Properties of selected flaring events observed by SphinX and other instruments within AR 11024

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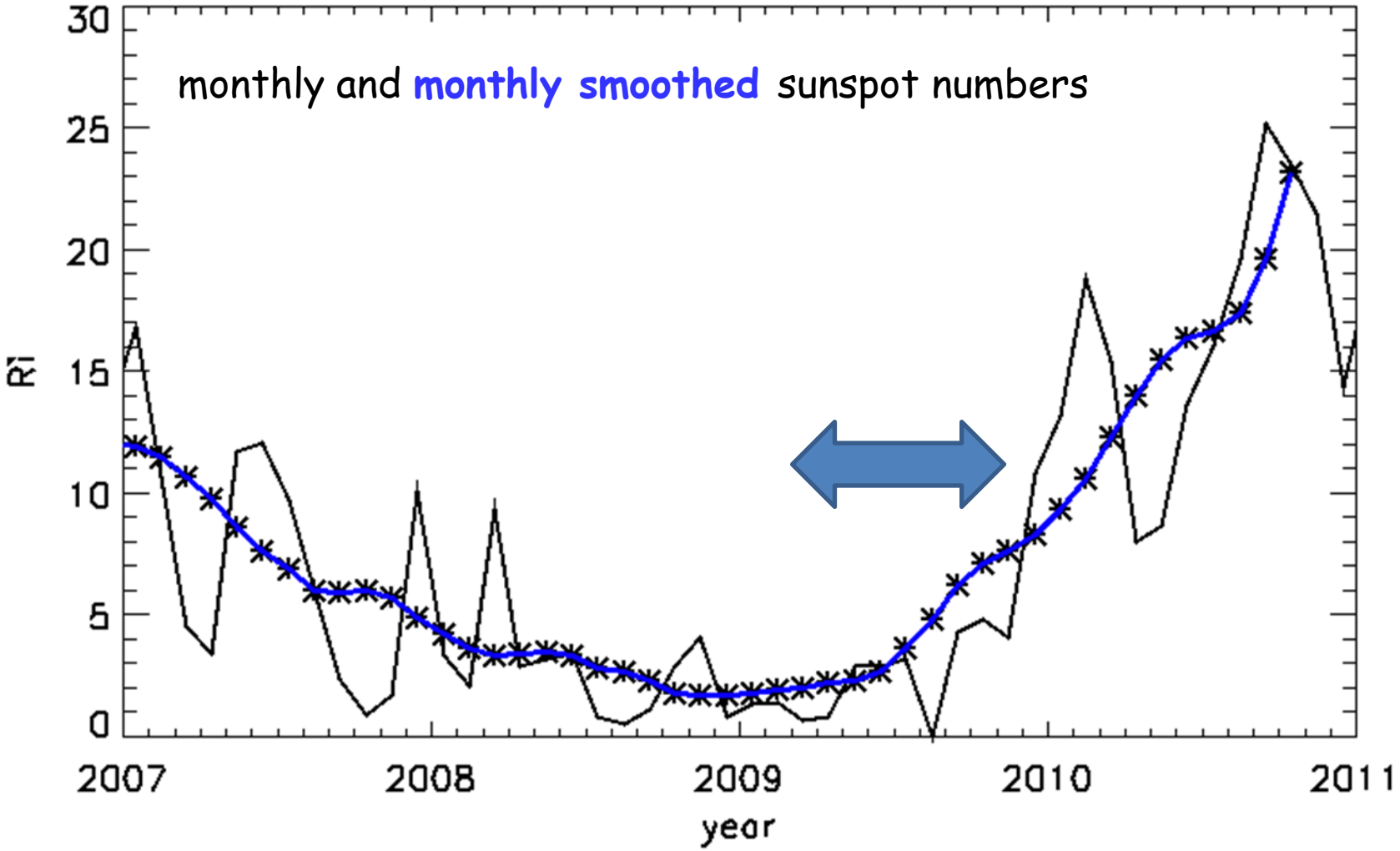
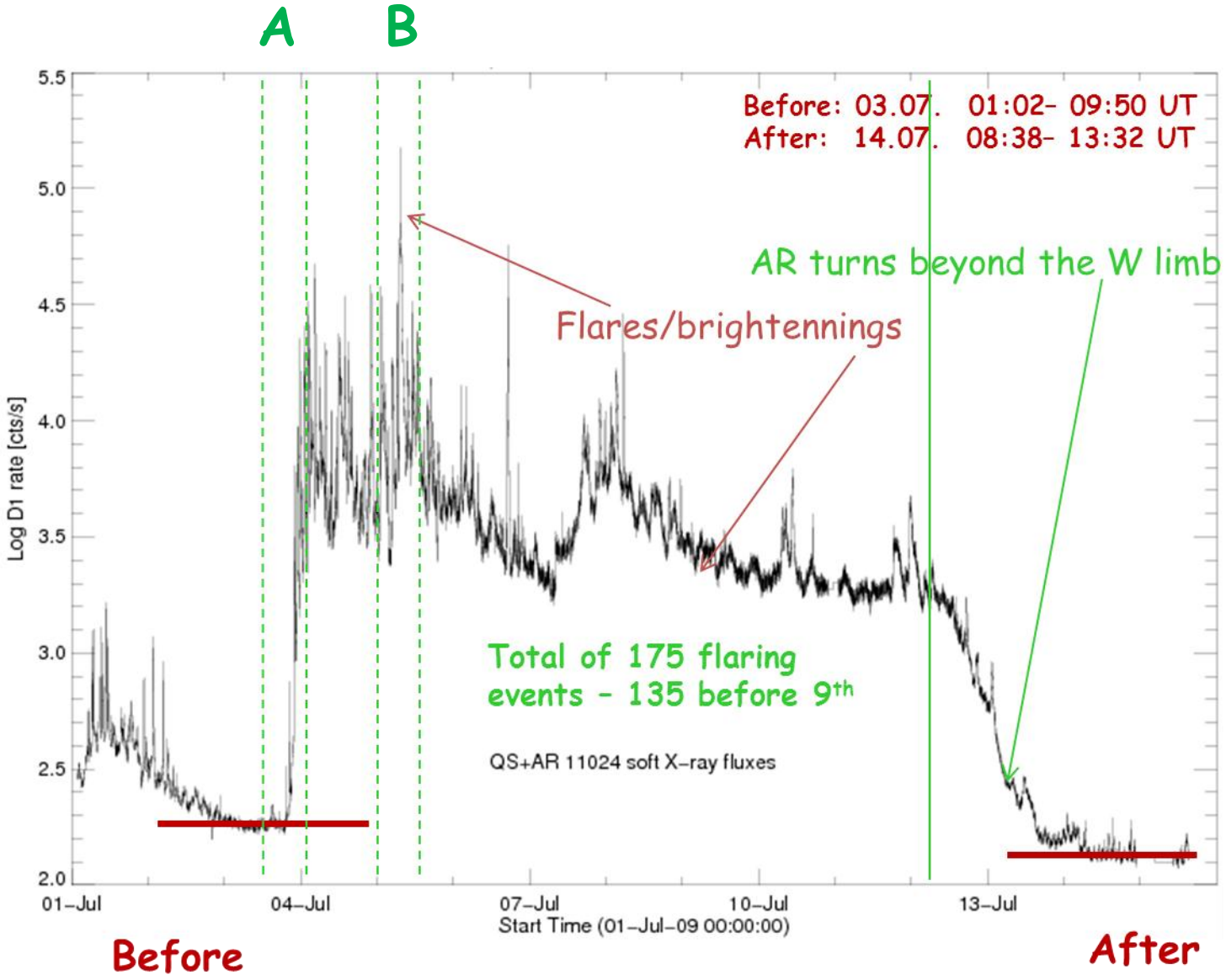
Harvard -Smithsonian Center for Astrophysics, Cambridge, USA

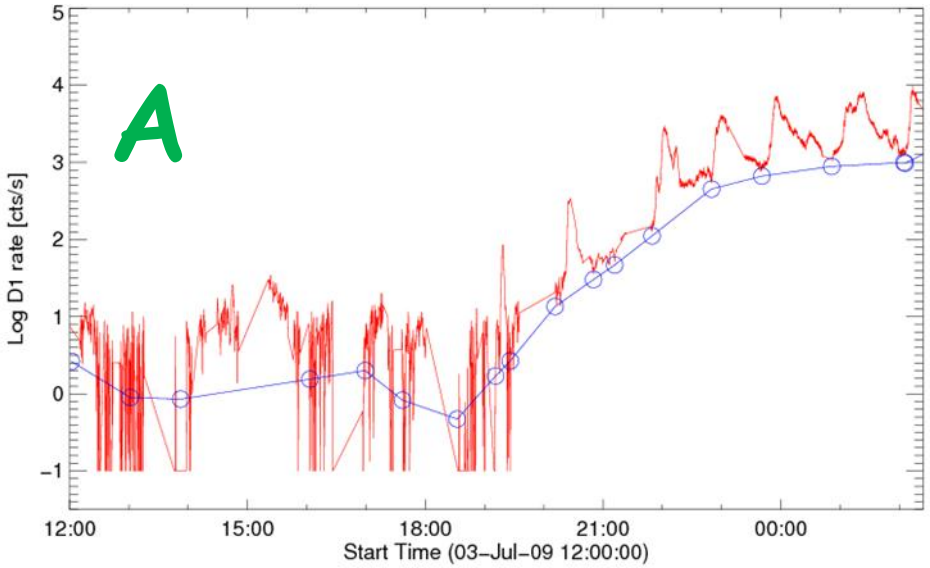
23/24 activity minimum & SphinX

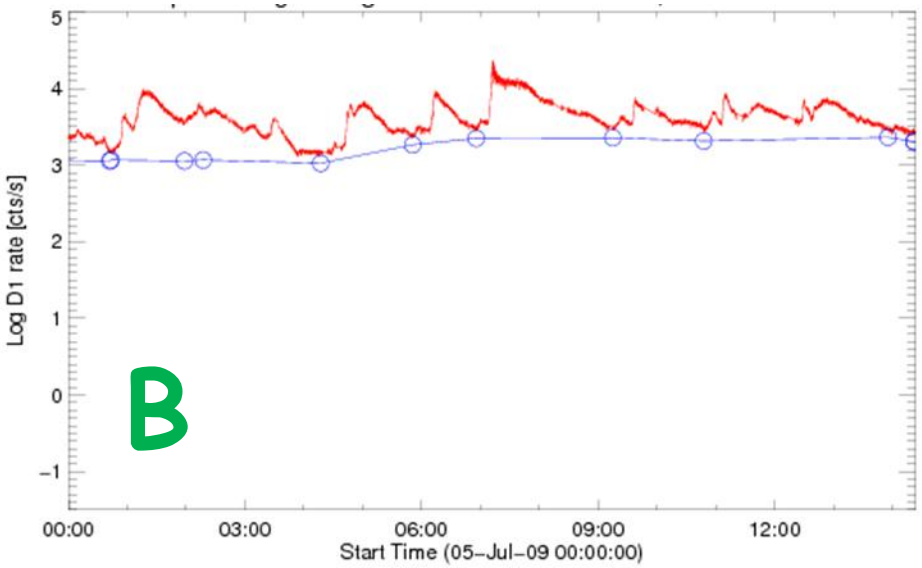


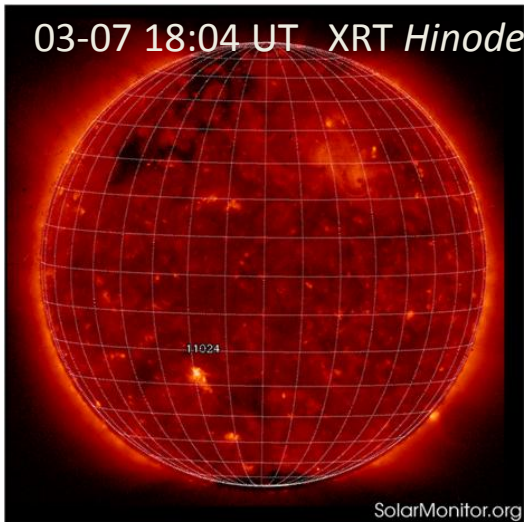
SphinX flux as measured above 1.19 keV (1-16 July 2009)

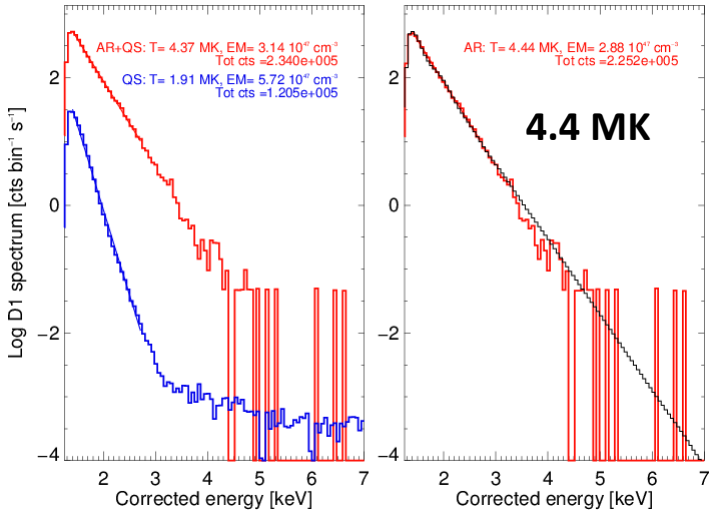


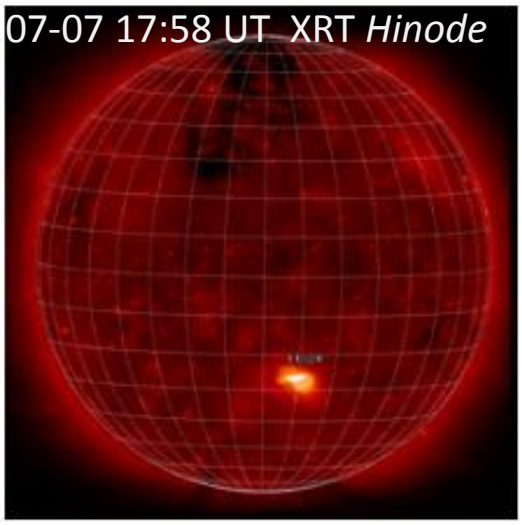
Subtraction of AR contribution (226 points selected)



