STEREO & RHESSI observations of the December 31, 2007 solar flare

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hard X-ray (HXR) observations

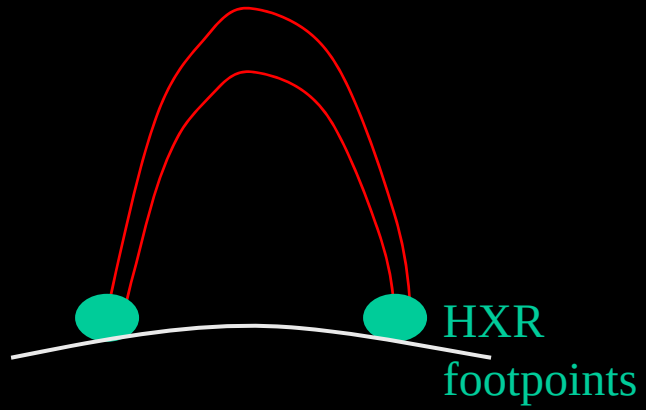
- flare-accelerated electrons produce HXR emission by the bremsstrahlung mechanism

this presentation

- partially disk occulted flares: RHESSI statistical results
- December 31, 2007 flare

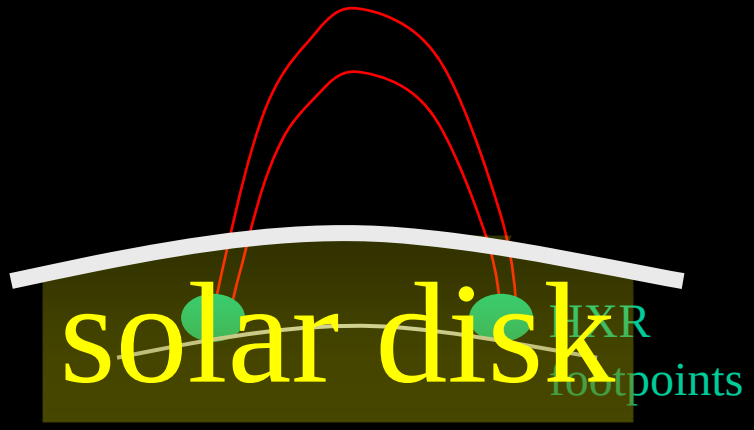
X-rays from partially disk-occulted flares

Standard flare scenario:
high density chromosphere
→ HXR footpoints
low density corona
→ very weak HXR emission



X-rays from partially disk-occulted flares

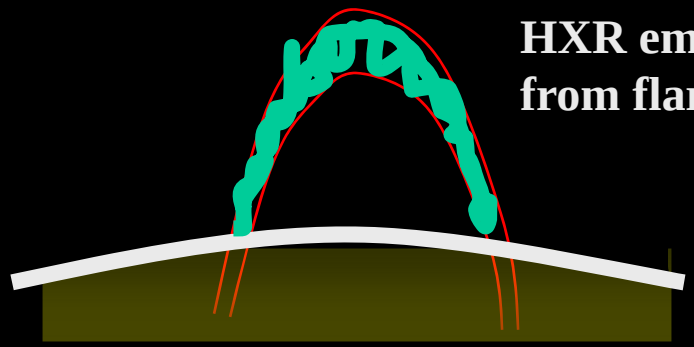
for flares occurring behind the solar limb, footpoint emission is occulted
→ purely coronal emission can be studied



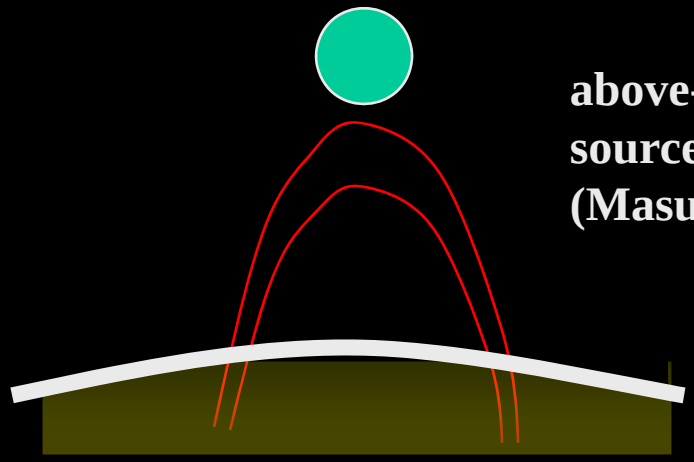
Statistical studies:
Roy & Datlowe 1975, McKenzie 1975,
Mariska et al. 1996,
Tomzcak 2001, Krucker & Lin 2008

X-rays from partially disk-occulted flares

Possible coronal sources:

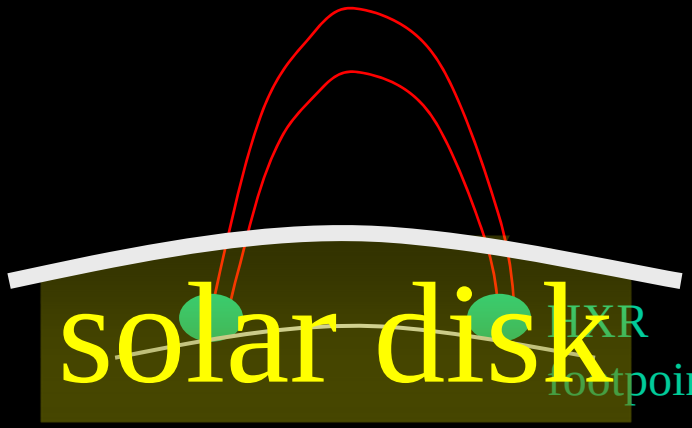


HXR emission from flare loop



above-loop-top source (Masuda flare)

for flares occurring behind the solar limb, footpoint emission is occulted
→ purely coronal emission can be studied



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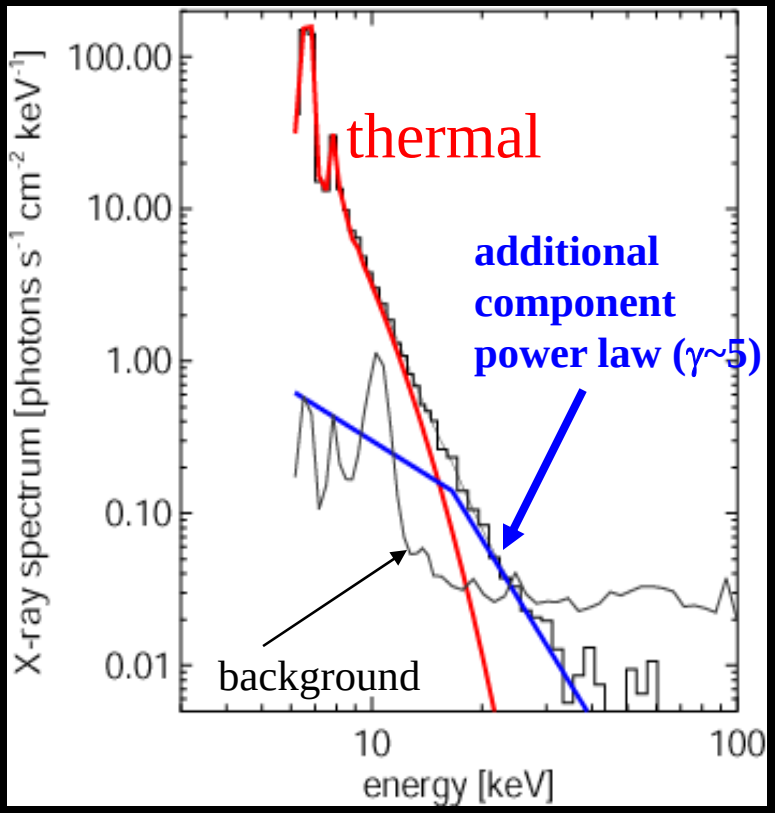
X-rays from partially disk-occulted flares

typical spectrum of partially occulted flare shows 2 components:
-) thermal
-) faint emission at higher energies



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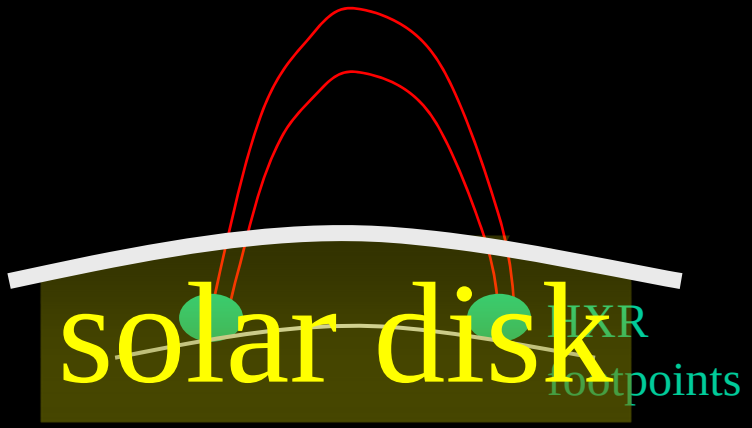

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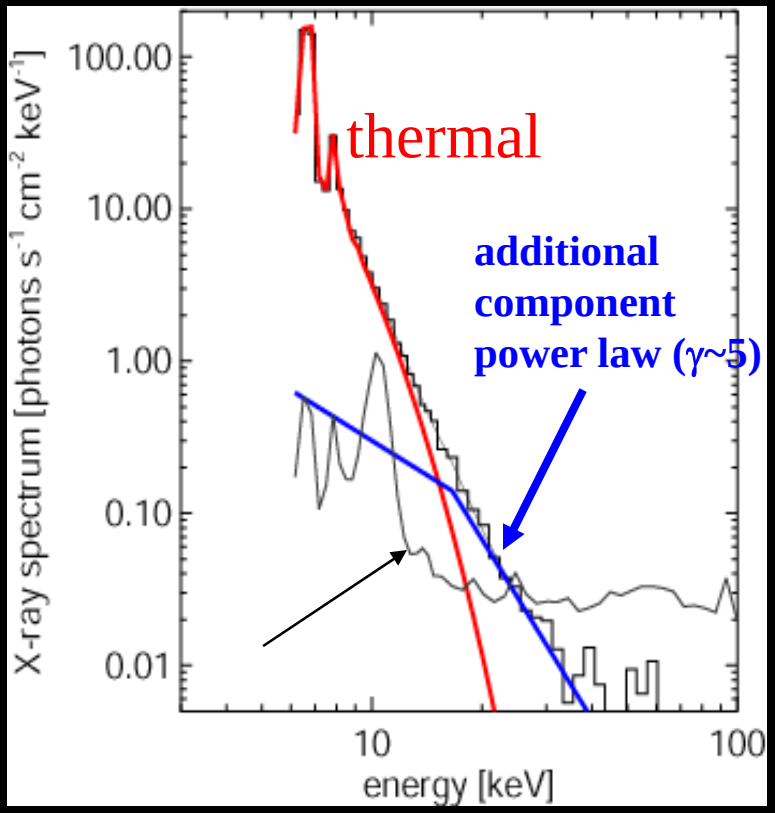
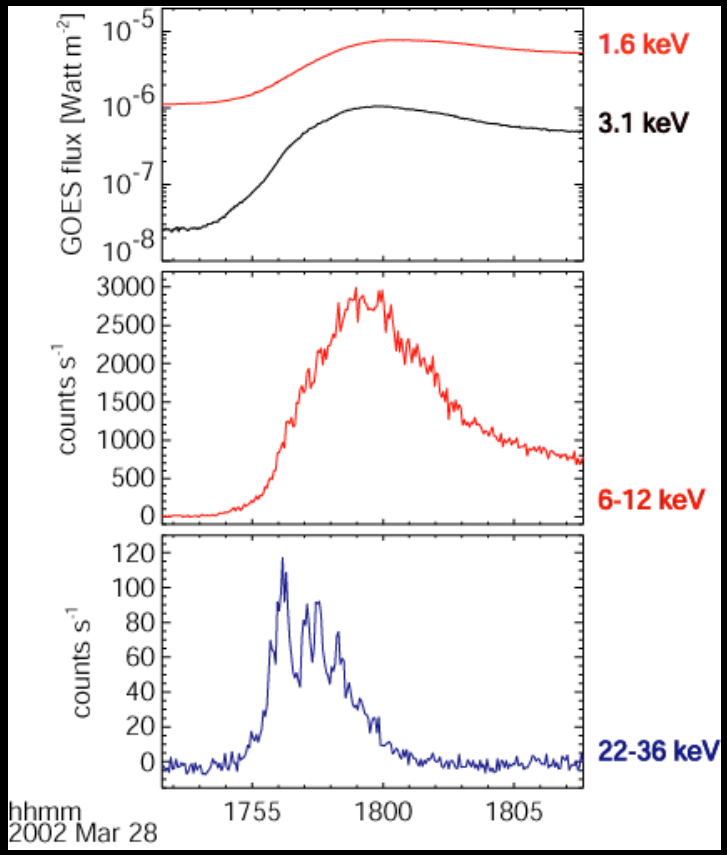


