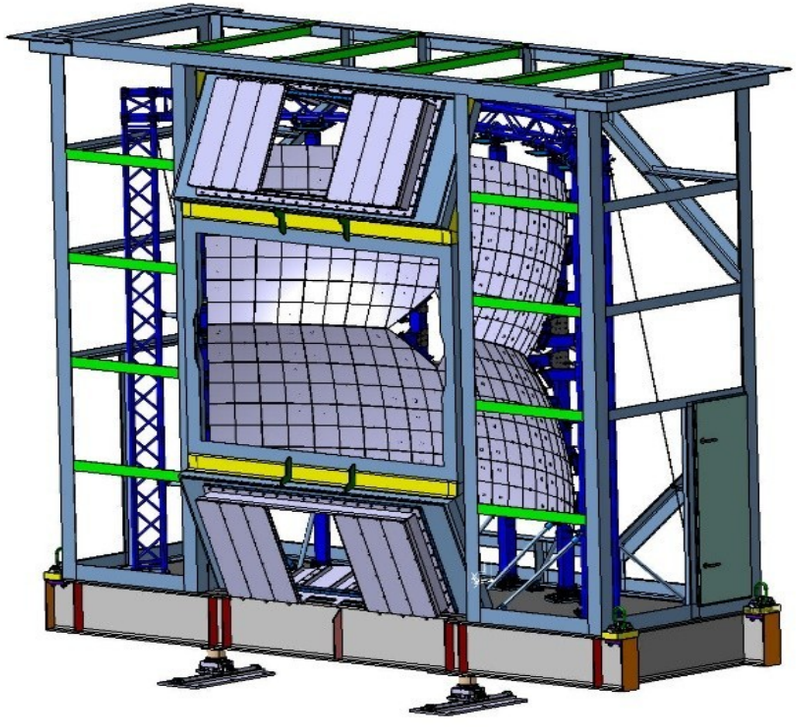


BERGISCHE UNIVERSITÄT WUPPERTAL

NRW-FAIR Netzwerk

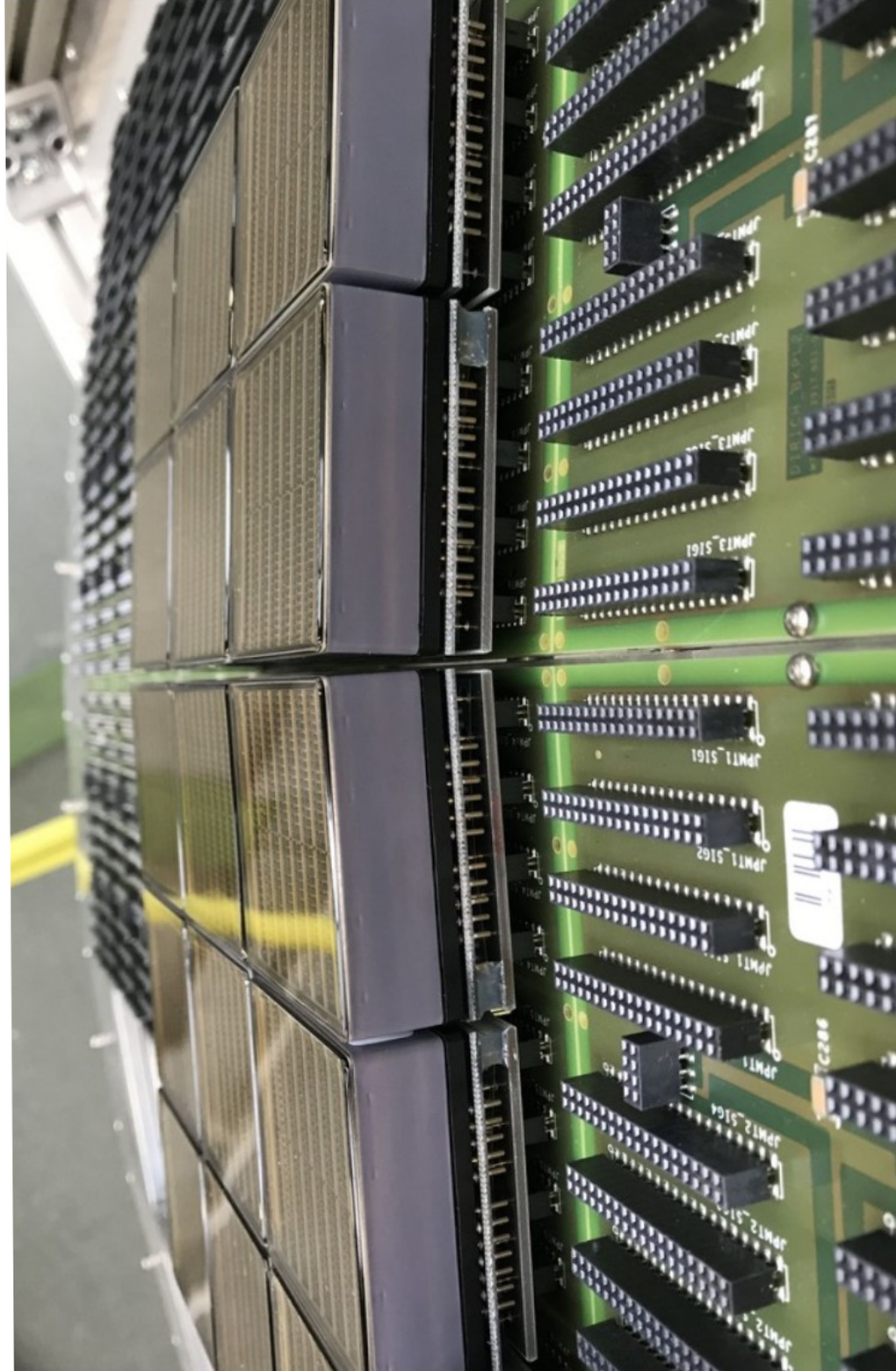
Status of the CBM RICH detector

J. Peña-Rodríguez on behalf of the CBM RICH team
Bergische Universität Wuppertal, Germany

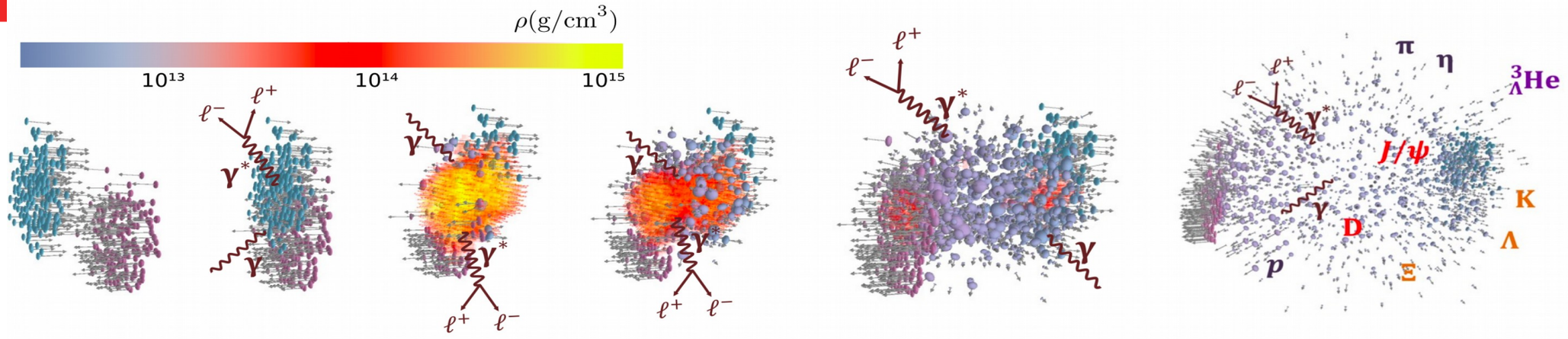
46th CBM Collaboration Meeting, Lanzhou, China

