



***eRD101*: Modular Ring Imaging CHerenkov Detector (mRICH)**

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August 29, 2023

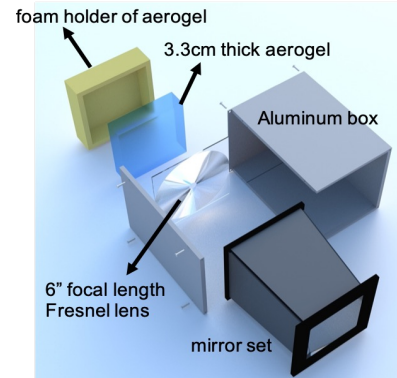
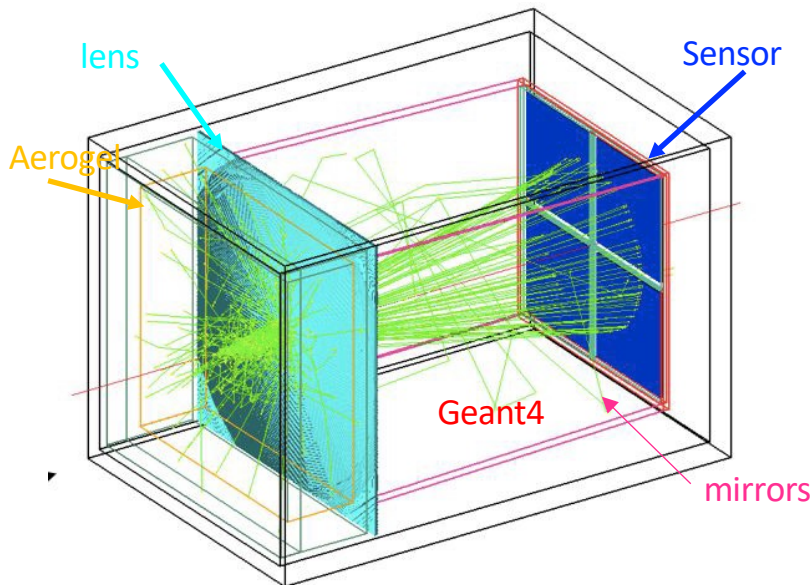
***eRD101* objectives:**

- Complete JLab beam test data analysis
 - extract single photon angle resolution and associated mRICH characteristics
- Optimize mRICH design/ new prototype – testing new photosensor performance and aerogel properties due to its compact and modular design

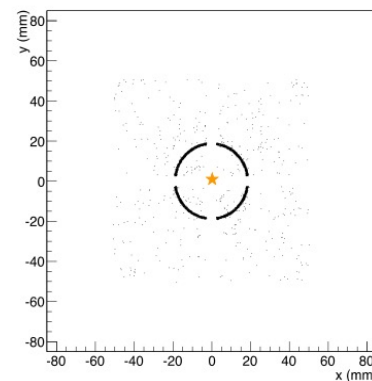
ePIC mRICH – Working Principle

- *Compact, modular and projective*

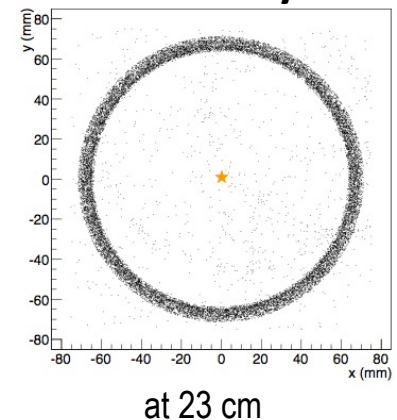
- Radiator: Aerogel, $L \sim 3 - 4$ cm and $n = 1.03$
- Focusing: 6" Fresnel lens



Lens-Based



Proximity

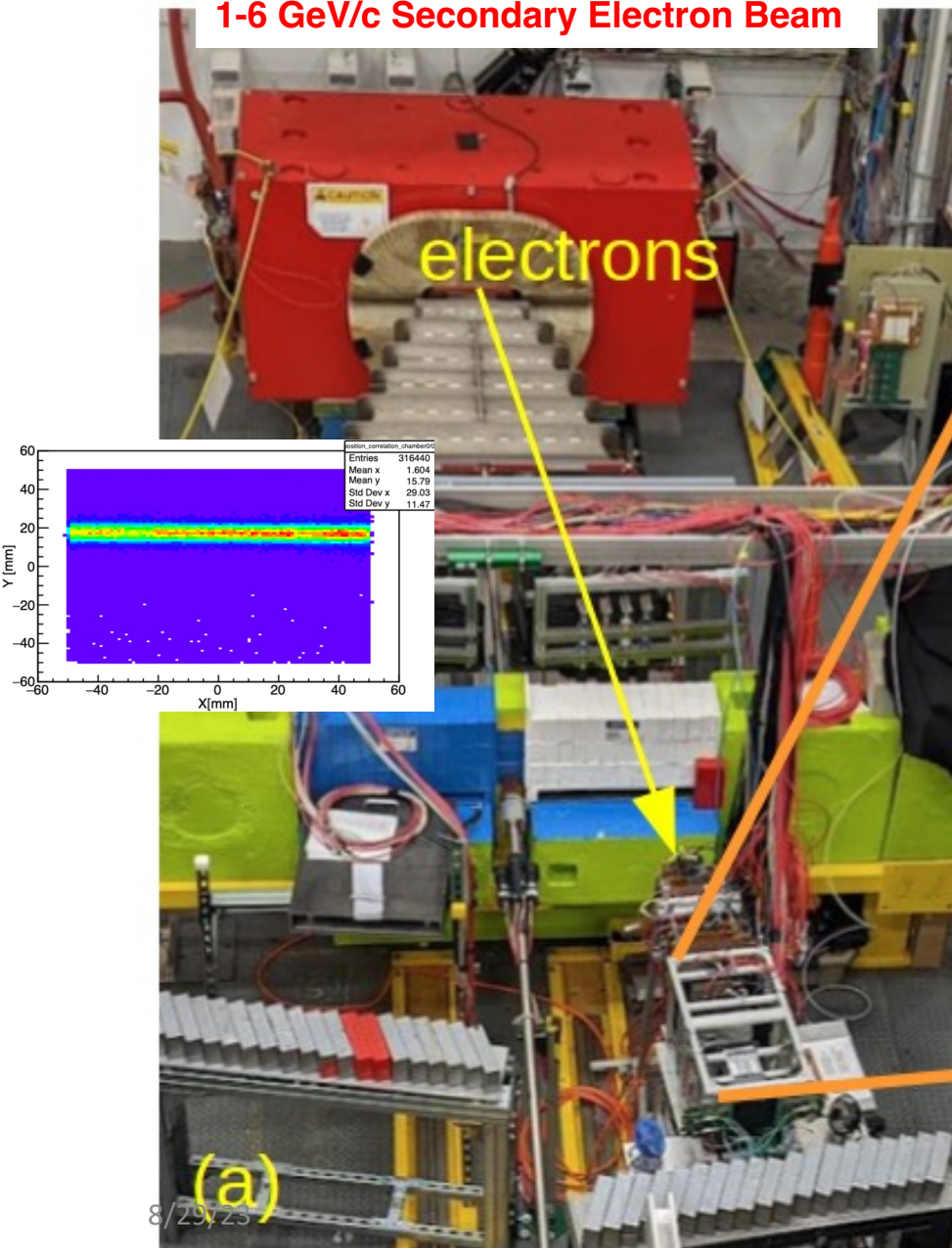


- ❖ Compact PID device with momentum coverage up to 8 GeV/c for π/K and e/π up to 2.5 GeV/c or more.
- ❖ The emission point error is minimized at the lens focal plane, and chromatic dispersion error is reduced by UV filtering (acrylic).
- ❖ R&D is at very advanced stage – 3 beam tests already!

