# Generic R&D and DIRC@EIC Simulations

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Progress on chosen topics

DIRC Annual Meeting
JLab, 18.05.24

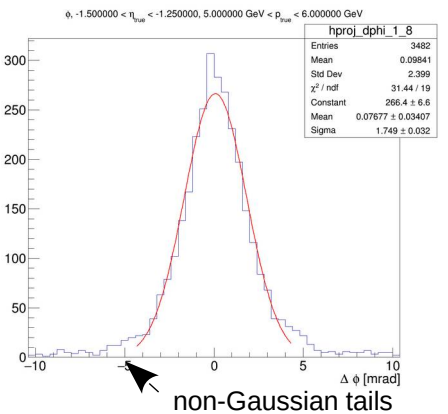
# Topics

- realistic tracking
- e/$\pi$ performance
- PID LUT for fast simulation @ ePIC
- bar  box window
- plate for light guide section

# Realistic Tracking

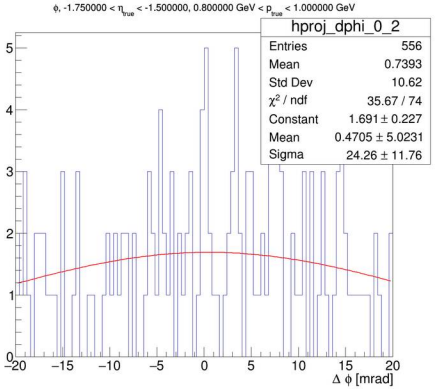
- several versions of tracking where released, latest on 27.11.23 (from M.P.)
- 13 bins in momentum [0.3, 10] and 14 bins in eta [-1.75, 1.75]

typical bin:

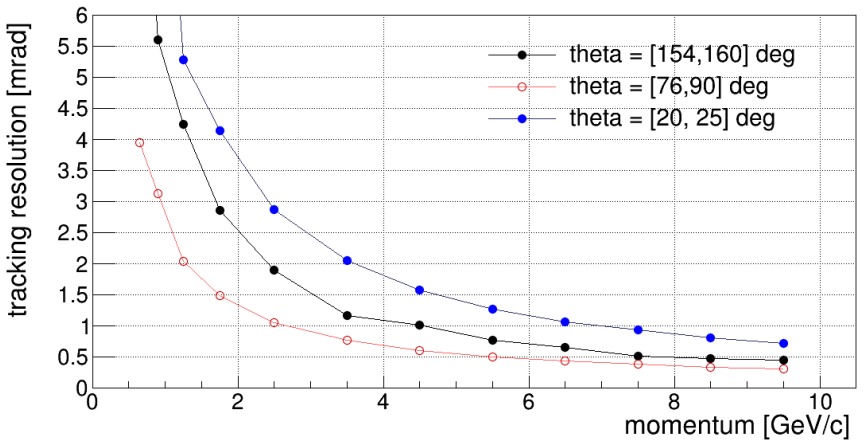



non-Gaussian tails

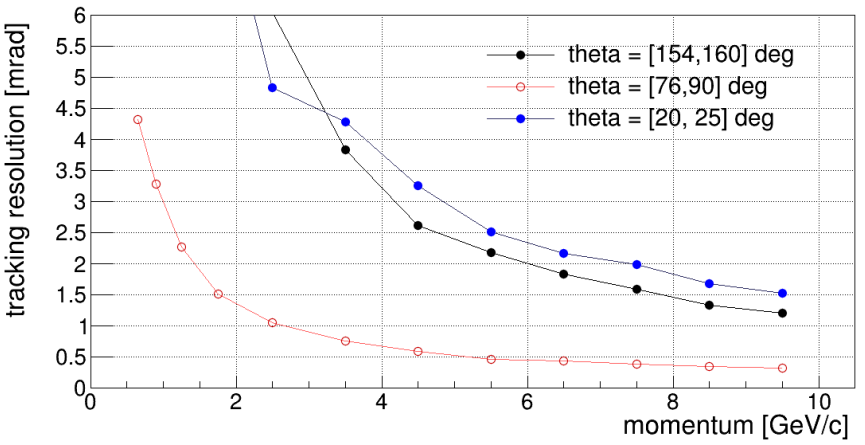
bin with low stat (@ low momenta):




Polar



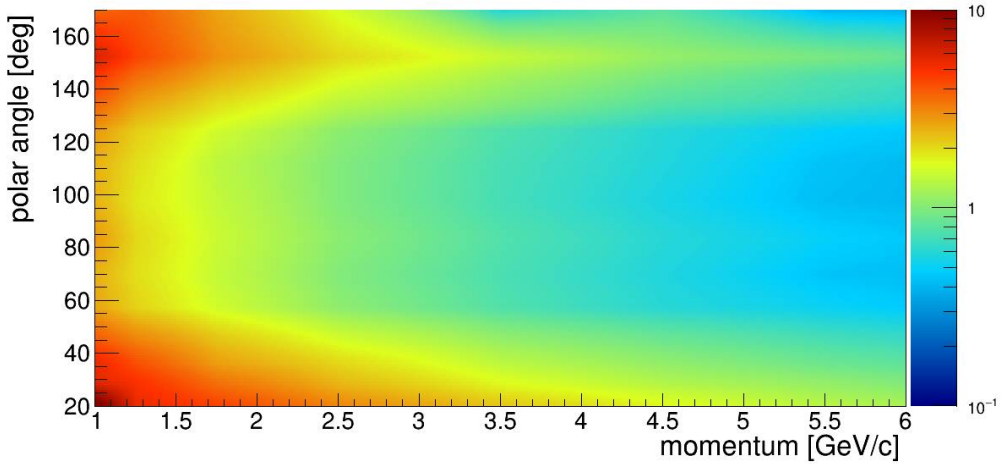

Azimuthal



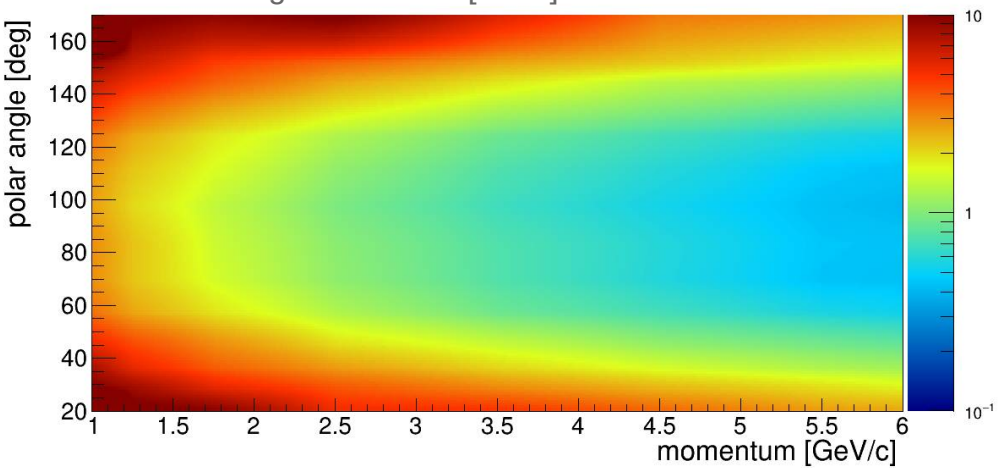
# Realistic Tracking

binned data are interpolated to create resolution maps

polar angle resolution [mrad]:



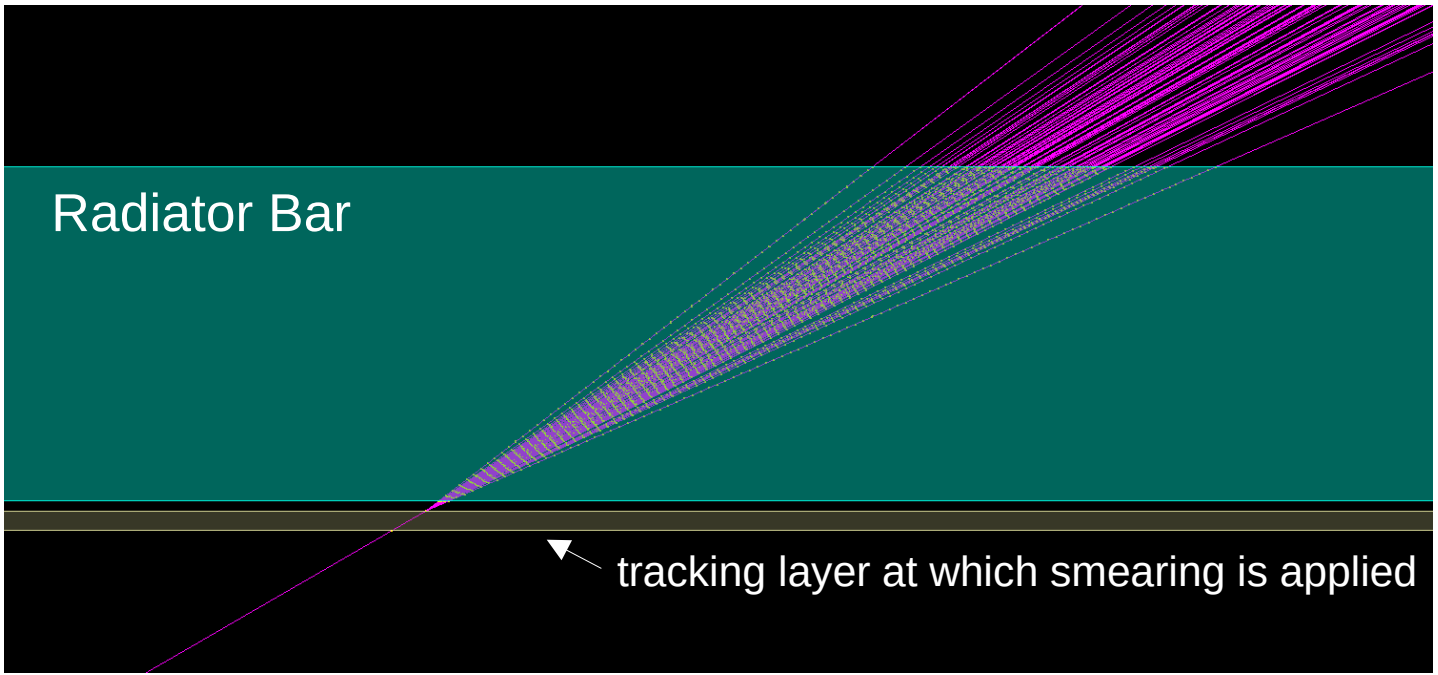

azimuthal angle resolution [mrad]:



