Microflares with Hinode, RHESSI & SDO

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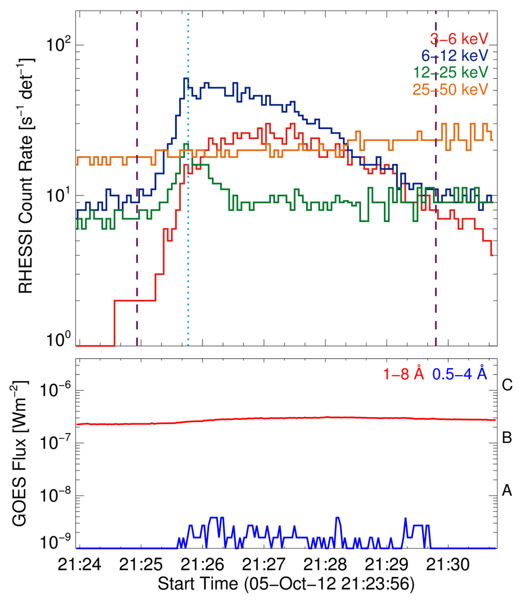
Overview:

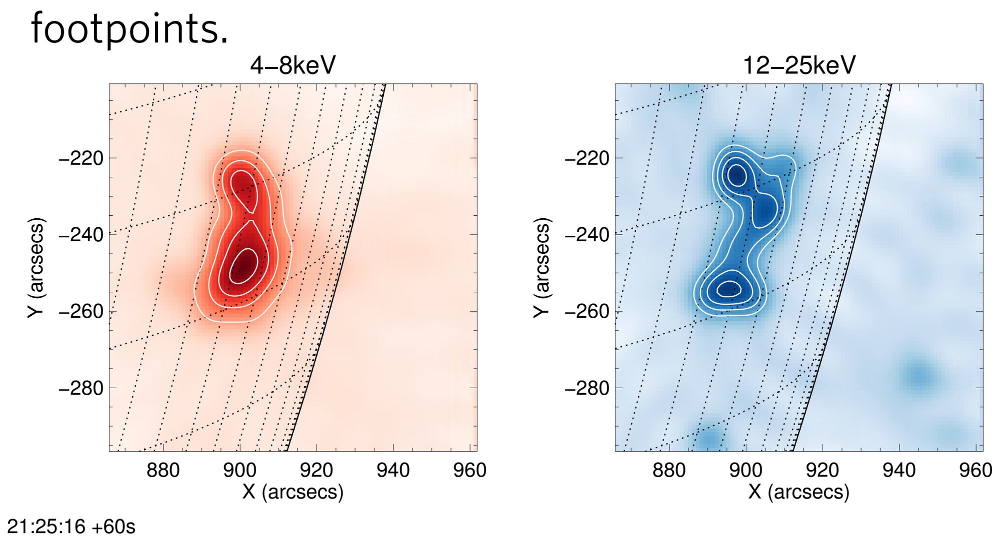
Microflares are small active region flares (GOES A and B-class) that demonstrate similar signatures of electron acceleration and plasma heating as larger flares. This, combined with their high occurrence rate, simpler configurations and weaker emission that does not substantially saturated observations, makes them ideal candidates for studying flare energetics (Hannah et al. 2011). RHESSI imaging and spectroscopy allows the HXR emission from the flare-accelerated electrons to be studied as well as the thermal response (SXR) to this non-thermal input. The EUV images from SDO/AIA and SXR from Hinode/XRT show the lower temperature flare behaviour and using a regularized inversion method (Hannah & Kontar 2013; code available online[†§]) to determine the Emission Measure (EM) distribution we can quantify the thermal properties of the microflares.

We present (wip) analysis of the RHESSI emission, EM maps from SDO/AIA and the DEM from SDO/AIA and Hinode/XRT for two B-Class microflares.

