eRD14 mRICH for EIC - FY2021

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 future EIC experiments.

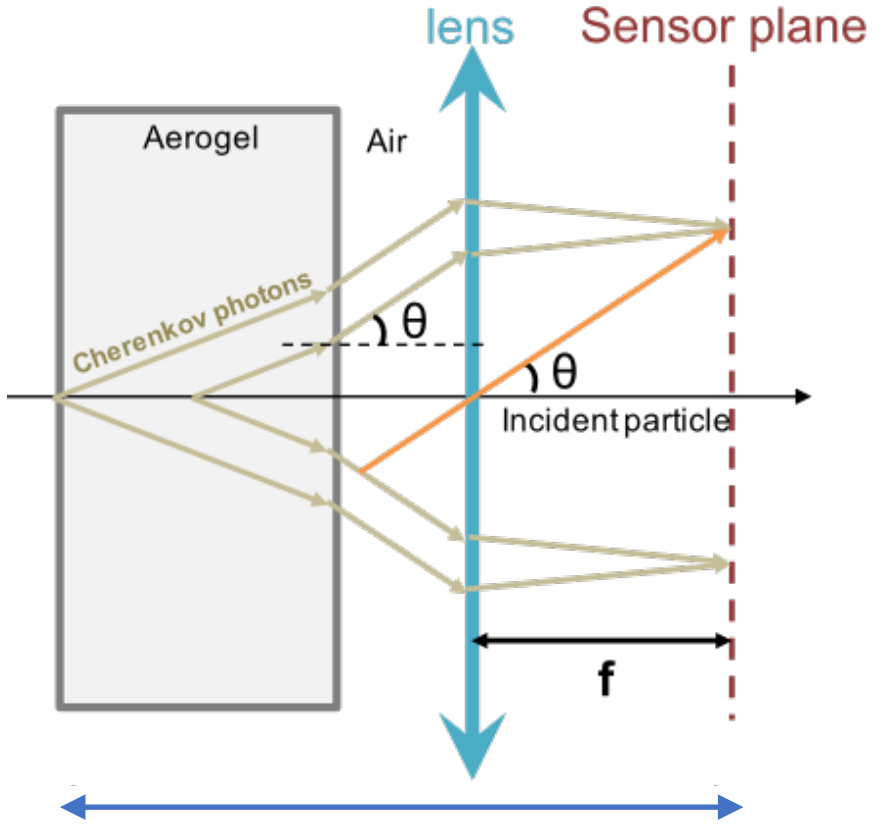
Active team members + more

- **X. He**, M. Sarsour, D. Sharma, & S. Syed (GSU)
- M. Contalbrigo, L. Barion & A. Movsisyan (INFN & Ferrara)
- M. Mirazita, & V. Lucherini (INFN @ LNF)
- Z. Zhao (Duke)
- G. Varner, I. Mostafanezhad & S. Tripathi (UH/Nalu)
- Y. Ilieva (USC)
- JLab team

Outline

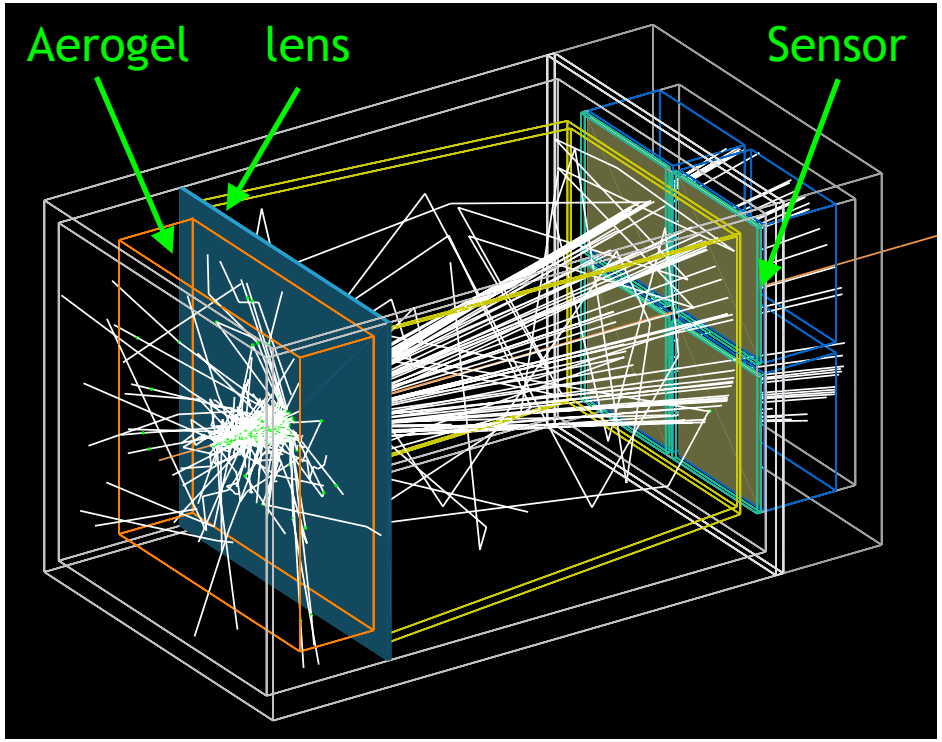
- Brief mRICH intro
- FY20 progress report
- Proposed activities in FY21
- Summary and outlook

EIC mRICH – Modular, Compact and Projective



~ (aerogel thickness + lens focal length)

