dRICH Interaction Tagger status

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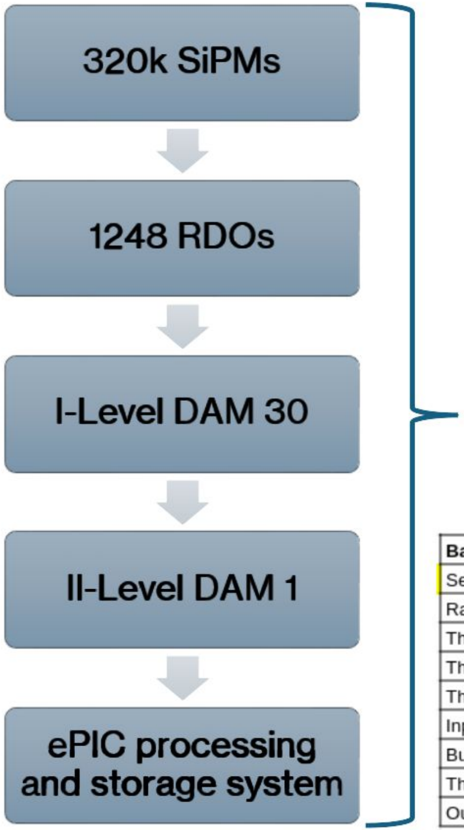
The dRICH data throughput challenge



dRICH DAQ parameters	
RDO boards	1248
ALCOR64 x RDO	4
dRICH channels (total)	319488
Number of DAM L1	27
Input link in DAM L1	47
Output links in DAM L1	1
Number of DAM L2	1
Input link to DAM L2	27
Link bandwidth [Gb/s] (assumes VTRX+)	10
Interaction tagger reduction factor	1
Interaction tagger latency [s]	2,00E-03
EIC parameters	
EIC Clock [MHz]	98,522
Orbit efficiency (takes into account gap)	0,92

Bandwidth analysis		Limit
Sensor rate per channel [kHz]	300,00	4.000,00
Rate post-shutter [kHz]	55,20	800,00
Throughput to serializer [Mb/s]	34,50	788,16
Throughput from ALCOR64 [Mb/s]	276,00	
Throughput from RDO [Gb/s]	1,08	10,00
Input at each DAM I [Gbps]	50,67	470,00
Buffering capacity at DAM I [MB]	12,97	
Throughput from DAM I to DAM II [Gbps]	50,67	10,00
Output to each DAM II [Gbps]	1.368,14	270,00

Sensors Dark Count Rate: 3 - 300 kHz (increasing with radiation damage → with experiment lifetime).

Detector throughput: 14 - 1400 Gbps.

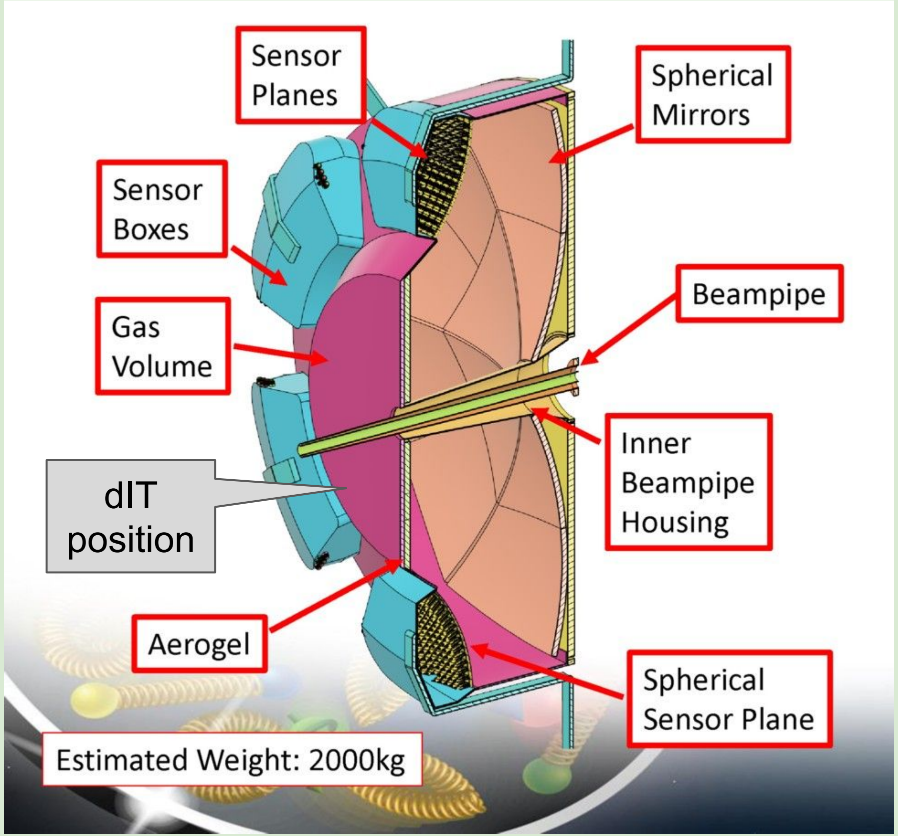
EIC bunch crossing: bunch crossing rate of 100 MHz.

