EVOLUTION of XUV EMISSION from INDIVIDUAL AR as SEEN by SphinX and the OTHER INSTRUMENTS

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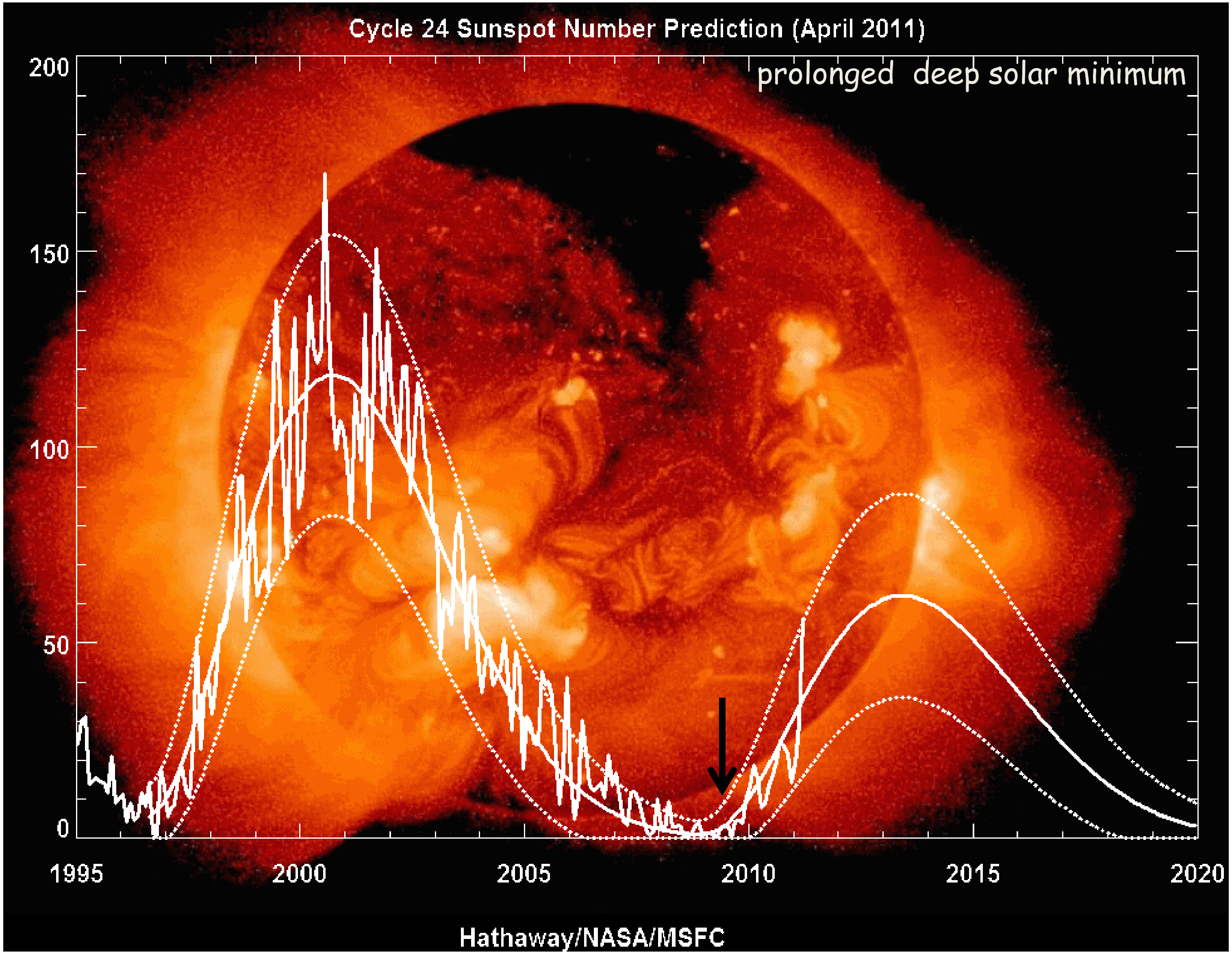
Data used in the analysis

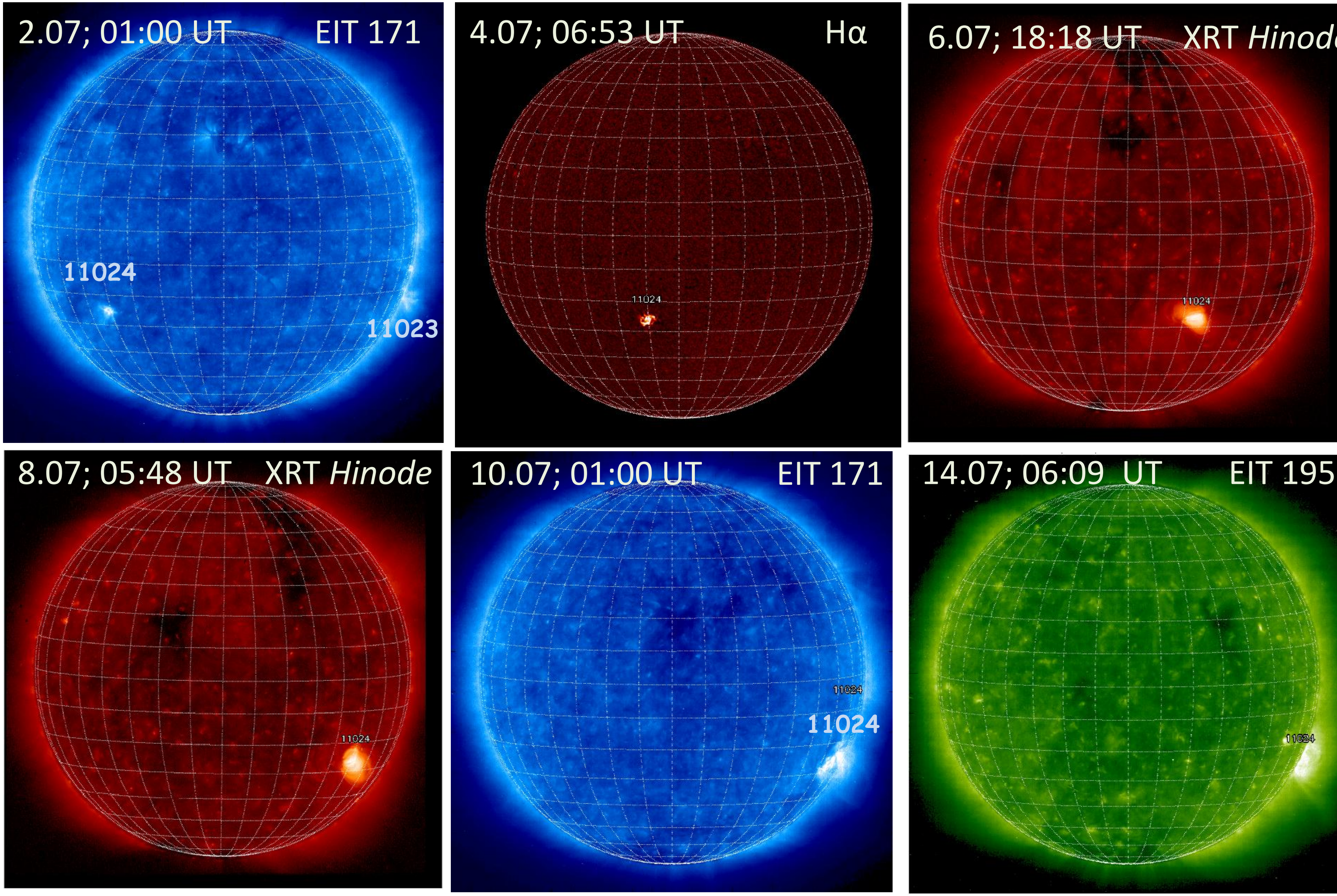
- SphinX: Solar Photometer in X-rays on *Coronas-Photon* satellite
- EIT images full-disk observations (195 Ǎ filter; Fe XII, T~1.5 MK) every 12 min. from *SOHO* experiment; the pixel size is 2.6-arc second
- XRT Be images from *Hinode* (1 arc second pixels)

http://solarscience.msfc.nasa.gov/images/ssn_predict_l.gif

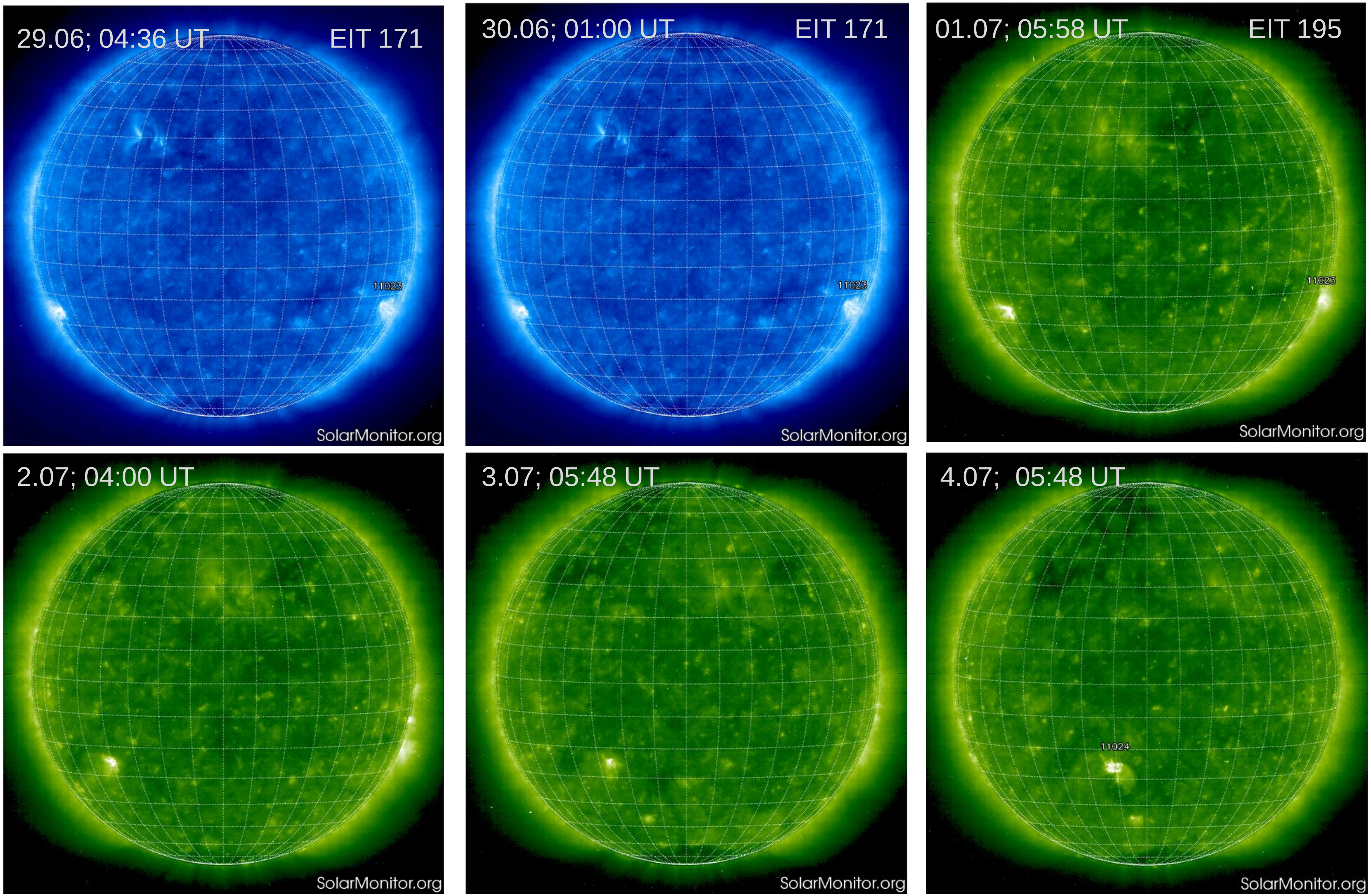


Plenty of data have been collected with different instruments onboard CORONAS-Photon, despite very low solar activity in the February-November 2009 period.

