Performance of Prototypes for the $\overline{\text{P}}$ANDA Barrel EMC

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Outline

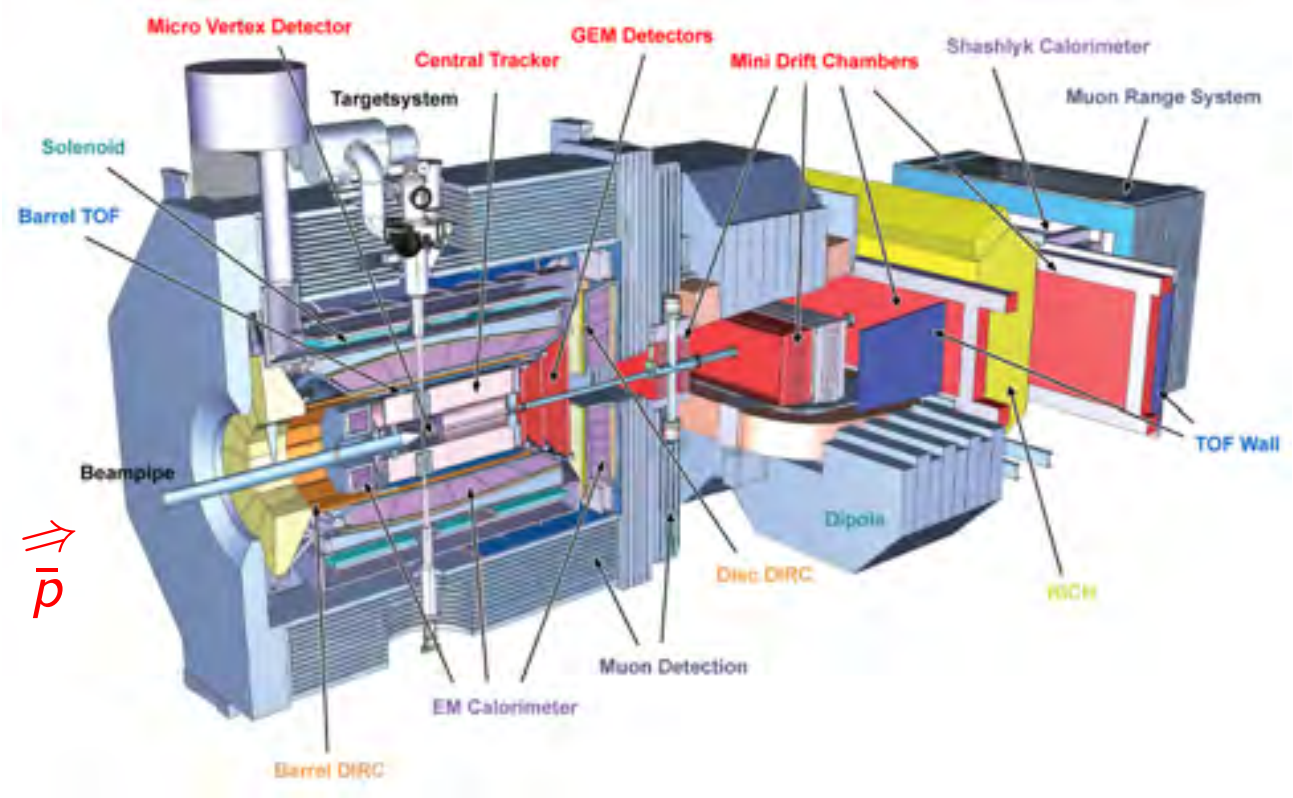
The PANDA Detector

The Barrel Prototype PROTO60

Test Beam Results

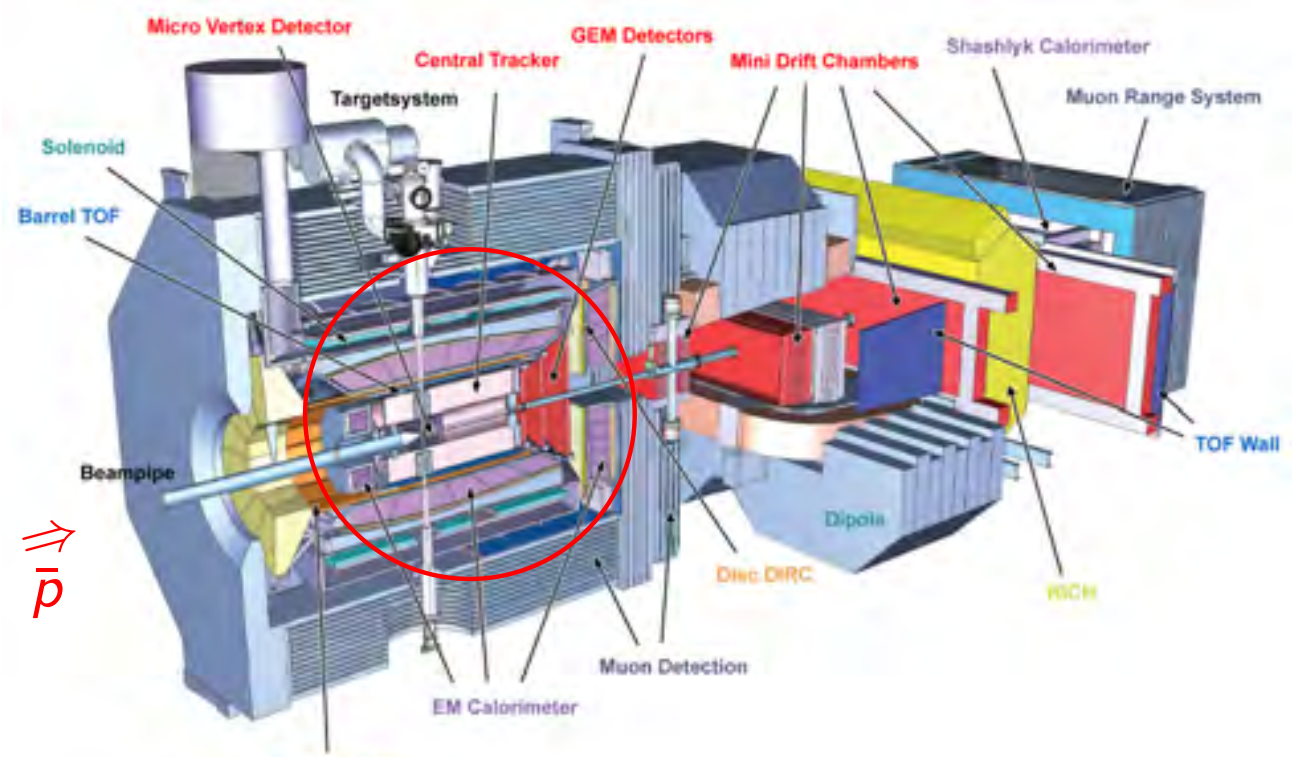
Outlook

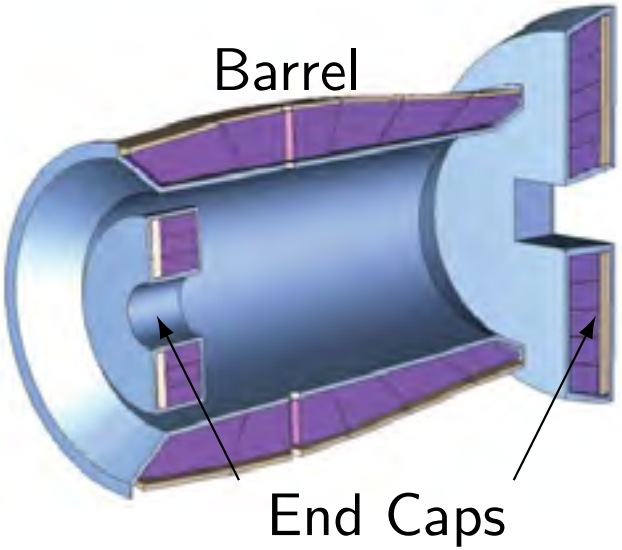
Electromagnetic Calorimetry at PANDA



- Detection of electromagnetic probes with high resolution within a large dynamic range
