The PANDA barrel-TOF detector

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The PANDA experiment at the new Facility for Antiproton and Ion Research (FAIR) at GSI in Darmstadt, Germany, is a fixed target experiment with antiprotons colliding with stationary targets, in particular hydrogen. Among others the main goals of the experiment are studies of open questions in hadron physics by performing charmonium spectroscopy and investigating possible exotic states as glueballs and hybrids. The PANDA detector will include a barrel-TOF subdetector system for multiple reasons: its main purpose is the identification of low momentum particles with $\beta < 0.7$. These particle the DIRC detectors can not detect, because they do not produce Cherenkov light in the radiators. For an assumed time resolution of $\sigma = 100$ ps a three standard deviation separation power for π/K separation is obtained up to at least 430 MeV/c. In addition the TOF detector will deliver a seed for the track reconstruction by providing a 3D starting point and time information. Because the PANDA experiment will run without a hardware trigger the TOF detector will also serve as a software trigger for event selection. Furthermore the barrel-TOF detector will be a preshower detector that can detect whether a gamma has already showered before it would have reached the electromagnetic calorimeter (EMC).

The barrel-TOF detector will be placed between the barrel DIRC detector and the EMC, ~50 cm radially away from the interaction point, with the readout electronics placed at the upstream end of the detector. It covers polar angles between 22° and 140° using a barrel arrangement around the strawtube tracker (STT). The detector must have a small footprint of ≤ 2 cm thickness to fit between the DIRC and EMC. Also a time resolution of $\sigma < 100$ ps is mandatory to fulfill the requirements.

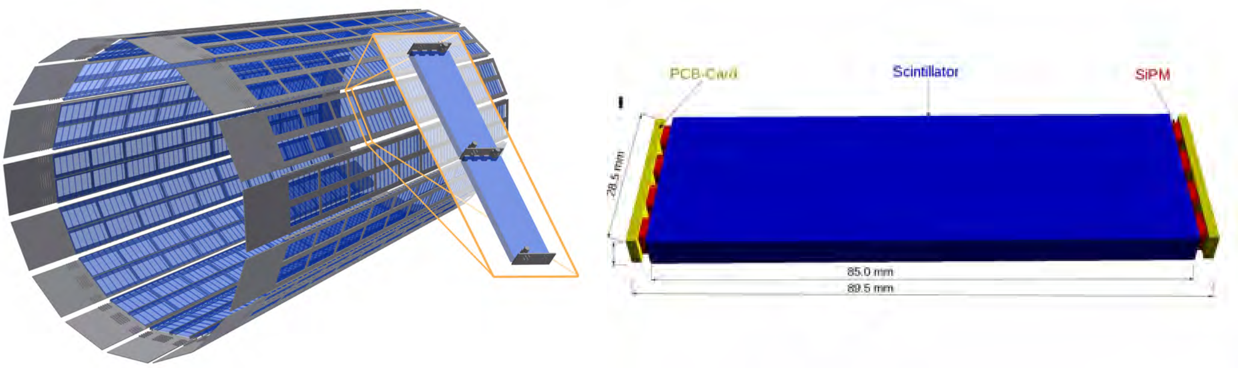

Figure 1: Left: barrel arrangement of the 16 super modules mounted with one SciTil module enlarged. Right: scintillating tile module with 4 SiPMs at the opposite sides.

For the implementation of the TOF detector it is planned to use EJ-232 scintillating tiles (SciTil) with a size of $85 \times 28.5 \times 5$ mm^3 with four equidistantly placed SiPMs with 3×3 mm^2 active area glued to both 28.5×5 mm^2 sides. The four SiPMs per side will be connected in series or in a “hybrid” connection, a mixture of serial and parallel connection. With this the time resolution can be improved because the capacitance of the readout channel is decreased, what leads to faster rising signals. Also the number of readout channels is significantly reduced, compared to reading out every SiPM. One double-layer PCB spanning glued to two scintillators form one module. These modules will then be assembled to a super module, a 2460×180 mm^2 PCB with connections for the modules and front-end readout electronics. The super modules can hold 60 modules, forming an active area of 1800×180 mm^2 (disregarding gaps). For the PANDA experiment 16 super modules form the barrel-TOF detector.

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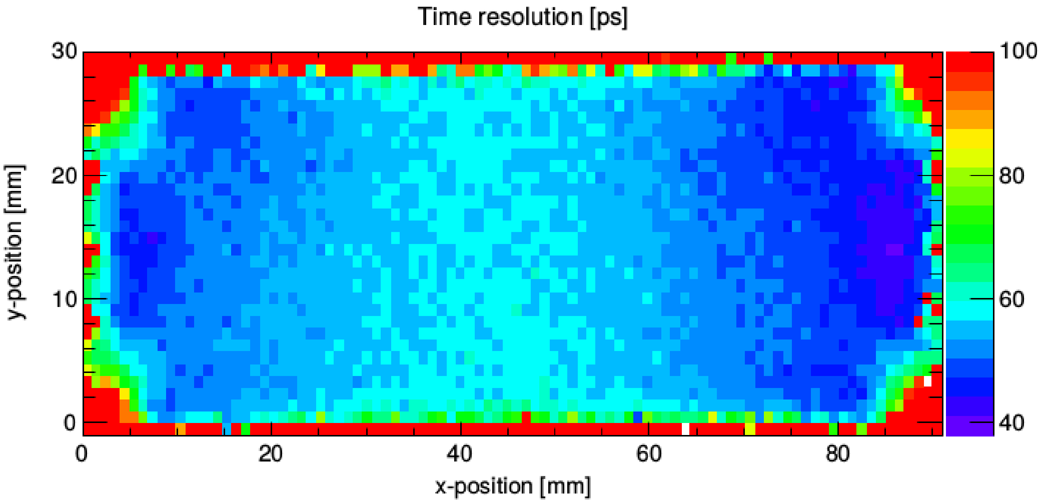

Figure 2: Time resolution obtained from a position scan of a 90 × 30 × 5 mm^3 EJ-232 SciTil, read out by Hamamatsu SiPMs attached to opposite sides with 4 SiPMs in series per side.

Time resolutions below 60 ps for SciTil counters have been measured in laboratory tests. For these tests the scintillators were scanned with an XY-stepper. With a collimated ^{90}Sr source and a small trigger scintillator behind the SciTil electron tracks were defined and the time difference between the two sides of the SciTil was measured at each scan point. The mean of all measured time resolutions gives the average time resolution for the SciTil. The best time resolution was obtained by wrapping the scintillator with aluminised mylar foil.

The measured time resolutions in the laboratory were verified parasitically at a CERN particle beam. Two TOF counters were build and placed about 30 m apart. With this configuration π/p separation was possible up to 10 GeV/c. The measured time resolution of the single counters was between 50 and 70 ps, well in agreement with the lab tests.

The detector R&D is meanwhile in a very mature state and a Technical Design Report was submitted recently.