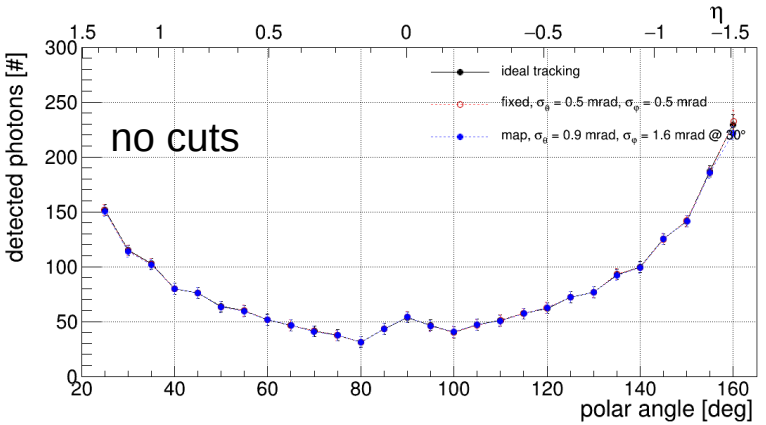
# Realistic Tracking

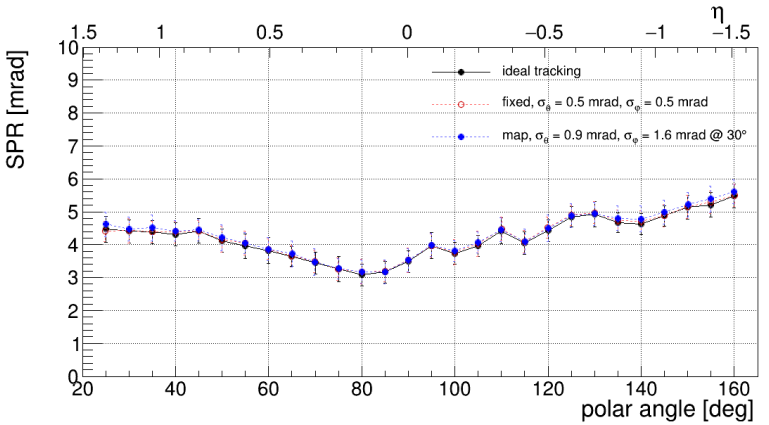
- smearing track direction with Gaussian in polar and azimuthal angle in global CS
- smearing at the “tracking layer” in front of radiator

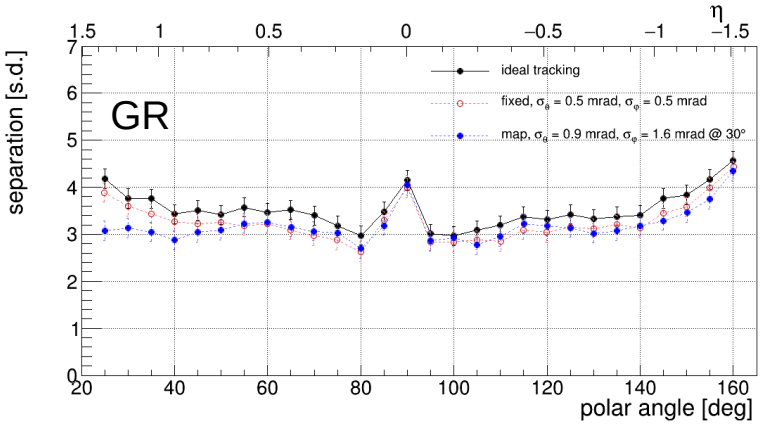
Event display of 100 pions @ 6 GeV/c smeared at tracking layer with 50 mrad