  - $10\,\mathrm{MeV} < E < 15\,\mathrm{GeV}$
- High rate capability
- Compactness
- Sufficient radiation hardness
- Timing information for triggerless DAQ concept

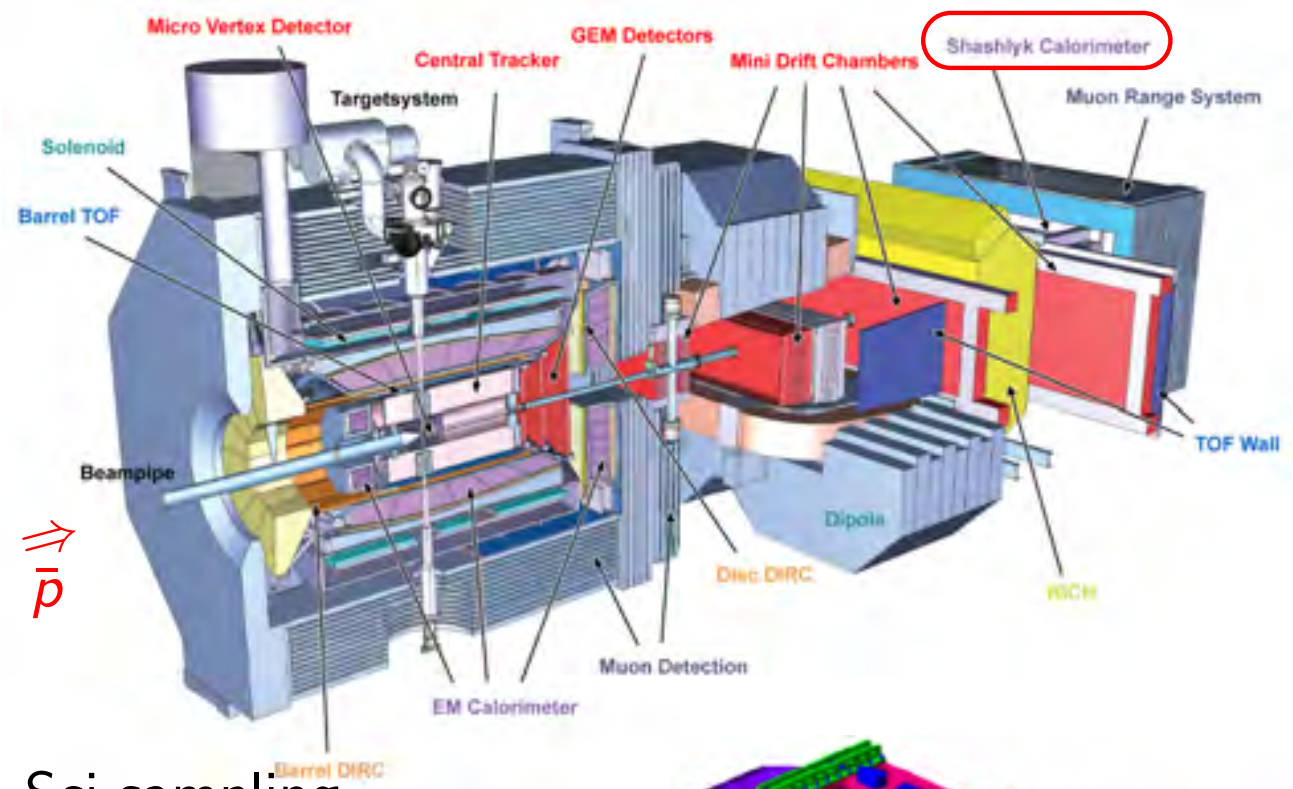
Electromagnetic Calorimetry at PANDA



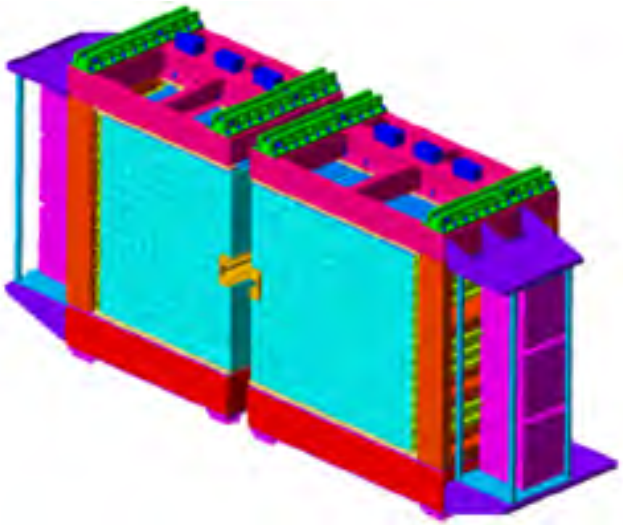


- Lead tungstate (PWO-II)
  - Length $200\,\mathrm{mm} \approx 22\ X_0$
  - Operating temperature $-25\,^{\circ}\mathrm{C}$

