RHESSI OBSERVATIONS OF THE 2005 JANUARY 20 SOLAR FLARE

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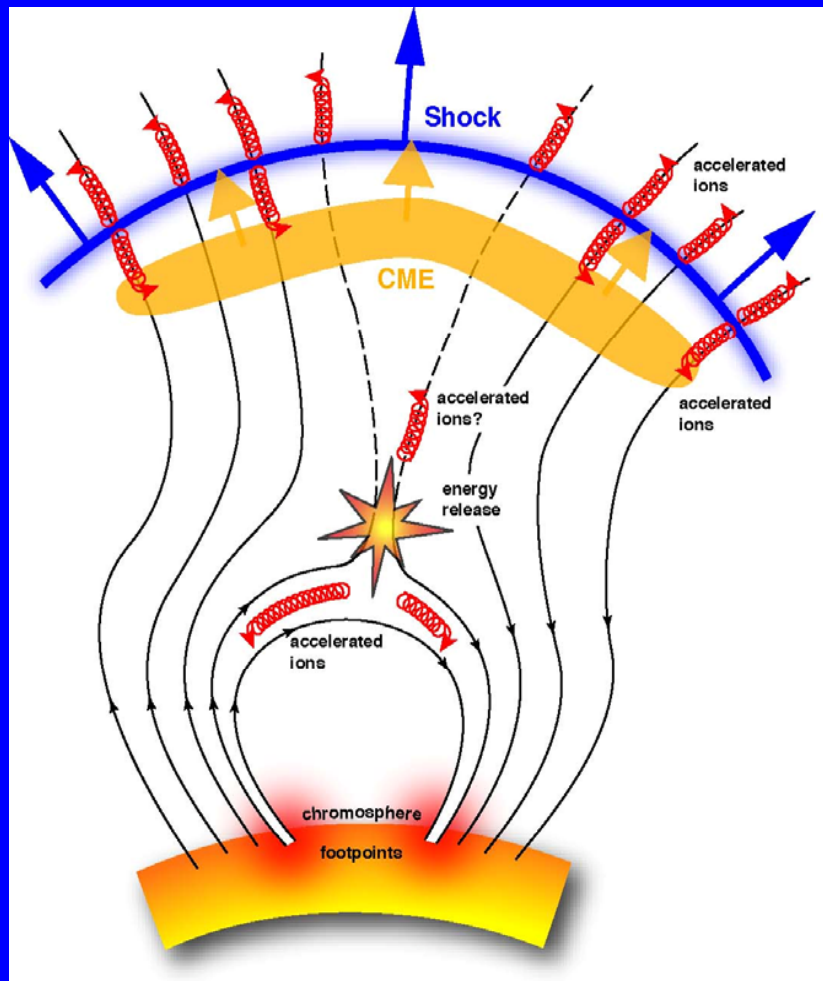
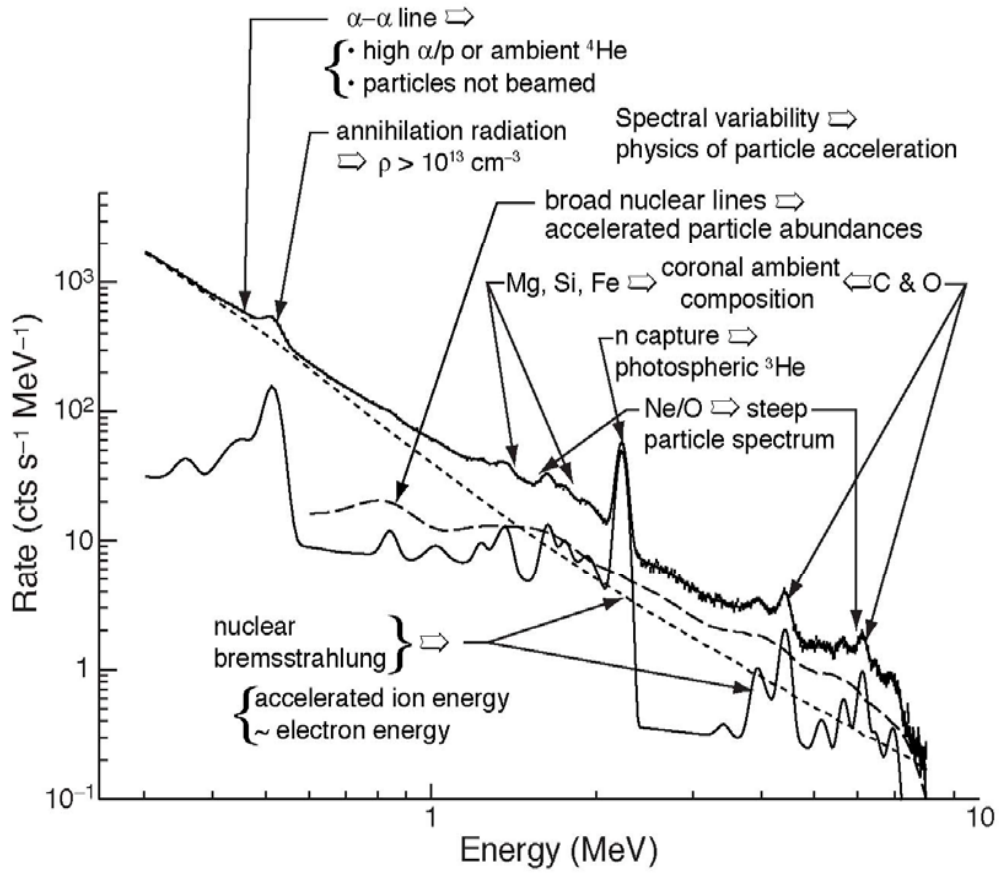
What can RHESSI tell us about the relationship between the flare-accelerated particles interacting at the Sun and SEPs/GLEs observed in the 2005 January 20 event?

