

PANDA EMC Update

ECE 13 and ECSG 04 Meeting Oct 2020

Update to the Technical Design Report

for the

PANDA Electromagnetic Calorimeter

(AntiProton Annihilations at Darmstadt)

Strong Interaction Studies with Antiprotons

PANDA Collaboration

October 8, 2020

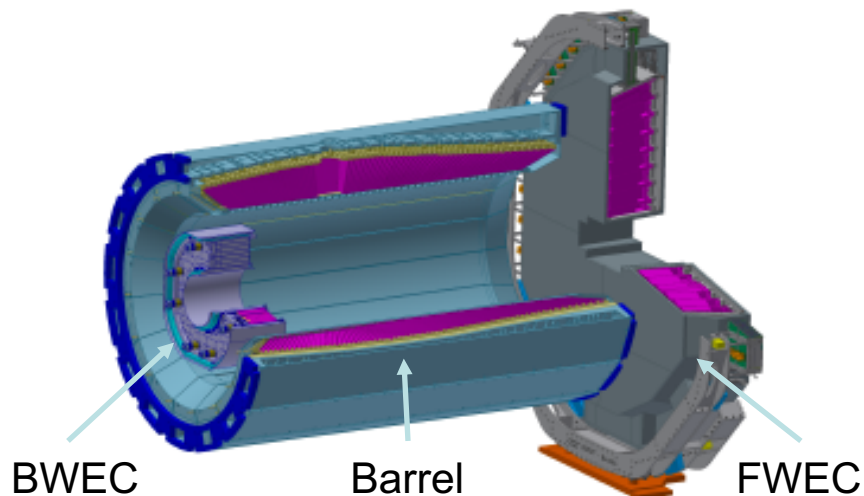
Fritz-Herbert Heinsius

Ruhr-Universität Bochum

for the PANDA collaboration



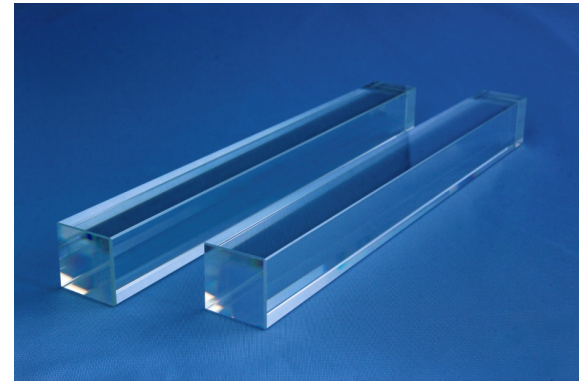
Text marked in blue are new developments since the TDR in 2008



Design Requirements



- 4π coverage: 99 %
- E_γ : 10 MeV – 15 GeV
- $\frac{\sigma_e}{E} = 1\% \oplus \frac{2\%}{\sqrt{E/\text{GeV}}}$
- Spatial resolution $< 0.1^\circ$
- Time resolution < 10 ns
- Dynamic range: 10^2 - 10^4
 - low noise
- Max. 500 000 hits/s
- Low pileup
 - free streaming DAQ
- Maximum annual dose: 125 Gray



PWO-II
24 types, 20 cm length

PWO-II Crystals



- 2008-2010 PWO-II production at BTCP, Russia
- Missing funding → bankruptcy of BTCP
- Limited availability of SICCAS (China) crystals (62)
- 2014: restart of PWO-II production at Crytur, Czech Republic
 - Use of existing pre-mixture of raw material (2016-2017: all raw material acquired from NeoChem)
 - Knowledge transfer (INP Minsk)
- 4400/700 FWEC/BWEC produced
- **Barrel: 6330 crystals to be produced at Crytur**
- 120 crystals/month
- **Stimulated recovery**
- 2018 Start of mass production at Crytur (>515 crystals)
- High quality

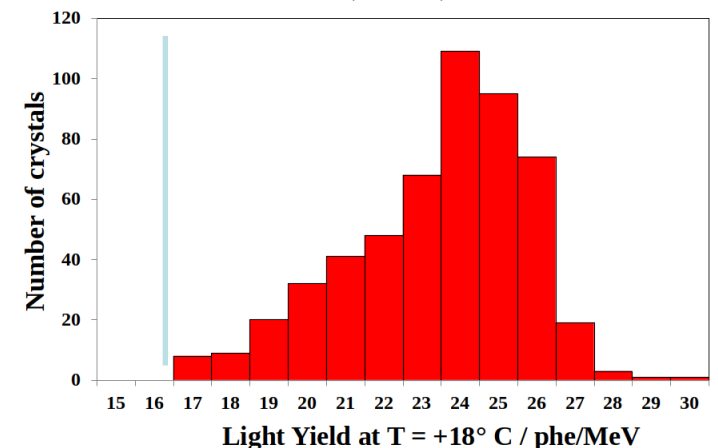
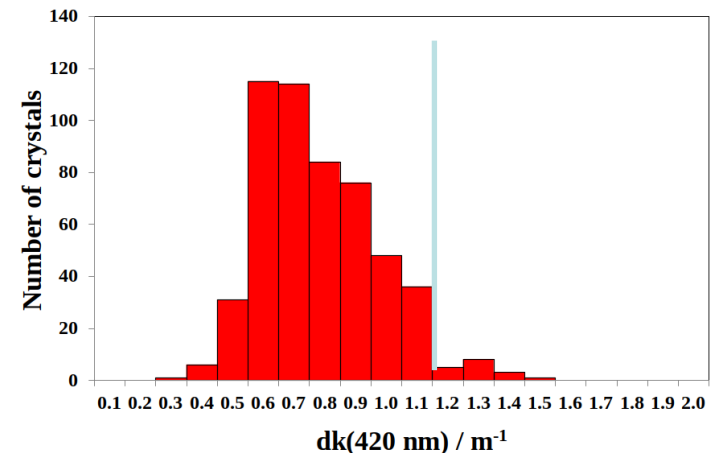
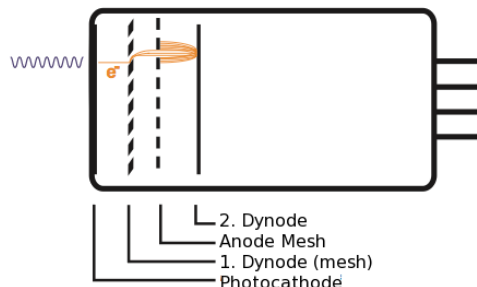
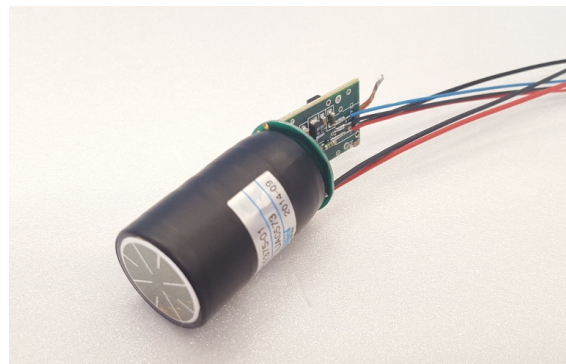