Agenda

- Overview
- **RICH** status
- **R&D**
- Summary



Di-leptons: a key observable

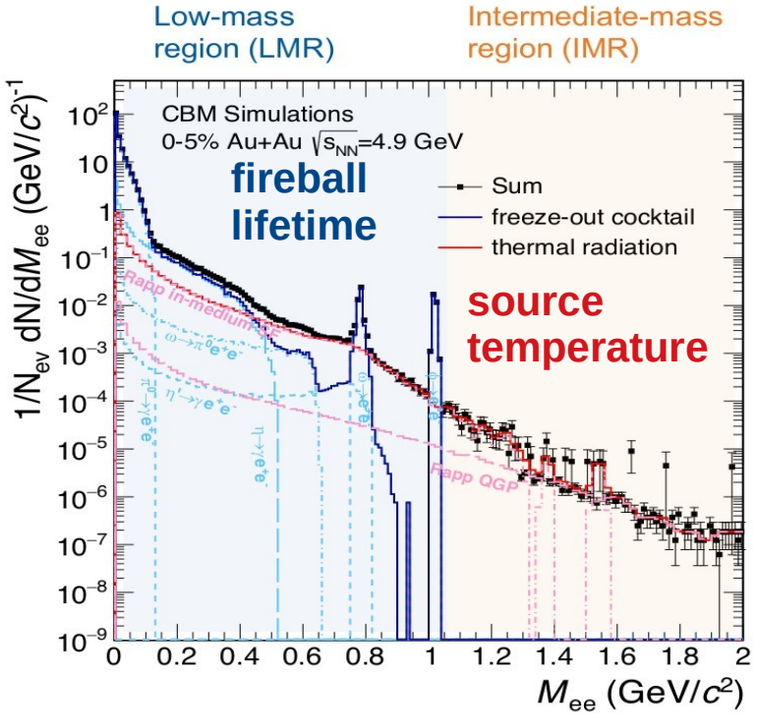


First collisions ---------- **Thermalization** ---------- **Freeze-out**

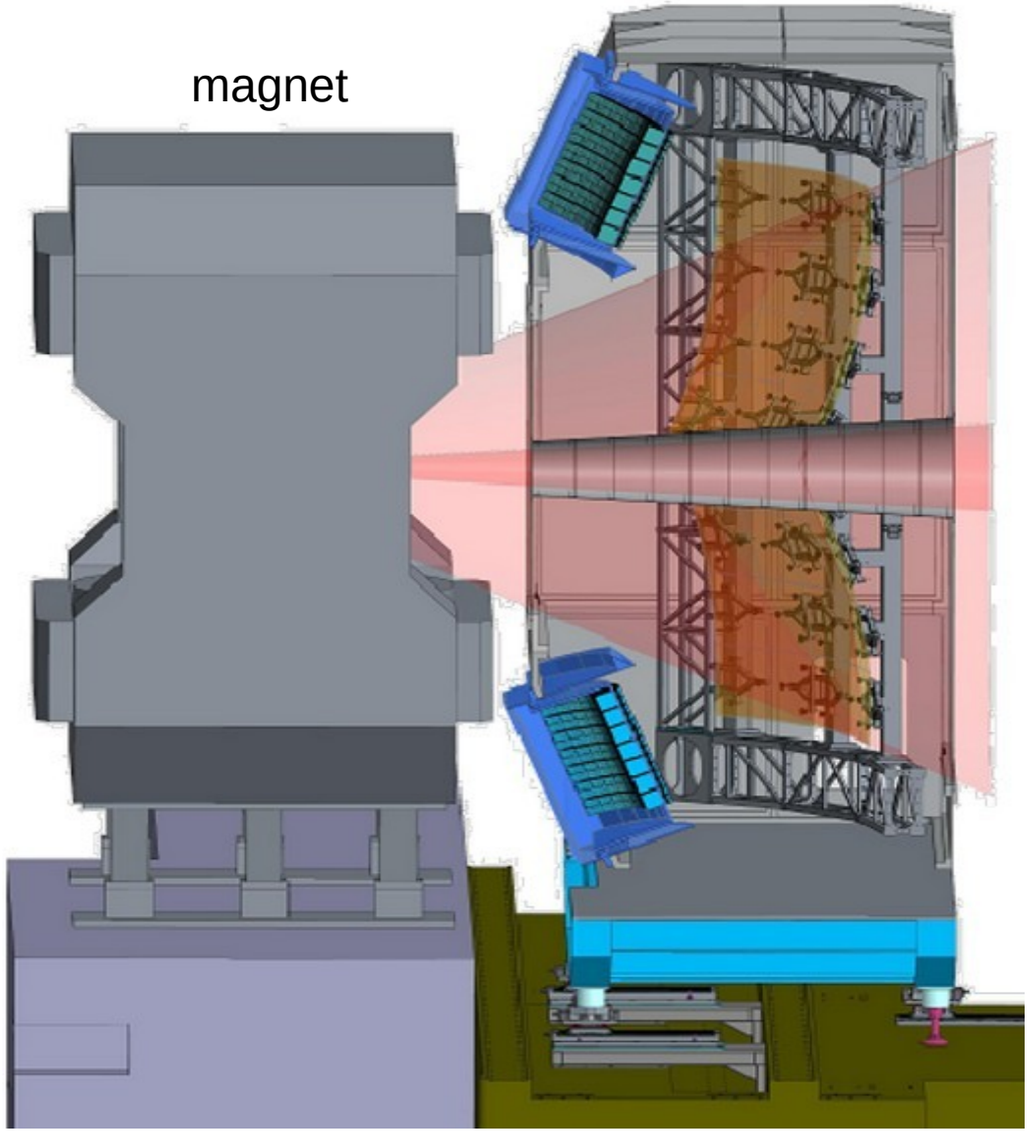
Di-leptons as **multi-messenger** of fireball

No strong final state interaction
- leave interaction volume undisturbed
- reflect the whole history of HI collision

Encodes information of matter properties
- degrees of freedom of the medium
- fireball lifetime, temperature, polarization
- restoration of chiral symmetry



The CBM RICH detector



CO_2 gas radiator

- pion threshold 4.65 GeV/c, n=1.00045
- UV cutoff < 190 nm
- ~60 m³ radiator gas volume
- ~1.7 m radiator depth
- good quenching of scintillation light

Mirror

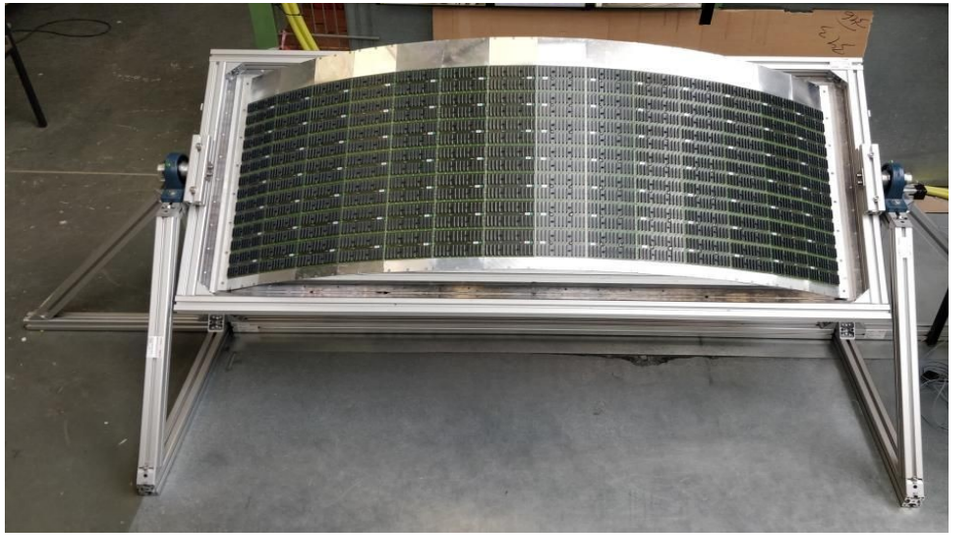
- 13 m² segmented mirror
- 80 spherical tiles 40x40 cm²
  d=6 mm, R=3.0 m
- Al + MgF_2 (+ HfO_2) coating

MAPMT readout

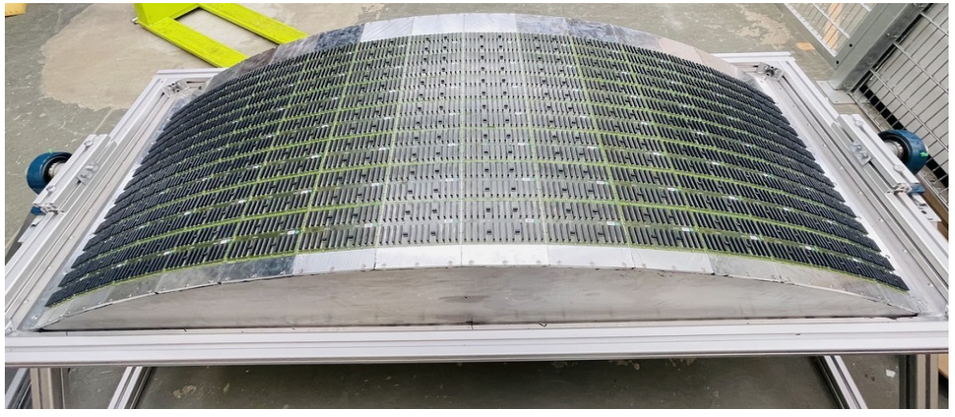
- 1100 Hamamatsu H12700 MAPMTs
- FPGA-TDC based readout chain, 64k channels
- excellent photon timing precision (< 300 ps RMS)

Mechanical structure

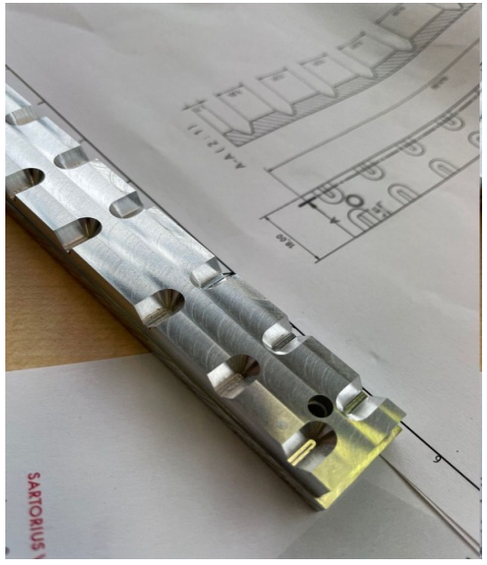
Camera 1



Camera 2



Mechanical support of the FEBs



	Camera 1	Camera 2
Frame:	100%	100%
Backpanels:	100%	100%
Pressure tightness:	100%	100%
Cooling:	100%	-
Readout electronics:	40%	-
Cabling:	10%	-

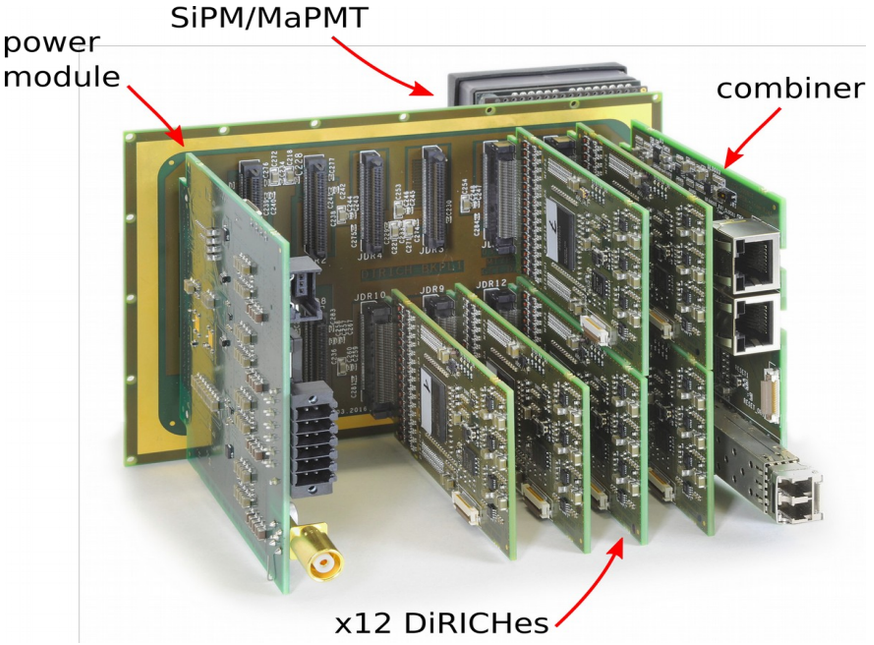
Front-end electronics

Electronic module production:

2500 DIRICH TDC modules : 45% produced
210 DIRICH Concentrator : 100% produced
210 DIRICH Power modules : 100% produced
220 Backplane PCBs : 100% produced

