Flare abundances/DEM study based on analysis of RESIK spectra

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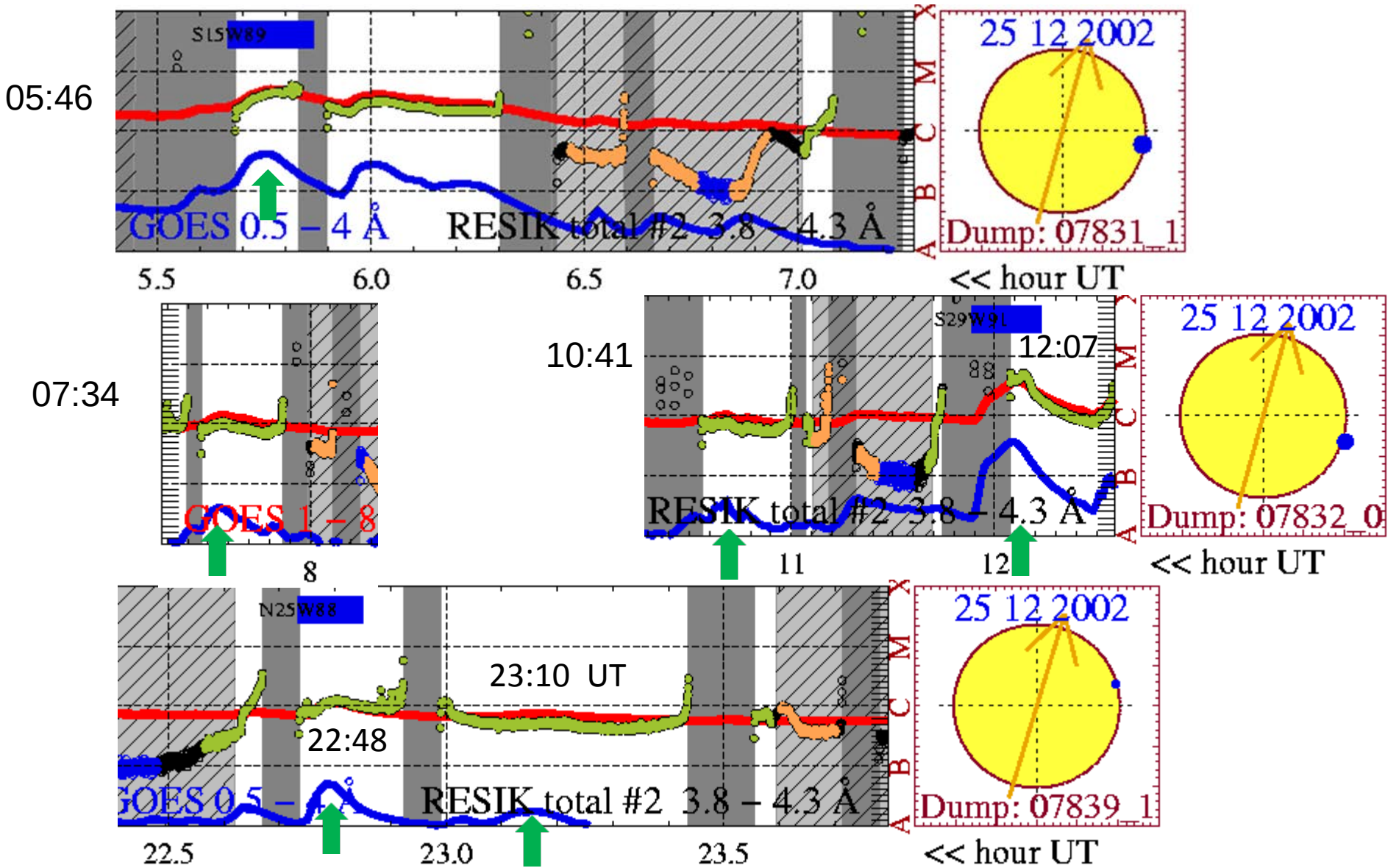
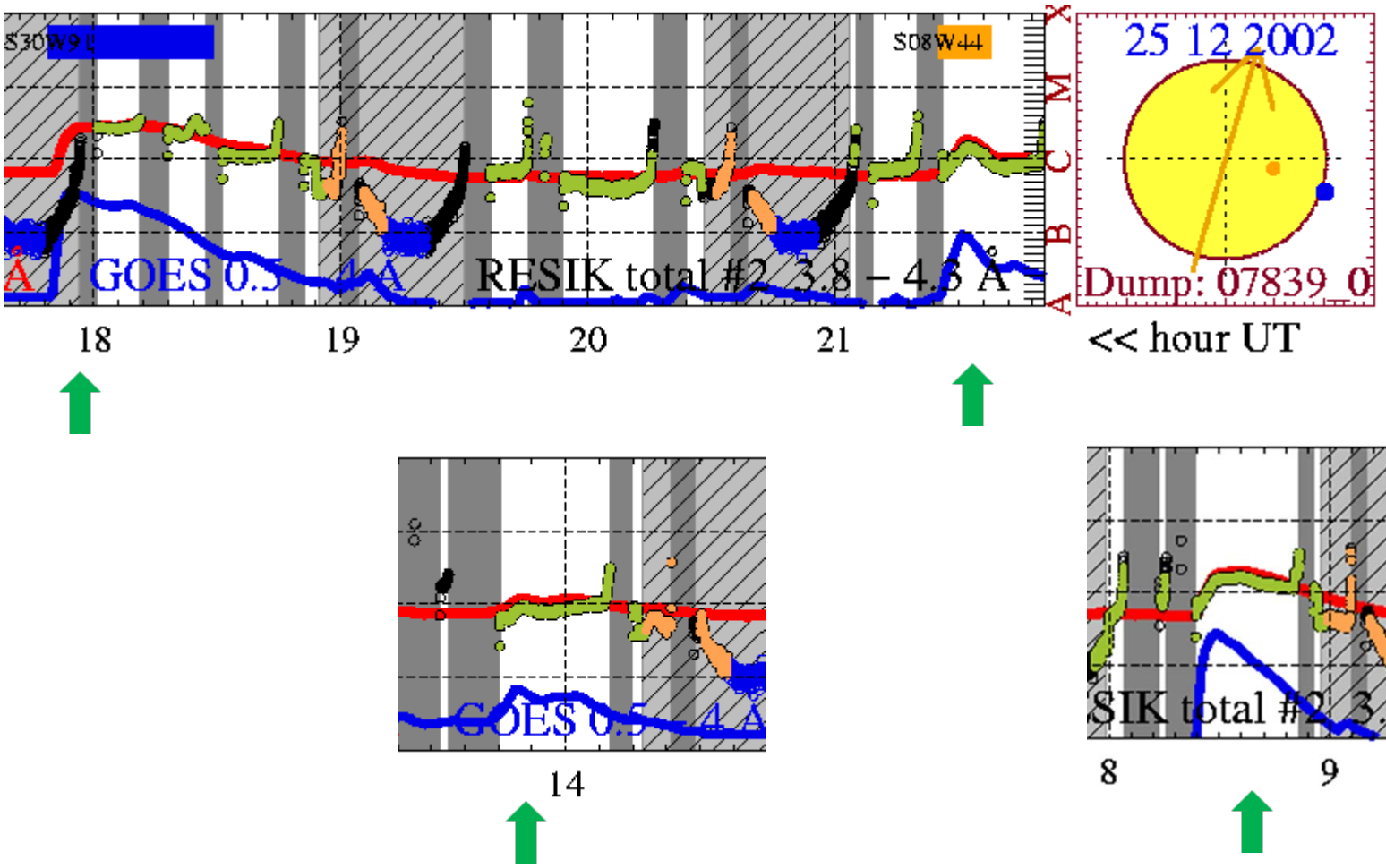
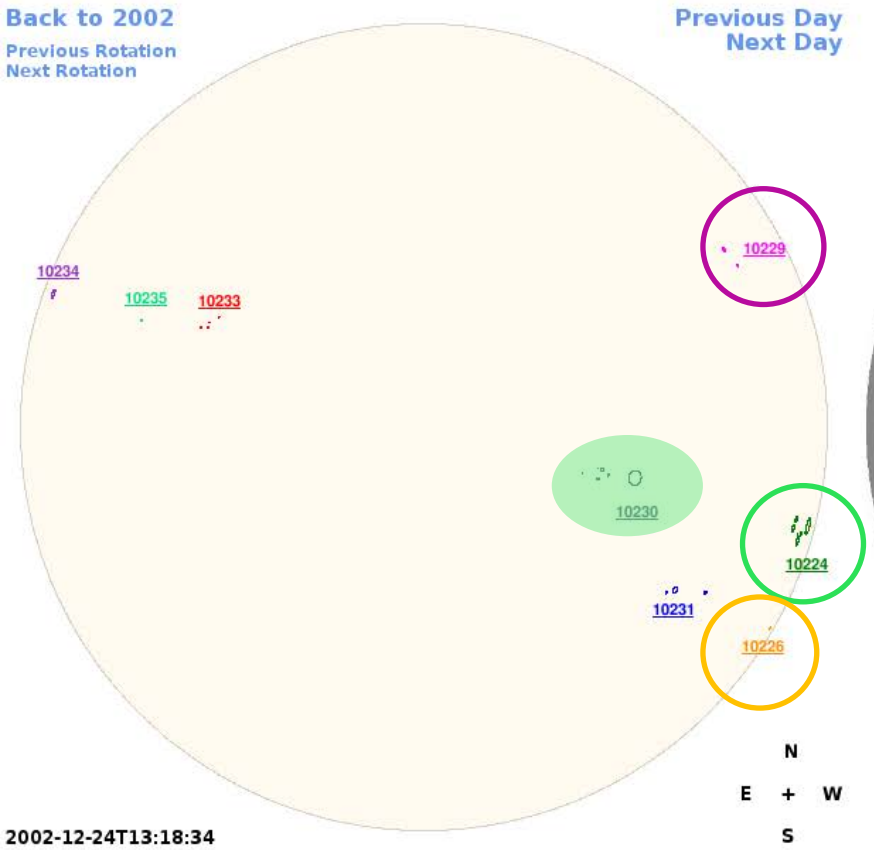
REntgenovsky **S**pektrometer s **I**zognutymi **K**ristalami **RESIK**

