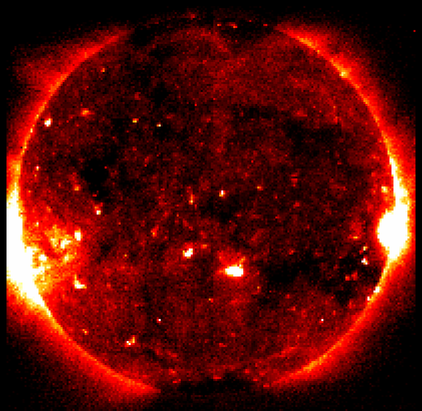
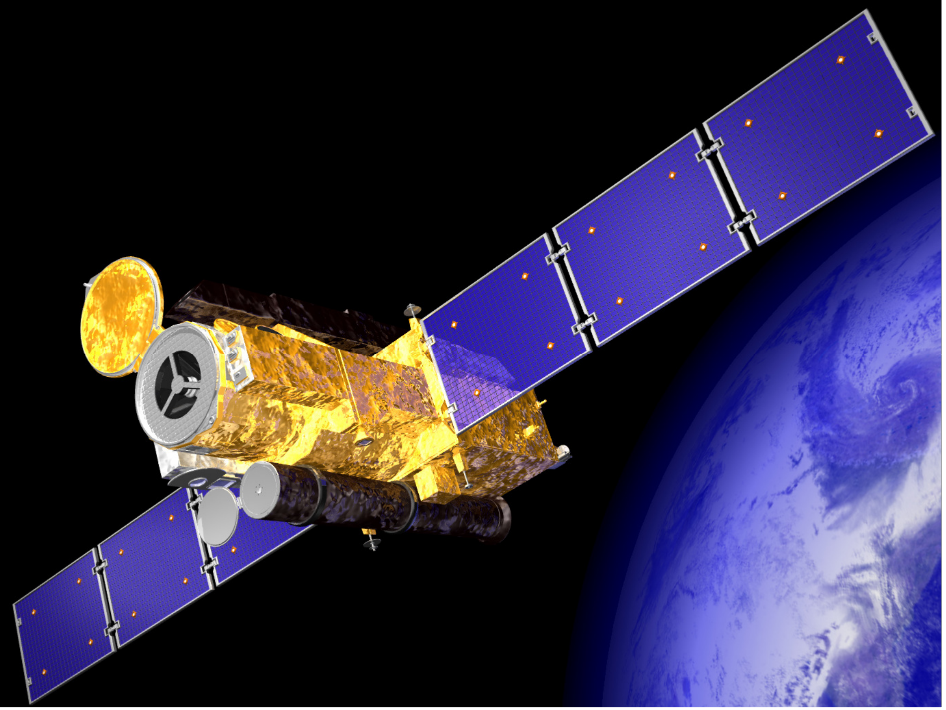
Multiplicity of Solar X-Ray Corona in Time and Space

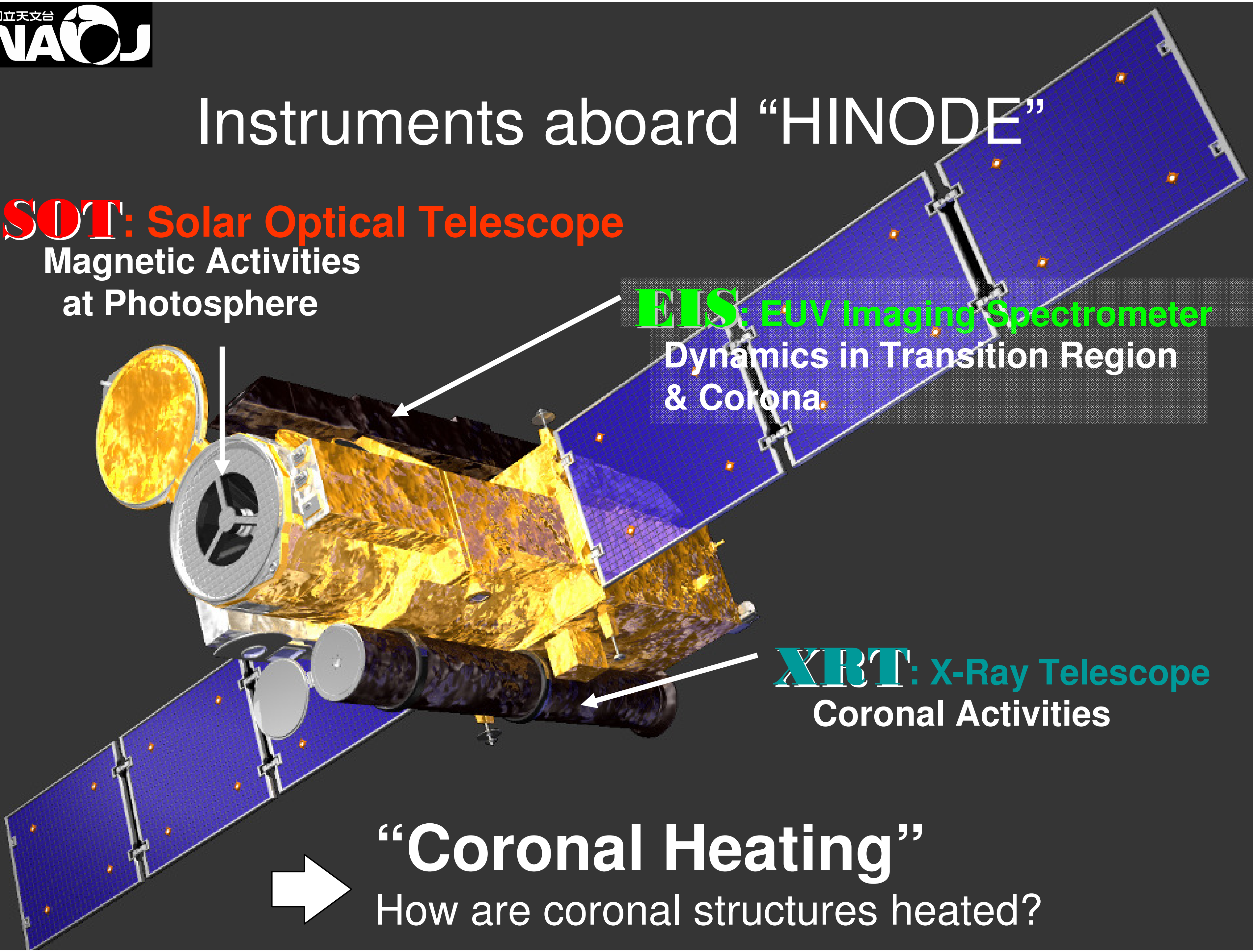
--- initial views by “HINODE” **XRT** ---

R. Kano, H. Hara (NAOJ), and the **XRT** team





Instruments aboard “HINODE”



