RICH Collaboration

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Supported by:

OPTIMISATION OF THE CBM-RICH GEOMETRY

Tariq Mahmoud, University of Giessen

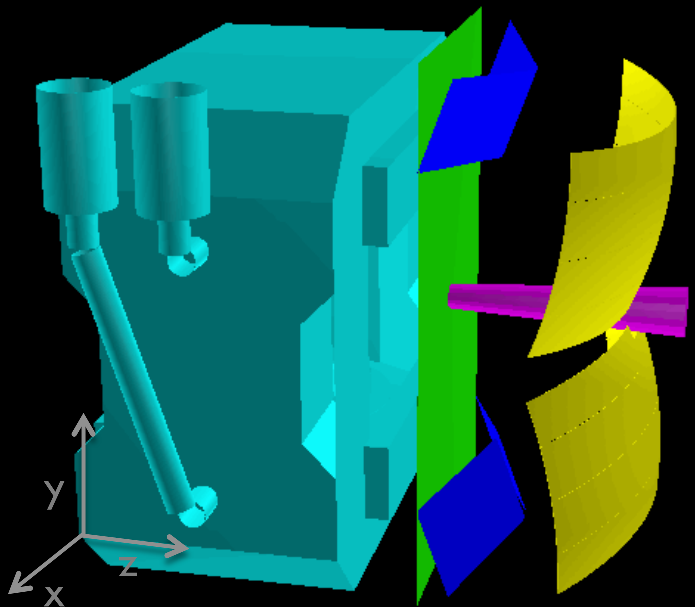
Outline

- Introduction
- Geometry Optimization of the PMT-plane
  - Rotation angles around x and y
  - Position y- & z-coordinates
  - Plane dimensions
- Shielding box
- Conclusion

Introduction

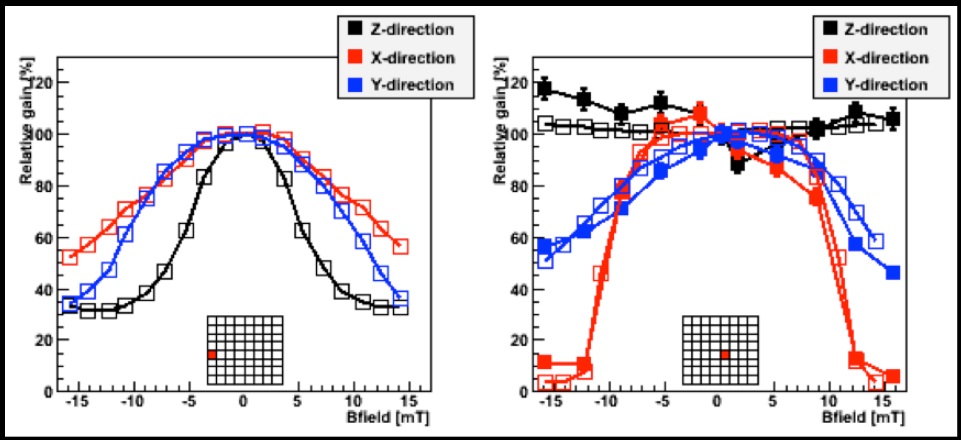
- RICH concept:
  - **Radiator:** CO_2;
    γ_{th} = 33; $p_{\pi,th}$ = 4.65 GeV/c; V ≈30 m^3; L=1.7 m
  - **Mirror: SIMAX-glass, Al+MgF_2**;
    R = 3m; d ≤ 6mm; 11.8 m^2; tiles of 40×40 cm^2
  - **Photon detector:**
    H12700 series of Hamamatsu (5.3x5.3 cm^2)

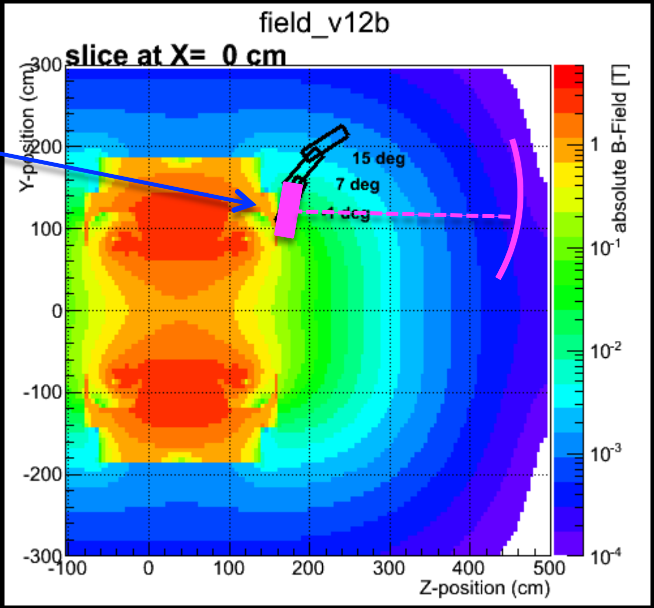
  - **Implemented** in the CBMRoot framework

