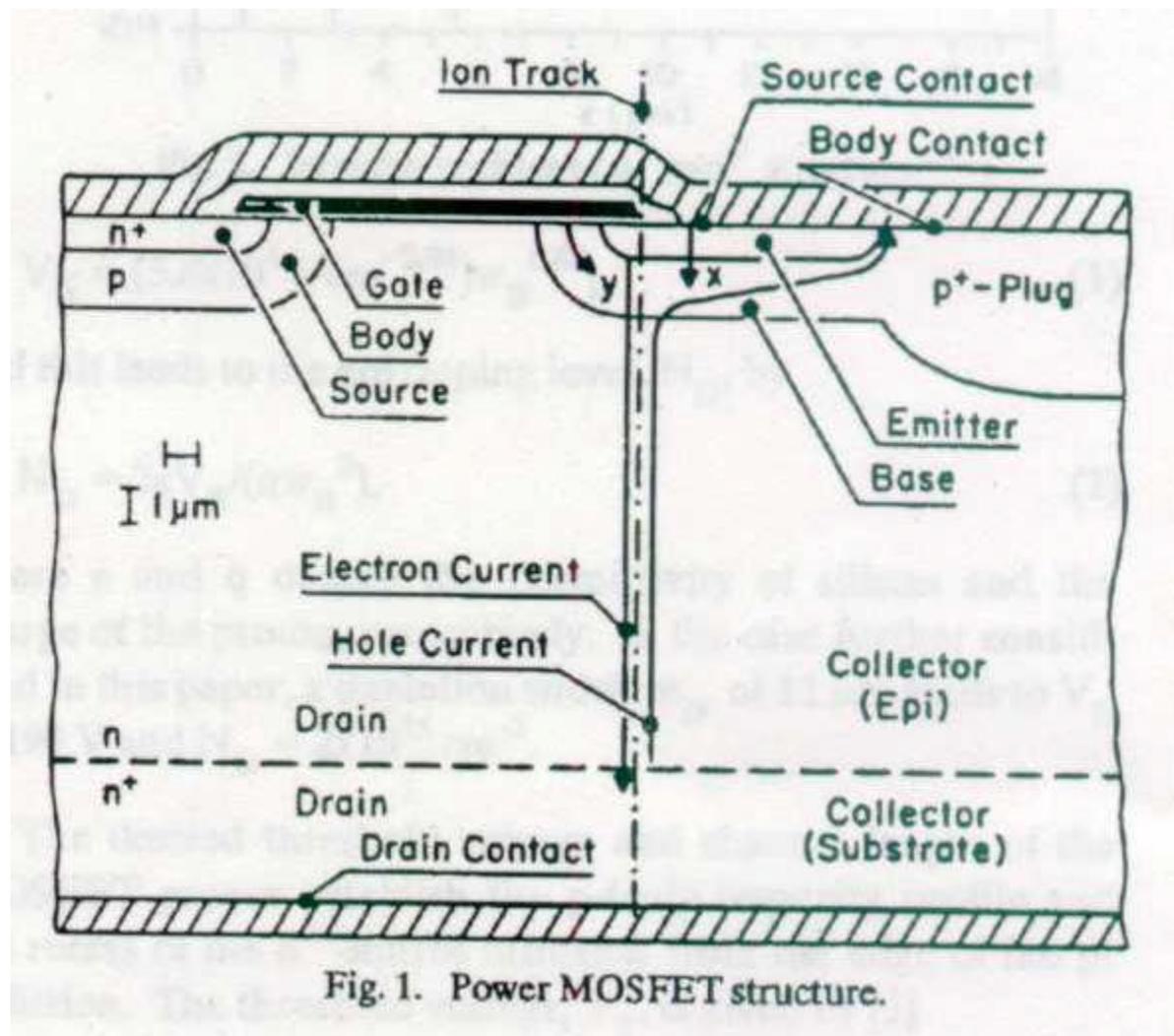


SEB in Power MOSFETs



MOSFET Structure

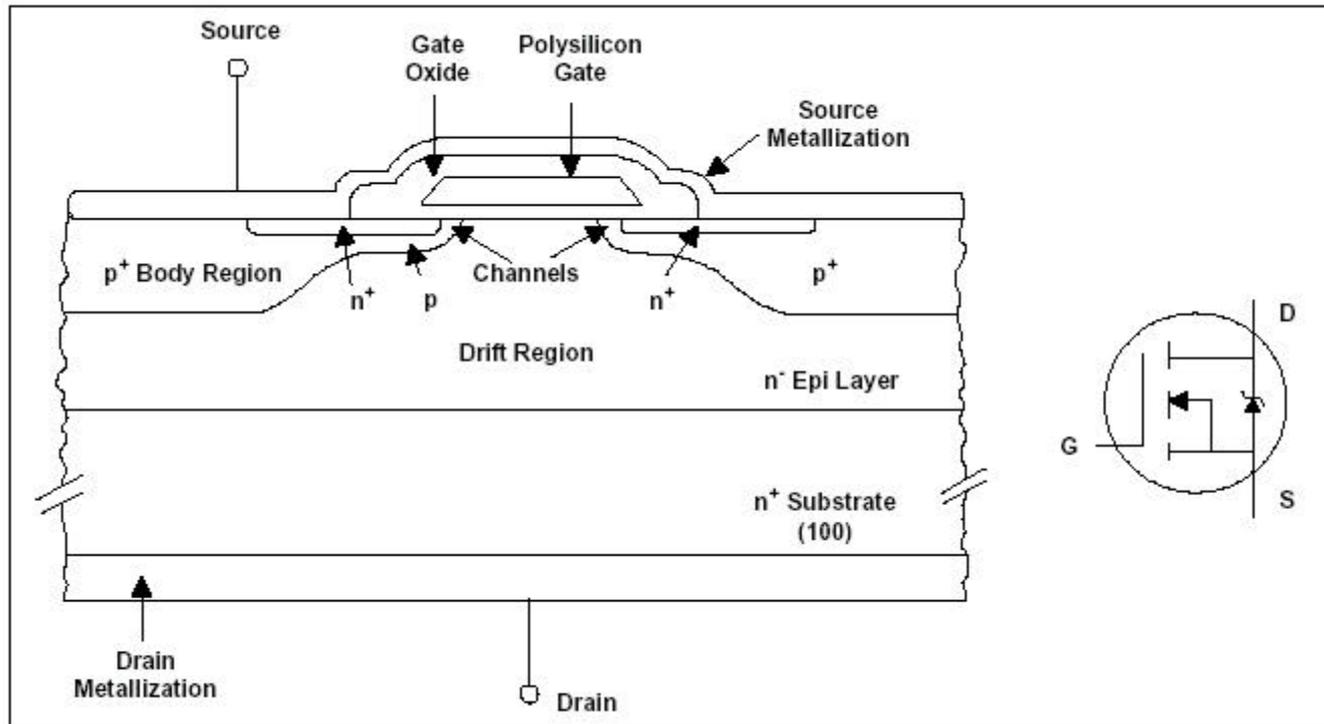
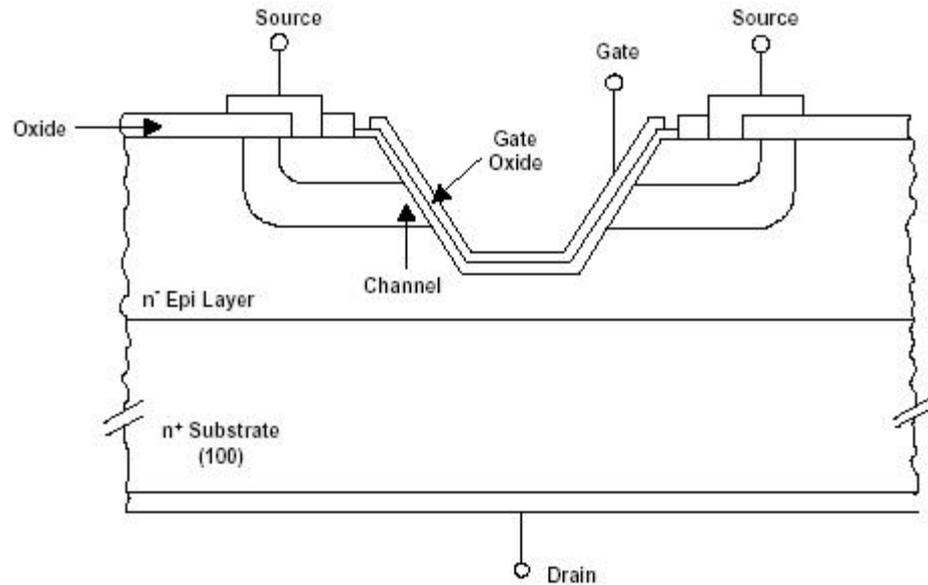


Figure 3. Schematic Diagram for an n-Channel Power MOSFET and the Device.

