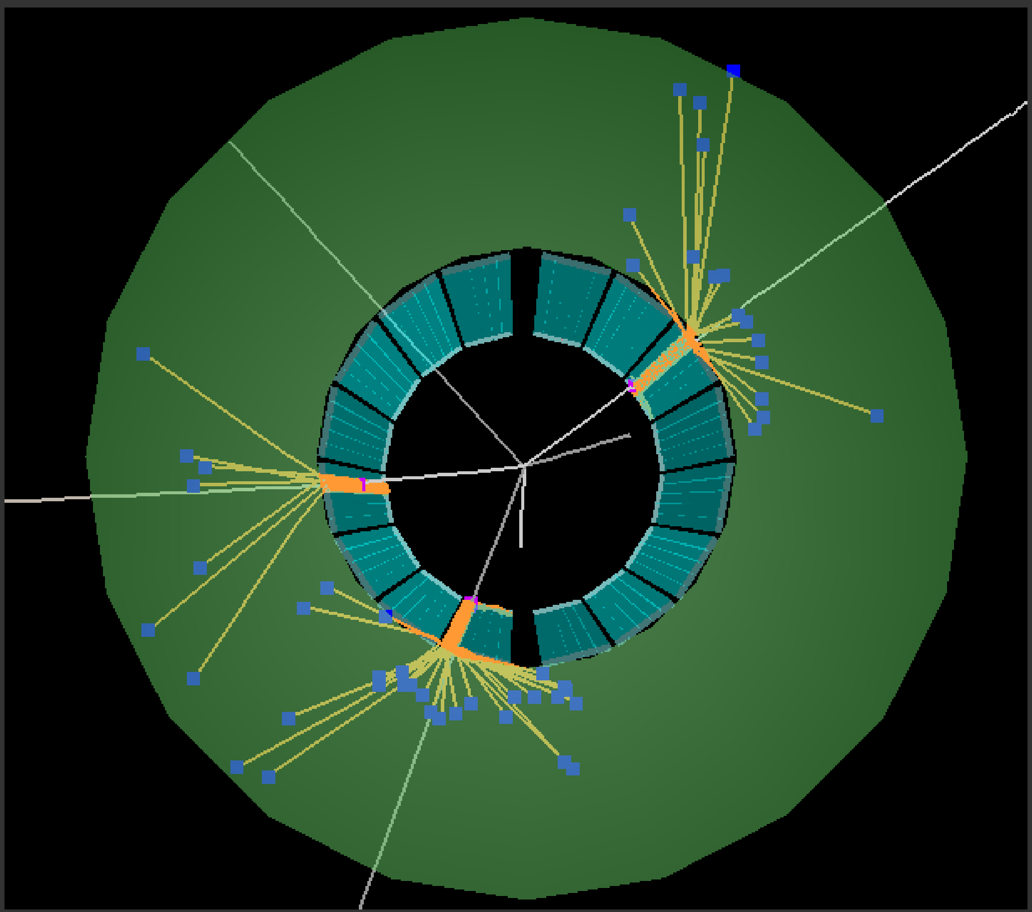


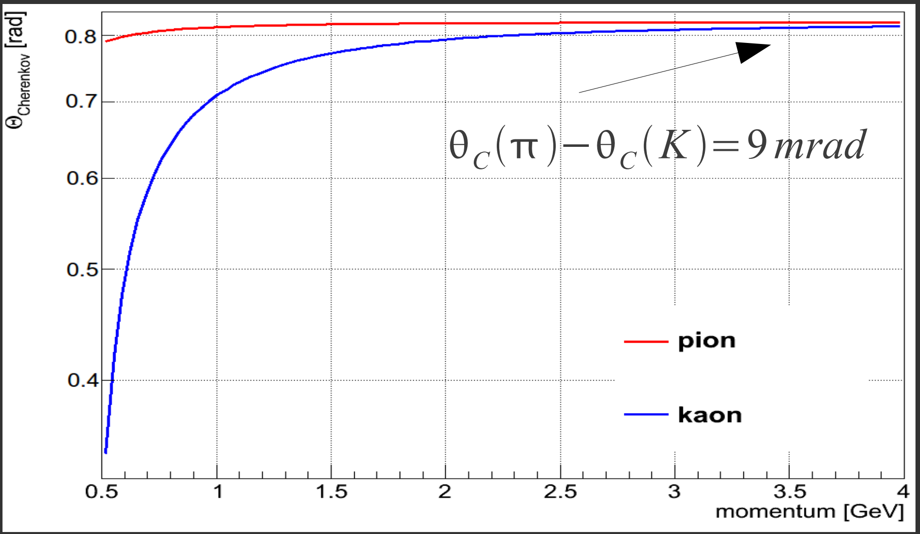
Simulation and Reconstruction for the PANDA Barrel DIRC

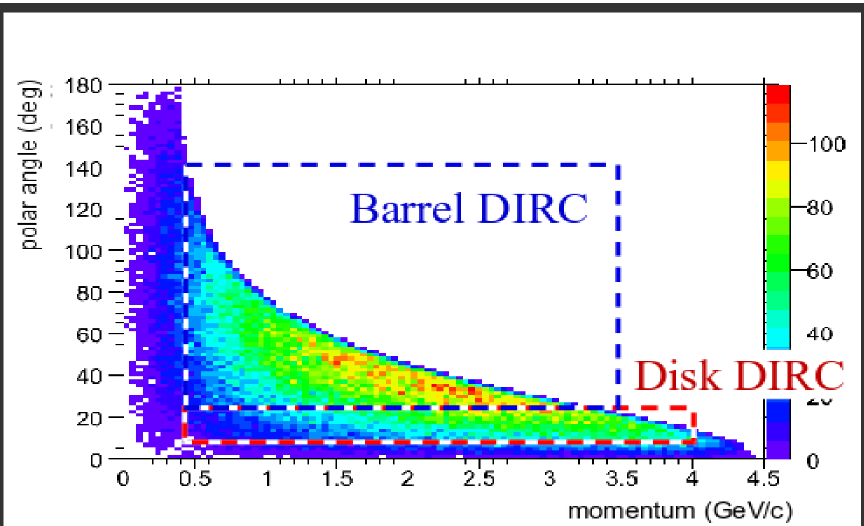
Maria Patsyuk

PANDA DIRC requirements

- PANDA particle identification requirement: ≥ 3 standard deviations π/K separation in the momentum range 0.5 GeV/c – 3.5 GeV/c (PID)

- 3 σ π/K separation at 3.5 GeV/c requires ≤ 2.5 mrad Cherenkov angle resolution





Kaon distribution of the radiative decay

J/ψ -> K+K- γ

(search of glue balls)

The development of a more detailed description of the resolution requirement is ongoing.

Design goal: $\sigma_{\theta_C}=2.5\,mrad$ (for 3.5 GeV/c)

Tracking, multiple scattering ... $\sigma_{correlated}\simeq 1\,mrad$

$$\sigma^2_{\theta_C}=\sigma^2_{correlated}+\frac{\sigma^2_{\theta_C^{photon}}}{N_{photons}}$$

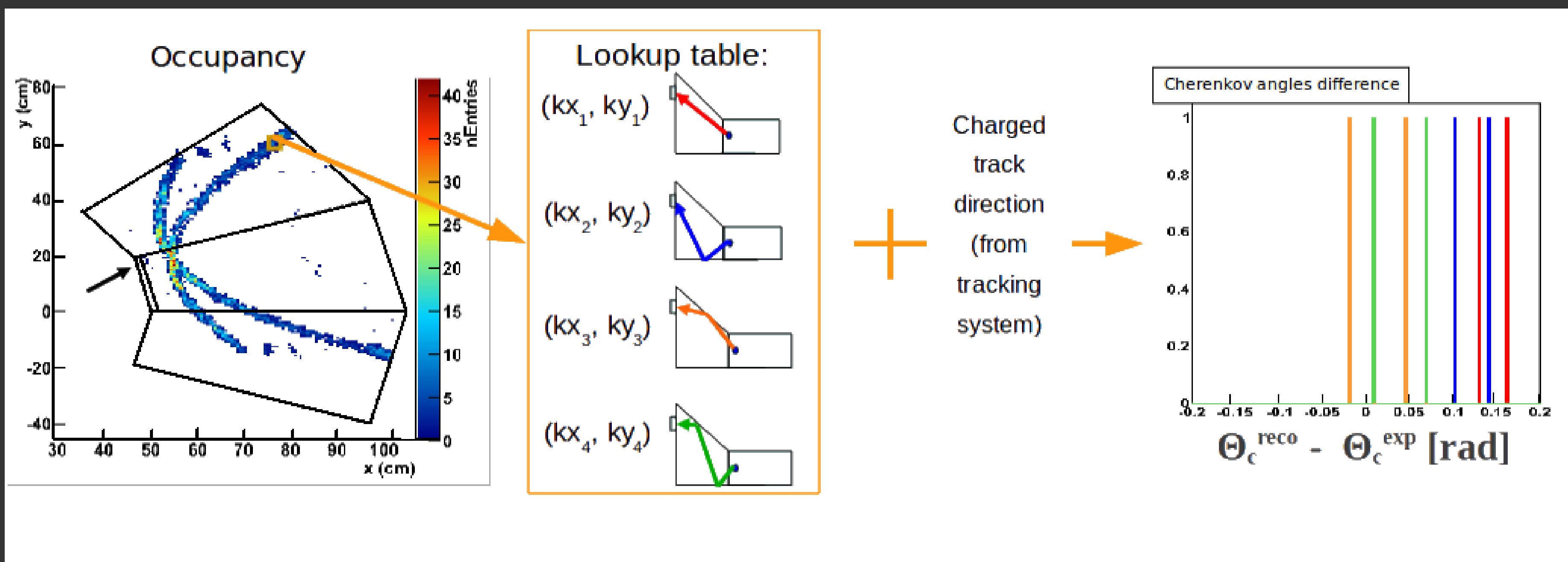
To reach PID design goal:

For photon yield ($N_{photons}$) ≥ 20 photons per track

Required single photon Cherenkov angle resolution ~11 mrad

Reconstruction method

To evaluate the performance of different designs a proven BABAR-type reconstruction was used. The Cherenkov angle is determined for each detected photon by comparing the direction of the particle track (taken from other detector systems) and the direction of the detected photon, approximated using the pixel and the bar positions (taken from the look-up table) → single photon resolution of the detector.