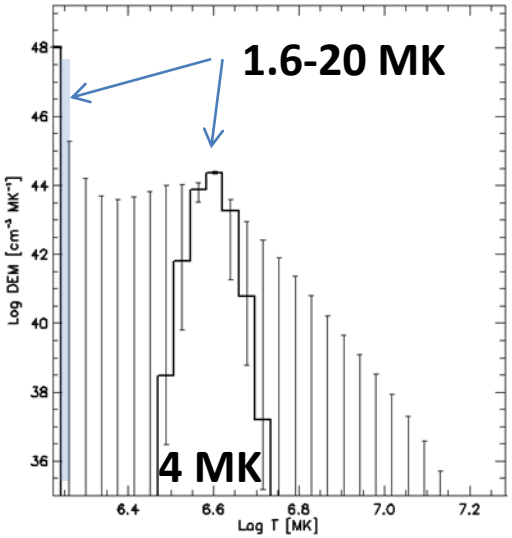


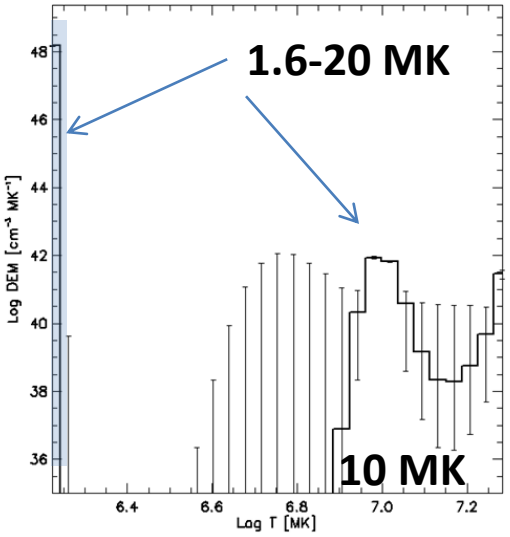


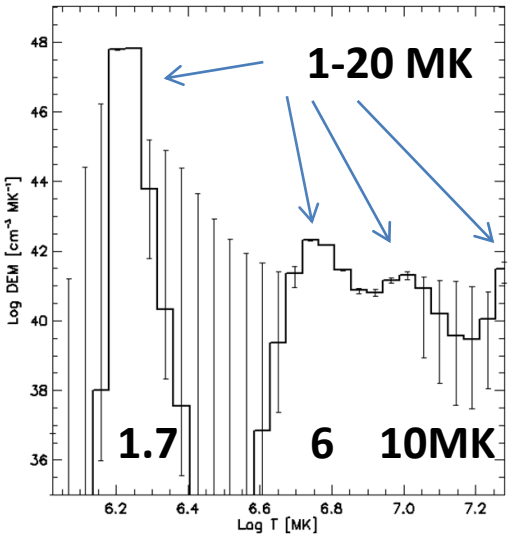


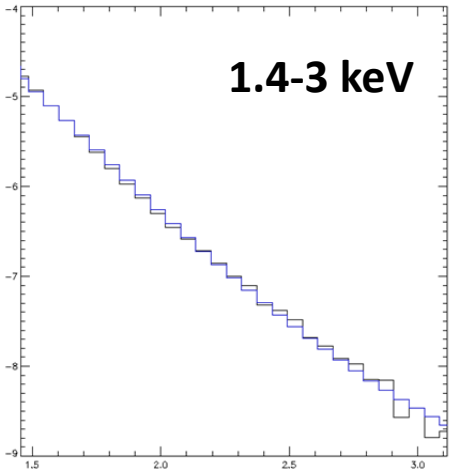


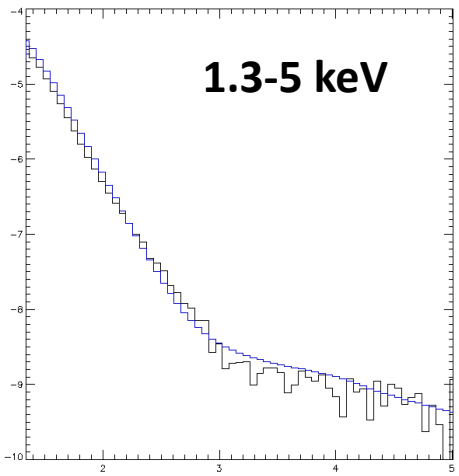
DEM for quiet Sun (pre-AR emission)

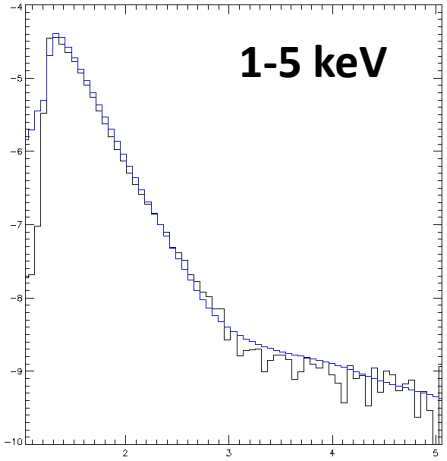




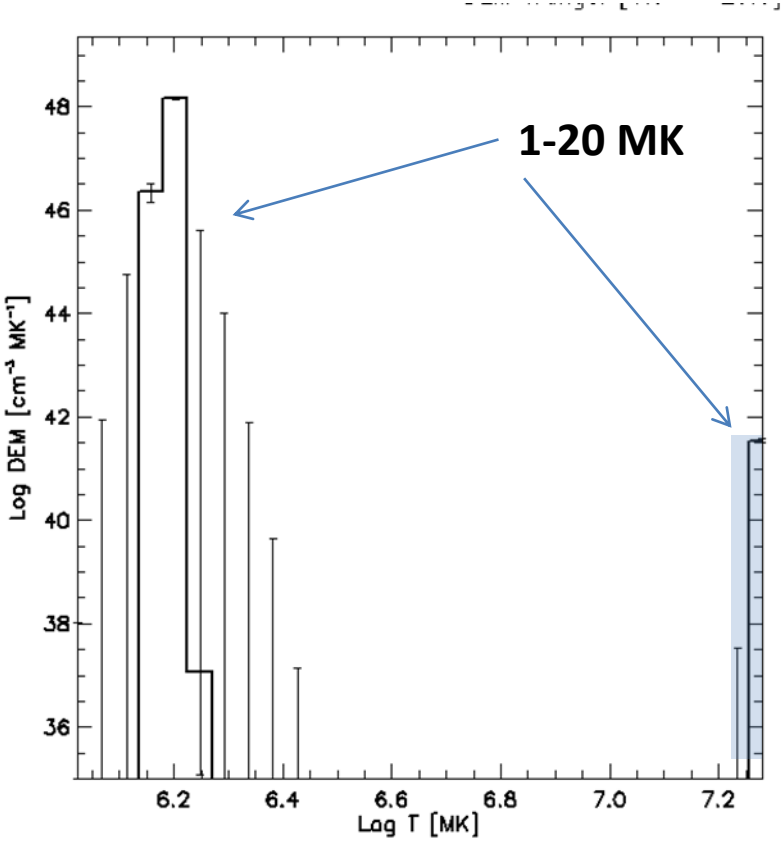




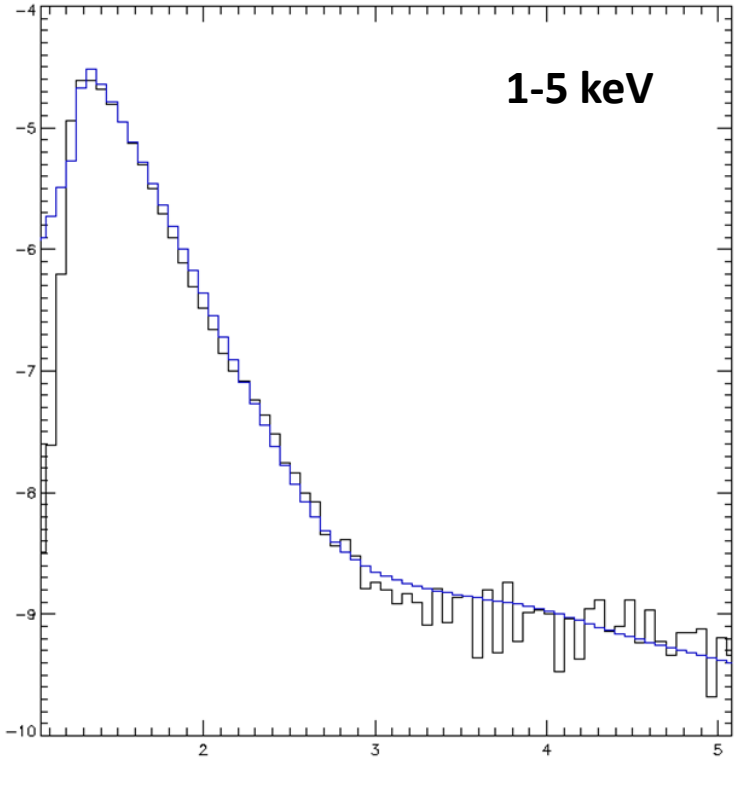




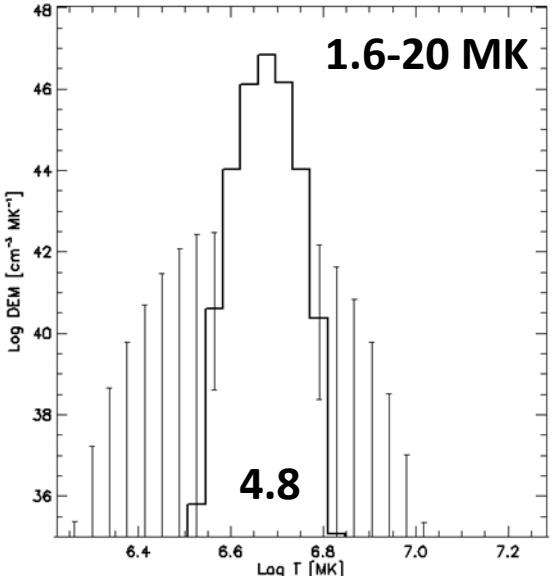
DEM for quiet Sun (post-AR emission)

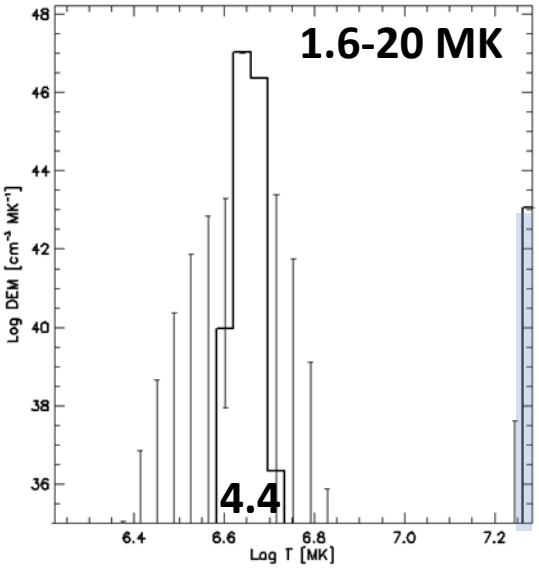


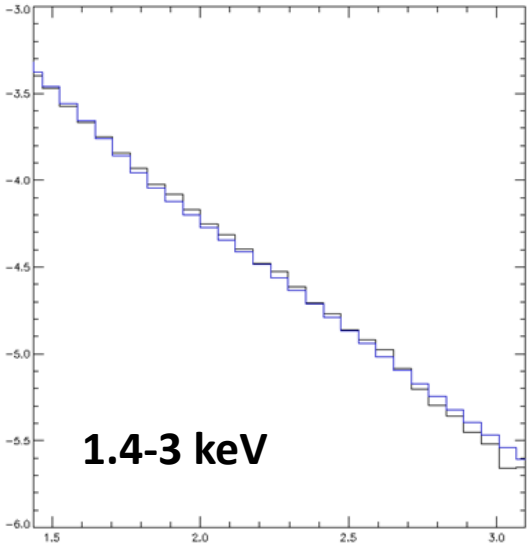
1.6 MK

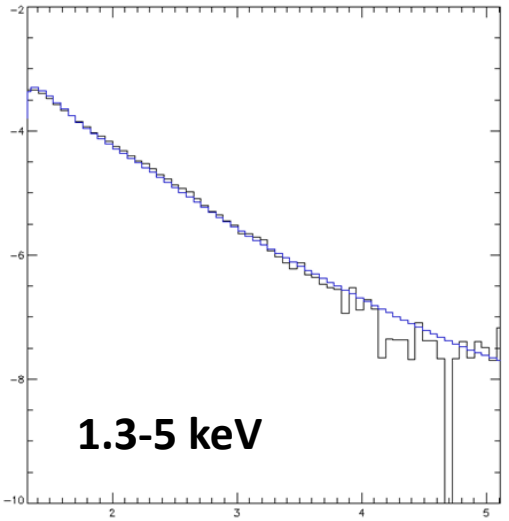


DEM for AR emission before the flare (signal summed over dt=10 min., ~1 mln counts)







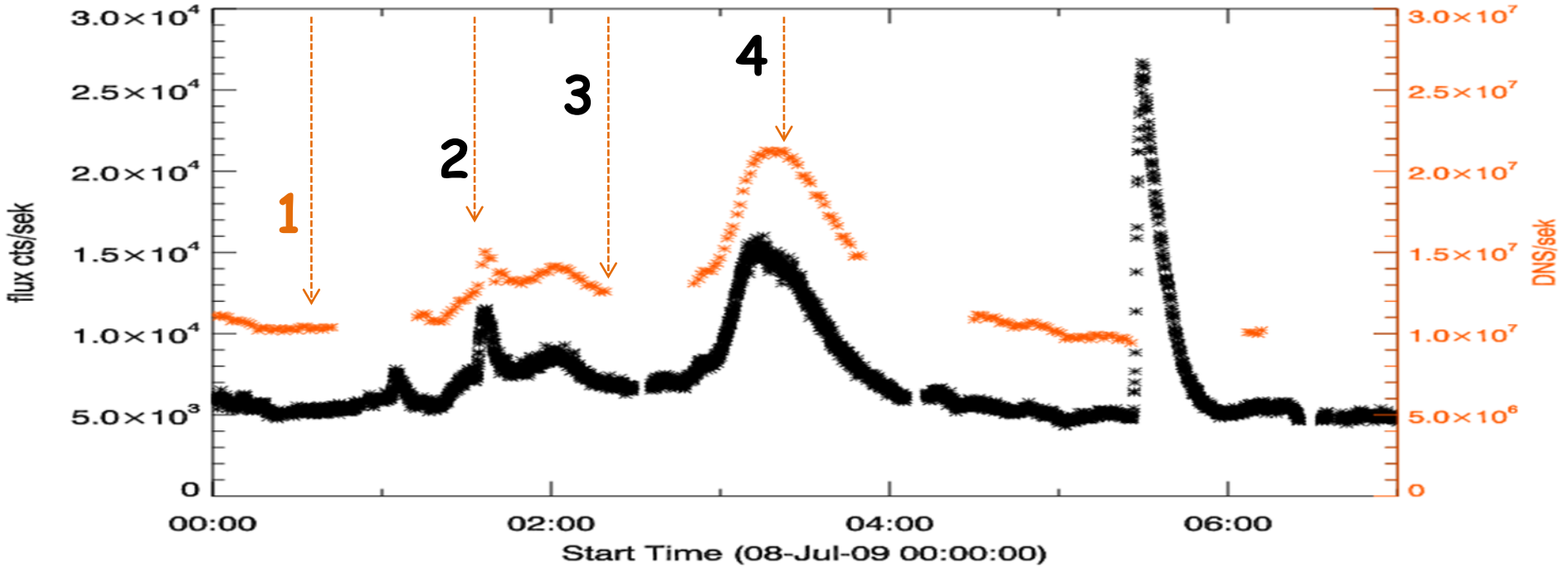


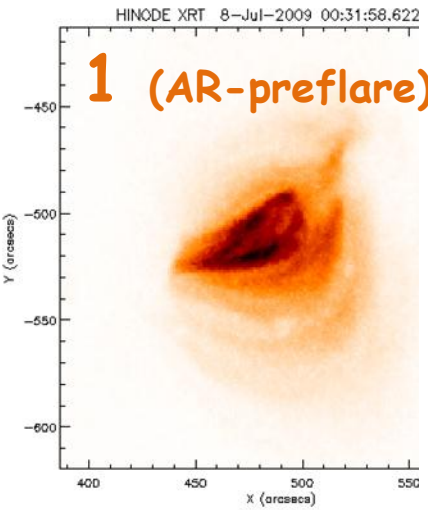
Temperature & EM from SphinX

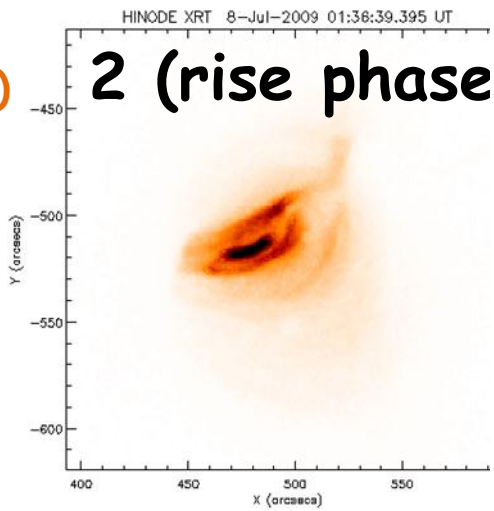
Isothermal approach:

