The RICH detector for the CBM experiment at FAIR

Jordan Bendarouach[1], for the CBM Collaboration

[1] Justus Liebig University Gießen, Germany

CBM (logo, left margin)

Compressed Baryonic Matter experiment at FAIR (left margin)

Motivation

CBM at FAIR: Explore the QCD phase diagram in the region of high net-baryon density with A+A collisions at energies from 2 to 11 AGeV/c (SIS100)

Features of the phase diagram at high μ_B ?
- Quarkyonic phase?
- Phase transition(s)?
- Critical point/ triple point?
- **Need for high precision data including rare probes**

EM probes
Low-mass region:
- Photons: early temperatures of the fireball
- Low mass vector mesons: hadron dynamics
Intermediate-mass region:
- Slope: indicates thermal radiation of the fireball
- Also hints for a quarkyonic phase?
High-mass region: J/Ψ (SIS 300?)

Efficient and clean electron identification together with a combined pion suppression factor of 1000 to 5000 (using in addition 4 layers of TRD) are required.
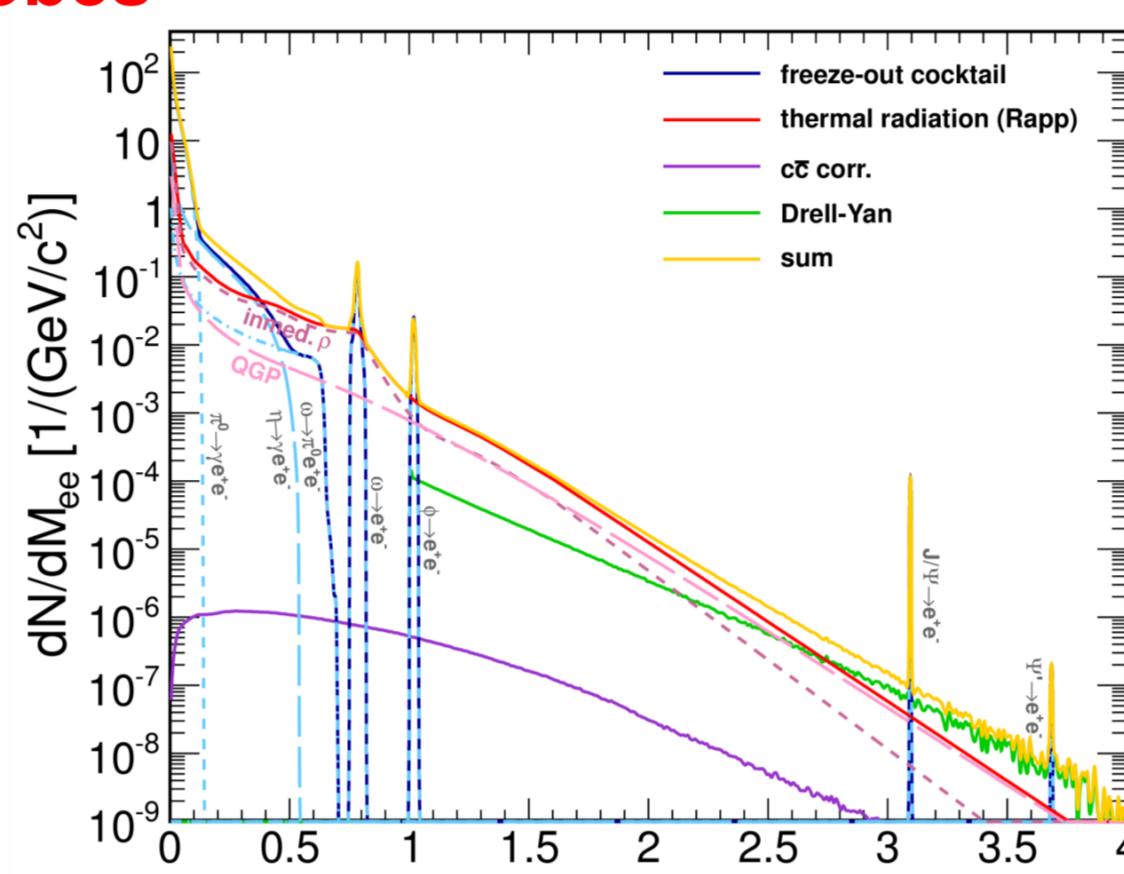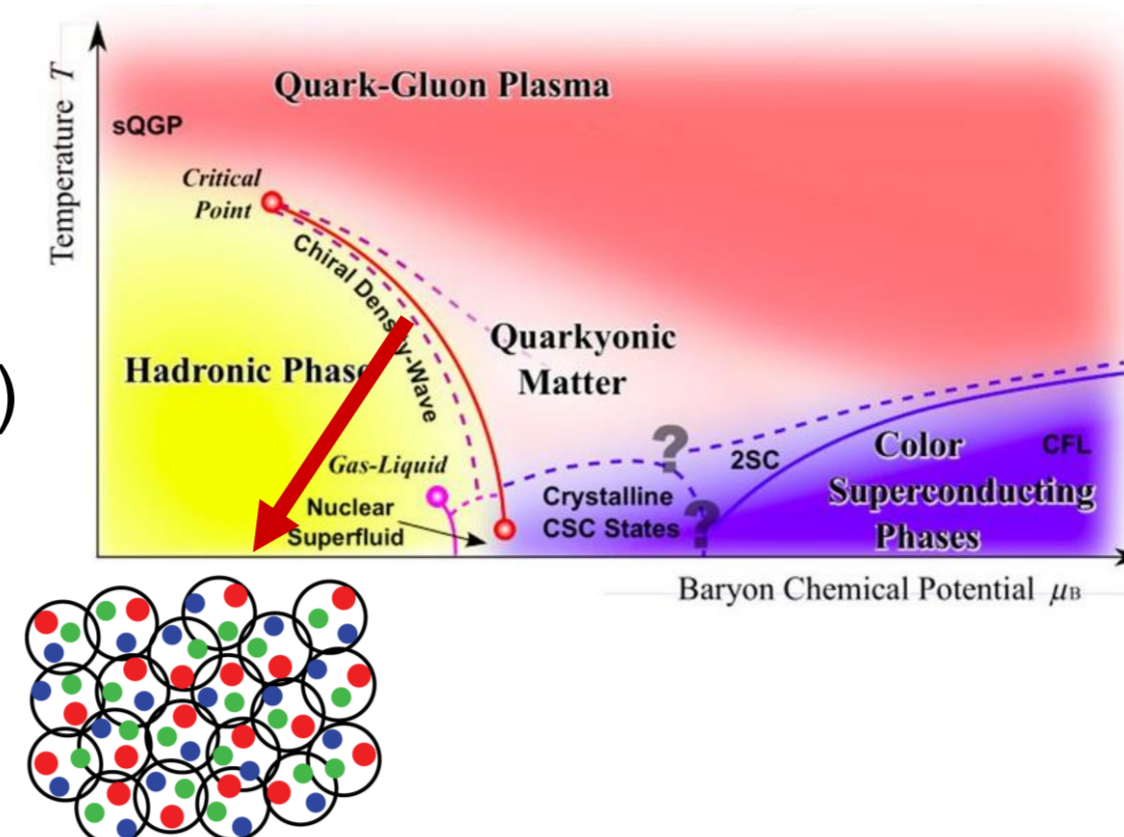
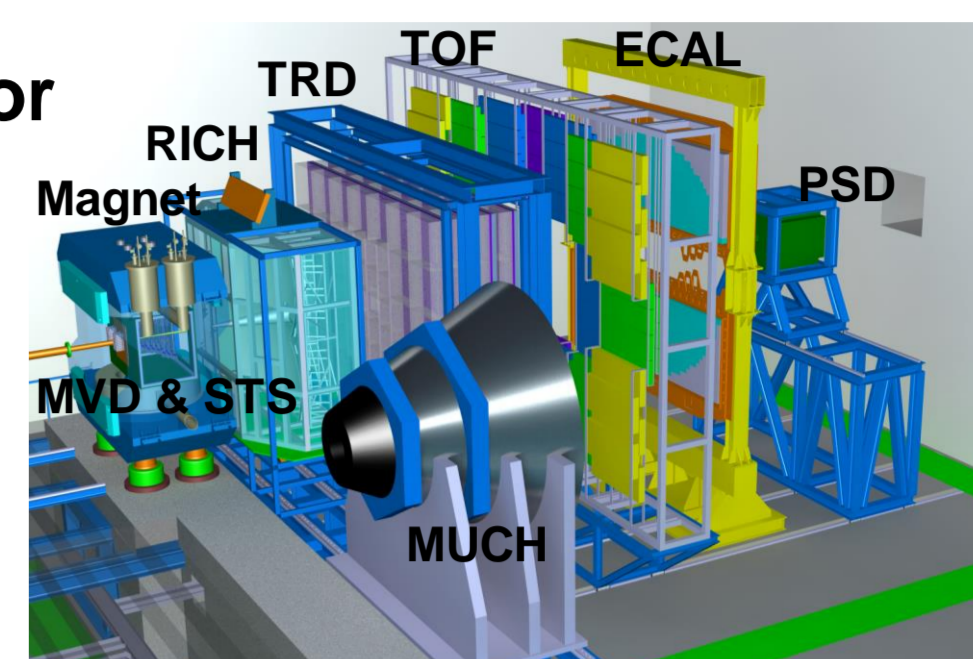Cocktail of central Au+Au collisions at 25 AGeV/c

Concept of the CBM RICH Detector

Ring Imaging CHerenkov (RICH) detector
- Gaseous RICH for e- ID (p < 8 GeV/c)
- CO_2 as radiator gas ($p_{\pi,th}$=4.65 GeV/c)

