

# **HIGH-ENERGY SOLAR PHYSICS WITH GLAST**

**THE HIGH-ENERGY SOLAR EXPERIMENT  
VACUUM DURING SOLAR CYCLE 24**

**SUMMARY OF GAMMA-RAY OBSERVATIONS  
>10 MeV**

**OUTSTANDING QUESTIONS THAT  
GLAST CAN ADDRESS**

**RHESSI OBSERVATIONS OF THE 2002 JULY 23  
FLARE**

## STATISTICS OF HIGH-ENERGY GAMMA-RAY FLARES

24 flares observed  $>10$  MeV in over a solar cycle by the SMM spectrometer ( $\sim 150$  cm<sup>2</sup>). 1980-1989

18 of these flares were X-class X-ray flares and 6 were M-Class (1/10 soft X-ray flux of X-class).

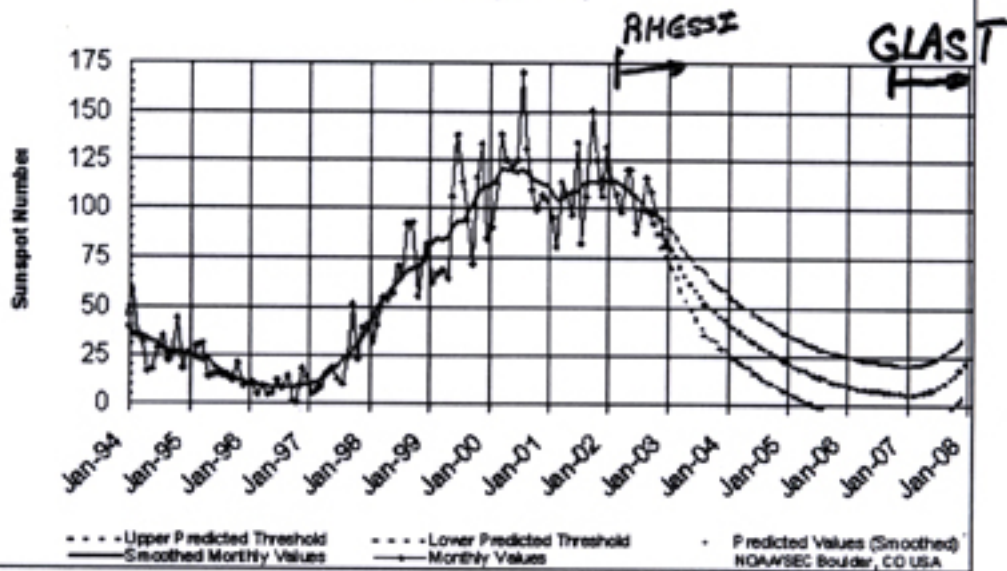
Evidence for beaming of high-energy radiation comes from distribution of high-energy flares on the Sun and from hardening of spectra for flares near the limb (suggests a pancake distribution of radiation).

There were 88 X-class flares:

	Full sample $>10$ MeV	No $>10$ MeV	
% observed at heliocentric angles $>60^\circ$	$42 \pm 8$	$71 \pm 23$	$31 \pm 8$

### ISES Solar Cycle Sunspot Number Progression

(Data Through 31 Jan 03)