Dedicated series testing of each produced module

< 10 % faulty modules on first test most of them **can be reworked**



Heat dissipation system of power modules

Thanks to Jan Lietz

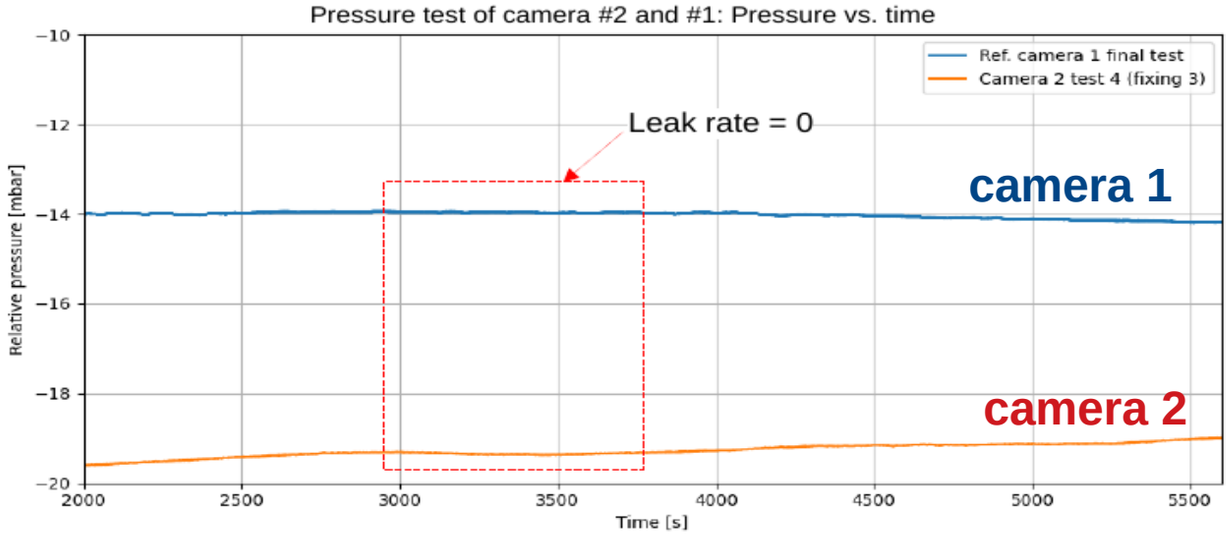
Pressure testing: camera 2

Over / Underpressure test up to **20 mbar** measured over 90 min

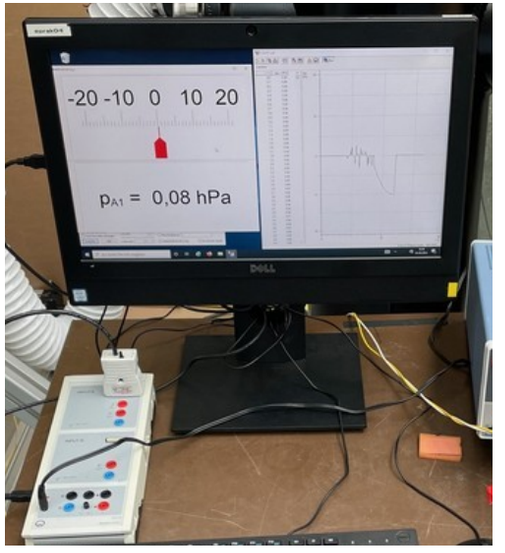
leak rate < $1x10^{-4}$ mbar m^3/s

Also serves as test of mechanical stability (**20 mbar ~ 200 kg** load on PMT plane!)

Deformation < 0.2 mm



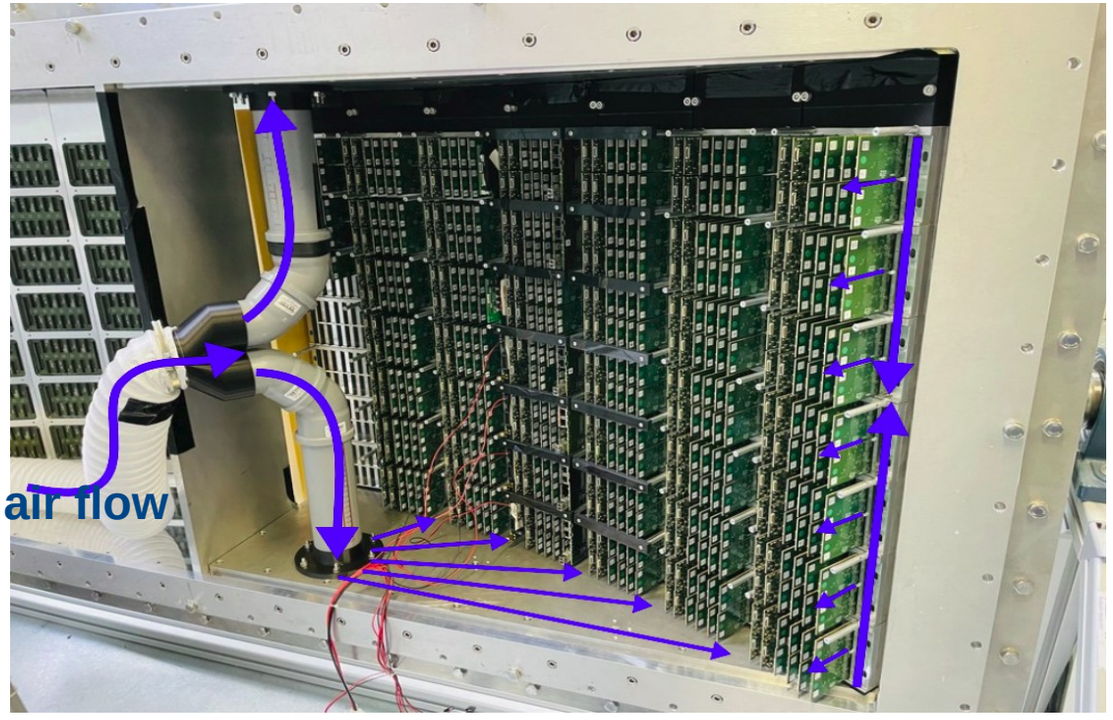
Pressure monitoring CASSY-system

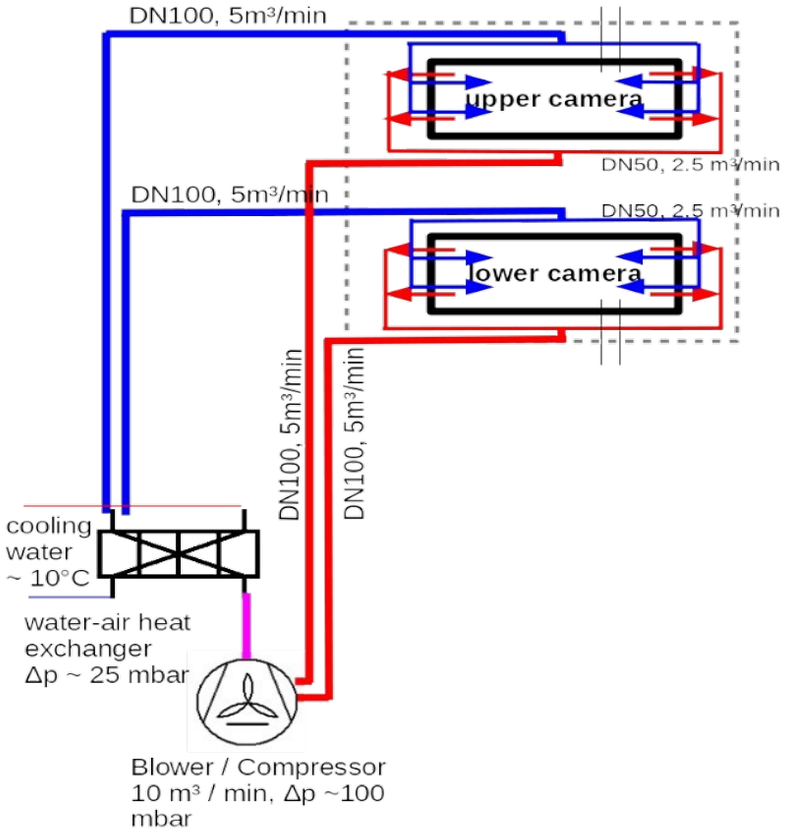


2nd camera is mechanically ready and gas tight

Cooling system

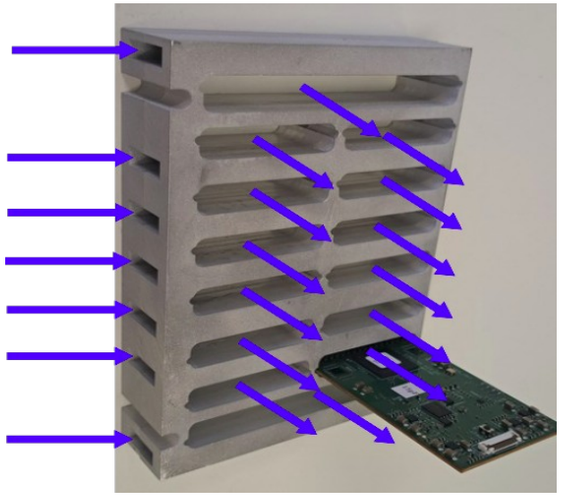
- Around **3kW** heat dissipation per camera
- Camera volume enclosed by shielding box
- **Closed-loop** air circulation cooling
- Heat exchanger to cooling water (cave)
- Electric blower for enforced air circulation
- **“Reverse” air-flow**, away from photon sensors



