SH1 and SH2.1 (Sun & Corona, IP Transport)

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(*Caltech*)

Topics

- First Results from RHESSI (really!) (12 papers)
  - The devil is in the details - new puzzles
- Some topics never die
  - Particle Acceleration (38 papers)
  - Particle Transport (8 papers)
- TGFM (Thank goodness for modellers) (21 papers)
- Future prospects (14 papers)

93 papers total

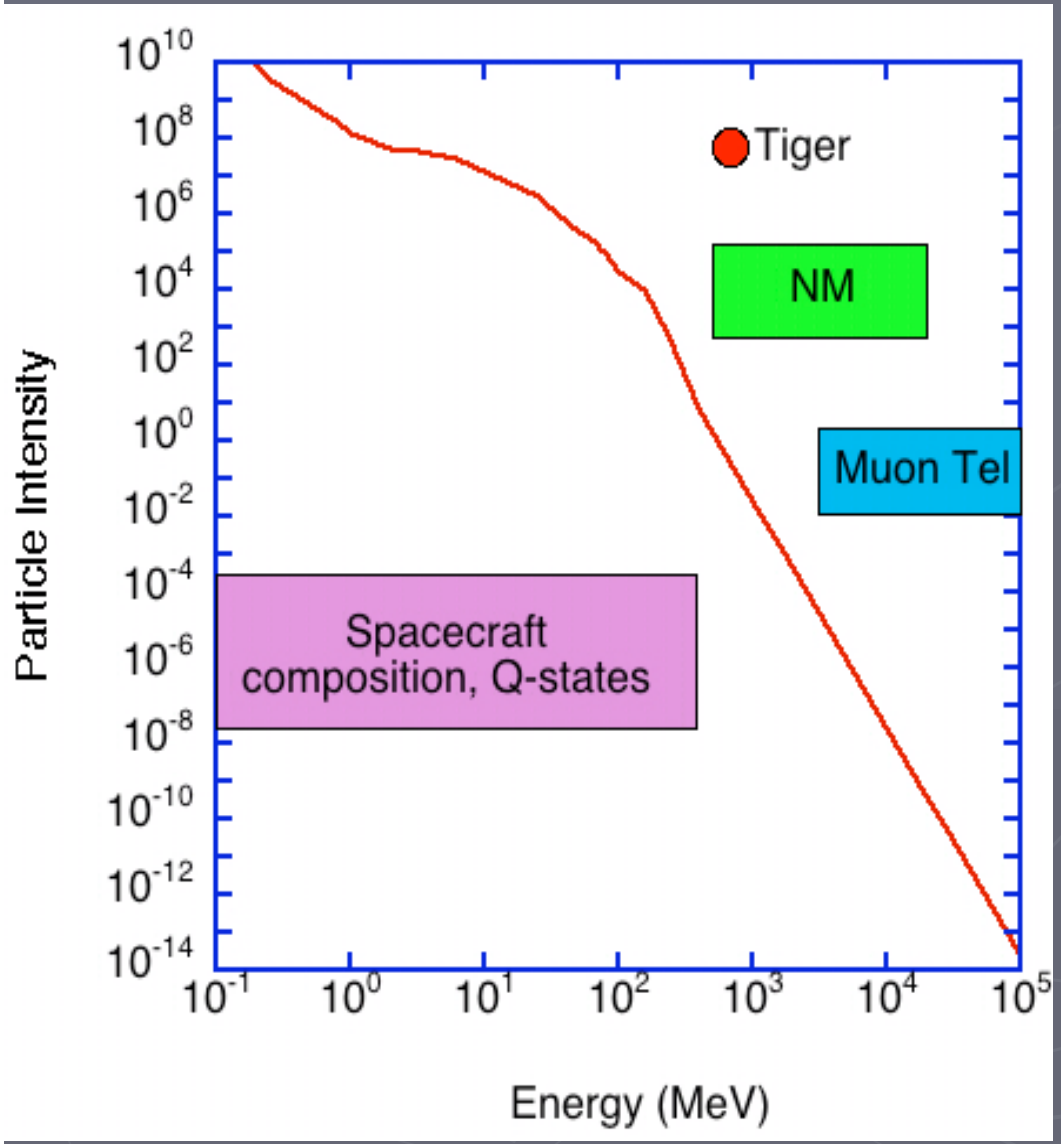
What do we want to know about solar energetic particles?

- Where they are accelerated
- What is being accelerated
- How they are accelerated
- How they reach us

Tools

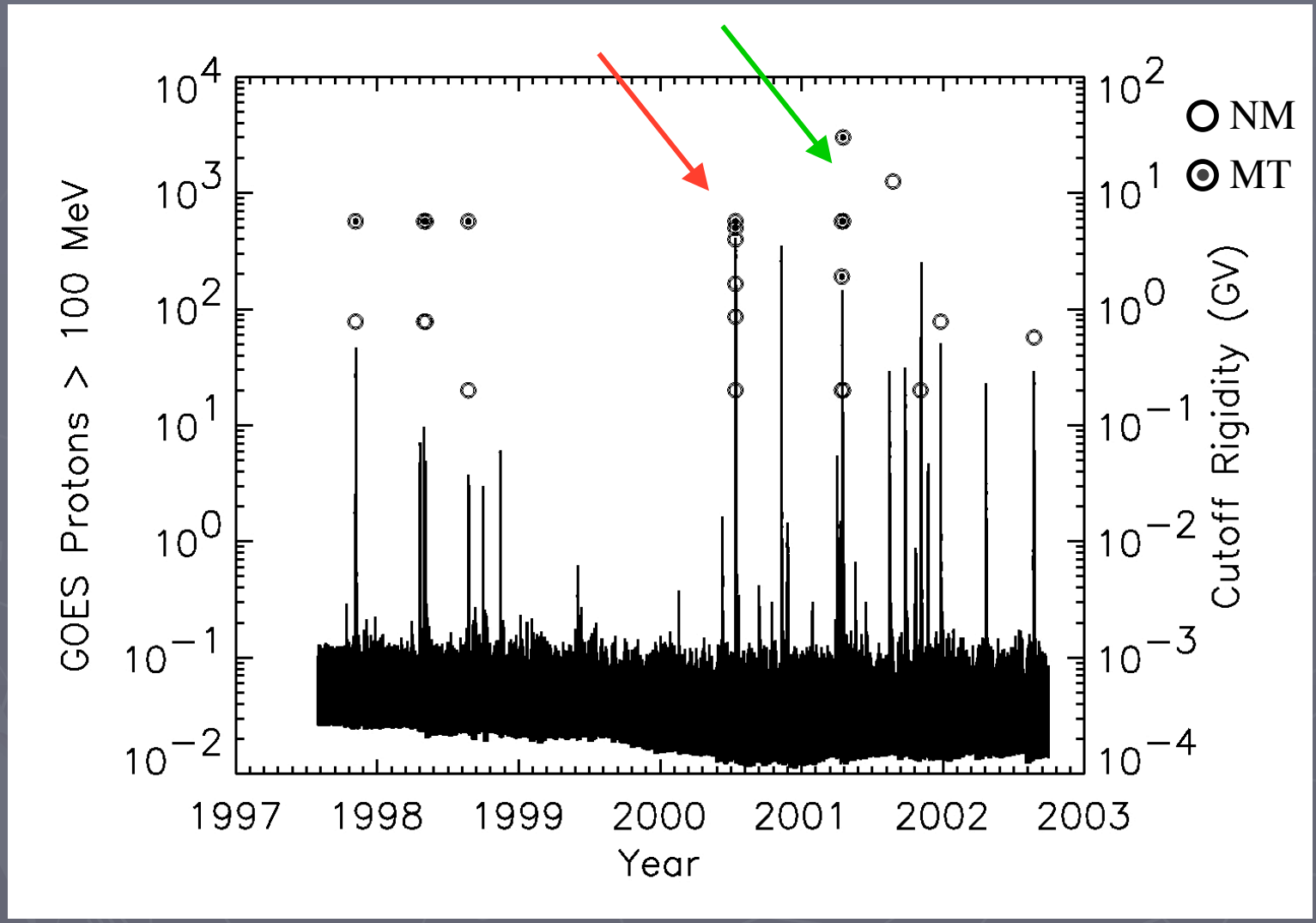
- Particles
  - Onsets, Composition, Charge States
- Photons
  - Images/Movies, Wavelengths, Spectra

Particle Measurements



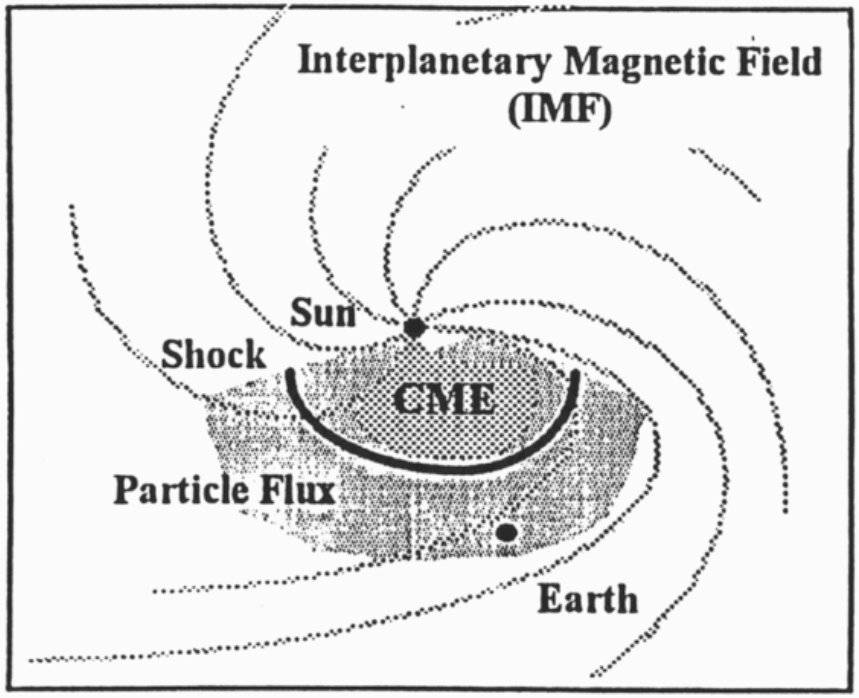
- Spacecraft
  - IMP8, Wind, SOHO, ACE, Cassini, GOES, NOZOMI, SAMPEX, MITA
- Neutron Monitors/SNT
  - Tibet, Mt. Chacaltaya, Mt. Haleakala, Mt. Norikura, Spaceship Earth, ...
- Muon Telescopes
  - L3+C, GRAPES, GRAND, BUST, Andyrchy, Carpet

