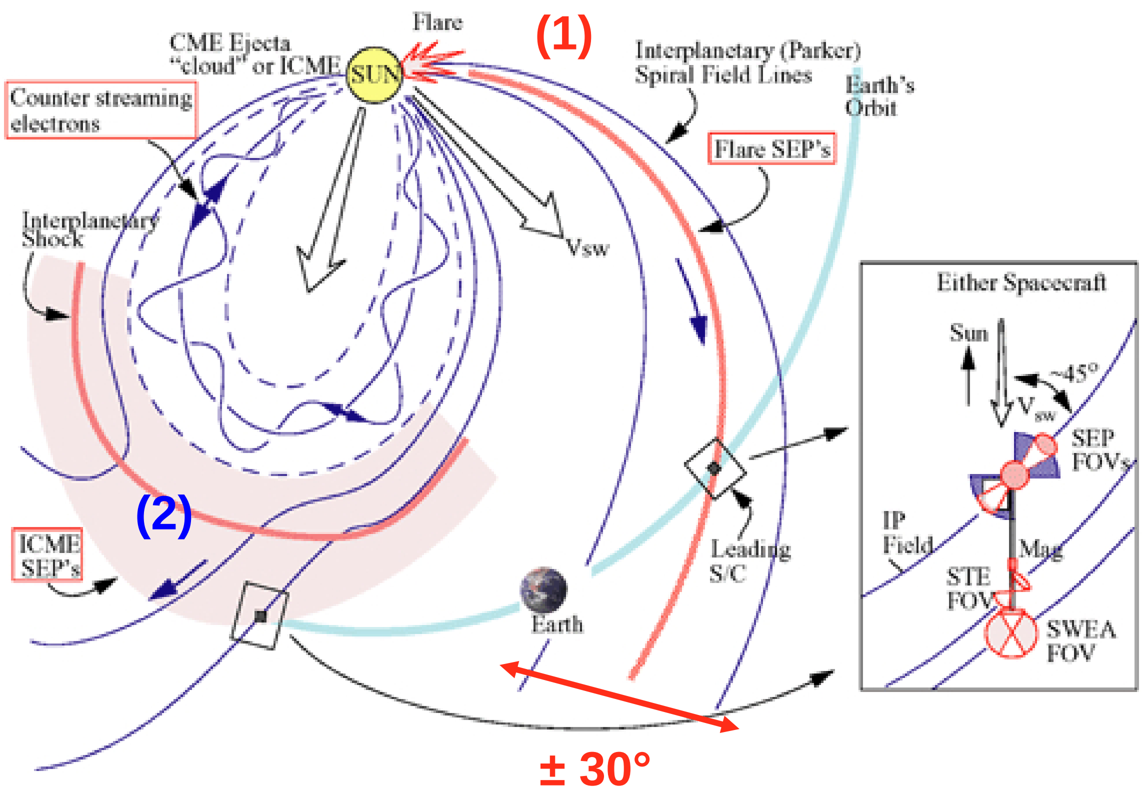
SUMMARY BREAKOUT SESSION C
Solar Energetic Particles

Sessions	Presentations	
(1) Longitudinal Spread of SEPs	4	Klecker
(2) SEP Transport / Cross-field diffusion	6	Klecker
(3) SEP Acceleration Mechanisms	7	Mewaldt
(4) SEP Event Lists	3	Mewaldt

SUMMARY BREAKOUT SESSION C
Longitudinal Spread of SEPs



Classical Picture

(1) Impulsive Events

- Localized source
- Low flux
- Electron-rich
- ^{3}He-rich, etc

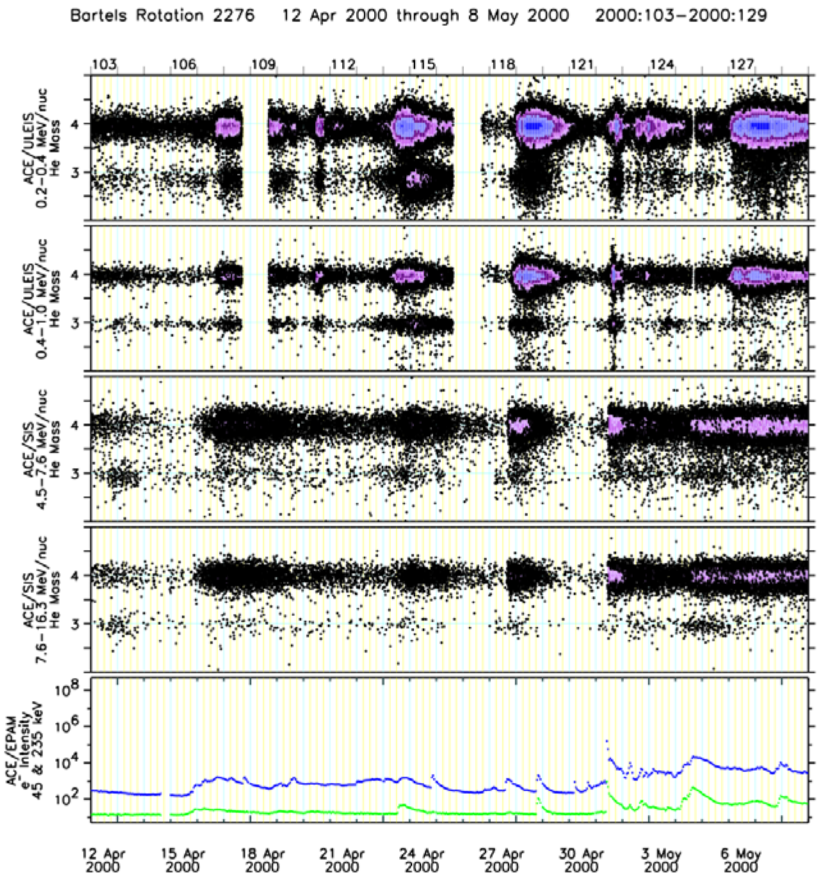
(2) Gradual Events

- Extended Source
- High Flux
- Electron-poor, etc

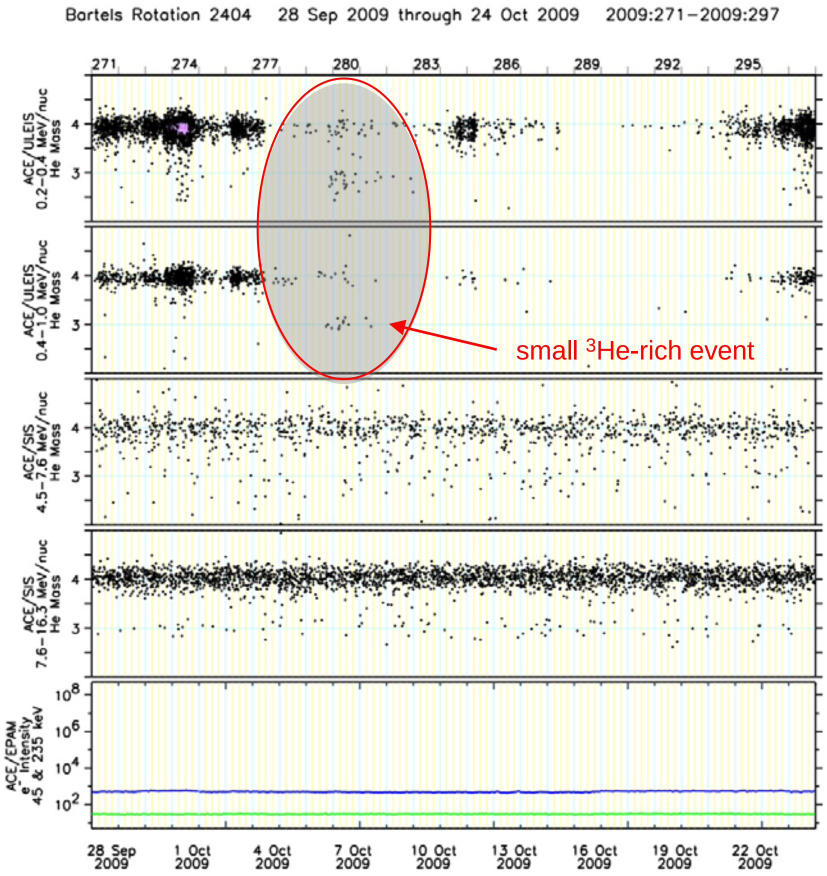
^{3}He Observed with ACE: Solar Minimum--Solar Maximum Comparison

- at solar maximum there are lots of ^{3}He-rich events
- at solar minimum ^{3}He-rich events are rare—provides a better opportunity to correlate events between different spacecraft without (much) confusion

