

Concealed Ejecta: The Search for a Unarmed Flare

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Introducing Flare Spectra

- Two hard x-ray sources:
 - Thermal emission consists of thermal electrons producing a relatively soft spectrum that falls off quickly at higher energies
 - Thick-target emission produces a much harder spectrum, resulting from high-energy electrons colliding suddenly with very dense material
- Magnetic reconnection occurs in the top of the flaring loop
- Particles are energized at the reconnection site

Introducing Flare Spectra

- If reconnection site is dense enough for frequent collisions, its temperature increases and thermal emission is produced
- If a CME occurs, particles are removed from the reconnection site, decreasing the density
- Electrons can then escape and are sent at very high-energies down the loop to its footpoints where they encounter dense plasma and produce non-thermal emission

Introducing Flare Spectra

- To better understand thermal processes within a flare, Longcope et. al analyzed an X-class flare with no CME on 26 Feb 2004 and found that its spectra fit best to two thermal models, rather than a thermal + non-thermal model
- My project was to find a second case of a two-thermal flare

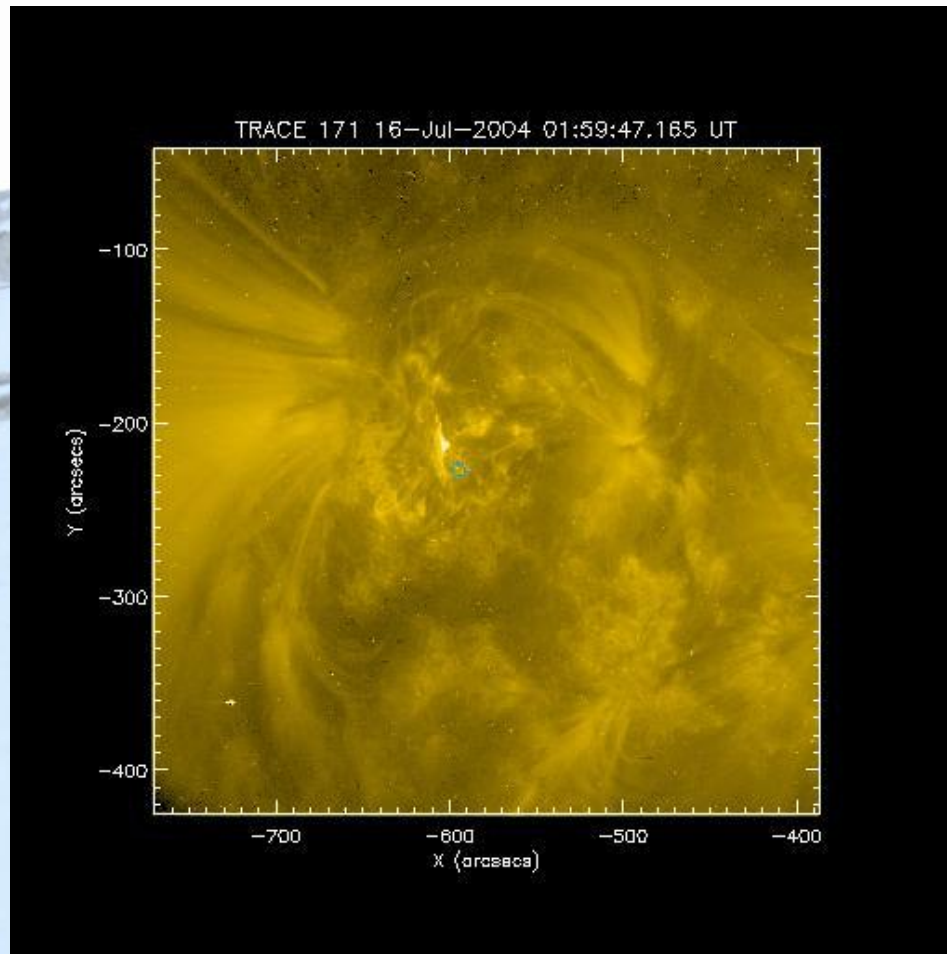
A Promising Trail

- An X 1.3 flare at 01:43 16 July 2004 was chosen for this analysis – based on the Wang and Zhang paper stating that it was not associated with a CME
- Analysis plan:
 - Fit to several spectral models
 - Produce RHESSI images to pinpoint the locations of the emission in different energy bands, and augment by overlaying onto TRACE images to determine location within the loops
- Learning to execute these tasks took about three weeks, when I was ready to start producing results

Impassable!