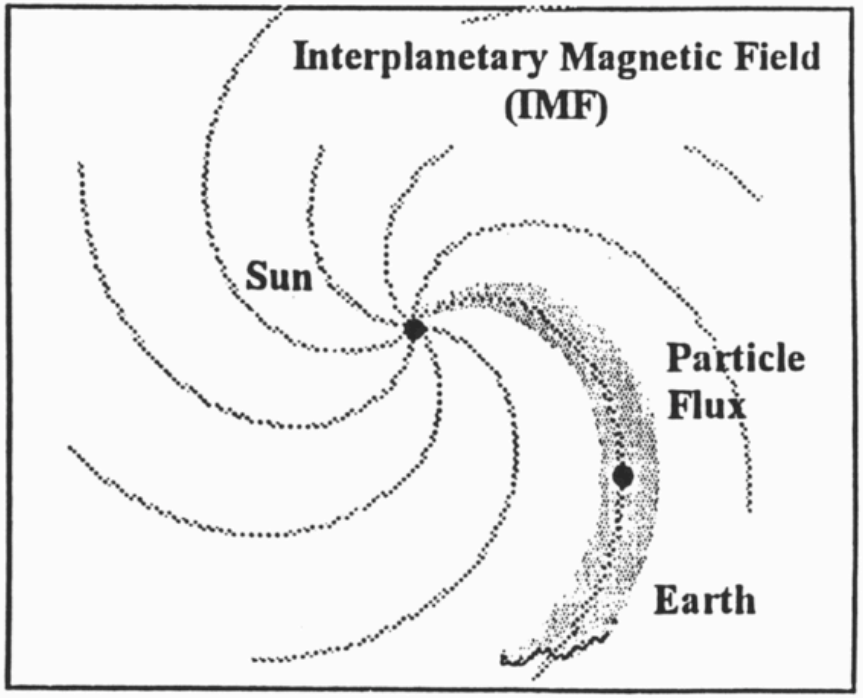
Particle Measurements



- Bastille (7/14/00) event
- Easter/Resurrection (4/15/01) event

Two Main Acceleration Processes



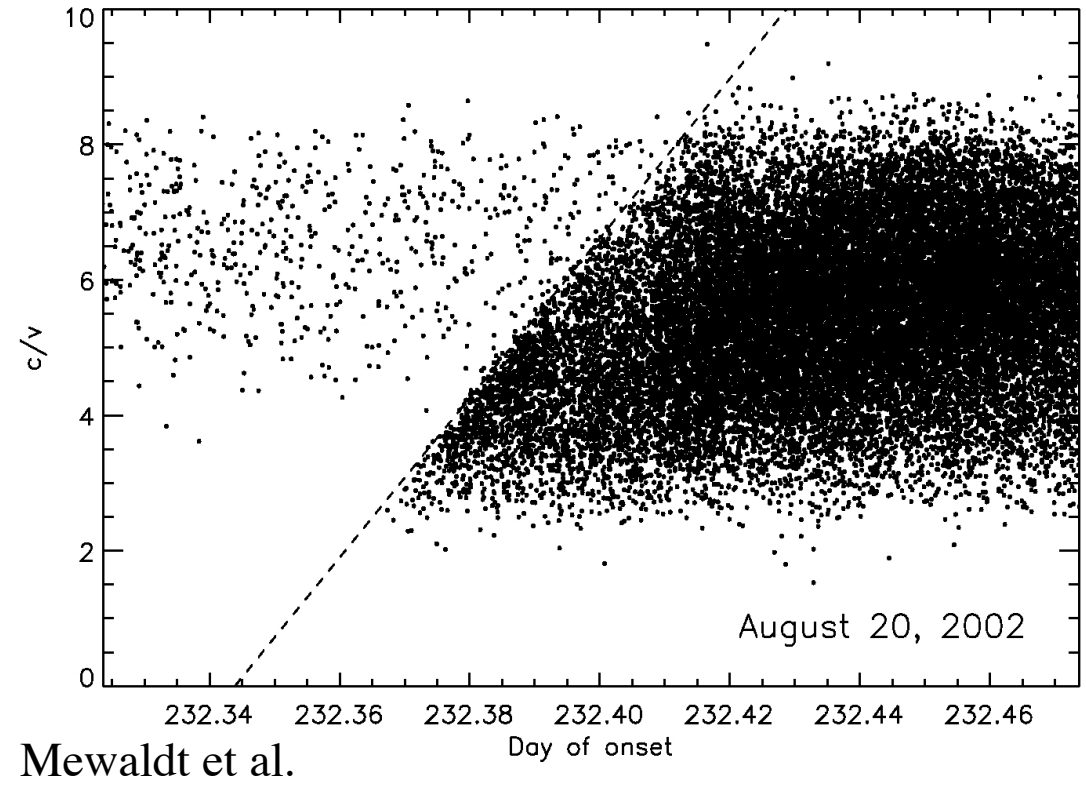


CME-driven Shock
Fe/O ~ 0.1
$^{3}He/^{4}He$ <0.01
Q_{Fe} ~ 10-14

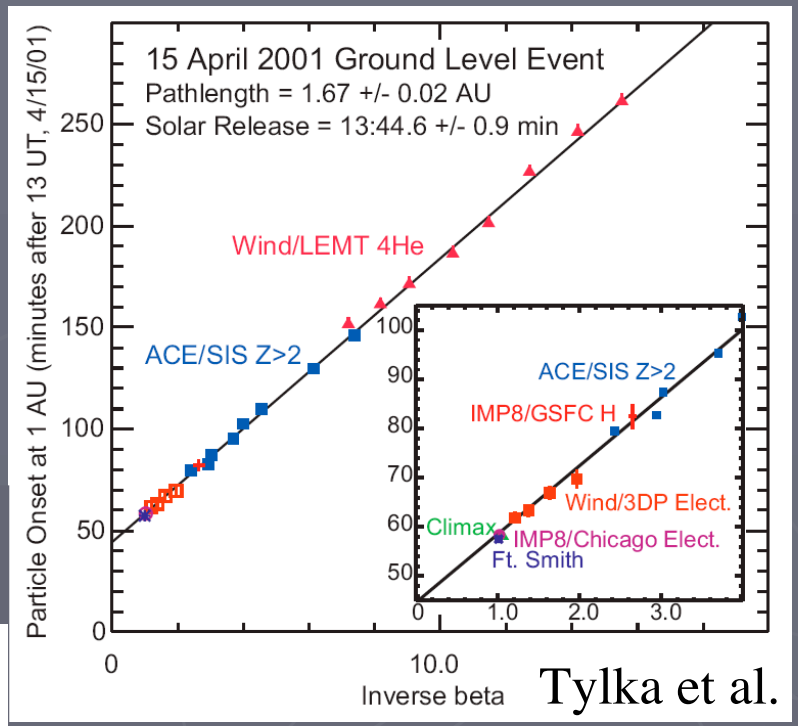
Flare-related
Fe/O ~ 1
$^{3}He/^{4}He$ ~ 0.1 - 1
Q_{Fe} ~ 20

Where?

- Timing Studies
  - T *vs* c/v (Mewaldt et al., Tylka et al.)



Mewaldt et al.

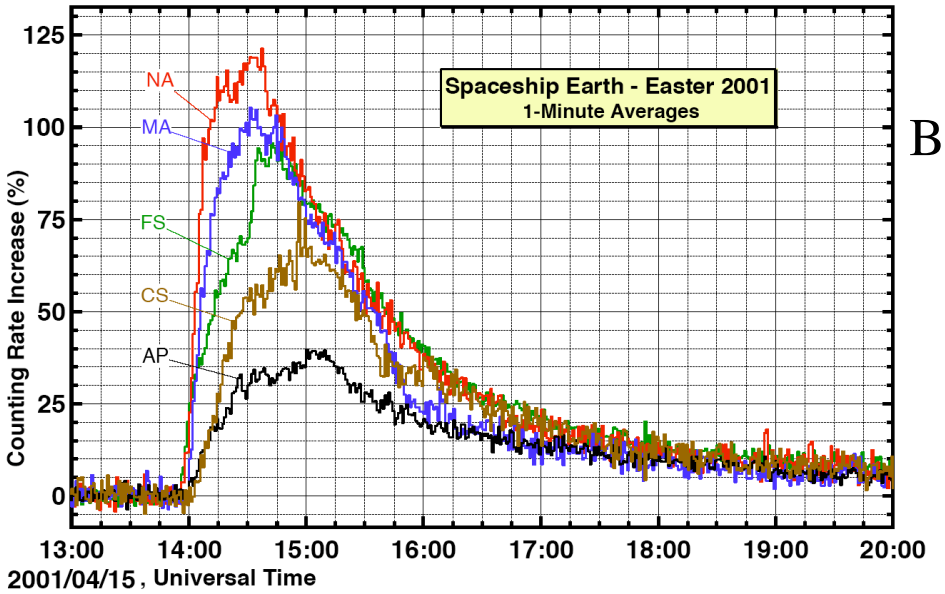


Tylka et al.

Where?

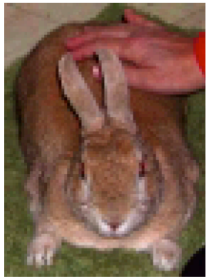
- Timing Studies
  - T *vs* c/v (Mewaldt et al., Tylka et al.)
  - injection/transport models with NM data (Bieber et al.)
  - NM & electron velocity (Kahler et al.)

Different methods agree rather well



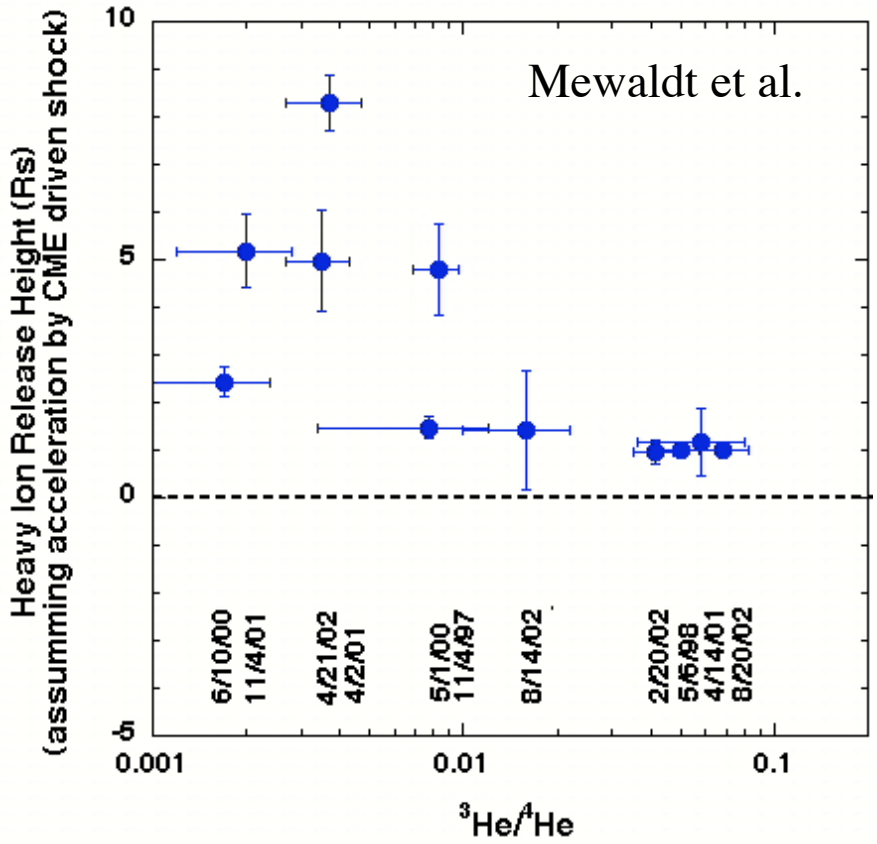
Bieber et al.

