PANDA Collaboration Meeting - Frascati

08. - 12. September 2014

Performance of the New Prototype of the Forward Shashlyk EMC for Photons from 55 MeV up to 650 MeV at MAMI

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Overview

Modification of the modules compared to the 2011/2012 version

Energyresolution

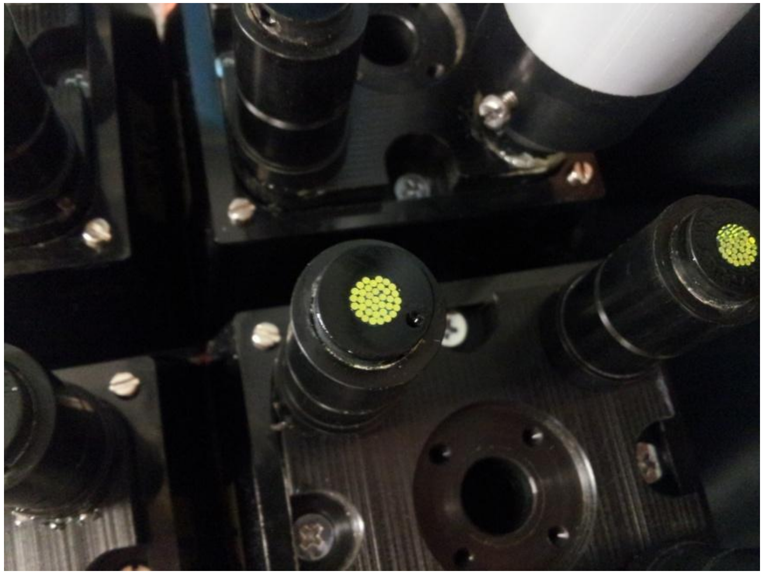
Homogeneity of the reconstructed energy

Position- and timeresolution

Modifications of the Modules Compared to 2011/2012

Modules were redesigned at IHEP Protvino:

- New mould to produce the 5.5 x 5.5 cm^2 scintillator tiles separately
- All side faces of the scintillator tiles painted with white color
- TYVEK between scintillator and lead tiles
- New fibers from Kuraray with higher light output
- Redesign of the holding and housing structures for the PMTs
- All modules equipped with Hamamatsu R7899 PMTs and a new version of the Cockcroft-Walton HV generator



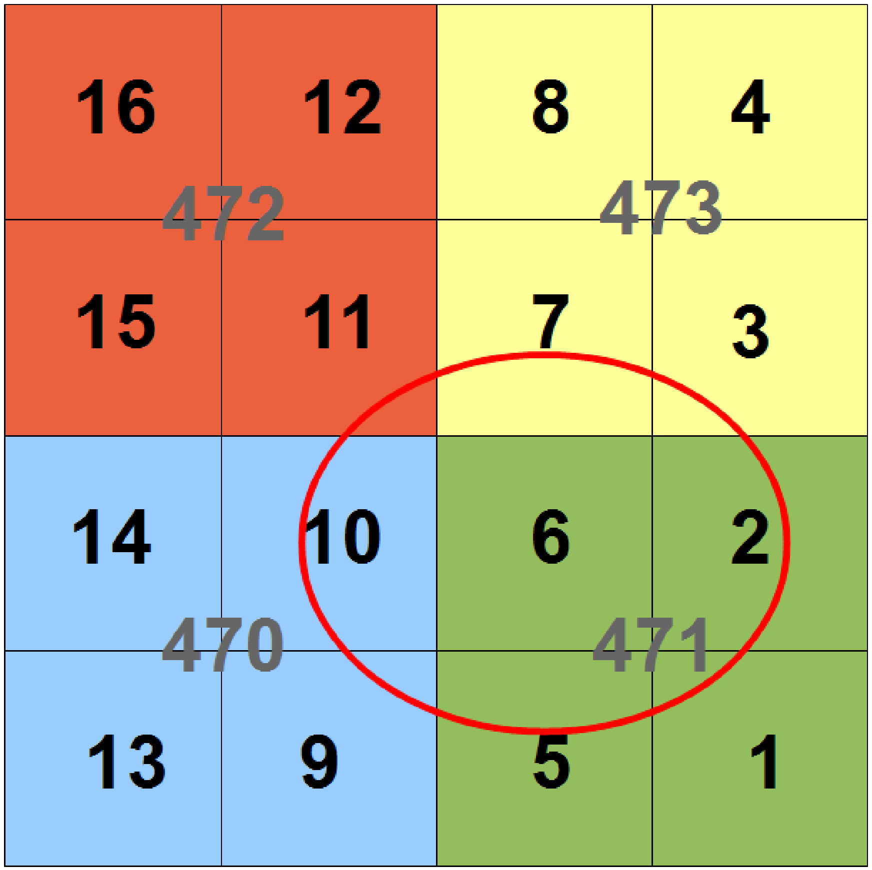
LY improved

from 1.5 ± 0.3 p.e./MeV
to 2.8 ± 0.3 p.e./MeV

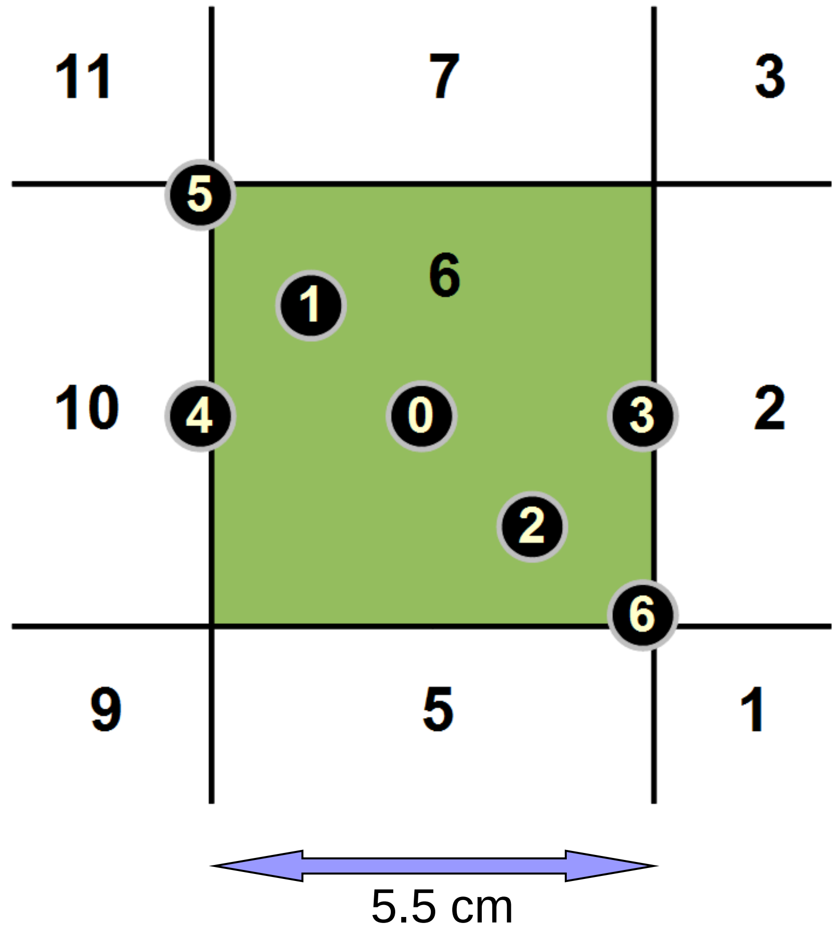
Beamtime at MAMI

- Beamtime at MAMI from 20. to 21. July 2014
- Tagged photon beam from 55 MeV up to 650 MeV
- 4x4 matrix (2x2 quadmodules) of the Schashlik EMC mounted on a xy-carriage
- Plastic paddel in front of the modules for charged particle rejection

