The dual RICH detector for the Electron Ion Collider

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On the behalf of the EIC_NET initiative

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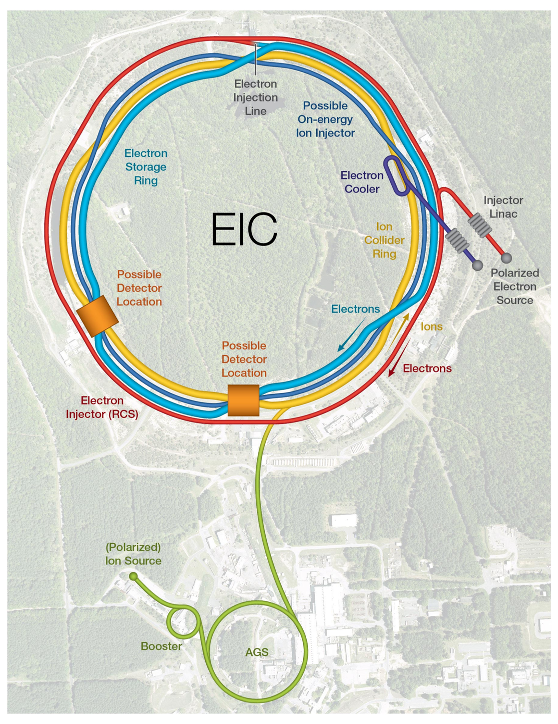
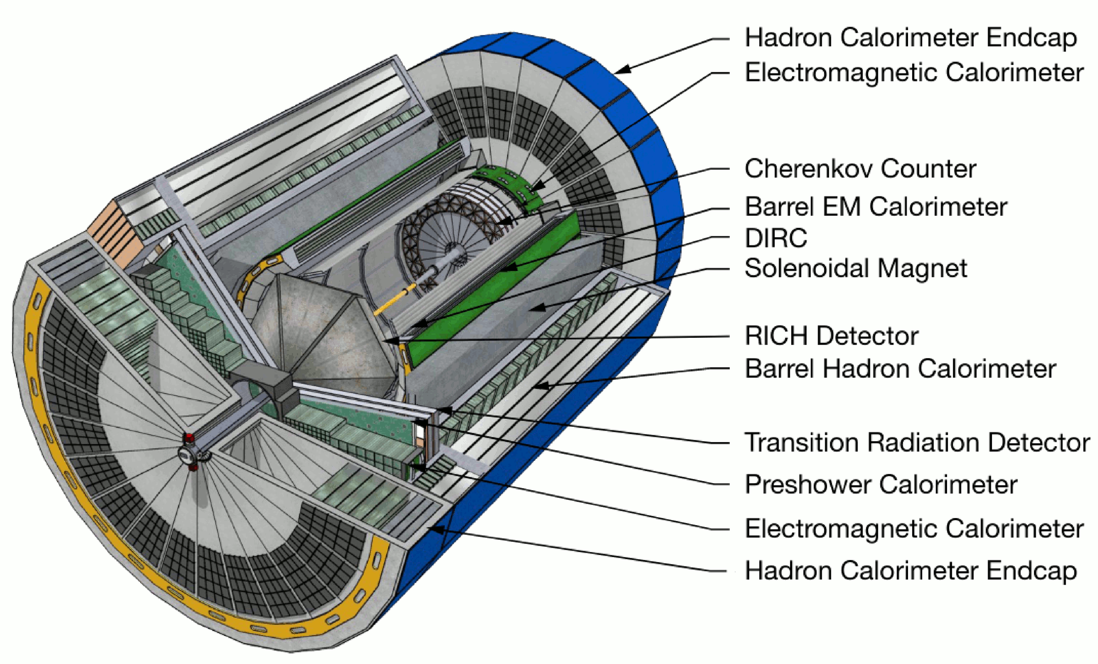
