hpDIRC

The generic design of the hpDIRC for the EIC was developed by the eRD14 consortium, supported since 2011 by funding from the BNL program for Generic Detector R&D for an Electron Ion Collider. In this proposal-independent design the radius of the barrel is 100cm, divided into 16 sectors, and the total length of the bars plus the prism is about 450cm. The expected performance, based on a detailed Geant simulation, exceeds the design goal of 3 s.d. separation of pions and kaons at 6 GeV/c momentum.

Key elements required to achieve this performance are high-quality bars made of synthetic fused silica as Cherenkov radiators and lightguides, radiation-hard 3-layer spherical lenses to generate a flat focal plane, and lifetime-enhanced MCP-PMTs with small pixels and fast readout electronics to detect the photons with a precision of about 1mm and 100ps.

It is important to note that the expected hpDIRC performance does not depend strongly on the radius and length of the barrel, which can be adjusted to optimize integration of the hpDIRC into the EIC central detector. Furthermore, the detailed geometry of the prism expansion volumes can be adjusted to optimize the orientation of the MCP-PMTs in the magnetic field.

To study the performance a detailed standalone Geant4 simulation was developed and validated with a joint PANDA/EIC DIRC prototype in test beams at GSI and CERN. The simulation uses wavelength-dependent properties of all optical components and sensors, including the measured features of commercially available MCP-PMTs, in particular the dimension, pixel size, efficiency and timing performance of the PHOTONIS Planacon XP85112.

The development of the HRPPD LAPPD by Incom Inc. is currently in progress. If this sensor is able to provide the same quality of performance as PHOTONIS sensors, it will be an interesting alternative.

The current hpDIRC design assumes narrow bars with a width of 35mm and a length of 4200mm. These parameters have not been optimized for cost or performance yet, and wider bars could reduce the system cost. Matching the width and thickness to the size of the BaBar DIRC bars, keeps the reuse of those bars as an option. Both, the HRPPD LAPPD and reusing of BaBar DIRC bars would, therefore, offer potential significant cost saving.

Details of the hpDIRC design in ATHENA:

- **Segmentation:** 16 sectors arranged as a barrel with 1060mm radius
- **Sector**: one bar box, one readout box per sector
- **Bar Box**:
    - 11 long bars per sector 17mm (T) × 35mm (W) × 4200mm (L), separated by ≈100μm air gaps
      (the width of the bars can be chosen to increase azimuthal coverage)

- Each long bar made of either two new 1500mm-long pieces and one new 1200mm-long piece glued together or of three BaBar bars (with one additional 525mm-long bar or plate glued to the end)

- **Readout Box**:
  - Fused silica prism as expansion volume, 240mm (H) 360mm (W) 300mm (L)
  - 20 MCP-PMTs with 3 x 3 mm^2 pixel size (commercial 2'' MCP-PMT option)
  - 100 ps timing precision per photon (sensor, electronics, synchronization)
  - 13 cm longitudinal space for sensors, readout boards and cables behind the prism
- **Overview:**
  - Total number of bars: 528 for the new bars option, 704 for the BaBar DIRC bar reuse option
  - Total number of MCP-PMTs: 320 for commercial 2'' MCP-PMT option
  - Total number of readout channels: 327680
  - Radiation-hard 3-layer spherical lens glued to each long bar; flat mirror glued to other end
  - Number of sectors, barrel radius and bar length will be optimized for integration in ATHENA, the hpDIRC performance is largely independent of the barrel radius and bar length

Additional information:

- **Material Budget:** ~16% of a radiation length at normal incidence
- **Cabling:** HV for photon sensors, LV for front-end electronics, optical fibers for laser pulser calibration system
- **Digital signal out:** Few cables, no unusual requirements.
- **Services:** Dry nitrogen for flushing the bar boxes, nitrogen or compressed air for cooling of readout cards
- **Support Structure:** self-supporting (CFRP, aluminum alloy or similar)
- **Weight of all hpDIRC components (without support structure):** ≈1500kg