OPTIMISATION OF THE CBM-RICH GEOMETRY
Outline

• Introduction

• Geometry Optimization of the PMT-plane
  • Rotation angles around x and y
  • Position y- & z-coordinates
  • Plane dimensions

• Shielding box

• Conclusion
Introduction

- **RICH concept:**
  - Radiator: $\text{CO}_2$;
    \[ \gamma_{th} = 33; \quad p_{\pi,th} = 4.65 \text{ GeV/c}; \quad V \approx 30 \text{ m}^3; \quad L=1.7 \text{ m} \]
  - Mirror: SIMAX-glass, Al+MgF$_2$;
    \[ R = 3 \text{ m}; \quad d \leq 6 \text{ mm}; \quad 11.8 \text{ m}^2; \quad \text{tiles of } 40 \times 40 \text{ cm}^2 \]
  - Photon detector:
    H12700 series of Hamamatsu (5.3x5.3 cm$^2$)

- **Implemented** in the CBMRoot framework
Introduction

- **Problems with stray field:**
  - Stray field at the PMT plane around 100 mT
  - PMT’s QE drops at fields higher than 1 mT!
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• **Solution:**
  - Rotating the mirror-PMT plane system by $\beta=10^\circ$
  - Shielding with a box of steal

• **Consequences:**
  - Optimised PMT geometry destroyed!
  - Re-optimisation
Simulations Environment

- **Starting point:**
  - RICH mirror rotated by 10° to escape the stray field in the vicinity of the PMTs
  - Y=162 cm and Z=212.6 cm, $\theta_X = 5°$ and $\theta_Y = 5°$
Simulations Environment

- **Strategy:**
  - Scan wide ranges of rotation angles \((\theta_X, \theta_Y)\) and position coordinates \((y,z)\)
  - Simulate 10k events of \(e^\pm\) within CBM acceptance with \(0 < p_t < 4\) GeV/c
  - Fit rings with **elliptical fit** and look at *ring* parameters:
    - \(dR\), ring resolution \(\rightarrow\) minimise
    - \(B/A\), ellipticity \(\rightarrow\) maximise
  - Look at control parameter:
    - \(\alpha\), incident angle of photons at PMT-plane. Can be tolerated up to 40°

- **Procedure (4 steps):**
  - Find optimal \(\theta_X - \theta_Y\) – combination
    - Find optimal \(Y-Z\) – combination
      - Iterate
        - Optimise dimensions
Step 1: Scan Of Rotation Angles

- Ranges: $0^\circ < \theta_X < 31^\circ$ and $0^\circ < \theta_Y < 23^\circ$
- At each combination determine integrated values of $dR$, $B/A$, $\alpha$

Enlarged PMT: $(\Delta_Y, \Delta_Z) = (0,0)$
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<table>
<thead>
<tr>
<th>$\theta_X$</th>
<th>$\theta_Y$</th>
<th>$B/A$</th>
<th>$dR$</th>
<th>$\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>13</td>
<td>0.905</td>
<td>0.359</td>
<td>18.61</td>
</tr>
<tr>
<td>21.6</td>
<td>8.9</td>
<td>0.9</td>
<td>0.357</td>
<td>17.45</td>
</tr>
</tbody>
</table>

Broad $dR$ minimum and $B/A$ maximum.
Take: $\theta_X = 20^\circ$ and $\theta_Y = 10^\circ$
z- and y- coordinates are correlated
Find best z-y-combination (with highest $B/A$ and lowest $dR$)
Optimised coordinates with $B/A=0.9$, $dR=0.36$ cm, $\alpha=18.6^\circ$

Step 3: iteration (scan $\theta_X-\theta_Y$ ranges) $\rightarrow$ no changes in results
Step 4: Dimension Optimisation

- **PMT plane structured in modules:**
  - Each module contains 3x2 PMTs $\rightarrow$ 15.9 x 10.6 cm$^2$
  - Plane dimensions must be integer multiples of modules
  - Considering 7 x 7 modules
    $\rightarrow$ 14 x 21 MPTs $\rightarrow$ 74.2 x 111.3 cm$^2$
After All …

Optimized geometry with full acceptance

Best $B/A$ and $dR$ values on the area with highest ring intensity
Shielding Box

Volume:
\[ V = 0.1087 \text{ m}^3 \rightarrow \text{weight} = 850 \text{ kg} \]

Holes on:
- right and left sides for services
- outer sides for cooling

Space to PMT-plane:
- right, left, and outer sides: 5 cm
- inner side: 2 cm

Thickness:
- back & inner side: 3 cm
- inner side extension: 3.5 cm
- right, left, and outer sides: 1 cm
Remnant Stray Field

Maximum of about 1 mT at the left-bottom edge
Conclusion

• **RICH geometry optimized to cope with magnetic field**
  - Mirrors and PMT-plane cover the CBM acceptance
  - PMT-plane is implemented with details down to pixel level

• **Escaping/reducing the stray field:**
  - In the new geometry …
    - The mirror--PMT-plane system is rotated by $10^\circ$
    - Shielding box is designed and implemented
    - Possibility to implement $\mu$-metal between individual PMTs

• **Next:**
  - Test cylindrical PMT-plane geometry (closer to ideal case).