- Unfortunately, the reconnecting loops in the flare of interest were too small to resolve for the purposes of magnetic modeling, so even though the structure of the flare was quite interesting, it had to be abandoned
- When we began searching for a new CMEless flare, it became evident that this flare indeed **WAS** associated with a CME!

Impassable!



Route-finding

- Dr. Longcope chose the flares for both his prior study and the current one based on Wang and Zhang's list of X-class flares not associated with a CME
- Using the GOES flare catalog and the LASCO CME catalog, flares were determined as "CMEless" if a CME did not originate within a 1 hour window centered on the flare
- CMEs are observed in LASCO when they have at least reached 2.5 solar radii, so extrapolations based on trajectory must be used to determine time of origin

Route-finding

- There are three faults with the flare-selection criteria:
 - Some CMEs are not in the catalog
 - Extrapolation may be incorrect near solar surface
 - CME may not come within 1 hour around flare start but still be associated if the flare is very long
- Once qualifying flares are found, most do not have RHESSI data available

Route-finding

- Of all the flares in the Wang and Zhang list, only the two already studied had RHESSI data
- Thus we determined to look for M-class flares, using the same selection criteria
- Some X-class flares were found that were not in the Wang and Zhang list
- Most had no RHESSI data; those that did had no TRACE data, except one

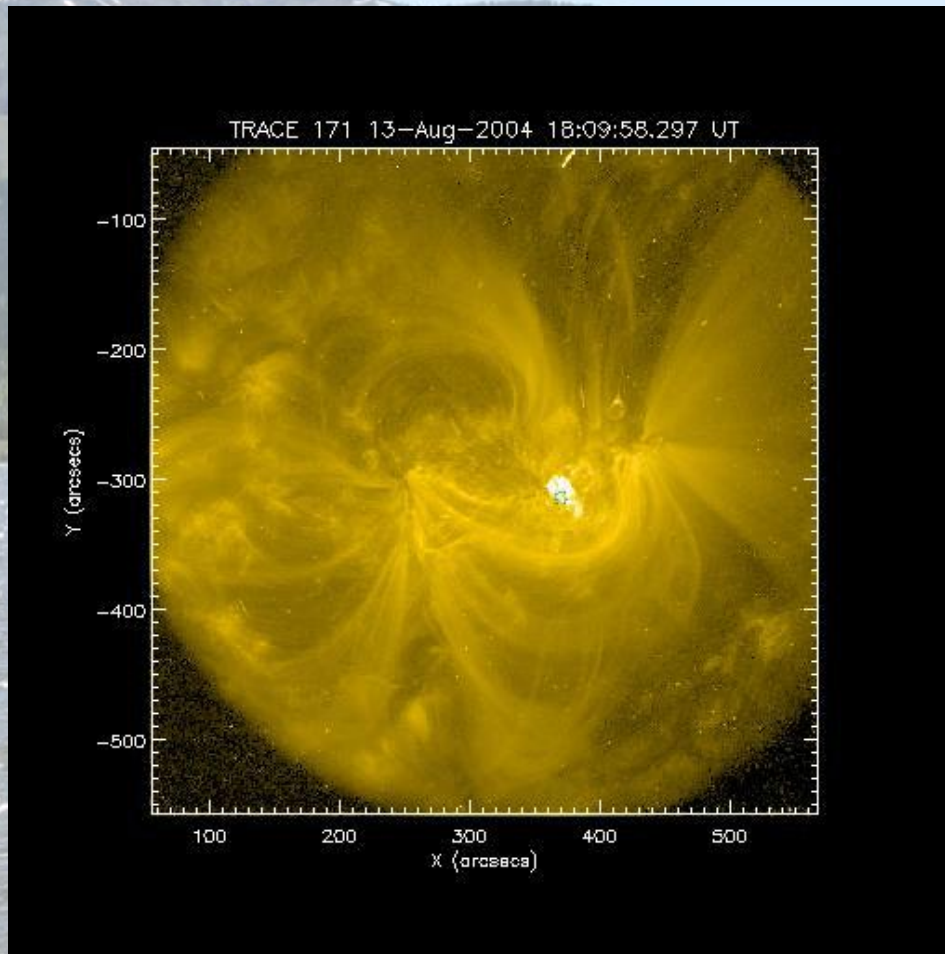
The Analysis Proceeds

- The flare we selected, an X 1.0 flare on 13 Aug 2004, had a CME extrapolated to about 45 minutes after the end of the flare
- Nevertheless, we proceeded on to analyze the flare
- Making the images and fitting the spectra turned out to be very difficult, as the RHESSI software presented no end of problems

