The mRICH detector at the mCBM experiment

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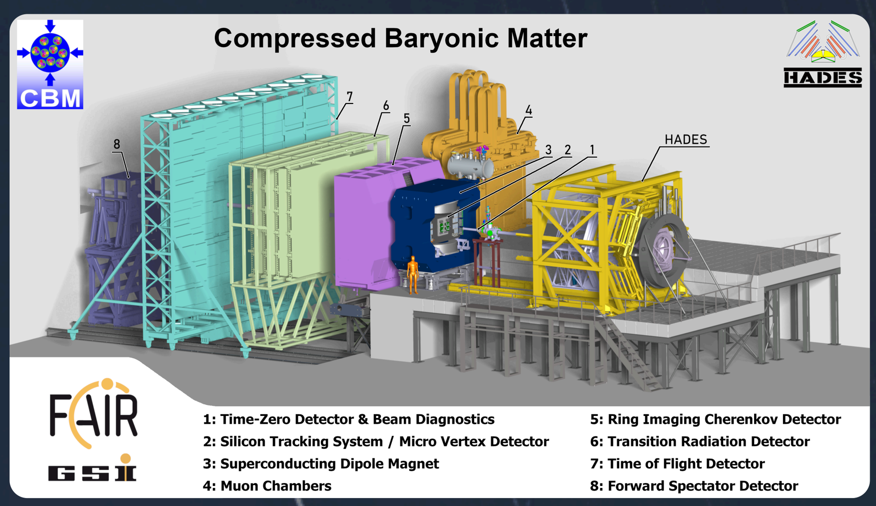
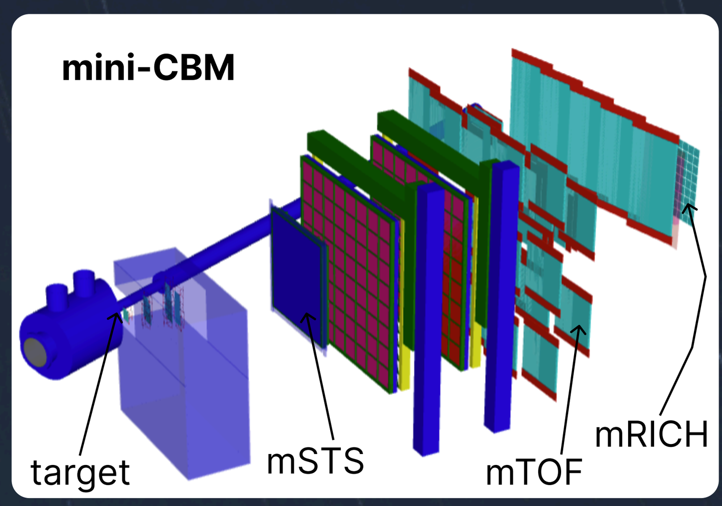
CBM and mCBM

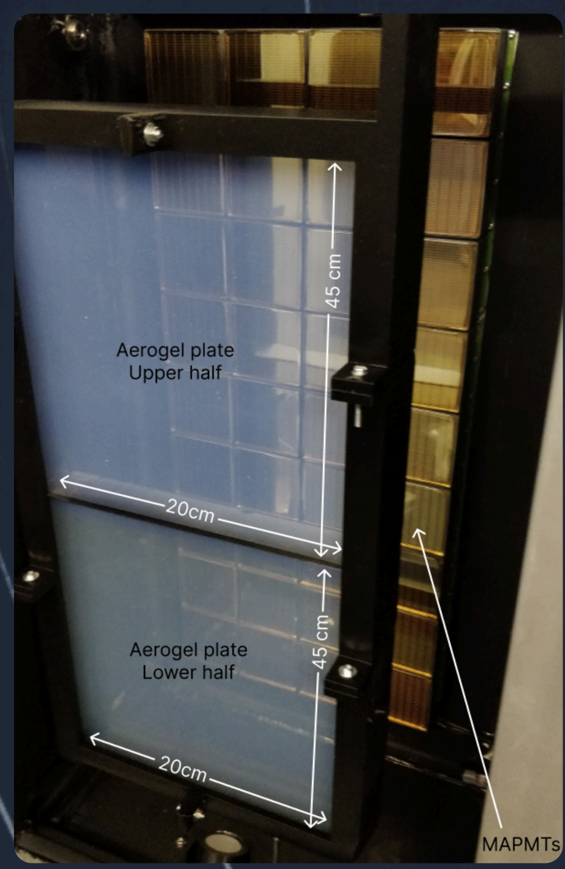
CBM (Compressed Baryonic Matter) is a fixed target experiment presently under construction that investigates heavy ion collisions like Au-Au and Ni-Ni. The mini-CBM (mCBM) is a prototype apparatus located at GSI Darmstadt, Germany. This prototype aims to test all subsystems of the CBM experiment, featuring scaled-down versions of nearly all detectors later present in the final experimental setup. One goal of this effort is to establish the free-streaming readout scheme envisioned for CBM.