Solar Maximum



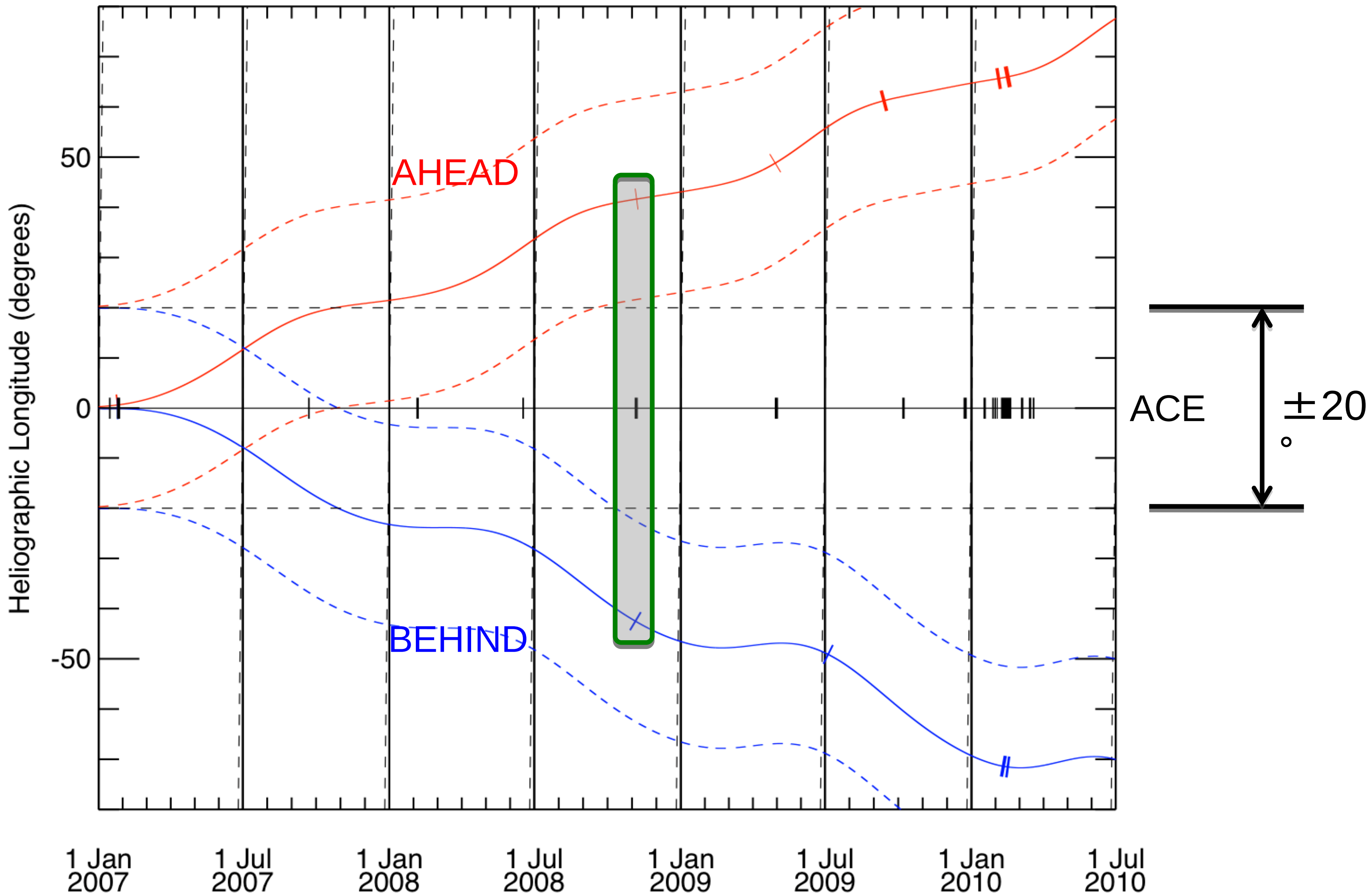
Solar Minimum



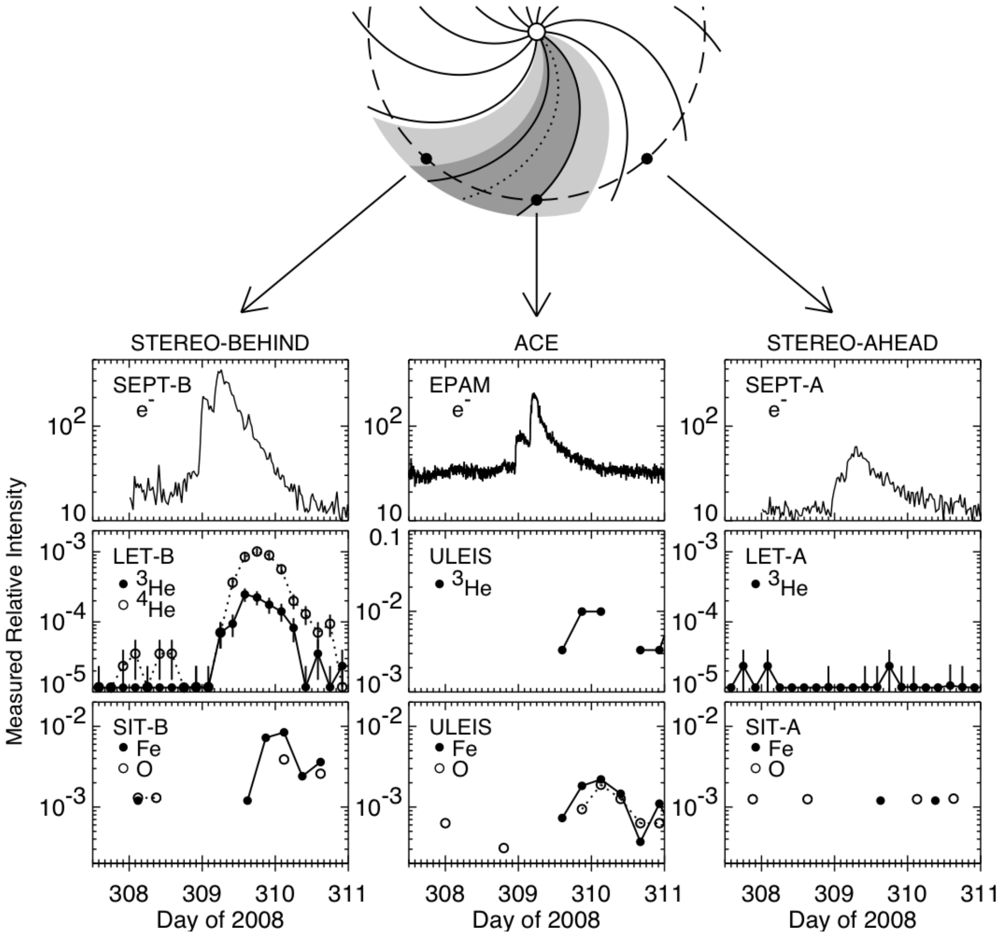
Wiedenbeck et al

^{3}He rich Events at ACE, STEREO-Ahead, and STEREO-Behind

- an event observed on both STEREO spacecraft and on ACE



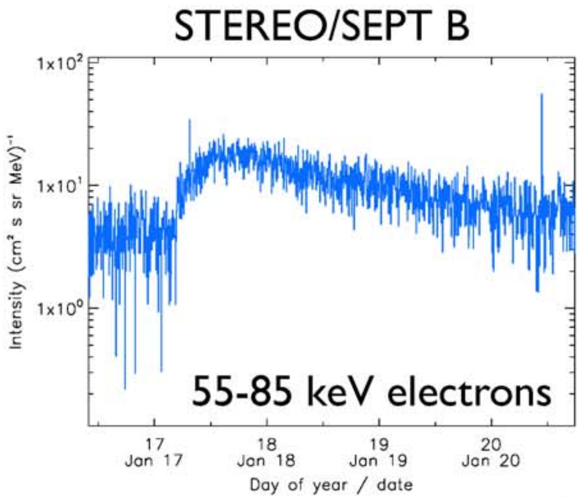
Event Observed over a Wide Range of Heliographic Longitudes



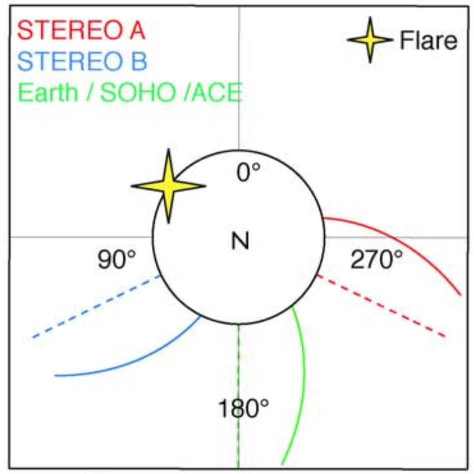
<u>3-4 Nov 2008 event</u>

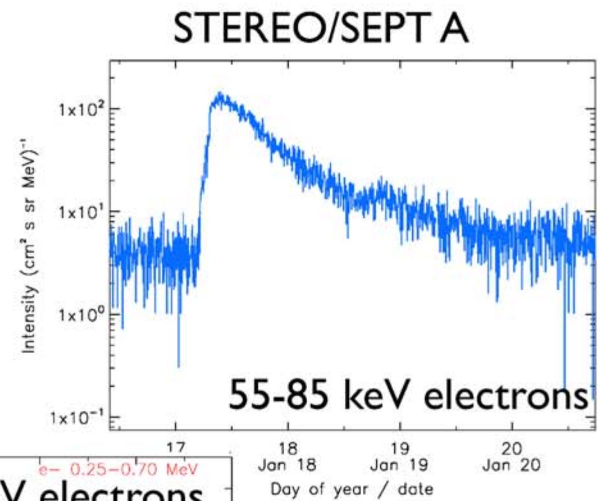
- the STEREOs were located ±41° from ACE
- electrons were observed at all three spacecraft using STEREO/SEPT and ACE/EPAM
- ^{3}He and heavy ions with enhanced Fe/O were observed at STEREO-B and ACE
- the lack of an ion detection at STEREO-A might be due to sensitivity limitations
- results discussed in Wiedenbeck et al. 2010, SW12 Proceedings

SUMMARY BREAKOUT SESSION C
Longitudinal Spread of SEPs: Jan 17, 2010

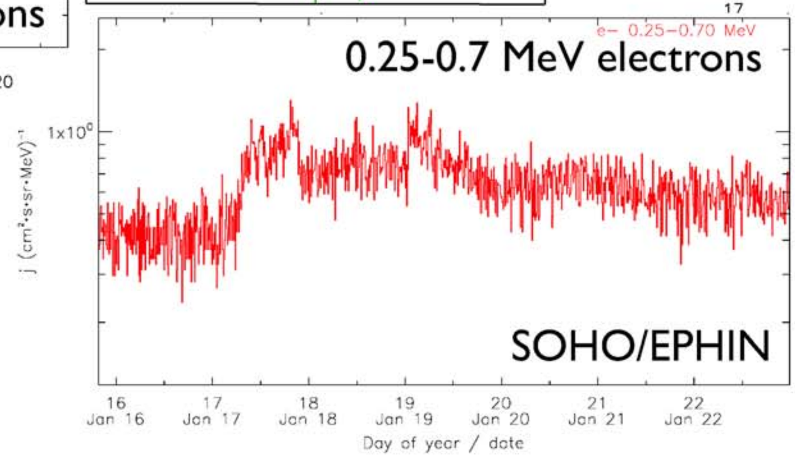


Long. Sep.: 108°





Long. Sep.: 118°



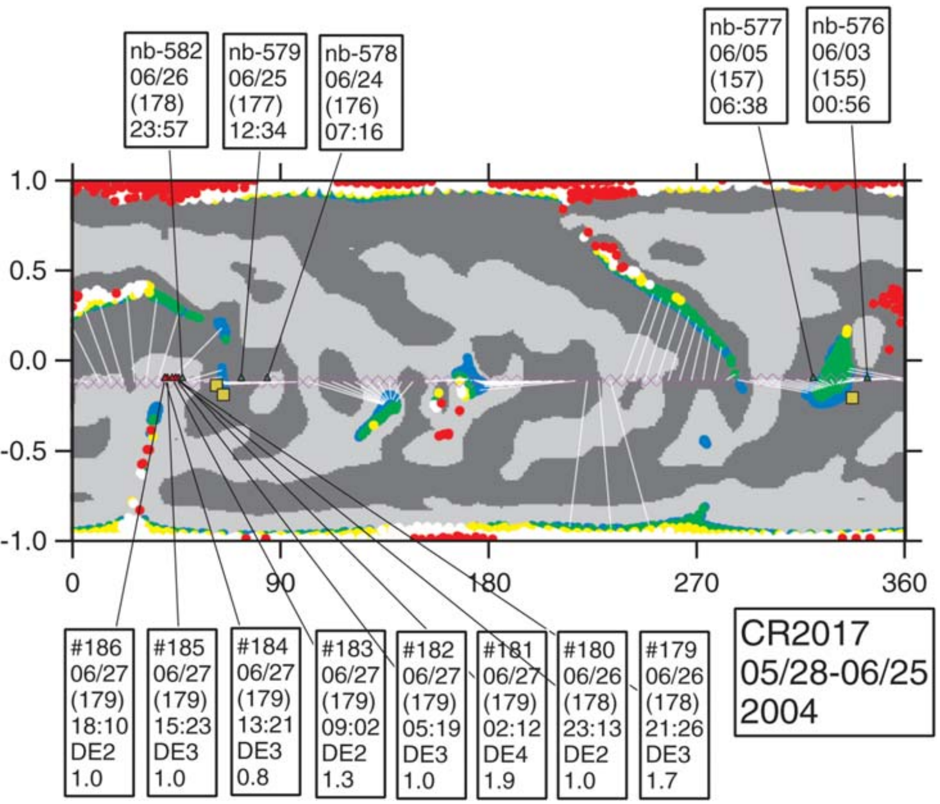
Long. Sep.: 169°

Dresing et al

SUMMARY BREAKOUT SESSION C
Longitudinal Spread of SEPs

Zur Anzeige wird der QuickTime™
Dekompressor „“
benötigt.

SUMMARY BREAKOUT SESSION C
Longitudinal Spread of SEPs



Non-beam events (~500/700) can come from any longitude or can cluster about active region longitudes

Beam events

Spikes and ***Pulses*** (smaller events)—
Occur in sequences
Tend to map to open field lines near flaring active regions

Ramps (larger events)—
Isolated (or at culmination of sequences)
Can map near or relatively far from flaring active regions
Consistent with acceleration by CME-driven shocks

SUMMARY BREAKOUT SESSION C
SEP Transport / Cross-Field Diffusion

Electron events with weak scattering in the inner heliosphere

- Haggerty & Roelof
- Agueda et al
- Wang et al.

