

HXR footpoint sources and chromospheric dynamics from RHESSI data.

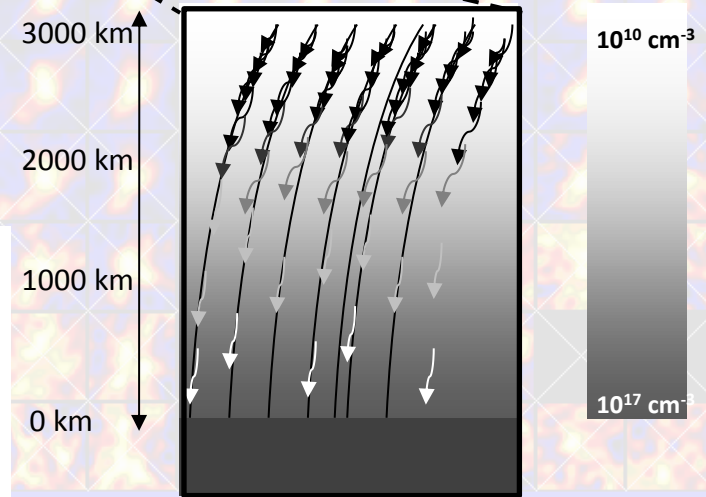
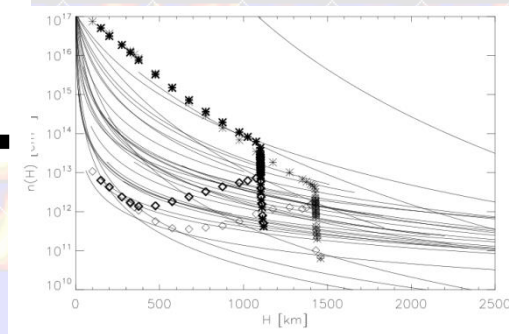
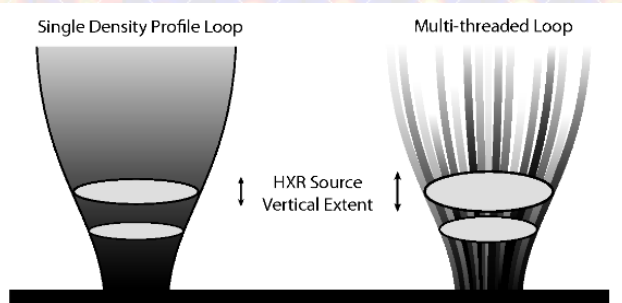
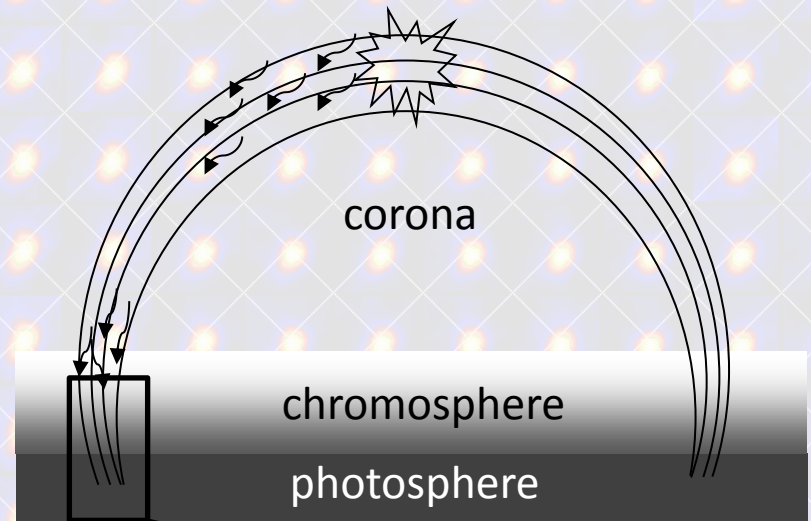
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¹Solar Physics Division, Space Research Centre PAS

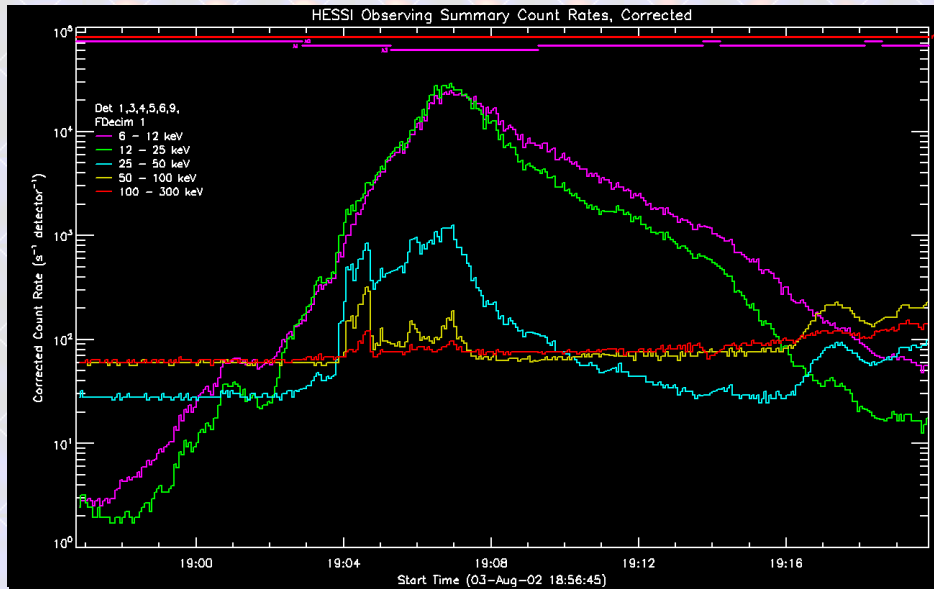
²Astronomical Institute, University of Wrocław

Energy-altitude relation

- Takakura, K. et al. 1987, *Sol. Phys.* 107, 109
 Matsushita, K. et al. 1992, *Publ. Astron. Soc. Japan* 44, L89
 Aschwanden, et al. 2002, *Sol. Phys.*, 210, 373
 Brown, J et al., 2002, *Sol. Phys.*, 210, 373
 Liu, W. et al. 2006, *ApJL* 649, 1124
 Mrozek, T. 2006, *Adv. in Space Res.* 38, 962
 Kontar, E. P. et al. 2010, *ApJ* 717, 250
 Mrozek, T. & Kowalczyk, J. 2010, *CEAB* 34, 73
 Battaglia, M. & Kontar, E.P. 2011, *A&A* 2011, 2B
 Battaglia, M. & Kontar, E.P. 2011, *ApJ* 735, 42
 Battaglia, M. et al. 2012, *ApJ* 752, 4B
 O'Flannagain, A.M. et al. 2013, *A&A* 555, A21



The flare

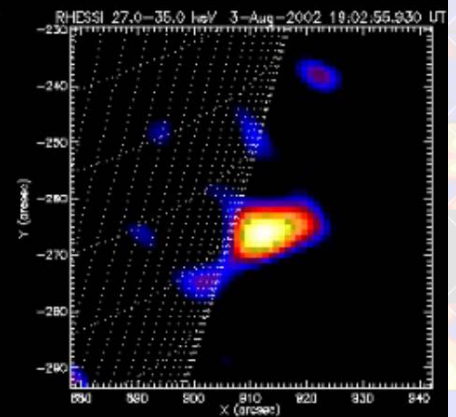
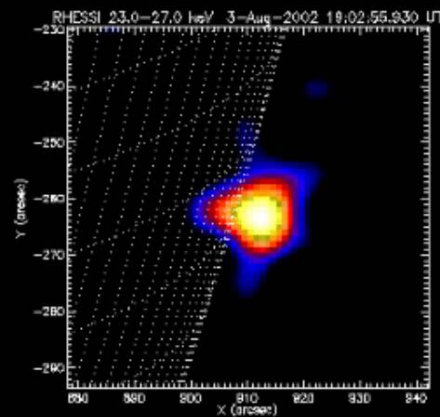
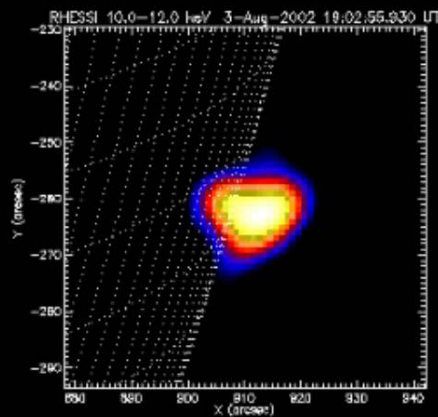
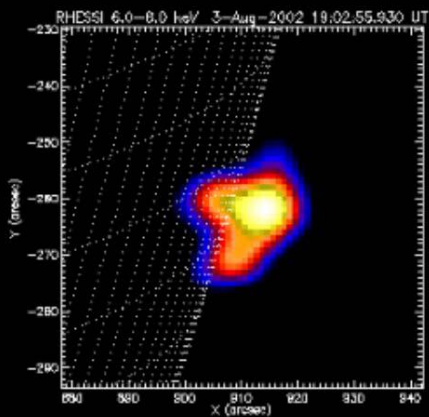


