First results for the energy resolution of the PROTO120/PROTO7 with a tagged photon beam @Mainz

Christoph Rosenbaum, D. Bremer, S. Diehl, P. Drexler, V. Dormenev, T. Eissner, C. Le Galliard, M. Imre, M. Kavatsyuk, T. Kuske, D. Marchand, R. W. Novotny, P. Rosier, A. Ryantzev, P. Wieczorek, A. Wilms, H.-G. Zaunick

$\overline{\text{P}}$ANDA L. collaboration meeting

September 9th, 2014

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

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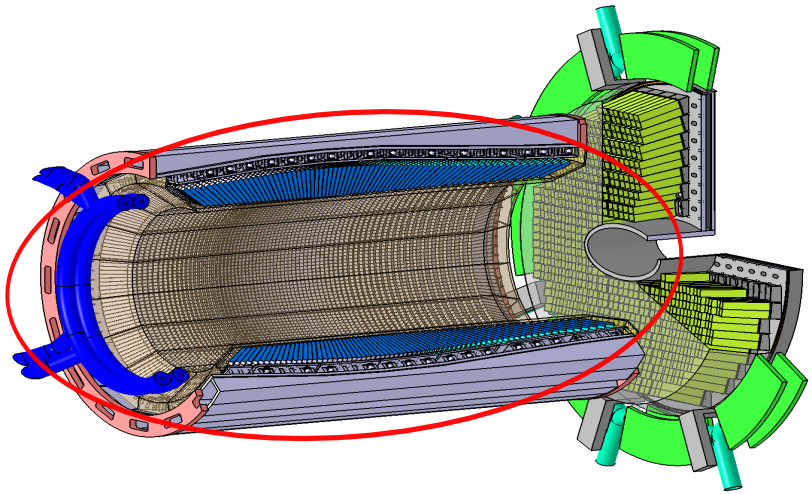
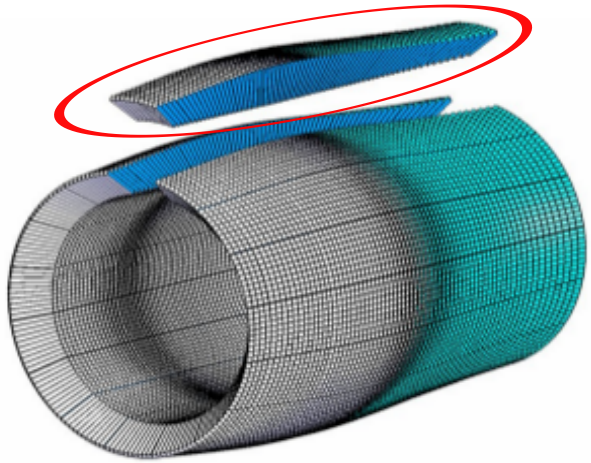
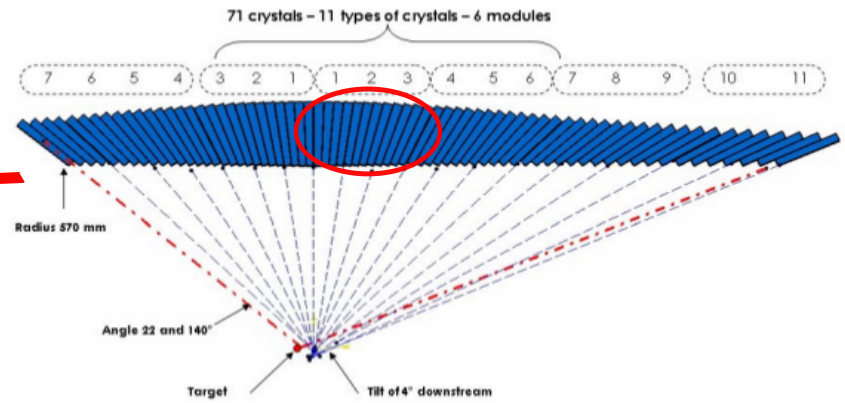
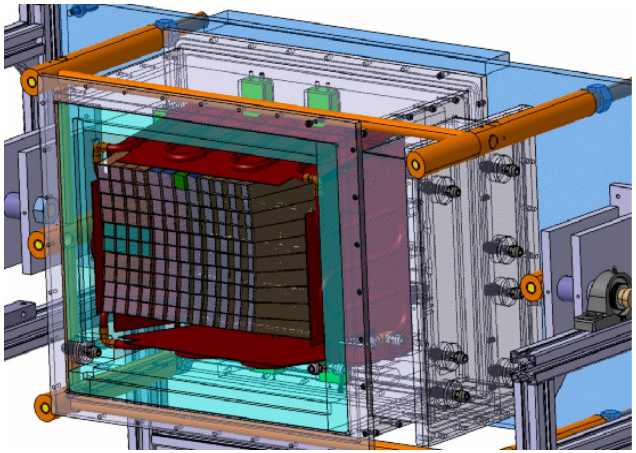
Helmholtz International Center

PROTO120

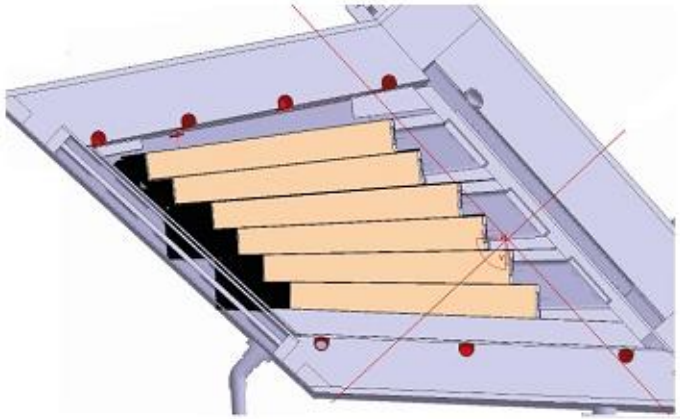


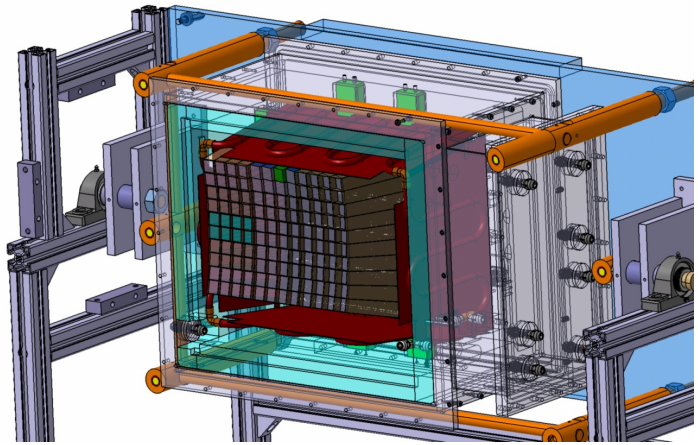



71 crystals – 11 types of crystals – 6 modules
7 6 5 4 3 2 1 1 2 3 4 5 6 7 8 9 10 11
Radius 570 mm
Angle 22 and 140°
Target
Tilt of 4° downstream



PROTO60 vs. PROTO120





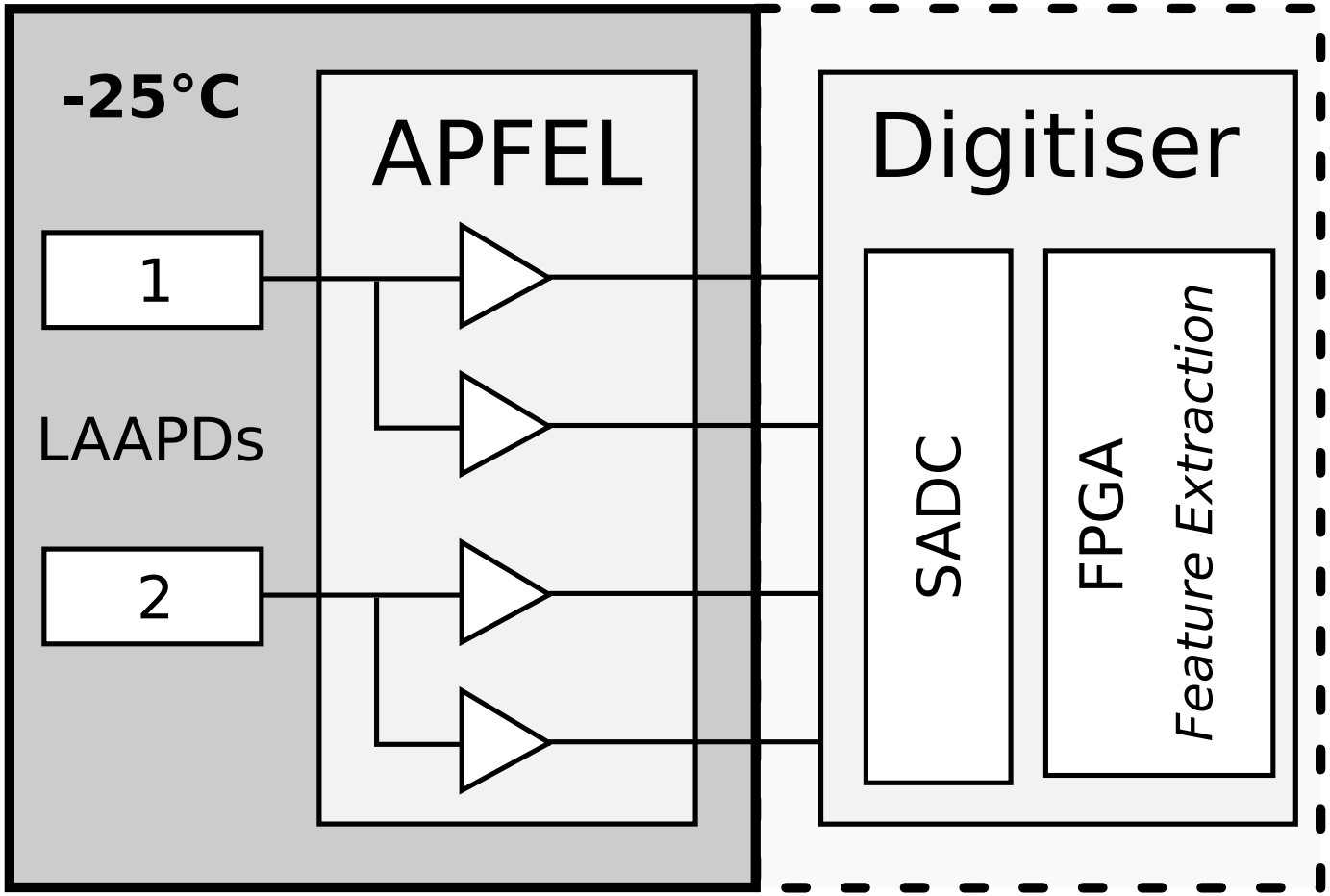
PROTO60

- single LAAPD readout with 1 cm^2 effective area (quadratic)
- low-noise low-power charge preamplifier (LNP)
- trick: different gains in inner and outer ring
- required resolution parameters achieved

PROTO120

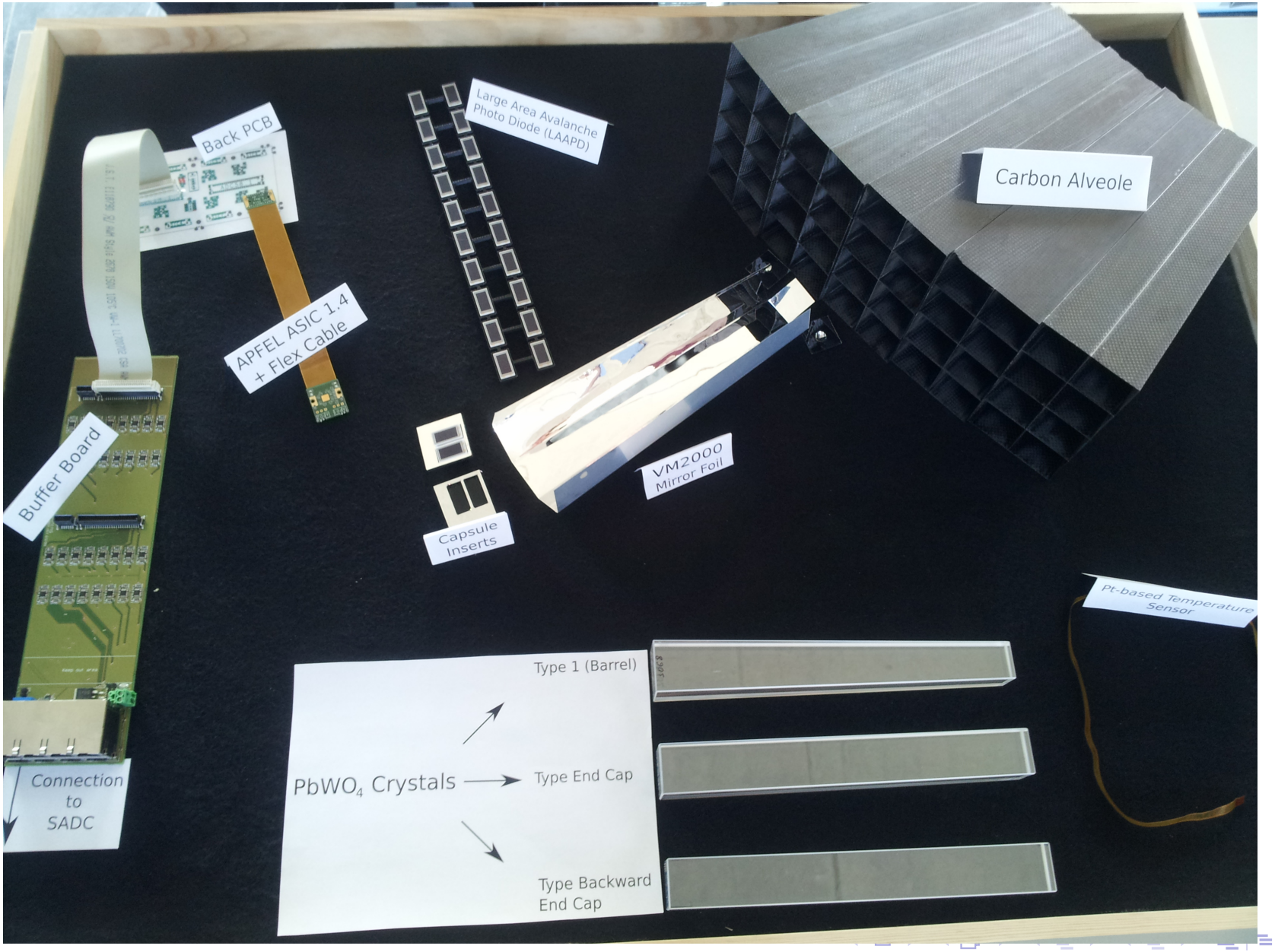
- 120 PWO crystals of type 1, 2 and 3
- 2 LAAPDs per crystal
- APFEL readout 1.4 with final dynamic range
- close to final mechanics
- new x-y-z table