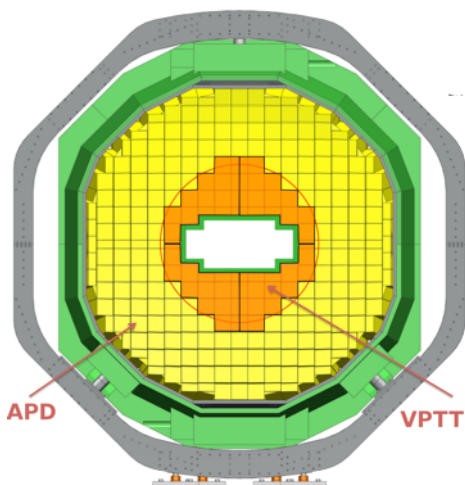
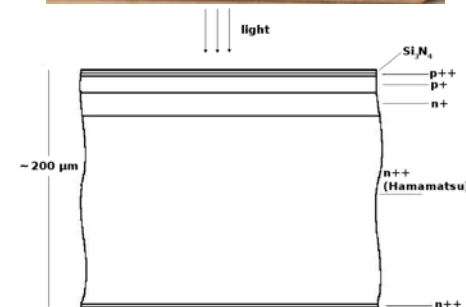
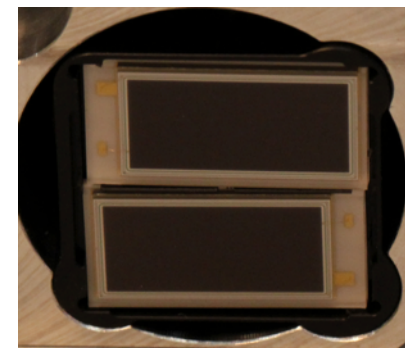
Photo Detectors



VPTT



APD



APD: 80 % fw endcap
 100 % barrel
 100 % bw endcap

Quantum eff. (typ.)

Active area

Gain

Dark current (Anode)

Capacity

≈ 23 %

200 mm²

av. 63 (≈ 50% 1.2 T)

< 1 nA

≈ 22 pF

≈ 80 %

6.8 x 14 = 95.2 mm²

150 / 200

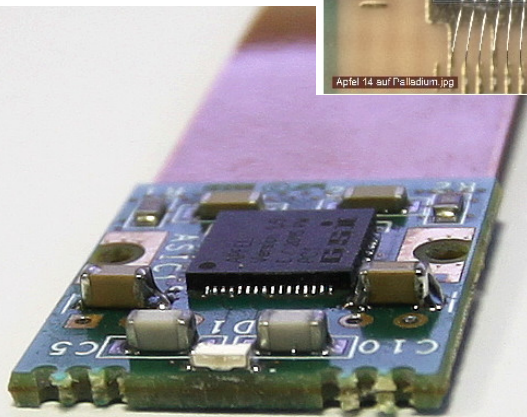
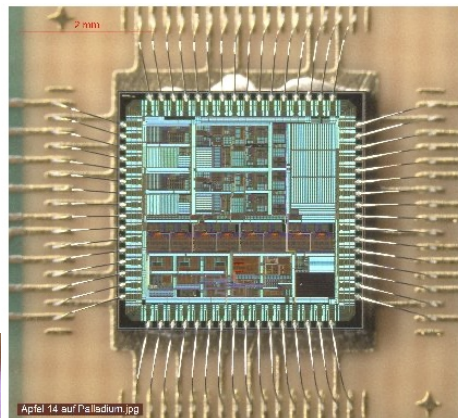
1 pA – max 40 nA

≈ 250 pF

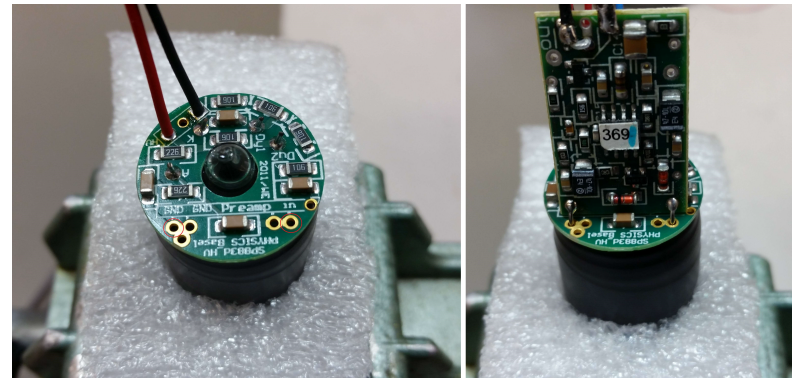
Preamplifiers



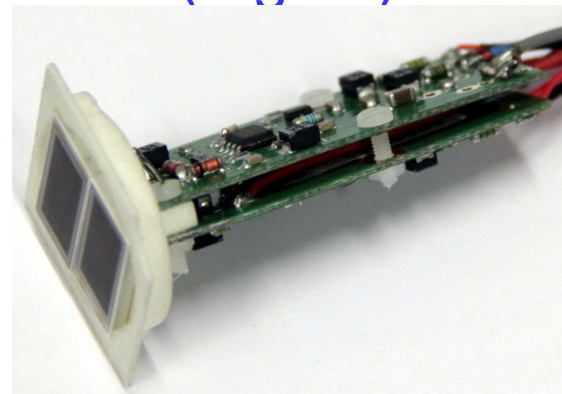
- APFEL ASIC
- Barrel/BW endcap
- Space constraints
- All available



- Low Noise Preamplifier
- Forward Endcap:
- VPTT (3 gains)



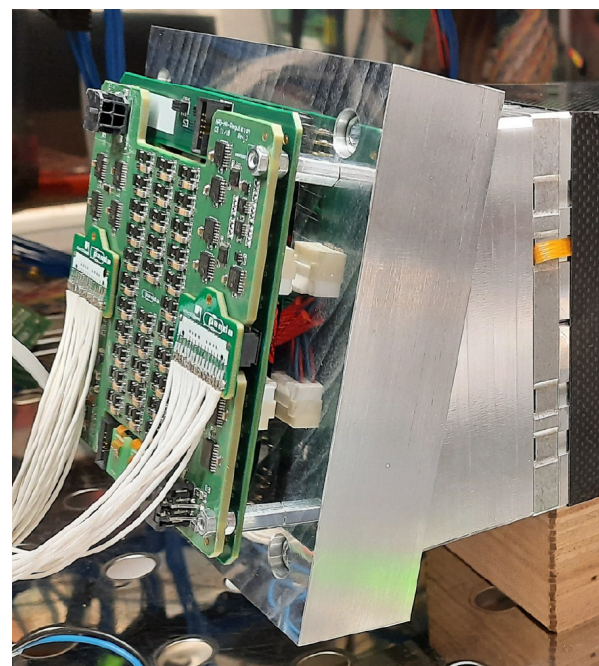
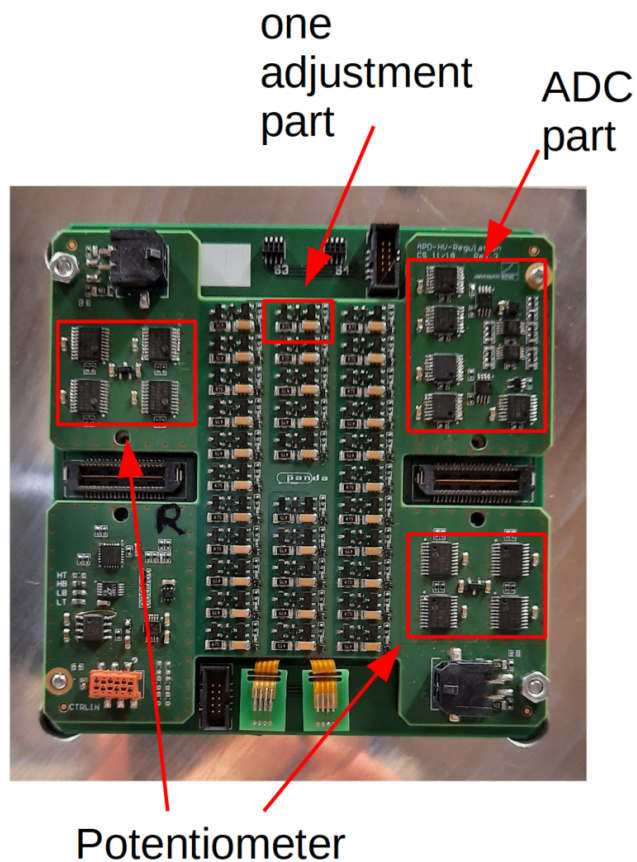
- APD (1 gain)



