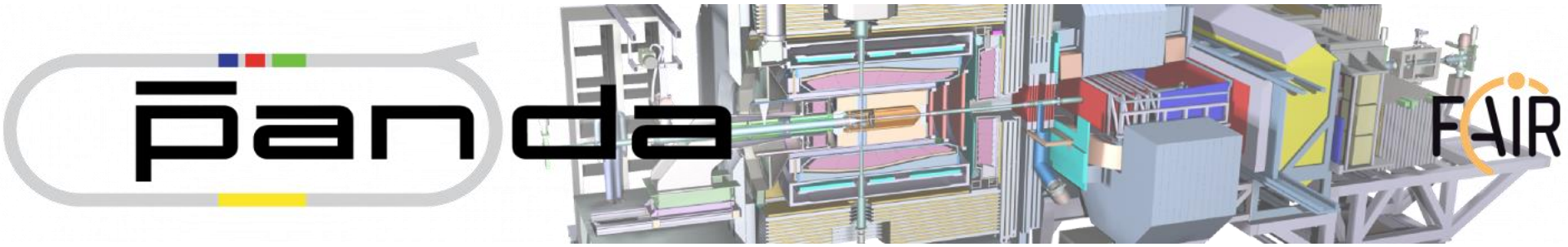
Construction and Assembly of the First Barrel Slice for the Electromagnetic Calorimeter of the



Experiment

Markus Moritz*, and for the PANDA collaboration
*2nd Physics Institute, University Giessen, Germany

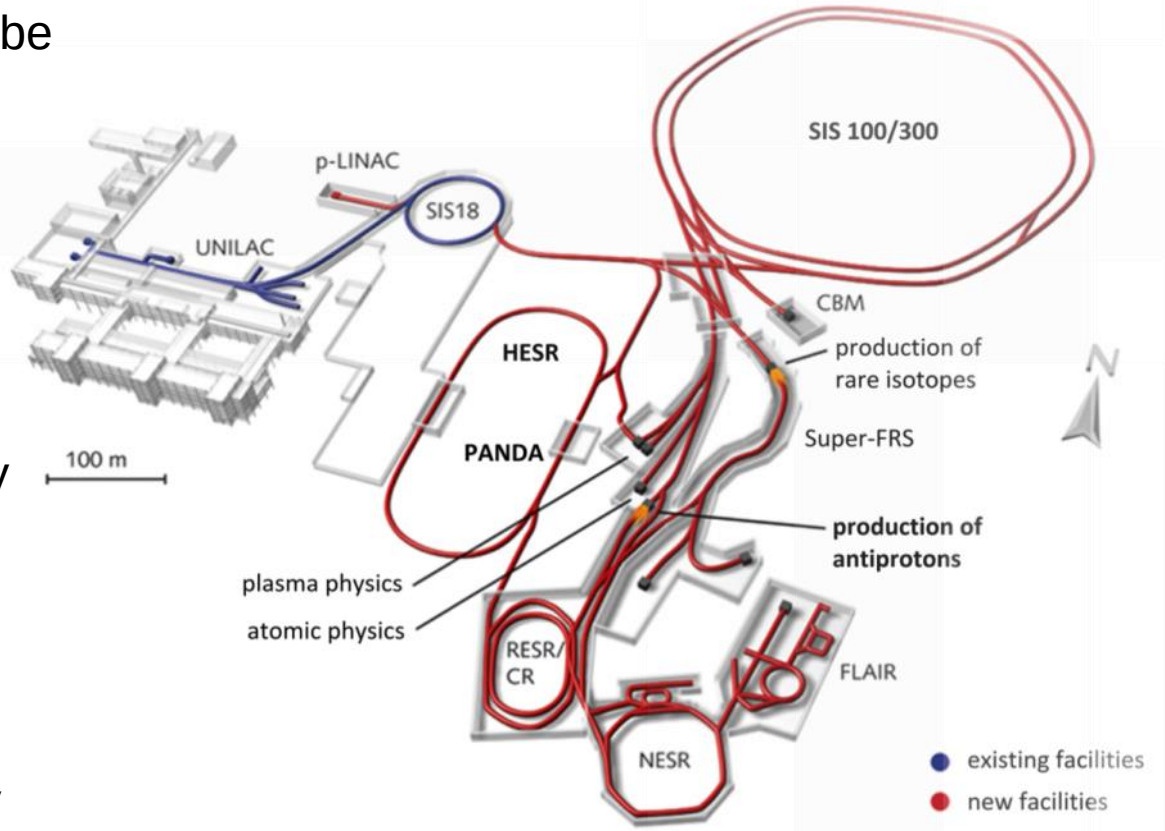
International Conference On Exotic Atoms And Related Topics
EXA 2017

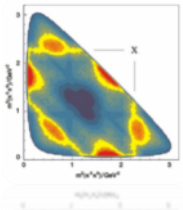
Outline

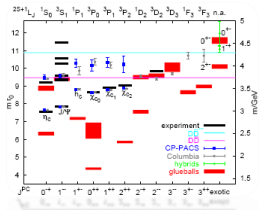
- **Introduction**
  - PANDA @ FAIR
- **Prototype tests**
  - PROTO 60 & 120
- **First slice**
  - Detector preparations
  - Assembly procedure
  - Workspace & Tools
- **Ongoing activities**

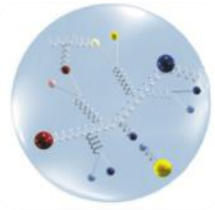
Future Facility for Antiproton and Ion Research (FAIR) near Darmstadt

- Various physics programs can be operated in parallel.
- PANDA will be one of the key experiments.
  - Anti-Proton Annihilation at Darmstadt.
  - Charmonium Spectroscopy
  - Gluonic Excitations
  - Study in-medium effects of hadronic particles
  - Open-charm Spectroscopy
  - Hypernuclei
  - Electromagnetic Processes



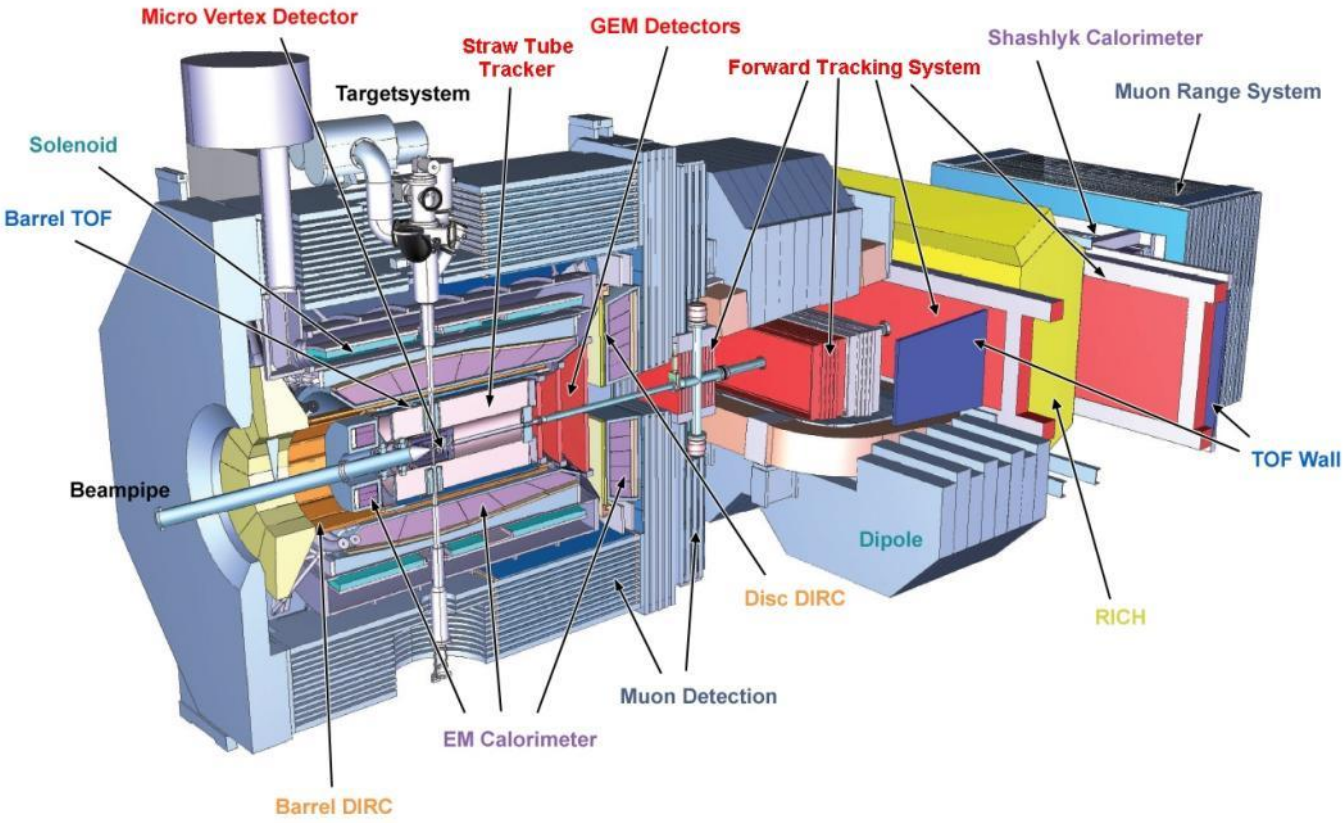






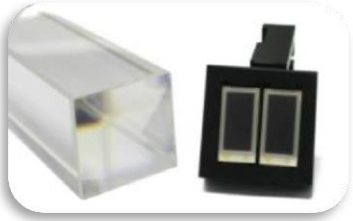
- Cooled antiproton beams between 1.5 GeV/c and 15 GeV/c
- Fixed target experiment
  - hydrogen
  - thin wires
- High luminosity

