Recent Results with the Backward EMC Prototype

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PANDA LVIII Collaboration Meeting

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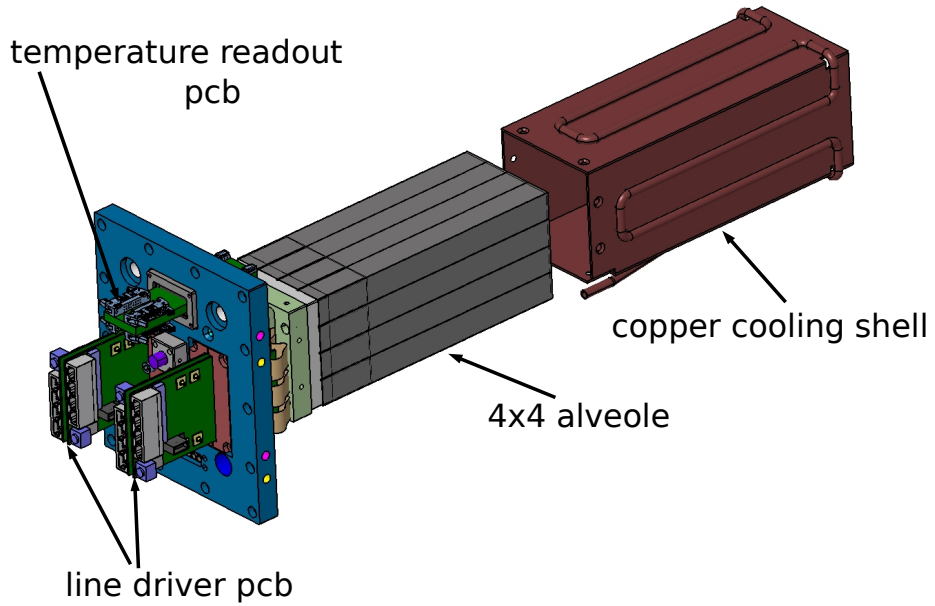
Prototype “Proto16”

Backward EMC Prototype "Proto16"

PROTO16

- Mechanics
  - Carbon fibre alveole with 16 $PbWO_4$ crystals
  - Two mounting plates separated with glass fibre feet
  - optical fibre to every crystal
- Cooling
  - Cooling shell
  - Insulated with VIP
  - Nitrogen supply
- Monitoring
  - Flat thermal sensors
  - THMP
- Readout
  - Two APD per crystal
  - APFEL ASIC
  - Line driver



Upgrades of Proto16

- Used optical grease between APD and crystals
- Shielding for the distribution (sender) boards
- Receiver boards replaced by passive adapters
- Embedding of PANDA (Uppsala) ADC and TRB readout

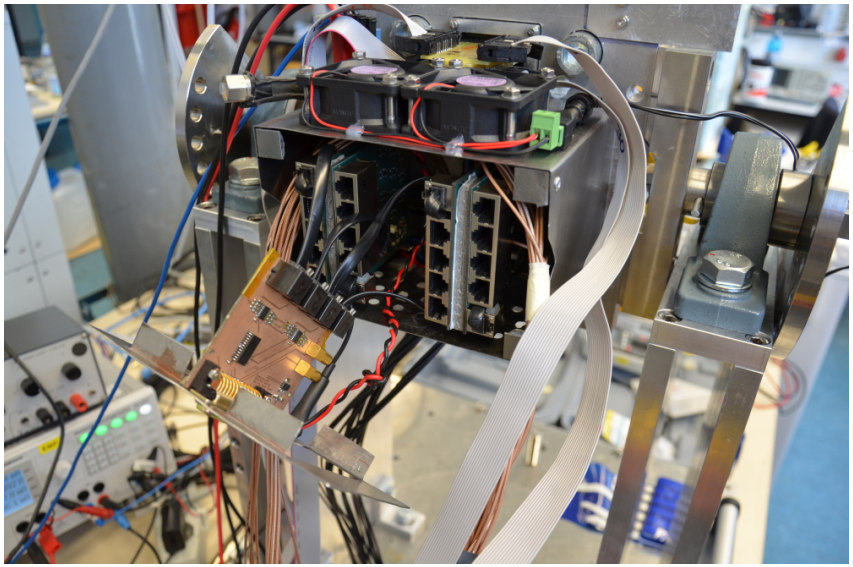
Shielding

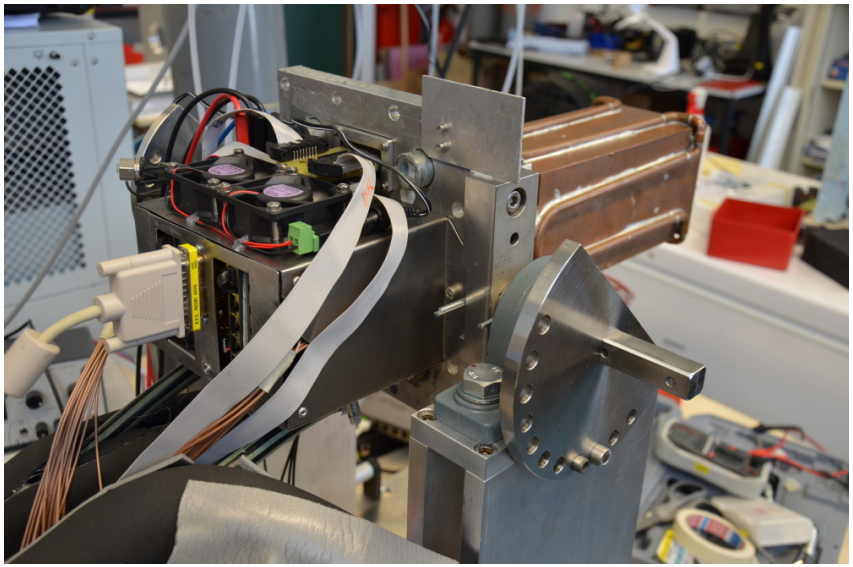
Provides

- Power supply for ASIC and line drivers
- Shielding for ASIC programming cables
- Ventilation

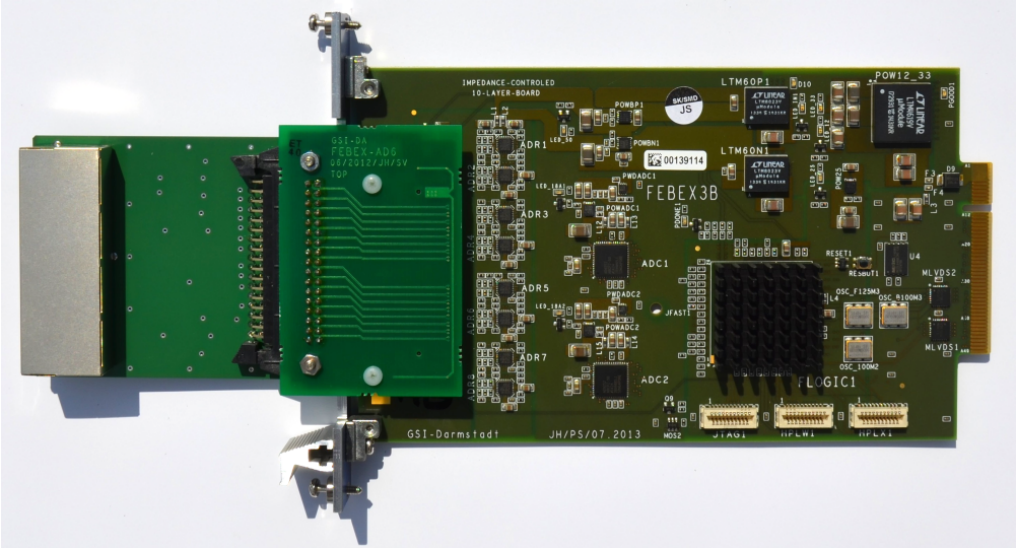
Open issue

- Shielding for Pt100 sensor cables
- Had to be unplugged during beam test





New "Receiver" Boards



- General passive adapter RJ45 to pin header connector
- Used with the Febex sampling ADC
- Possibility for voltage divider to attenuate signals

