The dRICH Project

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, eRD…)

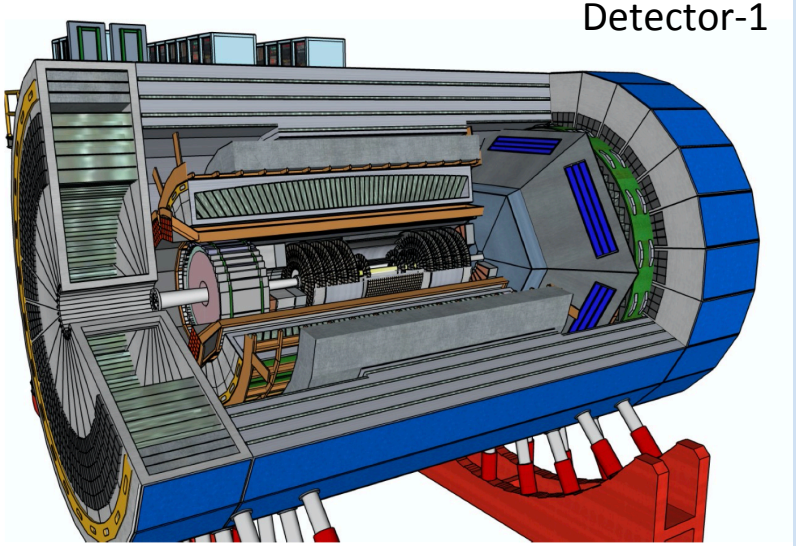
INFN

BA, BO, CS

CT, FE, GE,

LNF, LNS, RM1,

SA, TO, TS



Duke University

NISER

Georgia State University

Stony Brook University

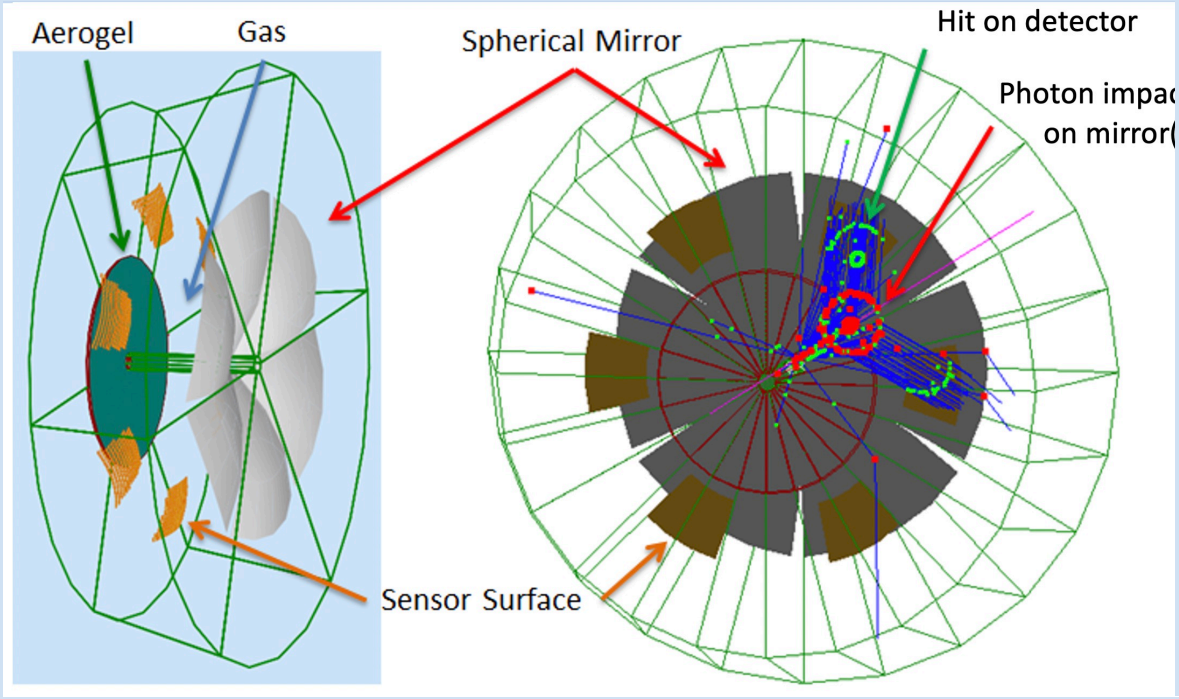
p: 41 GeV, 100 to 275 GeV → p/A beam

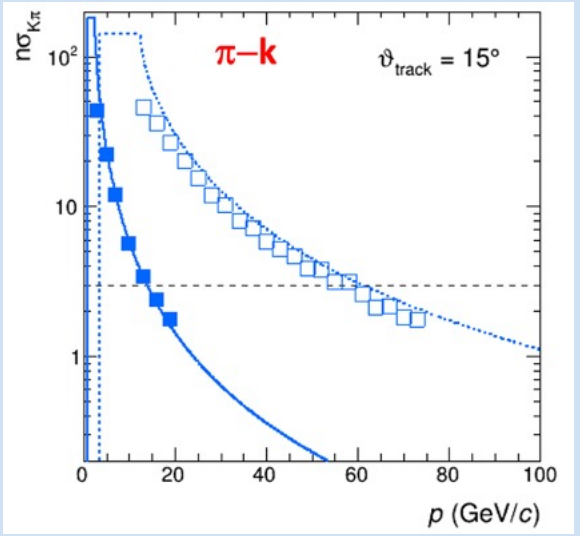
e beam ← **e: 5 GeV to 18 GeV**

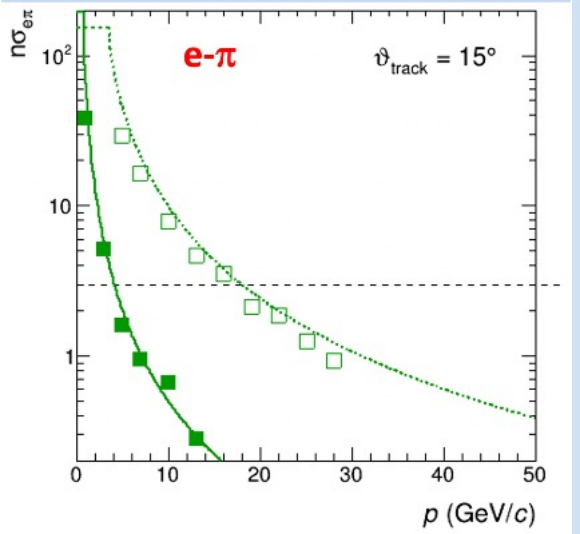
Contalbrigo Marco - INFN Ferrara

Dual Radiator RICH @ EIC

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)

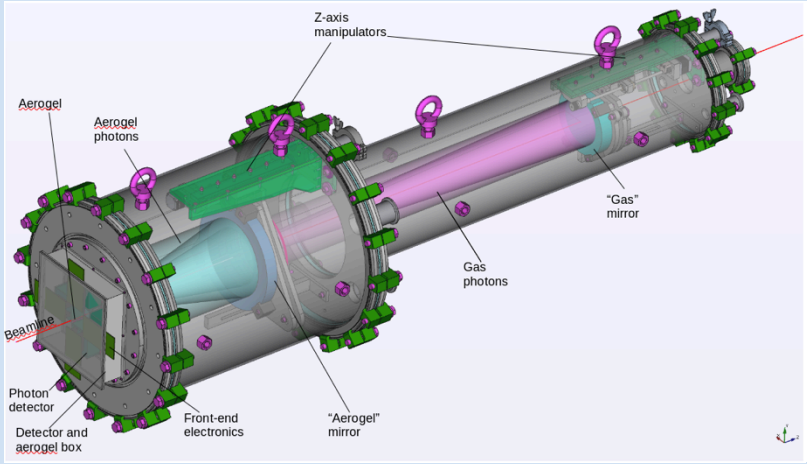
Detector: 0.5 m²/sector , 3x3 mm² pixel. → SiPM option

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

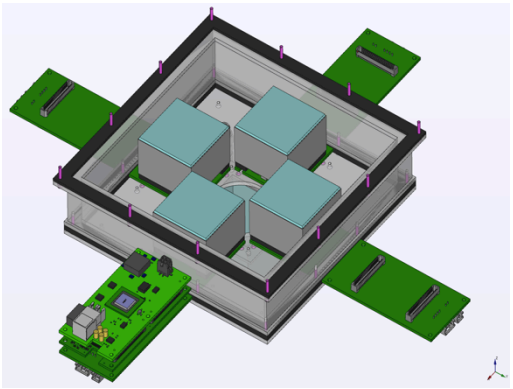
Targeted R&D eRD102

Prototipe to validate dual-radiator working principle,
study compatibility with B field and streaming readout,
optimize performance and define specifications for components