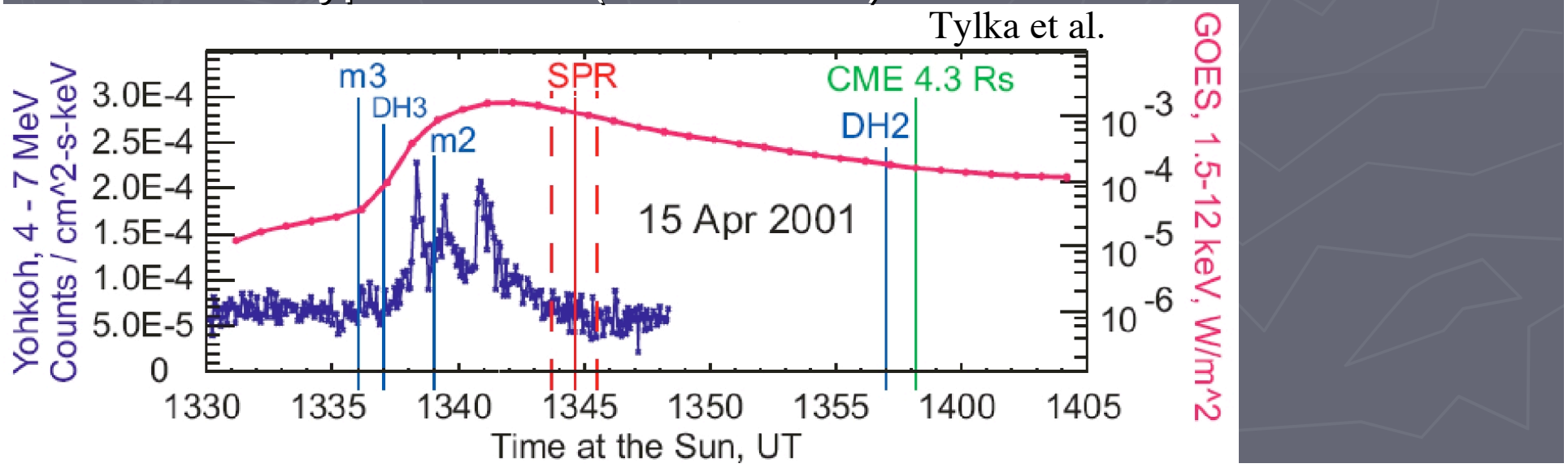
(Harley)



Where?

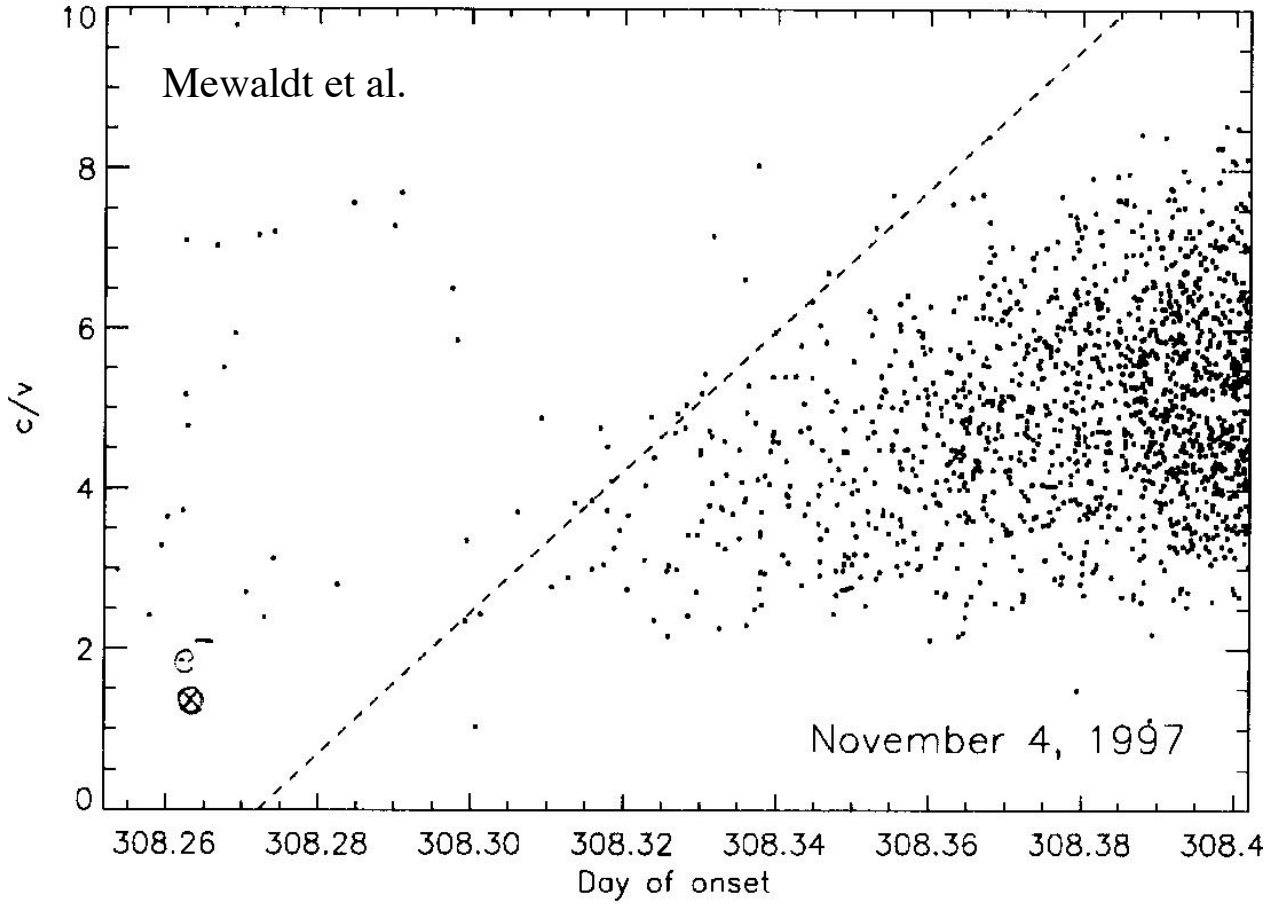
- Most big events point to CME-shock accel.
  - After CME lift off — 2-10 R_S
  - After type III radio — Flare
  - After HXR emission — Flare
  - Association with DH & metric type II radio (Cliver et al.) — Shock





Where?

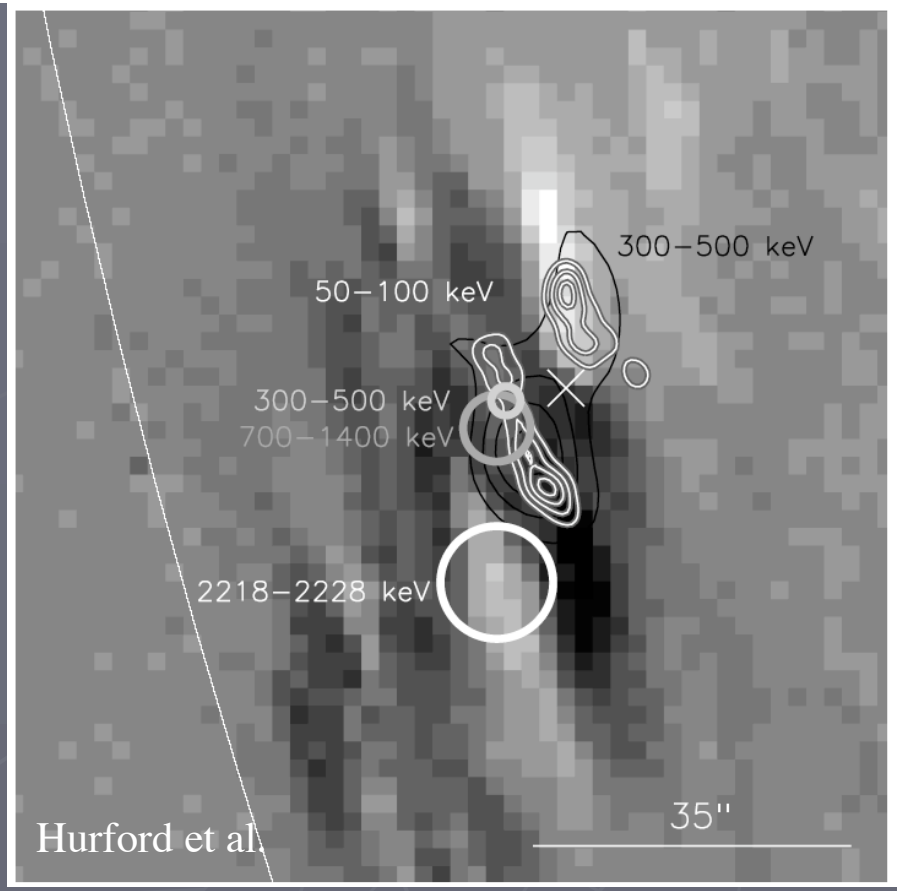
Scattering / Pitch angle distributions

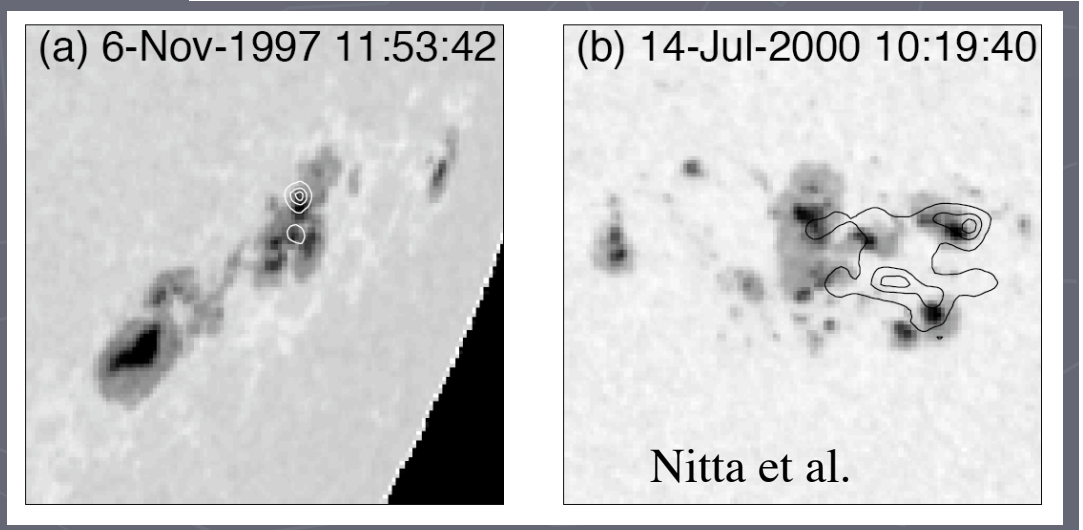


- Injection/Release - all species/energies together?
  - Tylka et al., Posner & Kunow - yes
  - Kahler et al. - no (H^+ before e^-)
  - Mewaldt et al. - sometimes (heavies after e^-)

Where?