APD Characteristics

APD characteristics

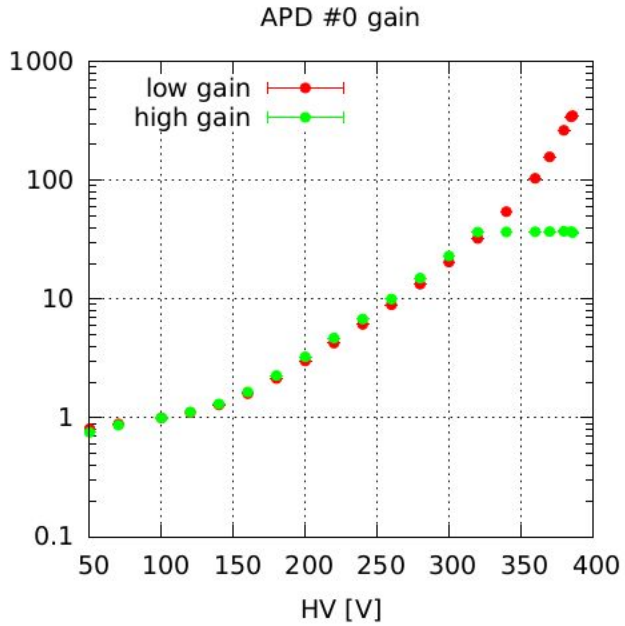
- Measured with the Proto16:
  LED pulses through optical fibres
- Last time: changing light intensity
  Now: only one intensity for all voltages
- Normalising at $U = 100$ V
- Fit function:

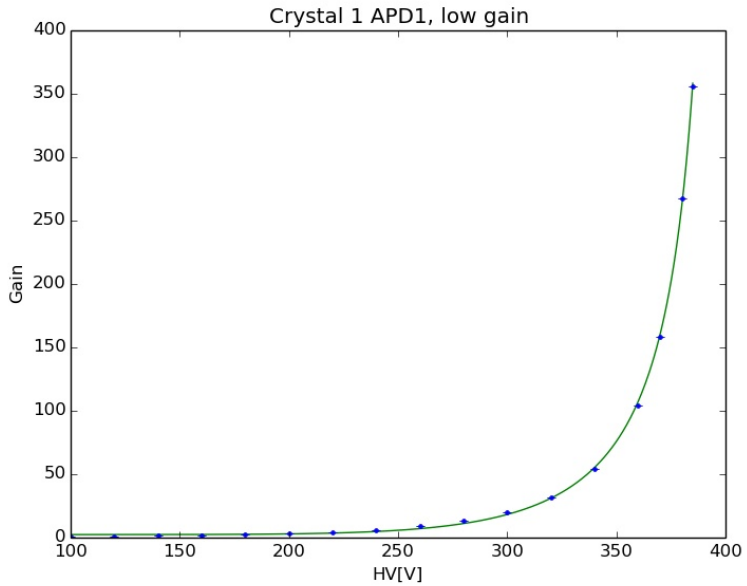
$$M = \frac{A}{1 - (U/U_{\mathrm{br.}})^k} + C$$

- Calculate U for every single APD for given M

Two Gains for Beamtime

- G = 150: $\frac{1}{G}\frac{\partial G}{\partial U} = 5\ \frac{\%}{V}$ **L**
- G = 400: $\frac{1}{G}\frac{\partial G}{\partial U} = 10\ \frac{\%}{V}$ **H**