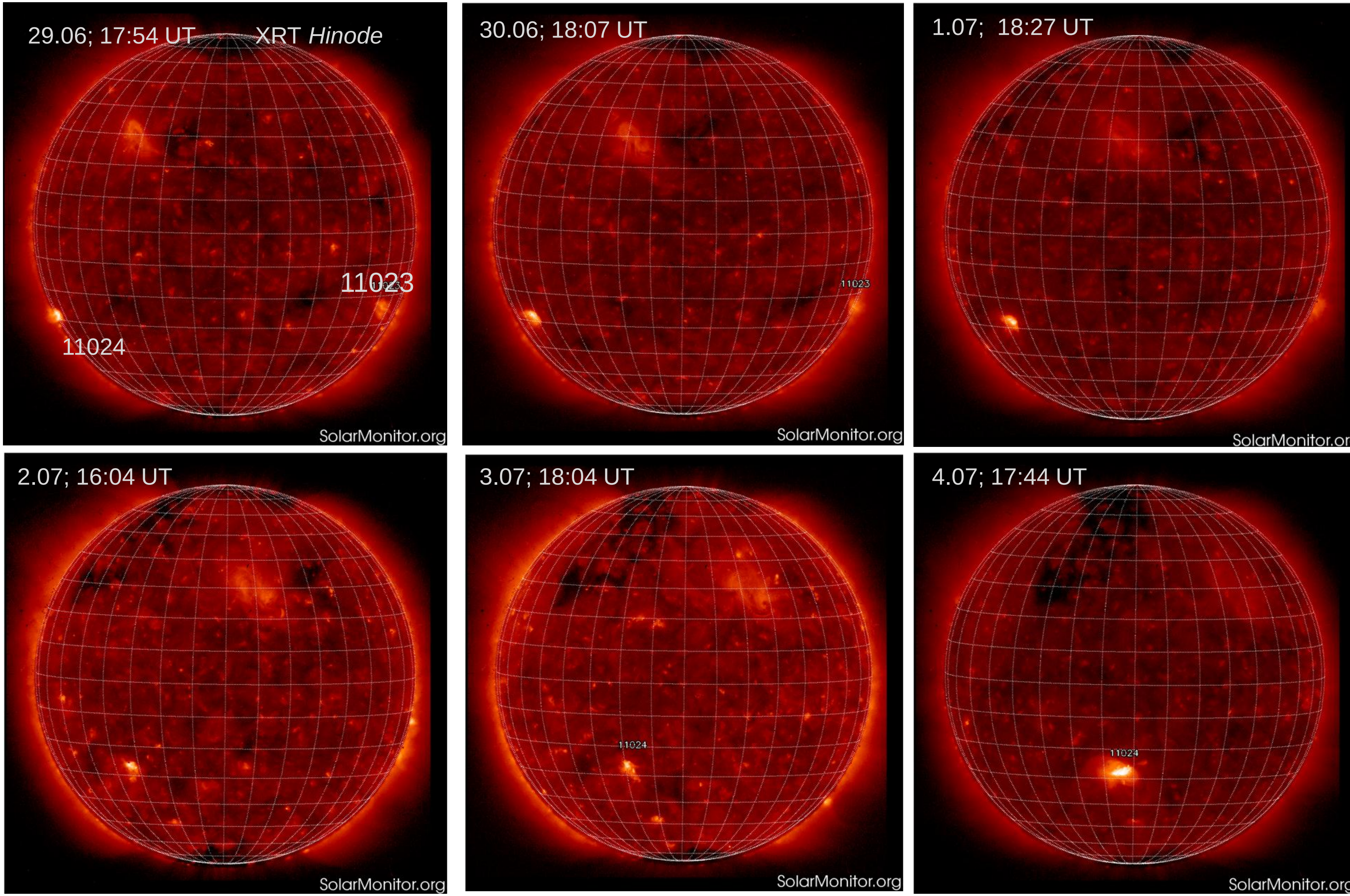
Active Region 11024 evolution: 2-14.07.2009



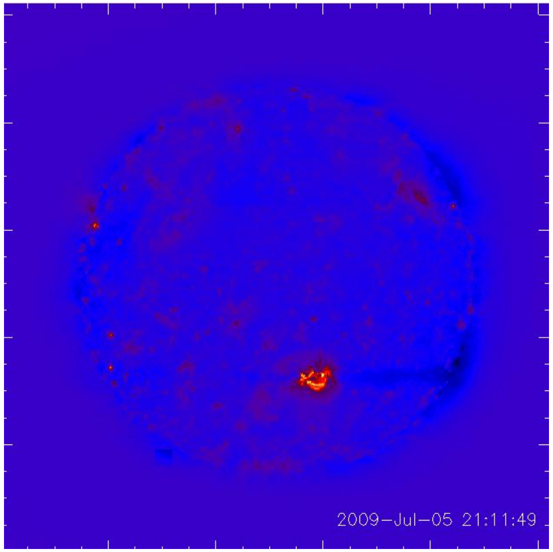
EIT images – beginning of the AR evolution

