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3D Monolithically Stacked CMOS Active Pixel Sensor Detectors for Particle Tracking Applications.

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Typical tracking systems for particle trajectory reconstruction in High Energy Physics experiments are based on different separated sensing layers, featuring pixels and/or strips sensitive elements.

In this work we propose an innovative approach to particle tracking based on CMOS Active Pixel Sensors layers, monolithically integrated in a all-in-one chip featuring multiple, stacked, fully functional detector layers capable to provide momentum measurement (particle impact point and direction) within a single detector. This will results in a very low material detector, thus dramatically reducing multiple scattering issues.

To this purpose, we rely on the capabilities of the CMOS vertical scale integration (3D IC) technology. The chip prototype has been fabricated within a multi-project run using a 130nm CMOS Chartered/Tezzaron technology [1], featuring two layers bonded face-to-face (Fig. 1). Several test structures have been integrated, namely single pixels, as well as small matrices, e.g. featuring 5x5 and 16x16 pixels. Each pixel is 10x10 micrometers, with different sensitive element (photodiode) dimensions.

Tests have been carried out both on single sided (single tier) detectors (2D) and on full 3D structures, providing the functionalities of both tiers. To this purpose, laser scans have been carried out using highly focussed spot size (below two micrometers at 780nm and 531nm wavelengths), obtaining coincidence responses of the two layers (Fig. 2). Tests have been made as well with X-ray sources an on the electrons/positrons Beam Test Facilities at the INFN LNF Frascati (Rome), Italy.

[1] 3DIC Consortium http://3dic.fnal.gov/

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