Radiation Hardened Technologies for Microelectronics in Space

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RADIATION HARDENED TECHNOLOGIES FOR MICROELECTRONICS IN SPACE

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Recorded Video: https://youtu.be/H3hKGy6fHIQ

PURDUE UNIVERSITY | School of Electrical and Computer Engineering

Background

Fukushima Daiichi nuclear disaster

Background-2

Space also full of radiation

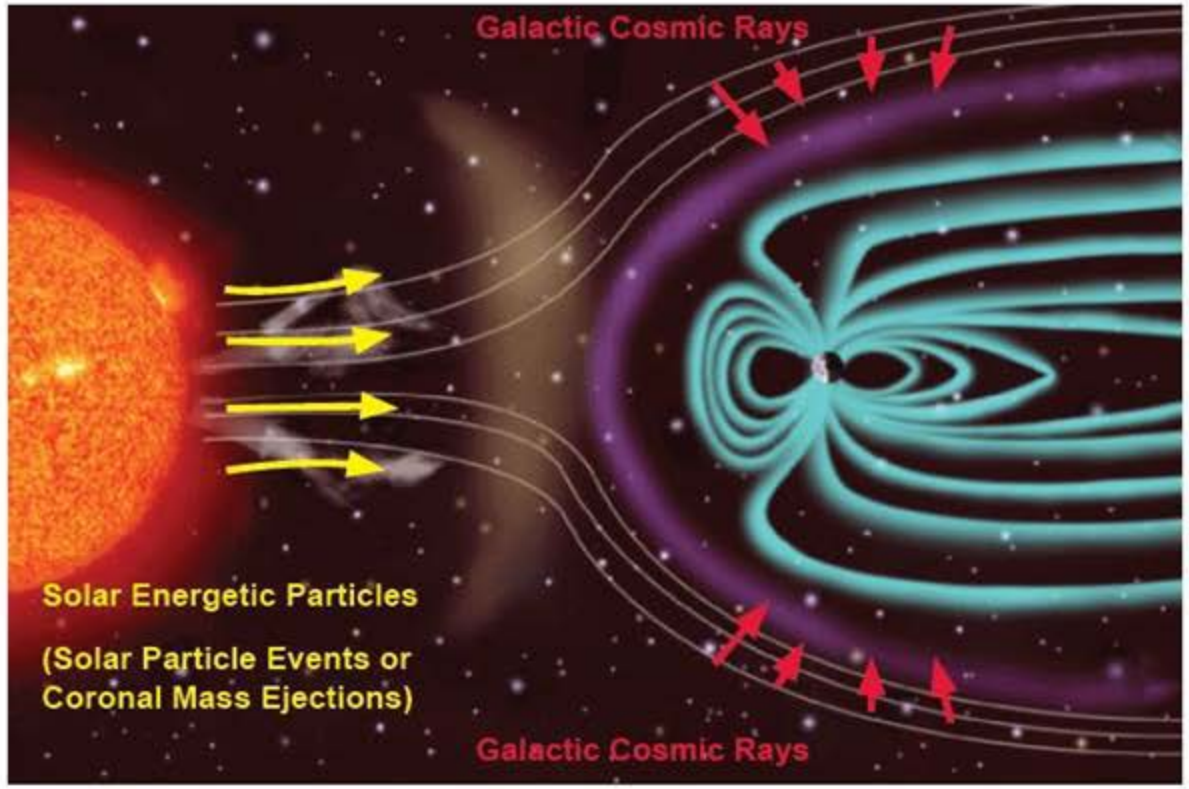


Figure 1: Sources of space radiation

Image Credit: NASA

Background-3

Radiation Environment Models

- Low Earth Orbit
  - Space Station orbit (51.6 deg, 500 km apogee, 500 km perigee)
- Three parameters
  - Solar energetic particle
  - Galactic Cosmic Rays
  - Trapped Protons and Electrons

Background-4

Radiation Effects Model and Device Under Test

- Three effects
  - Total Ionizing Dose (TID) – Radiation Absorbed Dose (Rad)
  - Displacement Damage Dose (DDD)
  - Single Event Effects (SEE) – Cosmic Ray Effects on Microelectronics (CREME96)
- Devices
  - Microchip ATMX150RHA Rad-Hard CMOS 150nm cell-based ASIC
    - 16k32 for SRAM
    - 6k39 for DPRAM
    - NRB1 for D type flip-flops

