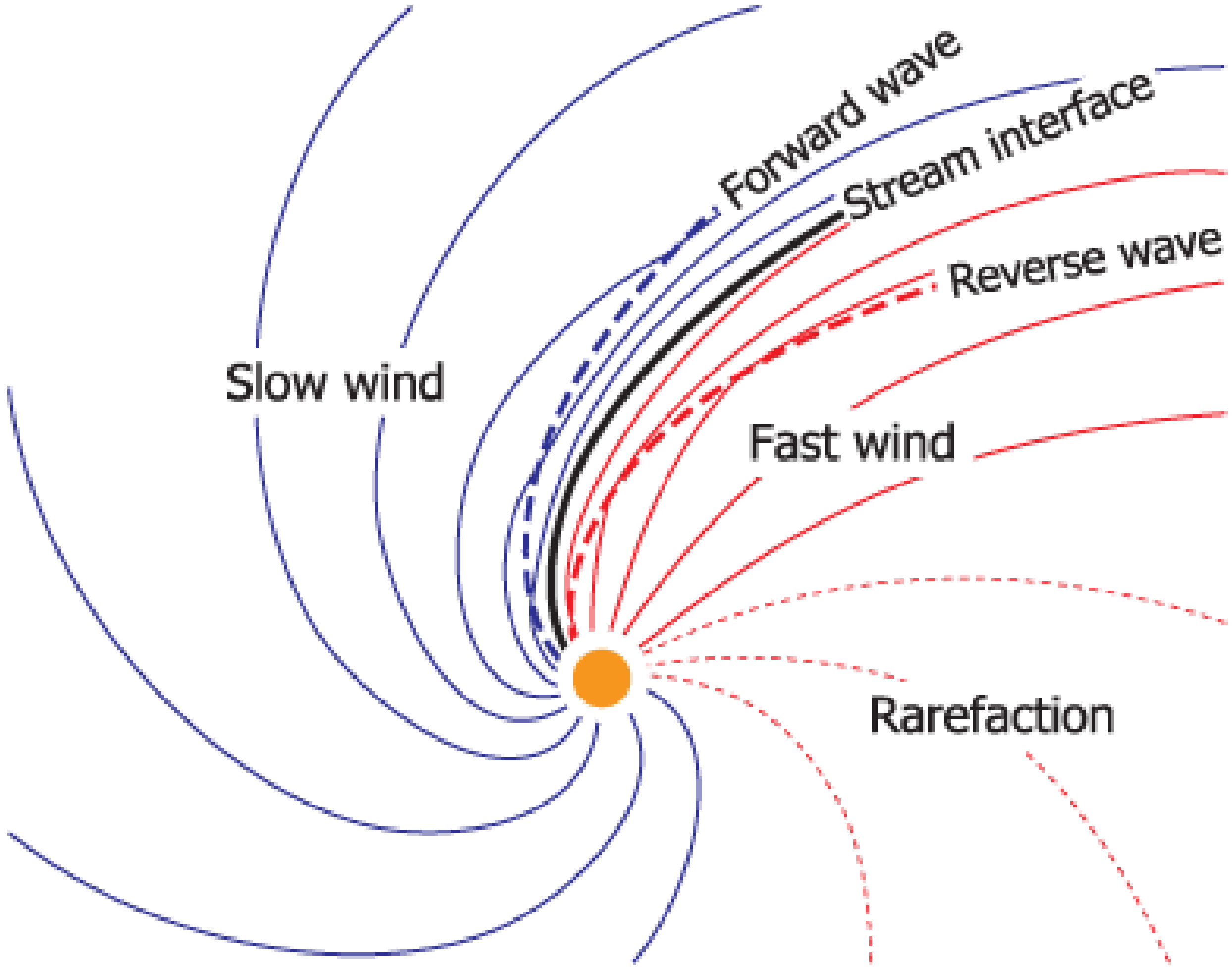
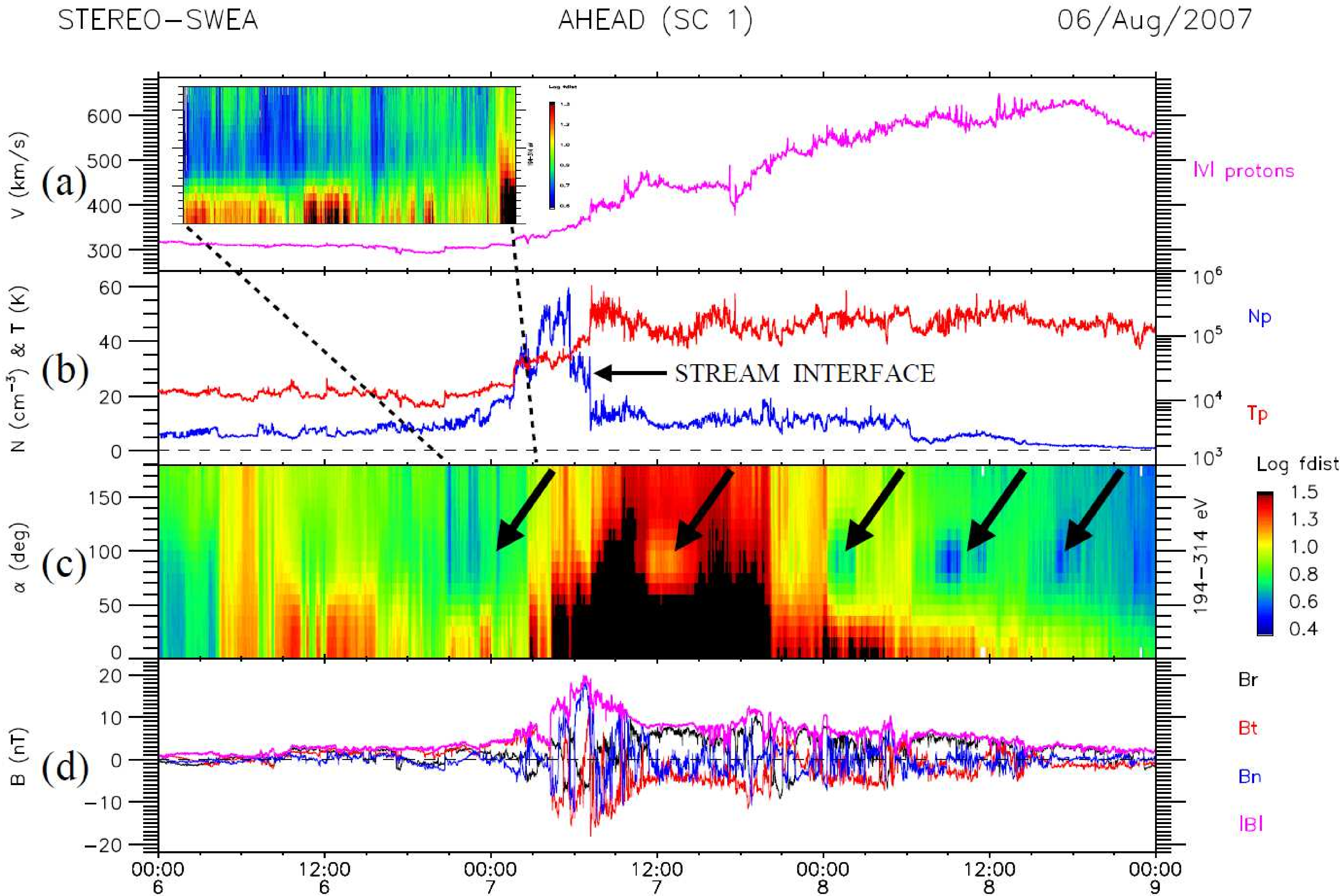
Co-rotating Interaction Region (CIR)



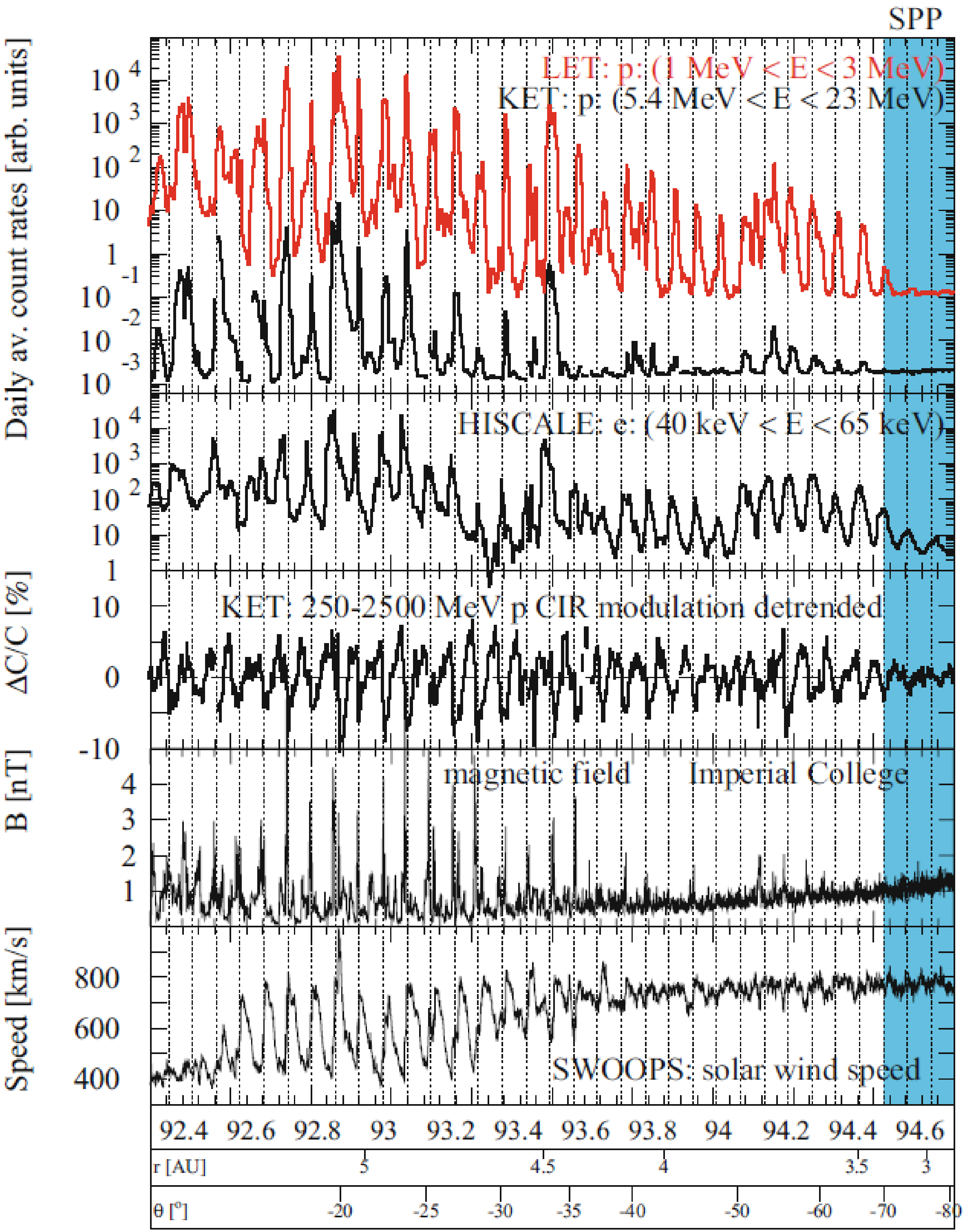
http://solarphysics.livingreviews.org/Articles/lrsp-2013-5/CIR_2panel.png



