Energetics of the Corona

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Associated with many CME eruptions is a reconfiguration and energization of the low corona. In particular, solar flares are often the most energetic signatures of a CME in the low corona. We will discuss the energetic signatures of the low corona in the aftermath of a CME, emphasizing the high energy particle and photon emissions accompanying these events and their apparent association with topological structures in the magnetic field

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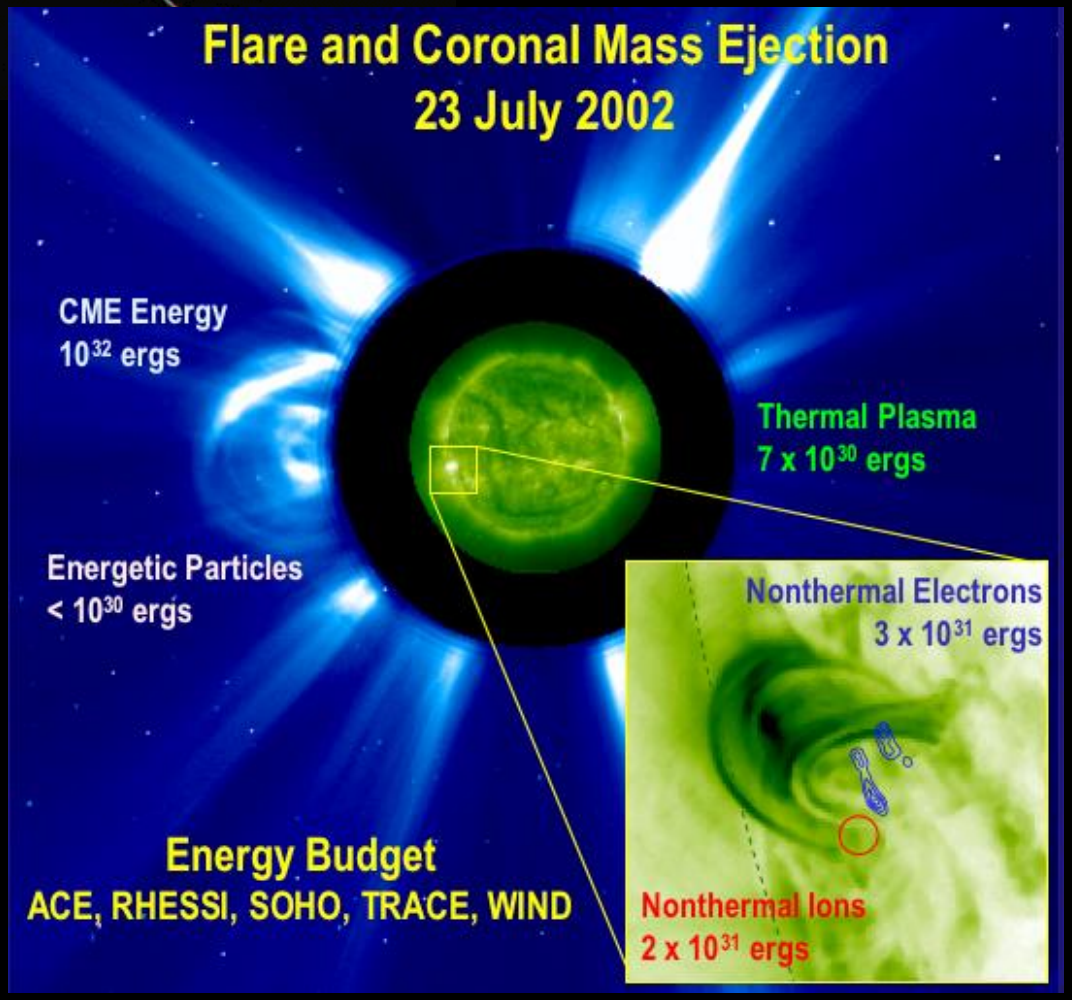
The "whole" story