Physical relevant interaction: one every ~ 200 bunch crossing → interaction rate of 500 kHz.

A system tagging the interacting bunches can solve the throughput issue.

An ML-guided data reduction system is being developed by INFN RM1 as a complementary option to solve the issue.

The dRICH Interaction Tagger



The dRICH Interaction Tagger (dIT) will be a scintillating detector-based component of the dRICH, designed to tag events in which at least one charged particle with sufficient energy passes through.

Requirements:

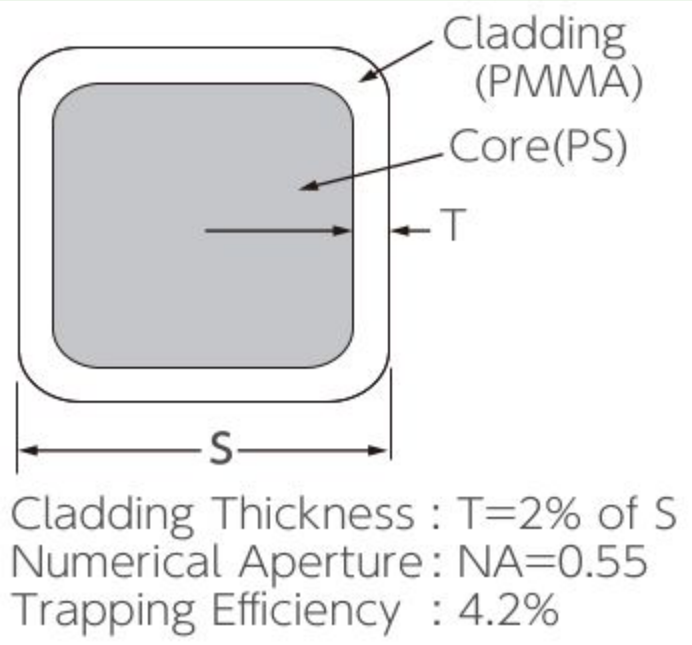
- High efficiency (no false negative);
- Good timing ~1 ns;
- Reduction factor > 10;
- Thin due to strict geometrical constraints.

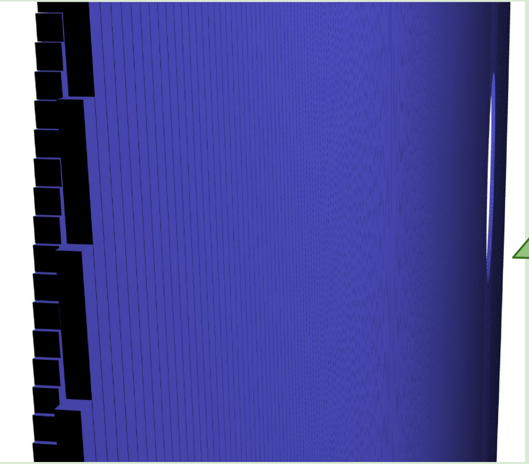
We are developing a hodoscope based on Scintillating Fibers (SciFi) to meet these requirements. It consists of two layers of square-shaped SciFi, rotated by 90°.

