The Endcap Disc DIRC detector of PANDA

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Abstract

At the international FAIR laboratory, an upcoming significant enlargement of the GSI installations near Darmstadt, Germany, the PANDA antiproton experiment will investigate fundamental questions of hadron physics in the charm quark energy range. Antiprotons in the 1.5 to15 GeV/c momentum range will interact with gas jet or pellet fixed targets. The Endcap Disc DIRC (Detection of Internally Reflected Cherenkov light) covers the forward endcap solid angle of the PANDA target spectrometer to positively identify charged kaons. Monte-Carlo simulations indicate that from 1 up to 4 GeV/c one can achieve kaon-pion separation with a separation power of at least 3 standard deviations. For the upcoming CERN test beam in August 2018 the read-out electronics has been upgraded to the TOFPET-ASIC Version 2.

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1. Introduction

The FAIR laboratory at Darmstadt will add new accelerator and storage rings to the present GSI infrastructure. The fixed-target antiproton PANDA experiment [1], to be installed on the HESR ring which provides a continuous stored 1.5 to 15 GeV/c antiproton beam, will use proton and, less frequently, noble gas targets. PANDA has four physics pillars: hadron spectroscopy in the charm-quark range, nucleon structure, hadrons in matter, and exotic nuclei [2]. The experiments in these physics areas need excellent Particle Identification (PID).

The Endcap Disc DIRC (EDD) [3, 4] in the forward endcap of the PANDA target spectrometer provides positive PID for charged kaons with polar angles $\theta < 22°$ except for the particles in the elliptical phase space $\theta_X \times \theta_Y = 10° \times 5°$ that are to be measured in the PANDA forward spectrometer.

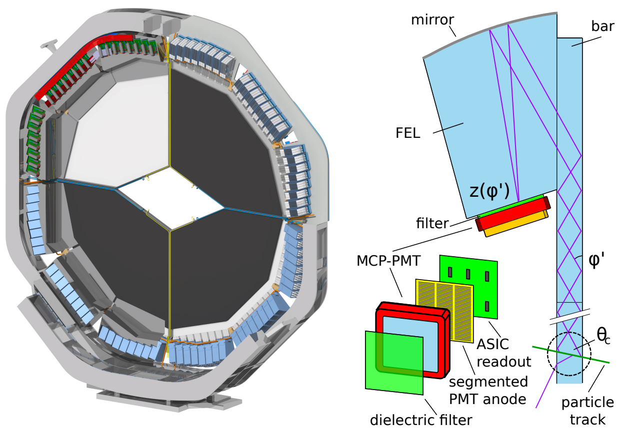

Figure 1: On the left seen from downstream a partial cut-away of the EDD with its four independent quadrants. From the top going clockwise, initially one sees the EDD holding plate (light grey), the radiator (dark grey) made from synthetic amorphous fused silica and the optical components of the readout modules. Added subsequently are the EMC-EDD common holding frame (middle grey), the ROM boxes (dark grey), and finally the electronics PCB boards plus cabling. On the right a Read-out Module (ROM) with bar and FEL and schematically the filter plus sensor plus read-out package for the three vertical pixel columns.

2. The Endcap Disc DIRC

Some of the stringent conditions to be satisified by the EDD shown in figure 1 are briefly given below (for more details see [4, 5]). It has to fit into the small gap between the PANDA solenoid housing and the forward electromagnetic calorimeter. The latter also sets a limit on the allowable EDD radiation

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length. Radiation levels will be high on inner parts. The foreseen MCP-PMT sensors need to cope with a one tesla magnetic field and provide the required lifetime expressed as 7 C/cm^2 collected anode charge. The EDD system should also feed information into the Online Trigger [6].

3. Monte Carlo-simulated performance

The fine granularity Monte Carlo simulation [7] of figure 2 shows the EDD performance as obtained using the PANDA-Root framework [8]. The wavelength-dependent optical transmission properties have been included for all the optical components. A dielectric LongPass $\lambda > 355$ nm filter is placed in front of the blue sensitive MCP-PMT photocathode. The log-likelihood analysis uses position and timing information of the detected Cherenkov photons. The kaon-pion separation power in figure 2 is displayed as standard deviation (s.d.) values.

The performance fall-off near the horizontal side indicated by the blue area is due to the saggital direction component of the charged particle tracks, as direct and reflected pattern branches of the Cherenkov photons do overlay here. Except for such small areas of edge effects the results from the Monte-Carlo simulations meet or exceed 3 s.d. separation power for 4 GeV/c particles inside the required EDD $\theta < 22°$ angular range.

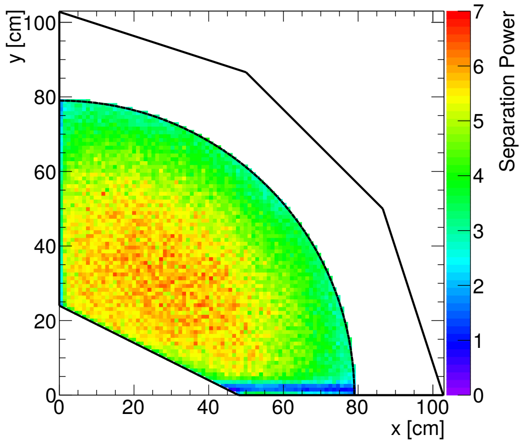

Figure 2: Monte Carlo performance simulation of an EDD quadrant carried out in the PANDA-Root framework [7]. Positively charged kaons and pions of 4 GeV/c momentum starting at the interaction point propagate through a realistic PANDA magnetic field. In the reconstruction the tracking information is taken to have 1 mrad accuracy. The separation power values are shown for polar angles up to 22° as other PANDA subsystems shield the EDD at larger angles.

4. Read-out system for test beam

With an average of 21 detected Cherenkov photons per particle the read-out system has to be able to digest a peak rate of 75 kHz per pixel. Version 1 of the free-running ASIC-based TOFPET system [9] was used for the Endcap Disc DIRC detector demonstrator prototype at the DESY 2016 test beam on the T24 beamline [7]. The TOFPET Version 2, with improved

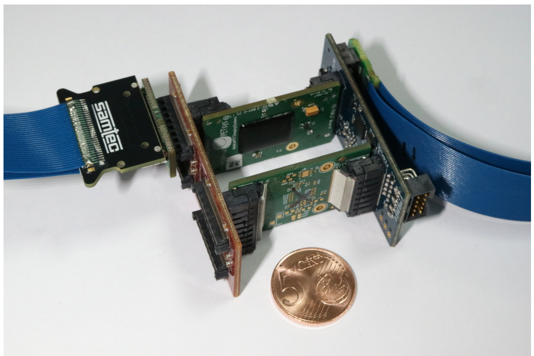

Figure 3: TOFPET Version 2. Ribbons of coaxial cables from the MCP-PMTs enter from the left into the small FEM128 boards holding the TOFPET ASICs.

timing and reduced power consumption, will be used for the upcoming CERN 2018 test beam. Similar to Version 1 it consists of a sequence of PCBs. New in Version 2 is the Front-End Module FEM128 shown in figure 3 which accepts 128 channels into 2 TOFPET ASICs. Signals then continue into a modified D board.

5. Conclusions

An Endcap Disc DIRC detector prototype, using more readout units and MCP-PMT sensors than previously at DESY in 2016, and upgraded to Version 2 of the TOFPET read-out system, will be investigated in a CERN 2018 test beam. Results of Monte-Carlo simulation studies indicate that the EDD performance goal of a kaon-pion separation with 3 standard deviations for particles with a momentum of 4 GeV/c can be reached.

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