Truncated V-Groove MOSFET



DOPING PROFILE

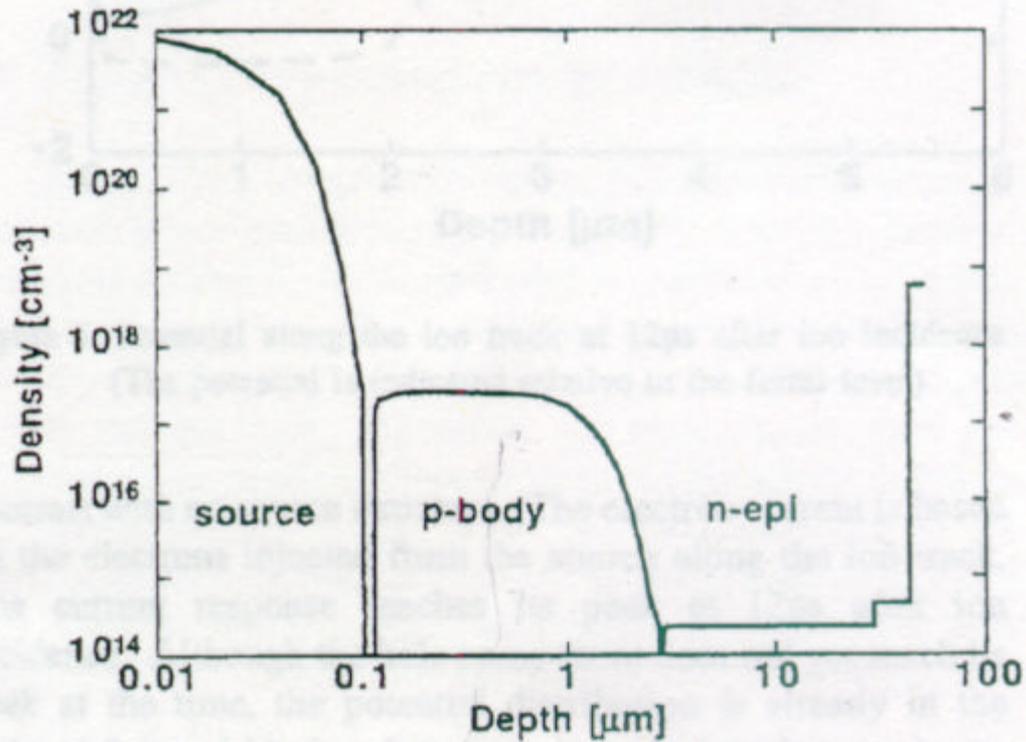


Figure 3. Doping profile for the models

Parasitic Components

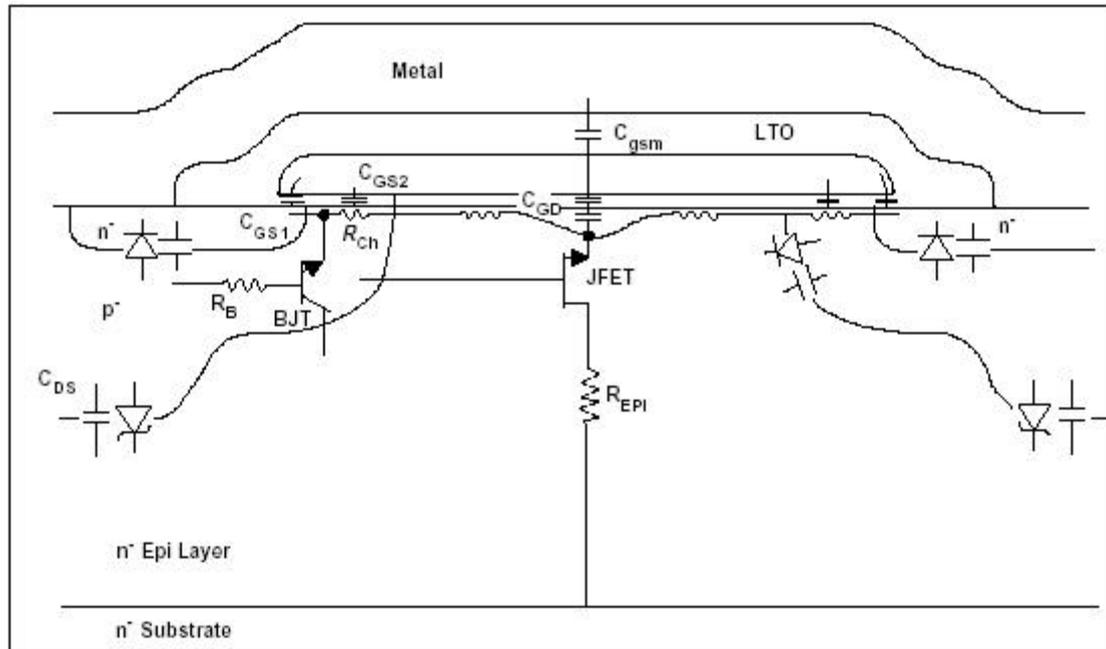
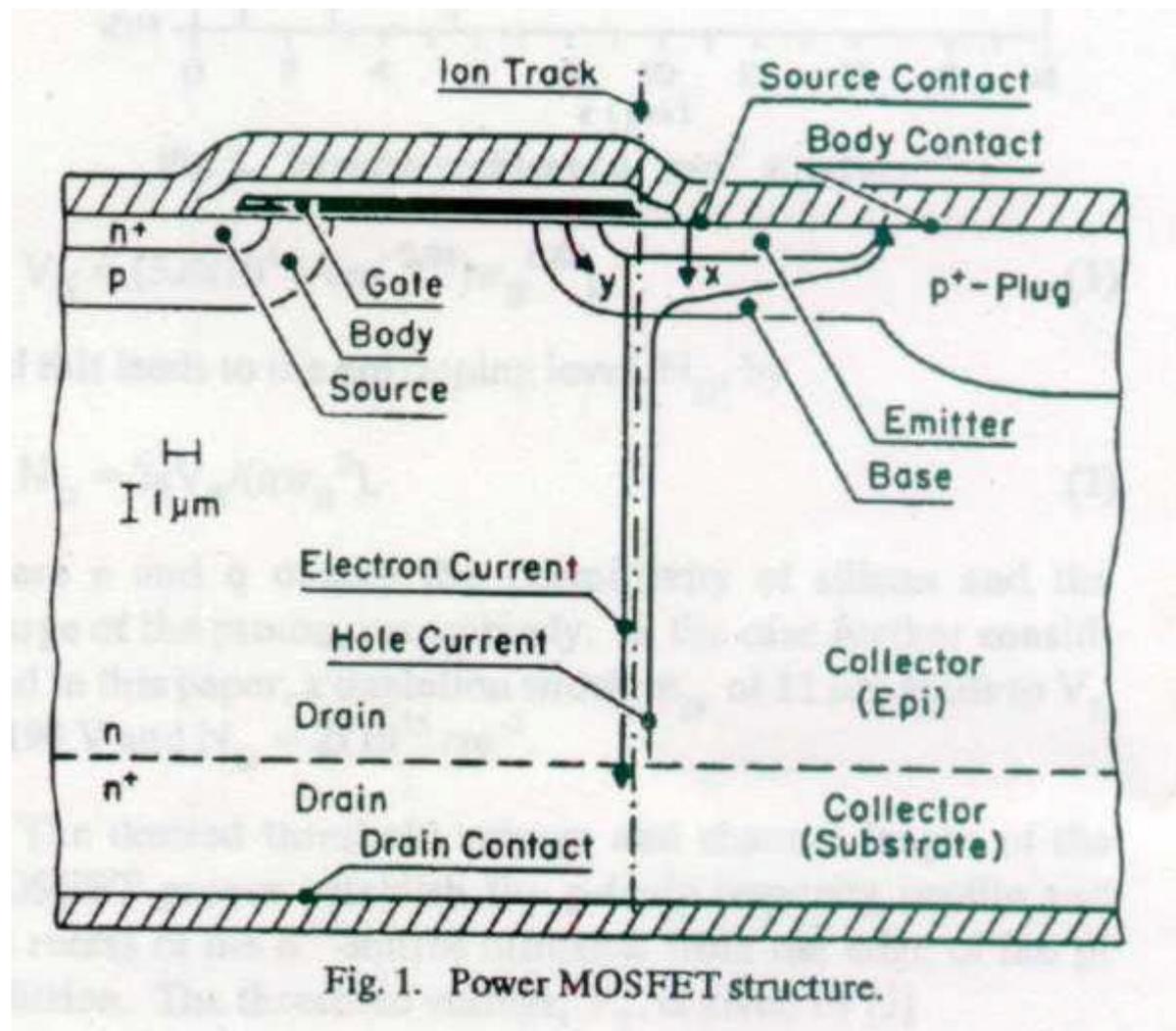
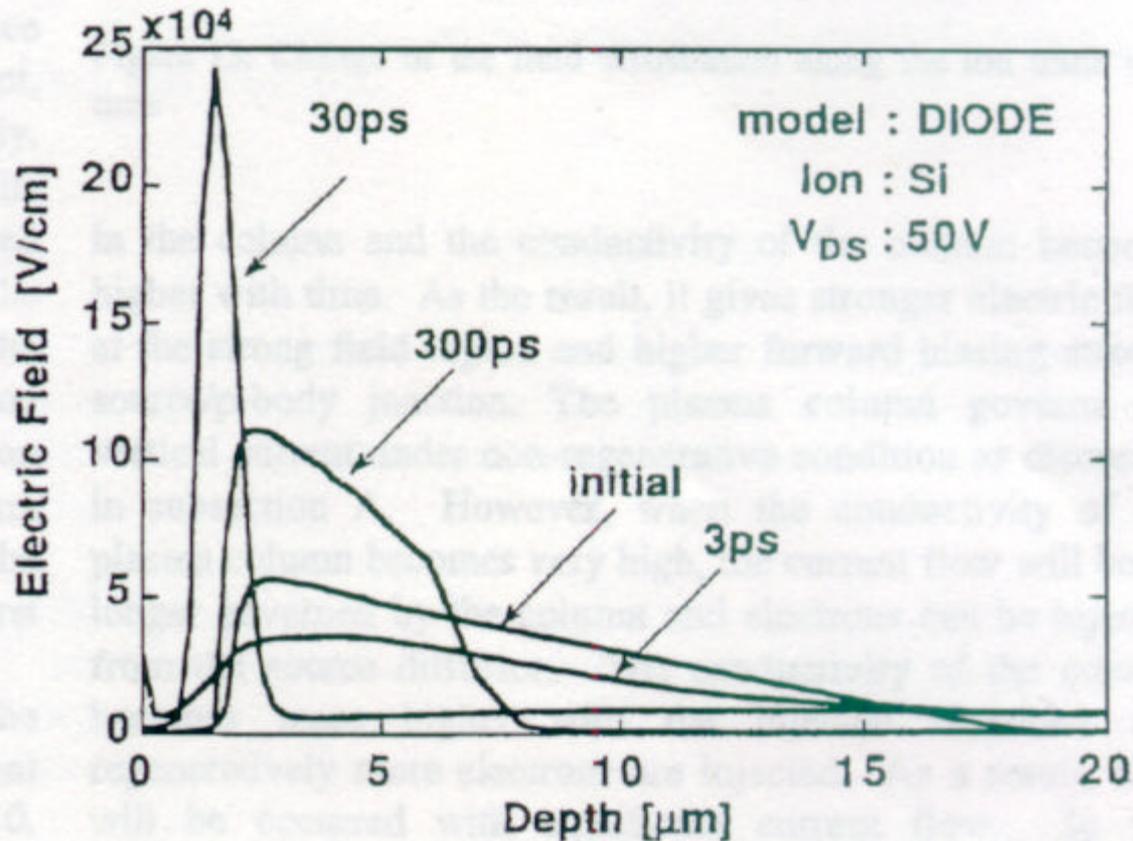