Lavraud et al. (2010)

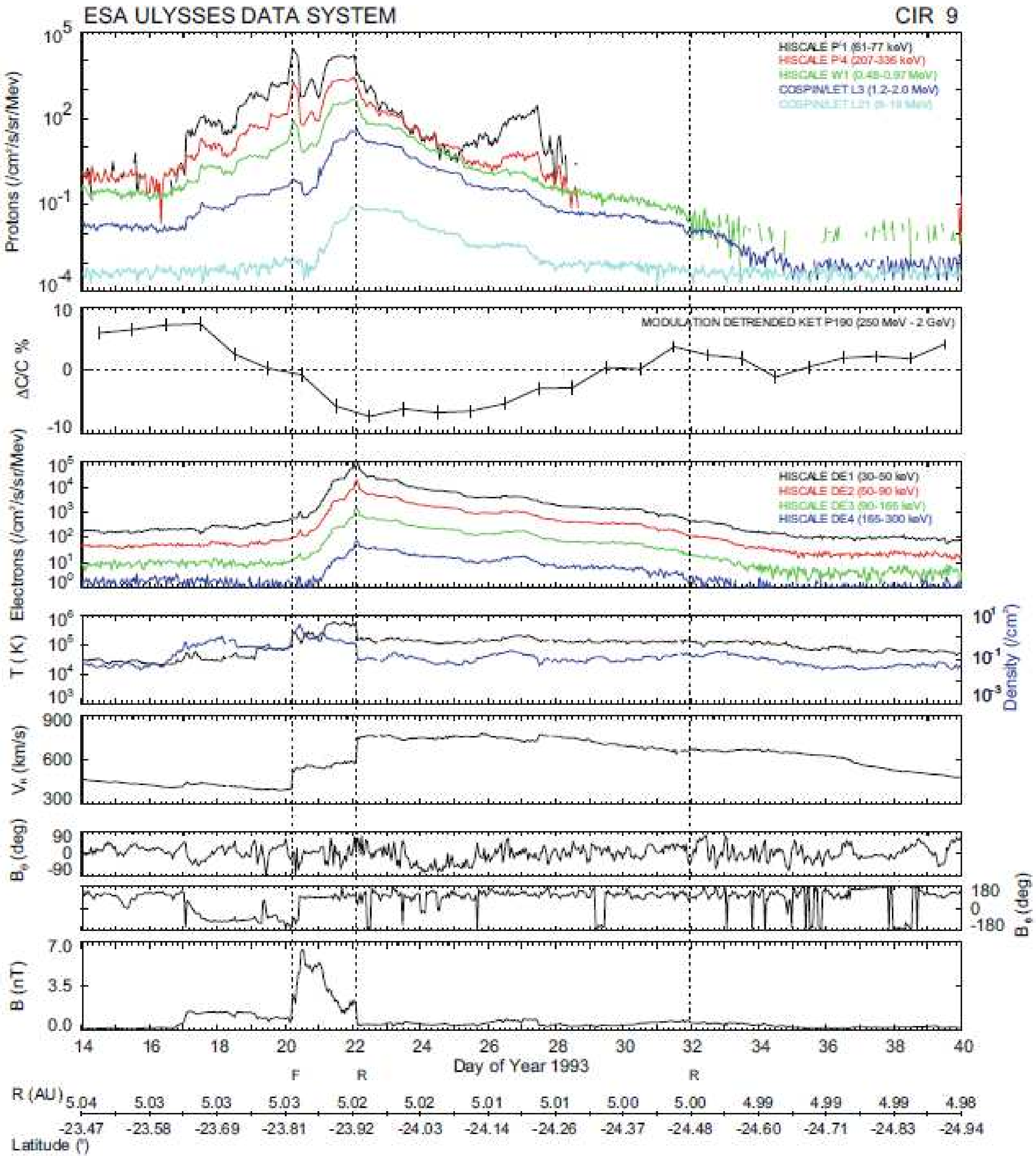
The amplitude of the CIR-induced changes cover almost five orders-of magnitude in intensity at times in the 1–3 MeV region, with similar but less dramatic changes at slightly higher energies.

The CIR-associated increases extend to the highest latitudes reached by Ulysses of just over 80°.



The peaks in the cosmic rays are anti-correlated with the peaks in the solar wind, indicating that the CIRs serve to exclude locally some of the high energy cosmic rays.

Fig. 6.3 (p.124) in Simnett et al. (2017)

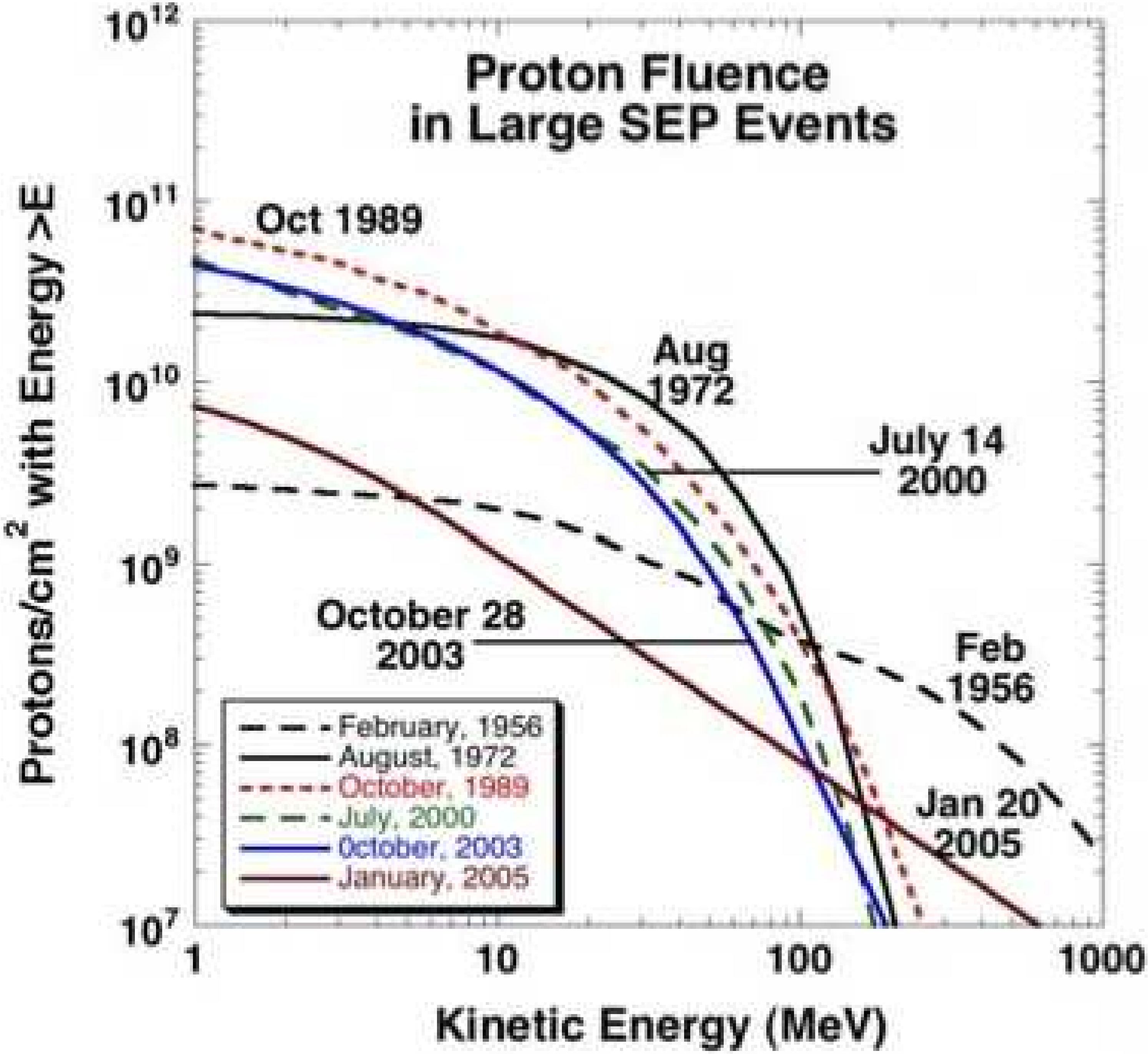


There are maxima in the ion intensity at both shocks. For the electrons, the intensity at the forward shock is little enhanced, but the reverse shock intensity is almost three orders-of-magnitude above the background.