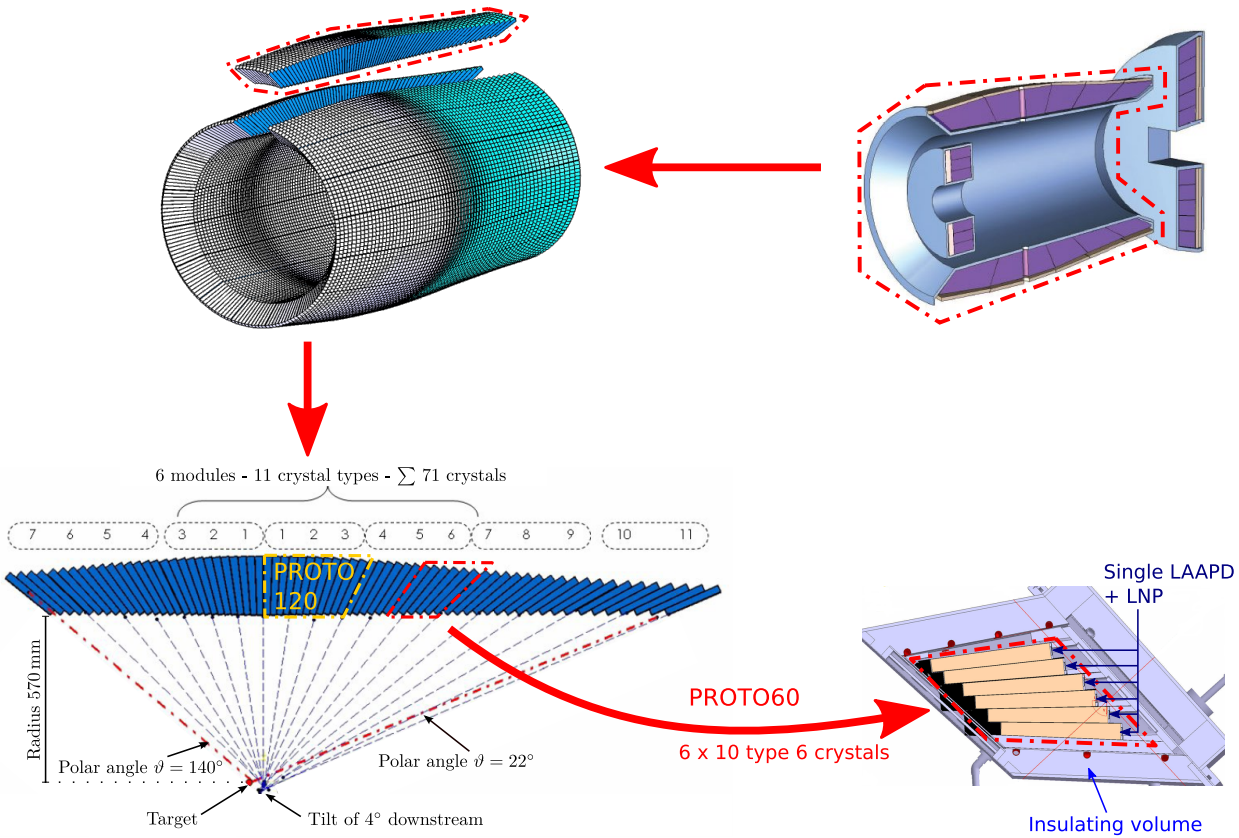
Electromagnetic Calorimetry at PANDA



- Pb-Sci sampling calorimeter (Shashlyk type)
- PMT + Sampling-ADC readout

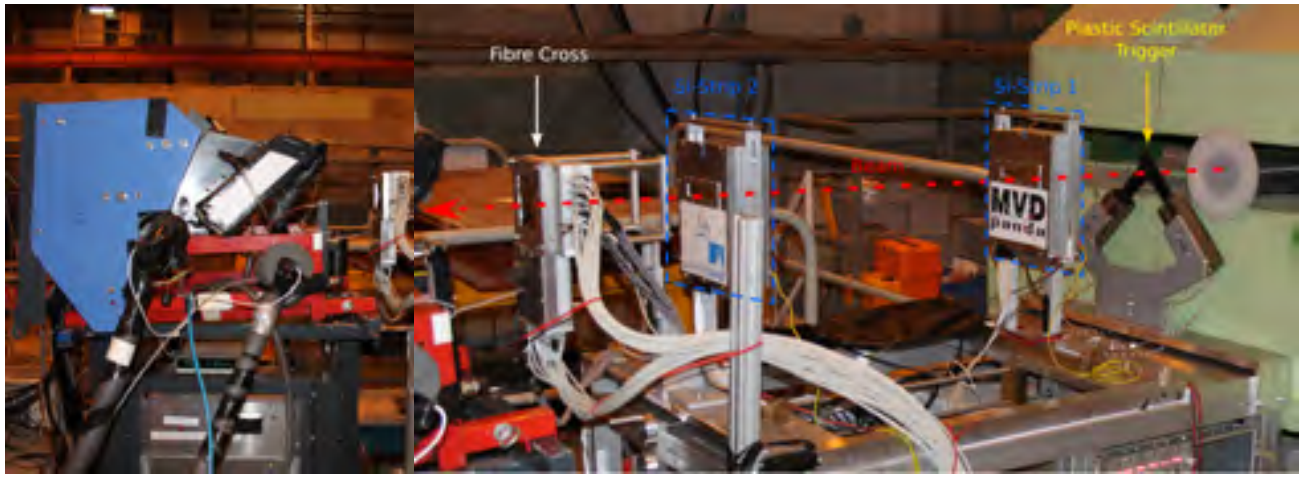


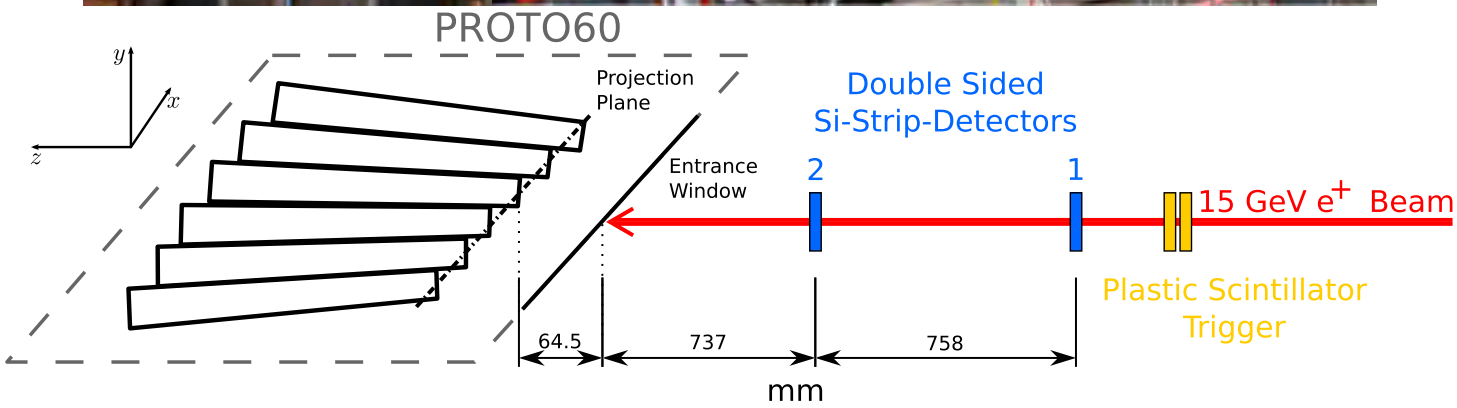
The Barrel EMC Prototype PROTO60



- Operating temperature $-25\,^{\circ}\mathrm{C}$
- Readout by Sampling ADCs (SIS3302, 50 MHz)
