Almost Monoenergetic Ion Event on 19 October 2009: STEREO/SEPT-B observations

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The known particle acceleration mechanisms working in space predict

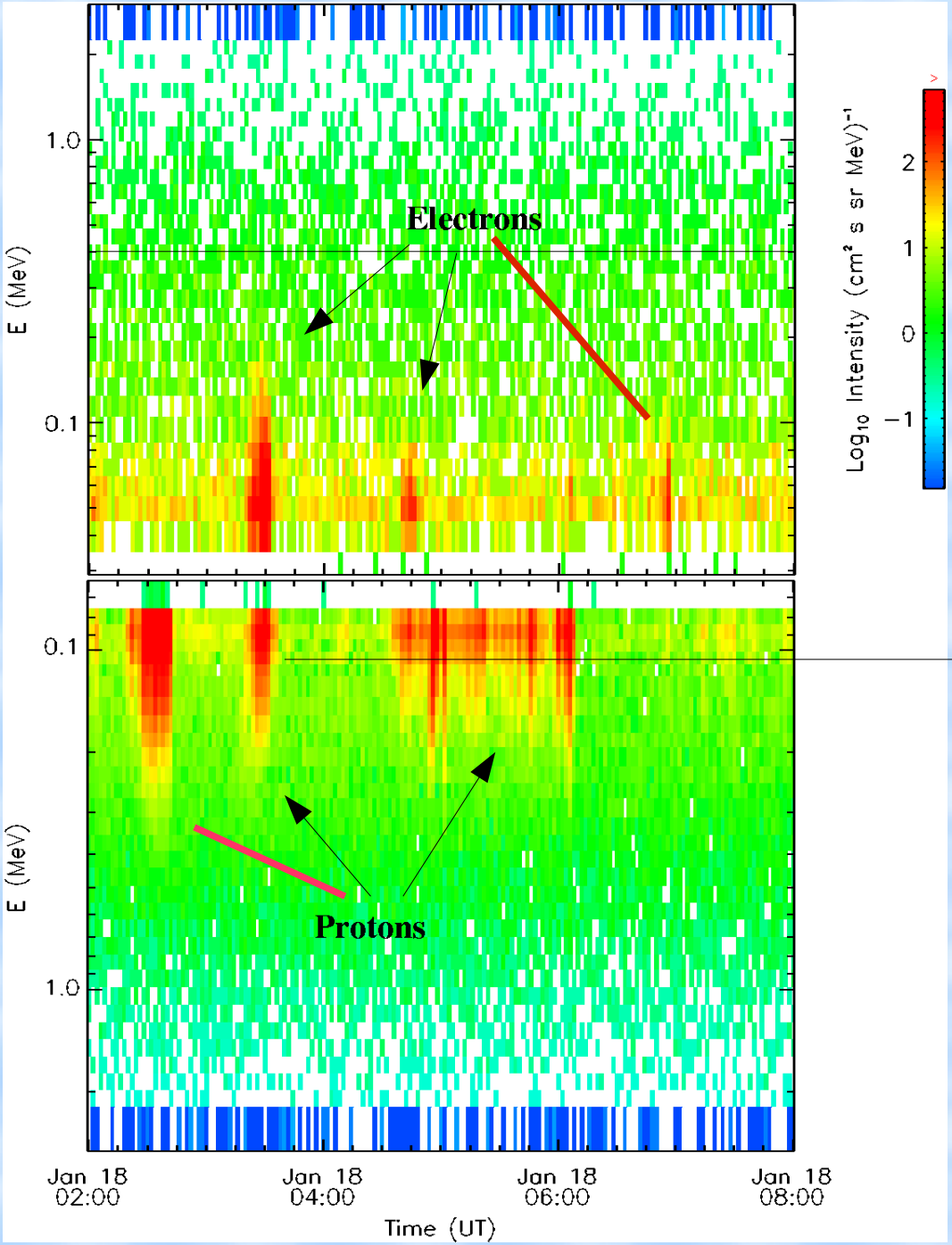
power-law like energy spectra.

Indeed, such spectra were detected by different space missions during the last 50 years.

We present an ion event energy spectrum of which is strongly different from a power-law distribution. It shows a narrow peak with

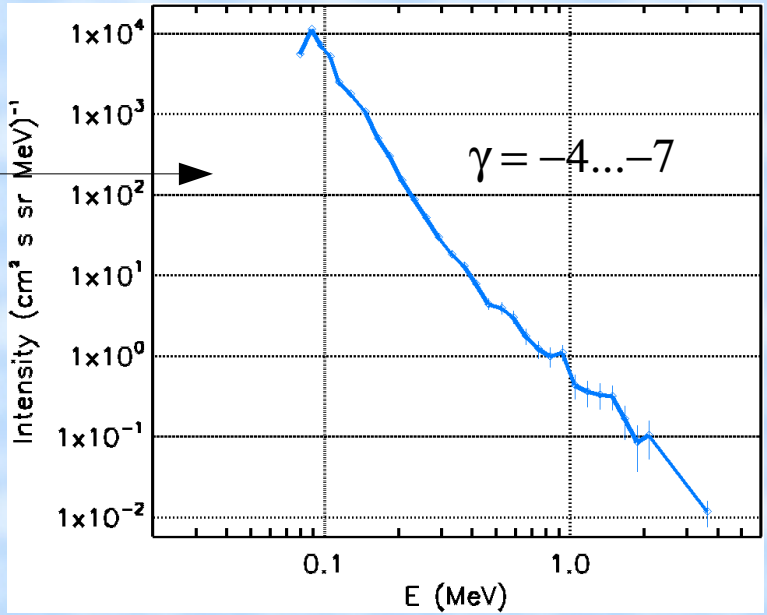
$$\Delta E_{FWHM} / E_{max} = 0.35$$

Electrons vs Protons: SEPT-A/anti-Sun telescope (STEREO-A)



A sequence of upstream proton & electron events.
Not all electron bursts are accompanied by protons and vice versa.

Energy spectrum of protons shows normally a power-law shape.

