Status of GLAST CsI Calorimeter

A. Chekhtman

On behalf of GLAST collaboration

Main instrument of GLAST

Large Area Telescope

4x4 array of identical modules
Detector dimensions 1.75m x 1.75m x 1.0 m

Sensitive to photons with energies 20 MeV – 300 GeV

and polar angles upto 70 degrees

Tracker module

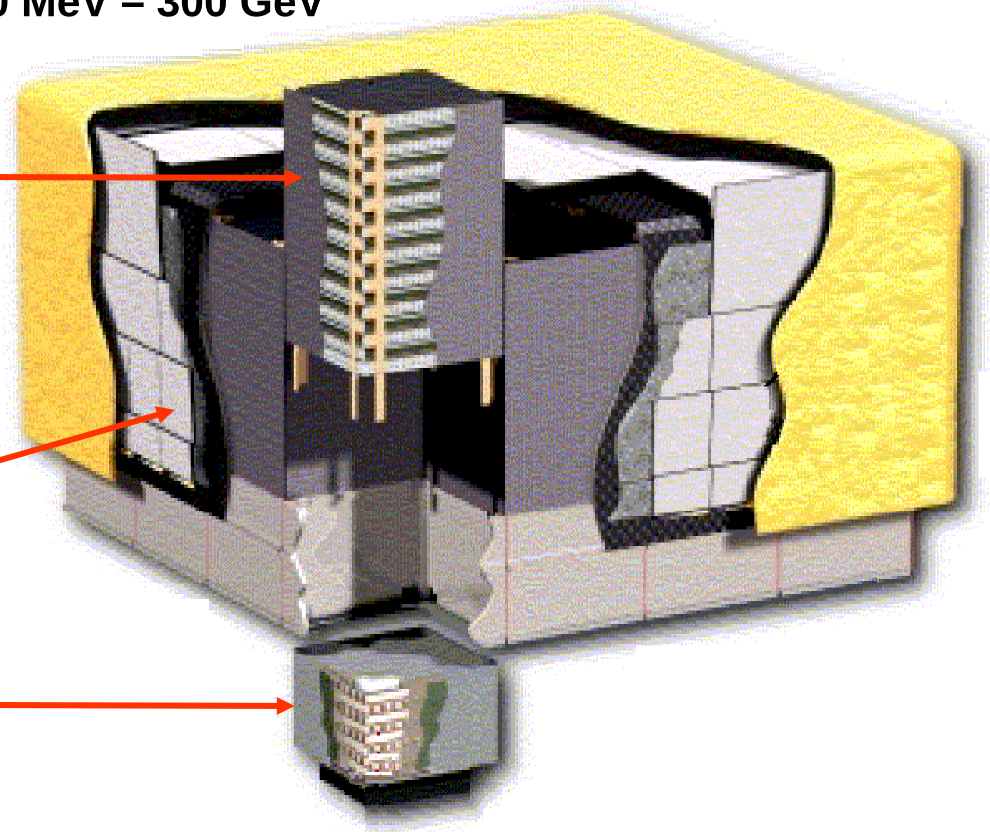
Si-strip detectors
tungsten radiators

Anticoincidence Detector

segmented plastic scintillator

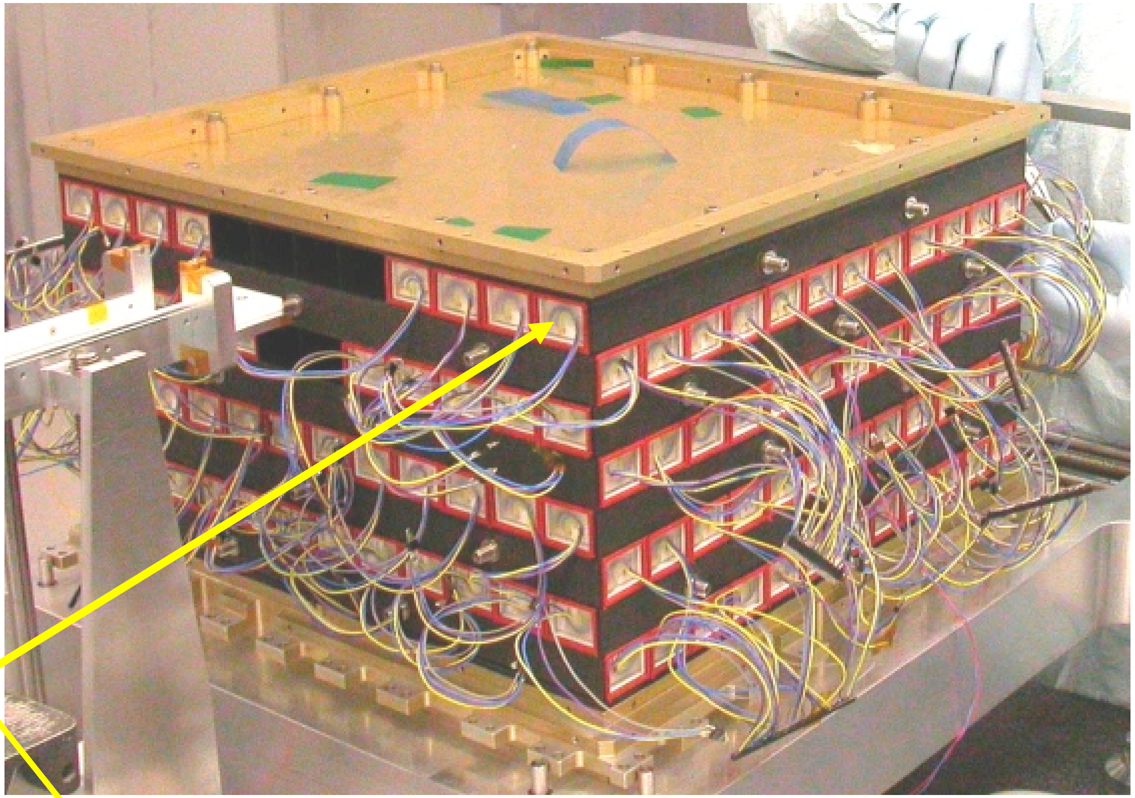
Calorimeter module

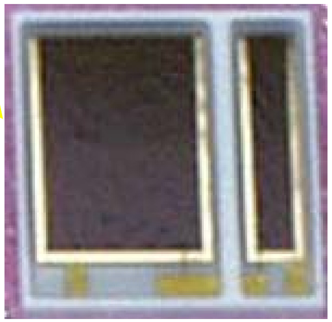
hodoscopic CsI crystal array



Calorimeter Module

- **8 layers of 12 CsI(Tl) Crystals**
  - **Crystal dimensions: 26.7 mm x 19.9 mm x 326 mm**
  - **Hodoscopic stacking - alternating orthogonal layers**
  - **Light tapering along the crystal (~0.65) for longitudinal position measurement**
  - **Total thickness 8.5 X_0**
- **Dual PIN photodiode on each end of crystals**
  - **Longitudinal position measurement by left/right asymmetry**
- **Electronics boards attached to each side of module**



