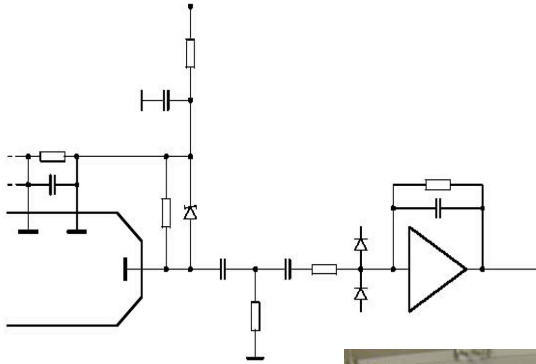
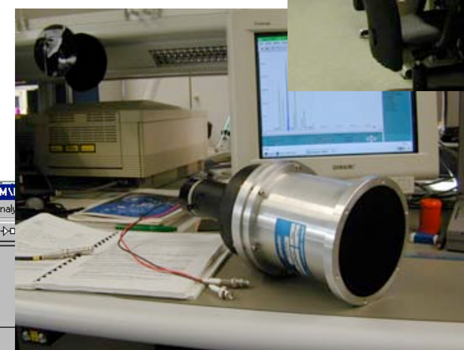
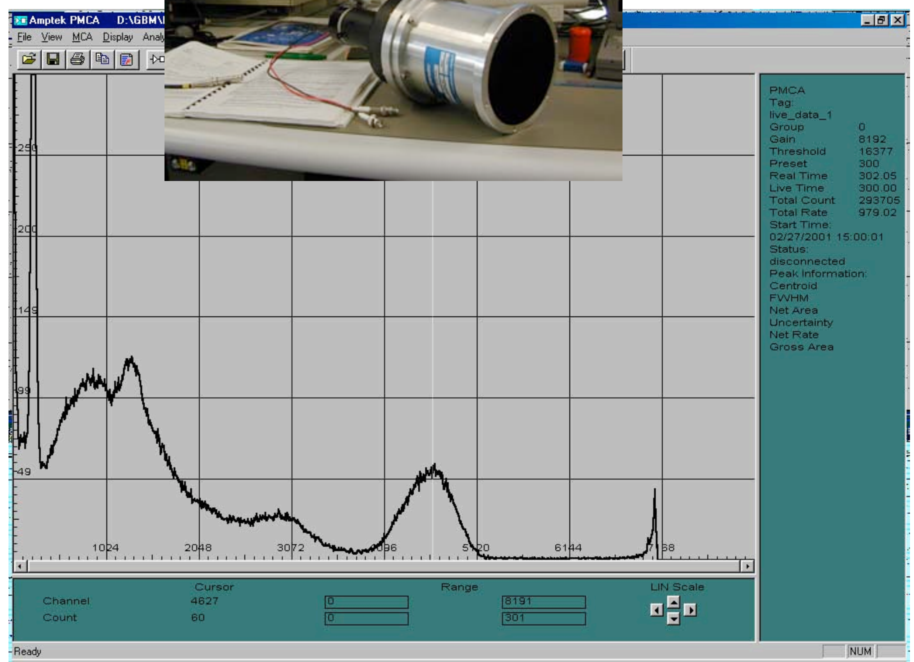
GLAST **B**urst **M**onitor







Calibration Overview – August 31, 2004

J. Fishman

Calibration Plan of the GBM

- GBM-MPE-PL-1-1, issue date: Dec 2003 >> GBM-PLAN-1016, Baselined at CDR
- By Jerry Fishman and Giselher Lichti
- Purpose
  - Outlines the plans for the calibration of the NaI and BGO detectors
  - Flight Det. Calib. Performed at three places: MPE, NSSTC and Spectrum Astro
  - Ancillary, Off-line Measurements at Low and High Energies
  - Generation of detector response matrices (DRMs) for NaIs and BGOs
  - Verification of detector-module requirements

Part I : Comprehensive Detector Calibrations at MPE :

>TP100 (NaI) , TP110 (BGO) & TP 120 (Mag. Suscept.)

