The dRICH Project

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

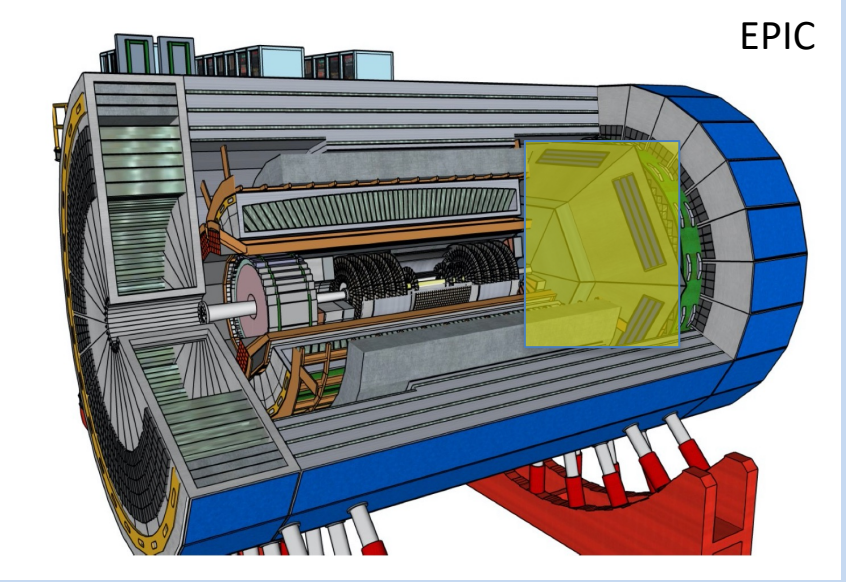
INFN

BA, BO, CS

CT, FE, GE,

LNF, LNS, RM1,

SA, TO, TS



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

All dRICH related activities have been supported via EIC eRD funds
EPIC promoting transition into detector sub-system organization

RICH Consortium

RICH Consortium: Collaboration agreement among the forward and backward RICH detectors for sinergetic efforts on simulations, aerogel, software, sensors, electronics and promote student exchange.

INFN BA, BO, CT, CS, FE, GE, LNS, SA, TO, TS
NISER Bhubaneshwar
BNL, Stony Brook University, Duke University
Ljubljana University
Invitation sent to Duquesne University, UCONN, GWU, GSU, UTFSM Valparaiso

EIC RICH Consortium

Charter

Jan 3, 2023

Preamble

The EIC RICH Consortium is a collaboration of institutions, which have joined together to collaborate in the design, construction, commissioning and operations of the RICH detectors in the backward and forward regions of the project EIC detector, EPIC, at Brookhaven National Laboratory. Henceforth the EIC RICH Consortium is referred to as "the Consortium."

The Consortium aims to maximize potential synergies among the participating groups. However, the individual sub-systems remain distinct in terms of funding, management, and responsibilities within the EPIC collaboration and towards the EIC Project.

dRICH in 2023

Goal: Consolidate the baseline configuration

Global layout: optimize the performance (acceptance, resolution) within EPIC
conjugate physics requirements with mechanical constraints

Mechanics: assess the feasibility of the over-pressure case

Readout: develop an EIC-driven detector plane based on SiPM + ALCORv2
define a sustainable streaming readout architecture

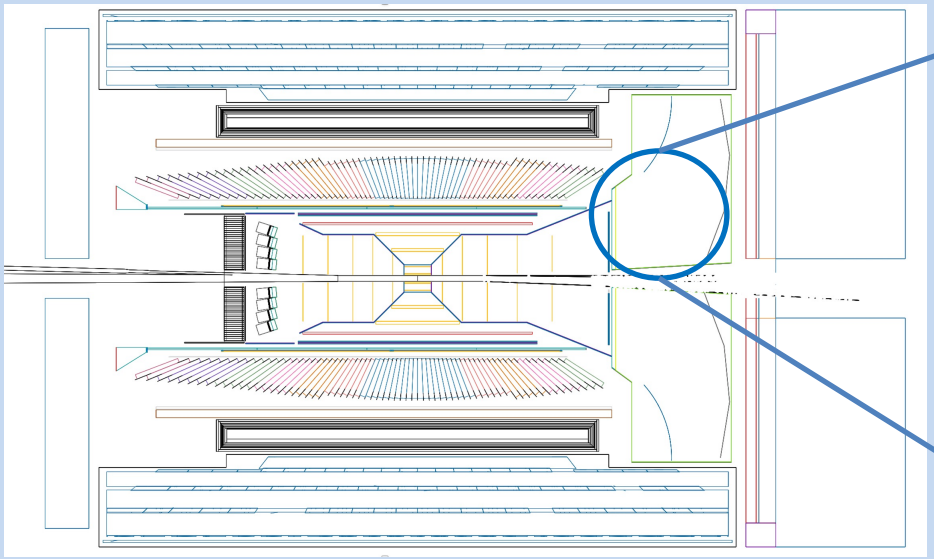
Aerogel: organize an common R&D among the EIC RICH detectors

Mirrors: validate carbon-fiber technology

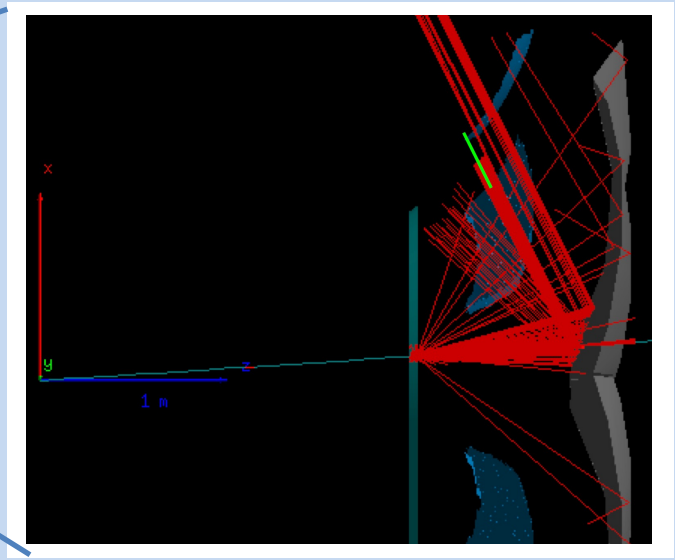
Prototype: evolve into EIC-driven technology solutions (from reference to realistic components)
organize a new test-beam campaign
study performance optimization

