Design of a control and monitoring system for the mirror alignment of the CBM RICH detector*

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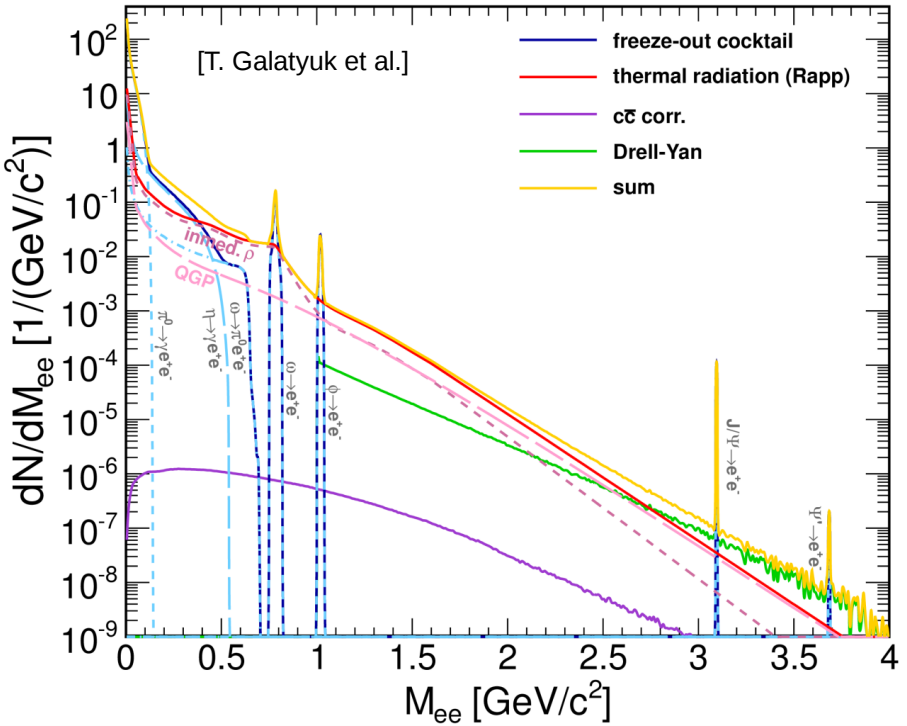
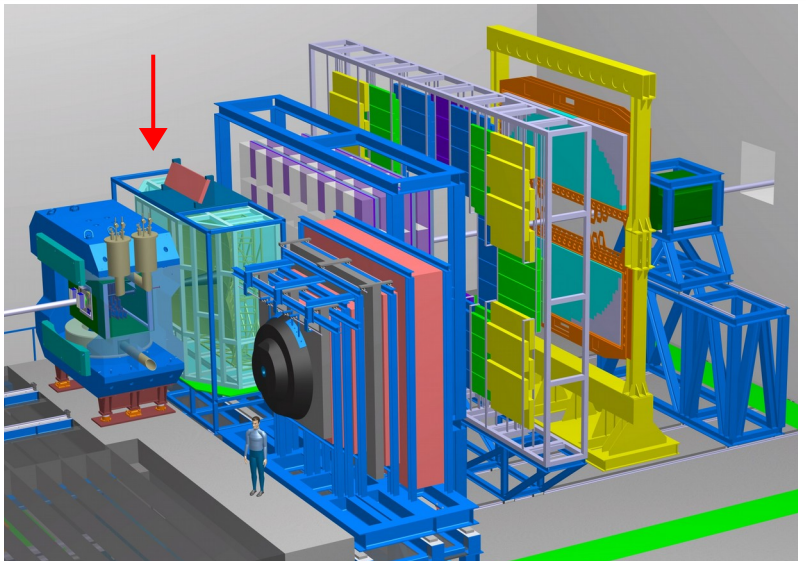
Introduction

- CBM at FAIR: explore the QCD phase diagram in the region of high baryon density with A+A collisions
- Energy range (Au-Au) from 2 to 11 AGeV beam energy @SIS100
- EM probes
  - $m_{ee} \leq 1$ (GeV/c²): γ, π⁰, η, ρ, ω, Φ
    γ: early temperatures of the fireball
    Low mass vector mesons: hadron dynamics
  - $1 \leq m_{ee}$ (GeV/c²) ≤ 3
    p_t slope: indicates thermal radiation of the fireball
    Also hints for a quarkyonic phase?
  - Higher energies (SIS300)
    J/Ψ: investigation of the charm quark propagation inside the medium
- Identify electrons with RICH detector
  - CO_2 radiator
  - 80 focusing spherical mirrors
  - Photon detector plane MAPMT

