Special Session on the 2005 January 20 Event

Gerry Share –RHESSI gamma ray observations

Victor Grechnev – What made this event so extreme?

John Raymond – Quasi-Parallel or Quasi Perp Shock?

Dick Mewaldt – ACE/SAMPEX SEP Observations

Bernie Jackson – SMEI Update

Claire Foullon – Characteristics of the ICME

Cara Rakowski – Modeling the ICME ejecta

SUMMARY OF RHESSI OBSERVATIONS

Gerry Share

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

A 'normal' impulsive component:

- starts at ~06:42 UT, peaks at ~06:47 UT, lasts about 10 min
- evidenced by electron bremsstrahlung and nuclear-line radiation
- accelerated ions with power-law index of ~-3
- interacting at a footpoint.
- Contains ~80% of protons that interacted in the solar atmosphere.

A harder photon component:

- begins at ~06:45 U, peaks at ~06:46 UT, lasts ~ 2 hrs
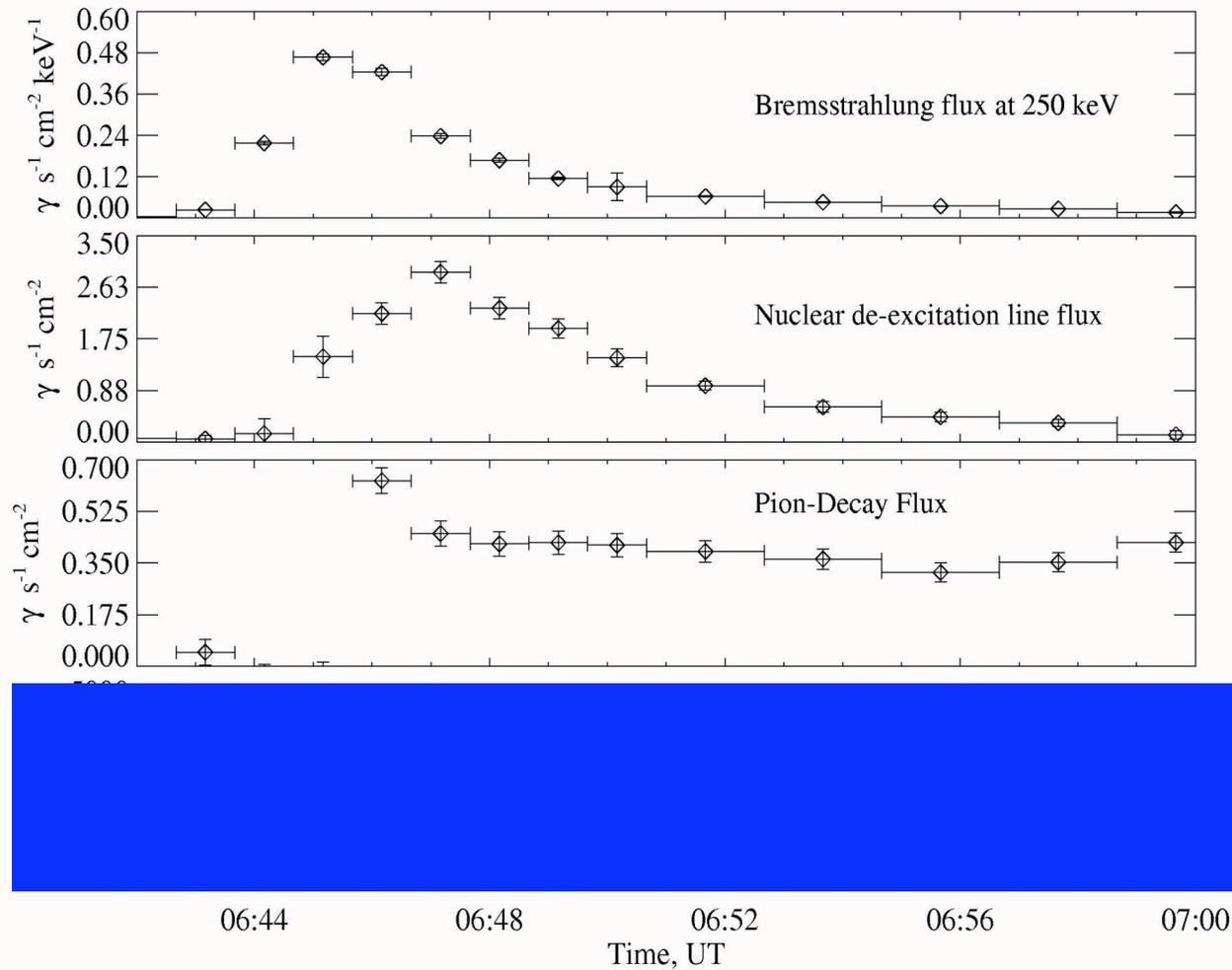- consistent with pion-decay radiation;
- Inferred accelerated-particle power law index ~-2.3.
- No conclusion possible about spatial extent of the source
- Contains ~20% of the protons that interacted at the Sun

