CRÈME Update

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NEPP Electronics Technology Workshop, 2019

NASA Grant 80NSSC18K0721 "Administering and Maintaining Single Event Rate Prediction Tools"

Administering and Maintaining Single Event Rate Prediction Tools

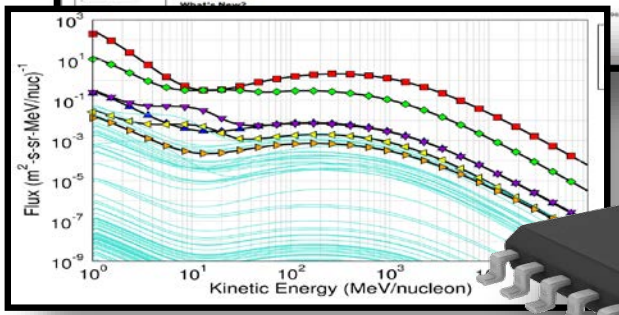
Objectives

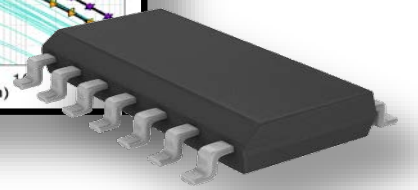
- **CRÈME maintenance and operations. Perform periodic diagnostic, performance, and regression tests. Monitor and regulate user traffic and behaviors that adversely affect site performance. Registration and user account maintenance. Provide tool support for user community. Maintaining frequently asked questions.**
- **Install RGENTIC at Vanderbilt and demonstrate public access.**
- **Define integration path between MTTF paradigm and classic SEE reliability (CRÈME) tools**
- **Define integration path between radiation confidence level modeling and existing reliability tools**

CRÈME Website

- ISDE hosts the CRÈME tool suite for predicting **on-orbit error rates** and proton **total ionizing dose** in microelectronics
- While there are multiple open-access options available, none are U.S.-based and controlled except for CRÈME
- ISDE maintains the code and operation of CRÈME, ensuring trust as well as continuing access

https://creme.isde.vanderbilt.edu





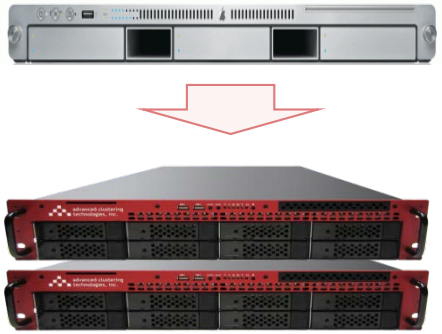
Brief History

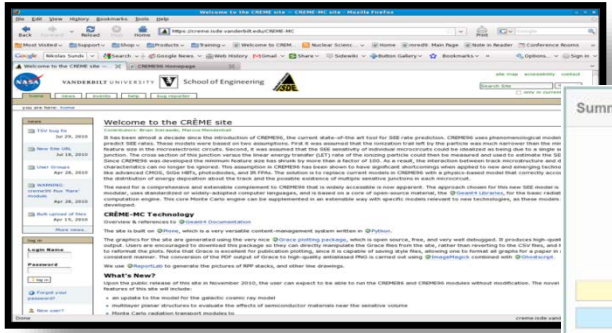
- **CREME86 was released by the James Adams at the Naval Research Laboratory in a series of Memorandum Reports**
- **Allan Tylka and NRL hosted CREME96 online in 1997**
- **NASA Marshall engaged in a program to update CREME96 in 2006**
  - Short comings in GCR environment models
  - Make physically-based rate calculations available
- **Vanderbilt developed a new server to host CREME96, CREME86 and CRÈME-MC codes and deployed in 2010**
  - Interest and funding for CRÈME waned
  - Almost no changes to hardware or software, only security patches and one bug fix in 2016

CRÈME Platform Update

Vanderbilt Engineering

- **Performance issues have motivated upgrades to hardware, operating system and content management system**
- **Rebuild of CREME site from ground up finished**
- **Latest web security recommendations enacted**
- **40GB+ user data transferred in June**





