White Light Flare Observations from the Solar Optical Telescope onboard Hinode

Kyoko Watanabe, Toshifumi Shimizu

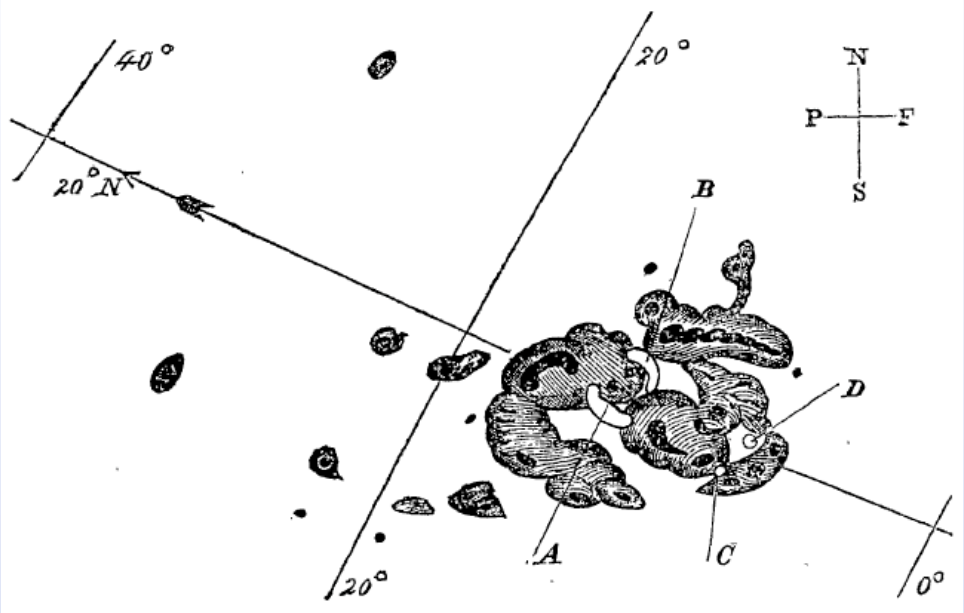
ISAS/JAXA, Japan

Solar activity during the onset of Solar Cycle 24 @ Napa
Flare Group E
2008/12/09

White Light Flare (WLF)

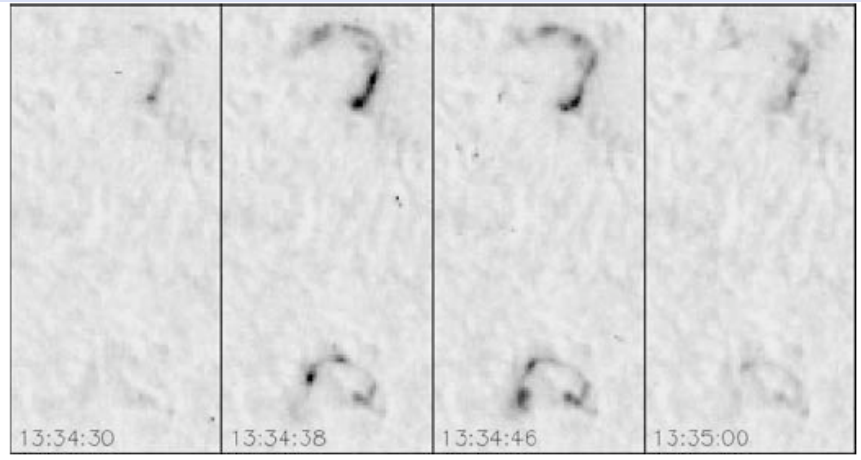
The first solar flare
observed by Carrington (1859)

Frequency near solar maximum
～15 events/year
↓
Still rare events



(Carrington 1859)

White light flares are observed
only with big flares (X-class)
(Hiei 1982, Neidig 1989)
↓
WLF came to be able to observe by
the satellite observation even with
a small flare such as C-class
(Matthews et al. 2003, Hudson et al. 2006)

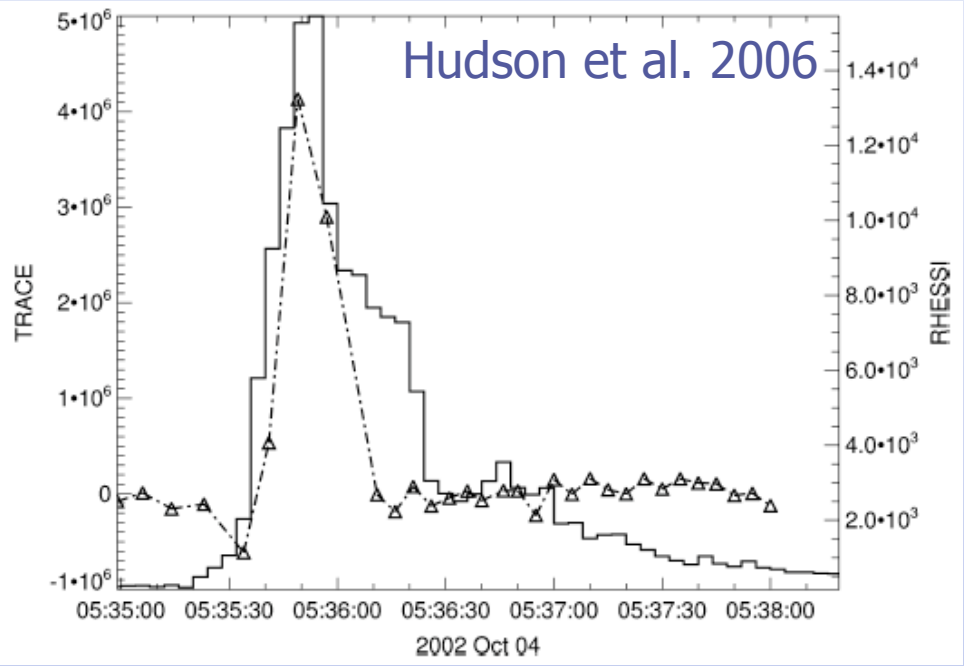


(Hudson et al. 2006)

White Light Flare (WLF)

Energy transport mechanisms (Neidig 1989)

- Heat conduction
- Electron beams
- High-energy (>4MeV) proton beams
- Low-energy protons
- Irradiation by 1-8Å X-rays
- Irradiation by 10-1030Å emission
- Alfven waves



