Shock Acceleration of Thermal and Hot Seed Ion Populations

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Building a Foreshock Database

- We have been engaged in building a database of field and particle observations upstream and downstream of shocks.
  - Have employed 8 undergraduate students.
    - Resulting in 1 finished Senior Thesis (David Sodaitis) and second underway (Michael Winder).
  - Have examined 66 shocks so far.
  - Provided material for IGPP Hawaii conference talk and paper plus 2 AGU posters plus 2 SHINE posters.

Preparing Shock Paper(s)

- We met Mihir and Maher 2 days in July to refine shock choices.
  - Selected 17 shocks for study using ACE/ WIND data.
  - Will produce 2 papers using proton, composition, and IMF analyses.
- Senior Mike Winder is serving as numerical analyst (and learning a lot!).
  - Mike will do his Senior Thesis with us.
- We are working on those papers now.

Example Event: 1999 / 47-49 (Cold Seeds)

Density compression: $\rho_d/\rho_u \sim 2.9 \pm 0.1$

and $\Theta_{Bn} = 50 \pm 2$.

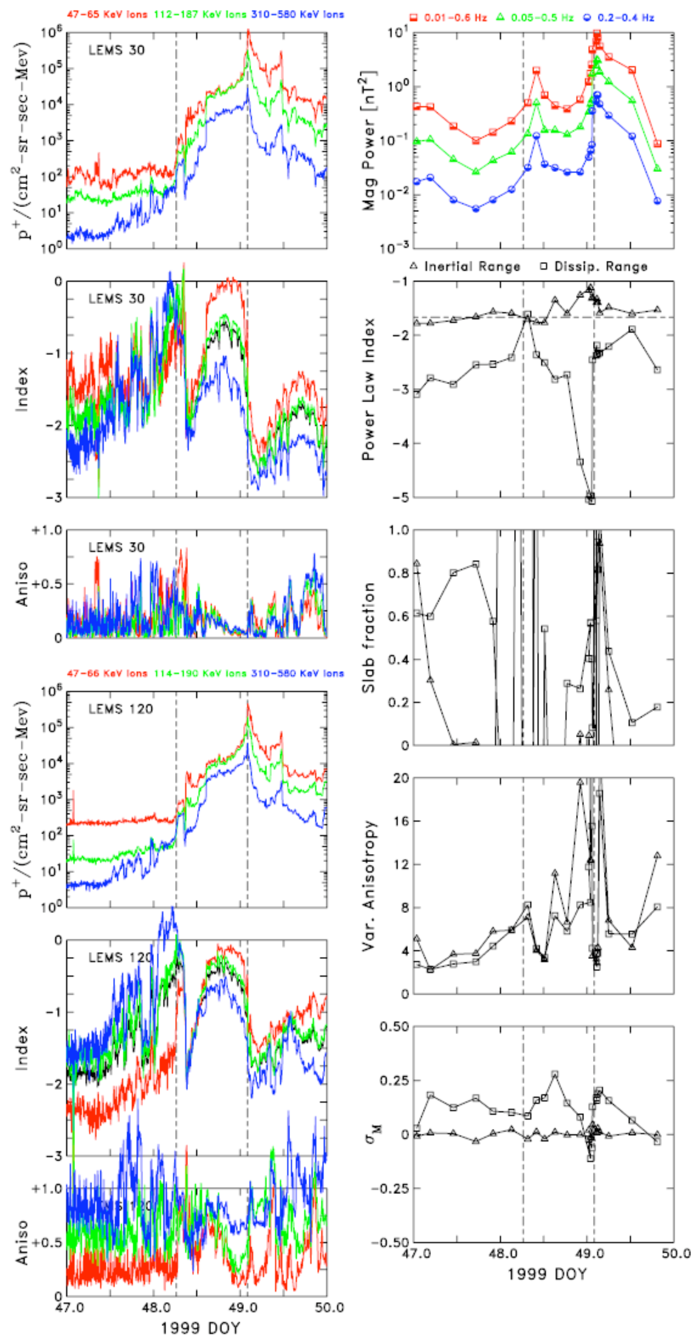
Clear proton foreshock of appropriate scale. Softening particle spectra on the same ESP scale.

Particle intensity index appropriate to shock strength.

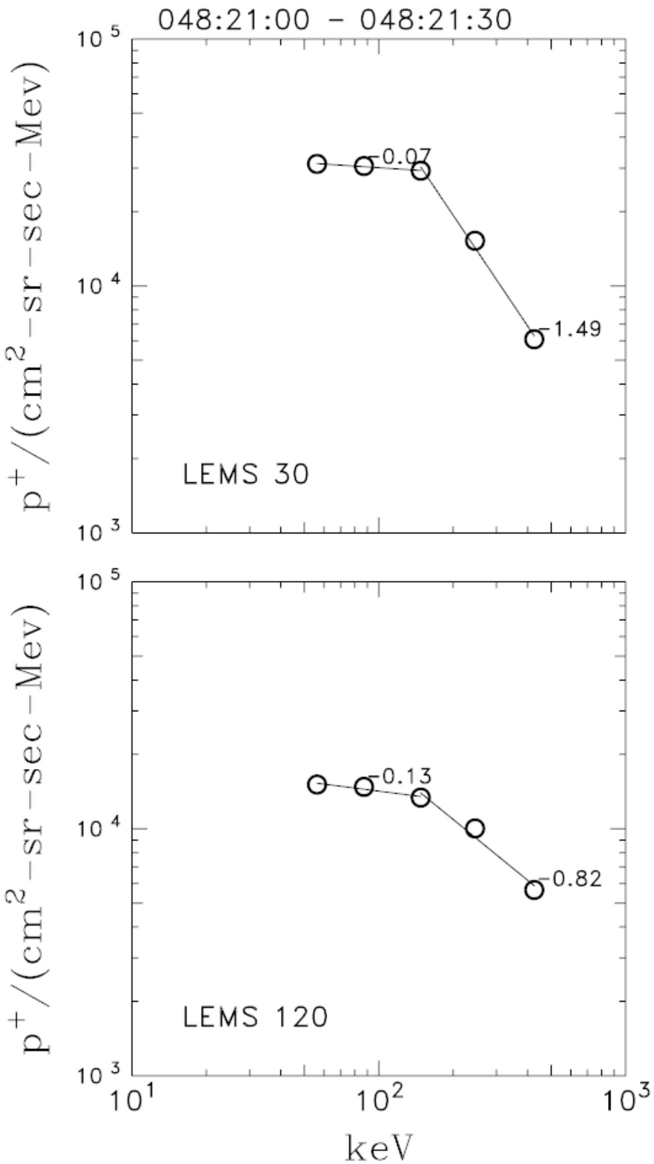
Small proton anisotropy.