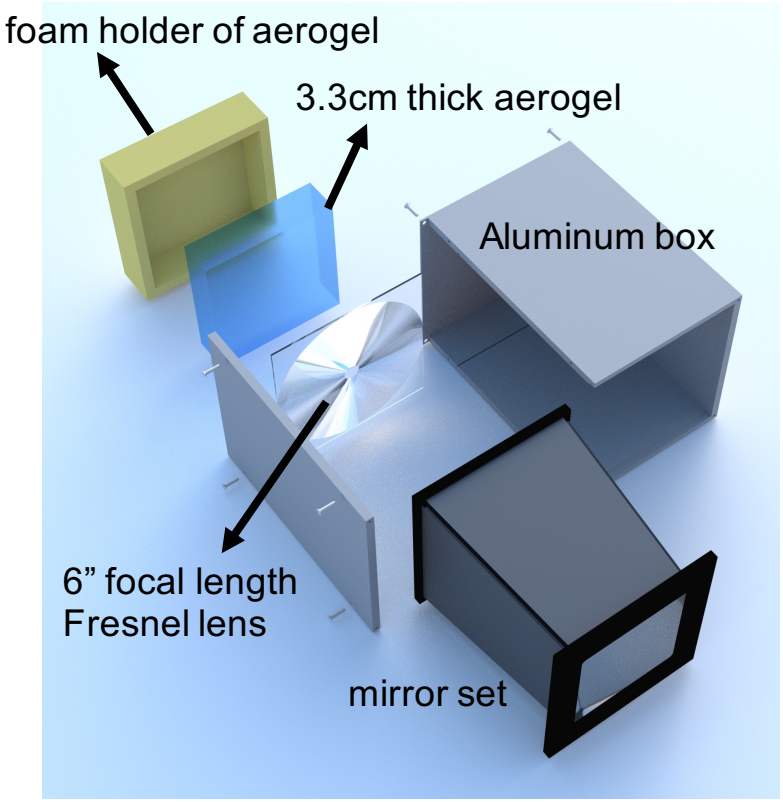
(Not to scale, for illustration purpose only)

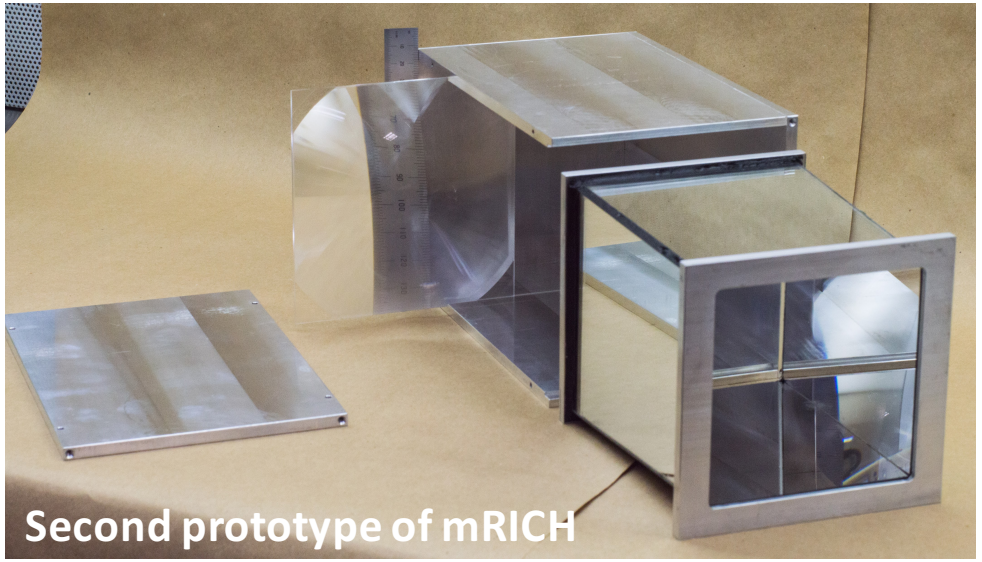


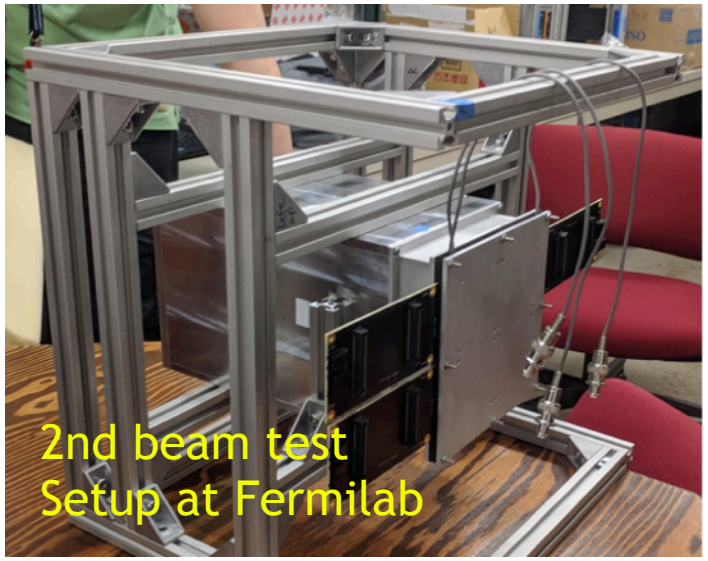
Geant4 Simulation

With realistic material optical properties

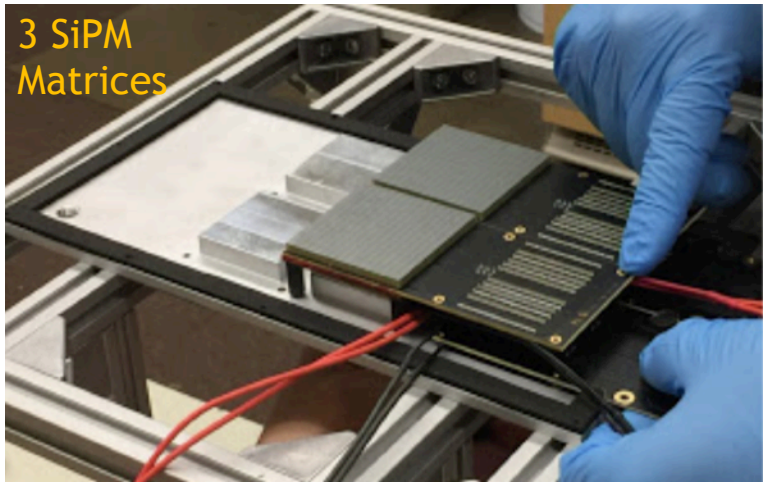
mRICH Prototype - Optical Component Design







Different photosensors and readout can be attached at the back of mRICH.



eRD14: Integrated Particle Identification for a Future EIC

P. Nadel-Turonski reporting

mRICH:

The successful implementation and operation of the SiPMs for the modular RICH was a significant achievement in this R&D activity. The test clearly shows that decreasing the temperature to -30 ^{0}C improves the thermal noise rate. The plan is that the Aerogel RICH detector provides hadron PID capability from 3 to 10 GeV/c (for π/K separation) and electron PID (for e/π separation) below 2 GeV/c. So, far, test beam results indicate a significantly worse result, which is mainly attributed to a lack of precise tracking. For the next beam test, this has to be considerably improved.

