

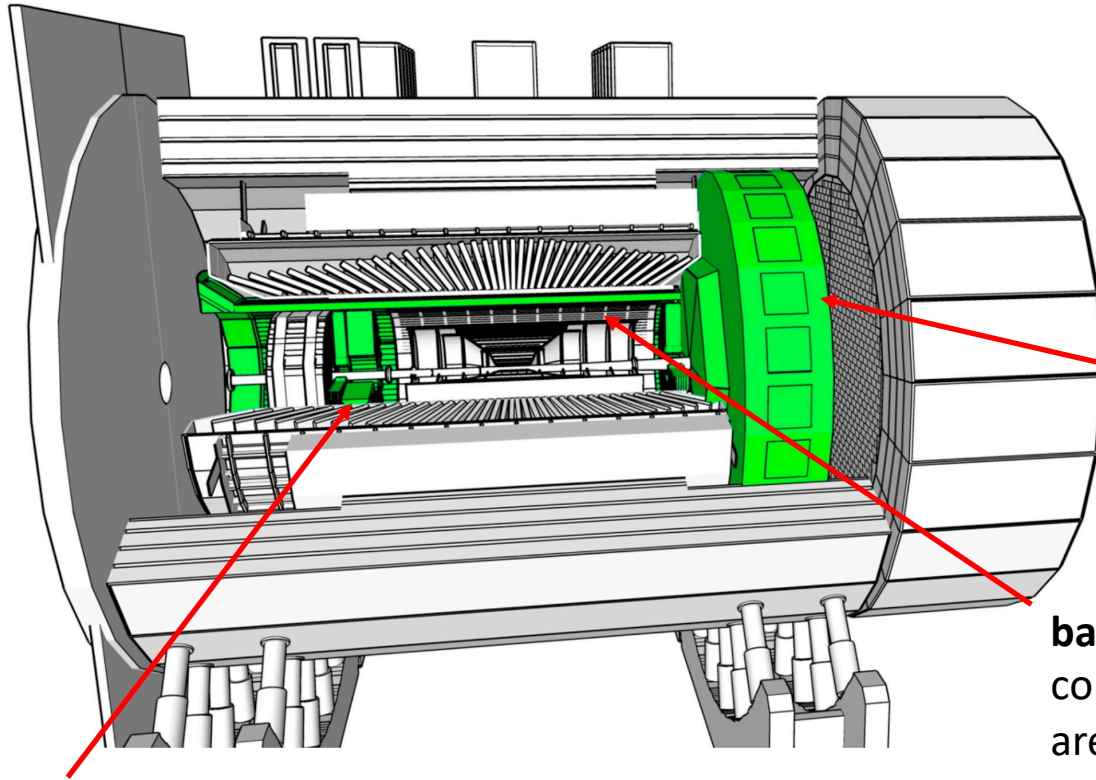
***eRD101*: Modular Ring Imaging CHerenkov Detector (mRICH)**

ANL (Junqi Xie), BINP (Alexander Barnyakov), BNL (Edward Kistenev and Alexander Kieslev), Duke University (Zhiwen Zhao), Glasgow University (Rachel Montgomery and Bjoern Seitz), Georgia State University (Xiaochun He, **Murad Sarsour** and Deepali Sharma), INFN/Ferarra (Marco Contalbrigo), JLab (Alex Eslinger and Benedikt Zihlmann), Tsinghua University (Zhihong Ye) and University of South Carolina (Yordanka Ilieva).

October 19, 2022

EIC Project R&D - DAC Meeting

EIC/ePIC mRICH

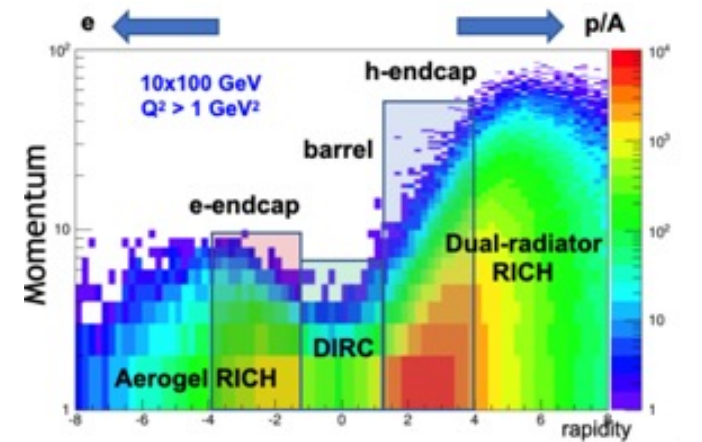


e-endcap: A compact aerogel RICH which can be projective. π/K separation up to ~ 10 GeV/c

mRICH

eRD101 objectives:

- Mitigate the risk factors of mRICH (Sensor & Aerogel)
- Optimize mRICH design



h-endcap: A RICH with two radiators (gas + aerogel) is needed for π/K separation up to ~ 50 GeV/c