- Energy und time determined offline with feature extraction algorithms

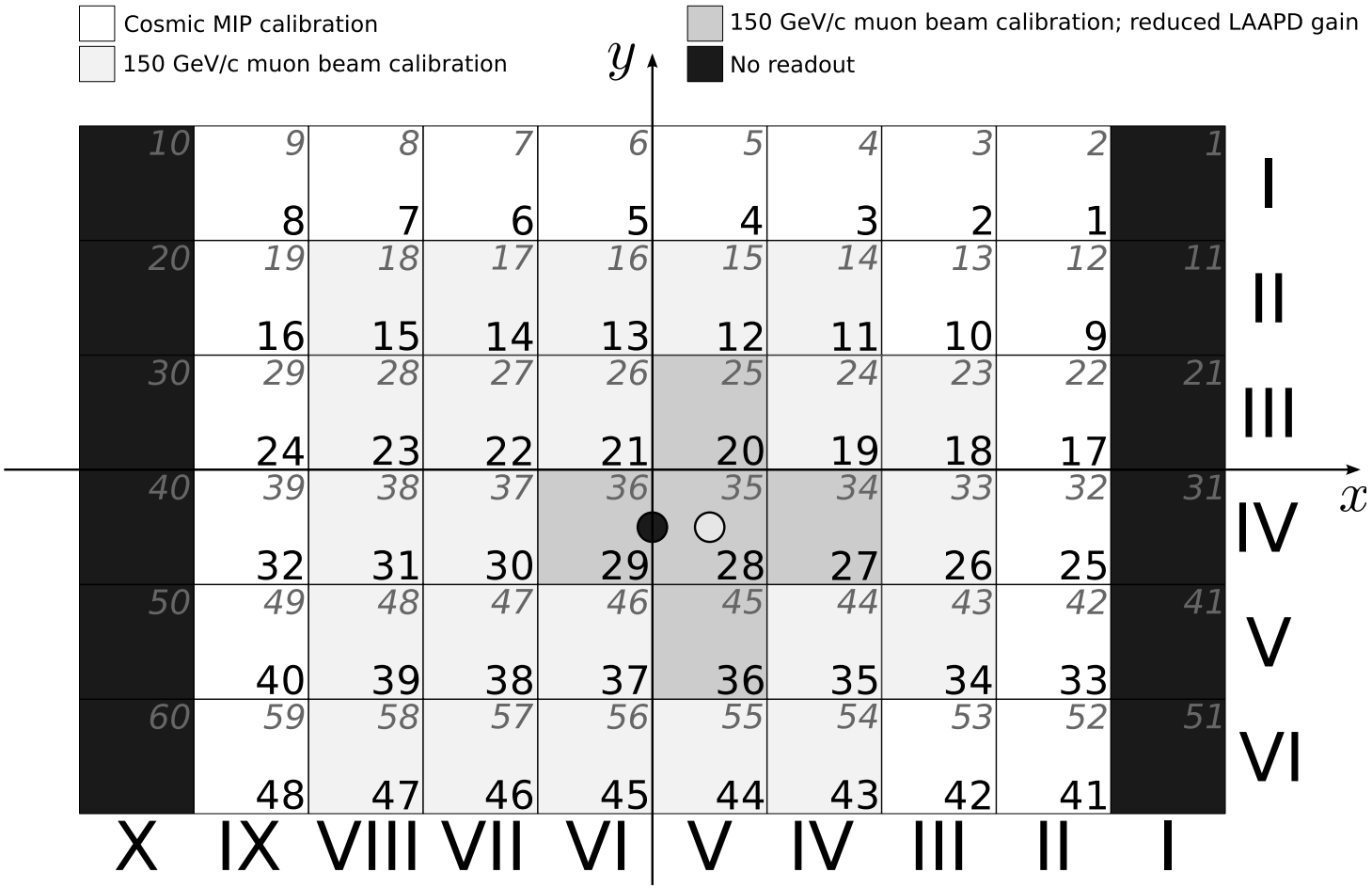
Setup at CERN-SPS



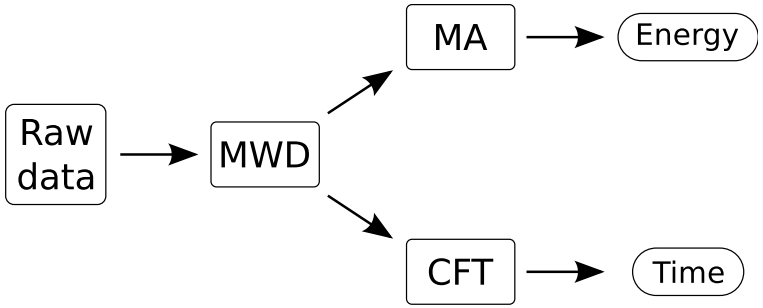


- Secondary 15 GeV/c positron beam, 2 positions
- Calibration via 150 GeV/c muon beam, cosmic MIPs
- Reference position provided by Si-strip detectors

