

Compact cost-effective solution for particle identification in the high-energy endcap at EIC

## dRICH



BA, BO, CS, CT, FE,  
GE, LNS, RM1,  
RM2, SA, TO, TS

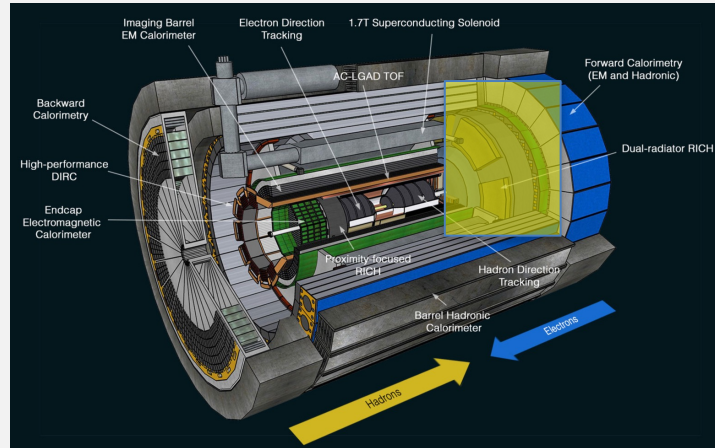


NISR



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## EPIC



## EIC RICH Consortium



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Forward particle detection

Hadron ID in the extended 3-50 GeV/c

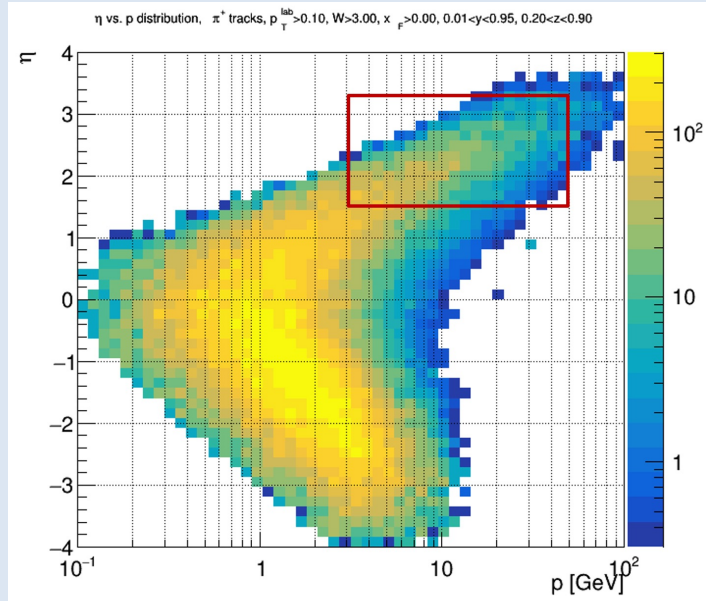
Support electron ID up to 15 GeV/c

### Main challenges:

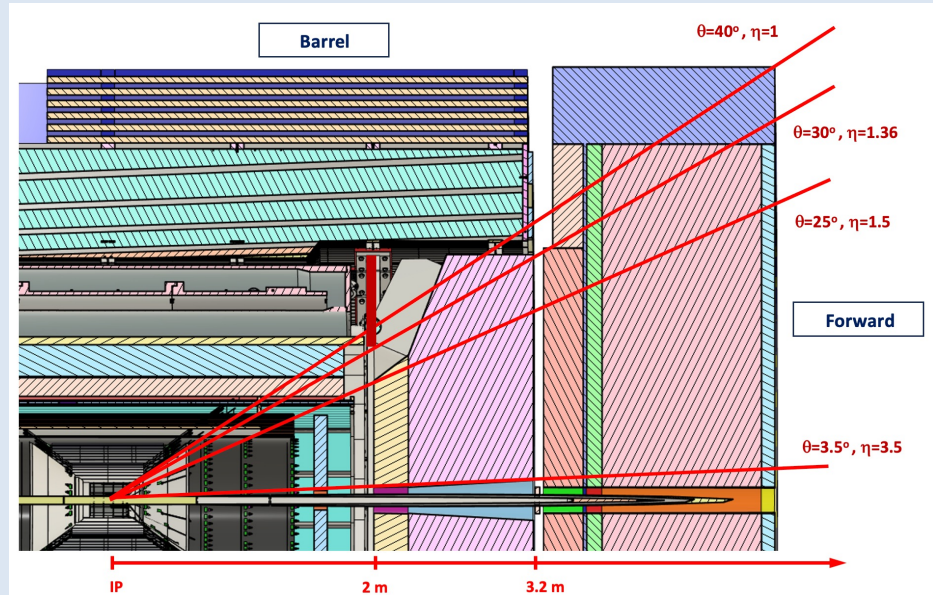
- Cover wide momentum range 3 - 50 GeV/c -> dual radiator
- Work in high (~ 1T) magnetic field -> SiPM
- Fit in a quite limited (for a gas RICH) space -> curved detector

Essential for semi-inclusive physics due to

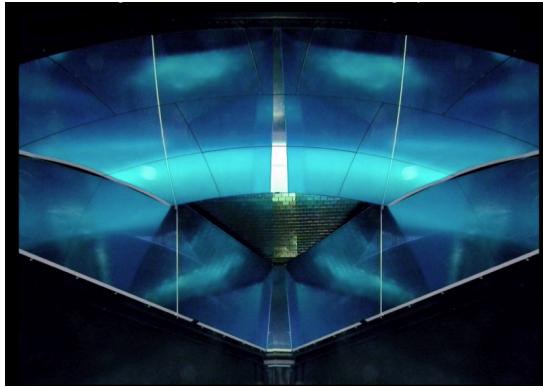
absence of kinematics constraints at event-level



