Solar corona during last activity minimum based on SphinX measurements

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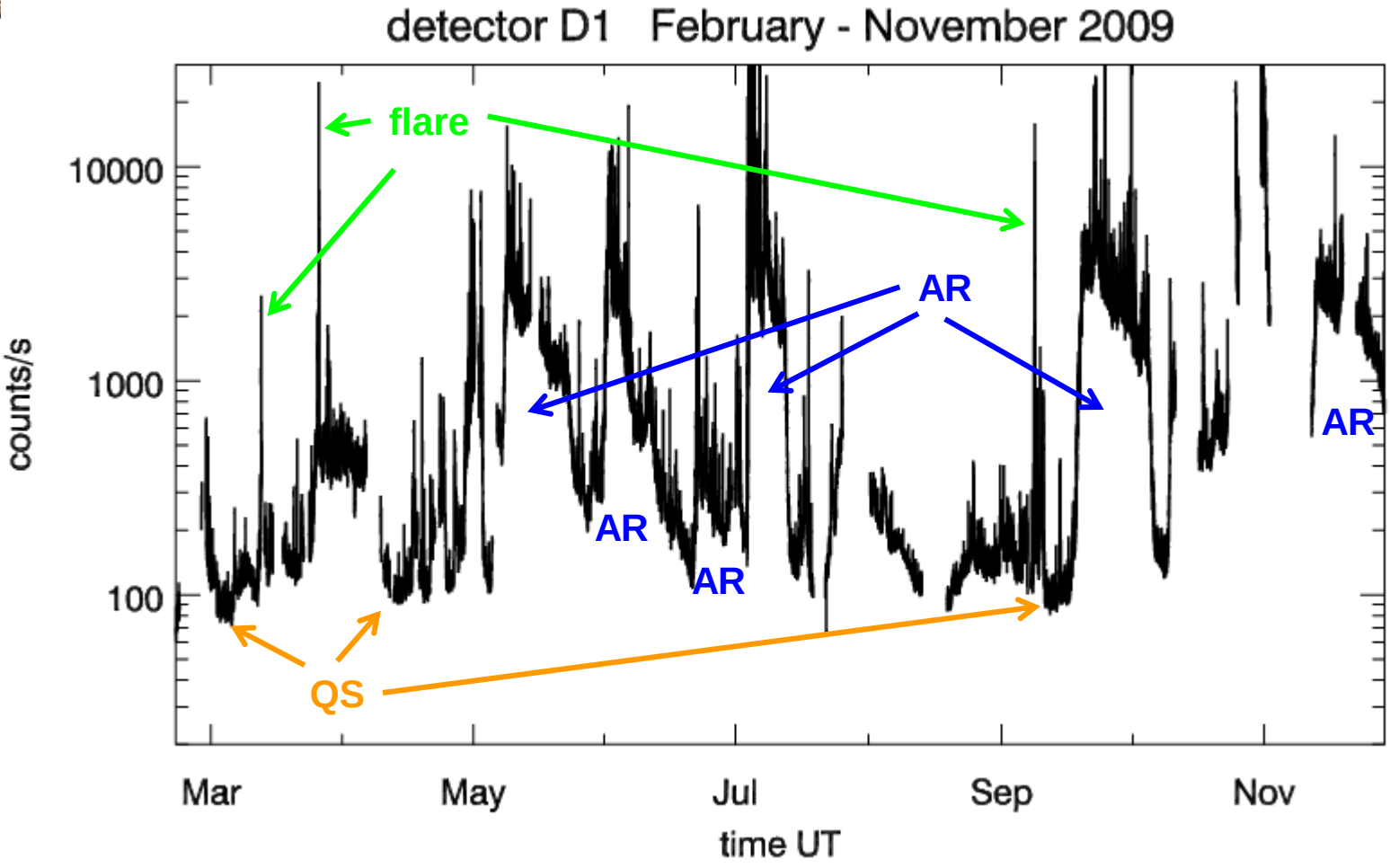
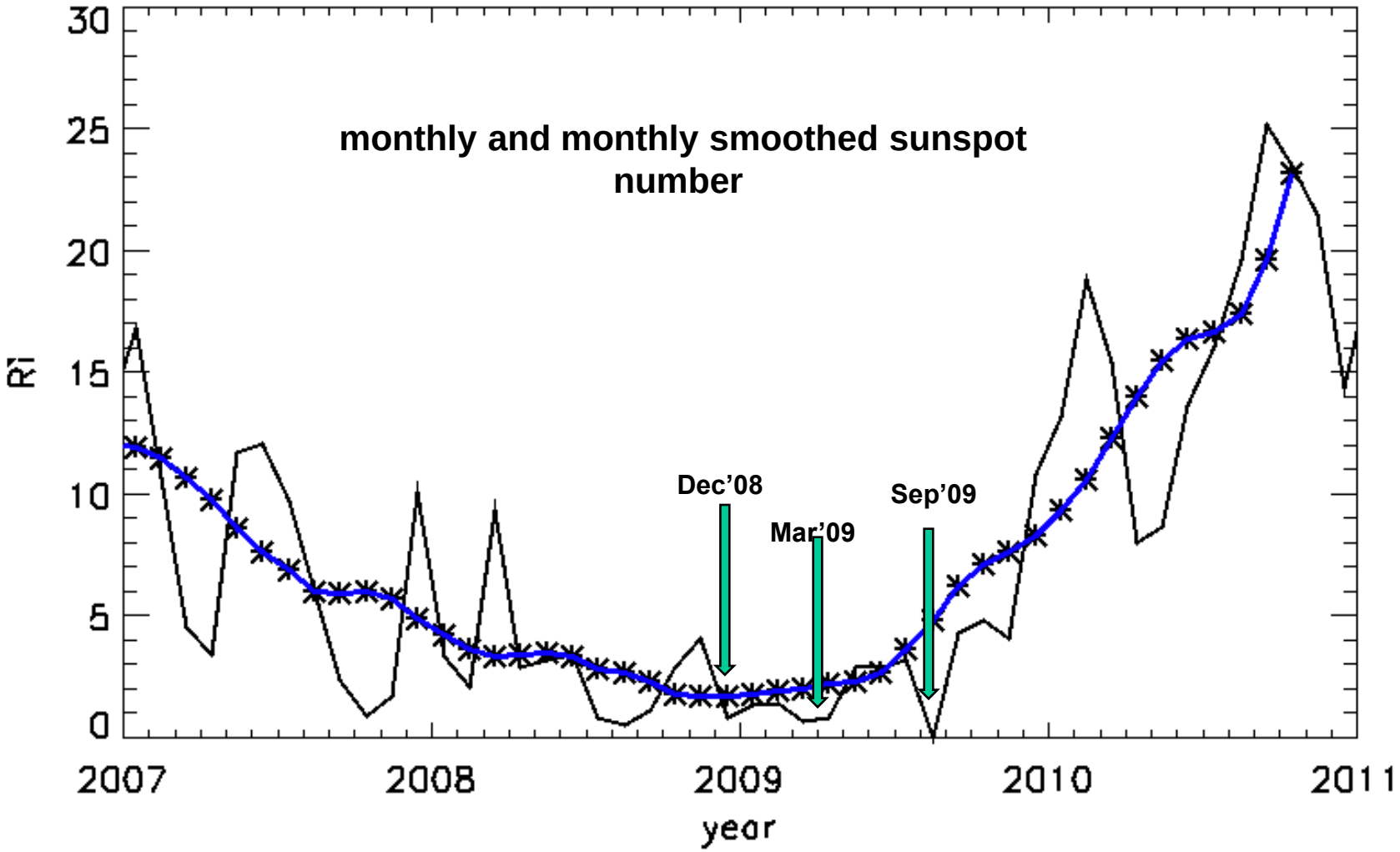
Sphinx