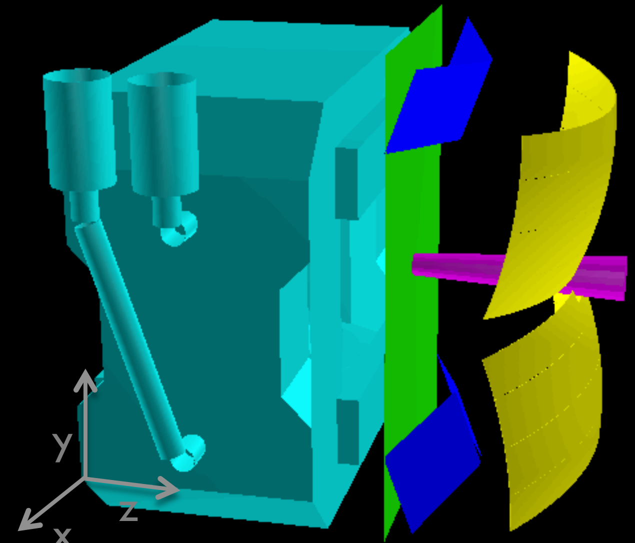


Introduction

- **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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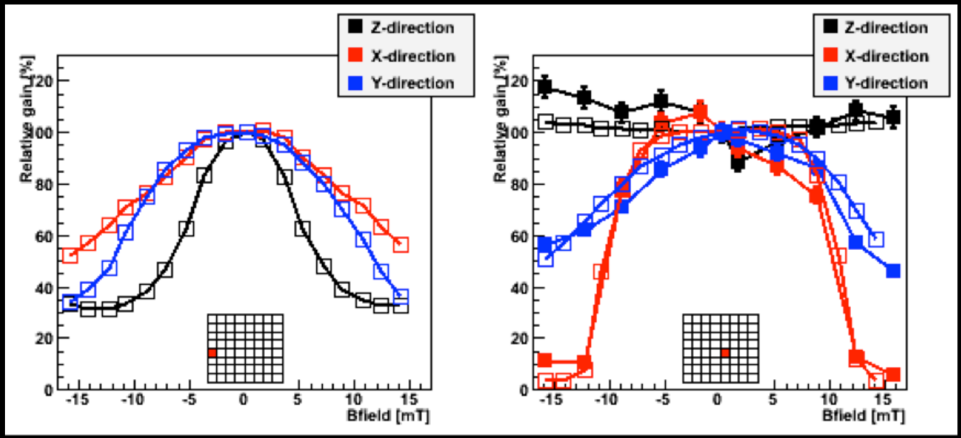
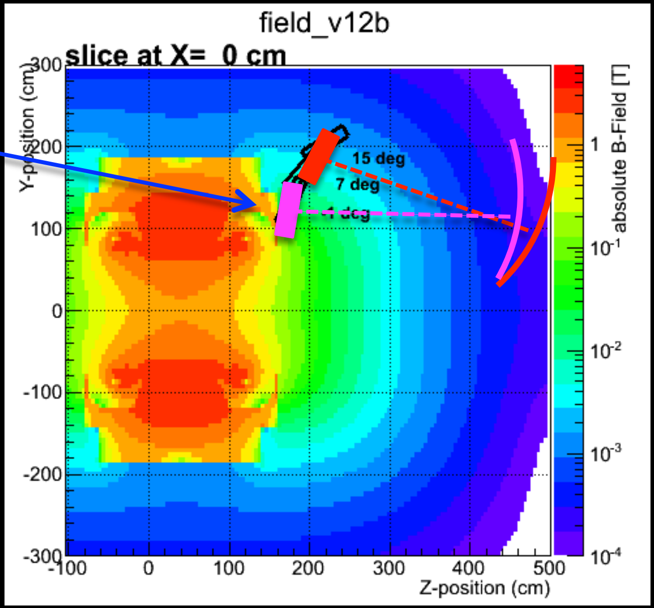
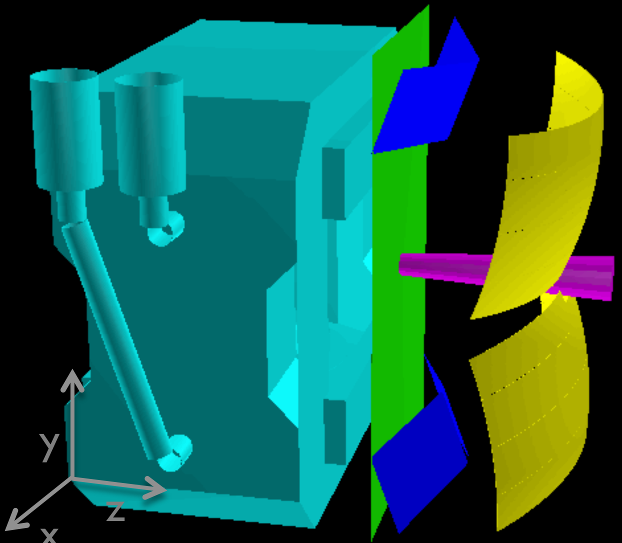




