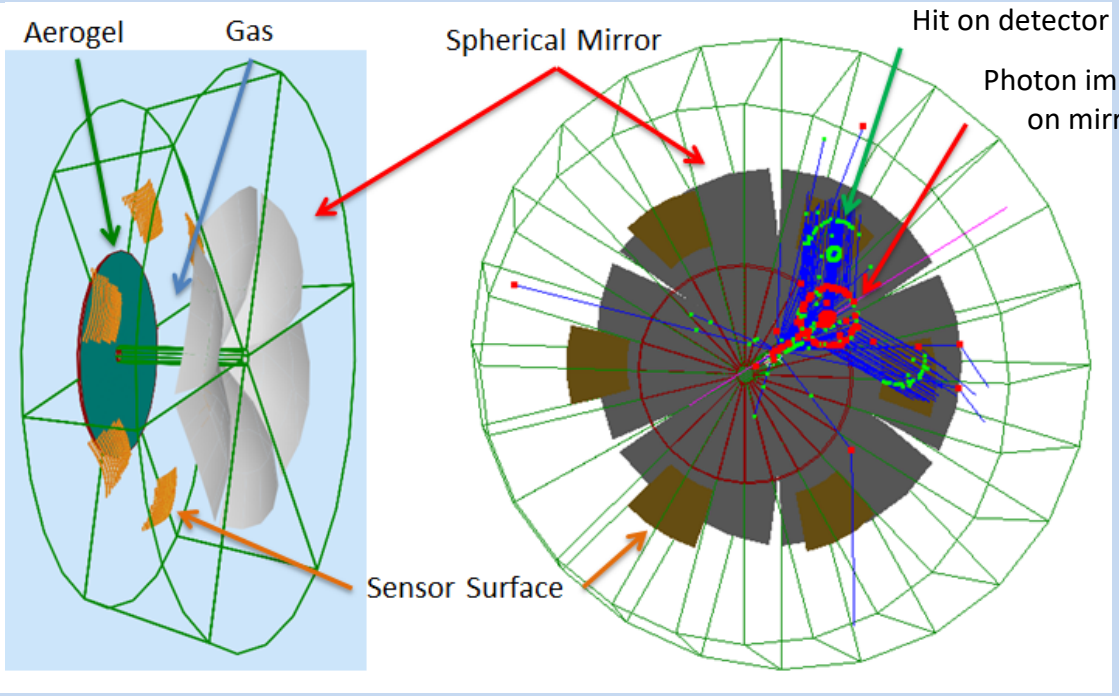
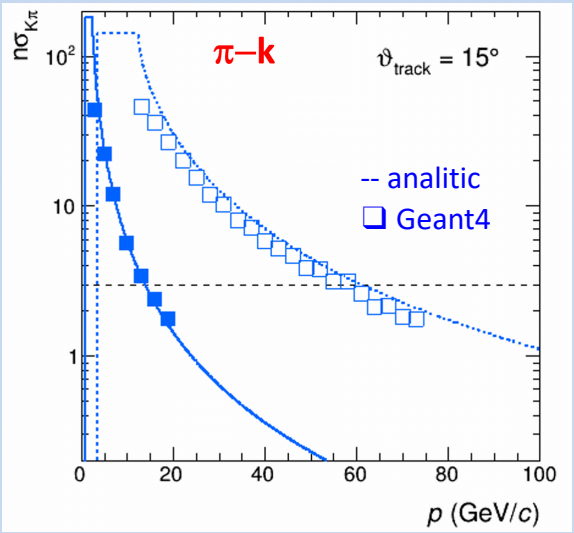
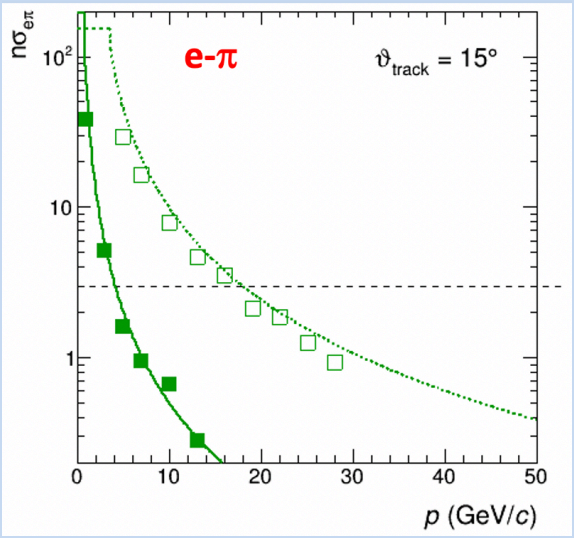
Dual Radiator RICH in EIC Hadron-endcap



- Polar angle: 5-25 deg
- Momentum: 3-60 GeV/c
- Magnet: 3T Solenoid





dRICH: effective solution, part of reference detector

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

Detector: 0.5 m^2/sector , 3x3 mm^2 pixel

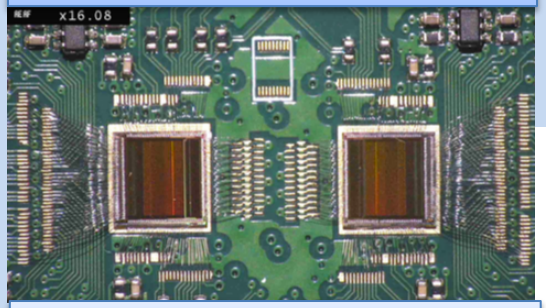
Single-photon detection in ~1T magnetic field