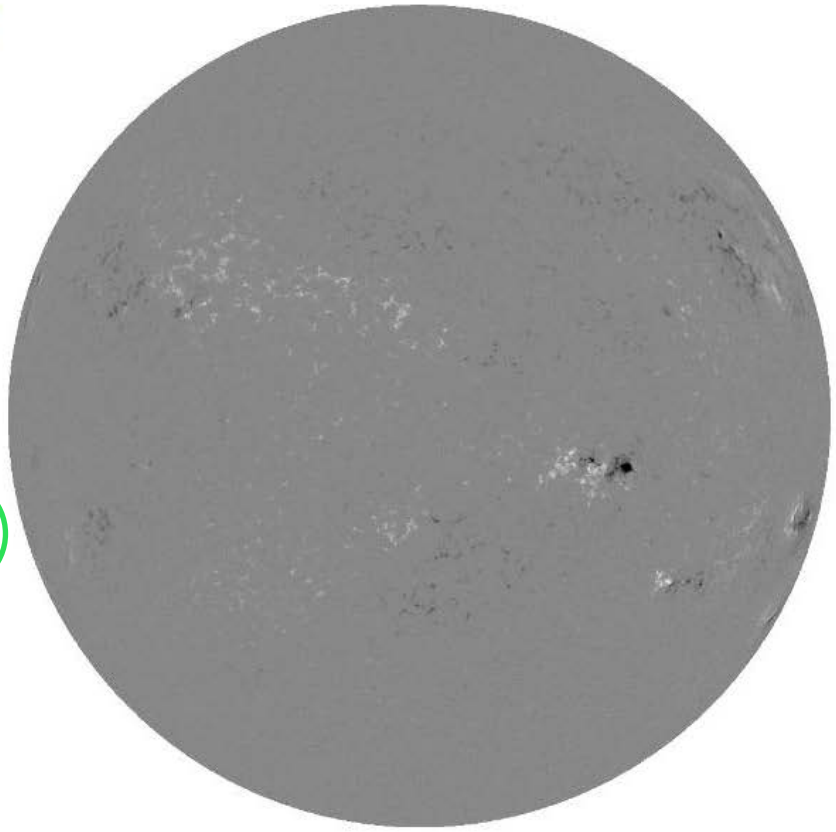


25 Dec. 2002 at 18:09 21:32 13:55 UT and
26 Dec. 08:30 UT



Debrecen Photoheliographic Data (24 Dec. 2002)





Inspection of Debrecen sunspots catalogue (*http://fenyi.sci.klte.hu/DPD/2002/index.html*), magnetic observations, RESIK offset data and RHESSI images (when available) indicated that only **ONE** analysed flare comes probably from the disc. ALL the rest are limb flares although NOT all of them originated in the same active region.

Flares on 25 (26) December 2002

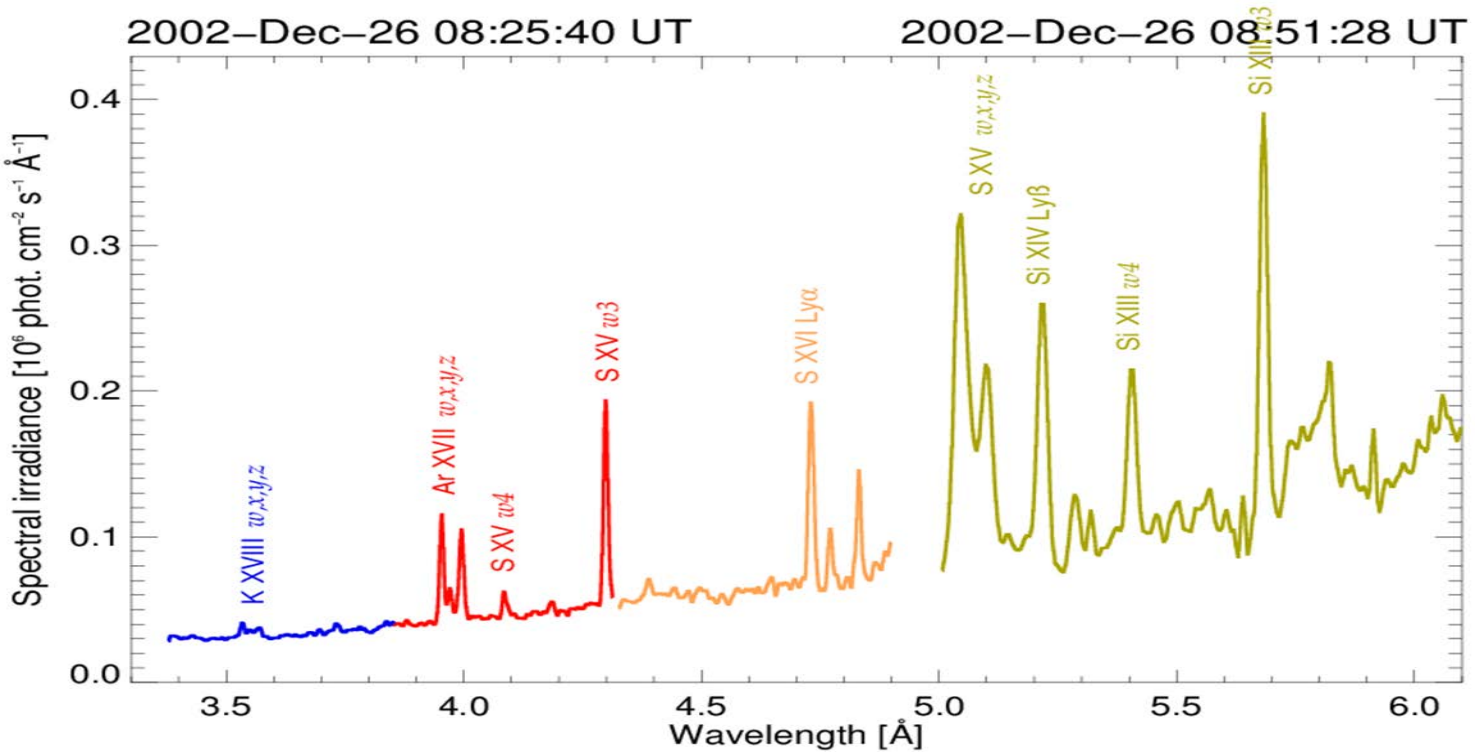
RHESSI for rise phase

Disc flare

No RHESSI

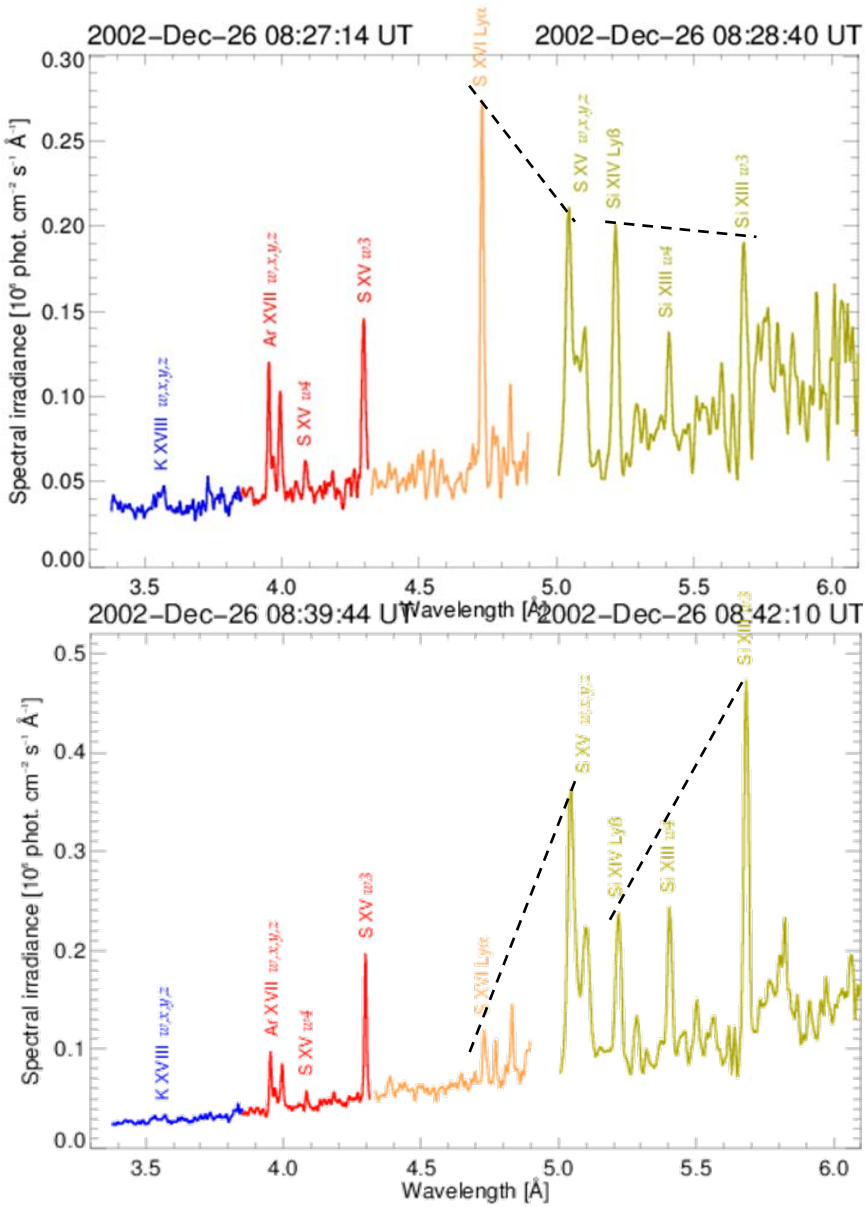
No.	Time max. [UT]	Number of spectra	*GOES* class	NOAA
1	05:46	115	C4.8	10224
2	12:07	60	C3.5	10226
3	18:00	82	C2.9	10226
4	08:30	53	C1.9	10226
5	21:32	22	C1.7	10230
6	07:34	21	C1.4	10226
7	22:48	6	C1.1	10229
8	13:55	19	C1.1	10224
9	10:41	14	C1.0	10226
10	23:10	9	B8.0	10224

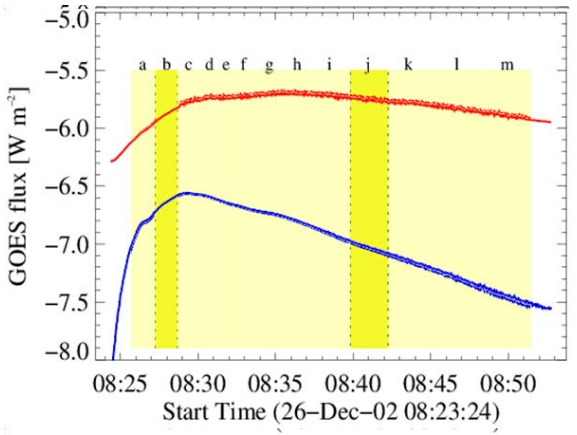
Time-averaged spectrum for an **C1.9** flare



The nominal wavelength coverage of RESIK is 3.3 Å – 6.1 Å. Recorded spectra contain many spectral lines formed in H- and He-like ions of various elements. The line and continuum is formed in hot coronal plasma from the T-range 3 MK ÷ 30 MK in various proportions for different spectral bands. This makes RESIK spectra uniquely suitable for investigations of the temperature structure of the source (DEM) as well as the plasma elemental composition.