GOES class: X1.5

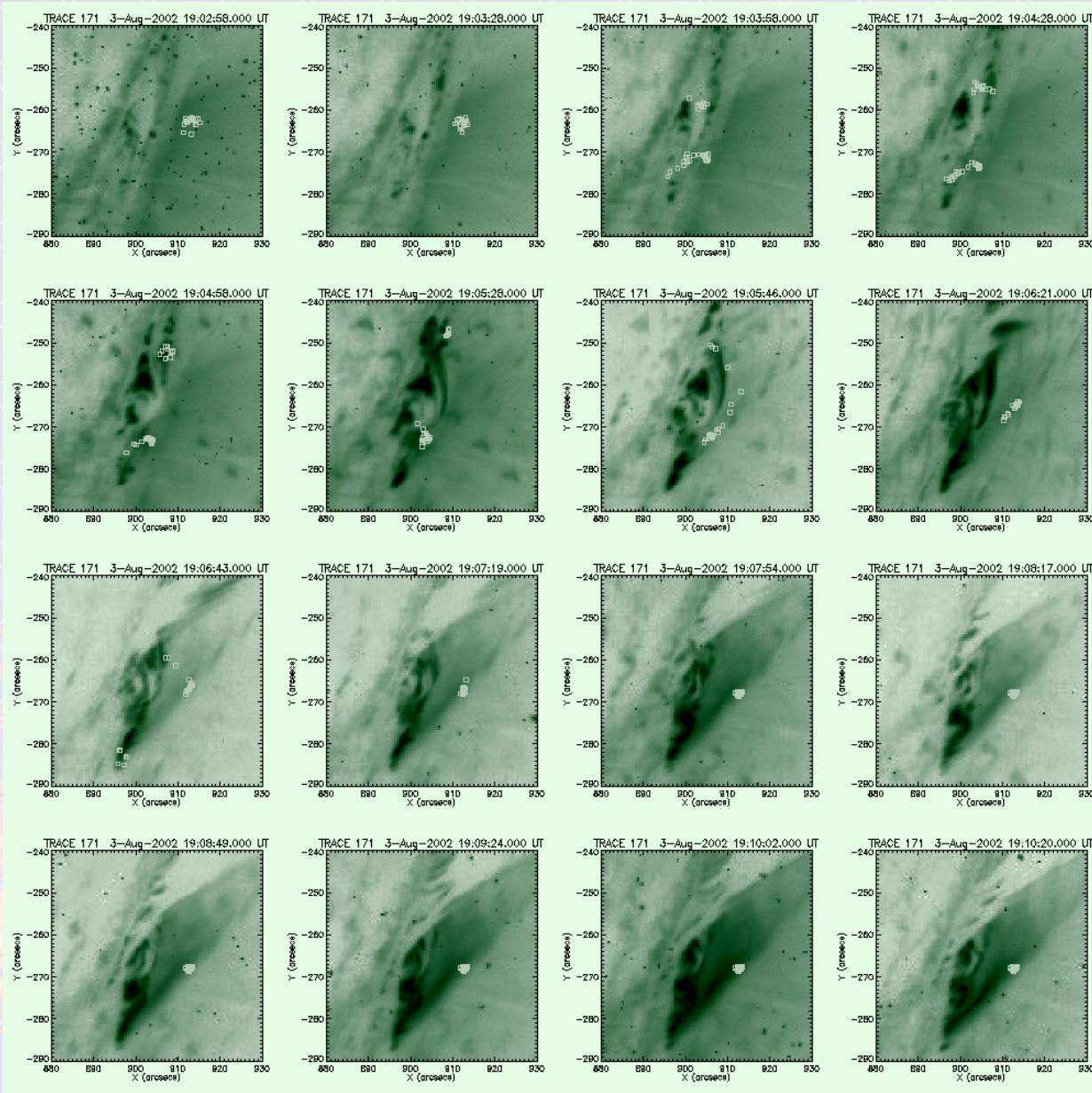
location: S15W70

observations:

- TRACE (171 Å, 30 s cadence)
- RESIK (2.05 – 3.65 keV)
- RHESSI (entire event)



Overall picture

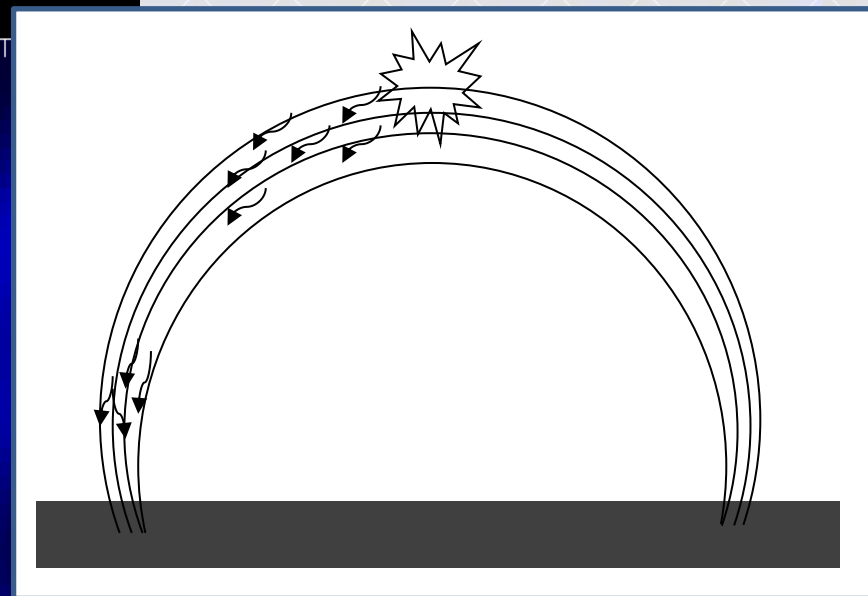
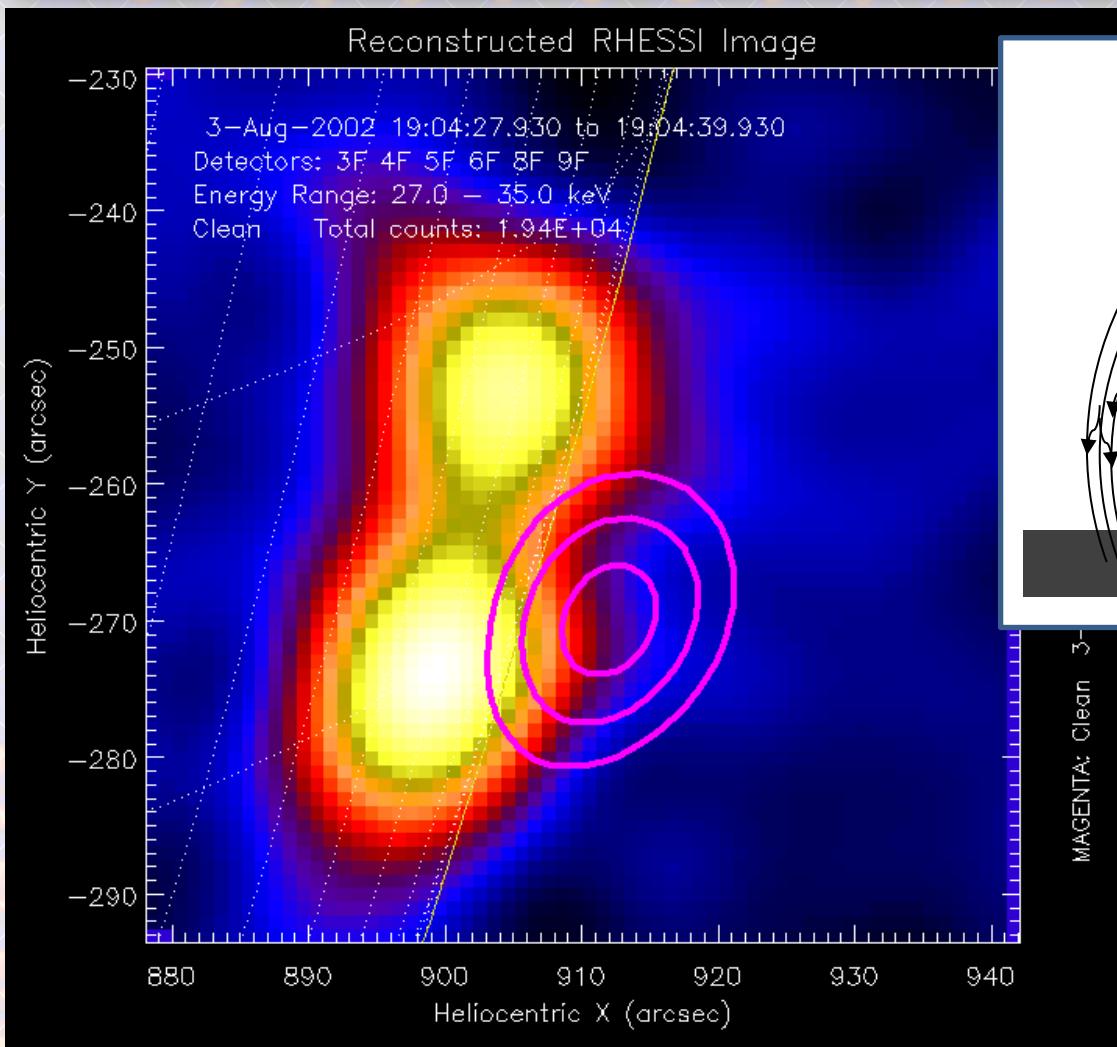


First minutes – coronal source

Footpoints are visible from ~19:04 UT

Starting from ~19:07 UT coronal source dominates again

Flare morphology

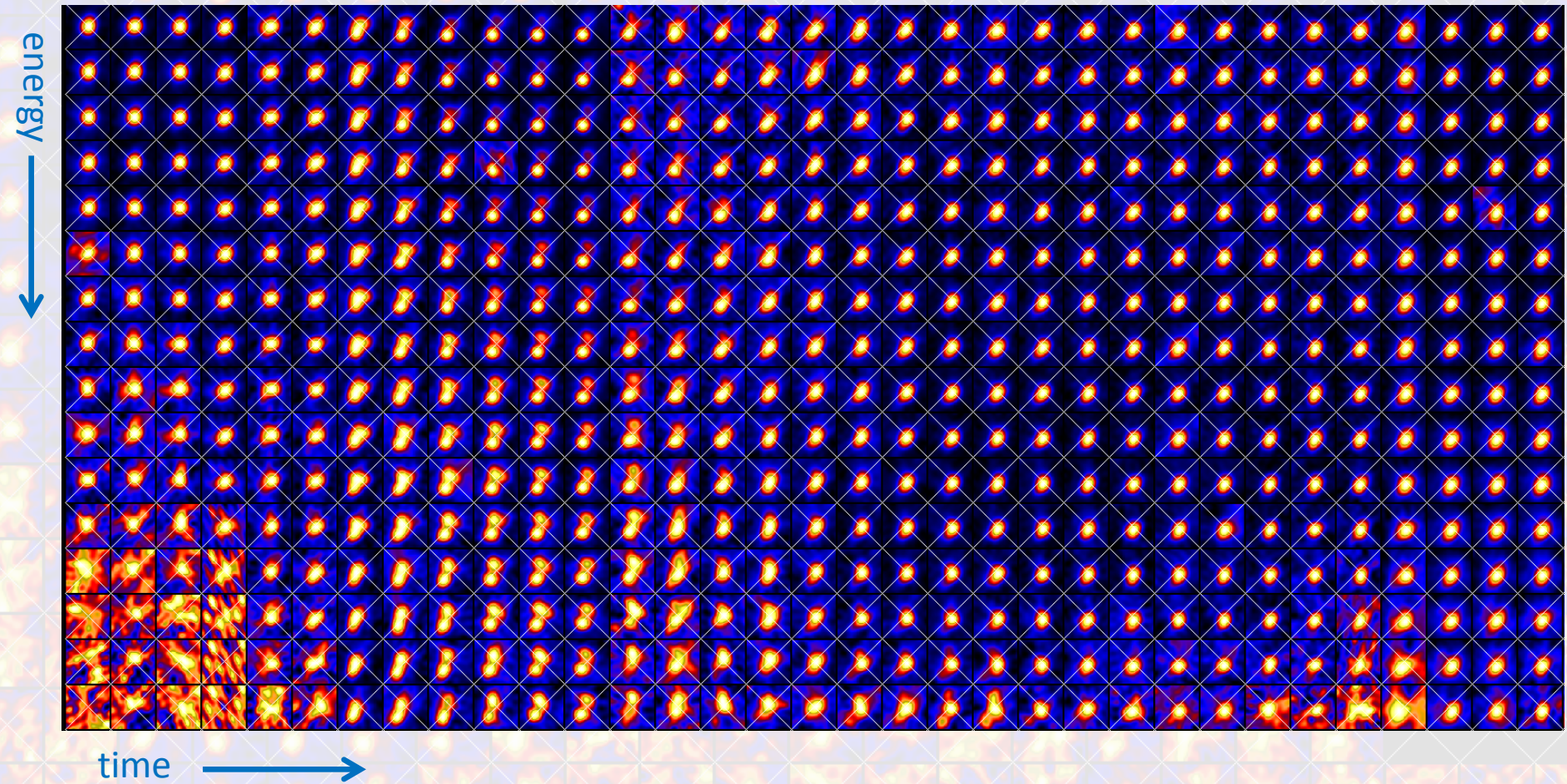


RHESSI image is consistent with our „intuition“. We see two footpoints and coronal source, so we observe single-loop flare.