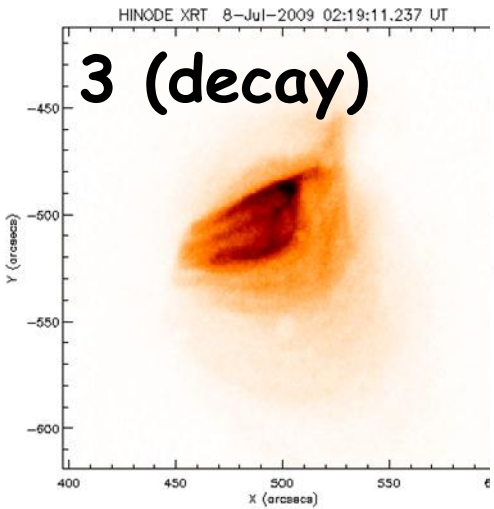
T from the slope of the spectrum in the range 1.4-3 keV
EM from total No. of counts in the spectrum

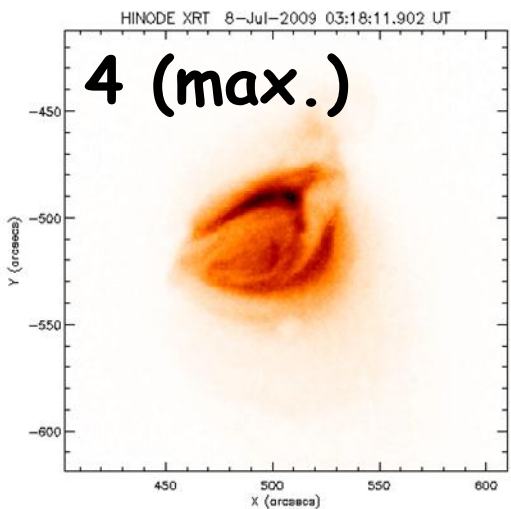
6 hours of evolution during 8th June











Volume & N_e determination

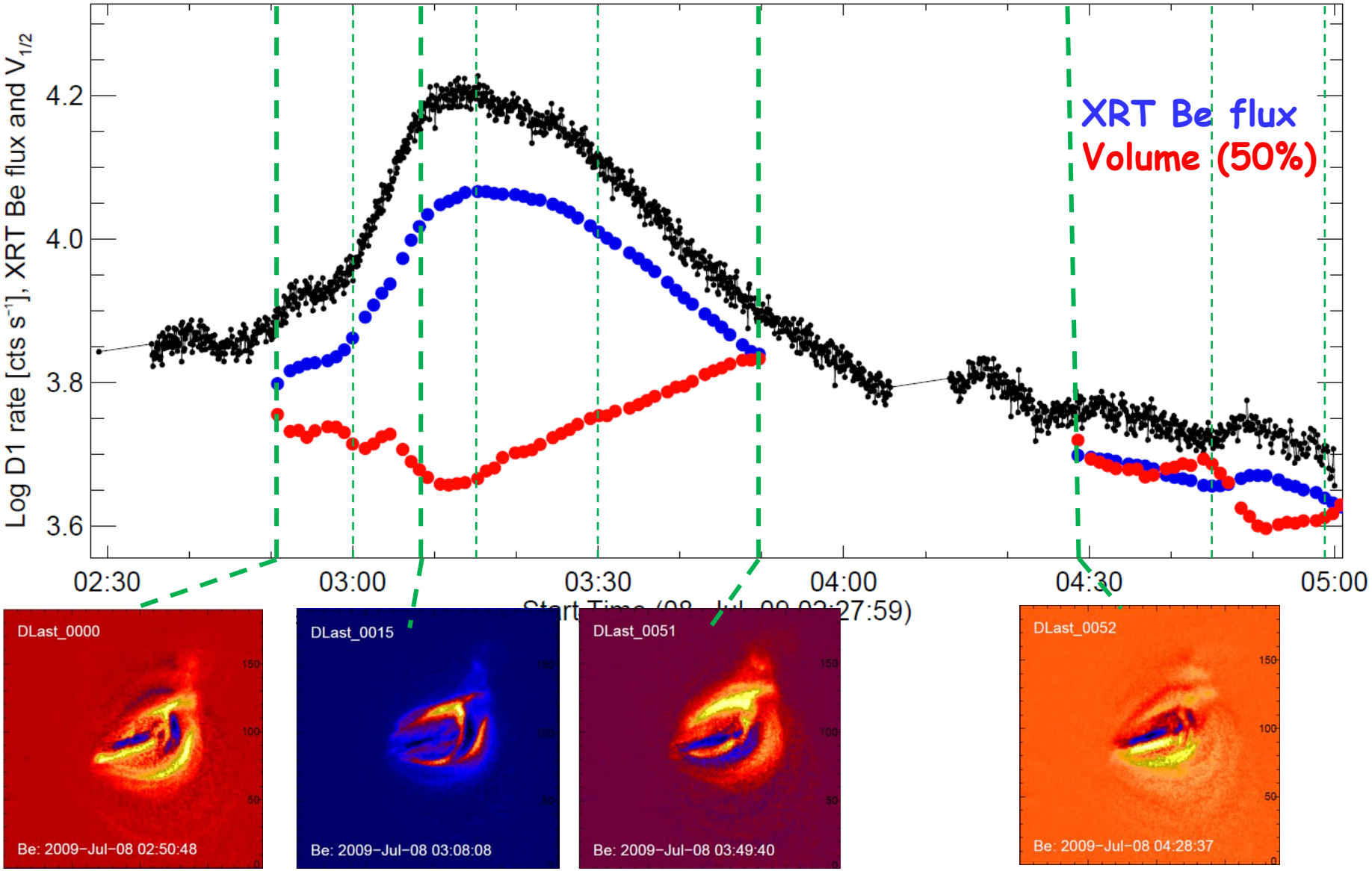
Hinode images in full (high) XRT resolution available:
each ~60 sec
~400 x 400 pixels of 1 arcsec size
(Be_medium and Ti_poly filters)

Pixels within the area above 90% of the **total flux** in ***Hinode*** XRT Be image →circular footprint with the same amount of pixels →equivalent volume

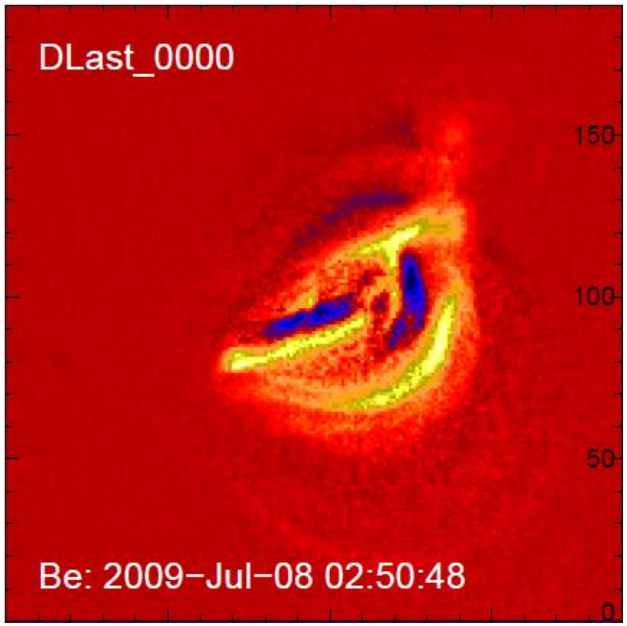
0.1 EM_{SphinX} and volume → **N_e** determination

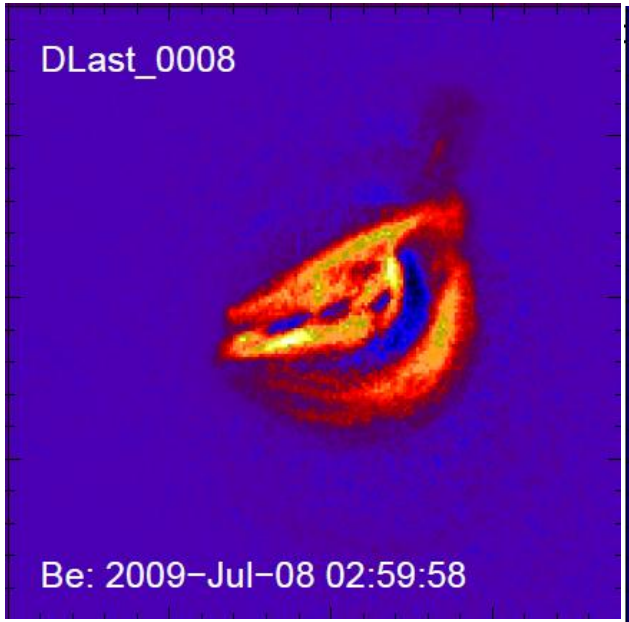
$$EM = N_e^2 \times V$$

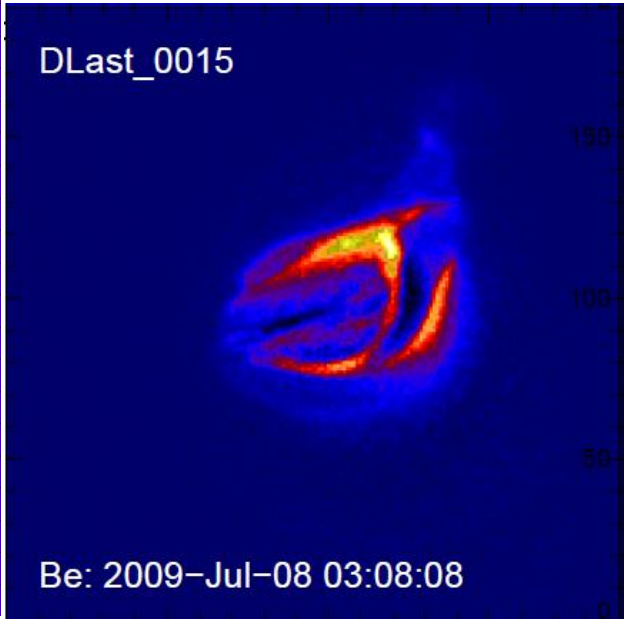
8 July 2009, 03:13 UT, B3.6

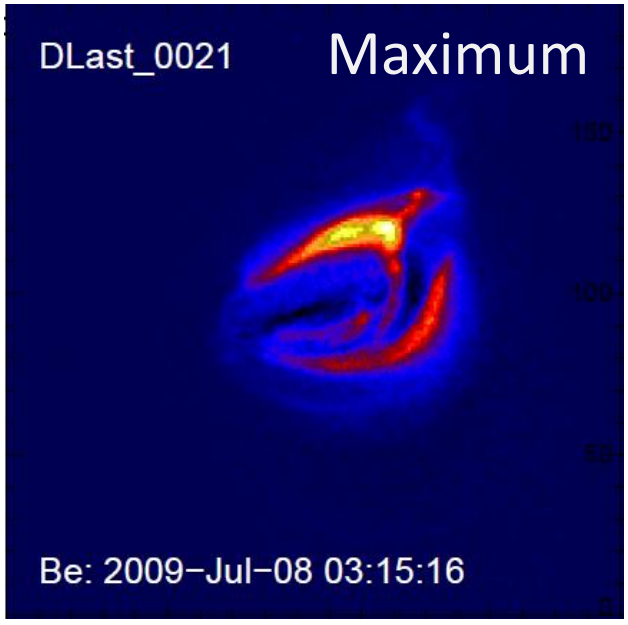


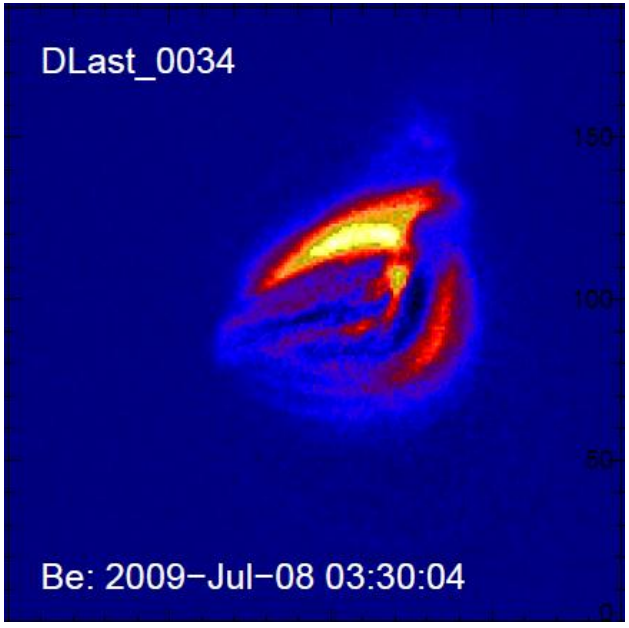
Morphology evolution - differential images relative to the last post-flare image