Wave foreshock appropriate scale.

Argued and confirmed to be cold ion seed population leading to shock acceleration.

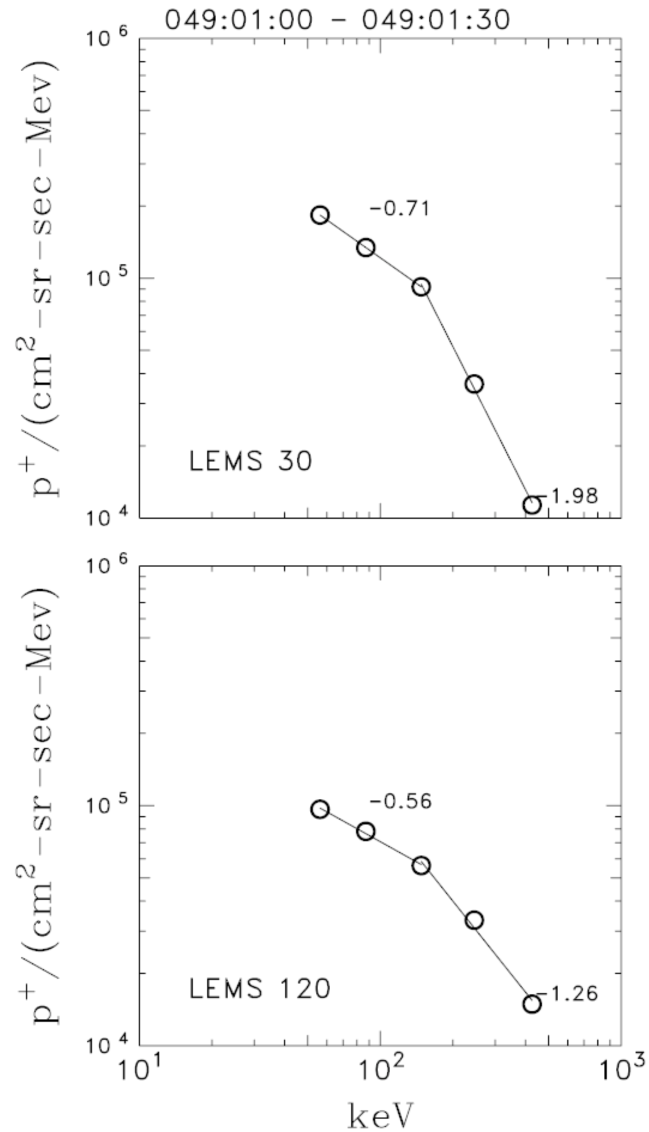


EPAM Spectra (Cold Seeds)



Weak spectra (either very soft or low in intensity) will behave as cold seed ions and accelerate to the form predicted by the shock strength.

Higher energies escape before steady-state form is achieved.



Example Event: 1998 / 217-219 (Hot Seeds)

Density compression: $\rho_d/\rho_u \sim 1.8 \pm 0.1$

and $\Theta_{Bn} = 82 \pm 3$.

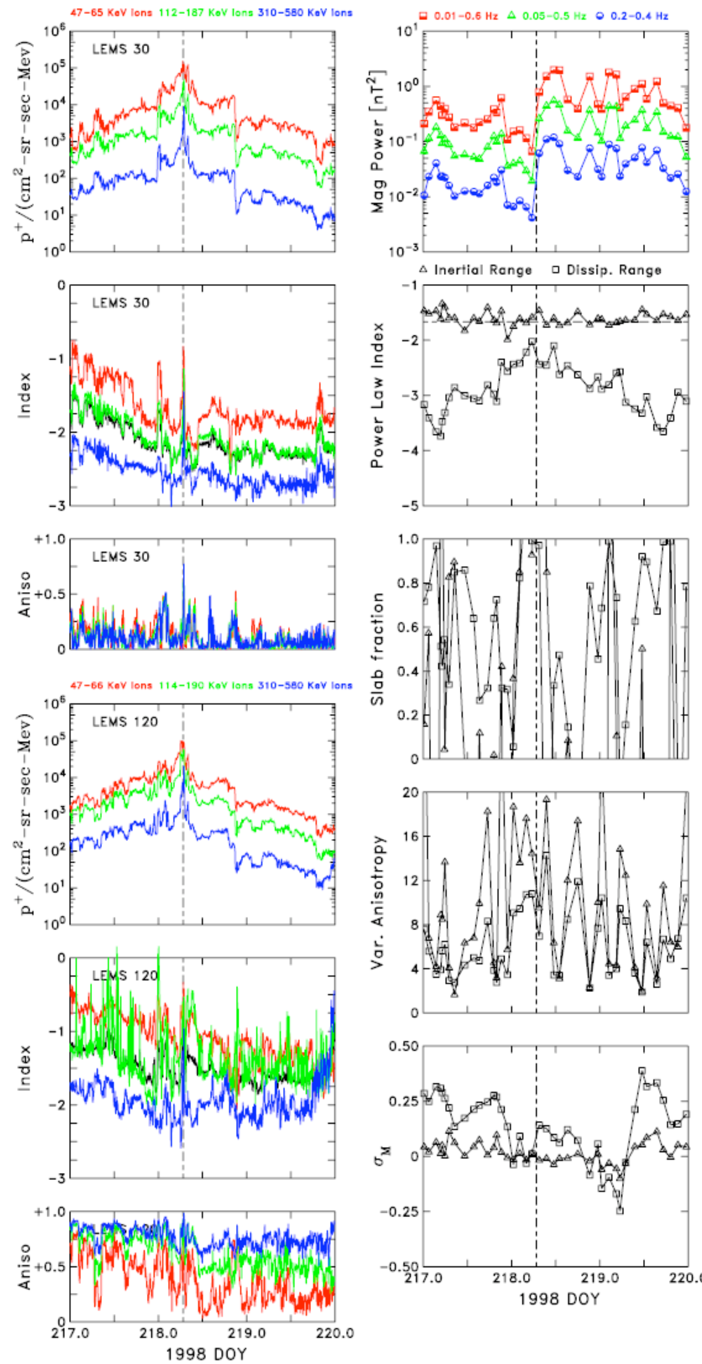
Very modest or questionable proton foreshock if SEP event is properly recognized.

Softening particle spectra on SEP scale.