B2.5: 05-Oct-2012, 21:25

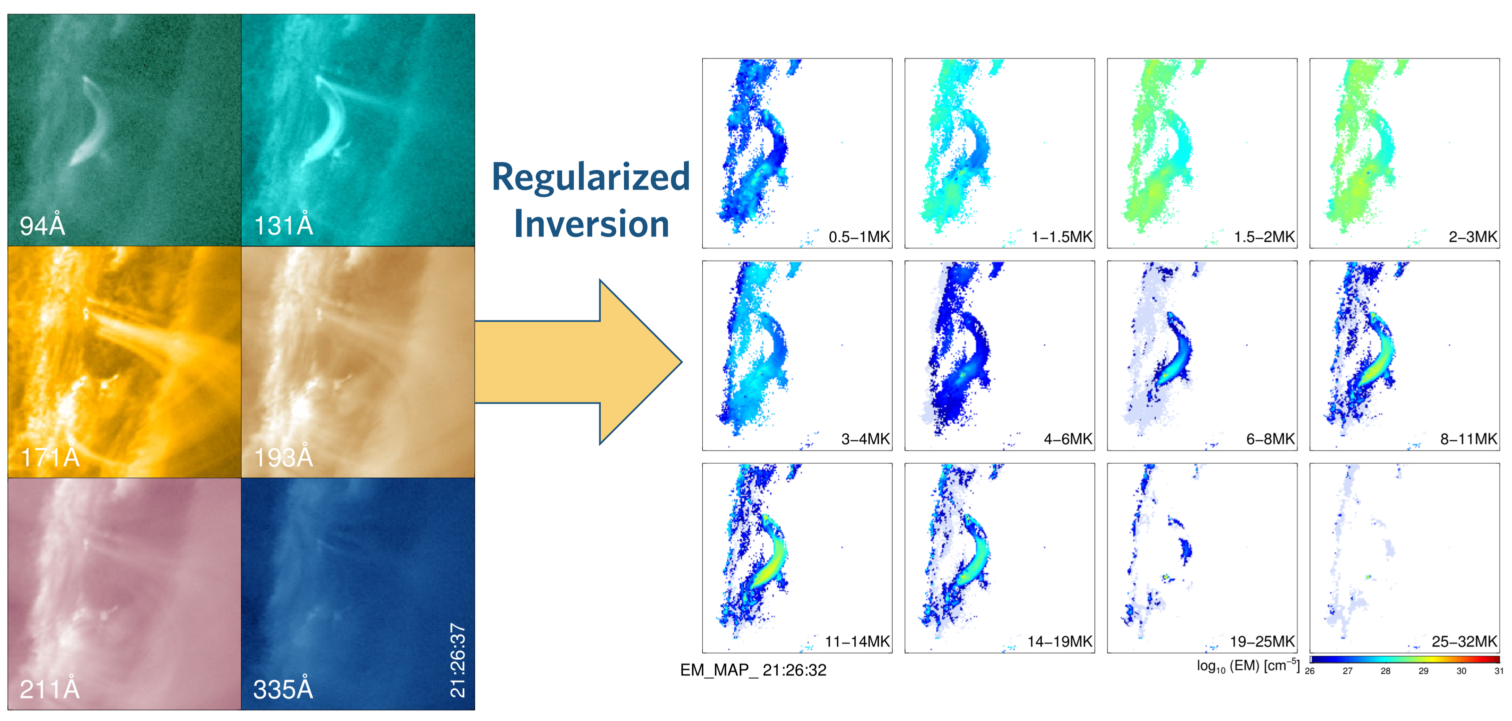
This microflare occurs near the limb of the Sun, providing a near side-on view. In the RHESSI CLEAN images below we see a hot thermal loop in 4-8 keV, with the higher energy 12-25 keV emission more concentrated at the ends of the loop at the footpoints.