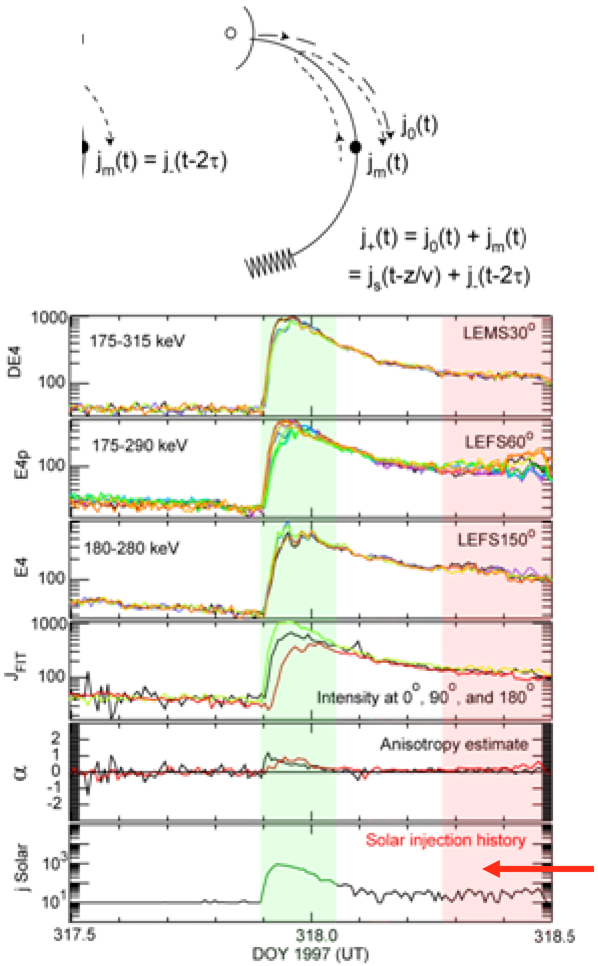
Cross-field transport

- Chollet et al.
- Klecker et al.

Radial evolution of gradual SEP events

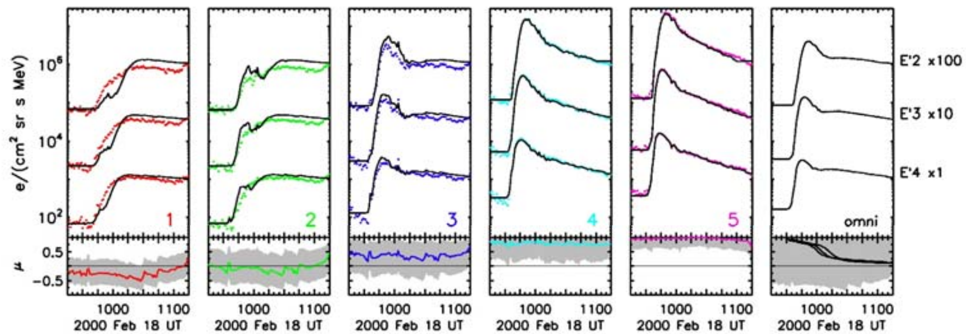
- Li

SUMMARY BREAKOUT SESSION C
SEP Transport / Electron Events



Solar Injection

Haggerty & Roelof



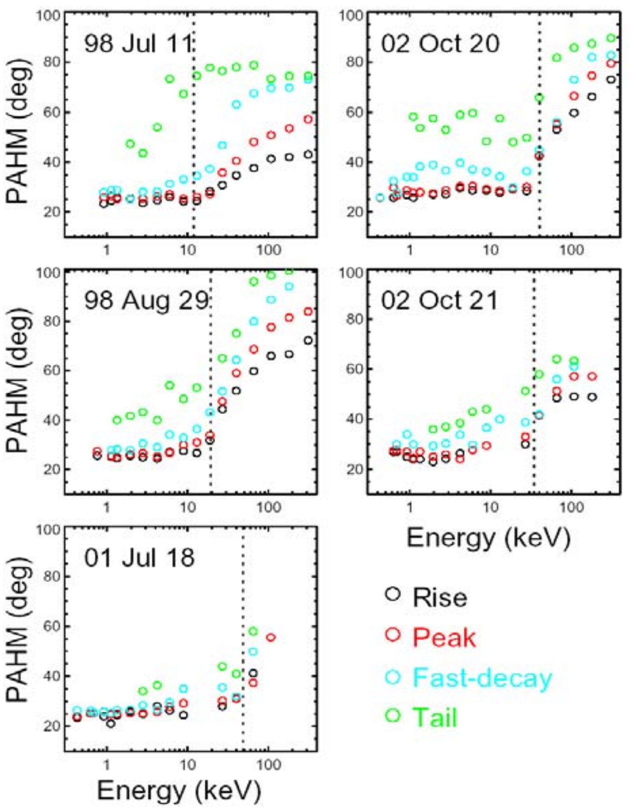
Best-fit parameters $\lambda_1 = 3.2$ AU; $\lambda_2 = 0.2$ AU; $r_{bs} = 1.2$ AU

Fit with Monte Carlo Transport Model

Agueda, et al.

SUMMARY BREAKOUT SESSION C
SEP Transport / Electron Events

$\rho_e = \rho_{Tp}$



*Two different PAD behaviors at low and high energies:

At low energies (~0.3keV to E_0), the PAHM remains roughly constant below 30° (corresponding to an actual PAHM of <~15°, limited by the instrumental response) from onset through the peak.

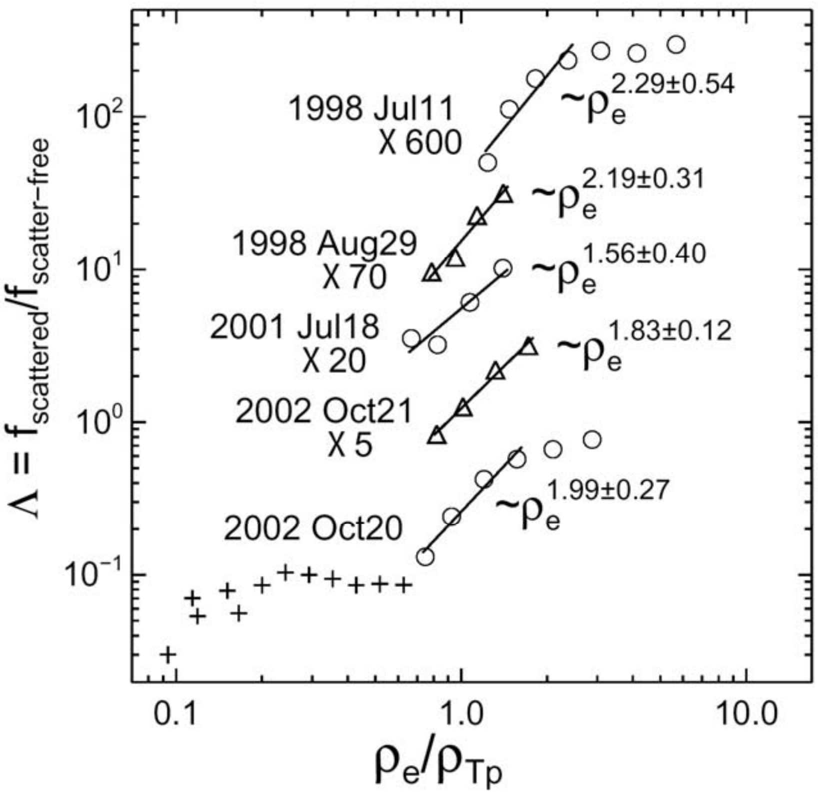
At high energies (E_0 to ~300 keV), the PAHM increases with energy, e.g., from ~30° at E_0 up to 85° at 300 keV at the peak; it also increases with time.

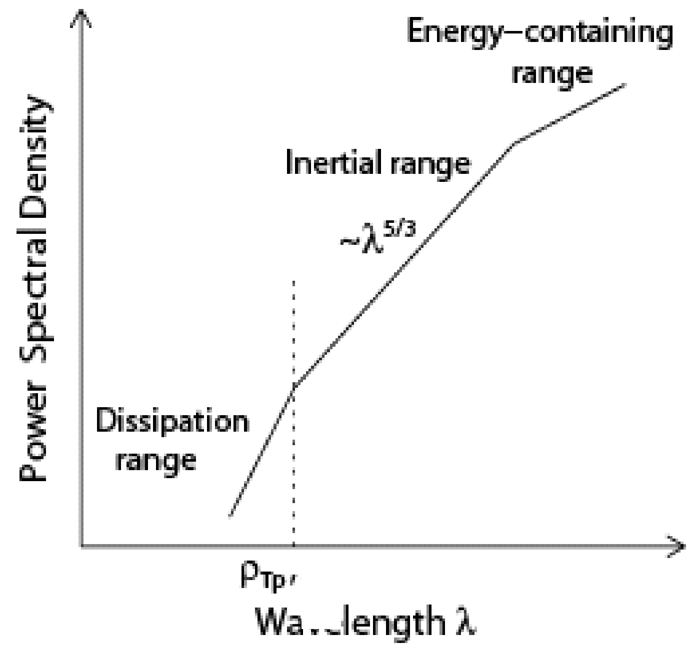
The energy transition E_0 varies from ~10 to 30 keV, from event to event.

L. Wang

Summary for the five events

The ratio Λ of the peak flux of outward-traveling scattered electrons to field-aligned scatter-free electrons



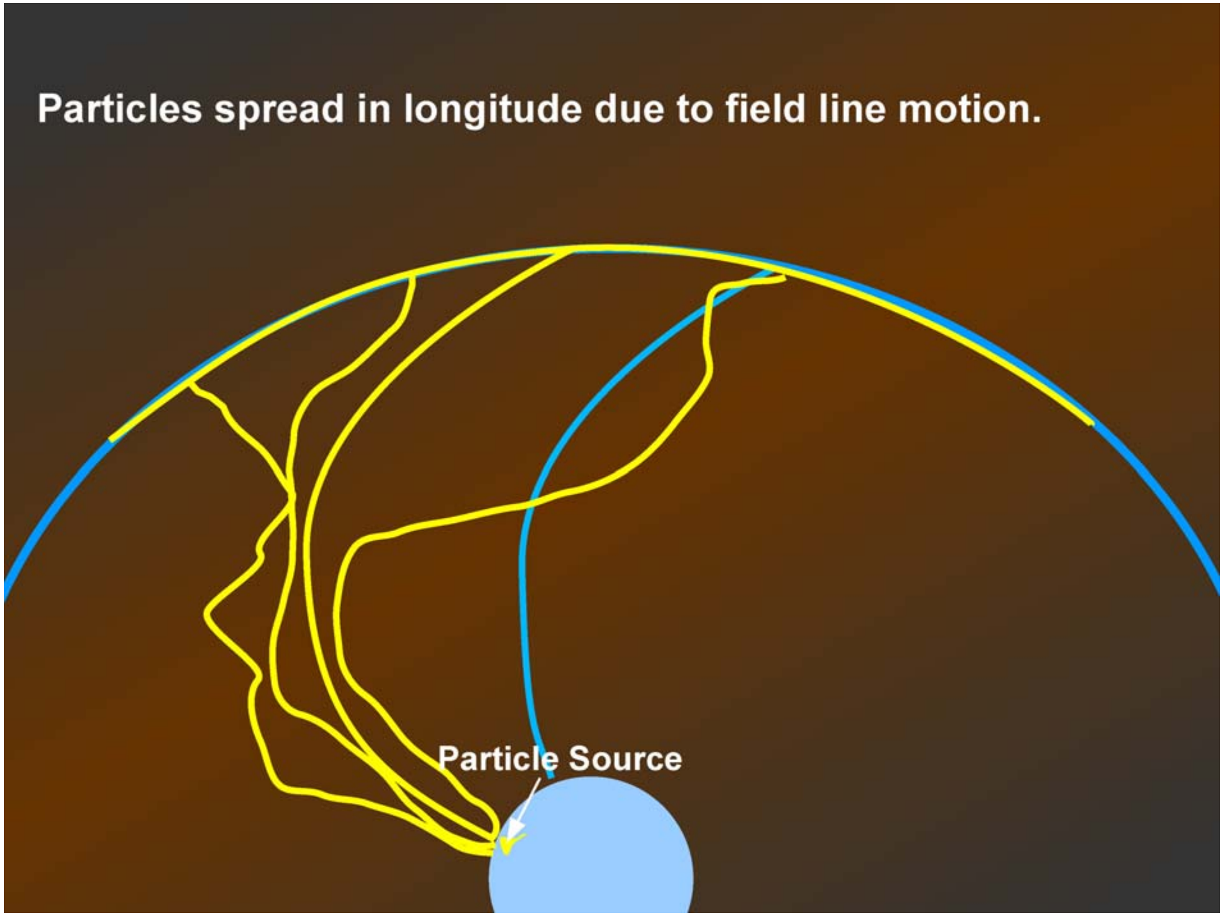


At energies with $\rho_e < \rho_{Tp}$, electrons would be weakly scattered because of weak power densities for resonant fluctuations/waves at scale $\lambda < \rho_{Tp}$ (the dissipation range).