Our strategy was to address committee recommendation and, at the same time, to improve mRICH design including GEANT4 simulation.

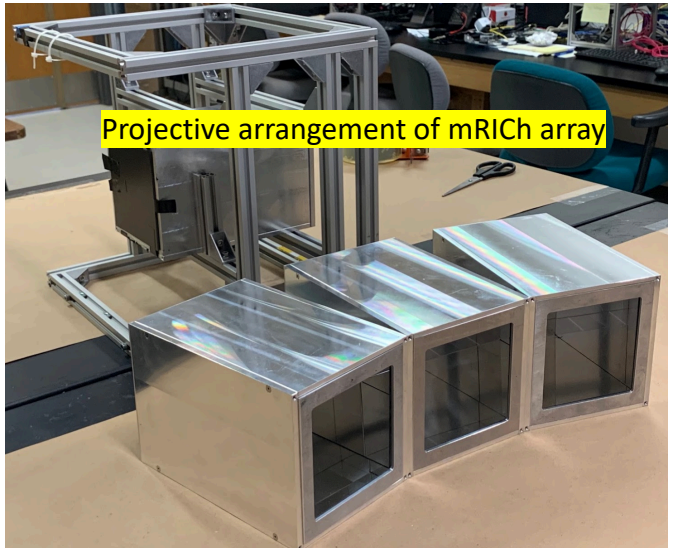
FY2020 Report

- Continued data analysis of the second mRICH beam-test performed in June 2018 at Fermilab (led by our new post-doc, Deepali Sharma).
- Preparation for the third mRICH beam test at JLab with tracking capabilities (participating teams: JLab, Duke, USC, INFN and GSU).
- Updating mRICH array in sPHENIX using Fun4All framework (led by Murad Sarsour).
- Active participation in the EIC Yellow Report activities.

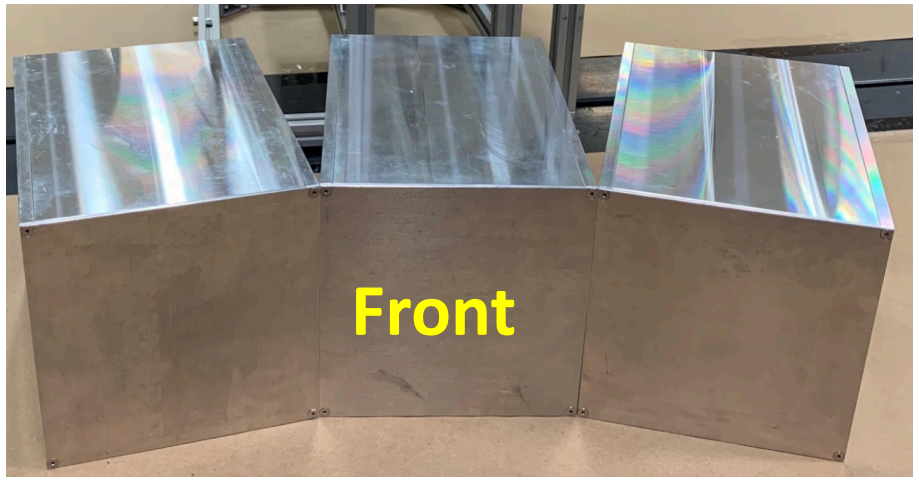
Strategy One - Continued Beam Test Efforts

MRICH TEST PLANNING AT JLAB

CONSTRUCT 3 MORE MRICH OPTICAL UNITS AT GSU TO BE IDENTICAL TO THE ONE USED IN THE 2ND BEAM TEST



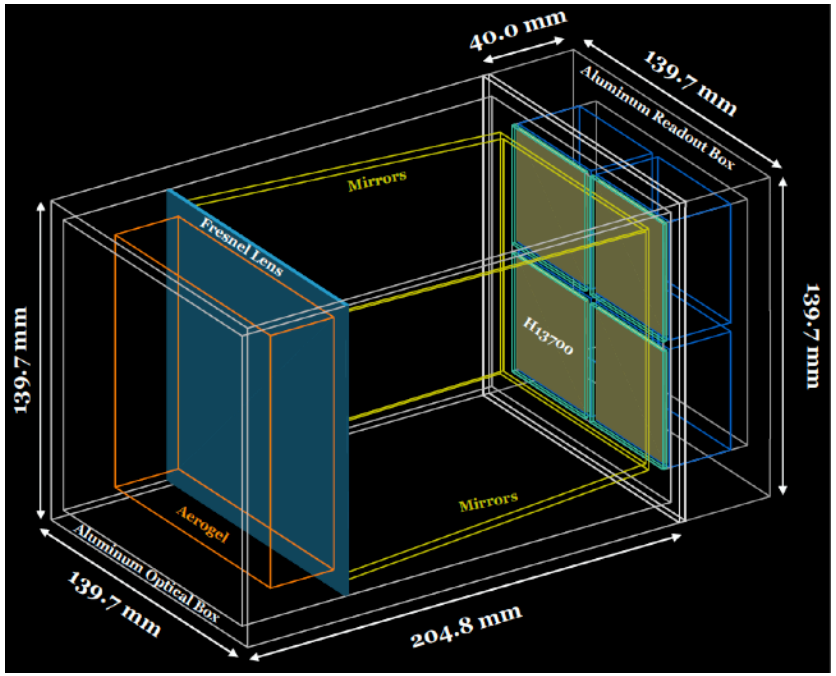
- Prepared for a beam test at Jefferson Lab in early May of 2020 using secondary electrons.
- Built three more optical modules. One of which was sent to JLab.
- Beam test is pushed to summer of 2021 because of COVID-19.