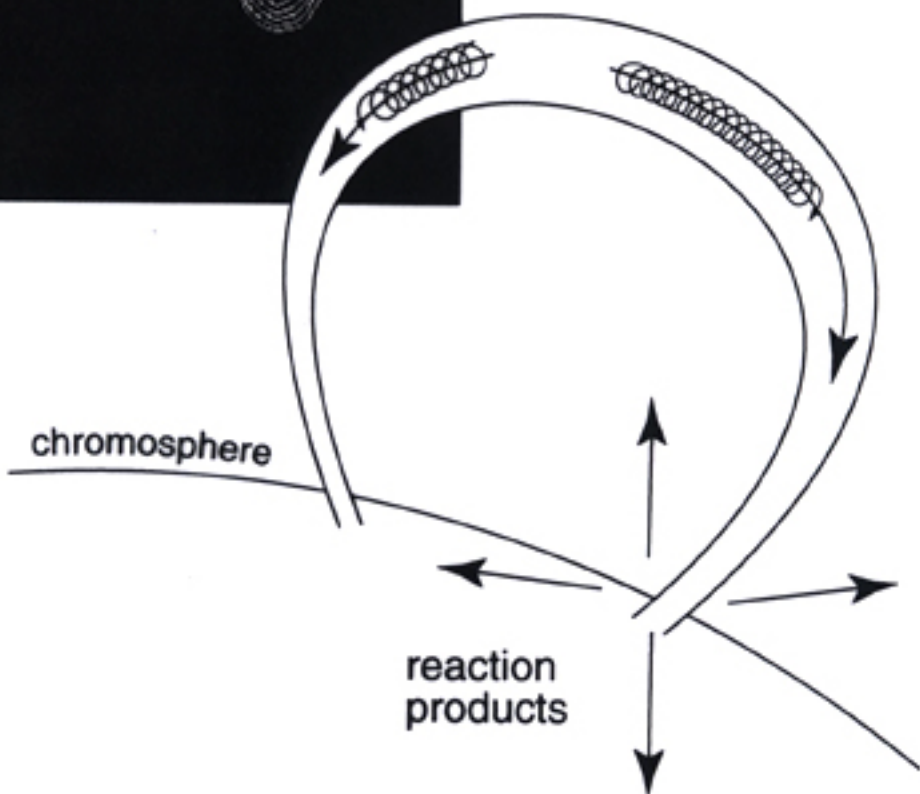


GLAST Can Observe The  
Rise of Cycle 24

# Neutron and $\gamma$ -ray Production in Solar Flares



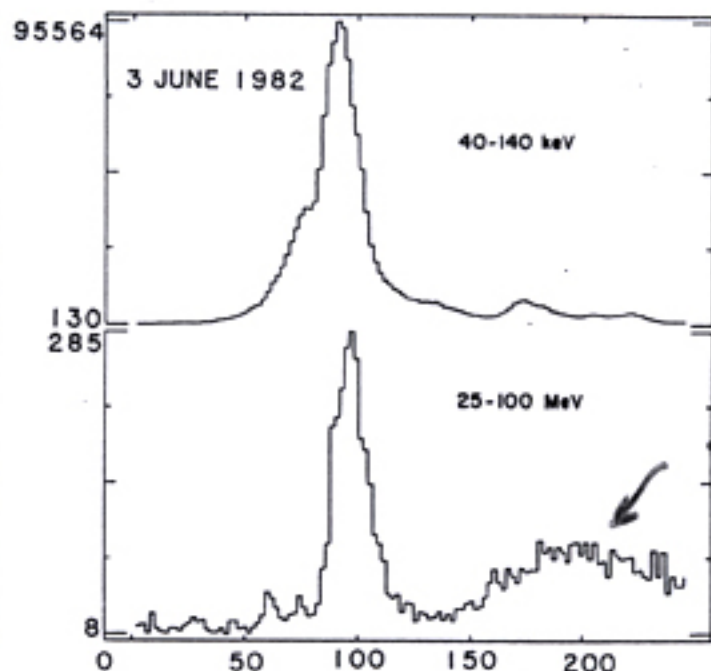
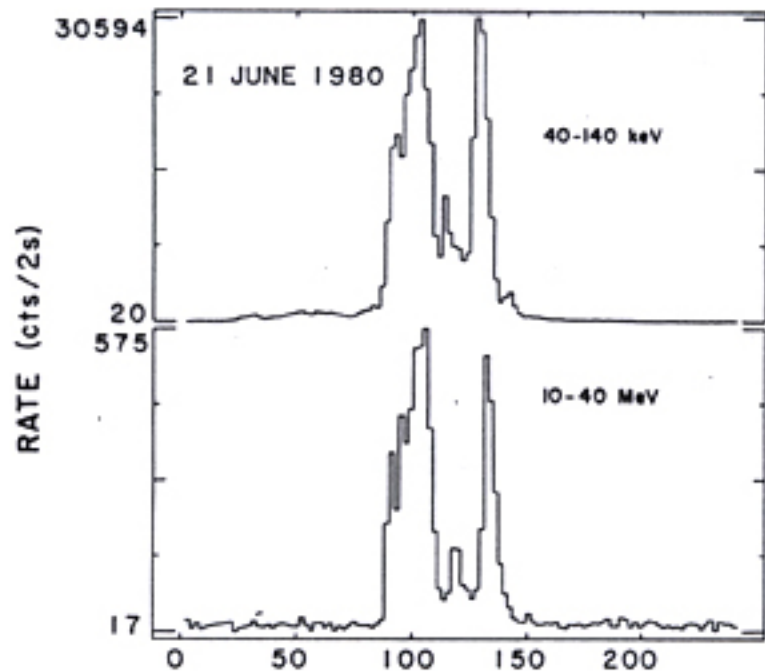
corona  
e, p,  $^3\text{He}$ ,  $\alpha$ , C, N, O, ...



electrons: X- and  $\gamma$ -ray bremsstrahlung

ions: radioactive nuclei  $\rightarrow e^+ \rightarrow \gamma_{511}$   
 $\pi \rightarrow \gamma$  (decay,  $e^\pm$  bremsstrahlung)  
 excited nuclei  $\rightarrow \gamma$ -ray line radiation

neutrons  $\rightarrow \left\{ \begin{array}{l} \text{escape to space} \\ 2.223 \text{ MeV capture line} \end{array} \right.$

