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## The readout system for the tracker of the High-Energy Particle Detector on board the CSES-02 satellite

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The High Energy Particle Detector (HEPD-02), part of the CSES-02 satellite, is a compact particle detector composed by a 3-layer pixel silicon tracker and a calorimetric system. HEPD-02 will be the first spaceborne instrument using Monolithic Active Pixels (MAPS) in place of micro-strips detectors; the tracker is composed of 150 CMOS 180 nm sensors, based on the development carried out for the ALICE ITK-2 at CERN. The stringent requirement in term of power budget and computational power available on a satellite required the development of a custom readout system implementing a sparsified readout architecture implemented on a single low-power FPGA.

### Summary (500 words)

The Low Earth Orbit (LEO) is an interesting location to observe charged particles either of cosmic origin or generated in the atmosphere and trapped in the Earth Magnetic field. Depending on the orbit inclination and the observed energy range, detectors flying in the Low Earth Orbits are currently performing a large set of measurements in the fields of astroparticle physics and the space weather, and more ambitious and specialized missions are constantly planned. This generates a demand for lightweight detectors suitable for space missions hosted on satellites, with their tight limits in terms of mass, power and data budgets and no possibility of servicing the hardware once deployed.

The High Energy Particle Detector (HEPD-02), part of the CSES-02 satellite, is a compact particle detector composed of a 3-layer pixel silicon tracker and a calorimetric system. The main purpose of the CSES mission is to investigate the relatively new field of “seismo-electromagnetics”, which consists in the study of a possible correlation of electromagnetic phenomena and particle fluxes with seismic events (the lithosphere-atmosphere-ionosphere-magnetosphere coupling). CSES detectors are also capable of producing relevant data for space weather and cosmic rays research.

HEPD-02 is designed primarily to detect particles, mostly electrons and protons trapped in the magnetosphere, in the energy range from few MeV to several hundreds of MeV. One of the HEPD-02 distinct features is the use of digital pixel silicon sensors for the tracking system. HEPD-02 will be the first spaceborne instruments where Monolithic Active Pixels (MAPS) are used in place of the more traditional micro-strips detector technology. In particular the tracker will be composed by 150 sensors fabricated in 180 nm CMOS technology, developed from the ALPIDE technology from the ALICE collaboration at the Large Hadron Collider.

The stringent requirement in terms of power budget and limited computational power available on a satellite required the development of a custom readout system implementing a sparsified readout architecture based on a single low-power FPGA.

A series of software procedures for calibration and testing, based on the experience from the ALICE experiment, have been developed to allow the test and characterisation of the tracker. Those procedures were then

adapted to be executed entirely on a soft-processor implemented in the tracker readout FPGA, allowing their use after the deployment of the instrument.

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