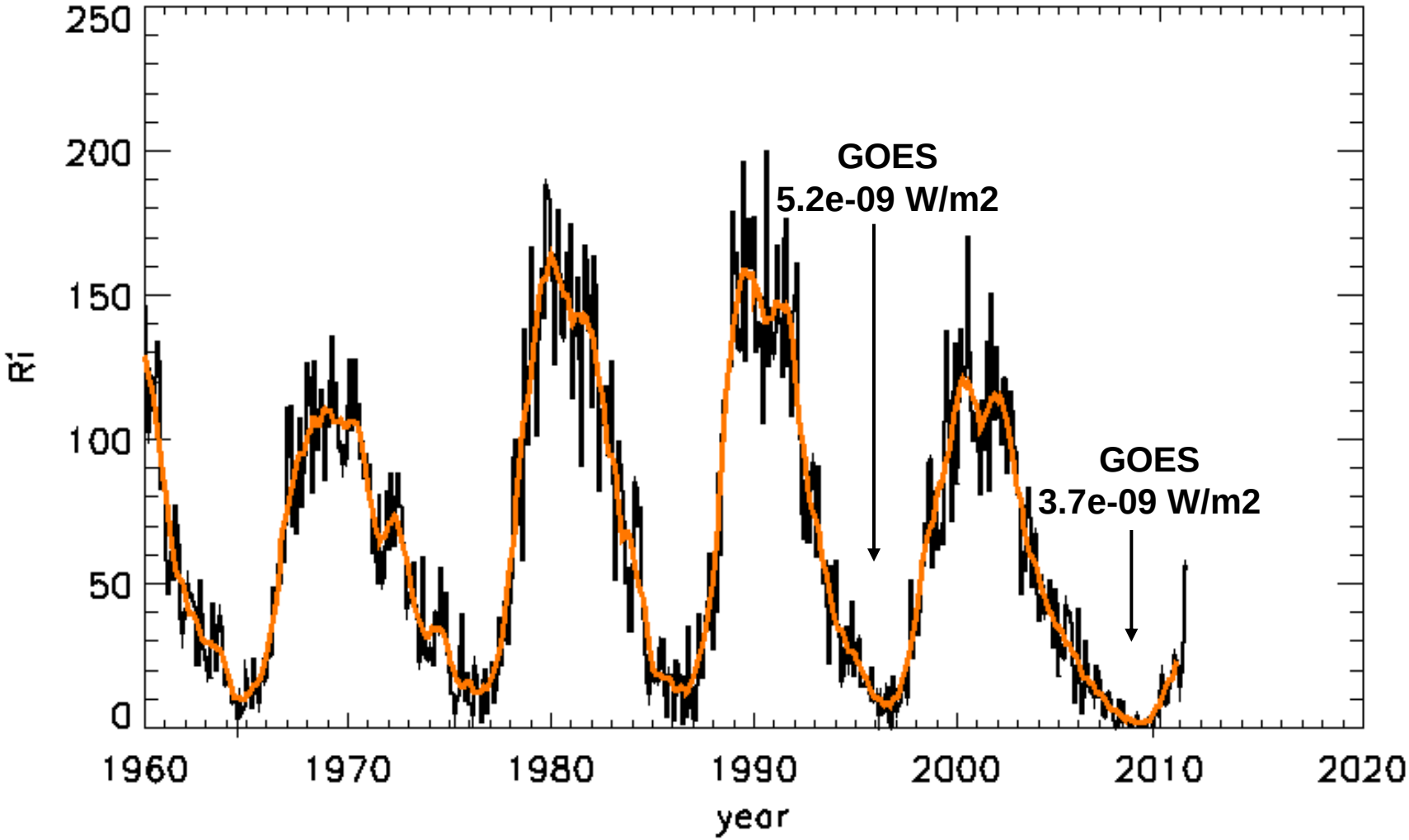


Count rates registered in detector D1, in energy range 1-15 keV, during entire Sphinx mission from February 20 to November 29, 2009.

The Sunspot Cycle



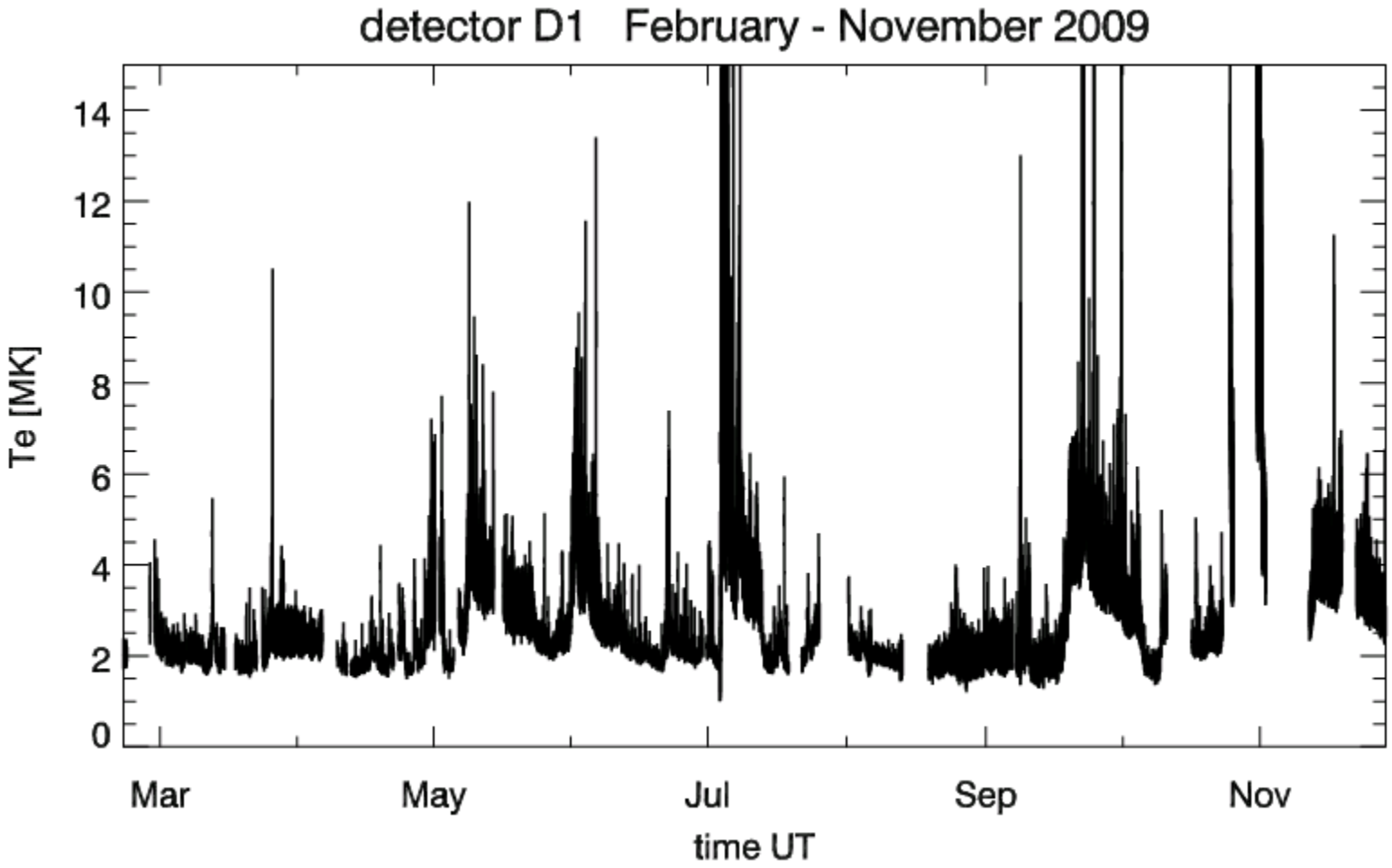
The Sunspot Cycle



The Sunspot Cycle

Cycle	Started	Finished	Duration (years)	Maximum (monthly SSN (Smoothed Sunspot Number))[4]	Minimum (monthly SSN; end of cycle)[5][6]	Spotless Days (end of cycle)[7] [8][9]
14	February 1902	August 1913	11.5	64.2 (Feb 1906)	1.5	~1019
15	August 1913	August 1923	10.0	105.4 (Aug 1917)	5.6	534
16	August 1923	September 1933	10.1	78.1 (Apr 1928)	3.5	568
17	September 1933	February 1944	10.4	119.2 (Apr 1937)	7.7	269
18	February 1944	April 1954	10.2	151.8 (May 1947)	3.4	446
19	April 1954	October 1964	10.5	201.3 (Mar 1958)	9.6	227
20	October 1964	June 1976	11.7	110.6 (Nov 1968)	12.2	272
21	June 1976	September 1986	10.3	164.5 (Dec 1979)	12.3	273
22	September 1986	May 1996	9.7	158.5 (Jul 1989)	8.0	309
23	May 1996	December 2008 [10]	12.6	120.8 (Mar 2000)	1.7	802 (through February 1, 2010) [11]
24	December 2008 [10]					
Mean			10.4	114.1	5.8	

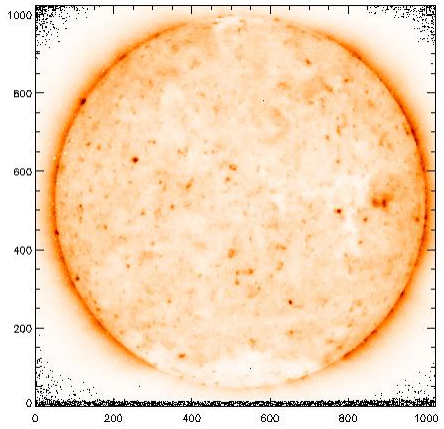
Electron temperature



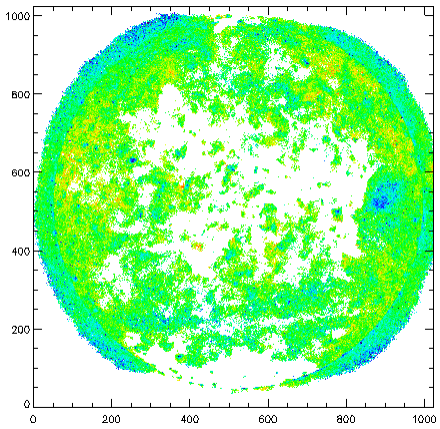
Solar mean temperature distribution during Feb-Nov 2009 calculated in 1T approximation from SphinX spectra

