Barrel-DIRC Protoype – Test Beam Data Analysis

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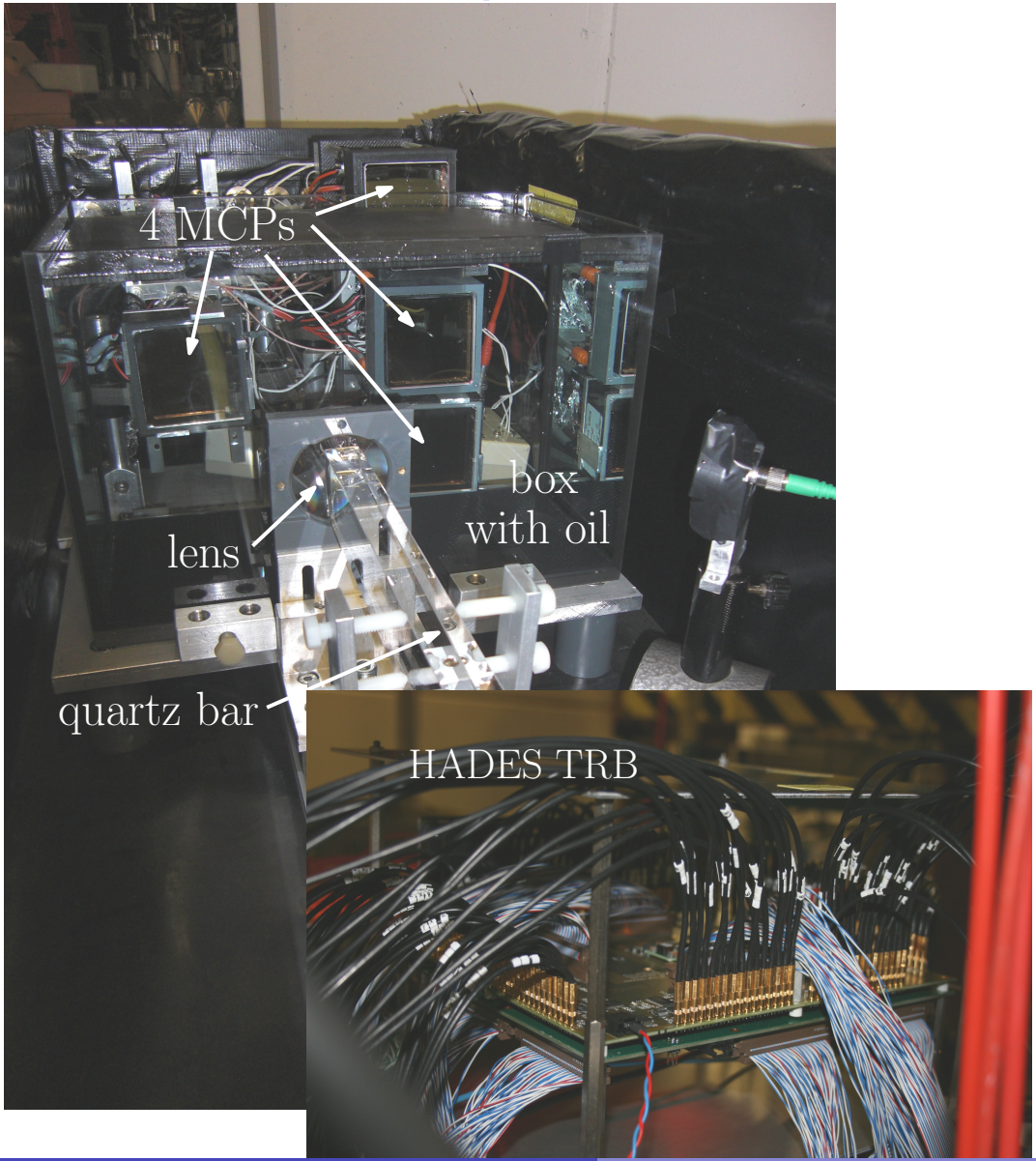
Test beam setup

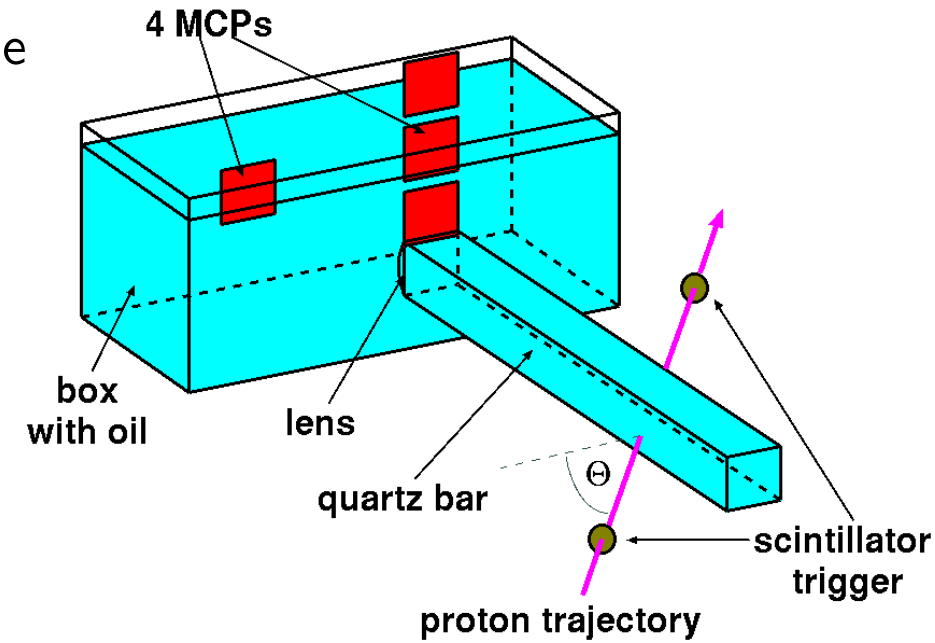


- Single fused silica bar (80 cm long)
- Spherical lens (BK7)
- Expansion volume filled with Marcol 82 oil
- 4 MCPs (Burle/Photonis 85011 and XP85013)
- Readout: HADES TRBs with HPTDCs & NINO chips
- Proton test beam ($T = 2\,\mathrm{GeV}$) in September 2009 at GSI

