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Performance of 3D-trench silicon sensors designed for high time resolution

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Developments on future tracking detectors go in the direction of a full 4D approach, in the sense of having both space and time measuring capabilities at the single pixel level. This is strongly motivated by the extremely high interaction intensities foreseen in the collider experiments of the next couple of decades and possibly beyond. Presently, no satisfactory technical solutions are available and important development programs are on the way. Minimal system requirements are the capability to sustain fluences greater than some 10^16 1 MeV n_eq/cm^2 and radiation doses of some Grad, space resolutions around 10 μm and time resolutions below 50 ps.
It is well known that 3D silicon sensors have very high radiation hardness and intrinsic structural and operational characteristics which can be exploited for fast response. During 2019, tests have been made by the TIMESPOT collaboration on developed 55-μm-pitch 3D-trench sensor prototypes, produced by FBK, Trento, obtaining extraordinarily good results in terms of timing. The tests have been performed both in laboratory, under a 1030 nm pulsed laser beam, and under minimum ionizing particle beam at the PSI laboratories (Paul Scherrer Institute, Villigen, Switzerland). Dedicated fast discrete-component electronics has been used for signal read-out. The tests yield values of time resolution of the order and below 30 ps (sigma). Such results indicate that, as of today, these devices are possibly the only ones capable to satisfy the complete set of system requirements for a future vertex detector and can be considered a very interesting solution to be further developed and finalized. An optimized new batch of sensors is presently under development and will be submitted soon.
This paper will describe the characteristics of the developed sensors, the kind of measurements performed and will discuss the results obtained. The ongoing activity about further 3D sensor and fast front-end electronics developments will be also briefly illustrated.

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