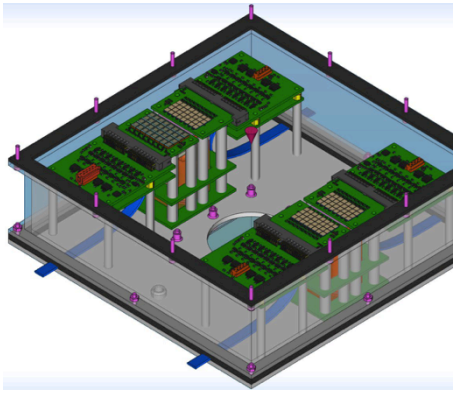
FY23 proposal
Just submitted

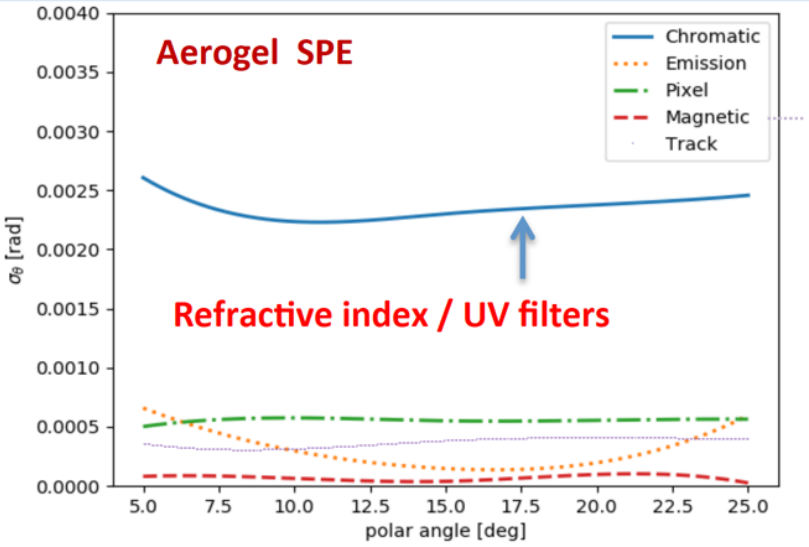


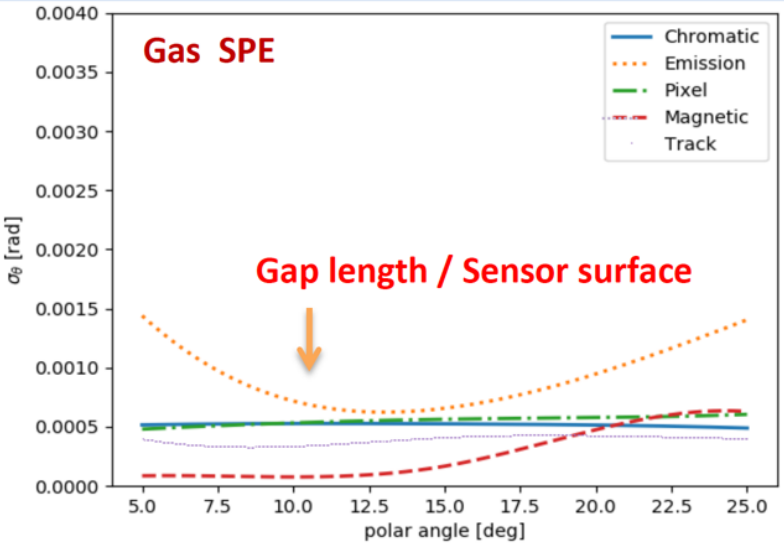
Reference detector



EIC driven detector



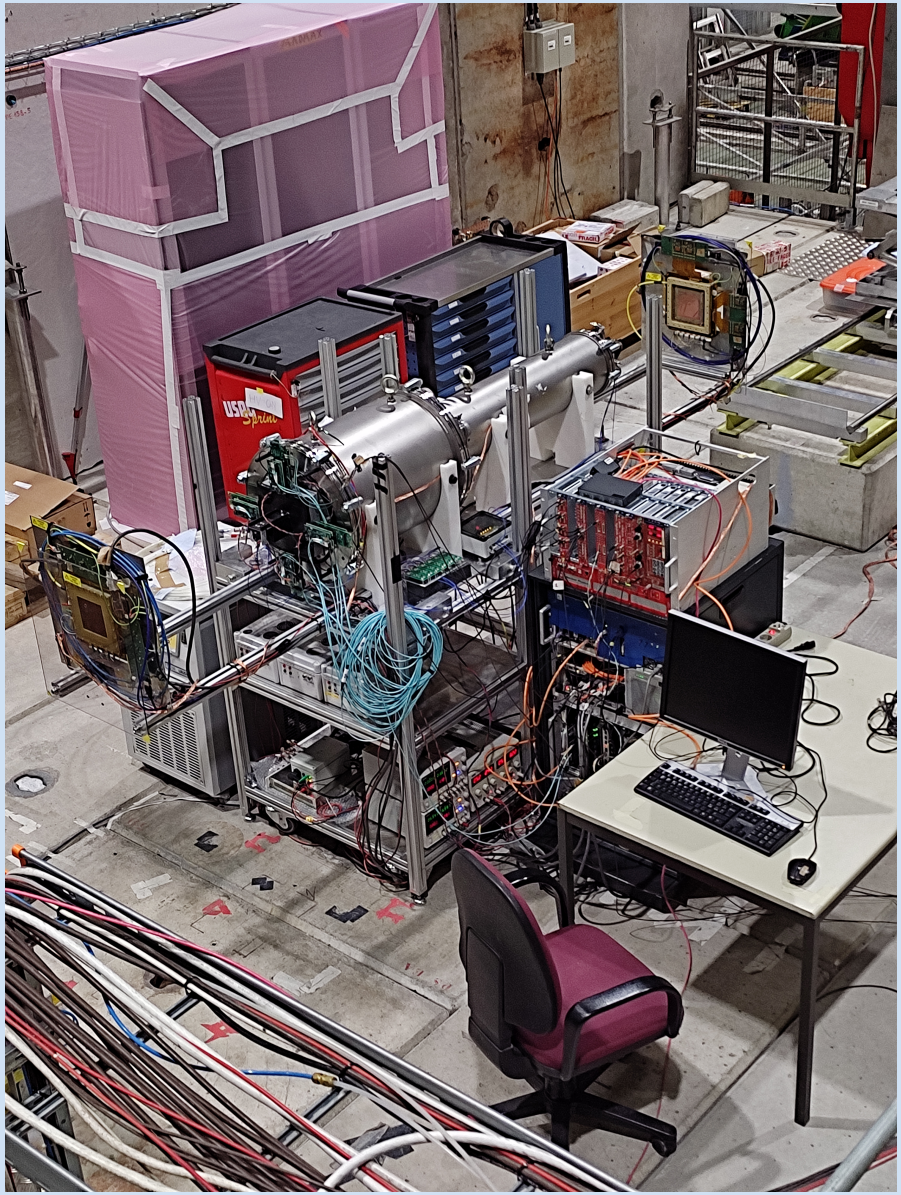




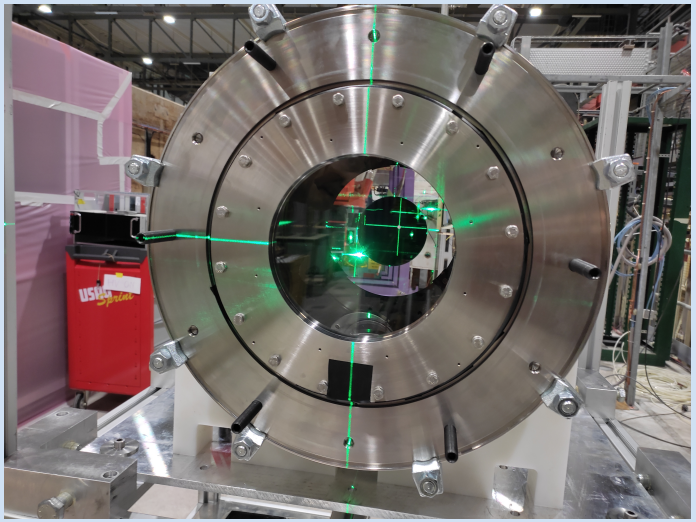

RICH 2022
XI International Workshop on
Ring Imaging Cherenkov Detectors
Dedicated to the memory of Jacques Séguinot
Edinburgh, UK
12 – 16 September 2022
Co-winner of the early career poster prize:
Sponsored by
CAEN
Tools for Discovery
Simone Vallarino
INFN Ferrara
The dual Ring Imaging Cherenkov detector
for the Electron-Ion Collider
SCAN ME
https://indico.cern.ch/e/rich2022
rich2022@ph.ed.ac.uk

dRICH Prototype

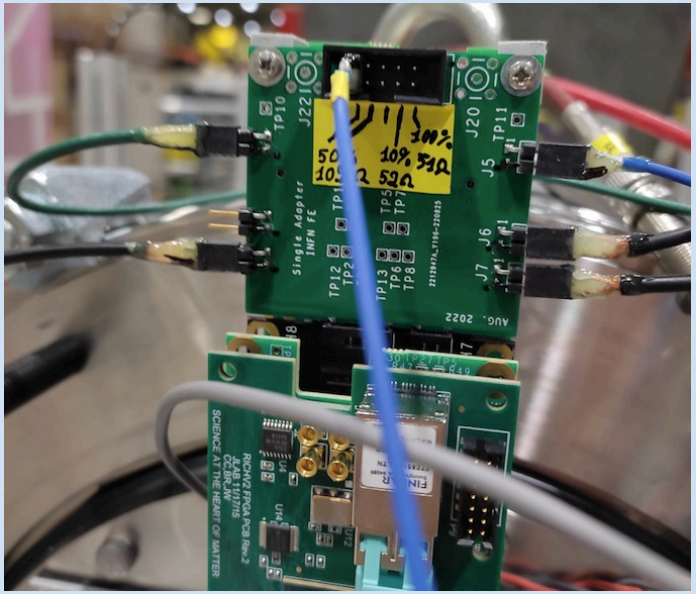
Test beam @ PPE158 - SPS September 2022



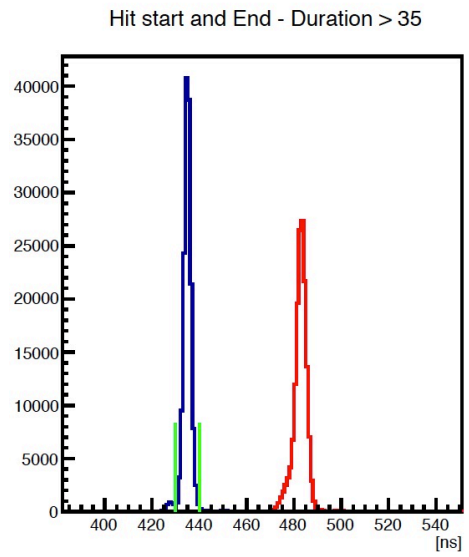
Refined alignment tools and procedure

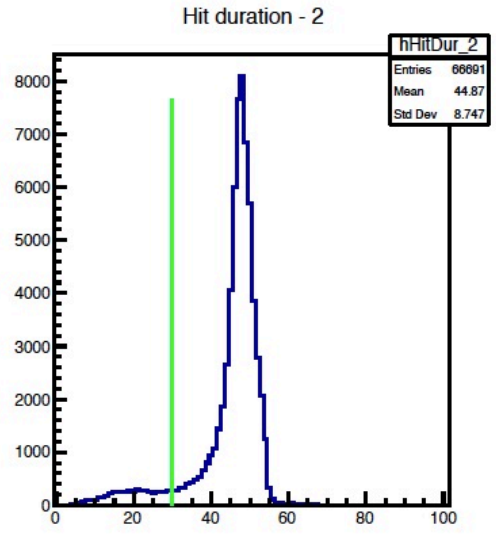


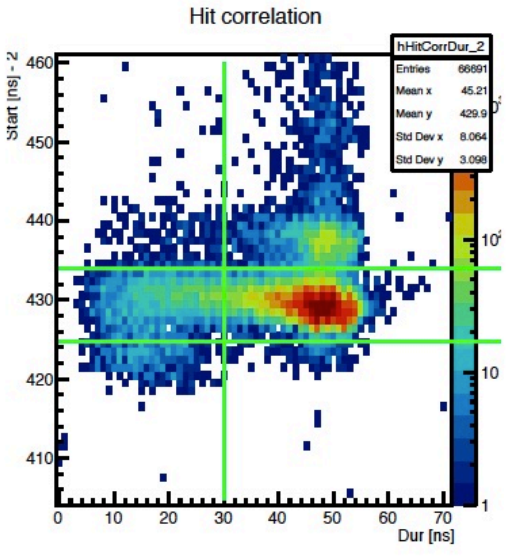
Beam information: time and Cherenkov tagging

