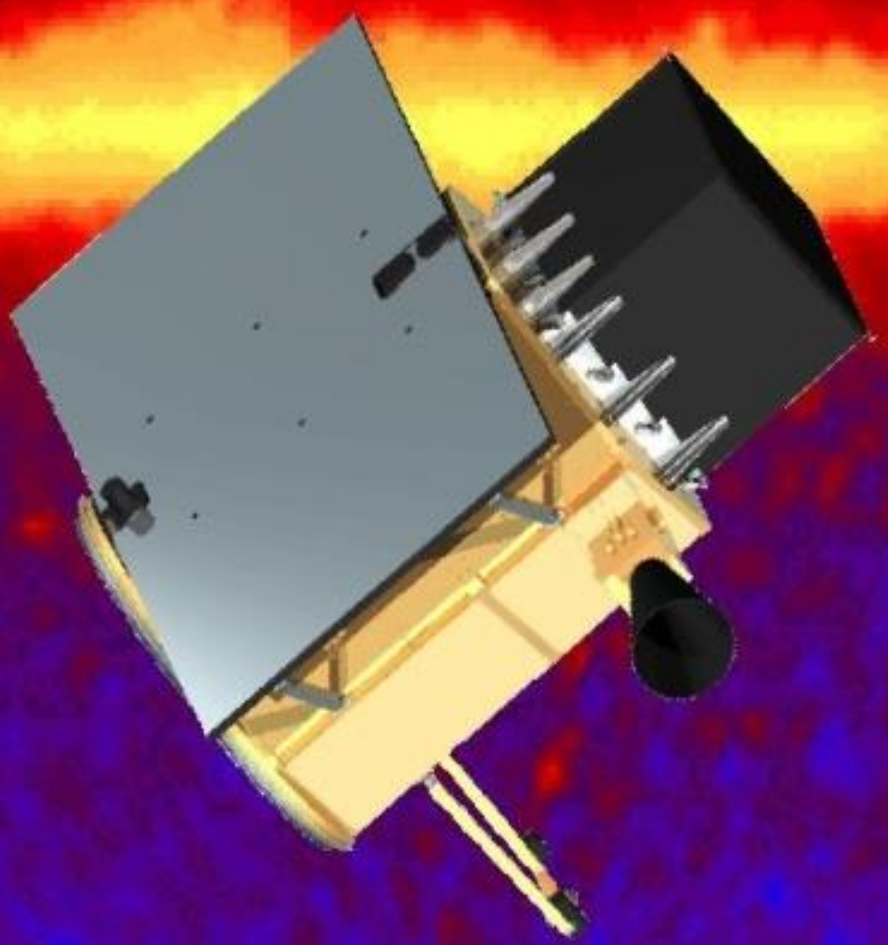
The Mini-Calorimeter detector for the AGILE mission



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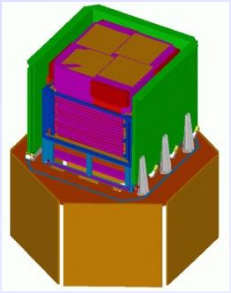
[a]IASF/CNR Sezione di Bologna, Italy
[b]IASF/CNR Sezione di Milano, Italy
[c]ENEA Bologna, Italy
[d]IASF/CNR Sezione di Roma, Italy

AGILE

Astrorivelatore Gamma ad Immagini LEggero
(Light Gamma-ray Imager for Astrophysics)



The AGILE Mission combines, for the first time in high-energy astrophysics a wide field-of-view instrument sensitive in the 30 MeV - 50 GeV band, with a 10-40 keV X-ray monitor.

It will explore a wide variety of celestial phenomena including active galactic nuclei (AGNs), gamma-ray bursts (GRBs), diffuse emission, pulsars, and other Galactic sources.

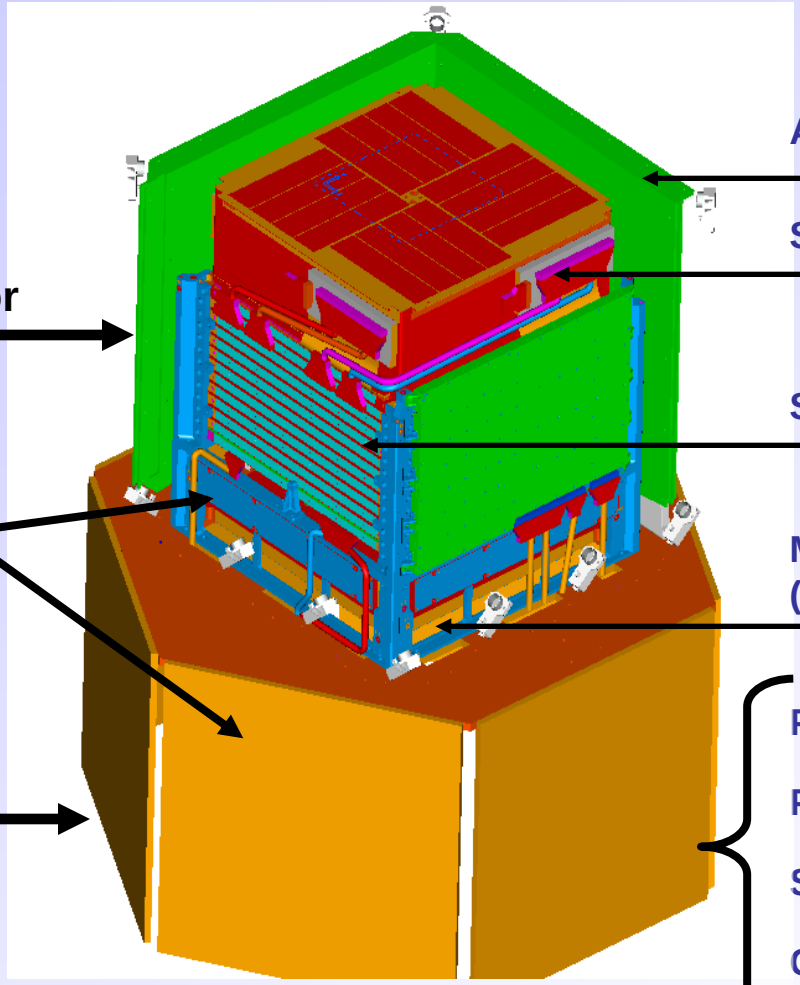
Mass:	**190 kg (120 kg payload)**
Power	**135 W (46 W payload)**
Launch:	**Autumn 2005**
Orbit:	**Equatorial at ~ 560 km**
Mission lifetime:	**3 years minimun**

