Coronal and photospheric signatures of solar activity during very quiet period

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Progress on EUV & X-ray spectroscopy and imaging II

November 17th – 19th, 2015, Wrocław, Poland

Outline

Introduction

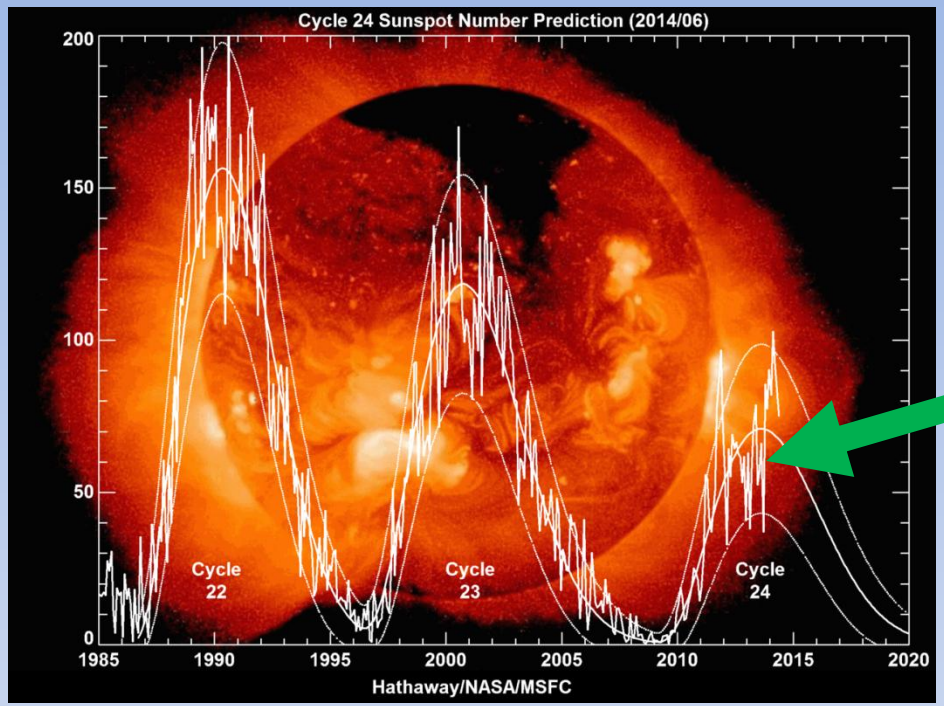
SphinX, Hinode & XRT

Data selection

Examples of common X-ray observations with SphinX and XRT in 2009

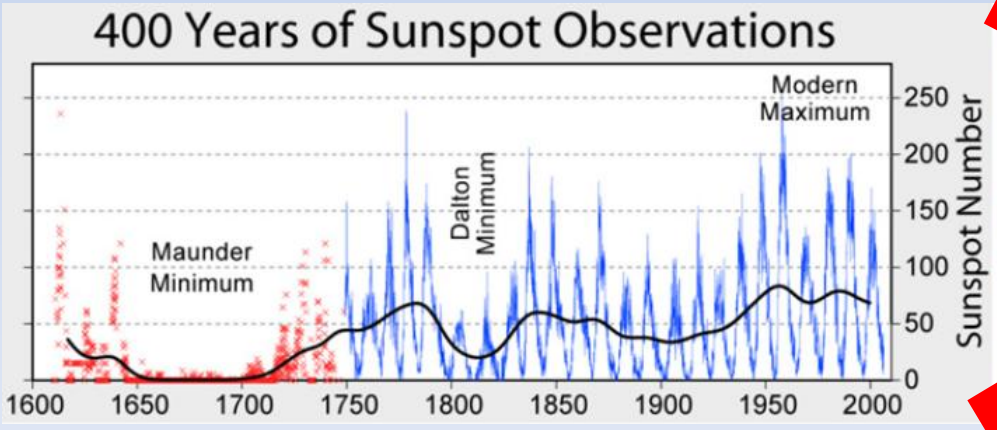
Conclusions

Analysis period - deep and prolonged minimum between cycles 23 and 24



Cycle 24 in progress

No another “Maunder Minimum” - sorry



Maybe next time.

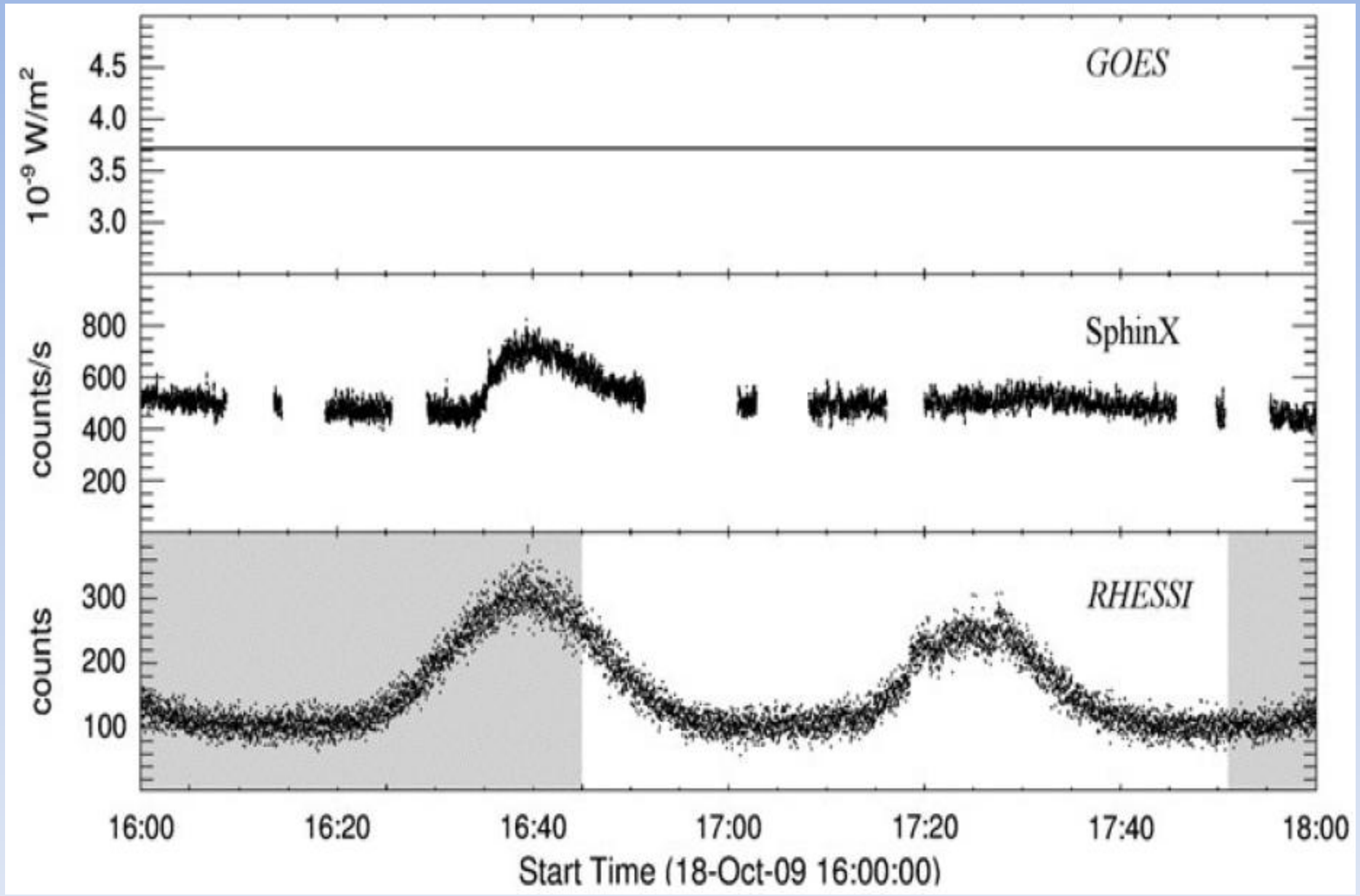
Why to study this period?