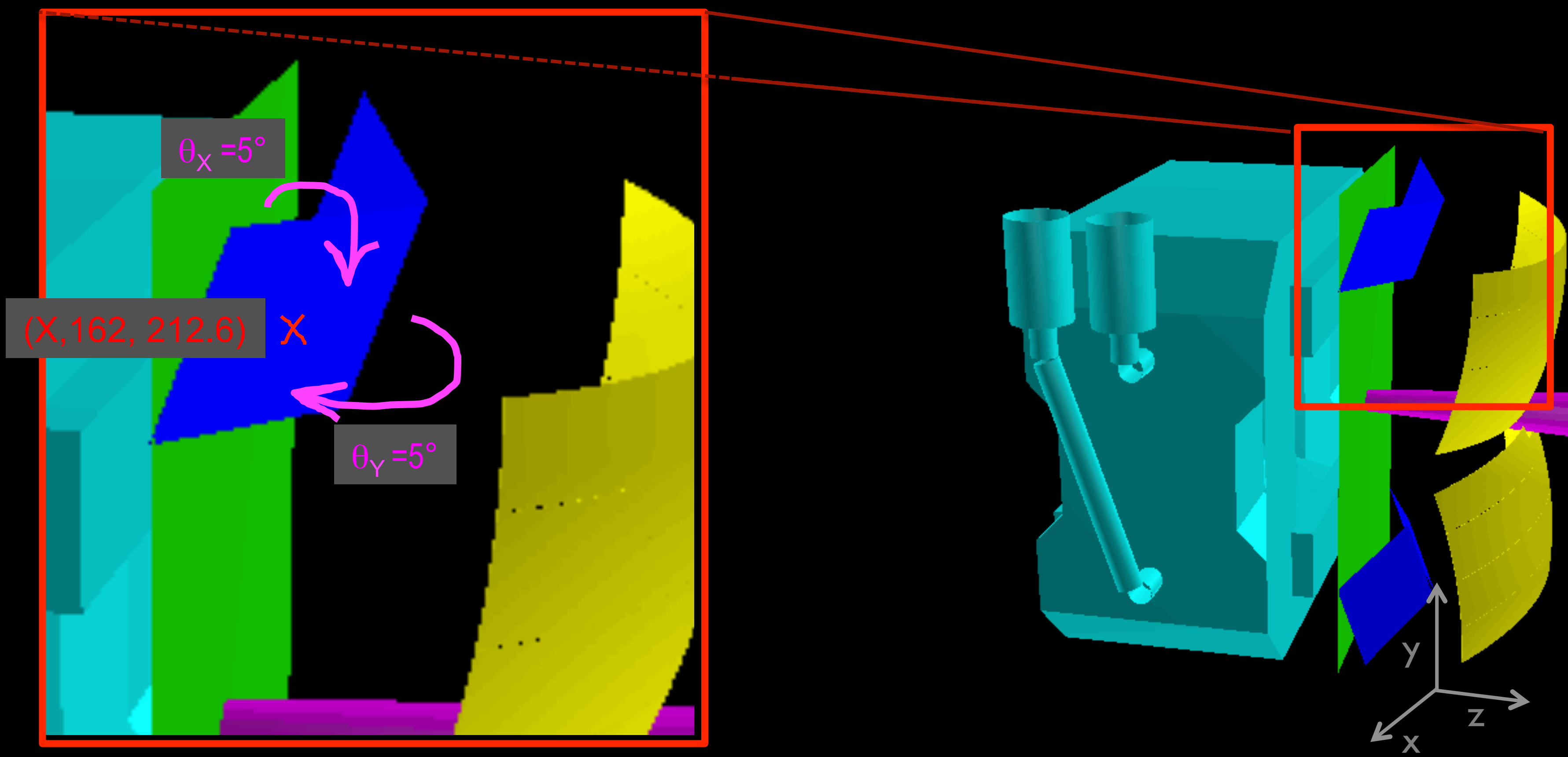
- **Solution:**
  - Rotating the mirror-PMT plane system by β=10°
  - Shielding with a box of steal

- **Consequences:**
  - Optimised PMT geometry destroyed!
  - Re-optimisation



Simulations Environment

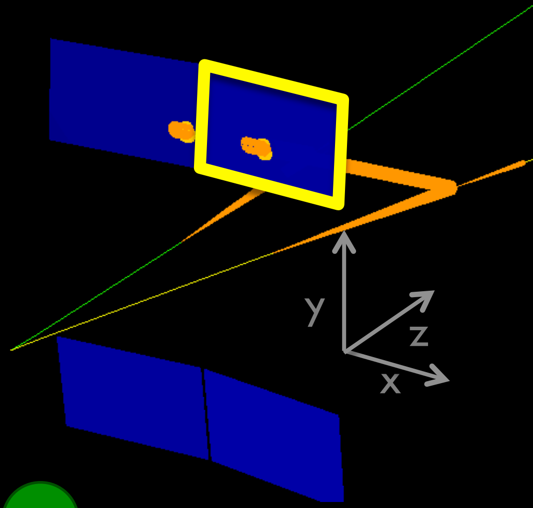
- Starting point:
  - RICH mirror rotated by 10° to escape the stray field in the vicinity of the PMTs
  - Y=162 cm and Z=212.6 cm, θ_X =5° and θ_Y =5°



Simulations Environment

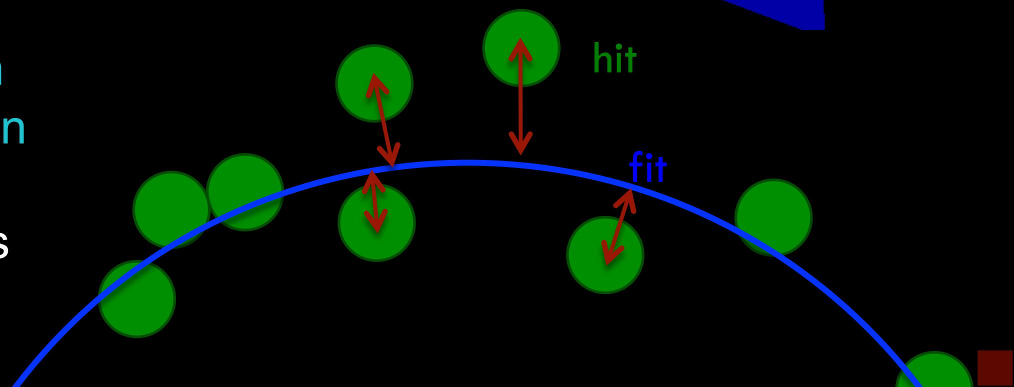
• Strategy:

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



• Procedure (4 steps):