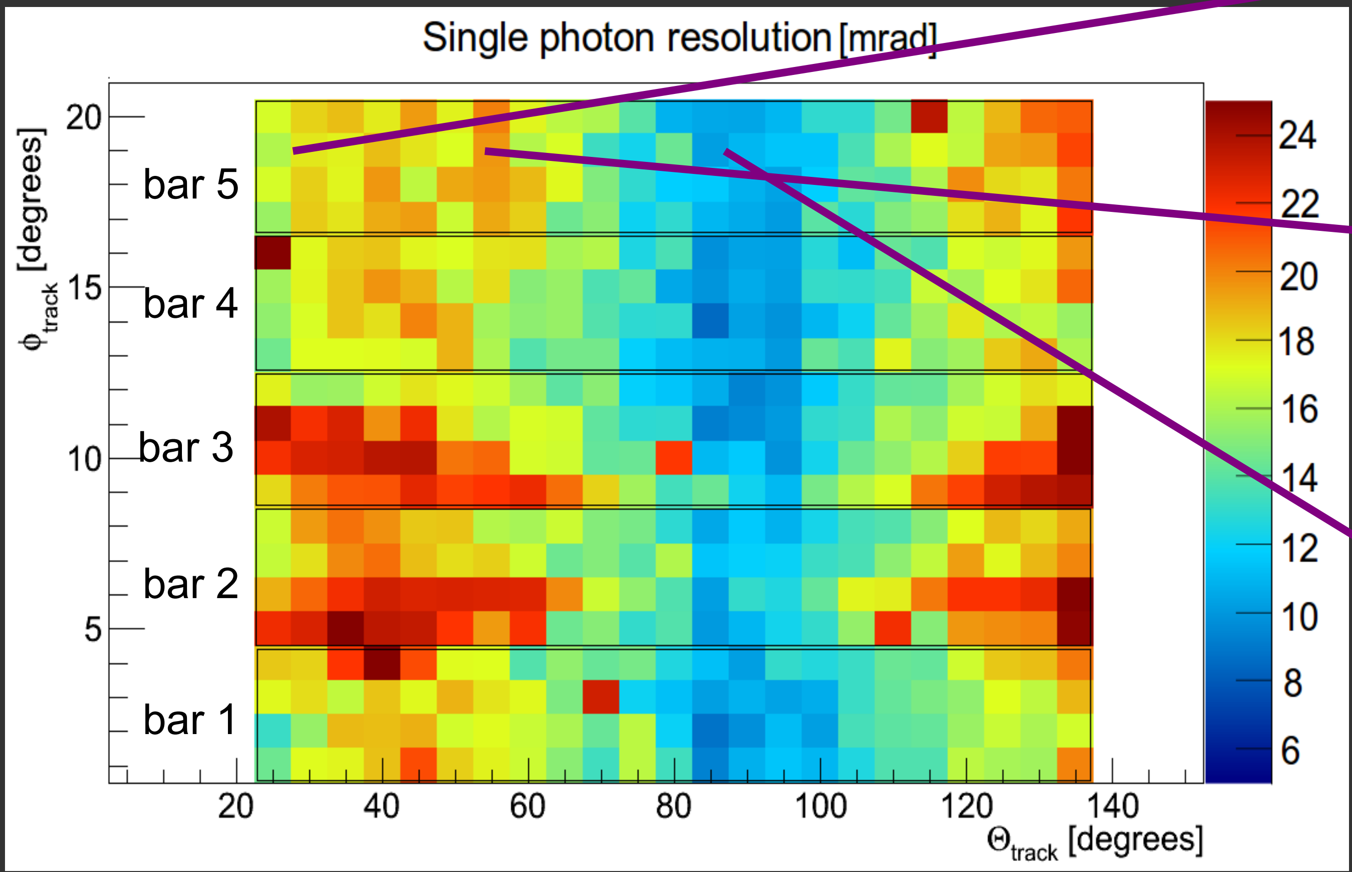
Apply this procedure to all photons from the same track → peak at the right $\Delta\theta_C$ value
+ combinatorial background

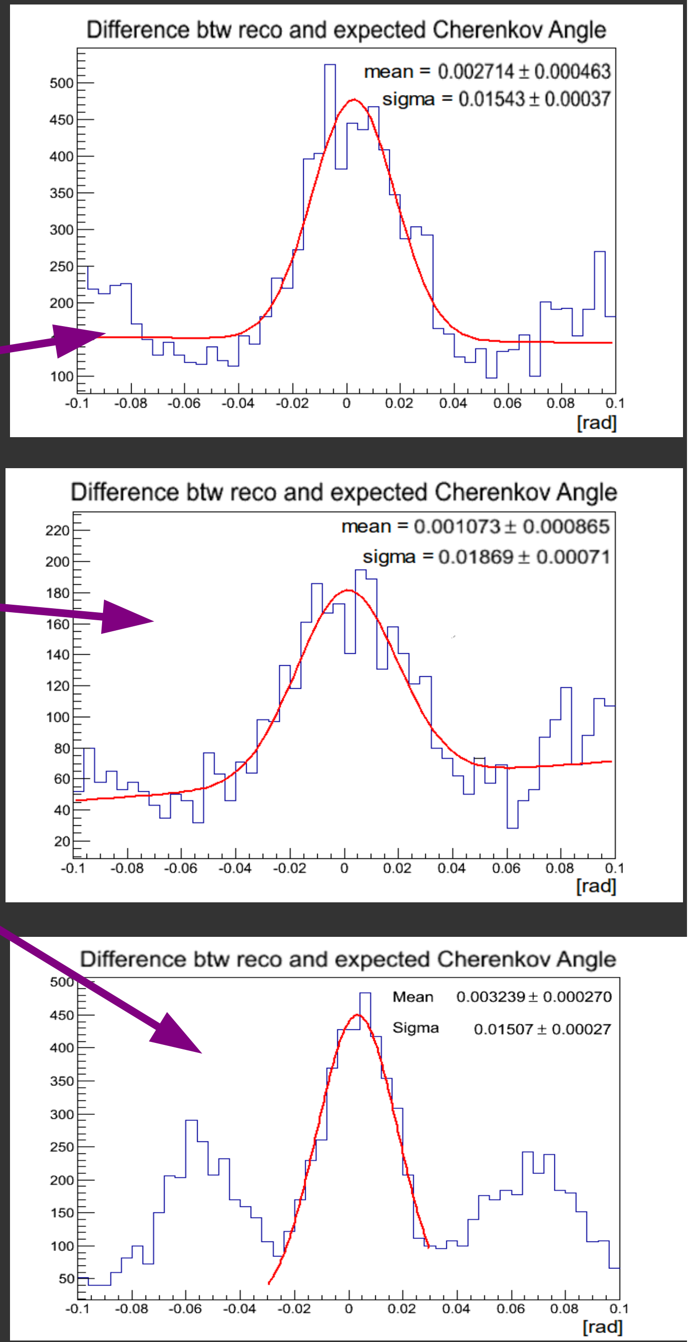
Reconstruction method

Simplified design: no focusing (fused silica bars are directly attached to the expansion volume (EV))

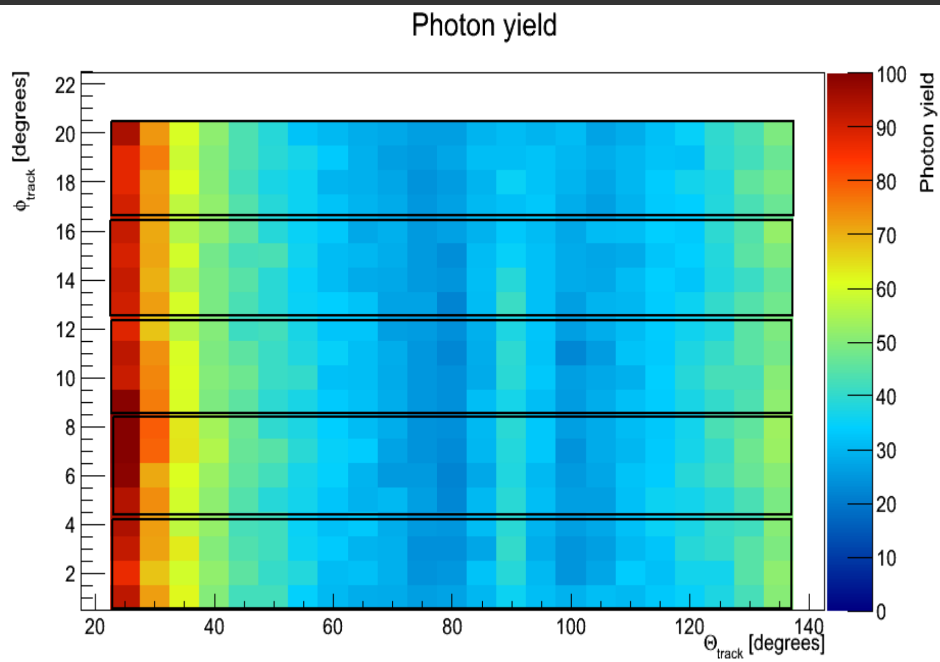
Simple estimation of single photon Cherenkov angle resolution - 18-19 mrad

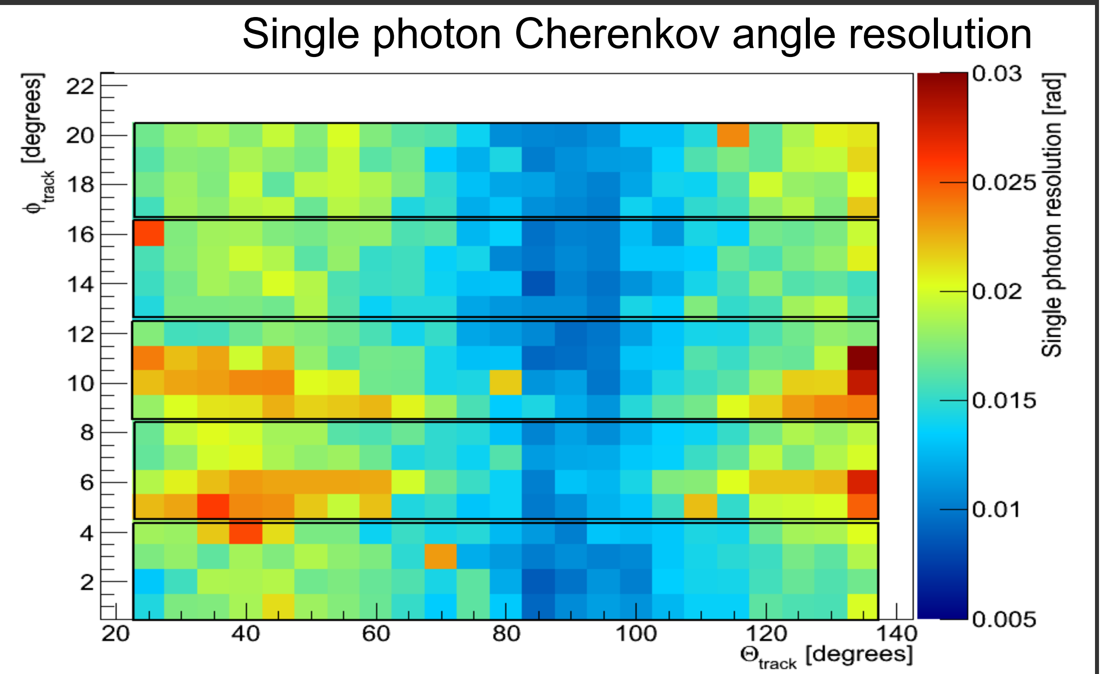
map of single photon resolution for one bar box, 3 GeV muons