- All produced

HV Regulation for APDs

- APD bias voltage differs for each APD → Needs to be measured
- Matching required
- **On detector HV regulation to optimize dynamic range**



FWEC: 3 cm space

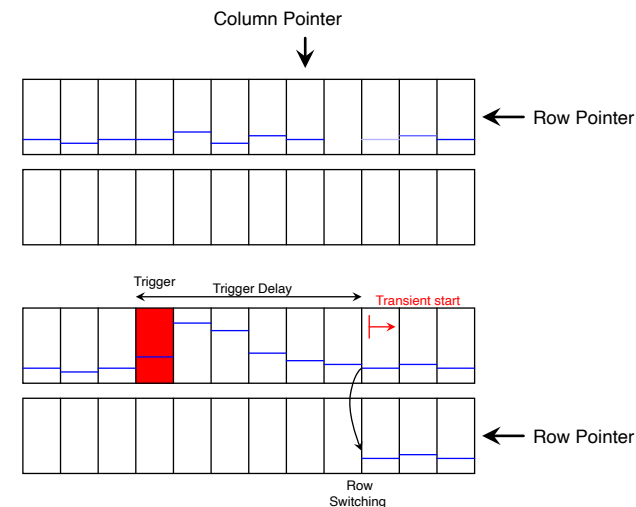
Sampling ADC: Endcaps

- Large dynamic range 14 bit
- FWEC: 32 shaper input, gain splitting (x14)
- BWEC: 64 differential inputs
- Very compact: 10 cm x 15 cm
- High speed output: 2x 4.8 Gbit/s
- Time synchronization interface
- Firmware with feature extraction on FPGA



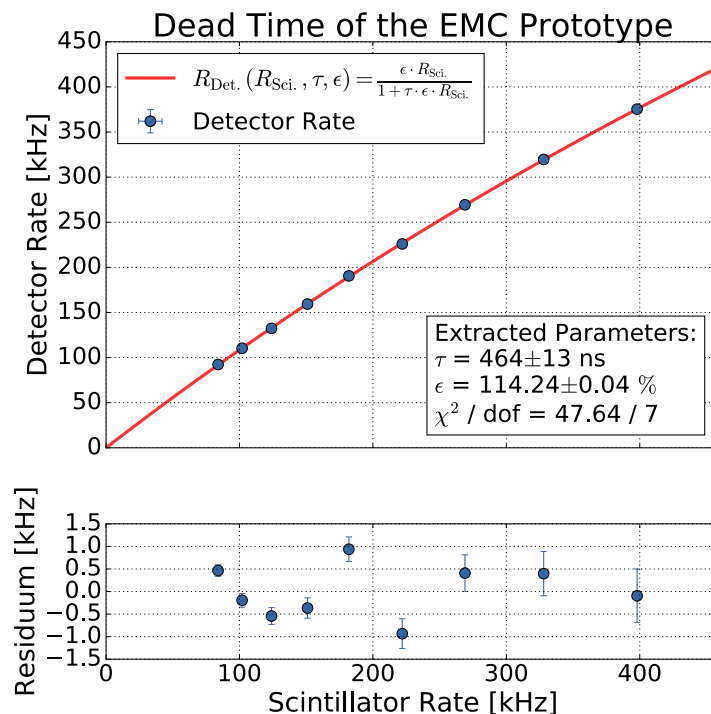
Hit detection ASIC: barrel EMC

- **Minimize cables**
- Analog buffer for fast sampling
- 12 bit pipeline ADC
- Integrated hit detection
- Optimized for APFEL ASIC
- In development



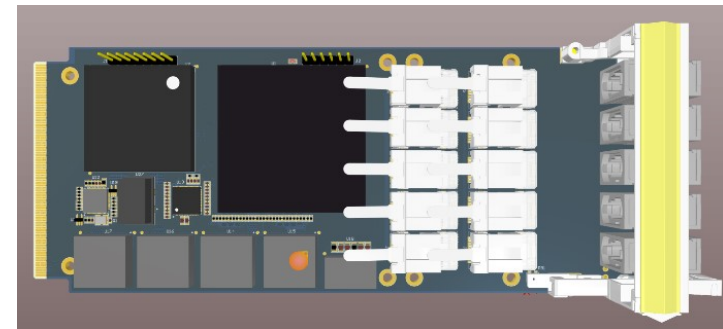
Transient recording in the analog buffer

- Feature extraction within FPGA of Sampling ADC
- Energy, time
- Pileup detection