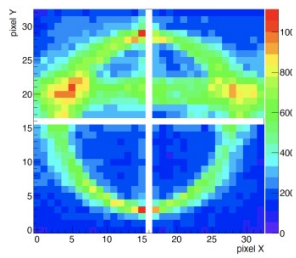
3rd mRICH Beam Test at JLab

late September to early October of 2021

1-6 GeV/c Secondary Electron Beam



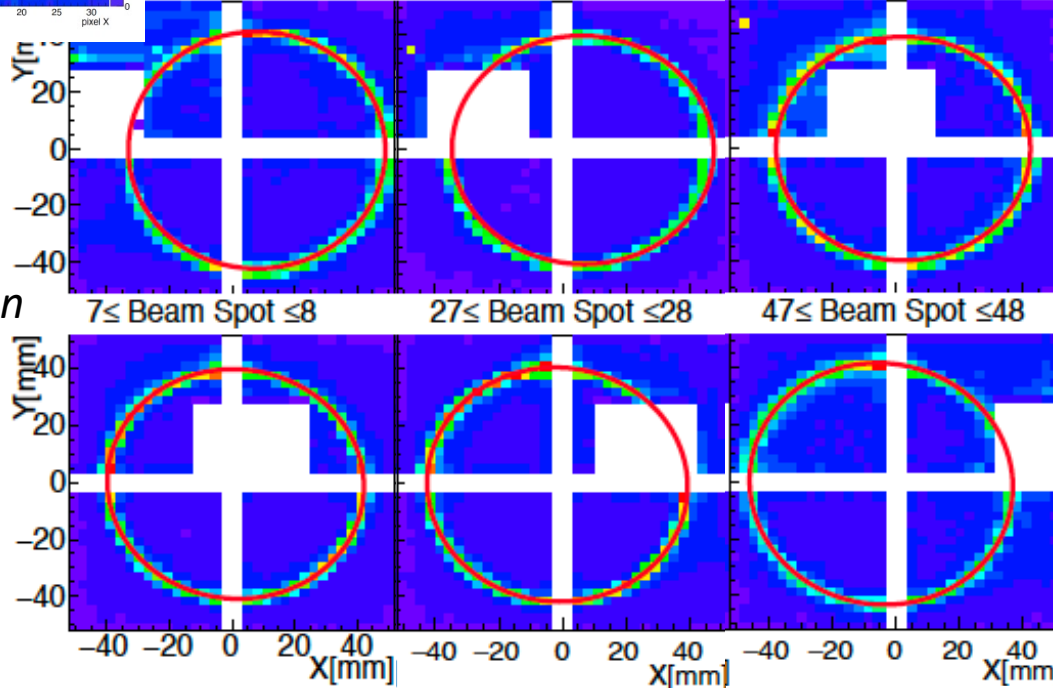
Results from JLab Beam Test



Beam Spot ≤ -42

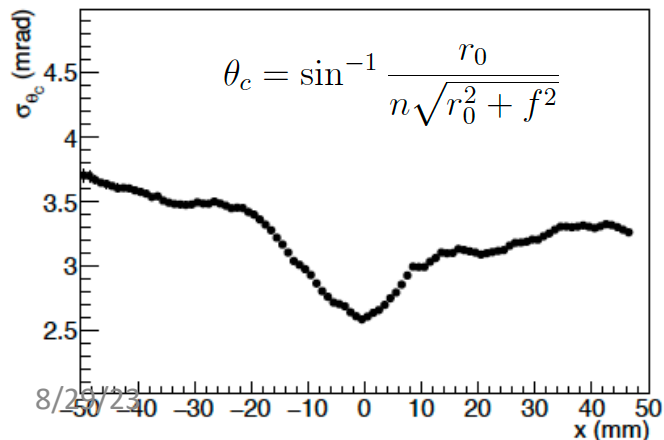
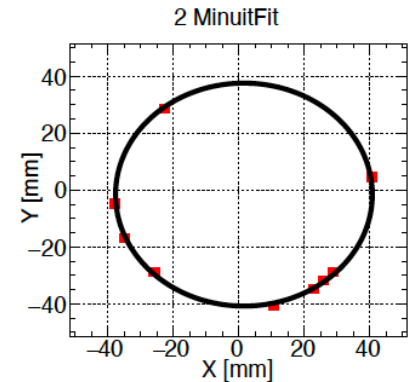
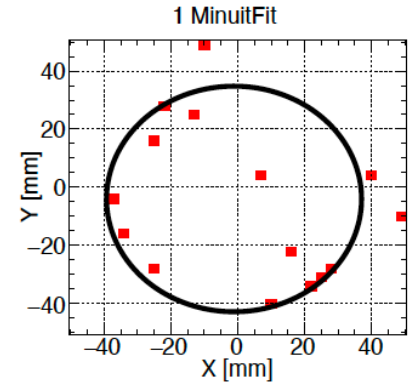
$-23 \leq \text{Beam Spot} \leq -22$

$-3 \leq \text{Beam Spot} \leq -2$

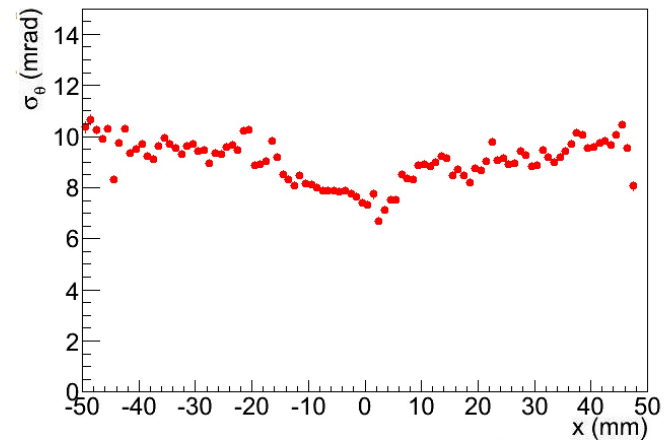


*Simple
elliptic
function*

Extract
Cerenkov
Ring
radius
iteratively!