Outside acceptance, reduced constraints

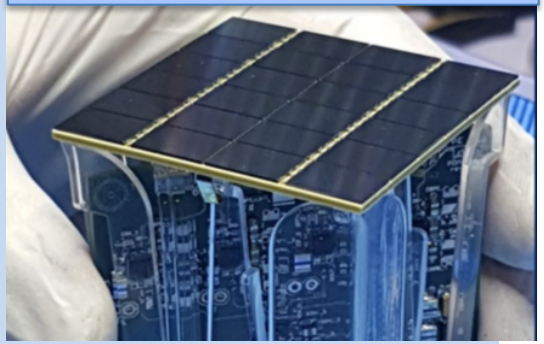
→ best candidate for SiPM option

INFN Groups and eRD14

INFN TO COMPASS RICH F-E
DARKSIDE F-E

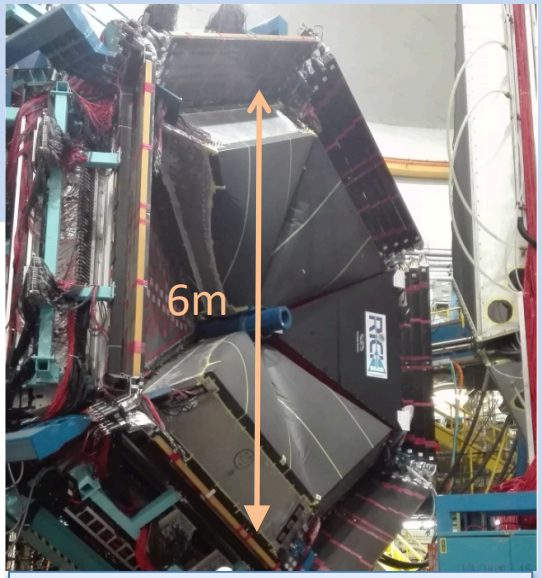


INFN BO ALICE TOF
DARKSIDE SiPM



INFN RM HERMES/Hall-A RICH
INFN CT Hall-A HCAL

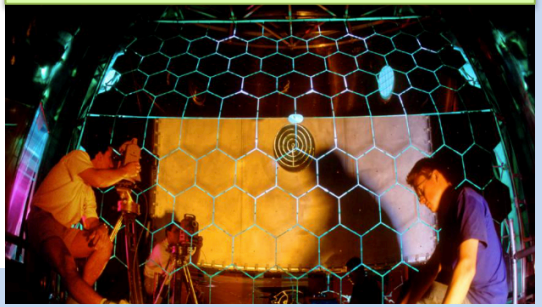
Enriched INFN expertise and manpower to support dRICH & SiPM program



INFN FE CLAS12 RICH
INFN LNF

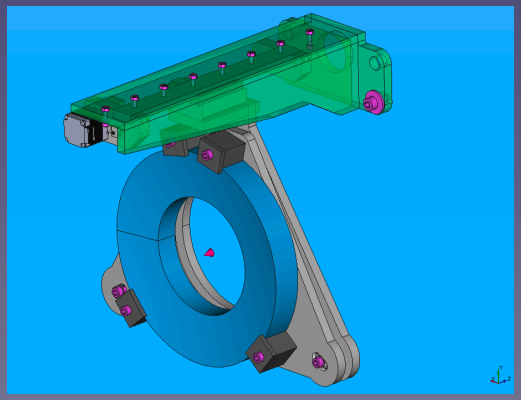
Collaborating with

INFN TS COMPASS RICH
INFN BA Gaseous DET (eRD6)

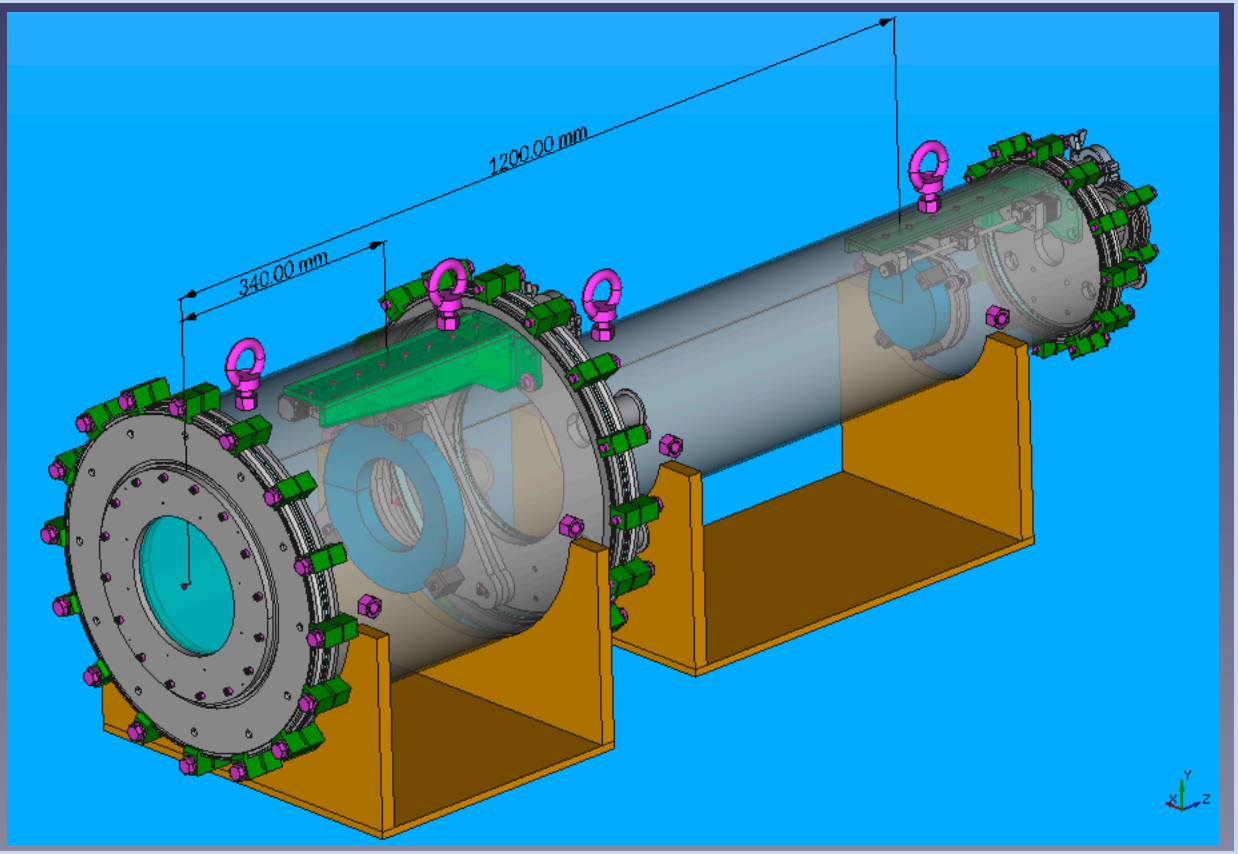


dRICH Prototype

Dual radiator imaging
Pressure vessel for gas & n tune
Sensor & readout friendly



New:
- Mirror design
- Alignment system
- Support brackets



Goal:

* First test-beam in October ‘21 at CERN PS T10 in synergy with ALICE

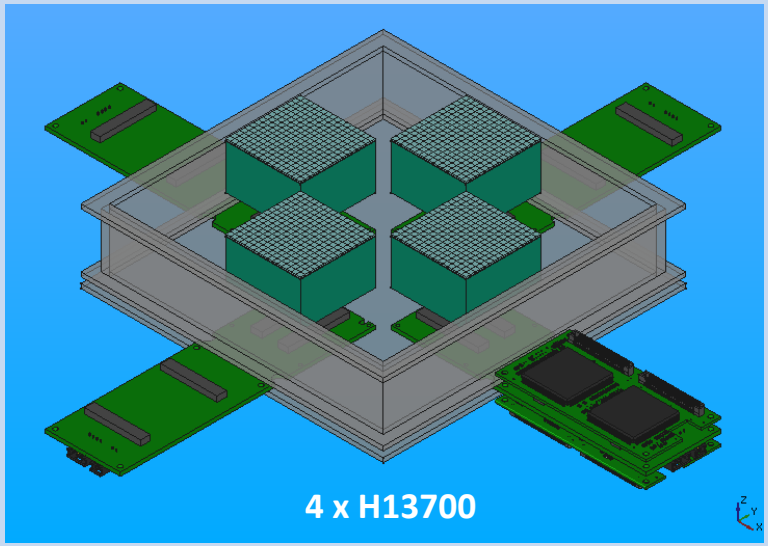
Procurement initiated (INFN in-kind):

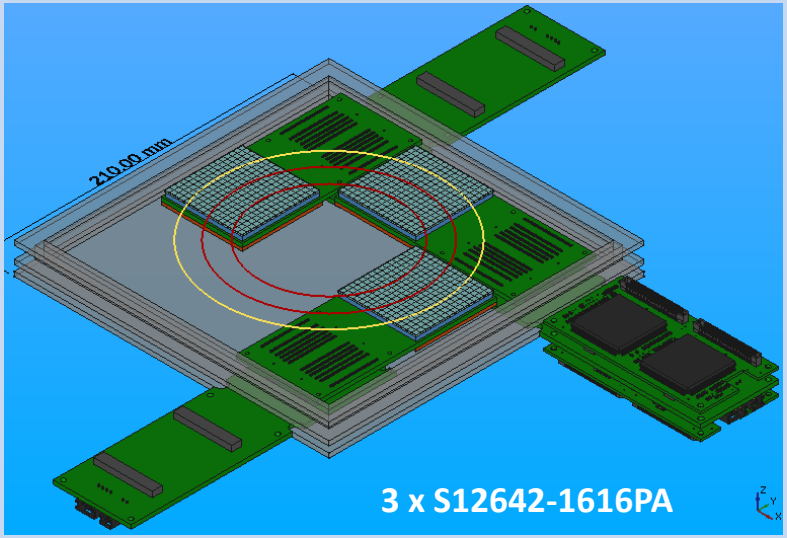
* Radiators: C_2F_6 gas (n=1.0008) and aerogel (n=1.02, n=1.03) compatible with mRICH

- Standard vacuum components (pipes, clamps, o-rings)
- Custom flanges

dRICH Imaging

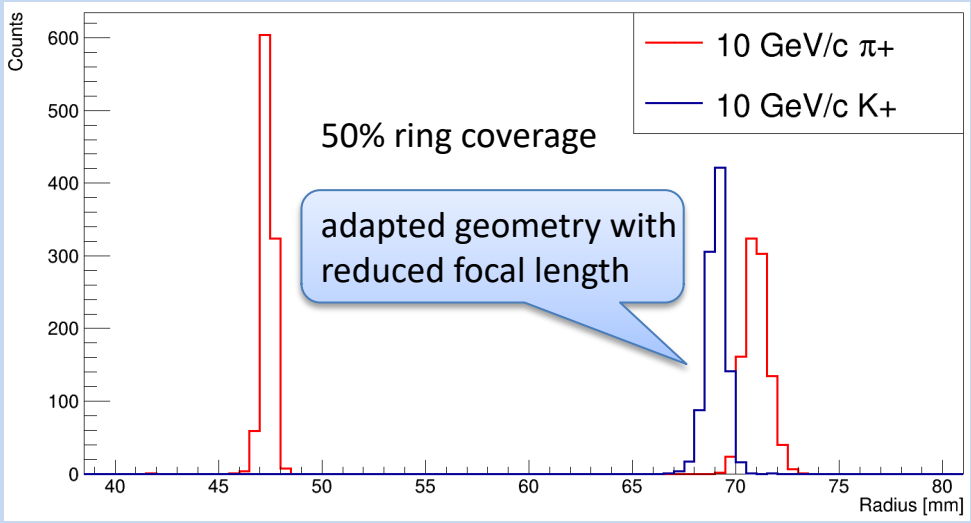
House the same principles and readout units used for mRICH test-beams
Compatible with H13700 MAPMT and S12642 MPPC + MAROC front-end
Allows to study the working principles and optical performance of the components