Figure 4. Power MOSFET Parasitic Components.

Charge particle hits device

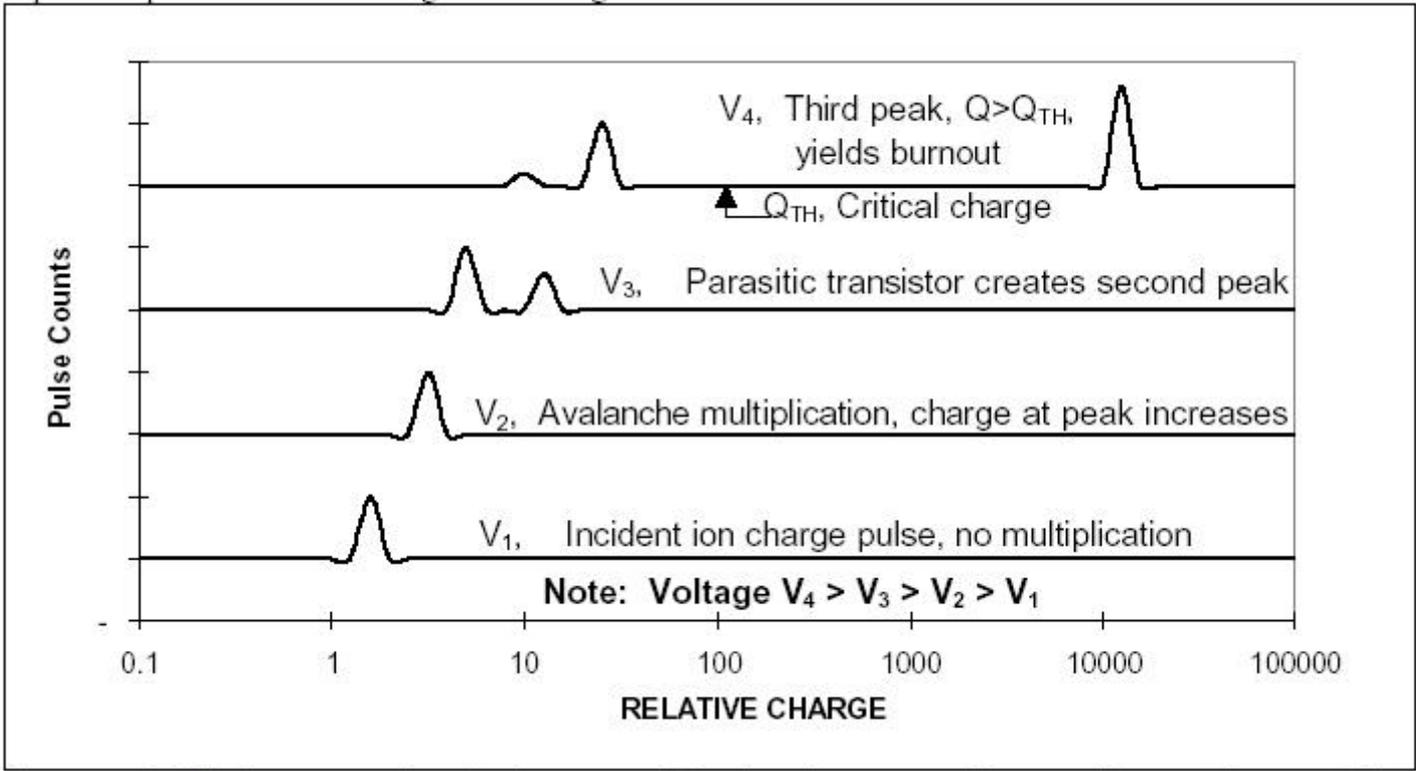


Electric Field with time



k Figure 10. Strong field region generated dynamically along the ion track

SEB MODEL



SOLUTIONS TO PROBLEM

Design the MOSFET to be SEB hard

Protect the device with a current limiting circuit

Operate the MOSFET at a voltage where it is not susceptible to SEB (de-rate)

ENVIRONMENTS OF CONCERN

- SPACE Heavy Ions, Protons
- Terrestrial – mostly neutrons from cosmic rays
- High Energy Physics – protons, neutrons, gammas, electrons, pions,