The dIT simulation

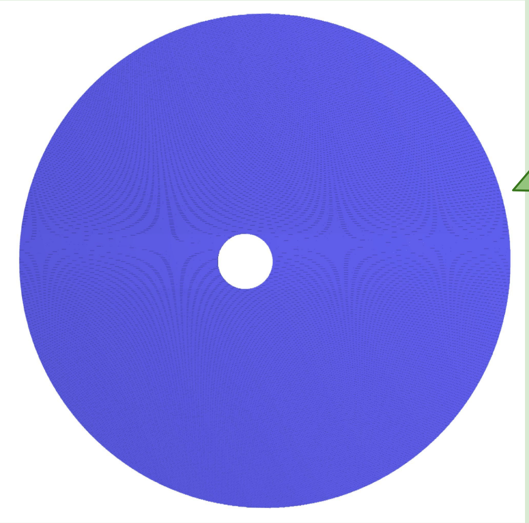
The SciFi simulation

- Two layers of 2 mm wide scintillation fibers, 2% cladding thickness
- XY-directions, 956 fibers/layer, 1.23 km of fiber length/layer;





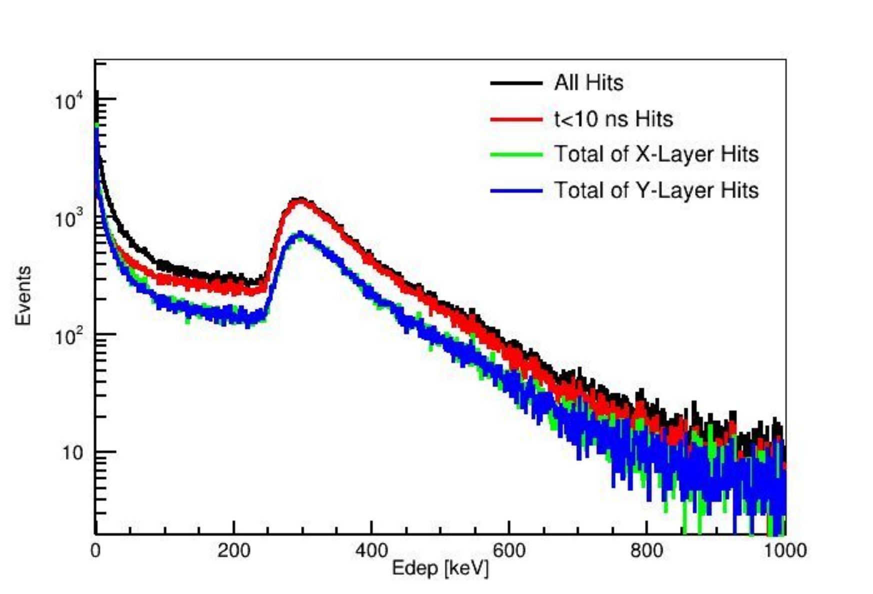
The 2-mm-wide squared-shape SciFi

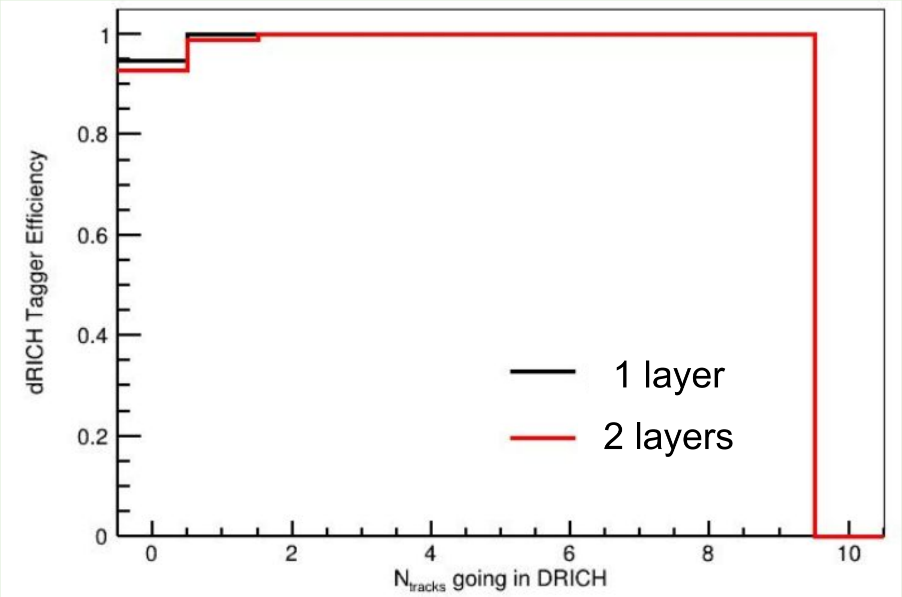


The dIT implementation. The beam pipe hole has an offset of ~ 25 mRad

The SciFi expected performance

- E_{MPV} = 300 keV/layer = 2400 photons ≅ 20 p.e./SiPM;
- The threshold could be set at 100 keV ≅ 7 p.e./SiPM → expected Poisson inefficiency < 0.1 %;
- Efficiency is estimated as the ratio of events with charged tracks having dIT over the number of events with dRICH hits.
- Overall expected efficiency 99.97%, if there is at least one track from the interaction point in the dRICH.