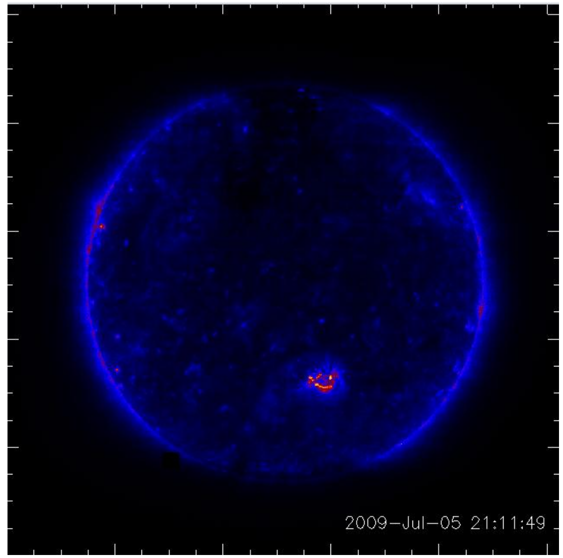


XRT *Hinode* images – beginning of AR evolution

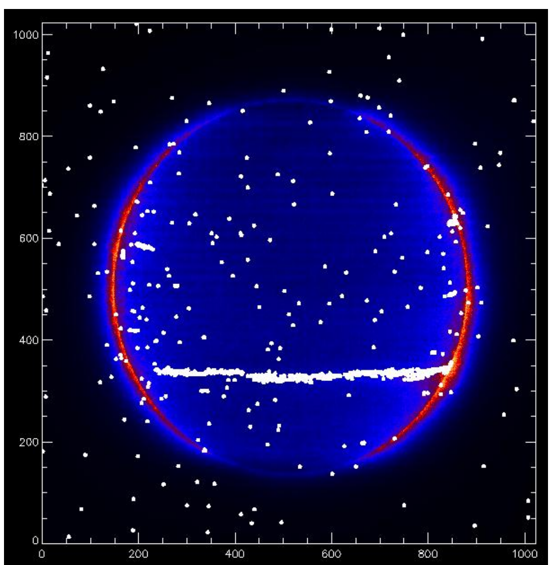


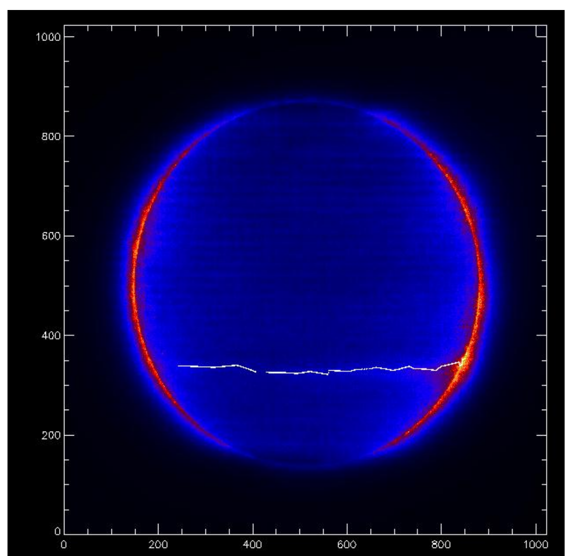
EIT 195 Ă radiation





1169 images available

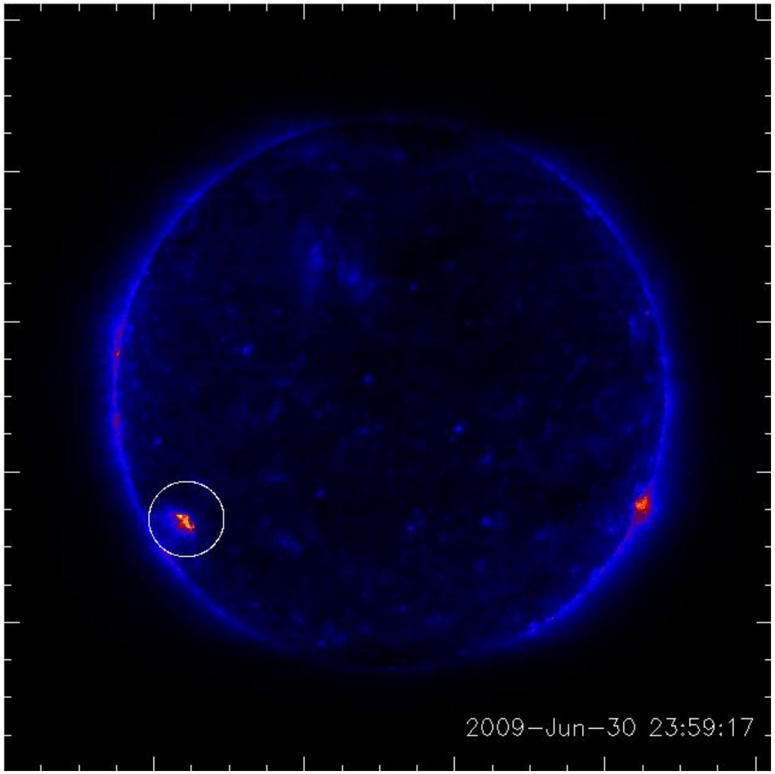


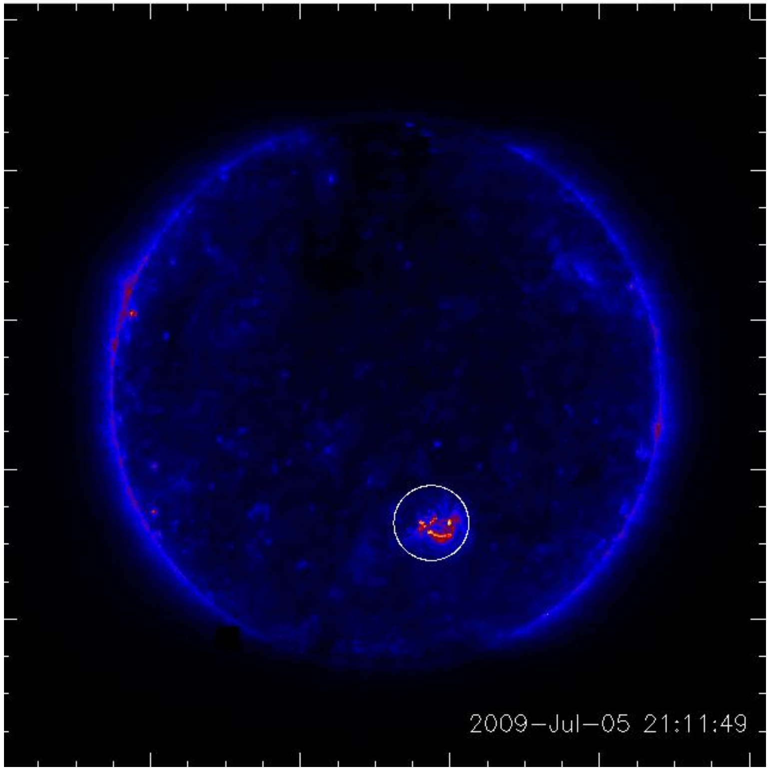


Maxima of individual images marked on the average EIT image and

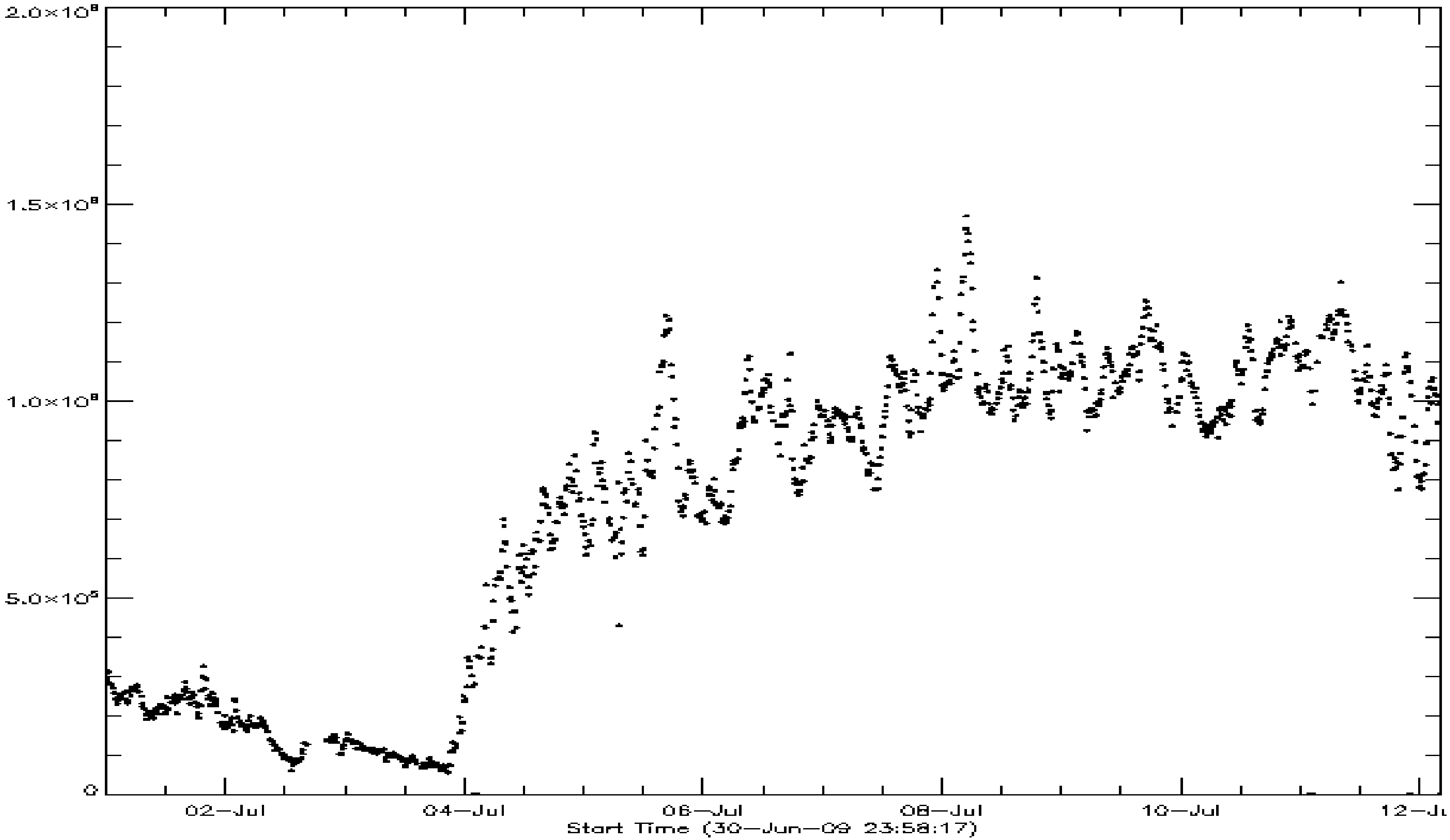
AR 11024 evolutionary track

EIT 195 Ă

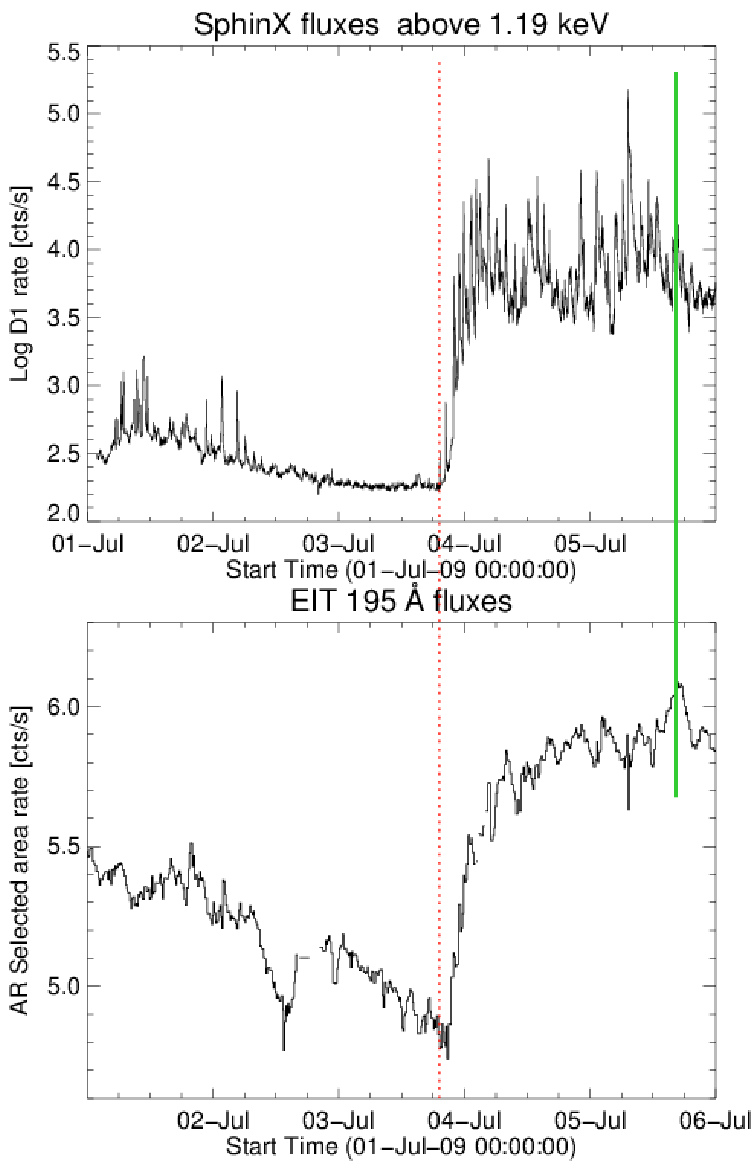




UV flux from AR 11024



EIT and SphinX fluxes comparison

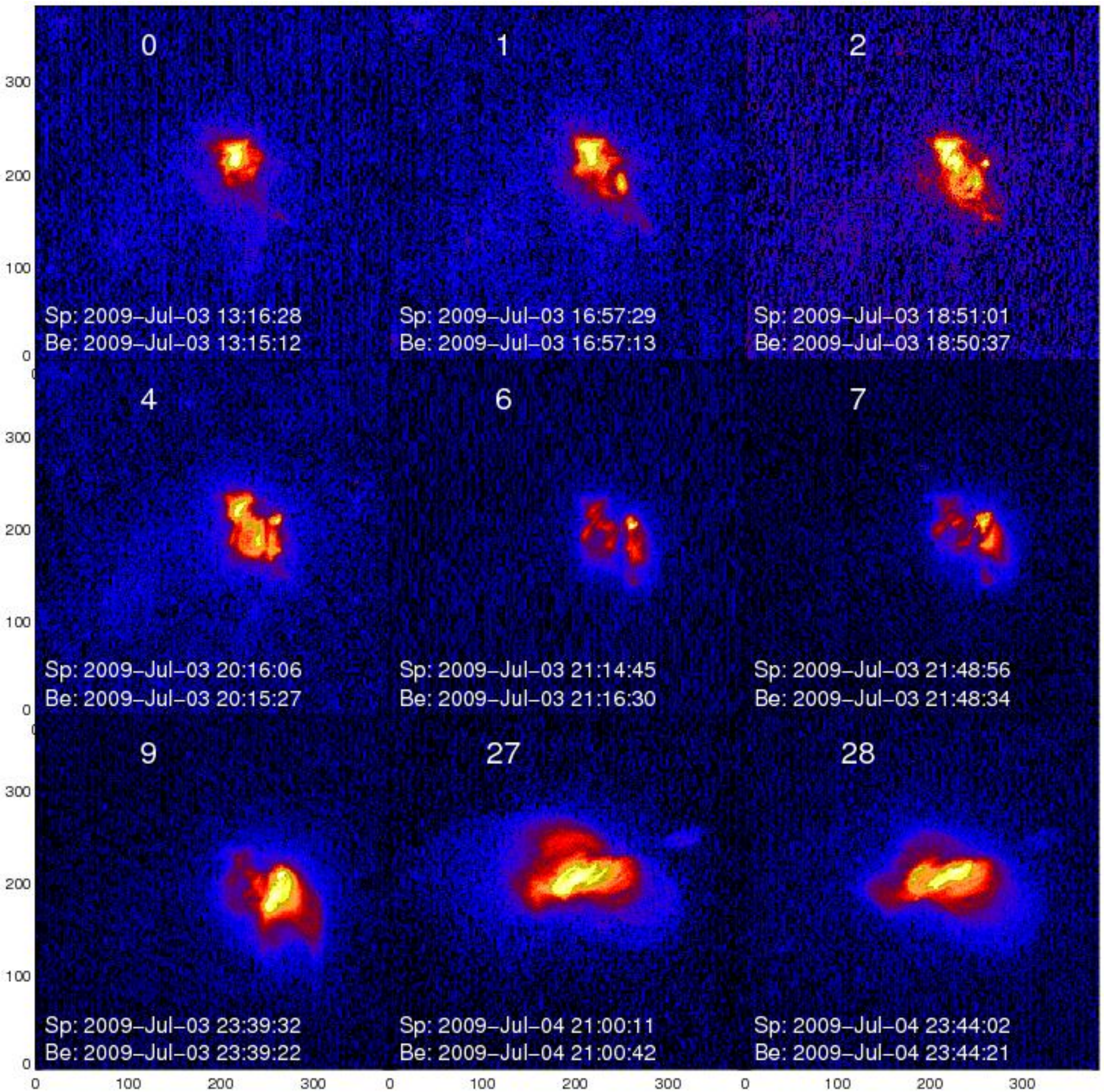


The SphinX soft X-ray radiation starts to evolve a little bit earlier (~2 hours) than UV radiation and its evolution is more dynamic than UV emission.

