

# Target Spectrometer EMC

Fritz-Herbert Heinsius

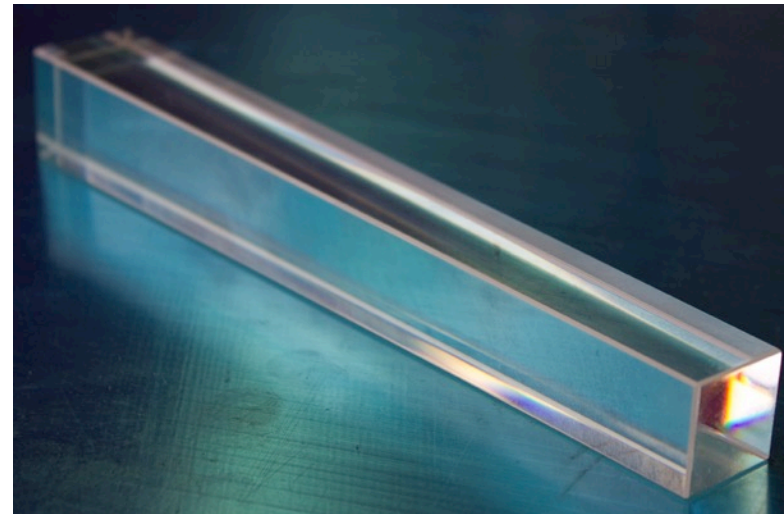
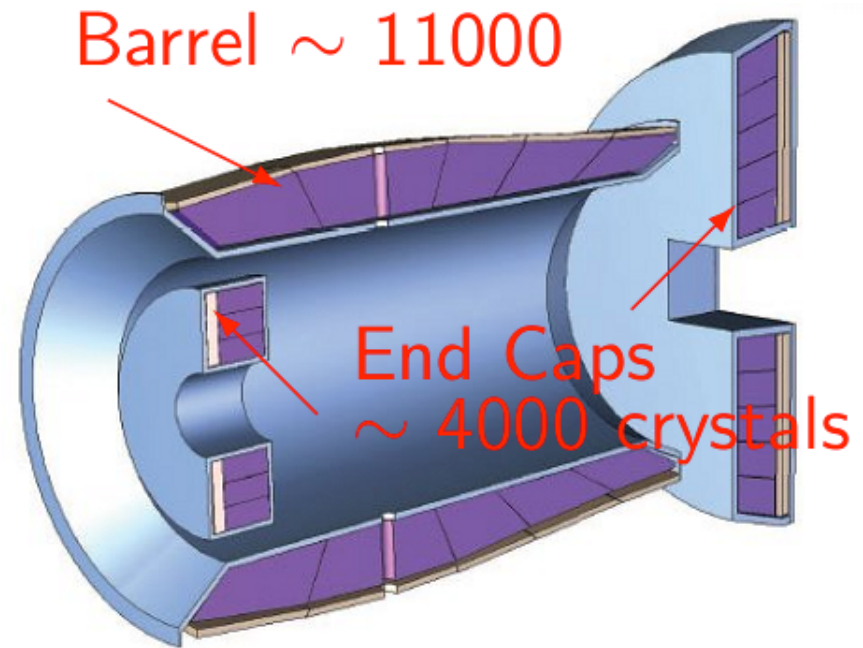
*Ruhr-Universität Bochum*



- Universität Basel
- Ruhr-Universität Bochum
- Rheinische Friedrich Wilhelms-Universität Bonn
- GSI Darmstadt
- Justus Liebig-Universität Gießen
- KVI-CART/University of Groningen
- Helmholtz-Institut Mainz/JGU
- RINP Minsk
- *Institut de Physique Nucleaire, Orsay*
- Charles University Prague
- IHEP Protvino
- Stockholms Universitet
- Uppsala Universitet

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- Photodetectors
- Electronics
- Mechanics
  - Forward Endcap
  - Barrel
  - Backward Endcap
- Cooling
- Monitoring and Detector Control Systems
- Prototype Tests
- Preassembly
- Software
- Timelines and Resources

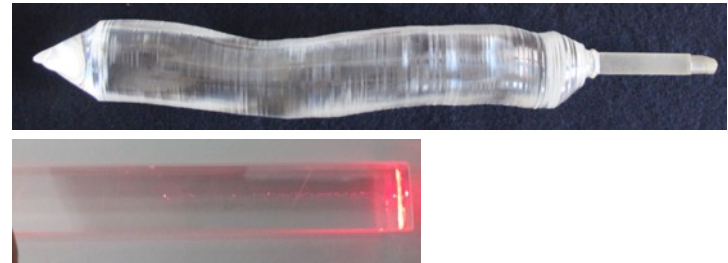


# PWO II Crystals



- Radiation hard
- operated at  $-25\text{ }^{\circ}\text{C}$  to improve light yield
- Available crystals
  - Forward/Backward EMC: 4400/700
  - Barrel: 3000 including one slice
- Missing crystals: 8350
- Alternative producer SICCAS
  - Limited quality

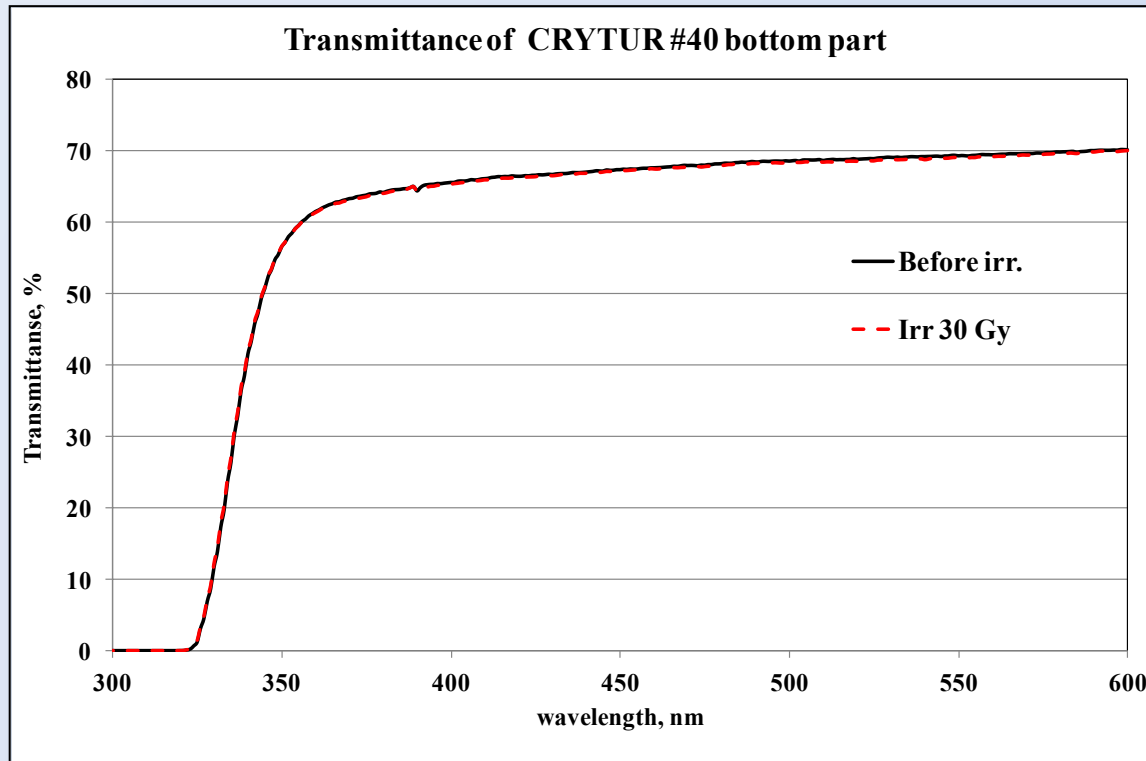
- New producer Crytur
  - Same process as BCTP, good progress



**dimension:  $20 \times 20 \times 200 \text{mm}^3$**

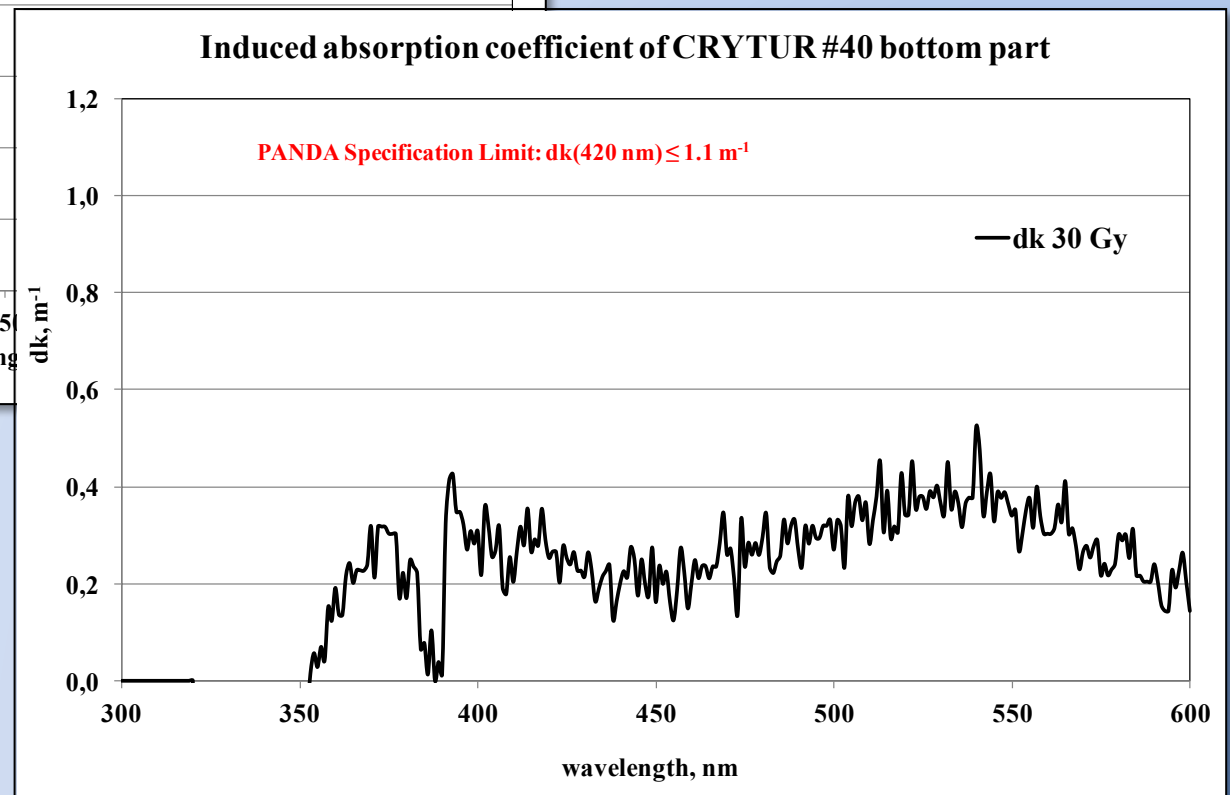
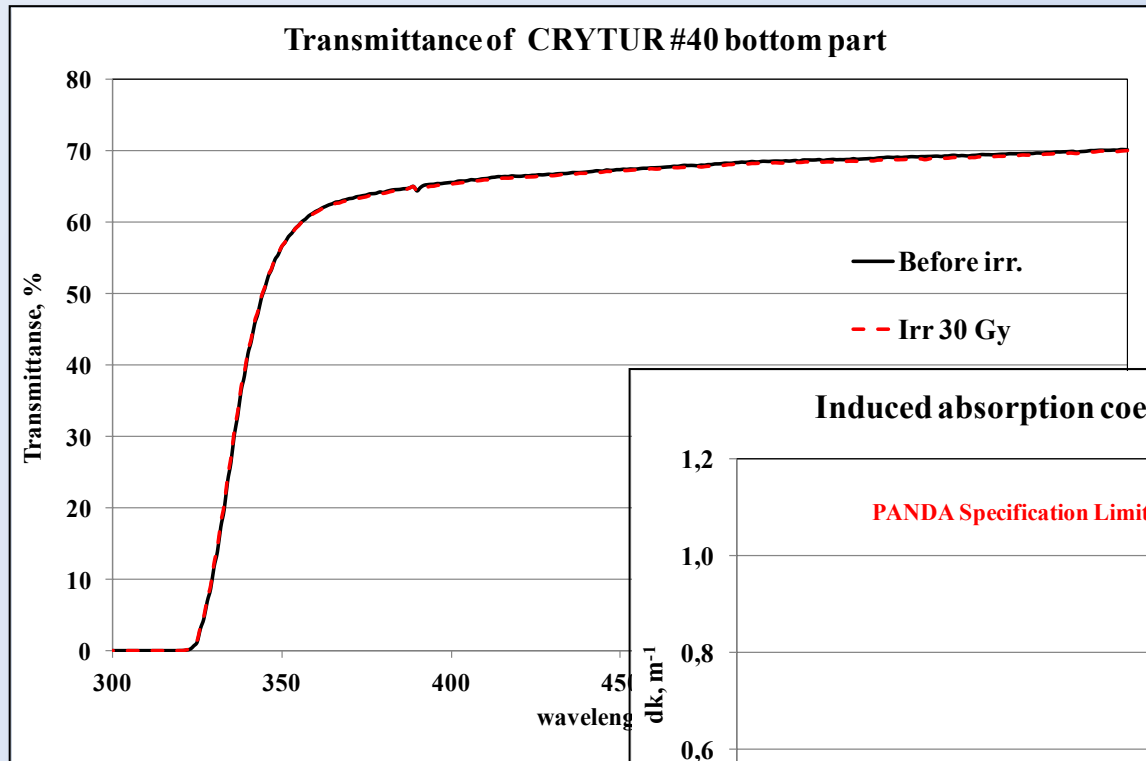
- *Raw Material to be ordered (now):*
  - 14 t @ NeoChem (Moscow)
- Preproduction 50-100 crystals
- Contract for mid 2016