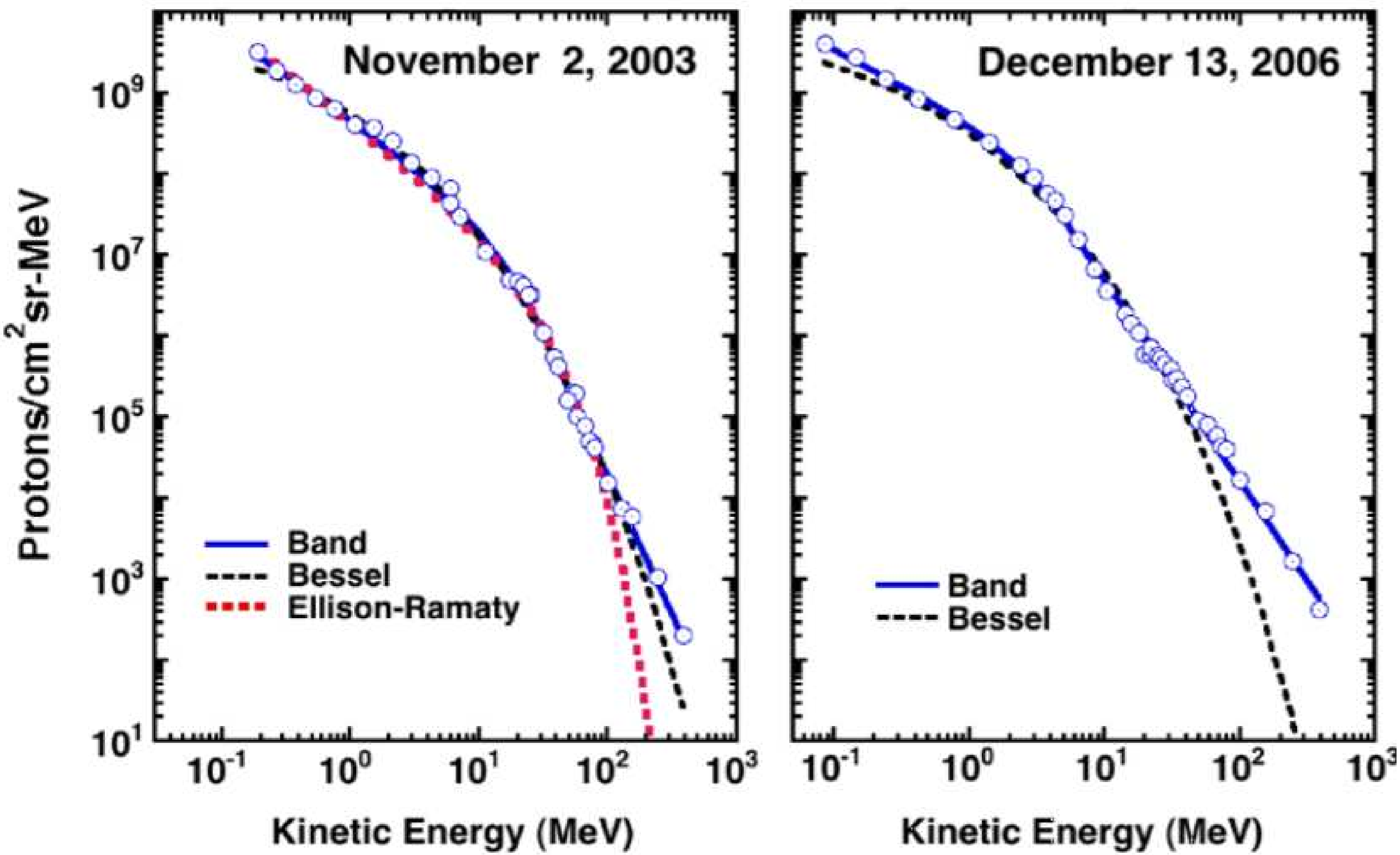
Careful examination reveals that the 1–3 MeV proton intensity tends to fall to the background level faster than the 40–65 keV electrons. In other words, the CIR is more effective in influencing the background electron intensity in the whole of the inner heliosphere than it is for the protons.

The CIR is effective in modulating the galactic cosmic rays, which are plotted in the second panel.

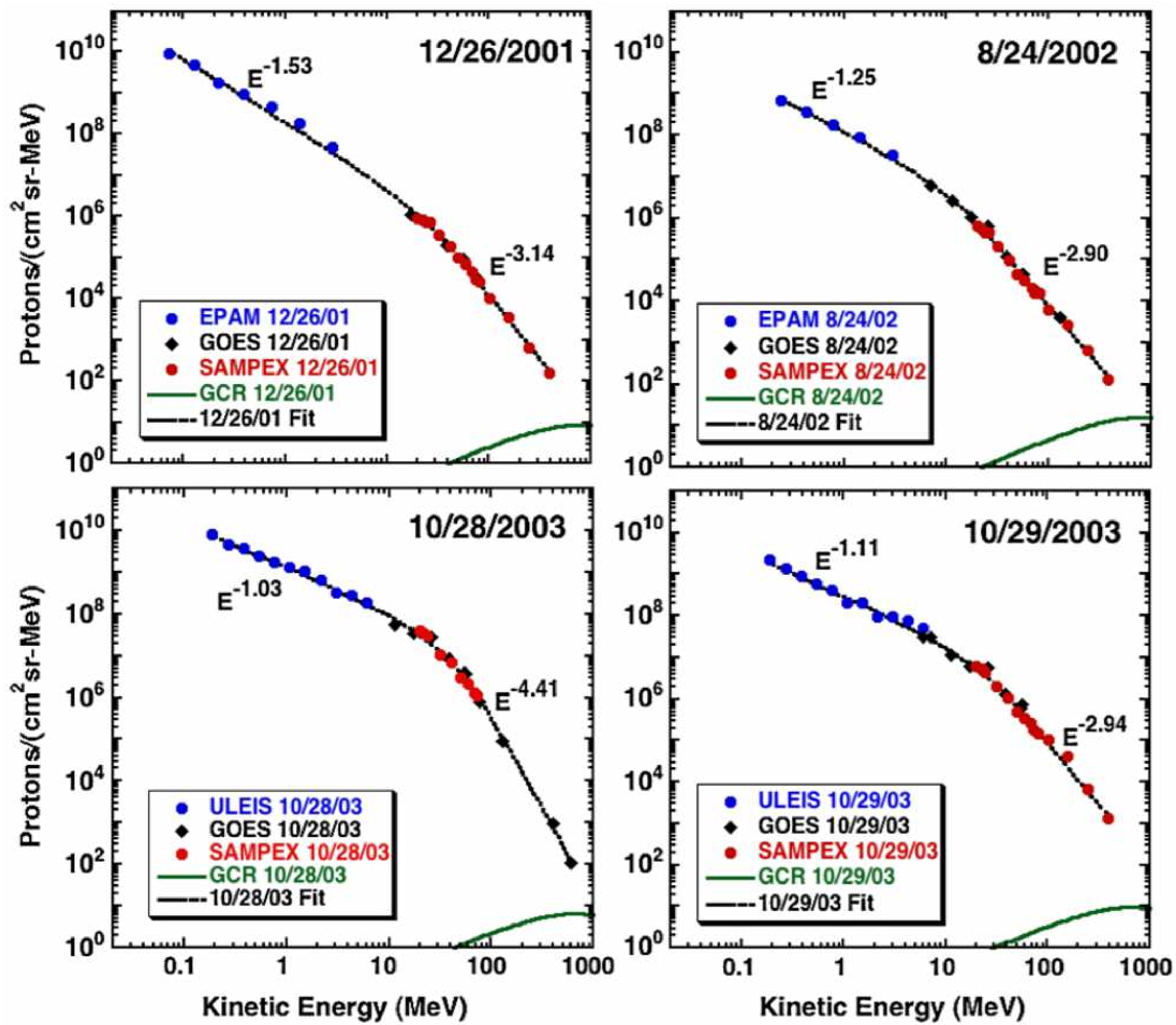
Fig. 6.4 (p.126) in Simnett et al. (2017)



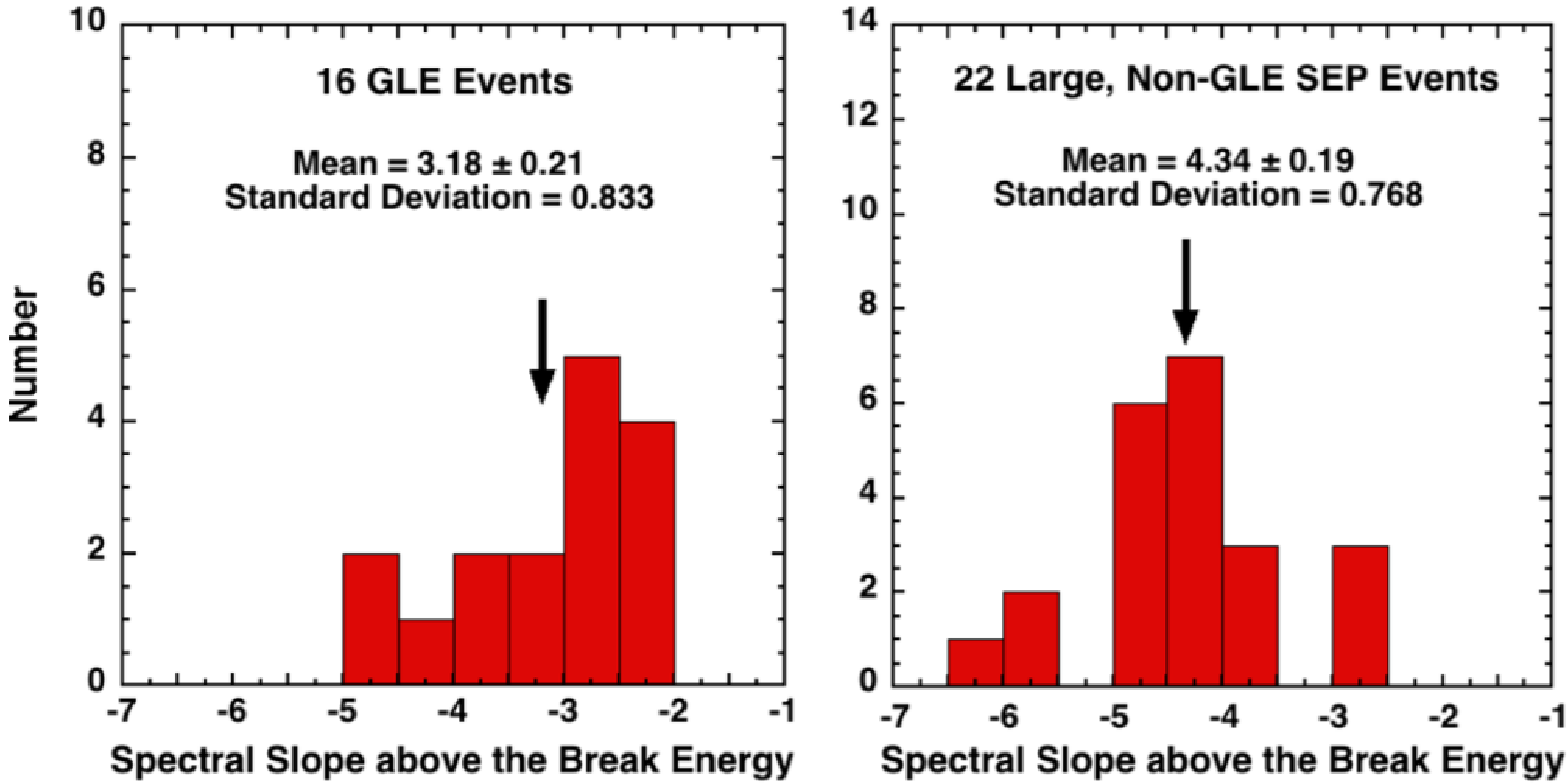
http://www.sciencedirect.com/science/article/pii/S0094576514003798



