



# REVIEW OF SOLAR ACTIVE REGION PROPERTIES DURING VERY LOW ACTIVITY LEVEL

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Research in Astrophysics from Space (E), Coronal Heating (E2.5)

# OUTLINE

- SphinX instrument, data and mission
- SphinX AR observations
- Preparation of data for analysis
- Examples of data analysis for AR 11017 and 11024
- Conclusions

# SphinX - Solar Photometer in X-rays



~3.7 kg

~10 W (peak)

0.85 keV -15 keV

~1  $\mu$ s

time accuracy

# SphinX detectors

## Si PIN diodes Amptek XR 100-CR

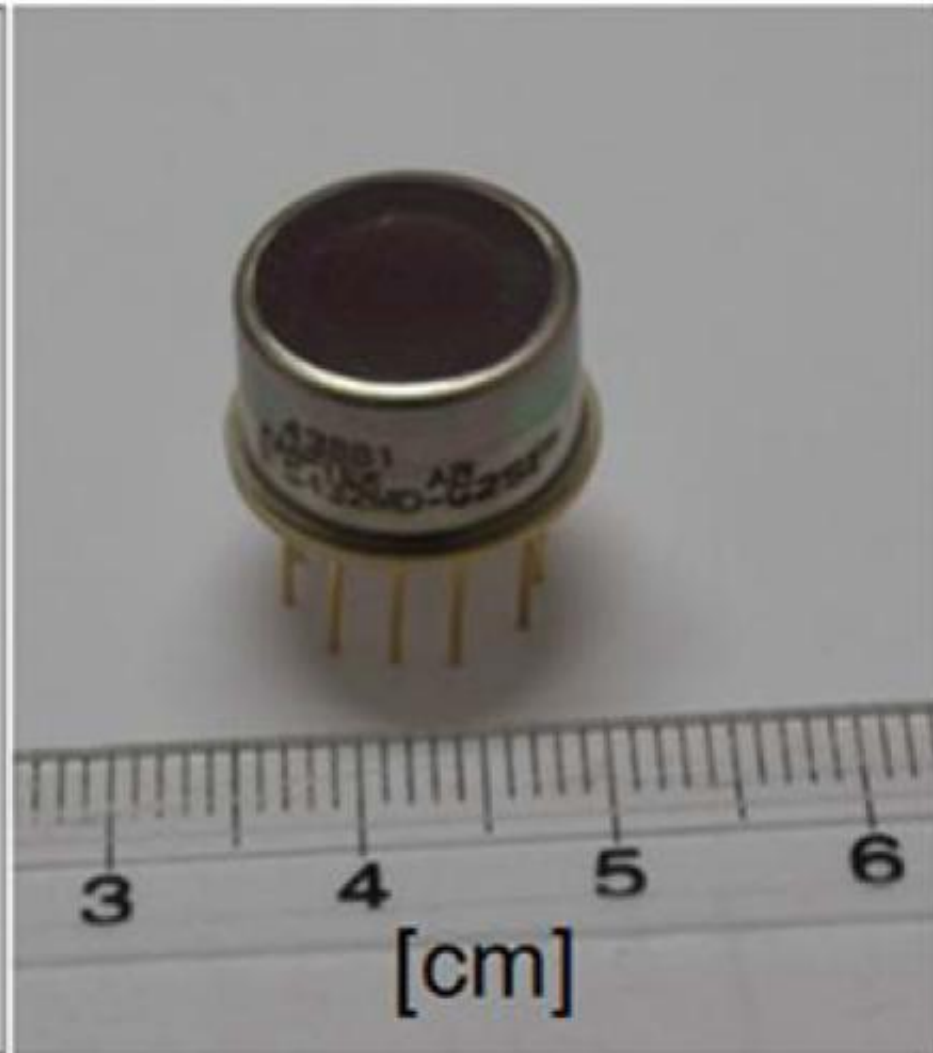
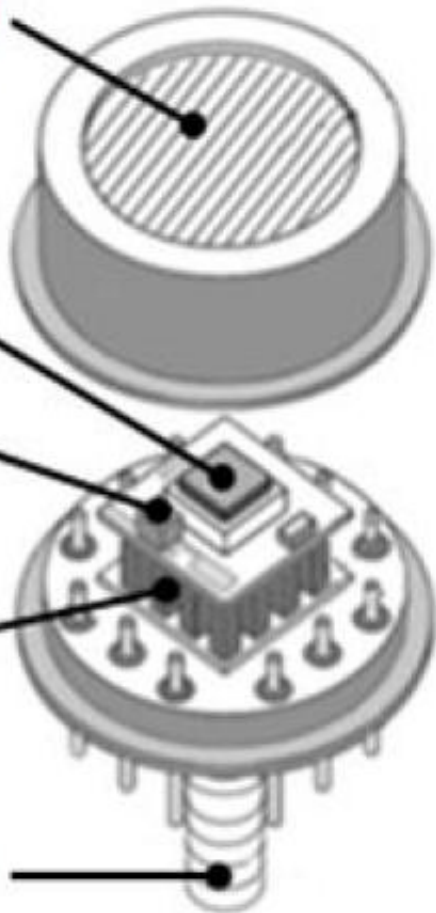
Beryllium window

Silicon crystal

FET transistor

Peltier cooler

Mounting stand



# SphinX data repository

[http://156.17.94.1/sphinx\\_l1\\_catalogue/SphinX\\_cat\\_main.html](http://156.17.94.1/sphinx_l1_catalogue/SphinX_cat_main.html)

## SphinX data catalogue

All SphinX data available here are Level\_1 data.

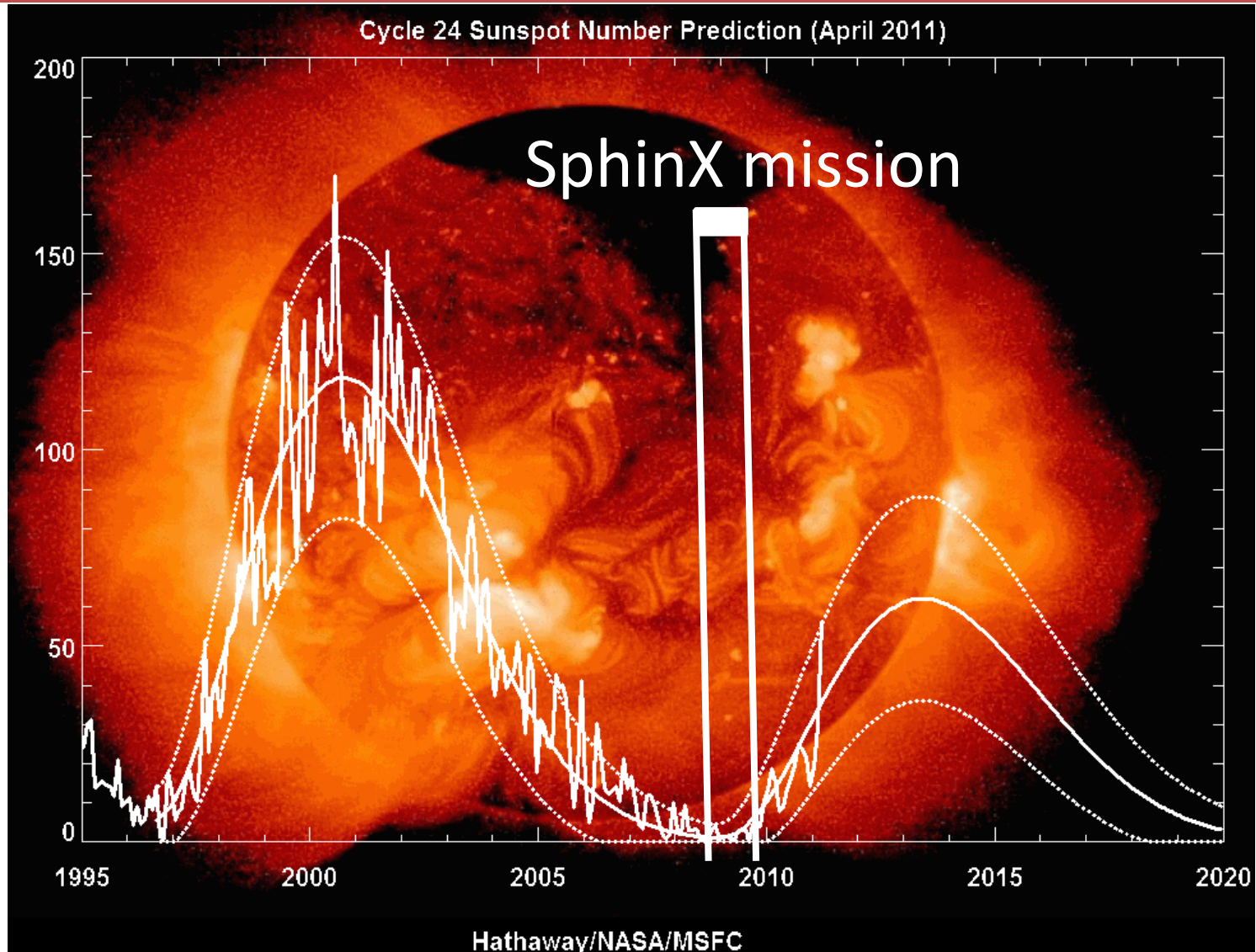


| 2009      |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|-----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| January   | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| February  | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |    |    |    |
| March     | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| April     | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |    |
| May       | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| June      | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |    |
| July      | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| August    | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| September | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |    |
| October   | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| November  | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |    |
| December  | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |

