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Deep Diffused Avalanche Photo Diodes for Timing at the High Luminosity LHC

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The high luminosity upgrade of the CERN Large Hadron Collider (HL-LHC) foreseen for 2026 will provide an instantaneous luminosity of $5 \cdot 10^{34}$ cm^{-2}s^{-1} and an average pile-up of 200 collisions per bunch crossing.
To reduce the effects of pile-up on the physics analyses, both the ATLAS and CMS experiments are planning to implement dedicated systems to measure the time of arrival of minimum ionizing particles with an accuracy of about 30 ps.
These systems include both scintillators coupled to photo-detectors and silicon detectors.
These timing detectors will be subjected to a radiation damage corresponding to a 1-MeV neutrons fluence (Φ_{eq}) of 10^{15} cm^{-2} for the goal integrated luminosity of HL-LHC of 3000 fb^{-1}.

In this talk deep-diffused Avalanche Photo Diodes (APDs) produced by Radiation Monitoring Devices are examined as candidate timing detectors for HL-LHC applications.
These APDs are operated at 1.8 kV, resulting in a gain up to 500.
A detailed characterization of the devices before irradiation is presented.
The timing performance of the detectors as well as their response uniformity is evaluated using a pulsed laser.
The response to charged particles is investigated using beta particles from a ^{90}Sr source.
The effects of radiation damage on gain, noise, and timing of the APDs are evaluated using detectors irradiated with neutrons up to $\Phi_{eq} = 10^{15}$ cm^{-2}.
The measurements are compared to TCAD simulations of the devices.

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