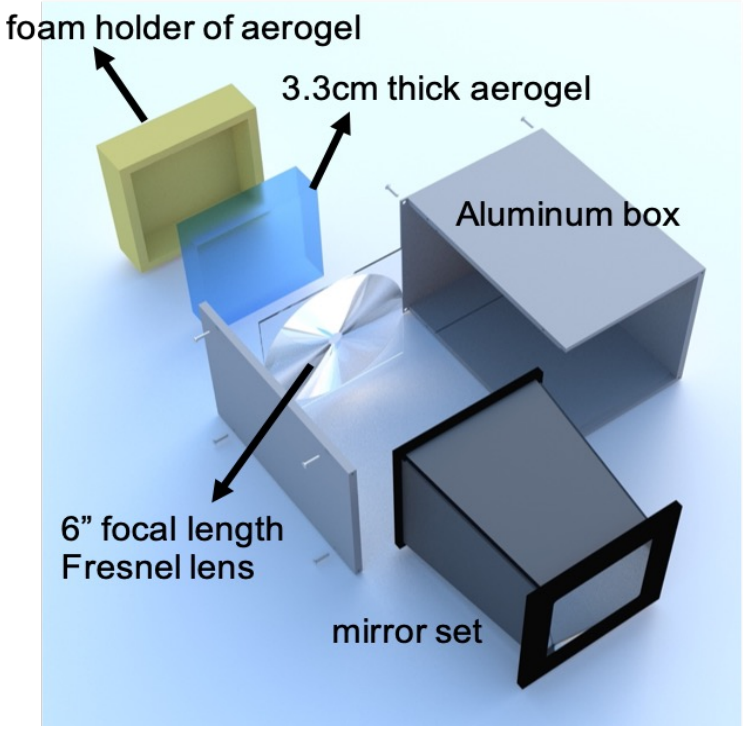
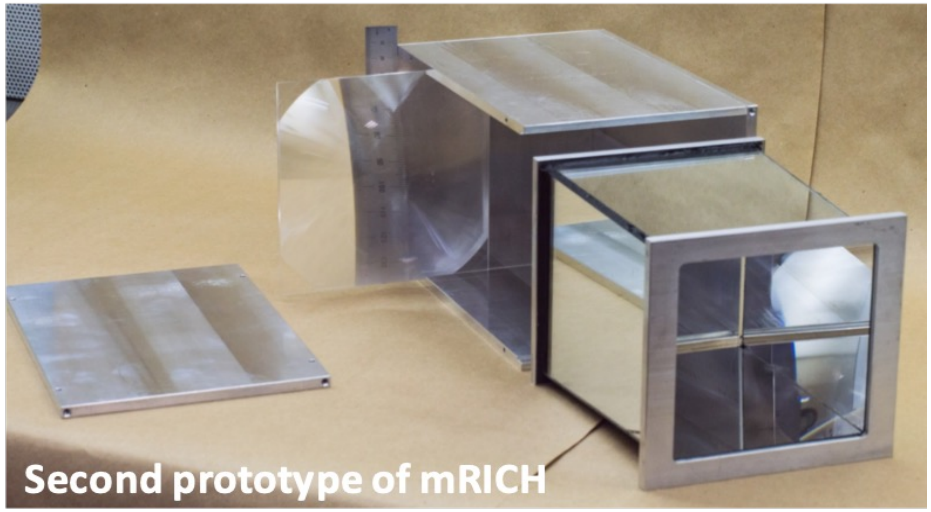
Modular Ring Imaging CHerenkov Detector (mRICH)

Murad Sarsour, GSU





- Compact PID device with momentum coverage up to 10 GeV/c for π/K and e/π up to 2 GeV/c or more.

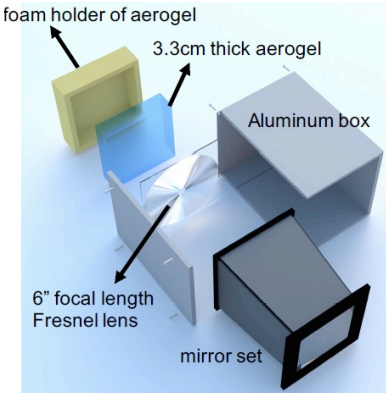
mRICH R&D project: eRD101

eRD14: PID consortium

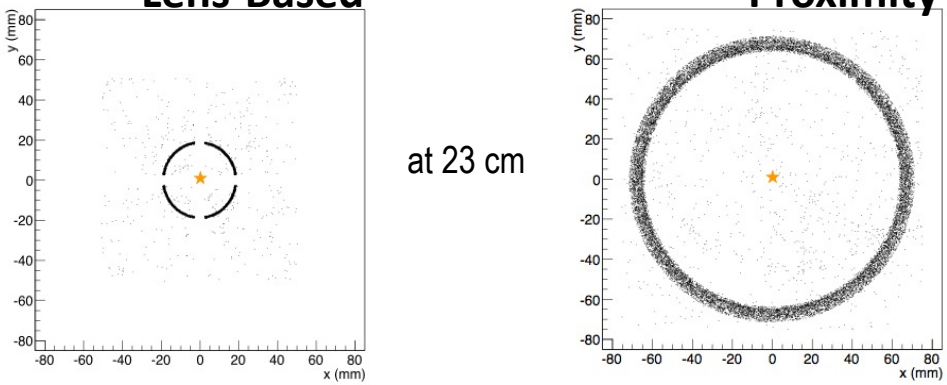
mRICH Concept

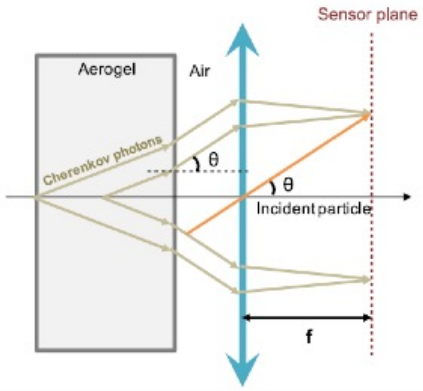
Overview:

- Modular and compact RICH detector (~11x11x25 cm)
- Radiator: Aerogel, L~3 cm and n=1.03
- Focusing: 6” Fresnel lens



Lens-Based at 23 cm **Proximity**

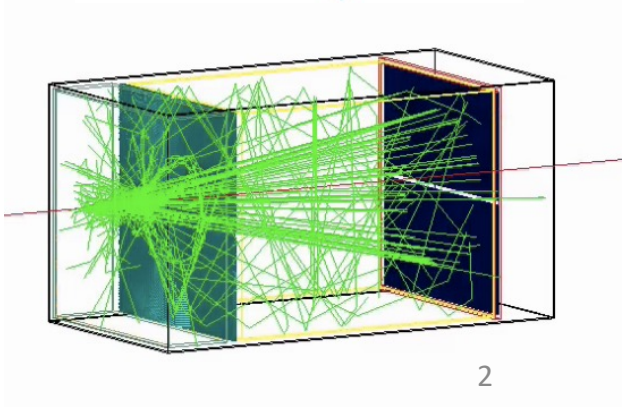




- π/K separation up to 10 GeV/c and e/π separation up to 2 GeV/c.

