GLAST Solar System Science

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Also see the following posters:

P16.15 Francesco Longo, et al. 'GLAST LAT detection of solar neturons'

P16.16 Ron Murphy, 'GLAST measurements of pion-decay emission in solar flares'

P17.8 Igor Moskalenko, et al. 'GLAST observations of the sun and heliosphere; what can we learn'

P17.16 Elena Orlando, et al. 'The extended solar emission: an analysis of the EGRET data"

Solar activity expected to rise in ~2008 and peak as early as 2011

GLAST is the only satellite capable of making solar observations >30 MeV

Coordinated LAT gamma-ray measurements with GBM (10 keV-25 MeV) and RHESSI (1 keV – 20 MeV; anneal in the next half year)

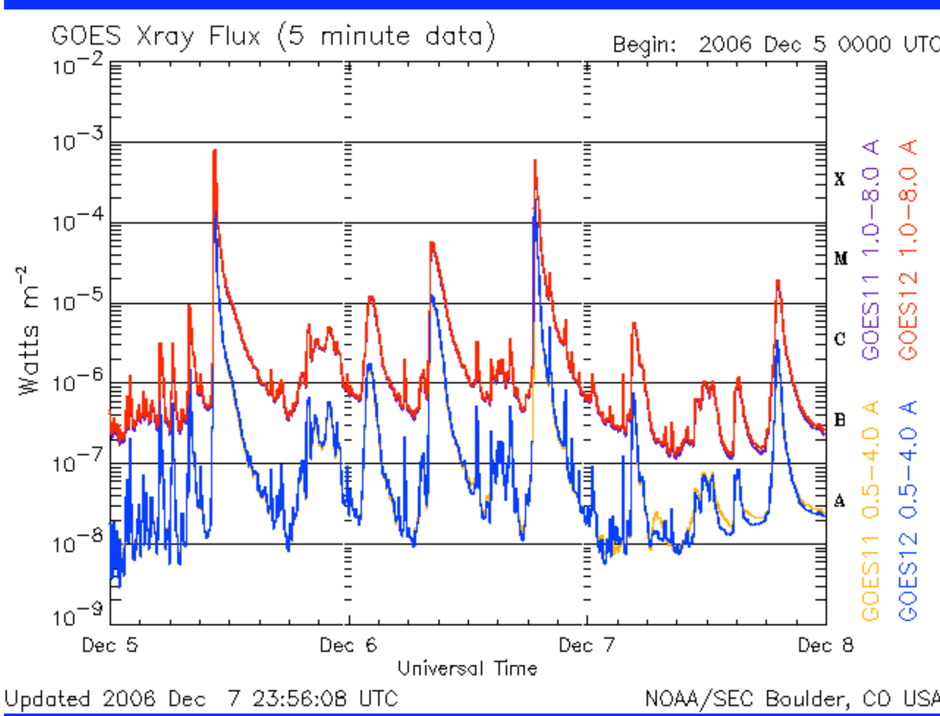
Comparison with solar energetic particle measurements on ACE, STEREO, SOHO, WIND and ground based neutron monitors, muon telescopes, Milagro

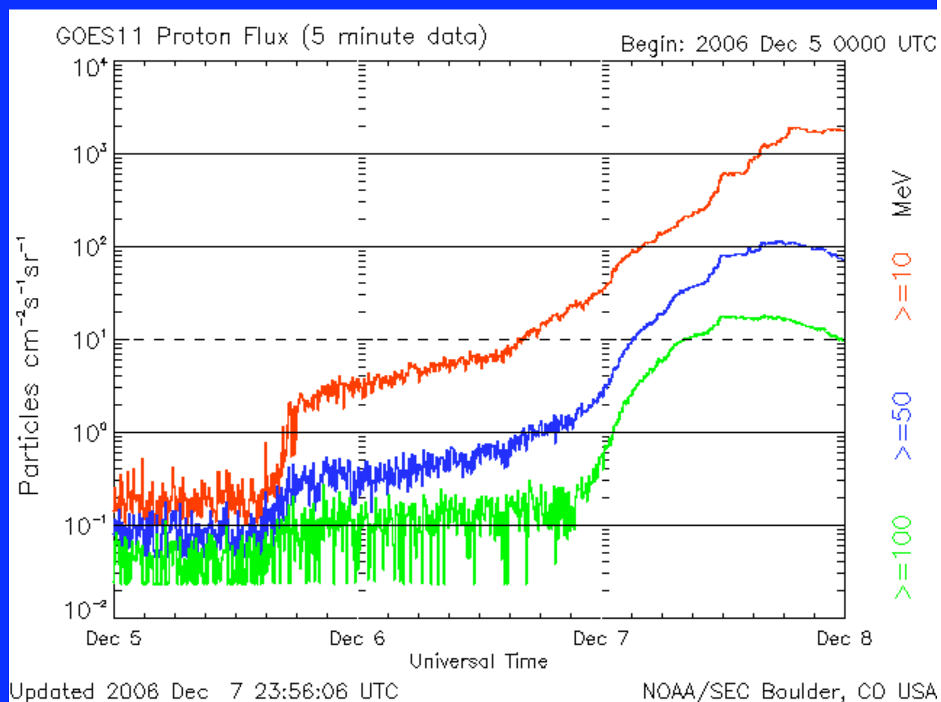
Ten's of high-energy flares will be observed