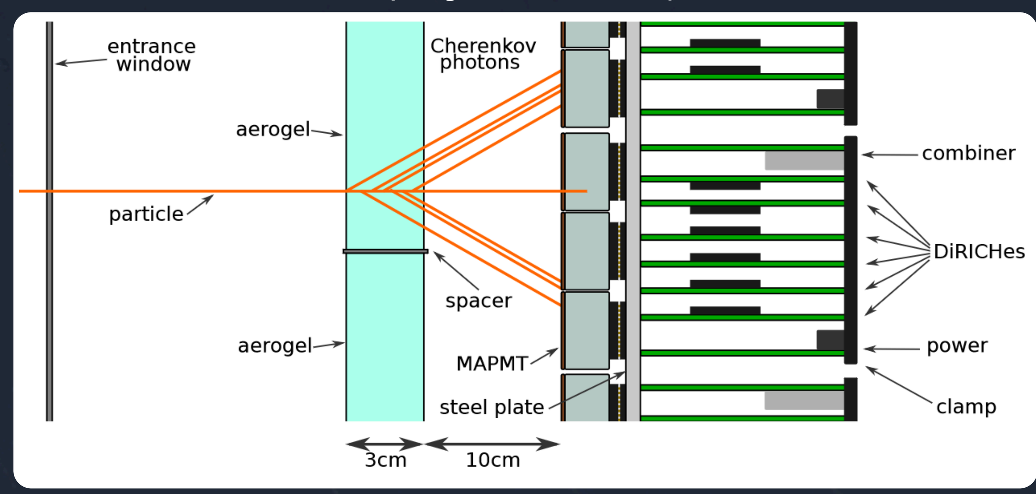


mRICH

- Same MAPMT-based readout chain as CBM RICH
- Prototype test of the CRI-based free-streaming readout
- Proximity focusing RICH using aerogel tile (same type as for CLAS 12)
- 36 MAPMTs, 36×12 DIRICH, 1 CRI
- Several beam campaigns over last years