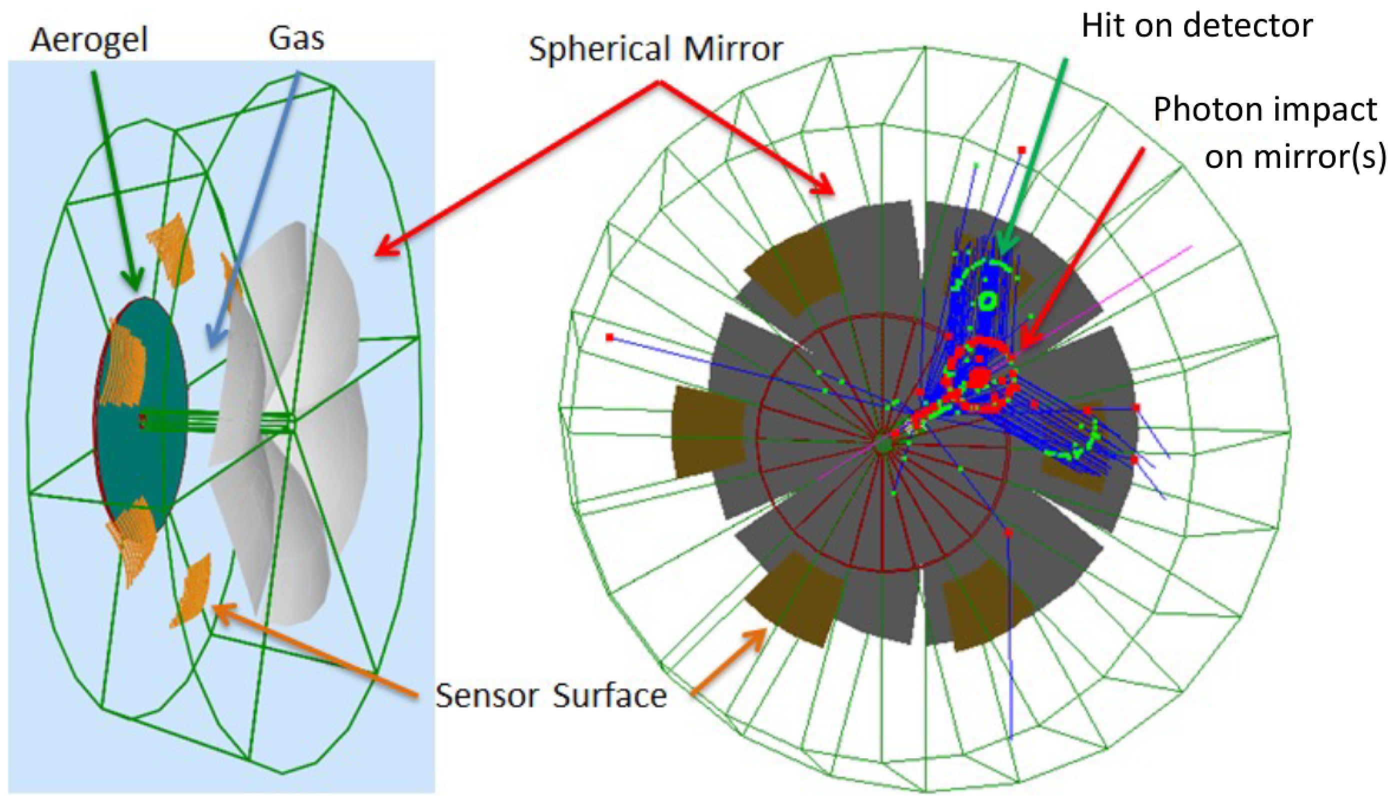
The Electron Ion Collider (EIC) is a new large-scale collider planned in the US at Brookhaven National Lab (BNL) and designed to collide polarized electrons with polarized protons and nuclei and investigate the dynamics of quarks and gluons, unlocking the secrets of QCD.