dRICH

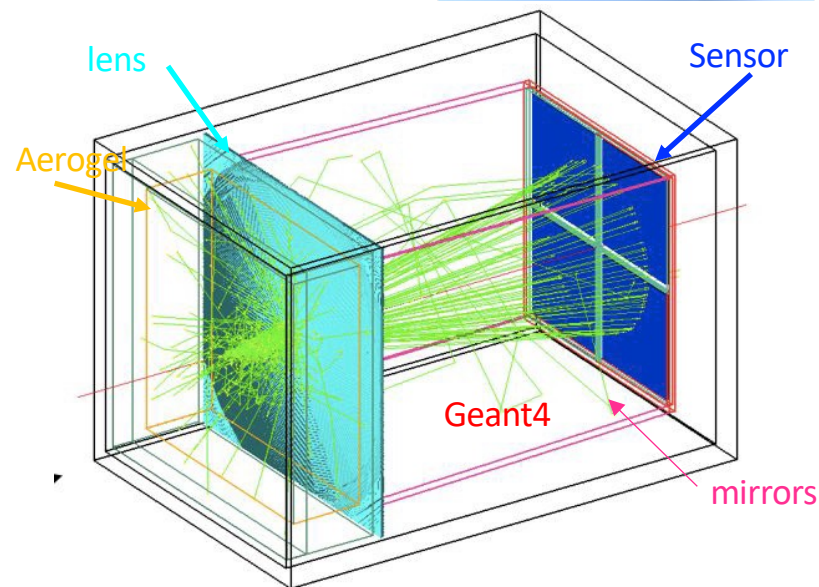
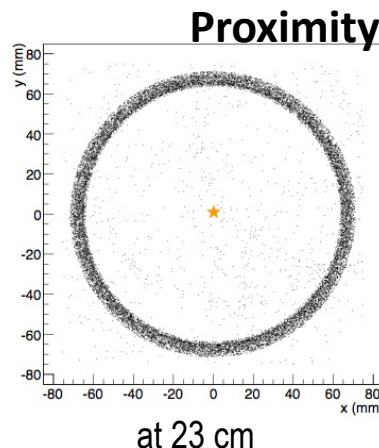
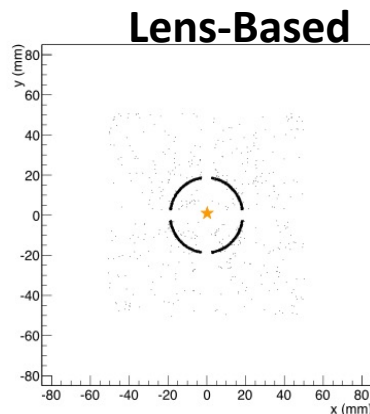
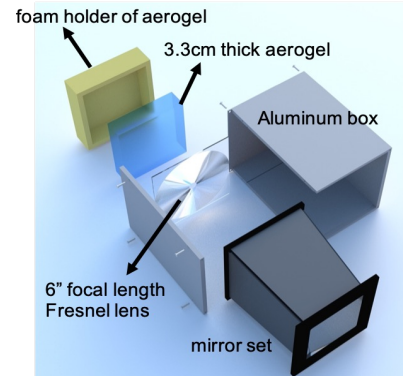
barrel: A high performance DIRC provides a compact cost-effective way to cover the area. π/K separation up to $\sim 6-7$ GeV/c

DIRC

ePIC mRICH – Working Principle

- *Compact, modular and projective*

- Radiator: Aerogel, $L \sim 3 - 4$ cm and $n = 1.02$ & 1.03
- Focusing: 6" Fresnel lens



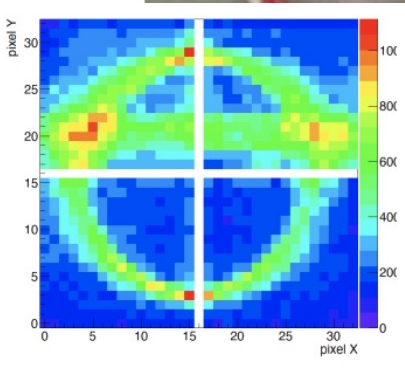
- ❖ Compact PID device with momentum coverage up to 10 GeV/c for π/K and e/π up to 2 GeV/c or more.
- ❖ The emission point error is minimized at the lens focal plane, and chromatic dispersion error is reduced by UV filtering (acrylic).
- ❖ R&D is at very advanced stage – 3 beam tests already!

3rd mRICH Beam Test at JLab

late September to early October of 2021

1-6 GeV/c Secondary Electron Beam

electrons



(a)

10/19/22

GEM Tracker 1

GEM Tracker 2

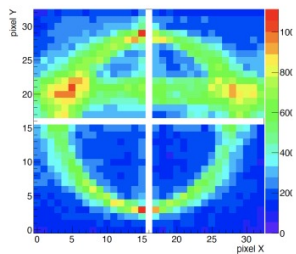
mRICH

(b)