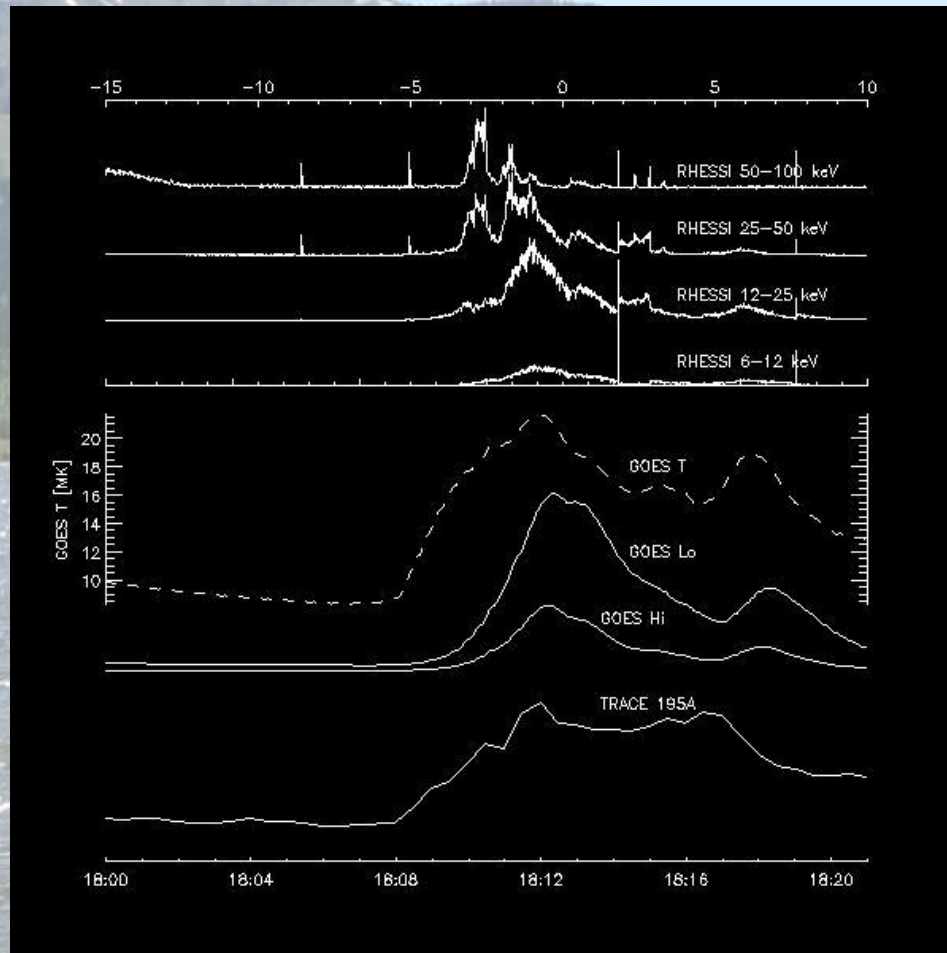
Results

- The spectra of this flare clearly fit best to the thermal + thick-target model, rather than the two-thermal model
- RHESSI contours overlaid onto TRACE images show emission in all energy bands –6-12 keV, 12-25 keV, and 35-100 keV – to be centered at the same place: the footpoint
- There is only one bright spot, as opposed to the normal two seen in footpoint emission