dRICH Geometry

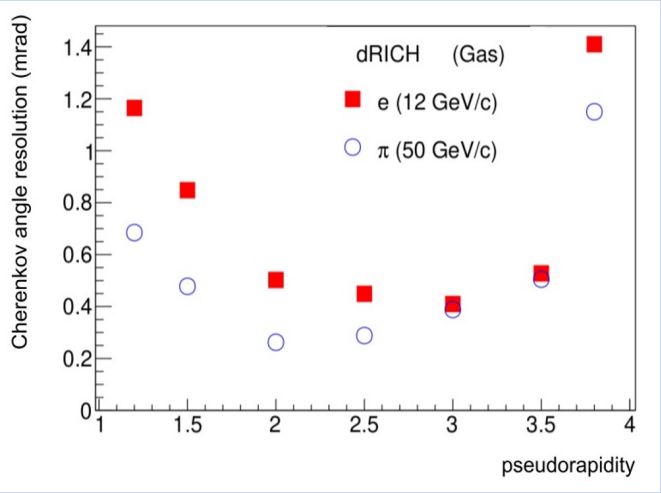
EPIC



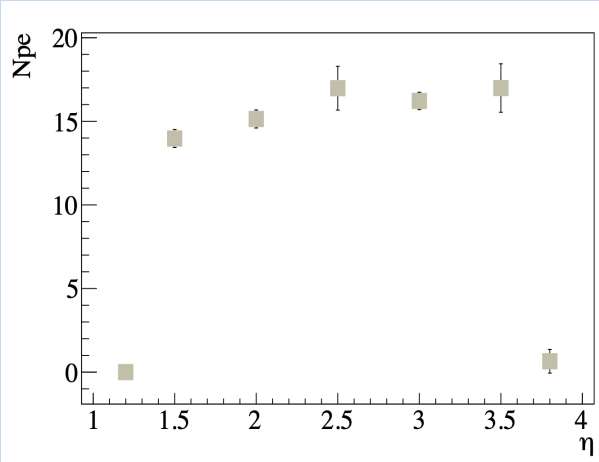
dRICH

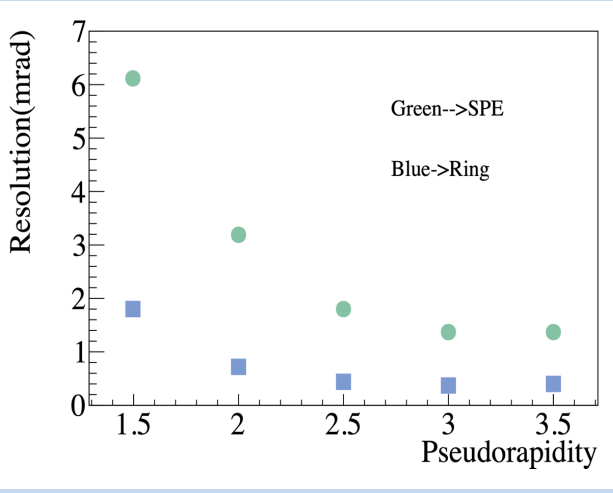


ATHENA reference

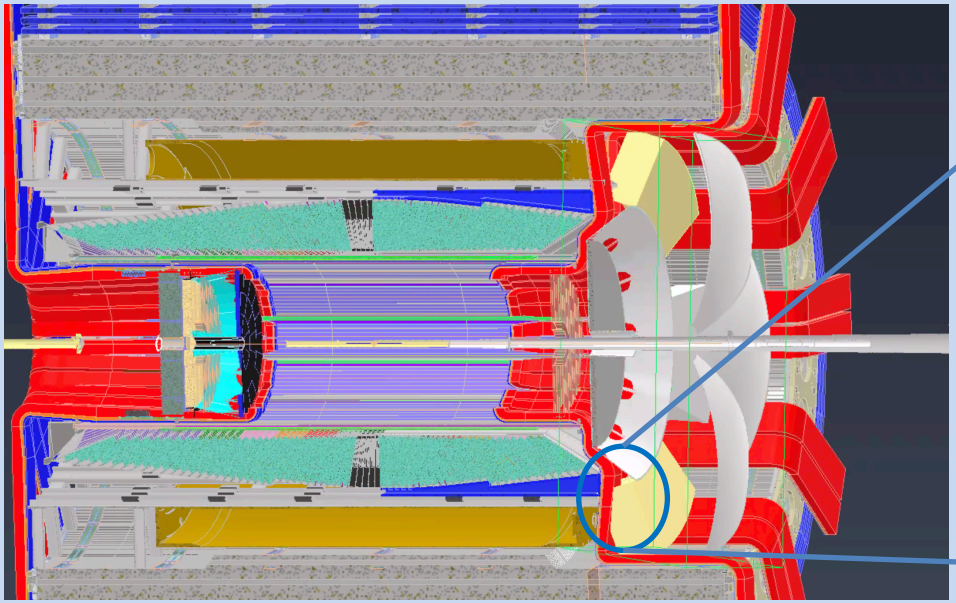


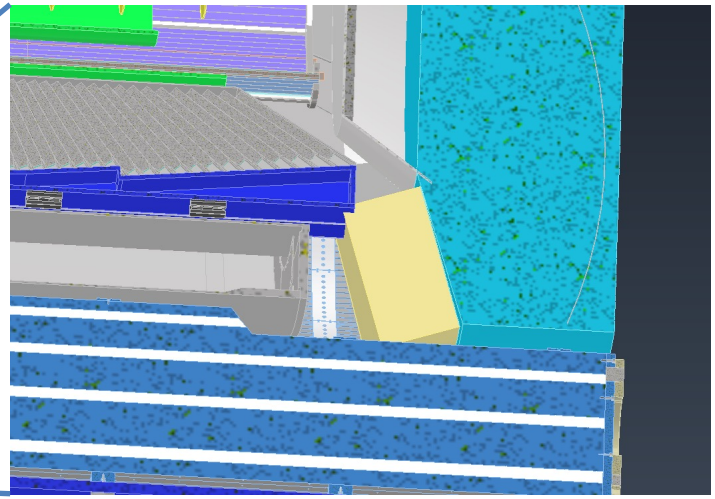
EPIC re-tuning



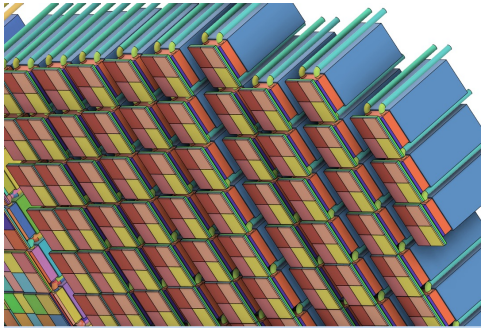


dRICH Mechanics & Integration

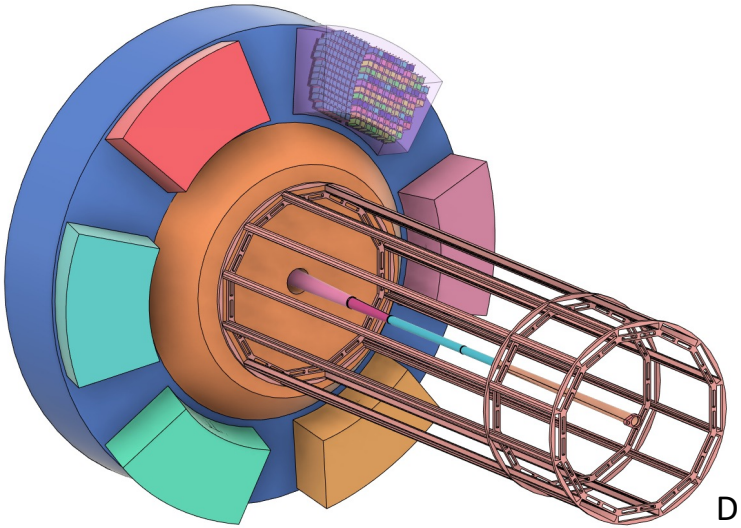




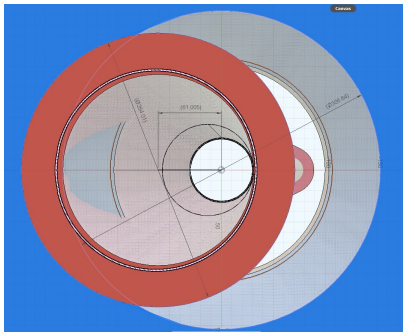
Detector unit array



Alex Eslinger (JLab)



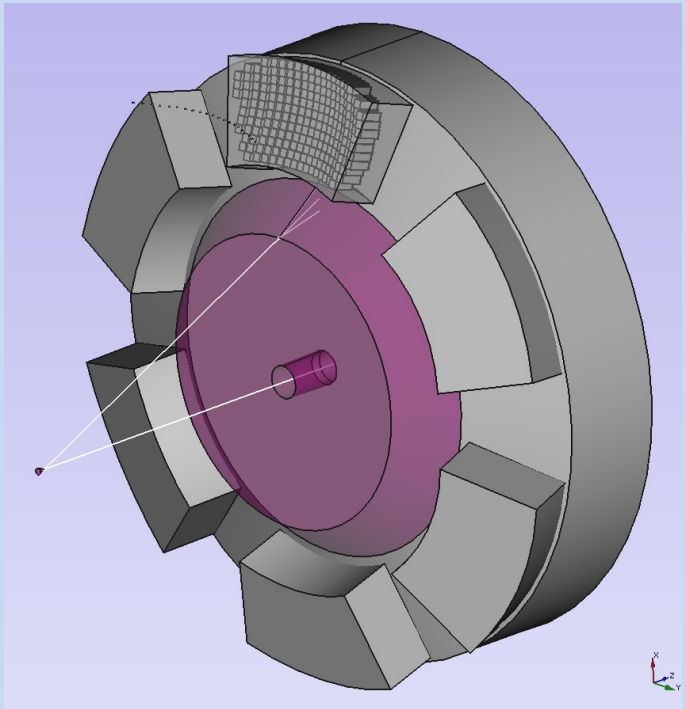
Beam pipe envelope



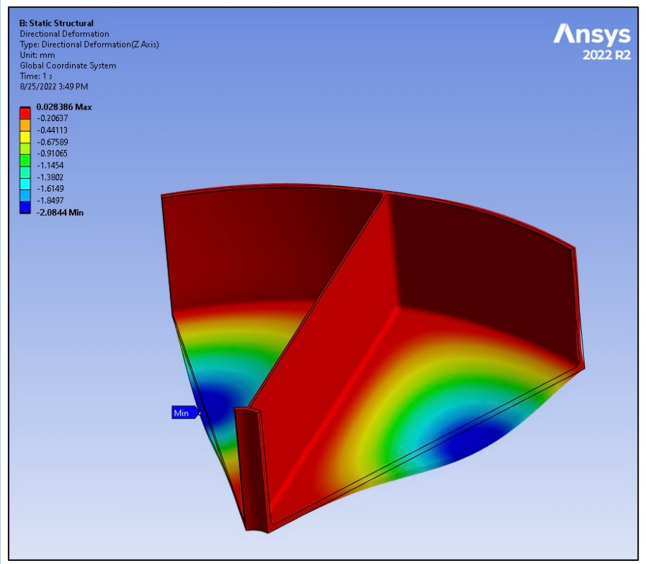
DIRC supporting structure

dRICH Vessel

General Layout

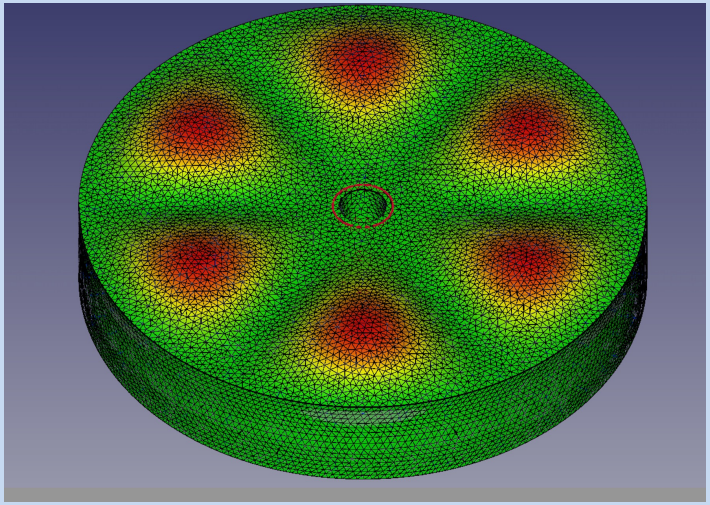


BNL: simple metal bulk (aluminum, steel)

