T 95: Pixel Detectors 3

Time: Thursday 16:15–18:15 Location: T-H26

T 95.1 Thu 16:15 T-H26

Effects of gamma radiation on DEPFET pixel sensors for the Belle II experiment — •Georgios Giakoustidis[1], Jochen Dingfelder[1], Ariane Frey[2], Botho Paschen[1], Benjamin Schwenker[2], and Marike Schwickardi[2] for the Belle II-Collaboration — [1]University of Bonn, Germany — [2]University of Göttingen, Germany

For the Belle II experiment at KEK (Tsukuba, Japan) the KEKB accelerator was upgraded to deliver e^+e^- collisions at a center of mass energy of $E_{CM} = 10.58\ GeV$ with an instantaneous luminosity of $8 \cdot 10^{35}\ cm^{-2}s^{-1}$. As the innermost part of the Belle II detector, the PiXel Detector (PXD), based on DEpleted P-channel Field Effect Transistor (DEPFET) technology, is most exposed to radiation from the accelerator. Prototypes as well as a module from the final Belle II production batch were irradiated with X-rays to doses up to 20 $Mrad$, corresponding to the expected lifetime exposure. The performance of the DEPFET sensors and front-end electronics will be presented and the results of two recent campaigns will be compared to previous results.

T 95.2 Thu 16:30 T-H26

CMOS Upgrade of the Belle II Vertex Detector — •Marco Vogt, Christian Bespin, Ivan Dario Caicedo Sierra, Jochen Dingfelder, Tomasz Hemperek, Fabian Hügging, Hans Krüger, and Norbert Wermes — Physikalisches Institut der Universität Bonn

The Belle II experiment at KEK in Japan will have an opportunity for upgrades of its detector components during a long shutdown in 2027, when several upgrades of the SuperKEKB $e^+ e^-$ collider are planned. At the expected high instantaneous luminosity of $6x10^{35}\,cm^{-2}$, SuperKEKB will generate a high rate of background particles, especially in the inner detector layers, the vertex detector. Here, hit rates will exceed 100 $MHz\,cm^{-2}$, inducing radiation levels of 100 $Mrad$ TID and fluences reaching $5x10^{14}\,neq\,cm^{-2}$. Such a high level of beam background will create new challenges and requirements that can be met by a new vertex detector.

A performant and robust vertex detector upgrade (VTX) is currently being defined by the Belle II collaboration. The baseline design foresees an all-layer pixel detector system based on the TJ-Monopix2 fully depleted monolithic CMOS sensor. For the inner layers of the VTX, a new ultra-thin all-silicon ladder concept is being developed and tested.

In this talk, the proposed monolithic CMOS upgrade will be presented. Technological aspects, system integration and performance estimations will be discussed.

T 95.3 Thu 16:45 T-H26

Irradiation burst study of Belle II PXD module components — Florian Bernlochner[1], Jochen Dingfelder[1], Georgios Giakoustidis[1], Matthias Hoek[2], Botho Paschen[1], and •Jannes Schmitz[1] for the Belle II-Collaboration — [1]University of Bonn, Germany — [2]University of Mainz, Germany

The Belle II detector started recording collision data in spring 2019. During physics runs, unexpected irradiation burst events occurred, which exposed the inner detectors and especially the PXD (PiXel Detector) to unwanted levels of prompt irradiation. Dedicated measurement campaigns were carried out at the Mainz Microtron (MAMI), which aimed to reproduce the observed effects of irradiation bursts on the PXD in Belle II. To this end, a focused high intensity (up to 10uA) pencil beam of 855 MeV electrons was used to irradiate full system demonstrators in several spatially confined fiducial regions. During first campaigns in 2020 the observed failure mode could be reproduced and restricted to vulnerable regions in one specific module component. In this talk, the results of the latest measurement campaign in December 2021 will be presented, focussing on possible protective measures against the impact of irradiation bursts on the PXD modules installed inside Belle II.

T 95.4 Thu 17:00 T-H26

KEK Total Ionizing Dose Measurement of PXD Modules and sensor effects at Belle II — Ariane Frey, Benjamin Schwenker, Yannik Buch, and •Marike Schwickardi — II. Physikalisches Institut, Georg-August-Universität Göttingen

The Belle II experiment at the Japanese B-factory SuperKEKB has started data taking in early 2019 and the peak luminosity will be ramped up to $8{\cdot}10^{35}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, which is 40 times higher than the previous luminosity delivered to the Belle experiment. It was therefore equipped with a new DEpleted P-channel Field Effect Transistor (DEPFET) based silicon PiXel Detector (PXD) for vertex detection to cope with higher beam backgrounds.

The monitoring of radiation effects on the new PXD is important throughout operation, since sensor settings have to be adjusted to ensure efficient operation. To compare observed effects to preliminary studies an accurate measurement of the total ionizing dose (TID) is needed. One way of dose monitoring is the diamond control units, that measure the radiation conditions for the Belle II detector. The diamonds are placed at different angles and positions close to the beam pipe and continuously take data. However, the diamonds do not measure the dose that the PXD received during beam times correctly, therefore the approach was chosen to estimate the TID of the PXD, using its occupancy. The drawback of this is that the PXD only sends out data while it is powered. To compensate that, the dose rate deposited when PXD DAQ is disconnect is estimated by scaling the dose rate of nearby diamonds with the ratio of pxd dose to diamond dose.