Hardware (2X):
- Pinnacle
- 12 cores
- 128 GB DDR
- 8TB HD
- 240 GB SSD

Software:
- Linux CentOS7

CREME96 Regression Tests

- Developed tests based on reference orbits and published part parameters
- Compared thousands of calculations between installations and found close agreement between rates

Reference Orbits
EELV LSA RFP (FA8811-17-9-0001), Oct 2017, Tables 10 and 11
* Note, distance converted from nmi to km

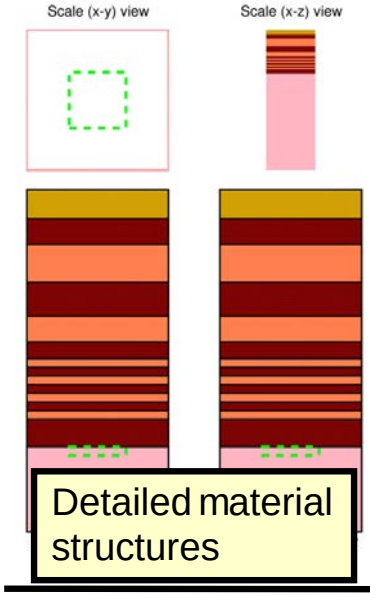
Orbit Description	Apogee (km)	Perigee (km)	Inclination (deg)
LEO	926	926	63.4
Polar 1	833	833	98.2
MEO Direct 1	18,177	18,177	50
MEO Transfer 1	20,368	1,000	55
GTO	35,786	185	27
Molniya	39,170	1,204	63.4
GEO 1	35,786	35,786	0
MEO Direct 2	20,368	20,368	55
MEO Transfer 2	20,368	1,000	55

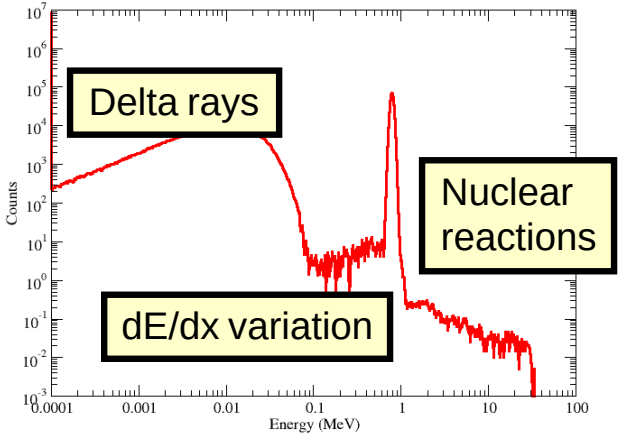
Heavy Ion and Proton SEU Parameters

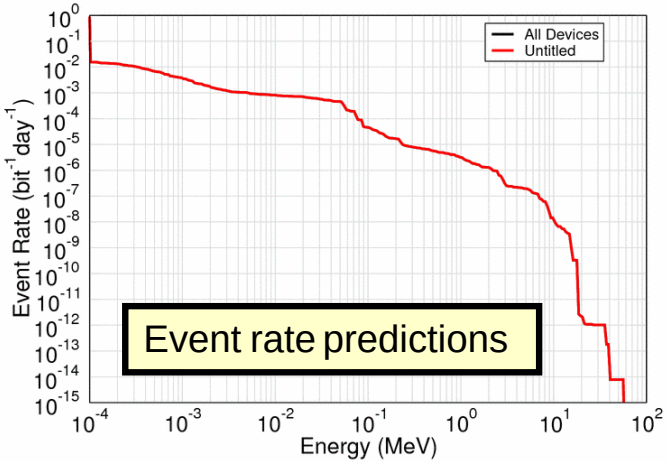
Table 1&4, E.L. Petersen, "Rate Prediction for Single Event Effects – a Critique," IEEE Trans. Nuc. Sci., vol. 30, no. 6, Dec. 1992.
Wang and Rezgui, "RTAX-S SEE Report-Analysis of NASA/Goddard High Speed SET/SEU Data," Actel, 2006.
Table 2, Stapor, "Two Parameter Bendel Model Calculations for Predicting Proton Induced Upset," IEEE Trans. Nucl. Sci., vol 37, no. 6, Dec. 1990.