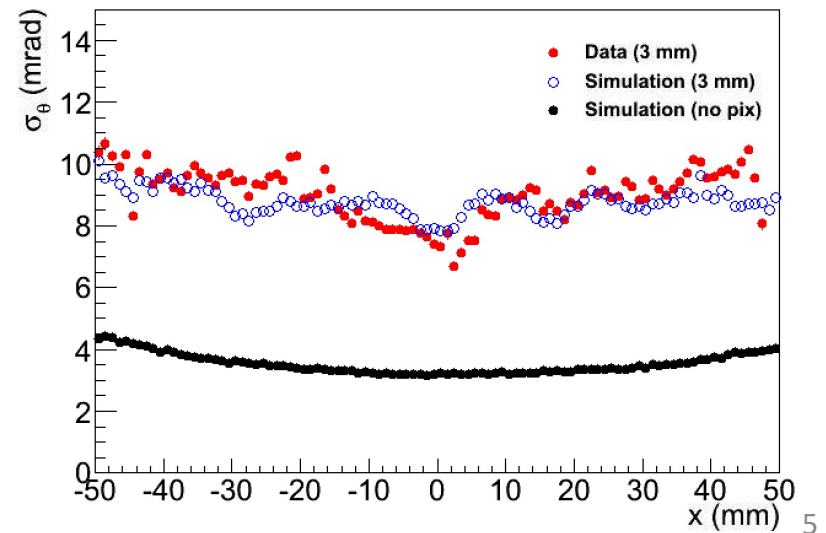
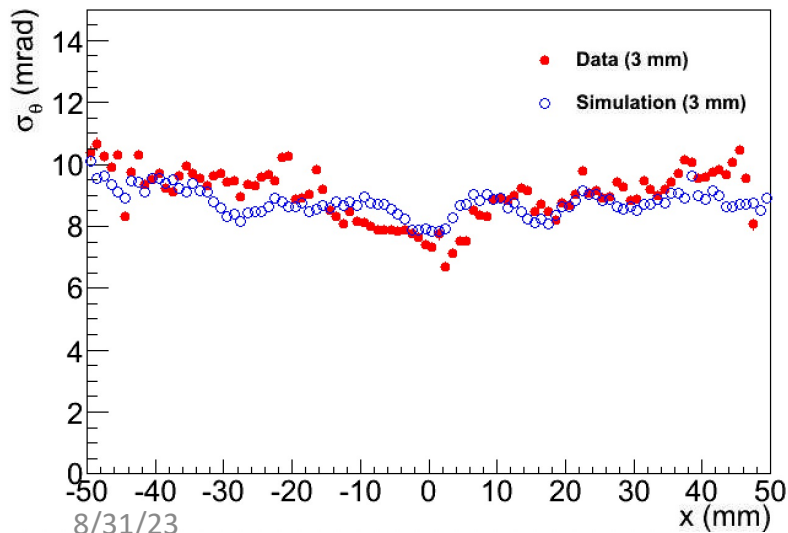
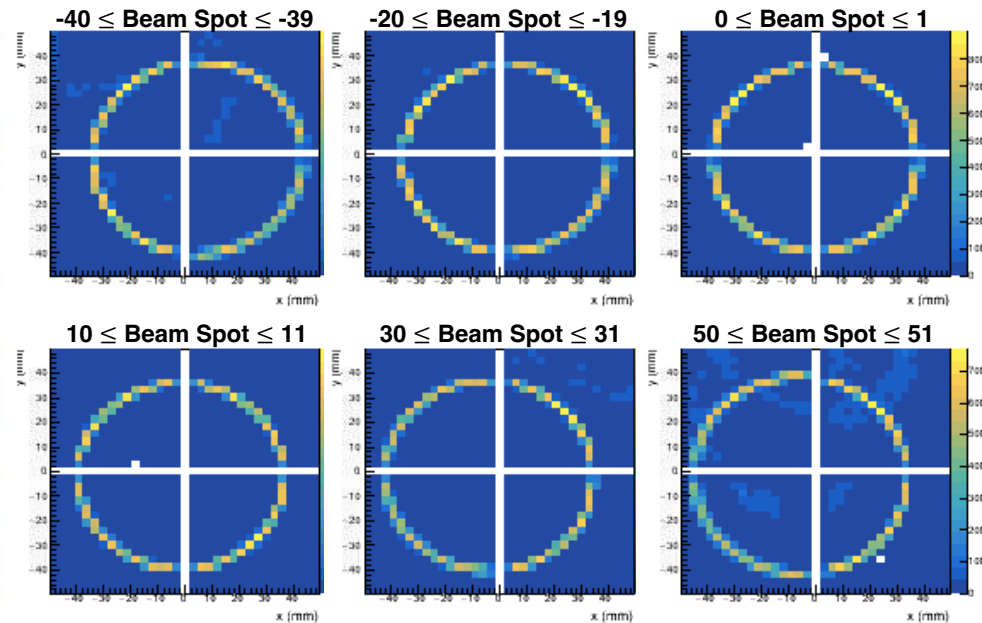
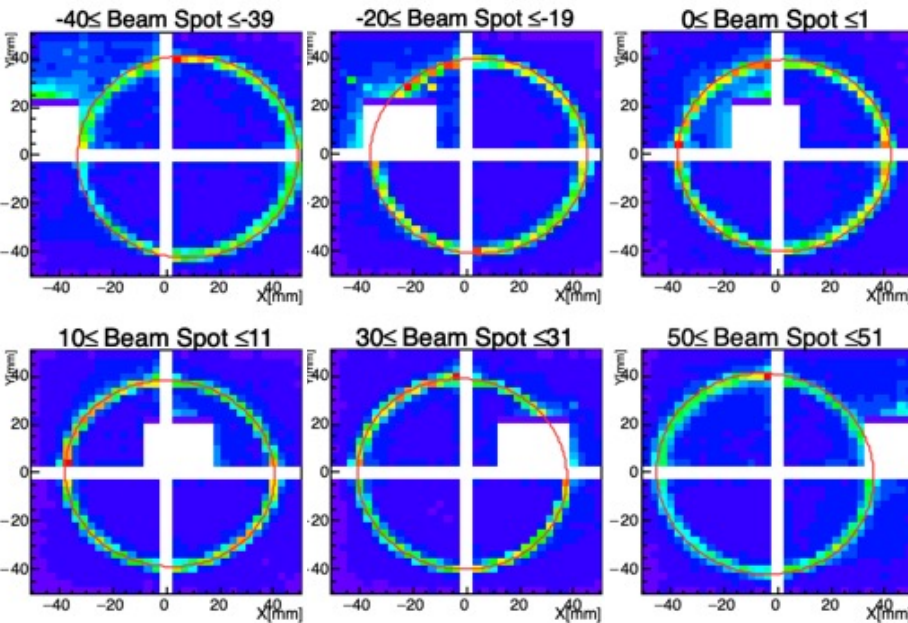
**Cherenkov
Angle
Resolution**