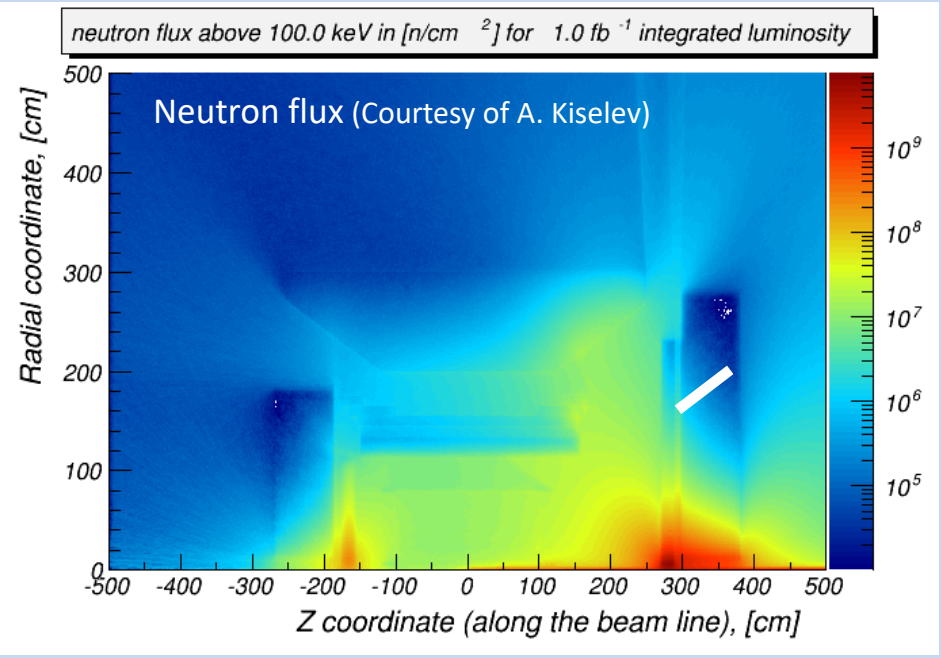


Goal:
- validate the dual radiator concept
- benchmark the simulation
- compare component alternatives

Next: dRICH Engineering
Migrate into EIC supported simulation platforms
Implement into EIC benchmark detectors
Study integrated PID for EIC detector proposals



PID Detector Challenge



dRICH sensor location relaxes requirements on neutron dose and material budget

Magnetic Field

~ 1 T order of magnitude, varying orientation

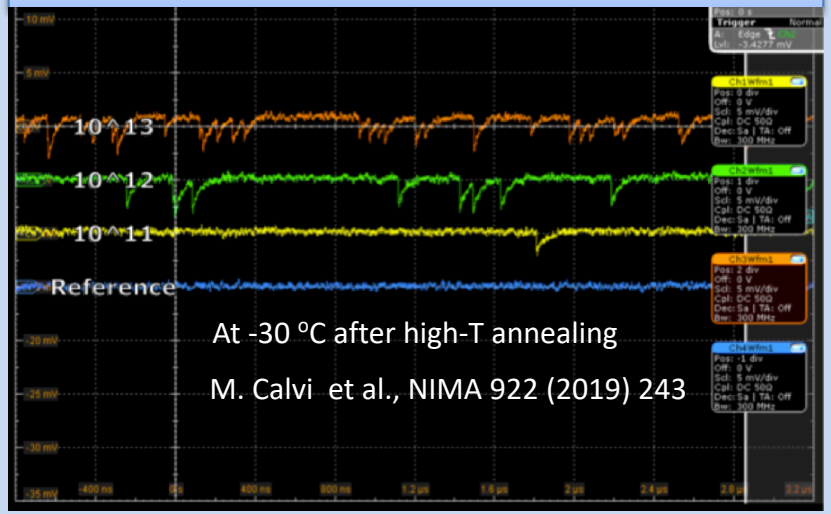
SiPM: PET study up to 7 T 10.1109/NSSMIC.2008.4774097

Neutron Fluence

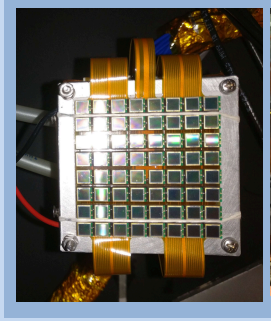
Moderate at dRICH location
Reference value ~ 10^{11} n_{eq}/cm^2
for several years at max lumi (10^{34})

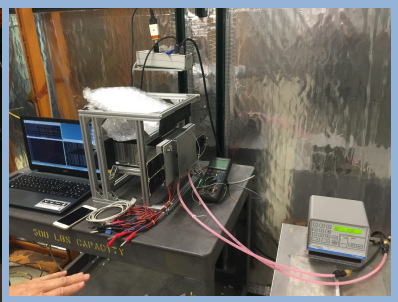
SiPM: radiation mitigation for SPE actively studied till 10^{11} n_{eq}/cm^2 and above 10.1016/j.nima.2019.01.013

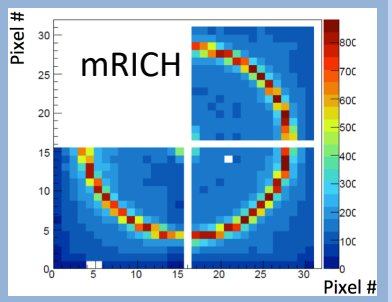
Key: Temperature treatment & precise timing



SiPM SPE capability under study since 2012 @ INFN
Contalbrigo++ NIMA 766 (2014) 22, Balossino ++ NIMA876 (2017) 89