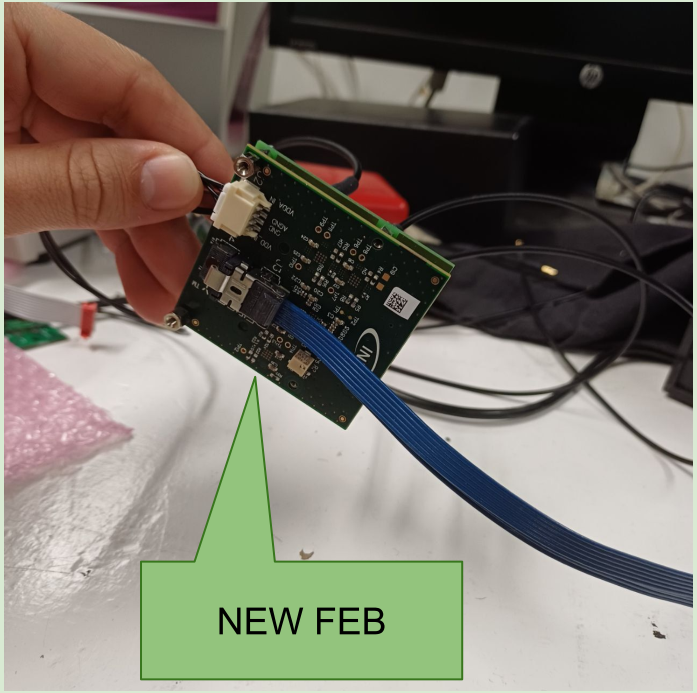


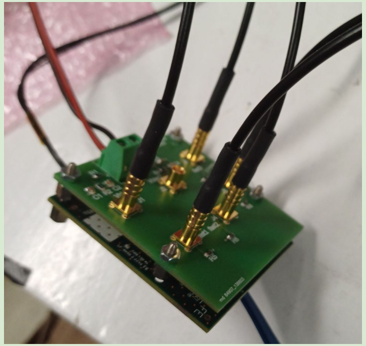


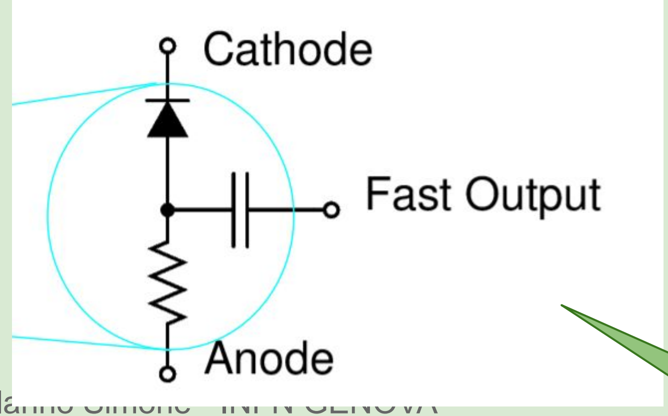
Lab activity status

Onsemi SiPM FEB

We developed a “new FEB” to use ALCOR to perform tests on our Scintillating Fibers and Onsemi SiPM with fast output.