SEB at 40,000 Feet

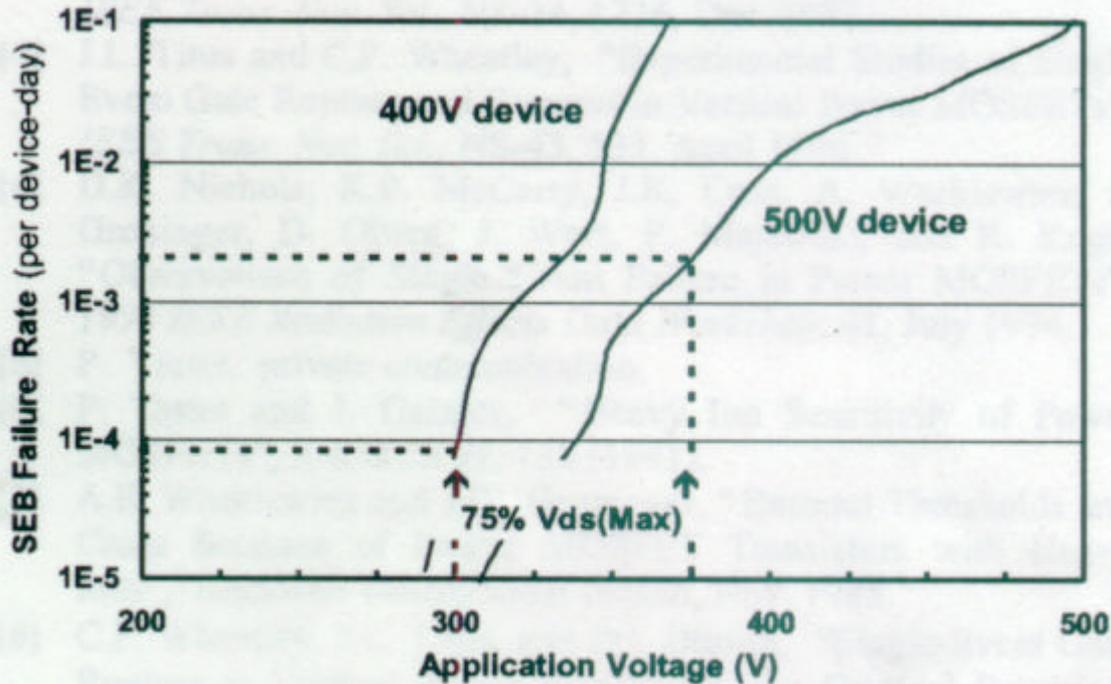
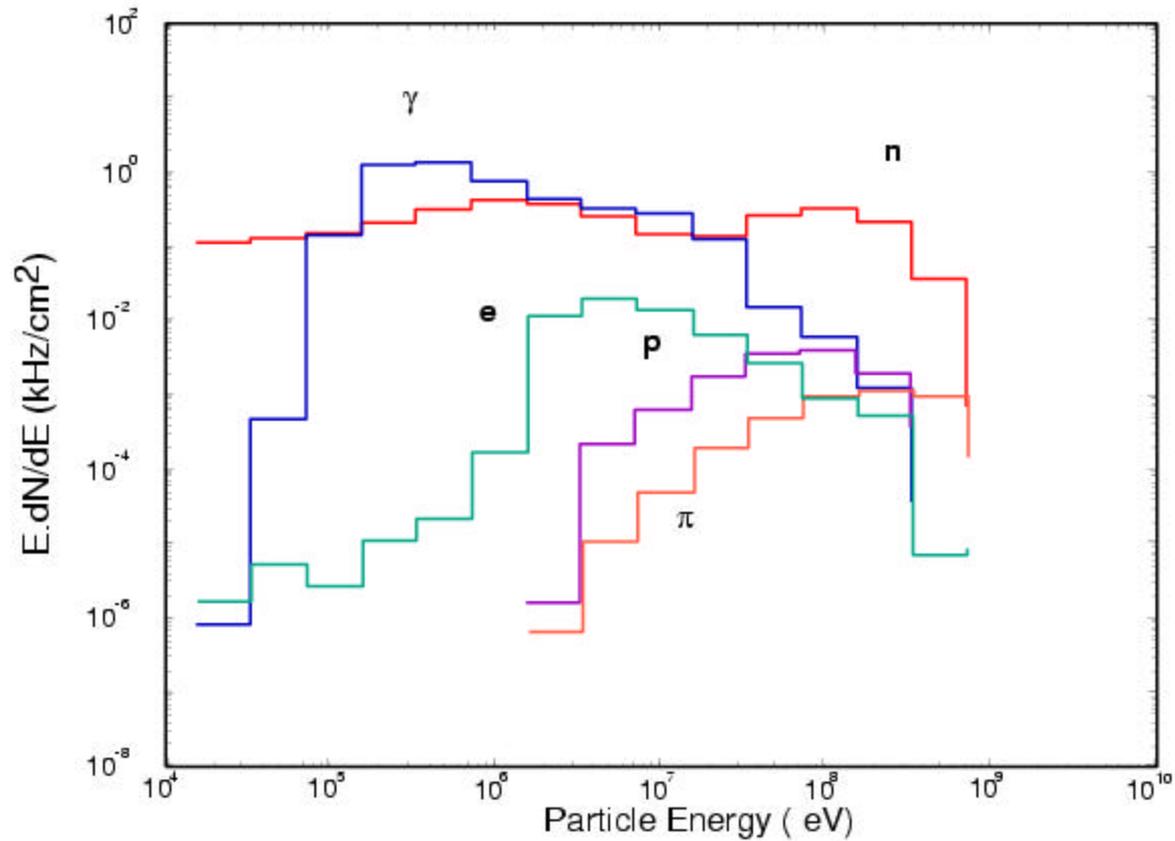


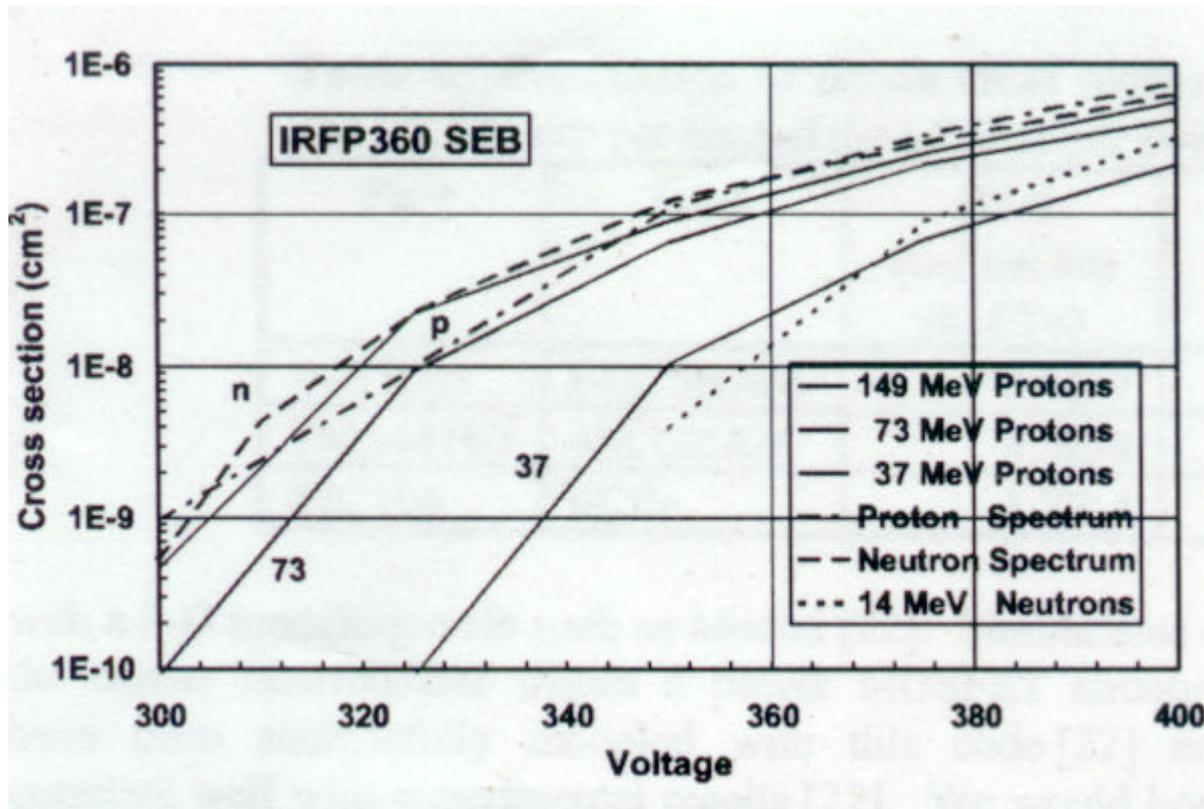
Figure 8. Expected neutron SEB rates at 40,000 feet. The data are calculated for the IR IRF360 and IRF460.

