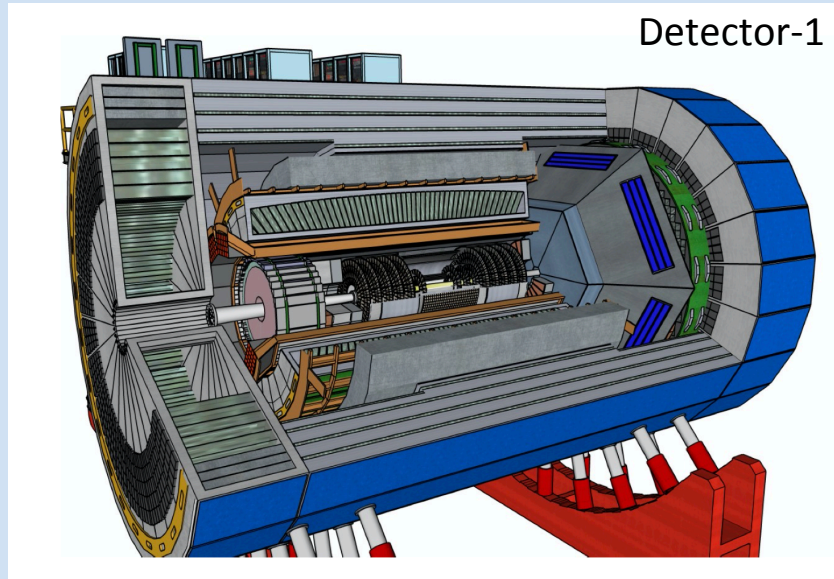**The dual-radiator RICH has been a common reference in the forward region since EIC Yellow Report**
Moving from generic EIC R&D (eRD14) to targeted EIC R&D (eRD102, eRD110, eRD109, …)

INFN

BO, CT, FE,

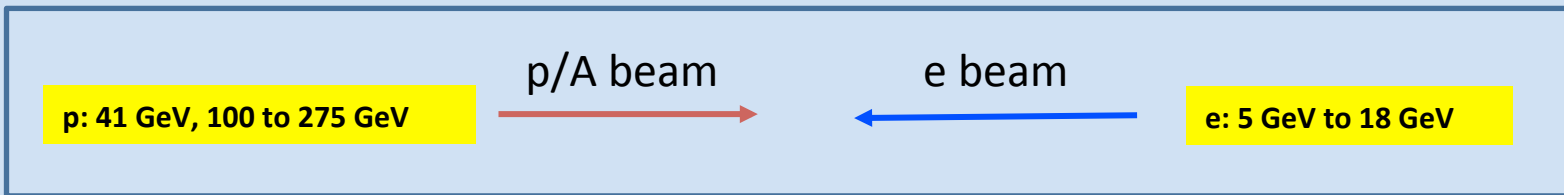GE, LNF, LNS,

RM1, TO, TS

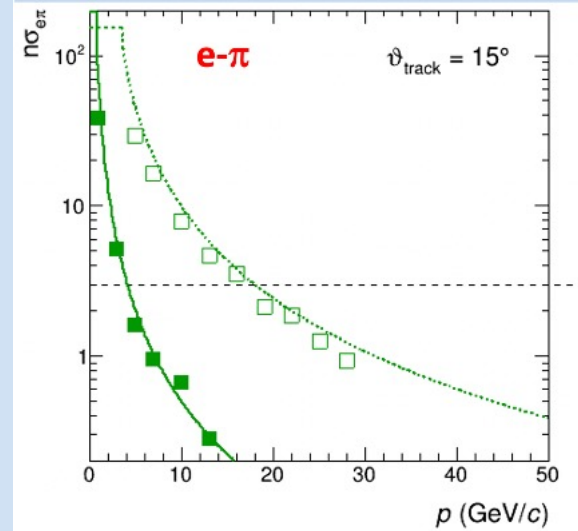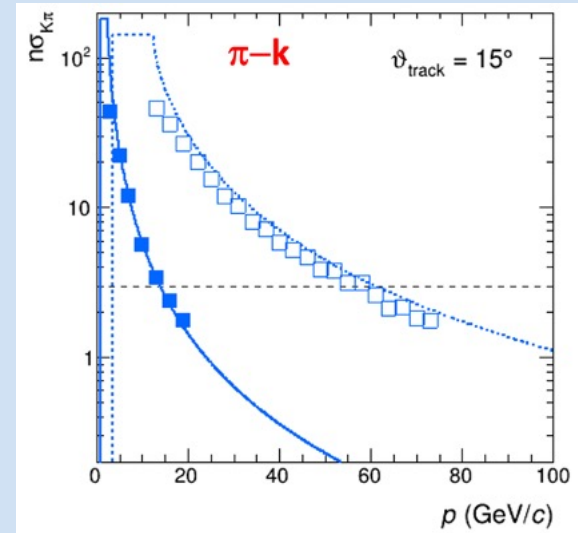BA, CS, SA, CT