At energies with $\rho_e > \rho_{Tp}$, electrons would scatter more due to stronger power densities for fluctuations/waves at scale $\lambda > \rho_{Tp}$ (the inertial range), and the power-law increase of Λ with ρ_e may be associated with the power-law increase of turbulence power density with λ ($P \propto \lambda^\beta$) .

L. Wang

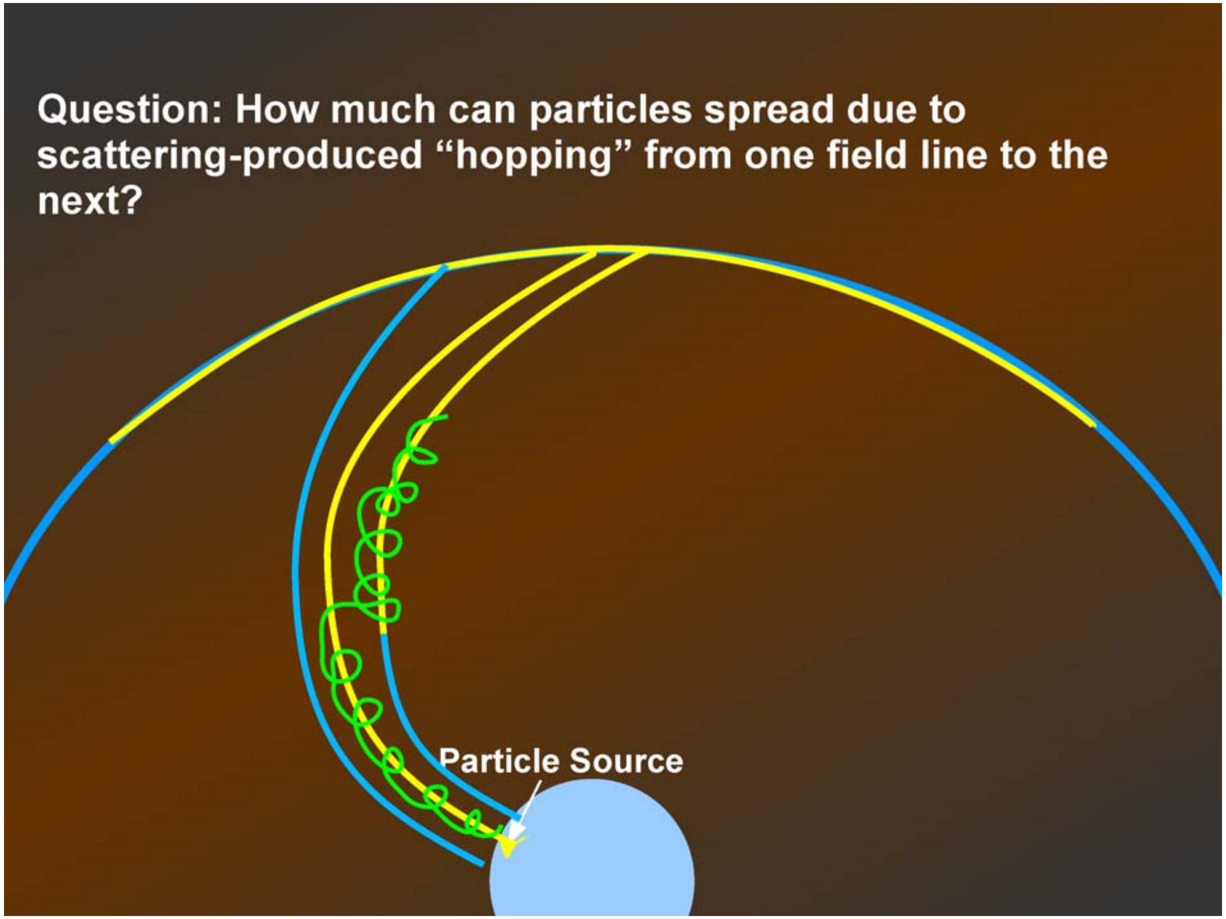
SUMMARY BREAKOUT SESSION C
Cross-Field Transport



Large -Scale:

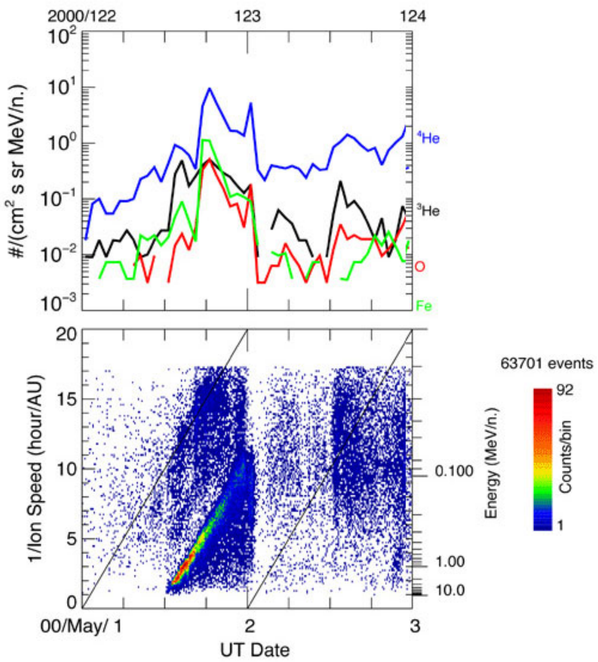
Field line motion

SUMMARY BREAKOUT SESSION C
Cross-Field Transport



Small-scale:

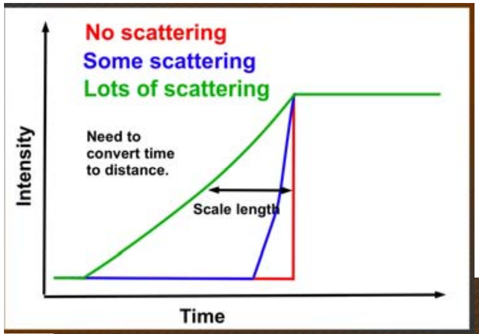
Cross-field diffusion

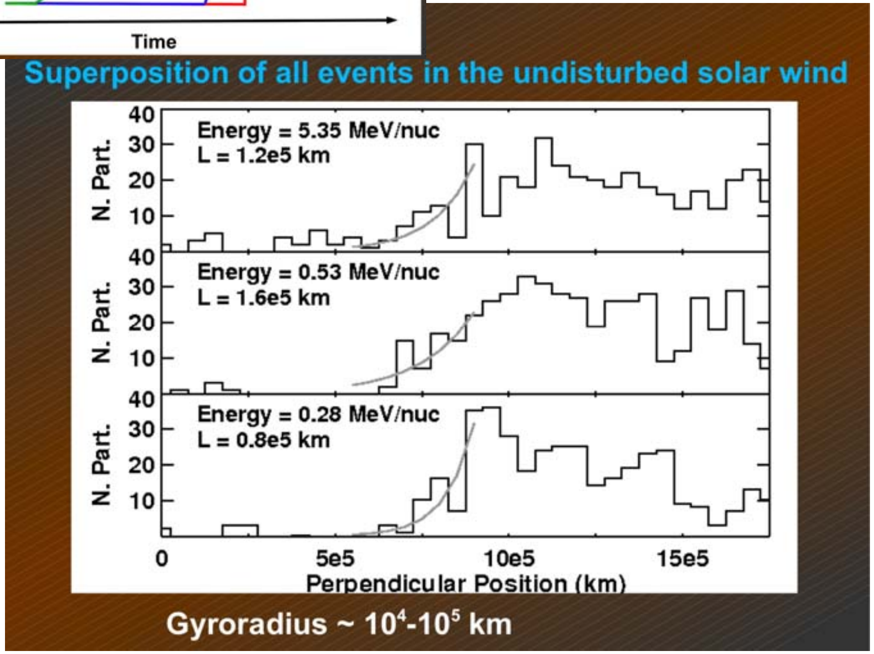


ACE ULEIS 1 May 2000

Chollet, et al.

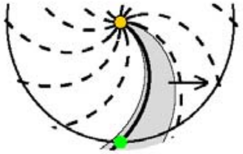
SUMMARY BREAKOUT SESSION C
Cross-Field Transport - Small Scales

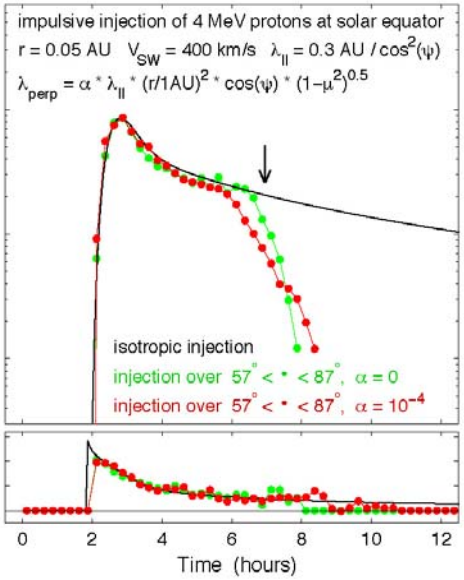




Chollet, et al.