AGILE is a small mission of the Italian Space Agency (ASI), the involved institute are:

IASF-CNR INAF, Milano
IASF-CNR INAF, Roma
Univ. Roma 1 and INFN
Univ. di Trieste and INFN
IASF-CNR INAF, Bologna
ENEA Roma
CIFS
Univ. Roma 2 and INFN
ENEA Bologna

Homepage: http://agile.mi.iasf.cnr.it/

AGILE Integrated Payload



Courtesy of AST

Anticoincidence

Super Agile (10 – 40 keV)

P/L Detector

Silicon Tracker

System Harness & Heaters

Minicalorimeter (.3 – 200 MeV)

GRID (30 MeV – 50 GeV)

P/L Shell

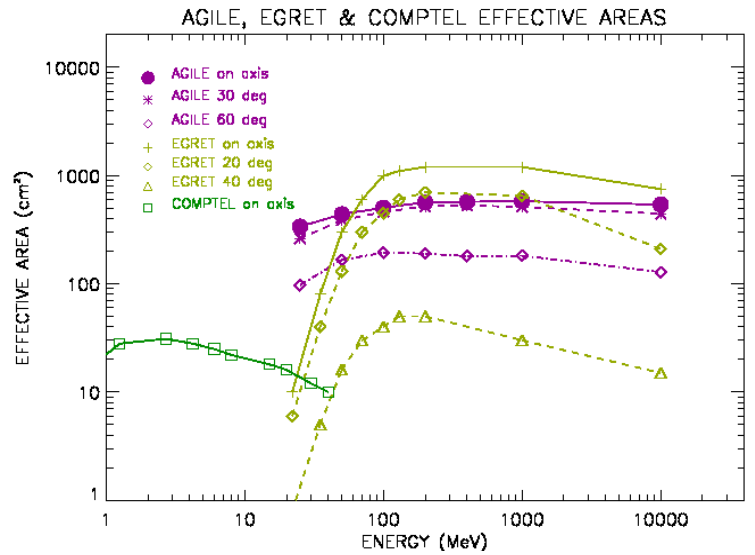
P/L Data Handling Unit

P/L Power Supply Unit

Star Sensors Units

GPS Units

Instrument Performance



AGILE-GRID

En. range ~ 30 MeV- 50 GeV

Aeff (400 MeV, 0º) ~570 cm2

FOV ~ 3 sr

PSF (400 MeV, 0º) ~1.22º

Source Loc. Acc. ~ 5' - 20'

ΔE/E ~ 1

Deadtime < 200 μsec

Super--AGILE

En. range ~ 10- 40 keV

Aeff (13.1 keV, 0º) ~ 80 cm2

FOV ~ 0.8 sr

PSF (pixel size) ~ 6'

Source Loc. Acc. ~ 1' - 3'

ΔE < 4 keV

Deadtime ~ 5 μsec

Minicalorimeter

En. range ~ 0.3- 200 MeV

ΔE ~ 1 MeV

Aeff (1- 10 MeV, 0º) ~500 cm2

Deadtime ~ 5 μsec

MCAL on AGILE

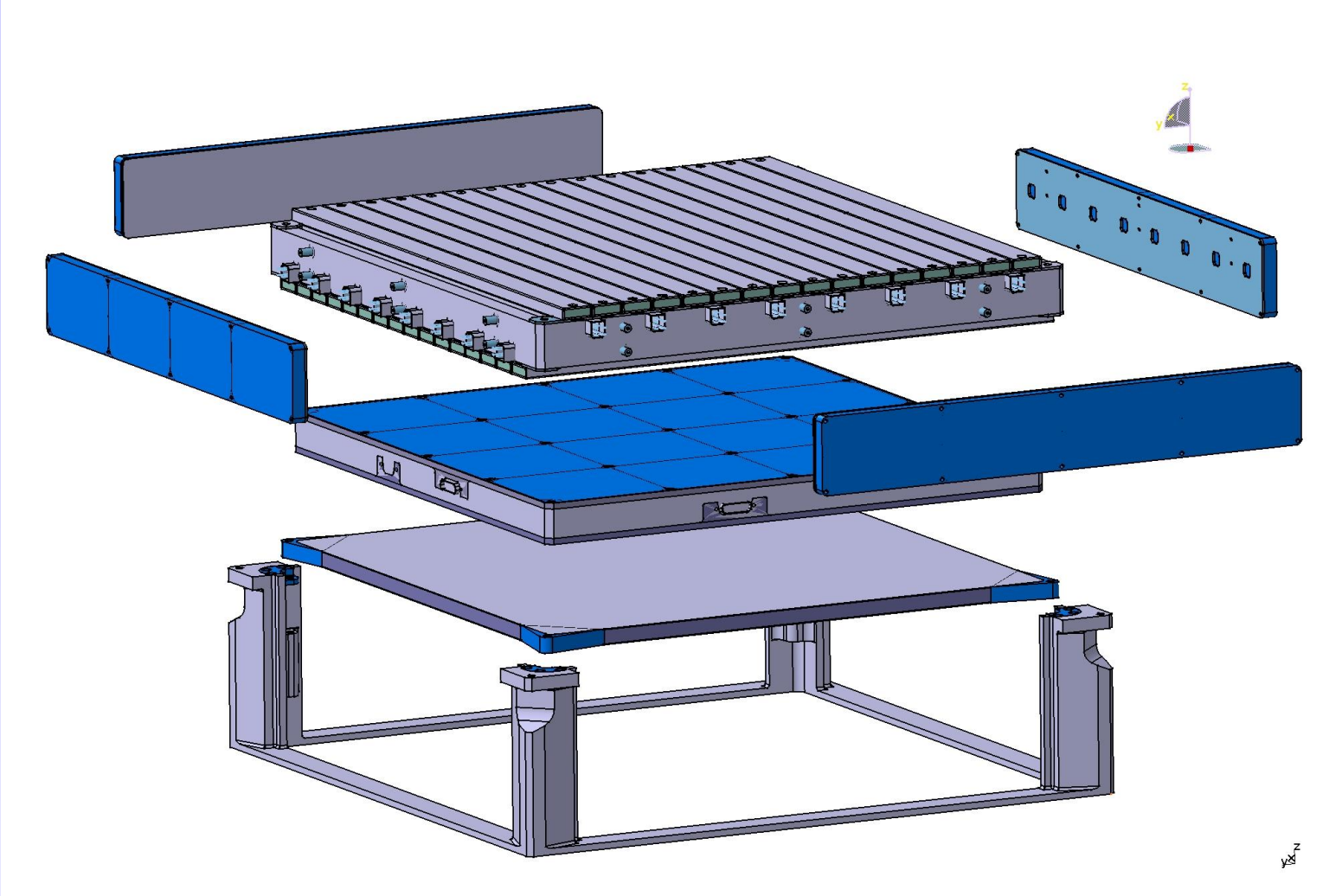
TASK

- **In the GRID operation mode, supply energy and position informations on the particles detected by the Tracker.**
- **In the BURST operation mode supply time and energy informations of impulsive gamma events.**
- **Continuolsly supply the background behaviour via ratemeters in variuos energy ranges**

