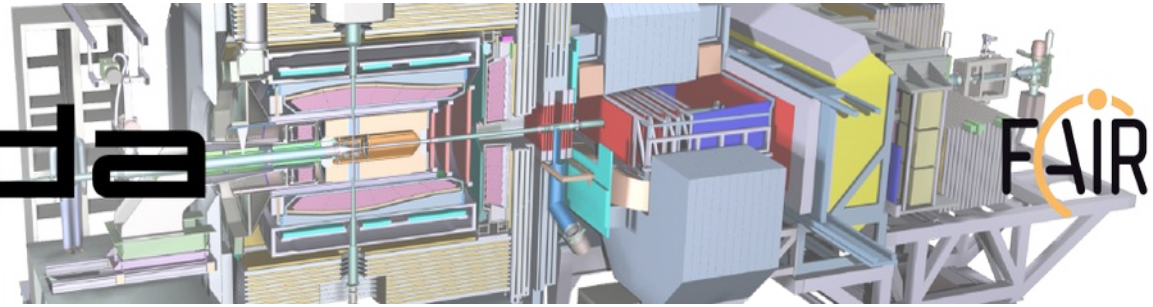
Status Barrel EMC
of the



Target Spectrometer

Markus W. H. Moritz
2nd Physics Institute, Giessen University, Germany

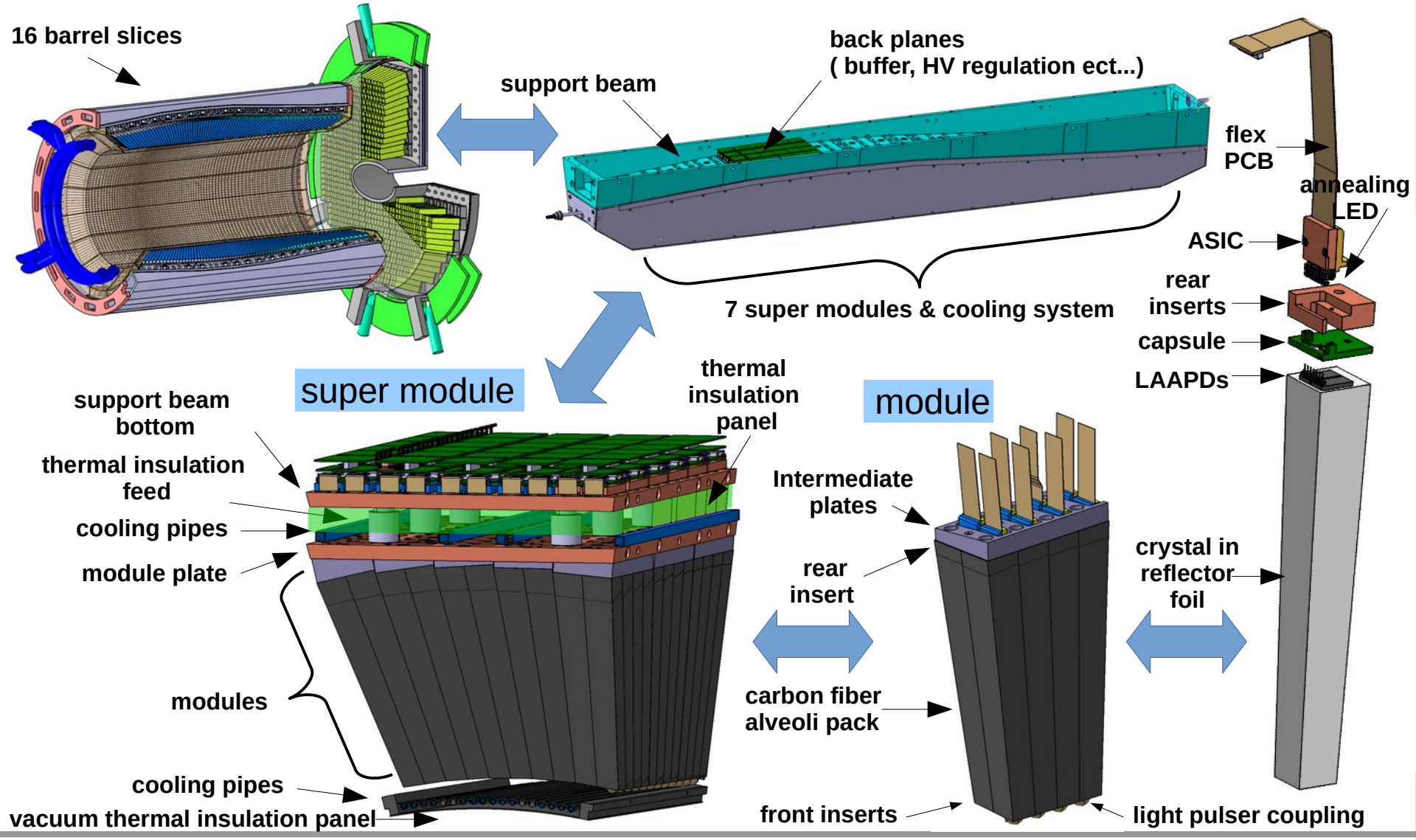
PANDA CM, October 2020

Barrel Calorimeter of the $\bar{P}$ANDA Target Spectrometer

target EMC

barrel slice

single detector unit

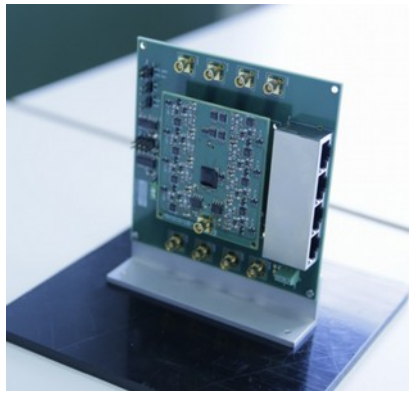
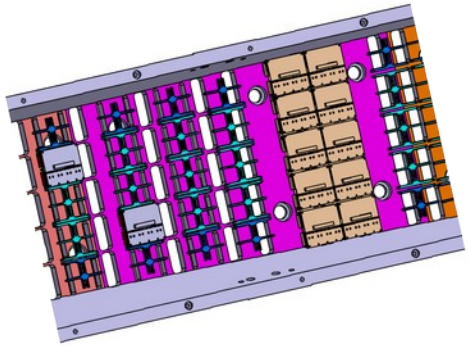