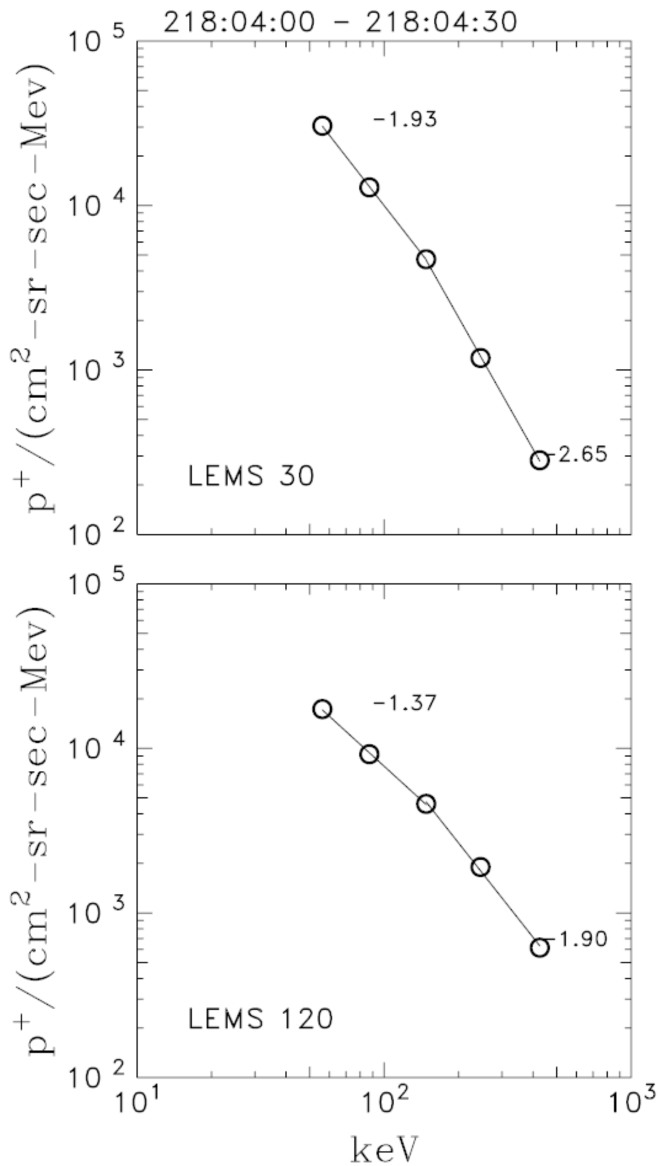
Moderate proton anisotropy.

Nonexistent wave foreshock.

Argued and confirmed to be hot ion seed population leading to shock acceleration.

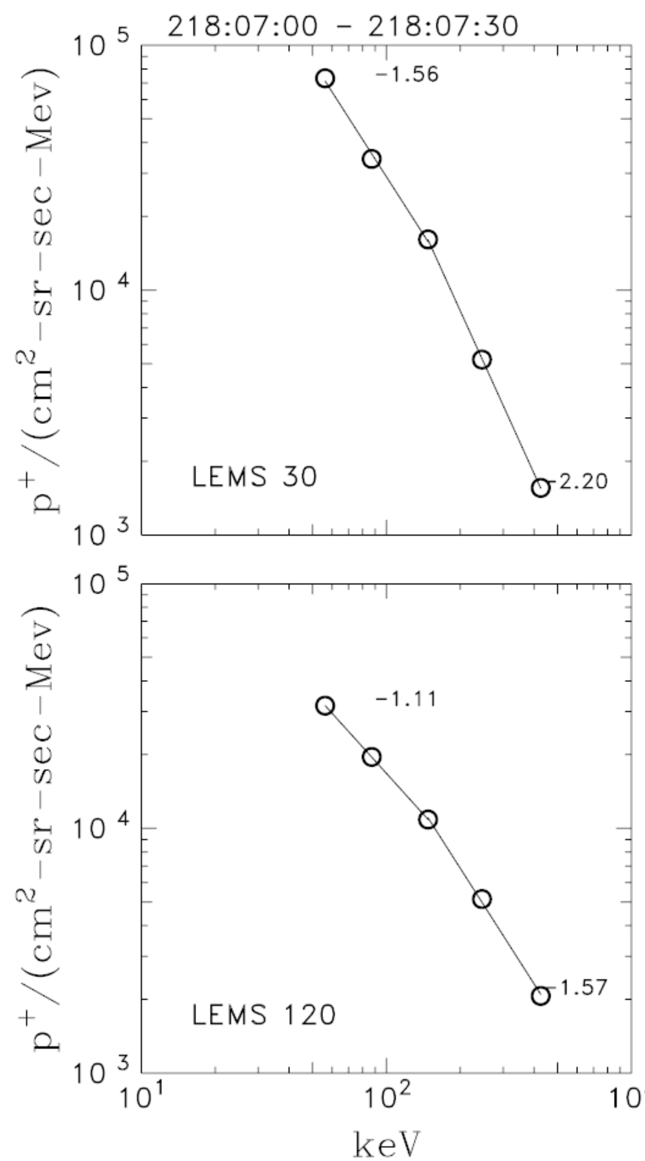


EPAM Spectra (Hot Seeds)

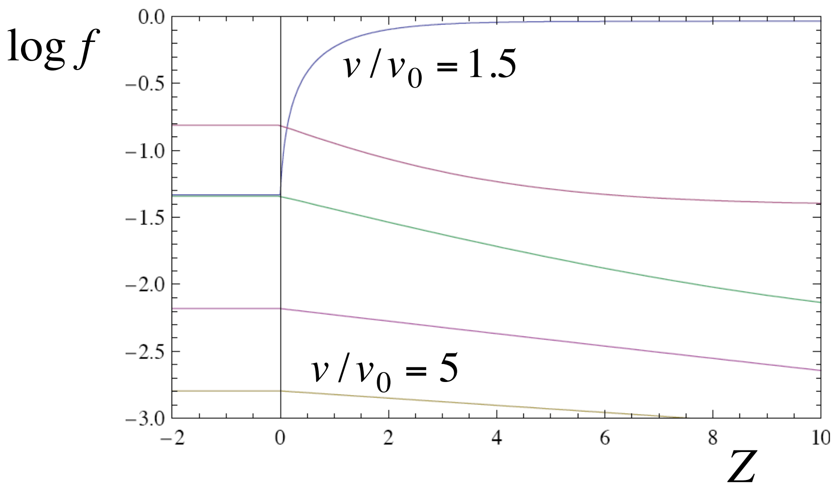


Hot source ions rise in intensity, but do not adopt asymptotic form dependent on shock strength.