The dRICH for EPIC detector

A dual RICH (dRICH), which exploits Cherenkov light produced by two different mediums, is being developed to discriminate between π, K and p in the full momentum range (4 GeV/c to 50 GeV/c), while working in a strong ($\sim$ 1 T) magnetic field, and support the electron identification in the hadronic endcap of EPIC, the first general purpose detector at EIC.

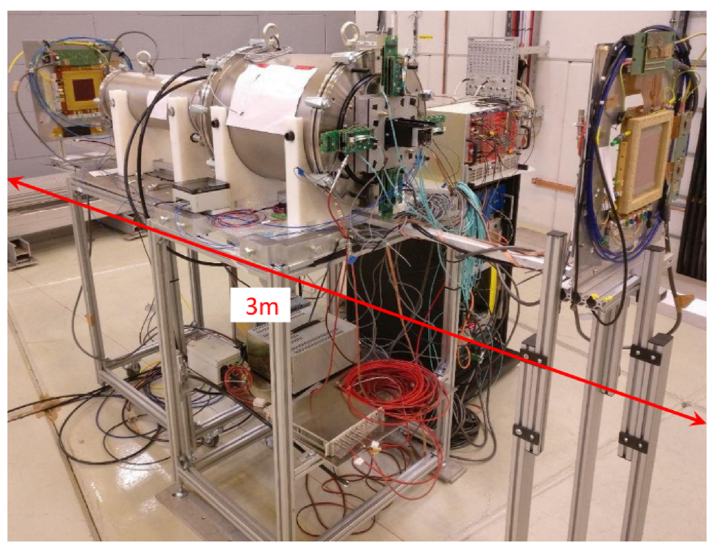


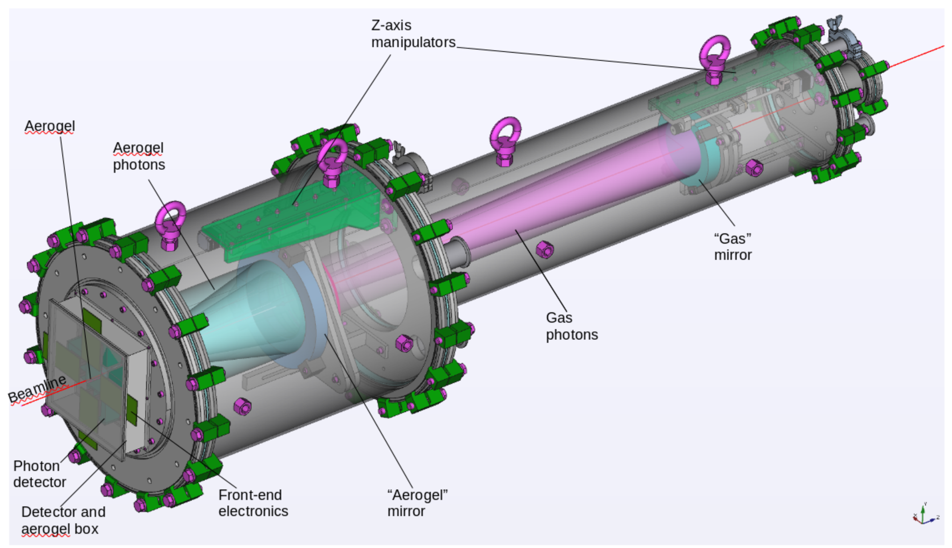


The EIC_NET prototype

We developed a prototype of dual RICH (dRICH) to prove the capability of discriminating particles in the expected conditions. The dRICH was assembled in summer 2021 and two test beams were performed in fall 2021 at CERN; two new test beams are ongoing right now at CERN. The full setup includes a tracker based on two GEM detectors and a flexible trigger system selecting the wanted beam portion by scintillator fingers placed upstream and downstream the apparatus.