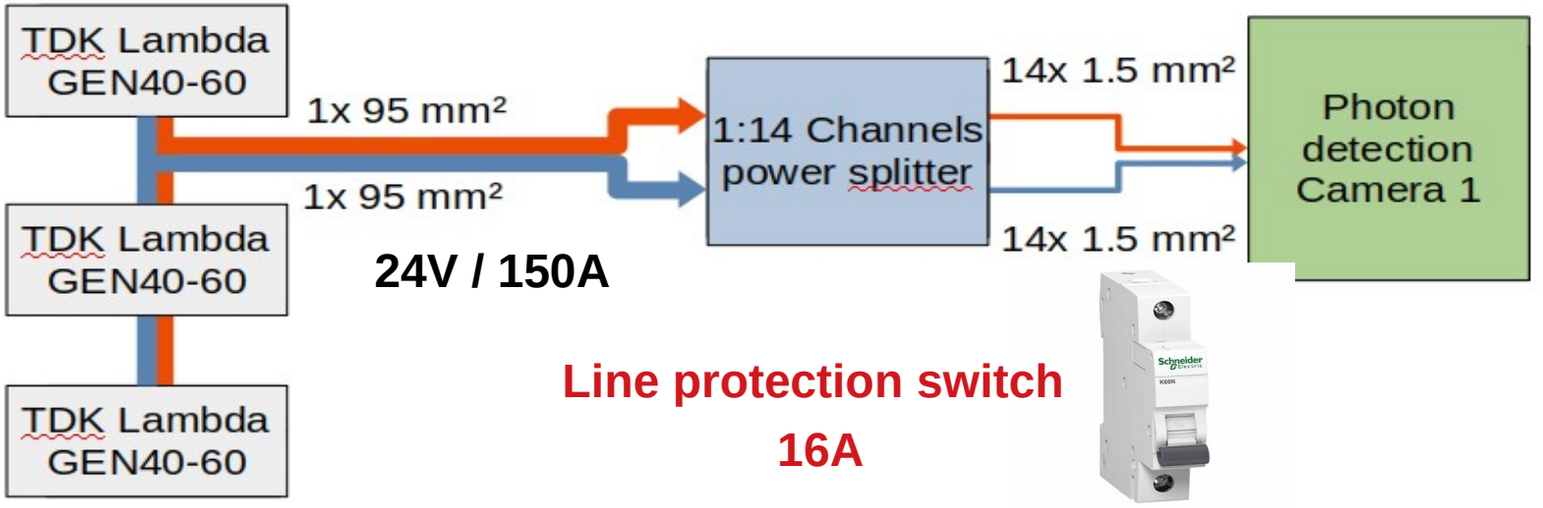


CNC-milled air distribution columns

air flow



Detector powering



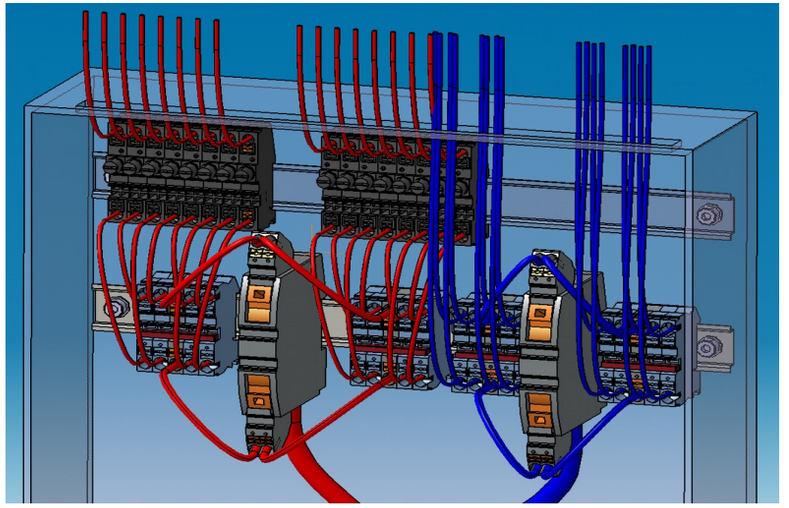
LV (Low Voltage) interlock loop

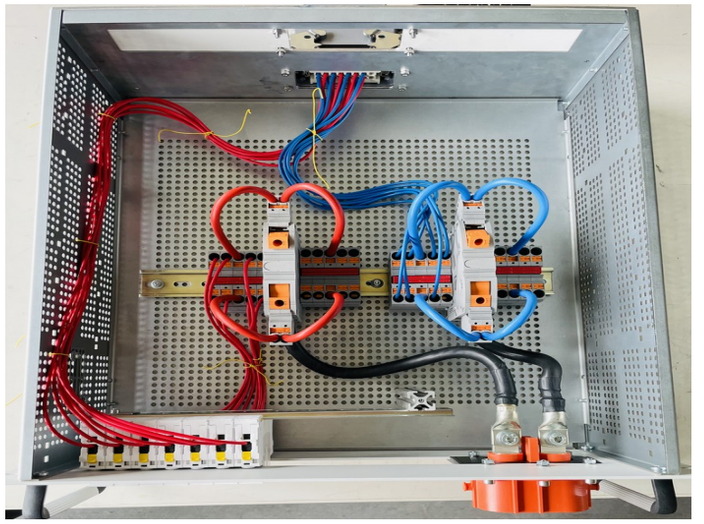
Temperature switches inside both cameras (**~60 deg** switch temperature)

+

Active sensors and online temp monitoring

Line protection switch 16A





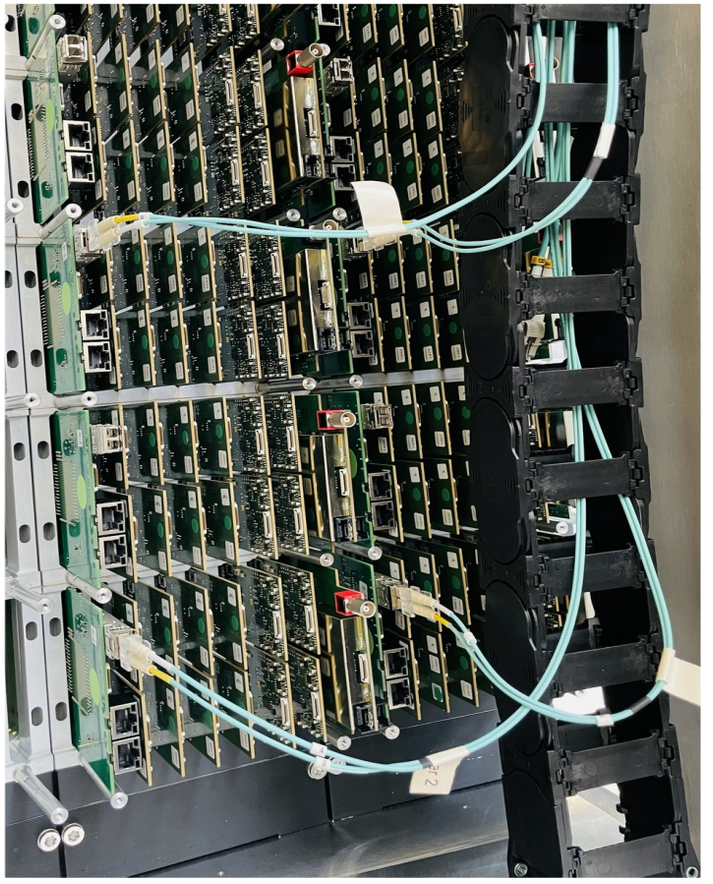
Cabling

Connections per column (x14)

- 7x HV, 3.3 mm Ø
- 2x LV, 2.5 mm Ø
- 1x 1-wire, 2.5 mm Ø
- 7x optical fibers, 3 mm Ø ???
- DOGMA: 7x optical fibers, 3 mm Ø ???

Column: 7 backpanels
Backpanel:

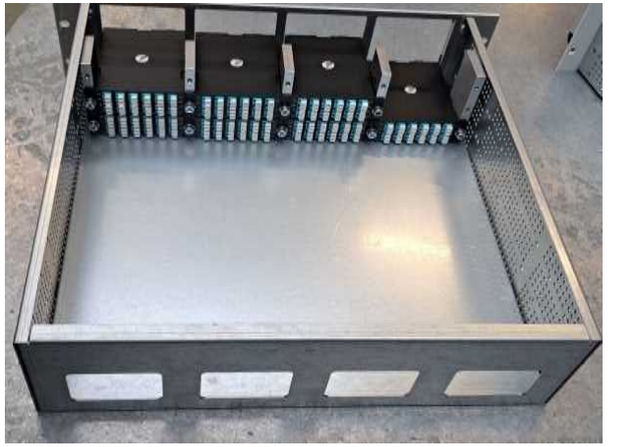
- 12 DiRICHes
- 6 MAPMTs
- 1 combiner
- 1 power module



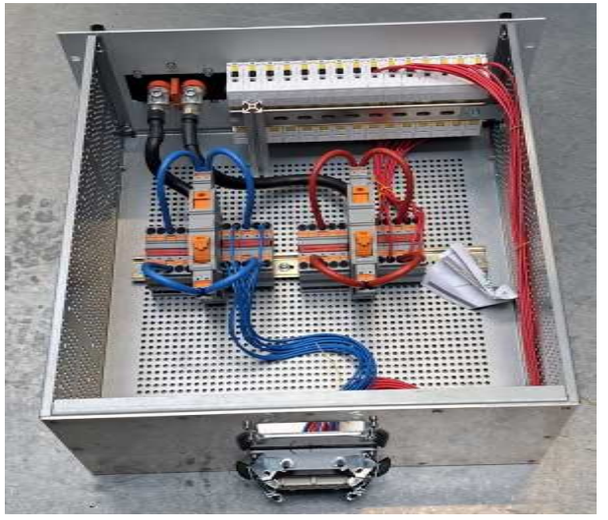
- All connections from cave to RICH detector **via interface rack**
- Interface rack fixed to detector
- Cabling from interface rack to FE electronics fixed to RICH vessel
- **Foldable** cable trays inside RICH cameras
- Easy uncabling / camera maintenance

Rack

MTP24 fiber interface rack
- one rack per RICH camera
- **12x** MTP24 optical fiber in from cave
- 12x12 = **144** SFP duplex out to FE electronics



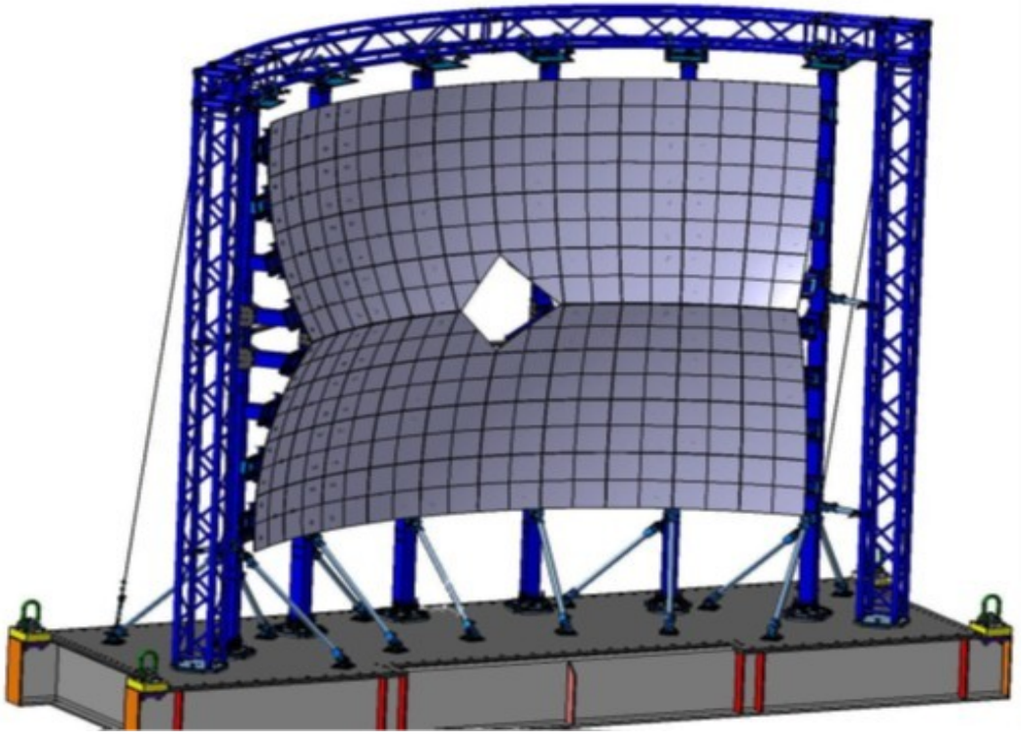
LV interface rack
- one rack per RICH camera
- **24V / 150A** in from cave
- **14x** individual fuses (**16A**) for each FE column