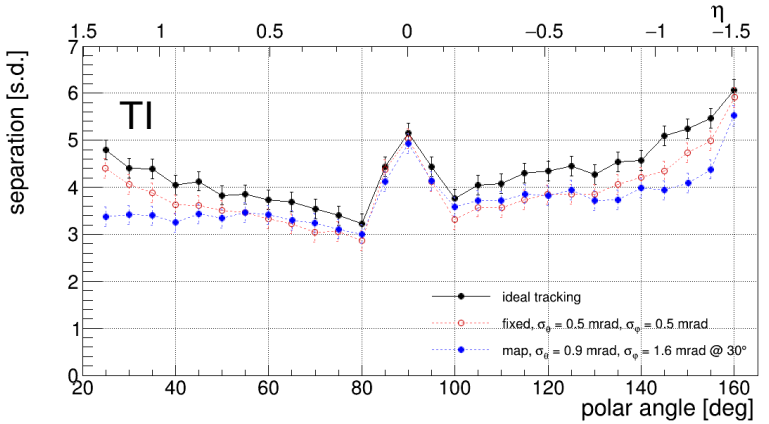


# Realistic Tracking for $\pi$/K @ 6 GeV/c

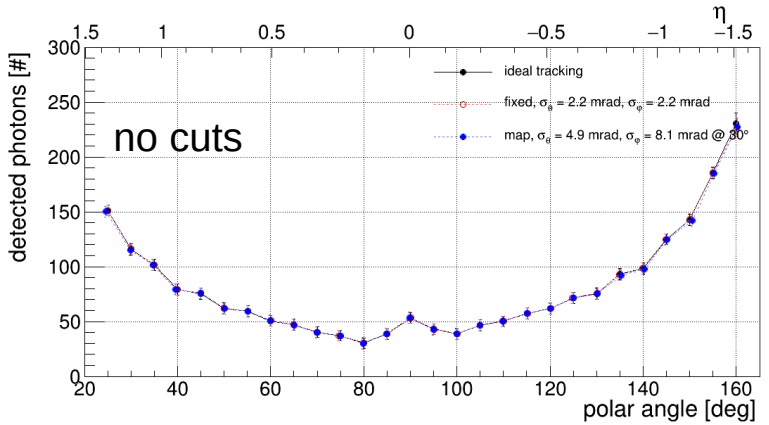


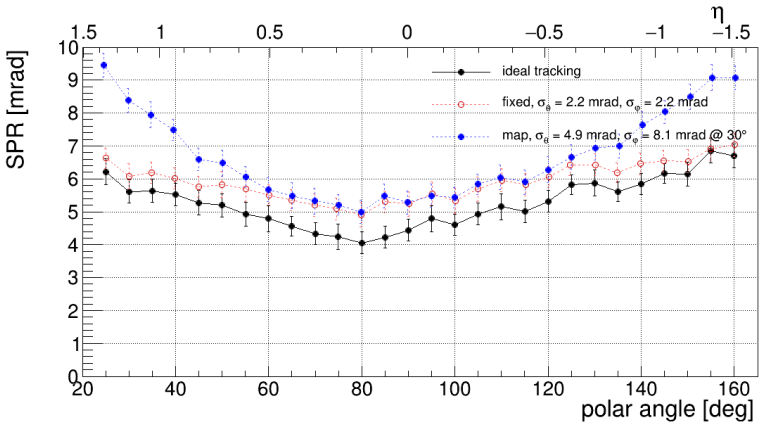



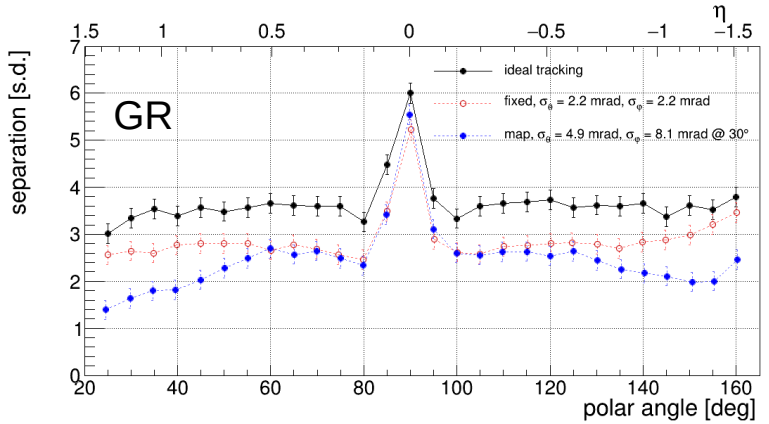



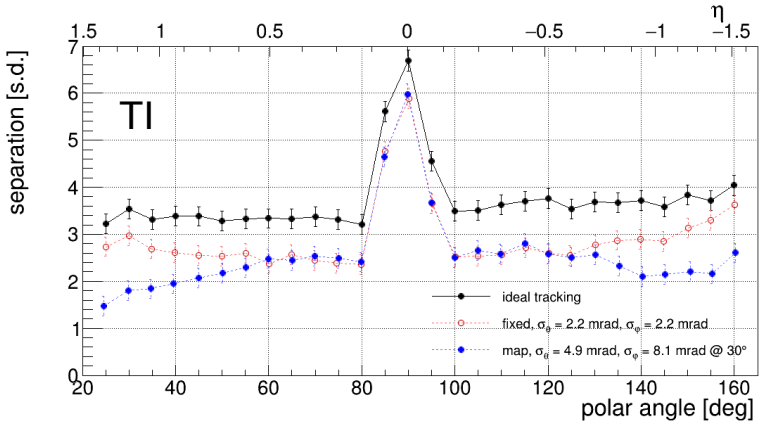



# Realistic Tracking for e/$\pi$ @ 1.2 GeV/c



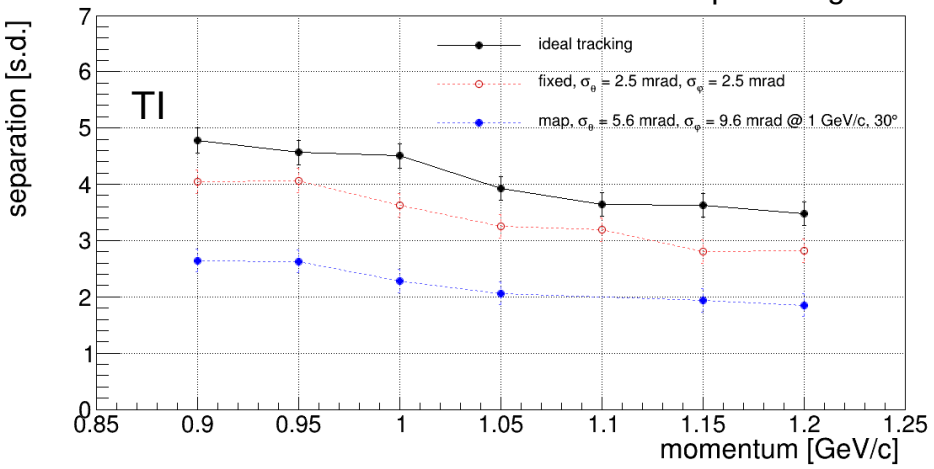



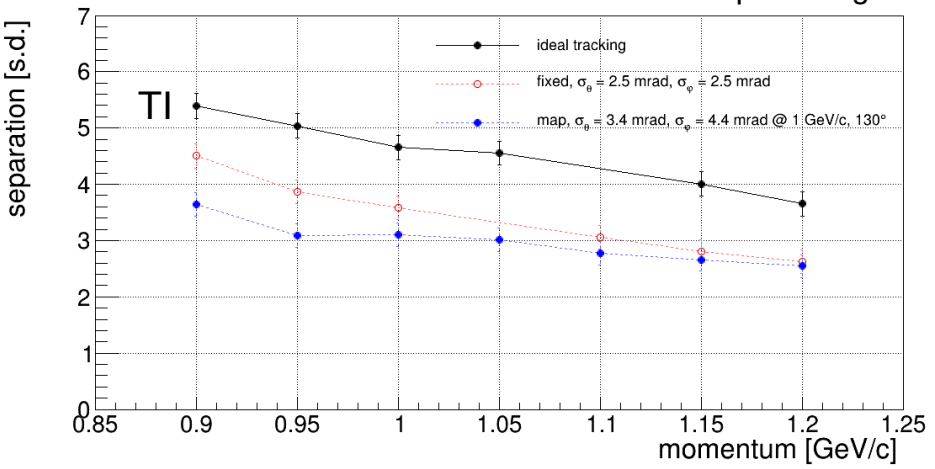



# e/$\pi$ Performance

30° polar angle




130° polar angle

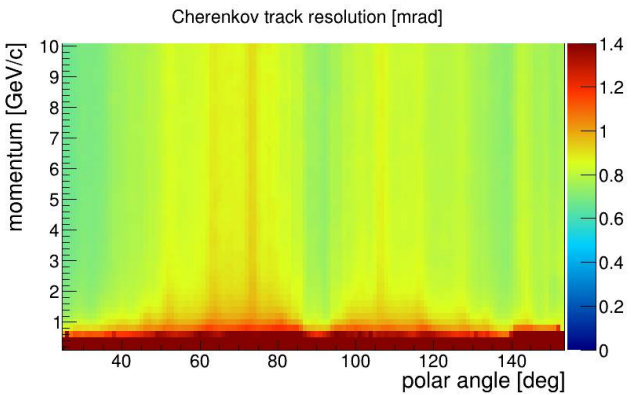


# Realistic Tracking Summary

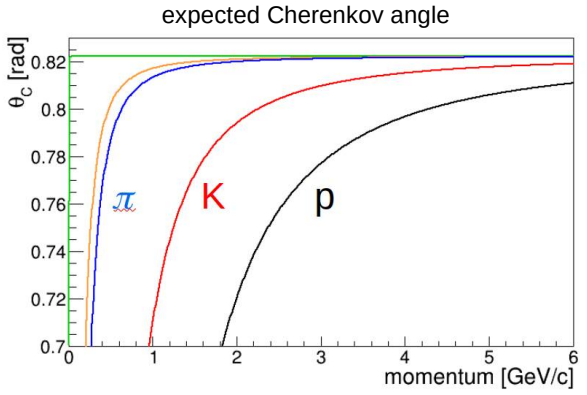
- Current angular resolution is larger then expected (×2 in polar angle, ×3 in azimuthal angle)
- DIRC PID goal for $\pi/K$ @ 6 GeV/c is barely reached with current tracking
  and not reached for e/$\pi$ @ 1.2 GeV/c
- Cherenkov ring fit is aimed to mitigate MS inside the radiator (but not to improve external tracking)

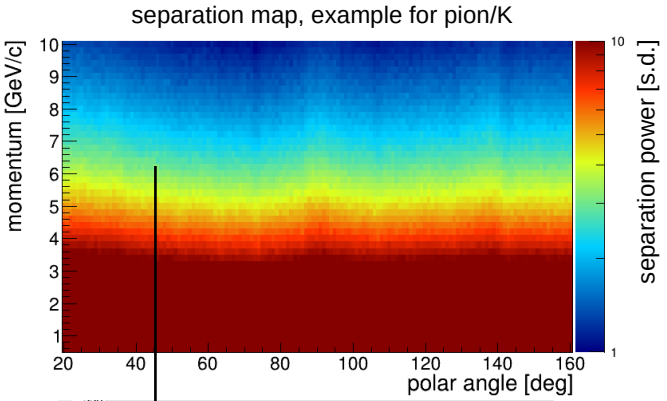
# PID LUT for Fast Simulation and Reco

Based on Cherenkov track resolution map obtained by using the full standalone Geant4 simulation and reconstruction



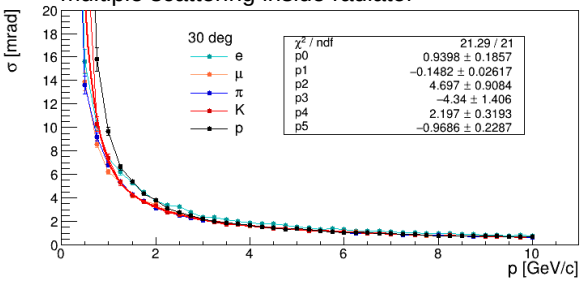

+



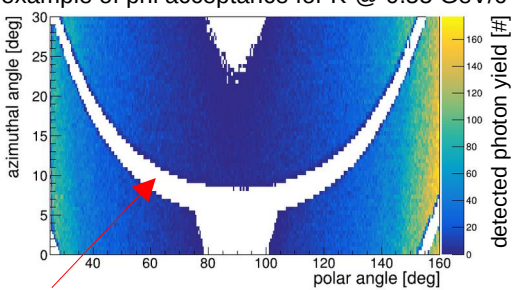




- uses 0.5 mrad tracking resolution combined with multiple scattering inside radiator
- accounts for azimuthal acceptance gaps
- includes threshold mode PID