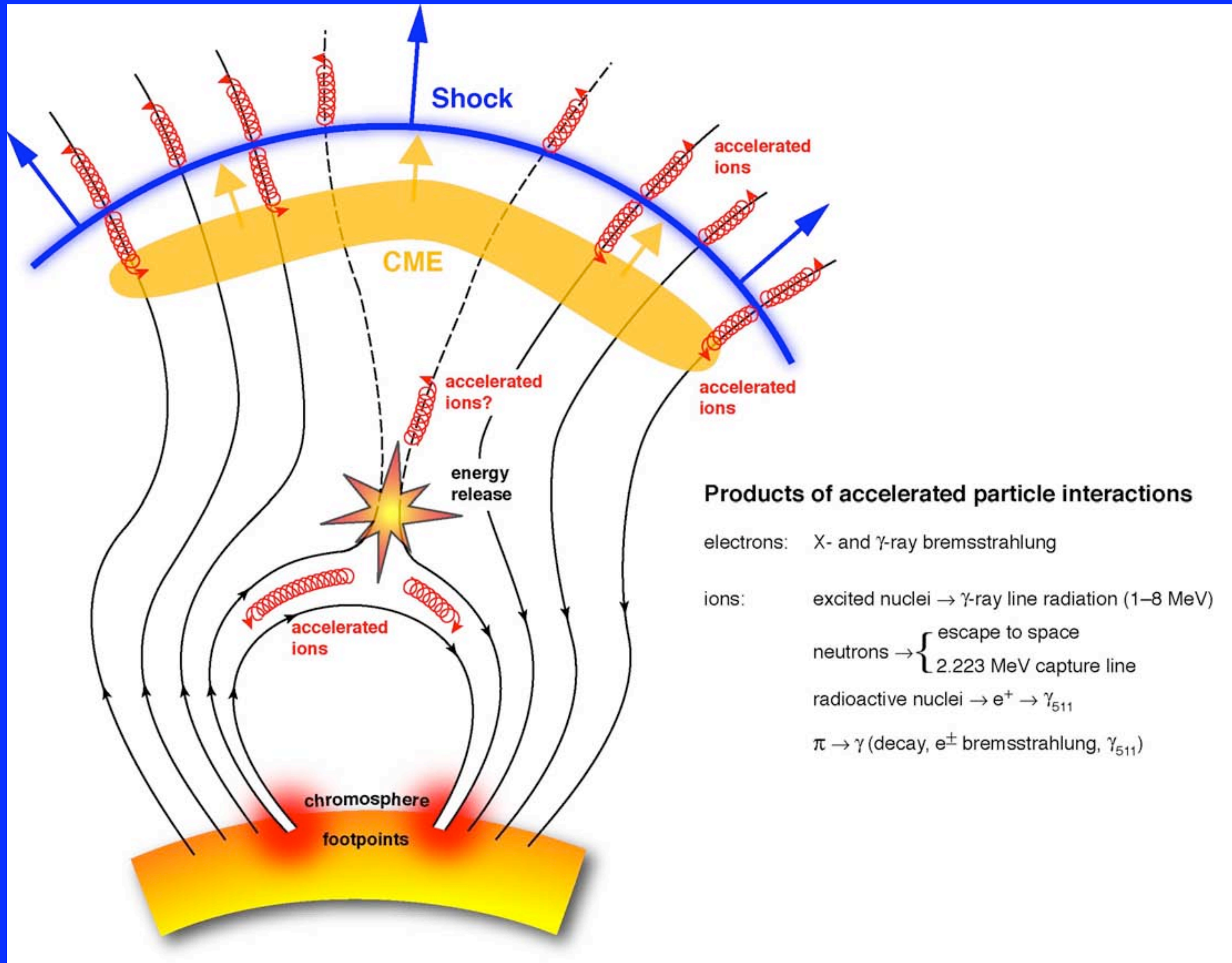
~20% solar coverage (~60% with ToO)

Links to NASA Living with a Star and Sentinels programs

Surprises though!
Active regions in January 2005 and December 2006 produced
intense X-Class Flares

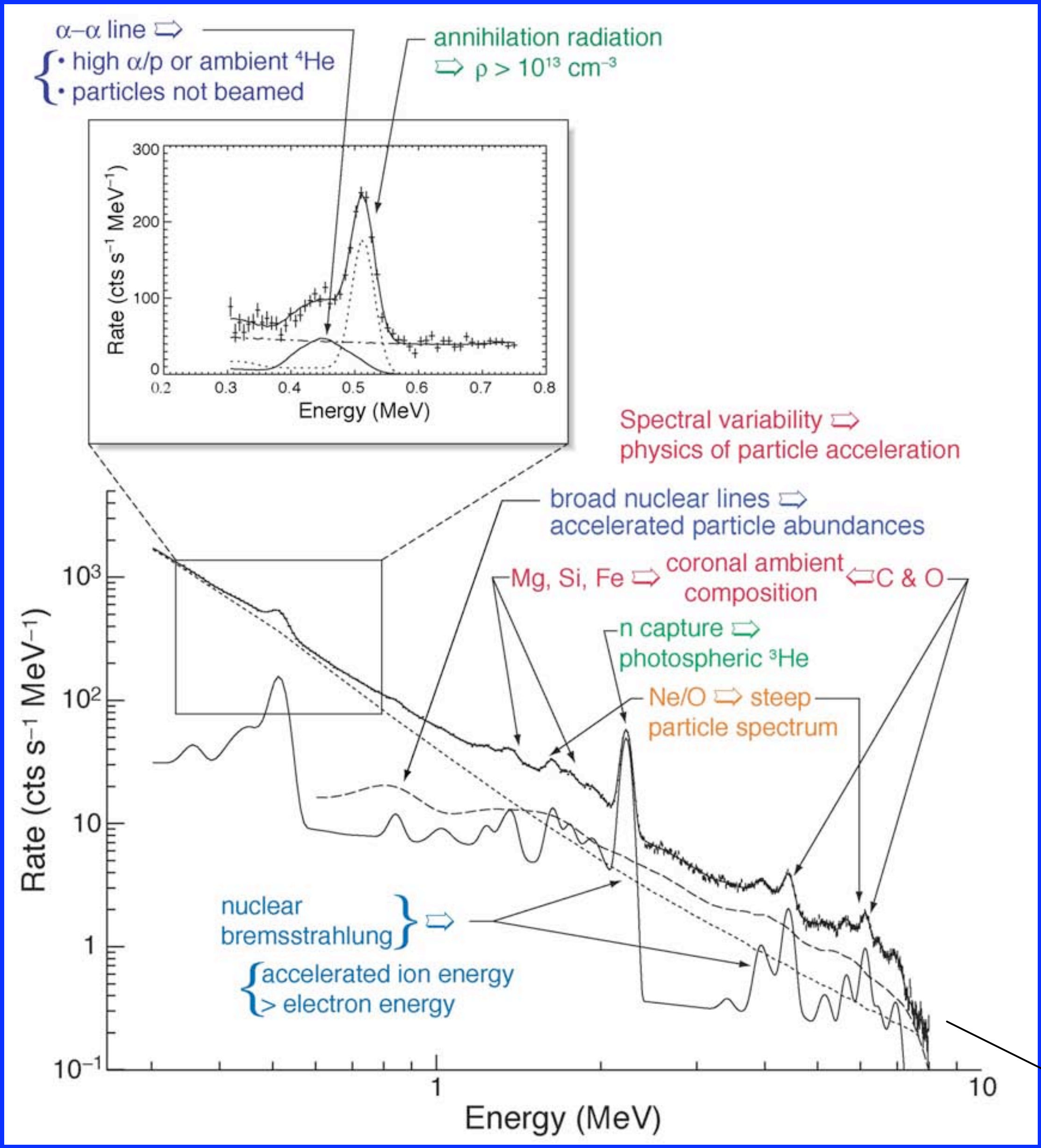






Study how particles are accelerated at the Sun and their relationship to Solar Energetic Particles (SEP) and Ground Level Events (GLE).

