

mRICH for EIC PID



mRICH stands for compact and modular Ring Imaging Cherenkov detector, which is designed for K/pi separation in a momentum range of 3 to 10 GeV/c and e/pi separation below 2 GeV/c for the EIC experiments.

Outline

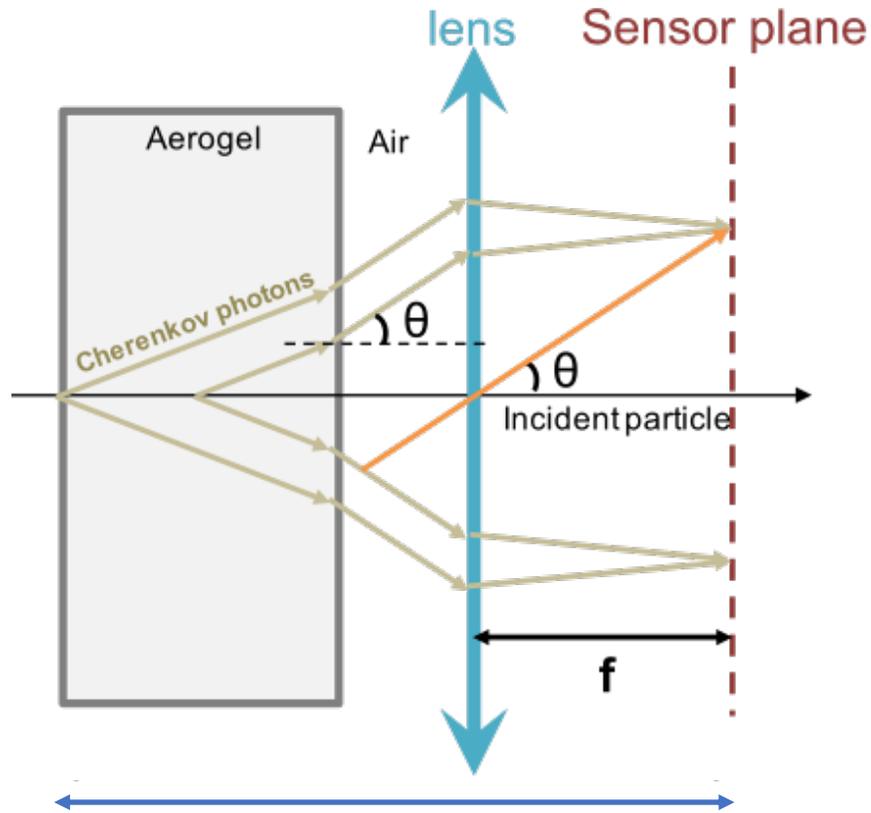
- mRICH today - report
- mRICH R&D plan
 - Near term
 - Long term

Institutions involved

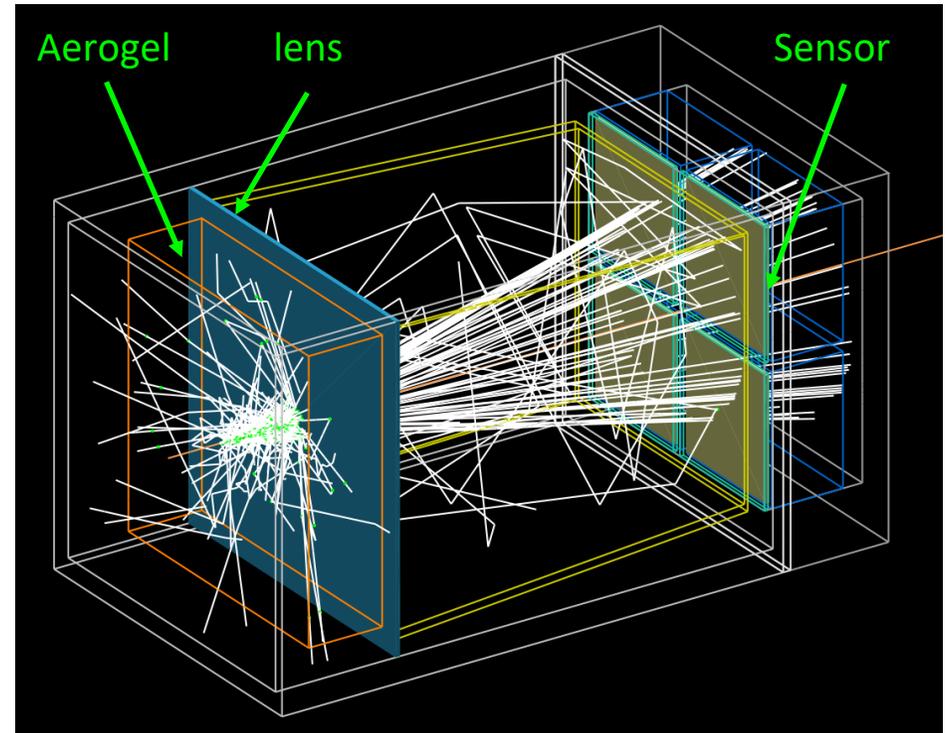
- Georgia State University
- INFN @ Ferrara and @ LNF
- Duke University
- University of Hawaii
- University of South Carolina
- Brookhaven National Lab
- Jefferson Lab
- Argonne National Lab



EIC mRICH – Working Principle



~ (aerogel thickness + lens focal length)