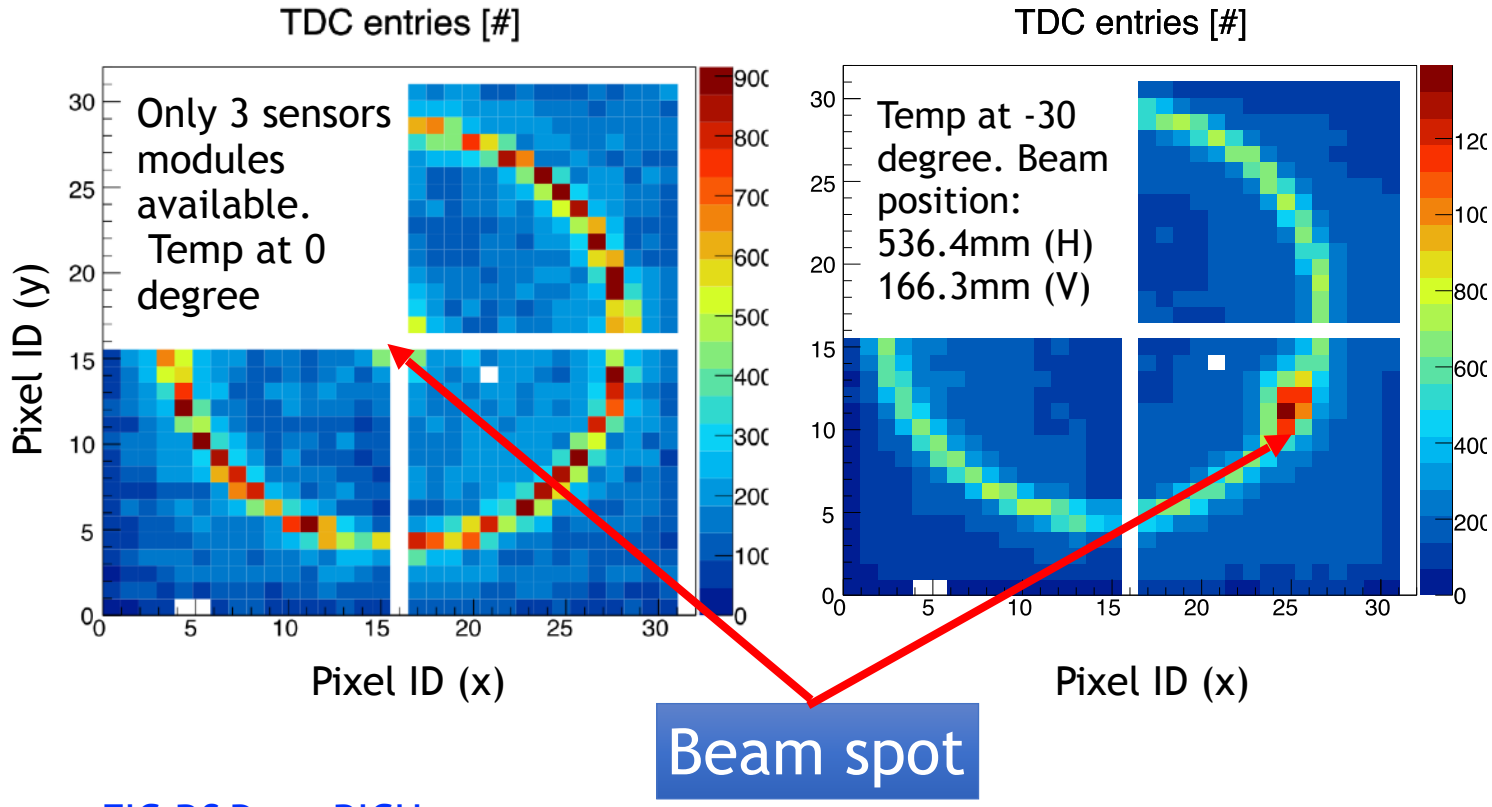
- Modular
- Compact
- Projective

Strategy Two - Continued Data Analysis and Refining GEANT4 Simulation Details

Fine tuned mRICH GEANT4 simulation to match the 2nd mRICH prototype hardware to the best of our knowledge to aid the ongoing data analysis. The display below is from the GEANT4 simulation which includes all possible components that can potentially affect the identification of the ring image.



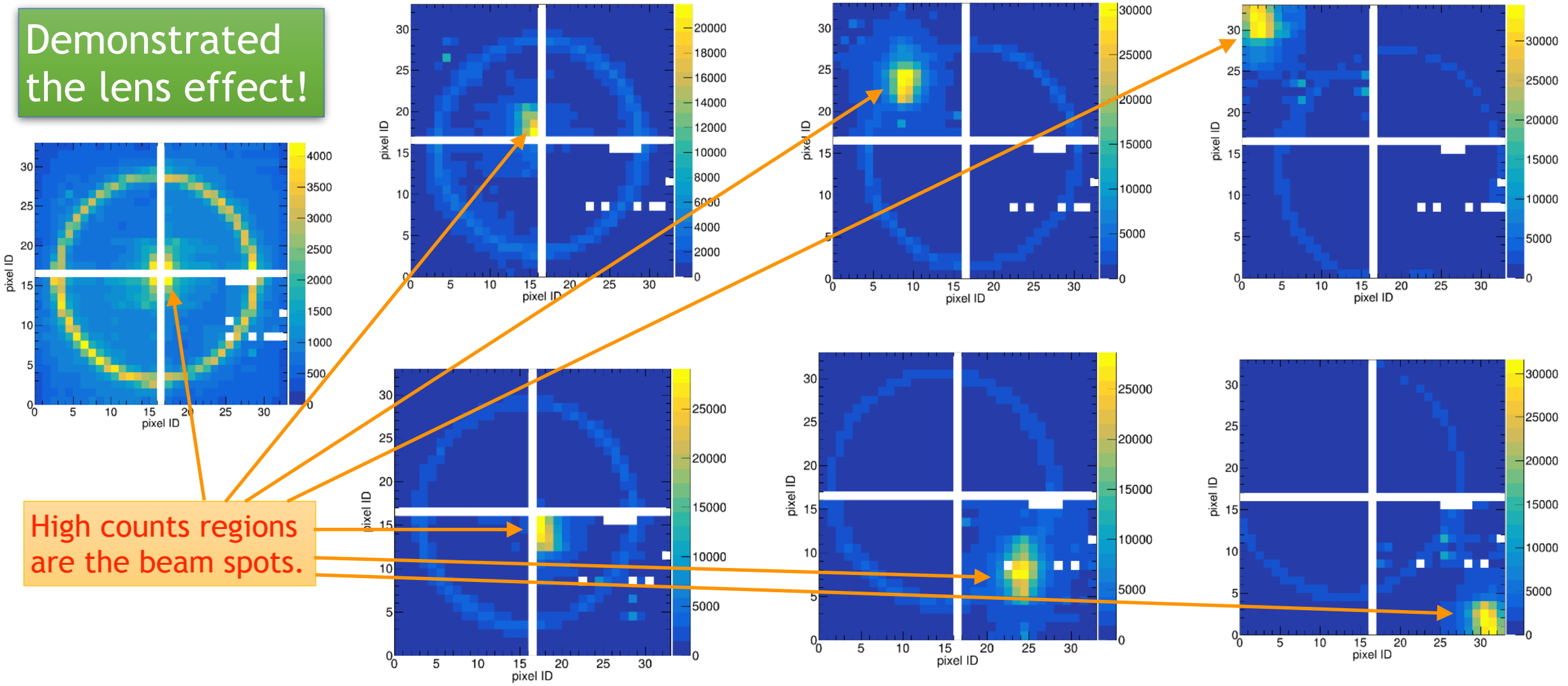
Ongoing analysis one: studying the temperature-dependent background noise in the data set recorded with SiPM matrices. [Note that there were only three SiPM matrices available during the 2nd mRICH beam test. SiPM hardware and readout were provided by the INFN group led by Marco Contalbrigo.