Systematic effects

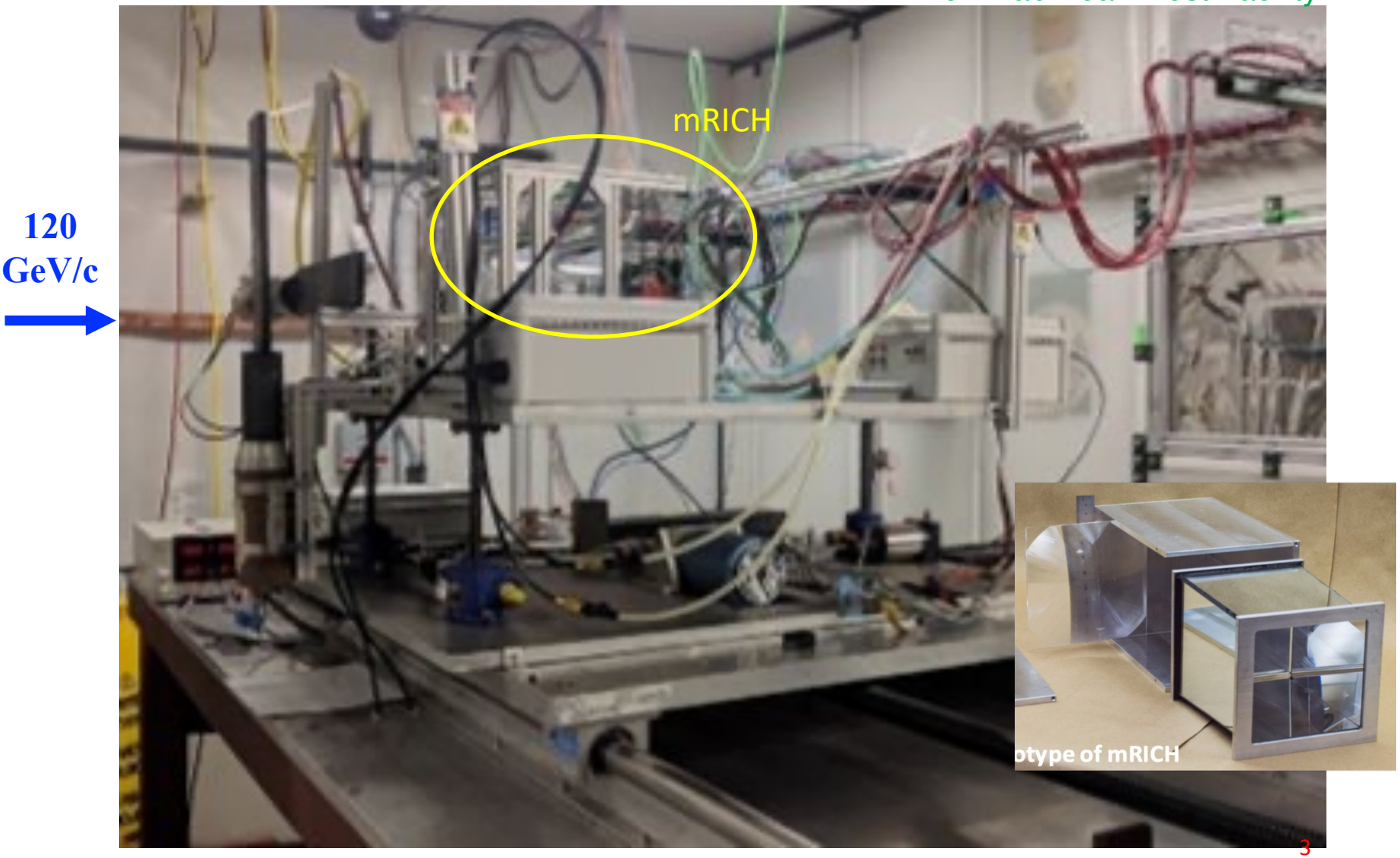
- Emission point error: minimized at the lens focal plane
- Chromatic dispersion error: reduced by UV filtering (acrylic).
- Pixel size error: the uncertainty raised by pixel size, a, error



Prototyping & Beam Tests

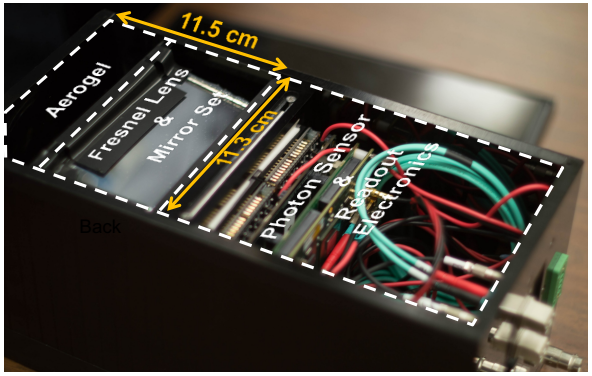
- Two beam tests: 2016 and 2018.

Fermilab Beam Test Facility



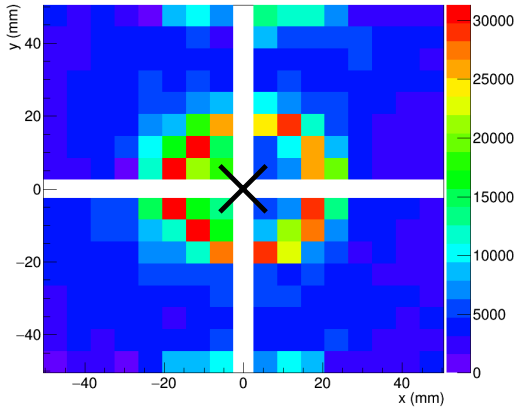
1st and 2nd Beam Test Comparison (120 GeV Proton Beam)

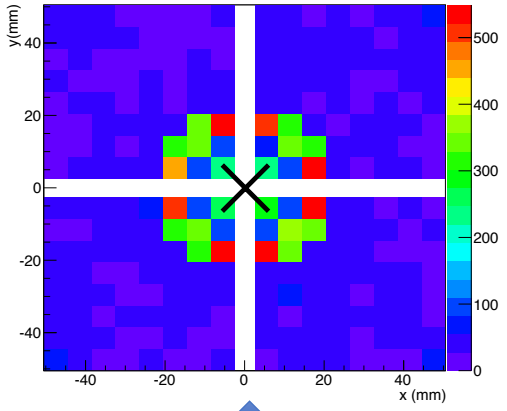
verified mRICH working principle and validated simulation



1st mRICH prototype was tested at Fermilab Test Beam Facility in April 2016

C.P. Wong et. al. NIM A**871**, 13-19 (2017)

