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Time resolution of LGADs and 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, sensors will not only face fluences of up 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), which have an additional gain layer to achieve fast signals through charge multiplication, are the prime candidate when it comes to timing, reaching a resolution of below 30 ps. However, their radiation hardness is not sufficient for future colliders. As an alternative, 3D sensors are an interesting research area, as they are known to be extremely radiation hard. In 3D sensors, there are columns etched into the sensor from the top (junction columns) and from the back (ohmic columns), causing short drift distances, low depletion voltages and a high electric field and, therefore, fast signals.
In this study, the time resolution of both LGADs and 3D sensors was investigated with MIP-like signals generated by a beta-source, as well as measurements using a laser with an infrared wavelength. We will demonstrate that 3D sensors can achieve time resolutions competitive with LGADs.
Transient current technique (TCT) timing measurements allow a position-resolved study of the time resolution. This is interesting especially for the 3D sensors, where the time walk component due to the more complex electric field structure influences the time resolution strongly. We will show that this can be observed in the position dependent time resolution measurements. Additionally, the timing performance of 3D sensors before and after irradiation with reactor neutrons will be demonstrated.

Collaboration

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