PROTO60 Scheme

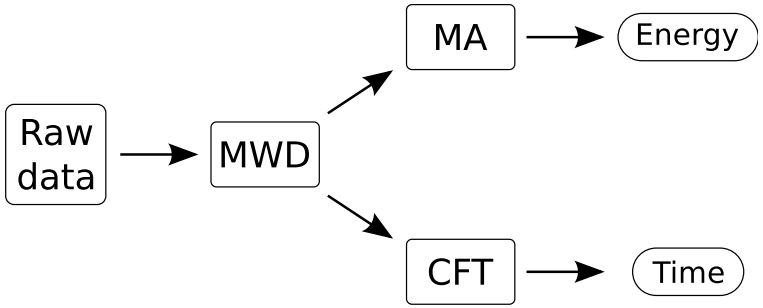


Signal Treatment



- Later on: Implementation to FPGAs
- Sampling rate 50 MHz $\Rightarrow$ 20 ns Binning

Signal Treatment



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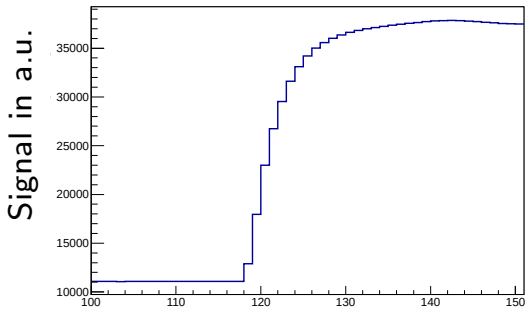
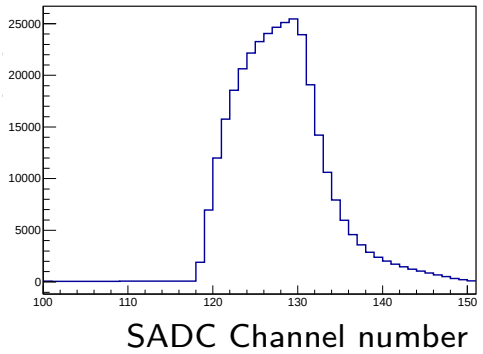


MWD



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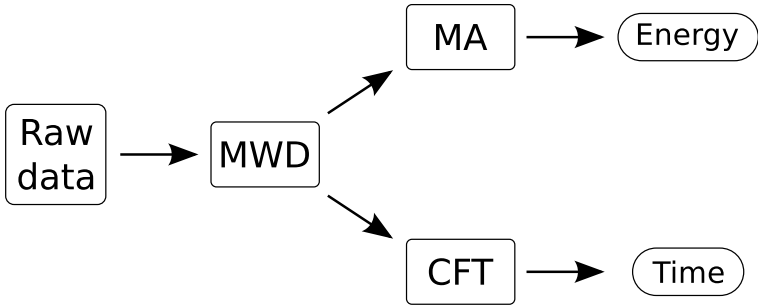

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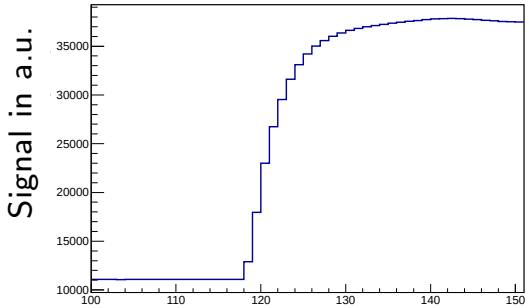
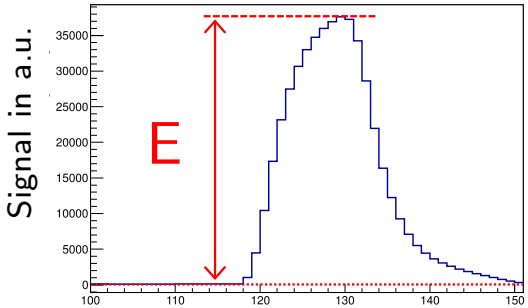
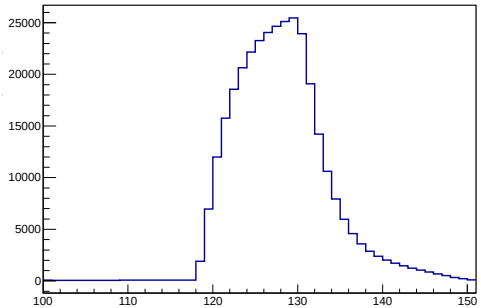


