

SPI

Imaging : 16° fully coded FOV
Angular resolution : 2.6°
Energy range : 20 keV- 8 MeV
Energy resolution : 0.2 %
Time resolution : 100 microsec
Shield : active BGO shield
Camera : 19 HPGe detectors.
Active cooling : 85 K



CAMERA CONCEPT

19 Hex detectors

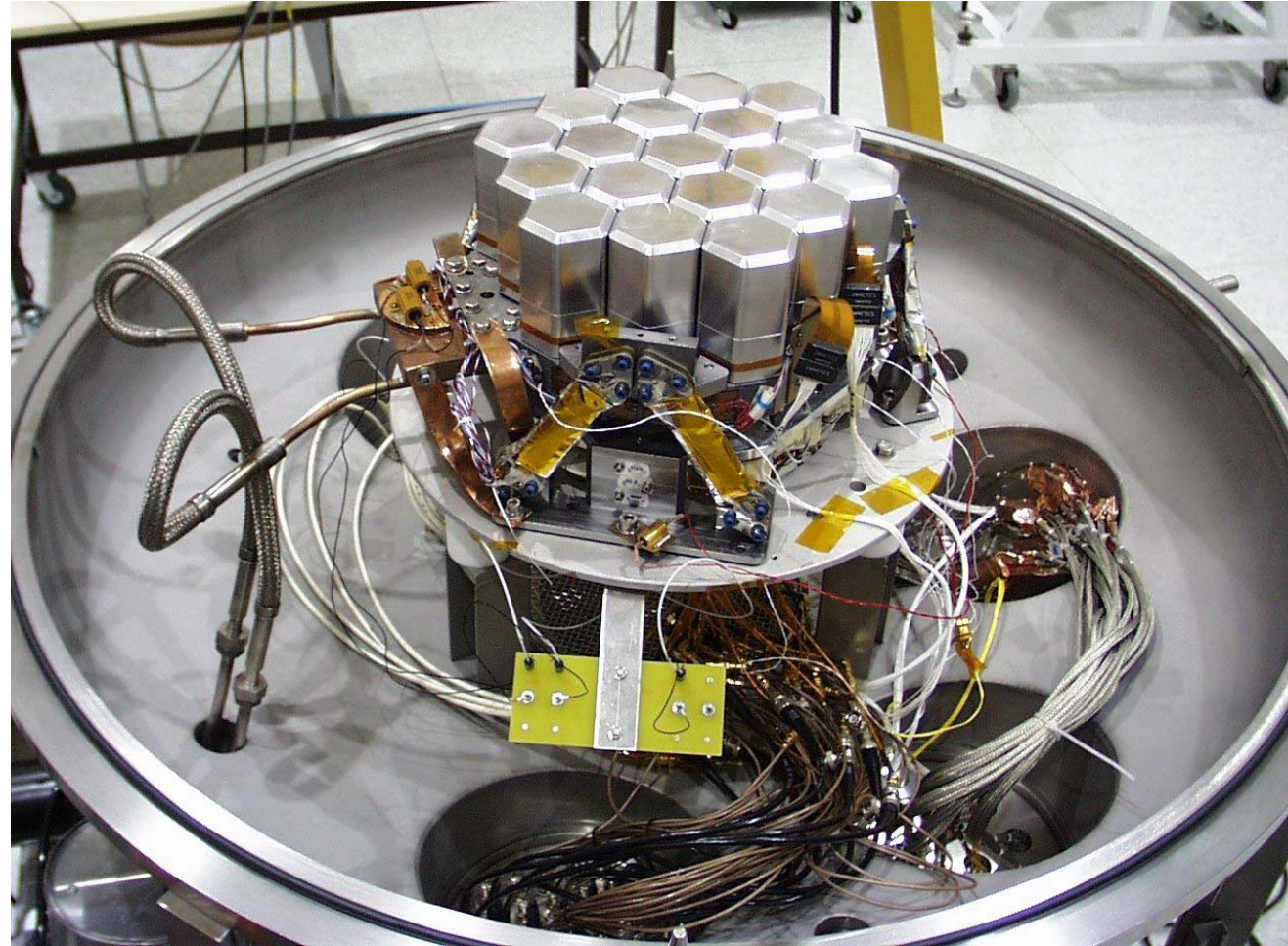
85 K stage

Annealing : 105 C

210 K stage

Preamplifier at 210 K

Beryllium cryostat



SPI CALIBRATIONS

4 STEPS :

- CAMERA CALIBRATION :

After camera integration (Sept 2000)

- SPI CALIBRATION AT CNES

After SPI integration (Dec 2000)

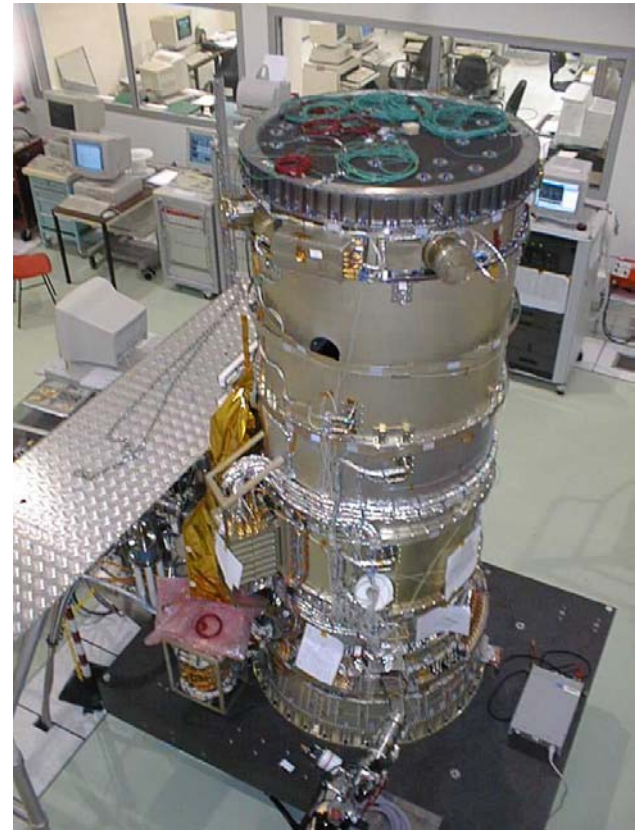
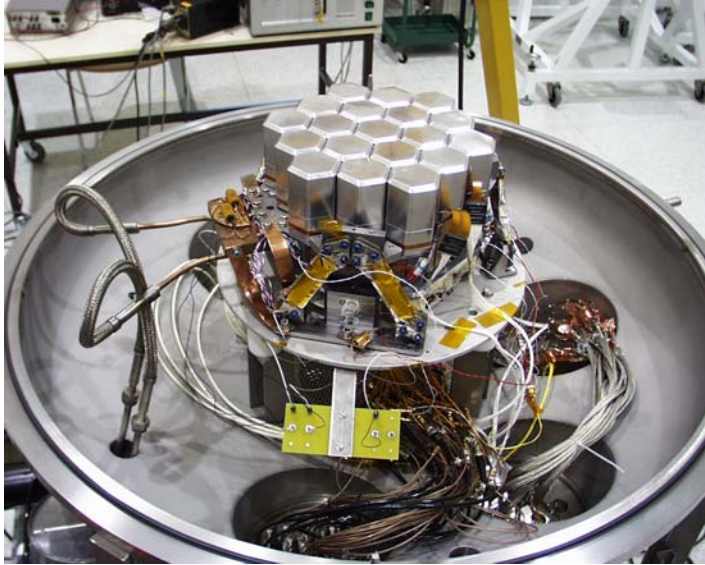
- SPI AT THERMAL TEST