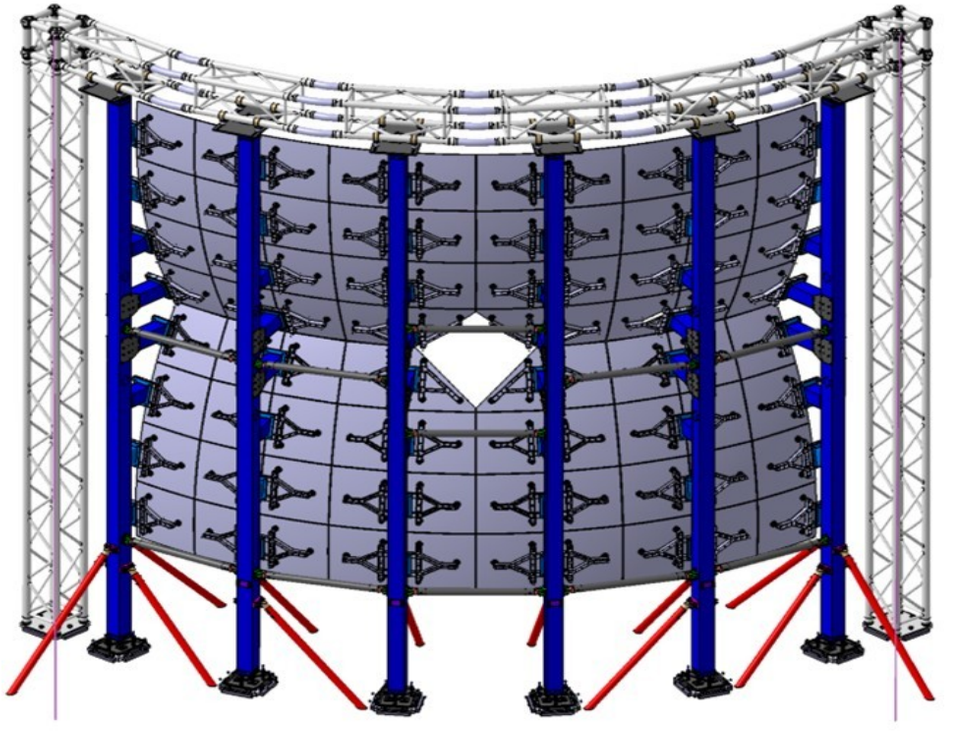


The total rack load:
- 2 boxes for LV (Low Voltage)
- 2 boxes for fibers
- 1 (2) patch plates for the SHV connections (200 in total)

Thanks to Dennis Pfeifer

Mirror wall



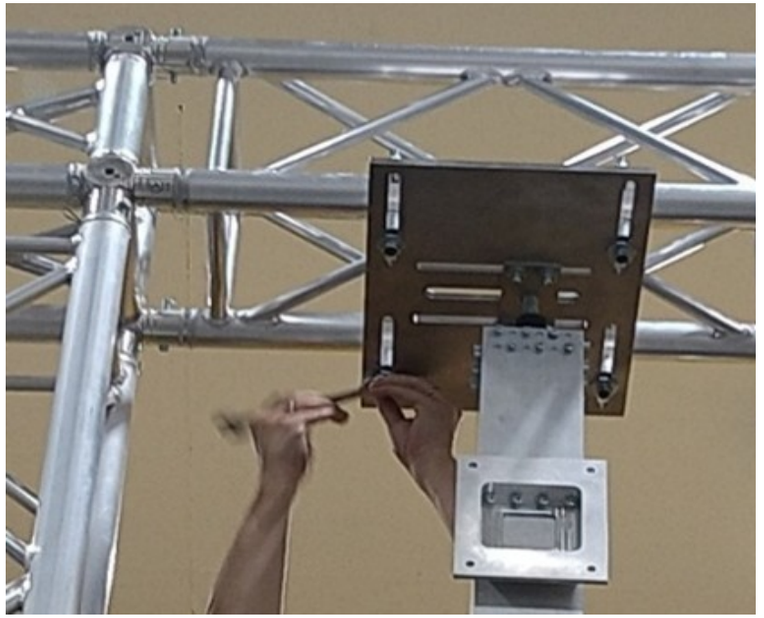


- Mirror wall only attached to the platform
- 6 aluminum pillars, **100x100 mm² x 2 mm**, each carrying 2(1) columns of **8 mirror tiles**
- **3-4 mm** gap between mirrors
- **< 1 mrad / < 1 mm** alignment / position accuracy
- Adjustable pillar feet for alignment

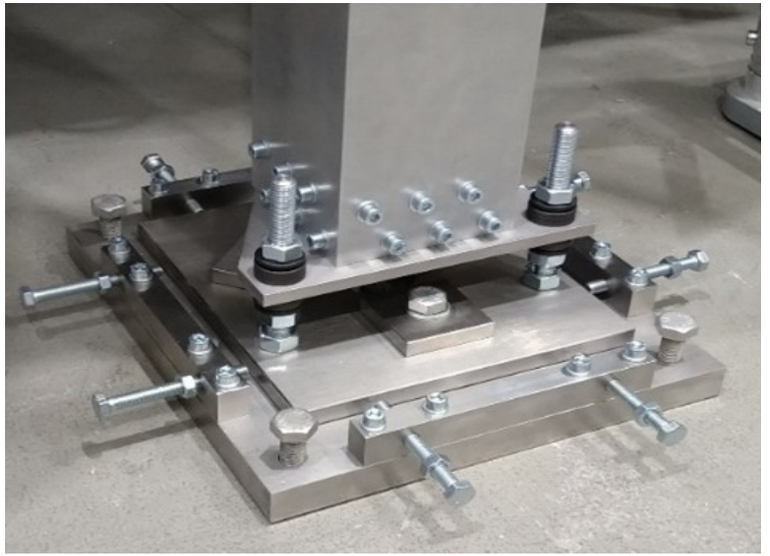
Mirror wall

Mirror mounting bracket
carrying two mirrors each

Upper pillar fixation+alignment

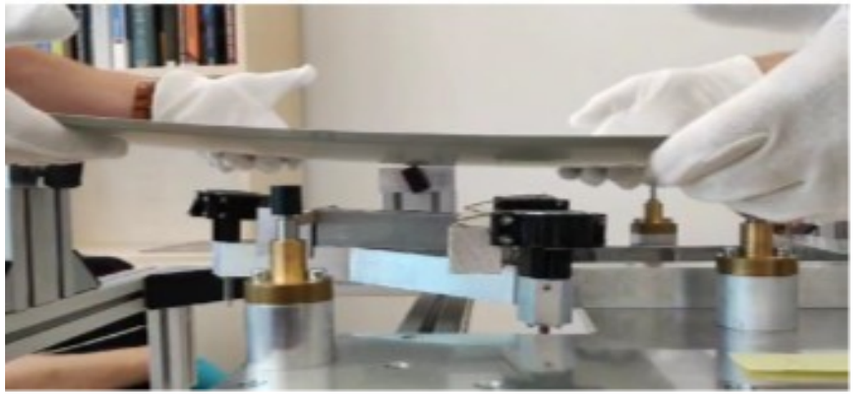


Lower pillar alignment foot



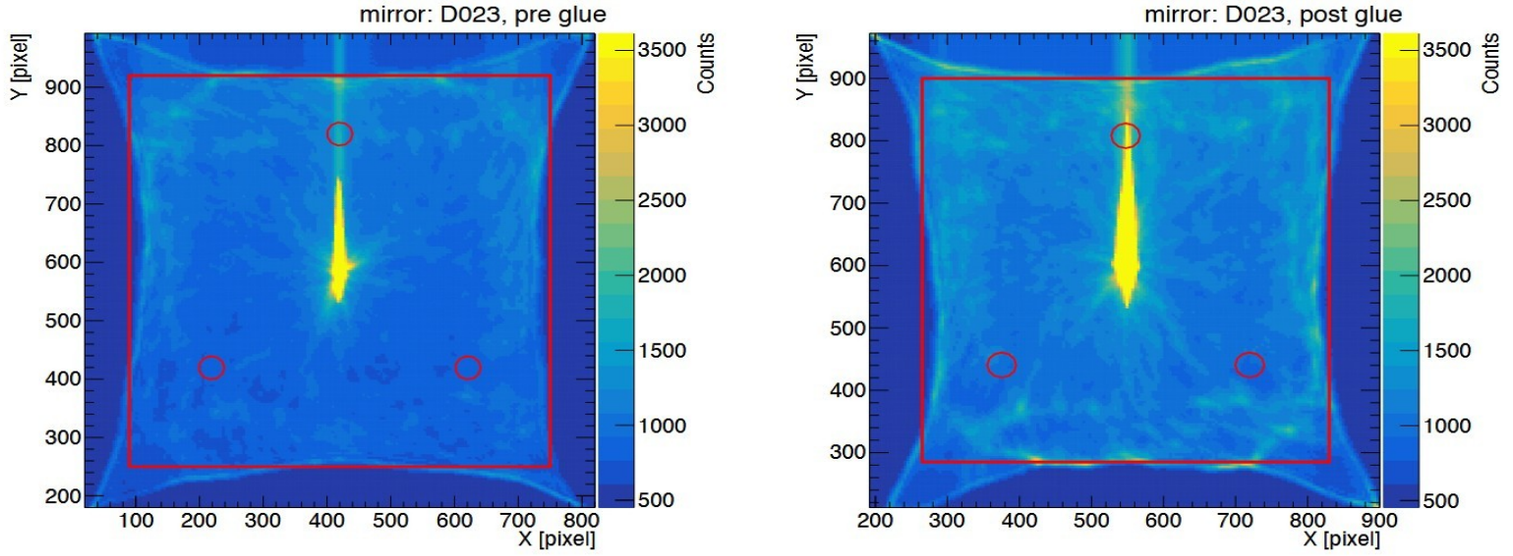
Mirrors + pilar assembly

Mirrors



Mirrors fixed by **3 glue pads** each

Glue : **Momentive RTV 157 1-component silicone**
- Radiation hard according to CERN yellow report (DOI: 10.5170/CERN-1982-010)



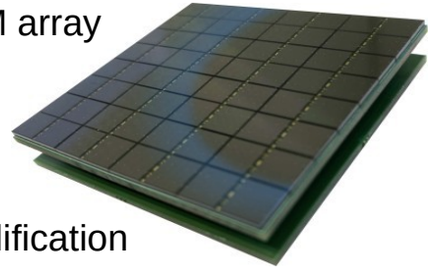
Comparison: before- vs after glueing. Procedure using optimized aluminum pads

Mirror and mirror tiles EDR feedback: homework in progress!