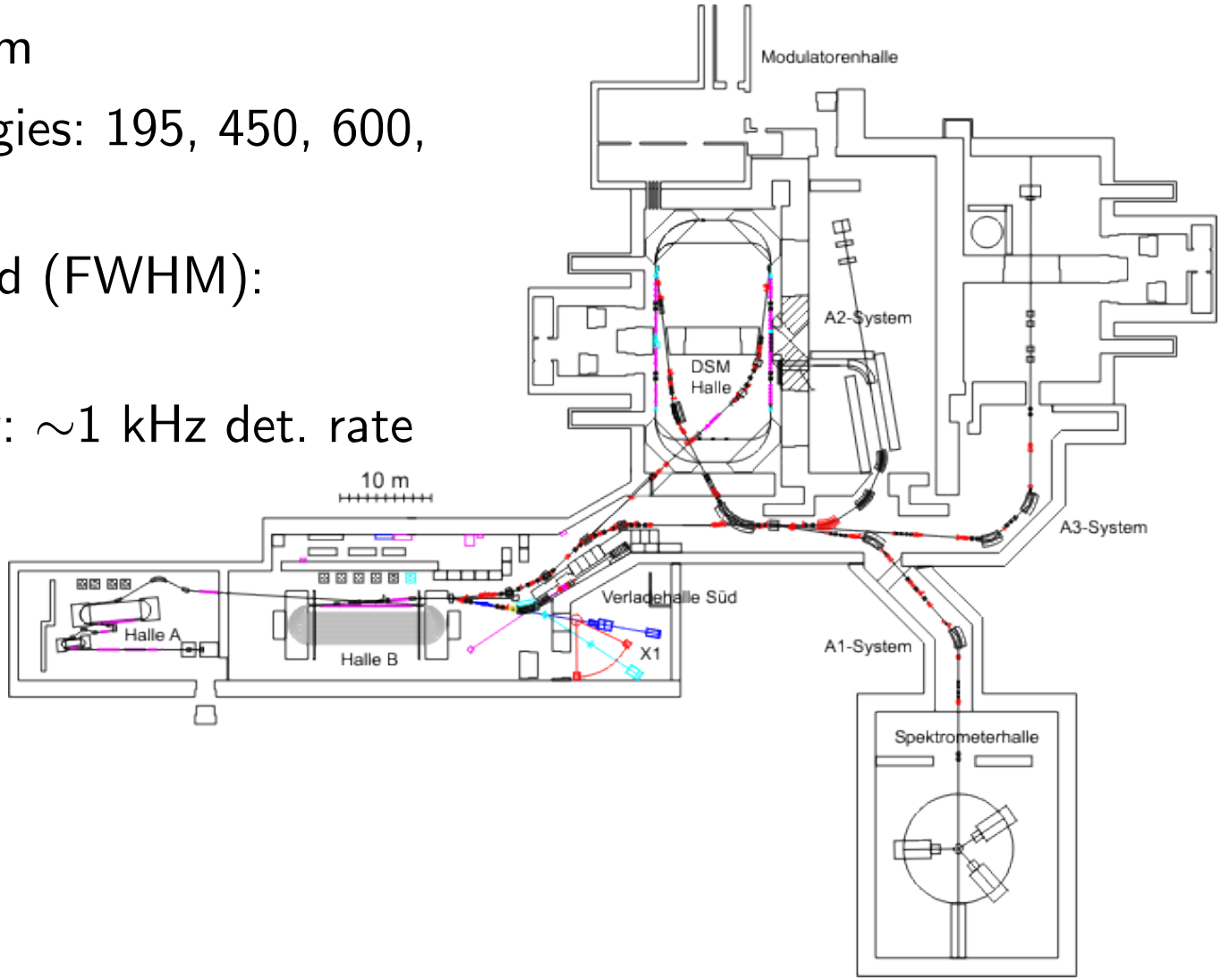




Beamtime Mai 2016

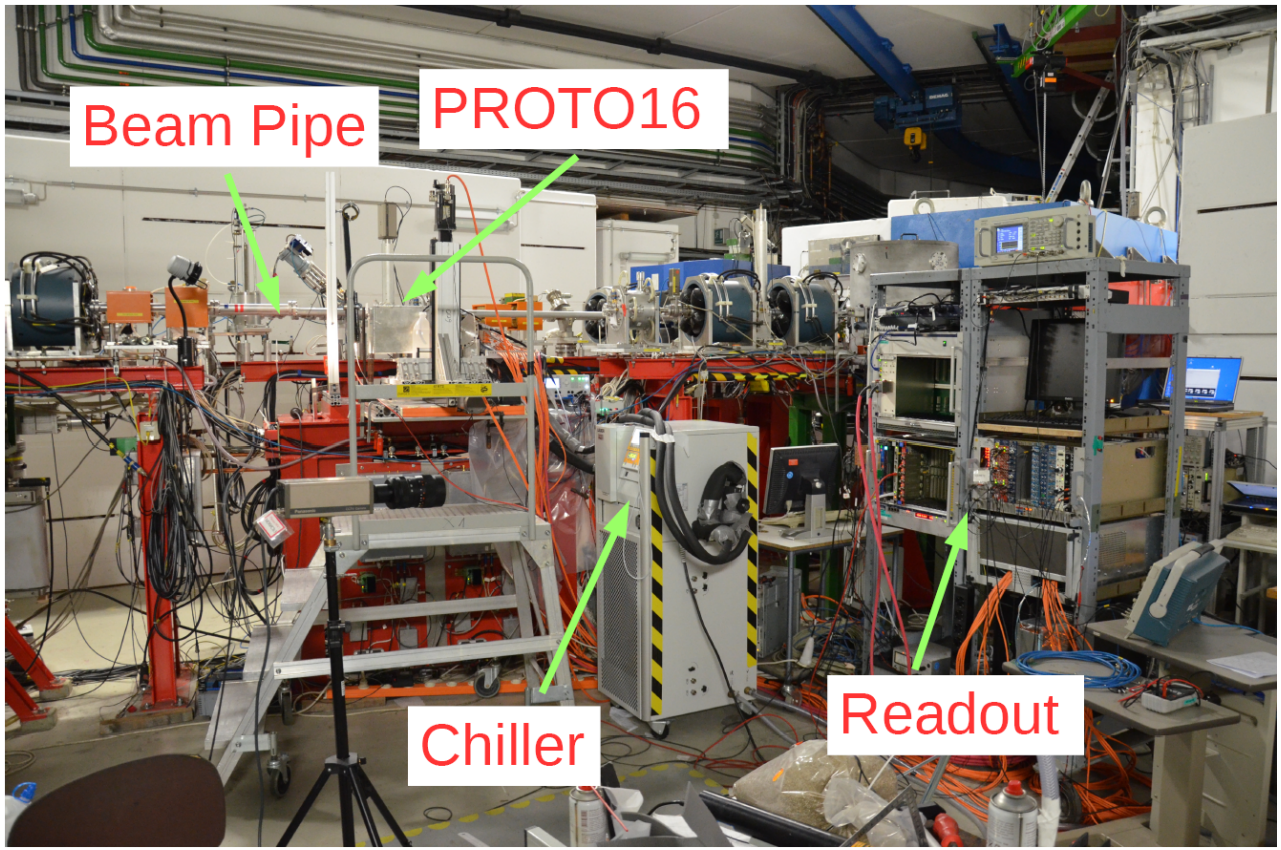
Beam test May 2016 at MAMI

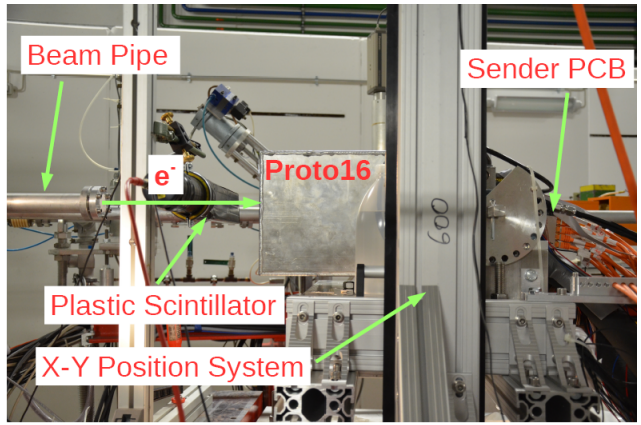
- About 50 hours: 27.5–30.5
- Electron beam
- 4 beam energies: 195, 450, 600, 855 MeV
- Energy spread (FWHM): 100 keV
- Low intensity: ∼1 kHz det. rate

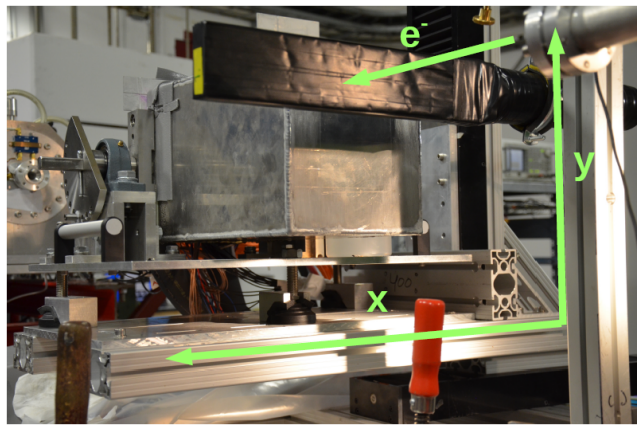


Test setup

- XY-table for centering each crystal on beam
- Rotatable plate for incidence angle scan
- Plastic scintillator for coincidence event triggering







Measurements

For each beam energy → this talk!

- Each crystal centered on beam
- Two APD gains: **L** and **H**

Position scan

- At 195 MeV and 600 MeV

Angle scan → this talk!

- At 600 MeV

PANDA ADC

- Energies: 195, 450, 600 MeV

Lowest Single Channel Threshold

Threshold Challenge for BWEC

Only one ASIC amplification for BWEC

- Find proper parameters to achieve:
  - No saturation at high energies ∼1 GeV
  - Lowest single channel threshold of ∼2 MeV
- Possible "adjusting screws":
  - ASIC **L** and **H**
  - ASIC amplification factor 10x and 20x
  - APD **L** and **H**
  - FEE attenuation or amplification

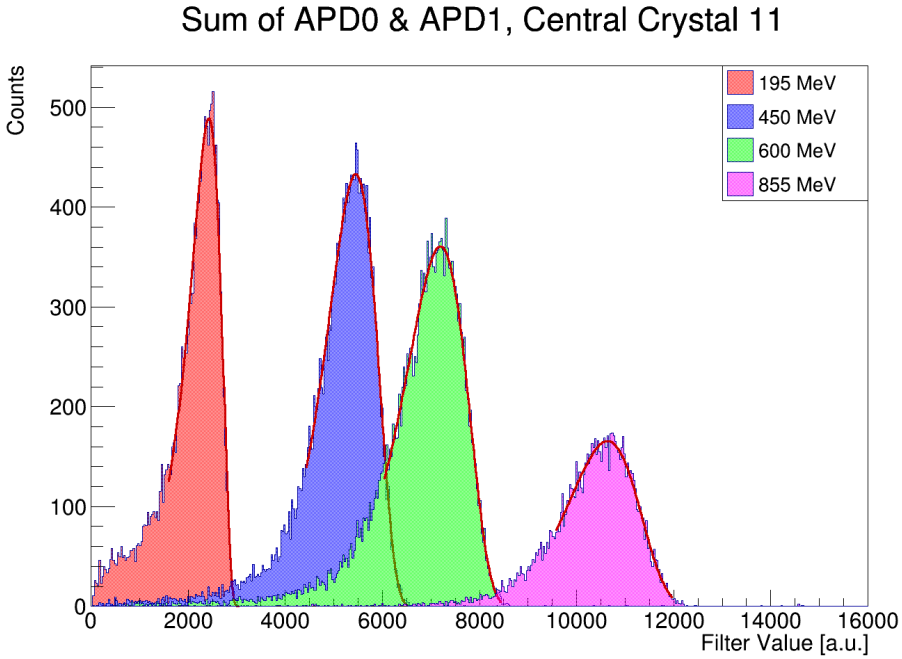
Have a look on different combinations:

APD	ASIC	
L	**L**	to small
L	**H**	interesting
H	**L**	interesting
H	**H**	way to big