SPI in representative thermal conditions (March - April 2001)

- SPI CALIBRATION AT BRUYERES LE CHATEL

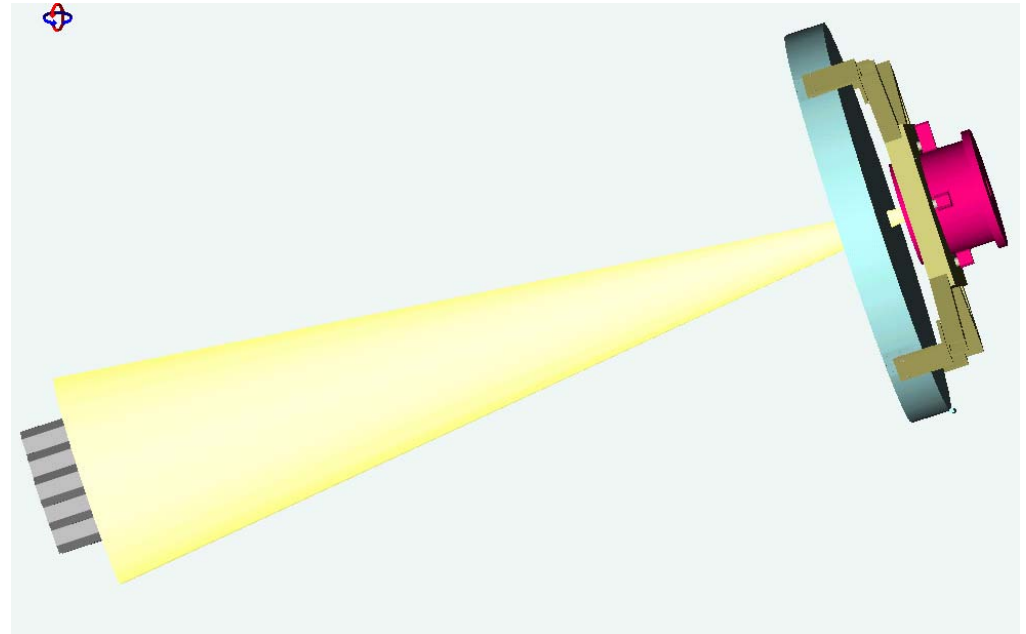
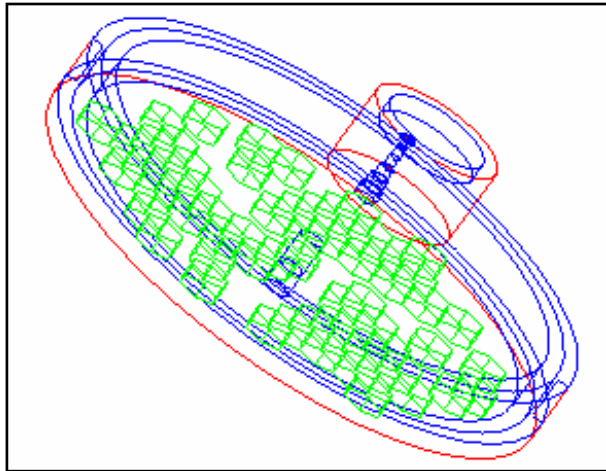
Latest calibration before SPI delivery at ESA (April - May 2001)

SPI FM CALIBRATIONS



CALIBRATION SYSTEM :

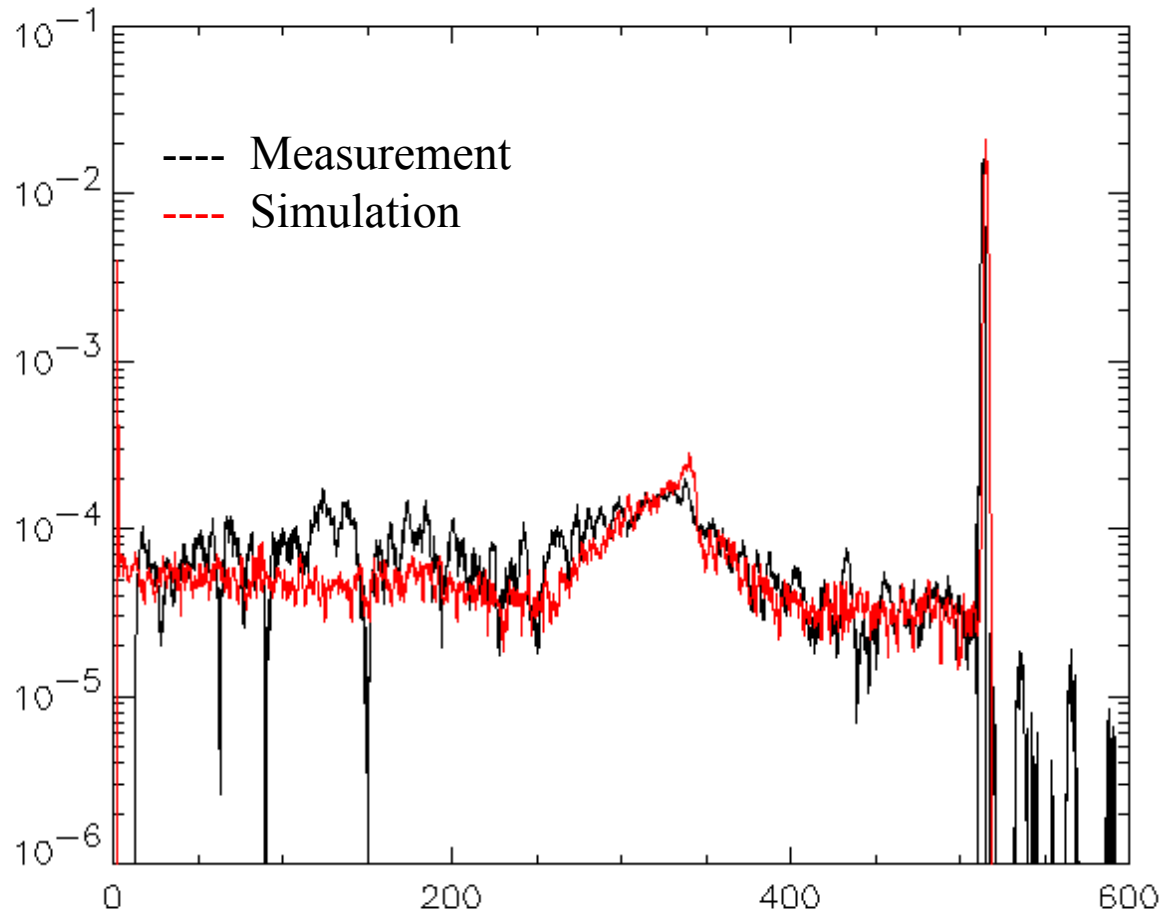
GUN (Sources collimator)