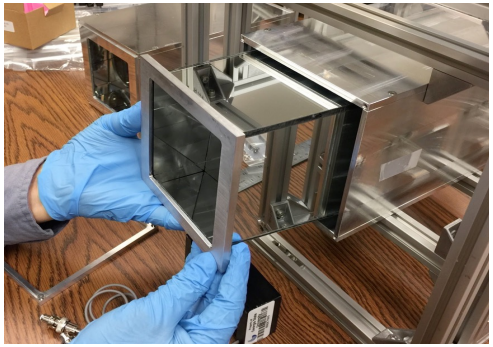




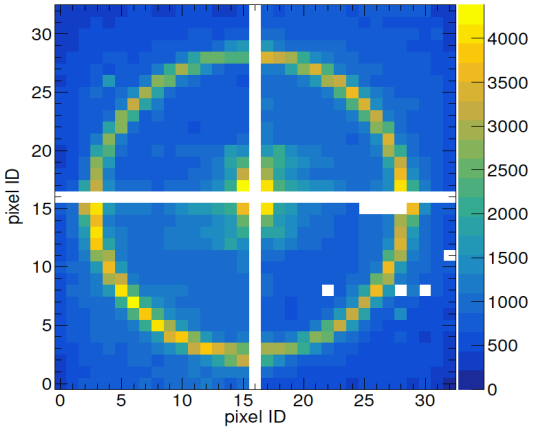
Images from 120 GeV Proton beam

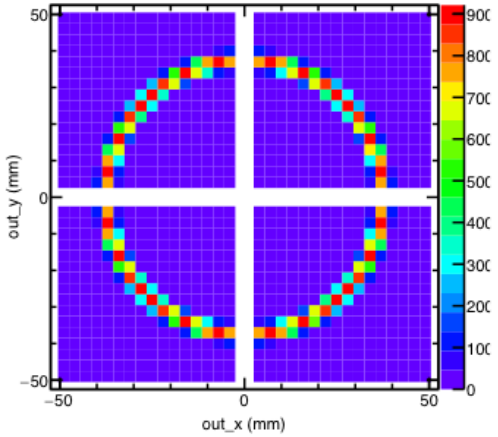
Simulated Images Using GEANT4

New features: a) separation of optical and electronic components; b) longer focal length (6”); c) 3mm x 3mm photosensors.

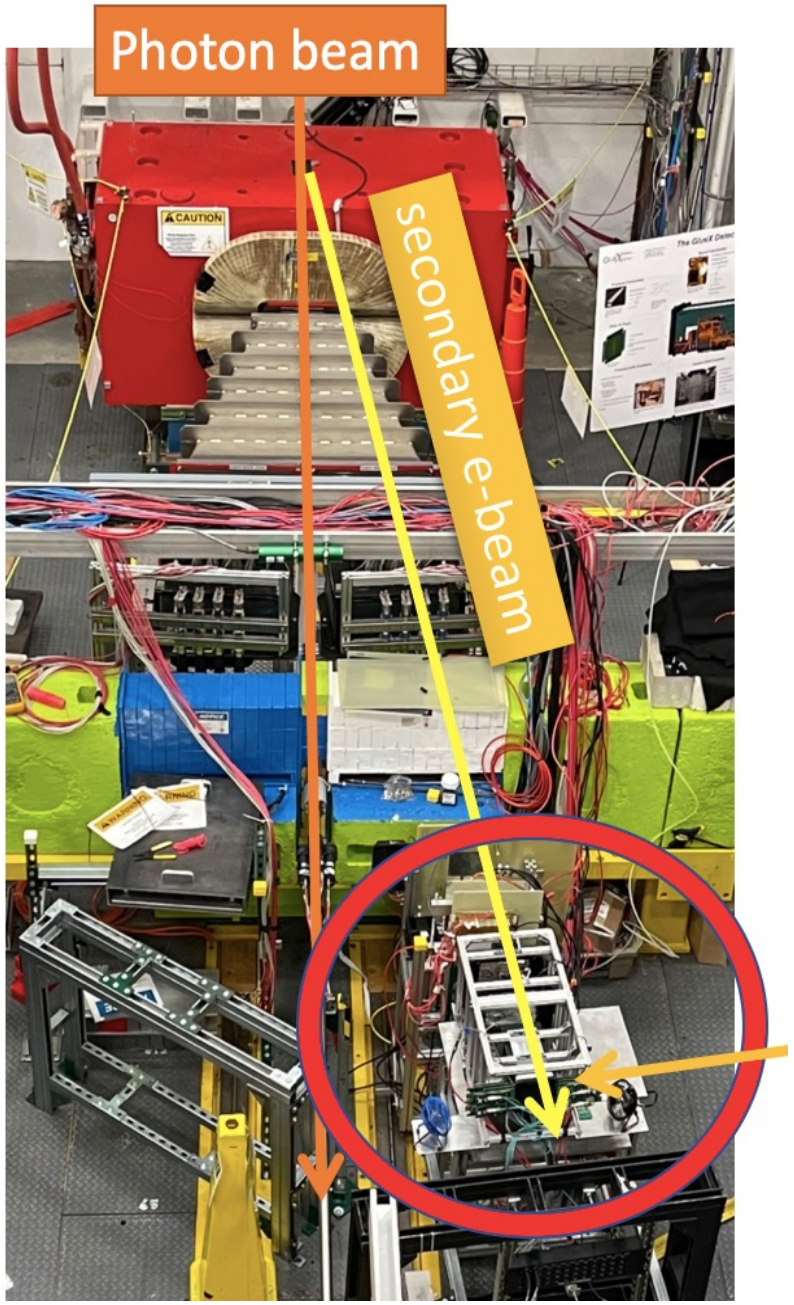


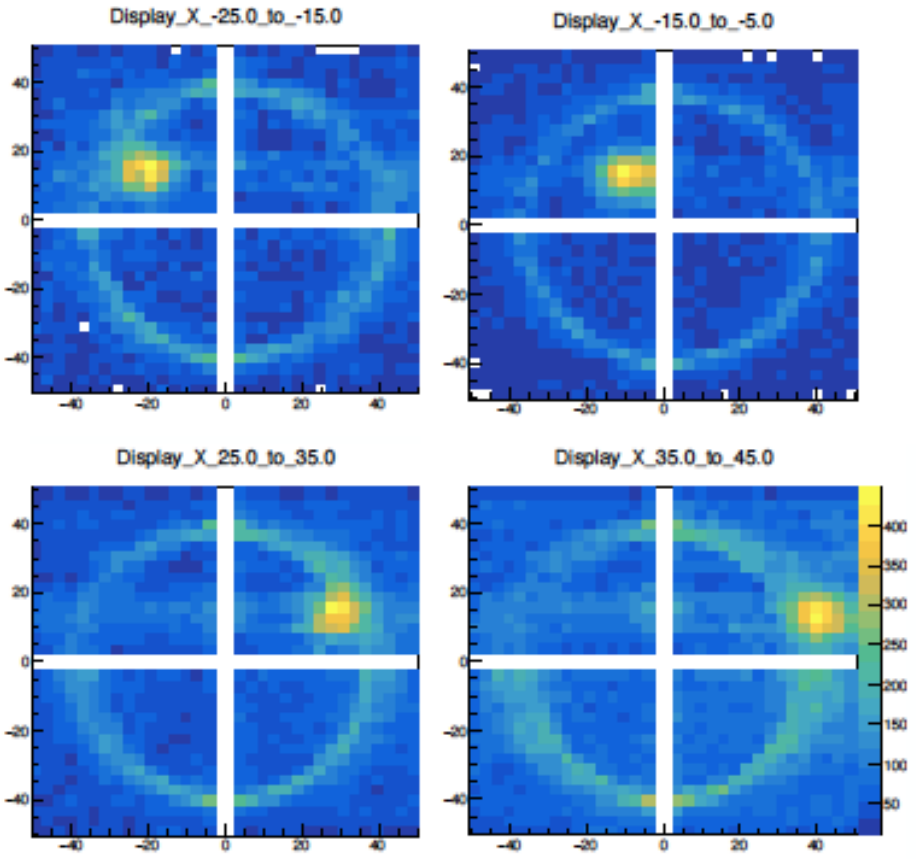
2nd mRICH prototype was tested at Fermilab Test Beam Facility in June/July 2018