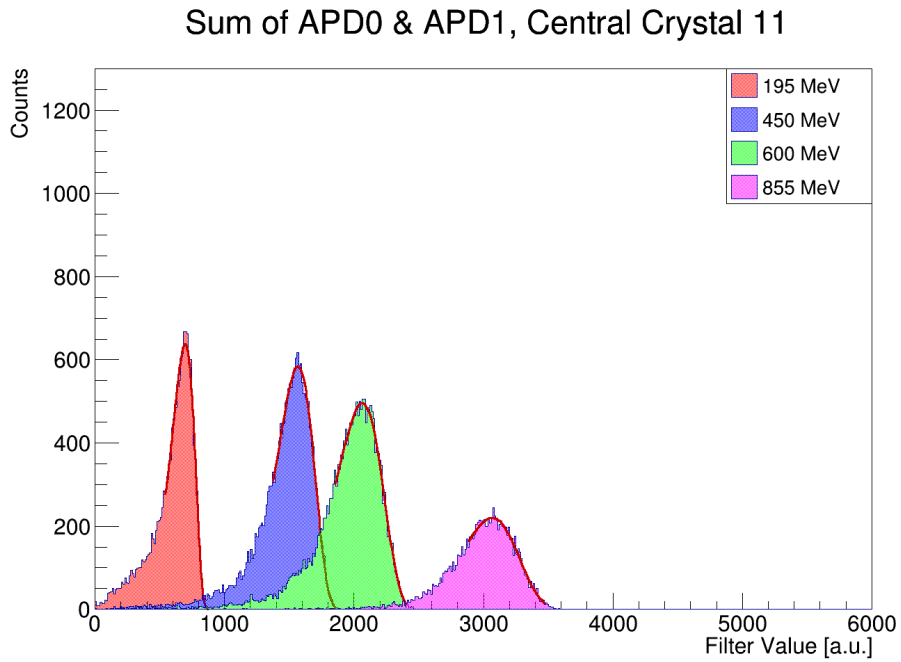
Threshold Scan - Single Channel Spectra

- Central crystal
- Value $= \frac{1}{2} \sum APD_i$
- **LL** to small (1/16 ADC range)
- **HH** way to big

LH - full ADC range



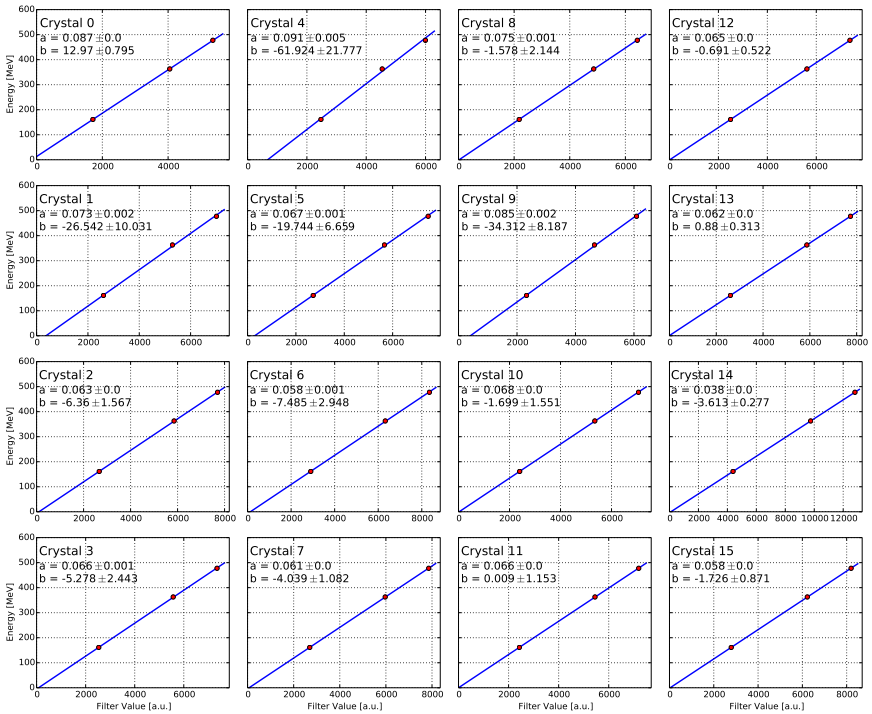
HL - 1/4 ADC range



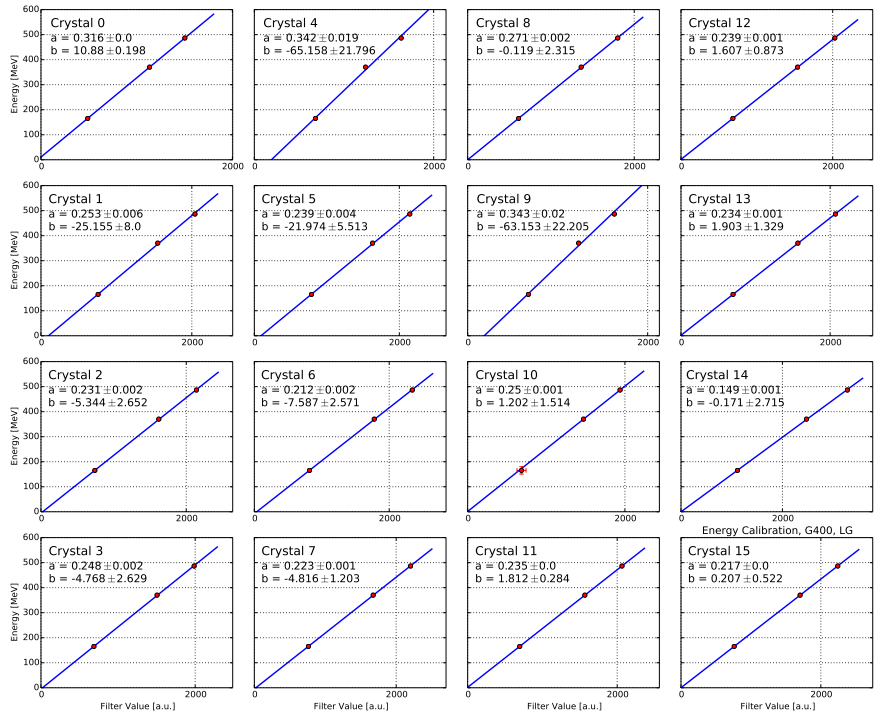
Threshold Scan - Energy Calibration

- Using central crystal data
- 195, 450, 600 MeV
- Deposited energy correction (beam data)