The following sources had been used :

^{137}Cs / ^{60}Co / ^{241}Am / ^{24}Na / ^{85}Sr / ^{54}Mn / ^{88}Y / ^{109}Cd / ^{228}Th / ^{57}Co

Single event spectra simulation and measurement for the central detector. Radioactive source : ^{85}Sr



SPI CALIBRATION AT BRUYERES LE CHATEL (May 2001)



CALIBRATION SCHEME

SPI without coded mask : Test efficiency and homogeneity

- Short distance sources (low intensity, 8 m).

11 different radioactive sources . Energy range : [60,1836] keV.

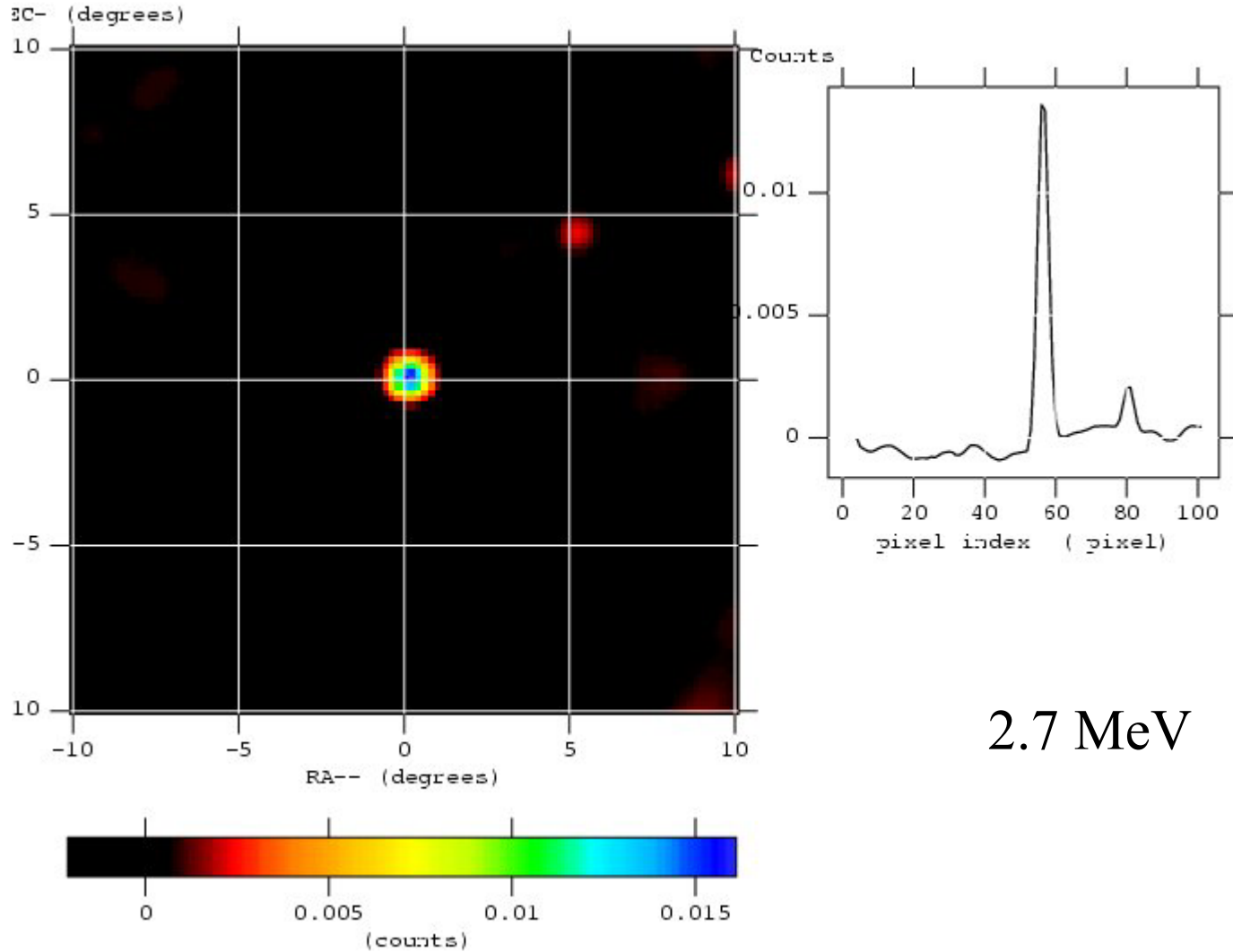
- 4 MeV-van de Graaf accelerator, calibration up to 8062 keV.

SPI with coded mask : Test of imaging

- Long distance sources (high intensity, 125 m),

Energy range : [60,2753] keV.

IMAGING PERFORMANCES



2.7 MeV

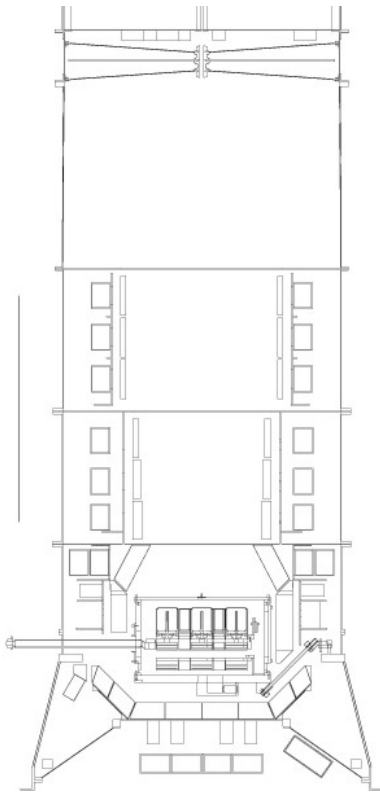
Response matrix generation by Monte-Carlo simulation