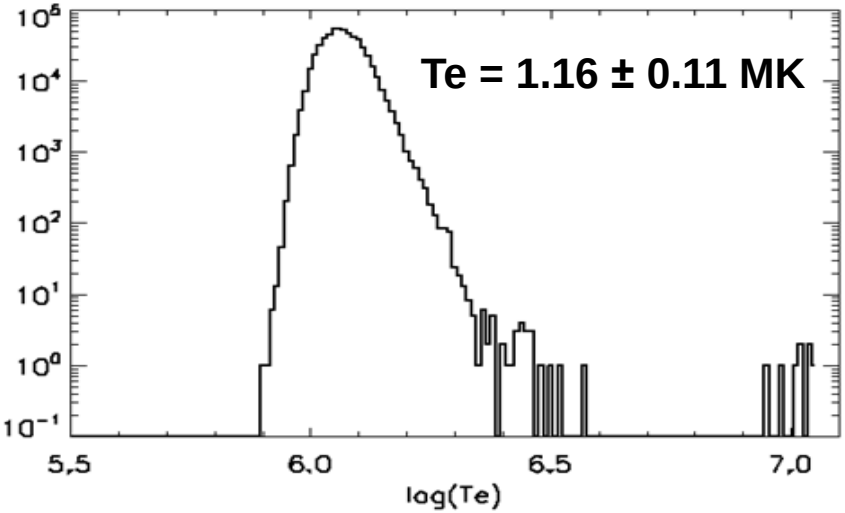
Hinode/XRT 20-Feb-09 06:01

Open/Al_mesh

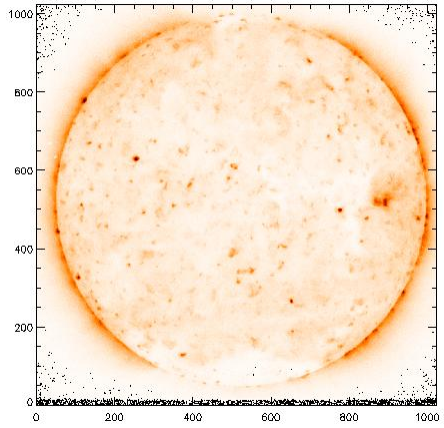


Te

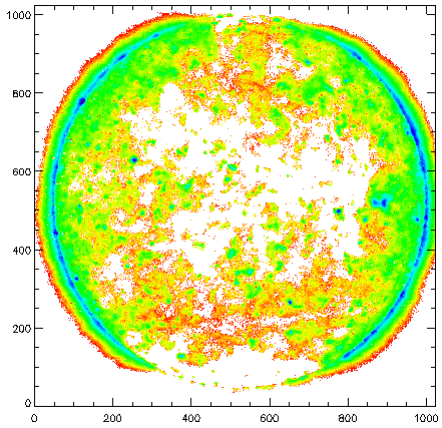


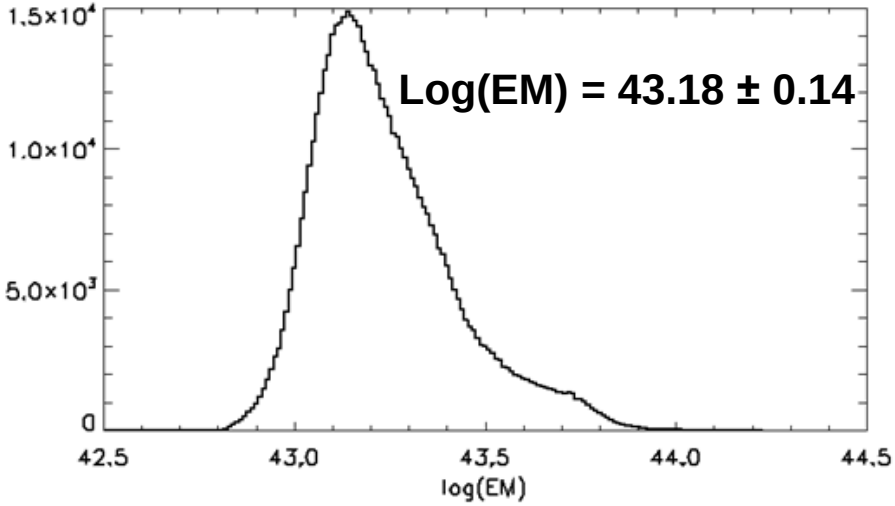


Open/Ti_poly

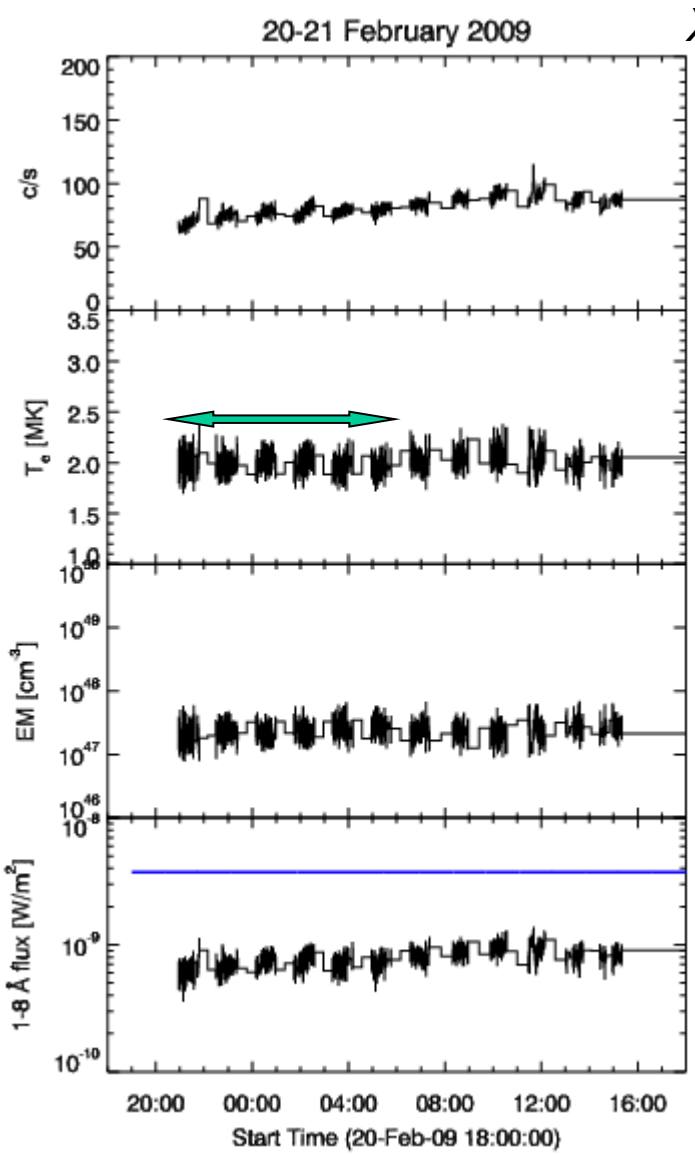


EM

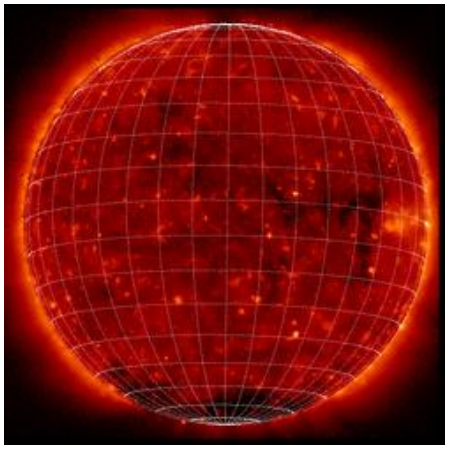