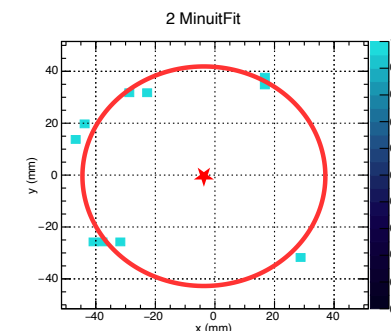
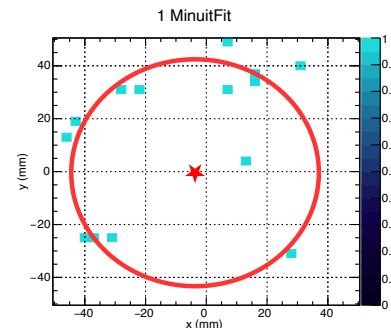
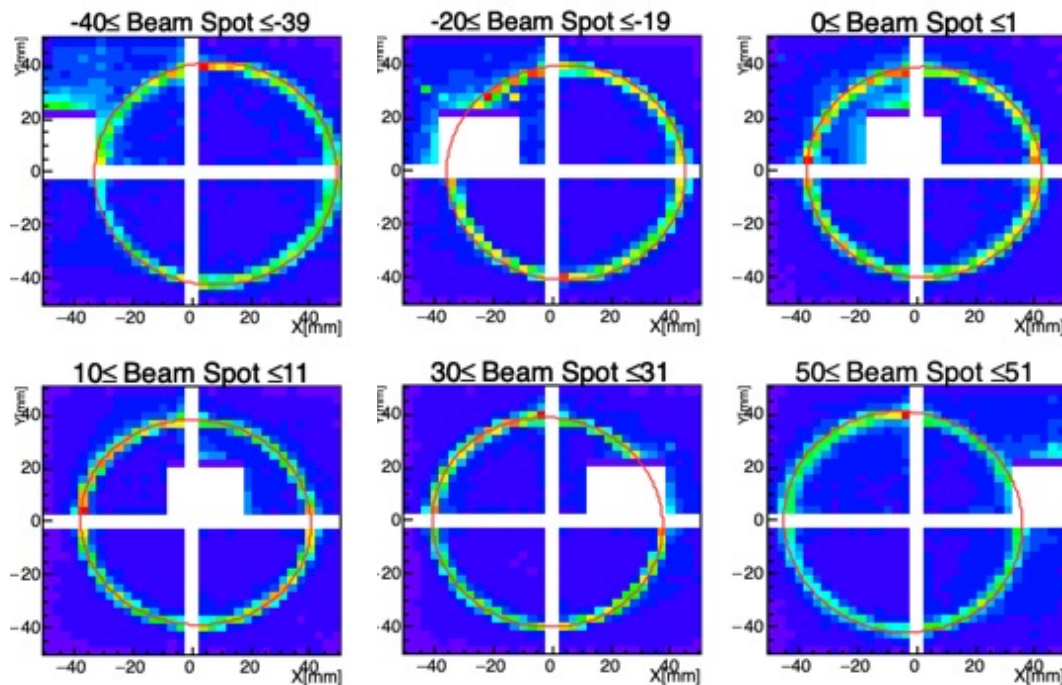
Top view

4

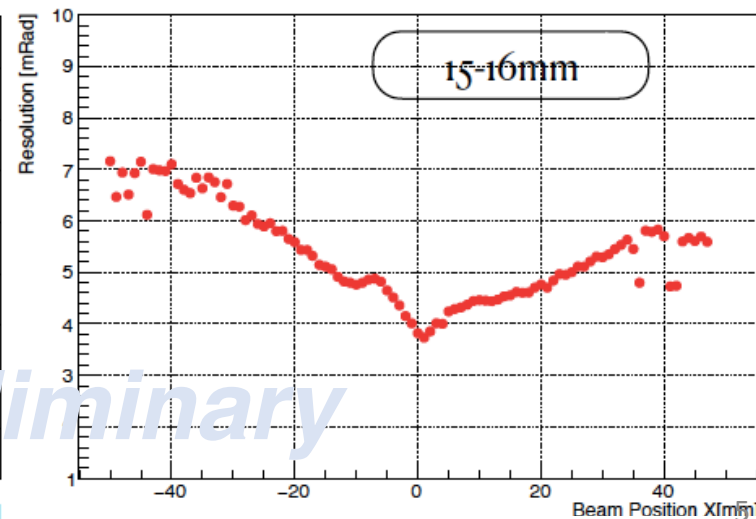
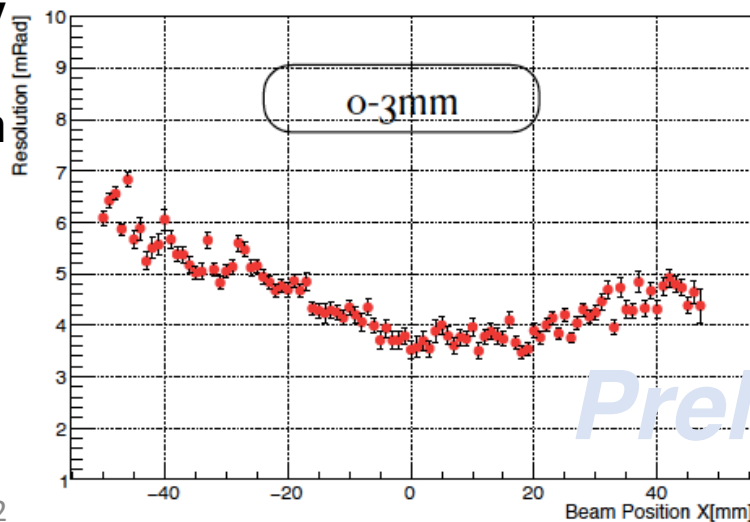
Results from JLab Beam Test