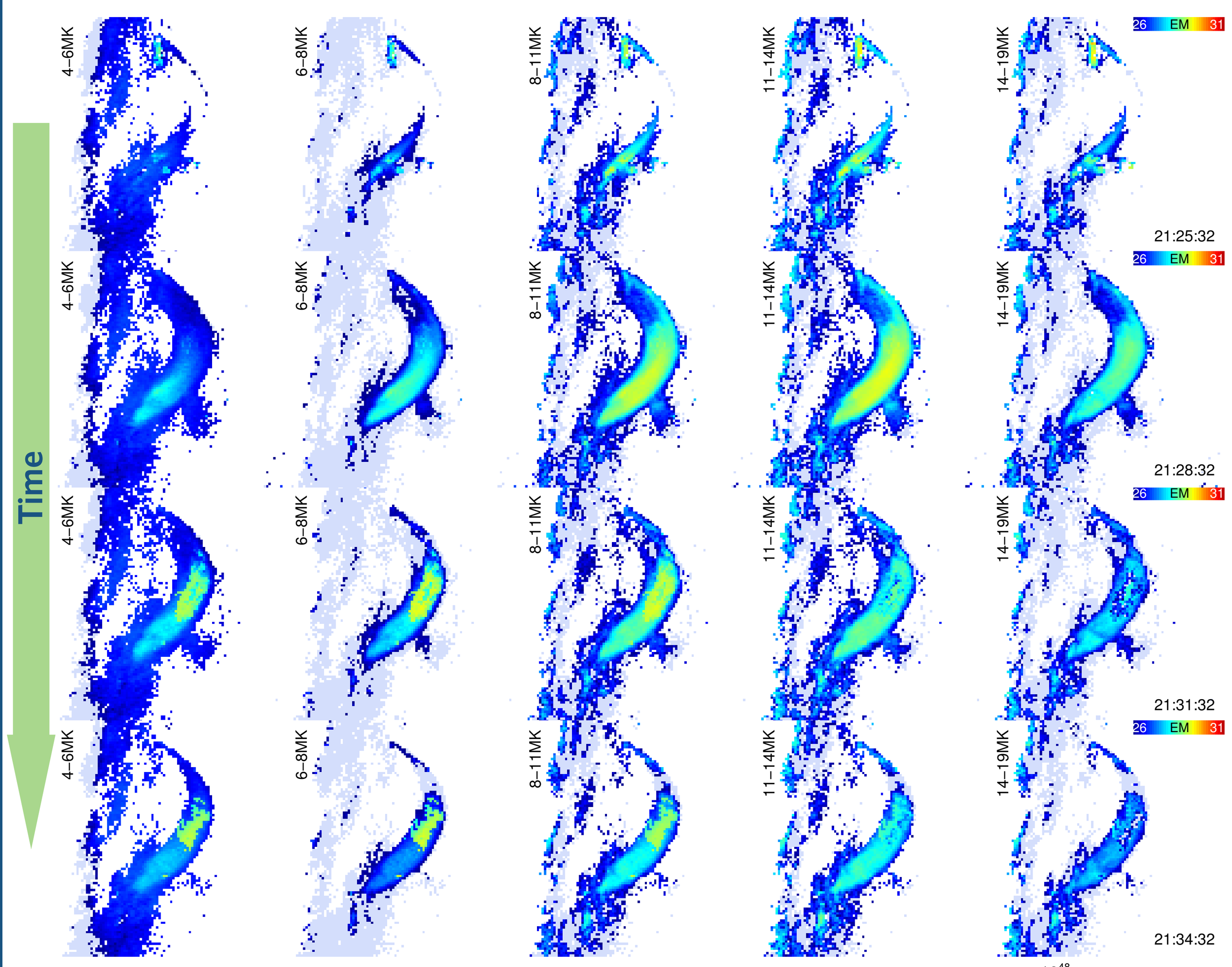




The RHESSI lightcurve shows a simple impulsive profile, quickly peaking in 12-25keV before being hidden by the background. Below 12keV peaks later, slowly reducing as the material cools to outwith RHESSI's sensitivity range.

