

High resolution tracking using 3D sensors with partial electrode depth using Timepix3 electronics

3D silicon pixel sensors [1] have low drift times due to their electrode geometry. It is assumed that within the given time resolution, the time-of-arrival (ToA) for every pixel of a track created by a particle would be identical, then, the track z-coordinate can be obtained only from the particle impact and end points.

Partial 3D silicon sensors (electrode depth: 230 μm , thickness: 300 μm) [2] bump-bonded to the Timepix3 ASIC (65,536 pixels of 55 x 55 μm^2 , ToA binning: 1.5625 ns) [3] were used for this investigation.

The detectors were placed in a 40 GeV/c pion beam and a relativistic mixed ion beam at different incident angles. ToA differences within particle tracks (ΔToA) were studied.

In the region of the sensor where the n and p electrodes are overlapping and parallel to each other, the measured ΔToA are indistinguishably short at the detector time resolution. Since the electrodes in the sensors do not fully penetrate the bulk, between electrodes tips and the opposite sensor surfaces, we found that ΔToA is proportional to the particle interaction depth and the applied bias. ΔToA increases up to 300 ns as the particle interaction depth moves from the electrode tip towards the sensor surface, from this we can gain multiple additional z-coordinates information of the particle track. In addition, we found that ΔToA correlates to the interaction position in the xy plane. A subpixel resolution of lower than 11.33 μm can be achieved when particles impact at an angle, this resolution is being improved upon.

We show with simulated and measured data how the ToA information can be used to improve the tracking resolution. The experimental results were reproduced in a simulation and compared with measurements obtained with planar silicon sensors of the same dimensions.

Bibliography:

- [1] Da Via, C. et al., NIM A 694, pp.321-330 (2012).
- [2] Pellegrini, G. et al., NIM A 699, pp.27-30 (2013).
- [3] Poikela, T. et al., JINST 9(05), p.C05013 (2014).

Submission declaration

Original and unpublished

Primary authors: Mr GAO, Tianqi (University of Manchester); DA VIA, Cinzia (University of Manchester (GB)); BERGMANN, Benedikt (Czech Technical University in Prague); BURIAN, Petr (Czech Technical University (CZ)); POSPISIL, Stanislav (Institute of Experimental and Applied Physics, Czech Technical University in Prague); FORCOLIN, Giulio Tiziano (Universita degli Studi di Trento è INFN (IT)); DALLA BETTA, Gian Franco (Universita degli Studi di Trento è INFN (IT))

Presenter: Mr GAO, Tianqi (University of Manchester)

Session Classification: Unknown (Virtual block)

Track Classification: Pixel sensors for tracking