Au+Au collisions at 25 AGeV

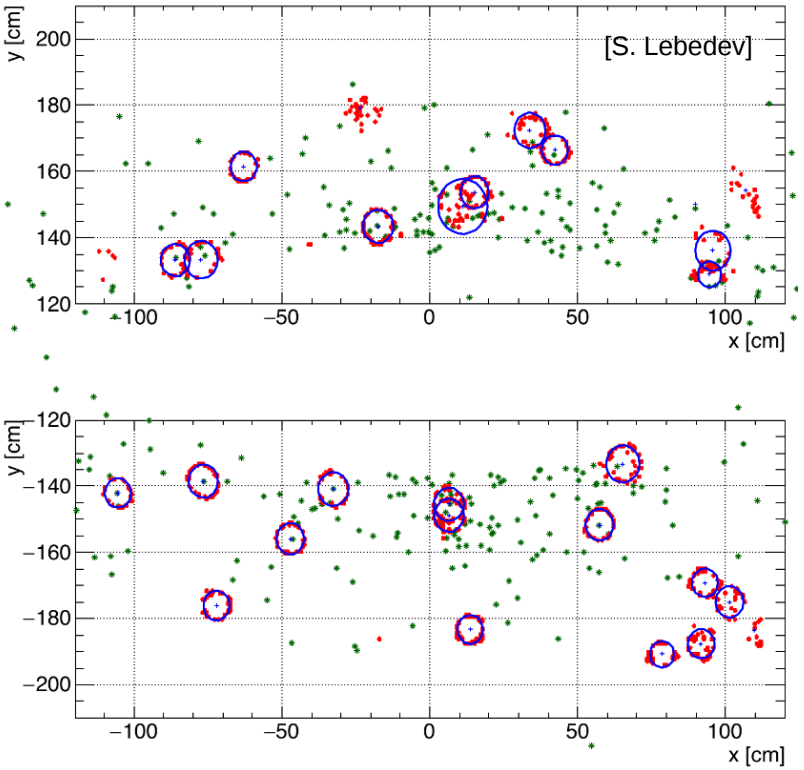




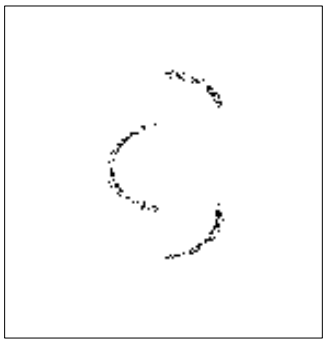
CBM detector set-up

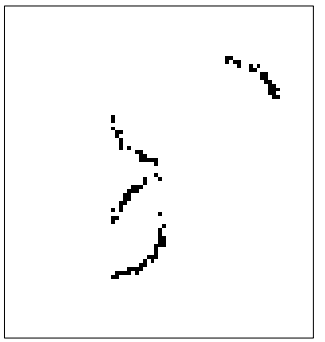
Introduction

- Challenges for CBM-RICH with respect to mirror precision:
  - Relatively high ring density environment
  - RICH will be exchanged with MUCH
- Perfectly aligned and stable mirror system is required for accurate and highly efficient ring reconstruction:
  expected ring reconstruction efficiency of 97% (Au+Au @ 8AGeV)
- In case of misalignment:
  - Efficiency losses in ring reconstruction: ring splitting, ring distortion, double rings, ring-track mismatches
  - Misidentification due to distorted ring parameters
- Development of an alignment correction cycle



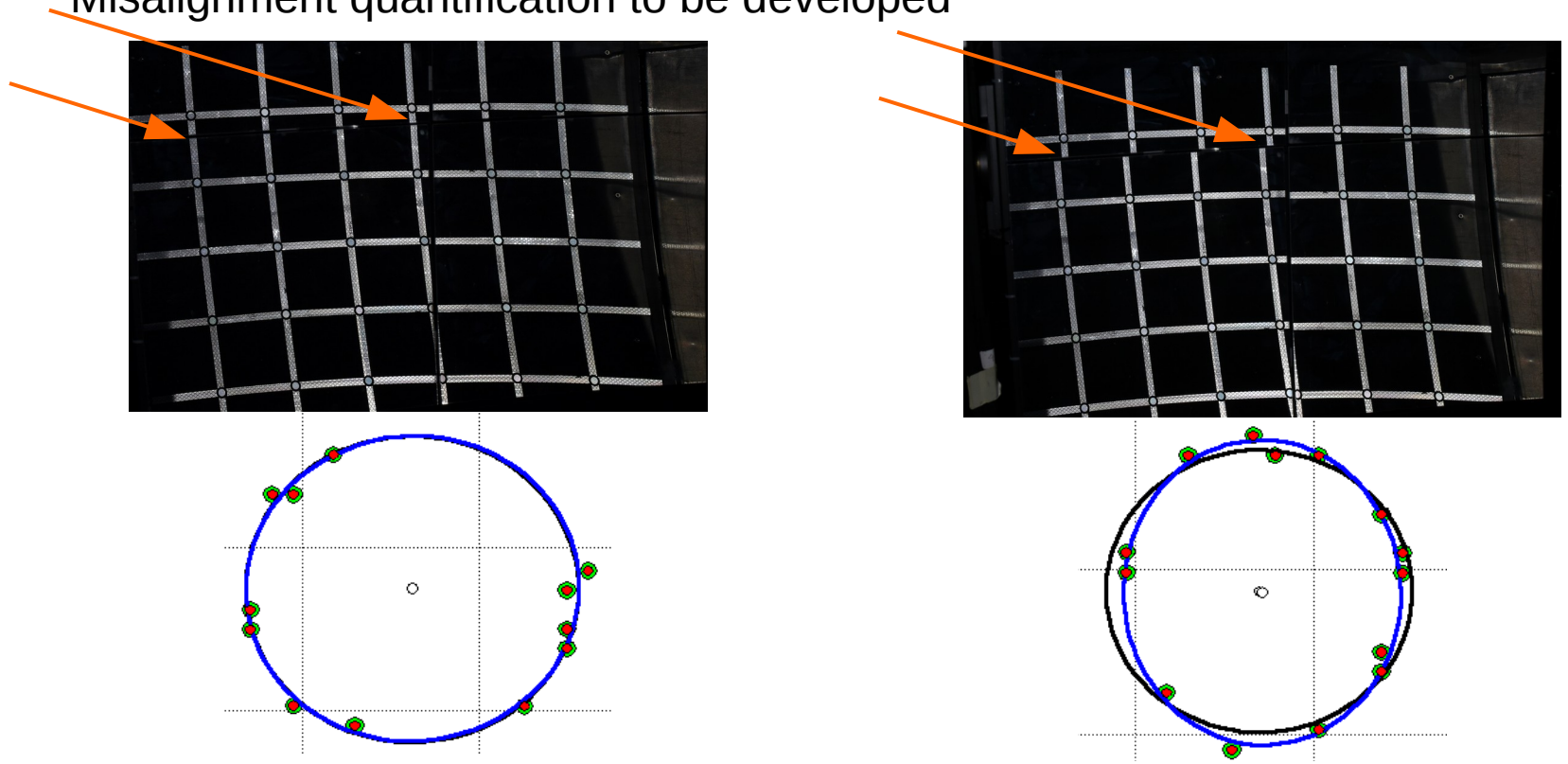
8 AGeV Au+Au collisions





Mirror alignment correction cycle

- Mirror alignment monitoring strategy
- Method based on hardware:
  - Fast qualitative monitoring with the CLAM* method
  - Misalignment quantification to be developed