JLab Beam Test (1-6 GeV/c Secondary Electron Beam)





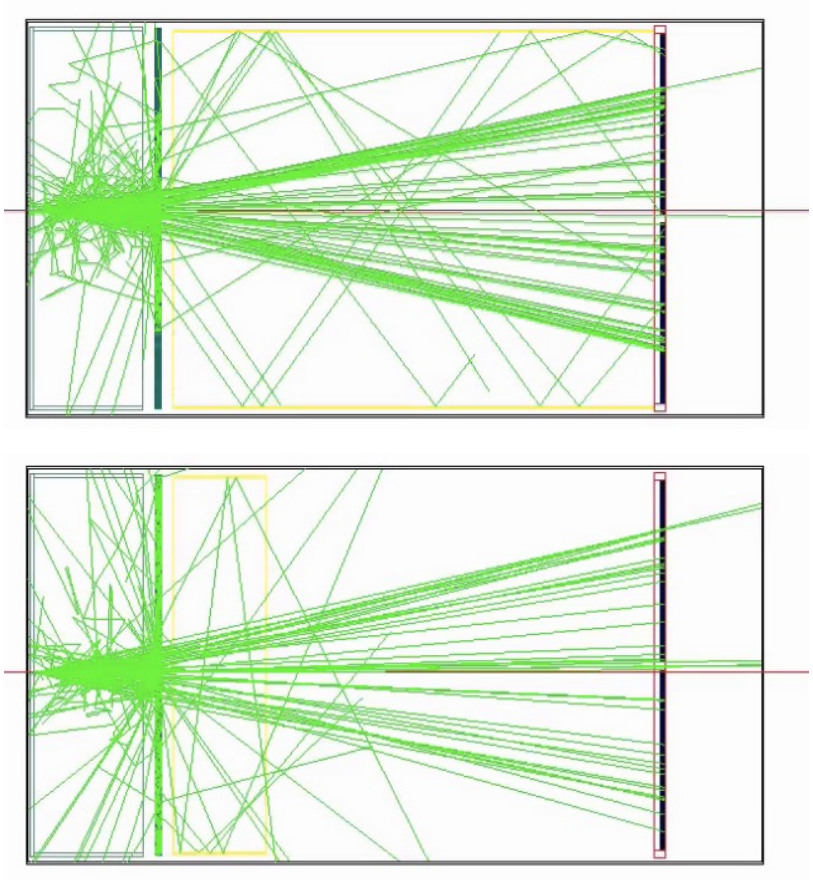
- *Determine the single photon angular resolutions*

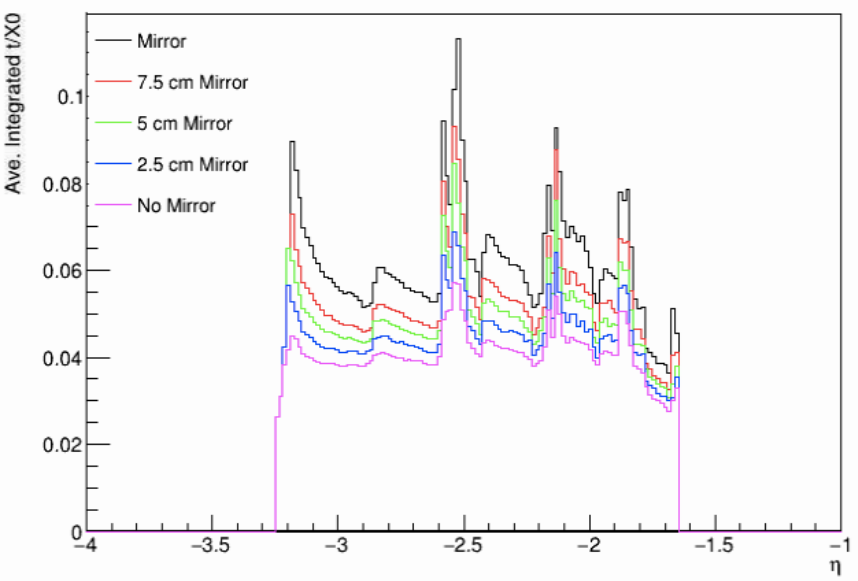
Second LAPPD@Fermilab

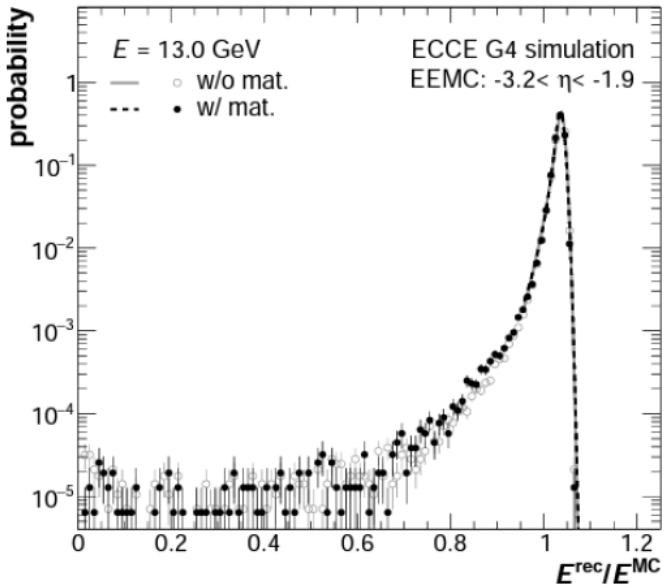
Wish list for mRICH?

- Mirror
- Sensor location
- Aerogel thickness
- 7” lens?