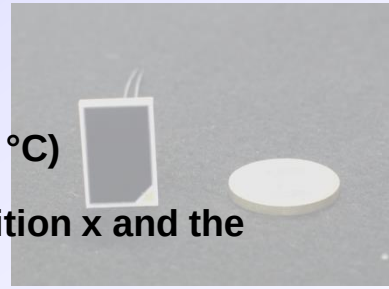
ARCHITECTURE

- **MCAL is made of 30 CsI(Tl) scintillator bars.**
- **The bars are arranged in two layer of 15 elements orthogonal to each other**
- **Each bar is optically coupled to 2 Photodiodes (PD).**
- **The signals of each bar are feed to the GRID and BURST chain where they are analysed at the same time**

MCAL assembly



MCAL Bar detectors

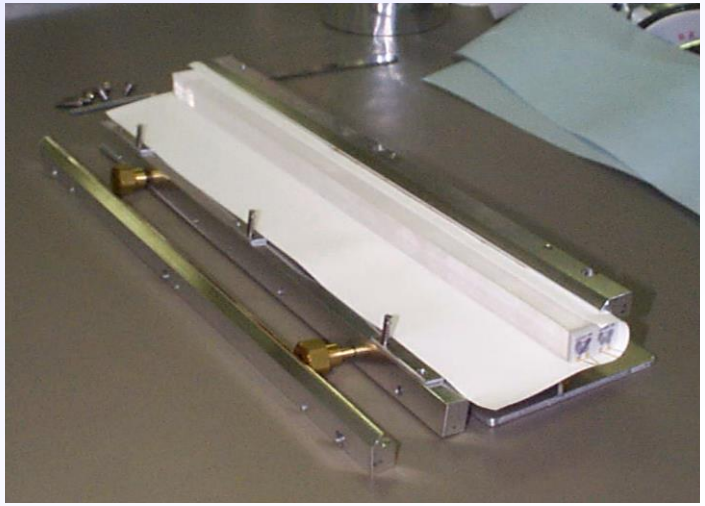


- CsI(Tl) scintillator 375 × 23 × 15 mm
- 2 custom PIN PD for each bar (Si active area 256 mm^2, 130 pF, I_l 1.5 nA @ 20 °C)
- The scintillation light collected by one PD depends from the interaction position x and the energy deposited E

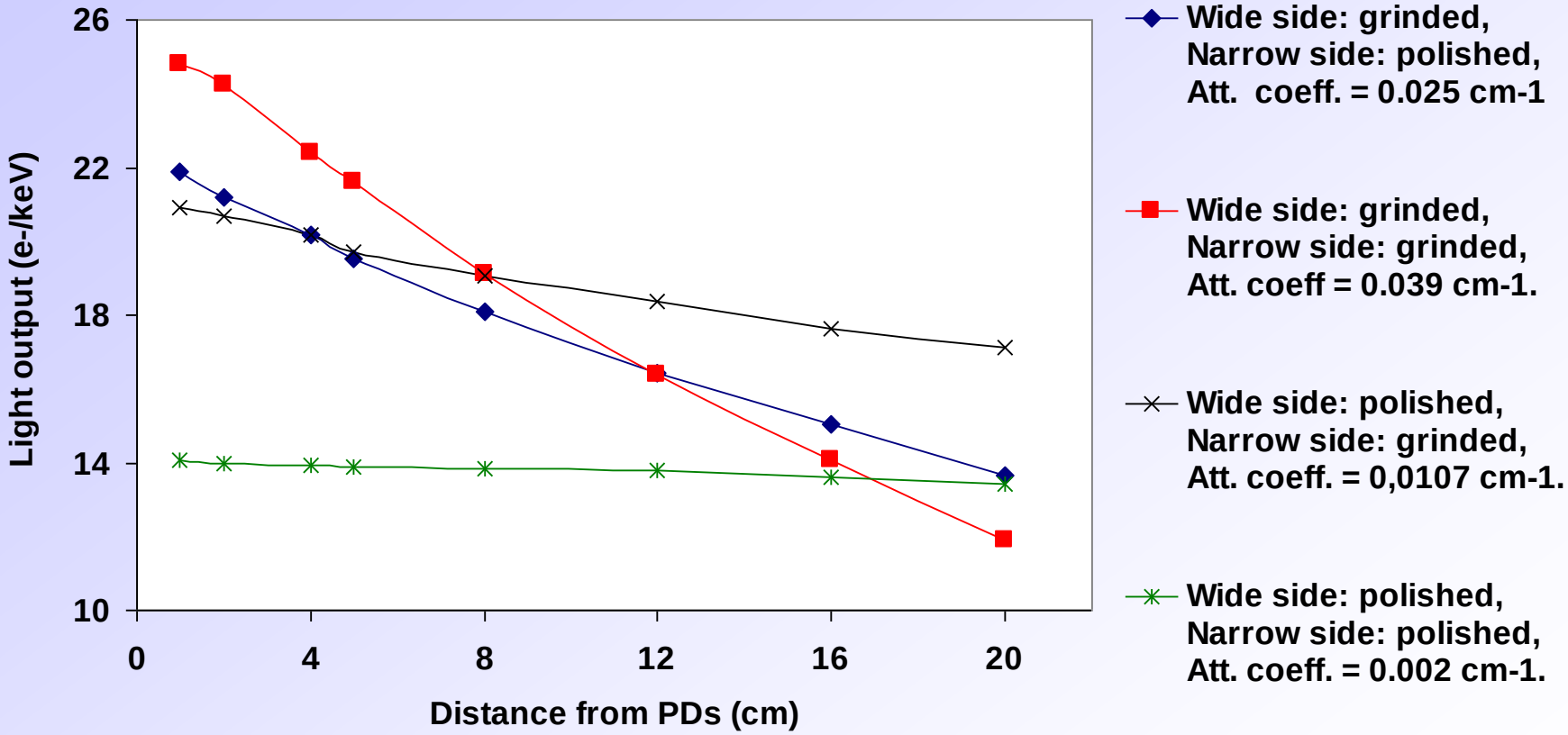
  $I \propto E*\exp(-\alpha x)$

  α in the range 0.002÷0.045 cm^{-1} depending from surface treatment and wrapping
- Weighting the signals A end B from the two PD of one bar the energy and position can be evaluated