Instrument Response: Overview

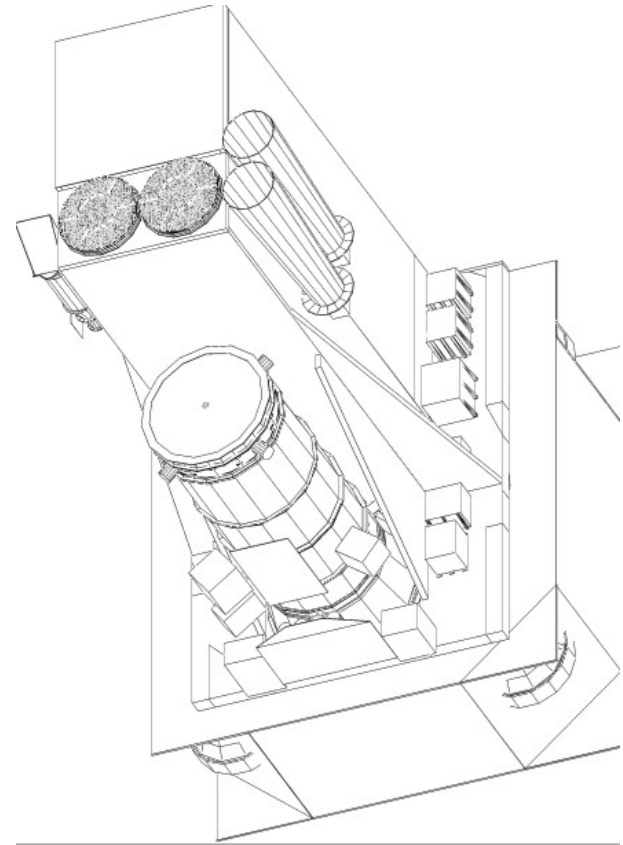
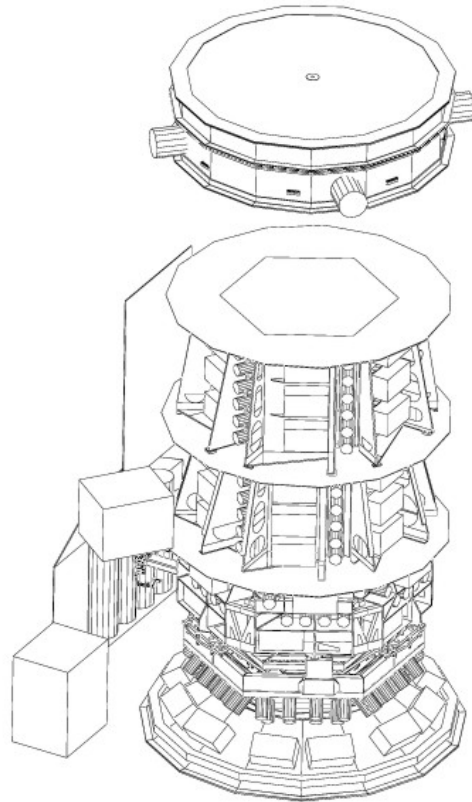
- A detailed mass model was created “by hand” based on technical drawings.
- Several “compression” schemes were devised to make the MC problem manageable in terms of CPU and storage.
- Simulations of the BLC calibration were performed at GSFC using the mass model and “MGEANT” MC SW.
- Comparison of these simulations with data led to improvements in the MC software and the mass model.

Instrument Model

These cutaway views give an idea of the level of detail in the SPI instrument model, which has been integrated with the Southampton "TIMM".



SPI cut-away views



TIMM-3

Instrument Response Corrections

Mask honey-comb support transmission correction curve. Points are the measurements for 4 offset angles, and the curves are from MC simulations.

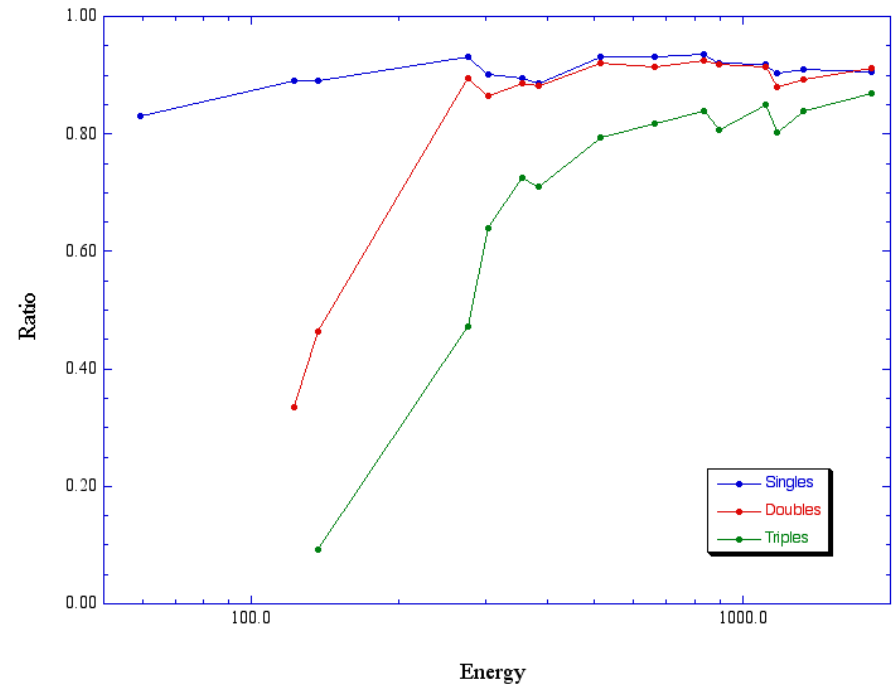
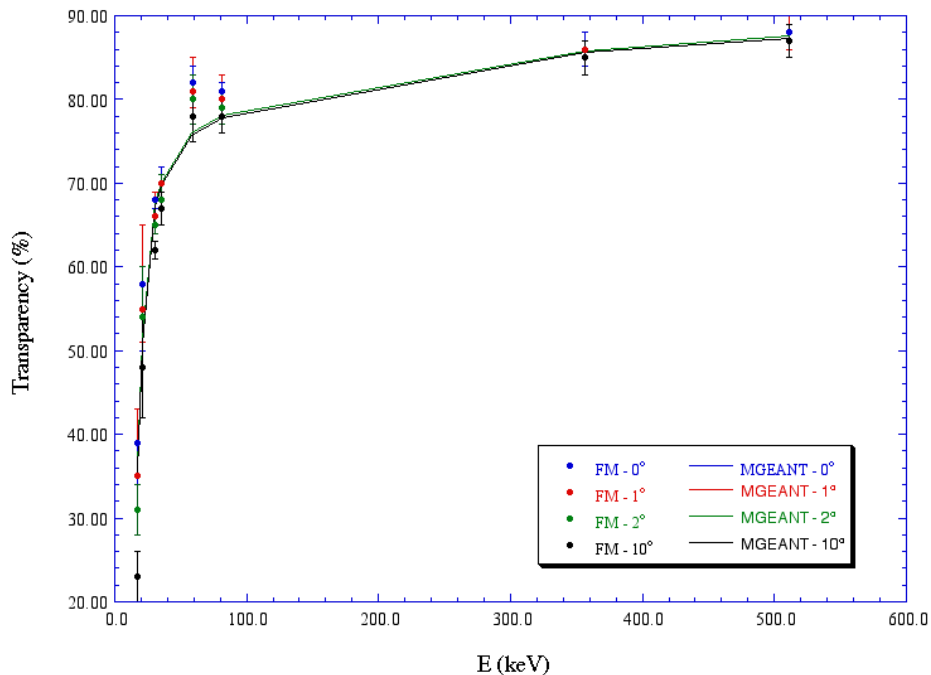


Photo-peak effective area correction factors for single, double & triple events. Extrapolation to Lowest and highest energies.