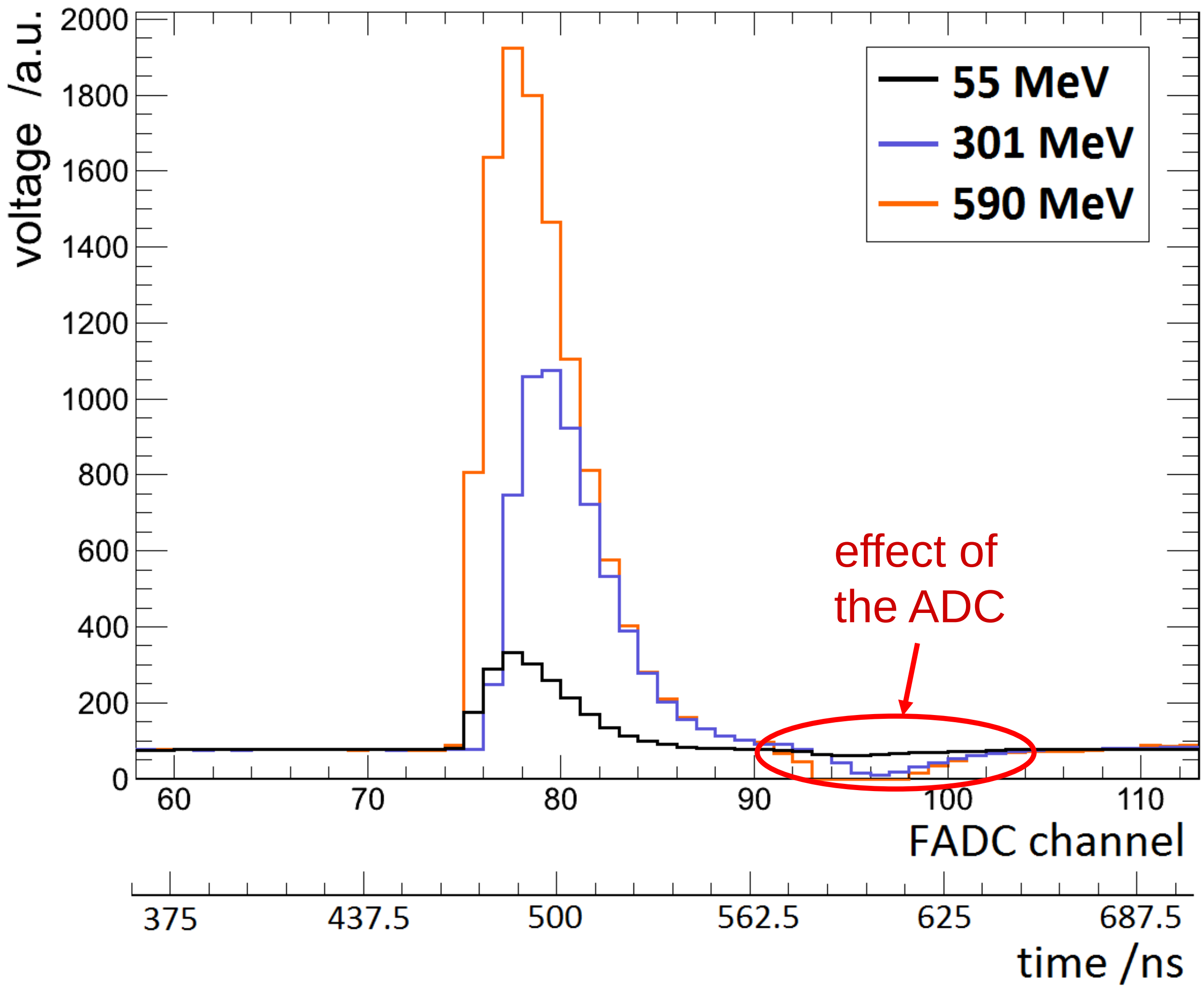
Interaction Points



seen from beam direction

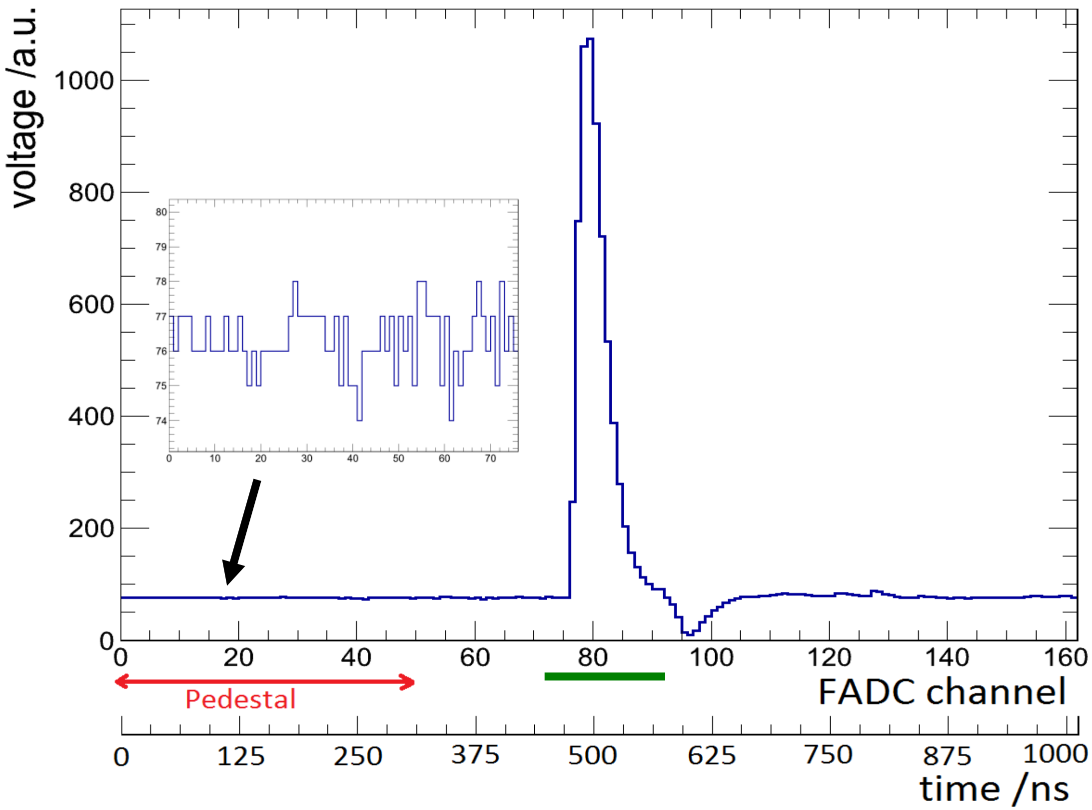


Traces and Feature Extraction



Traces recorded with a 160 MHz, 12 bit sampling ADC *(WIENER AVM 16)*

Traces and Feature Extraction



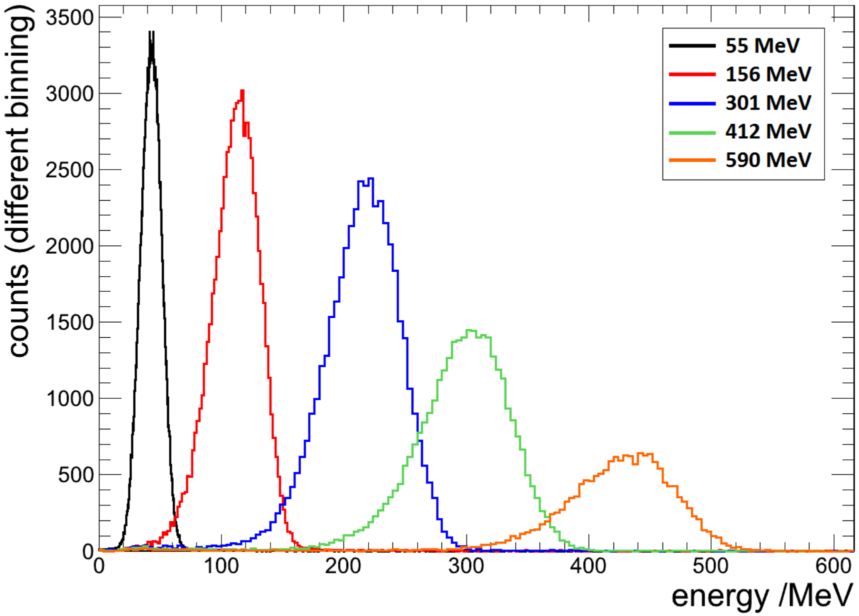
Pedestal:

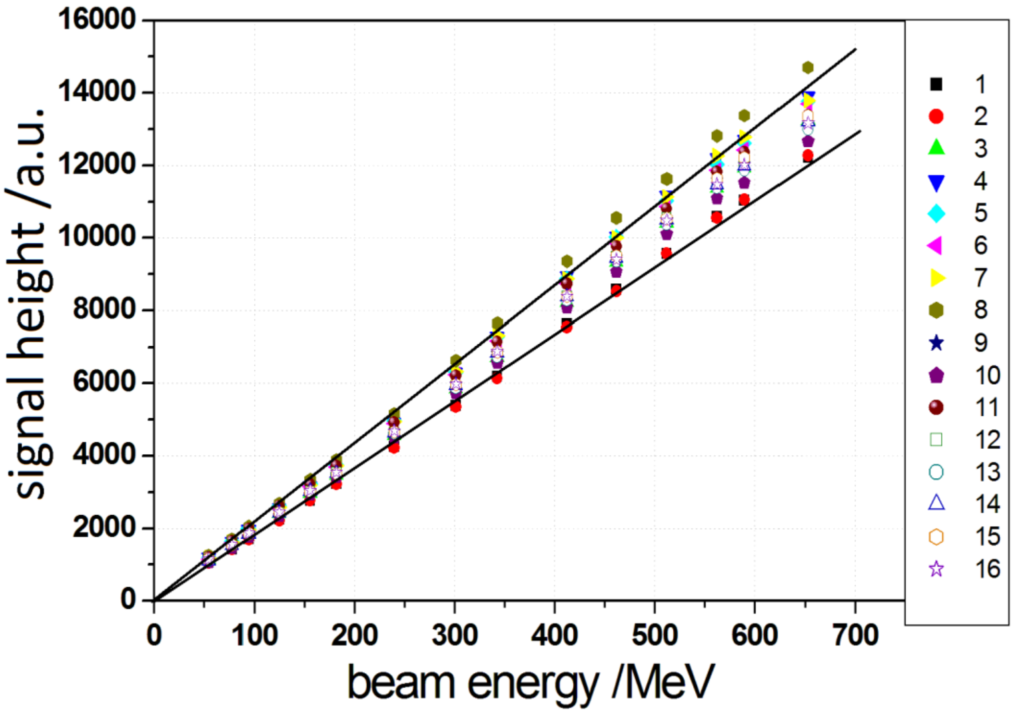
Averaged over first 50 channels (312.5 ns)

Energy Information:

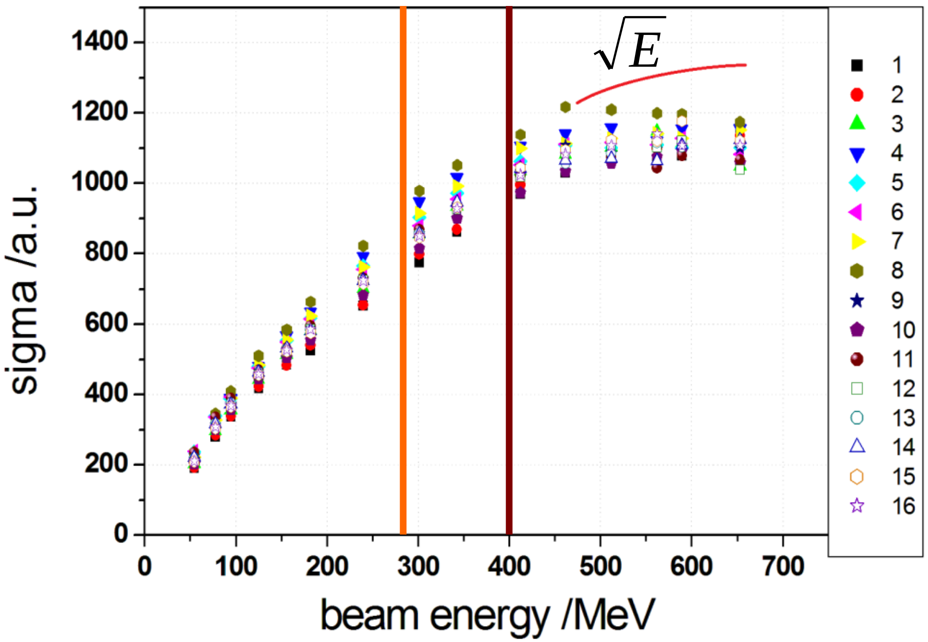
- Different feature extractions have been tested
- Best results: Integration over 144 ns excluding the undershoot

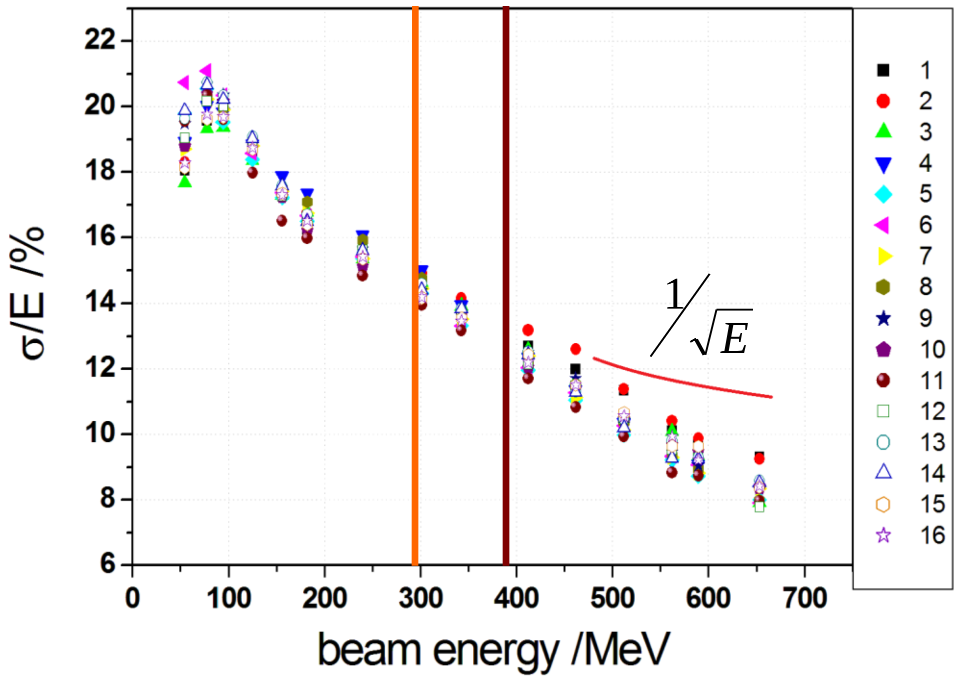
Lineshapes and Signal Height of Single Modules