# the most recent sample (#40): bottom part (1.2cm)



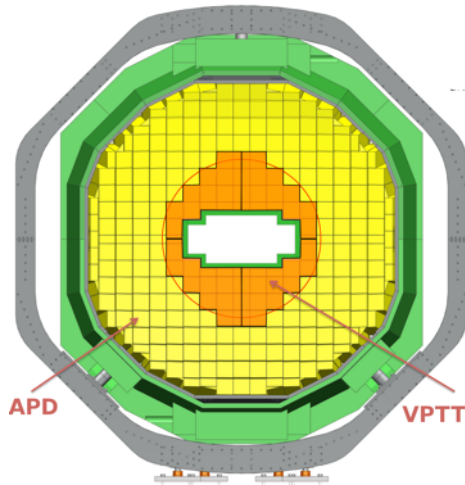
Rainer Novotny  
JLU Giessen

# the most recent sample (#40): bottom part (1.2cm)



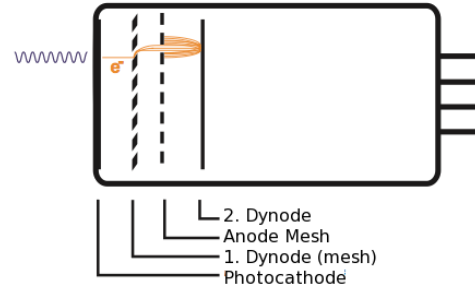
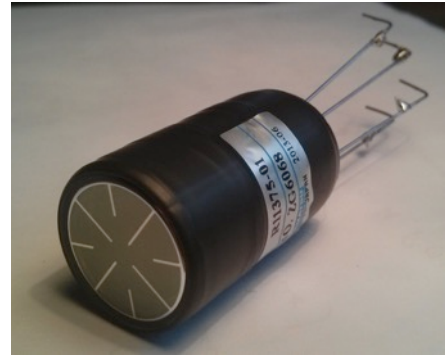
Rainer Novotny  
JLU Giessen

# Photodetectors



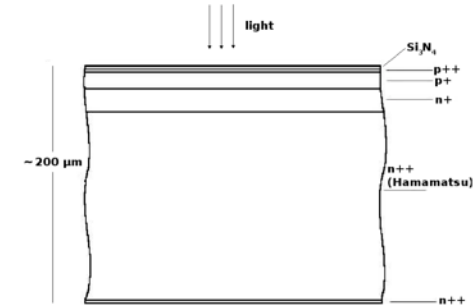
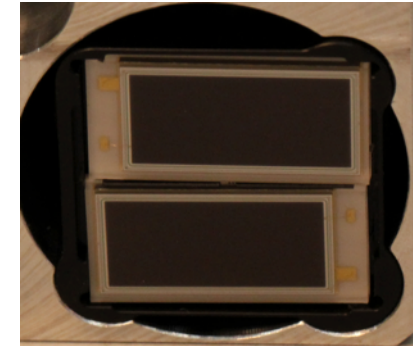
APD: 80 % fw endcap  
 100 % barrel  
 100 % bw endcap

## VPTT



≈ 23 %  
 200 mm<sup>2</sup>  
 typ. 50  
 < 1 nA  
 ≈ 22 pF

## APD



≈ 80 %  
 6.8 x 14 = 95.2 mm<sup>2</sup>  
 200 (100)  
 1 pA – max 20 nA  
 ≈ 270 pF

Quantum eff. (typ.)

Active area

Gain

Dark current (Anode)

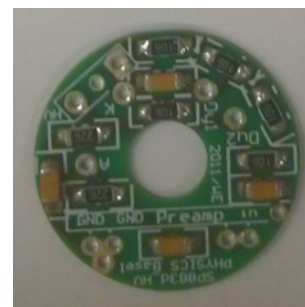
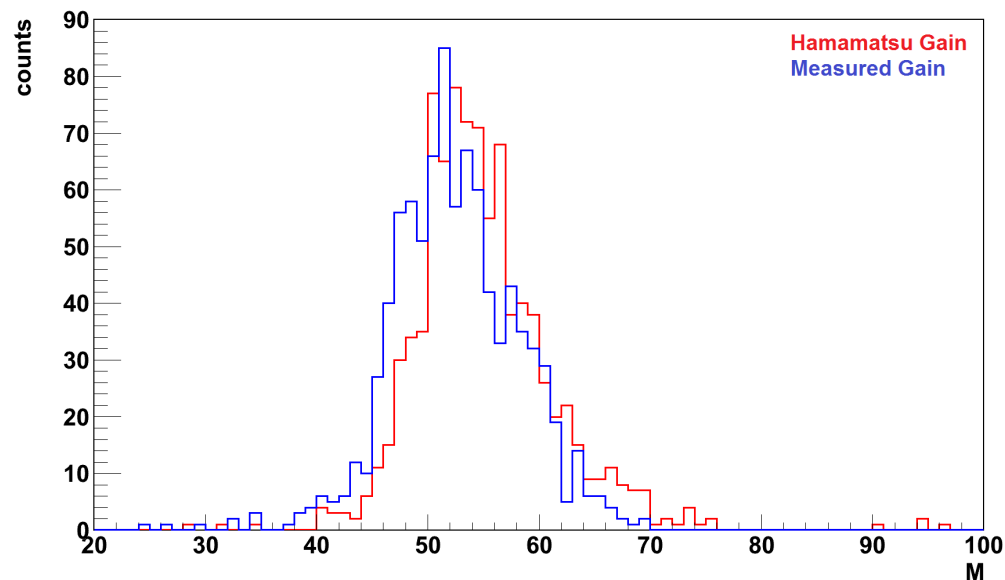
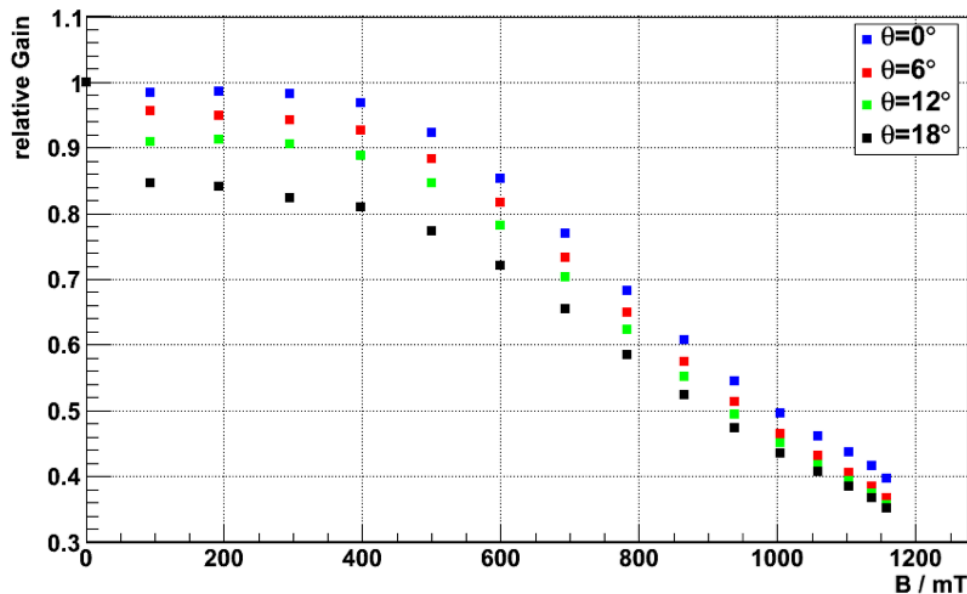
Capacity

# Photodetectors: VPTT

- All 900 VPTT tested

RU Bochum  
HISKP Bonn

Gain in magnetic field



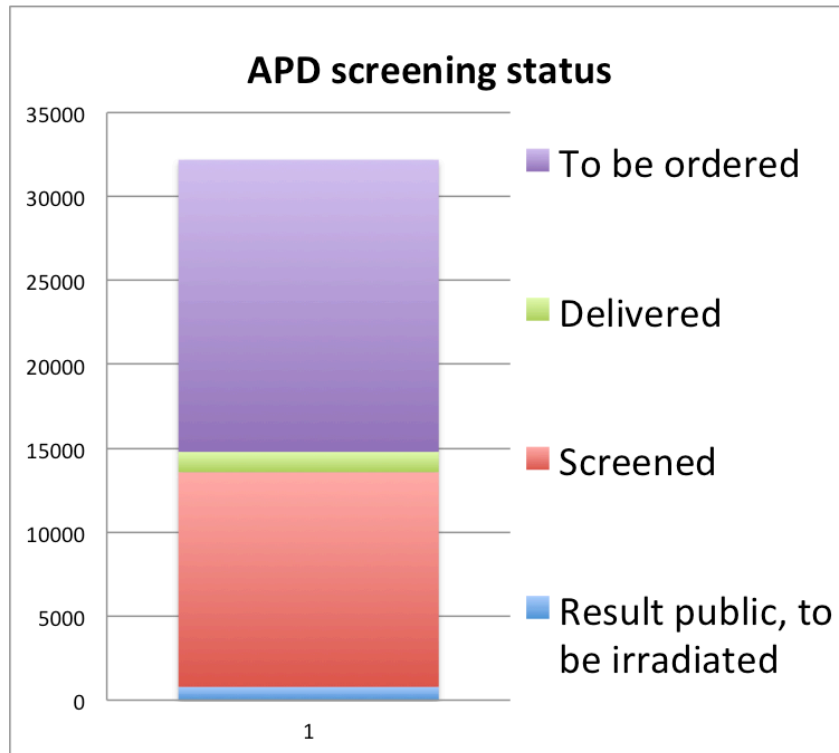
HV divider/filter



Optical coupling glue

# Photodetectors (APD)

- 14790 delivered (Sep 2014 to Aug 2015)
- Forward/Backward: all available; Barrel 6600



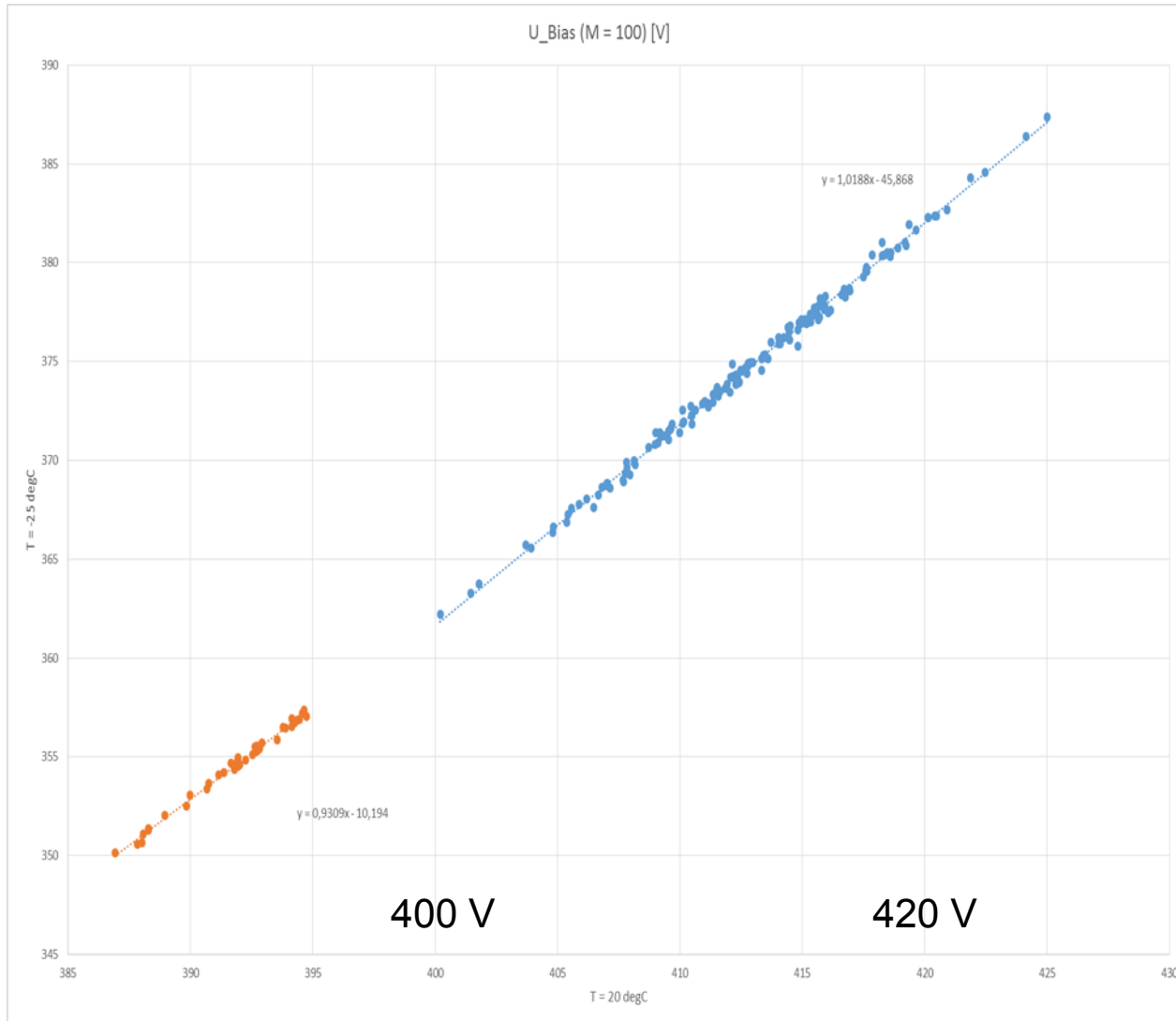
- Further order on hold by BMBF
  - Hamamatsu stopped production line
  - Restart 3-6 month
- Critical
  - Availability of results from screening process in APDlab for matching of forward endcap APDs (assembly 2016)
  - Availability of irradiation facility in Giessen (was reserved for 2015, but missed APD screening results)



