



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.

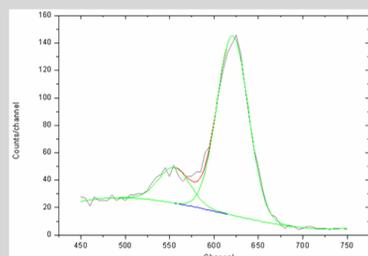
In November 2006 the high-energy calibration of the GBM-BGO spare detector was performed at the small Van-de-Graaff accelerator at SLAC, which produces a proton beam up to 400 keV. High energy gamma-rays from excited ⁸Be* (14.6 MeV and 17.6 MeV) and ¹⁶O* (6.1 MeV) were generated through (p, γ)-reactions by irradiating a LiF-target. For the calibration at lower energies radioactive sources (²²Na, ²³²Th, ²⁴¹Am/⁹Be and the ⁴⁰K 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 ²⁴¹Am/⁹Be Source:

The ⁹Be(α,n)¹²C reaction produces the first excited state of ¹²C.
¹²C* → γ (4.43 MeV) + ¹²C (ground state)

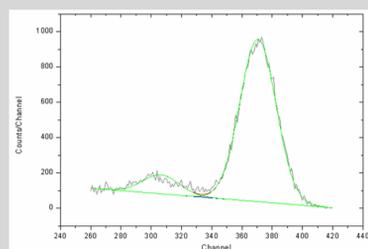


Fit-Conditions
Peak Type: Gaussian (2 x)
Baseline Function: Cubic
ROI: 450 - 750
Constraints on Width:
w₁ = w₂

Fit-Results
(peak-center x_c and -width w_g)
x_{c1}: 555.3 ± 1.5 w_{g1}: 41.6 ± 4.6
x_{c2}: 621.1 ± 0.4 w_{g2}: 41.6 ± 0.9
A1 = 0.20 * A2

γ-Radiation from Thorium Welding Rods:

1.4 x 10¹⁰ yr. ²³²Th nat. with decay products
²⁰⁸Tl → γ (2.6 MeV)

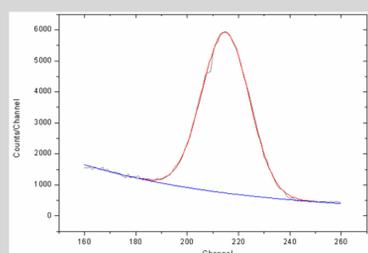


Fit-Conditions
Peak Type: Gaussian (2 x)
Baseline Function: Line
ROI: 260 - 420
Constraints on Width:
w₁ = w₂

Fit-Results
(peak-center x_c and -width w_g)
x_{c1}: 306.5 ± 0.7 w_{g1}: 28.1 ± 2.1
x_{c2}: 370.6 ± 0.1 w_{g2}: 28.1 ± 0.3
A1 = 0.12 * A2

γ-Radiation from Natural Background:

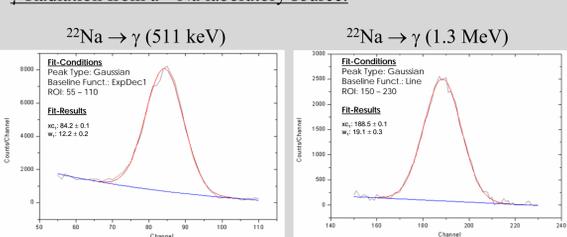
⁴⁰K → γ (1.46 MeV)



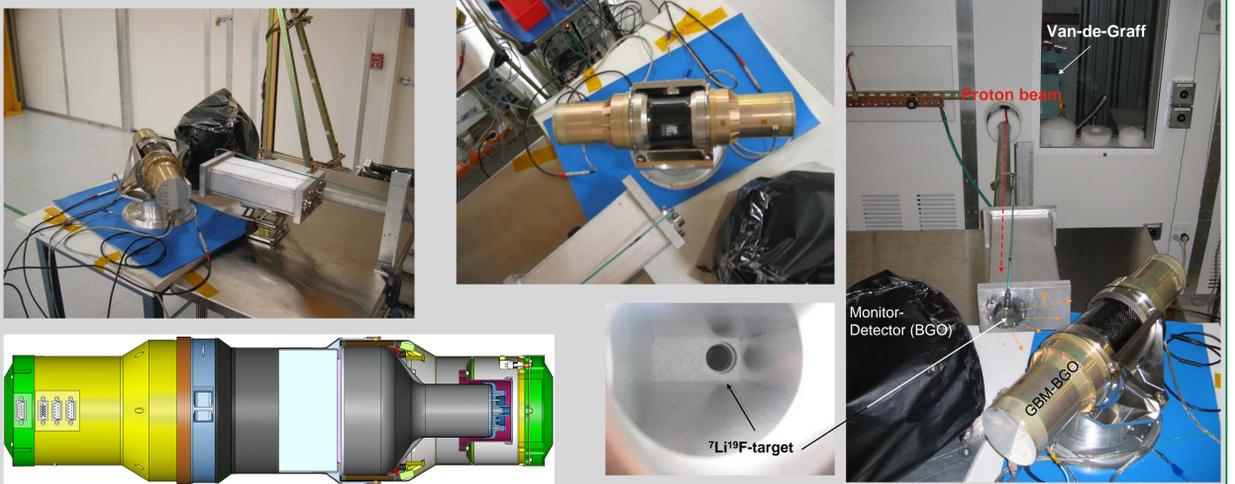
Fit-Conditions
Peak Type: Gaussian
Baseline Function: ExpDec1
ROI: 160 - 260