Accelerated particles
- **electrons/ions**

Thermal emissions
- **multi-thermal**
- **radiative losses**

Accelerated mass
- **gravity**
- **open open**

Integrated over time

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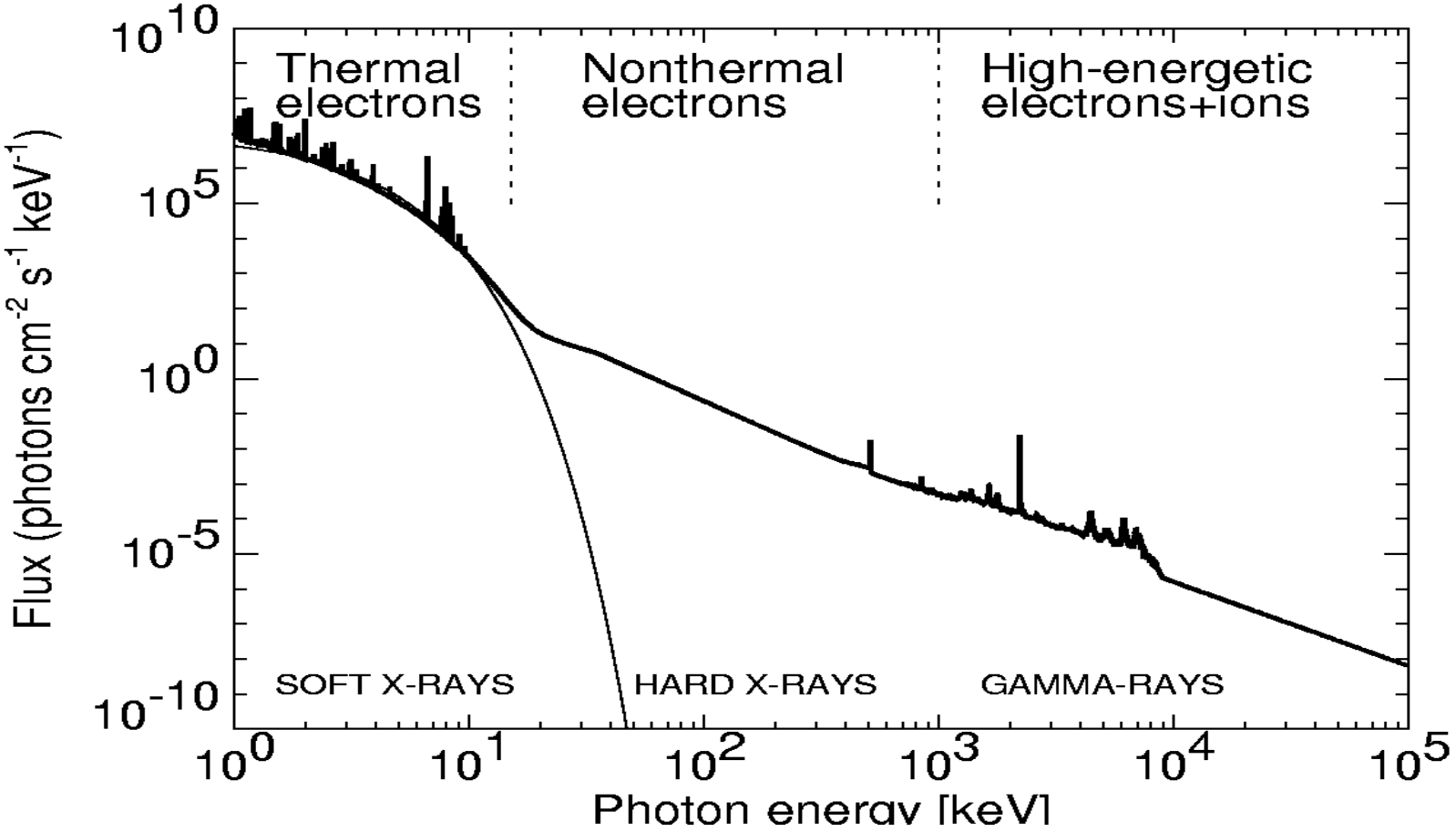
Accelerated particles at Sun