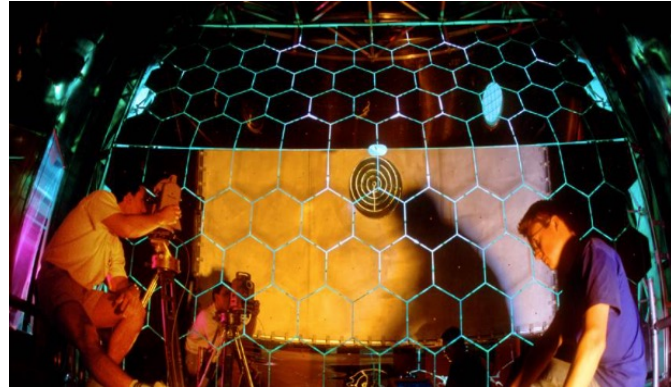
$\eta$	Nomenclature	Electrons and Photons			$\pi/K/p$	
		Resolution $\sigma_E/E$	PID	Min E Photon	p-Range	Separation
1.0 to 1.5	Forward Detectors	2%/E ⊕ (4*-12)%/√E ⊕ 2%	3 $\sigma$ e/ $\pi$ up to 15 GeV/c	50 MeV	$\leq 50$ GeV/c	$\geq 3\sigma$
1.5 to 2.0						
2.0 to 2.5						
2.5 to 3.0						
3.0 to 3.5						



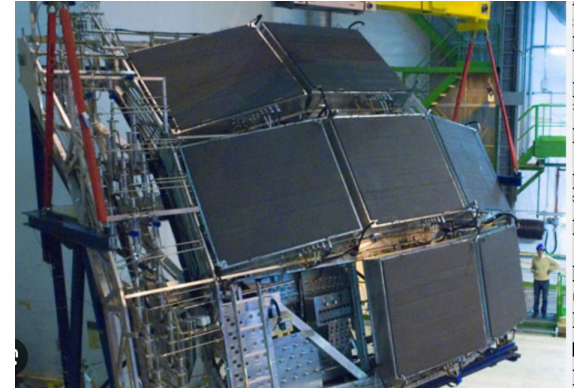
CLAS12 RICH



COMPASS RICH



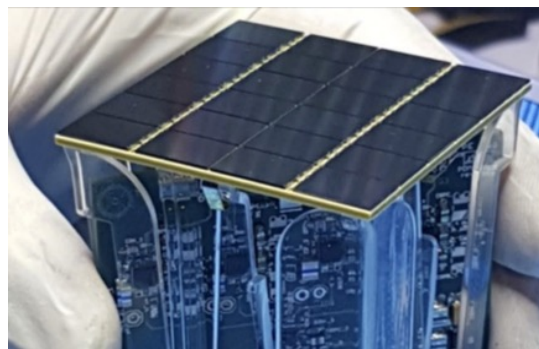
ALICE HMPID



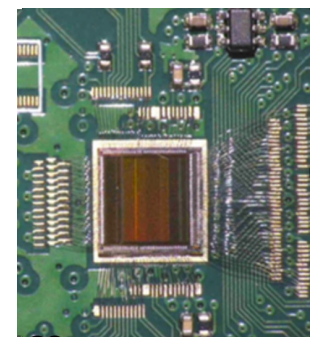
HERMES RICH



DARKSIDE



ALCOR



6.10.04 Particle Identification **Level-3**



6.10.04.03 dRICH **Level-4**



Photo-Detector **Level-5**

Front-end Asics **Level-5**

Data-acquisition **Level-5**

Mechanics **Level-5**

Gas radiator **Level-5**

Mirror **Level-5**

Aerogel Radiator **Level-5**

High-Pressure **Level-5**

Simulation

CAM from Project

CAM from Project + DSTC from EPIC (**M. Contalbrigo**)

## Work packages lead from EPIC

**R. Preghenella**, INFN-BO, INFN-FE, INFN-CS, INFN-SA, INFN-CT, INFN-TS, NISER

**F. Cossio**, INFN-TO, INFN-BO

**P. Antonioli**, INFN-BO, INFN-FE

**A. Saputi**, INFN-FE, INFN-CT, INFN-TS, JLAB, BNL

**F. Tessarotto**, INFN-TS, BNL

**A. Vossen**, DUKE, JLAB, INFN-FE, RICH Consortium

**G. Volpe**, INFN-BA, INFN-FE, RICH Consortium

**S. Dalla Torre**, INFN-TS, INFN-FE, INFN-LNS

**C. Chatterjee**, INFN-TS, DUKE, INFN-FE, RICH Consort.

## Possible work packages not yet active

Detector box **Level-5**

Gas purging **Level-5**

Cooling **Level-5**

Slow Control **Level-5**

Interlock **Level-5**

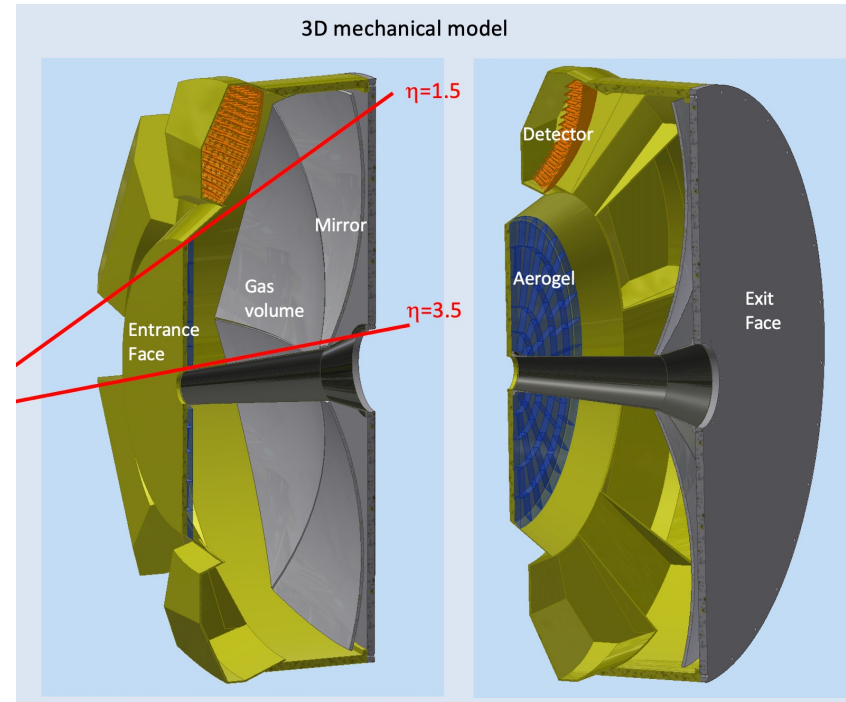
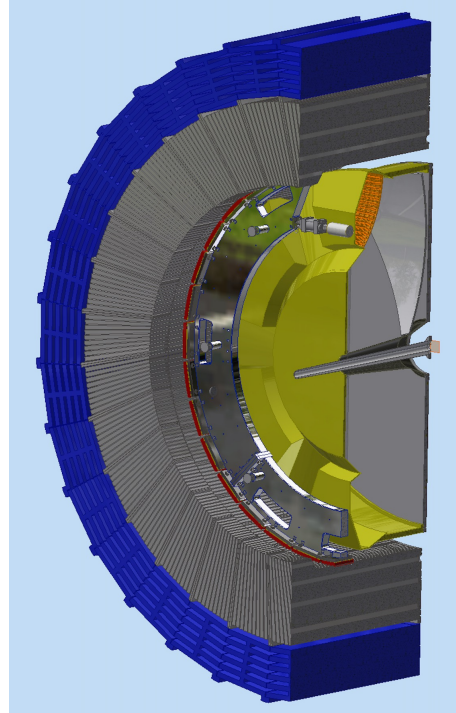
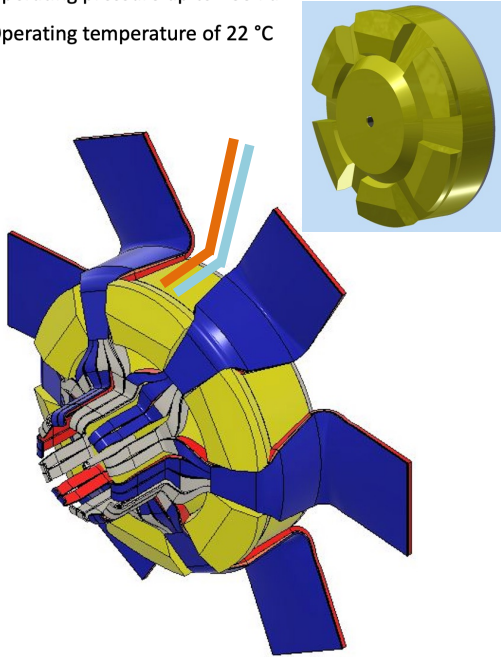
Alignment **Level-5**