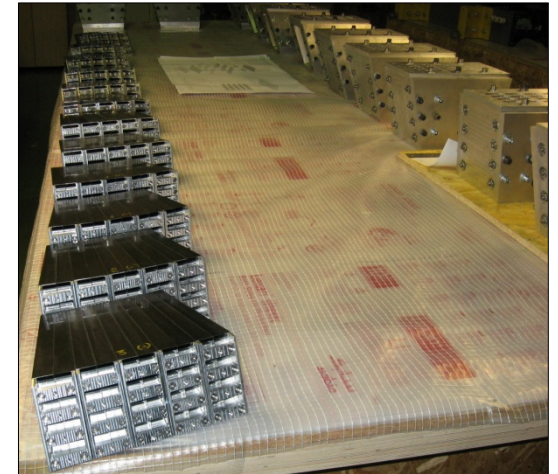
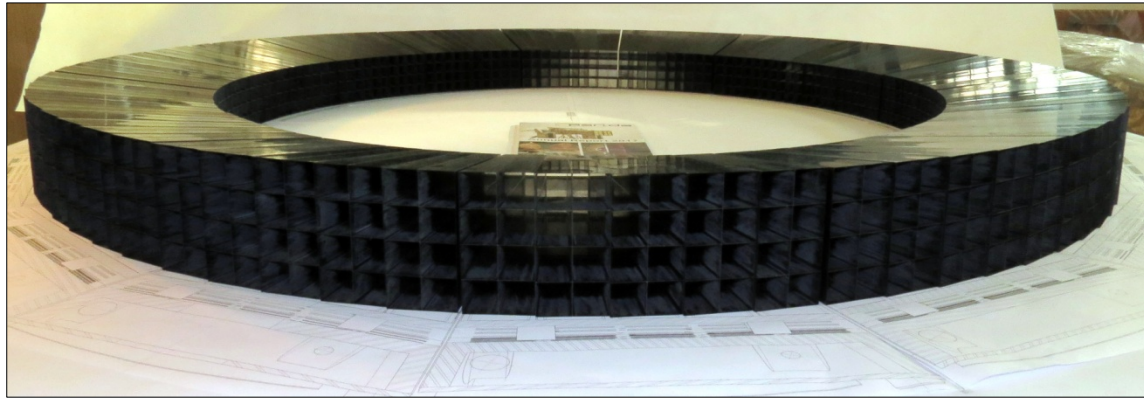
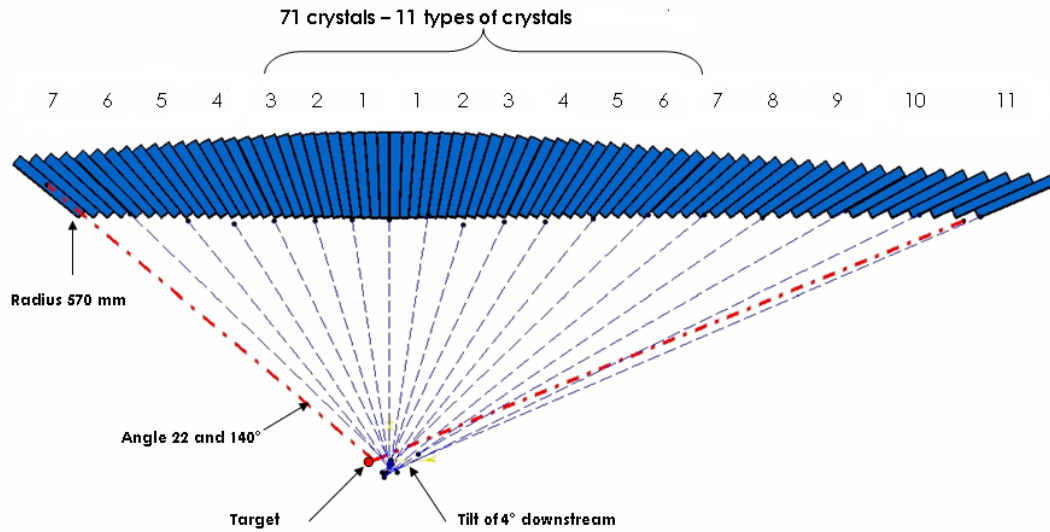
High speed data concentrator (DC)

- AMC board
- 60 FireFly optical transceivers 12 Gbit/s
- 16 backplane links 12 Gbit/s
- Kintex Ultrascale+ FPGA
- Data collector from front-end electronics and clock distribution to FEE