$T = -25^\circ\text{C}$

380 V

360 V



400 V

420 V

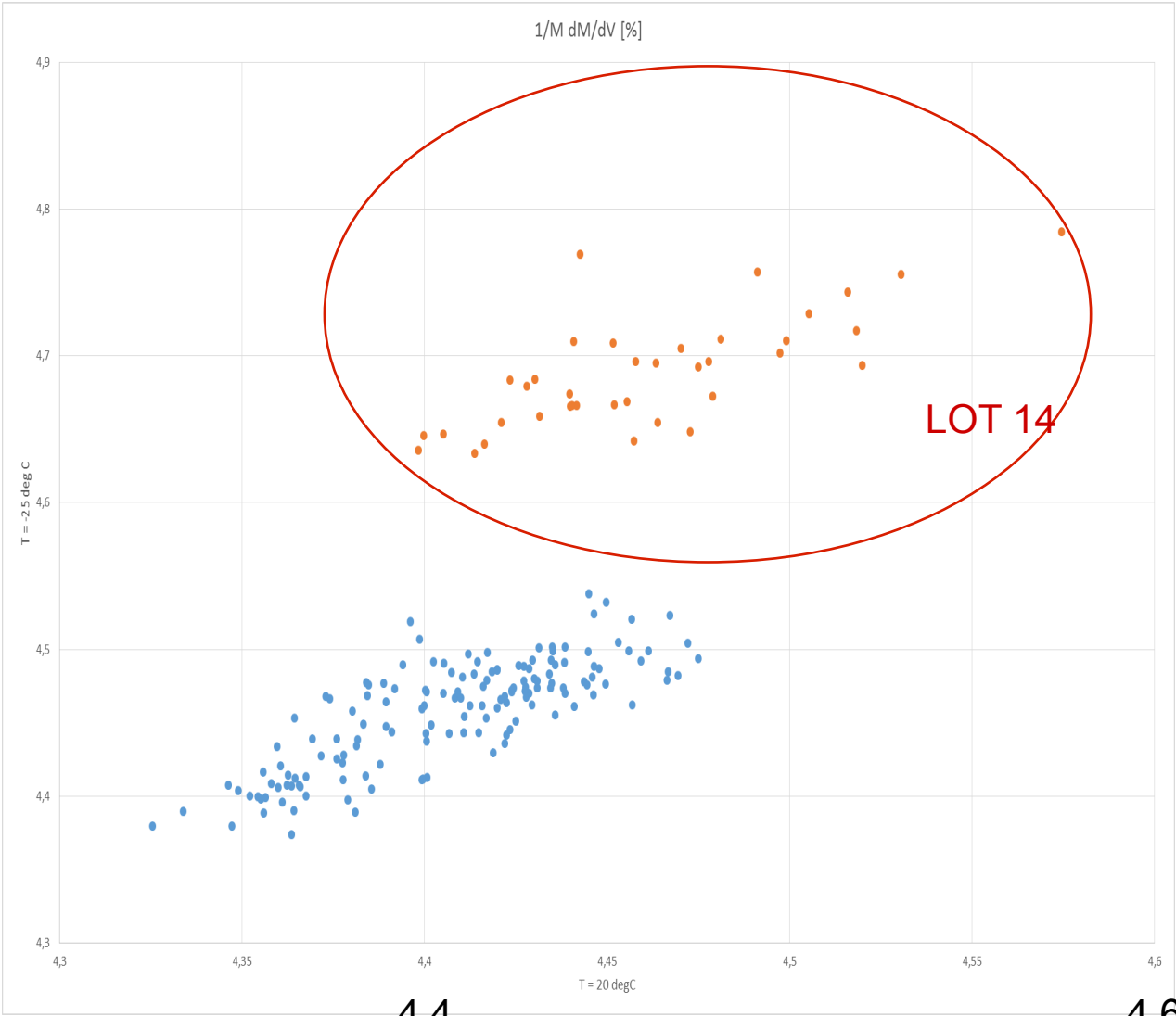
$T = 20^\circ\text{C}$

T = -25°C

4.8

4.6

4.4

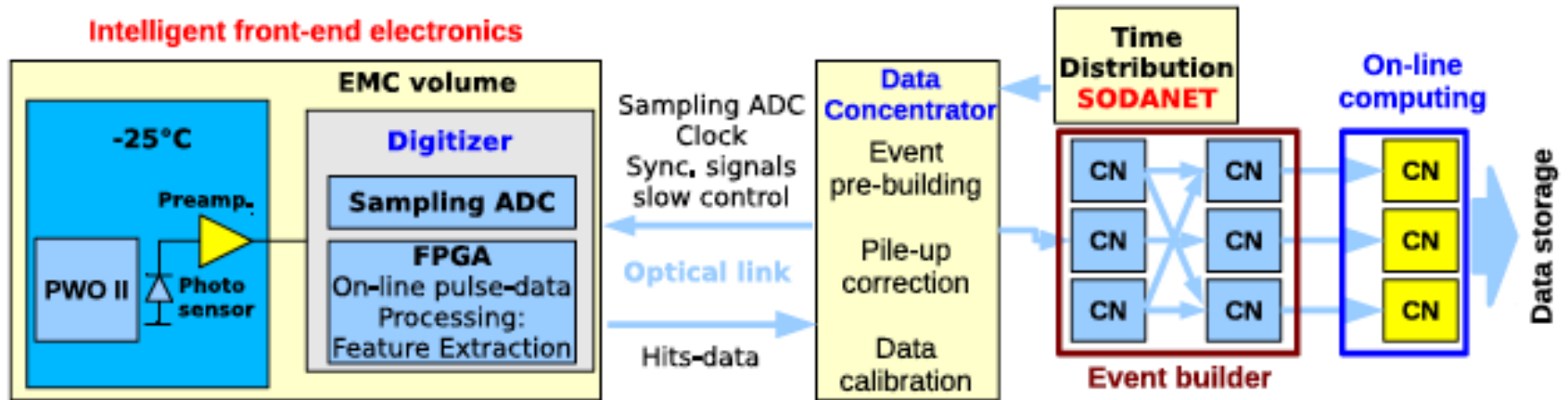


4.4

4.6

T = 20°C

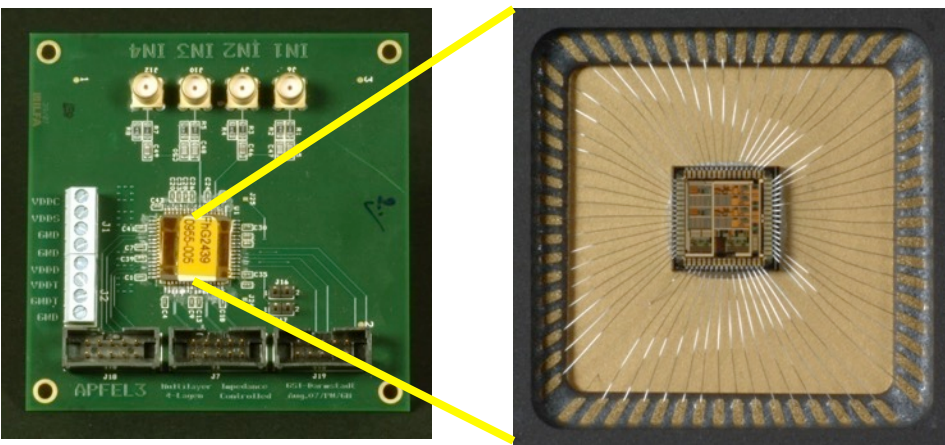
# Electronics



- APFEL-ASIC or Basel LN preamplifier
- Intelligent front-end: SADC
- Time-distribution system: SODANET
- Data concentrators
- Burst-building network
- On-line computing

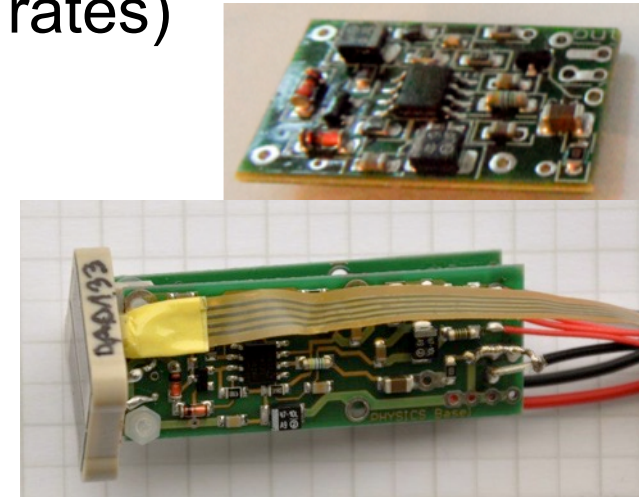
# APFEL ASIC

- Barrel/BW endcap
- Wafers diced
- 15800 ASIC chips expected (sufficient)
- Possible to produce PCBs for April 2016 (GSI)
- Test in Proto120 in Dec.



# Basel LNP

- Two versions for VPTT/  
APD forward endcap  
(higher rates)



- Gain optimisation to maximize dynamic range
- Production beginning 2016

# SADC

- 64 ADC channels (32 dual gain)
- 14 bit resolution
- 80 MHz sampling rate
- Feature extraction
- Two versions:
  - APFEL ASIC
  - Basel preamplifier
- 6 newest version Kintex-7 modules available
- December test beam Mainz with Proto120

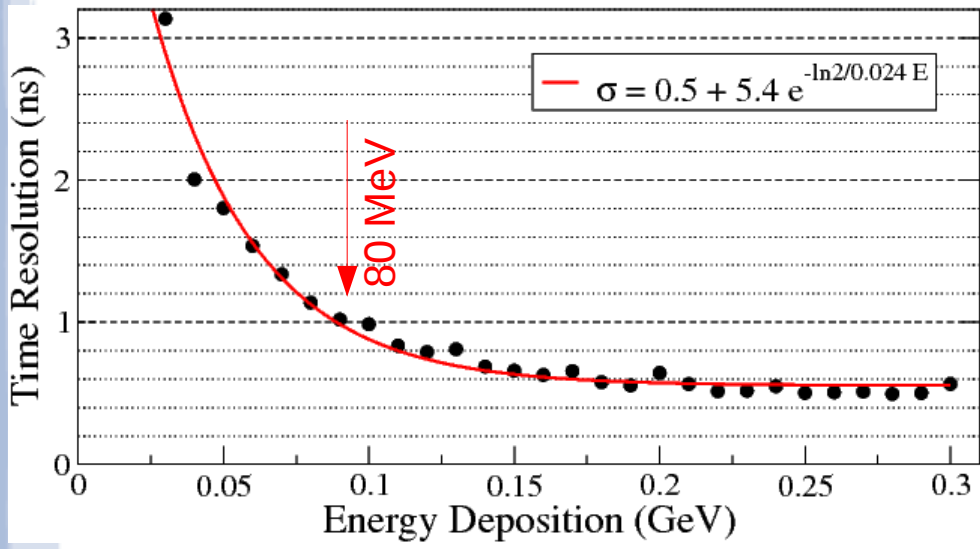


Pawel Marciniewski, Uppsala

# Time Resolution

## using Sampling ADC readout

Time resolution as a function of energy deposition (sampling rate 50 MHz - 20 ns)

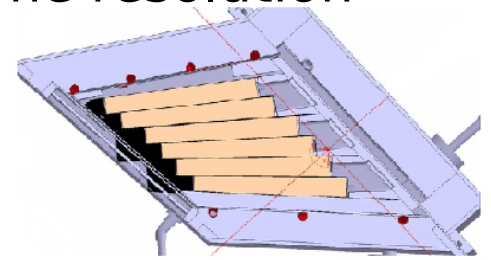


It is possible to achieve time resolution much ( $\times 20$ ) higher than SADC sampling rate

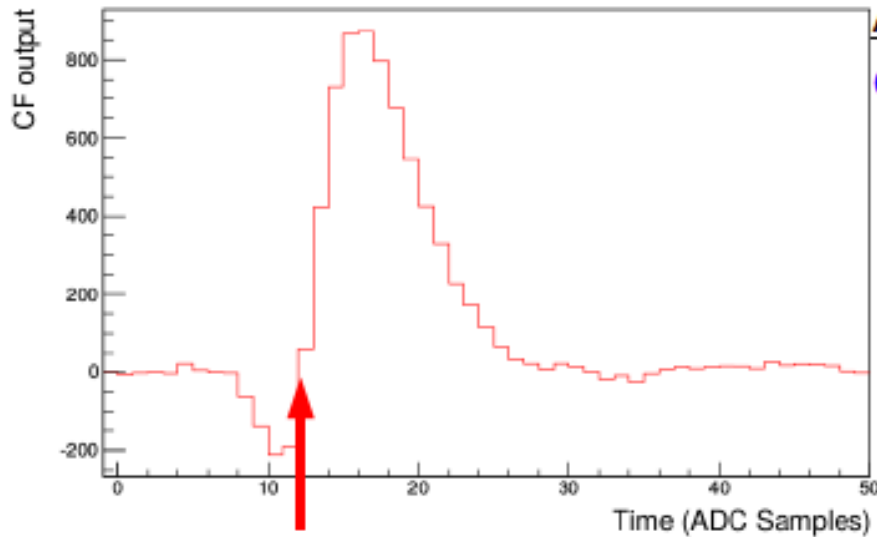
**Time-stamp** is generated using digital implementation of Constant-Fraction Discrimination (CFD)

### Time-resolution measurement:

- Proto60 set-up
- Tagged photons are shot between two PWO crystals to achieve two  $\sim$  equal energy depositions
- Time-difference between two crystals is used to derive time resolution

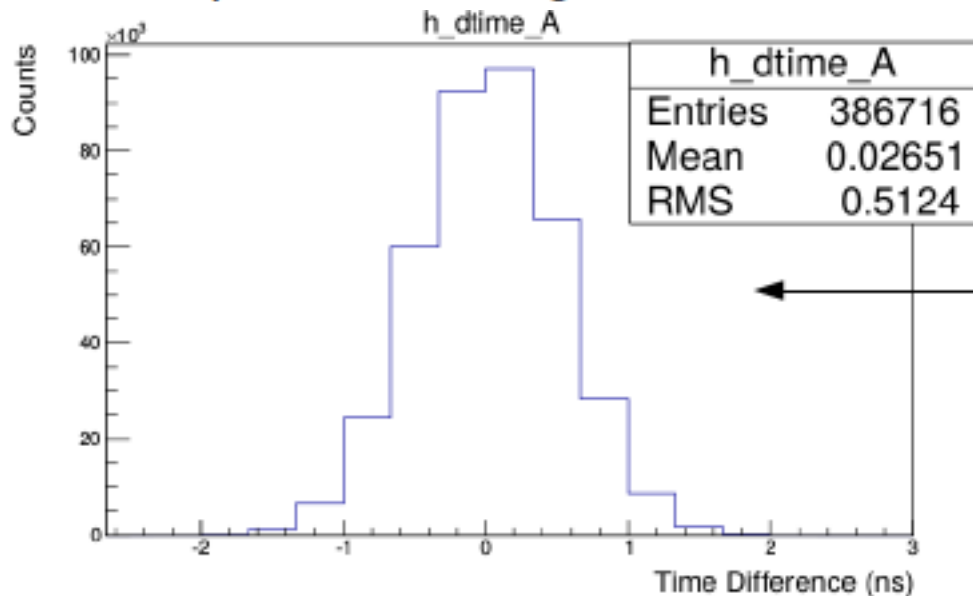


# Time measurement within SADC FPGA



- Achievable time resolution  $< 1$  ns for  $E > 100$  MeV
- Timing for tracking