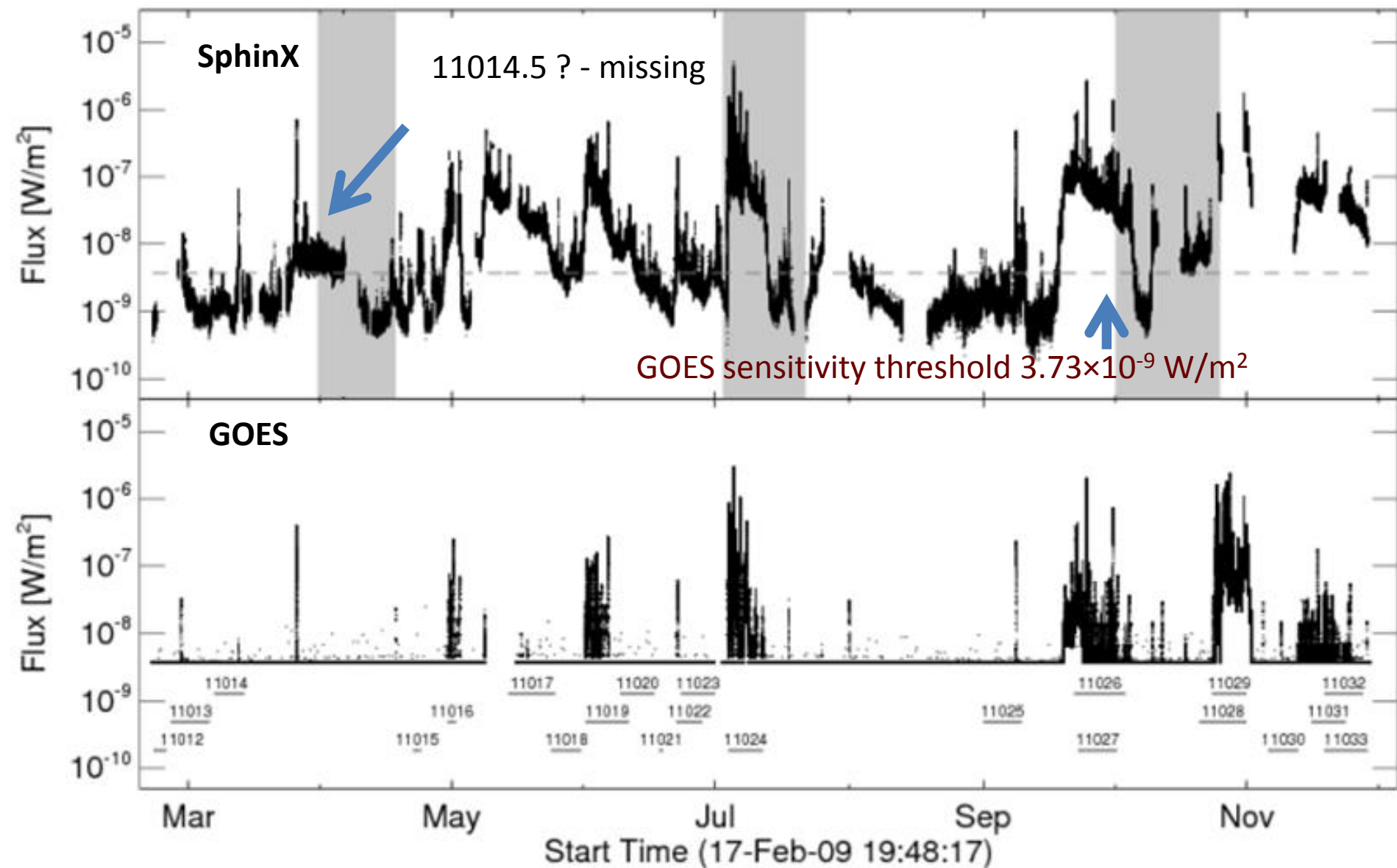
[Legend](#) [SphinX level-1 data description, calibration info and software](#)