Power Supply **Level-5**

..... **Level-5**

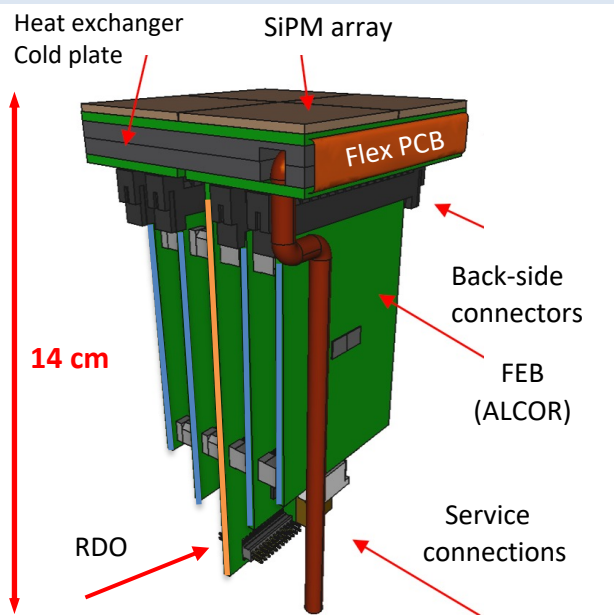
# ePIC dRICH

- $\Phi 3600$  mm x L1200 mm
- Operating pressure up to 200 Pa
- Operating temperature of 22 °C



**Acceptance:** defined by pipe and barrel ecal  
minimize material budget with the use of composite materials

**Interferences:** material budget concentrated behind the barrel ecal and its support ring  
readout electronics design in order to minimize the detector box volume



## Photon Detector Unit (PDU):

Compact to minimize space

4x Hamamatsu S13361-3050HS SiPM arrays

4x Front-End Boards (FEB)

4x ALCOR chip (ToT discrimination)

4x Annealing Circuitry

1x Read-Out Board (RDO)

1x Cooling plate ( $< -30$  C)

Active area is shaped to resemble the focal surface and best exploits the focalization

## Detector box:

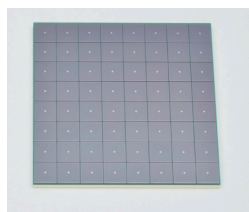
Shaped to fit the space

Quartz window

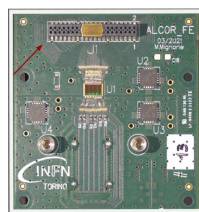
Cooling for sensors and electronics

Power distributing patch panel

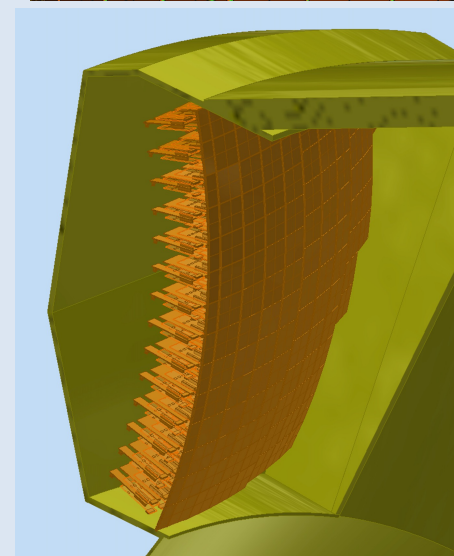
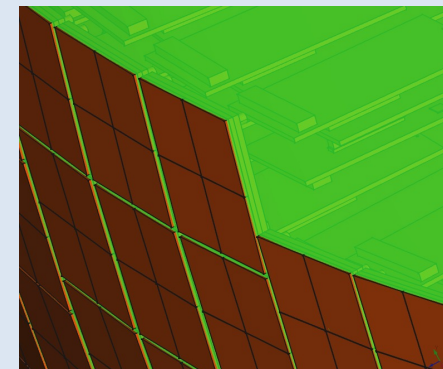
Heat insulation