Two distinct components in RHESSI

Deconvolution of the RHESSI Data

"Impulsive
Component"

"Extended
Component"

How are the RHESSI Components Related to the ~GeV protons observed at Earth?

Gerry said:

"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."

How are the RHESSI Components Related to the ~GeV protons observed at Earth?
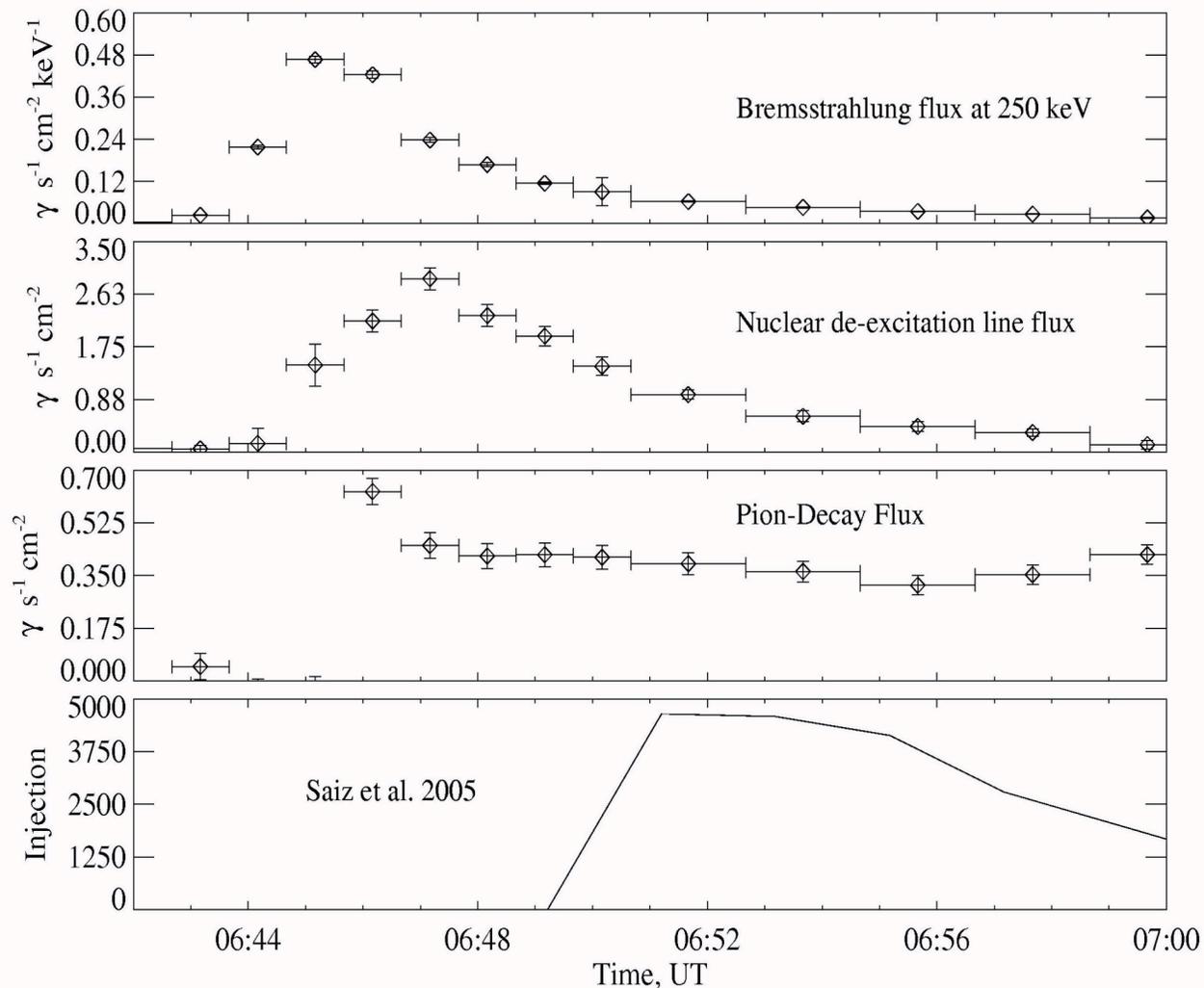
The Saiz et al GLE onset time corresponds to an interplanetary pathlength of ~1.1 AU.