Detector-1

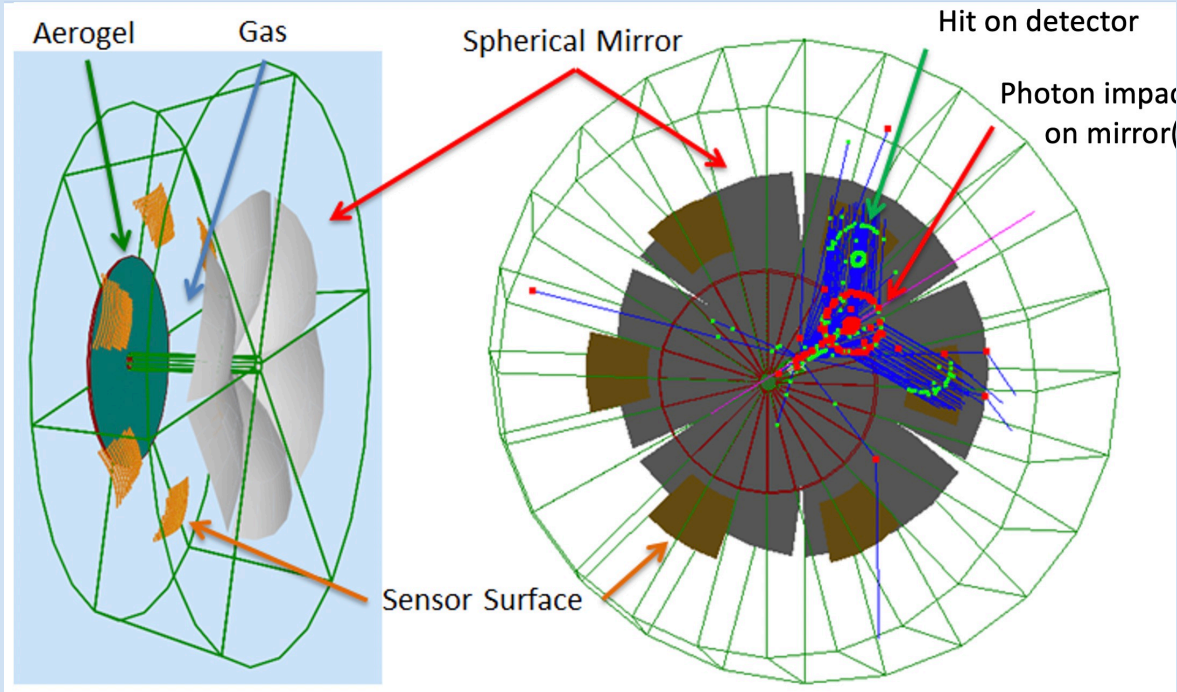Duke UNIVERSITY

NISER

Georgia State University

Stony Brook University

| p: 41 GeV, 100 to 275 GeV | p/A beam → | ← e beam | e: 5 GeV to 18 GeV |

Contalbrigo Marco - INFN Ferrara

INFN

Two main challenges : cover wide momentum range 3 - 60 GeV/c
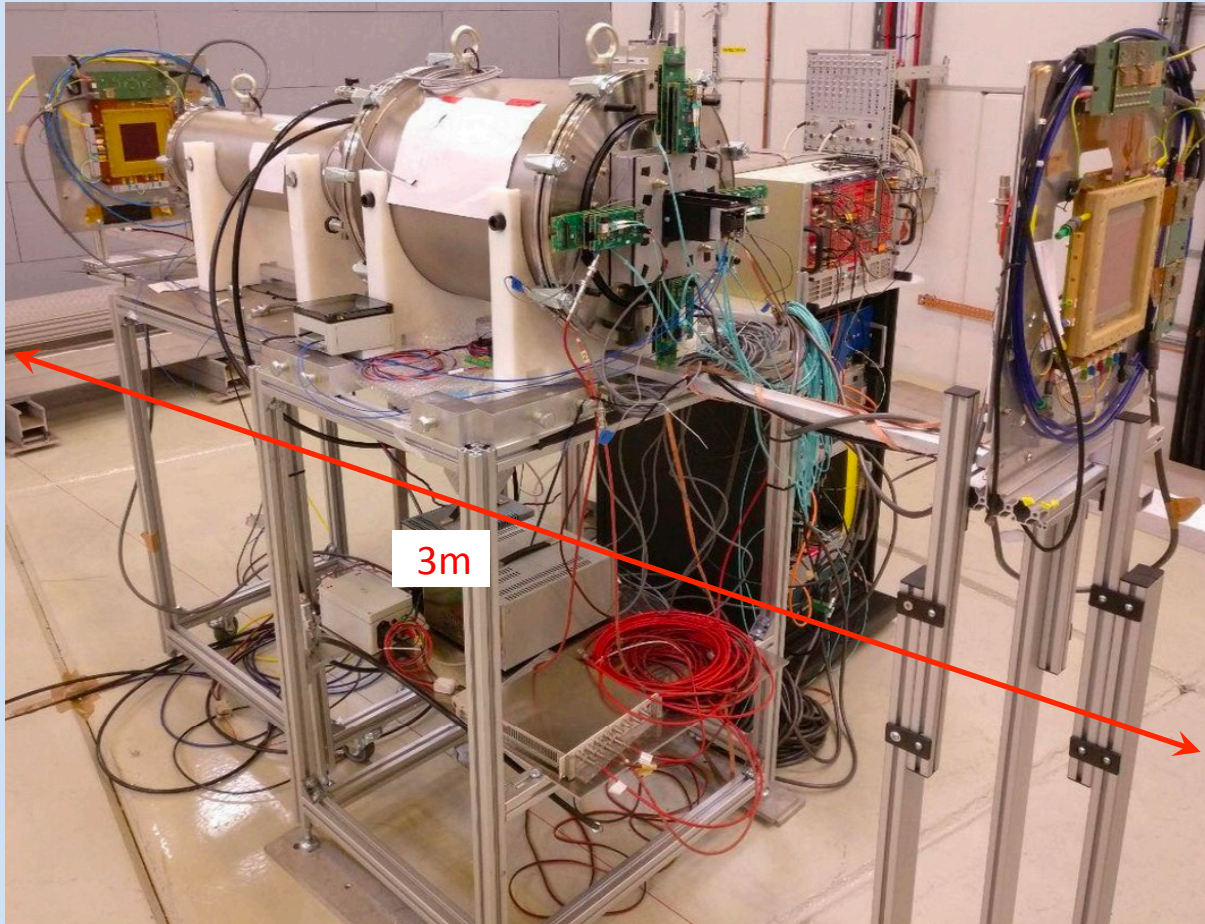work in high (~ 1T) magnetic field

dRICH: effective solution, part of EIC reference detector

Radiators: Aerogel (n_{AERO}~1.02) + Gas (n_{C2F6} ~ 1.0008)

Detector: 0.5 m²/sector, 3x3 mm² pixel → SiPM (LAPPD) option

Phase Space:
- Polar angle: 5-25 deg
- Momentum: 3-60 GeV/c

3m

Goals:

- Study dual radiator performance and interplay
- Study specifications and alternatives for optical components
- Test alternate single-photon detection systems
- Design parameters and optimization

Basic system commissioned in 2021 runs

2021 beam time:

- Most of the time was parassitic
- Sensors + readout shared with eRD101
- Beam line still under commissioning

Prevented a detailed systematic study
Nevertheless preliminary performance
study was possible