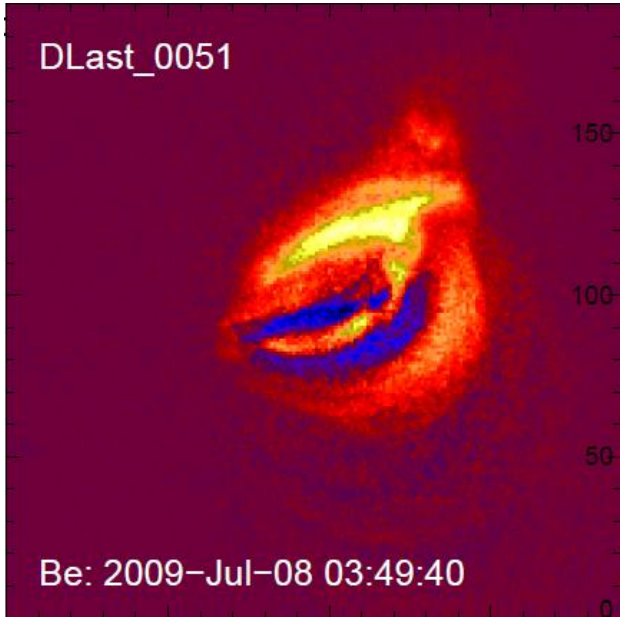




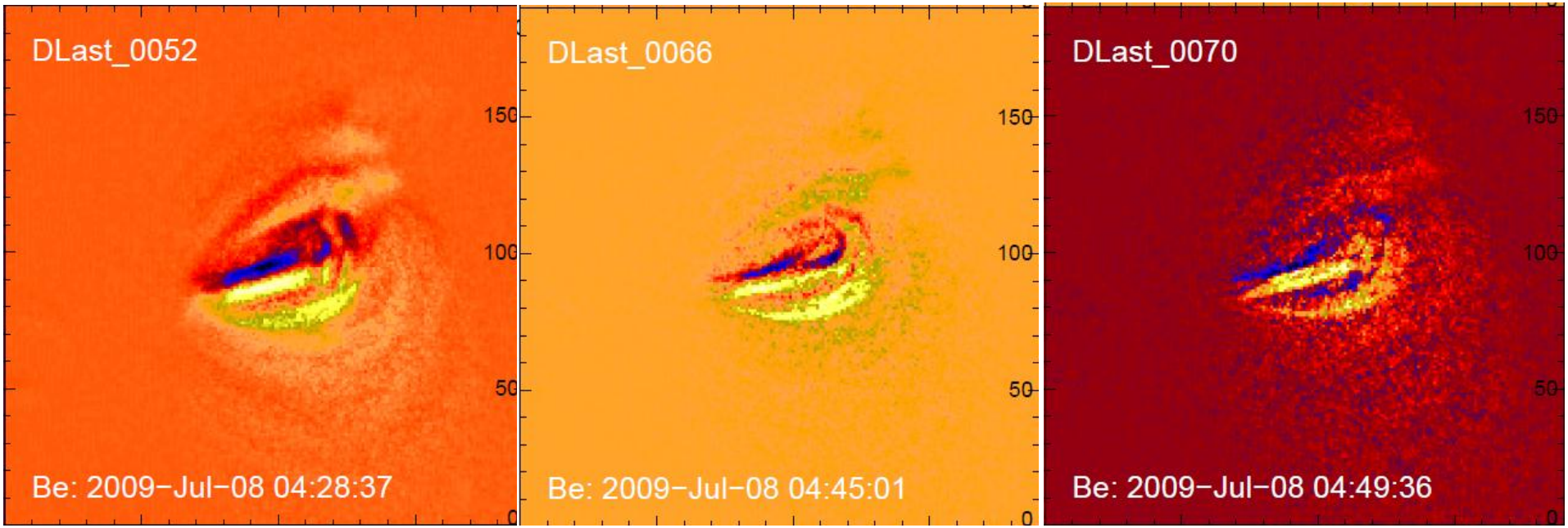






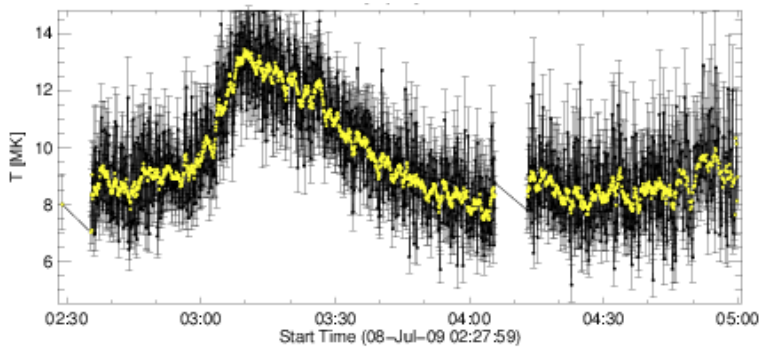


Late flare decay phase evolution (20 min.)

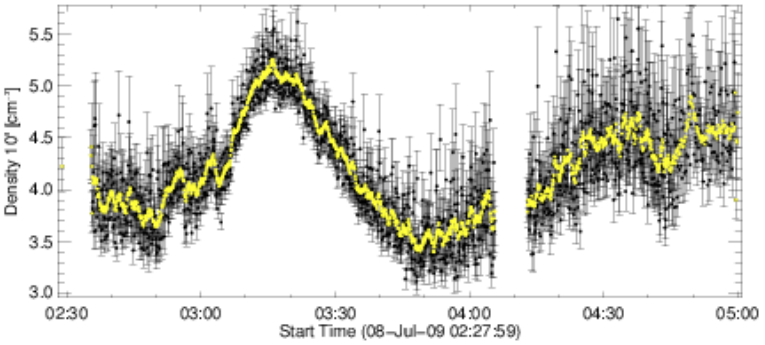


Thermodynamic parameters

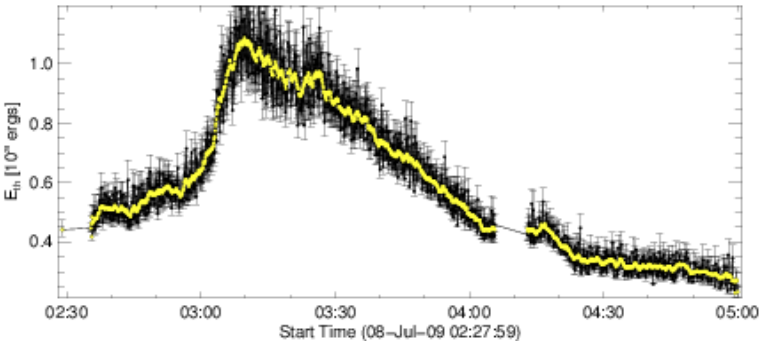
T



N_e



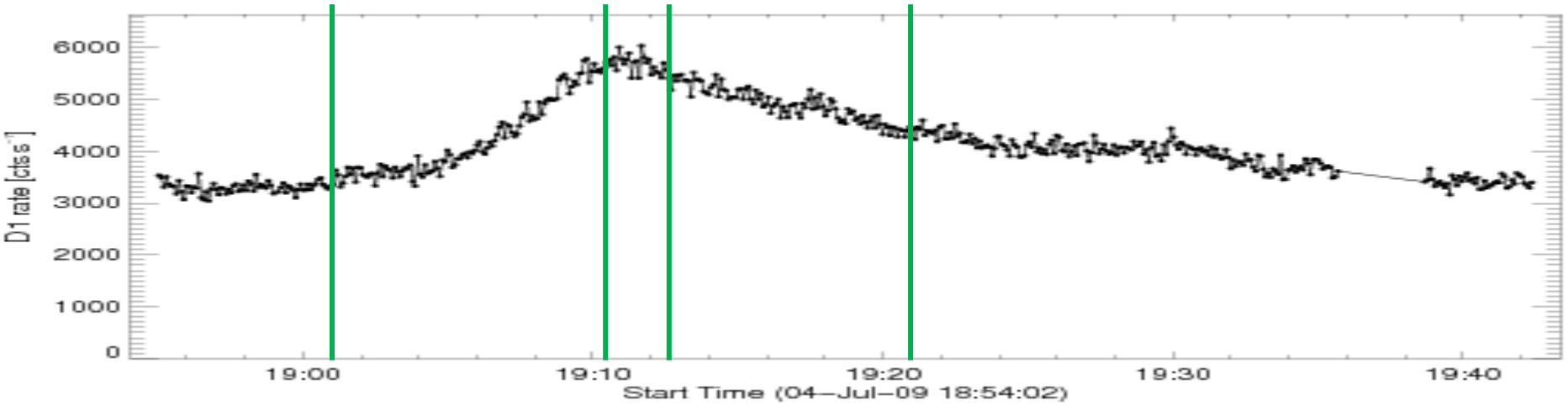
E_{th}

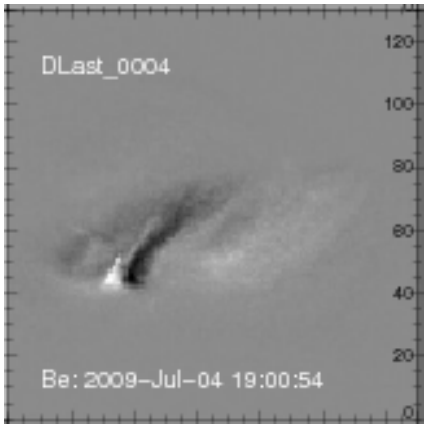


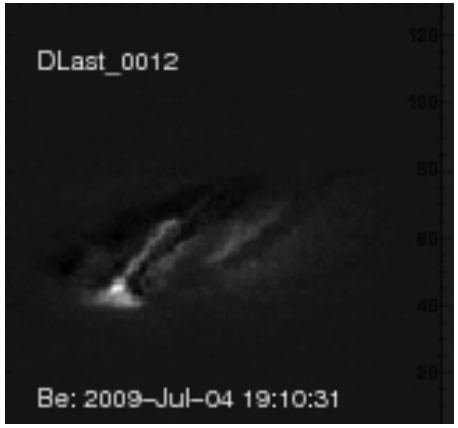
$EM, T, V \rightarrow N_e \rightarrow E_{th}$