Krucker & Lin 2008, ApJ

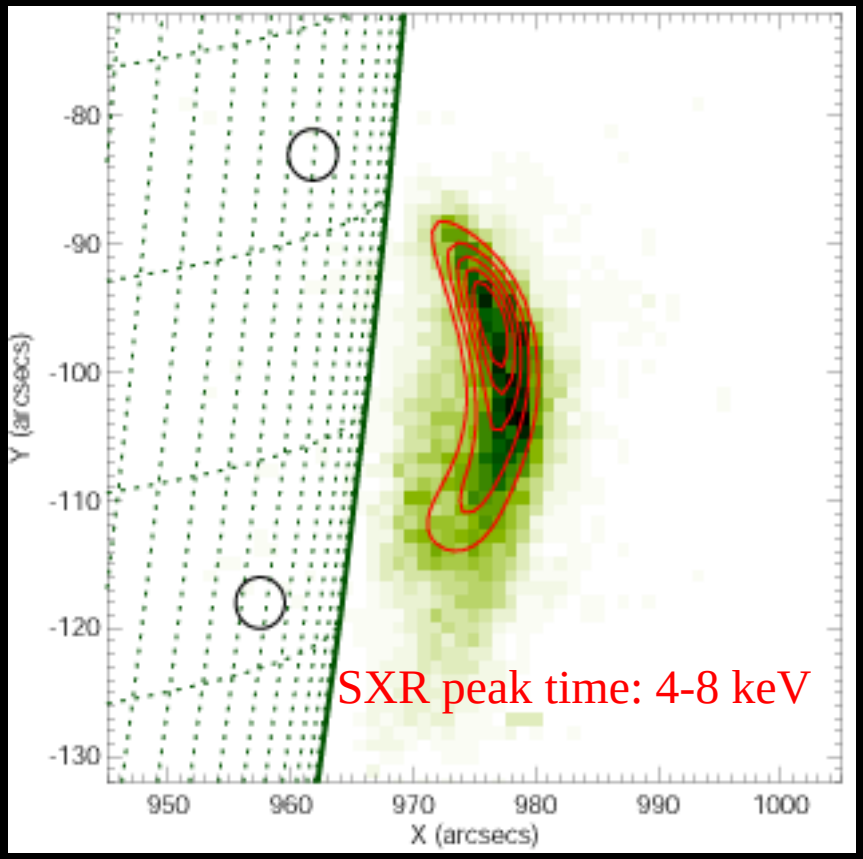
different time profiles!
thin target emission from flare-accelerated electrons

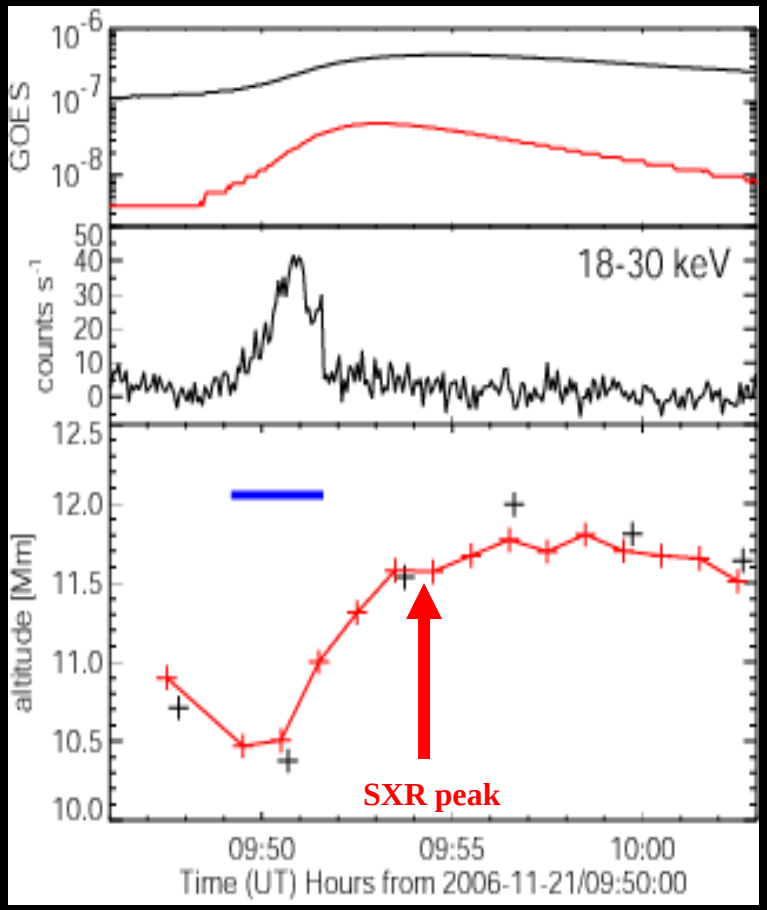


X-rays from partially disk-occulted flares

HINODE/XRT thick Be (image)
RHESSI (contours)

emissions from loop





Krucker, Hannah, & Lin, ApJL, 2007

X-rays from partially disk-occulted flares

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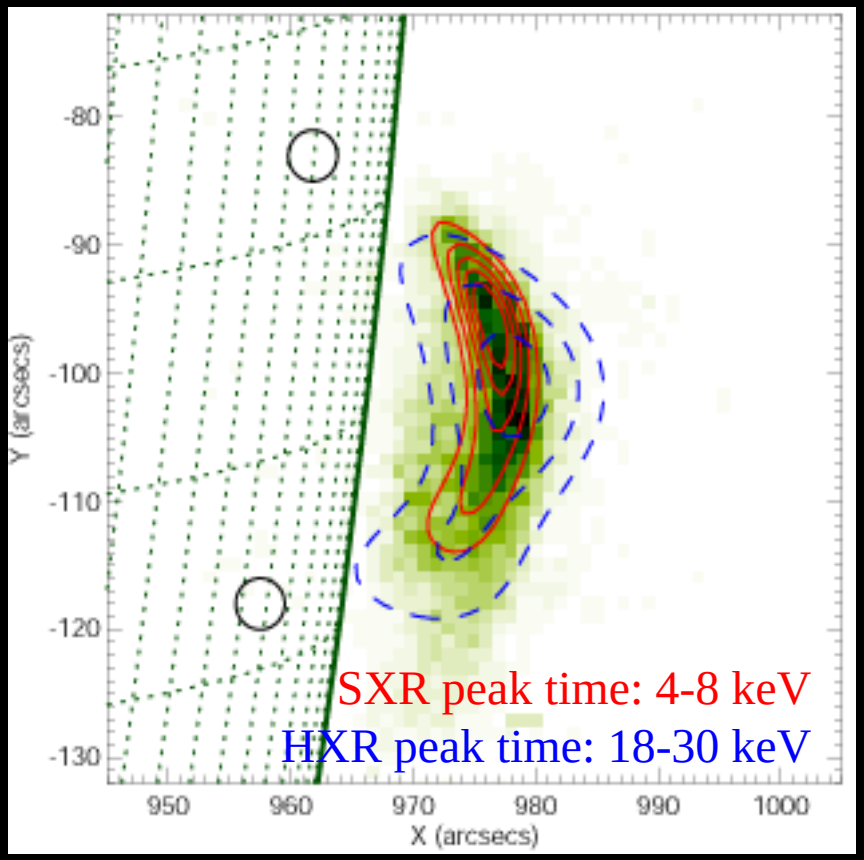
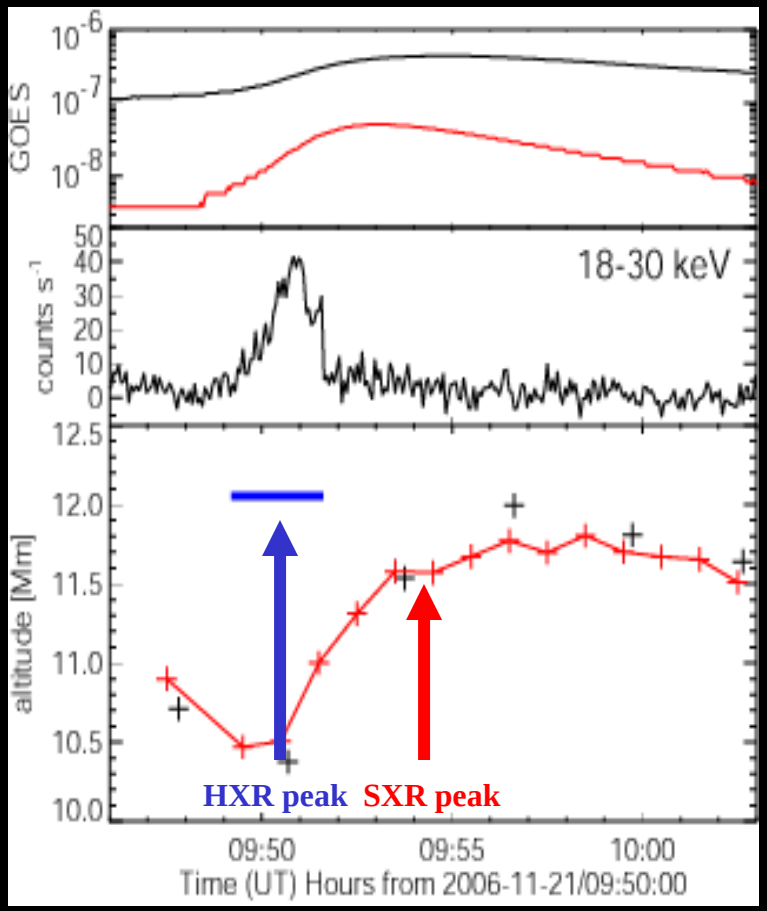
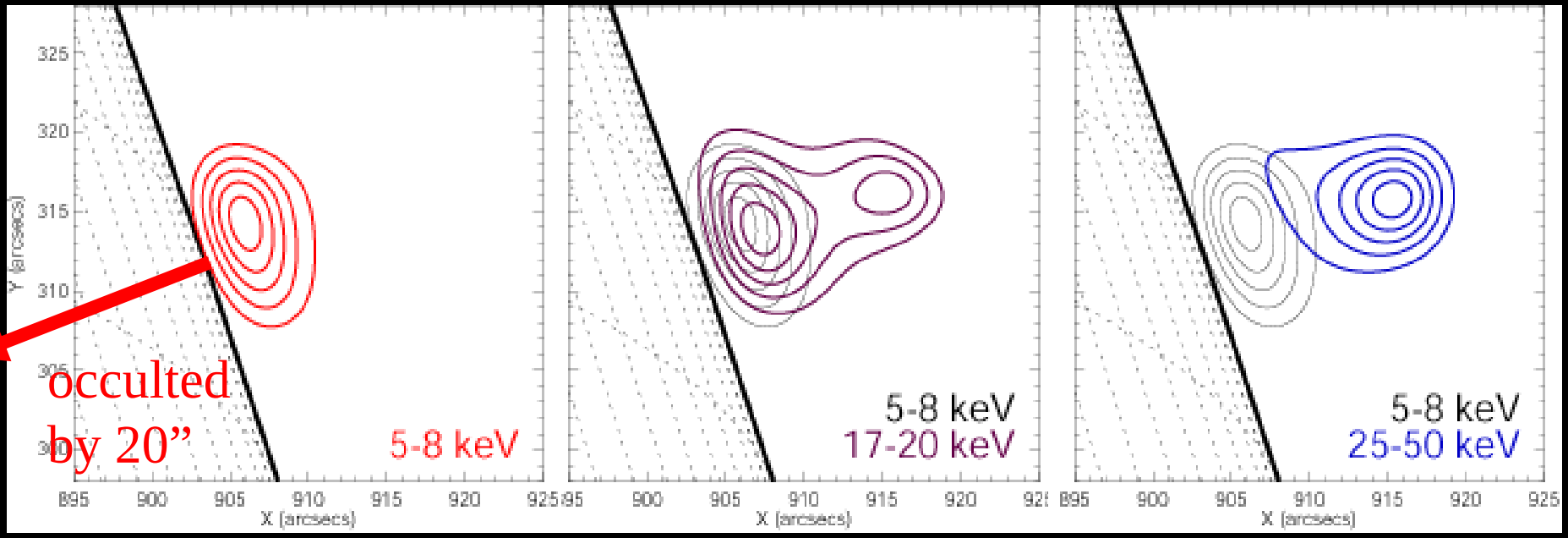


Thermal loop at SXR peak time is earlier seen in non-thermal emission.