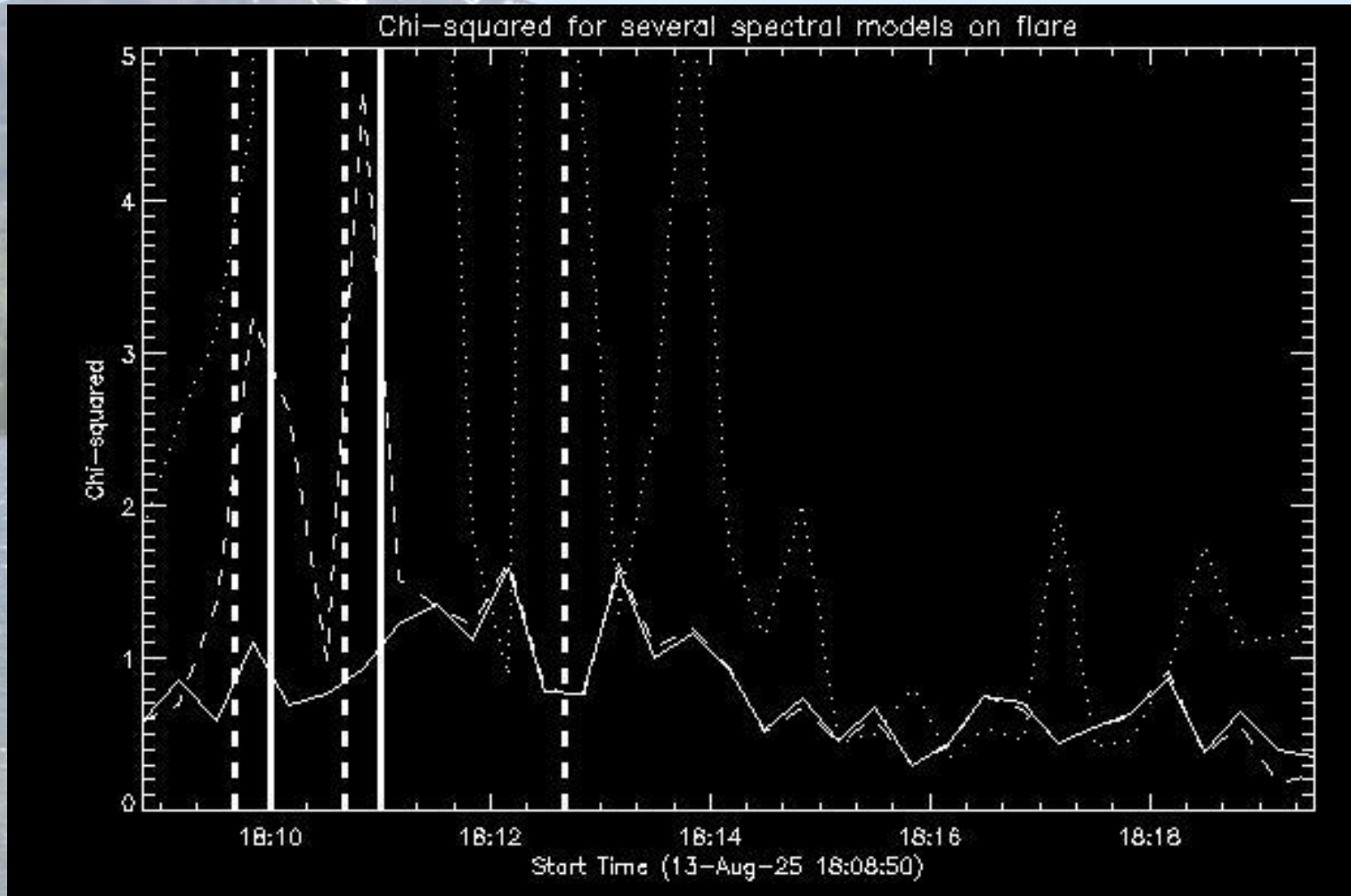
Results



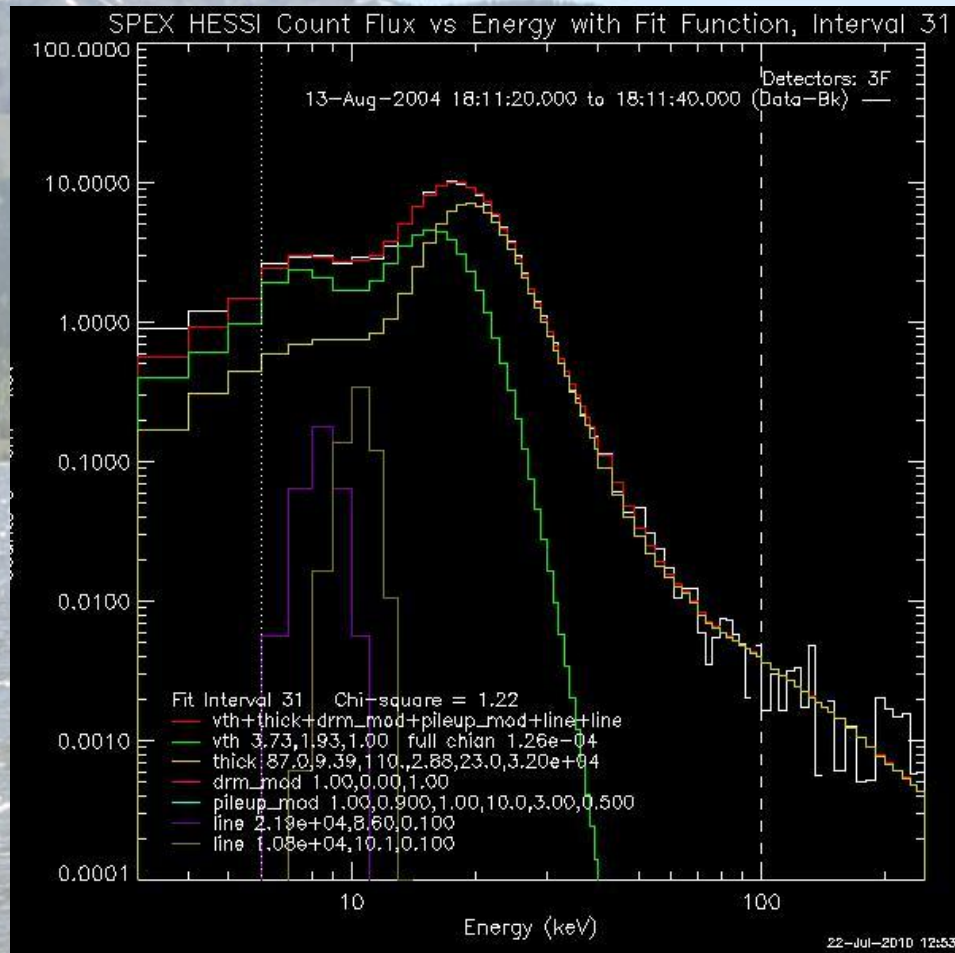
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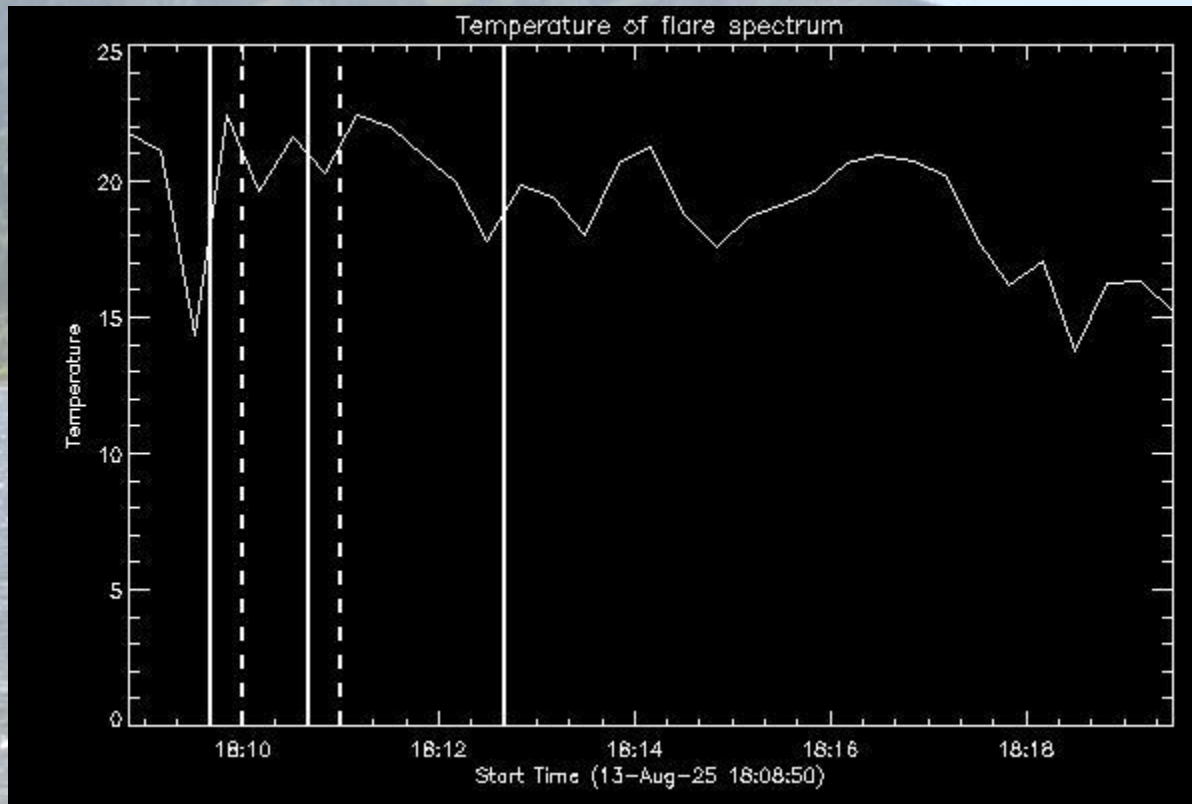