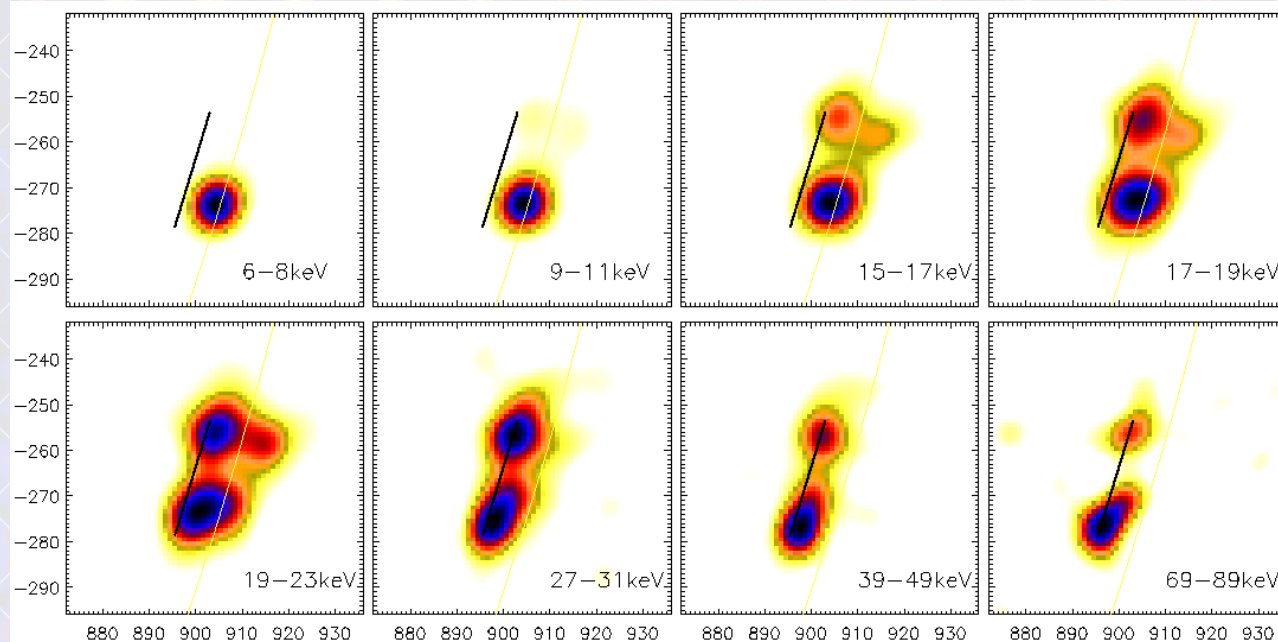
image – 27-35 keV sources (impulsive phase)
contours – 6-7 keV source (maximum)

Flare morphology

CLEAN, detectors: 3,4,5,6,8,9, narrow energy bands

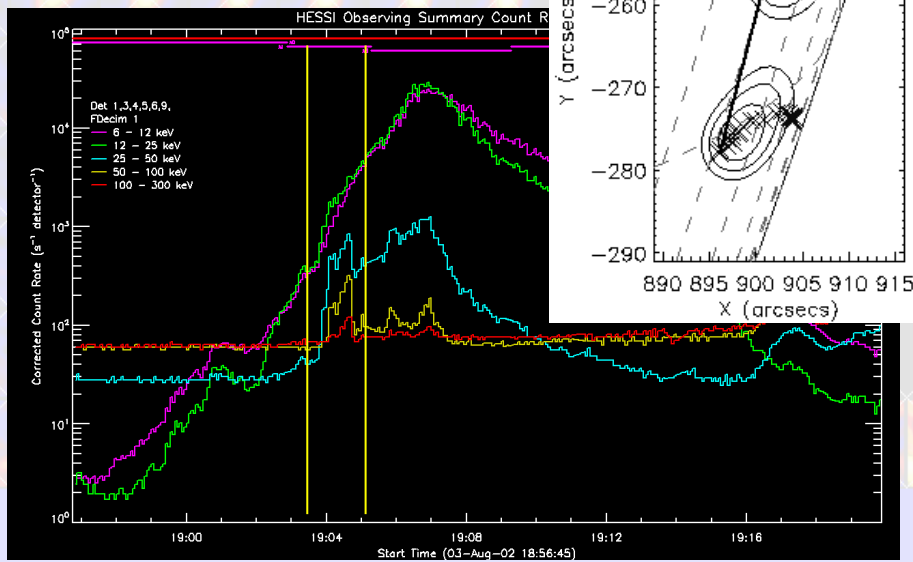
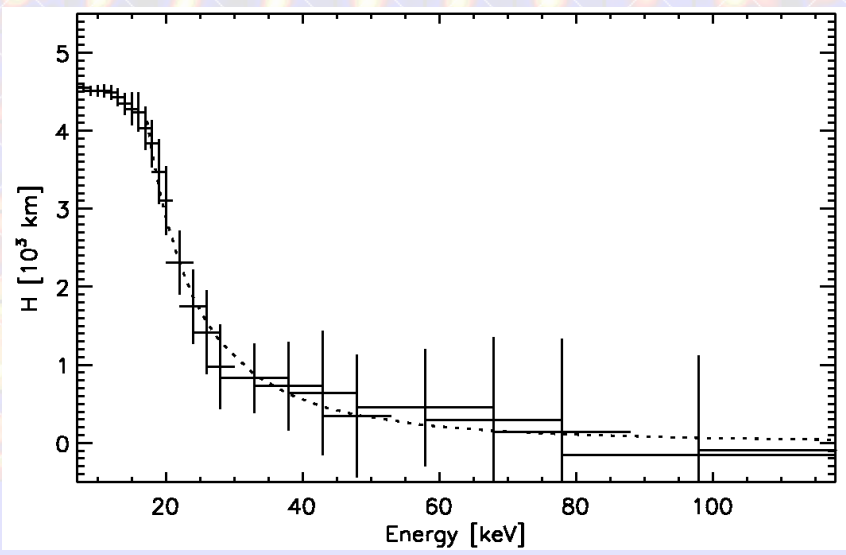


RHESSI: energy – altitude relation

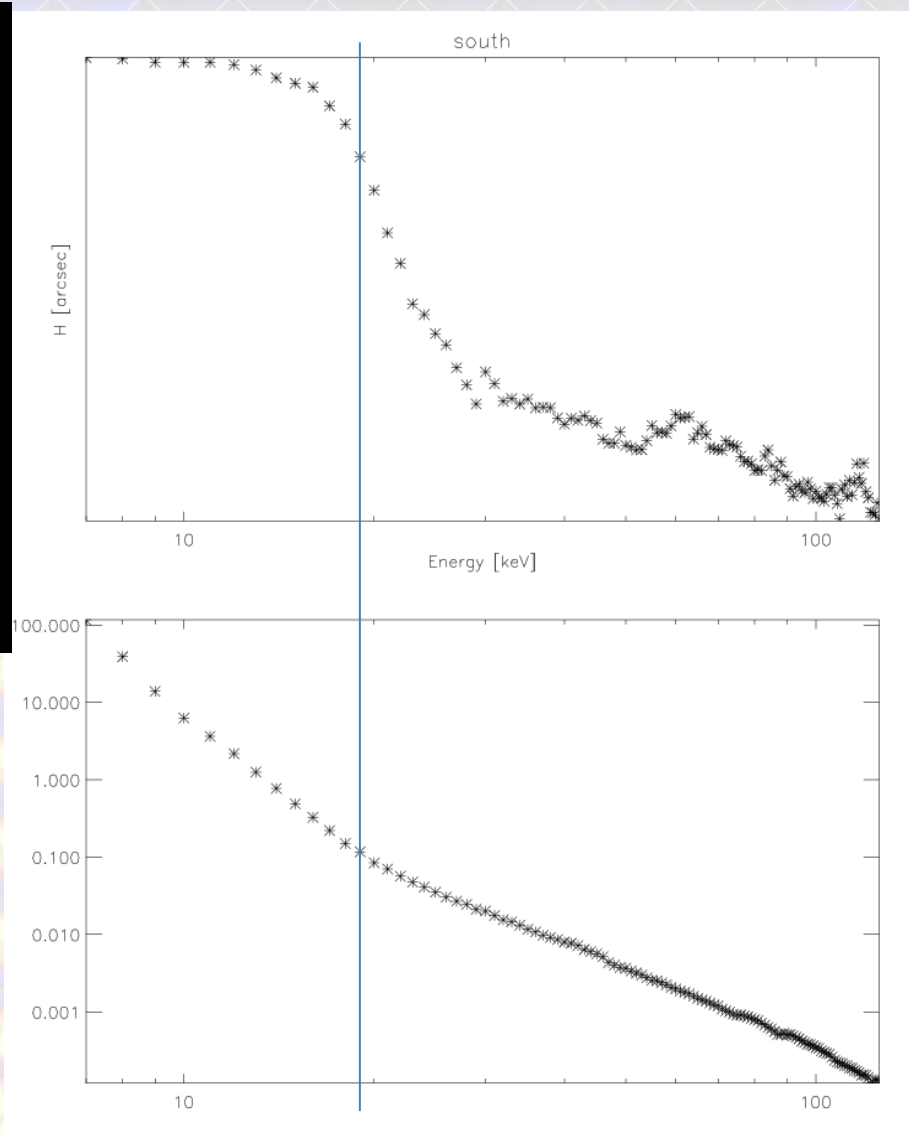
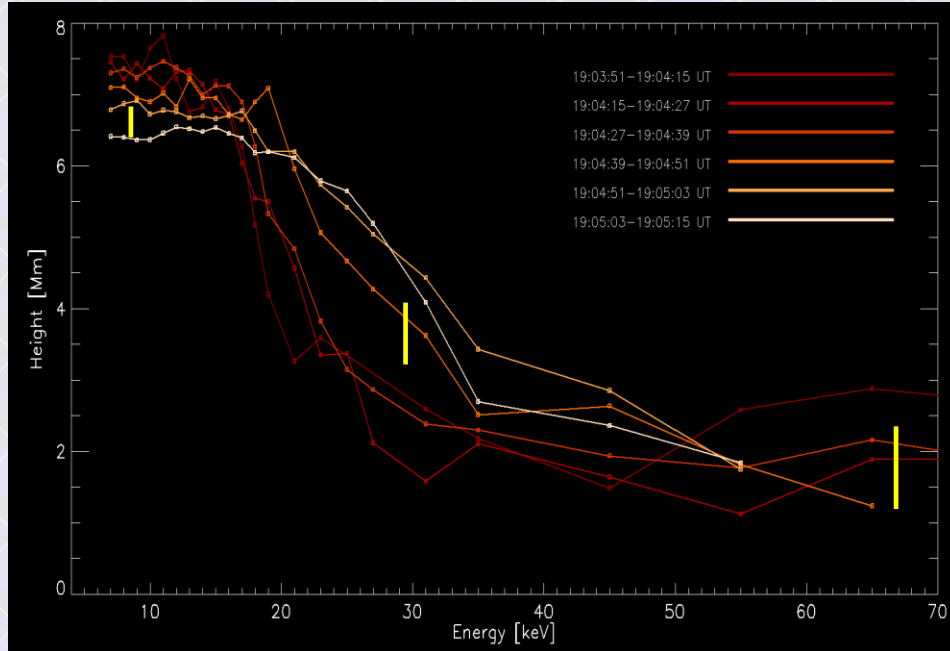


