Status of the Radiation effects master's program: Using an SRAM based dosimeter to measure LET, fluence, and beam uniformity

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While the concept of using heavy ion induced single event upsets (SEU) in Static Random Access Memories (SRAM) to measure beam characteristics is nothing new, our facility has lacked such a device. Through collaboration with NASA Goddard and JPL, we have been commissioned to build such a device as a basis for a thesis in the Radiation Effects Master's Program.

This device is composed of three components: a PCB containing four delidded SRAMs, an FPGA/ SoC combo to control the SRAMs, and a computer with a simple serial terminal installed. The concept is shown in Fig. 1.

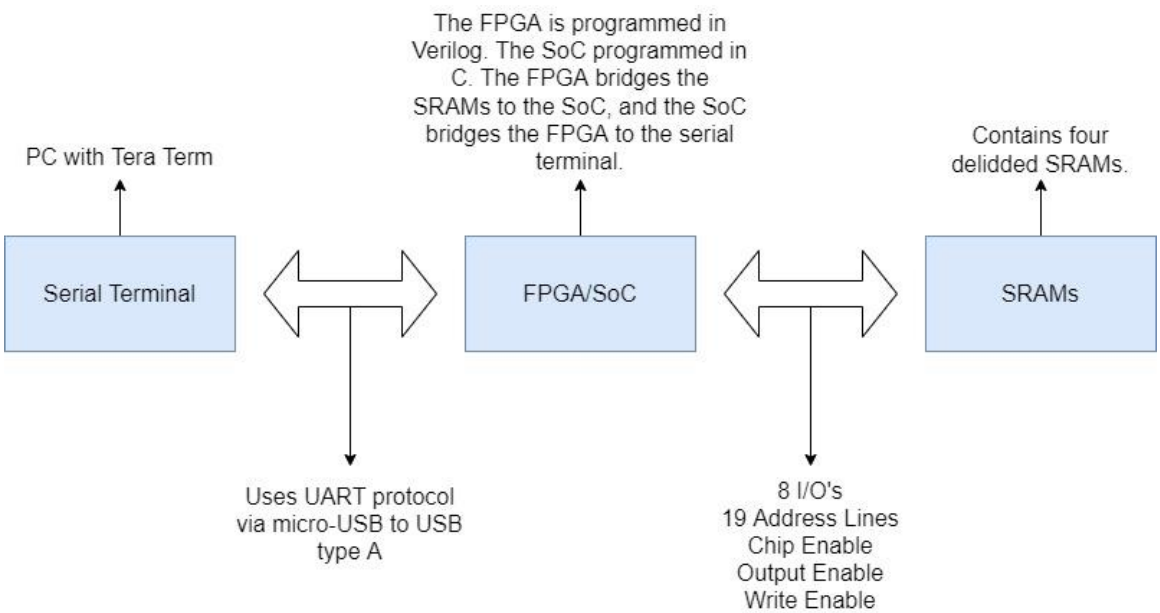

Fig. 1. Diagram detailing the dosimeter operation.

The device was tested as part of the Radiation Effects Boot camp held at the Cyclotron Institute in February 2022. 9.2 MeV/u ^{78}Kr and 13.6 MeV/u ^{14}N were delivered from the K150 cyclotron to test the cross-section[1] as a function of effective linear energy transfer (LET). Tilting the device allowed us to increase the effective LET, effectively allowing us to measure multiple LETs with the same beam. Preliminary data gathered on one of JPL's preexisting boards controlled by an FPGA/SoC programmed with our code closely matched previous results, as shown in Fig. 2.

[1] Cross-section here is defined as the number of bit errors per unit fluence.