Photon sensors
- Hamamatsu H12700 Multi-Anode PMTs
- MAPMTs distributed over 2 cylindrical surfaces with approx. 64 000 channels
- 2 large spherical mirrors (R=3m) as focusing optics

Mirrors
- 80 tiles of ~ 40x40 cm^2 and 6 mm thick distributed in 2 spheres
- Al+MgF_2 reflective and protective coating
- Vertical splitting of RICH geometry due to magnet
- MAPMT planes shielded by magnet yoke
- RICH and MUCH detectors will be interchanged approx. once every year
- RICH craned out of the beam line to the MUCH parking position, which might cause mirror misalignments
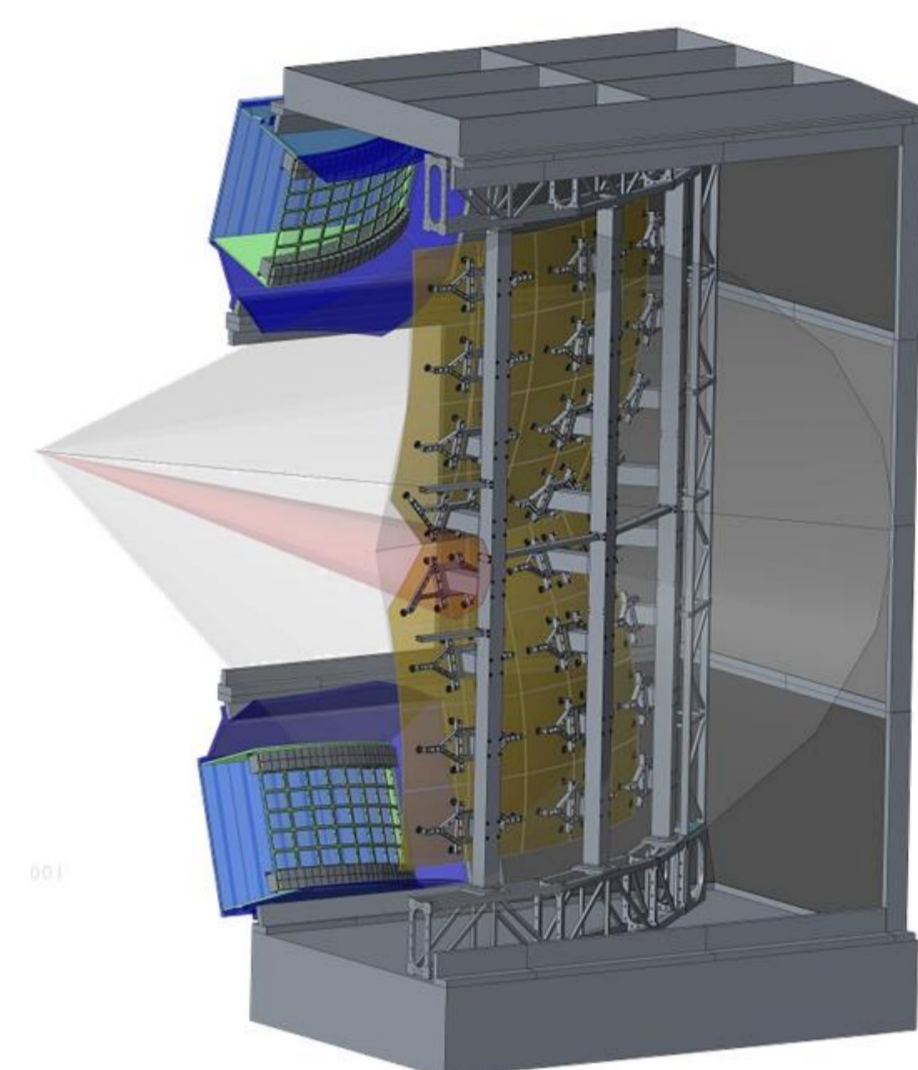
RICH software