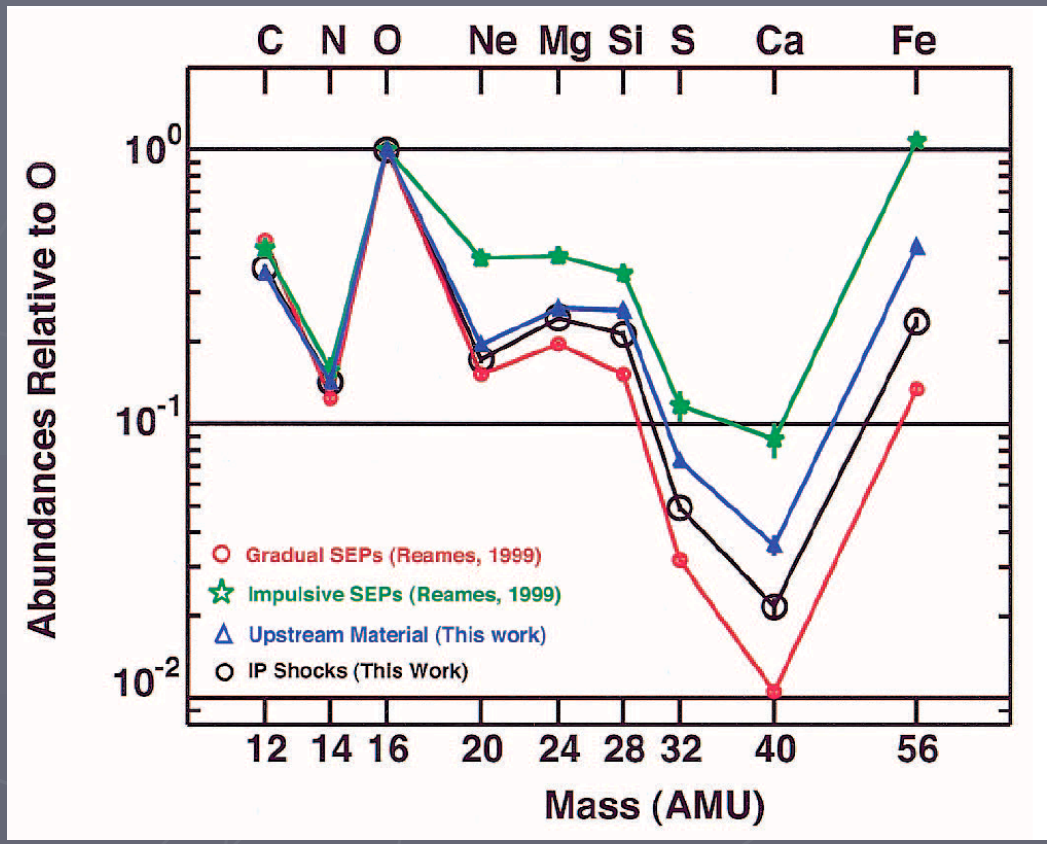
- RHESSI protons and electron acceleration locations are different (Hurford et al.)
- Size of HXR region and pre-eruption motion related to SEP characteristics (Nitta et al.)





What?

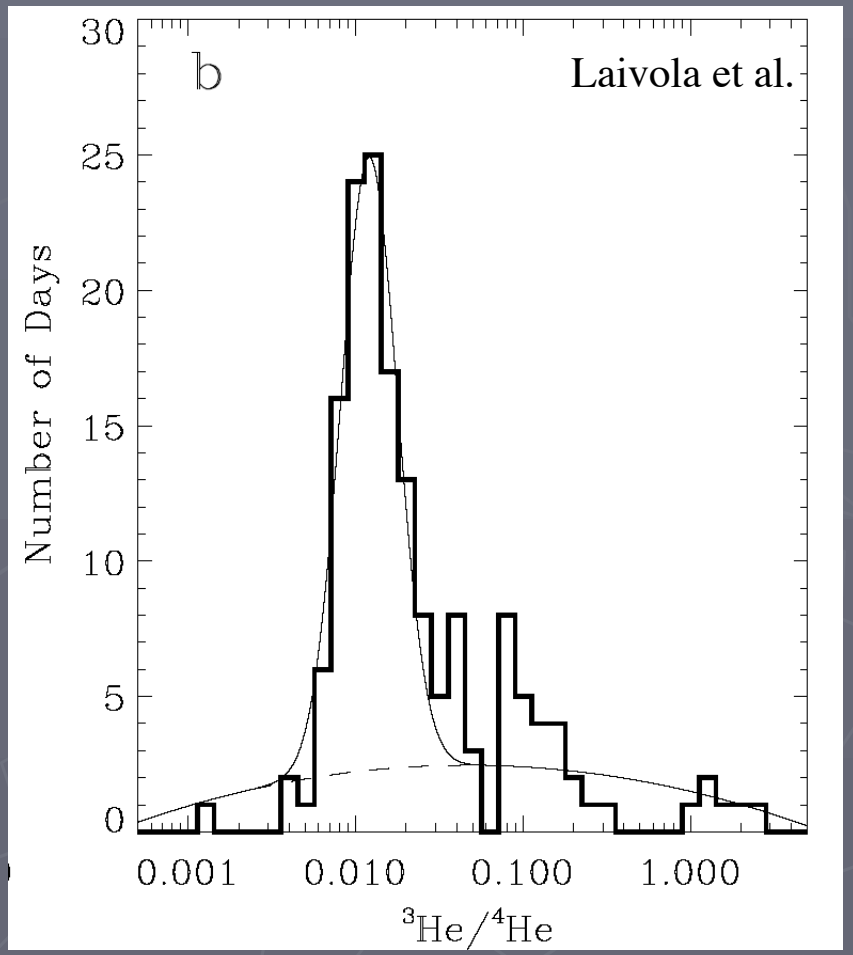
- Reames 1995
  - CME-shocks accelerate Solar Wind
- Desai et al. 2003
  - composition at shocks (1 AU) is not solar wind-like
  - composition most like upstream material



Upstream material = mix of flare and solar wind-like (on average 30% & 70%)

What?

- Flare Material (remnant? concurrent?)
  - $^3He/^4He$ in SEPs larger than solar wind values (Laivola et al.)



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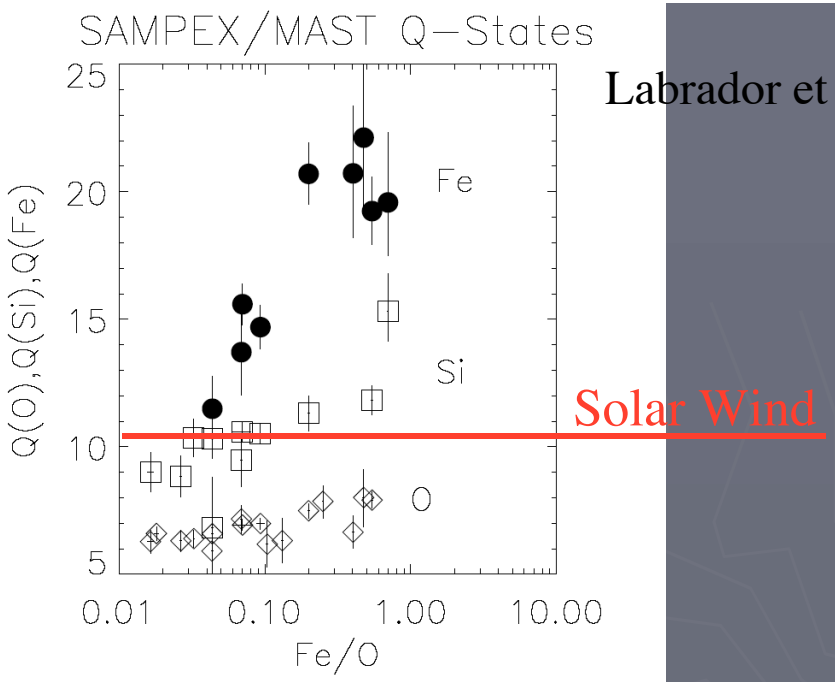
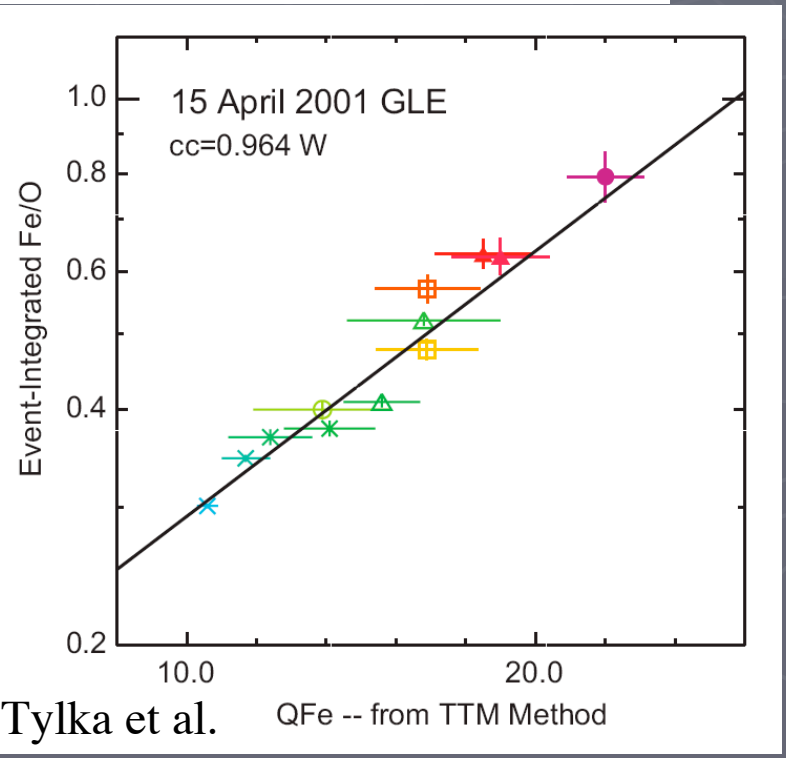


Labrador et al.