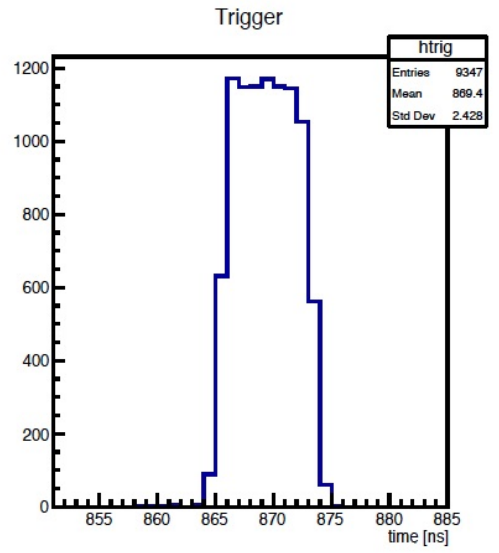


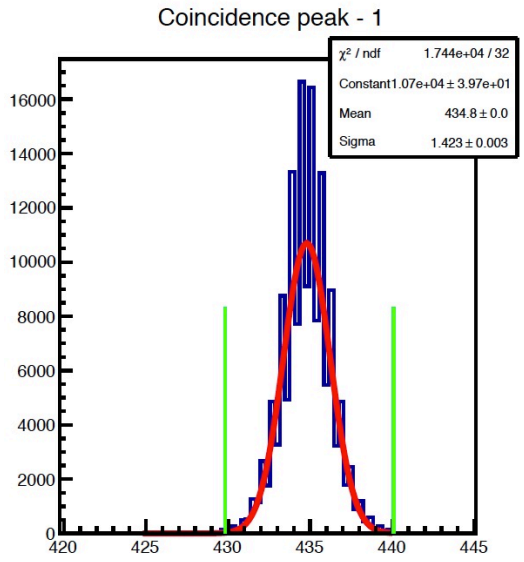
Time Analysis

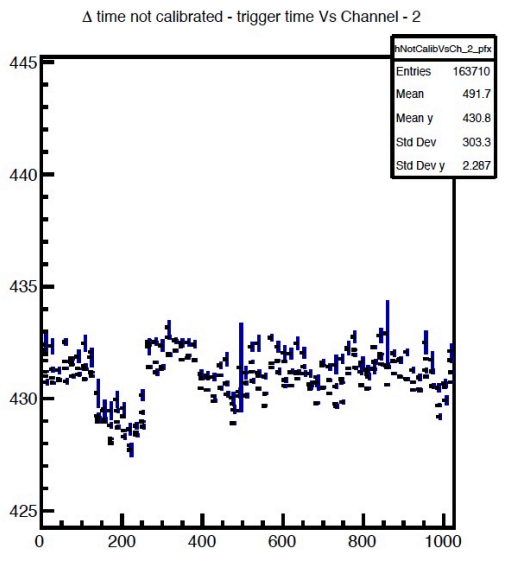




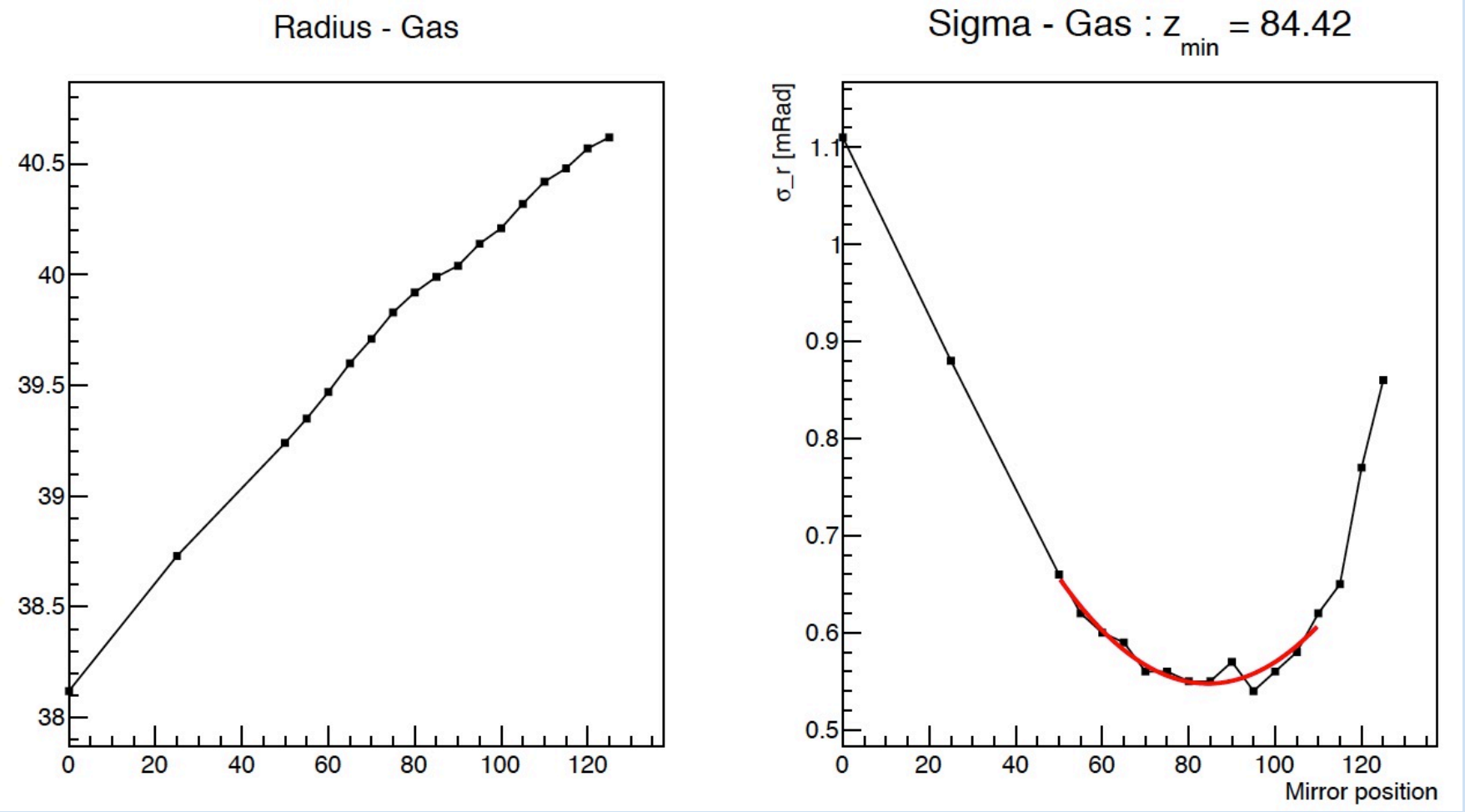






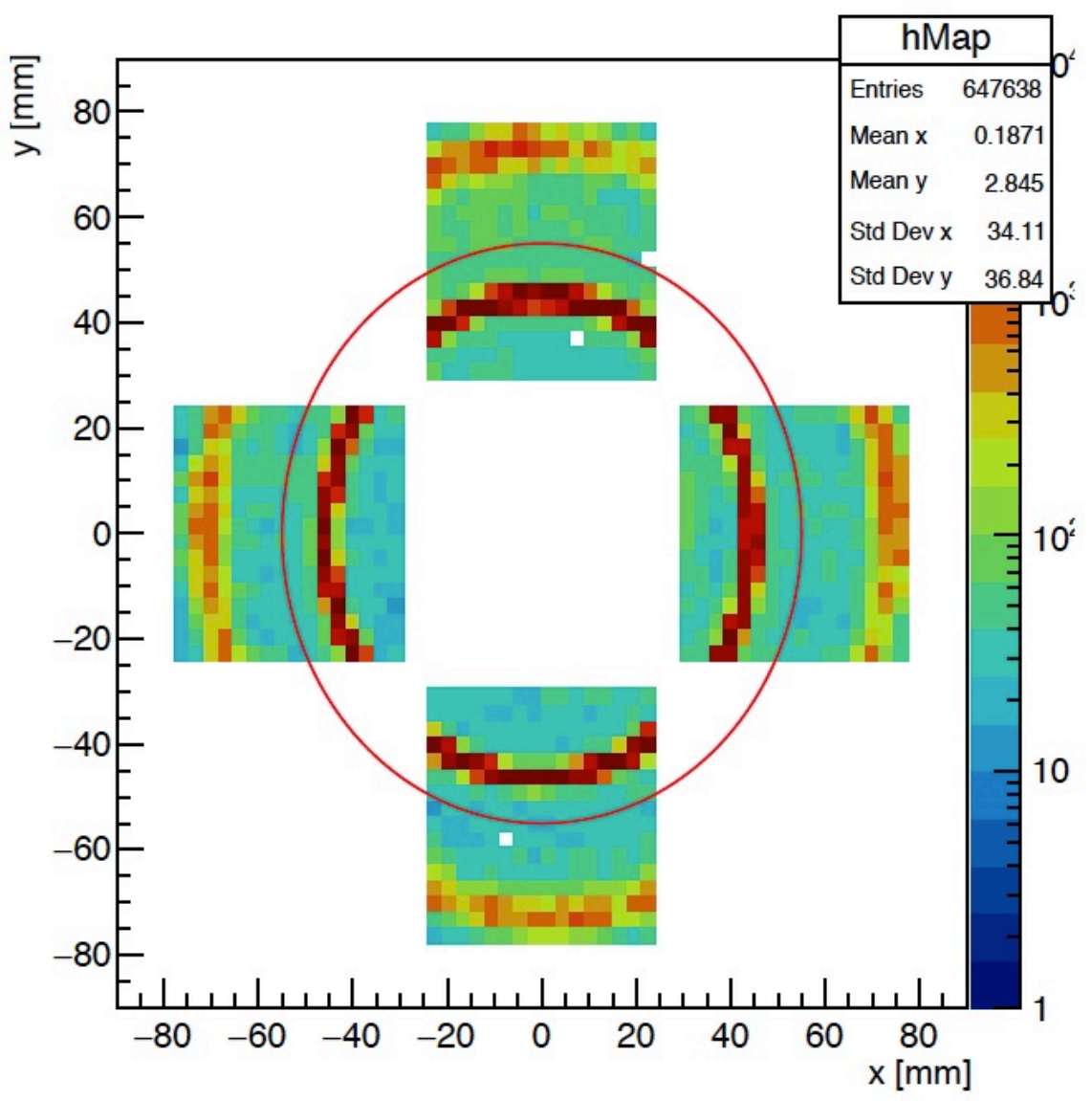


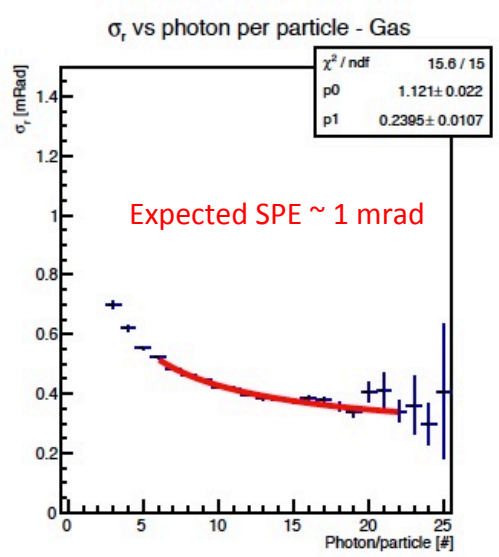
Scan the mirror position to align the focal plane on the sensor surface

