Contribution ID: **18** Type: **Oral**

A CMOS pixels upgrade for the Belle II Vertex Detector

Wednesday, 1 March 2023 15:30 (20 minutes)

The success of the Belle II experiment at KEK (Tsukuba, Japan) relies on the very high instantaneous luminosity expected from the SuperKEKB collider in the coming years, close to 6×10^{35} cm^{-2} s^{-1}. The beam conditions required to reach such luminosity cause a large rate of background particles to reach the innermost layers of the Belle II detector, which exceeds by far the rate of particles from signal events: this sets stringent constraints on the vertex detector, which must provide robust and efficient track and vertex finding for physics analyses.

In the 2026-2027 time frame accelerator upgrade works are planned, with a possible redesign of the interaction region being considered. In addition, while the current Belle II vertex detector has been showing excellent performance since the data-taking started in 2019, prospects show that, at full luminosity, its occupancy rates will fall close to the current technology's limits, with large uncertainties. For these reasons, the Belle II collaboration is considering the possibility to replace the current pixels-and-strips vertex detector with a fully-pixelated CMOS system, and R&D activities are ongoing.

The new system would employ a fully-depleted monolithic active CMOS pixel sensor, dubbed OBELIX, based on the TJ-Monopix-2 prototype, which benefits from the significant developments made in recent years for other particle physics experiments. This upgraded vertex detector will allow to reduce the material budget and improve the spatial resolution with respect to the current detector. Moreover, thanks to its fast readout architecture and timestamp resolution under 100 ns, it will provide a satisfactory safety factor with respect to the background rate expected at full luminosity.

This talk will briefly introduce the proposed upgrade for the Belle II vertex detector and provide an overview of the technological proposals. Then it will focus on the current status of the sensor and detection module developments, especially the in-laboratory tests of the TJ-Monopix2 sensor, relevant for the ongoing design of the OBELIX chip.

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Session Classification: CMOS

Track Classification: CMOS