CRÈME-MC Update

- **CRÈME-MC calculations now use MRED 9.6.2 consistent with Reed, "Physical processes and applications of the monte carlo radiative energy deposition (MRED) code" IEEE Trans. Nucl. Sci., vol. 64 no. 4, Aug. 2015.**

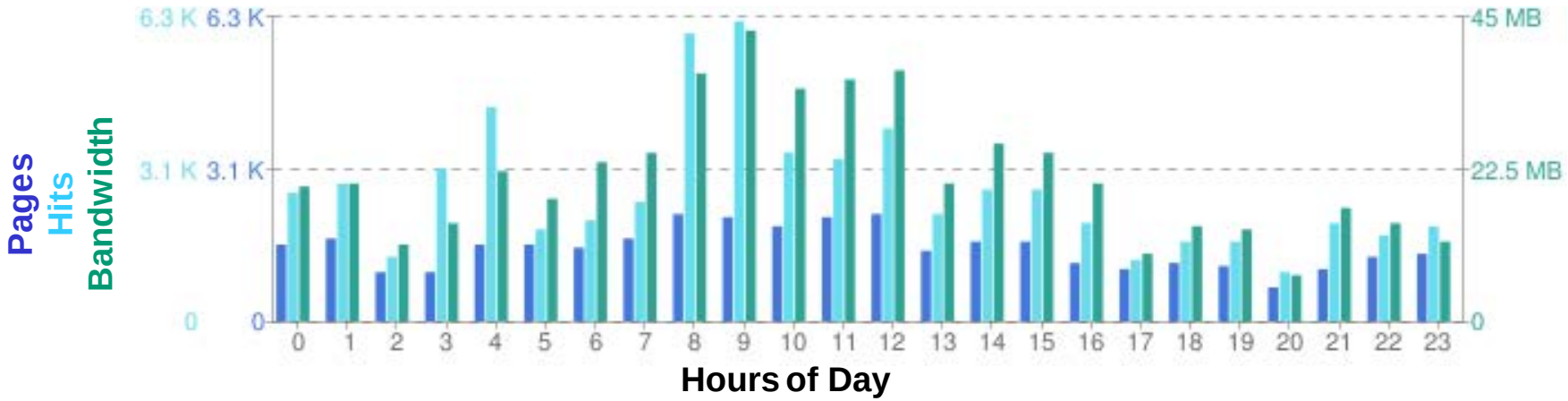






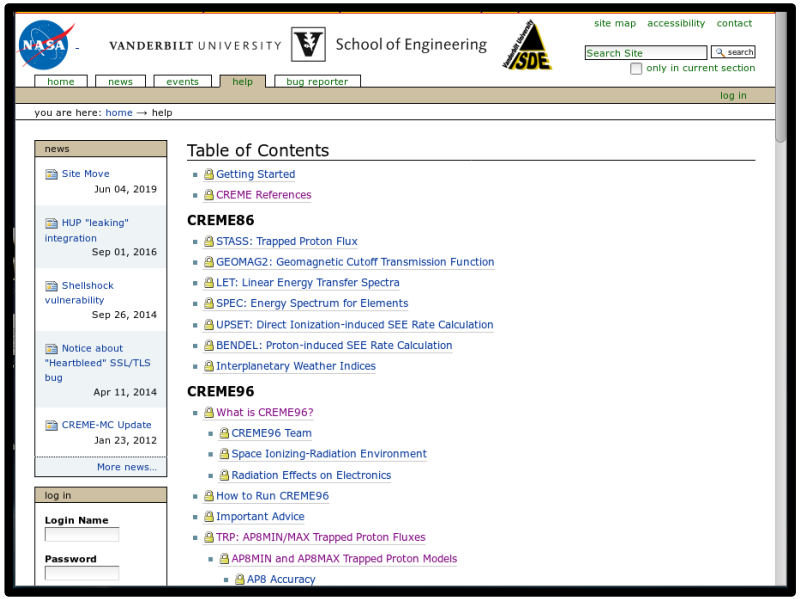
User Support and Logging

- **In the past year, processed 229 user registrations, now over 2800 user accounts!**
- **Added improved web logs for traffic monitoring and analysis**
  - 90 different users over past two weeks, 400 visits each day