Spectral variability SOL2002-12-26T08:30





DEM distributions have been calculated using absolutely calibrated RESIK spectra. **15 spectral bands** are identified in the range 3.3 Å -- 6.1 Å for the DEM inversion.

For each selected time interval 10 000 iterations for DEM inversion have been performed. Typically, better than 5 % agreement between observed and DEM predicted fluxes in every spectral band is reached.

The Differential Emission Measure (DEM)

For optically thin, mulithermal plasma:

$$F_i = A_i \int_{T=0}^{\infty} f_i(T)\phi(T)\,\mathrm{d}T$$

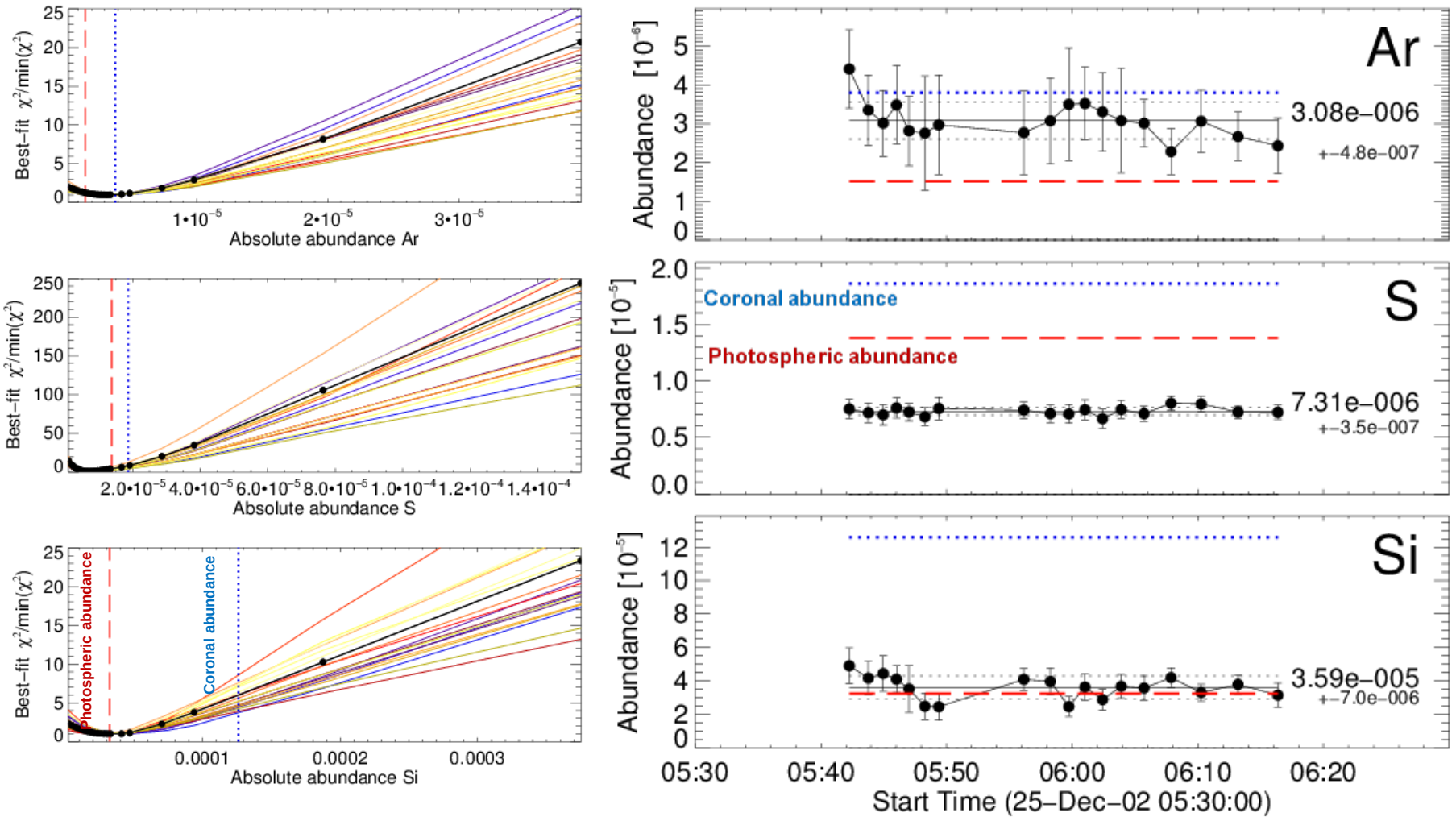
$$\mathrm{DEM} \equiv \Phi(\mathrm{T}) \equiv \mathrm{N_e^2}$$

F_i measured fluxes obtained from RESIK spectra in $i = 15$ spectral bands

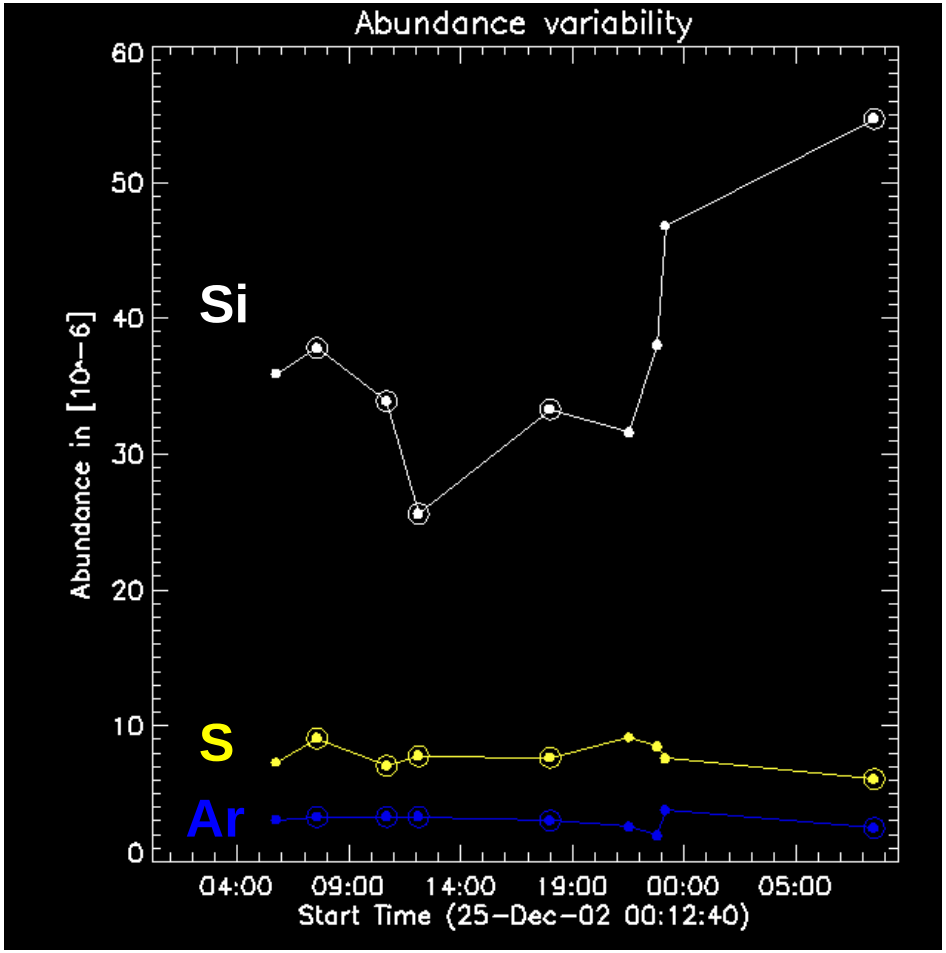
$f_i(T)$ calculable theoretical emission functions for every spectral band used, CHIANTI 7.0 atomic code has been used in this respect

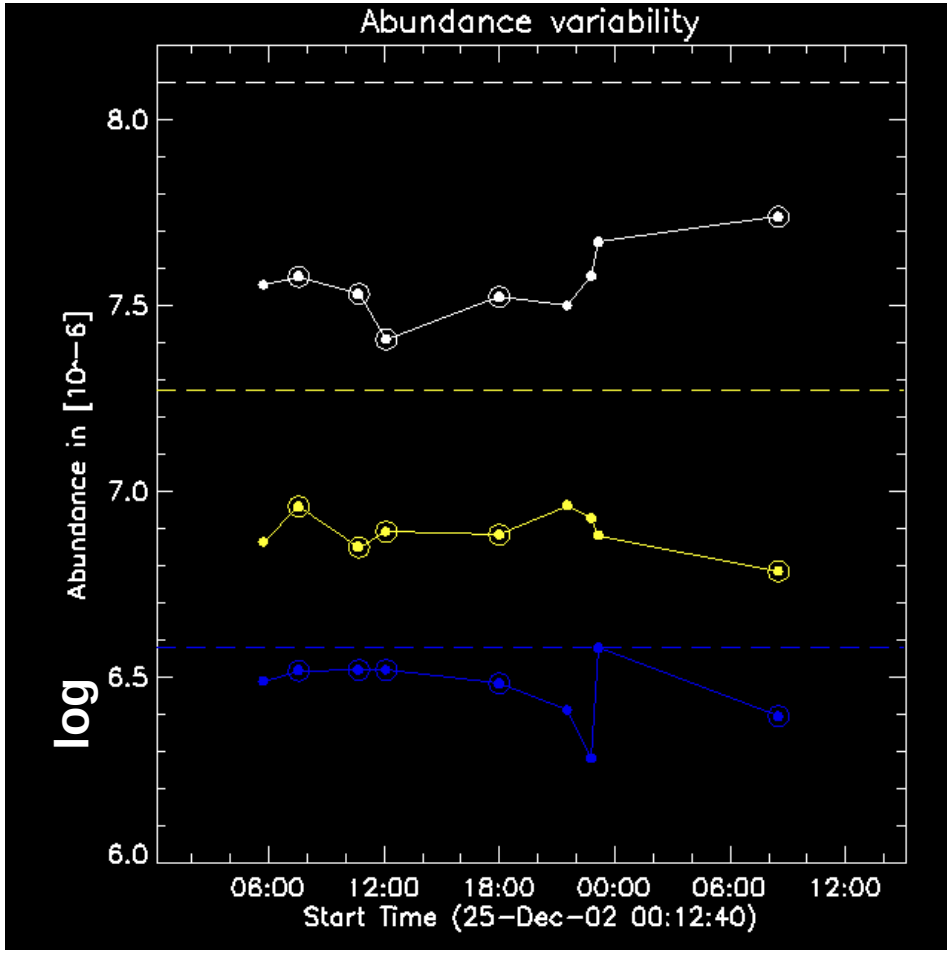
A_i elemental abundance constant over the source volume

