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# Deep Diffused Avalanche Photodiodes for Charged Particle Timing

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The upgrades ATLAS and CMS for the High Luminosity LHC (HL-LHC) highlighted physics objects timing as a tool to resolve primary interactions within a bunch crossing. Since the expected pile-up is around 200, with an rms time spread of 170ps, a time resolution of about 30ps is needed. The timing detectors will experience a 1-MeV neutron equivalent fluence of $\Phi_{eq} = 10^{14}$ and $10^{15}\text{cm}^{-2}$ for the barrel and end-cap regions, respectively.
In this contribution, deep diffused Avalanche Photo Diodes (APDs) produced by Radiation Monitoring Devices are examined as candidate timing detectors for HL-LHC applications. To improve the detector's timing performance, the APDs are used to directly detect the traversing particles, without a radiator medium where light is produced.
Devices with an active area of $8 \times 8\text{mm}^2$ were characterized in beam tests. Two readout schemes were investigated: 1) a direct coupling to the APD with off-sensor capacitive coupling and 2) a capacitive coupling on the sensor realized by means of a metallic mesh isolated from the detector by a kapton layer. The timing performance and signal properties were measured as a function of position on the detector using a beam telescope and an MCP.
Devices with an active area of $2 \times 2\text{mm}^2$ were used to determine the effects of radiation damage on current, signal amplitude, noise, and timing using a ps pulsed laser. These detectors were irradiated with neutrons up to $\Phi_{eq} = 10^{15}\text{cm}^{-2}$.

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