Frequently Asked Questions

- **Extracted questions with answers from past three years of email and compiled a FAQ document**
  - Typical questions involved CREME96 file formats, creating custom environments, and uploading files



CRÈME API

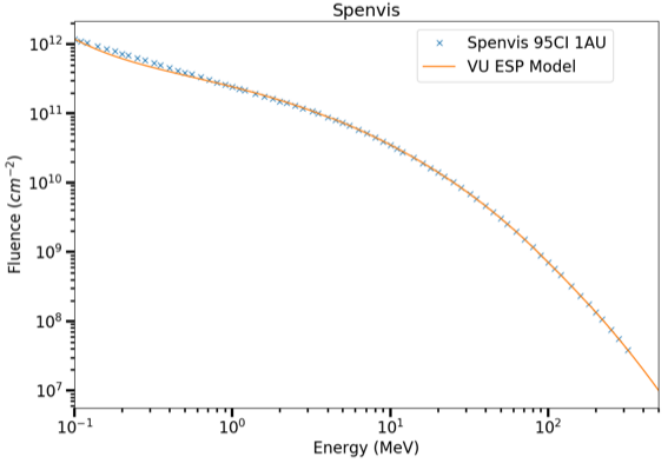
- **Completed XMLRPC interface to access CREME96 calculations (CFDRC SBIR funded)**
  - Enables incorporation of tools into space weather forecasting
  - Works with most modern programming languages
  - Decreases load on web server

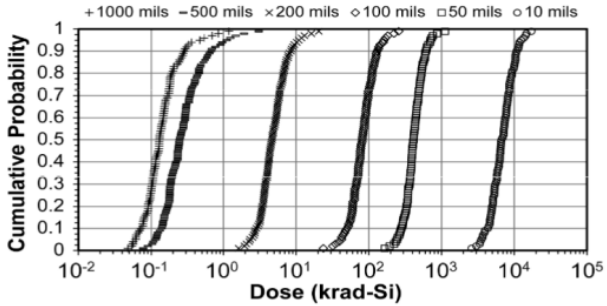
Python API example

```
import sys
import xmlrpclib

# Read in flx file
f=open(sys.argv[1],'r')
flx = f.read()
f.close()

proxy = xmlrpclib.ServerProxy('http://localhost:9000') # Connect to server

units=1
thickness=100
(tfx,out,err)=proxy.creme96.trans(flx,units,thickness) # Run transport

# Run PUP
devices=[
    dict({"label":"foo",  "comments":"", "method": 1, "A": 10, "bits_per_device": 1})
]
(pup,out,err)=proxy.creme96.pup(tfx,devices)
print pup
```

ESP/PSYCHIC

- ESP (proton) and PSYCHIC (ion) probabilistic environment models have been implemented based on personal communications with Mike Xapsos
- Codes output mission fluence for given confidence level and years in solar max
- Files can be written to CREME96 formats, but rate calculations accept environment fluxes
- More suitable for dose and destructive SEE calculations

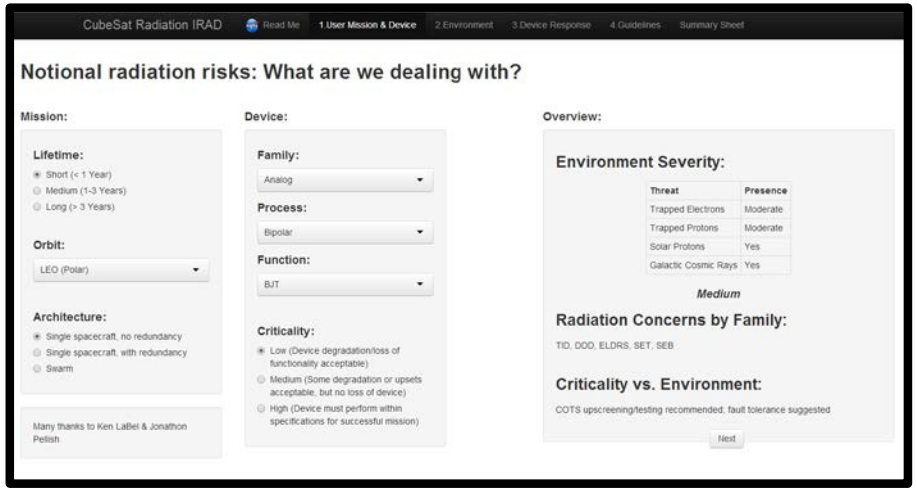




RGENTIC

- **RGENTIC installed at Vanderbilt**
- **Provides a guide for radiation effects appropriate for developers of small missions with little to no expertise**
  1. Select a mission class, lifetime, orbit, and architecture
  2. Compare environments and shielding levels
  3. Identify most prevalent radiation concerns
  4. Obtaining mitigation strategies