Front view

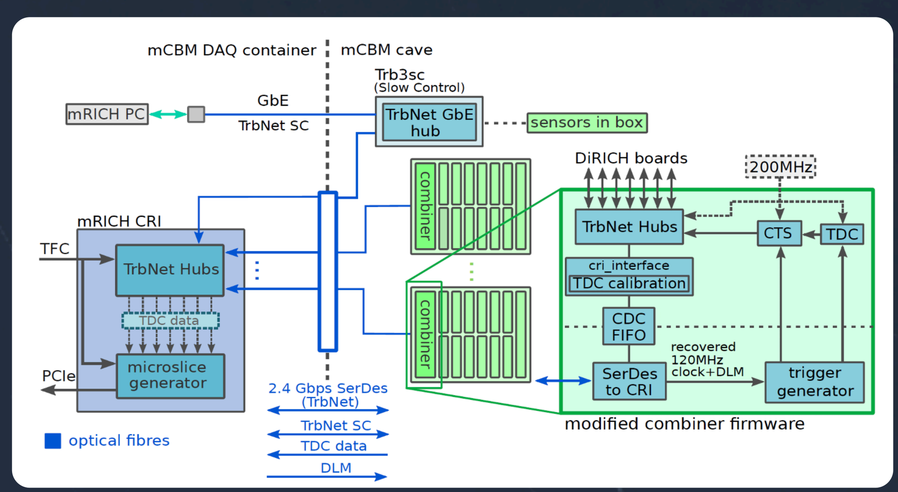


Schematic Cross-section

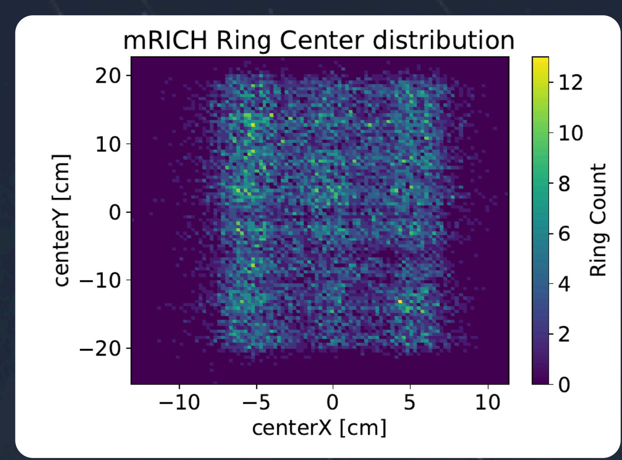
mRICH Readout Chain

The mRICH readout chain uses the DIRICH readout system, which is connected to the CBM CRI - Common Readout Interface.

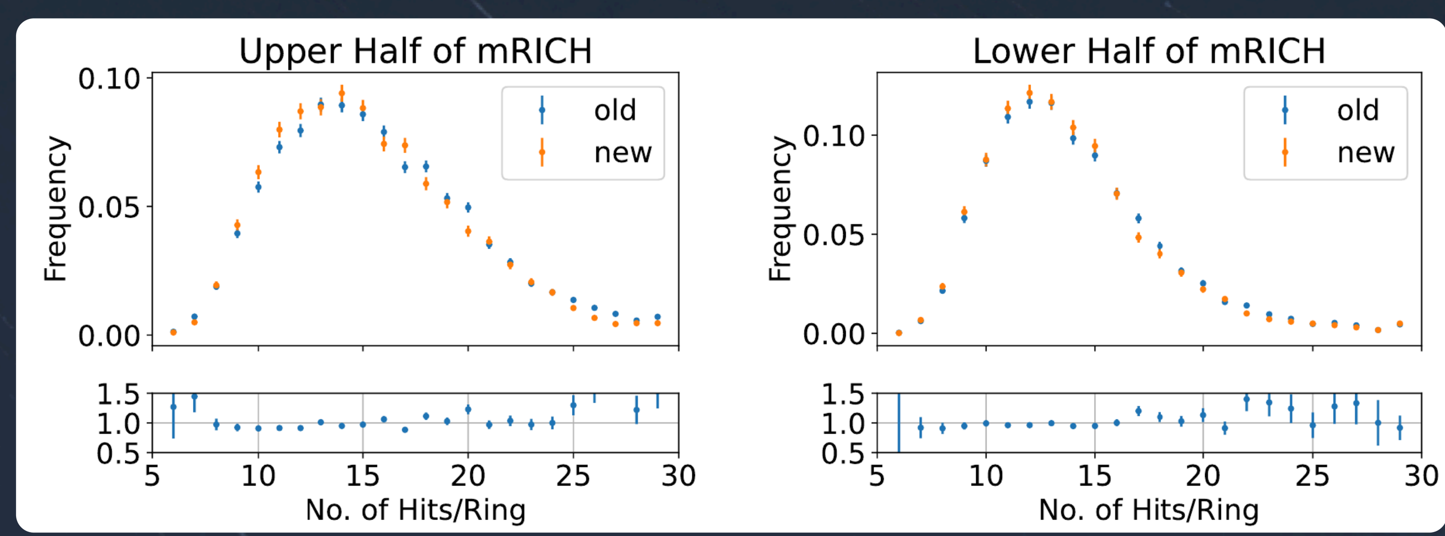
- **Data Acquisition:** Two DIRICH Front-End Boards (FEBs) read out each MAPMT, recording the leading and trailing edges of the signals.
- **Buffering:** Individual Hits (leading + trailing edge) are buffered on the DIRICH.
- **Data Transfer:** The CRI sends a periodic trigger (~10 kHz) to combiners, which merge data from the FEBs. Merged data is sent to the CRI via optical link.