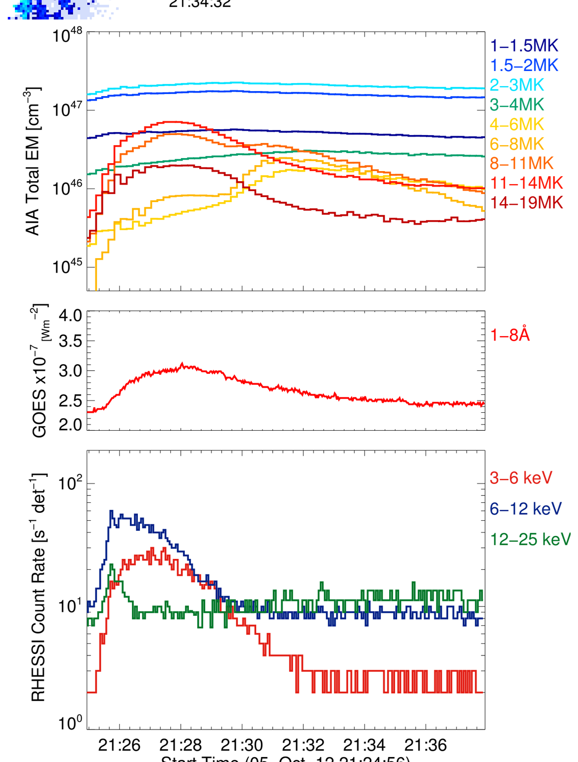
The regularized inversion code[§] takes the six SDO/AIA values in each pixel and recovers the source Emission Measure distribution EM(T)=n^2h (density n and line-of-sight h). At this stage the loops are mostly in the hotter temperatures.





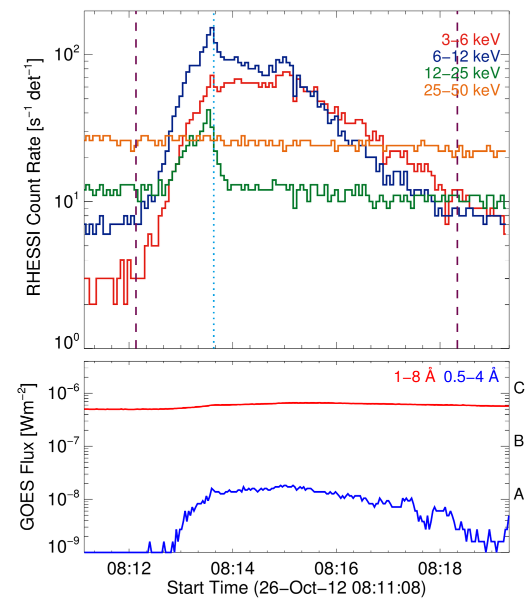
To the left we show the time evolution of the EM maps with the loop quickly heating before more slowly cooling. Note that thanks to SDO/AIA's time resolution we have maps every 12sec but for space here only show them every 3mins.