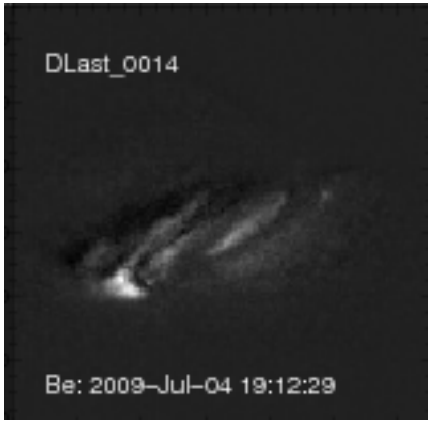
$E_{th} = 3kTN_eV$

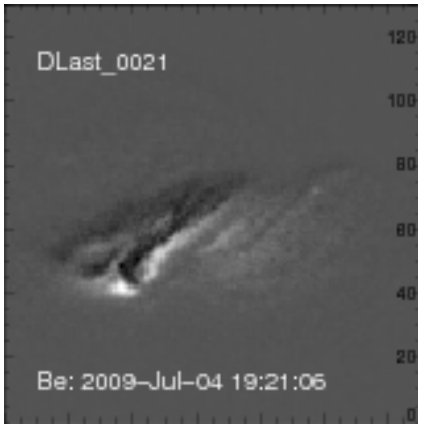
Another flare 4 July, 19:11 UT; A9



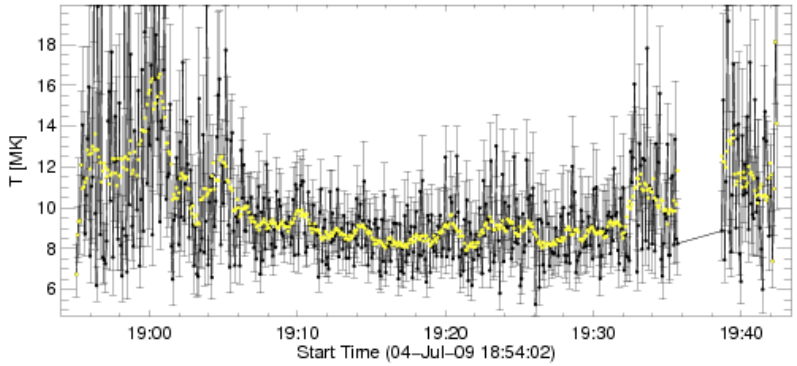


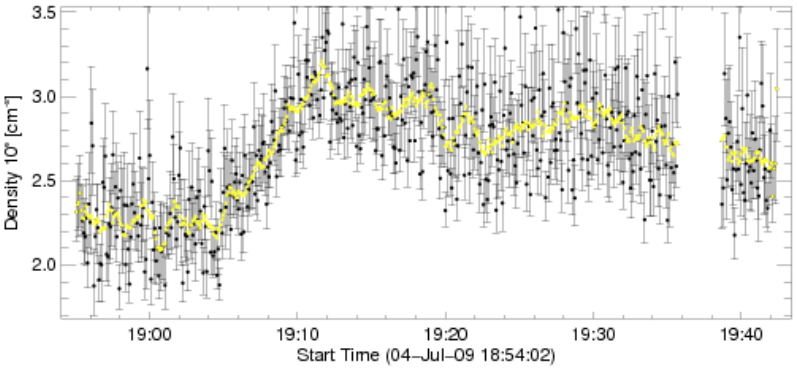




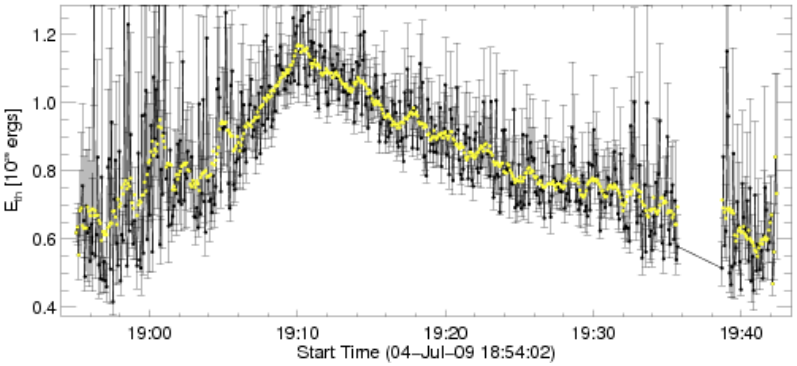


4 July, 19:11 UT; A9





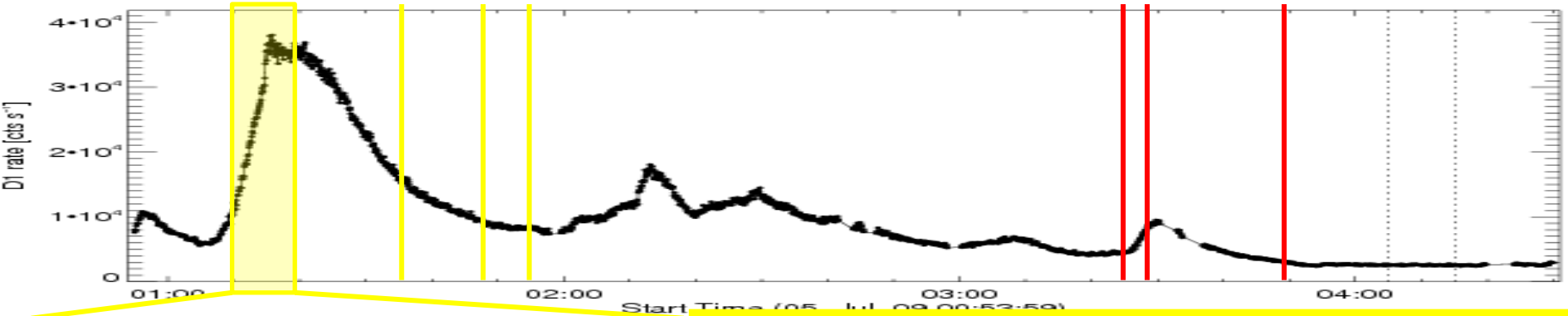
N_e

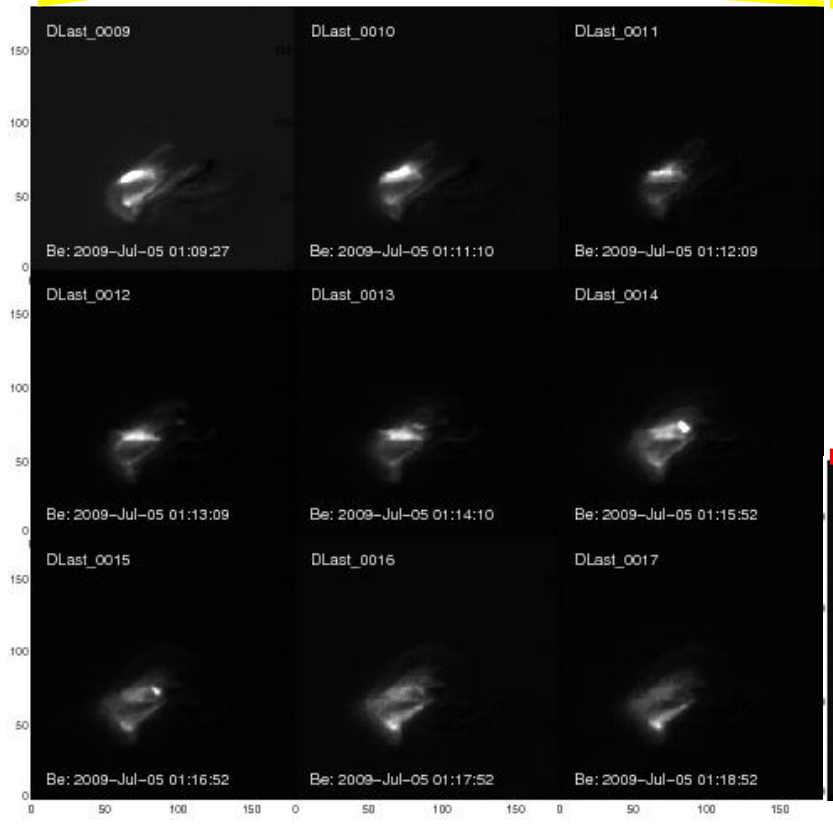


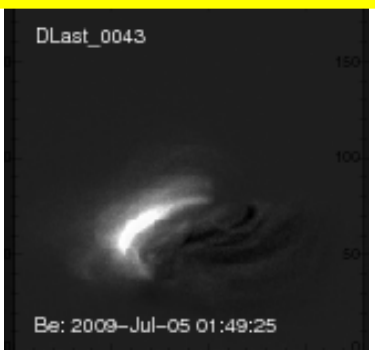
E_{th}

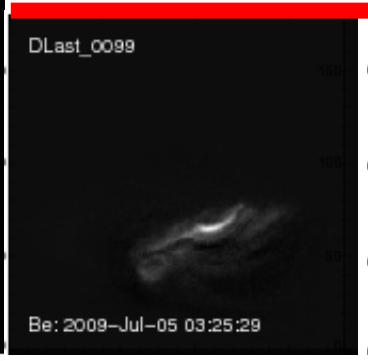
Fluctuating, but nearly constant temperature

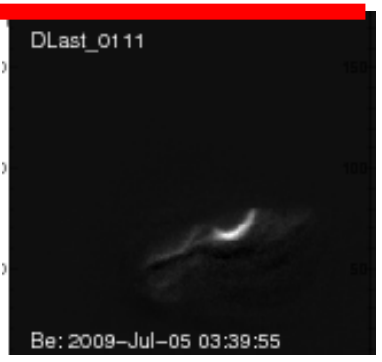
Third example:
5 July, 01:16; 03:30 UT C1.1; B2.2



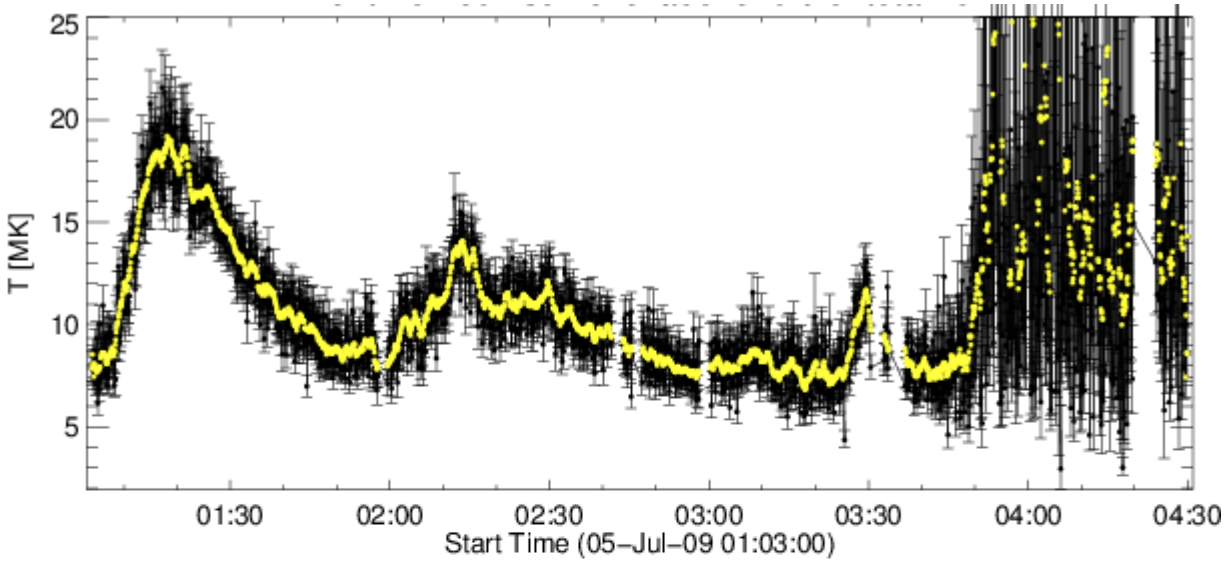


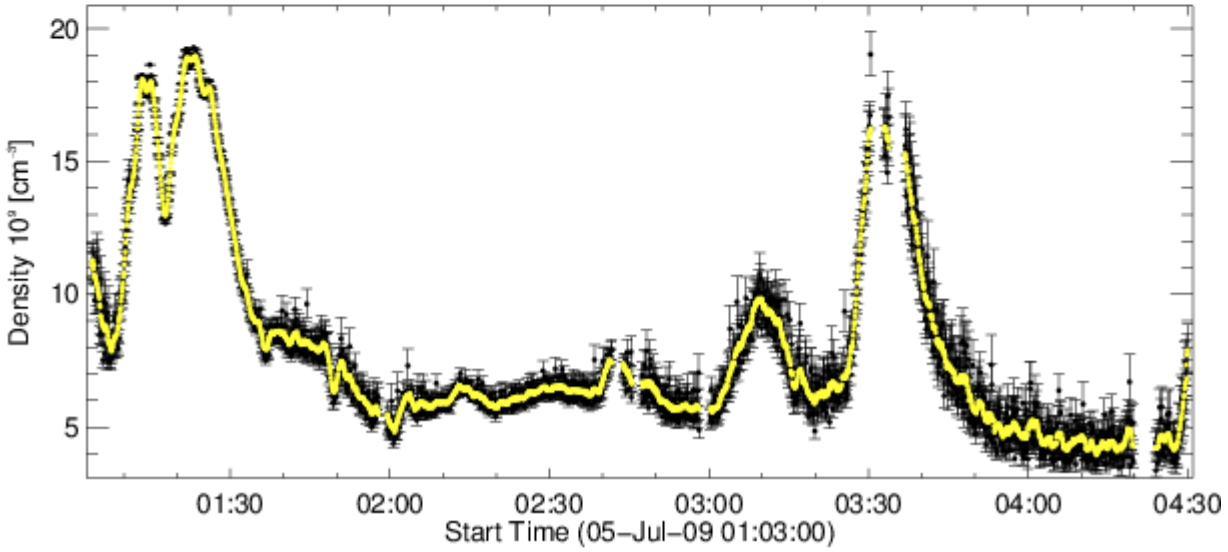




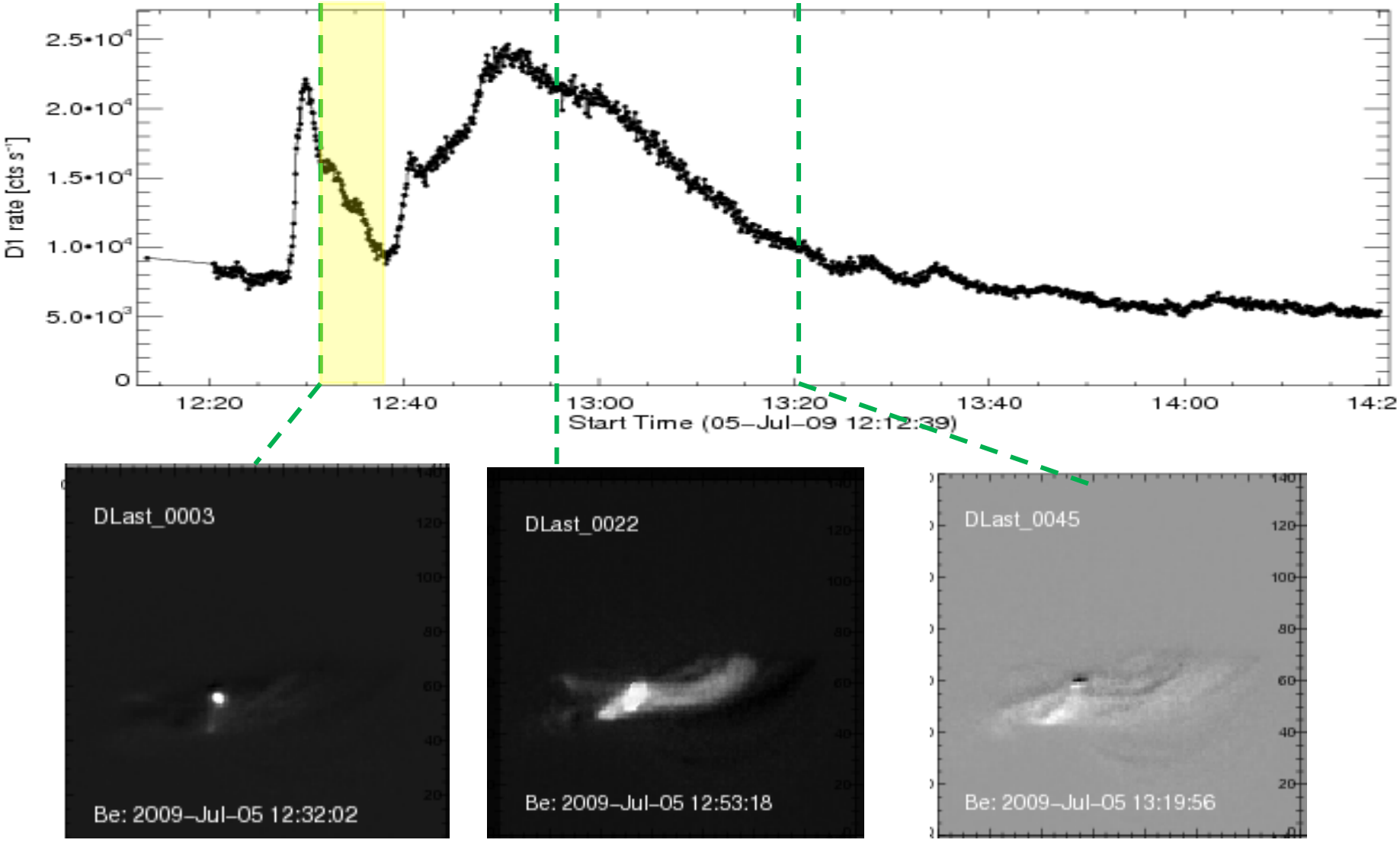


T, Ne

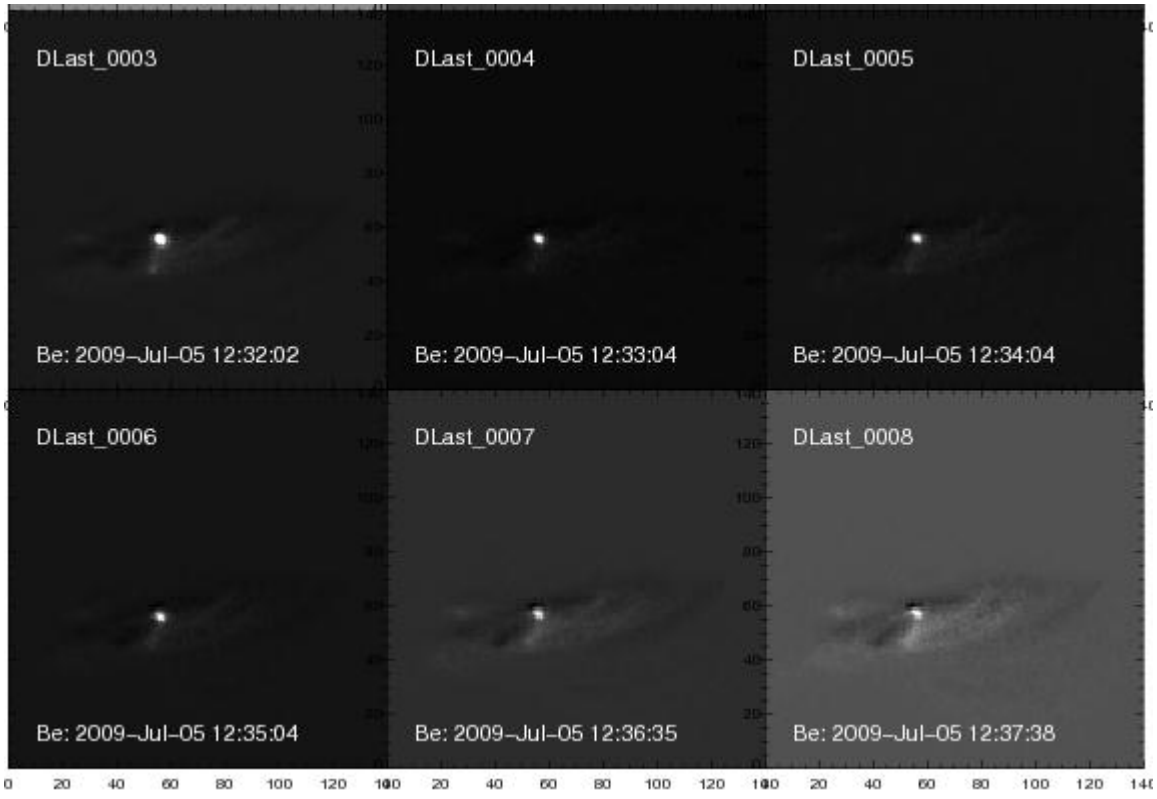

25
20
15
10
5
T [MK]
01:30
02:00
02:30
03:00
03:30
04:00
04:30
Start Time (05–Jul–09 01:03:00)