Good correlation were seen between white light and radio and hard X-rays

↓

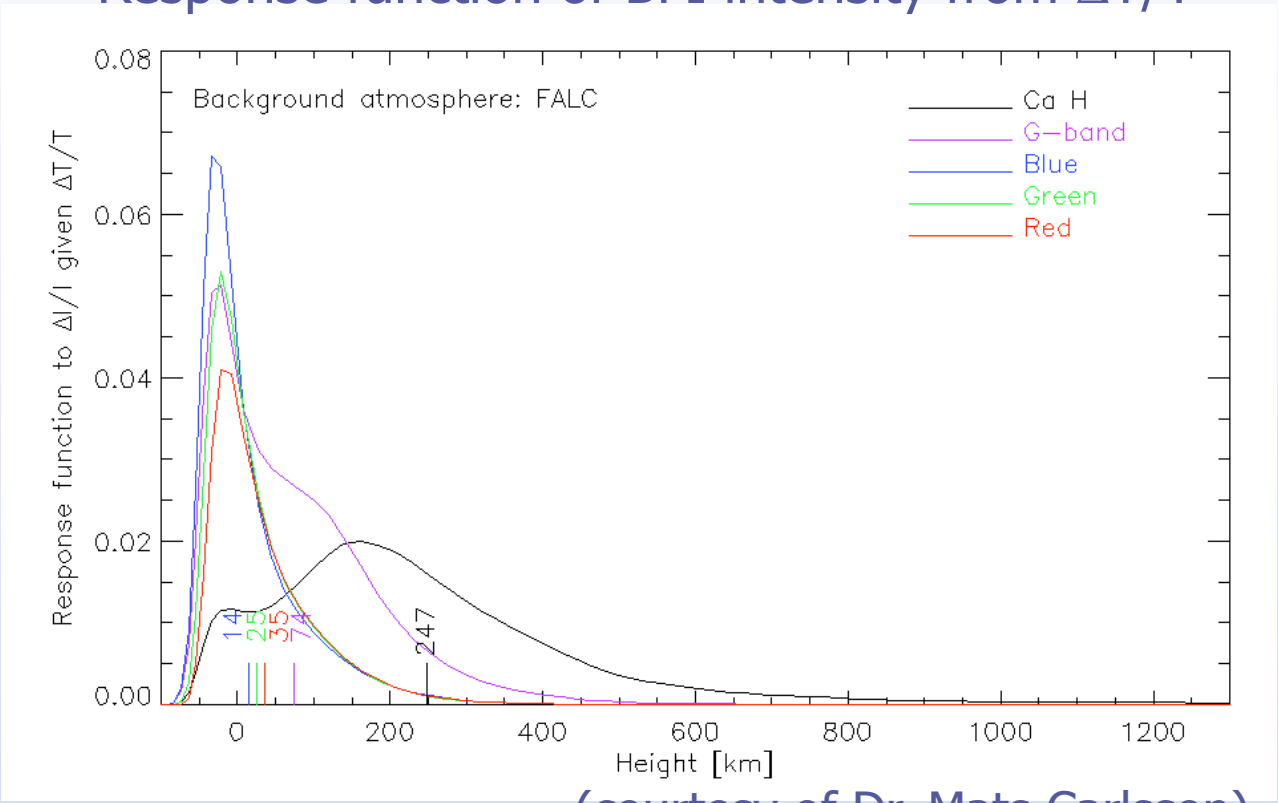
This suggests correlation with particle acceleration

Hinode/SOT

BFI:
- CN (3883 Å)
- Ca II H (3969 Å)
- CH (4305 Å)
- Continuum
  - blue: 4505 Å,
  - green: 5550 Å,
  - red: 6684 Å

White light flare
⇒ Continuum
⇒ G-band

Response function of BFI intensity from ΔT/T



(courtesy of Dr. Mats Carlsson)

We picked up the events which observed emission from G-band

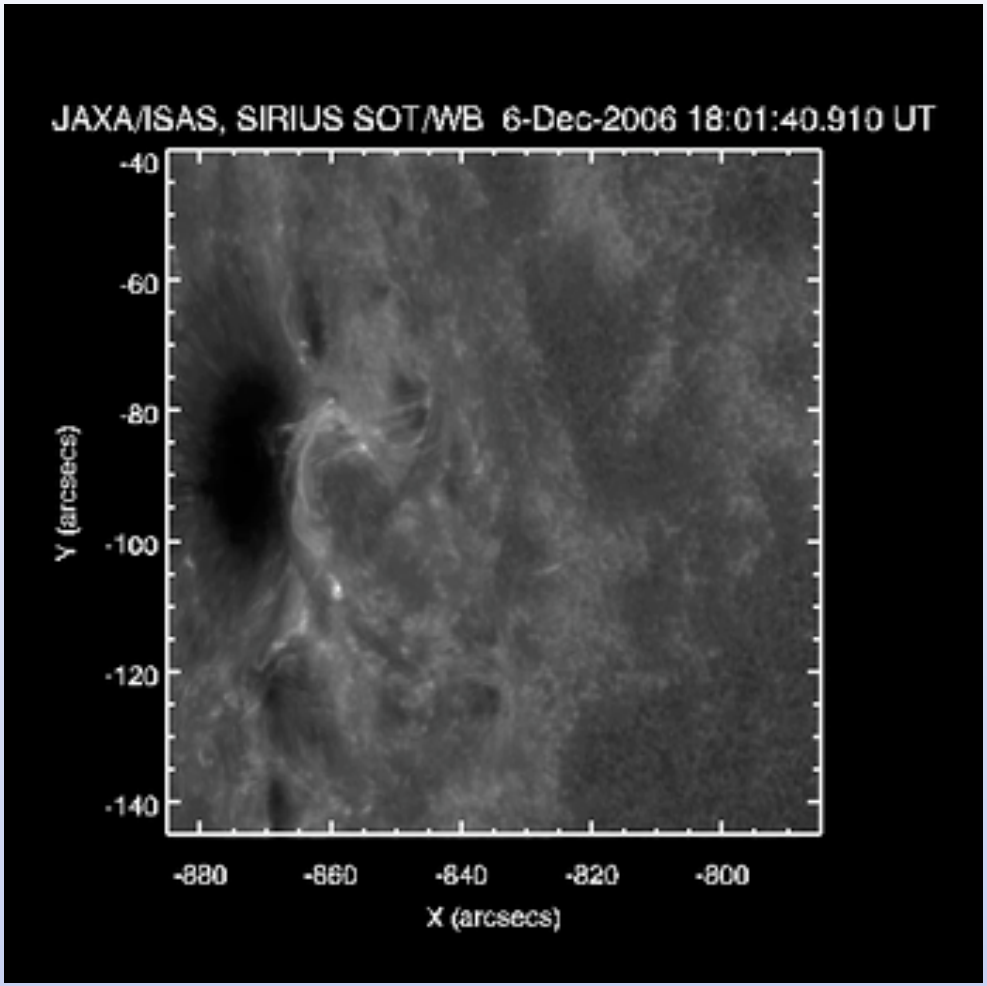
X-class: 4 flare → 3 events
M-class: 15 flare → 3 events
C-class: 136 flare → 3 events