Part II: Low Energy X-ray Calibrations with NaI Flight Spare Detector at the PUMA or BESSY X-ray Facility at MPE - TP 101 (NaI)

Part III,IV: Long/Short calibration (TP630/635) (– these are really verifications)

Part V: Aliveness test (TP105/115)

Part VI: Spacecraft Radioactive Source Survey (TP805)

Part VII: High-Energy Tests with the BGO Flight Spare Detector (TP111)

Detector-level Calibrations

- 1. Channel-Energy Relation & Energy Resolution at Different Energies (on-axis; covering the whole energy range)
- 2. - Angular Response – relative values of Efficiency vs. Energy (Used to compare to Monte Carlo Detector Response Matrices, DRMs)
- 3. - Angular Dependence of Energy-Channel Relationship and Energy Resolution (Performed at same time as #2, above)
- 4. - Rate-Dependence of #1 - over several rates, up to 10^5 cps
- 5. - Temperature Dependence of #1, in operating temperature range

Detector Magnetic Susceptibility

- GBM-PROC-TP120:
  - In three orthogonal axes, +/- 1.5 gauss
  - Uses radioactive source to measure gain (Na-22)
  - Detailed Procedure outlined in GBM-MPE-PL-11, A. von Kienlin, July 2004
    - Helmholtz coils in MFSA Ottobrunn facility, Germany
    - 26 orientations planned

Other Calibrations and Related Activities

- Some Calibrations will be verified in Huntsville, after detector delivery and also at the S/C Facility after integration on the spacecraft (These are termed Long and Short Calibrations)

- Scattering Measurements will be made at Spectrum Astro Post-integration to assess spacecraft scattering radiation into the detectors, see PLAN-1016. Source strengths ~5-10 mC . (Preliminary requirements have been given to Spectrum Astro)

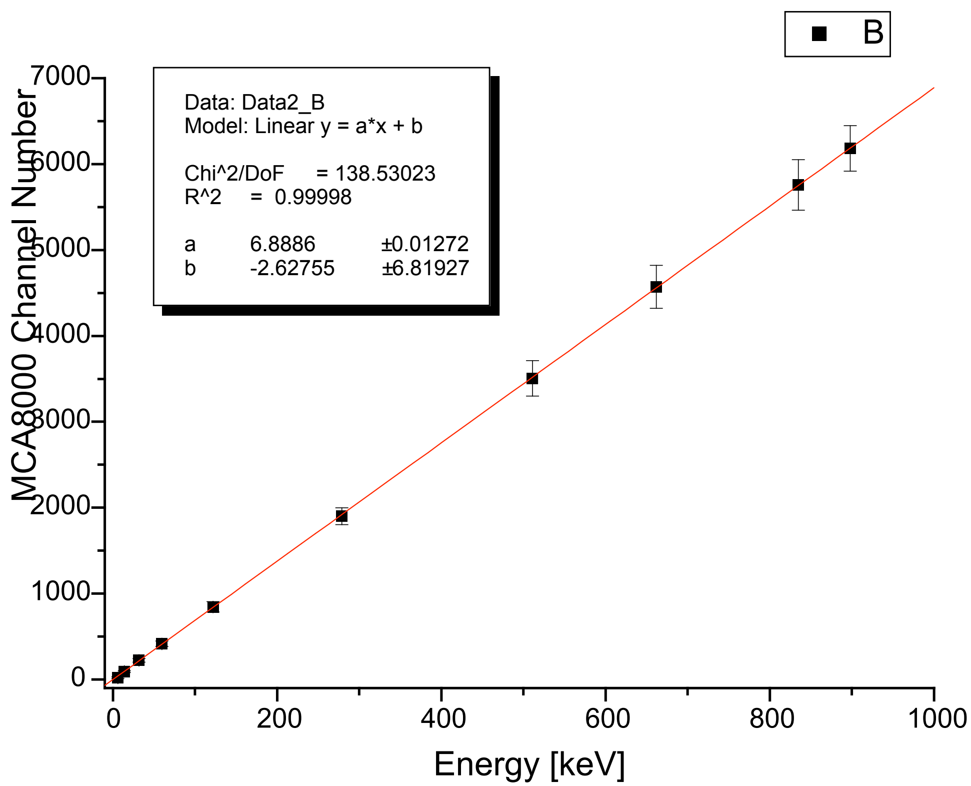
- The Low Energy Calibrations (~5-35 keV) have several options and are currently under discussion within the GBM team.