Fit-Results
x_c: 214.9 ± 0.1 w_g: 21.8 ± 0.1

γ-Radiation from a ²²Na laboratory source:

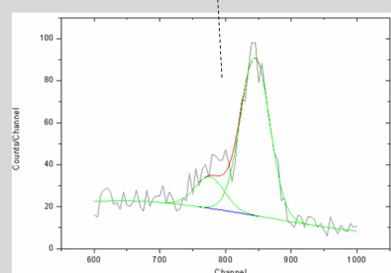
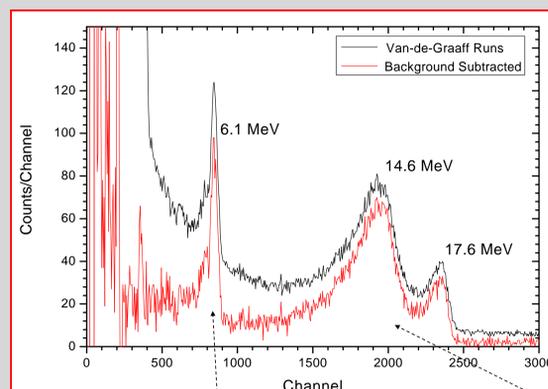
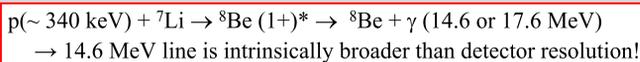


Setup at SLAC:



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:



Fit-Conditions
Peak Type: Gaussian (2 x)
Baseline Function: Cubic
ROI: 600 - 1000
Constraints on Area and Width:
A₁ = 0.20 * A₂ (from simulation)
w₁ = w₂

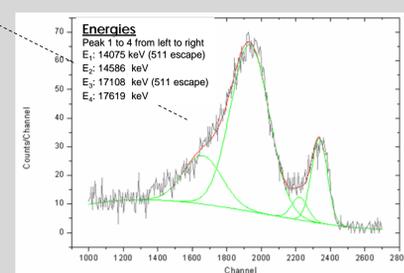
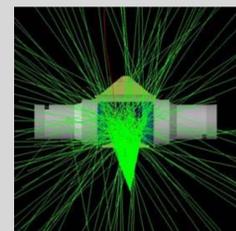
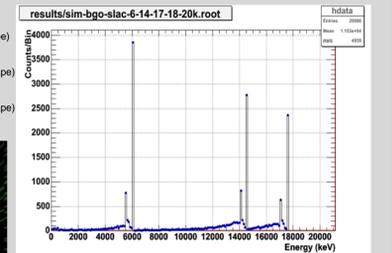
Fit-Results
(peak-center x_c and -width w_g)
x_{c1}: 776.1 ± 7.2 w_{g1}: 52.6 ± 16.4
x_{c2}: 845.0 ± 1.7 w_{g2}: 52.6 ± 3.6

Simulations:

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

Energies

E₁: 5619 keV (511 escape)
E₂: 6130 ± 60 keV
E₃: 14075 keV (511 escape)
E₄: 14586 keV
E₅: 17108 keV (511 escape)
E₆: 17619 keV

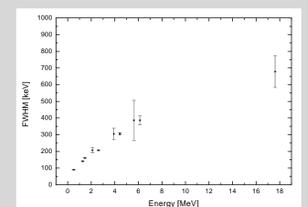
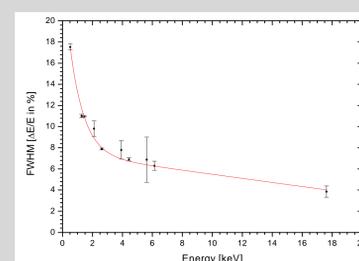
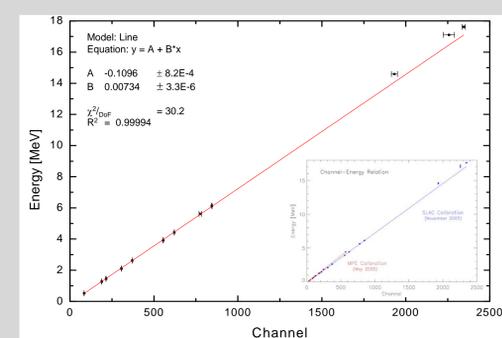


Fit-Conditions
Peak Type: Gaussian (4 x)
Baseline Function: Cubic
ROI: 1000 - 2700
Constraints on Area and Width:
A₁ = 0.29 * A₂ (from simulation)
A₃ = 0.27 * A₄ (from simulation)
w₁ = w₂
w₃ = w₄

Fit-Results
(peak-center x_c and -width w_g)
x_{c1}: 1659.7 ± 27.0 w_{g1}: 264.2 ± 42.3
x_{c2}: 1933.6 ± 8.1 w_{g2}: 264.2 ± 15.5
x_{c3}: 2222.4 ± 22.2 w_{g3}: 108.6 ± 44.3
x_{c4}: 2335.9 ± 6.8 w_{g4}: 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

χ²_{Dof} = 4.38042
R² = 0.98885

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