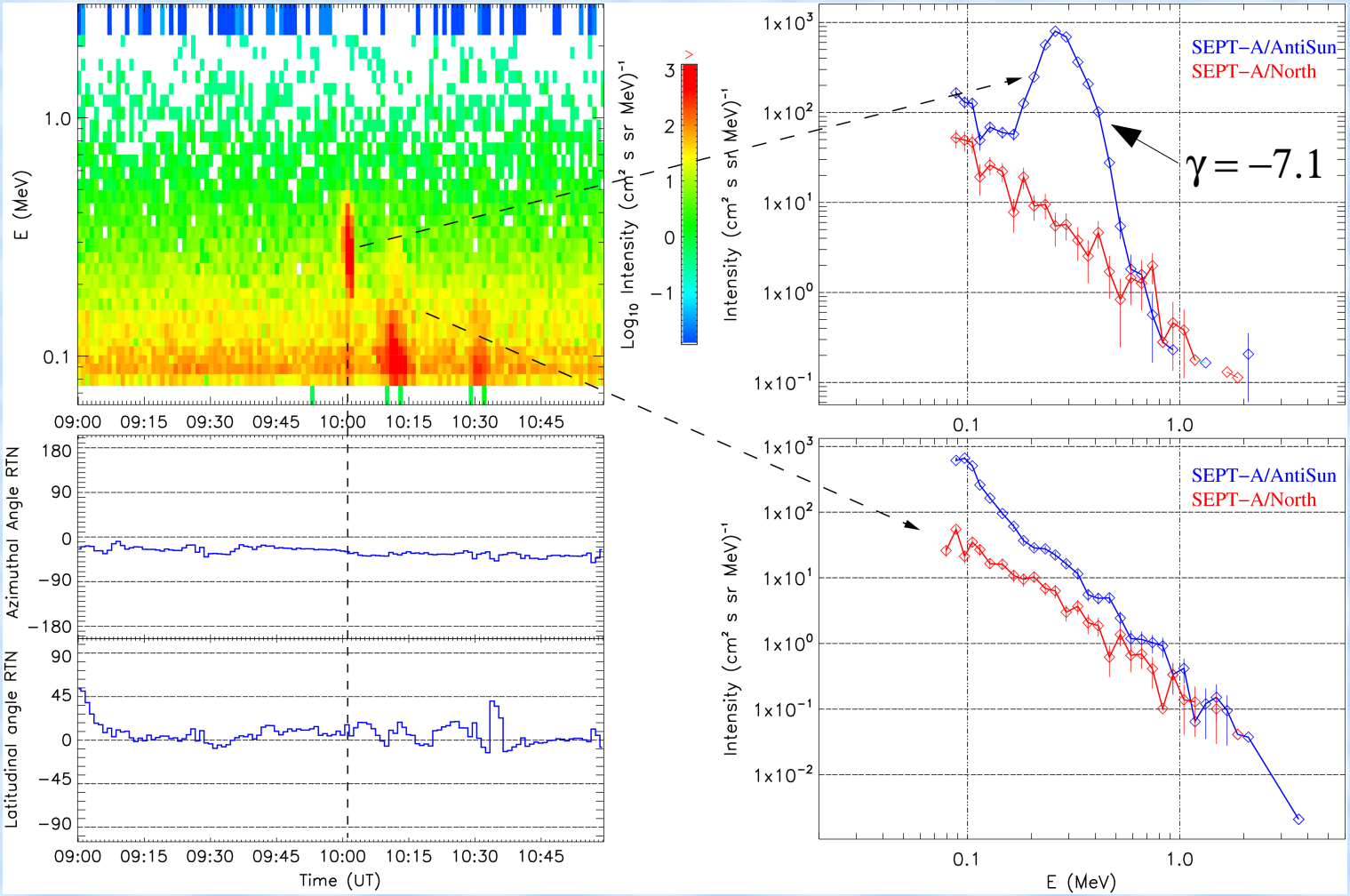


What does mean

Almost Monoenergetic Ion (AMI) Event?

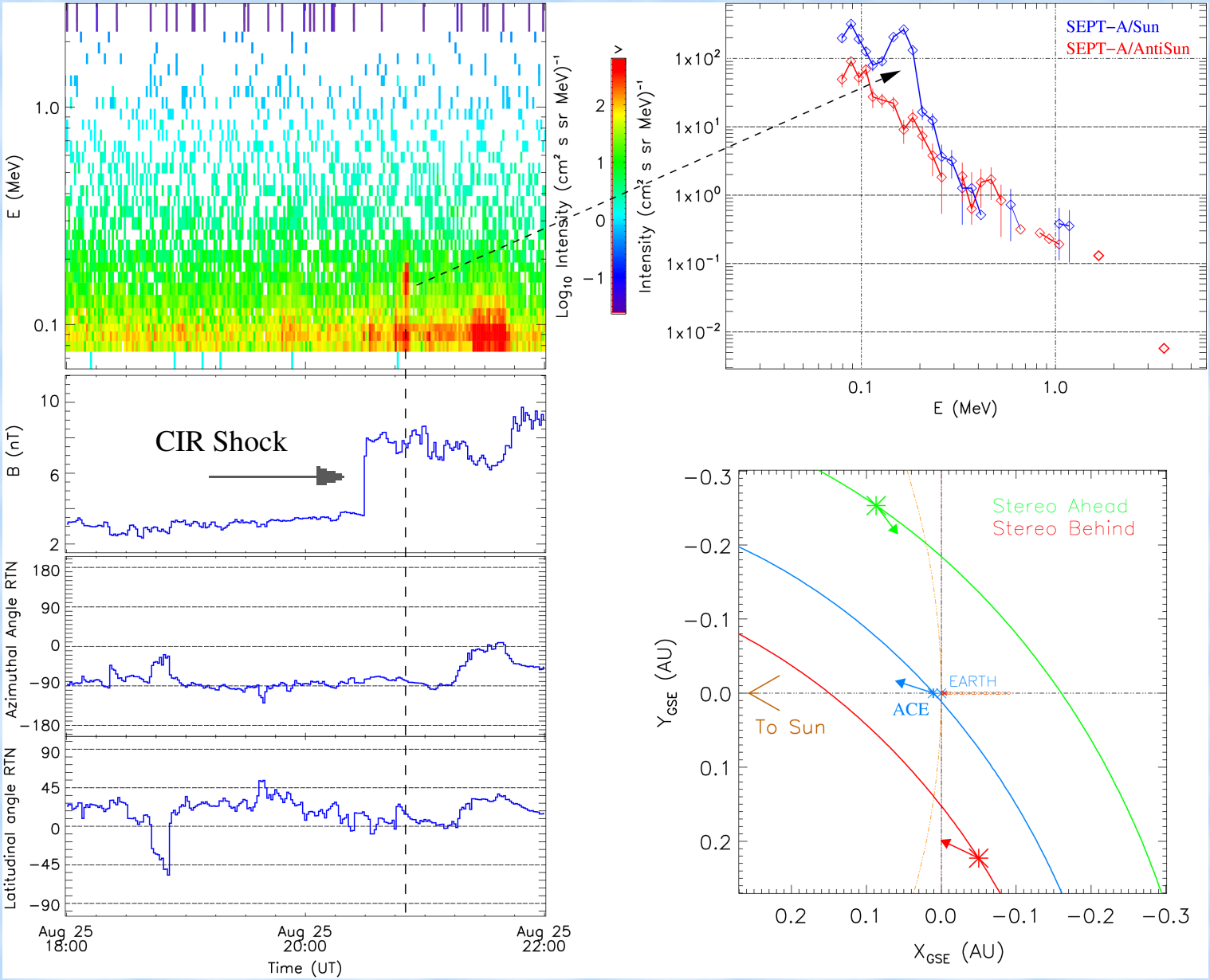
Earth's Upstream Almost Monoenergetic Event on 27-02-2007 (STA)

Term AMI was introduced by Lutsenko & Kudela (1999) attributed to energy peaks in spectra of Earth's upstream events. Similar events were observed also by STEREO/SEPT not only upstream of Earth's bow-shock, but also in association with IP shocks.