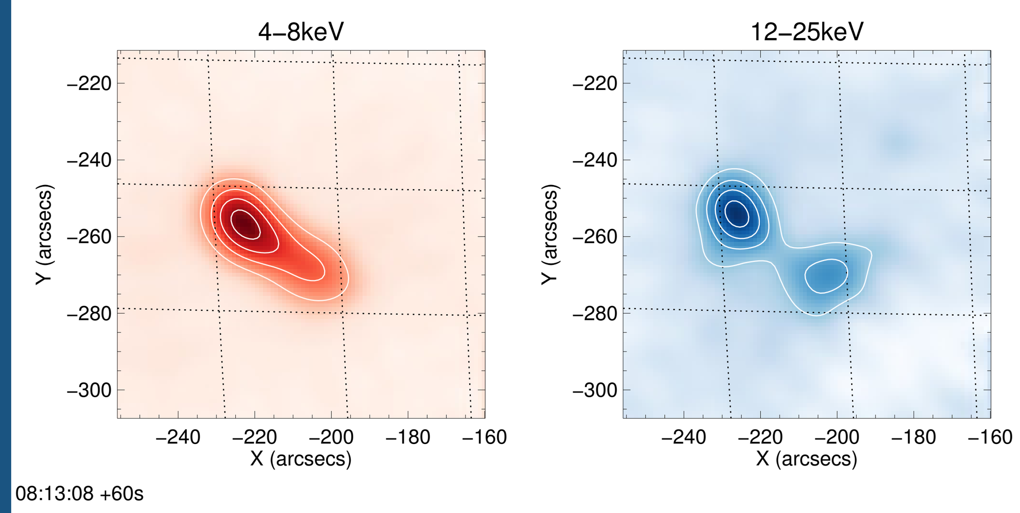
From the above EM maps we can calculate the total EM as a function of time for each temperature range, shown on the right. The hottest EM peaks the fastest however there is a plateau in the 6-8 MK, and the lowest temperatures barely change (suggesting that non-flare related material dominates). The hottest SDO/AIA emission matches both the GOES and RHESSI thermal (3-6 keV). Note that as the EM is not calculated for saturated pixels the maximum SDO/AIA EM reached here is an underestimate.



B6.0: 26-Oct-2012, 08:13

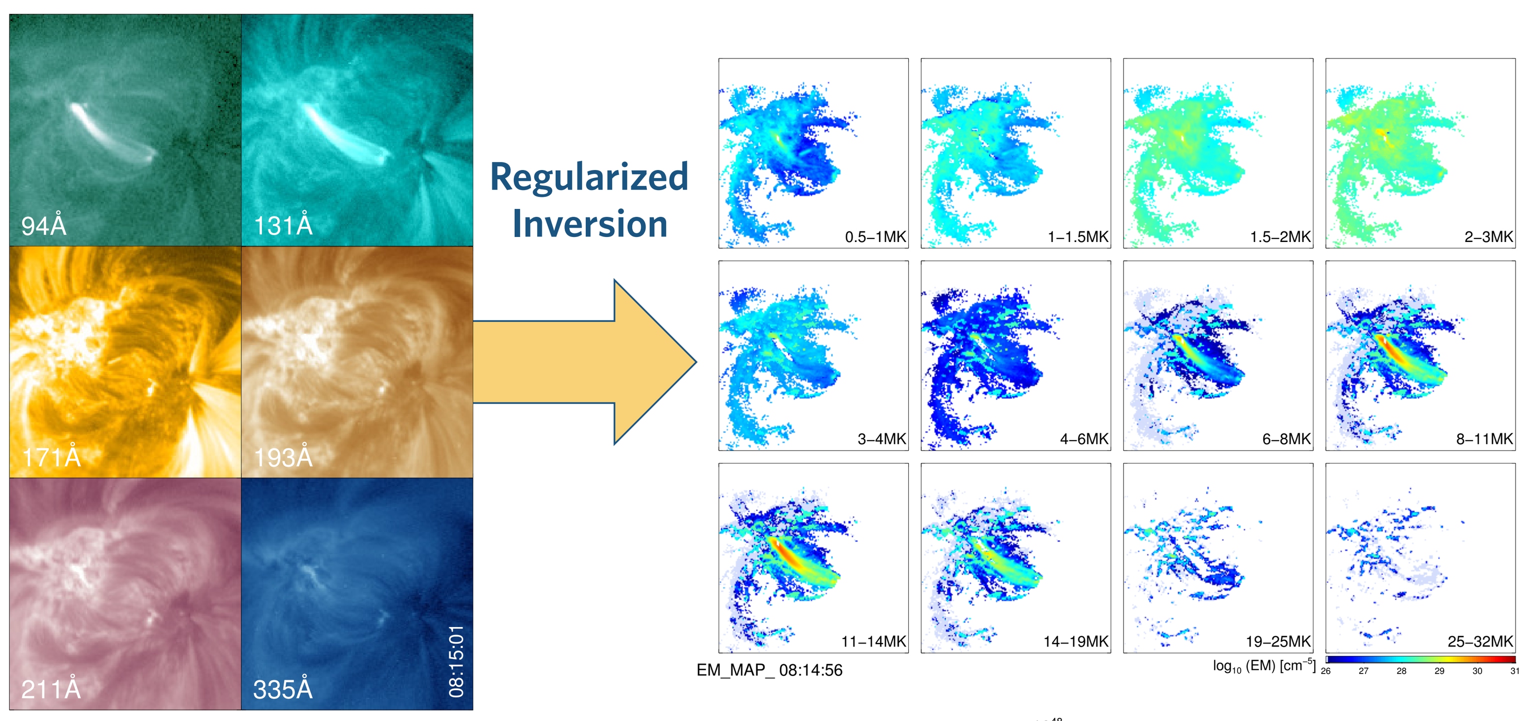
This microflare occurs closer to disk centre, providing a top down view. In the RHESSI CLEAN images below we see a hot thermal loop in 4-8 keV, with the higher energy 12-25 keV emission clearly concentrated at the ends of the loop at the footpoints.