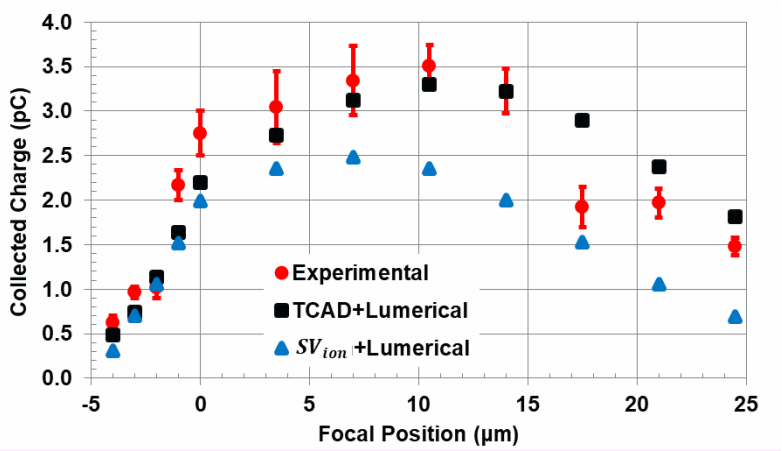
https://vanguard.isde.vanderbilt.edu/RGentic/



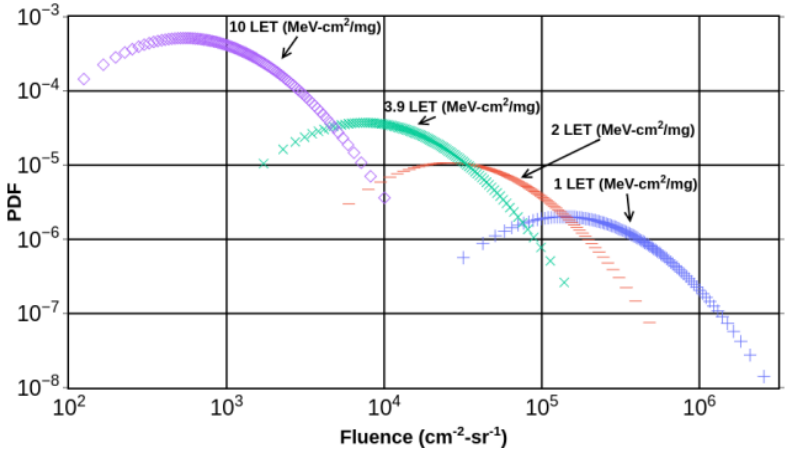
Developed by M. Campola under NASA IRAD

Related Research

- Ryder, "Correlation of Sensitive Volumes Associated with Ion- and Laser-Induced Charge Collection in an Epitaxial Silicon Diode", SEE Symposium, NSREC poster PA-4, (DTRA funded)



- Austin, "Inclusion of Radiation Environment Variability for Reliability Estimates for SiC Power MOSFETs," NSREC Poster PJ-5L



Future Directions

- Implement probabilistic environments and effects models. ESP/PSYCHIC for solar energetic particles and AP9/AE9/IRENE for radiation belts are of interest. Implementations will be compared to published datasets.
- Develop beta test application for Xapsos total-ionizing-dose confidence level model. Investigate extension to SEE.
- Host beta test site for RGENTIC, solicit community feedback.
- Survey radiation hardness assurance techniques for low-energy proton and electron-induced single event effects.
- Demonstrate ability to evaluate on-orbit non-ionizing energy loss in microelectronic material system.
- Explore applicability of existing analyses such as effective flux, RPP, classical reliability for complex, or non-homogenous systems of bits.