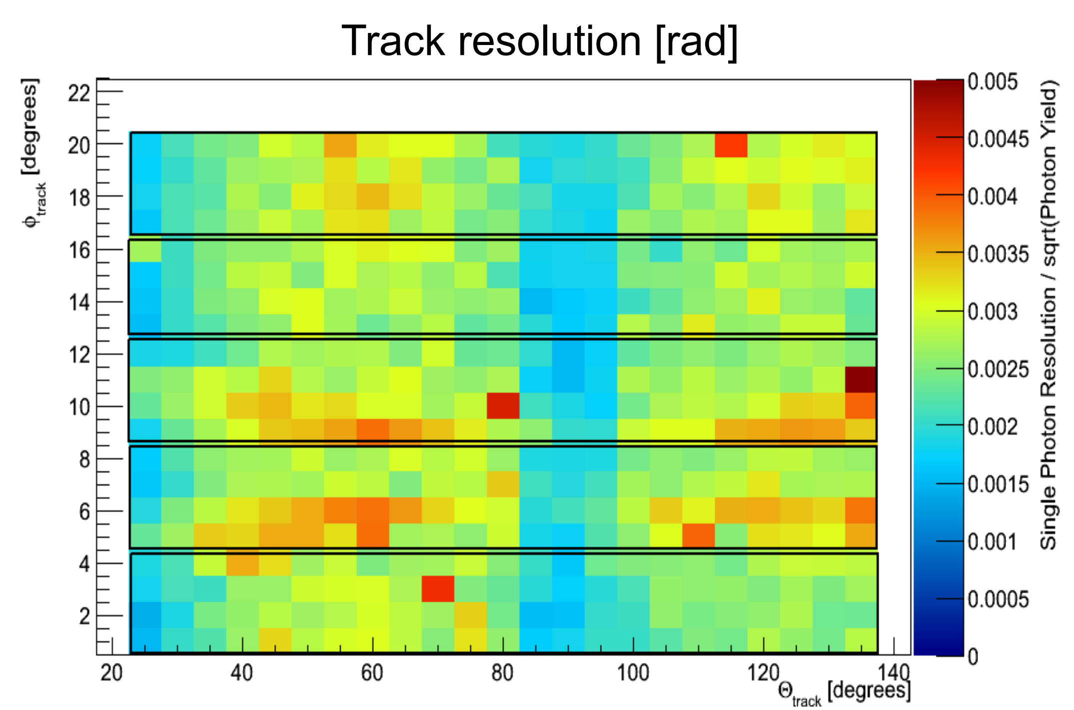


Performance of the 17 mm thick bars



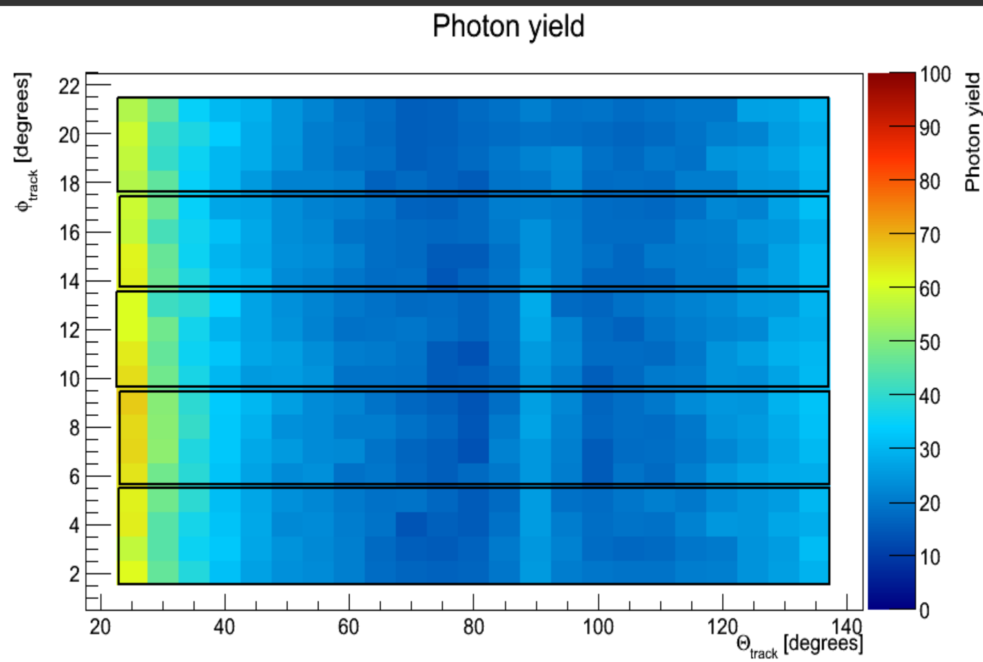


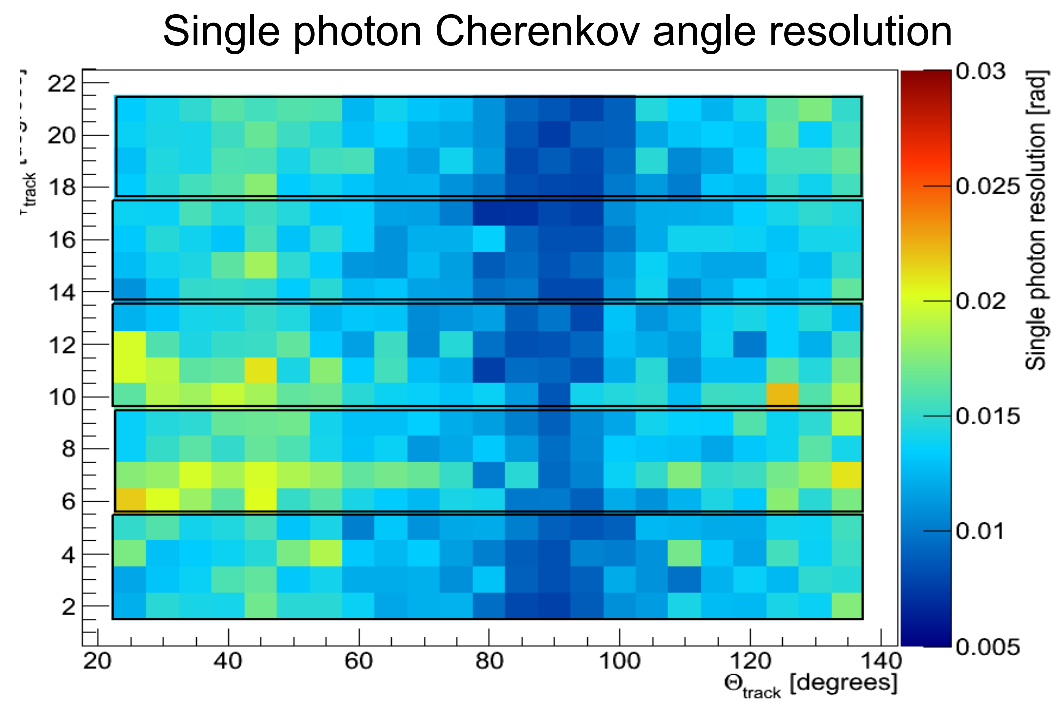
Expected average single photon Cherenkov angle resolution – 18 mrad



Single photon Cherenkov angle resolution agrees with expectation, the resulting track resolution does not fulfill PANDA requirement → either thinner bars or focusing is needed!

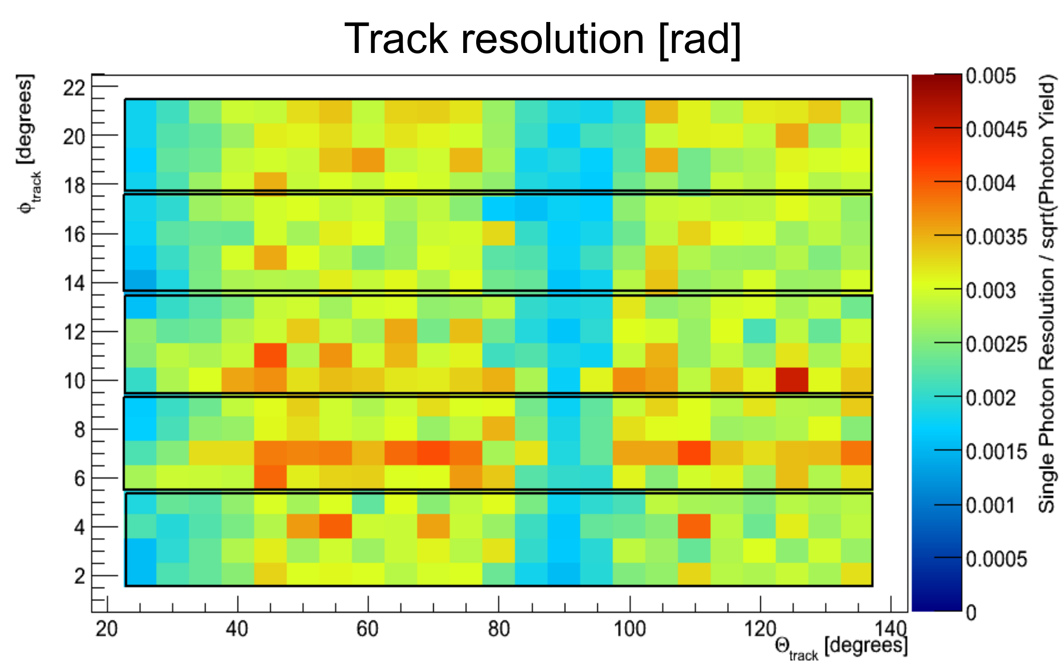
Performance of the 10 mm thick bars



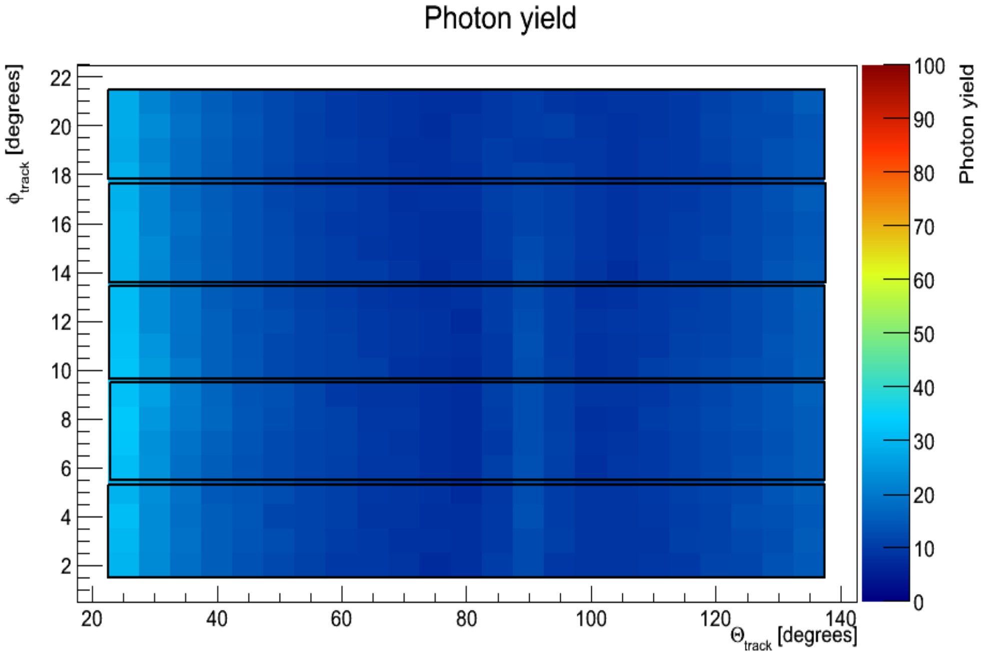


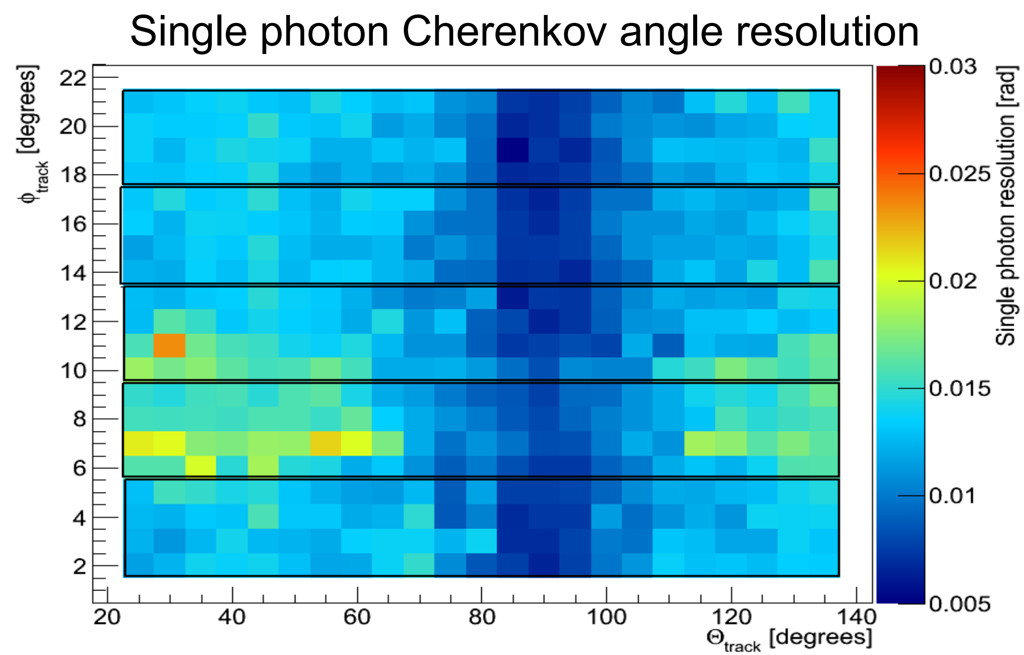
Expected average single photon Cherenkov angle resolution – 13 mrad

Single photon Cherenkov angle resolution gets smaller, the number of photons also, but the resulting track resolution stays about the same.