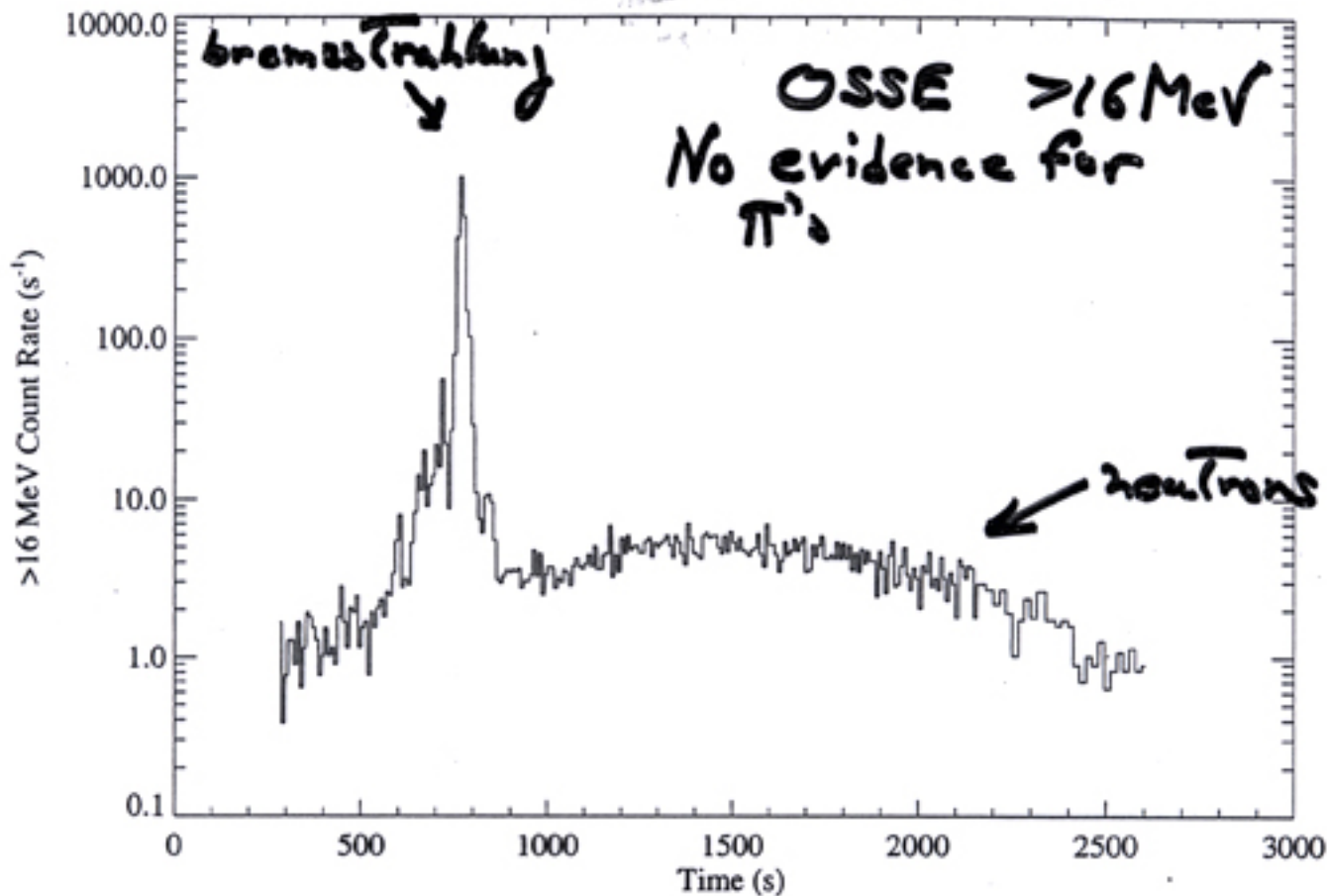


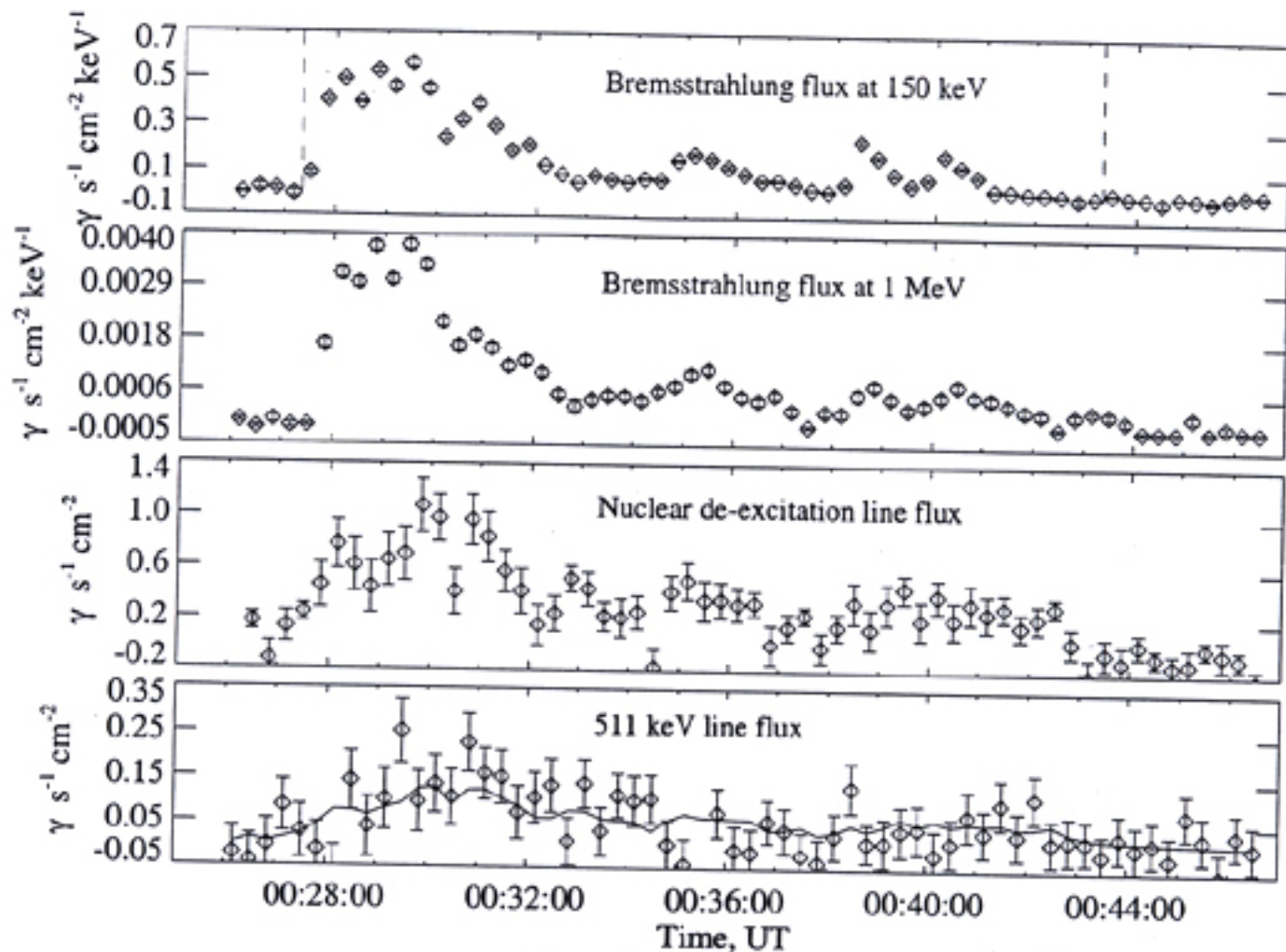
$\pi^+$ 's

TIME (s)