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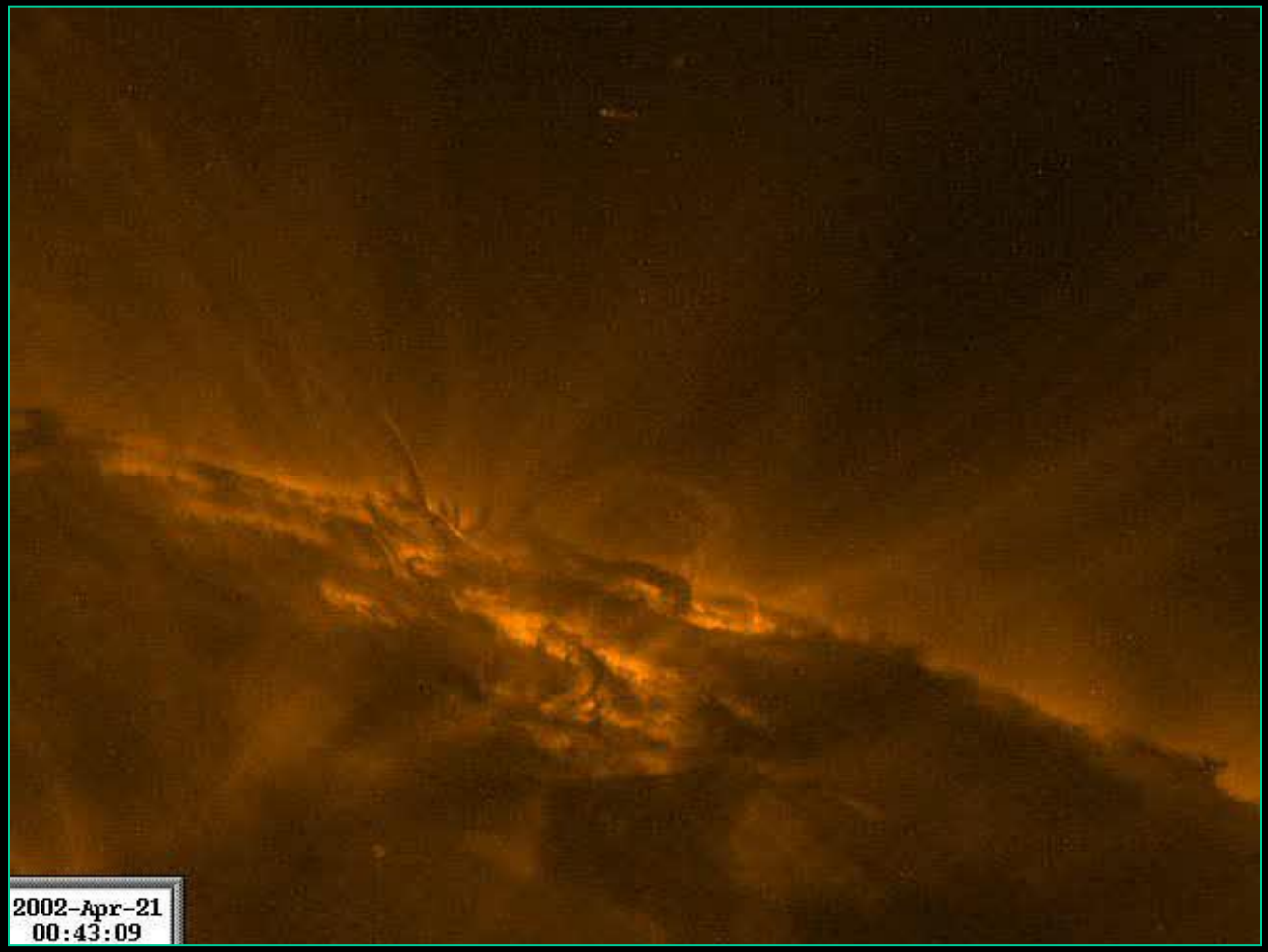
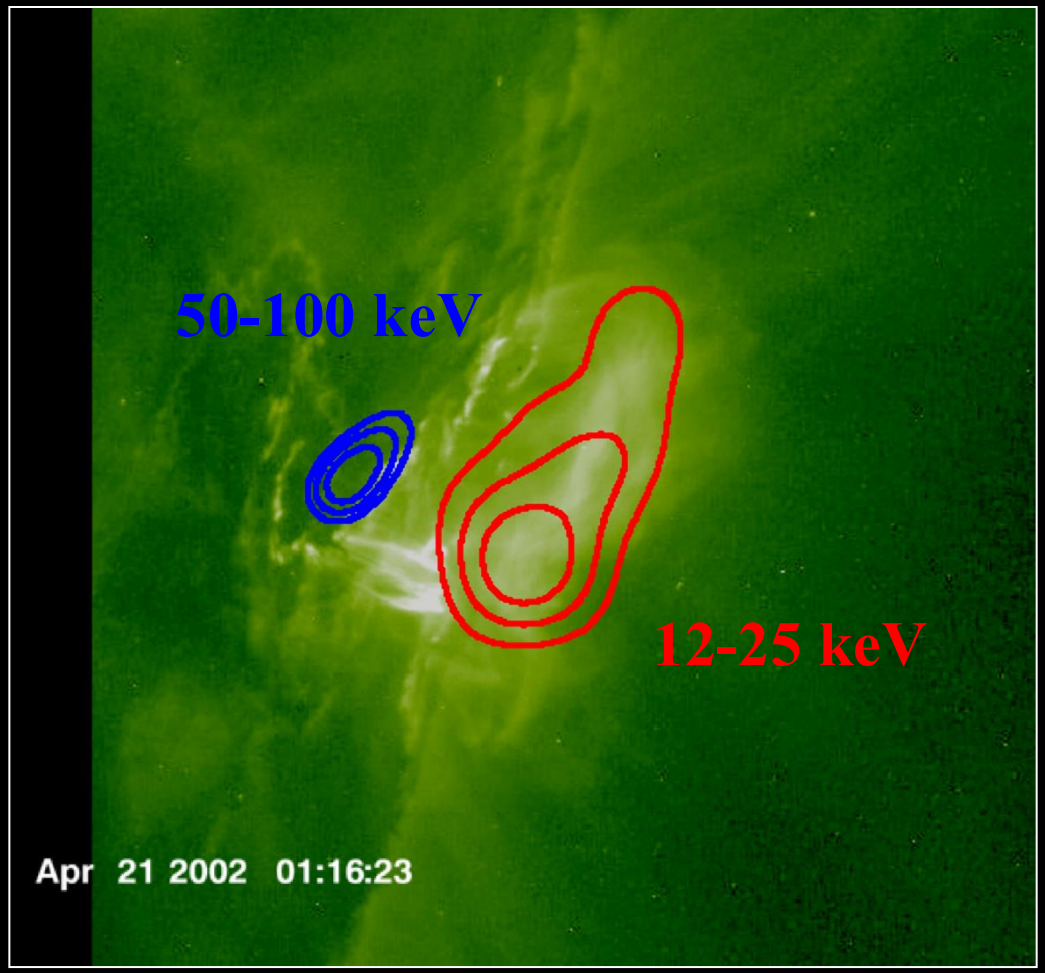
Apr 21 2002 TRACE movie