- Some Limited Calibrations at a High-Energy Particle Accelerator (Perhaps a science model only) – Duke University is the baselined facility

- It would be highly desirable to have a quick data run at Spectrum Astro using a portable van de Graff generator (ref. E. Bloom)

NaI/BB - Spectra

NaI Energy Calibration - Note linearity and low energy response



Low Energy Calibration Sources

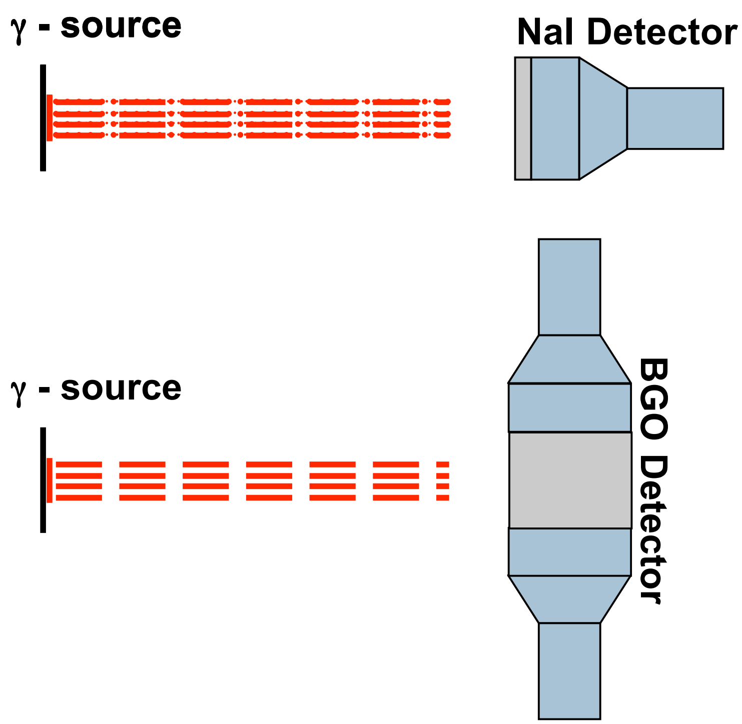
Isotope	Energy
Am-241	17, 60 keV
Cd 109	22, 88 keV
Ba-133	32, 81 keV
Bi-207	8, 12, 75 keV
Co-57	14 keV

Low Energy Calibration – Additional Tests

MPE is planning to perform a separate Low Energy Calibration on one or two non-flight NaI detectors (TP 101) at either PUMA facility at MPE or the BESSY facility in Berlin

These tests will be done mainly to explore subtle non-linearities at low energies and across the Iodine k-edge

Rate Dependence



- Measurement of rate dependence of
  - Channel-Energy Relation
  - Energy-Resolution
- as a function of counting rate

- 2 × NaI – detectors: (TP100-D)
  - ^{109}Cd, increasing count rate in steps up to 100 kcps
  - ^{22}Na, increasing count rate in steps up to 20 kcps
- 1 × BGO: (TP110 -D)
  - ^{137}Cs and ^{24}Na
  - Increasing count rate in steps up to 20 kcps

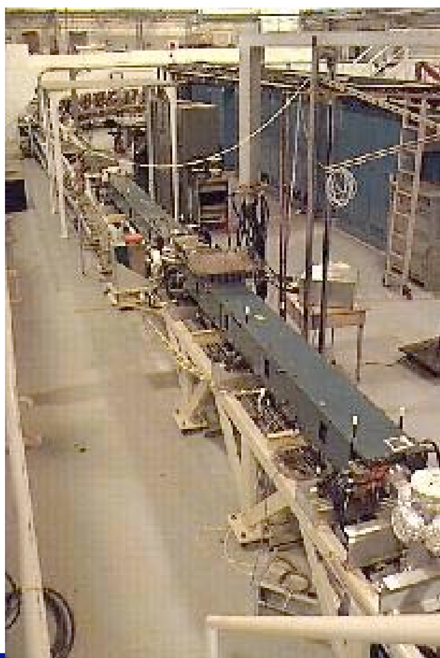
Low Energy Tests - The PUMA X-ray Test Facility

