Electromagnetic Calorimeter for HADES Experiment

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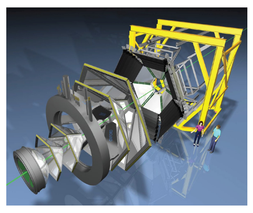
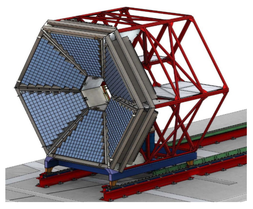
Motivation



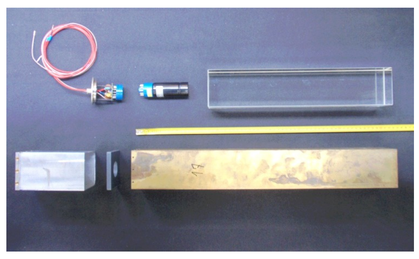
HADES setup
- installed at GSI SIS 18
- six identical sectors
- almost full azimuthal angle
- polar angle 18° - 85°
- high rate counting



ECAL detector
- planned for new accelerator SIS 100
- 978 modules of lead glass+ photomultiplier
- polar angle 12° - 45°
- novel electronics for read out

ECAL module

- totally needed 978 pieces
- lead glass on loan from end cap calorimeter of OPAL experiment
- lead glass type: CEREN 25
- dimensions 92x92x420 mm
- wrapped in TYVEK paper
- brass can 0.45 mm thick

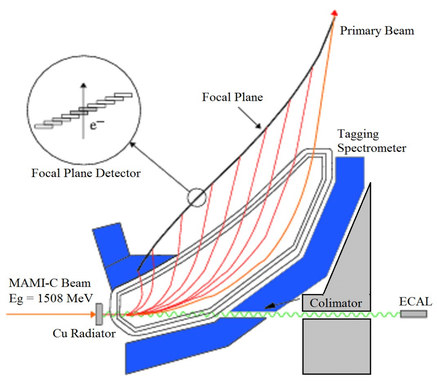


Glass properties:
- density: 4.06 g/cm^3
- radiation length (X_0): 2.51 cm
- refractive index: 1.708 (at 400 nm)
- Molière radius: 3.6 cm

LED light system:
- LED based system is developed for calibration and stability monitoring of ECAL modules

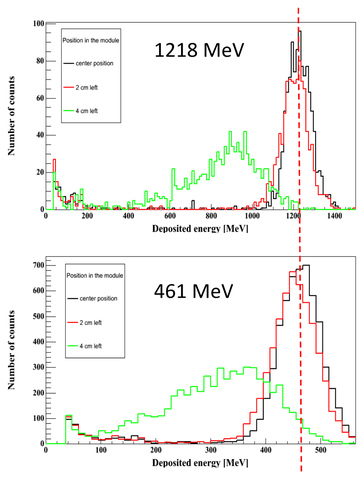
Test with Photon Beam at Mainz

Tagger
- used tagger to select 8 known gamma energies ranging from 81 up to 1399 MeV
- 8 different trigger signals – 8 energies measured in one measurement
- beam size in front of the modules ~ Ø 6 mm

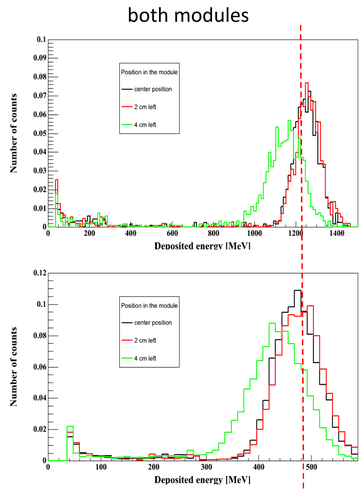


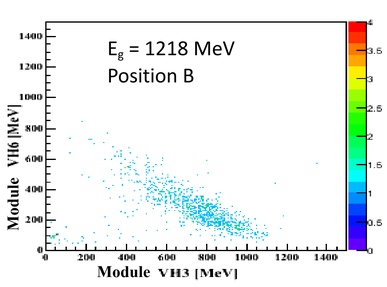
Energy leakage into neighbour module paralel with the beam

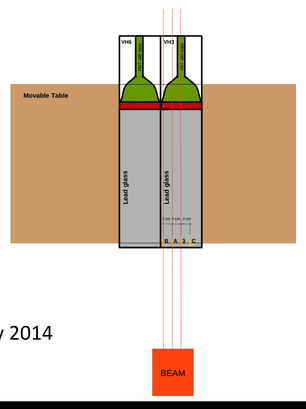
Deposited energy in primary hitted module only