25 Dec. 2002 at 05:46 UT C4.8



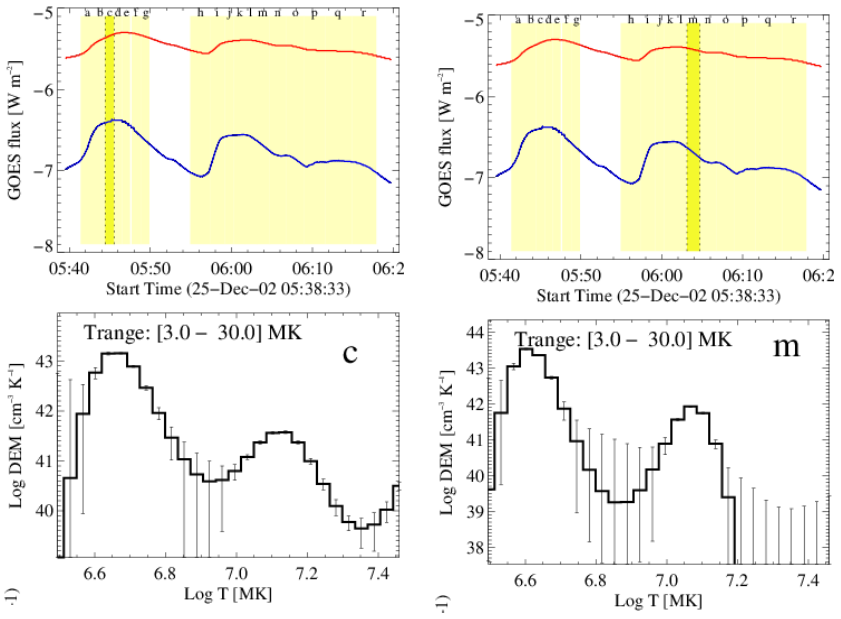
Abundances variability (circles →AR 10226)

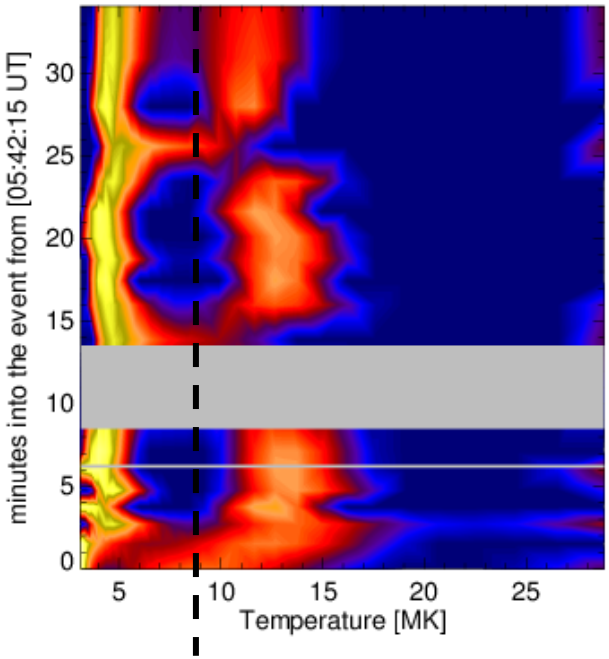


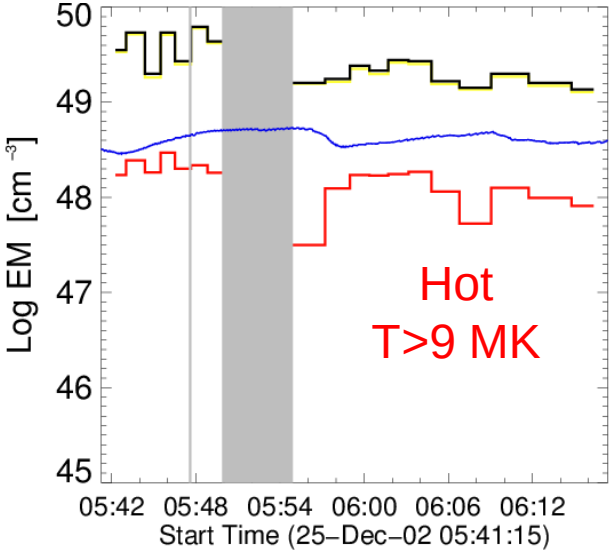


- - - - - - Coronal values

25 Dec. 2002 at 05:46 UT C4.8



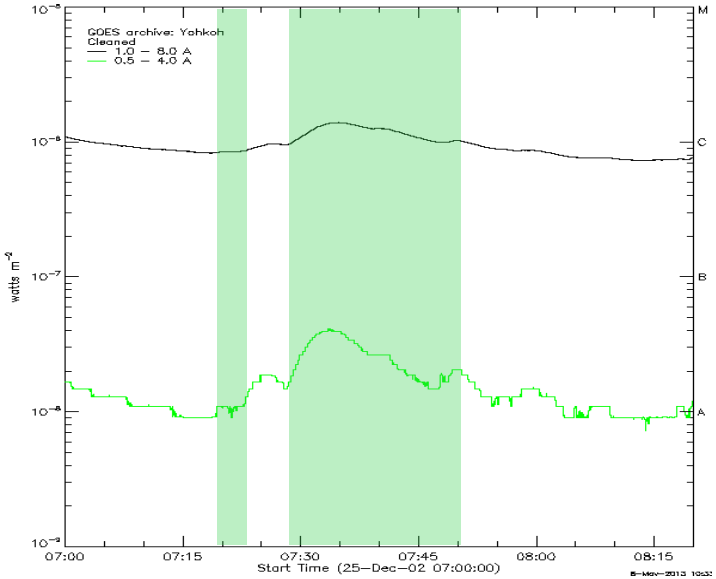


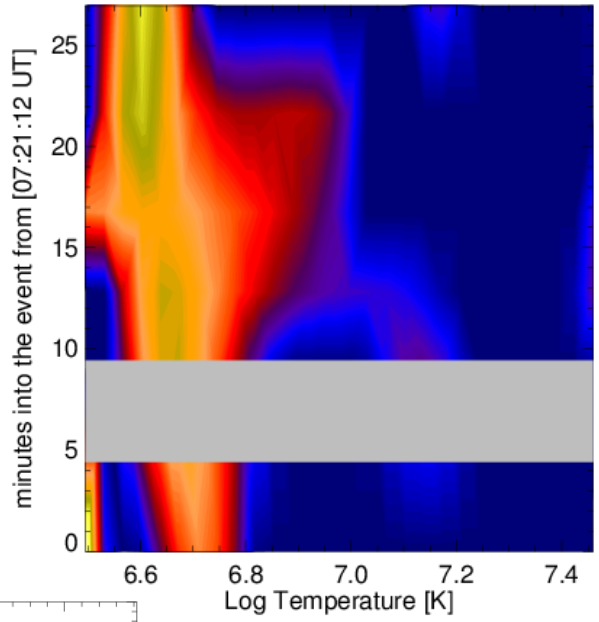


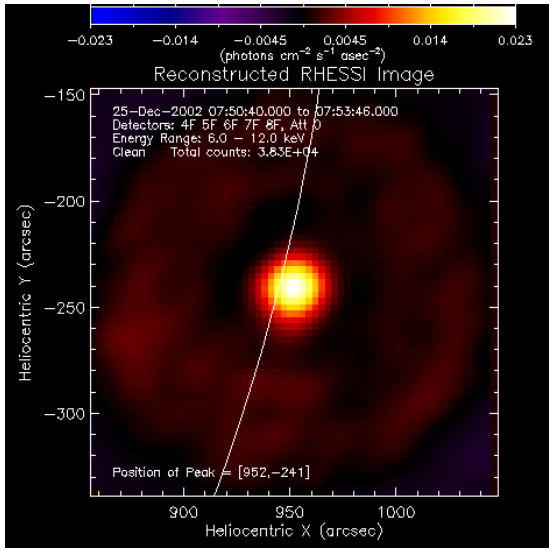
If we consider the total EM of the hot component to be contained in the RHESSI bright kernel, this allows for the estimation of the density of hot plasma.