Envisaged milestone (M8): Assembly of 1st full Barrel EMC slice

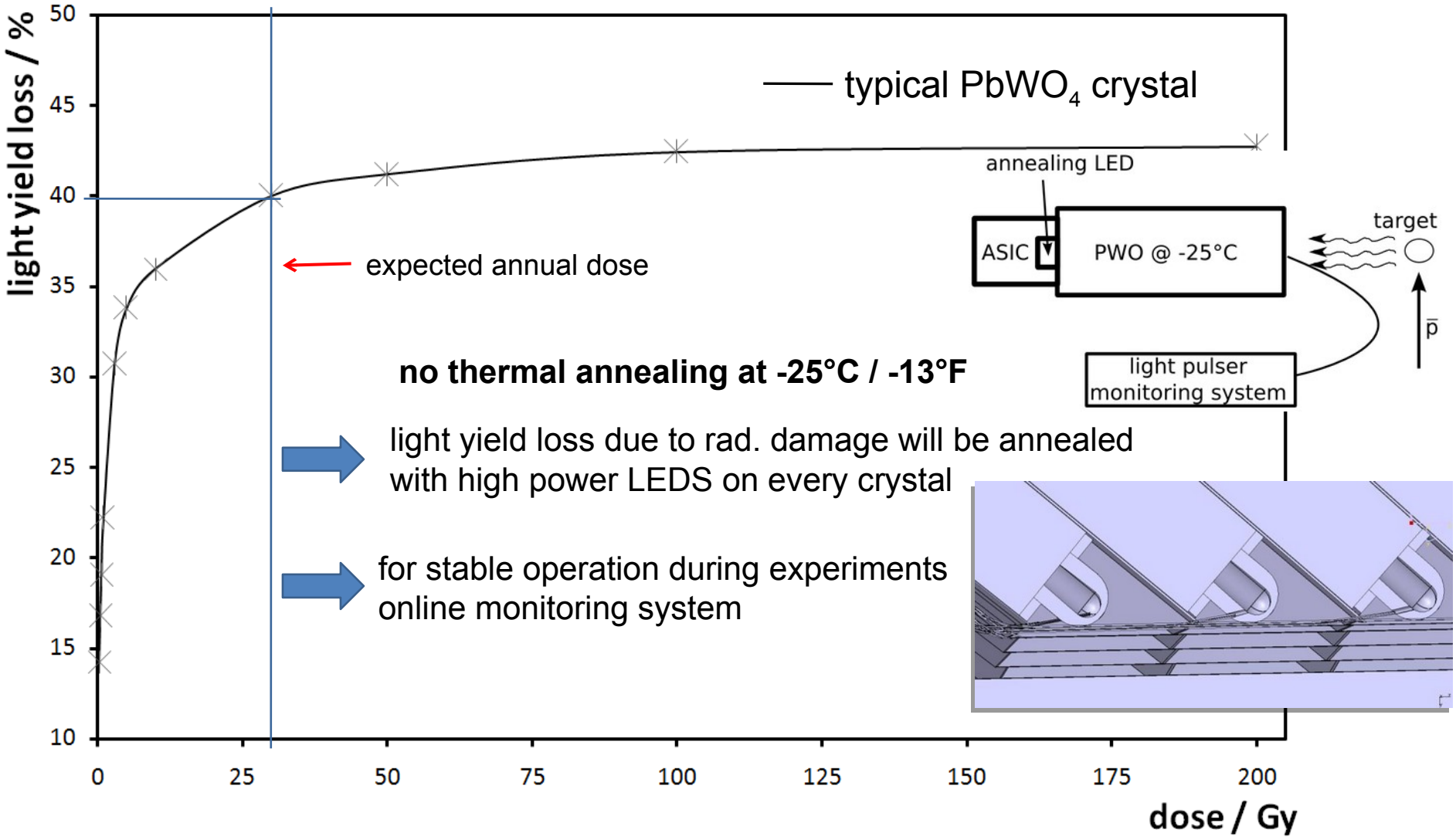
- Infrastructure ✓
- Mechanics ✓
- 710 detectors ✓
  - 710 crystals in 11 different geometries ✓
  - 1420 APDS
    - Screening including irradiation ✓
    - Matching ✓
    - Glueing ✓
  - Capsules ✓
  - Wrapping ✓
- Assembly of 18 modules ✓
- Assembly of Supermodules ✓
  - 360 left and 360 right handed APFEL-ASIC with flex PCBs ✓
  - ASIC housing or fixtures ✓
- Assembly of full 1st slice X
  - (Re-)design supportbeam ✓
  - Mod. preseries supportbeam CAD ready
  - Cooling & thermal insulation in progress
  - Backplanes in progress
  - Light pulser fiber coupling in progress





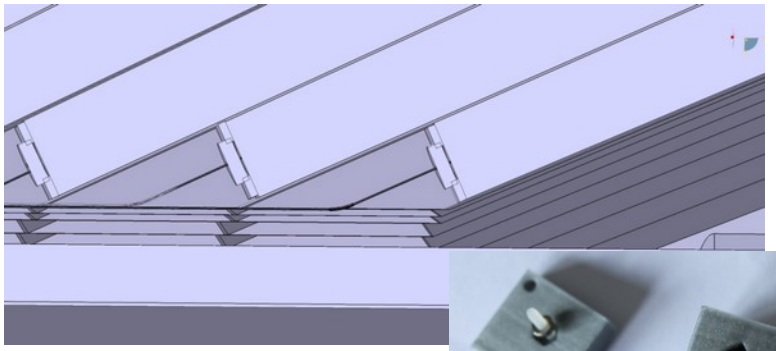



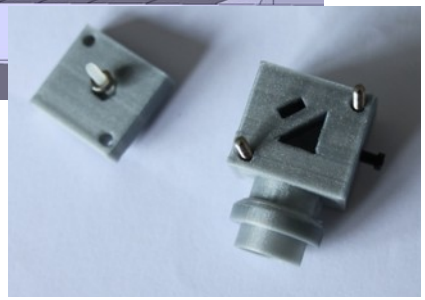
Assembly Procedure – Light Pulser Monitoring-

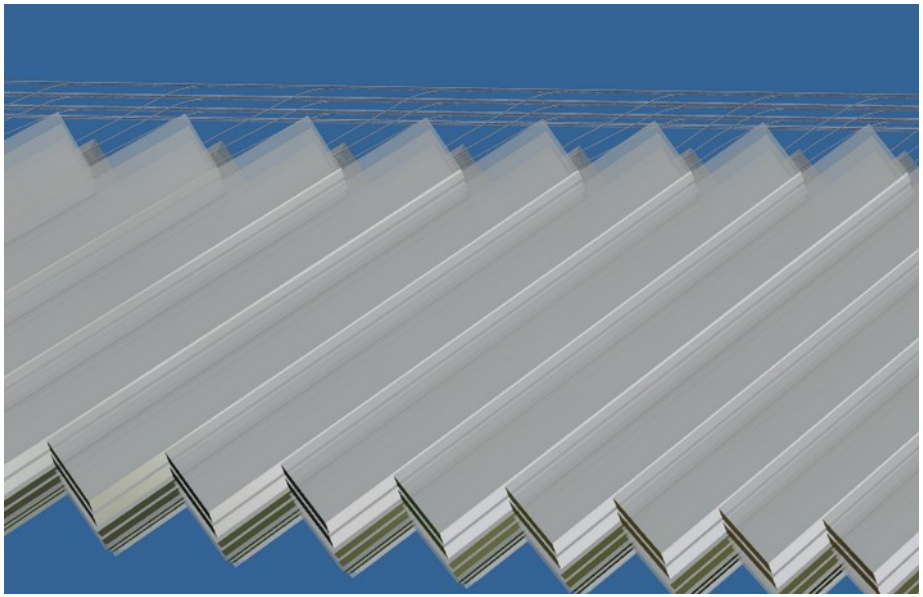


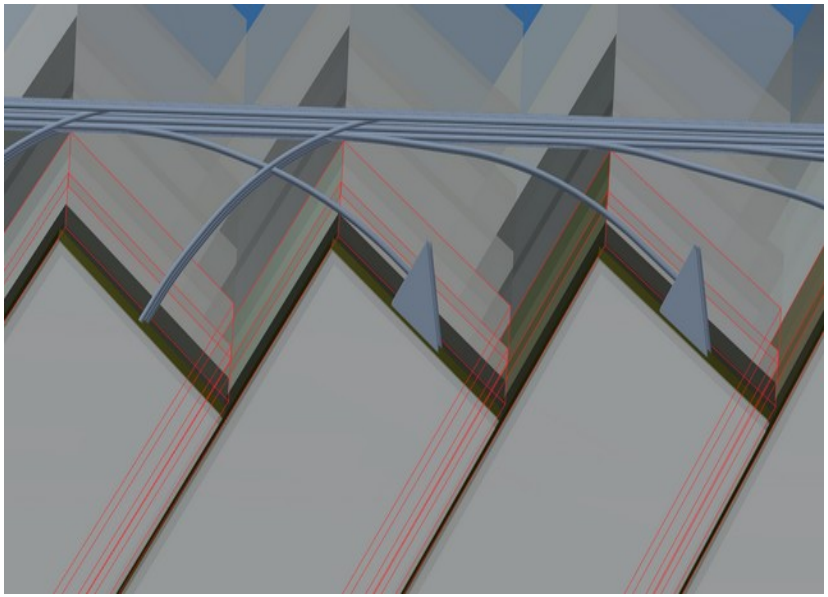
Assembly Procedure – Light Pulser Monitoring-

