KVI

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GSI

Forward and Endcap EMC

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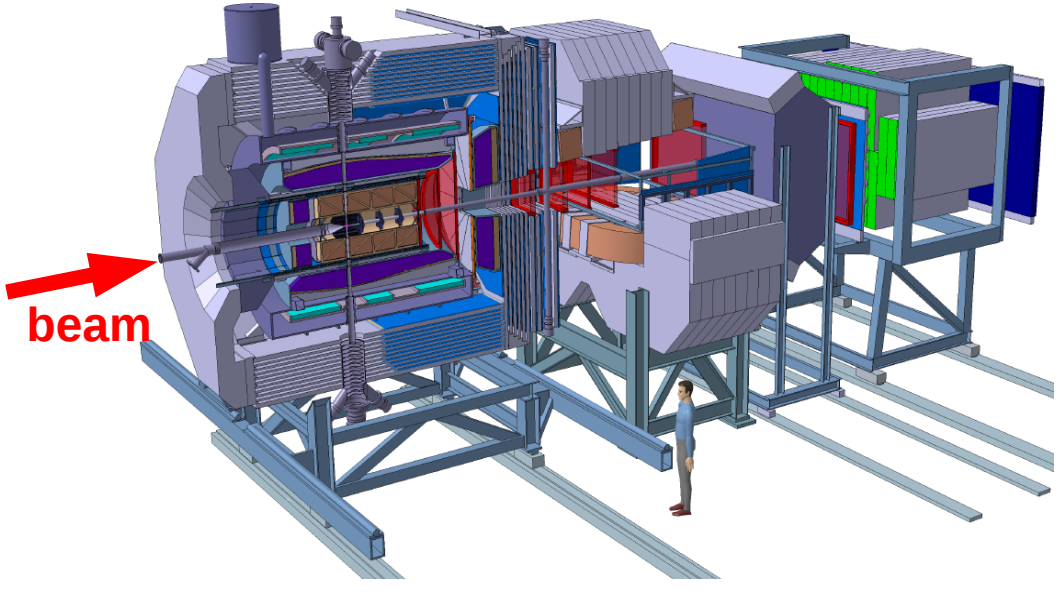
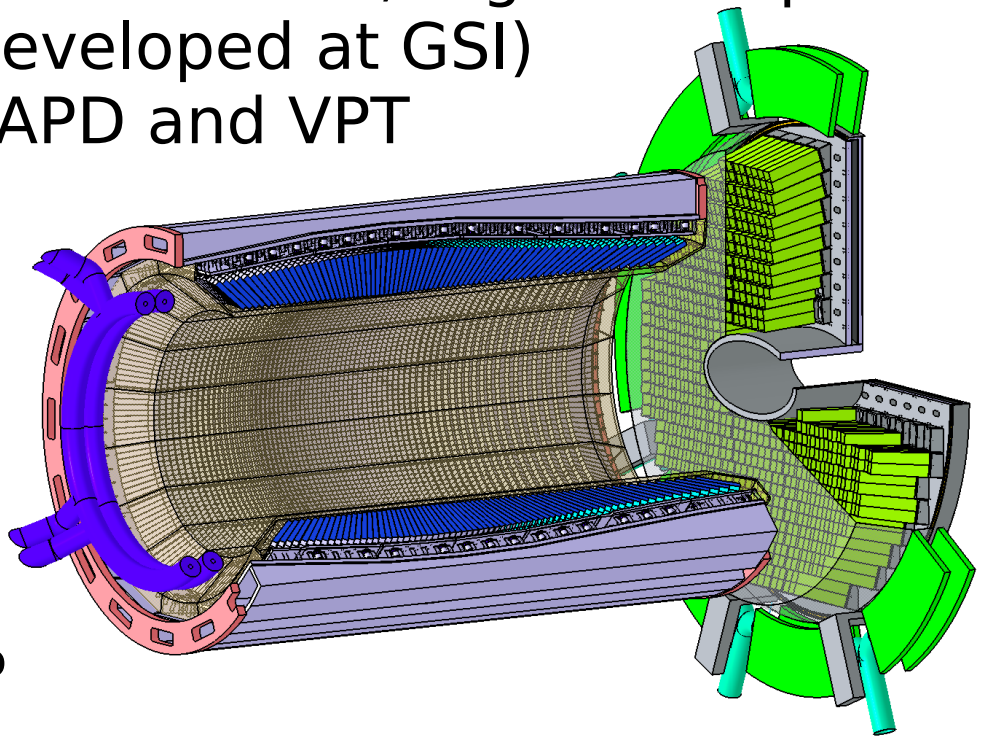
for the PANDA Collaboration