Little if any evolution of the spectrum from several hours upstream to immediately behind the shock



Planar Stationary SA

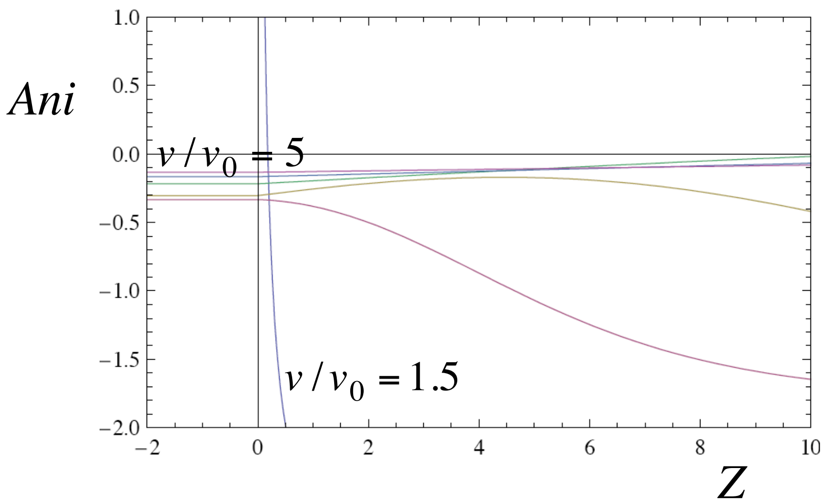


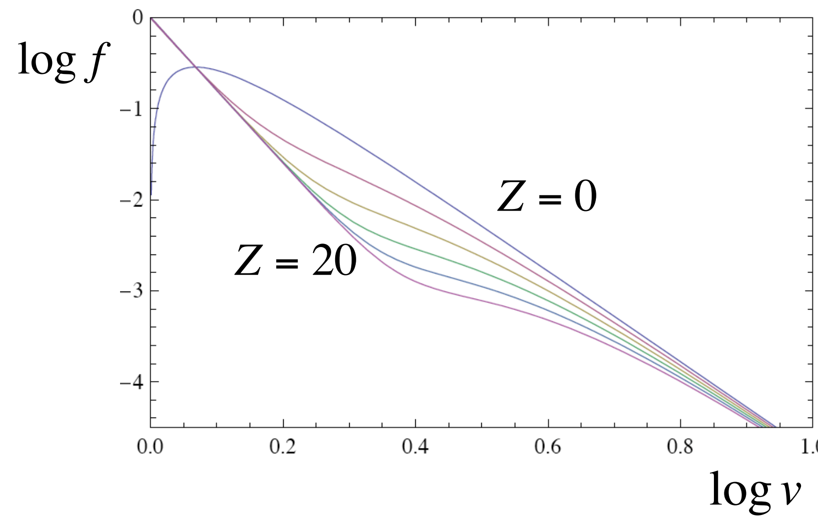
$$f_\infty = (v / v_0)^{-8}$$

$$K_{zz} = K_0 (v / v_0)^2$$

$$Z = Vz / K_0$$

$$\beta = 5$$





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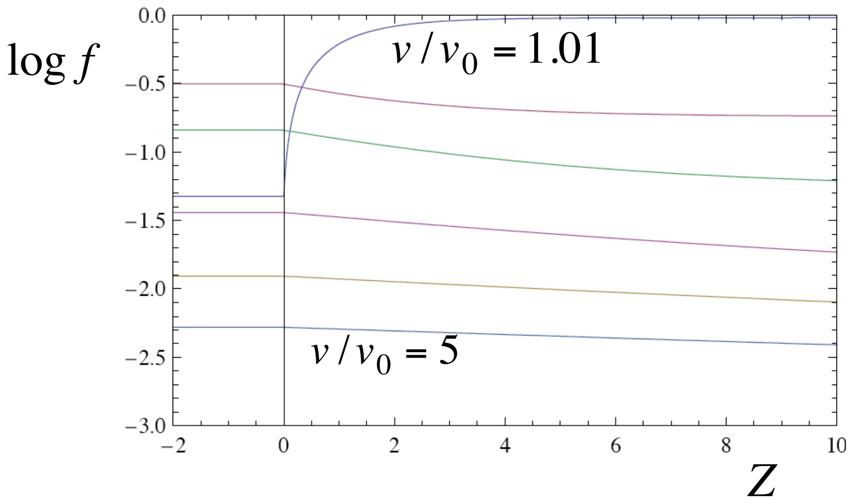
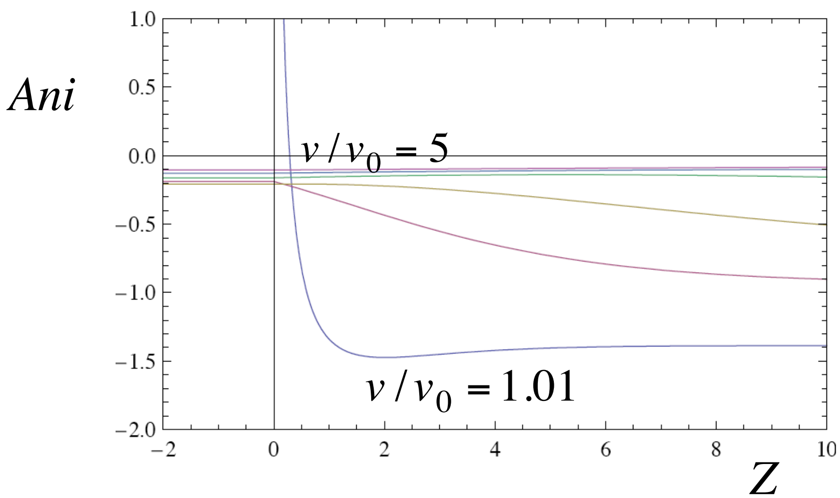