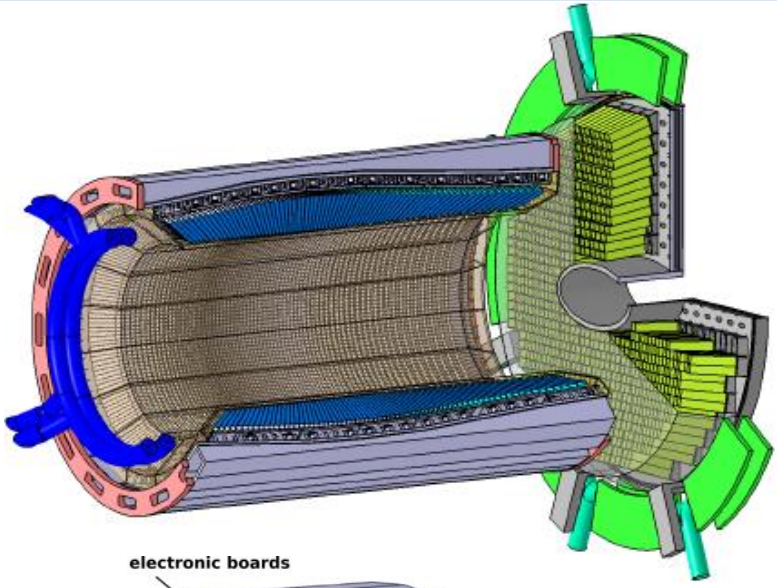
  10^{32} $cm^{-2}s^{-1}$

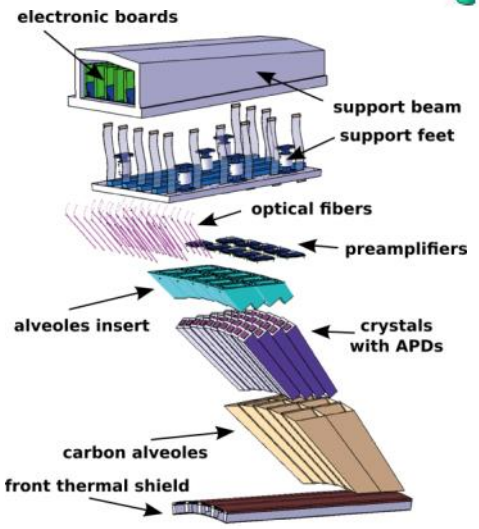


PANDA Target Calorimeter –Requirements-

- Inside 2T superconducting magnet -> compact
- High interaction rates up to 10^7 s^{-1} -> fast response
- Annual dose up to 30 Gy -> radiation hardness
- Good energy resolution over huge dynamic range 10 MeV up to 15 GeV-> effective background rejection
- 16.000 $PbWO_4$ crystals -> 4π
- Operating temp. = -25°C -> 4x incr. light yield
- Readout:
  - Barrel: LAAPDs
  - Forward End Cap:
    - inside: VPTTs
    - outside: LAAPDs

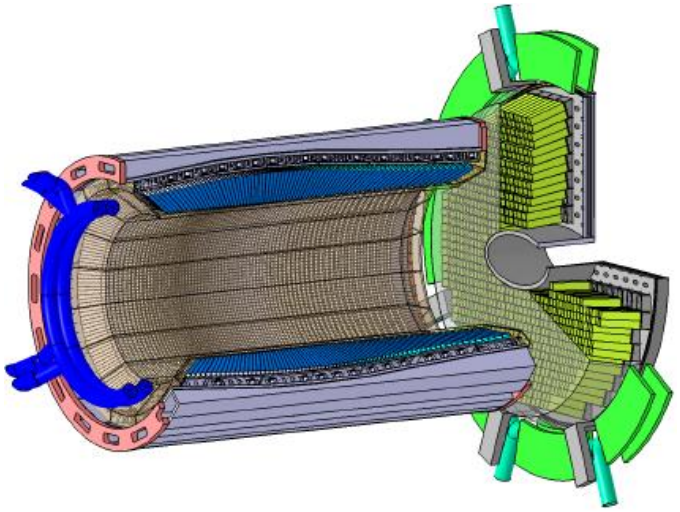






PANDA Target Calorimeter –Requirements-

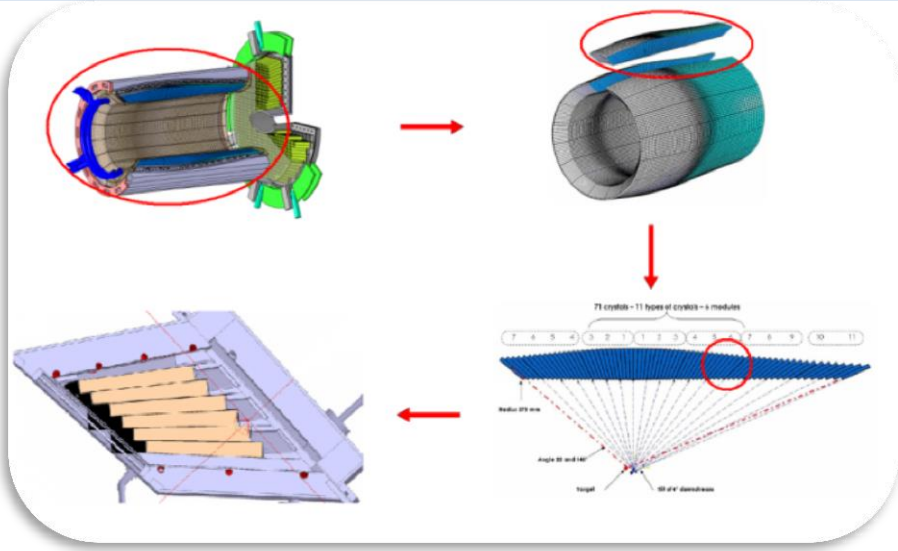
- Target Calorimeter based on high quality PWO-II crystals
- Physical goals required improved scintillators

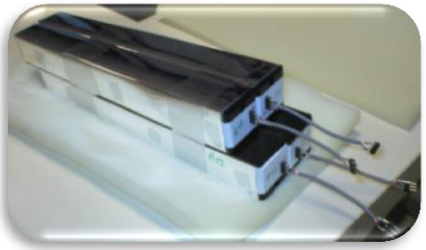


	PWO-I (CMS)	PWO-II (PANDA)
luminescence maximum, nm	420	420
La, Y concentration level, ppm	100	40
expected energy range of EMC	150MeV - 1TeV	10MeV - 10GeV
light yield, phe/MeV at room temperature	8-12	17-22
EMC operating temperature, °C	+18	-25
energy resolution of EMC at 1GeV, %	3,4	2,0