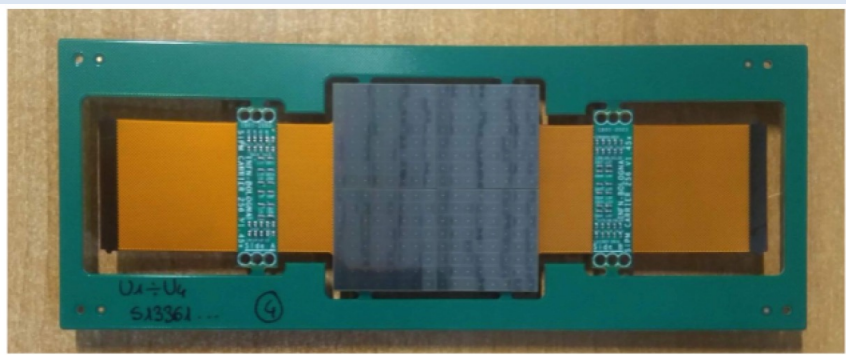
SiPM array



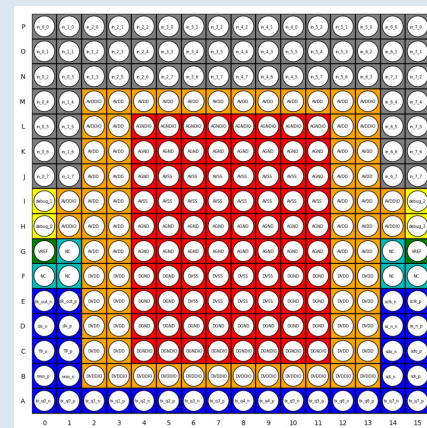
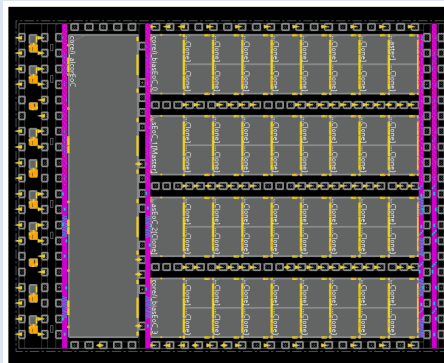
ALCOR chip



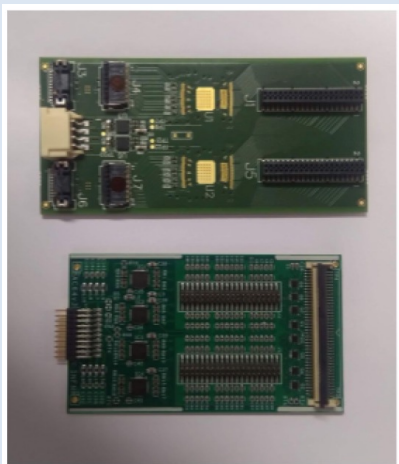
SiPM carrier board with 256 channels and flex connector circuits.



ALCORv64 digitizing chip



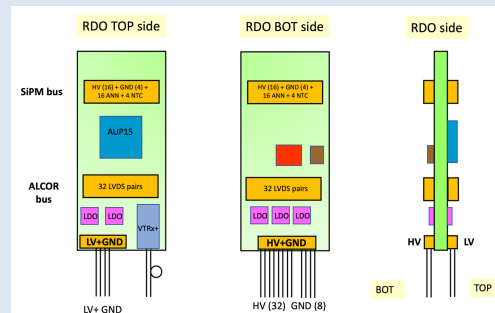
2x ALCOR front-end card and the adapter board



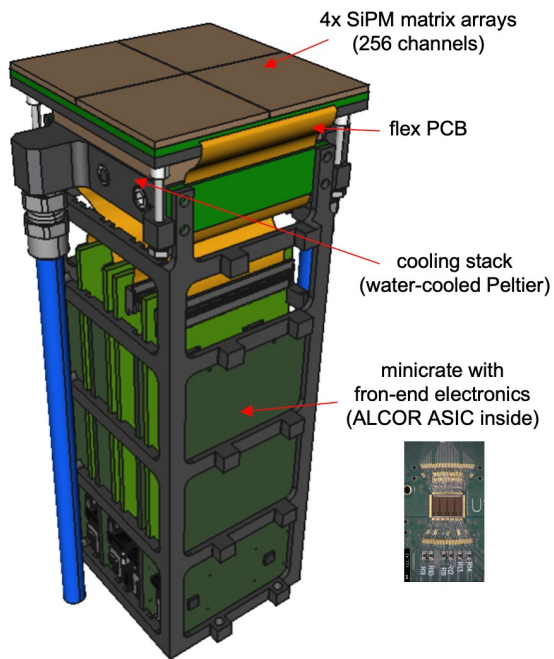
MasterLogic card to control SiPM bias voltage & monitoring service



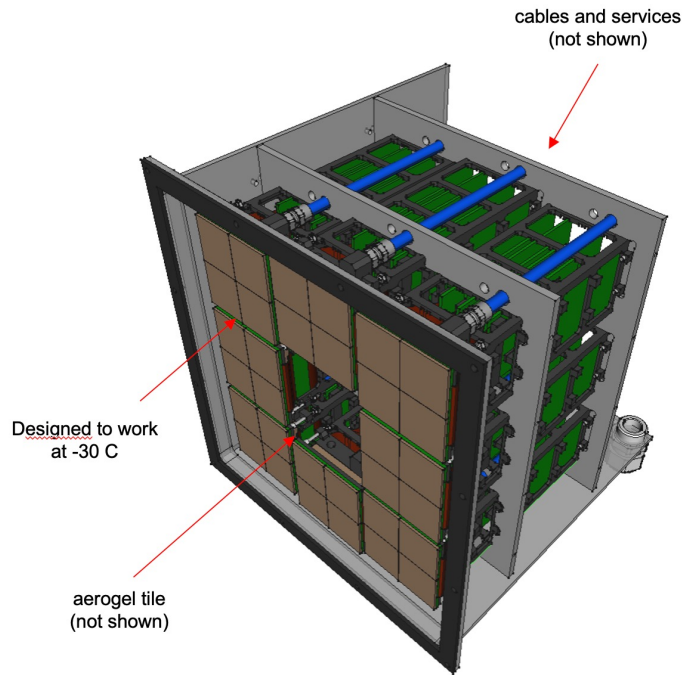
Readout Board to configure and connect to the back-end