- the first event shows a monoenergetic peak at 260 keV with FWHM=130 keV
- second and third events show "normal" power-law spectra
- no changes in IMF during and before the events

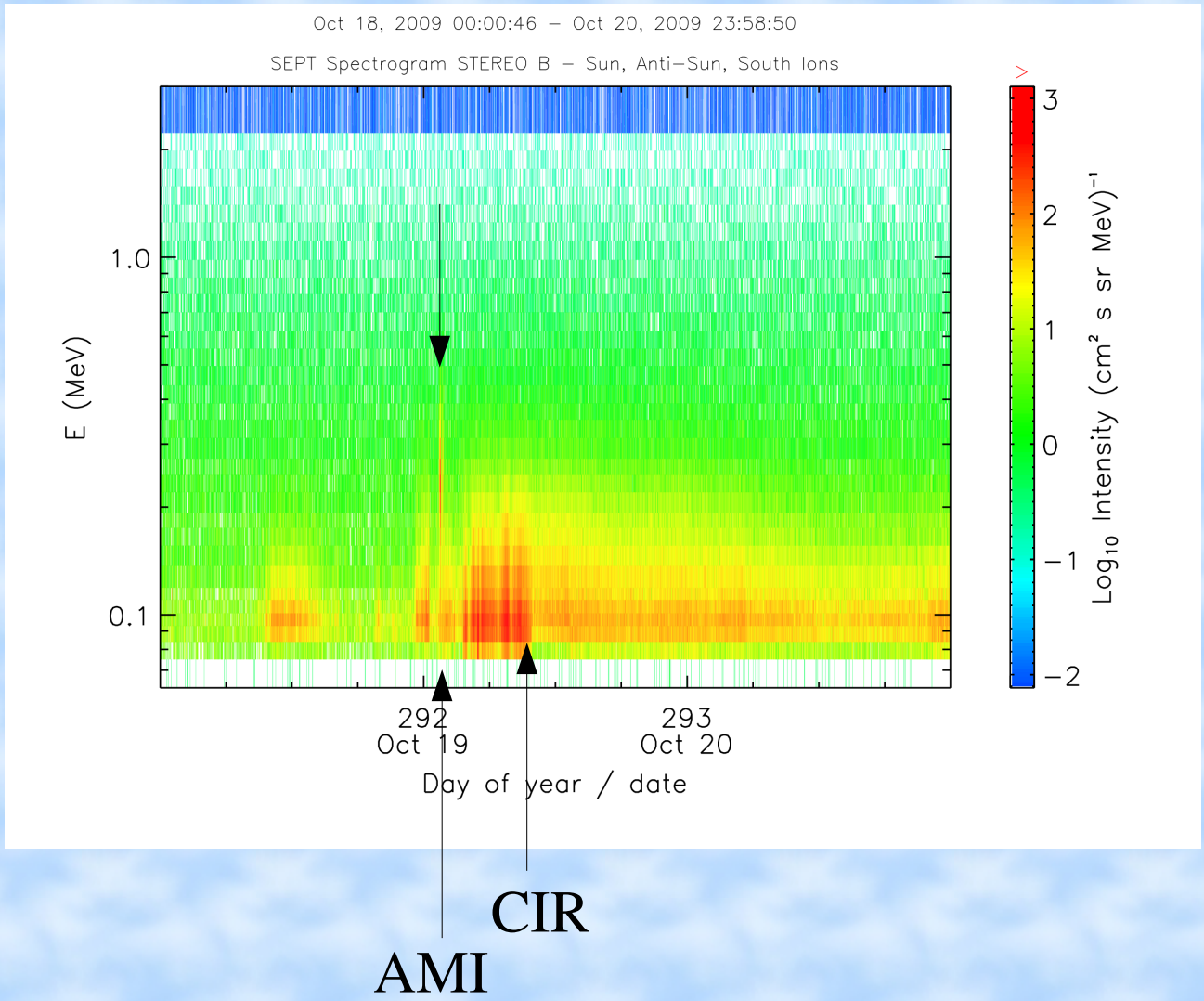
AMI event associated with a CIR shock on August 25, 2007 (STA)



Event on October 19, 2009

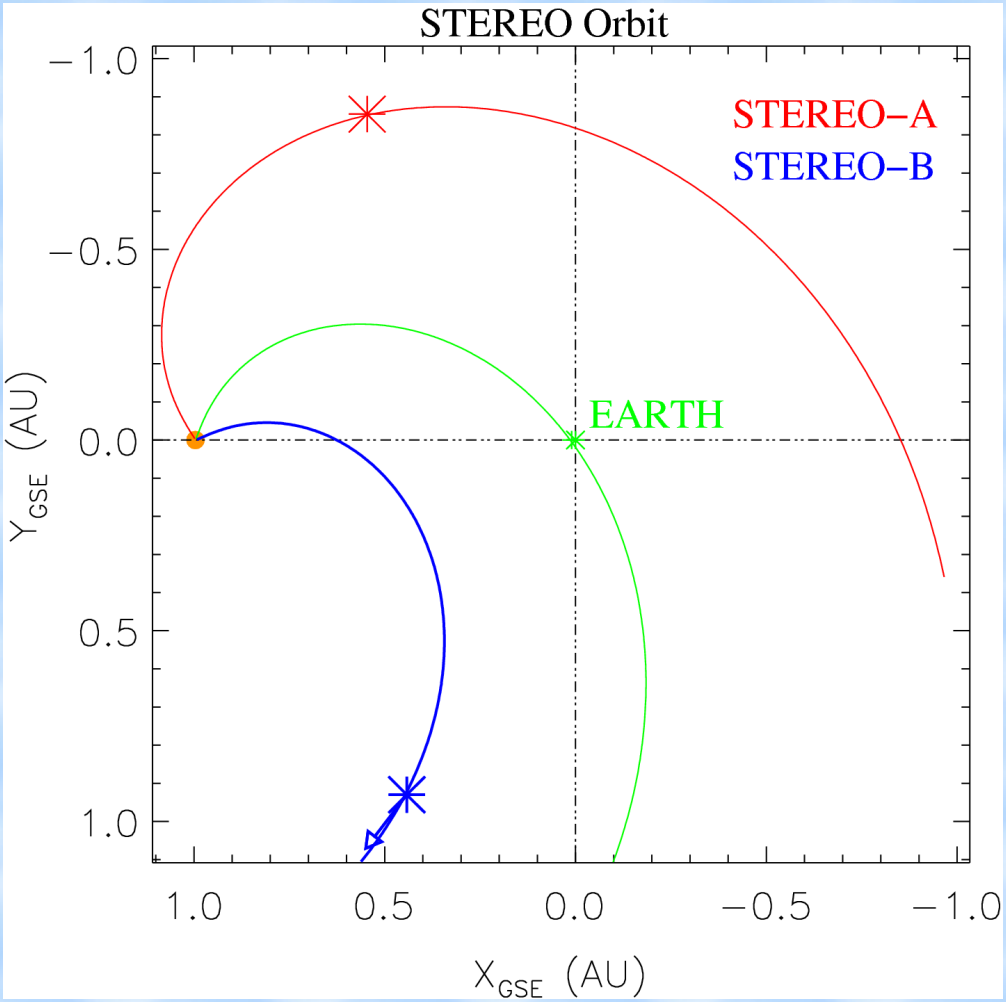
it was not associated with an in-situ IP shock