Geometry optimization
- Cylindrical shape adopted
- MAPMTs shifted from magnetic stray field of magnet
- ✓Optimized with respect to ring distortions, focusing and high detection performances
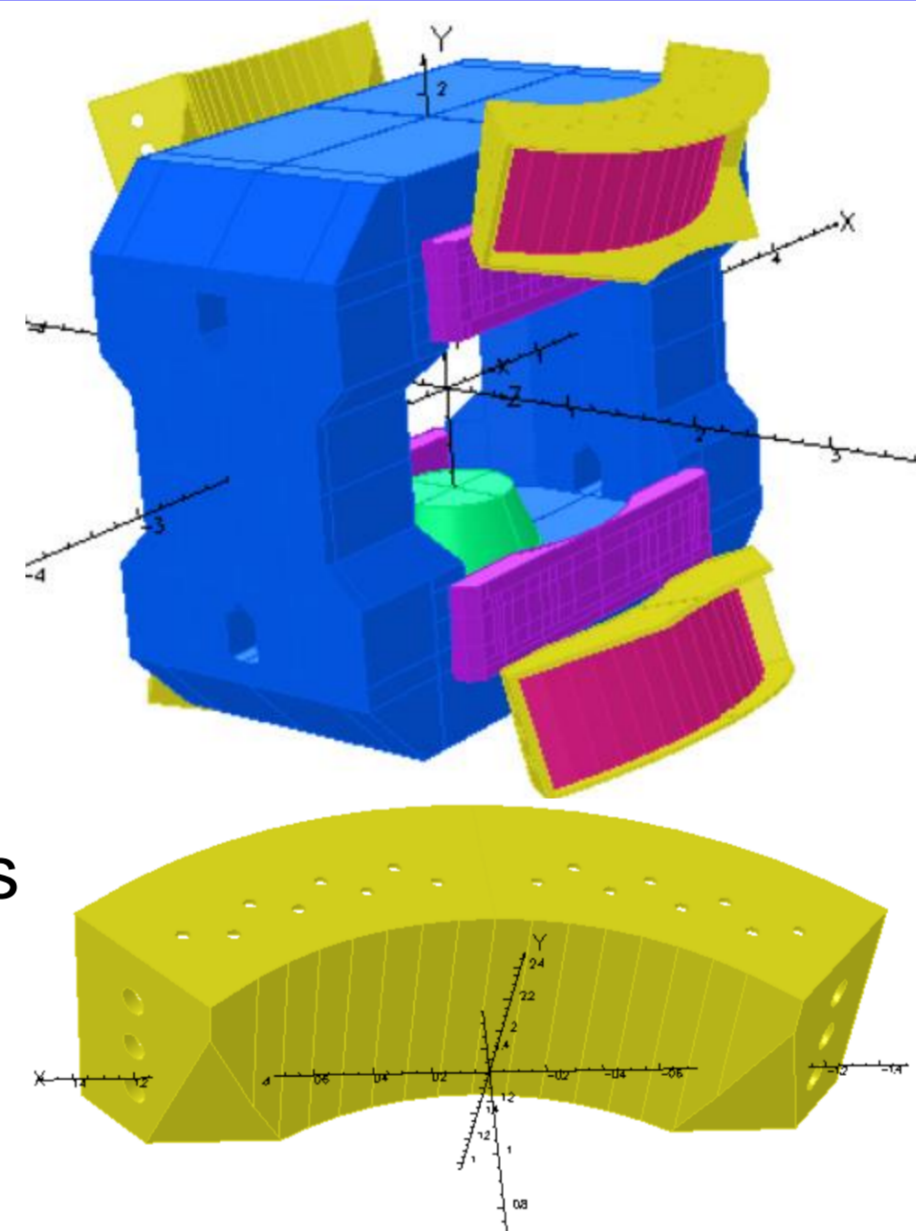
Shielding box
- Additional protection from magnetic stray field for MAPMTs
- Field strength of 0.3 mT in the hottest region (upper limit: 1 mT)
- Shielding box positioned away from magnet yokes
- Still needs optimization

Reconstruction results with newest geometry

- Latest RICH geometry implemented in software
- New shielding box design
- New QE measurements
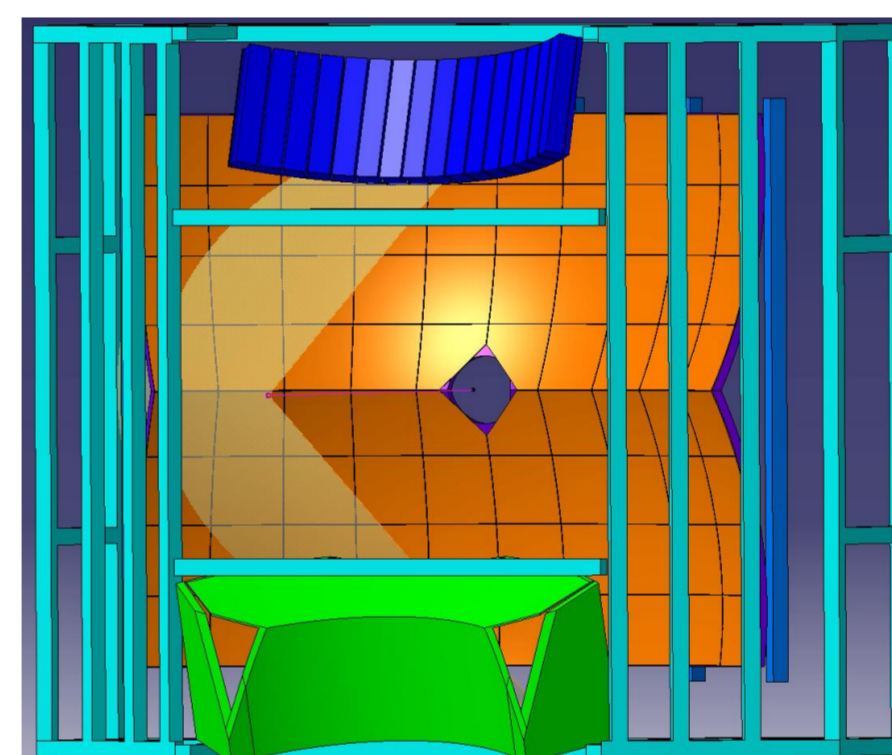
Efficiencies (%)	Au+Au collision energies 8 AGeV/c	25 AGeV/c
Ring reconstruction efficiency (all e+/-)	96.5	91.2
STS-RICH matching efficiency	91.8	83.7
Electron identification efficiency in RICH*	88.4	81.1
Pion suppression in RICH*	391	135