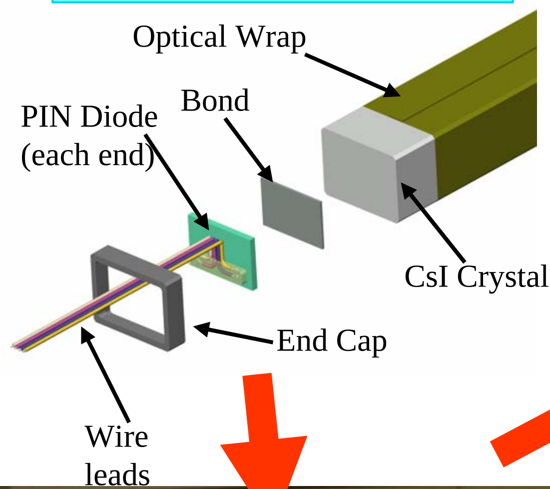


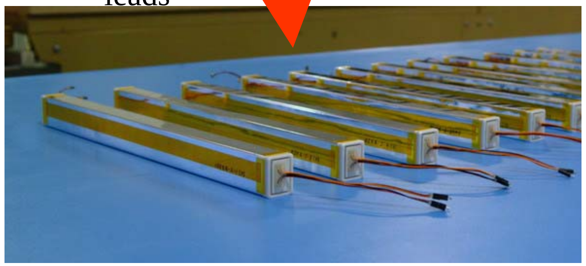
Calorimeter Assembly Flow

Dual PIN Diodes
4380

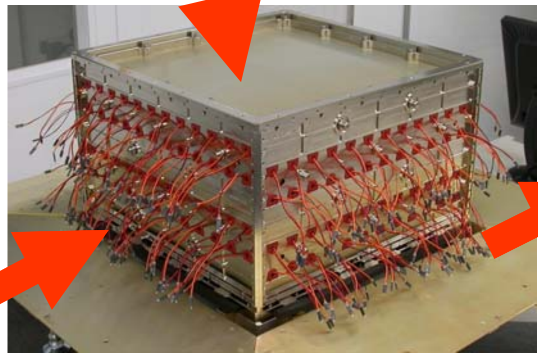
CsI Crystals
1830

Crystal Detector Element (CDE) Assembly
1830



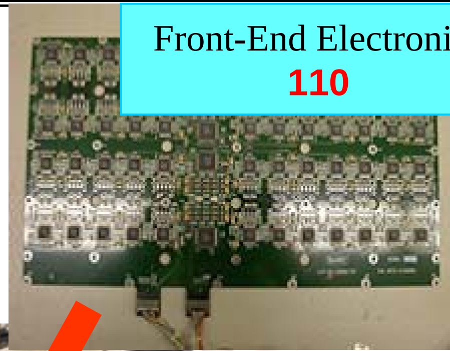


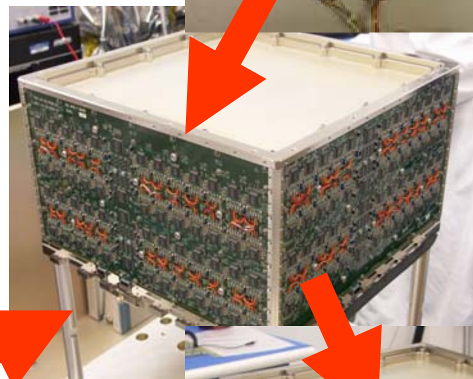
Mechanical Structure
19



PreElectronics Module (PEM)
19

Front-End Electronics
110





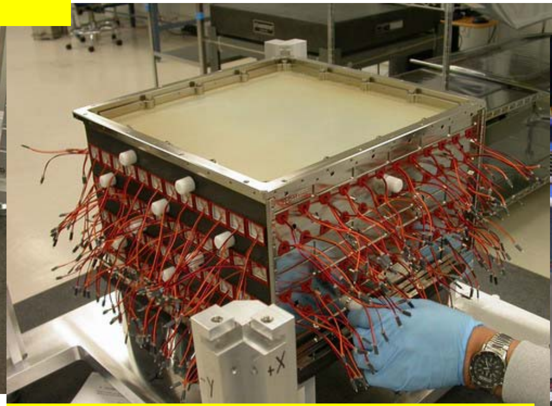
Module Assembly & Test
19

Calorimeter production responsibilities

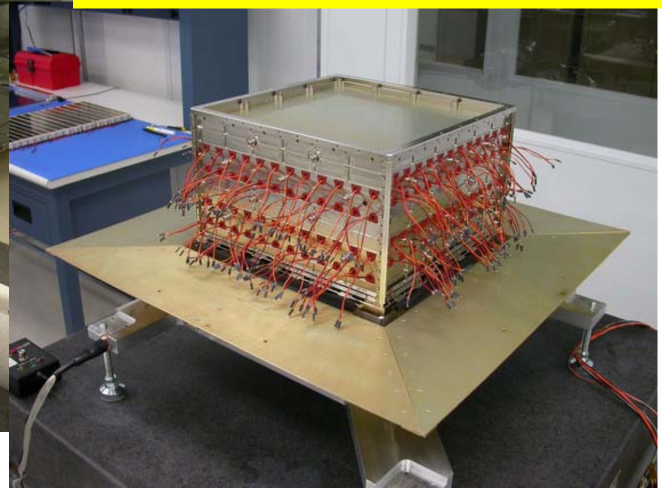
- CsI Crystals
  - Crystal production – AMCRYS, Kharkov, Ukraine
  - Production management & quality control – KTH + Kalmar University, Sweden
- Dual PIN photododes
  - Hamamatsu Photonics, Japan
- Crystal Detector Elements manufacturing
  - Swales Aerospace+Naval Research Lab
- Carbon composite structure
  - LLR Ecole Politechnique, France
- Analog Front End Electronics
  - NRL+SLAC
- Calorimeter module assembly and test
  - NRL