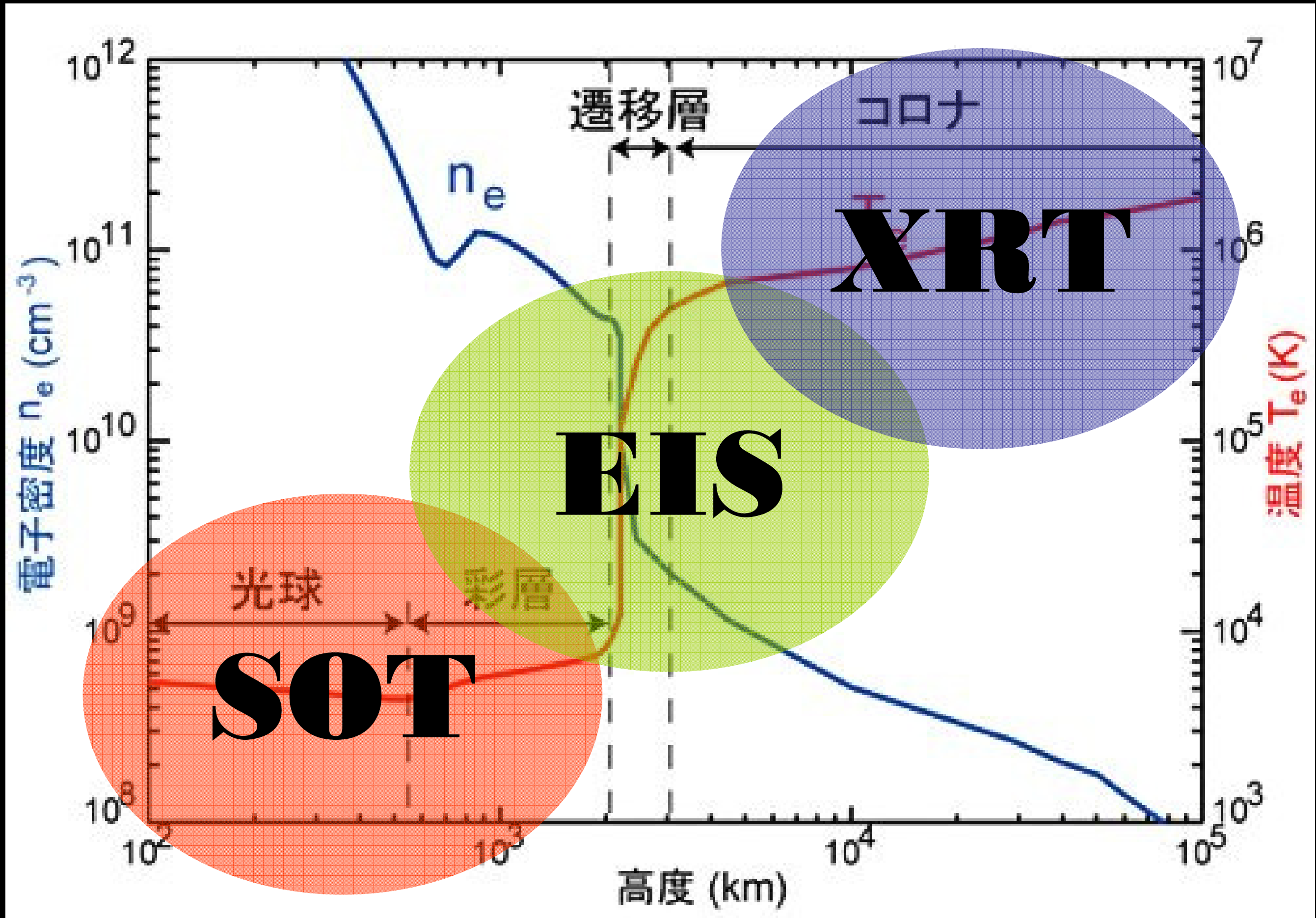
SOT: Solar Optical Telescope
Magnetic Activities
at Photosphere

EIS: EUV Imaging Spectrometer
Dynamics in Transition Region
& Corona

XRT: X-Ray Telescope
Coronal Activities

“Coronal Heating”
How are coronal structures heated?

Solar Atmosphere and Target for Each Instruments



Targets of XRT Observations

- **Photosphere/Corona Coupling**
  - Can a direct connection be established between coronal and photospheric events?
- **Coronal Heating**
  - How do coronal structures brighten?

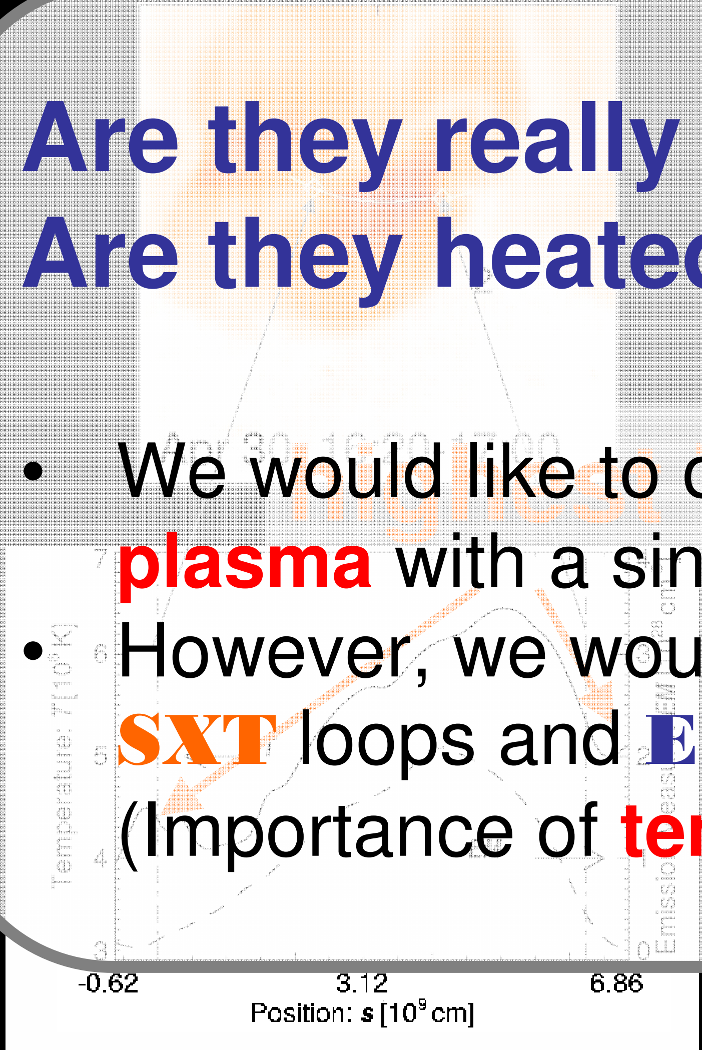
Coronal Loop Structures
&
Coronal Loop Heating

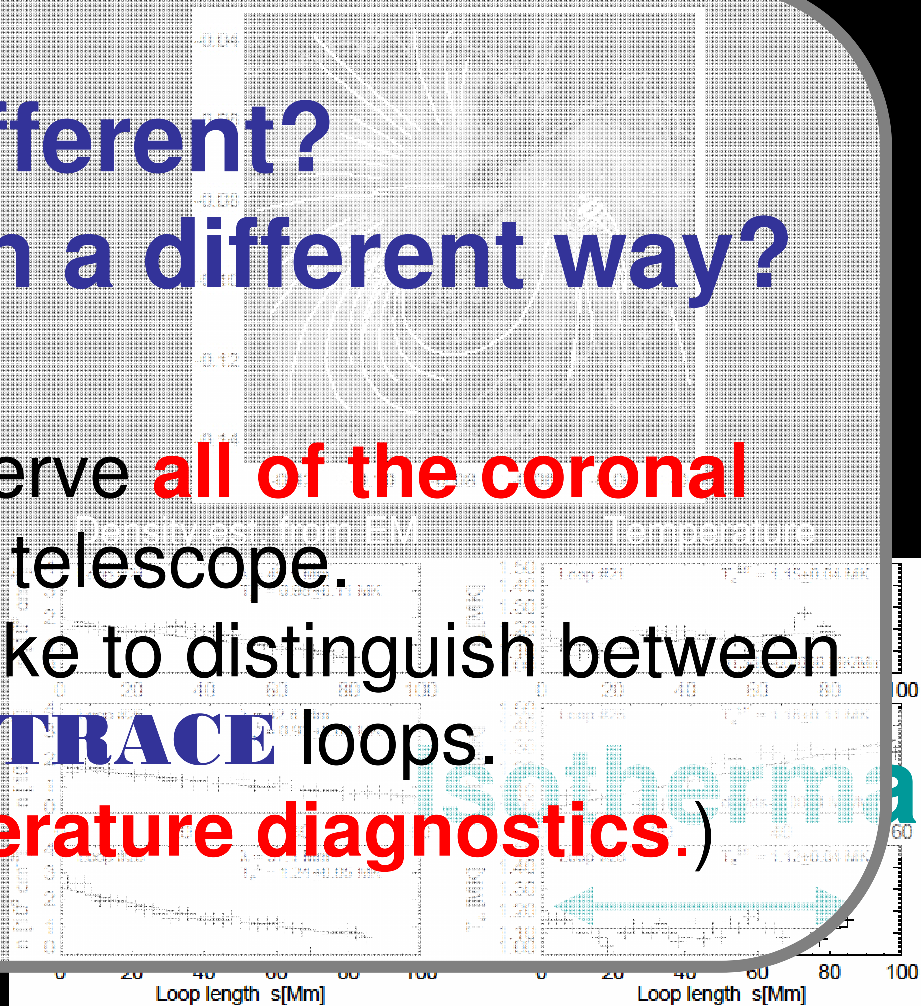
- **Flare Energetics**
  - What are the relations to the photospheric magnetic fields?
- **CMEs, Jets and other coronal dynamical events**