Research Question

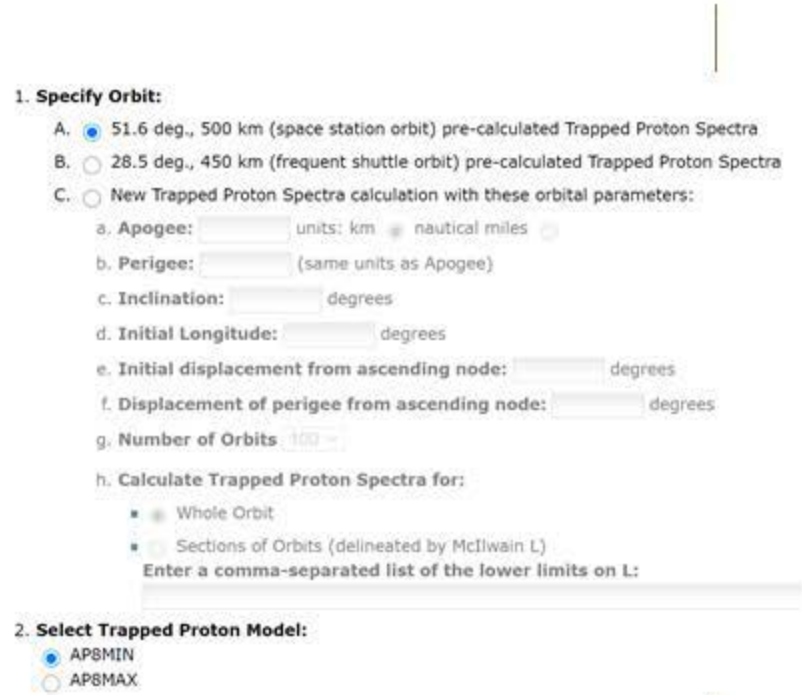
What needs to be discovered?

- SEE prediction
- TID prediction

SEE Prediction

TRP

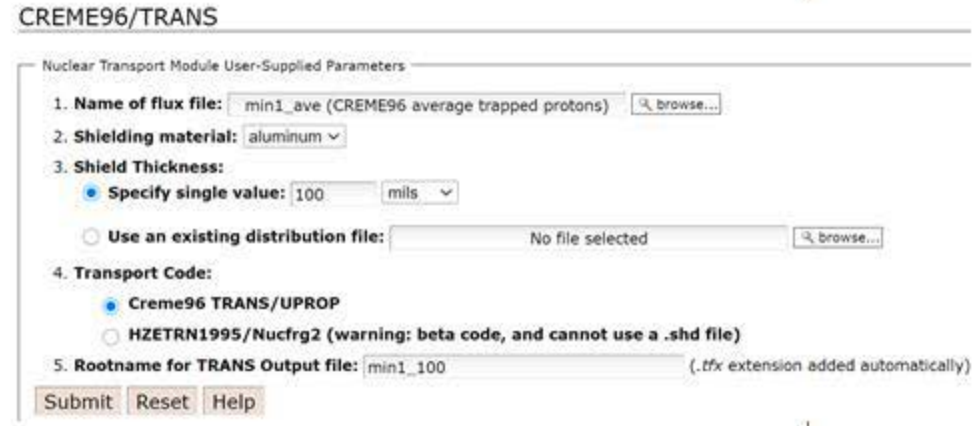
- Space Station orbit (51.6 deg, 500 km apogee, 500 km perigee)
- AP8MIN & AP8MAX



SEE Prediction-2

TRANS

- Orbit-Averaged Trapped Proton Fluxes
- Aluminum
- Shielding thickness: 0.1 ~ 180 mil
  - 100 mils = 0.254 cm
- Creme96 TRANS



SEE Prediction-3

Cross-section Parameter: Weibull function

DUT	x0	W	S	A
SRAM 16k32	1	24	1.2	3.61E-2
DPRA M6k39	2	34	1.4	2.43E-3
DFFN RB1	3	22	1	1.08E-4

The functional form of the Weibull is:

$F(x) = A\ (1- \exp\{-[(x-x_0)/W]^s\})$

where

- x = effective LET in MeV-cm^2/milligram;
- F(x) = SEE cross-section in square-microns/bit;
- A = limiting or plateau cross-section;
- x_0 = onset parameter, such that F(x) = 0 for x < x0;
- W = width parameter;
- s = a dimensionless exponent.