Time stamp: zero-crossing



Measurement with LED pulser and EMC prototype

Time difference between two channels

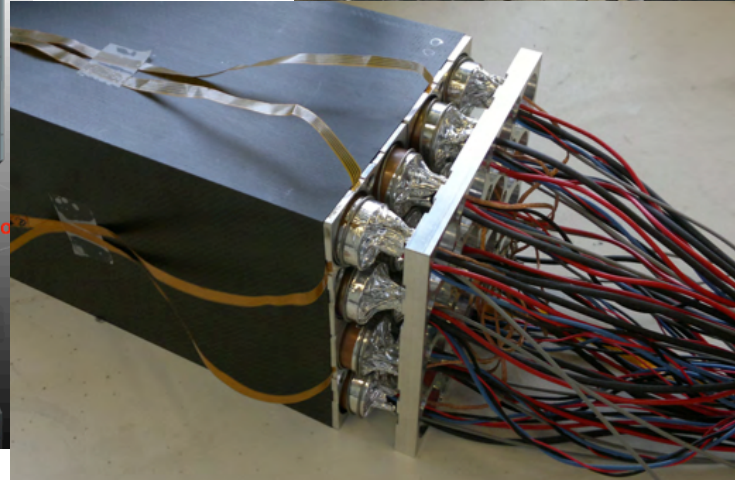
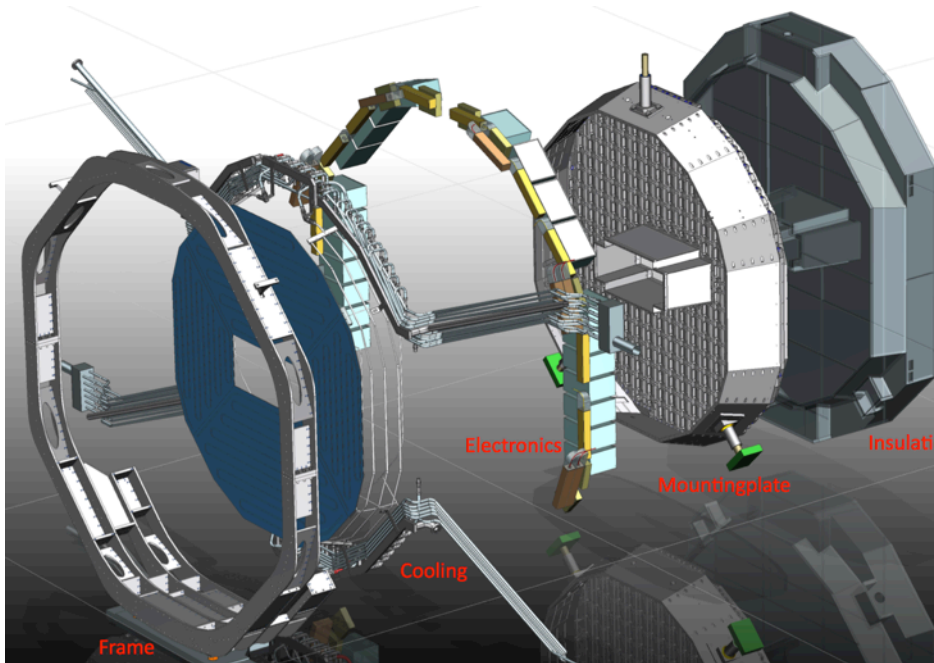
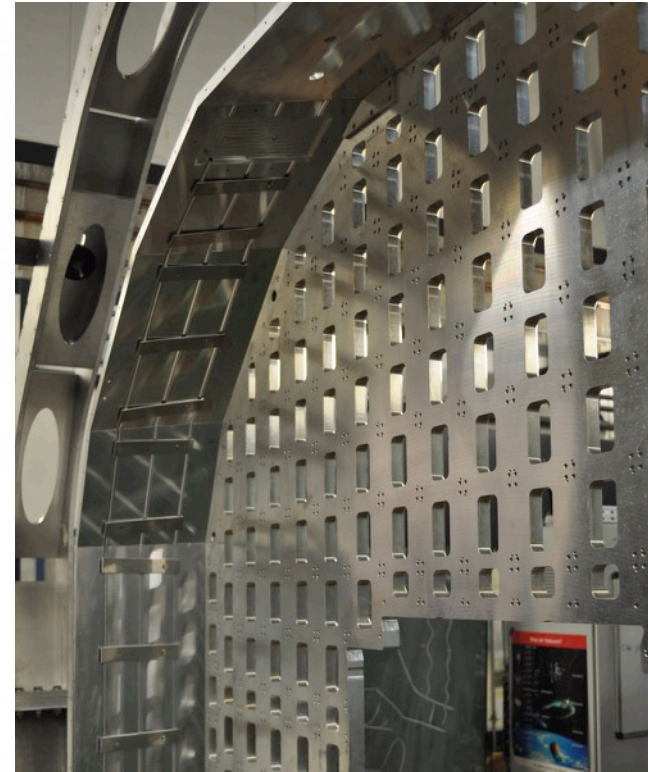
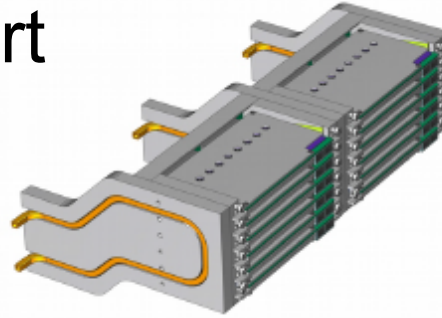
KVI-CART  
Myroslav Kavatsyuk



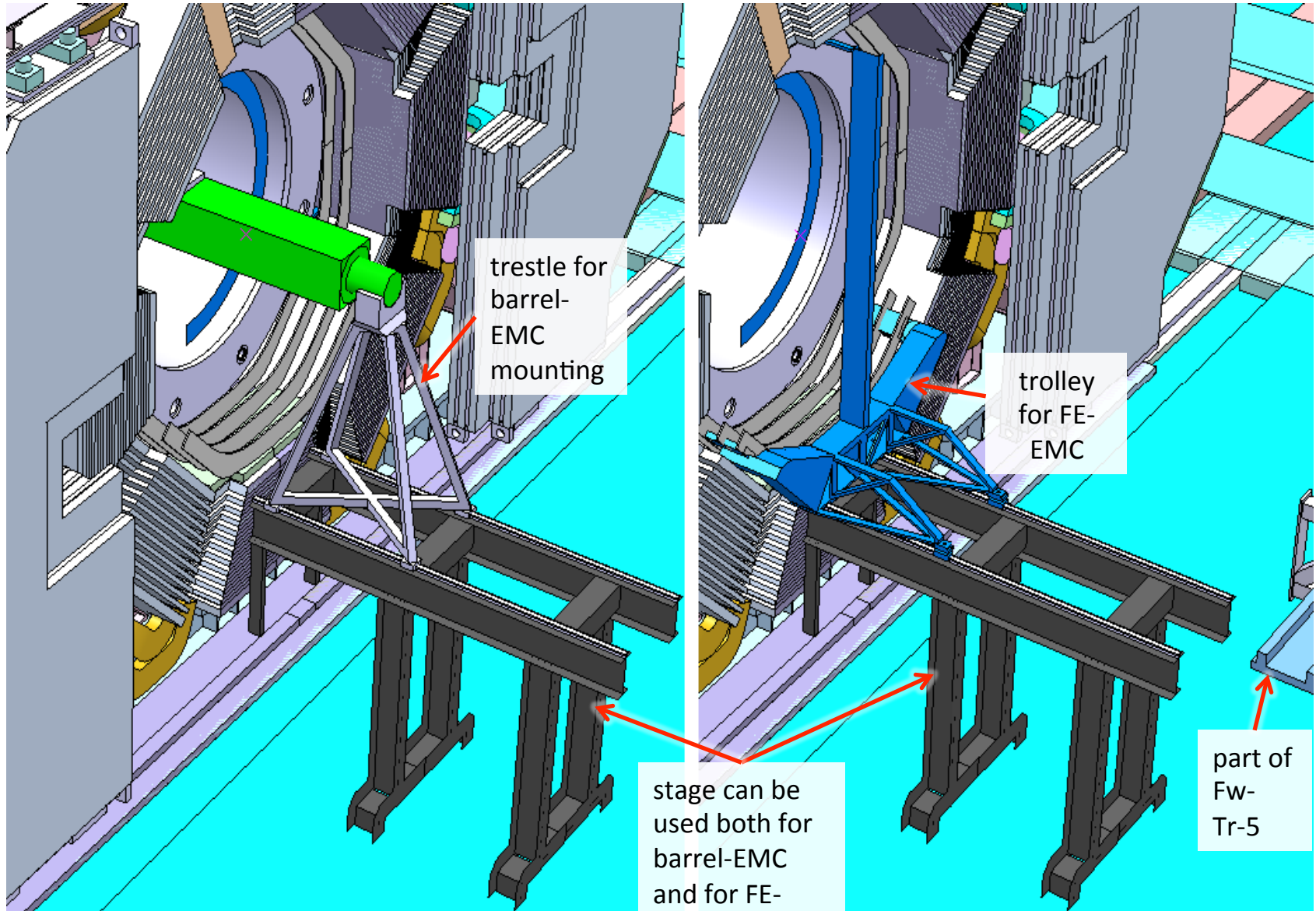


# Mechanics Forward Endcap EMC

- Backplate & support
- Submodules (alveoli, insertes, interface pcs.)
- VIP insulation ordered