SXT Loops vs. EIT/TRACE Loops

SXT loops in active regions

EIT Image





Are they really different?
Are they heated in a different way?

- We would like to observe **all of the coronal plasma** with a single telescope.
- However, we would like to distinguish between **SXT** loops and **EIT/TRACE** loops. (Importance of **temperature diagnostics**.)

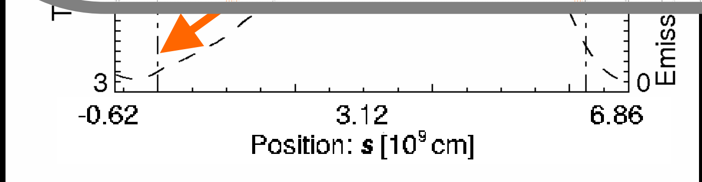
Kano & Tsuneta (1996, PASJ)

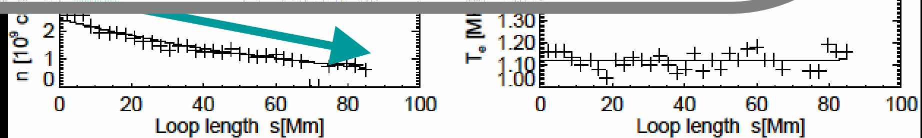
Aschwanden et al. (1999 &2000, ApJ)

SXT Loops vs. EIT/TRACE Loops

Do SXT loops have a dense plasma at the top?
Is it an apparent feature in a loop (by change of filling factor)?

- **EIS** can derive **the coronal density** with density-sensitive line pairs.
(Importance of the **coordinated observation** between **EIS** and **XRT**.)





Kano & Tsuneta (1996, PASJ)

Aschwanden et al. (1999 &2000, ApJ)

HINODE/**XRT** vs. Yohkoh/**SXT**

	HINODE/**XRT**	Yohkoh/**SXT**
Type of Optics	Grazing Incidence	Grazing Incidence
FOV	34 arcmin	42 arcmin
Pixel Size	**1 arcsec**	2.5 arcsec
PSF FWHM	**<1 arcsec** @ center	~ 3 arcsec
Bandpass	3 ~ 200Å	3 ~ 45Å
Temp. Coverage	**1MK** ~ 30MK	3MK ~ 30MK
Time Cadence		
Full Frame, Full-res.	min 9.5sec	256sec (Half Frame)
Full Frame, Half-res.	min 5.0sec avg. 102sec	128sec
Partial Frame, Full-res. (FOV = 300”~400”)	min 2.0sec avg. 15sec	8 sec in flare mode 32 sec in Quiet mode
Other New Items	Pre-flare Buffer Focus Mechanism	----

XRT characteristics

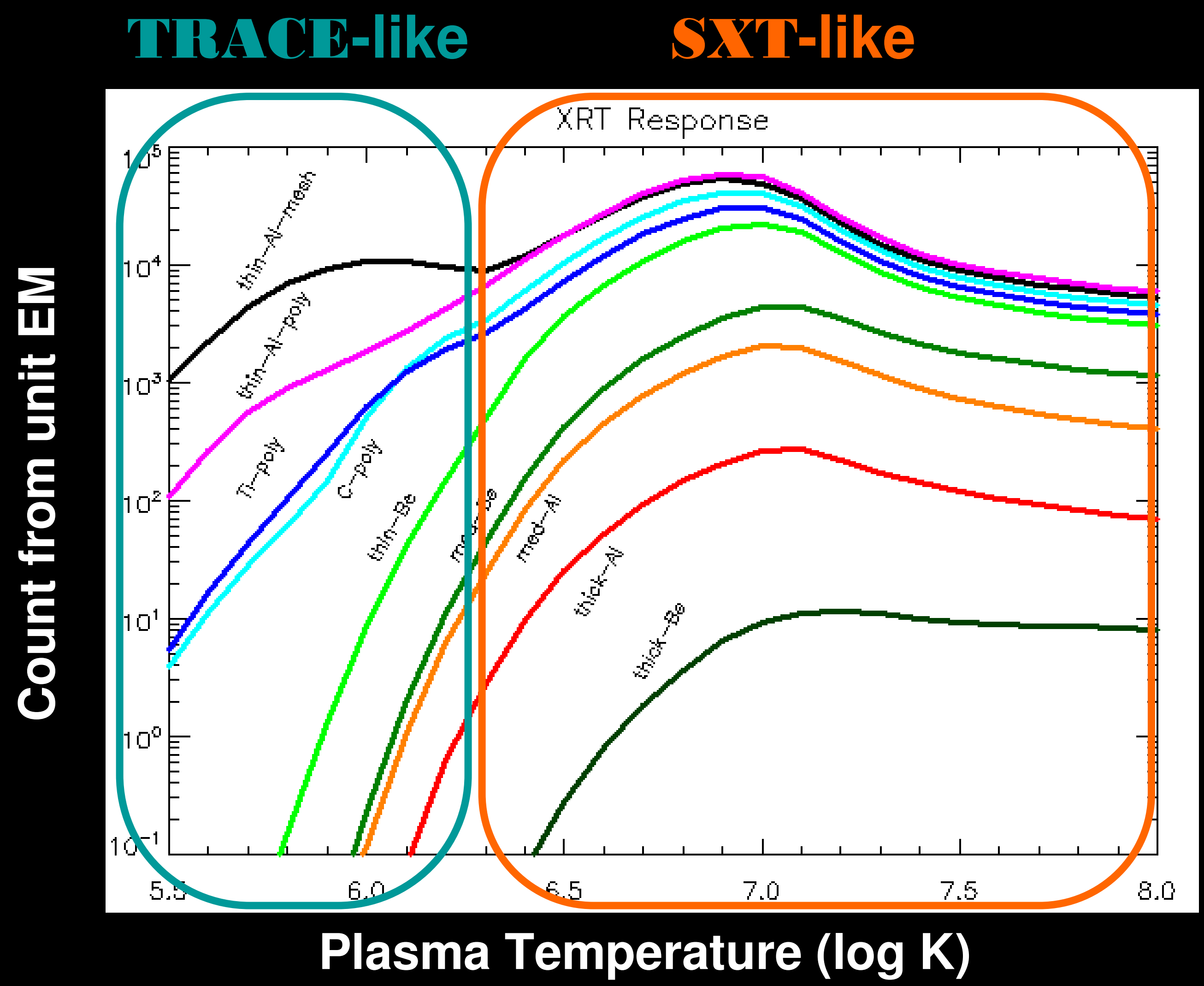
- **Temperature Response**
  - TRACE-like image and SXT-like image
- **Field-of-View and Spatial Resolution**
  - Focus Mechanism
- **Observation control by MDP**
  - Table Observation
  - Image Compression
  - Time Cadences
  - Preflare Buffer

