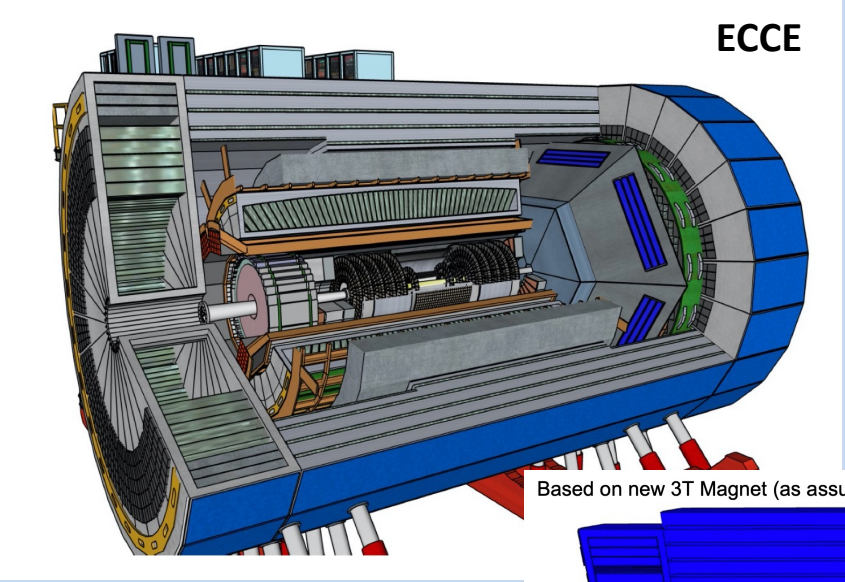
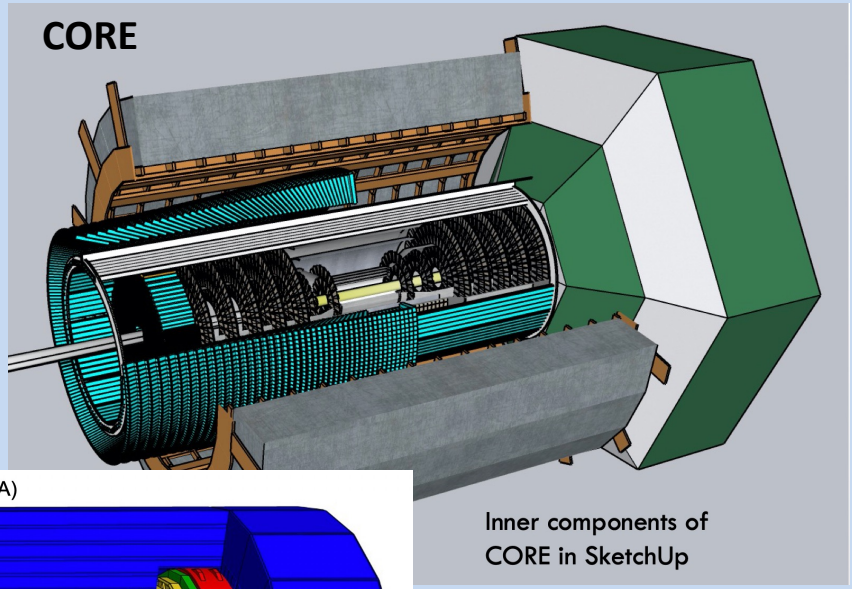
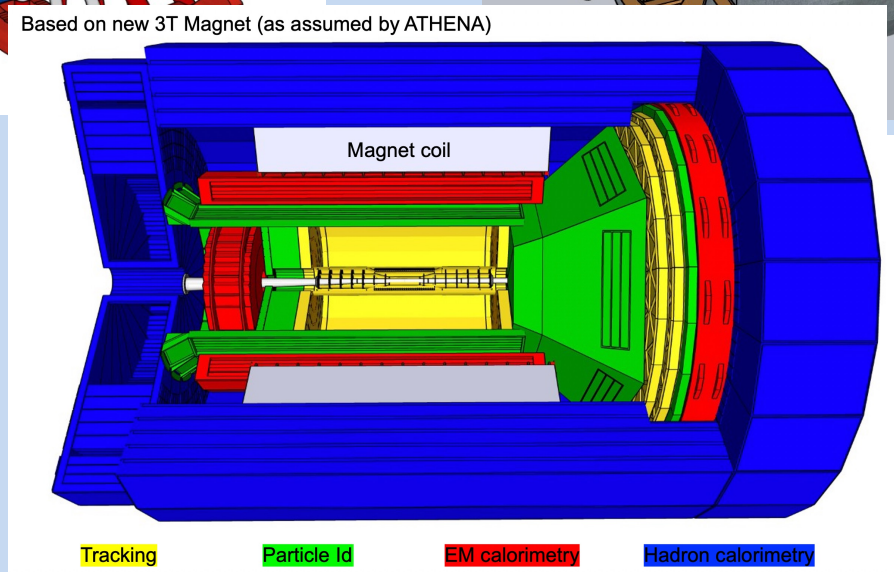
Dual Radiator RICH @ EIC







dRICH has been a common reference in the forward region

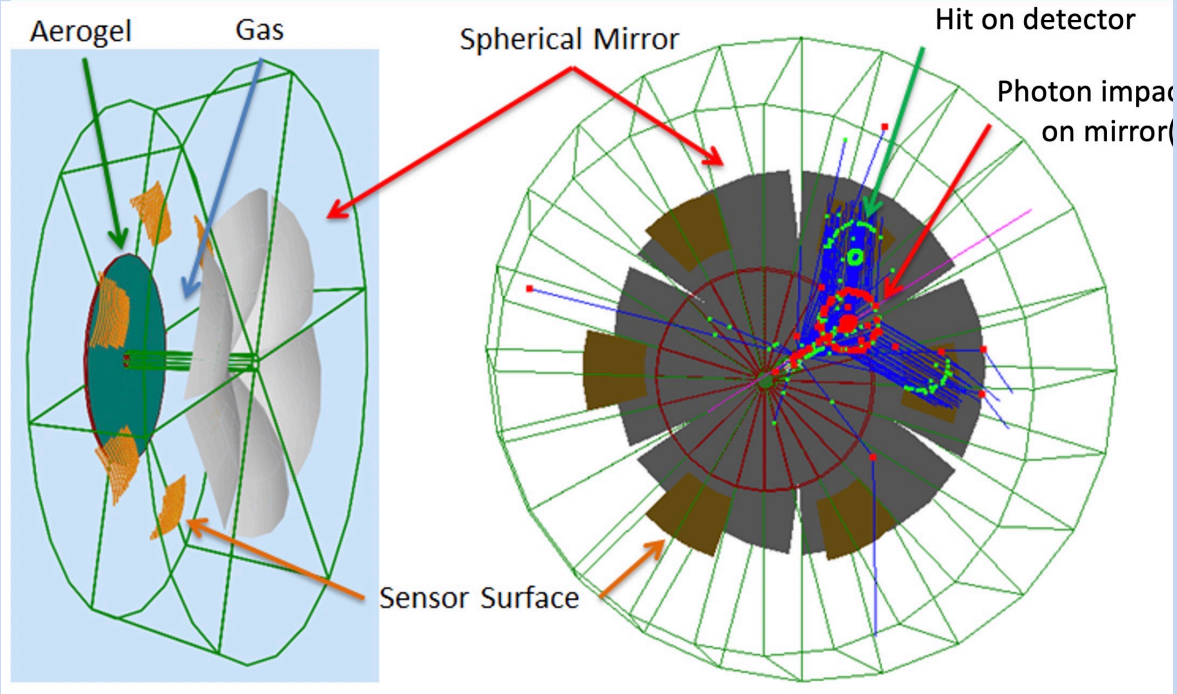
We expect it will stay

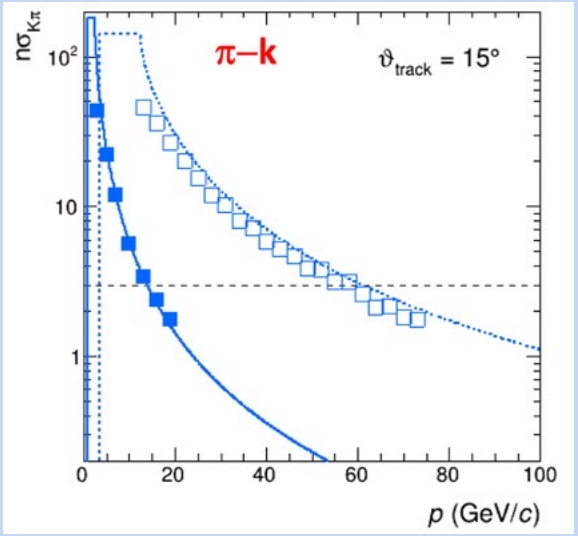
ATHENA

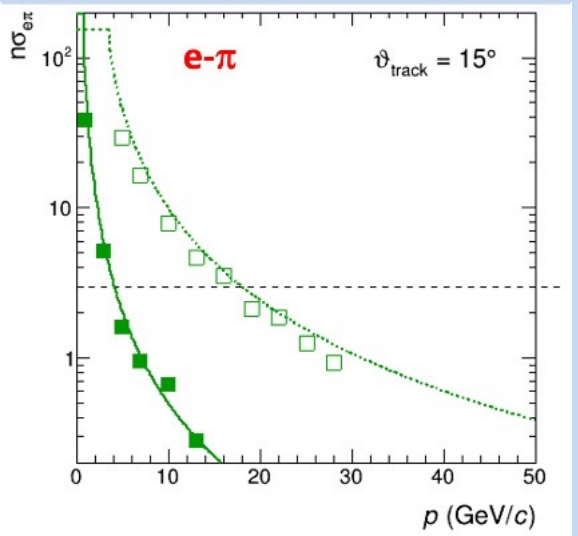
p: 41 GeV, 100 to 275 GeV	p/A beam →	← e beam	e: 5 GeV to 18 GeV