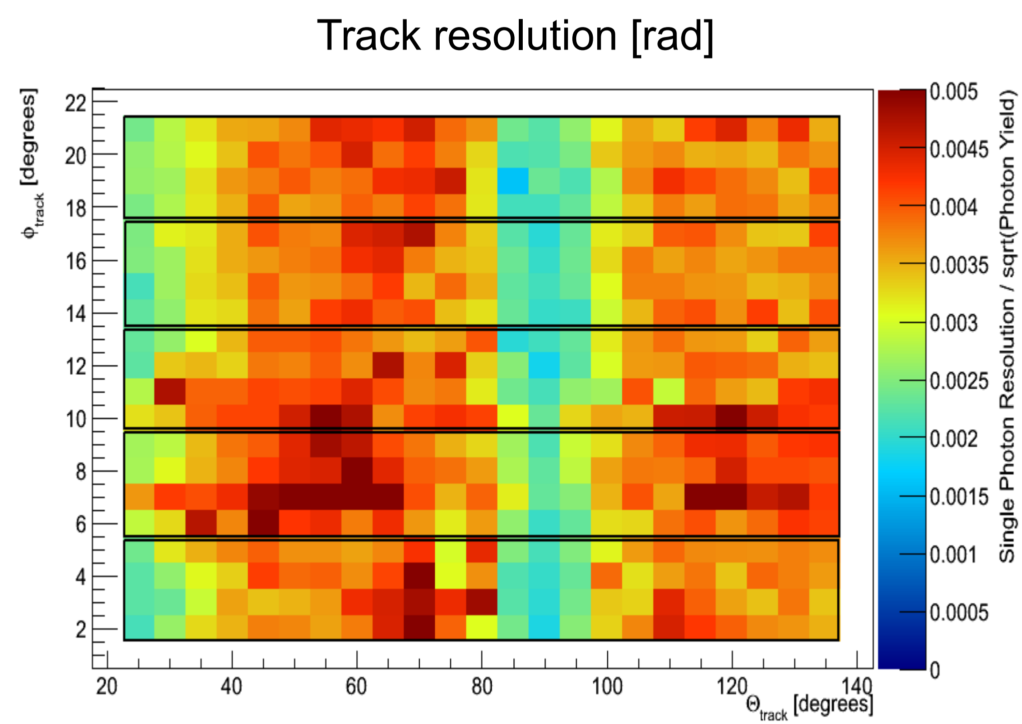


Performance of the 5 mm thick bars





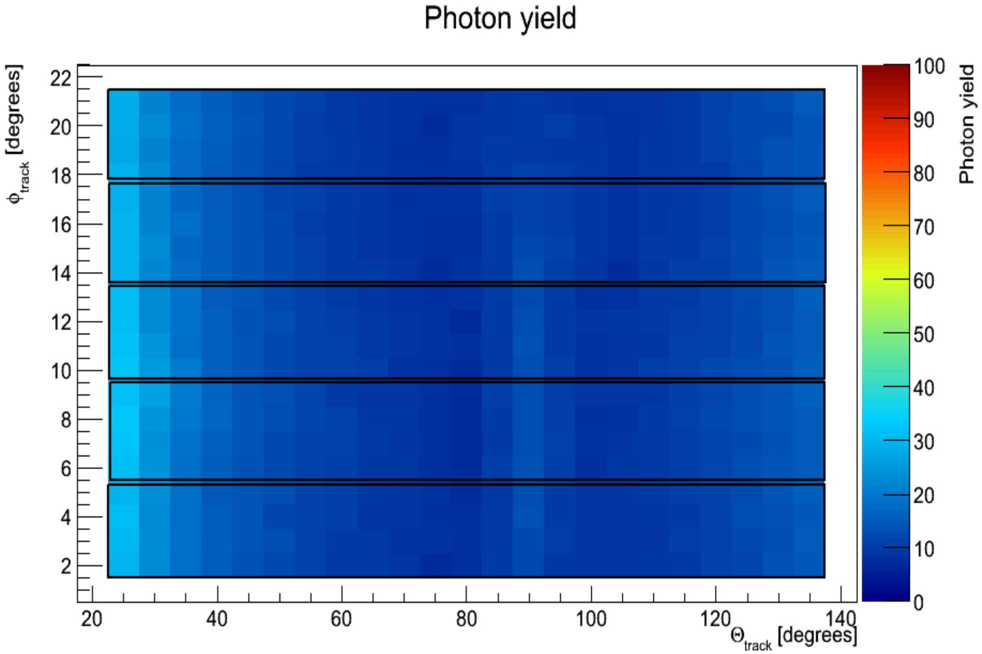
Expected average single photon Cherenkov angle resolution – 10 mrad

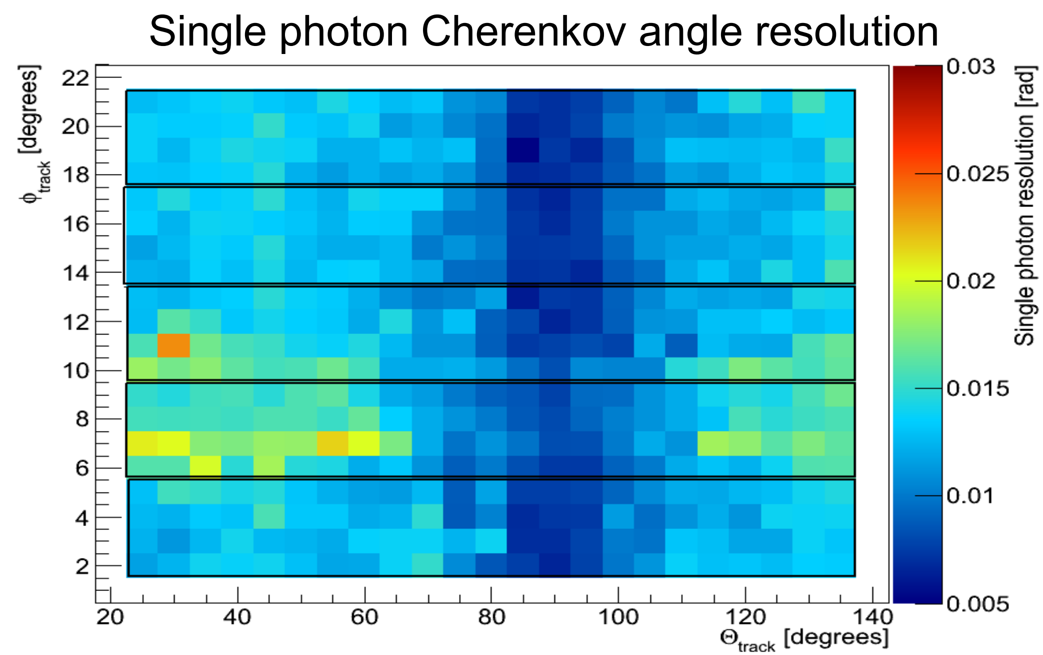


The photon yield and the single photon Cherenkov angle resolution improve, whereas the track resolution got worse

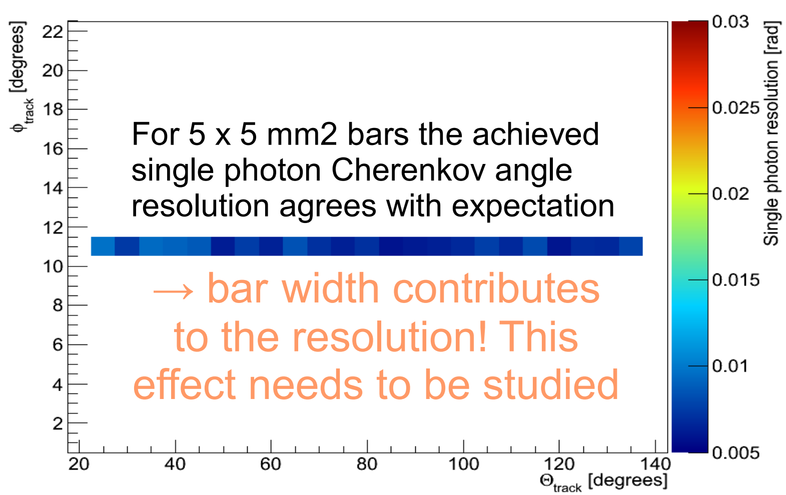
→ influence of the bar width on the single photon Cherenkov angle resolution!

Performance of the 5 mm thick bars



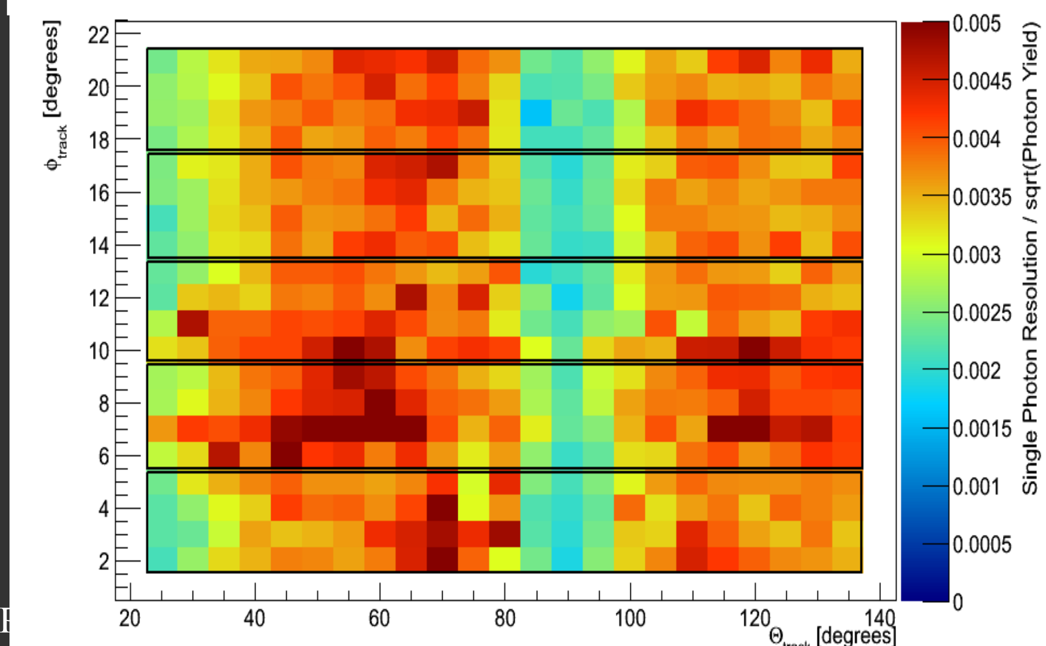


Expected average single photon Cherenkov angle resolution – 10 mrad



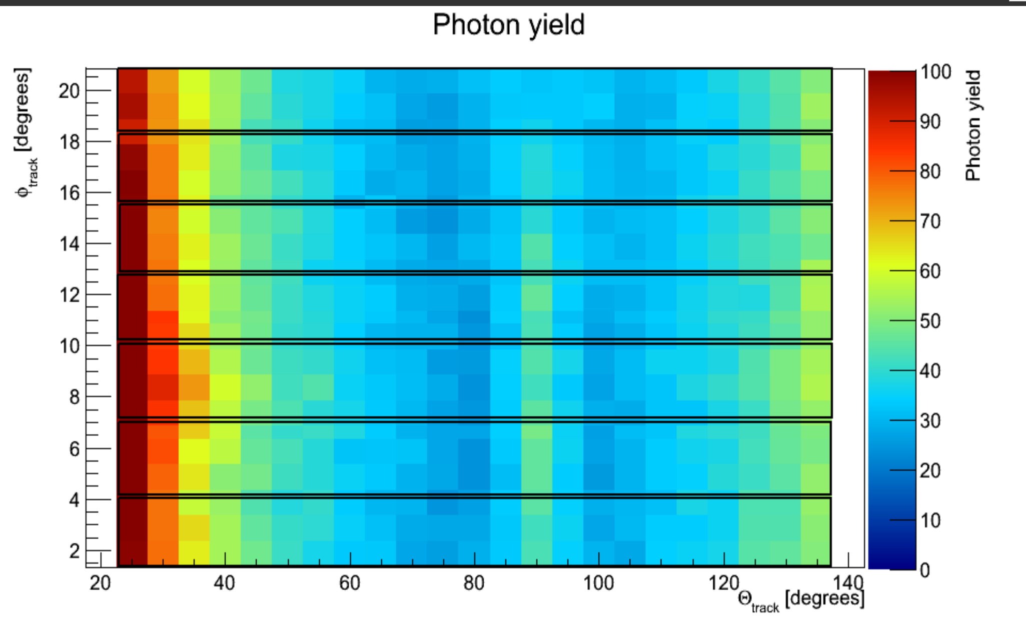
For 5 x 5 mm2 bars the achieved single photon Cherenkov angle resolution agrees with expectation