White Light Flare Events

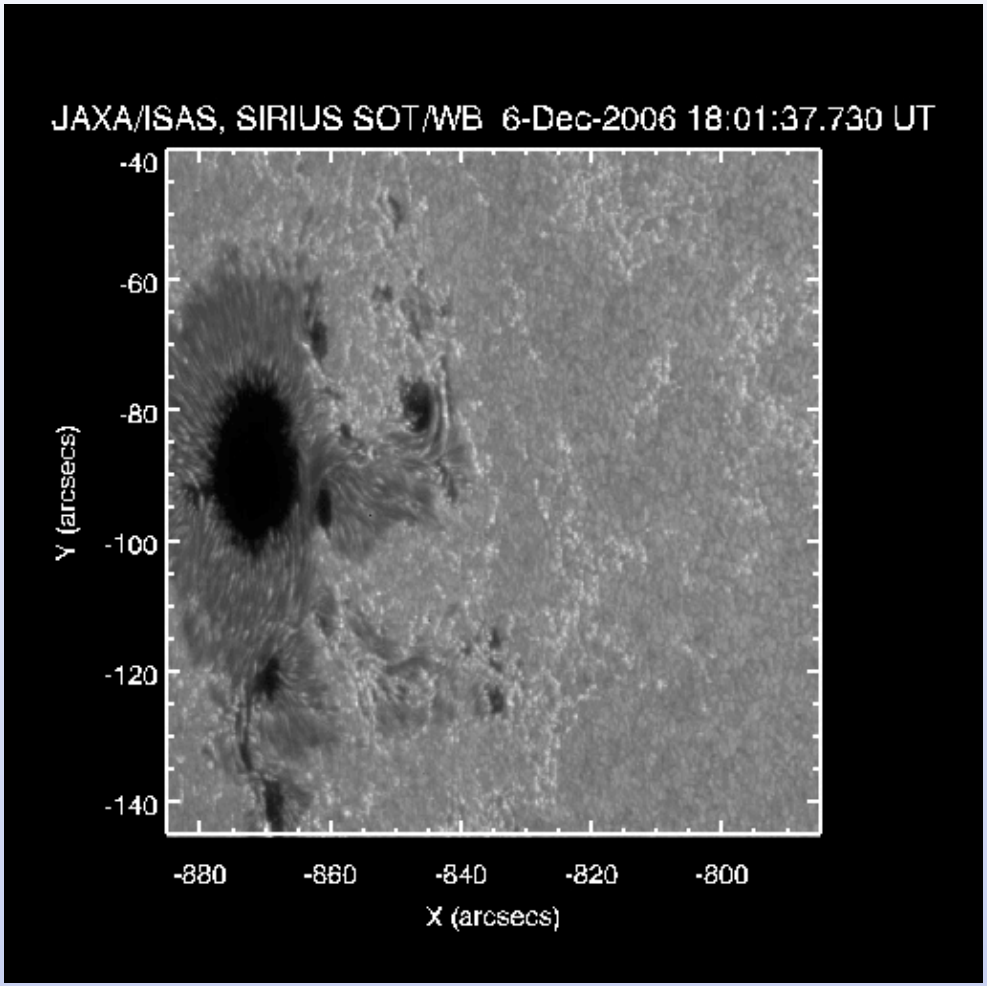
Date	Time [UT]	X-ray class	Sunspot loc.
2006/12/06	18:29	X6.5	S05 E64
2006/12/13	02:14	X3.4	S06 W23
2006/12/14	21:07	X1.5	S06 W46
2007/06/02	10:28	M1.0	---
2007/06/03	06:36	M4.5	S06 E63
2007/06/04	05:06	M8.9	S07 E51
2007/07/10	03:29	C4.4	S07 E53
2007/07/10	12:35	C8.2	S04 E47
2007/07/10	17:48	C5.2	S07 E45

White Light Flare Event
2006/12/06 X6.5 flare (AR10930)

