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Pioneering use of Monolithic Active Pixel Sensors in space: the HEPD tracker on the CSES-02 satellite

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The most advanced particle trackers for space experiments all rely on micro-strip silicon sensors, readout with custom ASICs including amplification and shaping stages. This technology proved to be efficient, robust and fully compliant with space requirements. Both in its single- and the double-sided versions, microstrips allowed for important experiments like Pamela, AGILE, Fermi, AMS-02 and Dampe. They are still the baseline option for near future enterprises like HERD. Nonetheless, microstrips have become a niche application for silicon foundries, with profound consequences on the pace of their development, the cost of their fabrication and the complexity of their implementation.
This work reports on what the authors consider to be a breakthrough in the field, i.e. the first space application ever of Monolithic Active Pixel Sensors. The CMOS-fabricated ALPIDE sensor [1], designed and constructed for the ALICE experiment at the Large Hadron Collider, has been used as the building block of a particle tracker to be operated within the HEPD payload, onboard the CSES-02 satellite. The process of spatialisation had mostly to cope with those characteristics that mark the difference between ground-based laboratory applications and space devices, i.e. reduction of the power consumption, implementation of redundant control and readout solutions, design of mechanics suitable to withstand launch stresses and guarantee heat dissipation.
The project resulted in a three-layer particle tracker, as large as 250 cm2, made of 150 ALPIDE sensors, controlled and readout with a Hybrid Integrated Circuit and supported by Carbon Fiber Reinforced Plastics staves, housed in an aluminium case. The system is going to be in operation in space by mid-2022 and it will possibly change the paradigm of tracking particles in space.
We describe in detail the HEPD-02 tracker project, demonstrating the advantages of using MAPS in space and manifesting the pioneering nature of the project for next-future larger size space missions.
Figure 1. A "turret"of the HEPD tracker, made of three layers of ALPIDE sensors.

[1] NIMA, Volume 824, 11 July 2016, Pages 434-438

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Authors: IUPPA, Roberto (Universita degli Studi di Trento and INFN (IT)); BEOLE, Stefania (Universita e INFN Torino (IT)); COLI, Silvia (Universita e INFN Torino (IT)); DE CILLADI, Lorenzo (Universita e INFN Torino (IT)); GEBBIA, Giuseppe (Università di Trento); RICCI, Ester (Universita degli Studi di Trento and INFN (IT)); RICCIARINI, Sergio Bruno (Universita e INFN, Firenze (IT)); SERRA, Enrico (INFN - National Institute for Nuclear Physics)

Presenter: IUPPA, Roberto (Universita degli Studi di Trento and INFN (IT))

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