Second stage of high-energy emission

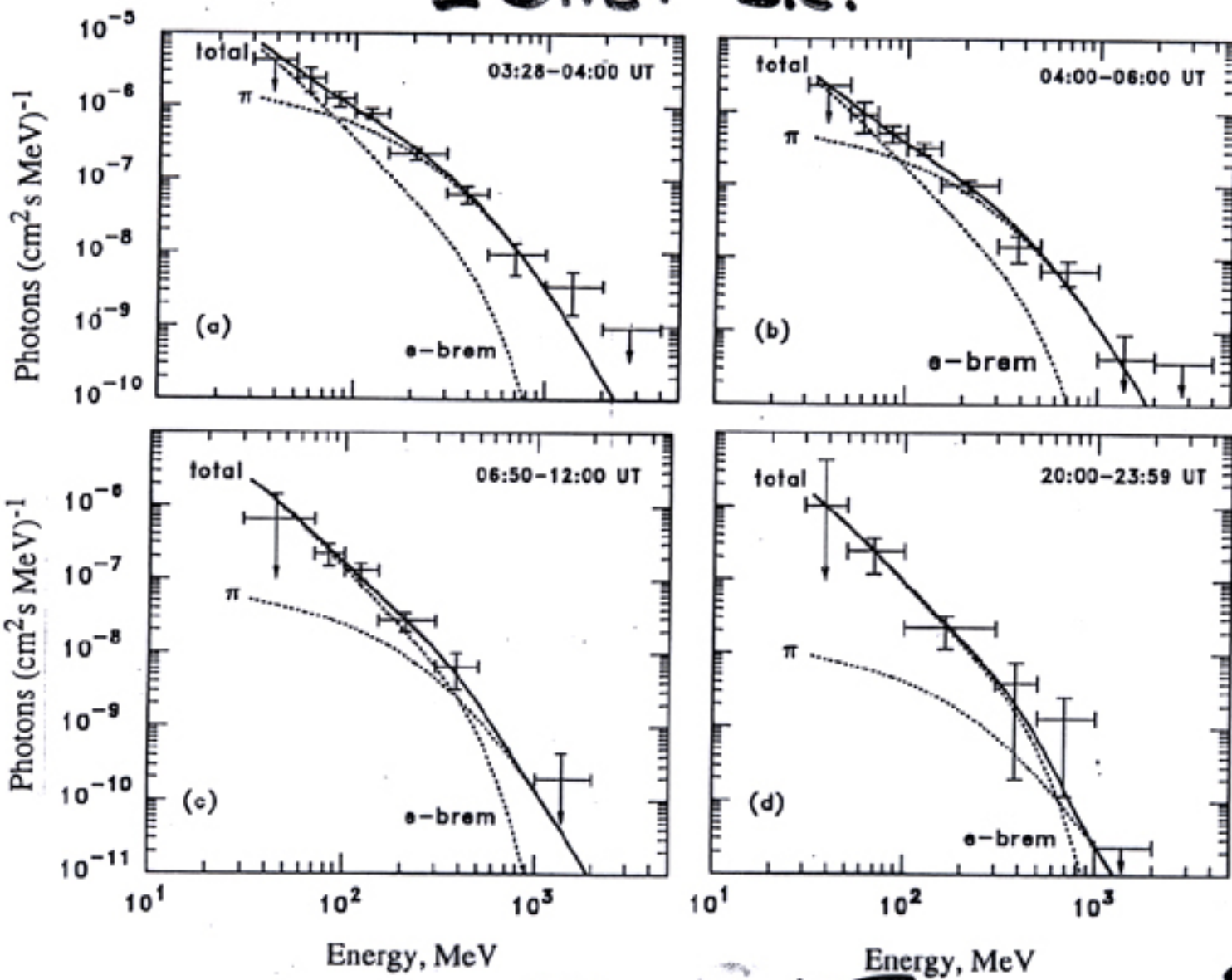
June 4, 1991





RHESSI 2002 July 23  
Share et al. 2003

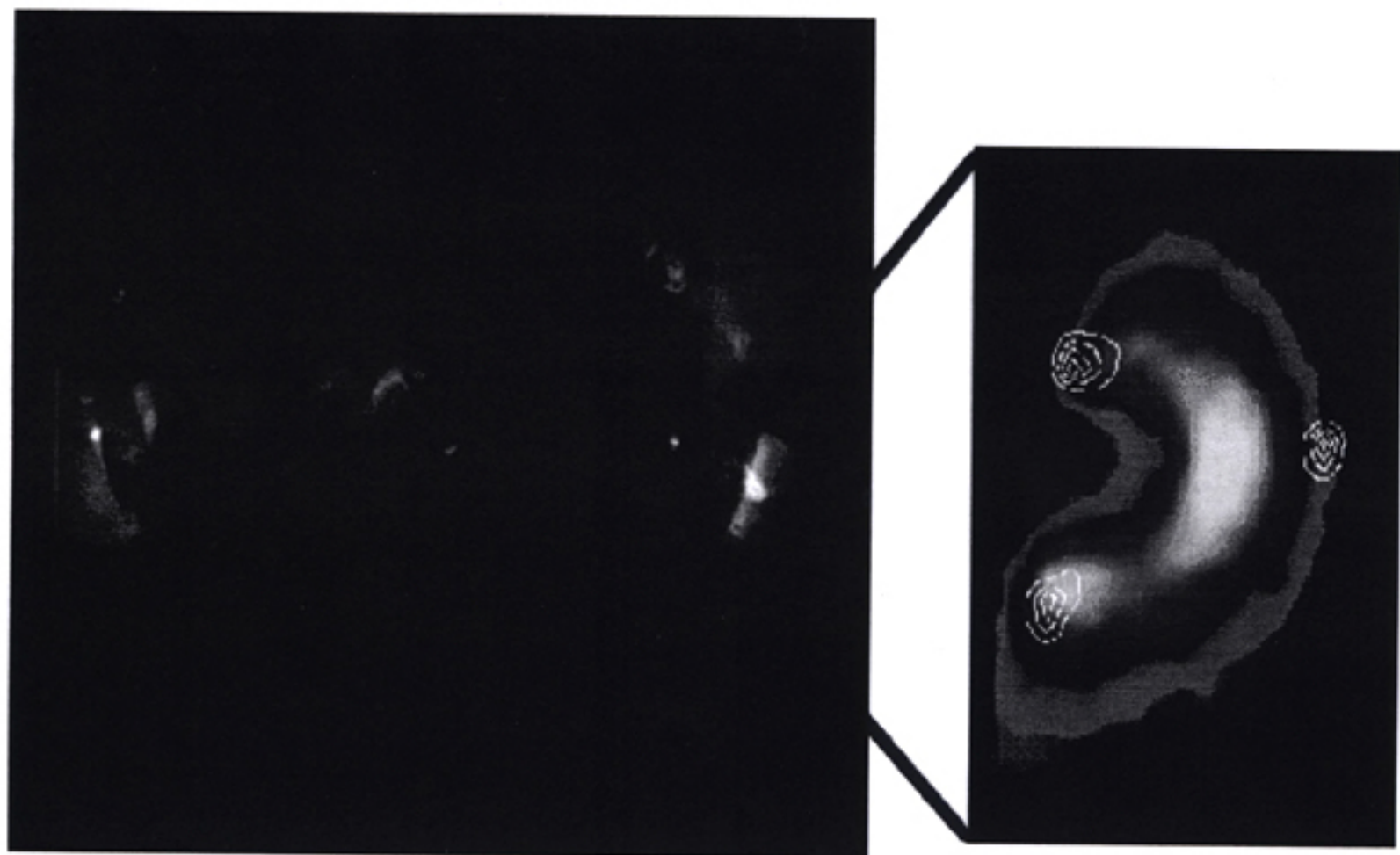
# EGRET S.C.



Spectral Evolution  
(gradual phase only)