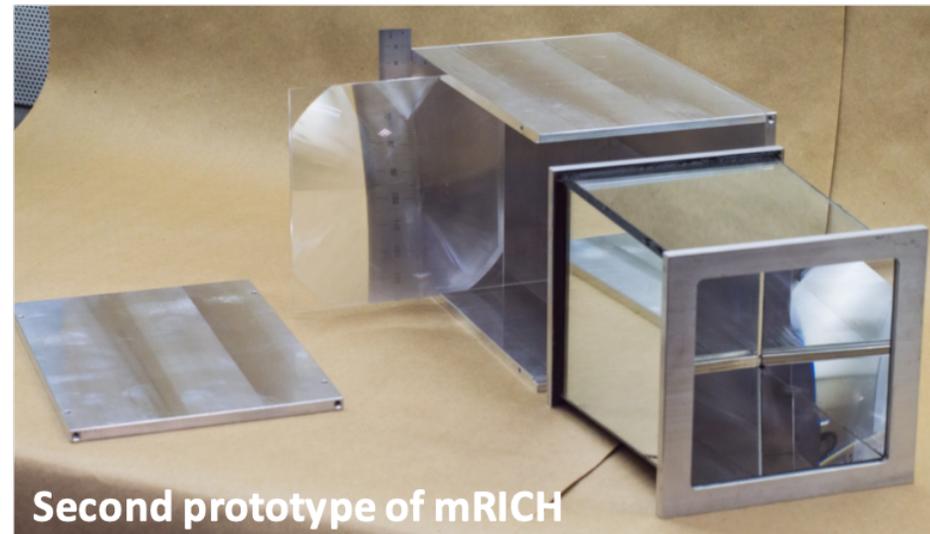
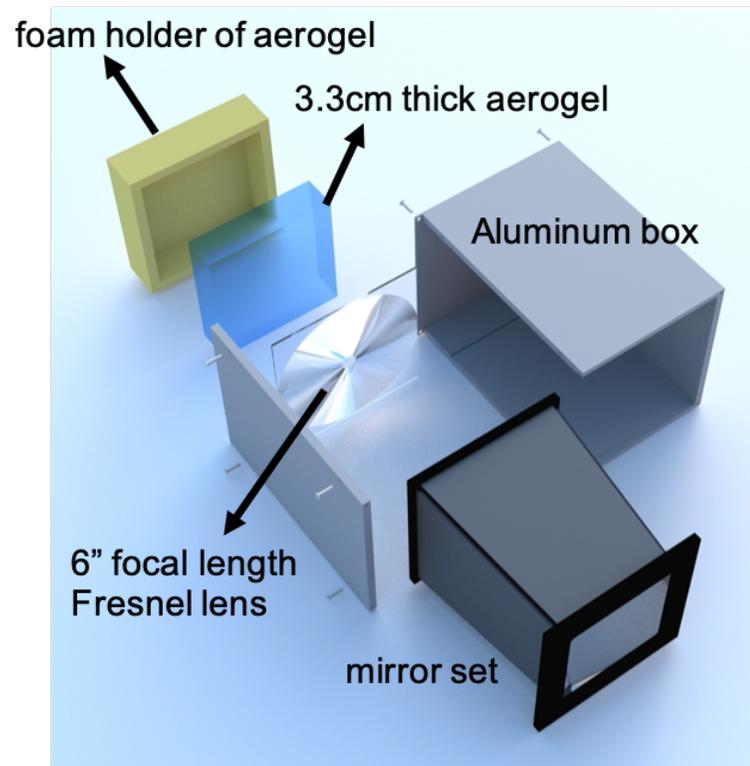
Geant4 Simulation

Compact, modular and projective

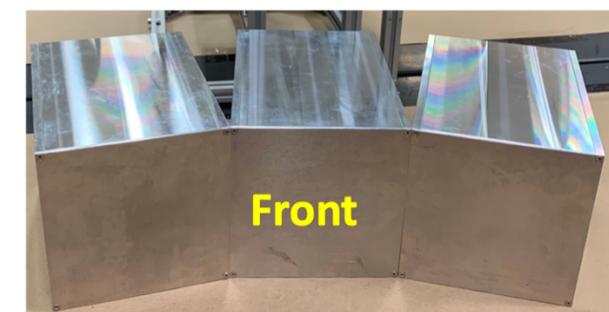
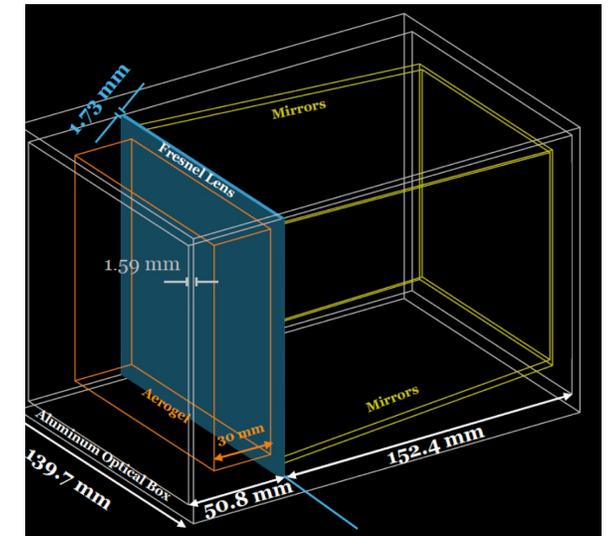
Prototyping & Beam Tests (Report on Past Activities)



- Two beam tests: 2016 and 2018. The results from the 1st beam test have been published (C.P. Wong et. al. **NIM A871 (2017) 13-19**).
- During this report period, prepared for two more tests in 2021 and improving GEANT4 studies.



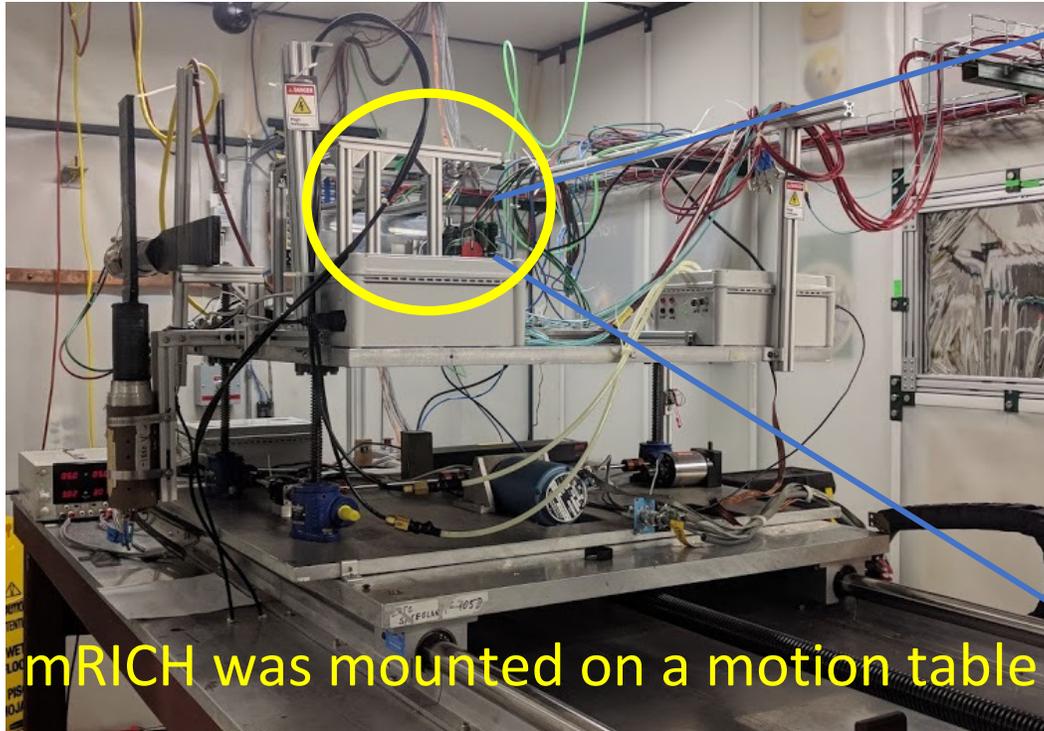
Dimension (from GEANT4 simulation)