Power Supply Environment

Particle Flux in the Power Supply Region



Neutron – Proton Comparison



PROTON SILICON INTERACTION

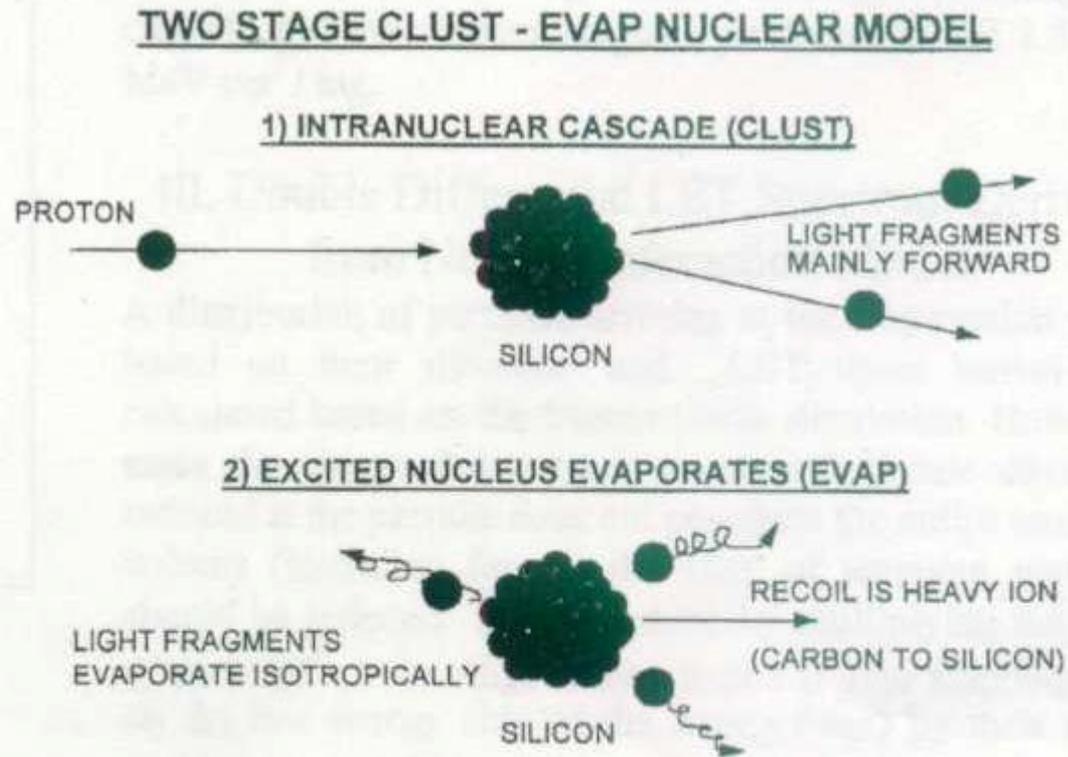
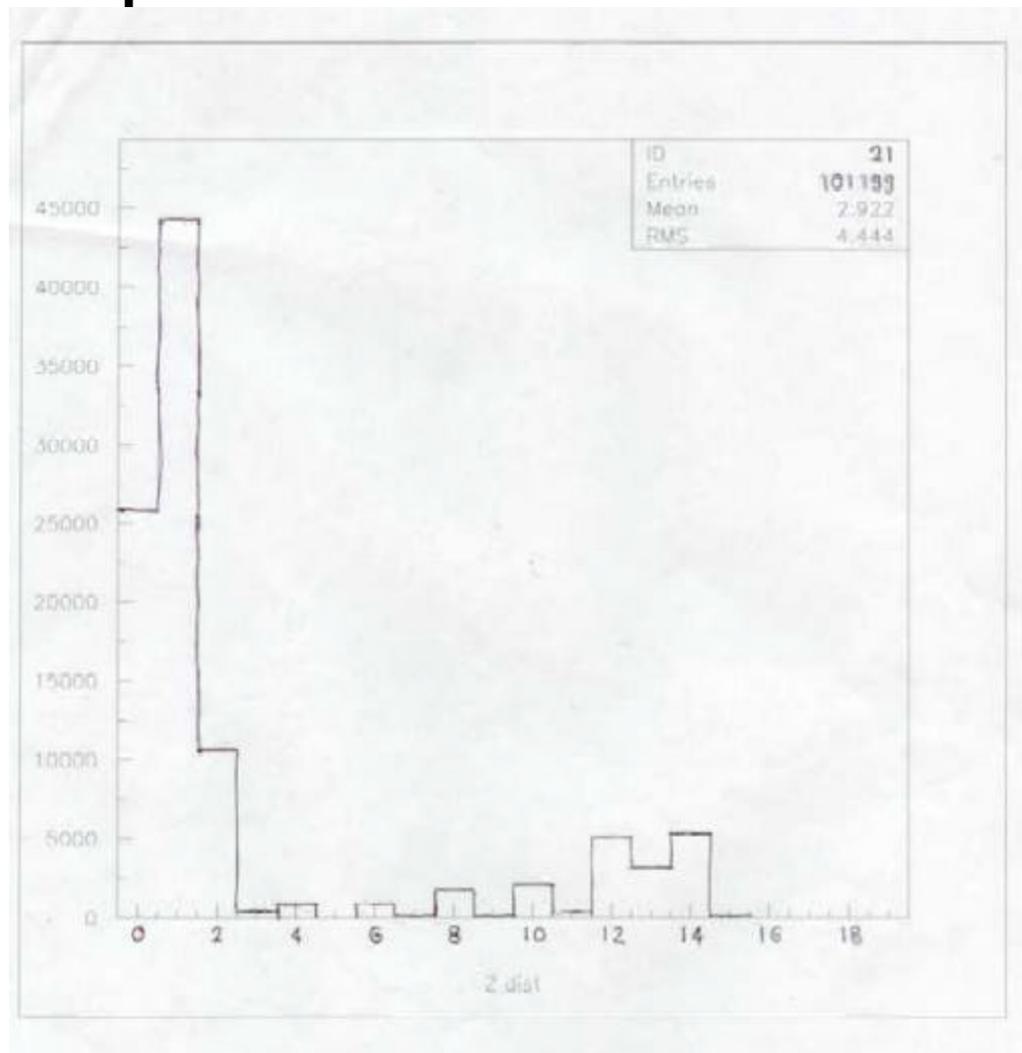
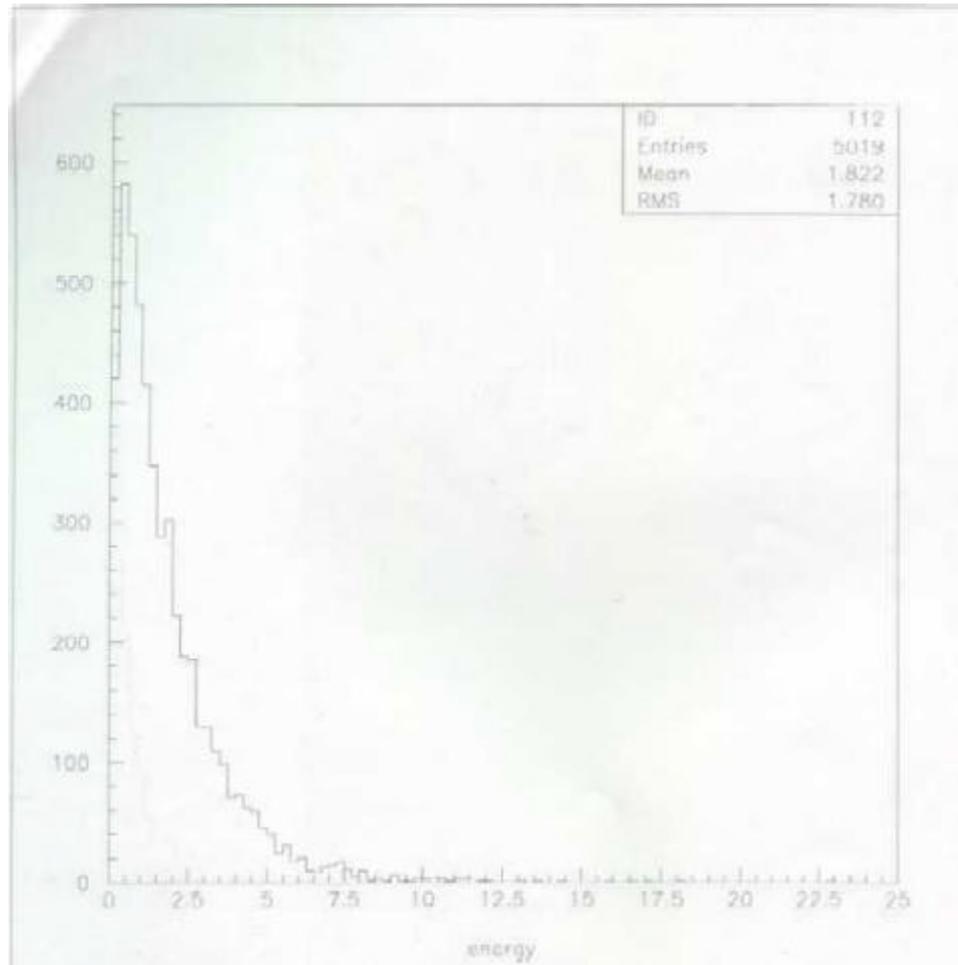