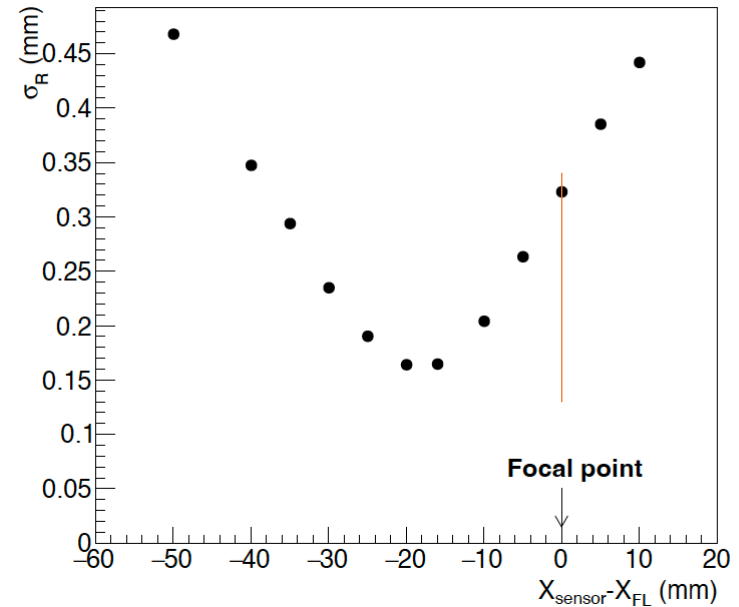
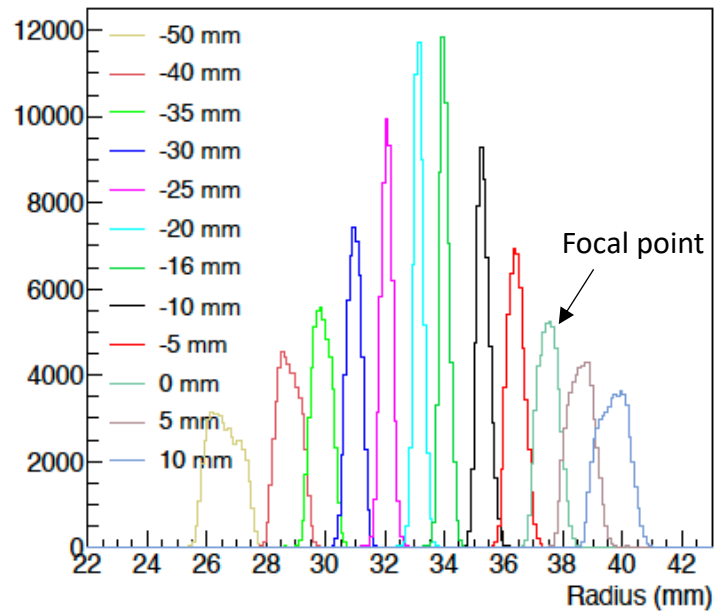
Advanced G4 Simulation of mRICH

Data: $p=1-6$ GeV/c

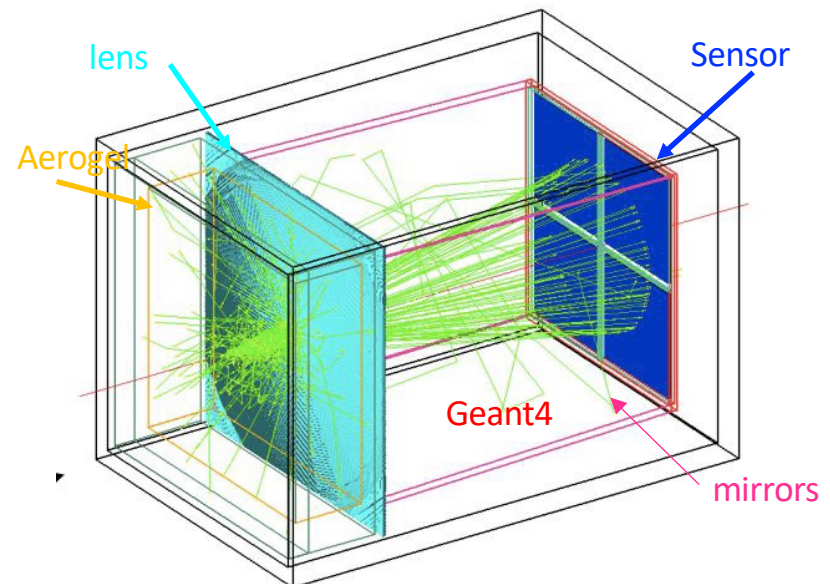
G4 Simulation: $p=3$ GeV/c



Additional Effects on the Resolution?