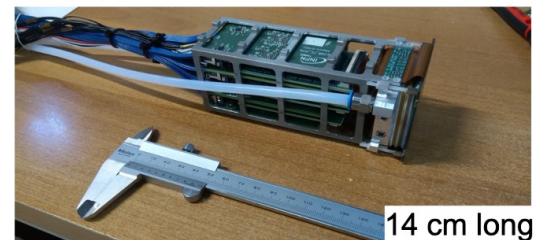
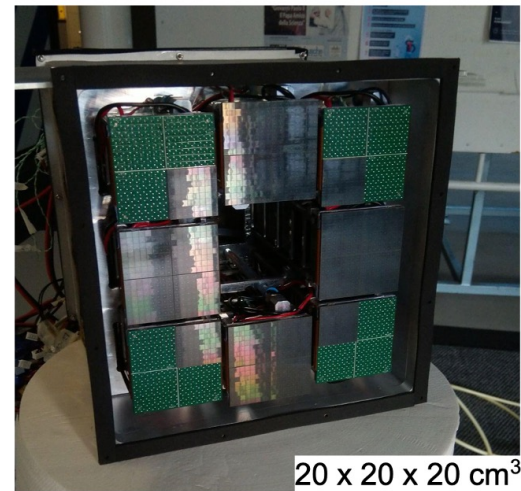
## Photon Detection Unit Streaming readout mode



## Readout Box 8 PDUs, 2048 channels



## Prototype Working Pooint -40:-20 C

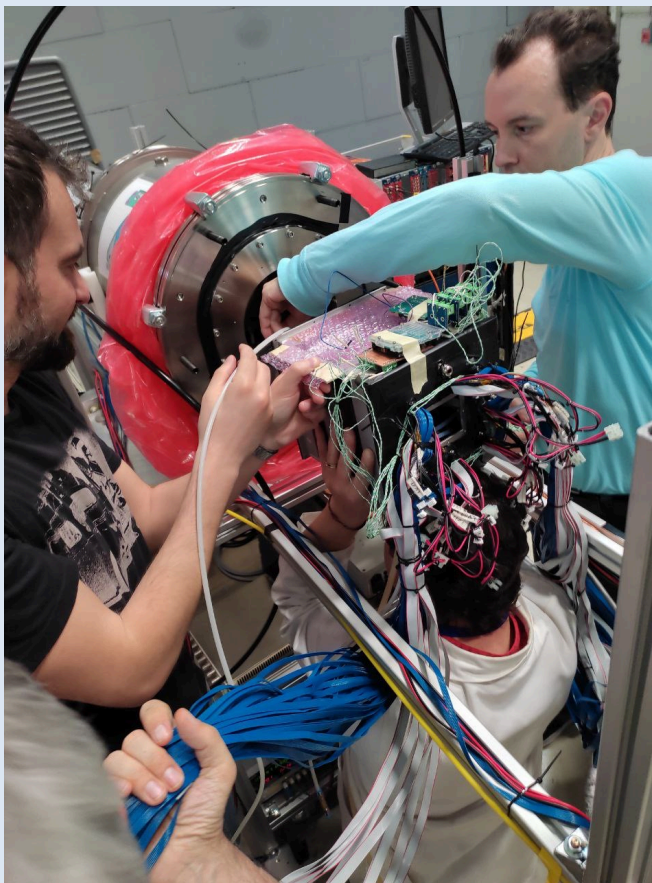




SiPM Detector



Detector Mounting



Tracking GEM+SciFi



## Successful campaign:

Mixed hadron beam 2-11 GeV/c

Various aerogel samples (1.020-1.026)

Two gas radiators ( $C_2F_6$ ,  $C_4F_{10}$ )

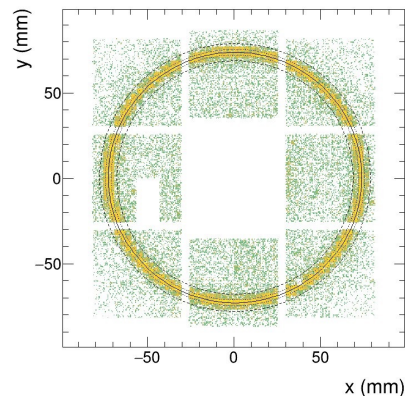
Two SiPM working points (-40 C and -20 C)

Two tracking systems (GEM & SciFi)

Many optical filters

Beam line Cherenkov tagging

Temperature monitor



$$X_0 = 0.72 \pm 0.01 \text{ mm}$$

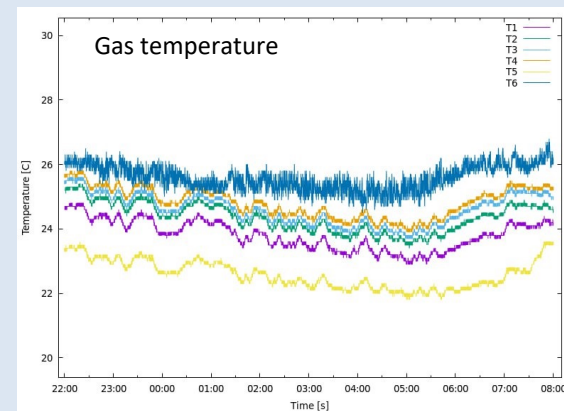
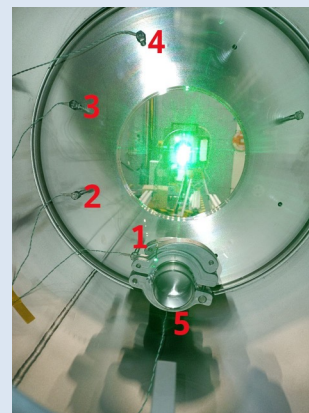
$$Y_0 = 0.50 \pm 0.01 \text{ mm}$$