EMC

- ~15000 $PbWO_4$ crystals operated at -25°C
- Photo detectors:
  - Large Area Avalanche Photodiodes (2 per crystal; Barel EMC; outer part of Endcap EMC?)
  - Vacuum Photo Triodes (Endcap EMC)
- Preamplifiers:
  - ASIC APFEL (preamp.+shaper; 2 channels; 2 gains outputs per ch; designed for LAAPD; developed at GSI)
  - Discrete LNP (designed for LAAPD and VPT developed at Basel)
- Prototypes:
  - Barel EMC in operation: 60 crystals; LAAPD; LNP
  - Endcap EMC in develpoment: 192 crystals; VPT+LNP, LAAPD+ASIC and LAAPD+LNP



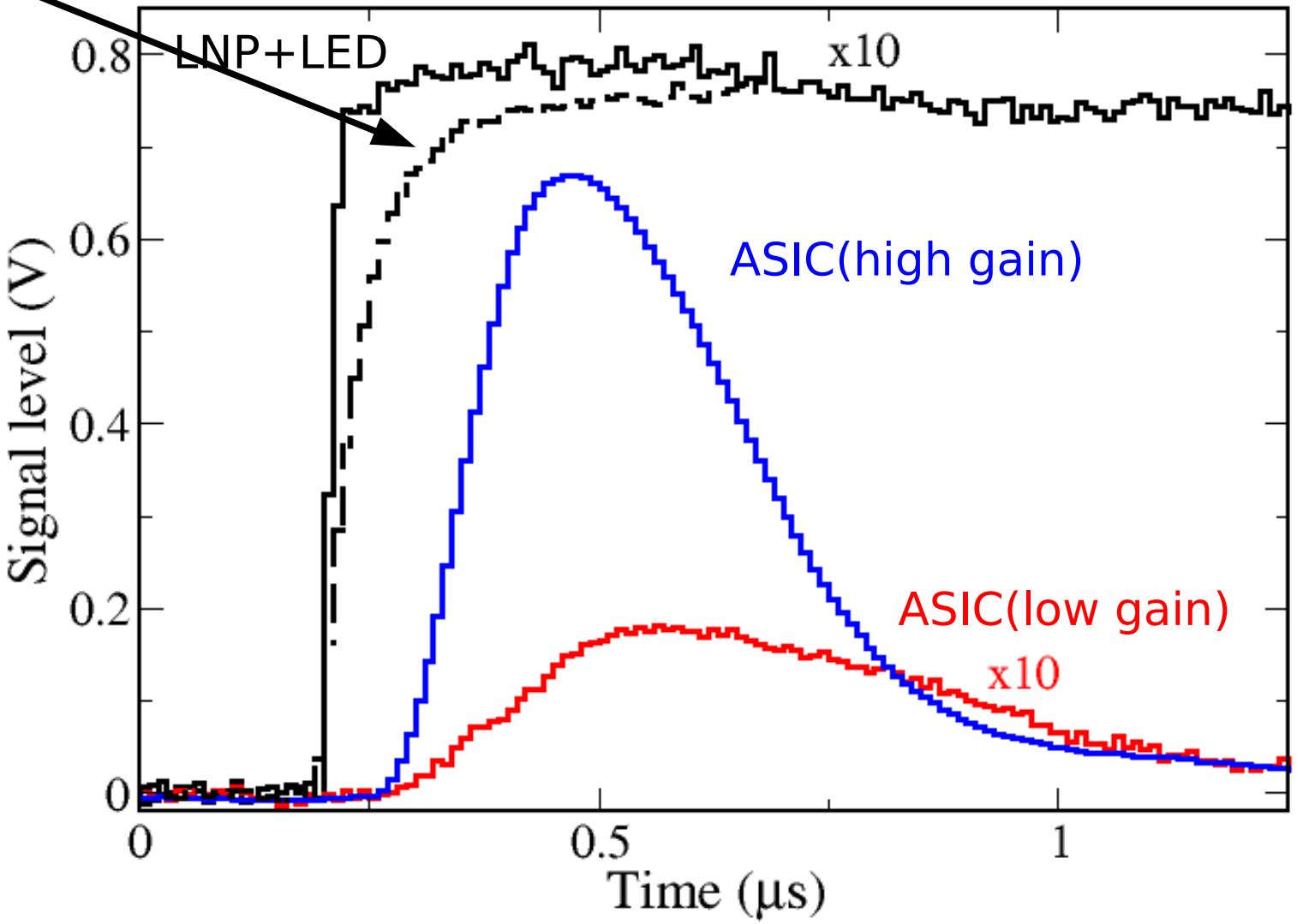
EMC Requirements
(TDR summary)