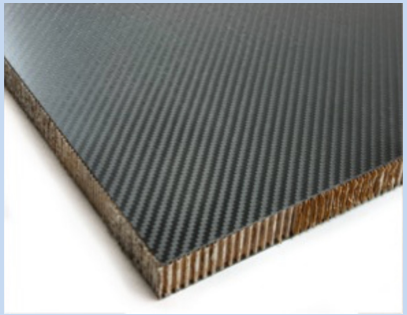


$\Delta_{Z\text{-}dir}$ = +0 / - 0.21 cm

Additional INFN expertise being involved

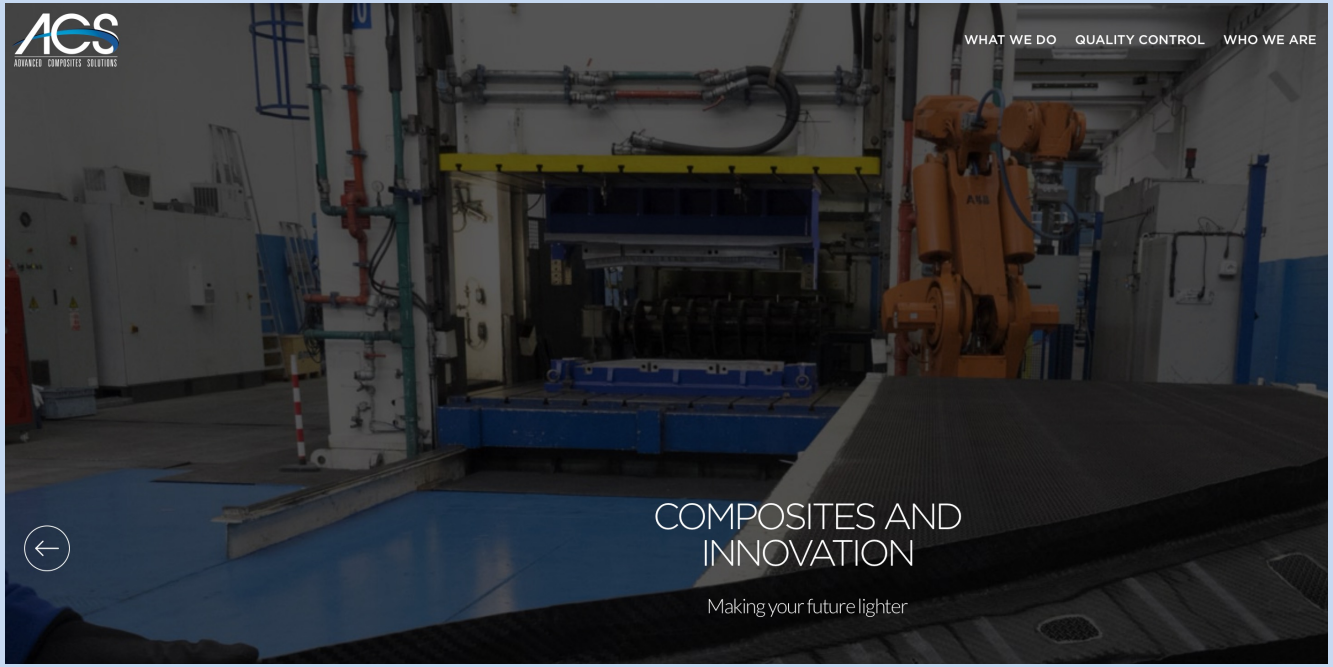


Composite materials and structural study
also for over-pressure version

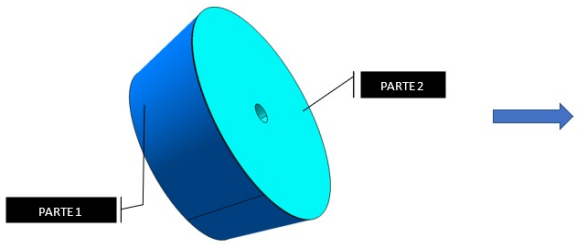


CFRP Prototyping

Advanced Composite Solutions (visited beginning of February)

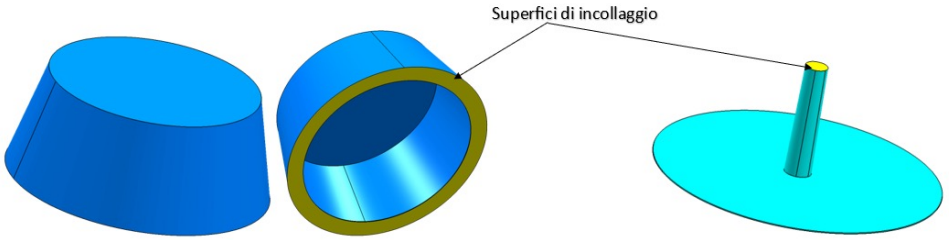


1:10 CFRP mockup



2 mm CFRP

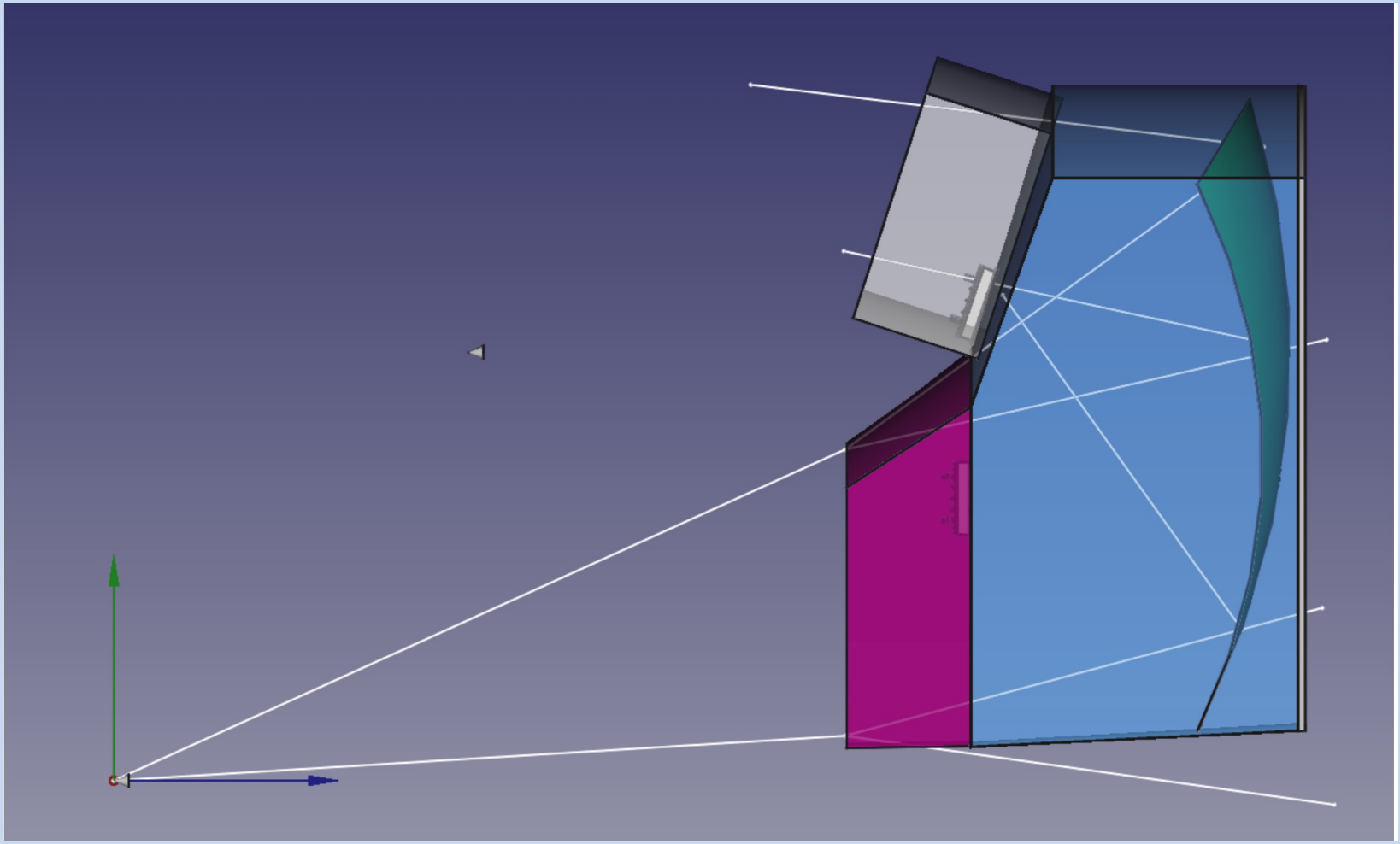
3 mm CFRP+nomex sandwich



Awaiting CFRP data-sheets from ACS to support modeling, mackup within two months
Sealing test at ACS, over-pressure tests planned at LNS

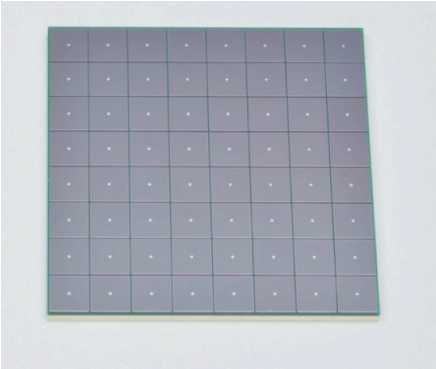
dRICH Prototyping

Possible real size prototype: study mechanical stability under pressure, joints and septa
test performance with detector box and mirror of small area at relevant locations, i.e. at max (min) rapidity