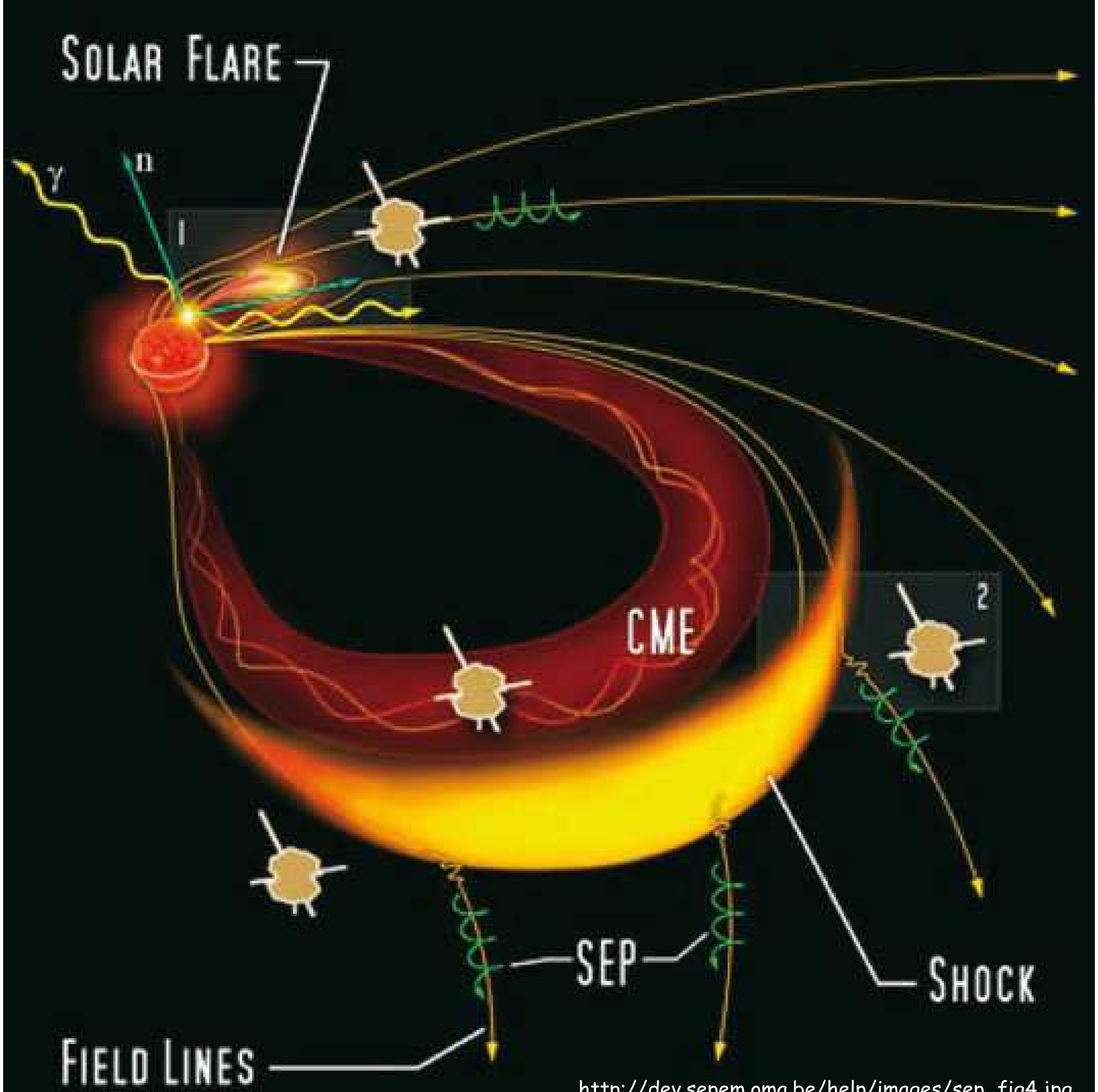
Mewaldt et al. (2012)



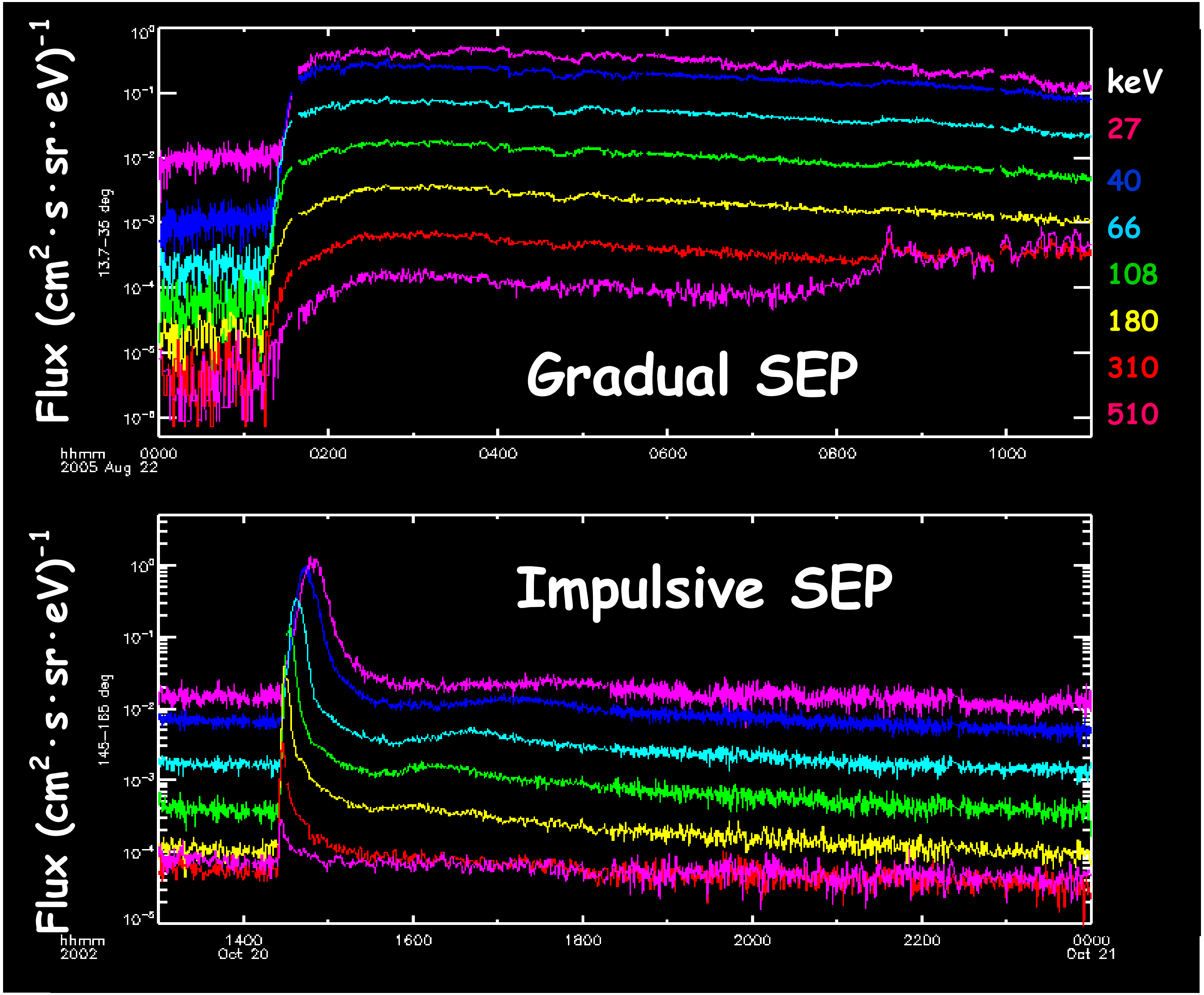
Mewaldt et al. (2012)



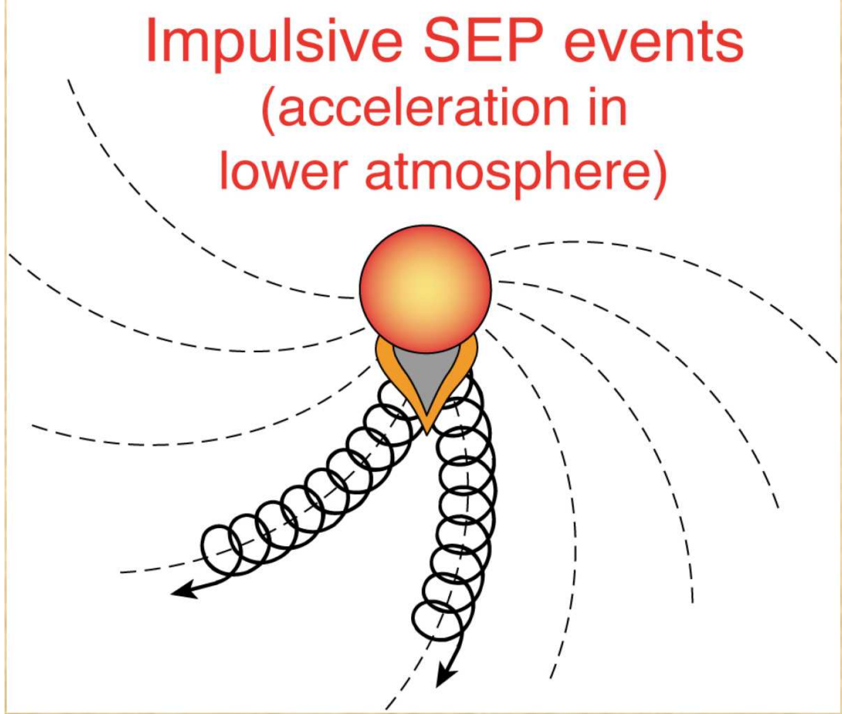
Mewaldt et al. (2012)

