Detector Lab's

Technical Seminars

A Digital Silicon Photomultiplier

The Circuit, its Characterization and Perspectives for Applications

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November 24th 2023 at 13:00

Medienraum, Staudingerweg 7, Building 2412, Room 03.431 (3rd floor – West)

Silicon Photomultipliers (SiPMs) are state-of-the-art photon detectors used in particle physics, medical imaging, and beyond. They are sensitive to ionizing radiation and even single photons in the optical wavelength regime. They achieve time resolutions in the order of 10 ps, which makes them candidates for timing detectors in tracking systems, e.g. in combination with scintillating crystals. The Geiger-discharge triggered in the sensitive elements of a SiPM, Single-Photon Avalanche Diodes (SPADs), yields signal amplitudes independent of the energy deposited by a photon or ionizing particle. This intrinsically digital nature of the signal motivates its digitization already on a SPAD level. A digital SiPM (dSiPM) developed at Deutsches Elektronen Synchrotron (DESY), and produced in a LFoundries 150-nm CMOS technology is presented, introducing embedded CMOS circuitry for on-chip signal processing. Key features of the DESY dSiPM are hit position information on a pixel level, and hit time stamps per quadrant and 3 MHz readout frame. The pixels comprise four SPADs and have a pitch of 70 µm. The four time stamps are provided by 12 bit Time-to-Digital Converters (TDCs) with a resolution below 100 ps. The chip is investigated in the laboratory to determine dark count rate, breakdown voltage, and TDC characteristics. A laser setup is used to characterize delay variations between individual pixels and to study the dSiPMs response as a function of the in-pixel position. Test-beam measurements demonstrate synchronous integration in a detector system, spatial hit resolution on a pixel level, and are used to study minimum-ionizing particle detection efficiency and time resolution. Finally, perspectives for applications of a digital SiPM, such as fiber readout or track timing will be discussed.

Finn Feindt studied at the University of Hamburg and achieved his PhD with a thesis about radiation damage studies on hybrid silicon pixel detectors for the Phase-2 Upgrade of the CMS pixel detector. Since then, he is working at DESY on the characterization of monolithic active pixel sensors and digital silicon photomultipliers, as well as on the development of data acquisition systems for pixelated detectors and their operation in test-beam experiments.