EIC-driven SiPM Detector Plane

Hamamatsu S13361-3050



MPPC arrays expected by end of March

Front-end re-design procurement started

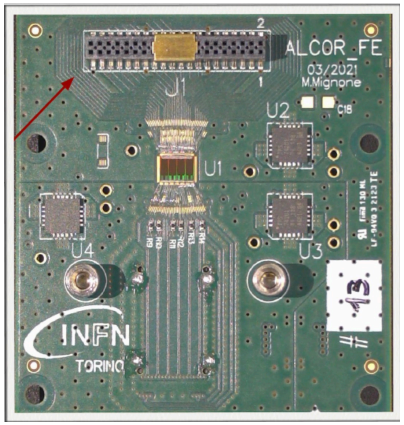
ALCOR v2 (bwetter dynamic range and rate)

Submitted for production

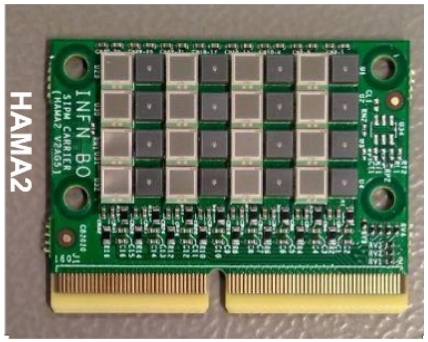
ToT architecture, streaming mode ready

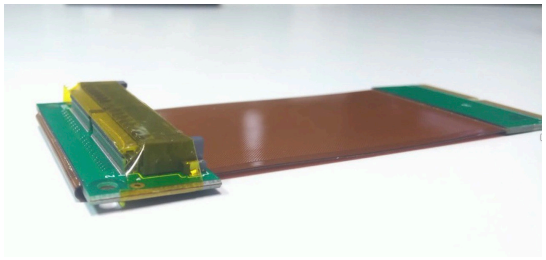
- 50 ps time bin
- 500 kHz rate per channel
- cryogenic compatible

ALCOR chip

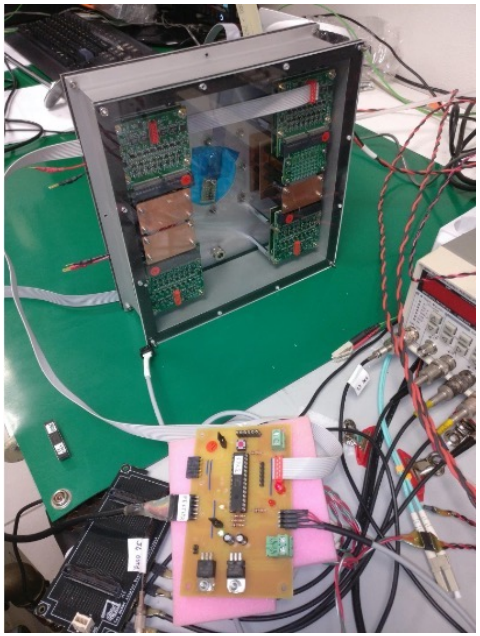


PCB with flex cable connection

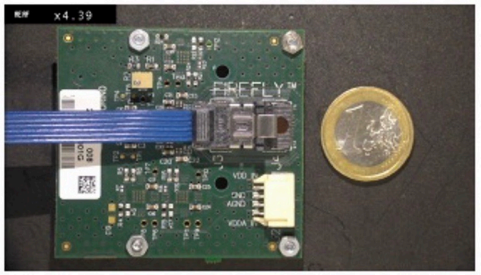




Integrated Cooling/ In-situ annealing

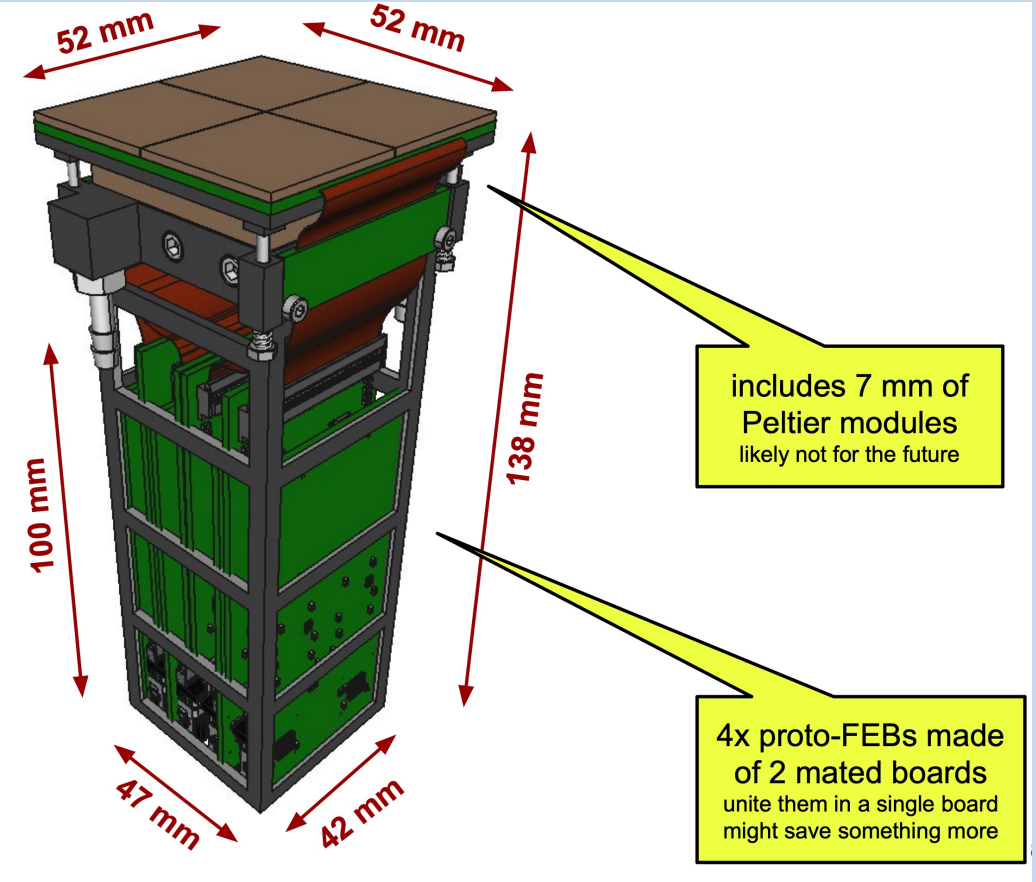


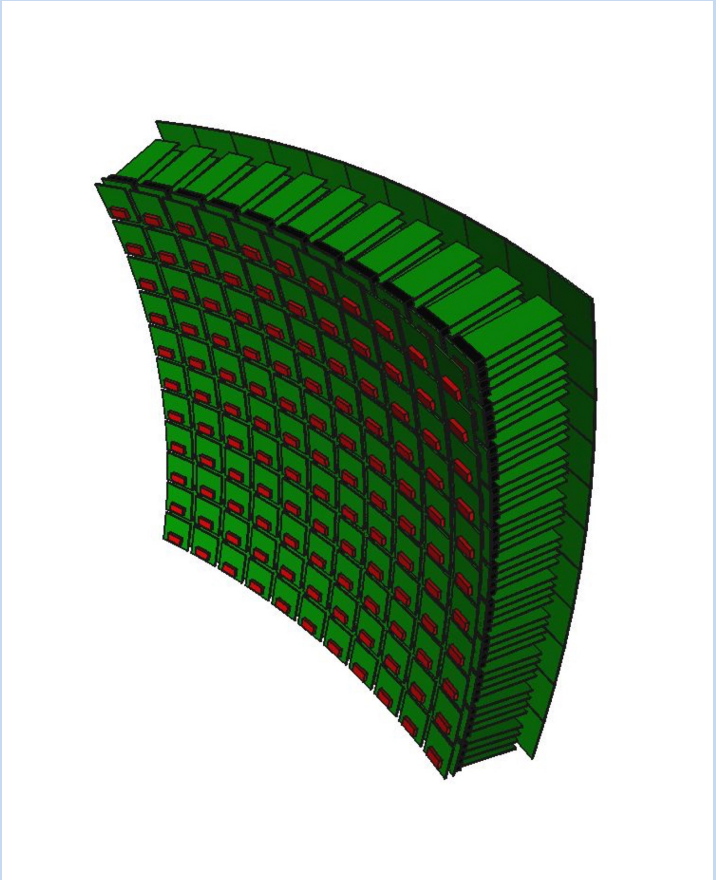
Streaming readout



dRICH Readout Unit

Evolving design account for: present choice of SiPM array
new front-end readout boards
cooling & in-situ annealing
stacking and tessellation





SiPM

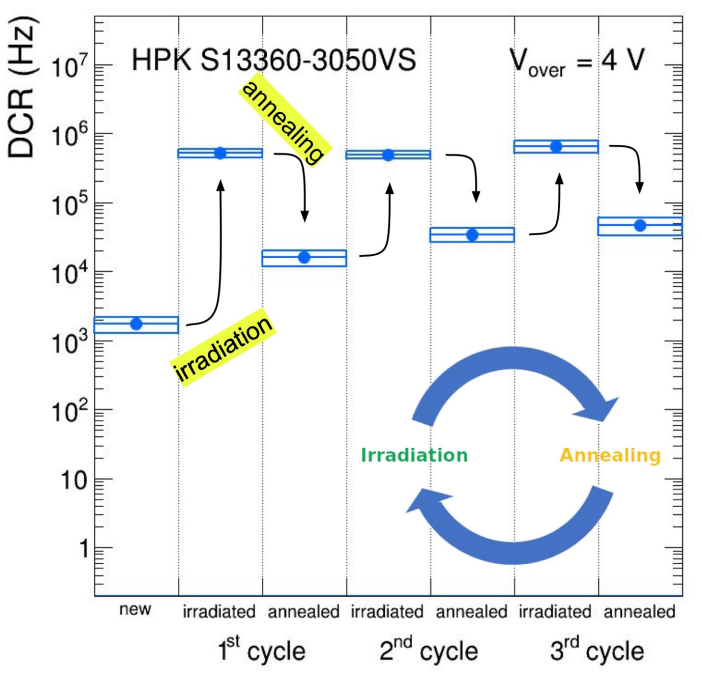
Timing measurement of irradiated (and annealed) sensors