The most intense UV spikes are NOT necessary the most intense in X-ray radiation.

We plan to perform similar comparison using XRT Hinode images for selected AR 11024 flux.

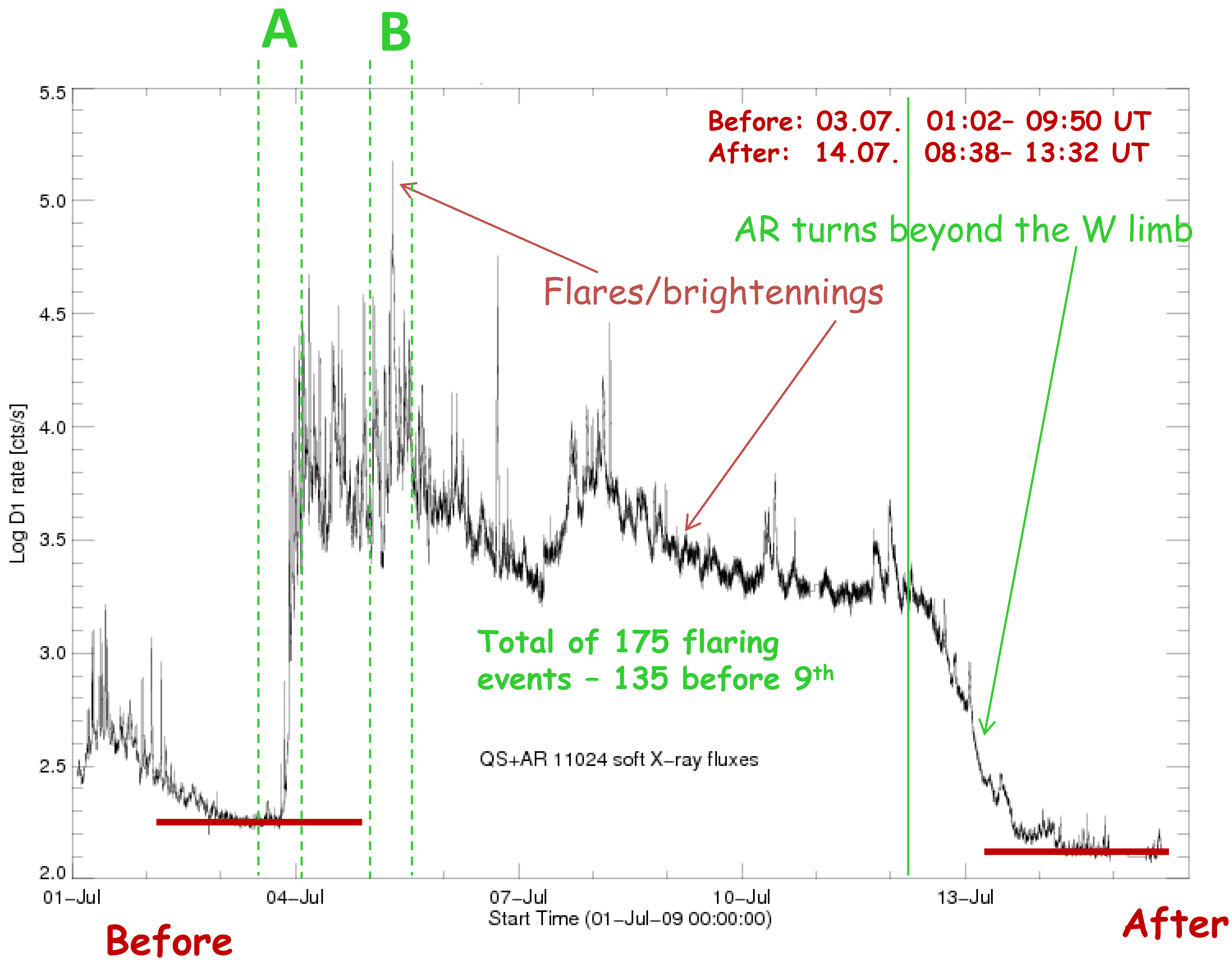
Active region XRT *Hinode* images



Hinode images in full XRT resolution available :
each 90 sec
~400 x 400 pixels
of 1 arcsec dimension
processed in Be medium and Ti filters.

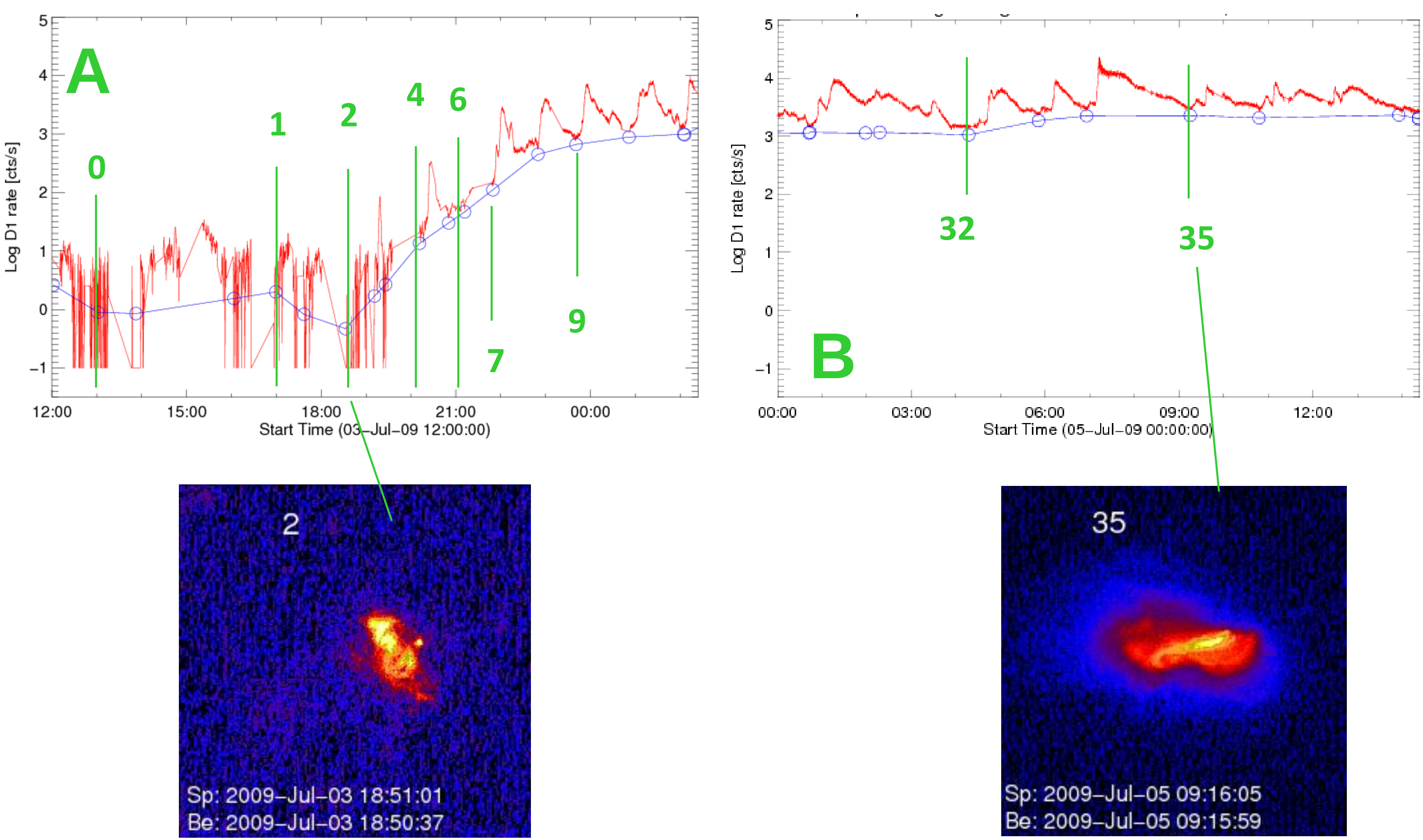
Images:
from **3 July 13:16 UT** to **4 July 23:44 UT**

SphinX flux above 1.19 keV (1-16 July 2009)



~120 000 spectra available for AR 11024

AR contribution...how to subtract? (226 points selected)



What can be deduced from SphinX data?

We measure spectra in the range 1-15 keV with energy resolution ~0.5 keV, so several independet lightcurves are available…The simple & easy analysis is to adopt an **isothermal approximation**… and determine the temperature and emission measure: **T**, **EM**

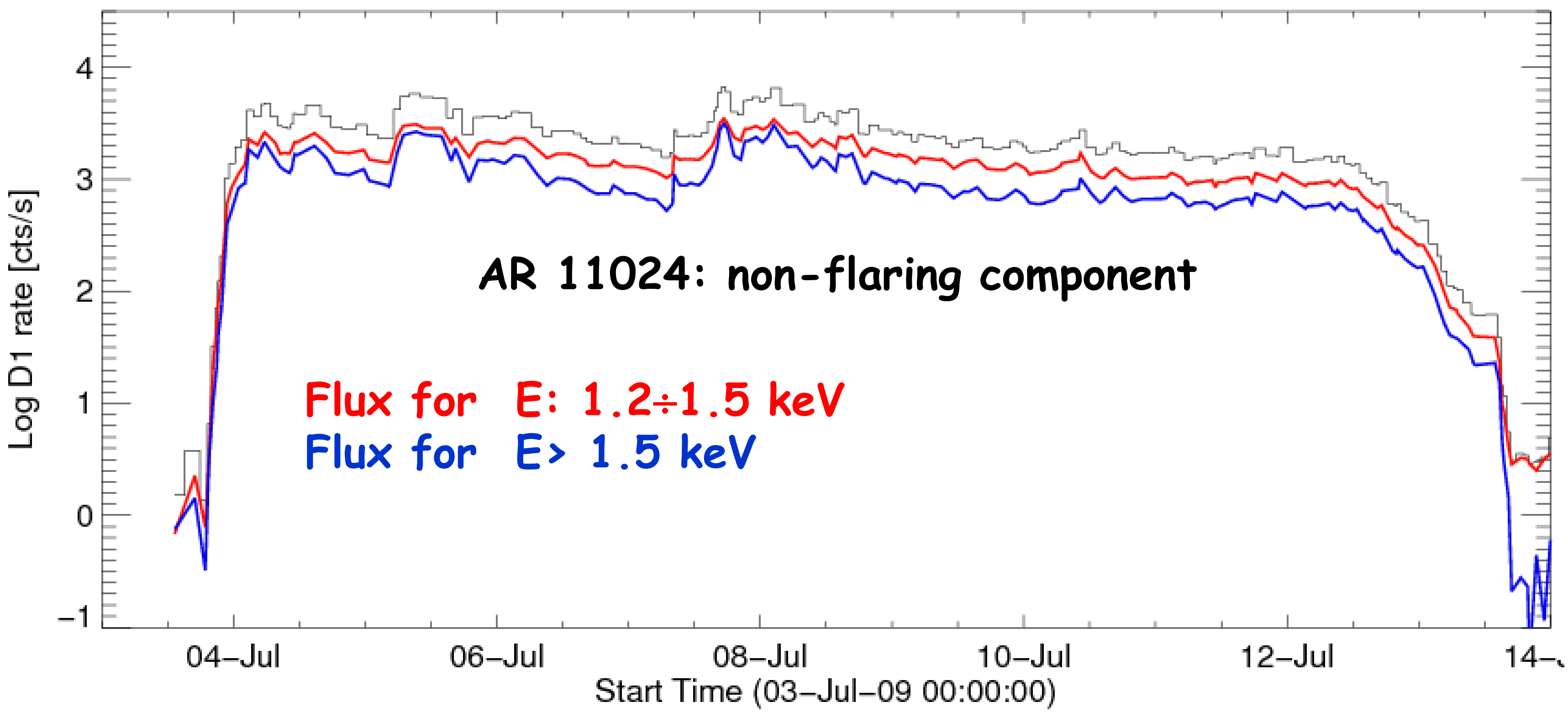
How can we do this ?