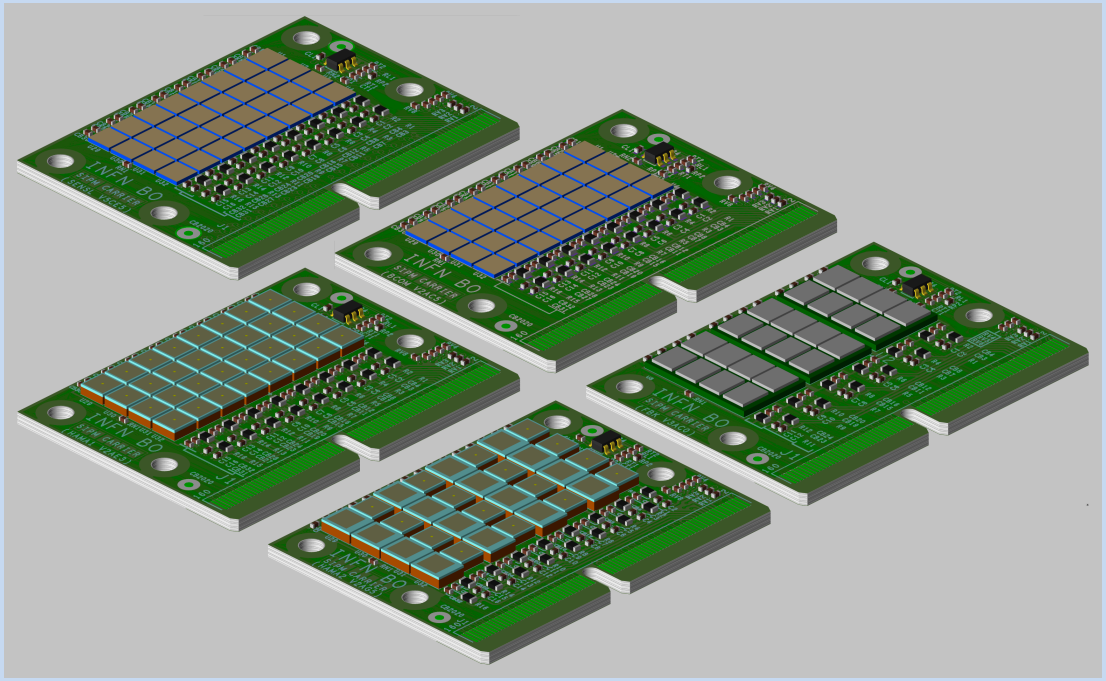


SiPM Program

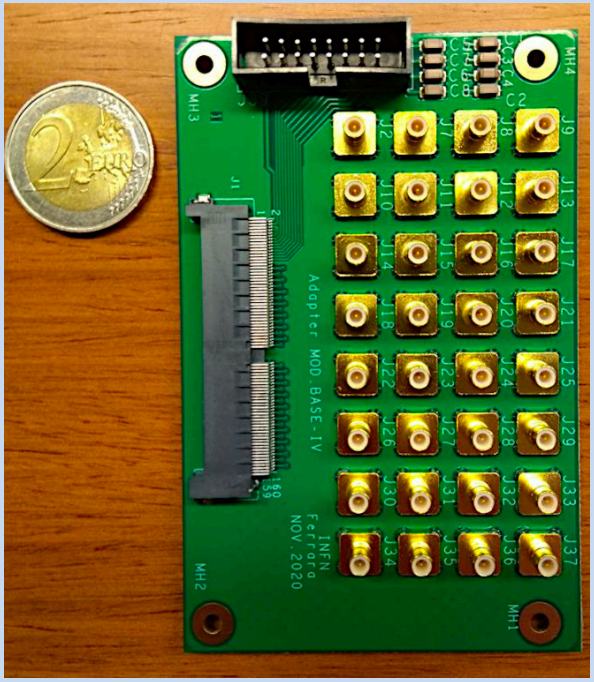
Assess performance of 3x3 mm^2 SiPM status-of-the-art selection

- (2x) OnSemiconductor microFJ-30020 and -30035
- (1x) Broadcom AFBR-S4N33C013
- (2x) Hamamatsu. S13360-3050VS and -3025VS
- (2x) Hamamatsu. S14160-3050HS and -3015PS
- (1x) FBK custom SIPM samples

Organized in matrices for irradiation and imaging tests
Carrier board compatible with high-T annealing cycles