- Lowest activity ever observed in X-rays
- Very simple morphology of observed structures

Available active Sun-observing X-ray experiments

- GOES
- RHESSI
- XRT
- SphinX
- Messenger – non solar

Comparison of observations from SphinX GOES and RHESSI



SphinX **S**olar **Ph**otometer **in X**-rays

~4kg/~10W (peak)

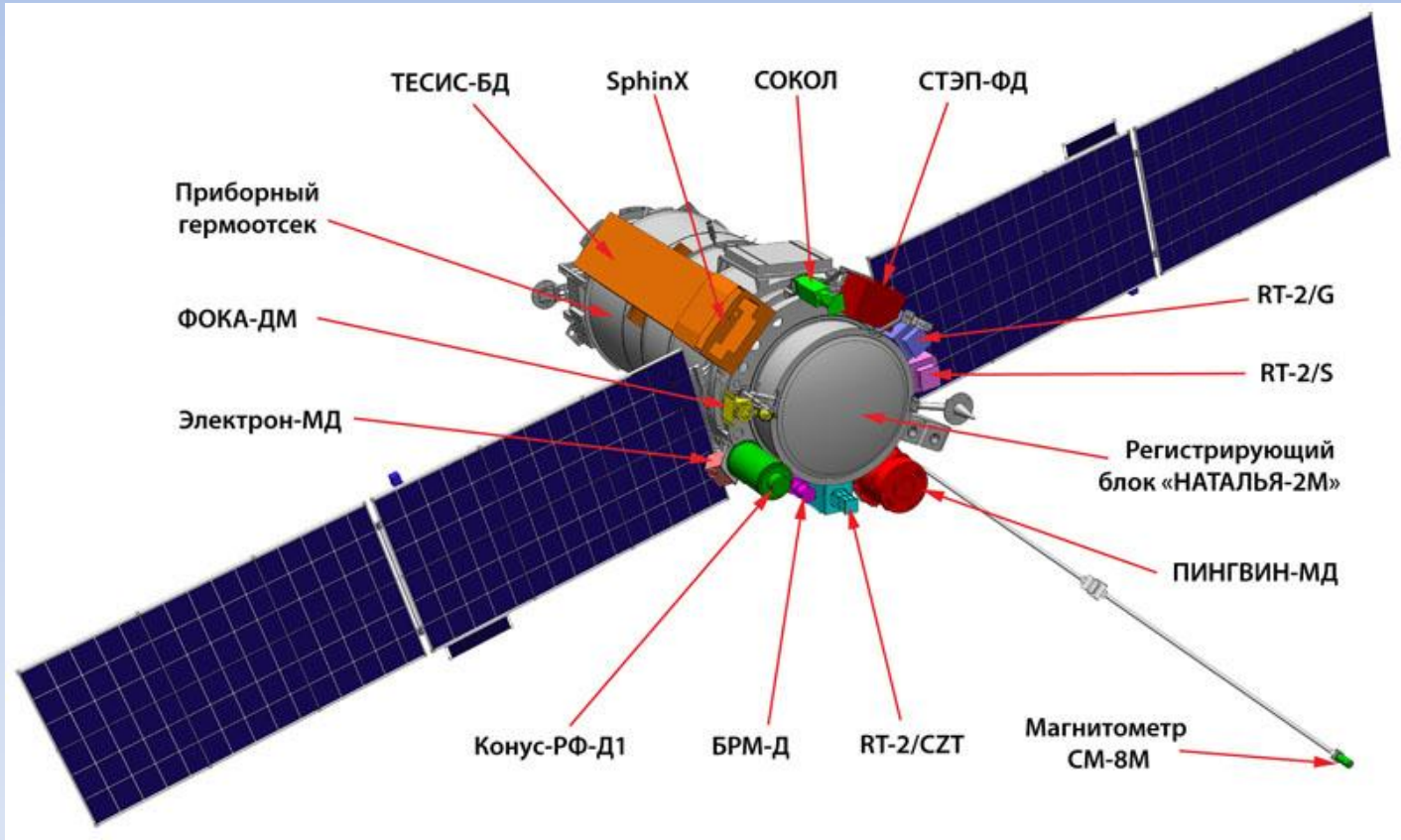
0.85 keV -15 keV

Time accuracy ~1 μs

Mission duration: February 20, 2009 – November 29, 2009

CORONAS-Photon satellite

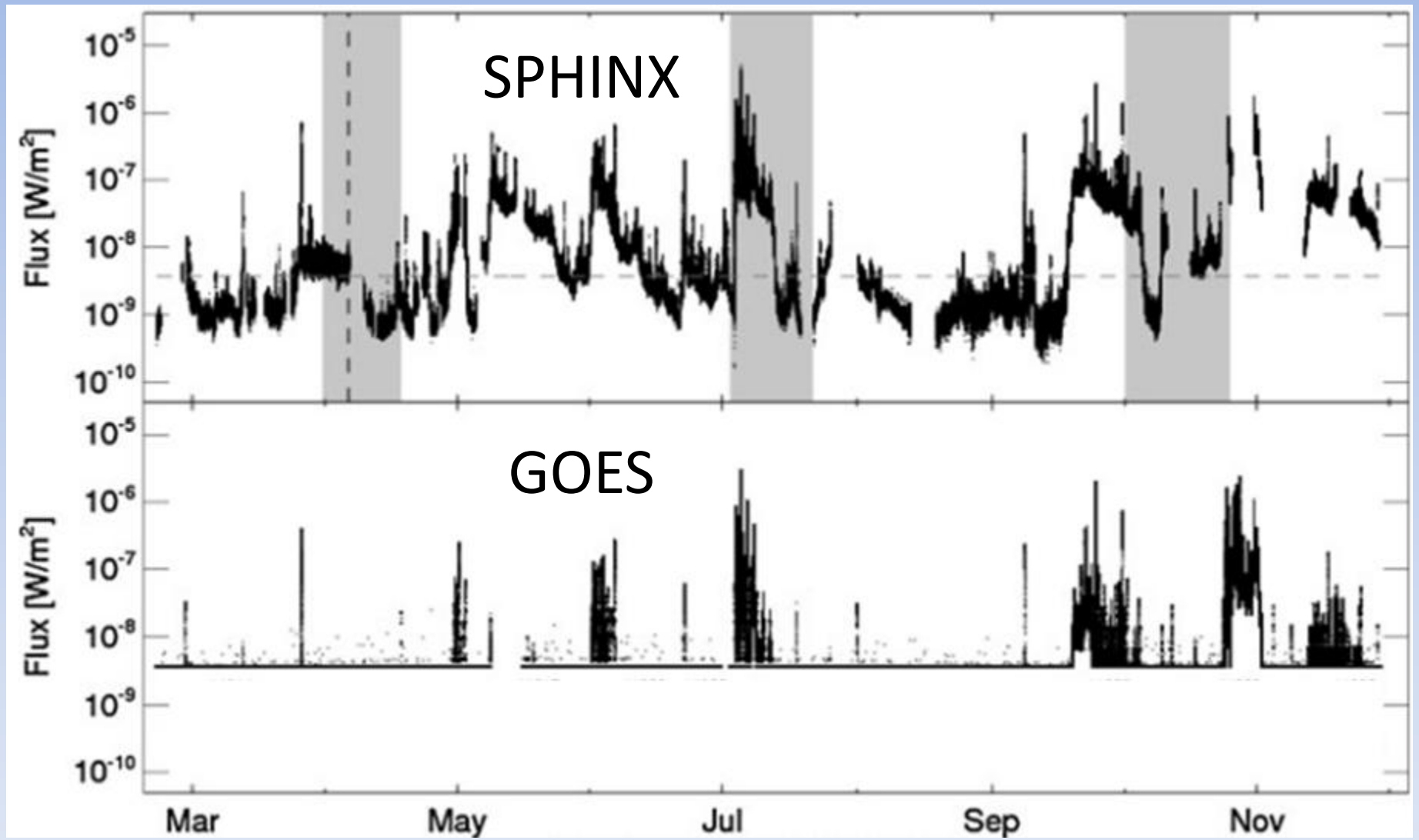
CORONAS-Photon
Complex Orbital Observations Near-Earth of Activity of the Sun-Photon
Third satellite in the Russian Coronas
Launch: 30 January 2009