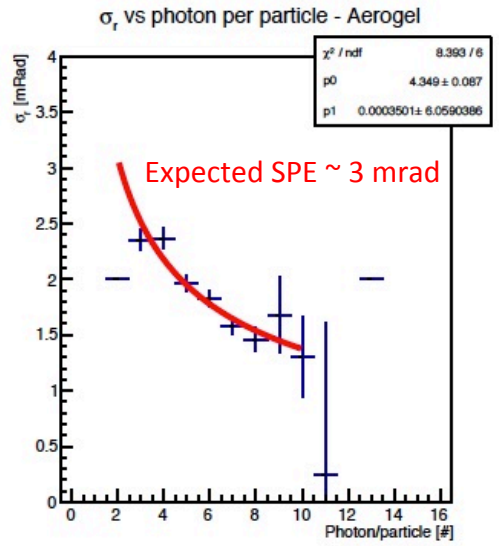


dRICH Prototype

Two radiators with 180 hadron beam with reference readout

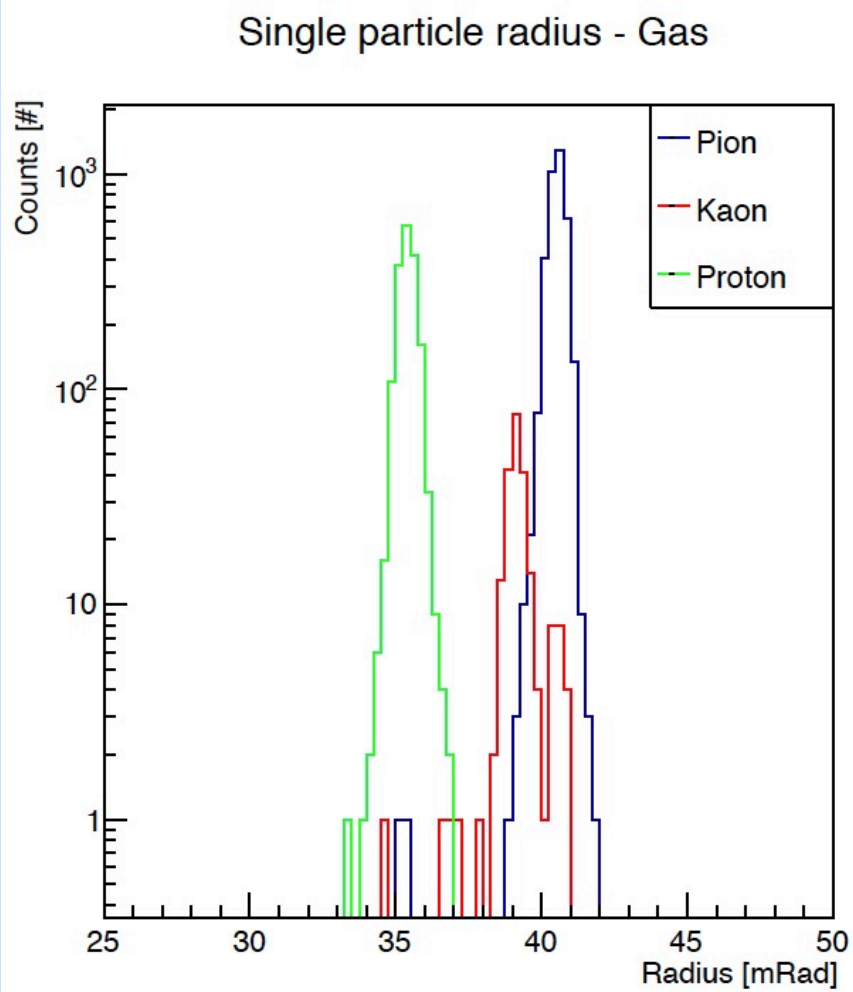


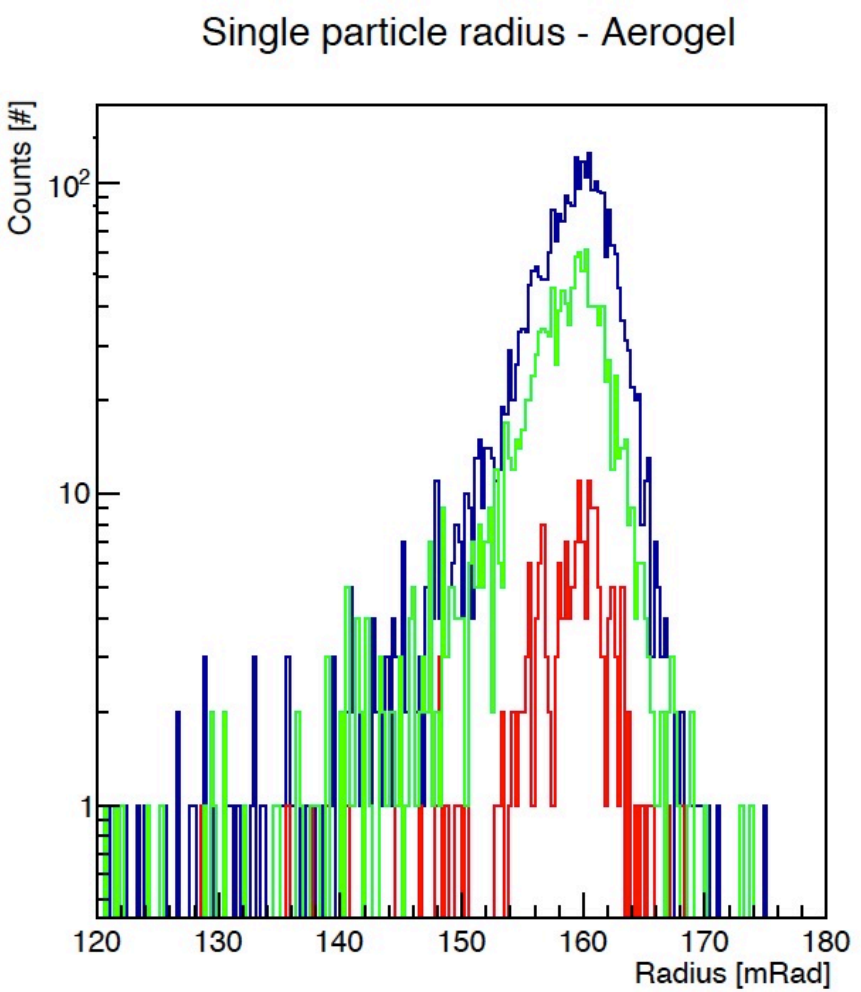




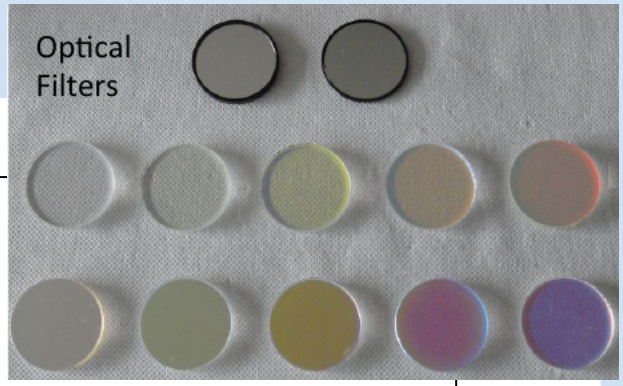
dRICH Prototype

Test at 50 GeV mixed hadron beam with tagging by beam instrumentation (3x gas Cherenkov)



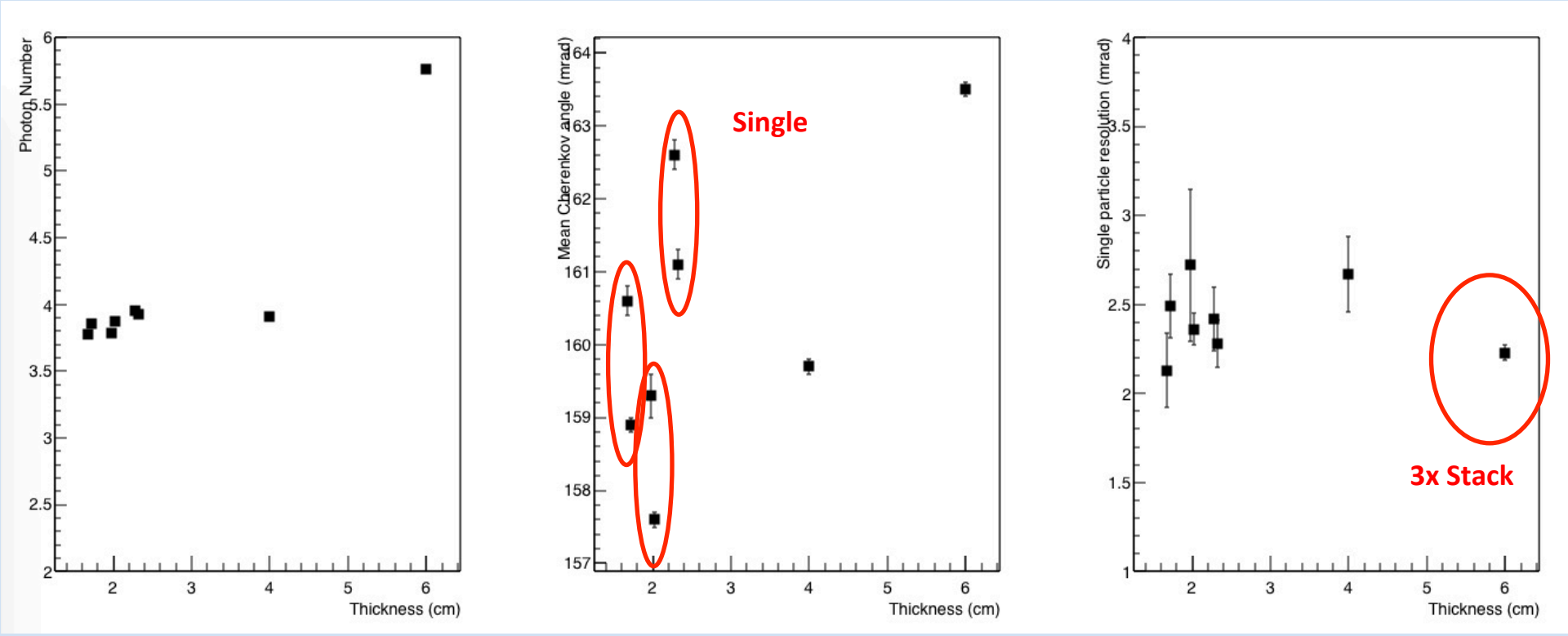


Chromatic dispersion measured prototype with optical filters



dRICH Aerogel

Compare single tile and stack of tiles (from Aerogel Factory)



Goals:

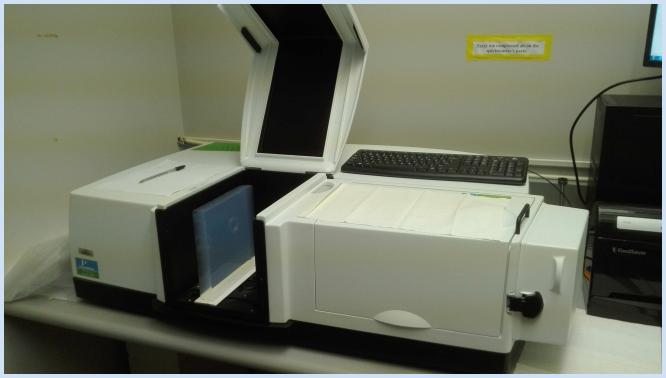
- Compare surfaces of same tile (only exit surface matters)
- Compare refractive index and photon yield among different tiles
- Check tile stack performance

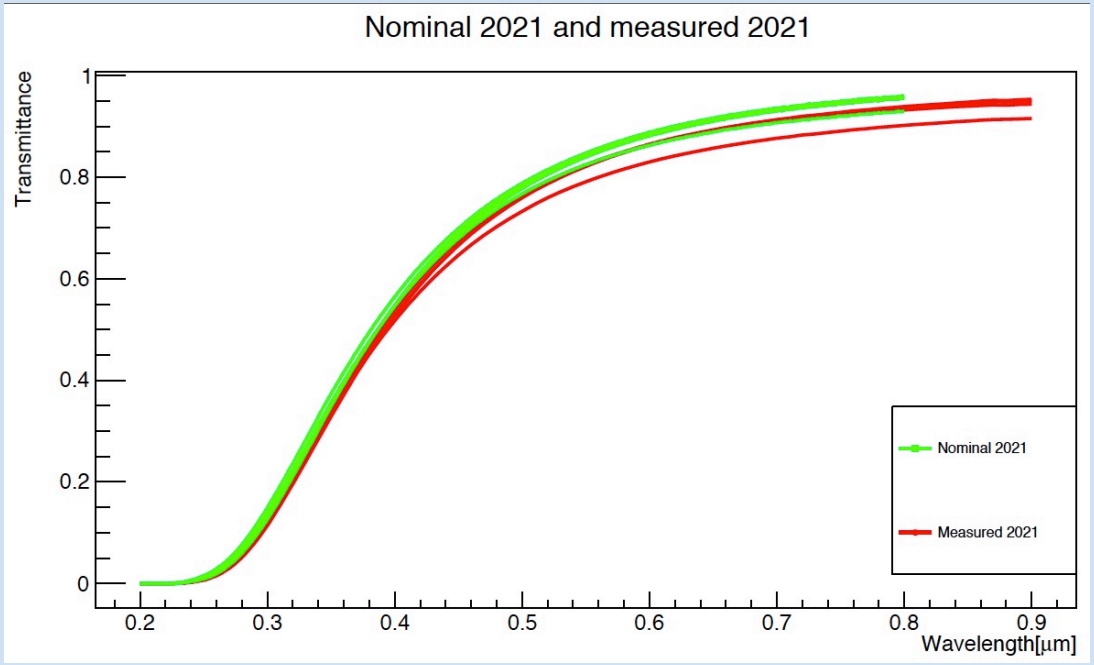
Next Steps: Aerogel

Existing facility to study detailed radiator optical properties and alternatives

Aerogel:
Safe handling and characterization (refractive index, surface planarity, forward scattering)