mRICH R&D: *Mirror Study*

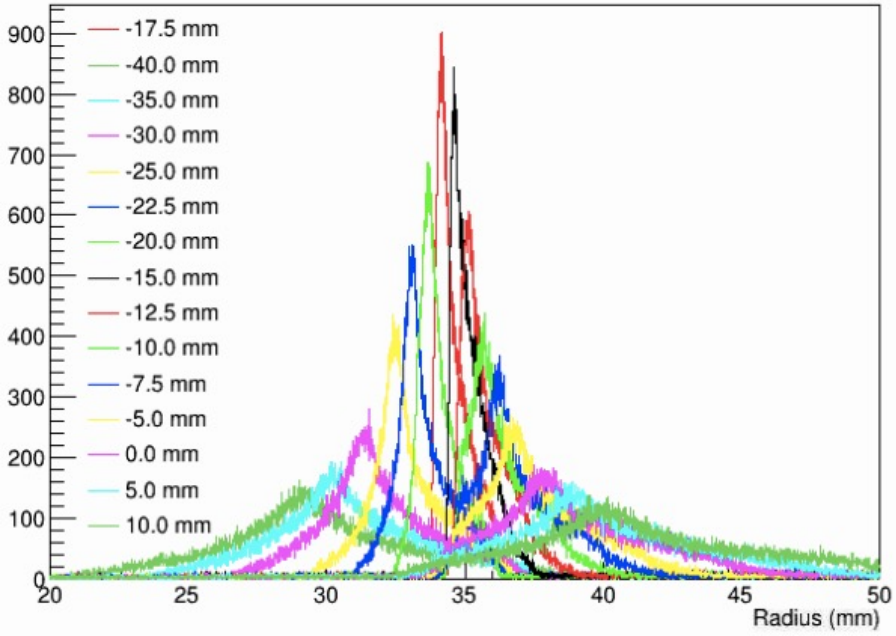


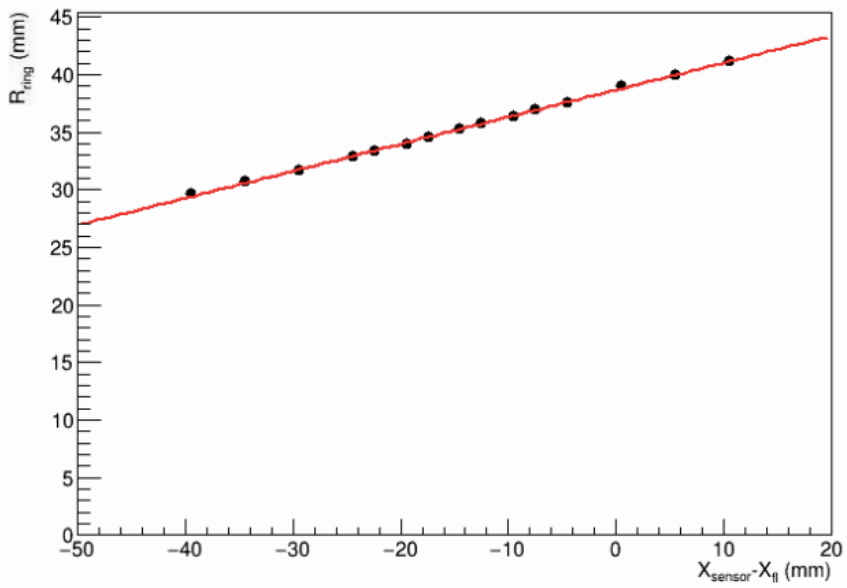


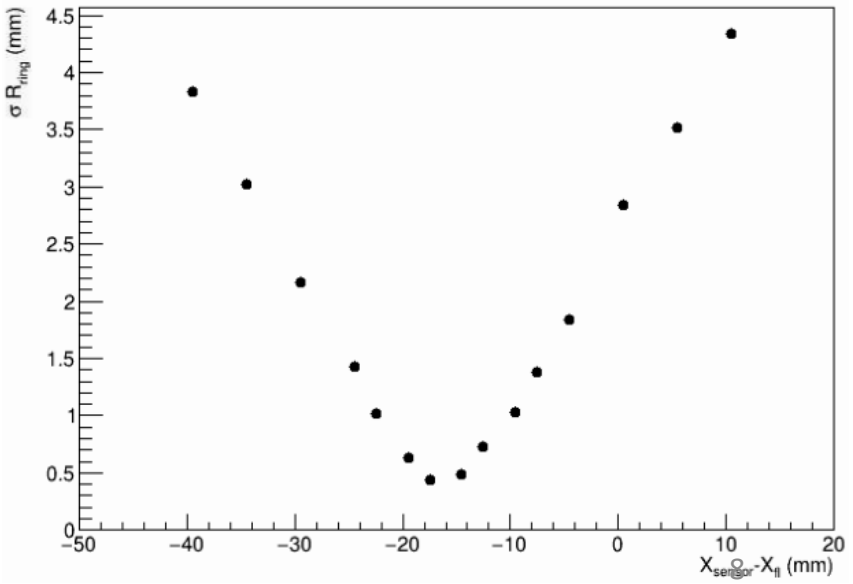


- 0.5 mm Mirror thickness
- 0.5 mm carbon fiber frame

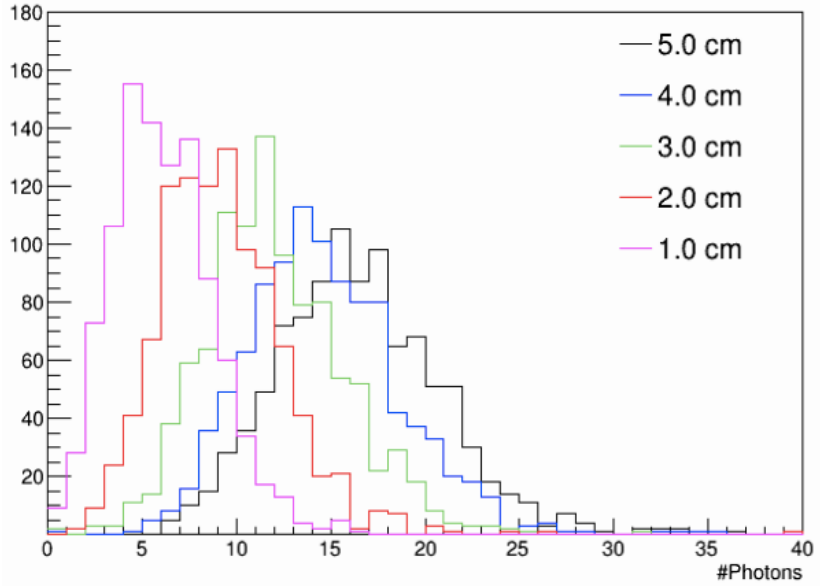
mRICH R&D: *Sensor Position*

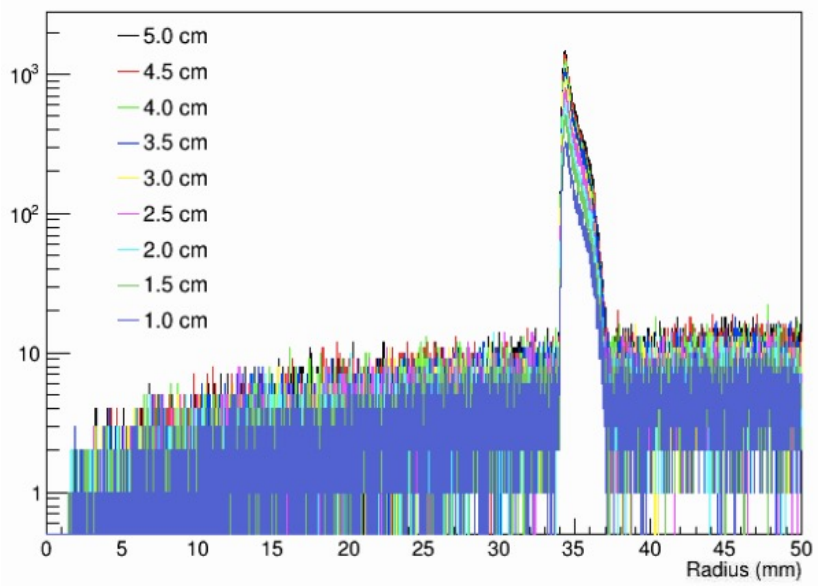


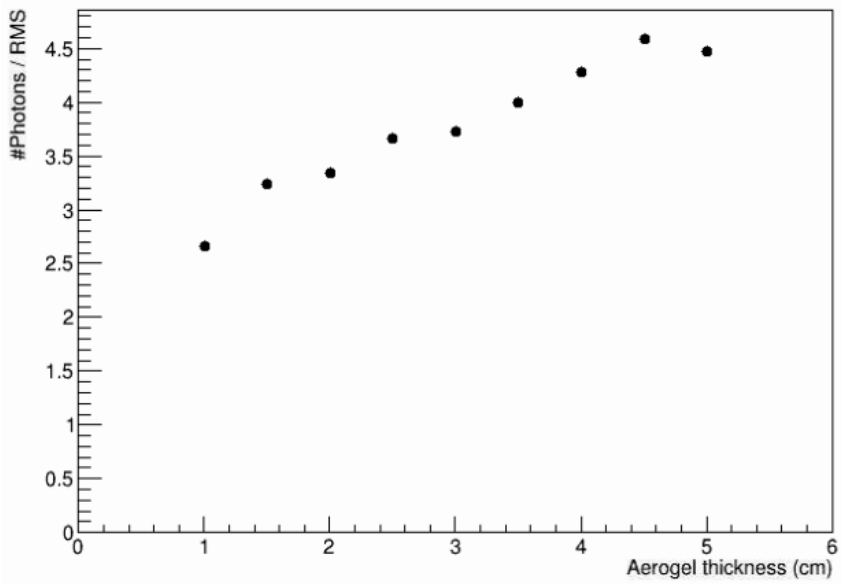


