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A Multi-Purpose Particle Detector for Space Missions

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Precisely characterizing a radiation environment is essential for space exploration—manned and unmanned missions to, for example, the Moon or Mars—and astroparticle-physics experiments—for example, solar observations and cosmic-ray measurements. Particle detectors used for such endeavors must be compact, use as little power as possible, and withstand the harsh space environment. We are developing the Multi-purpose Active-Target Particle Telescope (MAPT), a detector capable of omnidirectionally measuring particle fluxes with a large geometric acceptance. The detector fits into a cube with an edge length of 10 cm and weighs less than 3 kg. It is essentially a tracking calorimeter with a segmented active core made of scintillating plastic fibers. Besides tracking charged particles and ions, MAPT can also identify them by analyzing their energy-loss profiles using extended Bragg-curve spectroscopy methods. Anti-ions can be distinguished by the secondary particles created by their annihilation inside the detector. We simultaneously analyze track parameters and particle characteristics using Bayesian inference techniques to minimize the expected uncertainties of particle flux measurements. We tested basic implementations of a particle filter and a maximum-likelihood method and obtained an angular resolution of about 3 degrees and an energy resolution of better than 2.5% for 50 MeV protons. We present the expected capabilities of the detector, use cases, and first results from beam experiments and discuss the requirements and challenges of on- and off-line data analysis methods.

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