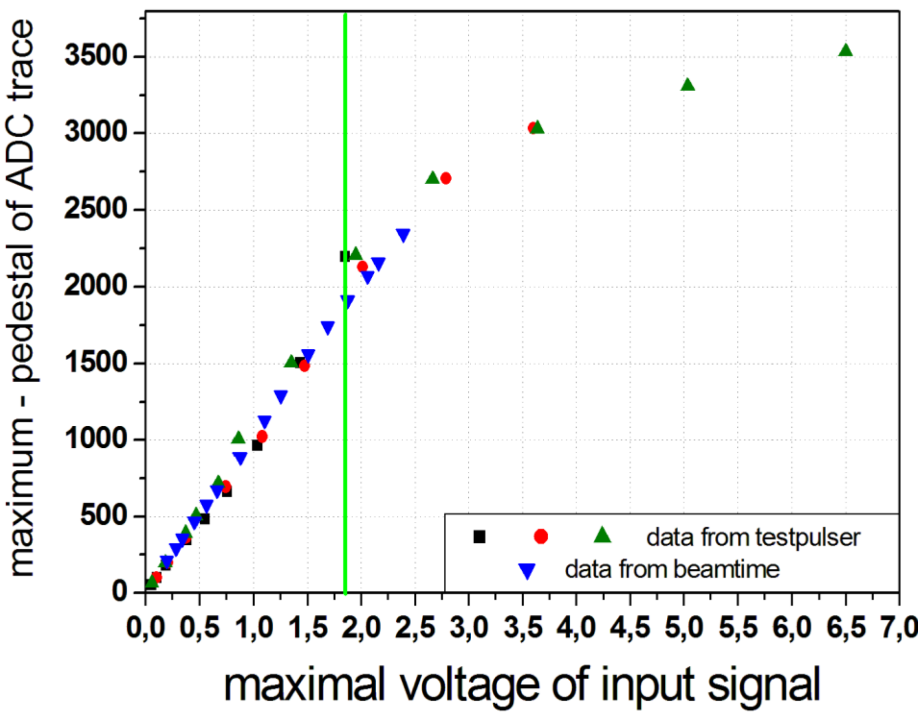
Sigma and Energy Resolution of Single Modules

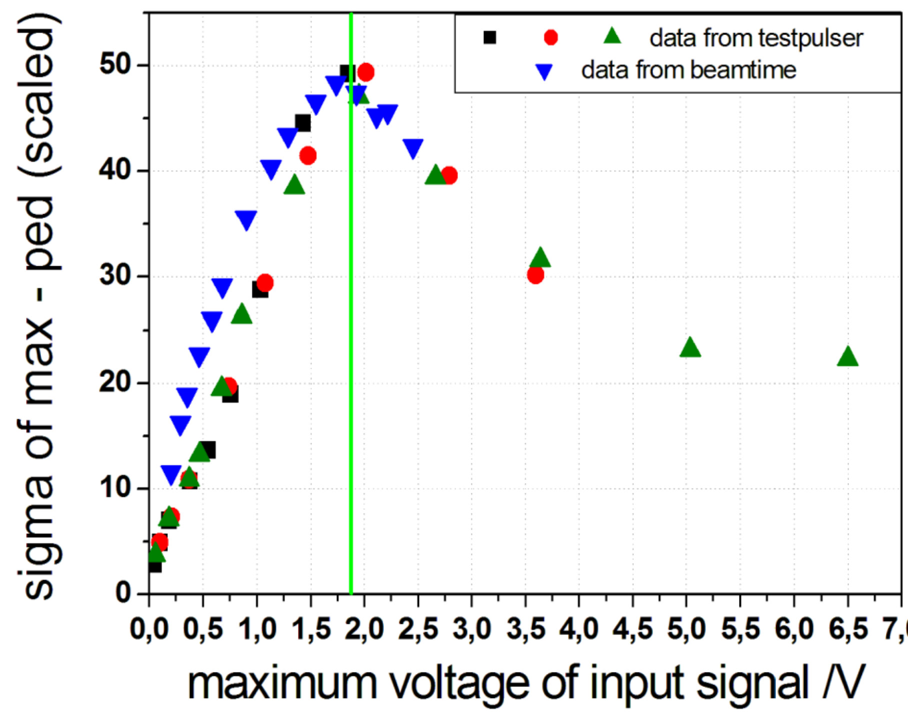




Test of the ADC Linearity

- Pulsshape comparable to shashlik pulses created with a pulser
- Maximal voltage measured with oszilloscope before ADC





Explanation: ADC is AC coupled with limitted bandwith (wrong version)

