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Thermo-mechanical design for ALPIDE pixel sensor chip in a High-Energy Particle Detector space module

The Limadou collaboration includes all Italian scientists working on the project CSES (China Seismo-Electromagnetic Satellite), a constellation of satellites equipped with the most advanced technologies for correlating ionosphere perturbations with the occurrence of seismic events. For the launch of CSES-02, scheduled for mid-2022, the collaboration is realizing the High-Energy Particle Detector, aimed at detecting electrons and protons trapped in Earth's Magnetosphere, with energies 5 MeV-100 MeV and 30 MeV-300 MeV respectively. This payload consists of a particle tracker, a trigger system and a calorimeter, which work in time-coincidence to accurately identify particles and measure their energy and trajectory. The tracker is based on monolithic active pixel sensors ALPIDE [1], an innovative platform with superior performances in the field of pixel detectors, developed for the upgrade of the ALICE experiment at the LHC, at Cern.
The challenge in the construction of the tracker has been to adapt the ALPIDE technology to the space environment and to the specifications of the space register. Lightness and stiffness, essential features for structures in a tracker module, needed to balance with the need for withstanding structural and vibrational stress in the extended range of temperature occurring in the launch phase. Proper material choice with high thermal conductivity for the heat dissipation, innovative design of thermal paths and structural test results guided the project of mechanics. The modular particle tracker consists of 5 turrets, each one made of 3 stacked staves, with 150 pixel sensors in total. For readout and control purposes, ALPIDE sensors are wire-bonded to Flexible Printed Circuits, which enhances the fragility of the system and makes handling critical. Sensor supports in Carbon Fiber reinforced Plastic and an external aluminum frame preserve the mechanical integrity and provide the essential thermal bridges for heat dissipation.
We provide results from the intense campaign of structural, thermal and vibrational qualification tests that has been performed in compliance with the procedures required by the space register. It regards structure, module and turret elements. The envisaged solution is a novelty in the field of space applications and paves the way for important developments for particle and astroparticle physics experiments.

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

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