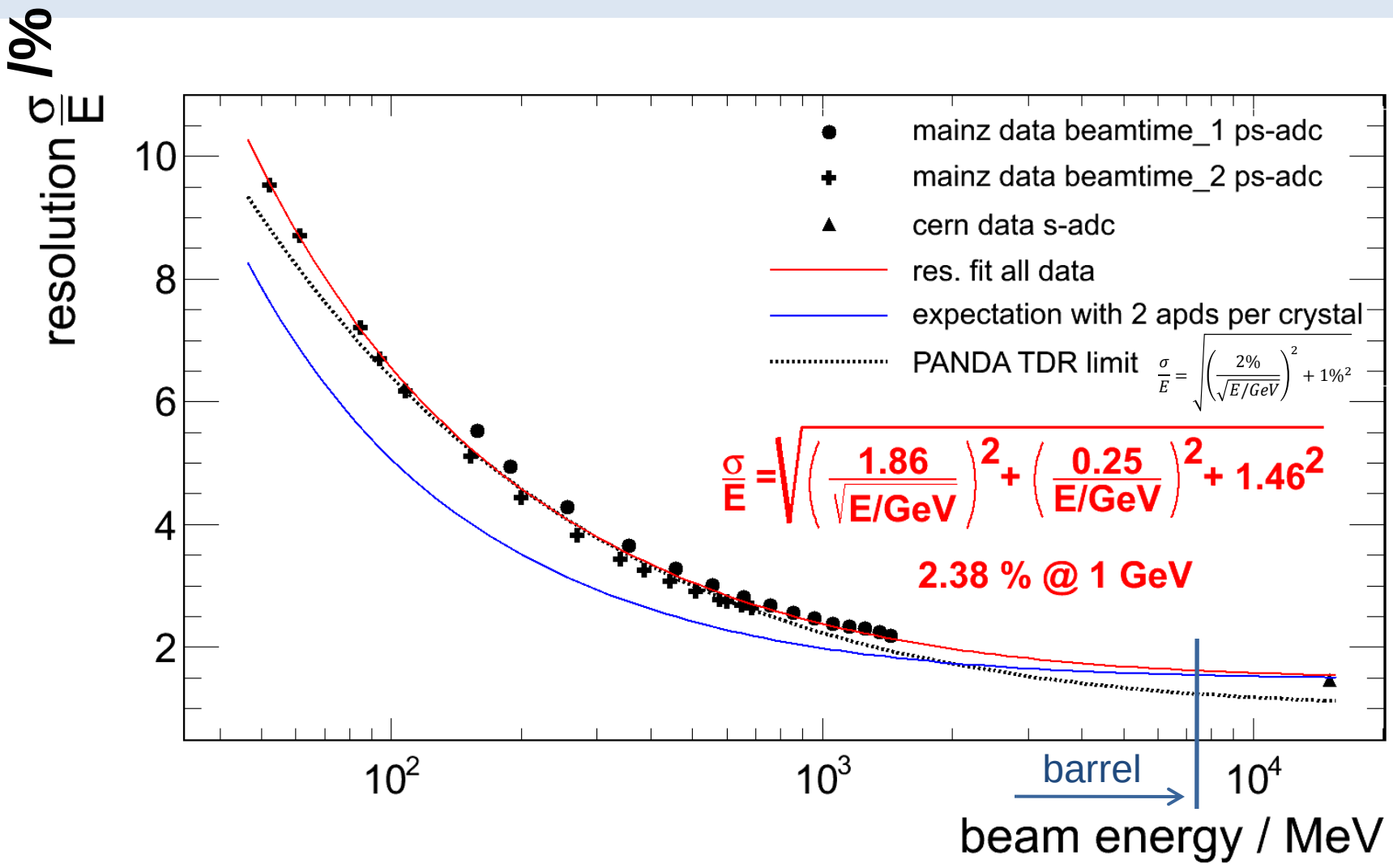
Prototypes –PROTO60-

- First prototype for the Barrel EMC
- 60 $PbWO_4$ crystals Type 6 geometry
- Operation temp.: -25°C
- Housing:
  - Thermal insolated
  - Flushed with dry nitrogen
- One LAAPD (10x10 mm^2) per crystal
- Discrete charge preamplifier:
  - Commercial J-FET transistors
  - low-noise
  - low Power



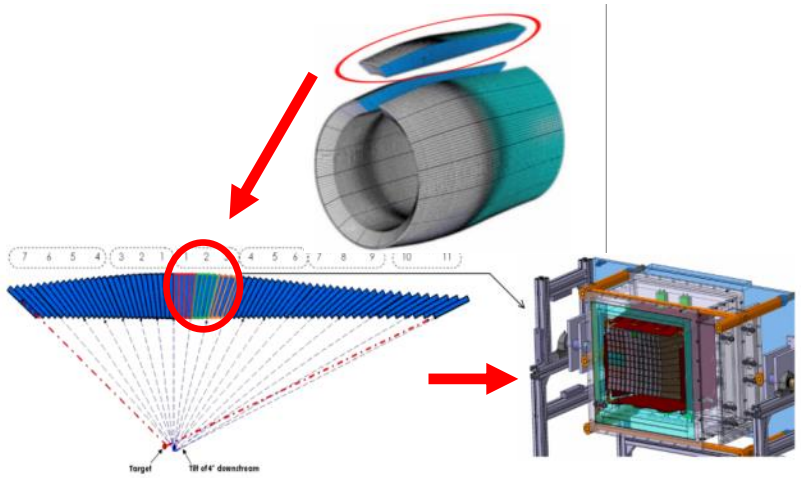


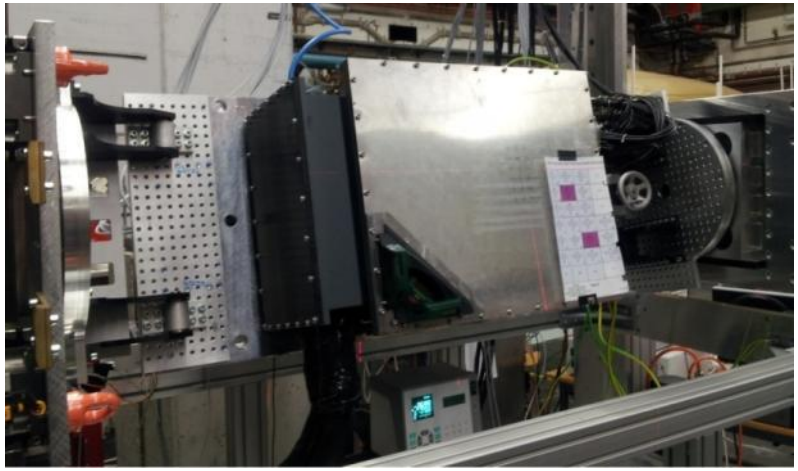
PROT60 –Energy Resolution Achieved With Peak Sensing ADCs-



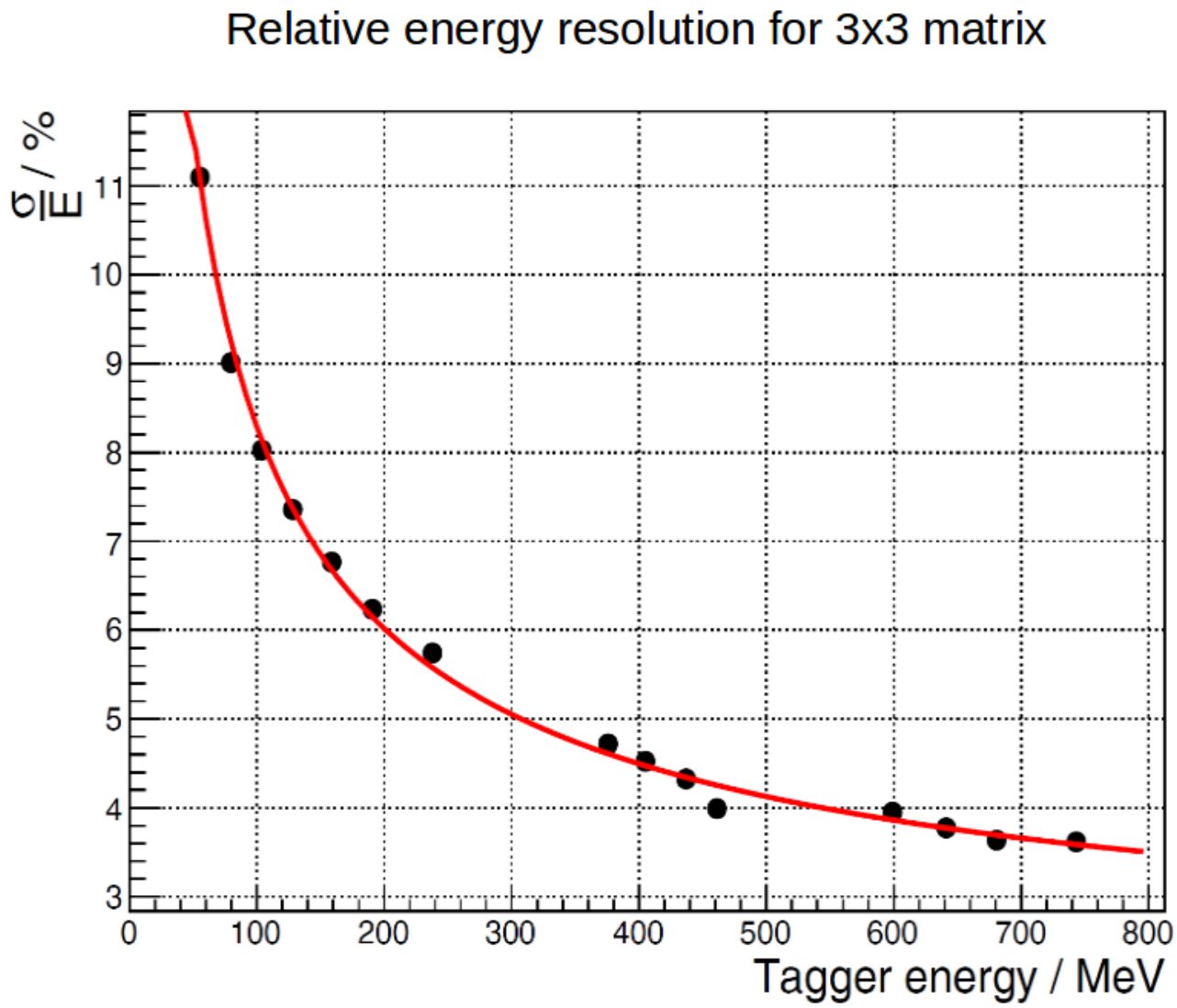
Prototypes –PROTO120-

- Close to final design
- 120 $PbWO_4$ crystals
- Operation temp.: -25°C
- Readout:
  - 2 LAAPDs per crystal
  - APFEL ASIC
    - High dynamic range
    - High count rates
    - Low power consumption
  - Sampling ADCs