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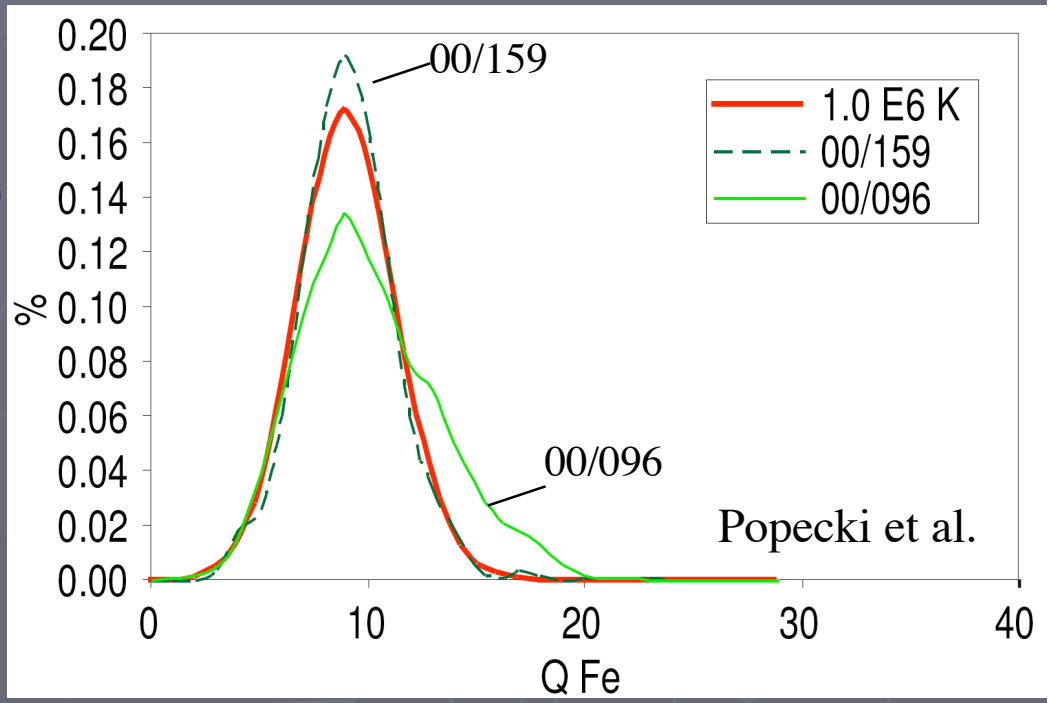

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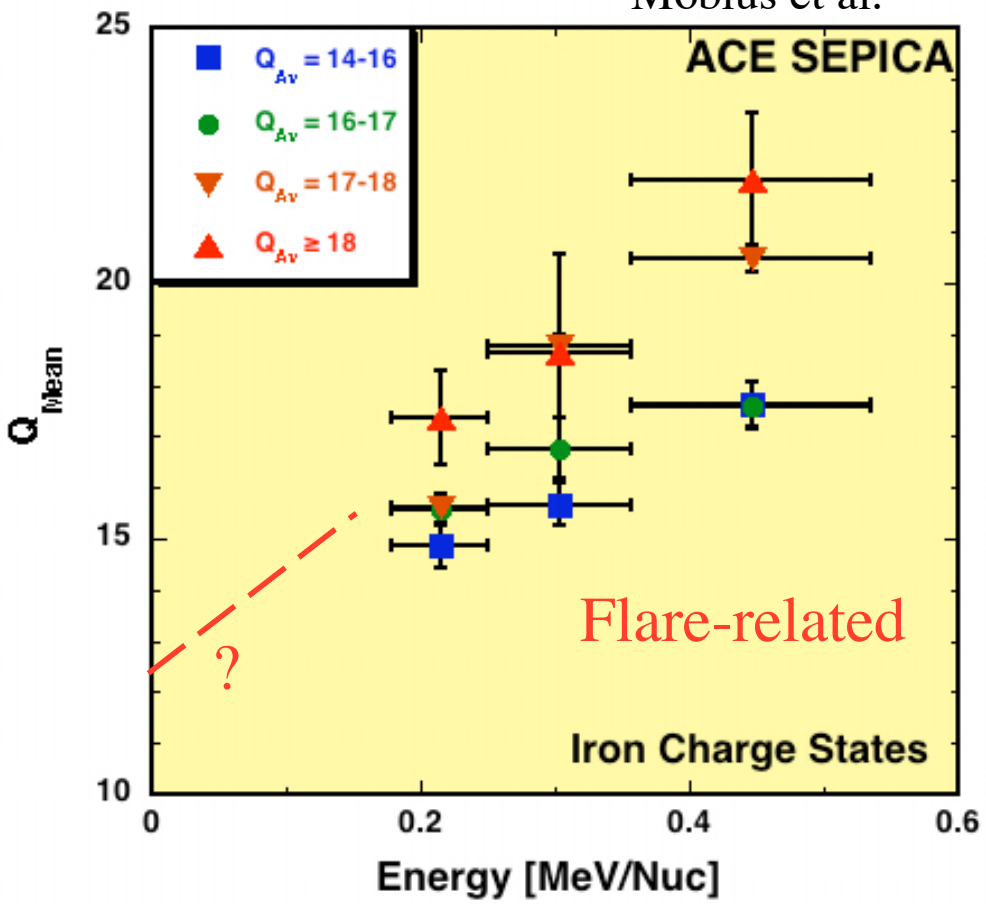
- But...
  - Maybe not enough material (Mewaldt et al.)
  - Shock events have Qs like solar wind (Klecker et al.)

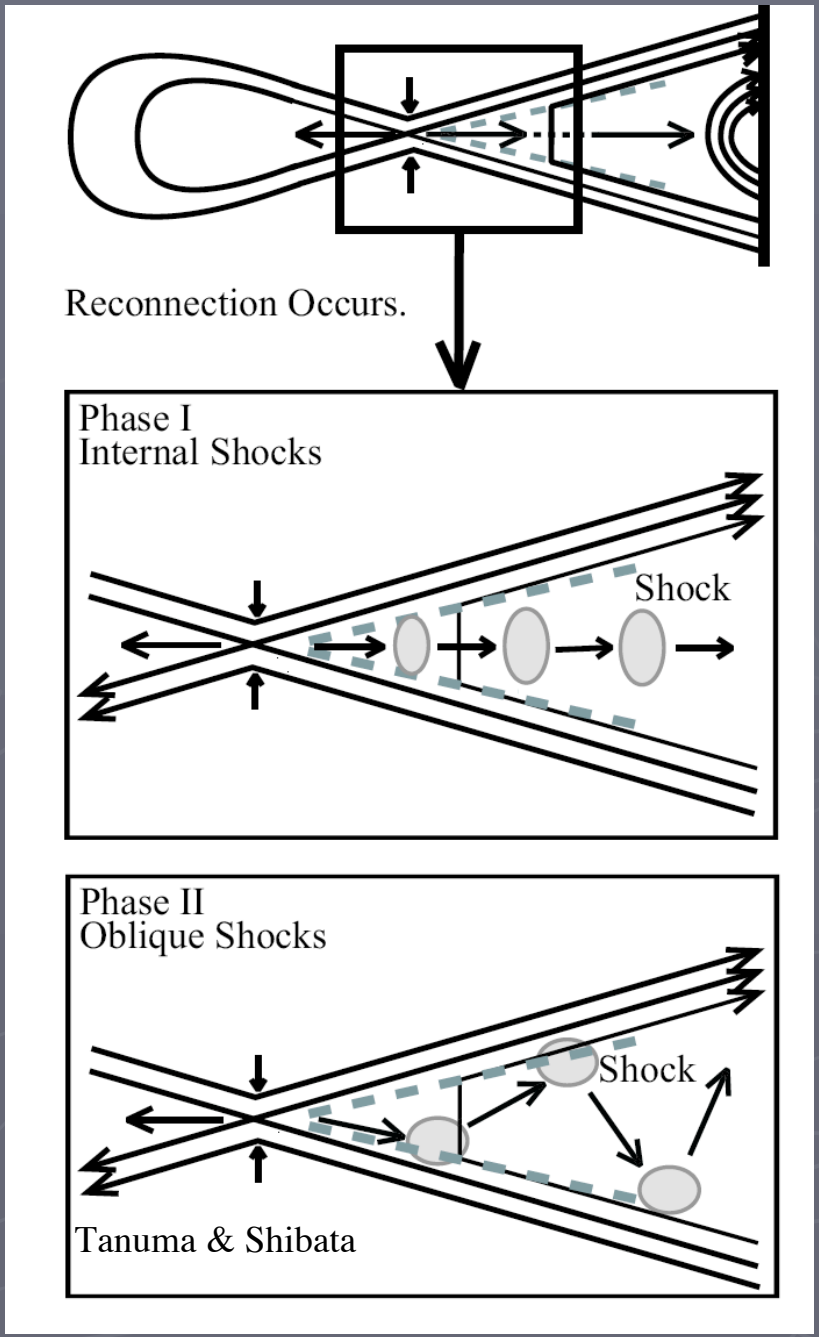
Möbius et al.



Suprthermal material may have solar wind-like Qs

How?

- Modelling flares
  - Shocks in reconnection jet (Tanuma & Shibata)
  - Shocks in flares and orientation (Naito)
  - Shocks in giant arcades (Shiota et al.)