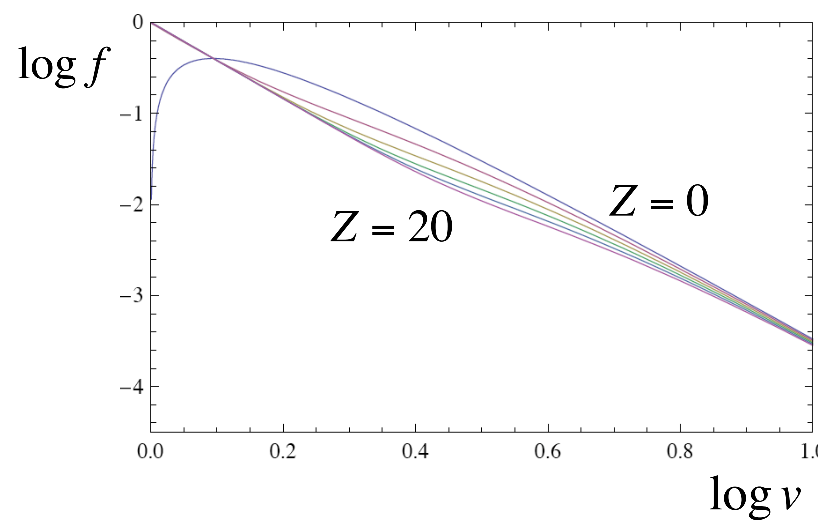
$$f_\infty = (v/v_0)^{-4.2}$$

$$K_{zz} = K_0 (v/v_0)^2$$

$$Z = Vz/K_0$$

$$\beta = 5$$





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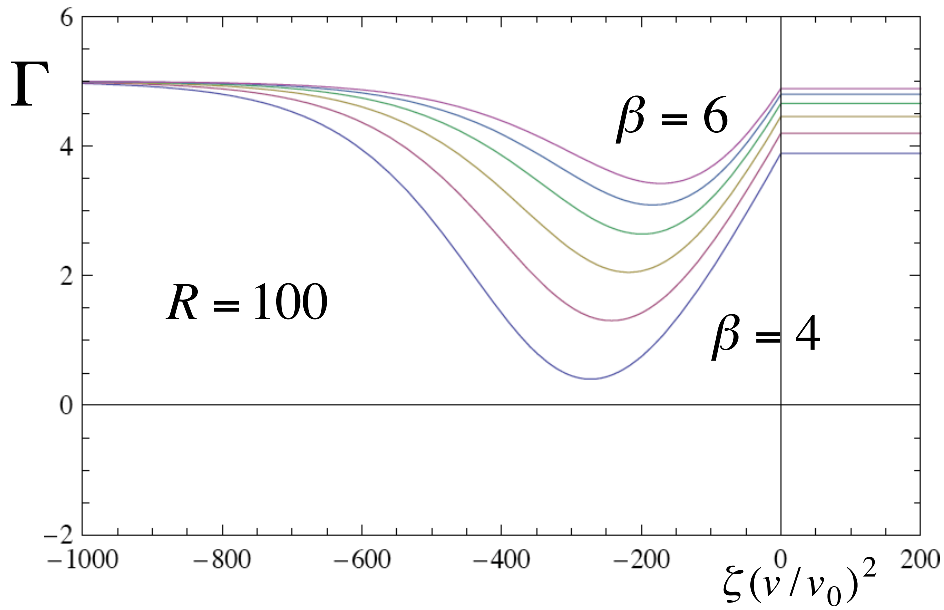
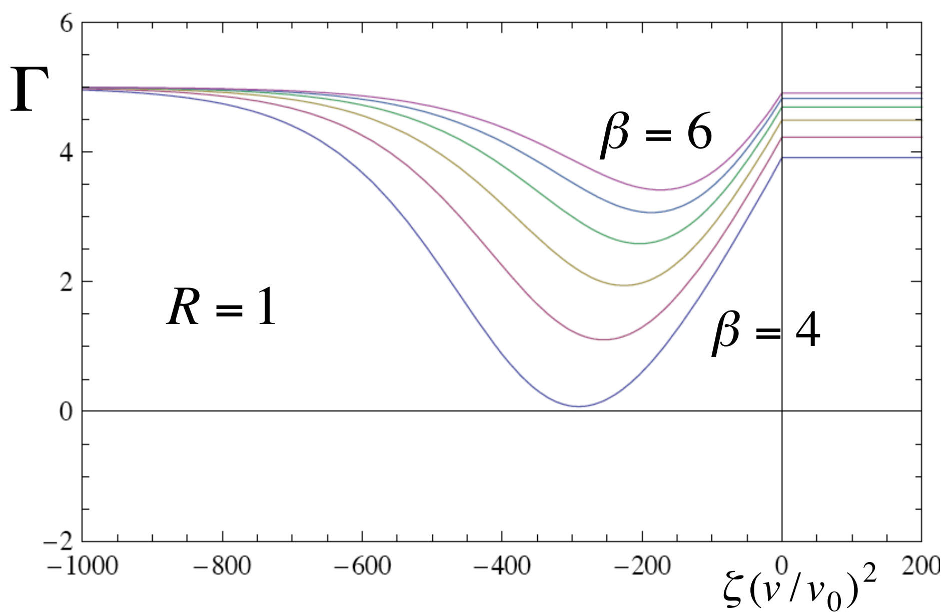