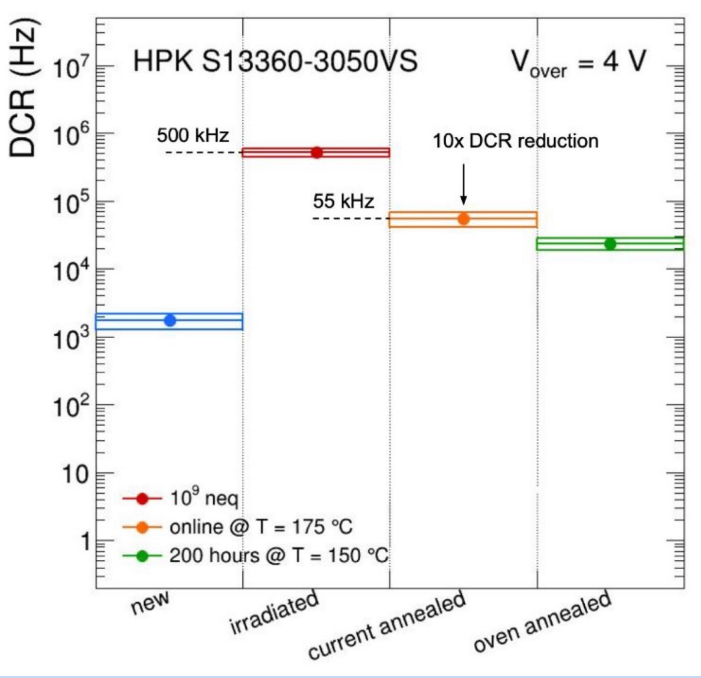
Comparison of the results achieved with proton and neutron irradiation sources

Study of annealing in-situ technique

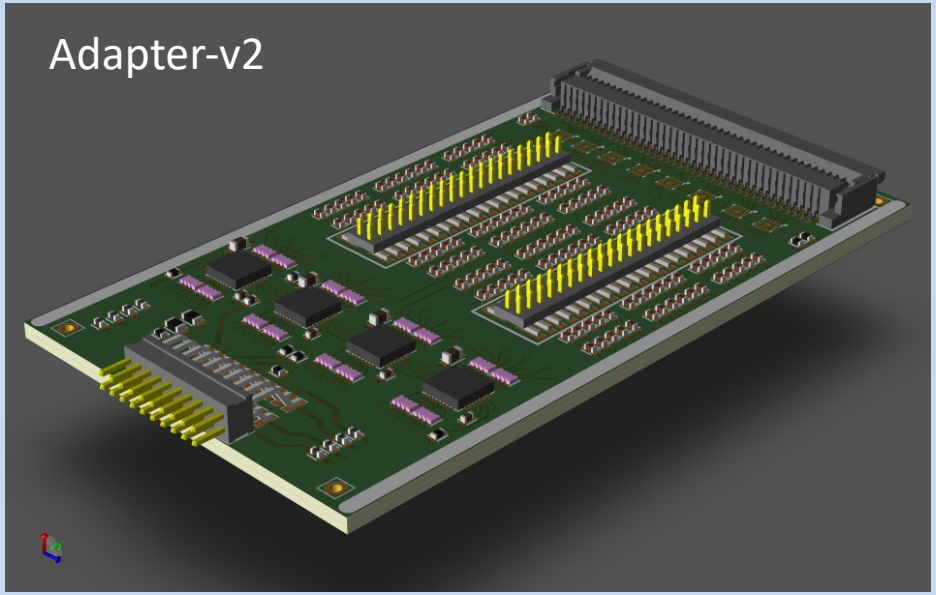
Follow new Hamamatsu developments: quench resistor (PDE, signal width), protective layers

INFN-FBK run: SiPM optized for single-photon detection and low dark rate





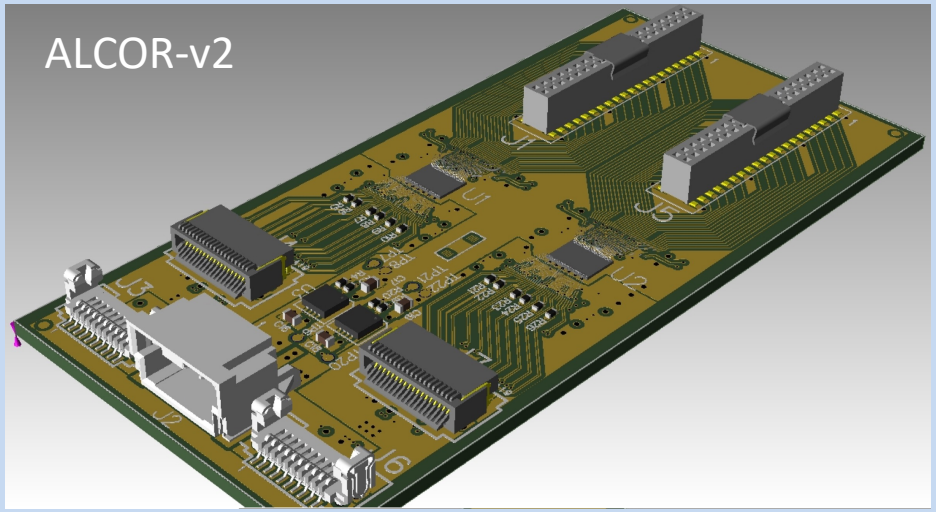
dRICH Front-End

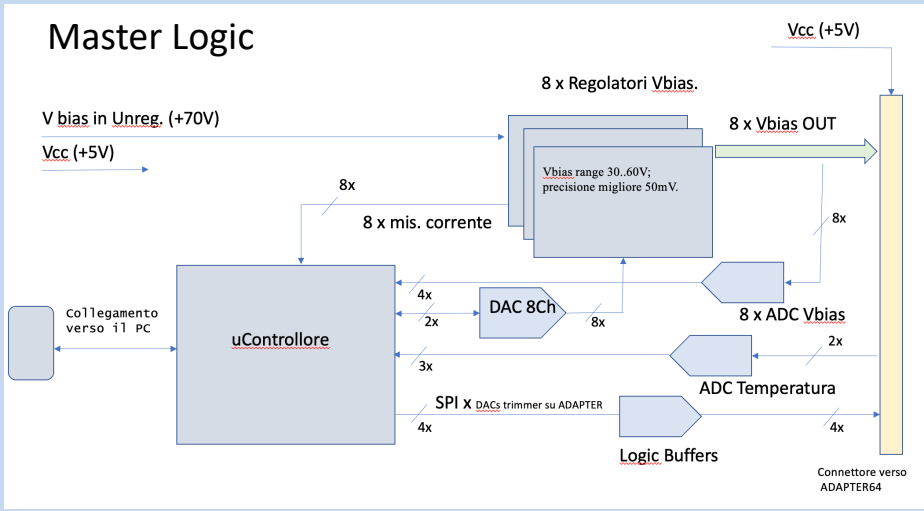


Alcor-v2, Adapter-v2 and MasterLogic
to drive 64 channels

- Vbias regulators and trimmers
- Temperature monitor
- In-situ annealing

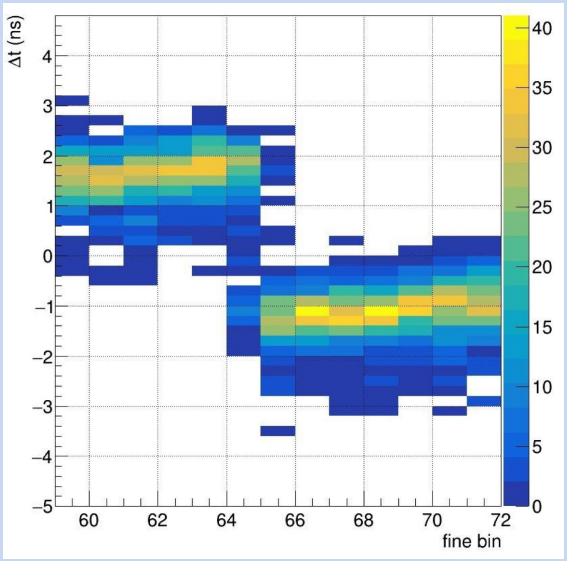
INFN funds granted in february for production