We could shift the profile back to correspond to the pion component if the real pathlength were ~1.6 AU.

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 extended component: $\leq 0.7 \times 10^{32}$

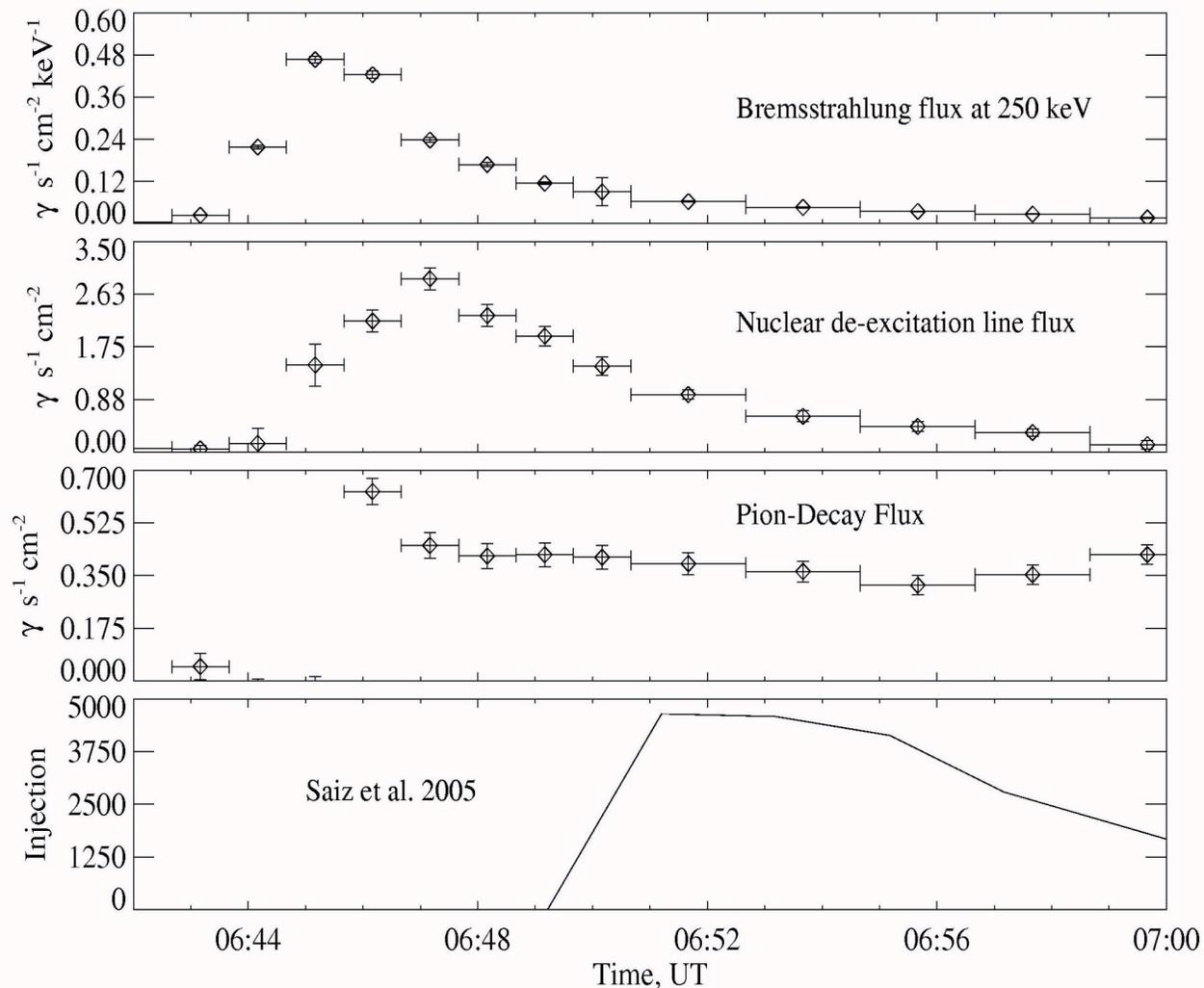Event integrated SEPs: 210×10^{32}

Power-law spectral index:

Solar flare impulsive component: ~3.0

Solar flare extended component: ~2.3

Event integrated SEPs: 2.15

How are the RHESSI Components Related to the ~GeV protons observed at Earth?

Could we shift the GLE back far enough to correspond with the "impulsive" RHESSI component?

Well, yes, but…

