Mid-Year Addendum to
EIC R&D project RD2011-3
DIRC-based PID for the EIC Central Detector

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Abstract

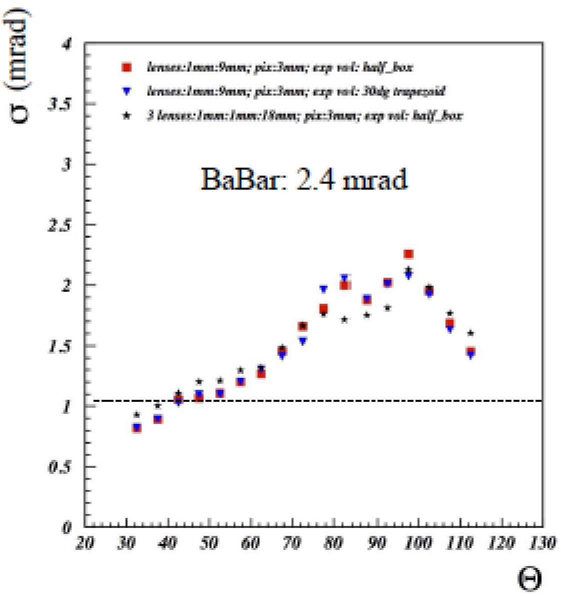
An essential requirement for the central detector of an Electron-Ion Collider (EIC) is a radially-compact subsystem providing particle identification (e/π, π/K, K/p) over a wide momentum range. To this end, the electromagnetic calorimeter needs to be complemented by one or more Cherenkov detectors. With a radial size of only a few cm, a Detector of Internally Reflected Cherenkov light (DIRC) is a very attractive option. This R&D project addresses three essential questions

1. development of a compact readout "camera" that can operate in the high magnetic fields
2. the possibility to extend the momentum coverage, in particular at forward angles
3. integration of a DIRC into the EIC full-acceptance detector.

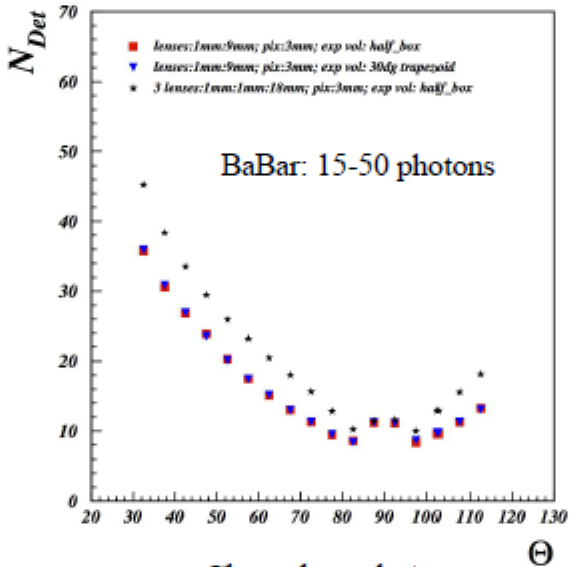
The work has two major parts. The first is to simulate and design the DIRC "camera" (focusing optics, expansion volume) for the EIC detector and to implement key concepts (e.g., new lenses) into a prototype that can be tested in-beam, as presented in section 4 of the proposal. The second, specifically described in section 4.3.1, is to set up a facility for testing of photosensors in high magnetic fields, and to carry out tests with sensors suitable for the DIRC and other EIC subsystems, aiming at establishing a baseline sensor solution for the EIC. The sensor test facility was added to the project in year two.

Progress Report

This proposal is in its third year of funding. The work has already yielded some very important results, including simulations showing that using triple lenses with a high index of refraction, it would be possible to reach 1 mrad Cherenkov angle (θ_c) resolution, corresponding to a 3σ separation at 6 GeV/c, for hadrons scattered in the forward part of the central barrel (30 degrees) and have sufficient photons at 90 degrees (where traditional lenses fail) to achieve performance comparable to BaBar.