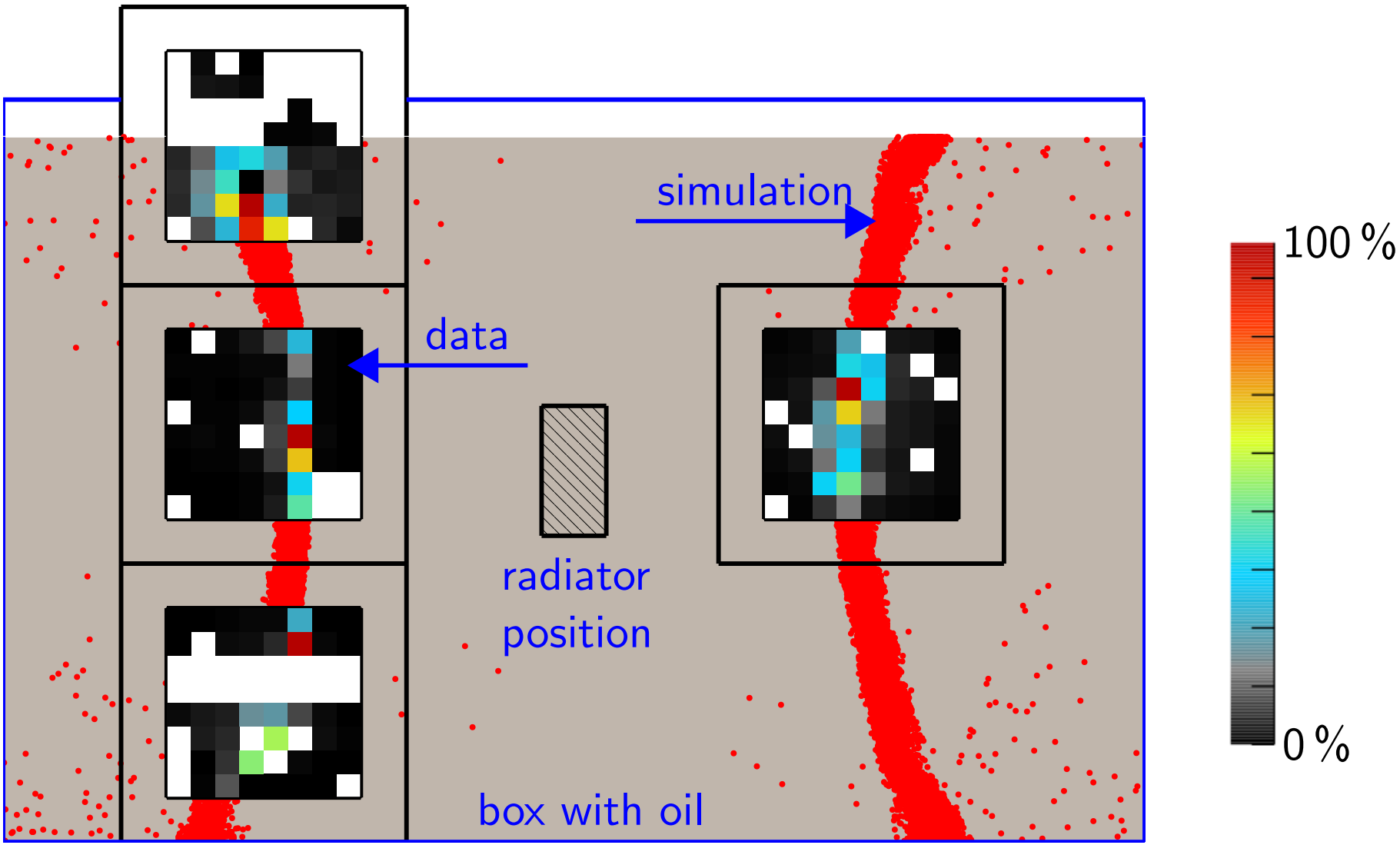
Goals of the prototype test

– Identification of Cherenkov rings
– Reconstruction of the Cherenkov angle

- Configuration:
  - Variation of beam incidence angle $\Rightarrow$ 2 different MCP positions are needed
  - Variation of beam position on radiator
- Simulation (drcprop) tuning for a better understanding

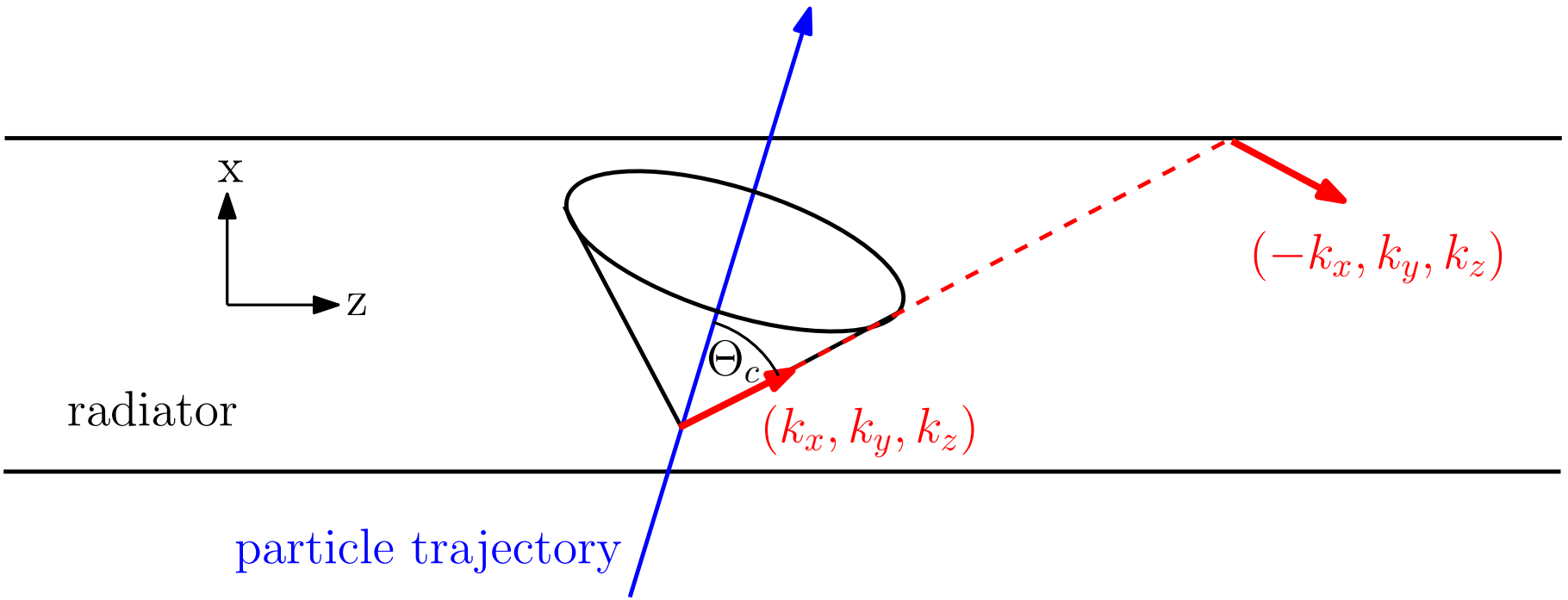


Cherenkov ring (data & simulation)

