GLAST Burst Monitor

High-Energy Calibration of a GLAST Burst Monitor BGO detector

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Abstract:

The understanding of the instrumental response of the GLAST Burst Monitor BGO detectors at energies above the energy range, which is accessible by common laboratory radiation sources (< 4.43 MeV), is important, especially for the later cross-calibration with the LAT response in the overlap region between ~ 20 MeV to 30 MeV.

In November 2006 the high-energy calibration of the GBM-BGO spare detector was performed at the small Van-de-Graaff accelerator at SLAC, which produces a proton beam up to 400 keV. High energy gamma-rays from excited ^{8}Be* (14.6 MeV and 17.6 MeV) and ^{16}O* (6.1 MeV) were generated through (p, γ)-reactions by irradiating a LiF-target. For the calibration at lower energies radioactive sources (^{22}Na, ^{232}Th, ^{241}Am/^{9}Be and the ^{40}K background line) were used. Our poster will summarize the results including spectra, the energy/channel-relation and the dependence of energy resolution.

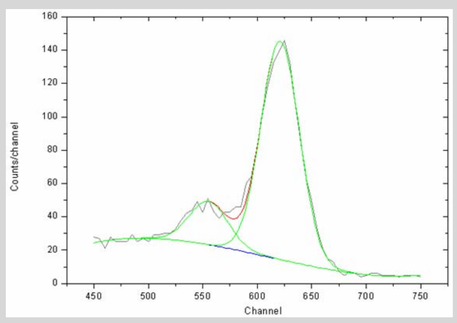
Calibration with radioactive sources:

Before and after the Van-de-Graaff runs spectra with radioactive sources were recorded in order to get a set of low energy lines, obtained at the same conditions (e.g. gain, which is dependent on the PMT high voltage setting and BGO temperature).

Irradiation with an ^{241}Am/^{9}Be Source:

The ^{9}Be(α,n)^{12}C reaction produces the first excited state of ^{12}C.

^{12}C* → γ (4.43 MeV) + ^{12}C (ground state)



Fit-Conditions
Peak Type: Gaussian (2 x)
Baseline Function: Cubic
ROI: 450 – 750
Constraints on Width:

$w_1 = w_2$

Fit-Results
(peak-center xc_i and -width w_i)

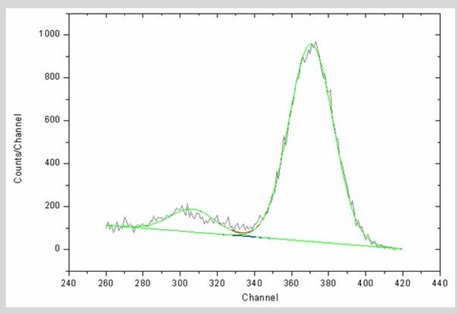
xc_1: 555.3 ± 1.5 w_1: 41.6 ± 4.6
xc_2: 621.1 ± 0.4 w_2: 41.6 ± 0.9

A1 = 0.20 * A2

γ-Radiation from Thorium Welding Rods:

1.4 x 10^{10} yr. ^{232}Th nat. with decay products

^{208}Tl → γ (2.6 MeV)



Fit-Conditions
Peak Type: Gaussian (2 x)
Baseline Function: Line
ROI: 260 – 420
Constraints on Width:

$w_1 = w_2$

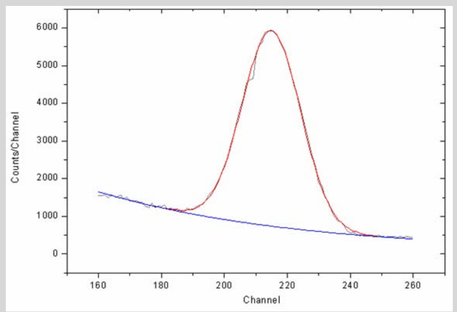
Fit-Results
(peak-center xc_i and -width w_i)

xc_1: 306.5 ± 0.7 w_1: 28.1 ± 2.1
xc_2: 370.6 ± 0.1 w_2: 28.1 ± 0.3

A1 = 0.12 * A2

γ-Radiation from Natural Background:

^{40}K → γ (1.46 MeV)



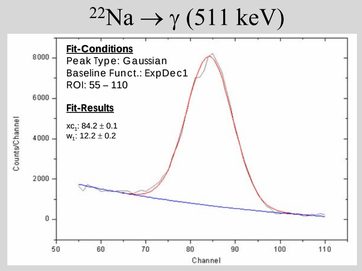
Fit-Conditions
Peak Type: Gaussian
Baseline Function: ExpDec1
ROI: 160 – 260

Fit-Results

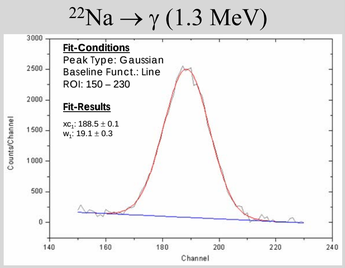
xc_1: 214.9 ± 0.1 w_1: 21.8 ± 0.1

γ-Radiation from a ^{22}Na laboratory source:

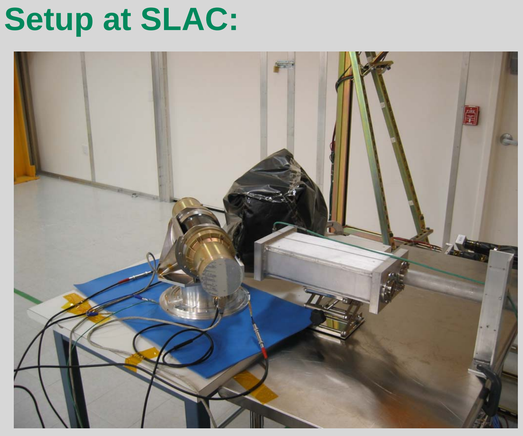
^{22}Na → γ (511 keV)

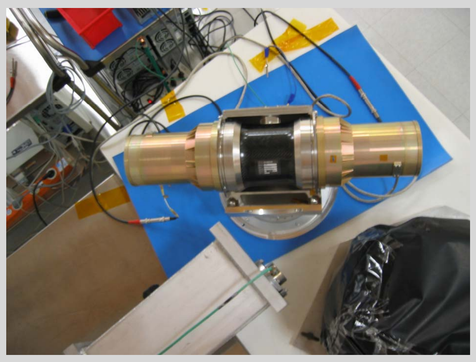


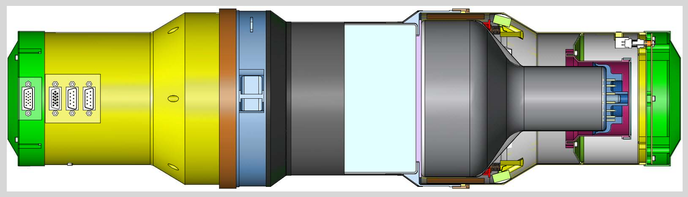
^{22}Na → γ (1.3 MeV)

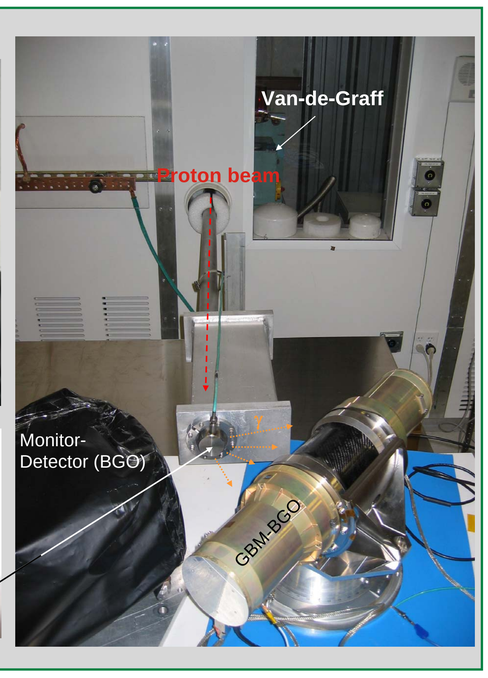


Setup at SLAC:







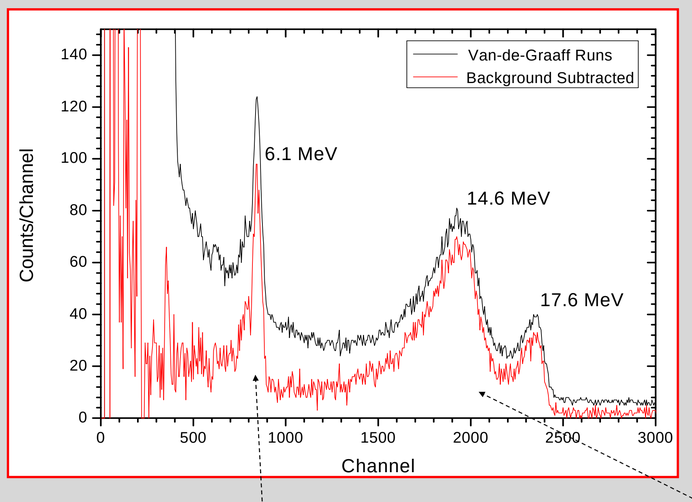


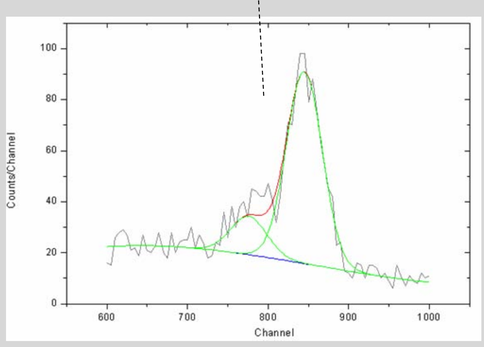
Van-de-Graaff Runs:

The Van-de-Graaff at SLAC is a small electrostatic accelerator that produces a up to 400 keV proton beam. The proton beam strikes a LiF target that terminates the end of the vacuum pipe and produces 6.1 MeV, 14.6 MeV, and 17.6 MeV gammas via the reactions:

p(~ 340 keV) + ^{7}Li → ^{8}Be (1+)* → ^{8}Be + γ (14.6 or 17.6 MeV)
→ 14.6 MeV line is intrinsically broader than detector resolution!

p (340 keV) + ^{19}F → ^{16}O* + α → ^{16}O + γ (6.1 MeV)





Fit-Conditions
Peak Type: Gaussian (2 x)
Baseline Function: Cubic
ROI: 600 – 1000
Constraints on Area and Width:

$A_1 = 0.20 * A_2$ (from simulation)
$w_1 = w_2$

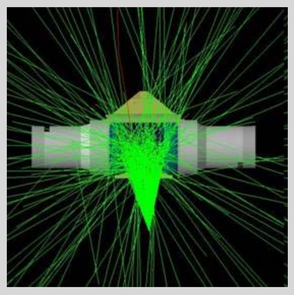
Fit-Results
(peak-center xc_i and -width w_i)

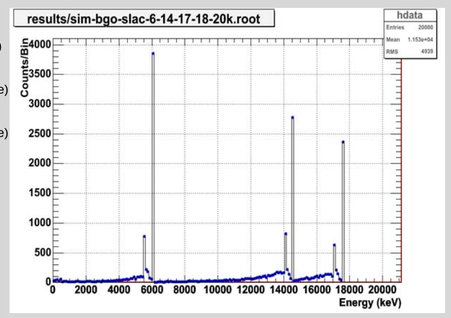
xc_1: 776.1 ± 7.2 w_1: 52.6 ± 16.4
xc_2: 845.0 ± 1.7 w_2: 52.6 ± 3.6