# SphinX mission

22 February – 29 November 2009



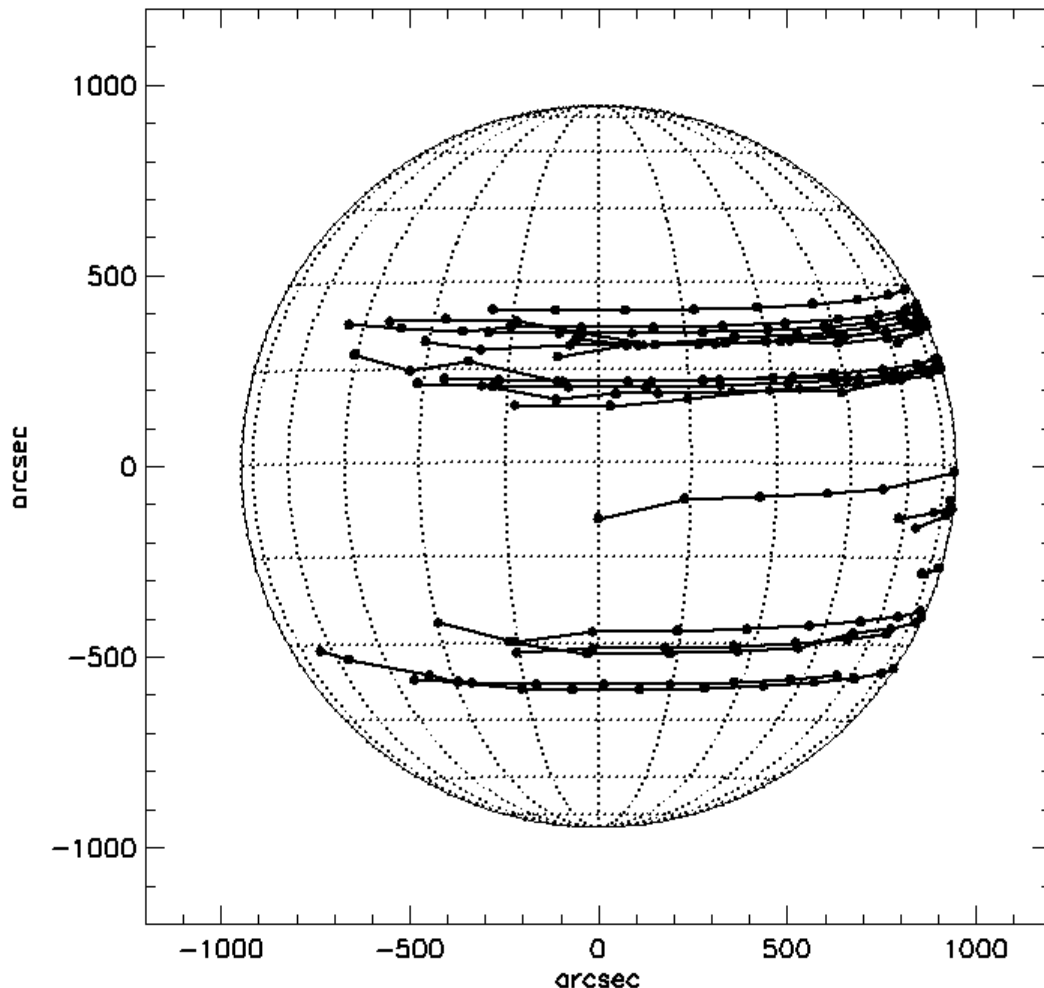
# SphinX observations



# AR seen during SphinX mission

Joint USAF/NOAA SolarRegion Summary reports

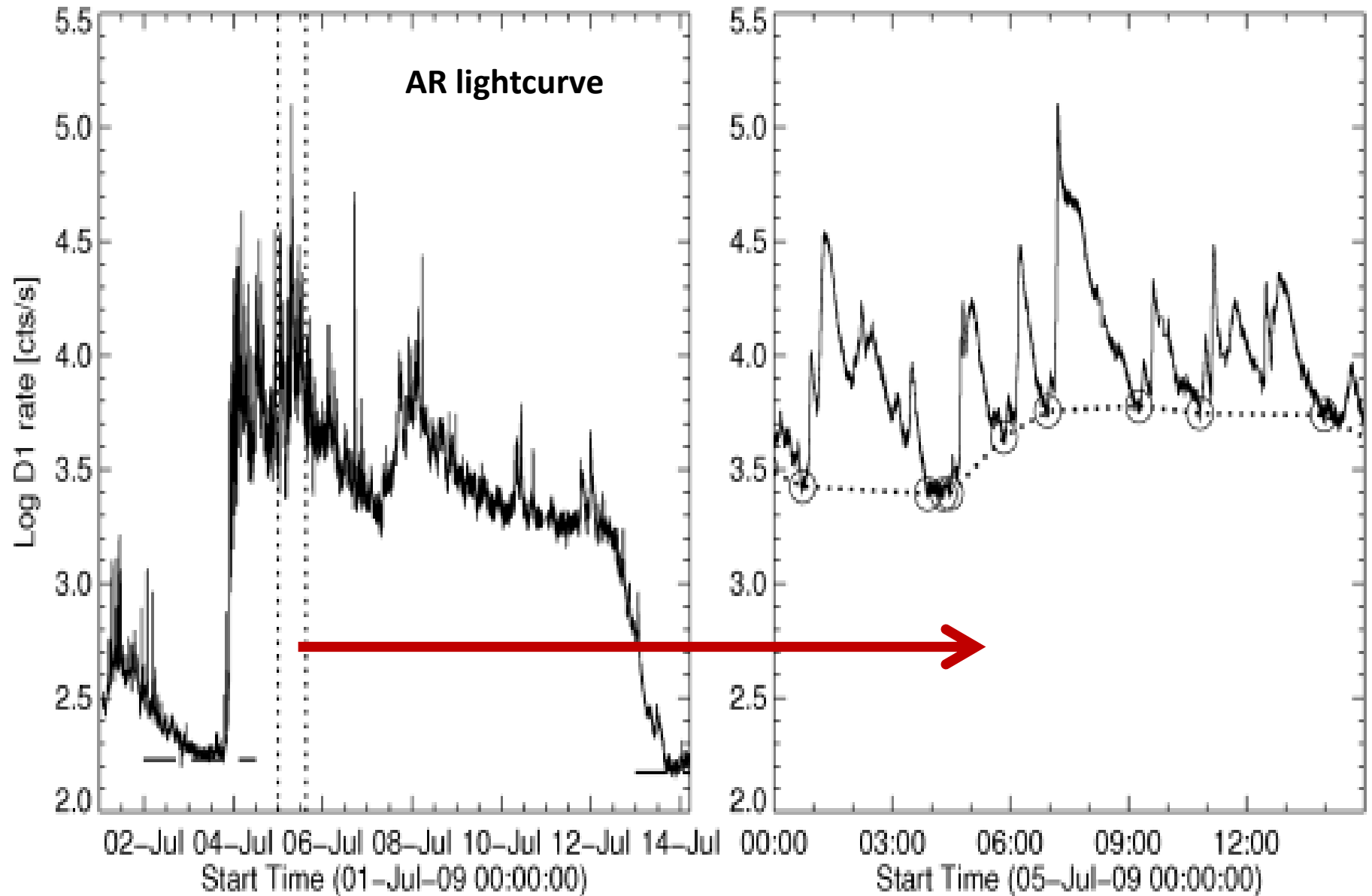
<http://www.swpc.noaa.gov/ftpmenu/warehouse.html>



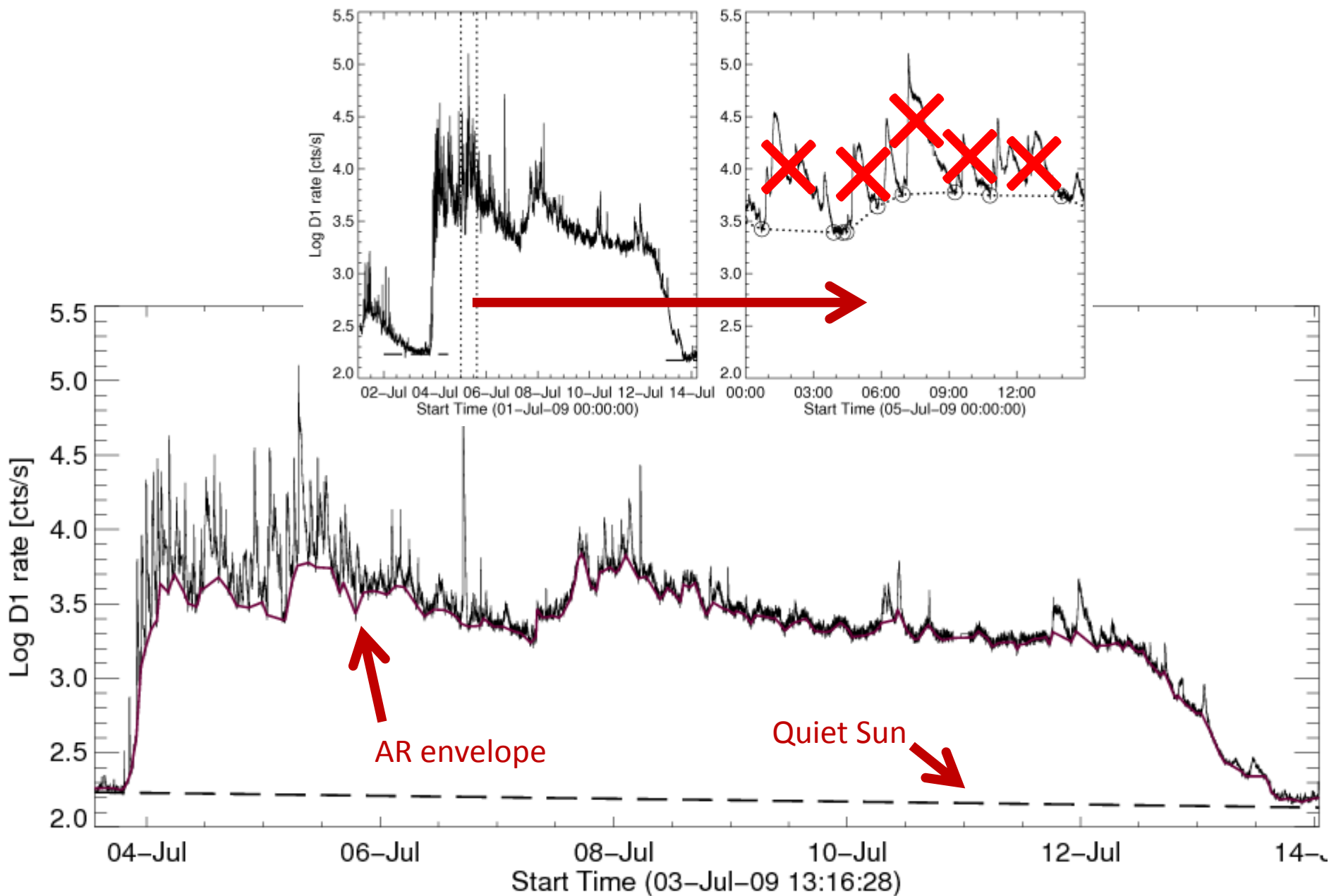
| No | NOAA AR number | date start | date end   | On disk [days] |
|----|----------------|------------|------------|----------------|
| 1  | 11012          | 2009-02-21 | 2009-02-24 | 4              |
| 2  | 11013          | 2009-02-25 | 2009-03-06 | 10             |
| 3  | 11014          | 2009-03-07 | 2009-03-14 | 6              |
| 4  | 11015          | 2009-04-22 | 2009-04-24 | 6              |
| 5  | 11016          | 2009-04-30 | 2009-05-02 | 6              |
| 6  | 11017          | 2009-05-14 | 2009-05-25 | 12             |
| 7  | 11018          | 2009-05-24 | 2009-05-31 | 8              |
| 8  | 11019          | 2009-06-01 | 2009-06-11 | 11             |
| 9  | 11020          | 2009-06-09 | 2009-06-17 | 9              |
| 10 | 11021          | 2009-06-18 | 2009-06-19 | 5              |
| 11 | 11022          | 2009-06-22 | 2009-06-28 | 7              |
| 12 | 11023          | 2009-06-23 | 2009-07-01 | 9              |
| 13 | 11024          | 2009-07-04 | 2009-07-12 | 12             |
| 14 | 11025          | 2009-09-01 | 2009-09-10 | 10             |
| 15 | 11026          | 2009-09-22 | 2009-10-04 | 13             |
| 16 | 11027          | 2009-09-23 | 2009-10-02 | 13             |
| 17 | 11028          | 2009-10-21 | 2009-11-01 | 12             |
| 18 | 11029          | 2009-10-24 | 2009-11-01 | 13             |
| 19 | 11030          | 2009-11-06 | 2009-11-13 | 11             |
| 20 | 11031          | 2009-11-16 | 2009-11-24 | 9              |
| 21 | 11032          | 2009-11-19 | 2009-11-28 | 10             |
| 22 | 11033          | 2009-11-19 | 2009-11-29 | 11             |