Omnidirectional dynamic spectrum at days around AMI



AMI occurs in front of small CIR activity at low energies < 300 keV

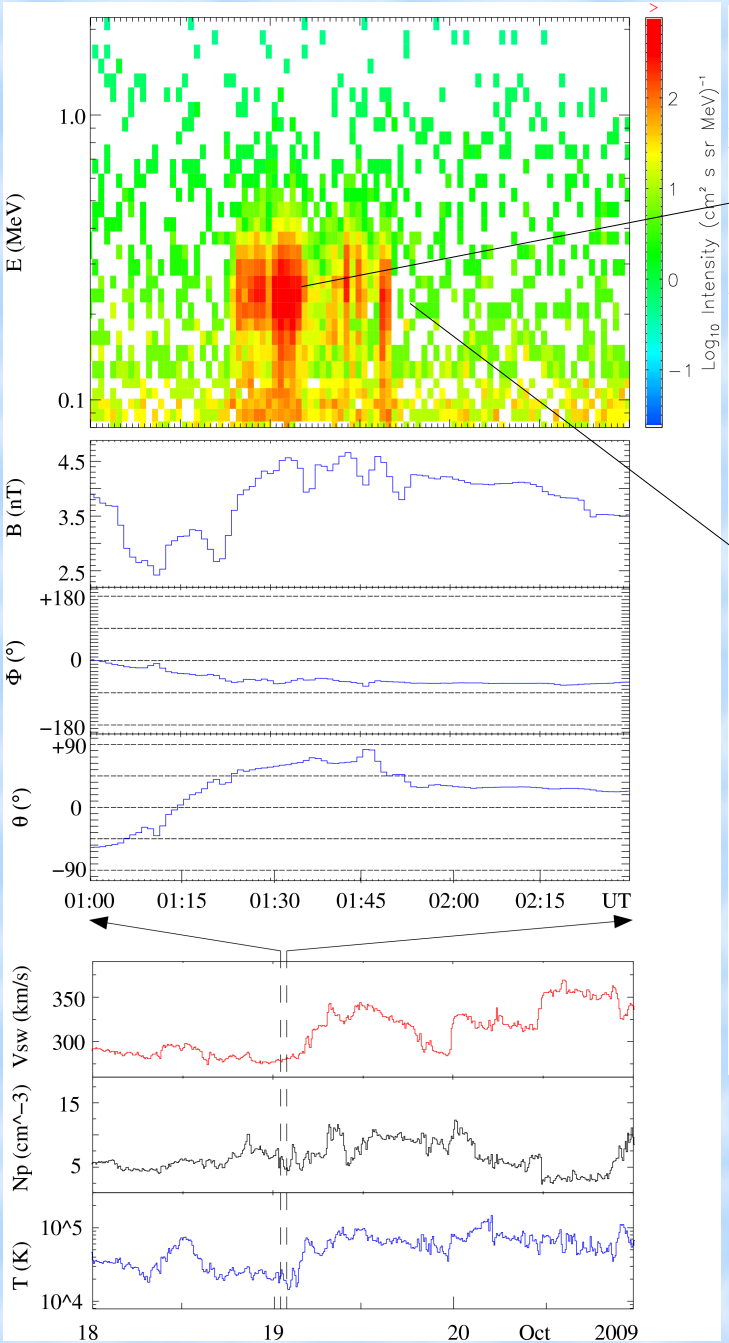
STEREO- B position on October 19, 2009

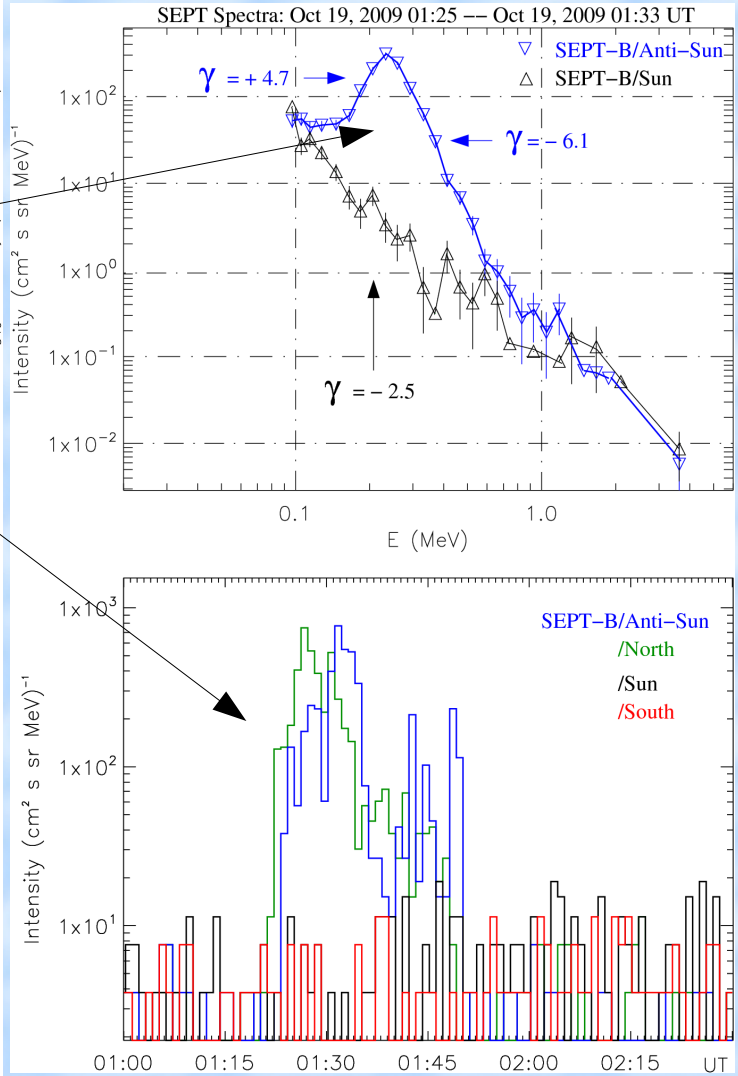


STEREO-B position (blue asterisk), nominal Parker spiral and magnetic field ecliptic component (blue arrow). Red and green colors for STA and ACE, respectively.

STB distance to Earth = 1 AU.