Figure 1. Two Stage Internuclear Cascade, Evaporation Model produces fragments and recoils of the inelastic proton - silicon interactions

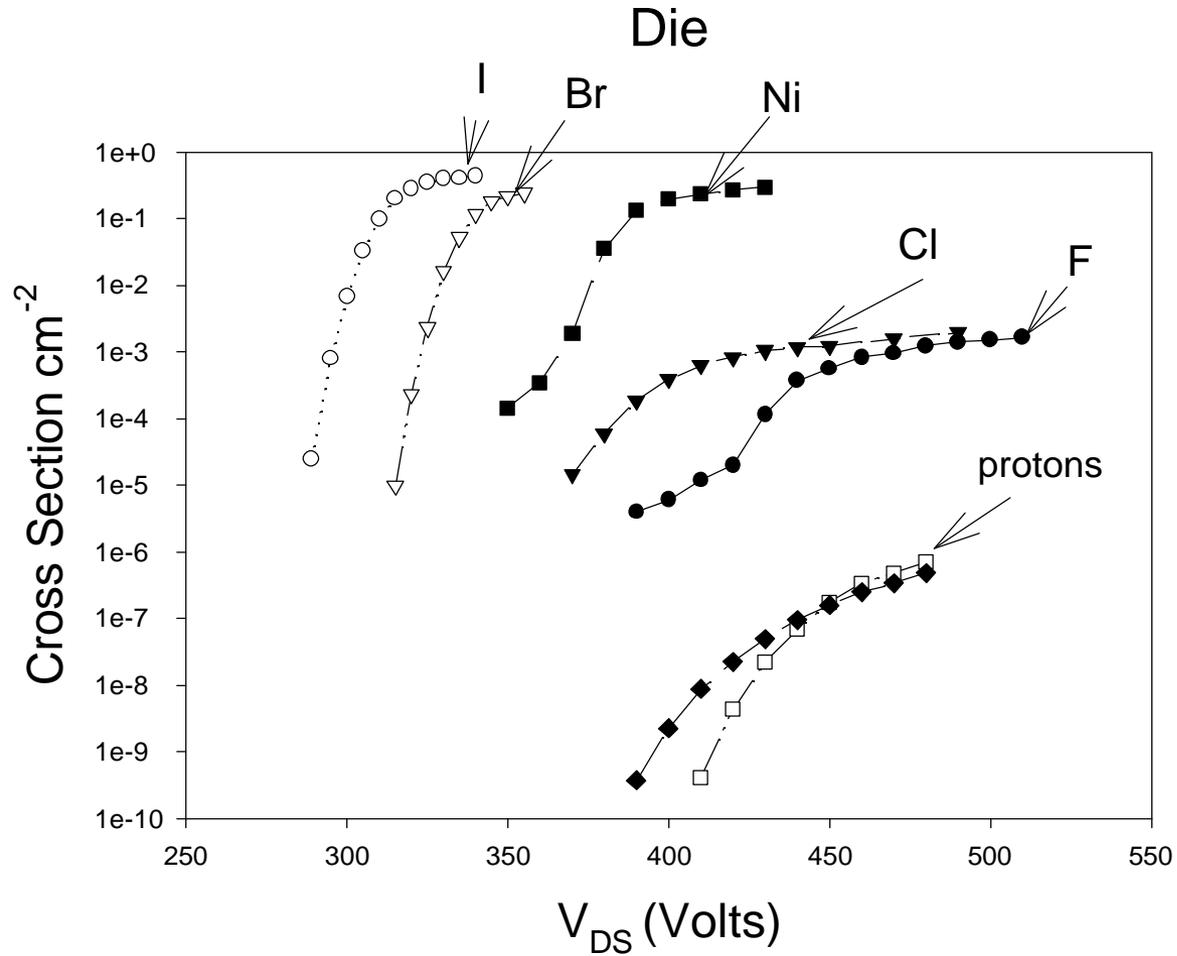
Distribution of reaction products (Z) in a proton-Si Interaction