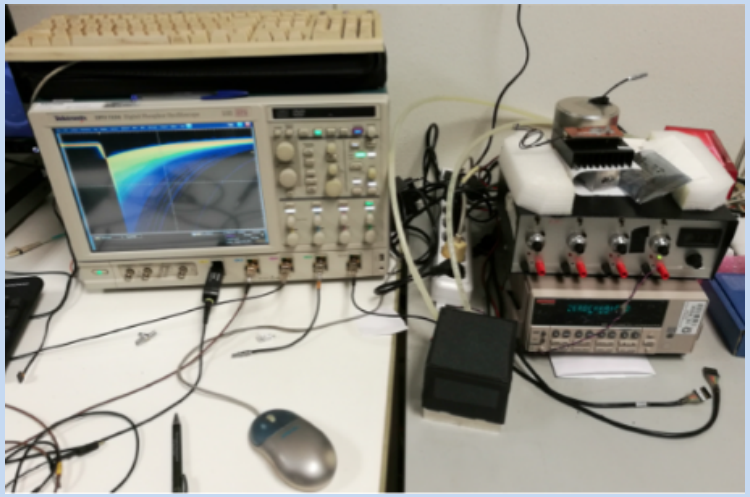


Test-board for lab characterization



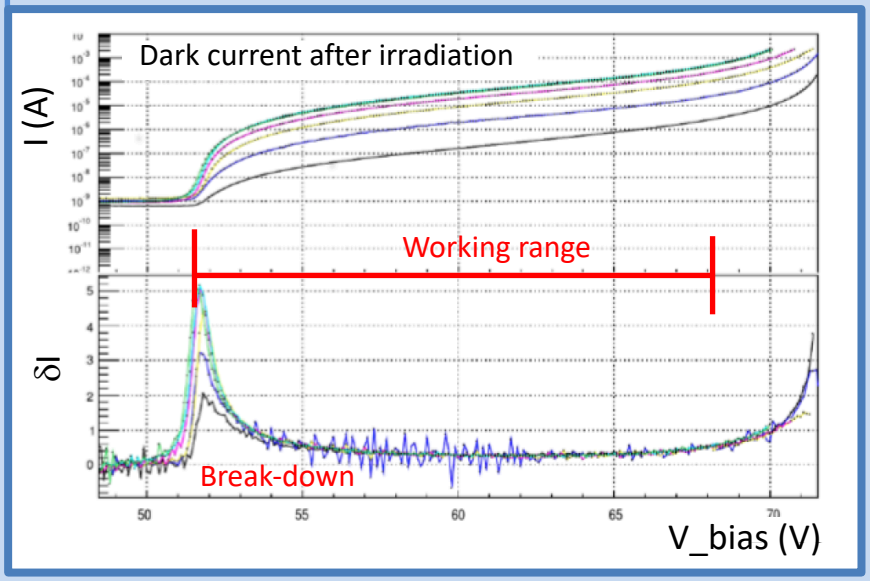
SiPM Characterization

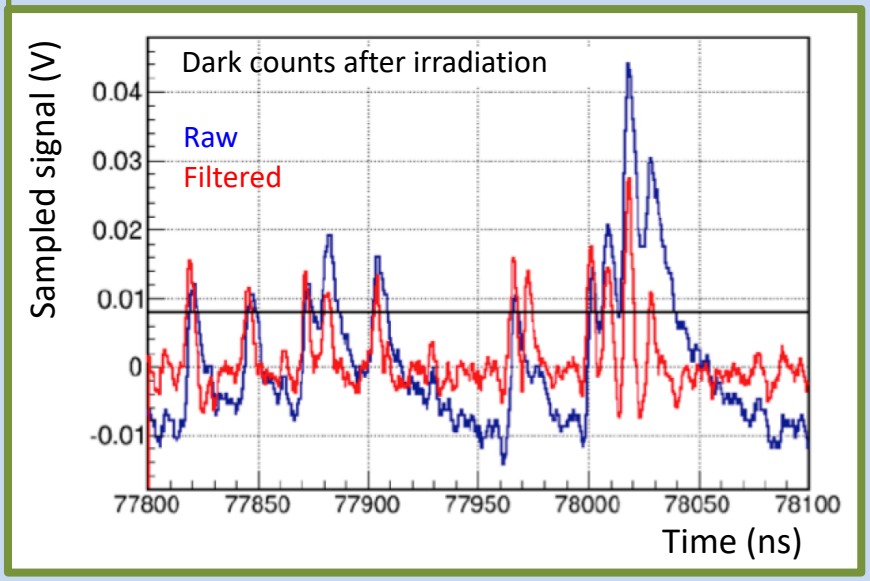
SiPM characterization vs temperature, pre- and post-irradiation, pre- and post- annealing



I-V characteristics & Signal sampling

Temperature control and treatments





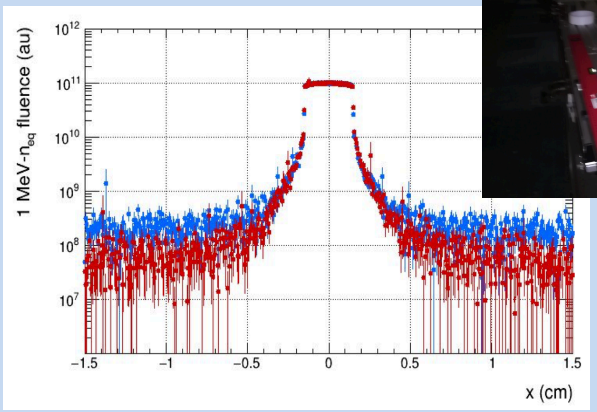
2021 dRICH & SiPM Beam Tests

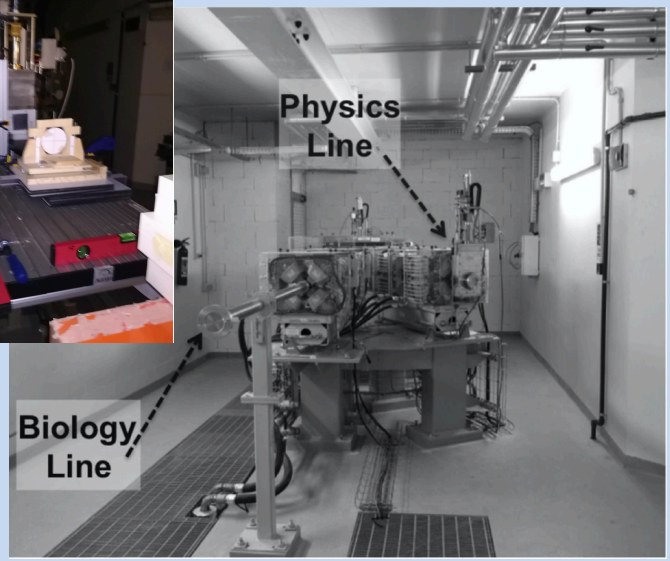
SiPM Irradition test
May ‘21 @ TIFPA (Italy)

Collimated proton beam

10^8-10^{11} n_{eq} fluence

Goal:
Assess post-annealing single-photon detection



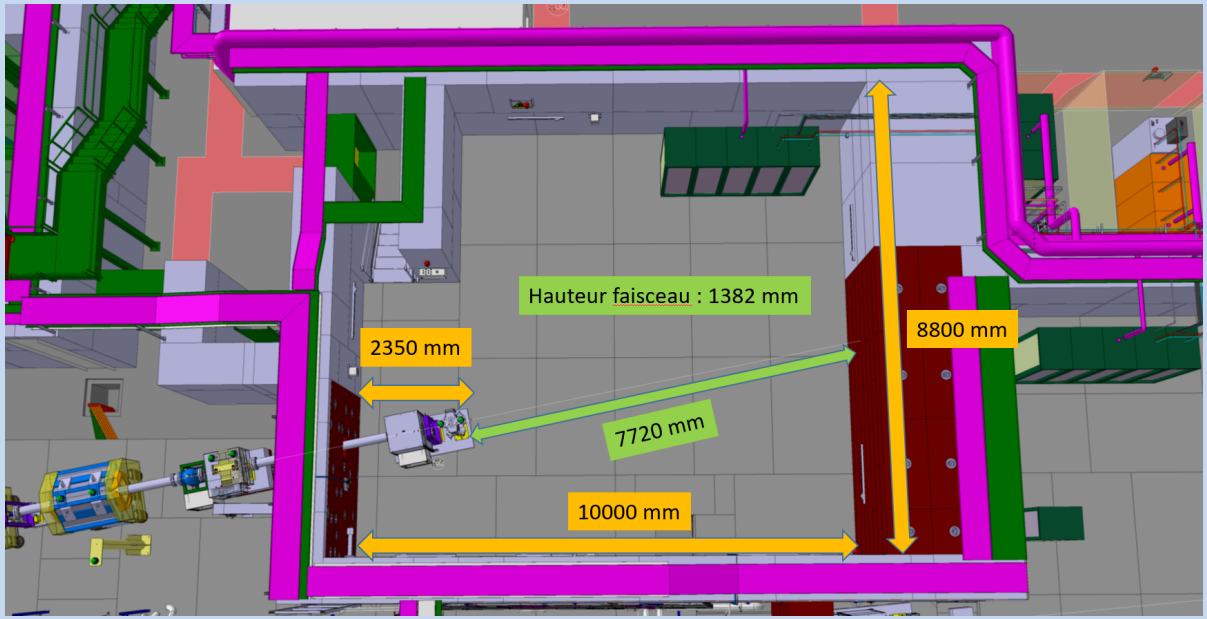


dRICH + SiPM beam test
October ‘21 @ CERN T10

Meson beam up to 10 GeV/c

Synergy with ALICE for Japanese (Chiba U.) aerogel test

Goal: Validate dRICH concept
Assess SiPM usage in realistic experimental conditions