* Momentum range: 0-6 AGeV

Mechanical designs

Detector supporting structure
- Reduce the material budget
- Mechanically rigid and stable frame
- Made of Al for lightweight structure
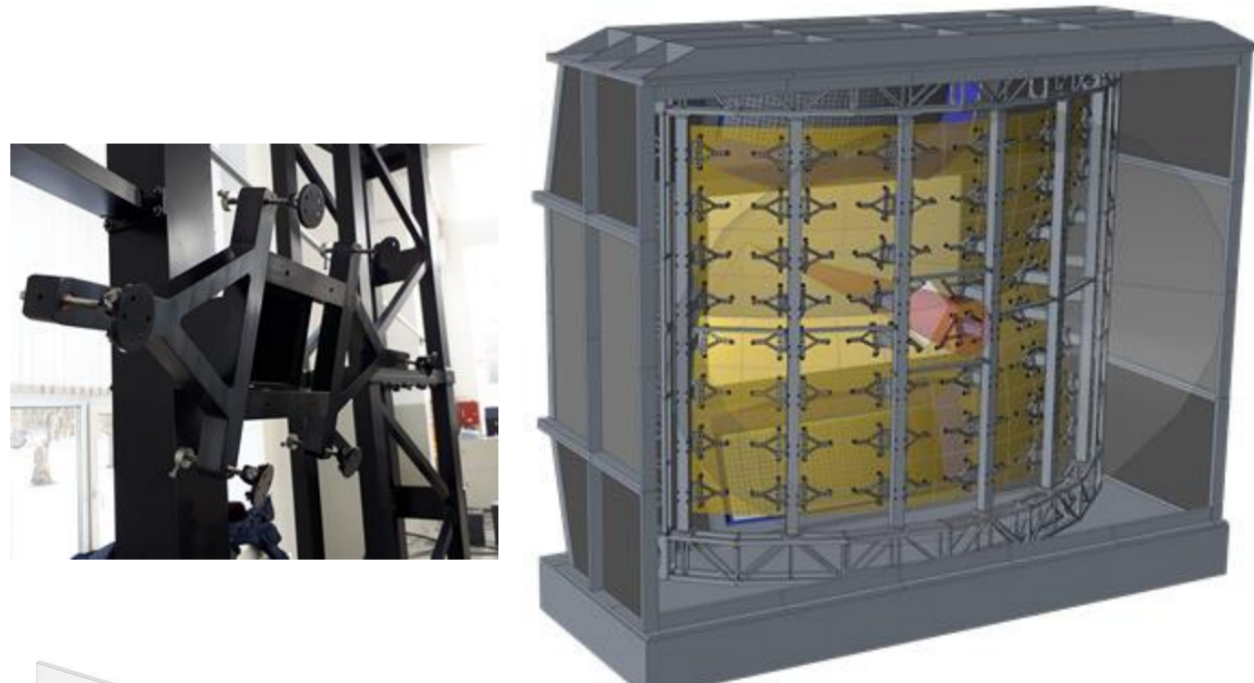
Mirror supporting frame
- 1 pillar supporting 2 mirror columns