Sum of deposited energy in both modules

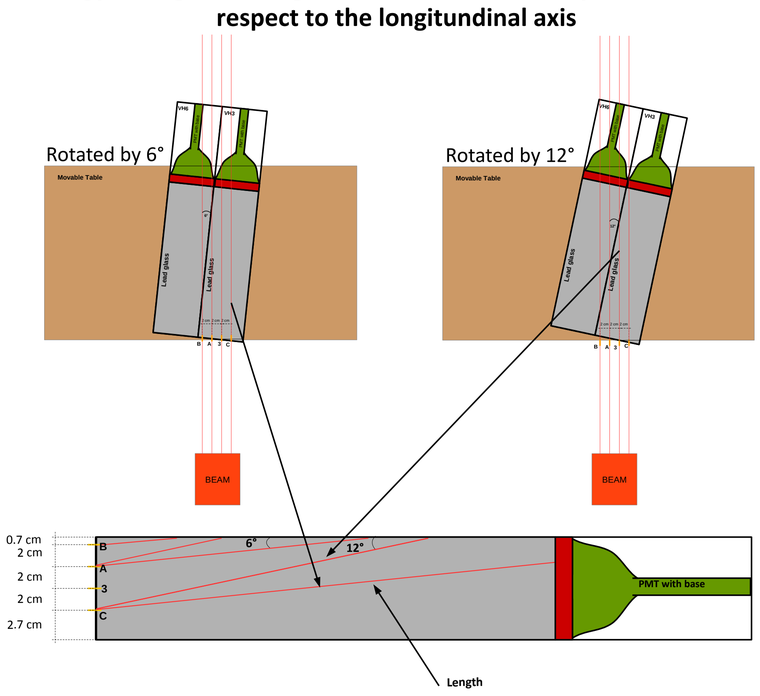




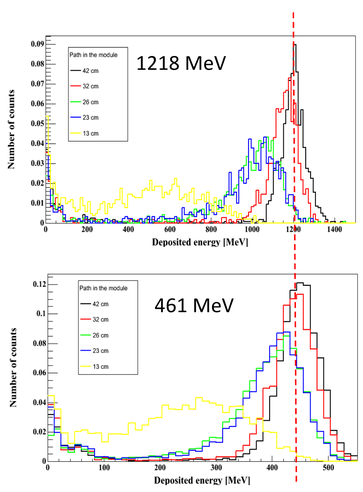


Measured in January 2014
Used 3" PMT

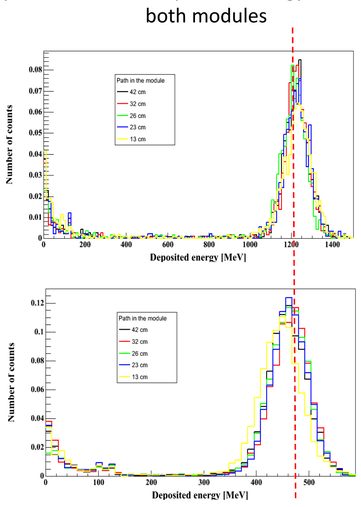
Energy leakage into neighbour module inclined by 6° and 12° with respect to the longitundinal axis



Deposited energy in primary hit module only



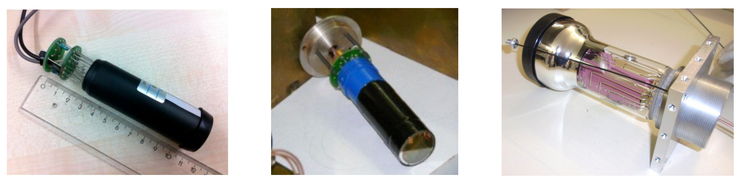
Sum of deposited energy in both modules



Measured in January 2014
Used 3" PMT

Choice of photomultipliers

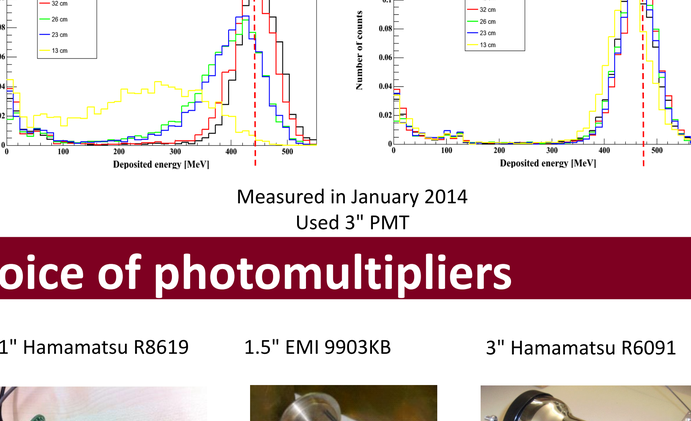
1" Hamamatsu R8619 | 1.5" EMI 9903KB | 3" Hamamatsu R6091



Totally needed **978 pieces.**

The 600 1.5" EMI photomultipliers from MIRAC experiment (WA98 hadron calorimeter) were tested and are ready to use.