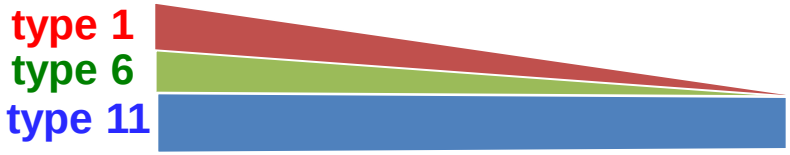
PROTO120 –Achieved Energy Resolutions-



1st Full Barrel EMC Slice –Some Milestones-

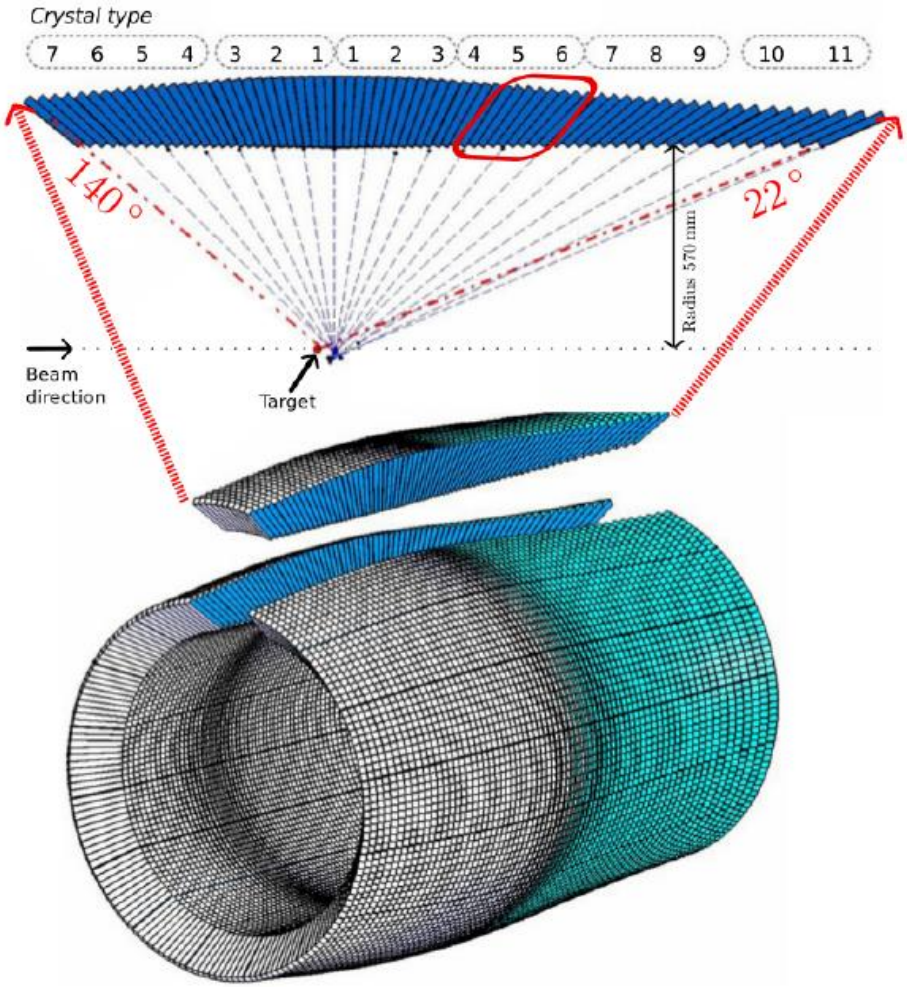
Assembly of:

- 710 Crystals in 11 different geometries



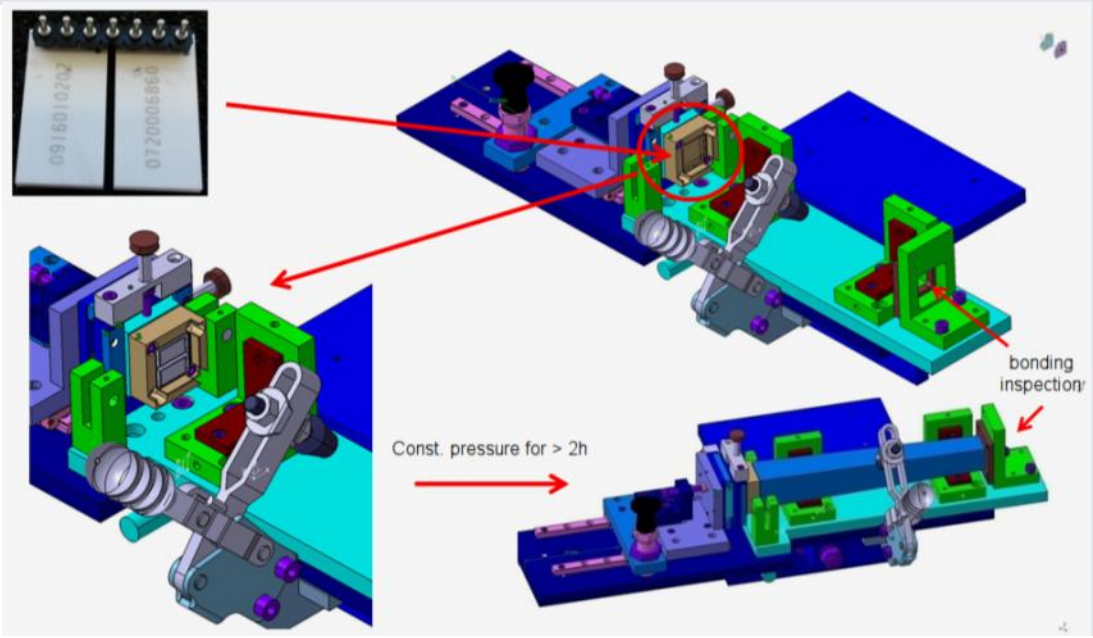
- 1420 matched APDs after 1st screening, gamma irradiation, 2nd screening.
- 360 left and 360 right handed APFEL-ASIC flex PCBs
- 178x3 Backplanes for
  - HV distribution and individual adjustments
  - Connection of signal cables Slow control

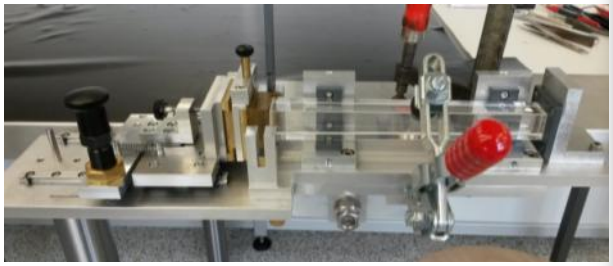
More than 4500 m of signal cables.



Detector Preparations

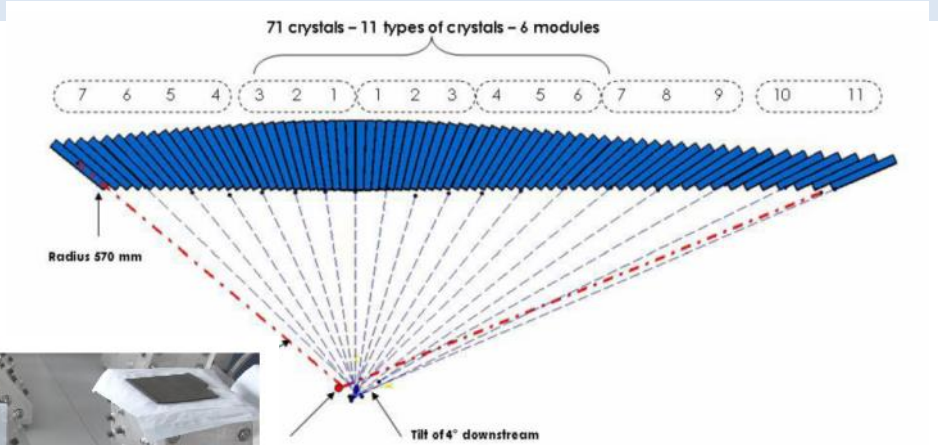
- Gluing:
  - Clean room environment
  - Special rad. hard optical glue
  - 8 gluing stations available for precise and parallel processing
  - 40 crystals per week (one module block)
  - 18 weeks per slice
- Reflective foil wrapping
  - Precise laser cut foils
- 3D print capsules