T 95.5 Thu 17:15 T-H26

Analog to Digital Converter ASICs scan on irradiated modules of the Pixel Vertex Detector at the Belle II experiment — •Tommy Martinov and Arthur Bolz — DESY, Hamburg, Germany

The Belle II detector placed at the SuperKEKB collider in Japan aims at studying heavy flavour physics through electron-positron collisions at a center of mass energy of approximately 10.6 GeV. The innermost element of the detector is the Pixel Vertex Detector (PXD). The pixels are based on the DEPFET technology (depleted p-channel field effect transistor). The PXD is composed of 10 ladders representing a total of approximately 3.6 * 10^6 pixels. The PXD detects charged particles with a transverse momentum higher than 40 MeV. On each module, four Drain Current Digitizers (DCDs) measure the drain currents of all DEPFET pixels. In each DCD, 256 ADCs convert the analog currents to digital signals. The characteristics of the ADCs are influenced by several components and reference voltages in the DCD. An ADC scan needs to be performed in order to calibrate the ADCs and optimize the number of channels considered as ”good”. The Belle II detector has been taking data for three years and it has become vital to evaluate the ageing of the different components of the detector. This presentation focuses on the ADC calibration as a way to assess the operation quality of the PXD DCDs in 2022 after three years of data taking.

T 95.6 Thu 17:30 T-H26

Challenges of offset calibration in irradiated modules of the Pixel Vertex Detector at the Belle II experiment — •Maria Konstantinova and Arthur Bolz — DESY Hamburg

The Pixel Vertex Detector (PXD) is situated as the innermost subdetector of the Belle II experiment at the SuperKEKB collider in Japan. Each PXD module includes a matrix of 192’000 pixels based on the Depleted P-channel Field-Effect Transistor (DEPFET) technology. The matrices are read out in rolling shutter mode such that 1000 channels are digitized in parallel by four custom Drain Current Digitizer (DCD) ASICs. For a consistent response to transversing charged particles during operation, homogeneous pedestal currents must be subtracted for each pixel to obtain as much room as possible for analogue-to-digital conversion of the signal current. Therefore, a narrow pedestal spread is achieved by adding a 2-bit DAC offset current to every pixel. The offset currents show non-linear behaviour which is dependent on the hardware architecture and may change during module operation in a harsh radiation environment in the interaction region. In this talk those effects are analyzed and the challenges they pose to a good offset calibration of PXD are discussed.

T 95.7 Thu 17:45 T-H26

Characterizatoin of DEPFET Pixel Modules for PXD2 — •Larissa von Jasienicki, Jannes Schmitz, Patrick Ahlburg, Georgios Giakoustidis, Botho Paschen, Florian Bernlochner, and Jochen Dingfelder for the Belle II-Collaboration — University of Bonn, Germany

The SuperKEKB electron-positron collider in Japan has reached unprecedented luminosities. The Belle II experiment operating at the SuperKEKB collider is equipped with a PiXel Detector (PXD) based on the Depleted P-channel Field Effect Transistor (DEPFET) technology, which serves as the innermost two layers of the VerteX Detector (VXD) of Belle II and was designed to cope with the large particle rates. The current PXD is, however, incomplete, since (mostly) only the innermost of the two layers is installed. A new full-scale PXD (*PXD2*) is currently being built and is expected to be installed in 2023(?).

This talk highlights improvements in the lab characterization of individual PXD2 modules. In particular, the biasing requirements of the sensors and investigations of the intrinsic properties like transconductance and gain of the DEPFET sensor will be discussed.

T 95.8 Thu 18:00 T-H26

Assembly and tests of the first TRISTAN detector modules — •Daniel Siegmann for the KATRIN-Collaboration — Max-Planck Institute for Physics, Munich, Germany

The TRISTAN (TRitium Invetigations of STerile to Active Neutrino mixing) project aims to search for the signature of a keV sterile neutrino in the tritium beta decay spectra by upgrading the detector system of the KATRIN experiment. This extension of the experiment will be performed after its neutrino mass survey.

To reach a high sensitivity to the sterile neutrino mixing angle the strong activity of the KATRIN tritium source is required. The resulting high electron rate is one of the greatest challenges for the TRISTAN project. It will be approached by distributing the rate among 3500 pixels, resulting in count rates of 100 kcps per pixel. To resolve the kink-like signature of the keV sterile neutrino signal the detector needs to maintain an excellent energy resolution of 300 eV (FWHM) at 20 keV and a low energy threshold.

The TRISTAN detector is segmented into 21 identical modules, each hosting 166 independent pixel. The development and tests of the first detector modules will be presented in this talk.

This work is supported by the Max Planck society and the TU Munich ("Chair for Dark Matter, Susanne Mertens").