Next Steps: Optical Components

Existing facility to study detailed radiator optical properties and alternatives

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

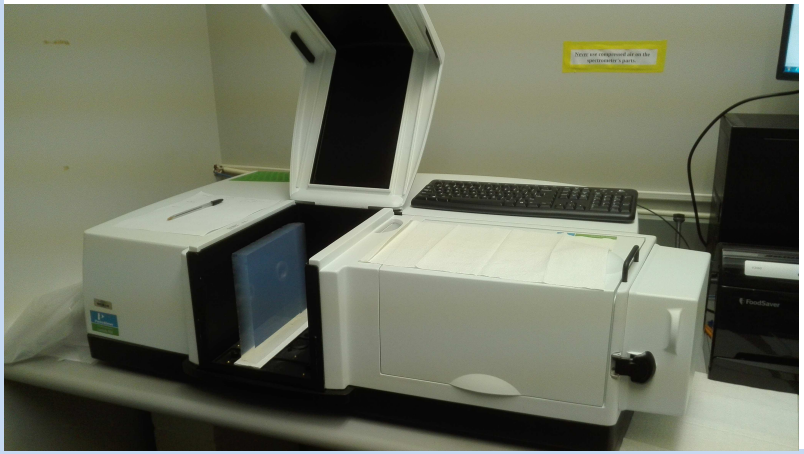
Budker Institute (Russia, CLAS12), Chiba University (Japan, Belle-II), Aspen (USA, R&D)

Gas: Safe handling and purging

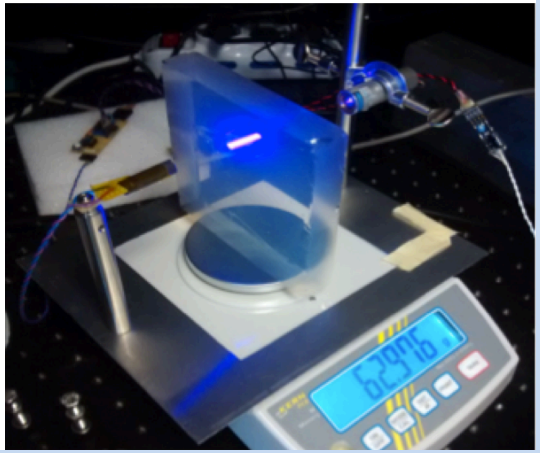
Alternatives to greenhouse gases

Interplay between radiators: UV filters, refractive index optimization

Spectrophotometer



Characterization station



Controlled storage

Next Steps: Optical Components

Existing facility to study detailed mirror optical properties and alternatives

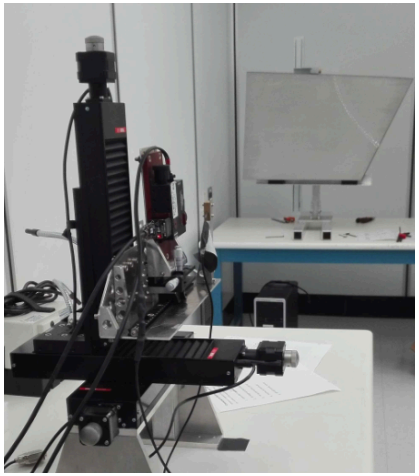
Mirrors: Safe handling and characterization
(surface map, radius of curvature, reflectivity)

Carbon fiber (mature) vs glass skin (cost-effective)

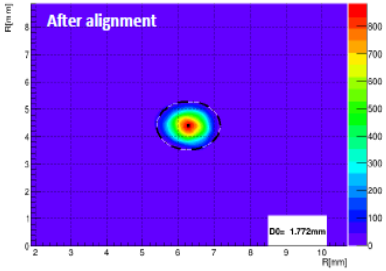
Mechanics: Composite materials from aeronautics technology