Orbit

Height - 550 km
Period - 96 min
Inclination - 82°

SPHINX data coverage



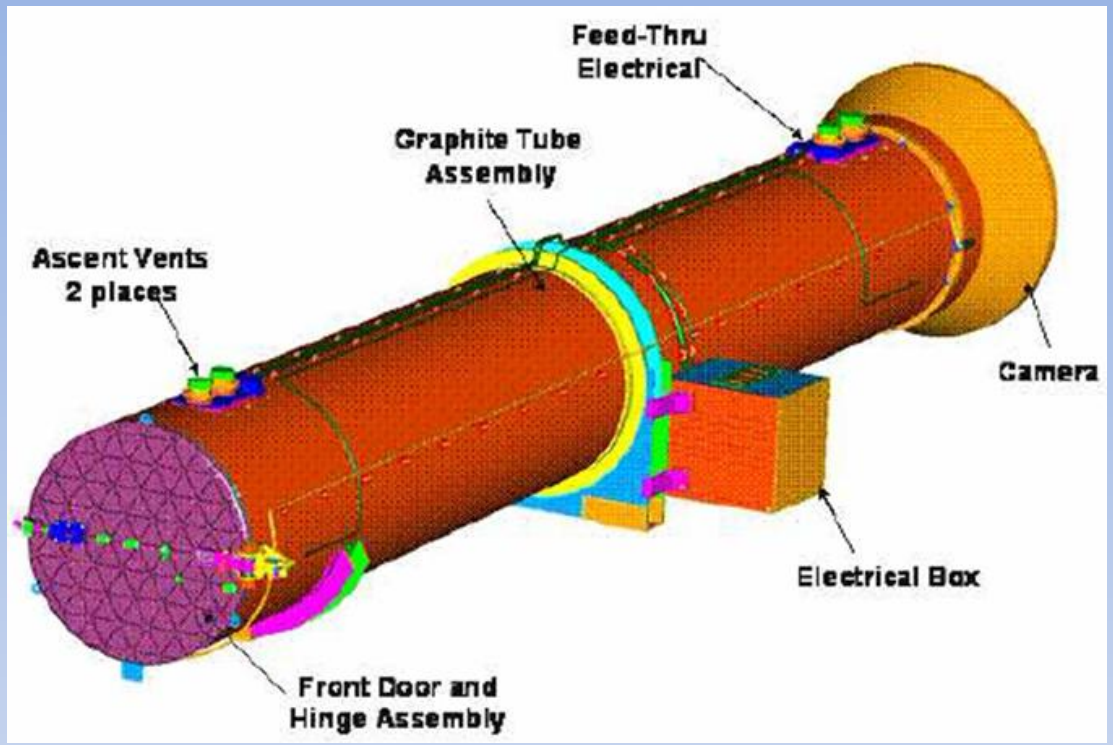
XRT telescope

Wolter-I-like grazing incidence optics

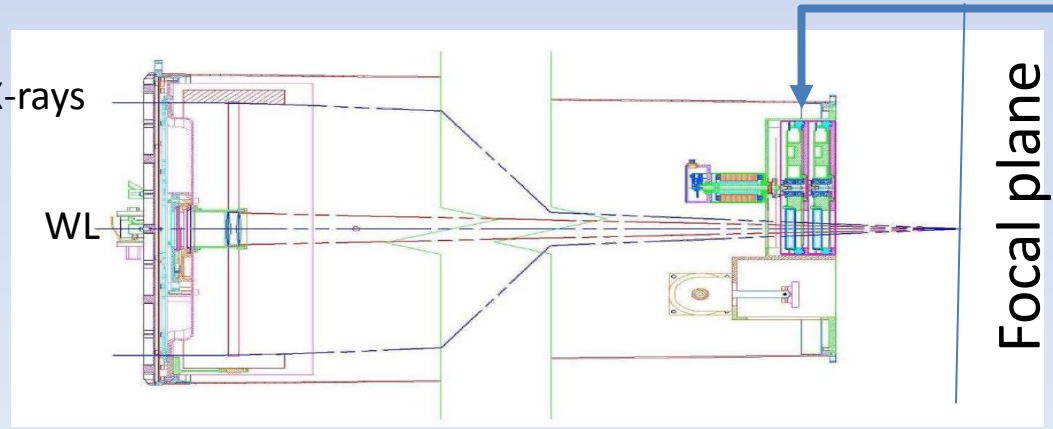
Wavelength range 6-200 Å

Field of View *> 30 arcmin*
Full disk images possible

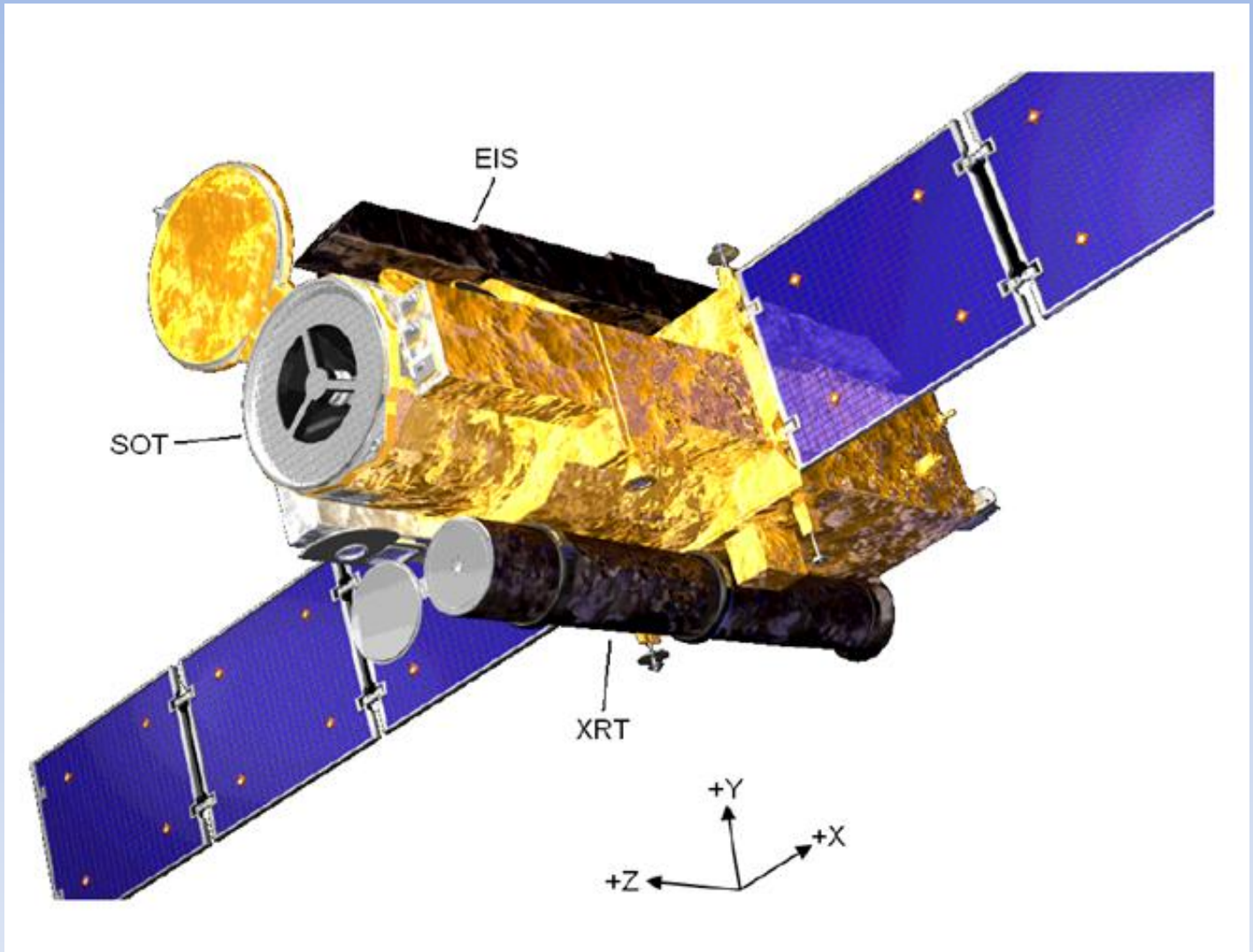
Detector CCD max 2048×2048 pix



Golub, et al., *The X-ray Telescope (XRT) for the Hinode Mission, 2007, Solar Physics, 243, 63*



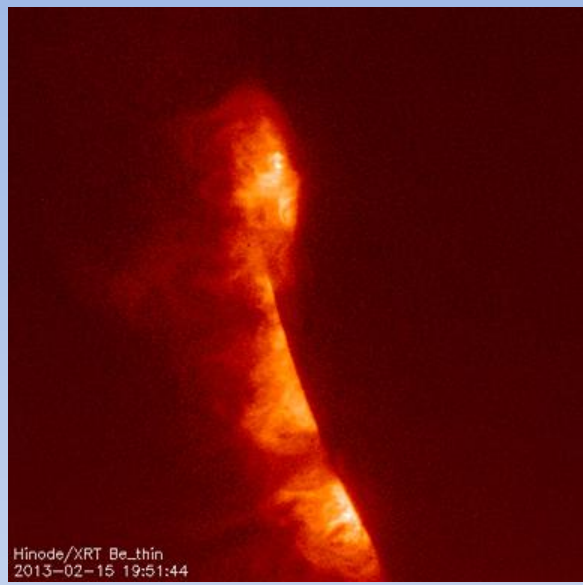
Solar B, renamed Hinode (pronounced 'hee-no-day')
Launch – 22 September 2006