QS electron density

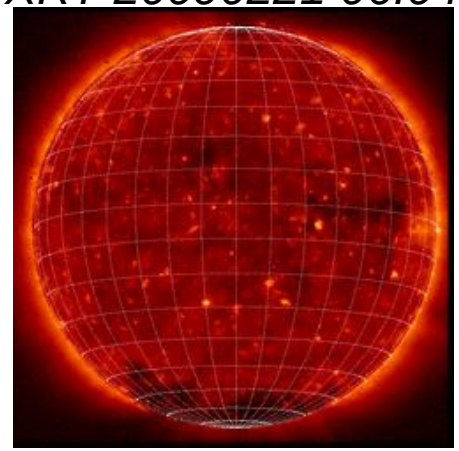


XRT 20090220 18:03



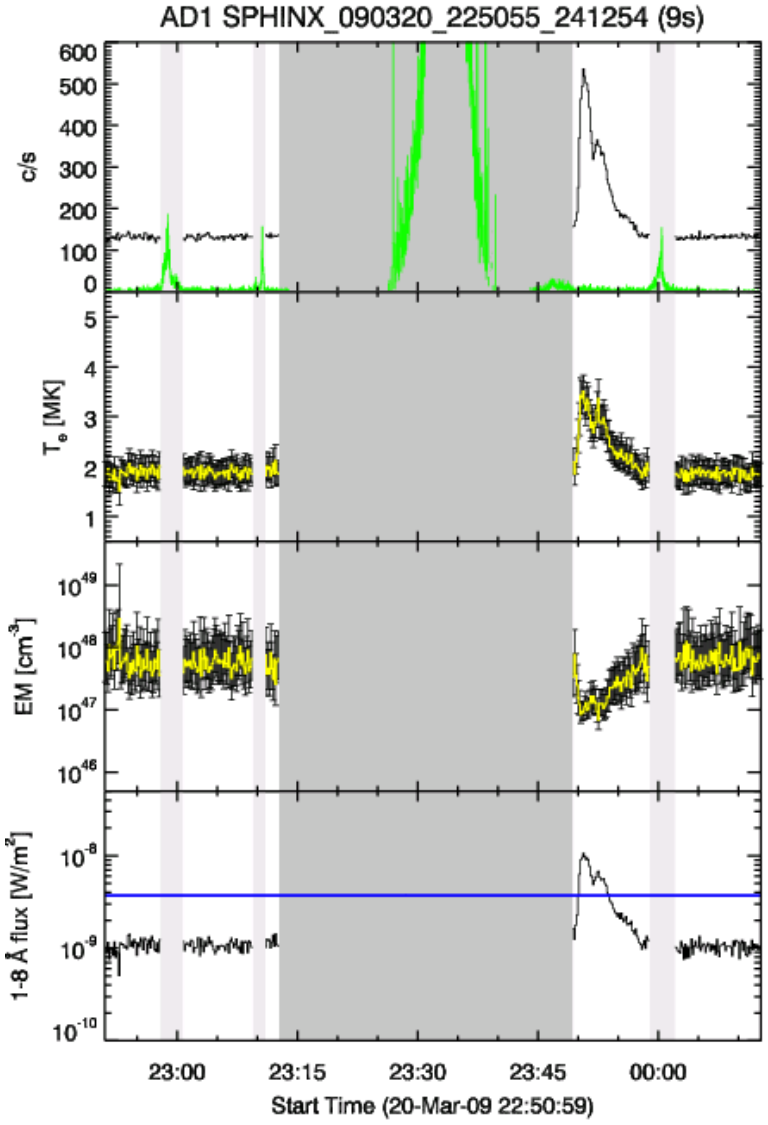
Te = ~1.8 MK
EM =2.50 - 4.0*10^{47} cm^{-3}

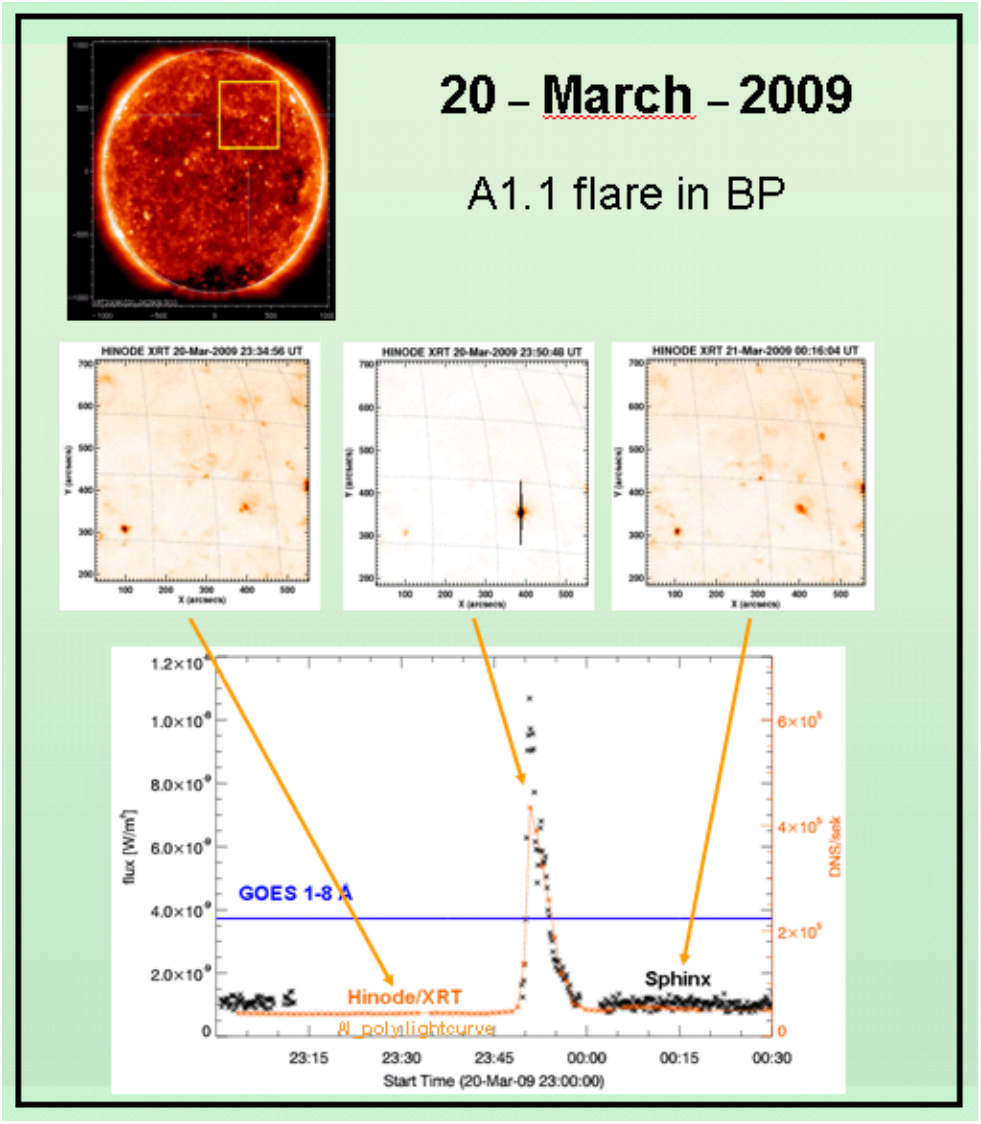
XRT 20090221 06:04



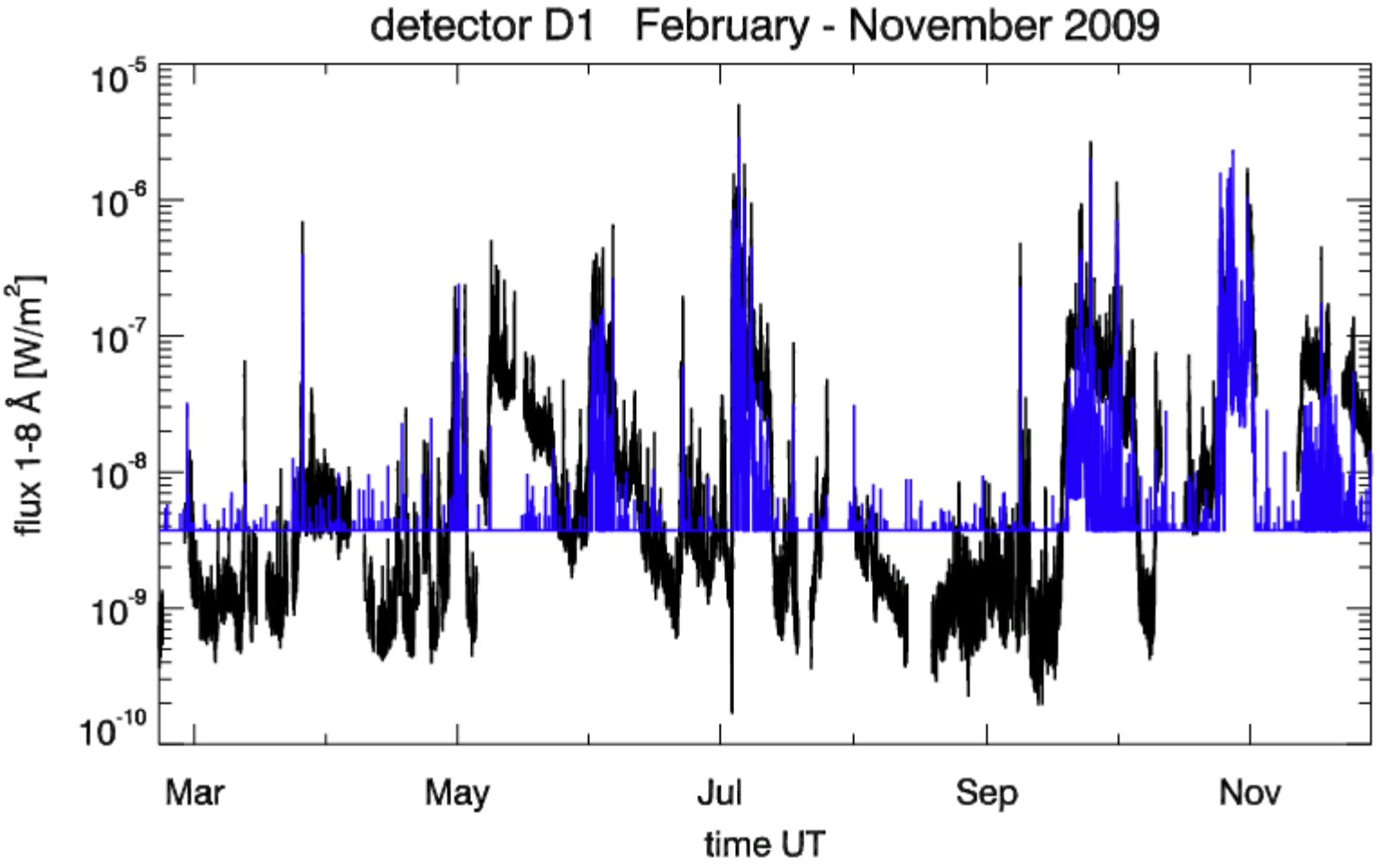
Hcor = 1.5e9 cm
Ne = 7.4 – 9.3 10^{7} cm^{-3}