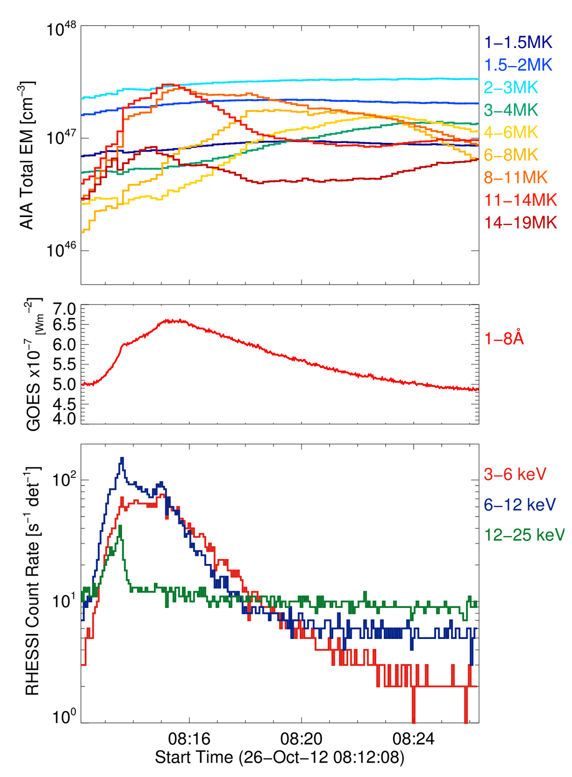


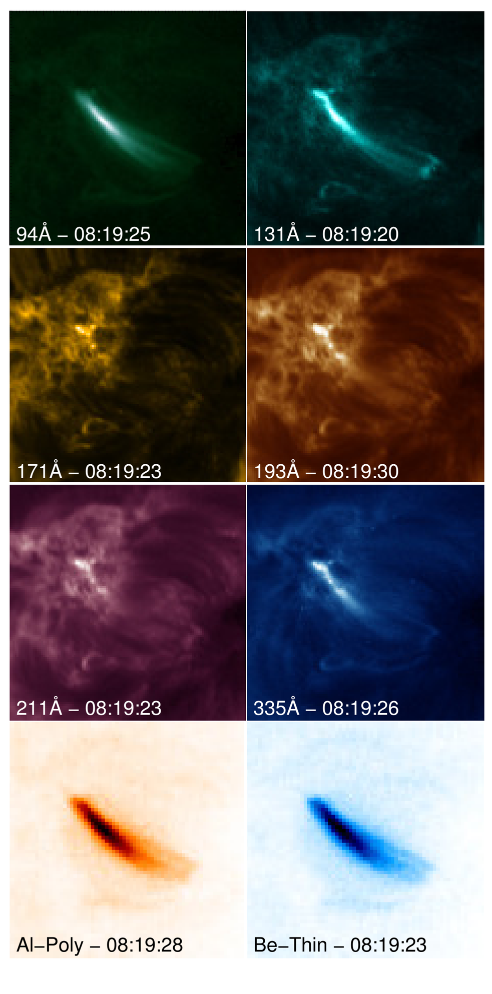
The RHESSI lightcurve shows an impulsive start which peaks quickly in 12-25keV. The thermal emission (< 12keV) peaks later and slowly reduces though there is an additional peak of emission in 6-12 keV about 08:15.