LH - Energy Calibration

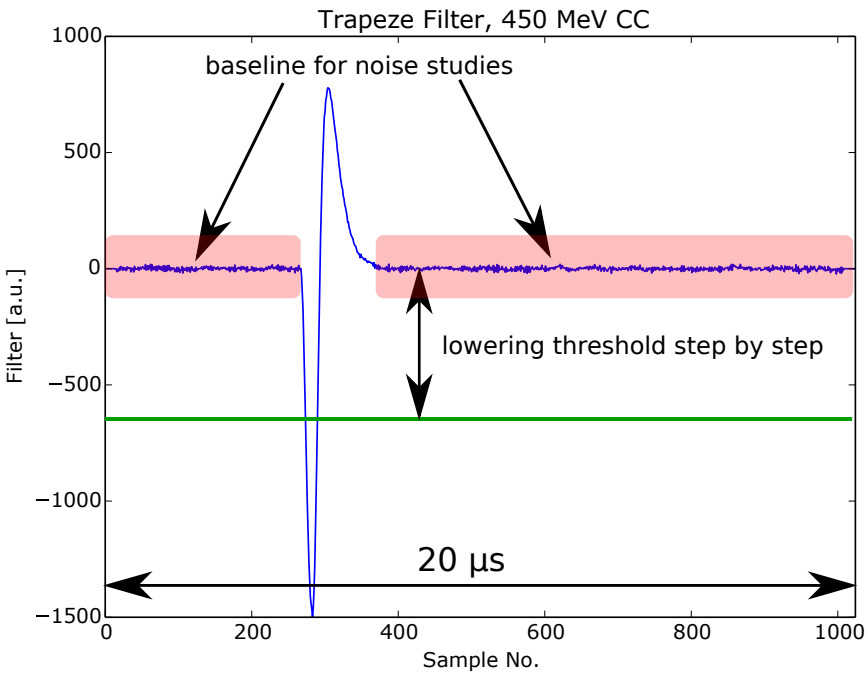


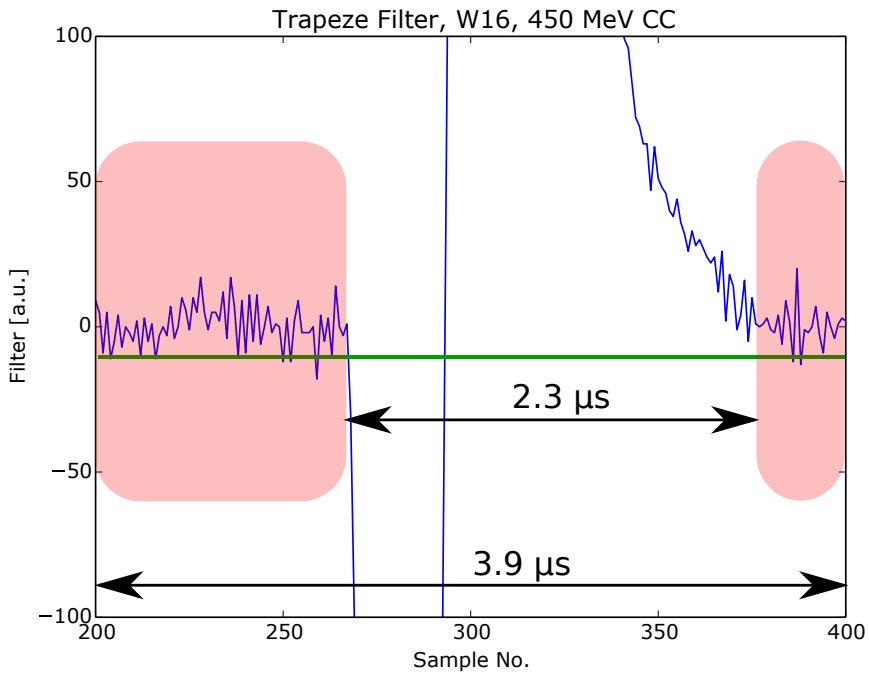
HL - Energy Calibration



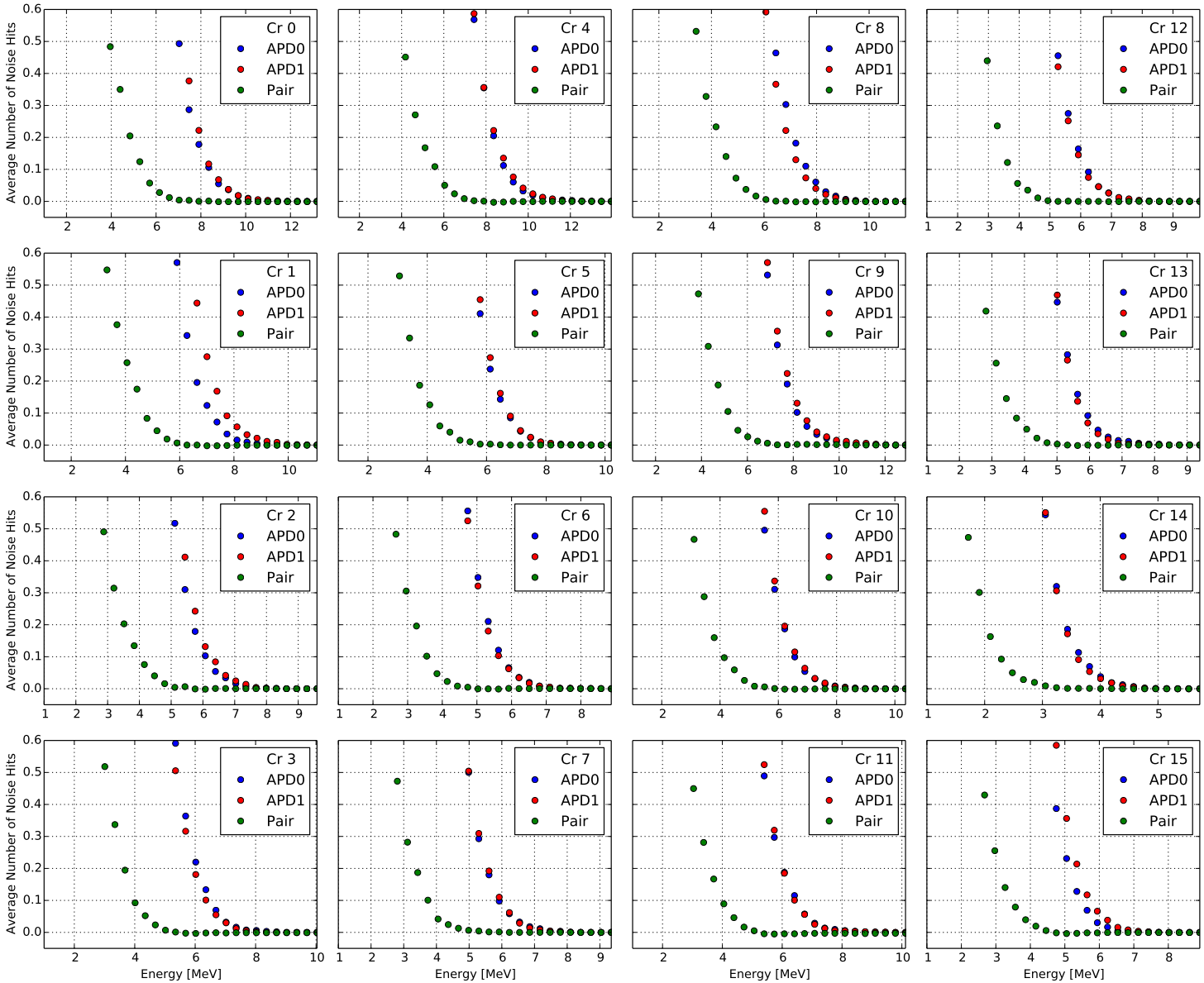
Threshold Scan - Method

- Using filtered traces
- Lowering threshold step by step
- Count number of hits on trace at a given threshold
- Average of 1390 events (traces)