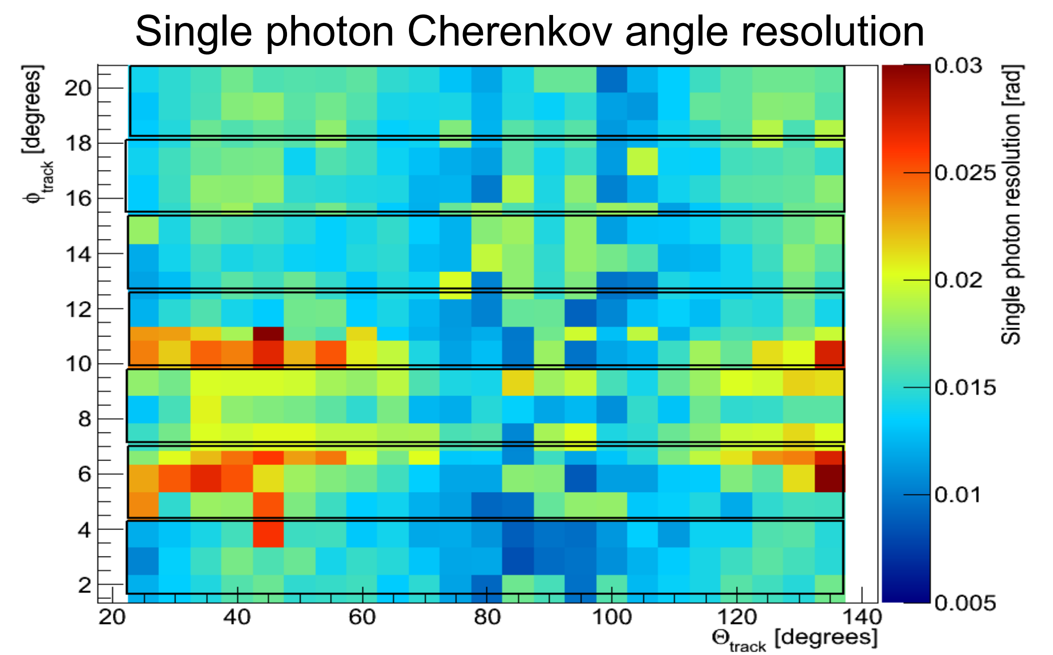
→ bar width contributes to the resolution! This effect needs to be studied

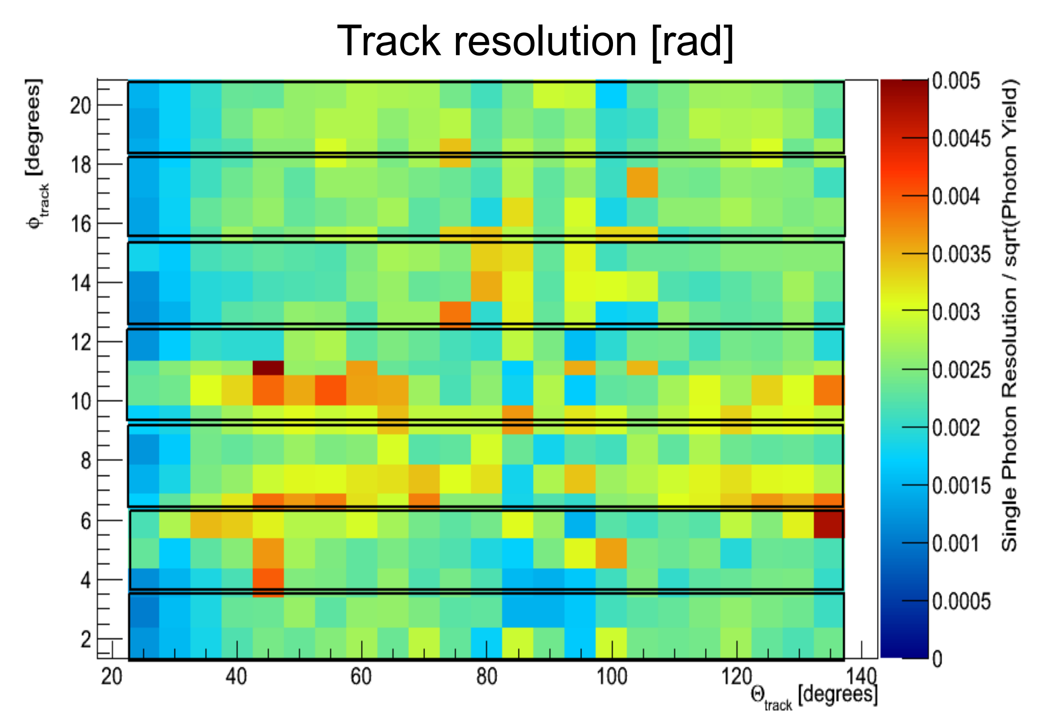


Performance of the 7 bars in the bar box

2.3 cm width

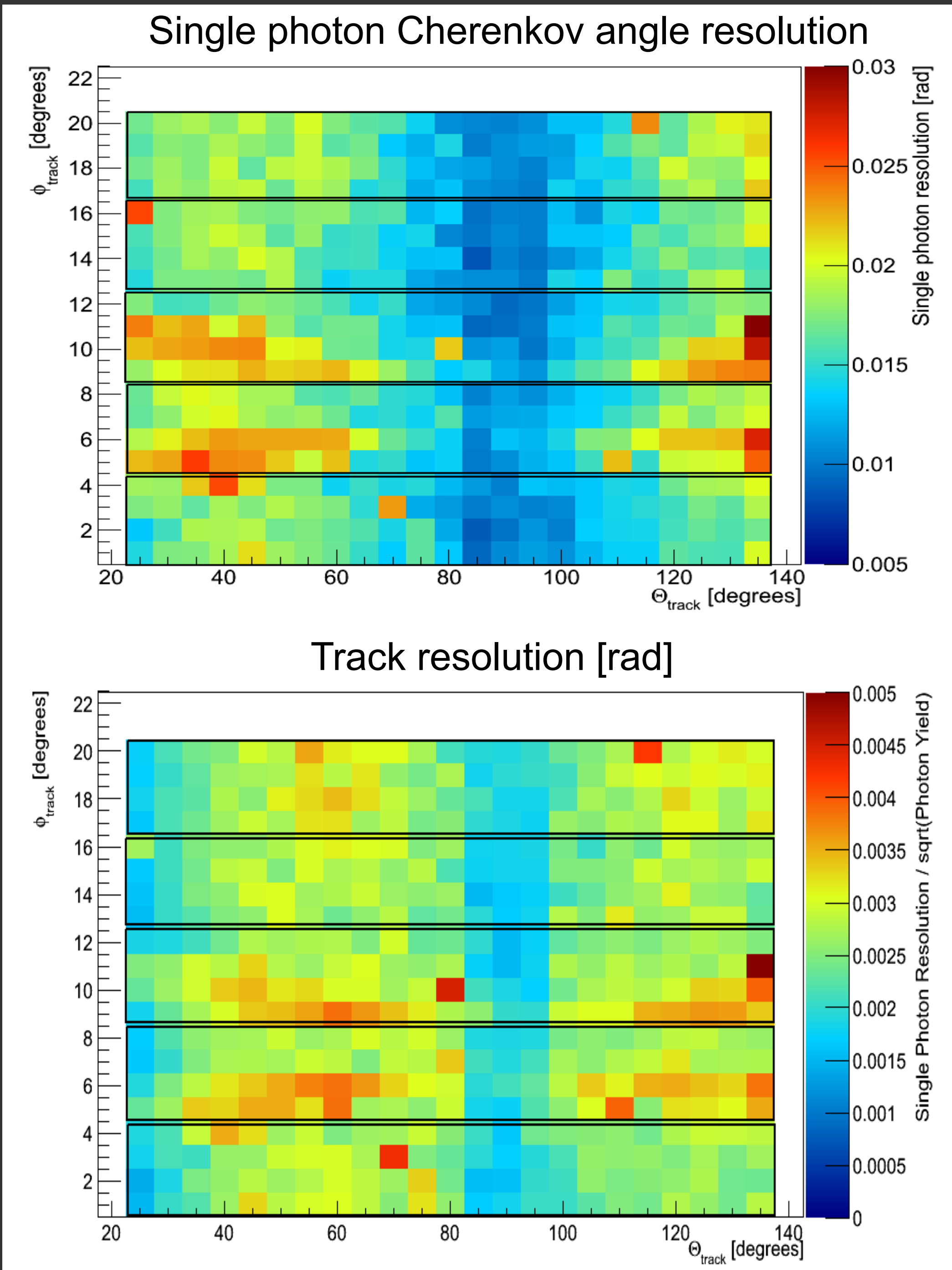




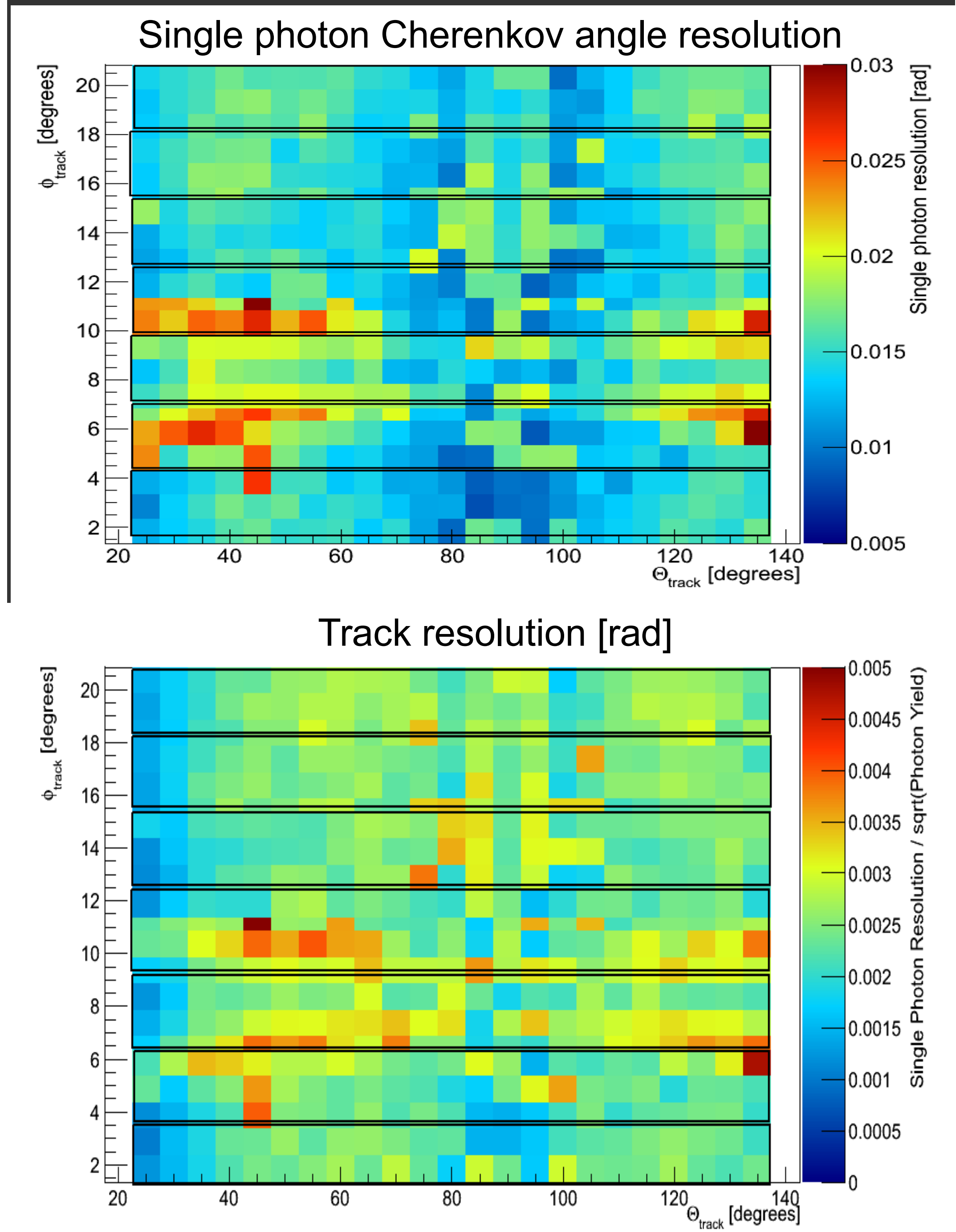


For narrower bars the single photon Cherenkov angle resolution is about the same as for the default ones.