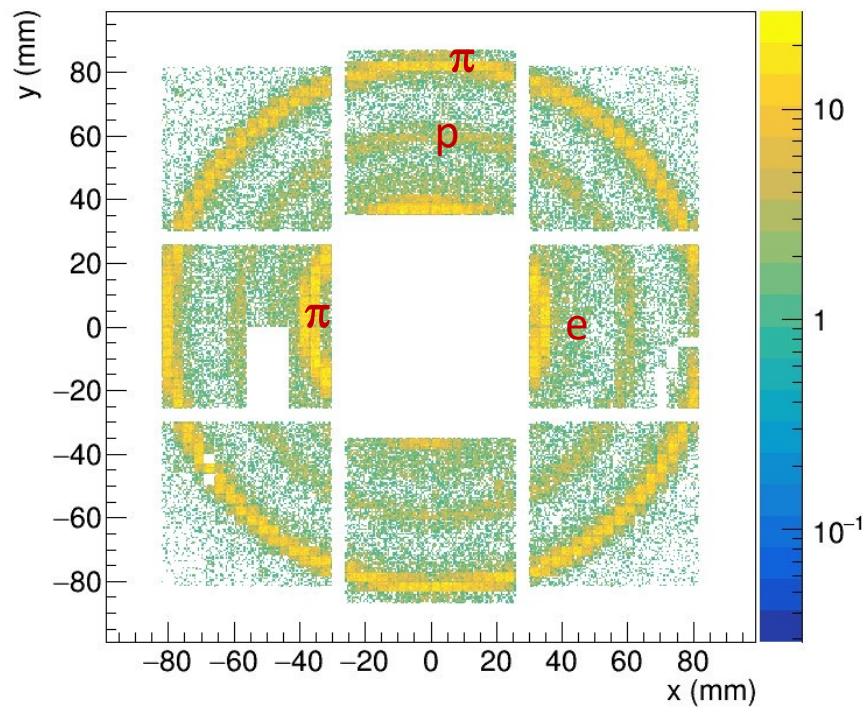
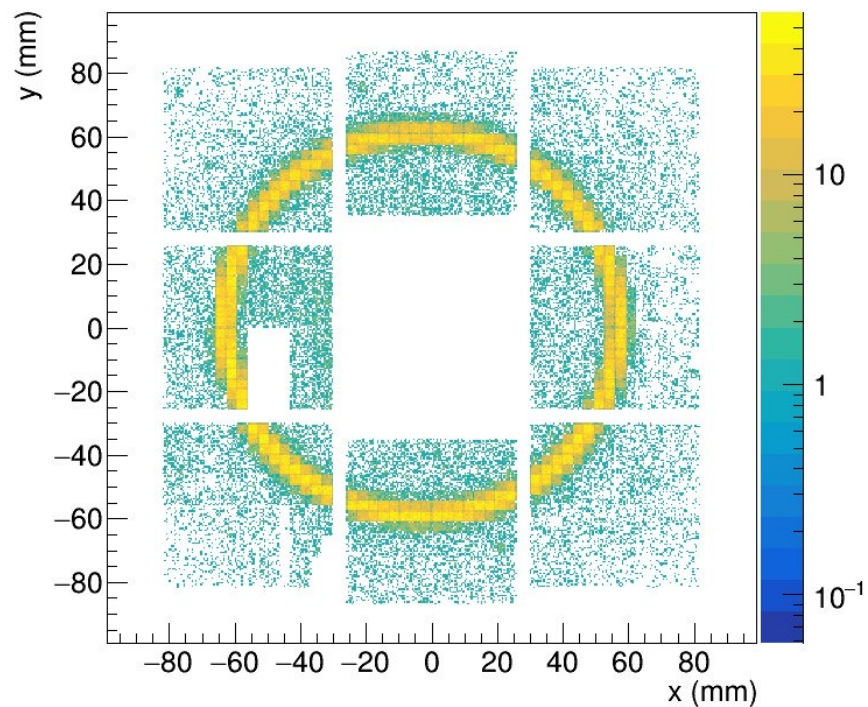
$$R = 73.42 \pm 0.01 \text{ mm}$$

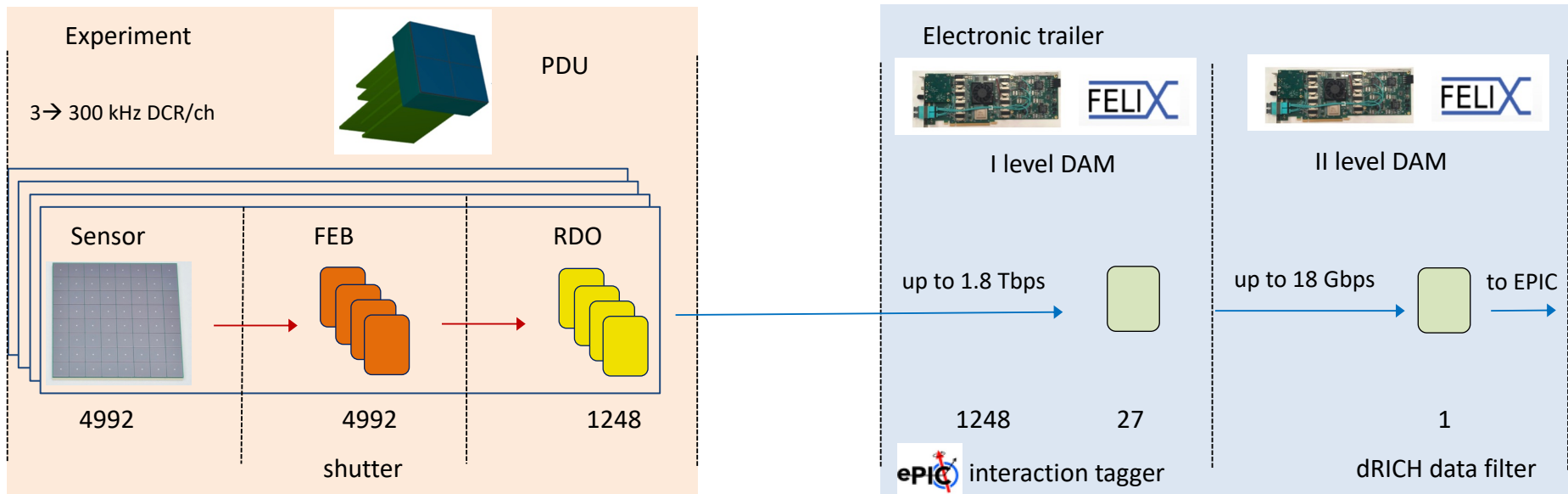
$$\sigma_R = 1.68 \pm 0.01 \text{ mm}$$

$$N_{\text{sig}} = 20.12 \pm 0.09$$

$$N_{\text{bkg}} = 12.55 \pm 0.10$$



Aerogel + C<sub>2</sub>F<sub>6</sub> radiators, positive beam, 8 GeV/cC<sub>4</sub>F<sub>10</sub> radiator, negative beam, 11 GeV/c



Goals: **Maximise modularity** (detector shaping) and **capability** (data stream)