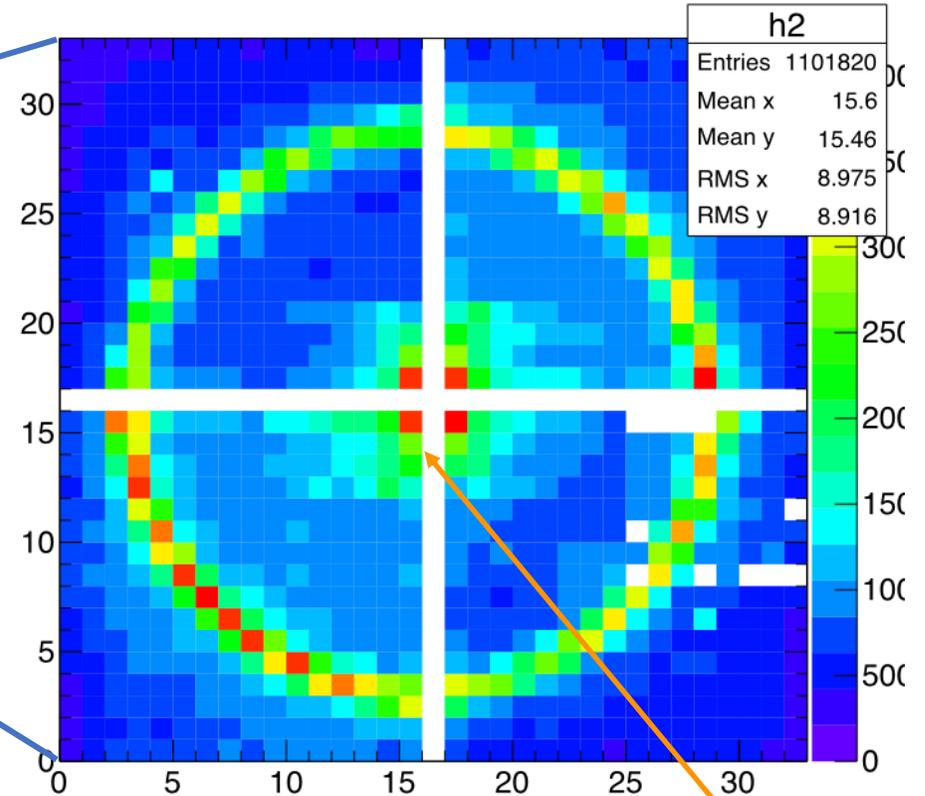
2nd mRICH Beam Test - Verify the PID Capability

Fermilab Beam Test Facility, from July 25 to August 6, 2018

→
120 GeV/c
proton



mRICH was mounted on a motion table



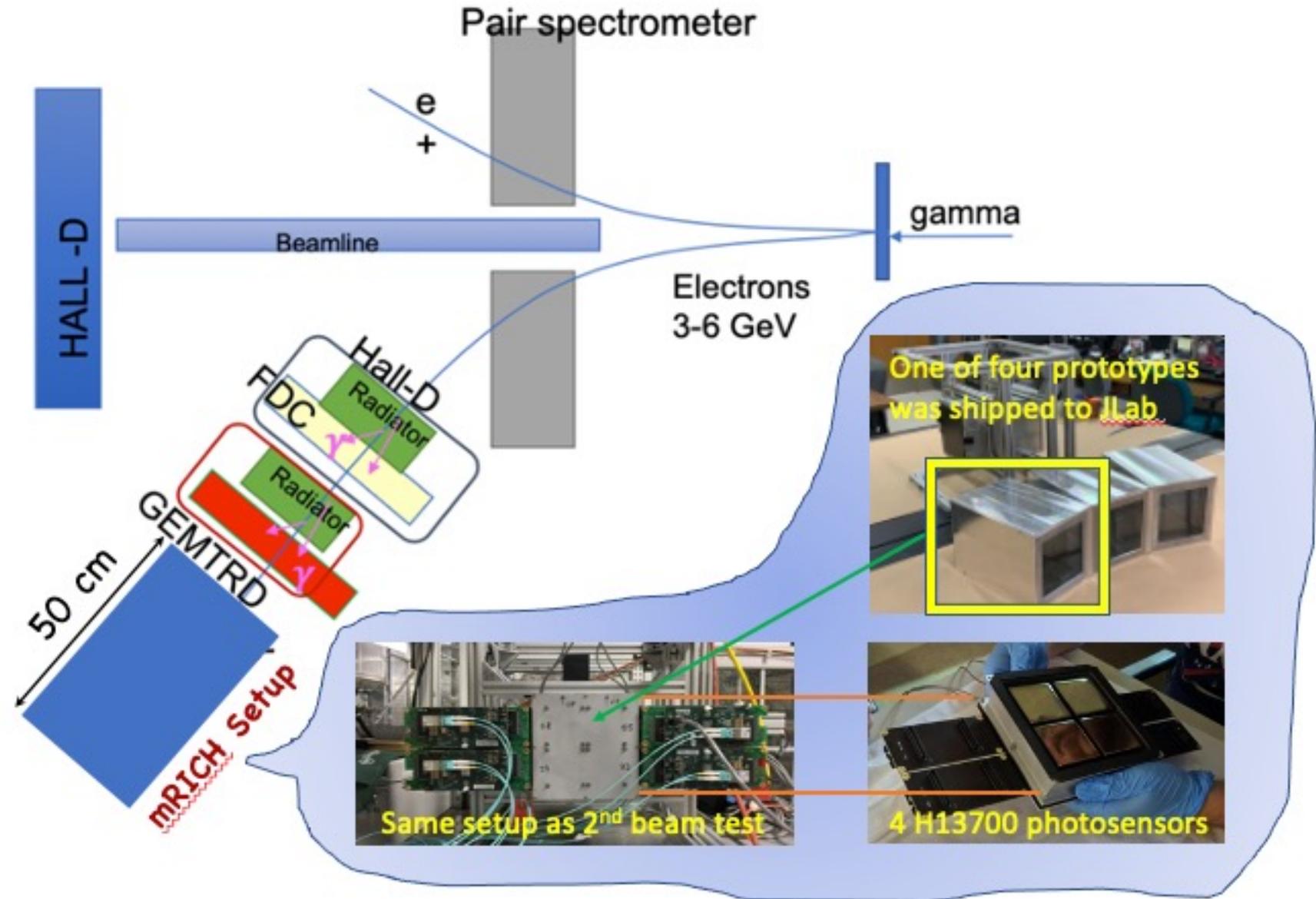
Beam spot

One remaining data analysis from this test is still ongoing, which is led by our postdoc for studying the noise level of the SiPM matrices as a function of the cooling temperature (-30°, -20°, -10°, -0° and room temperature).