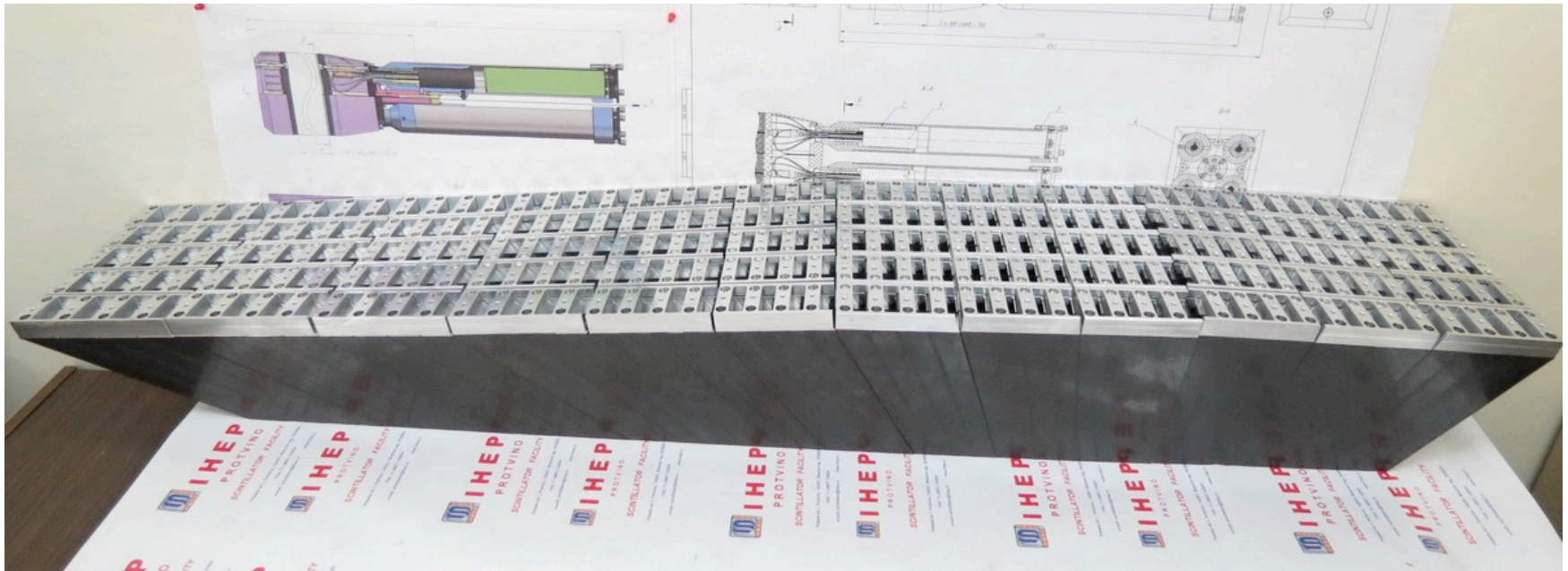
# Forward endcap mounting



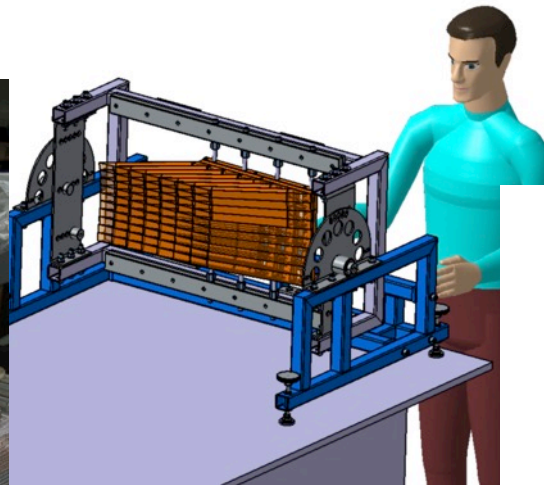
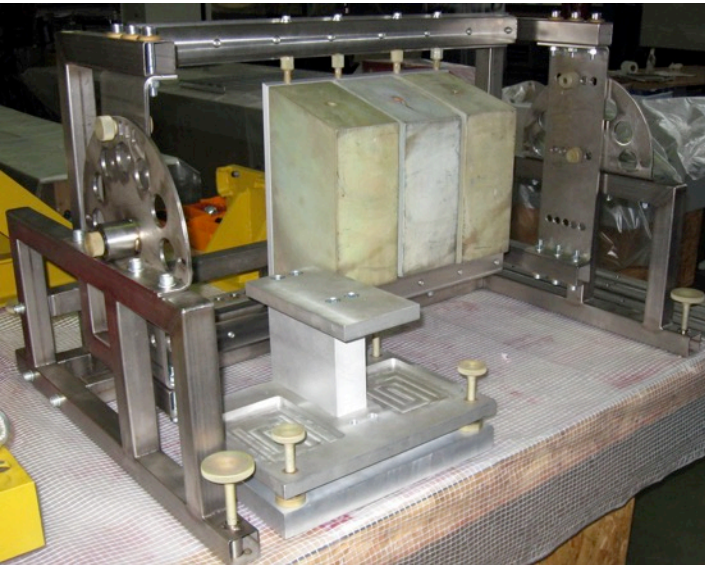
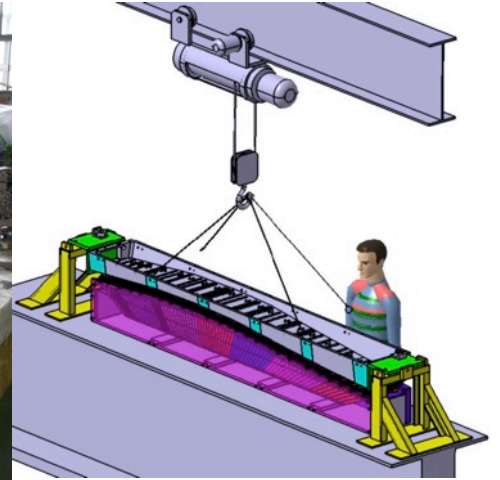
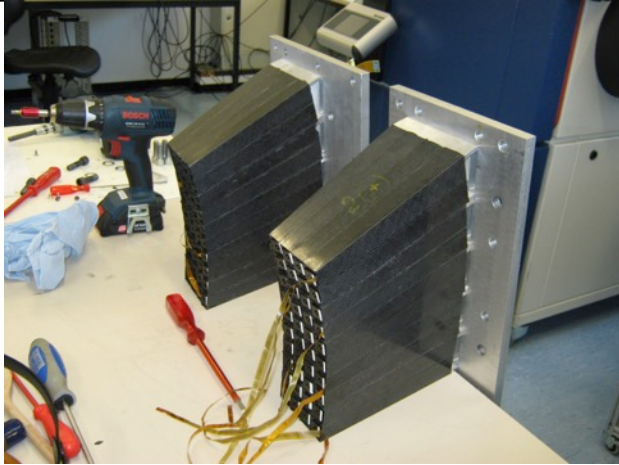
stage can be used both for barrel-EMC and for FE-EMC

# Mechanics Barrel EMC

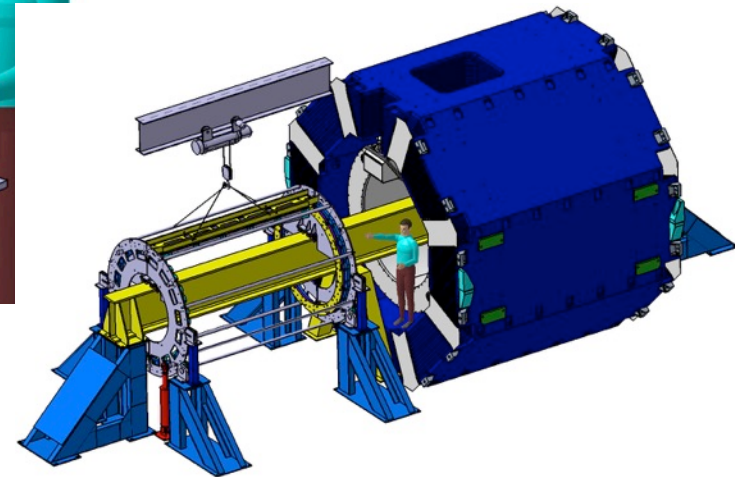
- IHEP-FAIR contract
- 1<sup>st</sup> slice 2016
- Proto120 testbeam december → final concept first slice



# Barrel EMC Assembly

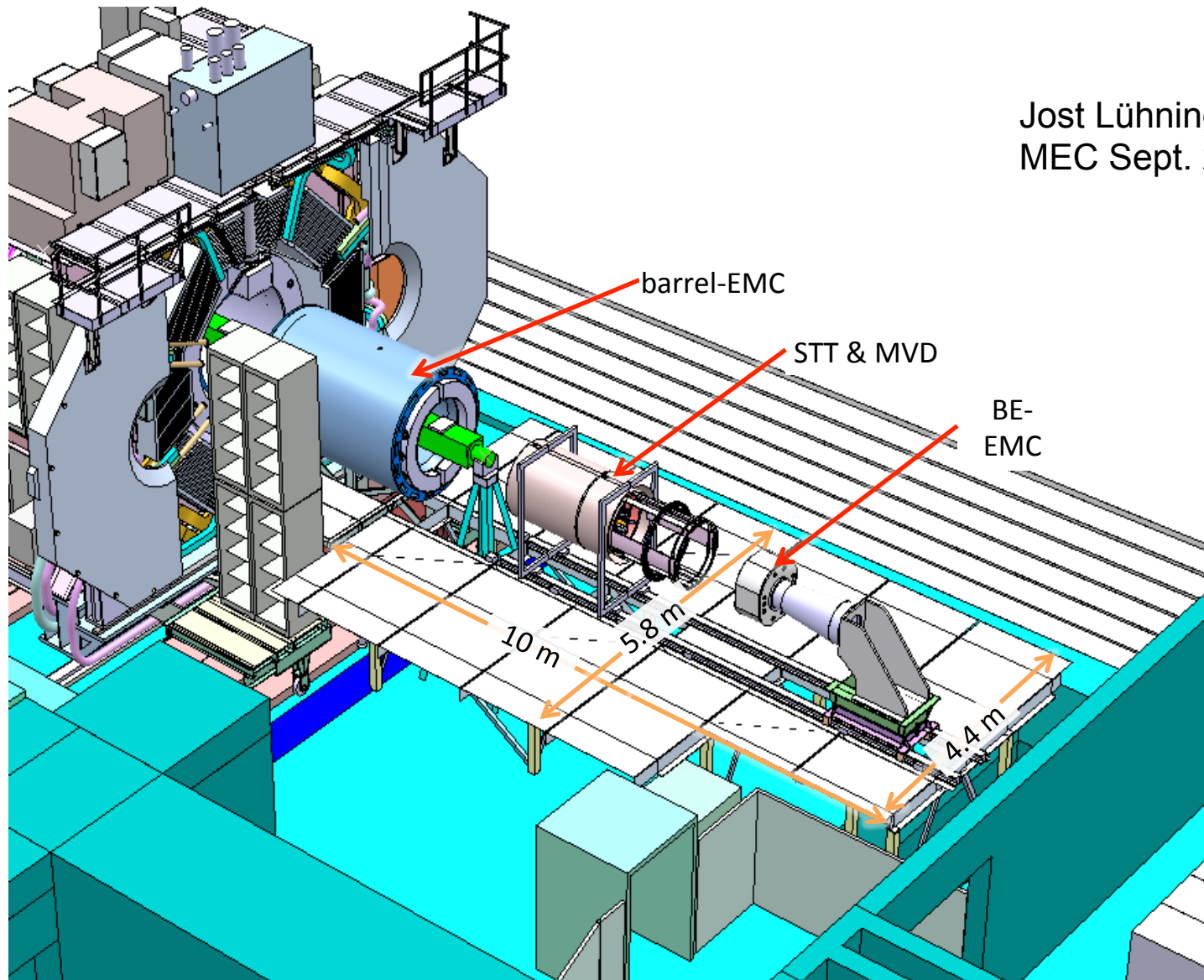


Andrey Ryazantsev  
IHEP Protvino



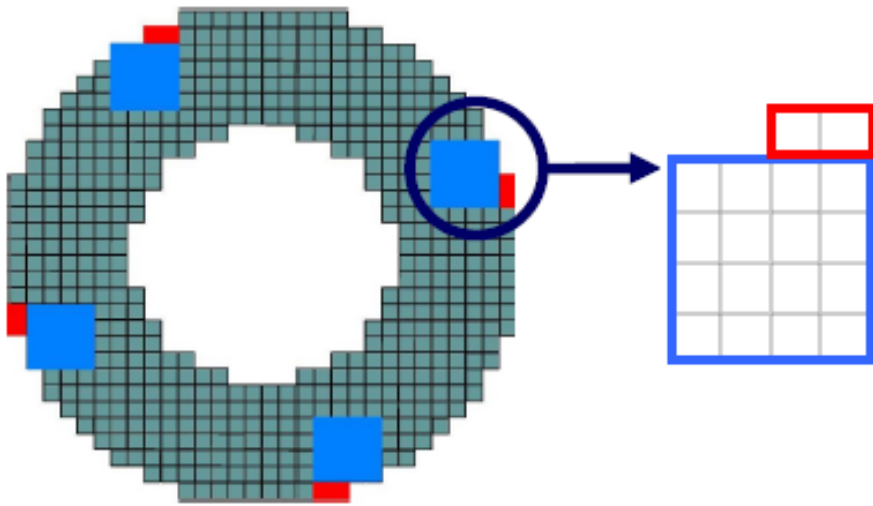
# Platform for Mounting Detectors from Upstream Side

Jost Lühning  
MEC Sept. 2015



# Mechanics Backward Endcap EMC

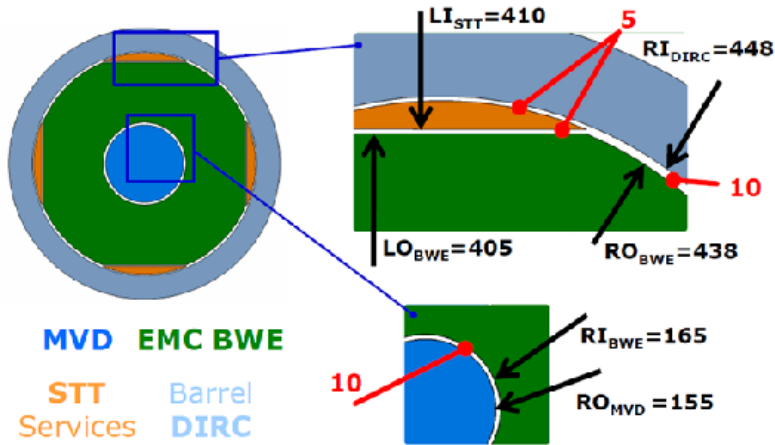
**18 PbWO<sub>4</sub>** Crystals divided  
in two groups: 16 and 2  
crystals



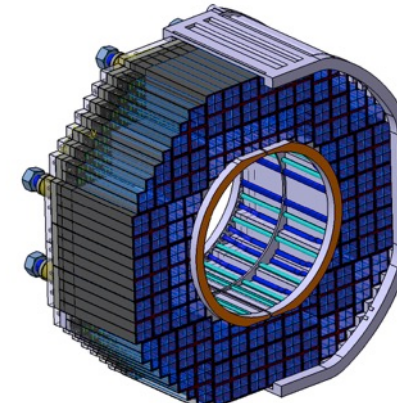
- Critical: Integration with other detectors

# Possible clash with MVD on space

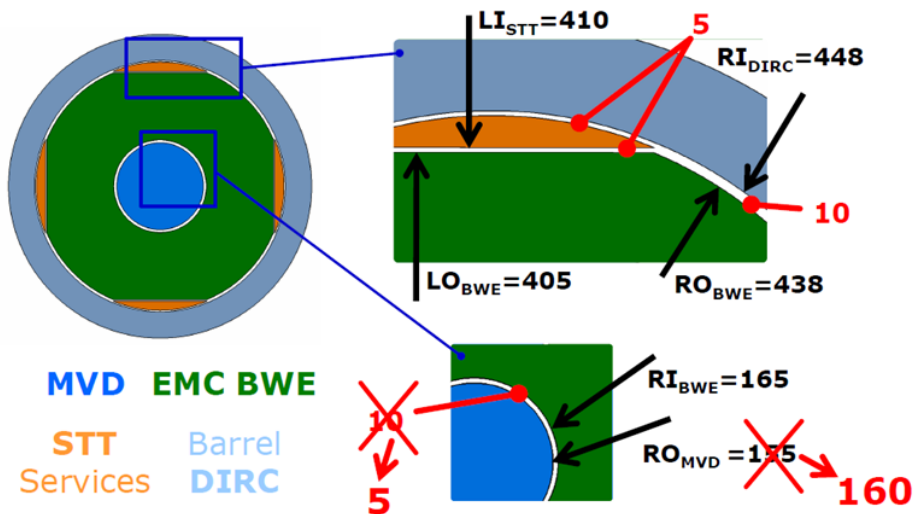
11-Jun-2014  
PANDA Technical Board



- Values of volume dimensions agreed upon in **technical board** and **mechanical session**. Recently put anew into discussion
- BWEC design well advanced **based on agreed dimensions**
- Change of design **waste of resources**



10-Dec-2014  
PANDA Mechanical Session



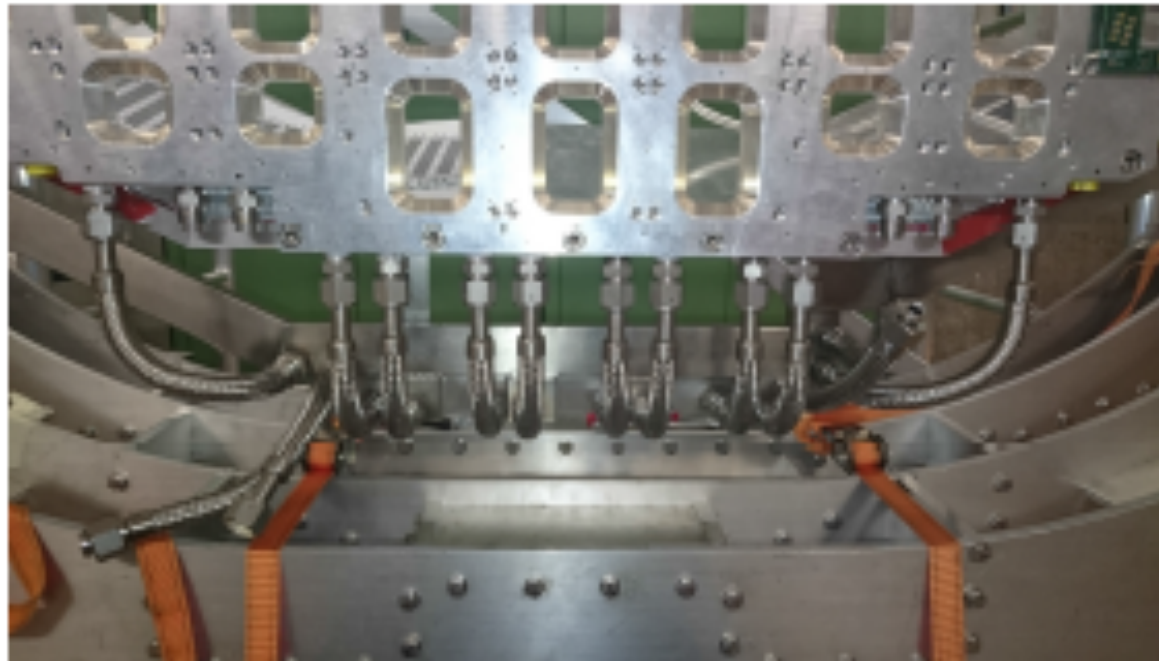
# Cooling

- Prototype for forward endcap and one slice operational in Bochum (Nov. 2016)
- 5 kW cooling compressor, -32 °C
- Methanol water
- Underpressure
  