Main HXR peak:
19:04 – 19:05 UT

Reference level
defined with highest-
energy sources

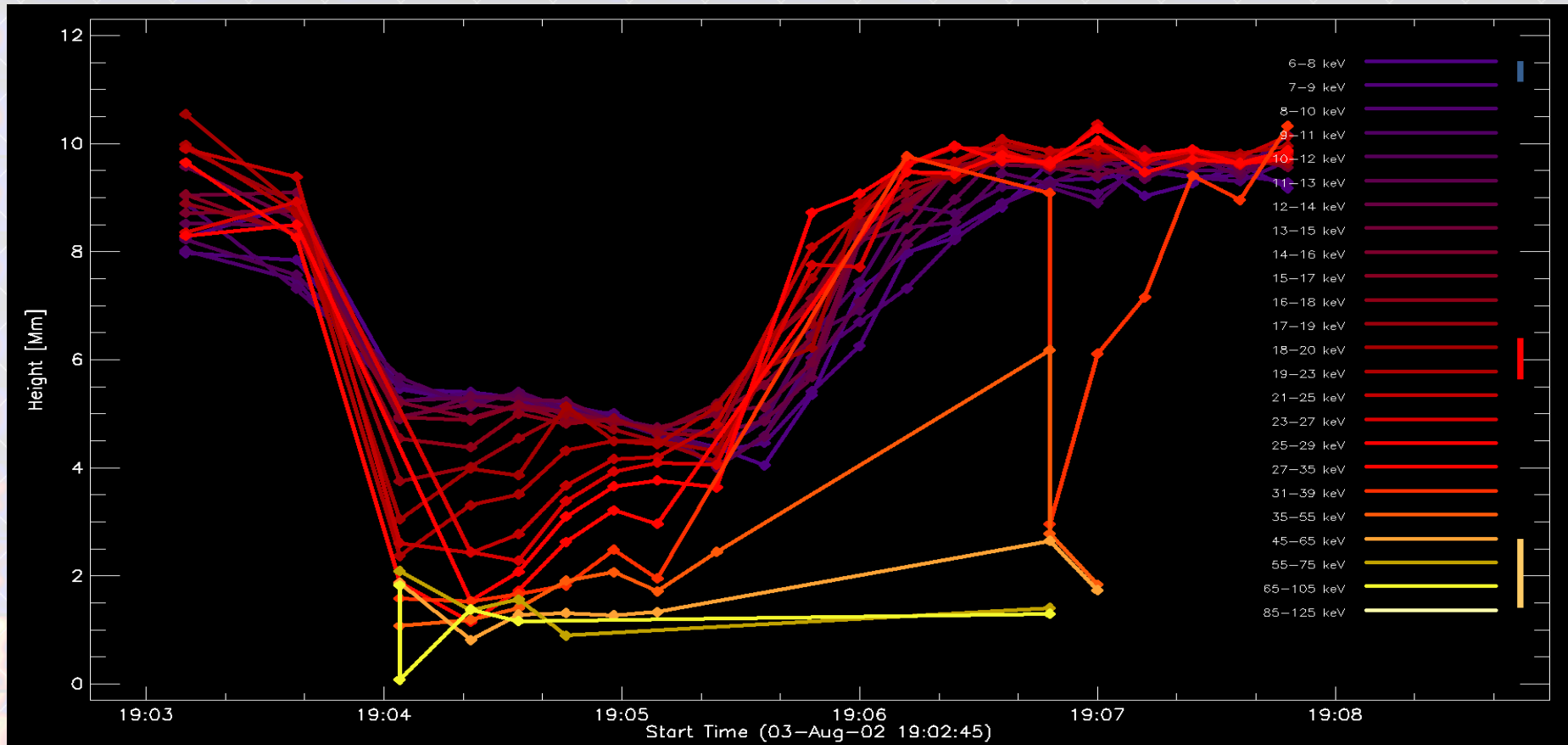


Time variation of HXR sources altitudes



- time evolution of sources altitudes
- downward (low energy sources)
 - upward (high energy sources)

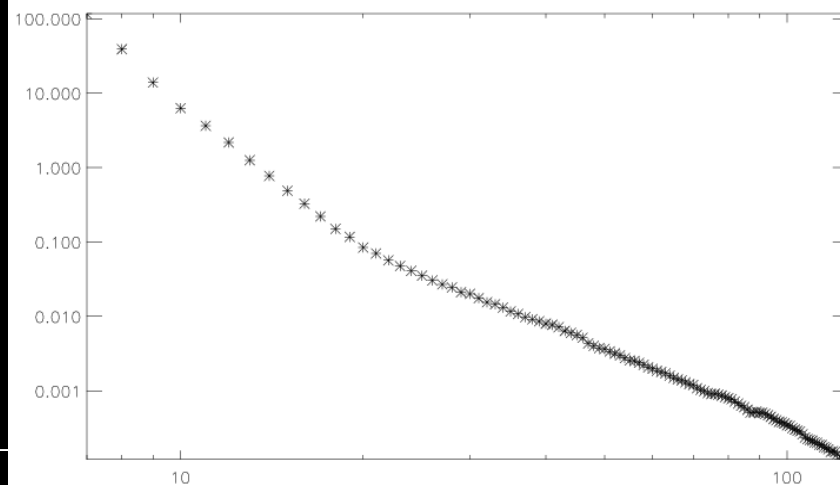
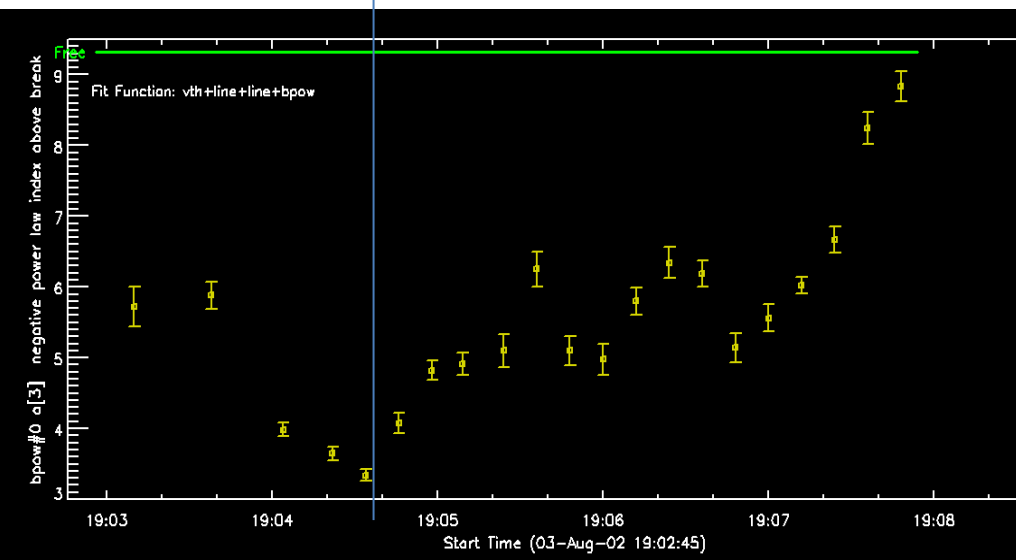
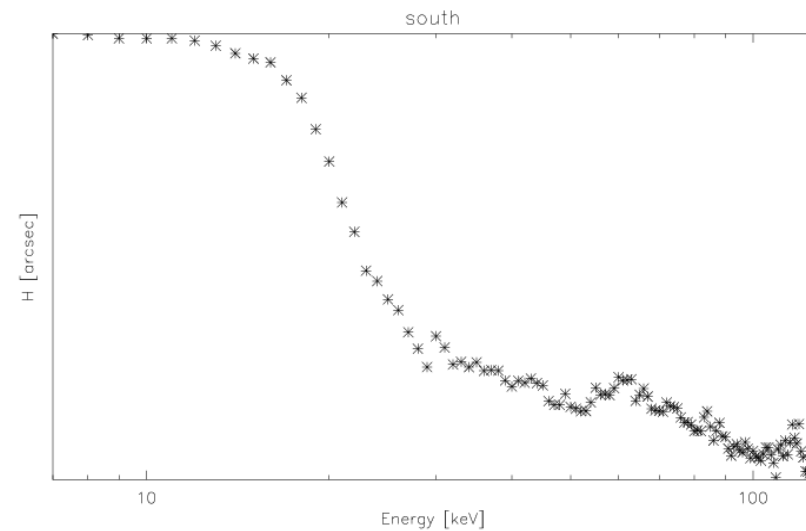
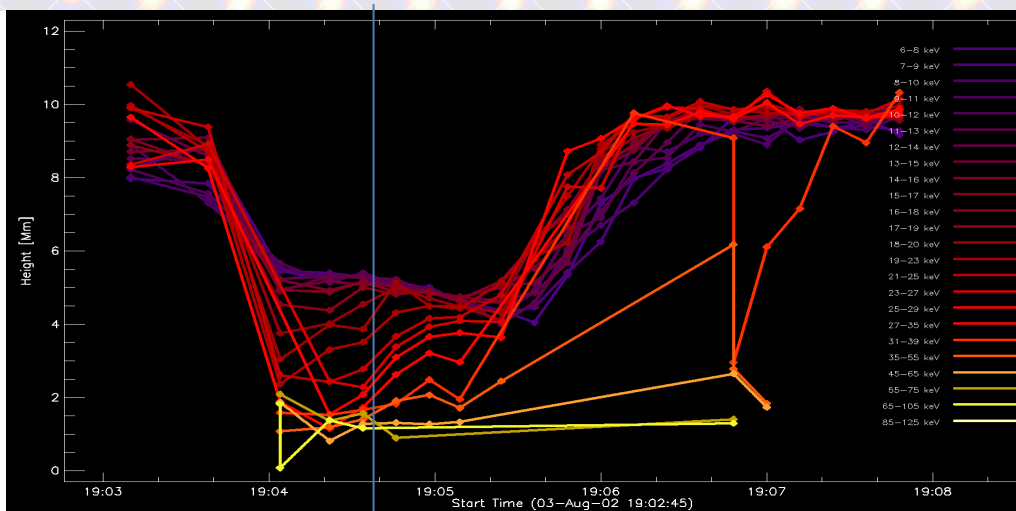
Time variation of HXR sources altitudes