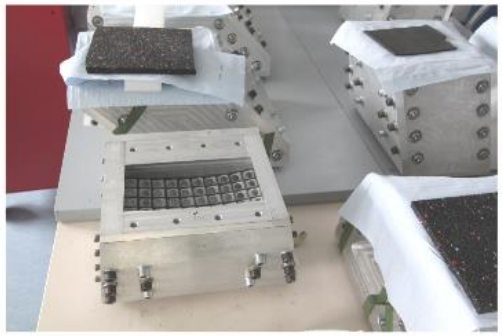


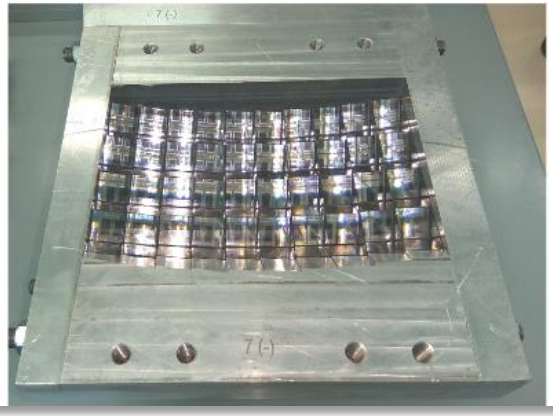


Assembly Procedure –Modules-

- Crystals inserted into carbon fiber alveoli

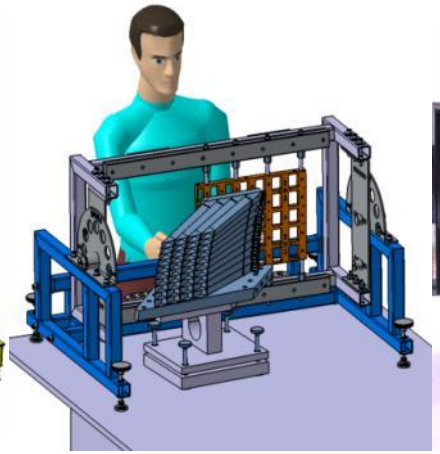


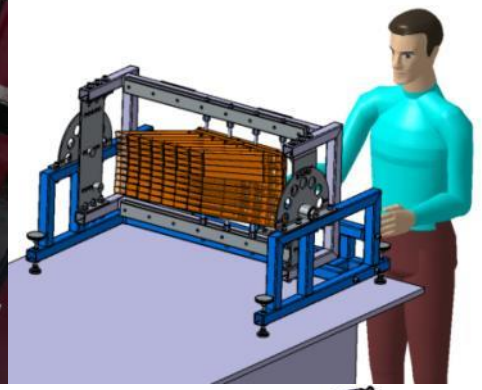


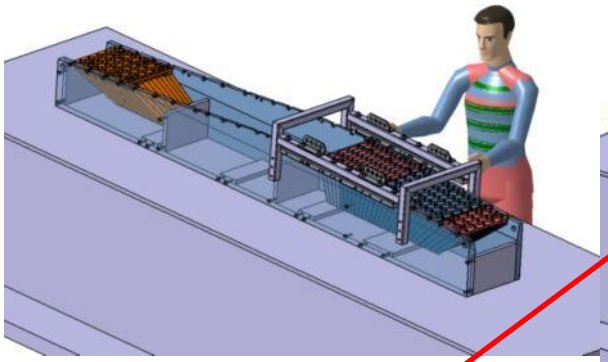


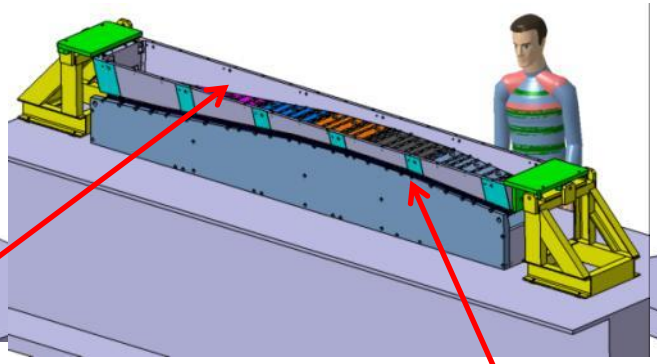
- 18 differently shaped alveoli packs are necessary from 7(-) to 11 (+)