Sum of 19 Gamma-Ray Line Spectra Measured by SMM



Pion Contribution

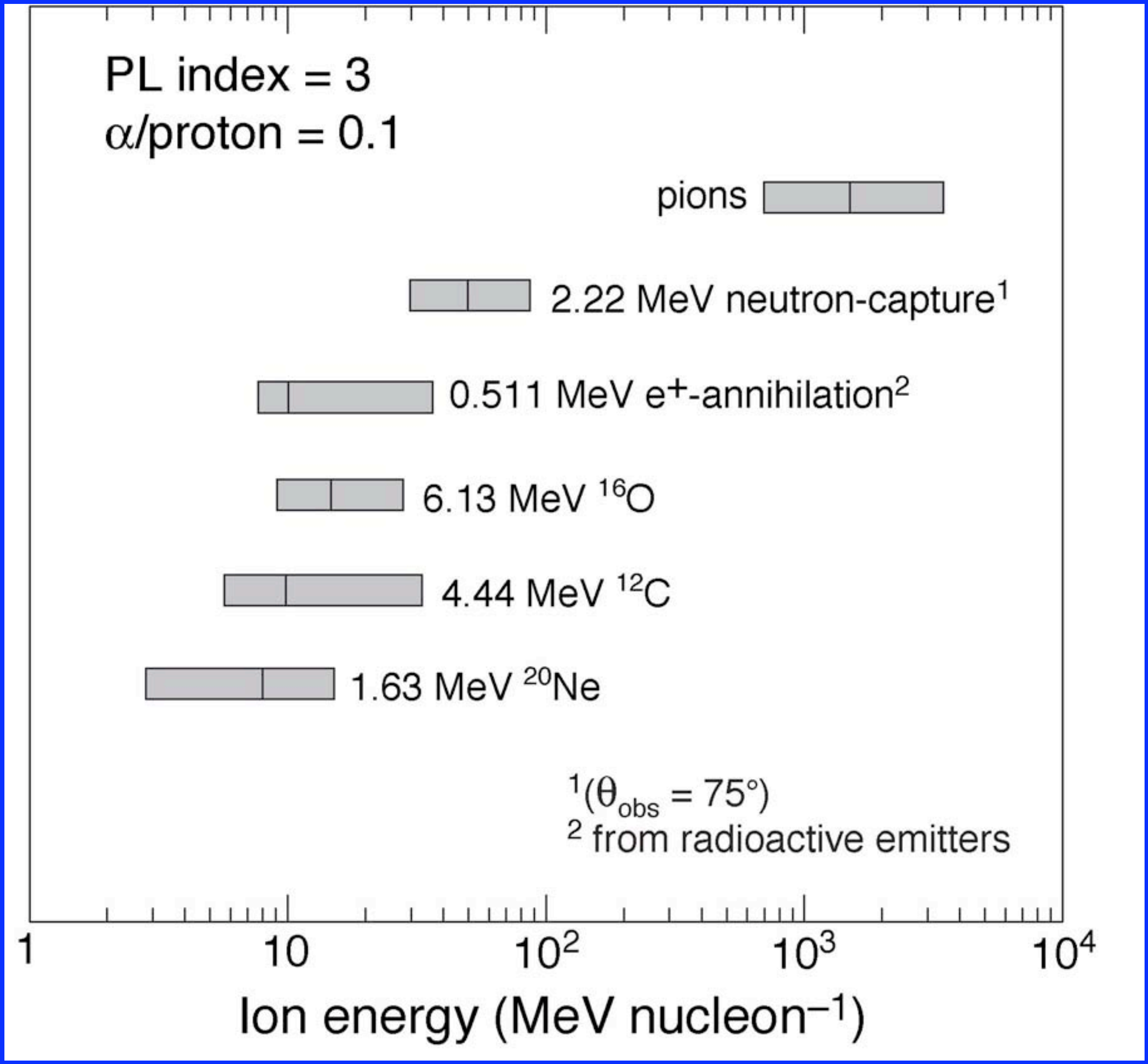
COMPARISON OF GLAST/GBM+ AND SMM/GRS*

Energy MeV	SMM P.P. Area, cm2	GBM P.P. Area, cm2	SMM FWHM, keV	GBM FWHM, keV
0.34	160	140	30	70
0.51	148	140	40	85
1.37	85	120	75	120
2.22	61	100	100	170
4.44	38	80	160	240
6.12	31	70	195	300

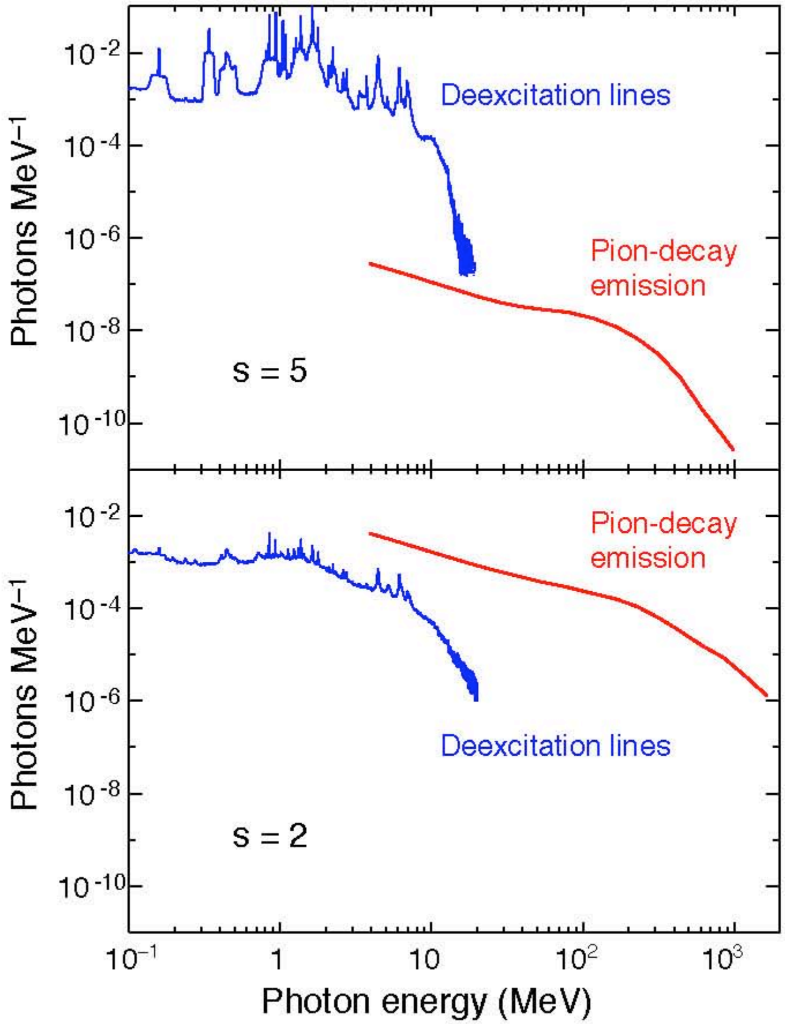
+ Two 12.7 cm Dia. x 12.7 cm Bismuth Germinate (BGO) detectors