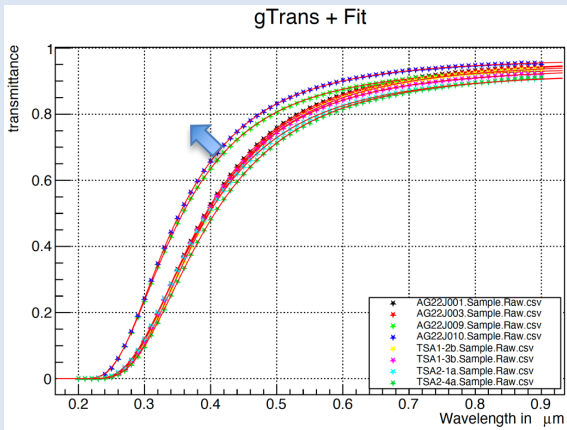
DAM Hierarchy: Maximum data rate capability till DAM-L1

Big data reduction at DAM-L1 with external input (2  $\mu$ s latency interaction tagger)

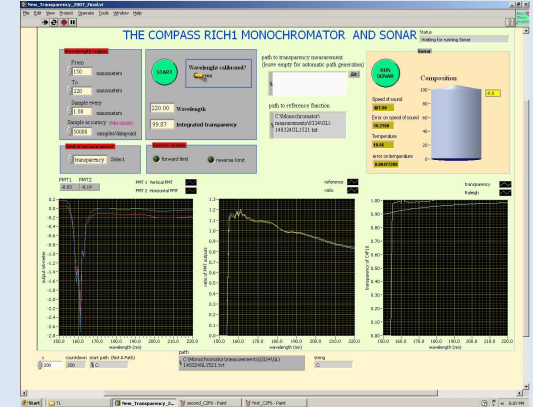
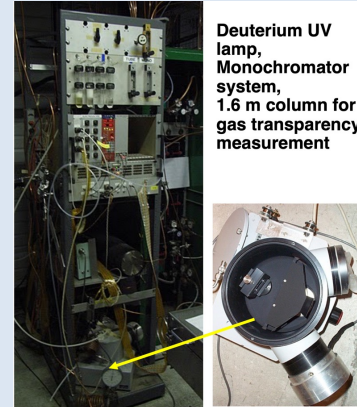
DAM-L2 data aggregation allows for effective data-reduction algorithms

Opportunity for online ML applications (involving INFN specific expertise)

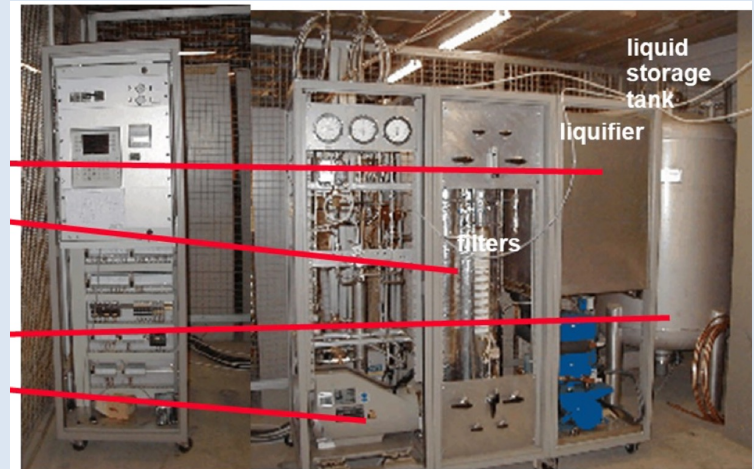
## Aerogel characterization & optimization (synergy with ALICE3)



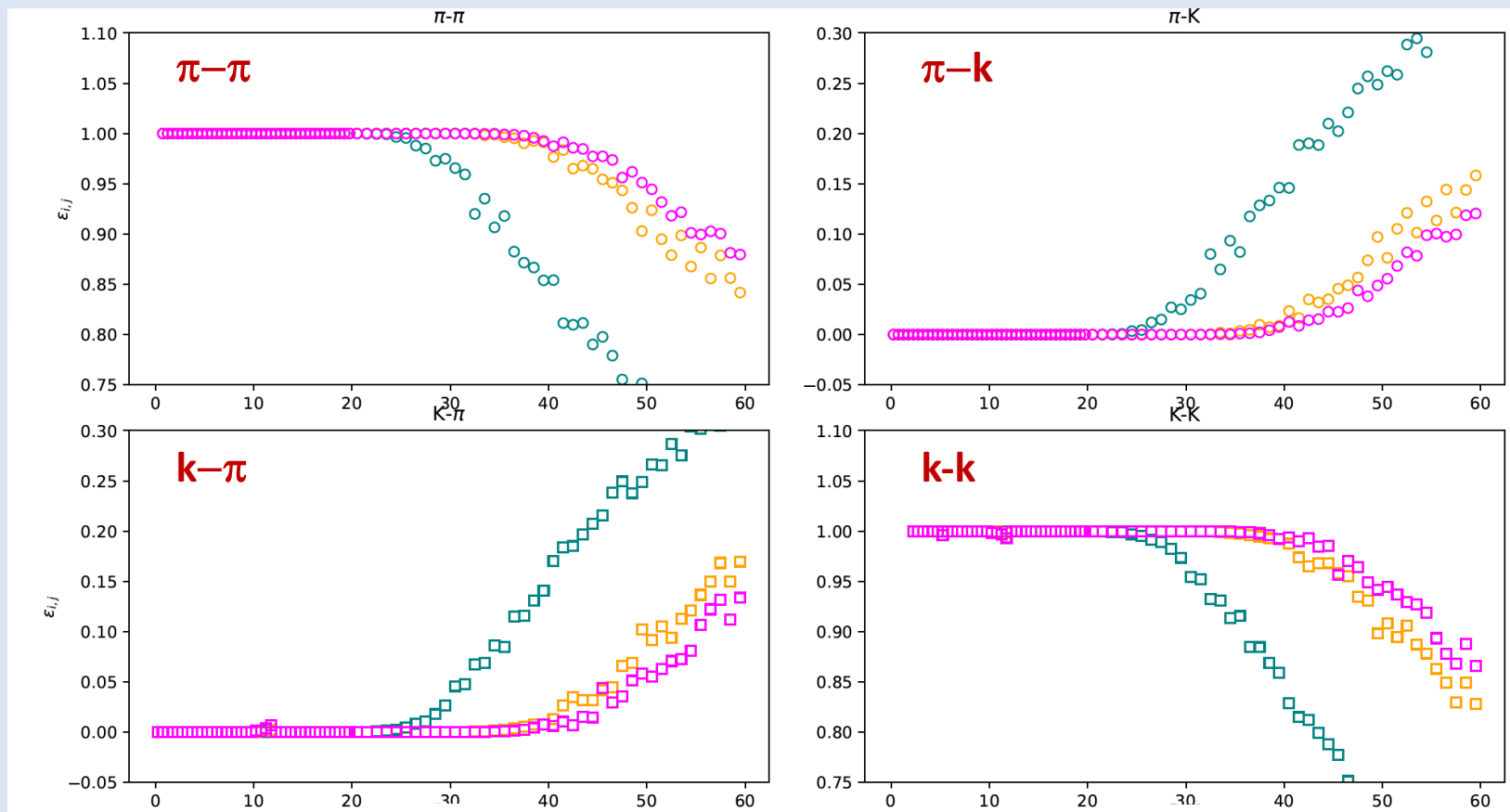
## Gas characterization & optimization (synergy with AMBER/CERN)