Dual Radiator RICH @ EIC

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







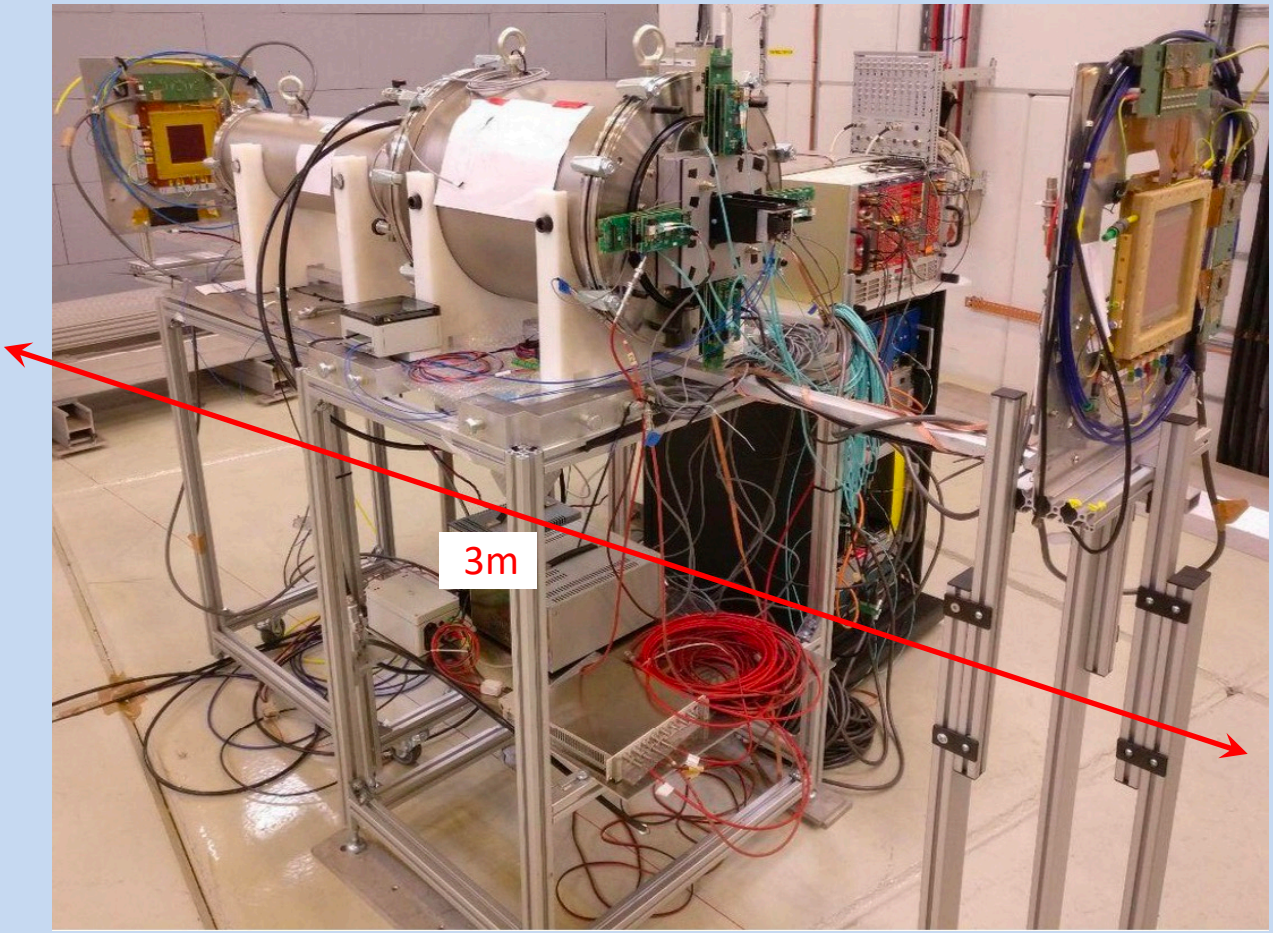
dRICH: effective solution, part of EIC reference detector

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

Detector: 0.5 m^2/sector , 3x3 mm^2 pixel. → SiPM option

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

dRICH Prototype



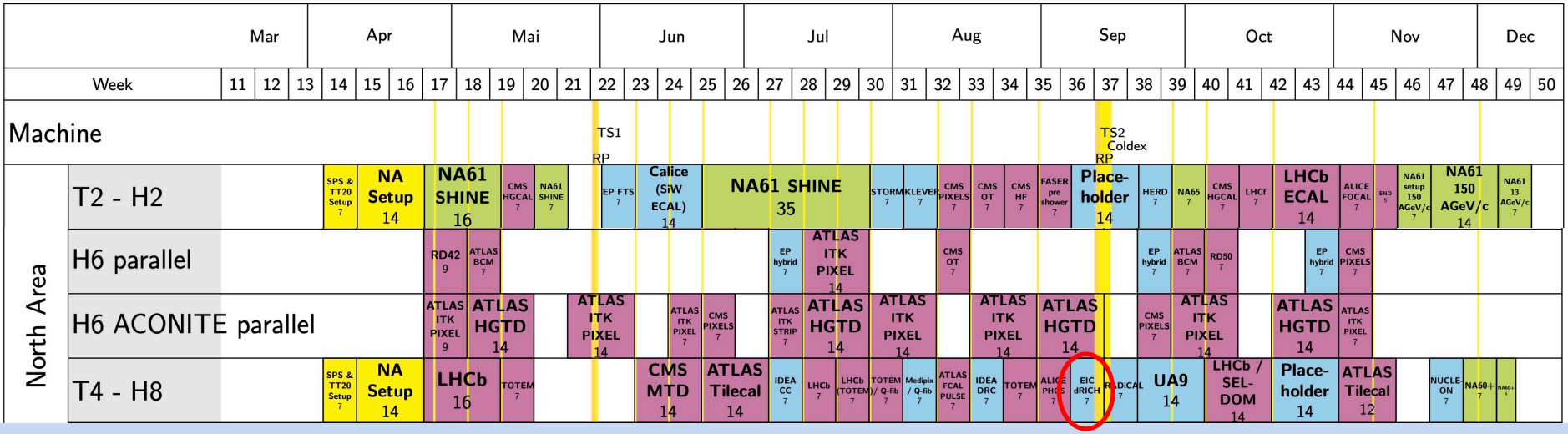
Goals:

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

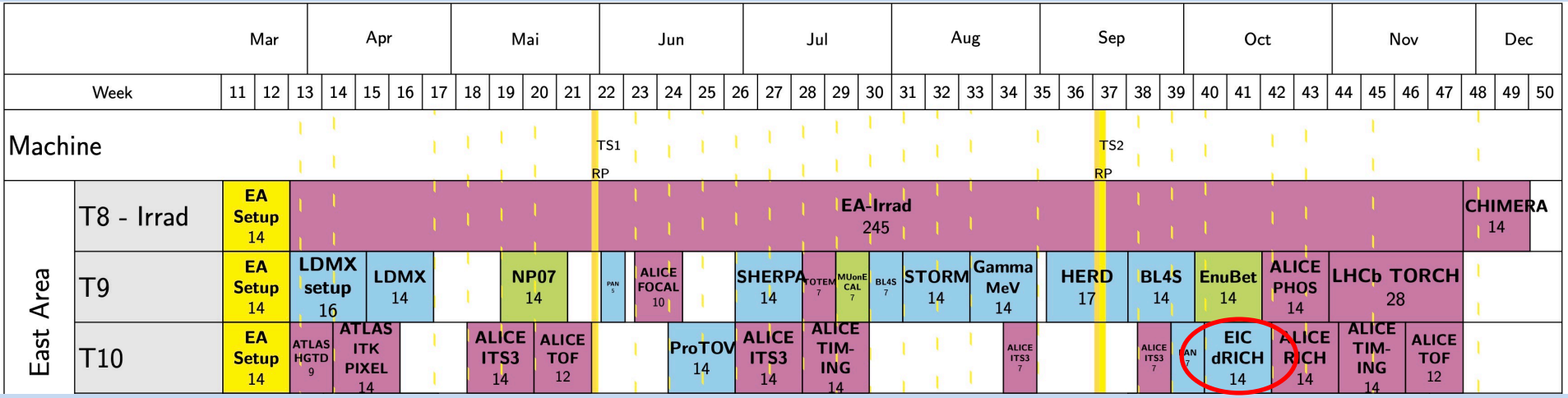
Basic system commissioned in 2021 runs

dRICH Test-beams

New campaign to approach the design performance
1 week at SPS with 20-60 GeV/c hadron beams. + 120 GeV/c pencil proton beam