* Seven 7.6 cm Dia. X 7.6 cm NaI detectors within AC shield

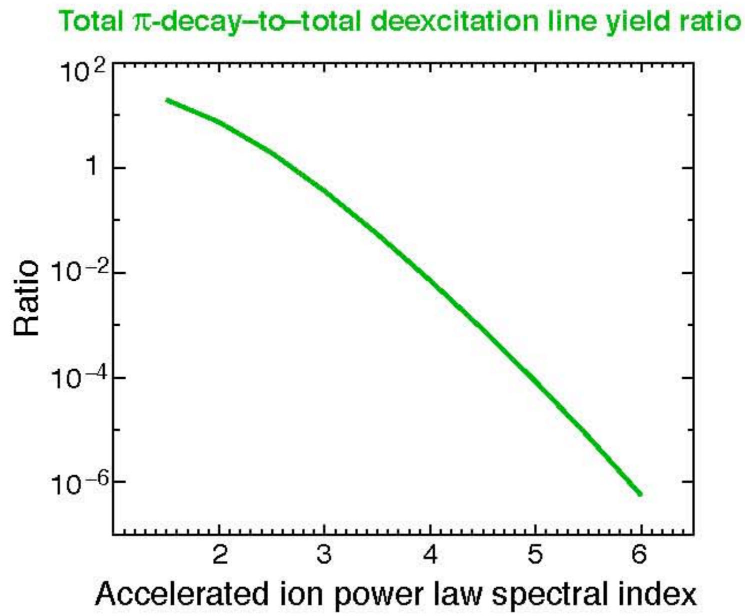
Measure the spectrum of flare-accelerated ions and electrons to energies > 1 GeV/nuc



Calculated Pion-decay Photon Spectra (cont.)



The ratio of pion-decay emission to nuclear deexcitation-line emission depends very strongly on the steepness of the accelerated-ion kinetic-energy spectrum



This ratio can be used to determine the accelerated-ion spectral index

Murphy, Poster 16.16

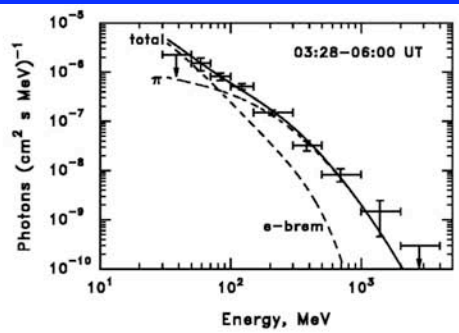


Fig. 3.— Photon differential energy spectrum for the 1991 June 11 flare event. Data were accumulated during the most intense portion from the end of earth occultation at 03:28 UT until 06:00 UT. The dotted curves are from Mandzhavidze and Ramaty 1995 for proton and electron power law spectra of indices −3.0, scaled so that their total, shown as a solid curve, is the best fit to the data. Uncertainties and upper limits are one standard deviation statistical.

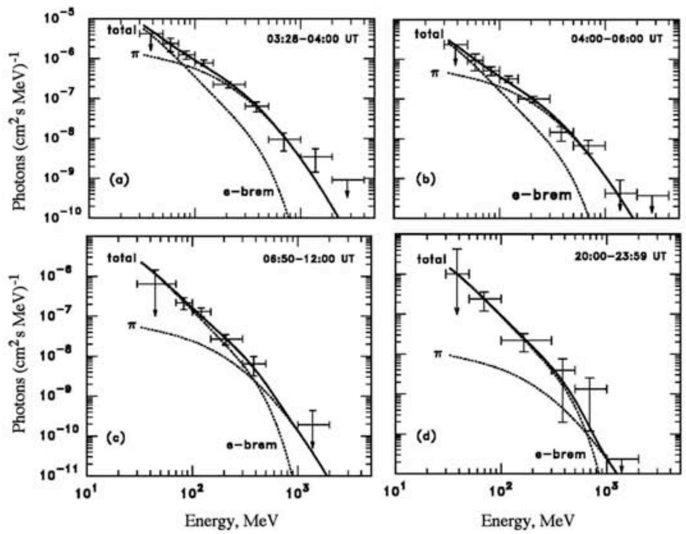
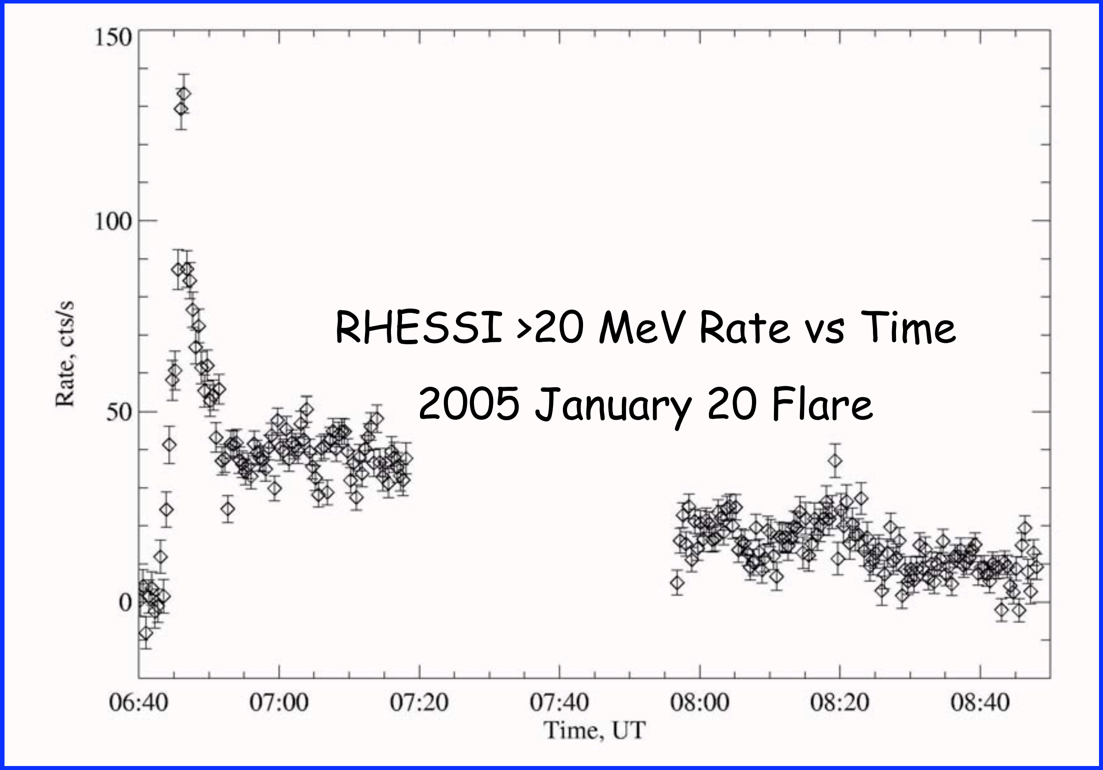


Fig. 4.— Photon differential energy spectra for four selected time periods in the 1991 June 11 solar event. The model curves, described in Figure 3, are fit to the data, and the solid curves are the total emission for the time interval. Uncertainties and upper limits are one standard deviation statistical.