5 bars in the bar box (3.2 cm wide)

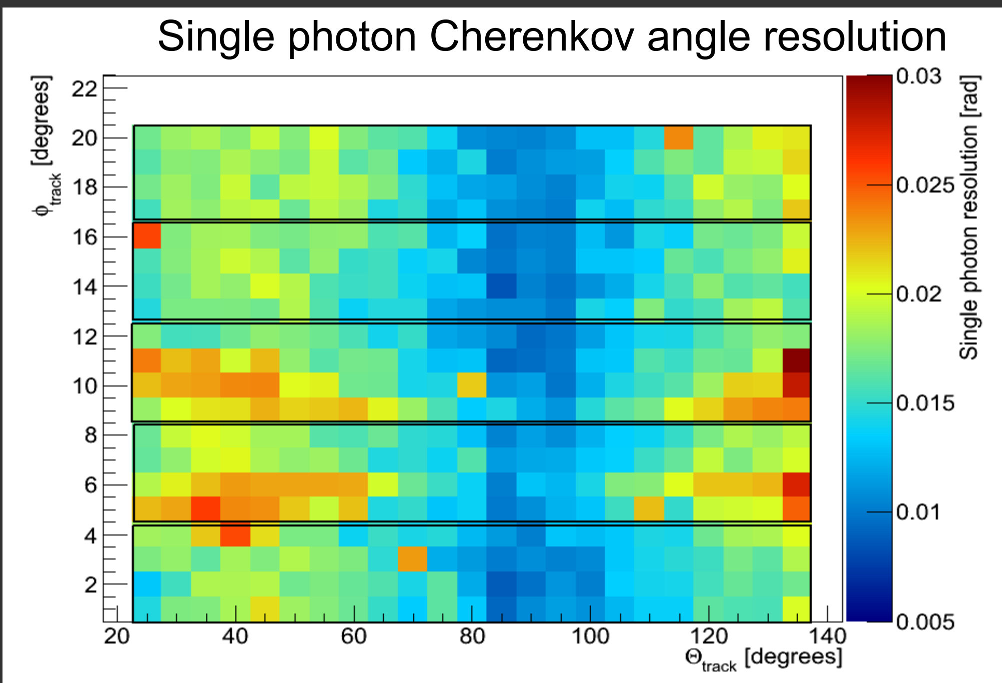


7 bars in the bar box (2.3 cm wide)

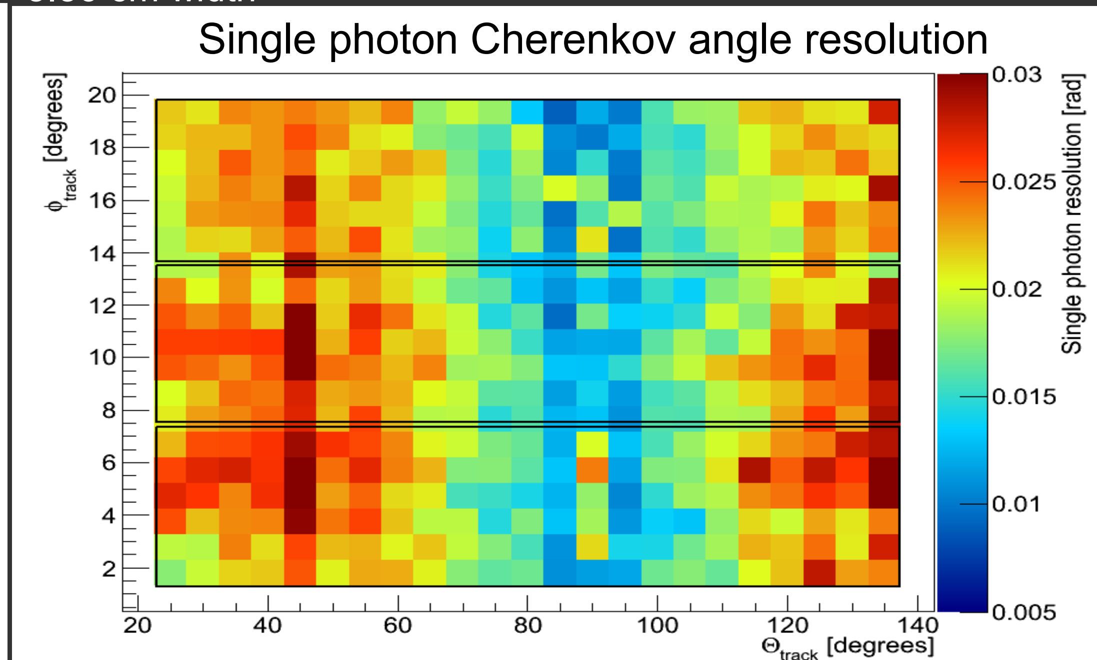


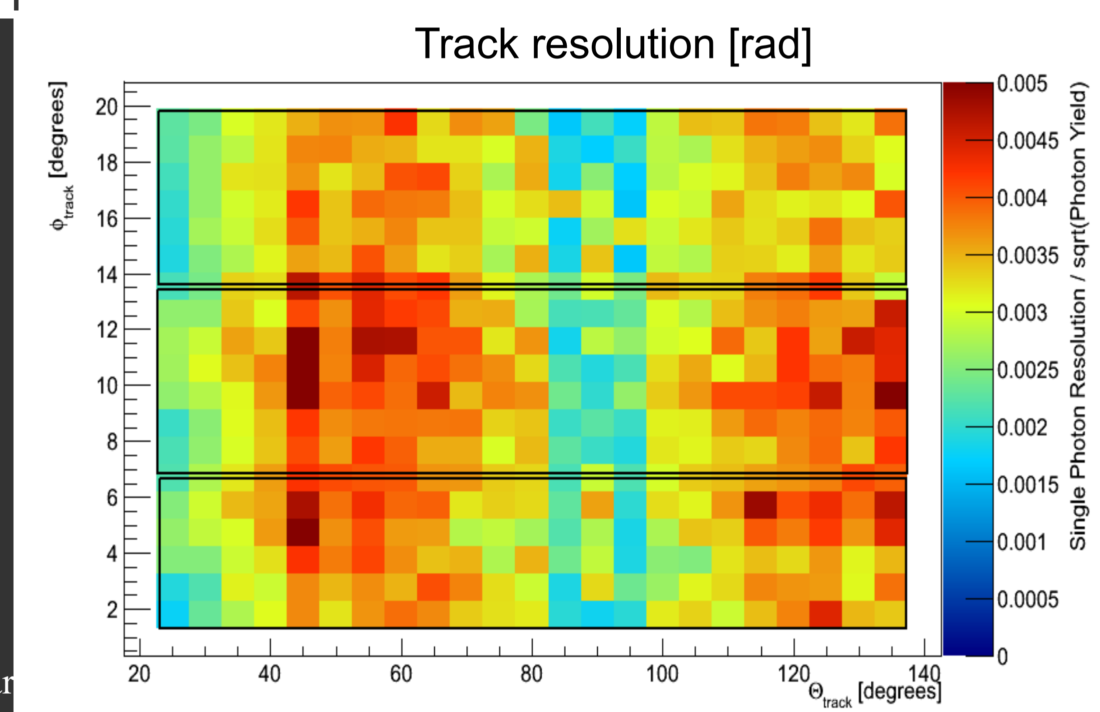
Performance of the 3 bars in the bar box

5.36 cm width



5 bars in the bar box



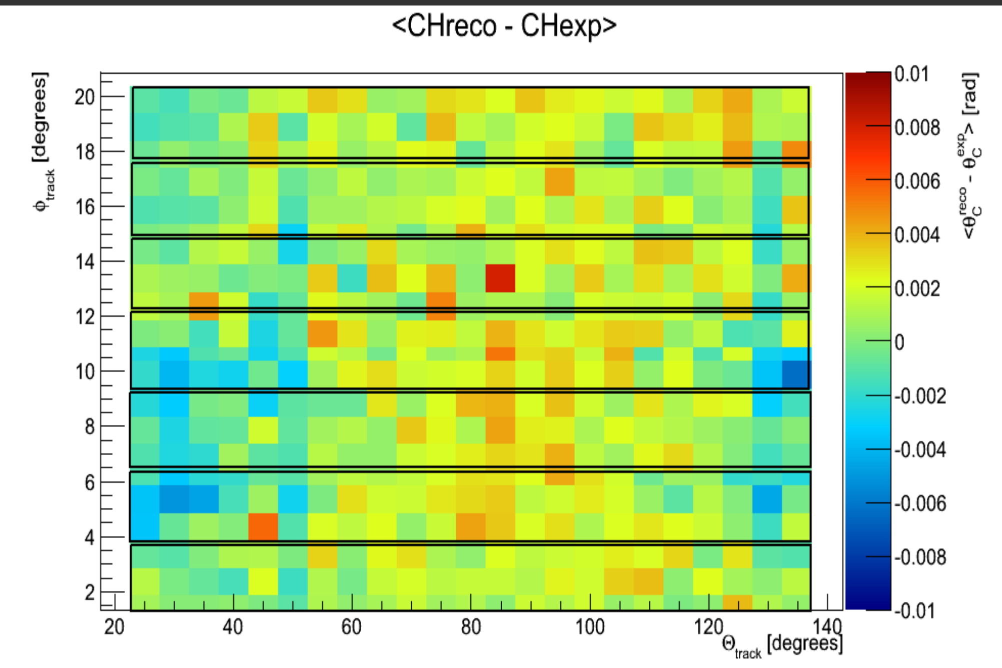


Bar width impacts to single photon Cherenkov angle resolution a lot compared to the case with 5 bars in the bar box.