QS flare activity





Sphinx D1 and GOES

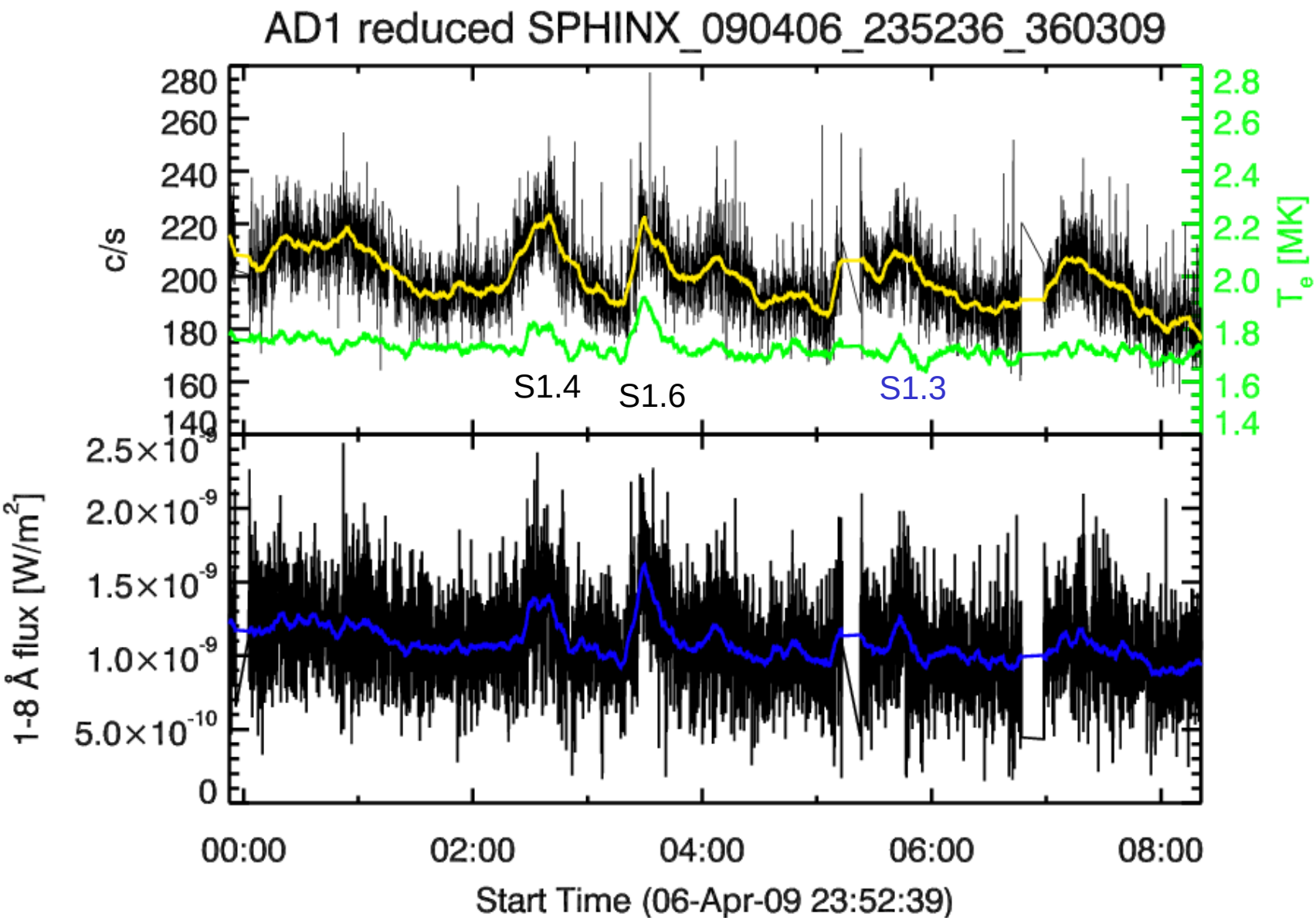


3.726e-9

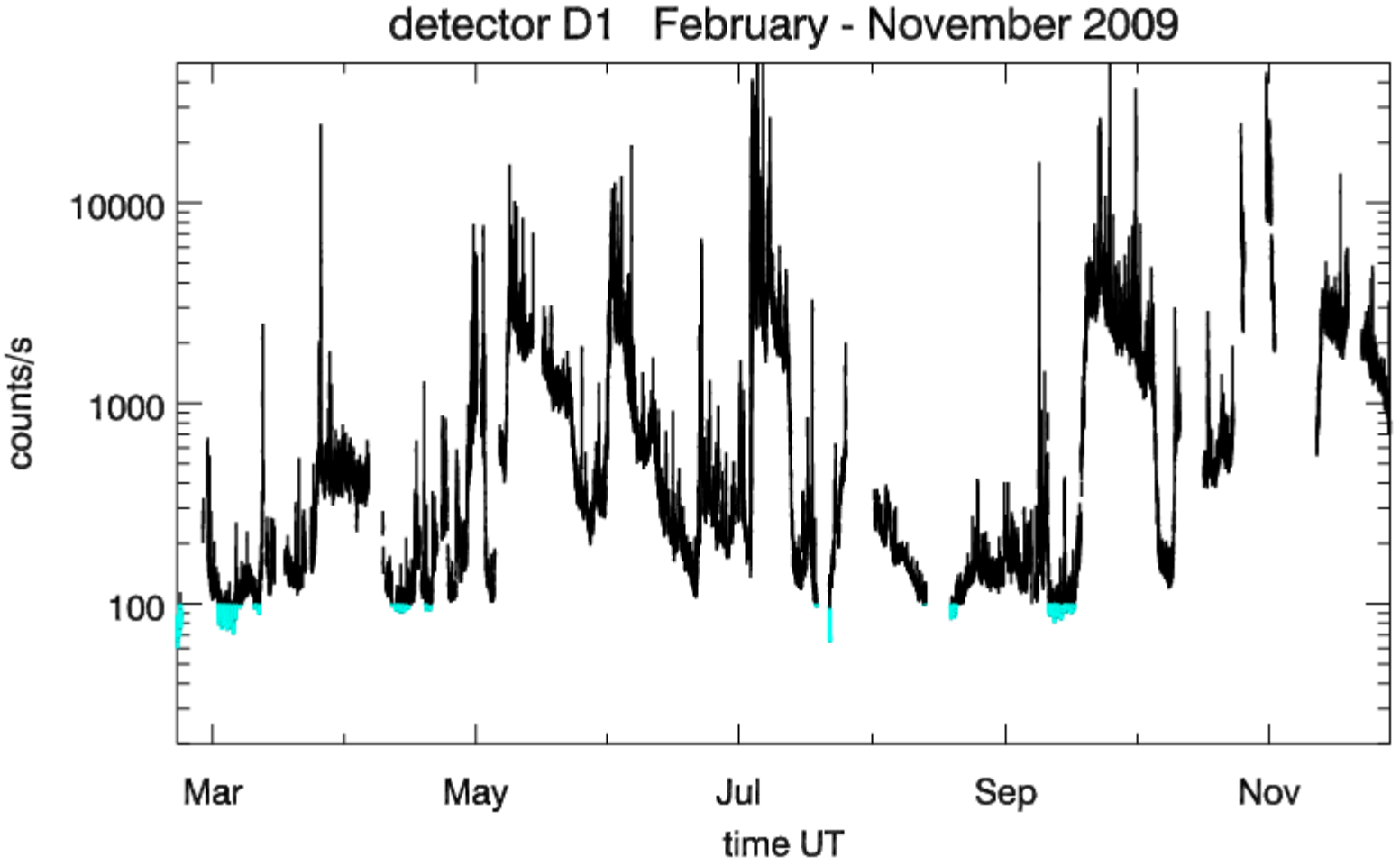
S class - S1 = 1. e-09 W/m²
Q class - Q1 = 1. e-10 W/m²