2 weeks at PS with 0.5-12 GeV/c hadron beams + 0.5-5 GeV/c electron beams



Optical Components

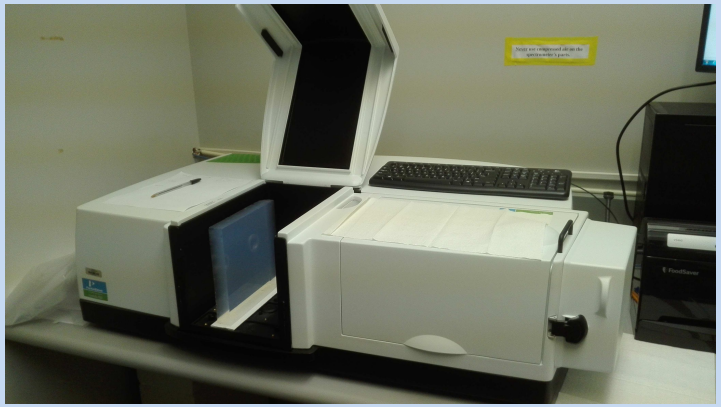
Aerogel

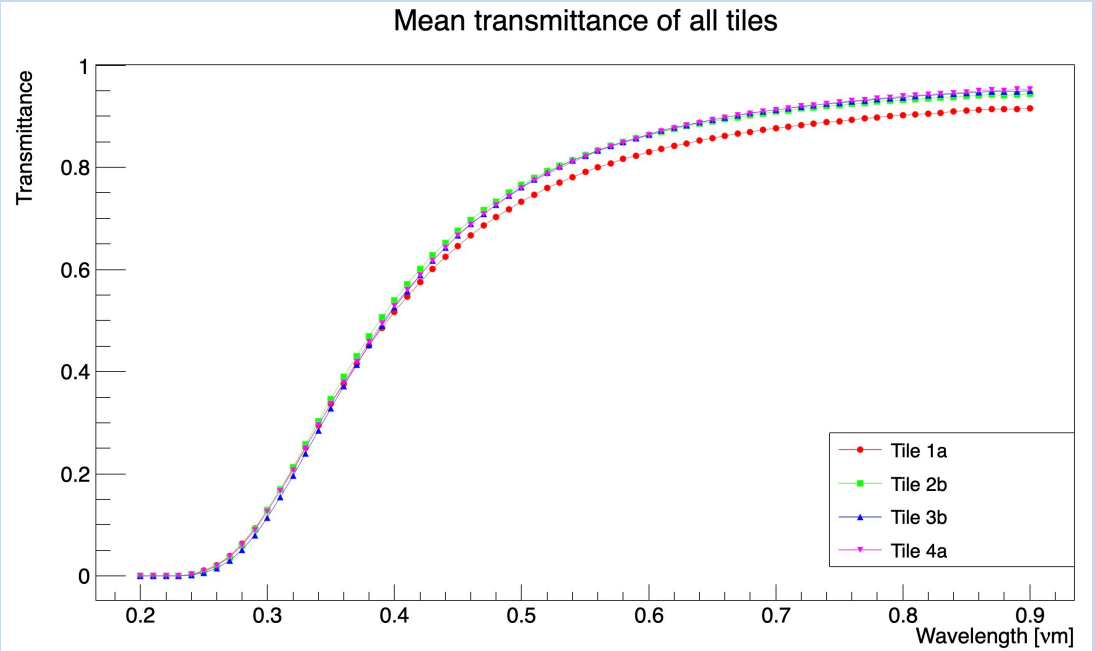
Japanese

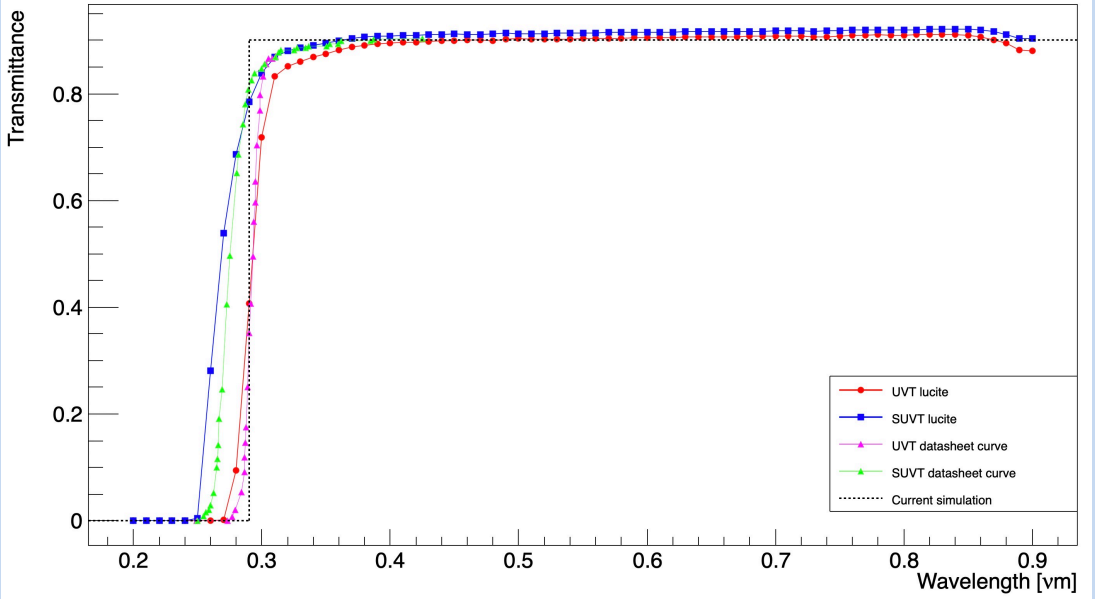
Russian

Optical quality characterization
Input for simulations and
Performance optimization

Acrylic windows







SiPM @ EIC

Meeting called by EIC Project

Extensive overview by Roberto
Very positive feedbacks

Underlying question:

Synergies and/or consortium ?

- within EIC

- with LHC

Meeting on SiPM Use and Needs at EIC

Friday 4 Feb 2022, 08:00 → 10:00 US/Eastern

Description Join ZoomGov Meeting

https://bnl.zoomgov.com/j/1619332550?pwd=SmlFTkpyTVVGNmJyNUoxcitWRjBRdz09

Meeting ID: 161 933 2550

Passcode: 214433

Find your local number: https://bnl.zoomgov.com/u/aboA1DlFap

Recording:
https://bnl.zoomgov.com/rec/share/Vj6bpWuDbG0co2IXuzr4Bs9WzE2Qw7y23_baK0OfEFGUBFtRUhW5t1xPSgRTT0bY.-qAXE2nVZAJEFDM1 Passcode: QCHva7&Y

08:00 → 08:05 **Introduction** 5m

Speakers: Patrizia Rossi (Jefferson Lab) , Thomas Ullrich (BNL)

08:05 → 08:35 **SiPMs for RICH detectors** 30m

Each talk should focus on what we have already highlighted in our e-mail, i.e.
where we are
where the technology has to improve
what the prospects are
where we can benefit from synergies
what we need to focus on

Speaker: Roberto Preghenella (INFN Bologna)

[20220204][EIC][Si...

08:35 → 09:05 **SiPMs for calorimeters** 30m

Each talk should focus on what we have already highlighted in our e-mail, i.e.
where we are
where the technology has to improve
what the prospects are
where we can benefit from synergies
what we need to focus on

Speakers: Craig Woody (BNL) , oleg tsai (ucla)

SiPMs_calor_0204... SiPMs for EIC 2-4-2...

09:05 → 10:00 **Discussion** 55m

some links shared on the chat
https://cds.cern.ch/record/2004811/files/LHCb-PUB-2015-008.pdf
S Korpar et al, NIMA 766 (2014) 107-109