3D Propagation Model





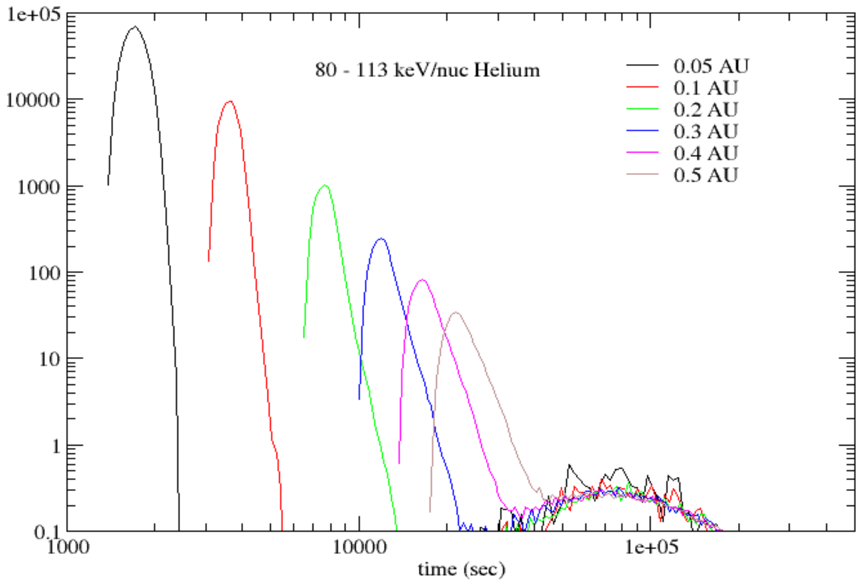
No Perp Diffusion

Perp diffusion

Klecker, et al.

upper limit for $\lambda_{perp} / \lambda_{||}$: $< 10^{-4}$ (at 1 AU)

SUMMARY BREAKOUT SESSION C
Radial Evolution of SEP Events



Helium Ions

SEP Measurements at different distances will provide information on turbulence / scattering

Gang Li

Solar Energetic Particle Breakout Session - Session C

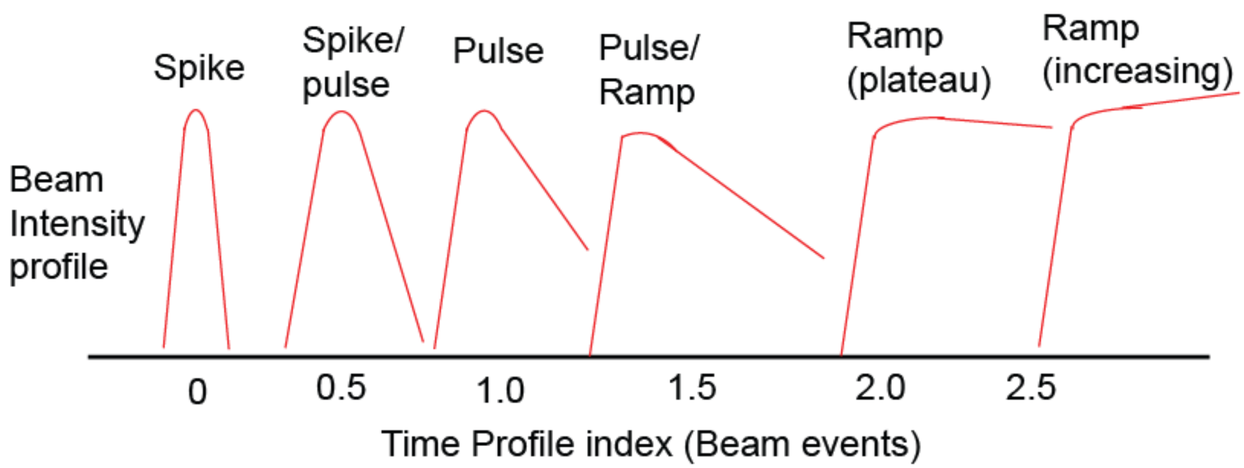
R. Mewaldt and B. Klecker – Chairs

Summary of
Session 3: SEP Acceleration Mechanisms
Session 4: SEP Event Lists

R. A. Mewaldt – Caltech

ACE/SOHO/STEREO/Wind Workshop
Kennebunkport, ME
June 10, 2010

SEP Acceleration Mechanisms – D. K. Haggerty & E. C. Roelof



Look at ~700 electron events!
Categorize profile, and probable source region

Beam events

Spikes and ***Pulses*** — Occur in sequences; map to open field lines near flaring active regions

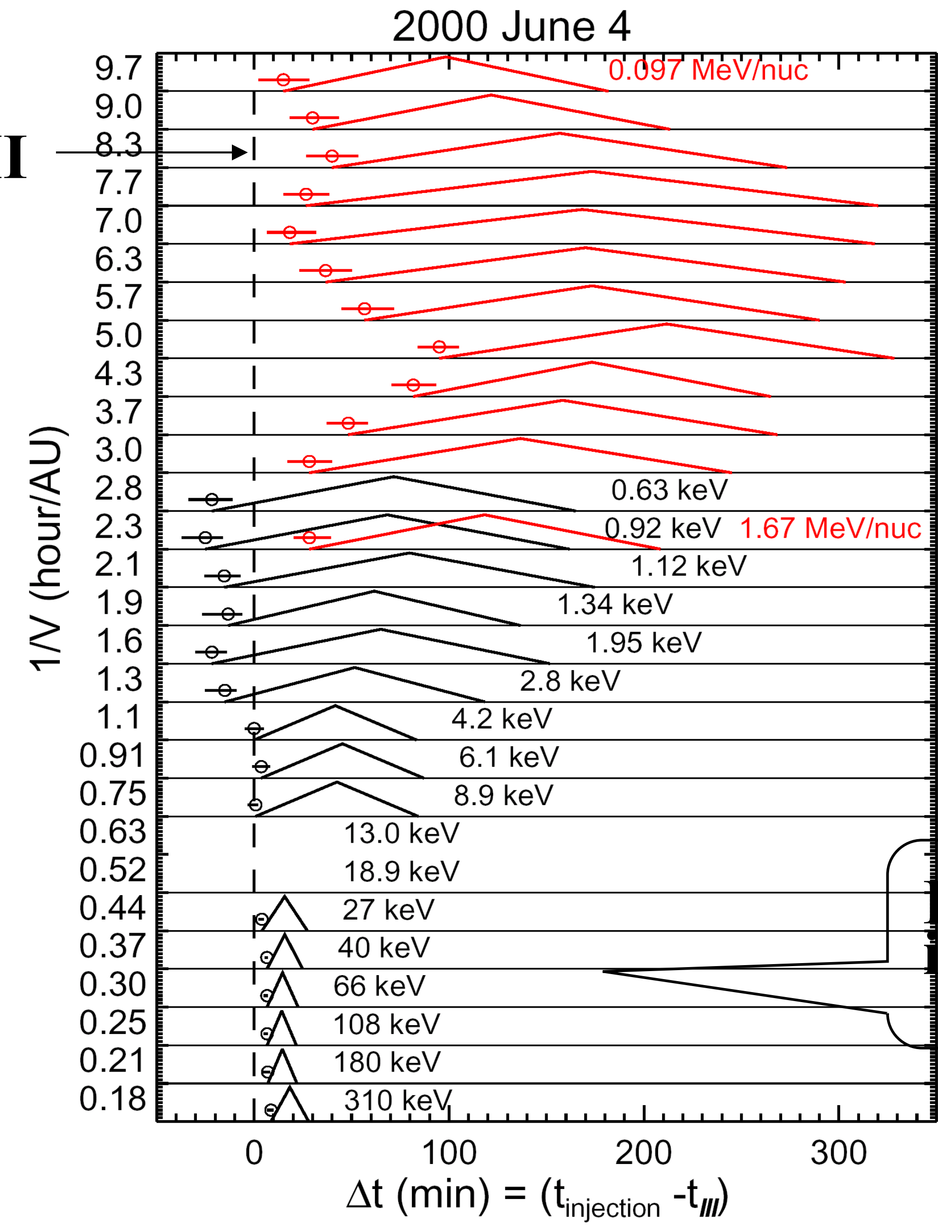
Ramps — Isolated; map near or far from flaring active regions; Consistent with acceleration by CME-driven shocks

Non-beam events (~500/700) can come from any longitude or can cluster about active region longitudes

When and Where are Impulsive SEPs Accelerated?

Linghua Wang, R. Lin, S. Krucker, G. Mason

Type III

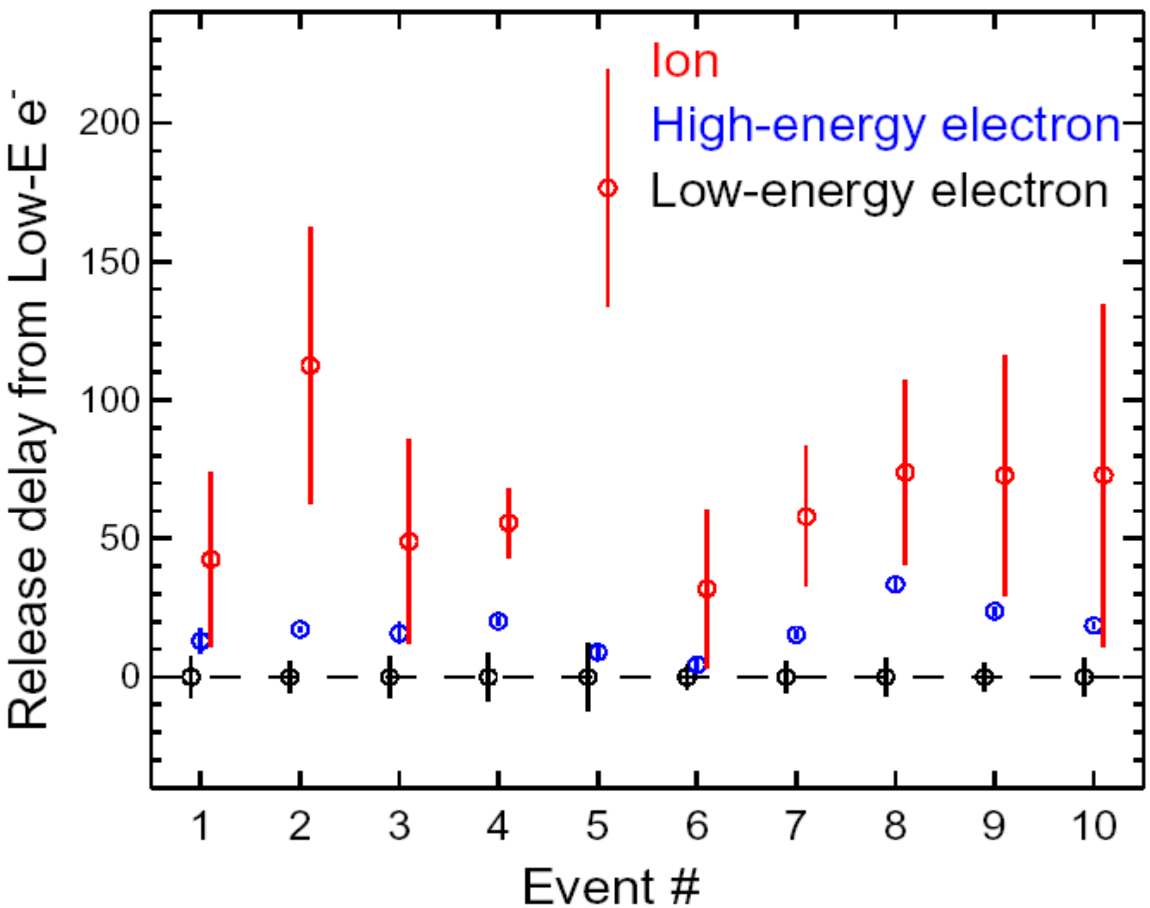


Red triangles: Ion injection profiles

Ion Delay: 48±21 min

Black triangles: Electron injection profiles

- **Need both low & high-energy electron sources (delay ~8 minutes)**
- **Averaged delay of ion release: 1.2 ± 0.2 hours**



Source of ion acceleration?