Apologies that our analyses are not yet complete. A significant component of the gamma-ray emission is above the 17 MeV upper range of the instrument. The effects of this radiation on the spectrometer was not originally in the instrument response and had to be determined.

The event as observed by RHESSI is composed of what appear to be two distinct components that complicate the interpretation.

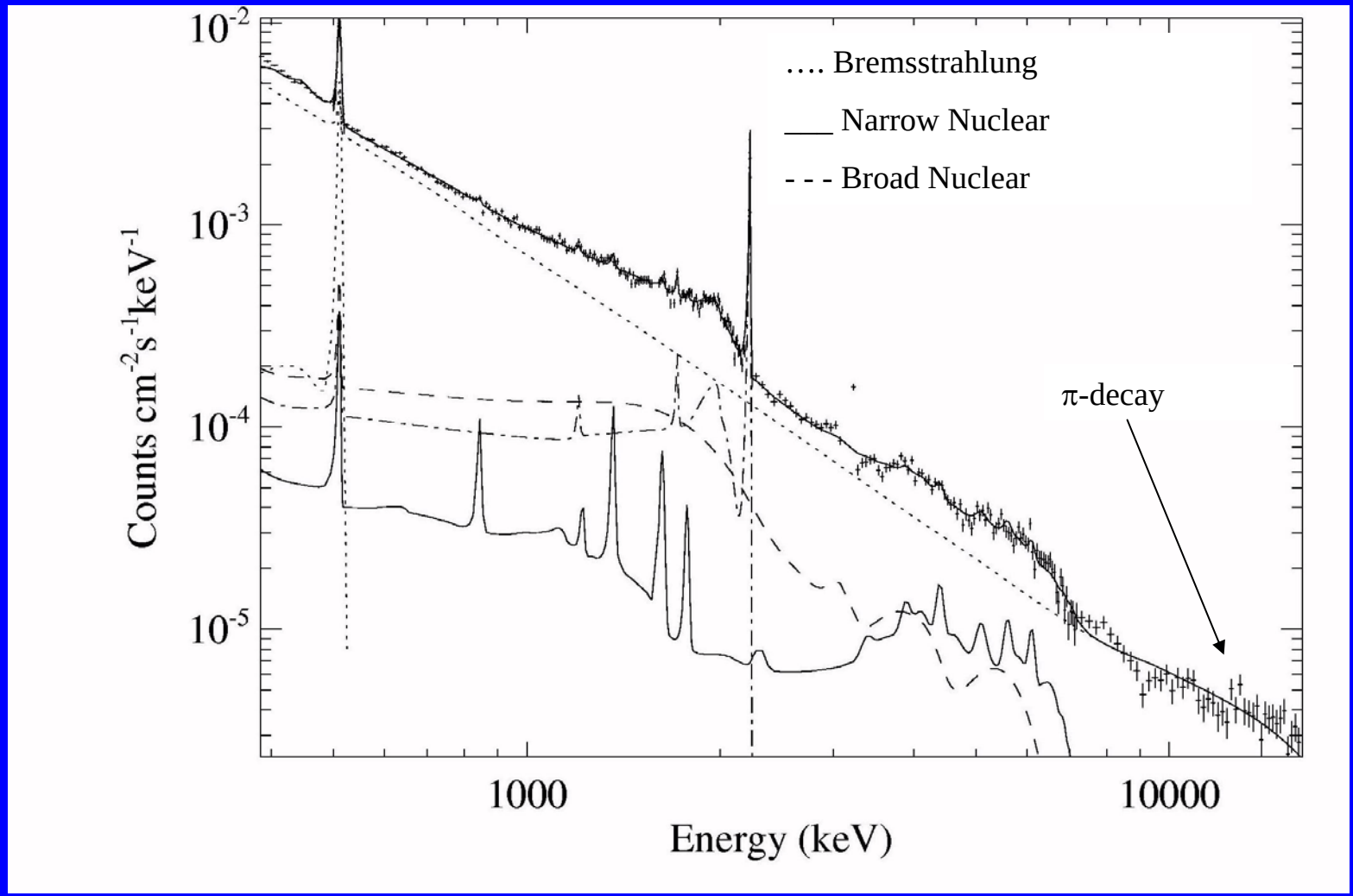


Cartoon illustrating particle acceleration and transport near the Sun.



Flare gamma-ray spectrum revealing the different components that provide information on the accelerated-particle population and ambient material

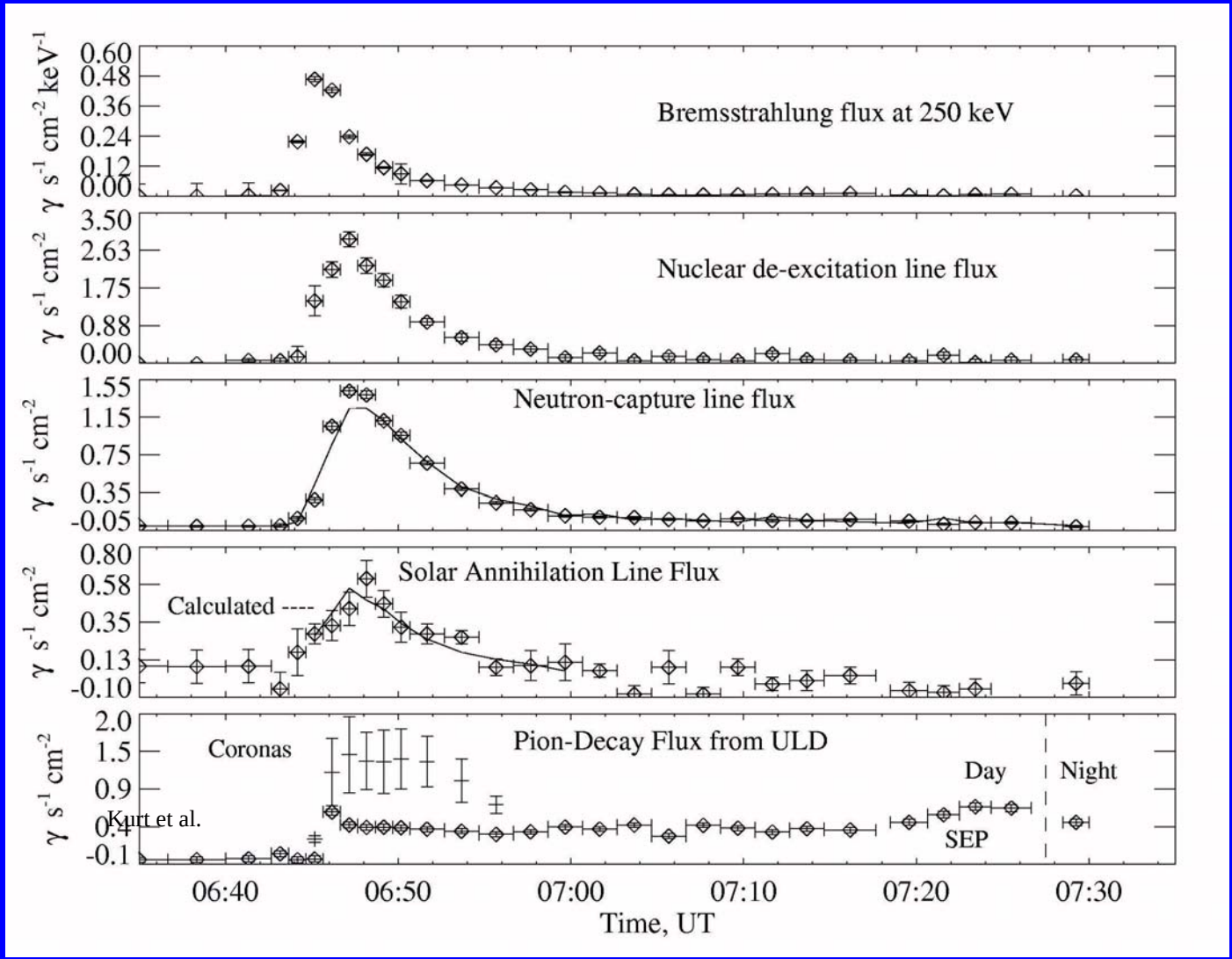
RHESSI spectrum of the 2005 January 20 Flare