Energy distrib. of Mg Reaction Product in Proton-Si Interaction

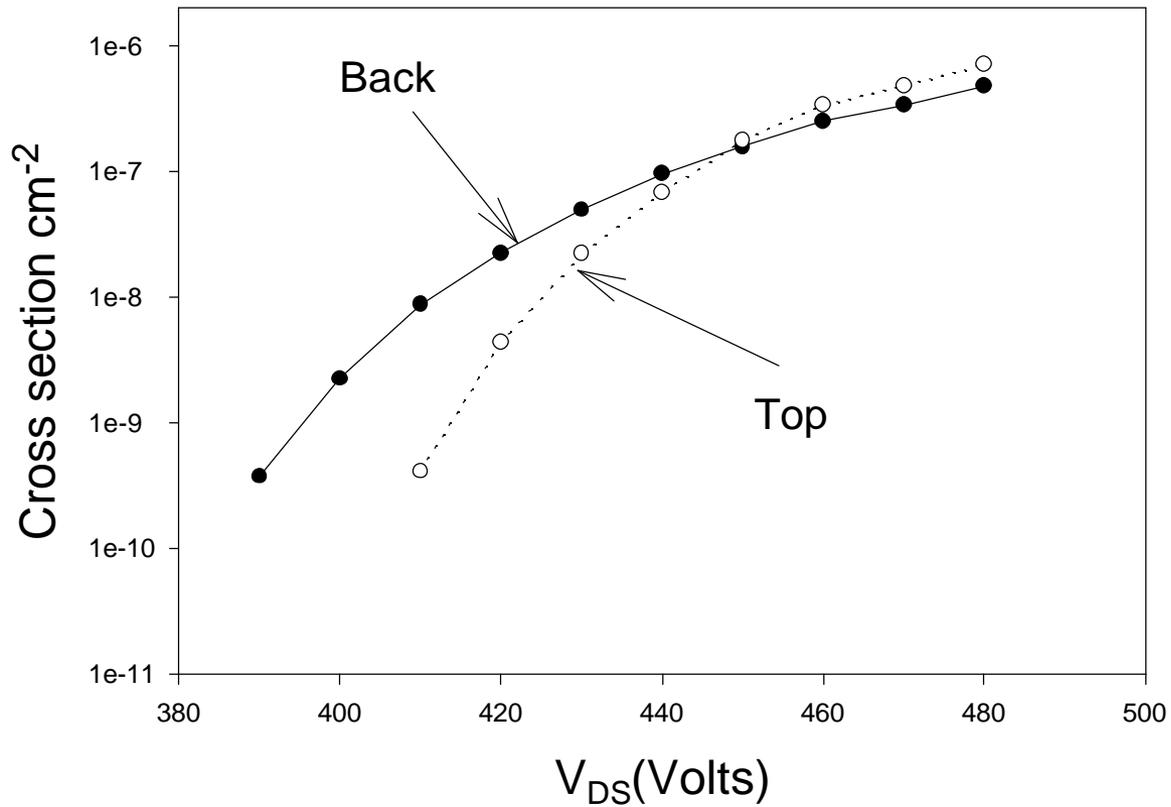


SEB FOR DIE



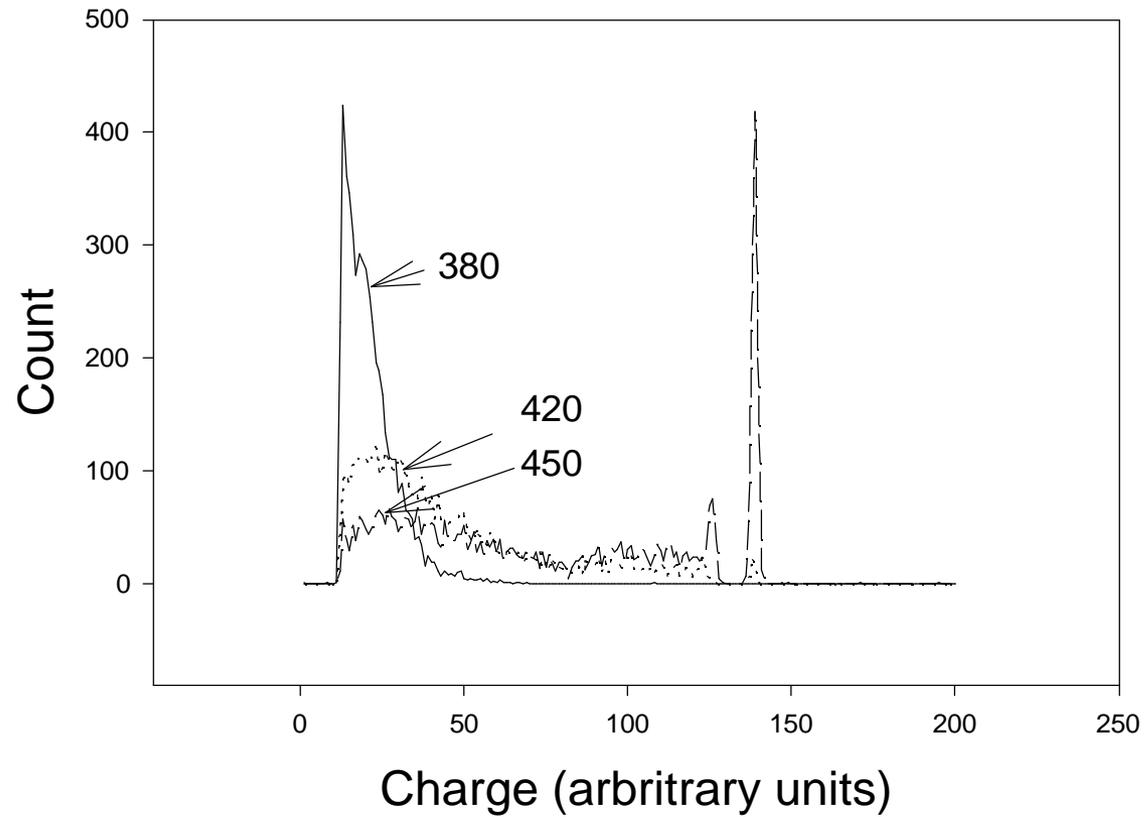
TOP-BACK COMPARISON

Die
158 MeV protons
Top and Back



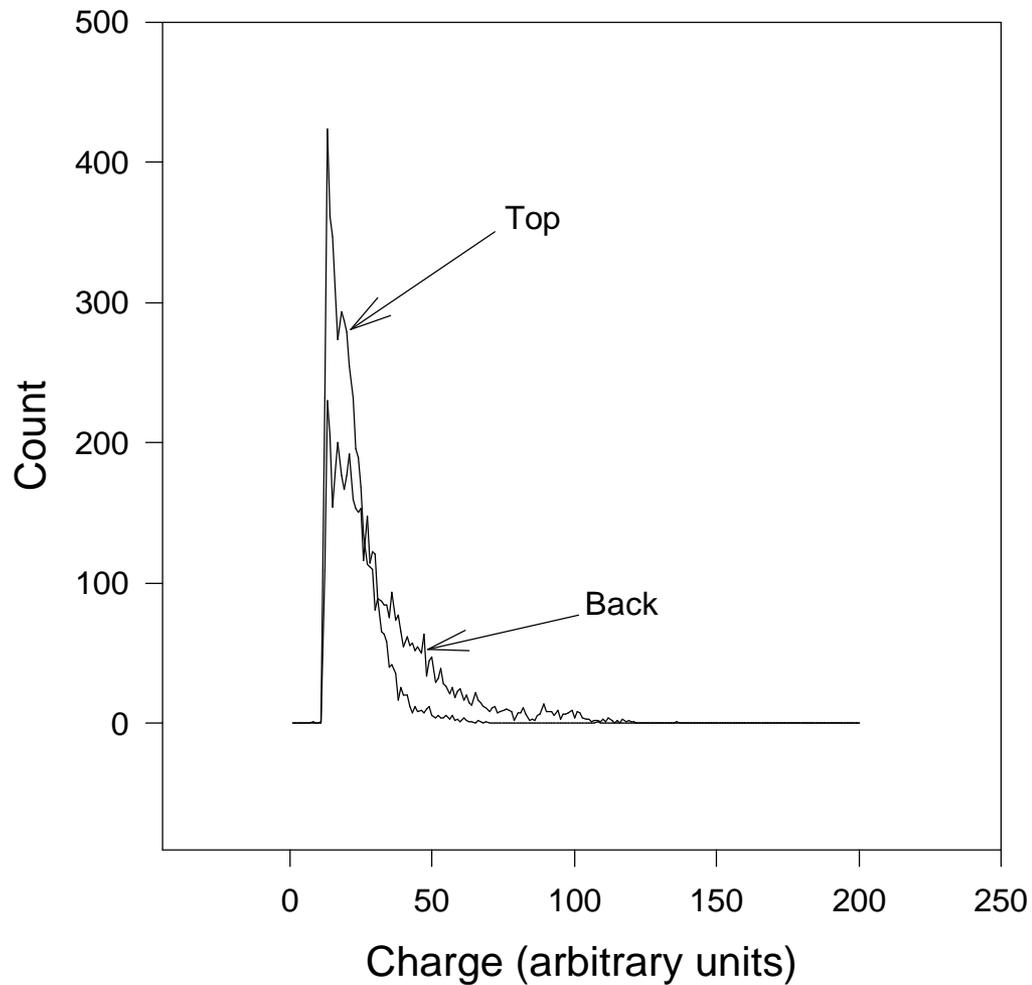
Charge Plot Top

Charge PHA Plot
158 MeV protons
Front, 380, 420, and 450 Volts



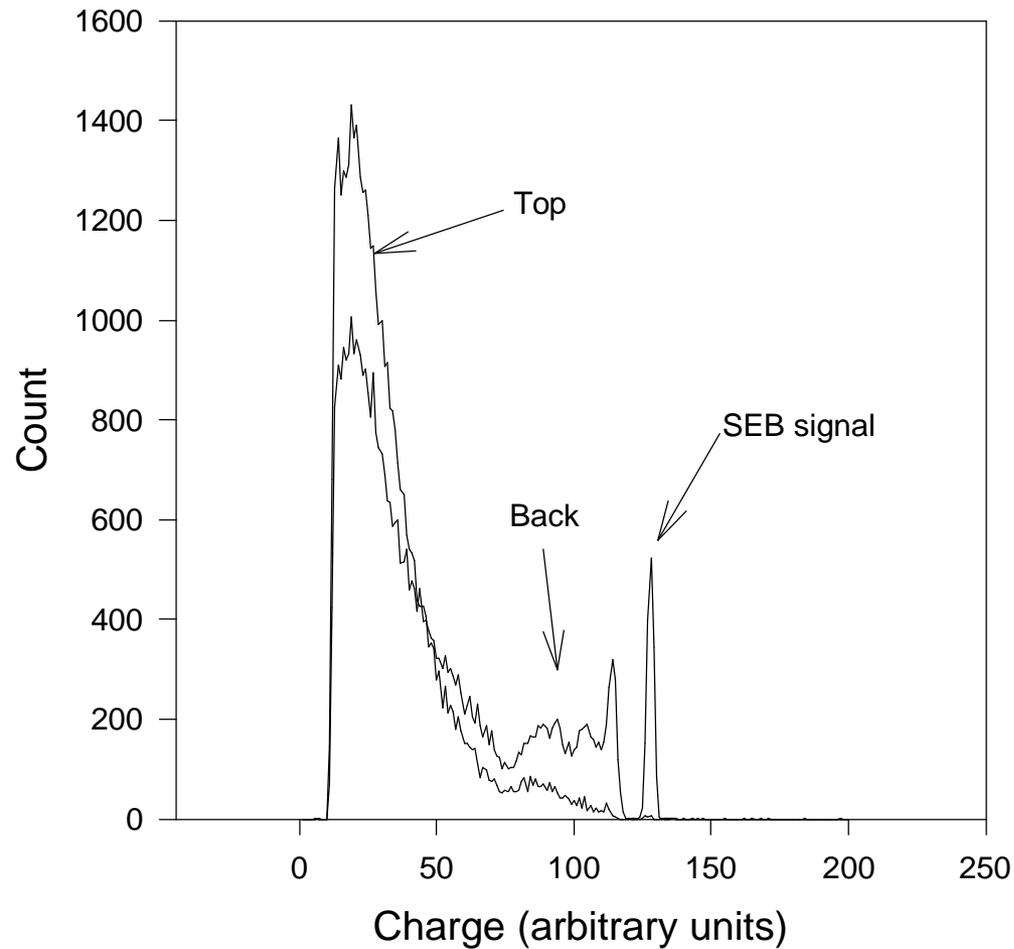
380 VOLTS

**Charge PHA plot for Die
158 MeV protons
Top and Back 380V**



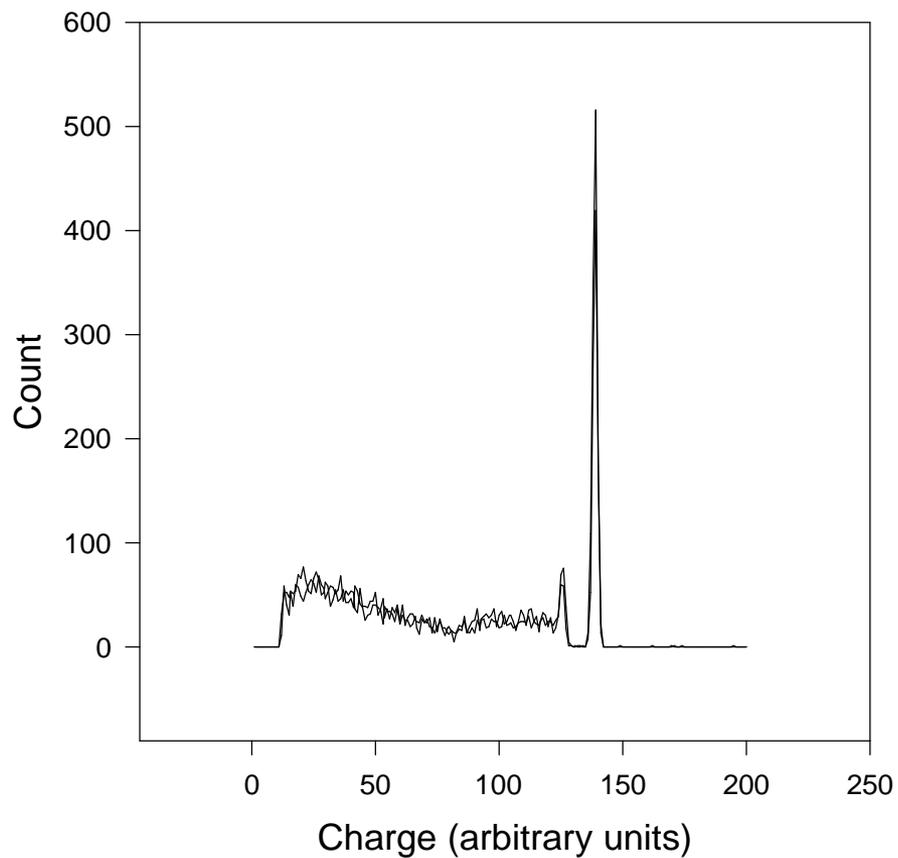
420 VOLTS

**Charge PHA plot for Die
158 MeV protons
Top and Back 420V HiRes**

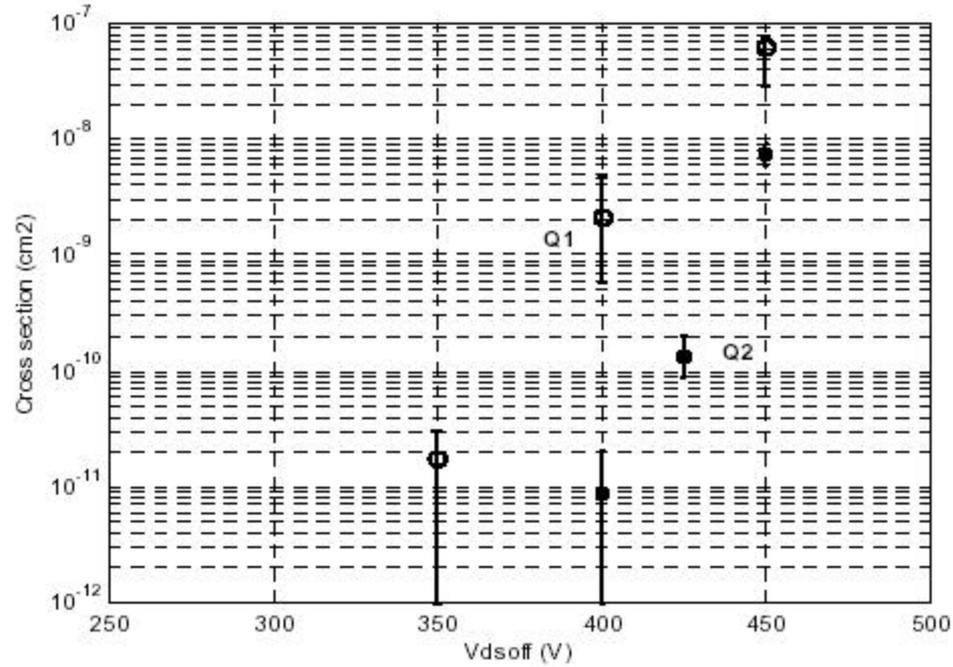


450 VOLTS