The Extreme Solar Event of 20 January 2005: Properties of the Flare and Origination of Energetic Particles

V.Grechnev[1], V.Kurt[2], I.Chertok[3], A.Uralov[1], H.Nakajima[4], A.Altyntsev[1], A.Belov[3], B.Yushkov[2], S.Kuznetsov[2]*, L.Kashapova[1], N.Meshalkina[1], N.Prestage[5]

[1]*Institute of Solar-Terrestrial Physics, Irkutsk*
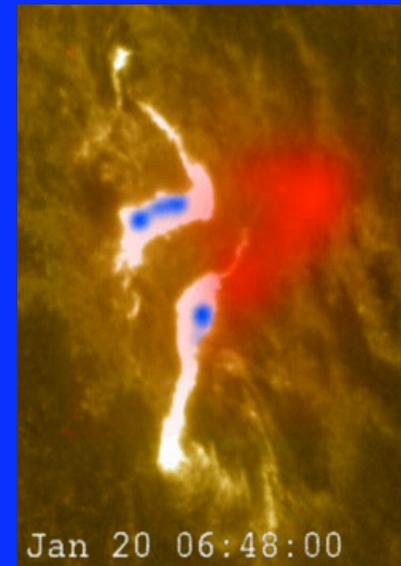[2]*Moscow State University, Moscow*
[3]*IZMIRAN, Troitsk*
[4]*Nobeyama Radio Observatory, Nobeyama, Japan*
[5]*The IPS Culgoora Solar Observatory, Australia*

*Deceased 17 May 2007

SHINE Workshop, Whistler, July-August 2007

Jan 20 06:48:00

From Victor Grechnev: What made this event so extreme?

