DIRC-based PID for the EIC central detector*

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The planned Electron-Ion Collider (EIC) is expected to be the next large accelerator facility for high energy and nuclear physics in the USA. This unique, high luminosity polarized collider will address many questions about QCD and strong interaction physics [1]. The central detector of the EIC (see Fig. 1) will have a general purpose character that should offer high performance for a wide range of processes and kinematics.

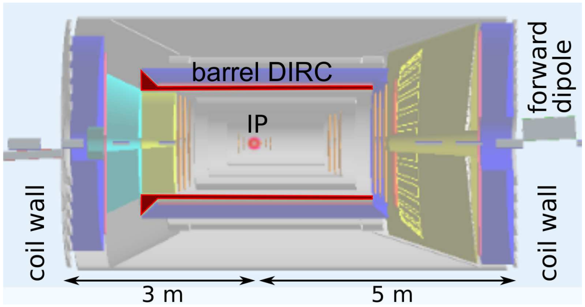

Figure 1: The central detector concepts developed at JLab and BNL. The Barrel DIRC location is highlighted in red.

One of the key requirements for the central detector is to provide radially compact Particle Identification (PID) (e/π, π/K, K/p) over a wide momentum range. It is expected that the PID system will need to include one or more Cherenkov counters to achieve this goal. With a radial size of only a few cm, a DIRC counter (Detector of Internally Reflected Cherenkov light) is potentially a very attractive option. The BABAR DIRC has proven to be robust, easy to operate, and to provide clean separation between pions and kaons for momenta up to about 4 GeV/c. Several new DIRC projects (Belle II, PANDA, LHCb, GlueX) are being prepared around the world. A future EIC DIRC can benefit from many aspects of these R&D efforts, but it also provides its own unique set of challenges and priorities, in particular due to the higher momenta of the produced particles compared to the other DIRC counters, and because of the impact of the DIRC readout volume on the neighboring detector components.

The *DIRC@EIC* R&D Collaboration was formed by groups in the United States and Germany[1] in 2011 with funding from DOE. The goal is to investigate ways to extend the momentum range of clean pion/kaon separation of DIRC counters from 4 GeV/c, the current state of the art, to about 6 GeV/c, required for the EIC detector. Possible design improvements include a complex focusing system, multi-anode sensors with smaller pixels, a time-based reconstruction algorithm, and chromatic dispersion mitigation using fast photon timing.

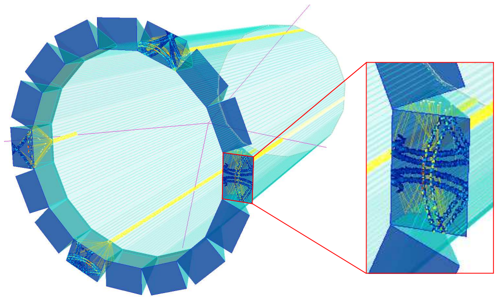

Figure 2: Geant simulation of an EIC DIRC design with narrow bars and compact prisms. The zoom shows the accumulated hit pattern for 4 GeV/c momentum kaons.

Detailed detector simulations, using Geant [2] and standalone ray-tracing software, are used to optimize the design configuration of the DIRC counter in terms of the performance and the best integration with the EIC detector. Fig. 2 shows the Geant simulation for the EIC DIRC in a geometry with narrow bars as radiators and compact fused silica prism as expansion volumes.

Figure 3: Photo of the novel 3-component lens prototype.

The first example of a real-world application of these new design ideas is the prototype of an improved multi-component spherical lens (see Fig. 3) which was built and tested in the Barrel DIRC prototype in the summer of 2014 with a pion beam at GSI. The analysis of the data is still ongoing, first results indicate that the new lens offers a significant improvement over simple two-component lenses. This result is of particular interest to the PANDA Barrel DIRC design, demonstrating the synergies of the two projects.

References

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