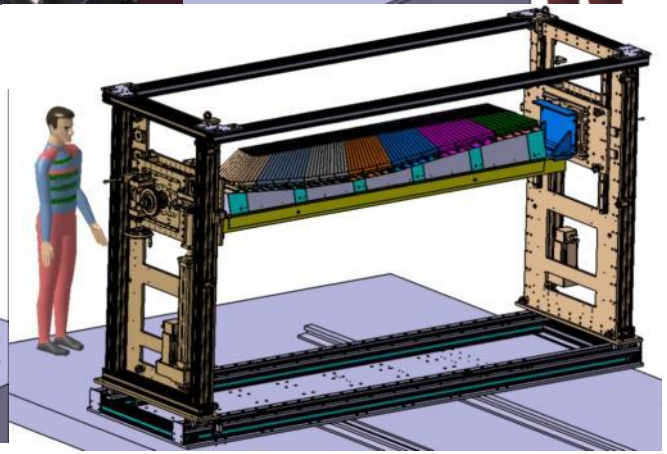
Assembly Procedure –Supermodules-

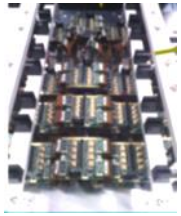








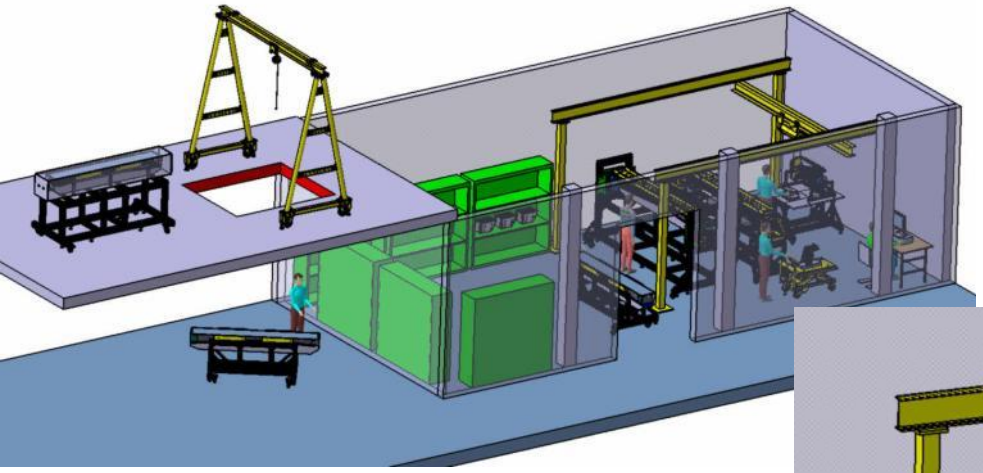


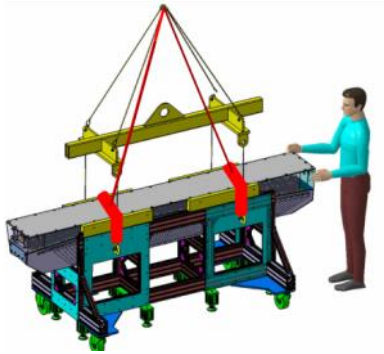


Backplanes will sit inside support beam

Thermal insulation feet between cooled crystal volume and support beam

Assembly procedure -Workspace design -



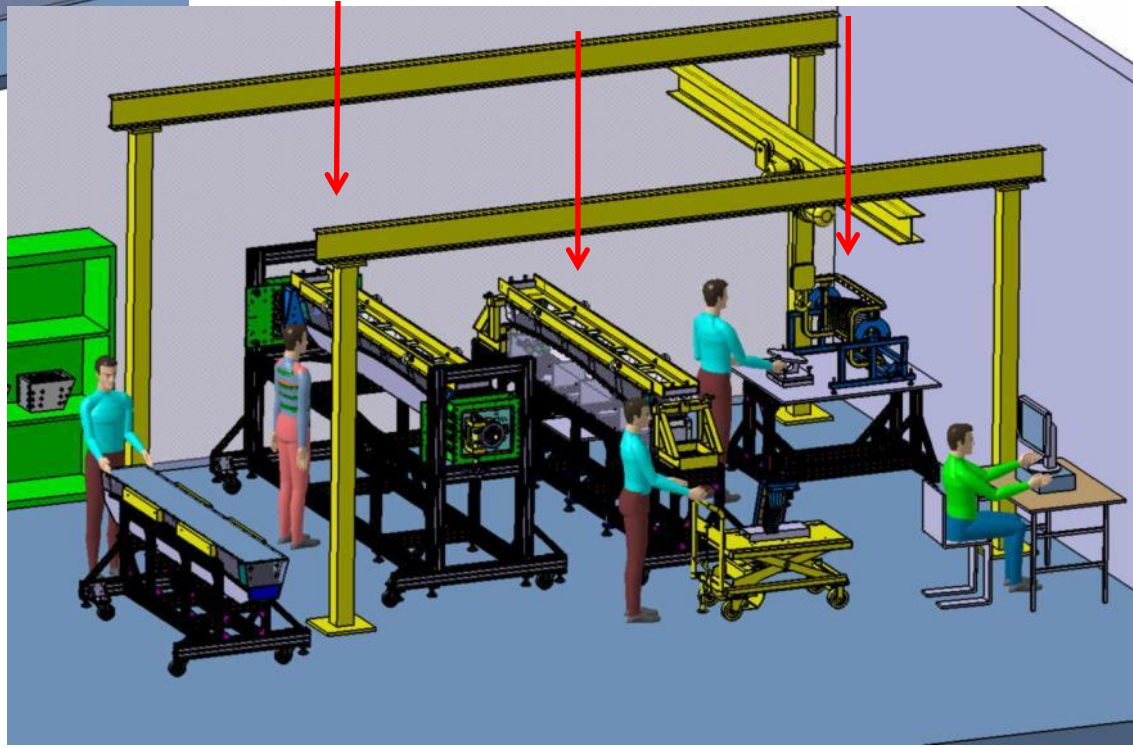


transportation & lifting unit

Slice test turning device

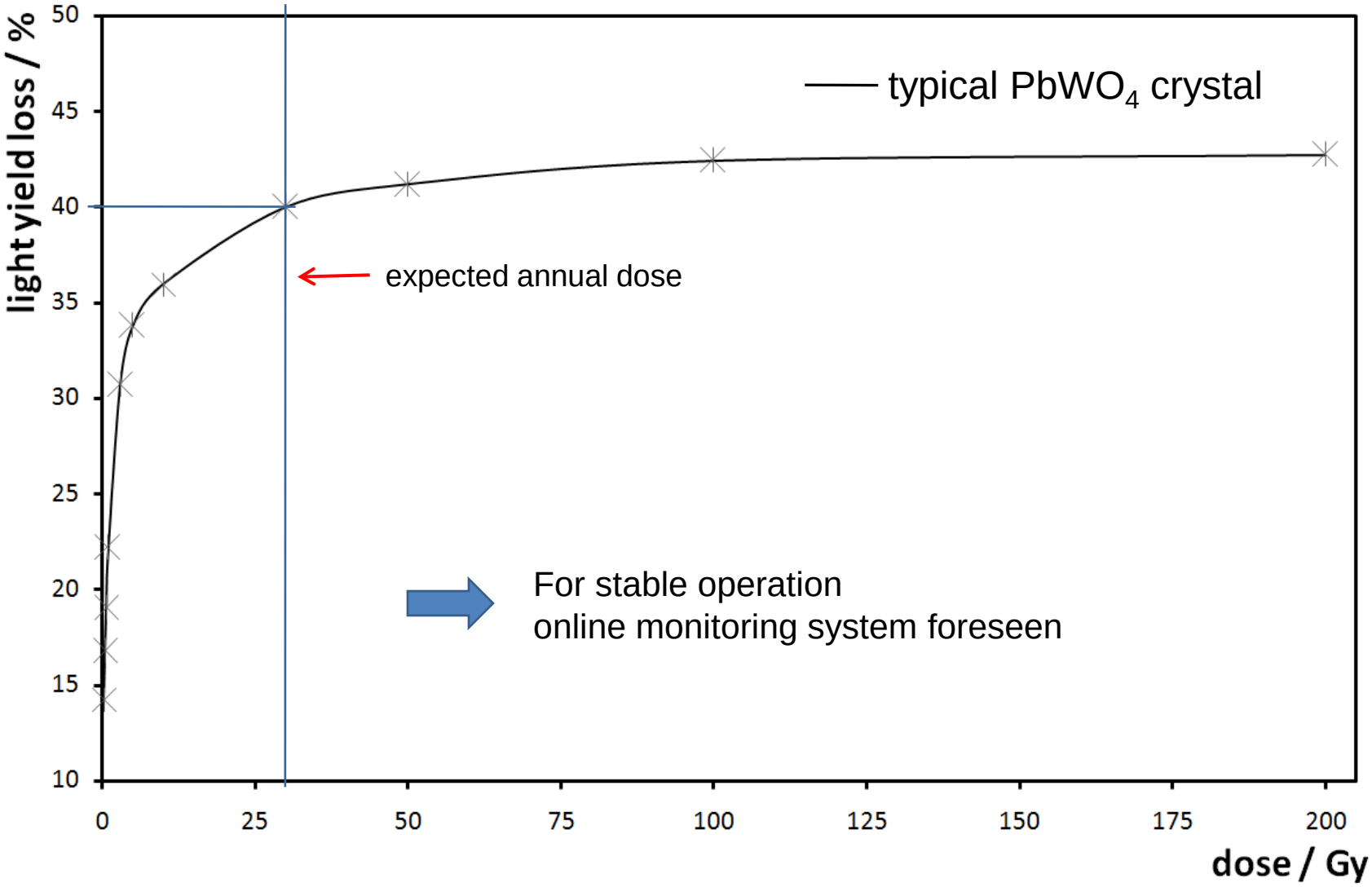
Slice assembly

Supermodule assembly

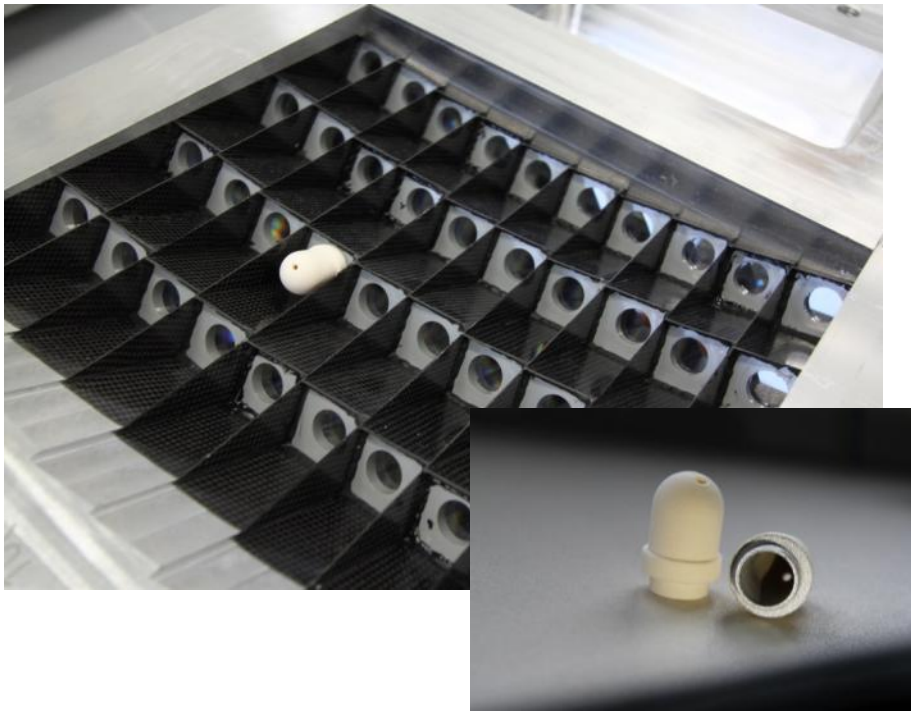


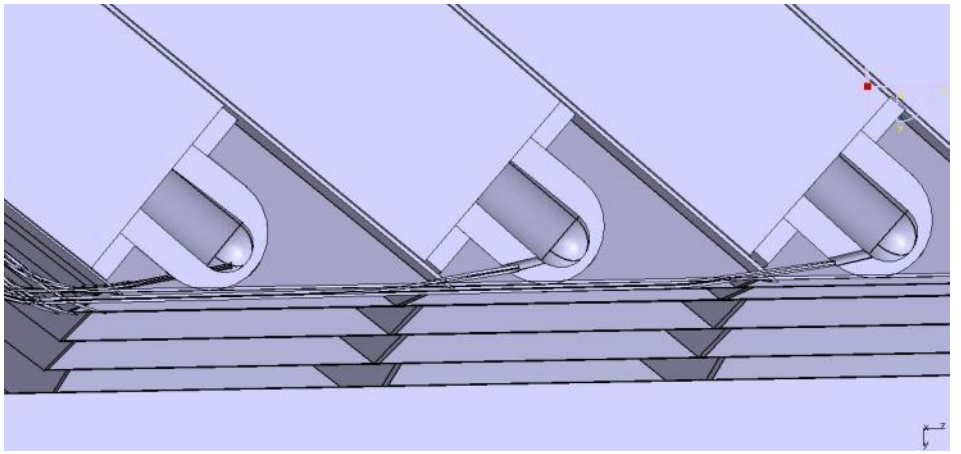
Workspace & Tools

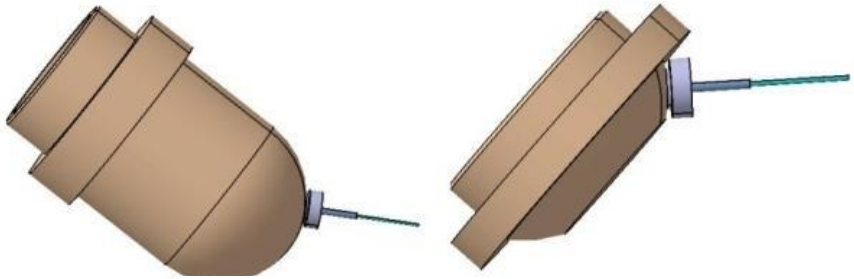
Ongoing activities –Light Pulser Fiber Coupling-