Spectrum dominated by a strong continuum (bremsstrahlung & pi-decay) extending to high energies. Line features are relatively weak, consistent with a hard accelerated-particle spectrum.

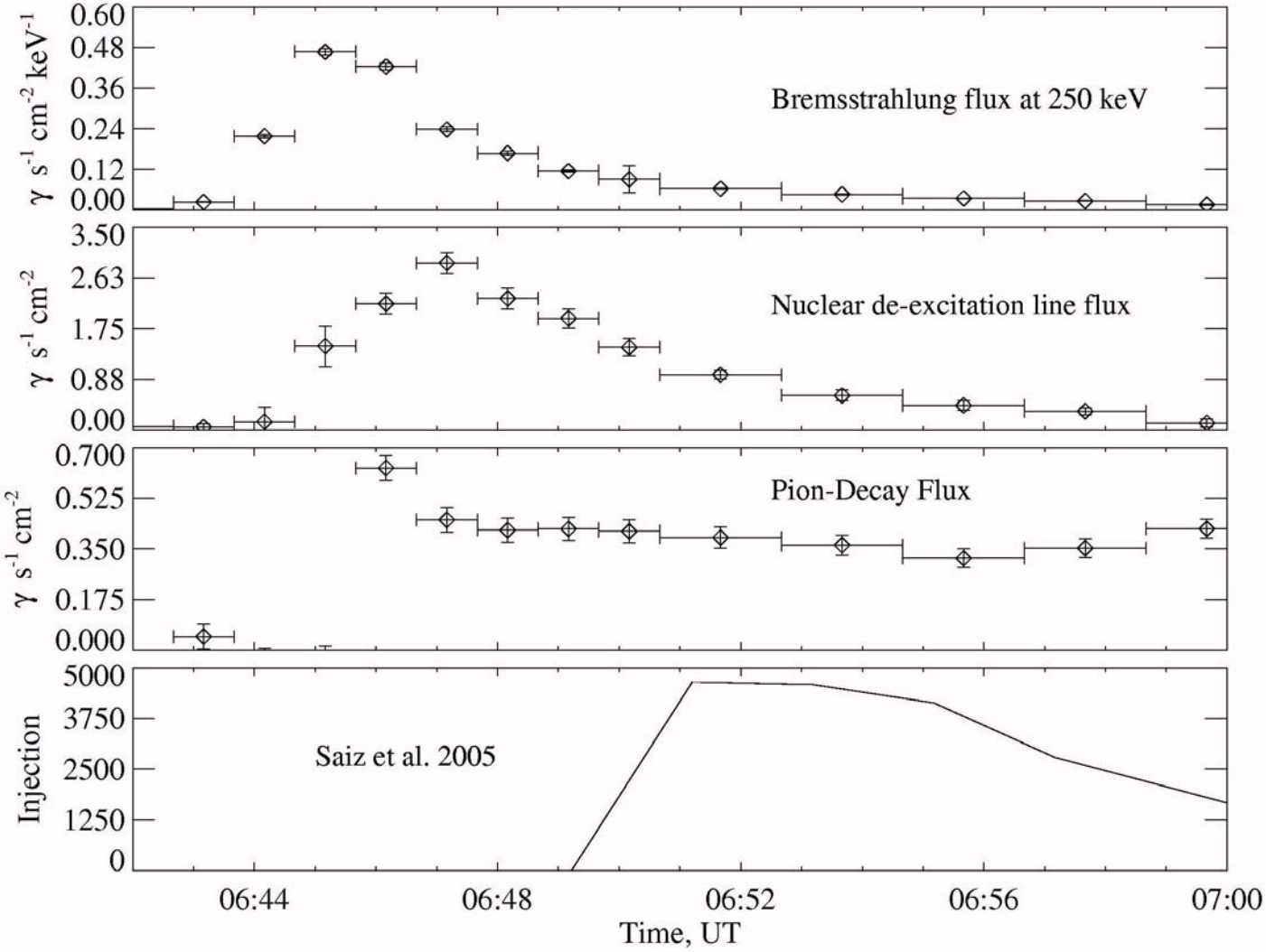
RHESSI gamma-ray time line in January 20 flare