GOES treshold = 3.726e-09 W/m² 3.7 S
D1 minimum = ~2.e-10 W/m² 2.0 Q

S class flares

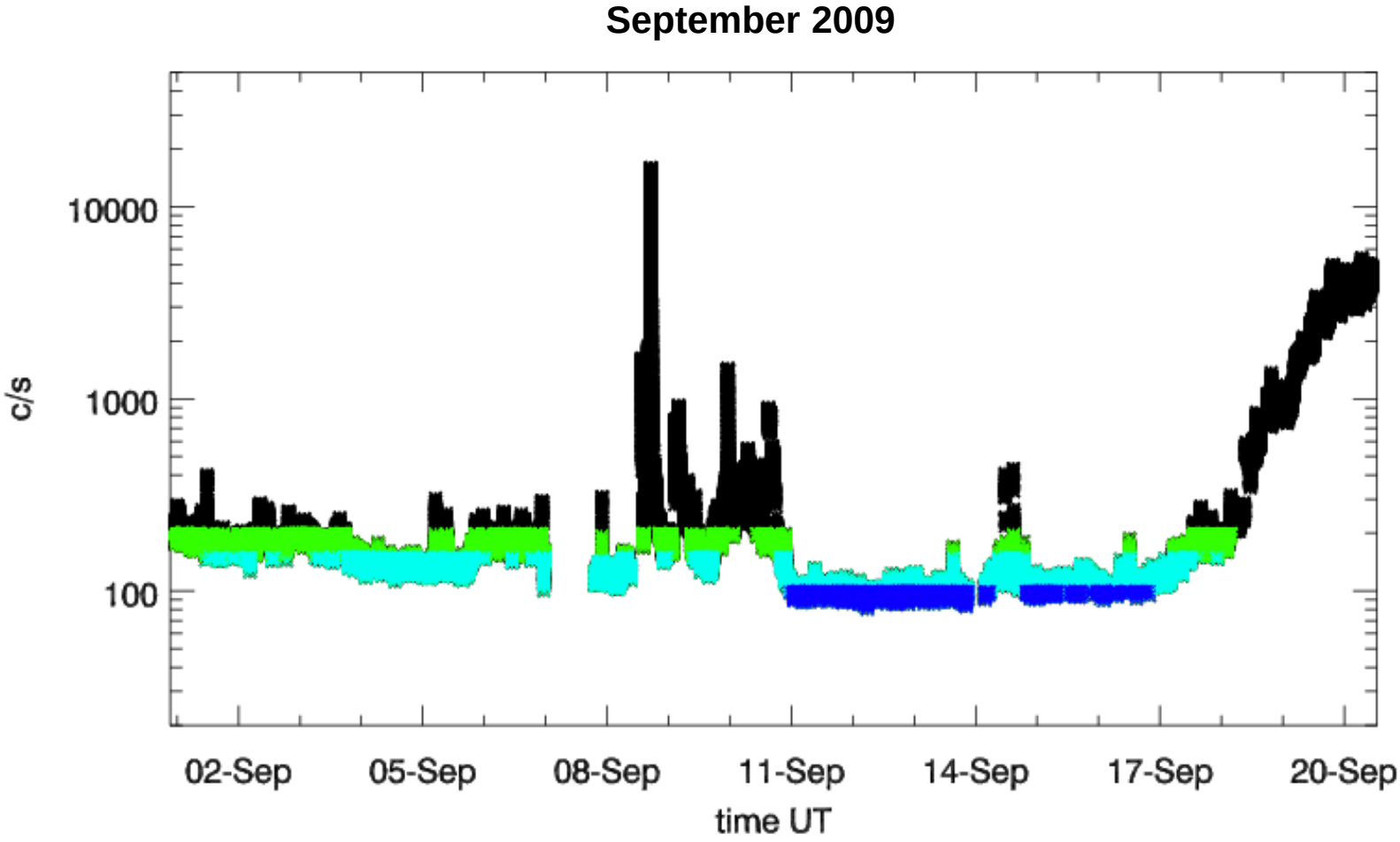


QS Sphinx spectra



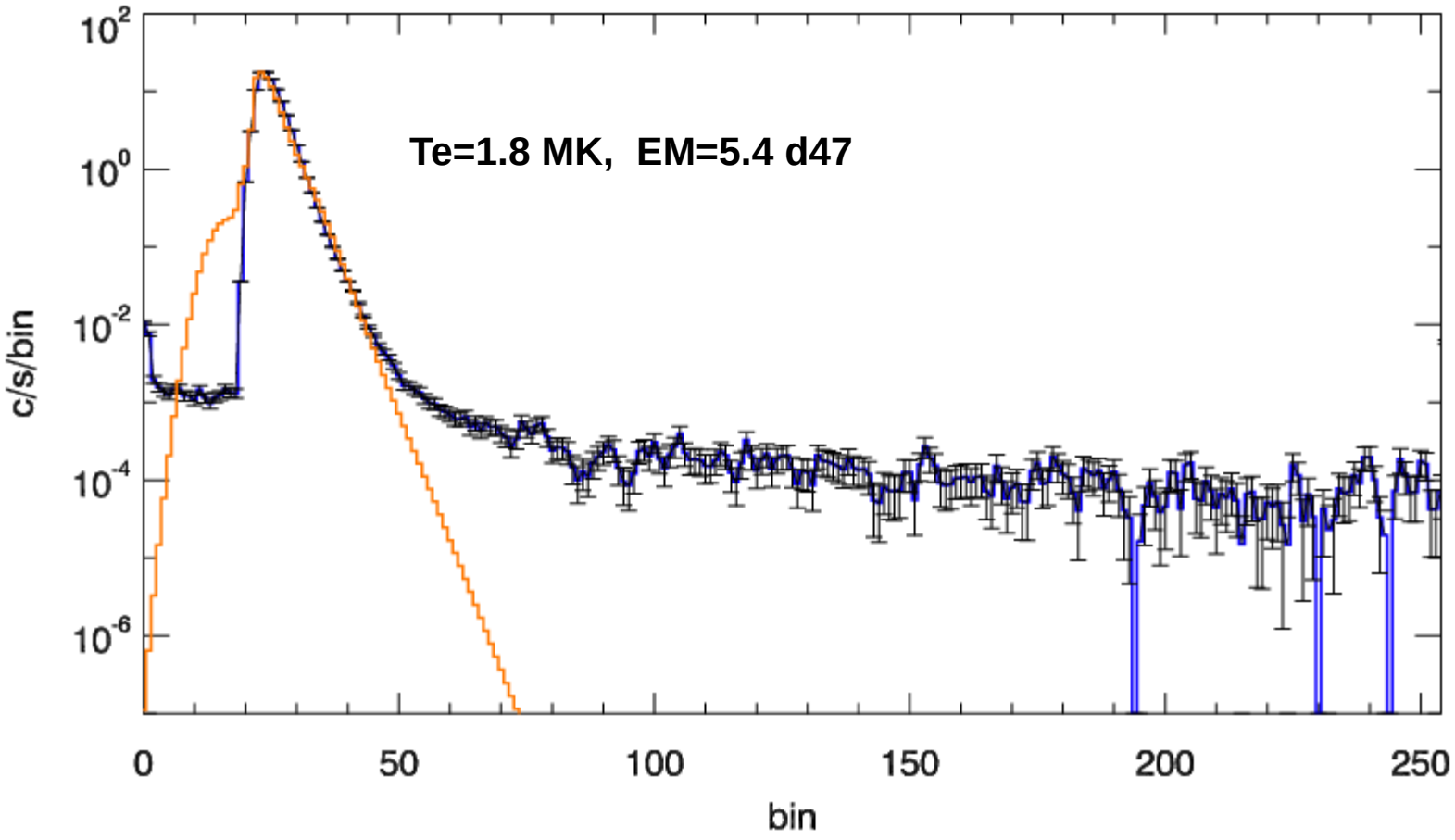
The mission long plot of D1 detector (1-15 keV) light-curve.
Time intervals in which count rates were below 100 c/s are shown in light blue.