PreElectronics Module (PEM) Assembly
Naval Research Lab

CDE Insertion into structure

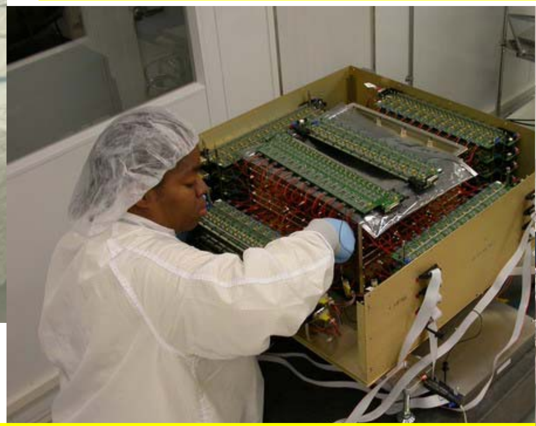


Closeout plates keep CDEs in place



Finished PEM awaiting test

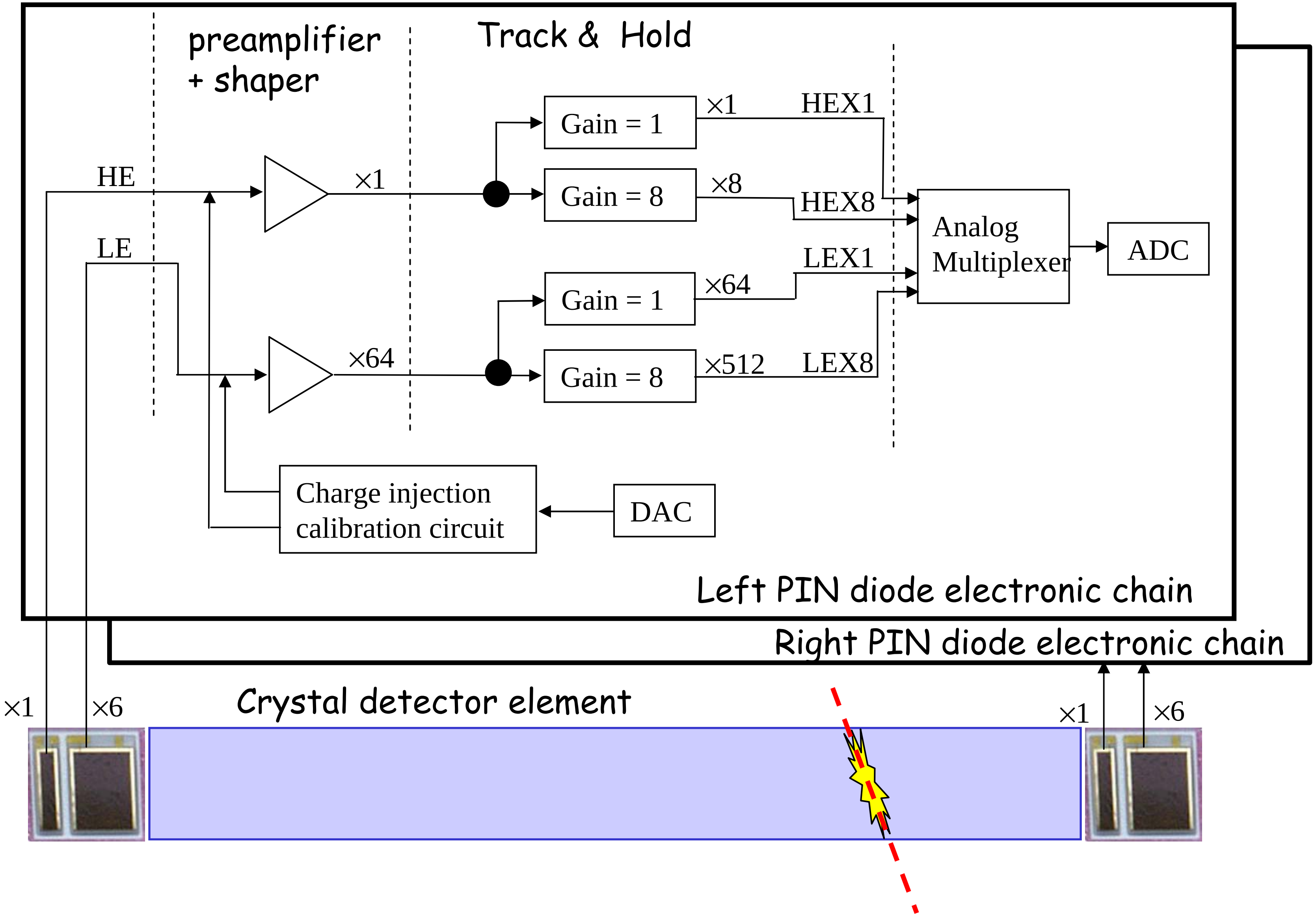
Even Eric can do it



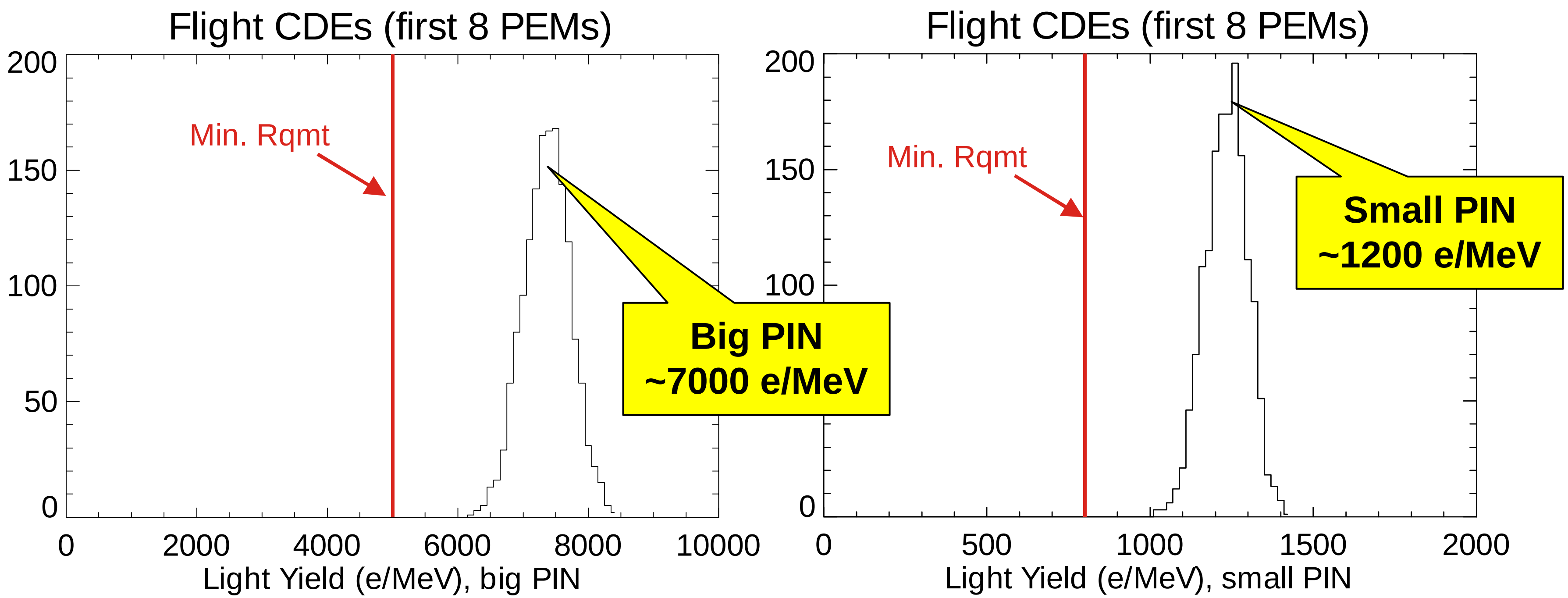