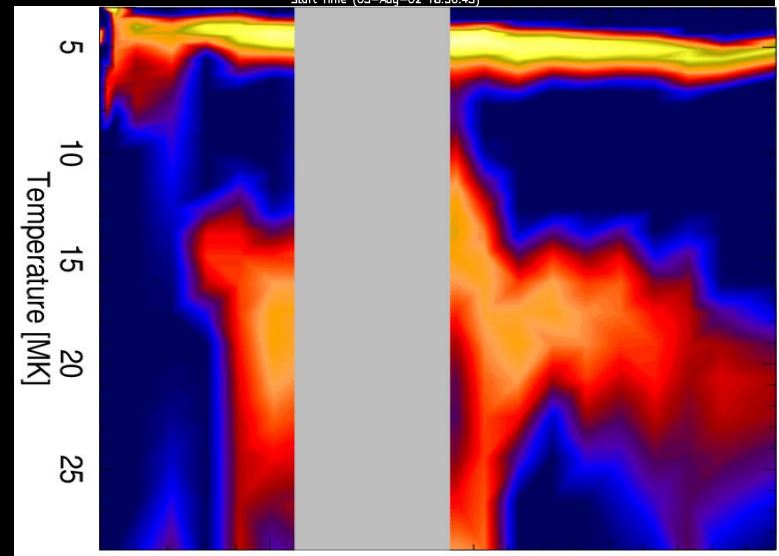
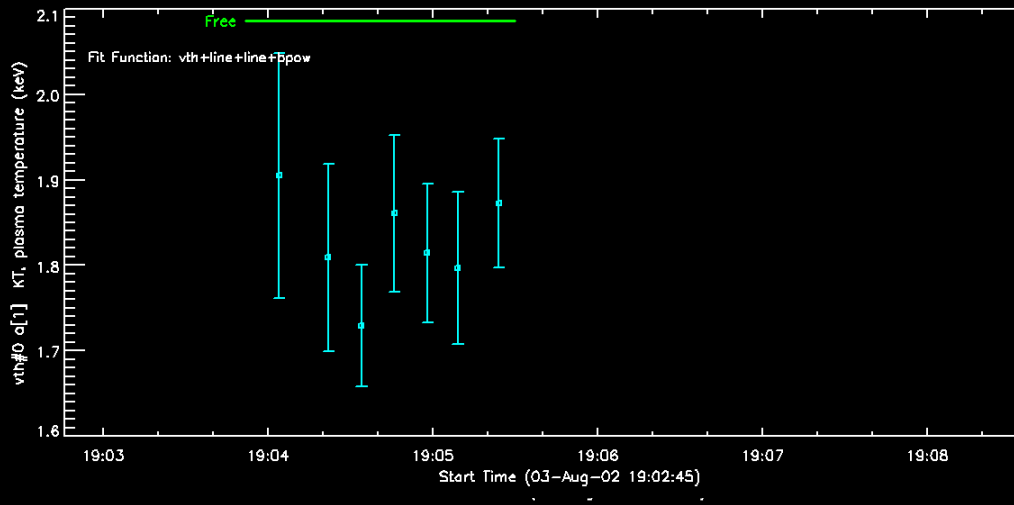
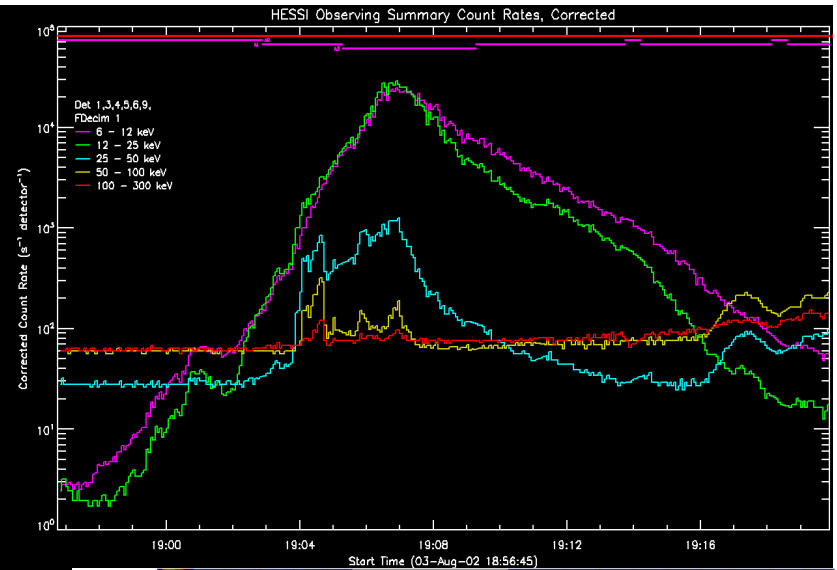
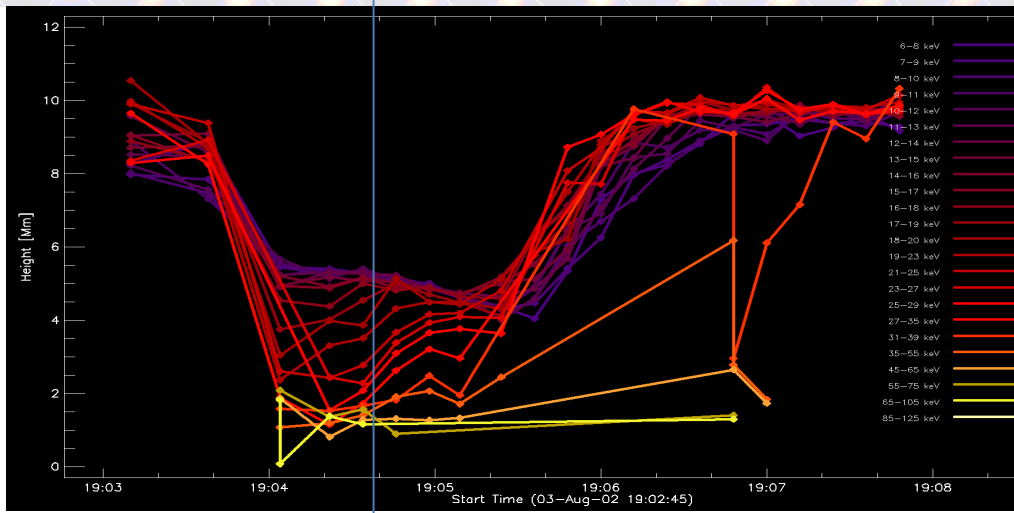
Three phases:

1. Early phase - single source high in the corona
2. Impulsive phase - double-footpoint morphology in higher energies, low energies dominated by southern source
3. Maximum&decay – single source in the corona

Time variation of HXR sources altitudes



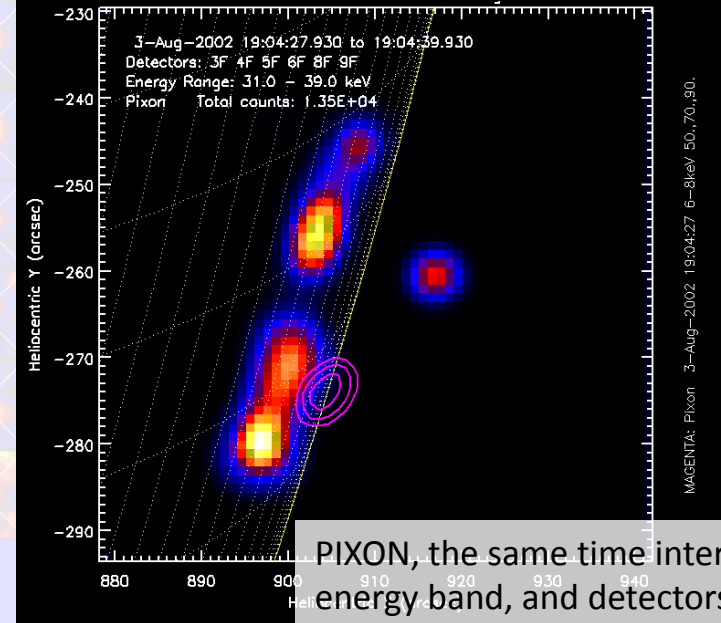
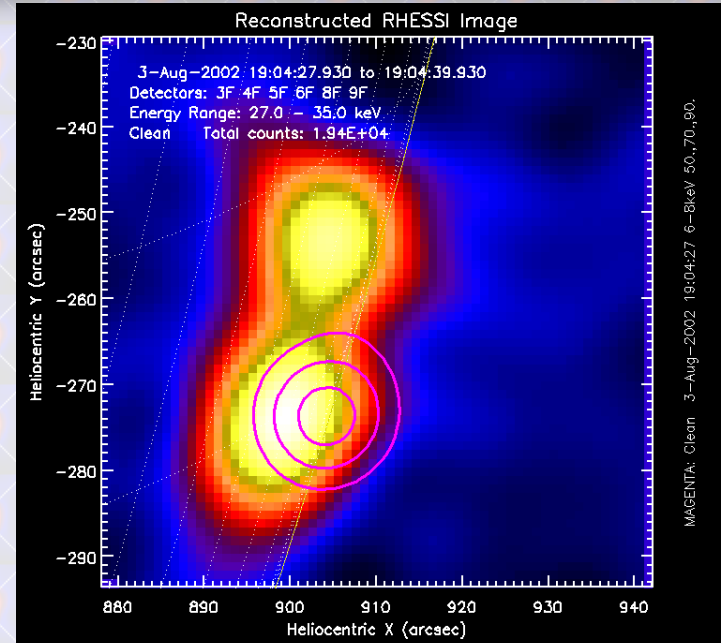
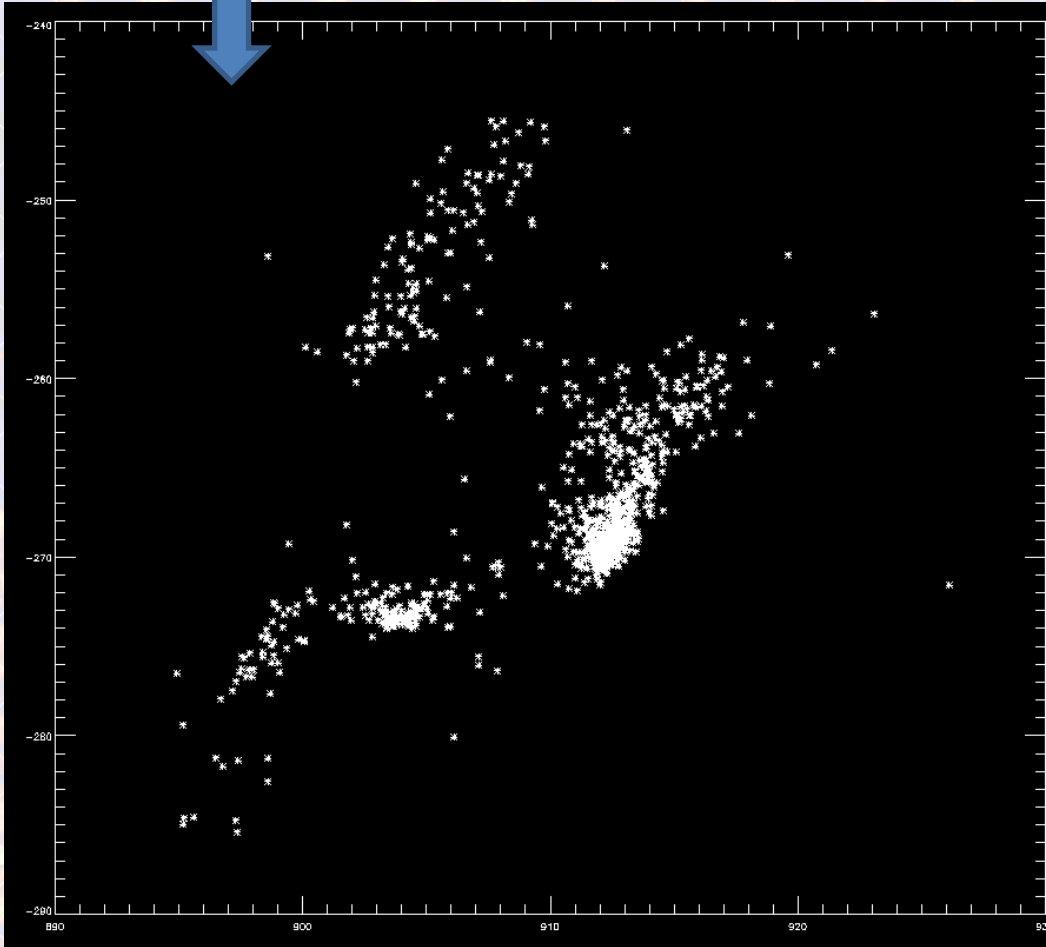
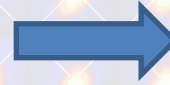
Time variation of HXR sources altitudes