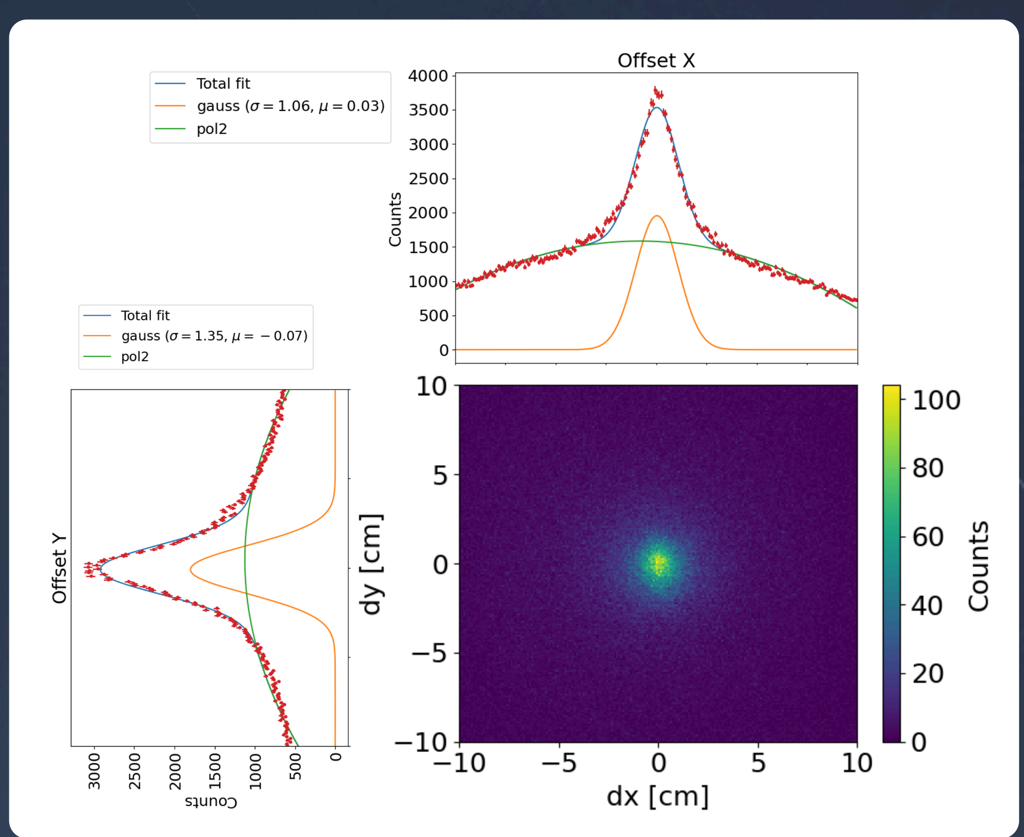
Aerogel tile aging



- Aerogel tiles stored under nitrogen
- Concern: Aging over last 5 years
- Performance observable
  - No of photons / Cherenkov ring
- Less than 1% drop in efficiency!
- No blind spots observed