Readout of PROTO120



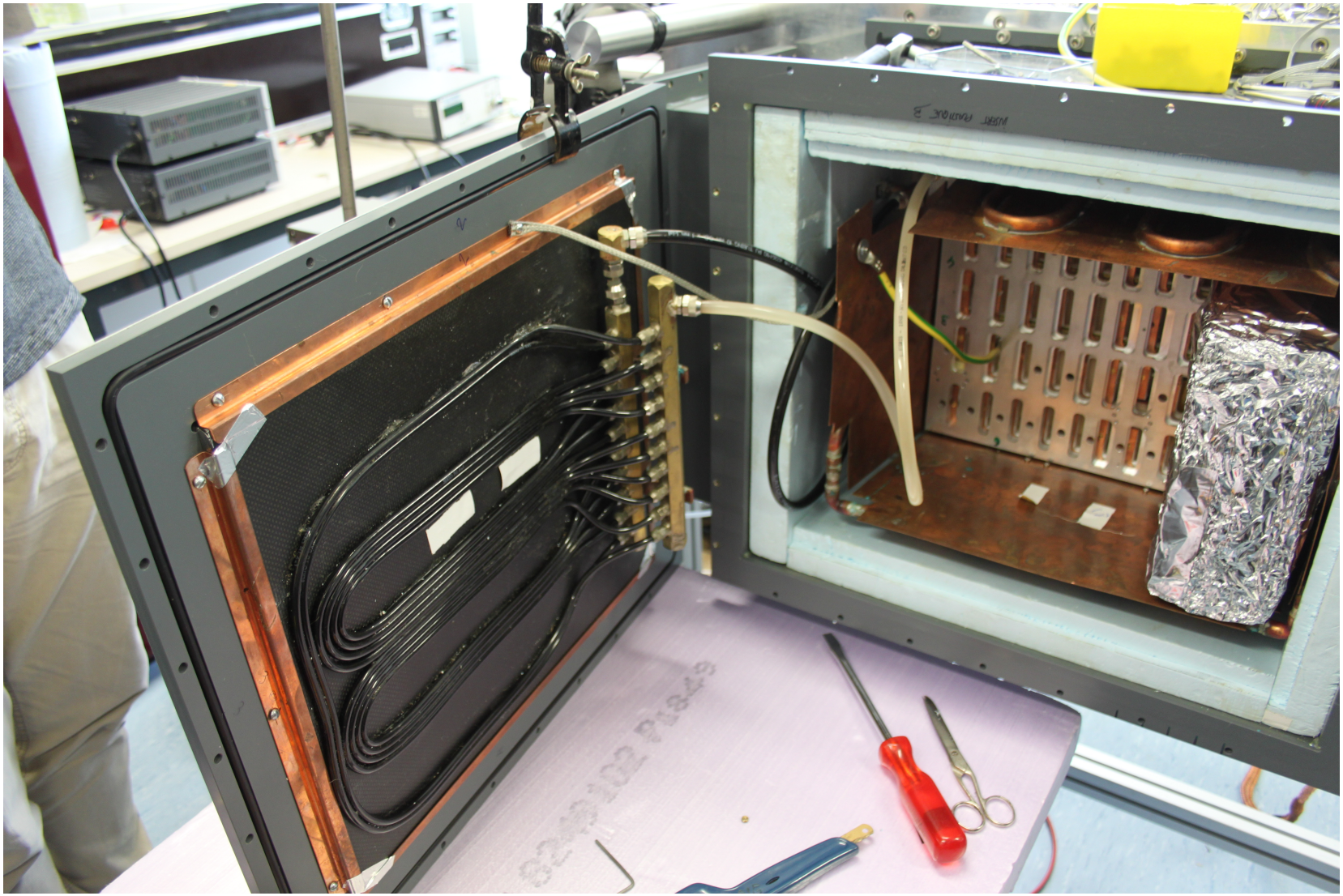
- 2 LAAPDs are read out simultaneously by one APFEL ASIC 1.4
- two channels with different gains
- dynamic range of 10000
- programmable amplification between 16-32

Readout


Back PCB
Large Area Avalanche Photo Diode (LAAPD)
Carbon Alveole
APFEL ASIC 1.4 + Flex Cable
Buffer Board
VM2000 Mirror Foil
Capsule Inserts
Pt-based Temperature Sensor
Connection to SADC
Type 1 (Barrel)
PbWO4 Crystals
Type End Cap
Type Backward End Cap