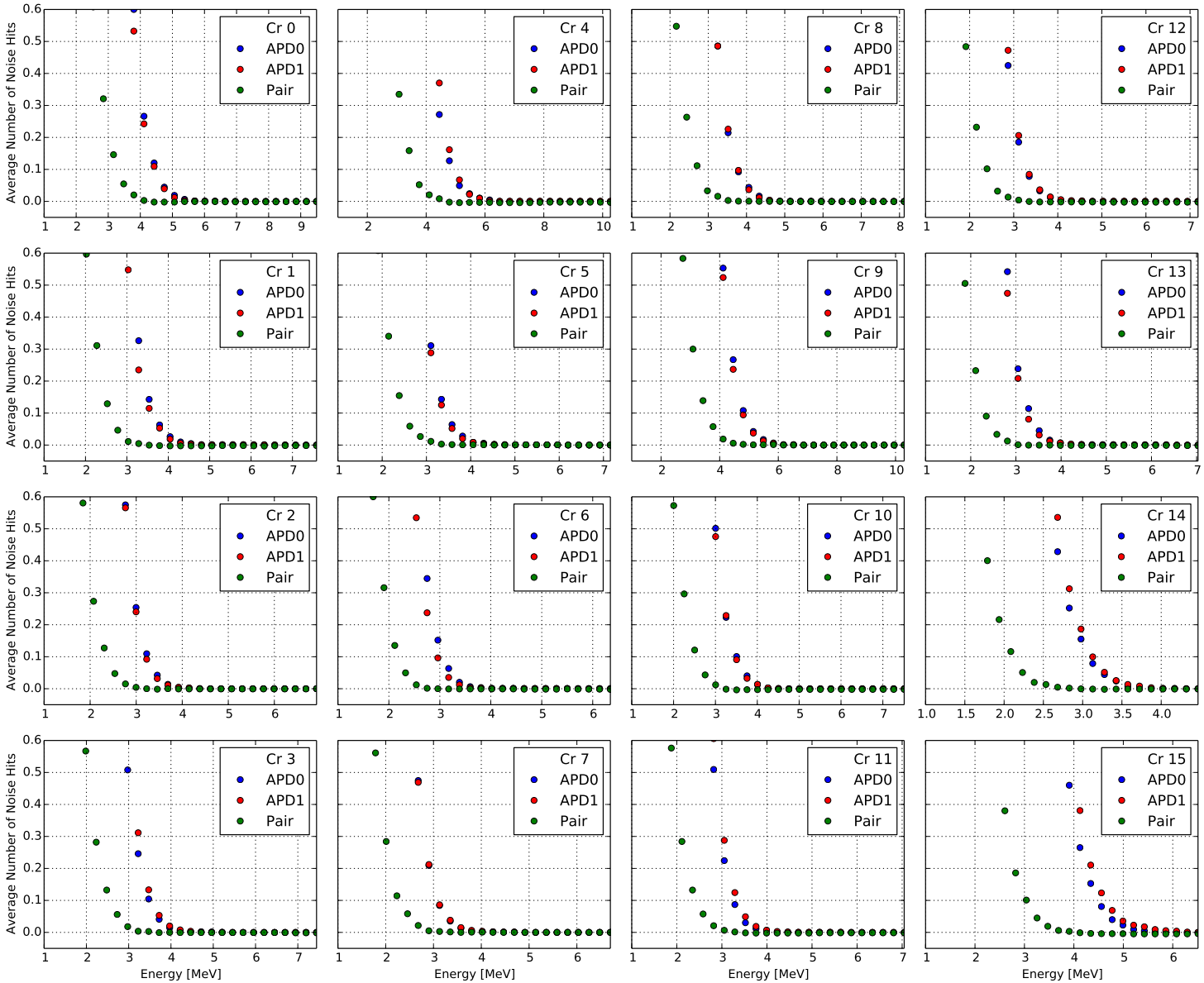




Threshold Scan - LH



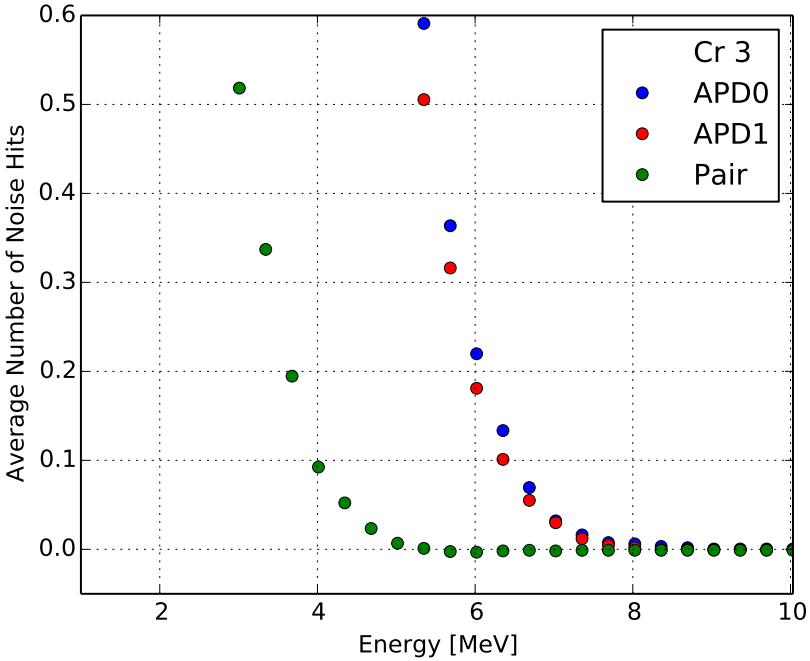
Threshold Scan - HL



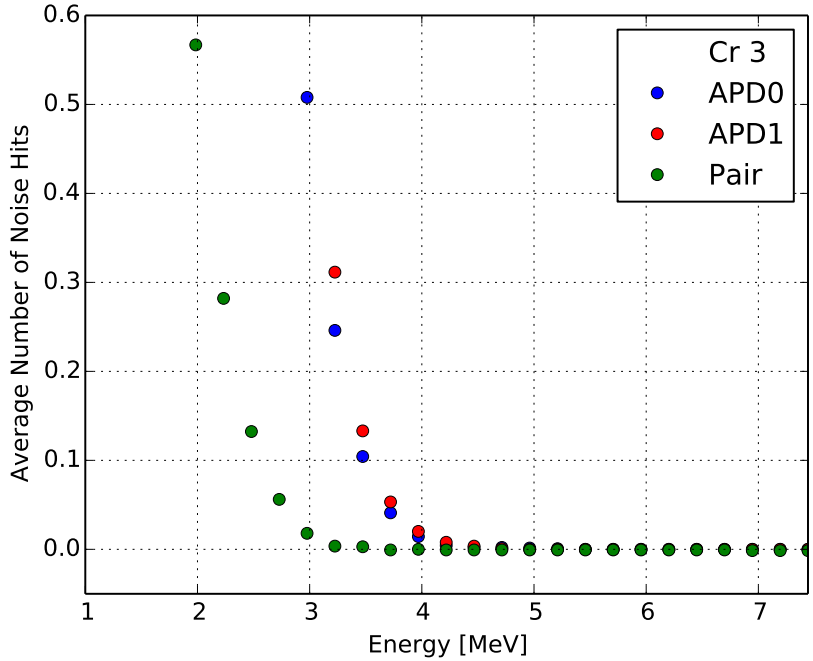
Threshold Scan - Conclusion

- Noise/signal ratio better at high APD gain
- Still some headroom until access noise
- Possible way to go:
  - Set APD gain $\rightarrow$ 2 MeV threshold
  - Attenuate/amplify at FEE level $\rightarrow$ exploit ADC range