Interplay between radiators:
UV filters, refractive index optimization





INFN 2023: Funds for new samples

Aerogel Factory: negotiate production of large

goals: study reproducibility
1st batch: 1.0206, 1.0206, 1.0199, 1.0204
2nd batch: 1.0201, 1.0207, 1.0210, 1.0218

negotiate large (20x20 cm^2) tiles with ALICE

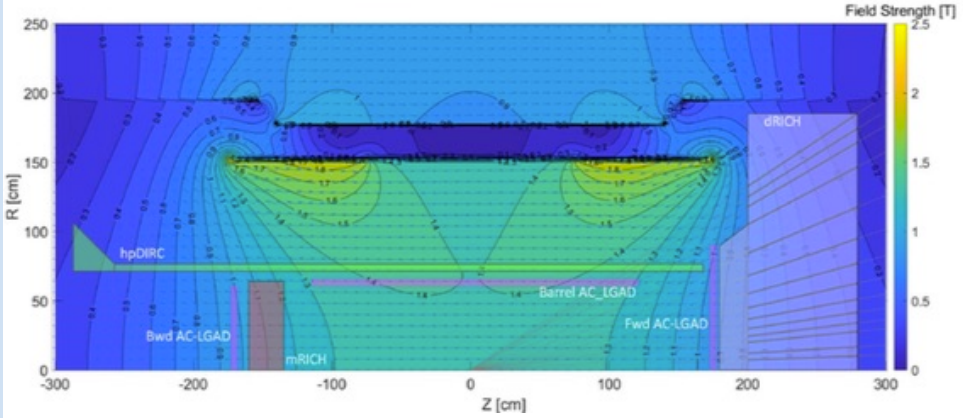
ASPEN: initial contacts with CUA (Tanja Horn)

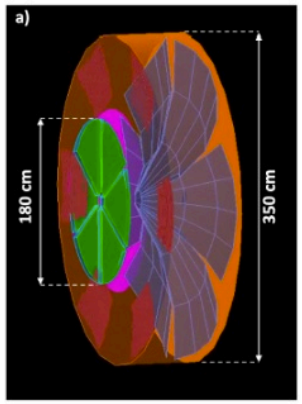
goal: obtain few samples at 1.02

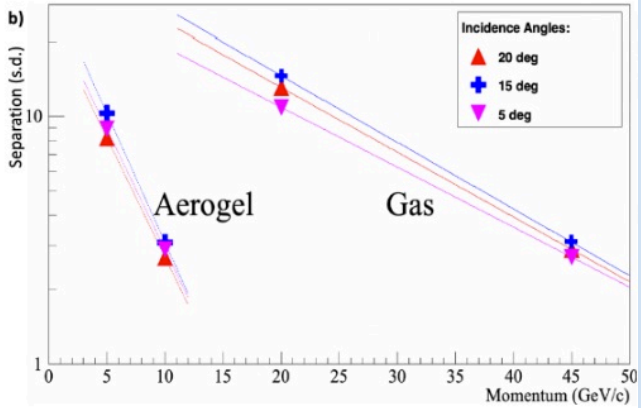
dRICH Simulations

Chandra @ RICH 2022

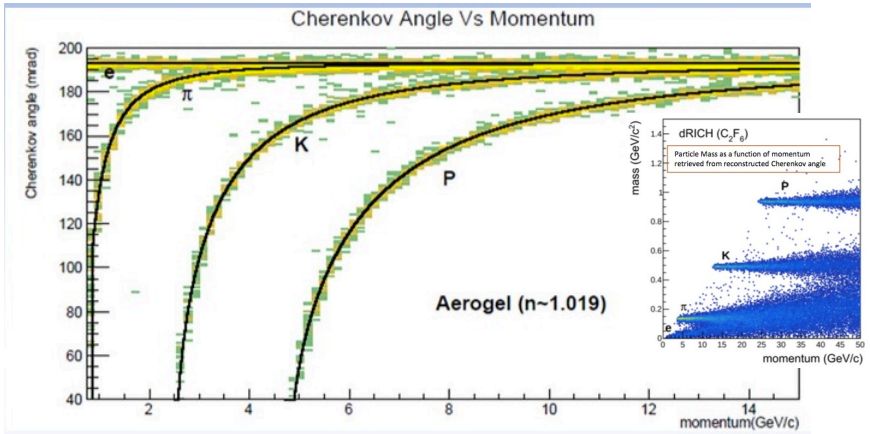
ECCE simulation

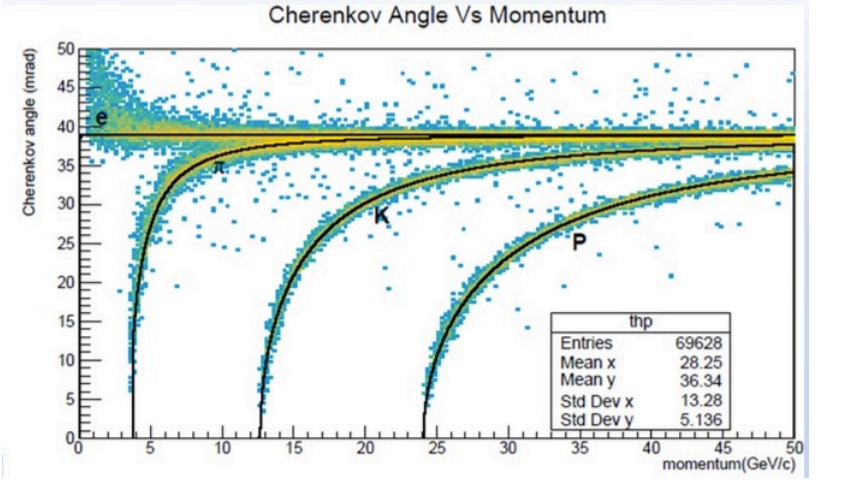






ATHENA simulation



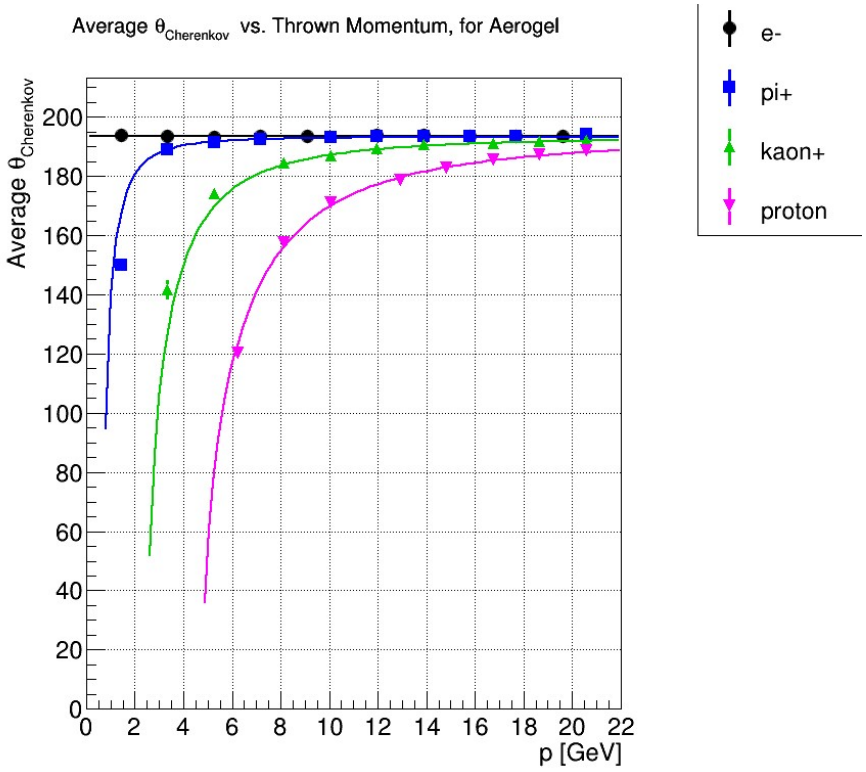


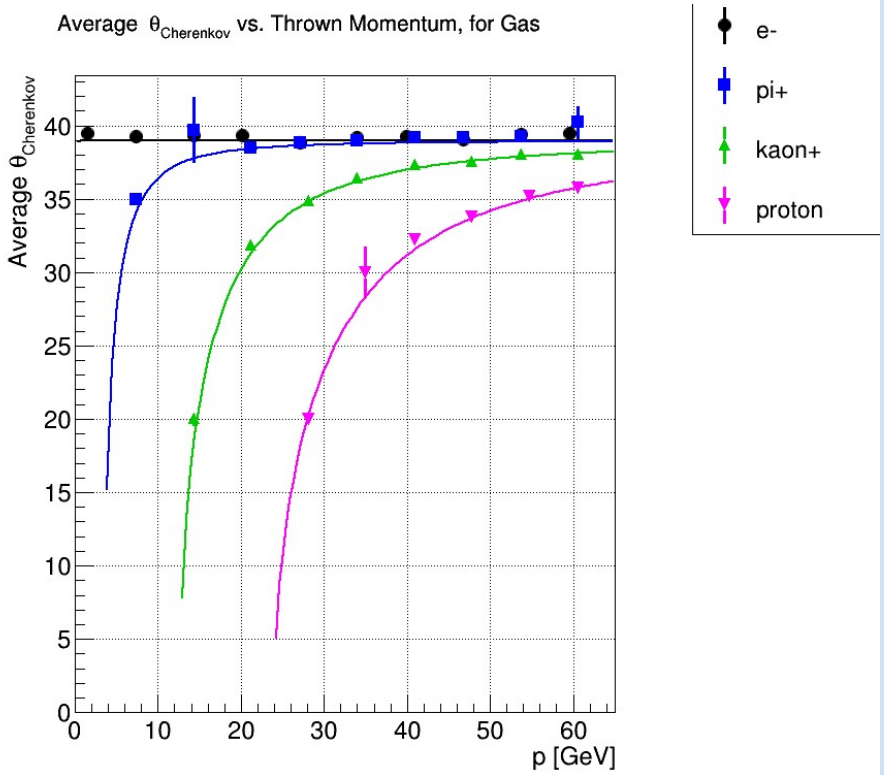
dRICH Simulations

dRICH simulation model was adapted to ATHENA and ECCE

Full simulation chain now implemented into EPIC

Inputs for a realistic model are becoming available from prototype

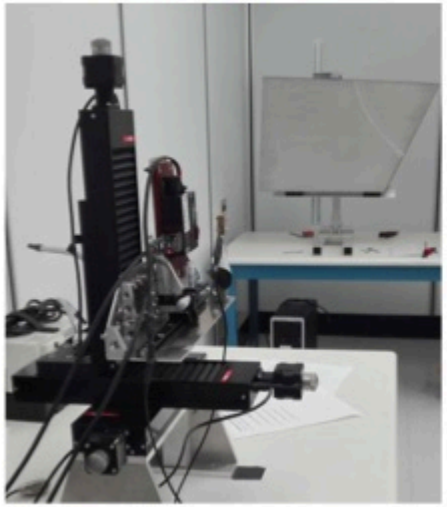




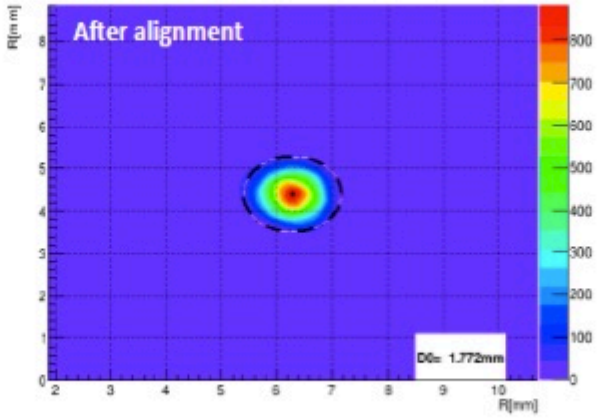
Next Steps: Mirror & Mechanics

INFN 2023: funds for a CFRP mirror demonstrator

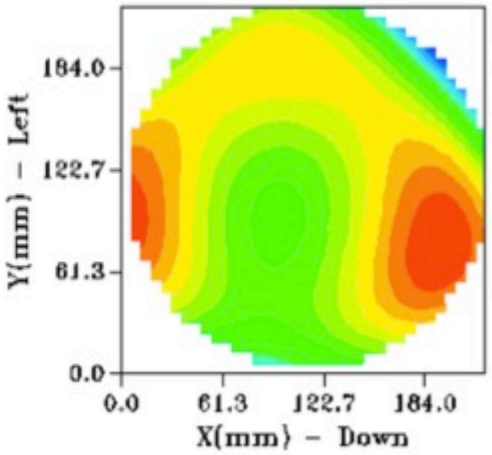
Surface Quality



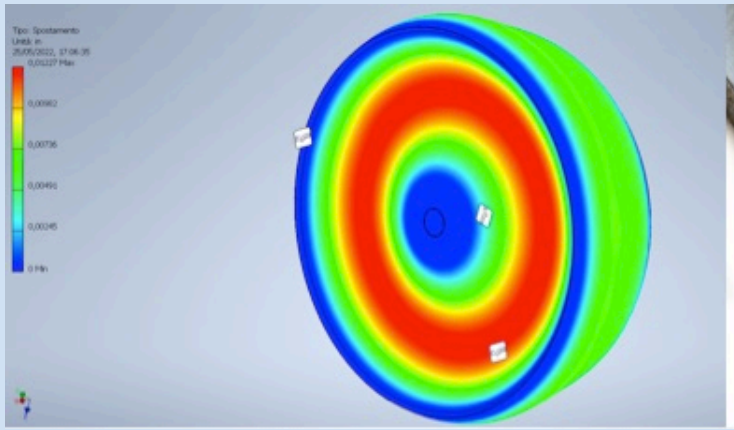
Pointlike source image



Shack-Hartmann sensor



INFN 2032: funds for a composite material study (targeted to over-pressure case)
Contacts with BNL and JLab for engineering support