TRACE data shows interesting morphological evolution



Apr 21 2002 RHESSI/TRACE

Hot (~20 MK) plasma high in corona



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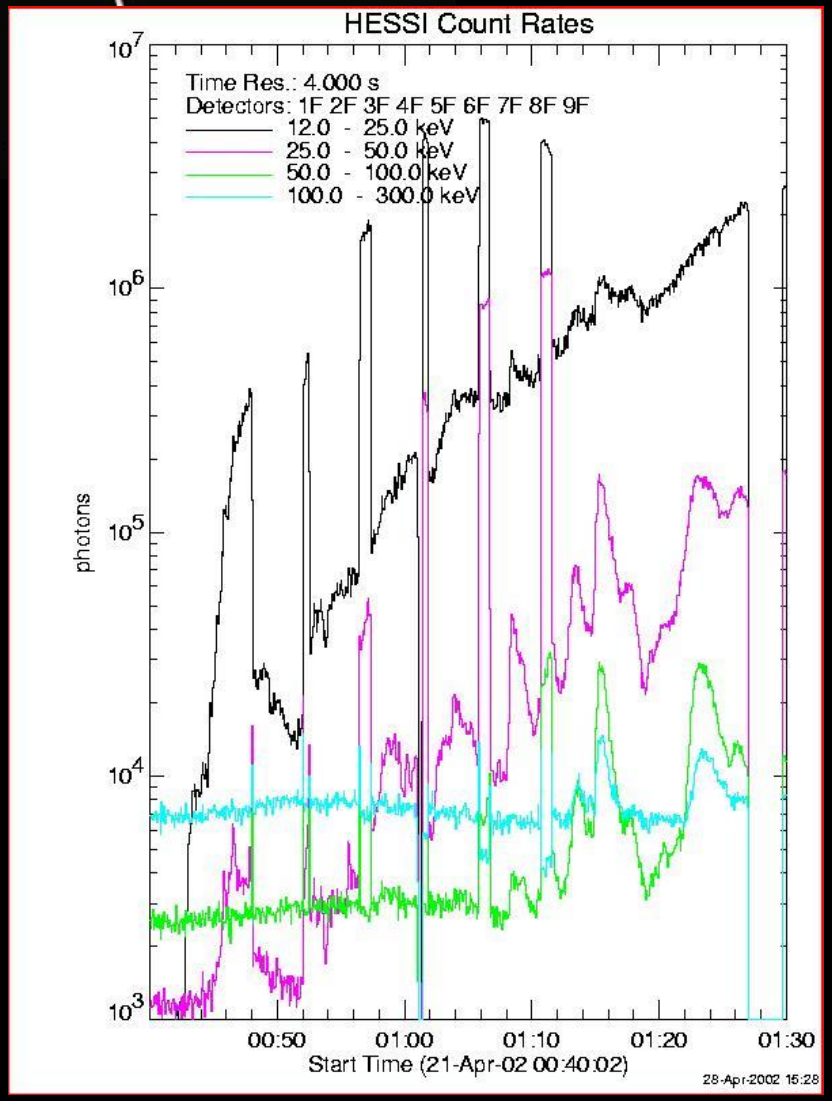
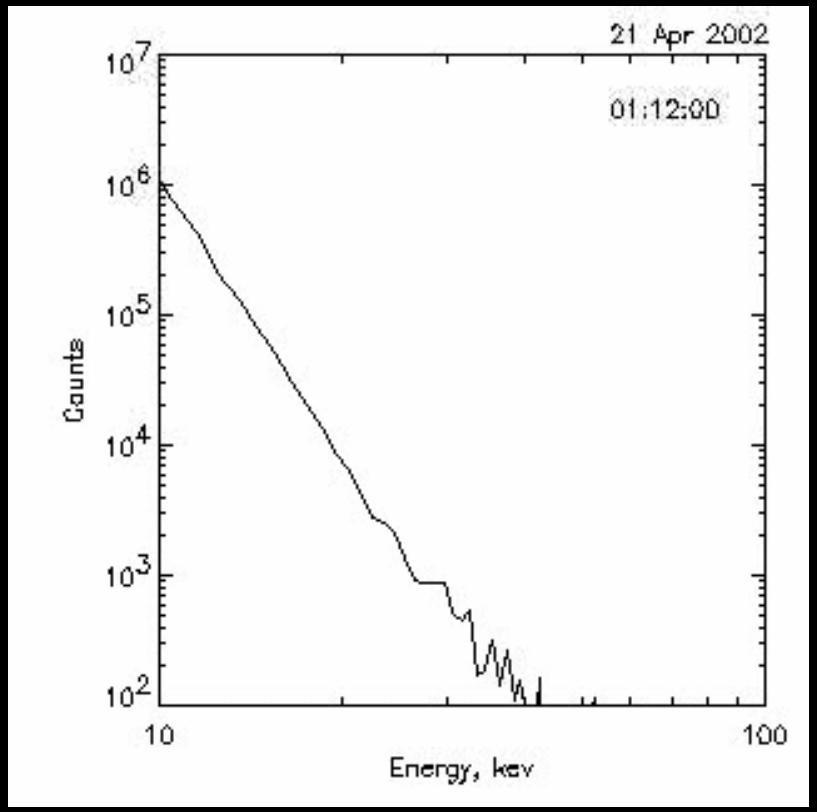
April 21 – X class flare