Position scans with 120 GeV/c proton beam

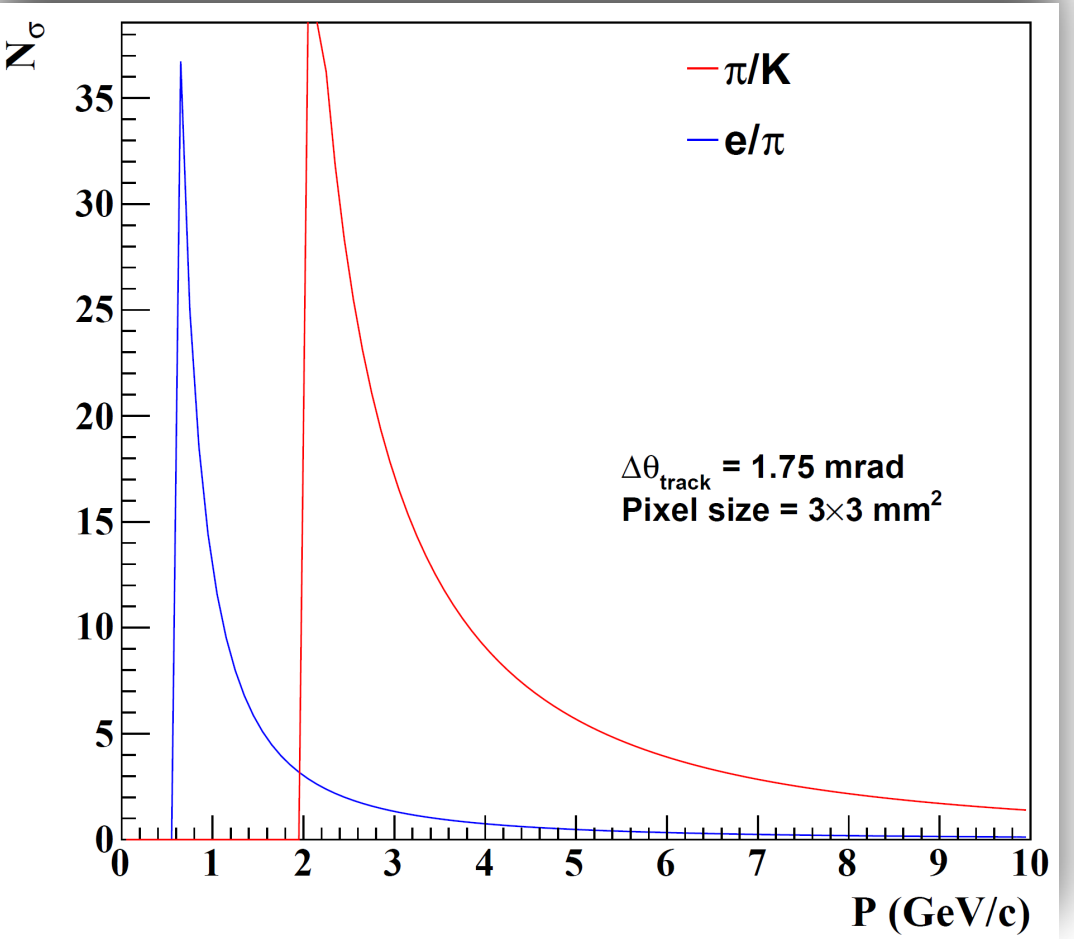
Ongoing analysis two: (1) # of Cherenkov photons on rings; (2) Lens focusing effect.

Demonstrated the lens effect!