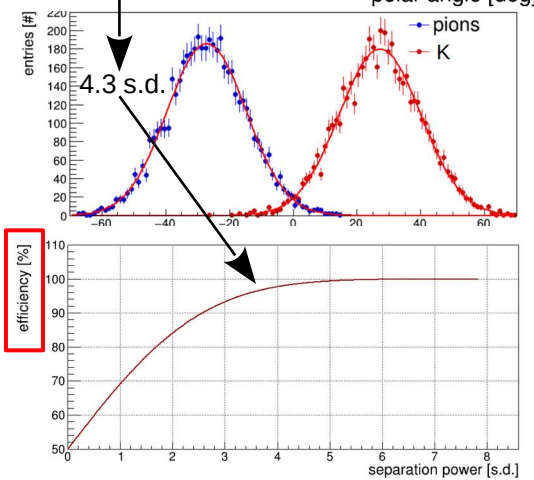
multiple scattering inside radiator




example of phi acceptance for $K^-$ @ 0.55 GeV/c




azimuthal acceptance gaps between bar boxes



# PID LUT for Fast Simulation and Reco

The LUT in ASCII:

```
...
11 1 9.80 69.00 21.50 0.3932 0.3792 0.2150 0.0125
11 1 9.80 69.00 22.00 0.3894 0.3757 0.2202 0.0147
11 1 9.80 69.00 22.50 0.3945 0.3764 0.2170 0.0121
11 1 9.80 69.00 23.00 0.3933 0.3803 0.2146 0.0118
11 1 9.80 69.00 23.50 0.3929 0.3747 0.2186 0.0139
11 1 9.80 69.00 24.00 0.3919 0.3760 0.2185 0.0136
...
```

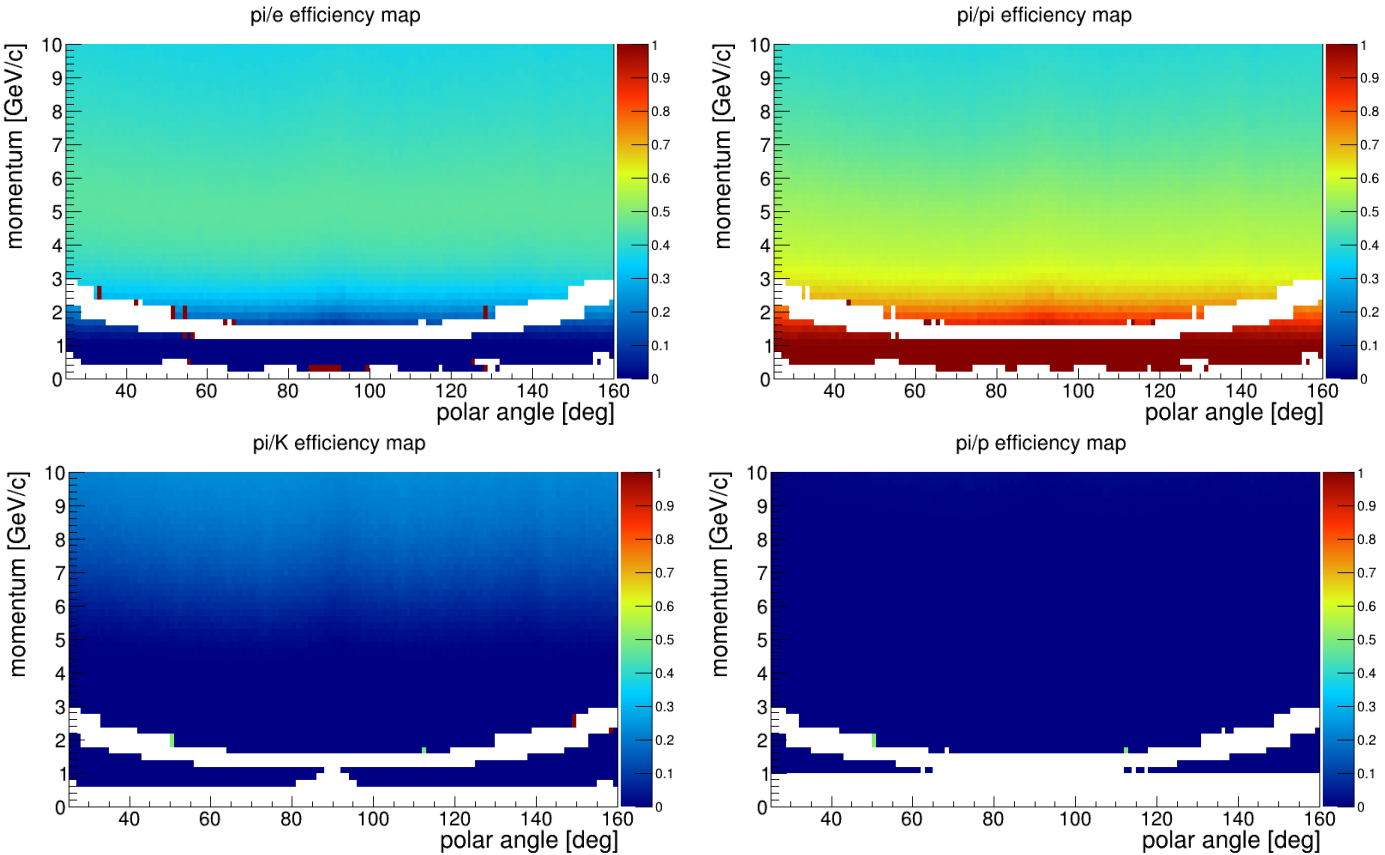
Full version is here:
https://github.com/rdom/fastpid/blob/master/hpdirc_fastpid.tar.gz

Description of PID LUT's columns:

1) PDG code of the particle (e 11, pi 211, K 321, p 2212)
2) charge (-1,1)
3) momentum, [0.2,10] with 0.2 GeV/c step, for higher momenta one should use 10 GeV/c
4) polar angle, [25,160] with 1 degree step
5) azimuthal angle [0,30] with 0.5 degree step, there is 12x azimuthal symmetry
6) probability for electron
7) probability for pion
8) probability for kaon
9) probability for proton

Probabilities are normalized to 1 (for e,pi,K,p).
If all probabilities = 0 then PID is not possible.

Example of probabilities for $\pi^+$ at 5.5° azimuthal angle:



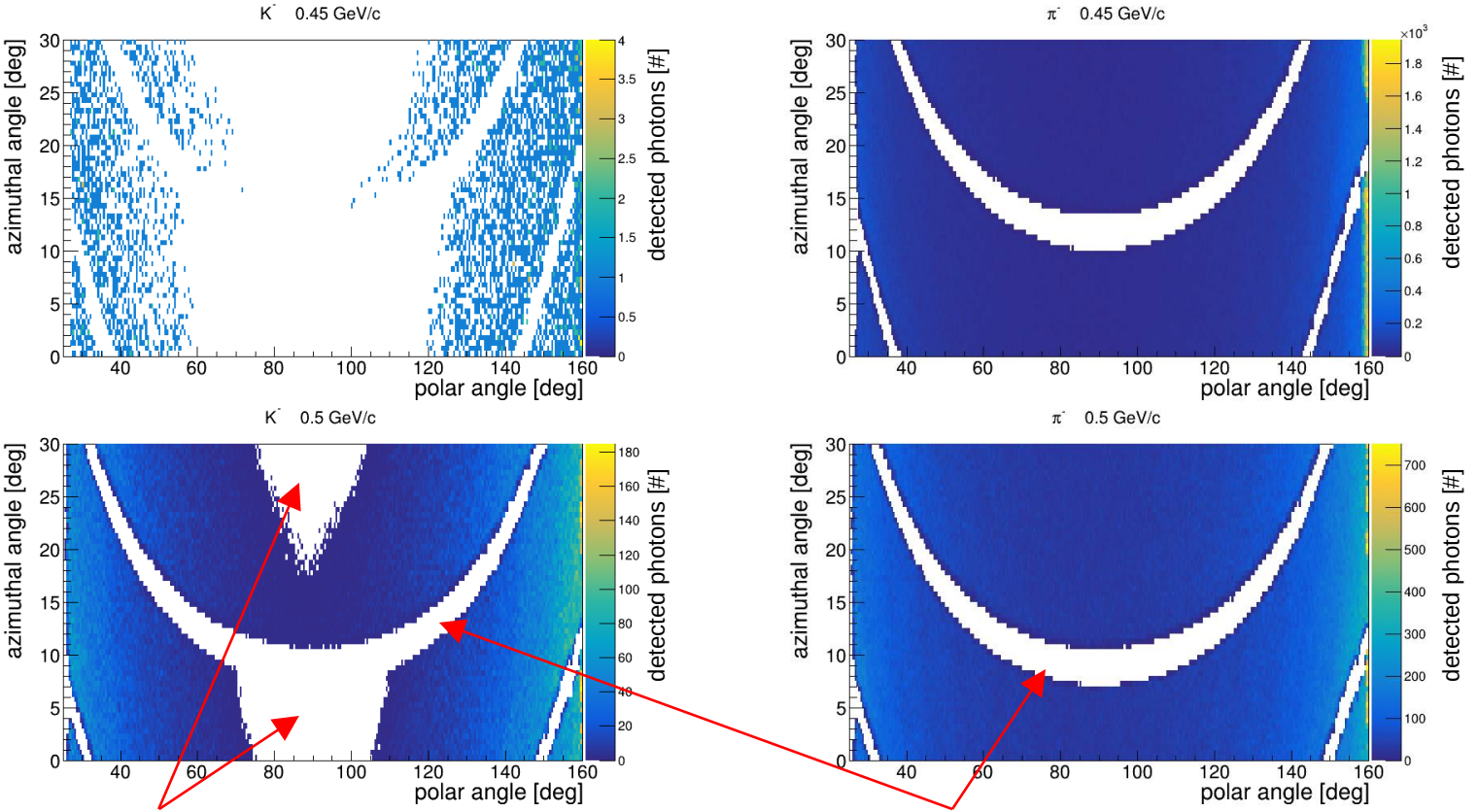
# PID LUT for Fast Simulation and Reco

Example of threshold mode

Require more than 5 detected photons for robust PID

➡ positive ID for pions over whole phase space @ 0.45 GeV/c

➡ positive ID for pions over large part of phase space @ 0.5 GeV/c

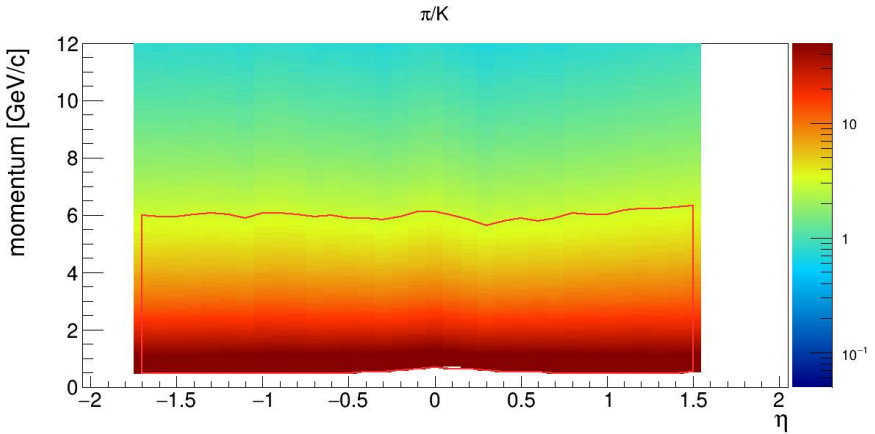


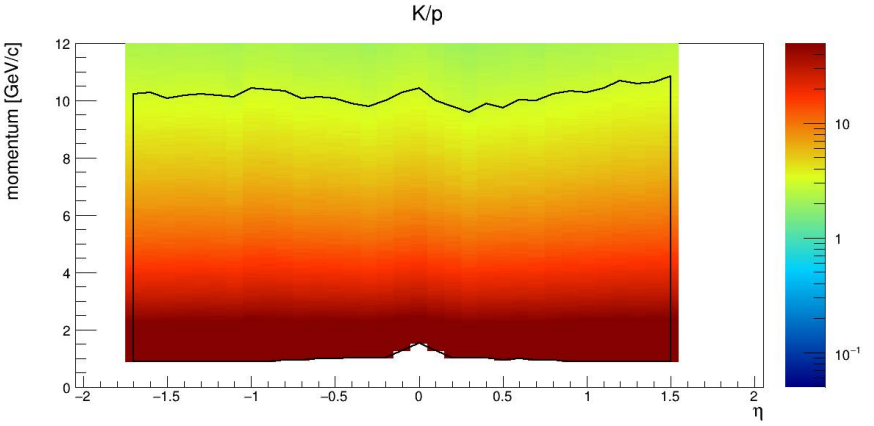

acceptance gap due to total internal reflection

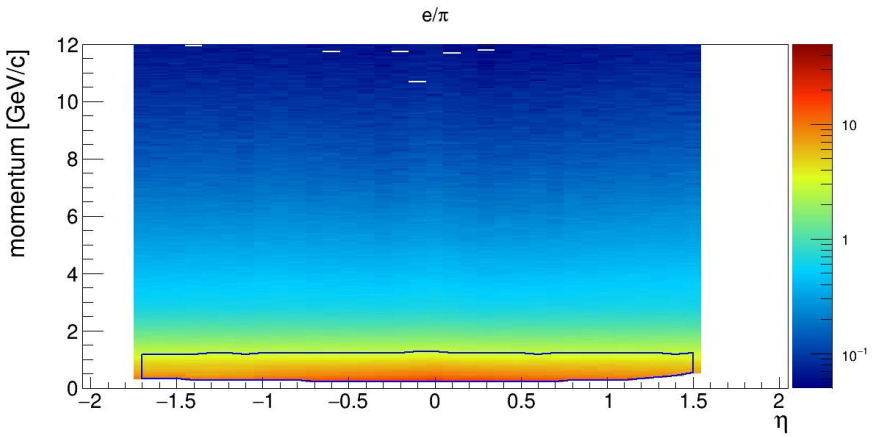
acceptance gap due to space between bar boxes

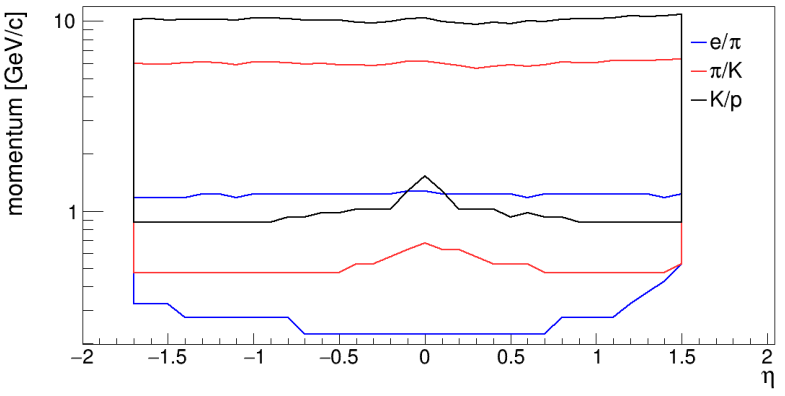
Fine binning in angle and momentum needed to deal with rapid changes in photon yield

