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Investigation of the Time Resolution in 3D silicon sensors

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Collider experiments as the upcoming Phase II-LHC or the future circular collider (FCC) will increase the demands of the detectors used for tracking. In the FCC hadron collider , sensors will not only face fluences up to to $1{\times}10^{17}\ n_{\mathrm{eq}}/\mathrm{cm}^2$, but also high pile-up scenarios. Therefore, sensors will be required that not only have a good spatial resolution and a very high radiation hardness, but also an excellent time resolution of 5ps. Currently, Low Gain Avalanche Diodes (LGADs) are the prime candidates when it comes to timing, achieving a resolution of below 30ps. However, their radiation hardness is not sufficient for future colliders. As an alternative, 3D sensors are an interesting research area due to their superior radiation hardness. In 3D sensors, the drift distances are short, the depletion voltage is very low and the electric field can be very high, thus the signals are fast and short.

In this study, the time resolution of different 3D sensors was investigated with signals generated by MIP-like electrons, as well as by measurements using a laser with an infrared wavelength. We will show that 3D pixel sensors can achieve time resolutions competitive with LGADs. Additionally, Transient Current Technique (TCT) Timing measurements allow to study the position dependence of the time resolution, which is interesting for 3D sensors due to their more complex electric field structure. These measurements prove the direct correlation between the time resolution and the electric field distribution. Furthermore, the performance of the sensors will be demonstrated before and after irradiation with reactor neutrons.

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