Major LDE Events from AR720

| Date | Time | GOES | Position | Microwaves | | Protons | | | CME |
				8.8 GHz	15.4 GHz	>10	>50	>100 MeV	V, km/s
15	22:48	X2.6	N14W09	20000	18000	300	10	0.4	2860
17	09:43	X3.8	N15W25	16000	17000	3000	300	25	2550
19	08:32	X1.3	N15W51	17000	15000	<100	<3	~0.1	2020
20	06:44	X7.1	N14W61	41600	77400	1800	1100	680	2000-2600

⇒ Extremeness of the 20 January event in:

- intensity of short-wave radio emissions and
- their hardness
- Not in CME speed

Conclusion

- Particles responsible for **leading** GLE spike on 20 January were predominantly accelerated within magnetosphere of the solar active region.

- 20 Jan. 2005 event was <u>typical major proton flare</u>.

- Microwaves in such events are generated by large number of hard-spectrum electrons in strongest magnetic fields (sunspots' umbrae).

- Uncertainty still persists about **later** manifestations, when three kinds of mechanisms might contribute:

  – Flare-acceleration (strong B, high n, T~20 MK, impulsive)
  – CME-driven shock (weak B, low n, T~1.5 MK, impulsive)
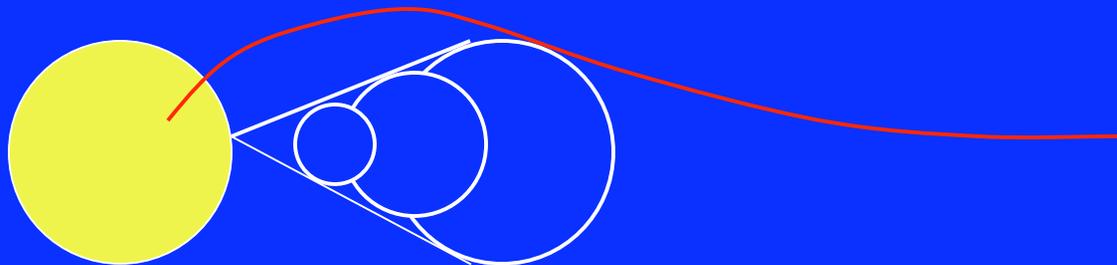 – Post-eruptive acceleration (moderate B, low n, T~5 MK, gradual)
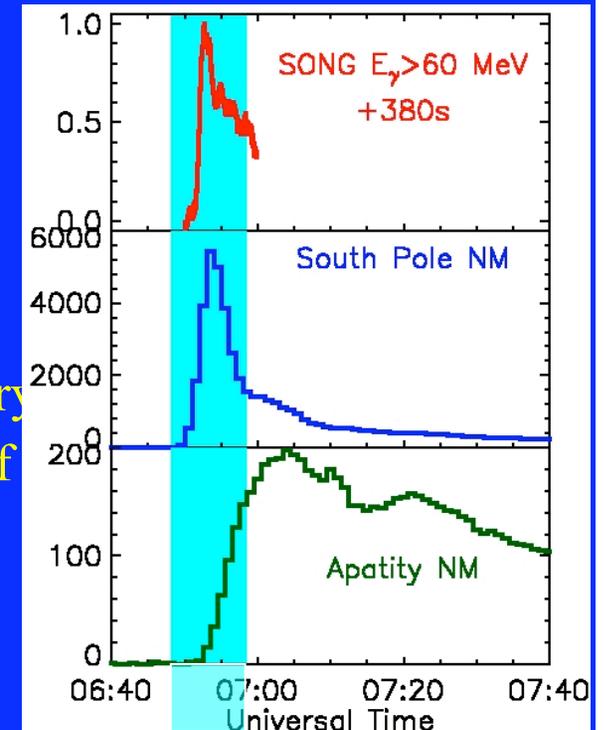
Questionable

Predominant flare acceleration

Jan 20, 2005 CME

Quasi-Parallel or Quasi-Perp?