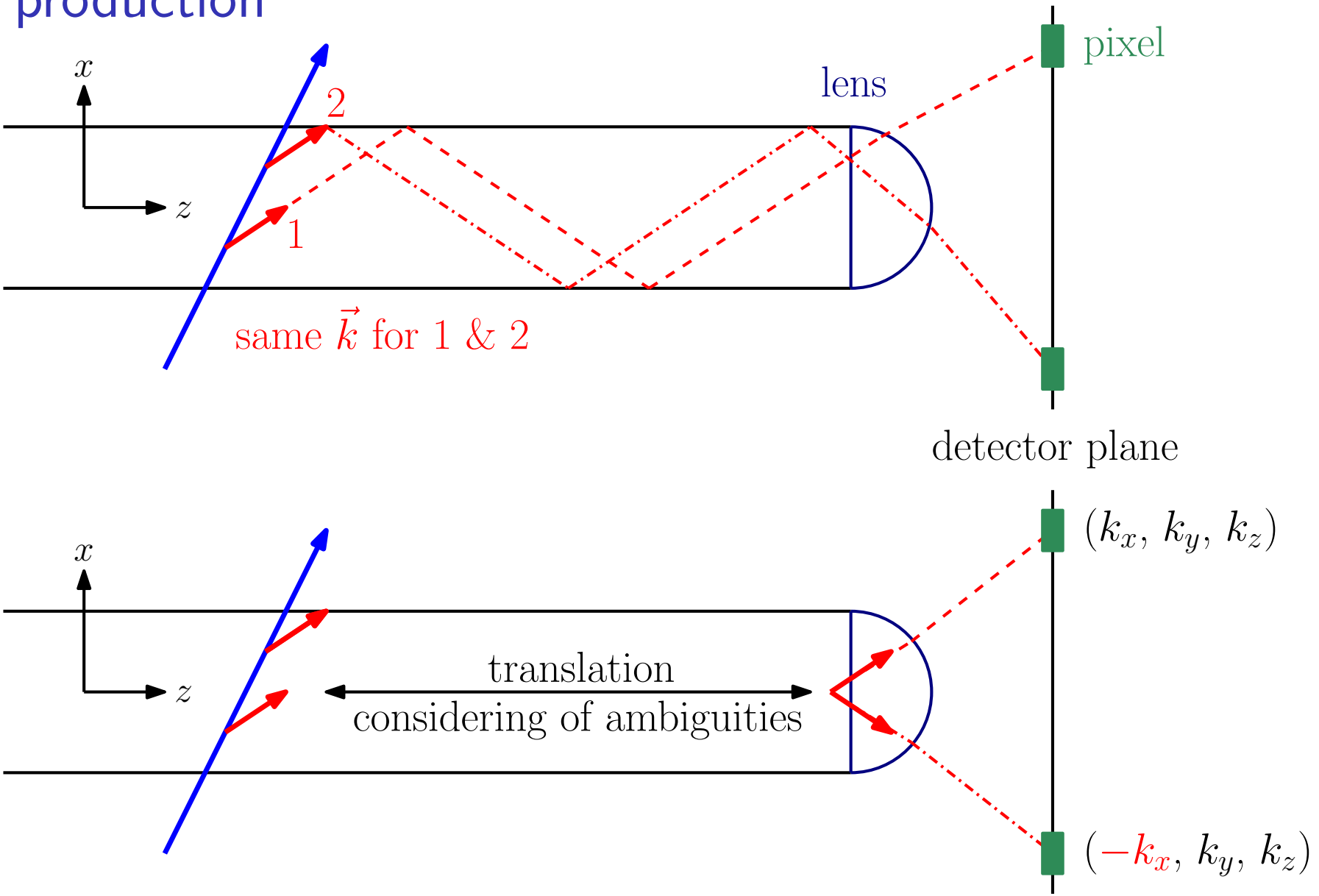


BABAR method

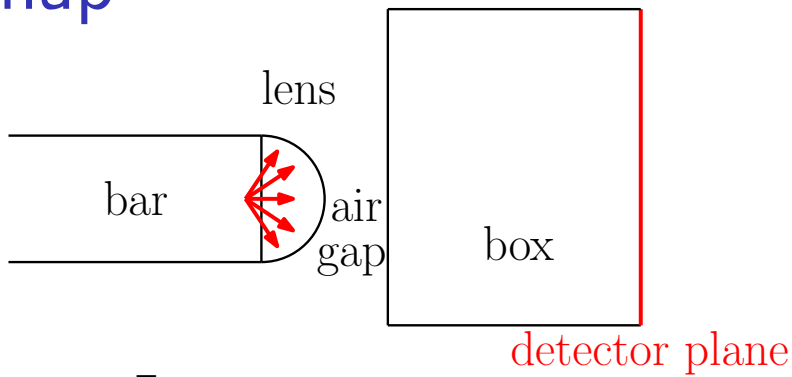
- Pixel information (position)
- Look up table ($\vec{k}$-map, $\vec{k}$: photon direction at production)
- Particle track
- $\Rightarrow \Theta_c$ (considering of ambiguities)