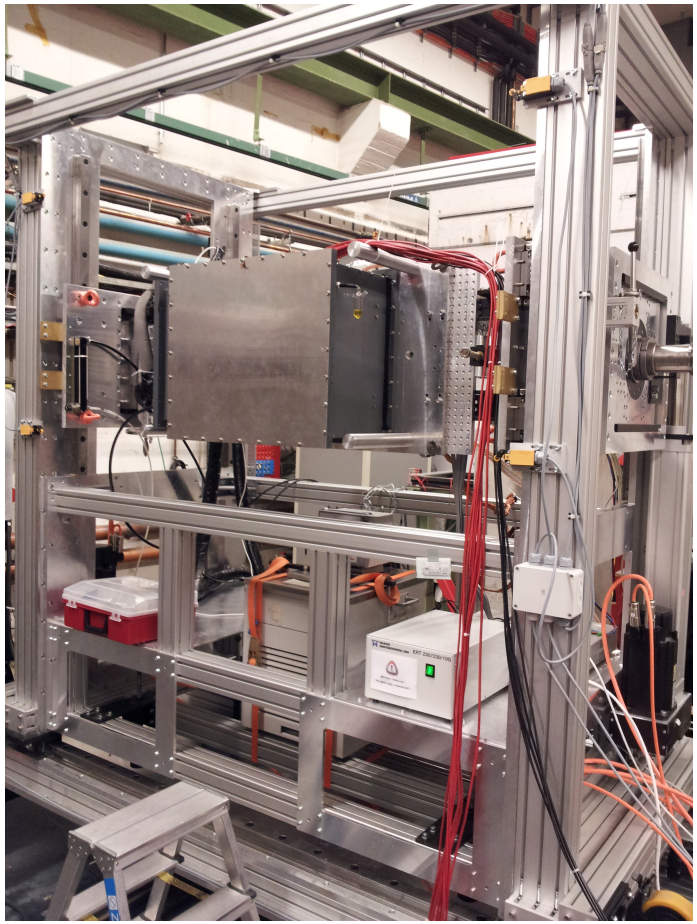
PROTO120/PROTO9/PROTO7 Setup

Shielding



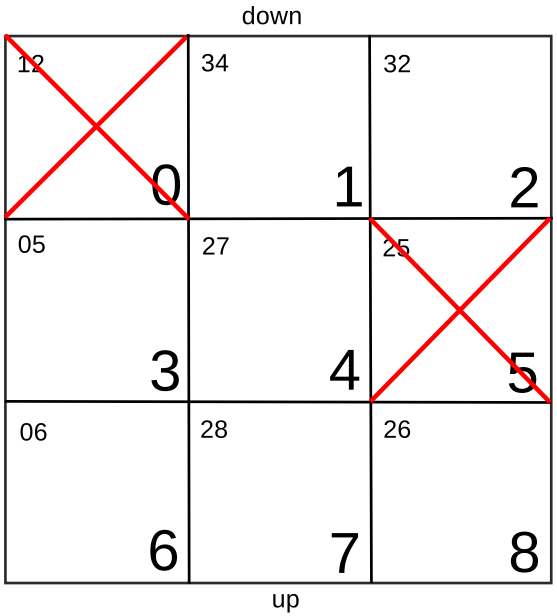
Beamtime in Mainz

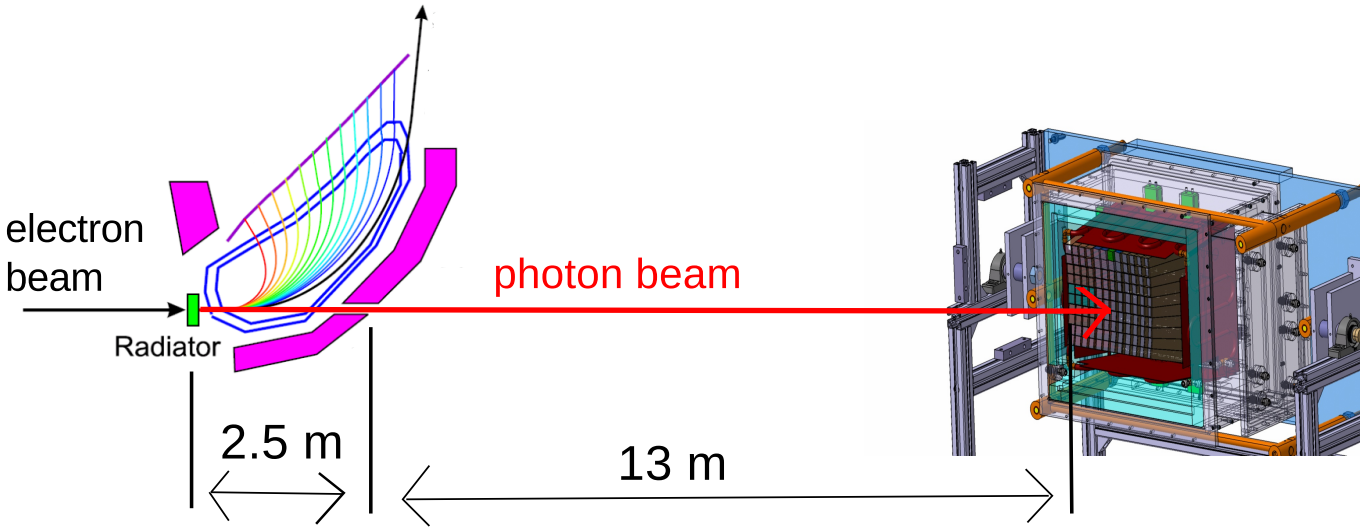
- assembly at MAMI



Setup

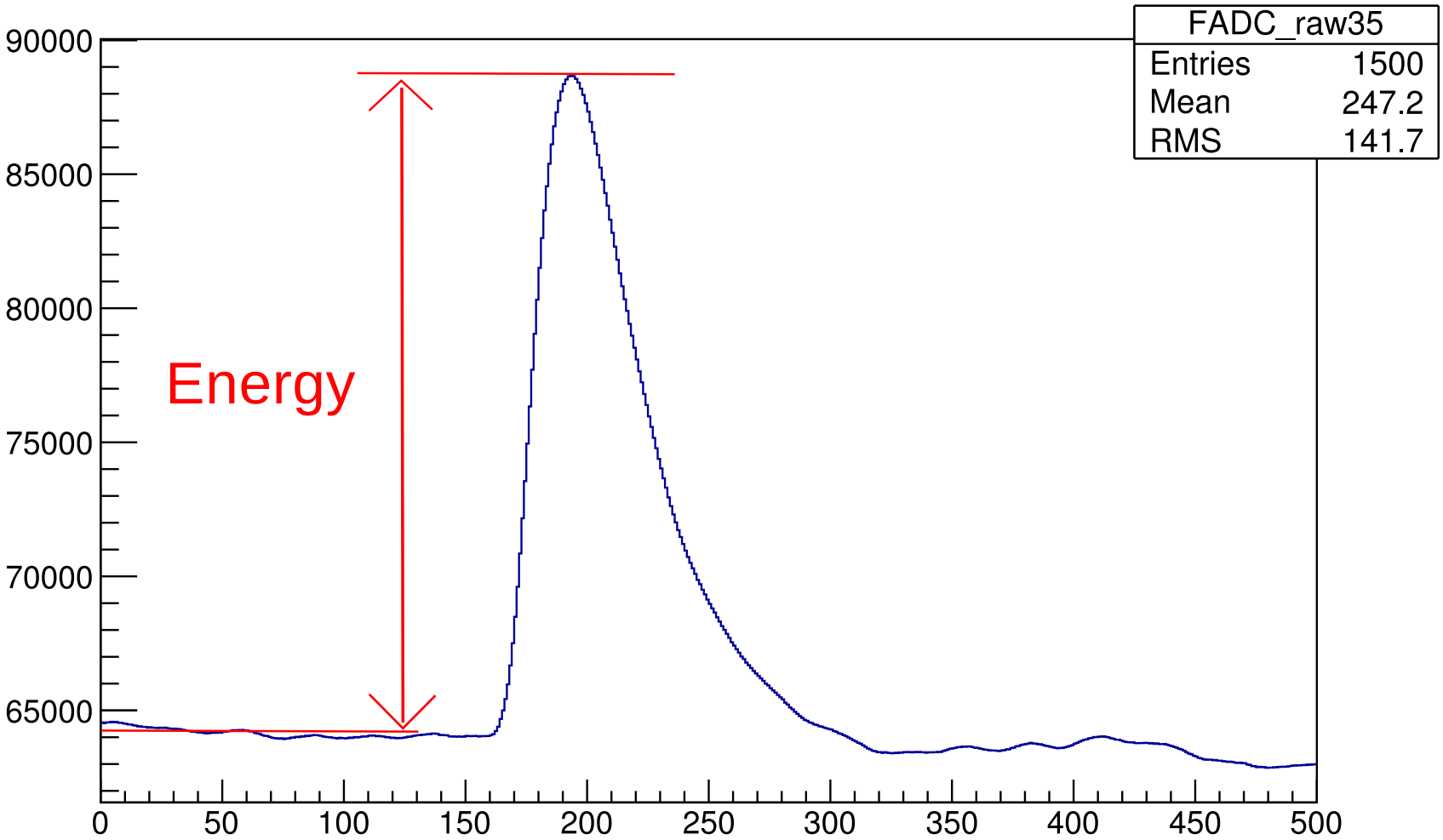
- read out 7 crystals (28 channels) of type I with SADCs (SIS3302)
- 830 MeV tagged photon beam
  - calibration run in each crystal
  - one long run in the central crystal
- currently only high gain with relative gain 32 analysed



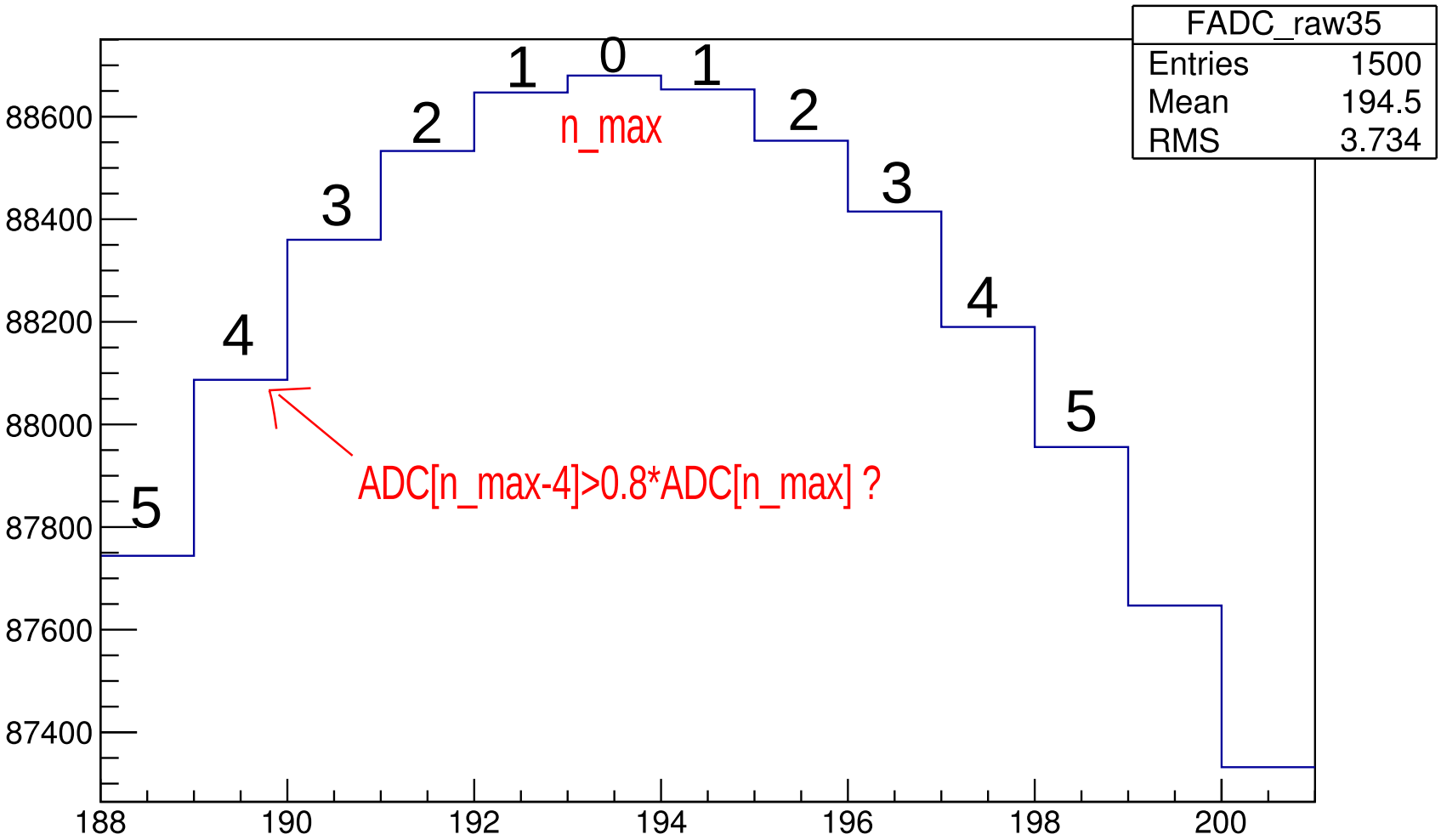


Feature extraction

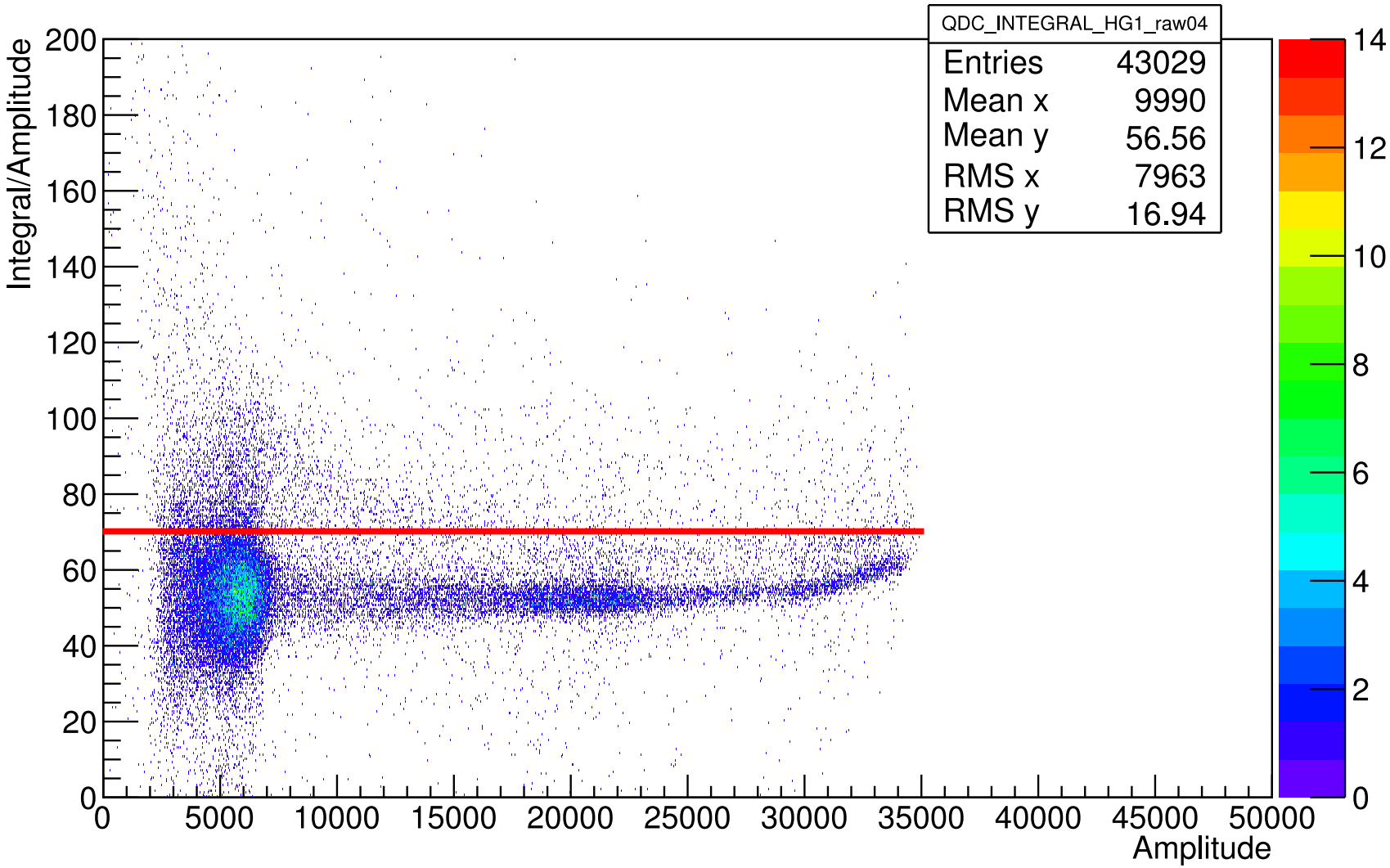
- pulse height (pulse maximum - baseline) is extracted as energy information