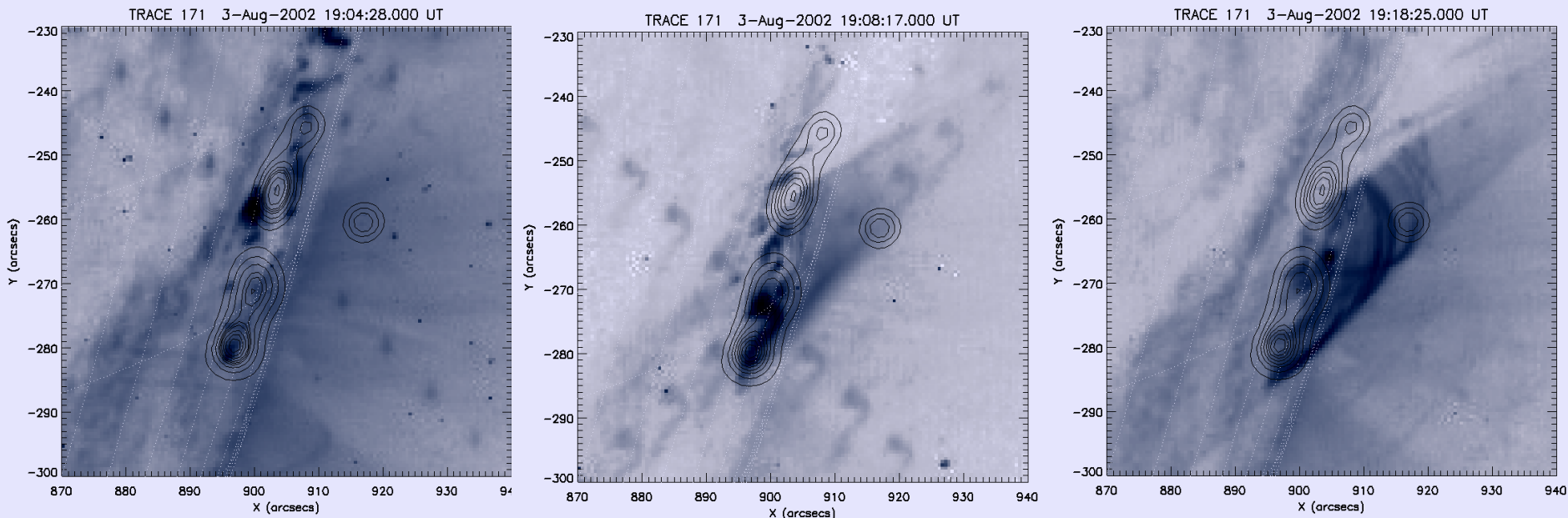
Actual flare morphology

Centroids for each
reconstructed source

image: 27-35 keV
contours: 6-7 keV



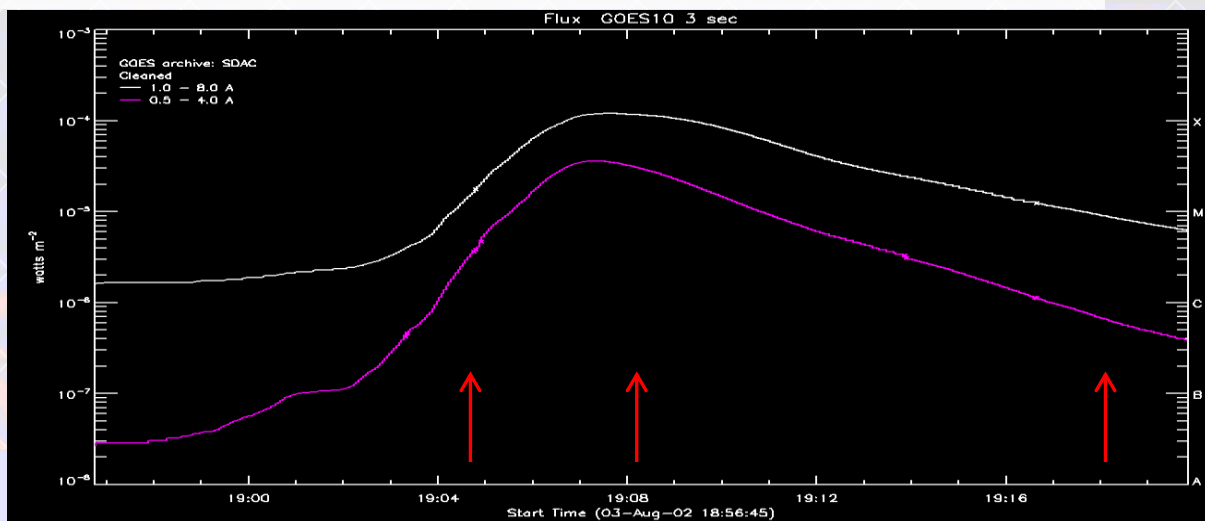
Flare morphology



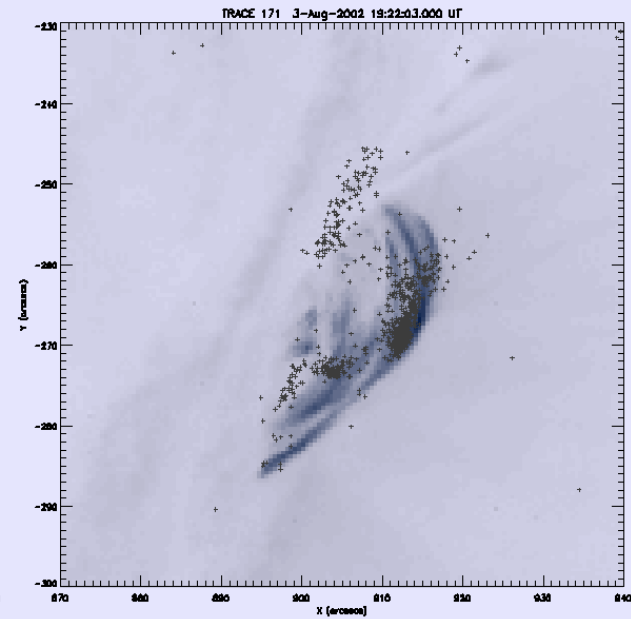
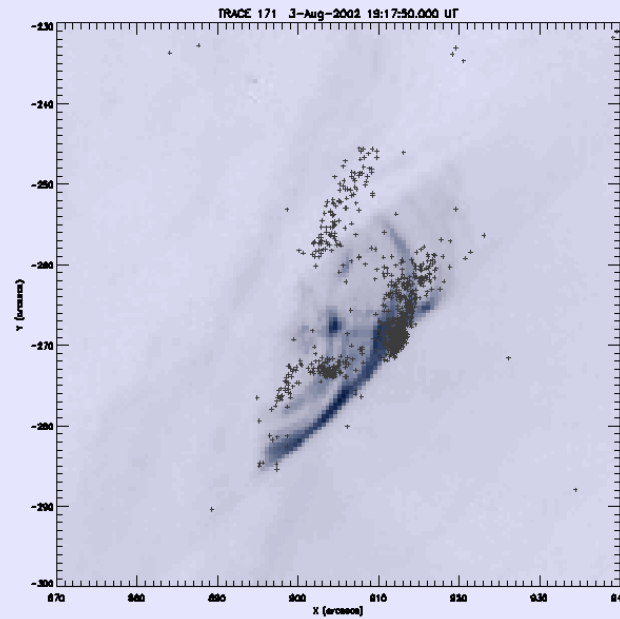
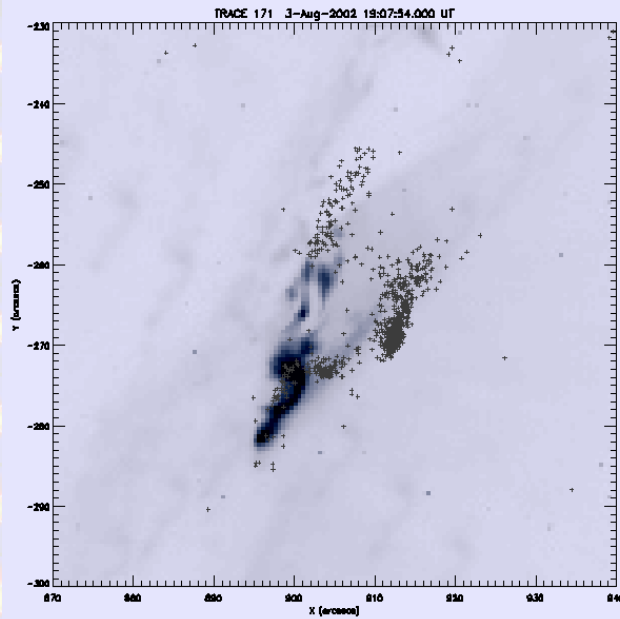
contours – 27-35 keV sources during impulsive phase (19:04:27 UT – 19:04:39 UT)

RHESSI PIXON image fits better to structures visible on EUV images.

Footpoints are cospatial with small loop as well as with system of higher loops.