Relative energy resolution



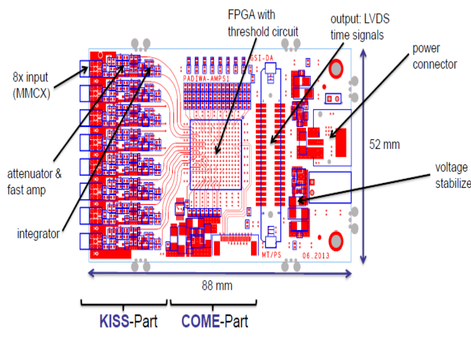
Measured with CAEN ADC, signal shaped by MA8000 shaper.

Comparision of pulse shapes

Comparision of pulse shapes induced by cosmic muons, LED pulses and gamma beam.

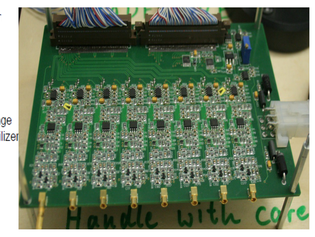
Front-end electronic

New PADIWA-AMPS1 layout with Q2W



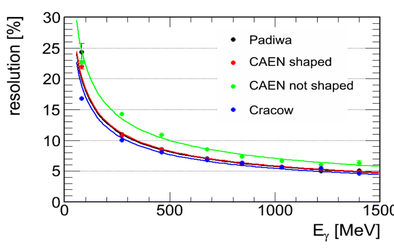
- 8 input channels
- Signal split into two paths:
  - Fast path: fast discriminator for time measurement
  - Slow path: signal integrated for amplitude measurement
- Integrate input signal with a capacitor
- Discharge via a current source and measure time of discharge -fast crossing of zero
- Differential LVDS output
- Discriminator threshold for each channel via slow control lines
- TDC done by TRBv3 board
- Control via SPI:
  - Temperature, input status, edge count, id, non-volatile memory, in-system programmable

Cracow design

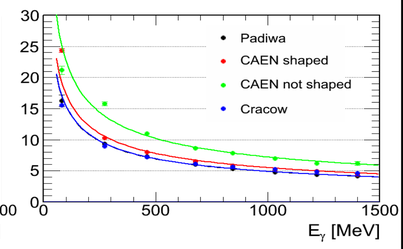


- 8 channel FEE developed by Jagiellonian University of Cracow for TRBv2 (Trigger- and Readout-board)
- Time measurement with TDC on TRBv2
- Amplitude measurement with ADC on TRBv2 Shower-Addon Board
- Threshold-settings for each of 8 channels
- Different shaping time and gain were tested and modified at GSI Darmstadt to optimize energy resolution
- Energy resolution with **pulser: 0.6%** at 100 ps time precision
- Energy resolution with **LED-PMT signal: 3.6%** at 150 ps time precision

Relative energy resolution on gamma beam-1.5" EMI



Relative energy resolution on gamma beam-3" Hamamatsu



Conclusions & Results

Energy resolution was studied to be able to decide which size of photomultiplier is the most suitable in terms of physical and economic point of view.

Resolution of modules with a photomultiplier with 1" PMT is significantly worse than that one with 1.5" and 3" diameter, and is not suitable for our purpose

Measurements done with standard CAEN ADC are in a good agreement with the measurements done with the two new front-end boards.

Measurements with rotated modules confirmed the results of our simulations, namely that we are able with a good precission to recover particles hitting more than one module or placed close to module border.

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Supported: Work supported by GSI, HIC for FAIR, EMMI and Czech MSMT LG 12007, GACR 13-067595 and AS CR M100481202 grants

Acknowledgment:
We would like to express special thanks to A. Neiser, P. Ott, P. Otte, A. Thomas, P. Skott from Institut für Kernphysik, Johannes Gutenberg-Universität, Mainz, Germany, for their help with the measurements and to the staff of the MAMI facility for providing excellent beam conditions.