Since several channels are available, two different methods can be applied. (In the framework of statistical uncerainties they should give the similar equivalent values for: **T**, **EM**)

1: E-band-ratio

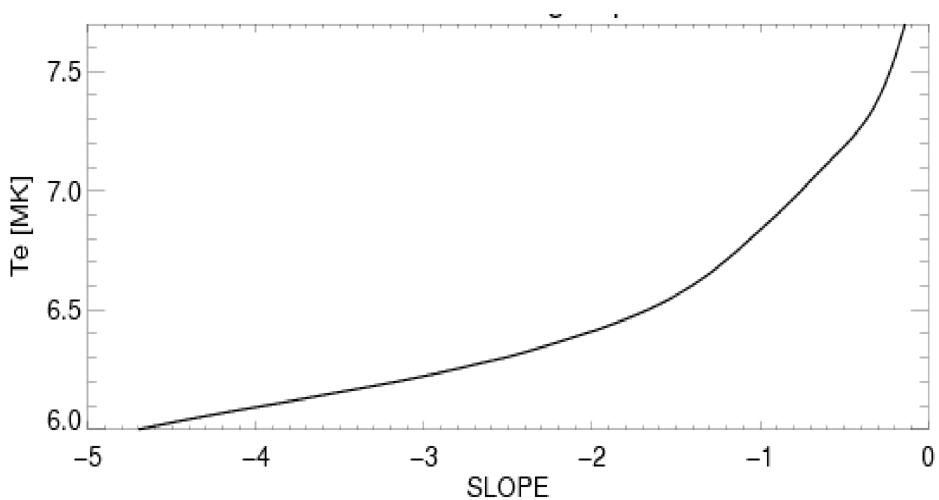
Standard method using the dependence of fluxes ratio in 2 energy bands on the temperature (as used for *GOES* observations and called sometimes filter ratio techniqe). We must select two energy bands:

- should contain enough photons
- have substantially different dependence of emissivities on T

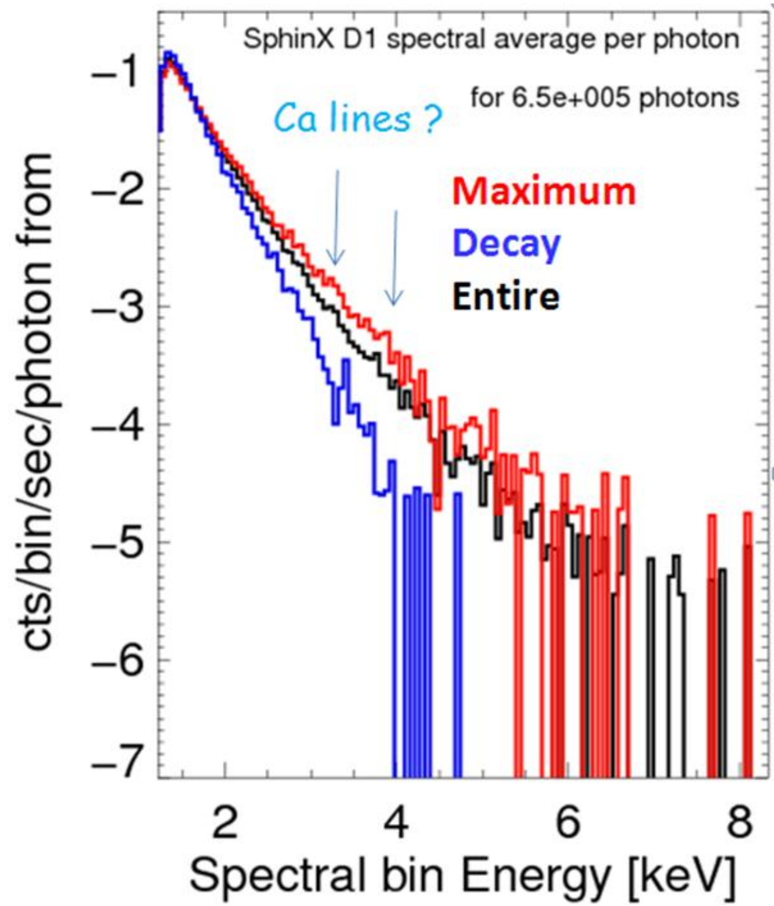


2: slope & total counts

Theory predicts monotonic dependence of the slope of the spectrum on the temperature:

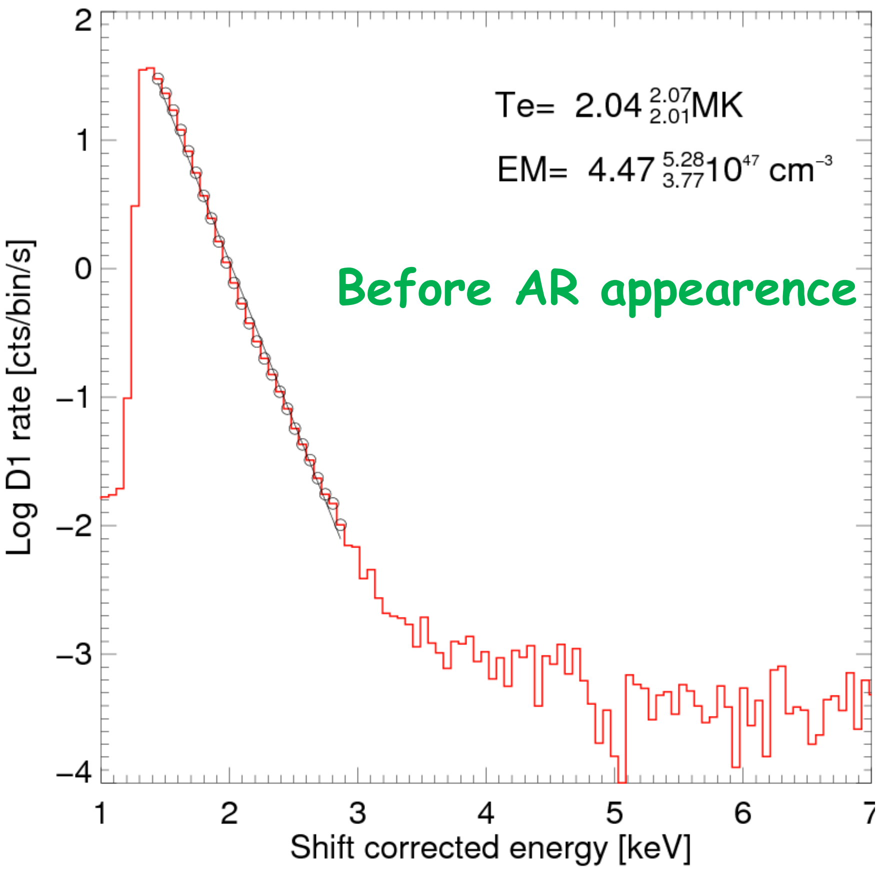


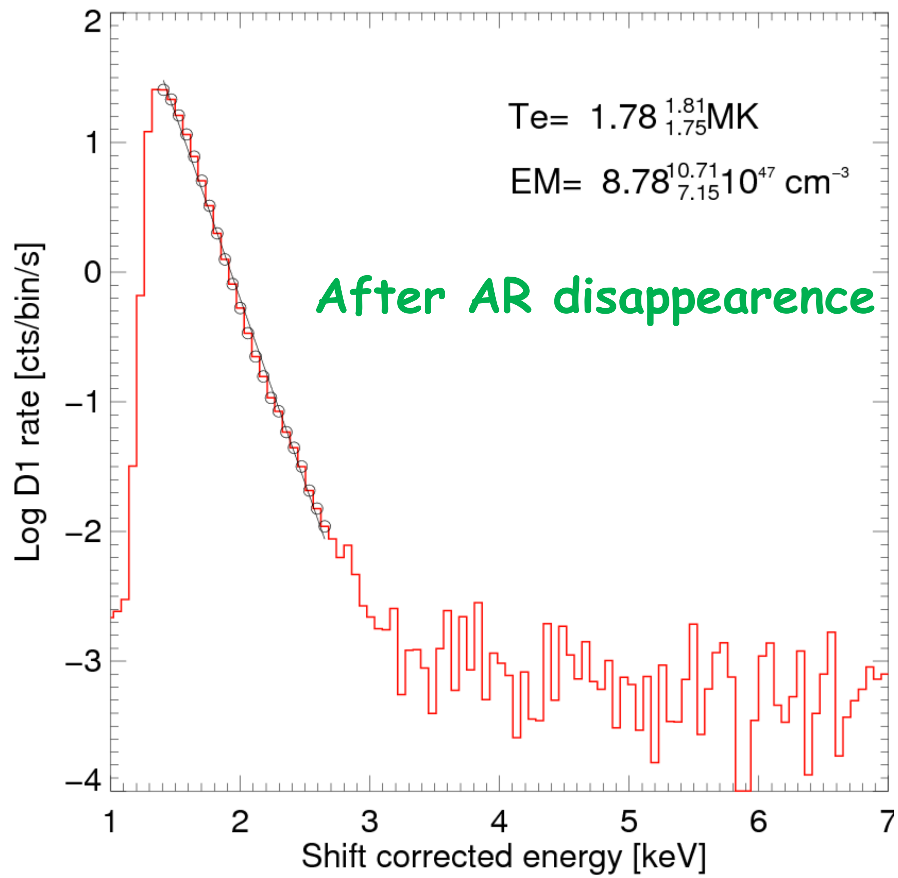
Fitting the observed spectrum inclination in the statistically important range (1.2 keV< E < 3 keV) defines **T**. Then **EM** is estimated from the total amount of photons above 1 keV.