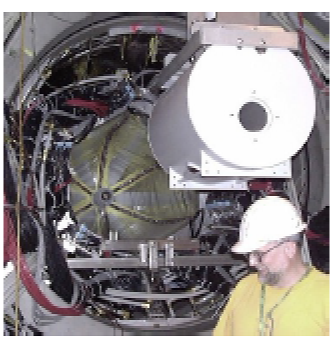


Cherenkov angle resolution
(for each track)



Cherenkov photons

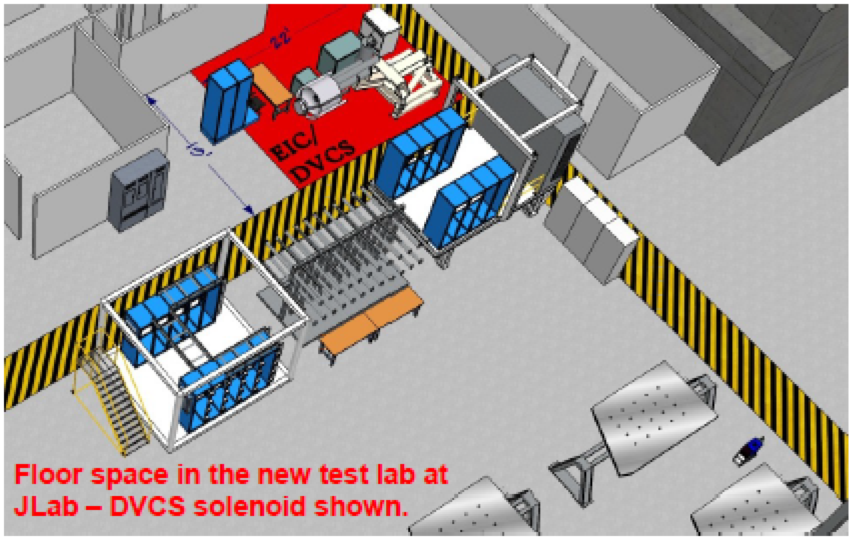
After establishing this proof-of-principle, work will continue on more detailed simulations, design and construction of the prototype, and testing of hardware components. The latter will be done both at GSI (timing) and JLab (magnetic fields), where we are in the process of setting up a sensor testing facility. JLab has made permanent floor space available in the new test lab area, and put two 5 T magnets at our disposal. The larger is the so-called DVCS solenoid mentioned in the proposal. It was used for the DVCS experiments in CLAS at 6 GeV, but will be replaced by a larger solenoid in the new CLAS12 detector, while the smaller is called the FROST magnet, after the polarized target for which it was originally used.



CLAS FROST solenoid
with 5 inch bore

CLAS DVCS solenoid with 9 inch bore

In comparison with the DVCS solenoid, the smaller bore size of the FROST magnet creates a limitation on the maximum sensor size, but the smaller magnet is much easier to set up and operate. In particular, it does not require additional hardware, nor special technical assistance, for which the proposal had reserved funds. It also consumes less liquid helium during cooldown and operation. We thus plan to start the sensor tests using the smaller magnet, for which the setup is now in progress. The facility should become operational in the spring of 2014. When the larger magnet is installed (as shown in the floor plan illustration), the smaller magnet can be stored in the corner.



The saved funds could be rolled over to the next year or used for sensor procurement. Since MCP-PMTs with small pore size (2-6 microns) offer a lot of promise in terms of their performance in high magnetic fields (gain and timing as function angle in fields up to 1-3 T), we are trying to obtain additional sensor beyond the two ones from Katod (with 2 and 5 micron MCPs, respectively) that we are procuring as part of the proposed budget. It is our hope that we will be able to borrow additional small-pore MCP-PMT prototypes from industry. Hamamatsu, Photek, and Photonis were contacted and have indicated their interest in providing samples for the test. Furthermore, a small LAPPD prototype could be tested if it fits the bore of the magnet. Should it not be possible to borrow these sensors, we would like to use the saved funds for additional procurements.

We are currently transitioning between postdocs. Our first postdoc, H. Seraydarian, left ODU in September 2013 to join her husband in DC. Following a slight delay due to the government shutdown, a search was carried out, and as of mid-December three highly qualified candidates have been interviewed. We expect an offer to be made to the successful candidate before the end of 2013. The outcome of the search will be presented at the R&D meeting in January. The new candidate focus on finalizing the simulations for the EIC detector, and the prototype, and is expected to make a contribution to the in-beam testing of the prototype. During the hiring process, it was possible to strengthen the sensor testing effort by assigning another postdoc (K. Park) to work on it for three months (Dec - Feb) at 50%. Funds for the remaining two months (Oct - Nov) will be rolled over to year four.

Budget and Timeline

We are at this point not asking to revise the project timeline or deliverables described in section 5 of the proposal. We believe that we can reach all major year 4 goals on time despite the postdoc transition. We also believe that we will be able to reach most of the year 3 goals, although we will have to asses the details once the hiring process is complete. We plan to incorporate this into the end-of-year proposal update. In addition, we are very optimistic about the sensor testing facility, and once the first tests are completed in the first half of 2014, we may want to feed that experience into the proposal update as well.