Example of event display

◼ Recorded hit

— Sensor

— Geometrical selection

— Gas and aerogel reconstructed rings

Time distribution of hit
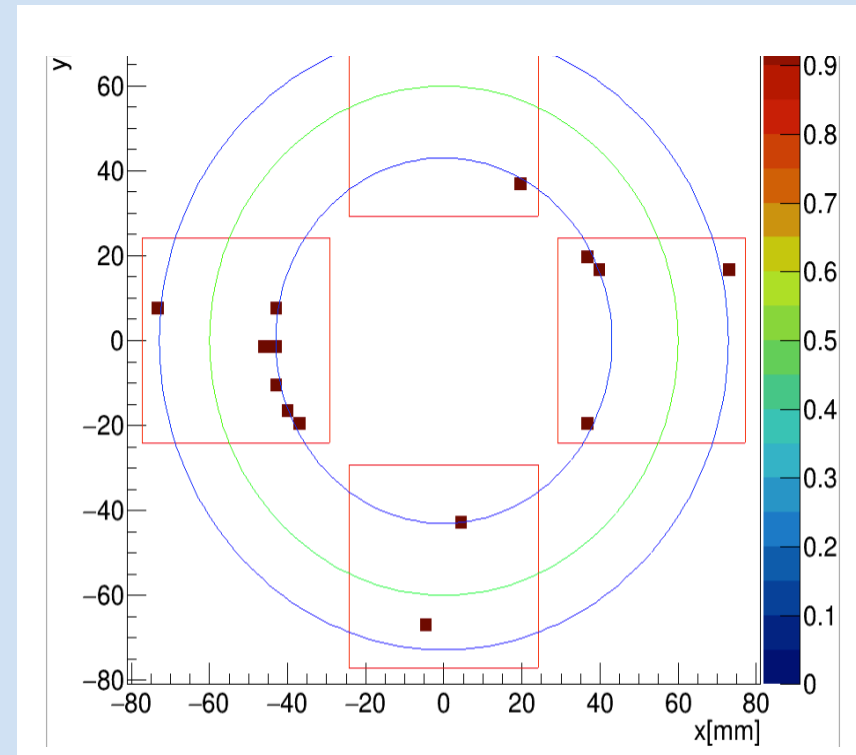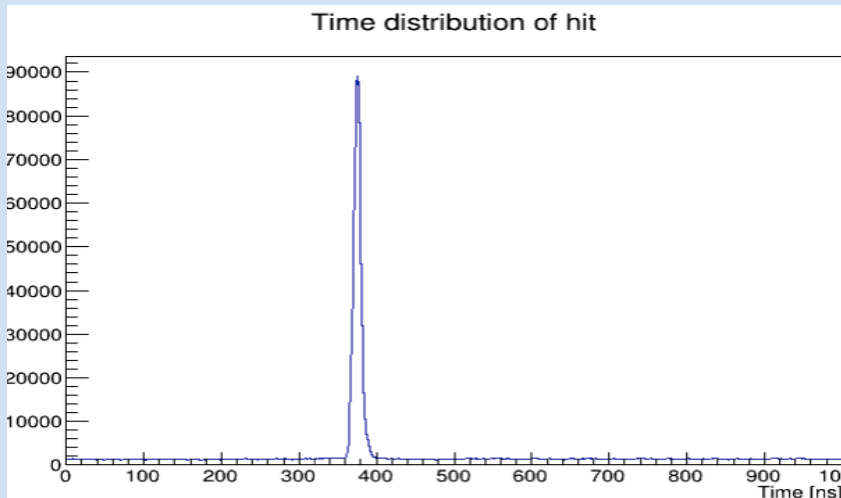
Tracking based on two GEM chambers,
to correct for beam particle trajectory
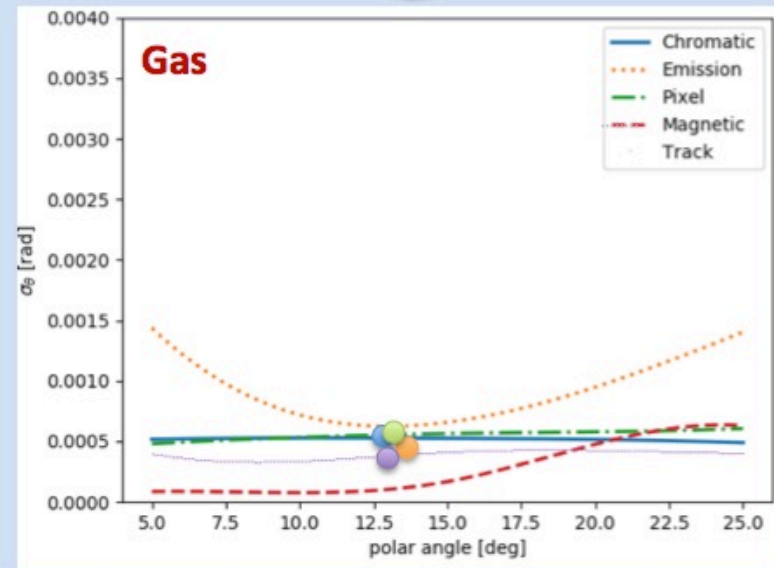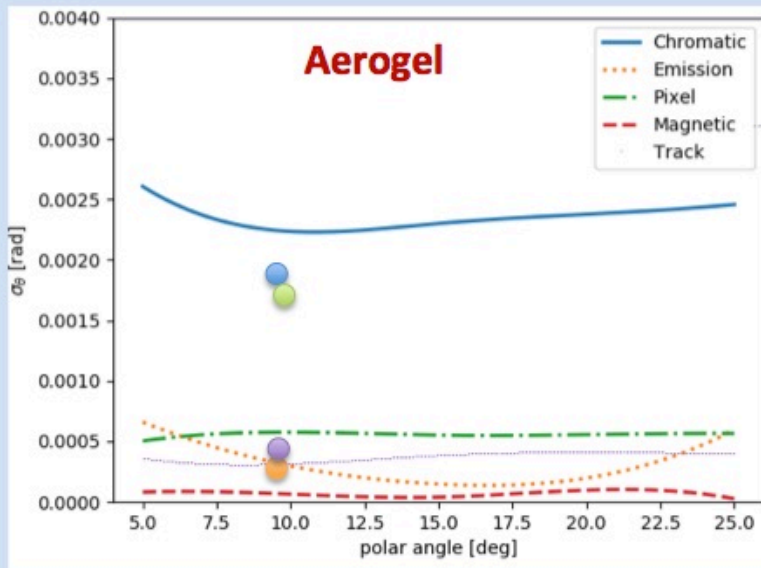
Imaging obtained with reference readout:

- H13700 multi-anode PMTs
- MAROC3 readout (CLAS12)

Particle position at aerogel

Particle slope

π^- rings before corrections

π^- rings
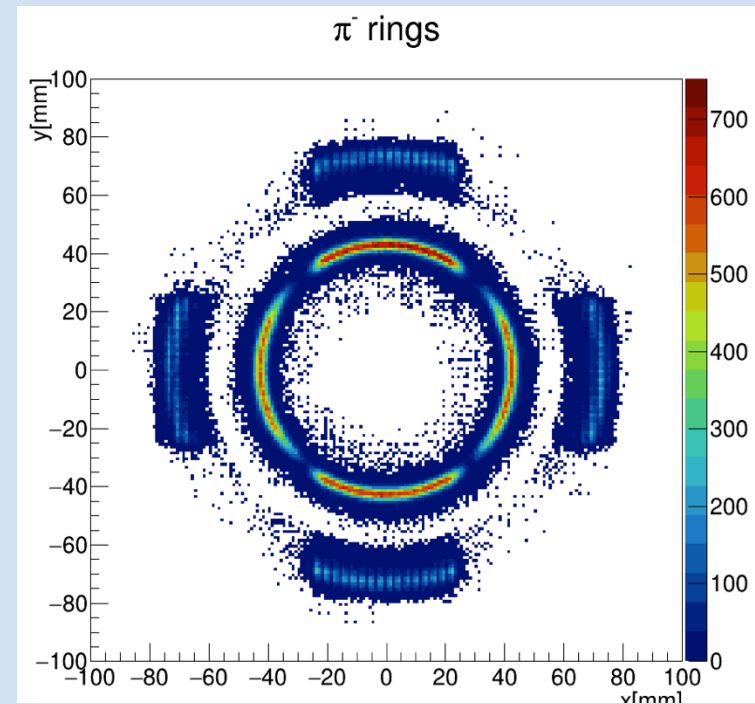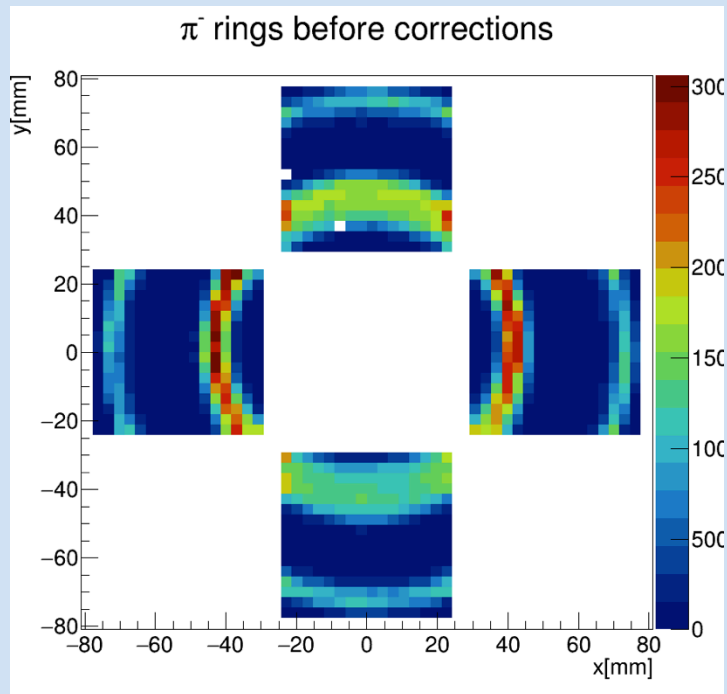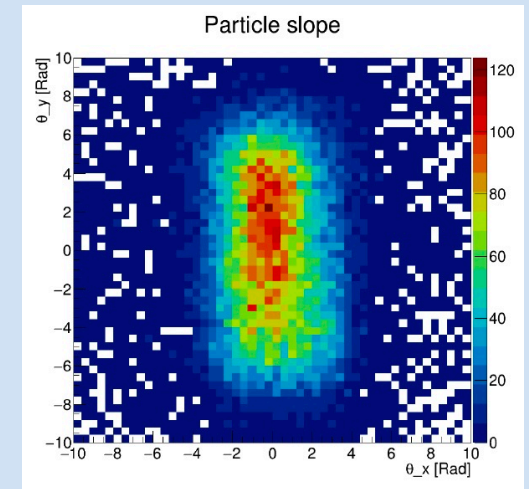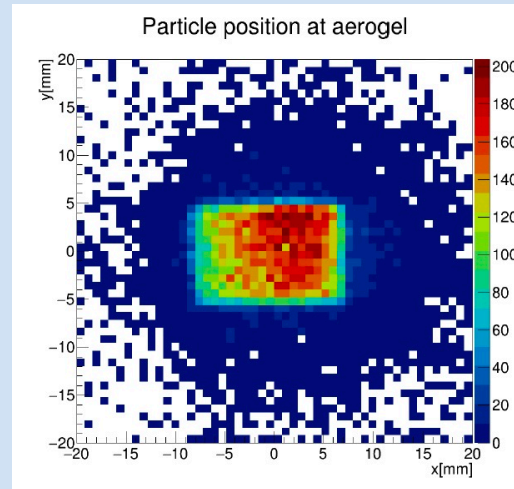
1 p.e. error (mrad)		Aerogel		Gas	
		Demo	dRICH	Demo	dRICH
Pixel	(3mm pixel)	1.9	(0.6)	0.6	(0.5)
Chromatic	(300 nm filter)	1.8	(2.2)	0.6	(0.5)
Emission	(1 cm out of focus)	0.3	(0.3)	0.4	(0.6)
Tracking	(0.5 mrad)	0.4	(0.3)	0.4	(0.4)
Total		3.0	(2.3)	1.1	(1.0)