LH $\sim$ 5 MeV Threshold



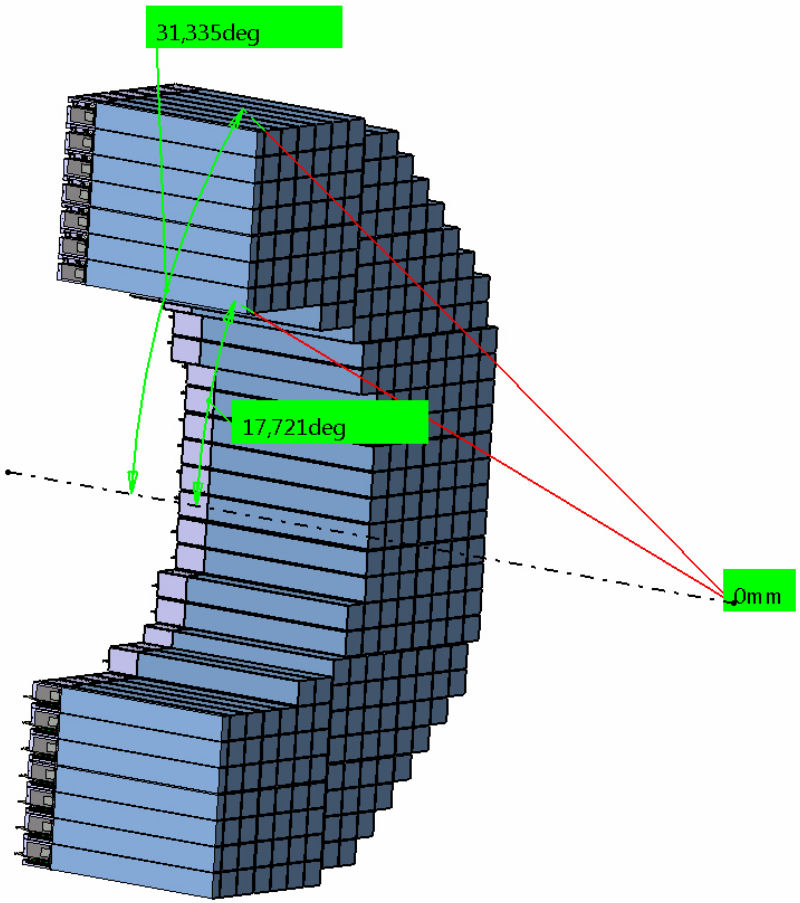
HL $\sim$ 3.5 MeV Threshold



Angle Scan

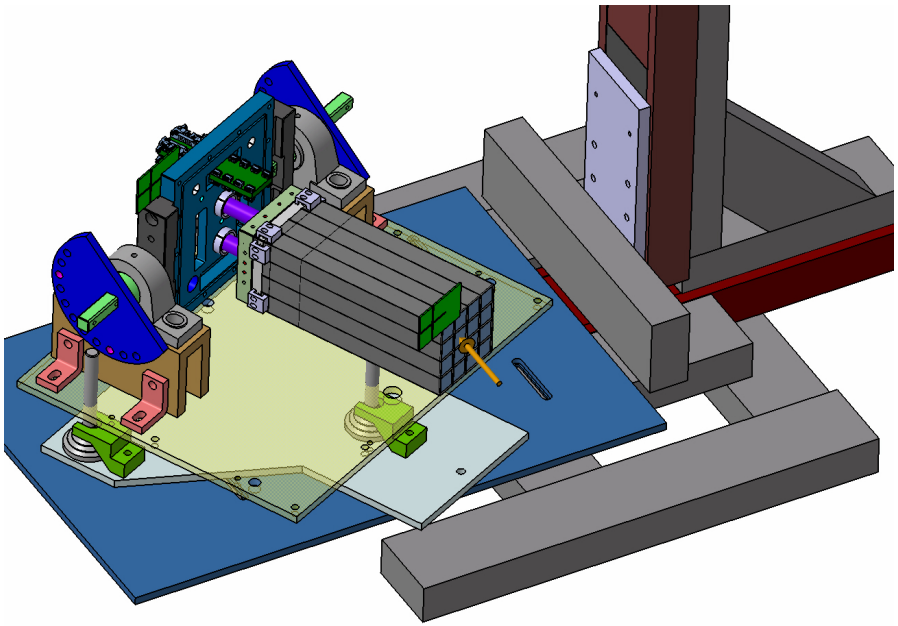
Angle Challenge for BWEC

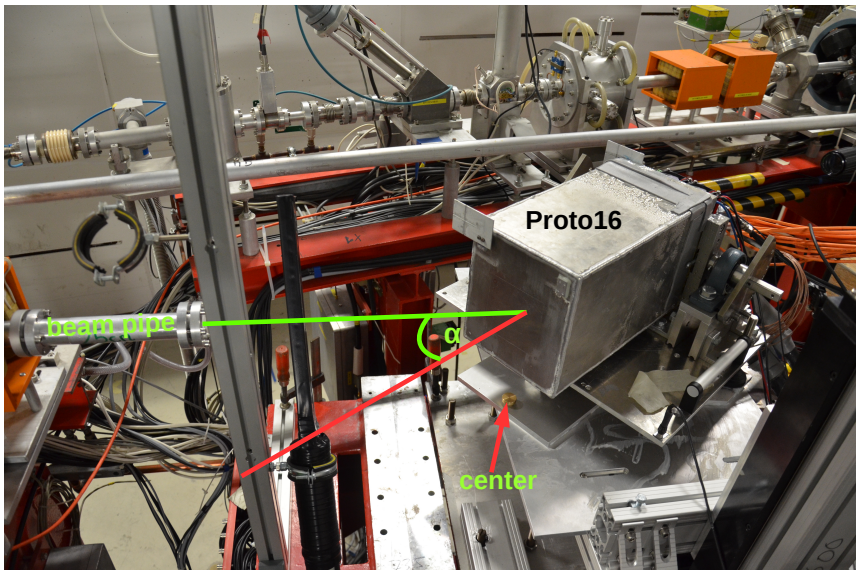
- BWEC crystals not aligned with scattering angle
- Incidence angle between 17°and 32°
- Influence on energy resolution?



Angle Scan - Positioning System Update

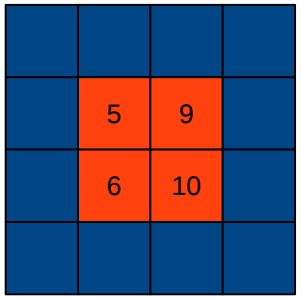
- Add rotation axis to Proto16 X-Y table
- Coordinate transformation $\rightarrow$ center of projection
- Data for 0°, 15°, 25° and 35° at 600 MeV



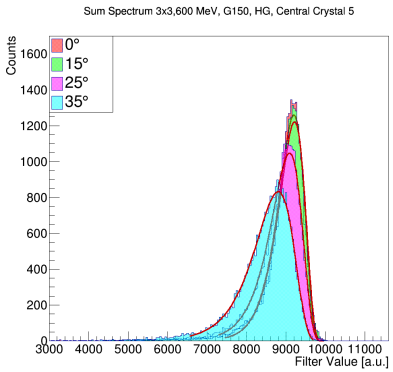


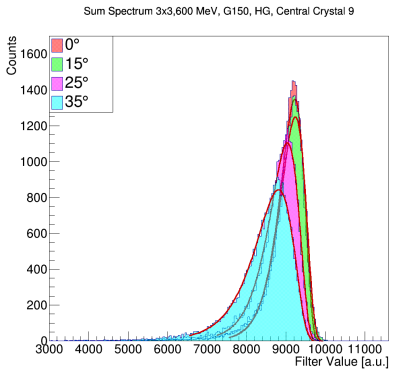
Angle Scan - Comparing 3x3- and 4x4-Matrix

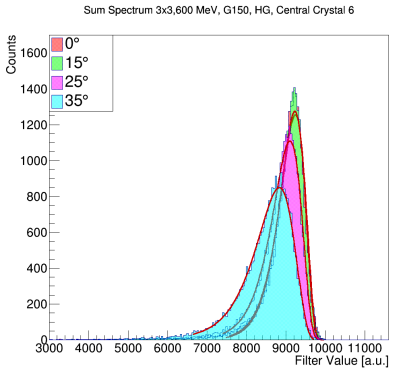
- Losing deposited energy in 3x3 matrix
- No problem if there are enough neighbouring crystals