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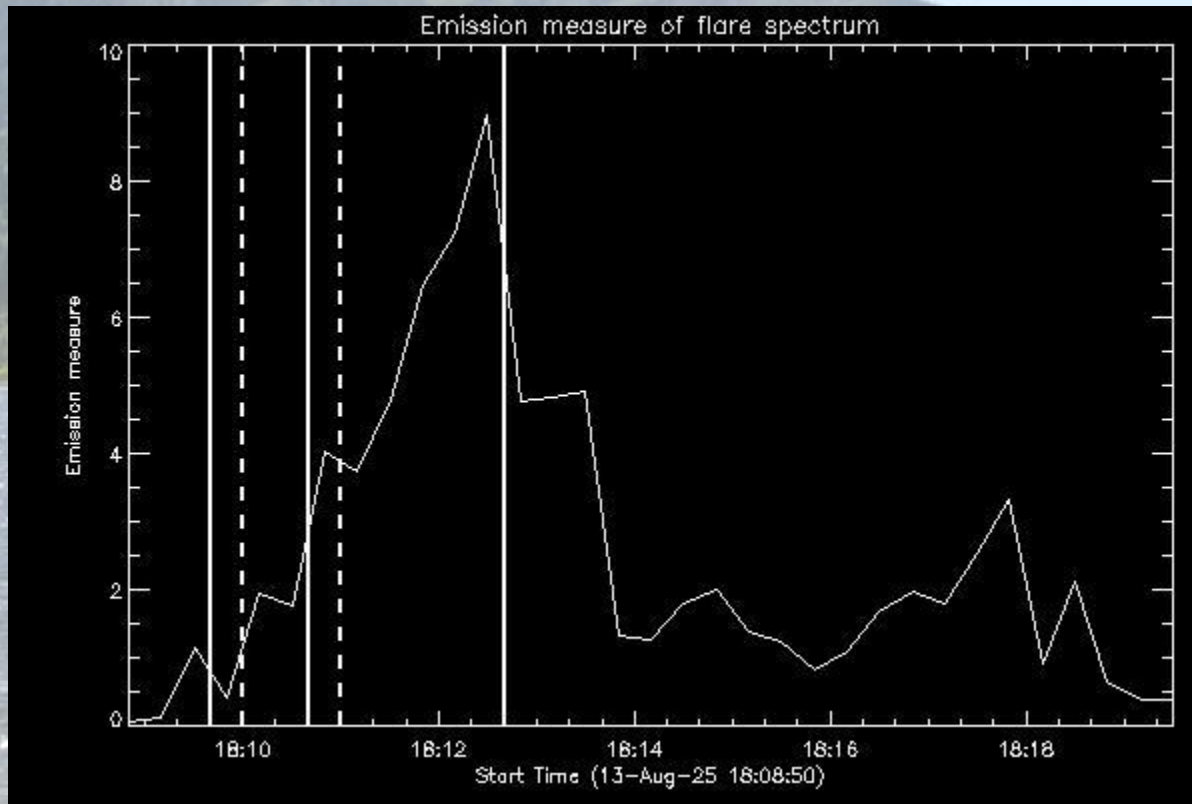
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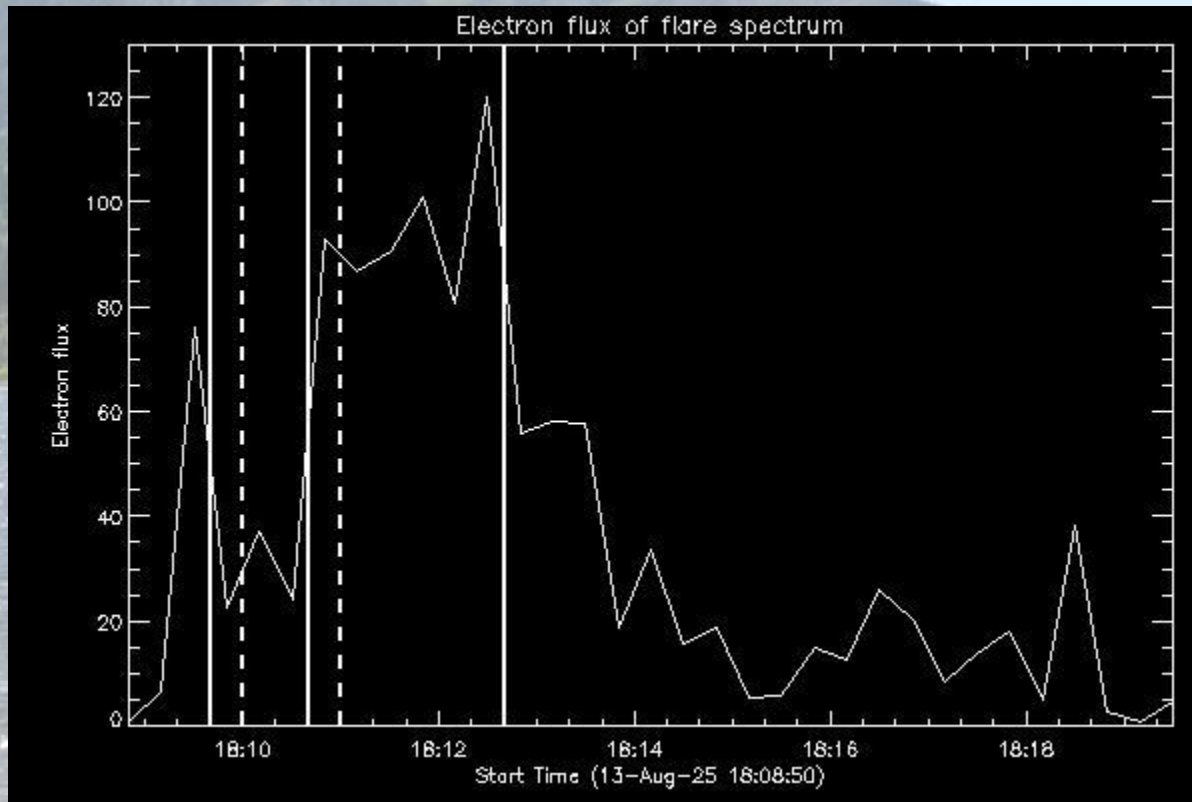