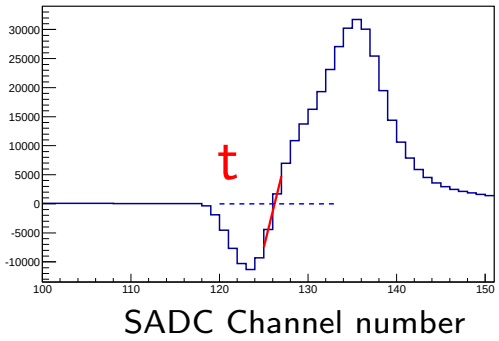
MWD + MA



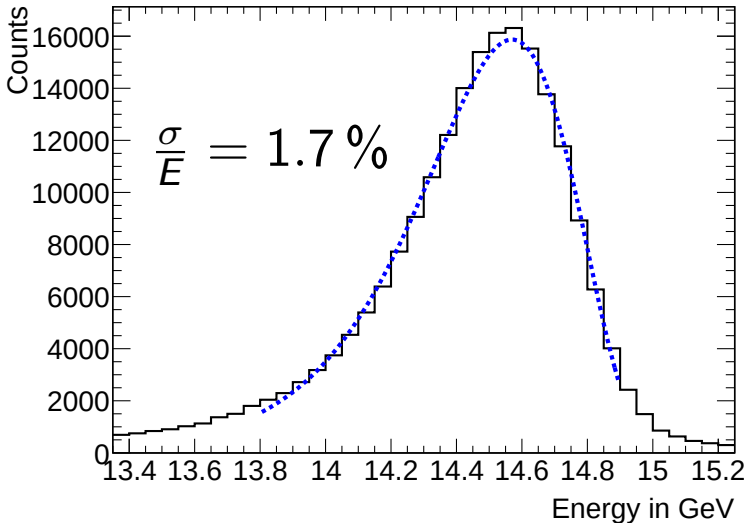
MWD



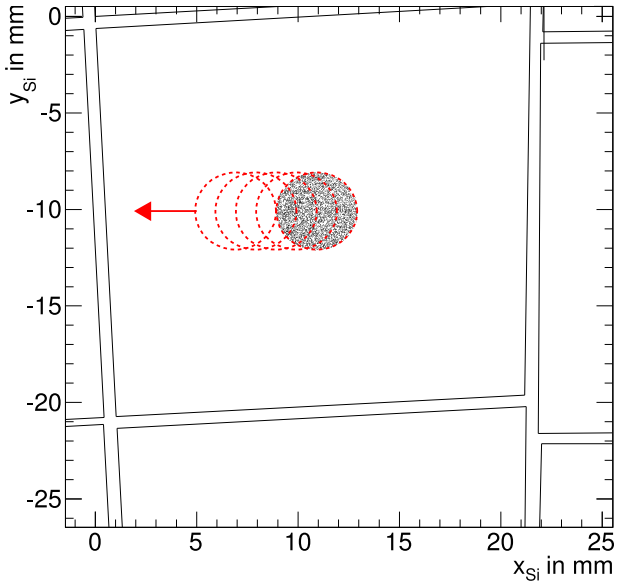
MWD + CFT

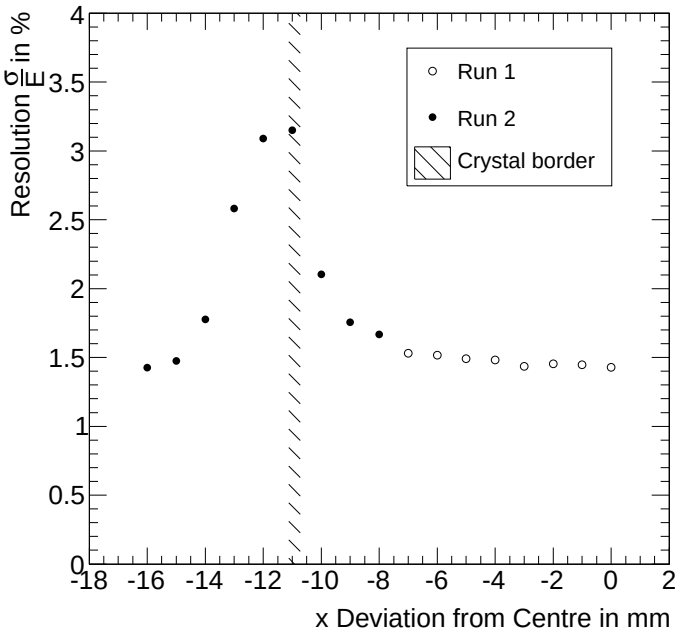


Energy Resolution

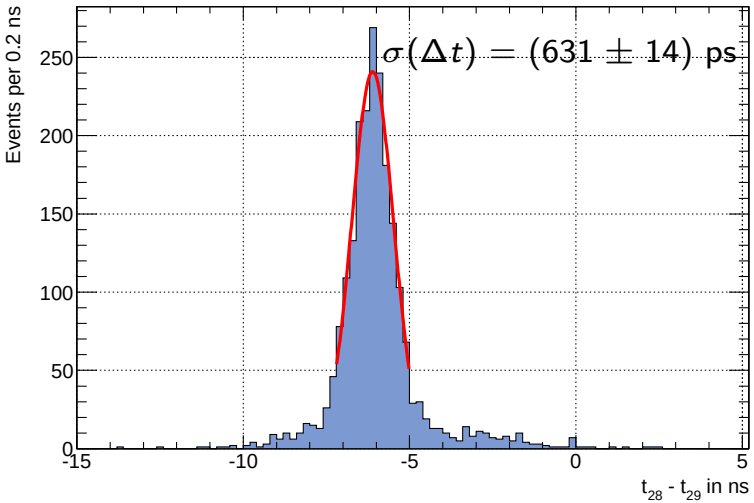


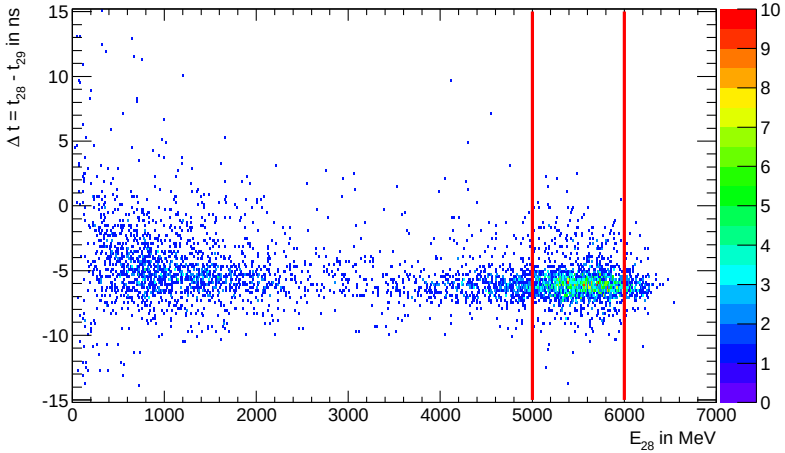
- Overall energy resolution
  - 15 GeV positron beam
  - Extracted via fit of Novosibirsk function
- Position dependence
  - Restricted beam size $\varnothing 4\,\mathrm{mm}$



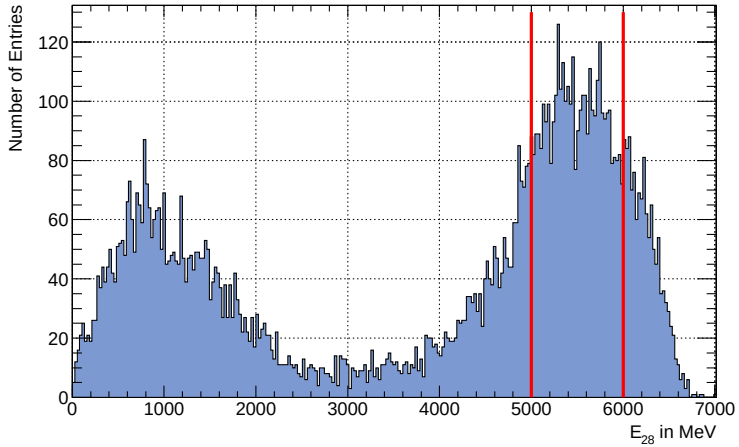


Time Information





- Time extracted with CFD algorithm
- Time difference of two neighbouring crystals
- Energy ratio within 10%
- Single crystal time resolution: $\sigma_t = \frac{\sigma(\Delta t)}{\sqrt{2}} = (441 \pm 15)$ ps at 5.5 GeV dep. energy