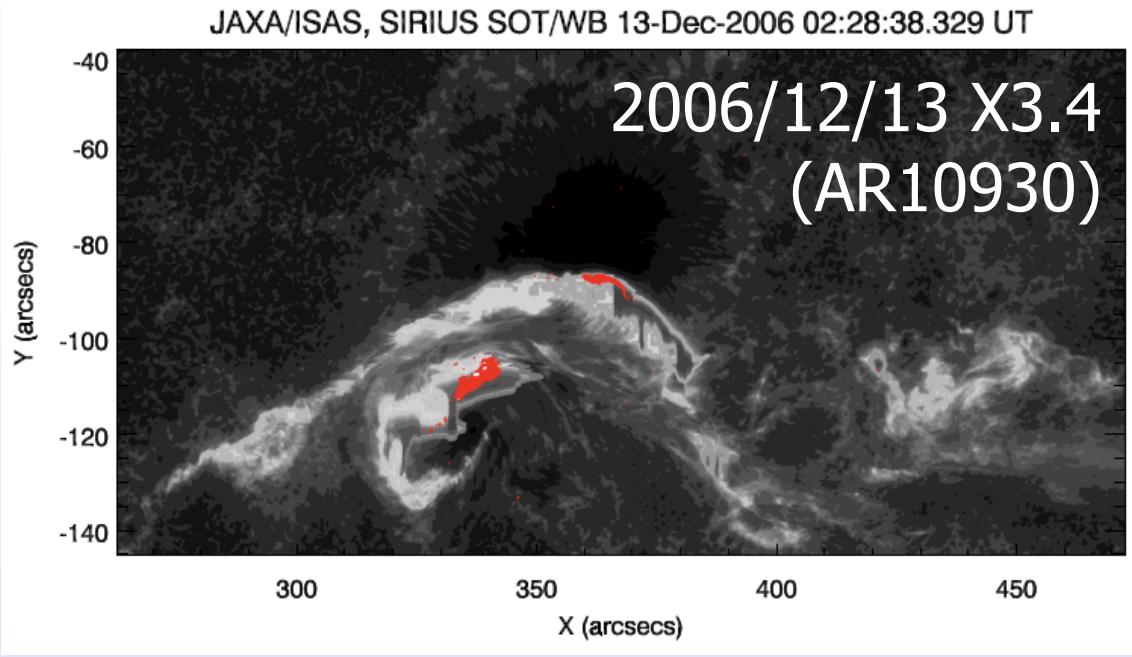
Ca II H

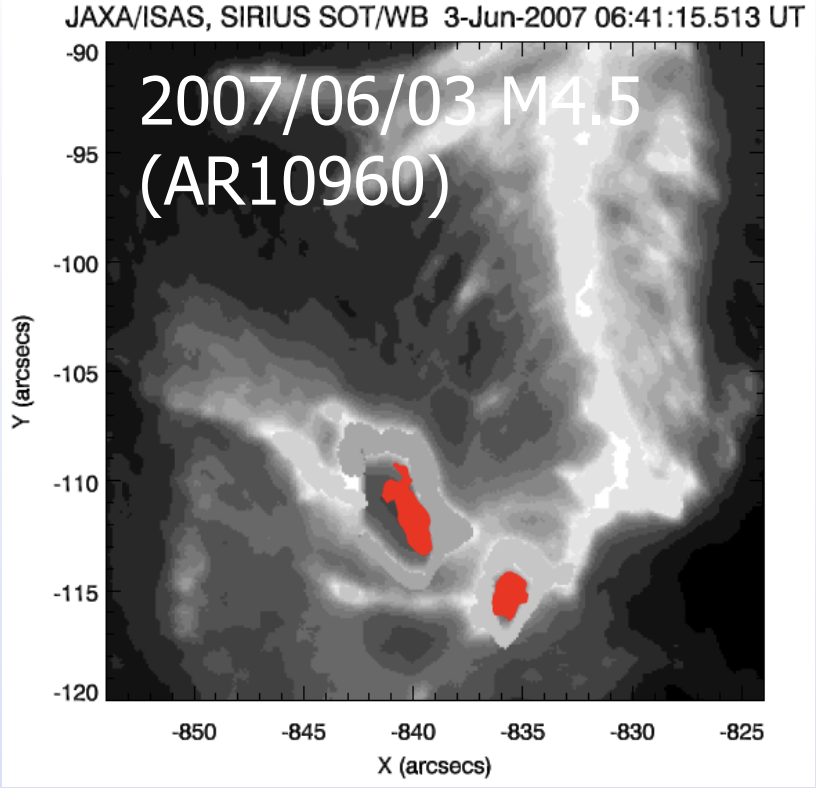


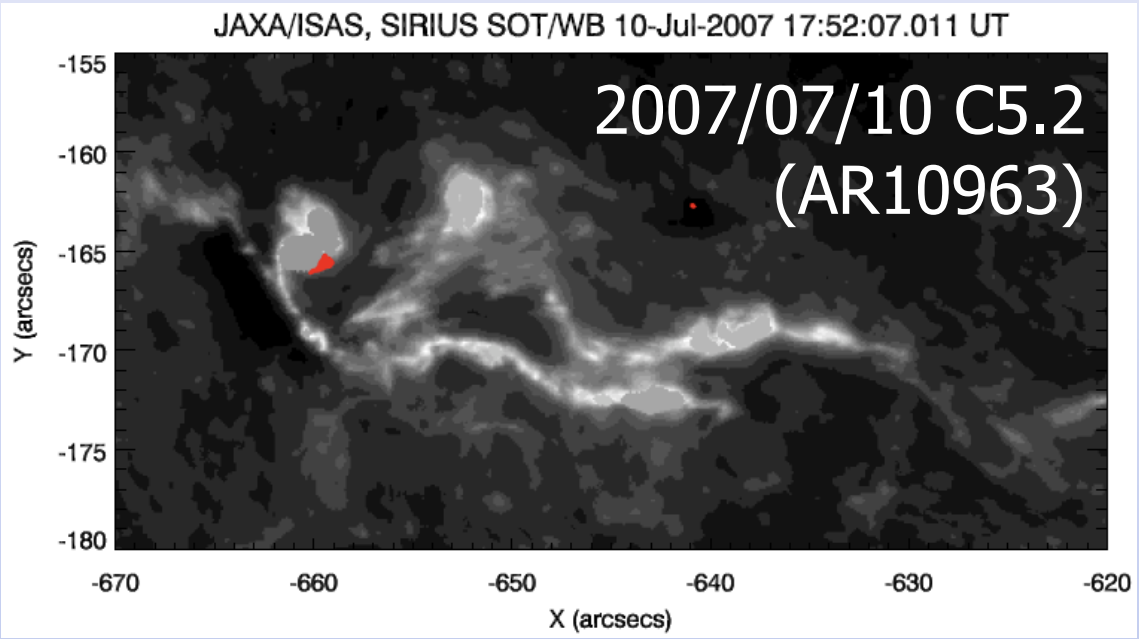
G-band



White Light Flare Events

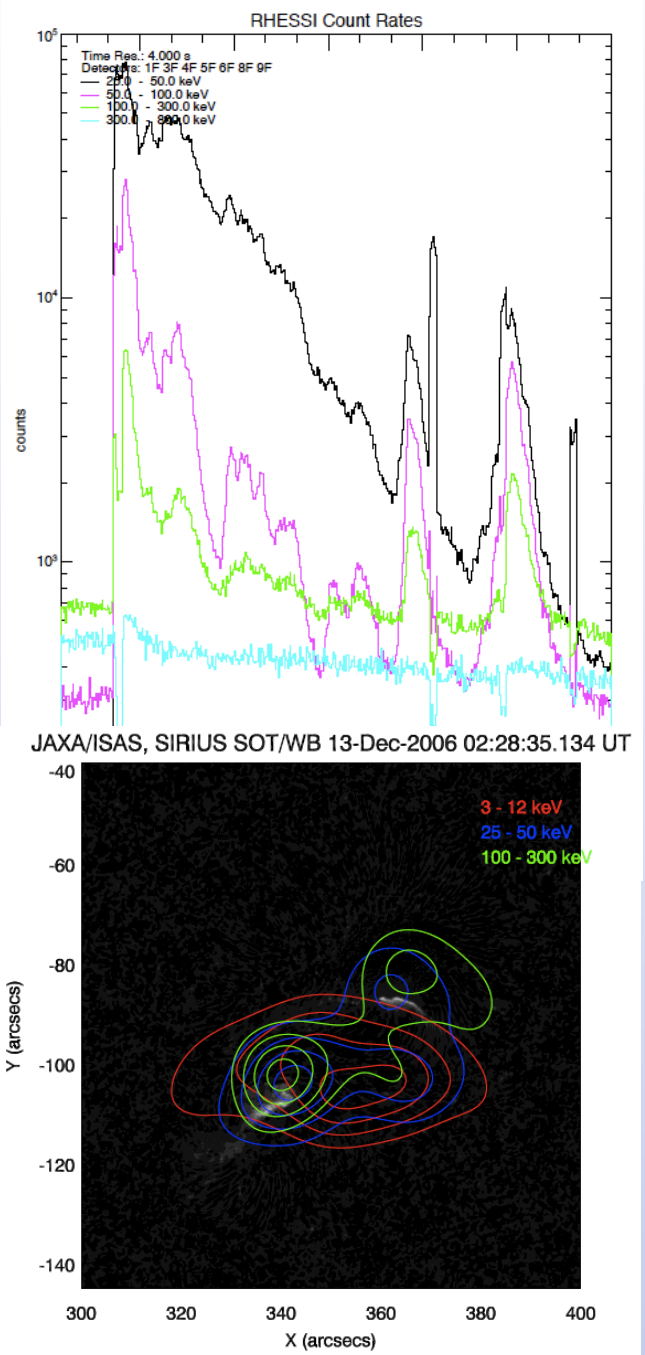


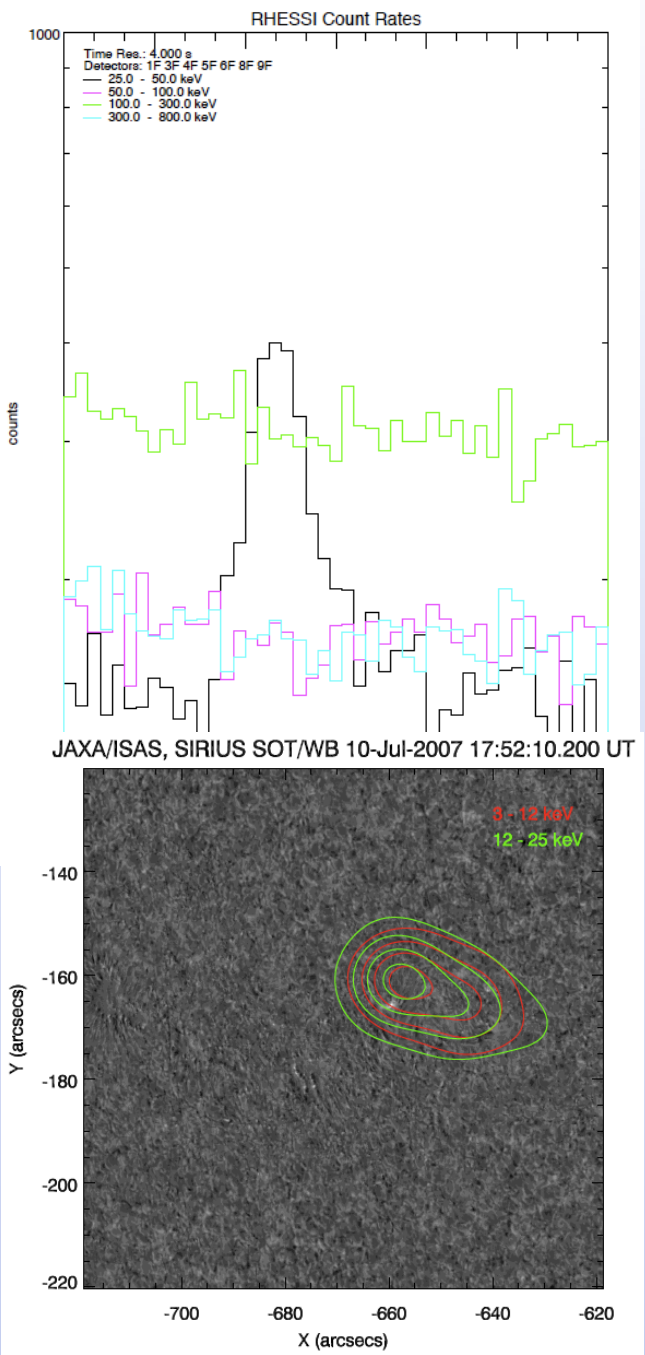