- Space very limited
- Fiber long term bending radius: 33 mm
- Idea: route fibers from up and downstream
  - Advantage:
    - More fibers can directly coupled
    - Rest (39X10) with 90° prism
  - Disadvantage:
    - 1€/m of single fiber



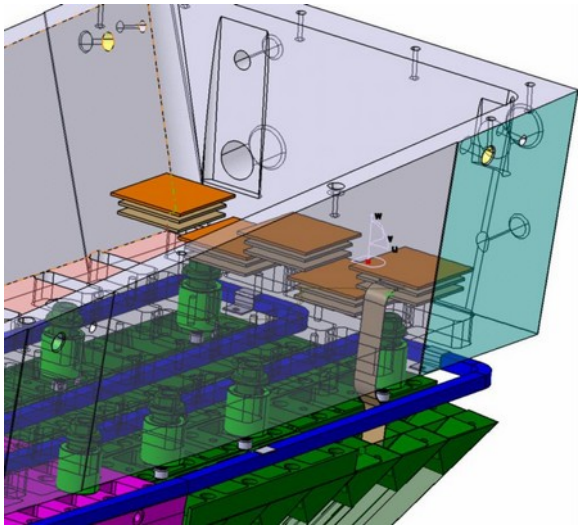


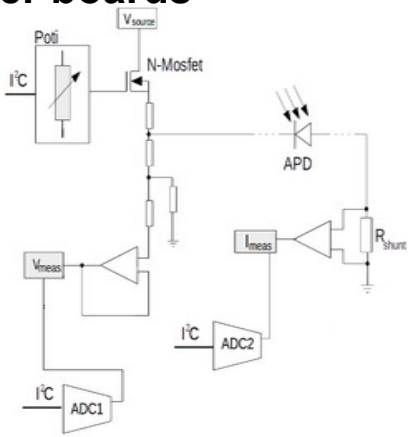


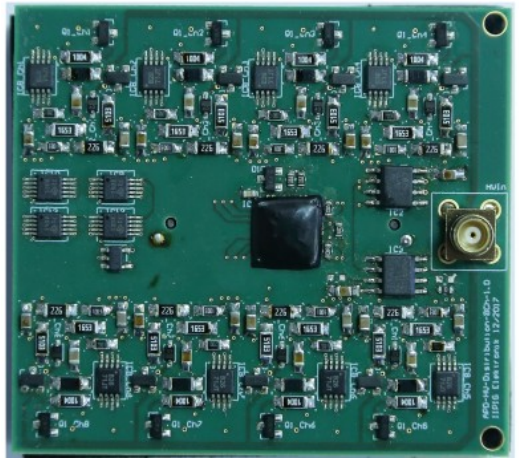


3 Layers

- **Top: HVD board**
  - Adjust bias voltage of 8 APDs
  - 50V from HV input downwards in < 0,1V steps
  - All channels fed from the same HV source
    → safes space inside support beam
  - Online measurement of APD voltage and current
- **Middle: Connector board to multiplexer boards**
- **Bottom: Board for FlexPCBs / ASICS**
  - Connectors to FEs
  - 8x2 Diff. Line drivers
  - APFEL I/F buffers
  - Temp/Humidity sensors
  - HitDetection ASIC







HVD board

Backplanes

3 Layers

- **Top: HVD board**
  - Adjust bias voltage of 8 APDs
  - 50V from HV input downwards in < 0,1V steps
  - All channels fed from the same HV source
    → safes space inside support beam
  - Online measurement of APD voltage and current
- **Middle: Connector board to multiplexer boards**
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  - Connectors to FEs
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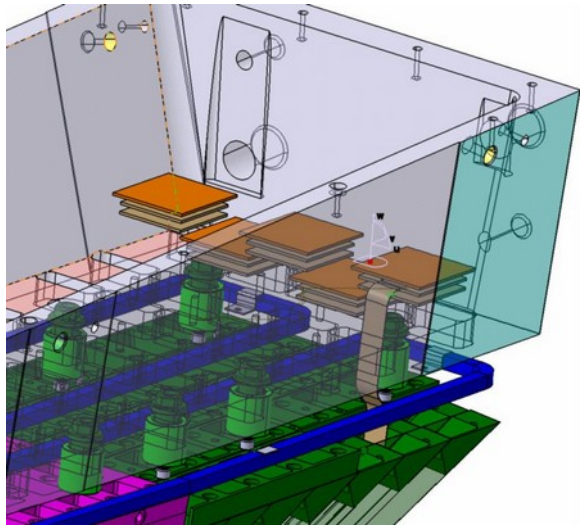
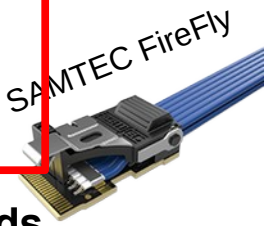
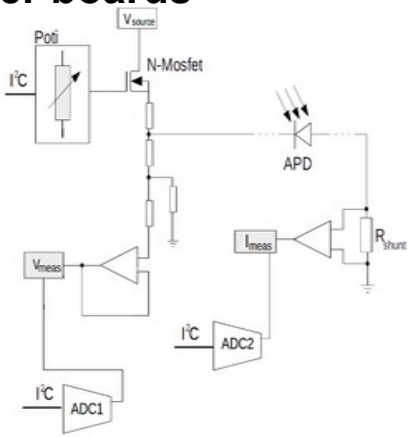
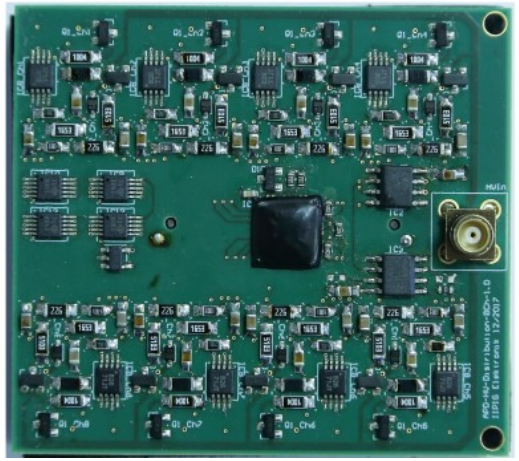