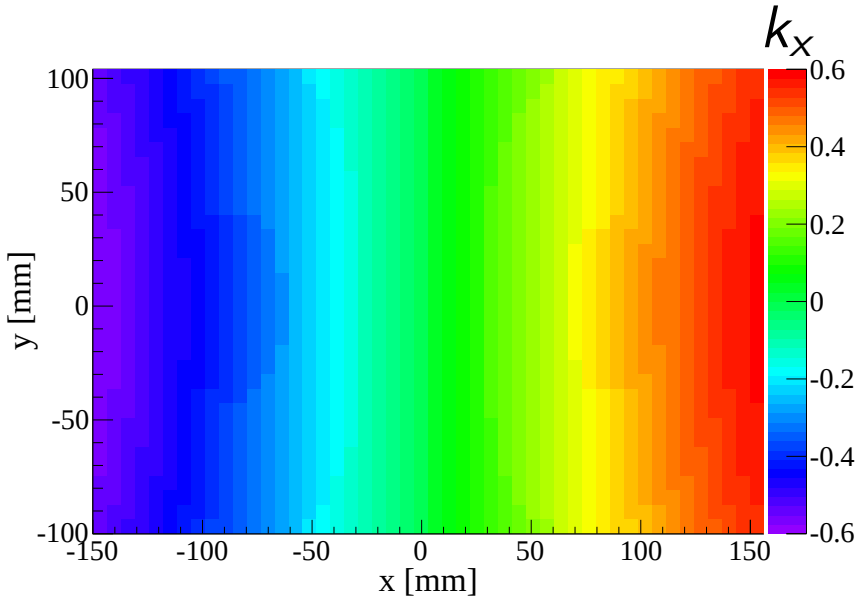
$\vec{k}$ production

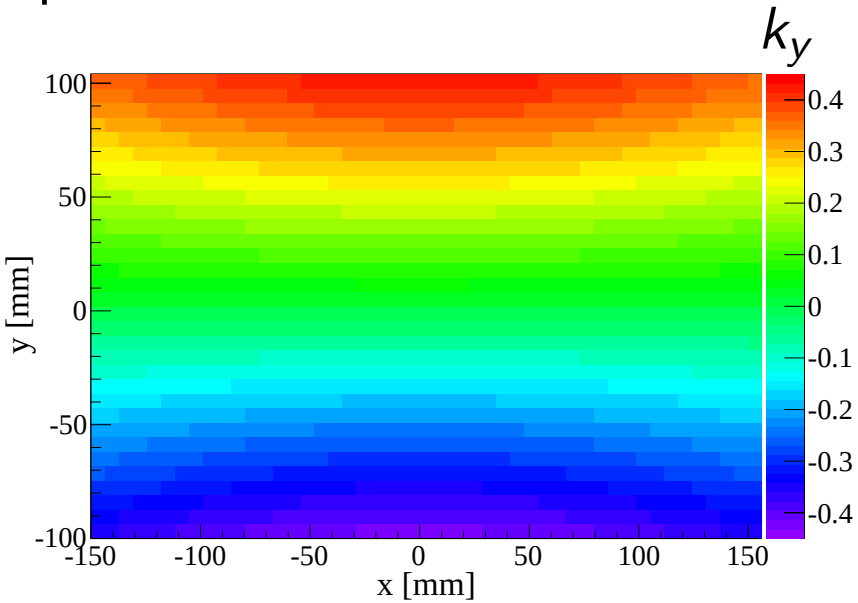


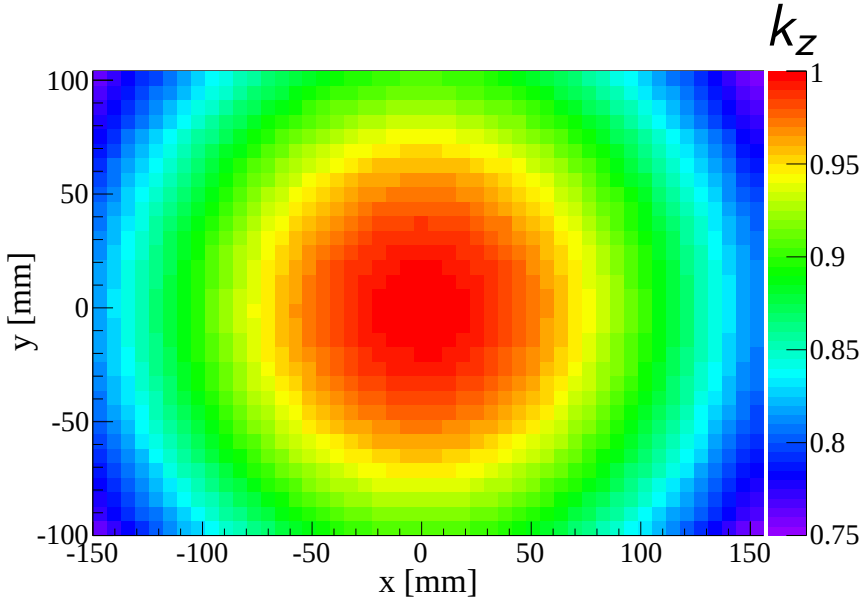
$\vec{k}$-map



- $2 \cdot 10^7$ photons hit the detector
- averaged $\vec{k}$ component for each pixel

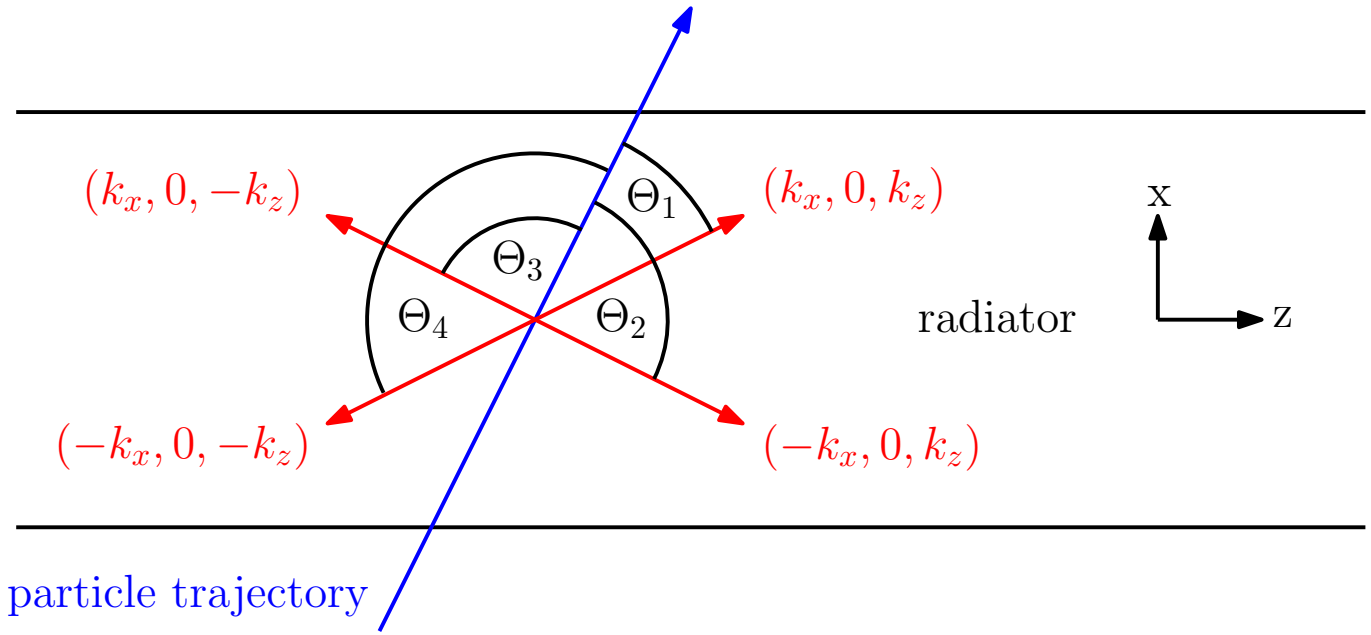






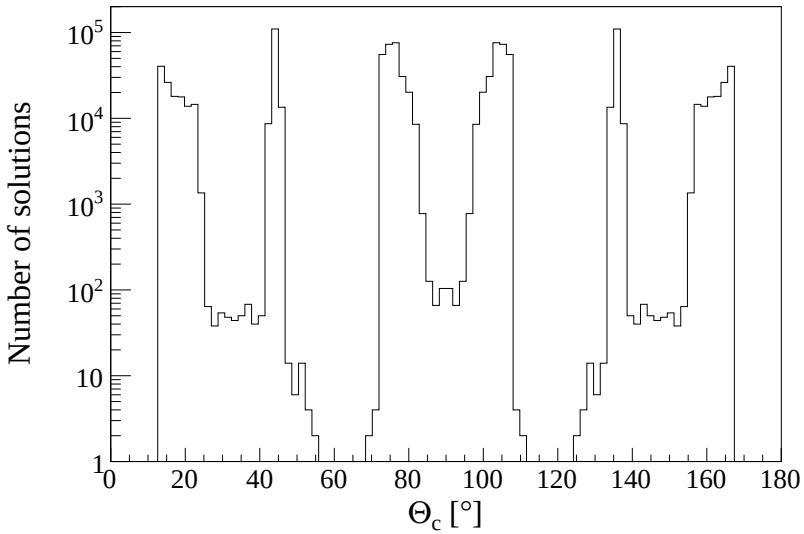
Ambiguities (prototype)

- Ambiguities:
  - Bar: left/right, up/down, back/forward $\Rightarrow$ 8 solutions
  - Expansion volume: direct/(left/right) $\Rightarrow$ 2 solutions
  - $\Rightarrow$ Total: 16 solutions
- Solution elimination:
  - Time information can resolve back/forward and expansion volume ambiguities
  - Symmetry: $\Theta_{1,2} = 180^\circ - \Theta_{4,3}$
  - Physical Limits: fused silica & detector efficiency $\Rightarrow \Theta_c < 48^\circ$

