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Photon and minimum ionizing particle detection with ultra fast Geiger mode APDs

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Major advances in silicon pixel detectors, with outstanding timing performance, have recently attracted significant attention in the community. In this work, we present and discuss the use of state-of-the-art Geiger-mode APDs, also known as single-photon avalanche diodes (SPADs), for the detection of minimum ionizing particles (MIPs) and optical photons with best-in-class timing resolution. The SPADs were implemented in standard CMOS technology and integrated with on-chip quenching and recharge circuitry. By using a femtosecond laser a SPAD in coincidence with a fast photodiode showed a timing resolution of 12 ps FWHM. For the MIPs two SPADs in coincidence allowed to measure the time-of-flight of 180 GeV/c momentum pions with a coincidence time resolution of 22 ps FWHM (9.4 ps Gaussian sigma). This measurement paves the road to a new generation of low-cost beam trackers with extremely high timing and spatial resolution. Radiation hardness measurements are also presented here, highlighting the suitability of this family of devices for a wide range of high-energy physics (HEP) applications.

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