- **CME shock?**
- **Waves (from electrons)?**
- **Scattering?**

Spatial Offsets of Interplanetary Electron and Ion Source Regions

E. Chollet, R. Skoug, J. Steinberg, J. Gosling & J. Giacalone

Bremsstrahlung

2.2-MeV γ

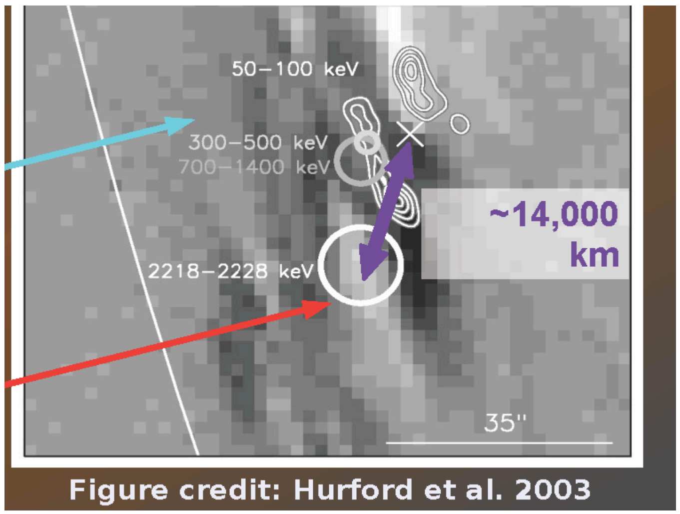
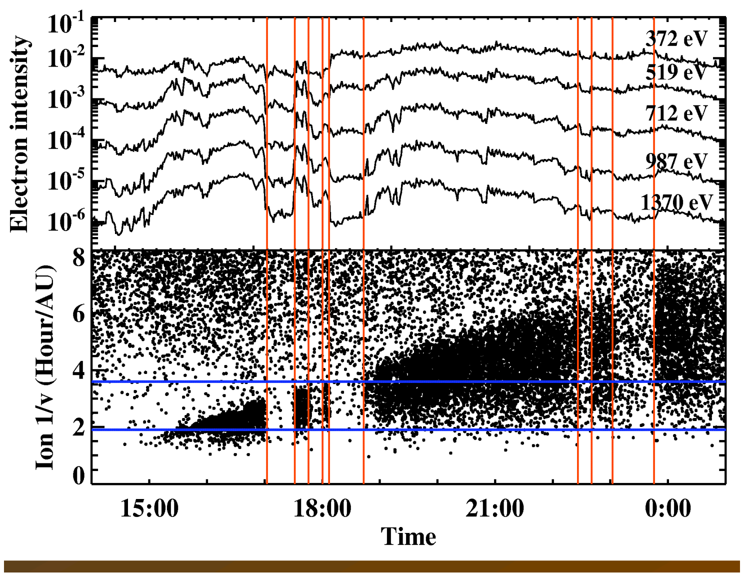


Figure credit: Hurford et al. 2003

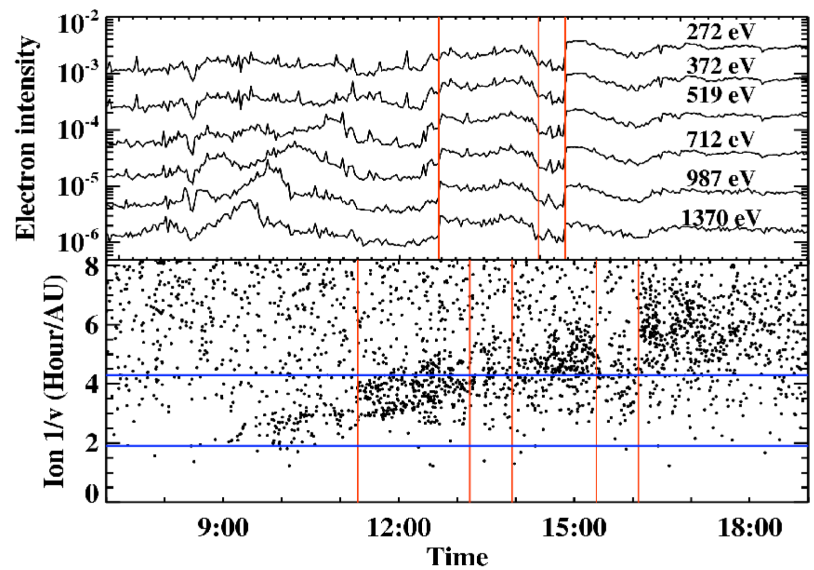
RHESSI finds that electron and ion Source regions are separated