mRICH Test at JLab (Planned Activities 1)

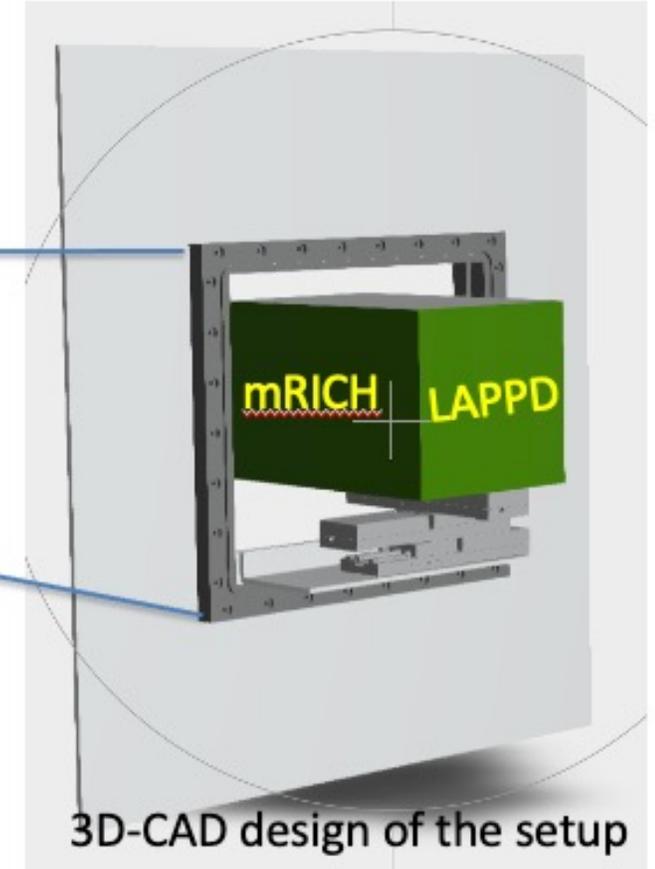
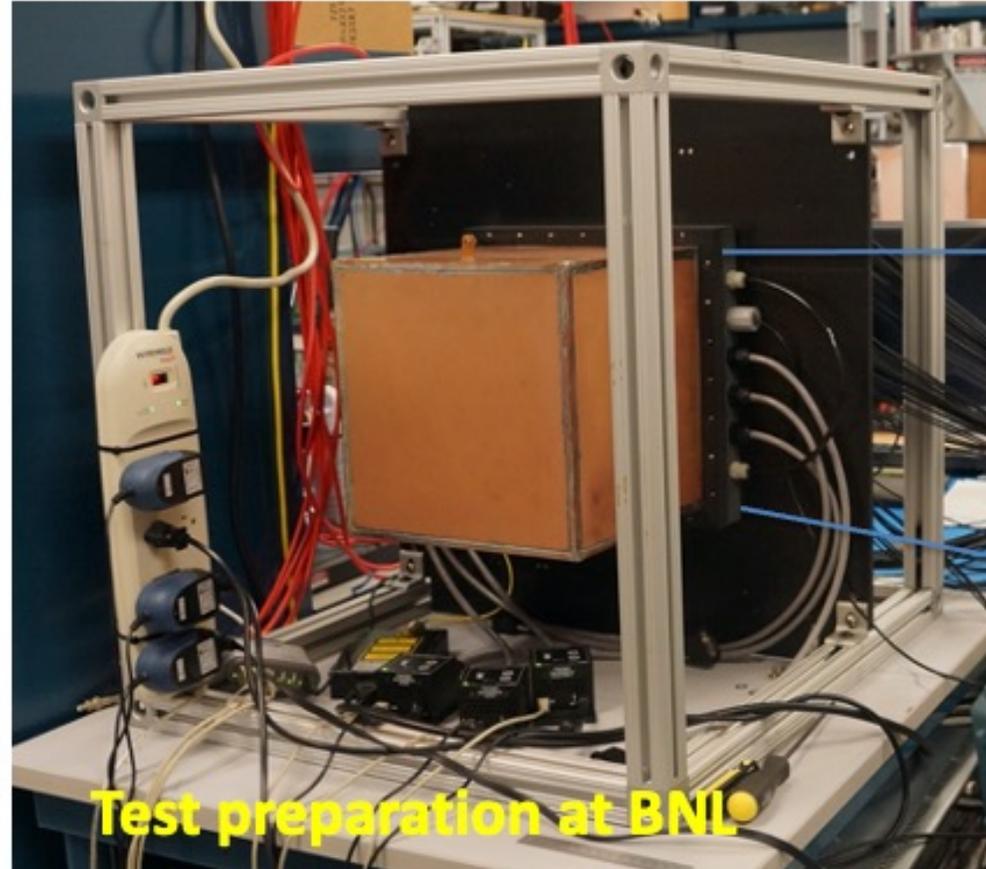


- Main goal is to test mRICH performance with a precision tracking.
- The test was originally scheduled in summer of 2020. Current schedule is in summer of 2021.
- Will use the same readout as it was used in 2nd mRICH test.



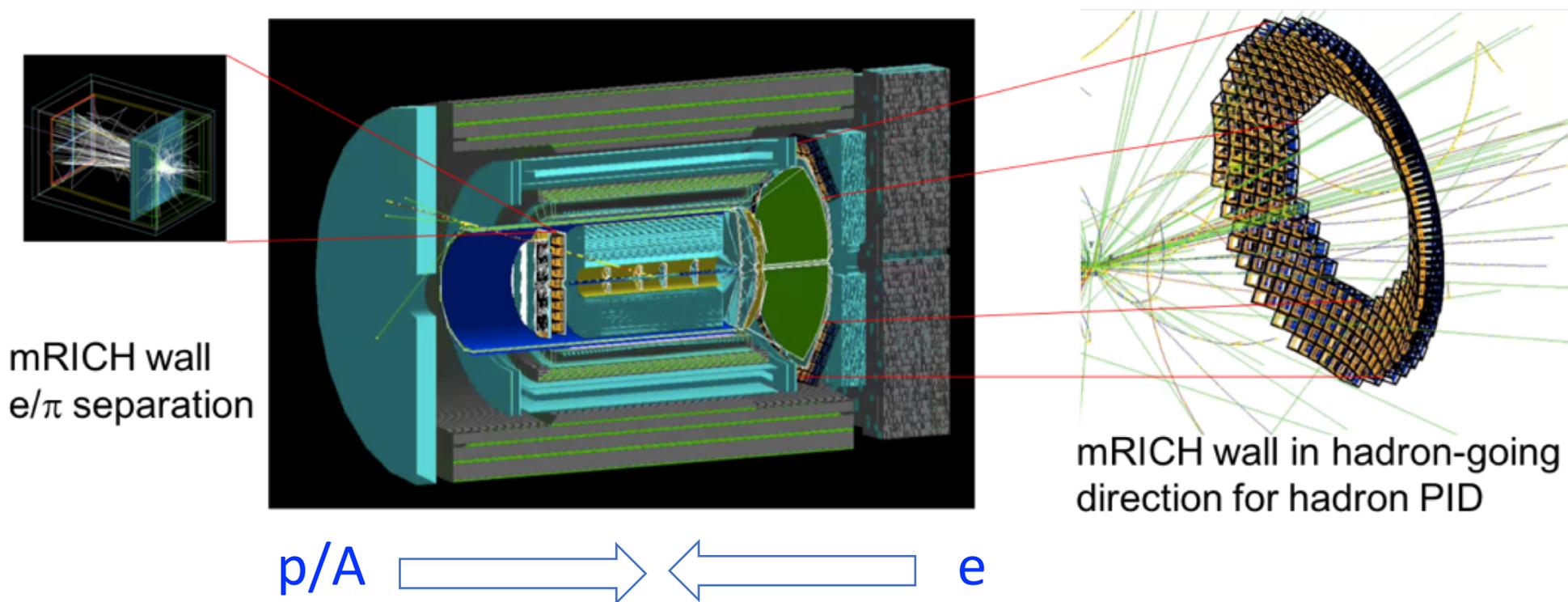
mRICH-LAPPD Fermilab Test (Planned Activities 2)