Connect test electronics for muon testing

7 PEM awaiting AFEE installation

Front-End Electronics of one crystal



PEM Checkout – Light Yield

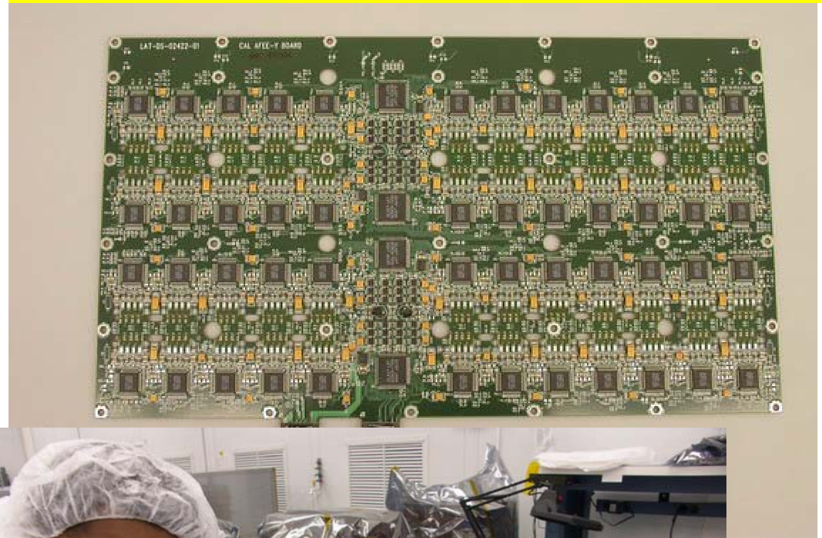


- **Using cosmic muons**
  - **Verify PIN diode bonds – end vs end, big vs small**
  - **Check light yield**
  - **Map light asymmetry**

