RCNP EXPERIMENT E

PROPOSAL FOR EXPERIMENT AT RCNP

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TITLE:

Observing Muon-induced Single Event Upsets for Individual Muons with Fast-scan SRAM chip

SPOKESPERSON:

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EXPERIMENTAL GROUP:

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Megumi Niikura	Department of Physics, Univ. of Tokyo	Assistant Prof.
Shin-ichiro Abe	Research Gr. for Radiation Transport Analysis, JAEA	Researcher
Dai Tomono	RCNP, Osaka Univ.	Assistant Prof.
Yoshitaka Kawashima	RCNP, Osaka Univ.	Researcher

RUNNING TIME: Installation time without beam — 1 day(for each beam time)
Data runs — 5 days

BEAM LINE: Ring : WSS, MuSIC-M1

BEAM REQUIREMENTS:

Type of particle	proton
Beam energy	392 MeV
Beam intensity	$>1.1\mu$A

BUDGET: Experimental expenses — 0 yen

SAFETY CONTROLLED ITEMS:

- None

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SUMMARY OF THE PROPOSAL

Recently, the cosmic-ray muon induced soft error has received much attention because a reduction in resilience to soft errors has become evident with a decrease in critical charge due to the device miniaturization and low voltage operation of VLSI chips. Our research group has conducted a series of irradiation experiments at MUSE in J-PARC and MuSIC in RCNP to clarify the difference in single event upsets (SEUs) induced by positive and negative muons. Our results show that the negative muon SEU cross section is much larger than the positive muon one. We have revealed that that muon capture reaction, which is unique to the negative muon, causes SEUs, especially multiple cell upsets (MCUs) since the secondary ions generated by the muon capture process have linear energy transfer (LET) large enough to cause SEU and MCU.
Conventionally, we performed a static test, i.e., memory chips are irradiated for several minutes after writing the data, and the error patterns are read after the irradiation. We can count the number of bit flips, but we cannot know what exactly happens in each event; which triggers bit upsets, direct ionization or muon capture reaction, how the secondary ions travel, and how many bit flips are caused by a single event.
To observe what is happening for each muon incident, we designed a special chip that can quickly check the error patterns. We construct a measurement system using this chip and pixel silicon detectors located in front of the chip. The pixel silicon detectors provide the information on when and where each muon passes, which will be associated with the errors observed inside the chip. SEUs caused by direct ionization arise immediately after the muon incident, whereas SEUs caused by muon capture reaction arise after a particular duration stochastically determined by a probability density function. Also, all bit flips caused by a single event can be regarded as a true MCU, whereas, so far, only bit flips adjacent to each other are regarded as an MCU. This experiment needs a DC muon beam since we need to know when and where each muon passes and associate that information with error patterns.
The result of this experiment is helpful to establish a simulation framework. The simulation-measurement correlation can be verified with the obtained result.