Simple elliptic
function fit



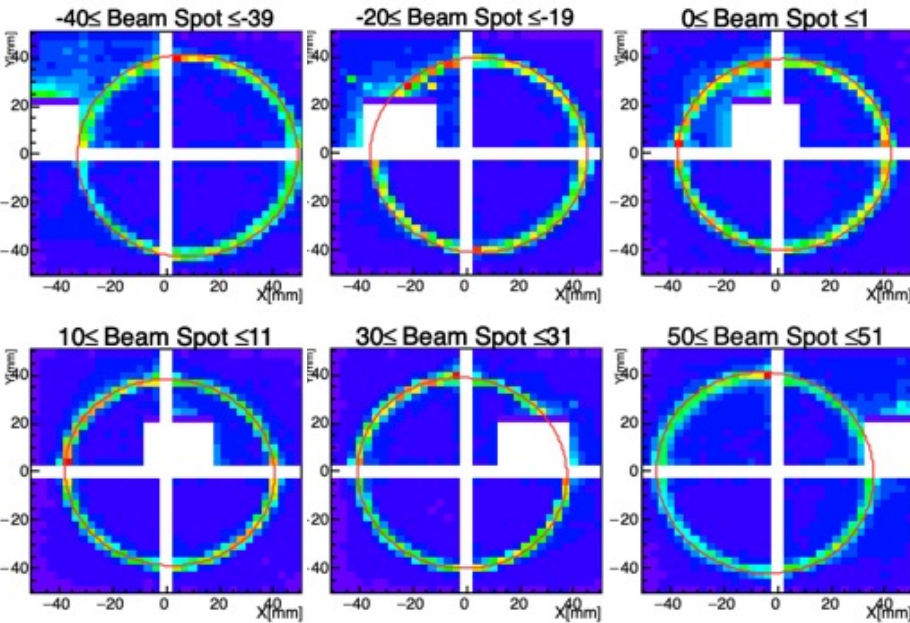
Cherenkov
Angle
Resolution



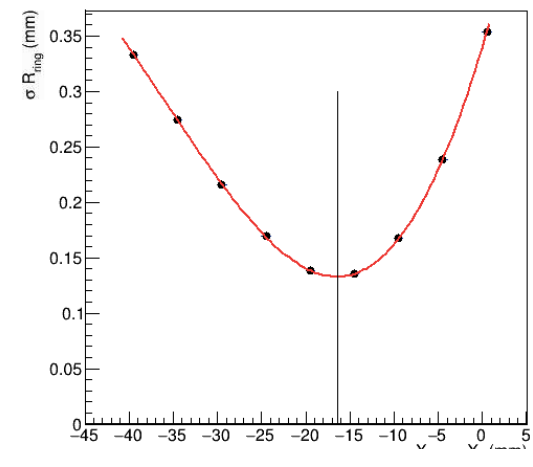
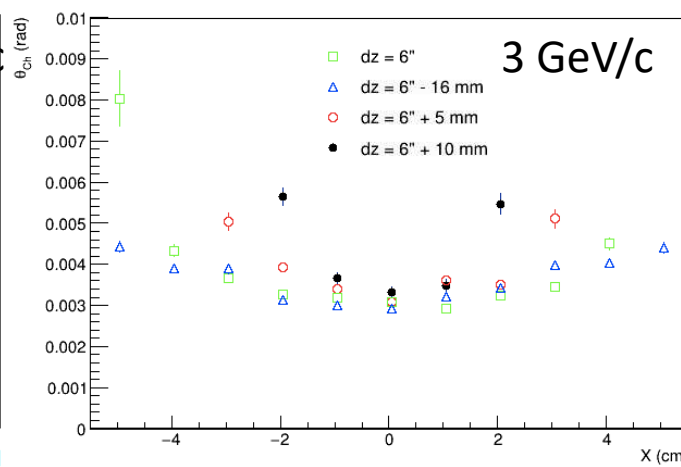
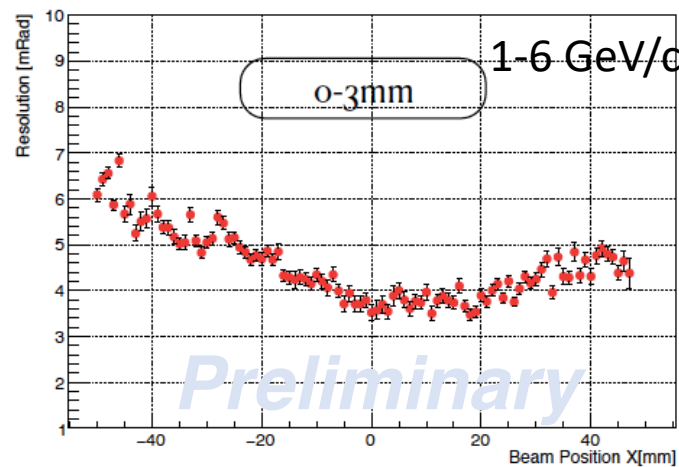
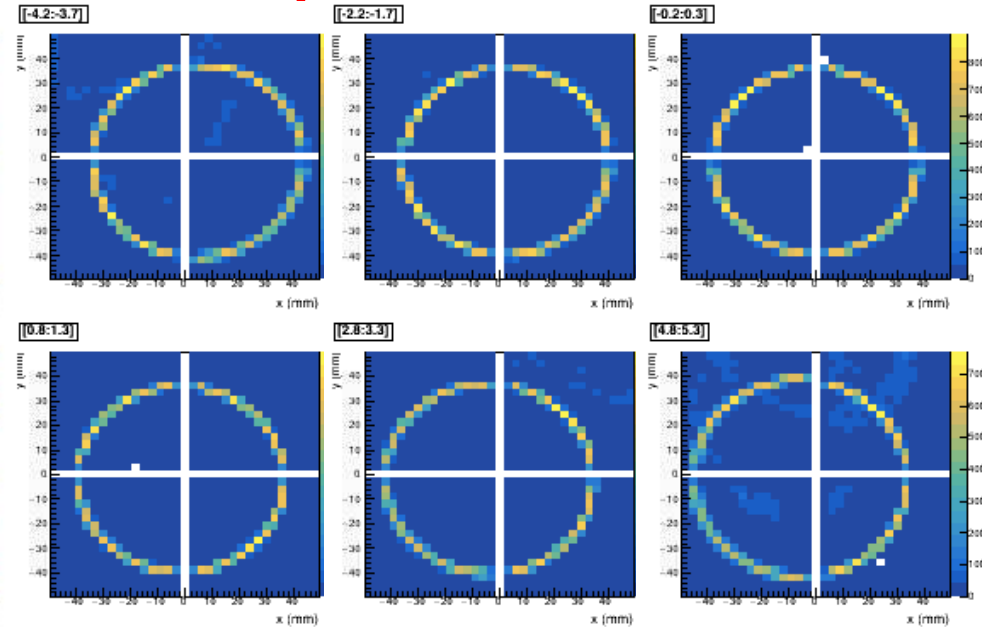
Preliminary