Krucker, Hannah, & Lin, ApJL, 2007

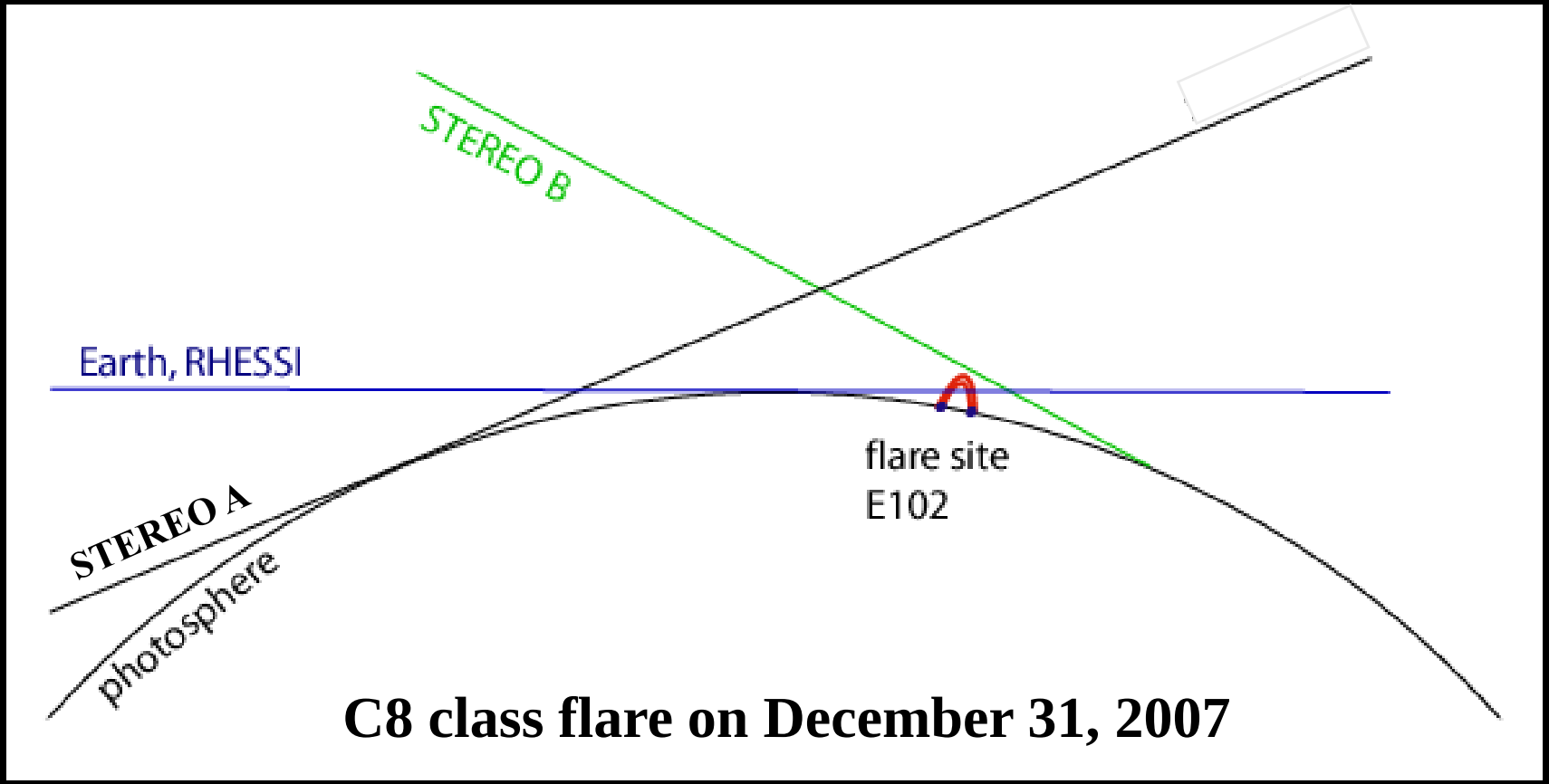
X-rays from partially disk-occulted flares: flare with above-the-loop-top source



Some events are different with an above-the-loop-top source, similar as Masuda flare. **Rarely seen.**

Main thermal source never reaches 25-50 keV source.

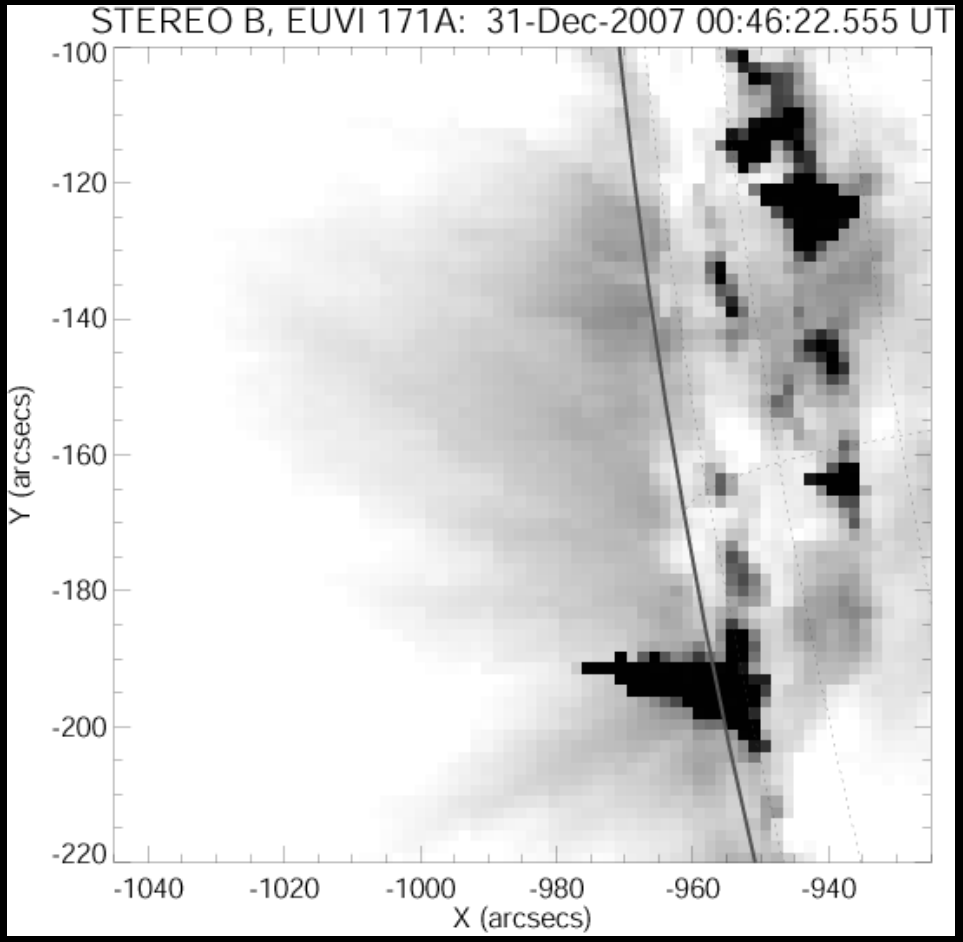
RHESSI and STEREO observations of a partially disk-occulted flare



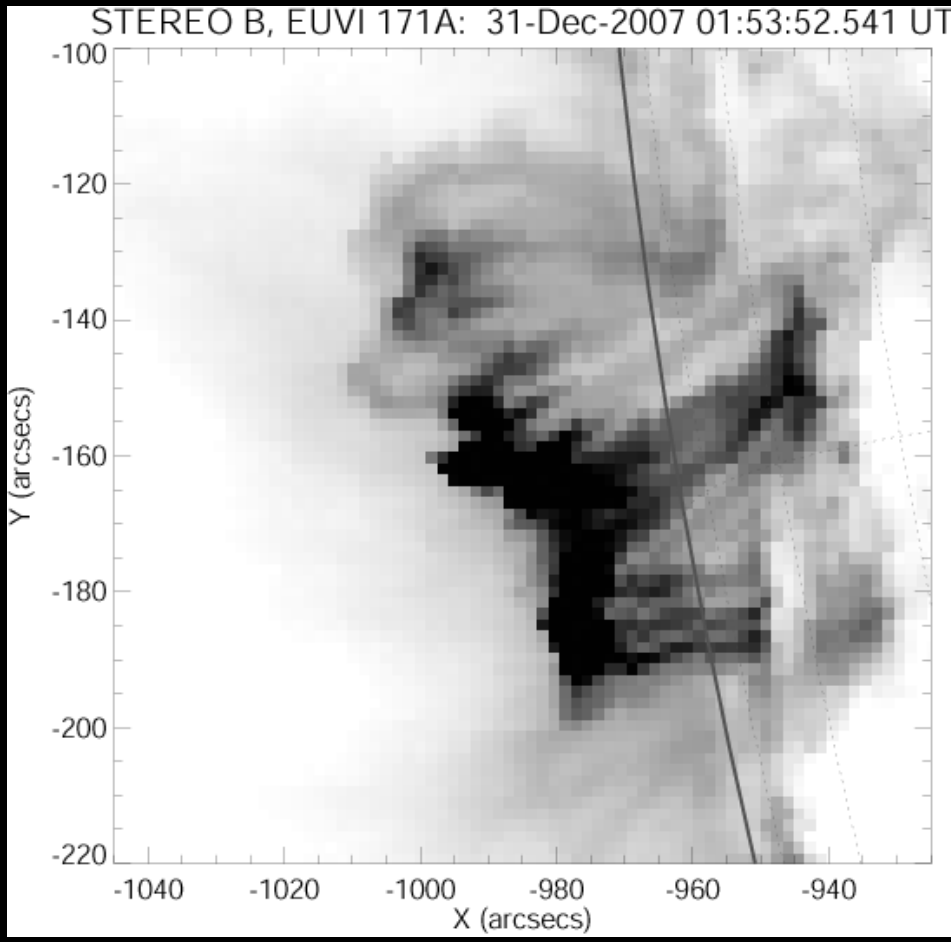
C8 class flare on December 31, 2007

STEREO B (flare is on disk)

Start of impulsive phase:
flare ribbons



about 1 hour later:
post flare loops



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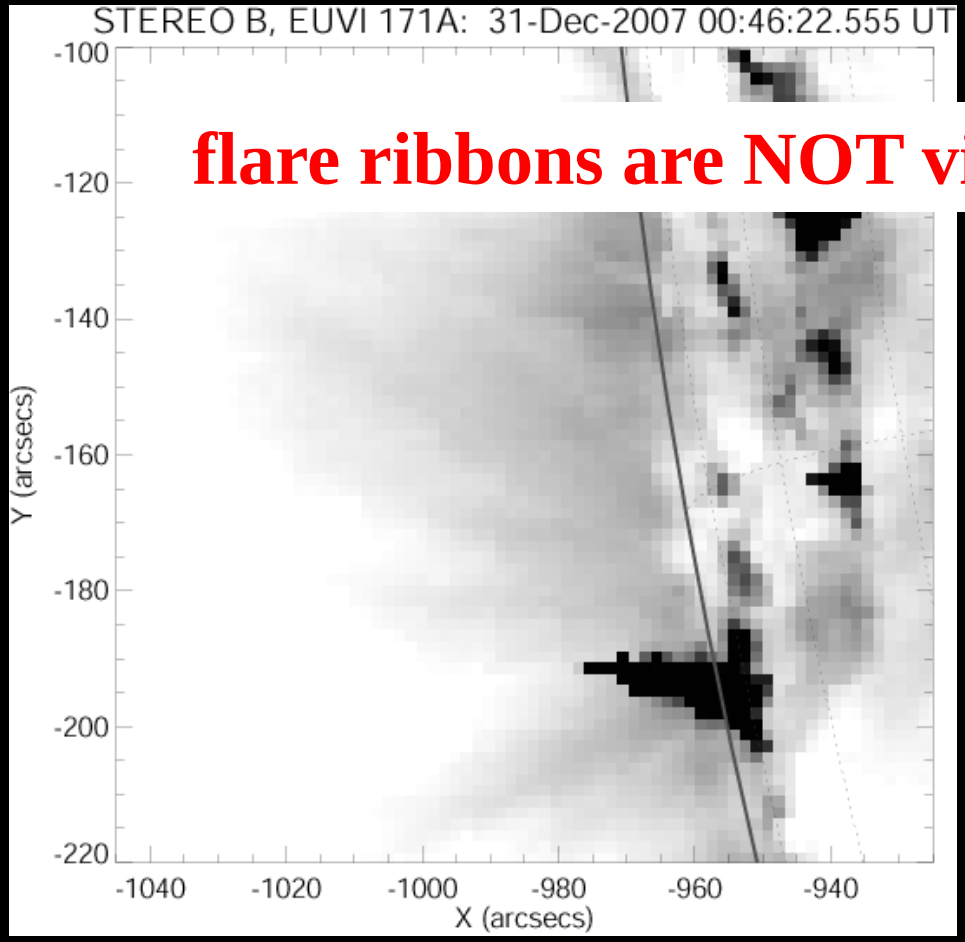
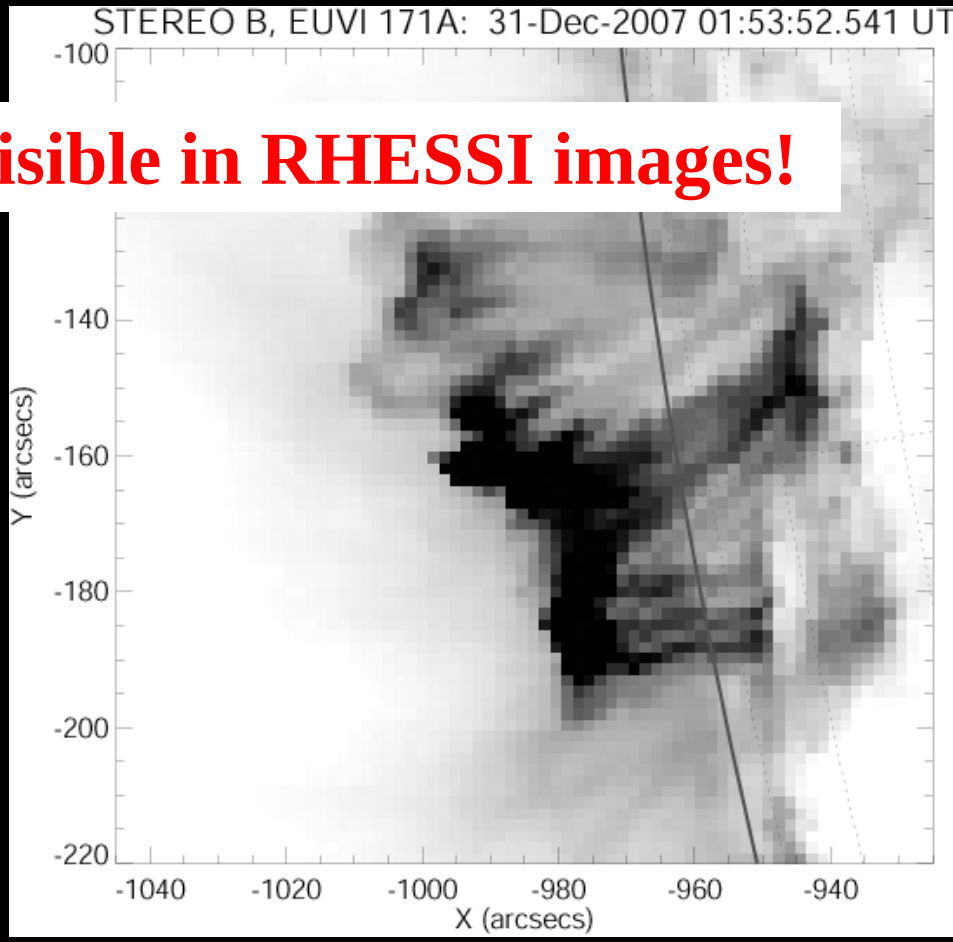
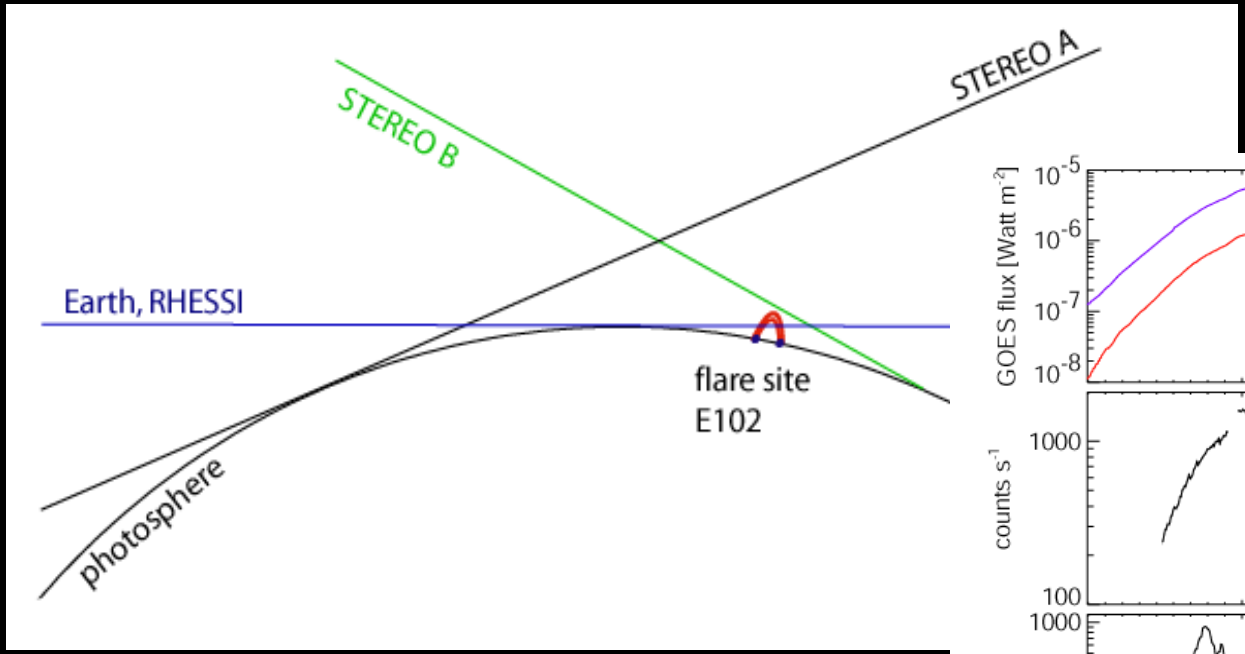