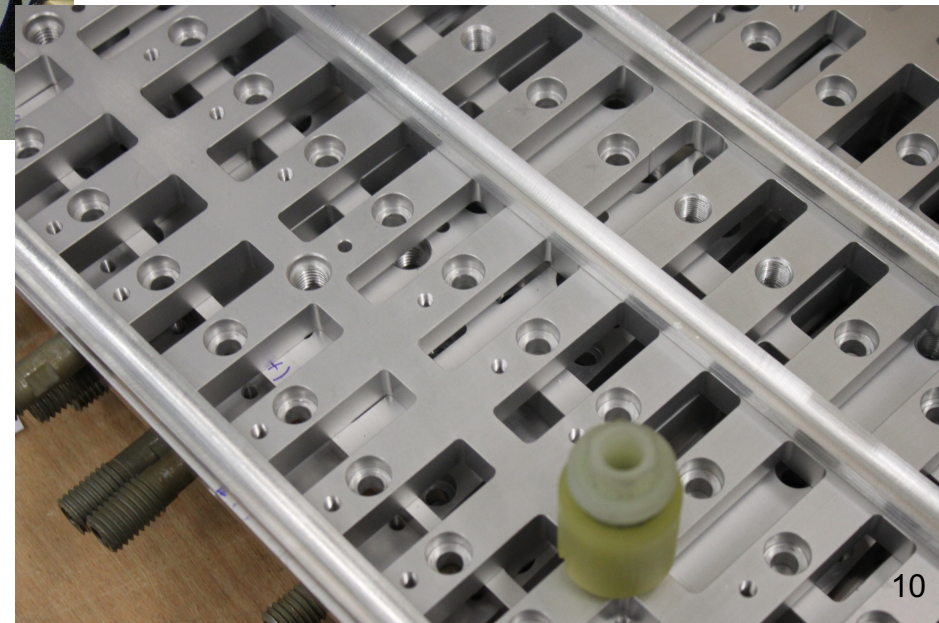
- Prototype expected November 2020

Mechanics Barrel

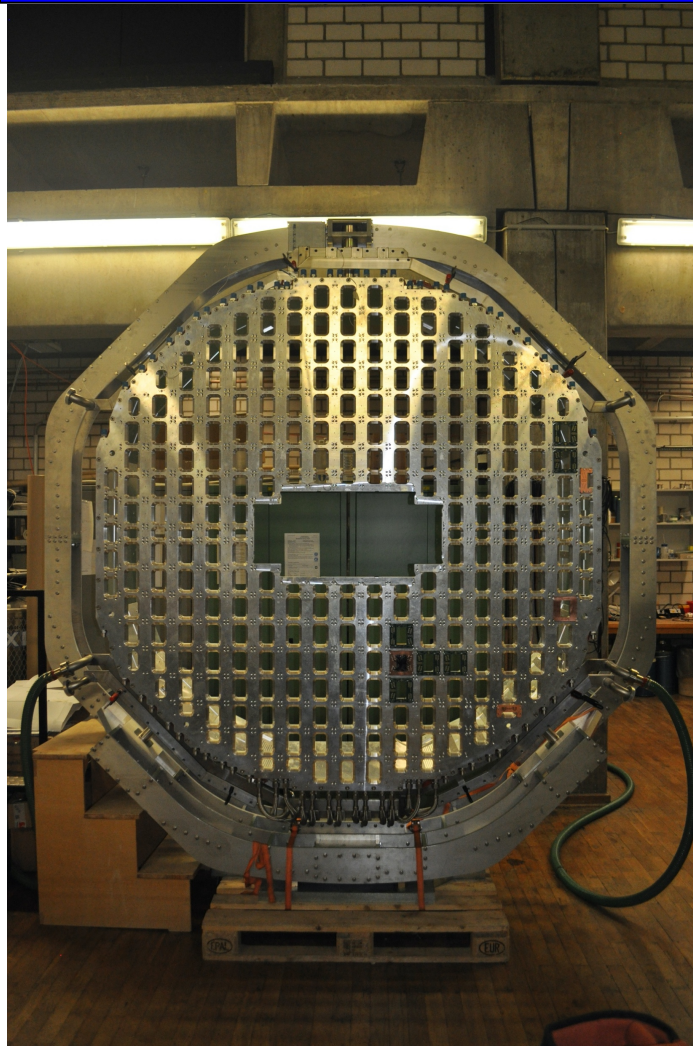


Alveoli packs and all mechanics for all 16 slices ready

Mechanics Barrel



Cooling lines
60% Water/40% methanol mixture

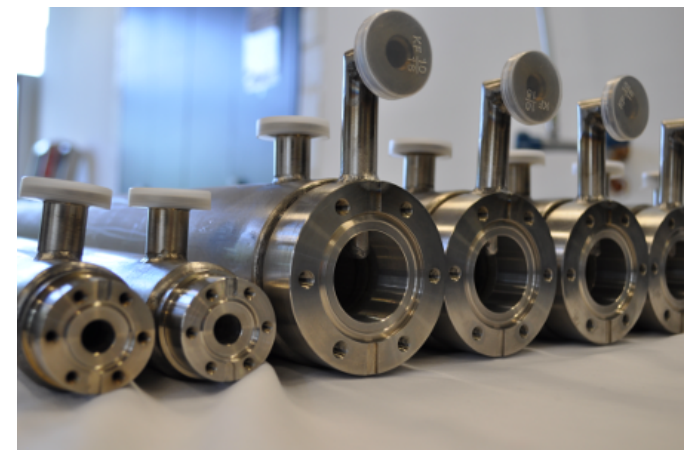


Support frame for **3856 crystals**
Holds also Disc DIRC



Connectors to **cooling lines**
within mounting plate

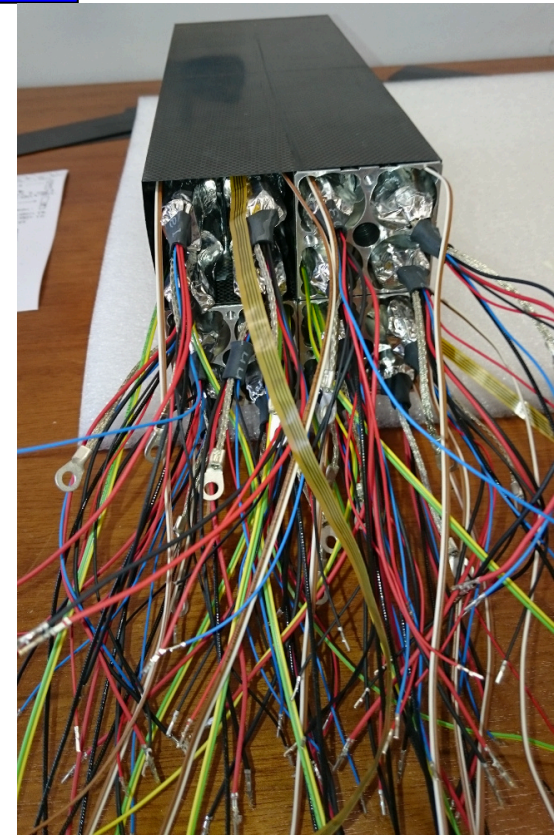
Vacuum insulated pipes
through magnet



Mechanics FWEC



Gluing of photo detectors to crystals

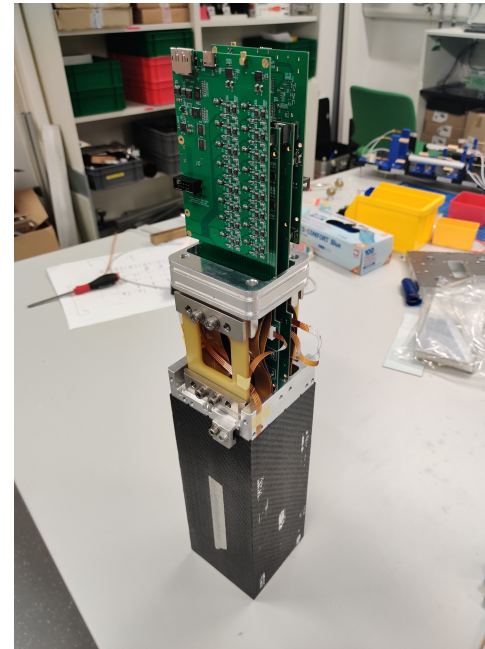
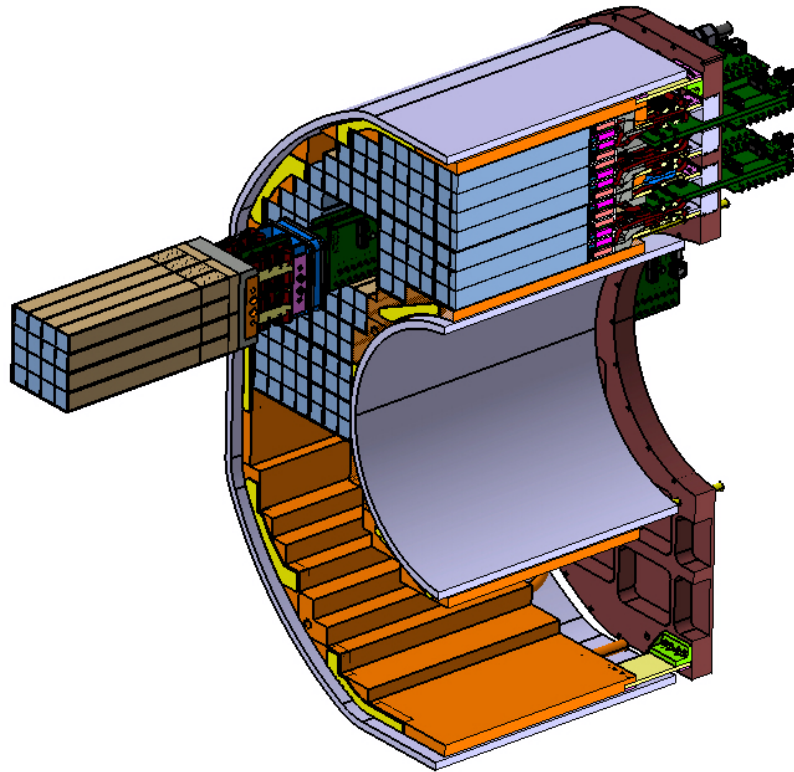


