Single Event Effects in Radiotherapy

Introduction

A single event effect (SEE) is a change of state of a micro-electronic device caused by a single energetic particle. Single event upsets (SEUs) is one kind of SEEs. A SEU on a Siemens Linac has been reported in a SRAM of PLC. With more and more integrated circuits in modern Linacs and treatment head, such as MLC, the probability of SEEs becomes larger. The consequences of the SEEs in radiotherapy, especially of safety functions and considerations, need further investigation.

Method and materials

A Linac with high energy (15MV) mode (Varian, Palo Alto, CA) was investigated. Integrated circuits used inside treatment room were identified. Of interest wert those CMOS and FPGA. The SEE rates were estimated based on published papers. Further estimation was made with Monte Carlo code and data from NASA's SEE test reports. SEEs in beam delivery and MLC control were also scrutinized.

Results

SEU rate of 0.047 events$\cdot$MiB$^{-1}\cdot$MU^{-1} for Varian 15 MV photons has been derived. If the response of the ICs is linear, a radiotherapy room with 32 patients/day, 1/8 patients treated with high energy, and 200 MU/patient, the SEUs will be 38 SEUs$\cdot$MiB$^{-1}\cdot$day^{-1}. If somewhat arbitrary one megabyte is taken for memory size in use, the SERs will be 38 events per day. Thus, there is a significant potential for quite a few SEEs in radiotherapy.

Conclusion

The SEE is well known phenomena of increased importance. SEE is a critical to electronic reliability in certain environment like radiotherapy. The SEE characteristics of electronics should be tested further and evaluated for clinical application. Further knowledge on their impact to radiotherapy, especially to under-dose or over-dose delivery, and control of parts like MLC, should be investigated. Care should be taken by the manufacturer to use ICs which are immune of SEEs.