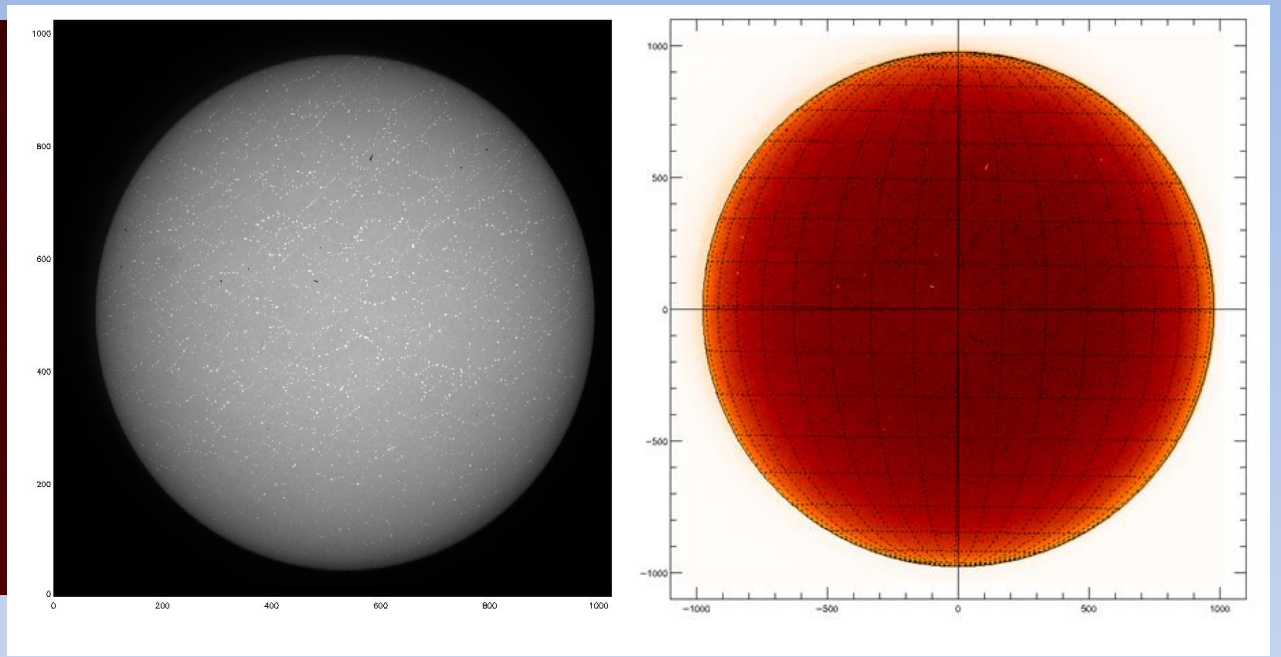


Orbit

Height - 600 km
Period - 96 min
Inclination - 99°

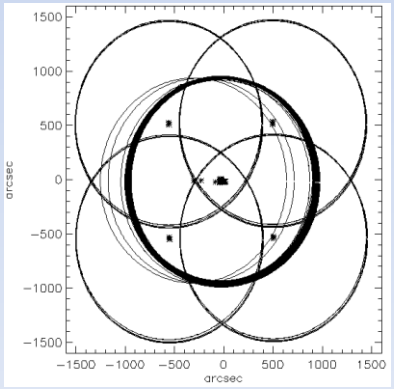
XRT images

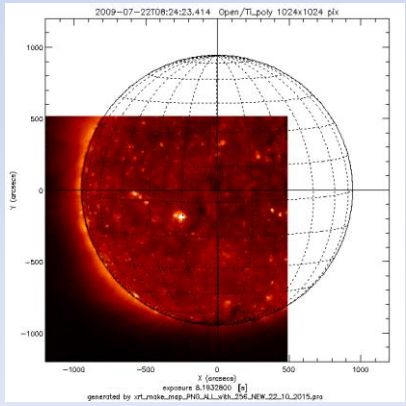




Most XRT data - PFI images

Full frame images - moderate cadence
On average two images daily



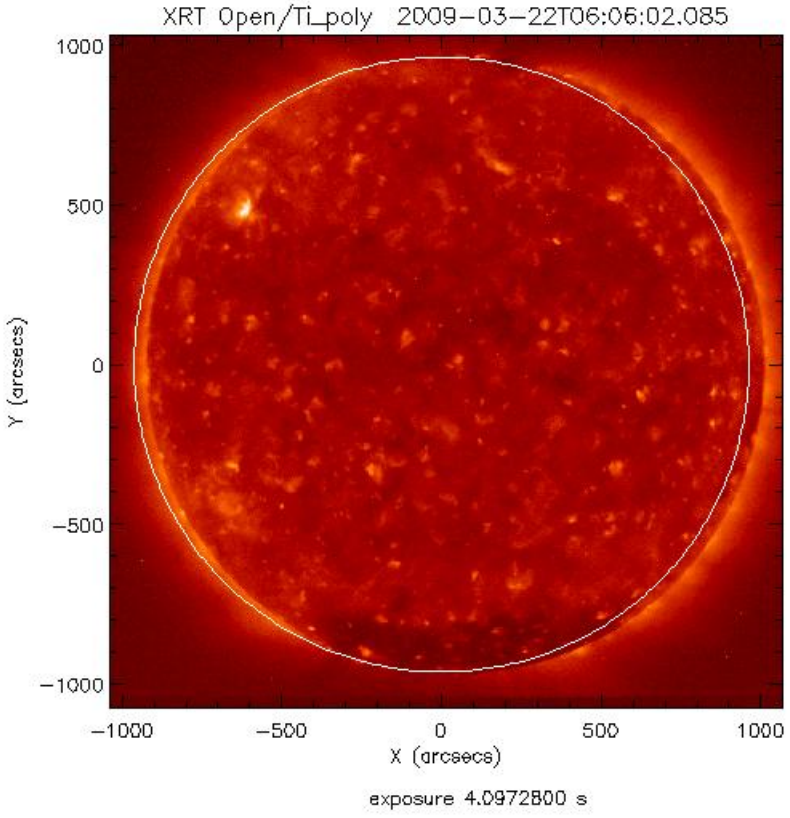