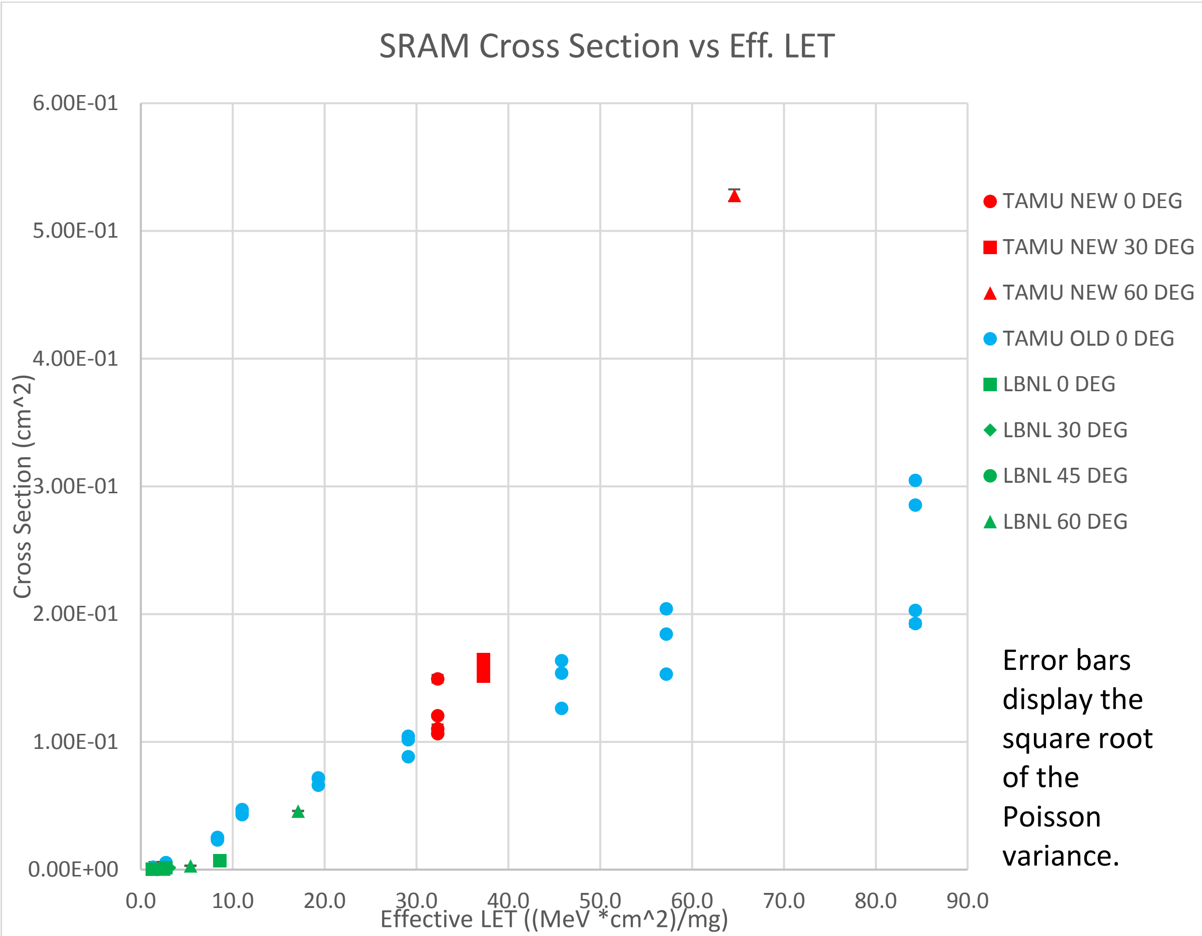

Fig. 2. Cross Section vs. LET. Data was recorded both on the K150 and at LBNL.

Our next step is to build a board in house using the cyclotron's new PCB fabrication equipment, as described in a separate paper.[2] Imaged in Fig. 3 is a rendering of the proposed design.

Once constructed, the plan is to characterize a variety of beam species, looking at variations of total bit upset and multiple bit upset (MBU) cross sections in response to differences in spatial location, effective LET, and device operational voltage. Appropriate characterization should lead to a dosimetry system that a radiation effects engineer can bring to other facilities, and confirm the beam that is reported as delivered to the device under test (DUT) is actually incident on the DUT. After characterization, and time permitting, a GUI will be created for the operation of the dosimetry system. This will either be created by R. Rinderknecht or a future Master's student.

[2] For details on the cyclotron's recently acquired PCB production capabilities, see: Printed Circuit Board Fabrication Facility: SEE Fab (L. E. Henderson *et al.*)

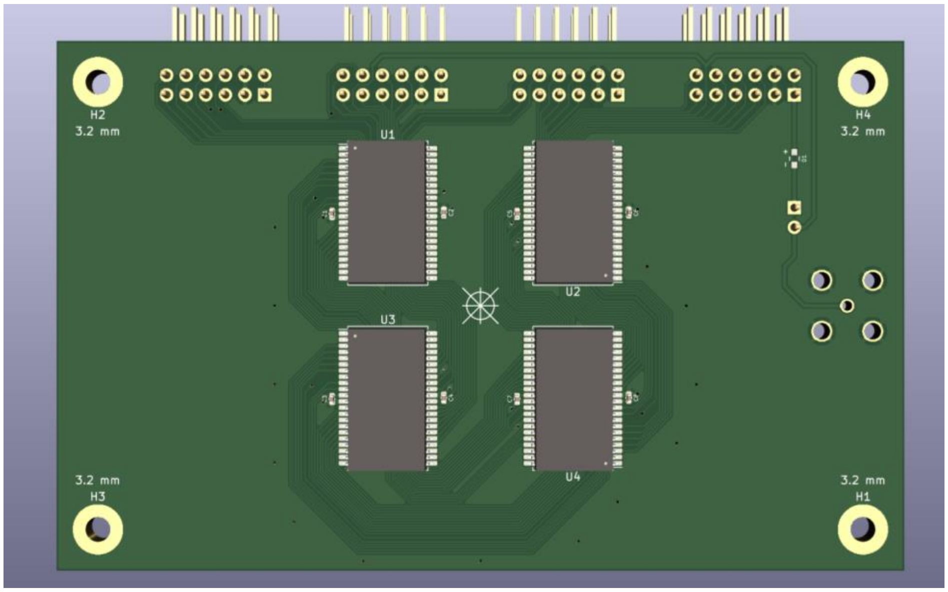

Fig. 3. The proposed 4 SRAM Dosimeter.

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In addition to the dosimeter, two analog boards have been designed and built for use in future radiation effects boot camps. One board features an LM124 op-amp, and with the appropriate choice of jumpers, can be configured as either a voltage follower, a unity gain inverter, or a 10 times gain inverter. The other board is voltage comparator, outputting low if VIN < 0.5 VCC, or high if VIN > 0.5 VCC. Both boards are configured with selectable load resistors. Single event transients (SETs) can then be recorded using an oscilloscope configured by R. Gallegos.