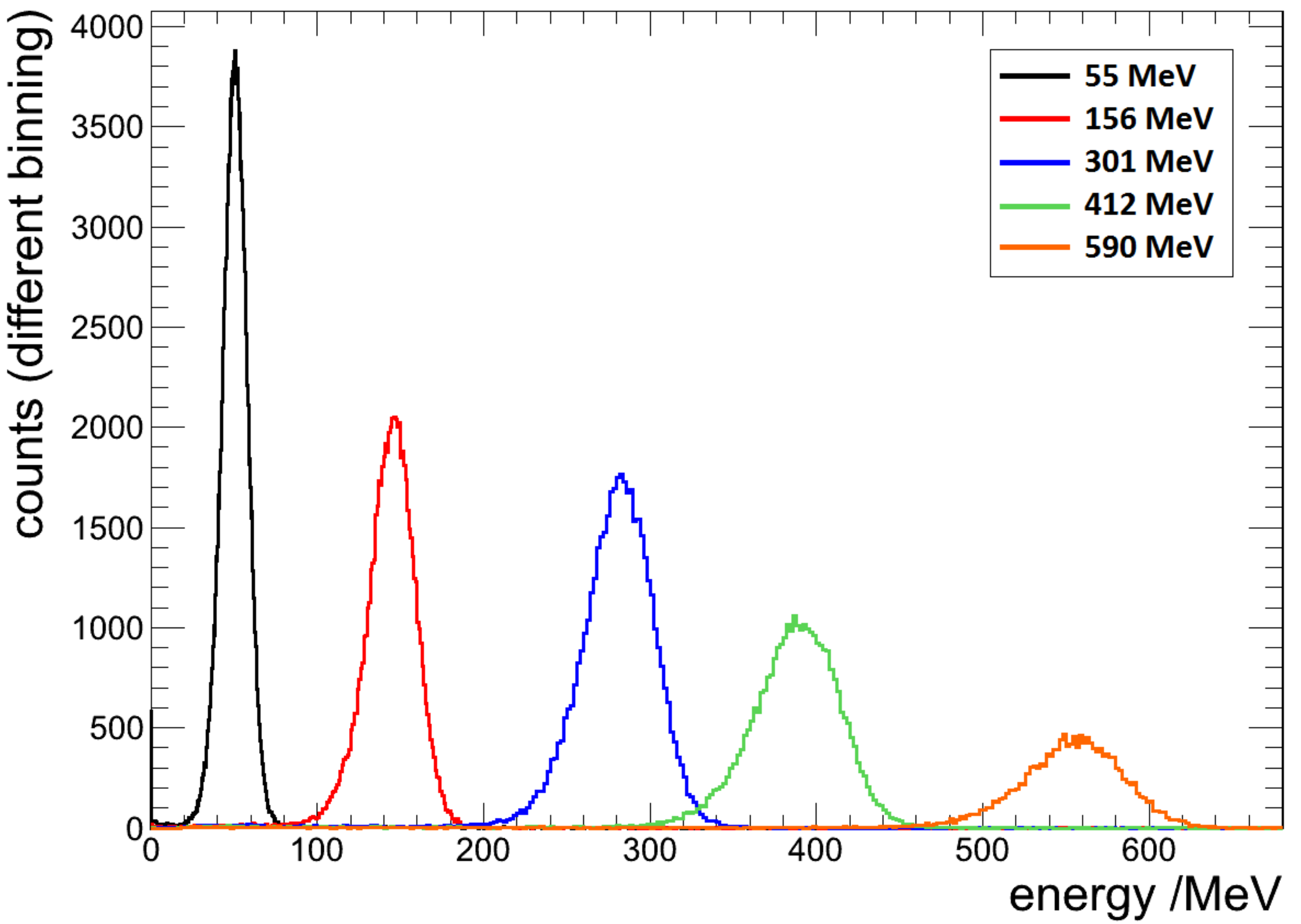
Calibration and Threshold

Calibration run: Shooting in the center of each module

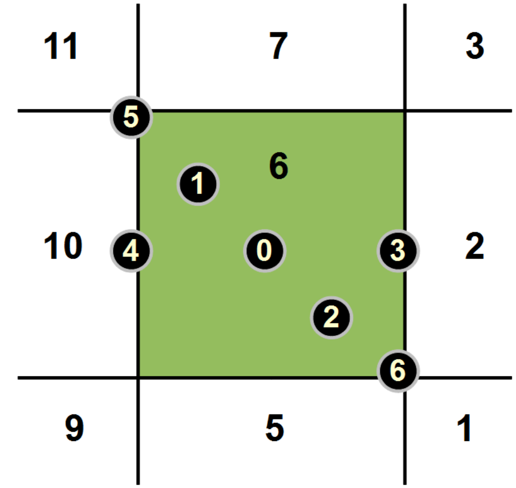
- Relative calibration of all modules to central module based on beam data up to 400 MeV
- Absolute calibration based on GEANT 4 simulations

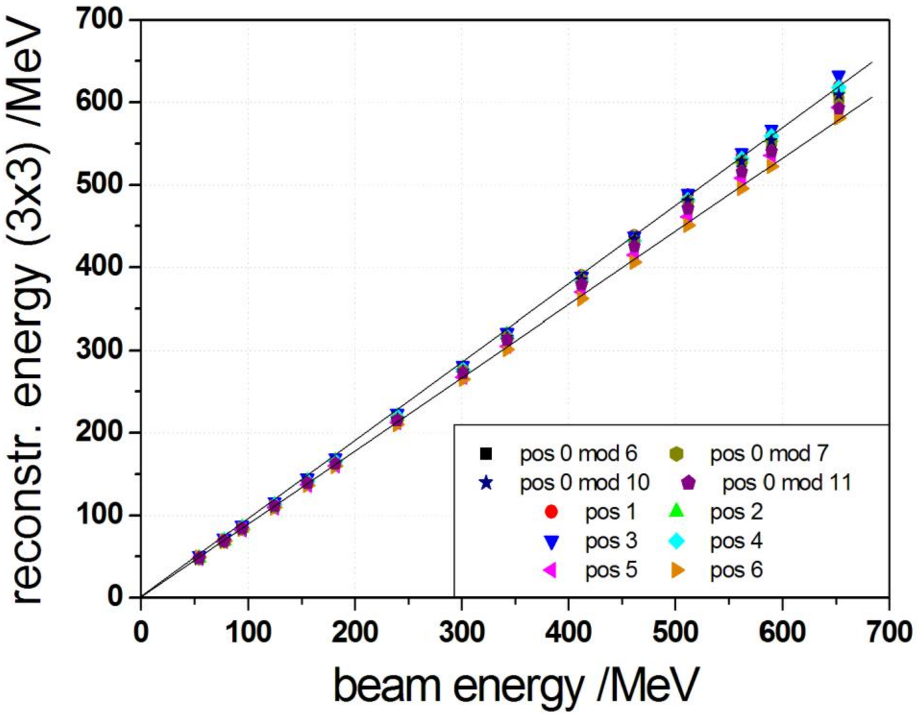
Threshold from noise distribution and threshold scan: **0.9 MeV**

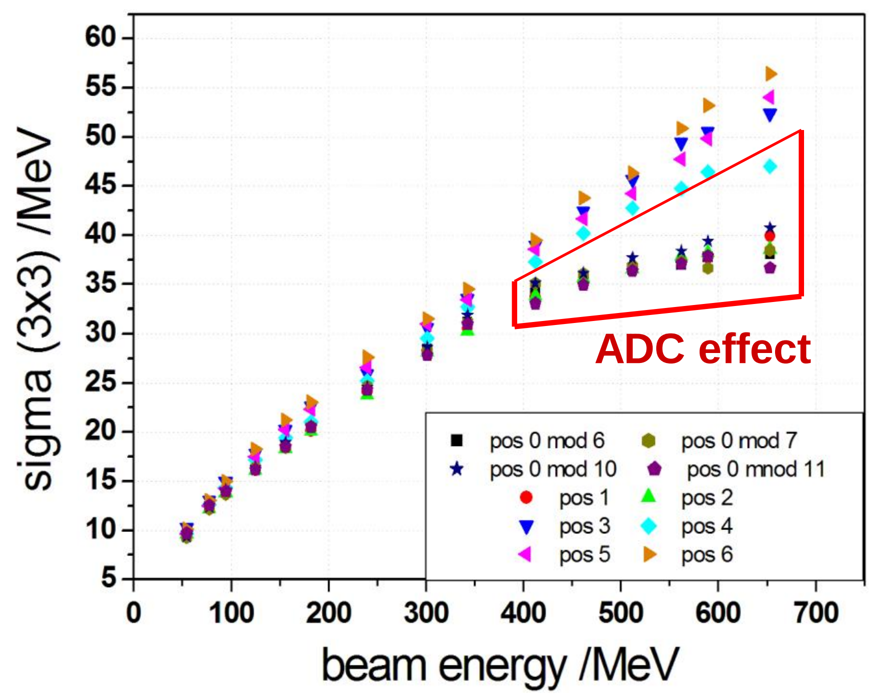
Lineshapes of the Energy Sum (3x3 matrix)