EGRET Observations, Bertsch et al. 1996; combined LAT and GBM observations are important.

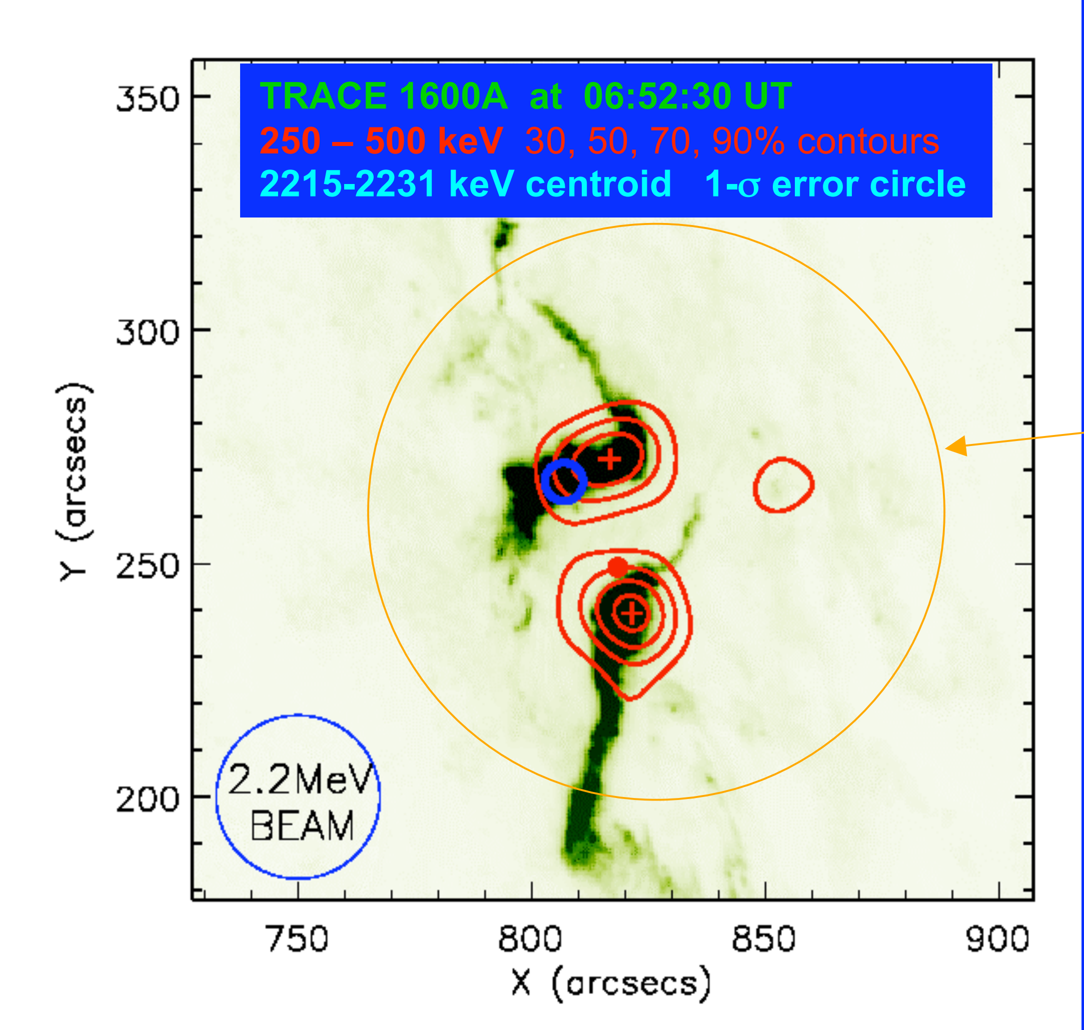
Study particle acceleration and magnetic trapping of high-energy ions from minutes to hours after flares (e.g. EGRET observation on June 11, 1991; Kanbach et al.)



LAT is 10^4 times more sensitive to pion radiation than RHESSI

20 January 2005 06:44-06:56

RHESSI, Hurford et al. 2007



GLAST Location

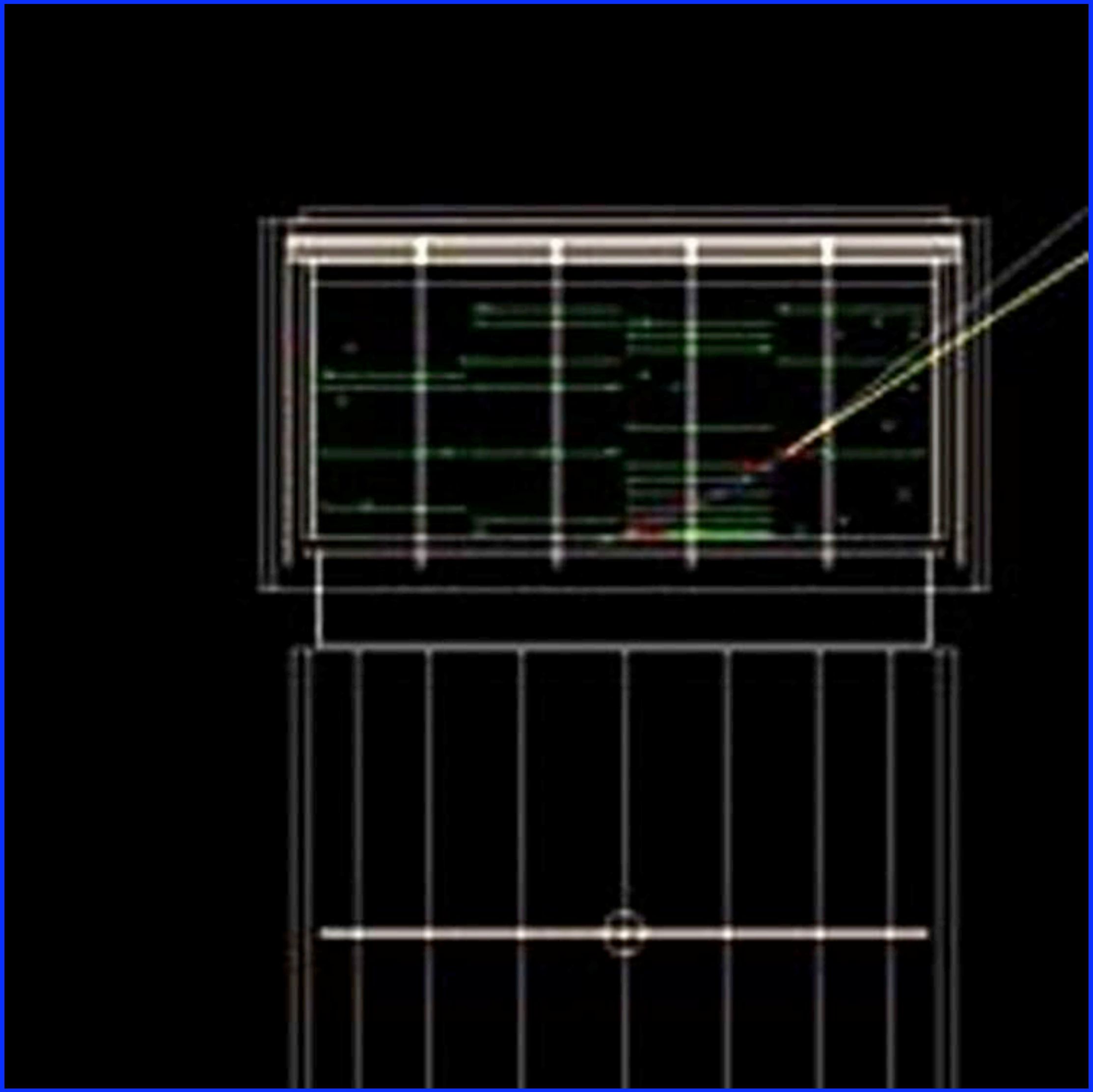
Localize the source of >1 GeV photons to ~30 arc sec