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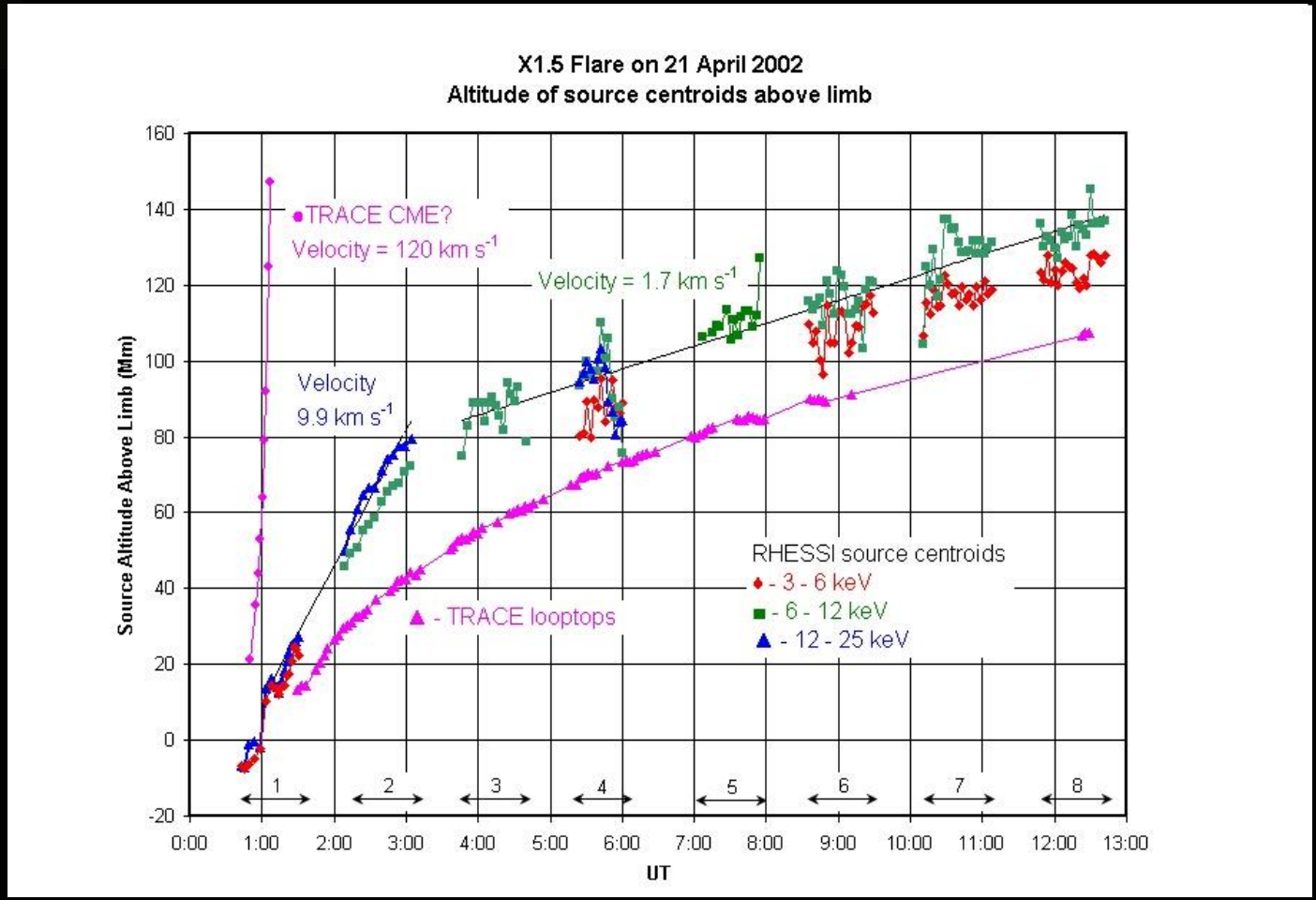
Apr 21 2002 Dynamic Evolution