SEE Prediction-4

PUP

- 10 million bits/device

CREME96/PUP

Direct-Ionization-Induced Single Event Upset (SEU) Rate User-Supplied Parameters

1. Input proton flux file:

min1_100 (CREME96 transported flux/environmen browse...

2. Rootname for PUP Output file: min1_100see (

3. Devices:

Label:	SRAM16K3:	DPRAM6K3	DFFNRB1		
Comment:					
Comment:					
Bits/device:	100000000	100000000	100000000	1	1

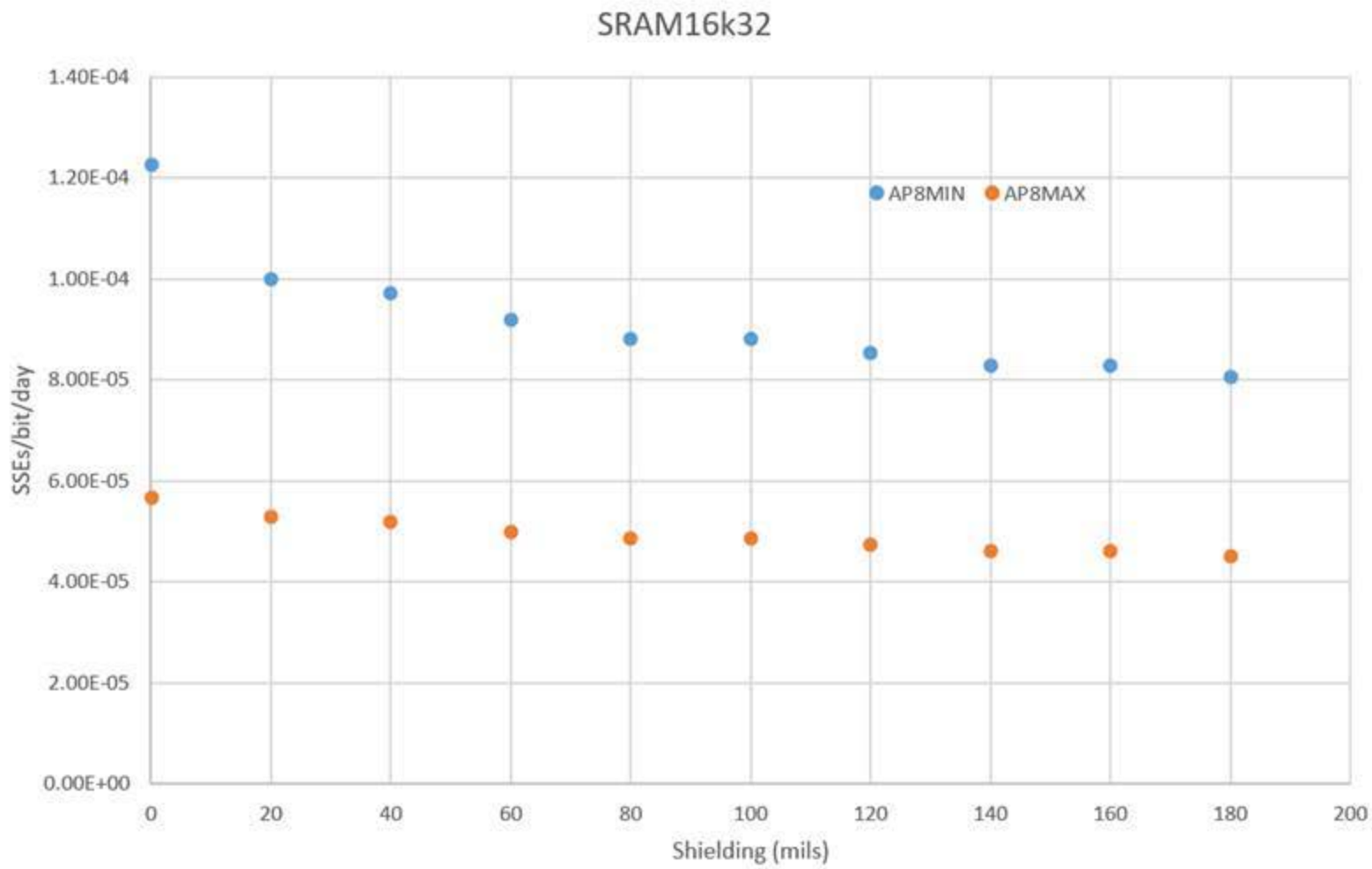
Cross-section parameters

Use buttons to choose one method in each column

Weibull:	◉	◉	◉	◉	◉
Onset: (MeV)	1	2	3		
Width: (MeV)	24	34	22		
Exponent:	1.2	1.4	1		
Limiting XS: (10^{-12} cm^2/bit)	36.1	2.43	0.108		