Additional Capabilities

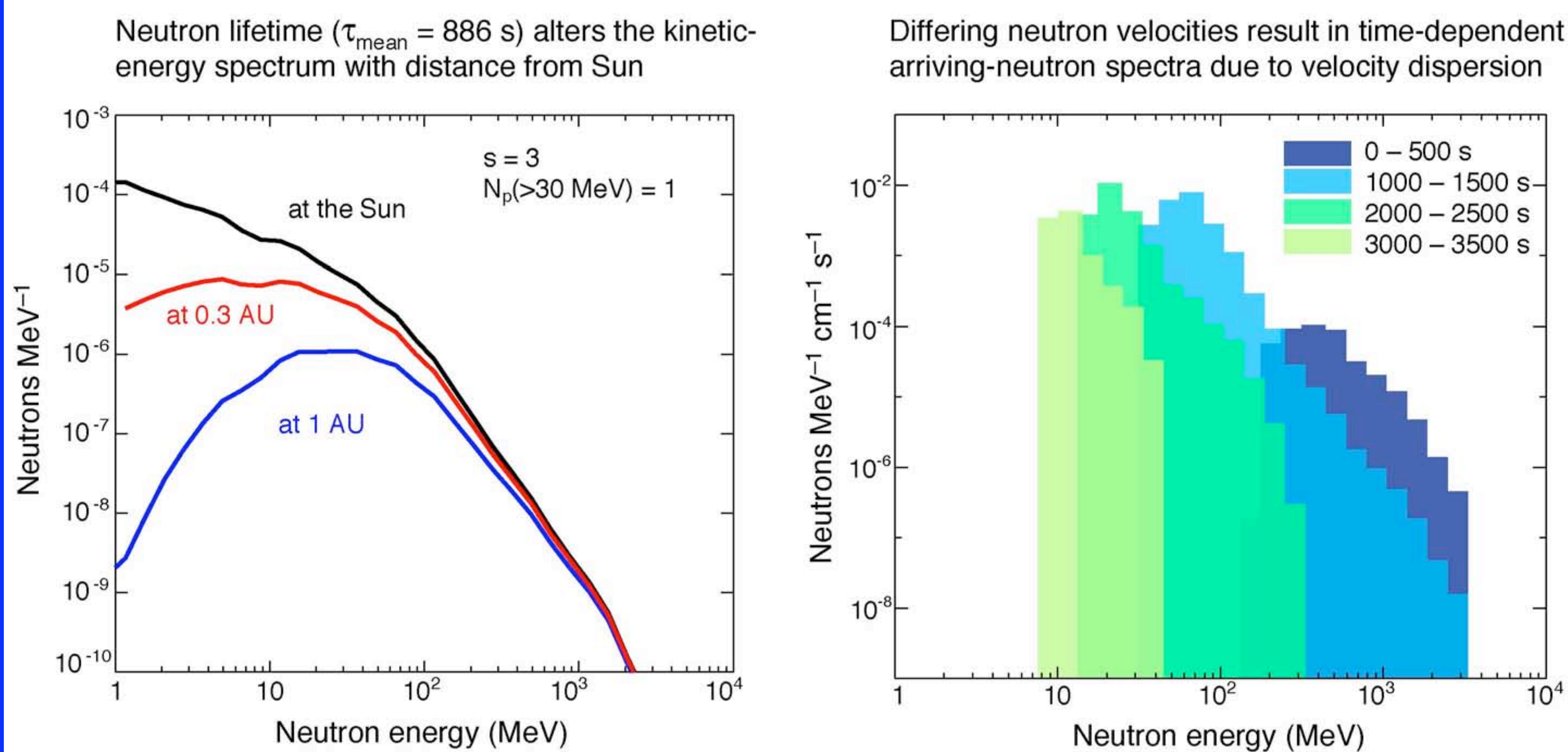
Understanding the newly discovered submm radio component in flares.

Study >10 MeV solar neutrons with GBM and LAT.

Potential to study partially-ionized heavy SEPs (rigidity dependence of flux, similar to performed on LDEF).



Simulation of a neutron interaction in GLAST, Longo, Poster P16.15



Murphy, Poster 16.16

GBM will also detect an increase minutes after the impulsive phase of the flare.

Non-Flaring Objectives

Observe pion-decay photons from cosmic-ray interactions in the photosphere to study solar modulation near the Sun (Seckel et al., Thompson et al.)

Observe Compton-scattered gamma rays from interactions of cosmic-ray electrons and sunlight to study solar modulation in the inner heliosphere (Moskalenko et al.; Orlando et al.).

