Simulation and Reconstruction of the PANDA Barrel DIRC*

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The PANDA experiment at the facility for anti-proton and ion research (FAIR) will study the strong interaction by precision spectroscopy. A detector system with excellent particle identification (PID) is therefore required. Charged hadron identification in the barrel region will be performed by a compact ring imaging Cherenkov detector based on the DIRC (Detection of Internally Reflected Cherenkov light) principle.

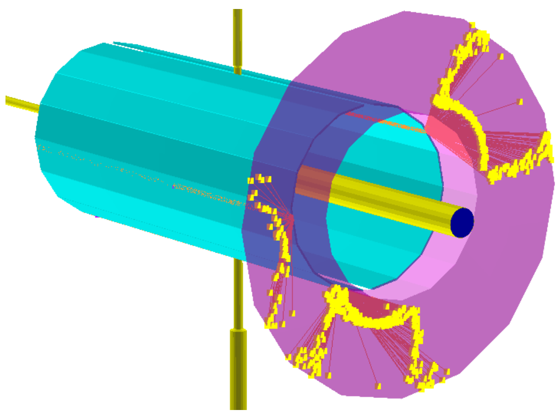

Figure 1: Display of a simulated event with three tracks in the barrel DIRC detector. The bar boxes are shown in cyan, the locations of Cherenkov photons on the detector plane are shown in yellow.

The design of the PANDA barrel DIRC [1], shown in Fig. 1, is based on the BABAR DIRC [2] with several important improvements, such as focusing optics and fast photon timing. The radiators are long, rectangular bars made from synthetic fused silica, each bar is 2500 mm long with a cross-section of 17 mm × 33 mm. Six bars comprise one bar box and 16 bar boxes surround the beam line at a radial distance of 50 cm. Cherenkov photons, emitted by a particle traversing the radiator bar, propagate along the length of a bar. A mirror, attached to the forward end of the bar, reflects them back to the readout end where they are focused via a doublet lens and an expansion volume on a flat detector plane. An array of multi-anode MCP-PMTs is used to detect the photons and measure the arrival time with a precision of approximately 100ps.

Several key design elements still need to be optimized. Among those is the shape of the radiator, where a 20 cm wide fused silica plate could be used in each bar box instead of six narrow bars, reducing the cost of radiator production. Furthermore, the lens doublet could be replaced with a mirror to focus the photons or a prism could be placed at the readout end of the bar in order to compress the phase space of the Cherenkov ring image and thus reduce the number of detector channels. Decisions about DIRC design choices will be based on the expected detector performance, in particular the single photon Cherenkov angle resolution and the photon yield per particle, which can be simulated using PandaRoot and Geant.

A new reconstruction method was developed, based on a proven BABAR-DIRC algorithm [2], which exploits the unique DIRC feature that the Cherenkov angle can be determined from a photon direction vector, defined by the exit point of the radiator bar and the location of the detector pixel, and the particle momentum vector, measured by the tracking system. This photon direction vector is determined using simulation and stored for fast reconstruction in lookup tables. As proof of principle we studied a simplified DIRC geometry without a focusing system, where the fused silica bars were directly attached to the expansion volume. A lookup table was created in simulation for a given bar, using a "Photon Gun" technique in which Cherenkov photons were produced at the end of a bar with directions covering the whole detector plane. For each pixel the initial photon direction was stored in the lookup table. The reconstruction was then applied to a sample of simulated events with single charged pions. The reconstructed single photon Cherenkov angle resolution is 17 mrad, in good agreement with the expected value, defined by the size of the bar, detector pixel, and expansion region, and the number of detector photons is between 20 and 60, depending on the polar angle of the track.

Following the successful test of the reconstruction algorithm we will next study the performance of different focusing options (thick lens, thin lens, focusing mirror) and radiator shapes (thickness, width, single plate instead of 6 bars) to provide the information required for the selection of the most effective barrel DIRC detector design.

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References

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[2] I. Adam et al., *"The DIRC Particle Identification System for the BA-BAR Experiment,"* Nucl. Instr. Methods **A** 538 (2005) 281.