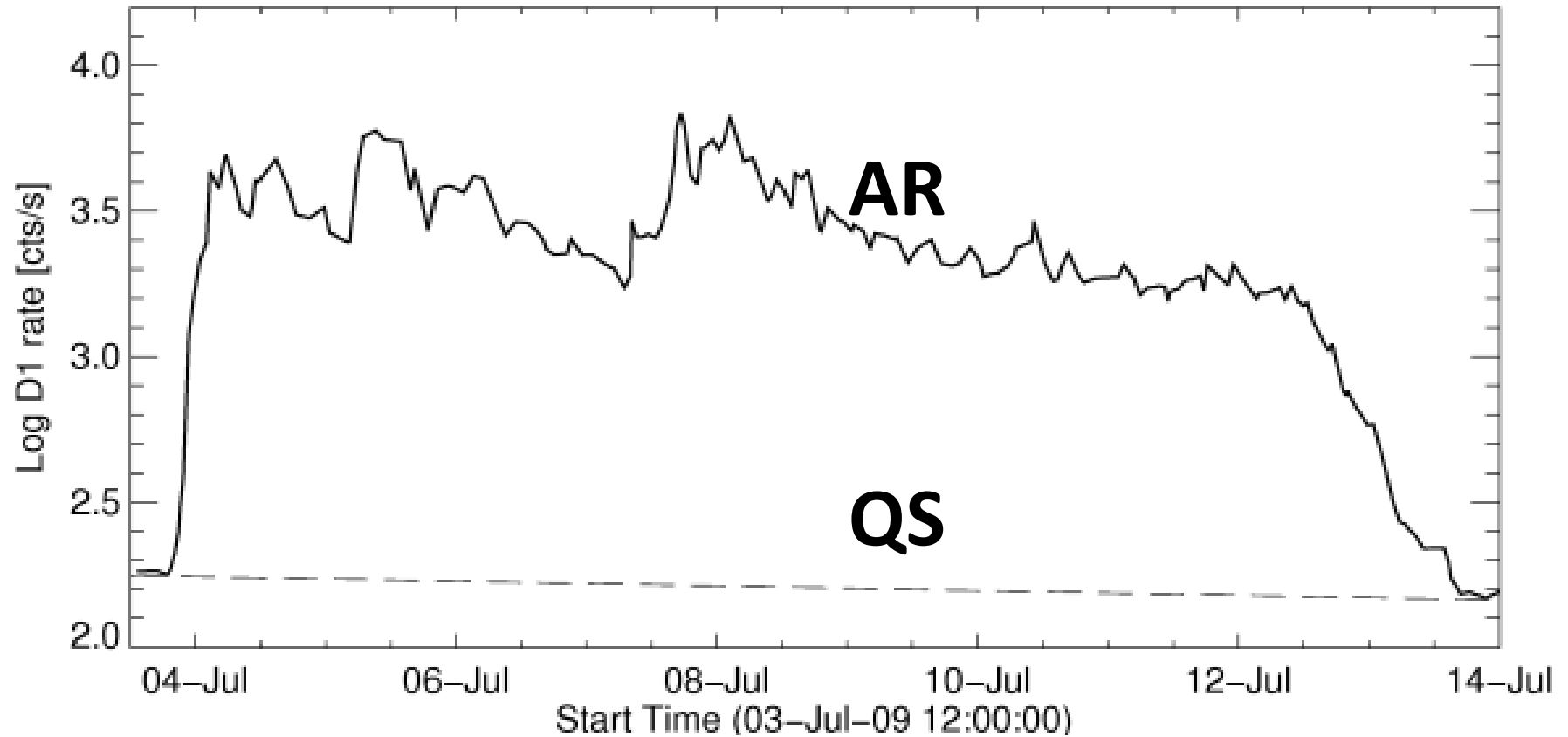
# Preparation of AR data for analysis



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# Preparation of AR data for analysis