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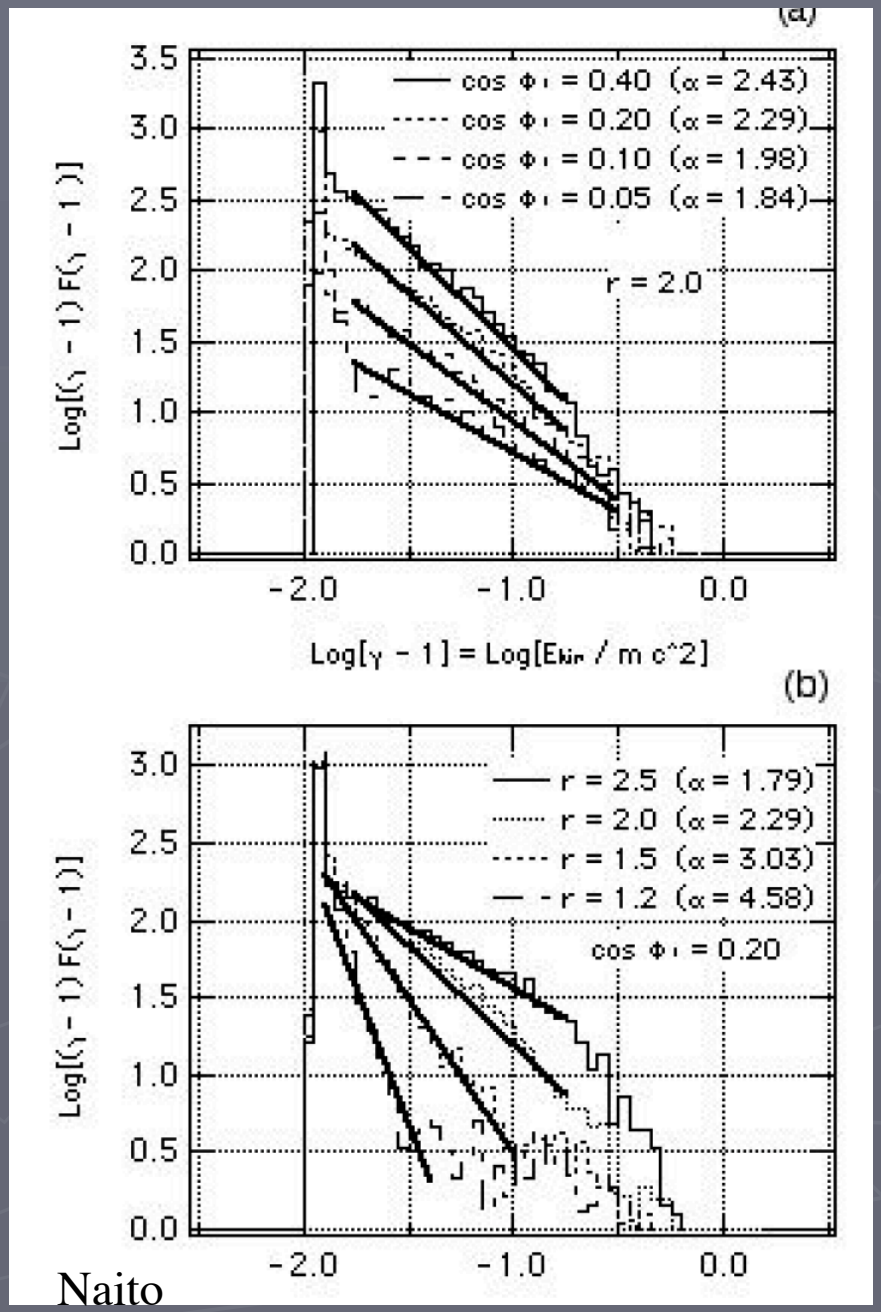
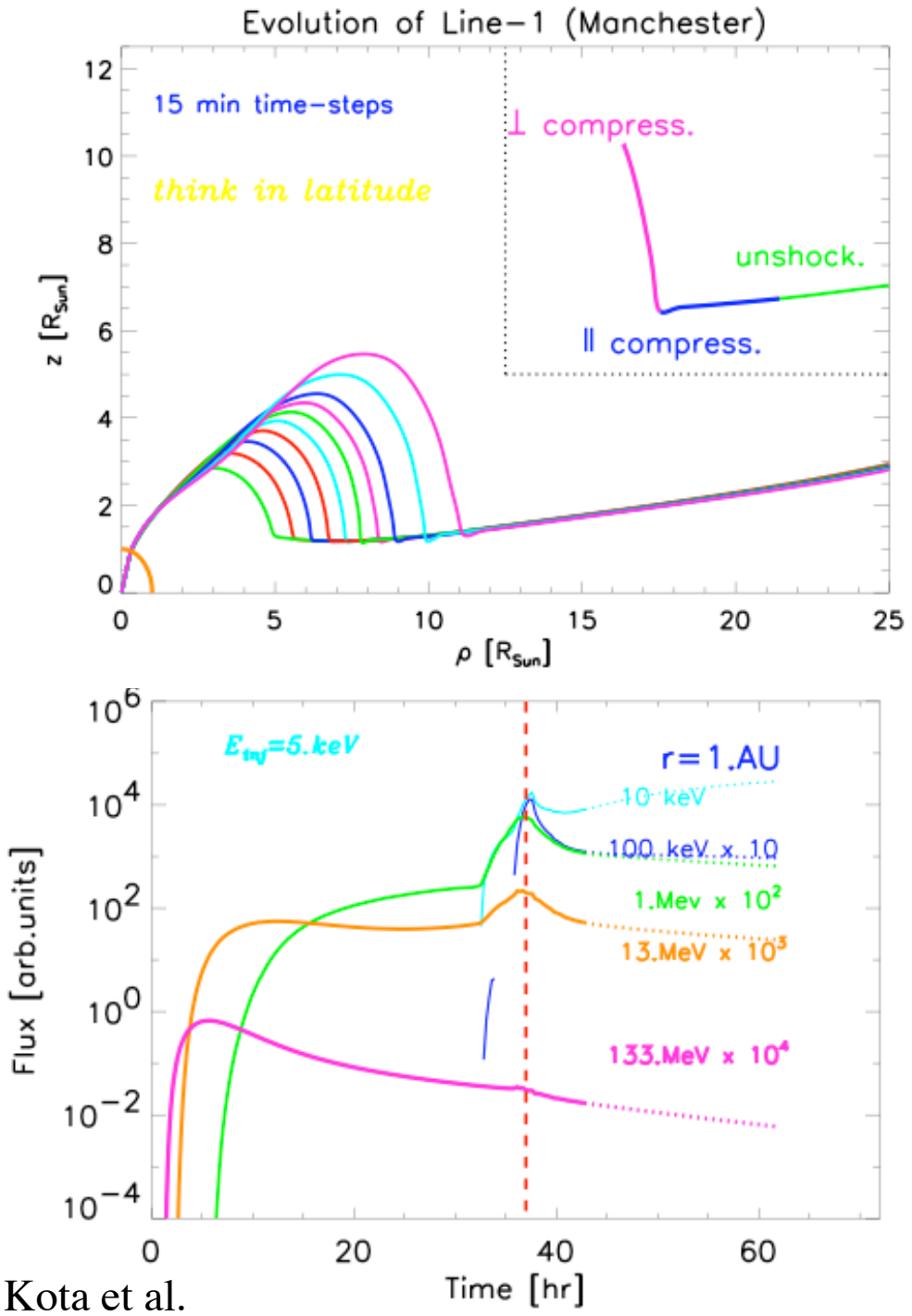


Naito

How?

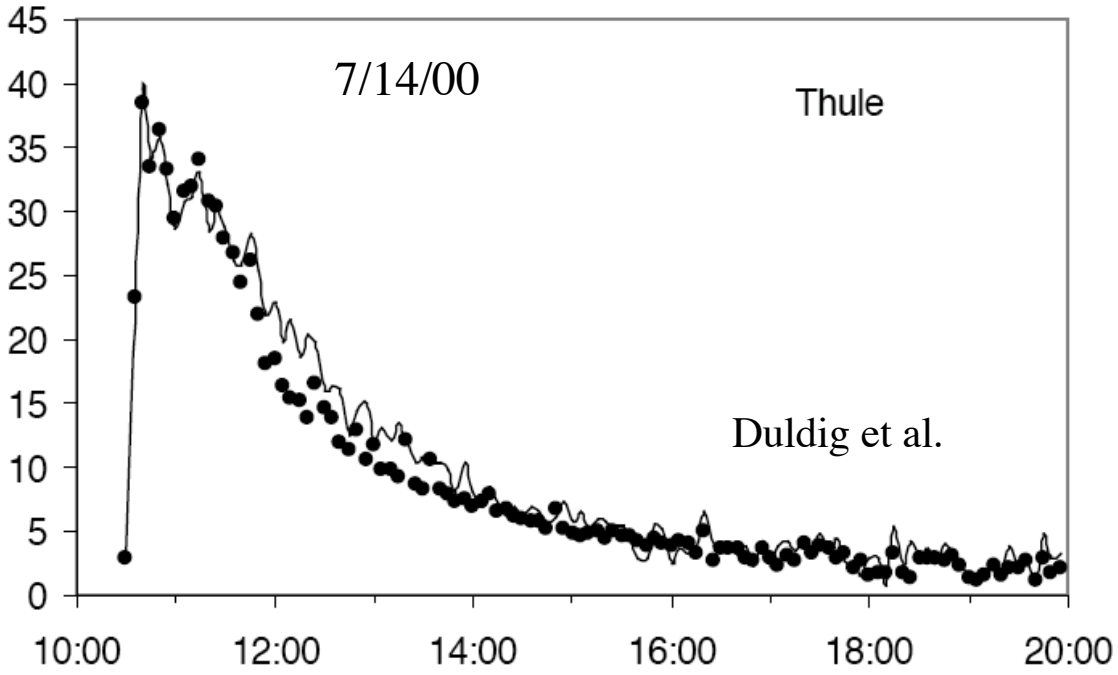
- Modelling flares
  - Shocks in reconnection jet (Tanuma & Shibata)
  - Shocks in flares and orientation (Naito)
  - Shocks in giant arcades (Shiota et al.)
- Modelling CME shocks (Kota et al.)

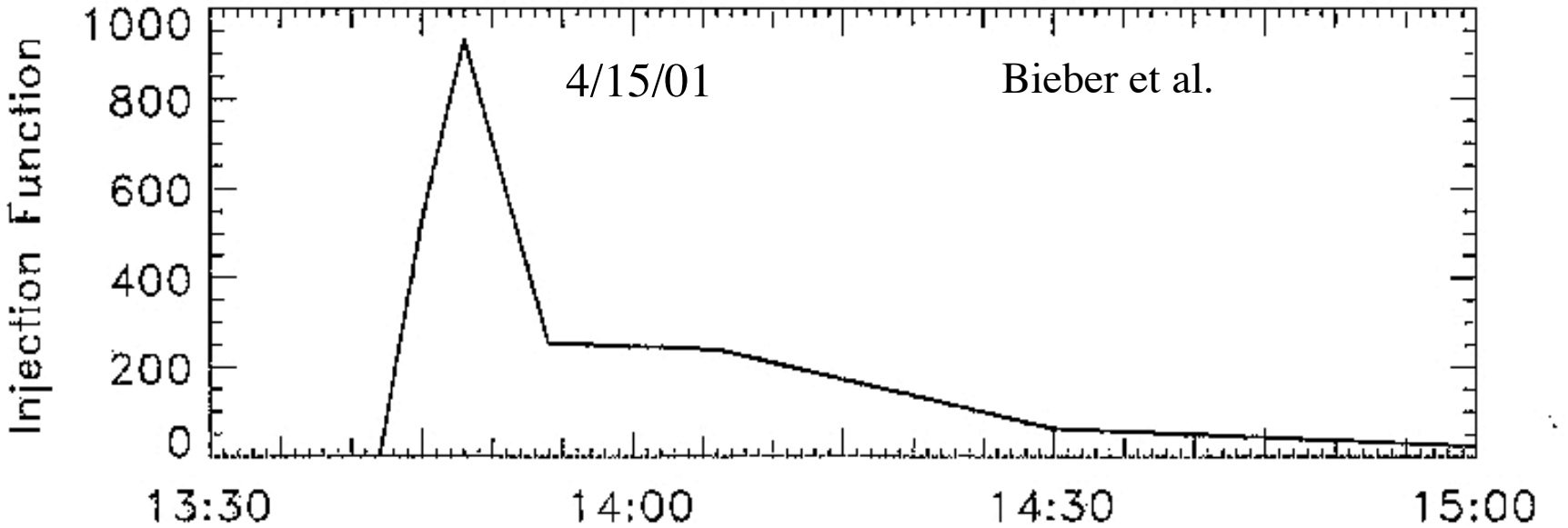


Kota et al.