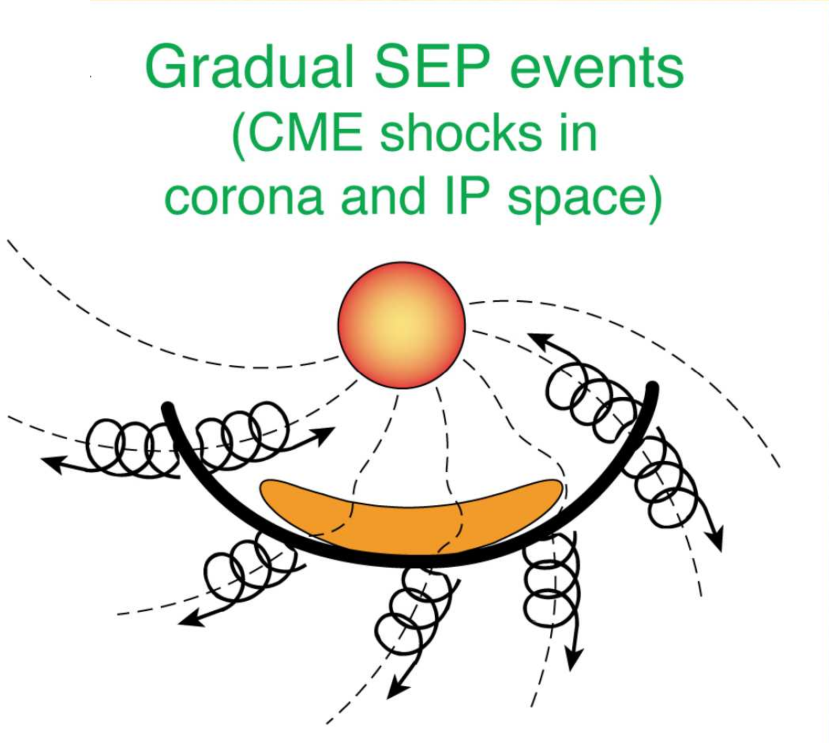


http://dev.sepem.oma.be/help/images/sep_fig4.jpg



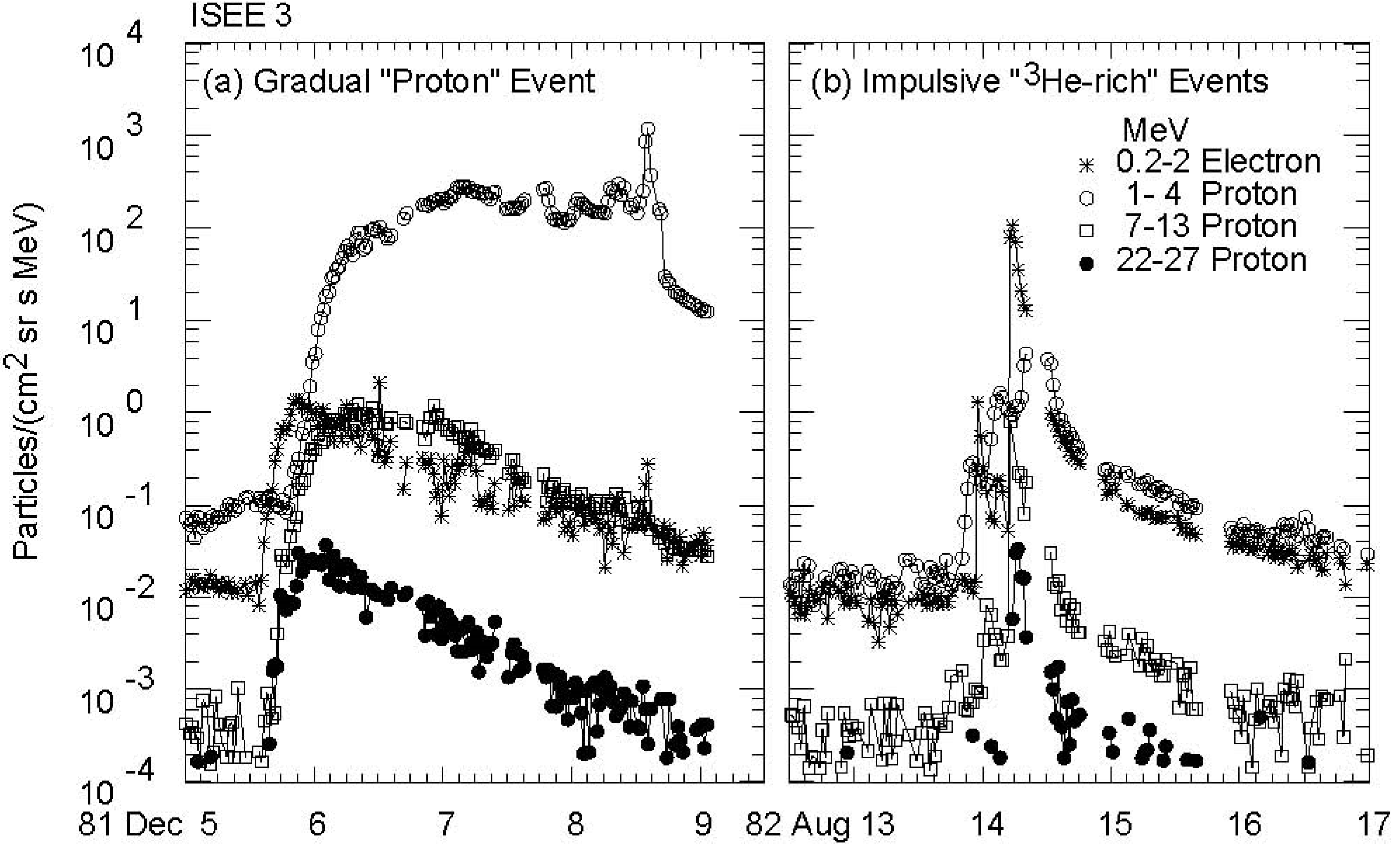
Gang Li in 2014 iSWWS



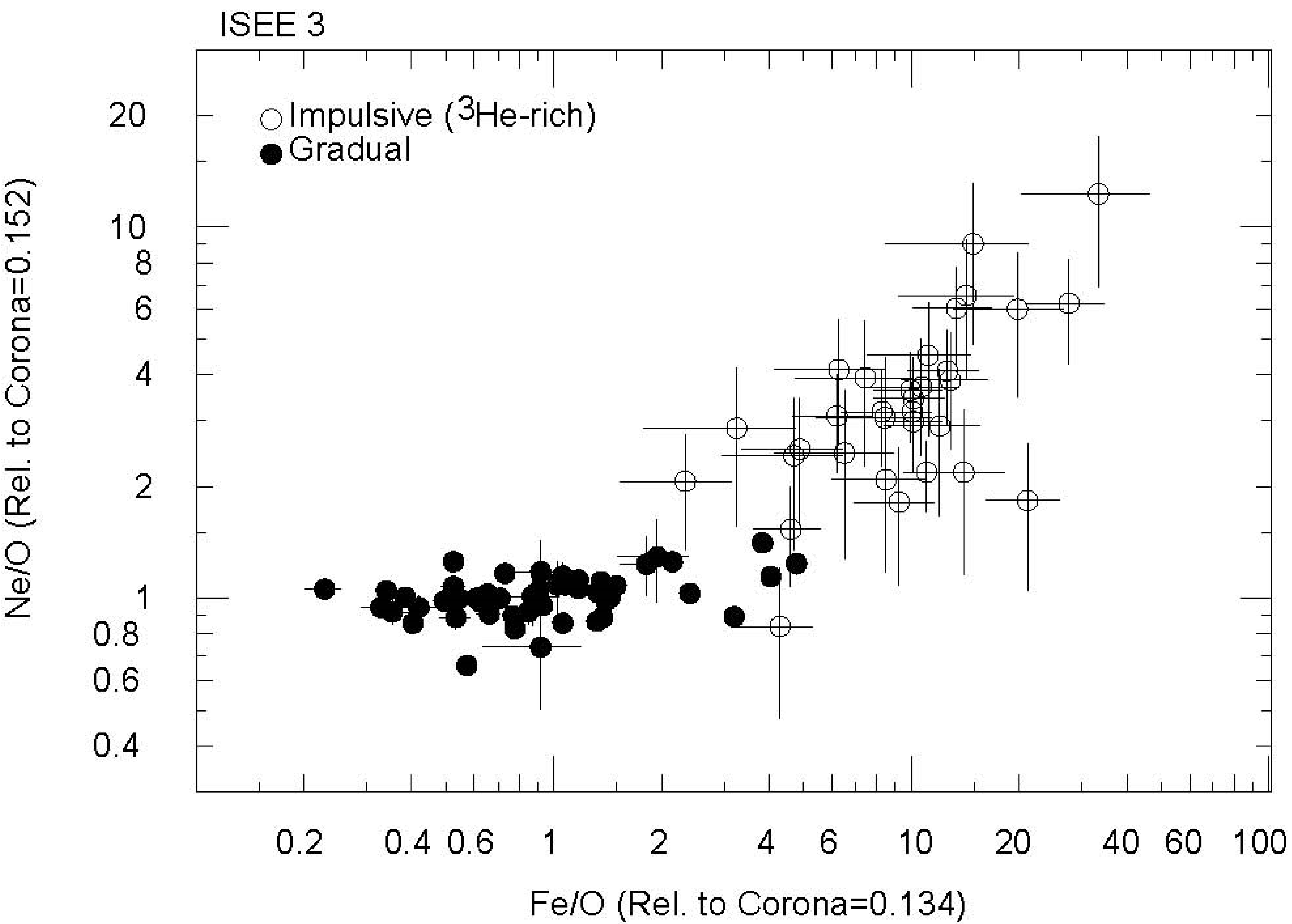


	IMPULSIVE	GRADUAL
PARTICLES:	ELECTRON-RICH	PROTON-RICH
$^3He/^4He$	~1	~0.0005
Fe/O	~1	~0.1
H/He	~10	~100
Q_{Fe}	~20	~14
DURATION	HOURS	DAYS
LONGITUDE CONE	<30°	~180°
RADIO TYPE	III, V(II)	II, IV
X-RAYS	IMPULSIVE	GRADUAL
CORONAGRAPH	---	CME
SOLAR WIND	---	IP SHOCK
EVENTS/YEAR	~1000	~10