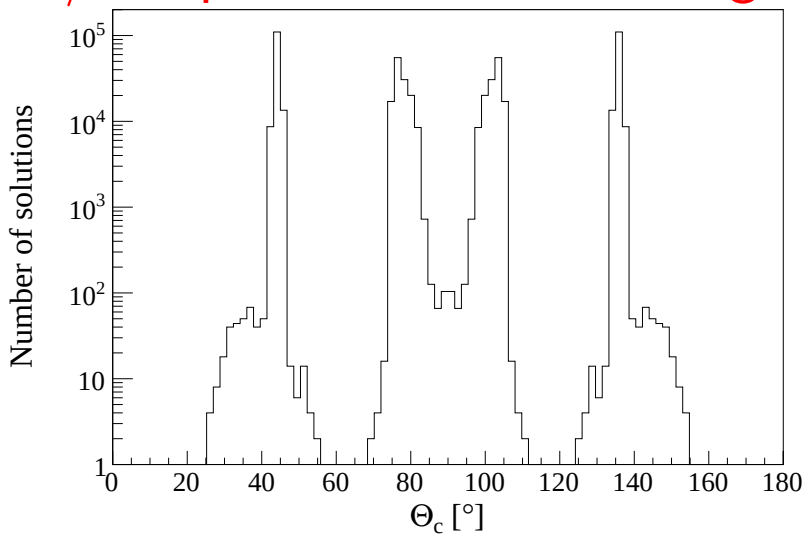


Cherenkov angle solutions ($T = 2\,\text{GeV}$ & $\theta = 30\,^\circ$)

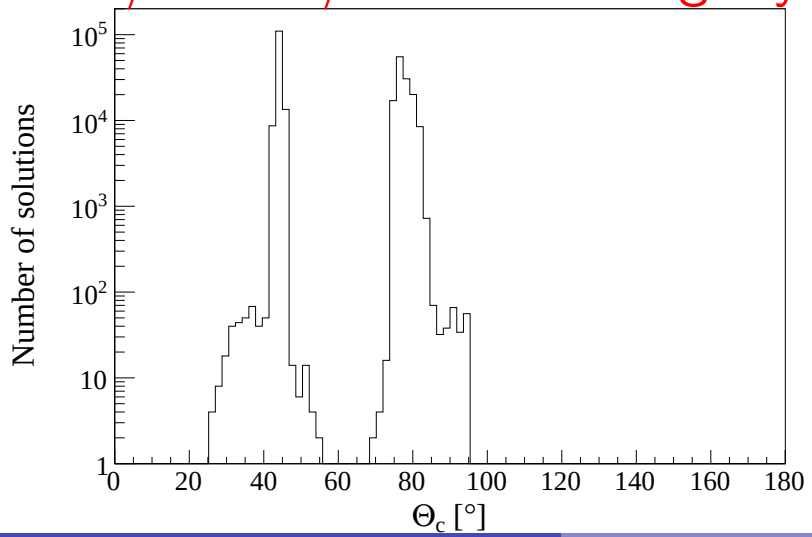
all



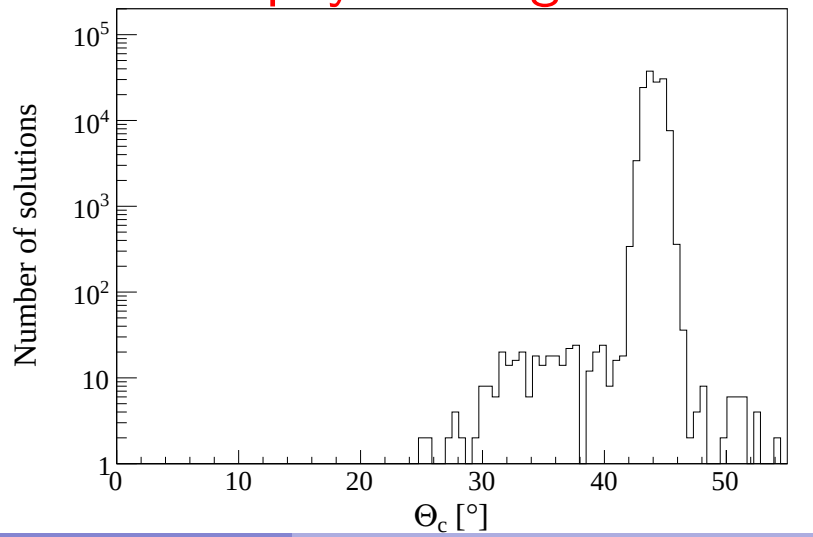
w/o expansion volume ambiguity



w/o back/forward ambiguity



physical region

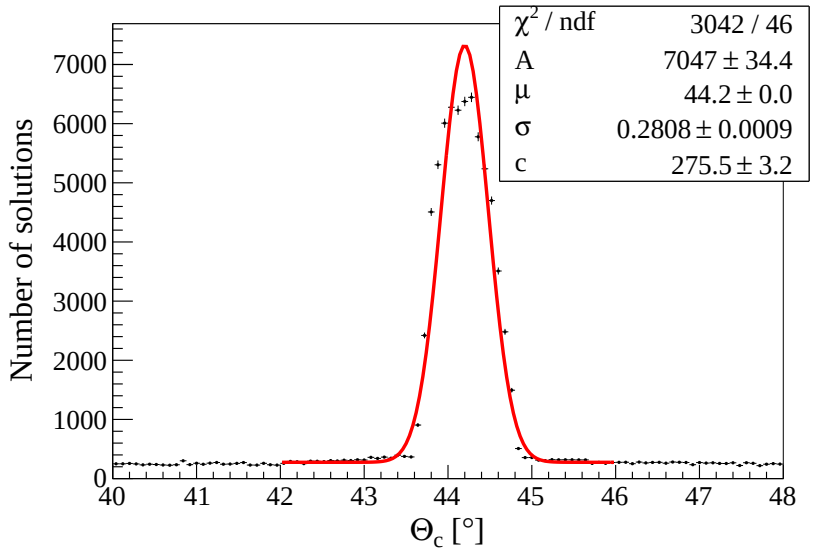


Resolution (drcprop)

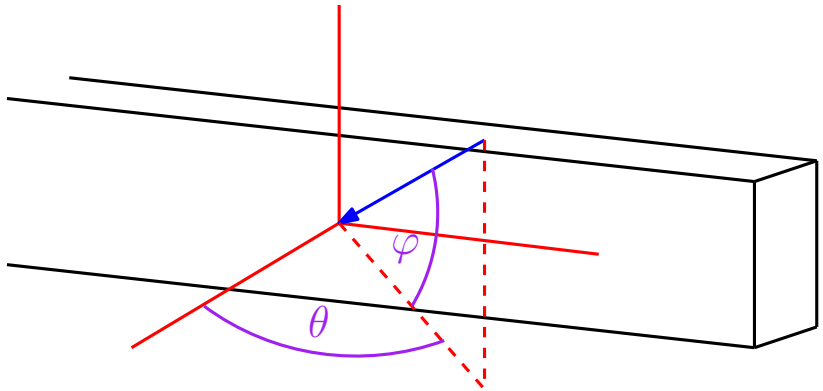
$$\sigma^2_{\Theta_c} = \sigma^2_{chrom} + \sigma^2_{pixel} + \sigma^2_{rest}$$