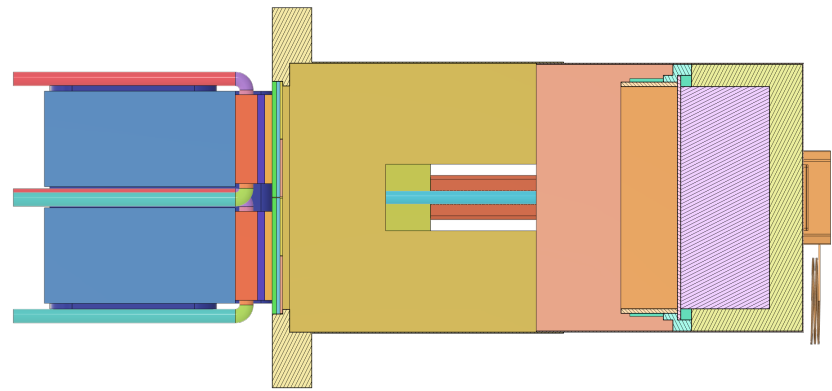
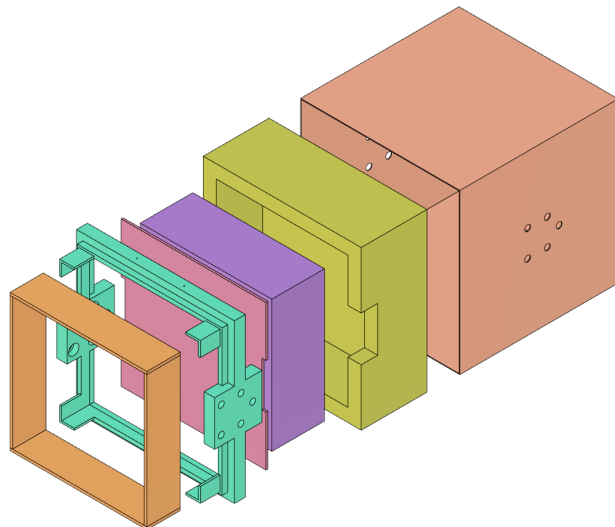
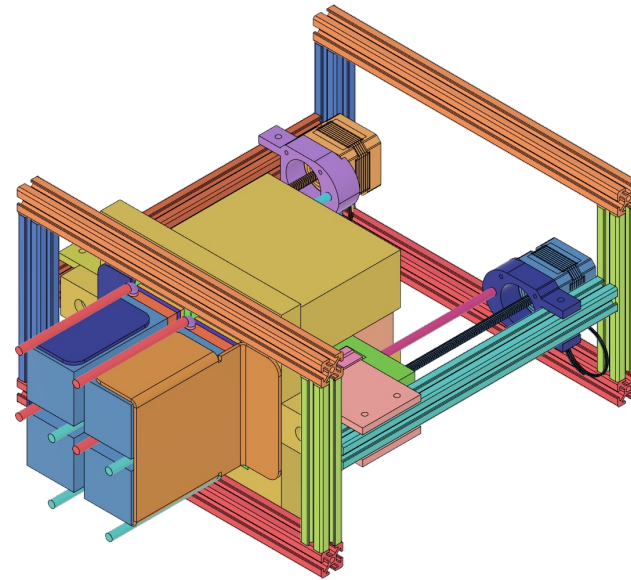
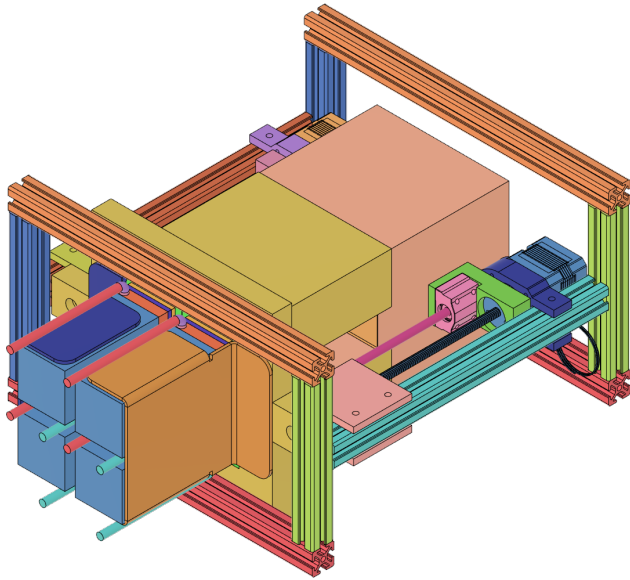


- Optimizing the photosensor plane location & aerogel block size



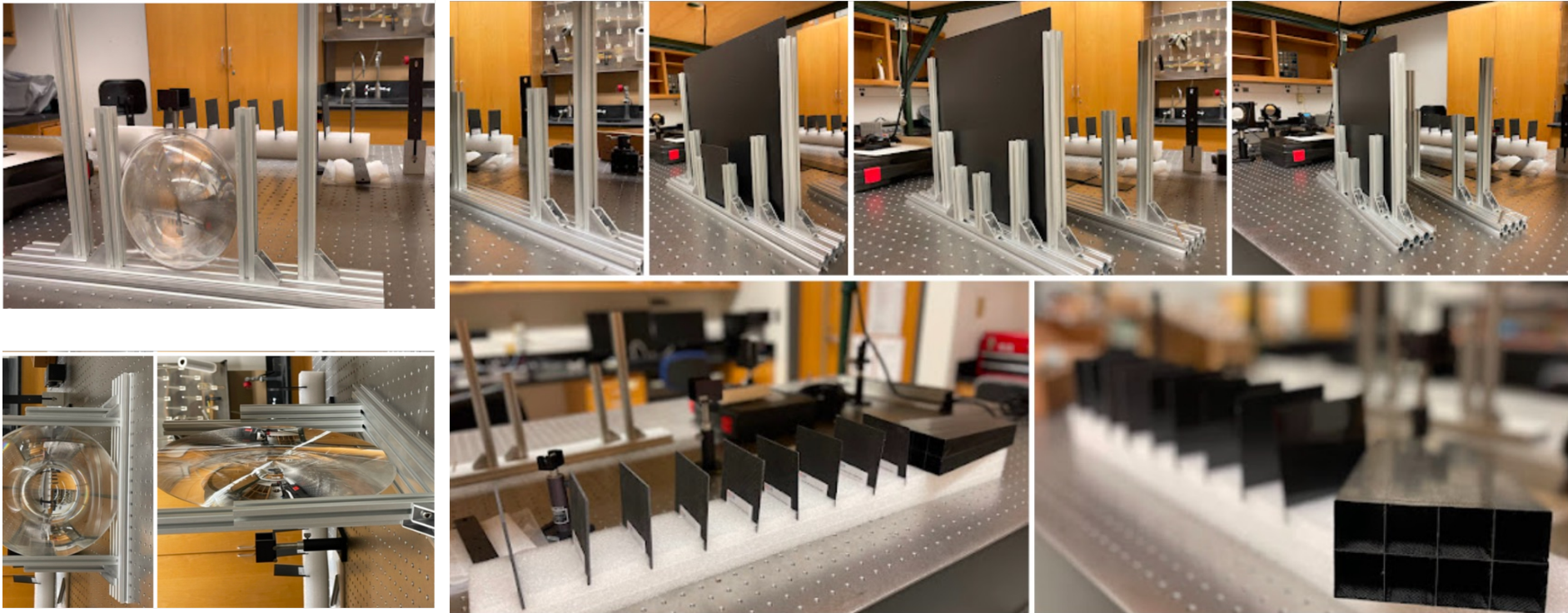
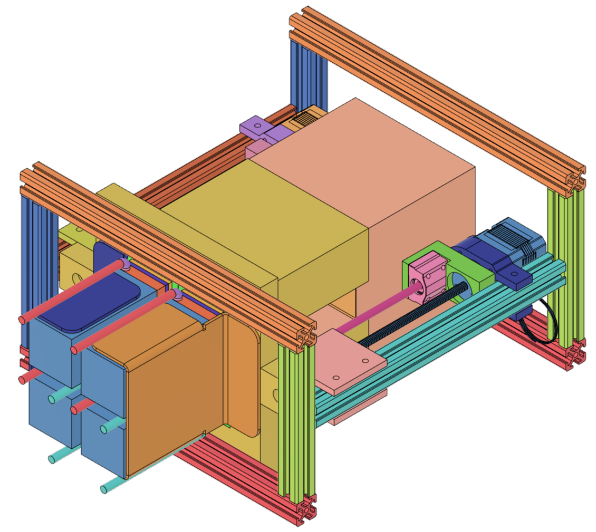
New mRICH Prototype Design

Alex Eslinger



Ongoing Activities

- New prototype – testing new photosensor performance and aerogel properties
- Dedicated lab at GSU for optical characterization