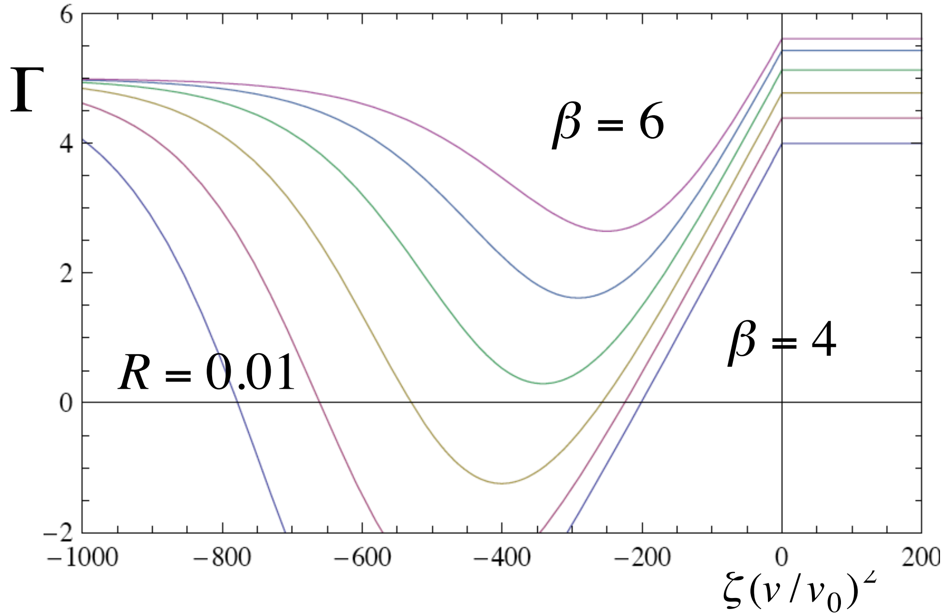


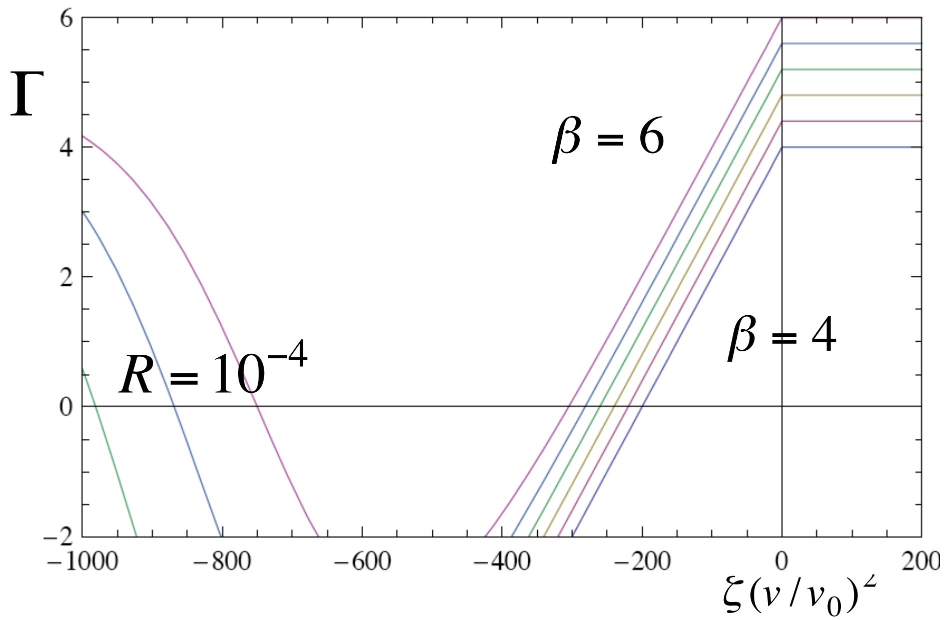
$$f_\infty(v) \propto v_0 \beta^{-1} \delta(v - v_0) +$$
$$R(v/v_0)^{-\gamma} S(v - v_0)$$

$$\zeta = \int_0^z V K_{0,zz}^{-1} (v/v_0)^{-2} dz'$$

$$\beta = 3/(1 - X^{-1})$$
$$\gamma = 5$$
$$v/v_0 = 10$$

Planar Stationary SA





$$f_\infty(v) \propto v_0 \beta^{-1} \delta(v - v_0) + R(v/v_0)^{-\gamma} S(v - v_0)$$

$$\zeta = \int_0^z V K_{0,zz}^{-1} (v/v_0)^{-2} dz'$$

$$\beta = 3/(1 - X^{-1})$$

$$\gamma = 5$$

$$v/v_0 = 10$$

Extra Slides

Example Event: 1998 / 273-275 (Cold Seeds)

Density compression: $\rho_d/\rho_u \sim 2.6 \pm 0.3$

and $\Theta_{Bn} = 52 \pm 6$.

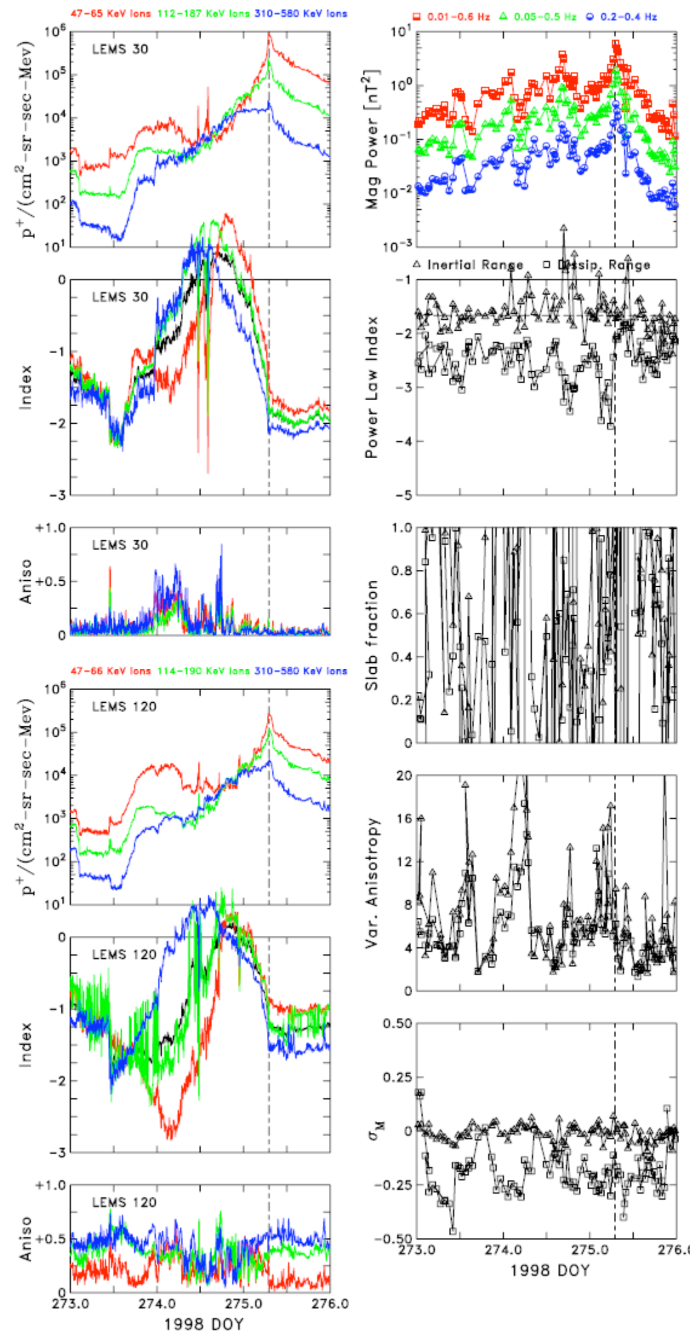
Apparent proton foreshock if SEP event is properly recognized (but extensive).

Softening particle spectra on realistic scale.