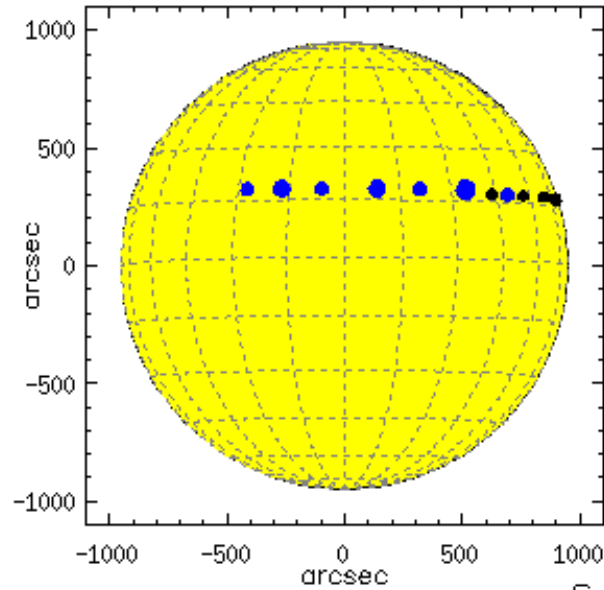


# AR data analysis on examples

**AR 11017**

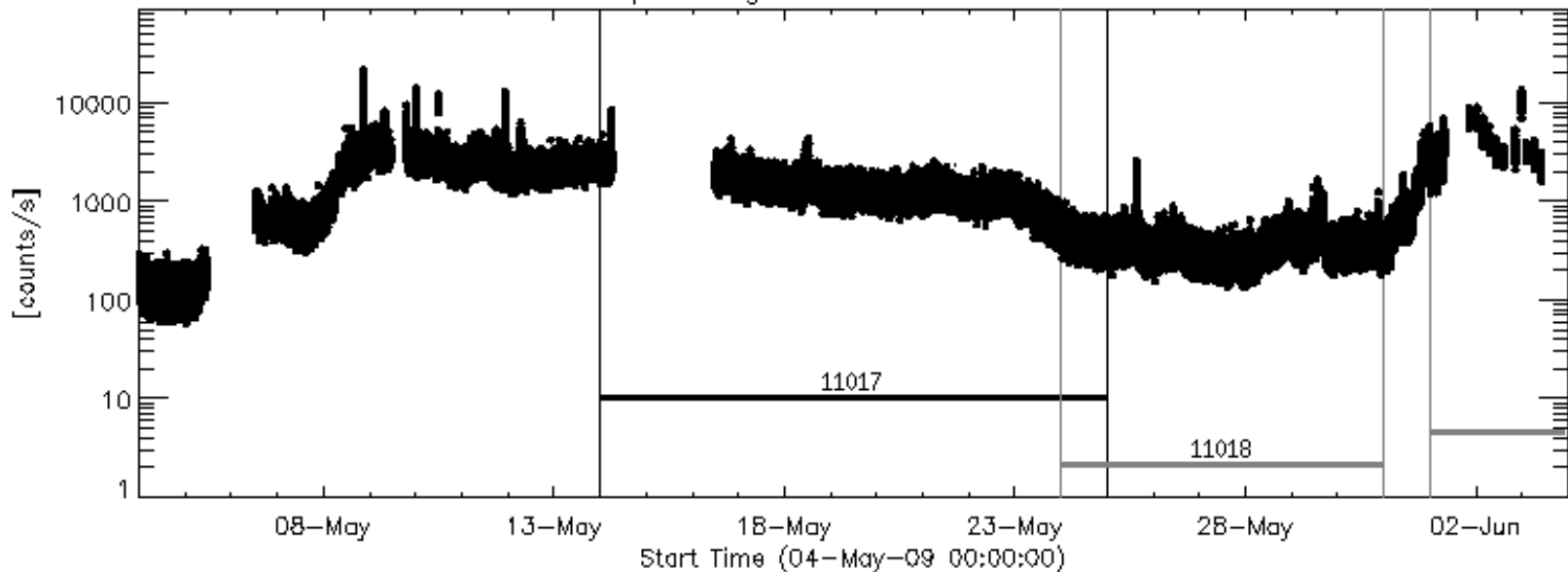
**AR 11024**

# AR 11017 - overview

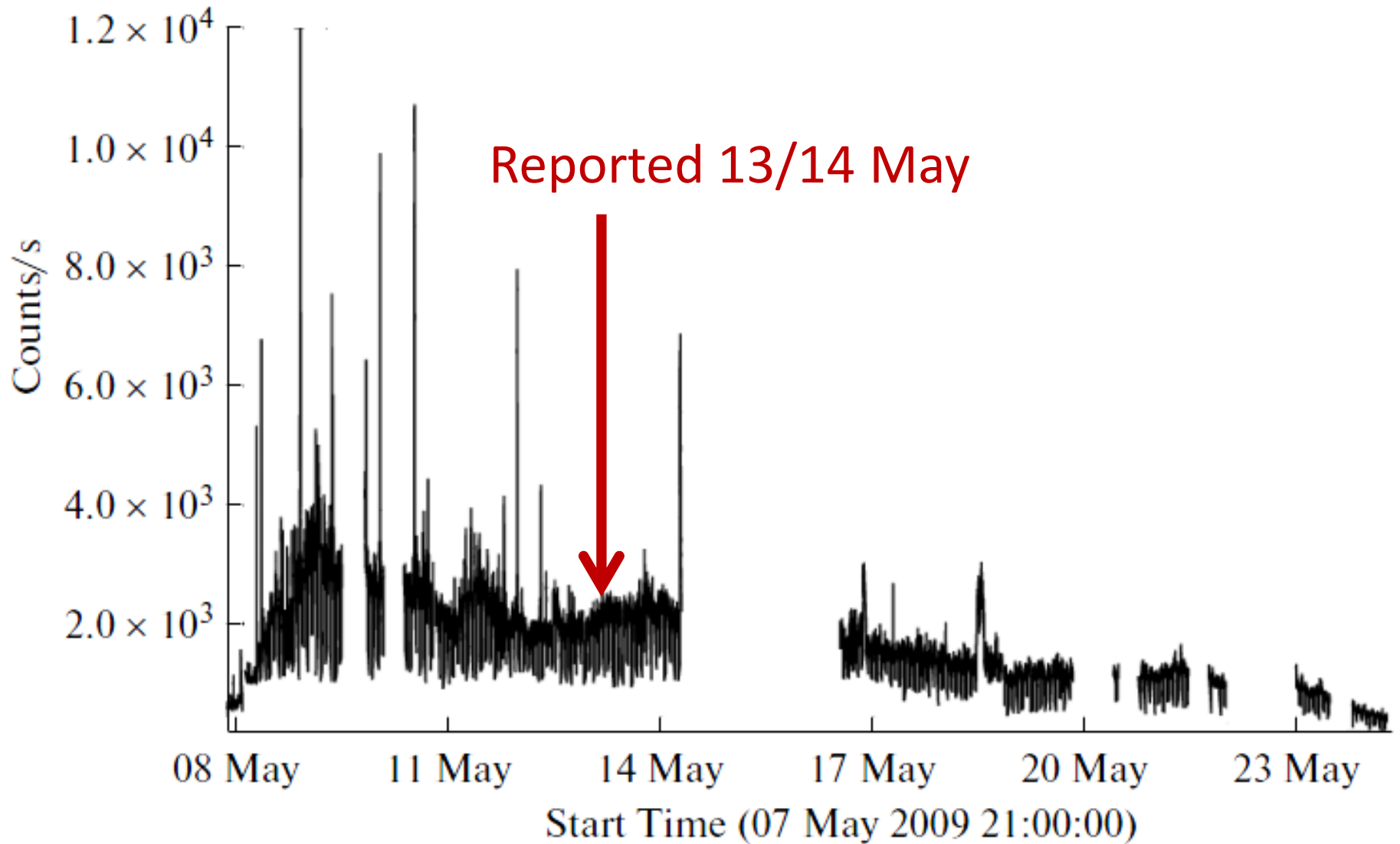


| Id | Date       | Location | Mag. Type |
|----|------------|----------|-----------|
| 1  | 2009-05-14 | N18E27   | $\beta$   |
| 2  | 2009-05-15 | N18E17   | $\beta$   |
| 3  | 2009-05-16 | N18E06   | $\beta$   |
| 4  | 2009-05-17 | N18W09   | $\beta$   |
| 5  | 2009-05-18 | N18W21   | $\beta$   |
| 6  | 2009-05-19 | N18W35   | $\beta$   |
| 7  | 2009-05-20 | N17W50   | $\alpha$  |
| 8  | 2009-05-21 | N17W44   |           |
| 9  | 2009-05-22 | N17W57   |           |
| 10 | 2009-05-23 | N17W70   |           |
| 11 | 2009-05-24 | N17W83   |           |
| 12 | 2009-05-25 | N17W96   |           |