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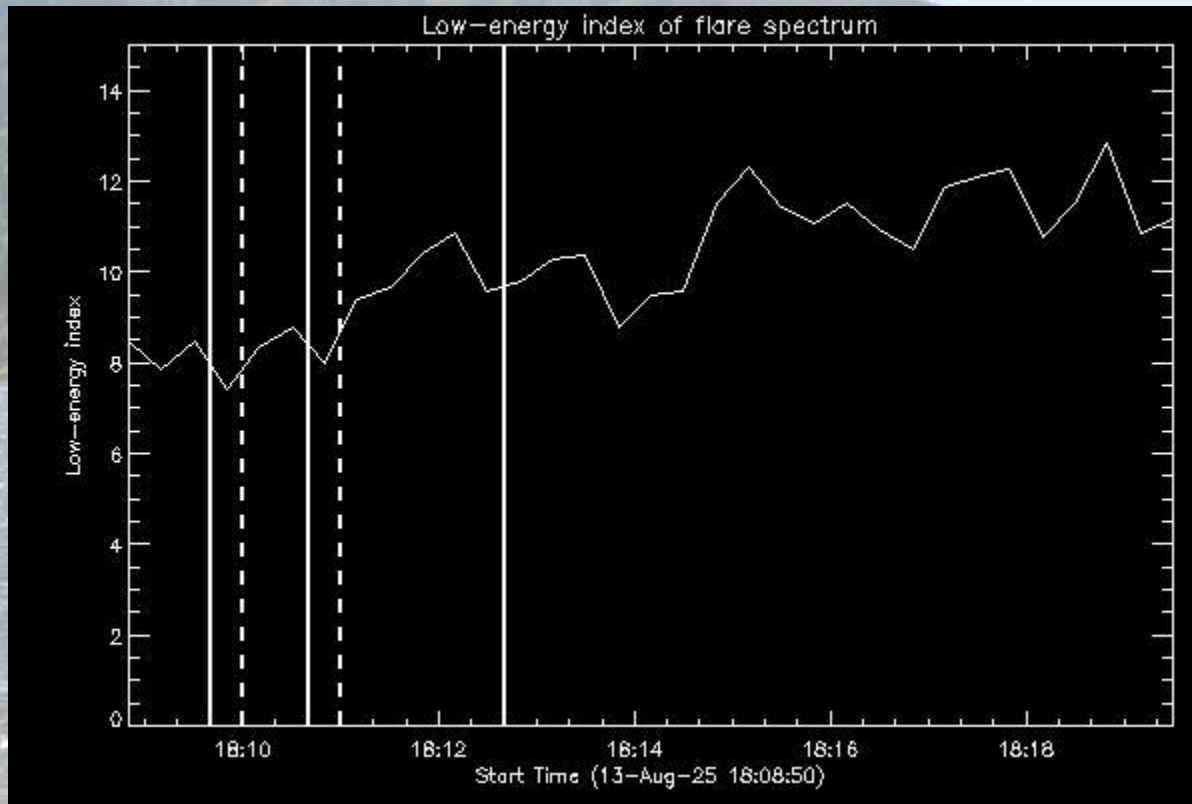
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