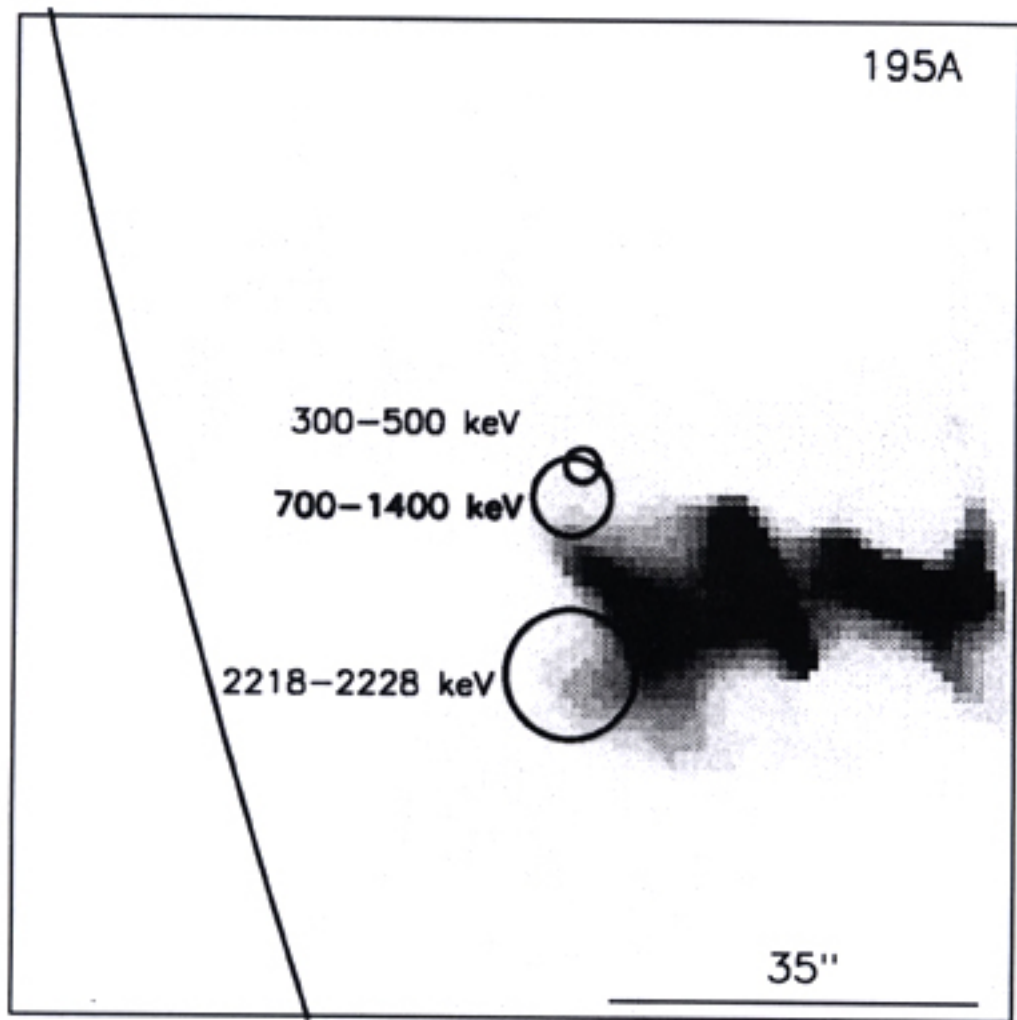
Berthel et al



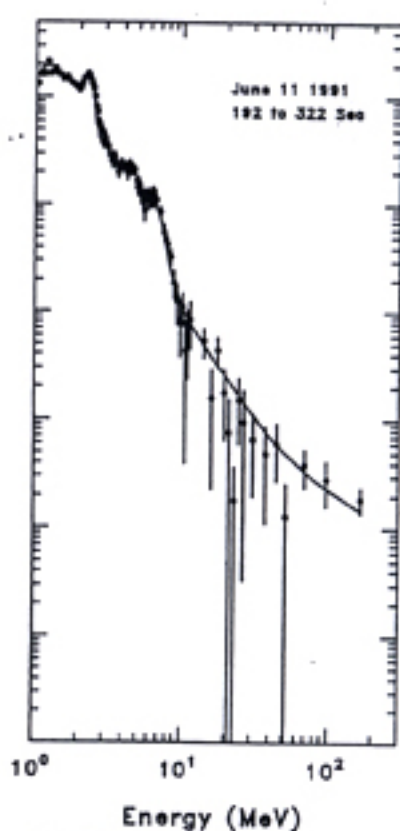
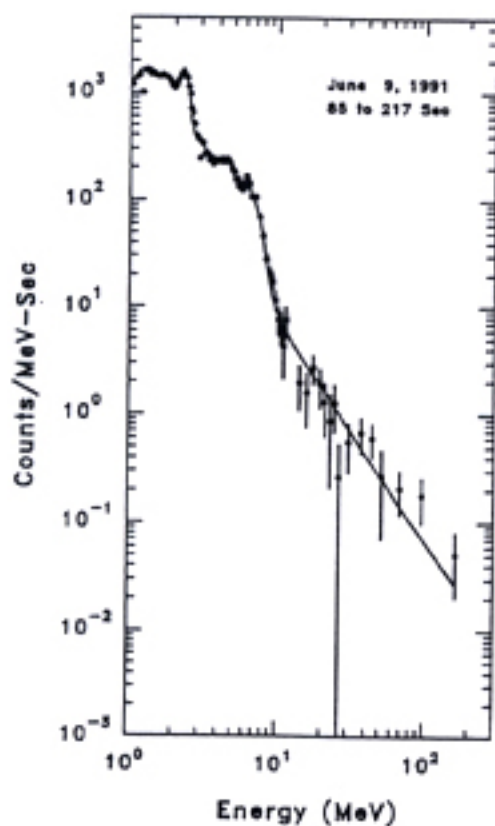
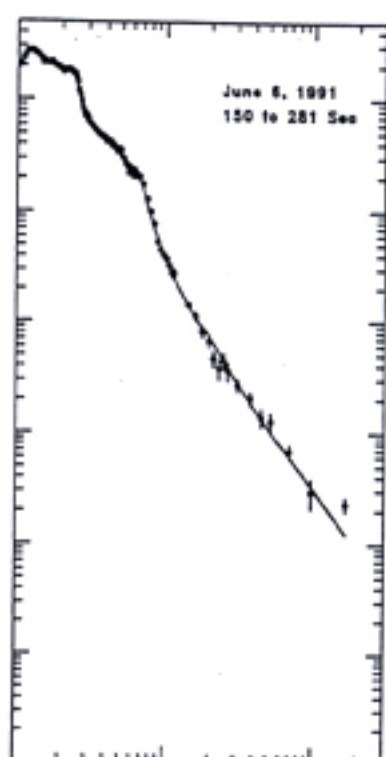
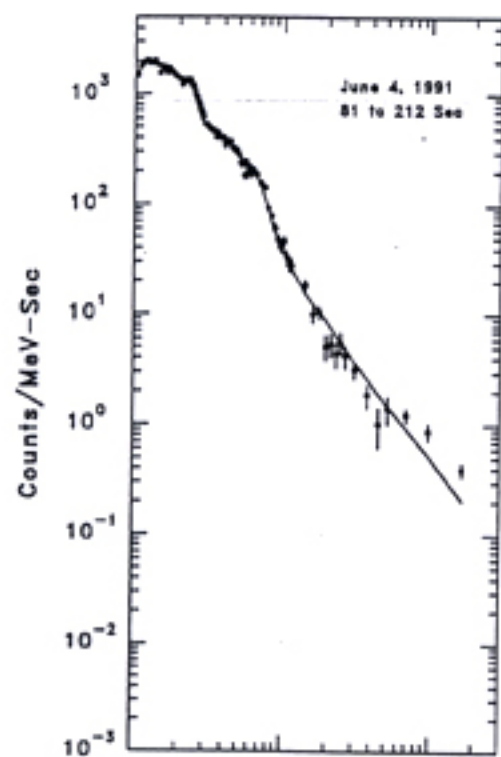