- Designed & built at Orsay
- DCS: Bochum





# Cooling



- Connection of forward endcap backplate cooling lines
- Test with cooling machine next year
- *Open:* Responsibility final cooling machine and design of barrel cooling

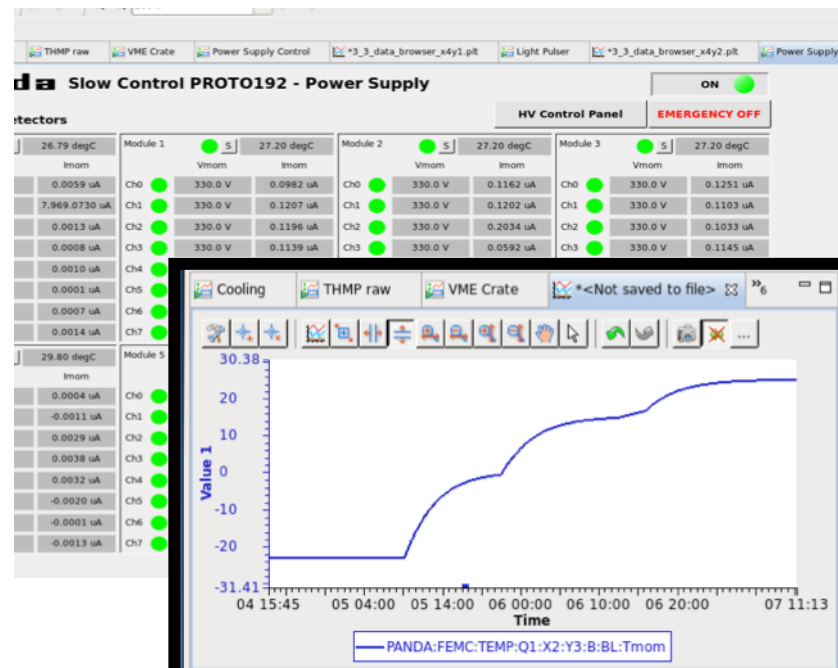
# Monitoring and Detector Control System

- Light pulser
  - Prototype ready
  - Stimulated recovery tests at Giessen
  - Final version 2016
- Temperature and humidity monitoring
  - Electronics ready
  - Sensors forward endcap: calibration ongoing
  - Sensors for barrel slice to be produced
- Detector control system
  - EPICS & CSS based
  - Prototype ready
  - All hardware types are integrated

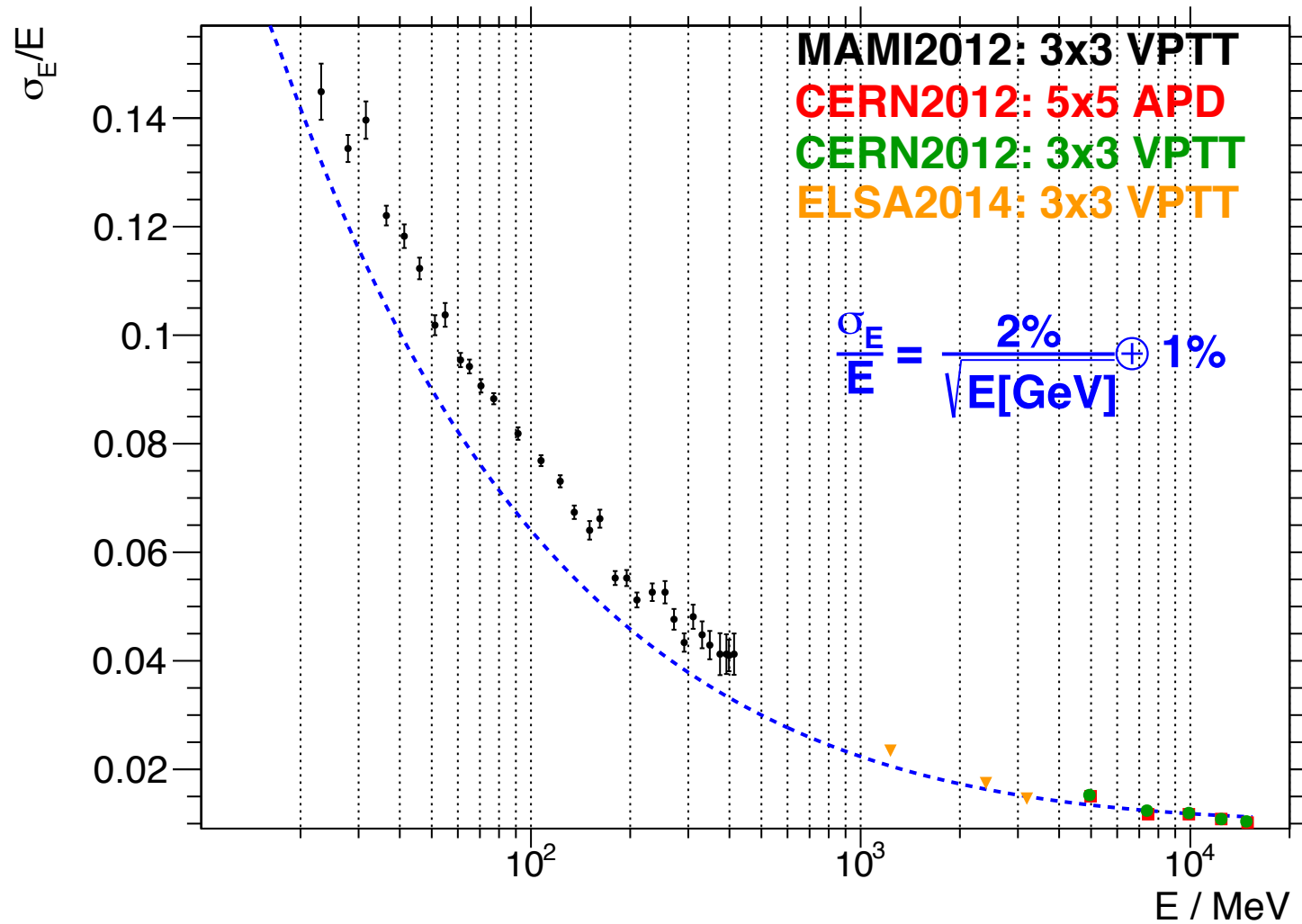


70  $\mu$ m Pt100

RU Bochum



# Prototype Tests: FW Endcap

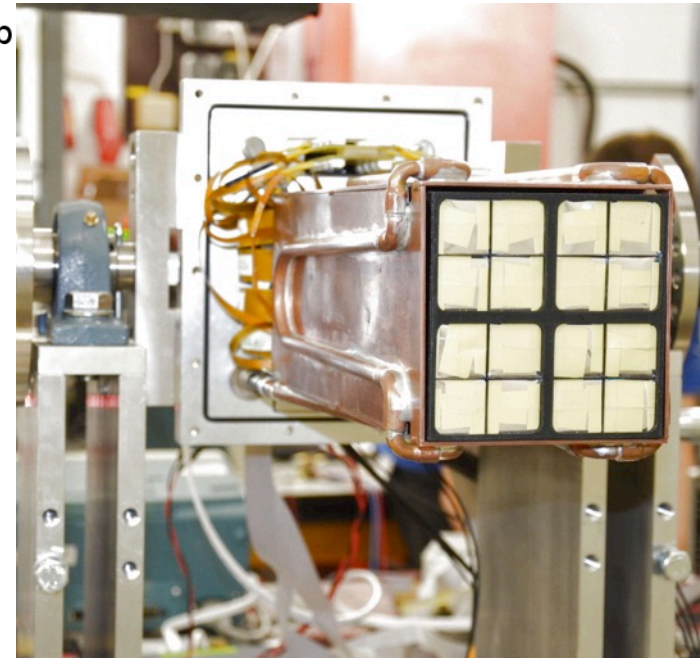
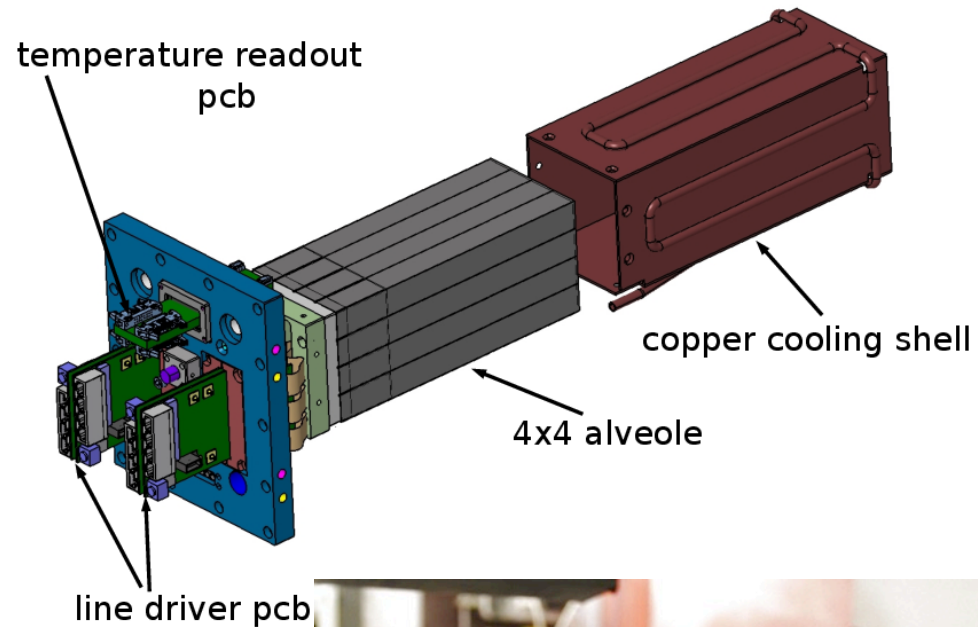


# Prototype Tests: BW Endcap

## Prototype Proto16

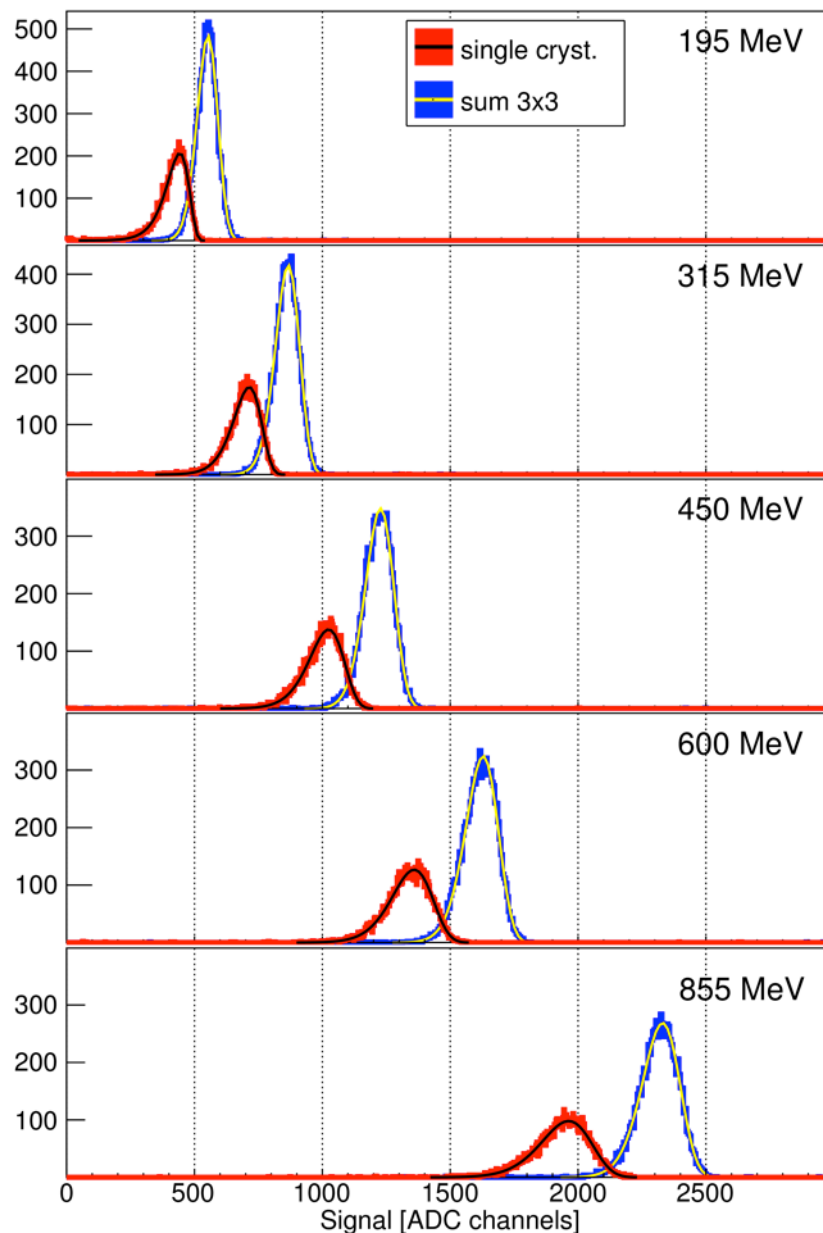
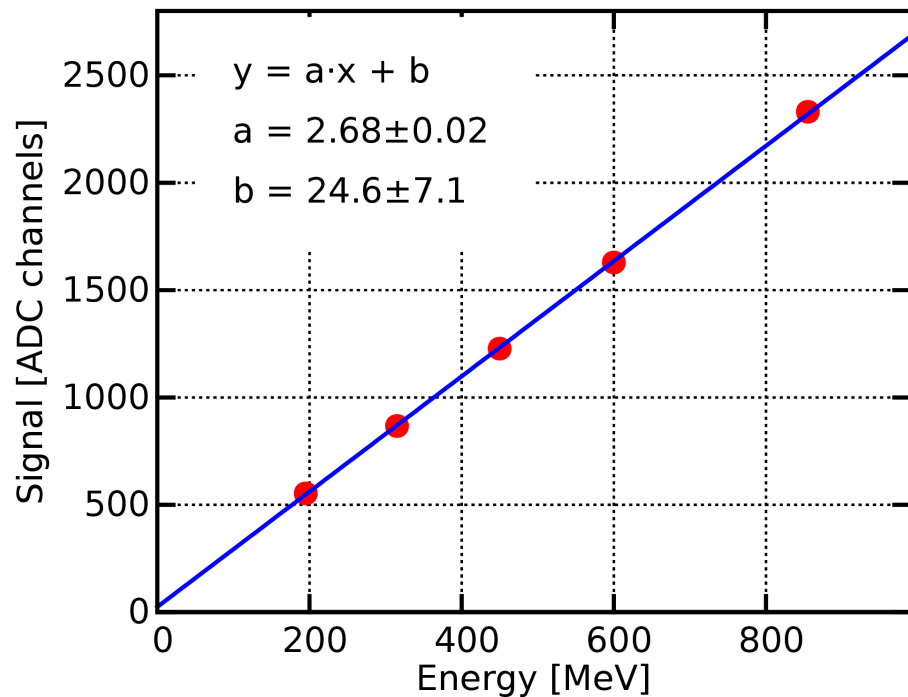
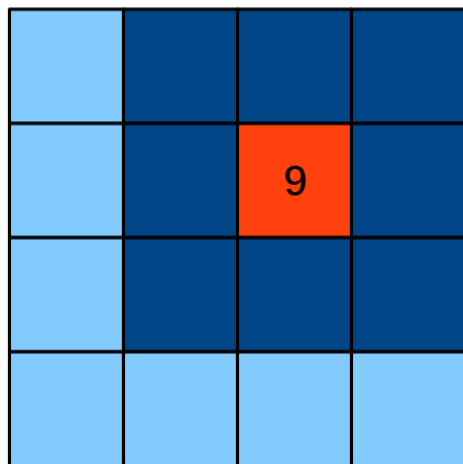
A complete setup with almost all final components