16 crystal submodule

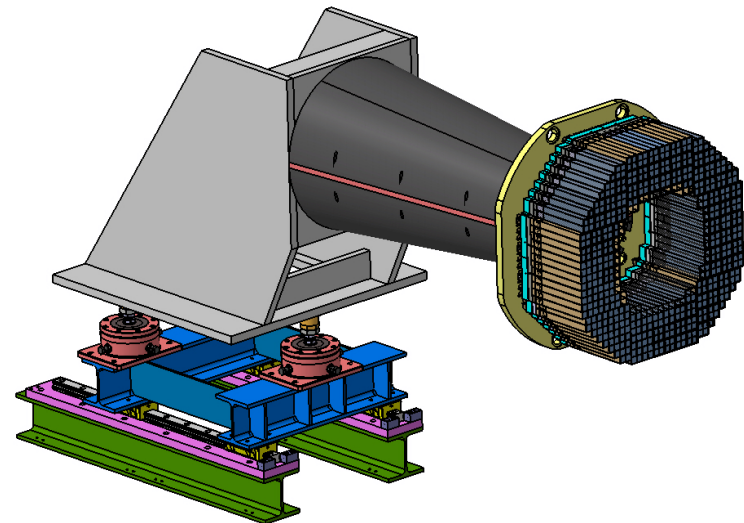


All VPTT submodules tested
APD submodules in production

- New design
- Straight crystals



16 crystal submodule

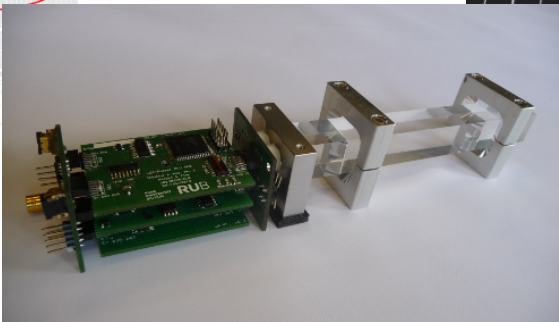
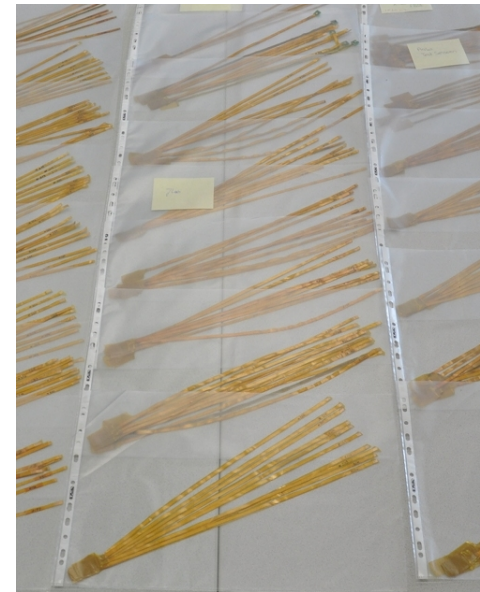
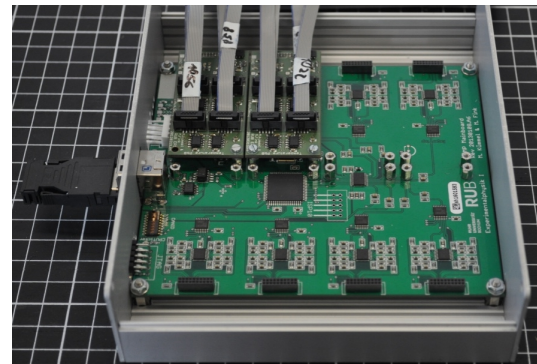
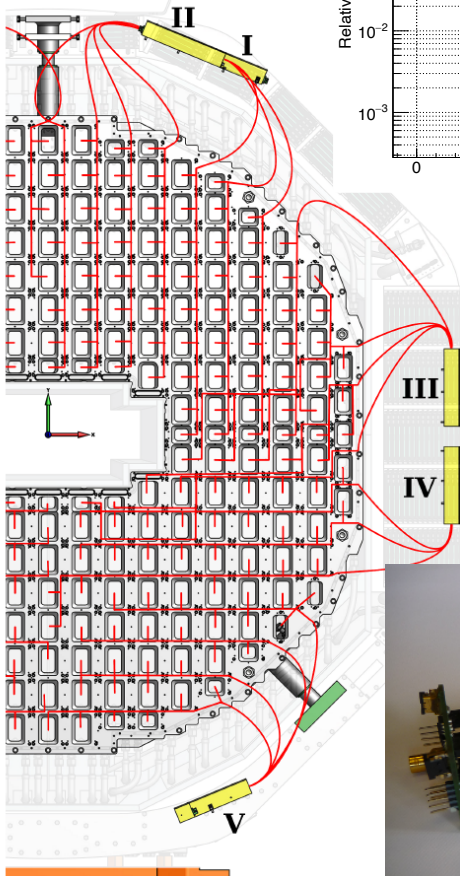
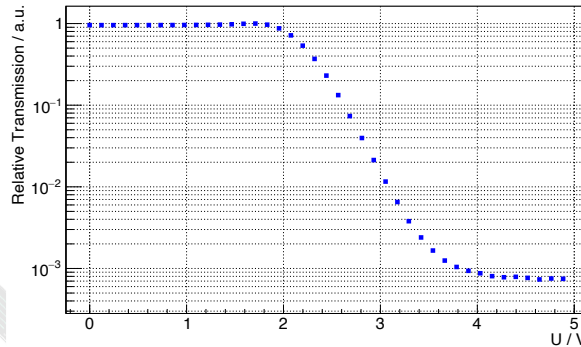


Monitoring



- Light pulser system
- **LCDs for intensity variation**

- **Pt100 temperature sensing between crystals $< 140 \mu\text{m}$**
- Resolution $< 0.02 \text{ }^\circ\text{C}$

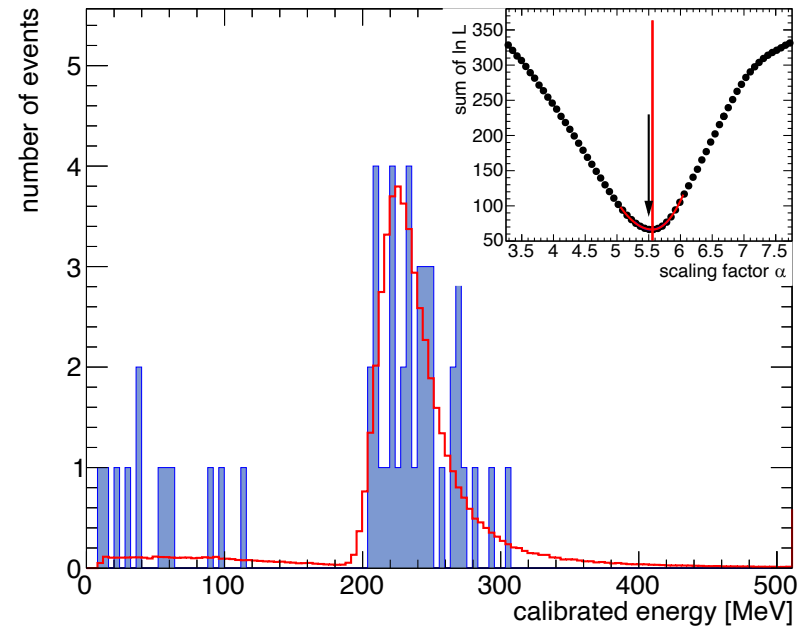
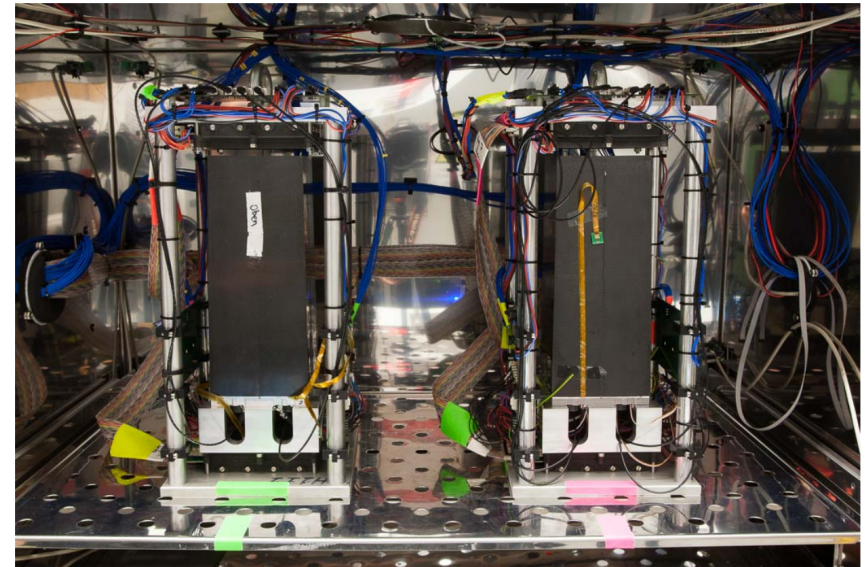
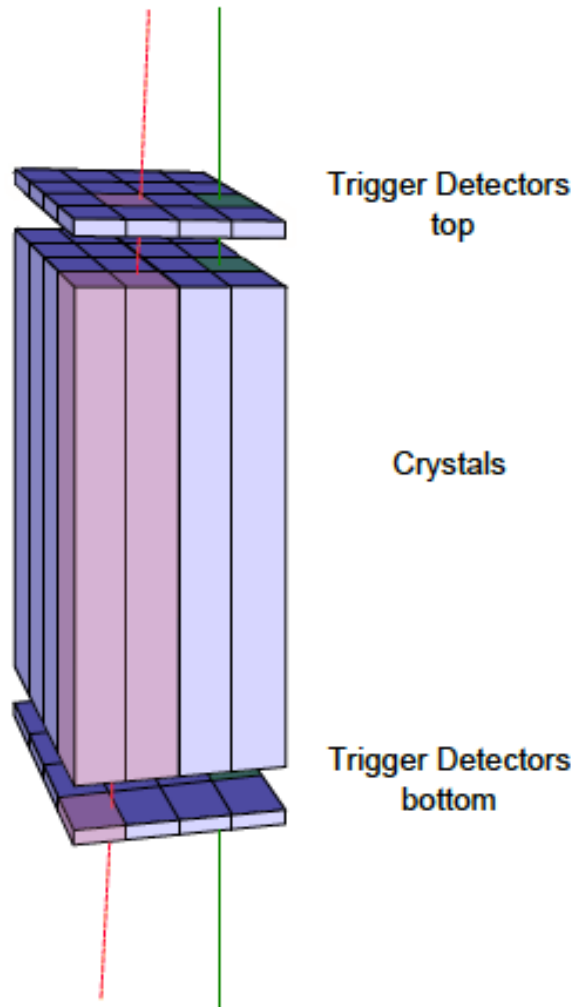