A charged particle crossing the dRICH initially passes through the aerogel ($n \simeq 1.02$) and produces the Cherenkov-photons cone of about 11 degrees aperture. The photons are reflected back by a first spherical mirror, and focused on the photon detector array. Then the particle passes through the C_2F_6 ($n \simeq 1.00085$) producing the Cherenkov-photon cone of about 2 degrees aperture. The first mirror has a central hole, to allow the photons produced in the gas at small angles to flight towards a second spherical mirror and be focused back on the same photon detector matrices. The information of the two imaged Cherenkov rings combined with the beam momentum should allows to discriminate between pions, kaons and protons.





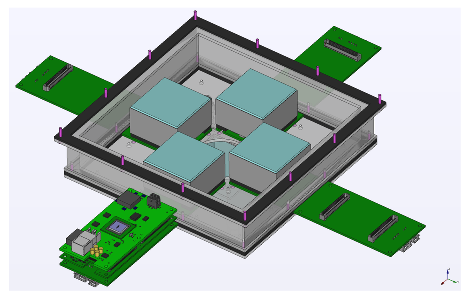
The prototype consists of two main parts, the gas chamber and the detector box. The gas chamber:

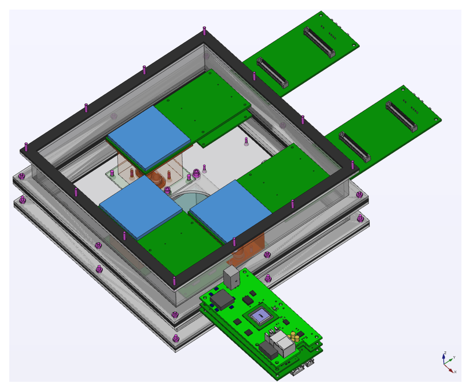
- mechanically sustains the dRICH, especially the spherical mirrors;
- includes the mechanics to regulate the mirrors angle and position along the detector axis;
- bears both under and over pressurization, to evacuate the air and introduce the C2F6;
- preserves light tightness.

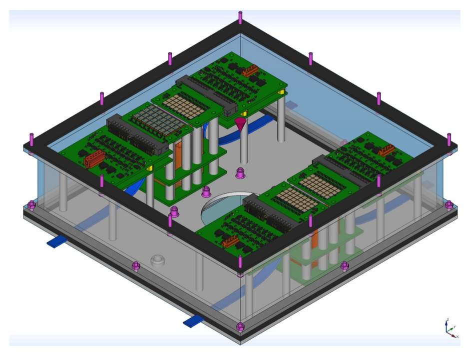
The detector box:

- houses the aerogel box;
- mounts the photon detector and the front-end electronics;
- supports a cooling system for the silicon photomultipliers (SiPM) matrices.

Three different kinds of photon detectors were tested in fall 2021, each with its own box. They are Multi-Anode Photomultiplier (MAPMT) with MAROC readout (used as reference), Multi-Pixel Photon Counter (MPPC) with MAROC readout (used as magnetic tolerant device prototype) and custom matrices of SiPM with ALCOR readout (developed to study the SiPM post-irradiation and post-annealing performance).