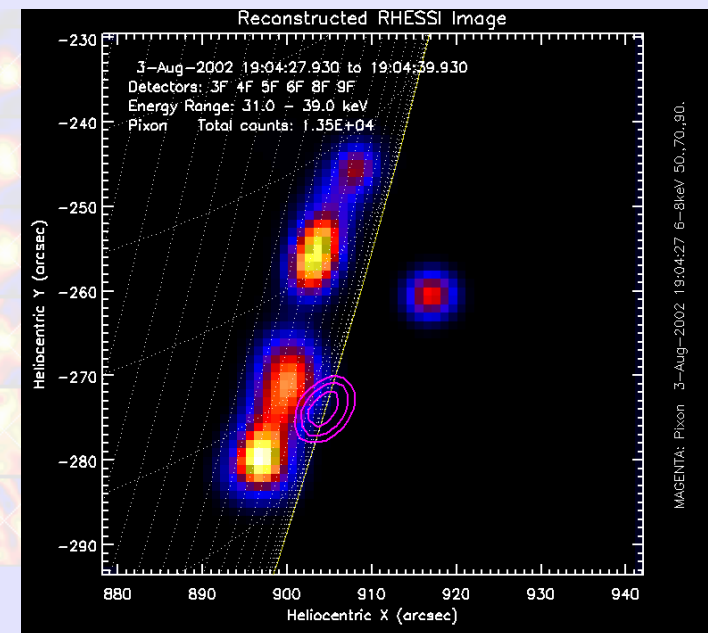


Flare morphology

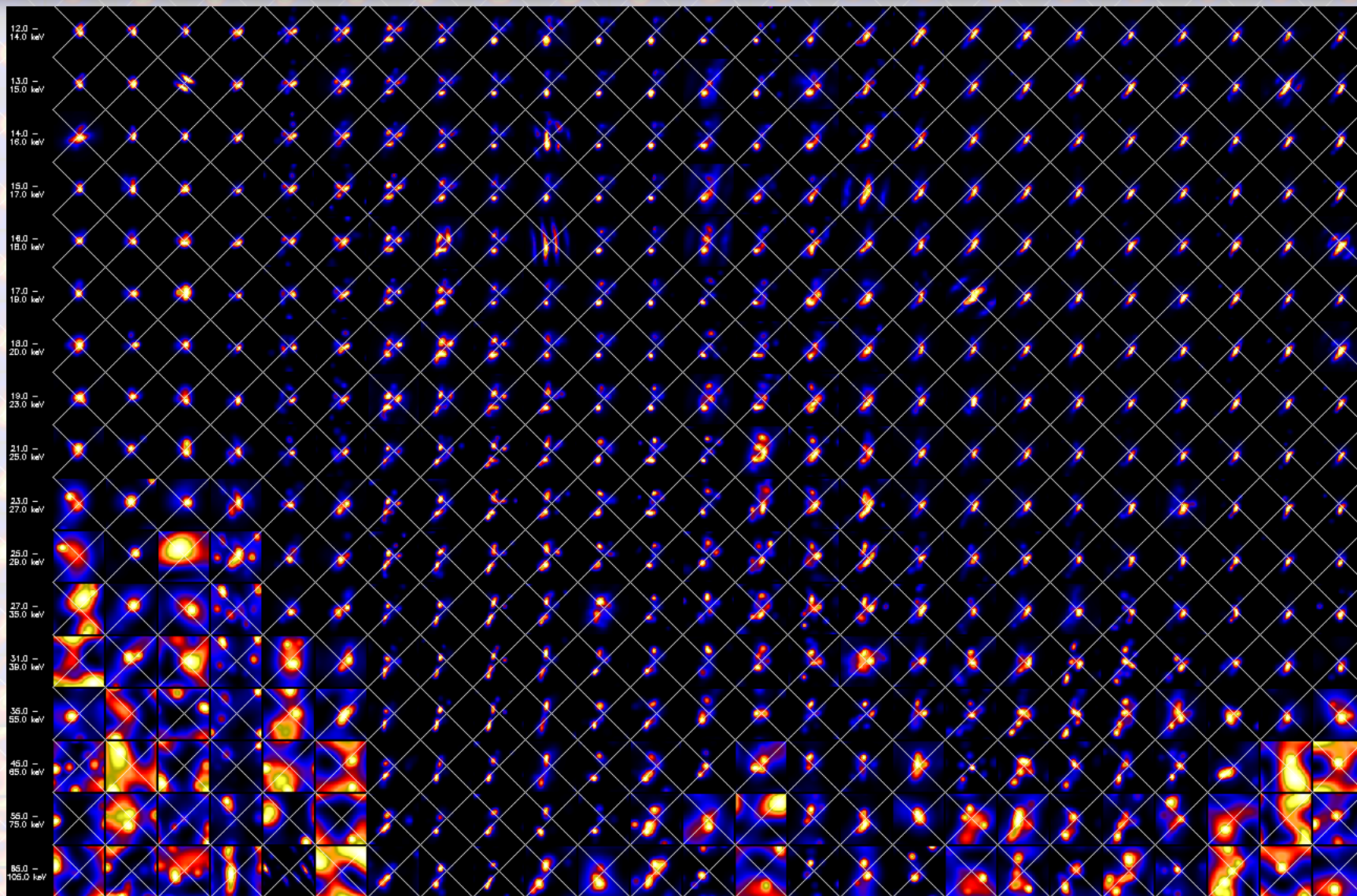


For small loop we are able to analyze energy-altitude relation.

The overall picture is rather complicated and misleading in terms of one-loop interpretation.

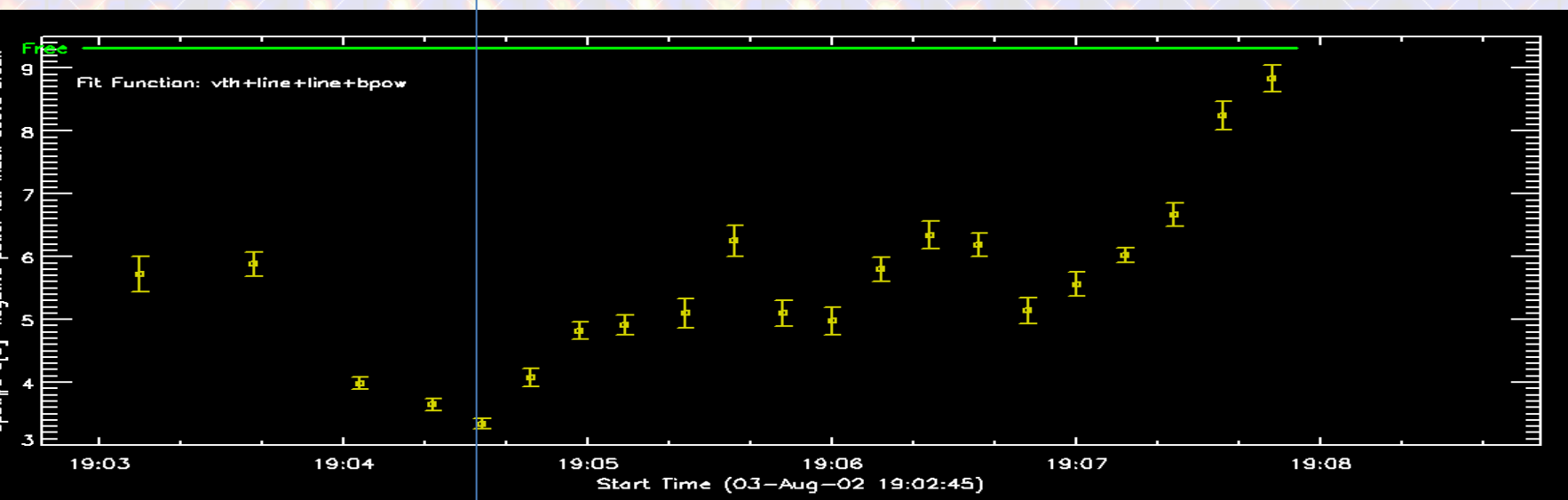
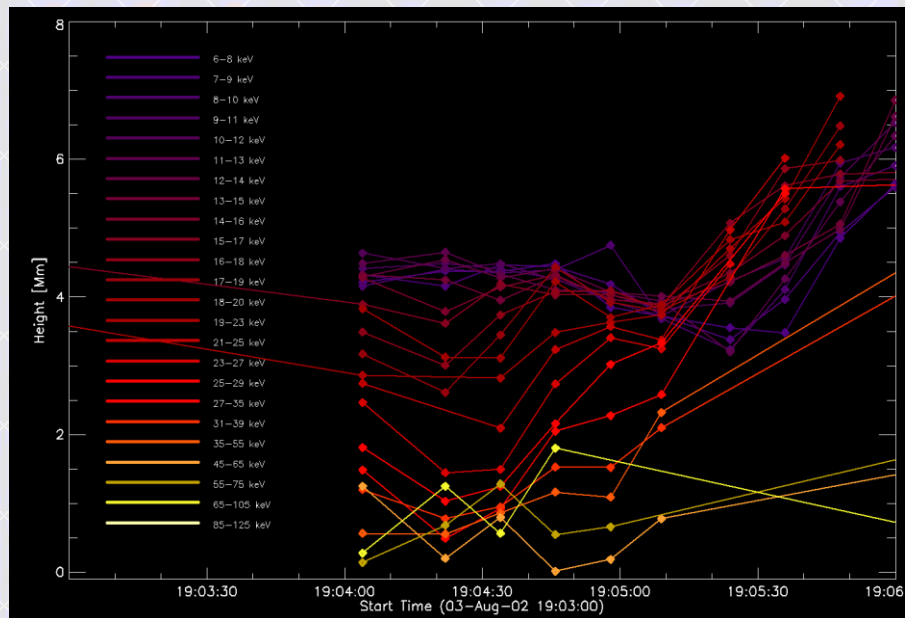
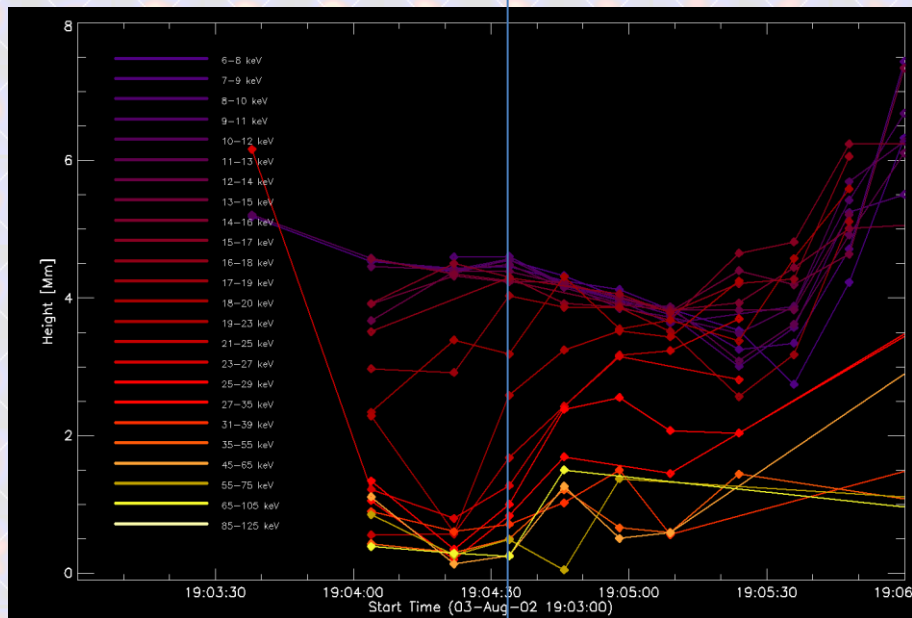