- 16 crystals
- 2 APD per crystal
- APFEL ASIC readout
- Line drivers (sender/receiver)
- Sampling ADC (readout of full traces)
- LED pulser, 1 optical fibre for each crystal
- Cooling (-25°C)
- Insulation with VIP
- Flat Pt100 sensors
- THMP temperature readout
- Carbon fibre alveole
- Cold and warm mounting plate
- Glass fibre support feet



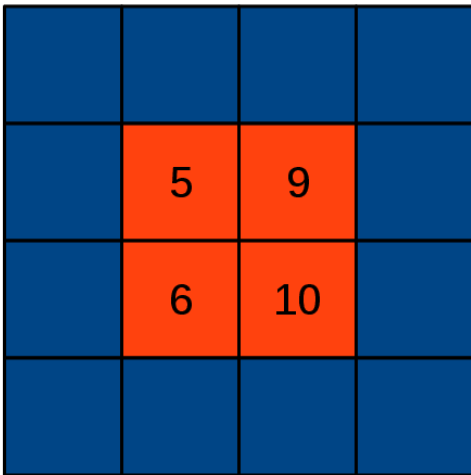
# Prototype beam tests at MAMI (2014/15)

Prototype response linearity: very good

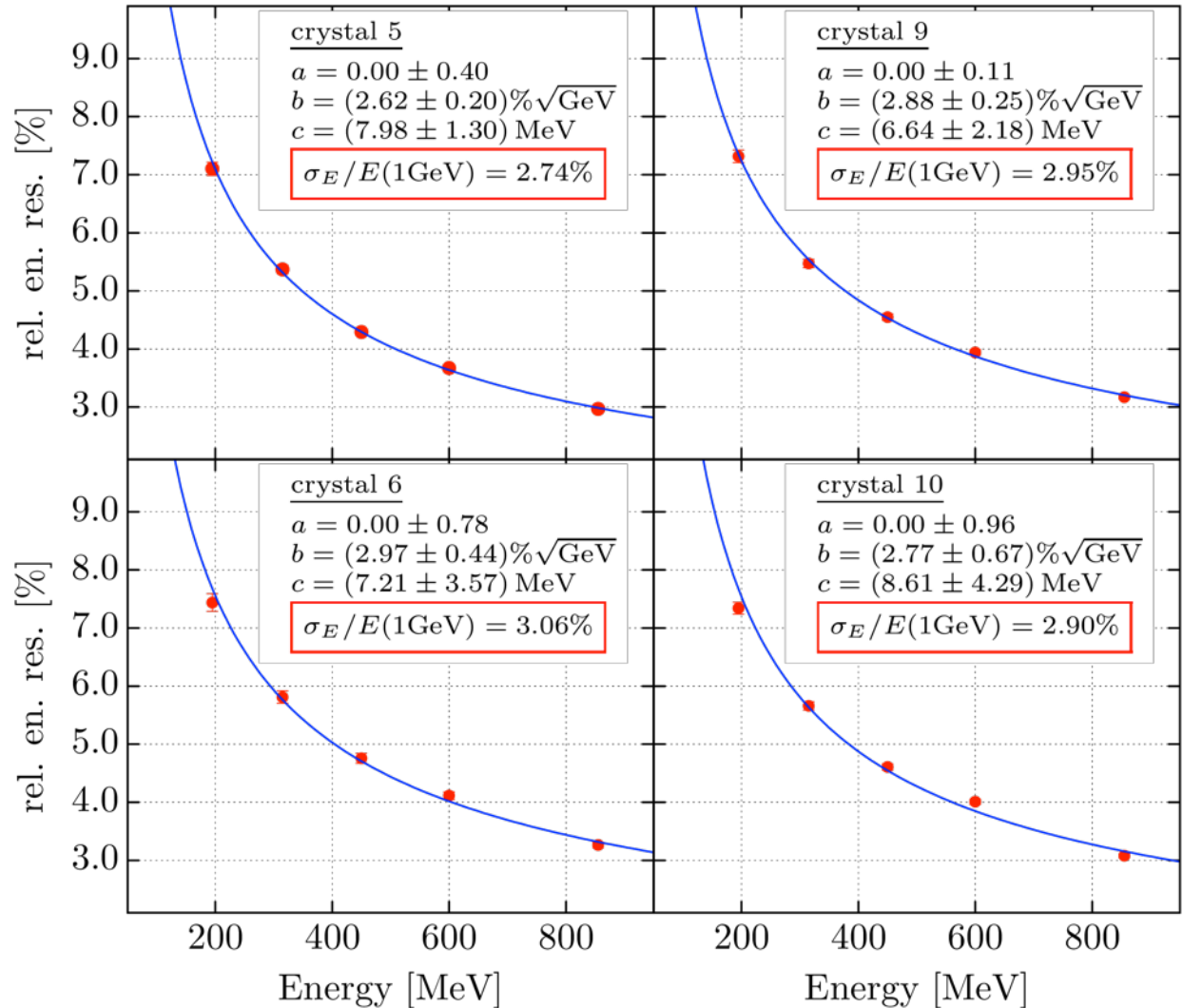


# Prototype energy resolution

$$\frac{\sigma_E}{E} = a \oplus \frac{b}{\sqrt{E}} \oplus \frac{c}{E}$$



**energy resolution  
@ 1 GeV: about 3%**

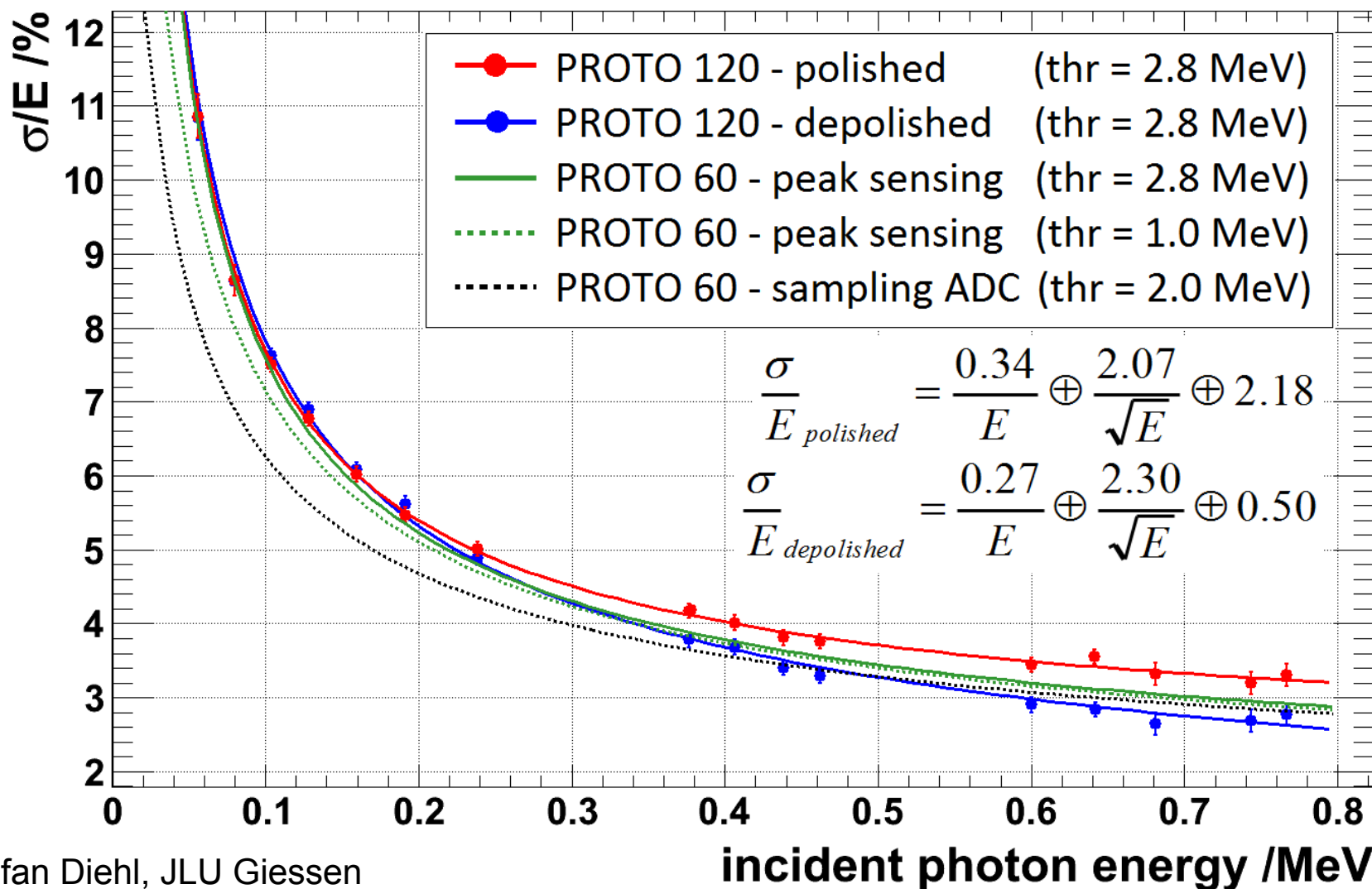


# Plans for 2016 (BW EMC)

- Design of a light distribution system (light fibres routing and coupling to the crystals)
- Mechanical tests for the holding structure including rails/insertion
- Finalisation of the signal quality tests for small pulses (single crystal energy threshold)
- Incorporation of the current version of the PANDA EMC sampling ADC and readout system
- Beam tests with an updated prototype