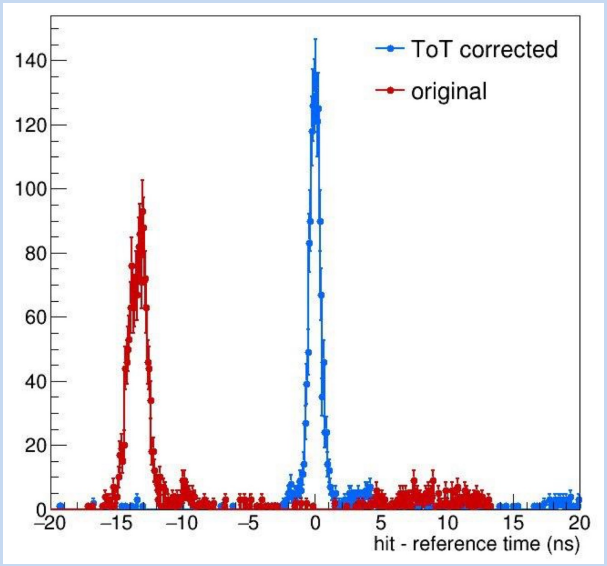


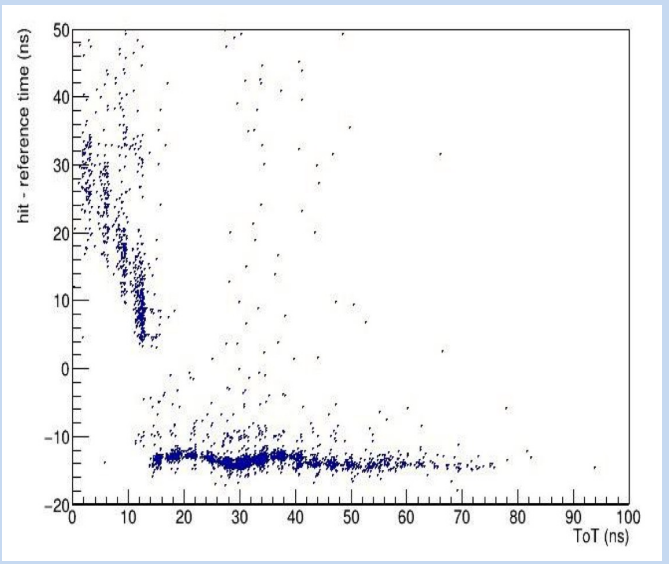
ALCOR ++

Fine TDC



Time-over-Threshold readout (good for time-resolution, afterpulses)

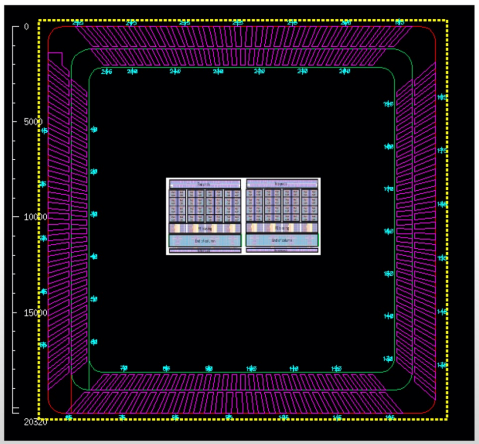




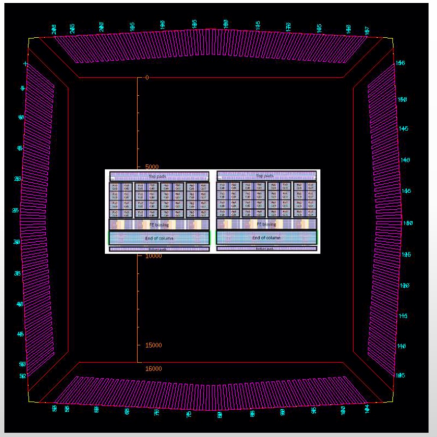
- TDC clock ambiguity
- TOT orphans and data coupling
- 400 MHz operation
- 64 channels packaging

Start evaluting chip packaging
- Standard bonding
- BGA higher cost, best implementation

PBGA 256

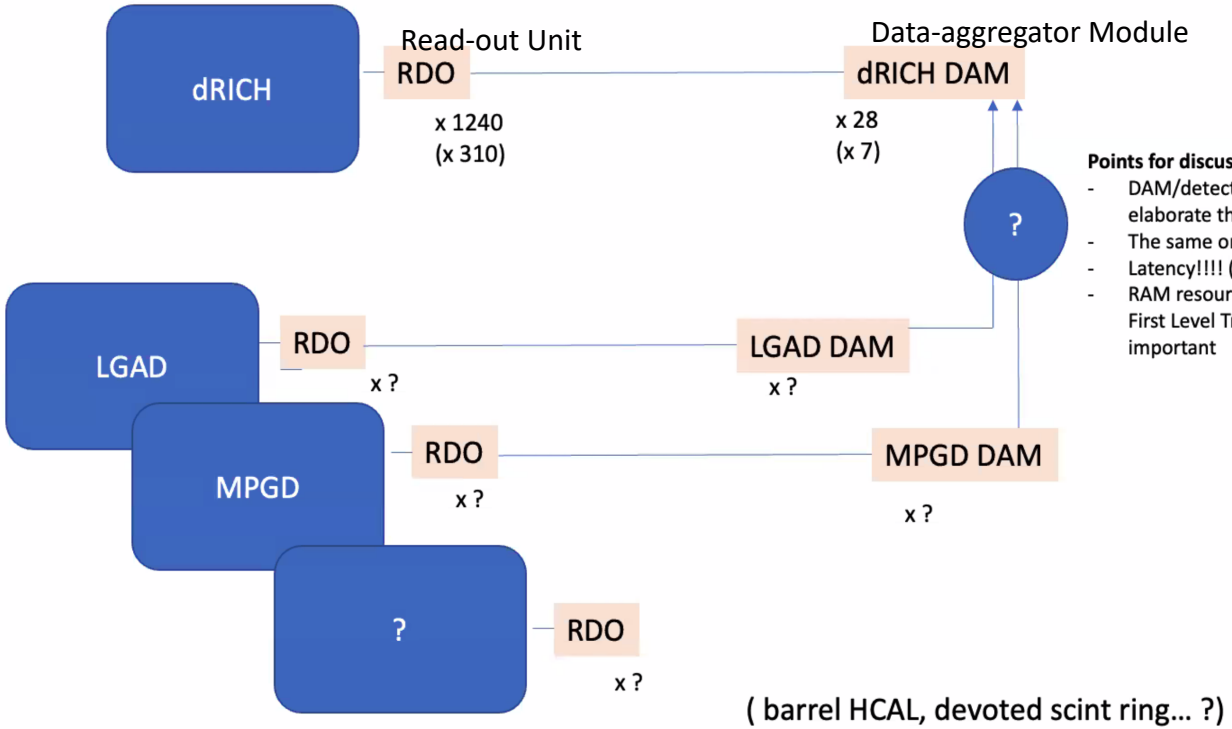


QFP 208



dRICH DAQ

Various cenario under discussion (under DAQ WG) for limiting the dRICH throughtput



Points for discussion:

- DAM/detector modularity not trivial to elaborate then "trigger logic"
- The same on receiving dRICH DAM
- Latency!!!! (10 usec?)
- RAM resources for BC pipelines (à la ZEUS First Level Trigger) in DAM become important

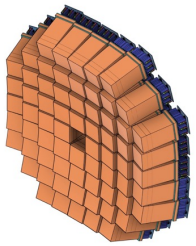
Detector	Channels	DAQ Input (Gbps)	DAQ Output (Gbps)
B0 Si	400M	<1	<1
B0 AC-LGAD	500k	<1	<1
RP+OMD+ZDC	700k	<1	<1
FB Cal	4k	80	1
ECal	34k	5	5
HCal	39k	5.5	5.5
Imaging bECal	619M	4	4
Si Tracking	60B	5	5
Micromegas Tracking	66k	2.6	.6
GEM Tracking	28k	2.4	.5
uRWELL Tracking	50k	2.4	.5
dRICH	300k	1830	14
pfRICH	225k	1380	12
DIRC	100k	11	11
TOF	332k	3	.8
Total		3334	62.9

In general adding readout lines (DAM and fibers) is just a matter of money
DAM "decision" tree could possibly implement a data reduction stream
A possible interaction tagger (beam activity sensitive) could serve a wide purpouse

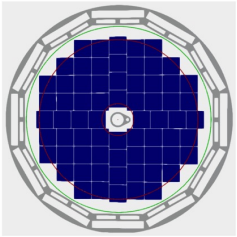
HRPPDs

EIC project driven, common development

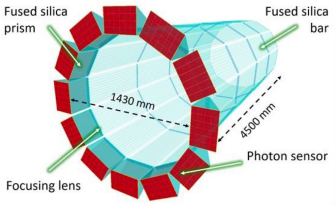
mRICH / pfRICH	either DC-coupled or Gen II, 10cm formfactor
DIRC	DC-coupled, 10cm