  $x \propto \ln(A/B)$ $E \propto \sqrt{A*B}$

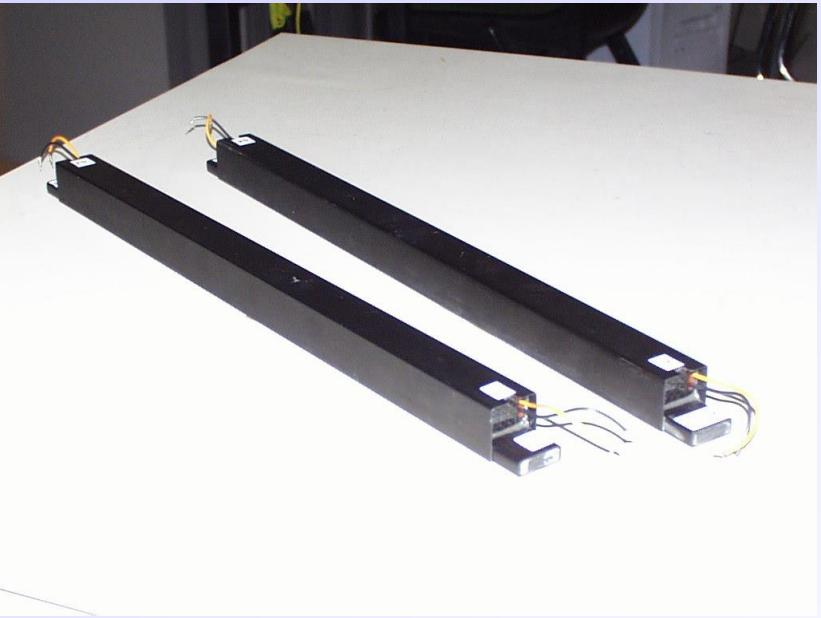


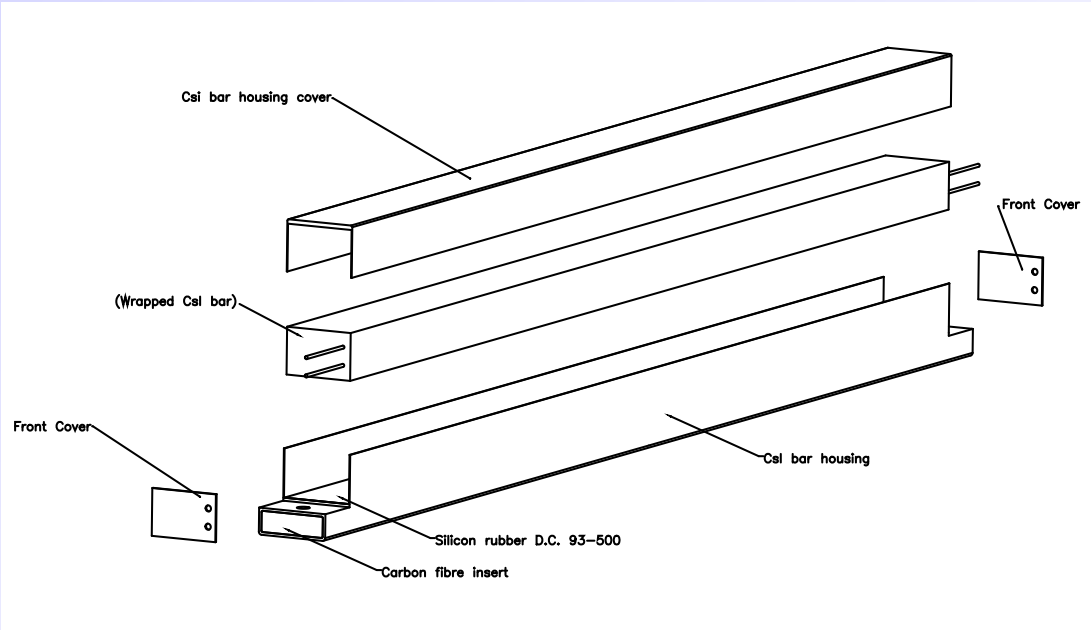
Bar surface treatment



Flight bar design

The bars with PD glued, wrapping etc. are hoisted in a carbon fibre structure to give modularity and strenght.

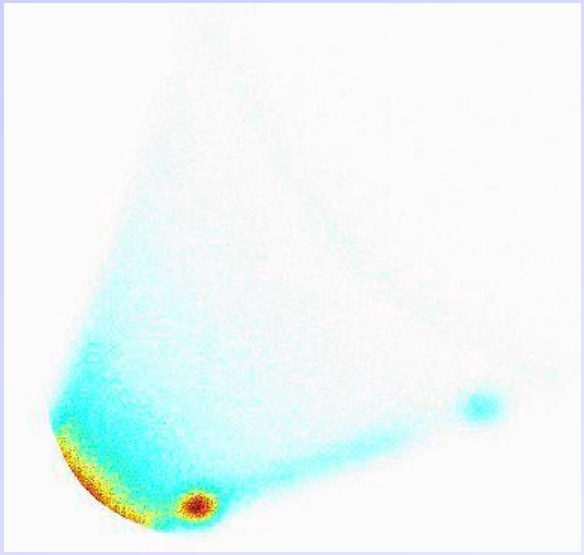




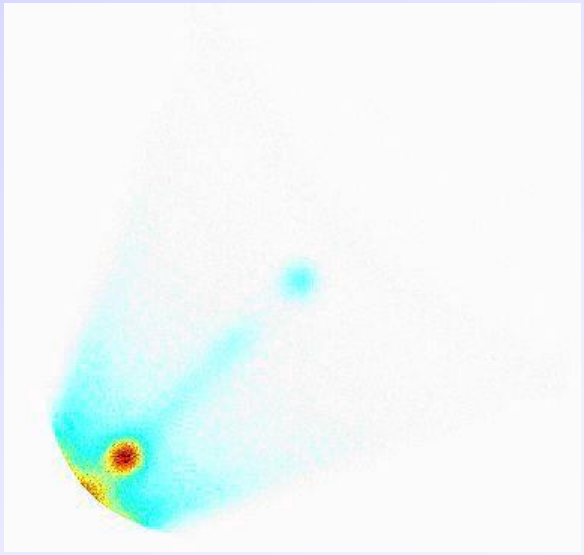
Two prototype bars have been tested in the MCAL temperature ranges (operative, non-operative etc).