Ongoing activities –Light Pulser Fiber Coupling-



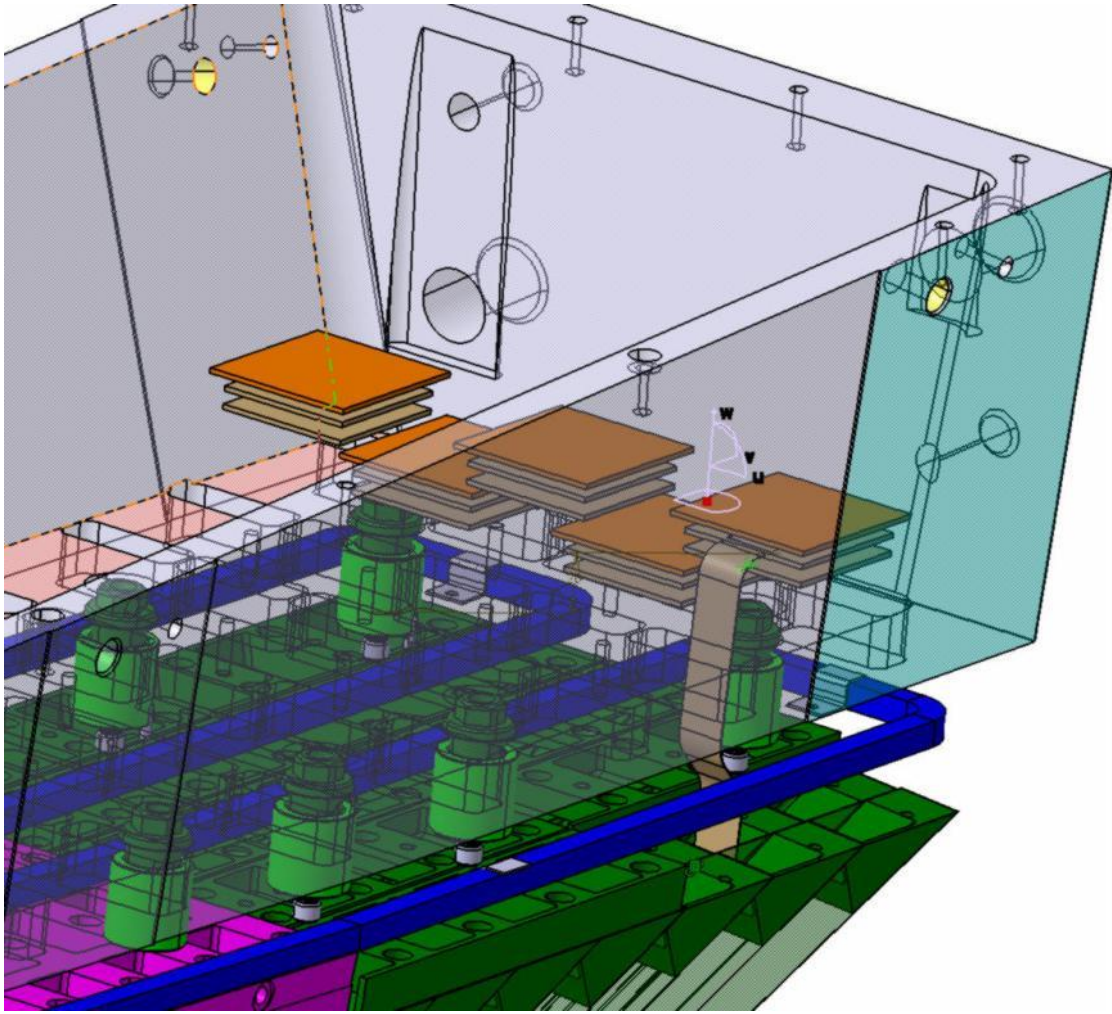




- Different lengths for different positions
- Inside coating with highly reflective material
- Prototypes currently tested

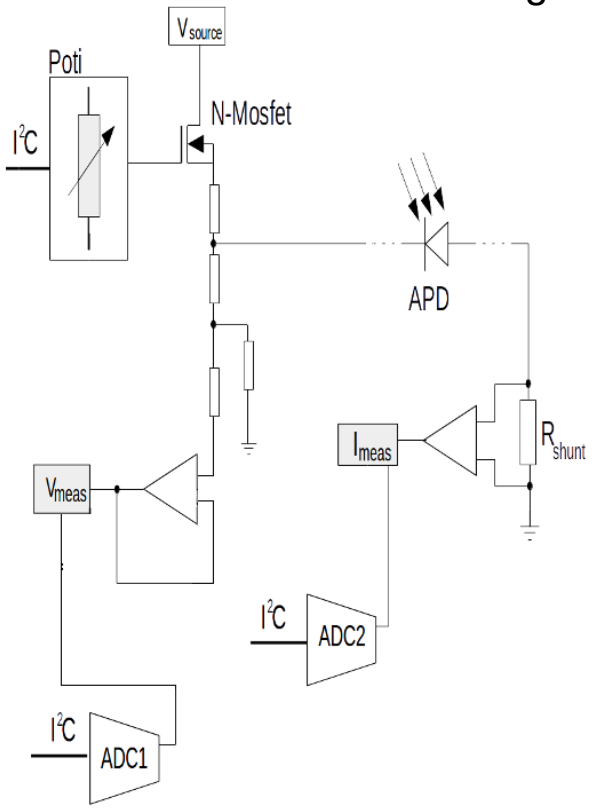
Ongoing activities –Backplanes-

- Present design: 3 Layers
  - HV distribution & regulation
  - Connector board for custom Bedea signal Cables
  - Board for FlexPCBs / ASICS
    - Connectors to FEs
    - 8x2 Diff. Line drivers
    - APFEL I/F buffers
    - Temp/Humidity sensors

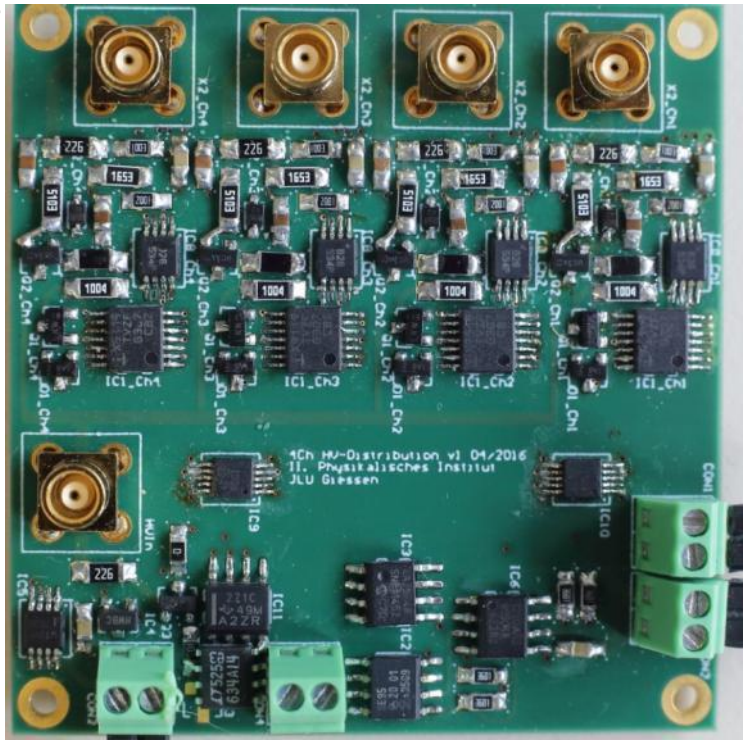


Ongoing activities Backplanes –HV distribution-

- Device to independently adjust bias voltage of 8 APDs
  - 50V from HV input downwards in < 0,1V steps
- All channels fed from the same HV source
- Online measurement of APD voltage and current



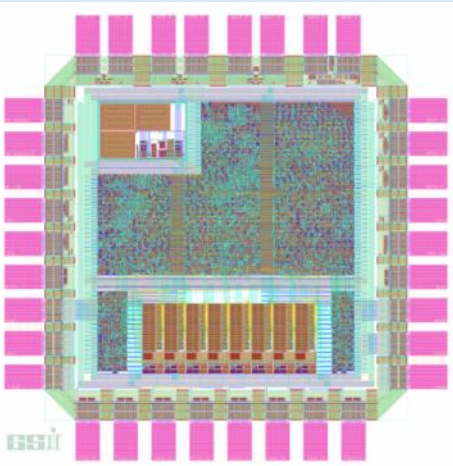
Single channel block schematic

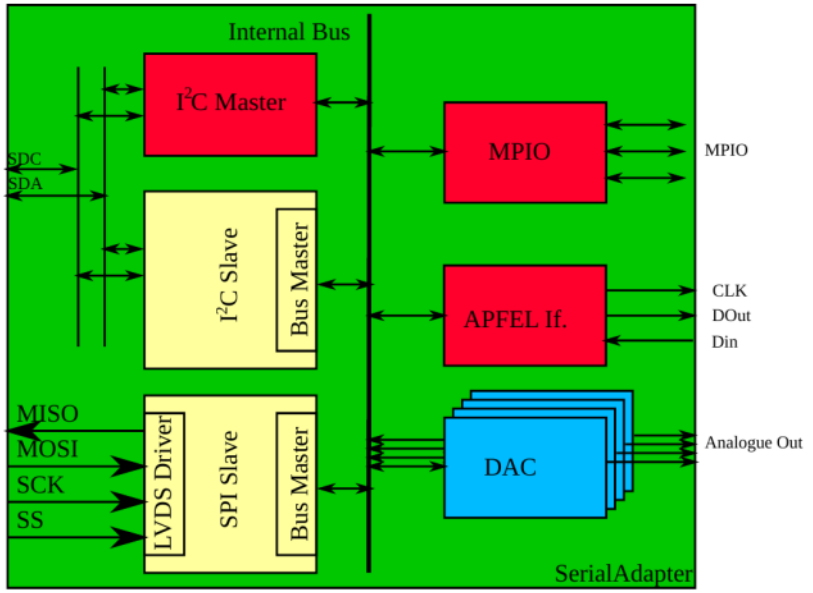


4-ch prototype
size: 6 x 5.5 cm²

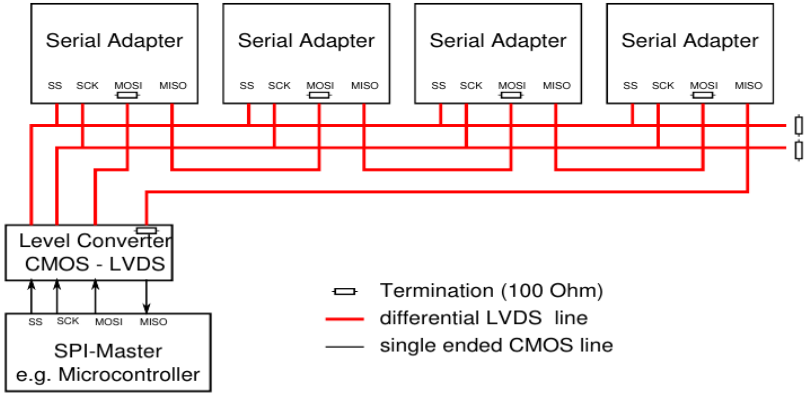
Ongoing activities -Serial Adapter ASIC-