AMI event on October 19, 2009



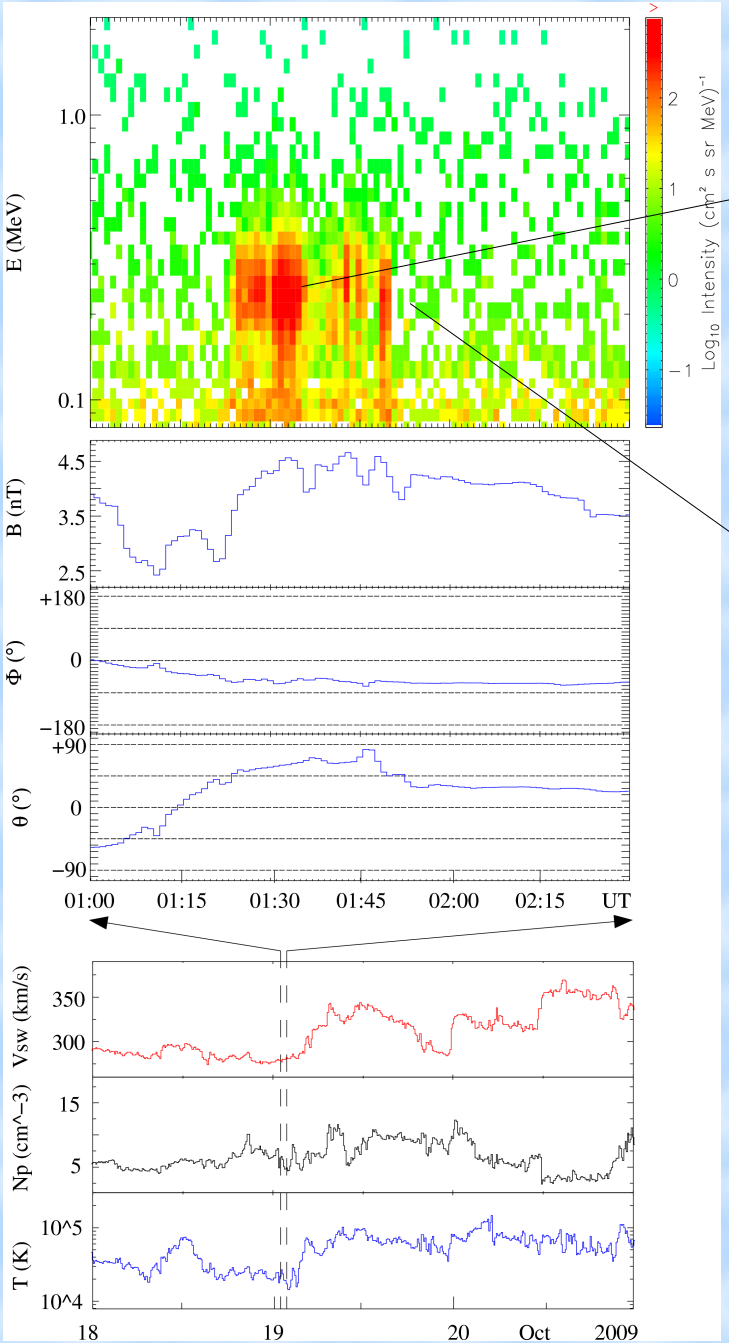


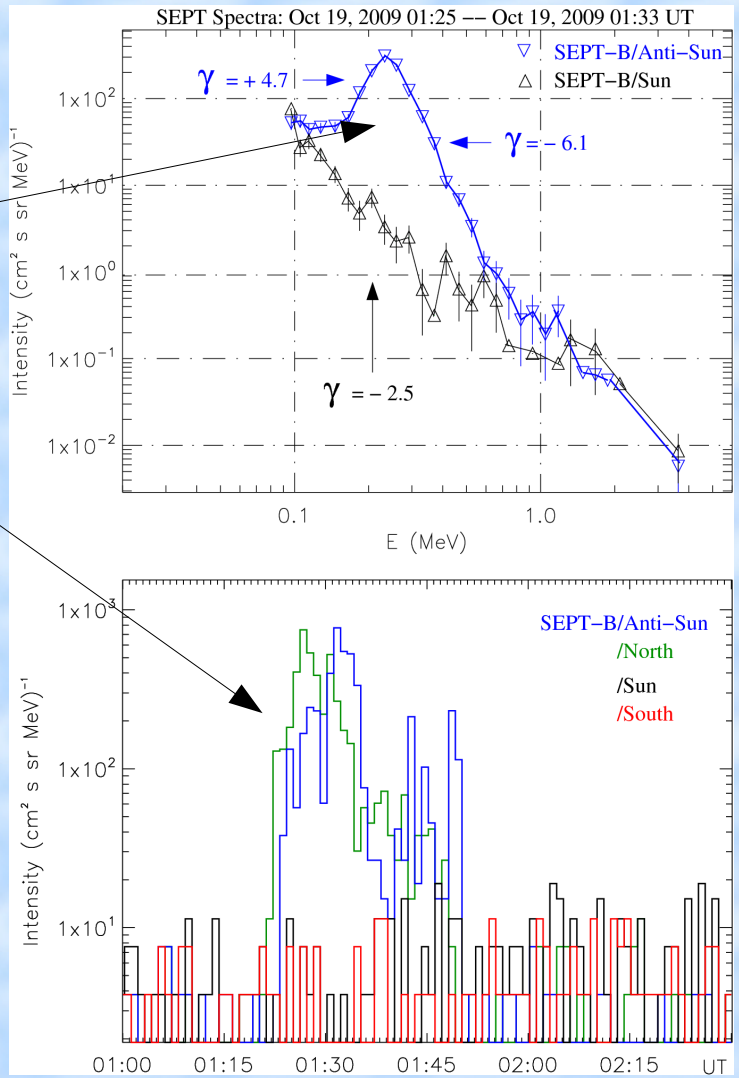
Energy spectrum from AntiSun and **Sun** directions

Time profiles

- AMI duration 27 min
- Anisotropic: from AntiSun & North, only
- Symmetric very stable peak at 230 keV
- Spiky time profiles

AMI event on October 19, 2009





Energy spectrum from AntiSun and **Sun** directions

Time profiles

- no shock;
- rotation of IMF;
- IMF directed to the AntiSun/North;
- Vsw = 275 km/s
- |B| = 4.5 nT

Where is the source of this AMI?

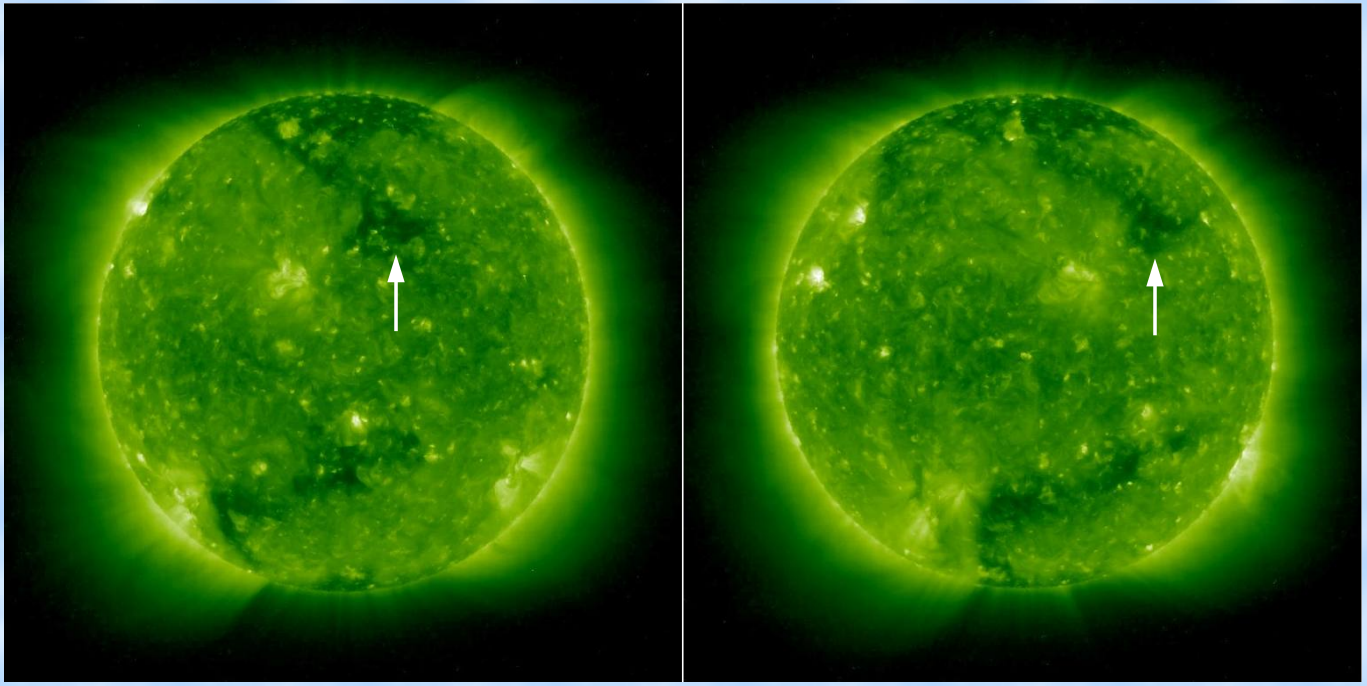
- No solar activity
- No connection to Earth