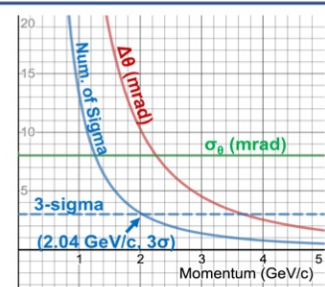
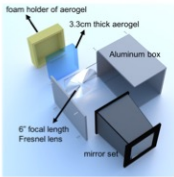
Summary and Outlook

- Completed JLab beam test data analysis and extracted single photon angle resolution. Submitted to NIMA.
- Completed new mRICH prototype design
 - allows to Optimizing the photosensor plane location & aerogel block size
- Optimize mRICH design/ new prototype – testing new photosensor performance and aerogel properties due to its compact and modular design

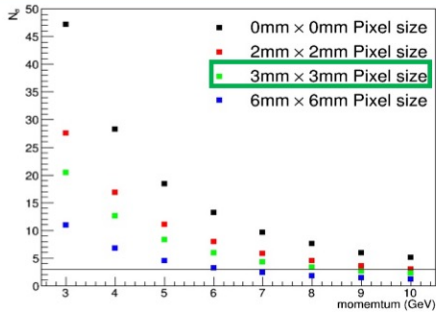
THANK YOU



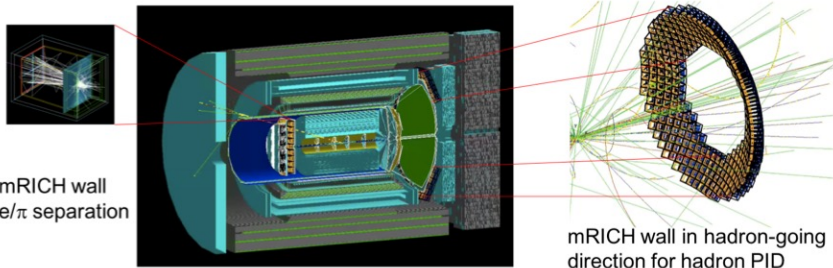
Modular and compact ring imaging Cherenkov (mRICH) PID detector for EIC experiments



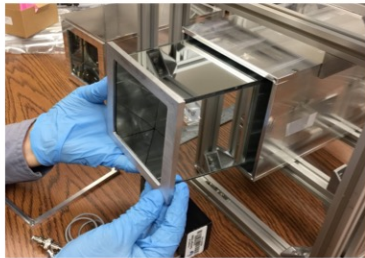
- Projected e/pi separation of mRICH 2nd prototype detector (**blue solid line**)
- 2nd prototype detector can achieve 3-sigma e/pi separation up to 2 GeV/c



- Projected K/pi separation of mRICH 2nd prototype detector (**Green dots**)
- 2nd prototype detector can achieve 3-sigma K/pi separation up to 8 GeV/c

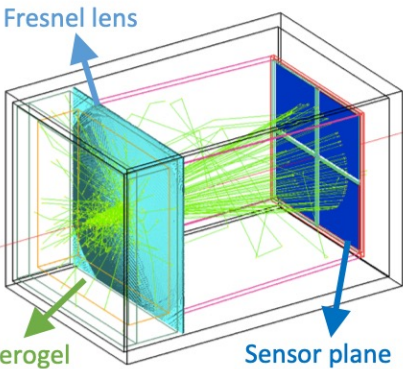
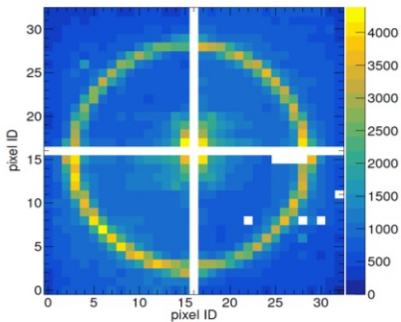


New features: a) separation of optical and electronic components; b) longer focal length (6"); c) 3mm x 3mm photosensors.

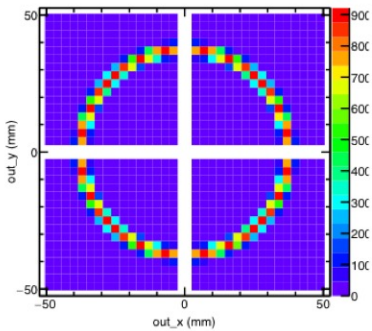


2nd mRICH prototype was tested at Fermilab Test Beam Facility in June/July 2018

Beam Test at Fermilab



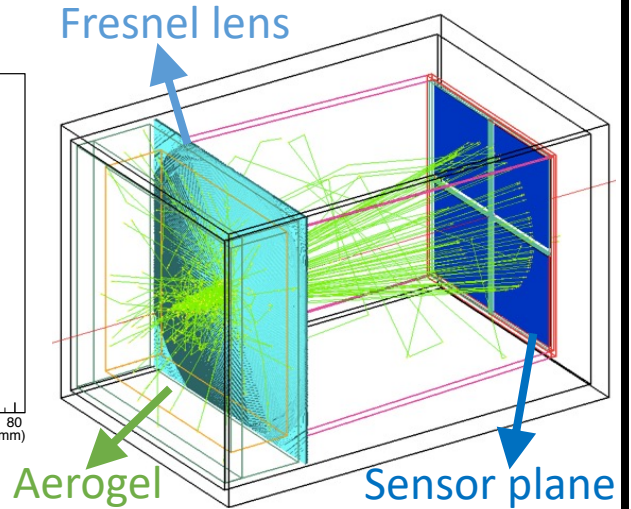
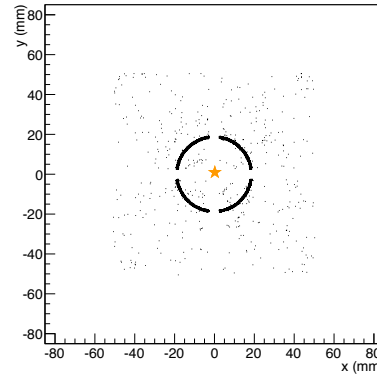
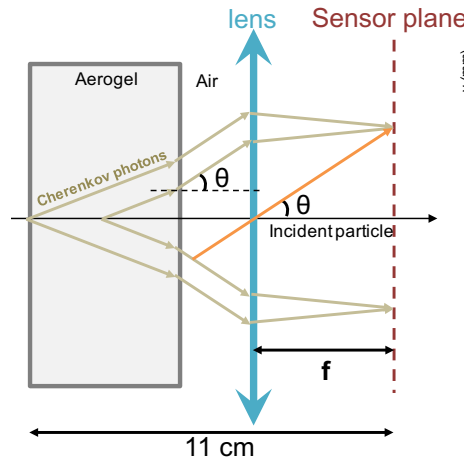
GEANT4 Simulation