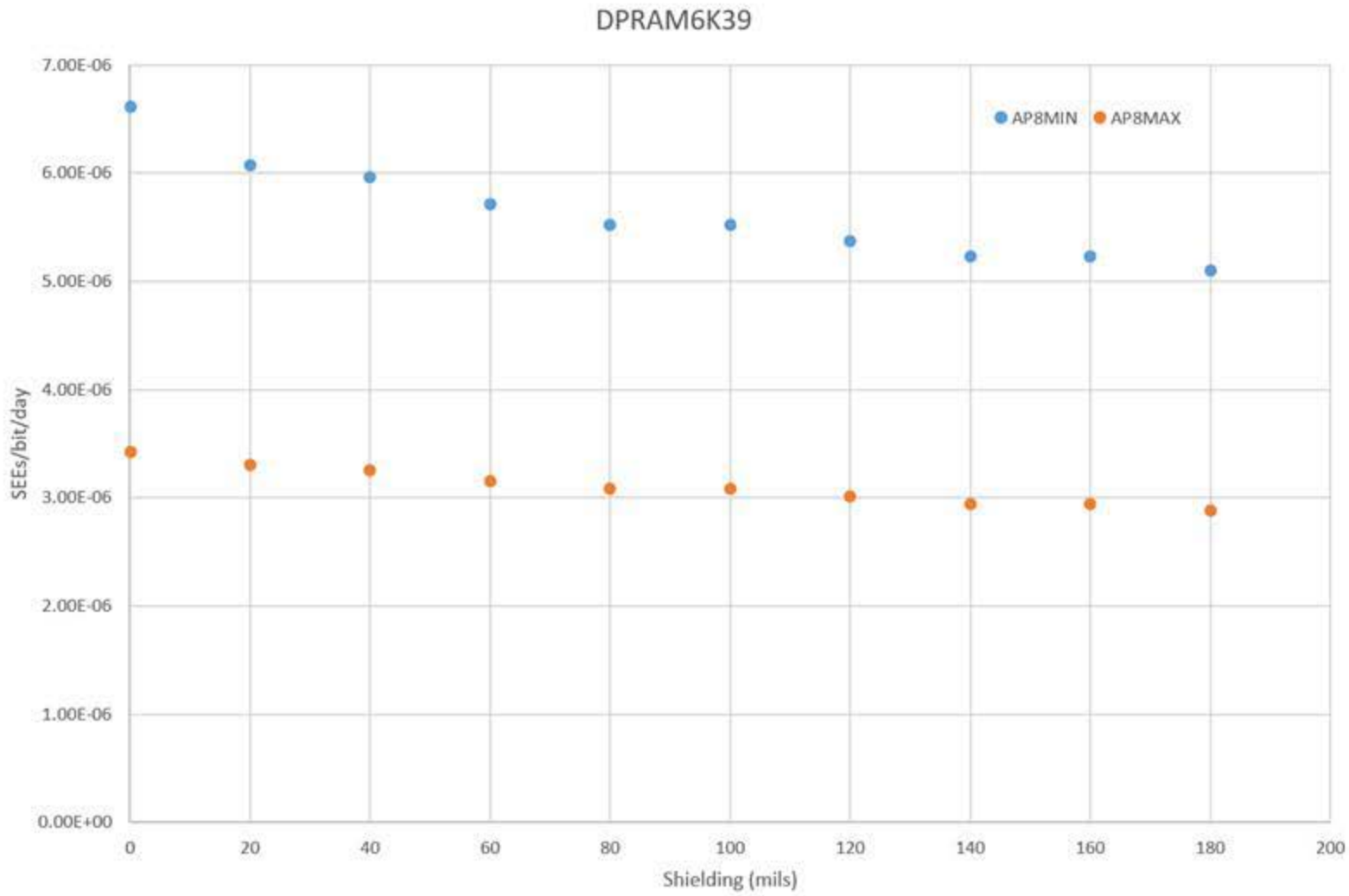
SEE Prediction-5

Result



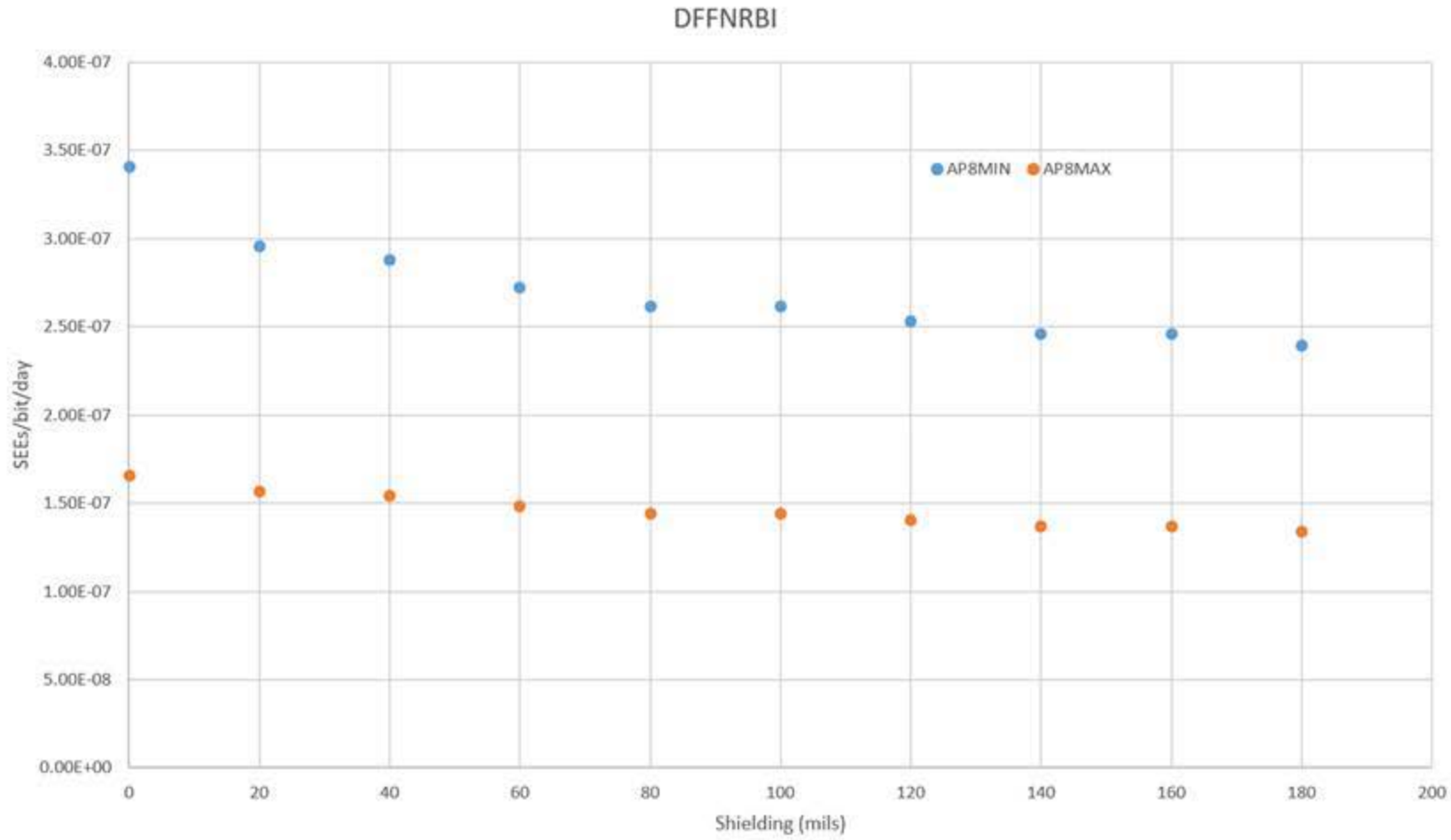
SEE Prediction-6