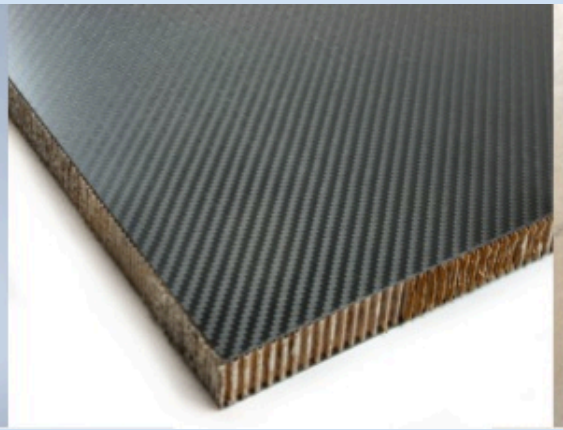
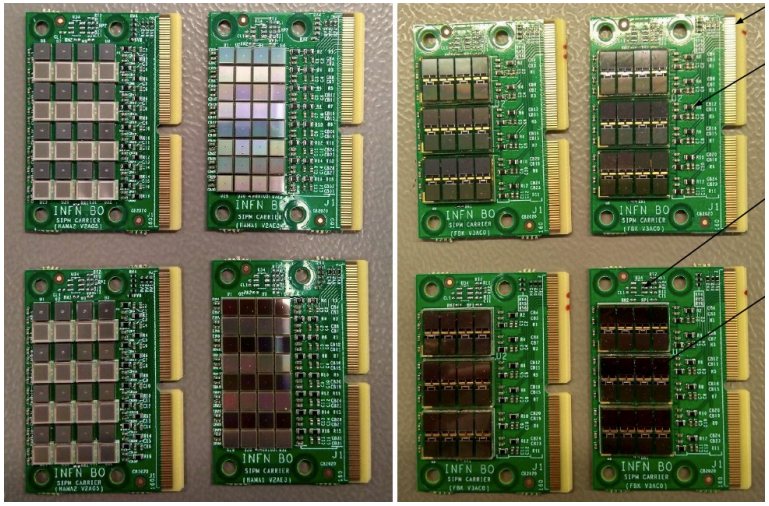
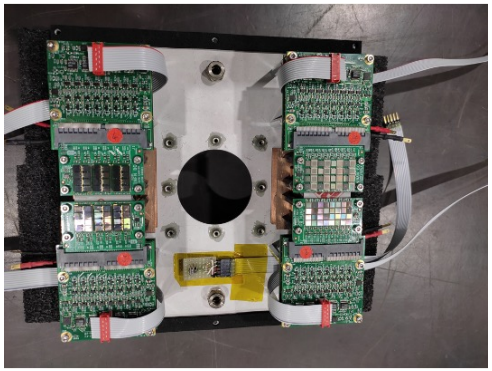


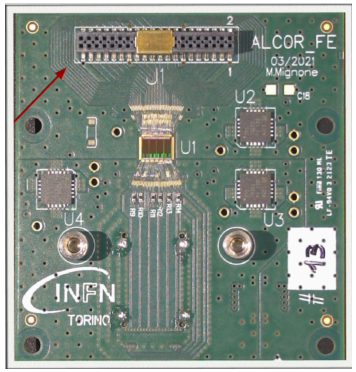
Photo-Sensors

Study solutions for single-photon detection within strong B-field

SiPM program: selection among various candidates
R&D dark count mitigation







INFN 2023: sensors, instrumentation, electronics, FBK R&D local support at SA, CS, MS

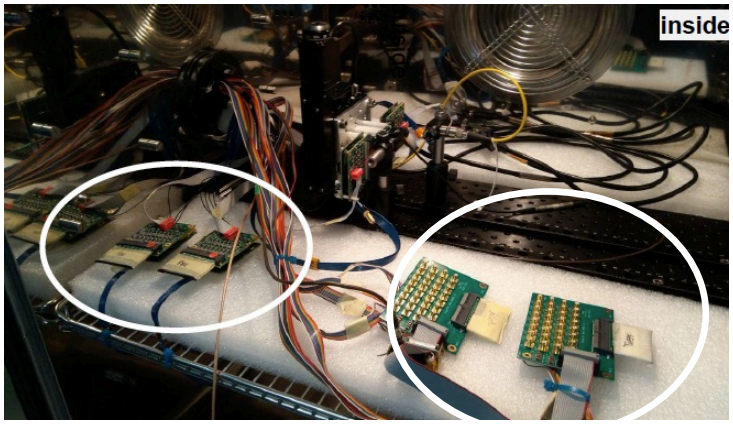
LAPPD program

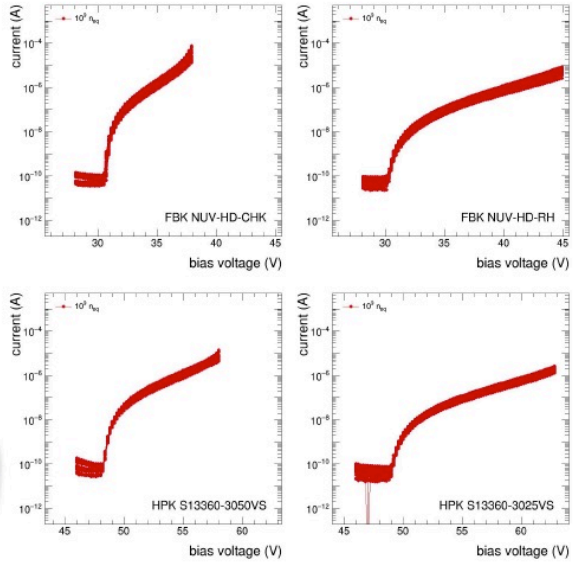
Test & guide developments @ Incom

INFN 2023: rent, instrumentation

Current measurements

- **climatic chamber**
  low-temperature operation
  all reported measurements at T = -30 °C
- **2x 40-channel multiplexers**
  automatic measurement of 2x SiPM boards (64 channels)
- **source meter**

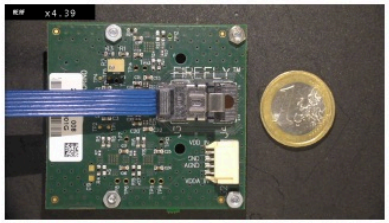


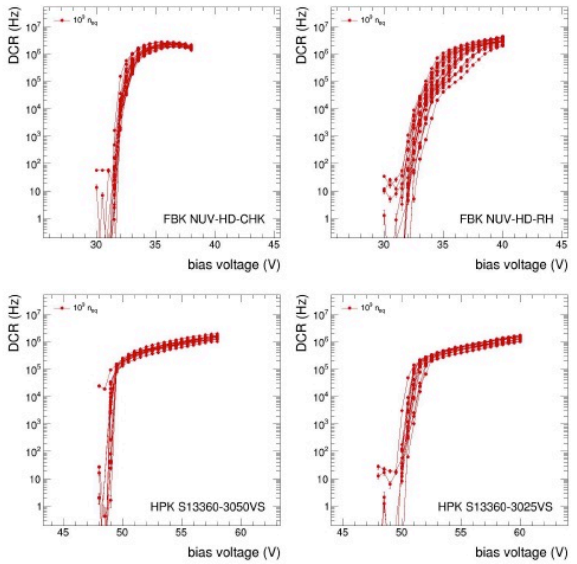


Roberto @ RICH2022

DCR measurements

- **climatic chamber**
  low-temperature operation
  all reported measurements at T = -30 °C
- **2x ALCOR-based front-end chain**
  automatic measurement of 2x SiPM boards (64 channels)
- **FPGA (Xilinx) readout**

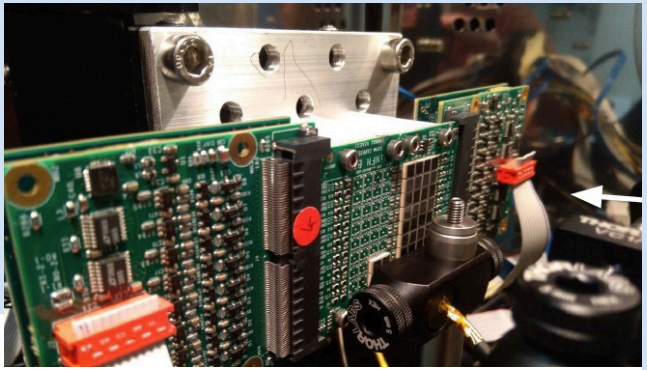




SiPM + ALCOR Light Response

Pulsed LED providing a relative PDE measurement

- compare different sensors
- compare before and after irradiation and annealing
- awaiting ALCORv2



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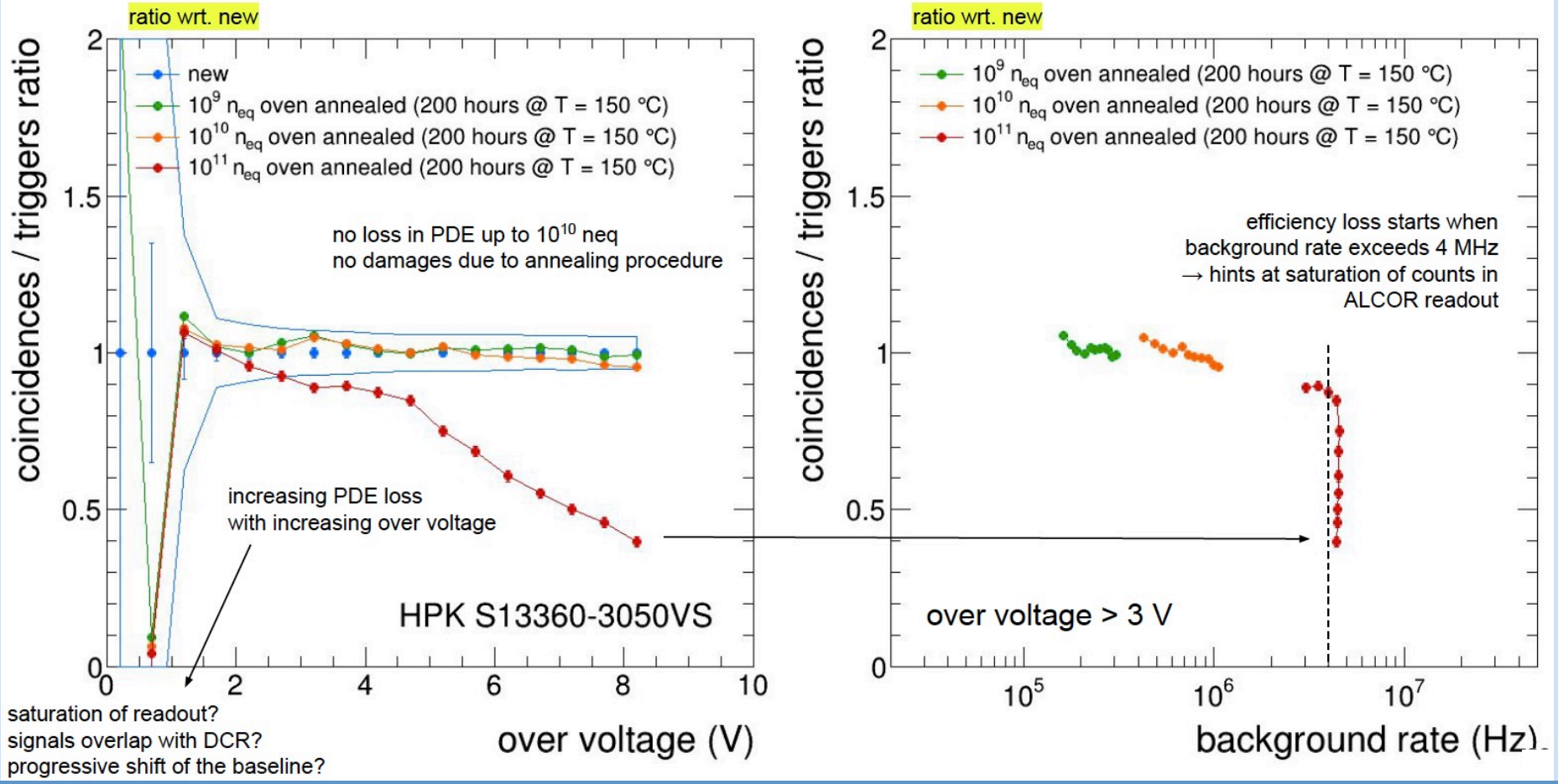

Compare sensor response to irradiation + annealing. S13360-3050VS most promising for the moment.