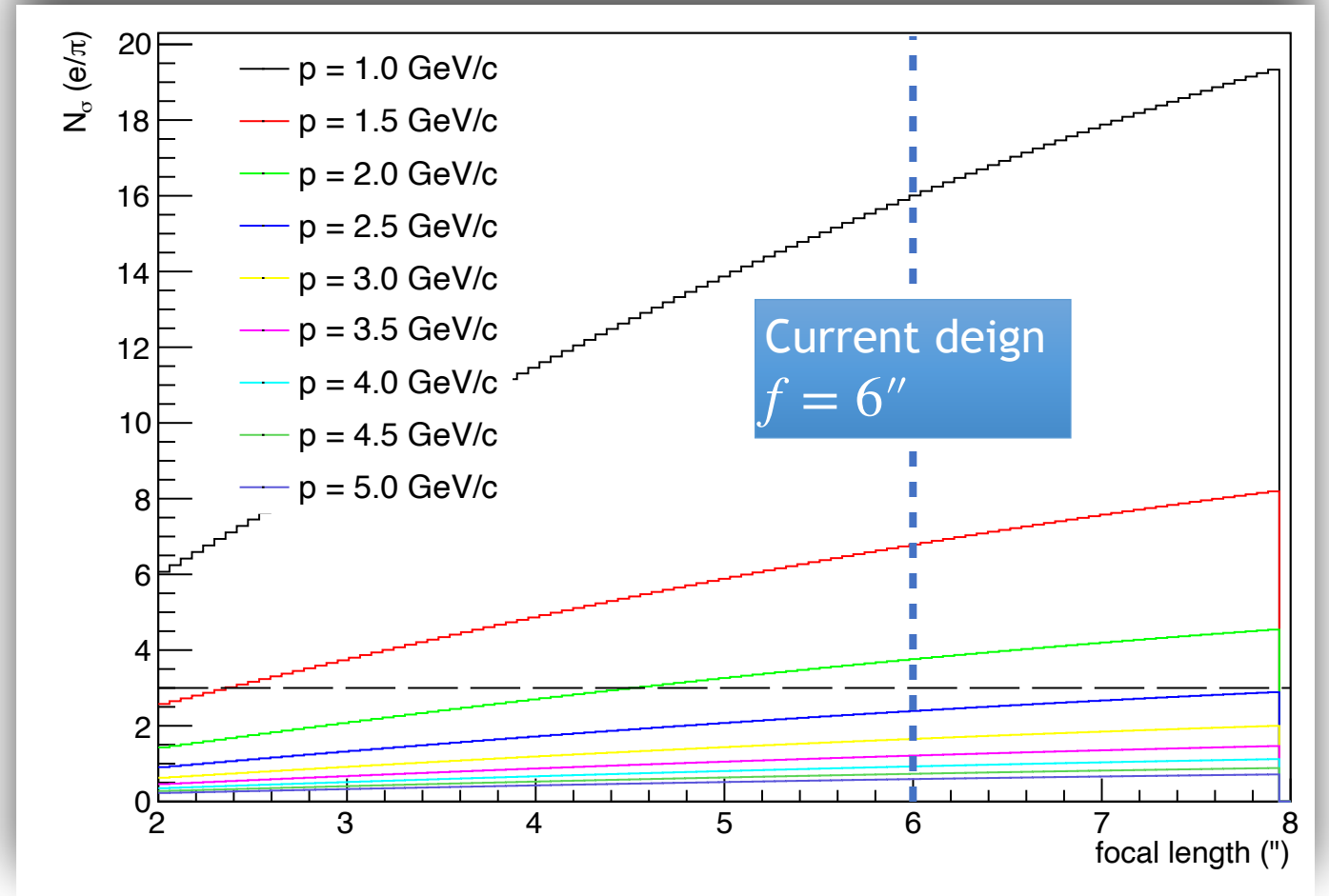


High counts regions are the beam spots.

EIC Yellow Report mRICH PID Parameterization



Performance vs particle momenta



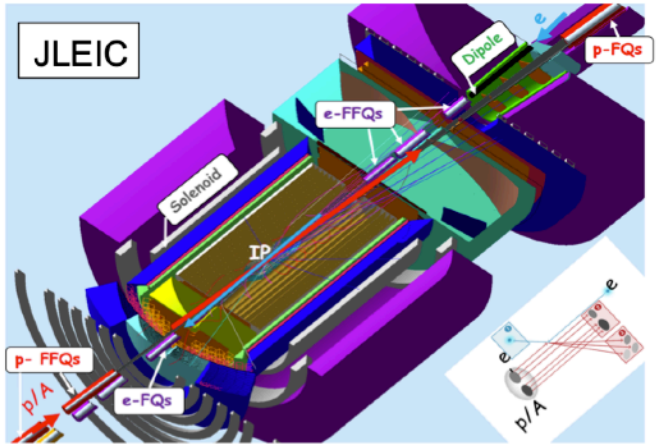
Performance (e/π) vs lens focal length

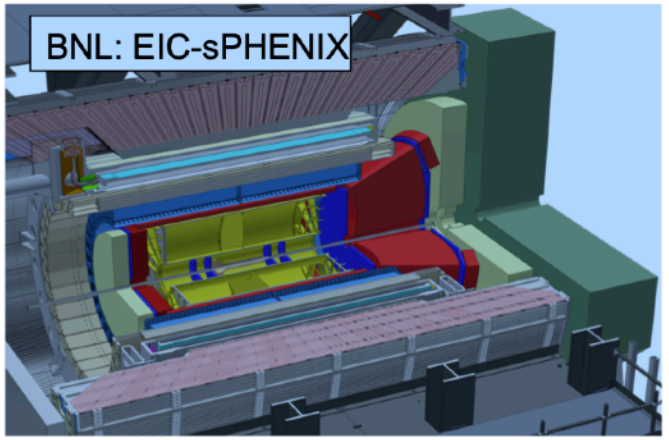
See eRD14 PID Proposal

Ongoing/Proposed R&D

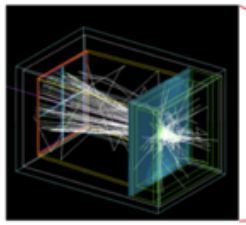
- Beam test at JLab with secondary electron beam.
- More realistic GEANT4 simulation.
- mRICH engineering (in order to maintain optical alignment, light materials and easy access/maintenance.
- Joint study with LAPPD team (test Gen-II LAPPD).