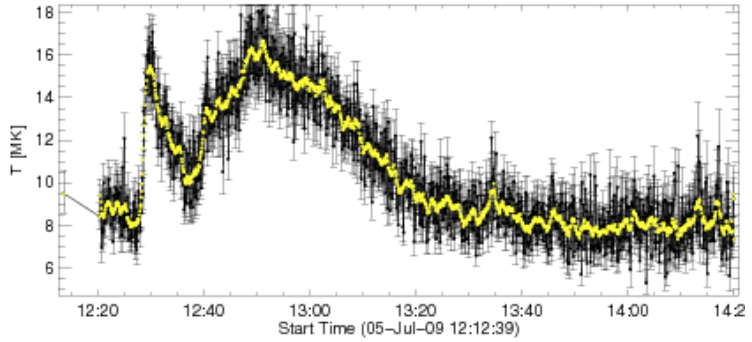

20
15
10
5
Density 10⁹ [cm⁻³]
01:30
02:00
02:30
03:00
03:30
04:00
04:30
Start Time (05–Jul–09 01:03:00)

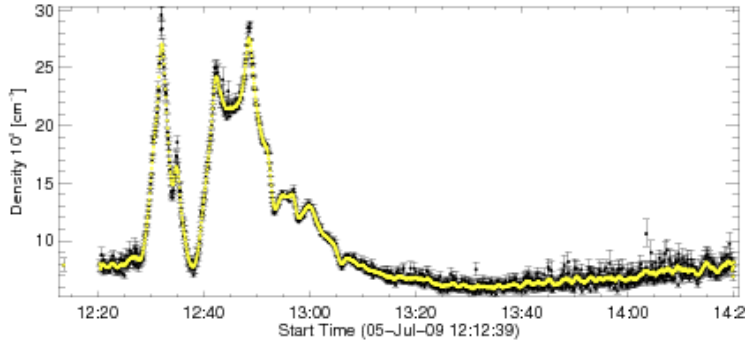
5 July, 12:30 UT B5.9 & 12:50 UT, B6.9

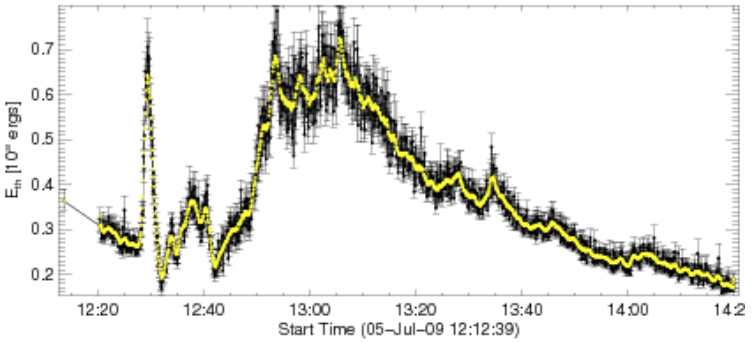


Spike decay evol. + Thermodynamic parameters

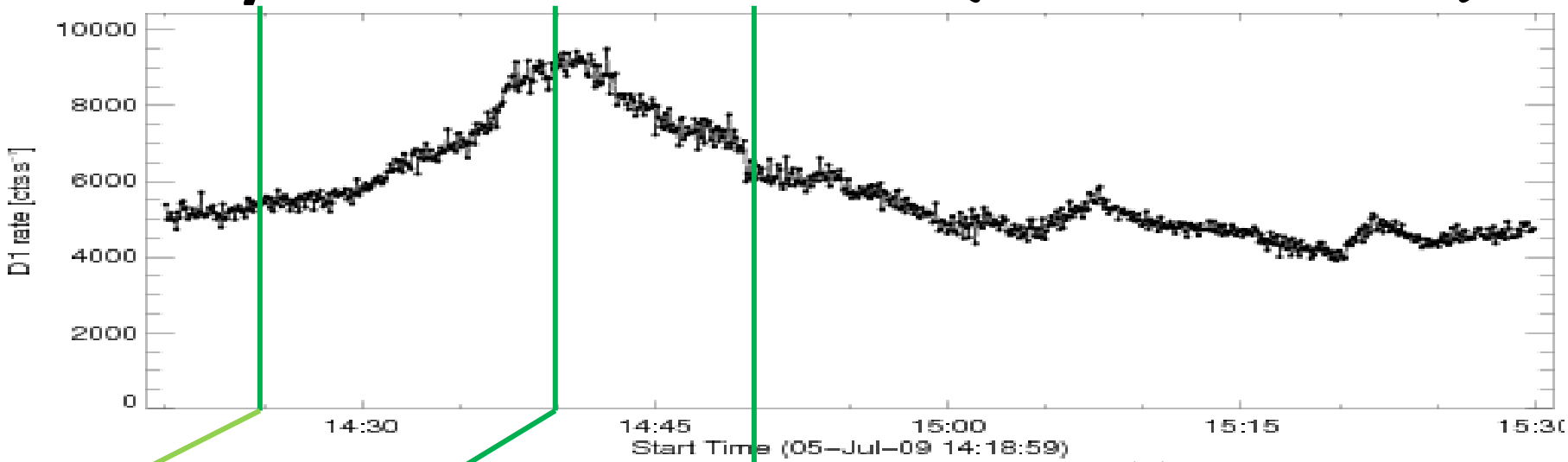


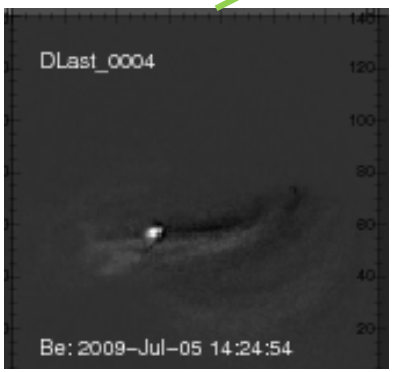


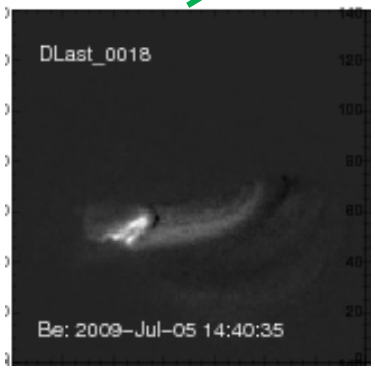


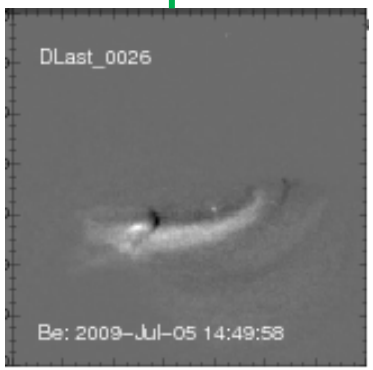


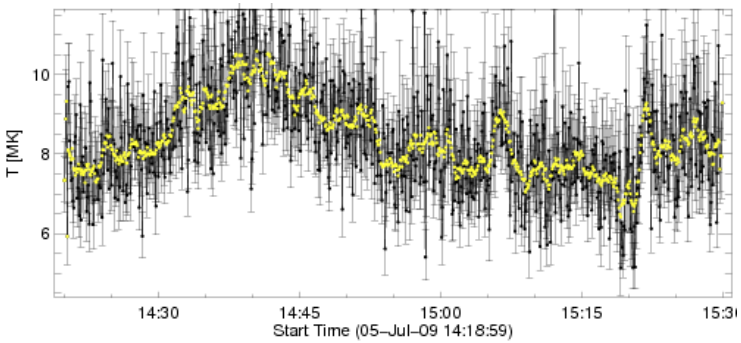
5 July, 14:41 UT, B1.7 (10 min. later)

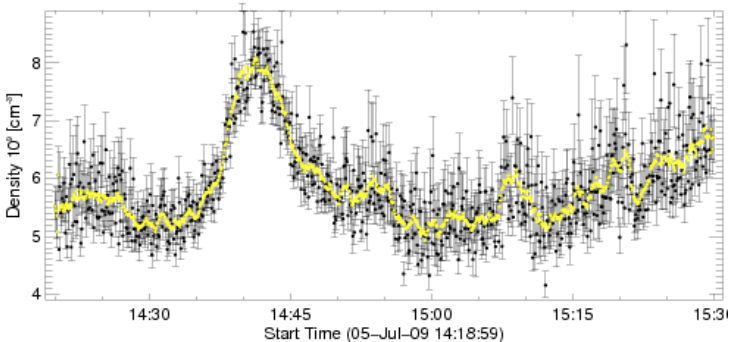




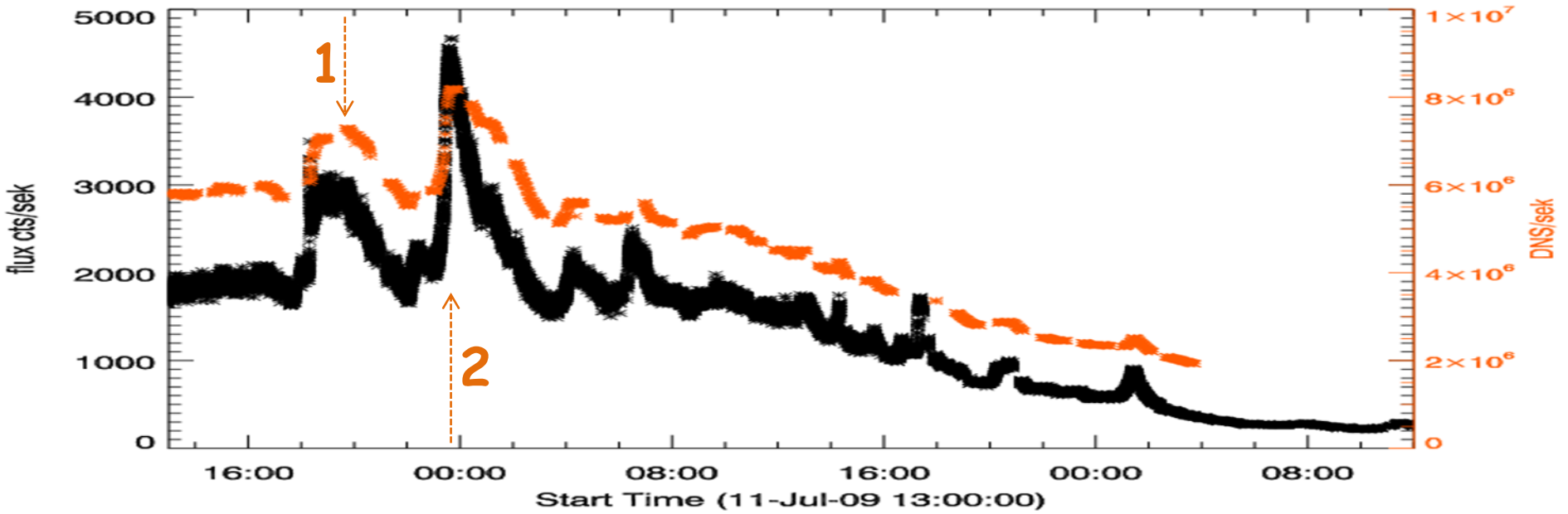


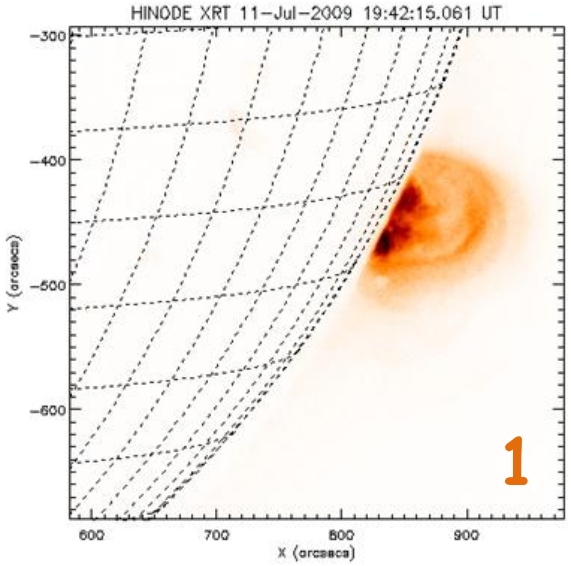


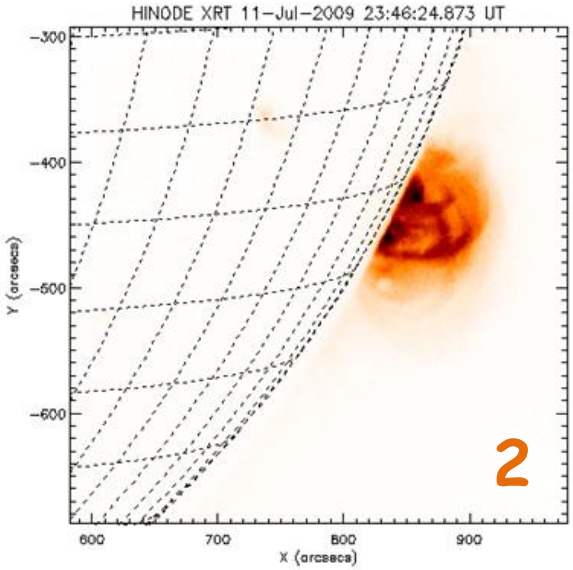




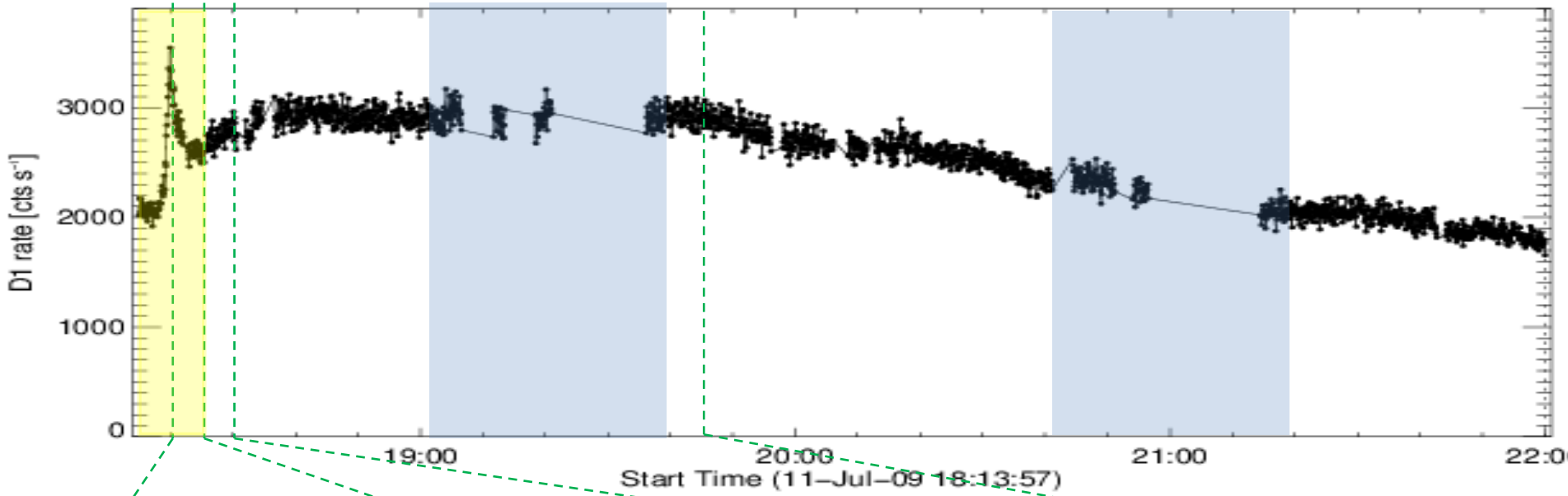
30 hours of AR rotating out of FOV (Hinode XRT Ti_poly filter)