Speaker: ALL

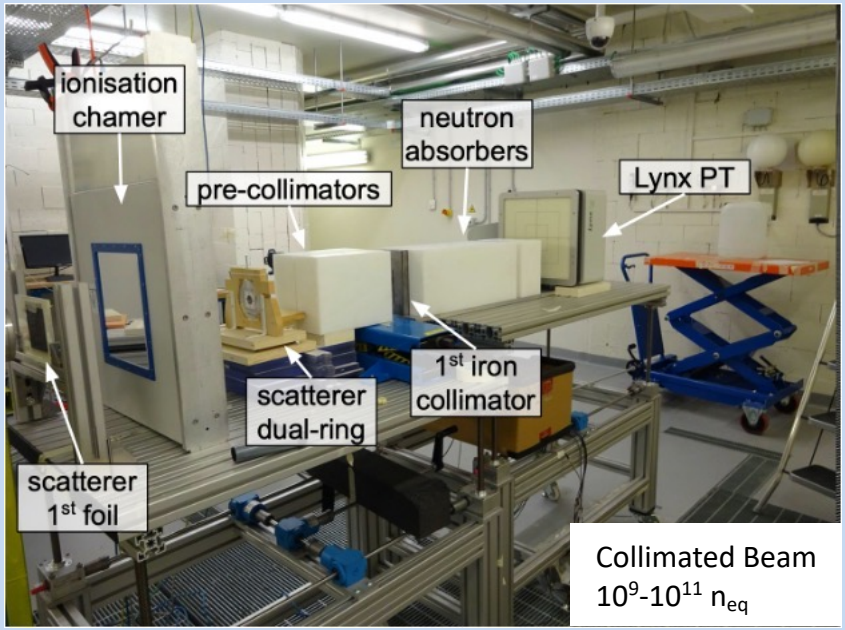
SiPM Irradiation Campaign

TIFPA Proton Beam Facility

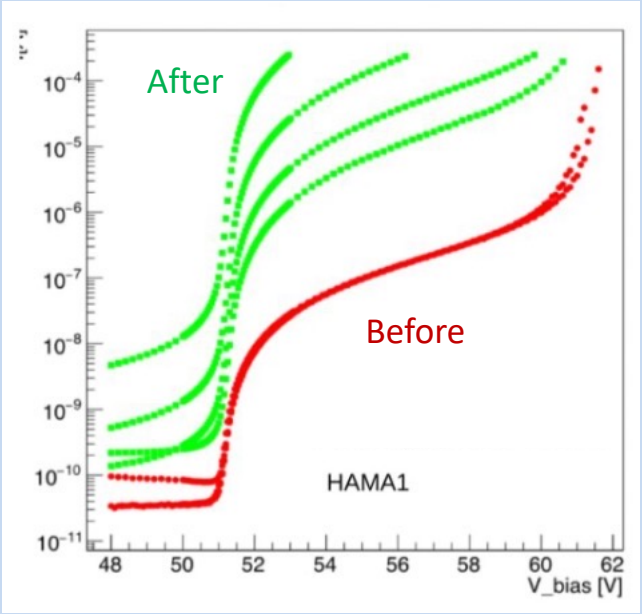
Hamamatsu
FBK

Broadcom
SensL

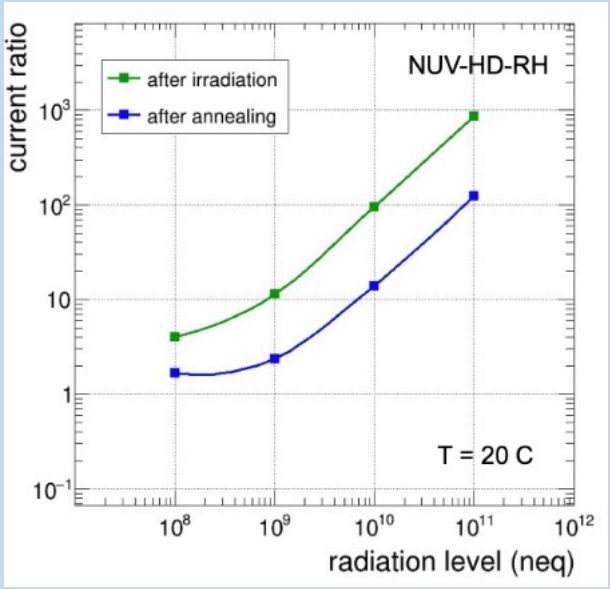
Protective layers



Collimated Beam
10^9-10^{11} n_{eq}



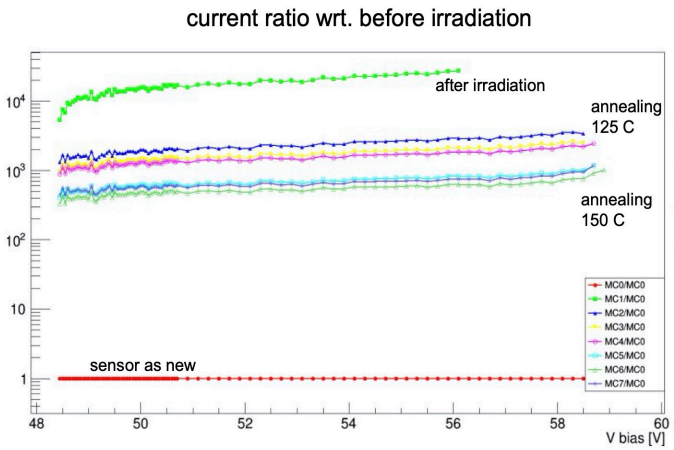
Various SiPM



SiPM Irradiation

Uniformate the treatment over the various SiPM

- **FBK SiPM carrier boards have been reworked**
  - solder paste used originally did not sustain T > 125 C
  - sensors unmounted and remounted on boards with high-T solder paste
- **FBK SiPM carrier boards to anneal like Hamamatsu**
  - we stopped at T = 125 C for FBK annealing
  - we stopped at T = 150 C for Hamamatsu annealing
  - we should align them for a fair comparison
  - discussed with Ferrara, annealing of FBK will be carried out there
- **annealing at higher temperatures ?**
  - originally we foresaw to reach up to T = 175 C for annealing



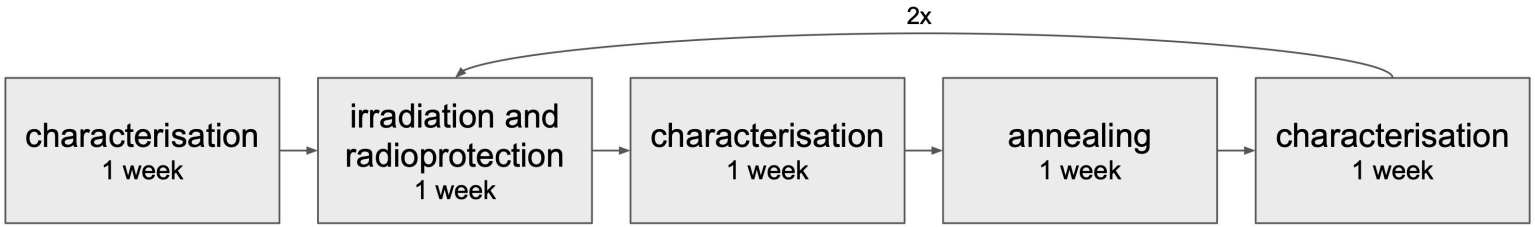
More realistic and efficient irradiation

test SiPM performance and annealing with increasing integrated NIEL

simulate a more realistic experimental situation

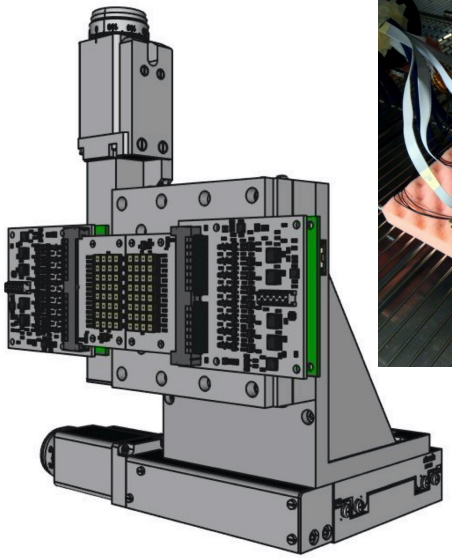
irradiate full SiPM carrier boards with flat proton field

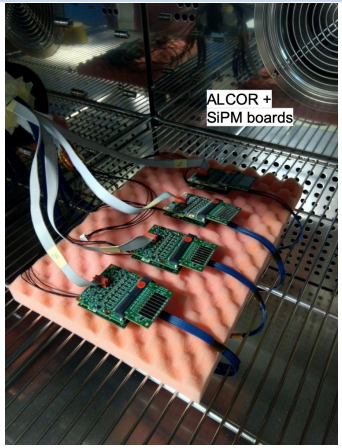
no collimators, his will make life much easier and very efficient use of beam

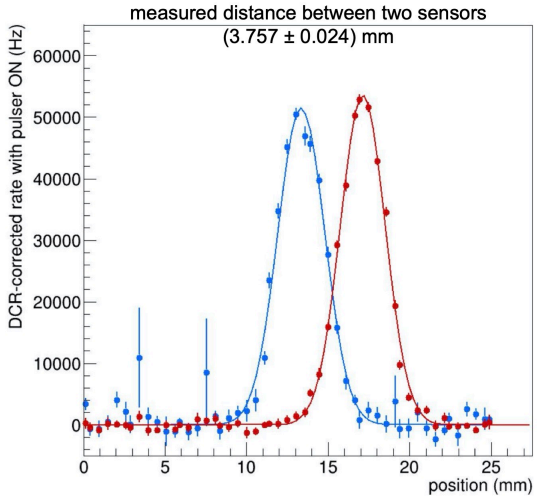


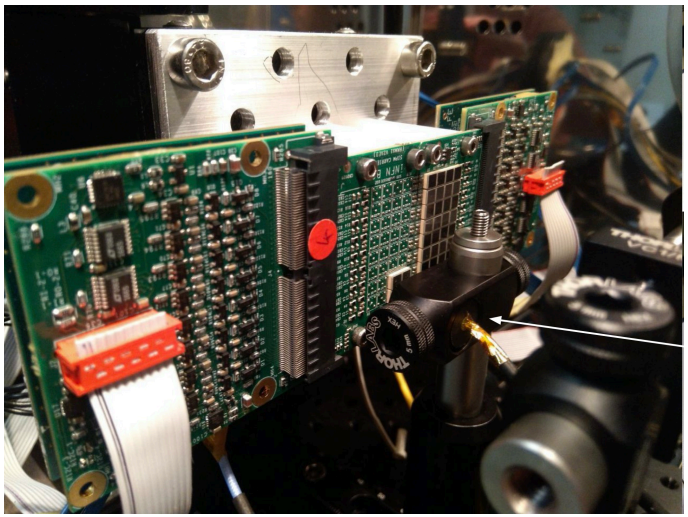
SiPM Characterization

- **use the complete electronics built in 2021 for laboratory tests**
  - SiPM carrier + adapter + ALCOR + readout
  - mount everything in the climatic chamber
  - with an LED / laser in front of the sensor
  - plus movimentation to inspect all sensors
- **study response of SiPM to pulsed light**
  - pulsed LED / laser
  - measure increase of rates
  - measure time coincidences
  - compare sensors with different NIEL
- **system is being setup in Bologna**
  - the goal is to have it as a permanent test bench
  - to be used to test SiPM response for 2022 irradiation plan
  - to be used to get ready for test beam (in case we want to)





