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#2-22 Ions and electron discrimination by Pulse Shape Discrimination technique : Application to solar energetic particles fluxes measurement around Mars (M-MATISSE-SP@M instrument)

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The M-MATISSE (for Mars - Magnetosphere ATmosphere Ionosphere and Space-weather SciencE) is an ESA Medium class (M7) candidate currently in Phase A study by the Europen Space Agency (ESA). The mission concept consists of two satellites observing Mars simultaneously from two different spatial positions. In particular, M-MATISSE will shed light on how the solar wind influences Mars' atmosphere, ionosphere and magnetosphere. The mission aims to study the impact of these interactions on the lower atmosphere and surface of Mars, a key aspect in understanding the habitability of the Red Planet, as well as the evolution of its atmosphere and climate. The SP@M (for Solar Particles @ Mars) instrument will measure Solar Energetic Particles (SEPs, mostly alpha particles, proton and electron) throughout the Martian magnetosphere and atmosphere. While most of today's on-board instruments discriminate particles using coincidence processing between 2 or more silicon detectors (SST) arranged as a telescope, where cross-contamination between detectors always occurs, SP@M proposes to use a single 1.5 mm thick silicon detector and to discriminate particle types using digital processing based on charge carrier collection time; proportional to particle penetration length inside the detector medium. This Pulse Shape Discrimination (PSD) concept, which has already proved successful in other fields as neutron/gamma ray discrimination, could drastically reduce data post-processing complexity, minimize the size of on-board electronics, and reduce the costs of future on-board instruments dedicated to solar particle measurement. After importing the CAD model of the SP@M system into Geant4, we irradiated (Monte-Carlo simulation) the silicon detector with proton, alpha and electron fluxes in the [30 keV - 10 MeV] energy range, representative of real solar particles fluxes around Mars. As output, the locations where electron-hole pairs for each incident particle are created are saved. Then, using the Garfield++ framework developed by the European Organization for Nuclear Research (CERN), we applied different electric fields to study the impact on charge drift velocity to the electrodes and necessary collection time. Finally, by integrating and convolving this number of collected charges with the transfer function of our charge sensitive preamplifier, we were able to estimate the pulse Rise Time. Even for low energetic particles (around 100 keV or lower), Rise Time measurement enables us to discriminate without ambiguity the type of simulated incident particles: 140 ns Rise Time duration for electron @ 100 keV vs 310 ns Rise Time duration for protons @ 100 keV. The next step of the project is to experimentally test our Geant4 model with 1.5 mm thick silicon detectors prototypes, using alpha and conversion electrons calibration sources under vacuum. If the experiment fits the Geant4-based simulations, this innovative concept will be a major breakthrough in solar particles measurement technique and viability.

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