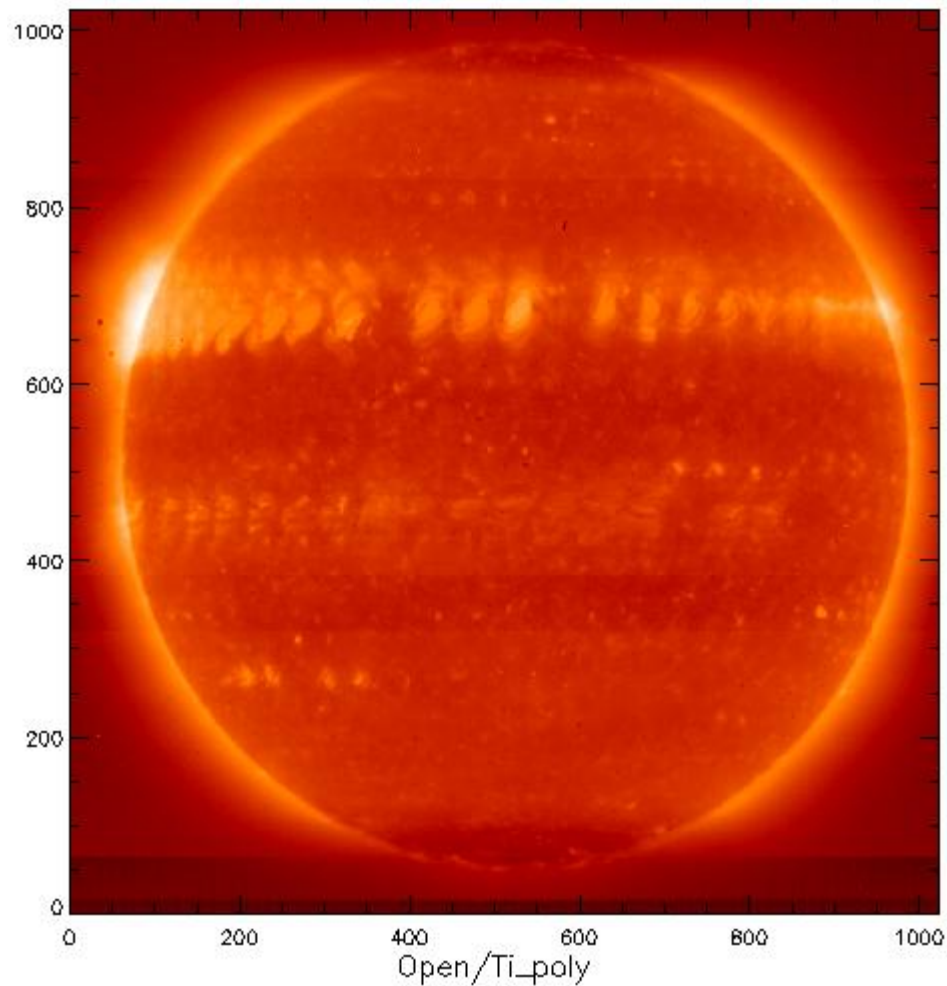
SphinX lightcurve for 11017 AR



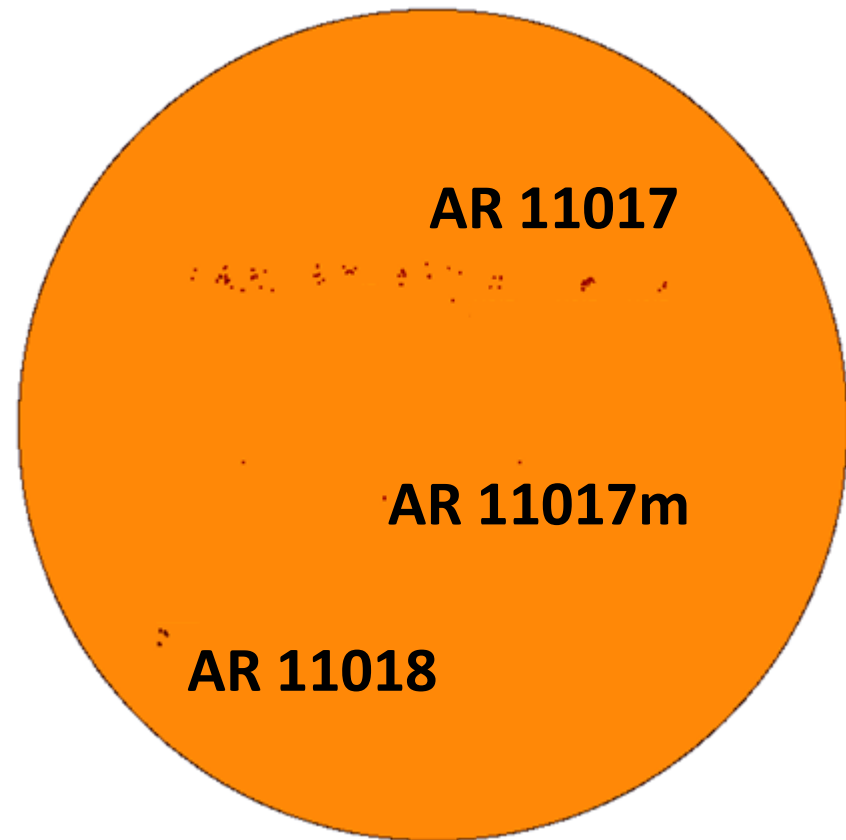
# AR 11017



# AR 11017



**XRT Ti-poly combined image**

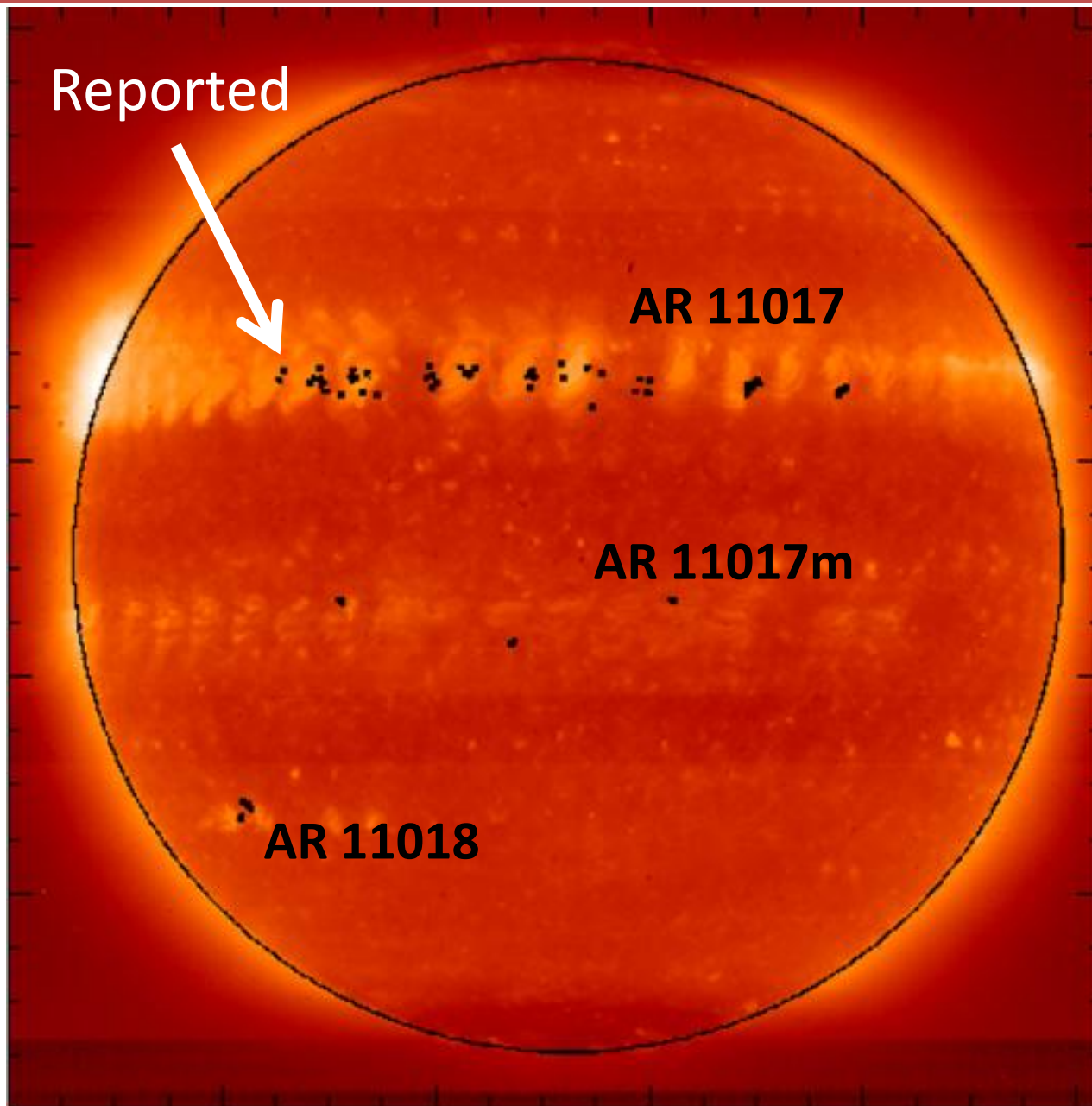


**SOHO/MDI - Debrecen Data  
(SDD)**

<http://fenyi.solarobs.unideb.hu/SDD/SDD.html>