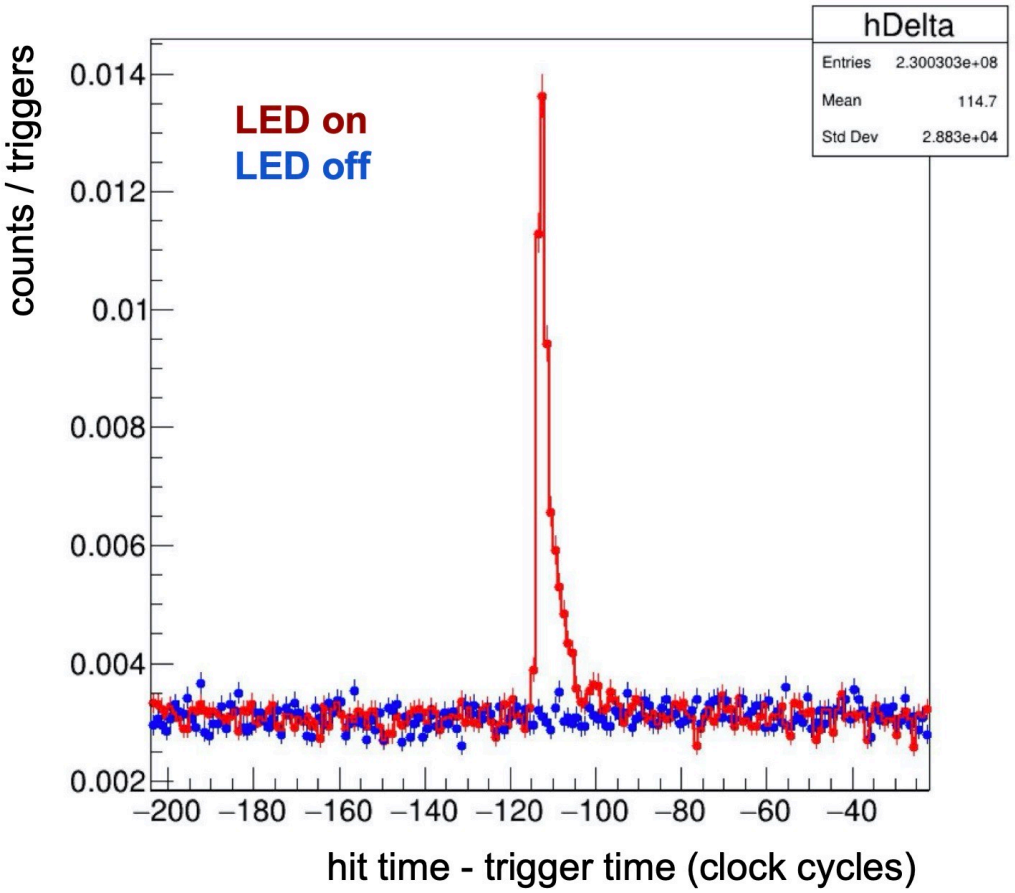


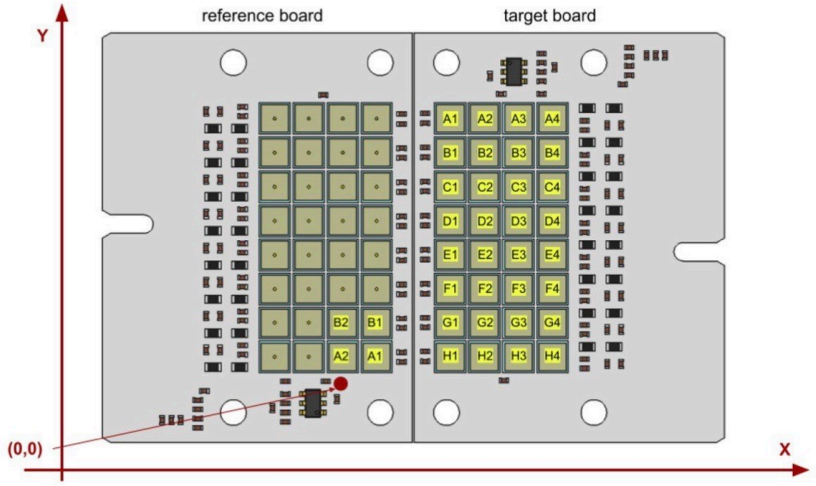


New motor for Low-T operation funded by CSNIII

SiPM Characterization

Directly compare post-irradiation and post-annealoing response with reference SiPM





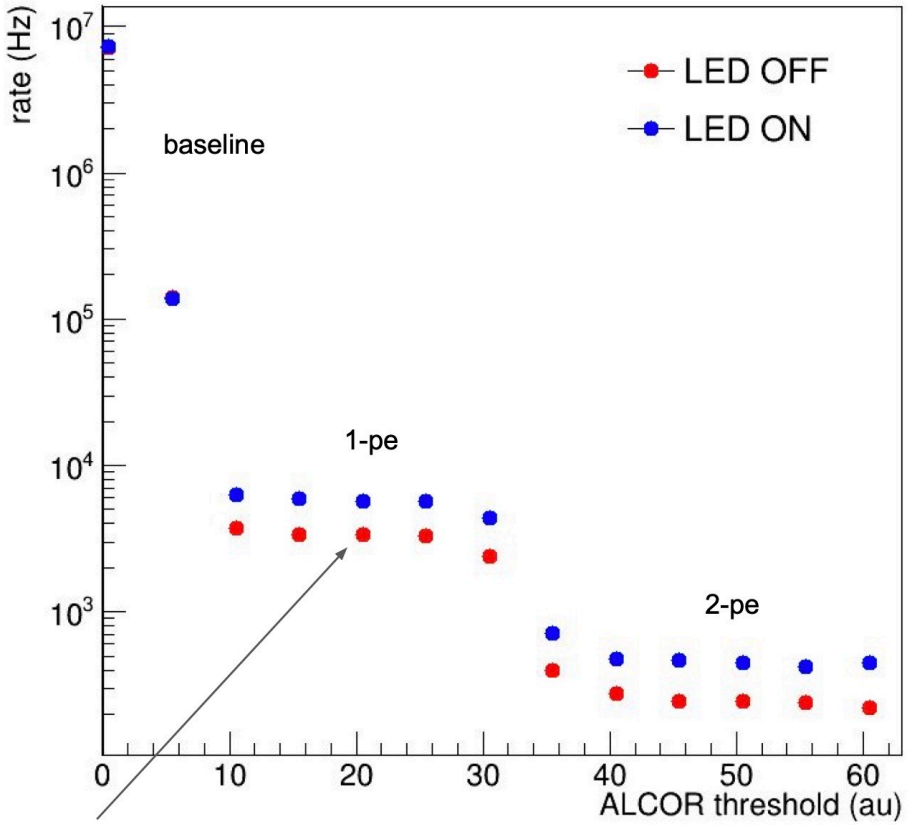
this is sensor C4
of the Hama1 irradiated board
which received NIEL = 10^{11}
and annealing at T = 150 C

measured at T = -30 C
with Vbias = 51.3 V
and threshold for 1-pe detection

SiPM and ALCOR

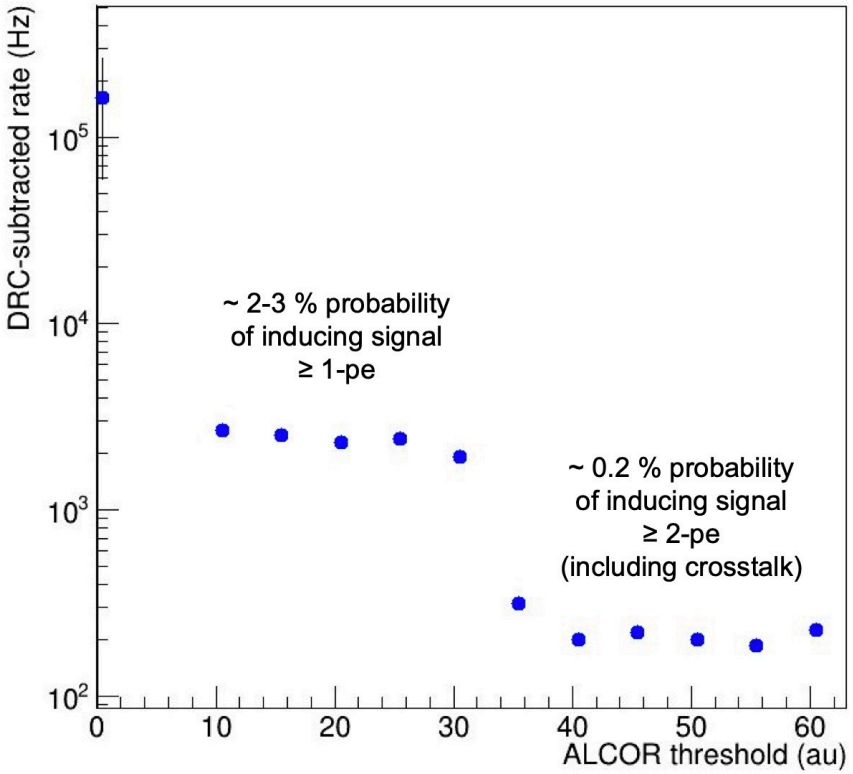
Study the SiPM+ALCOR response to the single photon regime

pulsed LED at 100 kHz frequency



this is the DCR

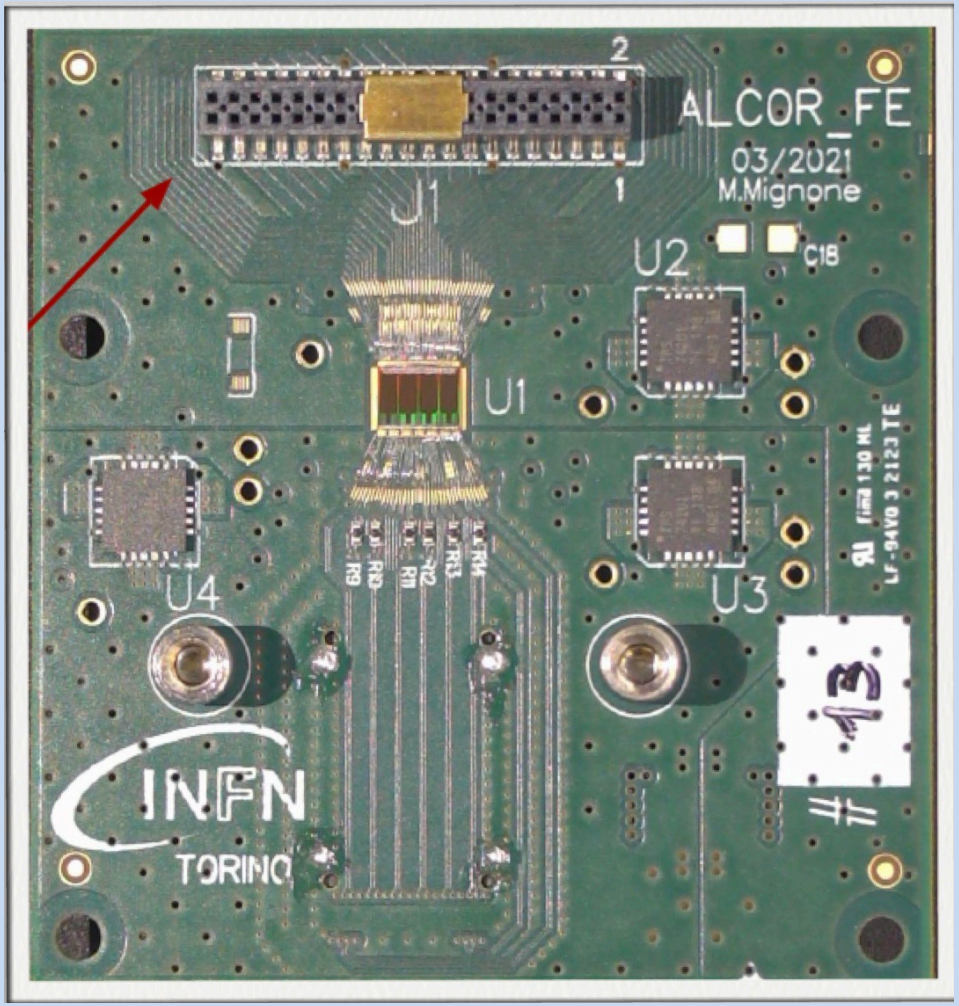
most of the time (~97%) there is no signal from SiPM
⇒ LED light emission is low



pulser ON - OFF

ALCOR Chip

- ALCOR (A Low Power Chip for Optical Sensor Readout) stems from an INFN R&D as a mixed-signal ASIC for the readout of SiPMs in the framework of Darkside. Optimised for cryogenic operation and low power
- pixel matrix mixed signal ASIC the chip performs amplification, signal conditioning and event digitisation, and features fully digital I/O
- Single-photon time tagging mode or time and charge measurement
- 4 LVDS TX data links, SPI configuration
- operation up to 320 MHz (TDC binning down to 50 ps)