mRICH Arrays in "real" Experiments

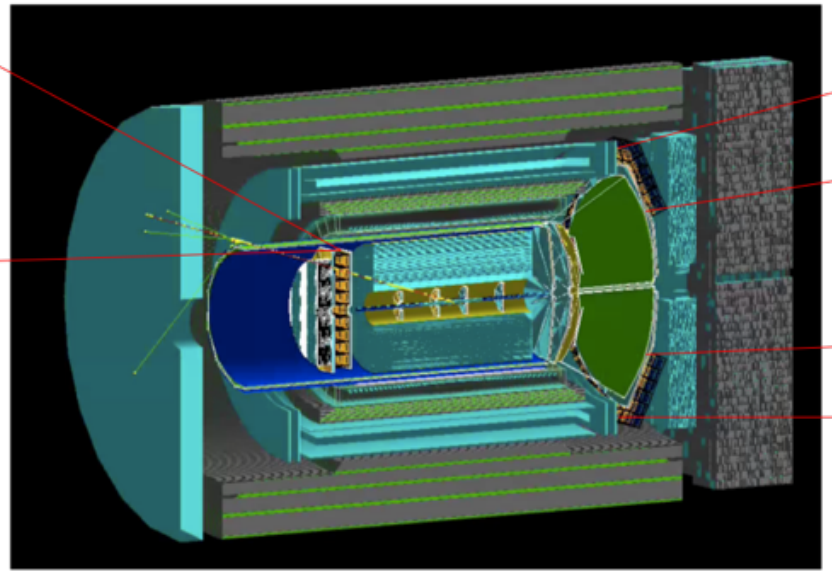


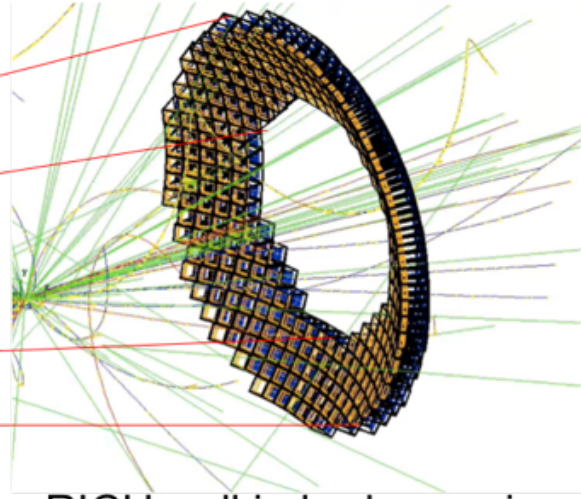


mRICH array implementation in Forward sPHENIX and JLab EIC detector concept in Geant4 simulation studies. Developed mRICH-based PID algorithms using a loglikelihood method.



mRICH wall
e/π separation

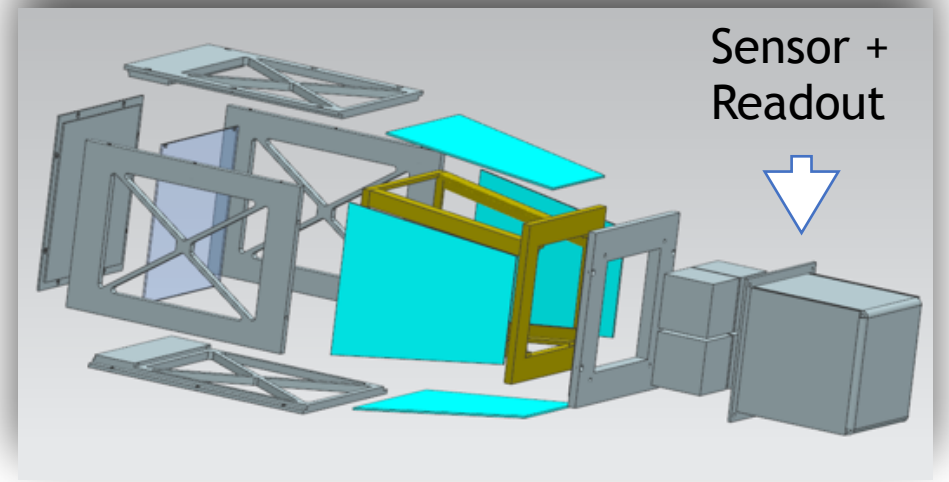


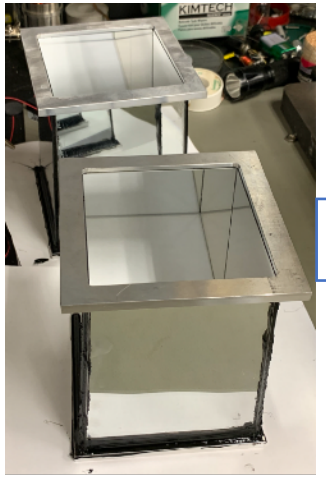


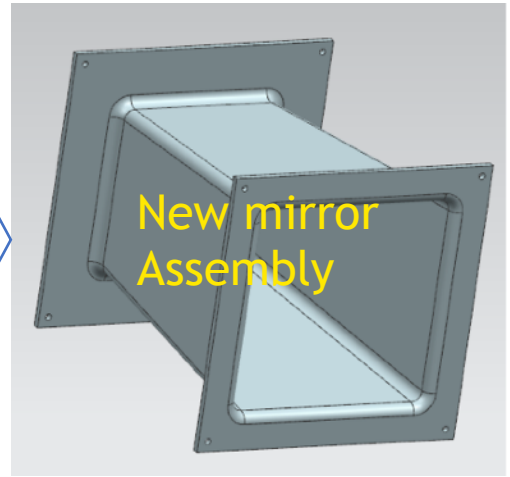
mRICH wall in hadron-going direction for hadron PID