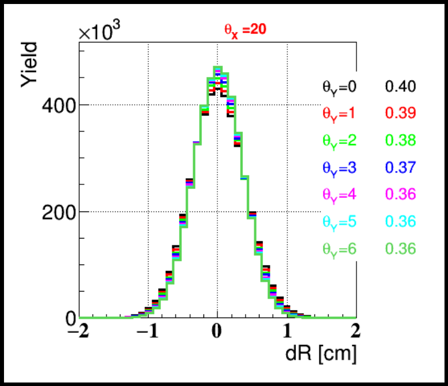
- Find optimal $\theta_X - \theta_Y$ – combination
  - Find optimal Y-Z – combination
    - Iterate
      - Optimise dimensions

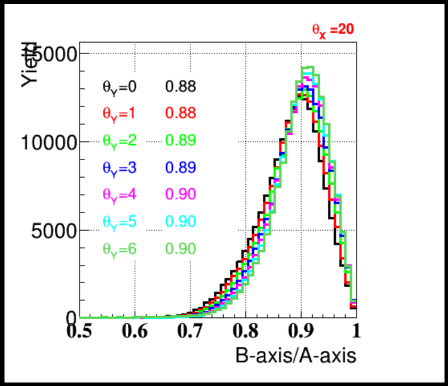


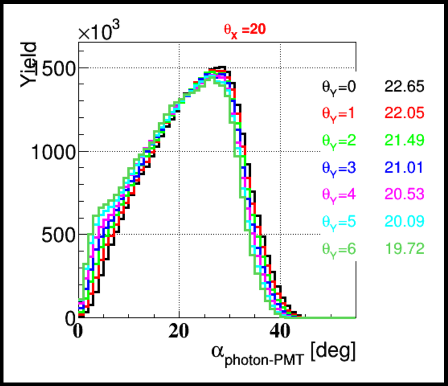
Step 1: Scan Of Rotation Angles

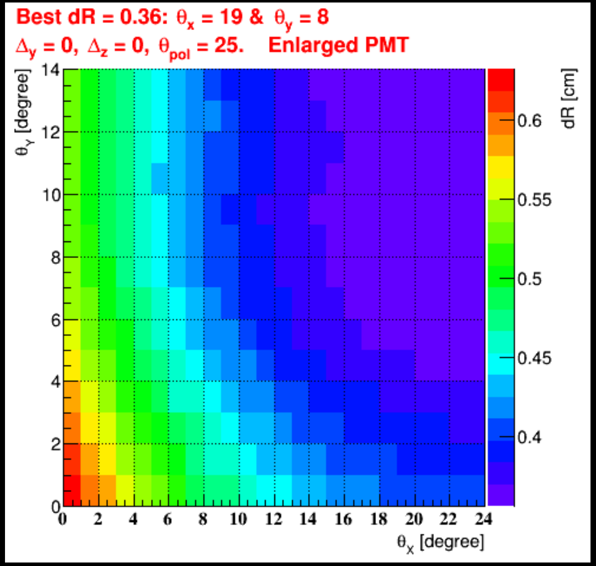
Enlarged PMT: $(\Delta_Y , \Delta_Z) = (0,0)$

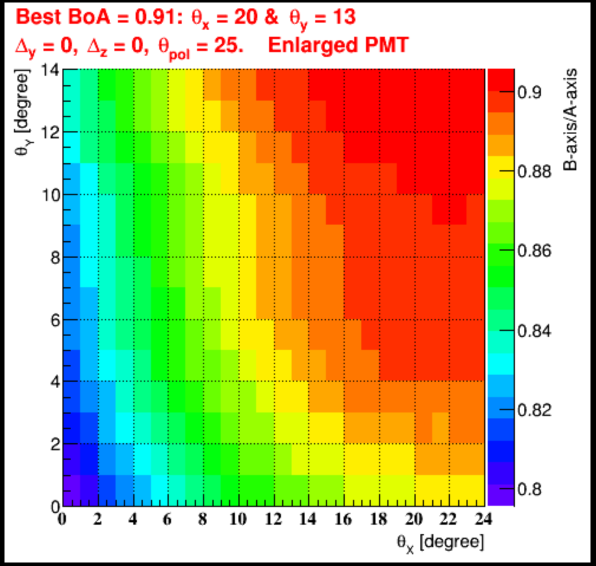
- Ranges: $0° < \theta_X < 31°$ and $0° < \theta_Y < 23°$
- At each combination determine integrated values of *dR, B/A,* α

