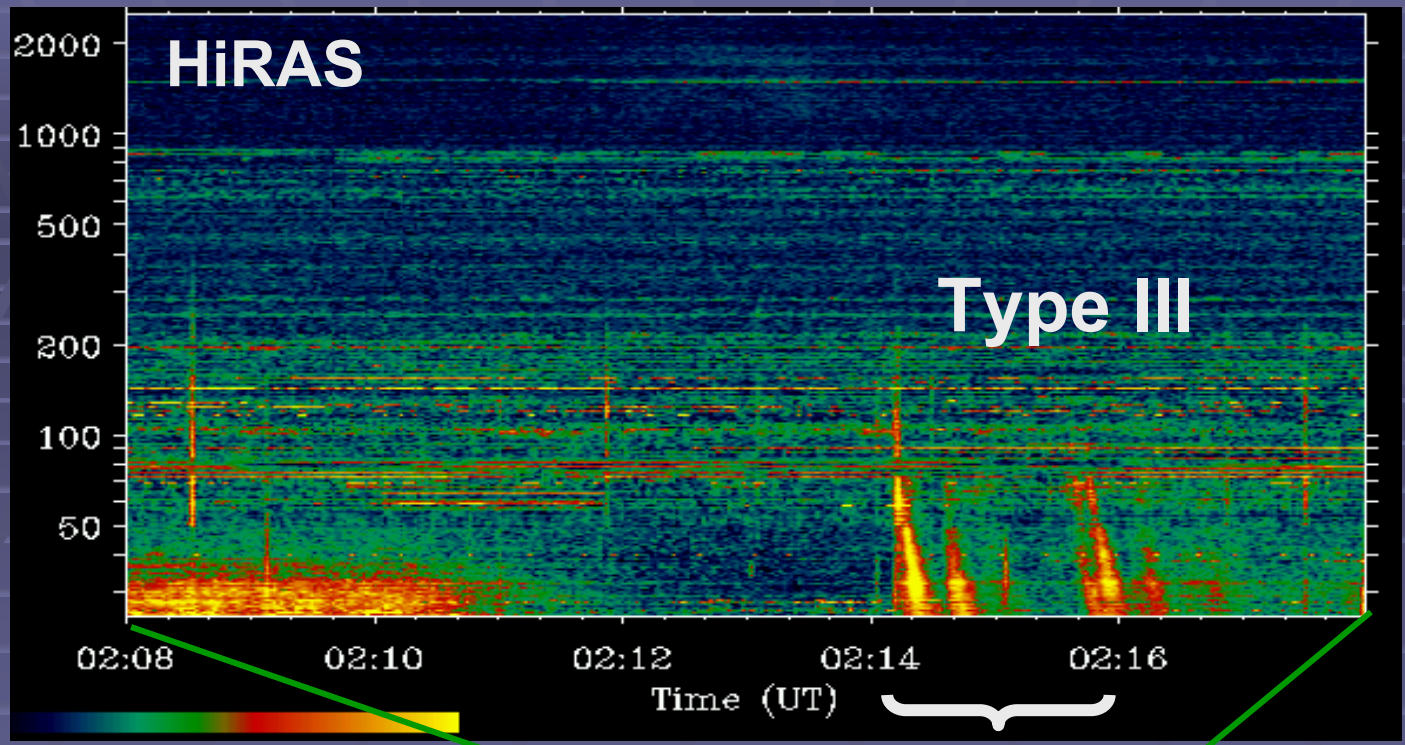
1 x 10^9 cm^-3

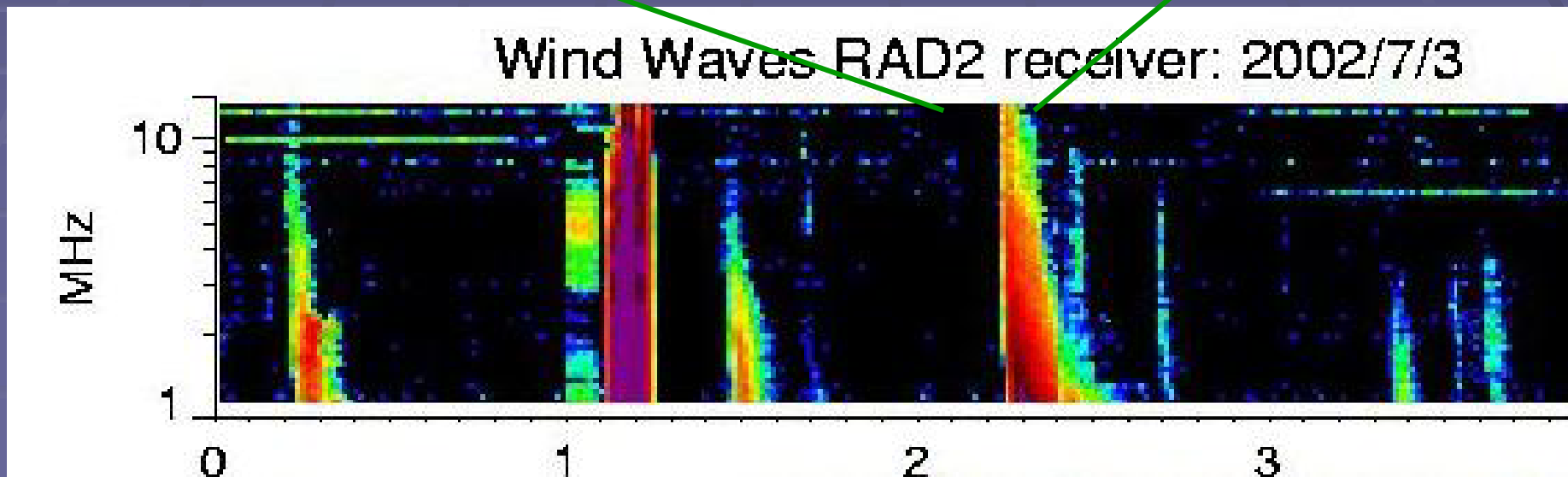
Other features

Confined Flare? .... No CME



Confined Flare? .... No CME





Summary

We observed a Hanaoka-Nishio type X1.5 flare using RHESSI and NoRH.

-The flare was induced by an emergence of a twisted dipole.

-Propagation (17 GHz) and trapping of electrons (17GHz and 20-50 keV) with $n \sim 10^{10}\,cm^{-3}$ that originated in the compact flare kernel (the foot point shared by the two loops).

←due to high confinedness of the flare region?

- No imaging spectroscopy (so far) !!!

NiCT