G-band emission were seen in the strongest (saturated) region of Ca II H emission

Hard X-ray data by RHESSI





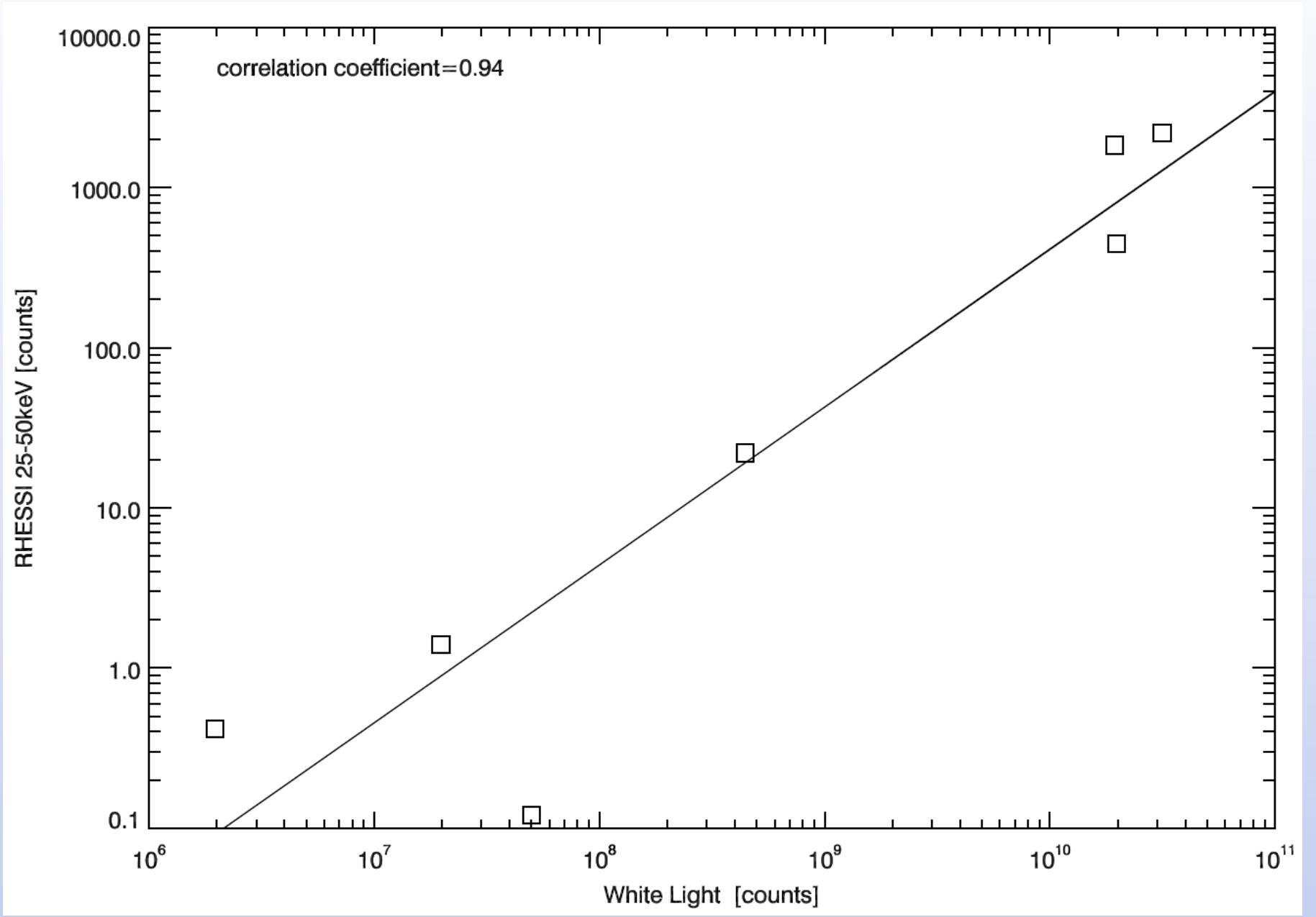
Hard X-ray emission (25-50keV) were observed from C-class flare