- Main goal is to test mRICH performance using LAPPD sensor and tracking.
- The test was originally scheduled in March of 2021 but delayed.
- mRICH was shipped to BNL for test setup integration.



GEANT4 Implementation of mRICH Arrays in EIC

Using sPHENIX Fun4All Framework



Goal: optimizing physics impact and acceptance coverage!



FY21 Activities (Summary)

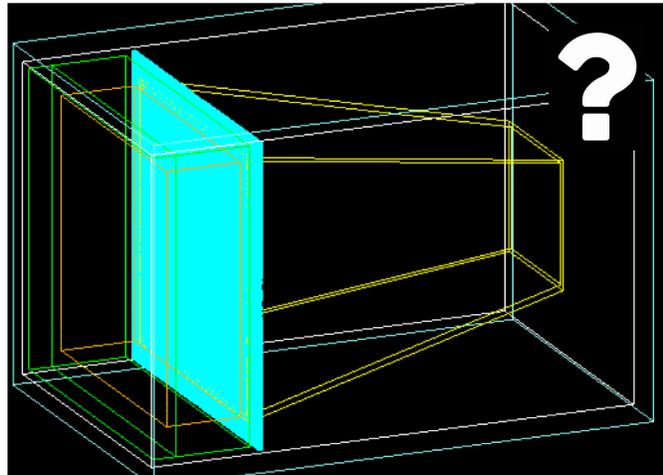
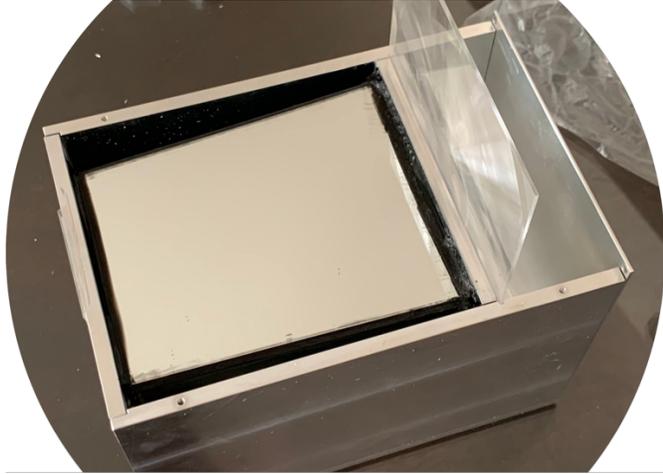
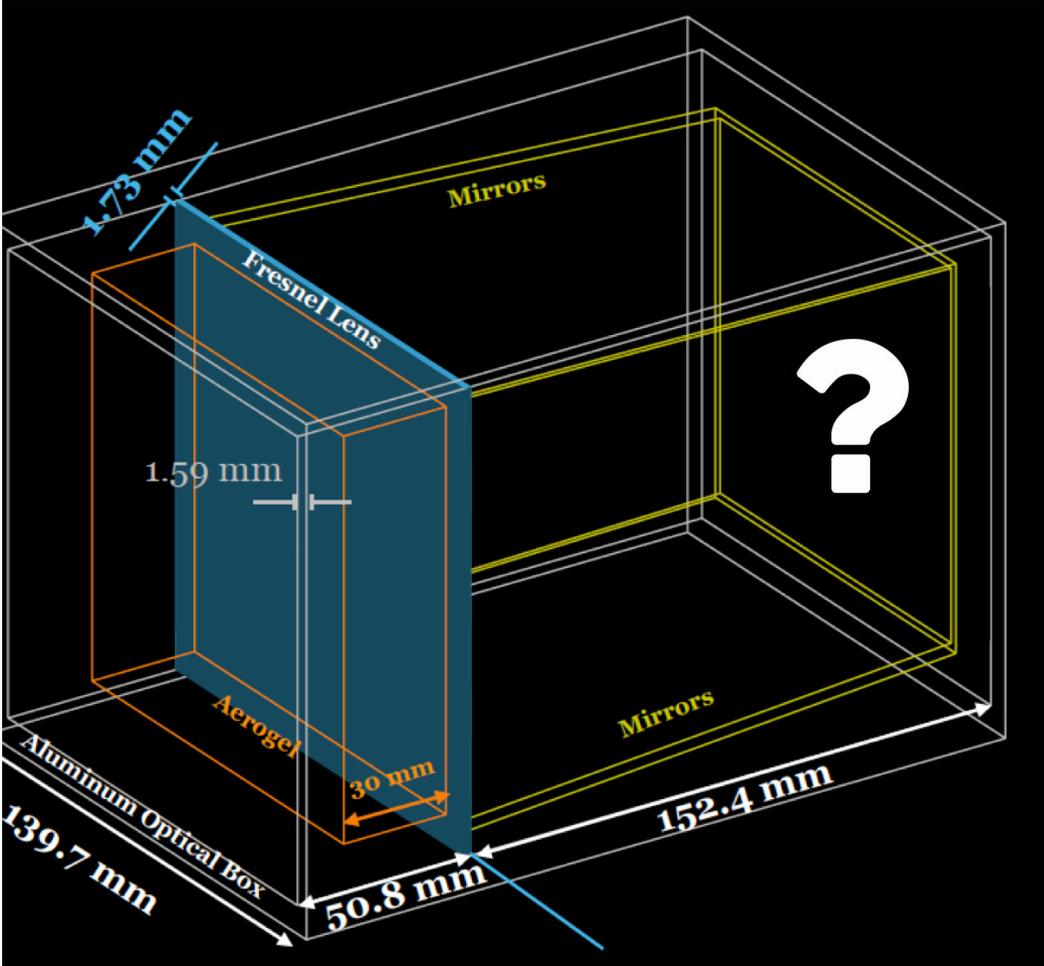
- **Continue the mRICH data analysis and fine tune simulation (based the 2nd mRICH beam test data):**
 - ◆ Quantitatively assess the effects of optical alignment on mRICH performance, which include focal plane location, sensor plane orientation, etc.
 - ◆ Quantify the temperature-dependent noise levels in the data set taken with three SiPM matrices.
- **mRICH beam tests at JLab and Fermilab.**
 - ◆ Set up an optical characterization system at GSU for measuring the optical properties of Aerogel, lens and mirrors.