	Required performance value		
Common properties			
energy resolution σ_E/E	$\leq 1\,\% \oplus \frac{\leq 2\,\%}{\sqrt{E/\mathrm{GeV}}}$		
energy threshold (photons) E_{thres}	10 MeV (20 MeV tolerable)		
energy threshold (single crystal) E_{xtl}	3 MeV		
rms noise (energy equiv.) $\sigma_{E,noise}$	1 MeV		
angular coverage $\%\,4\pi$	99 %		
mean-time-between-failures t_{mtbf} (for individual channel)	2000 y		
Subdetector specific properties	backward ($\geq 140°$)	barrel ($\geq 22°$)	forward ($\geq 5°$)
energy range from E_{thres} to	0.7 GeV	7.3 GeV	14.6 GeV
angular equivalent of crystal size θ	4°		1°
spatial resolution σ_θ	0.5°	0.3°	0.1°
maximum signal load f_γ ($E_\gamma > E_{xtl}$)	60 kHz		500 kHz
($p\bar{p}$-events) maximum signal load f_γ ($E_\gamma > E_{xtl}$)	100 kHz		500 kHz
(all events) shaping time t_s	400 ns		100 ns
radiation hardness (maximum annual dose $p\bar{p}$-events)	0.15 Gy	7 Gy	125 Gy
radiation hardness (maximum annual dose from all events)	10 Gy		125 Gy