IRF Compression

- The computational problem scales as $\sim N_{sky} \times N_{det} \times N_{ch}$, per mono-energetic input energy with statistics at each vertex, which becomes unmanageable
- Savings was achieved first, by tracking detailed MC events for vertices within single a “pie-wedge” subset of the detector array
- This is then convolved with a full (i.e. all directions) database of absorption path-lengths derived from the ray-tracing events

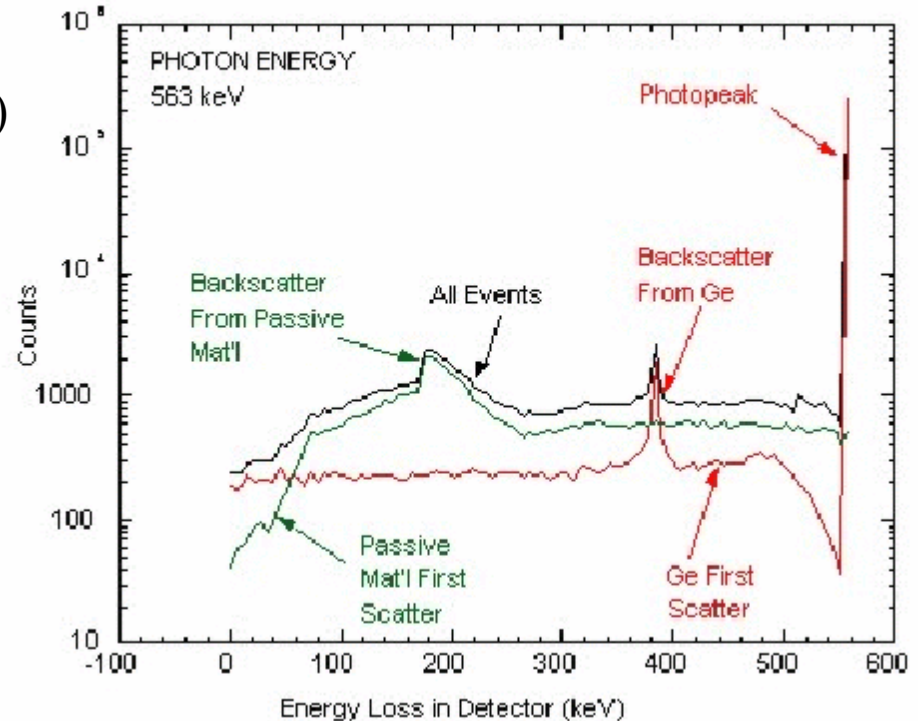
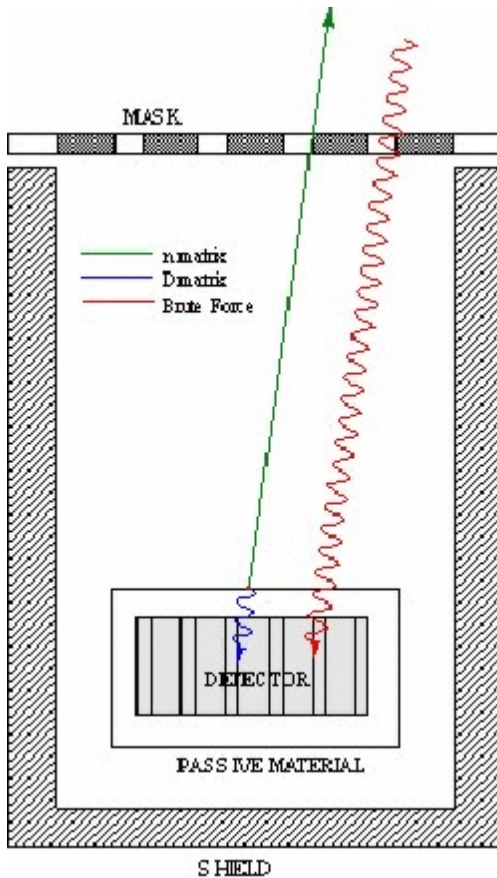
IRF Compression

- This leads to 2 large, databases of
 - spectra per detector-array vertex per direction (DMATRIX)
 - absorption path lengths per direction (over sampling instrument resolution by $\sim 5X$) (LMATRIX)
- From these, the basic response data set, or IRF is created
 - 5 dimensional object, $N_E \times N_\theta \times N_\phi \times N_{det} \times N_{spc-cmp}$
 - this comprises the basic end-user response database which is used directly in image reconstruction
 - and from which XSPEC “ARFs” are extracted

Response Decomposition

The response is approximated as a convolution of ray-tracing and detailed photon-propagation terms:

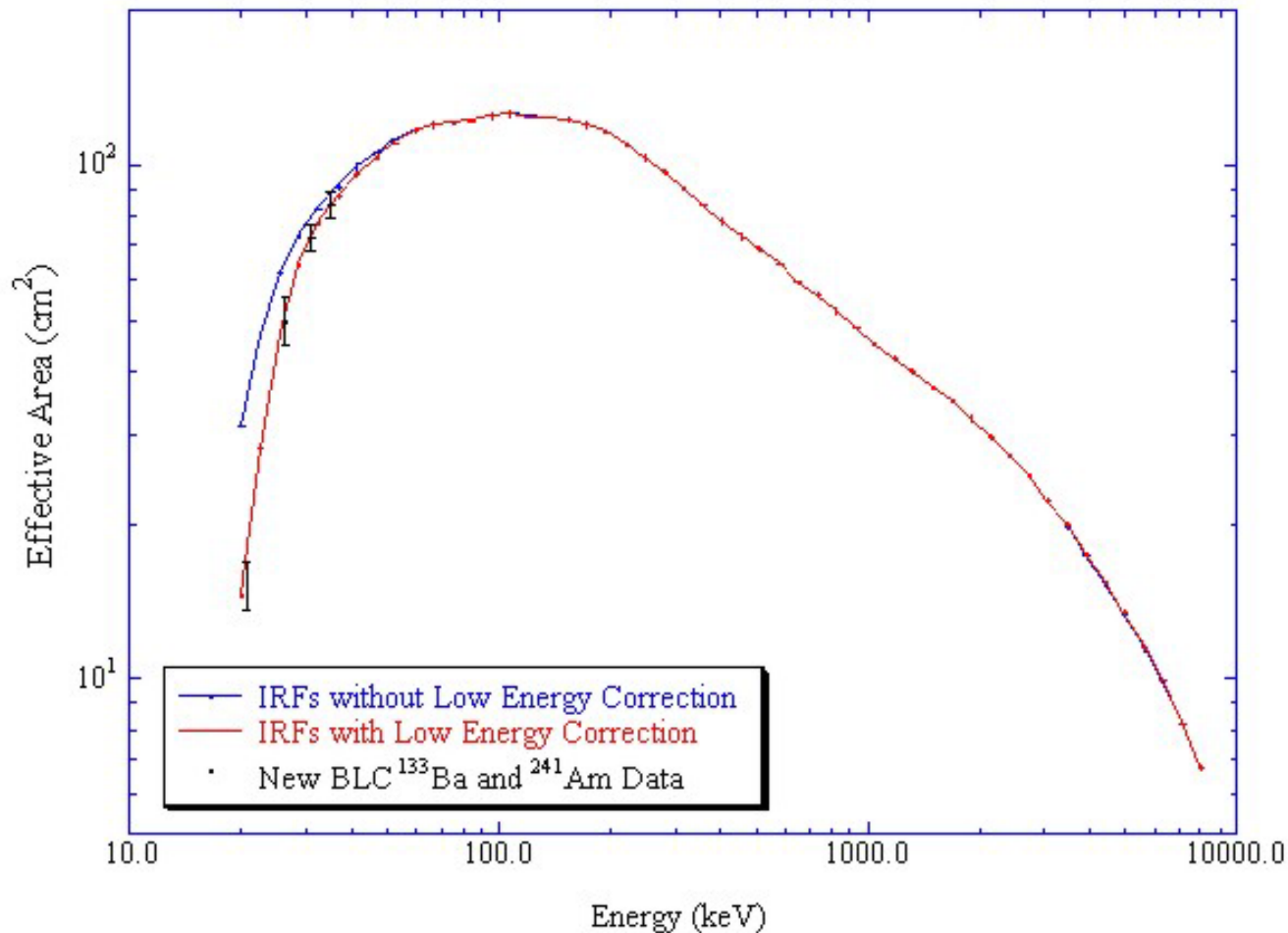
$$R(d, \theta, \phi, E, ch) = \sum L_i(d, \theta, \phi, E) \cdot D_i(d, \theta, \phi, E, ch)$$



Further computational and storage economy are achieved by recognizing that the response continuum can be reconstructed as a linear combination of components.

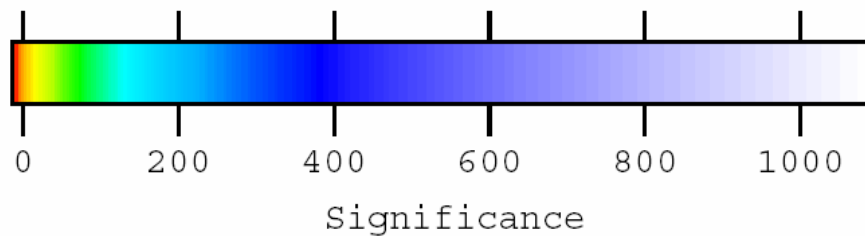
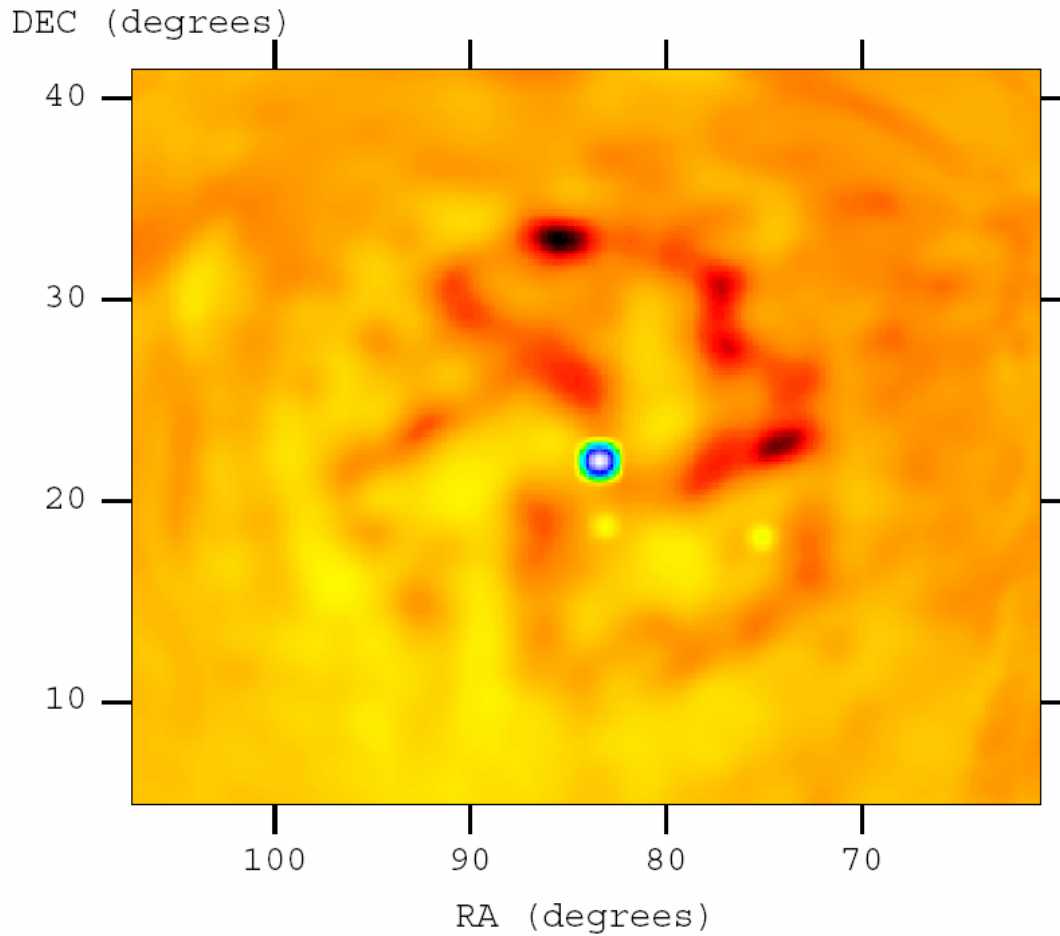
IRF Calibration

On-axis, total efficiency. Blue is uncorrected IRFs. Data points are ^{133}Ba and ^{241}Am measurements from CEA. Red curve is the recalibrated IRF.