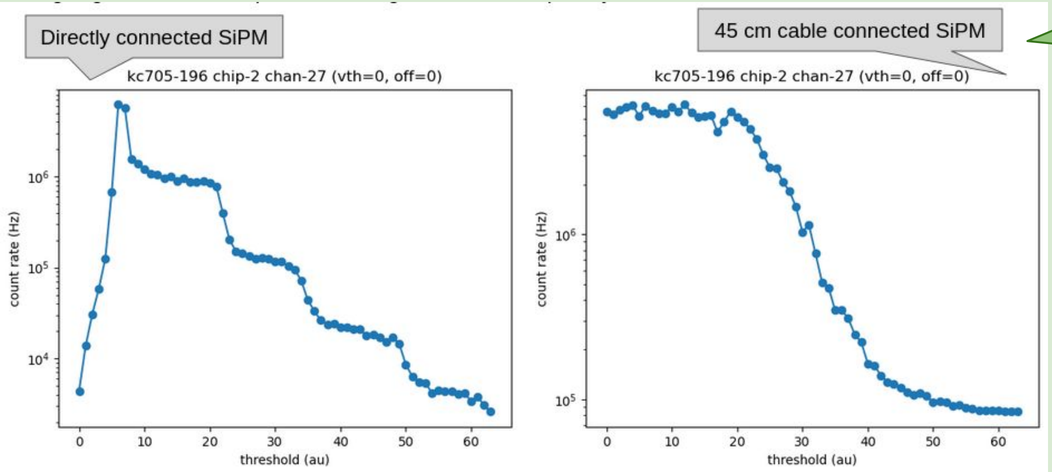


ON Semiconductor®

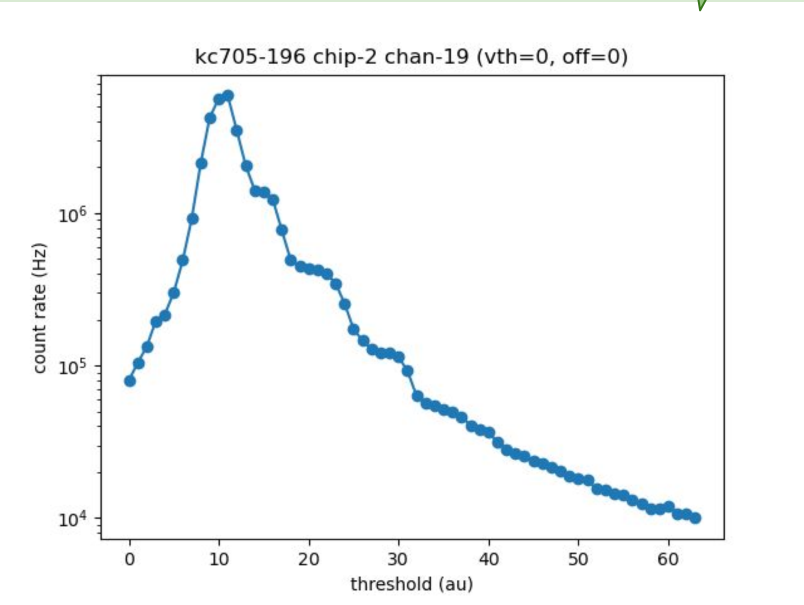
J-Series SiPM

New SiPM connection

Slide from the last update



Plot with new FEB



The new FEB allowed to improve the signal transmission from the SiPM to ALCOR through a ~m cable. The plots show threshold scan performed with ALCOR.

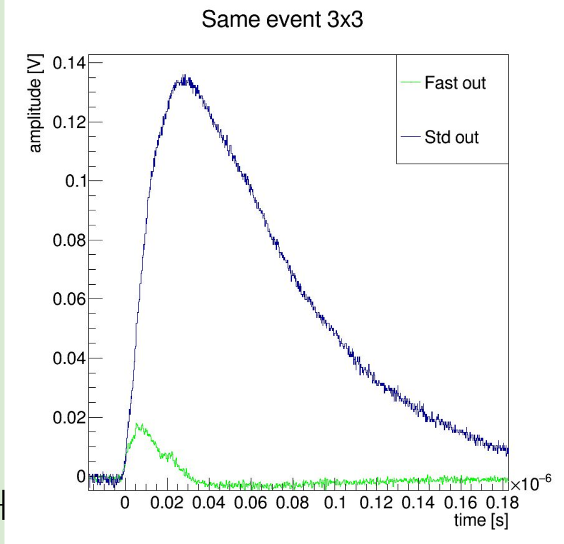
Fast signal SiPM study

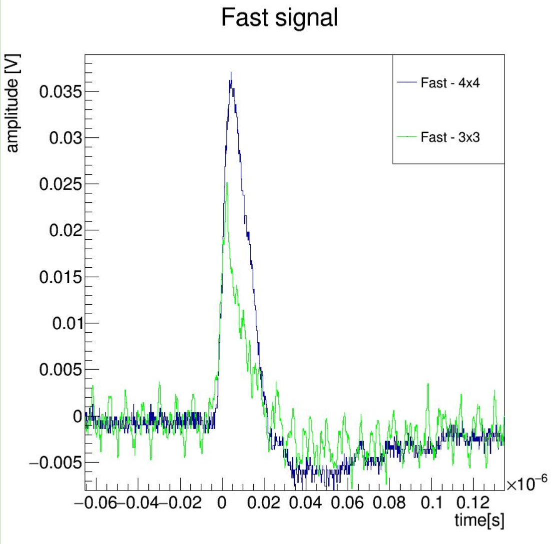
We performed some preliminary test with the Onsemi fast output SiPMs:

- The test setup included a plastic scintillator tile with VM2000 reflective layer and the SiPM readout;
- Sensors with 3x3 and 4x4 mm^2 active area were tested;
- Both fast and standard output were evaluated.