ULEIS and SWEPAM data show different ion & electron "dropouts" in ~1/2 of events



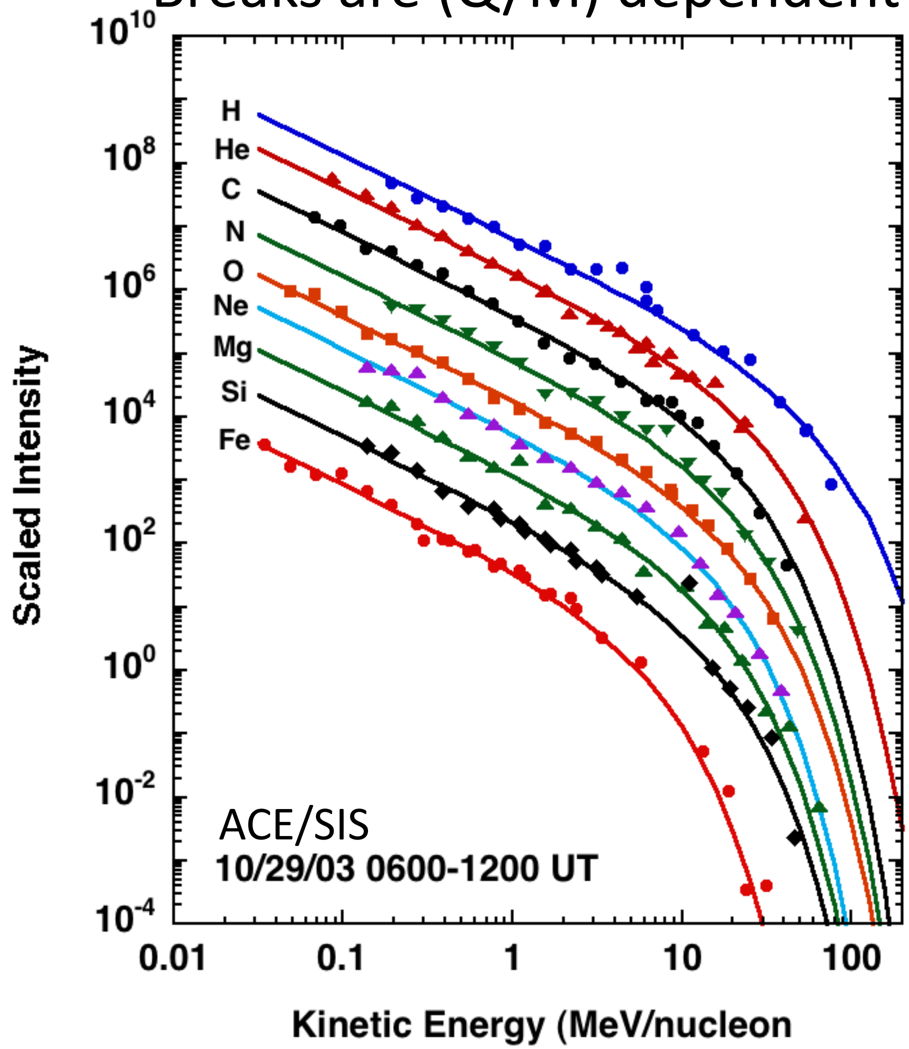
Simultaneous
←Dropouts

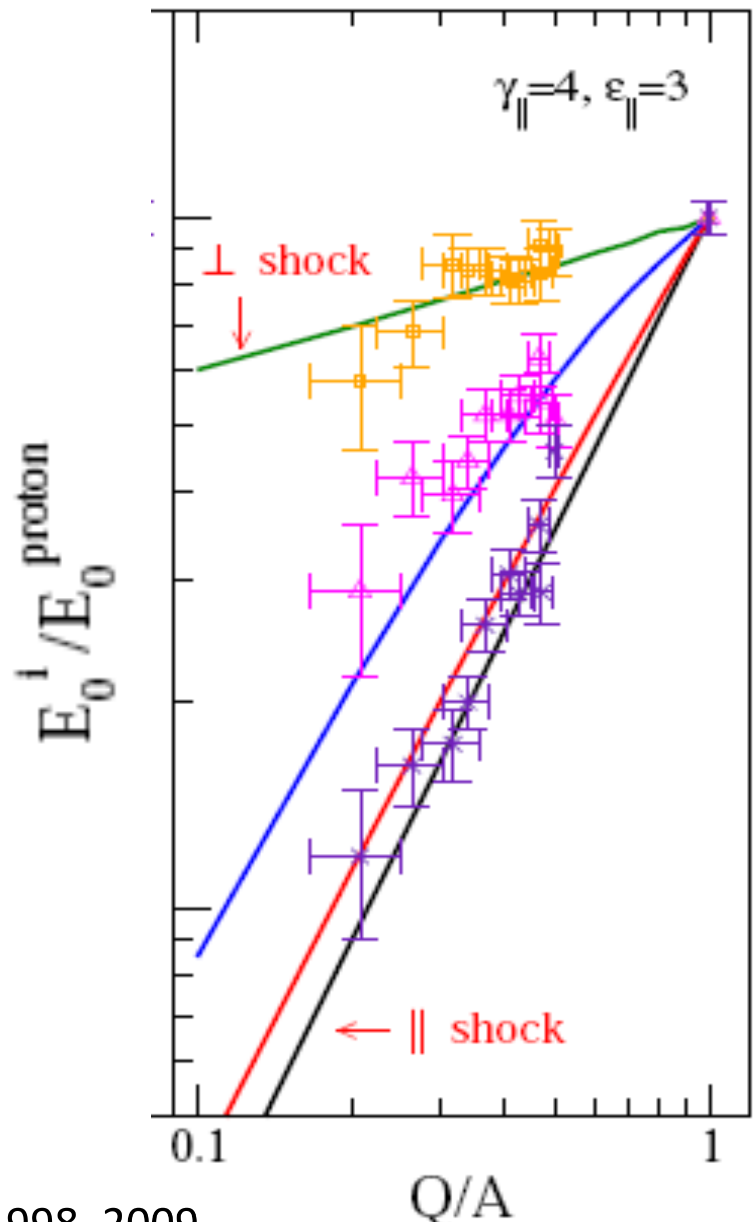
Dropout times
Differ →



Using SEP Spectra to Diagnose Shock Geometry close to the Sun
Gang Li, UAH

Breaks are (Q/M) dependent

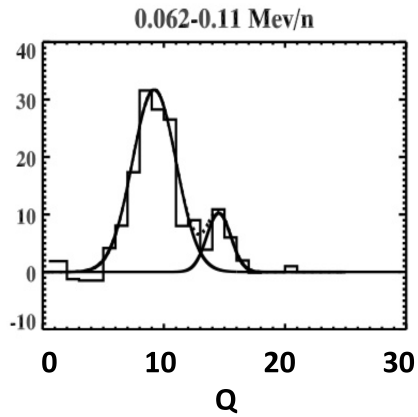


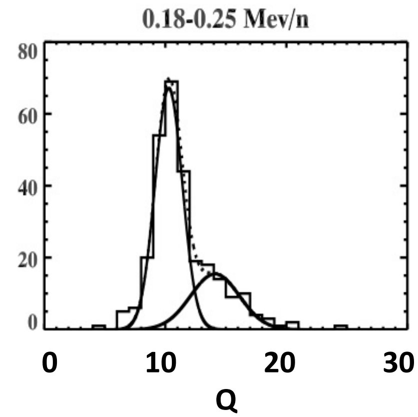


Li et al. ApJ, 702, 998, 2009

Consistent High Charge-State SEP Events on SEPICA

Z. Guo, E. Moebius, M. Popecki, B. Klecker, G. Mason, & P. Bochsler

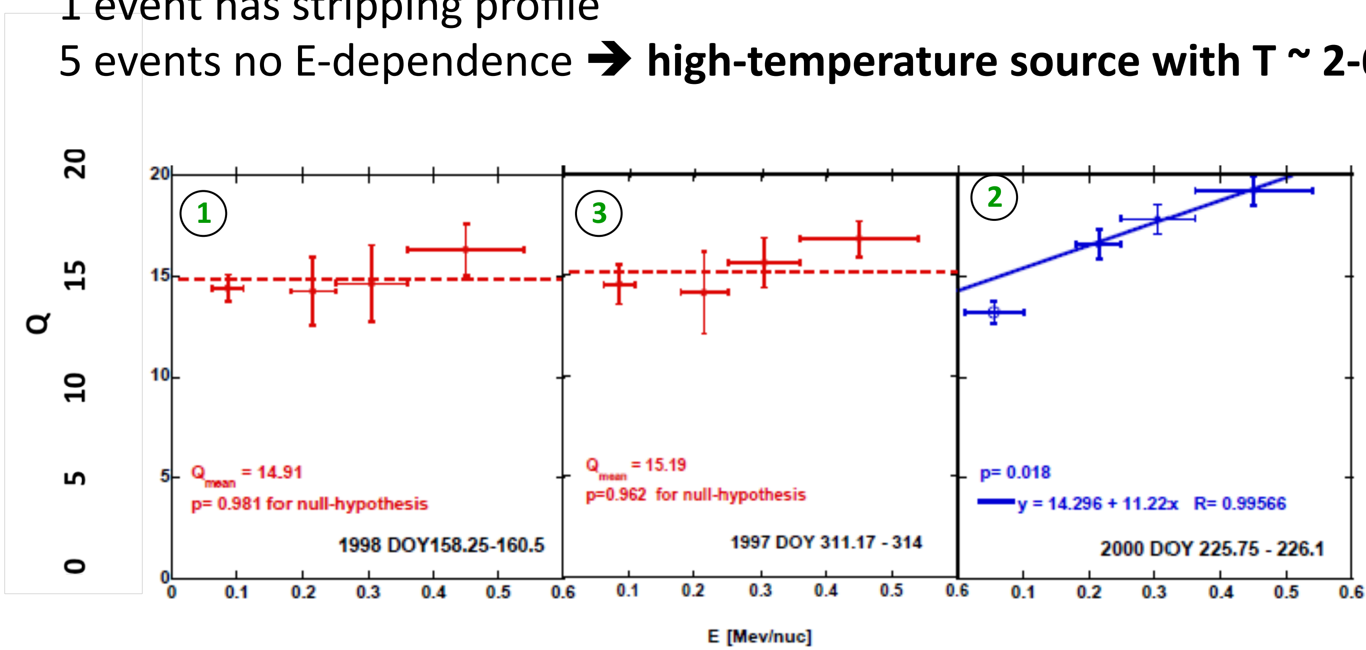




In some SEP events see evidence for high Ionization states (e.g., $Q_{Fe} \geq +14$)

In most cases see energy-dependence, Q_{Fe} ~ 10-12 → 16-18 with energy indicating stripping during/after acceleration

In six events see $Q_{Fe} \geq 14$ at all energies;
1 event has stripping profile
5 events no E-dependence → **high-temperature source with T ~ 2-6 MK**



Possibilities:
Accelerate CME ejecta?
High-T flare source?

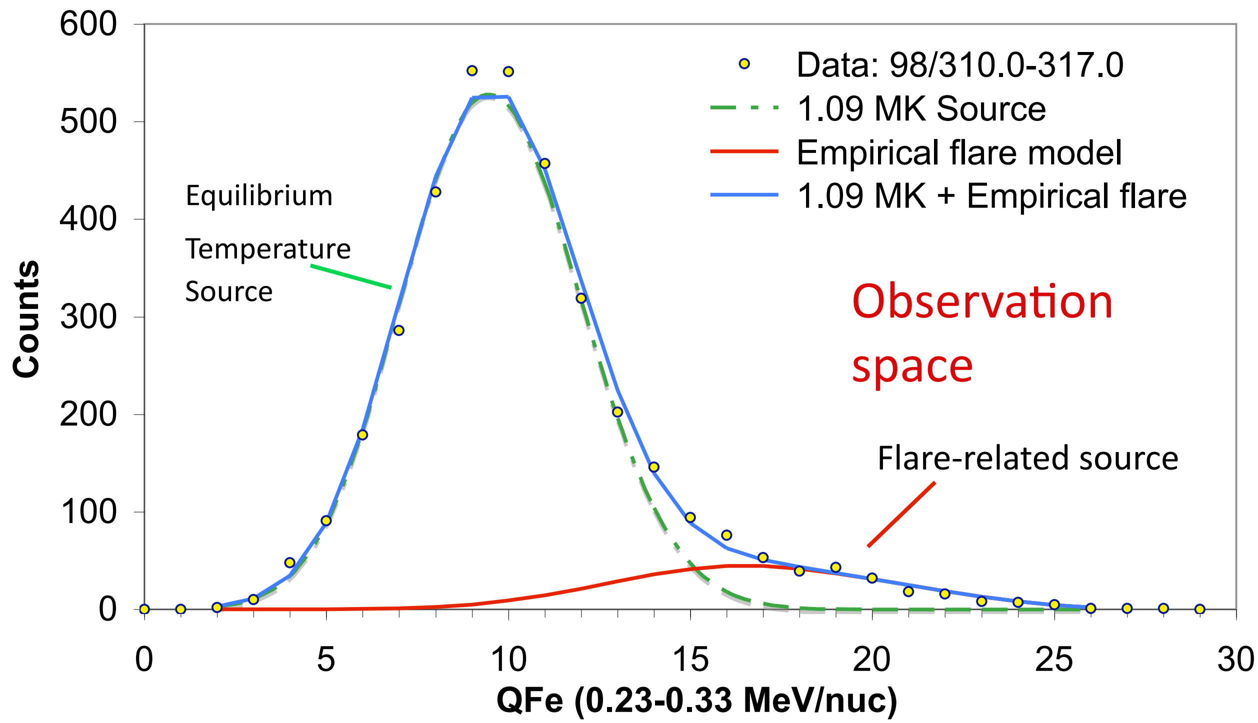
SEP Fe Charge State Distributions: Implications for Sources

Mark Popecki, Eberhard Moebius and Berndt Klecker

Looked at 4 events; 3 had two temperature components

Testing for two concurrent sources in the 98/310 event

- Empirical flare-associated model combined with 1.09MK thermal equilibrium model
- Halo CME and a series of flares in the western hemisphere.

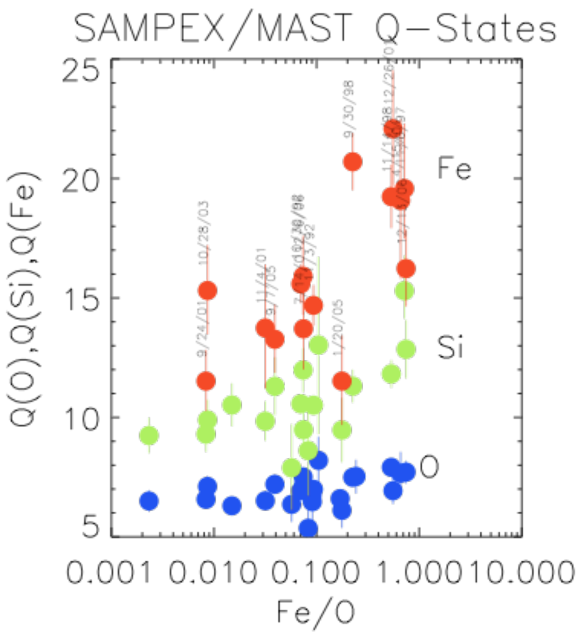


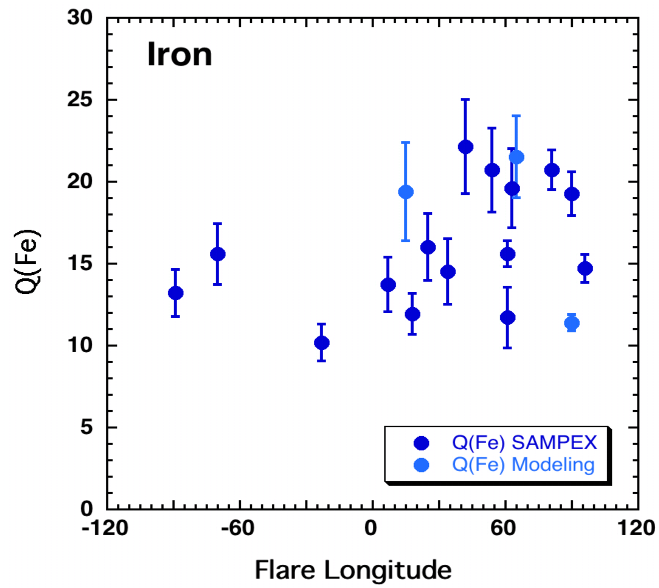
Halo CME and a long series of flares in W hemisphere between N22W18 and N24W81; cloud passage at Earth in latter part of event.

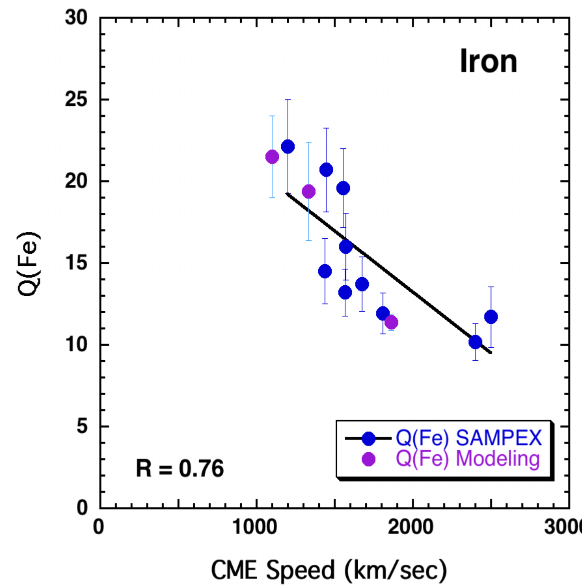
ACE News #127 11/2009

SEP Q-States above 20 MeV/nuc

A. Labrador, R. Leske, R. Mewaldt, E. Stone, and T. von Rosenvinge







- **Most high-charge-state events (Q_{Fe} ≥ 18) are Fe-rich**
- **Most events with Q(Fe) >16 occur in the western hemisphere**
- **Most high-charge-state events involve slower CMEs**
- **The largest SEP events are not high-charge-state events**

Possibilities:
Stripping?
Direct flare contributions from flares?
Remnant flare-suprathermals accelerated by CME-driven shock?