How?

- Extended Injection
  - NM (Bieber et al., Duldig et al.)
  - >100 MeV H^+ (Struminsky et al.)





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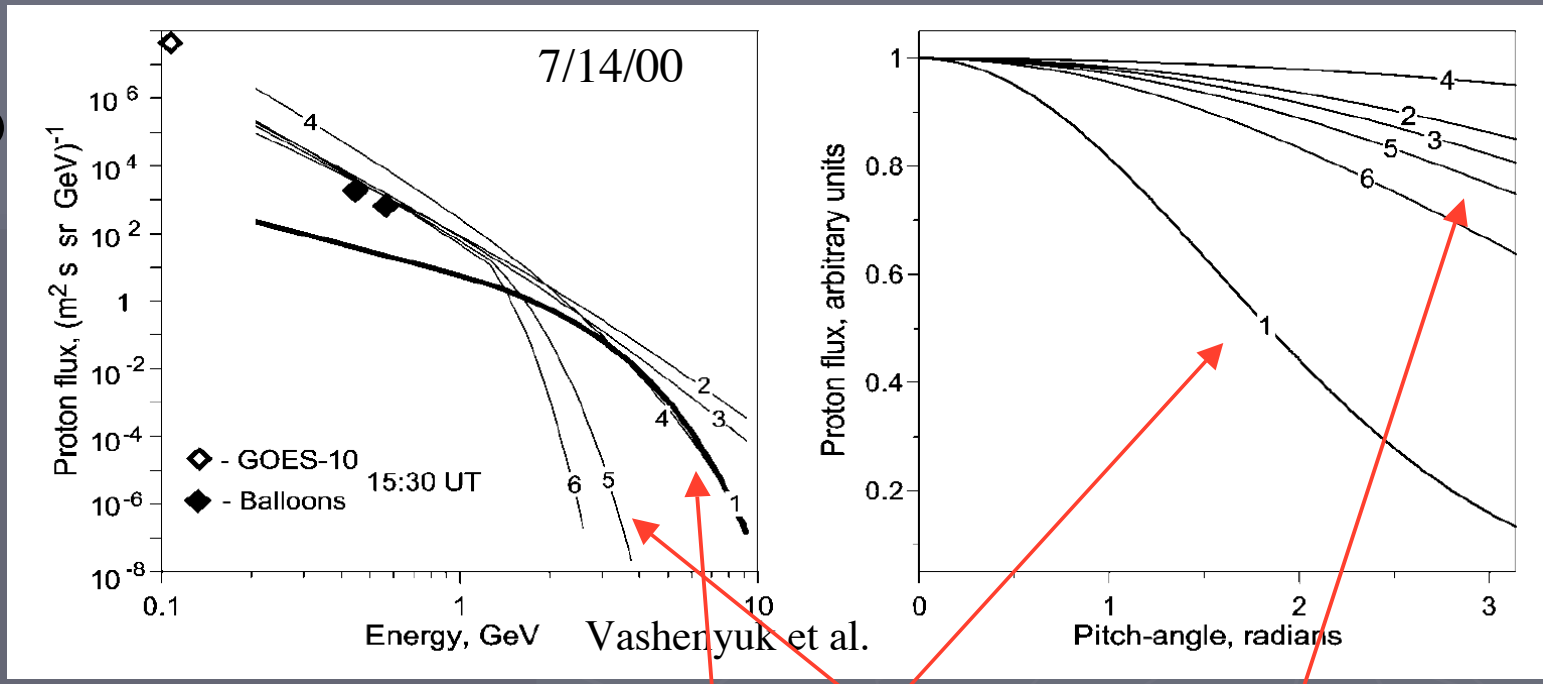


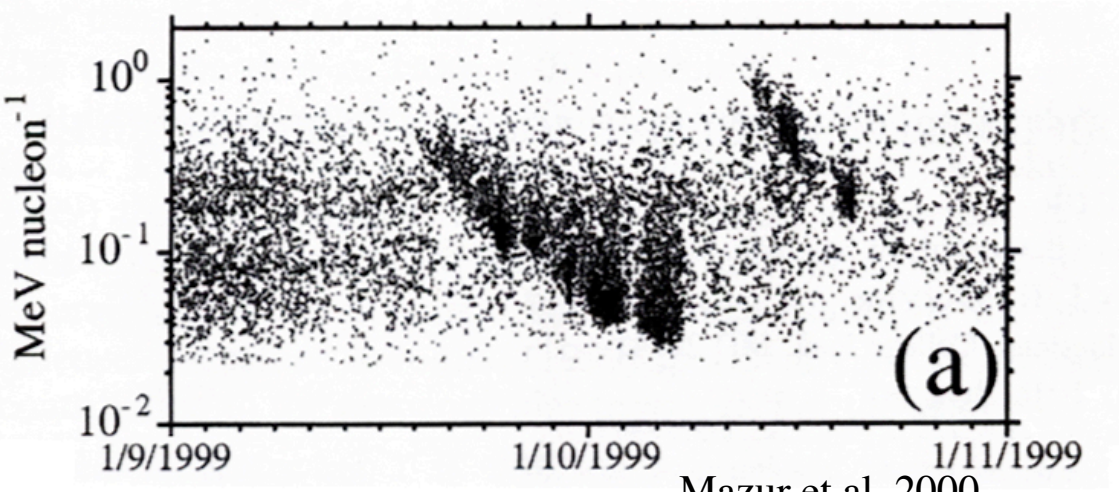
- Transport or acceleration?
  - Delay is getting to connected field line
  - 2 acceleration mechanisms (Vashenyuk et al.)

Prompt - hard, narrow

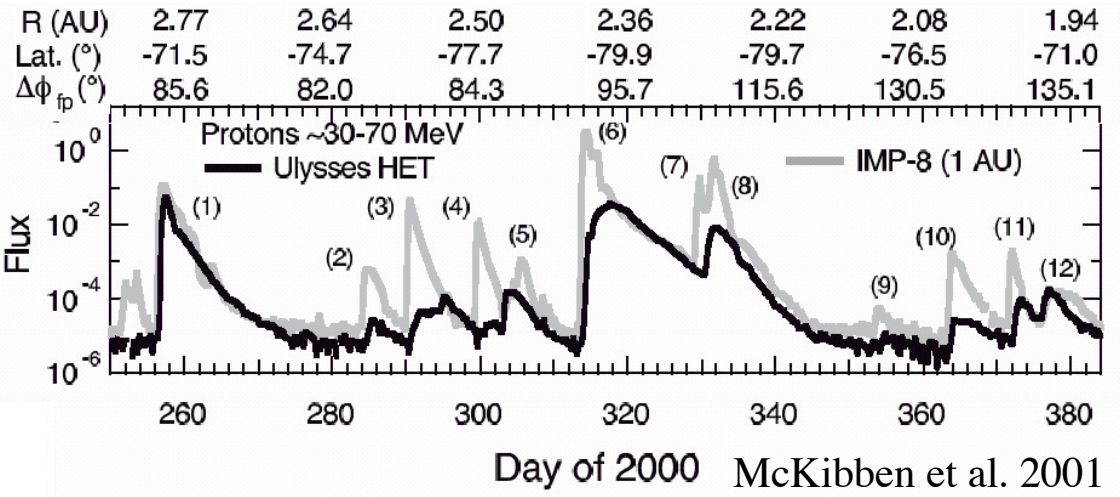
Delayed - soft, broad

Transport

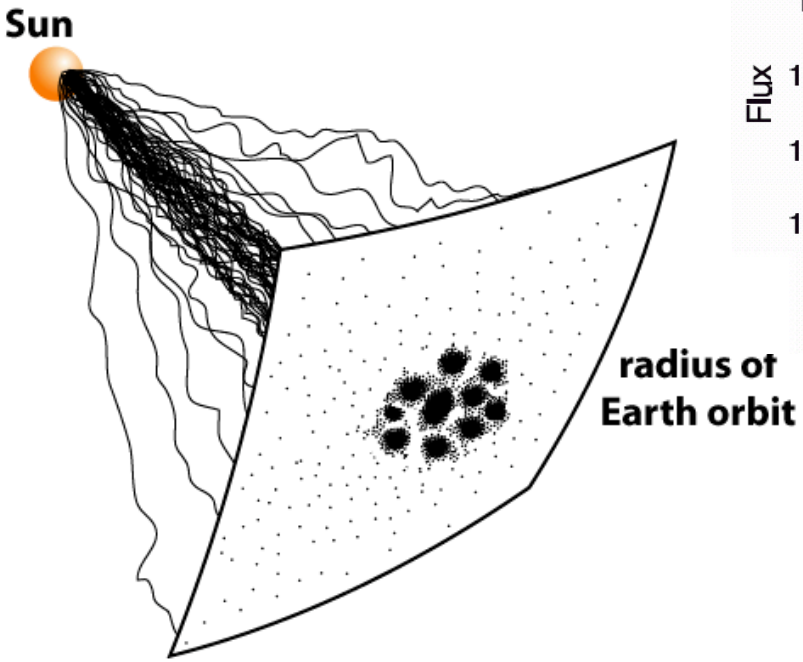
- Field line connection (Chuychai et al.)



