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Reciprocal contamination between electrons, protons and alphas in the radiation belts: Akebono RDM and Geant4 simulation

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The Japanese semi-polar orbiting satellite Akebono (EXOS-D), launched in February 1989, has observed the space environment at altitudes of several thousands km. The radiation monitor (RDM) onboard Akebono gives data of energetic particles in the Earth's radiation belt for twice solar cycles. The data from RDM are for electrons in three energy channels of $>$ 2.5, 0.95-2.5, 0.3-0.95 MeV, protons in three energy channels of 30-38, 15-30, 6.4-15 MeV, and alpha particles in one energy channel of 15-45 MeV [Takagi et al., IEEE 1993]. These energy ranges are however based on information of about 20 years ago so that the data seem to include some errors. In addition, these data include contamination of electrons and protons reciprocally. Actuary it is noticed that the electron data are contaminated by the solar protons but unknown quantitative amount of the contamination. Therefore we need data calibration in order to correct the energy ranges and to remove data contamination.

We examine the RDM instrument using the Geant4 simulation. Geant4 gives information of trajectories of incident and secondary particles whose are interacted with materials. It is confirmed from the results that electrons showed extremely complex trajectories caused by material interactions in the instrument. Some electrons are scattered in the shading material (Al) and the primary detector element (Si) before arriving the main detector elements of the instrument. Our simulation moreover confirms that signals of proton incidence appear in the electron and alpha channels. The results of the simulation successfully show reciprocal contaminations that electron contaminates onto the proton channels and proton contaminates onto the electron and alpha channels of the RDM detector.

It has been known that the solar protons enter the magnetosphere at high latitudes. Actuary the RDM instrument detects the solar flare particles often at high L values of $>$ 8. We compare the RDM data modified by Geant4 with the solar flare particle data provided by the OMNI web database. It is found from the investigation of the solar energetic particle events from 1989 to 1999 that the solar helium of a few ten MeV can enter to the inner magnetosphere of L ˜ 3 during the geomagnetic storms. In the inner radiation belt (L $<$ 2), the electron data are significantly contaminated by protons $>$ 40 MeV.

Keywords: radiation belts, high energy particles, particle detector, Geant4, solar energetic particles