Some of them off-pointed

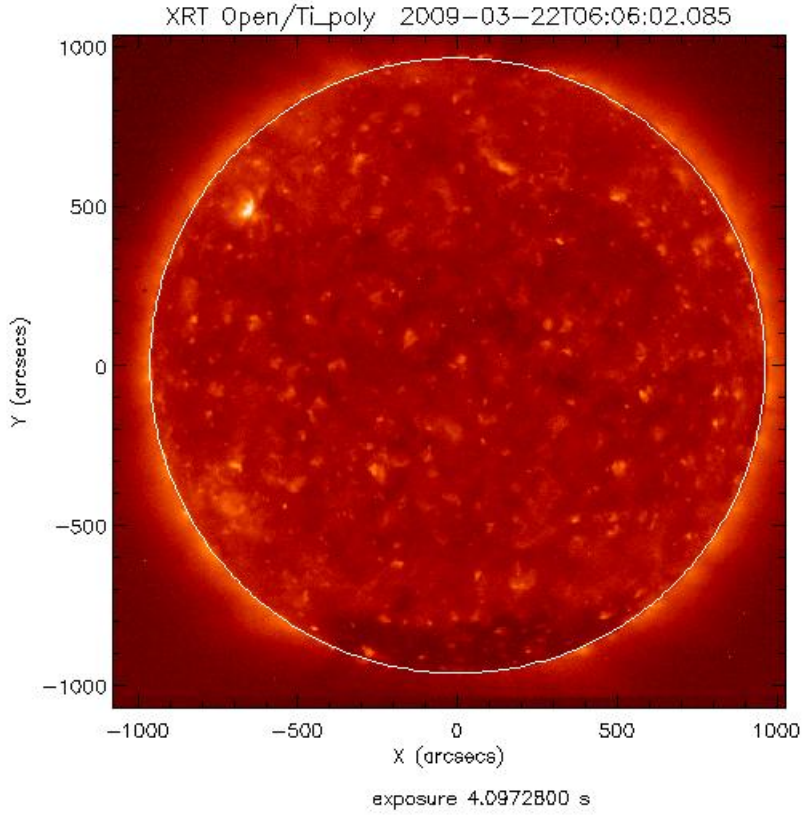
Alignment problem solved in 2014

XRT calibrated data

Before 2014



After 2014

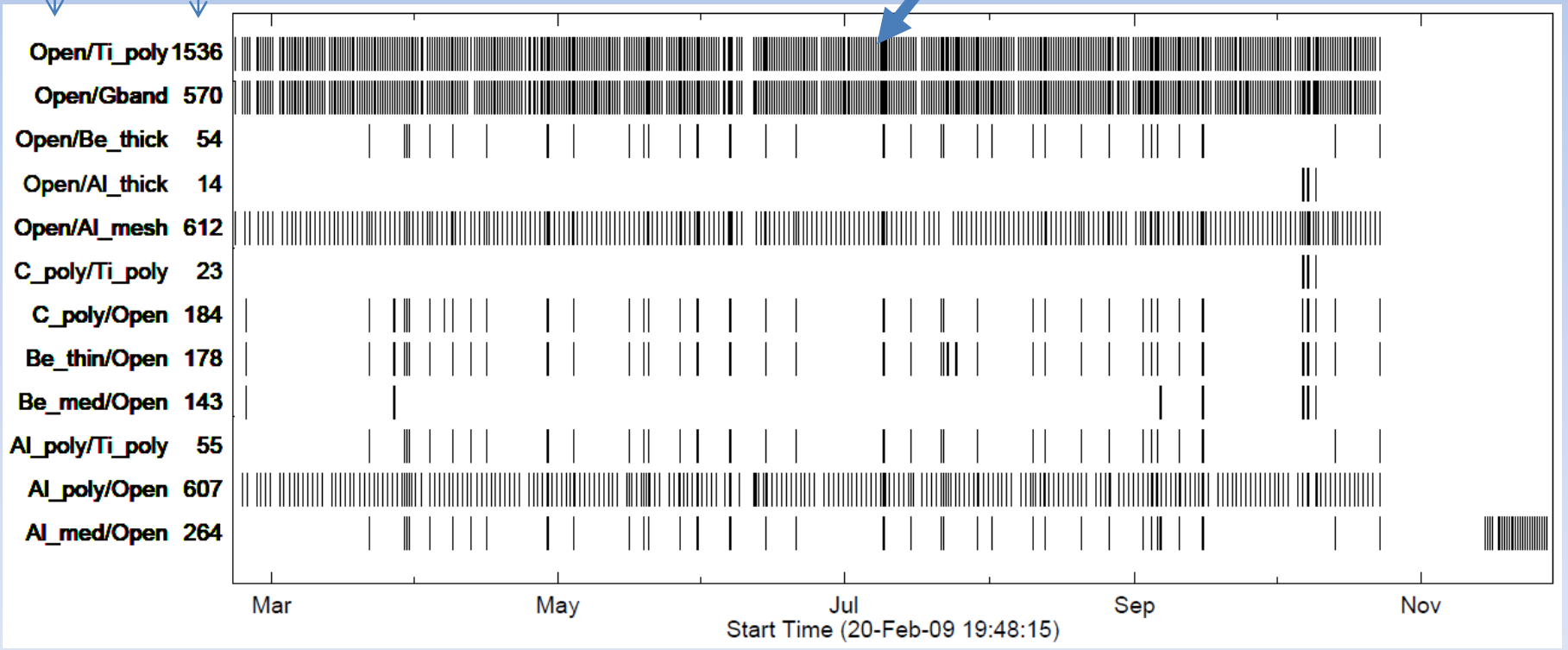


XRT full frames – 2009 coverage

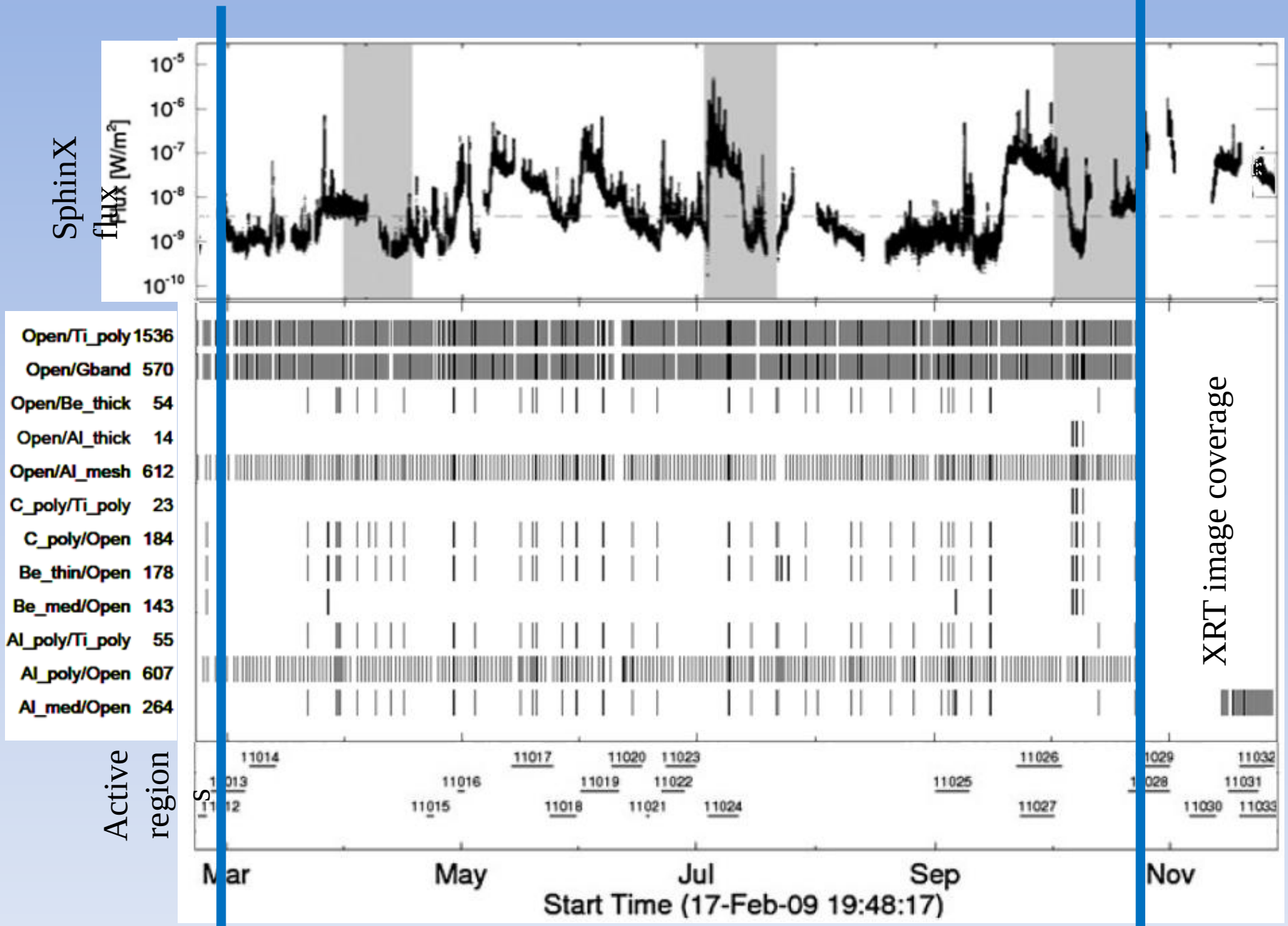
Best coverage in Open/Ti_poly filter configuration

Filter

Number of images



Movie!