5

1.2

Preparing the prototype for the next test beam campaign (fall 2022)

Targeted R&D proposal submitted in August '21, as an extension of the dismissed generic eRD14

Statement of work approved in July '22 with DOE funds (165 k$) following R&D progresses

Milestones:

- Implementation of dRICH simulations in the EPIC framework   [10/22]

- Assessment of the dRICH prototype performance with reference detector   [12/22]

- Realization of a suitable detector plane for the dRICH prototype (SiPM+ALCOR)   [03/23]

Goal pre-TDR at the end of 2023, TDR one year later

Progress with the analysis and simulation

Principle
- low-n (gas) radiator @ high-energy → long path for light yield
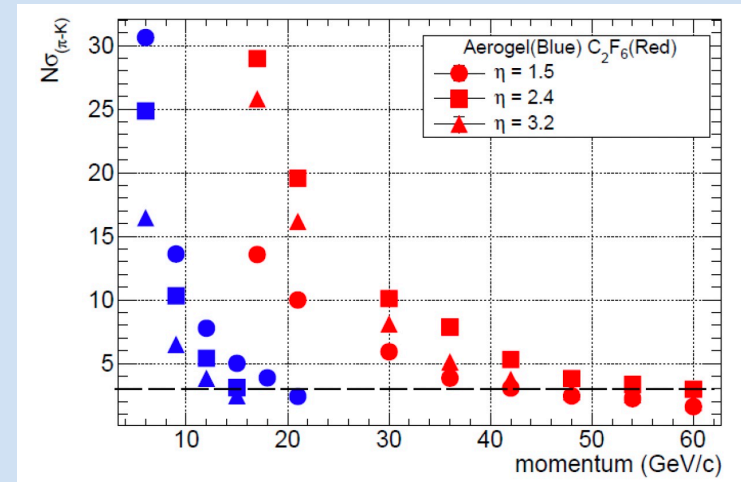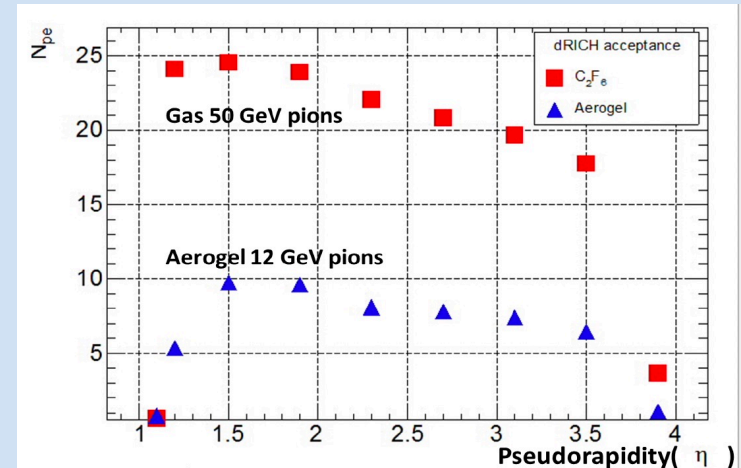- resolution vs emission point → proper light focalization

Consequence
- extensive volume and not trivial geometry
- bending inside the magnetic field

Performance is strictly related to the Detector-1 global layout

Goal: study realistic implementation for Detector-1

       compare with YR specifications

       benchmark with prototype performance

INFN in collaboration with DUKE, NISER

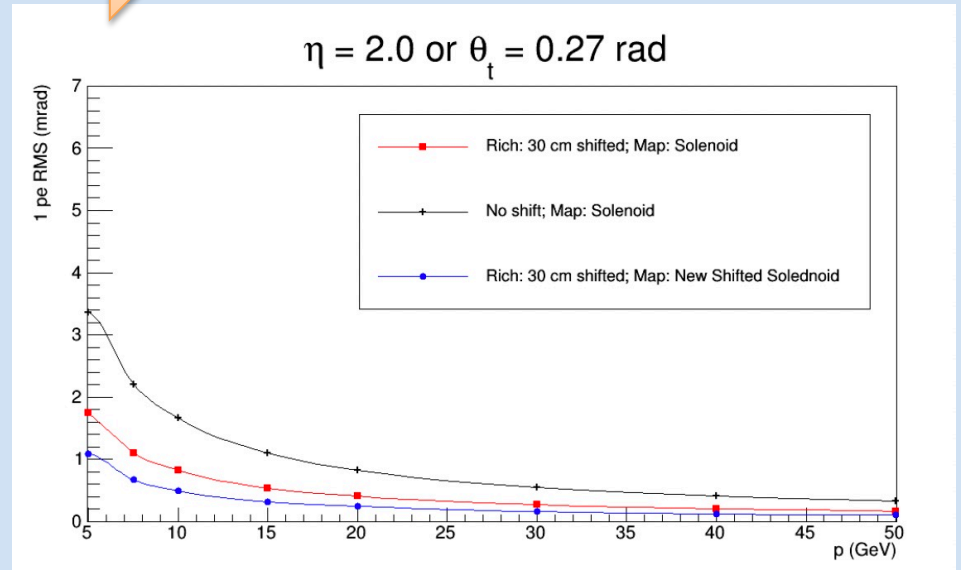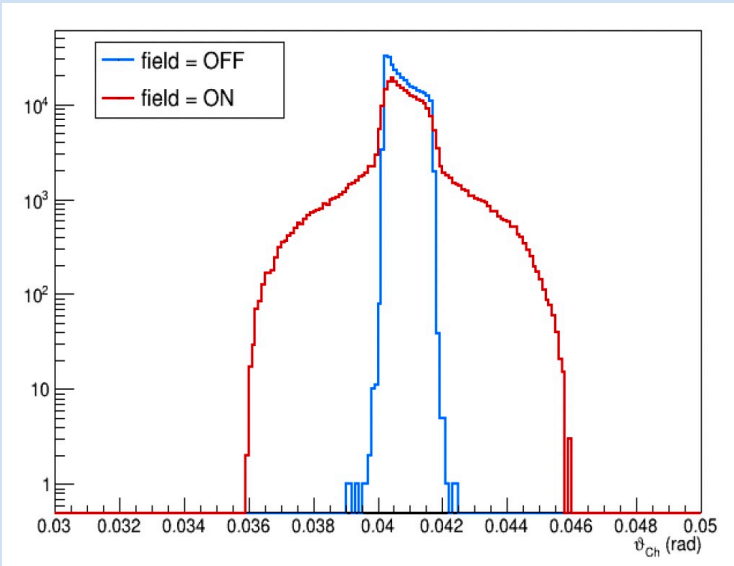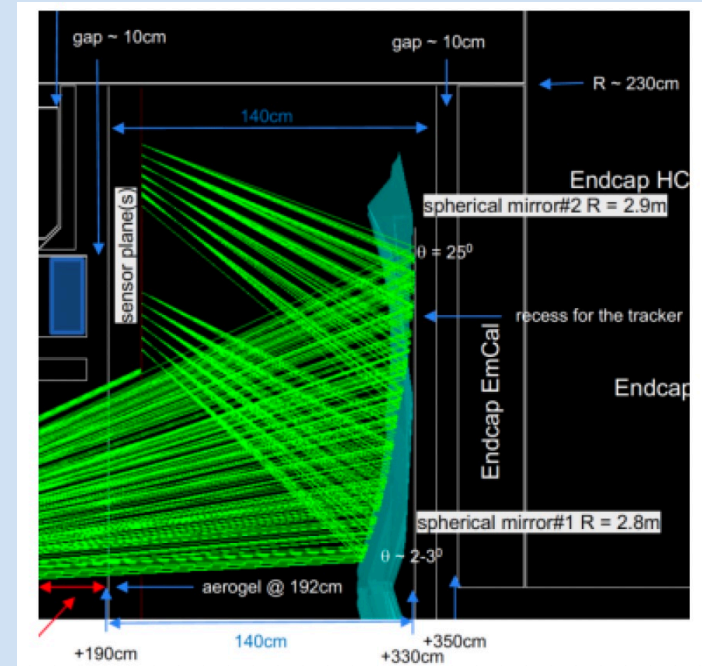Study optics vs geometry constraints