↓

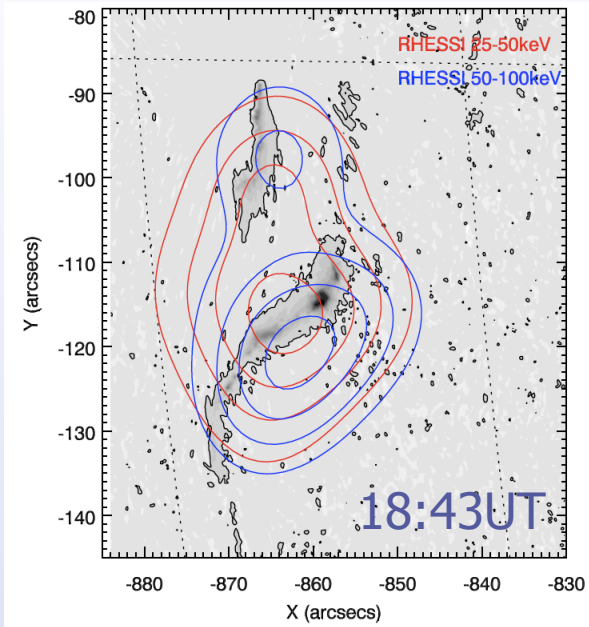
non-thermal electrons

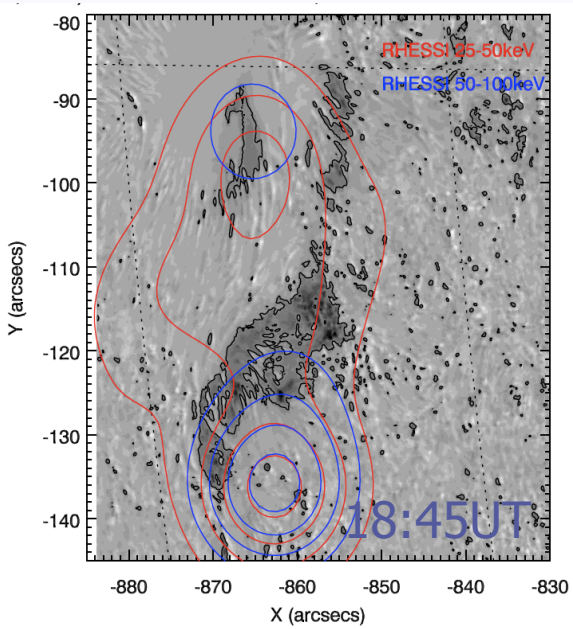
White light emission were seen at the same region of hard X-ray emission

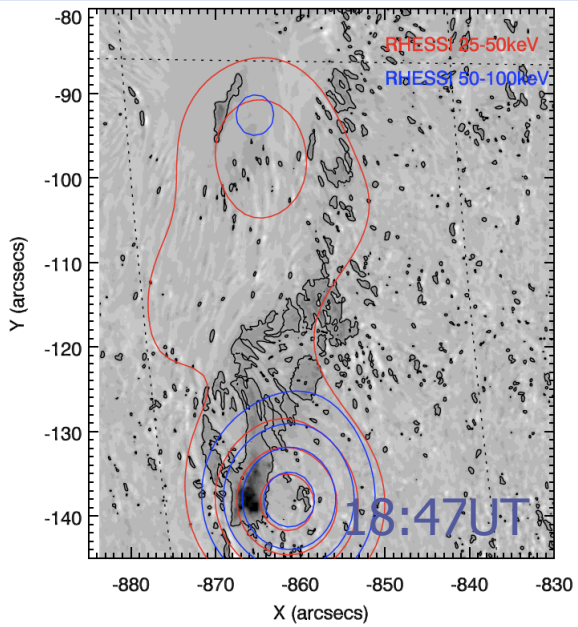
White Light vs HXR

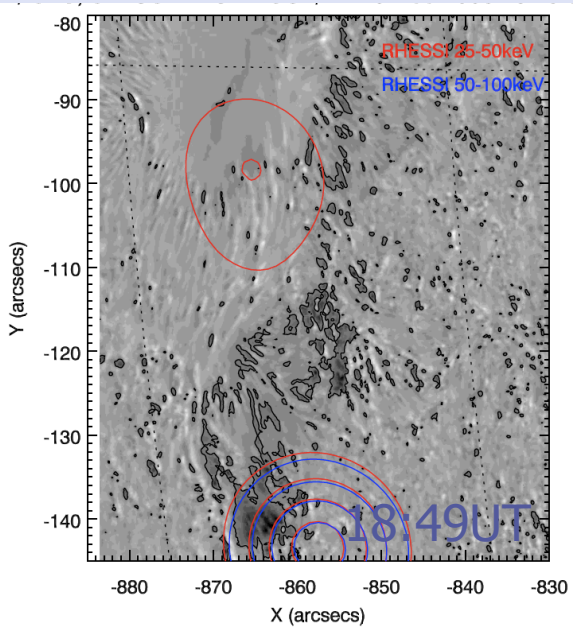


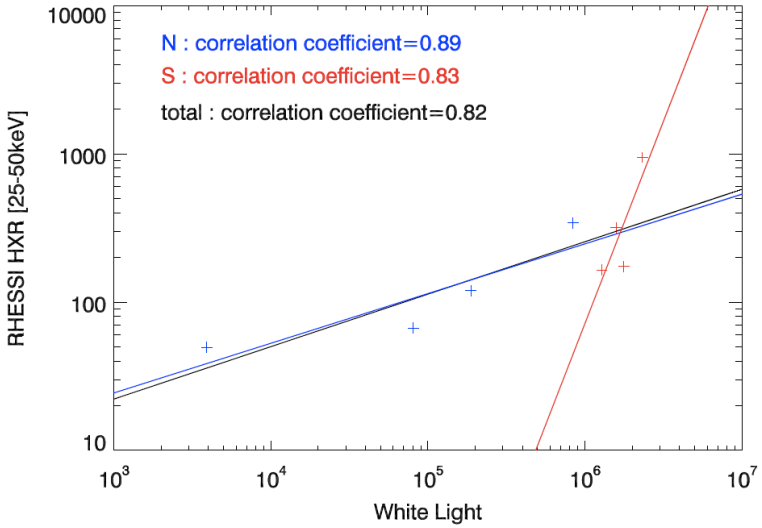
2006 Dec 6 X6.5 flare (AR10930)