Spatial resolution via Ring - track matching

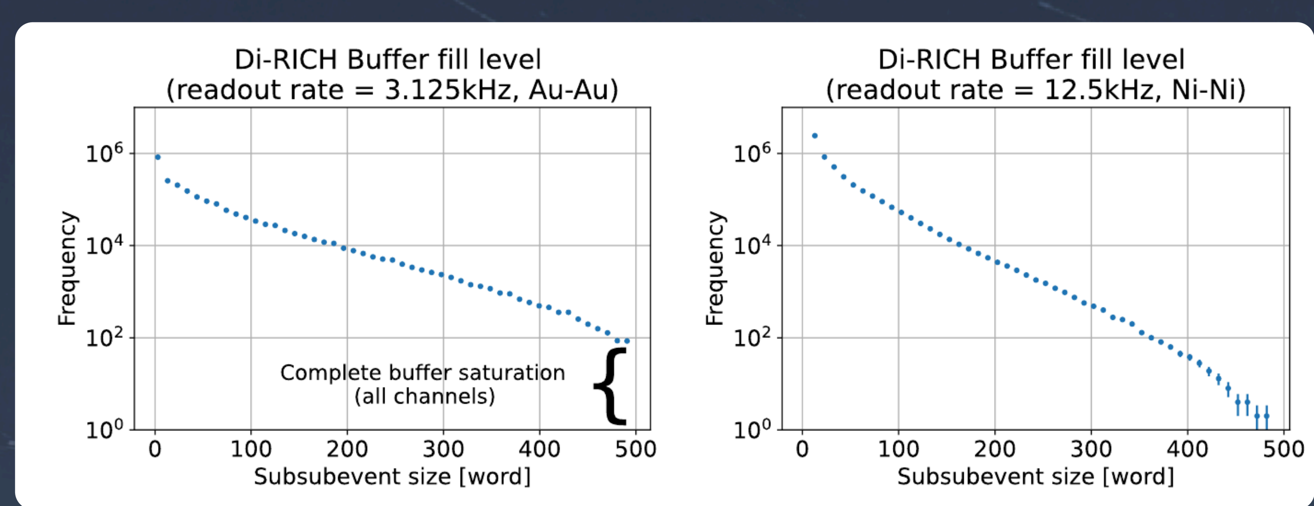


Tracks from the Silicon Tracking System and Time of Flight measurements were matched with RICH rings based on track projection towards RICH and matching of closest ring. Mean ring-track deviation was used to derive alignment offsets. Spatial resolution of matched track-ring pairs were found to be less than **1.5 cm** overall, with a resolution of 1.35 cm in Y and 1.06 cm in X direction.

Buffer management

Data could be lost in case of buffer overflow, this is a challenge for free-streaming readout, as FEB buffers are only emptied by periodic readout triggers.

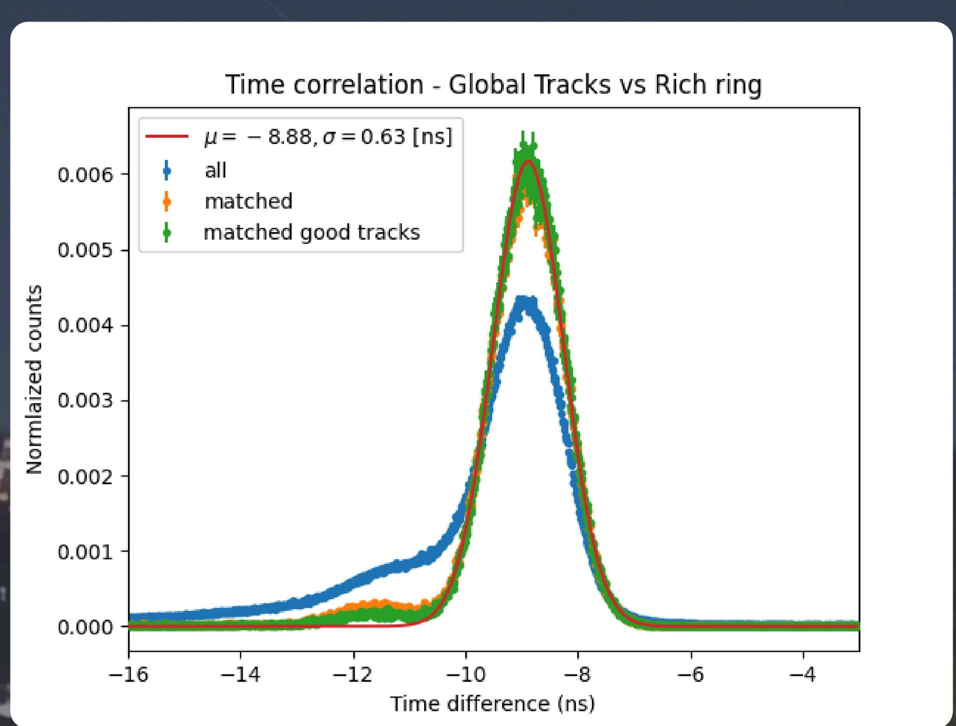
- DiRICH-FEB can store 490 words (15 words per channel, or 7 hits)
  - If the hit rate is too high then data will be lost
- Below are buffer fill levels for 2 runs
  - Au-Au with nominal readout rate → Saturated
  - Ni-Ni (smaller system) with 4 times higher readout rate → Not saturated



This demonstrates that increasing the CRI readout rate is an effective way to mitigate data loss. The readout chain must be able to handle high data rates without losing crucial information.

Timing Precision

We selected track-ring pairs based on their distance to measure the timing precision. This was achieved by subtracting the global track time from the median ring time. The RICH detector demonstrates a timing precision of **630 ps (sigma)** using mTOF as the global reference. This first result was obtained still without channel-individual time-offset calibration



Outlook

Future work on the mRICH detector focuses on:

- Firmware improvements: Increase of the Buffer size of the DIRICH FEB.
- Fully include mRICH into particle ID for mCBM
  - small acceptance makes this a challenge

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