Pulse Shapes

One time bin corresponds to 10ns

LNP + cosmic rays

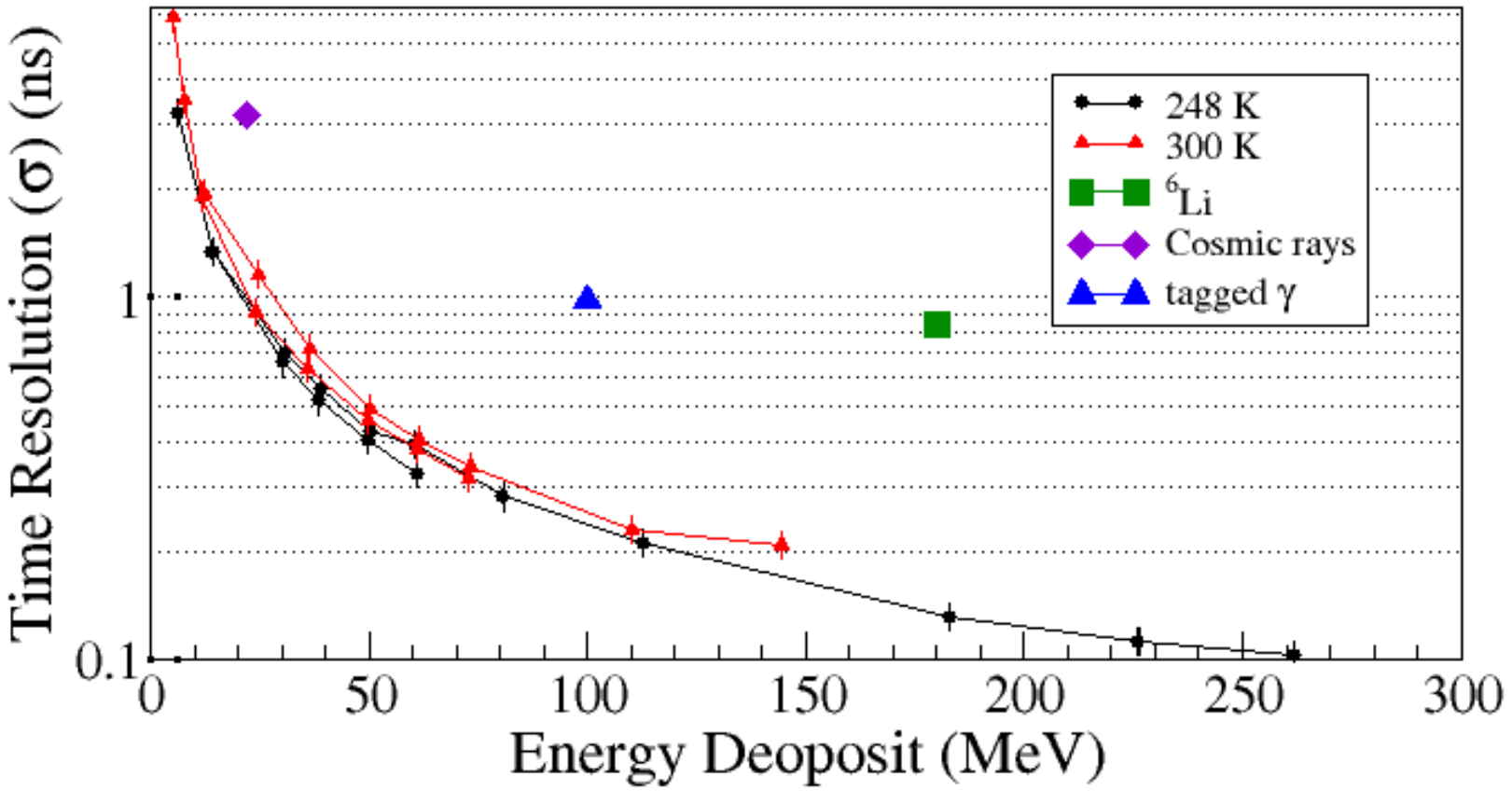