CAL Front End Electronics
Naval Research Lab

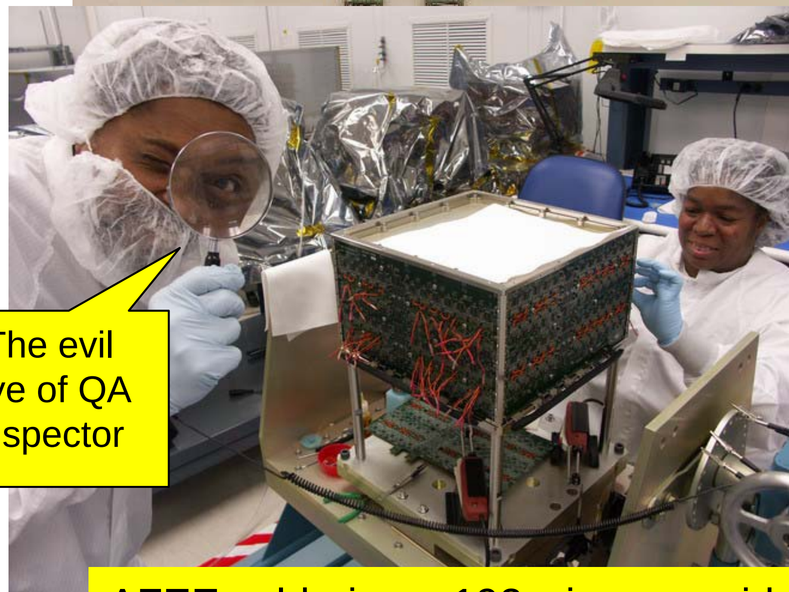
Over 12,000 ASICs packaged and tested

AFEE circuit board – 4 per CAL module



AFEE burn-in and T cycling – 8 at once

The evil eye of QA inspector



AFEE soldering – 192 wires per side

Environmental Testing

Setup for Vibration Testing

EMI/EMC Testing

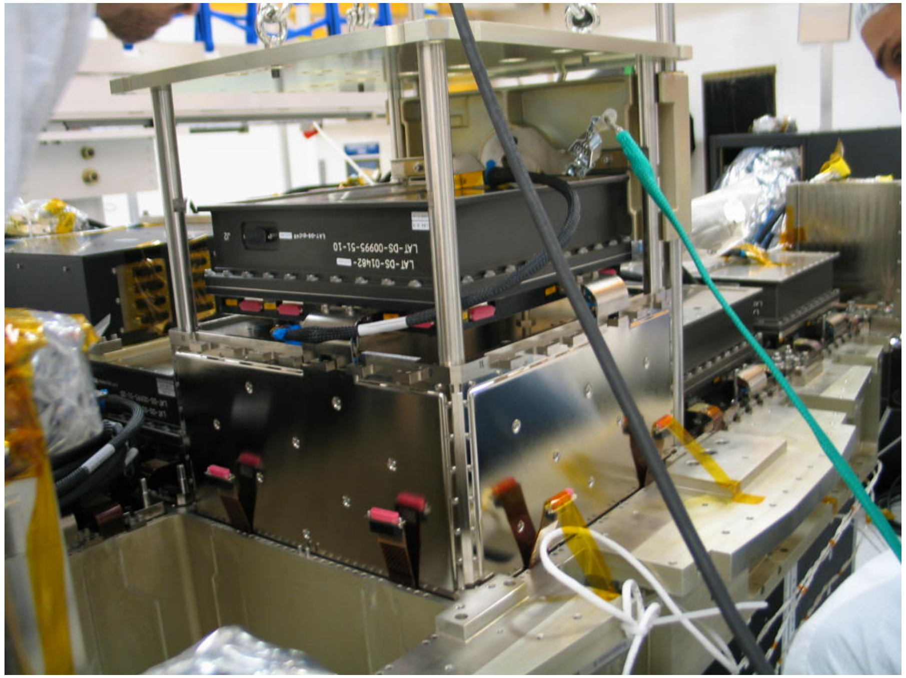
FM114 – 118 in TVAC chamber

“Big Blue” ThermalVac Chamber

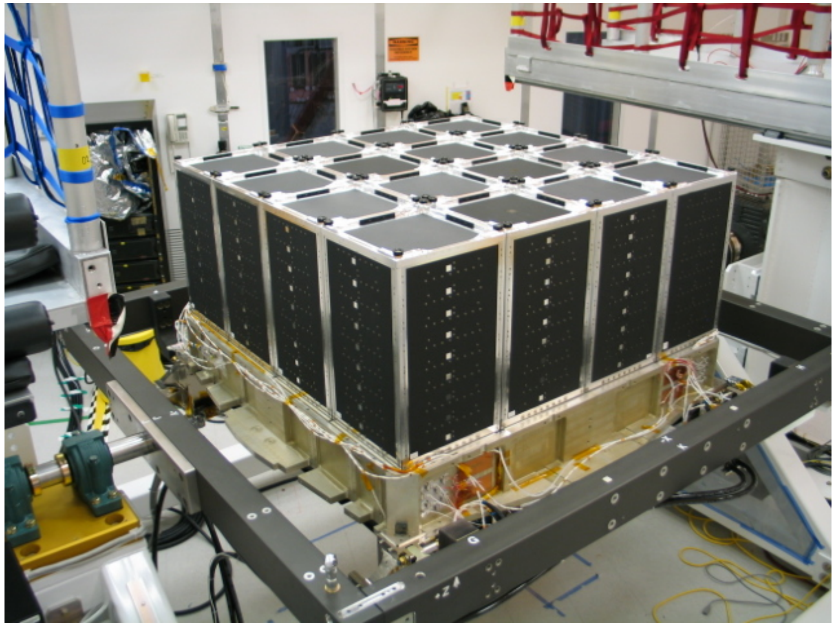
Further steps in LAT preparation for launch

- LAT Integration and tests (CAL+TKR+ACD+electronics)
  - SLAC, March, 2005 – May, 2006
- LAT environmental testing (vibration, thermo-vacuum, EMI, acoustic)
  - NRL, May-September, 2006
- In parallel – beam test of calibration unit (spare modules of calorimeter, tracker and ACD)
  - CERN, July-September, 2006
- Integration with spacecraft
  - Spectrum Astro, starting September, 2006
- Launch – September, 2007

LAT integration at SLAC



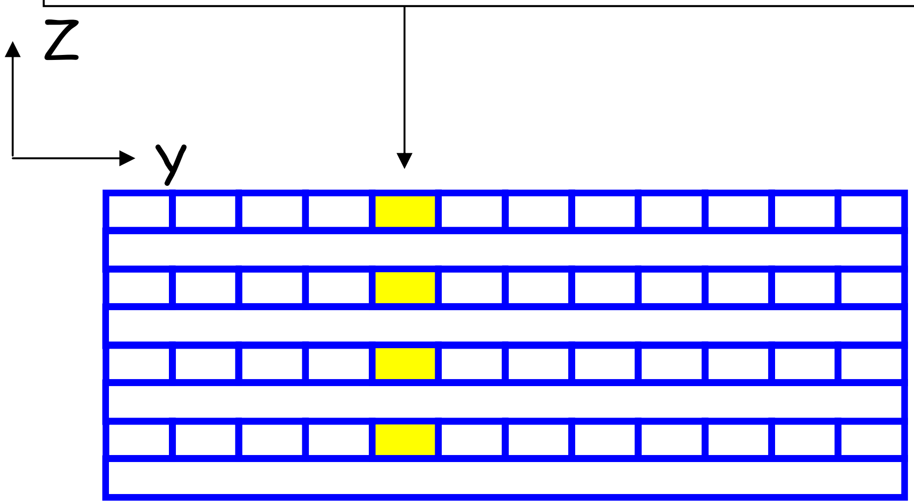
Insertion of a calorimeter module into the grid



