The plots in this column show the absorbed dose (cGy-Si) as a function of aluminum, polyethylene, carbon and titanium shielding that compare the Band fit with the Exponential fit for the 4 SPEs: July 2000, November 2001, November 1997, and October 2003.

The plots in this column show proton star density as a function of aluminum, polyethylene, carbon and titanium shielding that compare the ratio of the Band fit to the Exponential fit for the 4 SPEs: July 2000, November 2001, November 1997, and October 2003.

SUMMARY AND CONCLUSIONS

- The FLUKA radiation transport code has been successfully used to determine changes in the TID environment and the SEE behind aluminum, polyethylene, carbon, and titanium shielding masses when the assumed form (Band or Exponential) of the SPE kinetic energy spectra is changed. For all particle energies, it is shown that shielding mass combinations, the following are found to be true: The differences in the TID environment and the SEE between the two SPE spectral forms are most pronounced when the shielding mass is greater than 10 g/cm² or less than 1 g/cm².

- Band and Exponential spectra produce nearly identical results between 10 and 100 g/cm². Direct comparison of SPE spectra forms reveals that the Band form has higher particle fluence than the Exponential form at both low and high kinetic energies, while the two forms are nearly identical at intermediate kinetic energies. It is likely that TID and SEE are dominated by low-energy protons at low (<1 g/cm²) shielding mass values and high kinetic energy protons at high (>10 g/cm²) shielding mass values while intermediate mass protons dominate between 1 and 10 g/cm². Similar results were obtained using the HZETRN deterministic transport code in a simple two-dimensional slab geometry, as shown in the Appendix.

- The usual atomic number dependence of shielding mass effectiveness was observed. For example, using the Band July 2000 event spectrum, the shielding mass, measured by the thermal sphere radius, needed to reduce the event ionizing dose to 1 cGy or less in the concentric sphere configuration is 30 g/cm² polyethylene, 37 g/cm² carbon, 40 g/cm² aluminum, and 43 g/cm² titanium.

- Using the Exponential July 2000 event spectrum, the shielding mass needed to reduce the event ionizing dose to 1 cGy or less is 22 g/cm² polyethylene, 25 g/cm² carbon, 29 g/cm² aluminum, and 32 g/cm² titanium.

- For particle kinetic energies >50 MeV, proton star density displayed a very different depth distribution than did neutron and pion star density. Proton star density decreased rapidly with increasing shielding mass and was often overtaken by neutron star density between 10 and 100 g/cm². Pion and neutron star density was nearly constant as shielding mass increased, typically exhibiting a shallow maximum near 10 g/cm².

- In nearly all cases, the Exponential spectral form produced no pion stars at all – a result expected from the energetic threshold for pion production and the very small number of primary protons above that kinetic energy in the Exponential spectra. The Band and Exponential spectral forms produced comparable secondary neutron yields and plots of star density vs. shielding mass.

- Calculation of the >50 MeV proton event fluence at various shielding using the corresponding proton star density and the proton inelastic interaction length allowed estimation of SPE SEU counts for three spacecraft that are in reasonable agreement with the observed in-flight SPE SEU counts, thus at least partially confirming the validity of the FLUKA-based modeling process.