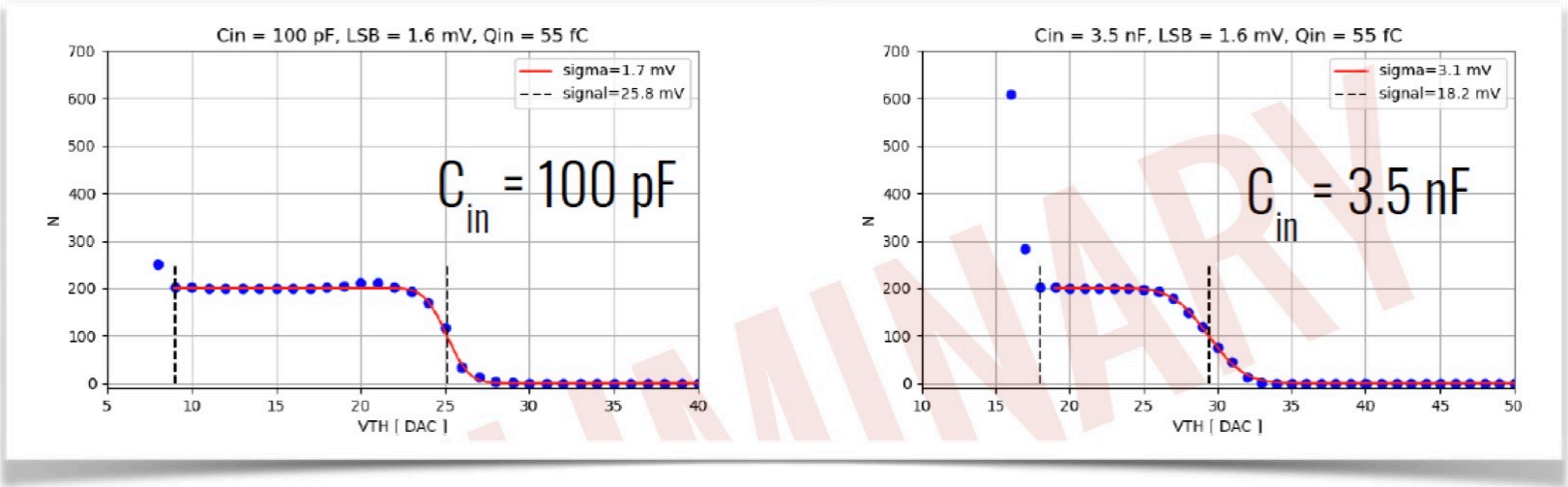
ALCOR Version 2

New features

1. Bug fixing (TDC control logic)

2. high gain
   - 2 branches and 4 gain settings already available (≃ 60 - 600 mV/pC) —> increase the gain
   - single-photon detector of SiPM with low-gain (3 10^5)

3. AC coupling on chip
   - not for v2 —> to have more flexibility for test with different SiPM



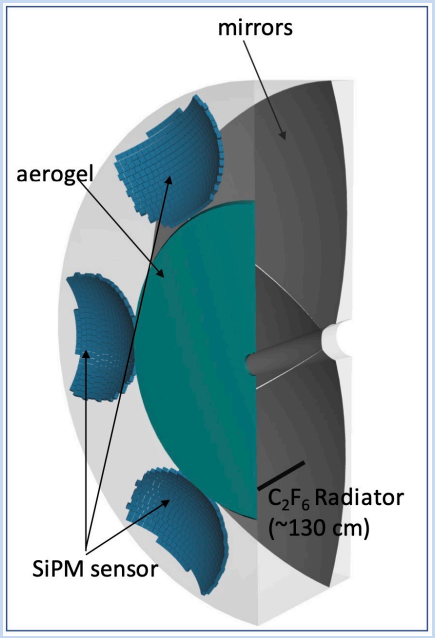
Submission end of April 2022
New ASICs (~40) expected by end of July 2022

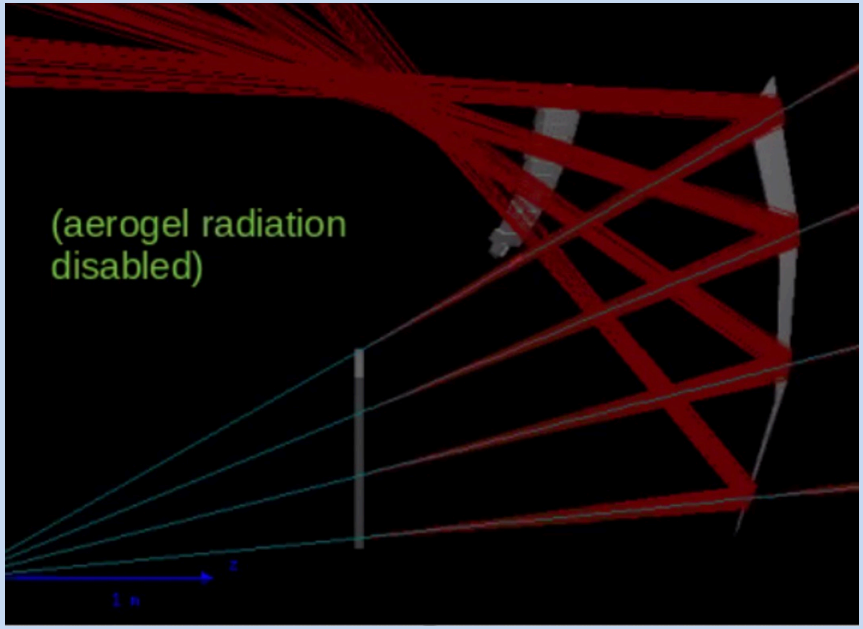
Simulation & Analysis

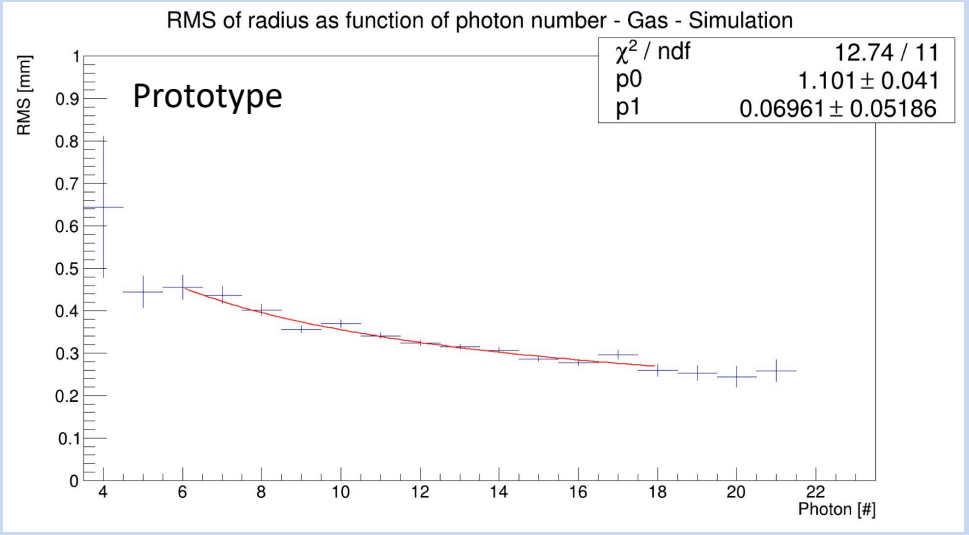
Collaboration with US groups (DUKE, Stone Brooks,…)