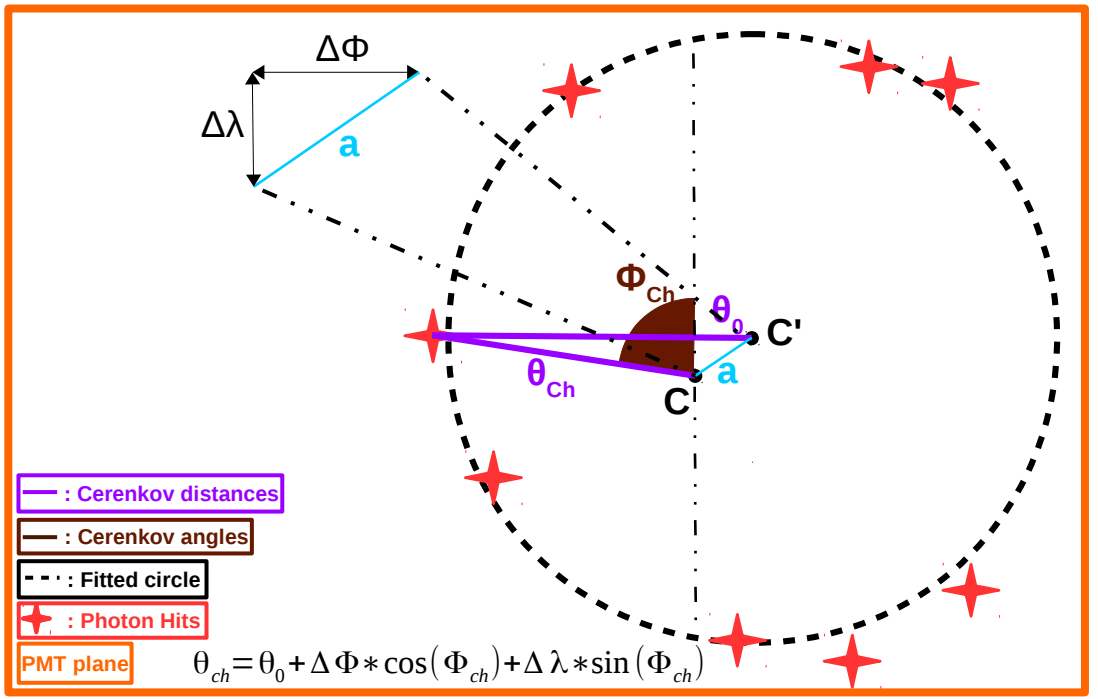


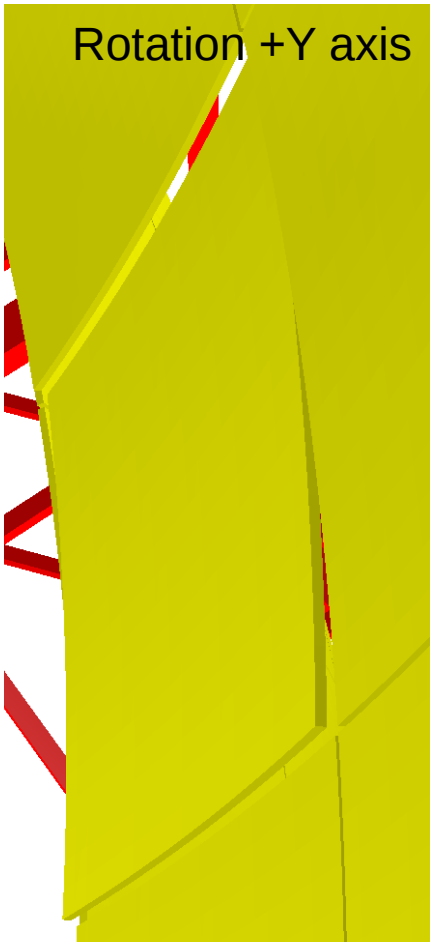
** Continuous Line Alignment and Monitoring method developed by COMPASS – Nucl. Instr. Meth. Phys. Res. A 595 (2008) 194*

- Method based on offline software correction presented here

Ring-Track distance*

- Distance calculated between fitted ring and extrapolated track hit on the PMT
- Parameter used to correct for mirror misalignments
- Mirror rotations definitions