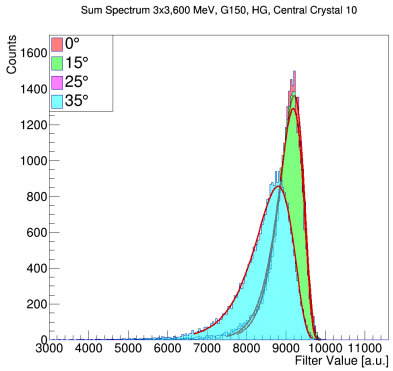


3x3 matrix - sum spectra

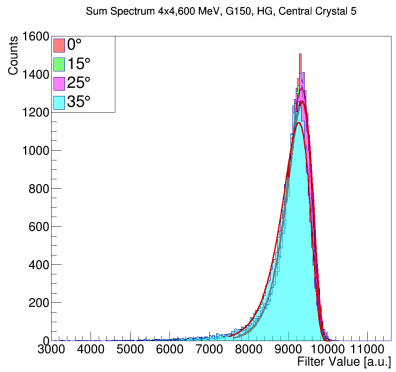


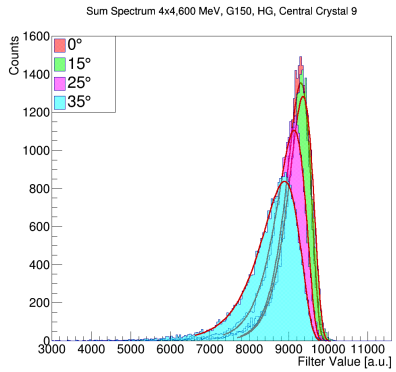


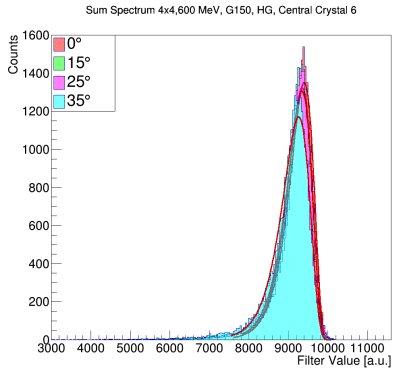


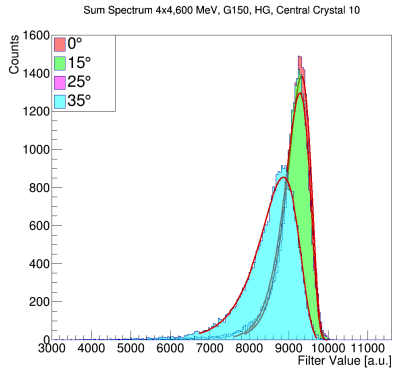


4x4 matrix - sum spectra



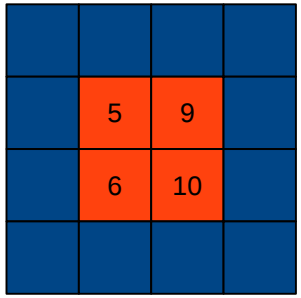




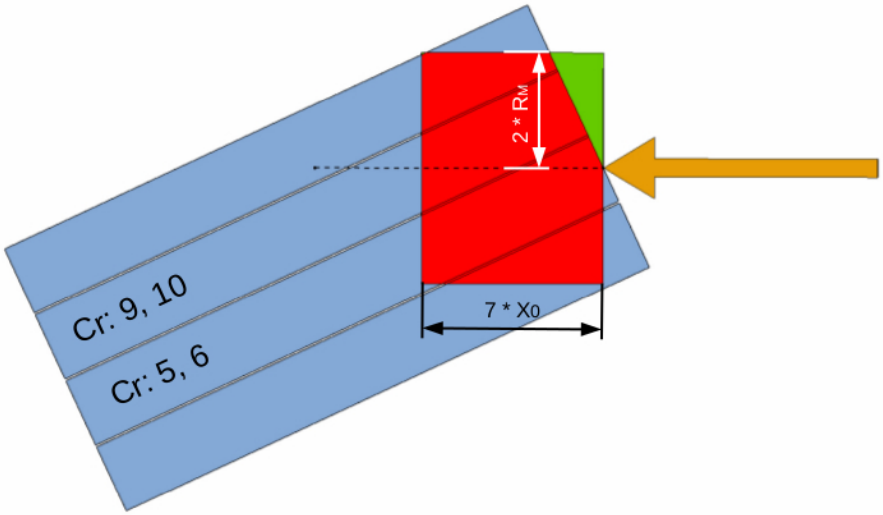


Angle Scan - Comparing 3x3- and 4x4-Matrix

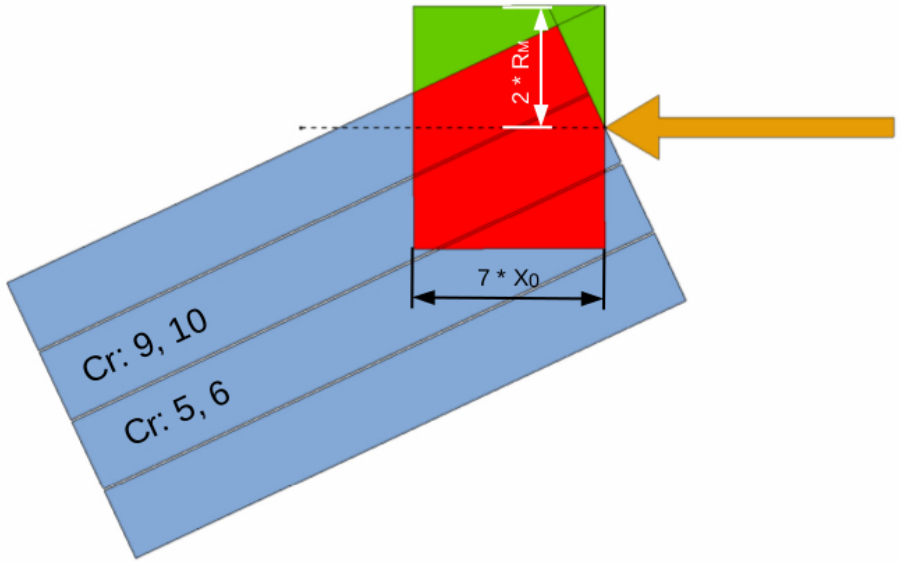
- The smaller the angel the better
- The more surrounding crystals the better



Inner crystals - less energy loss (4x4)

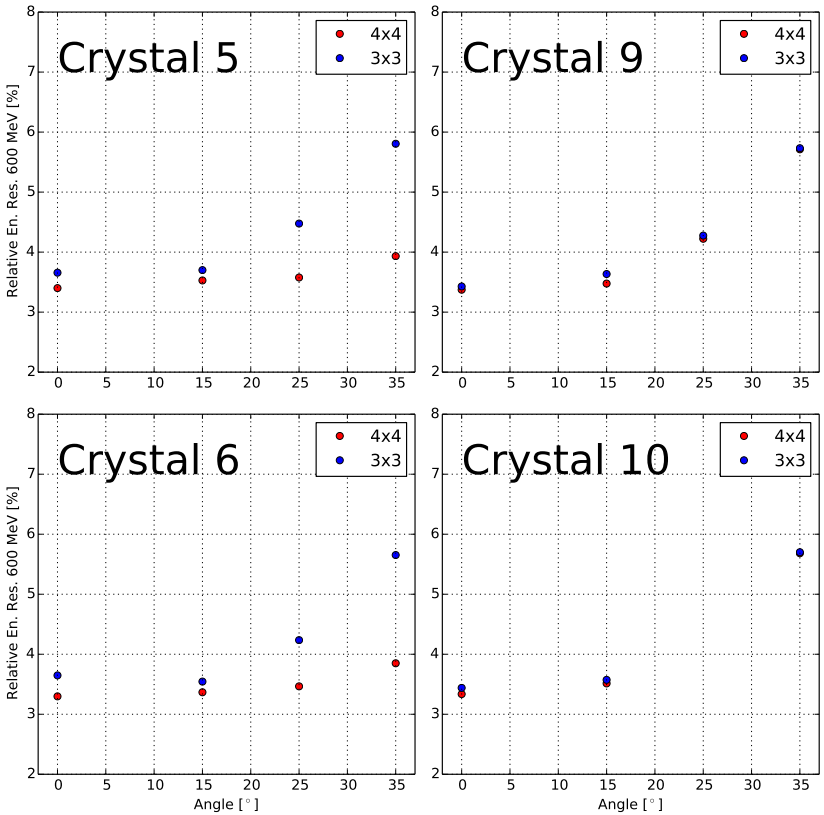


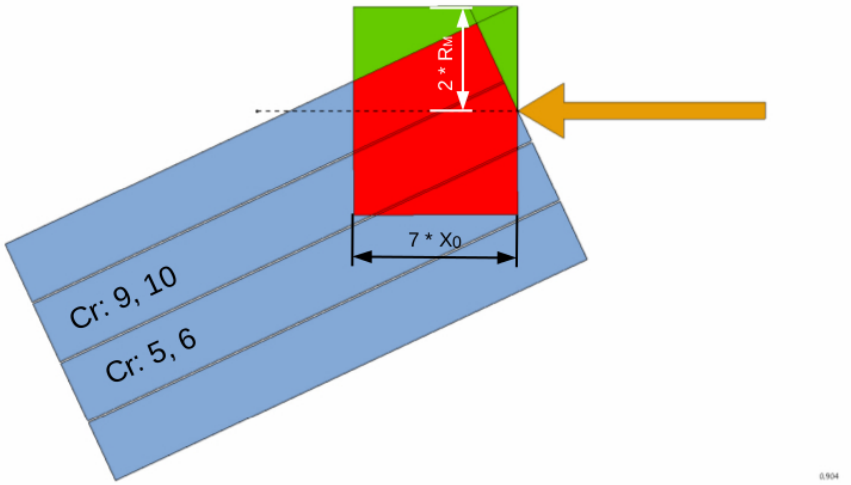
Outer crystals - no difference between 3x3 and 4x4

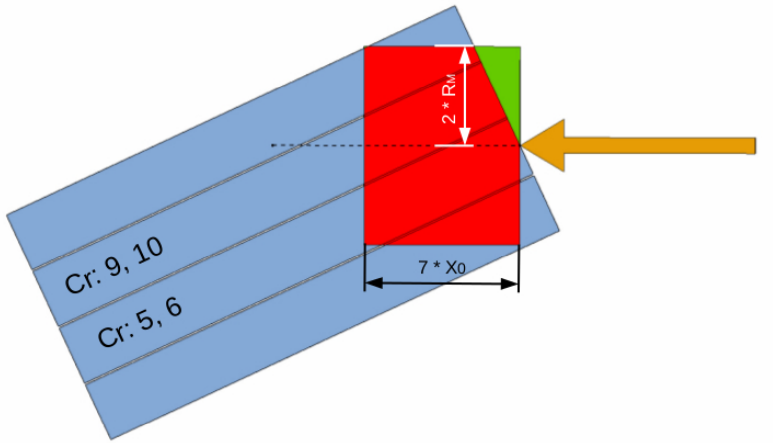


Angle Scan - Relative Energy Resolution

Relative energy resolution
as function of incidence angle
at 600 MeV:







Conclusion and Outlook

Conclusion

- Development of standard procedure to determine lowest channel threshold
- Perfect for finding a proper APD gain
- BWEC will have a nice energy resolution at the inner crystal ring. Some losses at outer ring.

Outlook

- Find proper APD gain and FEE att./ampl.
- Go on with analysis:
  - Position scan
  - PANDA ADC
- Preparing beamtime in December in the tagger facility (gammas) at low energies, and tagging pre-shower events with an extra detector