DCR after irradiation and annealing

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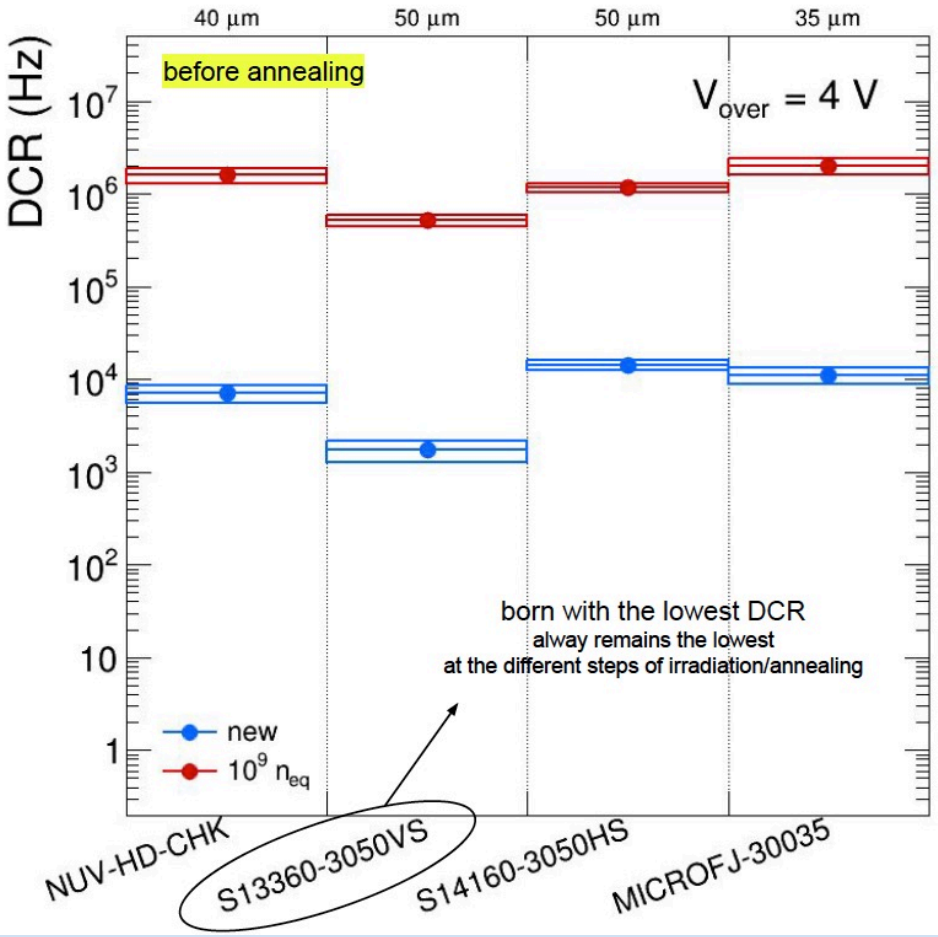

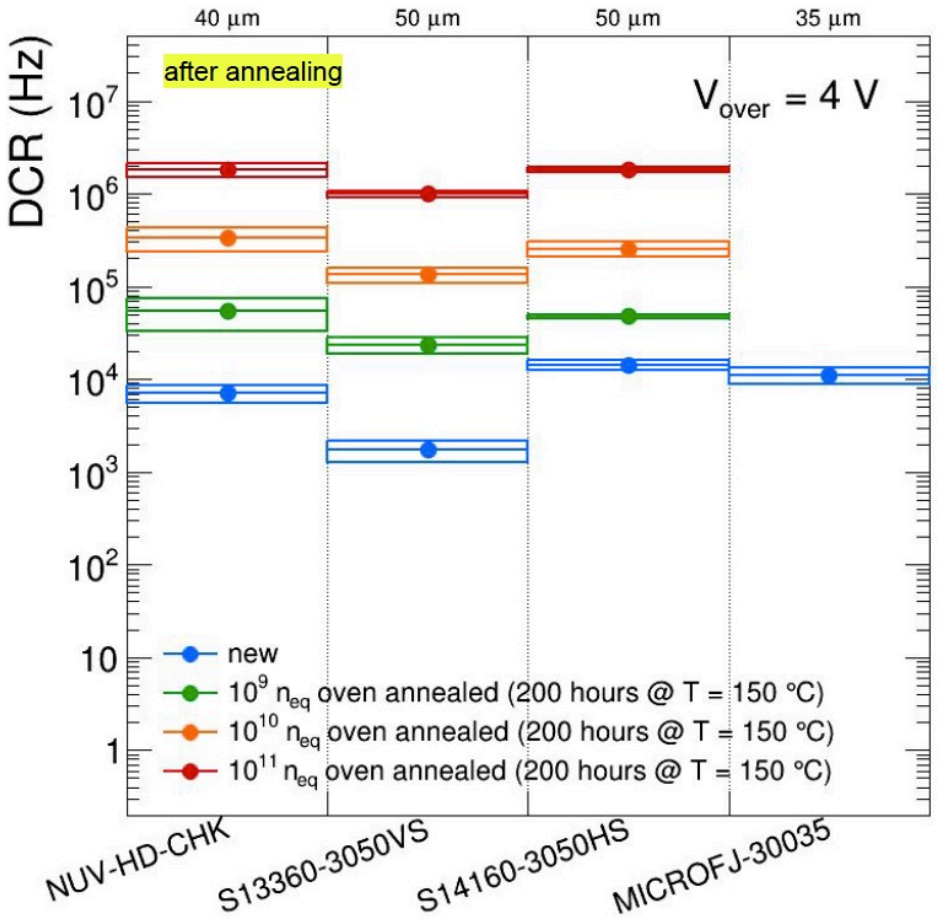

SiPM Irradiation-Annealing Cycles

Realistic study of sensor life with irradiation and annealing cycles

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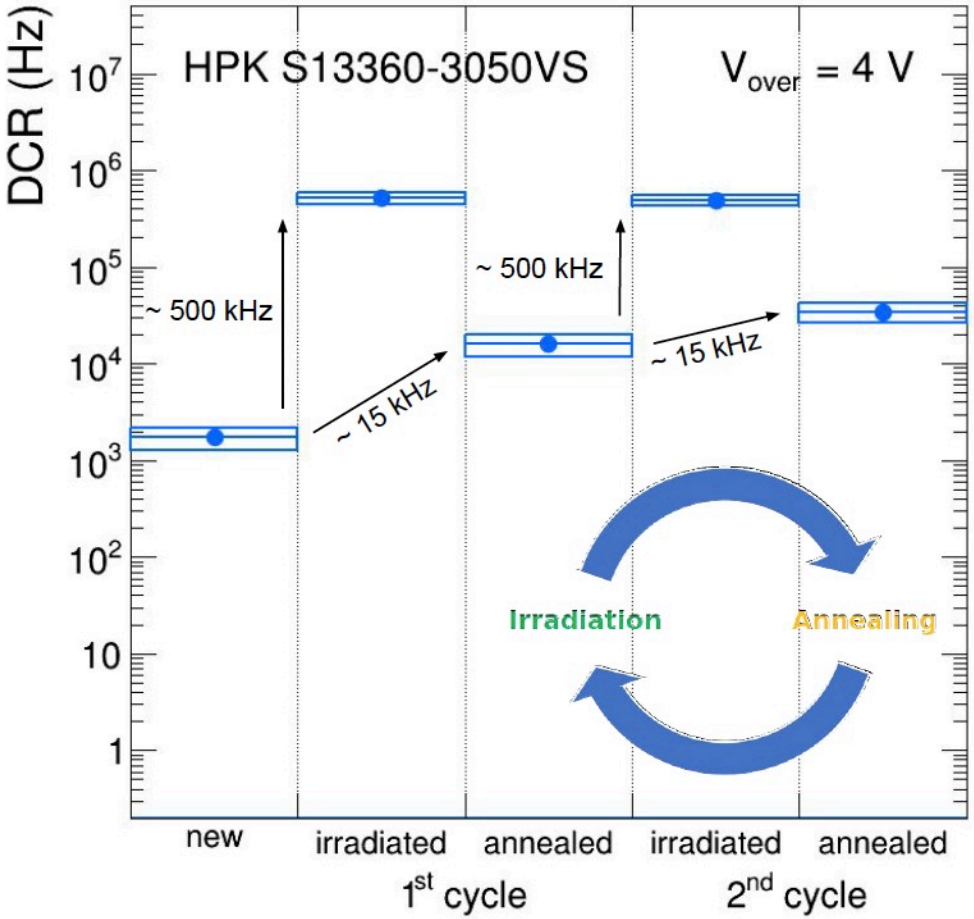


test reproducibility of repeated irradiation-annealing cycles

simulate a realistic experimental situation

- consistent irradiation damage
  - DCR increases by ~ 500 kHz (@ Vover = 4)
  - after each shot of 10^9 n_{eq}
- consistent residual damage
  - ~ 15 kHz (@ Vover = 4) of residual DCR
  - builds up after each irradiation-annealing

