The PANDA Barrel-TOF

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The $\bar{\mathrm{P}}$ANDA experiment is one of the scientific pillars of the FAIR facility that is being built in Darmstadt at the existing GSI Helmholtz Zentrum für Schwerionenforschung. It will study collisions of cooled anti-protons on Hydrogen in a fixed target environment.

In order to full fill physics program a good particle identification (PID) is necessary. At higher momentum ranges the PID can be done by the Barrel and Endcap Disc DIRC detectors. At momentum ranges below the Cherenkov threshold however a different approach to PID is needed.

The Barrel Time-of-Flight detector, shown in figure 1, is able to deliver PID at lower momenta from 0.3 GeV/c transverse momentum to about 1 GeV/c, see figure 2, as well as paritcle interaction times and vital timing information for the event separation as the Experiment will run with a free flowing DAQ and online event filter. The detector will be located immediately behind and mounted together with the $\bar{\mathrm{P}}$ANDA barrel DIRC around the interaction point inside the *Target Spectrometer*.

A single sensor time resolution of around 50 ps was achieved by using fast timing plastic scintillator tiles ($87 \times 29.4 \times 5$ mm^3) by Eljen Technology (EJ-232 / BC-422), read out by Hamamatsu SiPMs, in a serial connection of 4 sensors, seen in figure

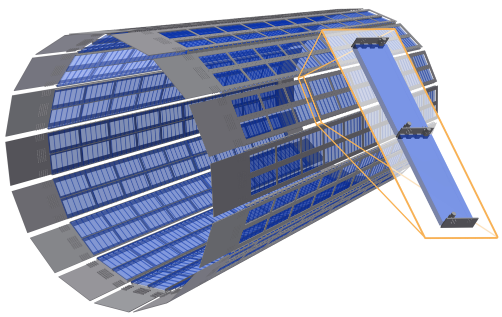

Figure 1: The figure shows a CAD drawing of the barrel TOF detector with its 16 segments housing 2 times 60 plastic scintillator tiles, read out by a serial connection of 4 SiPMs on each short end.

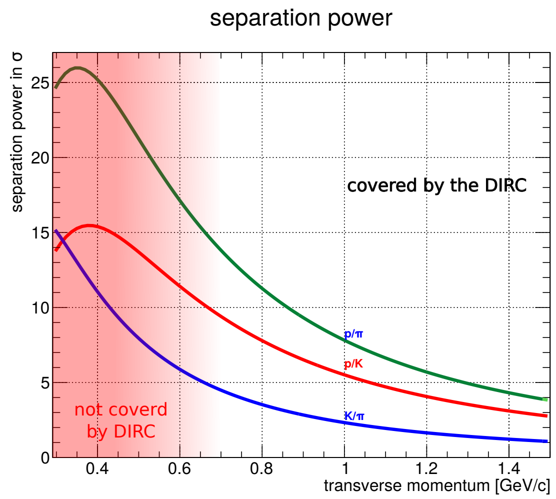

Figure 2: The figure depicts the separation power of protons, pions and kaons the detector is able to achieve vs the transverse momentum.

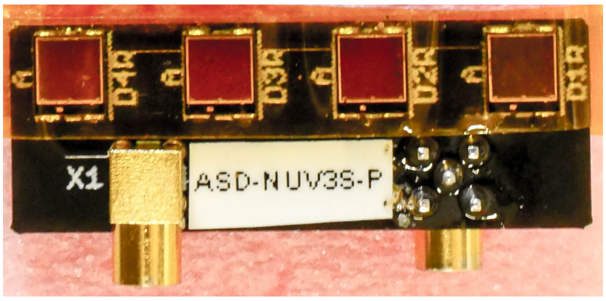

Figure 3: Shown here is the PCB that holds and connects 4 Hamamatsu 3×3 mm^2 SiPMs in series and connects to a larger PCB for data transmission via an MMCX connector.

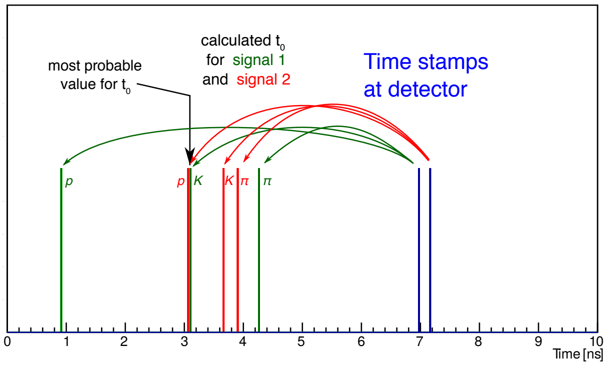

Figure 4: For every hit in the barrel TOF (blue) potential interaction times are calculated based on the path lenght and momentum information from the tracking detectors and a mass assumption (green and red). The combination of assumptions with the smallest spread gives us the most probable mass configuration.

3, which produces a faster signal output by lowering the effective capacitance of the SiPMs. Two lines of 60 tiles each form one larger segment, connecting all the sensors to the front end electronics with a large (2460×180 mm^2) printed circuit board, forming stand-alone detector elements. 16 of these segments are used to create the cylindrical shape of the barrel TOF covering an azimuthal angle of 22.5° to 140°.

Despite the short distance of the detector elements from the interaction point with a detector radius of roughly 50 cm, Monte Carlo studies of our detector in the full P̄ANDA setup show that our small time resolution permits the use of relative time of flight measurements to determine the identity of charged particles hitting our detector, without the need for a dedicated start timer. Using tracking information to calculate the traveled distance and momentum of multiple hits of one event and iterating through mass assumptions for every particle one can find a clustering of the calculated interaction or creation times (t_0) for each particle. This principle is depicted in figure 4.

The detector has been tested in two beam times at **add information** and CERN and most recently together with the barrel-DIRC group in Erlangen, where a position scan of the time resolution has been performed using a ^{90}Sr source validating the designs scintillator thickness of 5 mm and achieving the single side time resolution of around 50 ps. An increase in time resolution homogeneity compared to previous designs was achieved by spreading out the 3×3 mm^2 SiPMs to a more equidistant formation of the serial connection.

The main R&D for this detector has concluded. The front end electronics based on the TOFPET2 ASIC by PETsys Electronics are still not finalized yet and are the main focus for the upcoming efforts.