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The High Energy Particle Detector (HEPD) for the CSES satellite

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We present the advanced High Energy Particle Detector (HEPD) developed to be installed on the China Seismo-Electromagnetic Satellite (CSES), launch scheduled by the end of 2016. The HEPD instrument aims at studying the temporal stability of the inner Van Allen radiation belts and at investigating precipitation of trapped particles induced by magnetospheric, ionosferic and tropospheric EM emissions, as well as by the seismo-electromagnetic and anthropogenic disturbances. In occasion of many earthquakes and volcanic eruptions, several measurements, on ground and by experiments on LEO satellites revealed: electromagnetic and plasma perturbations, and anomalous increases of high-energy Van Allen charged particle flux. The precipitation of trapped electrons and protons (from a few MeV to several tens of MeV) could be induced by diffusion of particles pitch-angle possibly caused by the seismo-electromagnetic emissions generated before (a few hours) earthquakes. Due to the longitudinal drift along a same L-shell, anomalous particle bursts of precipitating particles could be detected by satellites not only on the epicentral area of the incoming earthquake, but along the drift path. Moreover, the opposite drift directions of positive and negative particles could allow reconstructing the longitude of the earthquake focal area. Although, the earthquake prediction is not within the reach of current knowledge, however the study of the precursors aims at collecting all relevant information that can infer the spatial and temporal coordinates of the seismic events from measurements. At this purposes, it is essential to detect particles in a wide range of energies (because particles of different energies are sensitive to different frequencies of seismo-electromagnetic emissions), with a good angular resolution (in order to separate fluxes of trapped and precipitating particles), and excellent ability to recognize the charge (that determines the direction of the longitudinal drift of precipitating particles). The East-West or West-East drift direction is an essential information to retrieve the longitude of the starting point of the burst precipitation and then to reconstruct the geographical area where the interaction between particles and seismo-electromagnetic emissions occurred. HEPD has been designed to provide good energy resolution and high angular resolution for electrons (3 - 100 MeV) and proton (30 - 200 MeV). The detector consists of two layers of segmented plastic scintillators and a calorimeter, constituted by a tower of scintillator counters. The direction of the incident particle is provided by two planes of double-side silicon micro-strip detectors placed in front of the trigger scintillator planes to limit the effect of Coulomb multiple scattering on the direction measurement. The electron angular resolution varies between 13° at 2.5 MeV and $\leq 1^{\circ}$ for energies above 35 MeV. The detector has a wide angular acceptance ($>60^{\circ}$) over the full energy range 2.5-100 MeV. The angle-integrated, total acceptance is larger than 100 cm^2sr between 2.5 and 35 MeV, decreasing at higher energies (about 40 cm^2sr at 100 MeV). The proton angular resolution is $\leq 1^{\circ}$ over the full detection range. The proton integrated-angle, total acceptance is larger than 100 cm^2sr between 30 MeV and 150 MeV, decreasing to 60 cm^2sr at 200 MeV. The good energy-loss measurement of the silicon track, combined with the energy resolution of the scintillators and calorimeter, allows identifying electrons with acceptable proton background levels ($10^{-5}-10^{-3}$).