Development of a mirror supporting frame, mounting scheme and alignment monitoring system for the CBM RICH detector

Motivation

CBM at FAIR: Explore the QCD phase diagram in the region of high net-baryon density with AA collisions at energies from 2 to 11 AGeV (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 and among them di-electrons

Concept of the CBM RICH Detector

Ring Imaging Cherenkov (RICH) detector
- Gaseous RICH for e- ID (p < 8 GeV/c)
- CO2 as radiator gas (p_CO2=4.65 GeV/c)

Mirrors and photon sensors
- 2 large spherical mirrors (R=3m) as focusing optics
- Hamamatsu H12700 Multi-Anode PMTs distributed over 2 cylindrical surfaces with approx. 84000 channels
- Dedicated readout chain and electronics developed

RICH Mirrors

Mirrors
- 80 trapezoidal glass mirror tiles of ~40x40 cm² and 6 mm thick distributed in 2 spheres
- Vertical splitting of RICH geometry due to magnet
- Al+MgF2 reflective and protective coating

Challenges with respect to detector stability and mirror alignment
- RICH and MUCH detectors will be interchanged approx. once every year
- RICH craned out of the beam line to the MUCH parking position
- Mechanical design and supporting structures for rigid, low mass and stable detector and mirror system
- System developed to monitor mirror alignment

Mechanical design

Detector supporting structure
- Reduce the material budget
- Mechanically rigid and stable
- Made of Al for lightweight
- Structure

Mirror supporting frame
- 1 pillar supporting 2 mirror columns
- 1 mirror frame supporting 2 mirrors
- Prototypes produced
- Deformation response with load and temperature
- Glue tests for RTV-157 and 24 hour epoxy

Mirror quality control
- High reflectivity and very good surface homogeneity
- Global control with D0 measurement
- Averaged on 4 mirrors: 1.19 mm at a radius of 2.22 mm larger than the mirrors radius of curvature
- Local homogeneity measurements
- Shack Hartmann test: quantitative analysis ongoing
- Ronchi test

Mirror alignment monitoring system

Two methods adapted from COMPASS* and HERA-B to qualitatively and quantitatively determine mirror rotations

CLAM method
- Qualitative alignment control
- Quantitative mirror rotation determination
- Successfully implemented in CBM-RICH prototype at CERN

Software corrections
- Uses data to quantify mirror rotations
- Range: [0.2; 10.5 mrad]

Mirror alignment cycle
- Detection and quantification with CLAM and software
- Correct track extrapolation to PMT plane
- Efficiencies (ring-track matching and RICH ID) and ring-track distances compared before and after corrections for a 1 mrad Gaussian misalignment
- Performances after corrections are close to ideal alignment

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