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Tracking in 4 dimensions

In this contribution we will present the progresses toward the construction of a silicon tracking system able to measure the passage of charged particles with a combined precision of ~ 10 ps and ~ 10 μm, either using a single type of sensor, able to concurrently measure position and time, or a combination of position and time sensors.
The recent development of controlled multiplications in Low-Gain Avalanche Detectors (LGAD) has opened up the possibility of manufacturing silicon detectors with signal larger than that of traditional sensors, but with still very low noise, therefore enabling precision time measurements. The basic mechanism of LGAD is to obtain charge multiplication within the bulk of a silicon sensor by adding a thin multiplication layer just underneath the p-n junction.
The inclusion of timing information in the structure of a recorded event has the capability of changing the way we design experiments, as this added dimension dramatically improves the reconstruction process. Depending on the type of sensors that will be used, timing information can be available at different stages in the reconstruction of an event, for example (i) at tracking reconstruction, if timing is associated to each point or (ii) during the event reconstruction, if timing information is associated to each track.
We will first review the current LGAD manufacturing schemes, the results obtained at beam tests, than the mitigation techniques implemented to built radiation hard LGAD sensors, and finally how 4D tracking is being included in future experiments and its impact in the reconstruction of physics quantinties. We will also present the research and development of the LGAD read-out electronics, showing the current best limits and reviewing the possible technological choices currently developed.

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