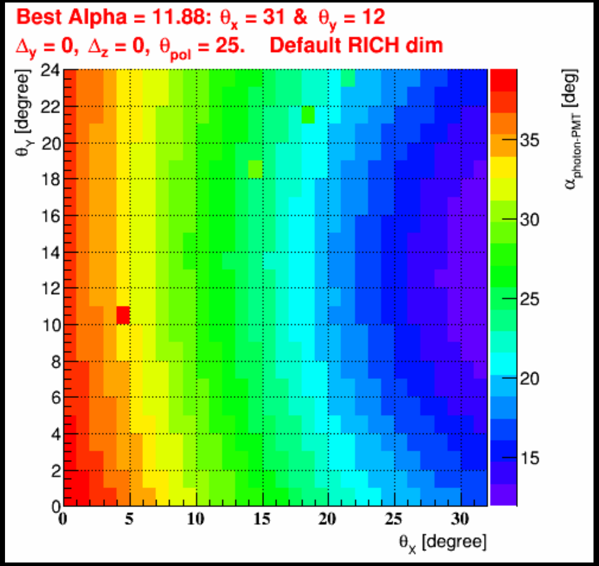












Step 1: Scan Of Rotation Angles

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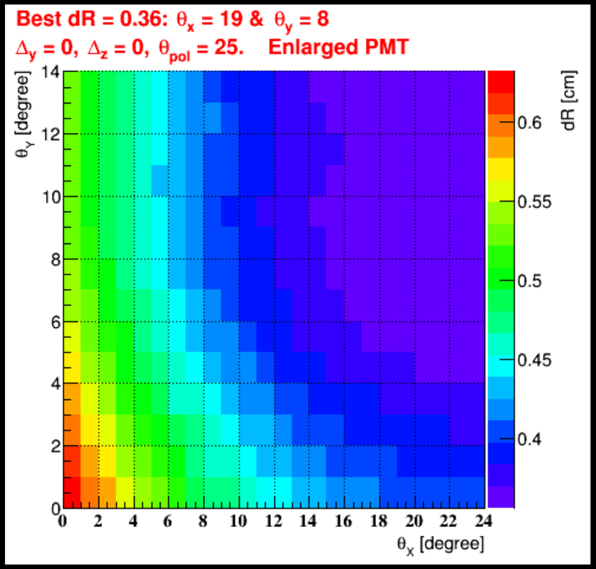
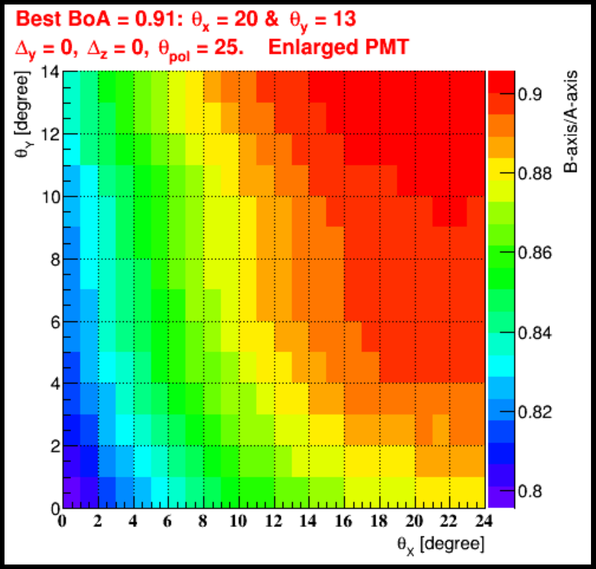
Enlarged PMT: $(\Delta_Y, \Delta_Z) = (0,0)$

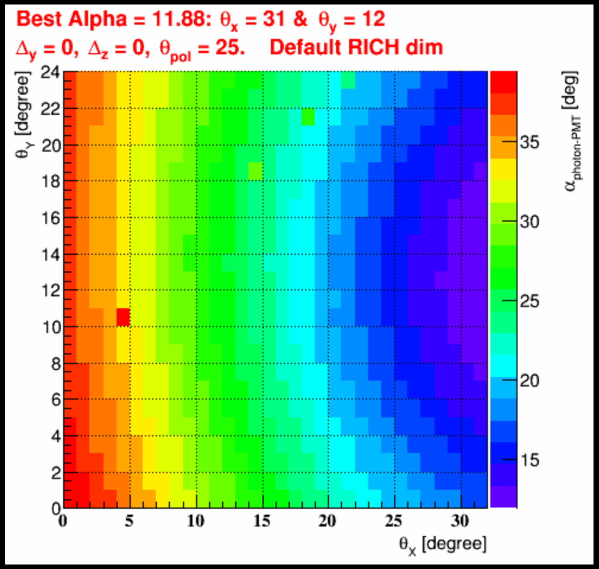
- Ranges: $0° < \theta_X < 31°$ and $0° < \theta_Y < 23°$
- At each combination determine integrated values of *dR, B/A, α*

Broad *dR* minimum and *B/A* maximum.
Take: $\theta x = 20°$ and $\theta y = 10°$

		Highest Mean	Lowest RMS	Lowest Mean
θ_X	θ_Y	B/A	dR	α
20	13	0.905	0.359	18.61
21.6	8.9	0.9	0.357	17.45