    radiator n vs thickness

    focal plane vs detector surface

Study magnetic bending effect

.....

S. Fazio

Assuming composite materials from aeronautics technology

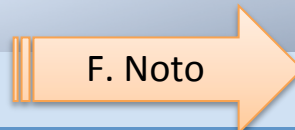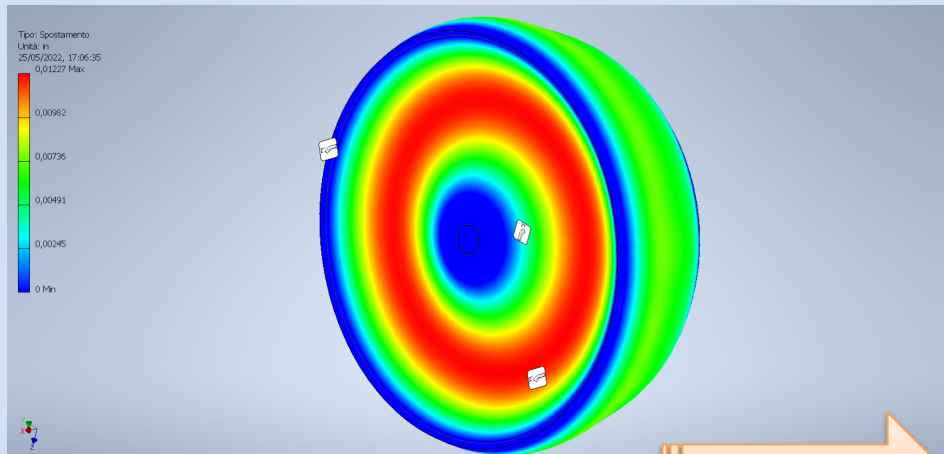Stiff and light, with a skeleton supporting alignment elements

Contacts with BNL to select alternatives and define specifications

High-P Ar: Alternate of greenhouse gas

Dedicated R&D planned to start in fall 2022

stage 1: simple cylinder of candidate material(s)
stage 2: prototype on scale

F. Noto

Targeted R&D proposal submitted in August '21, as an extension of the dismissed generic eRD14

Statement of work approved in July '22 with DOE funds (165 k$) following R&D progresses
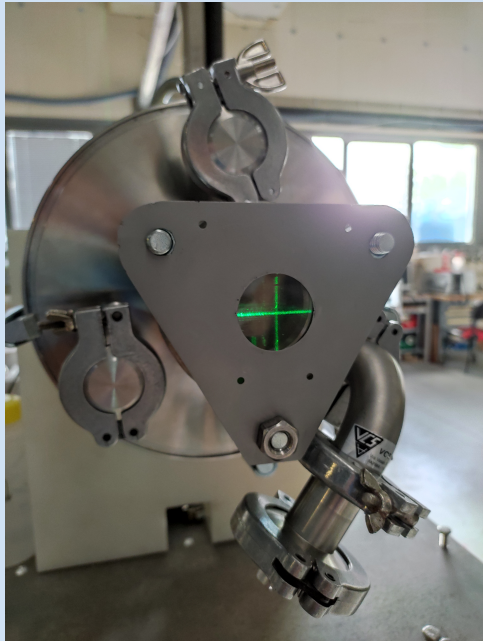
Milestones:

- Implementation of dRICH simulations in the EPIC framework [10/22]

- Assessment of the dRICH prototype performance with reference detector [12/22]

- Realization of a suitable detector plane for the dRICH prototype (SiPM+ALCOR) [03/23]

Goal pre-TDR at the end of 2023, TDR one year later

Prepare for the next test-beam campaign (fall 2022)
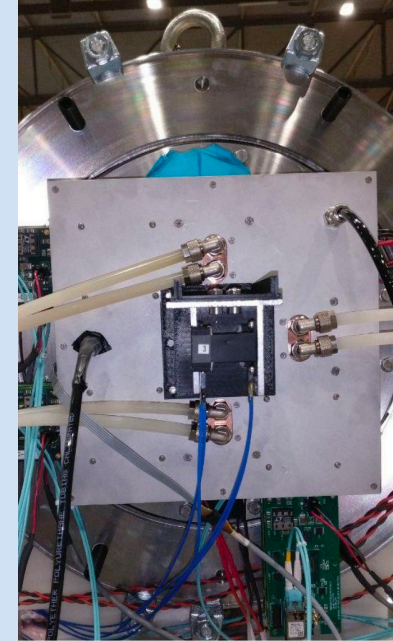
| Improved tools for alignment | Time and gain calibration | Upgrade support structure | Improved trigger |

Direct comparison between reference (MA-PMTs) and EIC-driven (SiPM)
Tagging time and PID of the beam particle

Existing facility to study detailed radiator optical properties and alternatives
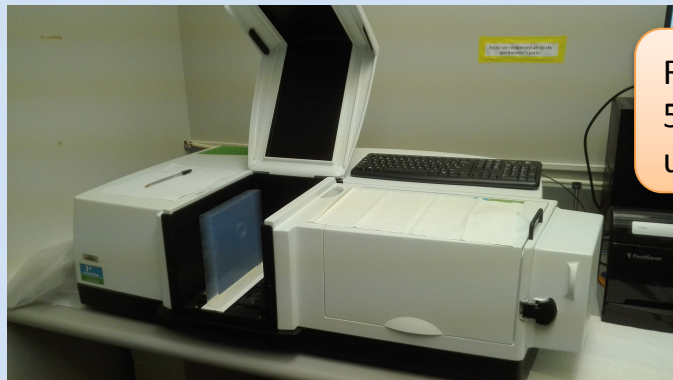
Safe handling and characterization: refractive index, surface planarity, forward scattering, interplay with gas