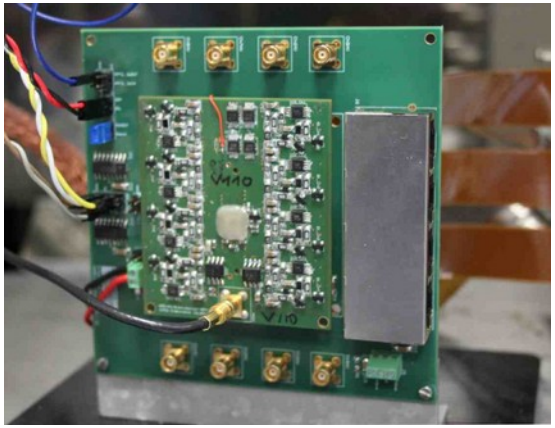




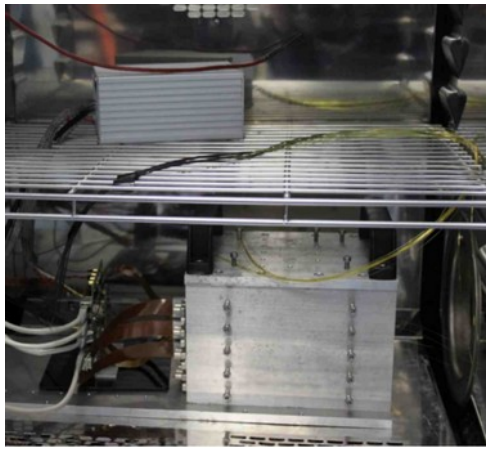
HVD board

Backplanes – Ongoing Activities-

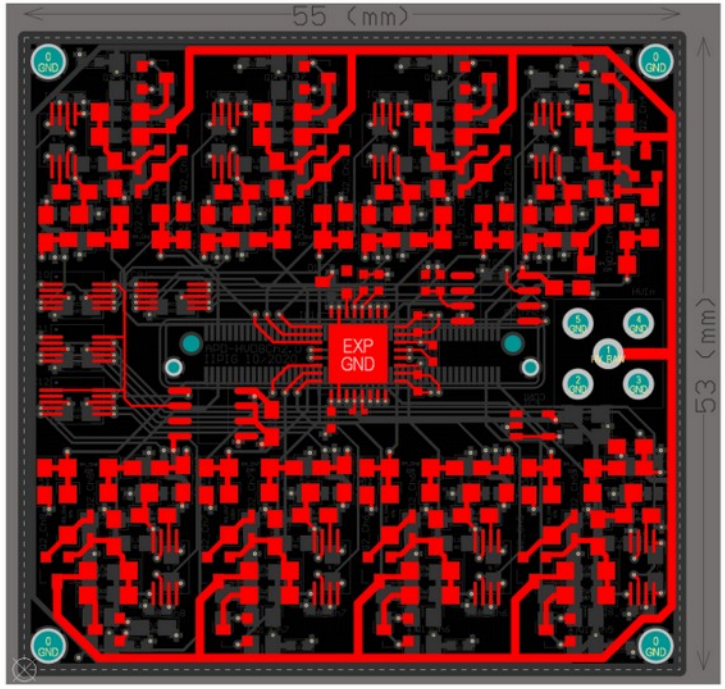
HVD test-board for full functionality tests before mass production



full triple sandwich tests with crystal matrix



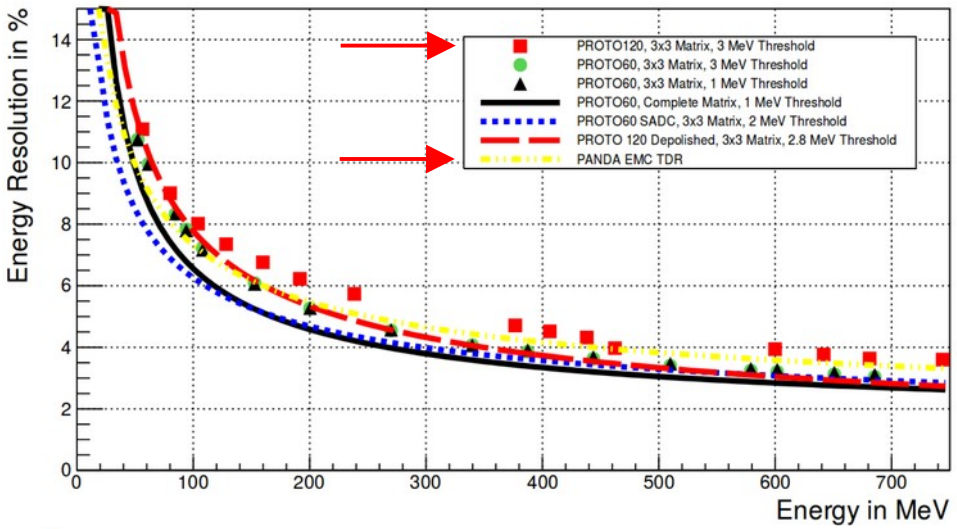
Final prototype is currently in production



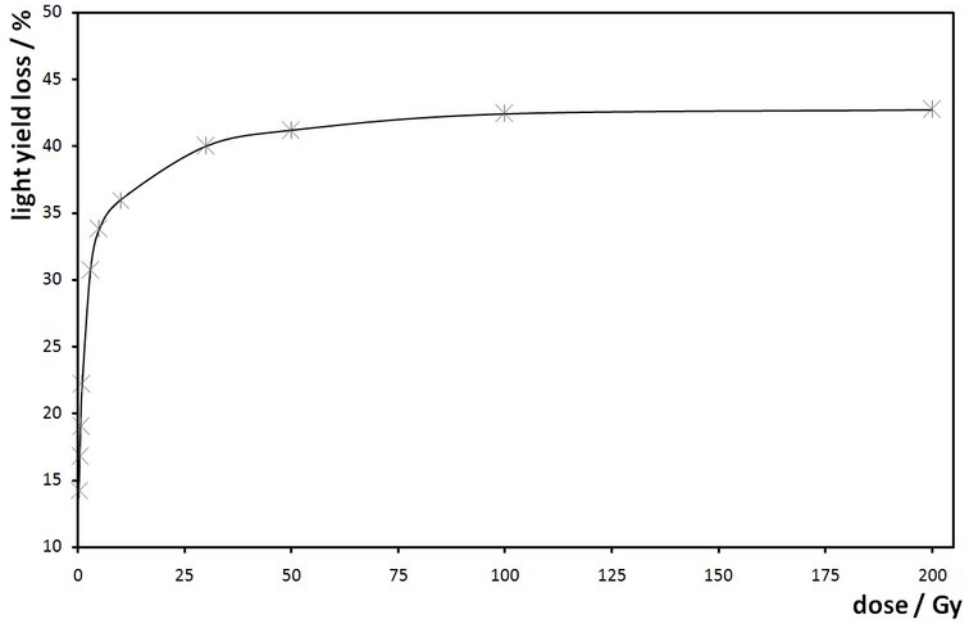
minor changes to the highvoltage regulation part and a decrease in size

Motivation

TDR resolution goal barely reached especially at low energies

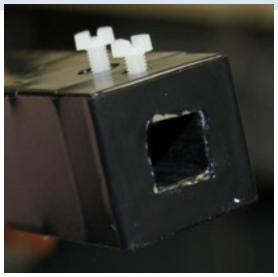


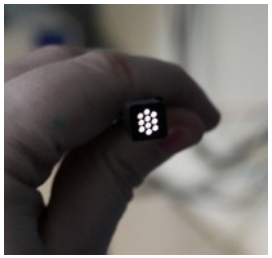
Fast light yield loss within first few gray

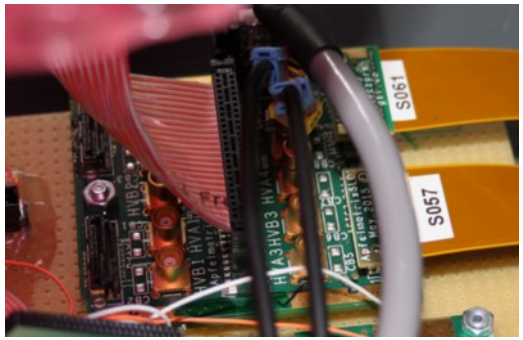


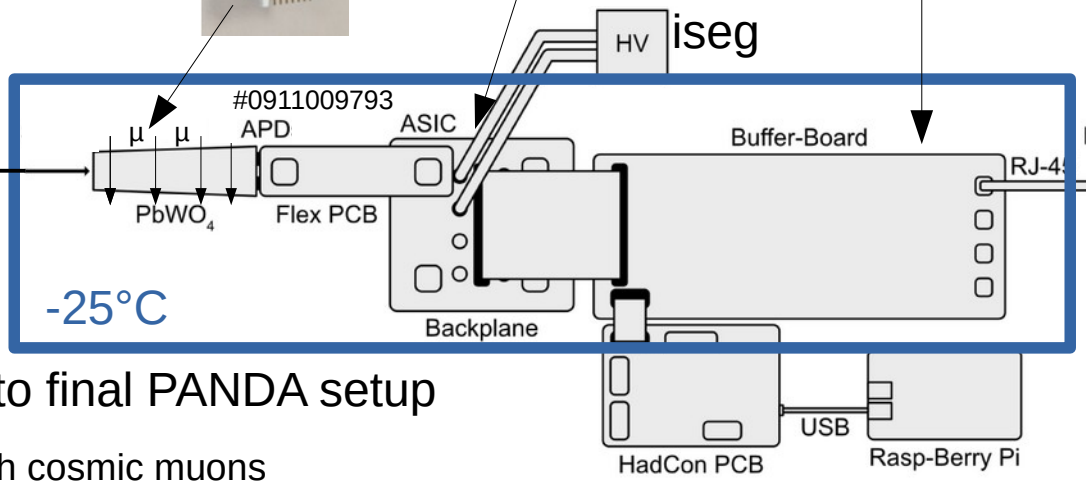
REMINDER - APD Gain Optimization – Light Pulser Measurements