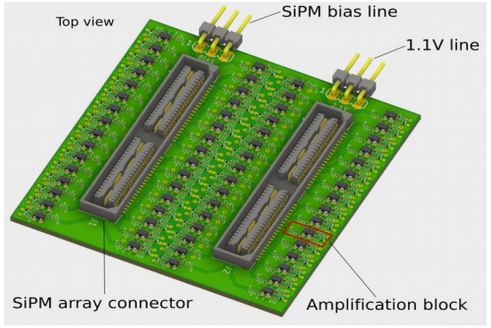
R&D: SiPM-based RICH

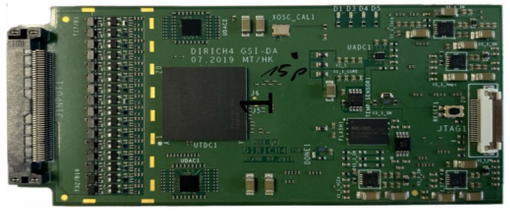
Electronics

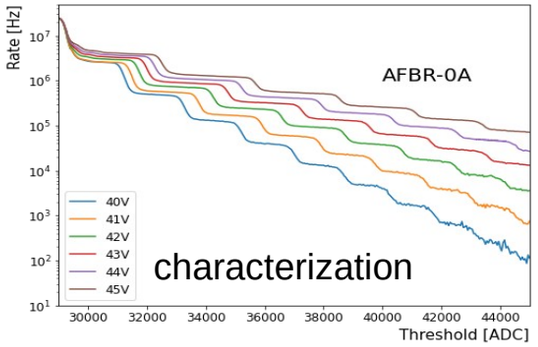
SiPM array



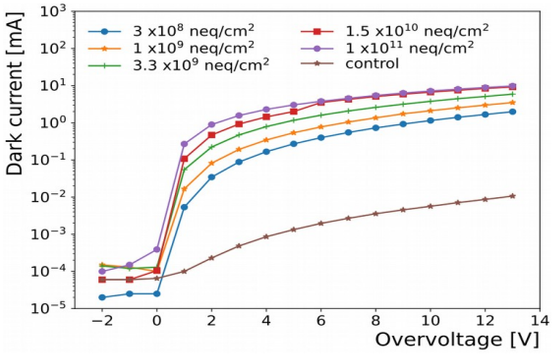
Amplification





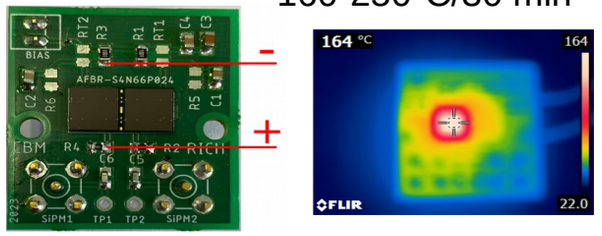


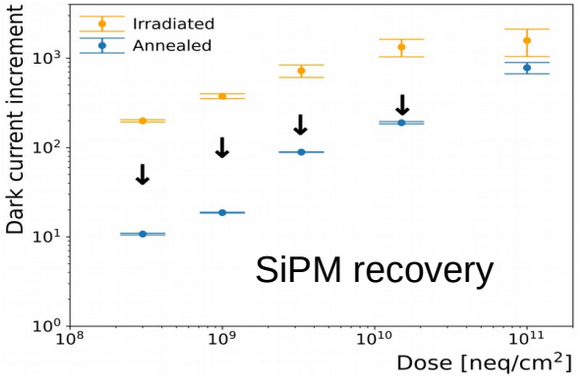
Radiation hardness



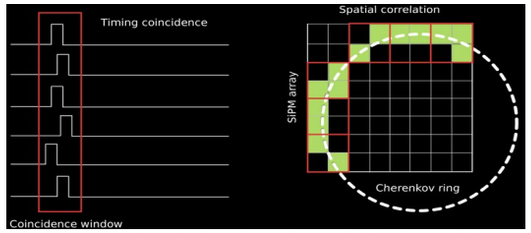
Annealing

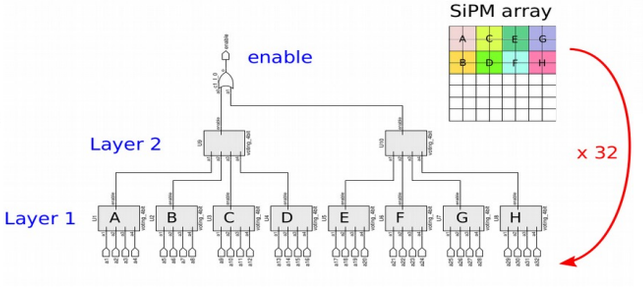
160-250ºC/30 min

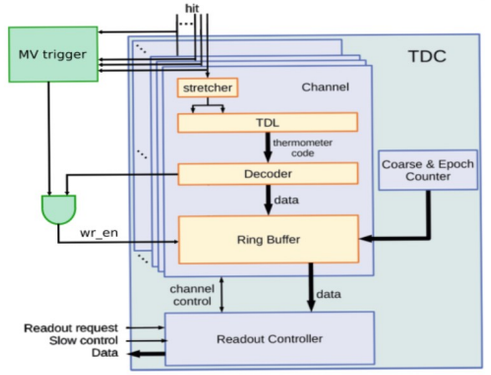


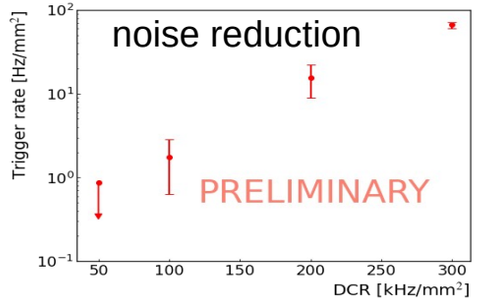


Trigger system

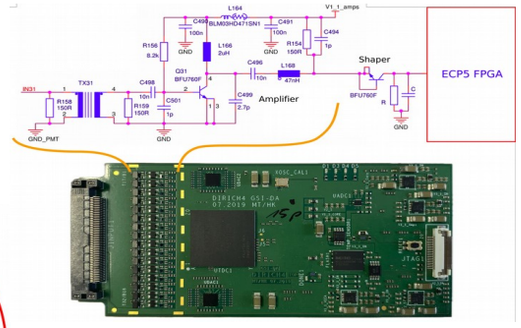


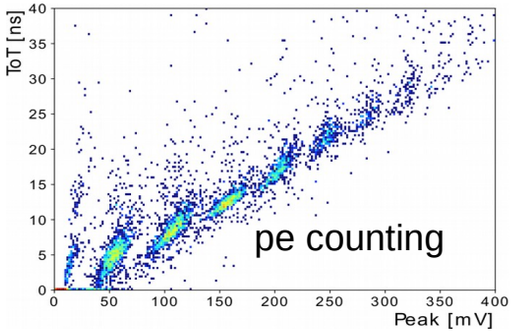


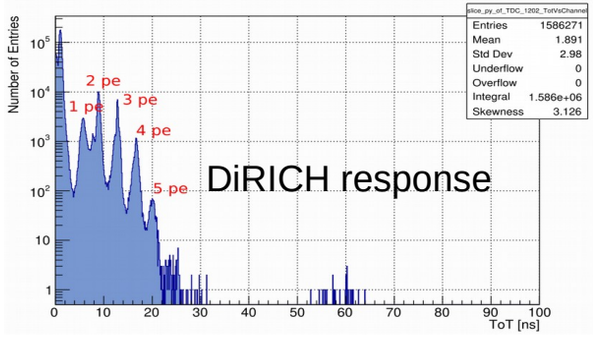




#photons-to-ToT

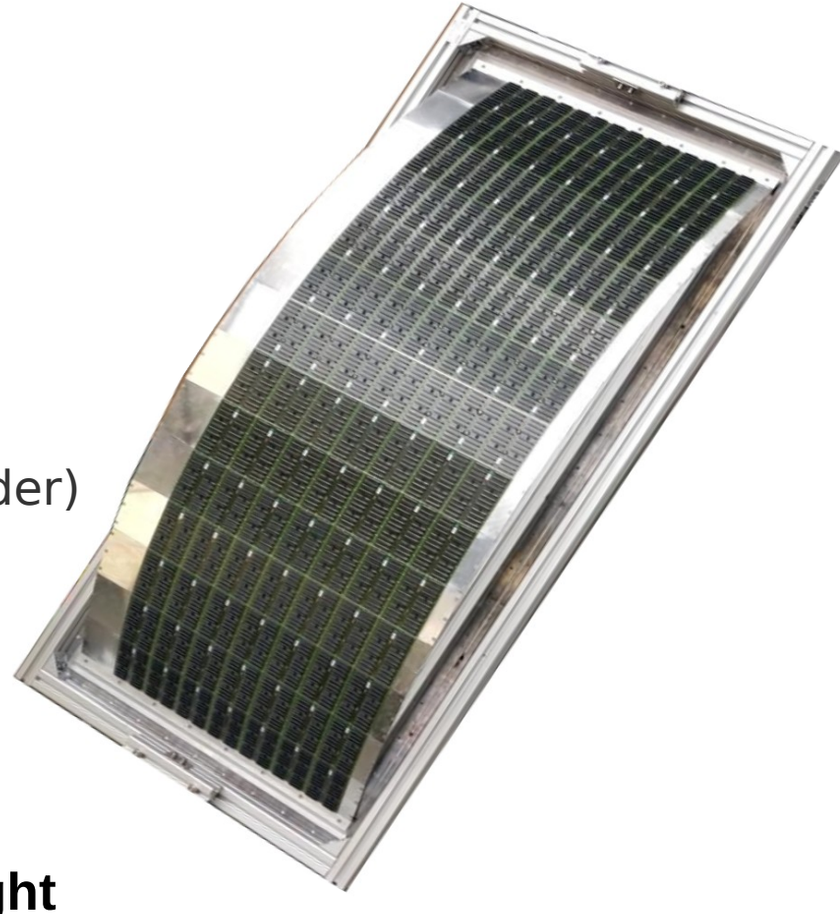






Summary and outlook

- Transition from **design to construction phase**
- Both photon cameras **almost fully assembled**
  - large fraction of front-end electronics produced
  - **full system cooling test** upcoming
- Mirrors will be purchased from **Oloumuc** (European tender)
- RICH ready for **first beam** : **end 2028**
- **R&D** towards possible future **SiPM upgrade**