QS Sphinx spectra



QS Sphinx spectra

September 2009

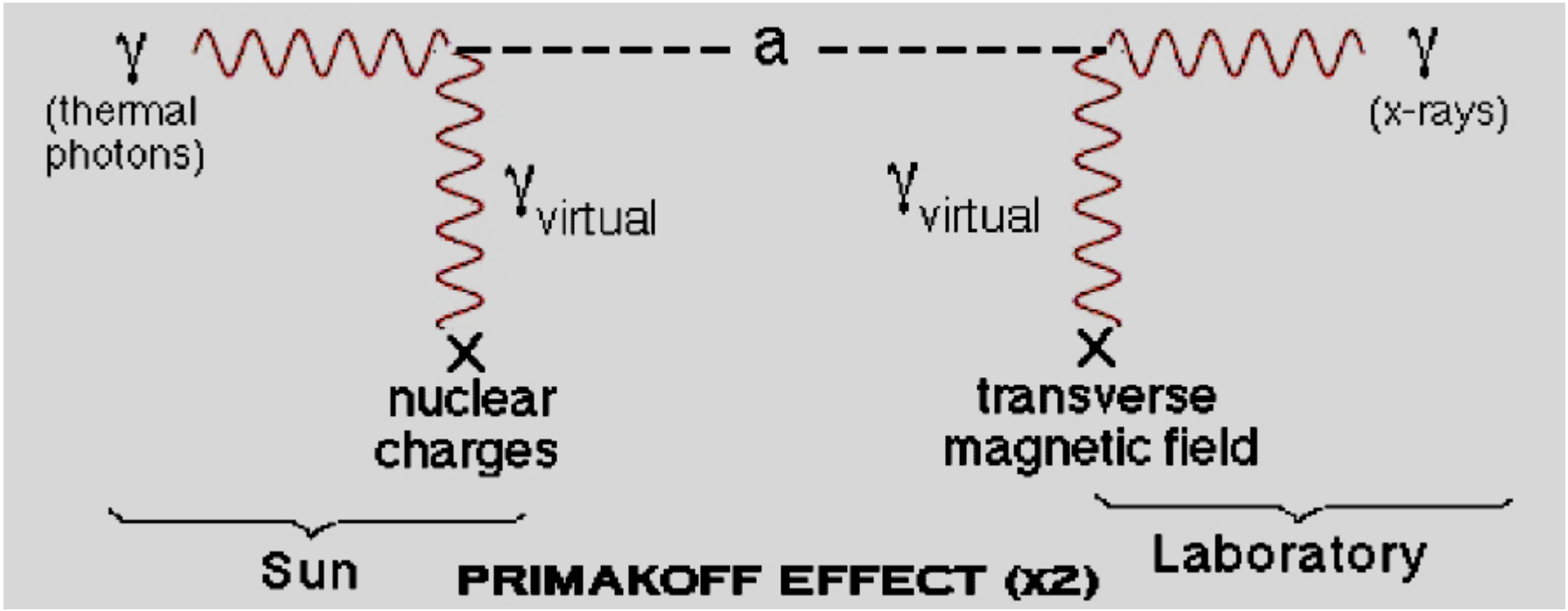


Quiet Sun (<100 c/s) spectra averaged on September 11-17,2009 (blue line) with errors. Orange line shows 1T fit to spectra.

axions

Axions are hypothetical elementary particles which appear in theory of strong interactions. They can interact with EB field to produce photons (Primakov process). Efficiency of this process is described by an unknown coupling constant g.

$g_{a\gamma\gamma}$ **- coupling constant**



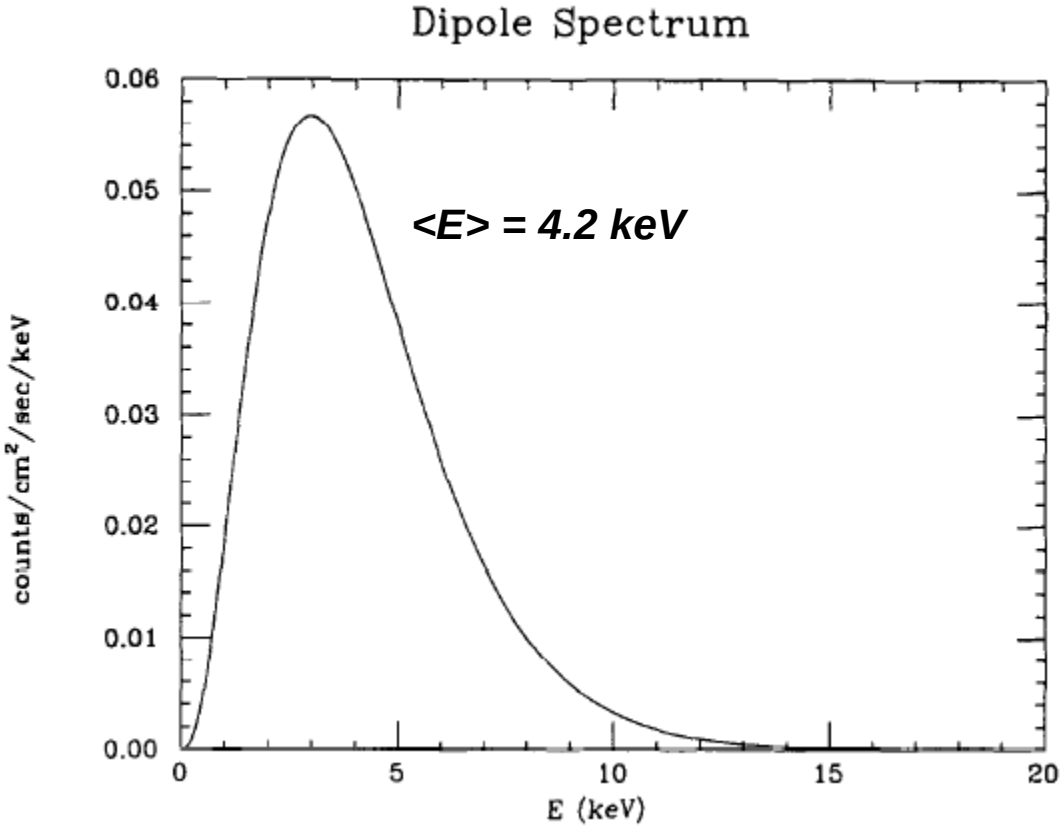
Zioutas et al. New Journal of Physics 11 (2009) 105020 (30pp)

Solar axions

Conversion of axion to X-rays in coronal magnetic field

Carlson & Tseng_Physics Letters B 365 (1996) 193-201

The X-ray flux of solar axions has a mean energy of 4.2 keV



$$P \propto g^2 |\mathbf{D}(x,y)|^2$$

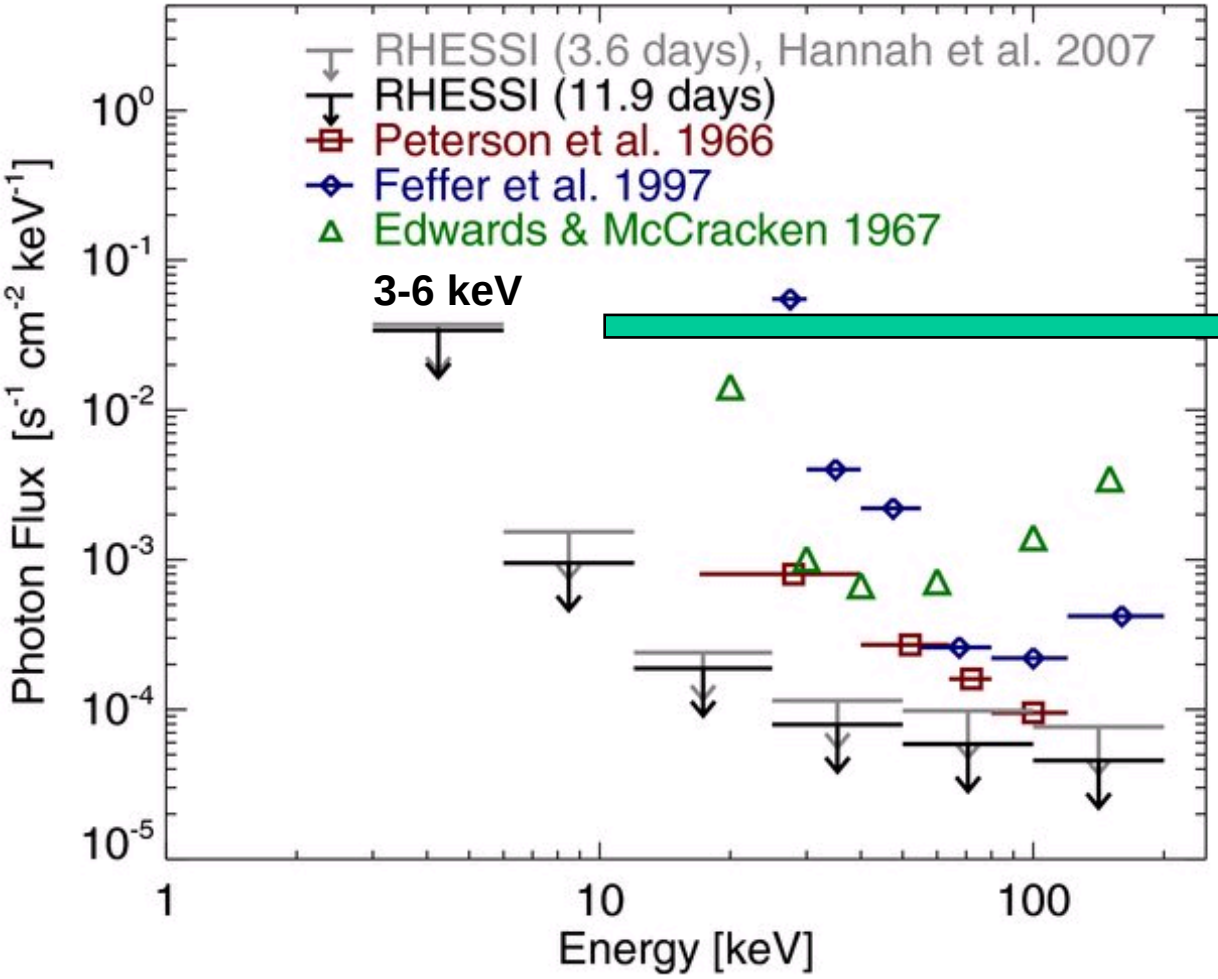
$$\mathbf{D}(x,y) = \int_0^L \mathbf{B}_\perp(x,y,z) e^{i\theta(z)} \mathrm{d}z$$

$$\theta(z) = \int_0^z \left(\frac{2\pi\alpha n_e(z')}{m_e E} - \frac{m^2}{2E} \right) \mathrm{d}z'$$