Studies of lunar and terrestrial albedo gamma rays

Terrestrial gamma-ray flashes

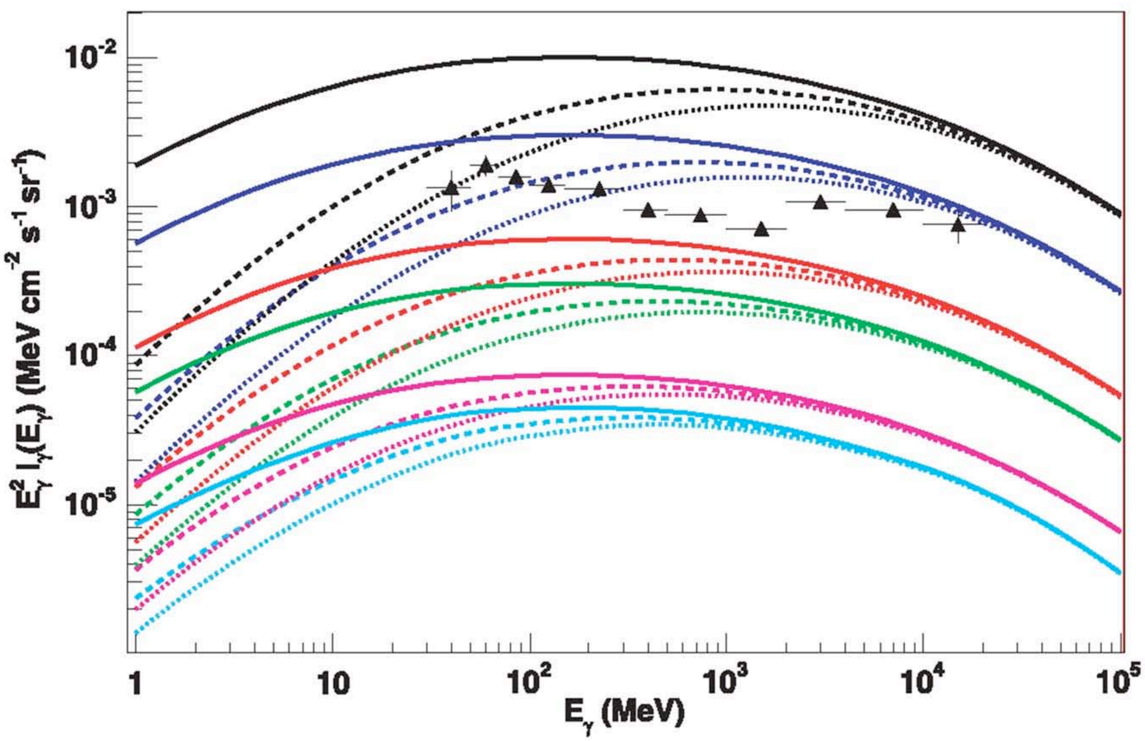
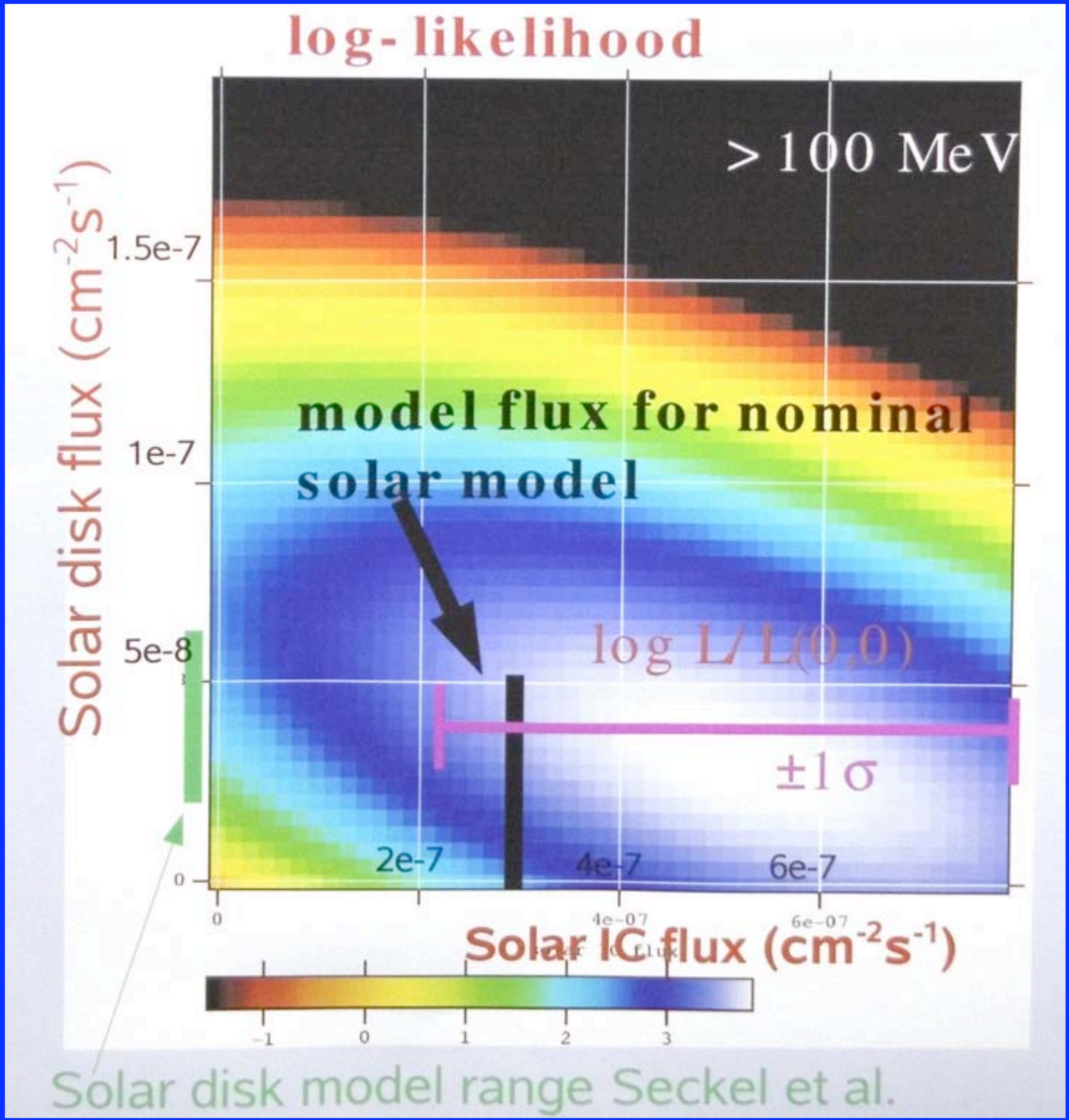