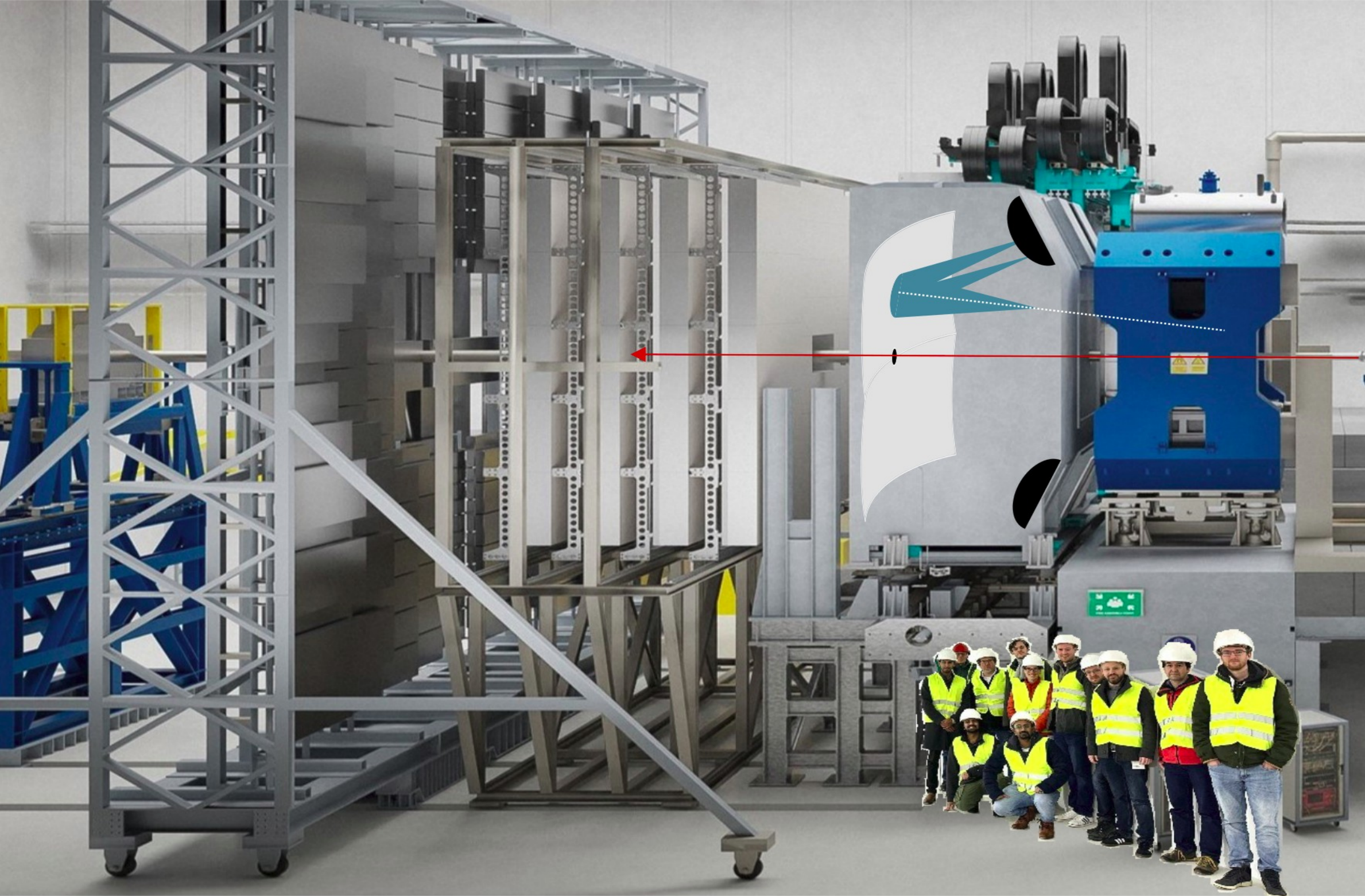


Highlights

- 2nd camera is mechanically ready and gas tight

- Mirror and mirror tiles EDR feedback: some homework

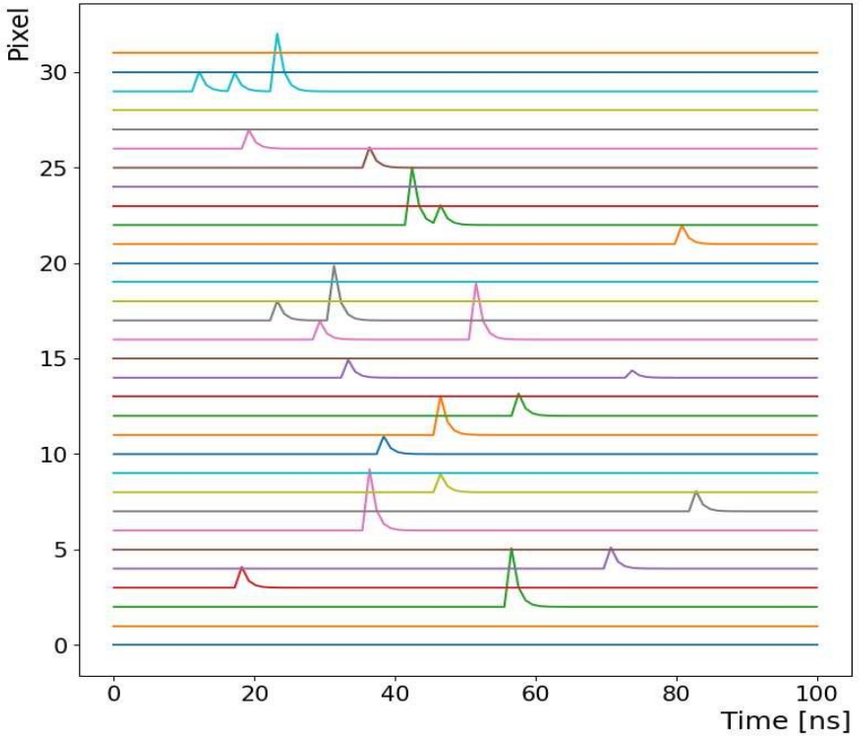
- Working on cabling and interfaces



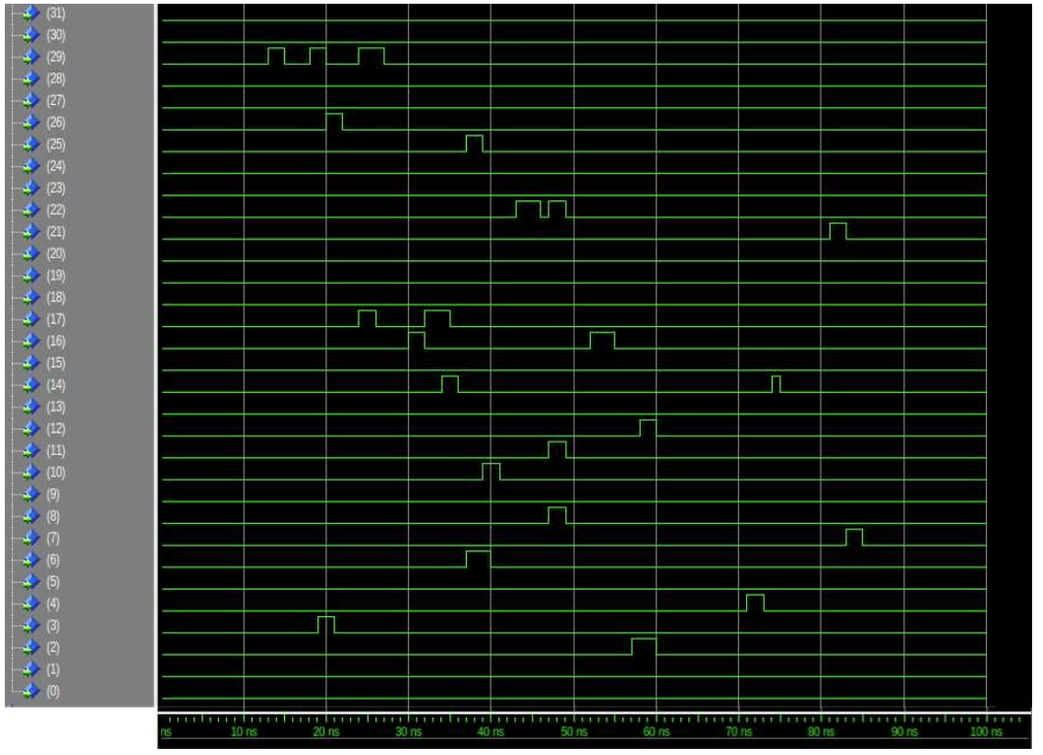
backup

Trigger of the SiPM-based camera

SiPM array simulation



FPGA trigger simulation

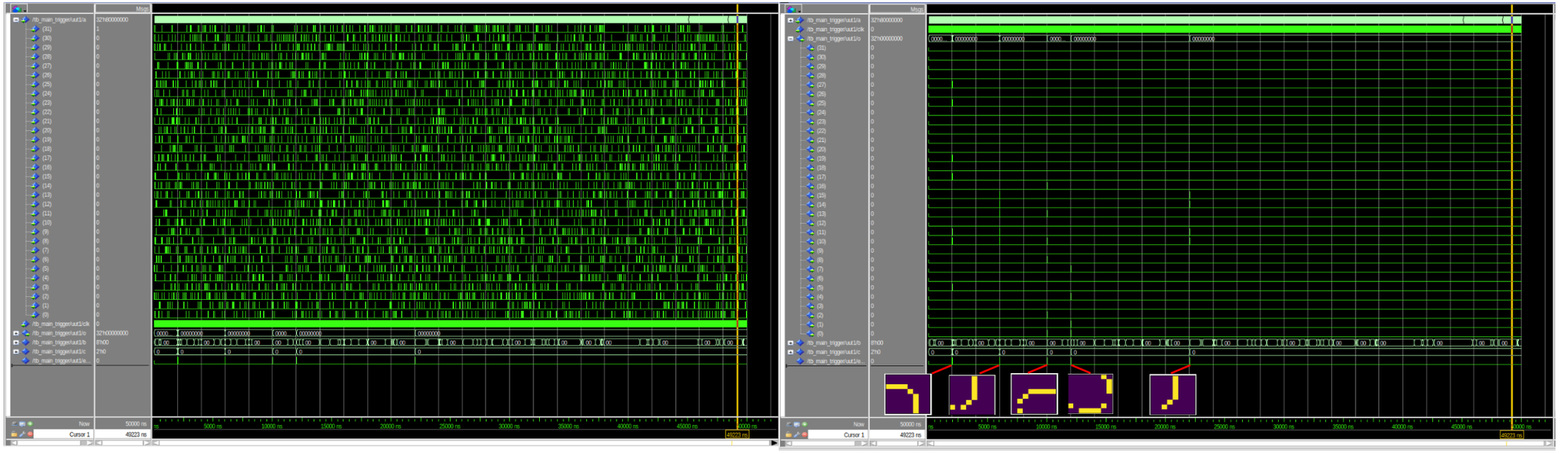


Trigger system evaluation using realistic SiPM signals: DCR, crosstalk, and afterpulsing. Keeping signal width information

J. Pena-Rodriguez.JINST.2025 SiPM simulation framework

Trigger of the SiPM-based camera

Input **Output**



32x individual SiPM pixels (50 us)

- Signal FWHM: 2 ns
- Dark count rate (DCR): 150 kHz/mm²
- Cross talk: 25%
- Afterpulsing: < 1%