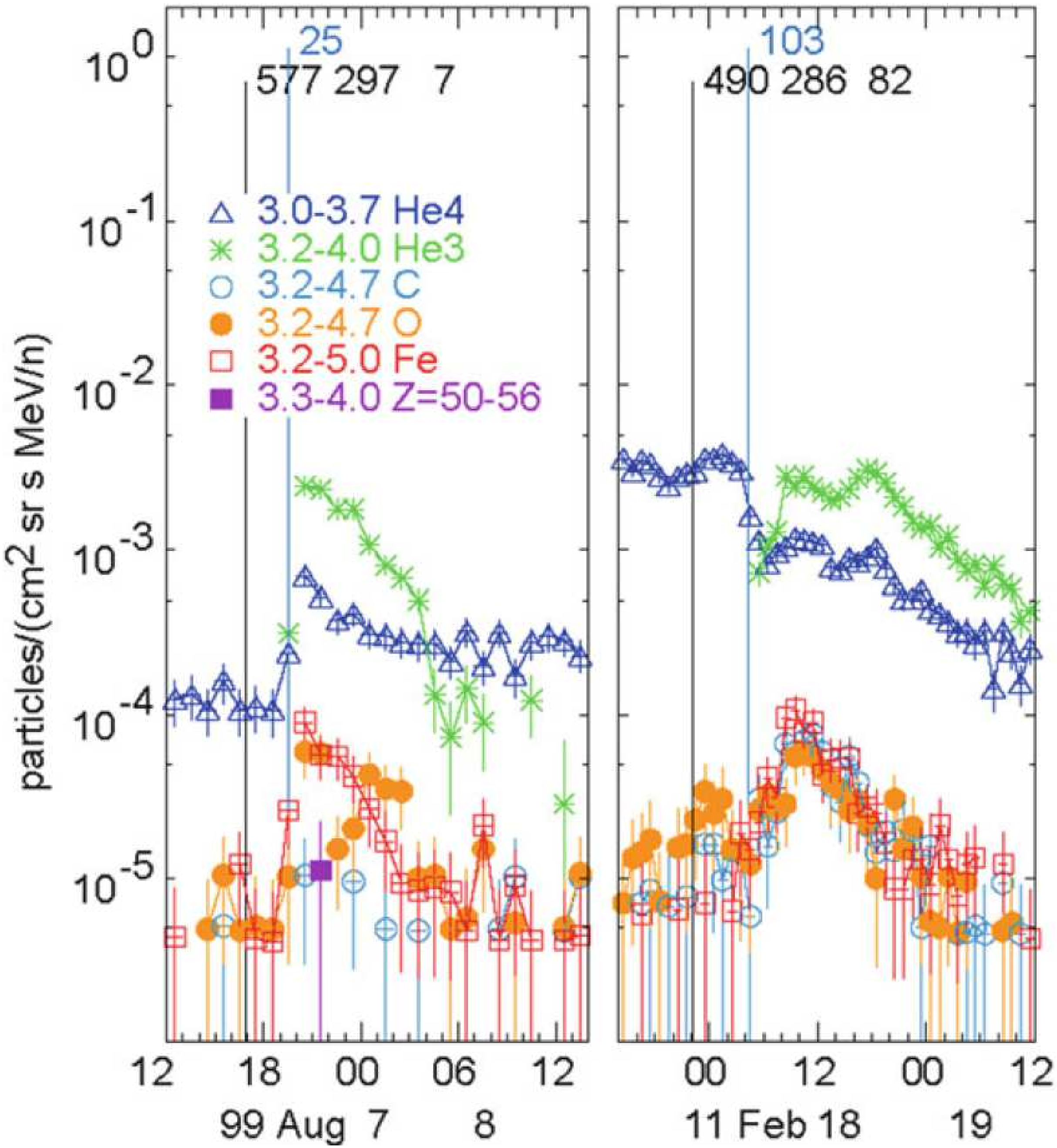
Gang Li in 2014 iSWWS


ISEE 3
(a) Gradual "Proton" Event
(b) Impulsive "3He-rich" Events
MeV
0.2-2 Electron
1- 4 Proton
7-13 Proton
22-27 Proton
Particles/(cm2 sr s MeV)
10 4
10 3
10 2
10 1
10 0
10 -1
10 -2
10 -3
10 -4
81 Dec 5
6
7
8
9
82 Aug 13
14
15
16
17

Reames (1999)

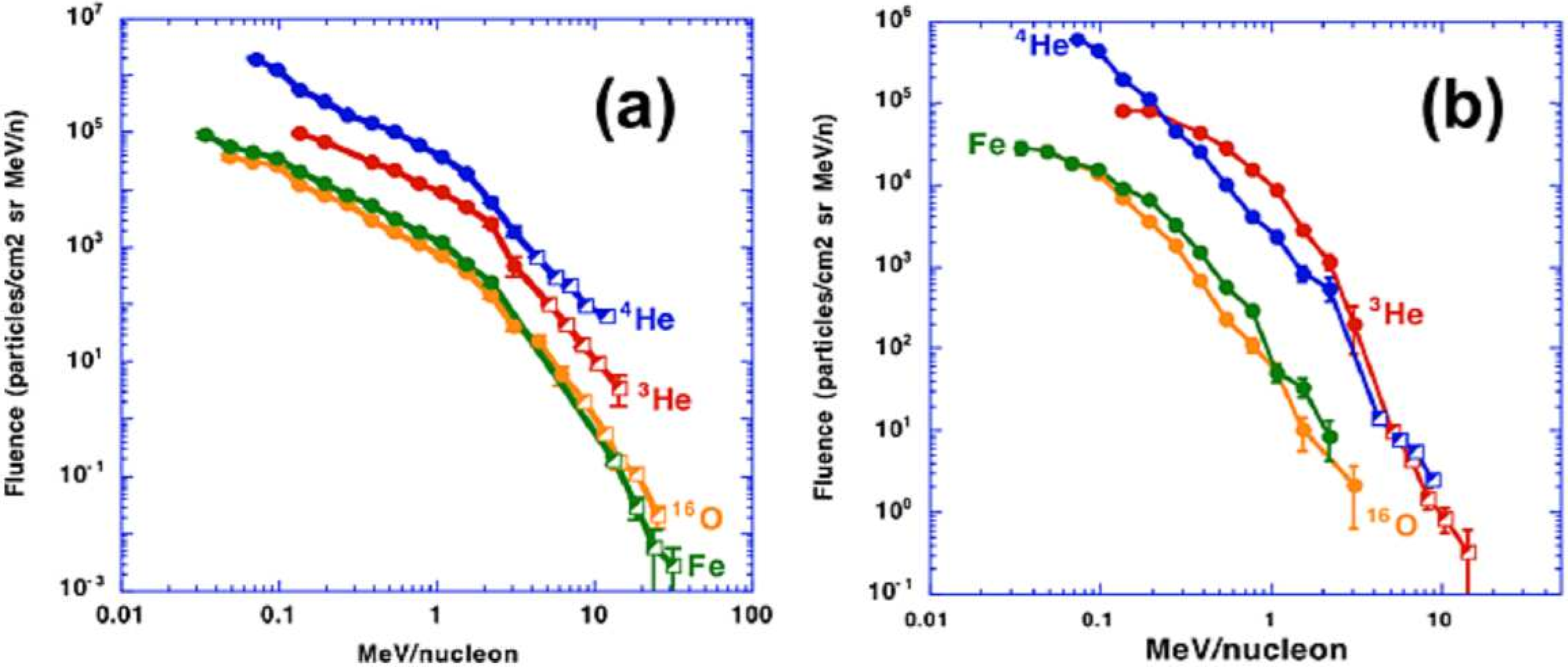

ISEE 3
Impulsive (3He-rich)
Gradual
20
10
8
6
4
2
1
0.8
0.6
0.4
Ne/O (Rel. to Corona=0.152)
0.2
0.4
0.6
1
2
4
6
10
20
40
60
100
Fe/O (Rel. to Corona=0.134)

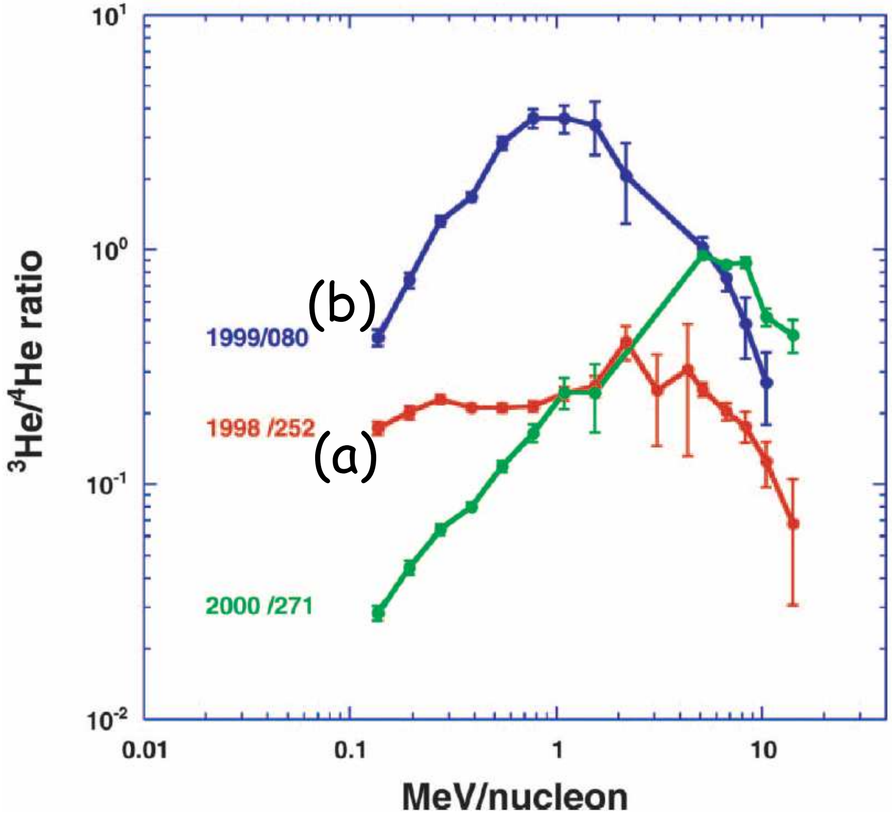
Reames (1999)



$^{3}He/^{4}He$ ratio is ~5×10^{-4} in solar wind, but can be >1 in impulsive SEP events. These two events have event-averaged Fe/O=1.24±0.28 and 1.34±0.20, compared with the reference value of 0.131±0.006.

Reames (2017)

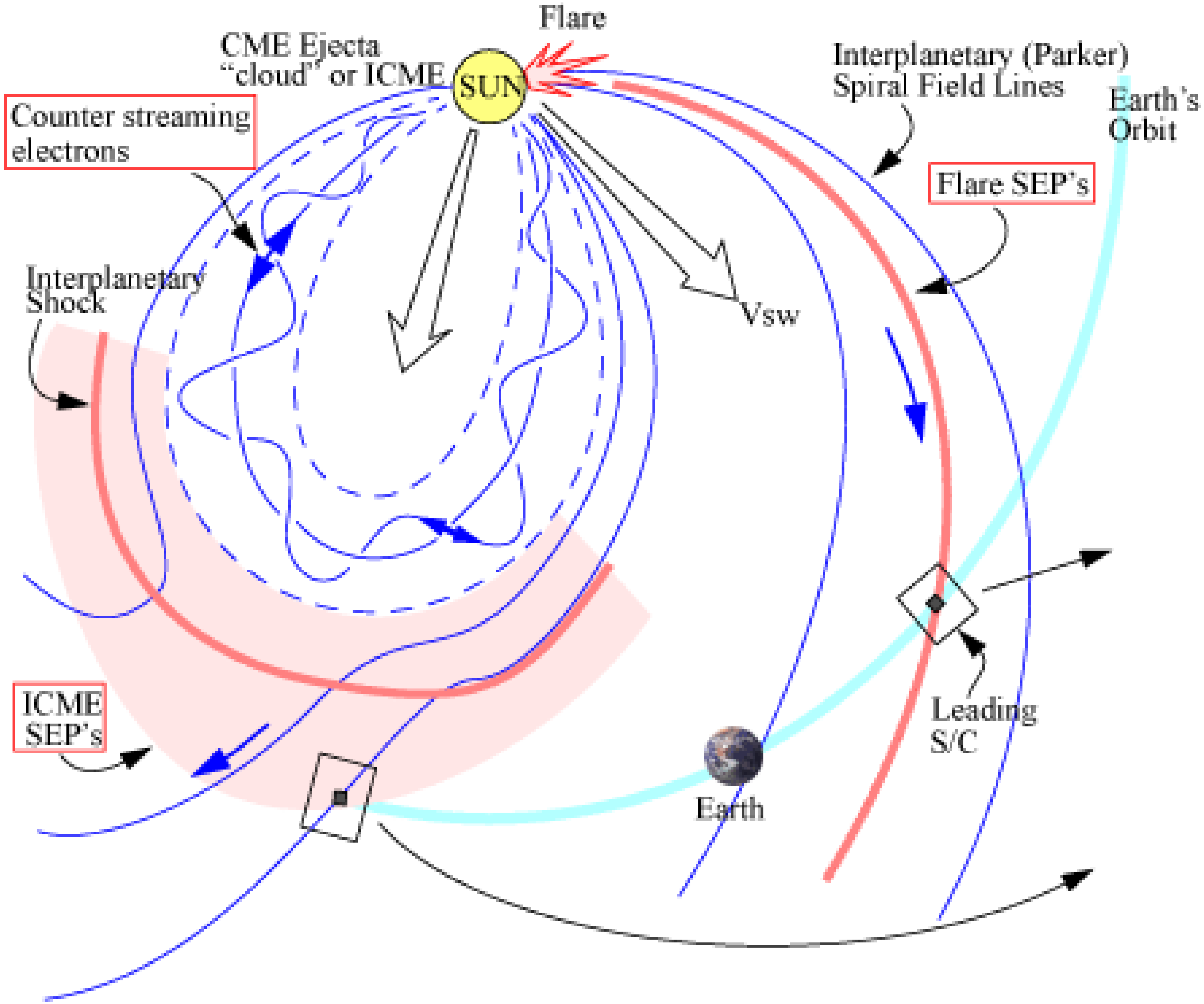




→ The ^{3}He/^{4}He variations make it difficult to characterize an impulsive event.