Plane of the signals from PDs

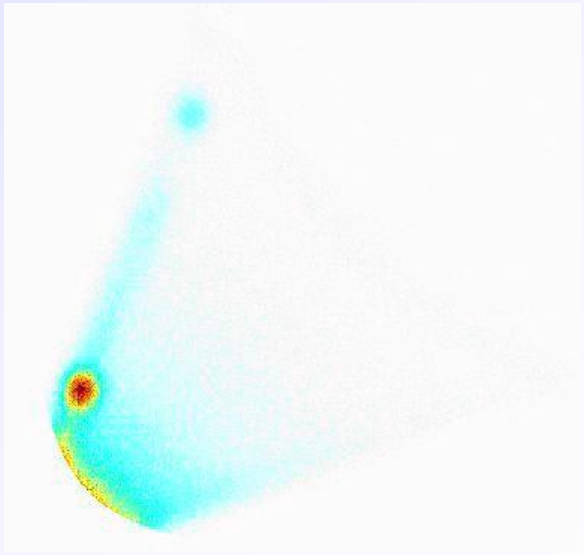
Test with a collimated ^{22}Na source (511 and 1275 keV)



1 cm from PD A

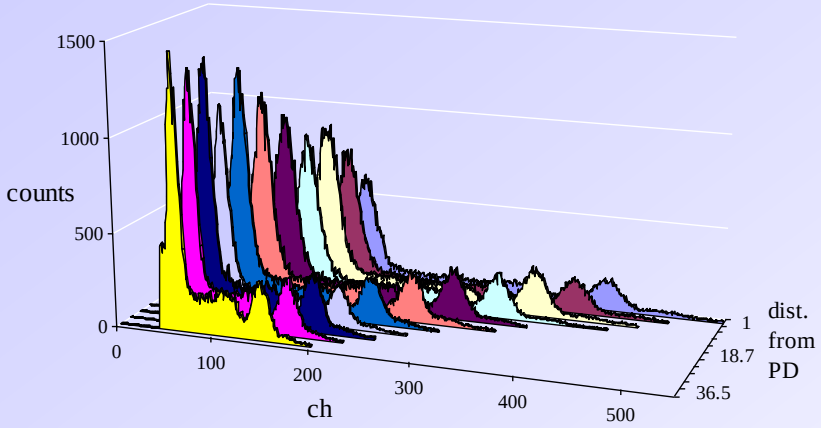


18.75 cm from PD A

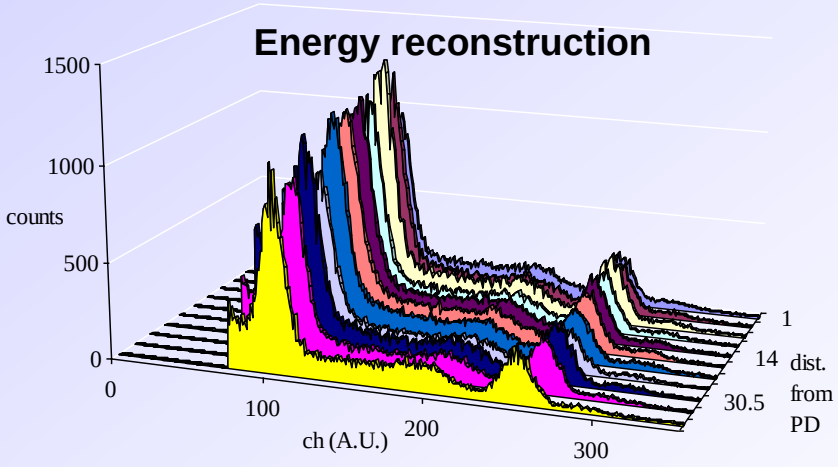


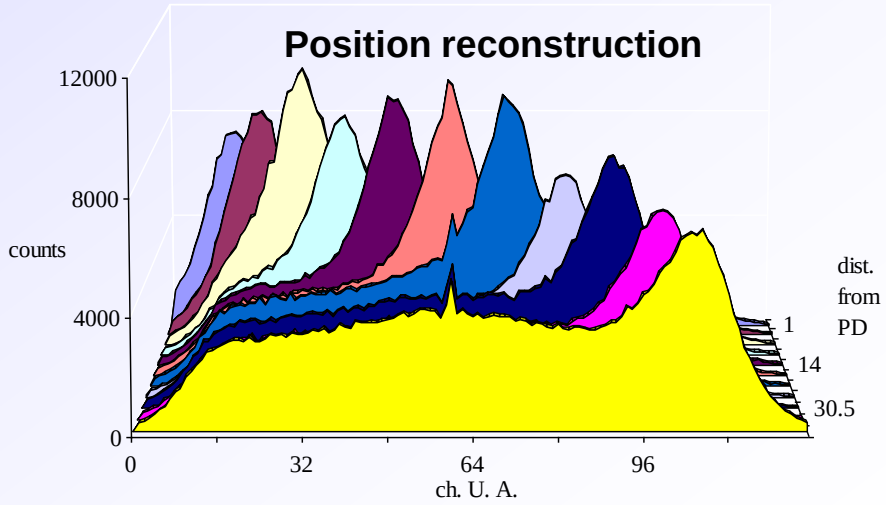
36.5 cm from PD A

Energy and position evaluation

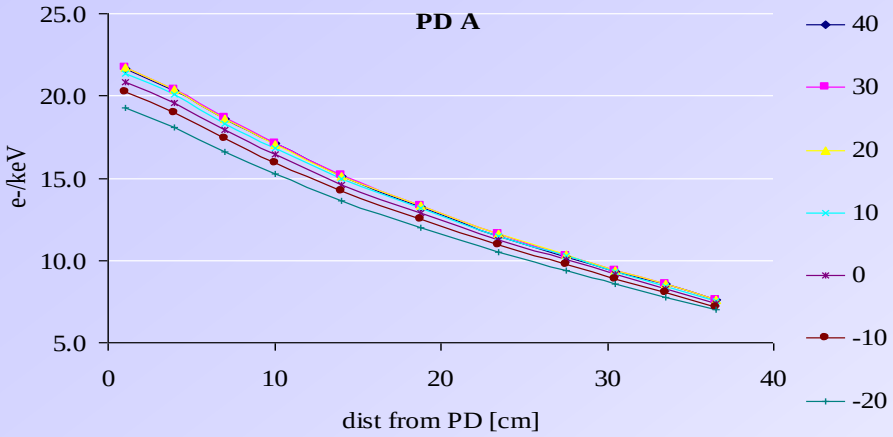


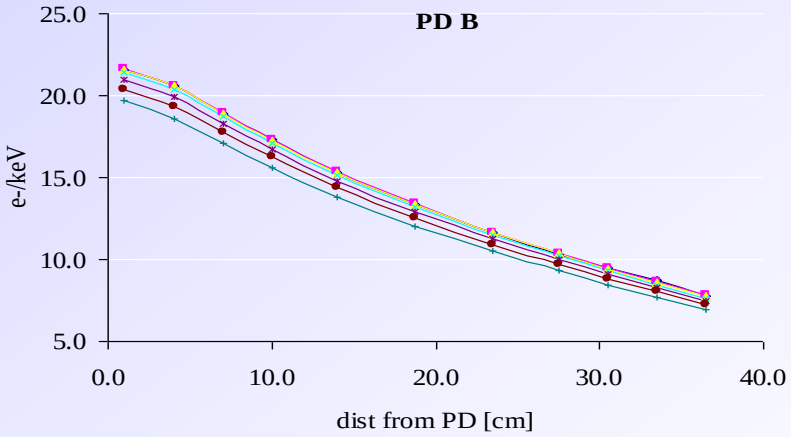
Collimated ^{22}Na spectra collected by one PD for different source positions.

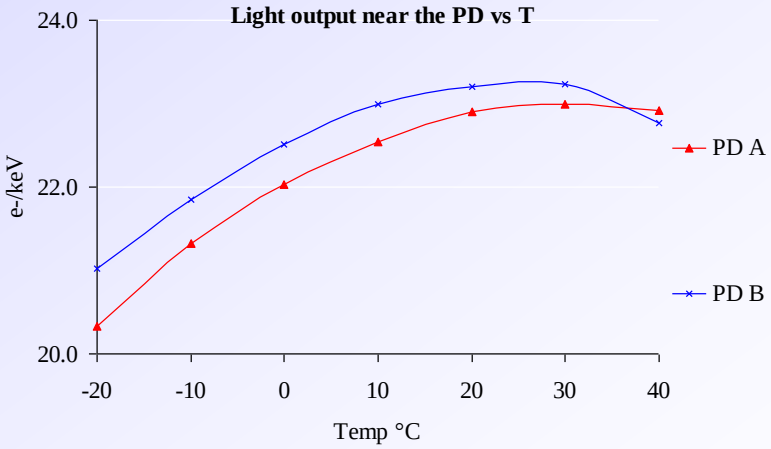




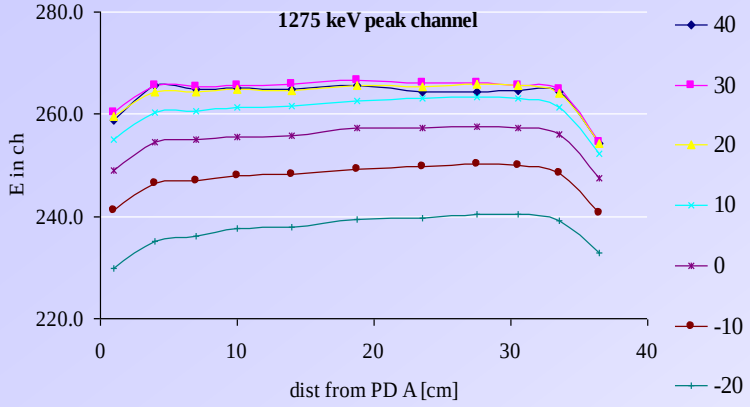