Advanced G4 Simulation of mRICH

Data



G4 Simulation

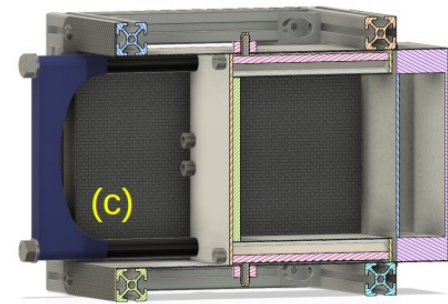
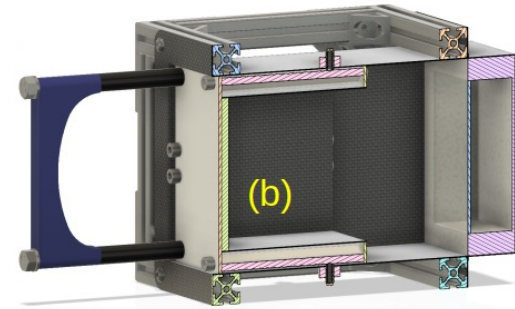
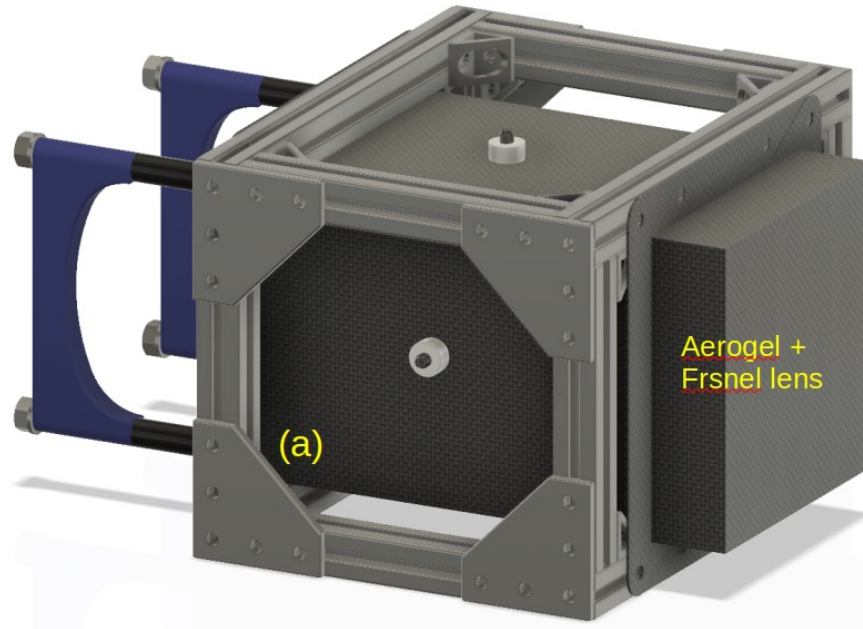