→ Fe/O at a few MeV amu is a better alternative for defining impulsive events.

Mason (2007)



http://helio-vo.eu/images/science_of_impact_c.gif

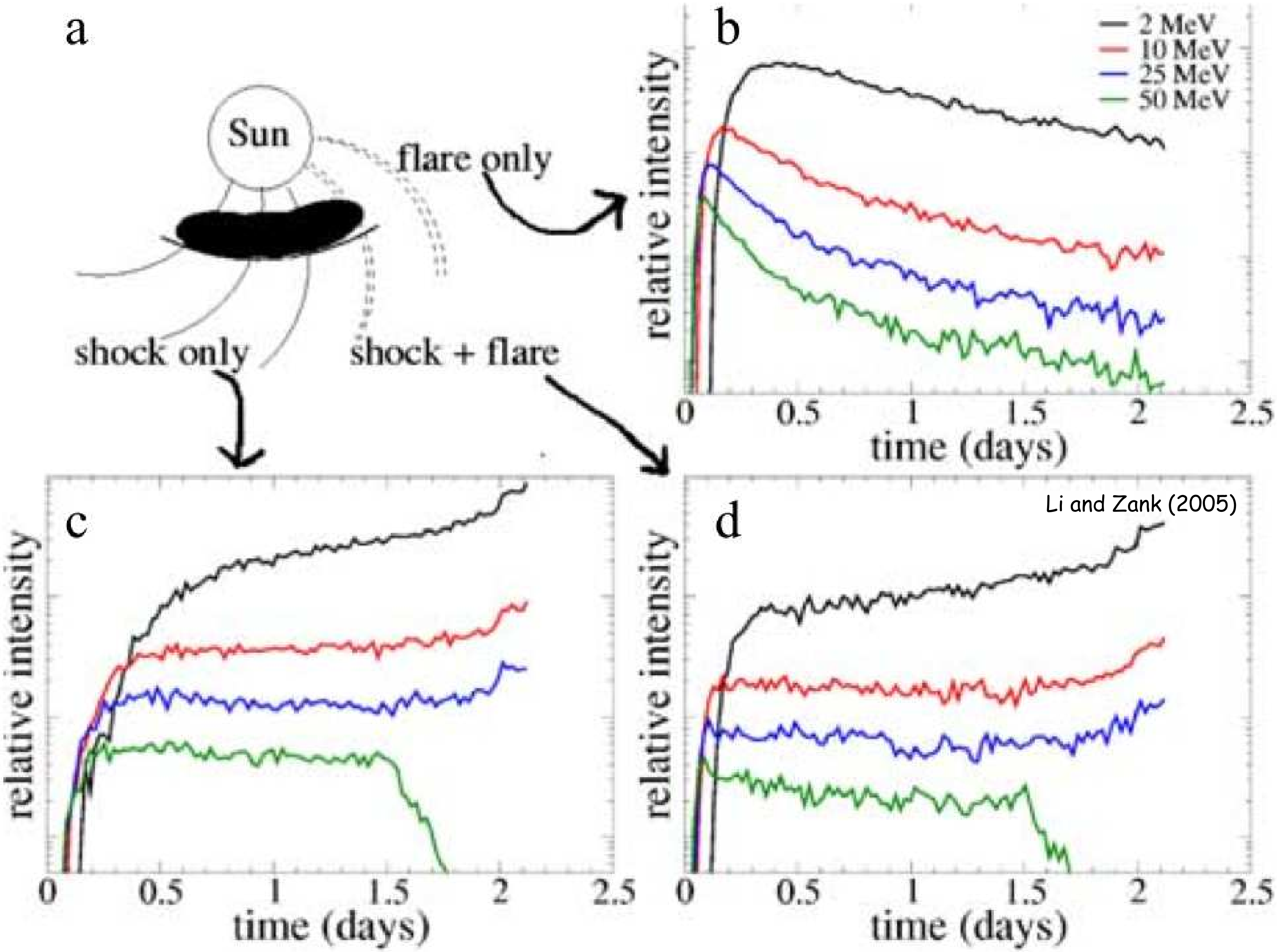
Plasma in the 400 km/s solar wind takes 4.3 days to travel 1 AU.

A shock wave with an average speed of 1700 km/s takes 1 day.

A 10 MeV proton or a 5 keV electron takes an hour.

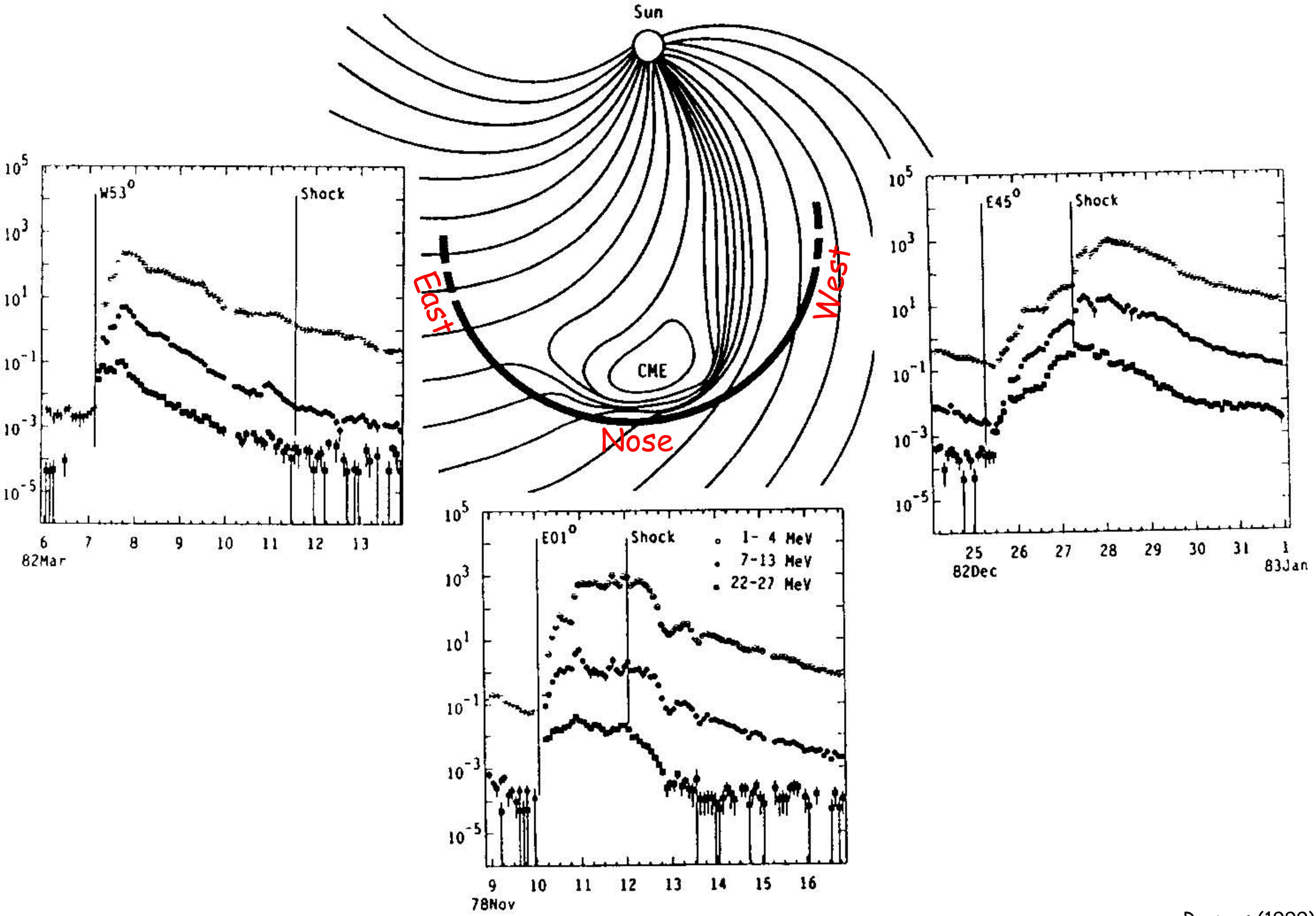
A photon of light takes 8.3 min.

Thus, it is not surprising that particles accelerated by a shock wave near the Sun arrive near Earth long before the arrival of the shock itself.