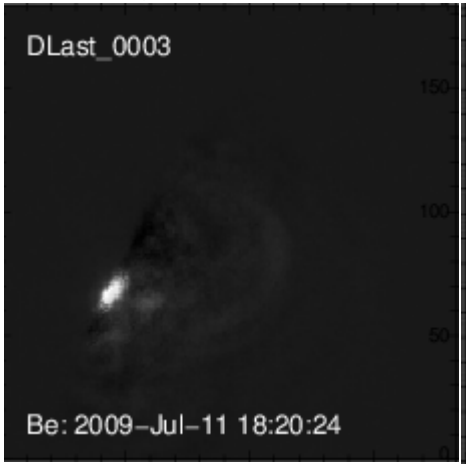


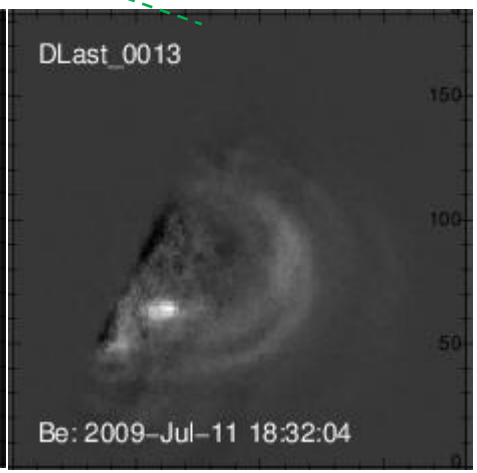


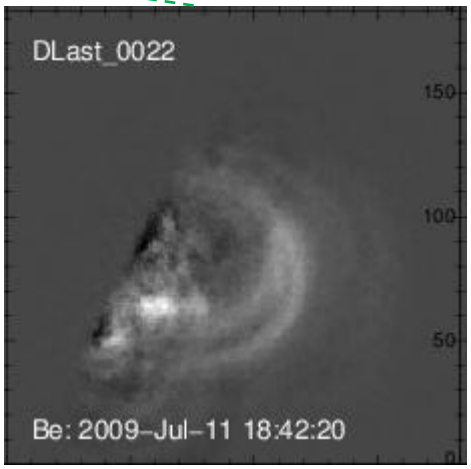


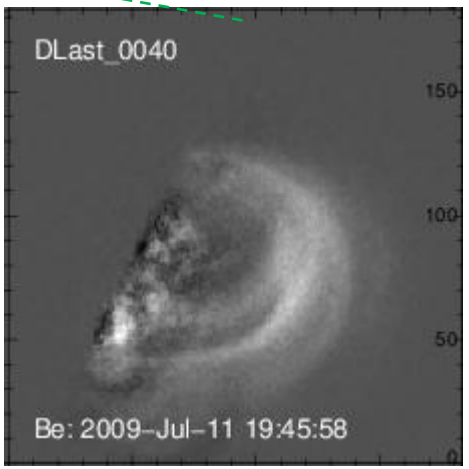
11 July; 18:20 UT



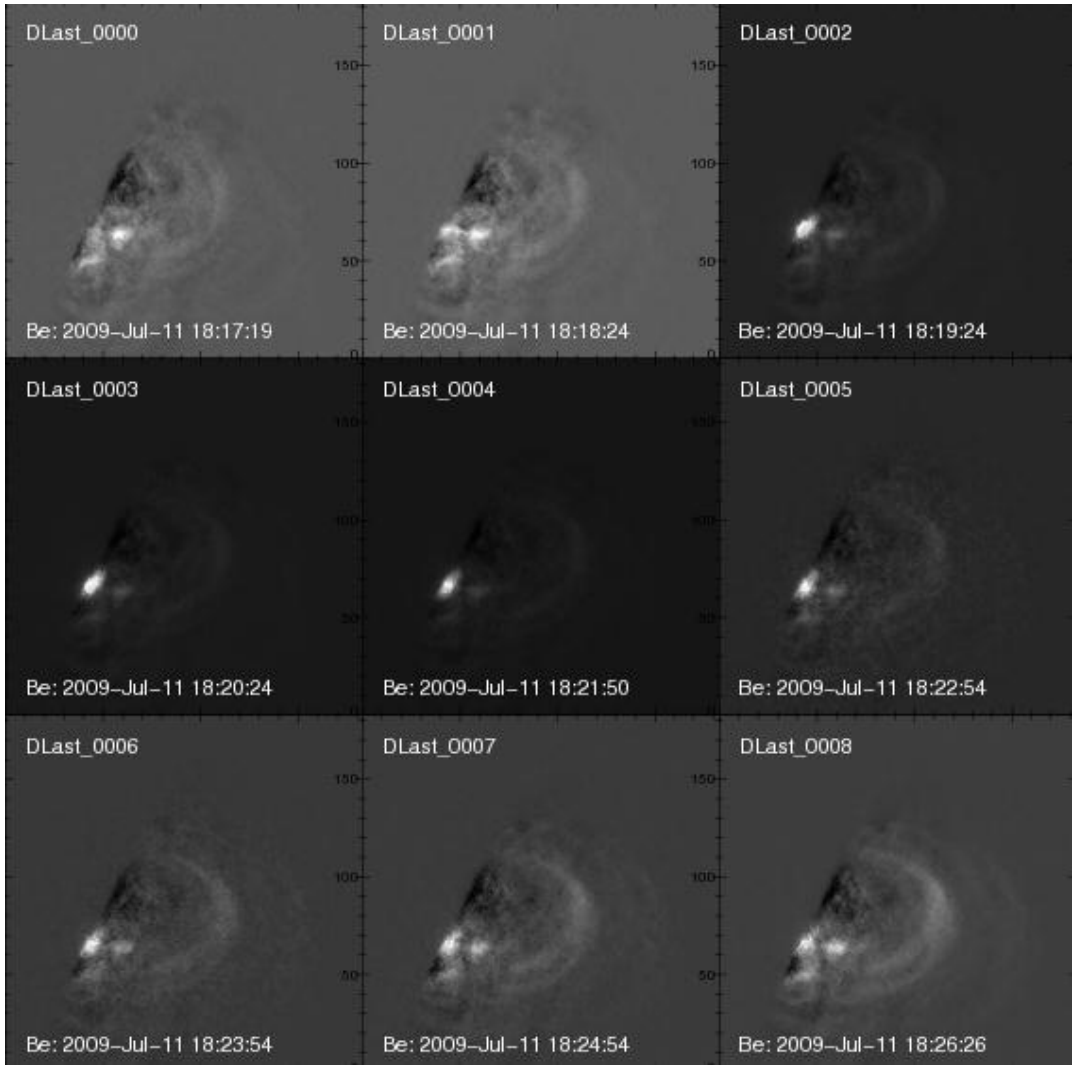


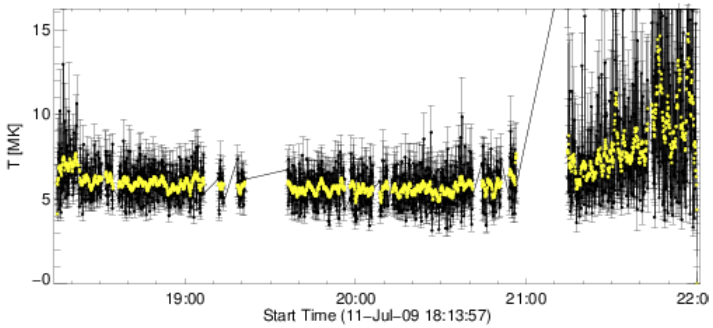


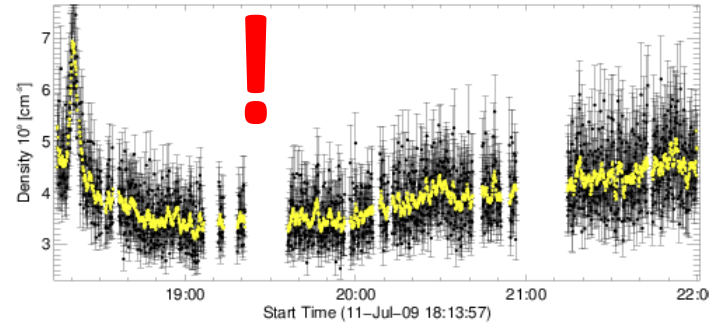


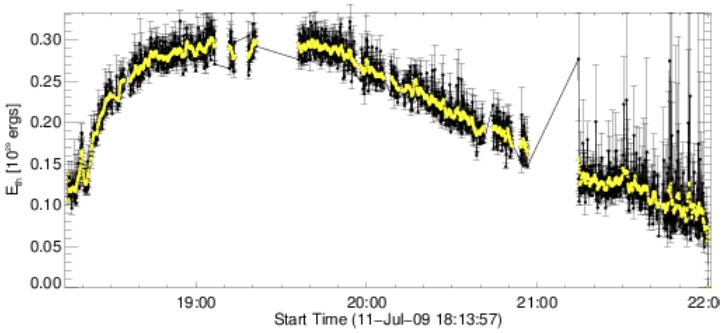


Spike evol.+ Thermodynamic parameters

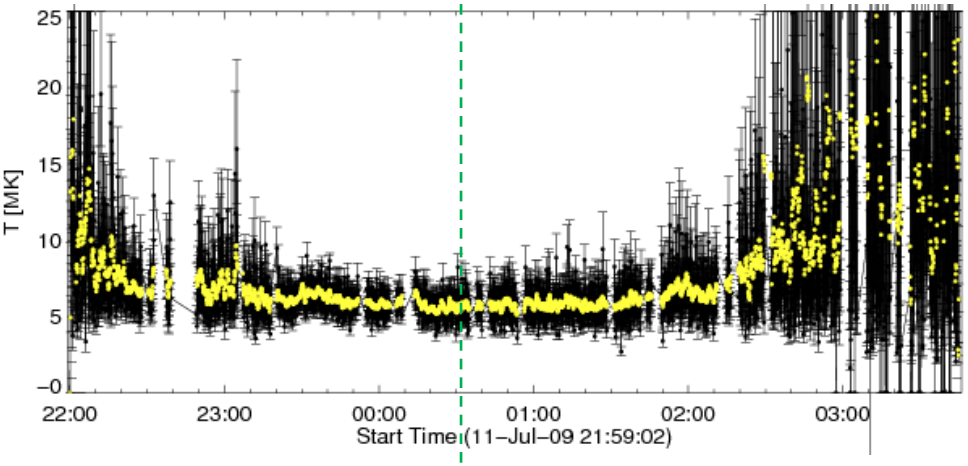


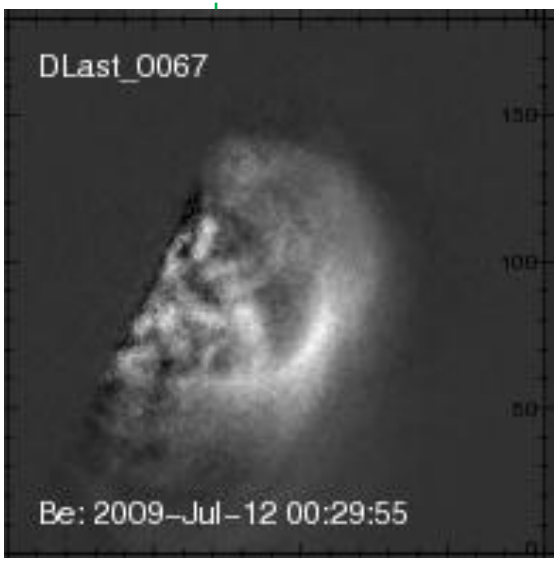




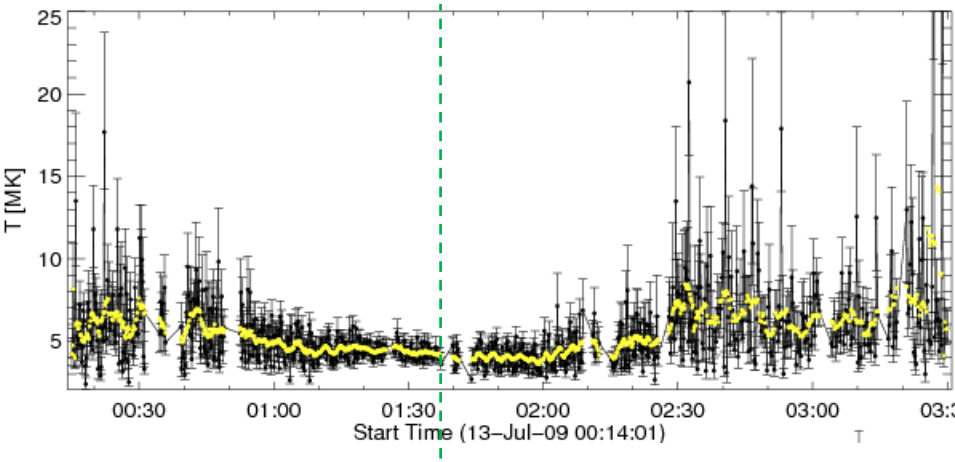


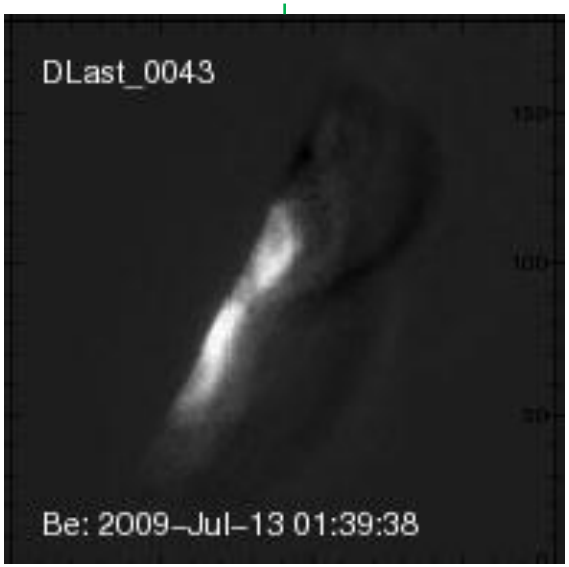
11/12 July, 23:36 UT





13 July, 01:25 UT





Flare characteristics

date	UT	class	T [MK]	Ne[10+9]	dt[min]
3.07	20:25	A1.3	6	11	13
4.07	13:56	B9.8	18	40	25
4.07	14:20	B4	10	11	10
4.07	19:11	A9	9	8	40
4.07	21:57	B1.9	11	13	9
4.07	22:10	C1.1	18	24	35
4.07	22:34	B2.4	10	12	9
4.07	22:46	B2.7	13	14	15
5.07	01:16	C1.1	19	19	50
5.07	03:30	B2.2	11	17	25
5.07	10:58	B2.7	11	15	15
5.07	11:10	B9.6	18	40	15
5.07	11:43	B4.7	13	10	45