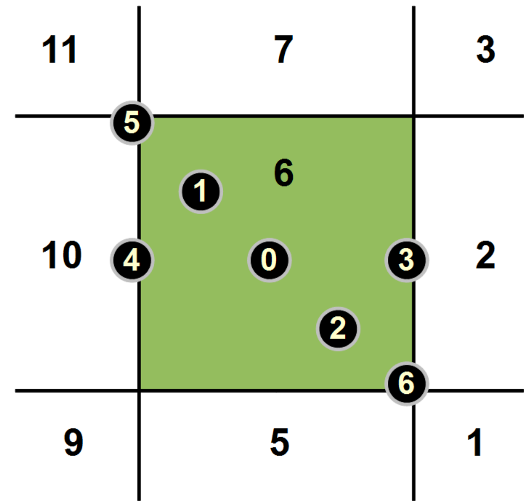


Reconstructed Energy and Sigma



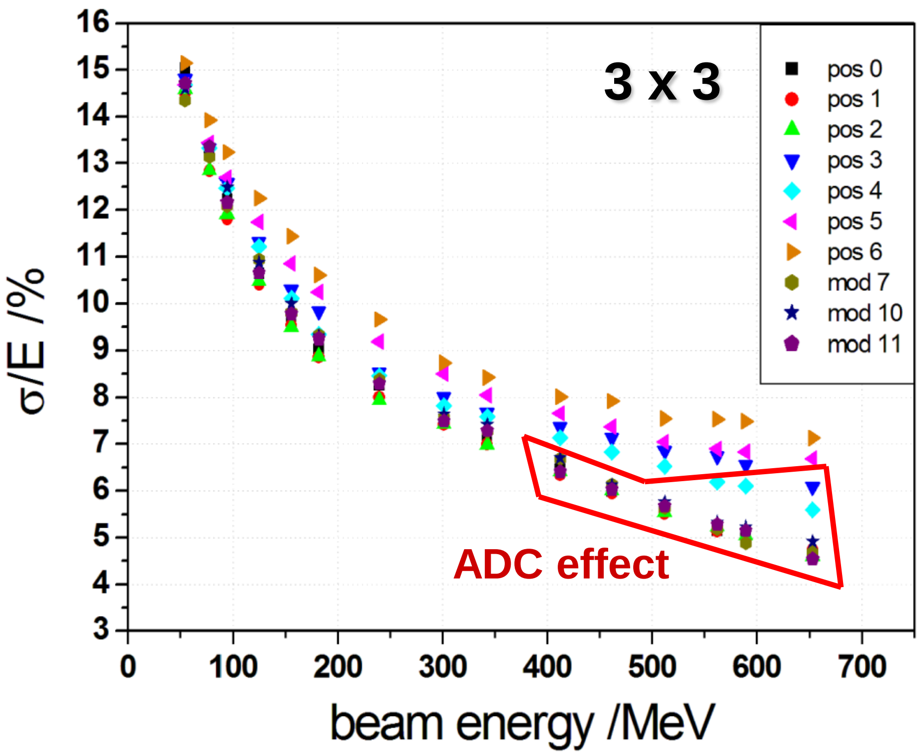


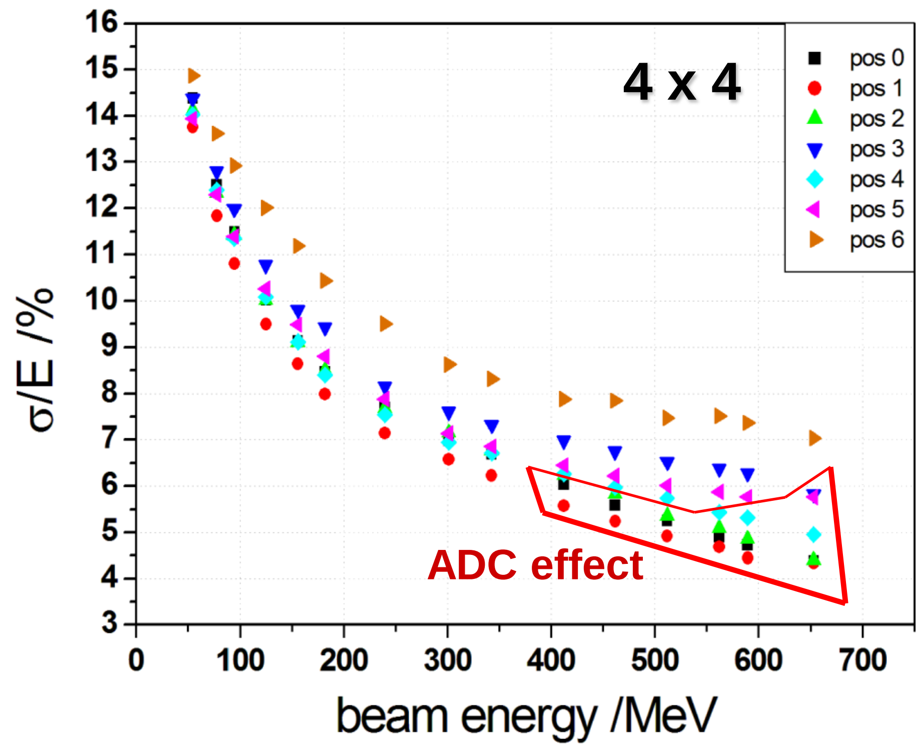




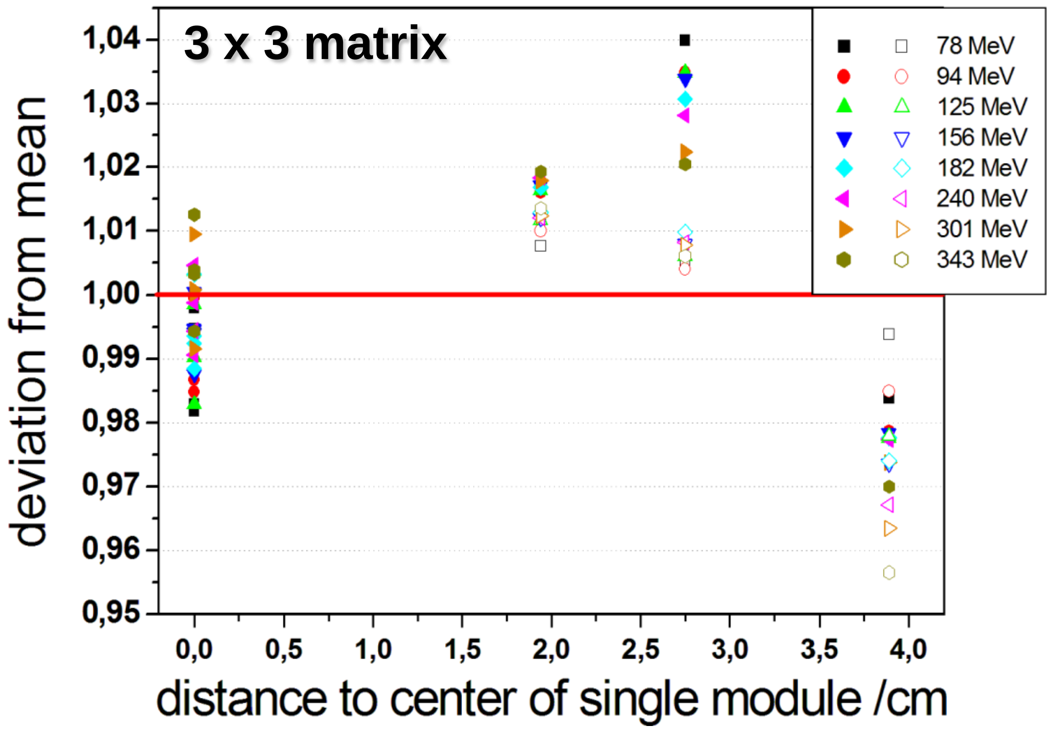
Energy Resolution

12 - 13 % @ 100 MeV
7.5 – 9 % @ 300 MeV

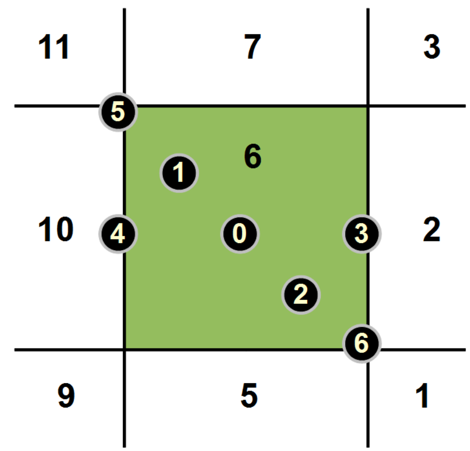




Homogeneity of the Reconstructed Energy



E > 400 MeV: slightly larger deviation due to the described effects



Variation for **central interaction** in different modules	< ± 1.8 %	avg. ~ ± 1.0 %
Maximal var. for **comparable points** (same leakage)	< ± 3.2 %	avg. ~ ± 1.6 %
Overall var. in a 3x3 matrix (incl. leakage)	< ± 4.5 %	avg. ~ ± 3.5 %
Overall var. in a 4x4 matrix (excl. edges)	< ± 3.0 %	avg. ~ ± 1.6 %