- $\sigma_{chrom} = 4.9\,\text{mrad}$
- Estimation:
  $\sigma_{pixel} = (5 - 8.5)\,\text{mrad}$
- σ_{rest}:
  - Focusing
  - Ambiguities

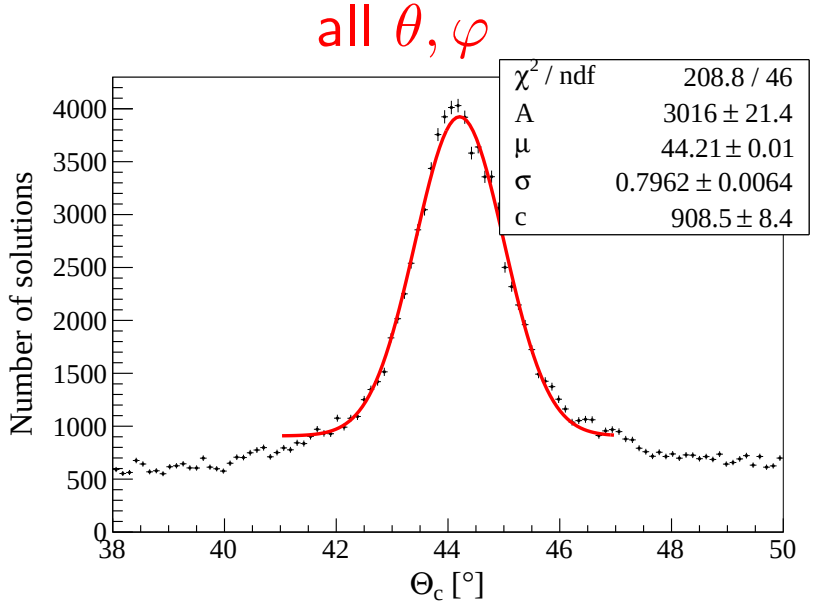
chromatic dispersion



Averaged resolution (drcprop)

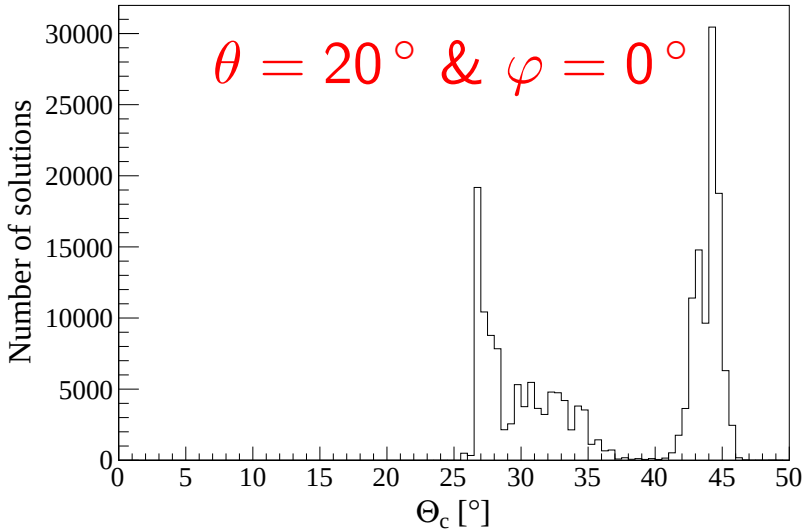


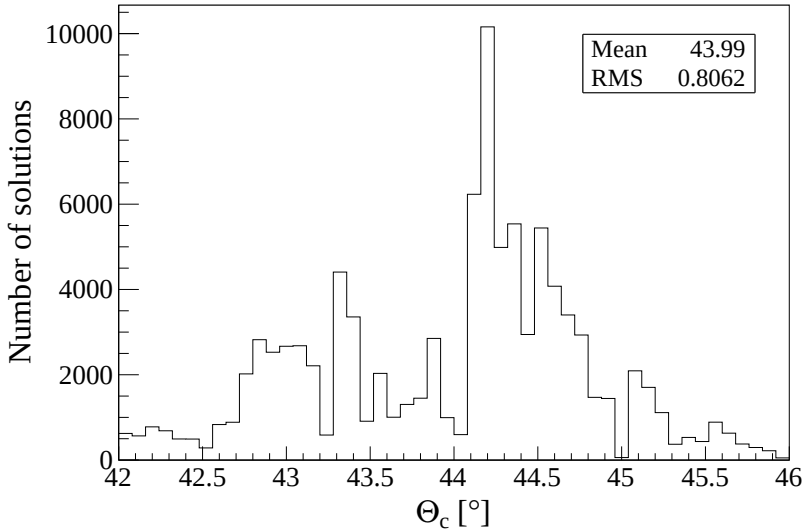
- all θ, φ: $\sigma_{\Theta_c} = 13.9\,\text{mrad} \Rightarrow \sigma_{rest} = 10.4\,\text{mrad}$
- Fit: $\Theta_c = 44.21^\circ$ (expected: 44.13°)



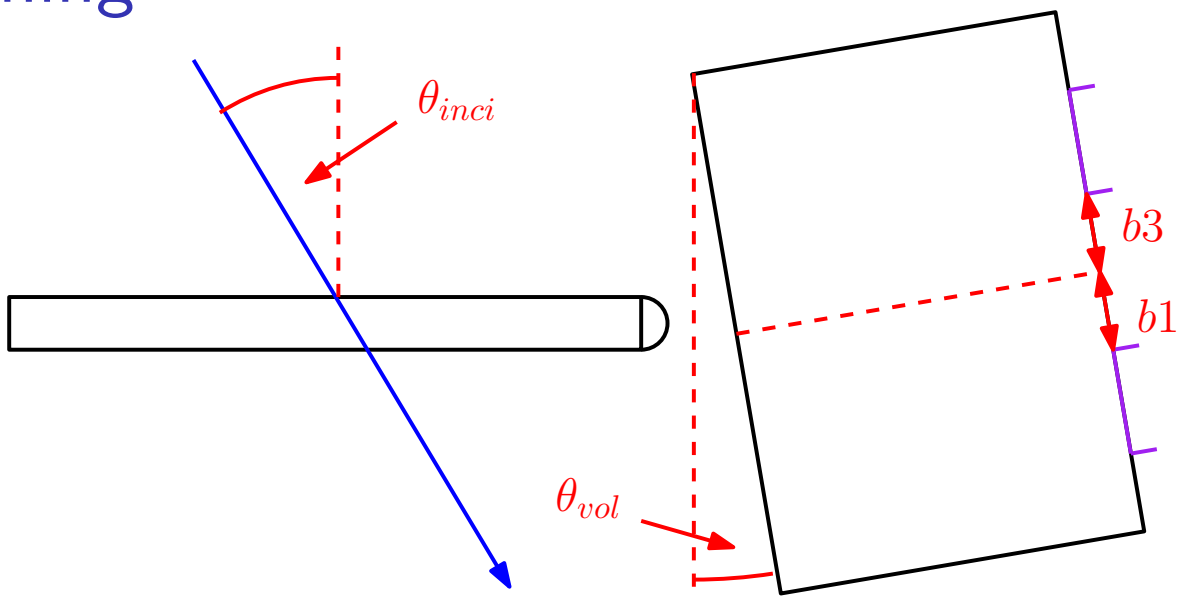
Resolution for a fixed beam angle (drcprop)