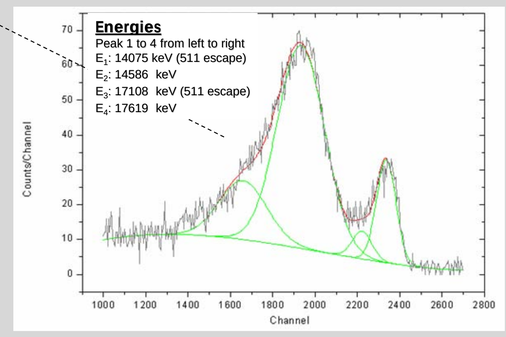
Simulations:

- Purpose: Determination of the photo-peak / escape-peak ratio
- Ratio will be used as constraint for the peak area in the fits!

Energies
E_1: 5619 keV (511 escape)
E_2: 6130 ± 60 keV
E_3: 14075 keV (511 escape)
E_4: 14586 keV
E_5: 17108 keV (511 escape)
E_6: 17619 keV







Fit-Conditions
Peak Type: Gaussian (4 x)
Baseline Function: Cubic
ROI: 1000 – 2700
Constraints on Area and Width:

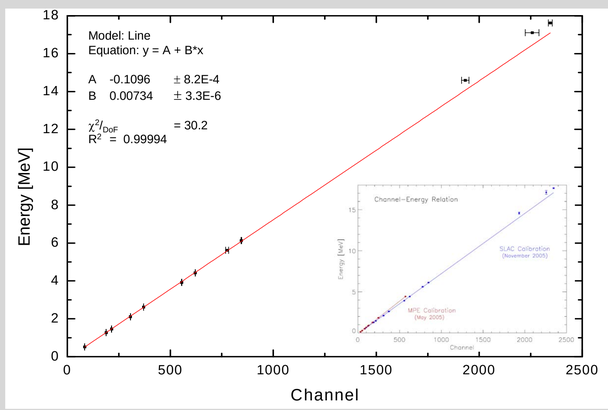
$A_1 = 0.29 * A_2$ (from simulation)
$A_3 = 0.27 * A_4$ (from simulation)
$w_1 = w_2$
$w_3 = w_4$

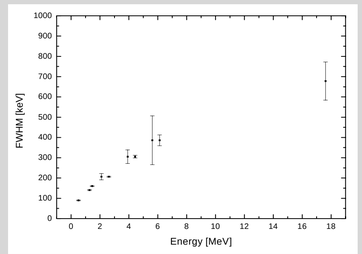
Fit-Results
(peak-center xc_i and -width w_i)

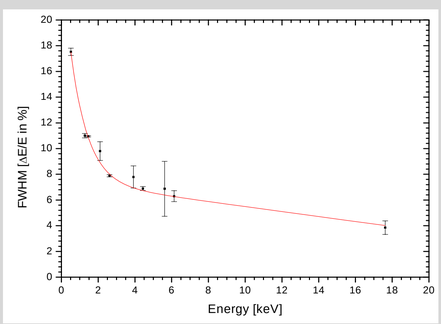
xc_1: 1659.7 ± 27.0 w_1: 264.2 ± 42.3
xc_2: 1933.6 ± 8.1 w_2: 264.2 ± 15.5
xc_3: 2222.4 ± 22.2 w_3: 108.6 ± 44.3
xc_4: 2335.9 ± 6.8 w_4: 108.6 ± 9.4

Calibration Results:

The channel-to-energy conversion and linearity of the BGO detector (EQM only) and the resolution FWHM (abs./rel.) of the detector at various energies.







Model: ExpLinear
Equation: y = p1*exp(-x/p2) + p3 + p4*x

p1 17.45798 ± 1.5172
p2 0.94544 ± 0.09909
p3 7.43079 ± 0.51181
p4 -0.19418 ± 0.08453

$\chi^2/_{DoF}$ = 4.38042
R^2 = 0.98885

For further information, please contact: azk@mpe.mpg.de