SPI Crab Nebula observations

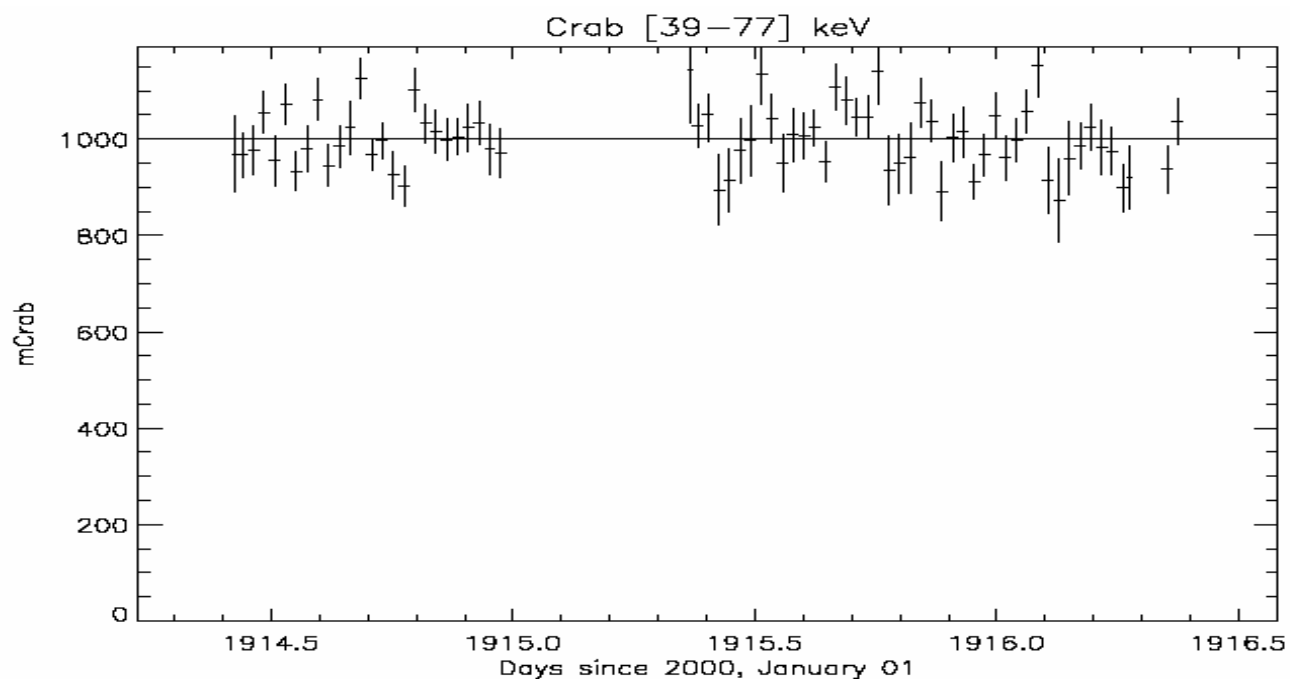
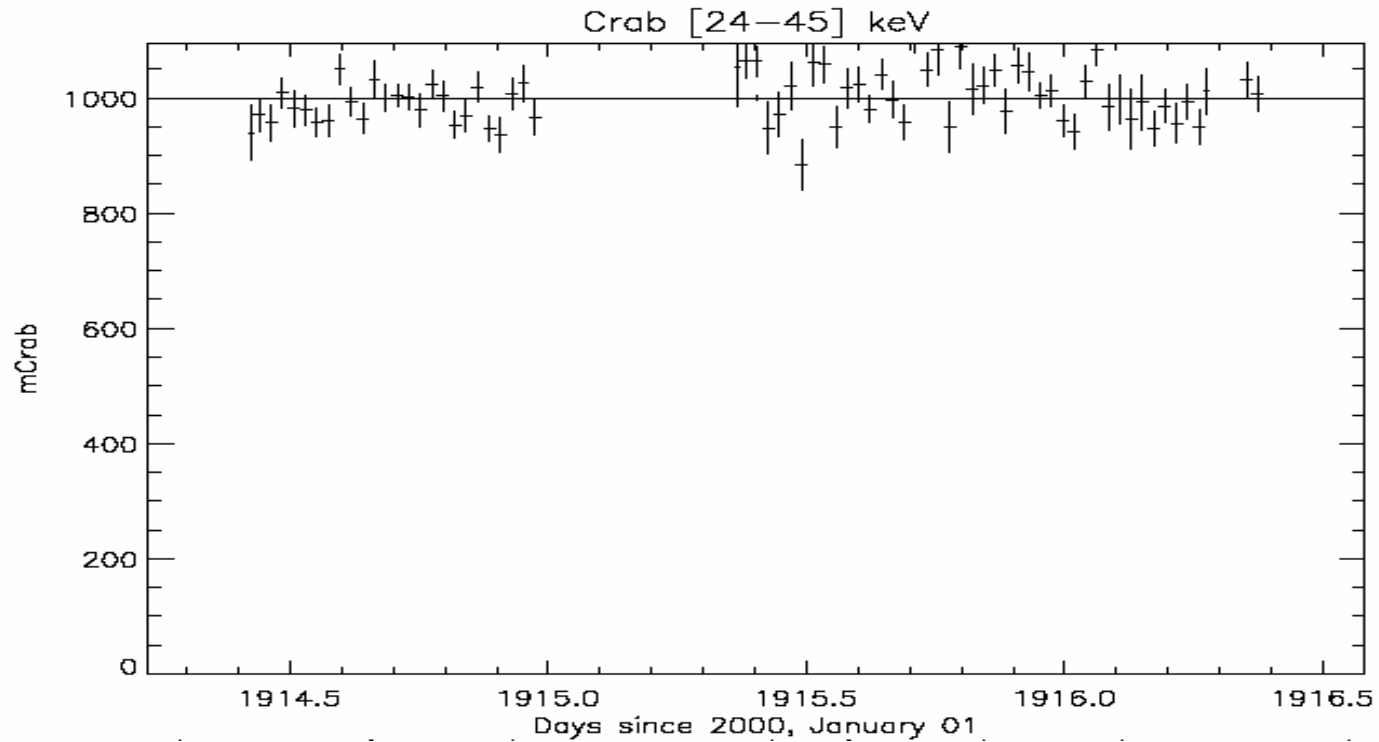
THE CRAB NEBULA 20-50 keV 567 ks