Pulse Shapes

LNP + cc

ds to 10ns

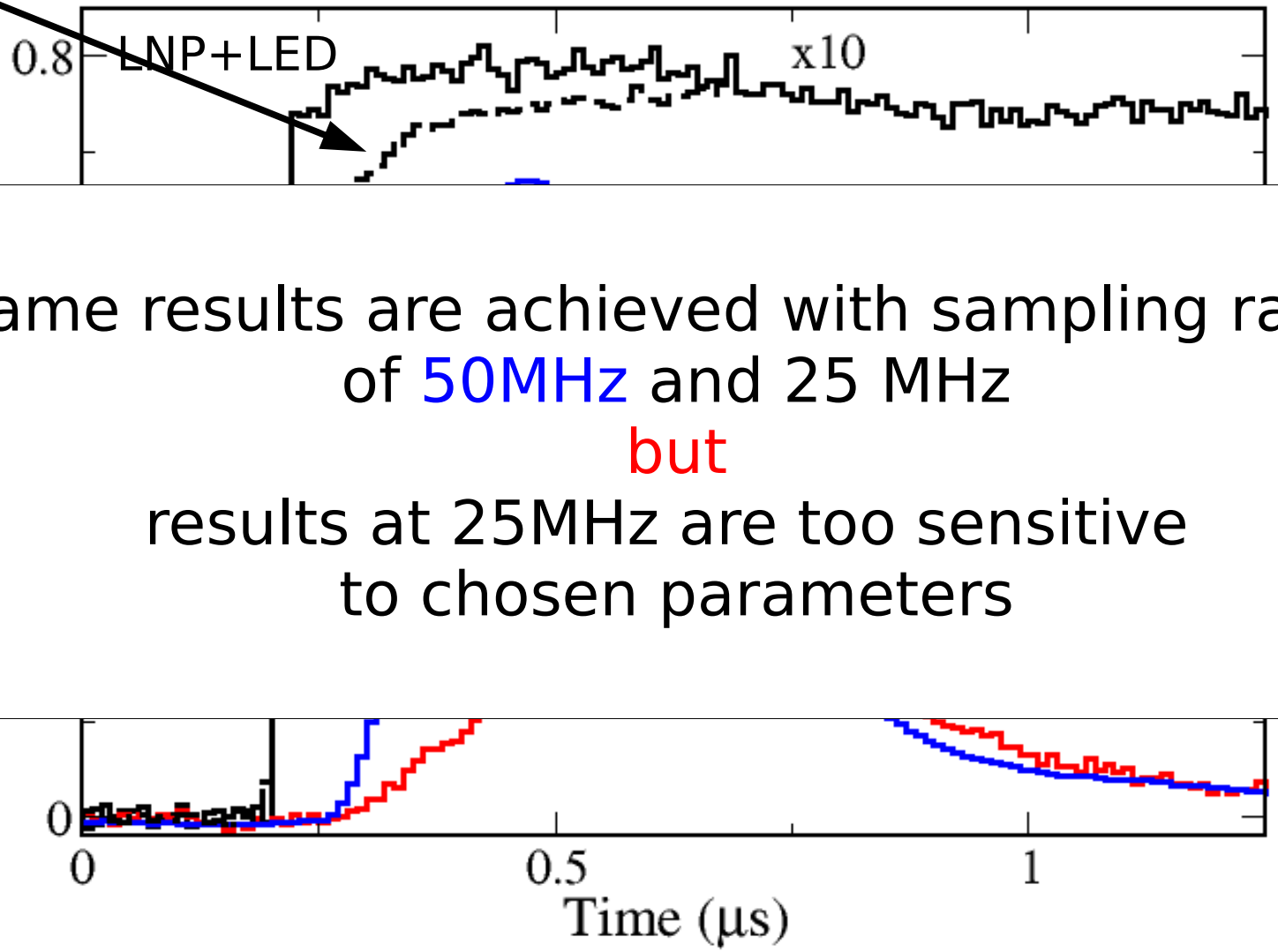
Time Resolution (LED)