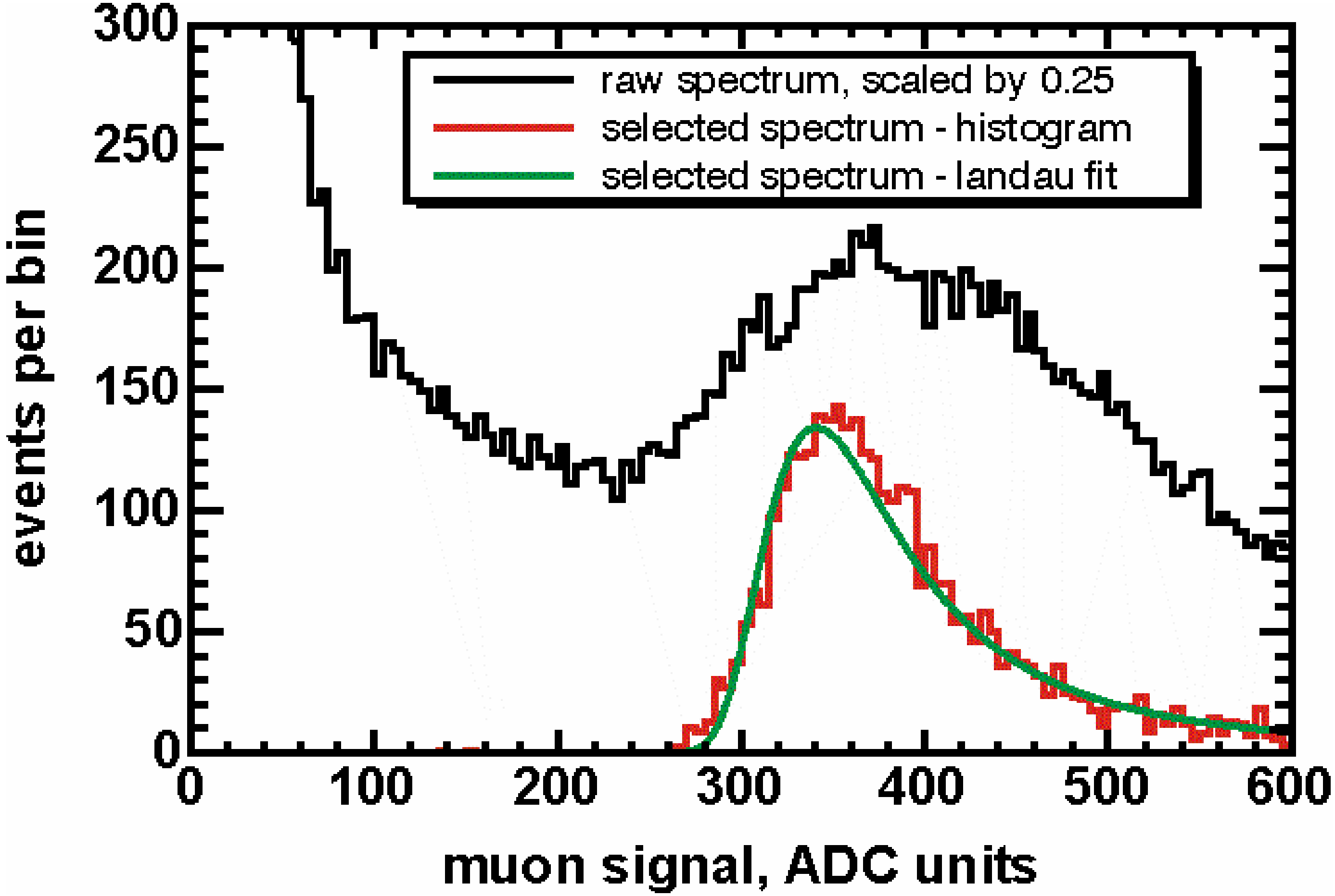
All 16 towers in place

Cosmic muon selection for energy scale calibration

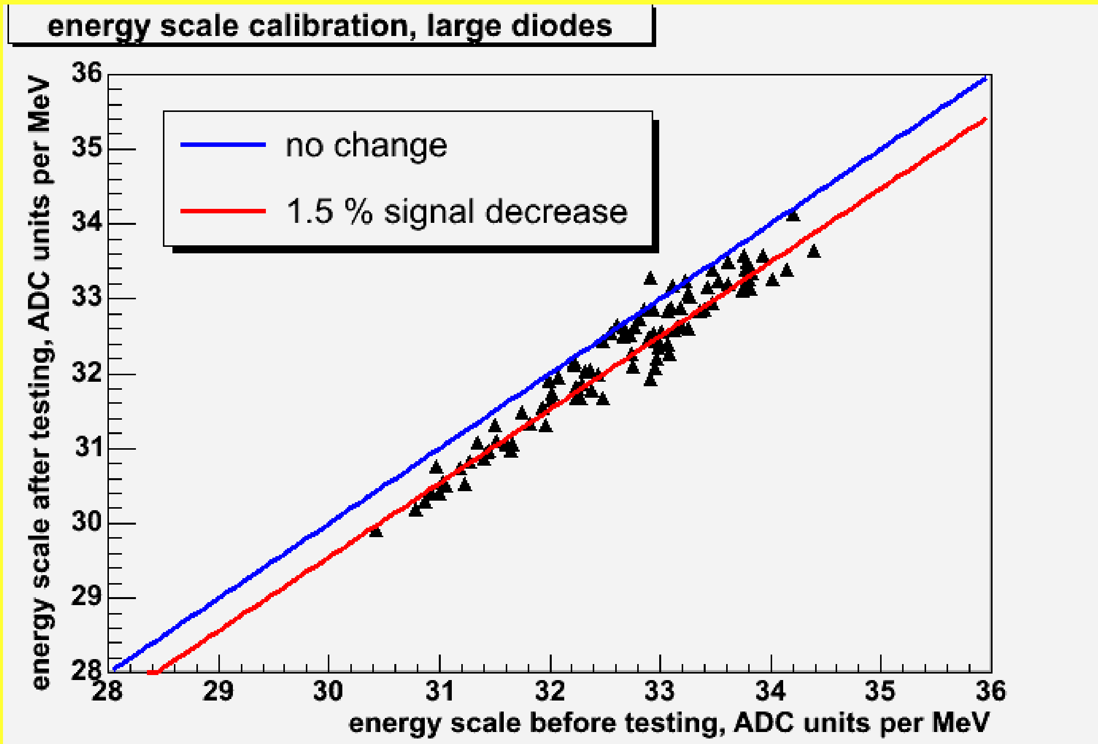
- Vertical muons selection :
  - 4 crystals in a column above the threshold (~ 0.2 MIP)
  - All other crystals below the threshold
- This selection significantly decreases the low energy tail from muons with partial pathlength (clipping a corner of a crystal).