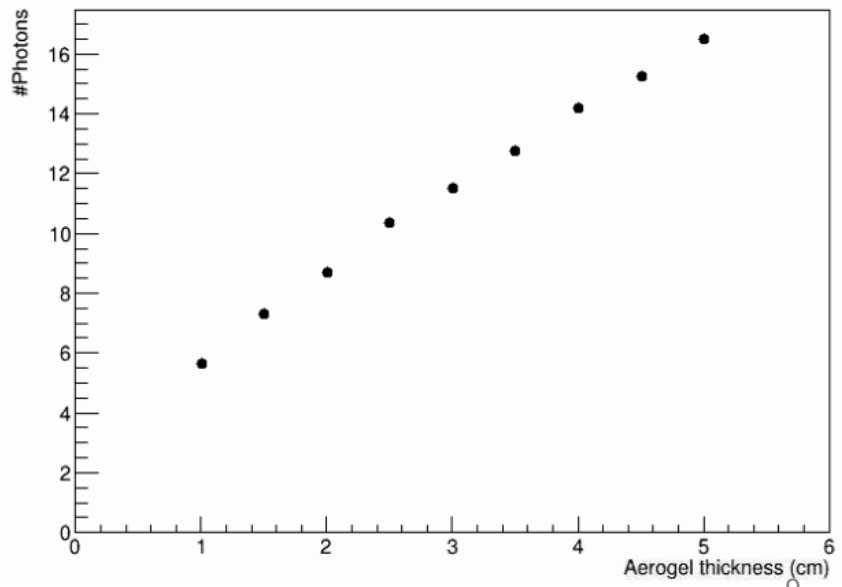


mRICH R&D: *Aerogel Thickness*

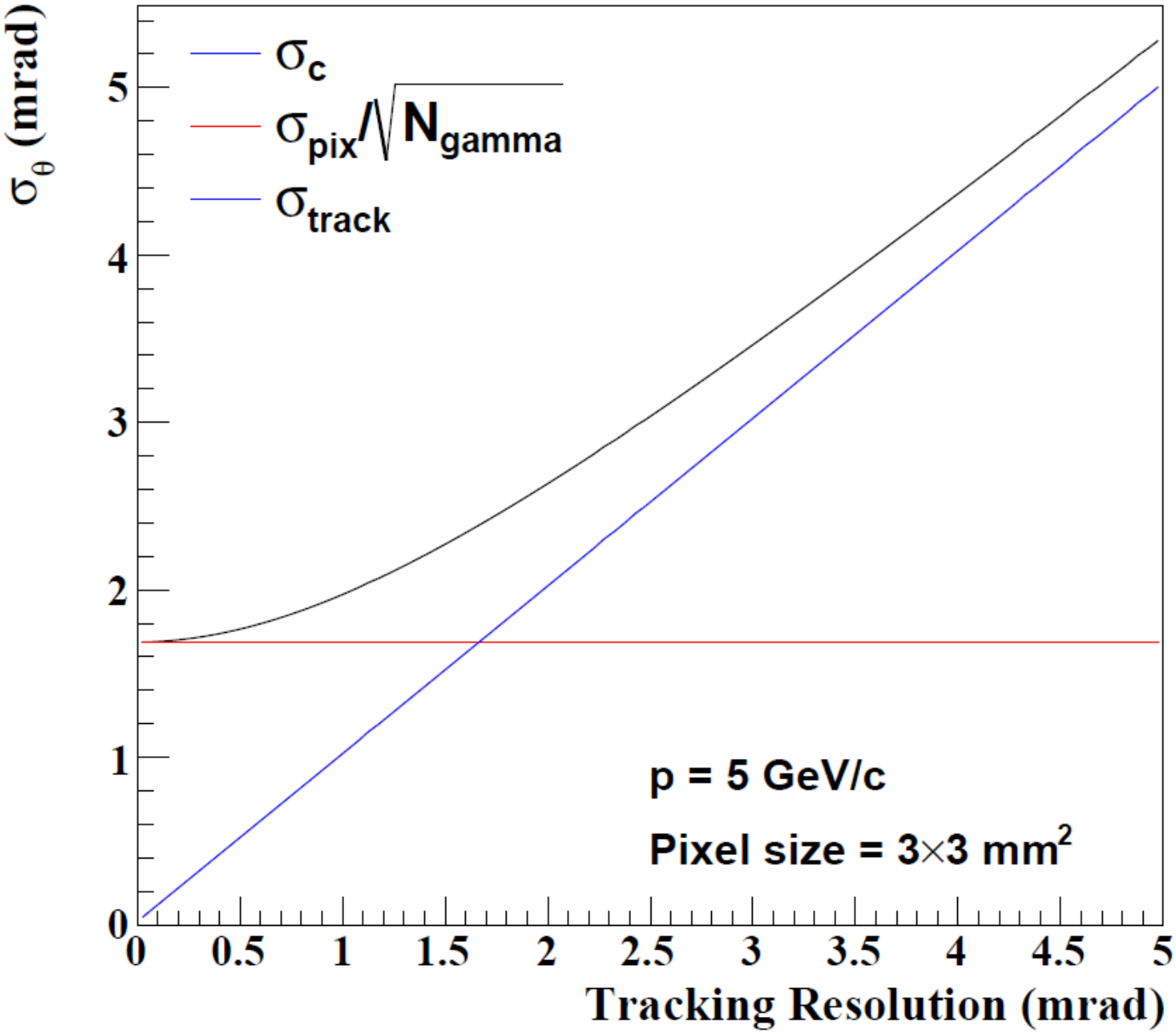








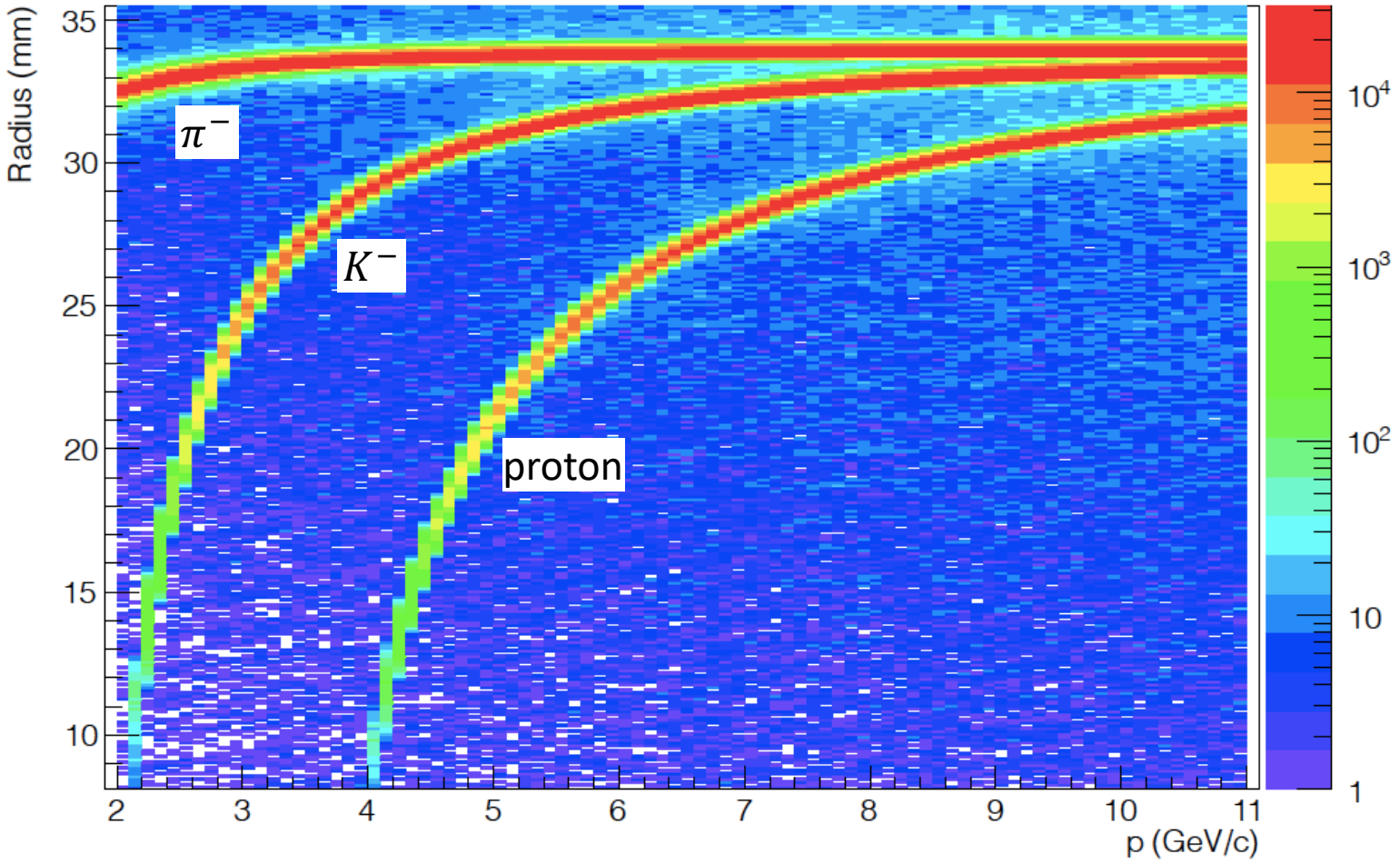
Additional Slides


σ_θ (mrad)
σ_c
$\sigma_{pix}/\sqrt{N_{gamma}}$
σ_{track}
p = 5 GeV/c
Pixel size = 3×3 mm^2
0
1
2
3
4
5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Tracking Resolution (mrad)