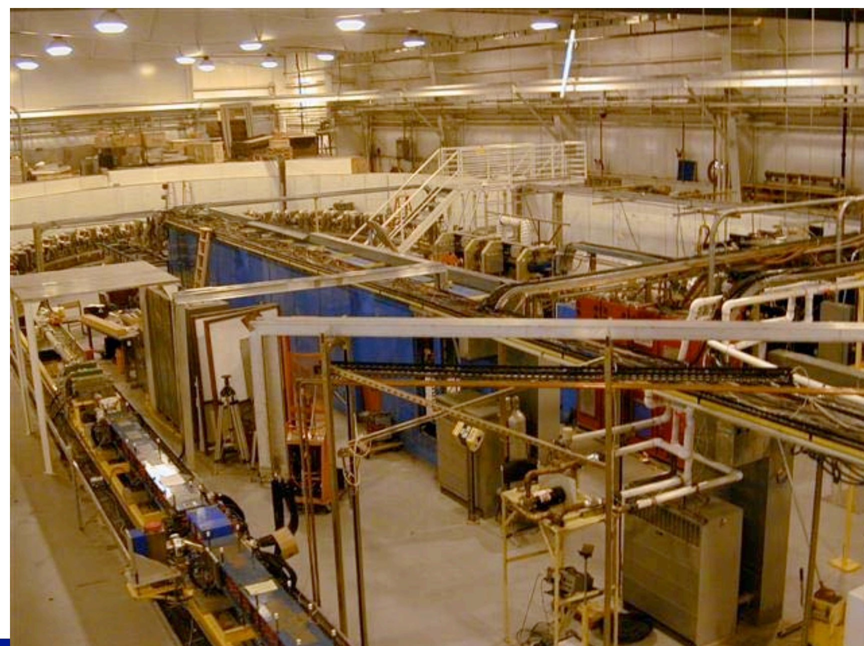
- GBM test with Puma (TP 101):
  - FM NaI detectors (number: TBD)
  - With flight-like thermal cover
  - Energy range: 3 – 17 keV
  - At different incidence angles

- Vacuum system
  - Length: 6 m
- Main instrument chamber
  - Length: 2 m
  - Diameter: 1.6 m
  - 10^{-7} mbar
  - Front door opens into class 10 clean room
- Multi-target X-ray source
  - produce a bunch of X-rays in the energy range 0.5 – 17 keV
  - energy spread: natural line width
  - Beam flux: ~10^4 photons/(cm_ s)
  - Collimators system inside vacuum tube
- Monitor counters
  - silicon drift chamber detectors
  - absolutely calibrated
  - Accuracy for spectral flux density < 2 %

