Time-based simulation of the PANDA barrel DIRC*

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The PANDA Barrel DIRC detector [1] will be used for hadronic particle identification in the high luminosity PANDA experiment at FAIR. The main task of the Barrel DIRC is to separate charged pions and kaons with better than three standard deviations for polar angles between 22° and 140° and particle momenta between 0.5 and 3.5 GeV/c. In the baseline design the PANDA Barrel DIRC is constructed from 16 radiator modules, each comprising 5 narrow fused silica radiator bars (1.7 cm × 3.2 cm × 240 cm) surrounding the beam line at a radial distance of 47.6 cm.

Realistic event-by-event simulations of different design options of the DIRC detector were performed within the PandaRoot framework [2, 3]. One of the main aspects of the current development is the time-based simulation, which is important in order to represent the real structure of the data output stream from the experiment. The time-based data structure introduces additional challenges to the data processing. One such challenge is related to the possible loss of Cherenkov photons due to the pile-up of events and the dead time of the photon detector. Another is a result of ambiguous assignment of Cherenkov photon signals (hits) to different events. The time-based simulation was implemented for the Barrel DIRC in order to study how these effects influence the performance.

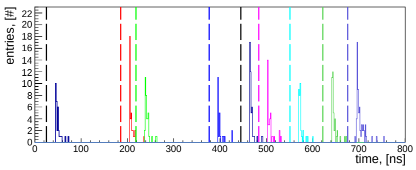

Figure 1: Time spectrum of detected photons after assigning time stamps. Colors represent different events. The vertical lines indicate start times of the events.

After the event is created a time stamp is assigned to each even/hit (see Fig. 1). Then hits are stored in a time-ordered buffer based on time stamp and pixel ID. If the same pixel is hit within the assumed dead time then the hit is discarded. Fig. 2 shows the map of hit loss probability as a function of dead time and event rate. The photon detectors, together with DAQ system, are expected to have a dead time of about 40 ns. At the design event rate of 20 MHz this yields a hit loss probability of about 5%.

Finally, hits are extracted from the time-ordered buffer for each event using the start time of the event and a time window, which is chosen conservatively to be 100 ns, in order collect all hits from the Barrel DIRC. Fig. 3 shows the time window as a shaded area for different events.

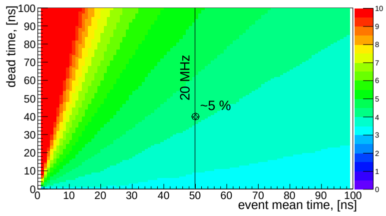

Figure 2: Map of the hit detection inefficiency due to the pile-up of events. The color scale indicates the percentage of lost hits.

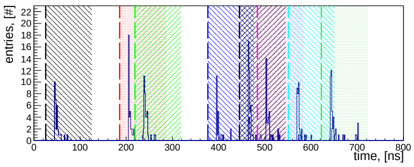

Figure 3: Time spectrum of detected photons after the hit finder. Shaded areas indicate the time window of reconstructed events.

Due to the pile-up, the reconstructed event could obtain hits from neighboring events. However, tracks from consecutive events are very unlikely to hit the same radiator module. Therefore, the corresponding hits are well-separated in pixel space and in reconstructed Cherenkov space and typically successfully associated to the correct events.

According to the DPM event generator simulation [4] 4% of events contain more than one particle hitting a radiator module. In those cases the overlapping hit patterns are successfully separated using the measured photon arrival time. This method leads to the correct association of hits to tracks in 90% of events with multiple particles per DIRC module, demonstrating that the design is rather robust in dealing with the time structure of PANDA events.

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References

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