Reconstruction/ PID

Focusing on a single module for performance studies!

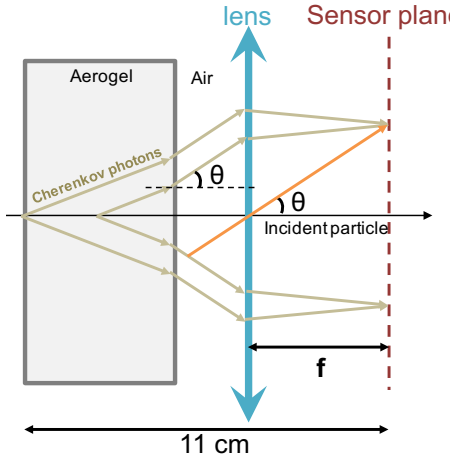
- Ring radius without considering the sensor pixelization!

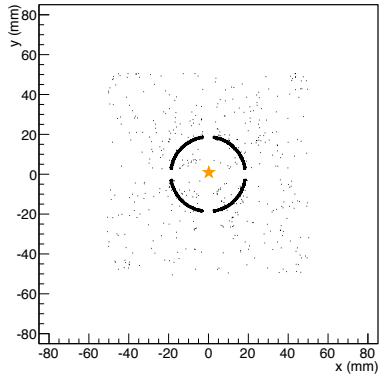


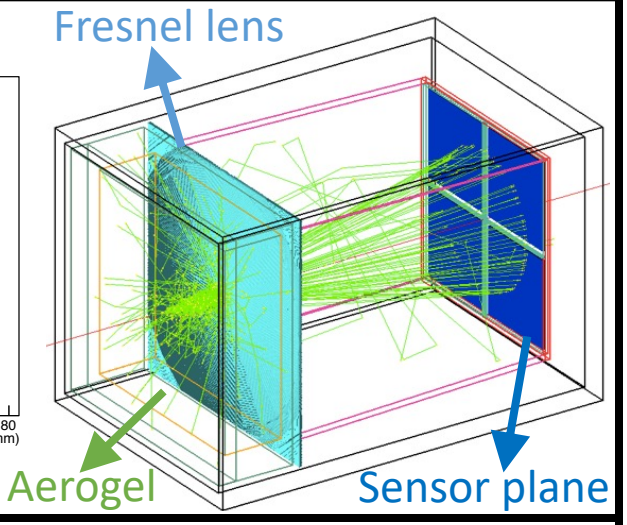
mRICH – lens-based focusing aerogel detector design