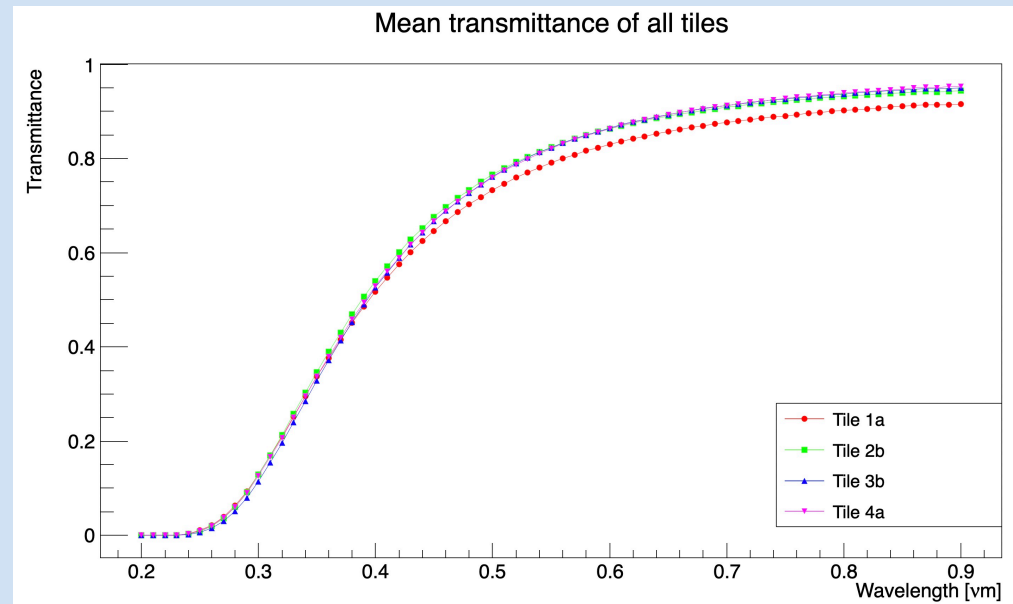Budker Institute - Russia: not accessible
Aerogel Factory - Japan: good quality, working on dimensions (in collaboration with ALICE3)
ASPEN – USA: promising quality for n=1.02, awaiting validation (in collaboration with CUA)

Request to CSN3:
10 keu for EIC
driven samples*

Request to CSN3:
5 keu for detector
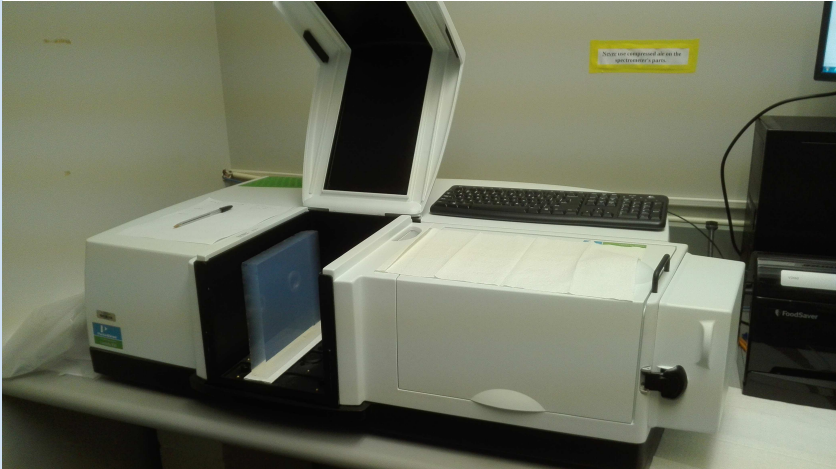unit renovation*

Mean transmittance of all tiles

* Costs based on previous procurements

Existing facility to study detailed radiator optical properties and alternatives
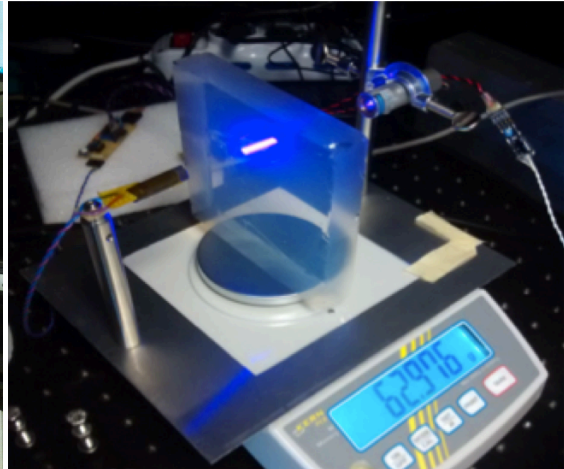
Safe handling and characterization: refractive index,
surface planarity, forward scattering, interplay with gas
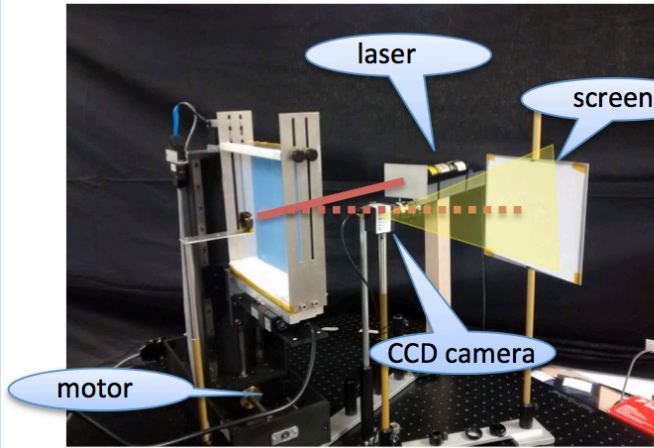
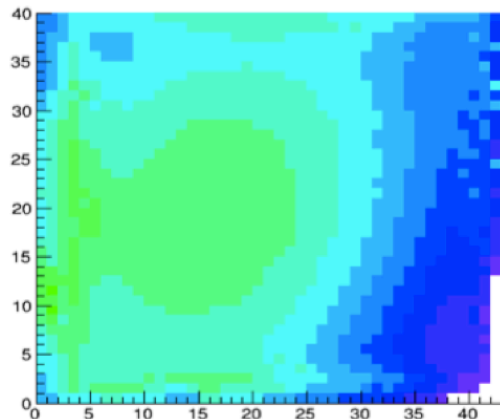Request to CSN3:
5 keu (FE+BA)
for lab & beam tests*

