Contribution ID: **10** Type: **Poster Presentation**

The Belle II DEPFET Pixel Detector and Cluster Shape Dependent Improvement of Spatial Resolution

Wednesday, 10 September 2014 14:00 (1h 40m)

On behalf of the DEPFET Collaboration

The high energy experiment Belle II - an upgrade of the previous successful Belle experiment in the KEK Japanese flavor factory - is under construction. Belle II will be built on a new electron-positron machine (SuperKEKB) designed to deliver instantaneous luminosity 40 times higher than the world record set by its predecessor KEKB, and 50 ab-1 in a decade of operation. Commissioning and first physics runs are expected in 2016.

Belle II will be equipped with a new pixel vertex detector (PXD), based on the DEPFET (DEPleted Field Effect Transistor) technology, which is now under construction. The detector is located extremely close to the interaction point and consists of two layers of DEPFET active pixel sensors, in total of 8 million channels. Production of sensors and other components (chips, readout electronics, mechanics, cooling...) is in time for installation in summer 2016.

The DEPFET technology combines detection in fully depleted silicon bulk with in-pixel amplification by a field effect transistor integrated in every pixel. Belle II will use DEPFET sensors thinned down to 75 microns, with low power consumption and low intrinsic noise.

Constraints on material budget, data rates, and signal-to-noise required several design decisions in the pixel layers. The rolling-shutter readout minimizes dead time, and a special "gated mode" feature allows to "freeze" data acquisition during periods of high beam background noise. To achieve feasible data rates, there are several levels of data reduction: pixel sizes vary by sensor region, and only data from regions of interest (ROIs) identified by silicon-only tracking (that is, using 4 layers of the Belle II strip vertex detector) or full tracking are stored.

The functionality of the chosen concept was confirmed in a beam test at DESY in January 2014, with pixel and strip sensors, pixel telescopes and magnetic field.

The simulation, data acquisition and analysis paths of the Belle II software framework (basf2) were successfully used for real DEPFET and strip detector data streams with ROI selection algorithms. A detailed study of pixel clusters in zero suppression mode found systematic effects of cluster shape on reconstructed position and spatial resolution. The observations on beam test data are confirmed with simulations and a general scheme of cluster-shape dependent response correction will be presented.

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Session Classification: Session 10: Posters 1 (Particle Physics, Pixel Detectors and Lifesciences)

Track Classification: Advances in Pixel Detectors and Integration Technologies