**How to test electronics used in the Cosmos ?**

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Our sun emits a large number of charged and uncharged particles including protons, heavy ions and neutrons. The radiation environment close to Earth is divided into two categories: particles trapped in the Van Allen belts and transient radiation. The energy levels of these particles can range in intensity from keV up to GeV [1].

Space instruments carry many electronic devices including micro-processors, registers in digital circuits, Analog-Digital Converters (ADCs) etc. If a charged particle from space, strikes a sensitive node of an electronic circuit, it may cause a disruption or a permanent damage [2].

There are two primary ways that radiation can effect electronics: total ionizing dose (TID) and single event effects (SEEs). TID is a long-term failure mechanism vs. SEE, which is an instantaneous failure mechanism. SEE is expressed in terms of a random failure rate, whereas TID is a failure rate that can be described by a mean time to failure [3]. SEEs are caused by a single, energetic particle, and can take on many forms. Single Event Upsets (SEUs) are soft errors, and non-destructive. They normally appear as transient pulses in logic or support circuitry, or as bitflips in memory cells or registers. Several types of hard errors, potentially destructive, can appear: Single Event Latchup (SEL) results in a high operating current, above device specifications, and must be cleared by a power reset. Other hard errors include Burnout of power MOSFETS, Gate Rupture, frozen bits, and noise in CCDs. In the space environment, electronincs designers have to be concerned with two main causes of SEEs: cosmic rays and high energy protons. For cosmic rays, SEEs are typically caused by its heavy ion component. These heavy ions cause a direct ionization SEE, i.e., if an ion particle transversing a device deposits sufficient charge an event such as a memory bit flip or transient may occur. Cosmic rays may be galactic or solar in origin. Protons, usually trapped in the earth's radiation belts or from solar flares, may cause direct ionization SEEs in very sensitive devices. However, a proton may more typically cause a nuclear reation near a sensitive device area, and thus, create an indirect ionization effect potentially causing an SEE [4].

Circuit quality control testing is required prior to the launching of space instruments in order to find out where the sensitive nodes are and also to protect against the charged particle strike [2]. In order to be able to test the electronics used in space, it should be provided to the experimenters combination of acelerators: with source 40 MeV protons and heavy ions at energies as high as 55 MeV/nucleon. There is no such center in Poland, yet !

**Bibliography**

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