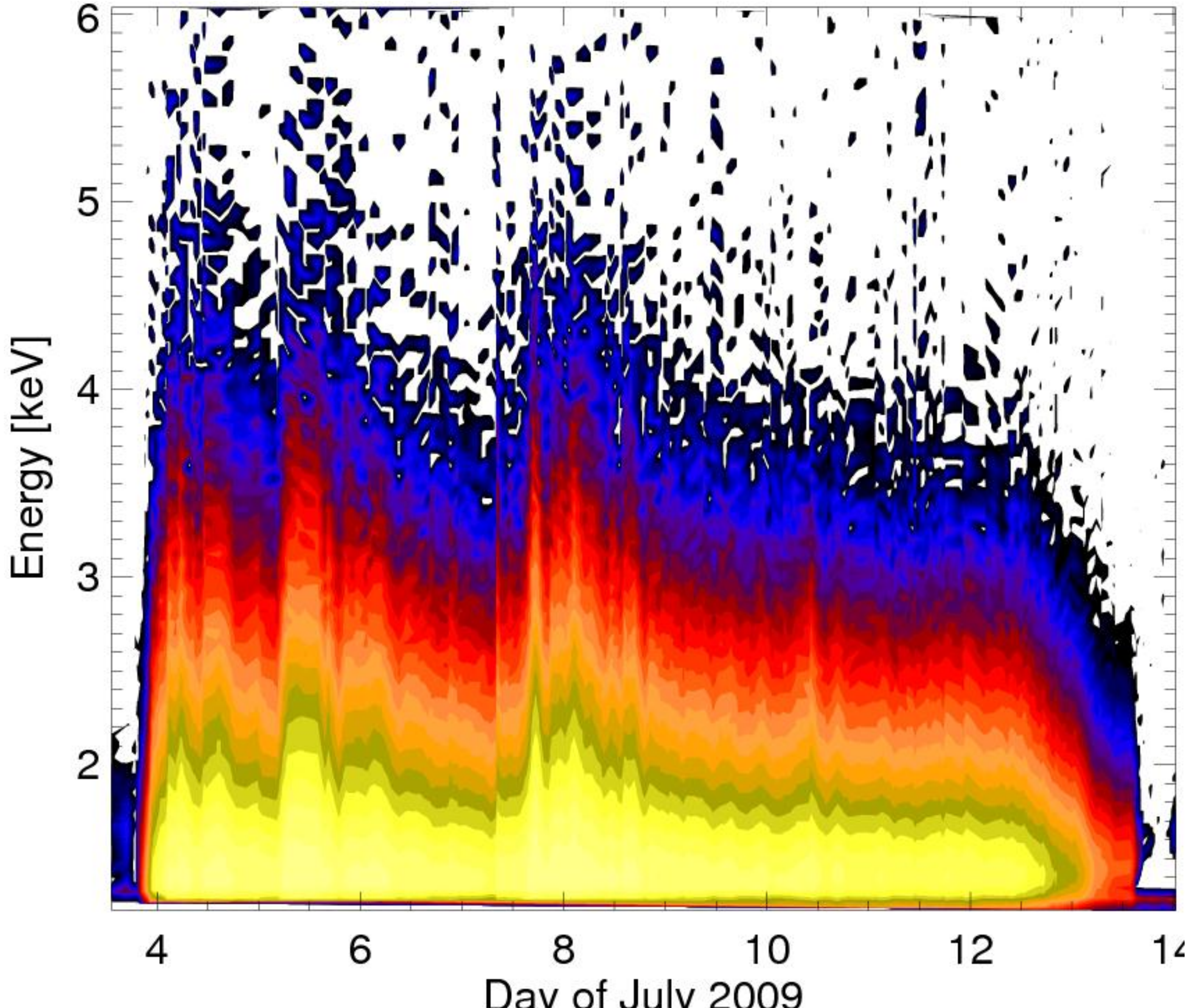
Results obtained using the method of fitting the inclination of the spectra support the results obtained using the energy bands ratio technique.