# 3 Sigma Contour



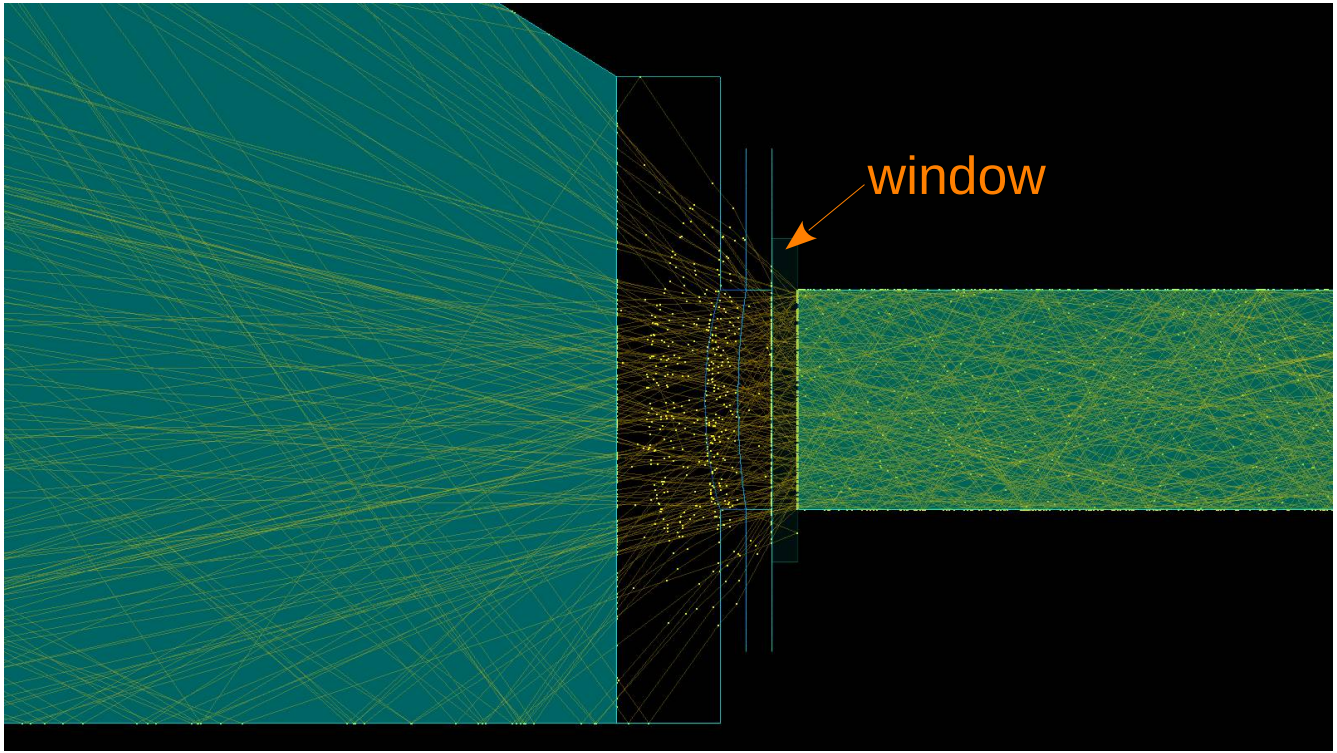



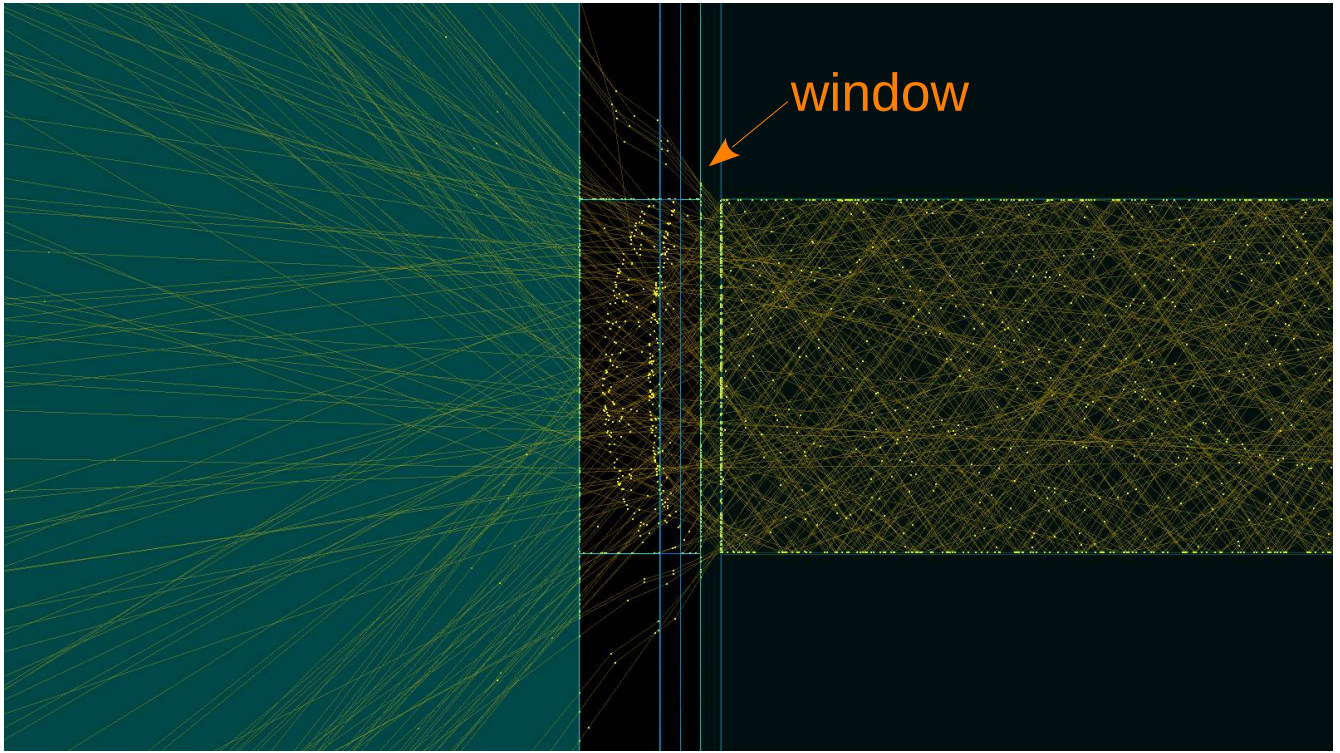
# Bar Box Window

Event display for 25 mm x 350 mm x 2 mm, polished sides, from side:

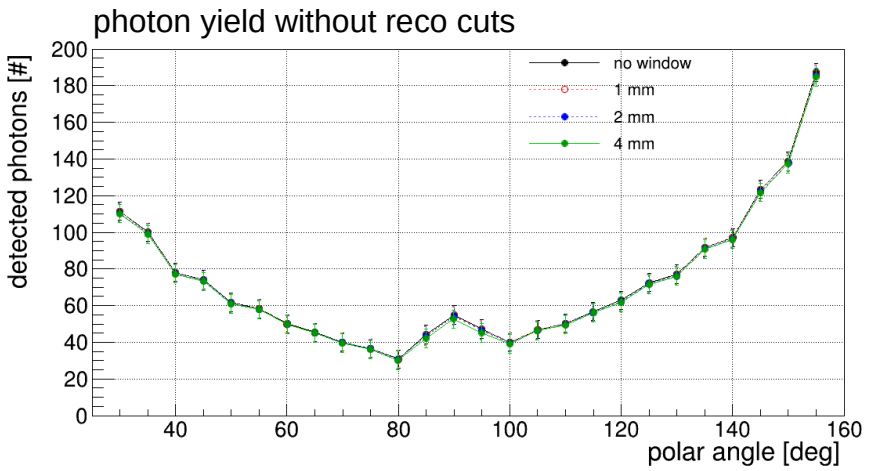


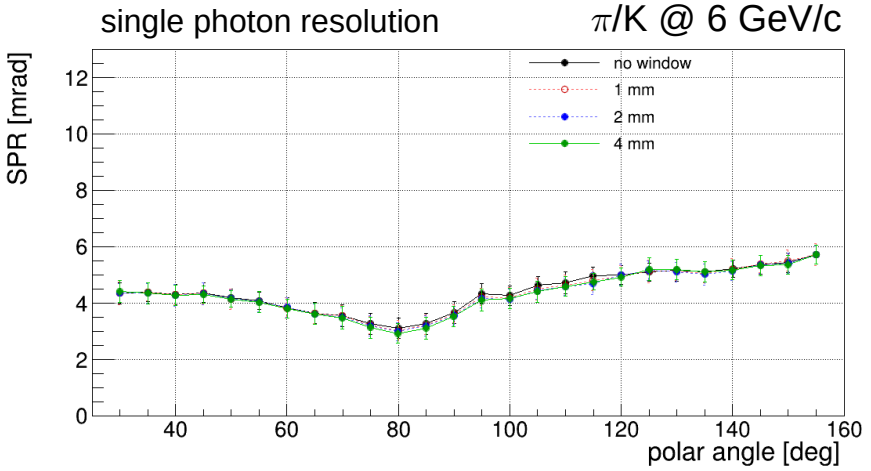
# Bar Box Window

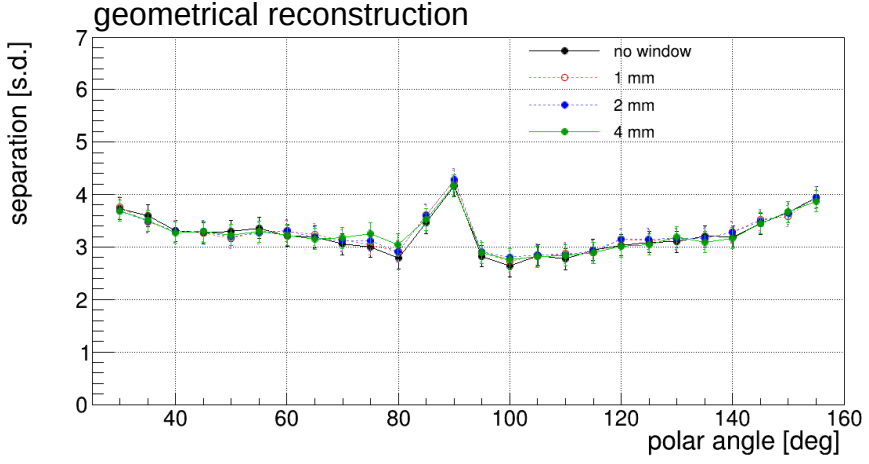
Event display for 25 mm x 350 mm x 2 mm, polished sides, from top:

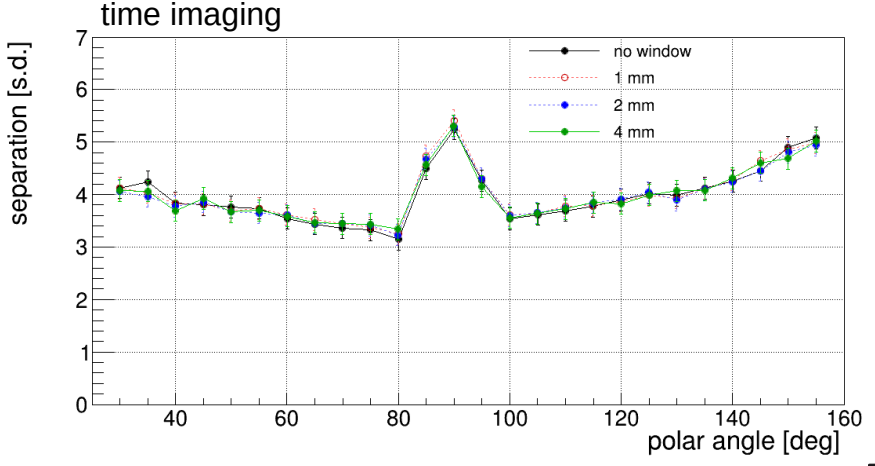


# Bar Box Window



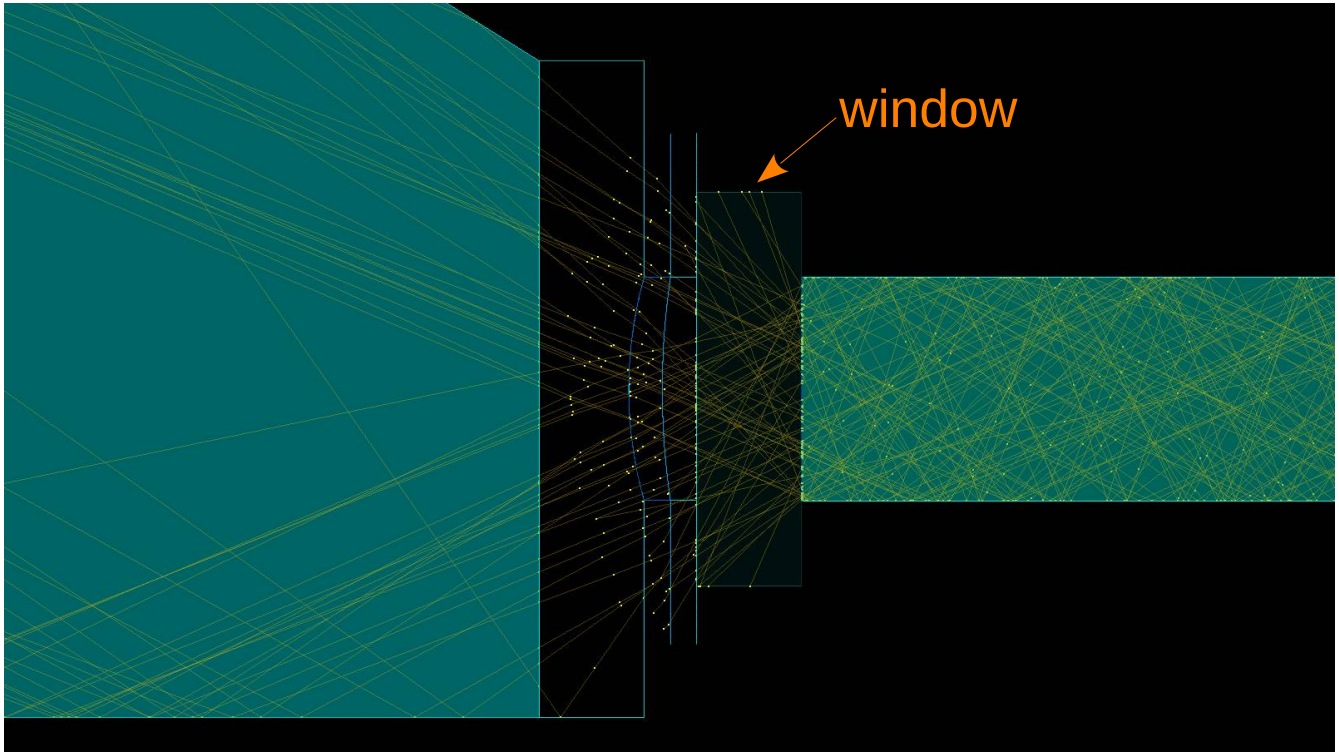



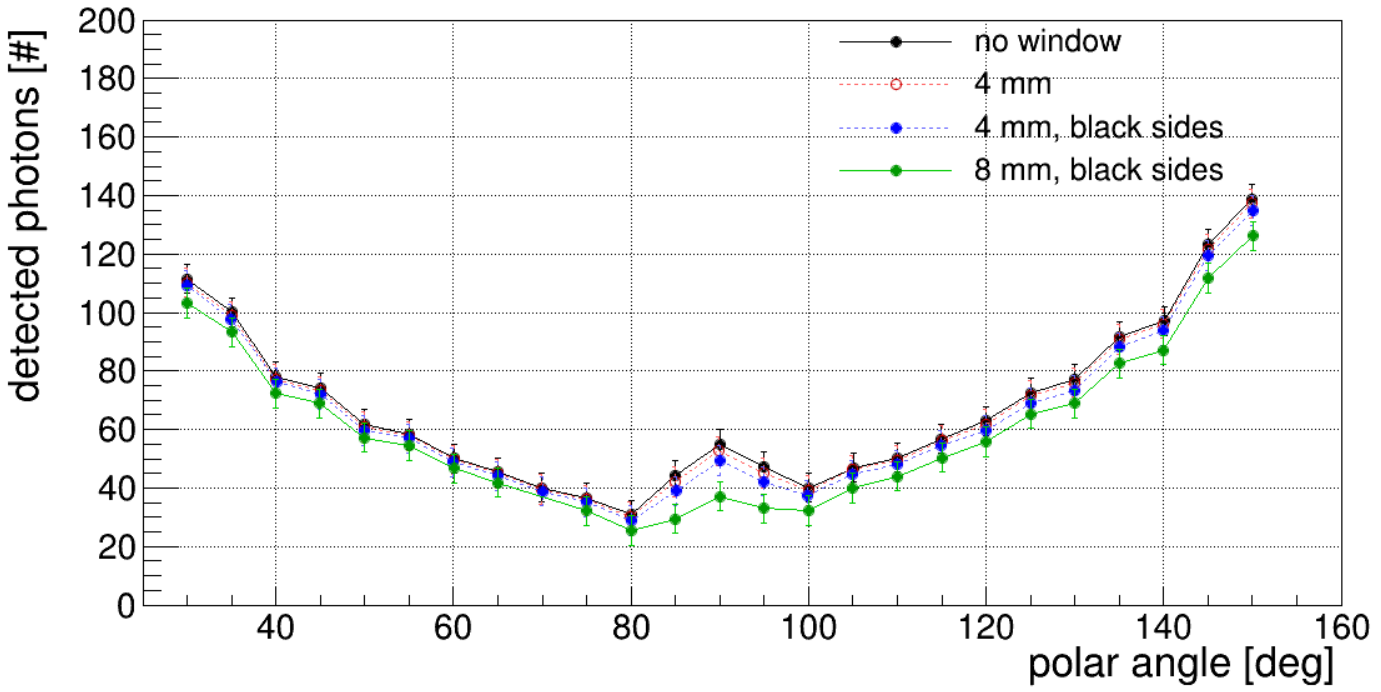
# Bar Box Window

Event display for 25 mm x 350 mm x 8 mm, black sides, from side:

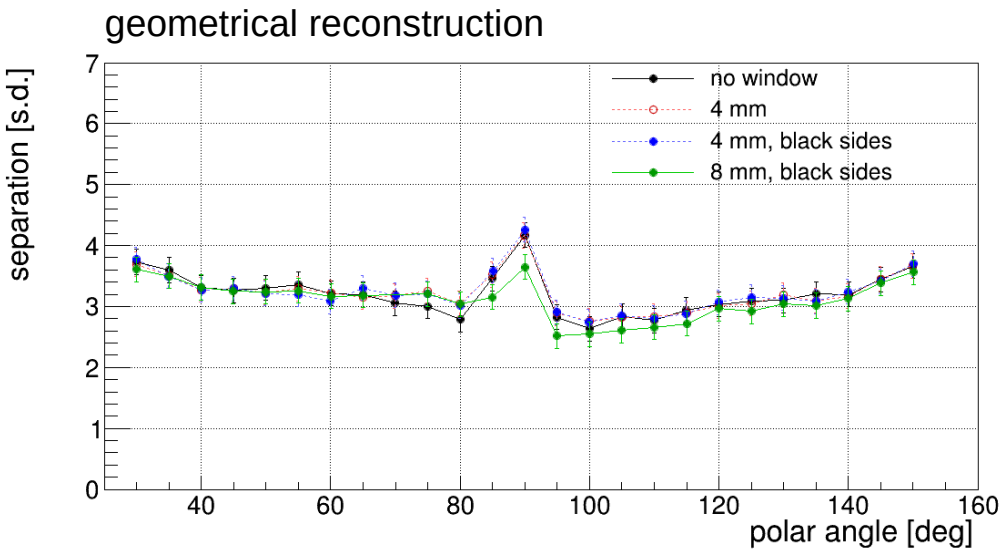


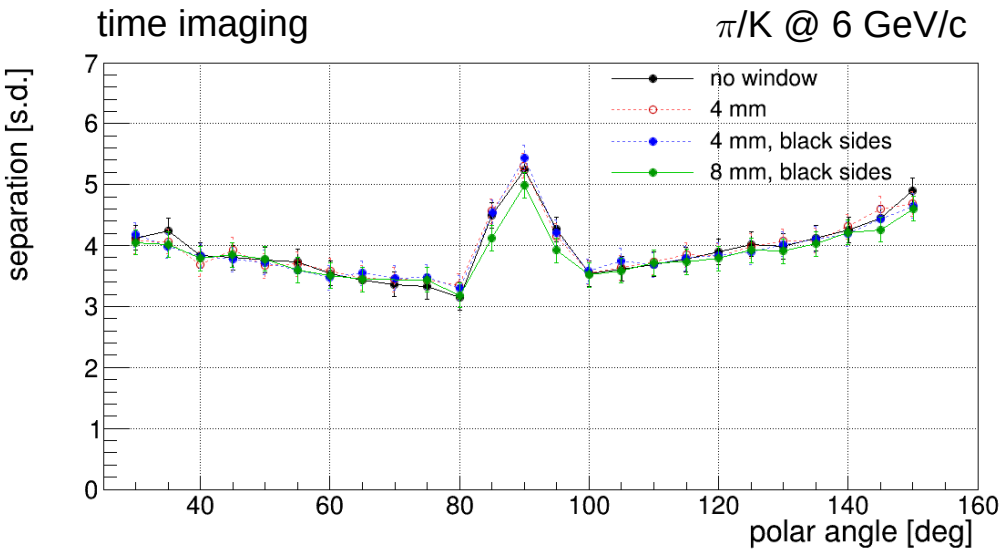
# Bar Box Window

photon yield without reco cuts:

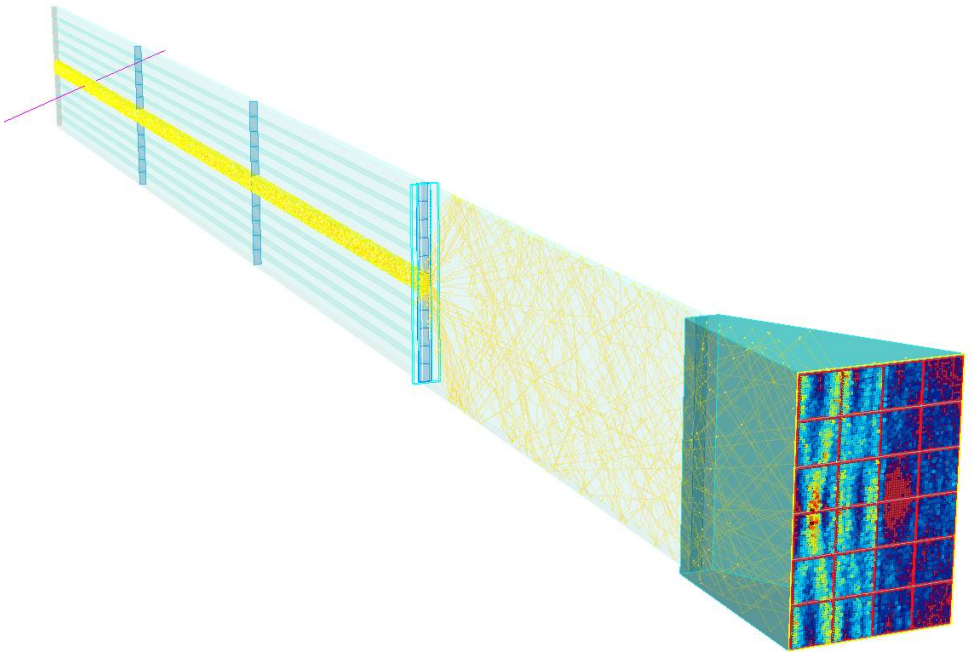


# Bar Box Window



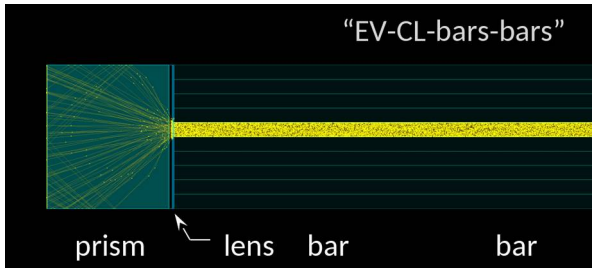



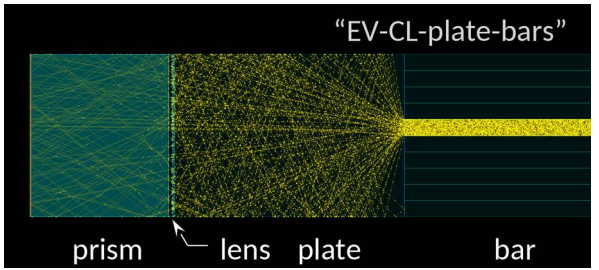
# Plate as Optical Guide

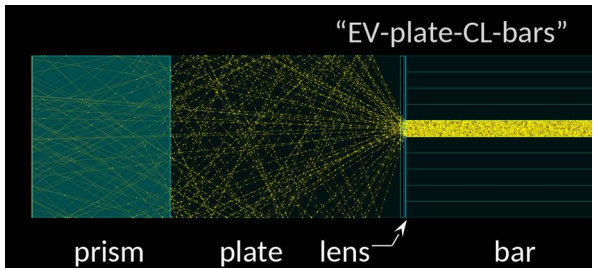


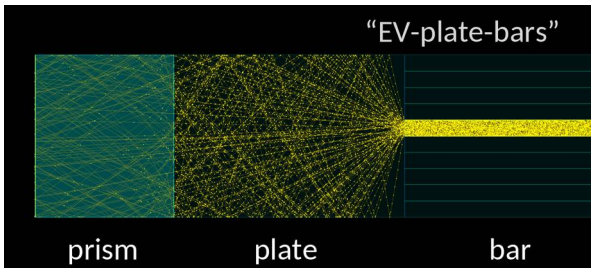
# Plate as Optical Guide

- cylindrical lenses with a plate as expansion volume

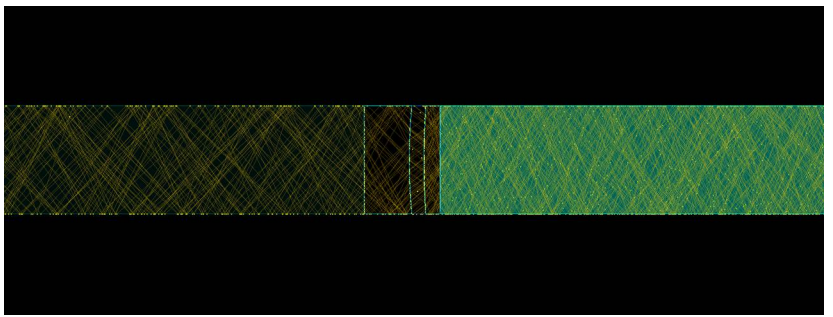


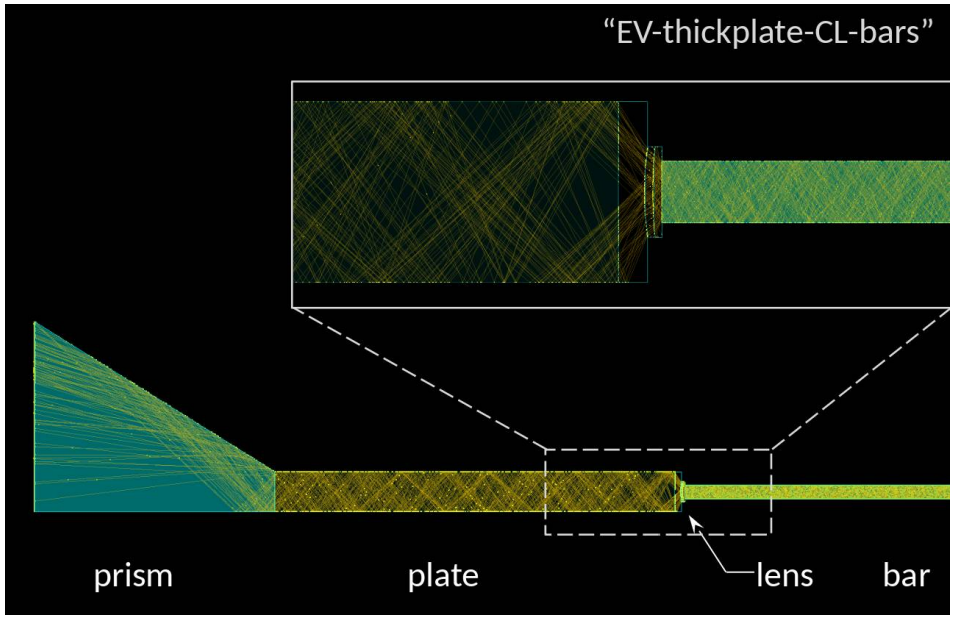




Lens between bars and plate:

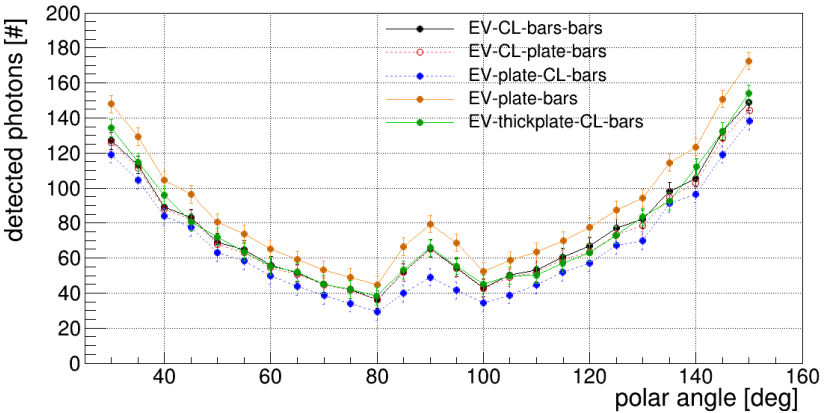


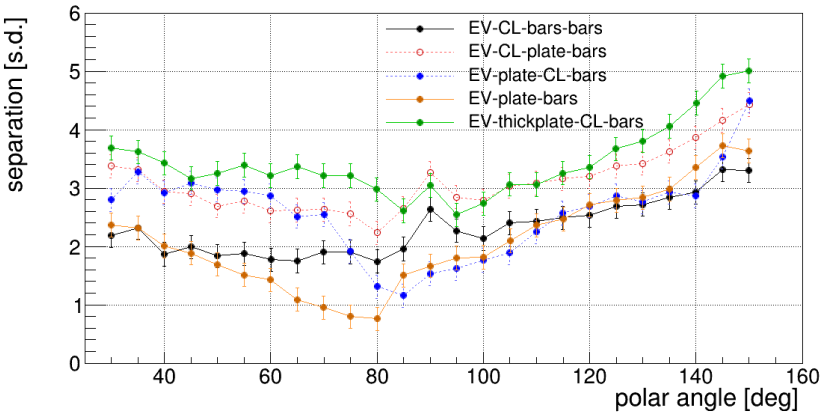
# Plate as Optical Guide

- cylindrical lenses with a plate as expansion volume




π/K @ 6 GeV/c, 100 ps time precision, 0.5 mrad tracking




→ best performance achieved for a hybrid design with the cylindrical lens placed between the narrow bars and a wide plate (50 mm thickness, can be optimized)

# Plate as Optical Guide

https://web-docs.gsi.de/~rdzhigad/www/research/ideal-focusing-thick-plate-ev