Caveat: possible contamination from scattered 2.22 line radiation



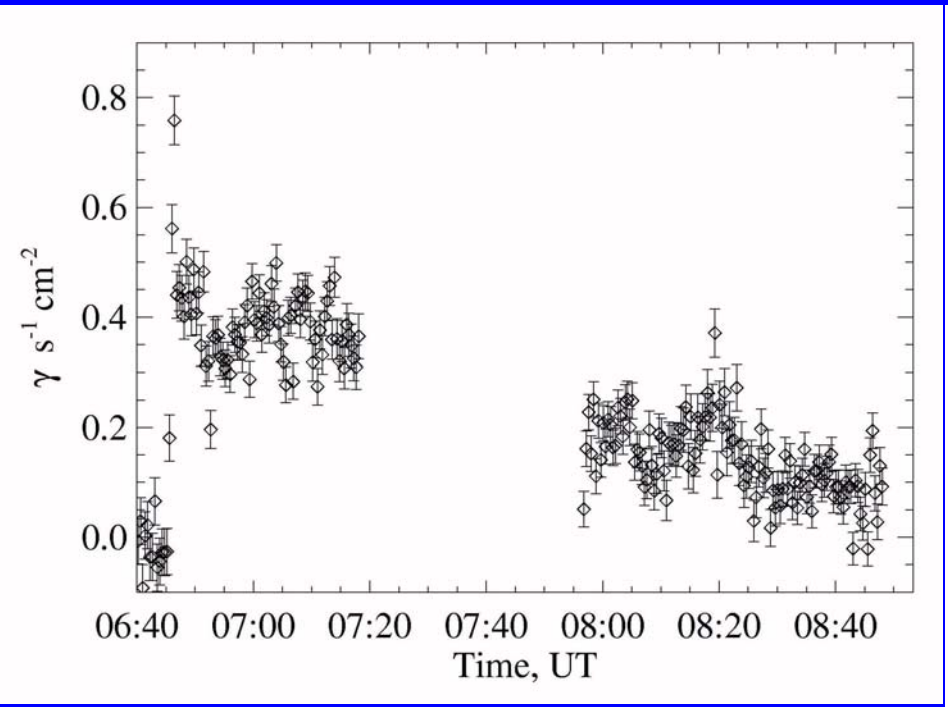
Top 4 panels reveal an impulsive particle acceleration phase with bremsstrahlung, followed by nuclear de-excitation radiation, neutron-capture and annihilation lines. Fluxes are consistent with an accelerated-particle spectrum following a power-law with index ~3. Bottom shows a distinctly different time profile for radiation >17 MeV that is consistent with pion-decay radiation suggestive of a harder component of accelerated particles (index ~2.3).