Preliminary

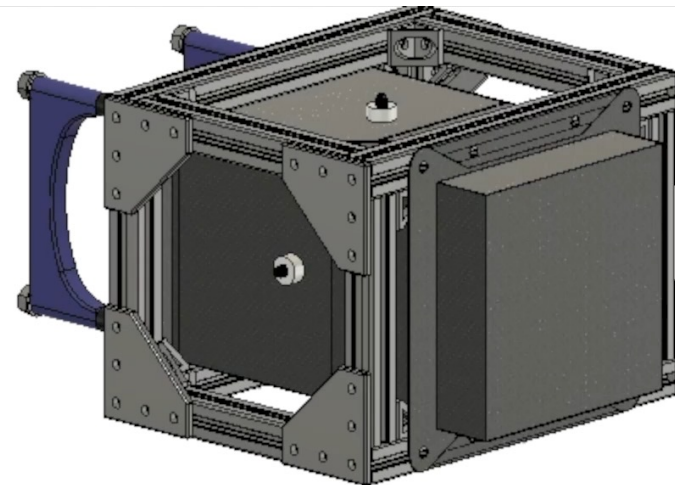
10/19/22

Location from Focal plane

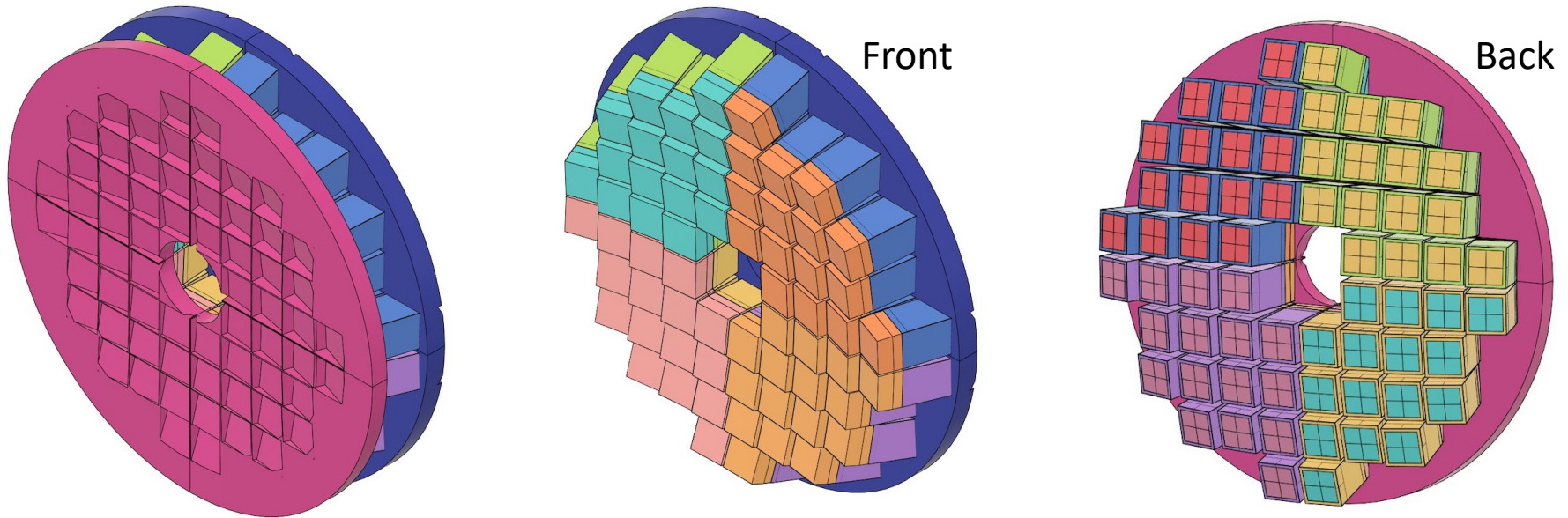
New mRICH Prototype Design



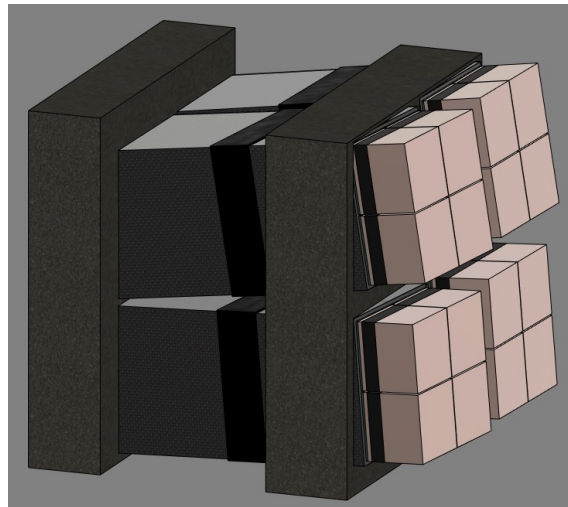
- Optimizing the sensor location and Aerogel thickness



mRICH Support Frame



- 4 modules support prototype



FY23 Activities

- Exploring photosensor and readout electronics
 - Develop a version of LAPPD (10cm x 10cm) for mRICH – Glasgow group
 - Synergies with eRD102 (dRICH) , eRD109 (readout elec.) , and eRD110 (sensor)
- Procurement of Aerogel
 - Collaboration between Tsinghua University & BINP to produce quality Aerogel
- Support structure - reduce material budget and test support integrity (JLab & GSU)
- Optimizing the photosensor plane location & Aerogel block size
 - New mRICH prototype - Nov./Dec. 2022
 - Procurement of materials for the mRICH mechanical components and the support structures - Spring 2023
 - ➡ followed with machining at GSU
 - Aerogel blocks @ 3 cm, 4 cm, and 5 cm - Spring 2023
 - Assembling of the new prototype at GSU - Summer 2023
 - Ready for beam test - End of FY2023

FY23 Budget Request

Category	Qty	Cost
Design support from JLab engineer	1	8 weeks
Postdoc at GSU	50%	\$60k (FY22 fund)
Postdoc at University of Glasgow	50%	\$40k
Machining support (GSU shop)	2-month	\$20k
Aerogel purchase	9 blocks	\$13.5k
Readout	1 lot	\$20k
Mirrors and Fresnel lens	4 sets	\$2k
GEM tracker and readout	1	\$15k
Material supplies	1 lot	\$3k

FY24/25 Activities

Following the success of the FY23 plan → focus on realistic beam tests with newly identified photosensors and readout.

- Highly contingent on progress in other eRD projects (102, 109, 110)

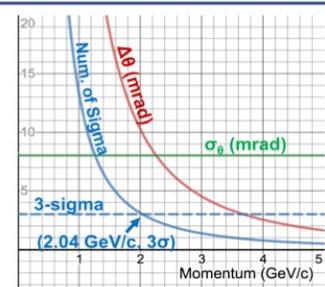
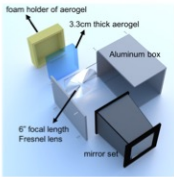
General plan – test beam:

- Optimizing the sensor plane location and testing Aerogel blocks with three different thicknesses: 3 cm, 4 cm and 5 cm
- Testing mRICH PID performance (K/π and e/π separation)
- Potential sites for beam test (Fermi & CERN and may be JLab)

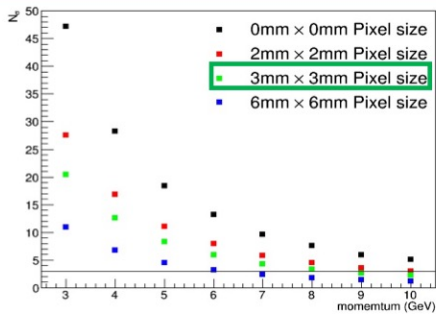
THANK YOU



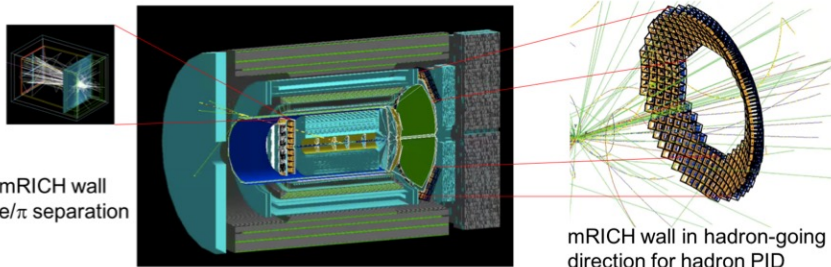
Modular and compact ring imaging Cherenkov (mRICH) PID detector for EIC experiments