  - The particles streamed from the Anti-Sun and Anti-Earth direction

- No in-situ IP shock

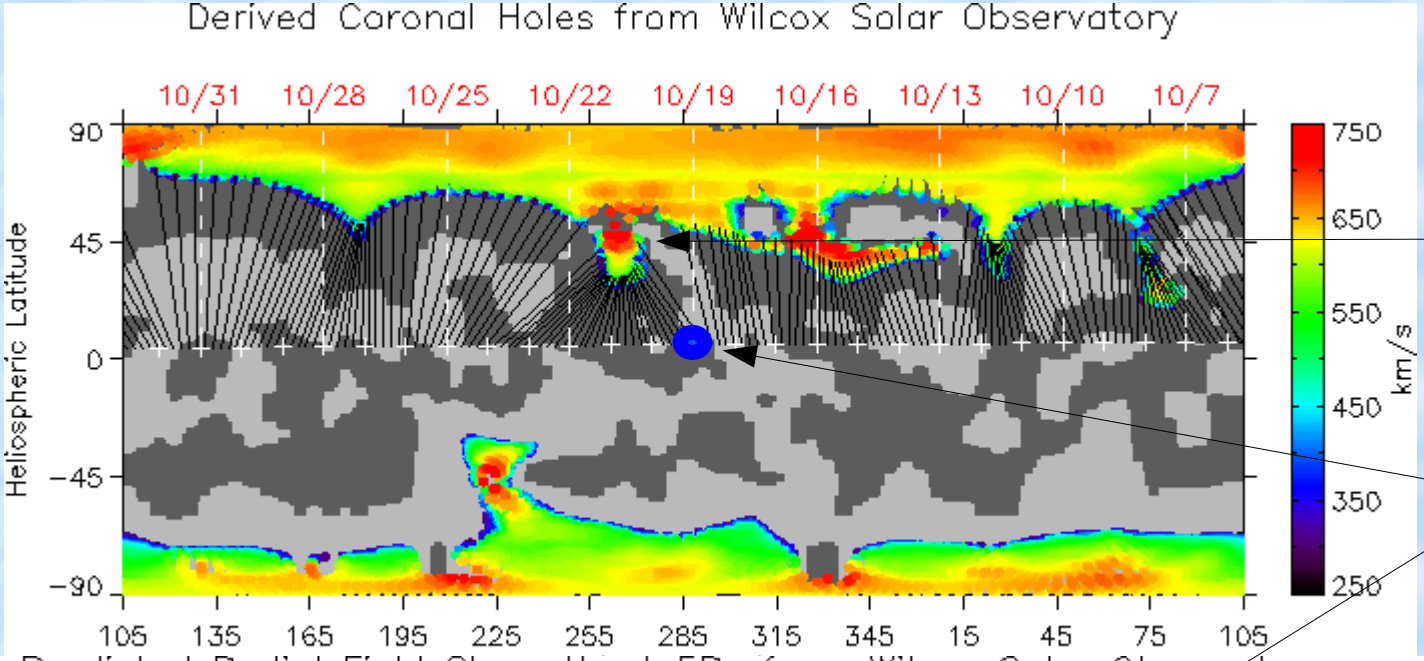
Possible a distant CIR could be the source ...

Small coronal hole at a suitable position



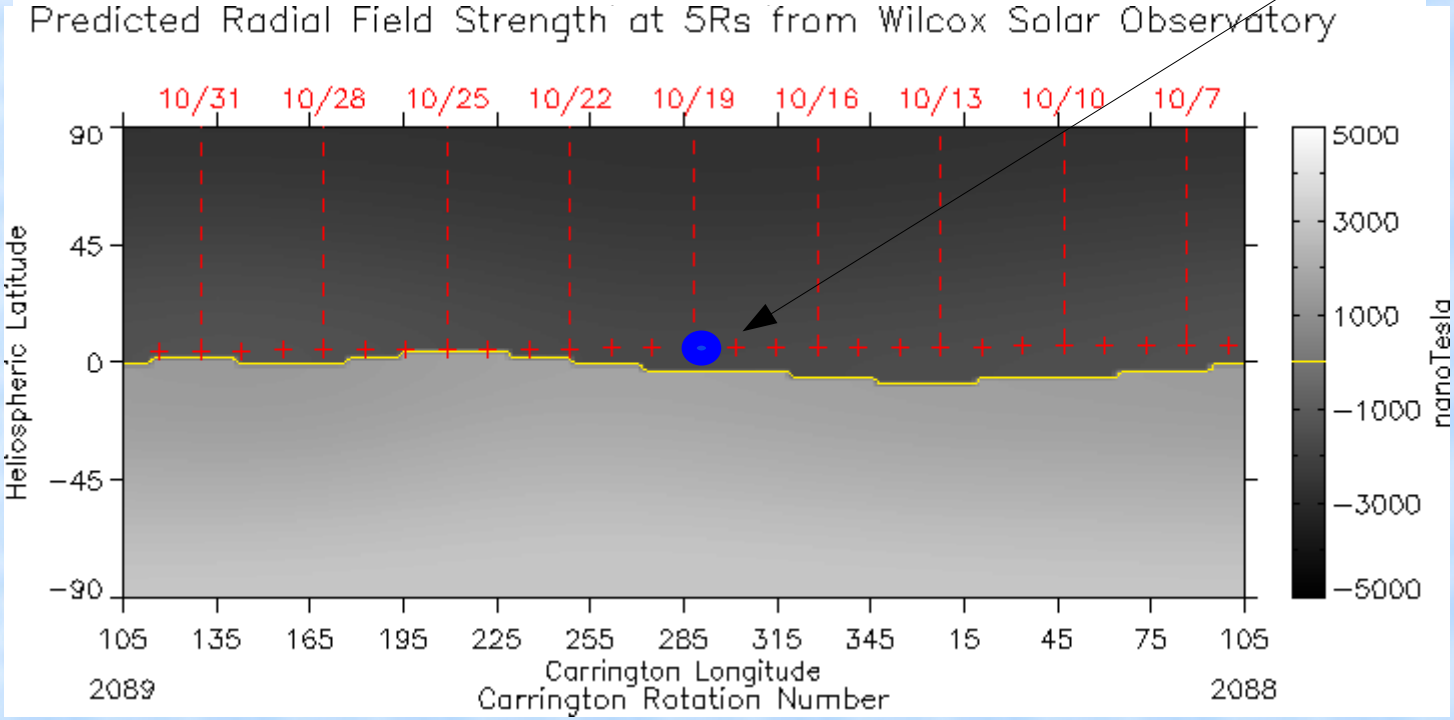
STB/EUVI 195 A images on 17 and 19 October 2009 showing a CH, which could be responsible for the solar wind high speed stream and the CIR near to STB on 19 October.