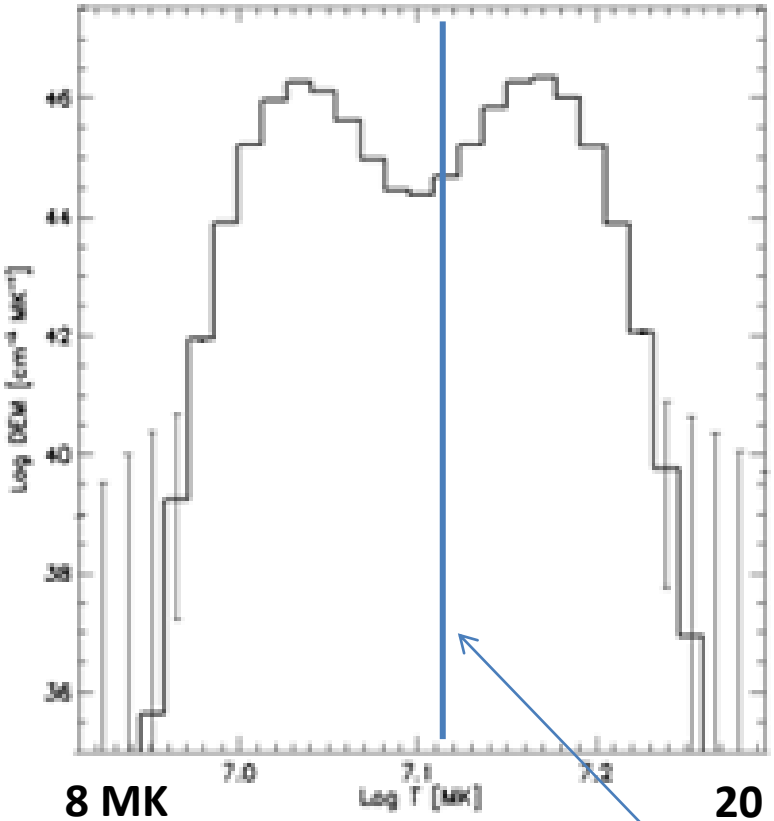
Flare characteristics

data	UT	class	T[MK]	Ne[10+9]	dt[min]
5.07	12:30	B5.9	16	27	10
5.07	12:50	B6.9	17	27	80
5.07	14:41	B1.7	11	8	40
6.07	01:40	A6.7	10	6	12
6.07	02:26	B3.3	13	11	30
7.07	23:45	B1.9	13	12	20
8.07	01:36	B2.2	14.5	11	25
8.07	02:01	B1.3	12	5	37
8.07	03:13	B3.6	13	5	70
11.07	18:20	A1.5	7	7	9
11.07	18:45	A1.3	6	3.5	120
11.07	23:36	A1.4	6	3	180
13.07	01:25	A1.2	5	6	110

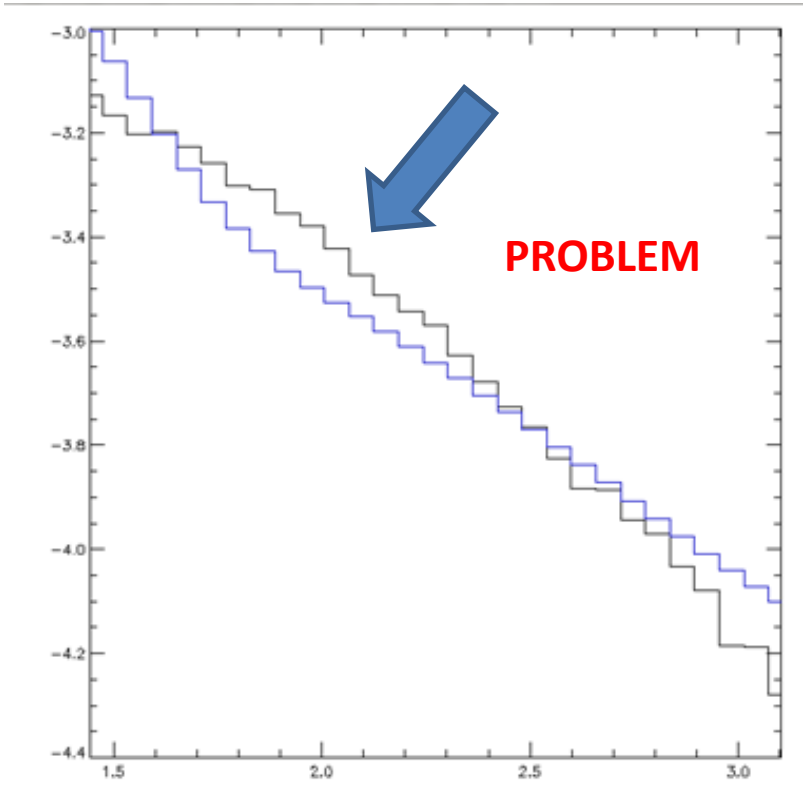
Concluding remarks

- Total of 26 events observed with SphinX on Coronas Photon and XRT Hinode have been analysed (A1.2-C1.1; 9-180 min.)
- An isothemal approximation has been adopted → T=5-19 MK; N_e=3x10^9 - 4x10^{10} cm^{-3})
- Long lasting flares indicate rather constant average temperature
- Flare morphology is complicated and dynamic: spike like flares are compact, only one flare among 26 analysed can be regarded as single loop event
- DEM analysis have been performed for selected events

DEM for flare max. phase



8 MK

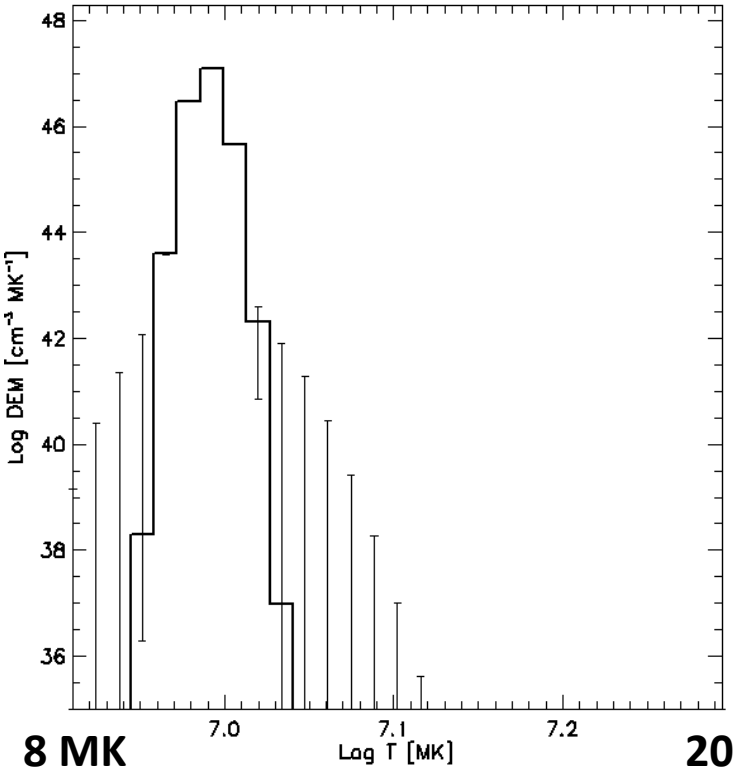


20 MK

DEM: 1.4-3 keV

Average T value from isothermal approach for the same time interval

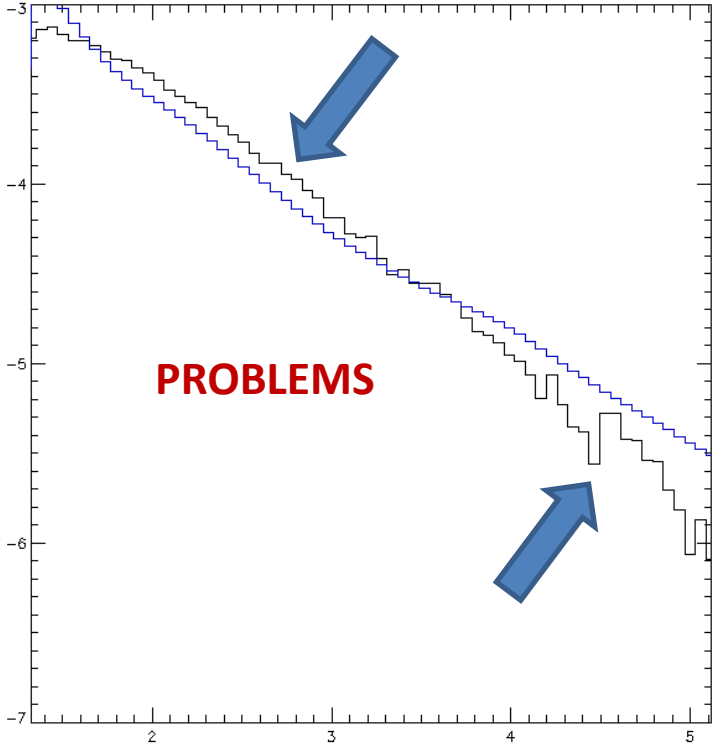
DEM for flare max.; extended E-range



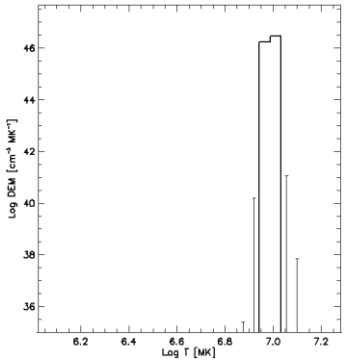
8 MK

20 MK

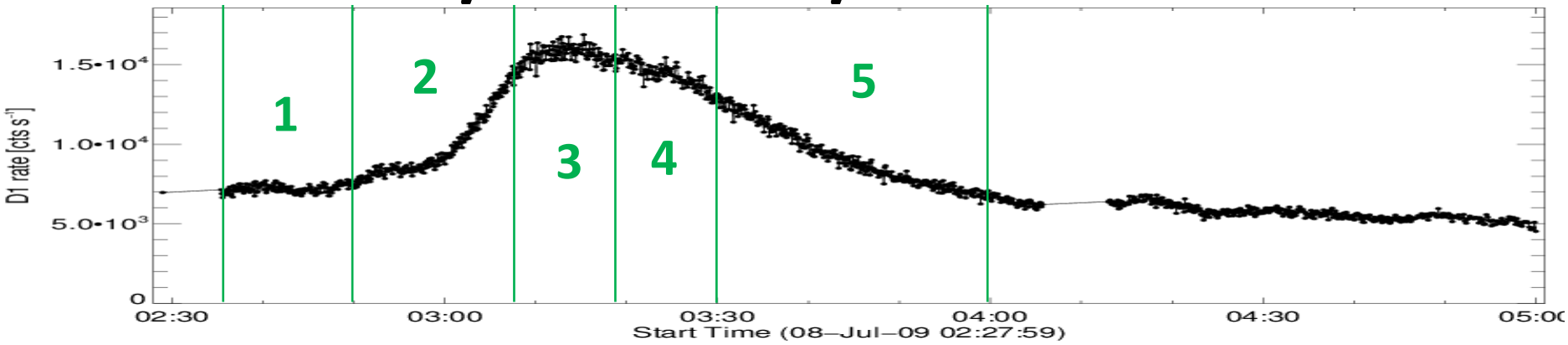
DEM: 1.3-5 keV

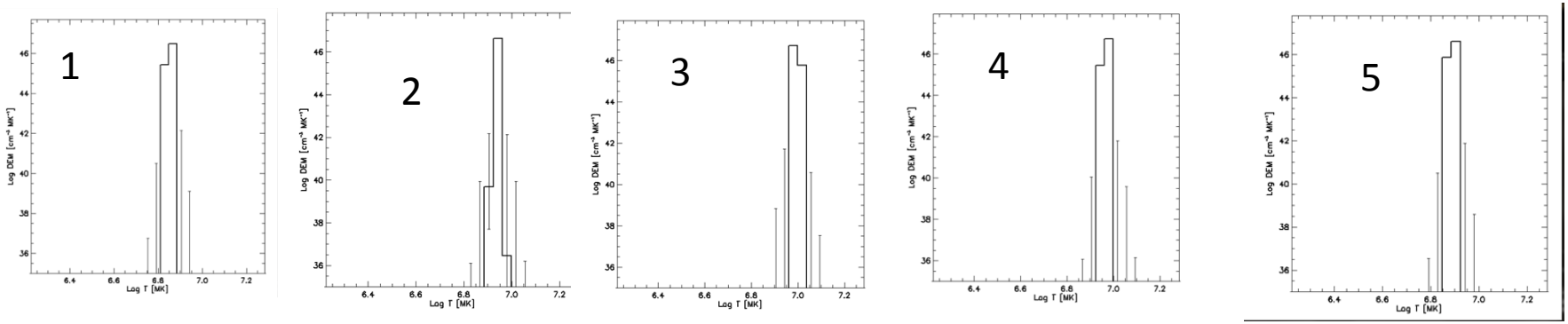


1-20 MK

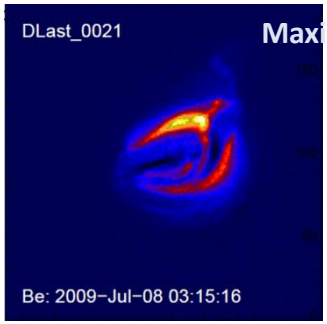


DEM analysis: 8 July 03:13 UT flare





	1	2	3	4	5
T	7.3 MK	8.8 MK	9.6 MK	9.5 MK	7.9 MK
EM	2.1+46	3.2+46	4.9+46	4.8+46	3.2+46



Decay phase of long lasting flare