Quiet „non AR" Sun spectra
→ average T= ~1.9 MK

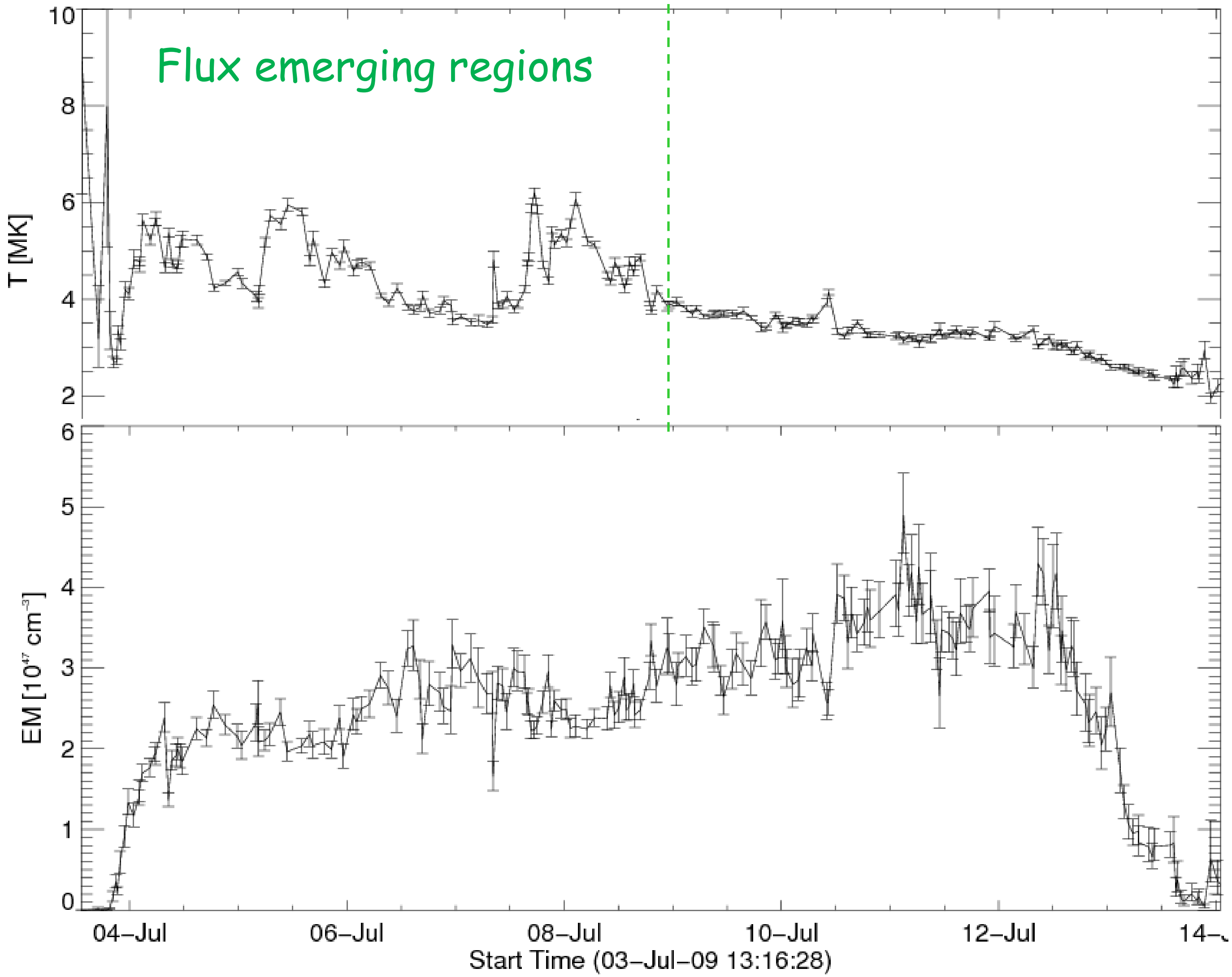




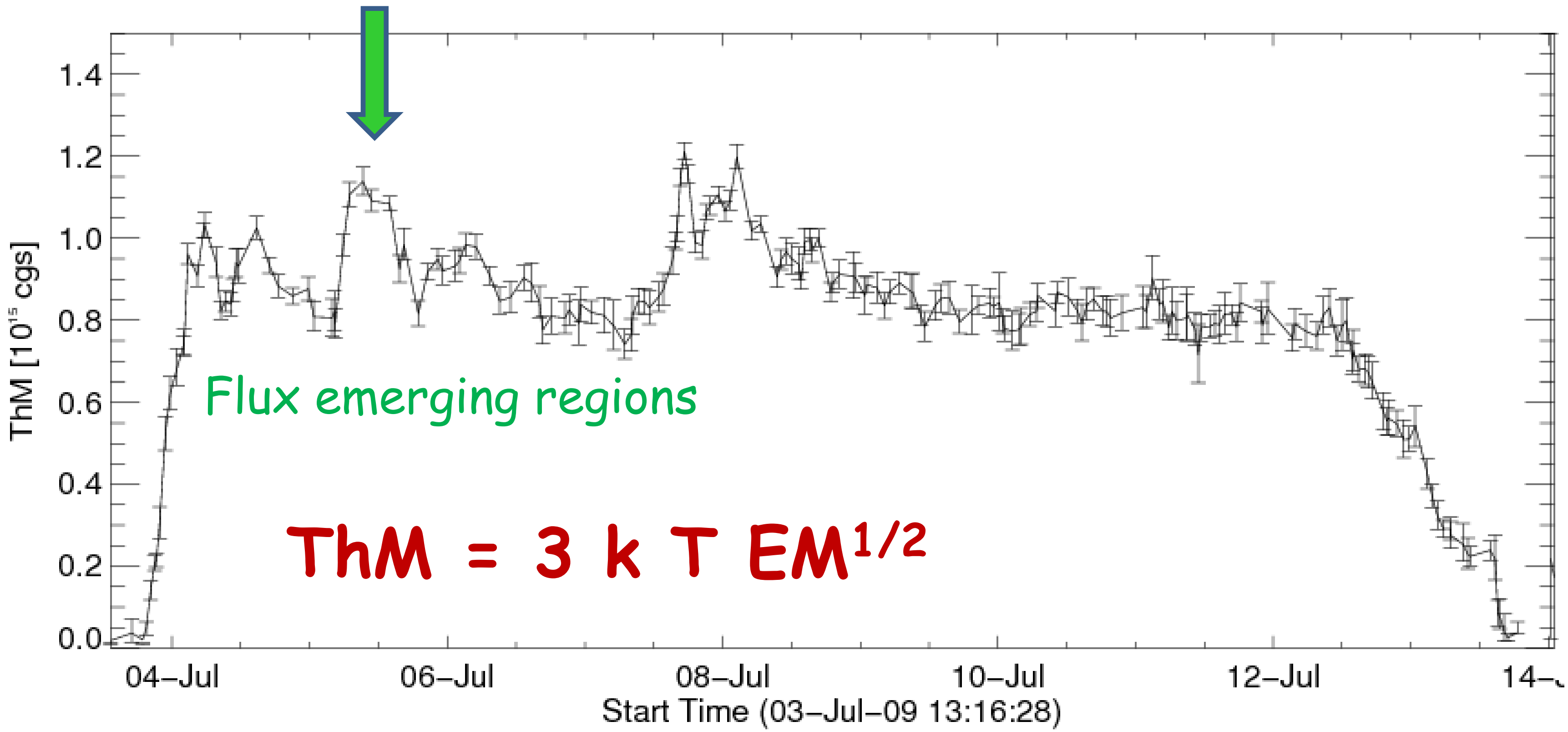
Evolution of AR 11024 spectra



T and EM evolution



AR thermodynamic measure

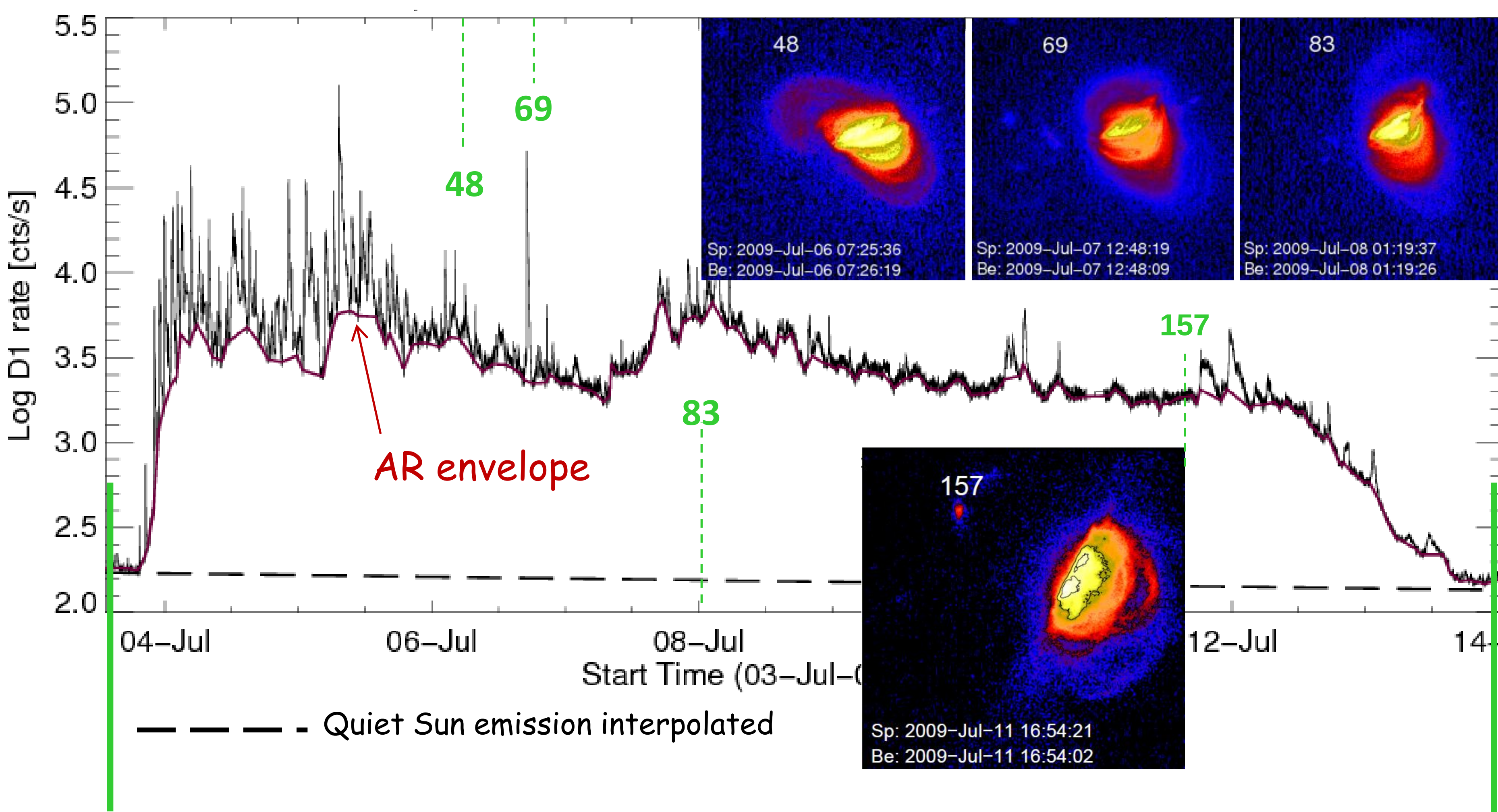


$E_{th} = 3\ k\ T\ N_e\ V$

$EM = N_e^2\ V \rightarrow Ne = EM^{1/2}\ V^{-1/2}$

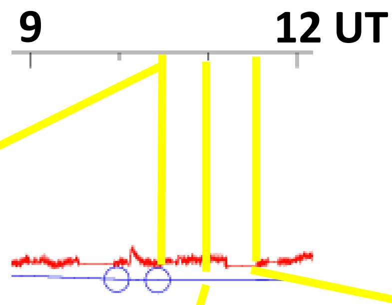
$E_{th} = 3\ k\ T\ EM^{1/2}\ V^{1/2} = V^{1/2}\ ThM$

Total flux above 1.19 keV

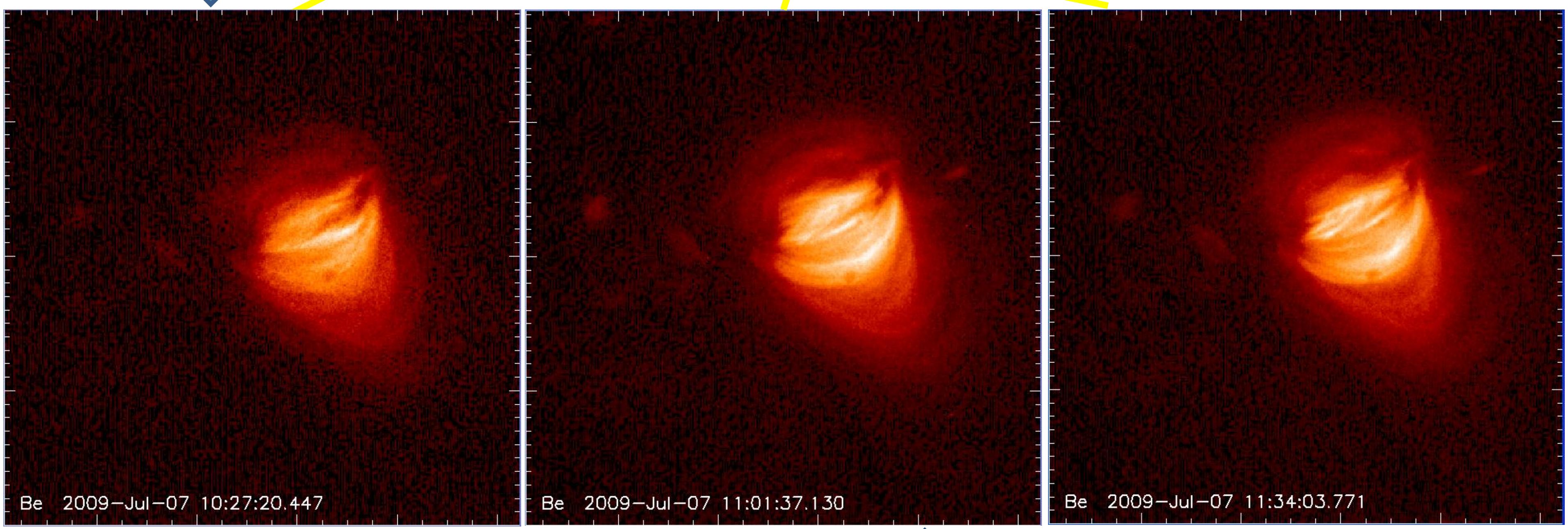


Hinode SXT high resolution sequences → 81 points common within 2 min.