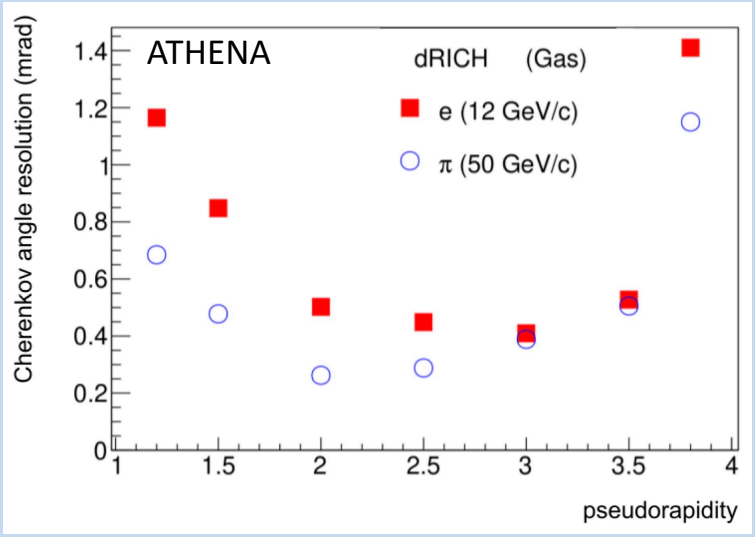
Match prototype framework

Implement AI algorithms









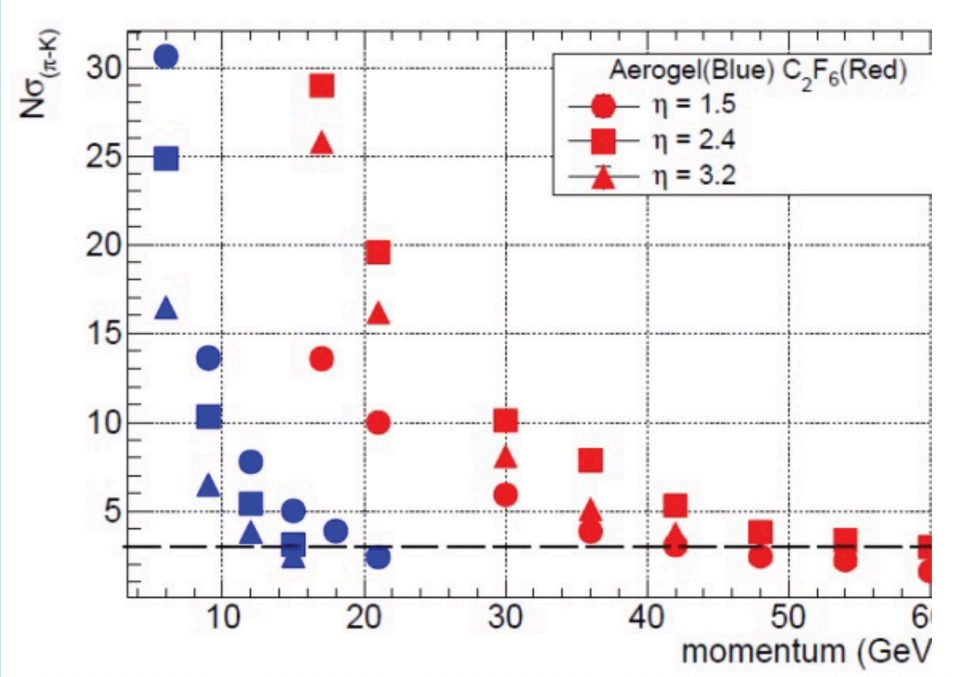
Simulation & Analysis

Study performed within ATHENA framework

Characterization of dRICH with single particle in vertex, true mc particle information

No noise has been included

No physics performance has been studied yet



Unexpected number of photons whit multi-particle events requires
- consistency checks
- pattern recognition algorithms

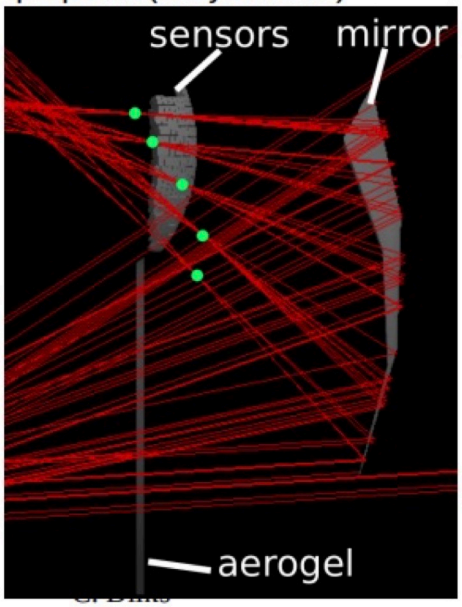
A survey on existing pattern recognition methods is ongoing

Meeting with experts from ALICE, CLAS12, COMPASS, HERMES, LHCb being organized as kick-off brain storming

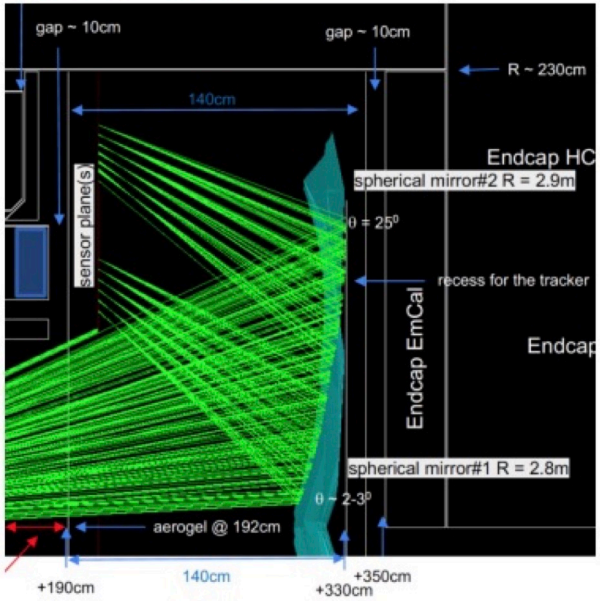
Simulation & Analysis

Optimization study: adjusting sub-mirror focal lengths for best focusing onto the sensor active surface

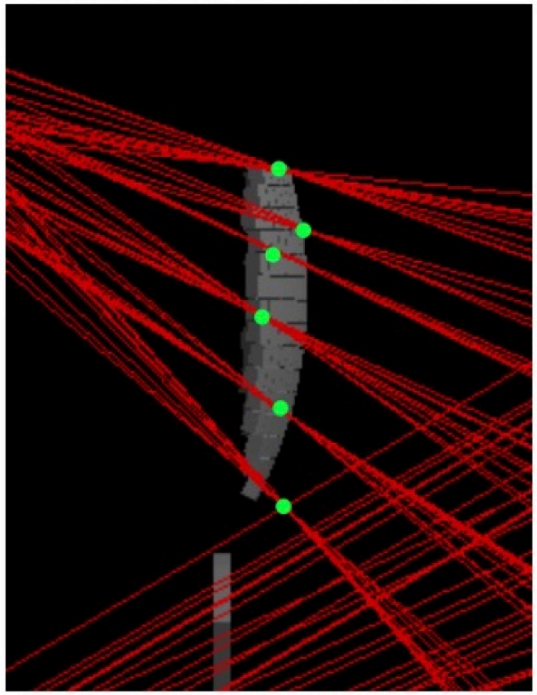
single-mirror config, 5 collimated photon beams; this is what we ran with for the proposal (canyonlands)



Alexander's dual mirror configuration, in standalone Geant4 sandbox



current status of dual mirror configuration in DD4hep:



Alternate Solutions

Alternate sensors and readout

LAPPDs

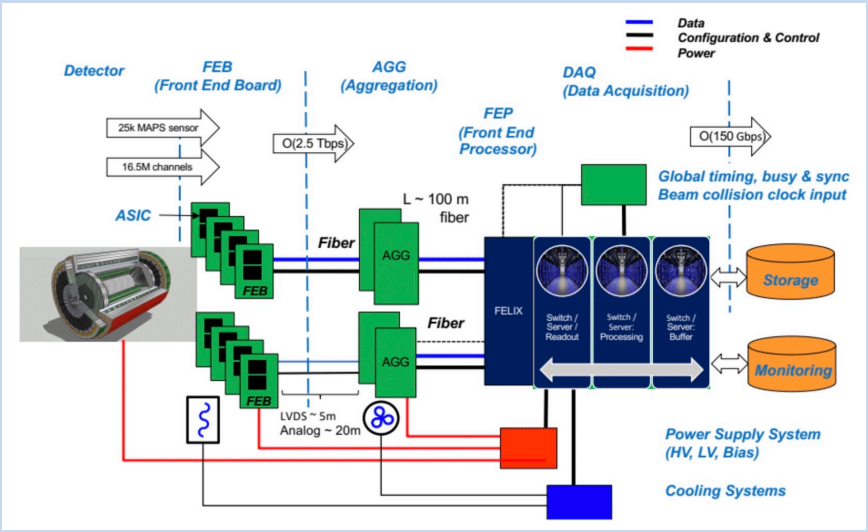
Deb's talk

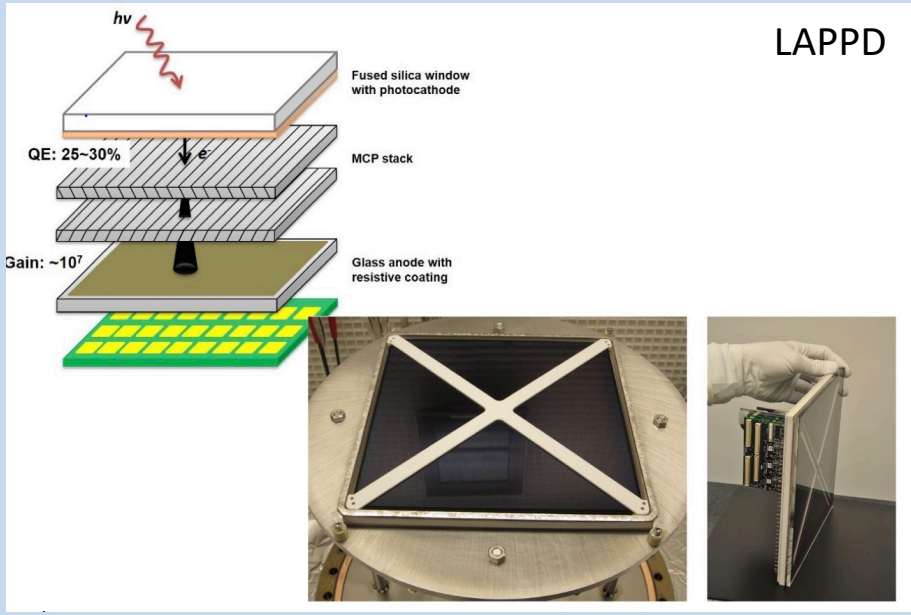
Streaming readout (+ AI)