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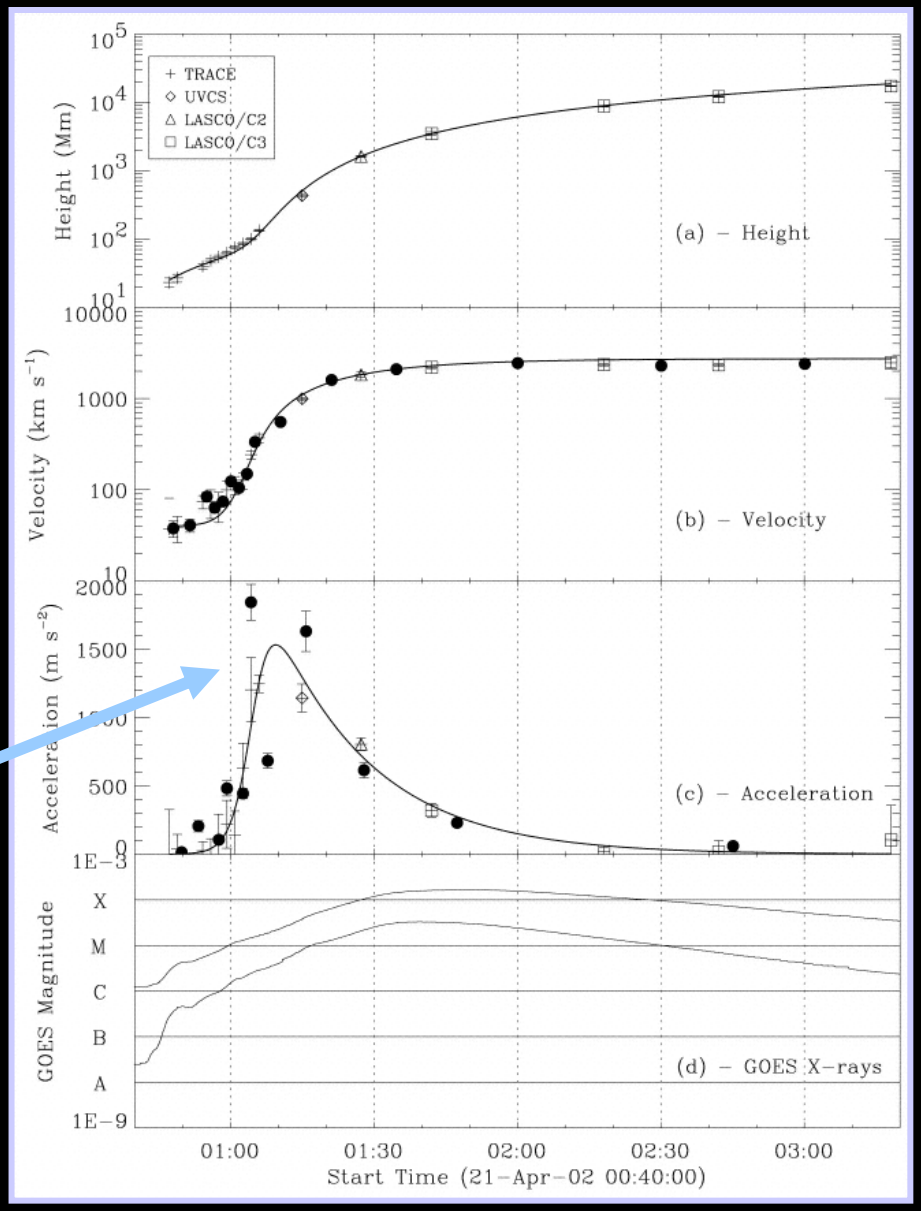
Apr 21 2002 Dynamic Evolution

