European space radiation research program at GSI

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Introduction

Space radiation has long been acknowledged as a potential showstopper for long duration manned interplanetary missions (Fig. 1). Our knowledge of biological effects of cosmic radiation in deep space is almost exclusively derived from ground-based accelerator experiments with heavy ions in animal or *in vitro* models [1]. In an effort to gain more information on space radiation risk and to develop countermeasures, NASA initiated several years ago a Space Radiation Health Program, which is currently supporting biological experiments performed at the Brookhaven National Laboratory. The European Space Agency (ESA) has recently established human space exploration beyond Low Earth Orbit as one of its goals, and in this frame, new space radiation activities have been initiated. Europe has a long tradition in radiobiology research at accelerators, generally focussing on charged-particle cancer therapy. This expertise can be adapted to address the issue of space radiation risk.

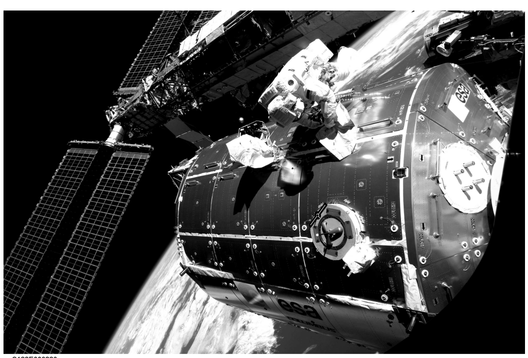

Figure 1: ESA astronaut Hans Schlegel works on Columbus exterior during the second spacewalk of the STS-122 mission. The astronauts are exposed to radiation plus many other stressors (including microgravity) during spaceflights (Official credit: ESA/ NASA)

Space radiobiology

A preparatory studied funded by ESA in 2006 made a careful review of the current knowledge in space radiation effects, gaps in knowledge, and ground-based facilities where radiobiology studies could be performed in Europe. The main conclusion of this study [2] was that more research is needed in the field of cancer and noncancer late effects induced by heavy ions and that GSI is the ideal facility for this kind of research in the energy range 100-2000 MeV/n, while GANIL in France can supply beams at lower energies. Based on these recommendations, ESA has issued in 2008 an announcement of opportunity (AO) for investigations into biological effects of cosmic radiation using the GSI accelerator facility. Over 30 proposals have been submitted in response to the AO, and 13 have been selected by an independent review panel for implementation at GSI. The projects include studies on the effects of heavy ions on DNA, central nervous system, retina, mucositis, bone, heart, as well as physics studies on low energy electrons and organ dose measurements.

Radiation damage to microelectronics

In addition to the health risk for manned missions, cosmic rays are of concern because it is well known that these energetic particles can damage integrated circuits (IC) in spacecrafts electronics [3]. The main effect associated with a hit of a heavy ion is the generation of electrical charges along their track through the semiconductor material inside the ICs (Fig. 2). In some cases it can lead to catastrophic failures when the deposited charge is high enough, such as latchup. Heavy ion testing at accelerator facilities is routinely used to study mechanisms of single-event effects (SEE). ESA has recognized that these tests must be also performed at high-energy accelerators, because range effects and nuclear interactions can modify the damage to microelectronics. For these very reasons, ESA is now supporting a study on the impact of relativistic heavy ions on different electronic devices (including MOSFET and SDRAM) led by the Fraunhofer Institute for Technological Trend Analysis using the GSI accelerator. The results of this study will be used to clarify the risk to electronic devices from very high energy cosmic rays, and to plan future testing of spaceflight hardware.

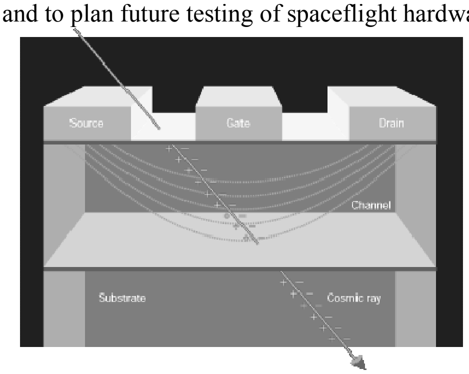

Figure 2: Effect of cosmic rays in electronic chips.

References

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[3] A. Holmes-Siedle and L. Adams, *Handbook of Radiation Effects*, Oxford Univ. Press, 2002.