Influence of the Inhomogeneity on the Energy Resolution

Inhomogeneity has improved significantly
compared to 2011/2012 (→ mean ± 10 % to 15 %)

Fit in the range between 100 MeV and 400 MeV gives (dep. on position):

$$\frac{\sigma}{E} = \frac{3.4\% - 4.0\%}{\sqrt{E}} \oplus (3.4\% - 5.1\%)$$

3x3 matrix

⇨ Variation of reconstructed energy < const. term of energy resolution

⇨ Significant influence only at high energies

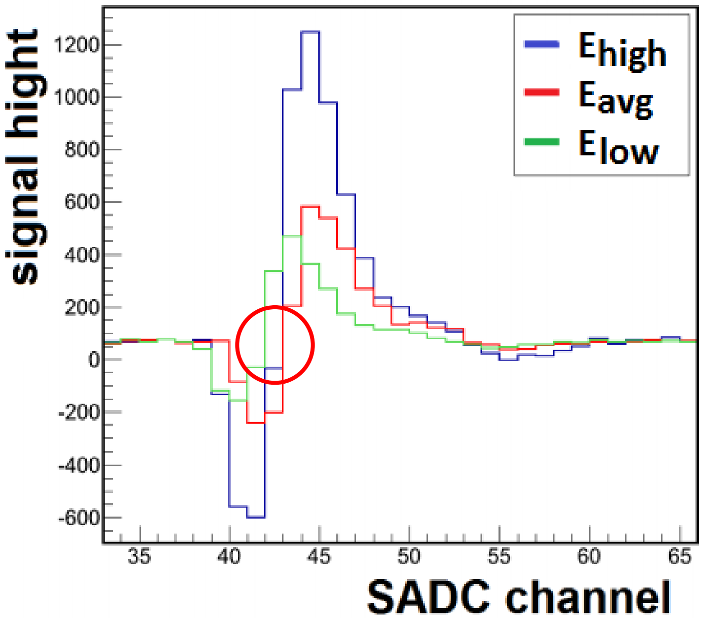
Influence @ 100 MeV (σ/E ~ 11.3 %): 1.6 % variation → σ/E + 0,1 %
3.2 % variation → σ/E + 0,45 %

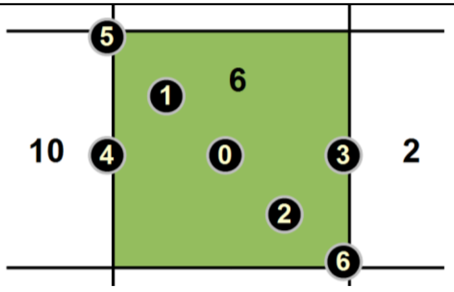
Influence @ 10 GeV (σ/E ~ 3.6 %): 1.6 % variation → σ/E + 0,3 %
3.2 % variation → σ/E + 1,2 %

Time Resolution

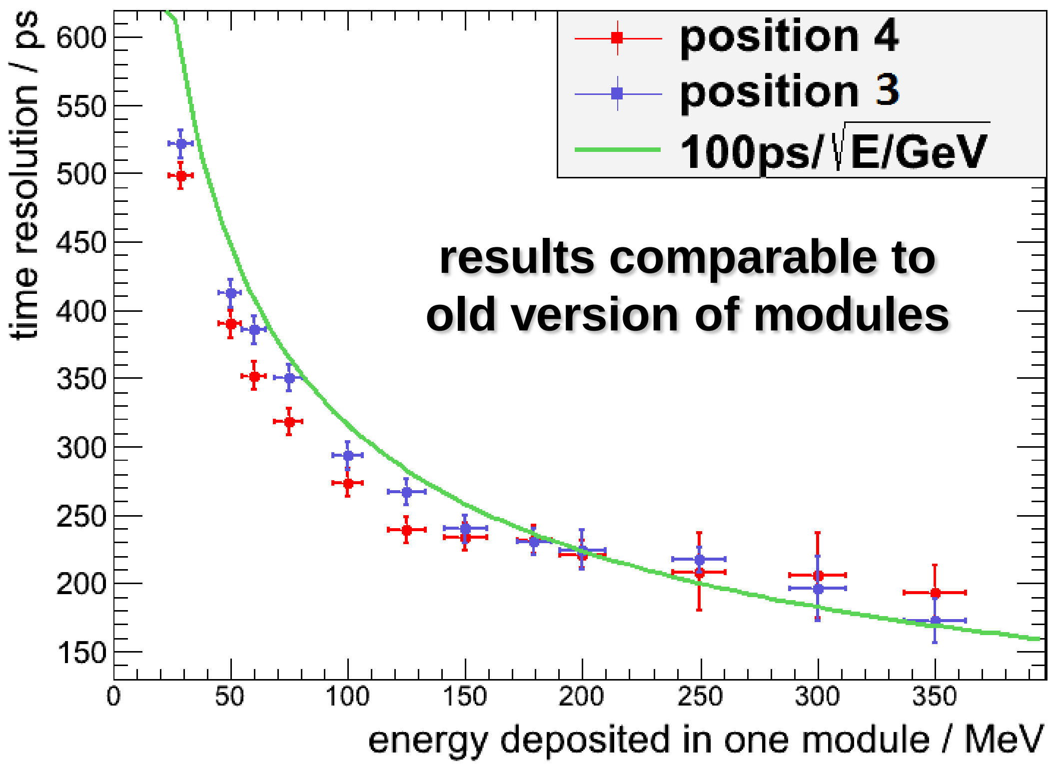
(extracted from time difference Δt between neighboring detectors)

$$CFD(n) = SADC(n-D) - R \cdot SADC(n)$$





$$\sigma_t = \frac{\sigma(\Delta t)}{\sqrt{2}}$$



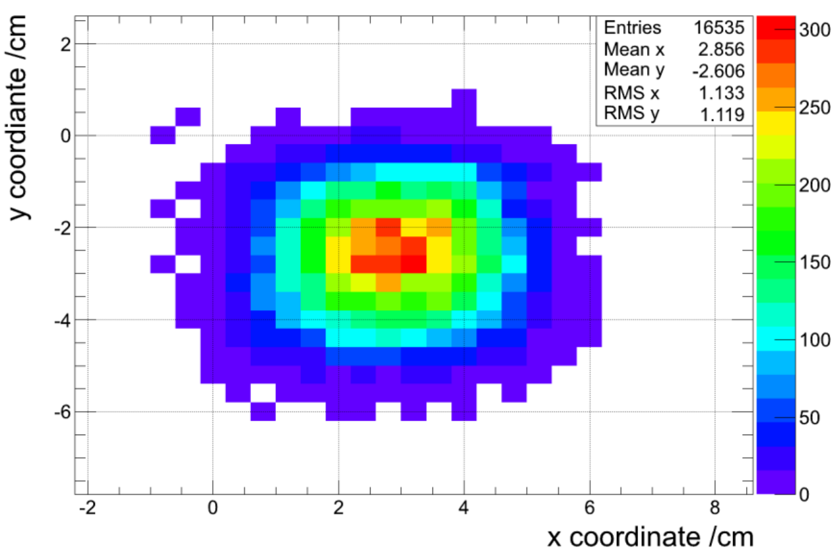
Position Resolution ($\sigma_{pos} = \sigma_{beam} + \sigma_{pos\text{-}det}$)