mRICH – lens-based focusing aerogel detector design

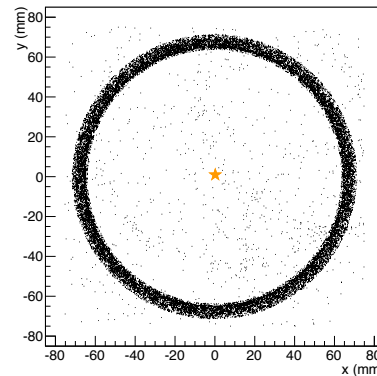
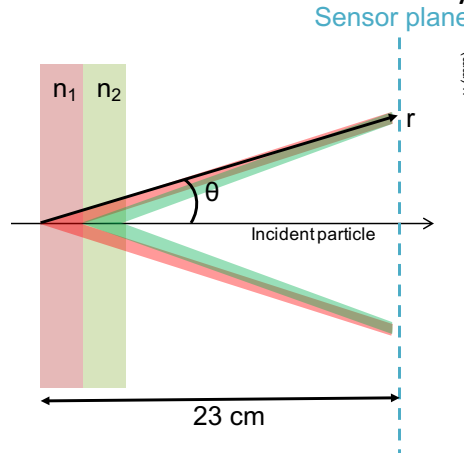
Smaller, but thinner ring improves PID performance and reduces length

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)

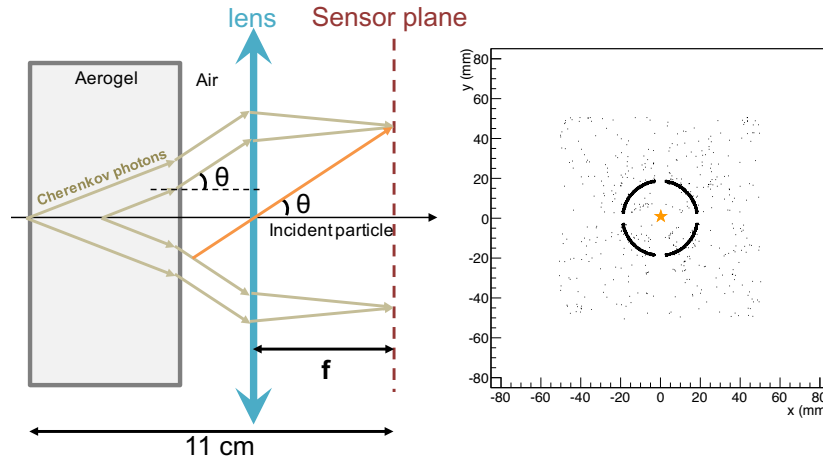


- EIC mRICH designed for K/pi ID up to 10 GeV/c
- BELLE-2 ARICH aims to separate pion and kaon up to 4 GeV/c

mRICH – lens-based focusing aerogel detector design

Smaller, but thinner ring improves PID performance and reduces length

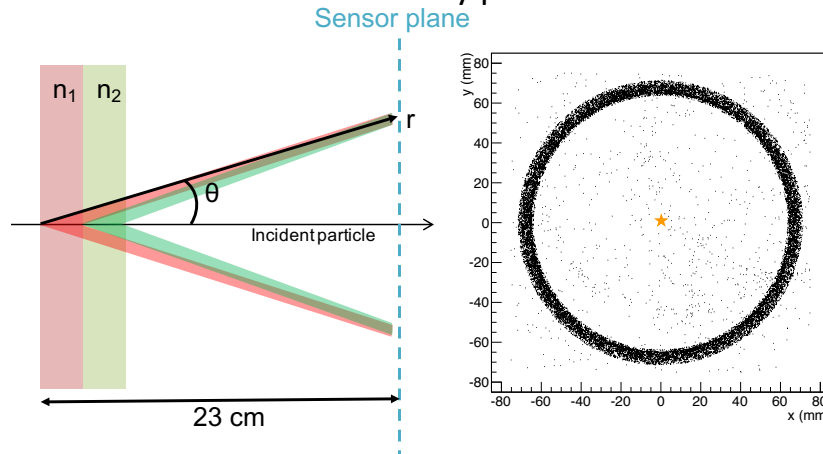
Lens-Based mRICH Design



- 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)

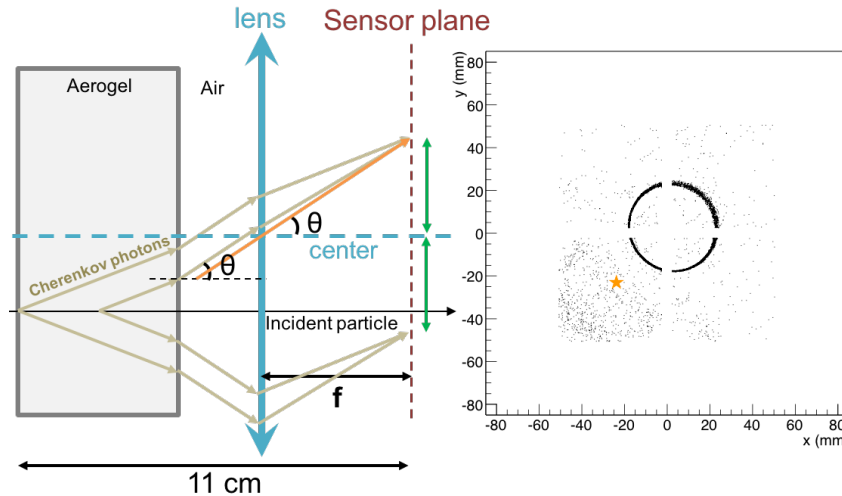


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mRICH – lens-based focusing aerogel detector design

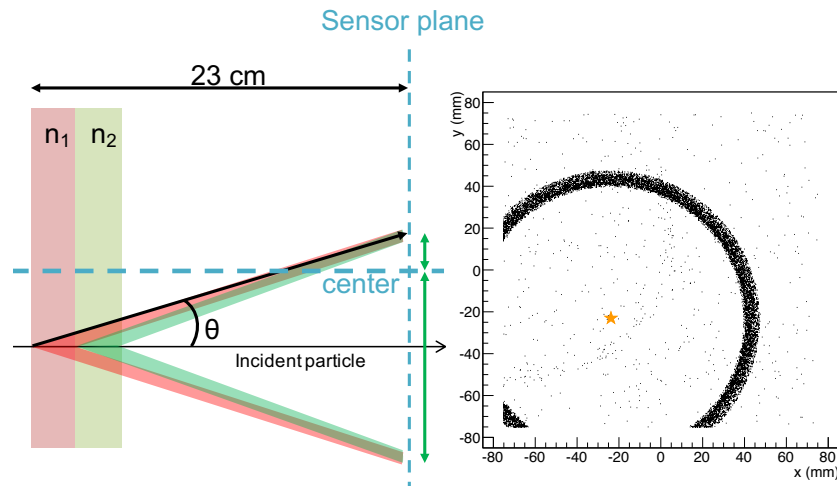
Ring centering of lens-based optics reduces sensor area (main cost driver)

