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Experimental investigation of the radiation shielding of a MCP detector in the radiation environment near Europa

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The Neutral Ion Mass spectrometer (NIM) is one of the six instruments in the Particle Environmental Package (PEP) designed for the JUICE mission of ESA to the Jupiter system. NIM will conduct detailed measurements of chemical composition of Jovian moon exospheres and is equipped with a sensitive MCP ion detector. To maintain high sensitivity of the NIM instrument, background signals arising from the presence of a large background of penetrating radiation (mostly high-energy electrons and protons) in Jupiter's magnetosphere have to be minimised. We investigate the performance of a layered-Z radiation shield, an Al-Ta-Al sandwich, as a potential shielding against high-energy electrons. The experimental investigations were performed at the PiM1 beam line of the High Intensity Proton Accelerator Facilities located at the Paul Scherrer Institute (PSI), Villigen, Switzerland. The facility delivers a particle beam containing e[U+F02D], [U+F06D][U+F02D] and [U+F070][U+F02D] with an adjustable momentum ranging from 17.5 to 345 MeV/c. The measurements of the induced radiation background generated during the interaction of primary particles with Al-Ta-Al sandwich were conducted by beam diagnostic methods and a MCP detector. Diagnostic methods provided for the characterisation of the beam parameters (beam geometry, flux and intensity) and identification of individual particles in the primary beam and in the flux of secondary particles. The MCP detector measurements provided information on the effects of radiation and the results of these measurements define the performance of the shielding material in reducing the background arising from penetrating radiation. In parallel, we performed modelling studies using GEANT 4 and GRASS methods to identify products of the interaction and predict their fluxes and particle rates at the MCP detector. Combination of the experiment and modelling studies yields detailed characterisation of the radiation effects produced by the interaction of the incident e– in the range of the beam momentum 17.5–345 MeV/c. The MCP measurements yield detection efficiency to the remaining primary radiation and the produced secondary radiation and the determination of beam attenuation coefficients in the range of investigated beam momenta. The studies define key performance parameters for the shielding and show direction for its further improvements.

Literature

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