Light output vs Temp.

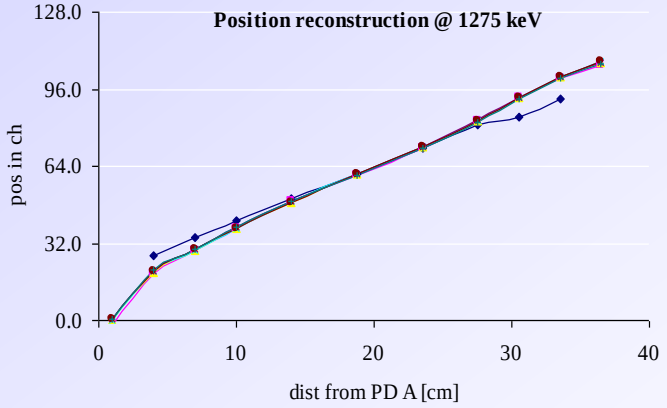


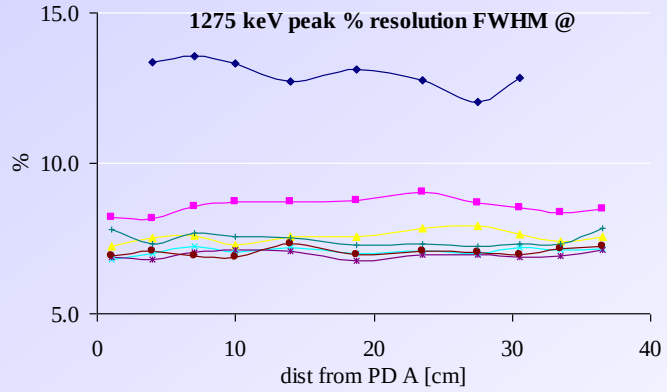


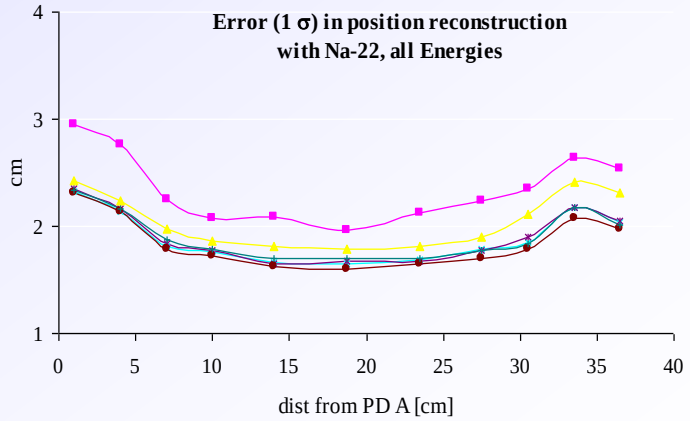


Energy and position resolution









All parameters evaluated with pre-amps shoving ~ 850 e^- rm noise at room Temp.

MCAL operative modes

1) **GRID: MCAL is 'slave' of the Tracker. On command all the PD signals are stretched, AD converted and sent to the Data Handling.**

Operative range for each bar is 1 ÷ 500 MeV.

MCAL can start a GRID event if it detects more than 50 MeV on the whole system.

The FEE can handle an event rate up to 1300 Hz.