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)

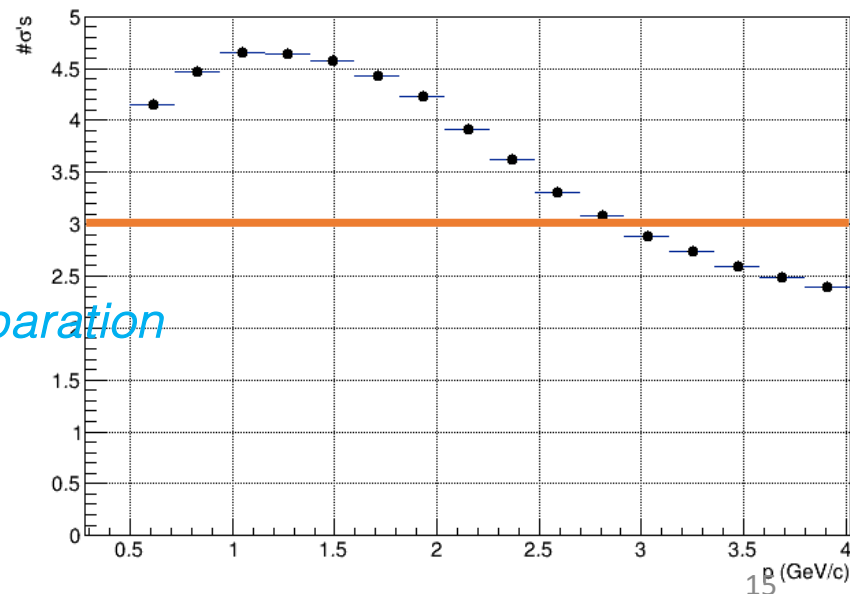
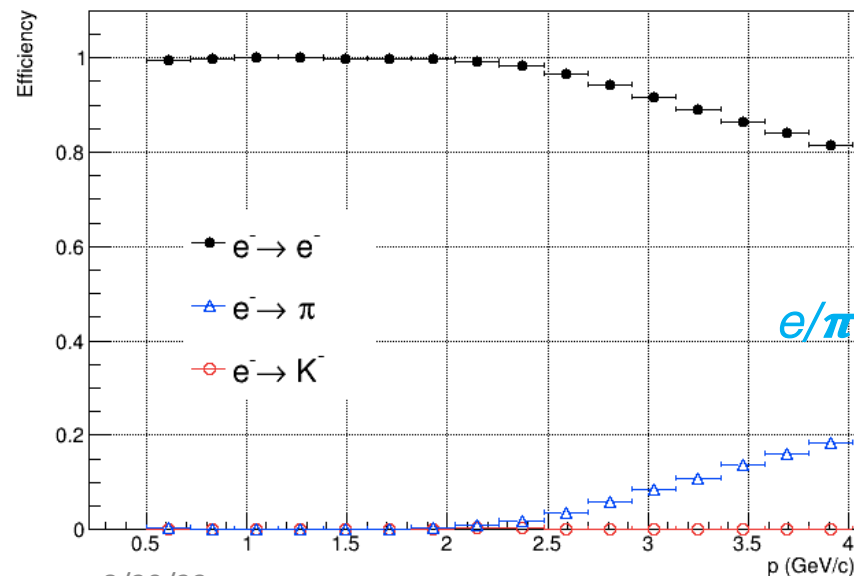
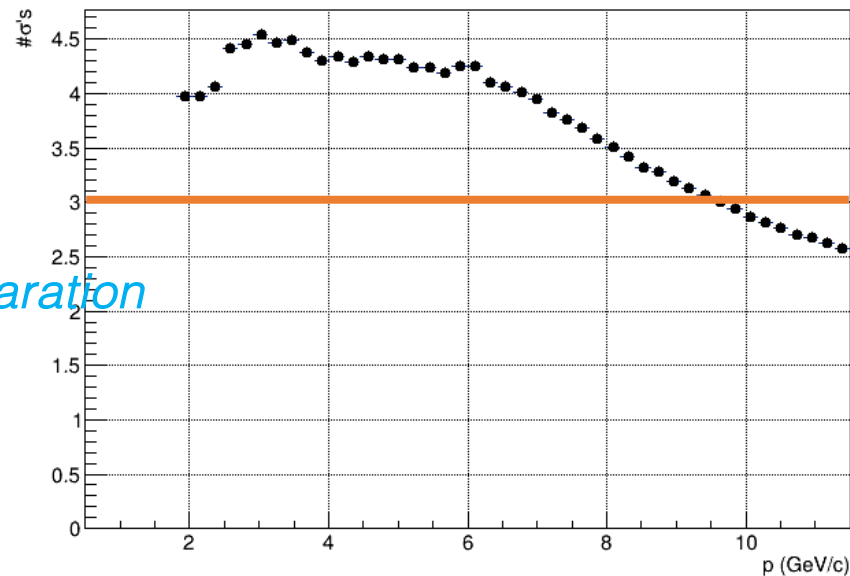
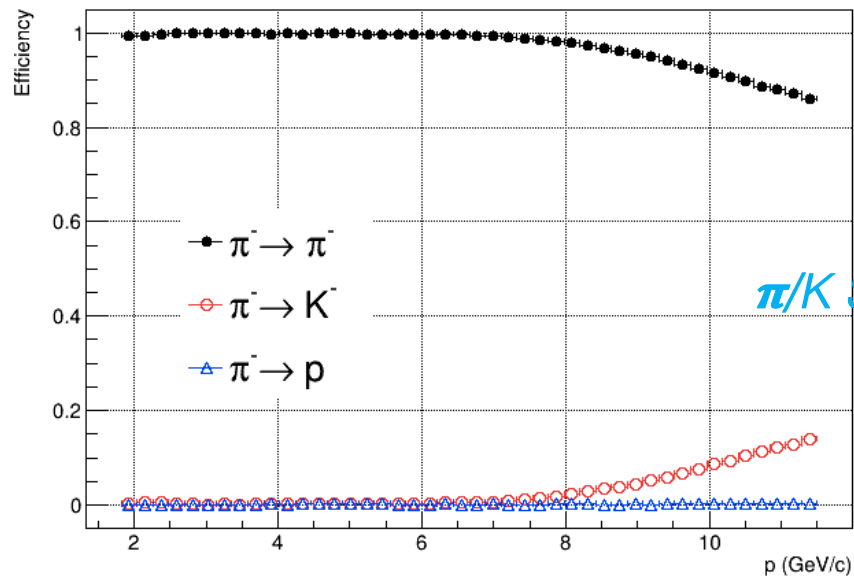


- 9 GeV/c pion beam incident at third quadrant (star) in simulation
- Ring is centered at point of incidence

mRICH PID Performance

- 3 cm Aerogel @ $n = 1.02$
- SiPM Q.E.

$\Delta\theta = 1.75$ mrad



mRICH PID Performance