Expected performance from datasheet:

- Fast output rise time ~ 100 ps;
- Fast output pulse width (FWHM) 1.5 ns →limited by the plastic scintillator's response time (~10 ns).





The Onsemi fast-output SiPM appears to be a promising option for improving the timing performance of our detector.

Further tests will be carried out to evaluate the Time-over-Threshold (ToT) measurement compared to the standard output signal.

Conclusions and outlook

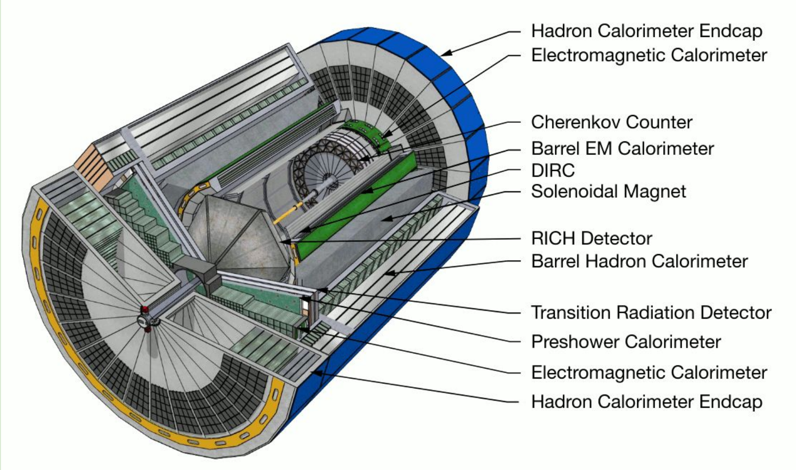
- The dRICH Interaction Tagger is an effective solution to the high data throughput challenge;
- Simulations show that the two-layer SciFi design provides a highly efficient hodoscope;
- The purchased SciFi is expected to be delivered in early June, enabling final testing and performance verification;
- With our DAQ setup, we are able to acquire signals from SiPMs connected via cables of meter-scale length;
- The Onsemi fast-output SiPMs are promising candidates for improving timing resolution, potentially down to ~200 ps;
- The reliability of the fast-output ToT measurement is currently under investigation.

Thanks for your attention

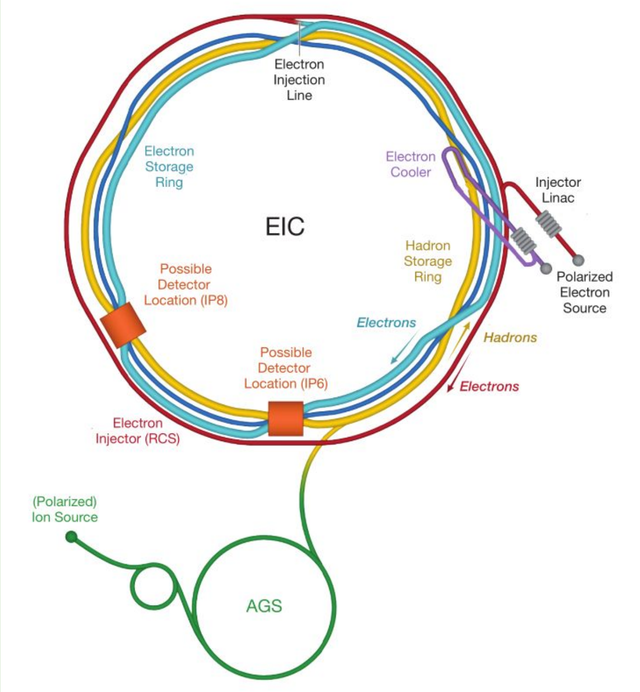
Backup slides

Electron-Ion Collider EIC

- Beams of various ion species, from proton to uranium;
- Highly polarized beams ~ 70%;
- Variable *e+p* center-of-mass energies in the range 20 ÷ 140 GeV;
- High collision electron-ion luminosity $10^{33} \div 10^{34}$ $cm^{-2}s^{-1}$;
- Up to two general-purpose detectors;
- The first will be the electron-Proton/Ion Collider experiment
- The experiment is scheduled to start in 2036.