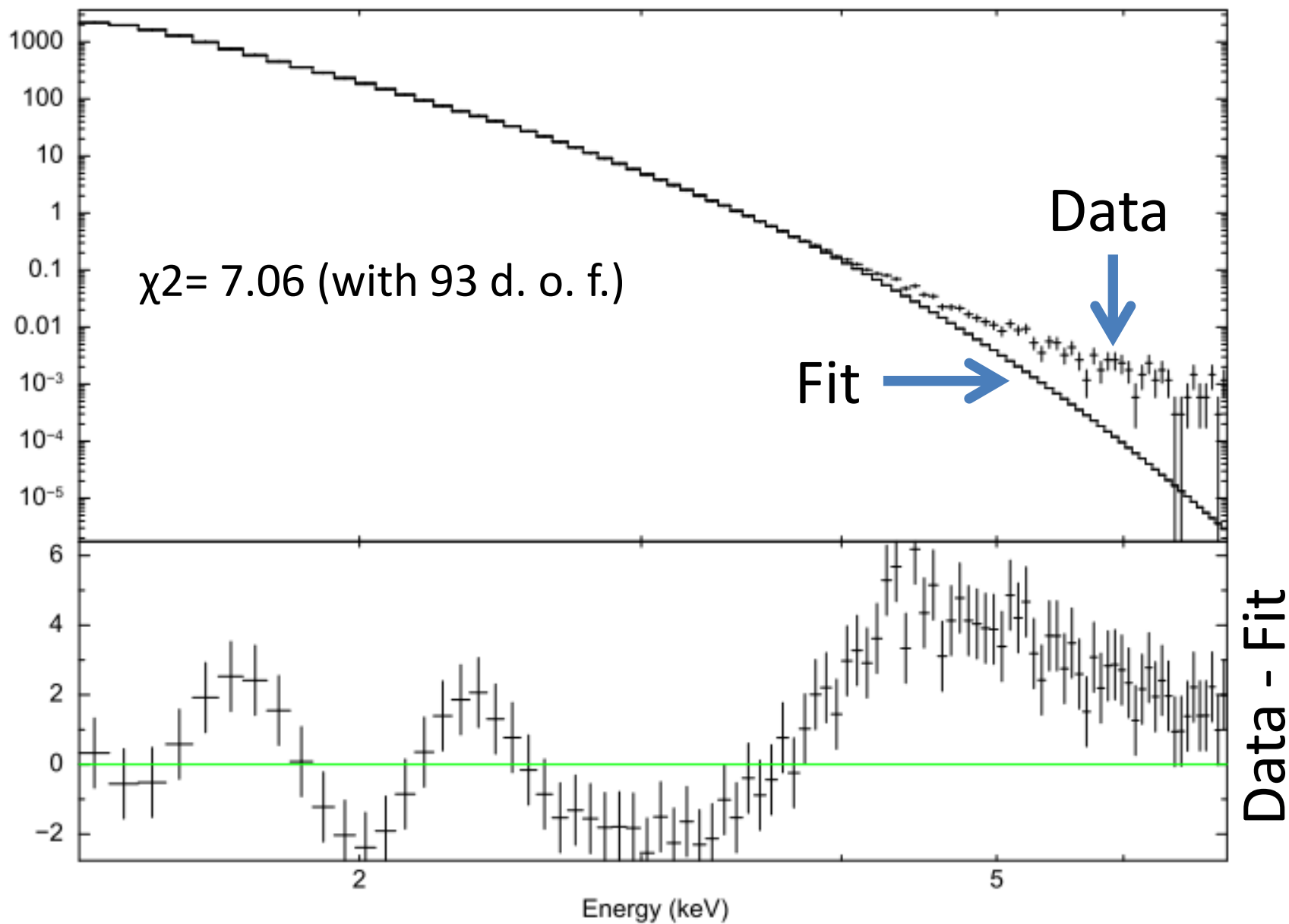
# AR 11017

**XRT + SDD superimposed**

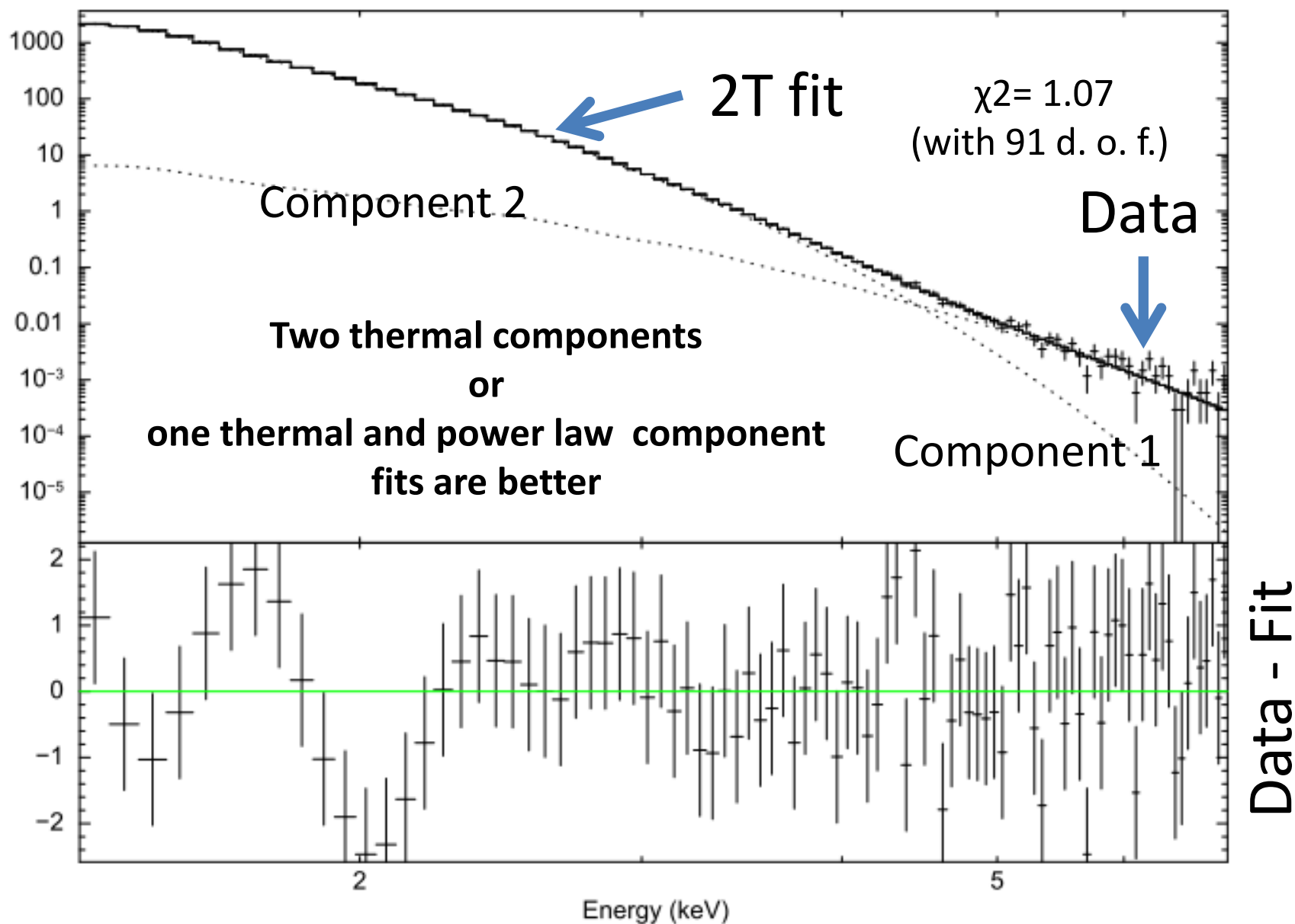




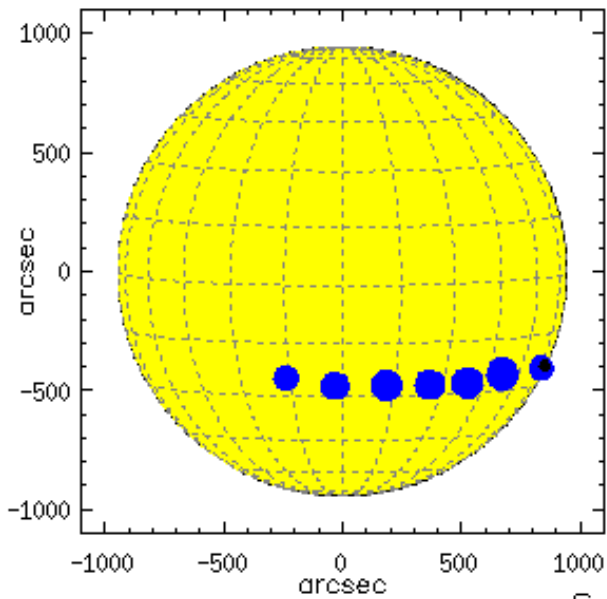
# AR 11017 spectrum – isothermal XSPEC fit



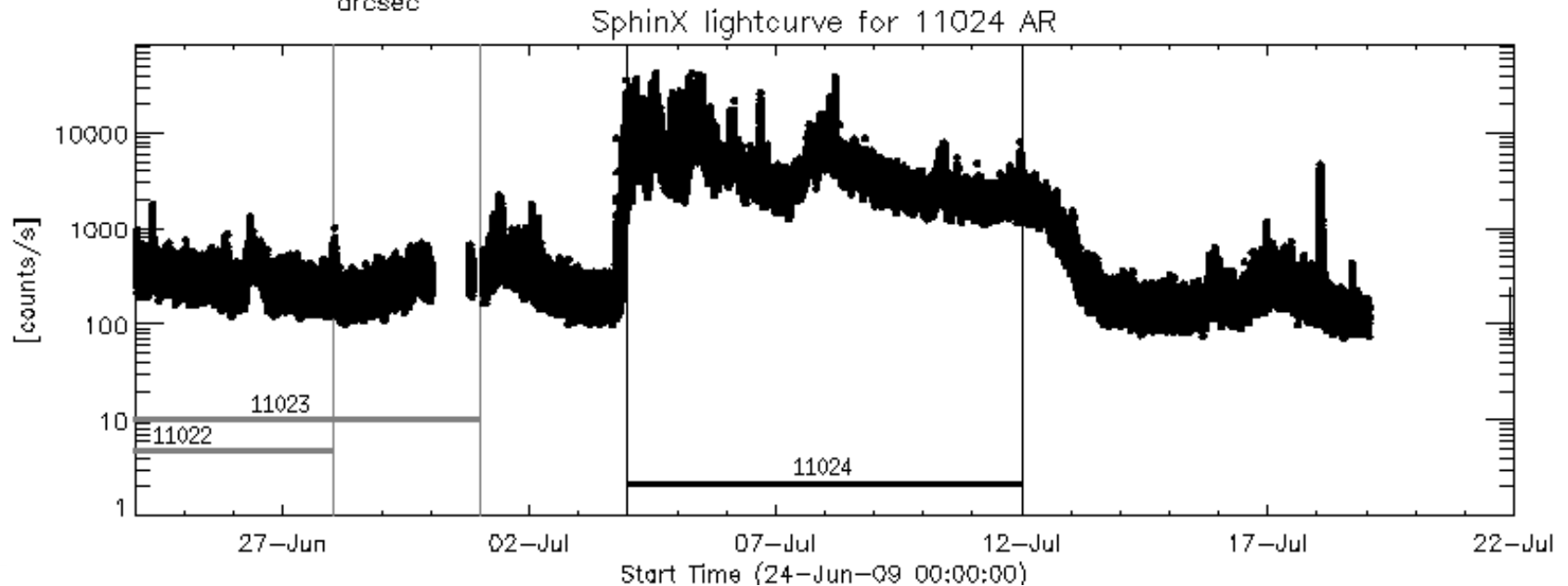
# AR 11017 spectrum – multicomponent XSPEC fit