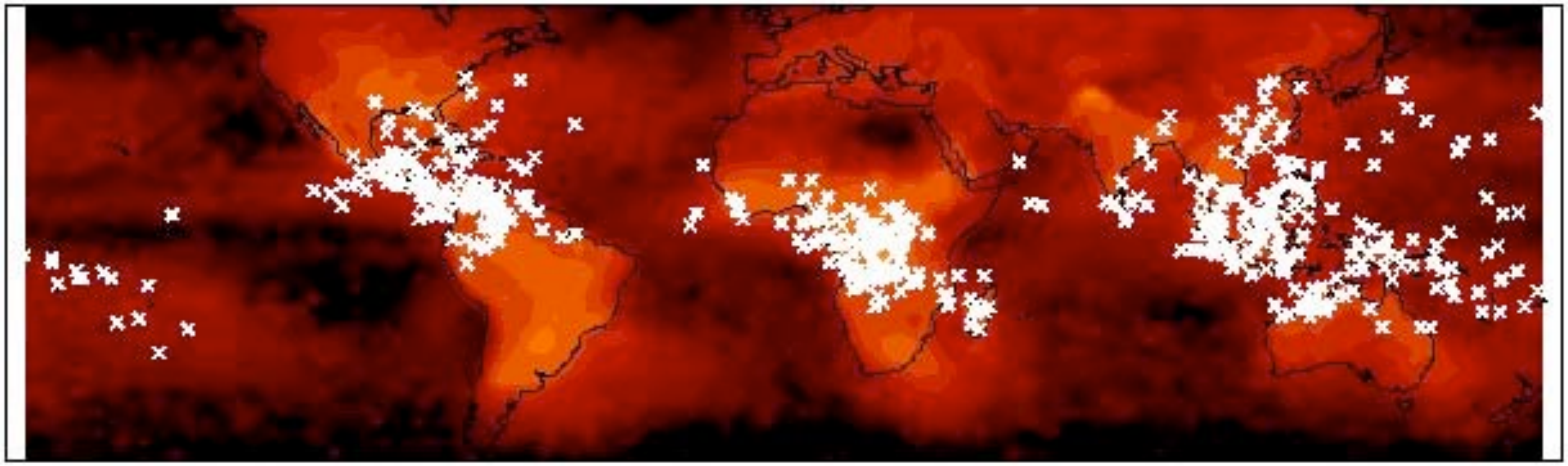
FIG. 4.—Differential intensities for selected θ. Line sets (*top to bottom*): 0°.3, 1°, 5°, 10°, 45°, and 180°. *Solid line*, No modulation; *dashed line*, Φ_0 = 500 MV; *dotted line*, Φ_0 = 1000 MV. *Data points*, Diffuse extragalactic γ-ray flux (Strong et al. 2004a).

Moskalenko, P17.8; calculation of Compton-scattered sunlight by CR electrons at different angles from the Sun and for different levels of solar modulation

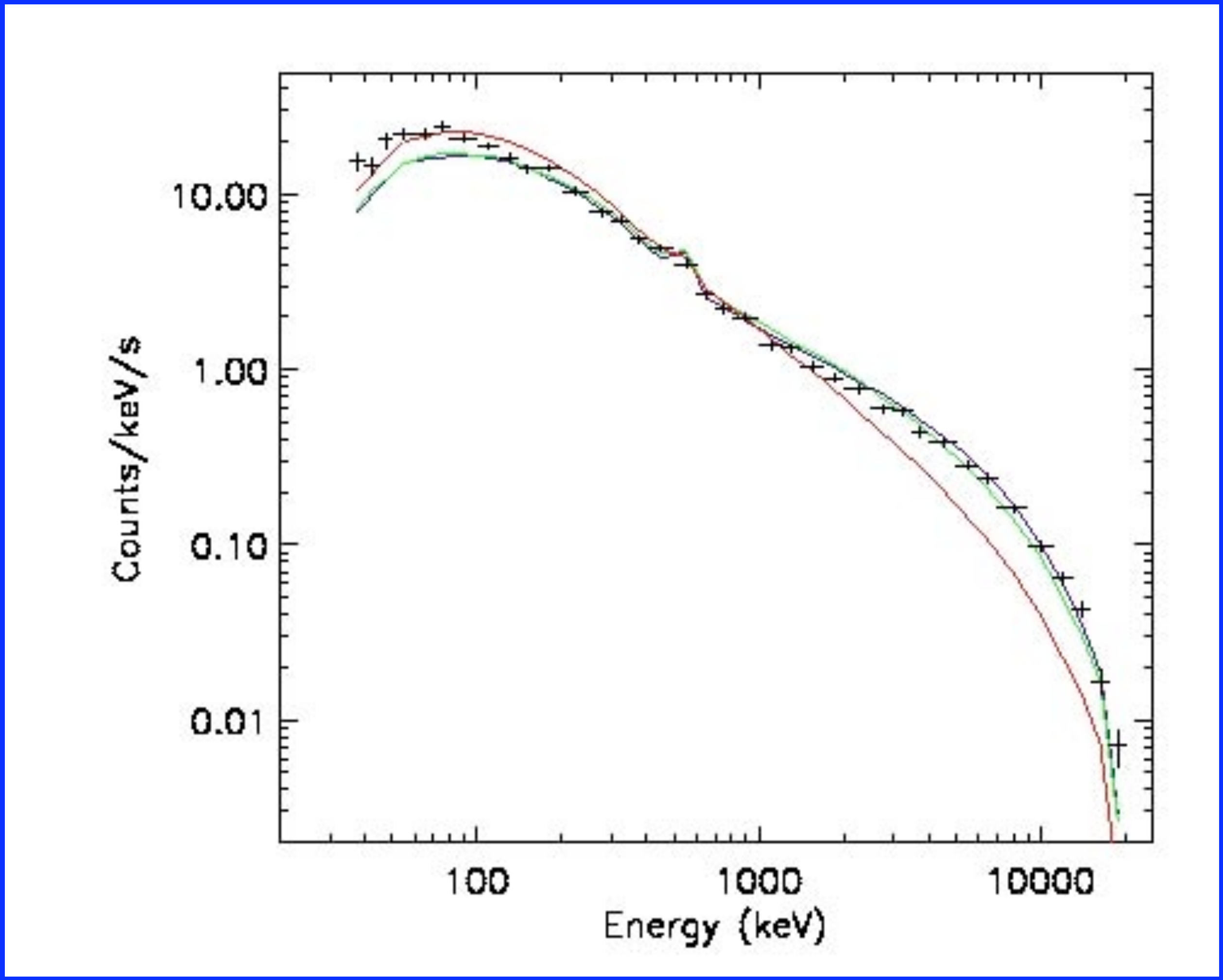


Orlando, P17.6; Discovery of both solar disk pion-decay emission and extended Compton-scattered radiation in combined analysis of EGRET data from June 1991.!!

Terrestrial flashes observed by RHESSI
(David M. Smith, UCSC)



~1 ms duration; associated with lightning were discovered by BATSE; tens per day globally.



RHESSI summed TGF spectrum extending up to ~20 MeV will be detectable by GBM and perhaps by LAT

GLAST LAT will avoid saturation suffered by EGRET

Hiro Tajima studied saturation effects in the upper Si layers due to intense 20-150 keV X-rays. For a flare with peak hard X-ray intensity ~10% of the largest expected:

~1.2 × 10^6 photons s^{-1}; 0.1 mm of W reduces flux to ~2.2 × 10^5 photons s^{-1}; taking into account energy deposition in Si (>30 keV) ➔ 5 × 10^3 counts s^{-1} in top layer of silicon

→ ~1% deadtime

At the peak of the most intense flare expect

→ ~10% deadtime in top Si layer

ACD tile + threshhold >0.3MeV → OK

Issues:

Affect of +-35 deg offsets each orbit and spacecraft rotation (solar panel access to Sun) on GBM background determination for solar flare and GRB afterglow studies?

GBM solar-flare triggering algorithm to reorient LAT for trapping and extended acceleration studies?

Possibility for extended Solar ToO (7-10 days; e.g. CGRO June 1991); would help GBM background determination.

Saturation of NaI detectors in intense flares?