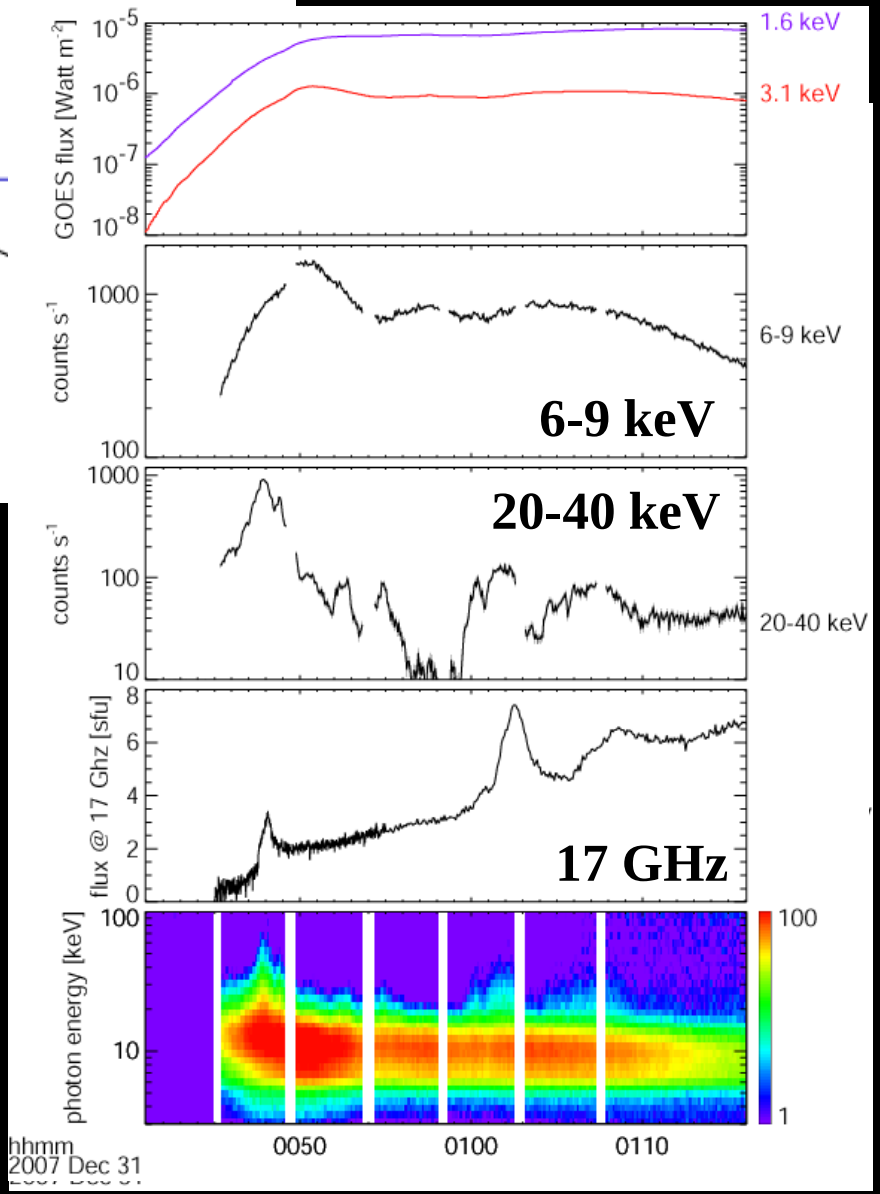


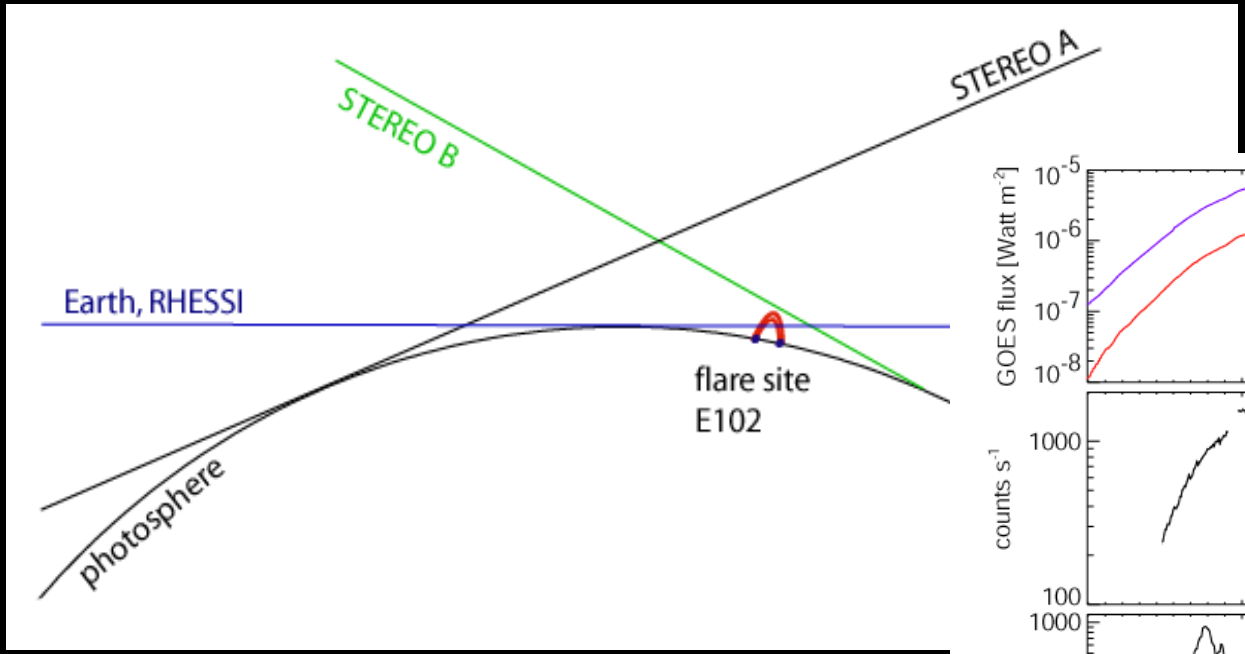
flare ribbons are NOT visible in RHESSI images!

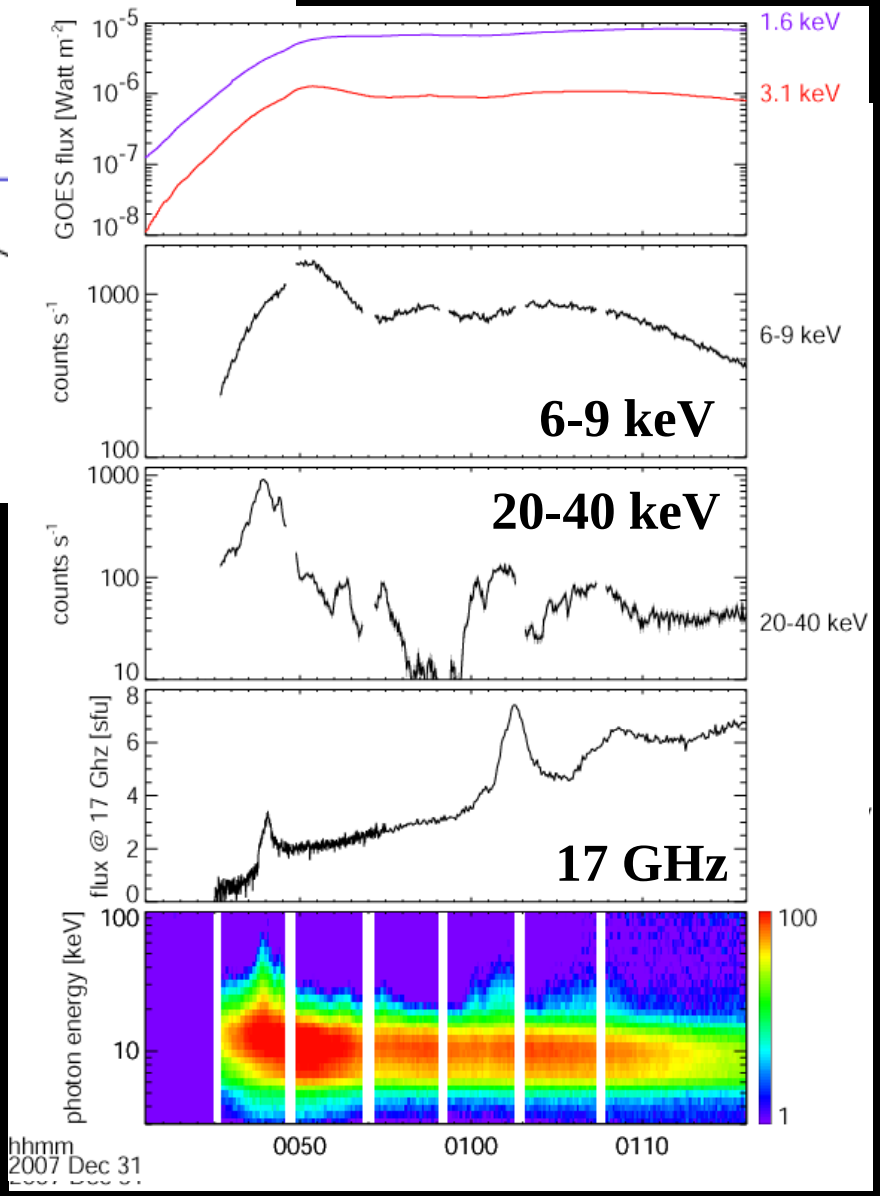


Hard X-ray observations:

Non-thermal emission above 20 keV
up to ~80 keV
unusually intense (for occulted event)
spectral slope between 3.5 and 4.5







Hard X-ray observations:

Non-thermal emission above 20 keV up to ~80 keV

unusually intense (for occulted event) spectral slope between 3.5 and 4.5

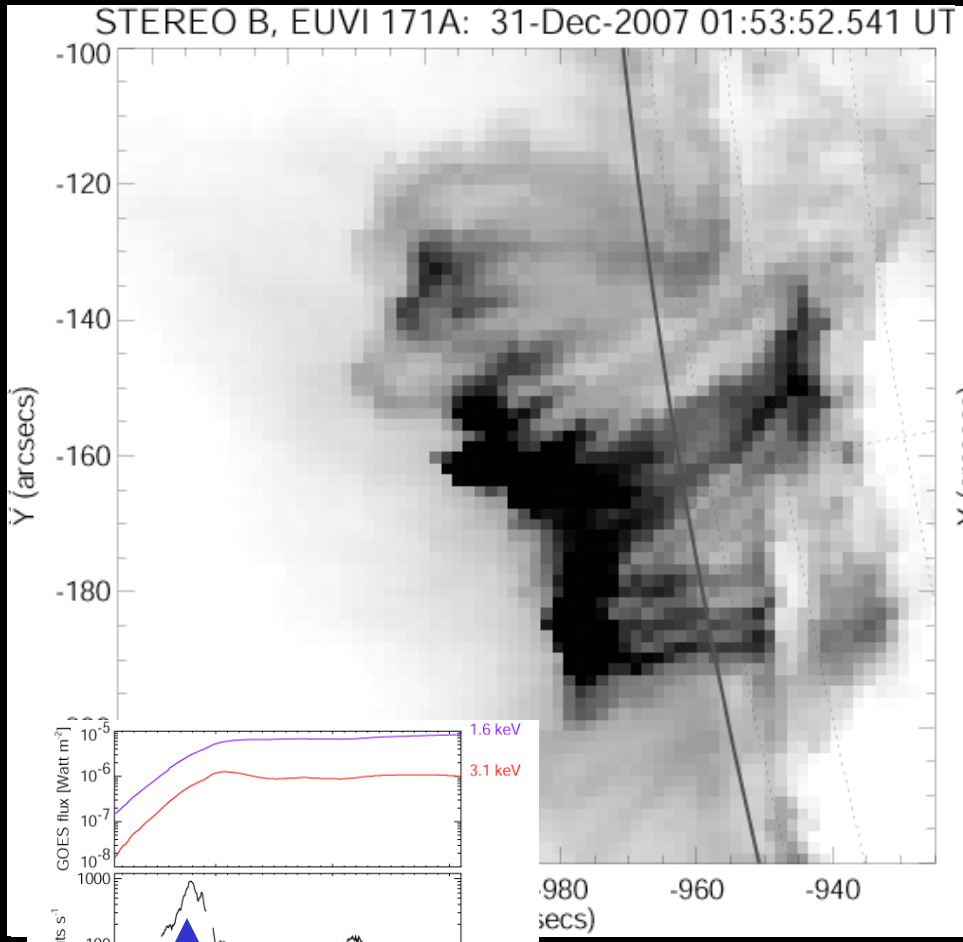
Radio observations:

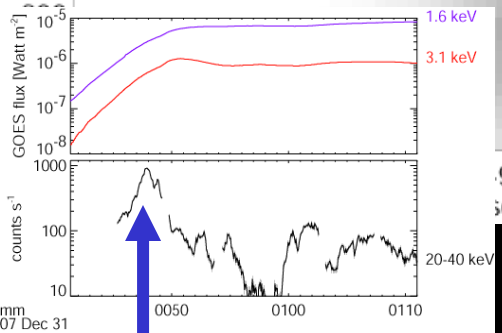
microwave emission with decreasing spectrum (non-thermal)

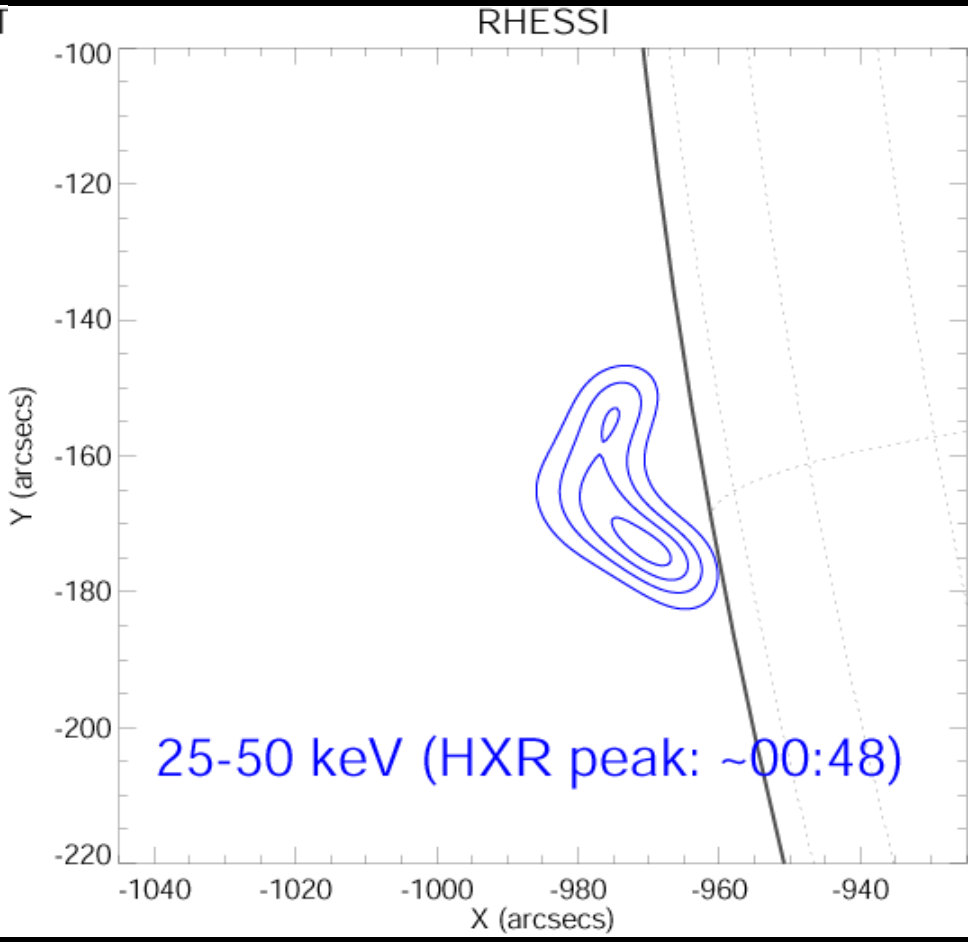
RHESSI imaging: HXR peak

for comparison:
STEREO post flare loops

HXR peak time;
loop? above flare arcade?







RHESSI imaging: HXR peak

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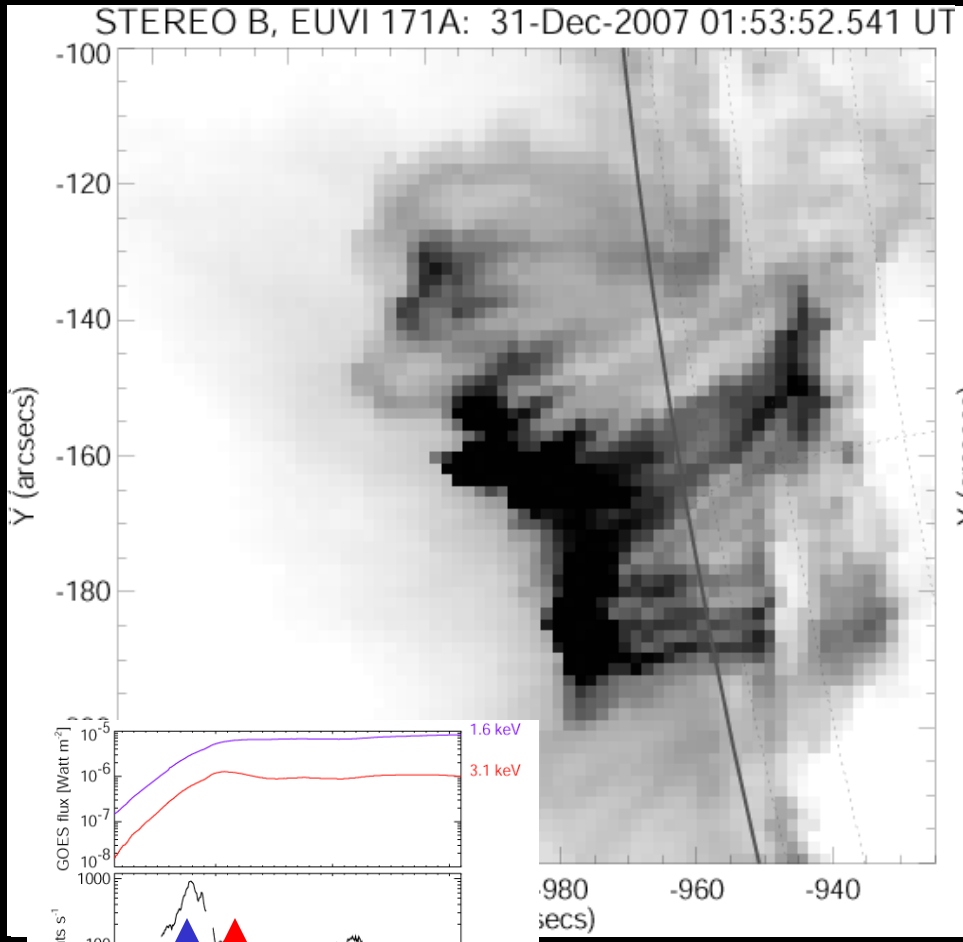
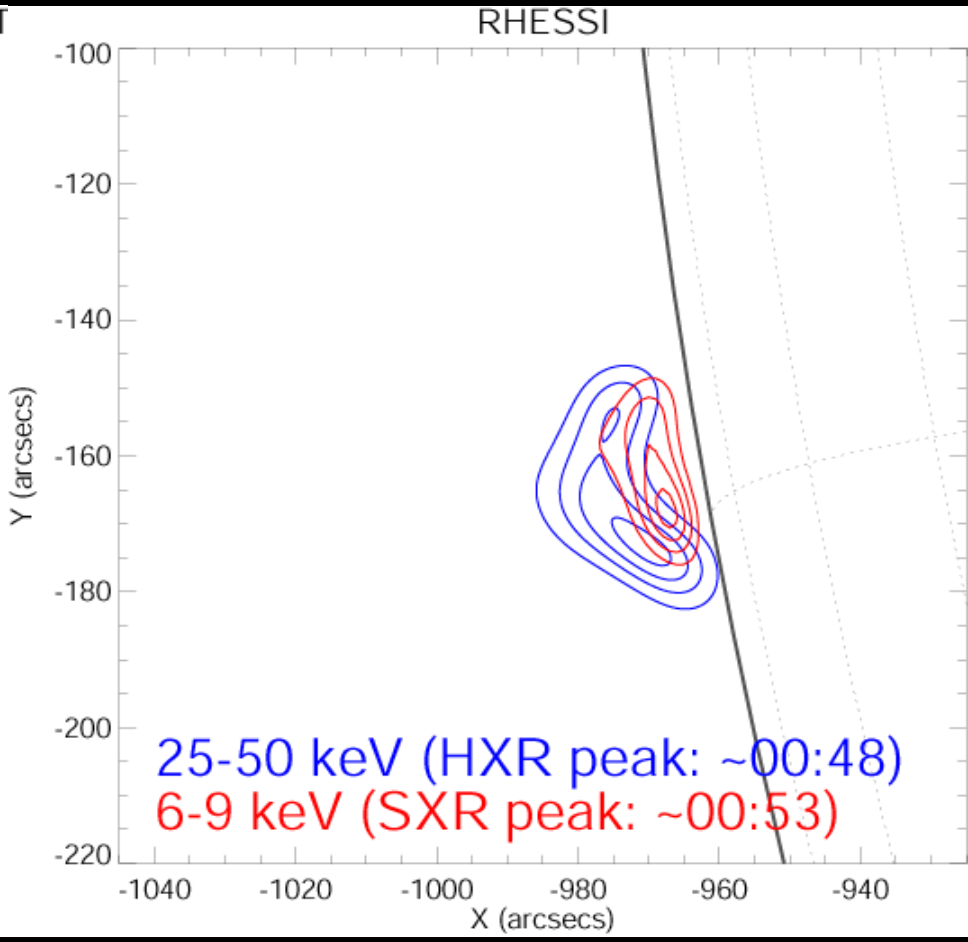
loop? above flare arcade?
thermal loops are below