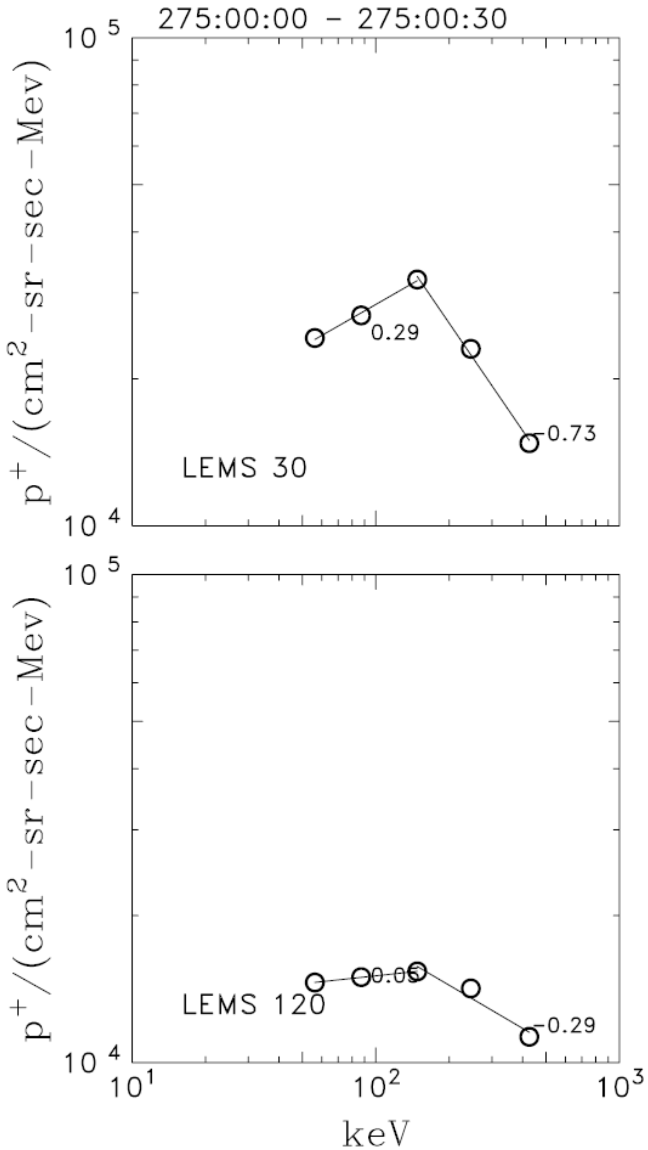
Small proton anisotropy.

Modest wave foreshock.

Argued and confirmed to be cold ion seed population leading to shock acceleration.



EPAM Spectra



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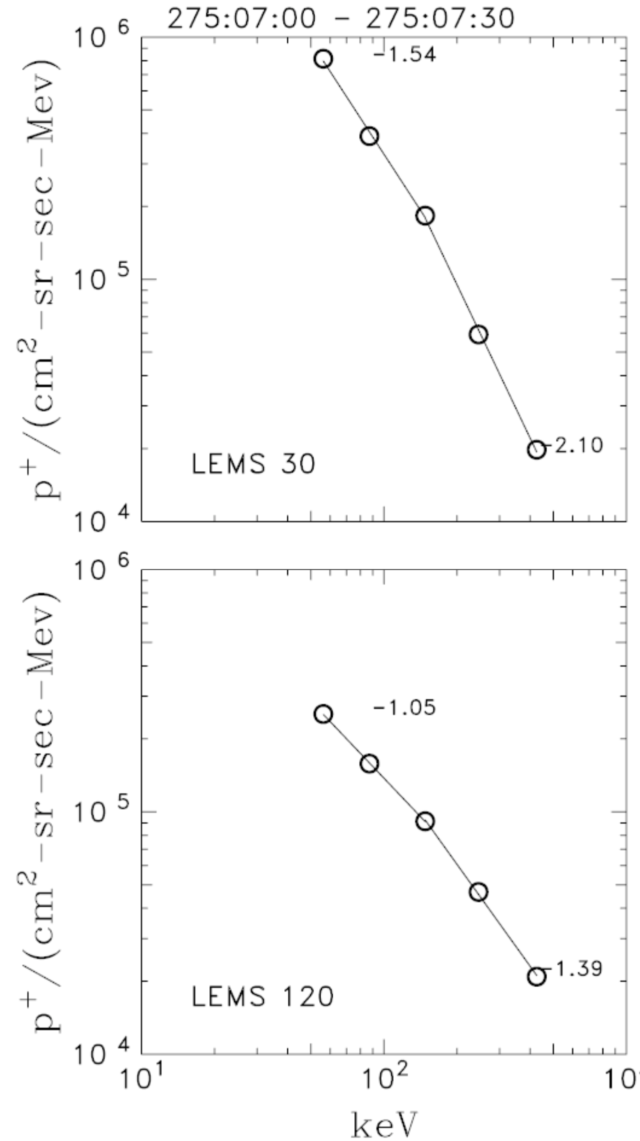
Higher energies escape before steady-state form is achieved.



Example Event: 1999 / 264-266 (Hot Seeds)

Density compression: $\rho_d/\rho_u \sim 2.4 \pm 0.5$

and $\Theta_{Bn} = 64 \pm 7$.

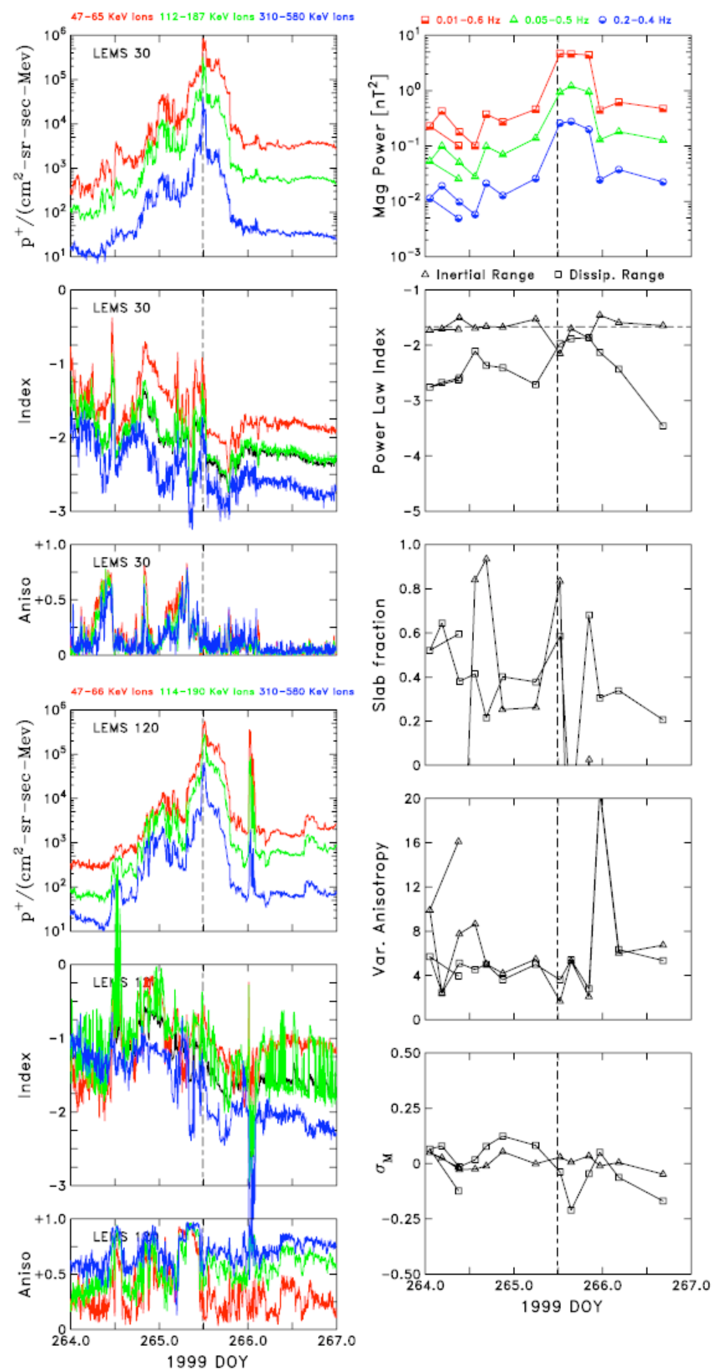
Questionable proton foreshock if SEP event is properly recognized.