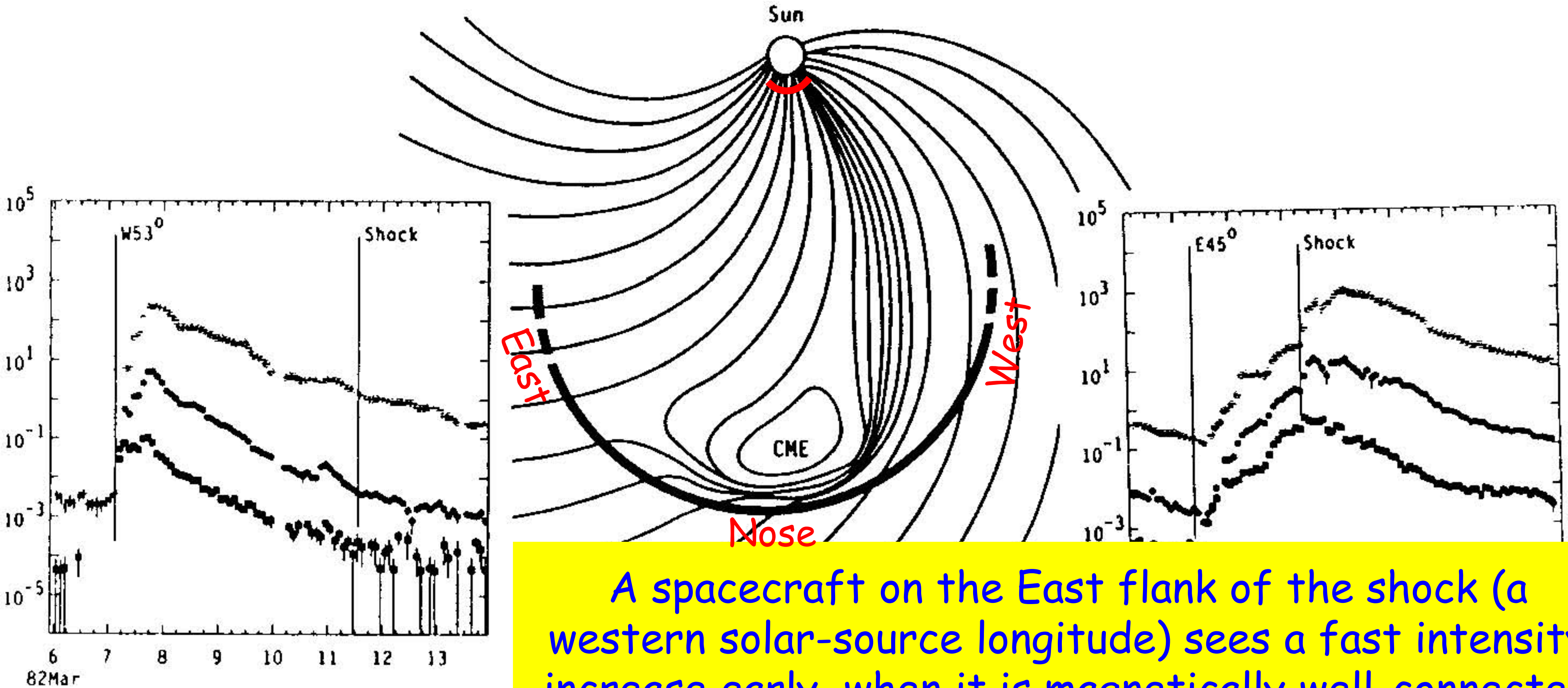
Gang Li in 2014 iSWWS

Assuming the strongest acceleration occurs near the nose of the shock, where the shock is strongest and the speed is likely to be highest, and declines around on the flank.



Reames (1999)

Assuming the strongest acceleration occurs near the nose of the shock, where the shock is strongest and the speed is likely to be highest, and declines around on the flank.

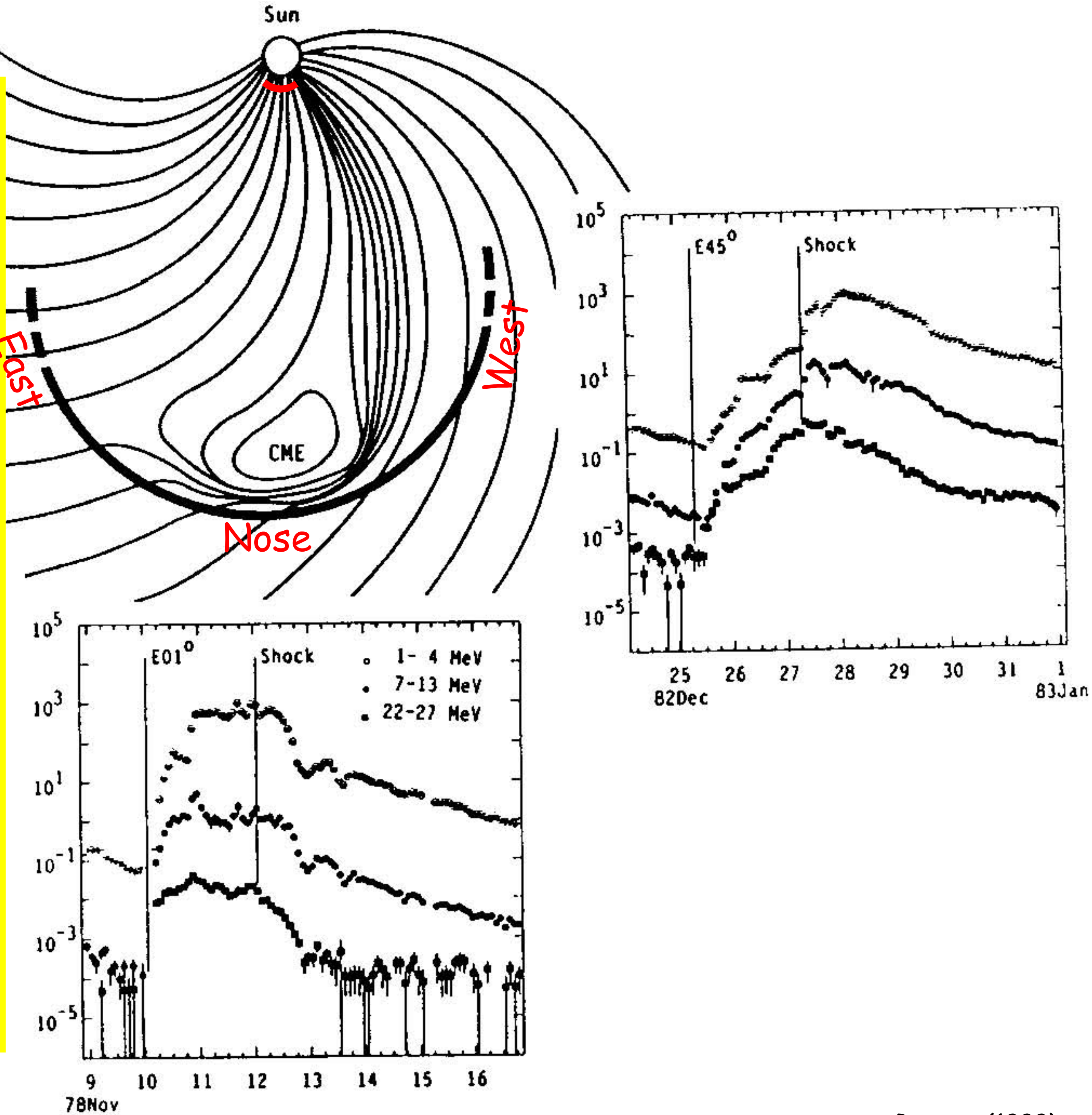


A spacecraft on the East flank of the shock (a western solar-source longitude) sees a fast intensity increase early, when it is magnetically well-connected to the strongest source at the “nose” of the shock as it first appears near the Sun. At later times the intensity decreases as the magnetic connection point moves gradually around the shock toward its weaker eastern flank. When this flank of the shock would be expected to pass the spacecraft, the shock may be very weak or may have dissipated completely so far around from the nose.

Reames (1999)

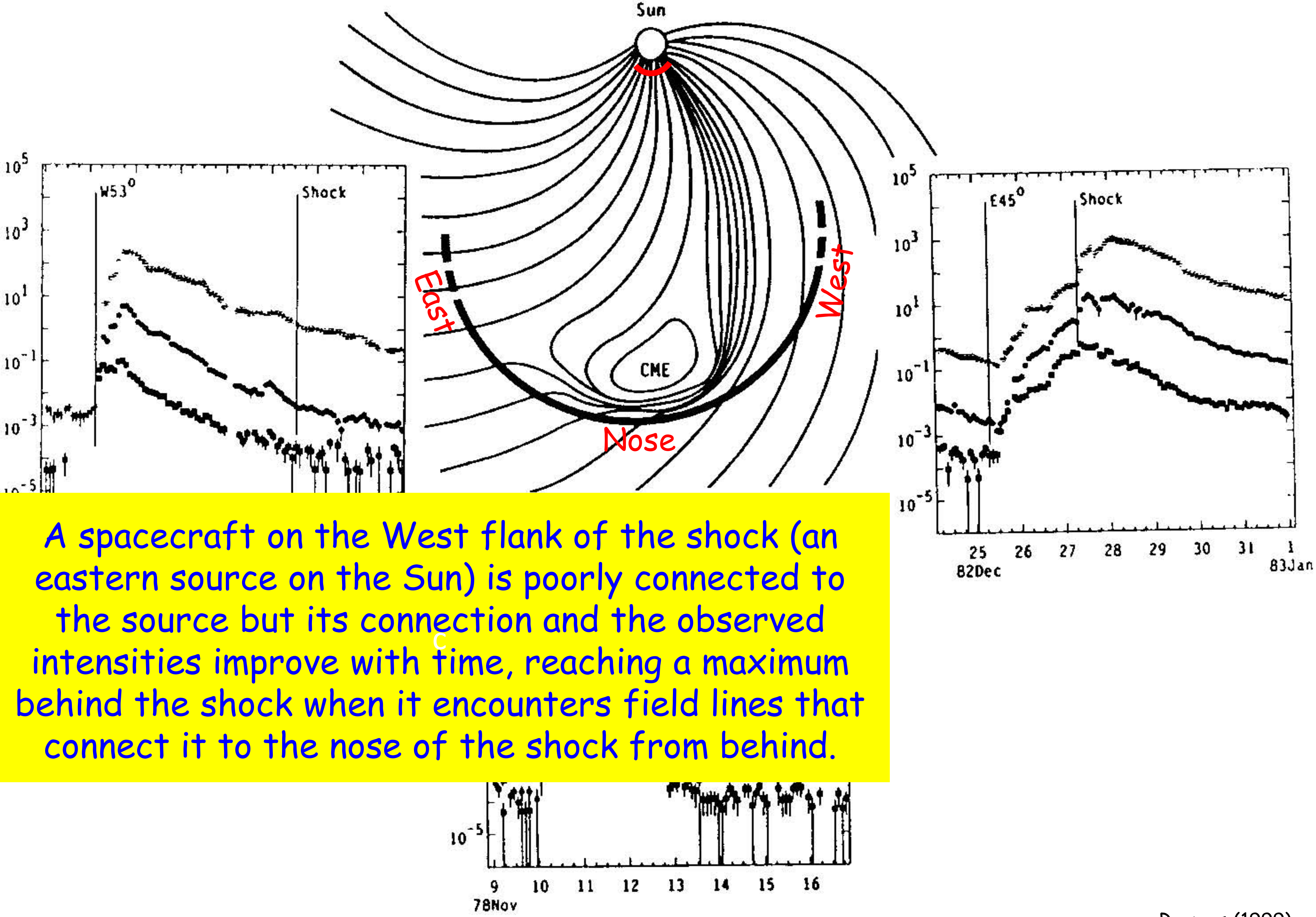
Assuming the strongest acceleration occurs near the nose of the shock, where the shock is strongest and the speed is likely to be highest, and declines around on the flank.

A spacecraft observing a source near central meridian is magnetically connected far to the West of the shock nose early in the event but the intensity increases as the shock moves outward and the connection point approaches the nose. The connection to the shock nose occurs as the shock itself passes the spacecraft. Thereafter, the intensity may decline suddenly as the spacecraft passes inside the CME driving the shock.



Reames (1999)

Assuming the strongest acceleration occurs near the nose of the shock, where the shock is strongest and the speed is likely to be highest, and declines around on the flank.



A spacecraft on the West flank of the shock (an eastern source on the Sun) is poorly connected to the source but its connection and the observed intensities improve with time, reaching a maximum behind the shock when it encounters field lines that connect it to the nose of the shock from behind.

Reames (1999)