Wilcox synoptic maps of coronal holes and HCS



Coronal hole

STB



Predicted radial field strength

Br at R = 5Rs.

The yellow line indicates where

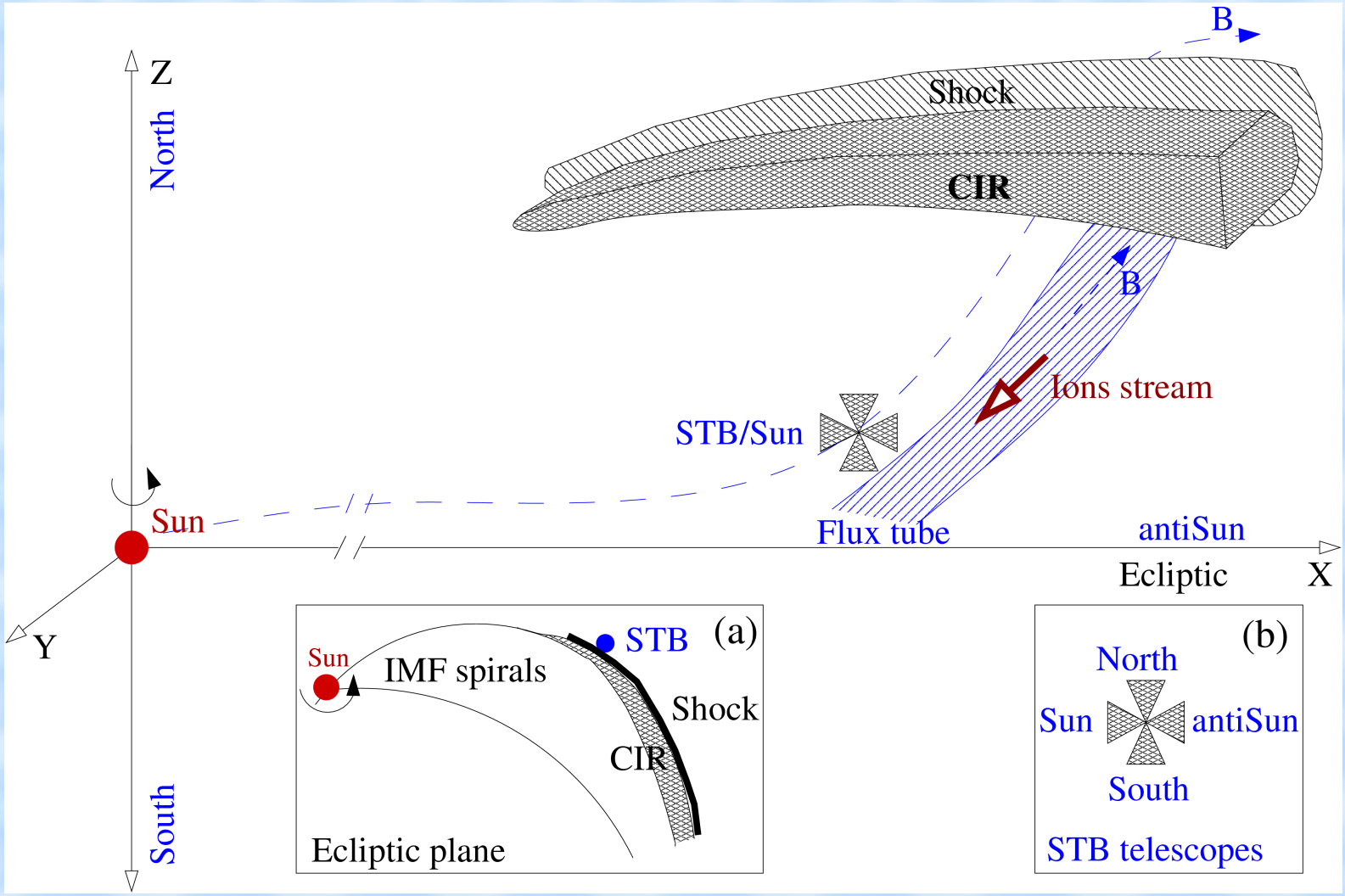
Br = 0 gauss (i.e. the current sheet).

CIR associated with this CH was

not detected with HI

(C. Davis & J. Davies, priv. com.)

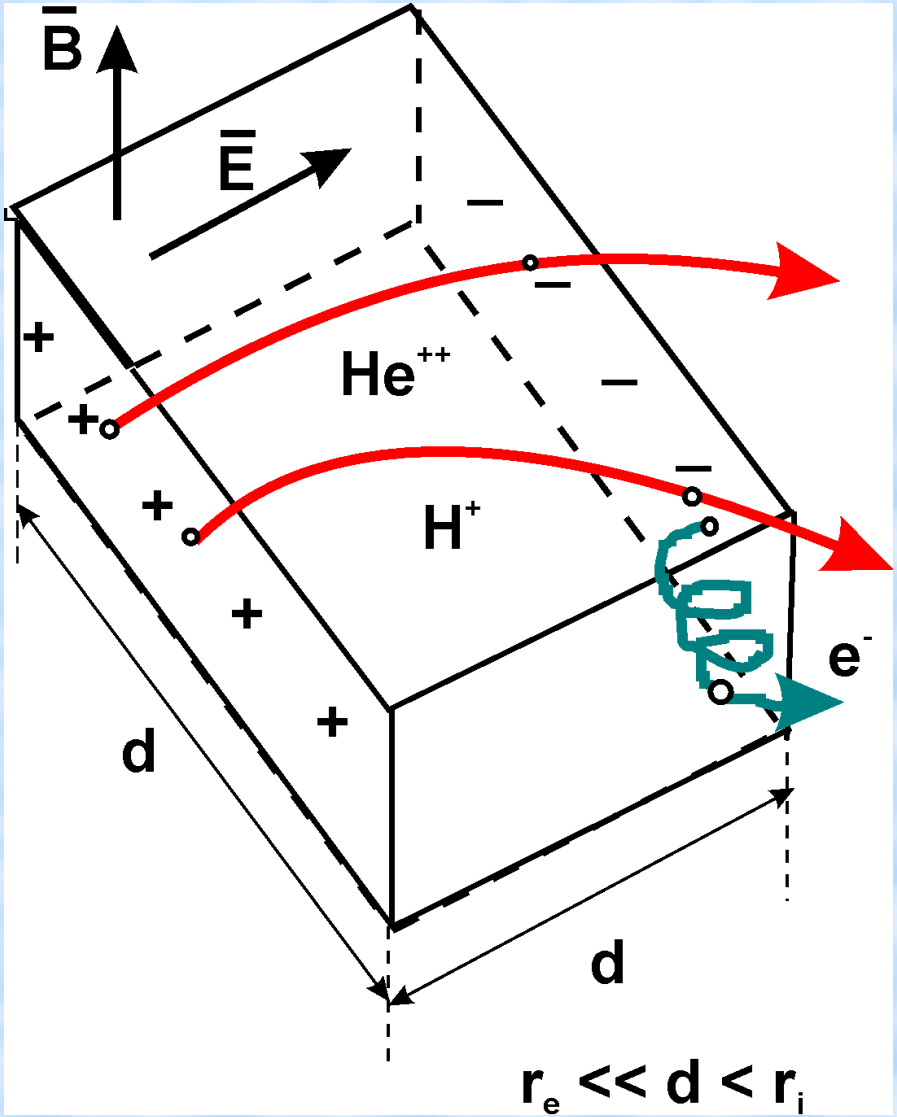
Cartoon of possible source: CIR/CIR shock?