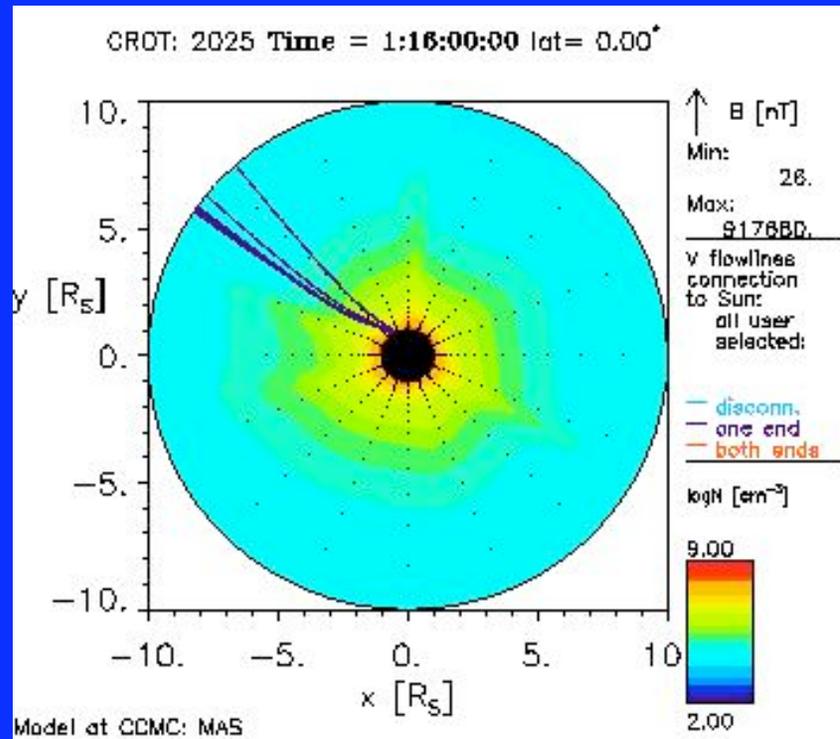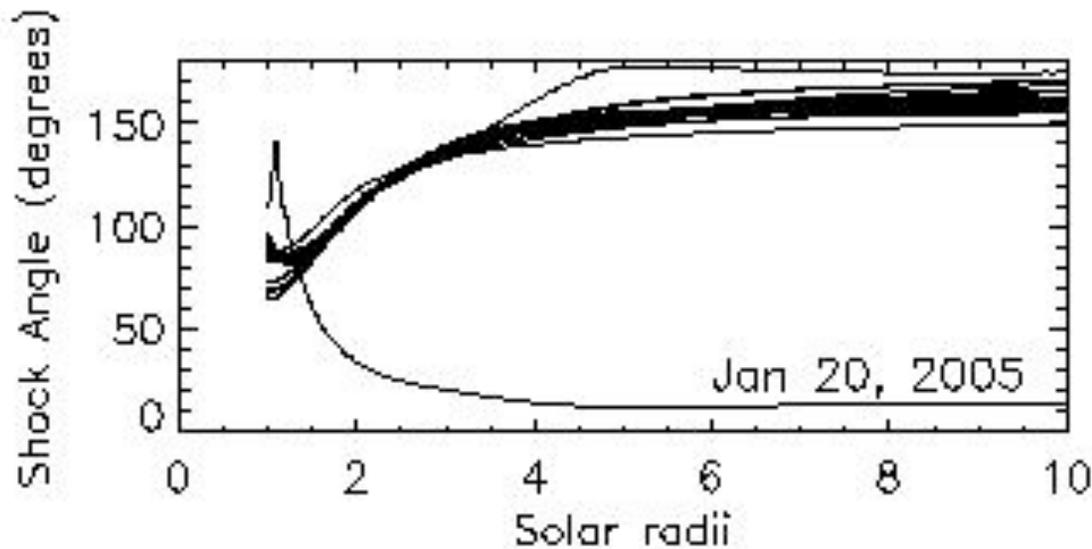J. Raymond, Y.-K. Ko, P. Riley, J. Linker, A. van Ballegooijen

For simple expansion model and MHD model of coronal field, compute the angle between shock normal and field.