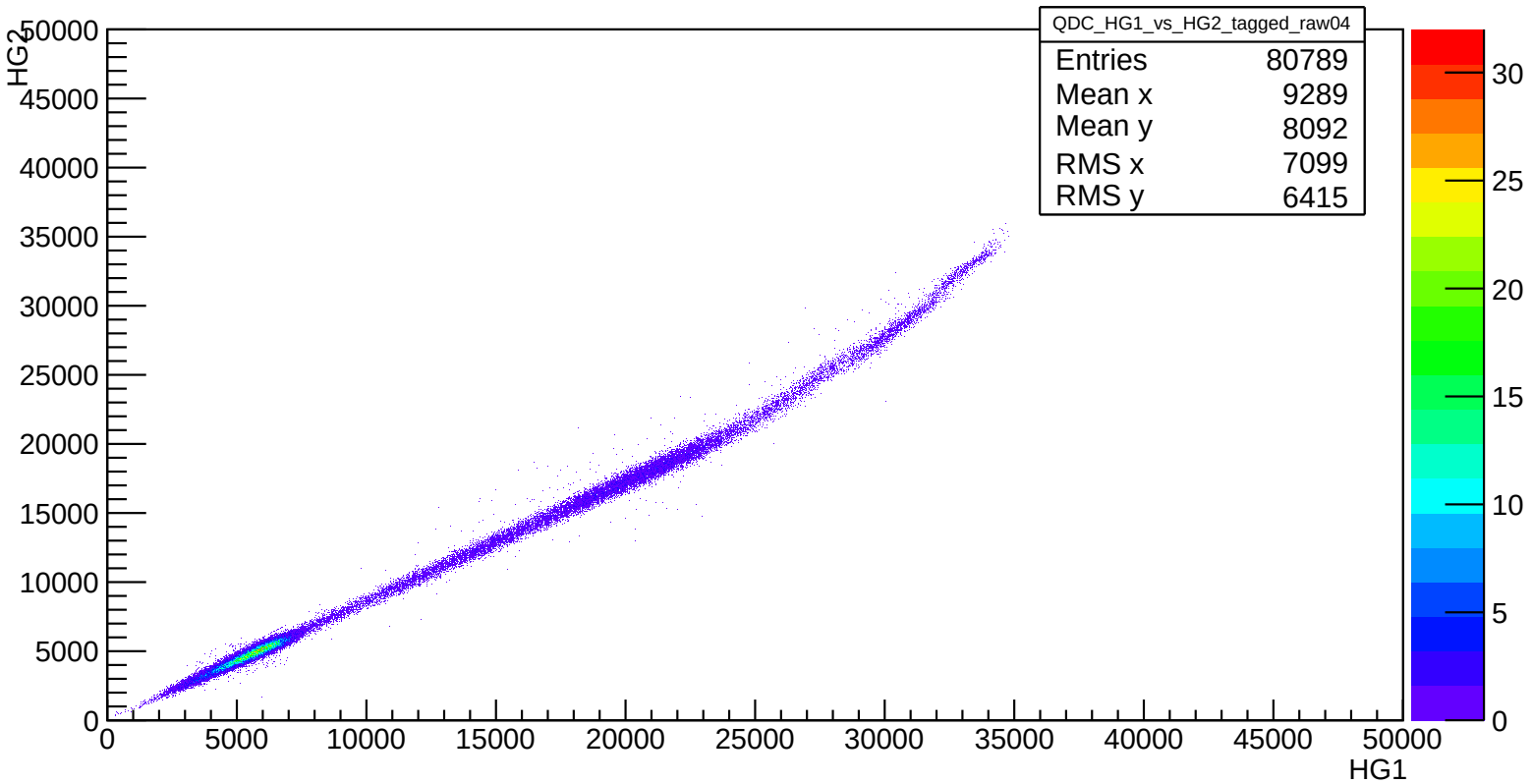
Spike rejection



Pile-up rejection

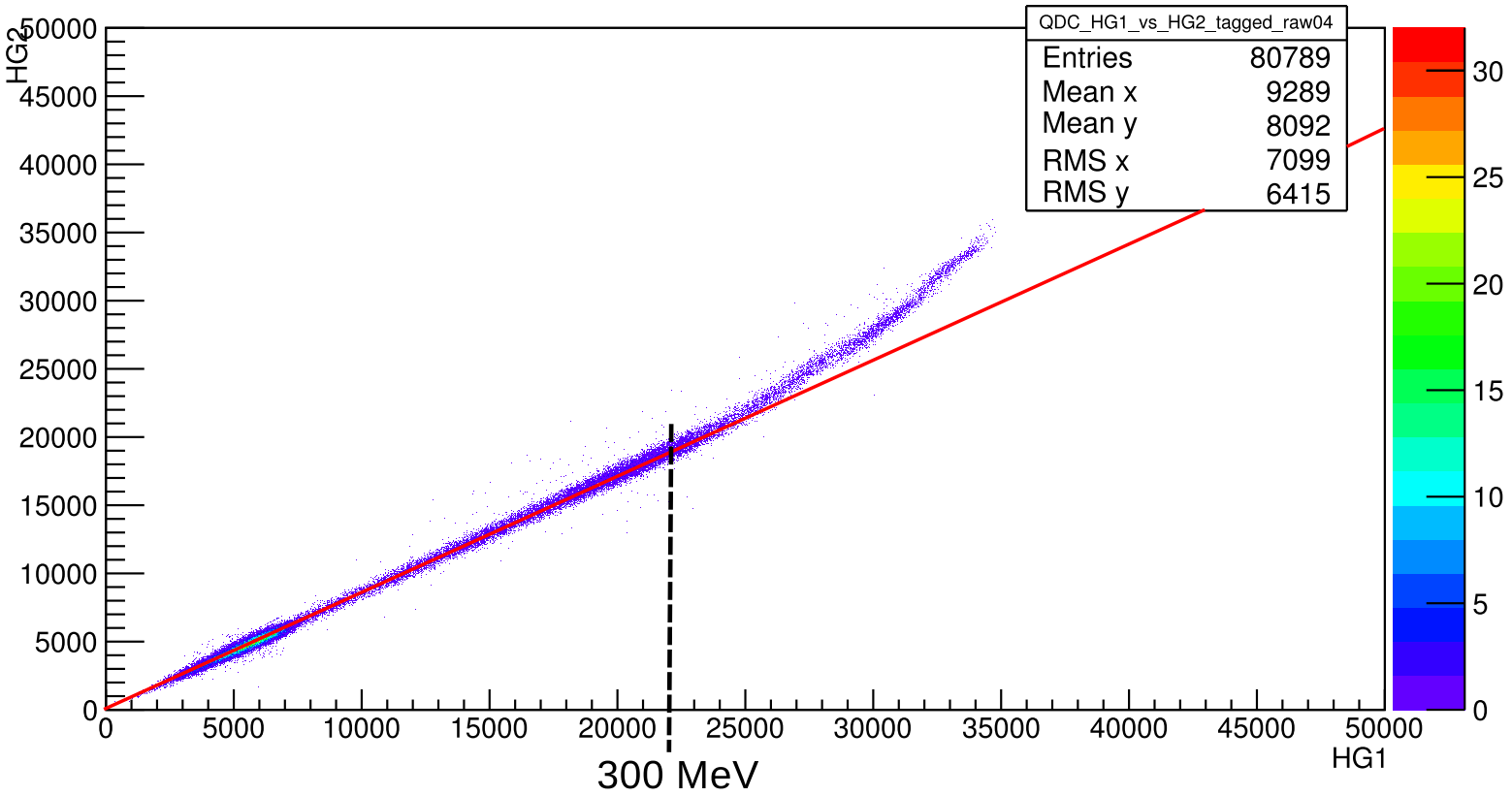


APD linearity for central crystal



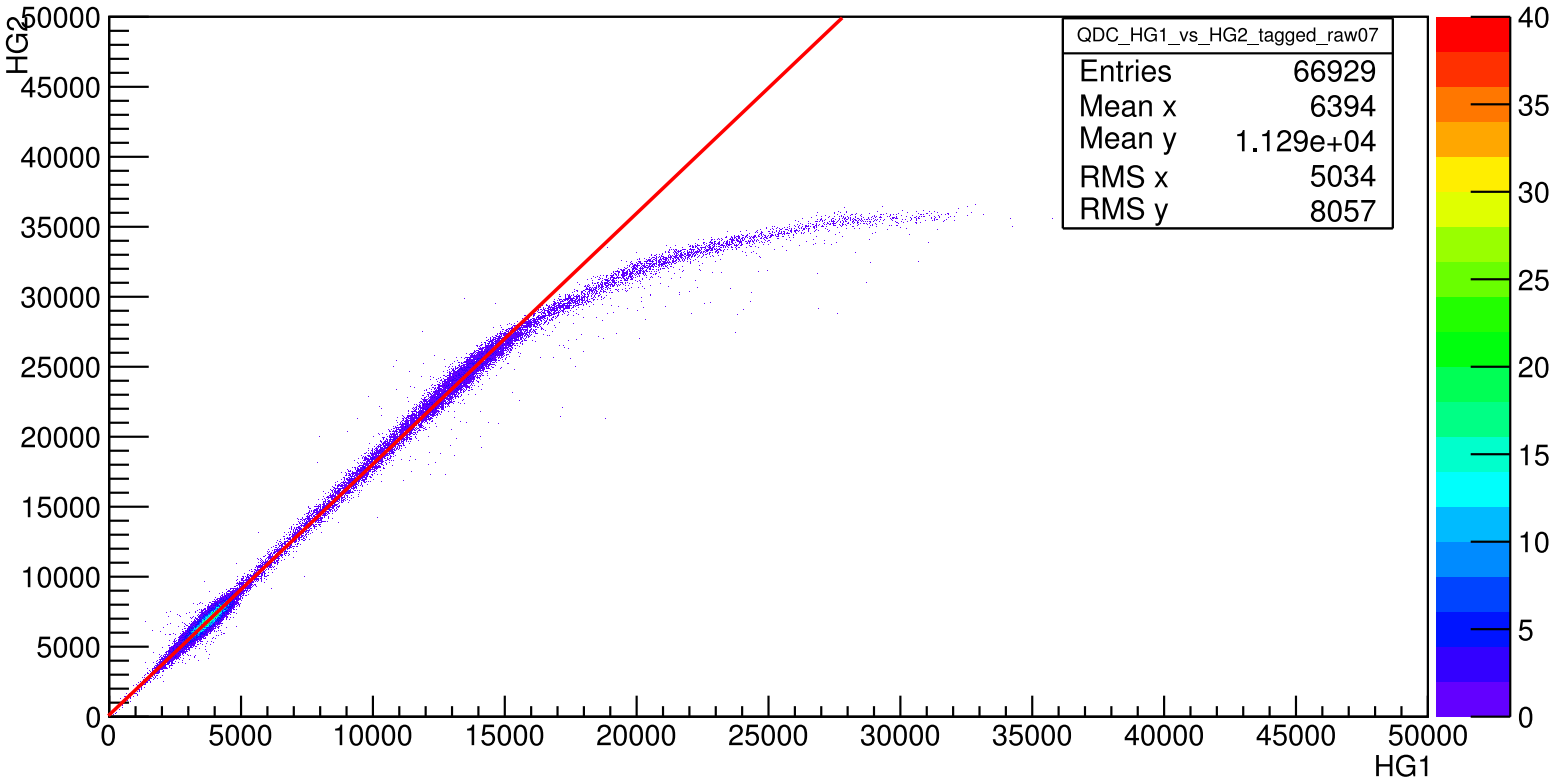
APD1: U_{Bias}=366.96 V, APD2: U_{Bias}=371.38 V and Mean: U_{Bias}=369.09 V (at -25°C and M=150)

APD linearity for central crystal



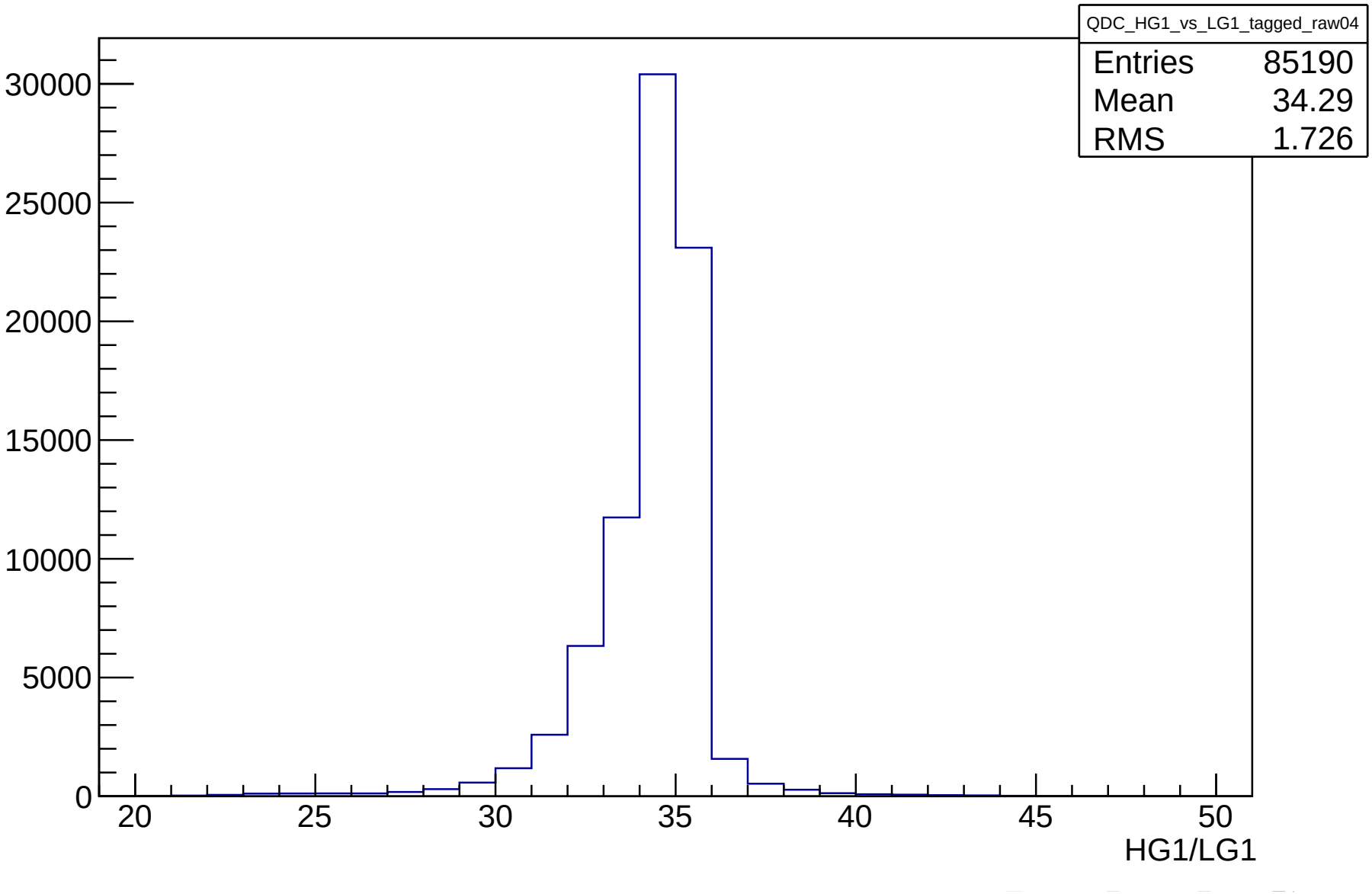
APD1: U_{Bias}=366.96 V, APD2: U_{Bias}=371.38 V and Mean: U_{Bias}=369.09 V (at -25°C and M=150)

APD linearity for peripheral crystal 7



APD1: U_{Bias}=372.62 V, APD2: U_{Bias}=366.22 V and Mean: U_{Bias}=369.42 V (at -25°C and M=150)