- Temperature/Humidity monitoring board with ADC

Pre Calibration



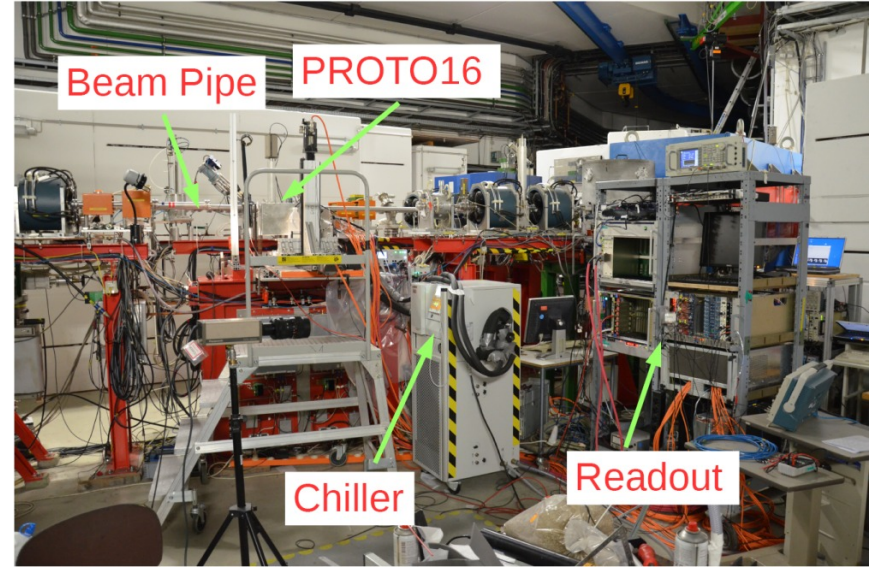
- Submodule pre calibration with cosmic radiation