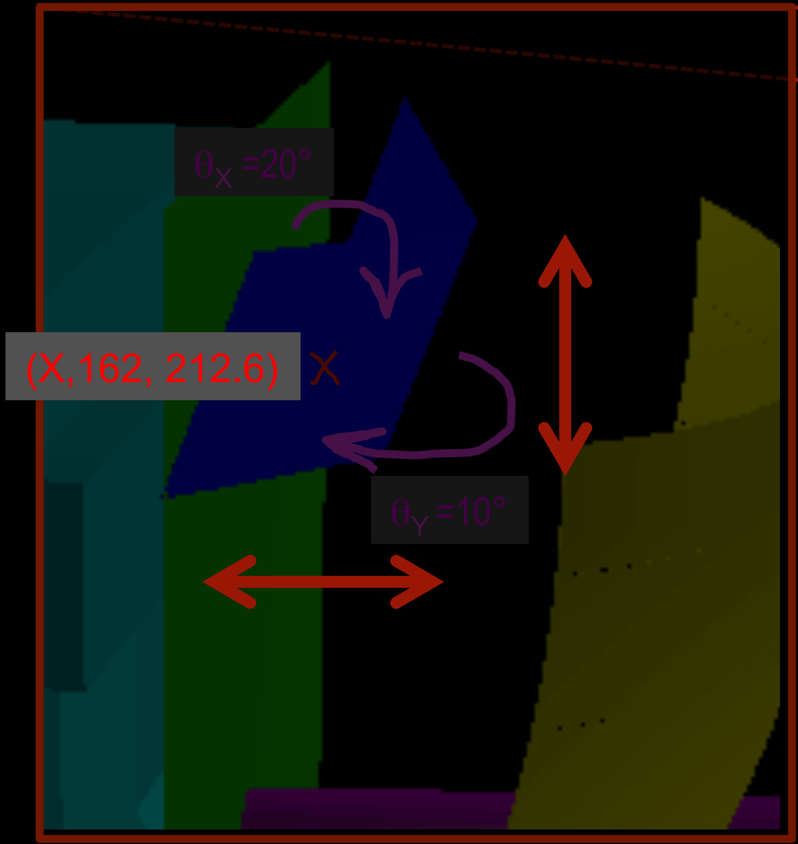


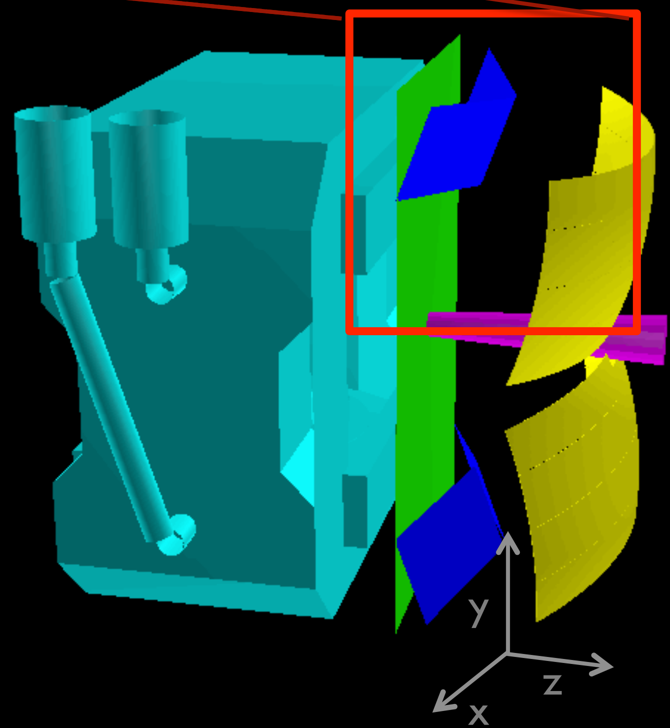




Step 2: Position Optimisation

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, α=18.6°

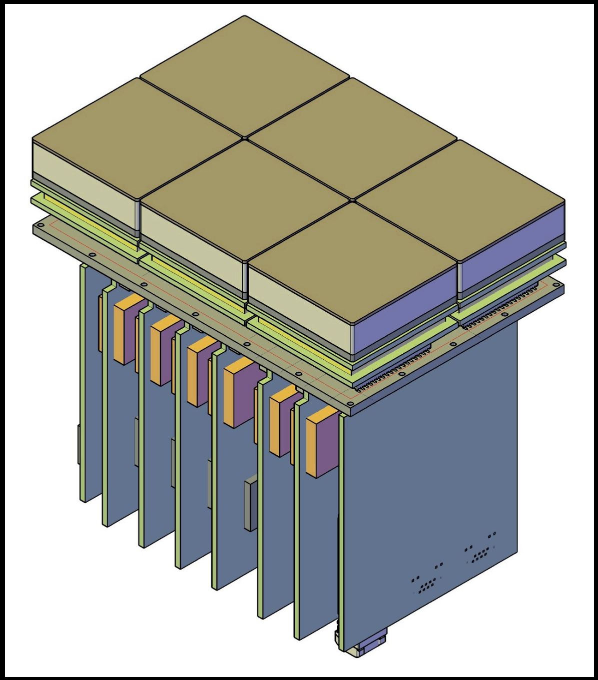




Step 3: iteration (scan θx-θy ranges) → no changes in results

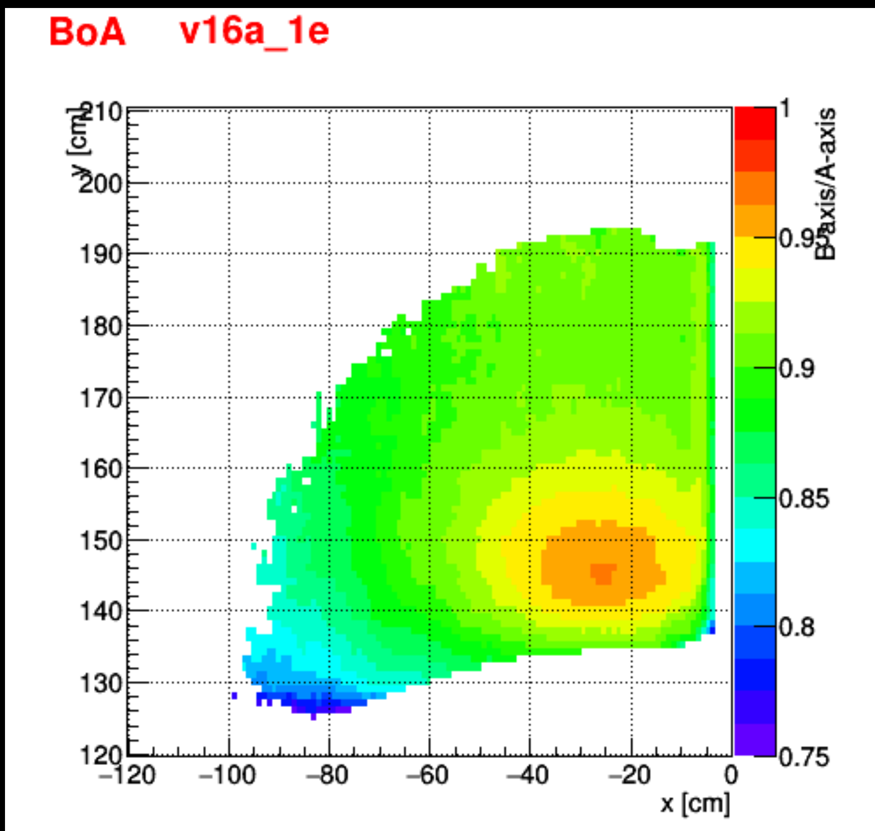
Step 4: Dimension Optimisation

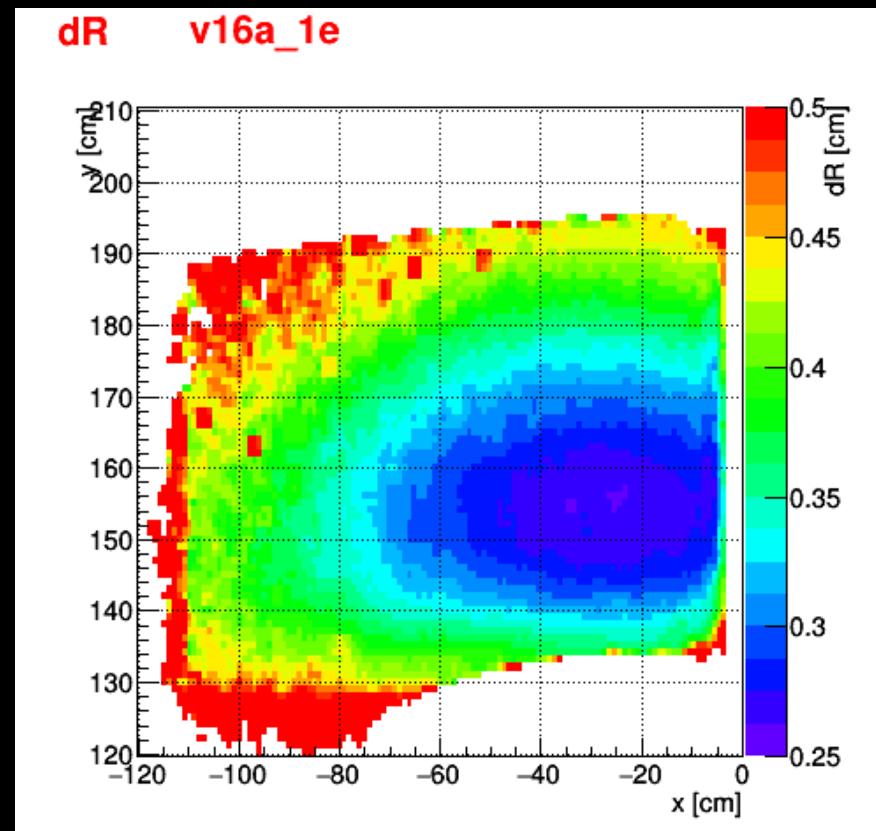
