

**Simple Comparisons of Stochastic
Tools to OLTARIS for Space
Radiation Models and Continuation
into a Benchmark Set**

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MCNEG 08
March 3-4, 2008

Outline

- Space Radiation Introduction
- OLTARIS Tool Introduction
- Monte Carlo Tools of Interest to NASA
- Results/Comparisons
 - Free Space Webber Spectrum SPE
 - Free Space 1977 Solar Minimum GCR
- Discussion About Results
- Benchmark Set
- Future Work

Space Radiation Introduction

- Solar Proton Event (SPE)
 - Many defined
 - *Benchmark*: Webber Spectrum
- Galactic Cosmic Rays (GCR)
 - *Benchmark*: 1977 solar min spectrum
 - Nothing special about this spectrum
 - Old Badwar-O'Neil model (have new model)
 - Ground neutron data determines modulation
 - Sunspot data determines cycle
 - 28 isotopes in source

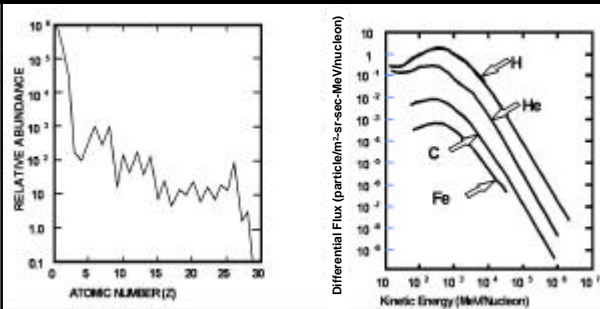
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Space Radiation Introduction

GCR Spectrum



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Space Radiation Introduction

- Space Radiation Engineering
 - Ability to analyze any space vehicle or habitat from inception to operations
 - Response functions that reflect the needs and requirements of the users
 - Boundary conditions that fit the missions
 - Analyses that fit the mission phase
 - Fidelity
 - Productivity
 - Uncertainty
 - Appropriate methods for each mission phase to perform the analysis needed

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OLTARIS Tool Introduction

- Web based interface to HZETRN/NUCFRG2
 - Deterministic transport
 - Simple parameter inputs
 - Ray-traced based vehicle models
 - Human phantoms
 - ITAR controlled
- Currently directed toward Orion work
- Generalization occurring
 - Slab capability
 - New response functions
 - Better boundary conditions
 - More particles and better neutron methods

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OLTARIS Tool Introduction

- HZETRN/NUCFRG2 advantages
 - Straight ahead approximation
 - Continuous slowing down approximation
 - Energy perturbation marching method
 - Abrasion/ablation models with quantum corrections
 - Tripathi's absorption cross section model
 - Flexible, fast, and accurate

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Monte Carlo Tools of Interest

- Ordered by our experience and access
- MCNPX/LAQGSM/CEM/FLUKA-physics
- PHITS/JQMD
- FLUKA/RQMD/DPMJET
- HETC-HEDS/NUCFRG2
- MARS/LAQGSM
- MULASSIS/GRAS/GEANT4

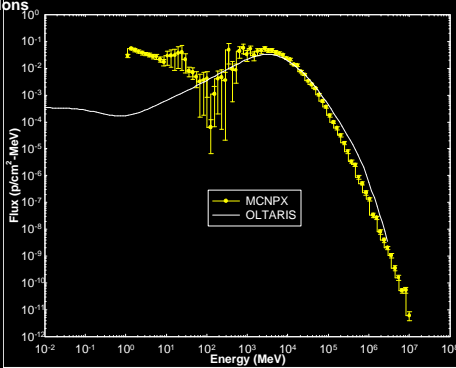
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Results / Comparisons - GCR

Al-H₂O slab Heavy Ions
20 g/cm² Al
30 g/cm² H₂O
MCNPX had pions
and photons on



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Discussion About Results

- Initial problems
 - What tally to use: F1, F2, F4???
 - Units conversion!!!!!!!!!!!!
 - HZETRN: p/cm²-(MeV/nucleon)-time
 - MCNPX for a multiparticle source
 - F1: p/(MeV)-sr-time-source?
 - F2/4: p/cm²-(MeV)-time-source?
 - Source biasing
 - Consistent particle and cross section models
- Conversion from flux to dose and dose equivalent by particle and totals
 - Over 2000 isotopes in output
 - Not done

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Benchmark Set

- Progressively more complex space radiation models
 - Beam on single material slabs
 - Multi-material slabs with SPE and GCR
 - Human phantoms in spherical multi-material shells with SPE and GCR
 - Human phantoms embedded in a complex CAD based vehicle model with SPE and GCR
- OLTARIS results for each model possible
- Human phantoms: CAM/CAF, MAX/FAX, GOLEM/LAURA, etc...

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Future Work

- Better understanding of the Monte Carlo tools available
- Ability to utilize other deterministic tools like ATTILA in space radiation problems
- Uncertainty and fidelity narrowed or at least identified with each tool
- Productivity identified with each tool and each space radiation problem
- Addition of new tools to cover gaps in existing and future missions

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