X-ray Analysis Filters

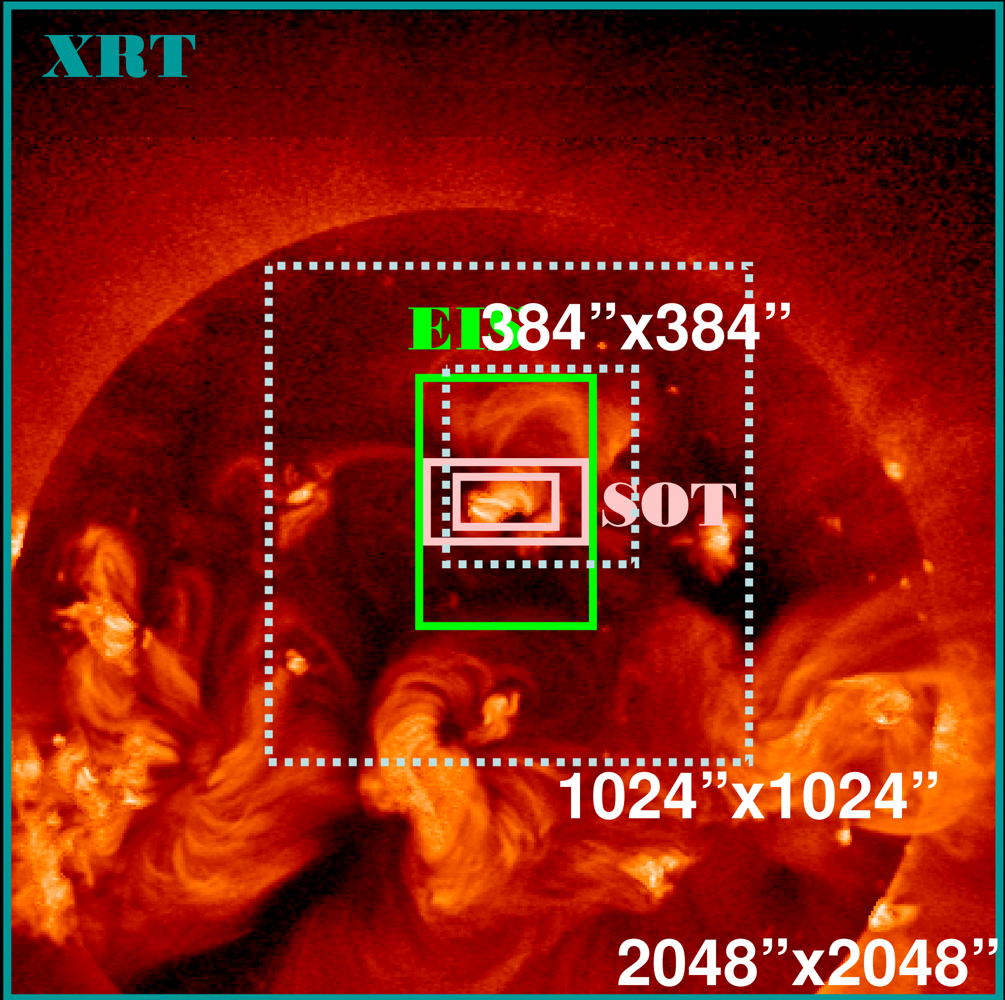
- XRT has 9 X-ray analysis filters and a G-Band filter.

Name	Metal	Metal Thickness	Substrate	Substrate Thickness
Thin-Al/Mesh	Al	1600 Å	Mesh	
Thin-Al/Poly	Al	1250 Å	Polyimide	2500 Å
C/Poly	C	6000 Å	Polyimide	2500 Å
Ti/Poly	Ti	3000 Å	Polyimide	2300 Å
Thin-Be	Be	9 µm	Mesh	
Med-Al	Al	12.5 µm		
Med-Be	Be	30 µm		
Thick-Al	Al	25 µm		
Thick-Be	Be	300 µm		

XRT Temperature Response

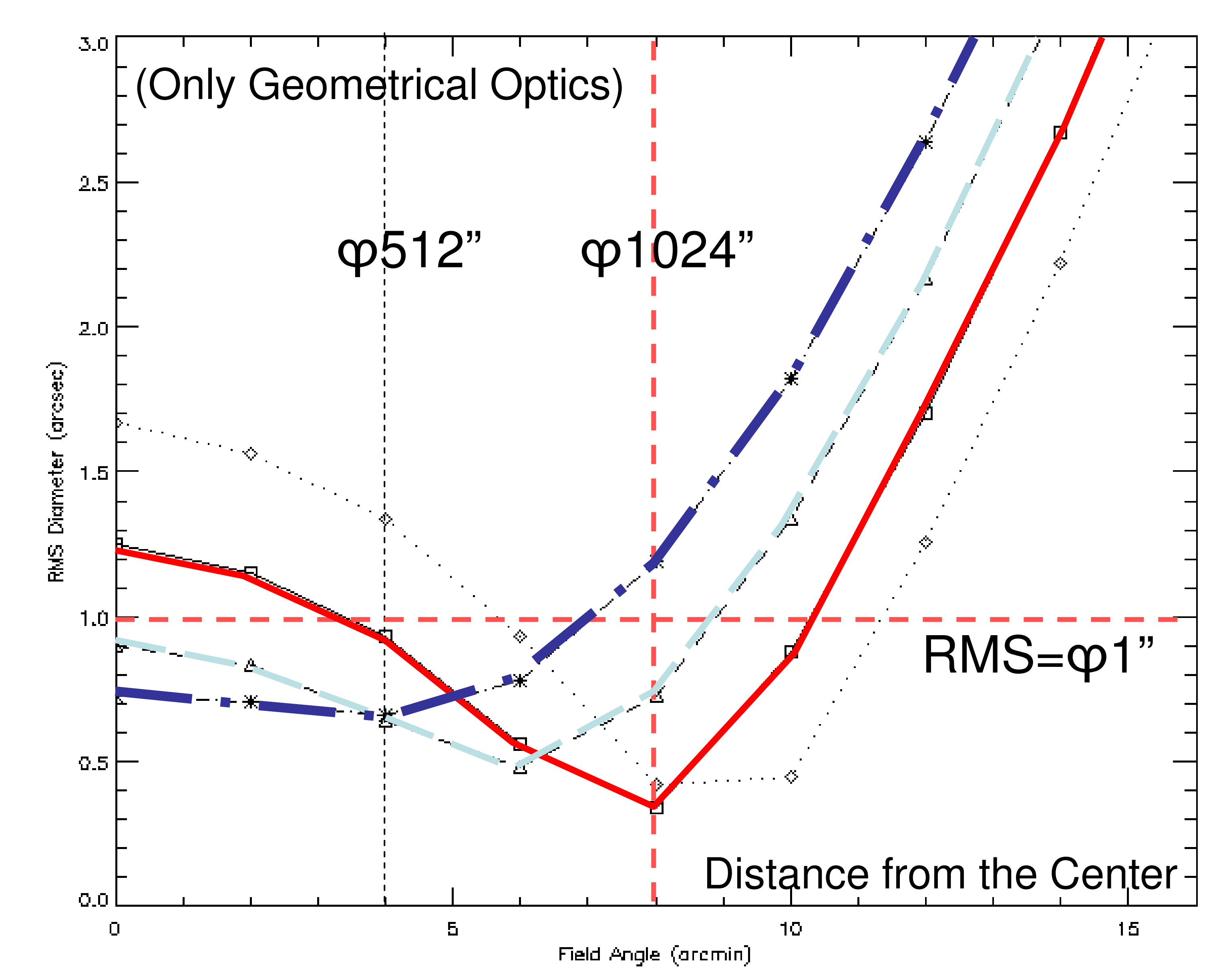


Field of View (FOV)