Rhessi Quiet Sun data

Hannah, et al., 2007, ApJ, 659, L77

Hannah, et al., 2010, ApJ, 724, 487



Limits on axion coupling constant

$g_{a\gamma\gamma} = 10^{-10}\ GeV^{-1}$

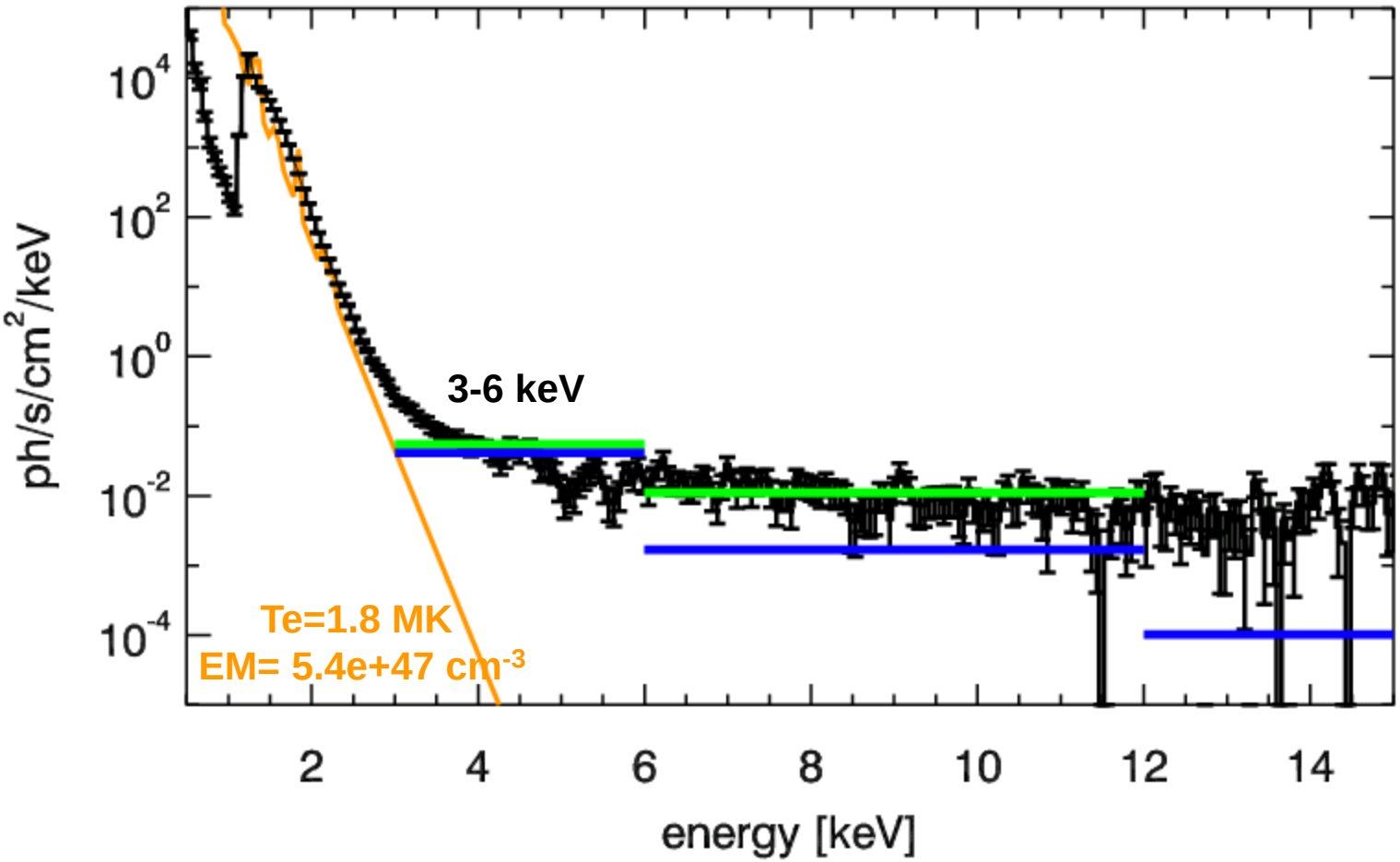
$g_{a\gamma\gamma} << 6 \cdot 10^{-15}\ GeV^{-1}$

(KK axions)

RHESSI upper limits of the quiet-Sun photon flux spectrum

QS Sphinx spectra

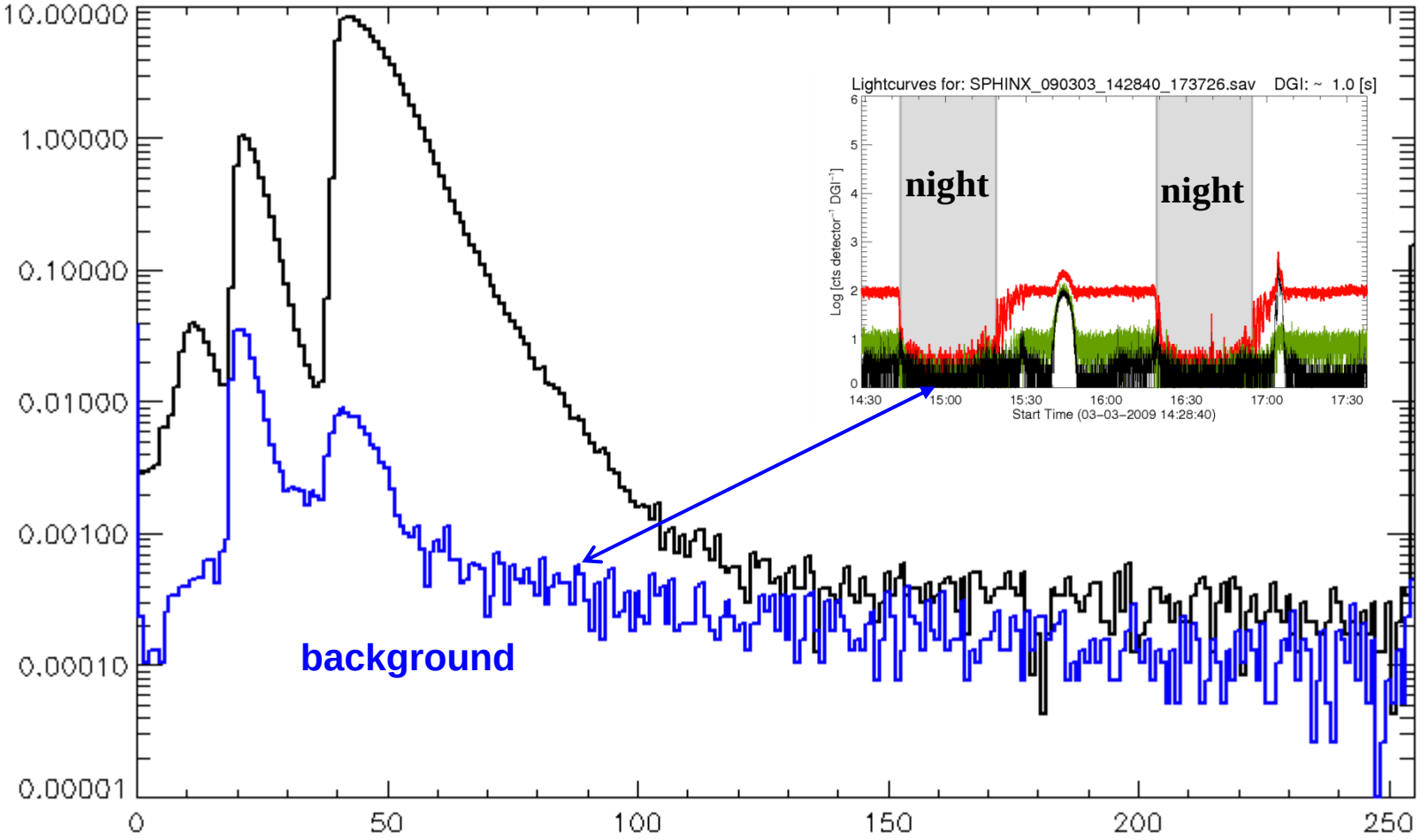
September 2009



Average Sphinx (black and green) and RHESSI (blue) quiet-Sun photon flux spectrua during 11-17 September 2009.

QS Sphinx spectra

February-March 2009



Solar (black) and background (blue) spectra. Background spectrum was measured during satellite nights.

SphinX and QS topics

- Comparison with Hinode
  - solar minimum activity and Sun as a star
  - Te and EM diagnostics
  - mean QS density
  - QS short time (small events) variability
- Comparison with RHESSI
  - spectra and solar background
  - axions
- Correlation with GOES