Position Reconstruction

- Centre of gravity algorithm

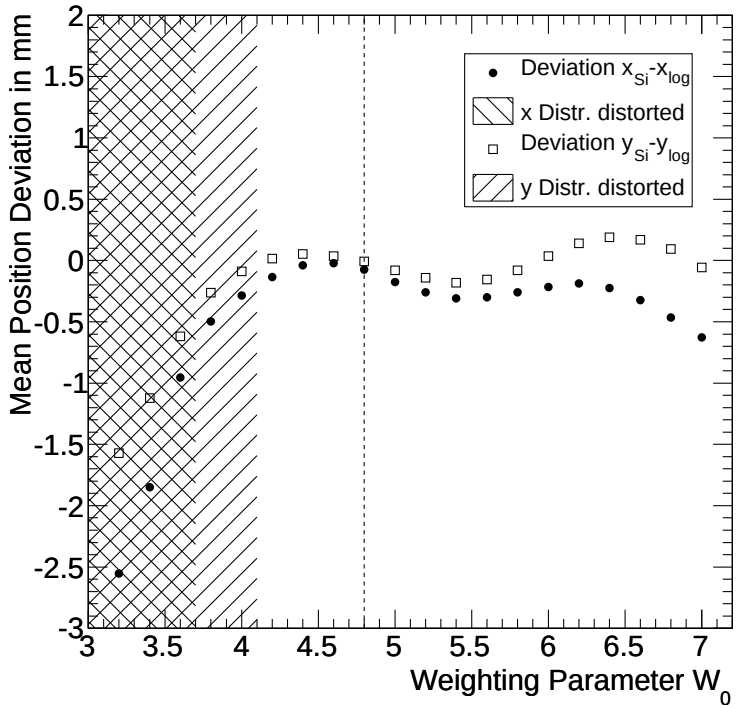
$$x_{cg} = \frac{\sum_i w_i x_i}{\sum_i w_i}$$

- Logarithmic weighting:

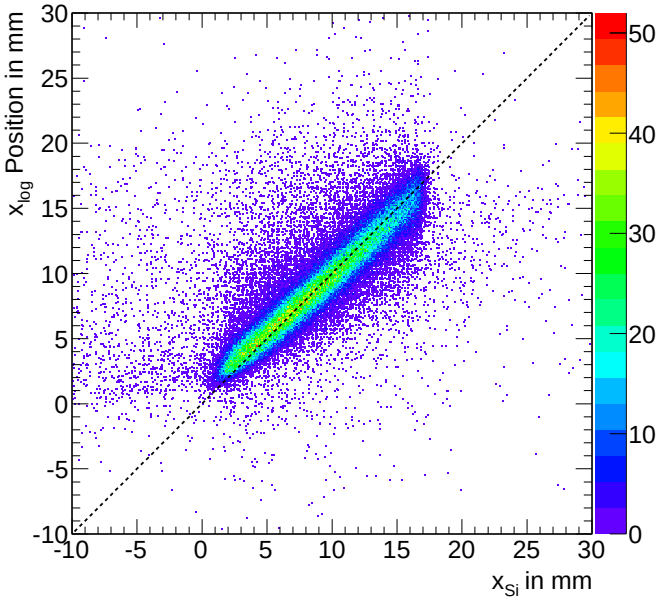
$$w_i = \max\left\{0, W_0 + \ln\left(\frac{E_i}{E_T}\right)\right\}$$

$$E_T = \sum_i E_i$$

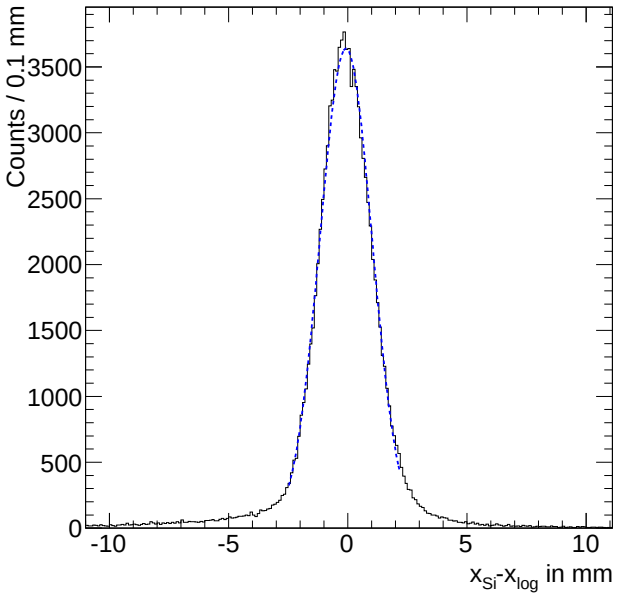
- Optimal W_0 requires no further corrections

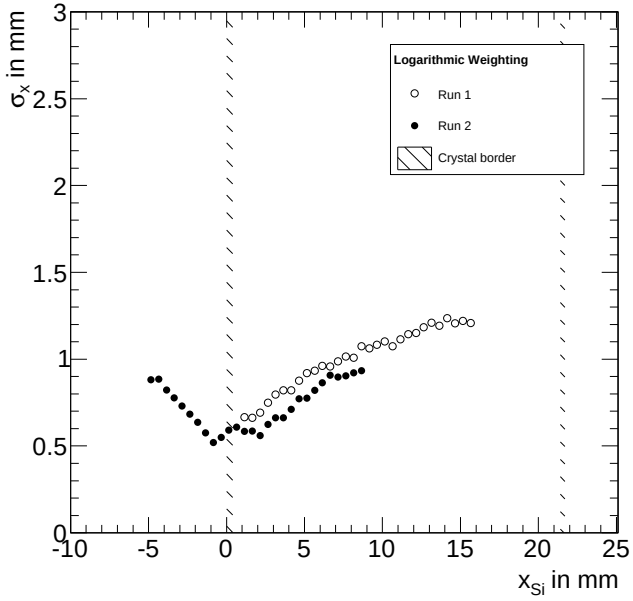


Position Resolution



- Overall position resolution
  - $\sigma_x \approx \sigma_y \approx 1.1\,\mathrm{mm}$
- Position dependent response
  - Evaluation in slices of $0.5\,\mathrm{mm}$ along x_{Si}