Mazur et al. 2000



McKibben et al. 2001

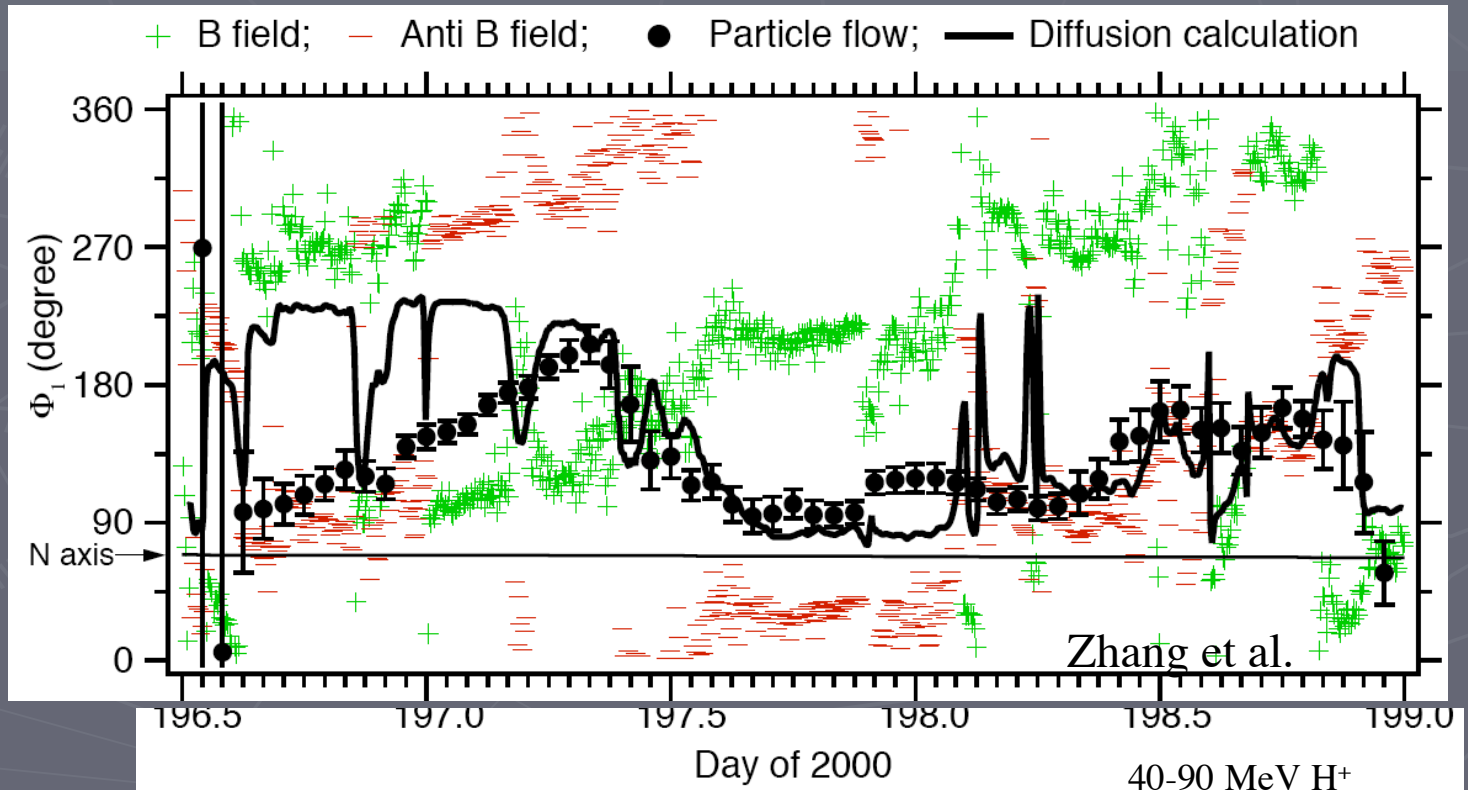


Chuychai et al.

Transport

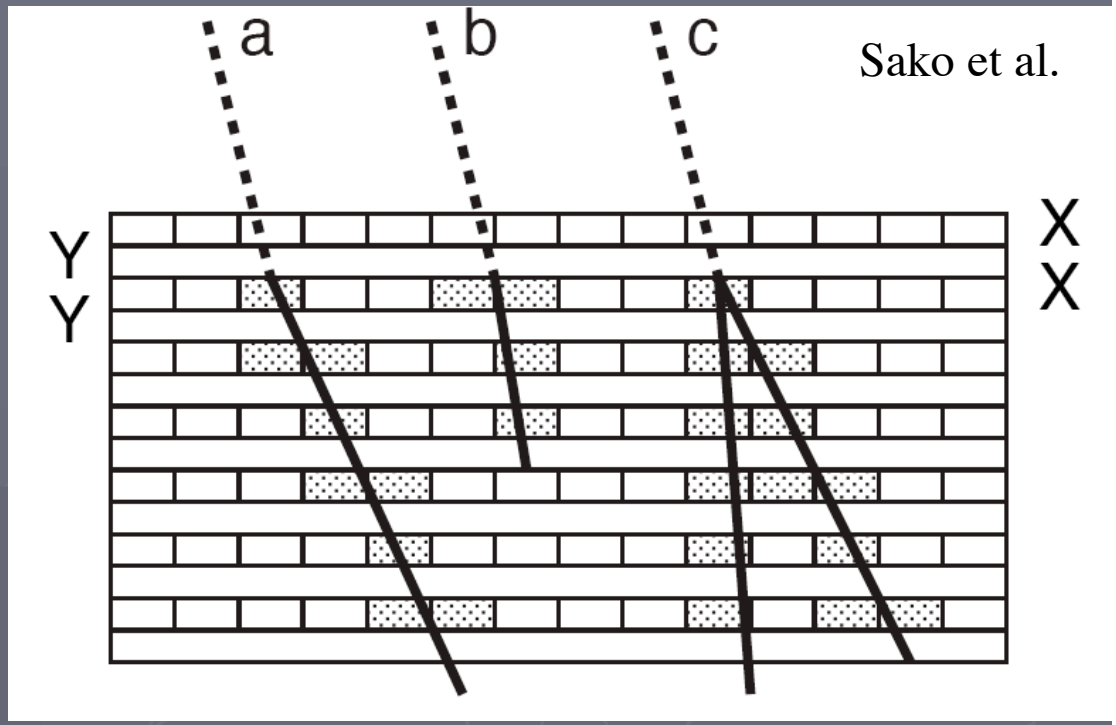
- Field line connection (Chuychai et al.)
- Particle diffusion (Zhang et al.)

Significant cross field diffusion



The Future

- New SNT
  - Mt. Sierra Negra - 19N (Valdes-Galicia et al.)
  - Super SNT (Sako et al.)



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  - Mobile NM (Moraal et al.), RECORD (Ksenotontov et al.)

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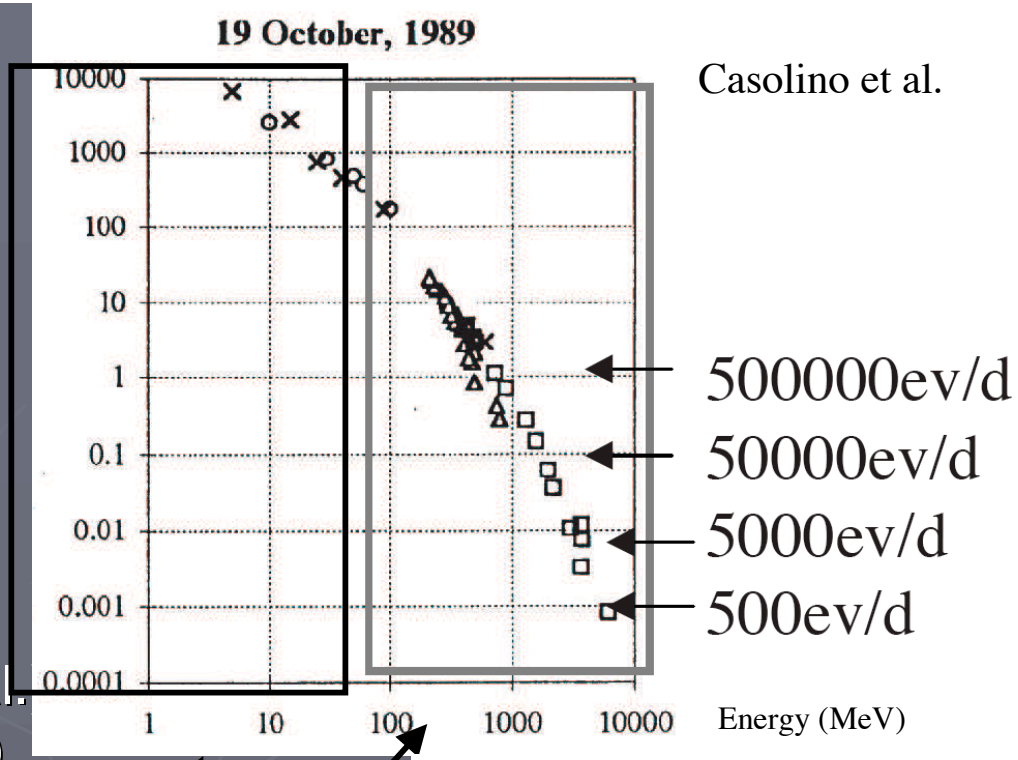
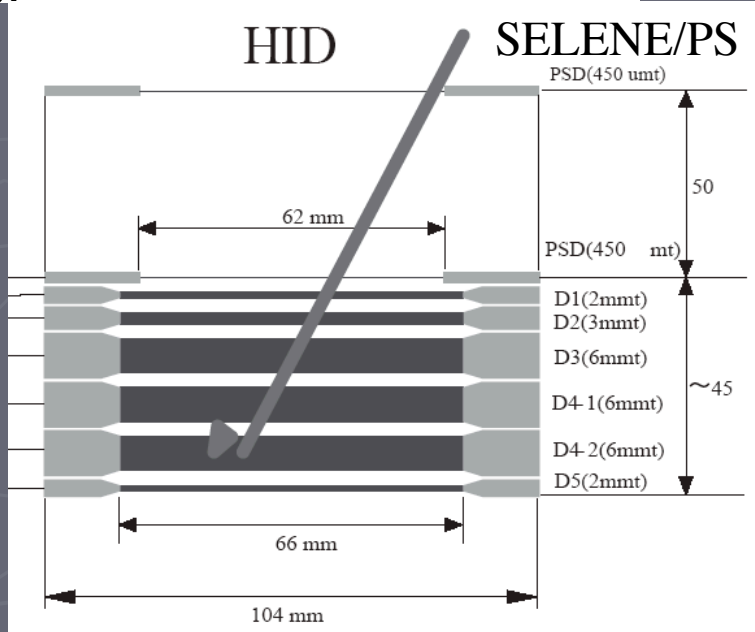
  - Mobile NM (Moraal et al.), RECORD (Ksenotontov et al.)
- Spacecraft Instruments
  - ResursDK1/PAMELA - 2005 (Casolino et al.)
  - SELENE/PS - 2004 (Takashima et al.)



Casolino et al.

3-400 MeV/n Heavies



Takashima et al.