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#1-40 Upgrade of the Belle II Vertex Detector with depleted monolithic CMOS active pixel sensors

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The Belle II experiment currently records data at the SuperKEKB e+e- collider, which holds the world luminosity record of 4.7x10^34 cm-2 s-1 and plans to push up to 6x10^35 cm-2 s-1. In such luminosity range for e+e- collisions, the inner detection layers should both cope with a hit rate dominated by beam-induced parasitic particles and provide minute tracking precision. A research and development program has been established to develop a new pixelated vertex detector (VTX), based on the most recent CMOS pixel detection technologies. The VTX strategy entails higher space-time granularity, lighter overall structure and services compared to the current operating vertex detector based on two different technologies. The expected gains include more robustness against the machine background as well as higher vertexing and tracking performance.

The VTX design matches the current vertex detector radial acceptance, from 14 mm up to 140 mm. It includes 5 to 6 layers equipped with the same depleted monolithic active pixel sensors, OBELIX. Specifications target to sustain a maximal average hit rate of 120 MHz/cm2 with triggered read-out within an overall material budget lower than 3 % of X0. The two innermost layers are made of 4-sensor long modules cut out from processed wafers and submitted to post-processing operations in order to connect them at one end. Air cooling is currently under study for those two layers. The three to four outer layers use a light mechanical structure supporting a liquid-cooled plate in contact with the sensors connected to a flex printed cable.

The OBELIX sensor is designed in the Tower Jazz 180 nm technology, which pixel matrix is derived from the TJ-Monopix2 sensor originally developed for the ATLAS experiment. Featuring a 33 µm pitch and a time over threshold digitization over 7 bits, OBELIX time-stamps hits with a 50 ns binning. The digital trigger logic matches the required 30 kHz average Belle II trigger rate with 10 µs trigger delay.

Two switchable additional features are intended for the outer layers coping with hit rates below 10 MHz/cm2. One corresponds to time stamping hits outside the matrix with 3 ns precision. The other provides continuous hit-information with 30 ns binning but with degraded position-precision for track-triggering. Recent simulations, showing that the degraded spatial granularity can still lead to useful track reconstruction efficiency at the first trigger level, will be discussed. The radiation environment requires a tolerance to 5x10^14 1 MeV n_eq/cm2 and 1 MGy. In addition, the minimal material budget limits the cooling power and hence necessarily means warm operation of the sensor. This is a considerable challenge taking into account its estimated power dissipation around 200 mW/cm2 at the maximal average hit rate of the inner layer.

We will review all project aspects: the latest characterization of the TJ-Monopix2 forerunner sensor in beam after irradiation, design of OBELIX sensor, optimization of the geometry and cooling.

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