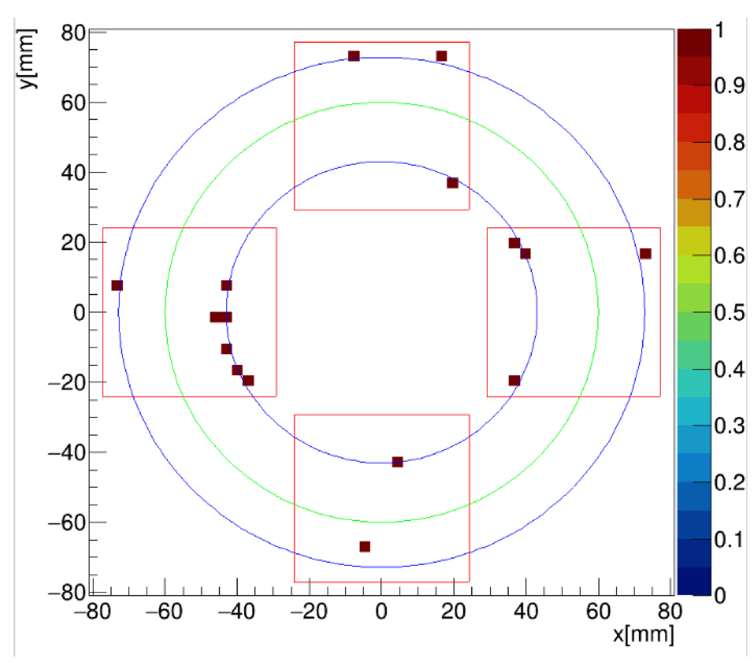

MAPMT detector box


MPPC detector box

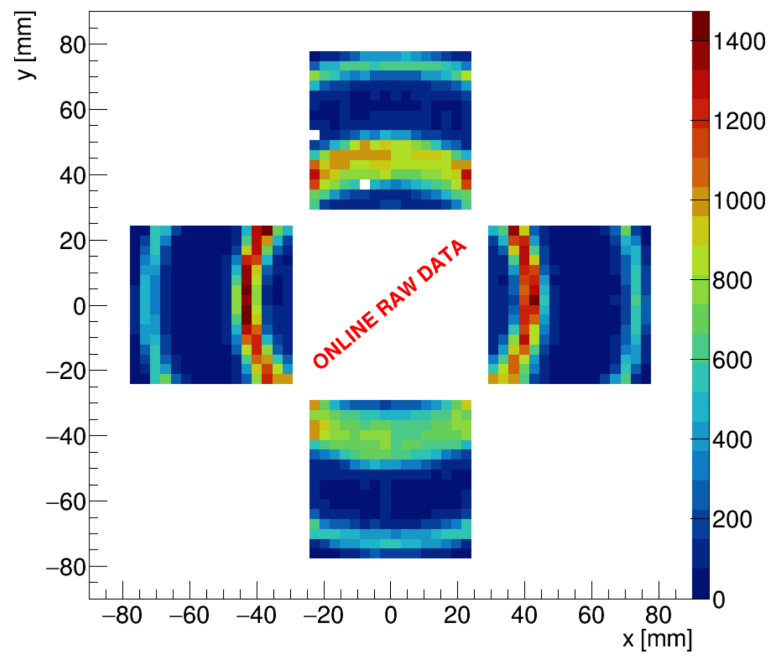

SiPM detector box

Fall 2021 test beams

The simulation of the prototype shows that it should be able to distinguish at 3σ between charged particles in the full momentum range. A substantial part of the 2021 beam time was devoted to the commissioning of all the subsystems, validation of the full readout chain, optimization of the beam parameters after the CERN facility renovation, and the alignment of the components. Nevertheless, enough data were acquired in dual ring imaging mode to allow a first study of the photon yield and optical performance in comparison with the simulation. The two following plots illustrate examples of the preliminary results, in particular the display of one event (left) and the envelope of the rings produced by a slightly diverging π^- beam (right). Data analysis is ongoing to isolate the instrumental effects and study the contributions to the resolution.