- 1 mirror frame to support 2 mirrors
- Prototypes of pillar and mirror:
  - Produced and under tests
  - Study deformation response (with load and temperature) of pillar
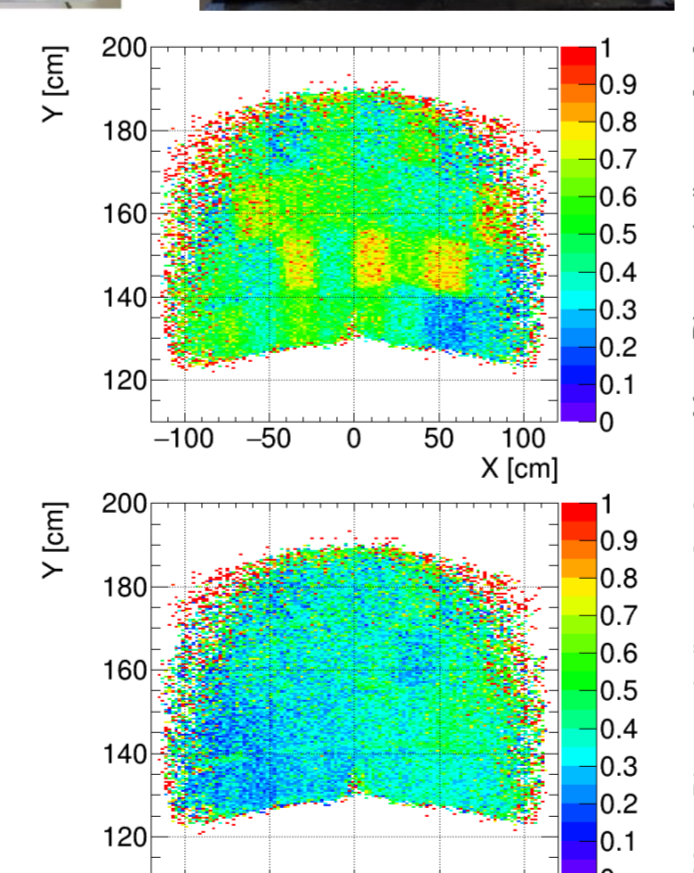- Glue tests
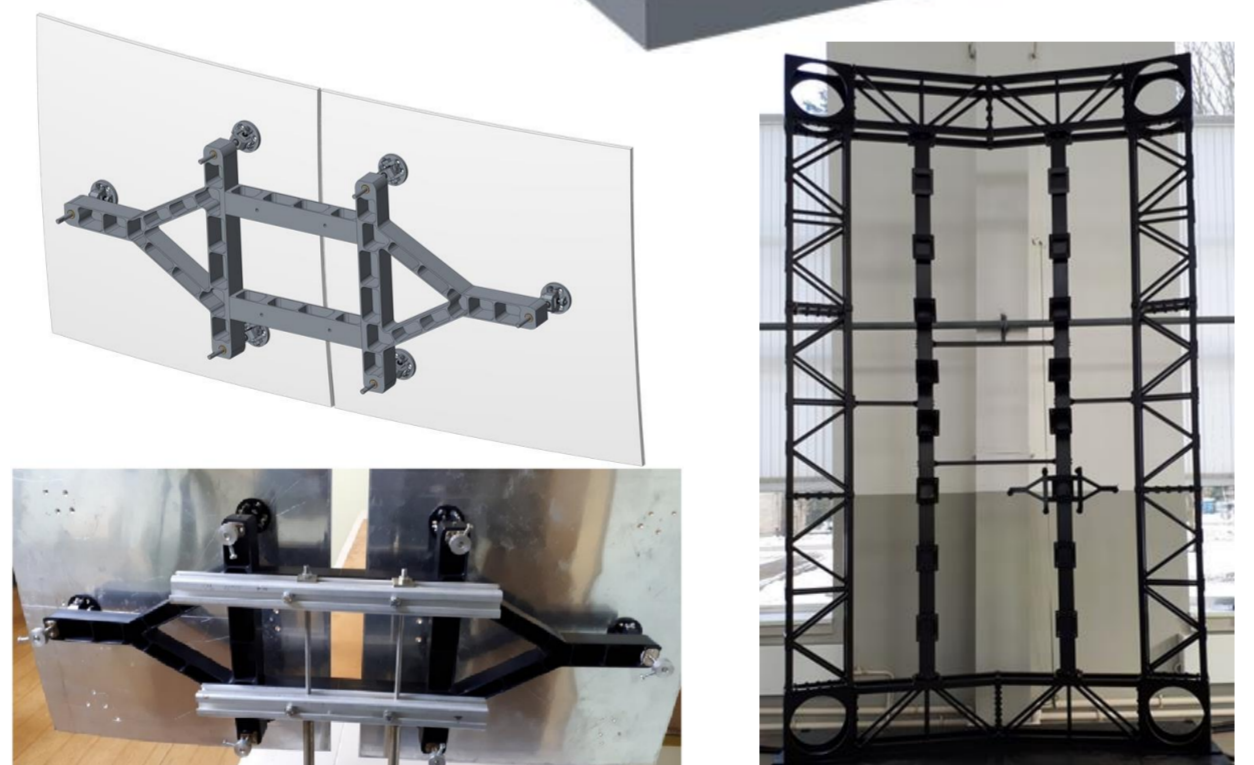
Mirrors