Setup









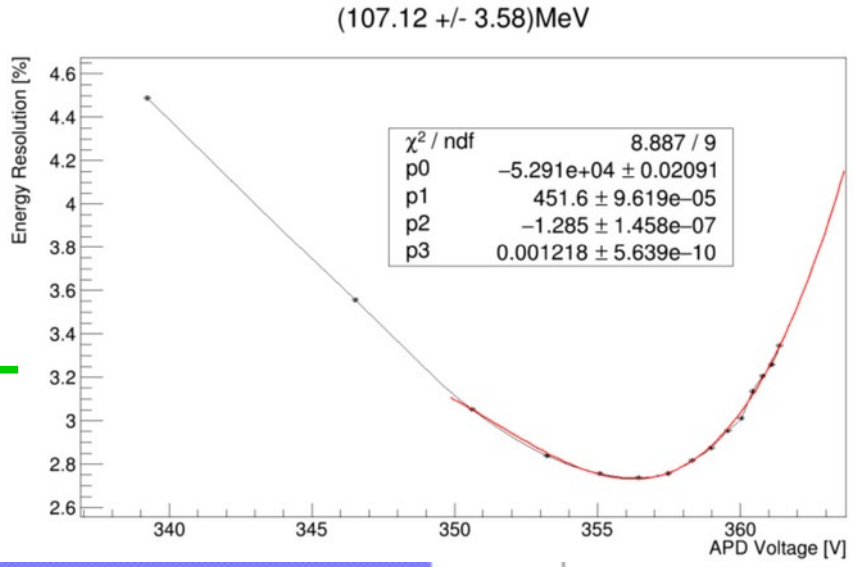
PANDA SADC with opt. feature extraction (Oliver Noll)

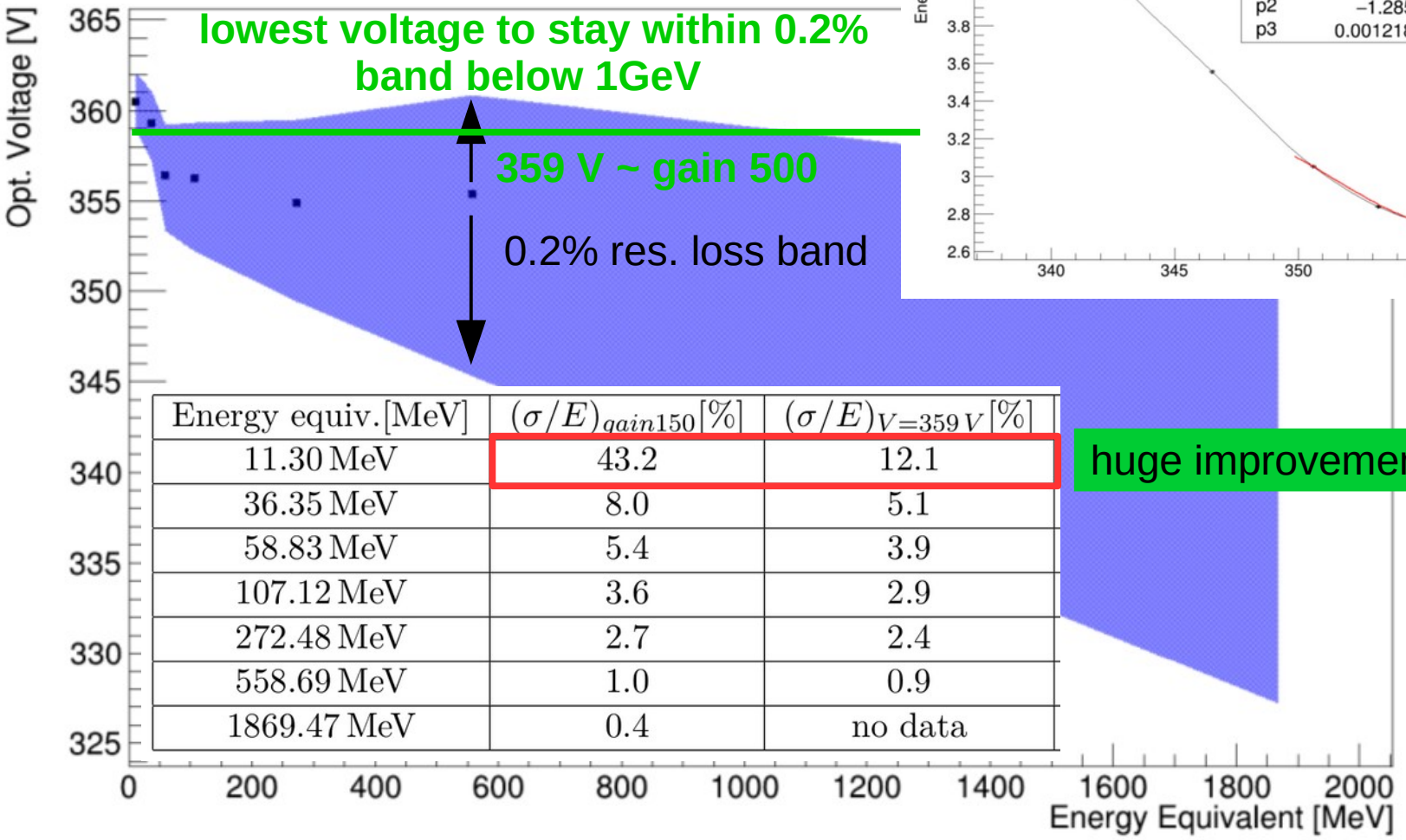
very close to final PANDA setup

- Setup calibration with cosmic muons
- Light pulses from 11,3 MeV up to 1.9 GeV measured