2 MHz/channel DCR → **~ 1 kHz / DIRICH**

7 MHz/channel DCR → **~ 20 kHz / DIRICH**

+ correlated (**Cherenkov**) signal

Cooling system

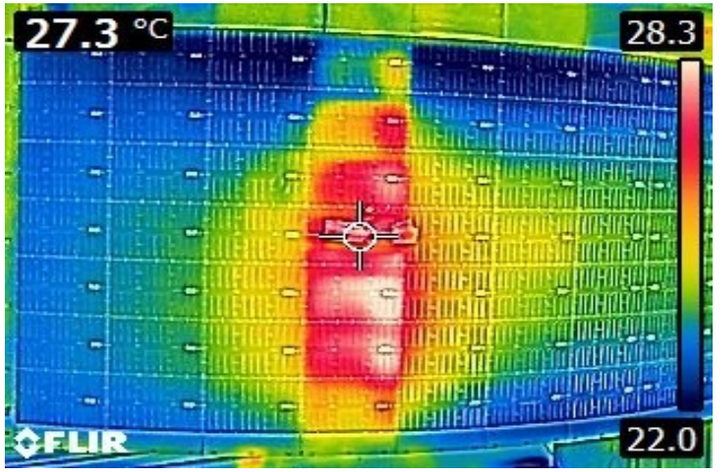
Keep MAPMT cathode temp **< 30°C**
despite heat load from front-end electronics

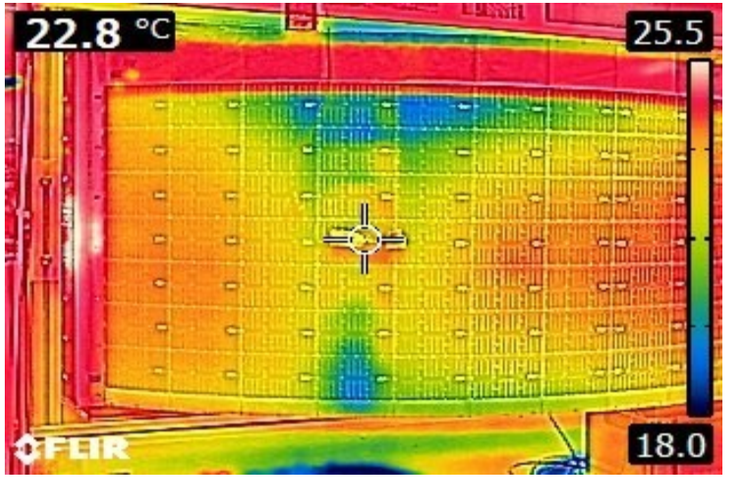
Blower freq. : 10 Hz
Air flow (per column): 54 kg/h
T air : 11.3 °C
MAPMT Temp : 27 °C
Electronics Temp: 47 °C

Blower freq. : 20 Hz
Air flow (per column): 105 kg/h
T air : 10.5 °C
MAPMT Temp : 23 °C
Electronics Temp: 33 °C

T room ~ 25 °C

External view

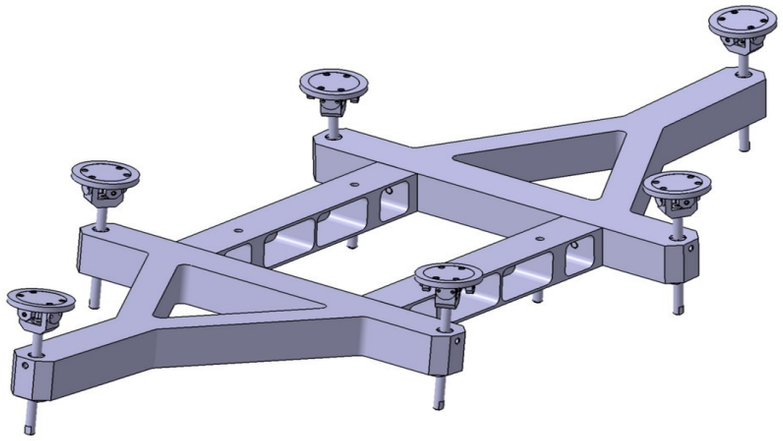


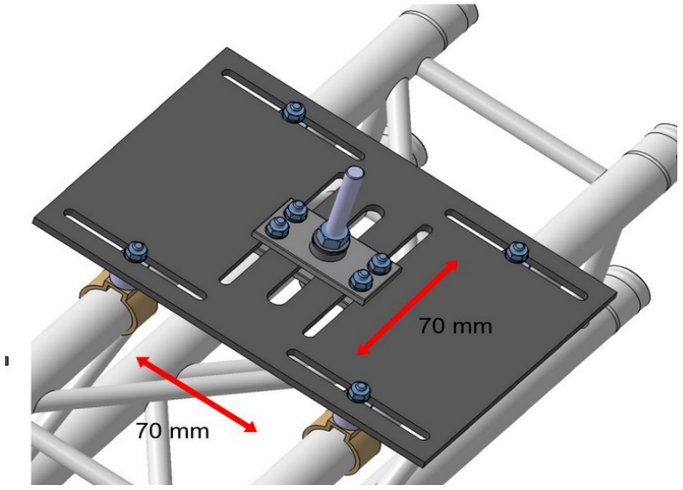


Internal view

Mirror wall

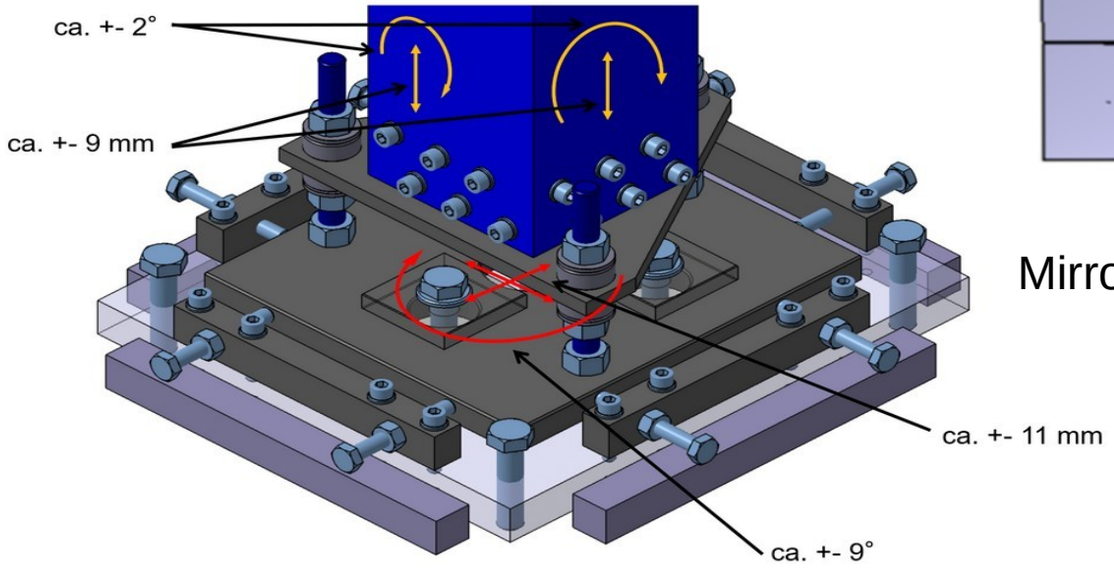
Mirror mounting bracket
carrying two mirrors each

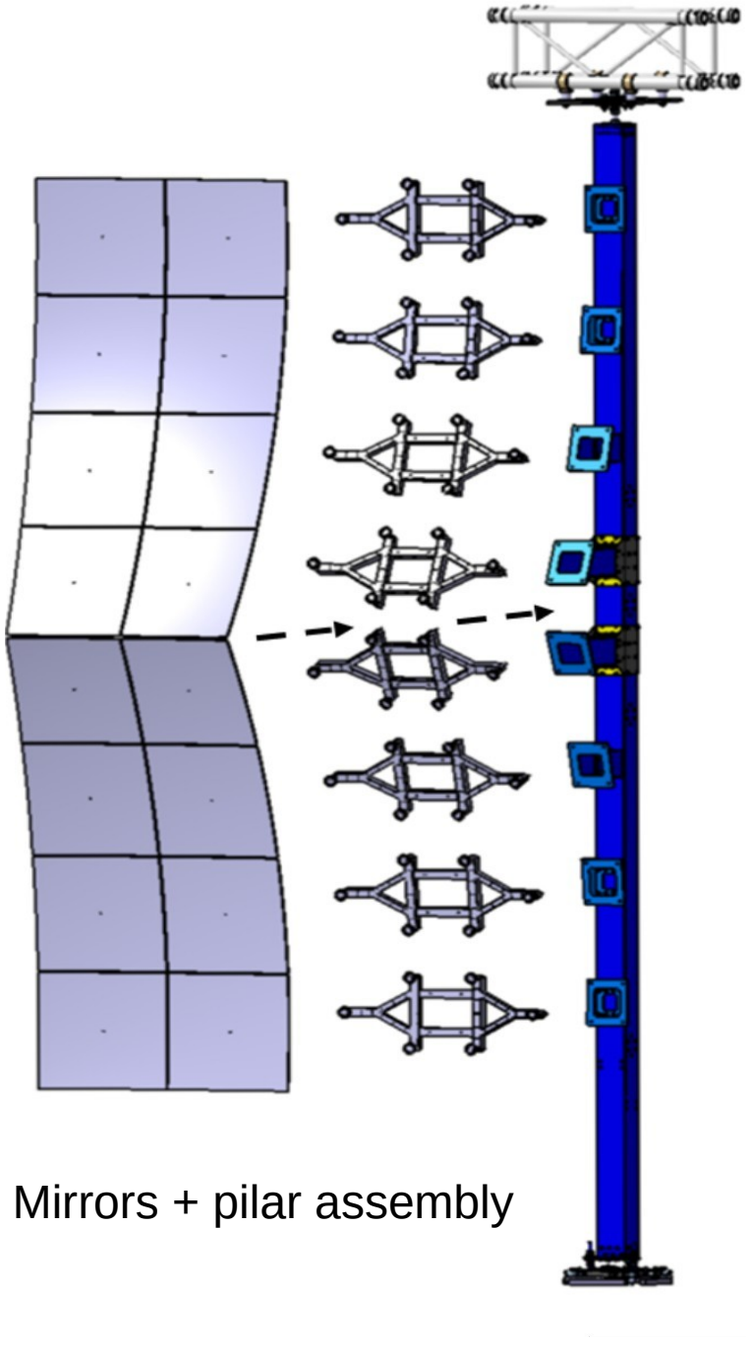




Upper pillar fixation+alignment

Lower pillar alignment foot





Mirrors + pilar assembly

RICH alignment feet

Full RICH **~15t** – resting on 3 feet
Load capacity : **5-7 t / foot**
Height adjustment: Δ = **3 cm**
Movable in beam-direction: ~ **40 cm**