Brookhaven National Laboratory

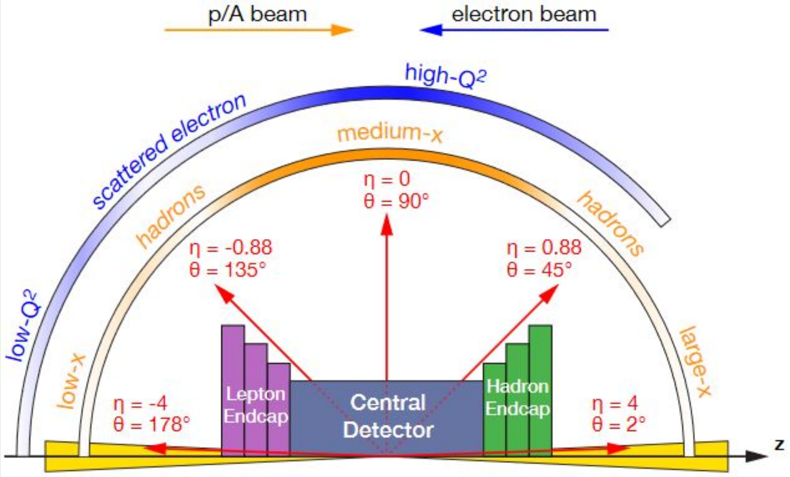


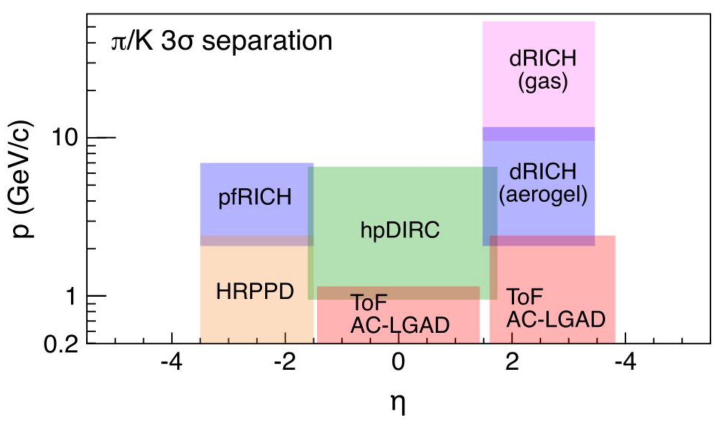
electron-Proton/Ion Collider experiment ePIC

ePIC is built around a superconductive solenoid providing a ~1.7T magnetic field along the beamline.
It is composed of three main parts:

- The Barrel surrounding the beamline;
- The Electronic Endcap in the backward direction;
- The Hadronic Endcap in the forward direction.

Each one includes high-precision detectors for tracking, calorimetry, and particle identification (PID).