- Select proton Θ_c region $(42 - 46)^\circ$
- Only few pixel are hit $\Rightarrow$ distribution is too coarsely pixelated $\Rightarrow$ fit depends on the bin size
- Solution: unbinned fit or RMS in the expected region

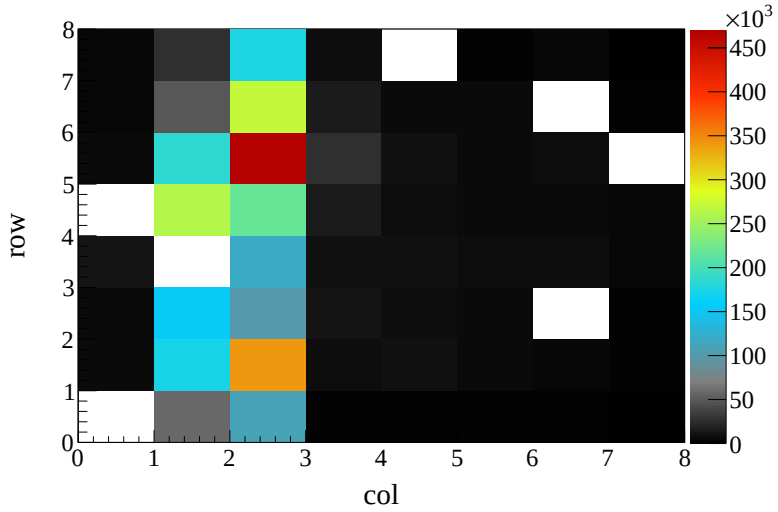




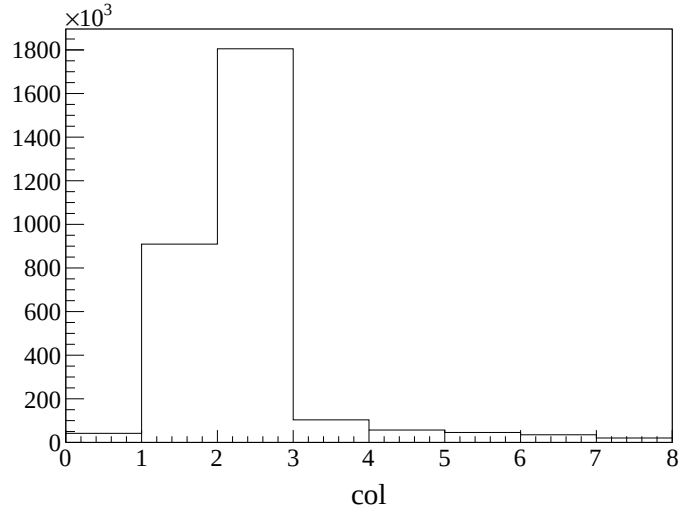
Simulation tuning



Column center of gravity:

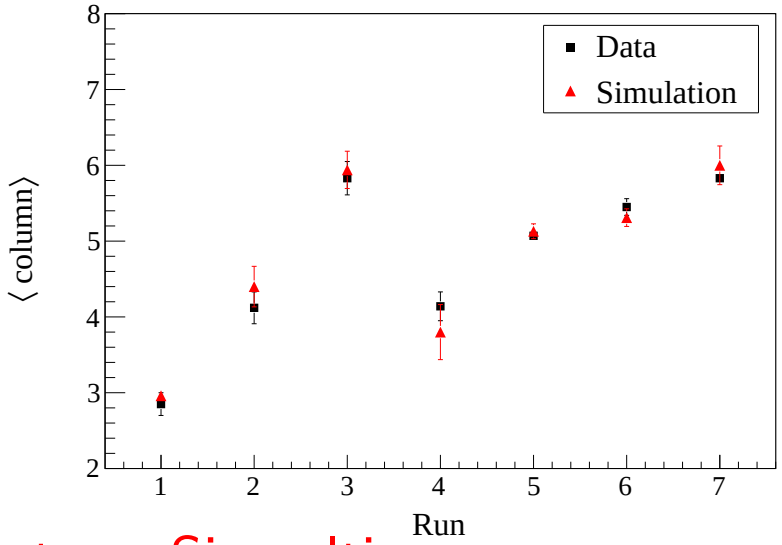


projection

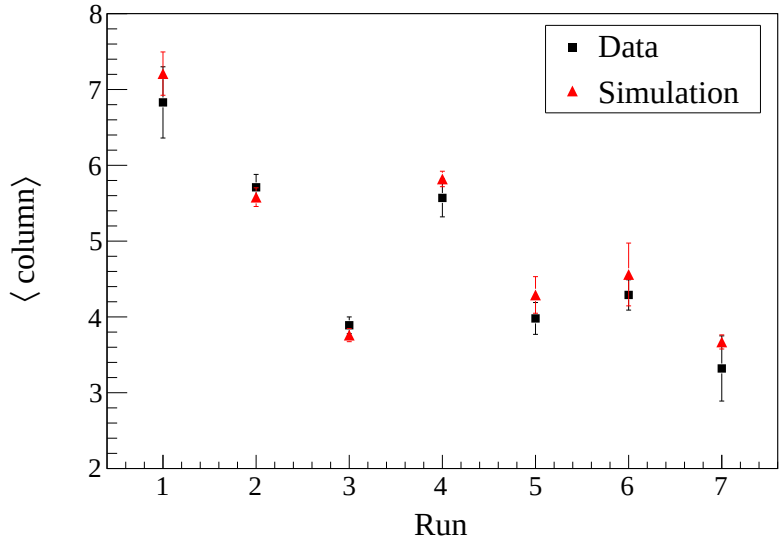


Simulation tuning (II)