Result



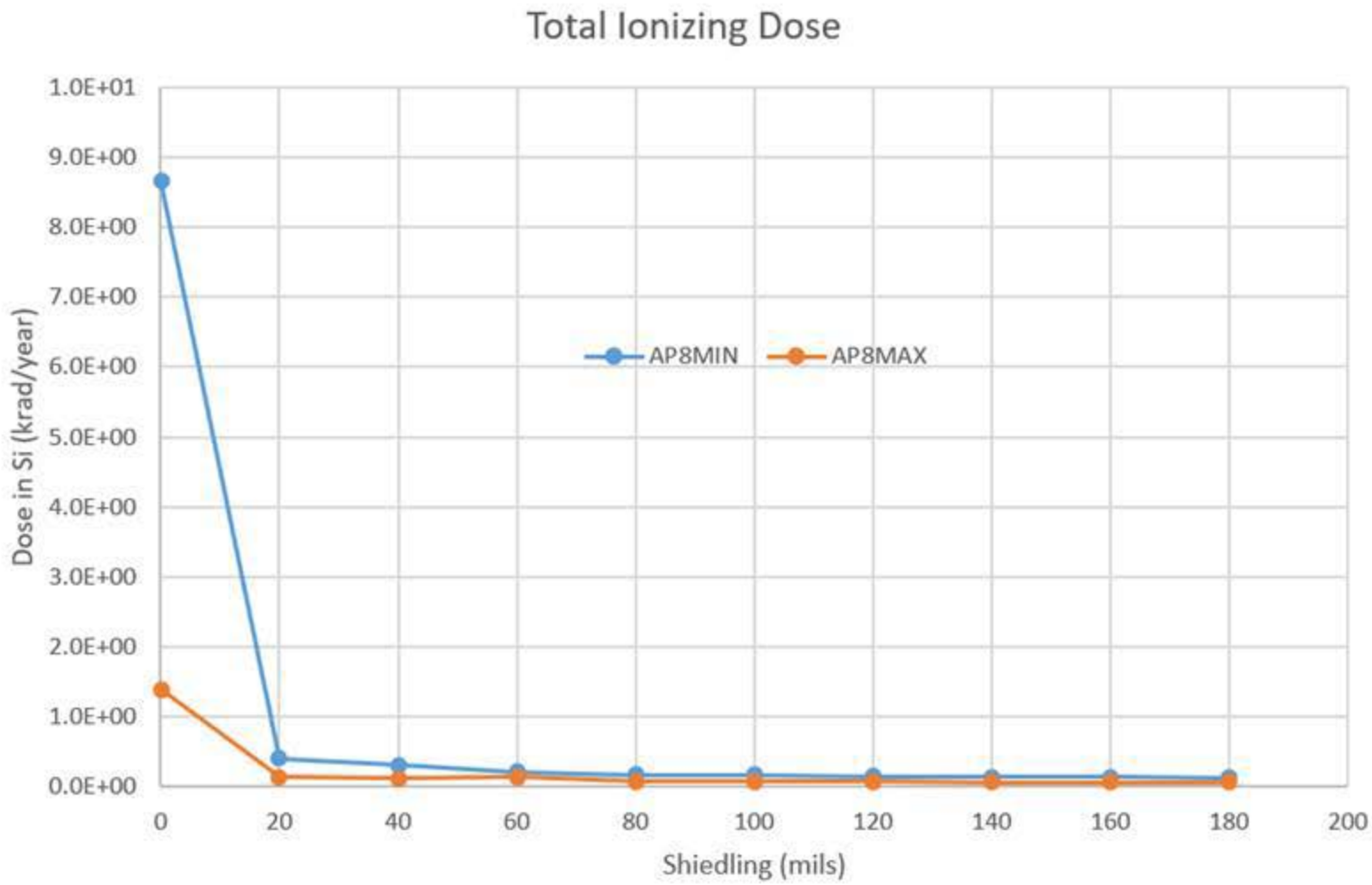
SEE Prediction-7

Result



TID prediction

Result



FUTURE DIRECTION

More software and database

Study more about radiation hardening technology

ACKNOWLEDGEMENT

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