Jan 20, 2005 Flare at Carrington 179, +14

Field line connected to ACE at Carrington 147, -5 at 30 Rsun

CCMC MAS model and traceback to solar surface with more advanced SAIC model
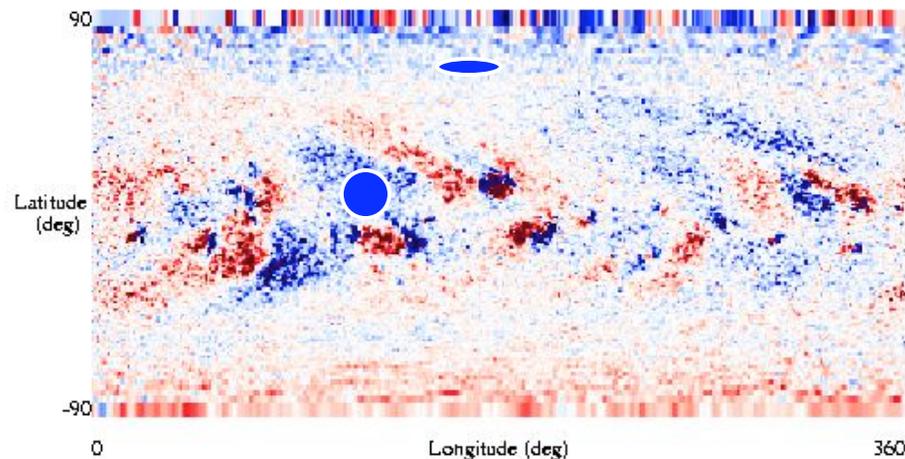
Quasi-perp near 2

Quasi-par above 4

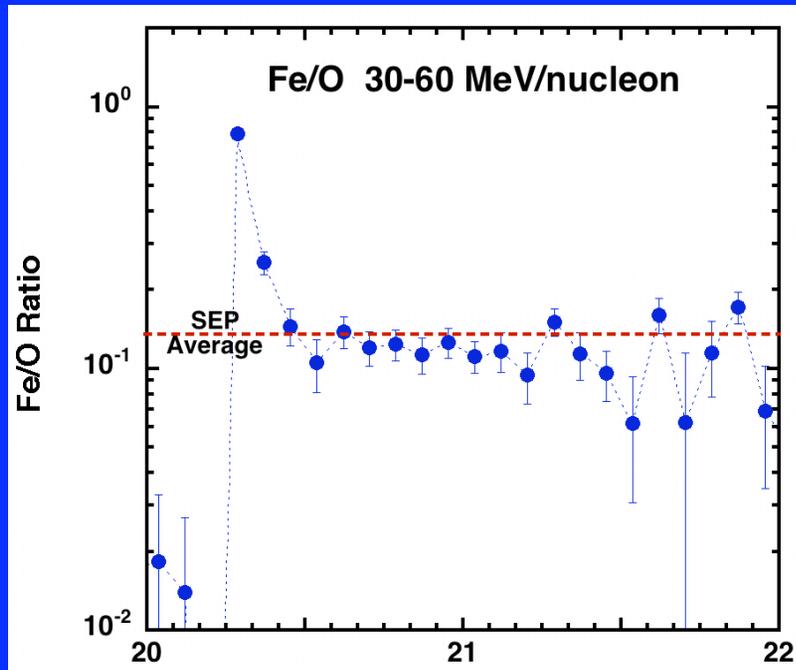Some oddball field lines within 5°

2 regions where lines originate

Both have negative field, while ACE has positive!

Time-dependent Fe/O shows an strong enhancement in the first ~2 hours.

Is this the signature of a flare component?

SAMPEX says that the Fe charge state averaged over the event was Q ~12.

The observed charge state at the start of the event (during the Fe/O spike) does not appear to be different.

This makes transport distortion almost certainly the origin of the initial spike.