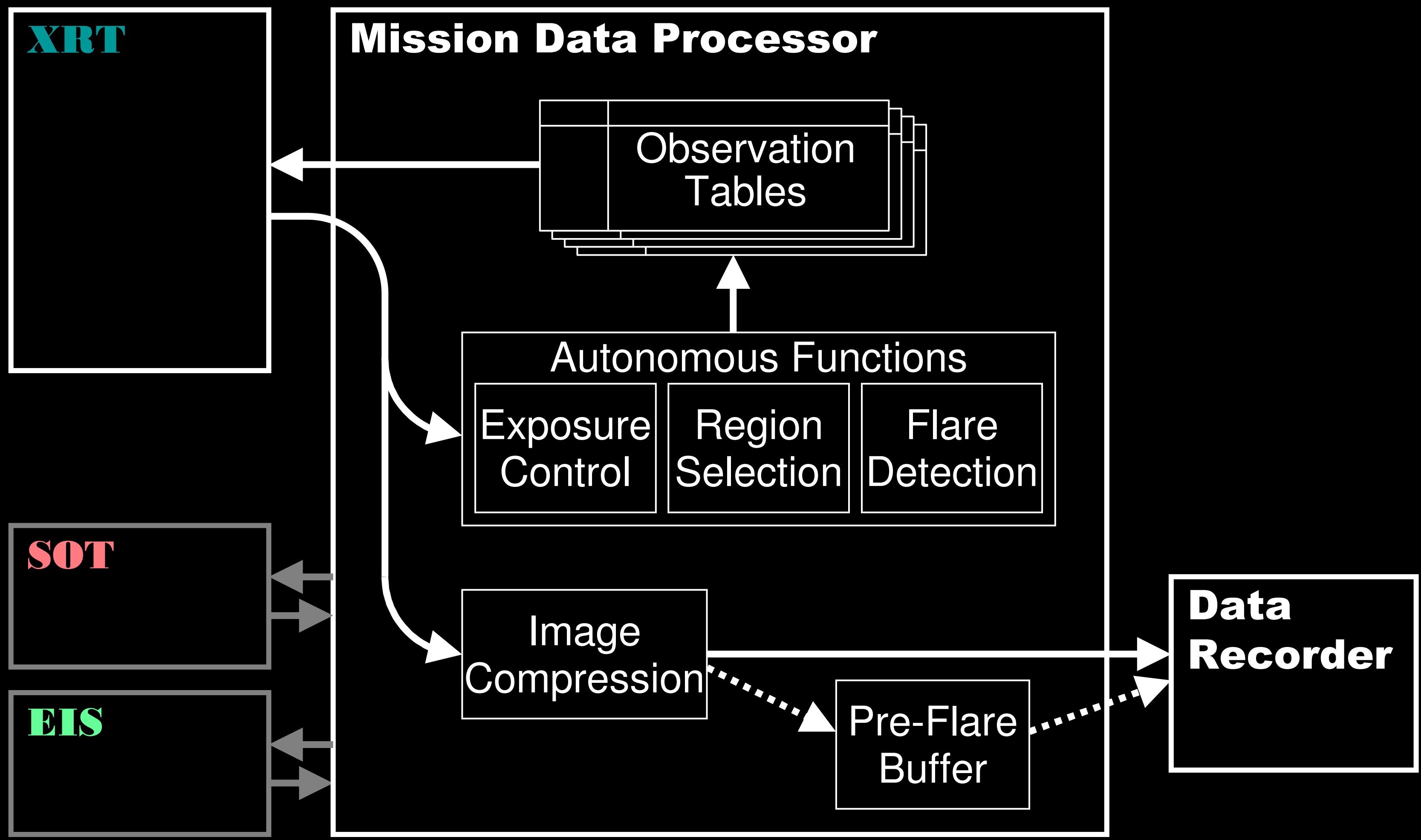


- To point **SOT** at a certain target on the solar disk, we have to change HINODE pointing. Therefore, **XRT** will not always observe the full solar disk.
- Many varieties of FOV size are available.
- Especially, for high-res.-observation, we recommend FOV= 1024"x1024" around CCD center.

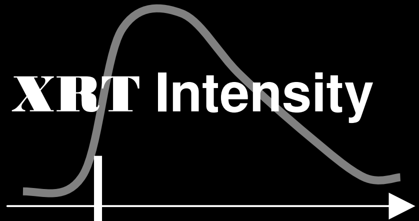
Aberration at Different Focus Pos.



Observation of XRT



Flare Observation



XRT
- Detect a flare.
- Report the location to all telescopes.

XRT
- Switch the current observation to Flare one.
- Lock the Pre-Flare Buffer.
- (There is an option not to switch to Flare observation.)

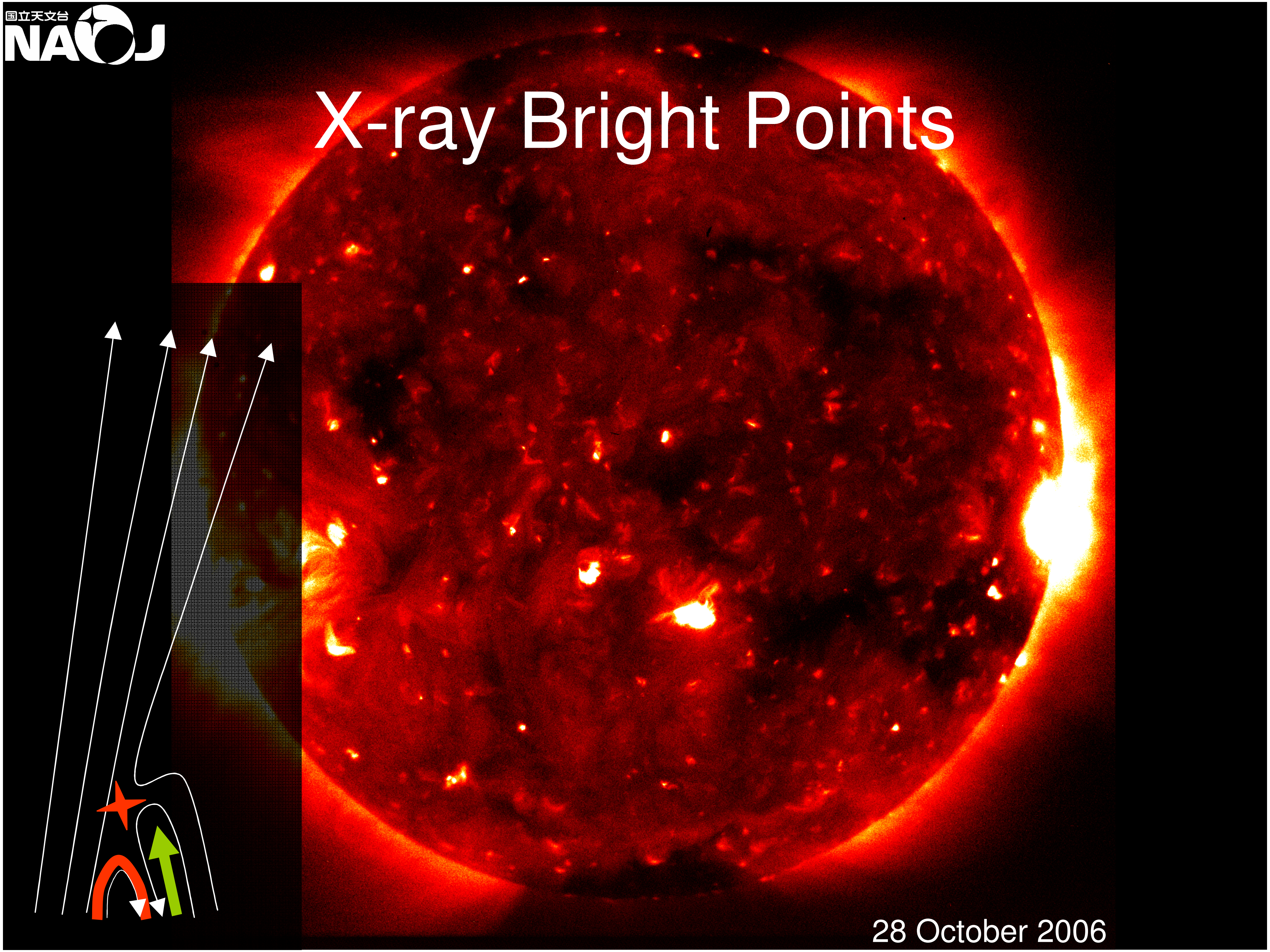
SOT
- Switch the current observation to Flare one, if the flare location is in **SOT**-FOV.
- (There is an option not to switch to Flare observation.)