Gas system



dRICH performance is studied within the ePIC simulation framework (with tracking resolution and magnetic bending)



	INFN	Shared	DOE
Mechanics	Detector box (FE, LNS)	Vessel (FE, LNS) Insulation (TS)	Aerogel & mirror supports (JLab) Installation tools (JLab/BNL)
Photo-detector	Sensors (BO,CS,SA,CT,TS) PDU (cool plate) (BO)		
Readout	ALCOR (TO) FEB (TO) Master Panel (FE)		
DAQ	RDO (BO)	Data stream (GE, RM1, RM2)	DAM (BNL)
Radiators	Aerogel (BA)		Gas (BNL) Aerogel QA (Temple, BNL)
Mirror			Mirror (JLab/Duke) Coating (Duke)
Services			Gas Plant (BNL) Cooling Plant (BNL) Power Plant (BNL)
Monitors	Gas monitor (TS)	Slow Control/Interlock LED+Laser	

BO: new space under discussion (ex Tier1) & elec. + mech. support

CS: lab (+new) space

TS: lab space & tech. support

TO: micro-electronic workshop

LNS & CT: tech. support

RM1 & RM2: tech support

BA: lab (+new) space & tech. support



GE: lab space & electr. support



SA: lab (+new) space & tech. support

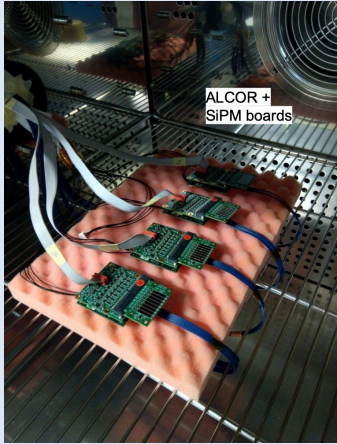


FE: lab space, clean room & elec. + mech. support

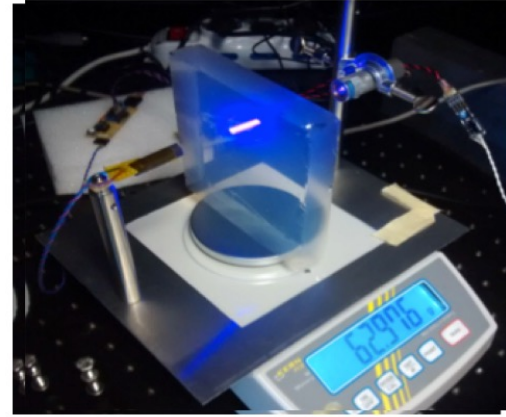
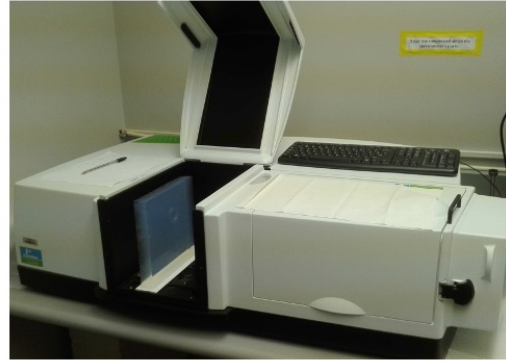




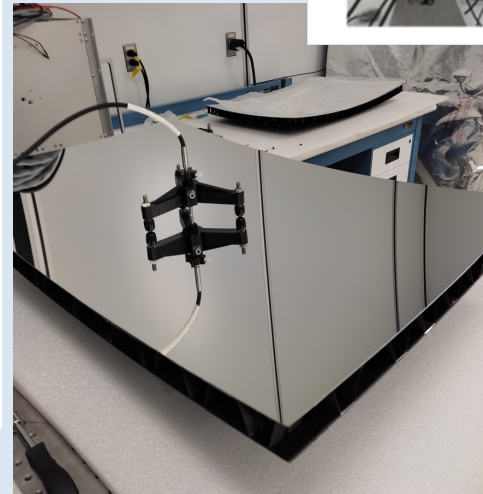
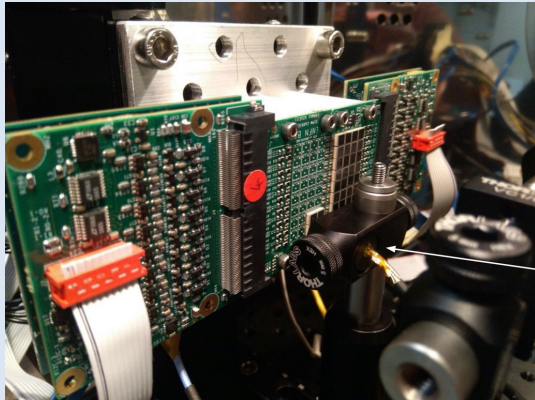
Sensors: INFN (CS/SA/CT) – TS – BO



Aerogel: Temple - BNL – INFN (BA)



Mirror: JLab – Duke – INFN (FE)



DOE granted the EIC dRICH R&D program (eRD102) about 150 keu/yr in the last three years

- Assumptions:
- 6 months delay of CD3 (now on spring 2026)
  - no delay of installation (now on Oct 30: unlikely)
  - possibility to split the major procurements in batches/years

