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The Silicon Vertex Detector of the Belle II Experiment

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In June 2022 the data taking of the Belle II experiment was stopped for the Long Shutdown 1 (LS1), which is primarily required to install a new two-layer DEPFET detector (PXD) and upgrade components of the accelerator. The whole silicon tracker (VXD) will be extracted from Belle II, then the outer four-layer double-sided strip detector (SVD) is split into its two halves to allow access for the PXD installation. Then a new VXD commissioning phase will begin such that it will be ready to take data by the end of 2023. We describe the challenges and status of this VXD upgrade.
In addition, we report on the performance of the SVD, which has been operated since 2019. The high hit efficiency and the large signal-to-noise are monitored via online data-quality plots.
The good cluster-position resolution is estimated using the unbiased residual with respect to the track, resulting in reasonable agreement with the expectations. A novel procedure to group SVD hits event-by-event, based on their time, has been developed. Using the grouping information during reconstruction allows to significantly reduce the fake rate while preserving the tracking efficiency.
So far, in the layer closest to the I.P., the SVD average occupancy has been less 0.5%, which is well below the estimated limit for acceptable tracking performance. As the luminosity increases, higher machine backgrounds are expected and the excellent hit-time information in SVD can be exploited for background rejection. We have developed a method that uses the SVD hit-time to estimate the collision time (event-T0) with similar precision to the estimate based on the drift chamber. The execution time needed to compute SVD event-T0 is three orders of magnitude smaller, allowing a faster online reconstruction that is crucial in a high luminosity regime. Furthermore, the front-end chip (APV25) is operated in “multi-peak” mode, which reads six samples. To reduce background occupancy, trigger dead-time and data size, a 3/6-mixed acquisition mode, based on the timing precision of the trigger, has been successfully tested in physics runs.
Finally, concerning the radiation damage, the SVD dose is estimated by the correlation of the SVD occupancy with the dose measured by the diamonds of the monitoring and beam-abort system. Although the sensor current and the strip noise have shown a moderate increase due to radiation, we expect the detector performance will not be seriously degraded during the lifespan of the detector.

Primary author: Mr BETTARINI, Stefano (University of Pisa and INFN)

Presenter: Dr KALIYAR, Abdul Basith

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