Tests in the lab
- High reflectivity and very good surface homogeneity
- D_0, Shack Hartmann and Ronchi tests ongoing

**Mirror alignment correction cycle**
- Combines 2 complementary methods from COMPASS and HERA-B experiments
- Corrections automatically calculated in software

## Photon detector

Multi-Anode Photomultipliers (MAPMTs)
- H12700 Hamamatsu
  - ✓High pixel resolution and QE
  - ✓Single photon response
  - ✓Low dark current and crosstalk
- QE increased in UV range with WLS films coverage
- Radiation hard
- ✓1100 ordered and 1000 tested against specifications
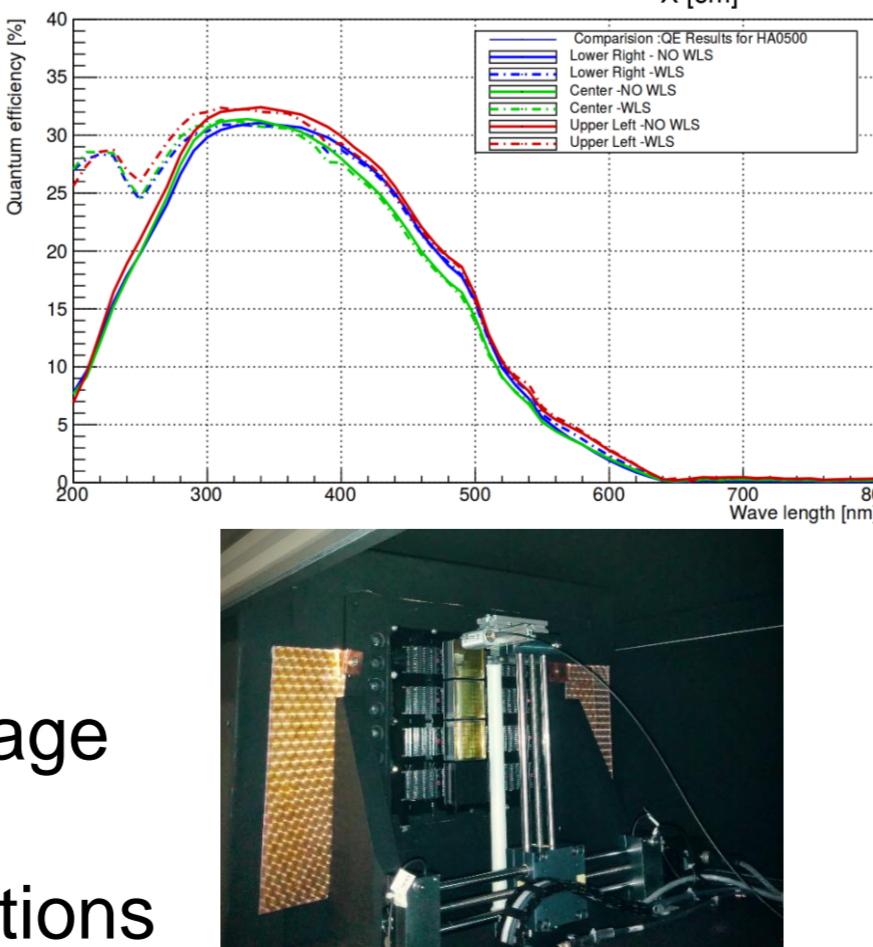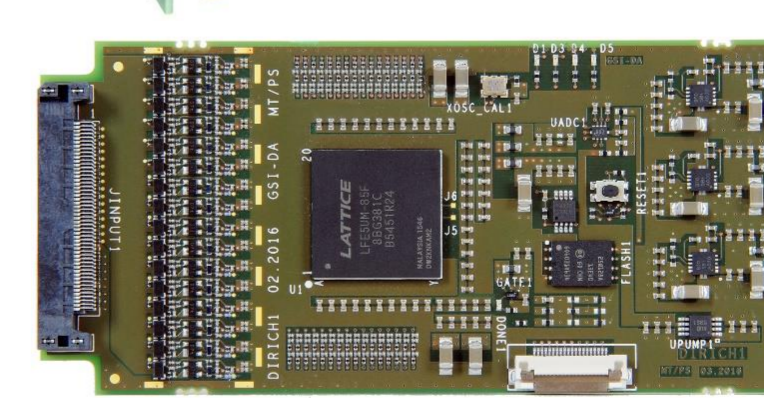
Readout chain and electronics