ASIC Gain variation

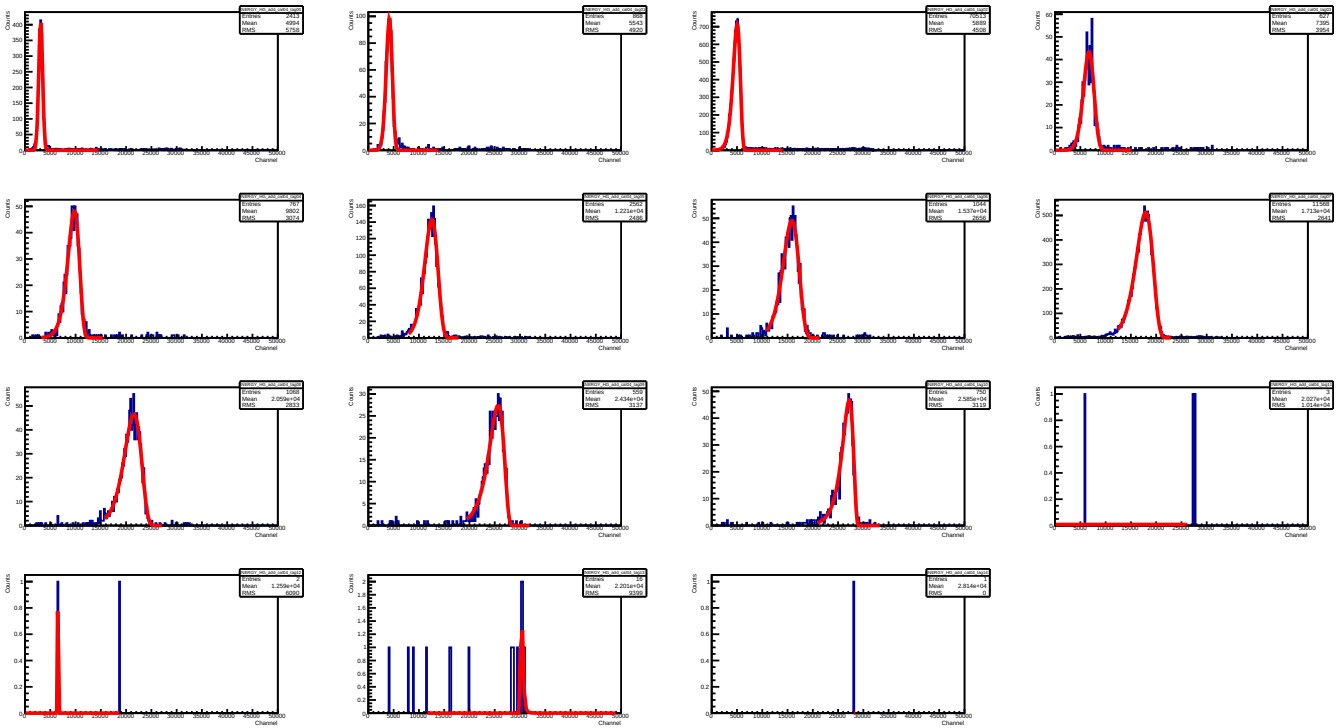


Relative calibration

- Fitting Novosibirks function:

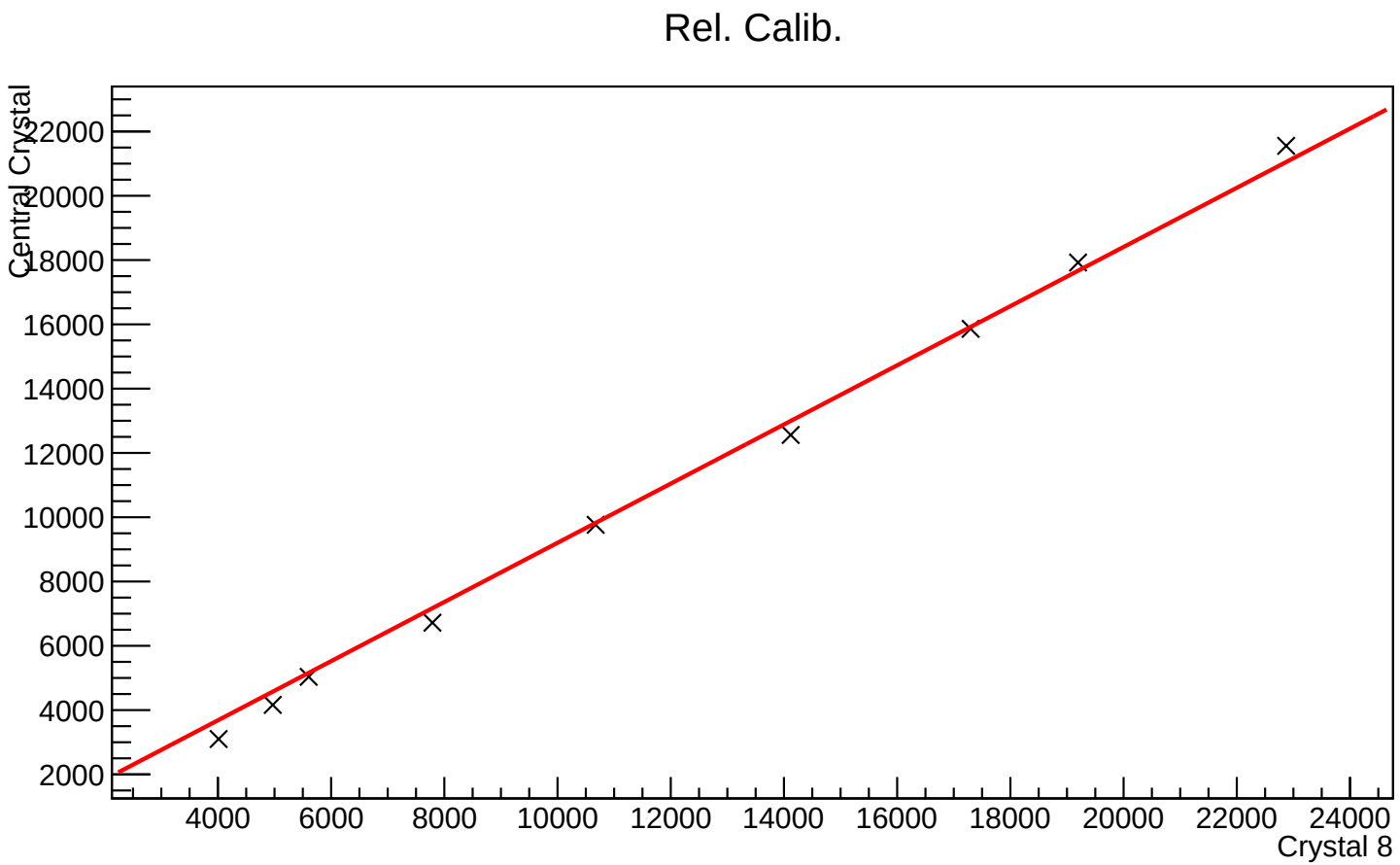
$$f(x) = Ae^{-\frac{1}{2}\left(\frac{\ln^2(1+\Lambda\tau(x-\mu_{max}))}{\tau^2}+\tau^2\right)} \quad \text{with} \quad \Lambda = \frac{\sinh(\tau\sqrt{\ln 4})}{\sqrt{\ln 4}\tilde{\sigma}}$$

and asymmetry τ, width $\tilde{\sigma} \equiv \frac{FWHM}{2\sqrt{\ln 4}}$ and mode μ_{max}



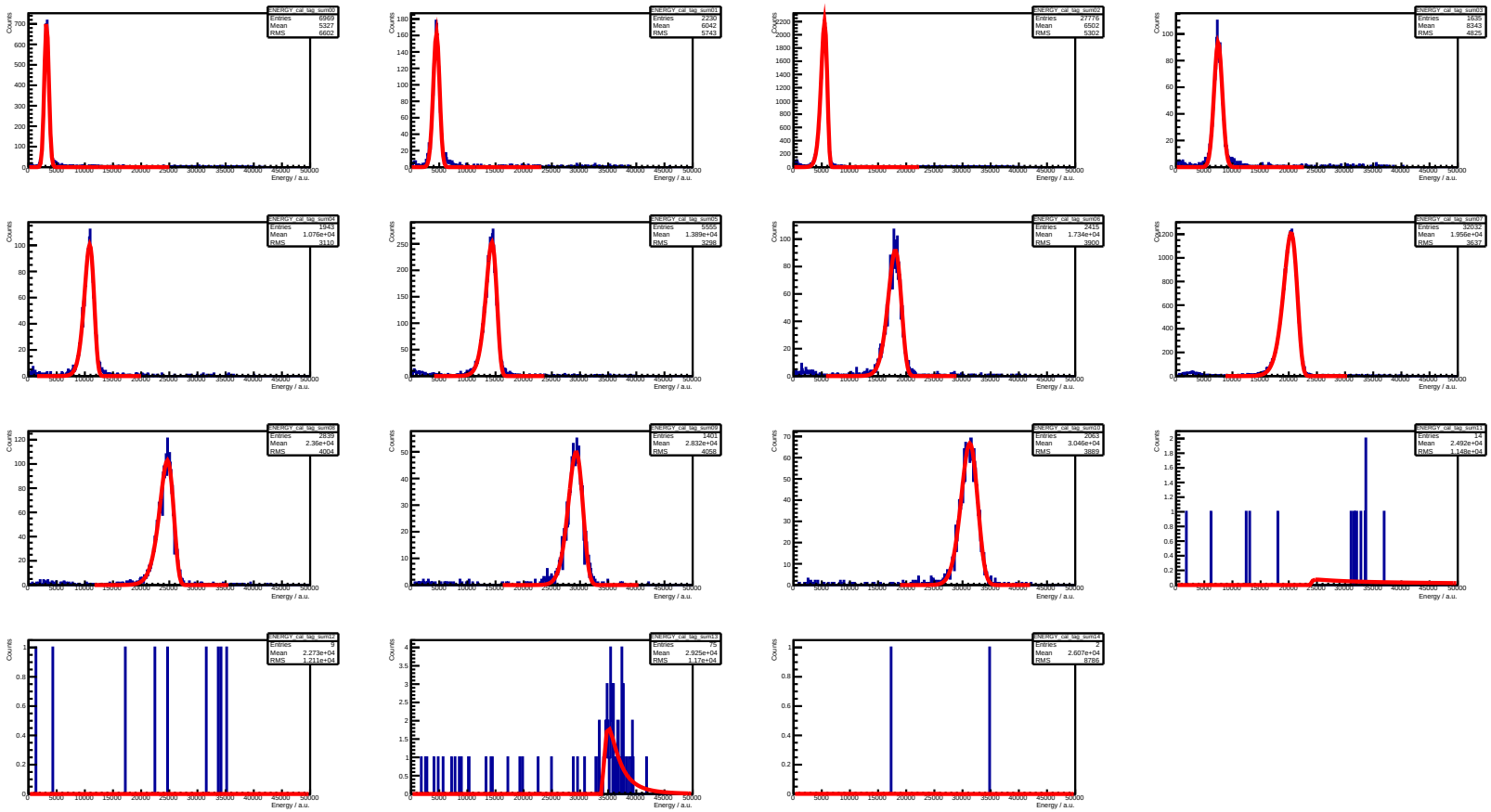
Relative calibration

- Relative calibration with the central crystal as reference crystal:



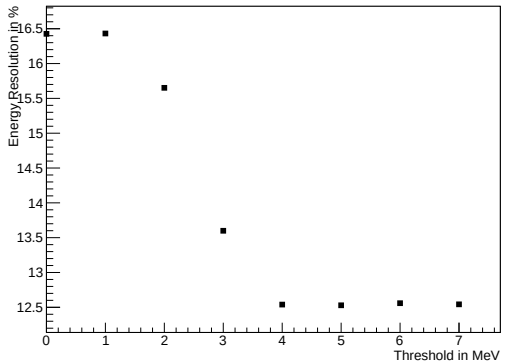
Energy resolution: Novosibirks fits

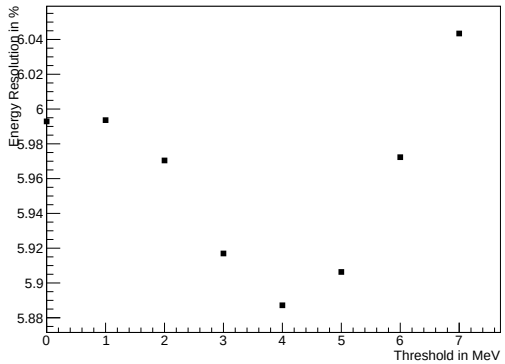
Fitting Novosibirks to the calibrated and tagged energy sum of the crystal matrix:



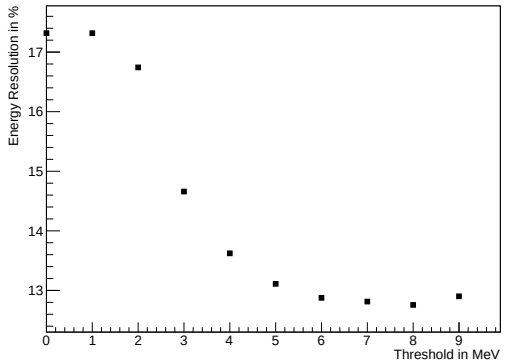
Threshold scan

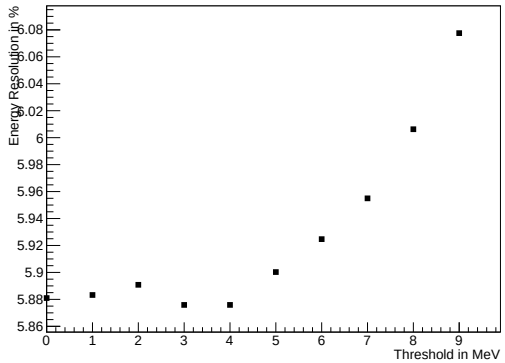
Both APDs:





One APD:



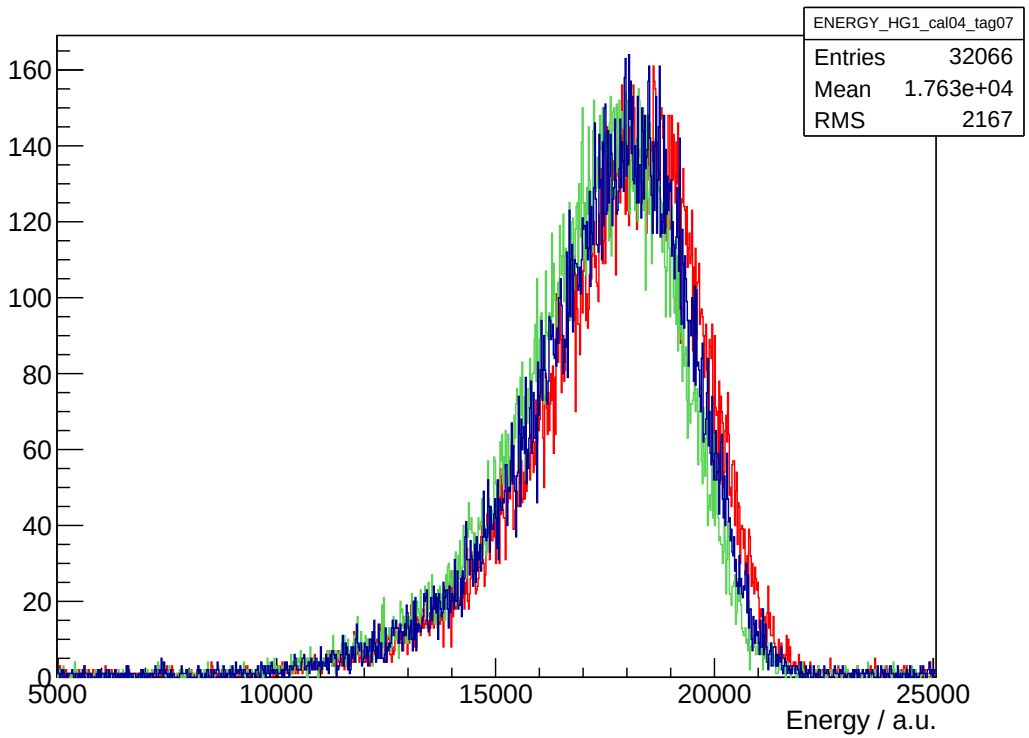


55 MeV

301 MeV

Sum of two APDs for central crystal

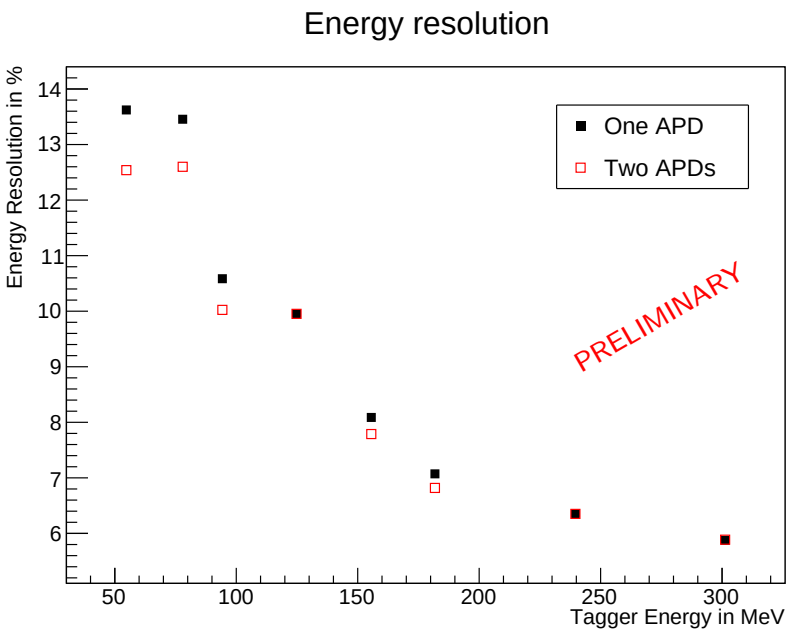
- incident energy: 301 MeV
- note: summed energy is divided by 2
- red: APD1, green: APD 2 and blue: sum of APDs



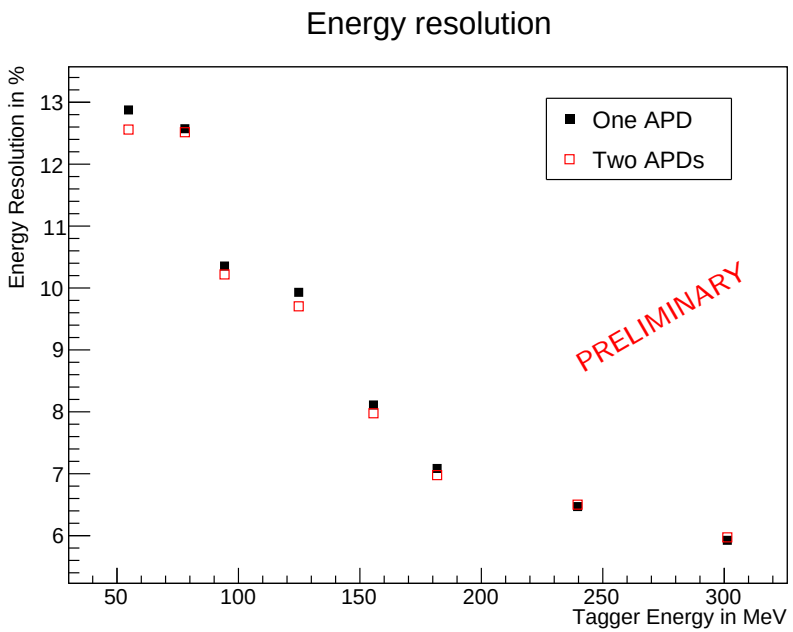
threshold 0 MeV

Comparison one and two APDs

- energy resolution for one APD (black) and both APDs added (red)

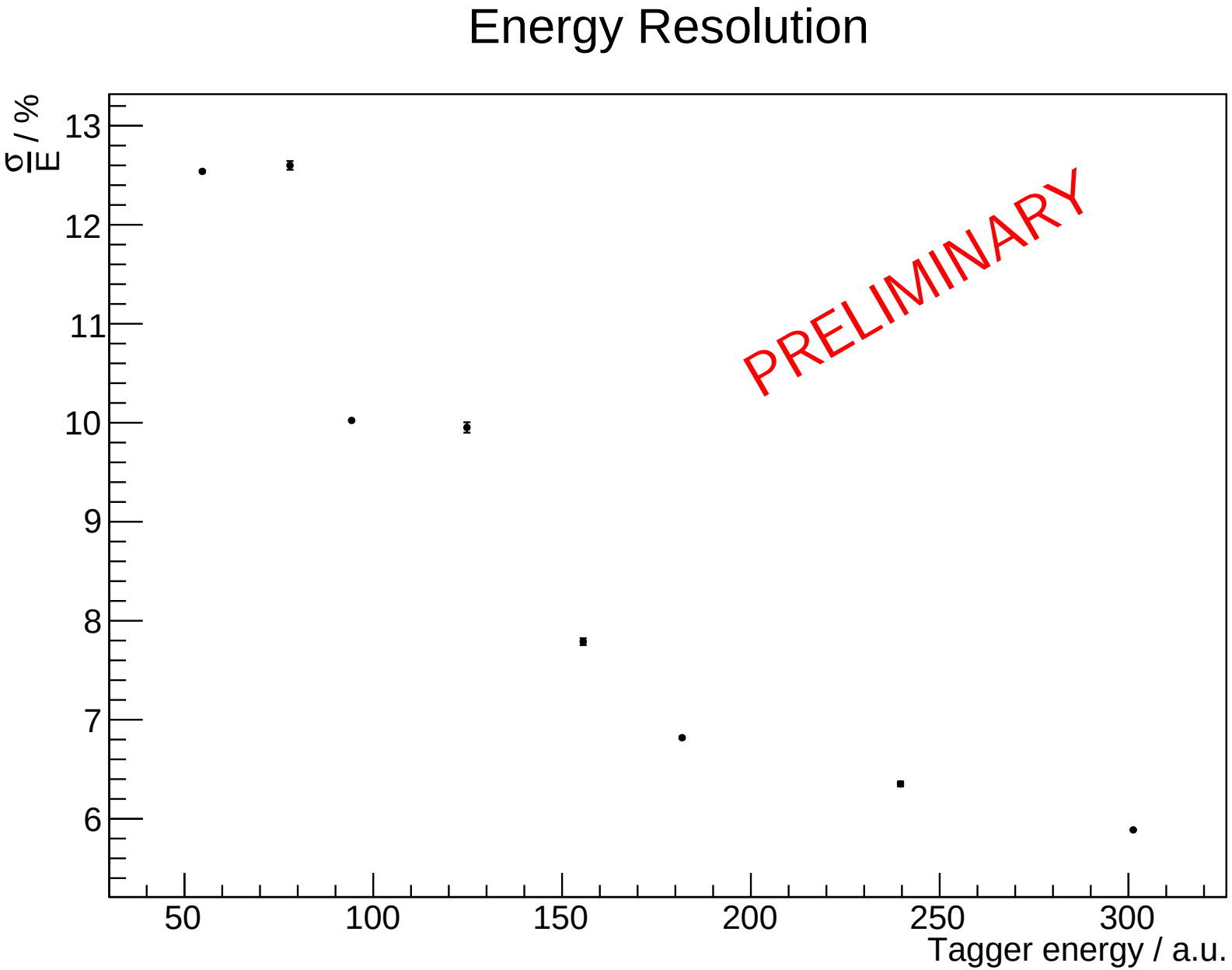


4 MeV threshold

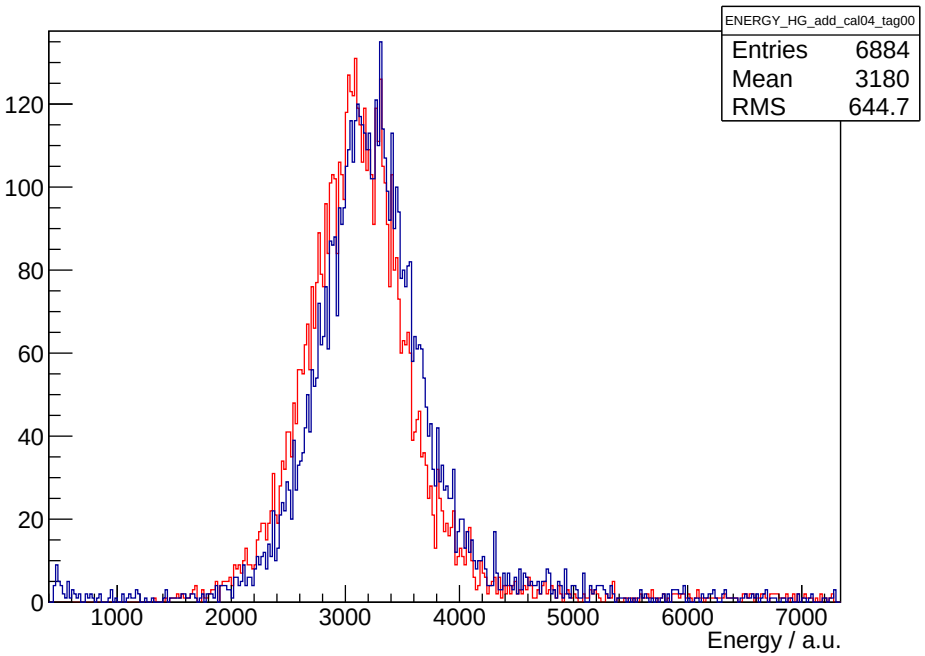


6 MeV threshold

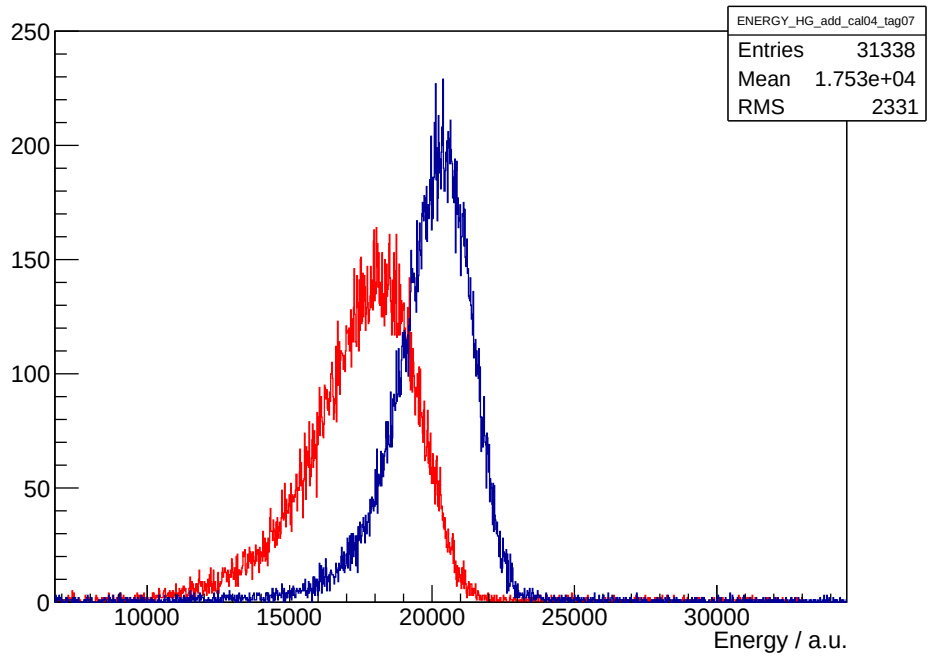
Energy resolution with threshold = 4 MeV



