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Characterisation of a digital SiPM in 150 nm CMOS Imaging Technology

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Silicon Photomultipliers (SiPMs) are well known as excellent light detectors in the ultraviolet to visible energy range with sub-nanosecond time resolution. Due to their unique characteristics, these detectors are widely used in high-energy physics and medical imaging systems. In conventional SiPMs, an array of Single Photon Avalanche Diodes (SPADs) is connected in parallel. In these devices the time resolution is intrinsically limited by the total output capacitance and the spatial resolution on the order of the physical size of the array.

In recent years, SPADs have been integrated into standard high-volume CMOS processes. This not only allows the production of large volumes of SiPMs at a relatively low cost but also offers the possibility of combining the excellent light detection efficiency and time resolution of SPADs with the flexibility and possibilities offered by CMOS imaging technology.

A prototype of a digital SiPM was designed at DESY in 150 nm LFoundry CMOS technology using 25 x 25 μm^2 SPADs. The main array consists of 32 x 32 pixels, containing 4 SPADs, quenching and readout circuitry. The readout is frame-based, operating with a 3 MHz clock. The data from the chip contains the hit map with the coordinates of the firing pixels and timestamps given by four shared 12-bit TDCs. The dSiPM has been characterized using the versatile Caribou DAQ system. Detailed Current/Voltage (IV) and Dark Count Rate (DCR) studies were performed in a temperature-controlled environment, Minimum Ionizing Particle (MIP) detection efficiency and spatial resolution measurements were carried out at the DESY-II Test Beam Facility using an electron beam, and a characterisation of the temporal performance was conducted using a laser setup.

In this contribution, the main features of the dSiPM are reported along with the results of the performed characterizations. Plans for future studies and developments are also presented.

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