2) **BURST: MCAL indipendently detects events in the range 250 keV e 250 MeV.**

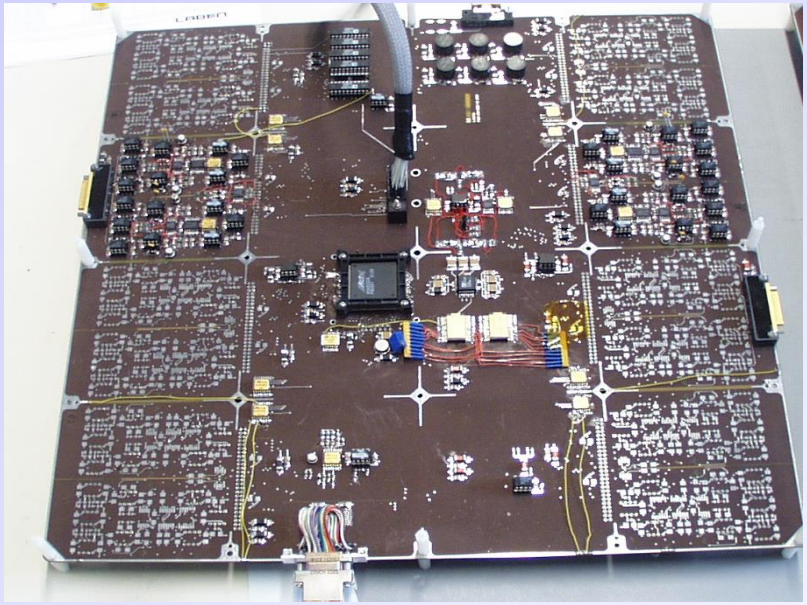
The AD converted data are processed in the Data Handling for transient event search. The FEE can handle an event rate up to 500 kHz.

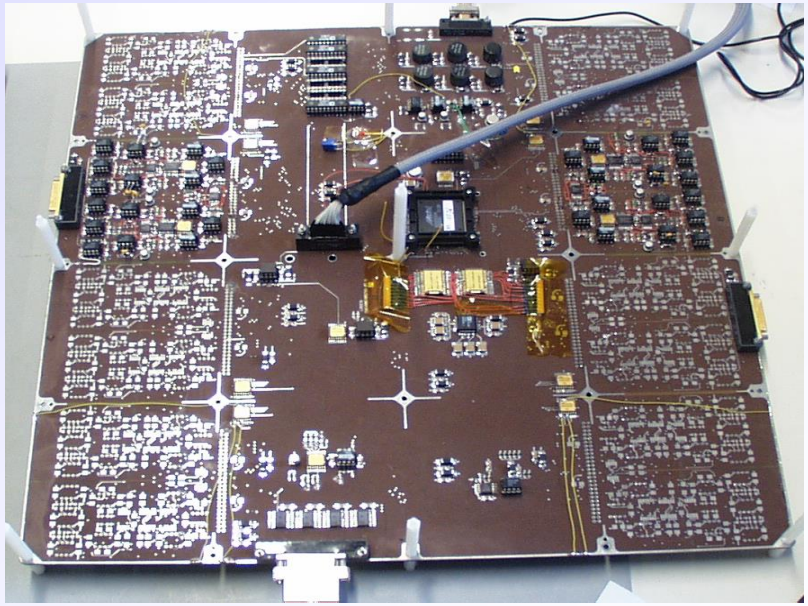
MCAL FEE deals, at the same time, the processing of the two modes as well as the generation of House_Keeping data, Telecommands implementation etc.

Energy resolution FWHM	**~ 10 % @ 1 MeV** **~0.7% @ 100 MeV**
Position resolution (1 σ)	**~20 mm @ 1 MeV** **~2 mm @ 100 MeV**
Time resolution (Burst)	**~2 μs**
Energy Range	**GRID: 1 – 500 MeV** **BURST: 0.25 – 250 MeV**
Event time of analysis	**GRID: ~60 μs** **BURST: ~10 μs/bar**

MCAL FEE

- **Overall power consumption: 5 W**
- **PD' s charge preamplifiers: ~ 850 e- rms**
- **GRID, BURST, HK & TC functions contained in two boards with the same footprint of the bar assembly**





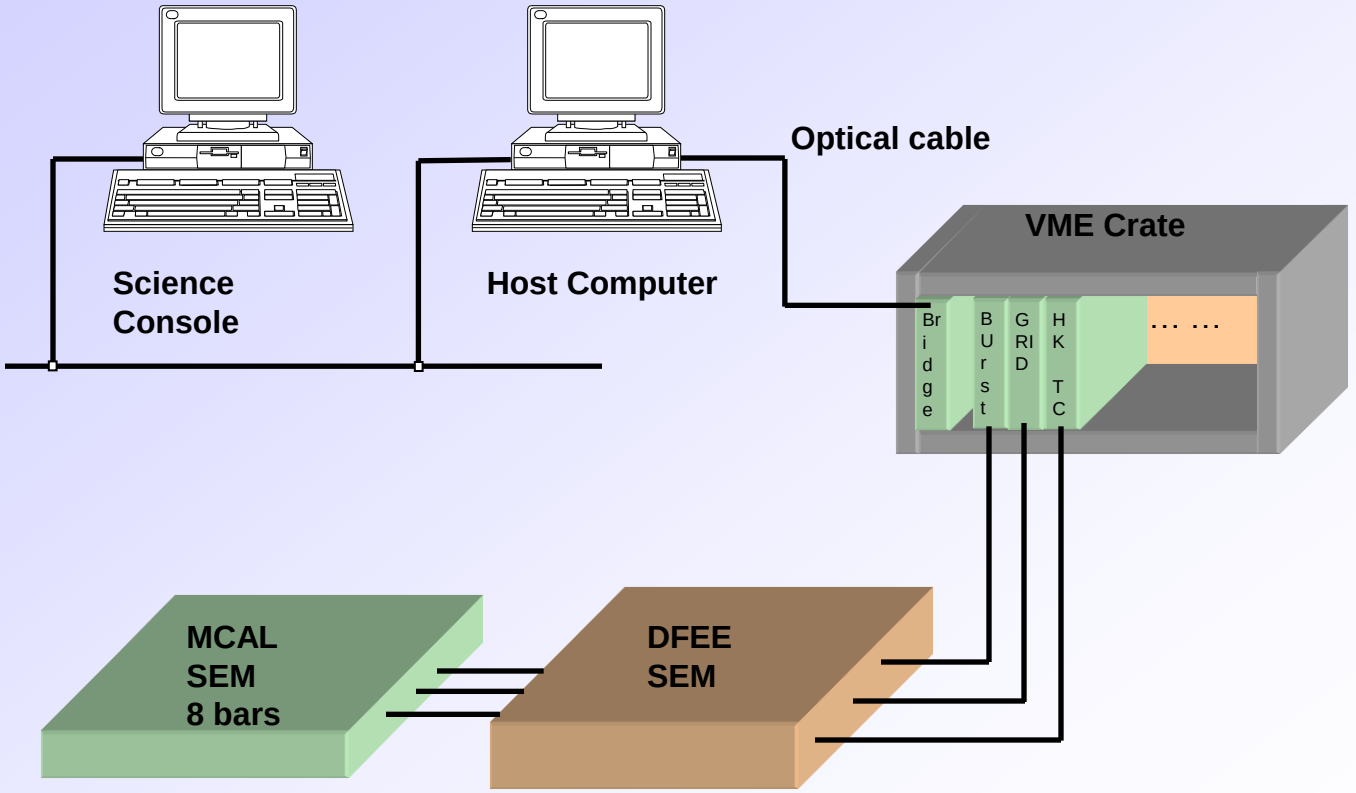
Simplified Engeneering Model of MCAL DFEE

