A DOSE OF REALITY: RADIATION ANALYSIS FOR REALISTIC HUMAN SPACECRAFT

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INTRODUCTION

As with most computational analyses, a tradeoff exists between problem complexity, resource availability and response accuracy when modeling radiation transport from the source to a detector. The largest amount of analyst time for setting up an analysis is often spent ensuring that any simplifications made have minimal impact on the results. The vehicle shield geometry of interest is typically simplified from the original CAD design in order to reduce computation time, but this simplification requires the analyst to "re-draw" the geometry with a limited set of volumes in order to accommodate a specific radiation transport software package. The resulting low-fidelity geometry model cannot be shared with or compared to other radiation transport software packages, and the process can be error prone with increased model complexity. The work presented here demonstrates the use of the DAGMC (Direct Accelerated Geometry for Monte Carlo) Toolkit from the University of Wisconsin, to model the impacts of several space radiation sources on a CAD drawing of the US Lab module.

METHODS

The DAGMC toolkit workflow begins with the export of an existing CAD geometry from the native CAD to the ACIS format. The ACIS format file is then cleaned using SpaceClaim to remove small holes and component overlaps. Metadata is then assigned to the cleaned geometry file using CUBIT/Trelis from csimsoft™. The DAGMC plugin script removes duplicate shared surfaces, facets the geometry to a specified tolerance, and ensures that the faceted geometry is water tight. This step also writes the material and scoring information to a standard input file format that the analyst can alter as desired prior to running the radiation transport program. The scoring results can be transformed, via python script, into a 3D format that is viewable in a standard graphics program.

RESULTS

The CAD model of the US Lab module of the International Space Station, inclusive of all the racks and components, was simplified to remove holes and volume overlaps. Problematic features within the drawing were also removed or repaired to prevent runtime issues. The cleaned drawing was then run through the DAGMC workflow to prepare for analysis. Pilot tests modeling transport of 1GeV proton and 800MeV/A oxygen sources show that reasonable results are converged upon in an acceptable amount of overall computation time from drawing preparation to data analysis. The FLUKA radiation transport code will next be used to model both a GCR and a trapped radiation source. These results will then be compared with measurements that have been made by the radiation instrumentation deployed inside the US Lab module.

DISCUSSION

Early analyses have indicated that the DAGMC workflow is a promising toolkit for running vehicle geometries of interest to NASA through multiple radiation transport codes. In addition, recent work has shown that a realistic human phantom, provided via a subcontract with the University of Florida, can be placed inside any vehicle geometry for a combinatorial analysis. This added functionality gives the user the ability to score various parameters at the organ level, and the results can then be used as input for cancer risk models.