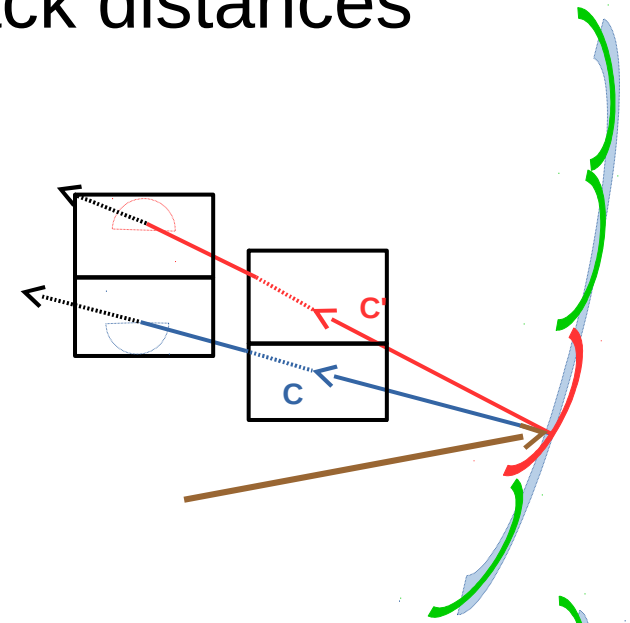


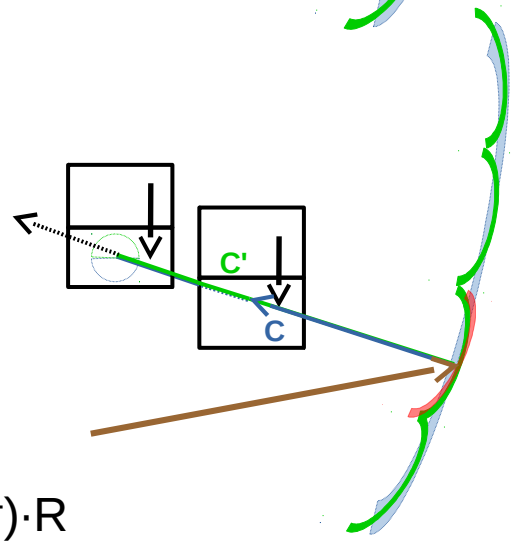


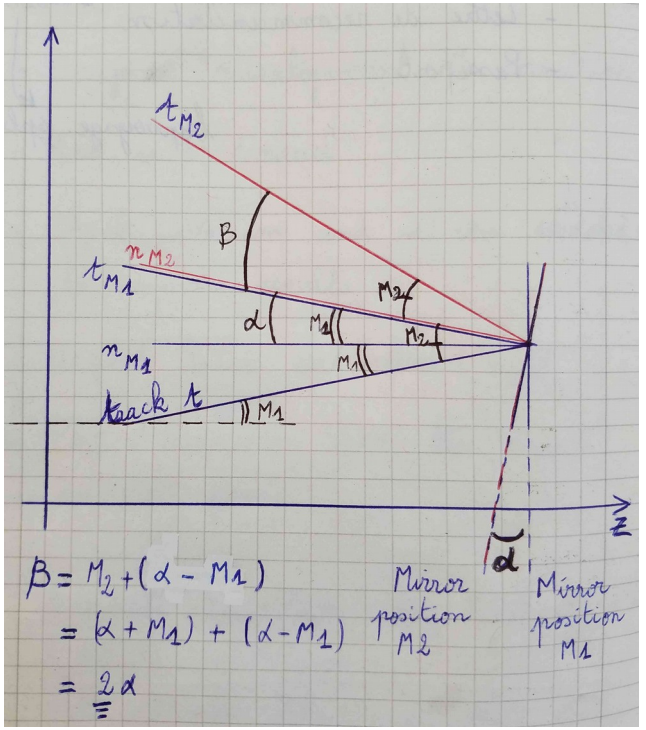
** Method inspired by the HERA-B experiment – Nucl. Instr. Meth. Phys. Res. A 433 (1999) 408*

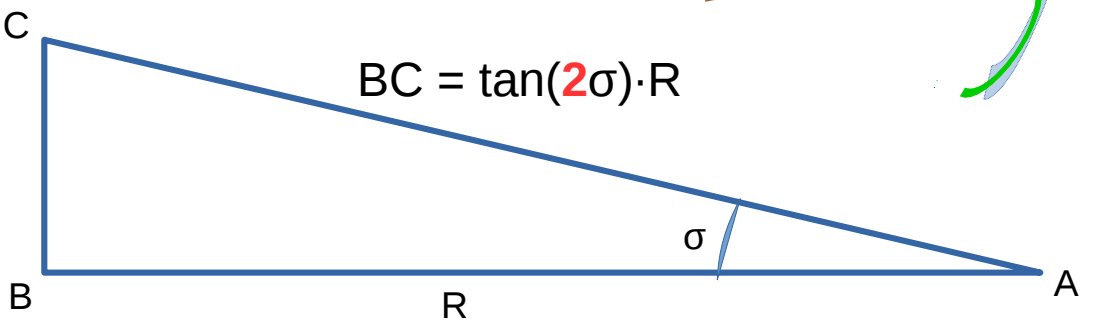
Impact of mirror rotations on ring-track distances

- Influence of misalignments on reflected photons and tracks
  - Brown: incoming track
  - Green: aligned mirror tiles
  - Red: misaligned mirror
- Correspondence mirror rotations versus shift on photon detector