Sum of Matrix vs. central crystal



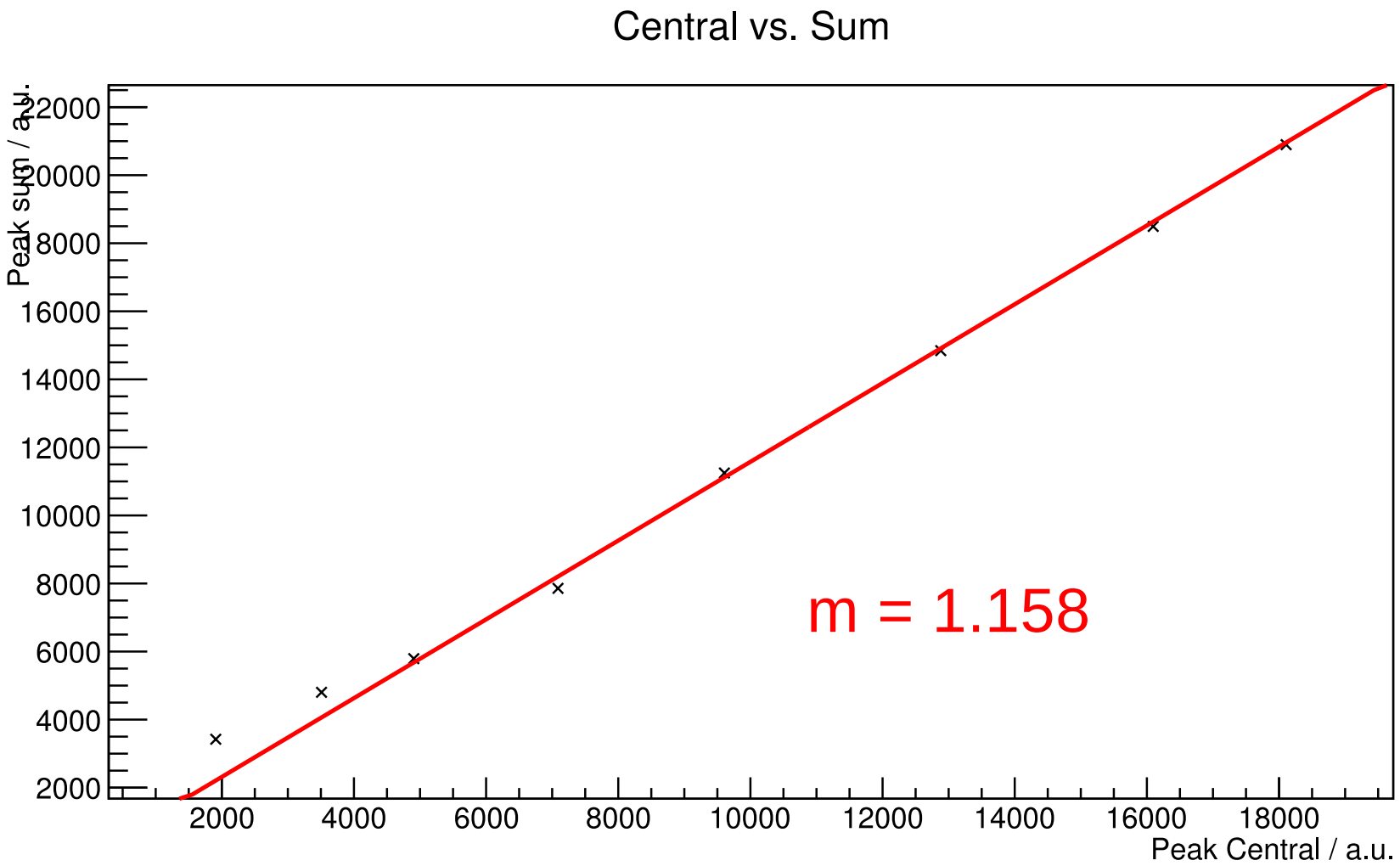
55 MeV



301 MeV

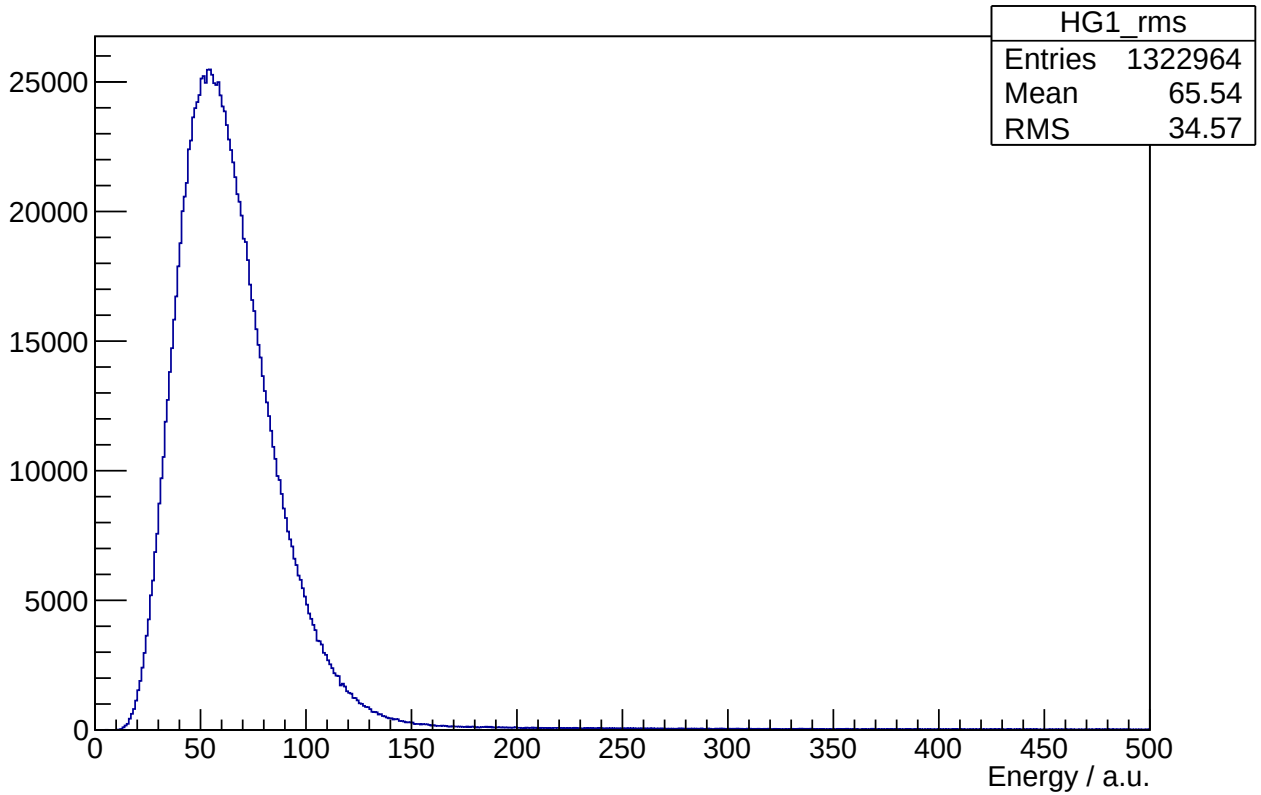
red: central crystal and blue: sum of matrix