Controlled storage
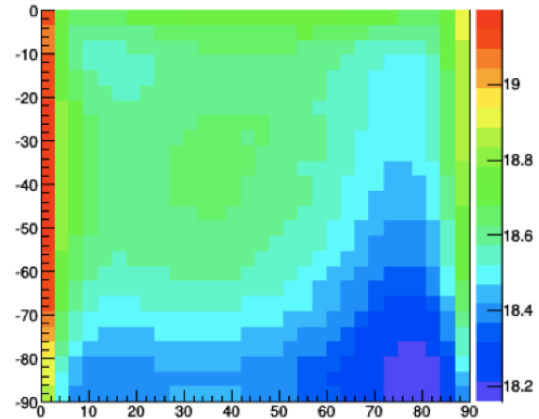
Spectrophotometer

Characterization station

Surface map by laser setup   vs   touch machine

laser

screen

CCD camera

motor

* Costs based on previous realizations

Existing facility to study detailed mirror optical properties and alternatives

Safe handling and characterization procedures (surface map, radius of curvature, reflectivity)
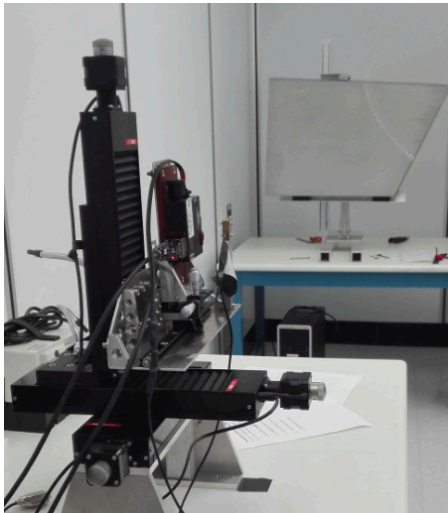
CMA - USA: Carbon fiber (HERMES, AMS, LHCb, CLAS12)
             requires validation for EIC   (2023)

Media-Lario: Glass skin (cost-effective)
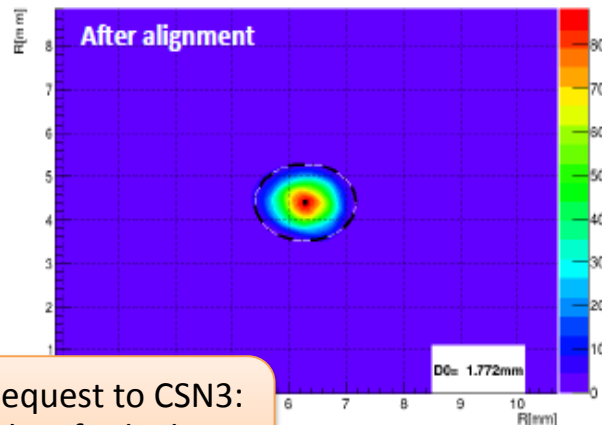   requires specific R&D

> Request to CSN3:
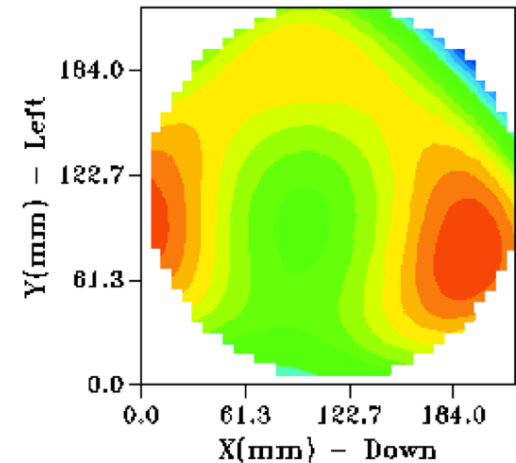> 12 keu for EIC
> driven CFRP demo*

| Surface Quality | Pointlike source image | Shack-Hartmann sensor |

> Request to CSN3:
> 3 keu for high-res
> CMOS camera*

* Costs based on previous realizations for CLAS12 RICH

Targeted R&D proposal submitted in August '21, as an extension of the dismissed generic eRD14

Statement of work approved in July '22 with DOE funds (165 k$) following R&D progresses

Milestones:

- Implementation of dRICH simulations in the EPIC framework   [10/22]

- Assessment of the dRICH prototype performance with reference detector   [12/22]

- Realization of a suitable detector plane for the dRICH prototype (SiPM+ALCOR)   [03/23]
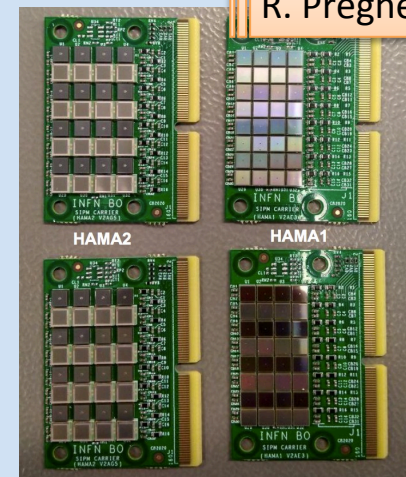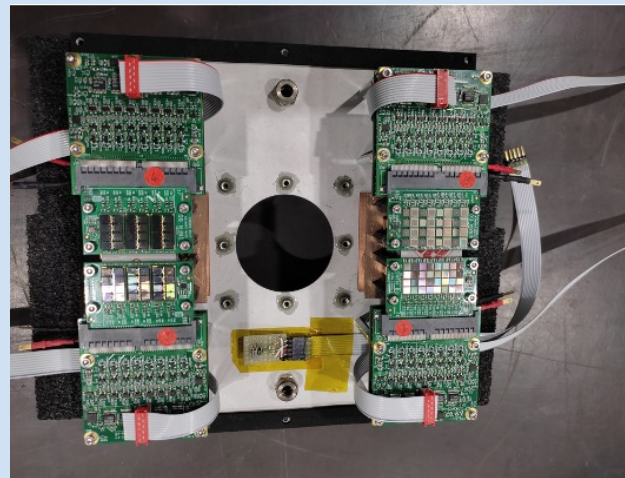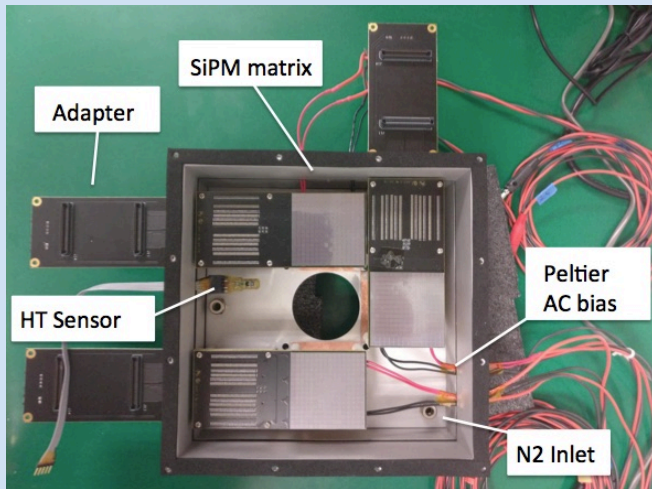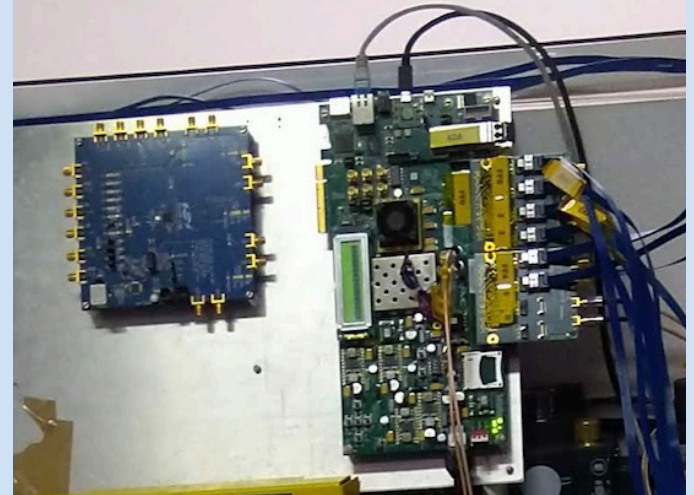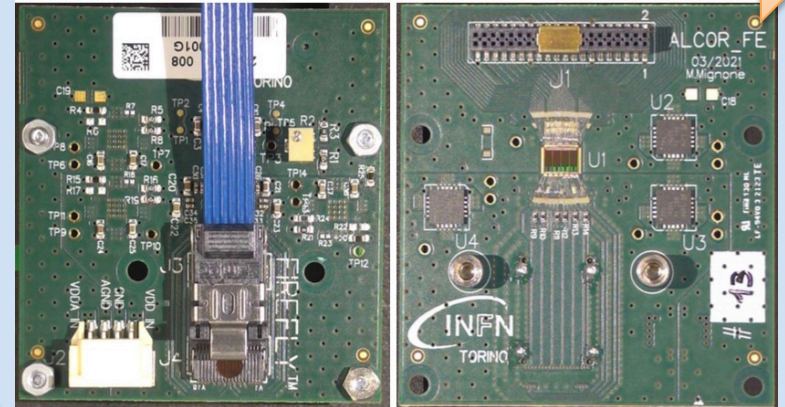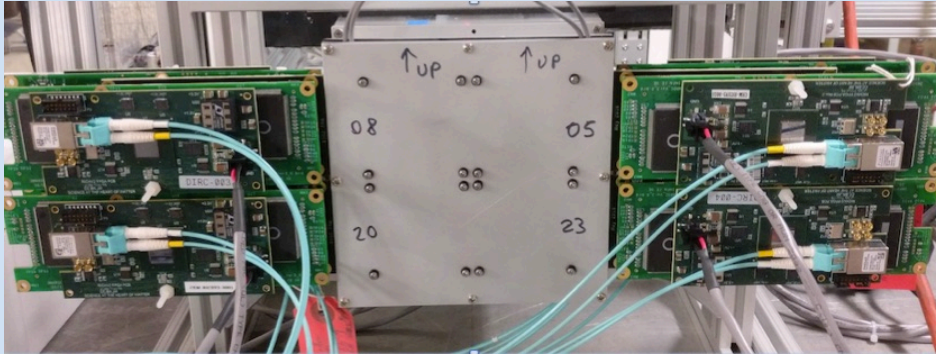