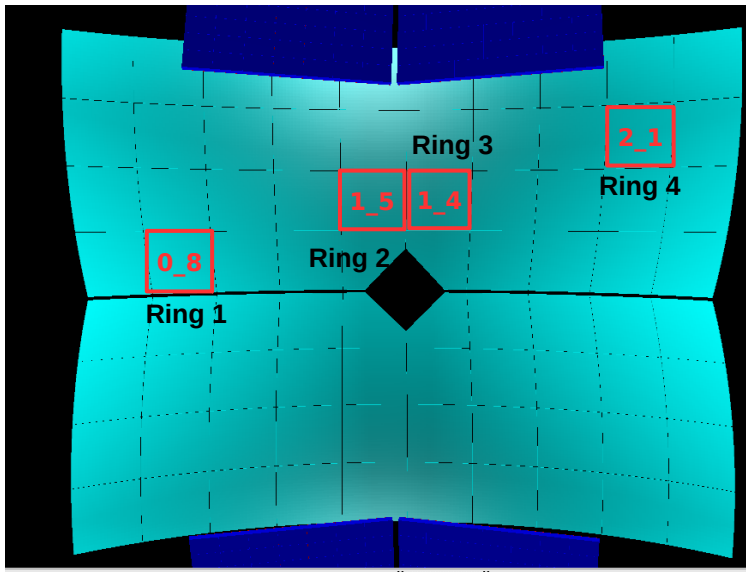


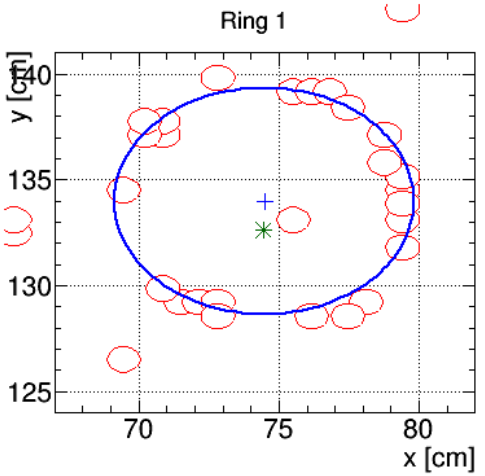


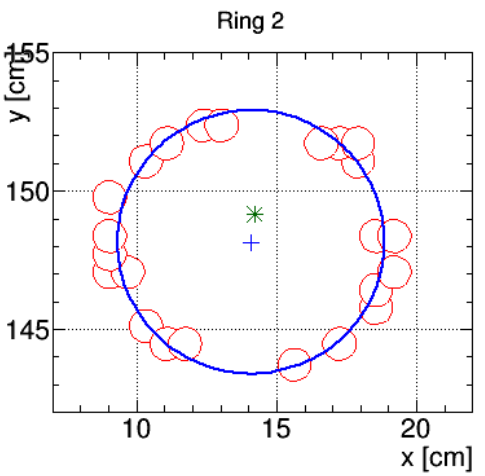


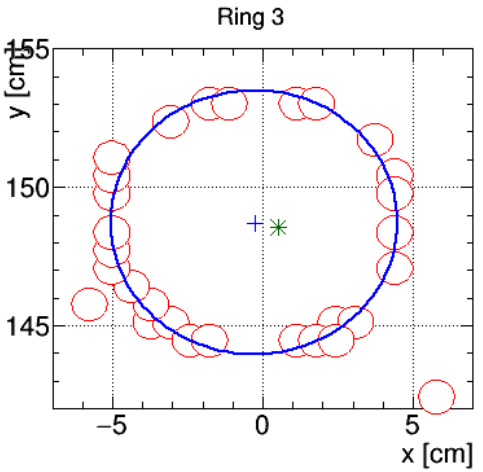
Impact of mirror rotations on ring-track distances

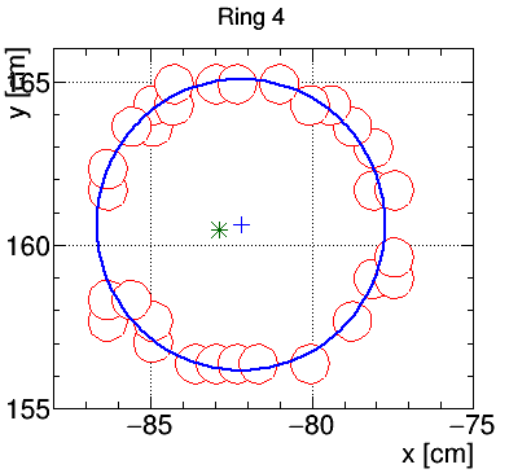
- Rotations: Top left: -X ; Top right: +X ; Lower left: -Y ; Lower right: +Y











Red circles: photon hits
Blue line: reconstructed ring from hits
Blue cross: center of reconstructed ring
Green star: extrapolated track hit

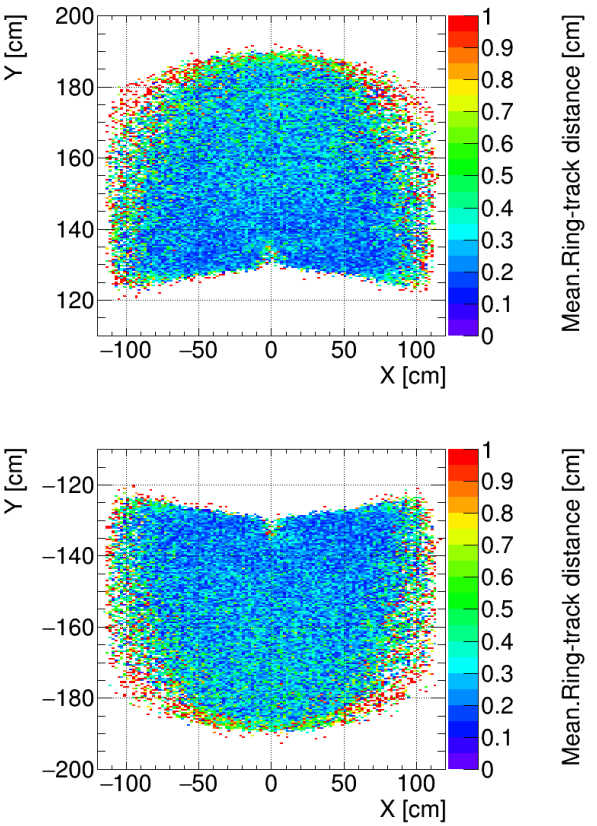
3mrad rotations applied, which corresponds to 0.9 cm shift

Correction cycle

- Run simulation data on a misaligned geometry
- Run first reconstruction:
  - Calculation of each mirror misalignments
  - Ring-track corrections computed
  - Corrections stored in a output file
- Run second reconstruction, where ring-track distances corrected with values from the output file
- One correction file per misaligned geometry required