The regularized inversion code[§] takes the six SDO/AIA values in each pixel and recovers the source Emission Measure distribution EM(T)=n^2h (density n and line-of-sight h). At this stage the loops have strong emission in 8-11MK & 11-14MK.

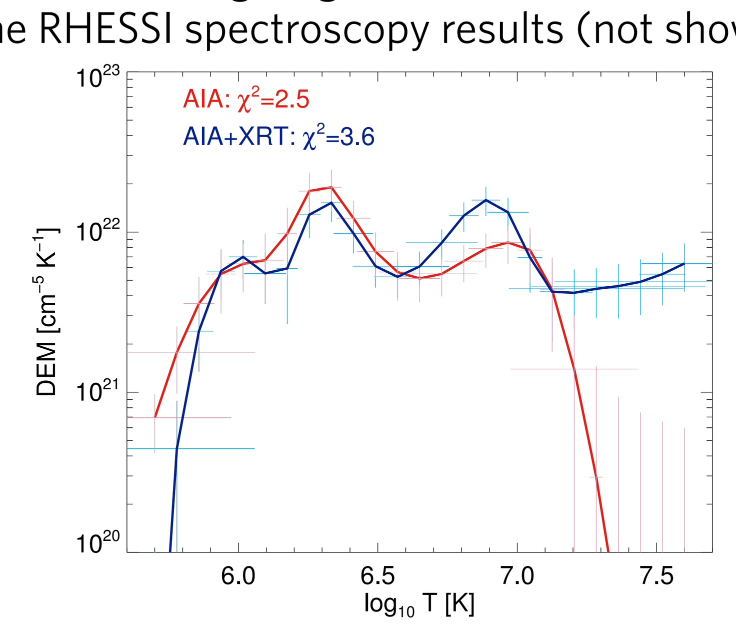


From the EM maps for each time interval (not shown) we can calculate the total EM as a function of time for each temperature range, shown on the right. The hottest EM peaks the fastest however it also appears to peak again later in the event. The hottest SDO/AIA emission matches both the GOES and RHESSI thermal (3-6 keV). At lower temperatures the rise in EM is smaller which suggests that non-flare related material dominates. Again note that as the EM is not calculated for saturated pixels the maximum SDO/AIA EM reached here is an underestimate.





For this microflare there is also Hinode/XRT data in multiple filters but it is badly saturated until later in the event. So we have only calculated a single DEM[†] of the hot thermal loops using just the SDO/AIA data and then SDO/AIA & Hinode/XRT. Unfortunately the addition of Hinode/XRT with the regularization method provides a poor constraint to the high T plasma (>16MK) giving a DEM value inconsistent with the RHESSI spectroscopy results (not shown).



Refs: Hannah et al. SSR 159 (2011), Hannah & Kontar A&A 553 (2013)

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[§]The EM map code: http://www.astro.gla.ac.uk/~iain/demreg/map
[†]Original DEM code: http://www.astro.gla.ac.uk/~iain/demreg

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