From Gallagher, Lawrence and Dennis (2003)

Peak acceleration coincides with peak of hard X-ray production (see also Zhang, 2001)



April 21 – Energetics

Mode	Log_{10}[Energy (ergs)]
Magnetic	32.3 ± 0.3
Flare	
Thermal Plasma (T > 10 MK)	30:8 ± 0.5
Nonthermal Electrons	31:3 ± 0.5
Nonthermal Ions (> 1 MeV nucleon^{-1})	< 31:6
CME	
Kinetic	32.3 ± 0.3
Gravitational Potential	30.7 ± 0.3
Energetic particles @ 1 AU	31.5 ± 0.6

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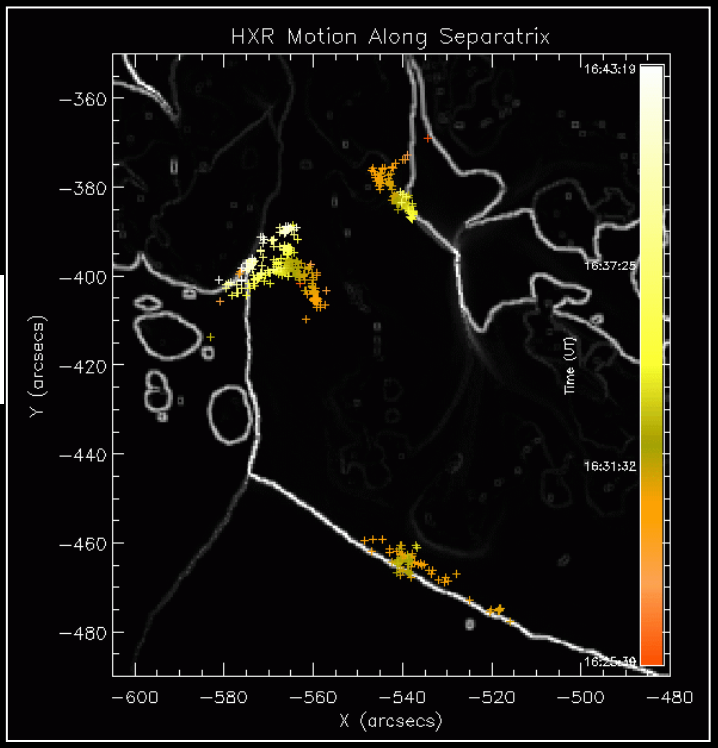
Relationship to Magnetic Topology: Potential



Evolution of hard X-ray emission relative to separatrices (from Metcalf et al., 2003).