EIS
- Switch the current observation to Flare one, if the flare location is in **EIS**-FOV.
- (There is an option not to switch to Flare observation.)

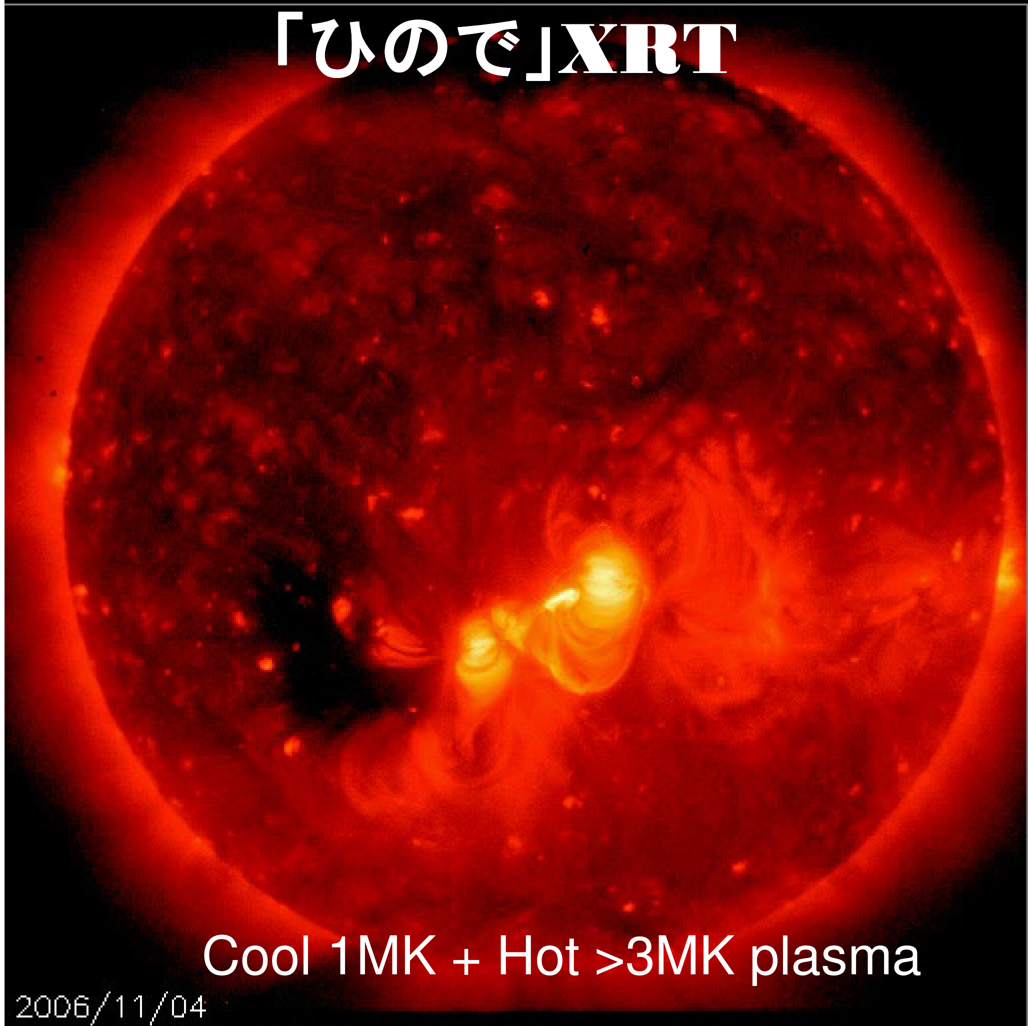
Solar Corona observed with X-Ray Telescope

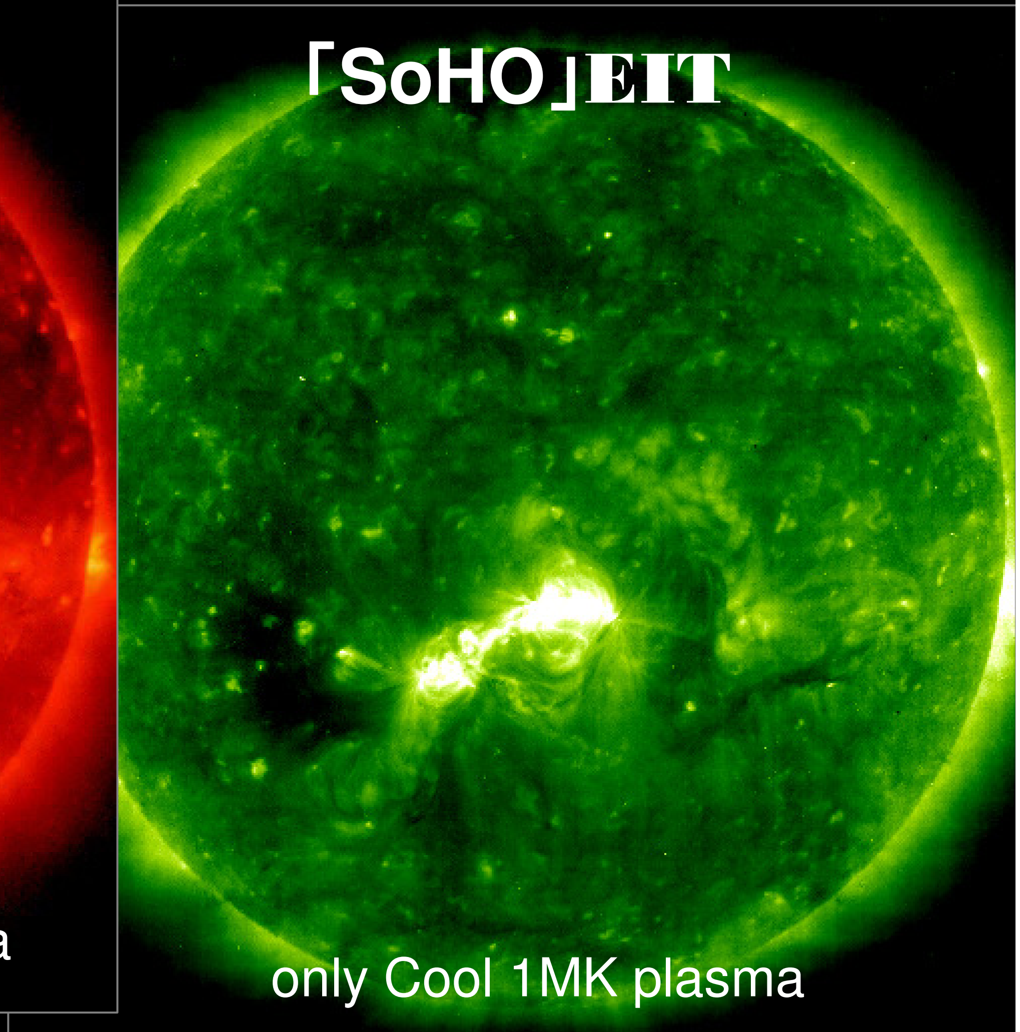
- Coronal Holes
  - X-ray Bright Points
- Quiet Sun
  - Formation of Arcade Structures associated with Filament Disappearance
  - Streamers
- Active Regions
  - Flares, Micro-flares
  - Jets, Coronal Mass Ejection
  - Thermal Structures for (quasi-Steady) Coronal Loops