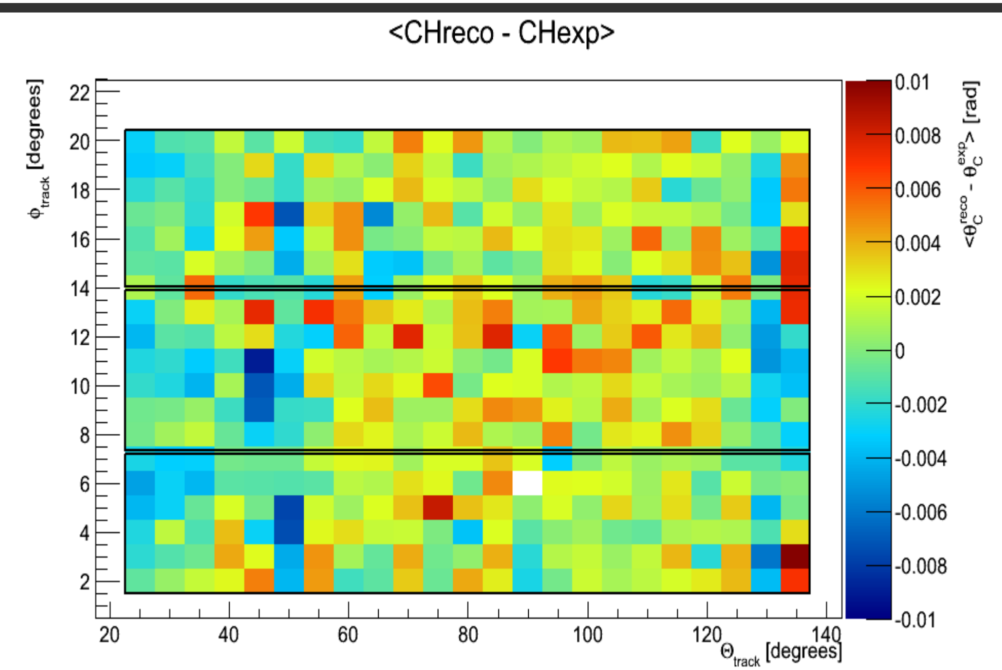
With wide bars the width of the bars can not be ignored anymore

Performance of the 7 bars in the bar box

2.3 cm width

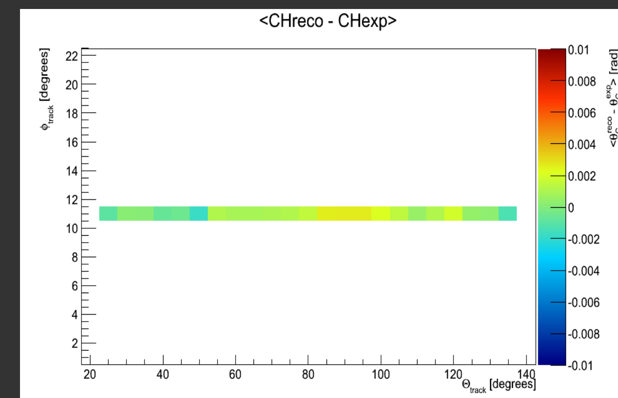


7 bars in bar box



3 bars in bar box

5 x 5 mm^2 bars



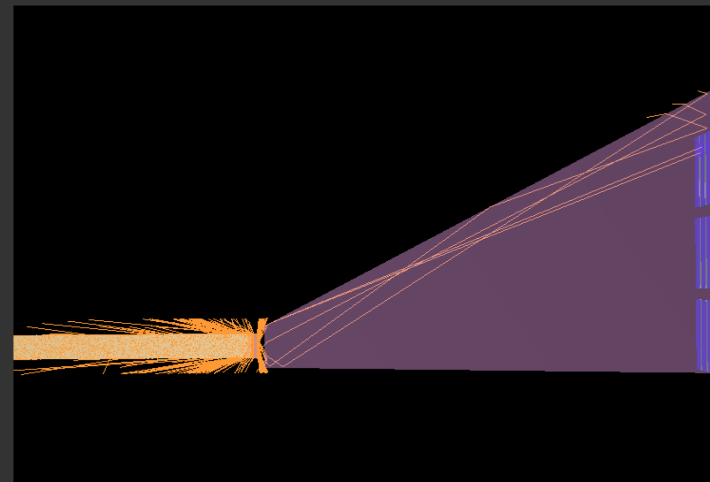
Wider bars →larger amplitude of the mean value for the difference btw the reconstructed and the expected Cherenkov angles. Study is needed!

Implementation of a new lens

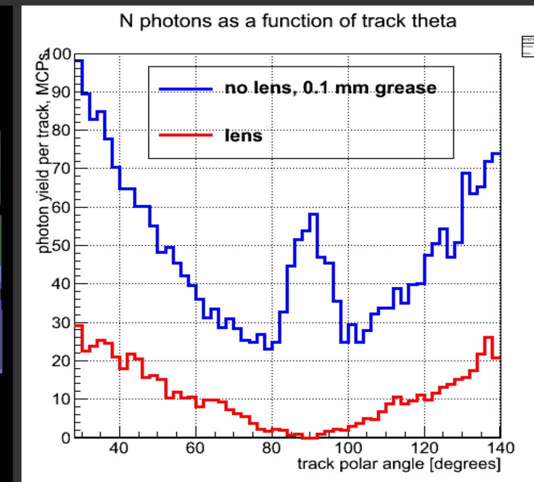
Problem with lenses in simulation – no detected photons at steep angles due to the air gap (which provides the change in the refractive indices)

New thin cylindrical lens without airgap (bending power due to the high refractive index material between two fused silica blocks) in geometry files:

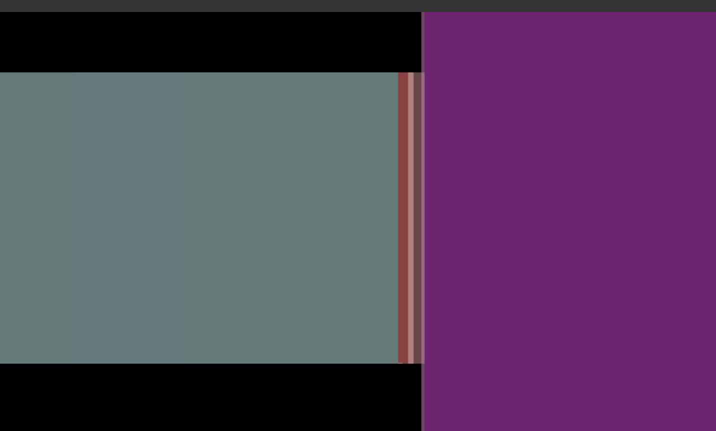
dirc_l3_p0.root (lens3)
dirc_l3_p1.root

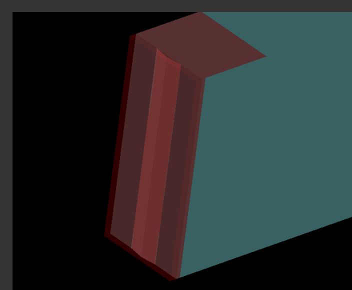


Photons getting out of the lens with air gap for a 90 degrees track



N photons as a function of track polar angle for the prototype geometry

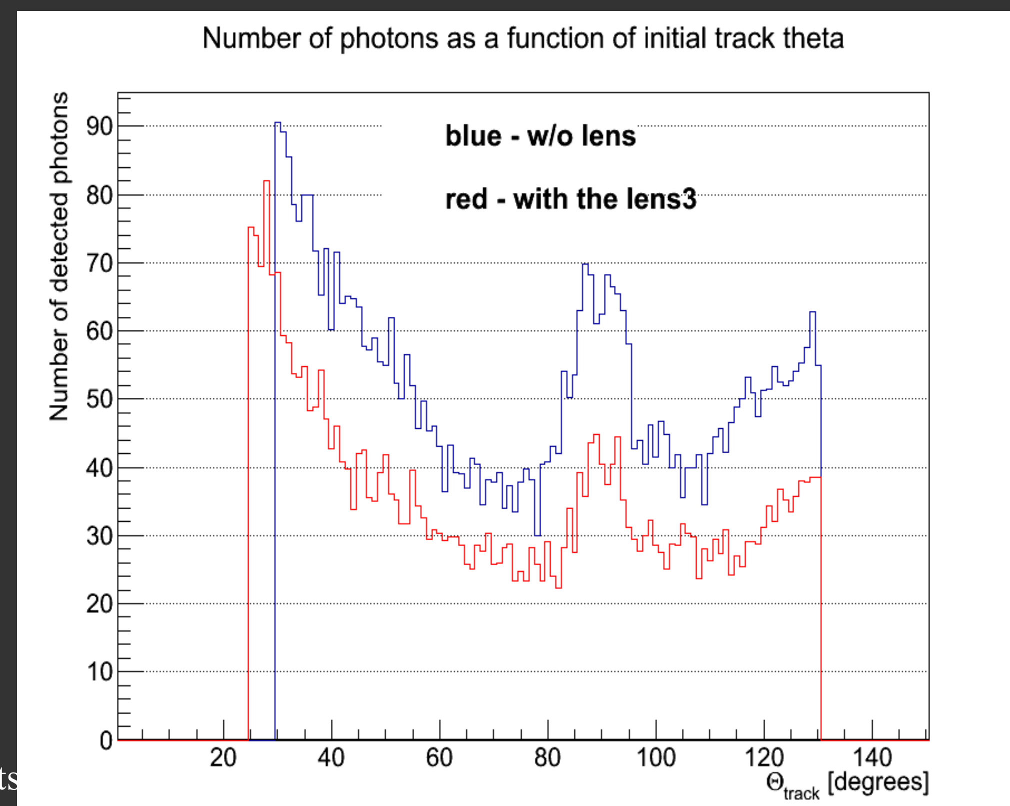




$n_{\text{quartz}} = 1.47$, $n_{\text{NLAK}} = 1.8$

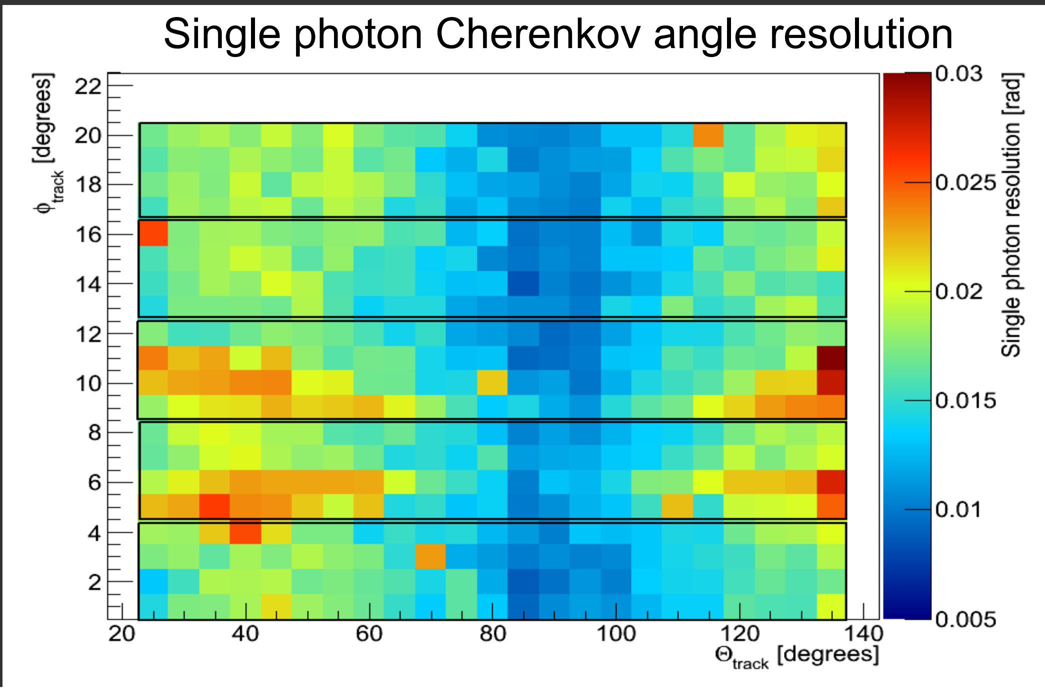
$$R = \left| \frac{n_1 - n_2}{n_1 + n_2} \right|^2$$