Each board includes the analogue chains for 15 bars. The circuits for GRID operations up to A/D conversion are contained in one board, the BURST operations are all developed in the other board.

MCAL Test Equipment

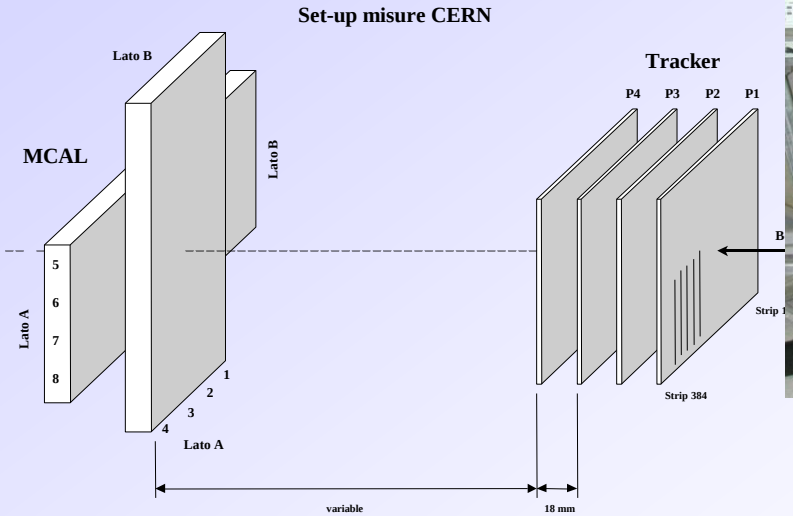
A dedicated Test Equipment has been realized for SEM MCAL test

The system is based on a VME bus with a board for each MCAL I/F (GRID, BURST, HK-TC)

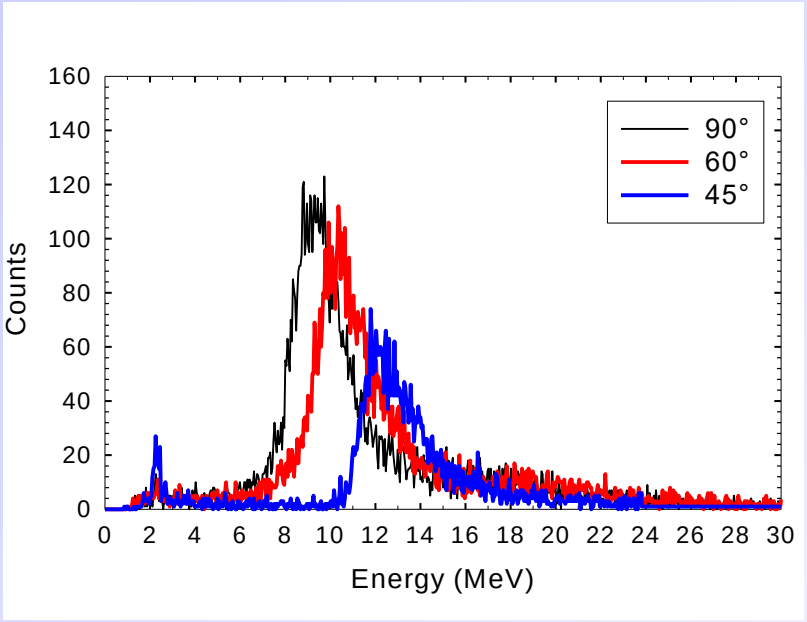


Test with particles

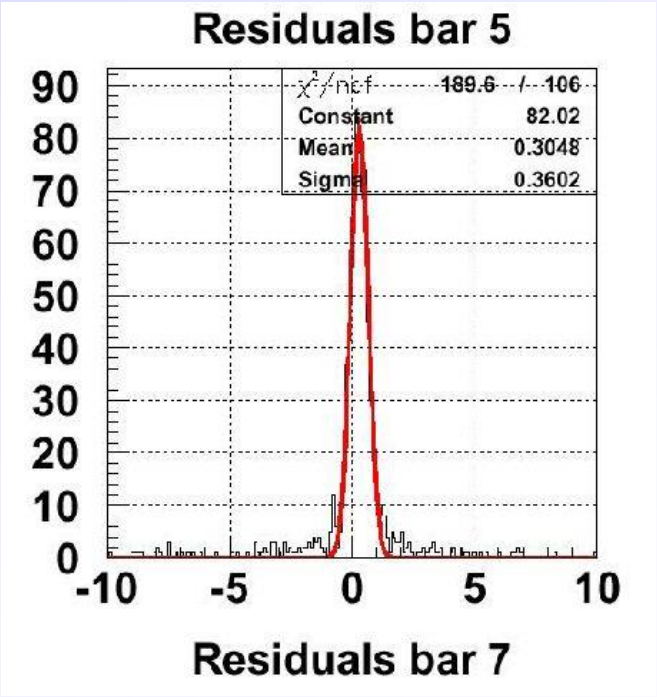
MCAL SEM (with early prototype bar detectors) has been tested both in laboratory and, togheter with a prototype Tracker and AC, with particle beam (CERN T-9 and T-11)



Test with particles



Energy lost by μ of 2 GeV/c impinging on MCAL with various angle



Difference between the position of interaction of μ impinging on one MCAL bar evaluated with the PD data and with the projection of the position evaluated in the Tracker.

Conclusions

AGILE will be launched at the end of 2005

The prototype studies on MCAL detector and electronics have demonstated the validity of the choosen design