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Solar Proton Damage in Germanium Detectors

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High-purity Germanium (HPGe) spectrometers used in space for gamma-ray astrophysics and planetary exploration are known to be damaged by high-energy particles. These radiation damages result in the degradation of energy resolution, which can however be restored to a satisfactory level through annealing processes (as successfully demonstrated aboard INTEGRAL and Mars Odyssey). Nevertheless, these damages must be evaluated quantitatively to optimize future missions. So far, studies on radiation damage in germanium detectors have been carried out with respect to galactic cosmic rays (GCR) with energies up to several GeV and their secondary particles (neutrons of several MeV), which are the main relevant radiation sources at 1 AU (or more) from the Sun. For missions close to the Sun, such as Messenger or BepiColombo to explore Mercury, solar protons are another important source of damage. Solar protons are produced during energetic solar particle events (SPE) and are characterized by energies up to 200 MeV, which is lower than energies of cosmic rays. The high stopping power of SPE protons makes them particularly damaging compared to cosmic rays (e.g., 150 MeV protons are stopped in a 6 cm-long Germanium crystal while 1 GeV protons deposit only 50 MeV). Moreover, solar protons cause non-uniform damages in the crystal, since their range is shorter than typical diameters of a couple of centimeters of HPGe detectors. In the frame of the MANGA project, where an HPGe spectrometer is considered to be on board the BepiColombo planetary orbiter, irradiation tests are carried out at the cyclotron of Louvain-la-Neuve. An n-type coaxial HPGe detector cooled to 95 K is exposed to 75 MeV protons. In order to measure the incremental degradation of energy resolution, the crystal is exposed to proton fluences within a range of 10^8 to 10^{11} p/cm^2. Initial results of the irradiation tests and of the annealing process are presented.