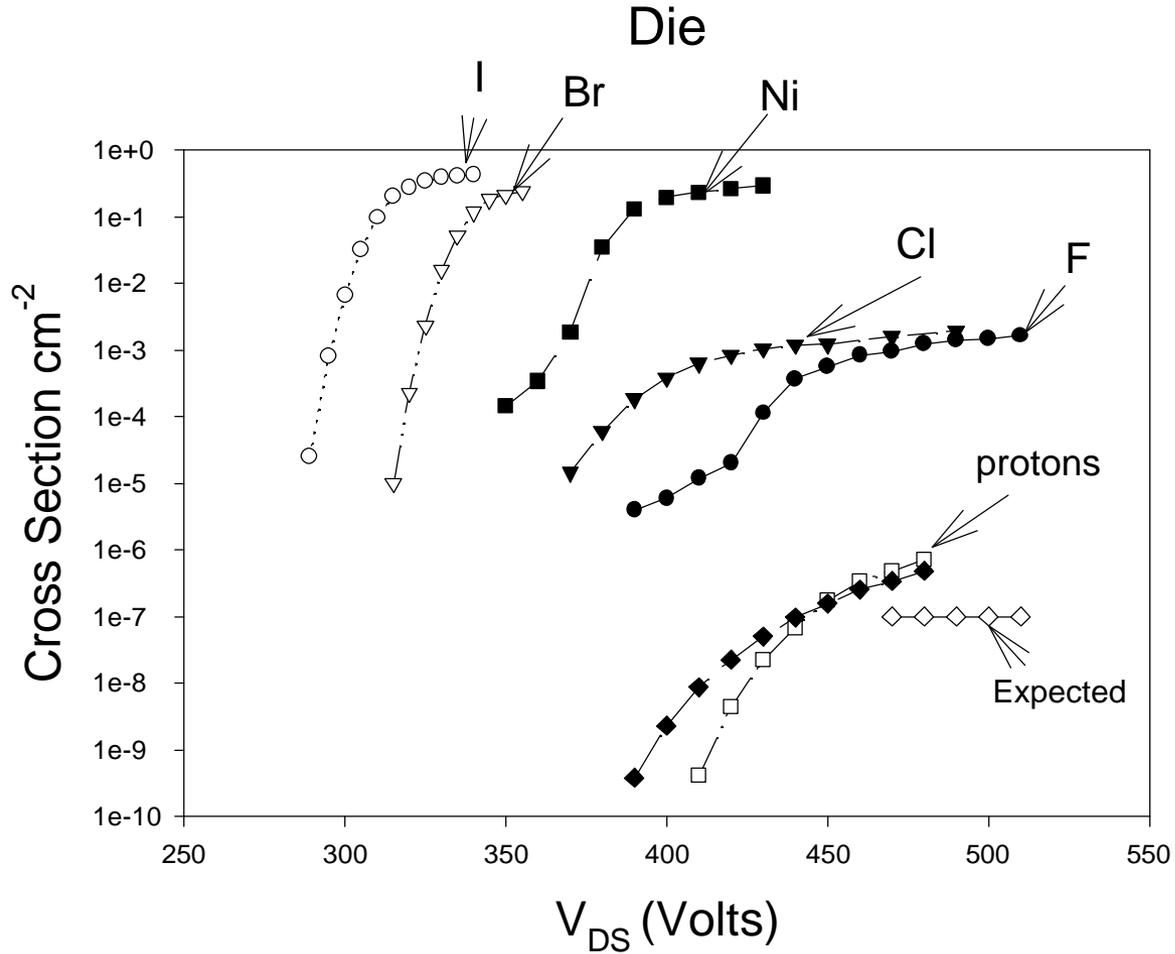
**Charge PHA plot for die
158 MeV protons
Top and Back 550 V**



CMS Measurements on Vicor



SEB in ON NTB10N60 MOSFET



Conclusions

- SEB in power MOSFETS is an issue in various environments including Space, HEP, and high altitudes
- Model for SEB is in general well understood but specifics with some particles (I.e. protons) yield unexpected results
- As voltage rating increases SEB becomes a problem even at sea level (mostly neutrons from cosmic rays)
- More research needed particularly in different Mosfet structures and PHA measurements of charge pulses as a function of voltage