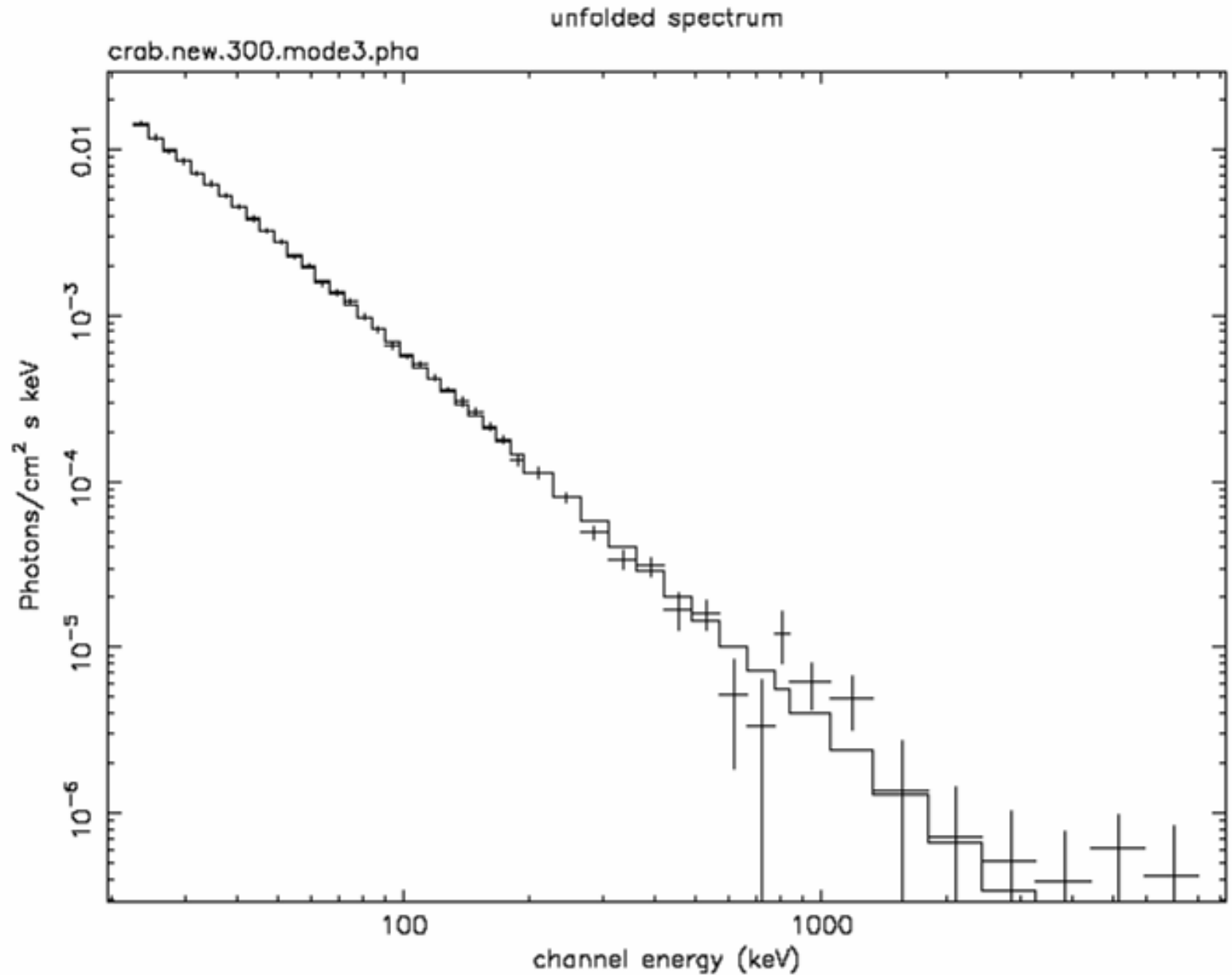
Crab Nebula

Stability in the FOV
Rev 300

10° circle around
the axis

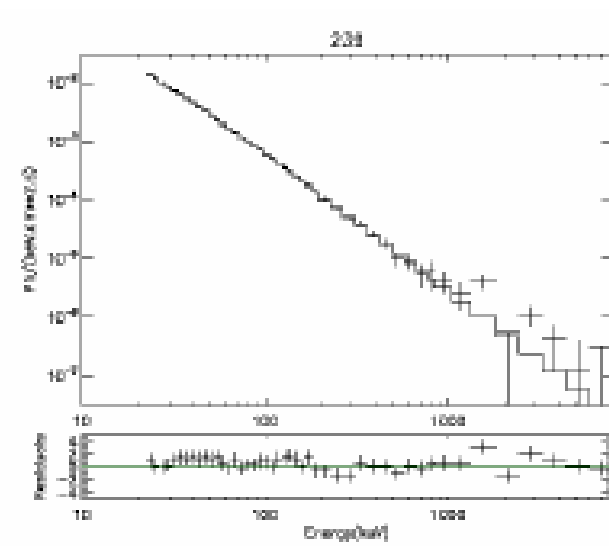
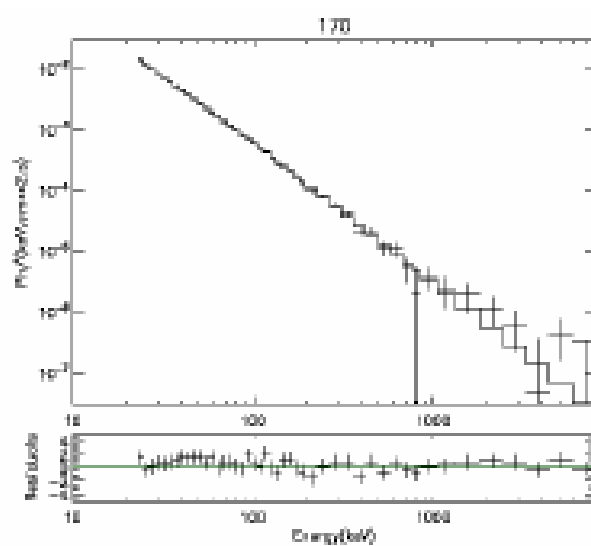
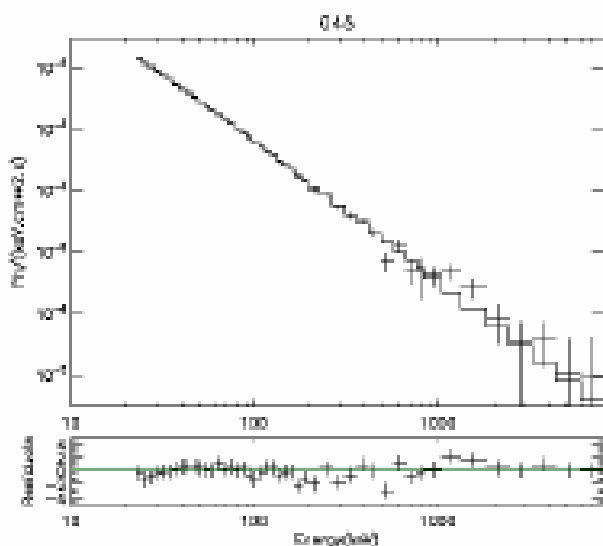


Crab Nebula - Calibration stability – revolutions 300 and 45



Crab Nebula observations

Rev #	Index 1	Ebreak (keV) fixed	Index 2	Norme @ 100 keV (ph cm ⁻² s ⁻¹)
45	$2.14 \pm 0.8 \cdot 10^{-2}$	90.0	$2.29 \pm 1.1 \cdot 10^{-2}$	6.3 E-04
170	$2.14 \pm 0.8 \cdot 10^{-2}$	90.0	$2.31 \pm 1.4 \cdot 10^{-2}$	6.04 E-04
239	$2.14 \pm 0.8 \cdot 10^{-2}$	90.0	$2.35 \pm 1.4 \cdot 10^{-2}$	6.00 E-04



Whole camera peak positions in keV and energy resolution