Peak sum vs. peak central as a function of energy



Noise I

Definition of noise: RMS of the baseline

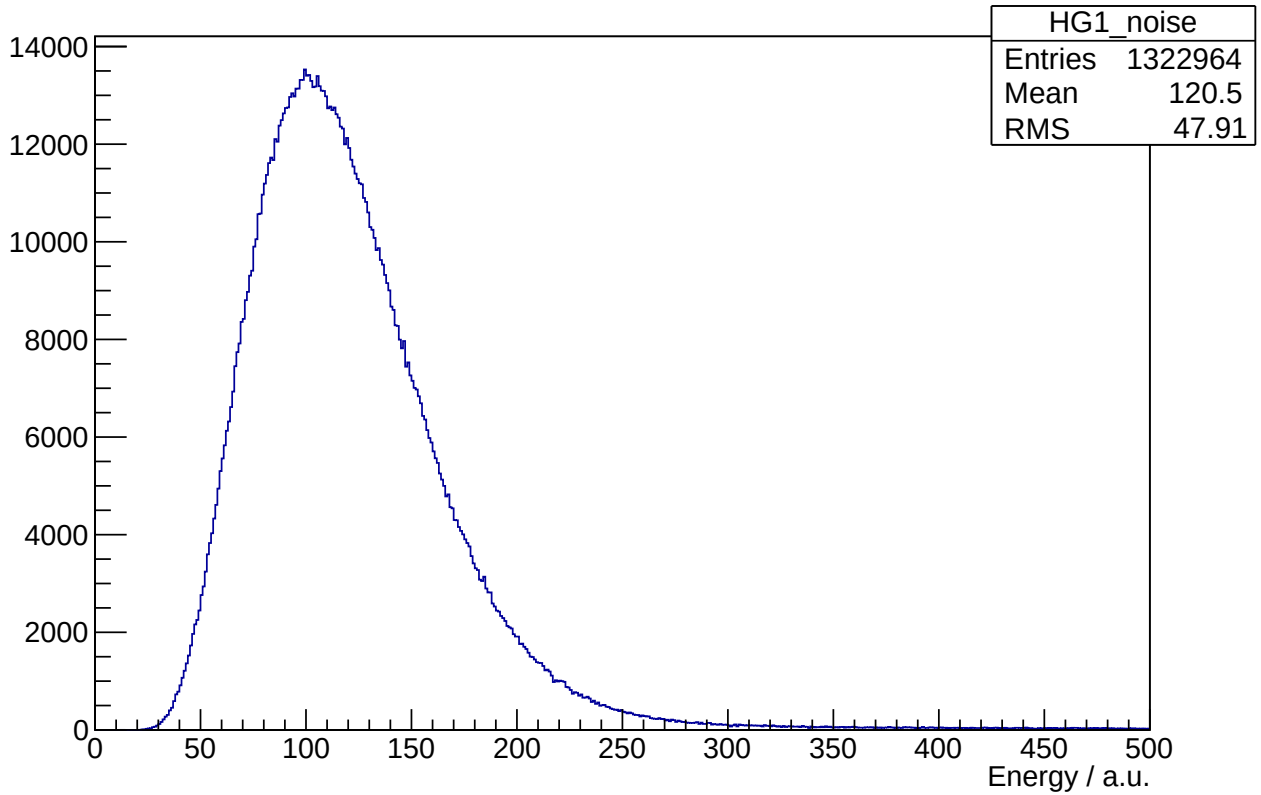


Noise

$\Rightarrow \approx 0.7$ MeV

Noise II

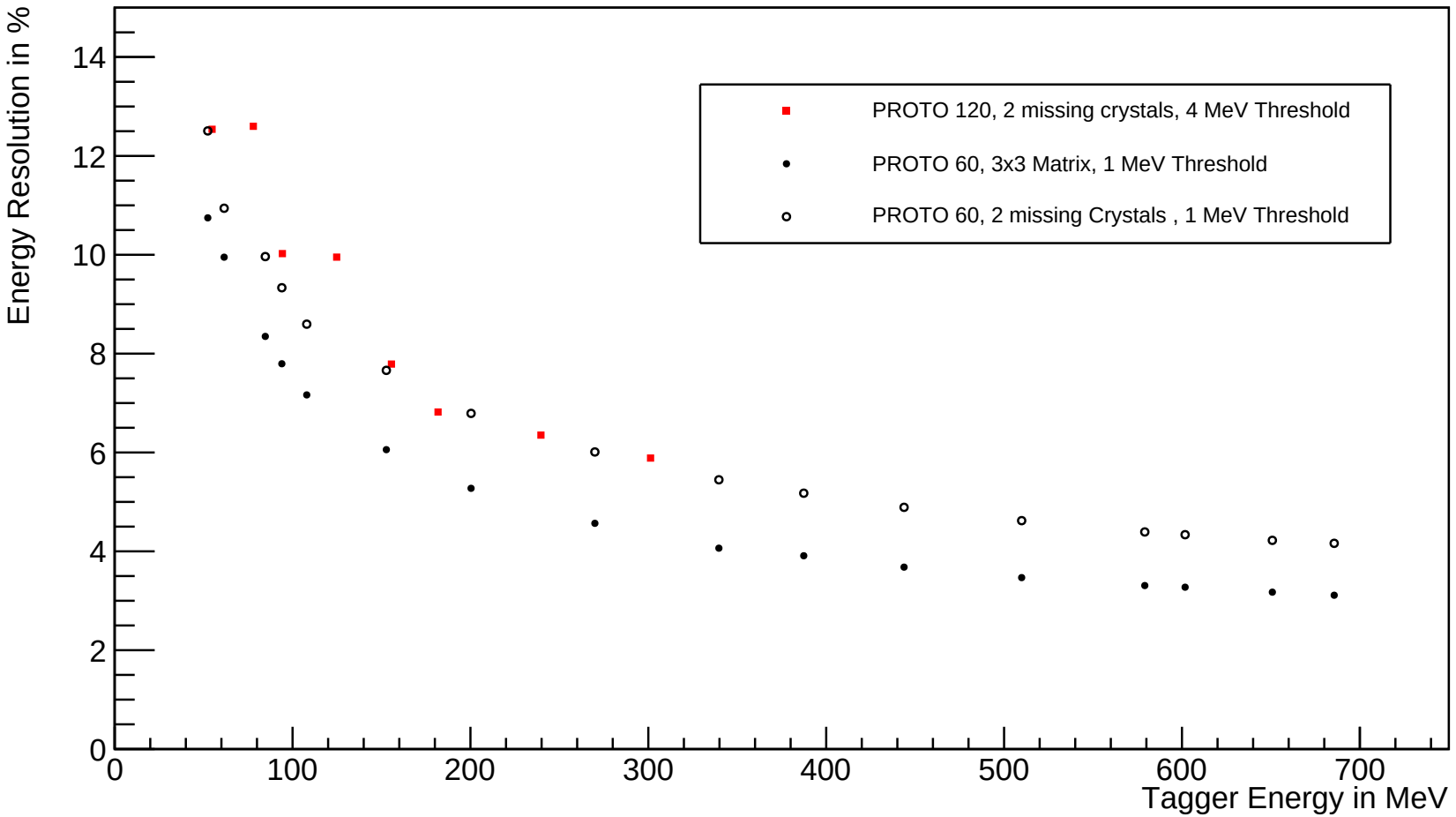
Definition of noise: Maximum value of baseline - baseline



Noise

$\Rightarrow \approx 1.5$ MeV $\rightarrow$ consistent with 4 MeV threshold

Comparison with PROTO60 data



Summary

Energy Resolution (preliminary)

- 10.02% at 100 MeV and 5.69% at 300 MeV for 4 MeV threshold and two APDs

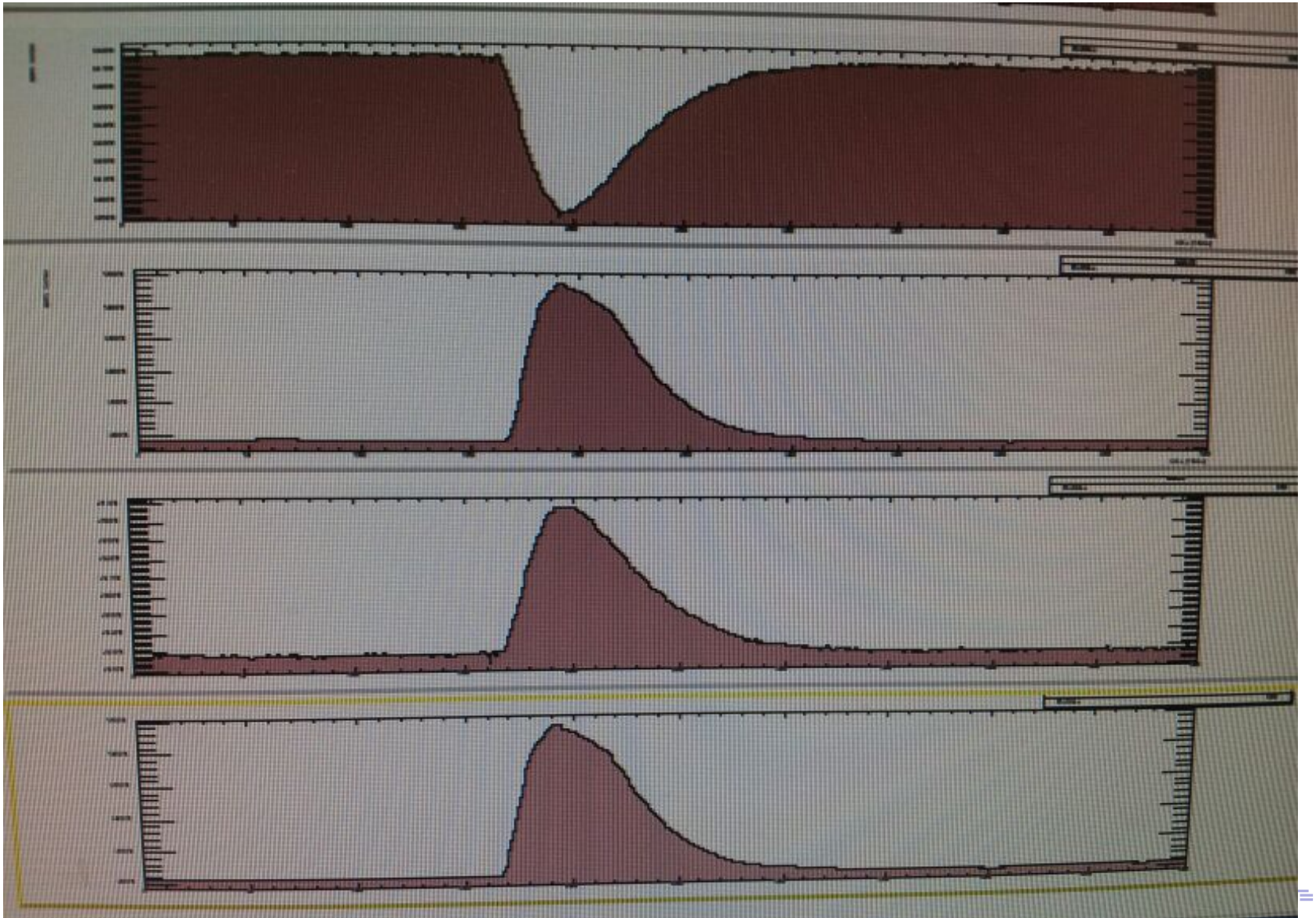
- no difference between one or two APDs at energies above 200 MeV
  - negligible influence of photon statistics
  - effect of different APD Gain?
- achieved threshold acceptable?
- different Feature Extraction?
  - use integral as energy information
  - different spike rejection
  - add traces before feature extraction (similar to CMS)
  - fit a function to the traces
- saturation starting at 300 MeV
  $\rightarrow$ using low gain when high gain saturates

Issues

- still some hardware issues:
  - reducing pick-up in a different way $\rightarrow$ grounding concept?
  - optimal use of the space $\rightarrow$ especially warm area
  - ASIC not accessable after mounting of crystal matrix to backplate
  - Back PCBs: holes and size do not fit backplate layout
  - thermal insulation / cooling concept: replacement formakeshift styrofoeam as insulation and bend protection for inner plastic tubes
  - improving flex cables (rigidity and length)
  - HV distribution box and HV cables strong source of pick-up noise
  - one HV for four detectors instead of one HV for each detector
  - current test just with commercial SADCs

Issues

- buffer boards / signal cables: polarity has to be clearly defined



Outlook

- Next beamtime (January?):
  - all 120 crystals
  - 3×3 matrix with roughed crystals
  - 3×3 matrix with asics with common ground

Outlook

- Next beamtime (January 2015?):
  - all 120 crystals
  - 3×3 matrix with roughed crystals
  - 3×3 matrix with asics with common ground

Thank you for your attention!

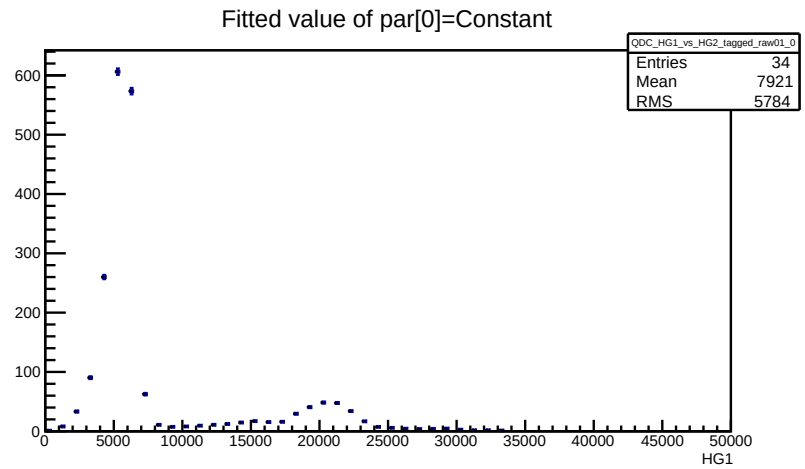
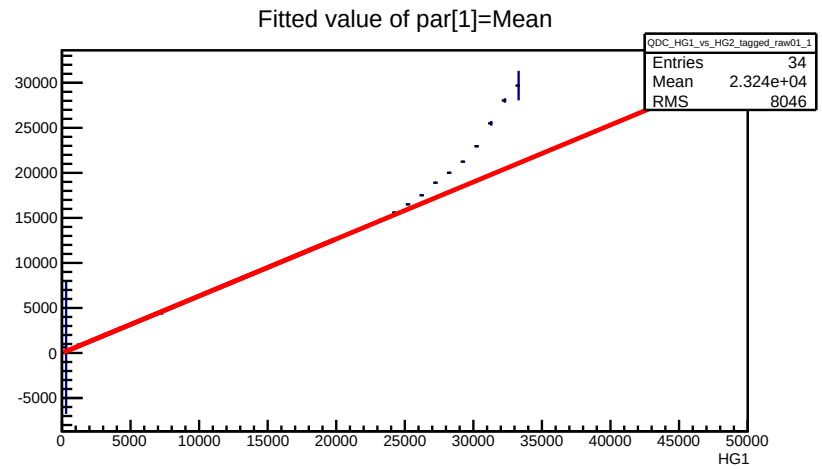
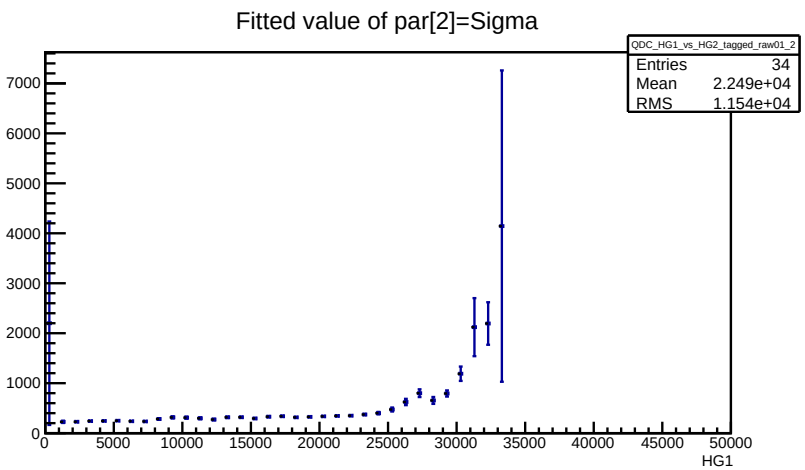
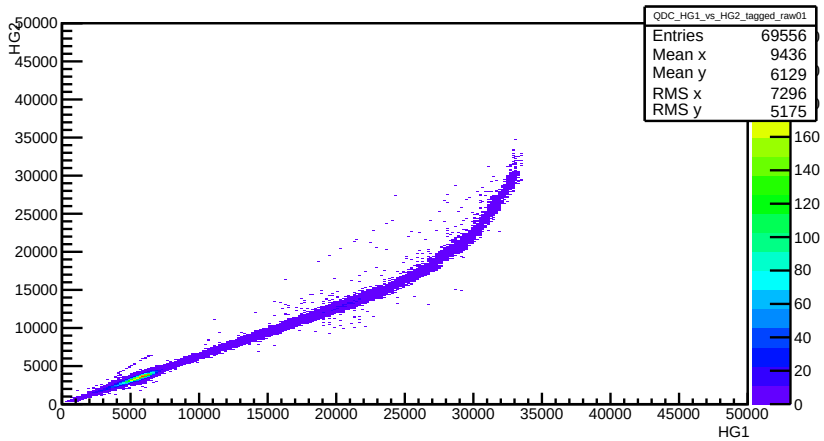
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

panda

HIC for FAIR
Helmholtz International Center

Bundesministerium für Bildung und Forschung

Backup

Relative APD calibration (for crystal 1)

- project slices along Y, then fit each slice and make a histogram for each fit parameter