Pulse Shapes

One time bin corresponds to 10ns

LNP + cosmic rays



Same results are achieved with sampling rates of 50MHz and 25 MHz

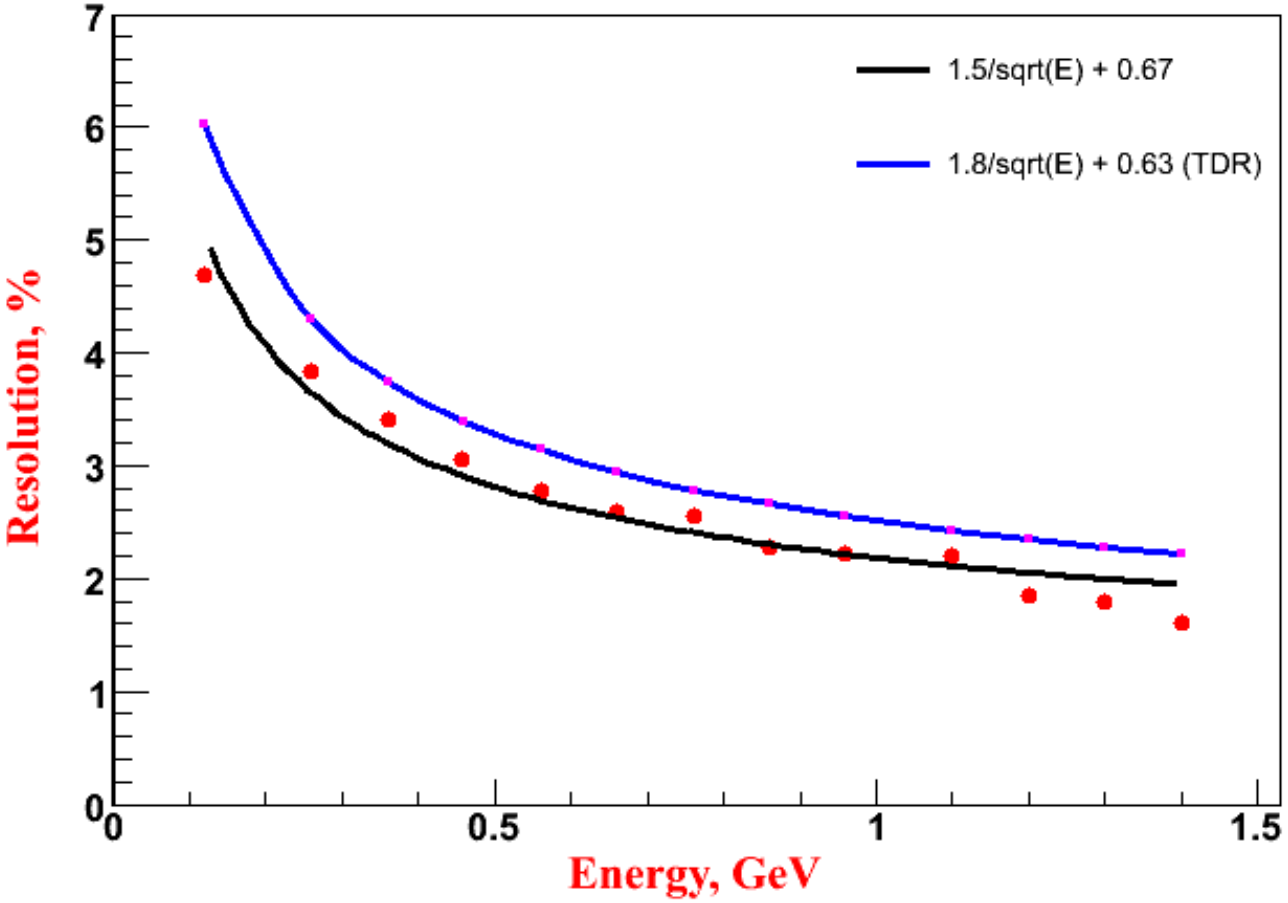
but

results at 25MHz are too sensitive to chosen parameters

Energy Resolution
tagged photon measurements at Mainz

SADC readout compared with conventional QDC, advantages:

- no analogue delay lines
- possibility to cower total required dynamic range
- Digital filtering for noise reduction (1.4 MeV → 0.3 MeV)



Energy resolution:

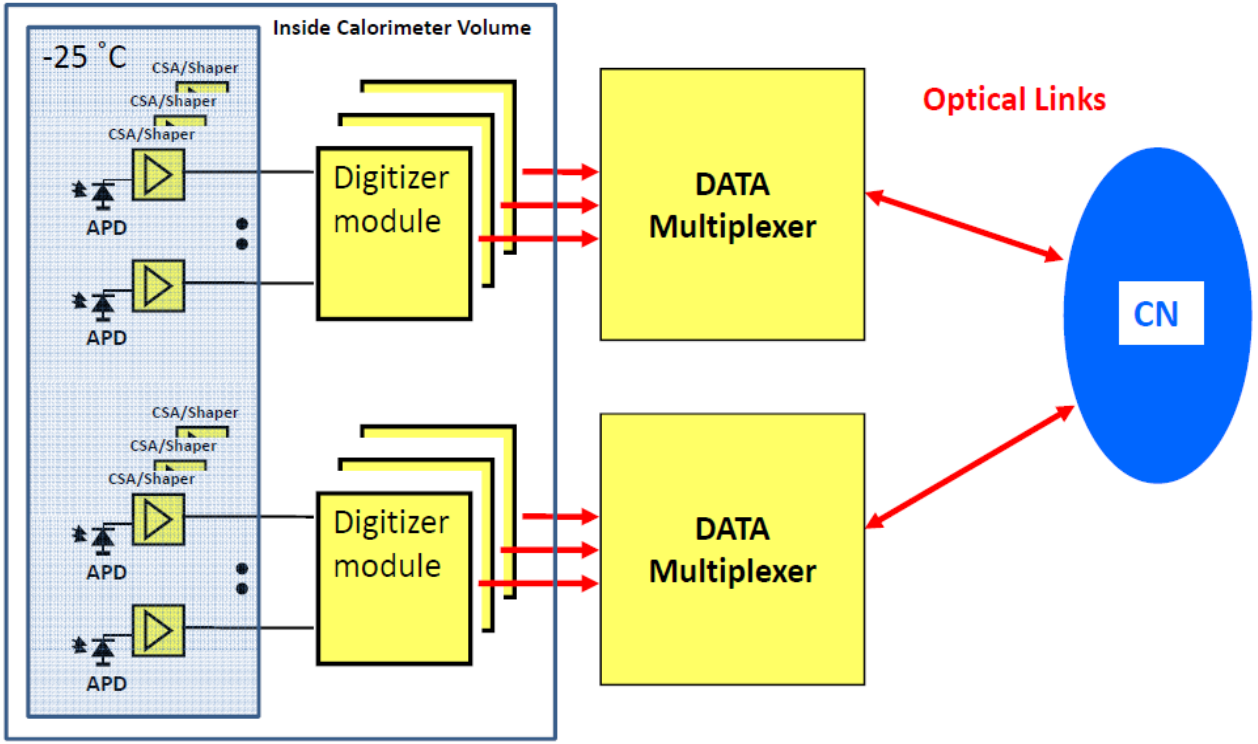
4,69 % @ 0.12 GeV

2.20% @ 1.0 GeV

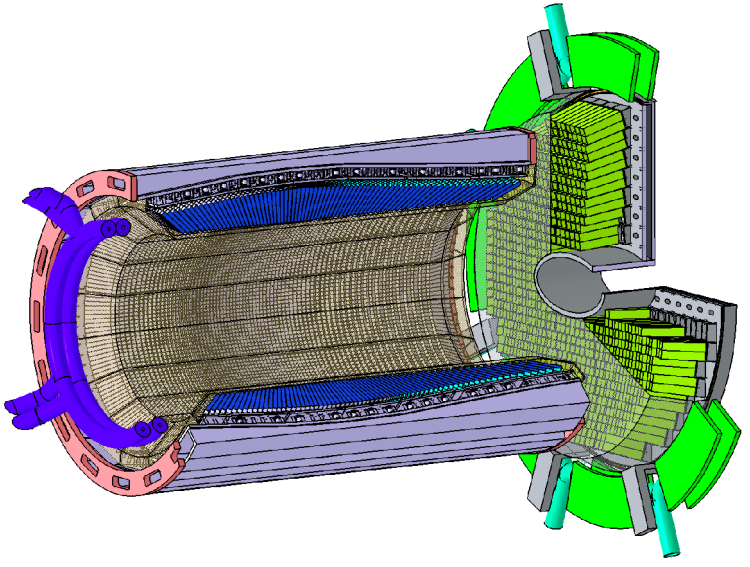
1.6 % @ 1.4 GeV

Measurements with Proto60:

- 1 LAAPD per crystal
- LNP preamp.



- Role of Digitizers:
  - extract energy, time
- Role of Multiplexers:
  - find clusters
  - calculate Zernike moments



Summary

- EMC Prototypes (Proto 60 and Proto 192) allowed or will allow to test performance:
  - LAAPD+LNP was tested (fulfil TDR requirements)
  - LAAPD+ASIC
  - VPT+LNP
- Digitizer prototypes have to be designed
- Hardware implementation of Feature-extraction algorithms has to be tested