STB position relative to CIR/shock. The magnetic field tube is filled with ions streaming along it from the CIR towards STB. The anisotropic ion beam(s) is detected in telescopes looking toward Anti-Sun and North, only.

Lutsenko (2001) hypothesis on the AMI origin:

Acceleration must take place in a region with **E** ⊥ **B** and dimensions ***d*** lower than ion and much greater then electron gyroradii.



Adopted from Lutsenko (2001)

Acceleration of plasma ions in such region must give 2 narrow lines in spectrum with energy ratio of 1:2.

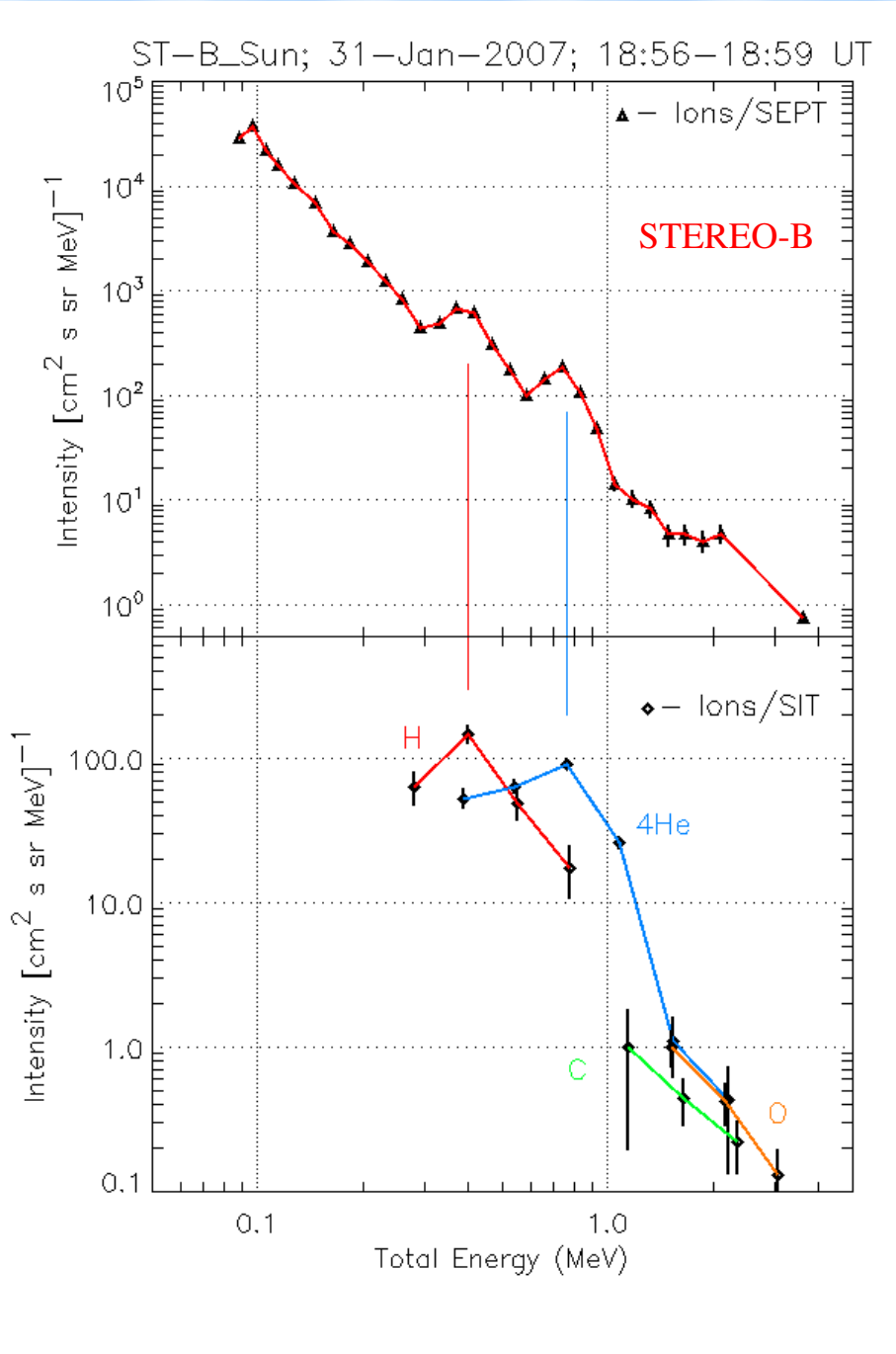
Electrons cannot be accelerated (they only swept out by ExB drift).

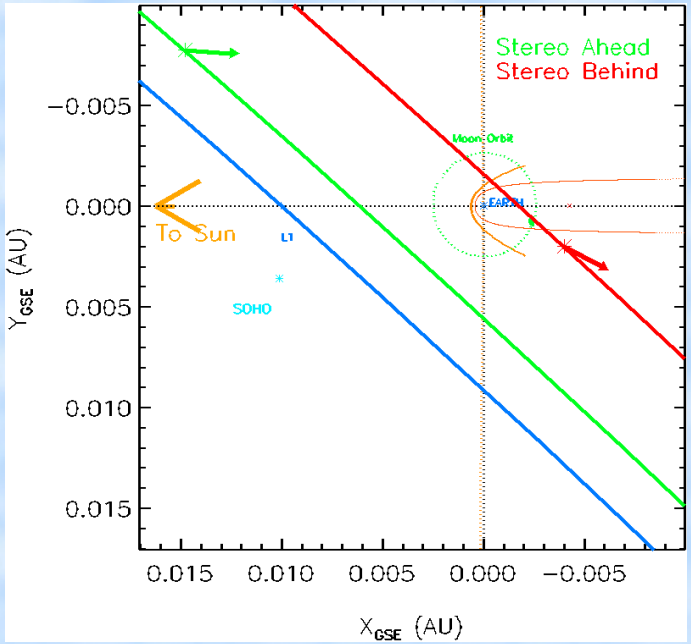
Conclusion

- SEPT-B detected an ion event with a narrow energy peak at 235 keV ($\Delta E/Emax = 0.35$) shortly before a weak CIR event. It was not associated with solar or Earth's magnetosphere activity .
- It is suggested that the monoenergetic ions were accelerated by an electrostatic field at a distant CIR.

The End

Comparison of energy spectra obtained with the SEPT and the SIT instruments





- two lines by SEPT
- two lines by SIT: first due to H^+, second due to He^{++}
- energy peaks match each other very well
- in both spectra the peak ratio is 1:2
- these observations support the idea that AMI events are due to H^+ and He^{++} beams accelerated in an electrostatic field