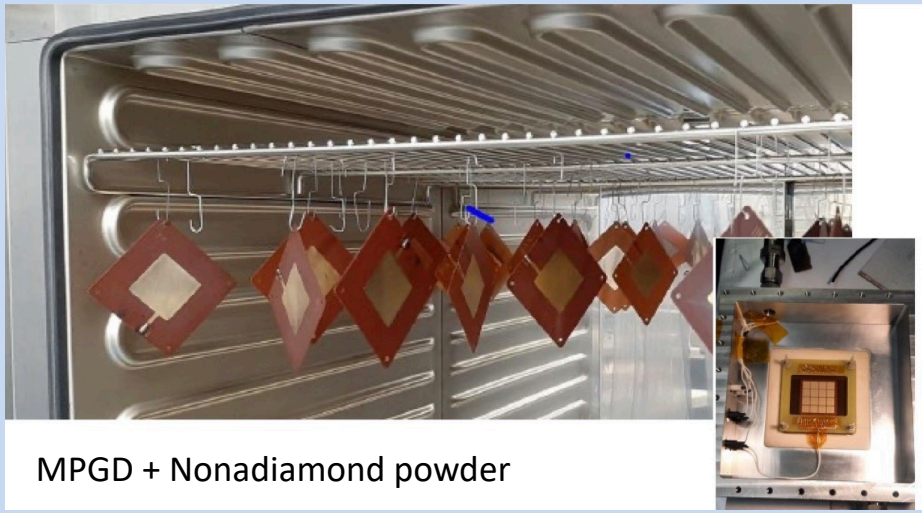
Challenging data troughput from SiPM
Smart (new) streaming scheme is required

INFN-GE issued a MAECI assegno di ricerca
No eligible candidates → redirected

Online AI applications for PNRR







LAPPDs

- The LAPPD 'for free' from INCOM received at the beginning of January
  - Ongoing effort to be in the position of starting the studies (pre-preliminary, at present)
  - Starting **interactions with GE** as soon as we are ready to start
  - A few slides from Deb to share with you the pre-preliminary
- On collaborative aspects
  - A first meeting with **NISER** (Bedanga Mohanty et al.) : they are purchasing an LAPPD and preparing the lab for characterization studies
  - Monthly meetings with them agreed upon
  - A meeting organized by Alexander Kiselev to form an **LAPPD Consortium**
  - EIC, but not only (similar to Si Consortium, AC-LGAD Consortium)
  - A workshop to launch the initiative ~ mid March 2022

Pressurized Gas

- At the moment, looking for pre-conceptual ideas
- 2 meetings with BNL engineers and Elke
  - June 7, 2021 (Elke, Silvia, Michael Gaffney, Mario Cubillo)
    - Also Francesco Noto invited, he did not attend
  - January 10, 2022 (Elke, Silvia, Paul Orfin, Cody Taylor)
- Outcome after the first meeting: not in the right direction
  - 10 cm thick Al plate forming the entrance windows!
  - Or similar options with stain steels …
- Second meeting, moving towards the right direction

Merging with the dRICH mechanics meetings with BNL+Jlab

dRICH Mechanics

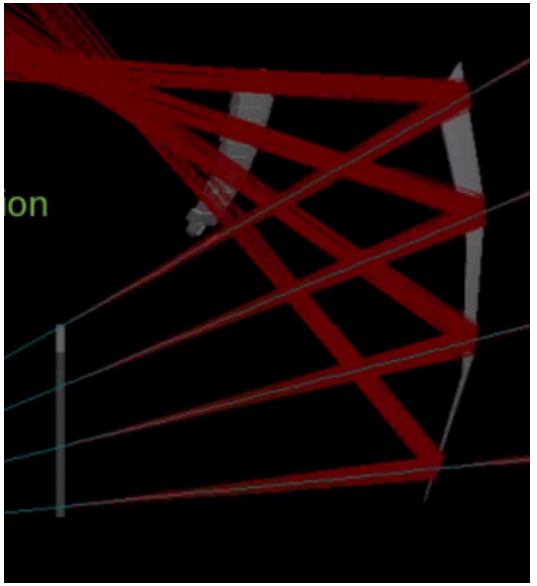
Few meetings with EIC management to involve engineering manpower from BNL and JLab

Aerogel: quartz foam
20 x 20 x 2 cm^3 bricks
Weight: 0.17 kg/brick
Surface: 200 bricks

Mirrors: carbon fiber reinforced polymer
sub-mirrors with $\leq$ 1m diagonal
Weight: 5 kg/m^2
Surface: 15 m^2

Structure: composite material skeleton
tedlar wrap (no high-pressure)
Acrylic/quarts entrance and exit windows
Aluminum detector boxes

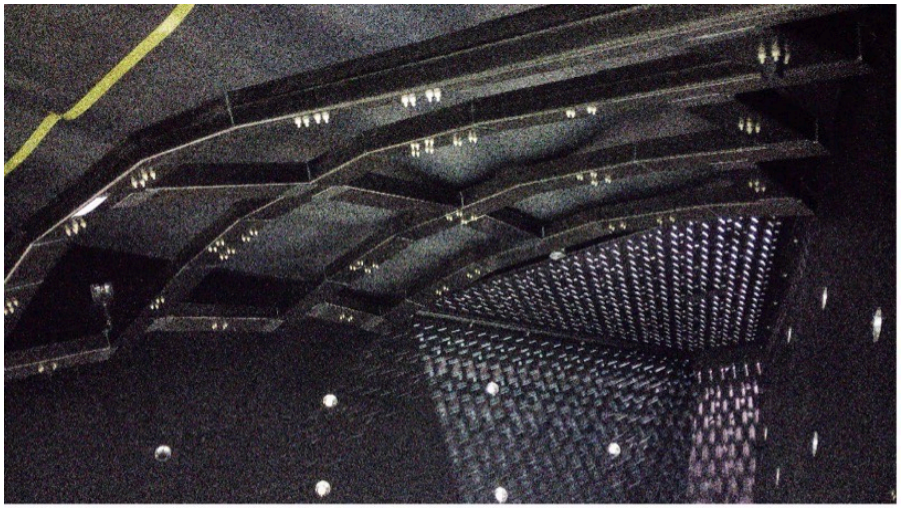
Detector: 6x SiPM + cooling plate + F/E electronics
Weight: 150 kg
Surface: 0.5 m^2
Power: 2 kW
Temperature range: - 40 C (stable working point)
+ 170 C (few-days annealing)



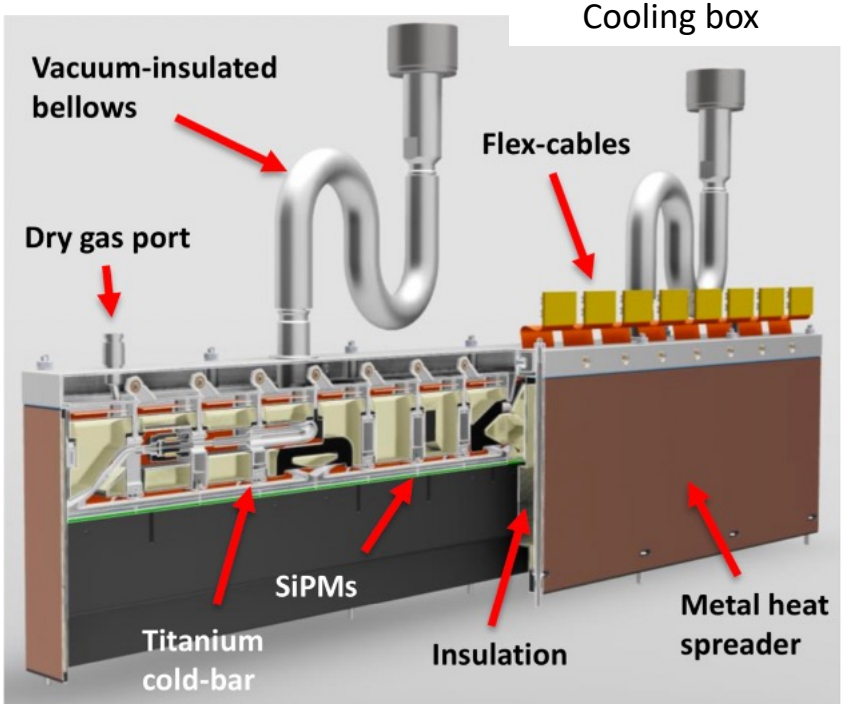
dRICH Mechanics

Revieweing specifciations and existing technical solutions

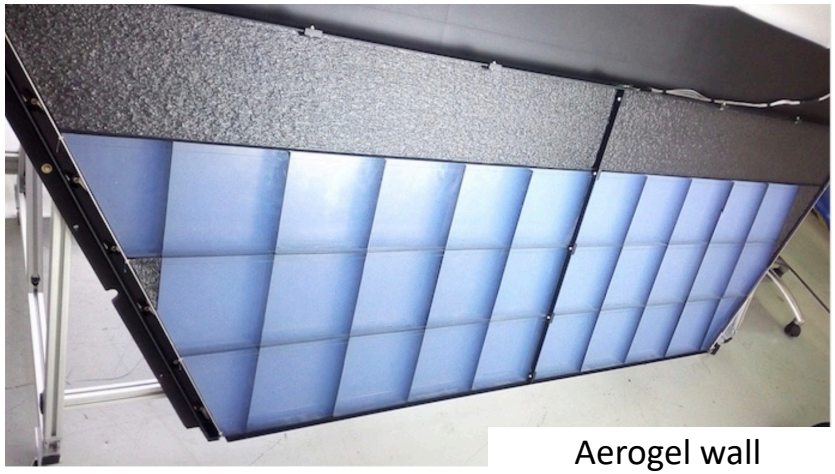
Structure



Cooling box



Mirrors



Aerogel wall

Summary

dRICH activity is making progresses in many areas (even if with different speed)

Prototype:
- qualitay assessment of components
- new test-beam preparation

SiPM:
- irradaition + annealing campaign
- detailed single-photon response characterization
- realistic and optimized protocols

ALCOR readout:
- version2 in preparation
- AI for online applications (i.e. streming readout)

Alternate solutions:
- Study alternatives as risk mitigations
- LAPPDs
- Pressurized gas

Networking:
- Creating a collaborative net (SiPM, LAPPDs, simulation, mechanics….)