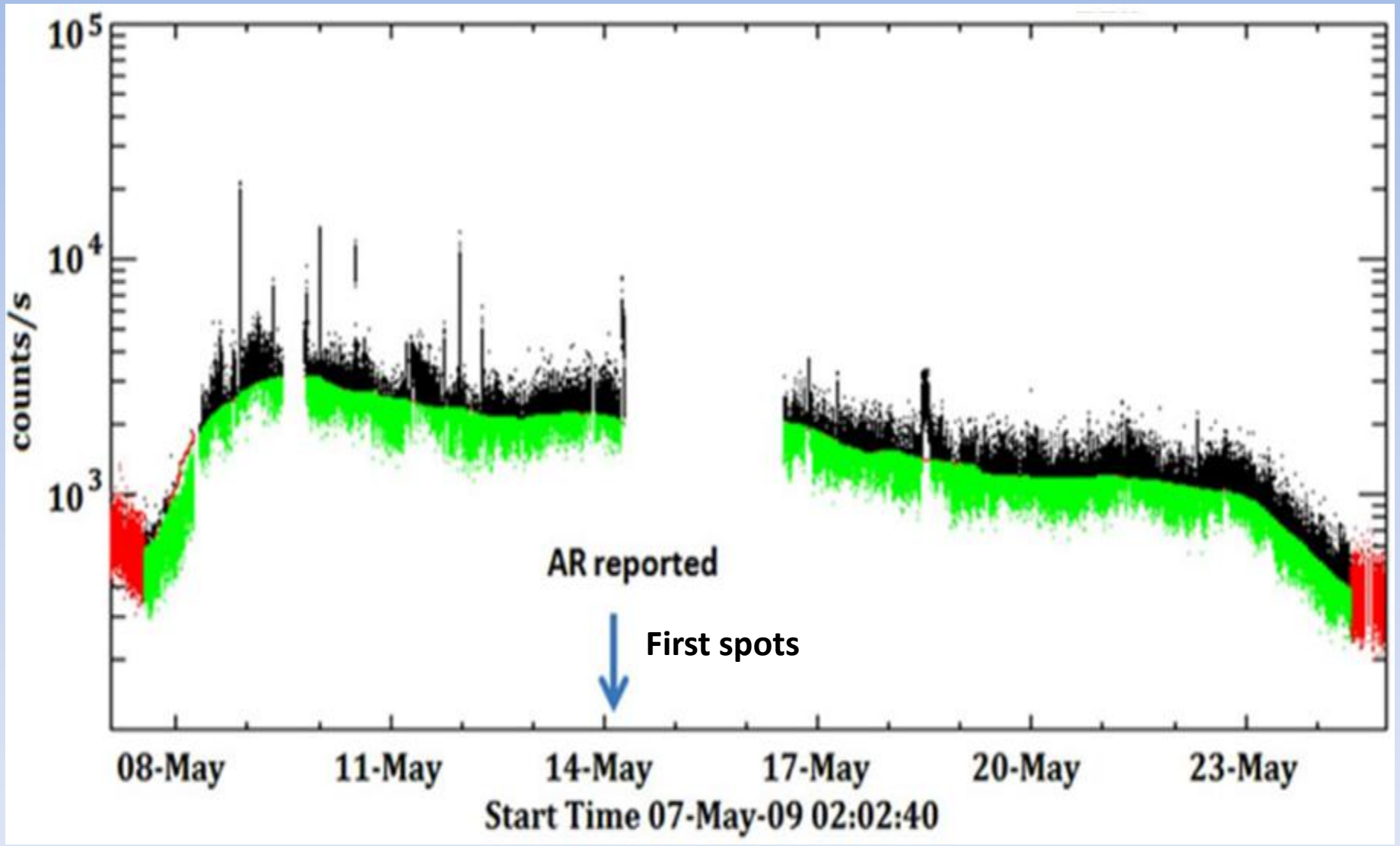
Data on ARs from NOAA reports

Comparison of SphinX and XRT data

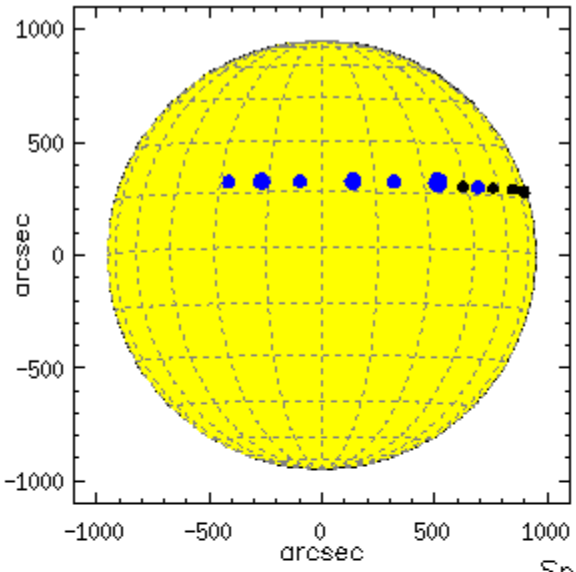
- Full disk soft X-ray emission
- XRT gives spatial resolutions for SphinX
- Imaging with moderate cadence (not good for flares)
- Good for studies of long lasting events
  such as ARs, CHs