REMINDER - APD Gain Optimization – Light Pulser Measurements

Results



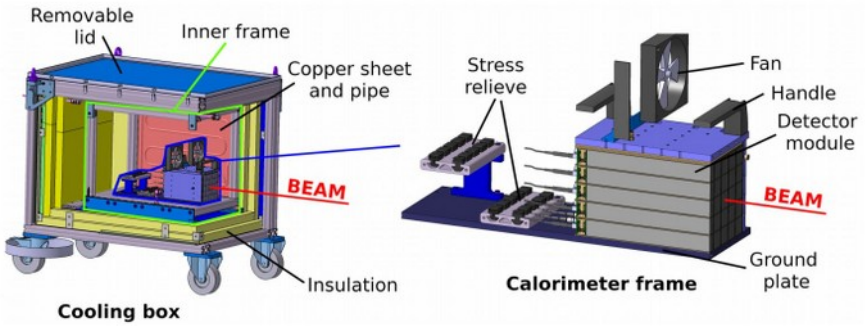


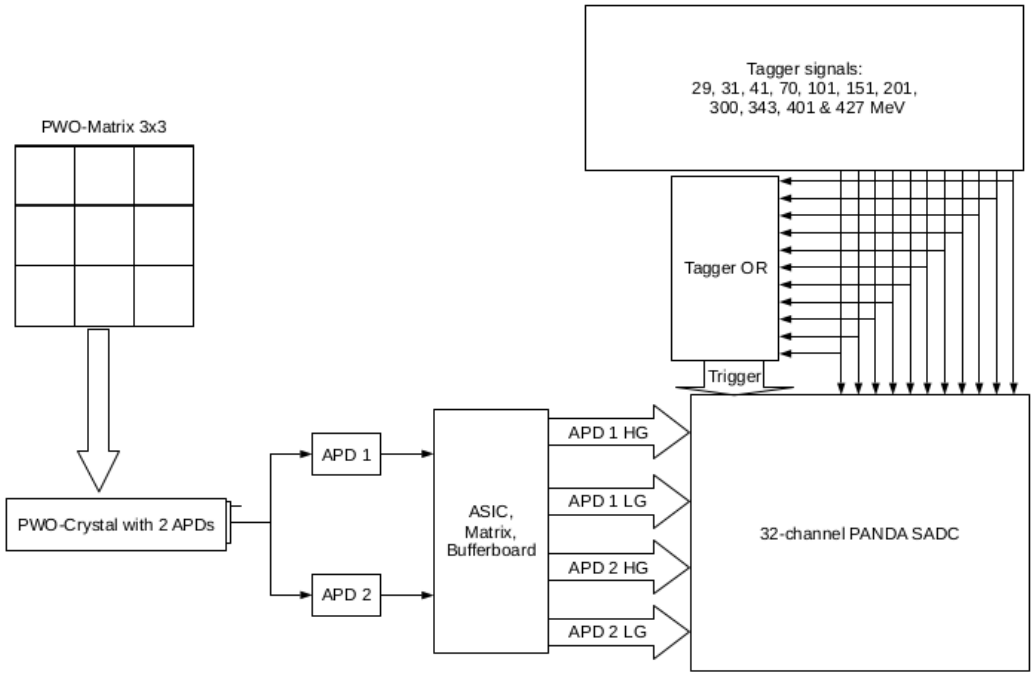
Energy equiv.[MeV]	$(\sigma/E)_{gain150}$[%]	$(\sigma/E)_{V=359\,V}$[%]
11.30 MeV	43.2	12.1
36.35 MeV	8.0	5.1
58.83 MeV	5.4	3.9
107.12 MeV	3.6	2.9
272.48 MeV	2.7	2.4
558.69 MeV	1.0	0.9
1869.47 MeV	0.4	no data

huge improvement for free ?

Setup

- 3x3 Matrix rectangular crystals @ -25°C
- 2 full screened & matched APDs per crystal
- Close to final read out
- Light Pulser
  - One fiber per Crystal
- Calib. reference in cooling box: fiber into APD with Basel preamp
- Tagged photons 29 MeV – 427 MeV





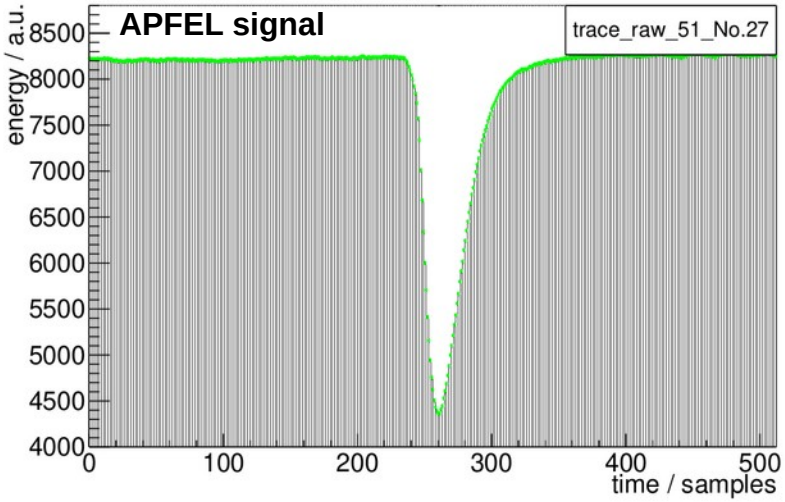
Procedure

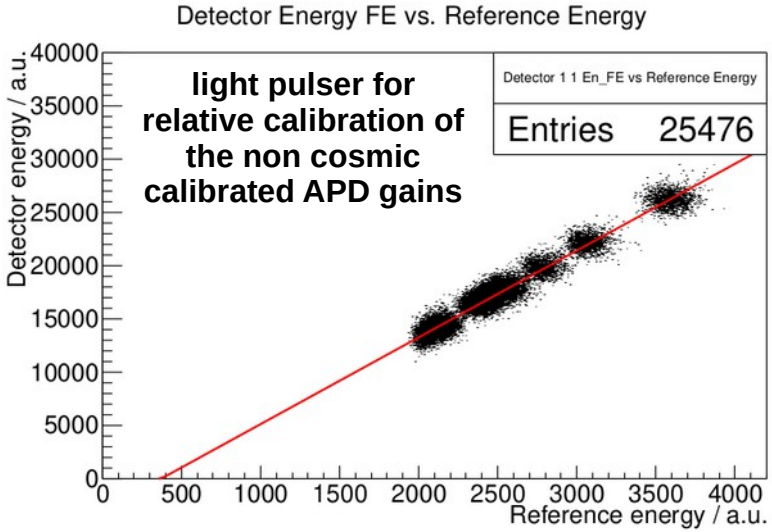
- Limited amount of SADC channels → dedicate run for each APFEL setting
- Beam into the center
- SADCs raw data collected
  - FPGAs have not been used

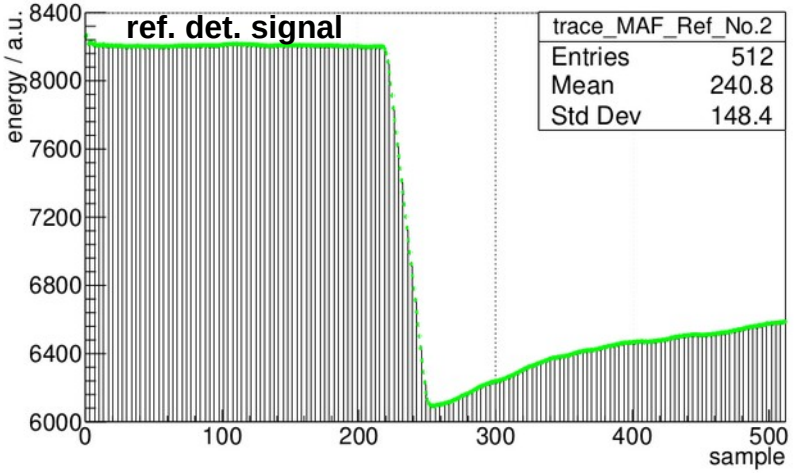
ASIC\APD	150	300	400	500
LG(×1)	Beam&LP	Beam&LP	Beam&LP	Beam&LP
HG(×16)	Beam&LP	Beam&LP	Beam&LP	Beam&LP
HG(×32)	Beam&LP	Beam&LP	Beam&LP	Beam&LP
HG(×16)				Cosmic

Analysis

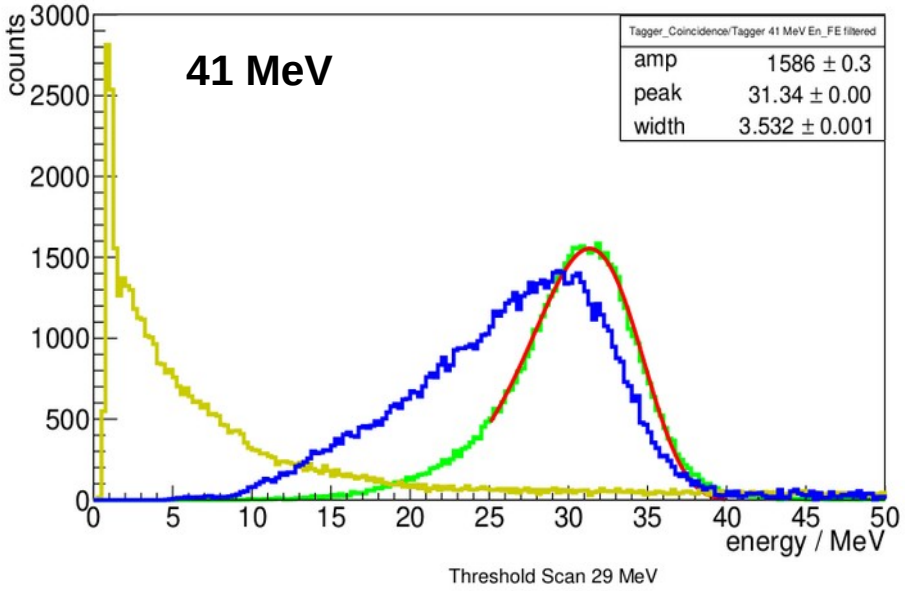
- Feature extraction:
  - APFEL signals: Oliver Nolls FE
  - Basel preamp: simple peak sensing algorithn
- Each APD threaded as individual detector
  - -> Individual calibration