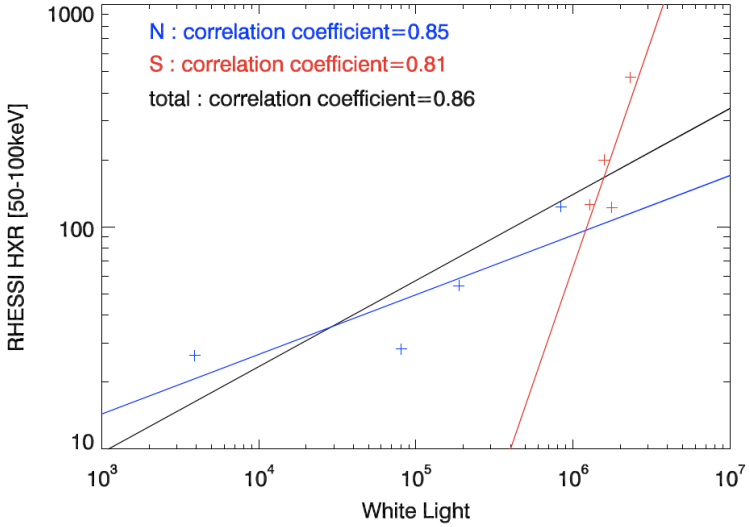






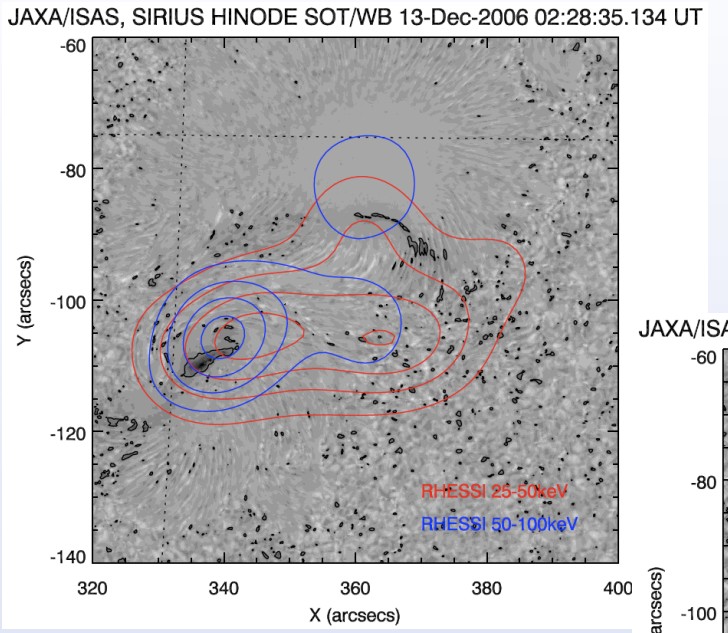




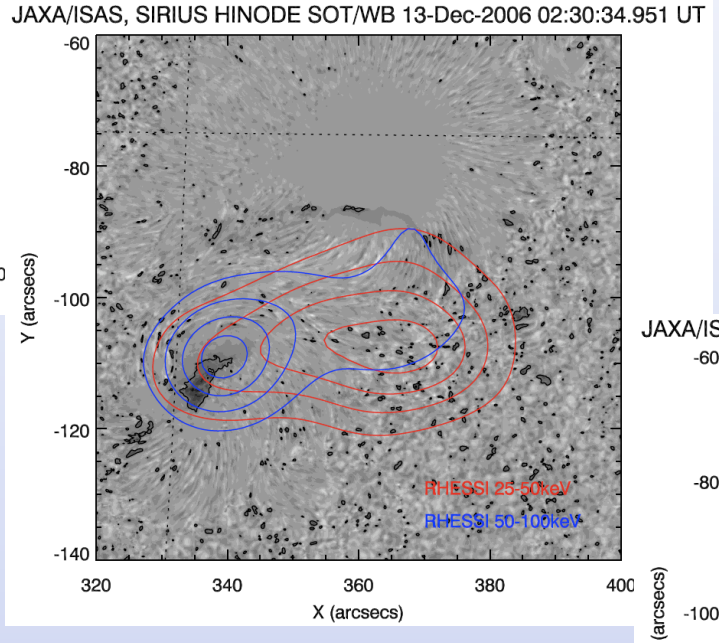


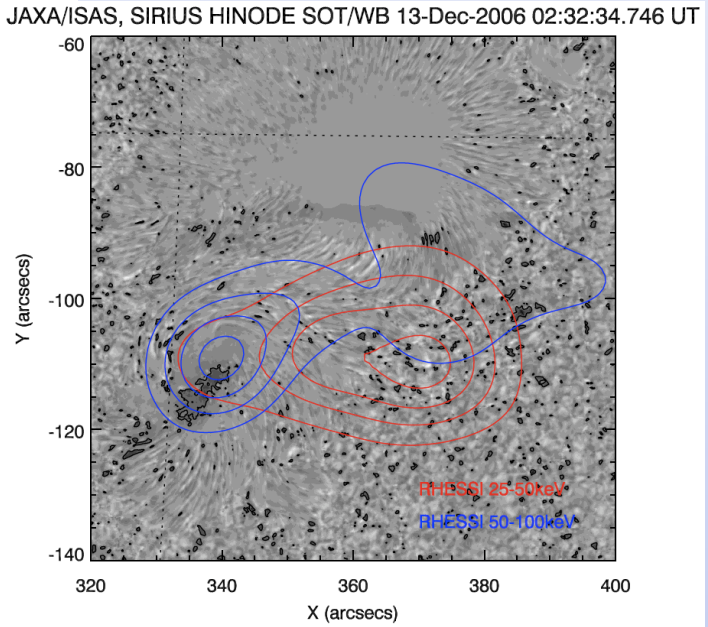
White Light: N < S
Hard X-ray (25-50keV): N < S
Hard X-ray (50-100keV): N < S

2006 Dec 13 X3.4 flare (AR10930)



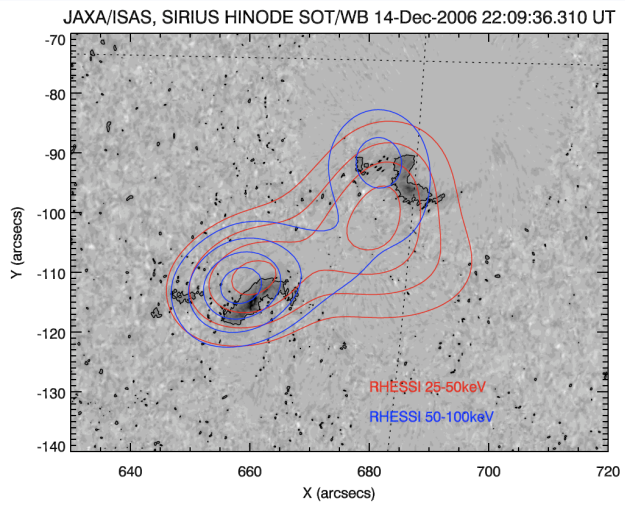
← White Light: E > W
Hard X-ray (25-50keV): E > W
Hard X-ray (50-100keV): E > W