For energetics we would like to relate particle production (spectra, flux, location) to

- **topology (separatrices/separator/ QSL, e.g. Demoulin, Longcope, …)**
- **total magnetic energy release**
- **rate of energy release.**

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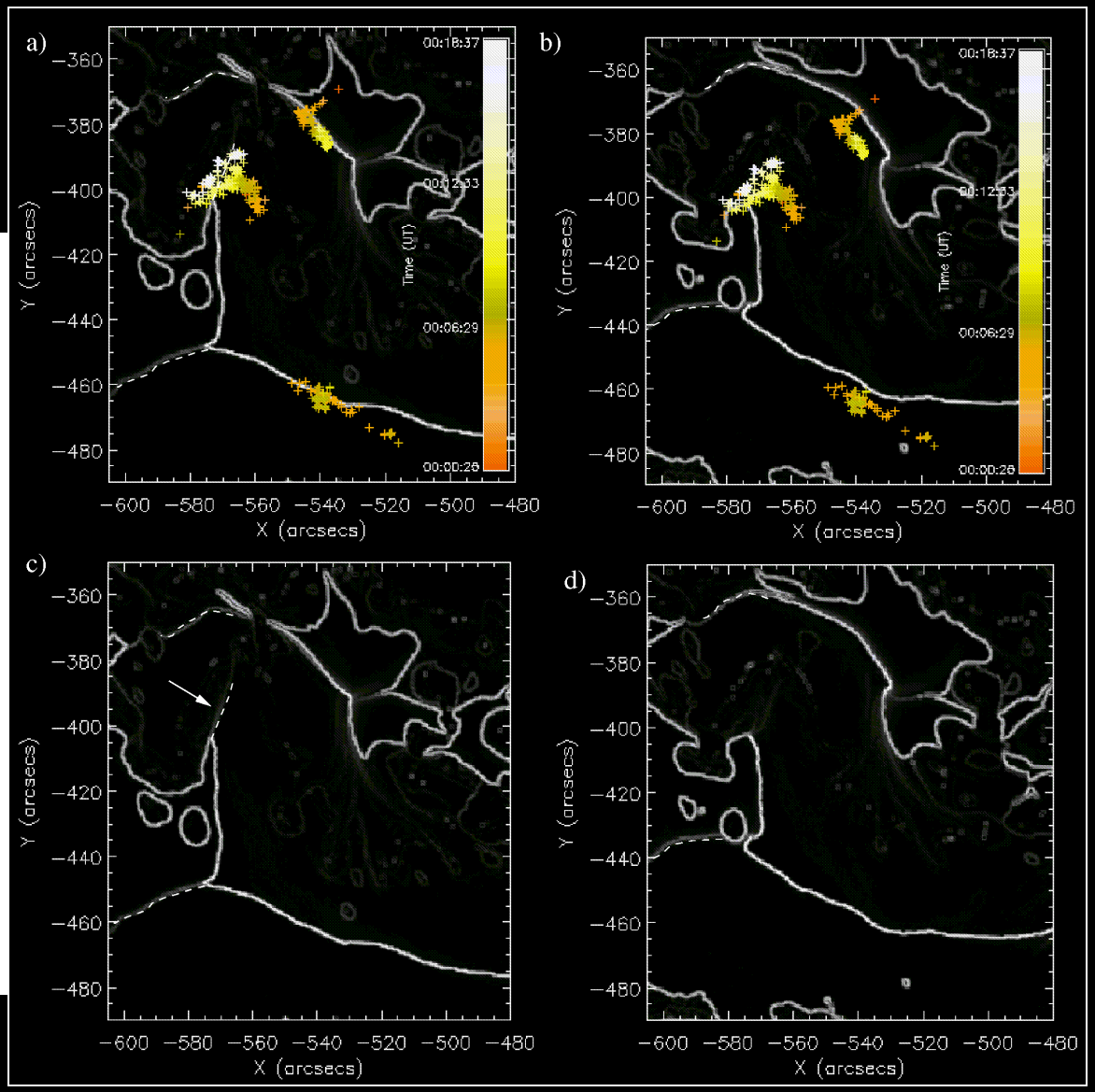
Relationship to Magnetic Topology: Linear FF

Evolution of hard X-ray emission relative to separatrices computed from a linear force free field extrapolation of the line-of-sight MDI magnetogram data with the assumption of (a, c) $\alpha = 1.75 \times 10^{-3}$ Mm^{-1} and (b,d) $\alpha = 3.5 \times 10^{-3}$ Mm^{-1}.



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"Global" Considerations

Hard X-ray and γ-ray emission tends to be relatively localized indicating preferential sites of particle acceleration.

Need to relate physics of particle acceleration to trigger and to global magnetic topology to understand energetics in these events.