Energy scale calibration with cosmic muons



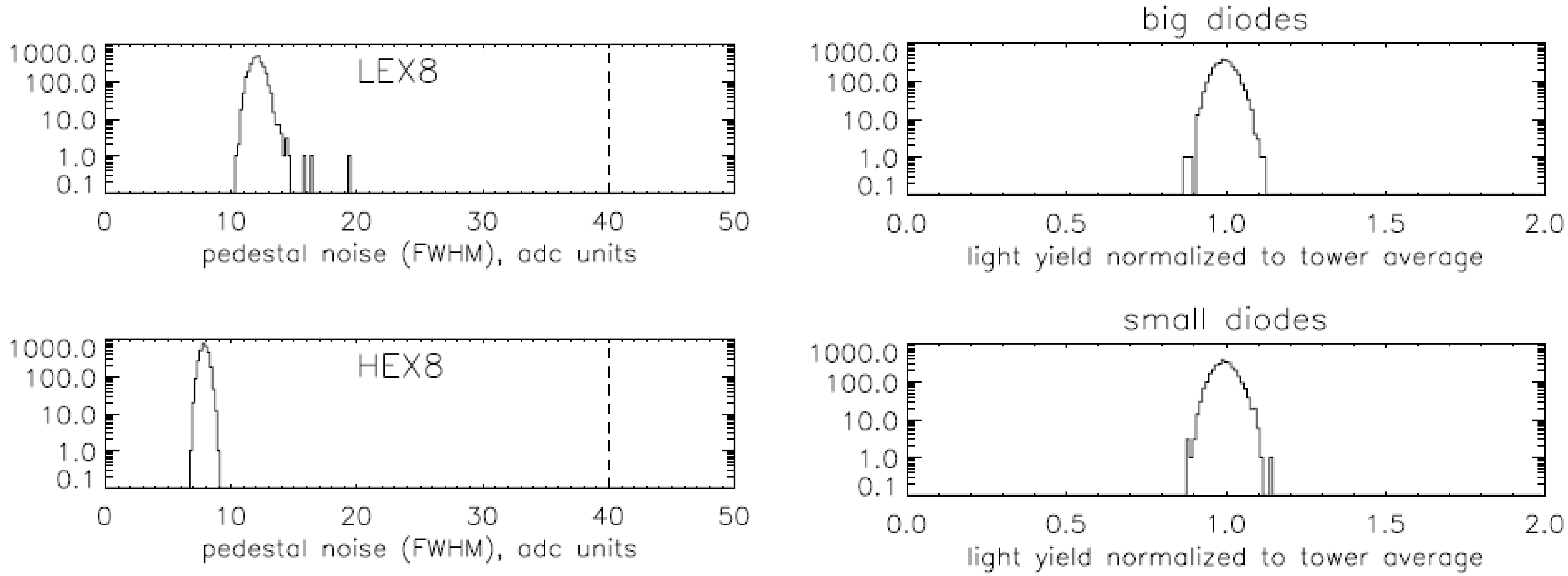
Energy scale stability during environmental testing of individual module



- X axis: energy scale calibration results for all 96 crystals of module FM112 immediately after assembly on Feb 1,2005
- Y axis: energy scale calibration on April 16, 2005 after
  – Burst and sine vibration test in all 3 directions at launch levels
  – 4 thermal cycles between -30C and +50C

- In ideal case, all 96 points should be on the blue line
- Spread along the line corresponds to ~10 % crystal to crystal non-uniformity within a module
- In reality there is some decrease of calorimeter response by 1-2 %. Possible reasons :
  – Small drift in electronics chain
  – Small degradation of optical properties of PIN diodes bonding to crystals
- The change is very small and will be taken into account by calibration

CAL Performance after LAT integration (all 1536 crystals)



- **Pedestal noise**
  - **10 adc units ~ 0.3 MeV for LEX8 range**
- **Diode light yield**
  - **No broken optical bonds**

Calorimeter calibration in flight

- To calibrate calorimeter response in 4 energy ranges we plan to use energy depositions of heavy ions from galactic cosmic rays
  - They are relativistic and produce well defined peaks
  - Highest peak (Fe) is at 11% of maximum energy of dynamic range
  - We should select heavy ions without nuclear interactions in the calorimeter (30-40% of all heavy ions)

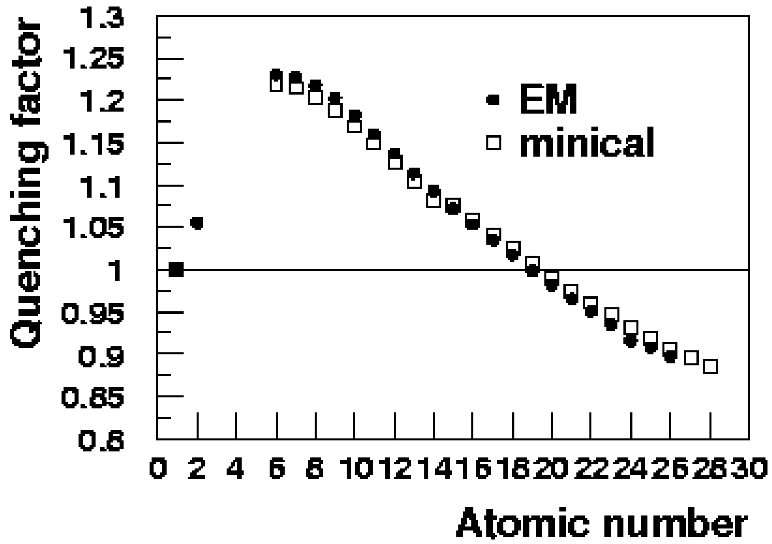
Range	5-σ Emin (MeV)	Emax (MeV)	MeV/ADC
LEX8	2	100	0.03
LEX1	2	1000	0.27
HEX8	60	8000	2.2
HEX1	60	70000	19