Beyond FY21 – toward TDR Readiness



- **System integration studies**
 - Engineering design of mounting mRICH array
 - Optical characterization
 - Cooling system (for the case of SiPM matrix readout)
- **mRICH-array simulation studies in EIC experiments**
- **PID algorithm development**
- **More tests of mRICH performance with available photosensors**

mRICH Design Improvement



- Focal plane location optimization
- Possibility of reducing the sensor plane size?

Mechanical Design Improvements



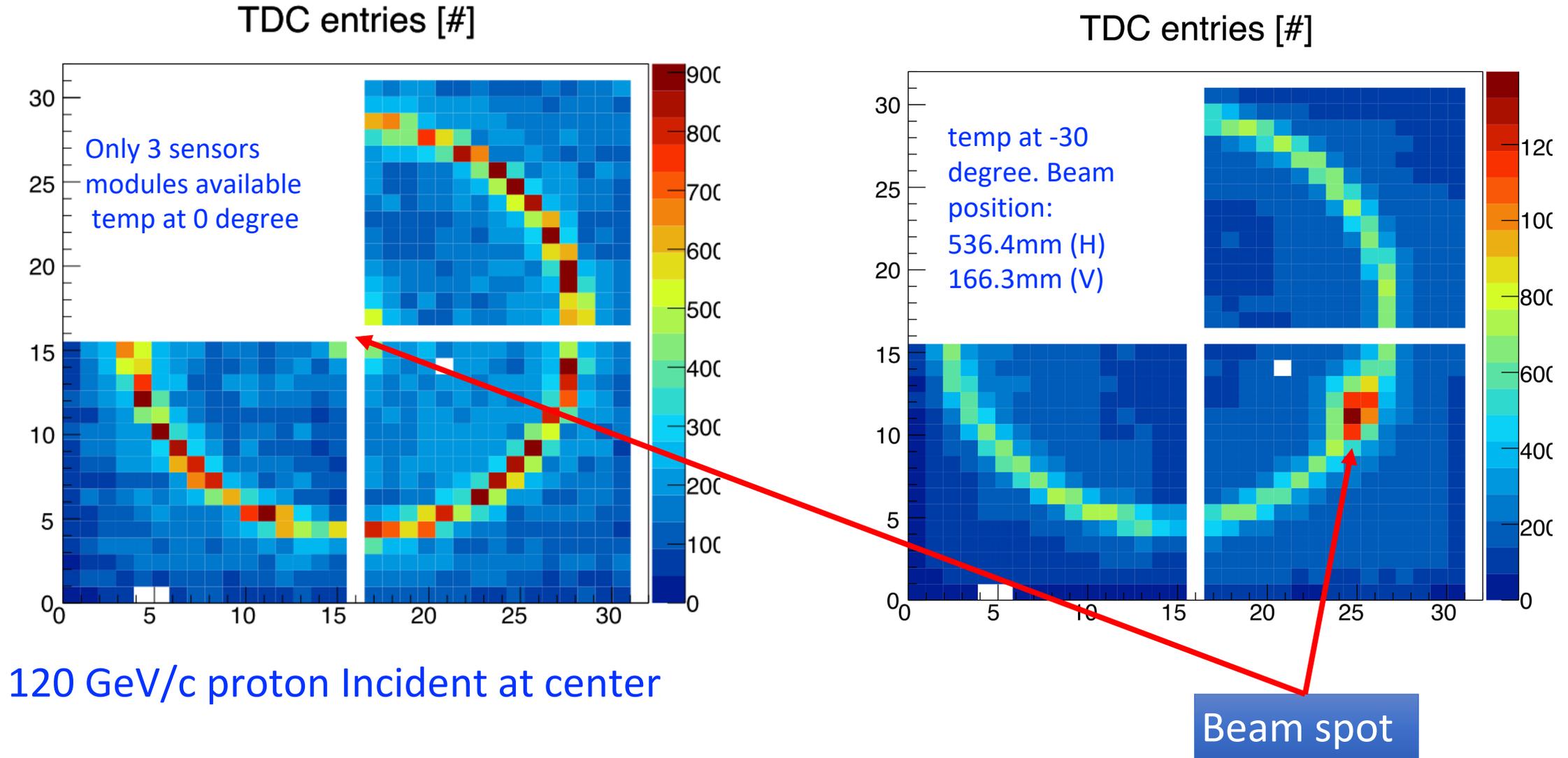
Less weight, mass production of components, easy assembly, light tight, etc.



THANK YOU

Backups

mRICH readout with SiPM matrix sensors



mRICH – lens-based focusing aerogel detector design



Smaller, but thinner ring improves PID performance and reduces length

Lens-Based mRICH Design

~ (aerogel + focal length)

- 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)

23 cm

- EIC mRICH designed for K/pi ID up to 9 GeV/c
- BELLE-2 ARICH aims to separate pion and kaon up to 4 GeV/c