Caveat: possible contamination from scattered 2.22 MeV line radiation

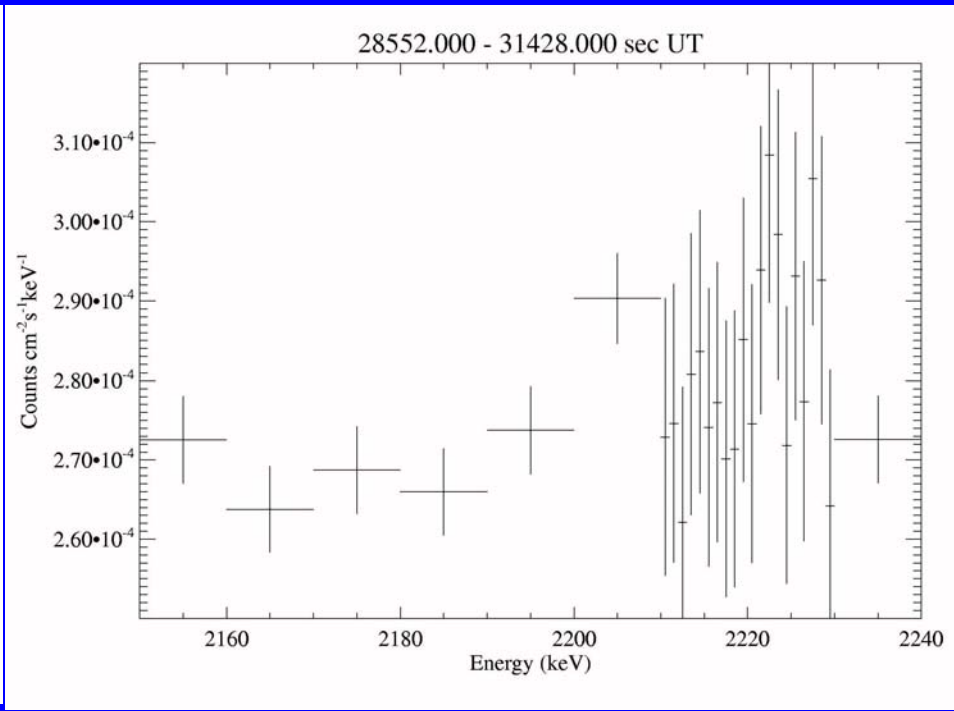


The bremsstrahlung and nuclear-line emission begin before the sharp rise of the >17 MeV emission and fall much more rapidly. Bottom panel shows an estimate of the GLE injection profile derived from neutron monitor data shifted back to the Earth for comparison with the gamma-rays.

>17 MeV



Evidence for n-capture line



The high-energy photon emission observed by RHESSI extends up to two hours after its sharp peak. There is weak 2.223 MeV line emission after 08:00 UT suggesting that the high-energy emission is from ion interactions.

Comparison of accelerated particles interacting at the Sun and observed in space (Mewaldt, priv. comm. 2005)