Flare morphology

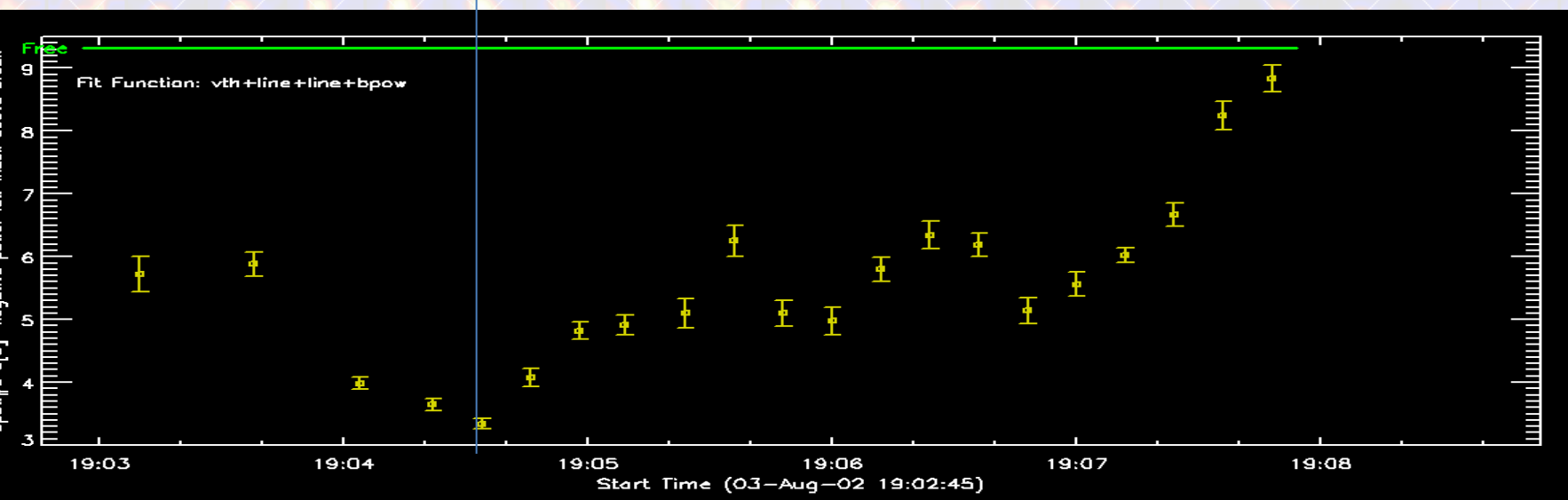
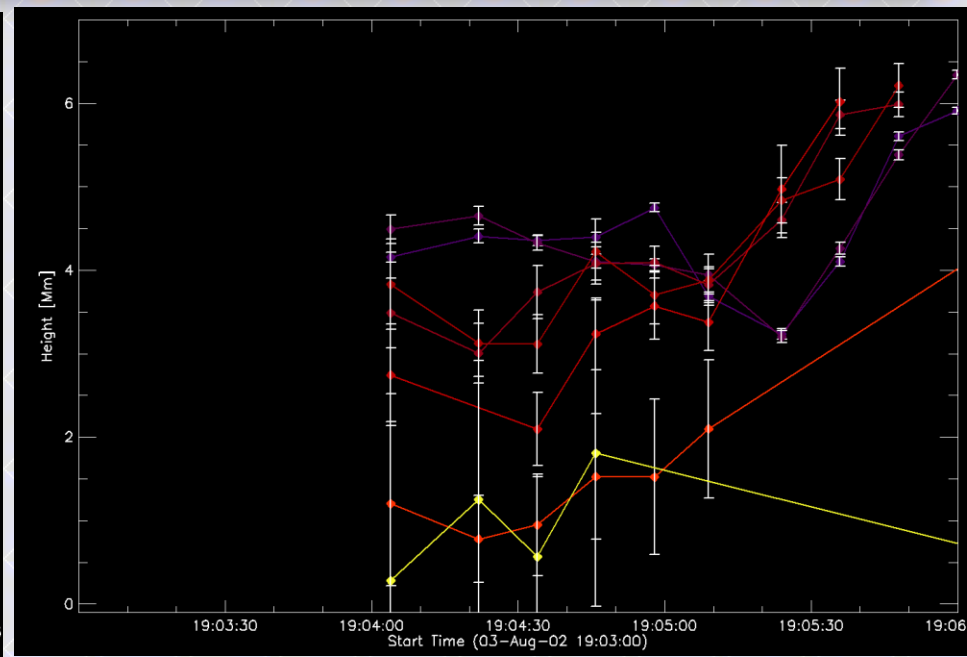
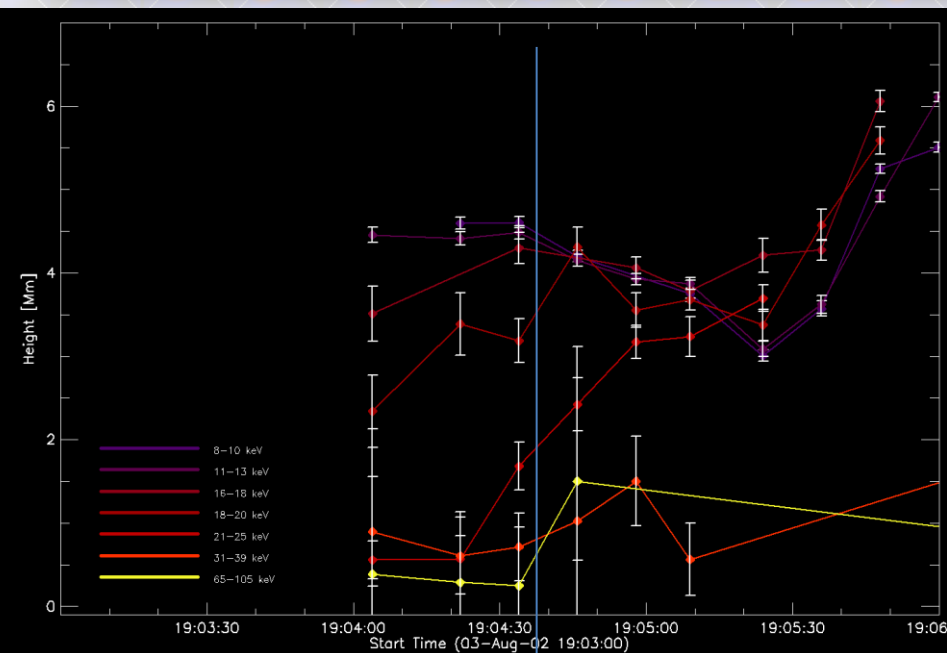


PIXON, 3-9 det (7 excl), natural weighting, 12-20s time intervals

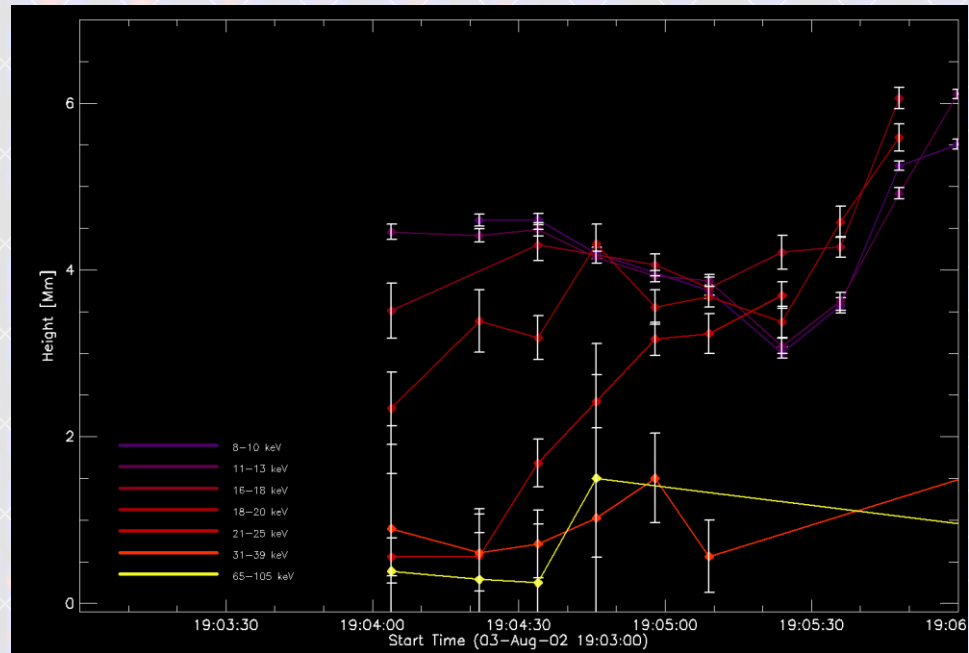
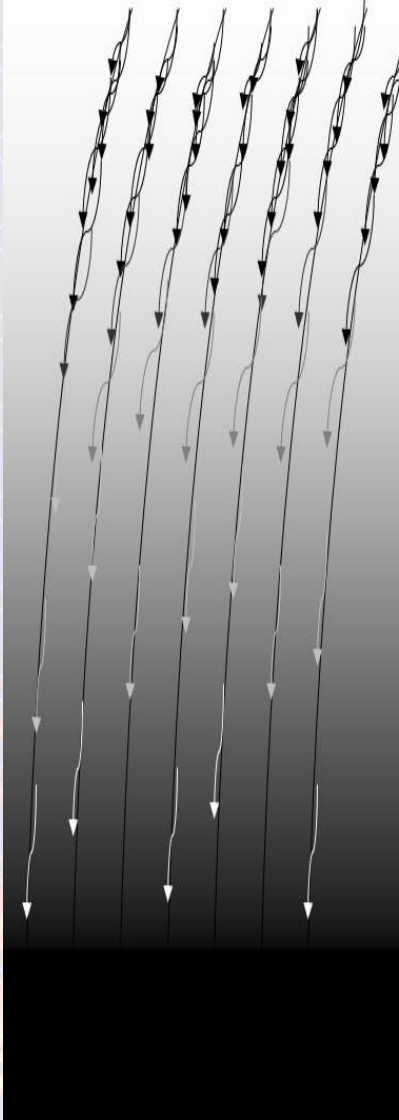
Flare morphology



Flare morphology



Chromospheric dynamics



Velocities: 150-200 km/s

Mass moved upward: $\sim 10^{13}$ g

Kinetic energy (we estimated mass) of evaporated plasma: 10^{28} ergs

The energy – altitude relation gives a chance for detailed investigation of electron beams propagating in chromosphere and the hydrodynamical response of heated plasma. The image reconstruction method/parameters can significantly influence results.

Flare morphology

