Operational experience and performance of the Belle II Silicon Vertex Detector after the first SuperKEKB Long Shutdown

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SuperKEKB and Belle II

SuperKEKB collides 7 GeV+ with 4 GeV− at √s = 10.58 GeV
Target instantaneouls luminosity 6 × 10^{30} cm^{-2}s^{-1} to collect 50 ab data sample
Belle II records collision data for precision measurements and searches for beyond-the-standard-model physics

Belle II Silicon Vertex Detector (SVD)

The SVD consists of 4 layers of double-sided silicon-strip detectors (DSSDs), which are outside 2 layers of pixel detectors (PXD)
The DSSDs are 300–320 um thick and have readout strip pitch 50/75 um (P side), 160/240 um (N side)
Readout with APV25 ASIC that has a 50 ns shaping time

Noise increased by 10 ~ 30% during Run 1 due to radiation damage on the sensors

SuperKEKB is trying to increase its beam current and optimize beam condition to achieve higher instantaneous luminosity
Higher background dose is anticipated, we monitor the SVD status continuously
No severe damage observed so far

Belle II detector

Physics performance is as good as Run 1

Future background rejection

Cluster grouping can reject the red background area and the cluster grouping can reject additional fake signals (blue area) coming from the off-time cluster contamination
These improvements lead to an increase in acceptable occupancy for track reconstruction to about 6% in layer 3

SNR at each sampling point of the APV25 differs between the background and the signal
Useful for 3-sample sampling to reject bkg and to reduce the SVD DAQ dead time

2022 June 2024 January

Timeline and operations

Run 1

Recorded integrated luminosity L = 436 fb^{-1}
Achieved instantaneous luminosity L = 4.7 × 10^{30} cm^{-2}s^{-1}
Smooth and stable operation without major issue
Excellent SVD performance
- Good SNR (13-30)
- Large hit efficiency (≥ 99%)
- Masked strips < 1%

VXD extraction

SVD extraction from PXD1

Run 2

Current hit occupancy is below 1%, but it is expected to rise as the background increases
Higher occupancy degrades tracking performance by increasing the number of fake tracks
We will implement hit-time selection and cluster-grouping methods, which are based on hit time to reject background and enhance occupancy acceptance,
With excellent hit-time resolution (< 3 ns) to remove off-time tracks
SVD has a feature that offers a 2000 times faster computing speed than a central drift chamber to provide collision time (10). It speeds up the High-Level Trigger reconstruction and helps cope with HLT reconstruction in the high luminosity condition

Belle II Vertex Detector: VXD = SVD + PXD

Physics performance is as good as Run 1

Hit-time selection

The hit time t is determined by the peak part of the signal sampling in the sampling window (6 samples).
The peak position in the sampling window varies with the collision, enabling the identification of hits from triggered collisions

Cluster-grouping

Ongoing study

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SDV hit time: Cluster-grouping

SVD hit time: Cluster-grouping

Completed hit selection with respect to trigger on an event-by-event basis.
Select a group close to 0 and prominent as a signal group to form tracks
Fake track rate can be reduced by 15%, outperforming the hit-time selection method.

Belle II detector

We are Here! Just beginning

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