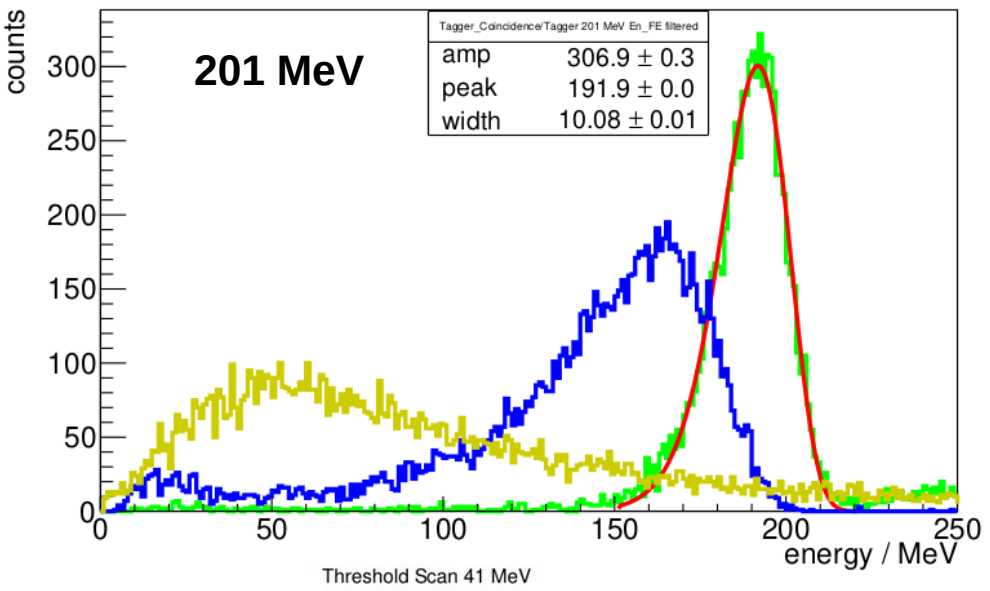


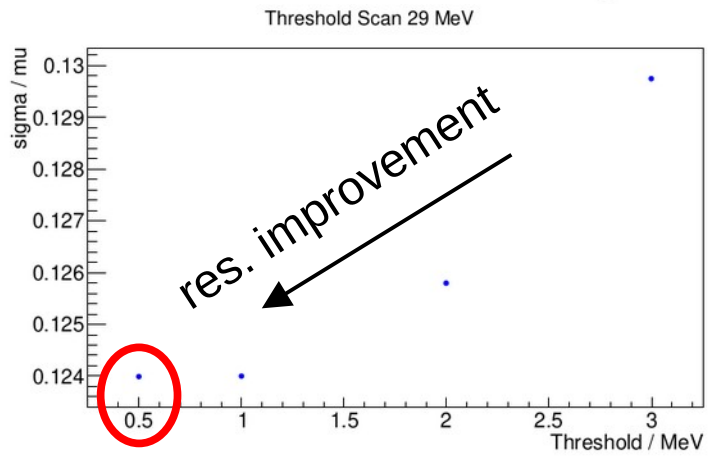


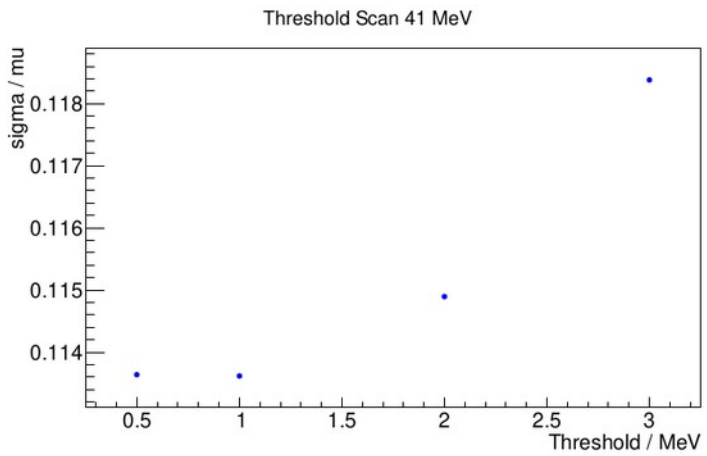


Analysis

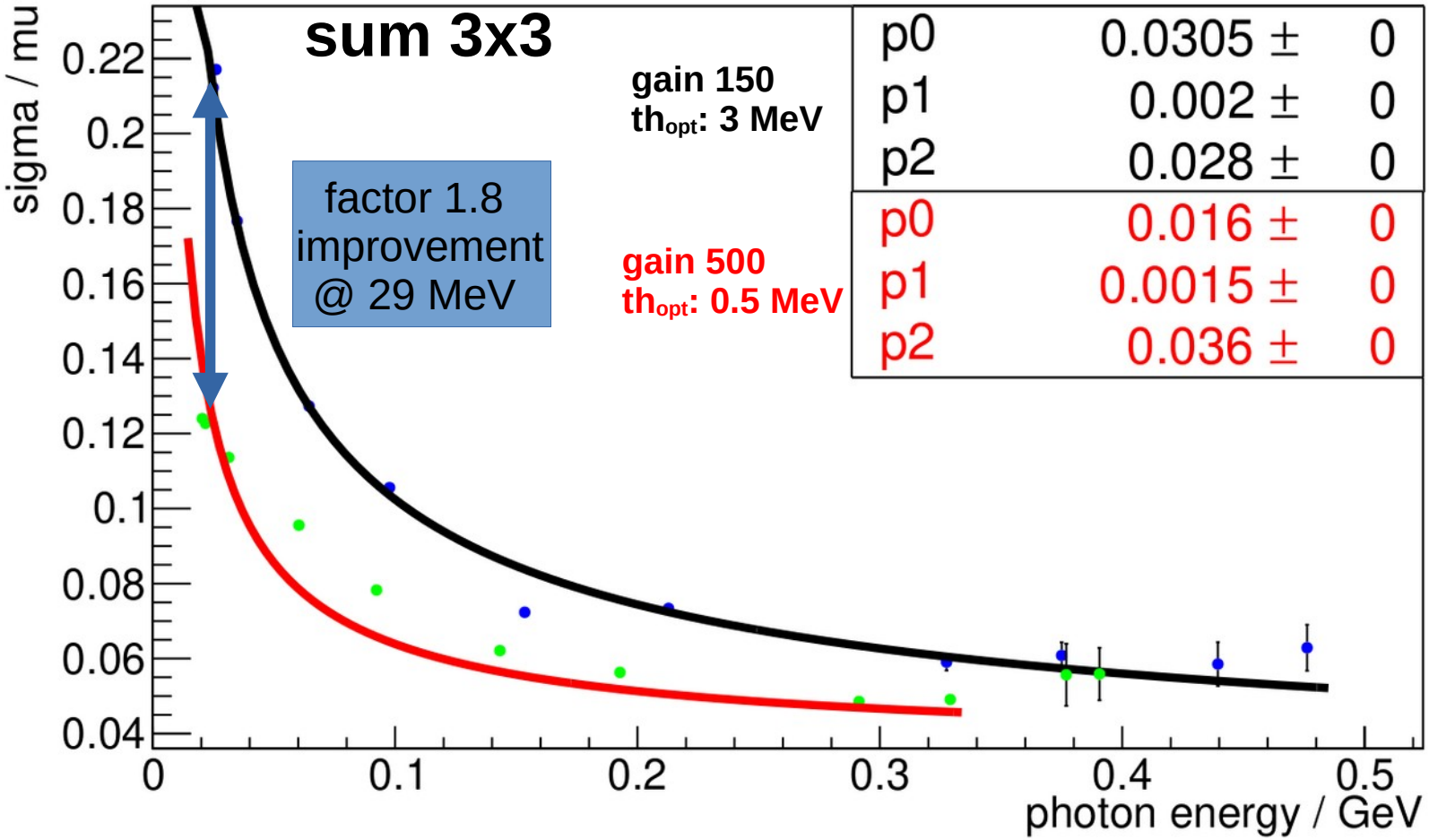

41 MeV
Tagger_Coincidence/Tagger 41 MeV En_FE filtered
amp 1586 ± 0.3
peak 31.34 ± 0.00
width 3.532 ± 0.001
counts
energy / MeV


