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Commissioning and First Running Experiences with the TOP Barrel PID Detector in the Belle II Experiment

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The Time of Propagation (TOP) detector is a novel Cherenkov barrel particle identification system built for the Belle II detector upgrade based on quartz radiator bars read out by Micro-Channel Plate PMTs. The readout electronics of the TOP system are built around a switched capacitor array waveform sampling ASIC operating at 2.7GSa/s. Acquired waveforms are processed in real time in the front end electronics, extracting the individual timing of detected photons to better than 100ps.

This talk presents the current status of commissioning, calibration and operation of the Belle II TOP detector.

Summary

During the upgrade of the Belle detector to accomodate the increased instantaneous luminosity of up to 8x10ˆ35cmˆ-2sˆ-1 delivered by the SuperKEKB accelerator, its barrel particle identification system was completely replaced by the novel Time of Propagation (TOP) detector. The Cherenkov photons generated in its 16 250x44x2cmˆ3 quartz radiator bars are detected by arrays of Micro-Channel Plate PMTs (MCPs). The traversing particle type is determined from its time of propagation and Cherenkov angle, which are reconstructed from the spatial and temporal distribution of photons detected in the MCPs.

In order to fulfill the performance requirements of separating kaons from pions in the momentum range of 1GeV/c to 4GeV/c with an efficiency of 90% in the challenging environment of high event rates and machine backgrounds, custom readout front end electronics (FEE) were developed for TOP. The signals of all 8192 MCP channels in the system are acquired by custom Ice Ray Sampler ver. X (IRSX) ASICs, which are continuously sampling into a switched capacitor array at 2.7GSa/s. The buffer depth of 10us allows the digitisation and data transfer of dynamically determined groups of samples upon arrival of an external trigger without incurring deadtime in the acquisition.

The TOP FEE is organised into 64 subdetector readout modules (SRMs). One SRM is assembled as a board stack of one Standard Control Readout Data (SCROD) controller board and four ASIC carrier boards hosting four ASICs each, for a total of 128 readout channels corresponding to eight MCPs per SRM.

As the data bandwidth going out of each SRM is limited during physics running, all signal analysis and data processing of the MCP waveforms is handled online on the carrier and SCROD boards. Photon pulses in the digitised waveforms are extracted using constant fraction discrimination and template fitting techniques implemented into the Xilinx Zynq SoCs integrated into the SRMs. Only the parameters of extracted photon pulses are transferred into the Belle II datastream to be used in the offline reconstruction.

The TOP detector has been fully assembled into the Belle II enclosure and the whole detector has been successfully rolled into its final position in the beamline. Each TOP module has been commissioned and tested with laser pulses and cosmic rays before and after its installation into the TOP enclosure. Combined calibration runs taken with the completed TOP system with laser pulses and direct charge injection have been taken continuously since the completion of the installation. A first global cosmic ray run including the whole outer detector of Belle II is planned to start in early Summer.

This talk will present the current status of commissioning, calibration and operation of the Belle II TOP barrel particle identification system, an overview of the online data processing as well as first look into global cosmic ray runs data, current performance figures and lessons learned up to now.

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