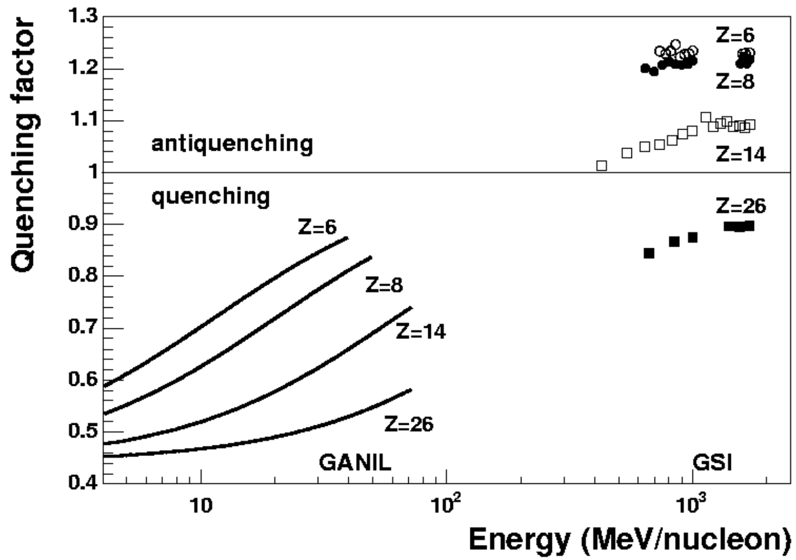
- Scintillation signals produced by heavy ions and photons are different
  - this difference ("quenching factor") for GLAST crystal detector elements was measured during beam test at GSI (Darmshtadt) in November, 2003
  - results of this measurement are submitted to NIM in December, 2005 (*B.Lott et al. Response of GLAST LAT calorimeter to relativistic heavy ions*)

Species (Z)	Abundance Relative to H	Enormal (MeV)
He (2)	14%	45
C (6)	0.38%	400
N (7)	0. 096%	550
O (8)	0.35%	720
Ne (10)	0.062%	1120
Mg (12)	0.073%	1610
Si (14)	0.054%	2200
Fe (26)	0.041%	7600

Quenching factors

Two plots from NIM GSI paper (*B.Lott et al. Response of GLAST LAT calorimeter to relativistic heavy ions*)



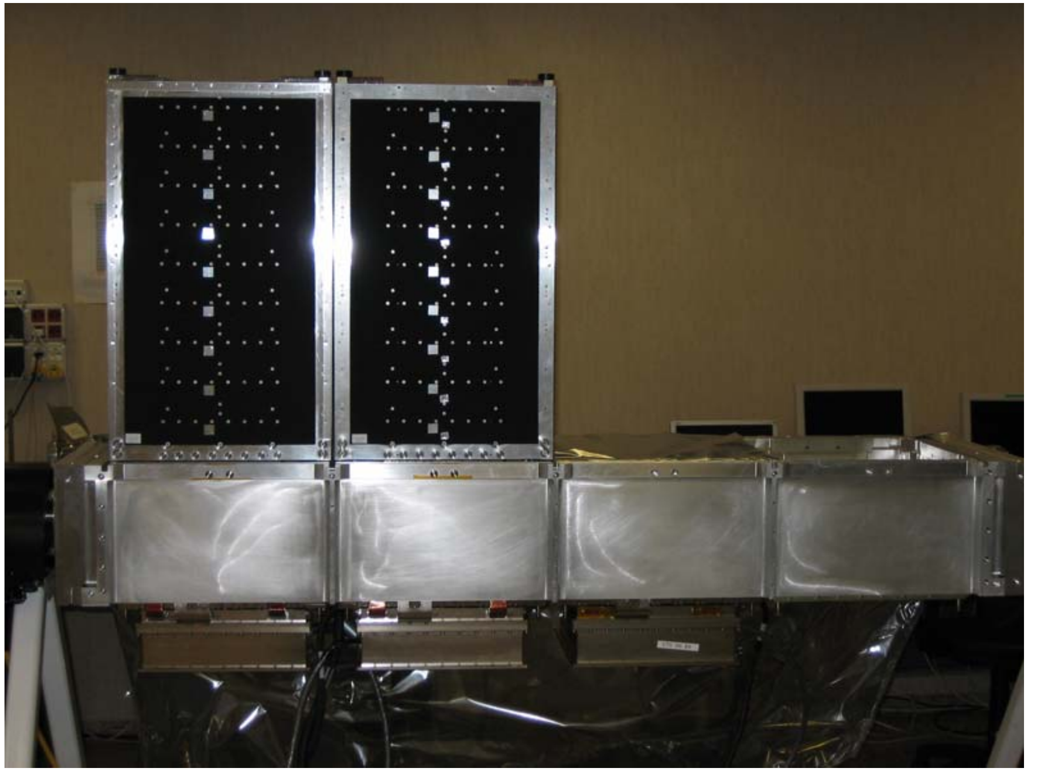


- **Quenching factor measured for E=1.7 GeV/nuclon**
  - **Unexpected result: scintillation signal for carbon is 20% bigger than for proton**
  - **Measurements with GLAST electronics (EM) and good lab electronics (minical) are consistent**

- **Measurements at GSI seem to be consistent with earlier measurements at low energies at GANIL**

The GLAST-LAT Calibration Unit

- Calibration unit is made of spare modules (3 calorimeter modules, 2 tracker modules, few ACD tiles)
- The beam test is scheduled at CERN for July-September, 2006



CU integration completed may 19 – currently under test in Pisa

Summary

- 16 flight and 3 spare calorimeter modules have been produced.
- Environmental testing and calibration of individual modules done successfully
- LAT instrument succesfully assembled at SLAC
- Environmental testing of full LAT is under way at NRL
- Beam test of calibration unit at CERN is scheduled for this year.