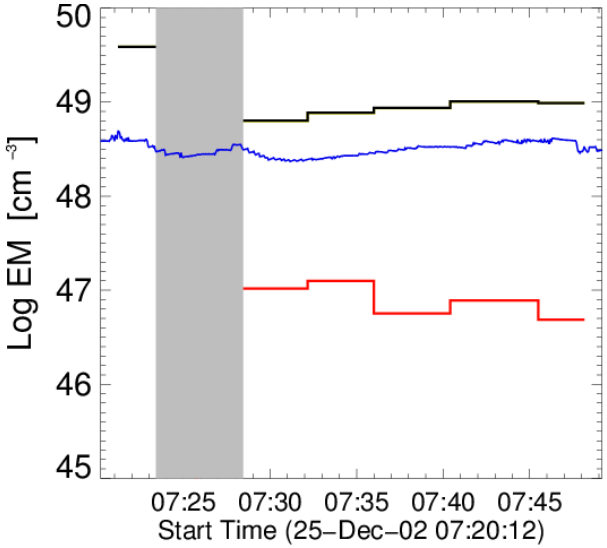
$N_e \approx 1.4 \times 10^{11}$ cm $^{-3}$

25 Dec. 2002 at 07:34 UT C1.4



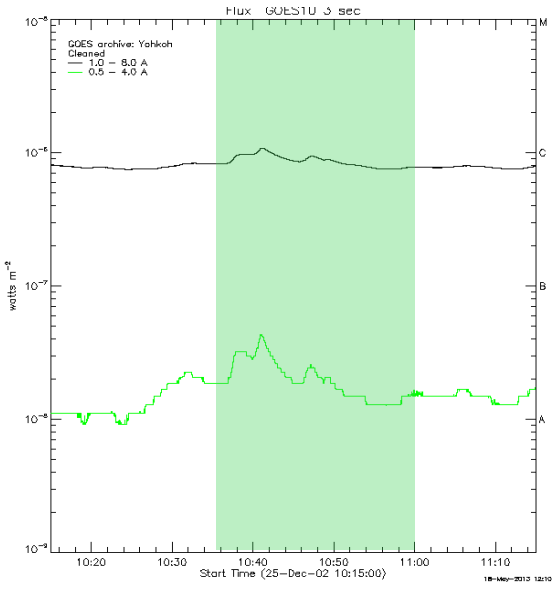


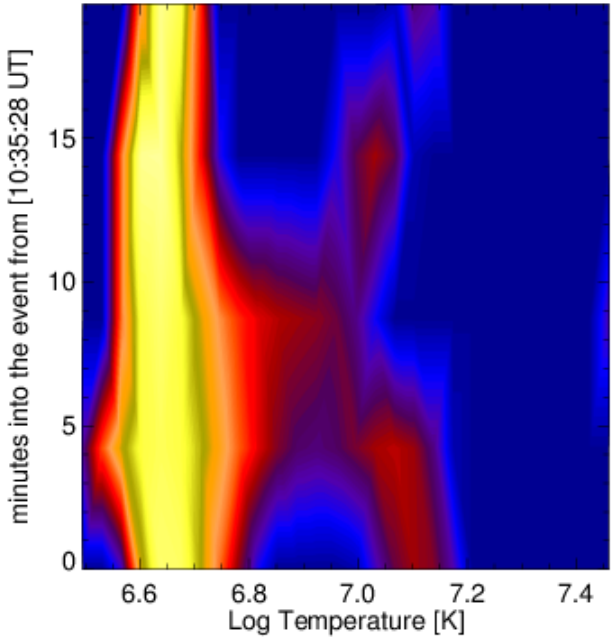


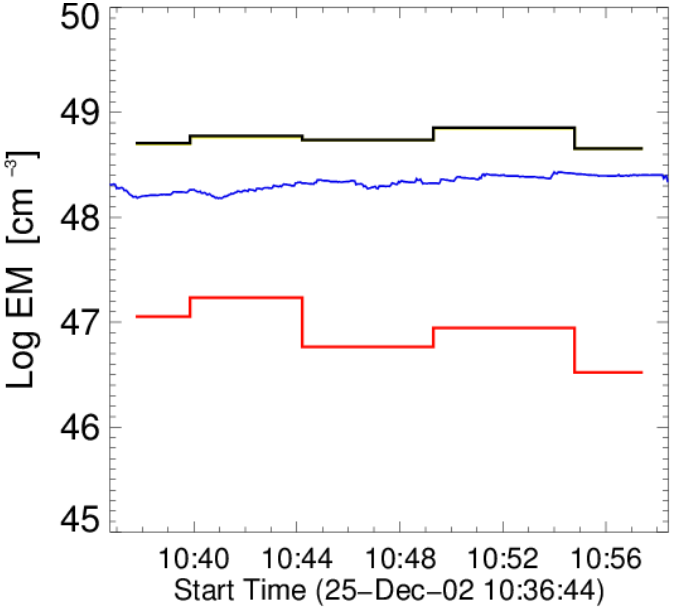


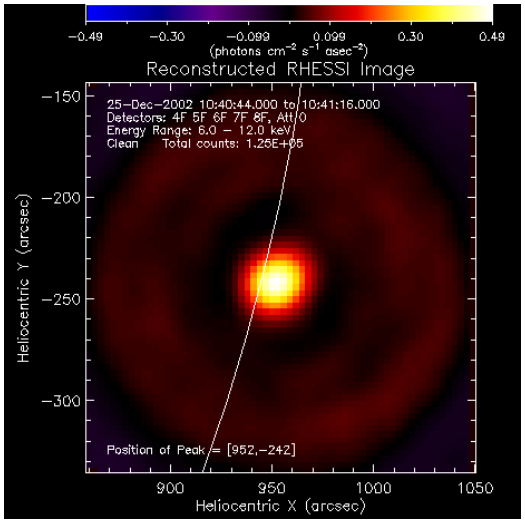
Ne≈3.8x10^{10} cm $^{-3}$

25 Dec. 2002 at 10:41 UT C1.0



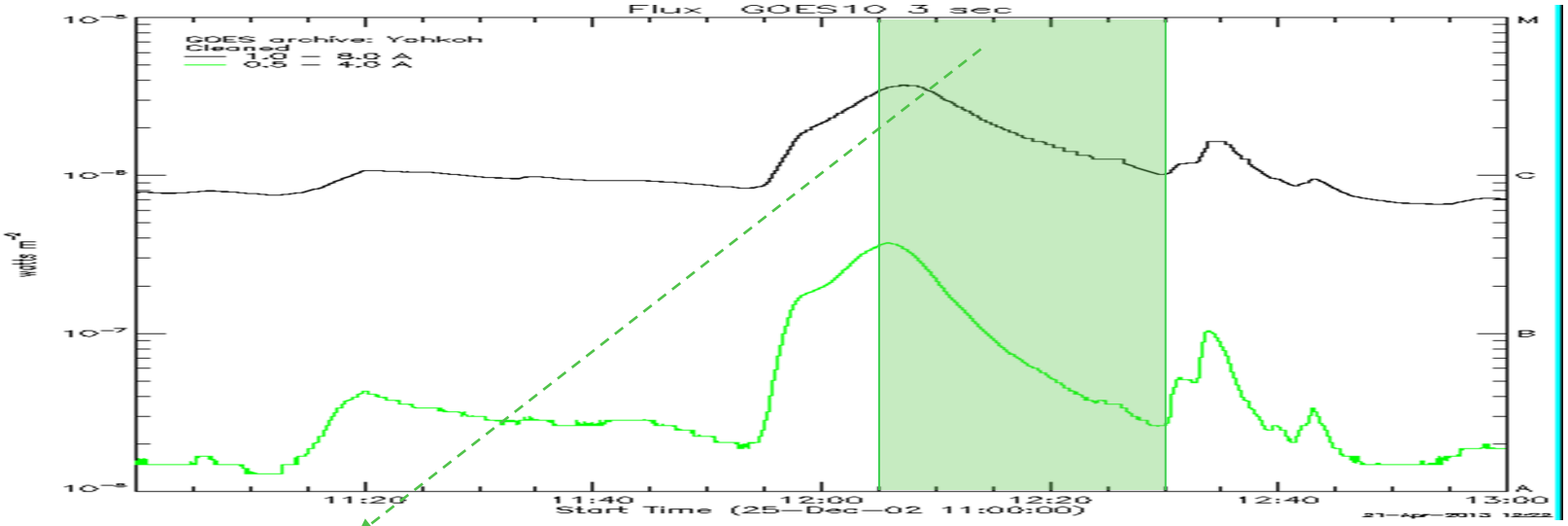


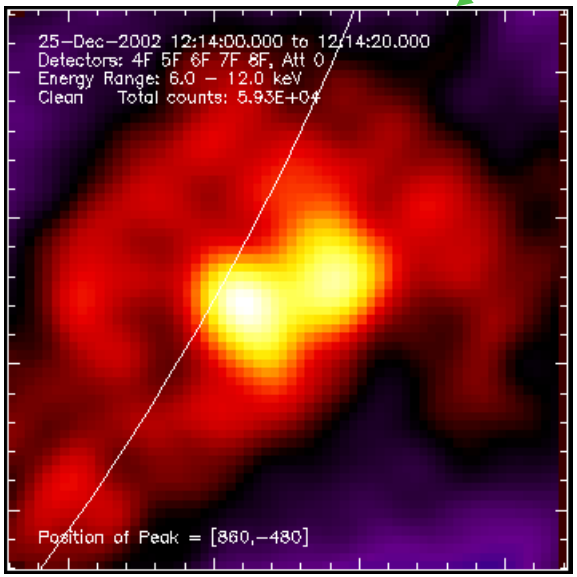




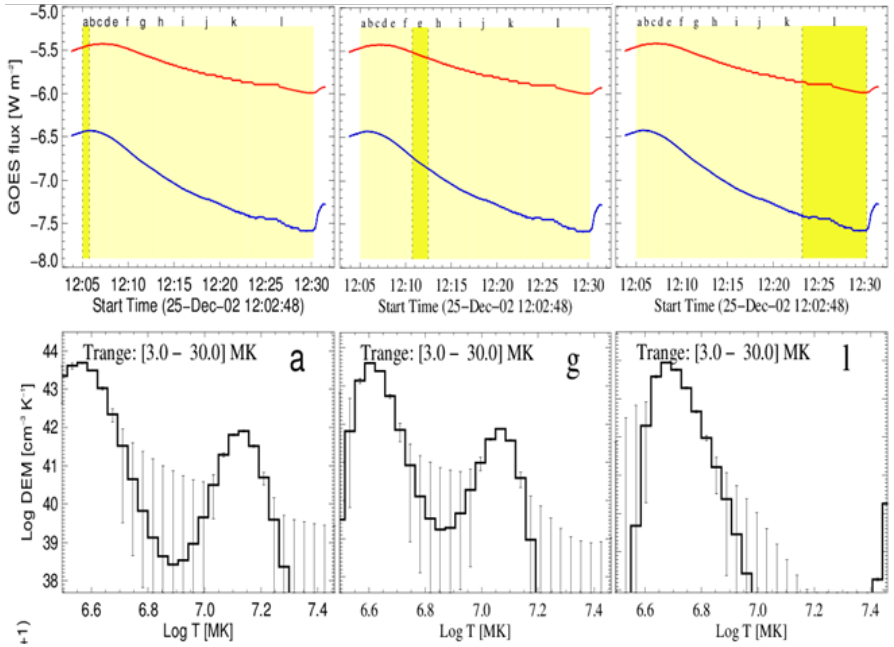
Ne≈4.3x10^{10} cm $^{-3}$