mRICH: 68 HRPPDs total

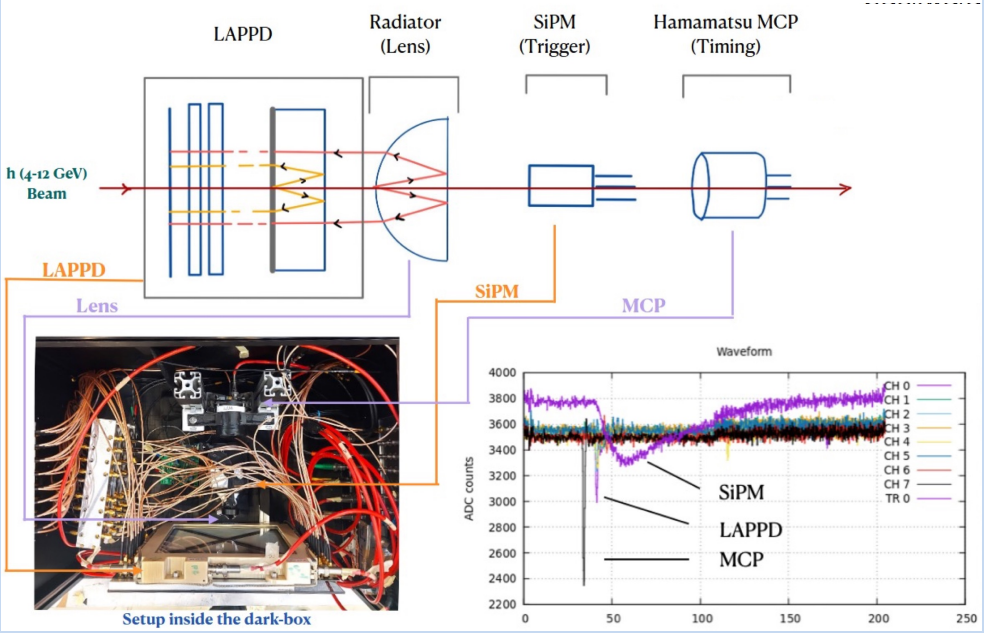


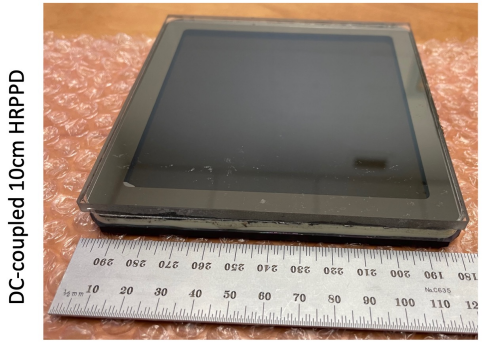
pfRICH sensor plane: 68 HRPPDs total



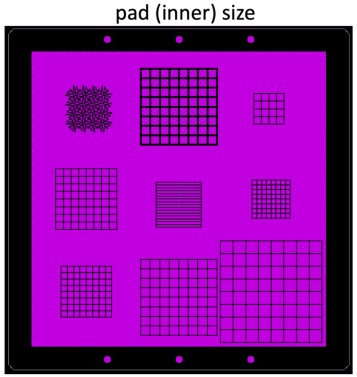
DIRC: 12*3*2 = 72 HRPPDs total

Beam test October 2022, CERN

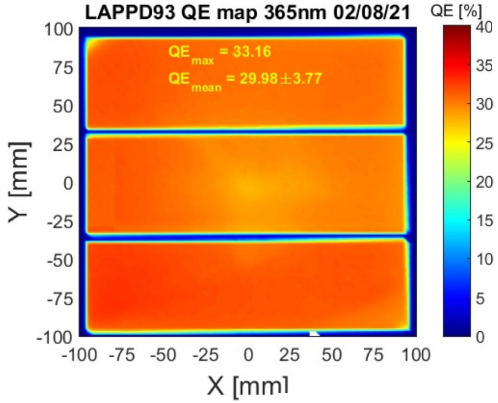




Active area

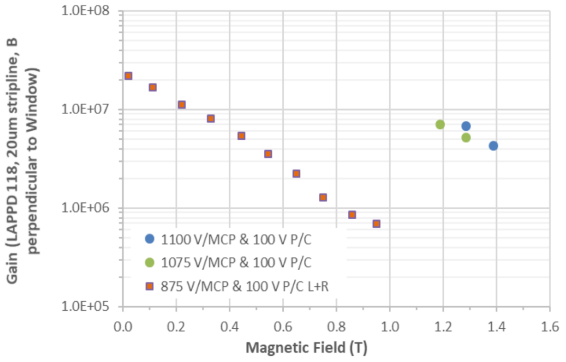


Pixalization/ coupling



Photon Detection Efficiency

Magnetic Field Tolerance



Aerogel

Joint effort among RICHes, under the umbrella of EIC project

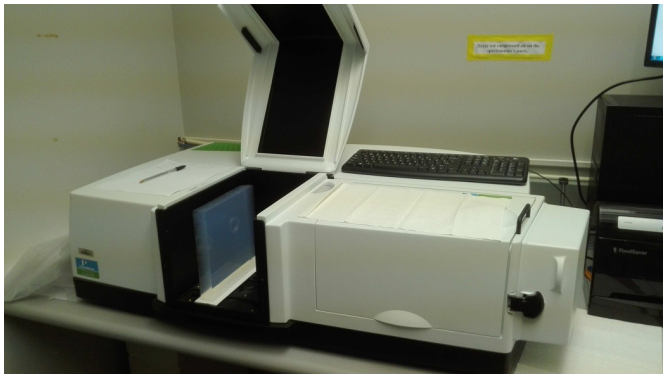
Define common specifications
Identify priorities in development
Negotiate test productions

✓ Chiba (Japan)
✓ ASPEN (US)
……..

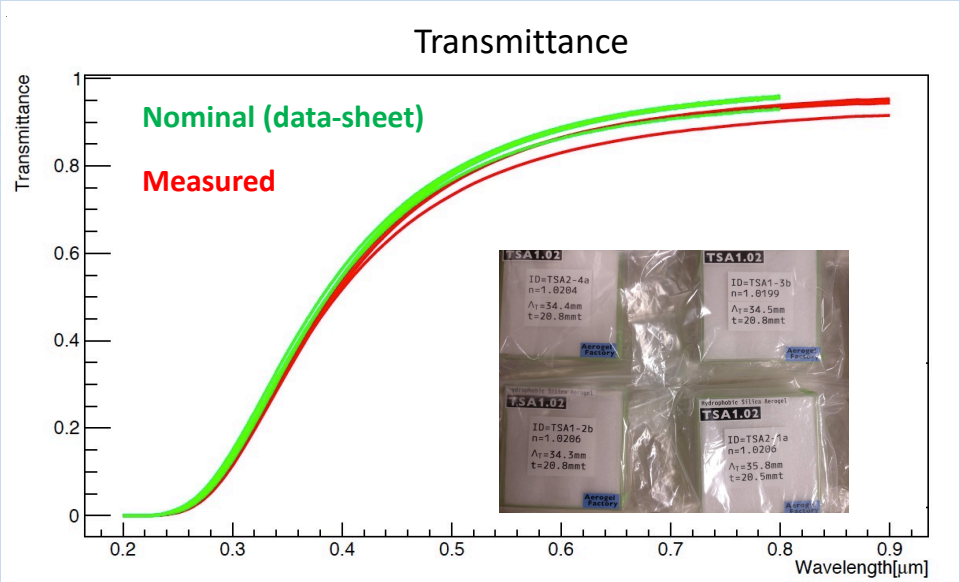
Synergy with ALICE R&D

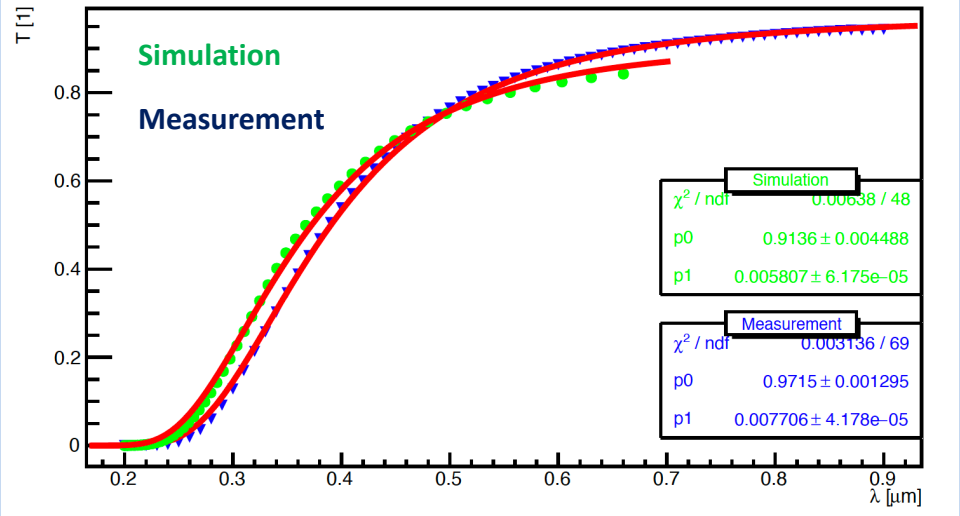
Laboratory characterization of optical properties

Radiators: refractive index, transmittance, surface planarity, forward scattering



Samples from Aerogel Factory (Japan)





Mirrors

Composite mirror applications (Tucson, AZ)

Meet to discuss EIC needs

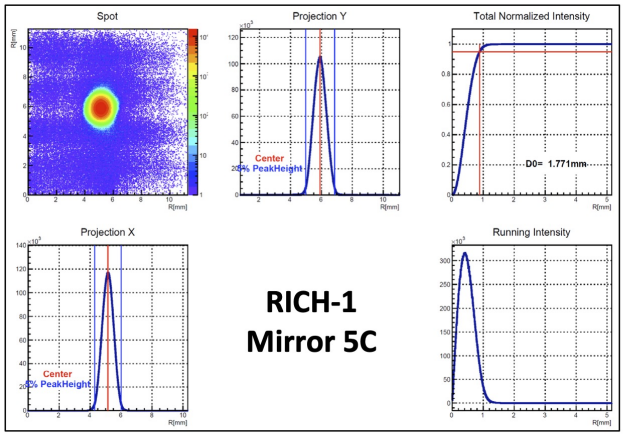
CMA ready to proceed with a demonstrator

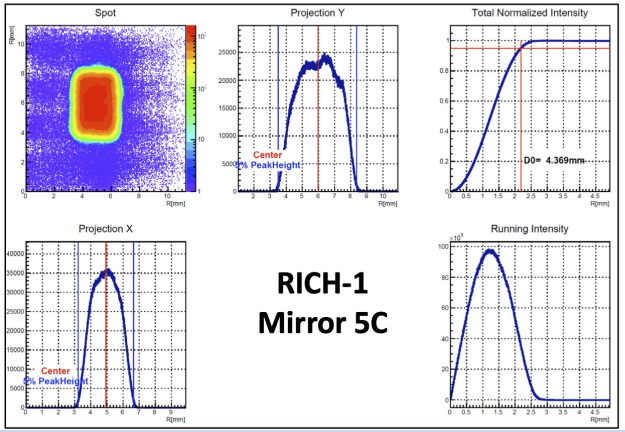
Slumped glass as cheap mandrel (no polishing)

RICH-1 core: more expensive (2x production time) rigid with material budget < 4.5 Kg/m^2