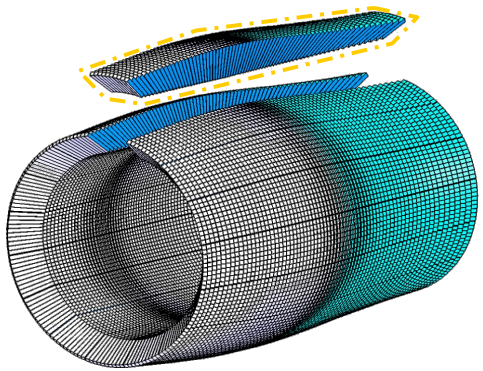


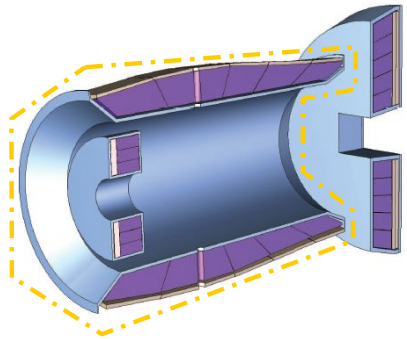
Summary

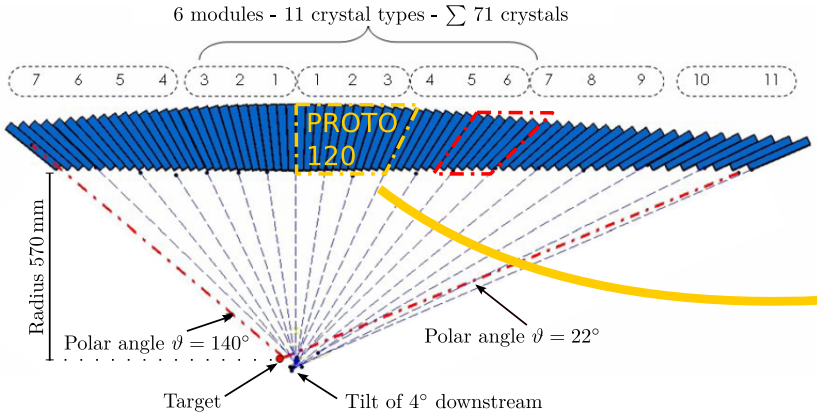
- The PROTO60 was tested at CERN-SPS at the highest design energy of 15 GeV
- Obtained Results:
  - Overall energy Resolution $\frac{\sigma}{E} = 1.7\,\%$
    - For restricted beam size ($\varnothing = 4\,\mathrm{mm}$) improved resolution up to 1.4 %
  - Time Resolution amounts to $(441 \pm 15)\,\mathrm{ps}$ at 5.5 GeV deposited energy
  - Overall position resolution of $\sigma_x \approx \sigma_y \approx 1.1\,\mathrm{mm}$

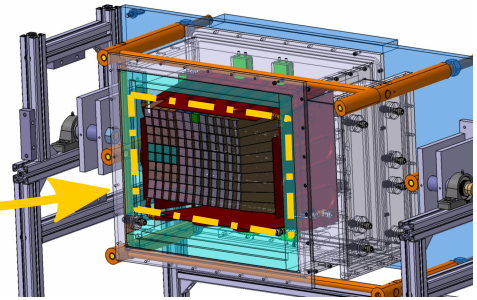
$\Rightarrow$ Set of test beamtimes covering design energy range complete

Outlook - PROTO120









Prototype Comparison

PROTO60

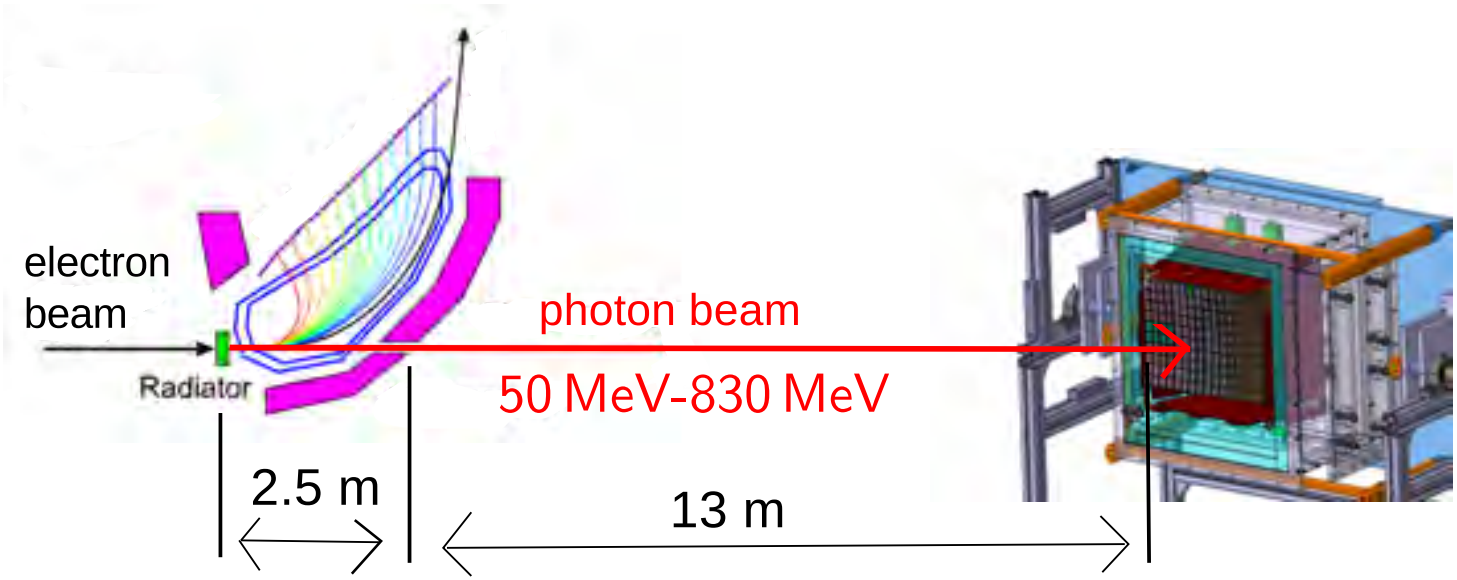
- 60 crystals, single geometry (type 6)
- Single LAAPD, 1 cm^2 (quadratic)
- Low-noise low-power charge preamplifier (LNP)
- Trick: different gains in inner and outer ring

$\Rightarrow$ Required resolution parameters achieved

PROTO120

- 120 crystals, three geometries (type 1, 2 and 3)
- 2 LAAPDs per crystal (rectangular)
- APFEL 1.4 with final dynamic range
- close to final mechanics

PROTO120 - First Beam Test at MAMI



- Test setup at MAMI with sub-matrix of nine crystals
- Analysis currently ongoing

Thank you for listening!