25 Dec. 2002 at 12:07 UT C3.5

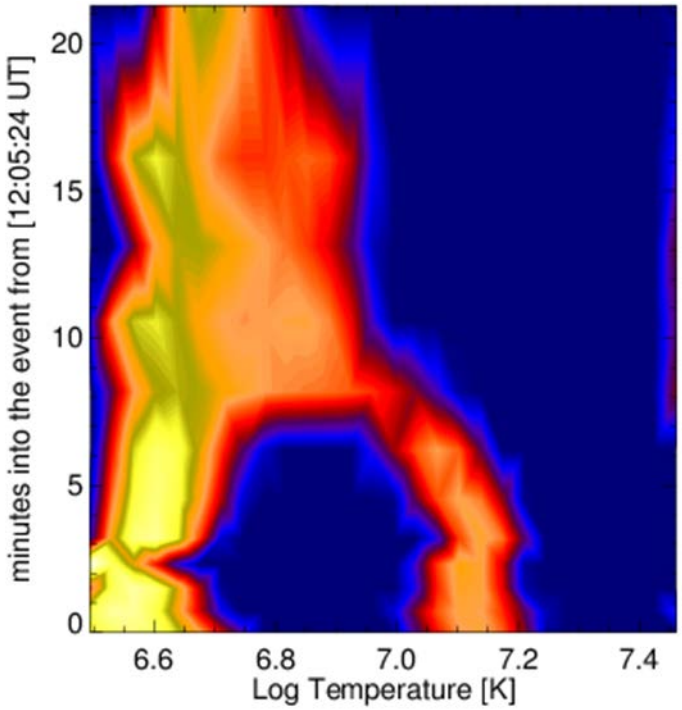


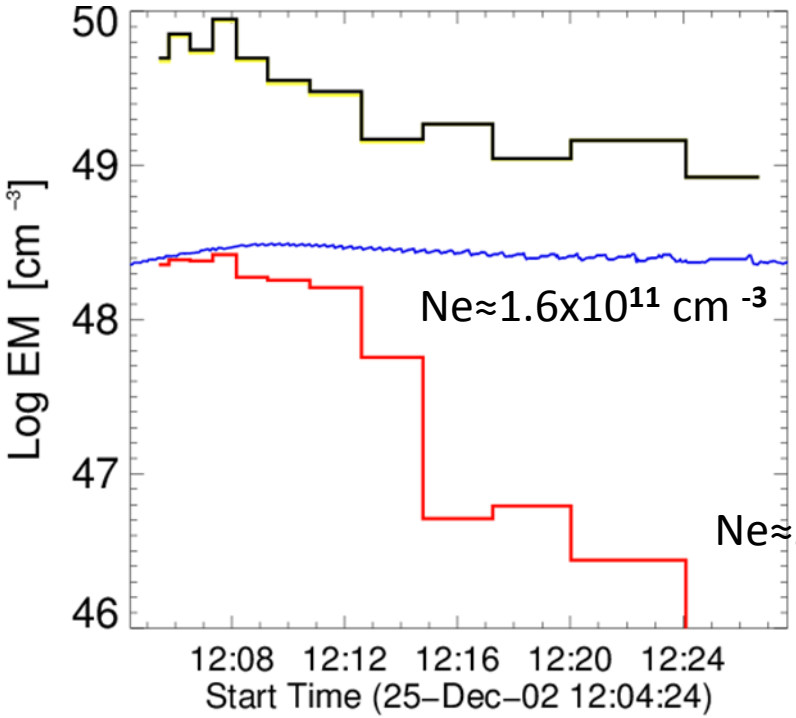


Two X - ray sources

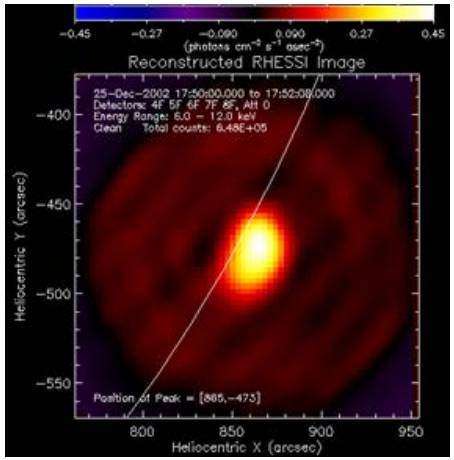


25 Dec. 2002 at 12:07 UT C3.5

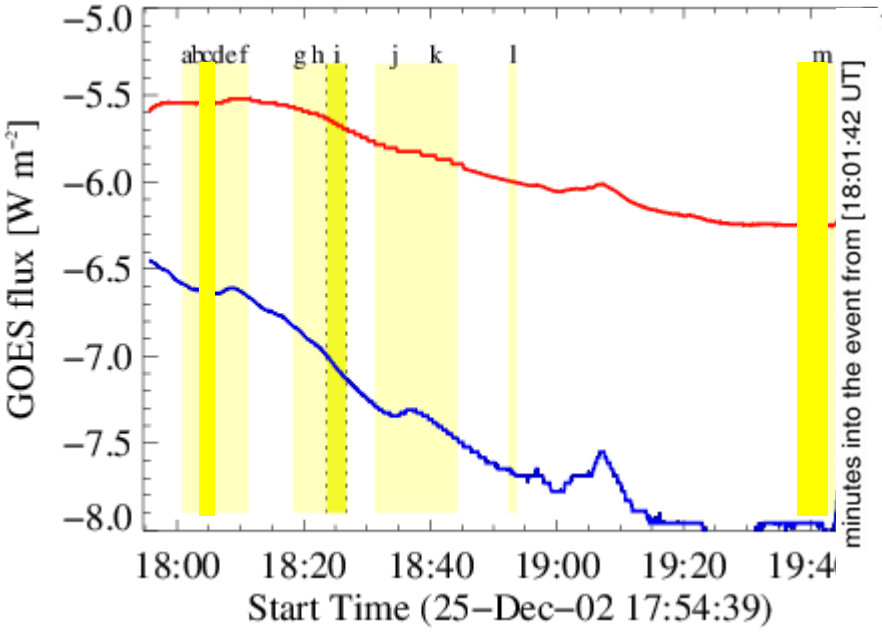


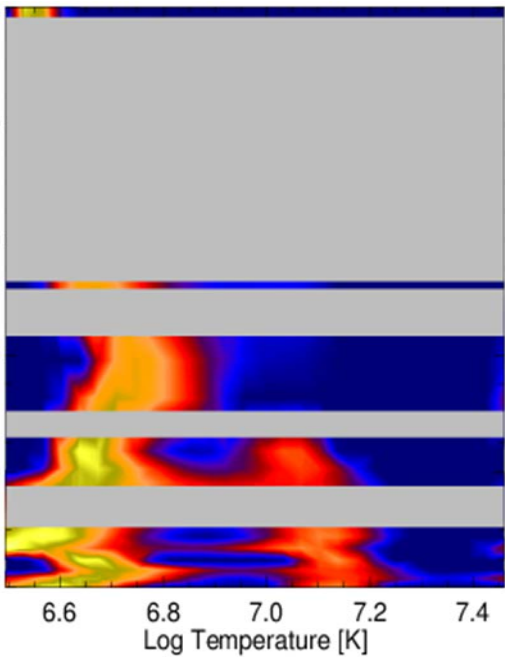


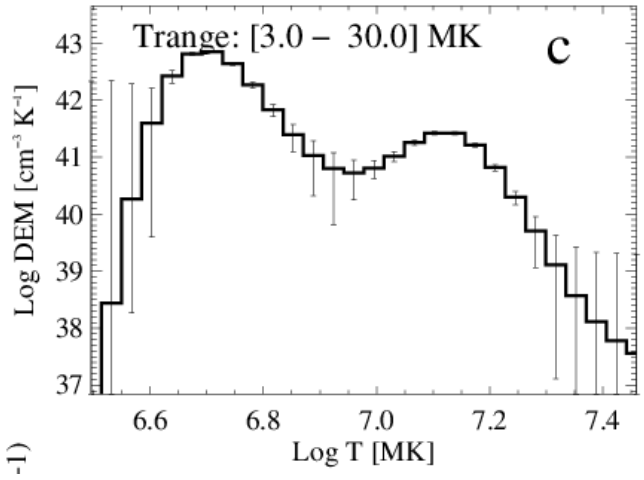
25 Dec. 2002 at 18:00 UT C2.9

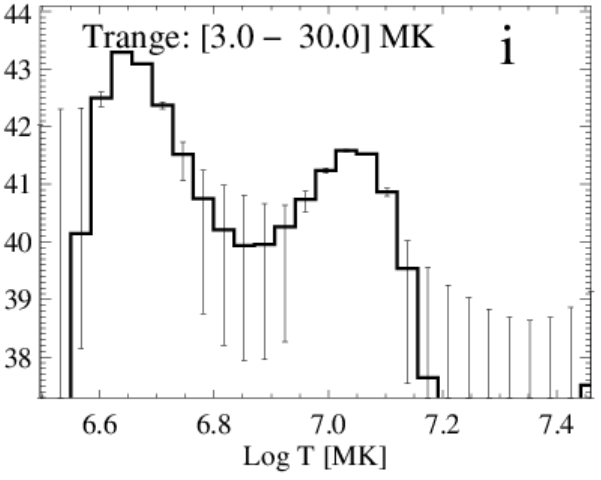


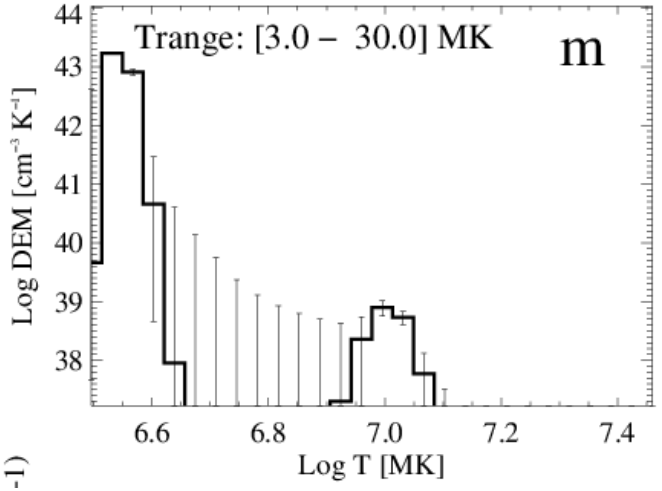
RHESSI data available during the rise phase only….