Smaller, but thinner ring improves PID performance and reduces length

Lens-Based mRICH Design

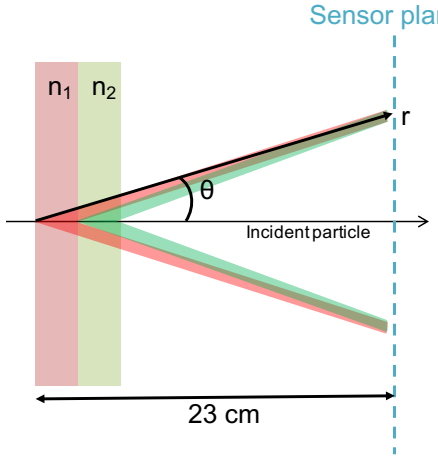


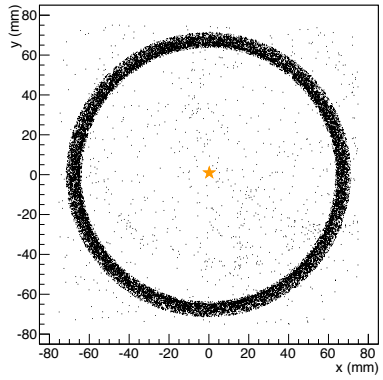




9 GeV/c pion beam launched at the center of xy plane in simulation

Two-Layer Proximity Focusing Design (BELLE-2 ARICH)



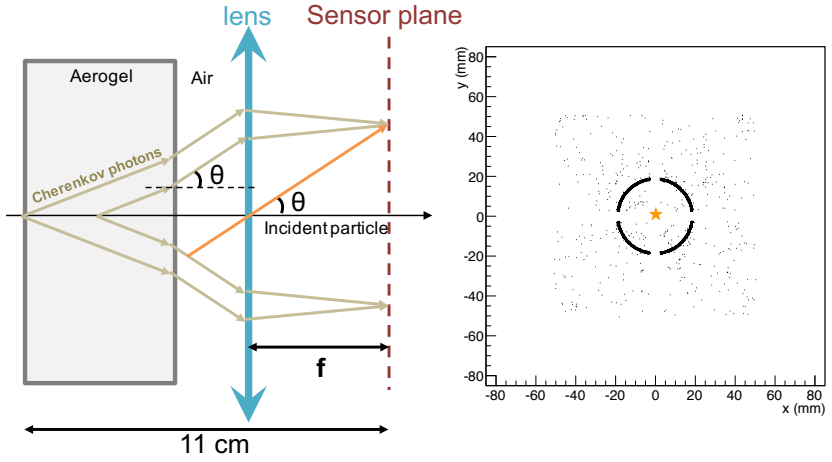


- EIC mRICH designed for K/pi ID up to 10 GeV/c
- BELLE-2 ARICH aims to separate pion and kaon up to 4 GeV/c

mRICH – lens-based focusing aerogel detector design

Smaller, but thinner ring improves PID performance and reduces length

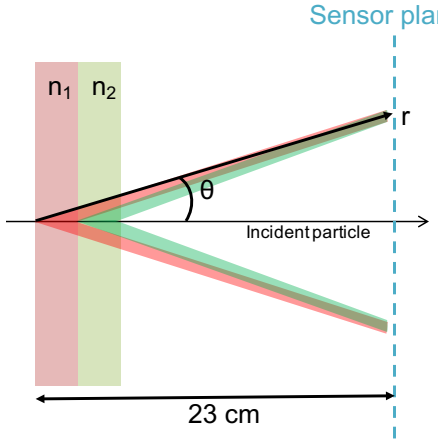
Lens-Based mRICH Design

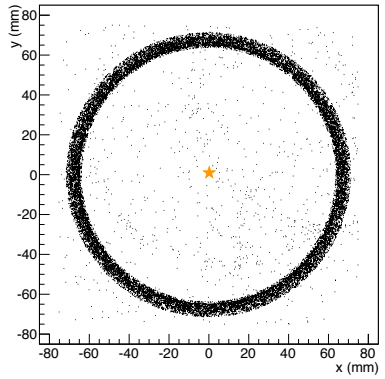


- 9 GeV/c pion beam launched at the center of xy plane in simulation
- **Smaller and thinner** ring image

9 GeV/c pion beam launched at the center of xy plane in simulation

Two-Layer Proximity Focusing Design (BELLE-2 ARICH)



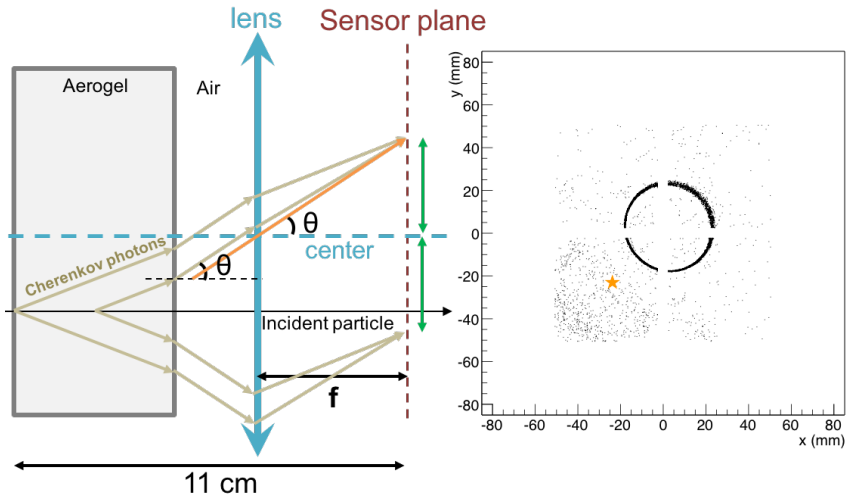


- EIC mRICH designed for K/pi ID up to 10 GeV/c
- BELLE-2 ARICH aims to separate pion and kaon up to 4 GeV/c

mRICH – lens-based focusing aerogel detector design

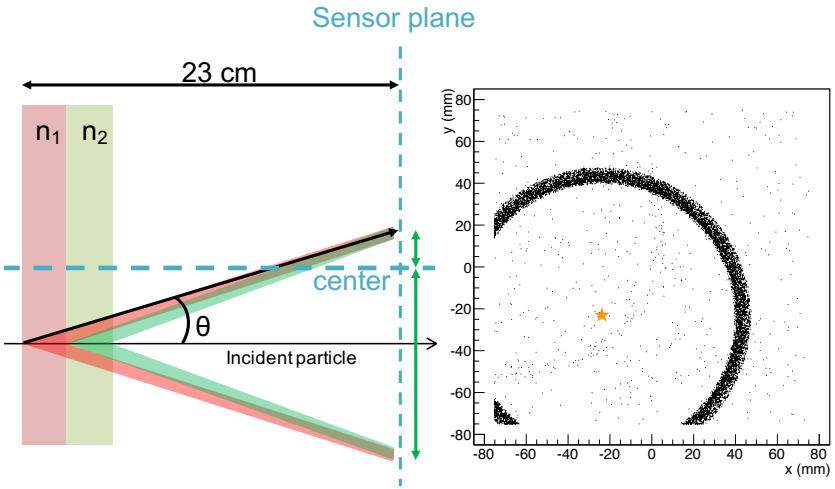
Ring centering of lens-based optics reduces sensor area (main cost driver)

Lens-Based mRICH Design



- 9 GeV/c pion beam incident at third quadrant (star) in simulation
- Ring image is **center** on the middle of the sensor plane

Two-Layer Proximity Focusing Design (BELLE-2 ARICH)



- 9 GeV/c pion beam incident at third quadrant (star) in simulation
- Ring is centered at point of incidence