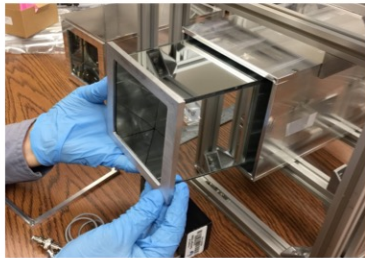
- Projected e/pi separation of mRICH 2nd prototype detector (**blue solid line**)
- 2nd prototype detector can achieve 3-sigma e/pi separation up to 2 GeV/c



- 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

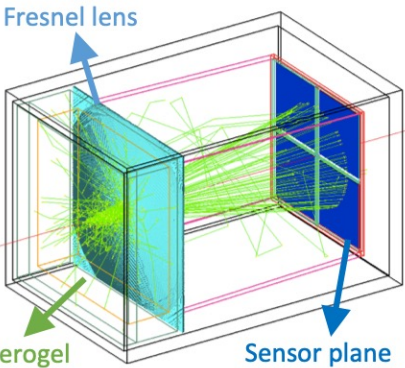
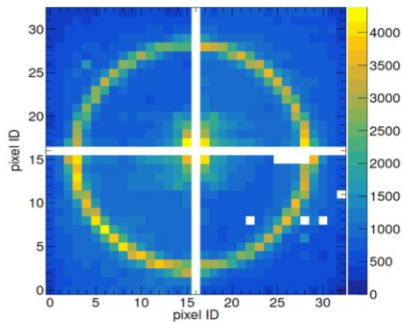


New features: a) separation of optical and electronic components; b) longer focal length (6"); c) 3mm x 3mm photosensors.

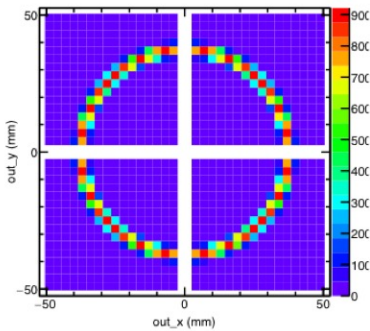


2nd mRICH prototype was tested at Fermilab Test Beam Facility in June/July 2018

Beam Test at Fermilab



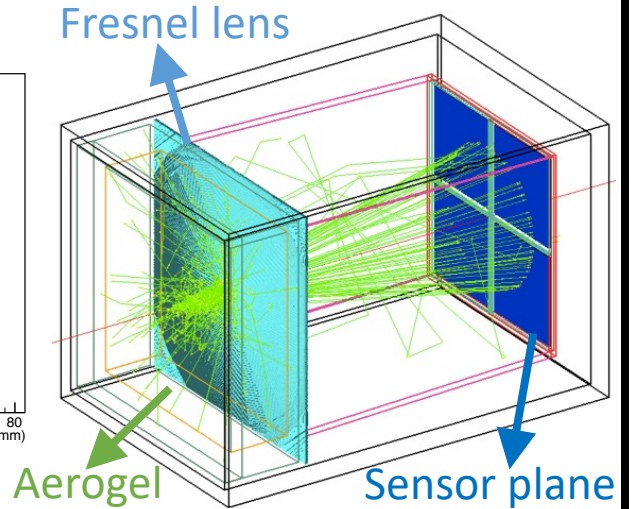
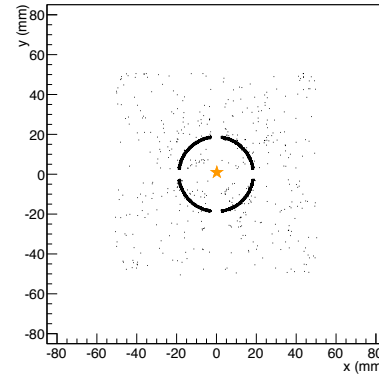
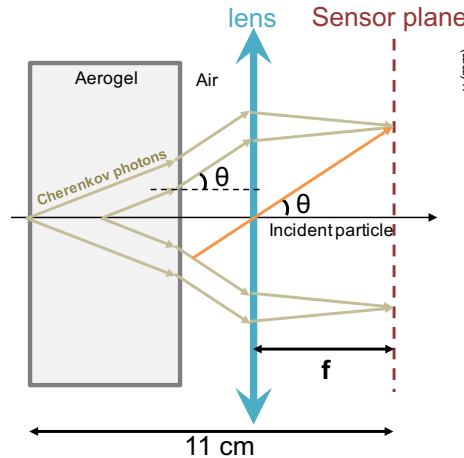
GEANT4 Simulation



mRICH – lens-based focusing aerogel detector design

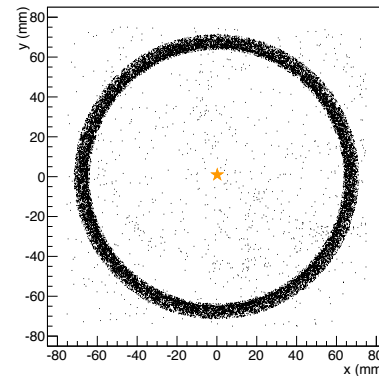
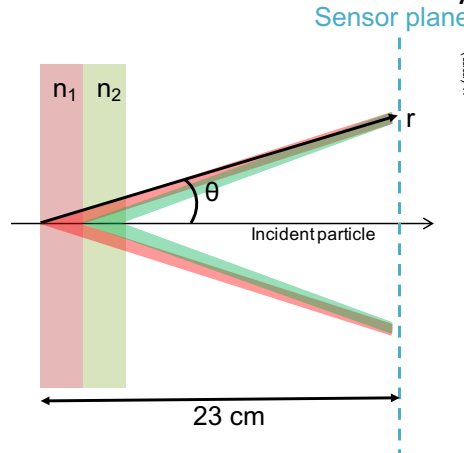
Smaller, but thinner ring improves PID performance and reduces length

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)