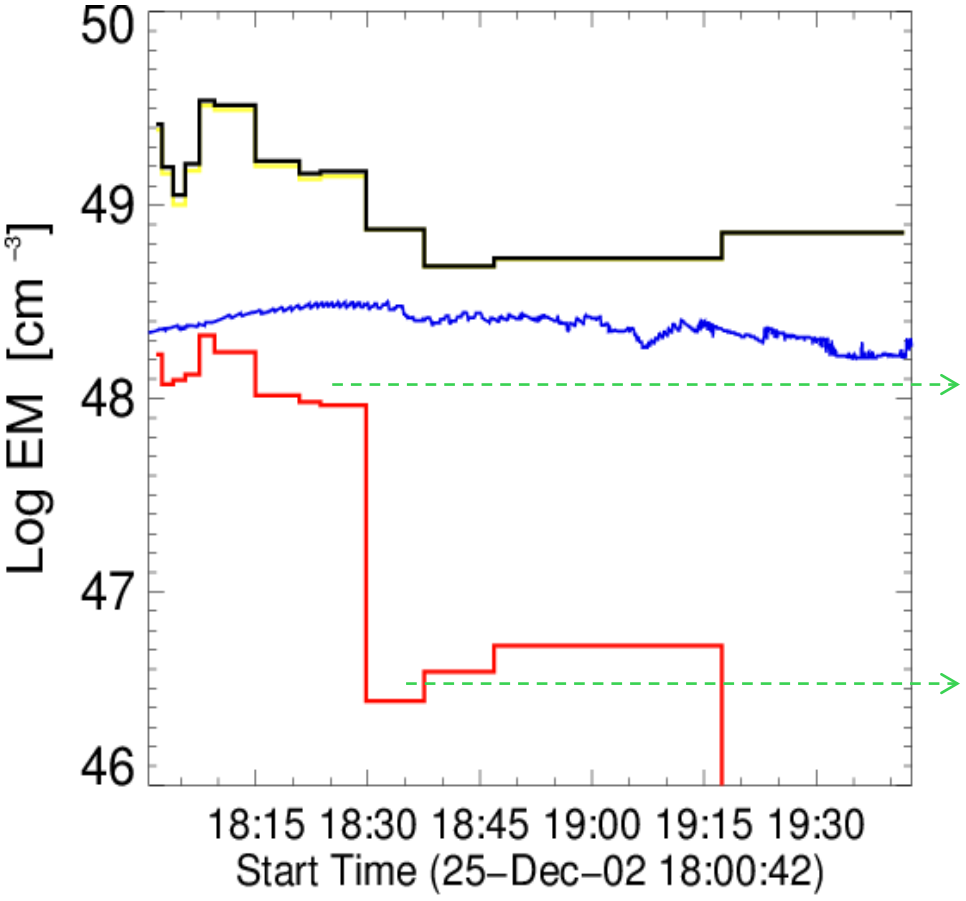








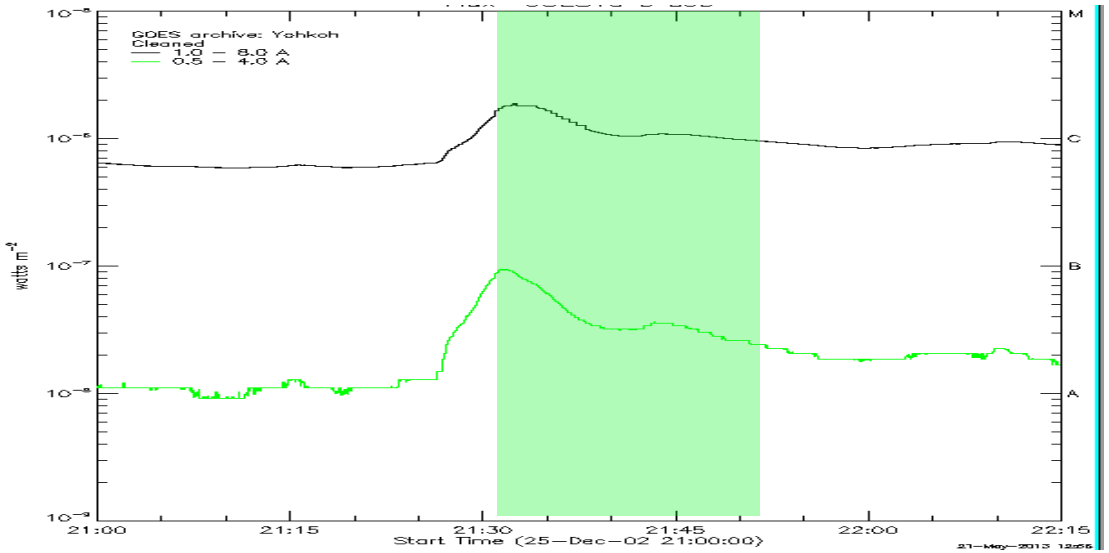
25 Dec. 2002 at 18:00 UT C2.9

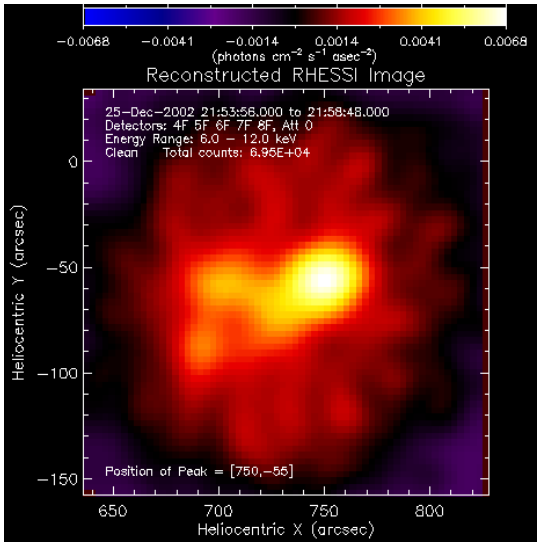


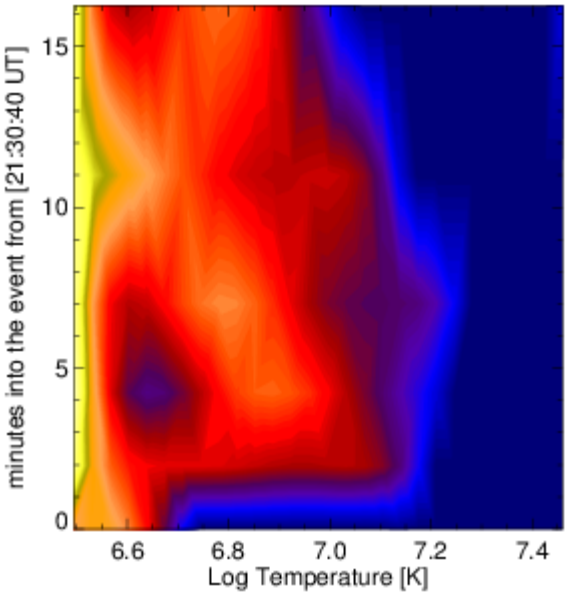
$N_e \approx 1.3 \times 10^{11}$ cm^{-3}

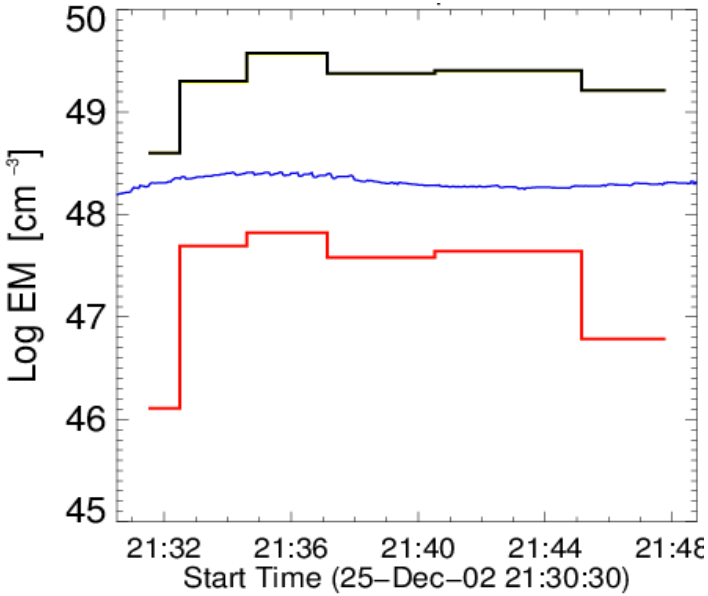
$N_e \approx 2.1 \times 10^{10}$ cm^{-3}