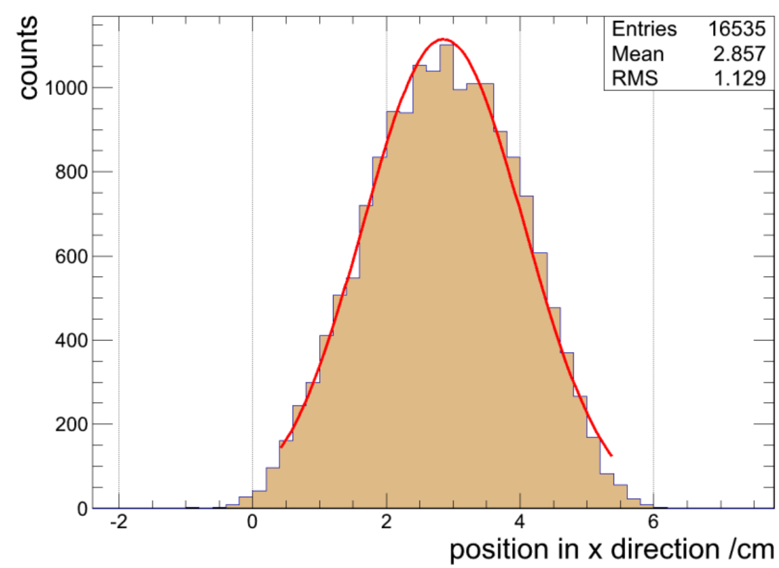
Center of gravity algorithm with logarithmic weighting:

$$x = \frac{\sum_i \omega_i \cdot x_i}{\sum_i \omega_i}$$

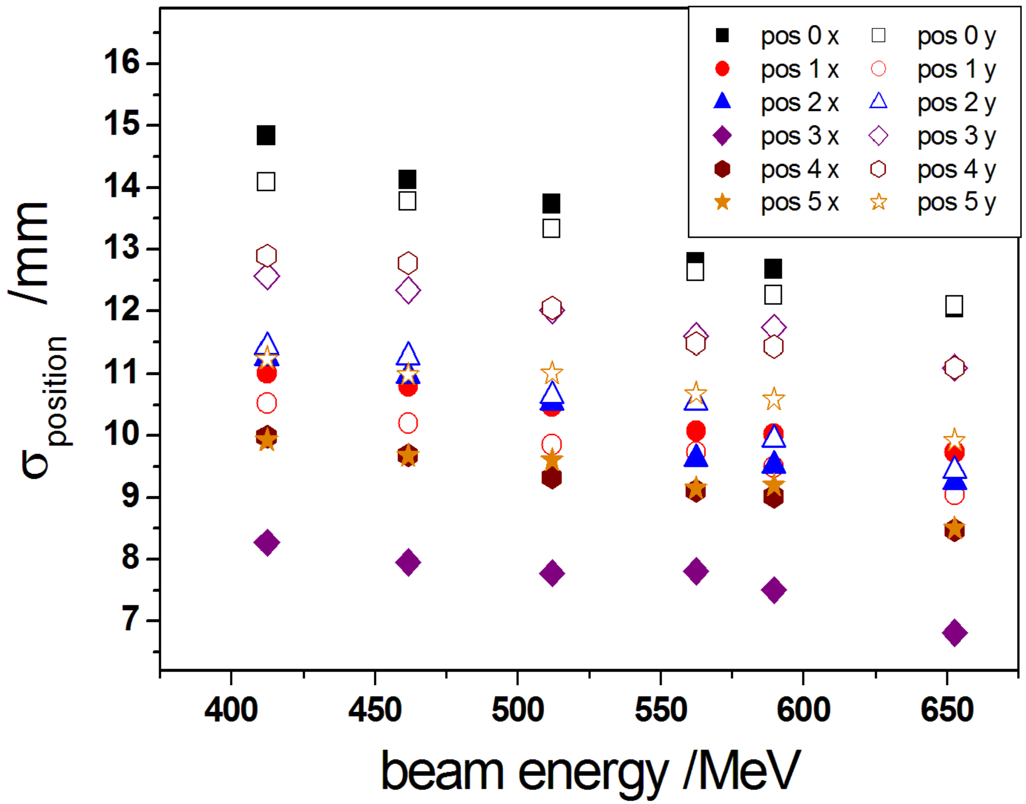
$$\omega_i = \left\{ \begin{array}{ll} 0 & \text{für } W_0 + ln\left(\frac{E_i}{E_S}\right) \leq 0 \\ W_0 + ln\left(\frac{E_i}{E_S}\right) & \text{sonst} \end{array} \right\}$$

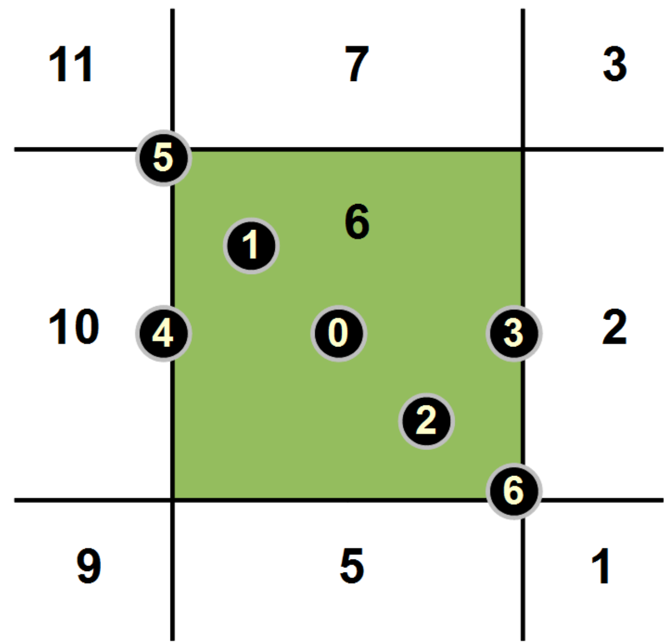
$W_0 = 4{,}6$





Position Resolution ($\sigma_{pos} = \sigma_{beam} + \sigma_{pos\text{-}det}$)





results comparable to old version of modules

- <u>From geometry</u>: beam radius ~ 5.1 mm
- **Real position resolution** of the detetctor is between ~0.9 mm (pos 0) and ~2.2 mm (pos 3) better

Conclusion

- Energy-, position- and timeresolution fulfill the requirements (values comparable to the 2011 / 2012 version)
- Homogeneity of the reconstructed energy has significantly improved (to an acceptable level) compared to 2011 / 2012
  - **Active part of the module has significantly improved**
- Effects seen at high energies (> 400 MeV) caused by the ADC (wrong version for the readout of shashlik modules)
  - Final concept: **Different sampling ADC** with another chip (not ready for operation at the present beamtime)
- **Several points concerning the mechanical design of the modules and the readout have to be discussed**

Thank you for your attention!