Softening particle spectra on SEP scale.

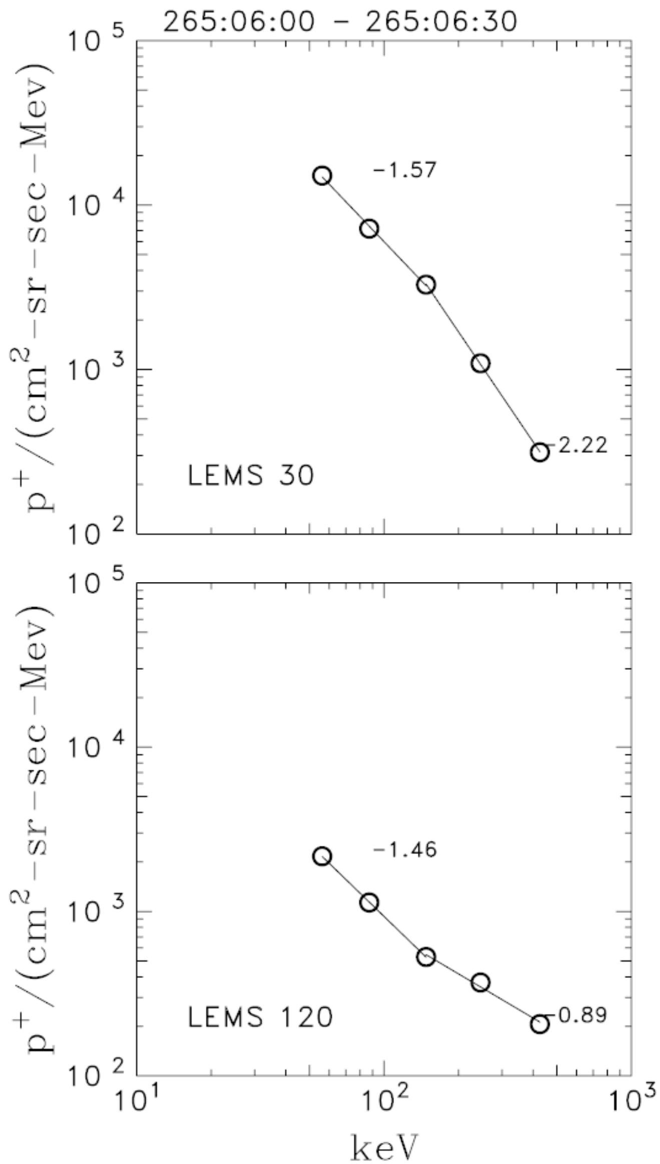
Strong proton anisotropy.

Questionable wave foreshock.

Argued and confirmed to be hot ion seed population leading to shock acceleration.



EPAM Spectra (Hot Seeds)



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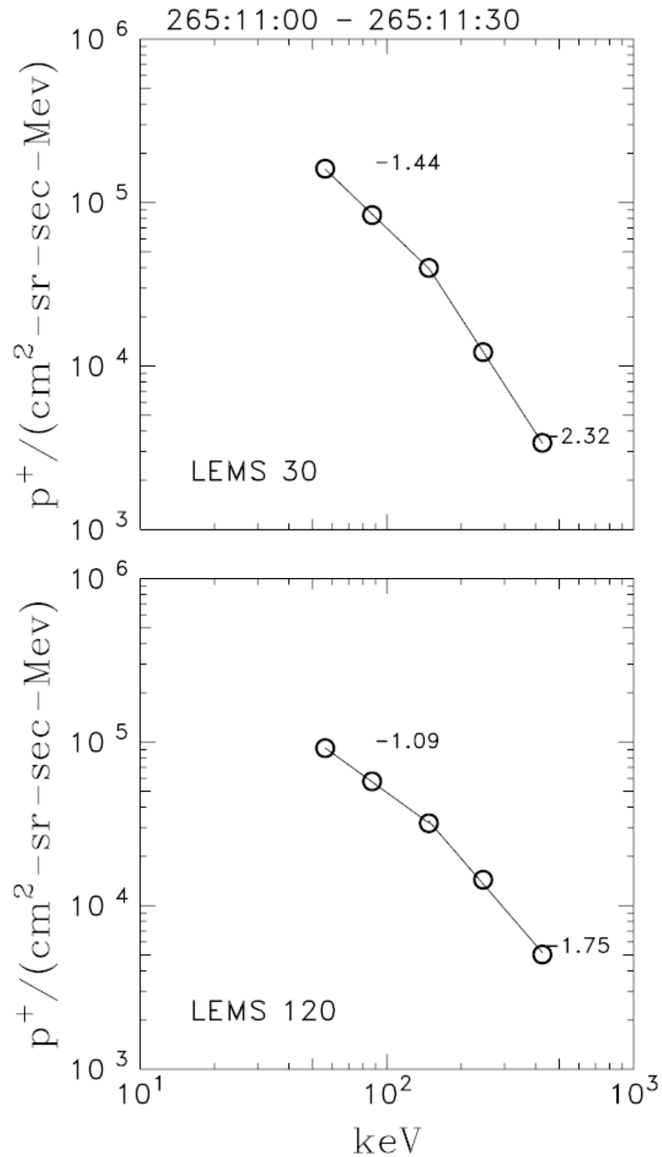

Shock Working List

Cold Seed Ions	Mixed Seed Ions	Hot Seed Ions
1998 / 275	2002 / 113	1998 / 218
1999 / 049	2002 / 138	1999 / 265
2001 / 239	2002 / 230	1999 / 294
	2004 / 103	2000 / 042
	2005 / 258	2000 / 097
		2001 / 169
		2001 / 229
		2003 / 149
		2003 / 150