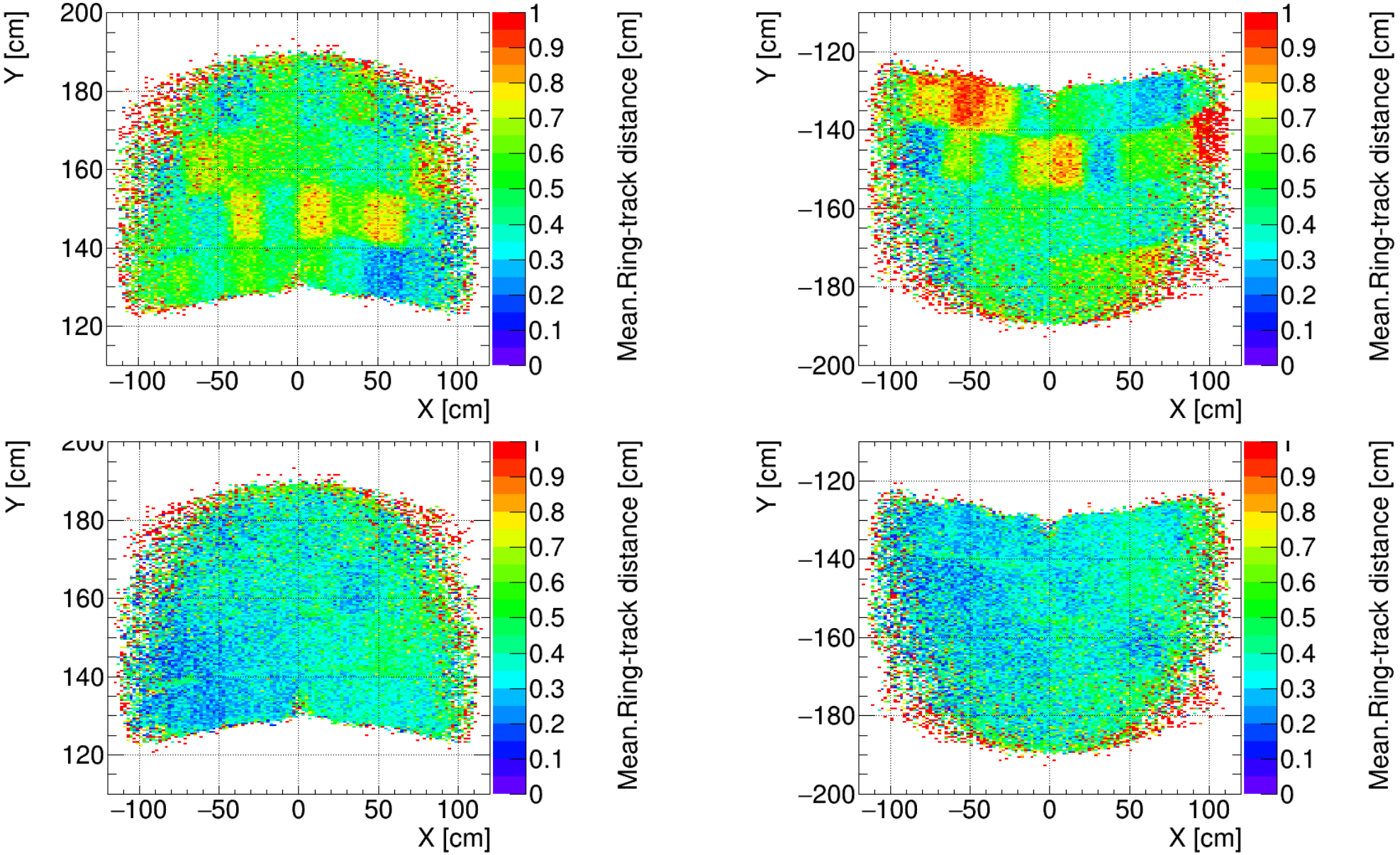
Parameters of the study

- Created misaligned geometry, where mirrors are randomly rotated with gaussian distribution
- Simulation data set run, with following parameters:
  - ~ 100k event with 4 e^- and 4 e^+
  - p in [1 GeV ; 9.5 GeV]
- Full photon detector coverage
- Several geometries simulated
- Automatic detection and correction for misalignments
- Following results shown without and with corrections



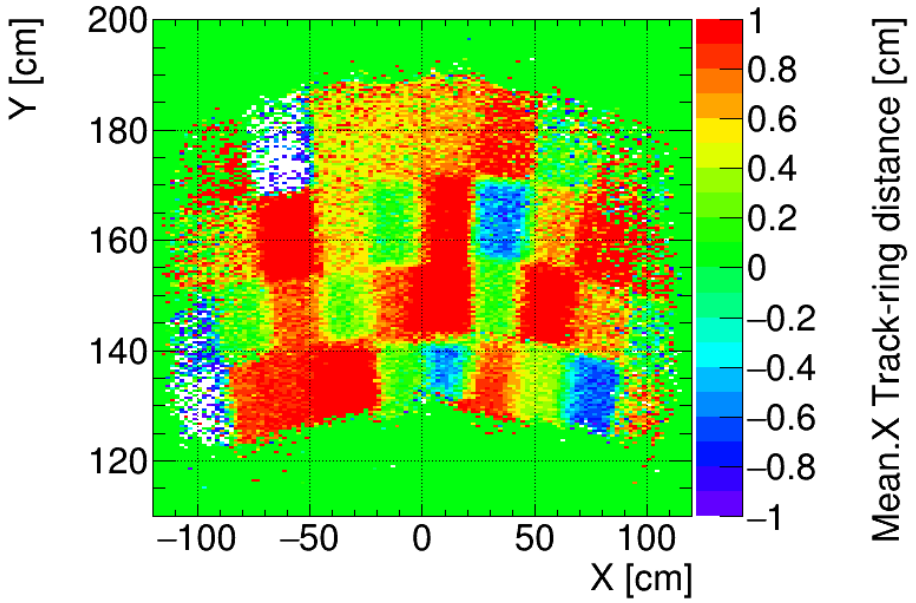
Residual misalignment of 0.67 mrad

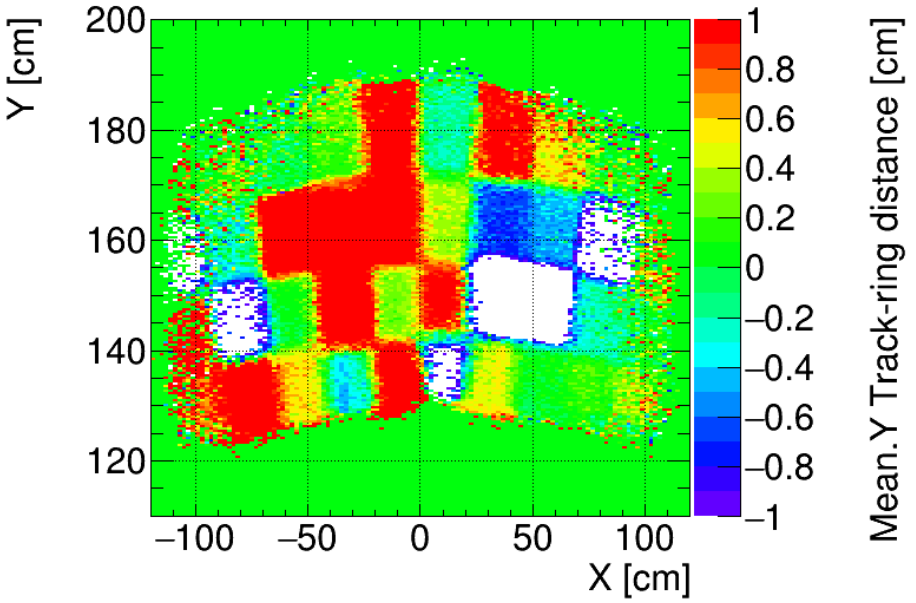
Ring-track distance correction for σ = 1 mrad ≡ 0.3 cm