Stiff and light, supporting alignment

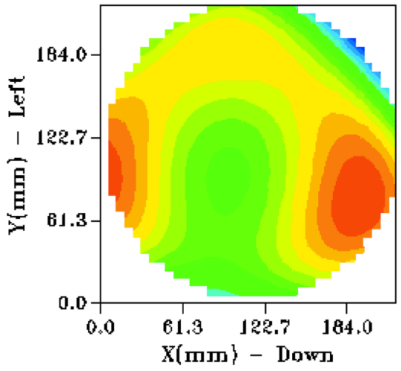
Surface Quality



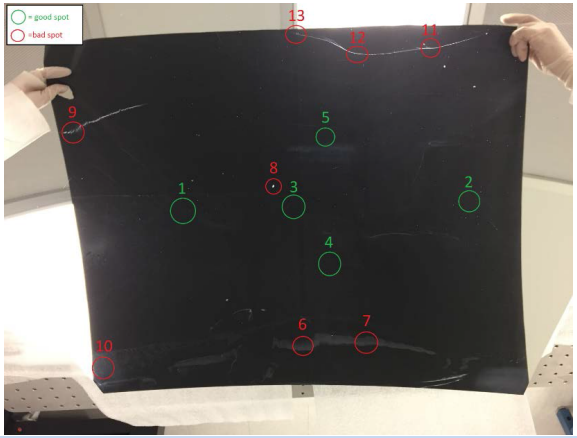
Pointlike source image

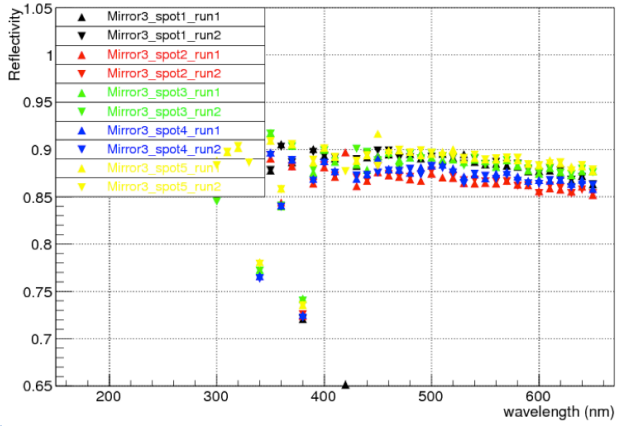


Shack-Hartmann sensor



Reflectivity





Next Steps: SiPM Readout

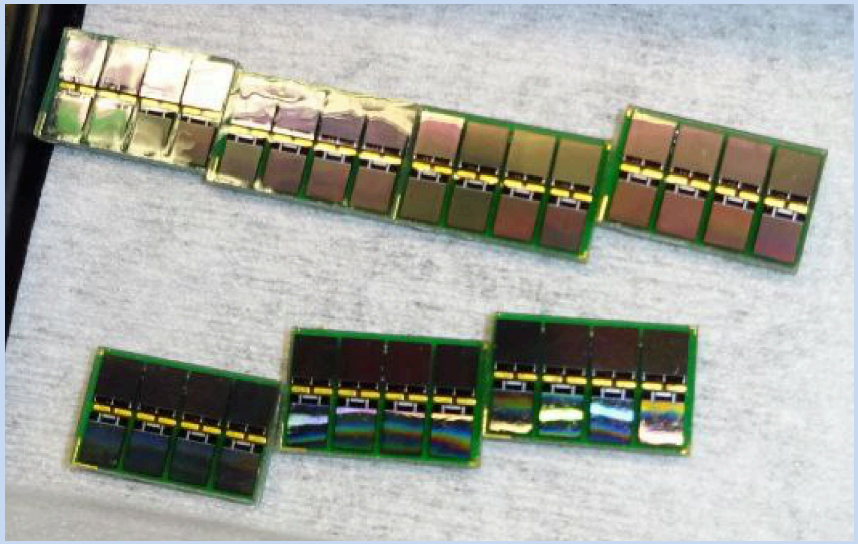
Custom SiPM solutions:
exploit INFN conventions with producers
e.g. FBK (development) and Lfoundry (production)

Custom readout solutions:
ToT readout based on
ALCOR (F/E) + ARCADIA (DAQ)

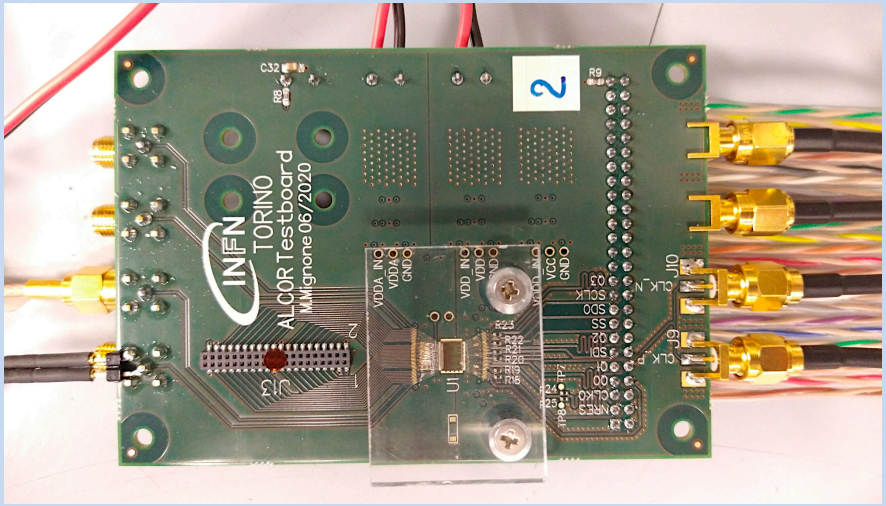
- 500 kHz per channel
- 50 ps time binning

(see talk on electronics & sensors)

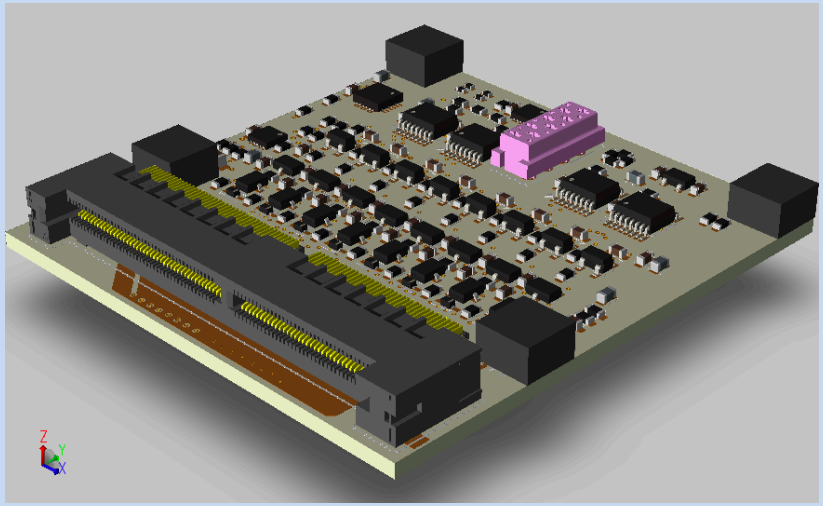
FBK: 15 μm and 50 μm SPAD sample



ALCOR test board



SiPM carrier to ALCOR adapter board



Conclusions

Activity in line with the plan and recommendations discussed with EIC R&D Committee

Goal: address crucial PID aspects at EIC synergic with other R&D programs
(gaseous RICH, electronics, sensors, mechanics….)

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

1st year: baseline prototype complete and first test-beam
++: component alternatives and performance optimization

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

1st year: post-irradiation characterization and imaging of a status-of-the-art SiPM selection
++: EIC dedicated solutions for sensors and electronics