25 Dec. 2002 at 21:32 UT C1.7



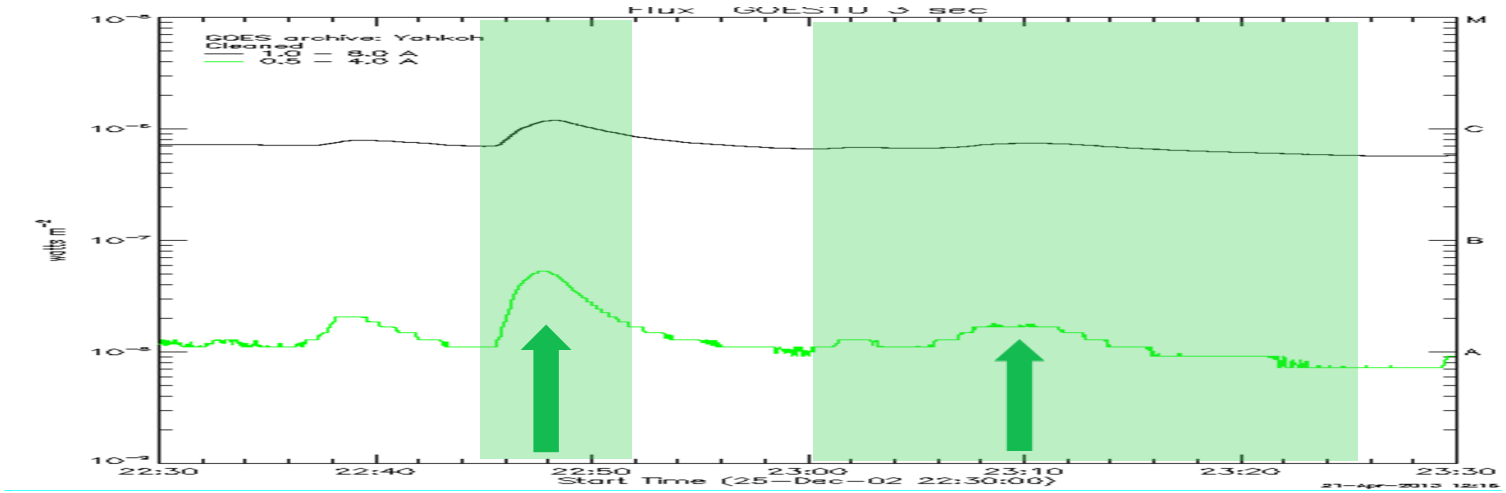


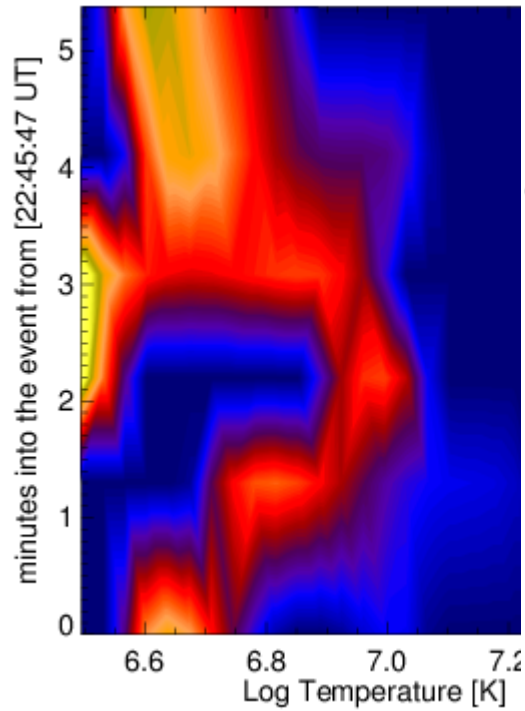


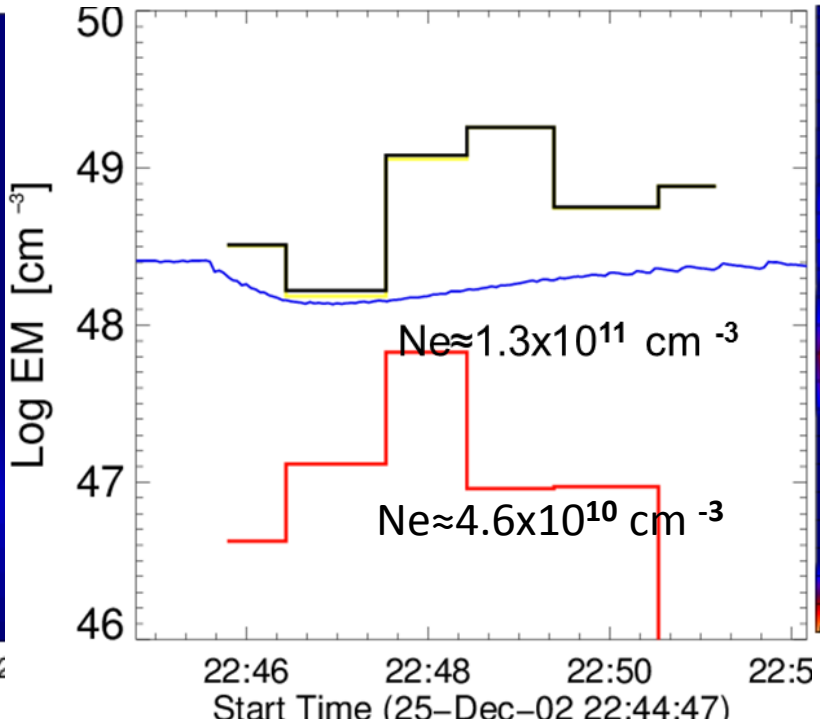


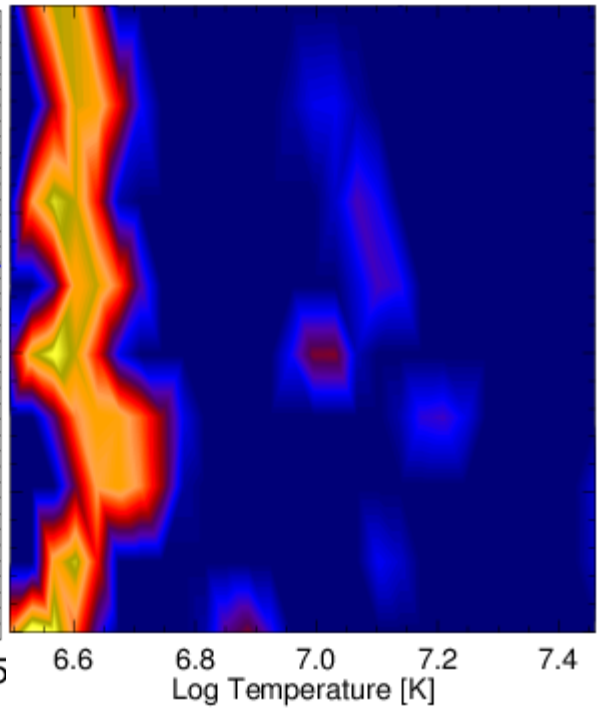
Ne≈1.3x10^{11} cm $^{-3}$

25 Dec. 2002 at 22:48 C1.1 & 23:10 UT B8.0

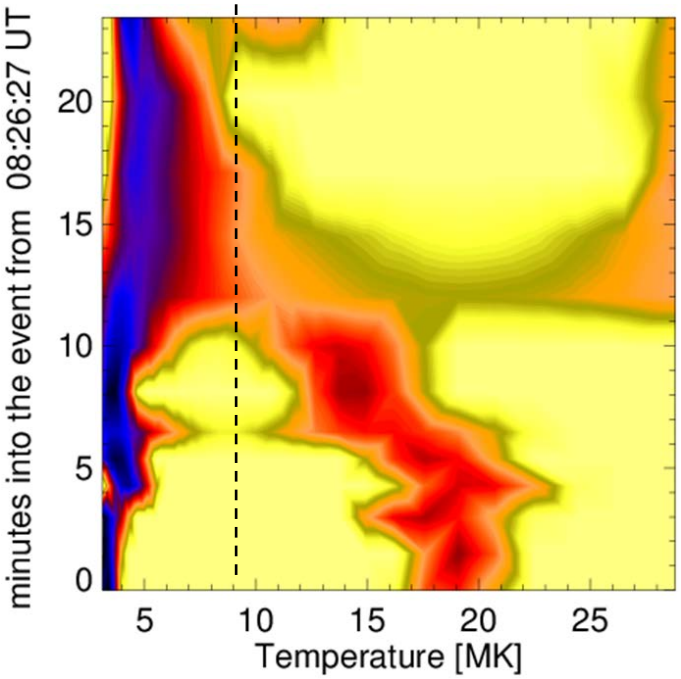


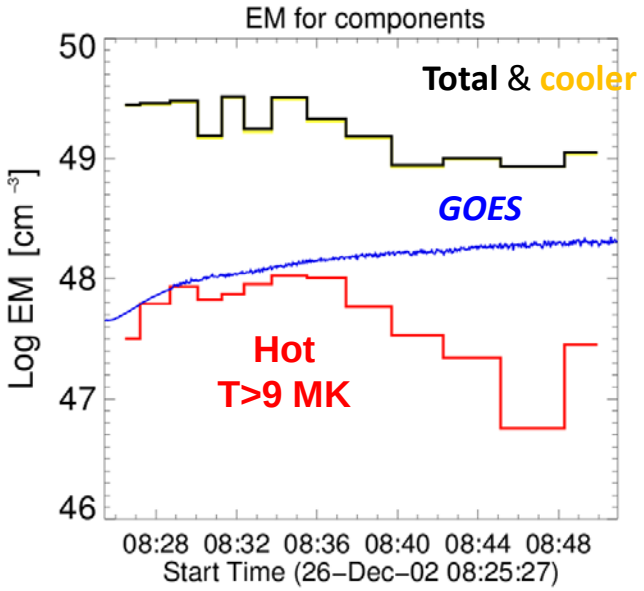


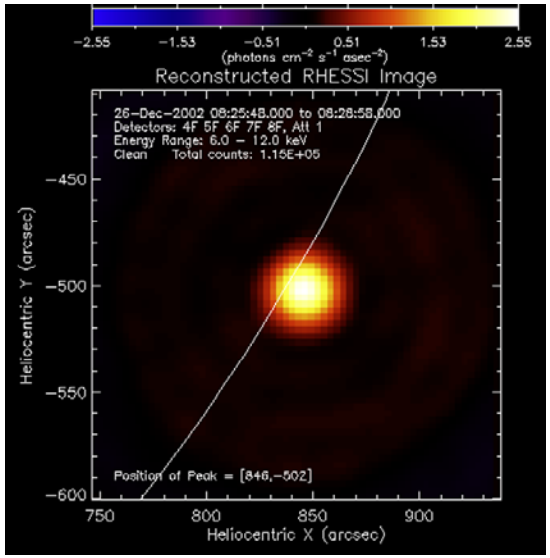


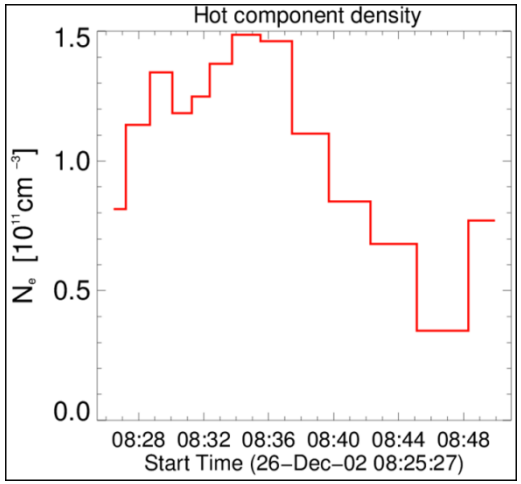


26 Dec. 2002 at 08:30 UT C1.9









Take home message

- Adjusting the plasma composition is apparently necessary before the DEM inversion: for analysed flares the adjusted abundances for Si, S and Ar are lower than the coronal values.
- Calculated DEM distributions have two components – a cooler component T < 9 MK (probably related to the non-flaring active region) and a hotter one T > 9 MK (flare proper).
- The total EM of the hotter component is orders of magnitude less than that of the cooler component.
- The presence of this tiny amount of hot plasma is nevertheless necessary in the data analysis for the observed fluxes in several spectral bands to be reproduced.
- With the emitting region size from imaging instrument RHESSI, a lower limit for the density of plasma can be estimated: typically this is ~ 10^{11} cm^{-3} around the flare peak and ~10^{10} cm^{-3} during late decay phase.