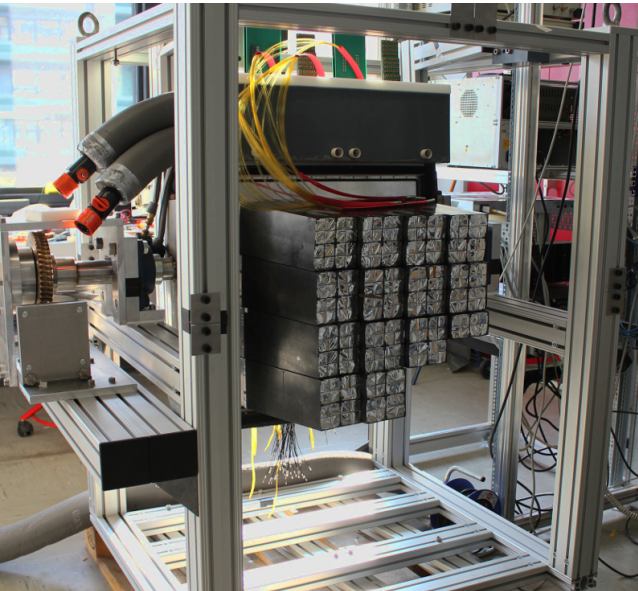
Prototype Performance



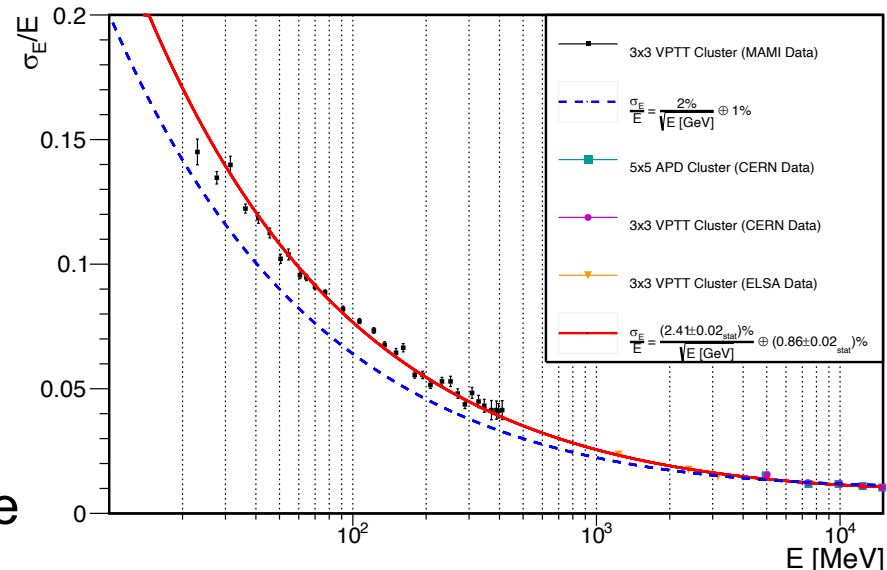
Barrel Proto120



BWECEC Prototype at MAMI



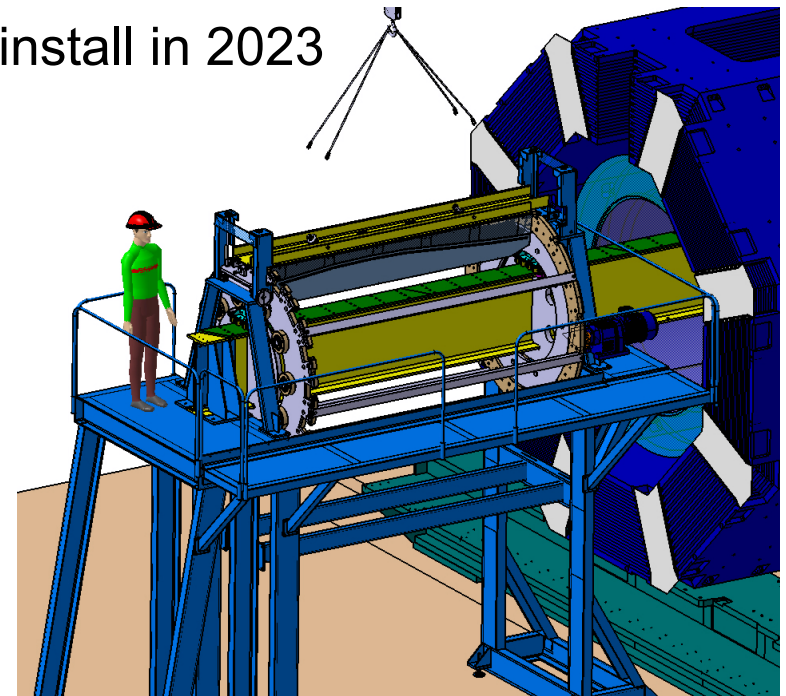
FWEC Prototype



Timeline: Barrel



- First slice assembled
- 2nd started 2020
- About 3-4 slices per year
- Assembly time depends on available crystals
- Crystal production increase with more furnaces
- At current rate 12/16 slices ready to install in 2023

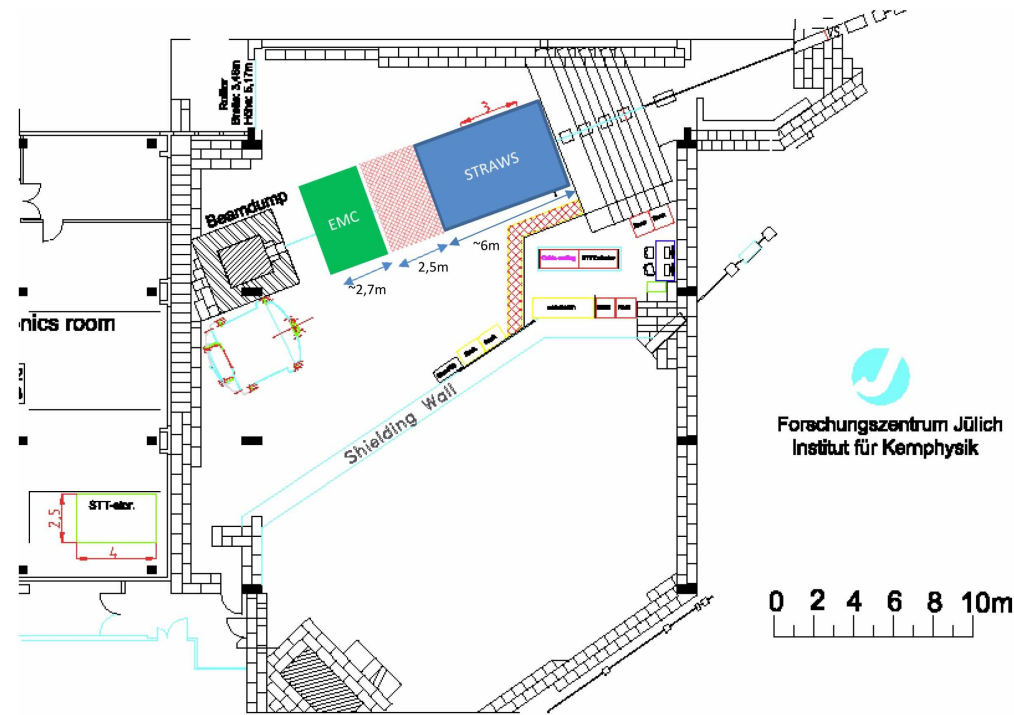
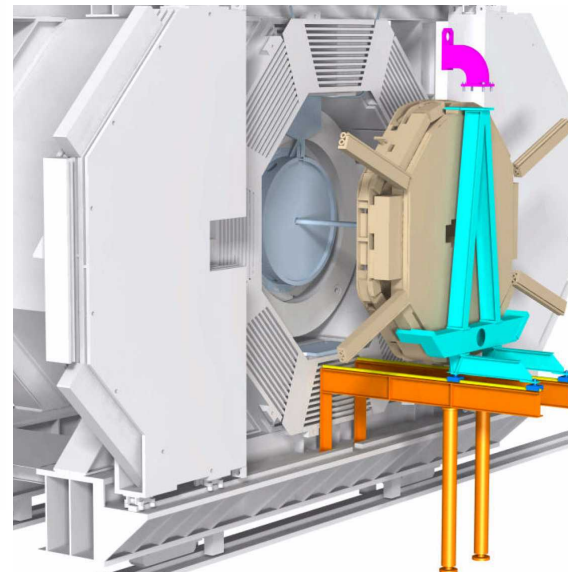
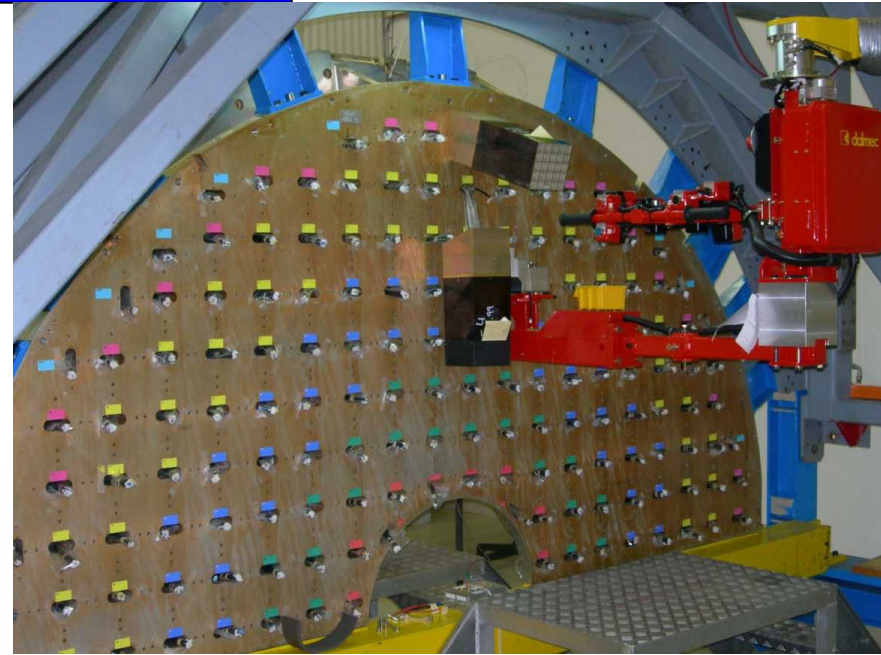


Installation of barrel at PANDA

Timeline FWEC



- Assembly up to 2022
- Test beam at COSY (Jülich) 2022/23
- Mounting at PANDA 2023



Timeline BWEC



- Assembly 2020/21
- **FAIR PHASE 0: Measurement of the electromagnetic transition form factor of the π^0 in the space-like region via Primakoff electroproduction at MAMI in the A1 experimental hall**
- Readiness for installation at PANDA in 2023

Primakoff π^0 Electroproduction Set-up

