Contribution ID: **54** Type: **Oral Paper**

3D Monolithically Stacked CMOS Active Pixel Sensors for Particle Position and Direction Measurements

Thursday 11 September 2014 08:30 (20 minutes)

Particle tracking systems for trajectory reconstruction in High Energy Physics experiments are usually based on different separated sensing layers, featuring pixels and/or strips elements. In this work we propose a 3D monolithically stacked, multi-layer detectors based on CMOS Active Pixel Sensors (APS) layers which allows at the same time accurate estimation of the impact point and of the incidence angle an ionizing particle. The whole system features two fully-functional CMOS APS matrix detectors, including both sensing area and control/signal elaboration circuitry, stacked in a monolithic device by means of Through Silicon Via (TSV) connections thanks to the capabilities of the CMOS vertical scale integration (3D-IC) 130nm Chartered/Tezzaron technology.

In particular, we present the results of the characterization of different chip prototypes, that have been extensively tested in laboratory using a variety of ionizing radiation sources (laser, X-rays). However, in order to evaluate the suitability of the two layer monolithic active pixel sensor system to reconstruct particle tracks, tests with proton beams have been carried out at the INFN LABEC laboratories in Florence (Italy).

Particle direction and angle measurements have been carried out by parallel reading of the corresponding outer and inner pixel matrices fostering particle momentum evaluation within a single, multiple layers, 3D vertically stacked APS CMOS detector. It should be noticed as well that this approach could significantly reduce the problems of the material budget and multiple scattering of tracking systems, since the top layer has been thinned down to about ten micrometres, and the distance between the two layers is of the same order of magnitude.

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Session Classification: Session 11: Pixel Detectors and Integration Technologies

Track Classification: Advances in Pixel Detectors and Integration Technologies