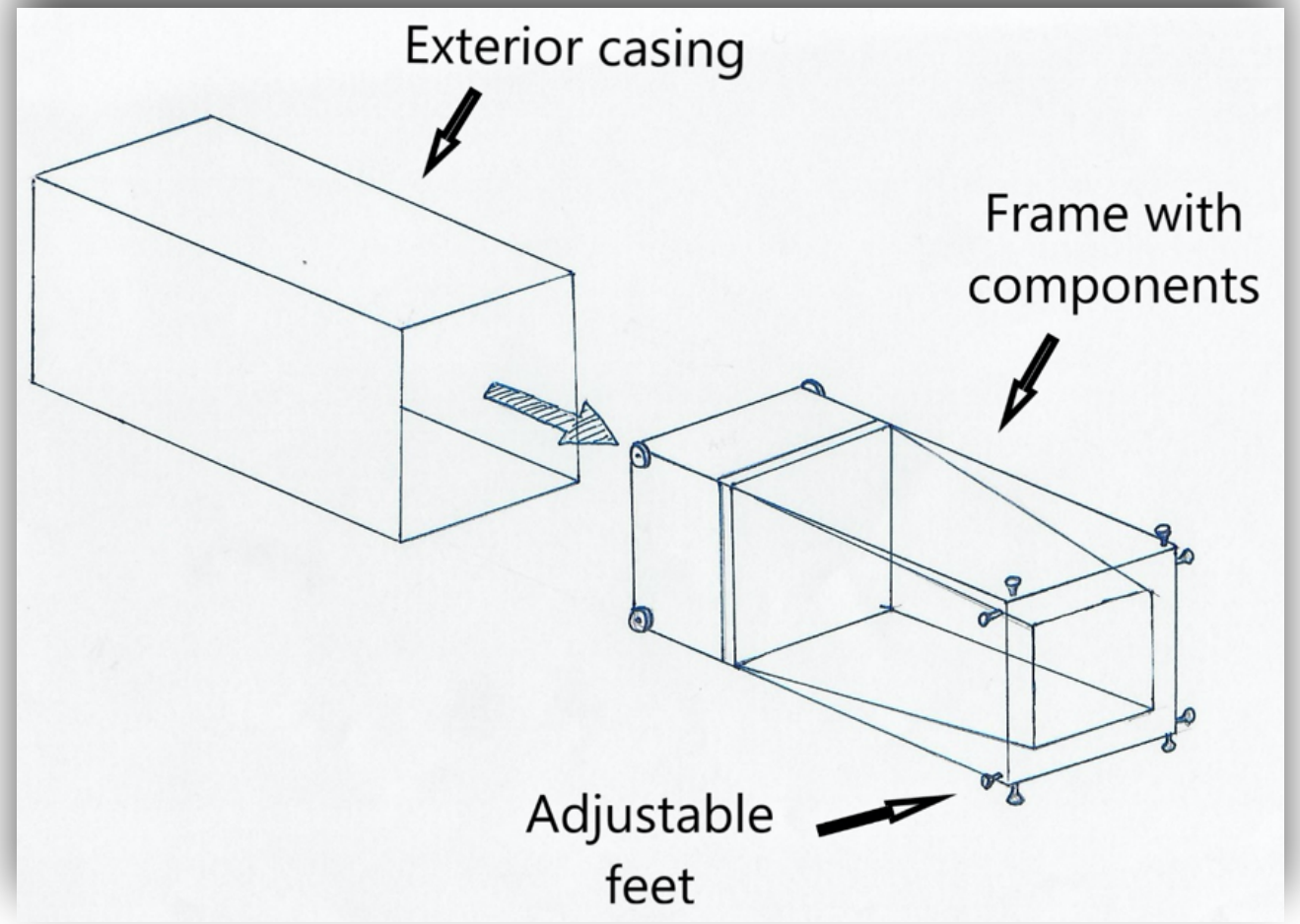
mRICH Engineering

- Precision assembly, light, easy access for integration and maintenance.
- Impact of material budget on the performance of the following sub-detector components.







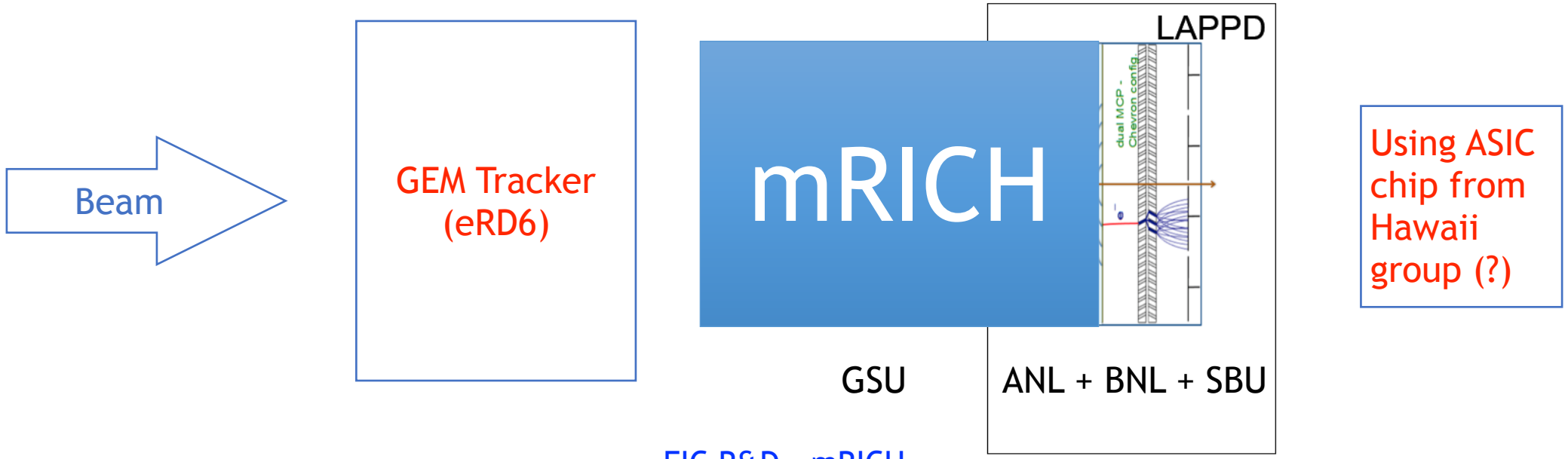


mRICH & LAPPD "Marriage"

We started working with other teams in PID Consortium and are preparing for an integrated beam test with LAPPD group at Fermilab. We had an initial discussion on this subject back in January of 2019 with Mickey Chiu and Alexander Kiselev at BNL. There was not much progress since then because of COVID-19 until recently. We had a planning meeting on July 13, 2020.

A very novel approach. Can we get PID, time and position from a single module?

A Conceptual Design Layout



Using ASIC chip from Hawaii group (?)

mRICH R&D Budget

	100%	80%	60%
Postdoc, INFN/JLAB, 2 months (Luca Barion)	\$7k	\$7k	\$7k
Postdoc, INFN/JLAB, 2 months (Aram Movsisyan)	\$5k	\$3k	\$2k
Postdoc, GSU (Deepali Sharma), 50%	\$27.3k	\$20.5k	\$13.7k
Grad Student, GSU	\$32k	\$27.3k	\$19.8k
Materials, GSU	\$4.5k	\$1.5k	\$1.5k
Travel and Conference Fee, INFN/GSU	\$10k	\$9k	\$7.5k
Total	\$85.8k	\$68.3k	\$51.5k

Table 4: Budget for modular Aerogel RICH.

[Note: Budget includes indirect costs imposed by institutions]

Summary

- First of all, I would like to take this opportunity to thank the members of the EIC Detector R&D Committee for your guidance and the continued support of the mRICH development.
- The third mRICH beam test was planned at JLab in May of 2020 with tracking capabilities.
- The mRICH team actively participated in the EIC Yellow Report effort and provided a “first-order” fast parameterization of mRICH performance to the Yellow Report PID Working Group.
- We also started working on re-engineering design of mRICH mechanical components in order to reduce material budget, weight, and to improve stability, easy integration and maintenance access.

THANKS!