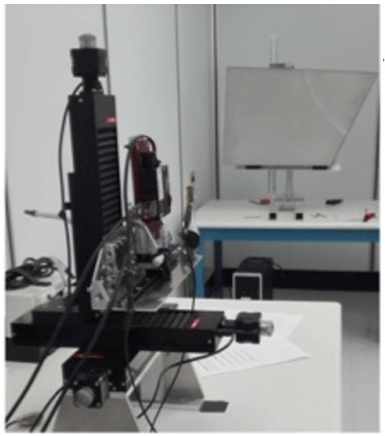
RICH-2 core: easier but less rigid → increase thickness but material budget still < 6 Kg/m^2

Mirrors: pointlike image, shape accuracy, surface rms

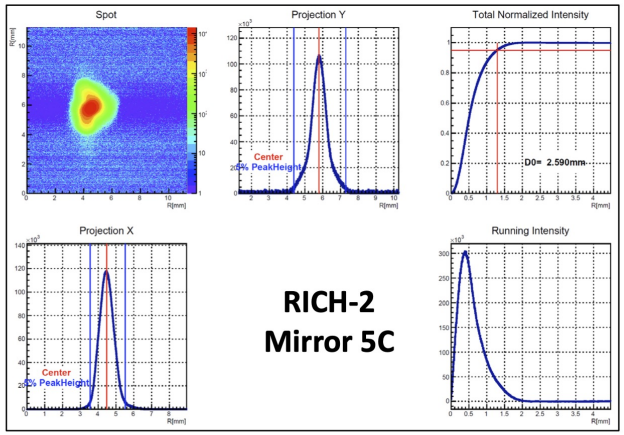


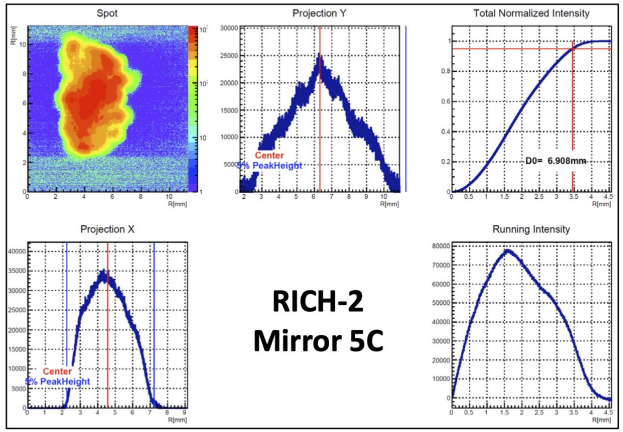


At minimum



Few mm from minimum

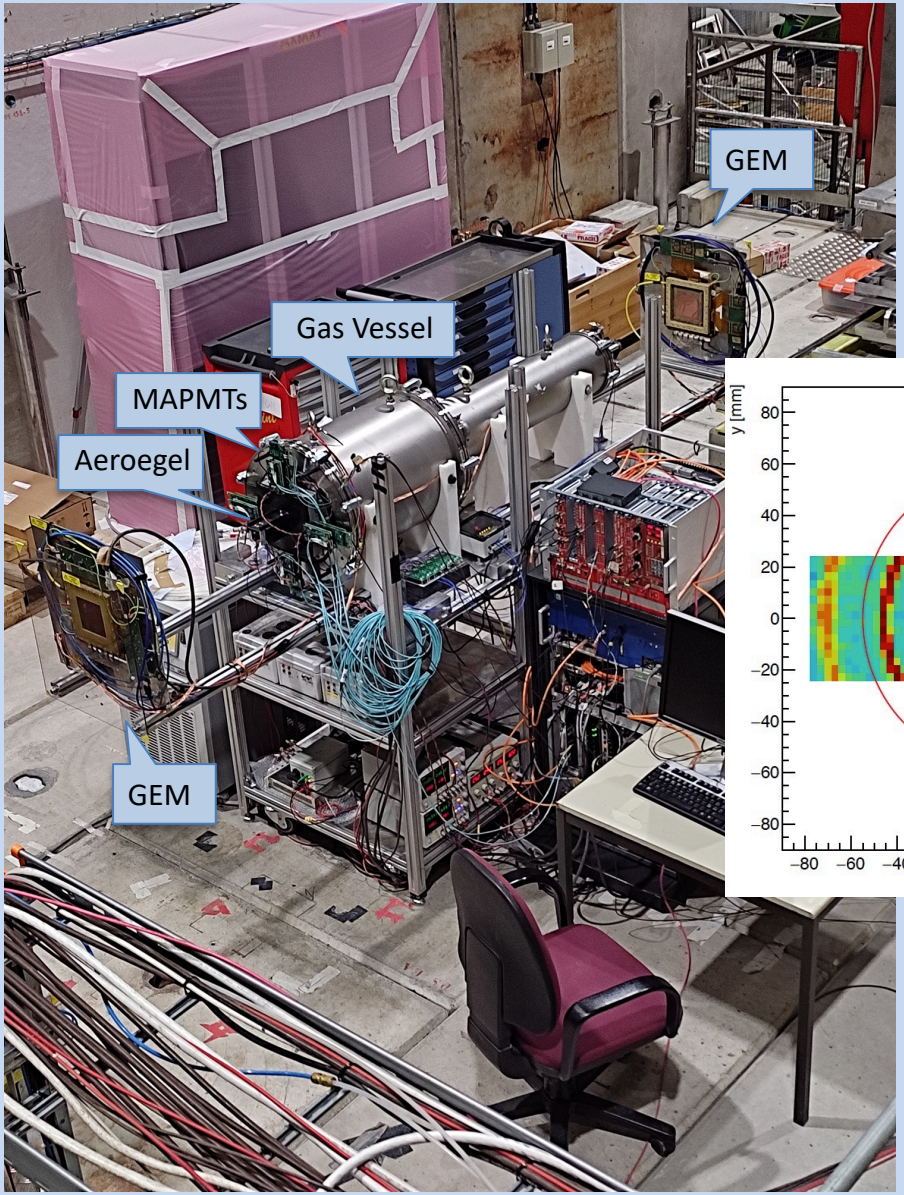


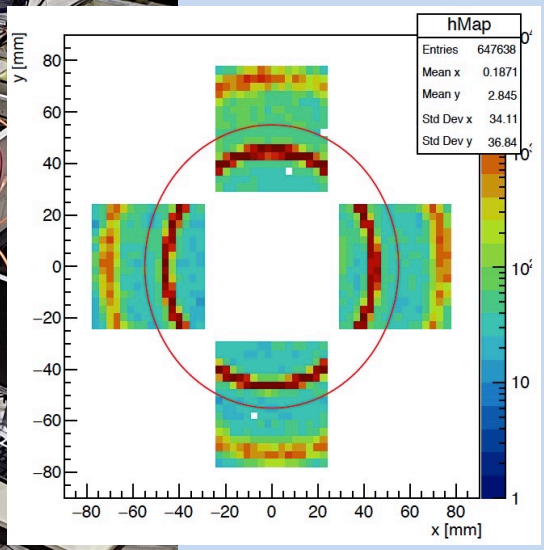


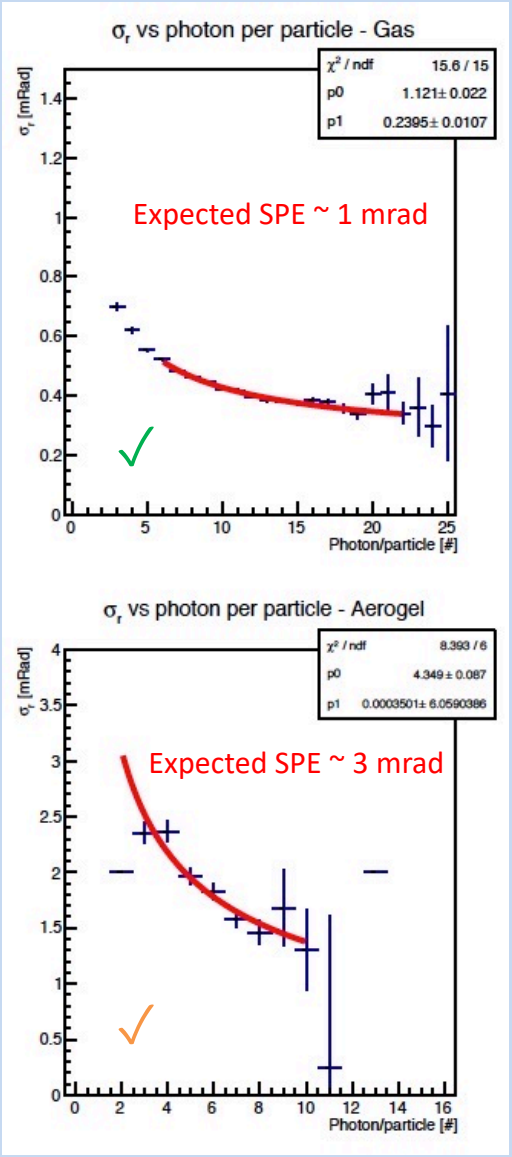
dRICH Prototype

Investigating synergic test-beam with ALICE RICH (October ‘23)

Goal: EIC-driven readout







dRICH in 2023

Goal: Consolidate the baseline configuration

Global layout: optimize the performance (acceptance, resolution) within EPIC
conjugate physics requirements with mechanical constraints

Mechanics: assess the feasibility of the over-pressure case

Readout: develop an EIC-driven detector plane based on SiPM + ALCORv2
define a sustainable streaming readout architecture

Aerogel: organize an common R&D among the EIC RICH detectors

Mirrors: validate carbon-fiber technology

Prototype: evolve into EIC-driven technology solutions (from reference to realistic components)
organize a new test-beam campaign