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HEPD-02 AND EFD-02: A KEY ITALIAN CONTRIBUTION TO CSES-02 LEO MISSION

Abstract

The possibility to continuously monitor fine details of terrestrial ionospheric coupling to the magnetosphere and atmosphere, gives LEO satellites a privileged role in the wide field of Earth Observation. Since 2018, the China Seismo-Electromagnetic Satellite (CSES) Program has been contributing to this sector owing to its multi-instrumental missions, whose goal is to investigate the near-Earth electromagnetic, plasma and particle environment for charting Earth's response to both internal (seismo/volcanic, anthropogenic) and external (solar, galactic) perturbation drivers.
Getting mileage out of CSES-01 success, CSES second mission (CSES-02) is steadily on its way to launch at the end of 2024. Compared to CSES-01, the new instrument suite has been enlarged, and Italy can boast a primary role in the design, testing and construction of two CSES-02 payloads, the High Energy Particle Detector (HEPD-02) and the Electric Field Detector (EFD-02).
HEPD-02 is designed to measure fluxes of electrons, protons and heavy nuclei in a wide range of energies (3-100 MeV for electrons; 30-200 MeV/n for the other species). Particularly suited for measuring (even short-time) particle flux variations in the perturbed radiation belts, HEPD-02 is expected to be sensitive to different populations (trapped, solar, galactic) according to energy and satellite's position along the orbit. Also, specific trigger configurations dedicated to gamma rays on a 5-ms time basis allow for the measurement of photon fluxes in the MeV-to-dozens Mev energy range, providing a chance to sense transient events like GRBs. The detector has an innovative design, amounting to the first use in space of a CMOS MAPS-based tracker and a matrix of large-size LYSO:Ce crystals, alongside plastic-scintillator layers for the trigger, upper calorimetric tower, and veto.
EFD-02 is meant for returning the three components of the local electric field in the DC/ULF, ELF, VLF, and HF frequency bands (up to 3.5 MHz) with a sensitivity in the order of μV/m, which represents the state of the art for ionospheric observations. Compared to its CSES-01 precursor, EFD-02 - which operates in a typical double-probe configuration - benefits from a renewed design, also including an improved bit depth and frequency resolution (clearer signals and optimized S/N ratio) and a novel bias-current control algorithm (for prevention of saturation). This latter feature is key to the study of plasma regions marked by abrupt density decreases, such as equatorial plasma bubbles.
We present here the main characteristics of the two instruments, as well as their performance and potential for scientific advancement.