3x2 MAPMT readout module
- Reads 6 MAPMTs distributed in 3x2 array
- 1 PCB
  - Mechanical fixation for MAPMTs
  - Gas and light tight
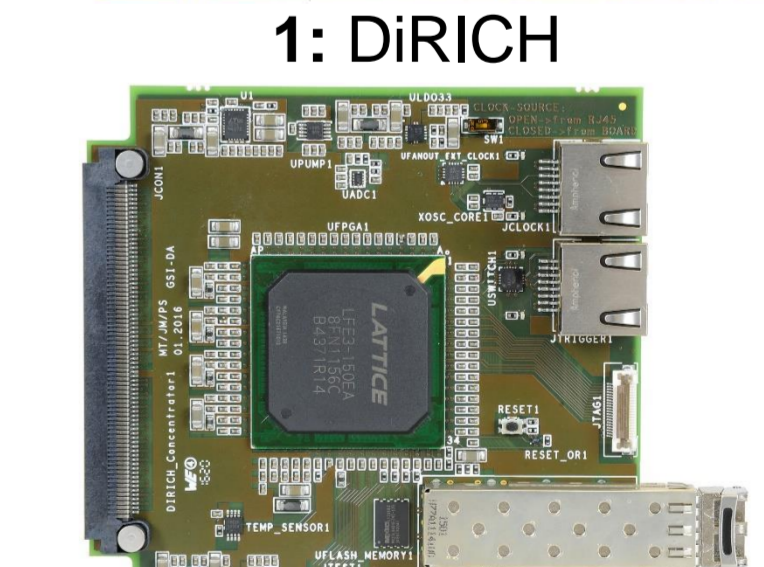- Backplane used as interface for readout FEE
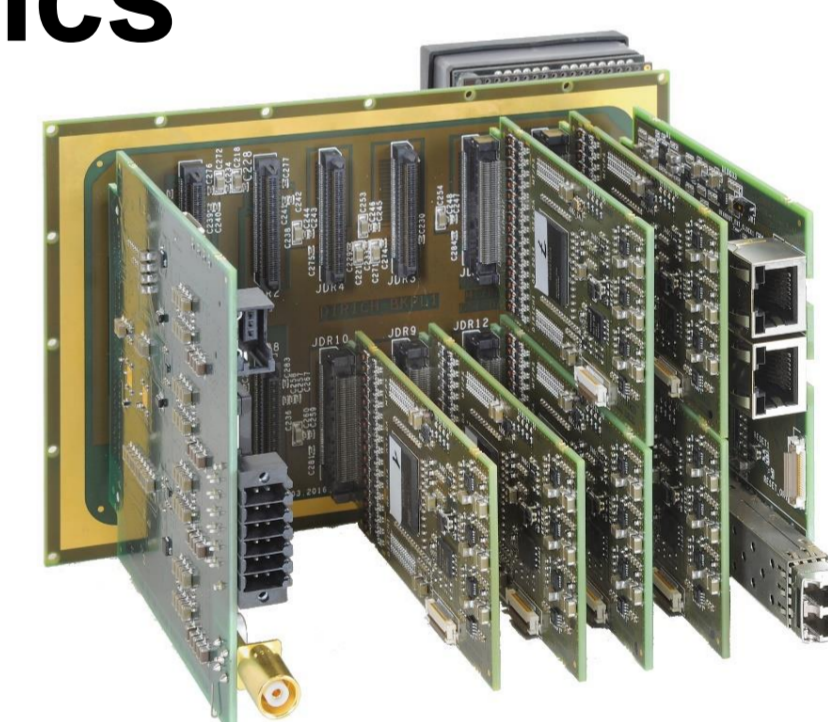
DiRICH module (1)
- Reads 32 channels
- Amplifies and shapes analog signal from MAPMTs
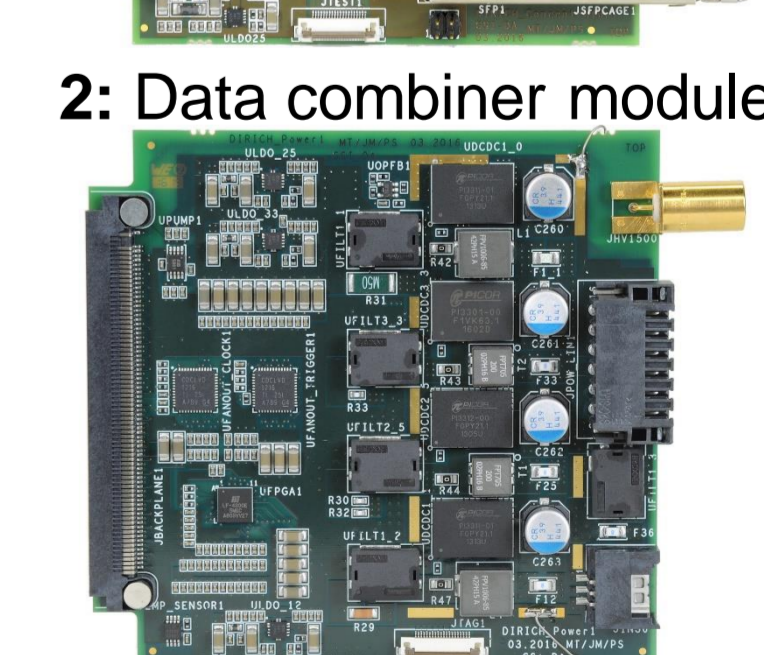- Discriminates the analog signal

1: DiRICH

Data combiner module (2)
- Gathers data from 12 DiRICHs (6 MAPMTs)
- Sends signal via output link
- Currently output data read via GO4, upgrade for CBM needed

2: Data combiner module

Power module (3)
- Provides low voltage to different modules
- Delivers high voltage to MAPMTs
- Used as remote voltage regulator

3: Power module

COSY test beam

Successful readout chain and electronics testing
Reduced set-up, proximity focusing optics, proton beam at 1.6 GeV/c:
- ToT analysis
- Timing calibration
- WLS decay constant determination
- Hit multiplicities VS threshold
- Successful validation of readout electronics for HADES RICH upgrade (see Posters: 861, 862)