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Fast Timing with 3D silicon sensors

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Novel collider experiments demand an increased performance of the silicon detectors used, such as withstanding 1×10^{17} n_{eq}/cm^2 in unprecedented pile-up conditions, and providing time resolution around 10ps. Currently, Low Gain Avalanche Diodes (LGADs) are the standard, achieving resolutions below 30ps. However, their limited radiation hardness is an area of ongoing research. As an alternative to LGADs, 3D sensors are interesting due to their proven radiation hardness. In 3D sensors, where the columns are etched into the sensor from the top (junction columns) and the back (ohmic columns), the drift distances can be very short, the depletion voltage is low and the electric field can be high, resulting in fast and short signals.

In this study, the time resolution of different 3D pixel and strip sensors was investigated with signals generated by electrons or an IR laser. Results show that 3D pixel sensors can achieve time resolutions of less than 30ps. TCT Timing measurements allow studying the position dependence of the time resolution, which is interesting for 3D sensors due to their complex electric field structure. We will show examples of position-timing maps, proving the direct correlation between time resolution and electric field. We also will demonstrate the time resolution of 3D sensors before and after irradiation, and show that 3D sensors can reach the time resolution of standard LGADs. In addition, our results demonstrate that the radiation-induced performance degradation in 3Ds can be less severe than in LGADs.
At last, we will present initial results from a production run of dedicated fast 3D sensors which have recently been produced at CNM as a common RD50 project. We will also discuss the general options for using fast 3D sensors as timing detectors in future collider experiments.

Submission declaration

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