X-ray Bright Points

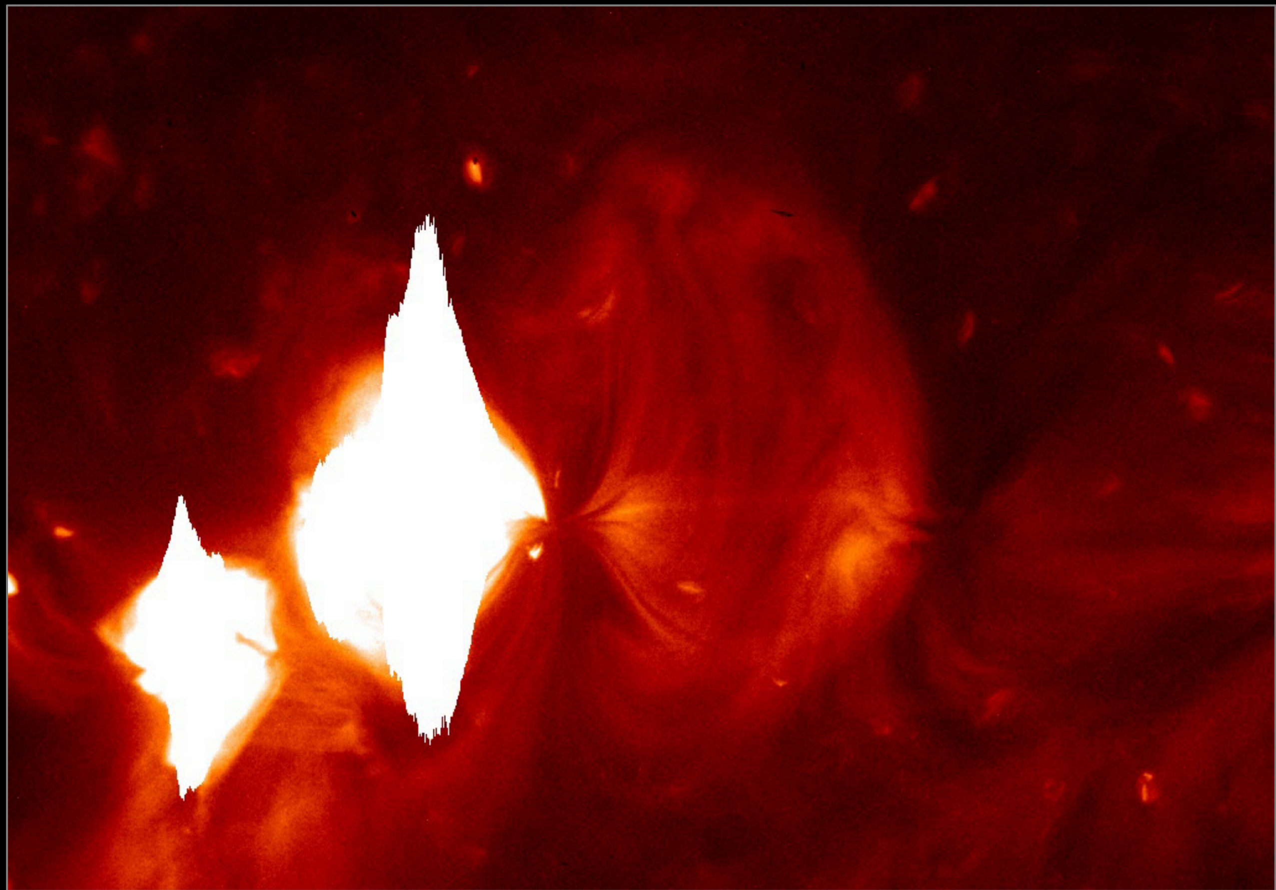


Global Structures

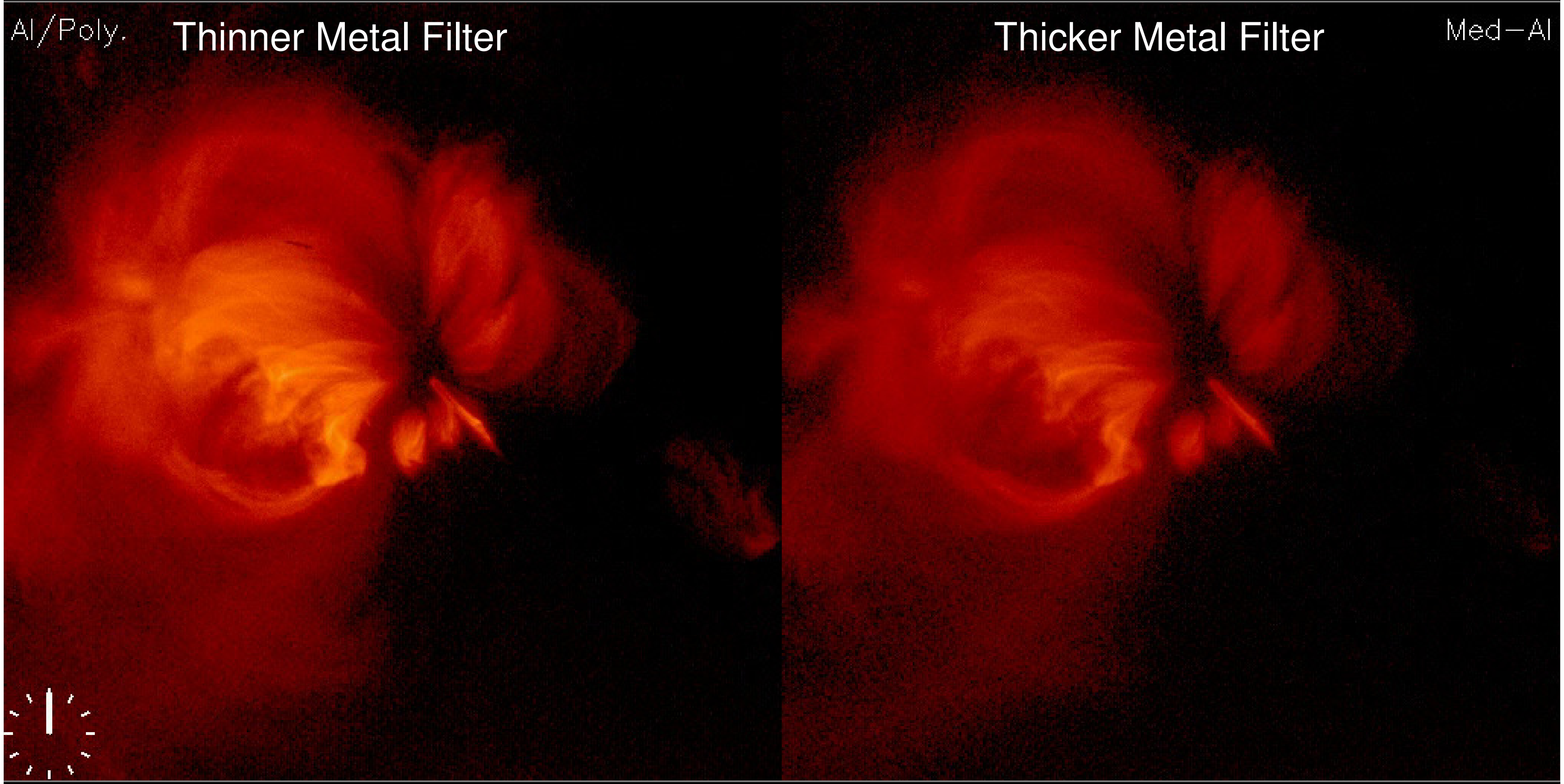




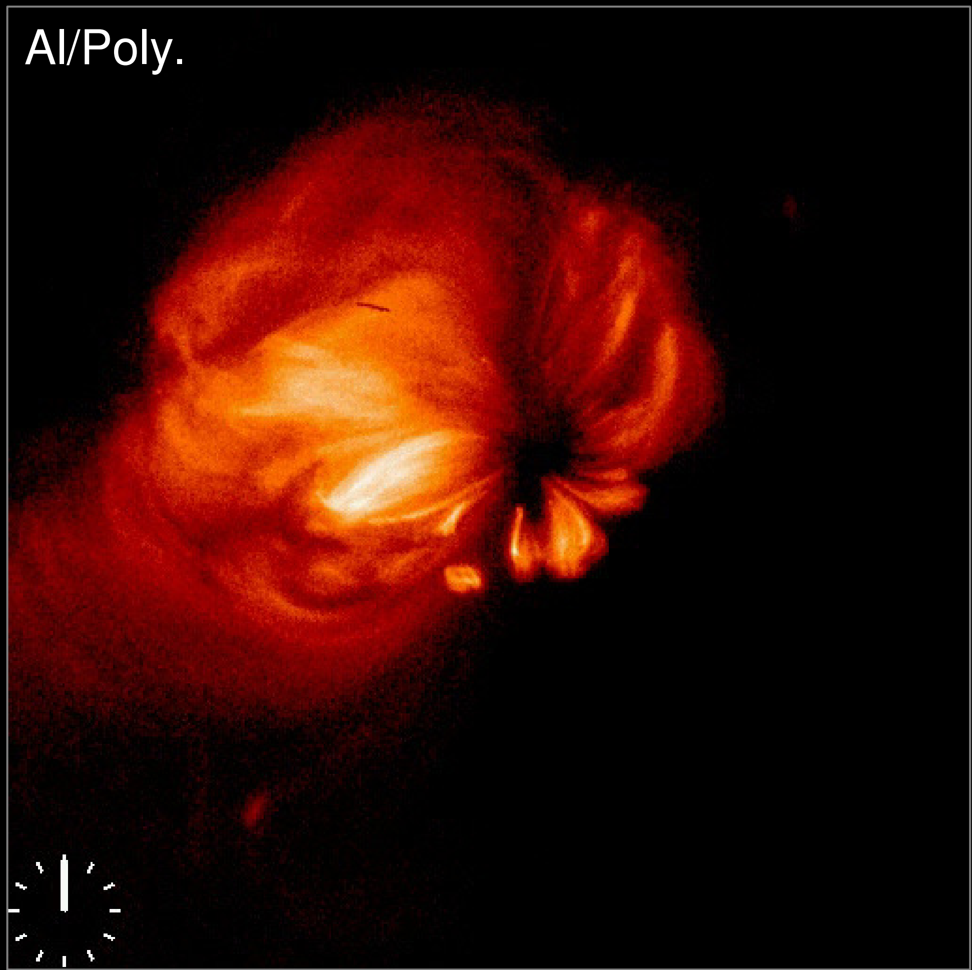
Coronal Loops



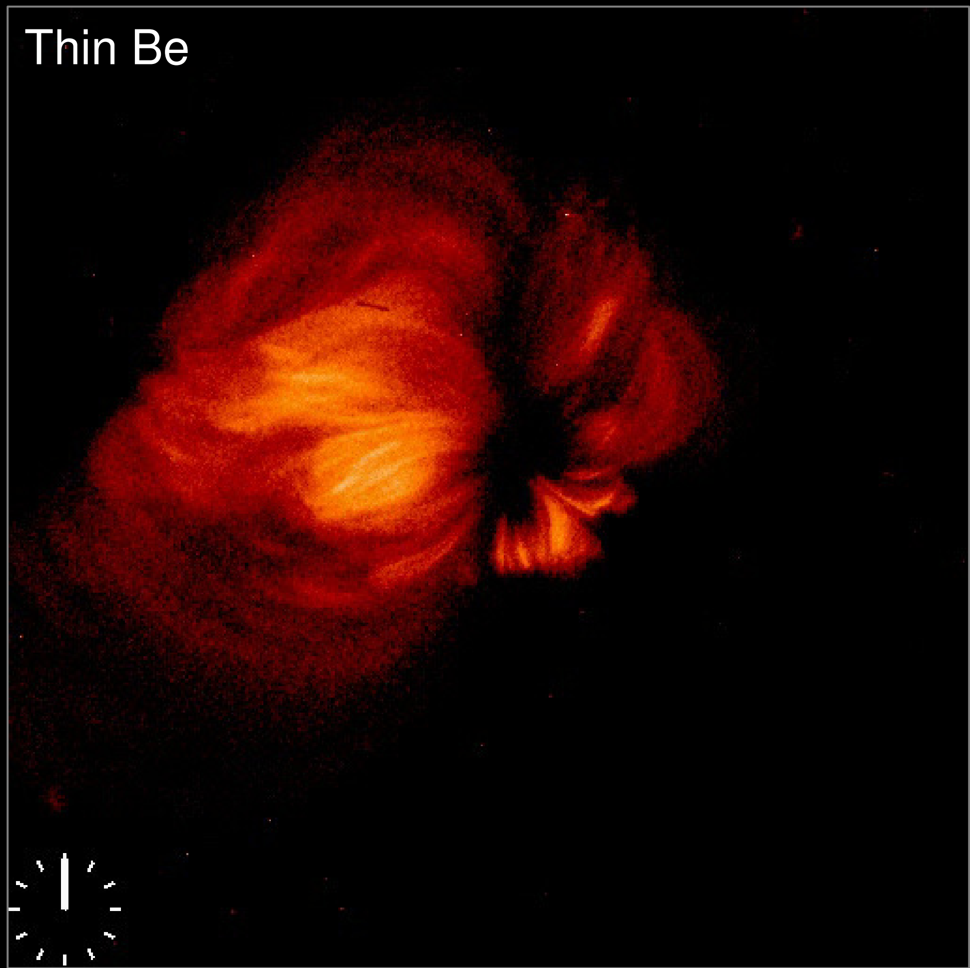
Flare



Micro Flares (1)



Micro Flares (2)



Summary

- **XRT** has high sensitivity for **low (1MK) temperature plasma**, as well as high temperature plasma.
- **XRT** has the highest spatial resolution as GI imager.

  Pixel Size = 1 arcsec
- **Observation Tables** respond to various observations.
- **Autonomous functions** support **XRT** automatic operation.
- Observers can select types of **Image Compression**
- **Built-in visible light optic** allows us to align **XRT** images with **SOT** images with sub-arcsec accuracy.