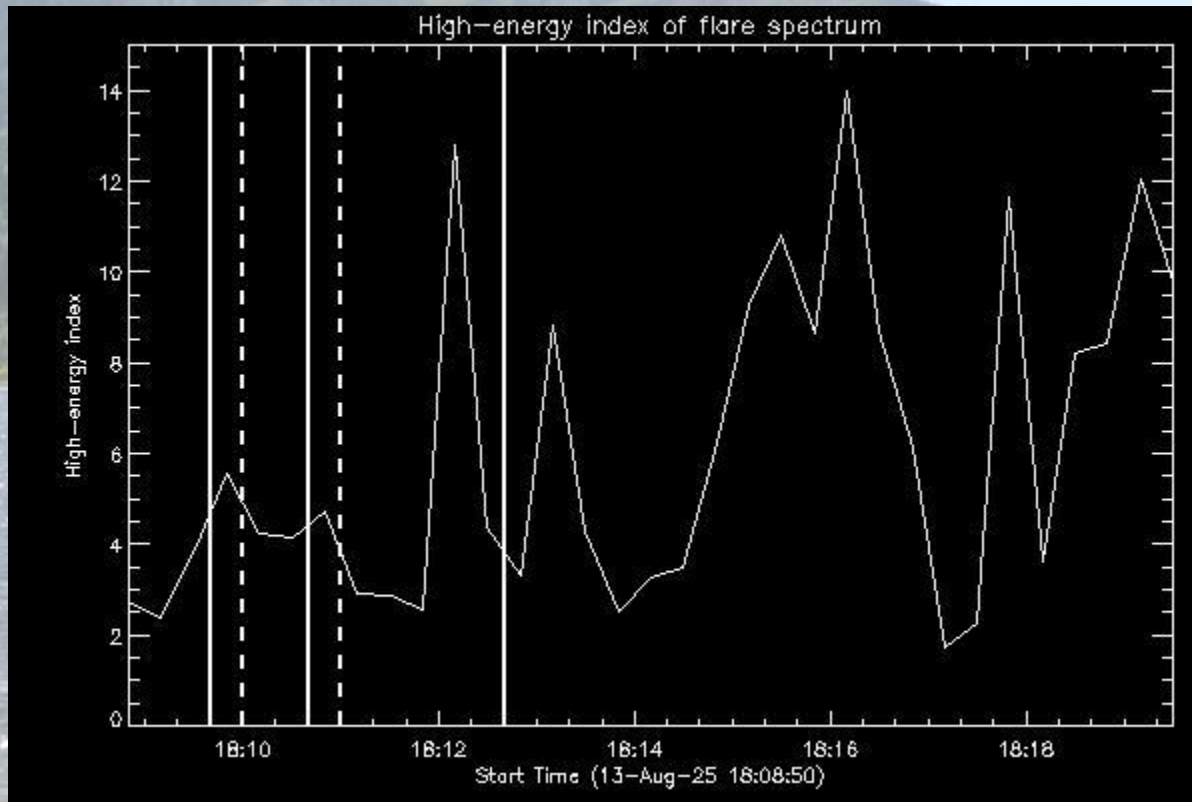
Results



Results



Results



Results

- Apparently the flare had such low densities in the reconnection site that electrons escaped to create non-thermal emission
- Thermal emission was produced by heating of the footpoint plasma during the electron bombardment
- Perhaps the flare was associated with the CME!

THE END