30 arcsec

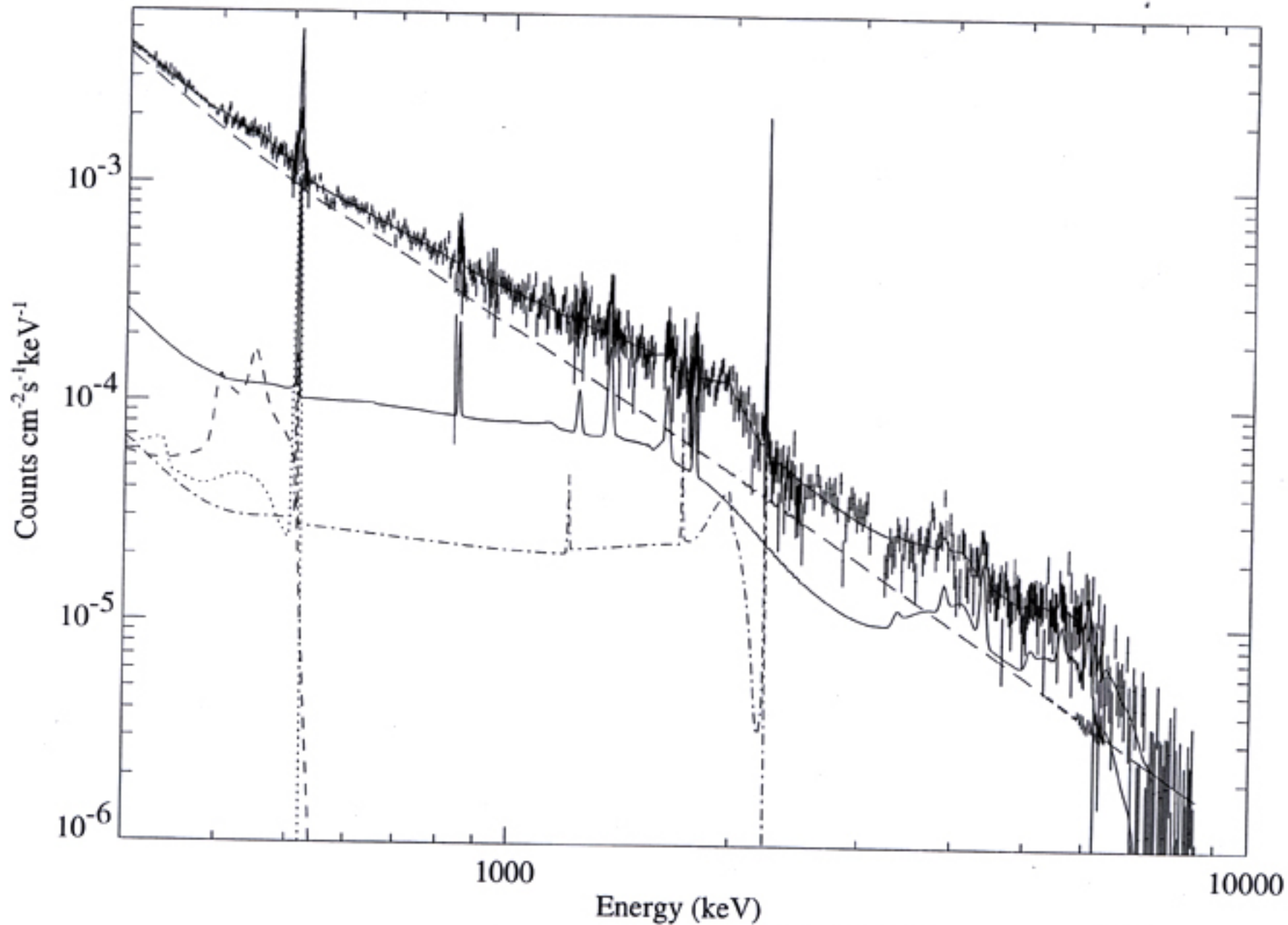
HESSI 1-10 MeV resolution 36 arcsec  
GLAST location 0.5-1 arcmin



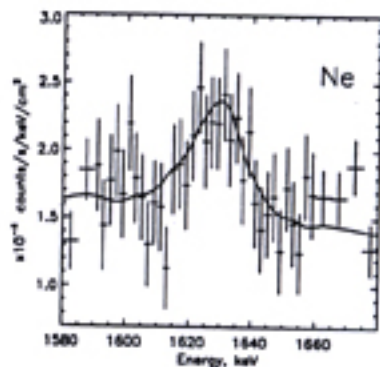
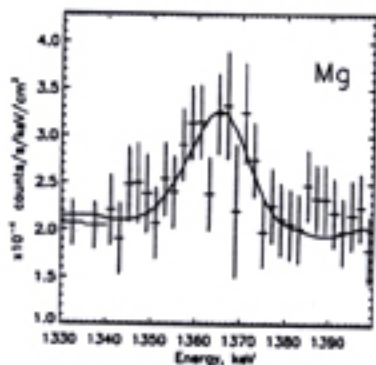
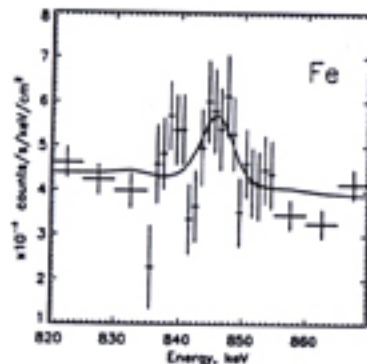
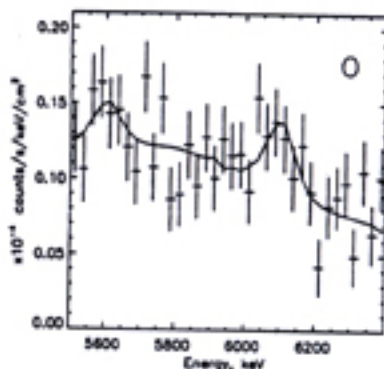
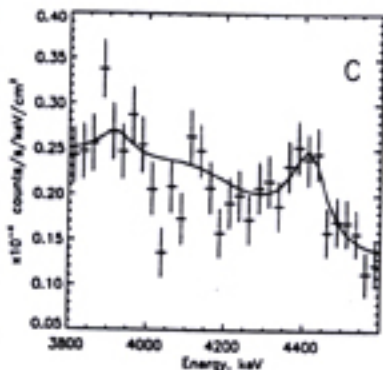
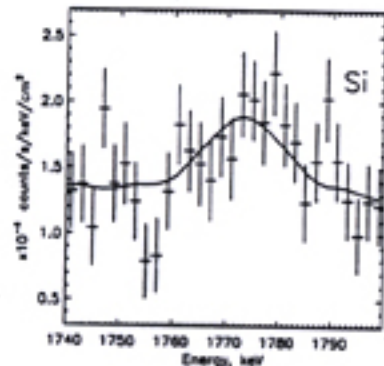
RHessi 2002 July 23  
Hurford et al. (2003)