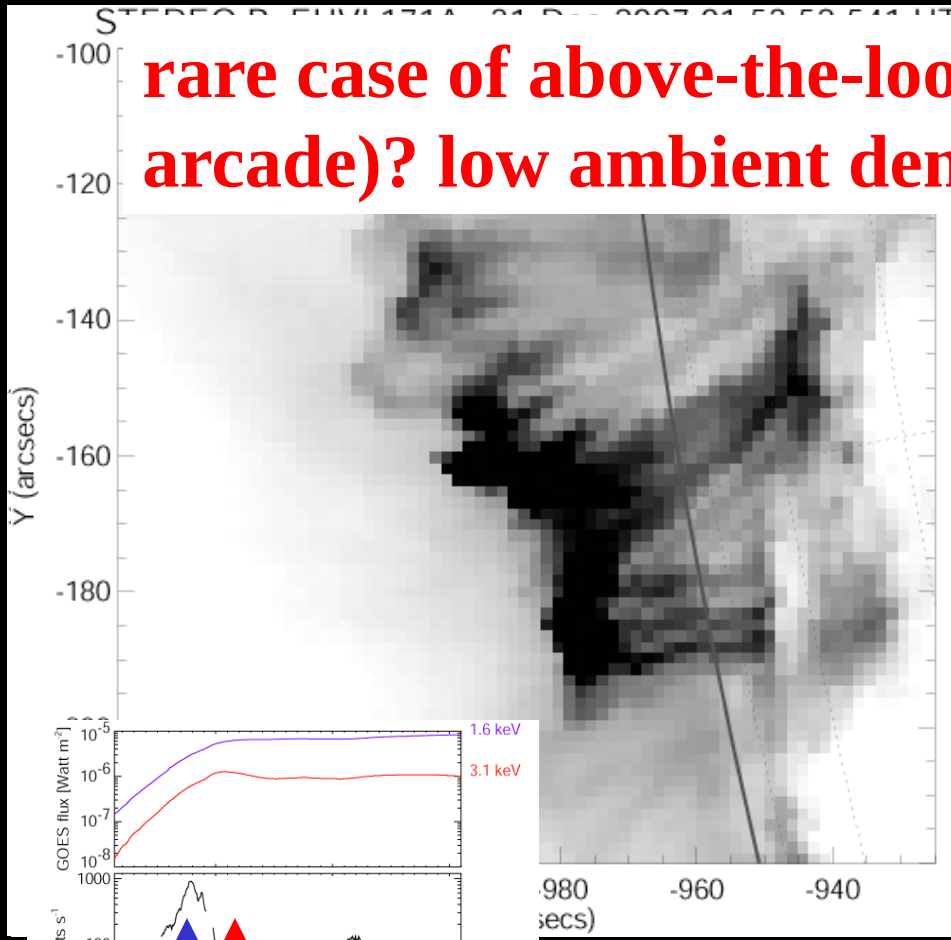


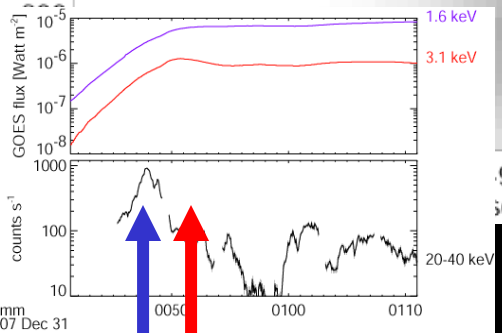
RHESSI imaging: HXR peak

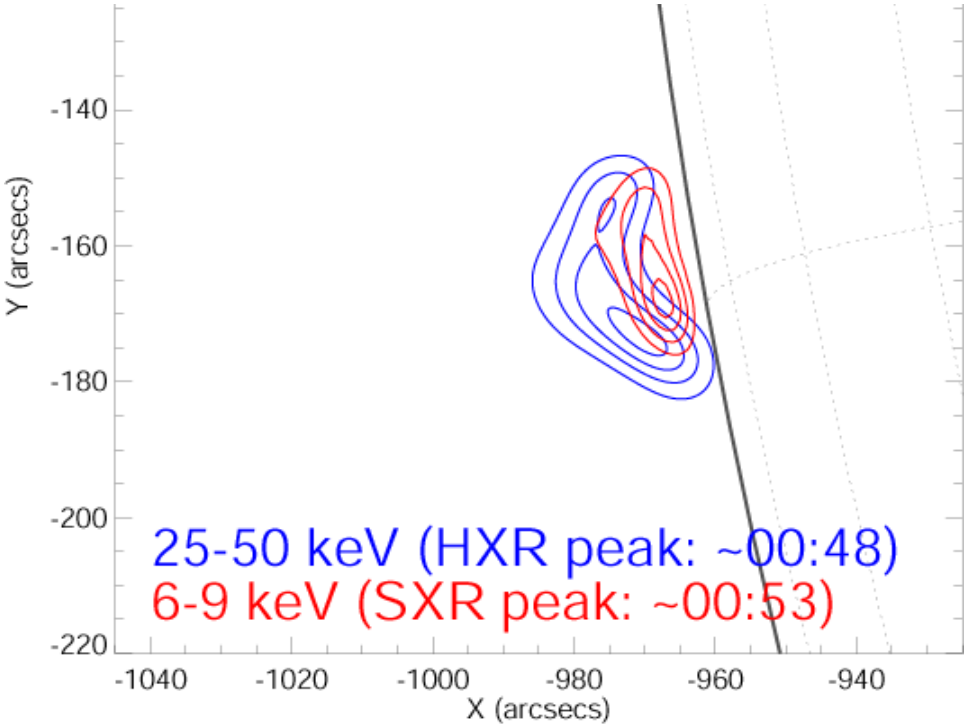
for comparison:
STEREO post flare loops

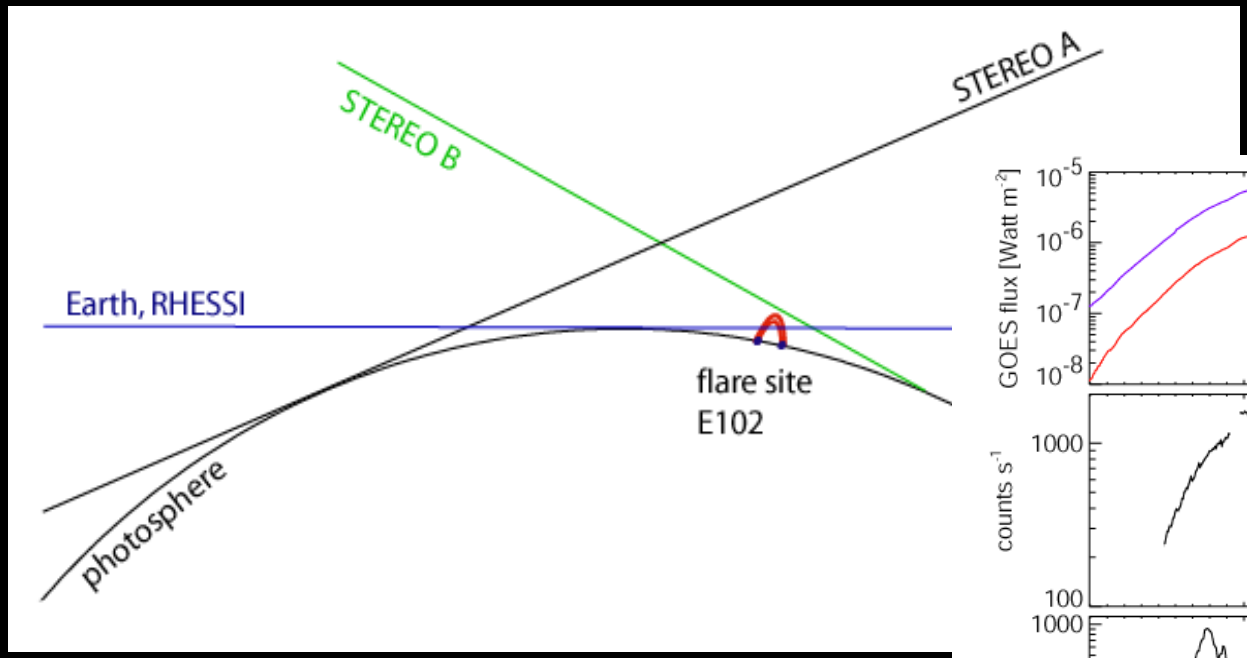
HXR peak time;
loop? above flare arcade?
thermal loops are below

rare case of above-the-loop-top source (along flare arcade)? low ambient density before flare.

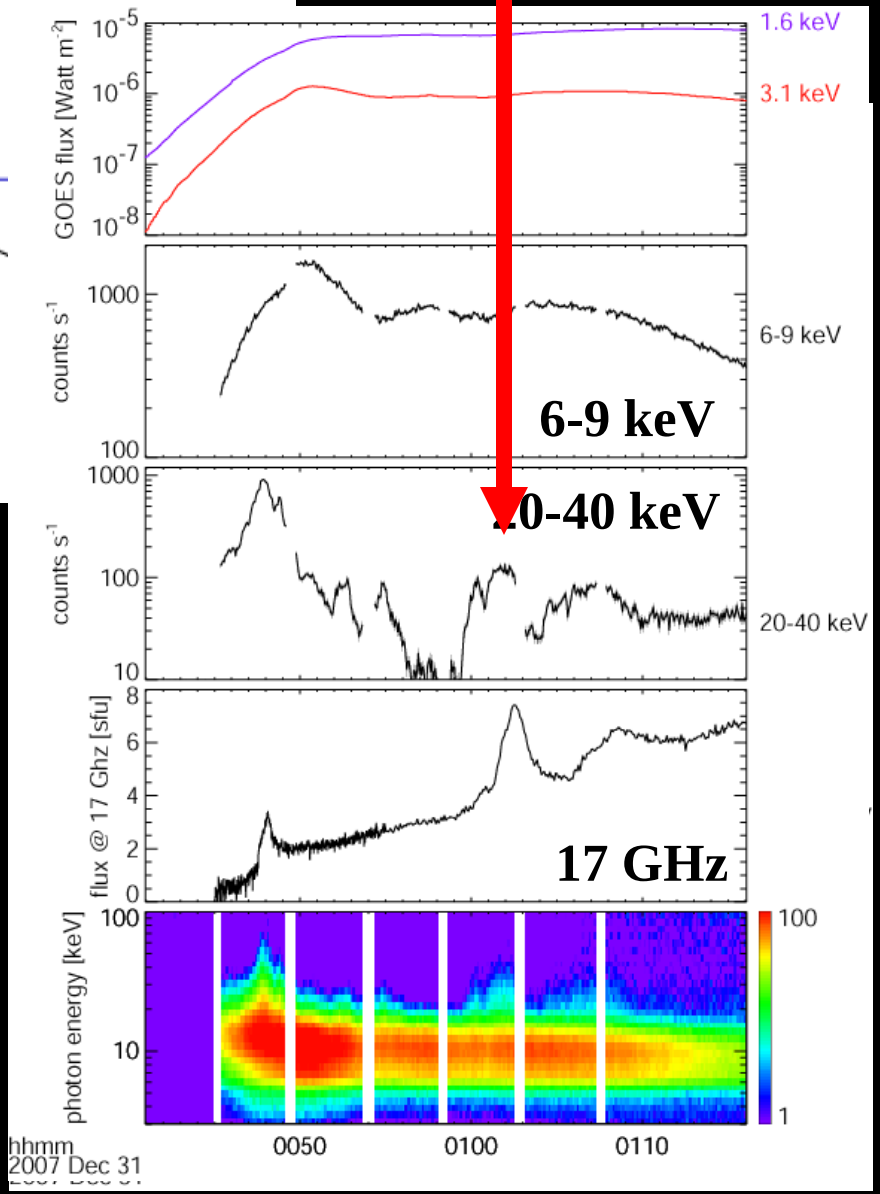








later peak



Hard X-ray observations:

Non-thermal emission above 20 keV up to ~80 keV

unusually intense (for occulted event) spectral slope between 3.5 and 4.5

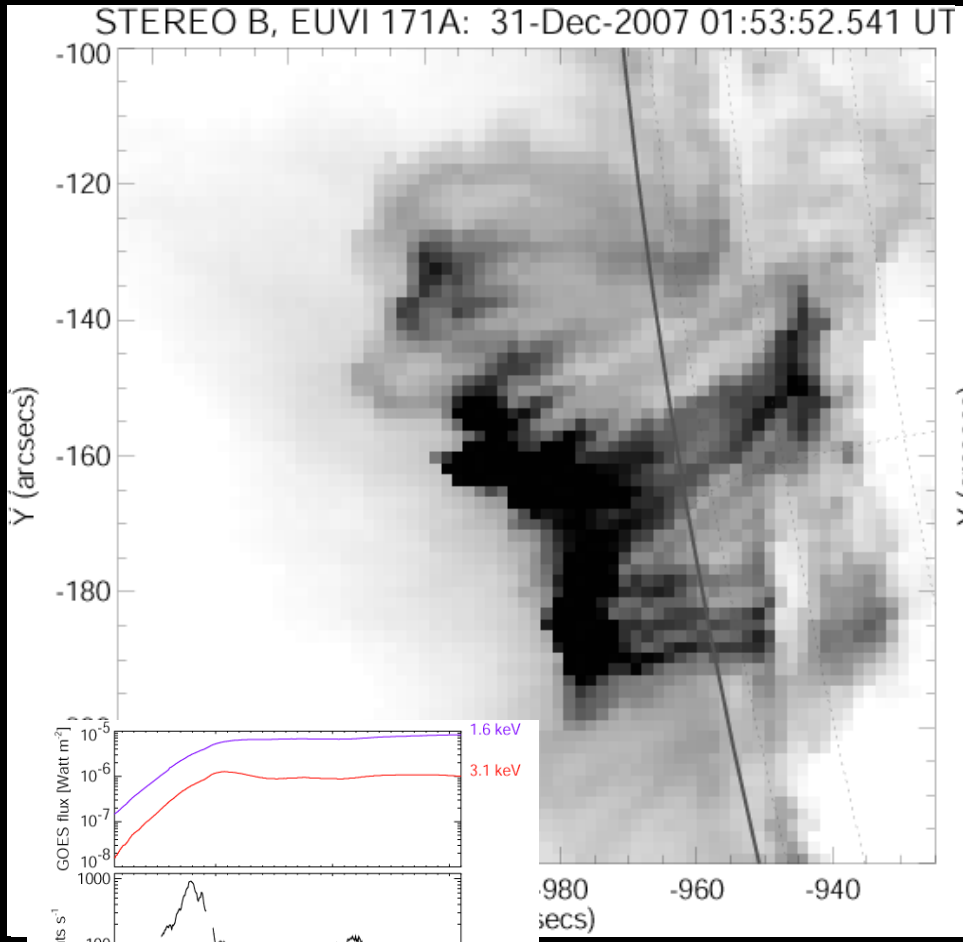
Radio observations:

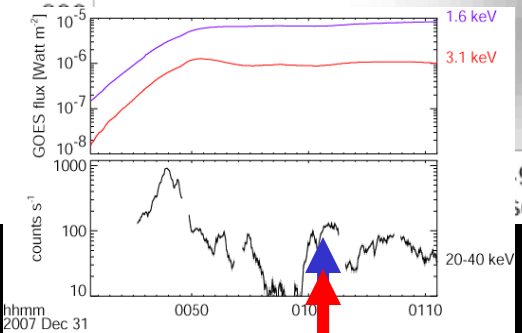
microwave emission with decreasing spectrum (non-thermal)

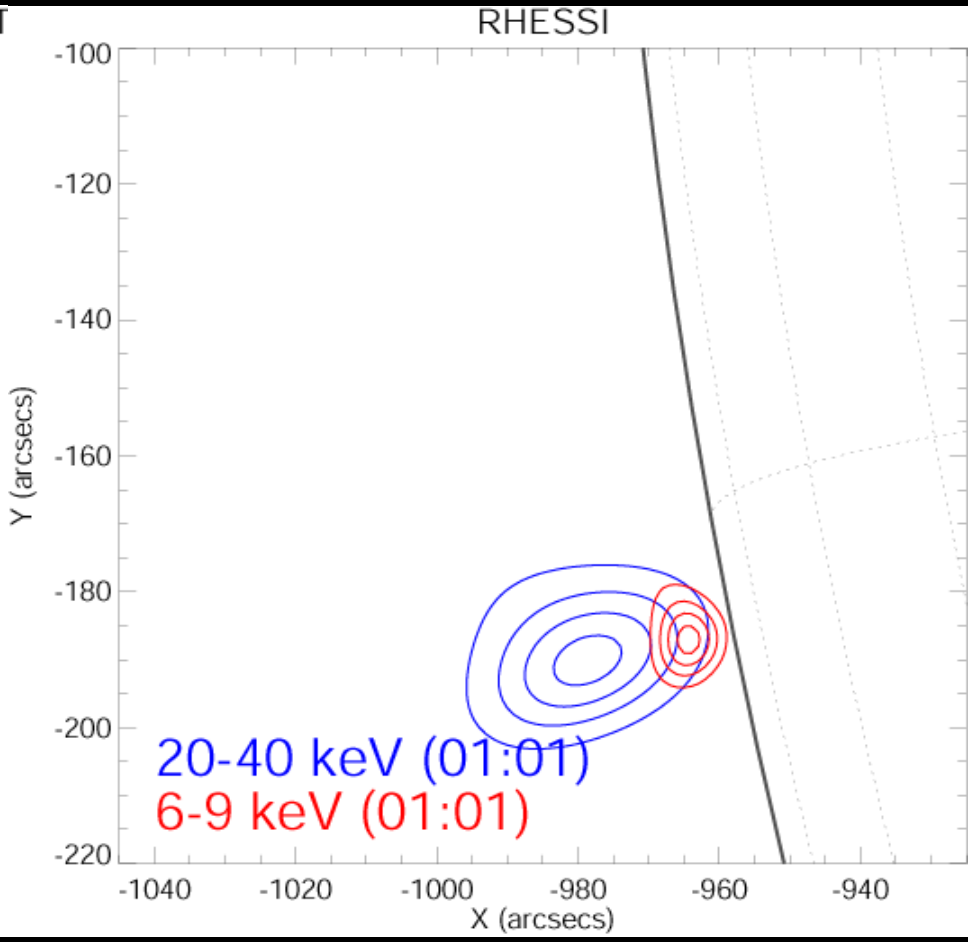
RHESSI imaging: later, faint emissions

for comparison:
STEREO post flare loops

elongated HXR source above thermal loops?



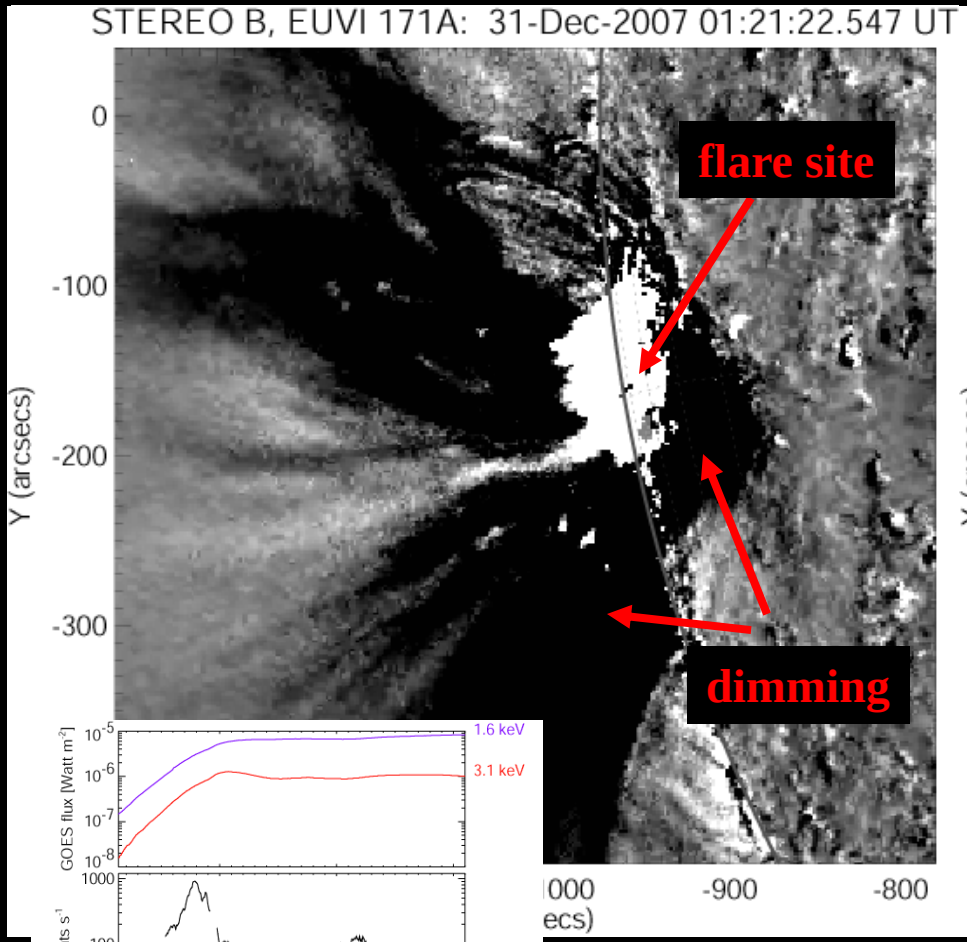


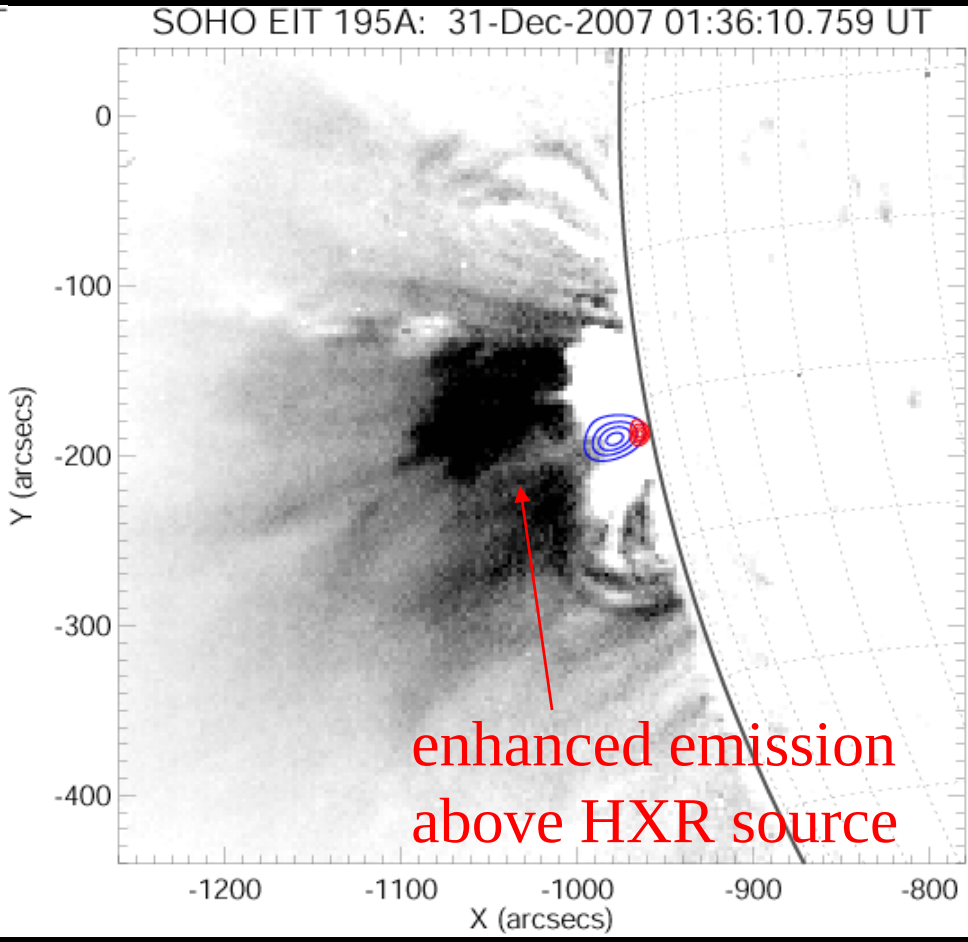


Comparison with EUV imaging

STEREO B 171A: difference image

EIT 195A difference image:



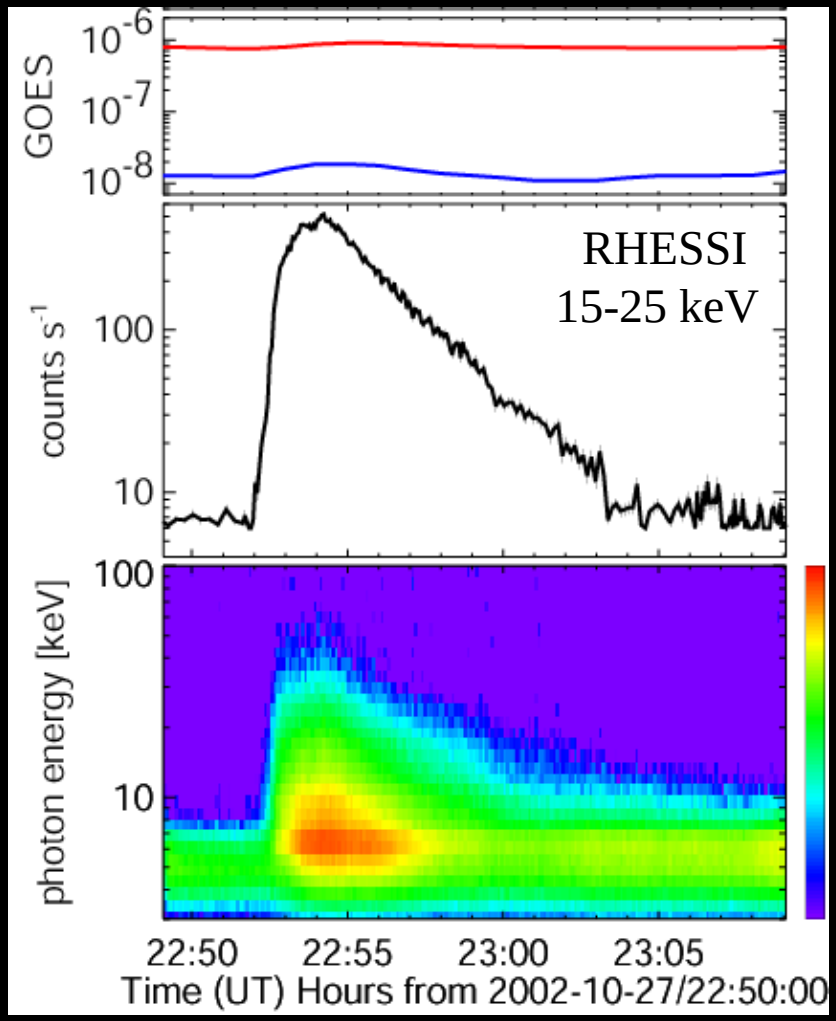


Summary

- great diagnostic potential of multi-view solar flare observations with STEREO
- 2007 Dec 31 event: unusually intense coronal HXR emission
- similar to Masuda flare?
- late phase emission related to CME?