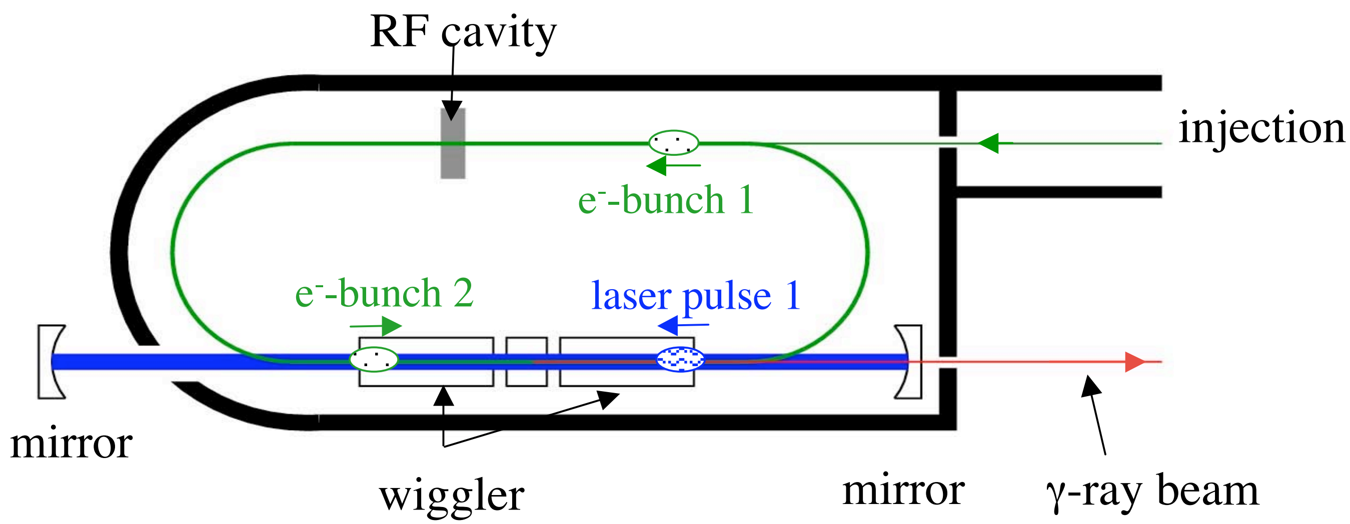
BGO - High energy tests

- The Duke University Free-Electron Laser Facility (DFELF) will be used for the GBM High Energy Gamma-Ray Calibration
  - at the high intensity gamma source location
  - utilized for tests of the MPE Mega Project
- calibrations will be performed at least six months prior to launch on the flight spare BGO detector
- test for non-linearity and saturation effects in the BGO crystal and PMT
- energy range: 2 - 35 MeV



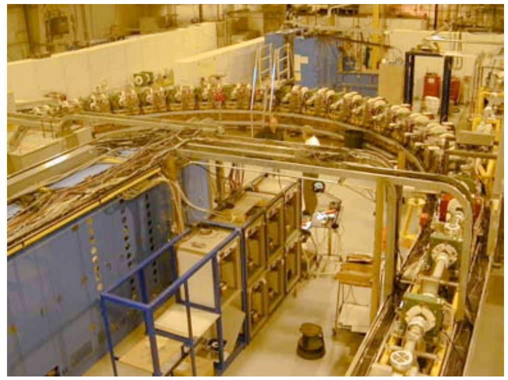


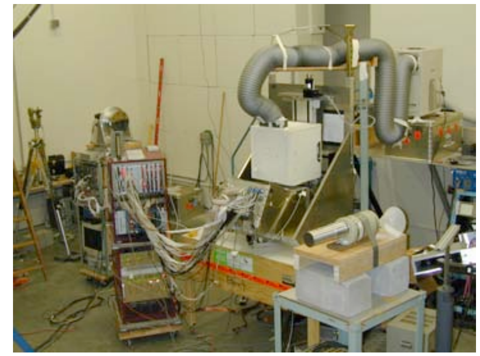
The High Energy Gamma-ray Source at the Free-Electron Laser Lab. (FELL) Duke University, Durham, NC



$$\gamma = \frac{E_e}{m_e c^2}; \quad E_{ph} = \frac{2\gamma^2 hc}{\lambda_w (1 + K_w^{\,2}/2)}; \quad K_w = \frac{eB_w \lambda_w}{2\pi m_e c}; \quad E_\gamma \cong \frac{4\gamma^2 E_{ph}}{1 + (\gamma\theta)^2 + 4\gamma \dfrac{E_{ph}}{m_e c^2}};$$

The High Intensity γ-ray Source (HIγS)