- Present design: two different buses for FE and HV regulators
- Idea: integrated Slow Control ASIC with common bus
- Daisy chaining of Backend-Interface for 5 (10) Backplane PCBs → Saves 4/5 of Slow Control Cables (36 vs. 180)
- First UMC180 MPW prototypes available

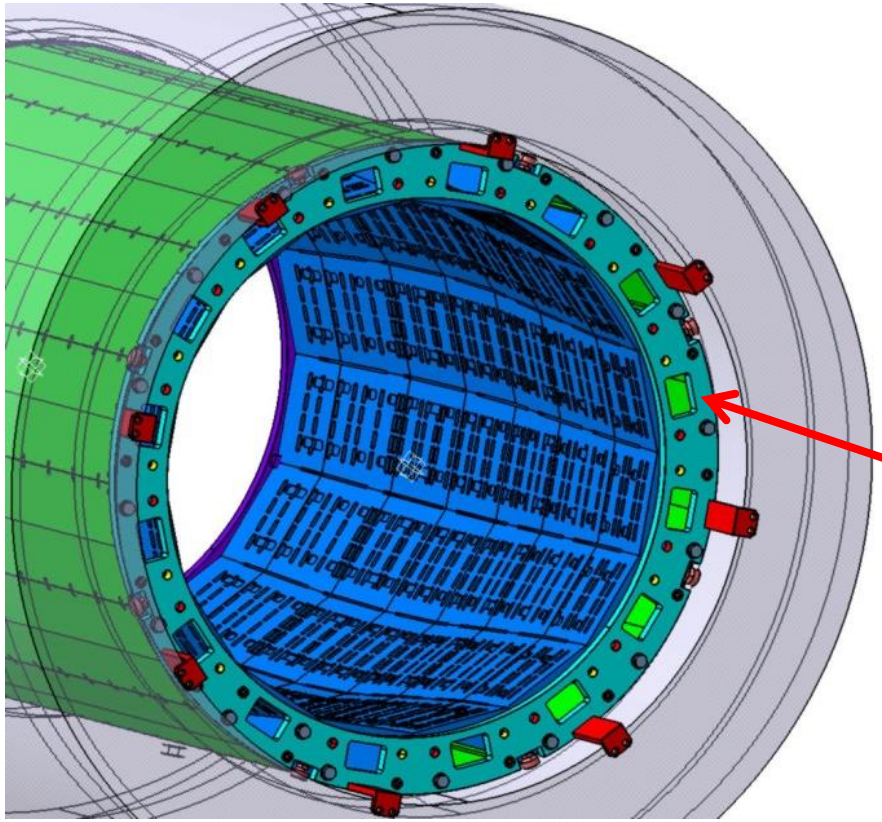




Using a daisy chained SPI interface



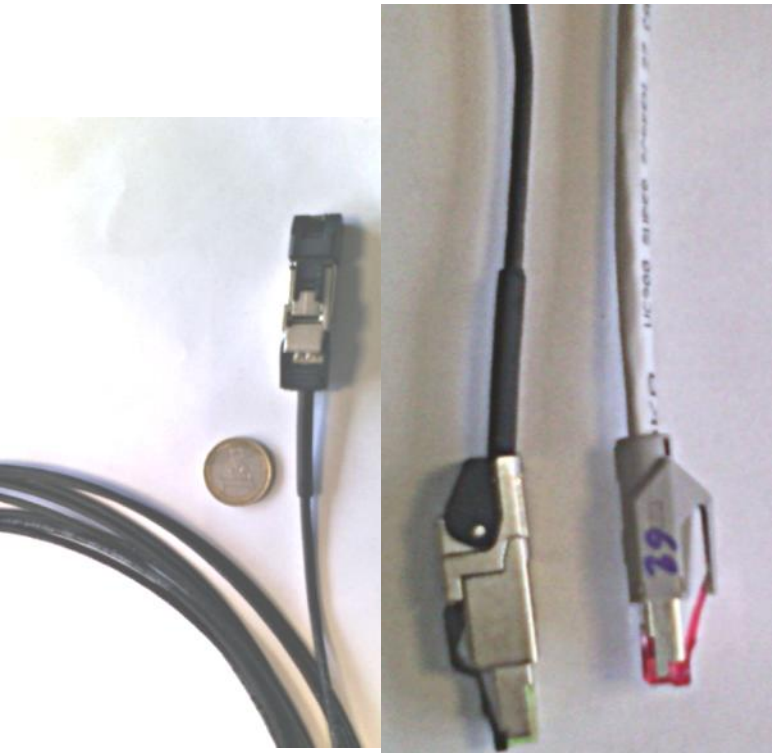
Routing –Situation overview-

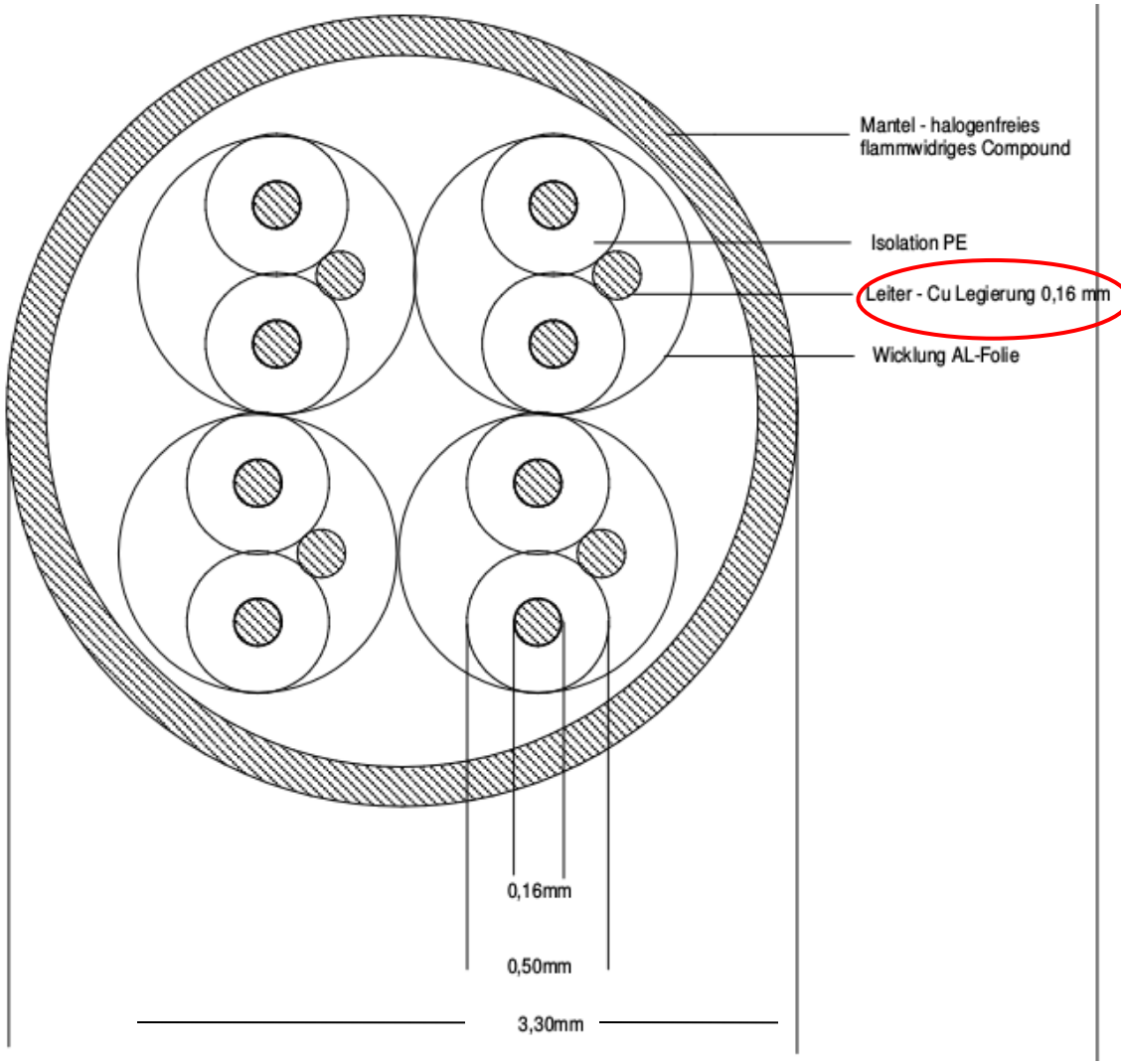


- Space limited
- Number and diam. of cables has to be as low as possible

Routing –Signal Cables-

Special Ultra-thin differential cables developed in corporation with company BEDEA (Germany)





Routing –Signal Cables-

Special Ultra-thin differential cables developed in corporation with company BEDEA (Germany)

All necessary cables will fit trough the window

Conclusion

- **First Slice of the Target Spectrometer Calorimeter will be ready soon**
- **Module assembly:**
  - Finished
- **Supermodule assembly:**
  - Infrastructure ready
  - Assembly will start as son as all ASICs with FlexPCBs available
- **Slice assembly:**
  - Infrastructure ready
- **Fiber coupling concept:**
  - First concept seems promising
- **Serial Adapter ASIC**
  - Reduces significant amount of slow control cables
- **Overall mechanical Design**
  - Final approval most likely