201 MeV
Tagger_Coincidence/Tagger 201 MeV En_FE filtered
amp 306.9 ± 0.3
peak 191.9 ± 0.0
width 10.08 ± 0.01
counts
energy / MeV

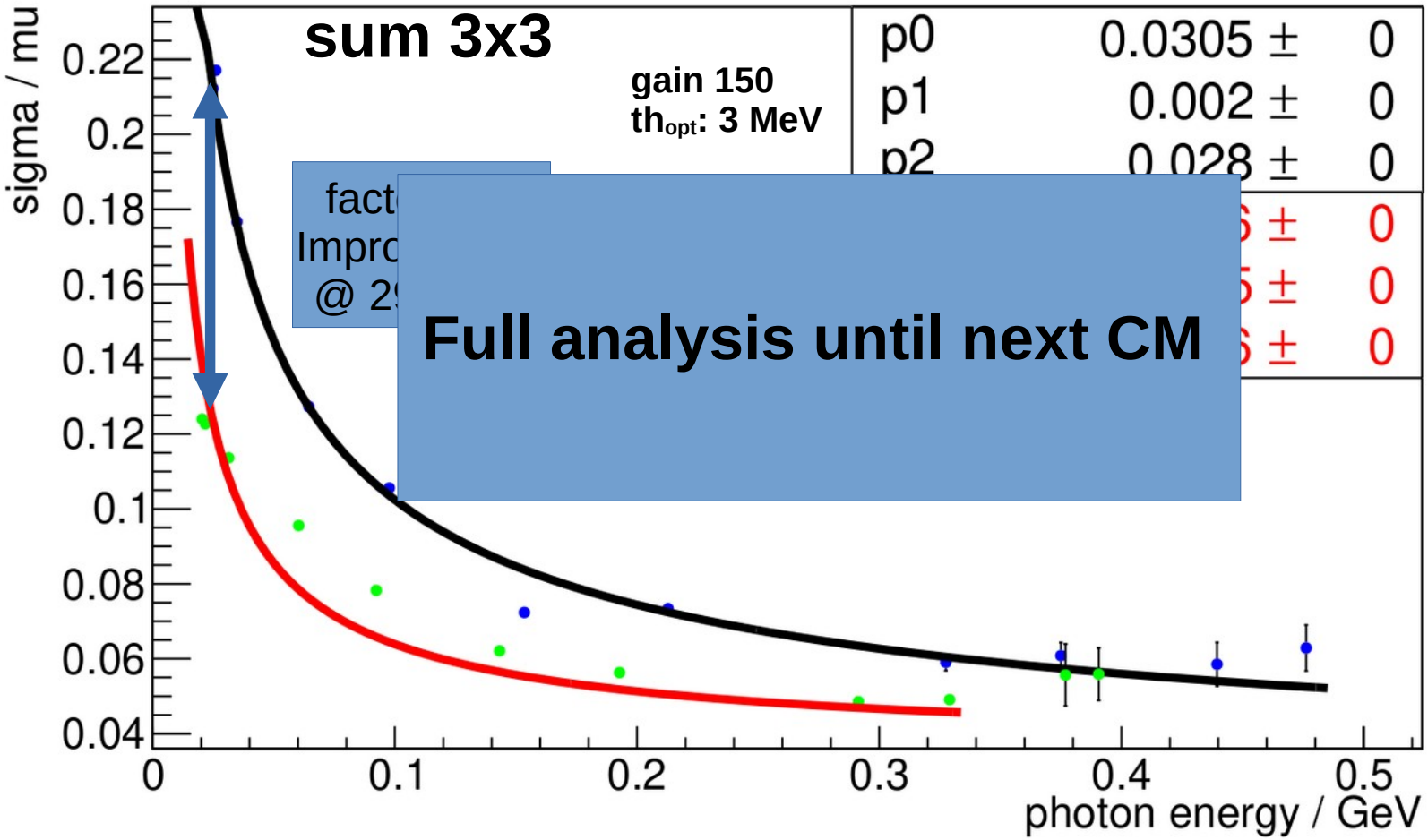

Threshold Scan 29 MeV
sigma / mu
Threshold / MeV
res. improvement


Threshold Scan 41 MeV
sigma / mu
Threshold / MeV

Results


sum 3x3
gain 150
th_opt: 3 MeV
factor 1.8
improvement
@ 29 MeV
gain 500
th_opt: 0.5 MeV
p0 0.0305 ± 0
p1 0.002 ± 0
p2 0.028 ± 0
p0 0.016 ± 0
p1 0.0015 ± 0
p2 0.036 ± 0
sigma / mu
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0
0.1
0.2
0.3
0.4
0.5
photon energy / GeV

Results


sum 3x3
gain 150
th_opt: 3 MeV
p0 0.0305 ± 0
p1 0.002 ± 0
p2 0.028 ± 0
Full analysis until next CM
sigma / mu
photon energy / GeV
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0
0.1
0.2
0.3
0.4
0.5

Crystal Production Status

	SLice1	missed		SLice2	missed		SLice3	missed		SLice4	missed		SLice5	missed
	L	R		L	R		L	R		L	R		L	R
1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
2	0	0	2	0	0	2	0	0	2	0	0	2	0	0
3	0	0	3	0	0	3	41	0	3	41	0	3	41	0
4	0	0	4	0	0	4	38	38	4	41	41	4	41	41
5	0	0	5	0	0	5	39	37	5	41	41	5	41	41
6	0	0	6	0	0	6	34	38	6	41	41	6	41	41
7	0	0	7	0	0	7	41	40	7	41	41	7	41	41
8	0	0	8	0	0	8	19	6	8	21	21	8	21	21
9	0	0	9	0	0	9	0	0	9	0	0	9	0	0
10	0	0	10	0	0	10	0	0	10	0	0	10	0	0
11	0	0	11	0	0	11	0	0	11	0	0	11	0	0
tot	0	0	tot	0	0	tot	212	159	tot	226	185	tot	226	185
				0			371			411			411	

- Second slice Complete
- Production third slice ongoing

- Additional crystals needed for next slices
- Approx one spare crystal per type and slice

			To be ordered	
type	total	total+spare	Left	Right
1	1280	1310	0	0
2	1280	1310	219	0
3	1280	1310	519	0
4	1280	1310	572	572
5	1280	1310	573	571
6	1280	1310	568	572
7	1280	1310	575	574
8	640	660	288	275
9	640	660	0	0
10	640	660	212	28
11	480	490	80	110
total	11360	11640	3606	2702
			6309	

full barrel:

Summary & Outlook

- **Mechanics**
  - Remedy drawing pre-series slice Supportbeam ready
  - Company offer received
- **Fiber coupling monitor system**
  - CAD routing scheme almost finished
  - More crystals could get direct coupling when routing from up and downstream
- **APD gain**
  - Increased APD gain will significant improve resolution
  - Evaluation optimum value ongoing
- **HVD Backplane**
  - Final prototype ordered
  - Start mass production soon
- **Crystal production status**
  - Production 3rd slice ongoing

Backup

APD Gain Optimization for the APFEL ASIC

PWO-II LY @ +18°C: 20 PMT-phe/MeV
PWO-II LY @ -25°C: 100 PMT-phe/MeV (LY@18°C X4)
APD covers ~13% crystal endface
PMT QE = 20%, LAAP QE= 80% → 52 APD-phe/MeV
APFEL ASIC max Input: 8.5 pC

$$E_{max}(gain_{opt}\,500) = \frac{8.5\,10^{-12}\,C}{52 \cdot 1.6 \cdot 10^{-19}\,C/MeV \cdot 500} = 2043.3\,MeV$$