Non-flaring intervals: 7 July 2009

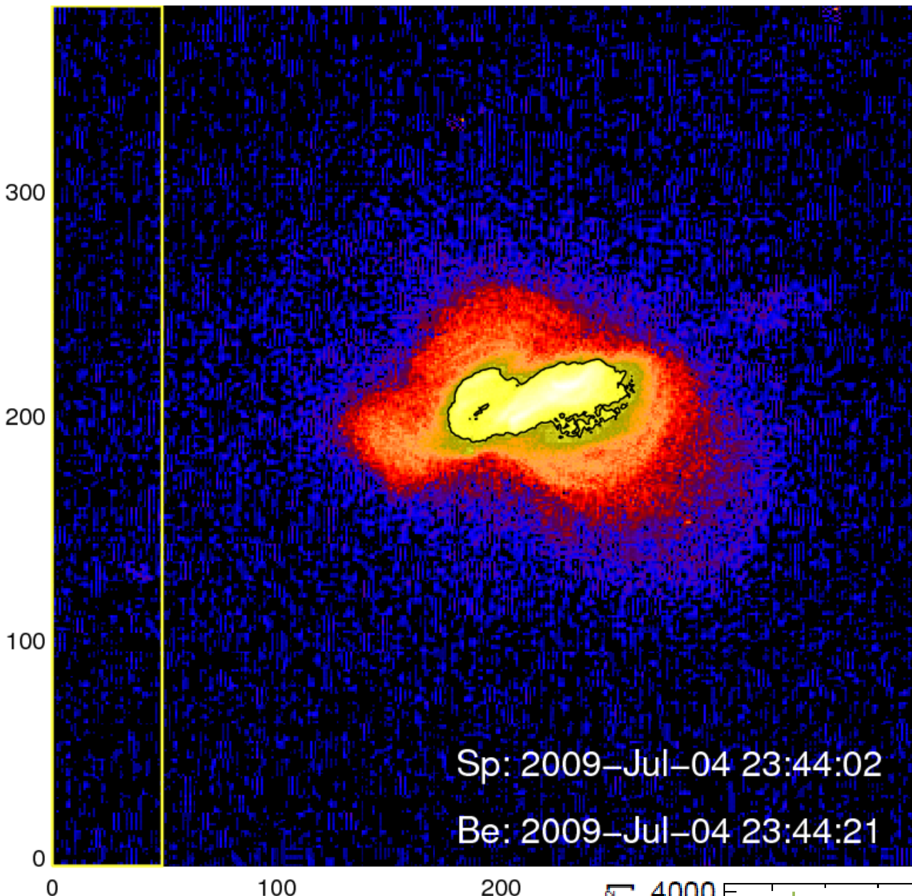


SphinX 67 interval:
10:25:18 ÷ 10:27:11 UT
average: 10:26:15 UT



SphinX 68 interval:
11:11:31 ÷ 11:12:58 UT
average: 11:12:15 UT

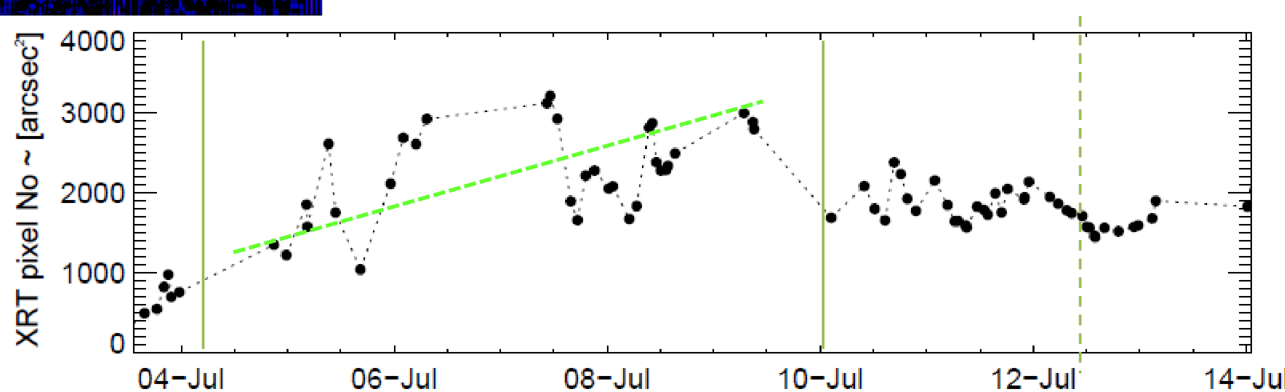
AR volume determination



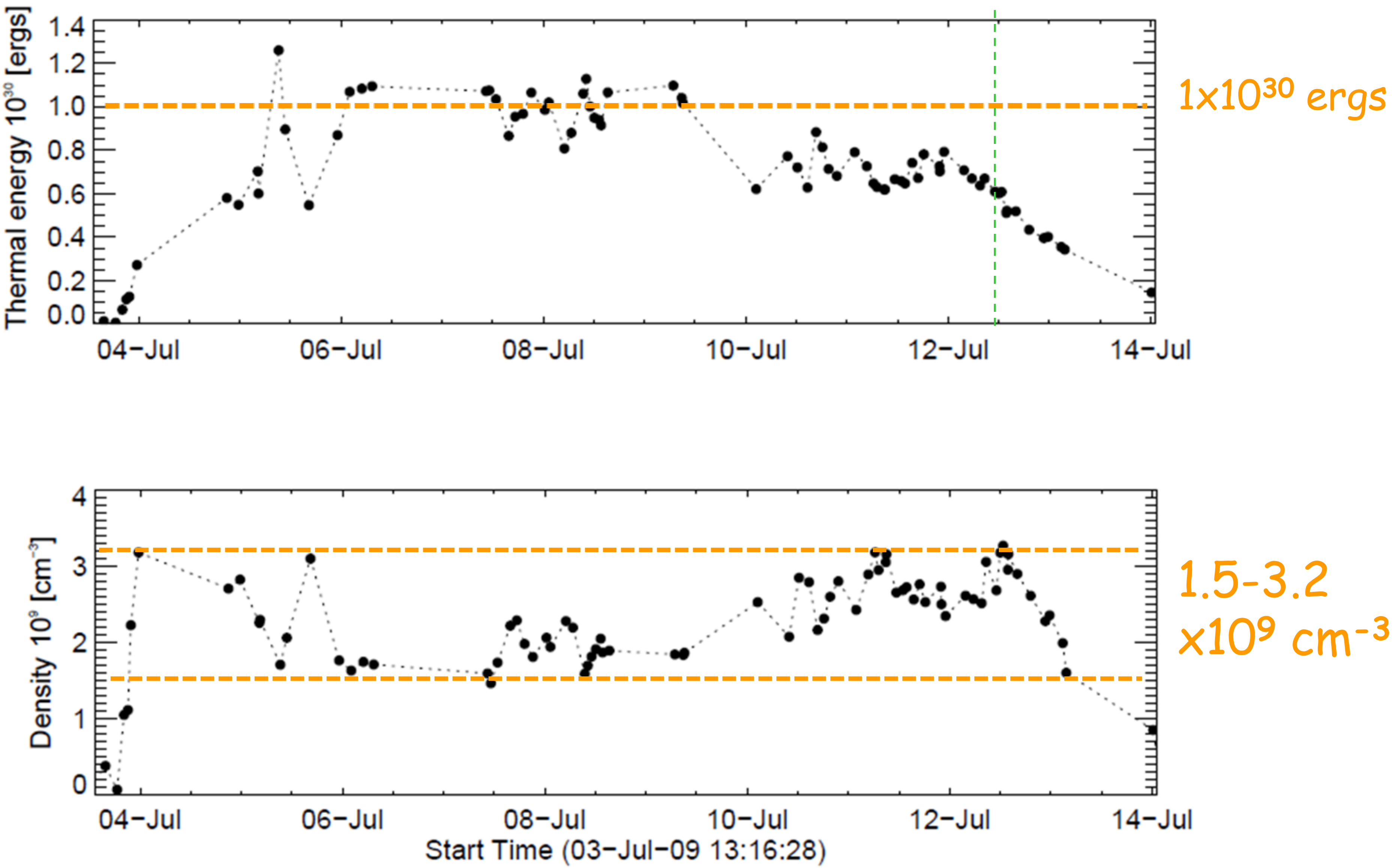
Pixels within the area above 50%
of the total flux in Hinode XRT Be image→
equivalent volume
circle with the same amount of pixels

81 times identified when AR spectra and XRT images were taken within 2 min.

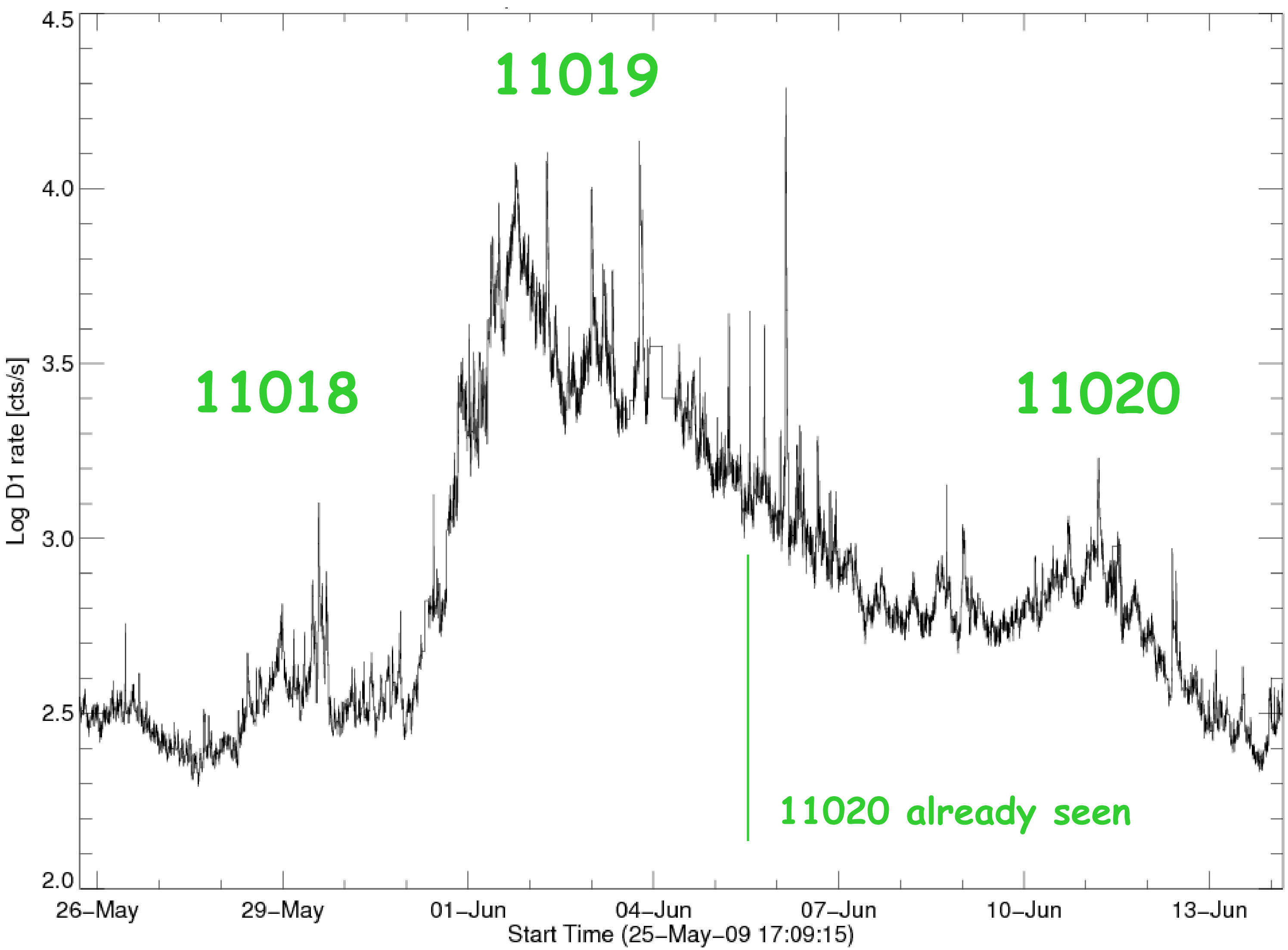
Slow AR volume variations
(on time scales of hours)



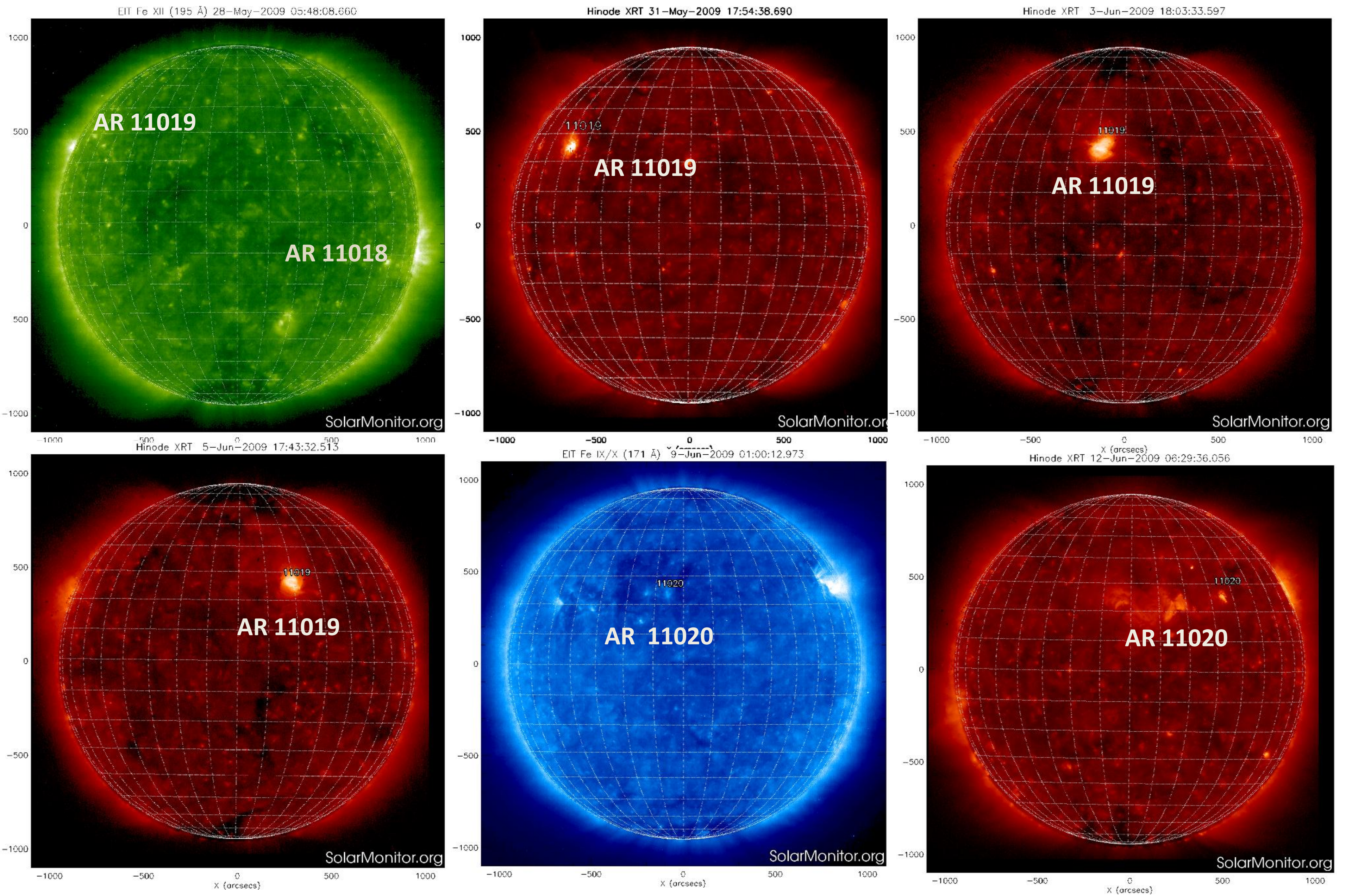
AR thermal energy & density



AR 11019 lightcurve



28.05, 31.05; 3.06, 5.06, 10.06, 12.06.2009



Concluding remarks

- The UV activity of AR 11024 region follows the X-ray one with some 2 hours delay.
- The average temperature for quiet Sun emission preceeding/following the Ar 11024 appearence is T ~1.9 MK as determined from SphinX data.
- The sequence of Hinode images in full XRT resolution → the morphology, its evolution and results in determination of emitting volume history.
- Temperature of AR 11024 is the highest when the region is young – this is connected with persistent emerging flux regions observed.
- The thermodynamic measure is a very good & observationally robust characteristic to be widely used is studies of energy balance.
- Provided the volume estimates are available the evolution of thermal energy content and the density can be investigated.
- Current work: the ARs evolution and individual events analysis.