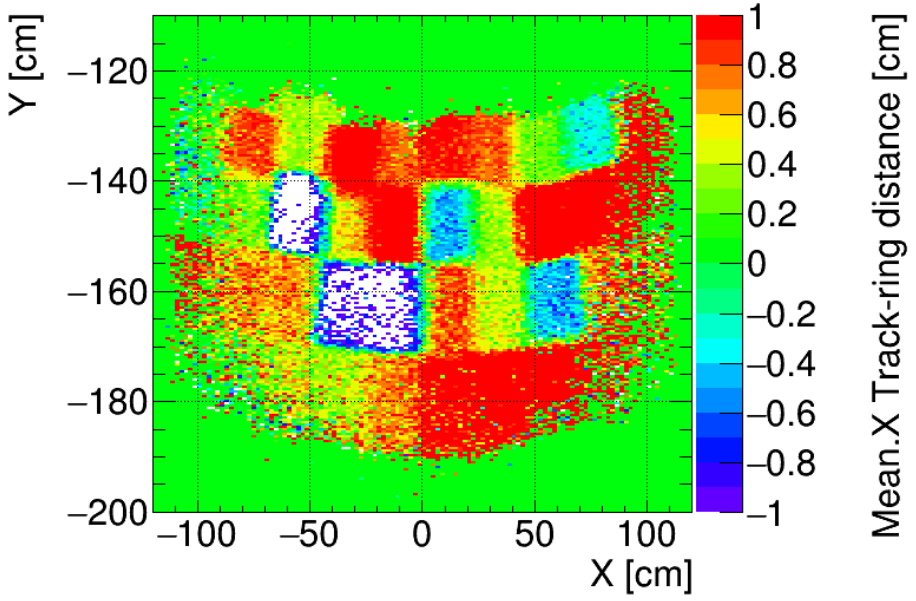


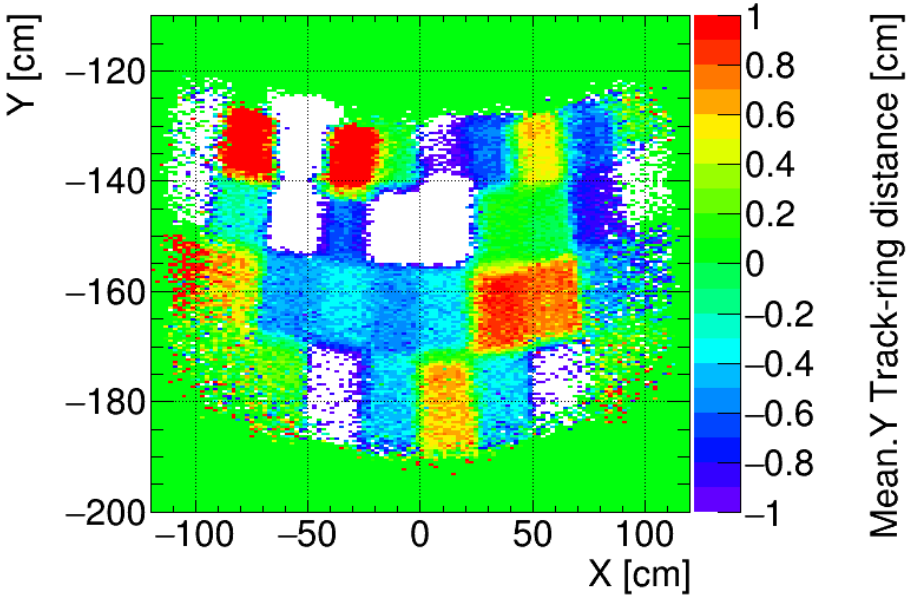
Residual misalignment of 1 – 1.2 mrad

Ring-track distance without correction for σ = 3 mrad ≡ 0.9 cm

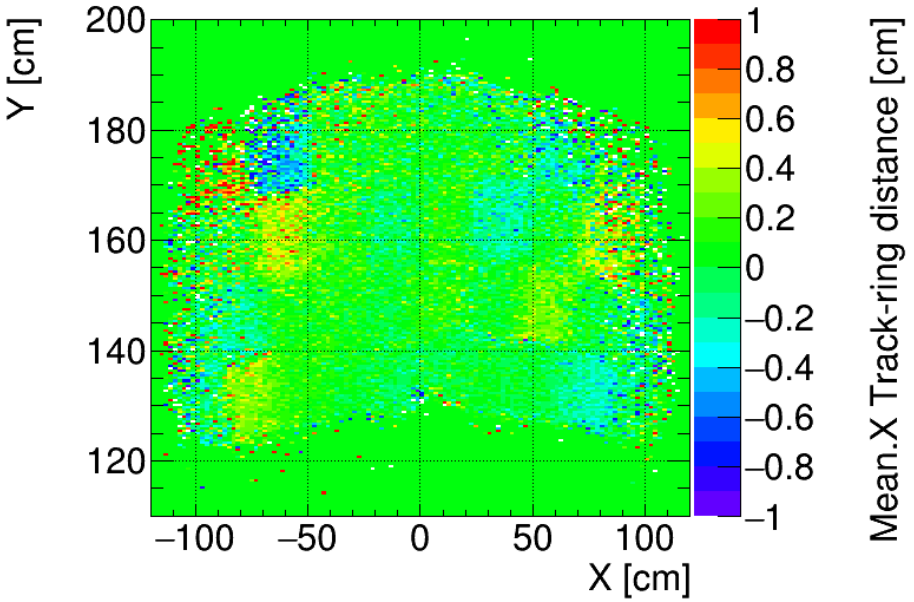


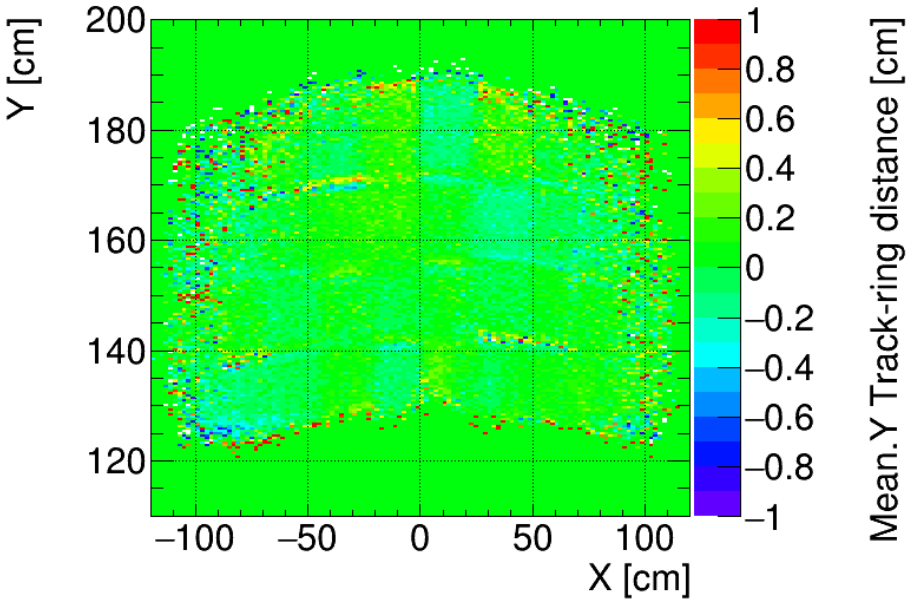


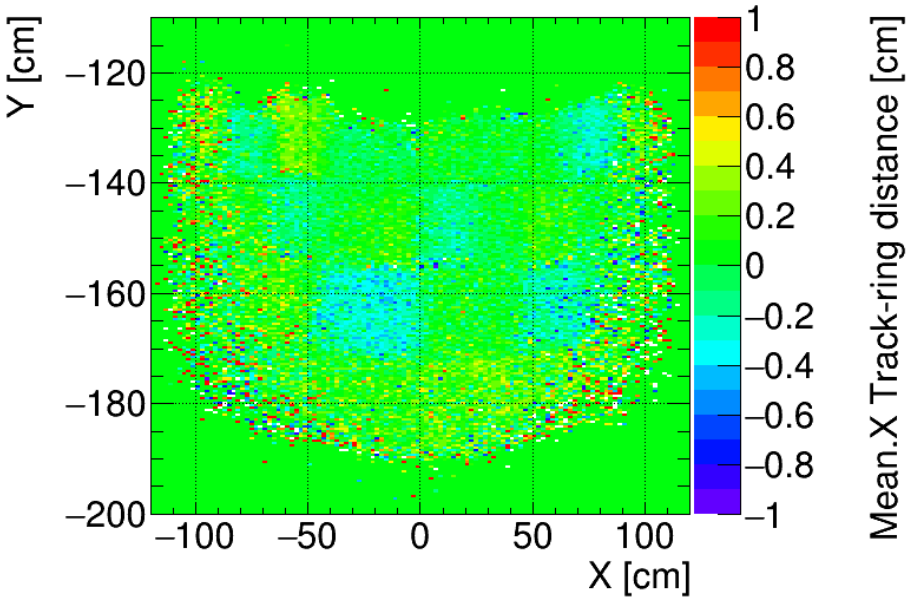


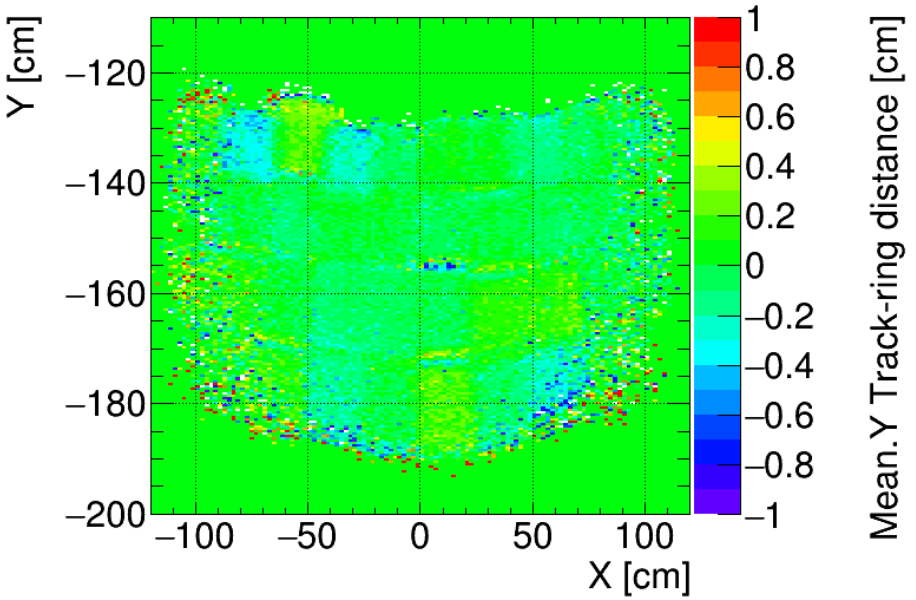


Ring-track distance with correction for σ = 3 mrad ≡ 0.9 cm









Residual misalignment of 0.67 mrad

Outlook

- Software correction cycle for mirror misalignments implemented
  - Investigate impact of correction routine on ring-track matching efficiencies and e^- ID efficiency
  - Run multiple corrections on same geometry
- Derive quantitative misalignment method from CLAM method

Thank you for your attention !