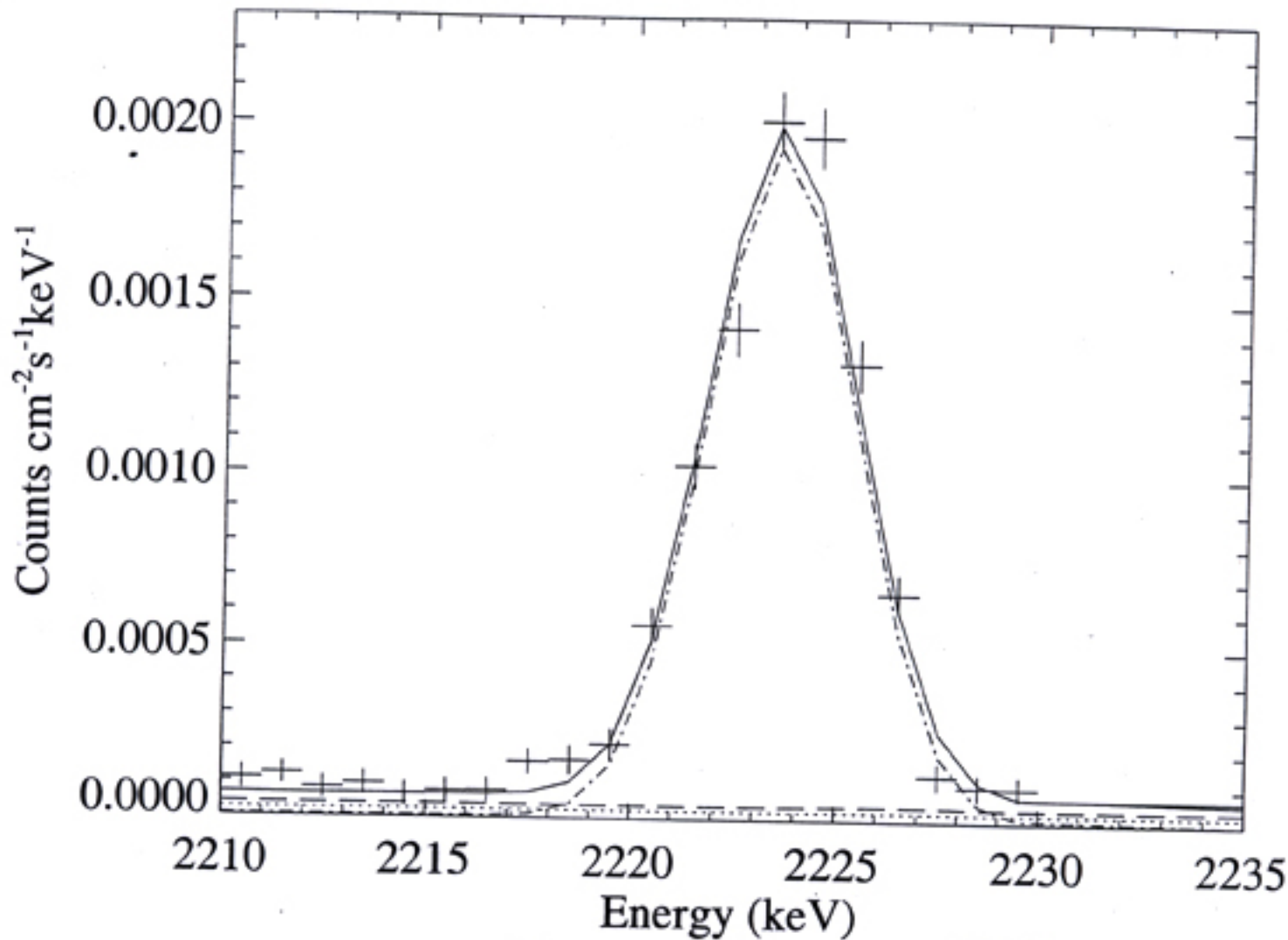
TASC spectral measurements  
 Bertsch et al.  
 $< 200$  MeV = close to impulsive phase



