Testing the Single Event Latch-up of PDA onboard Pico-satellite Cute-1.7

J. Kataoka[1], M. Iai[2], Y. Funaki[2], J. Kotoku[1], Y. Yatsu[1], Y. Kuramoto[1], H. Yabe[2] and T. Shima[3]
[1] *Department of Physics, Faculty of Science, Tokyo Institute of Technology, Tokyo 152-8550, Japan*
[2] *Laboratory for Space Systems, Tokyo Institute of Technology, Tokyo 152-8550, Japan*
[3] *Research Center for Nuclear Physics (RCNP), Osaka University, Ibaraki, Osaka 567-0047, Japan*

Tokyo Inst. Tech. is planning to launch 2nd pico-satellite Cute 1.7 in the winter of 2005, as a piggyback satellite of the Astro-F mission [2]. The prime purpose for this project is to establish a general "platform" of the pico-satellites, providing space laboratory to many researchers in various fields in the world. The second purpose is to reduce the diffculties of space technology by using the commercial off-the-shelf components. A very quick and low-cost development will allow us to test the latest electric devices in the space environment. In the forthcoming Cute-1.7 project, we will use PDA (personal digital assistance) as a fast and intelligent CPU which controls all the sub-systems connected by USB or serial interfaces [1].

However, the radiation tolerance of PDA is almost completely unknown. In the Low Earth orbit of Cute-1.7, the satellite passes through the radiation belt called South Atlantic Anomaly (SAA), where the geomagnetically trapped protons are accumulated and hit the satellites at a rate of $\sim 3\times10^3$ cts/cm^2/s (for $\geq$ 3 MeV protons measured at an altitude of 480 km). In order to obtain the Single Event Latchup (SEL) and the Single Event Uppset (SEU) rates expected in orbit, we monitored the performance of PDA under a constant illumination ($3\times10^7$$-$$3\times10^8$ cts/cm^2/s) of proton beam with a monochromatic energy 60 MeV. We also tested the PDA responses to 35 MeV and 45 MeV protons using Al attenuator.

Since the PDA size is very large (108×77 mm^2 for Hitachi NPD-20JWL), total surface area of the PDA cannot be illuminated by the proton beam uniformly in a single experiment (Fig.1). We therefore extended the beam spot as large as possible (about 30×10 mm^2), and shifted the target every 2000 sec to focus on the most important/sensitive part of the PDA (CPU, SD-card and SD-RAM etc). Beam intensity and the profile were checked by a plastic scintillator directly coupled with the photomultiplier tube. As a result, most of the surface area of the PDA (both from the front and reverse sides) was irradiated by protons with a total counts of 3×10^{11} /cm^2. This corresponds to more than 10 years dose of PDA in Cute-1.7 orbit.

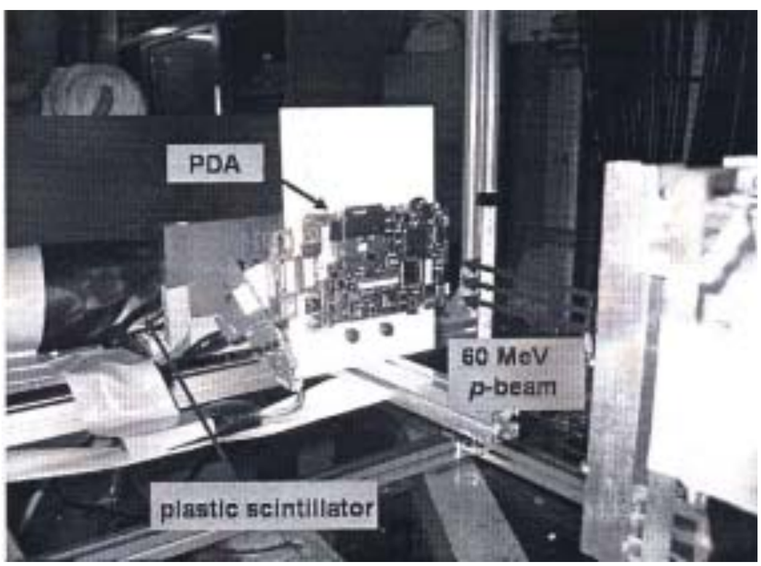

Figure 1: Setup of the SEL test in the RCNP AVF cyclotron facility.

To detect both the soft and hard errors in the PDA, we requested to read out stored data in the SD-card every four seconds, and compare them with the expected (true) values. We simply calculated the SEU cross section as a total number of error bits divided by number of input protons per unit area. If the PDA returned no answer, we think that it is a hard error caused by the SEL. In such a case, PDA is automatically powered-off and rebooted to avoid fatal damages. We find that the cross sections of the SEU and the SEL are 10^{-10} cm^2 and 10^{-11} cm^2, respectively (Fig.2). This means that both the SEU and the SEL may occur only once in $\sim$10 years, which is sufficiently low compared to the <1 year life of Cute-1.7 satellite. Therefore we conclude that the commercial PDA is radiation tolerant to be used for the Cute-1.7 mission.

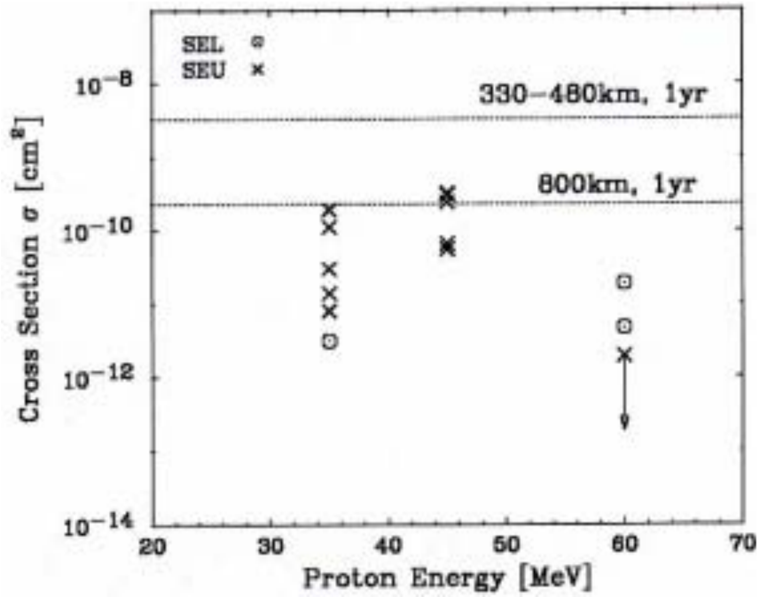

Figure 2: Resulting cross section of the SEL/SEU of the PDA used in Cute-1.7.

References

[1] J. Kotoku, J. Kataoka, T. Shima et al., 2005, SPIE, in prep.

[2] M.Iai, J. Kataoka, T. Shima et al., 2005, 18th AIAA/USU Conference on Small Satellites, SSC04-IX-8, Logan, USA.