- PMT plane structured in modules:
  - Each module contains 3x2 PMTs → 15.9 x 10.6 cm^2
  - Plane dimensions must be integer multiples of modules
  - Considering 7 x 7 modules
    → 14 x 21 MPTs → 74.2 x 111.3 cm^2



After All …

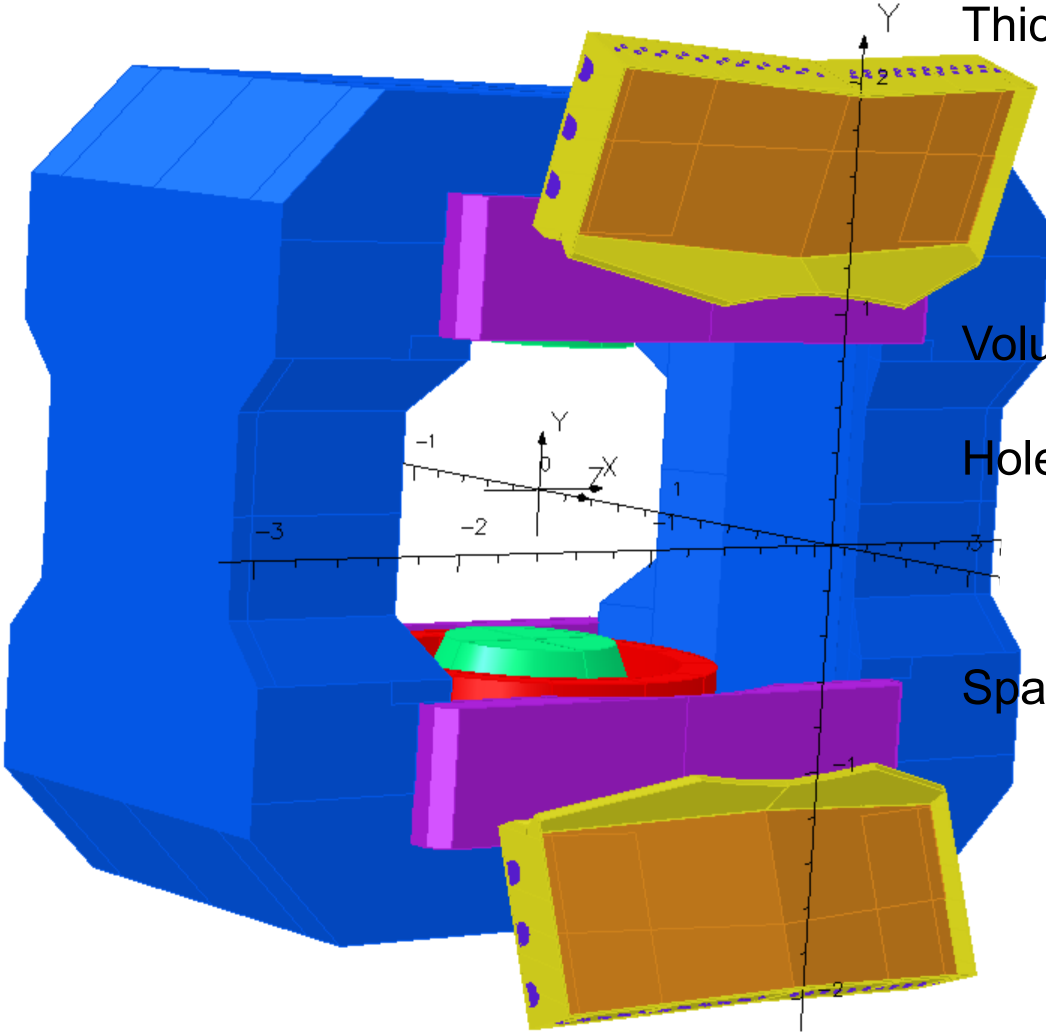
Optimized geometry with full acceptance





Best *B/A* and *dR* values on the area with highest ring intensity

Shielding Box



Thickness:

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

Volume:

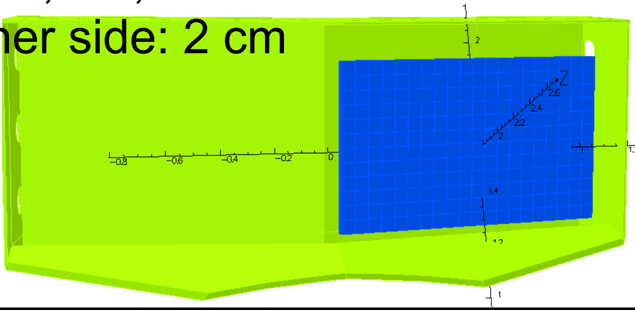
- $V = 0.1087\ m^3 \rightarrow$ weight=850 kg

Holes on:

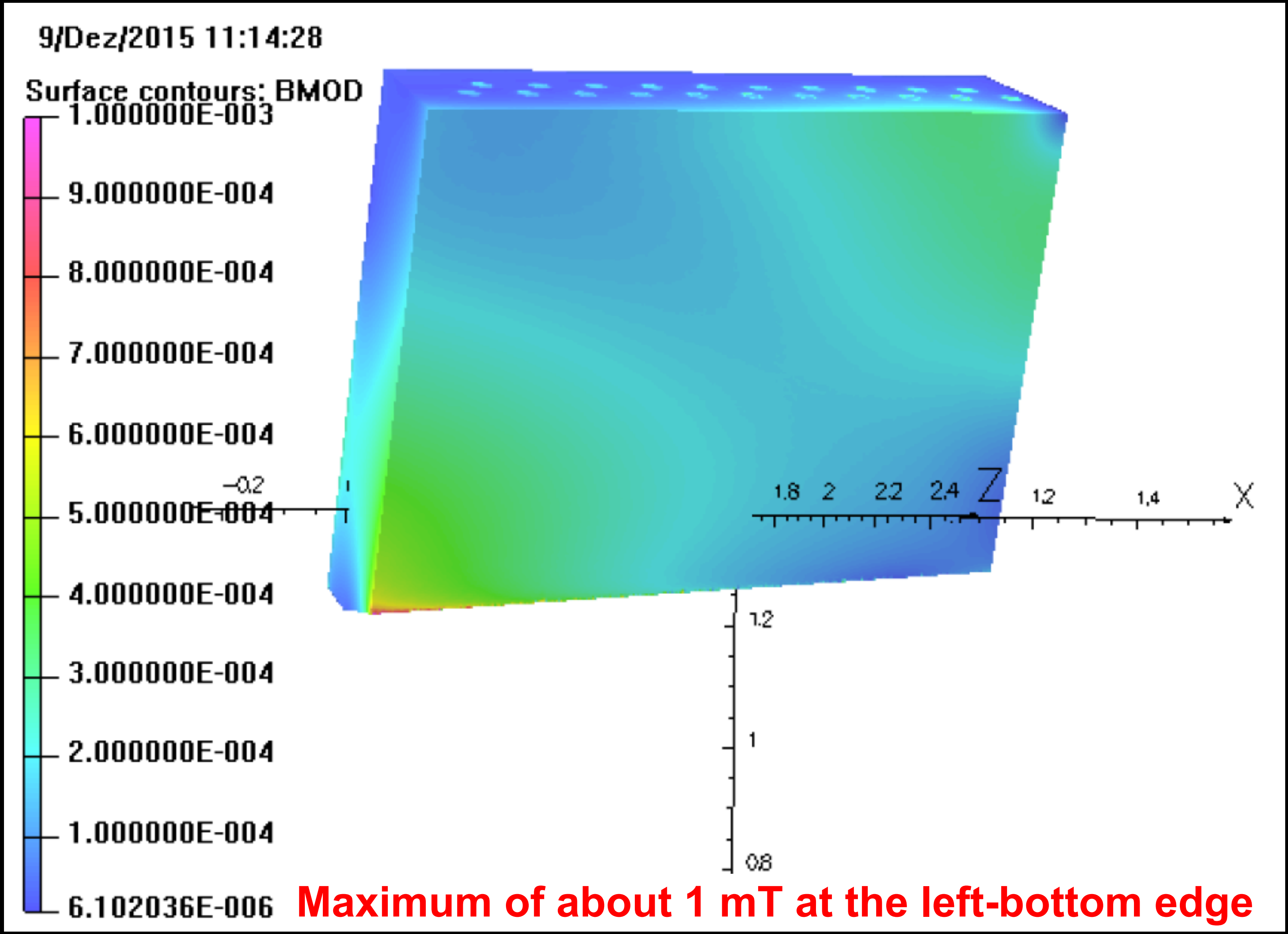
- right and left sides for services
- outer sides for cooling

Space to PMT-plane:

- right, left, and outer sides: 5 cm
- inner side: 2 cm



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°
    - Shielding box is designed and implemented
    - Possibility to implement μ-metal between individual PMTs

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