mRICH – lens-based focusing aerogel detector design

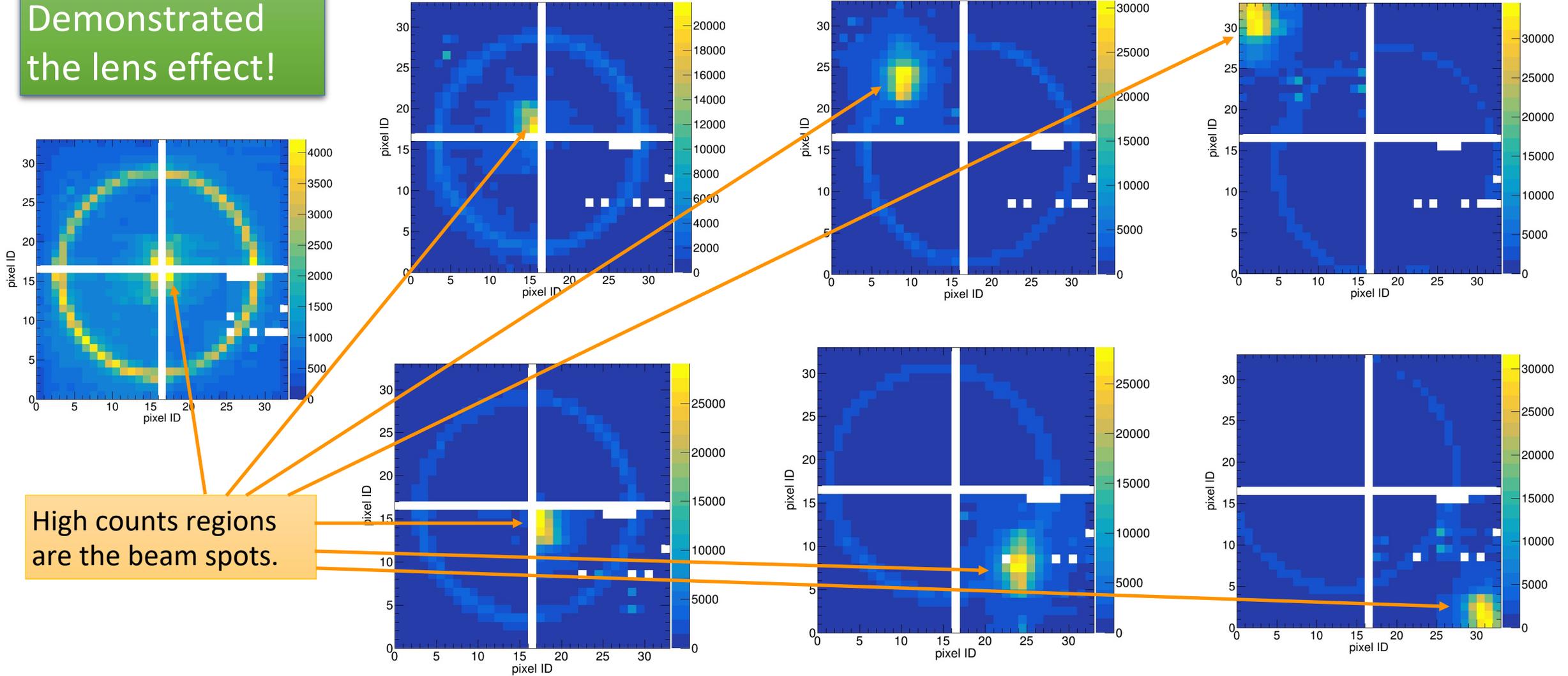


Smaller, but thinner ring improves PID performance and reduces length

<p>Lens-Based mRICH Design</p>		<ul style="list-style-type: none">• 9 GeV/c pion beam incident at third quadrant (star) in simulation• Ring image is shifted toward the central region on the sensor plane
<p>Two-Layer Proximity Focusing Design (BELLE-2 ARICH)</p>		<ul style="list-style-type: none">• 9 GeV/c pion beam incident at third quadrant (star) in simulation• Ring is centered at point of incidence

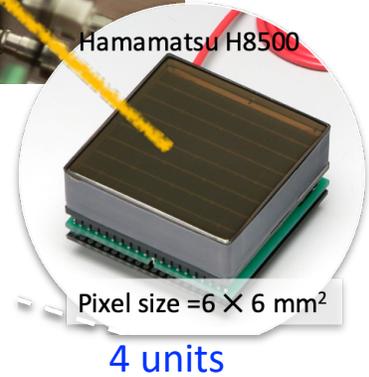
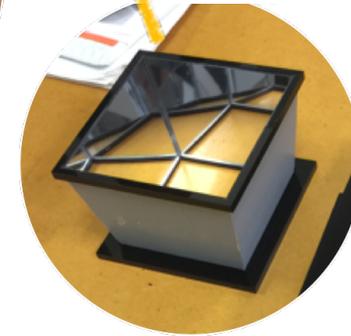
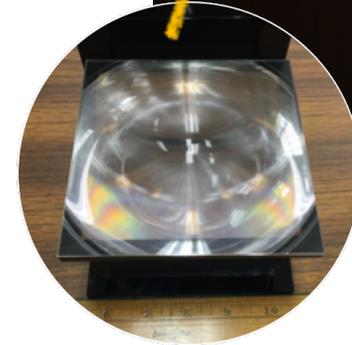
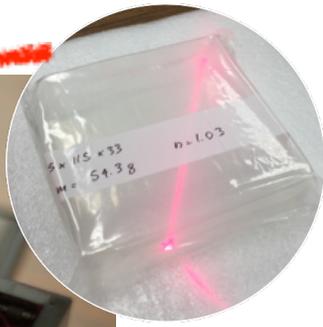
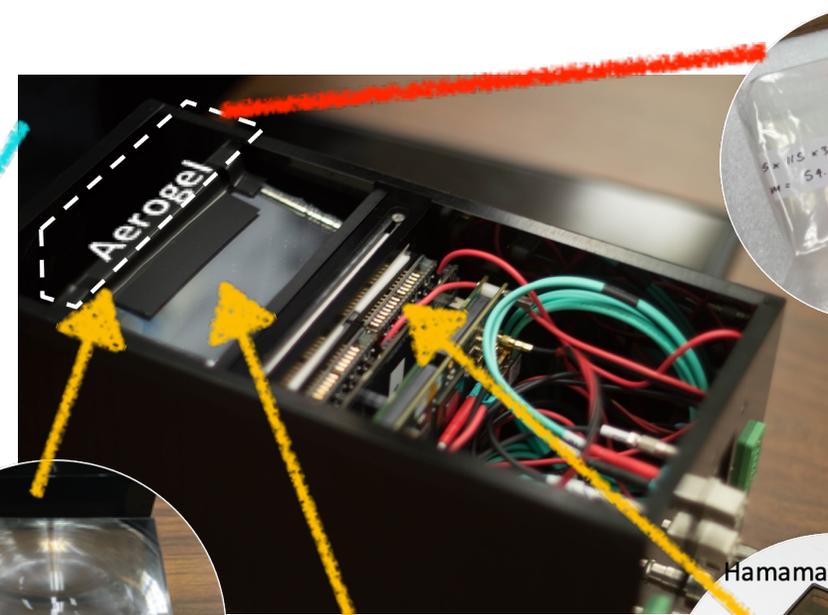
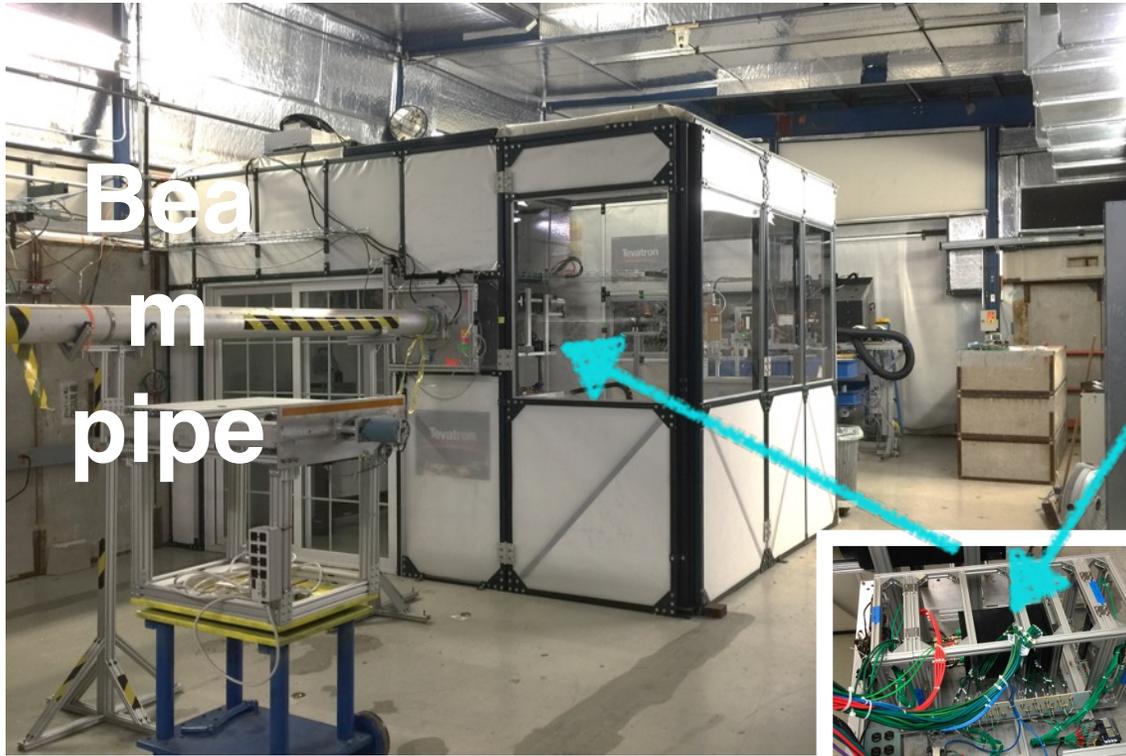
Position scans with 120 GeV/c proton beam