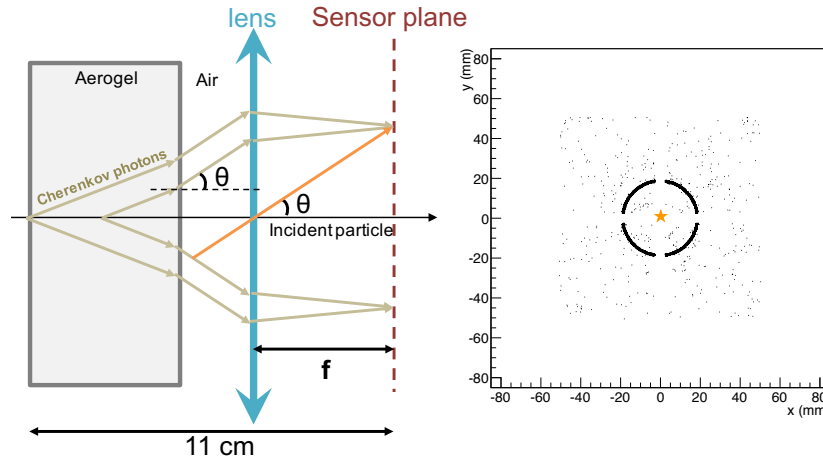


- EIC mRICH designed for K/pi ID up to 10 GeV/c
- BELLE-2 ARICH aims to separate pion and kaon up to 4 GeV/c

mRICH – lens-based focusing aerogel detector design

Smaller, but thinner ring improves PID performance and reduces length

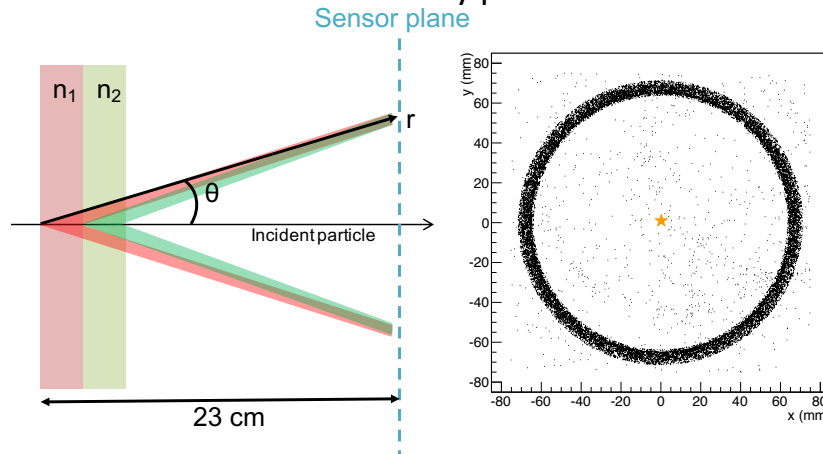
Lens-Based mRICH Design



- 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)

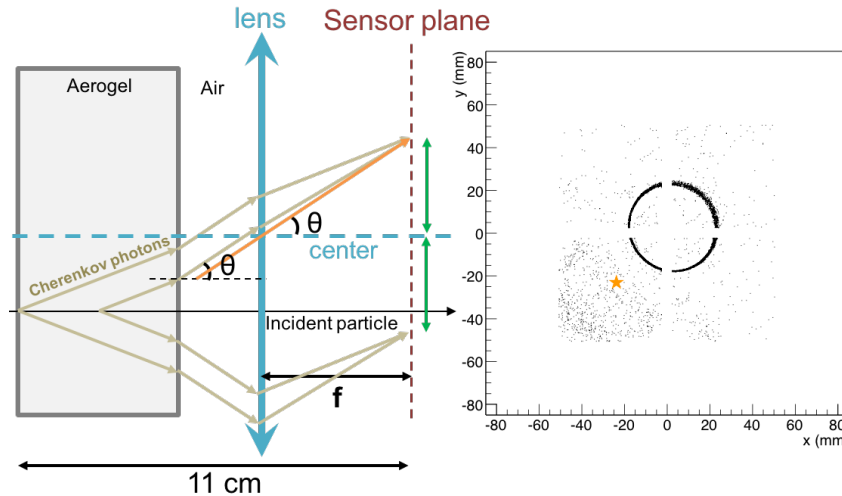


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mRICH – lens-based focusing aerogel detector design

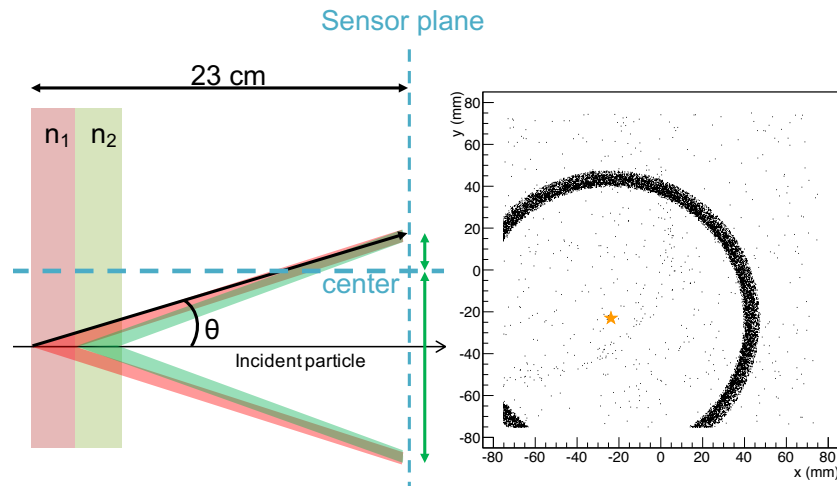
Ring centering of lens-based optics reduces sensor area (main cost driver)

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