STEREO-1 & 2 SEP Electron Event List

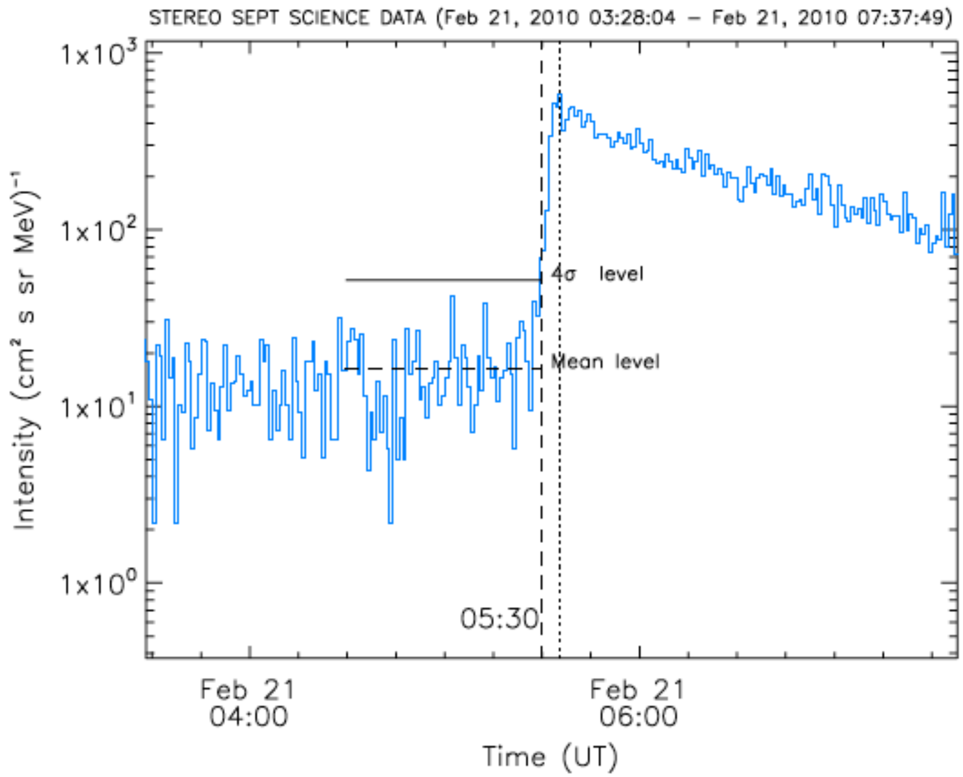
Nina Dresing, R. Gomez-Herrero,
A. Klassen, and B. Heber.

STEREO/IMPACT/SEP Sensors

~50 Electron Events > 55 keV

WWW2.physik.uni-kiel.de/stereo/

Looking for feedback from users



contact: dresing@physik.uni-kiel.de Intensities in 1/(cm^2 s sr MeV)

	Event Number	s/c	Doy	Date	Onset (UT)	dt (min)	Max (UT) 10 min av.	Max Intensity 10 min av.	Emax (keV)	Remarks	Link to browse plot
2007	1	A	023	2007-01-23	18:58	4	19:36	1.79E+02	145		Link
	1	B	023	2007-01-23	19:10	4	19:56	2.07E+02	145		Link
	2	A	024	2007-01-24	01:05	1	01:36	2.44E+02	145		Link
	2	B	024	2007-01-24	01:00	1	01:26	2.68E+02	145		Link
	3	A	024	2007-01-24	05:50	1	05:56	4.30E+02	165		Link
	3	B	024	2007-01-24	05:45	1	06:16	5.39E+02	165		Link
	4	A	139	2007-05-19	13:43	5	18:06	4.20E+02	375		Link
	4	B	139	2007-05-19	13:58	5	18:46	5.49E+02	375		Link
	5	A	140	2007-05-20	~6:00	1	10:26	3.05E+02	225	On the decay phase of previous event. Probably new injections on May 22	Link
	5	B	140	2007-05-20	~6:00	1	11:16	2.92E+02	225	On the decay phase of previous event. Probably new injections on May 22	Link
	6	A	143	2007-05-23	08:22	1	11:26	4.98E+02	295	Onset during ICME. Decay during CIR (ion contamination)	Link
	6	B	143	2007-05-23	08:12	1	13:06	4.95E+02	295	Onset during ICME. Decay during CIR (ion contamination)	Link
	7	A	207	2007-07-26	02:09	5	05:16	1.40E+01	65	Very small event - poor statistics	Link
	7	B	207	2007-07-26	02:43	5	05:06	4.20E+01	65	Small event - poor statistics	Link
	8	A	210	2007-07-29	02:16	10	06:56	3.34E+01	200	Small event	Link
2008	9	A	096	2008-04-05	16:30	1	16:46	2.53E+02	225	Only in A	Link
	10	B	141	2008-05-20	14:03	1	14:06	4.28E+01	150	Only in B. Impulsive onset	Link
	11	A	272	2008-09-28	22:36	10	02:16	3.49E+01		Uncertain event, slowly rising profile	Link
	12	A	308	2008-11-03	23:54	3	00:56	1.72E+01	150	Impulsive	Link
	12	B	308	2008-11-03	23:29	1	00:36	1.31E+02	145	Impulsive	Link
	13	A	309	2008-11-04	?	10	06:56	3.18E+01	145	Impulsive, uncertain onset due to overlap with previous event and poor statistics	Link
	13	B	309	2008-11-04	04:10	1	06:16	2.11E+02	145	Impulsive, overlaps previous event.	Link
	14	A	346	2008-12-11	09:54	5	10:36	1.47E+01	145	Small event, only in A	Link
2009	15	A	118	2009-04-28	11:43	5		4.12E+01	200		Link
	16	A	122	2009-05-02	19:54	1	20:46	4.55E+02	300		Link

List of 2 – 15 MeV Proton Events From STEREO/LET

R. A. Leske and C. M. S. Cohen, Caltech

List generated automatically *automatically*. Still being tested. Includes CIRs
Quantities tabulated so far include:

- **Start and end times (using 3-hour average rates)**
- **Proton peak intensities and fluences (4 energy bands each)**
- **Proton spectral index (with statistical uncertainty)**
- **He/H ratio (with statistical uncertainty)**
- **Guesstimate of event type (CIR or SEP) and whether or not electrons were detected by SEPT**

The draft list (and accompanying plots) is available in a link under
http://www.srl.caltech.edu/STEREO/Level1/LET_public.html

Automatically generated event list for STEREO-LET, requiring that 3-hour averaged 1.8-3.6 MeV proton rate exceeds 5x10^-4 particles/(cm^2 sr s MeV)

Peak Proton Intensities often occur at different times for each energy bin.
Proton fluences have had a constant background assumed to be 2.3x10^-5 particles/(cm^2 sr s MeV) subtracted.
The "2-Point Index" is obtained from the 1.8-3.6 and 4-6 MeV proton FLUENCES
The He/H ratio is that of the 1.8-3.6 MeV/n proton and He FLUENCES, where a constant background of 1x10^-5 particles/(cm^2 sr s MeV/n) has been subtracted from the He. Uncertainties in the index and He/H are statistical errors ONLY.

Event Types are tentative identifications ONLY, automatically determined based on spectral hardness and He/H ratio. Events with an added "?" fall within one standard deviation of the chosen boundary between SEPs and CIRs in at least one parameter (index or He/H). An "e-" after the type indicates that the peak of an SEPT electron event falls between the event start and end times.

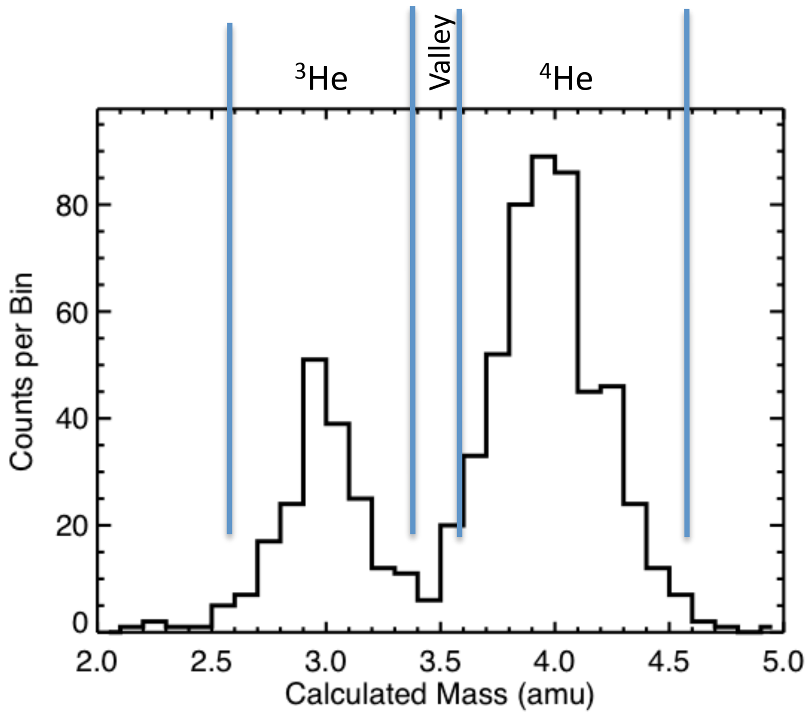
From 2007/005 through 2010/125, *111* events are found on Ahead, and *104* on Behind.

STEREO-Ahead/LET:

Evt	Start time		End time		Peak Proton Intensities p/(cm2sr s MeV)				Proton Fluences: p/(cm^2 sr MeV)				2-Point Index		He/H @1.8-3.6		Type
#	Year	DOY	Year	DOY	1.8-3.6	4-6	6-10	10-15	1.8-3.6	4-6	6-10	10-15	Value	+/-	Value	+/-	
0	2007	5.500	2007	11.500	0.00853	0.00093	0.00016	0.000085	2282.74	228.602	39.232	9.70986	-3.421	0.035	0.0453	0.0017	CIR
1	2007	11.500	2007	15.375	0.00744	0.00076	0.00020	0.000085	1104.18	150.959	38.696	8.70357	-2.982	0.044	0.0107	0.0012	SEP
2	2007	15.375	2007	20.000	0.00676	0.00027	0.00008	0.000061	1098.87	48.691	5.030	1.93305	-4.543	0.071	0.0160	0.0014	CIR
3	2007	20.000	2007	23.375	0.00410	0.00051	0.00009	0.000052	622.44	52.952	5.547	1.26934	-3.648	0.071	0.0121	0.0017	CIR
4	2007	23.375	2007	27.125	0.01391	0.00236	0.00077	0.000165	2896.73	475.221	75.101	8.86257	-2.722	0.025	0.0349	0.0013	SEP e-
5	2007	27.125	2007	32.750	1.19883	0.17764	0.02368	0.001807	152012.38	20849.186	2933.217	268.17221	-2.978	0.004	0.0101	0.0001	SEP
6	2007	32.750	2007	40.625	0.04022	0.00324	0.00051	0.000075	9608.59	900.100	99.935	7.20539	-3.514	0.017	0.0153	0.0005	CIR
7	2007	40.625	2007	48.375	0.07270	0.00234	0.00009	0.000052	12086.64	435.903	15.325	2.12264	-4.822	0.023	0.0274	0.0006	CIR
8	2007	48.375	2007	57.500	0.07684	0.00661	0.00039	0.000056	18048.19	1264.659	64.450	2.53850	-3.917	0.014	0.0337	0.0005	CIR
9	2007	57.500	2007	63.500	0.03764	0.00054	0.00006	0.000052	2734.57	35.257	2.871	2.00355	-6.189	0.080	0.0191	0.0010	CIR
10	2007	71.000	2007	76.625	0.32895	0.01972	0.00098	0.000066	44769.91	2247.970	90.794	4.11317	-4.373	0.011	0.0362	0.0003	CIR
11	2007	76.625	2007	84.125	0.00440	0.00028	0.00009	0.000066	969.04	56.059	10.299	2.11121	-4.180	0.067	0.0179	0.0016	CIR

Progress on Automating the Identification of ^{3}He-rich Periods using the STEREO/LET Instruments

M. E. Wiedenbeck, JPL/Caltech



Quantity	Trial Value
^{3}He energy	2.3-3.8 MeV/n
Time Interval	3 days
^{3}He counts	≥10 counts
^{3}He/^{4}He	≥0.1
Valley/^{3}He	≤0.5

Will be online soon at Caltech/STEREO site