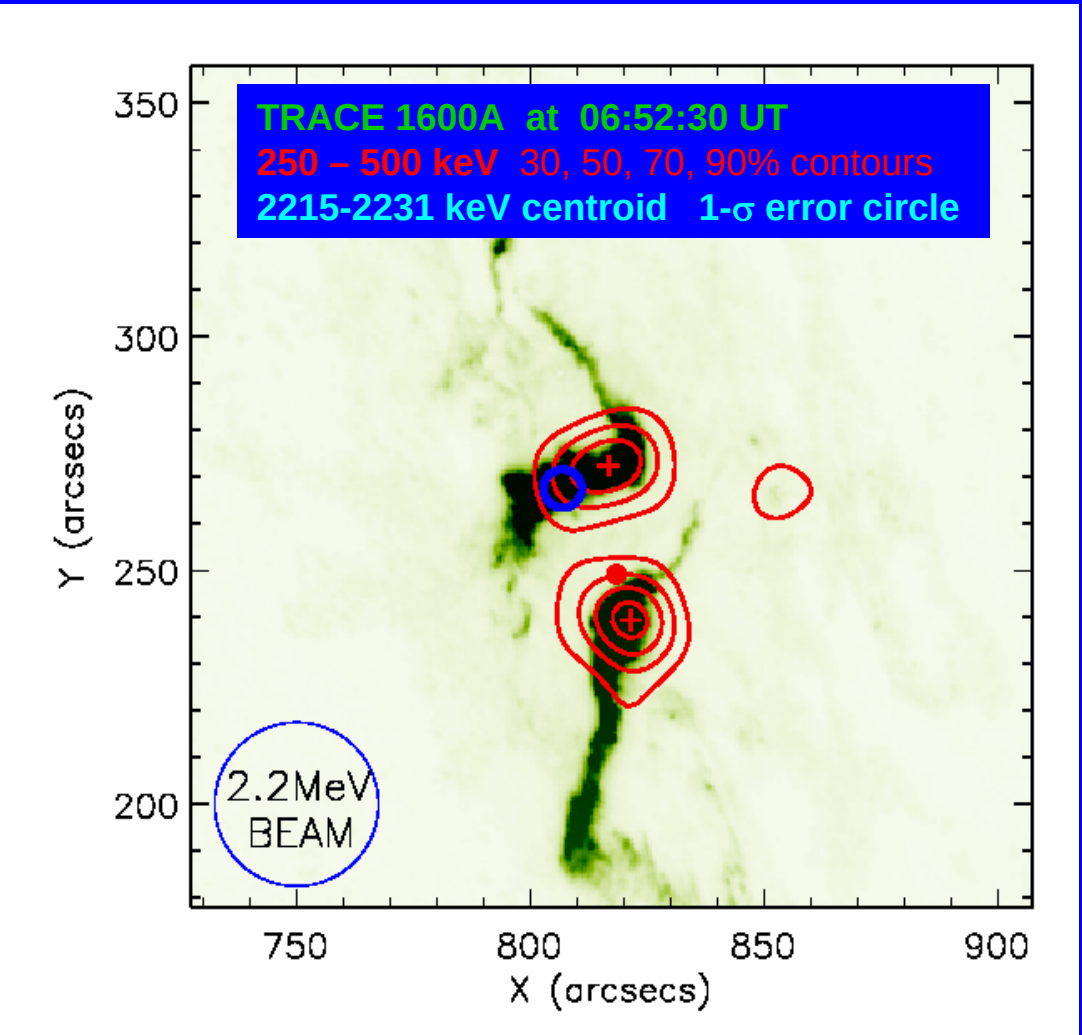
Total number of protons >30 MeV:

- Solar flare impulsive component: $(2.8 \pm 0.8) \times 10^{32}$
- Solar flare high-energy component: $\leq 0.7 \times 10^{32}$
- Event integrated SEPs: 210×10^{32}

Power-law spectral index:

- Solar flare impulsive component: ~3.0
- Solar flare high-energy component: ~2.3
- Event integrated SEPs: 2.15

06:44-06:56 UT



Hurford et al. (2006) have shown that virtually all of the accelerated ions during the impulsive phase interact in the Northern footpoint. No imaging of the later phase appears possible. Annihilation line measurements may provide some information on this later phase.

SUMMARY

RHESSI has observed what appears to be two distinct components of particle acceleration in the 2005 January 20 solar flare.

There is a 'normal' impulsive component beginning at ~06:42 UT, peaking at ~06:47 UT, lasting about 10 minutes, evidenced by electron bremsstrahlung and nuclear-line radiation from accelerated ions with power-law index of ~-3 interacting at a footpoint.

A harder photon component rose within ~1 min, peaking at ~06:46 UT, consistent with pion-decay radiation; emission lasted for ~2 hours. Inferred accelerated-particle power law index ~-2.3.

Only ~20% of the total number of >30 MeV protons interacting at the Sun produced this high-energy component.

Total SEP flux of >30 MeV protons ~50 X higher than number interacting at the Sun.

The acceleration of the particles producing the high-energy emission peaks about 3 min. before the onset of the injection of the GLE and 5 min. before its peak. All other gamma-ray emissions start even earlier.

These characteristics suggest an association between the acceleration processes producing the particles interacting at the Sun and those released to space. We do not have convincing evidence that the processes accelerating the flare and GLE particles are the same.

There is additional information in the RHESSI data relating to accelerated particle composition and the ambient chromosphere can address the flare/GLE association.