Today focus is on ARs

Motivation – delays in activity

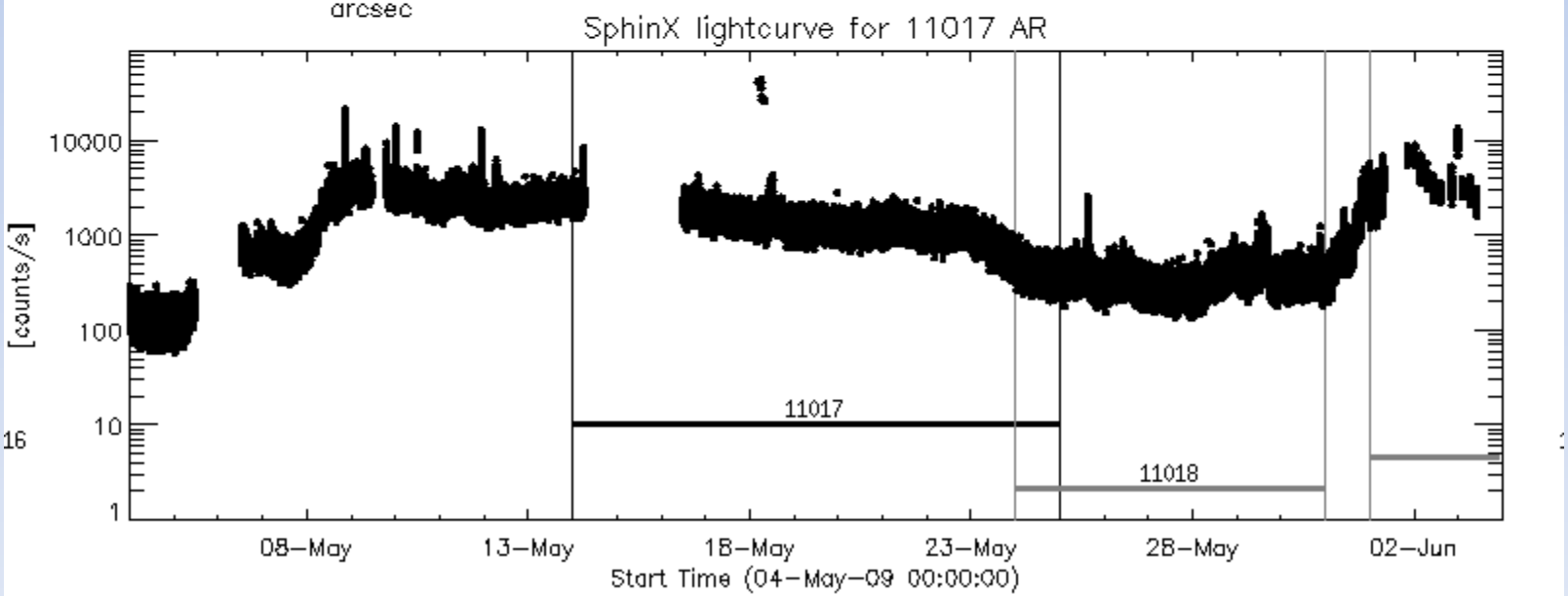


AR11017



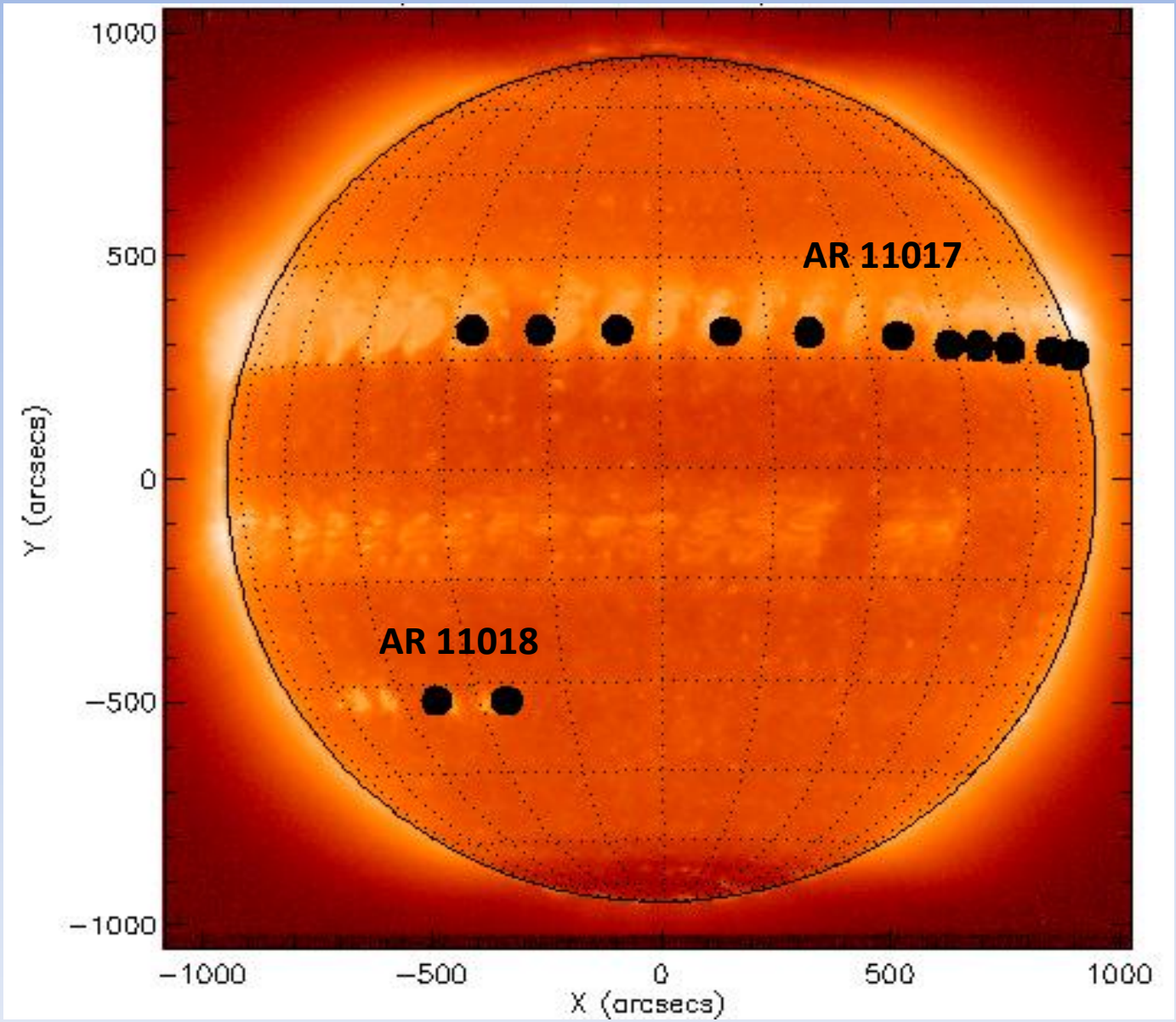
AR 11017 USAF/NOAA report

Id	Loc. date	Loc.	LO	Area	Z	LL	NN	Type	Mag. Type
1	2009-05-14	N18E27	190	0010	Bxo	06	02	ARS	β
2	2009-05-15	N18E17	186	0020	Bxo	07	08	ARS	β
3	2009-05-16	N18E06	184	0010	Axx	01	02	ARS	α
4	2009-05-17	N18W09	186	0020	Bxo	03	05	ARS	β
5	2009-05-18	N18W21	185	0010	Bxo	03	03	ARS	β
6	2009-05-19	N18W35	185	0030	Bxo	03	04	ARS	β
7	2009-05-20	N17W50	187	0010	Hrx	00	01	ARS	α
8	2009-05-21	N17W44	187					HaP	
9	2009-05-22	N17W57	187					HaP	
10	2009-05-23	N17W70	187					HaP	
11	2009-05-24	N17W83	187					HaP	
12	2009-05-25	N17W96	187					HaP	