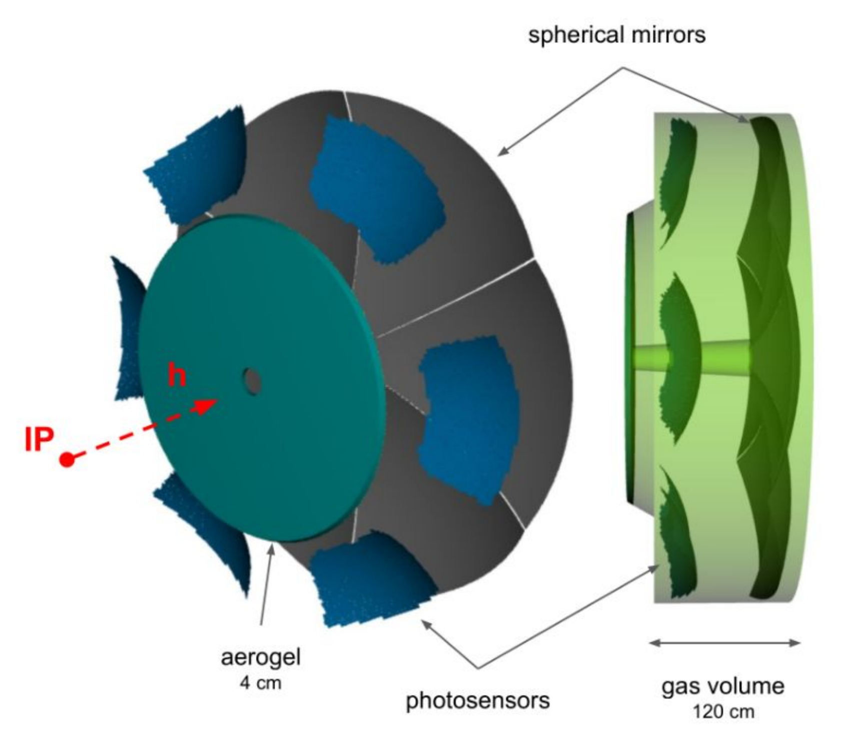




The PID at ePIC will be performed by combining the information provided by several detectors.

In the Hadronic Endcap, PID will be made by the AC-LGAD Time-of-Flight, which will identify low momentum pion and kaon in the forward endcap ($0.2 < p_H < 2.3$ GeV/c), and the dual-radiator RICH.

The ePIC dual Radiator Ring Imaging Cherenkov

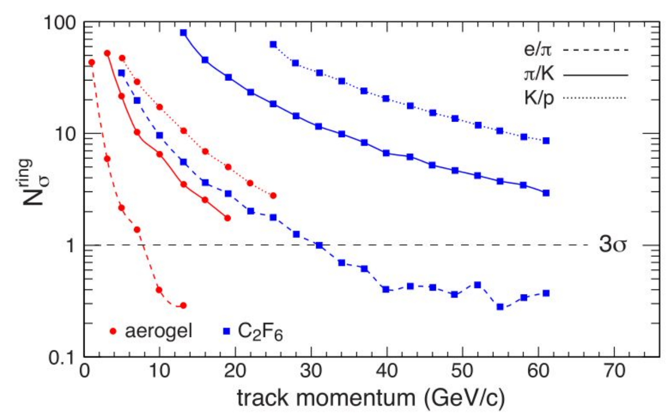


The identification of charged particles with momenta larger than 3 GeV/c in the hadronic endcap will face two major challenges:

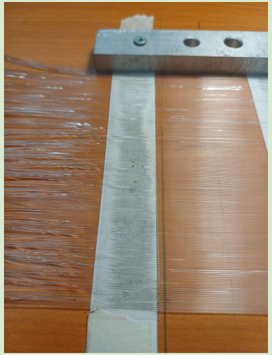
- to cover a wide momentum range (up to 50 GeV/c);
- to operate in a high (~1T) magnetic field.

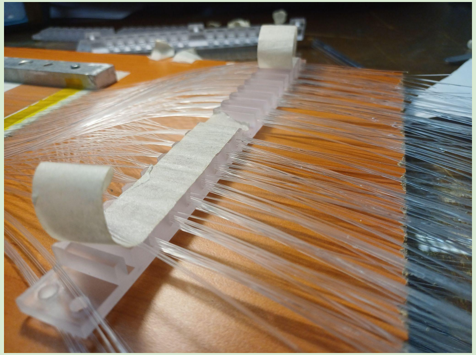
The two radiators, aerogel (n≃1.020) and gas (n≃1.0085) will allow for combining their information to identify hadrons over the full momentum range.

The **Silicon Photomultiplier (SiPM)** will be used as magnetic-insensitive photosensor.

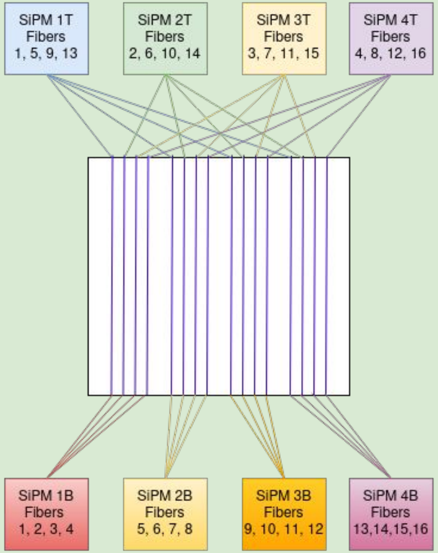


The SciFi tagger-tracker prototype





- 1 layer of tracker prototype based on 0.5 mm ∅ SciFi;
- 10 cm →200 fibers;
- 32 channels;
- Designed to identify the exact fiber that fired;
- A new 2 mm ∅ fiber sample was ordered from Luxium. It will be used to measure the performance of this large-diameter fiber.



ALCOR DAQ chain - first version

The DAQ chain