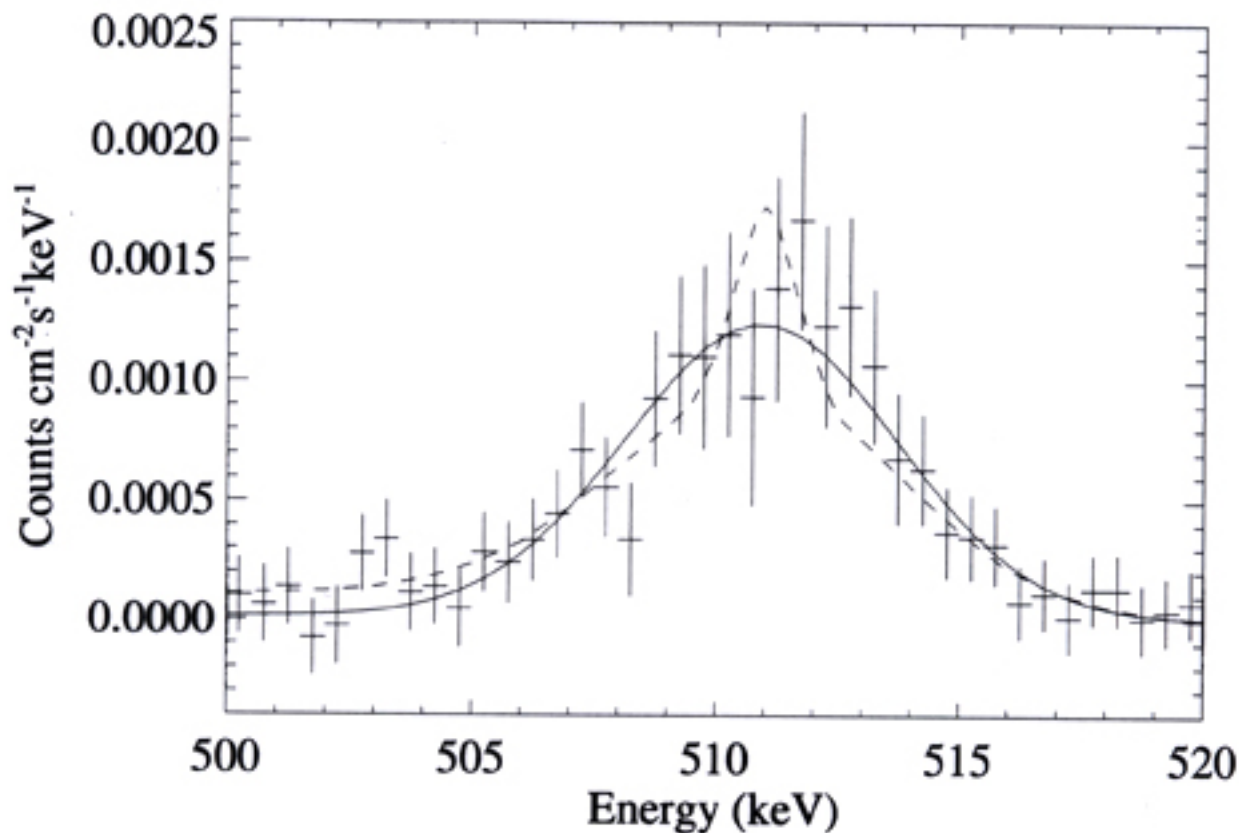
RHESSI 2002 July 23  
Lin et al. 2003



RHESSI 2002 July 23  
Smith et al. 2003



RHESSI 2002 July 23  
Murphy et al. 2003



RHESSI 2002 July 23  
Share et al. 2003

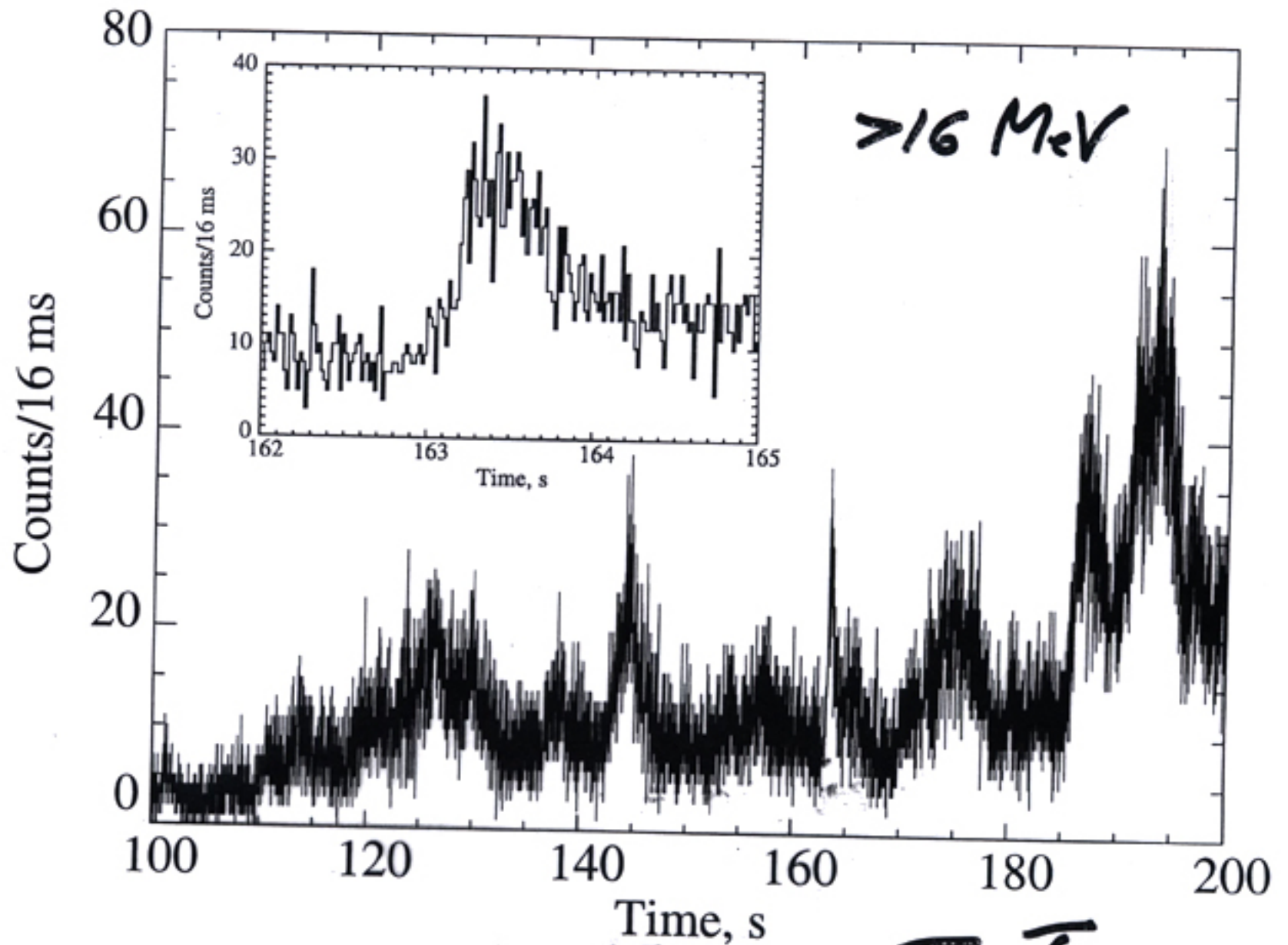
## COMPARISON OF GLAST/GBM<sup>+</sup> AND SMM/GRS<sup>\*</sup>

Energy	SMM	GBM	SMM	GBM
MeV	P.P. Area, cm <sup>2</sup>	P.P. Area, cm <sup>2</sup>	FWHM, keV	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

<sup>+</sup> Two 12.7 cm Dia. x 12.7 cm Bismuth Germanate (BGO) detectors

<sup>\*</sup> Seven 7.6 cm Dia. X 7.6 cm NaI detectors within AC shield





OSSE

~ 0.1 sec Temporal structure -  
⇒ high energy acceleration time scale