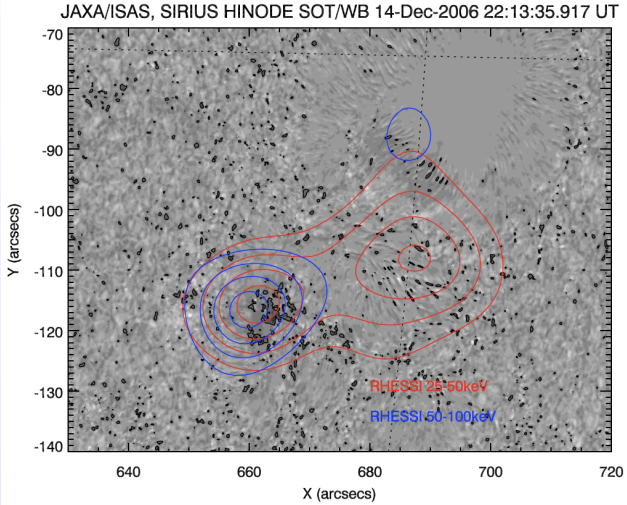


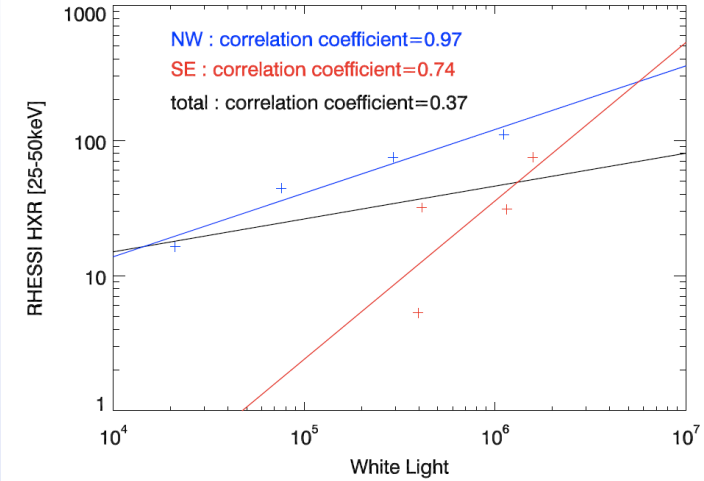


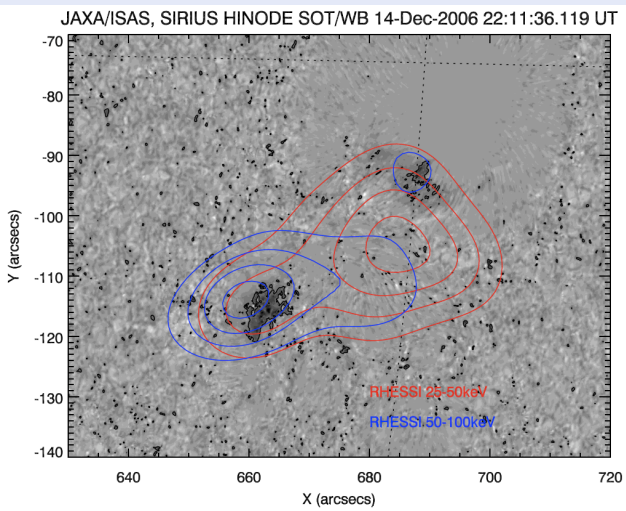
White Light: E > W
Hard X-ray (25-50keV): E < W
Hard X-ray (50-100keV): E > W

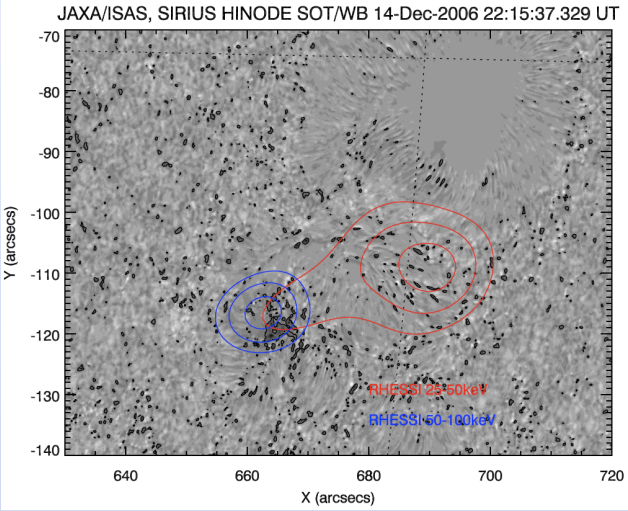
2006 Dec 14 X1.5 flare (AR10930)

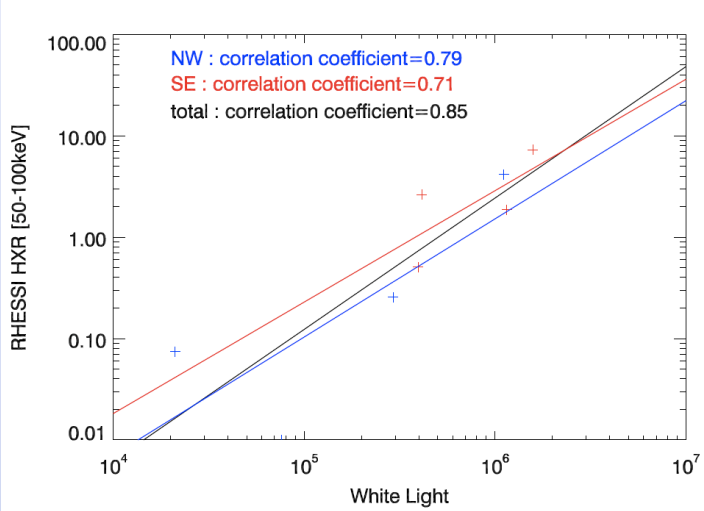












White Light: SE > NW
Hard X-ray (25-50keV): SE < NW
Hard X-ray (50-100keV): SE > NW

Discussion

- White light emission is related to non-thermal electrons especially accelerated electrons more than 50keV
  → these have to originate in same source

- G-band emission is coming from photosphere
  → 50-100 keV electron cannot reach to the photosphere through the chromosphere

- Hard X-ray emission in 50-100keV coming from chromosphere