Event

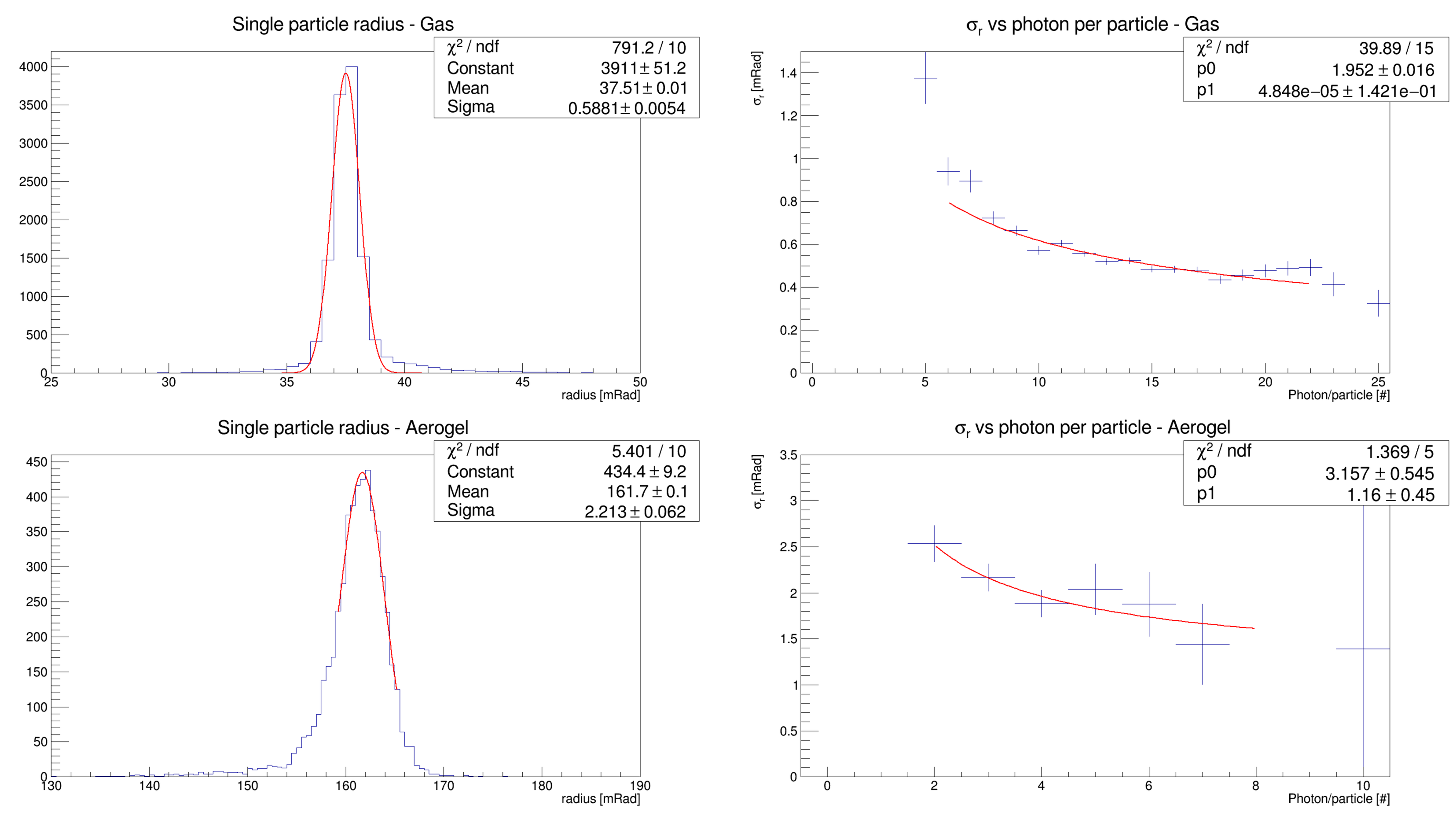


π^- rings

Results from 2021 data

On left: single particle radius for gas (top) and aerogel (bottom). It has been obtained by discriminating the origin of photons, applying the correction of position and a selection based on RMS.

On right: Trend of standard deviation as function of number of photon of ring for gas (top) and aerogel (bottom). p_0 [mRad] is the single photon resolution and p_1 [mRad] is the asinthotical constant term. The results for gas are quite in agreement with simulations, while for aerogel the resolution is worse than expected.



Current and future activities

Right now a test beam is ongoing at CERN and another one will occur in October. Based on experience we accumulate in 2021 test beams, we well be able to acquire a larger amount of high quality data to evaluate the performance of the prototype. This should allows us to better understand the contributions to the resolution and to isolate systematic effects of the prototype and analysis.

An improvement of simulation is under development, based on the characterization of the prototype components, allowing the validation of the results of analysis of the new data.

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