annealing cures same fraction of newly-produced damage

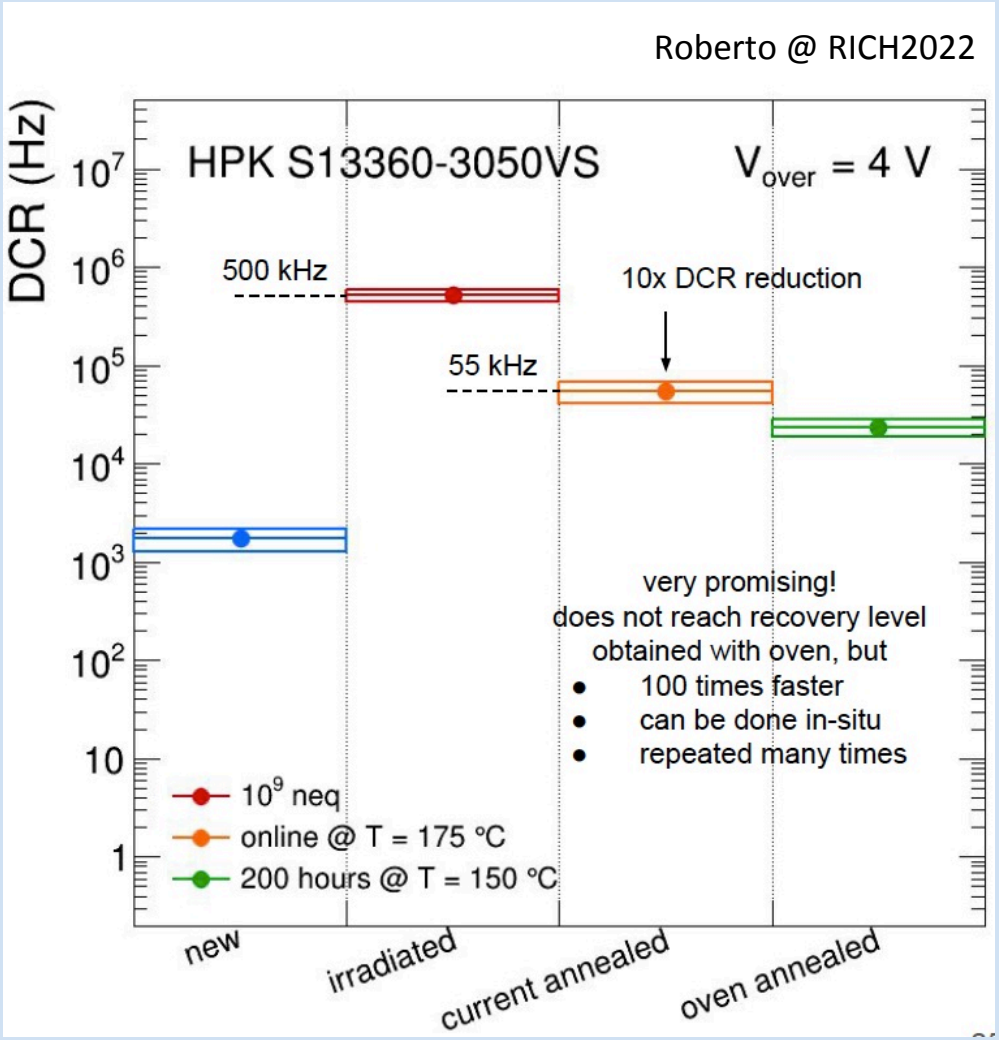
~ 97% for HPK S13360-3050 sensors

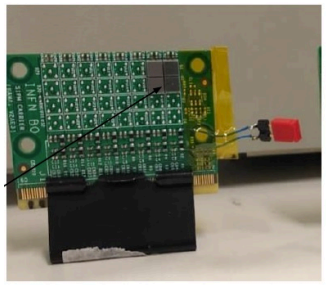
SiPM In-Situ Operations

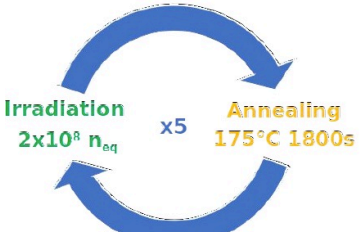
Study solutions for rapid and repeated annealing

Preparing for beam test (12-19 October 2022)

Roberto @ RICH2022



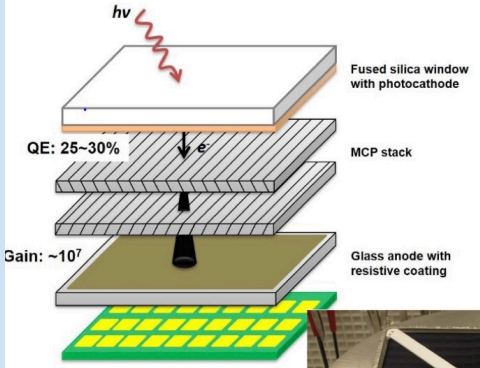




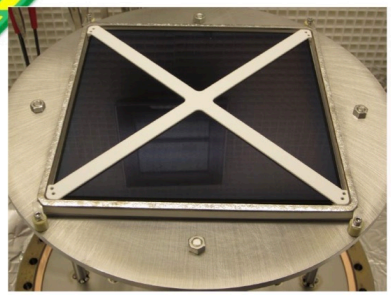
explore solutions for in-situ annealing

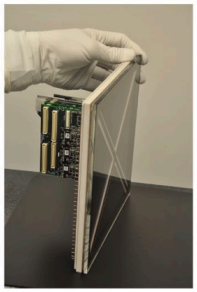
- total fluence of 10^9 n_{eq}
  - delivered in 5 chunks
  - each of 2 10^8 n_{eq}
- interleave by annealing
  - forward bias, ~ 1 W / sensor
  - T = 175 °C, thermal camera
  - 30 minutes
- preliminary tests
  - Hamamatsu S13360-3050

LAPDDs

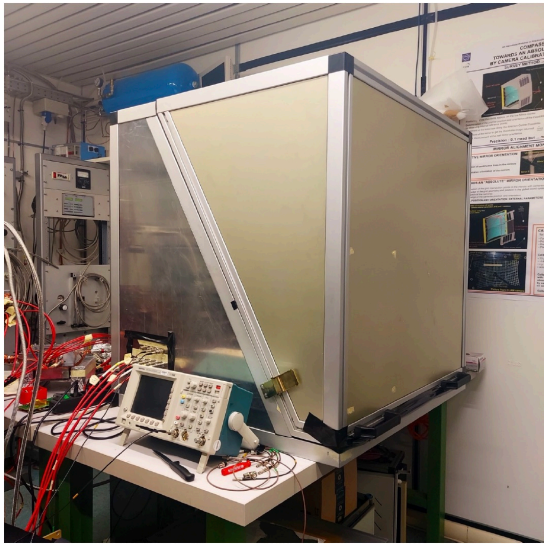


Large-area cost effective micro-channel plate detector

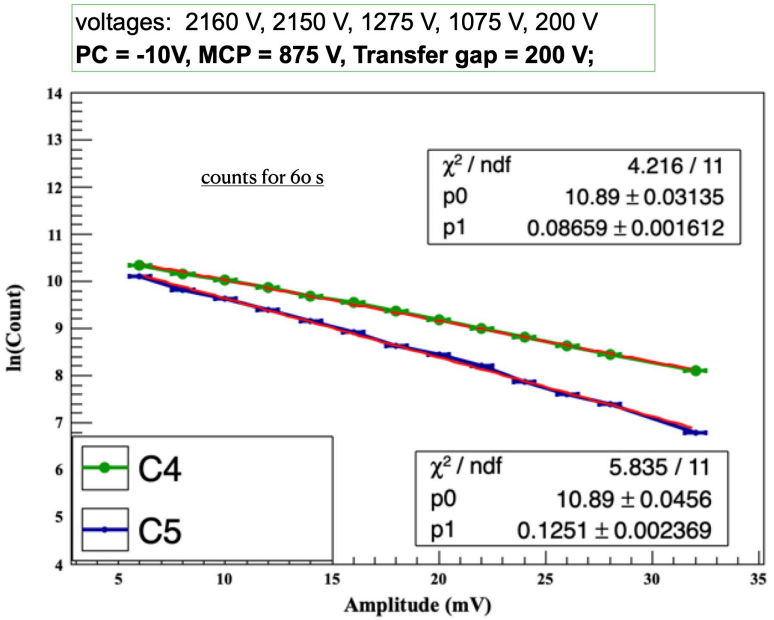




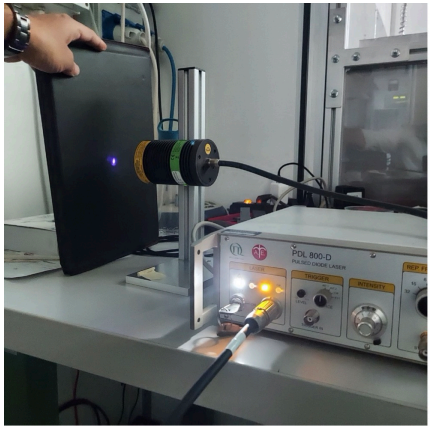
Test station in Trieste

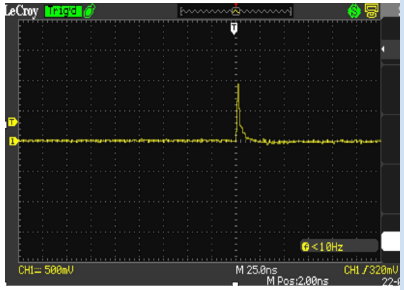


Measured dark rate: 140 Hz/m^2 at room temperature



Preparing single-photon response characterization



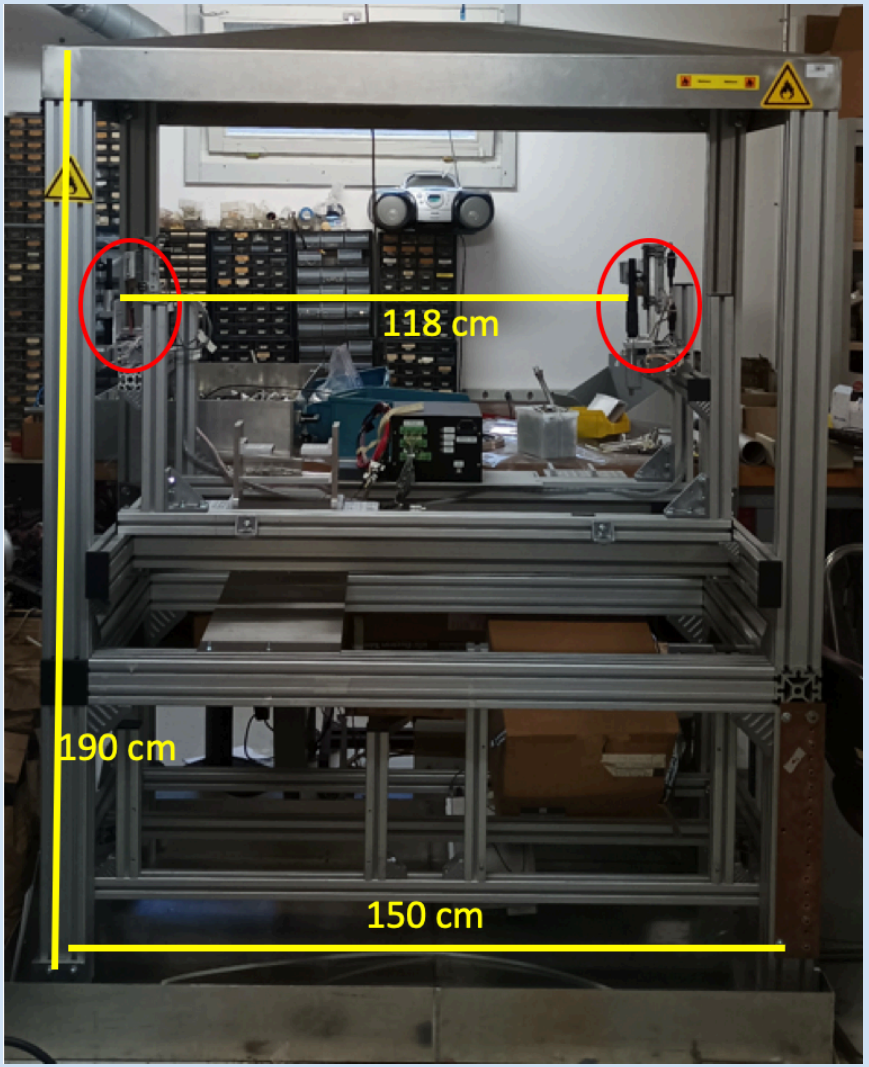


LAPDDs @ INFN

Test-beam 5-19 October 2022
CERN PS line T10

- LAPPD photodetector
- Quartz lens to produce Cherenkov light
- Fast beam monitor MCP and SiPM

Goal: Single photon time resolution



Conclusions

dRICH project aims to address **crucial PID aspects at EIC**

cost-effective compact solution for hadron PID in the forward region in a wide kinematic range

investigation of novel single-photon detector solution to be operated in high magnetic field

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 leading an international effort

Quite broad program (optics, sensors, electronics, mechanics, cooling, ….)

Many opportunities for contributions at the cutting edge of detector technology