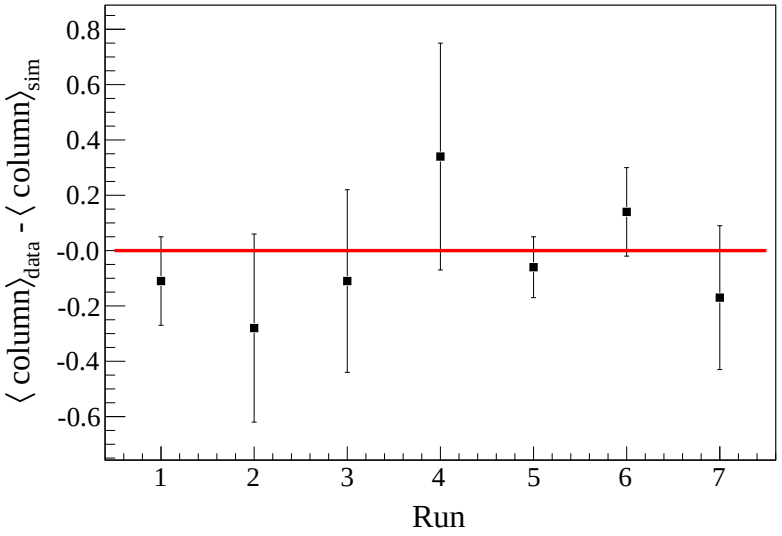
MCP1

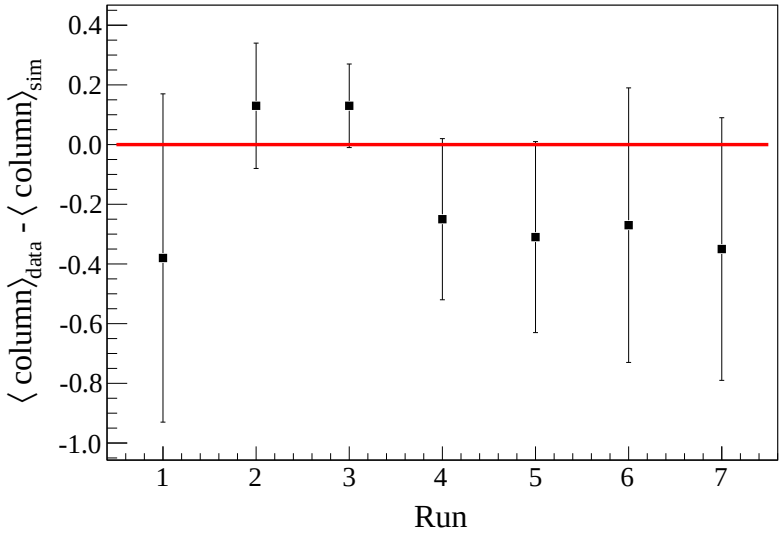


MCP3

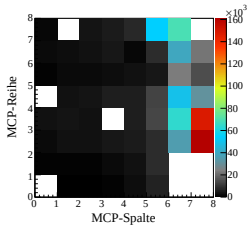
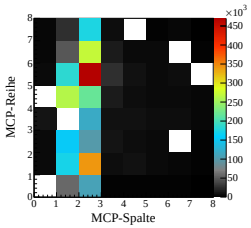
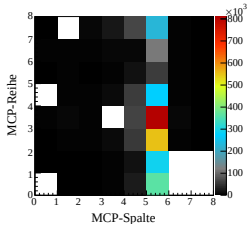
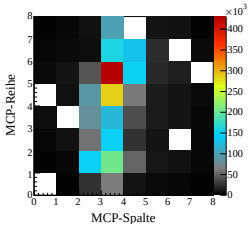
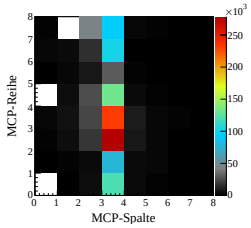
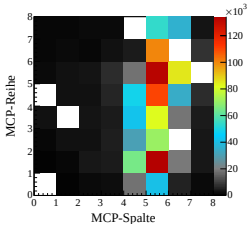
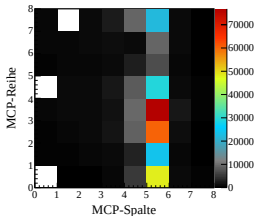
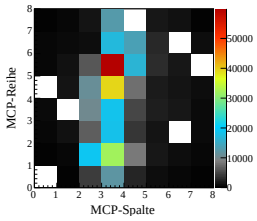
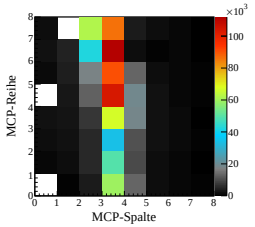
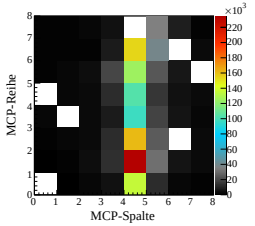


Data – Simualtion:



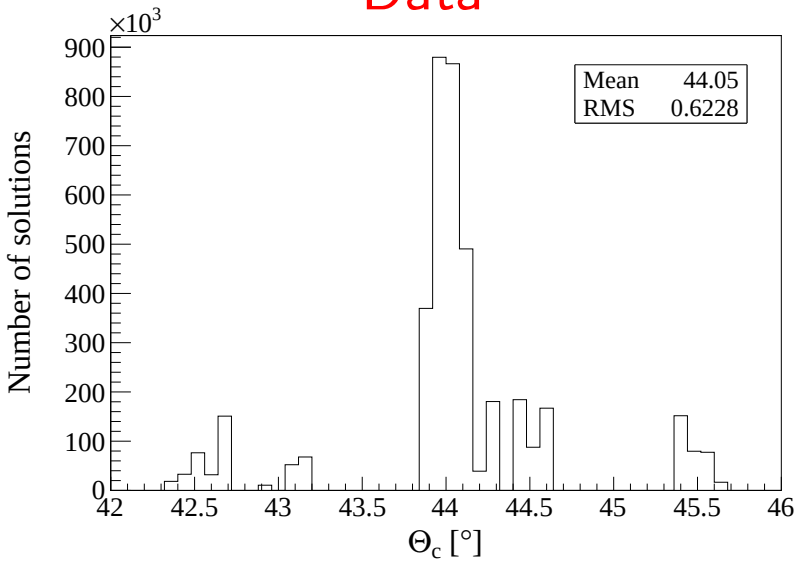


Beam incidence angle variation

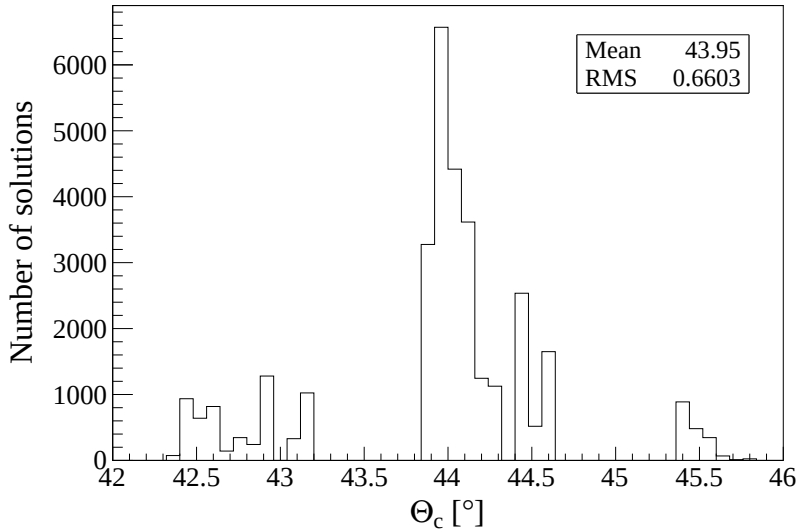
measured	tuning result	MCP3	MCP1
30 °	29.2 °		
27 °	27.0 °		
24 °	24.2 °		
24 °	23.8 °		
21 °	21.8 °		

Reconstructed Cherenkov angle

Data



Simulation



$\langle \Theta_c \rangle =$	44.05 °	43.95 °
$\sigma_{\Theta_c} =$	10.9 mrad	11.5 mrad

expected: $\Theta_c = 44.13\,^\circ$

Summary

- Test beam data are consistent with the drcprop-simulation
  - Cherenkov angle reconstruction
- See my thesis (coming soon) for a detailed data analysis
- BaBar Cherenkov angle reconstruction method can be used for $\bar{\text{P}}$ANDA (Maria Patsyuk)