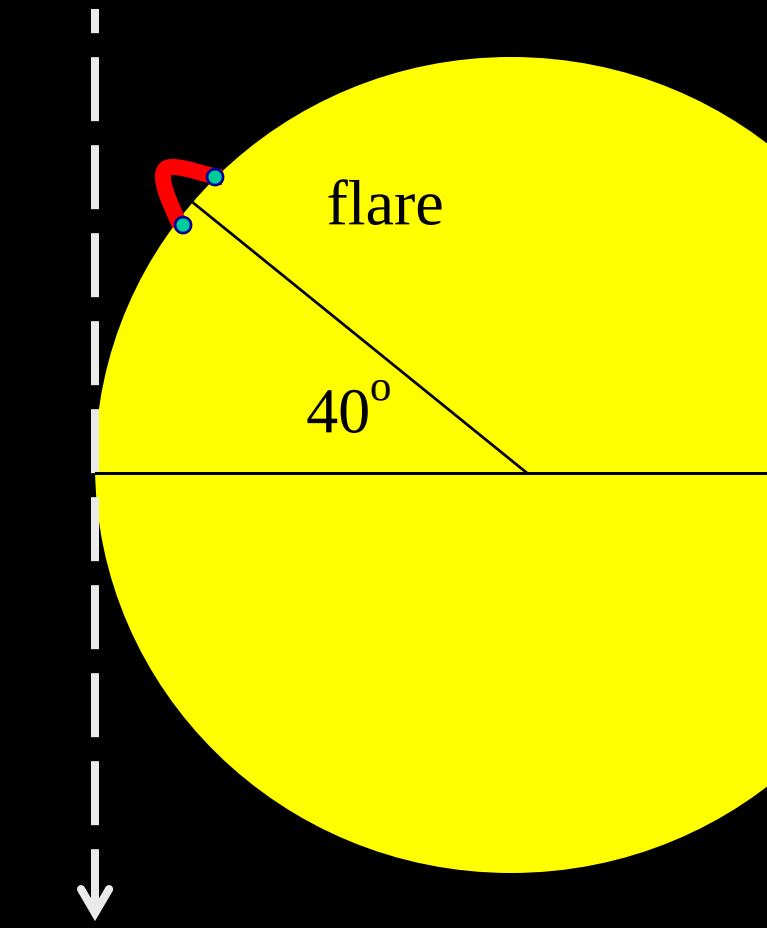
HXRs from CMEs

fast (2000 km/s) backside CME.
flare site 40 degrees behind limb.



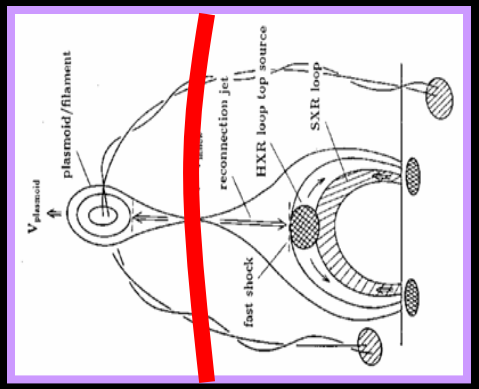
Krucker, White, & Lin, ApJL, 2007

small soft X-ray emission,
but large HXR burst!



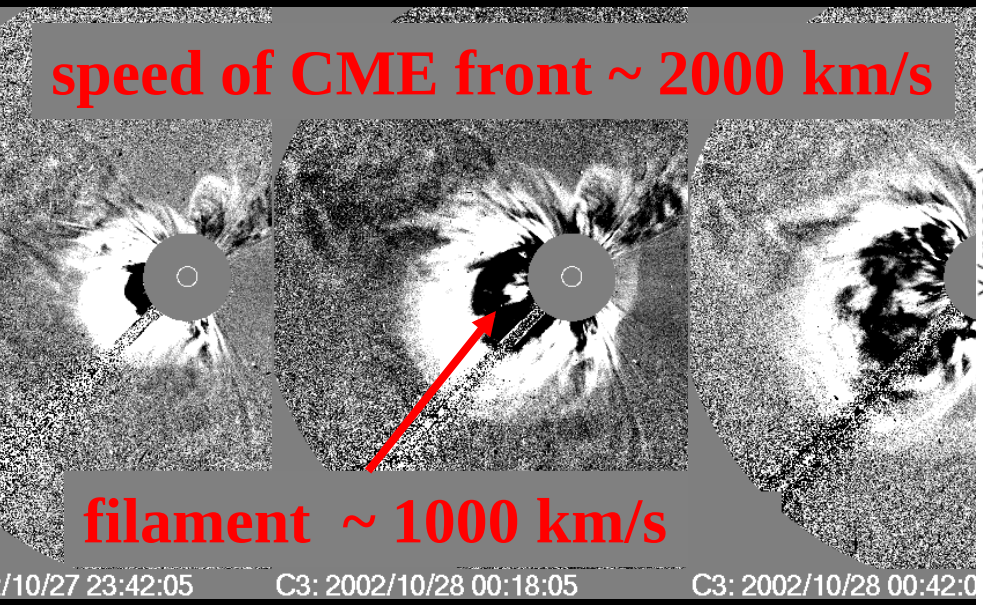
Kane et al. 1992
Hudson et al. 2001

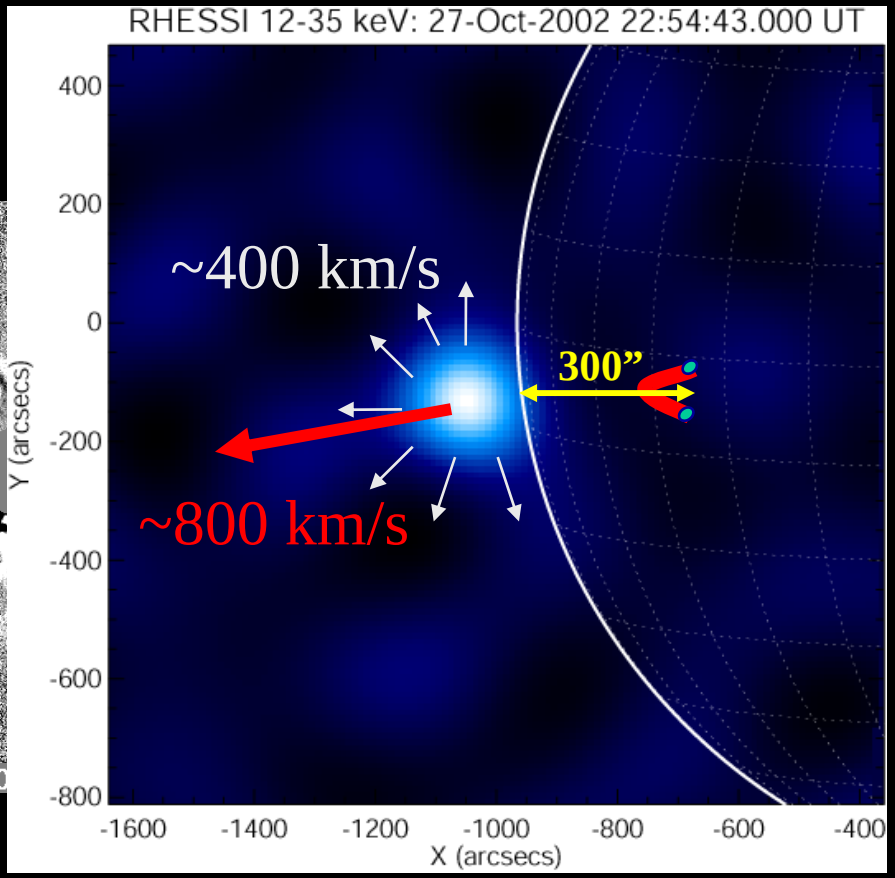
HXRs from CMEs



very large source (>200 arcsec)
expanding and rising

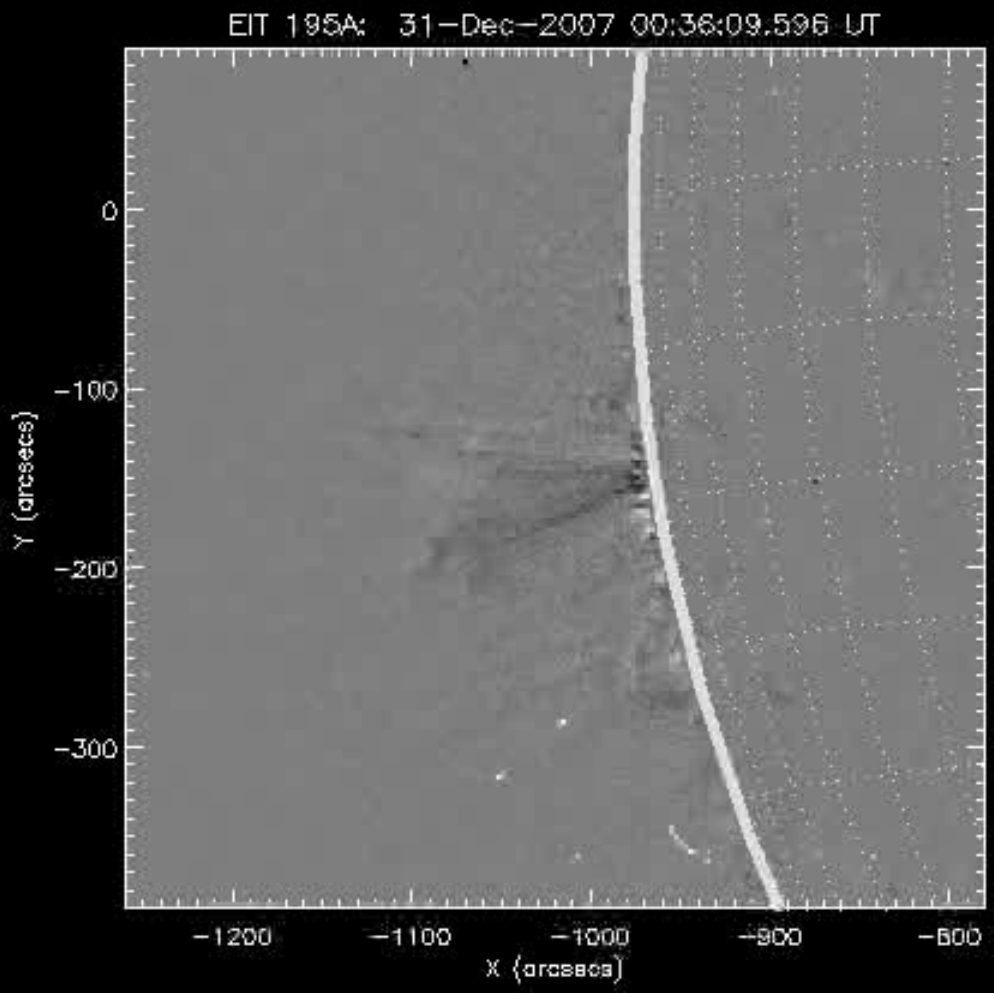
HXR emission from electrons
in magnetic structures related
to coronal mass ejections.



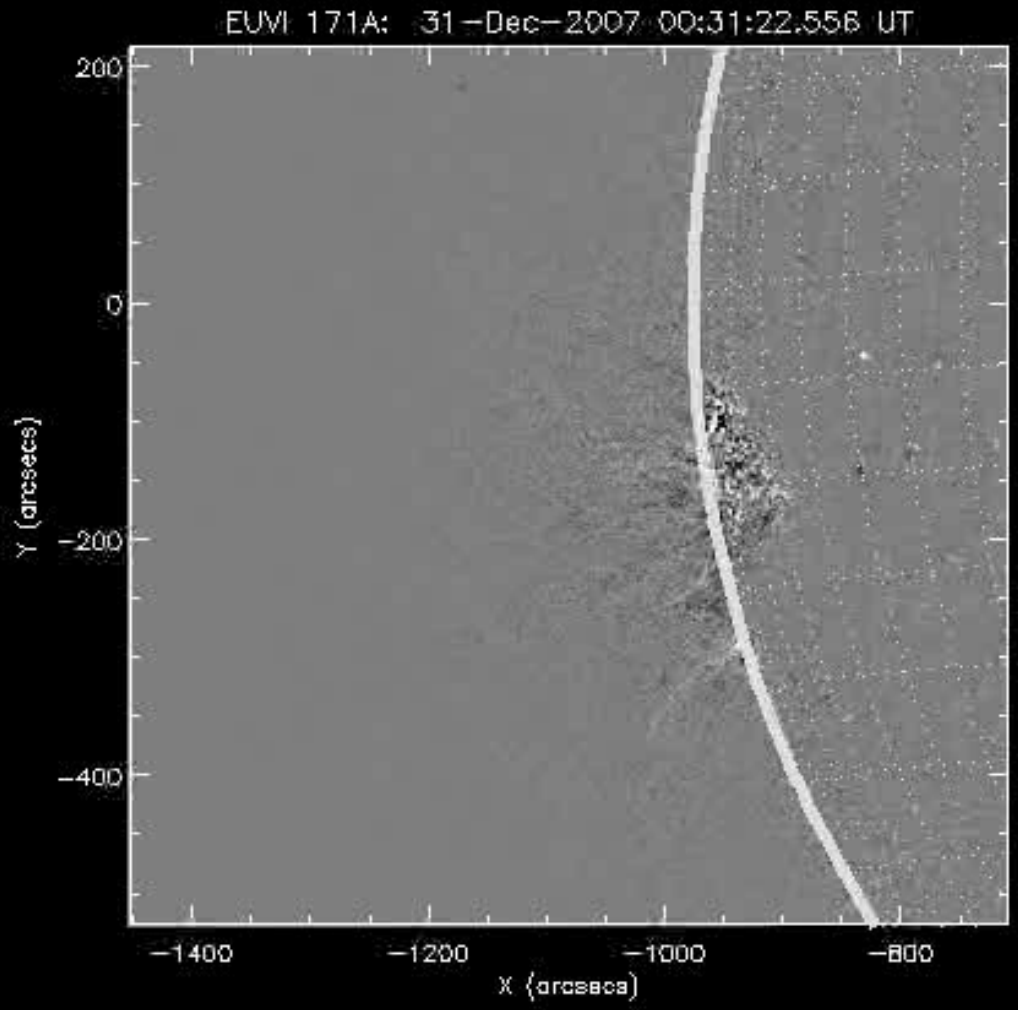


Krucker, White, & Lin, ApJL, 2007

EIT 195A (flare 12^{o} behind limb)



STEREO B 171A (flare on disk)



STEREO A 171A (flare 33^{o} behind limb)