# Prototype Tests: Barrel

PROTO 120 (3x3 array analysed) April 2015 MAMI

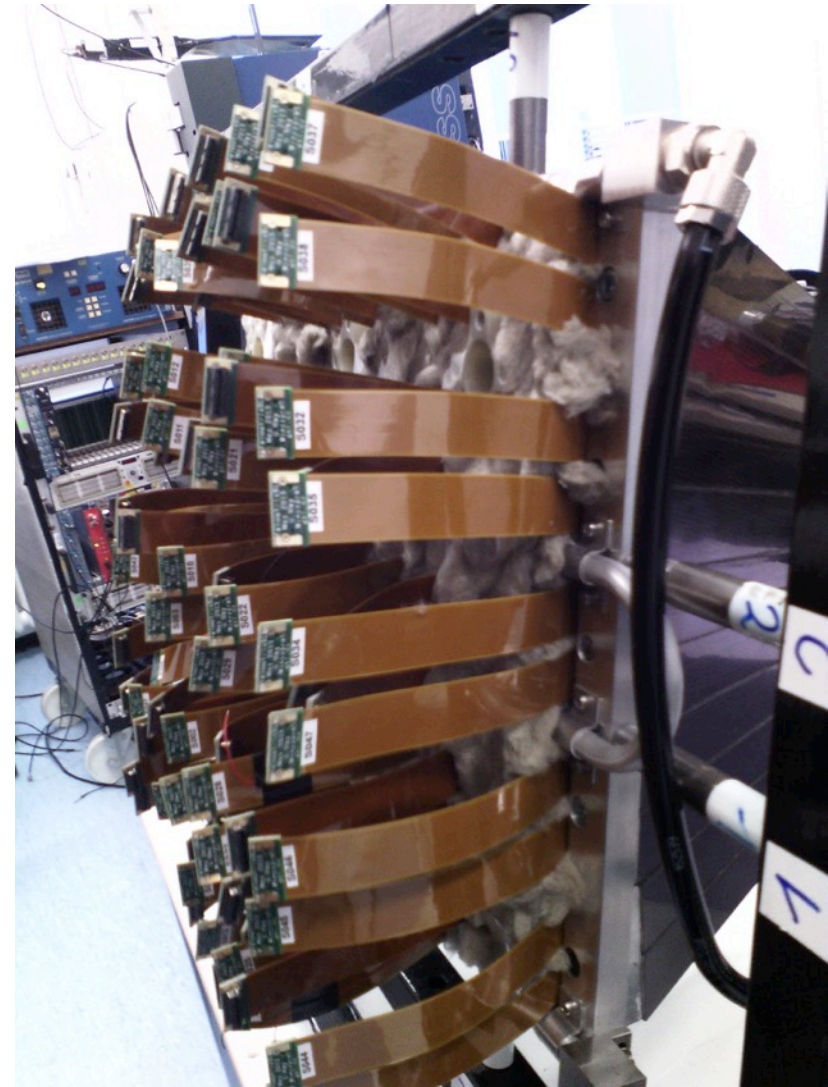
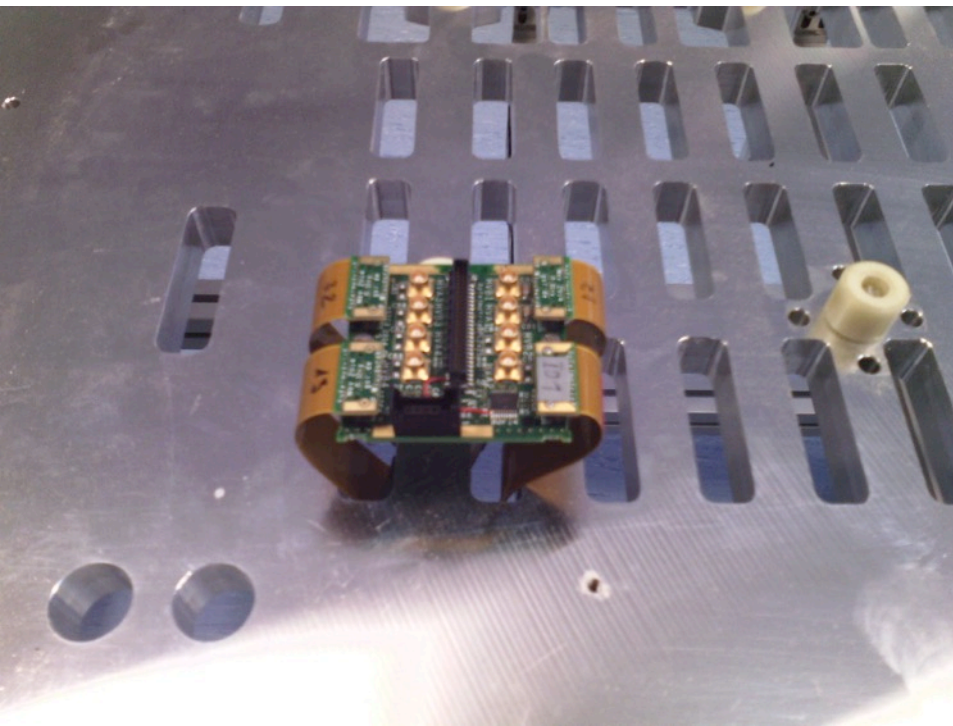




# Prototype Tests: Barrel

PROTO 120: next test @ MAMI: Dec. 11-13

- Two 5x5 matrices
- APFEL-ASIC readout
- New mechanics, cooling
- Monitoring from front



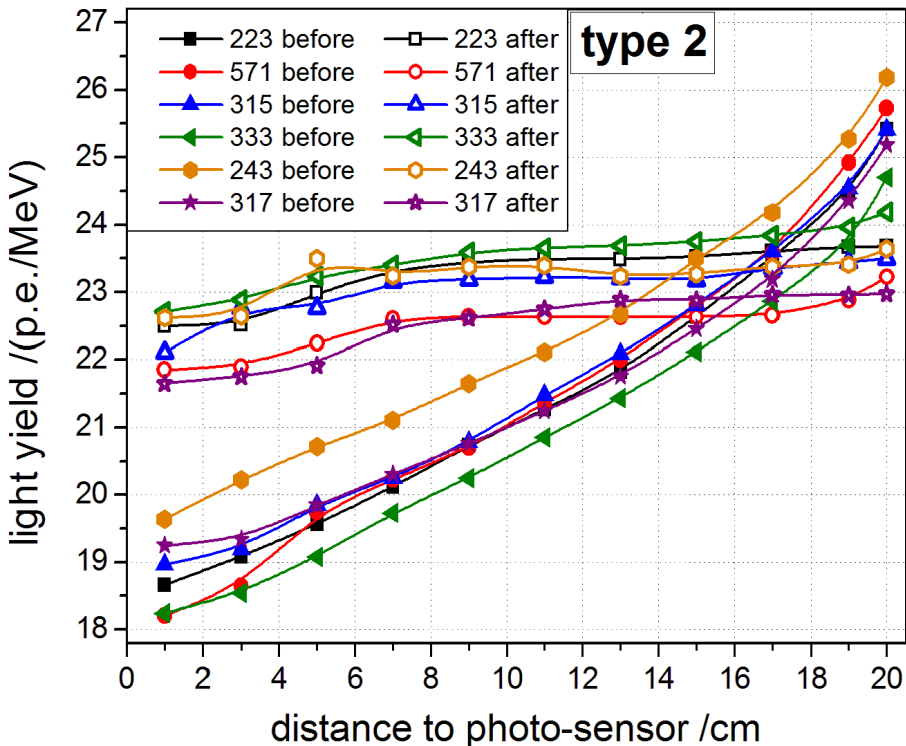
# Prototype Tests: Barrel

One matrix de-polished crystals (one side), to be tested

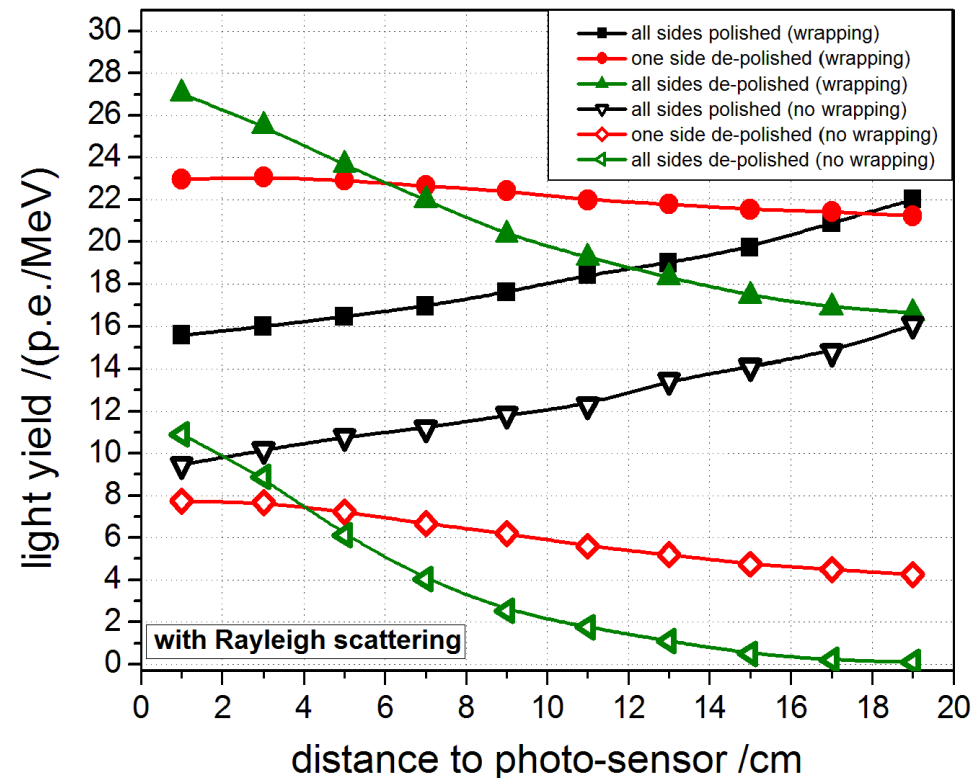
- Increases light yield in rear part of the crystal
- Homogenous response in the front part of the crystal

Stefan Diehl  
JLU Giessen

### Measurement with source 662 keV



### crystal with and without a reflective wrapping (Geant 4 simulation)



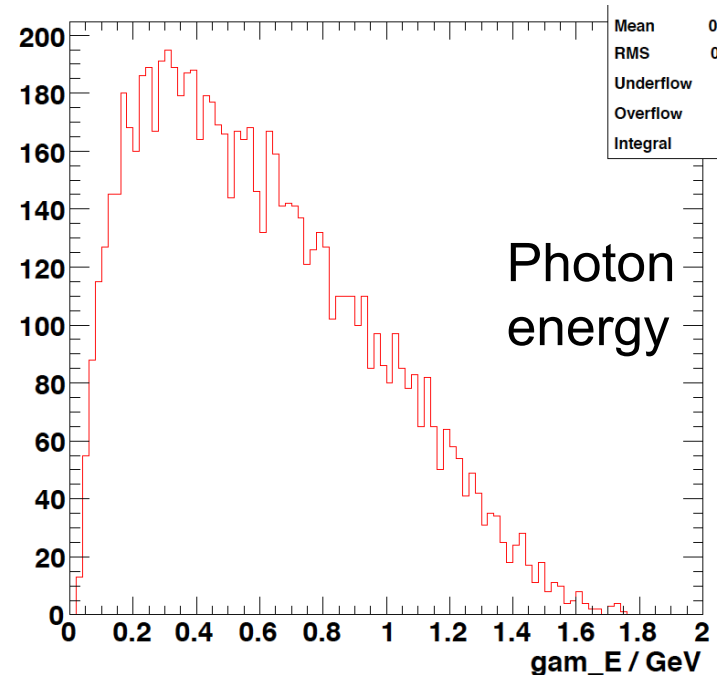
# Preassembly at FZ Jülich

- Forward endcap assembly
- Barrel slice
- Beam test at COSY  
– 2017



- Precalibration with  $\pi^0$

Simulation 3 GeV/c p momentum



# Software (Stefano Spataro)

## Geometry

- ❖ Mostly just crystals – almost no passive structures

## Digitization

- ❖ Time based simulation recently updated

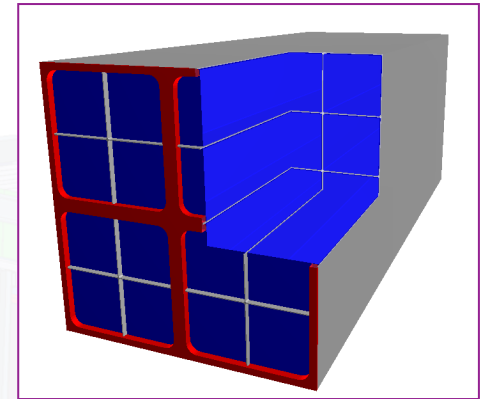
## Reconstruction

- ❖ Clustering, bump splitting, energy corrections, etc...
- ❖ Correlation to charged tracks
- ❖ Uncertainty in calibration, covariance matrices, stability, random maintenance
- ❖ Improve algorithms, split-off handling, covariance matrices
- ❖ Need to improve neutral reconstruction, noise suppression

## Recent Activities

- ❖ MC matching fixed
- ❖ Studies on preshower in the DIRC (by SciTil group)

Proposed EMC software coordination in Bonn, but BMBF stopped



# Timelines and Resources (Barrel)

- First slice
  - Start assembly April 2016 (delivery of mechanics)
  - Ready fall 2016 (*if manpower sufficient*)
- Full Barrel
  - Ready 3 years after availability of crystal funding (2019)
- To be done
  - Signal cables
  - Grouping of HV channels (HV distribution board)
  - Overall cooling concept
- Dec 2015
  - Final test Proto120
    - ASIC & mechanics

# Timelines and Resources (Barrel)

- Money
  - For first slice available (BMBF money to be released)
  - Available pcs.: Part of crystals, APDs
  - Funding available: SADC (Sweden), Mechanics (Russia)
  - Remaining crystals (EoI Russia)
  - Remaining APDs to be funded (Germany, Austria)
  - Monitoring, cooling, insulation, cables, power supplies, ... (to be applied for in Germany)

# Timelines and Resources (FW Endcap)

- Timelines
  - Jan.-Dec. 2016  
Submodule assembly
  - Dec 16 – Jun 2017  
Mounting and test
  - Fall 2017 beam tests
- Funding
  - Available, most parts available, remaining parts to be ordered in 2016 (BMBF money was partly withhold)
- Critical
  - Availability of matched APDs
  - Manpower for assembly

# Timelines and Resources (BW Endcap)

- Timeline

- Original schedule: -9/2015  
prototype/pre-series  
construction delayed due to  
FAIR schedule, further  
R&D ongoing
- For 2 years (was -9/2017):  
Component construction &  
testing, Module assembly &  
testing
- For 9 month (was -6/2018):  
Pre-assembly, off-site  
testing, Transport to FAIR,  
site-acceptance tests

- Funding

- Available pcs.: crystals,  
APDs, HV, APFEL-ASIC
- Funding available:  
everything else (Germany)  
and SADCs (Uppsala)



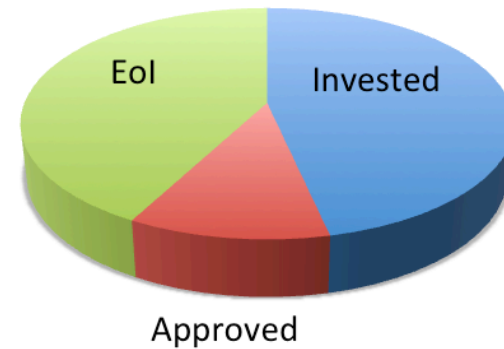
# Resources (Common)

- SADC & concentrator
  - Uppsala (hardware)
  - KVI-CART (software)
- Software coordination
  - Bonn (manpower limited)
- Cooling machine
  - open

# Summary

- Design well progressed
- EMC provides time signal  $< 1$  ns
- Forward endcap EMC in production
- New producer for crystals
- Critical issues
  - Crystal funding (Russia)
  - Remaining Barrel EMC parts and assembly (Germany)
  - Manpower forward endcap EMC and first barrel slice assembly
  - Keep space for backward endcap EMC fixed

Target Spectrometer EMC Investments



- Open/To Do
  - Cooling machine and barrel EMC cooling
  - Installation procedures
  - Software/calibration/online software