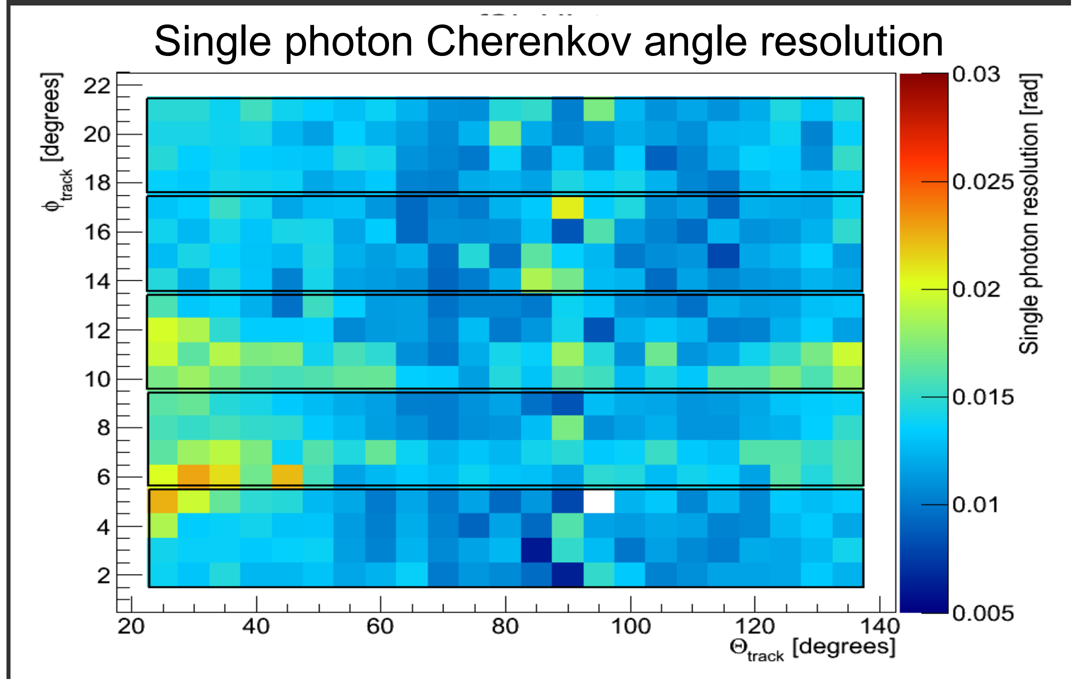
(reflection coefficient for 0 incident angle)

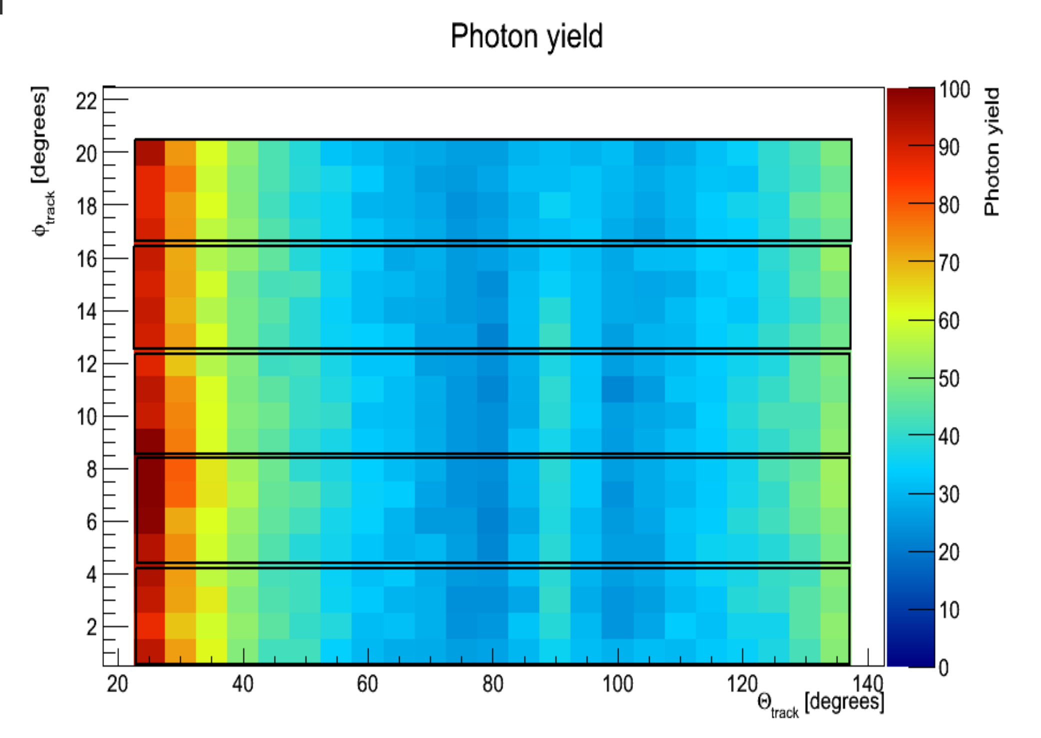


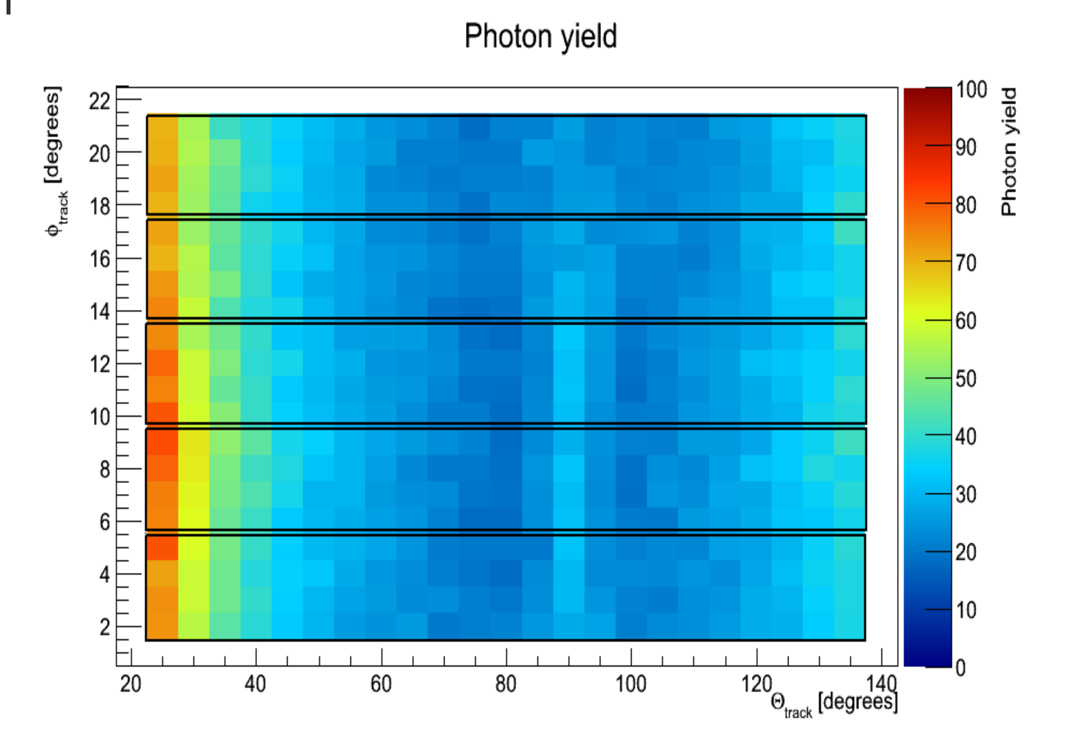
No lens

New lens

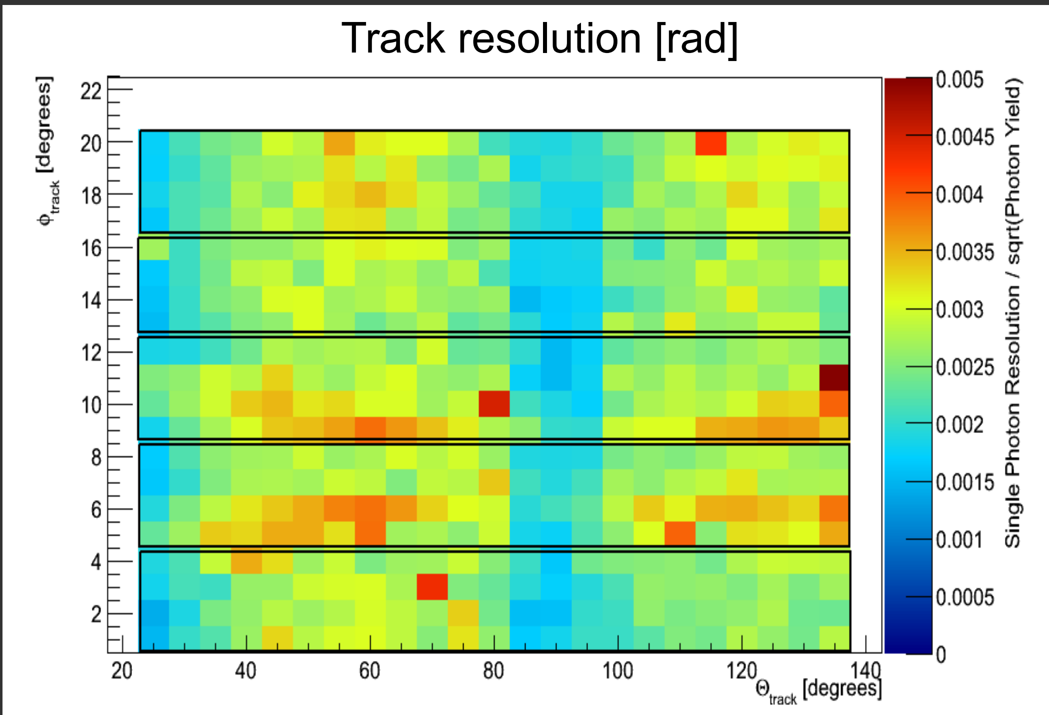




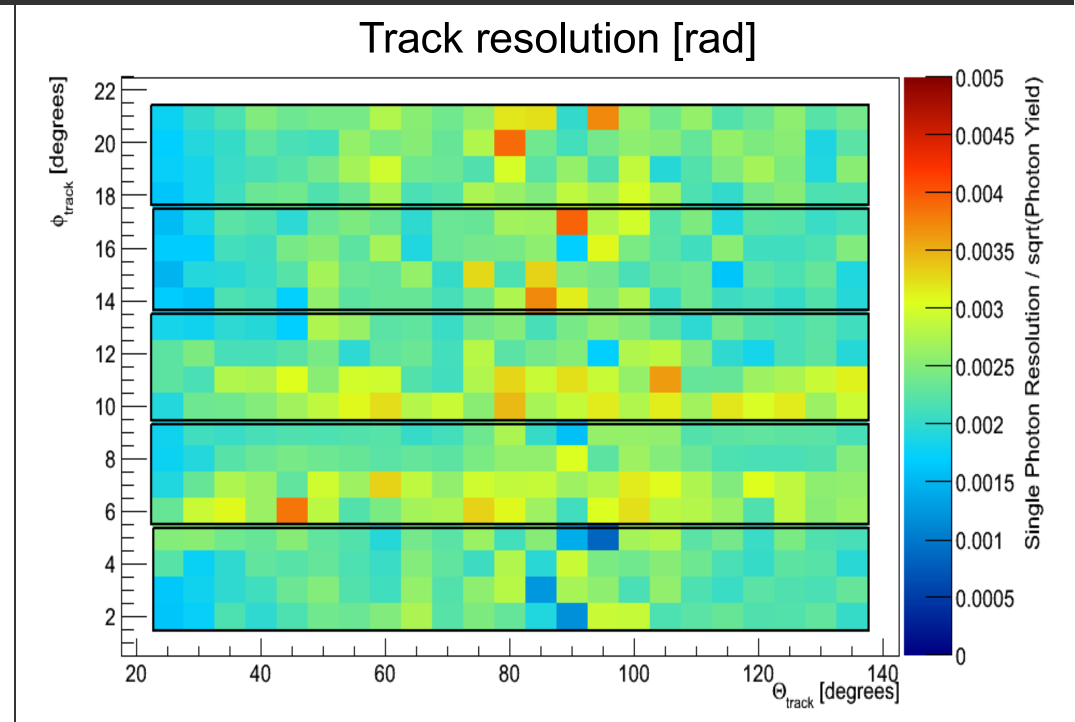




No lens



New lens



The design with a high refractive index lens is a promising candidate

A more detailed study is needed.

Conclusions

***1.** A method to evaluate and map the performance of the detector design in terms of single photon Cherenkov angle resolution and photon yield was developed and tested on the simplified DIRC designs with different bar dimensions without focusing optics.*

***2.** The required PANDA Barrel DIRC resolution is being studied in detail.*

***3.** The obtained Cherenkov resolution per track does not satisfy the PANDA requirement, therefore thinner bars or focusing system is required.*

***4.** More advanced design options are currently being evaluated.*