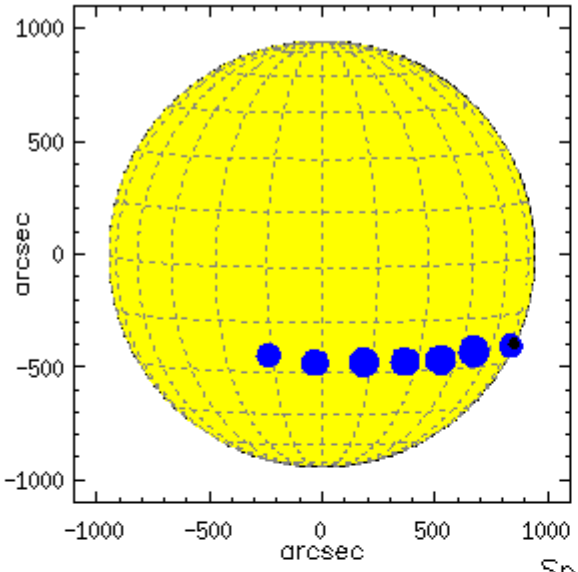


XRT OPEN/TI_poly stacked images
08 -25May 2009

08 -25May 2009



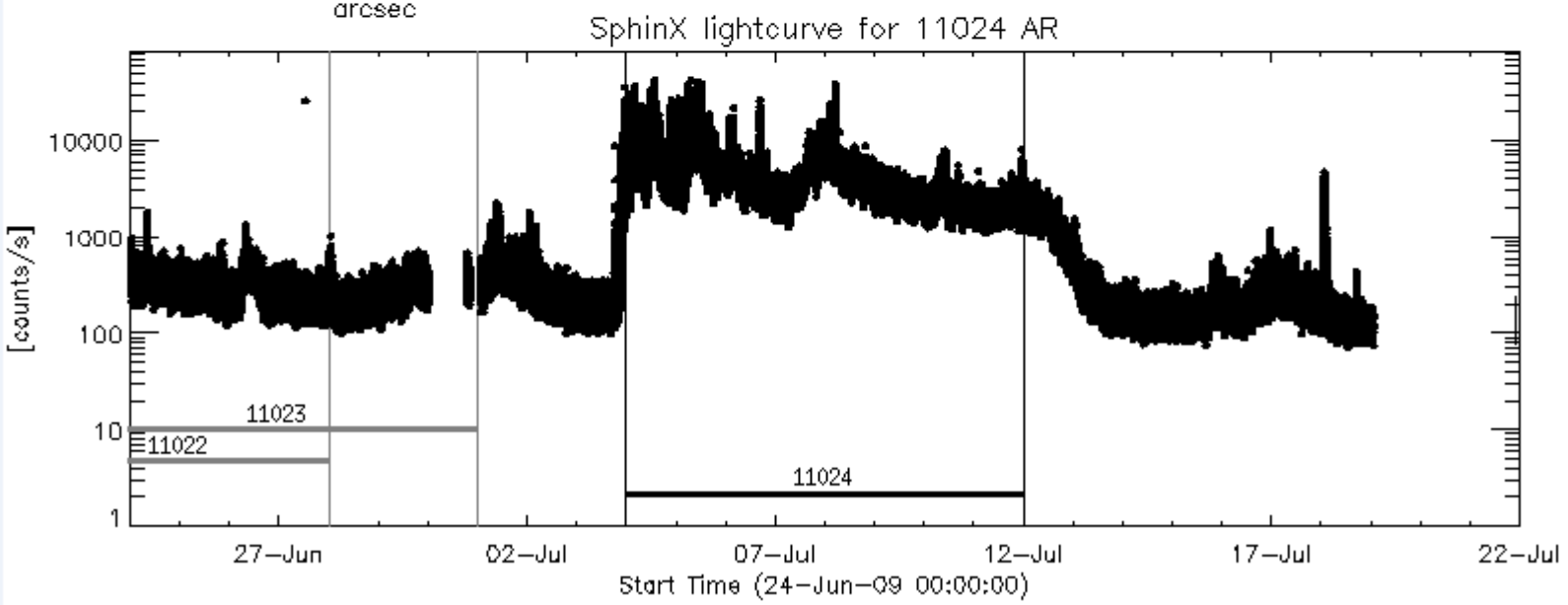
AR11023 and AR11024



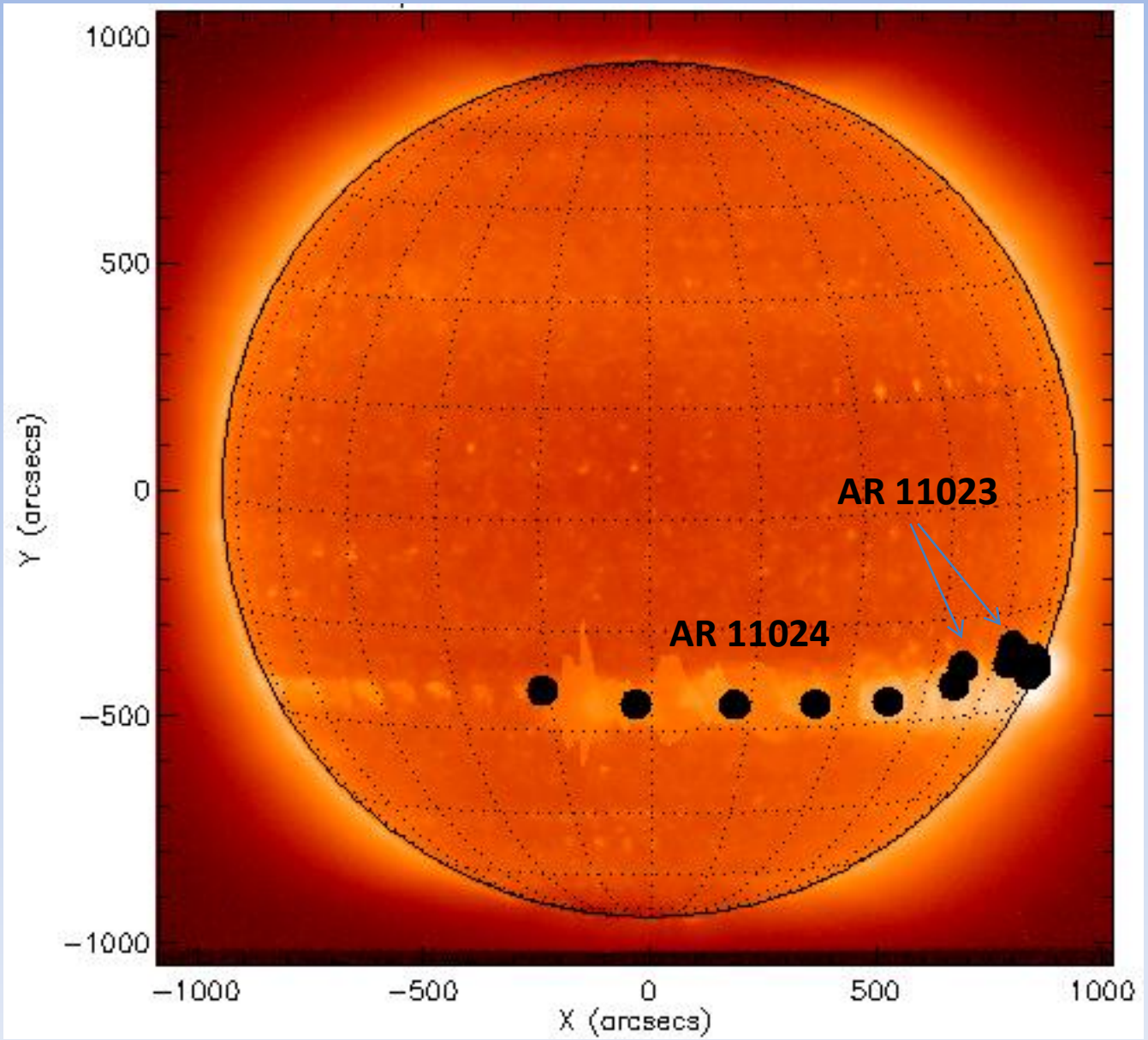
AR 11024 USAF/NOAA report

Id	Loc. date	Loc.	LO	Area	Z	LL	NN	Type	Mag. Type
1	2009-07-04	S25E16	246	0060	Dso	05	07	ARS	βγ
2	2009-07-05	S27E02	247	0100	Dsi	06	14	ARS	βγ
3	2009-07-06	S27W13	247	0170	Dsi	10	16	ARS	βγ
4	2009-07-07	S27W26	247	0160	Dsi	10	13	ARS	βγ
5	2009-07-08	S27W39	248	0180	Eai	11	11	ARS	βγ
6	2009-07-09	S25W52	248	0190	Esi	11	08	ARS	βγ
7	2009-07-10	S09W65	248	0230	Eao	13	05	ARS	βγ
8	2009-07-11	S25W79	248	0060	Eso	14	03	ARS	βγ
9	2009-07-12	S25W92	248					HaP	

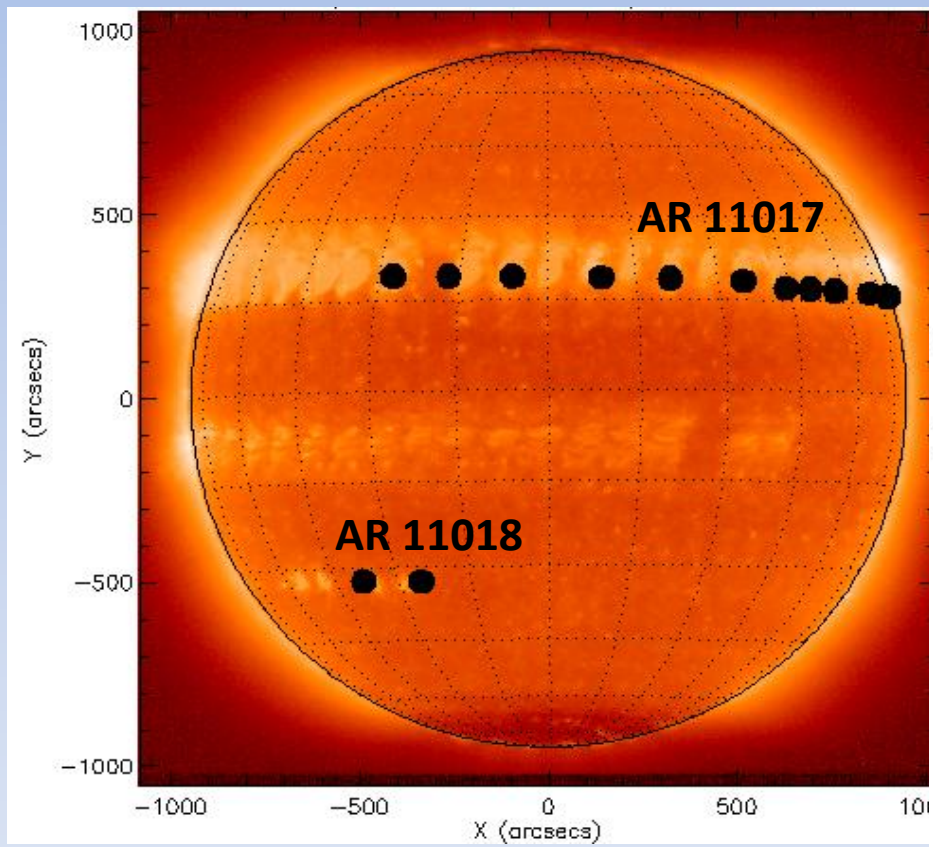
Due to return on 2009-07-23 at S26

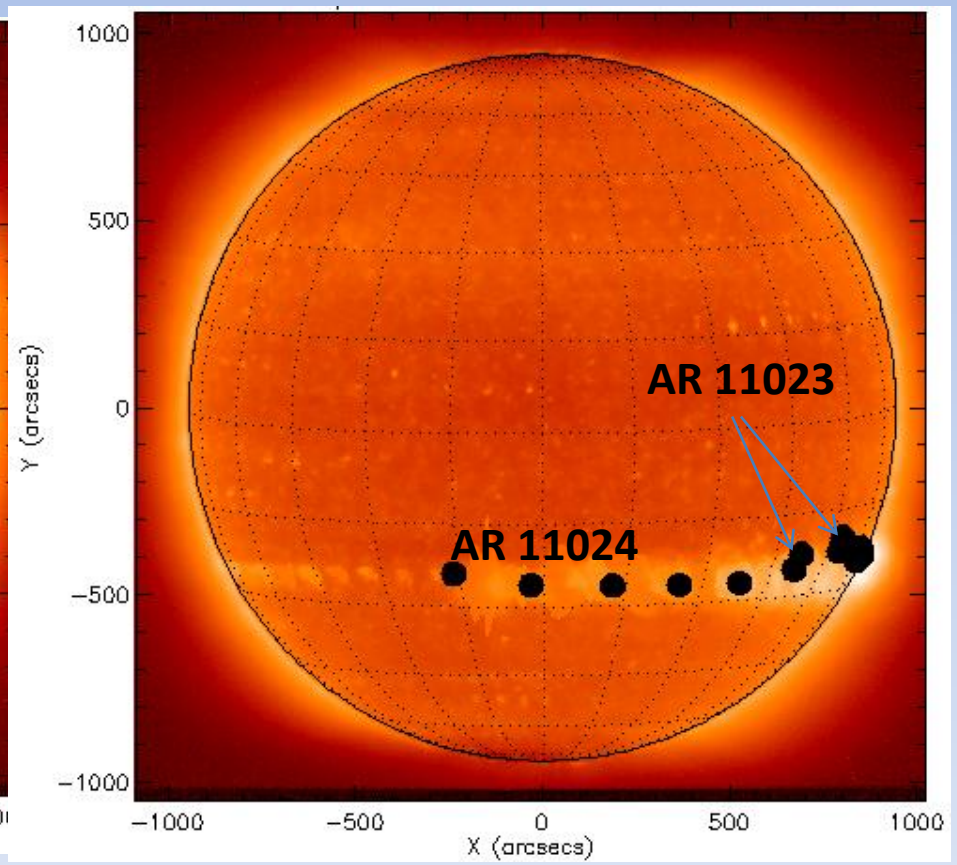


XRT OPEN/TI_poly stacked images
29 June - 14-July 2009



Comparison


AR 11017
AR 11018
1000
500
0
−500
−1000
Y (arcsecs)
−1000
−500
0
500
X (arcsecs)


AR 11023
AR 11024
1000
500
0
−500
−1000
Y (arcsecs)
−1000
−500
0
500
1000
X (arcsecs)

Conclusions and preliminary results

- Stronger coronal activity may appear 1 – 4 days before photospheric one.

- Coronal activity may accur for week or longer without signatures at photospheric level.

- The strength of coronal and photospheric activity may be not correlated when they occur together.

- Further works on this topic, including other atmosphere layers, are necessary.