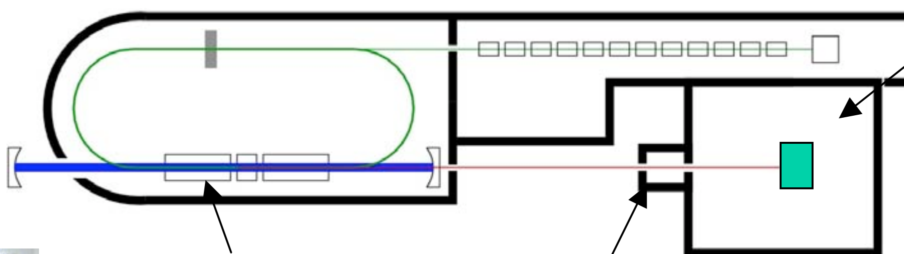




linac

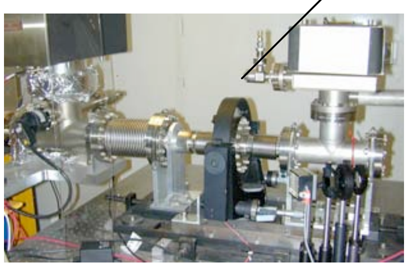
γ-ray vault

storage ring

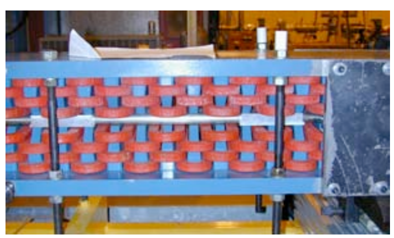


free electron laser

collimator hut



mirror



wiggler

Verifications, not really Calibrations, in Plan #1016

- Long Calibration (TP 635)
  - Purpose: Check gain and resolution of all detectors
  - before and after major tests, such as vibration, thermal-vacuum
  - before and after shipping of the detectors
  - will be performed at MPE, NSSTC and Spectrum Astro
- Short Calibration (TP 630)
  - TP 635 with a sub-set of selected detectors
  - Can be performed at various phases of the integration
- Aliveness Test (NaI: TP105, BGO: TP115)
  - natural background radiation will be used to ascertain that all detectors are functioning

Calibration Summary

Cal. Element & TP Nos.	Detectors/Type	Location of T./C.	Energy Range	Sources	Test Procedure Development	
					Lead	Others
I. Comprehensive Detector Calib. & Performance **TP100 (NaI)** **TP110 (BGO)** **TP 120 (Mag. Suscept.)**	All Detectors, including spares	MPE	6 keV-2.75 MeV	Radioactive Sources (complete set)	MPE	NSSTC
II. Low Energy X-ray Calibrations **TP101**	NaI Detectors Only	MPE (PUMA Facility at MPE)	3-40 keV	X-ray Tube & Filters; Monochrometer	MPE	NSSTC
III. Short Calibration (Short Performance Verification) **TP630**	As Needed	MPE, NSSTC, SpectrumAstro	32 keV – 1.3 MeV	Radioactive Sources (sub-set)	MPE	NSSTC
IV. Long Calibration (Long Performance Verification) **TP635** **TP610 (High Rate)**	All Flight Detectors	MPE & NSSTC, SpectrumAstro	6 keV-2.75 MeV	Radioactive Sources (complete set)	MPE	NSSTC
V. Aliveness Test **TP105 (NaI)** **TP115 (BGO)**	All Flight Detectors	MPE & NSSTC, SpectrumAstro	Background Radiation only	--	MPE	NSSTC
VI. Spacecraft Survey **TP805**	All Flight Detectors (on the spacecraft)	SpectrumAstro	32 keV – 1.3 MeV	Radioactive Sources (Cs-137, Co-60 ~5mC)	NSSTC	MPE, Spectrum Astro
VII. High-Energy Test	Non-Flight Detector-BGO only	Duke Univ. (DFEL	2.0-30 MeV	Free Electron Laser (Inverse Compton)	tbd	tbd-Dep. on

On-Orbit Gain Stabilization System

- Will use 511 keV Background line in an on-board software servo AGC system, similar to that used for BATSE
- Expected detector count rates and s/w parameters can be derived from BATSE Spectroscopy Detector data
- Improvements over BATSE on-orbit calibration:
  - Better energy resolution
  - Better background subtraction
- 50 min. integration vs. 5 min. for BATSE (Requirement: 2% gain stability over an orbit; various contributions to overall reqm't)