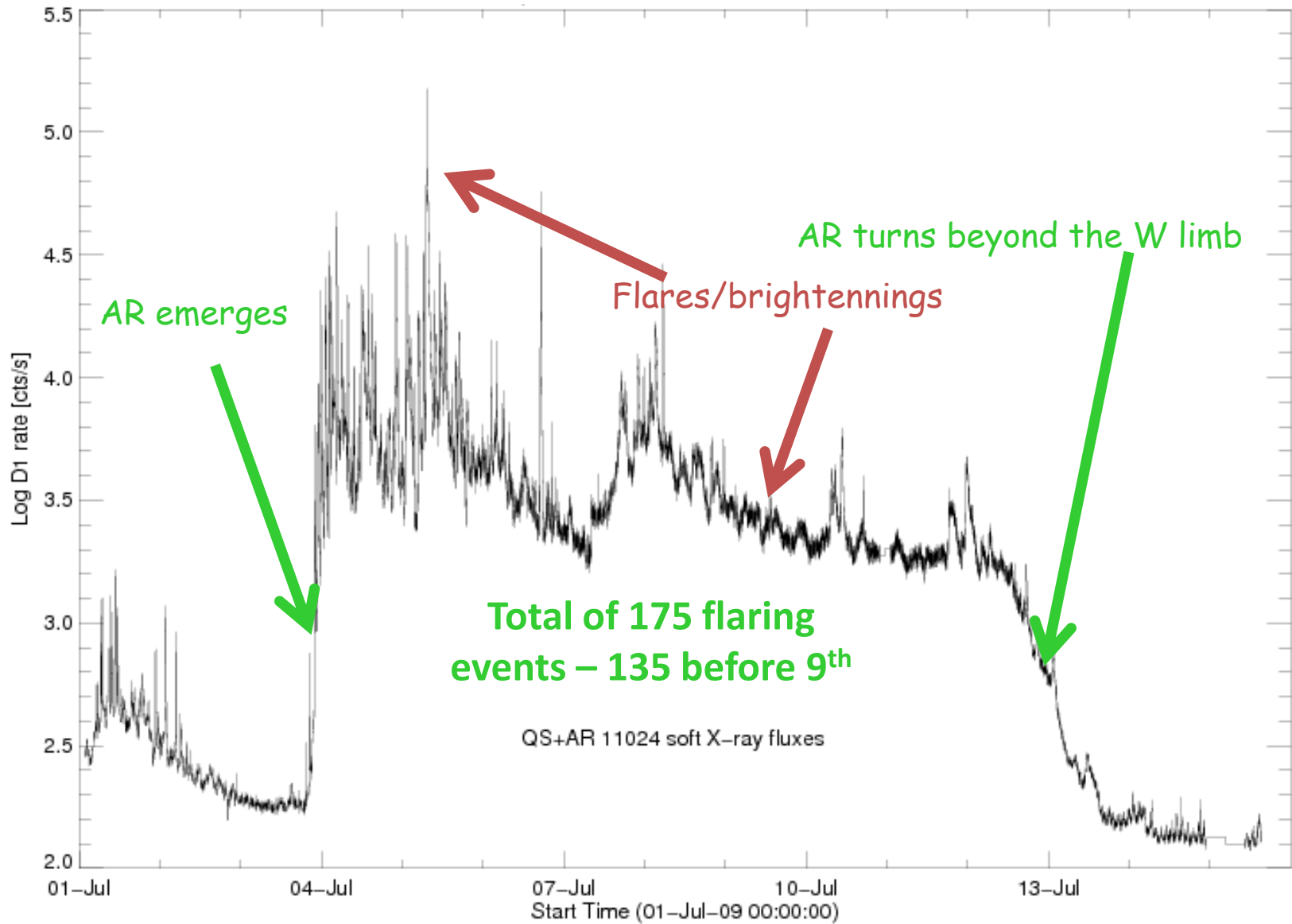
# AR 11024 - overview



| Id | Date       | Location | Mag. Type |
|----|------------|----------|-----------|
| 1  | 2009-07-04 | S25E16   | $\beta$   |
| 2  | 2009-07-05 | S27E02   | $\beta$   |
| 3  | 2009-07-06 | S27W13   | $\beta$   |
| 4  | 2009-07-07 | S27W26   | $\beta$   |
| 5  | 2009-07-08 | S27W39   | $\beta$   |
| 6  | 2009-07-09 | S25W52   | $\beta$   |
| 7  | 2009-07-10 | S25W65   | $\beta$   |
| 8  | 2009-07-11 | S25W79   | $\beta$   |
| 9  | 2009-07-12 | S25W90   |           |

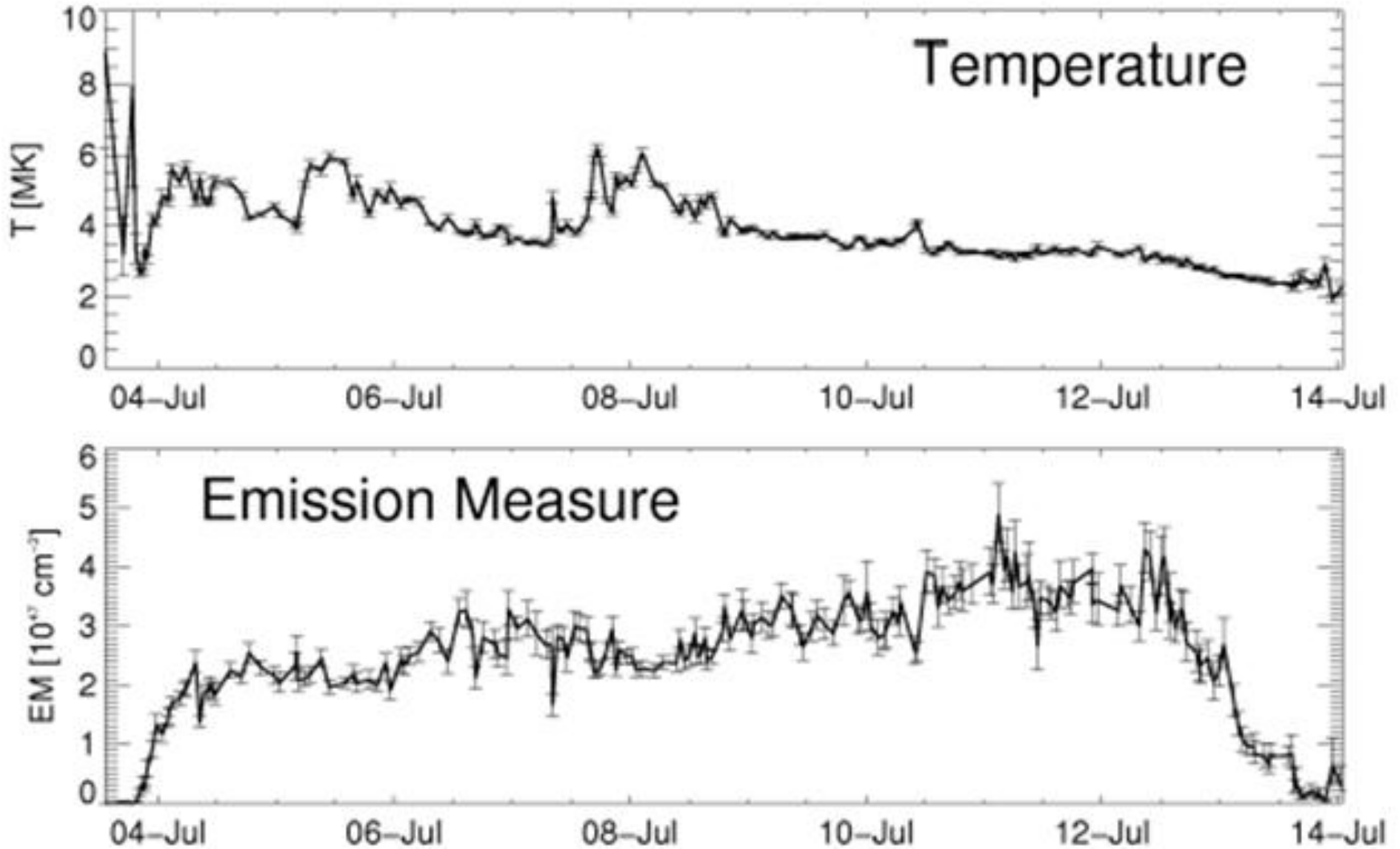


# AR 11024 - overview



# AR 11024

## Evolution of physical parameters of thermal plasma component



# Conclusions on SphinX AR observations

- SphinX data are useful to study AR properties in deep solar minimum of 2009 and early rise phase of cycle 24.
- SphinX data can be used to study space weather conditions during that period.
- SphinX observations allow to determine physical parameters of AR plasma
- Thermal model well explains most of plasma seen in AR.
- AR 11017 and 11024 temperatures are the highest in early development phase.
- Addition of a small thermal hot plasma component improves SphinX spectra fitting at high significance level.
- SphinX data do not allow to exclude that the excess in the hard energy tail is due to non-thermal emission.
- Addition of mixed thermal and nonthermal components also can explain the SphinX observations.
- In any case the above supports the presence of heating processes in AR plasma.



# Thank You

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