R. Preghenella

Goal pre-TDR at the end of 2023, TDR one year later
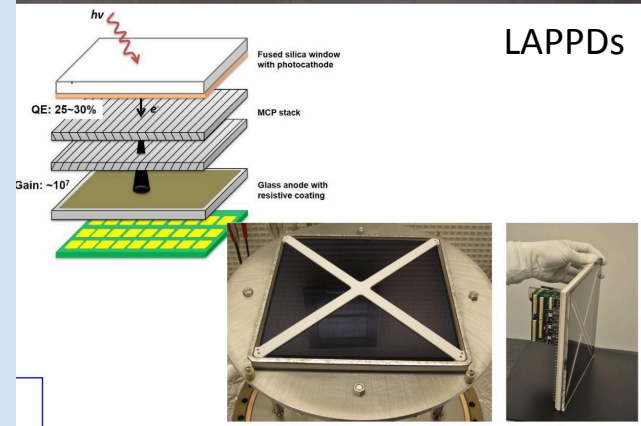
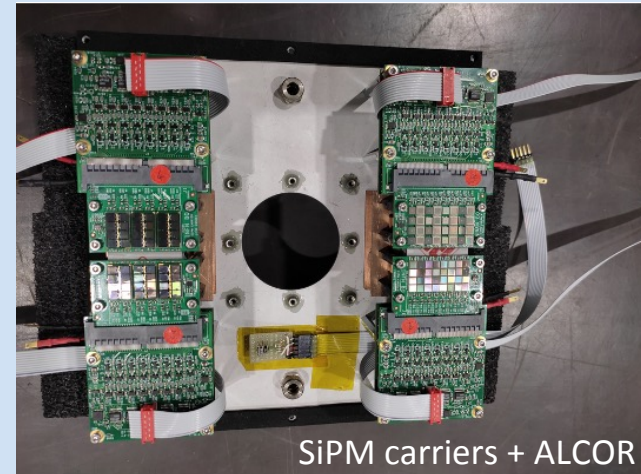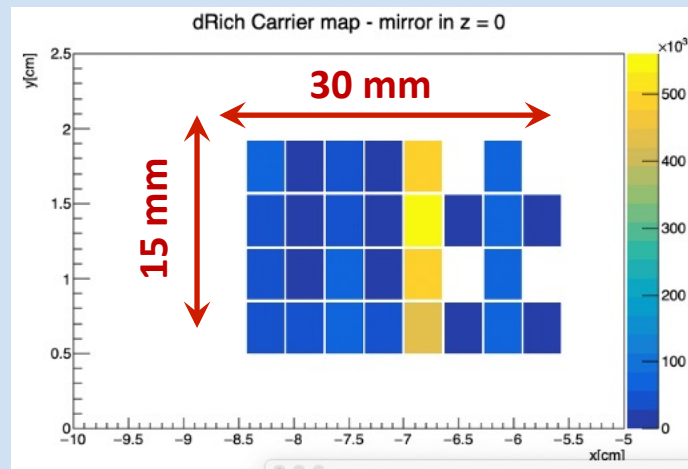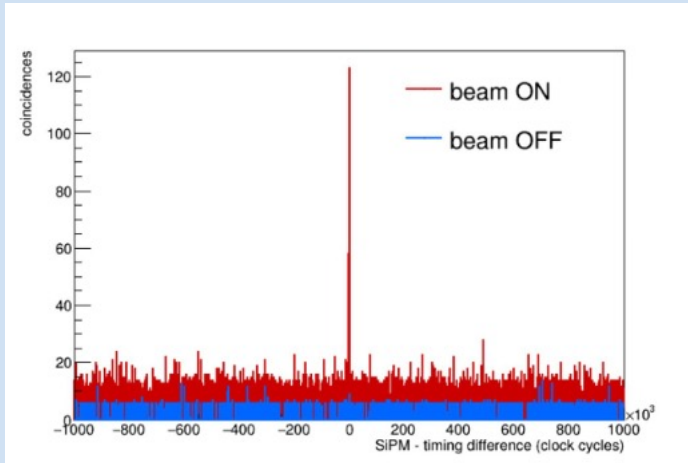CLAS12 reference readout
MAROC3 chip + SSP/VME DAQ

EIC driven readout
ALCOR chip + streaming DAQ

M. Battaglieri

SiPM carriers + ALCOR
September '21 @ CERN SPS

SiPM carriers + ALCOR
October '22 @ CERN PS

SiPM carriers + ALCOR

LAPPDs

Spring and Fall '23
SiPM plane + ALCORv2
LAPPD++

Request to CSN3:
support experts +
6/day shifters

EIC_NET collaborative effort to match a challenging agenda towards TDR in 2024

- ✔ Prototype: Baseline existing
  Systematics studies after proof-of-principle to benchmark design resolution

- ✔ Sensors: Well structured R&D ongoing on SiPM with LAPPDs as alternative
  Local facilities (FBK for development, Lfundry for production)

- ✔ Front-End: ALCOR chip. INFN started R&D awaiting eR109

- ✔ DAQ: High-rate streaming readout
  Investigating online data selection (correlations with other detectors, off-bunch inhibit)

- ✔ Simulations: Consolidate framework, being migrated to EPIC framework

- ✔ Aerogel: Refurbishing characterization laboratories
  Aerogel Factory: R&D on size
  ASPEN: start negotiation with CUA

- ✔ Mirrors: Refurbishing characterization laboratories
  World leading manufacturer based in USA (CMA)
  R&D planned in 2023

- ✔ Mechanics: Initiating a dedicated task force, high-pressure option to be validated with BNL/JLab
  R&D planned to start in fall 2022