Demonstrated the lens effect!



1st mRICH Prototype Beam Test - Proof of Working Principle

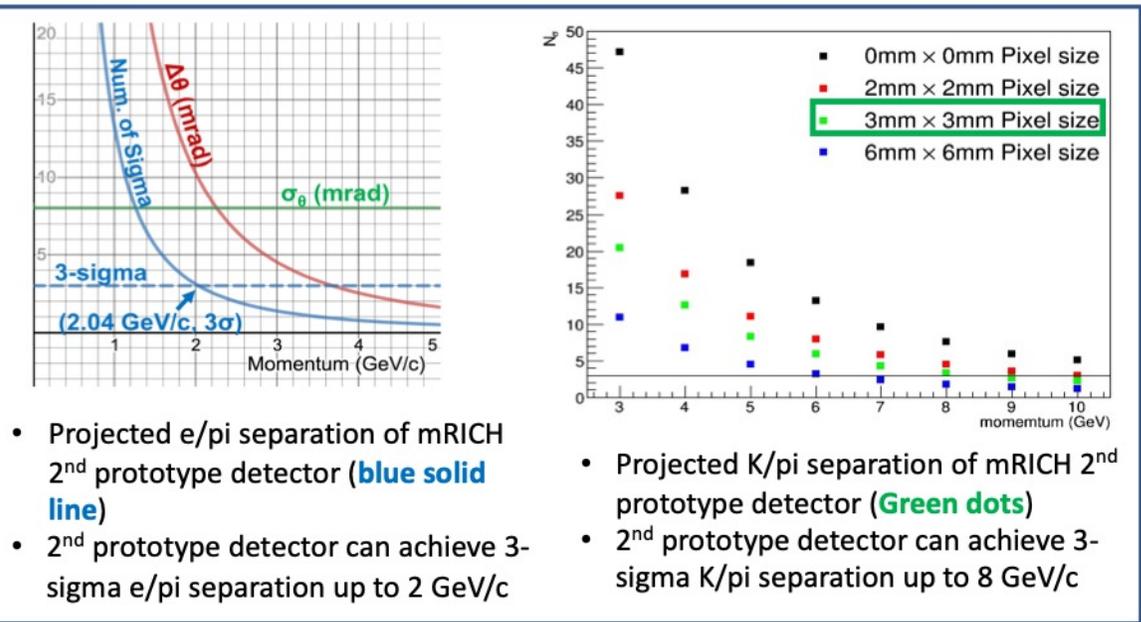
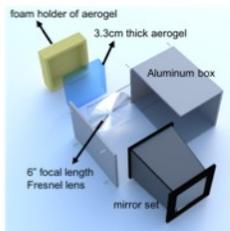
Fermilab Beam Test Facility, April 2016



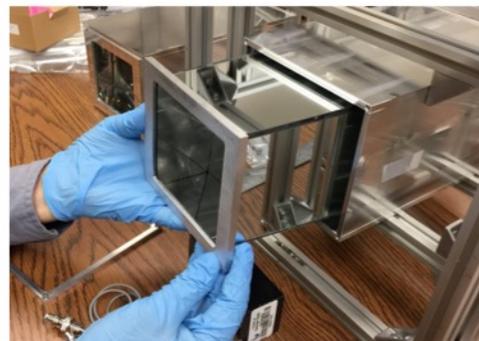
C.P. Wong et. al. NIM A871 (2017) 13-19



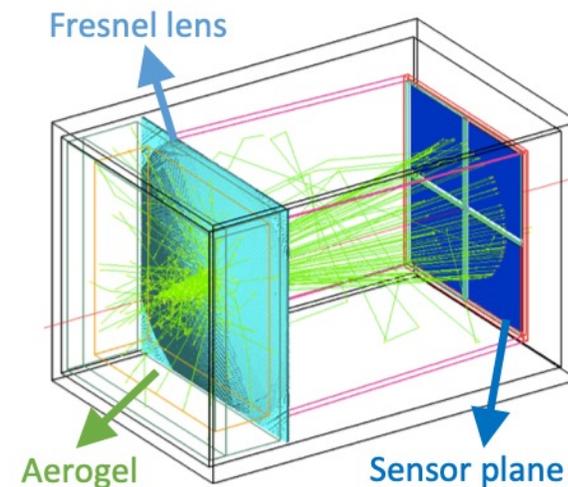
Modular and compact ring imaging Cherenkov (mRICH) PID detector for EIC experiments



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

