Validation of an MCNP5 to Mercury Input Translator

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A means for translating MCNP5 input files into a form that can be run by Mercury, a modern Monte Carlo particle transport code, will allow MCNP5 users to more easily take advantage of the high-performance computing benefits offered by Mercury. Any such translator must undergo a thorough validation process to ensure the accuracy of the translation. Presented below are various methods for, and the results of, the validation of a geometry translation using an MCNP5 to Mercury input translator.

Introduction:

- MCNP is a well-established Monte Carlo particle transport code with a wide range of applications
- Mercury is a modern Monte Carlo particle transport code suited for massively parallel architectures
- An MCNP5 to Mercury input translator was written, offering MCNP5 users an opportunity to experiment with Mercury
- The goal of this project was to validate the correctness of a representative geometry translation (Fig. 1, Below)

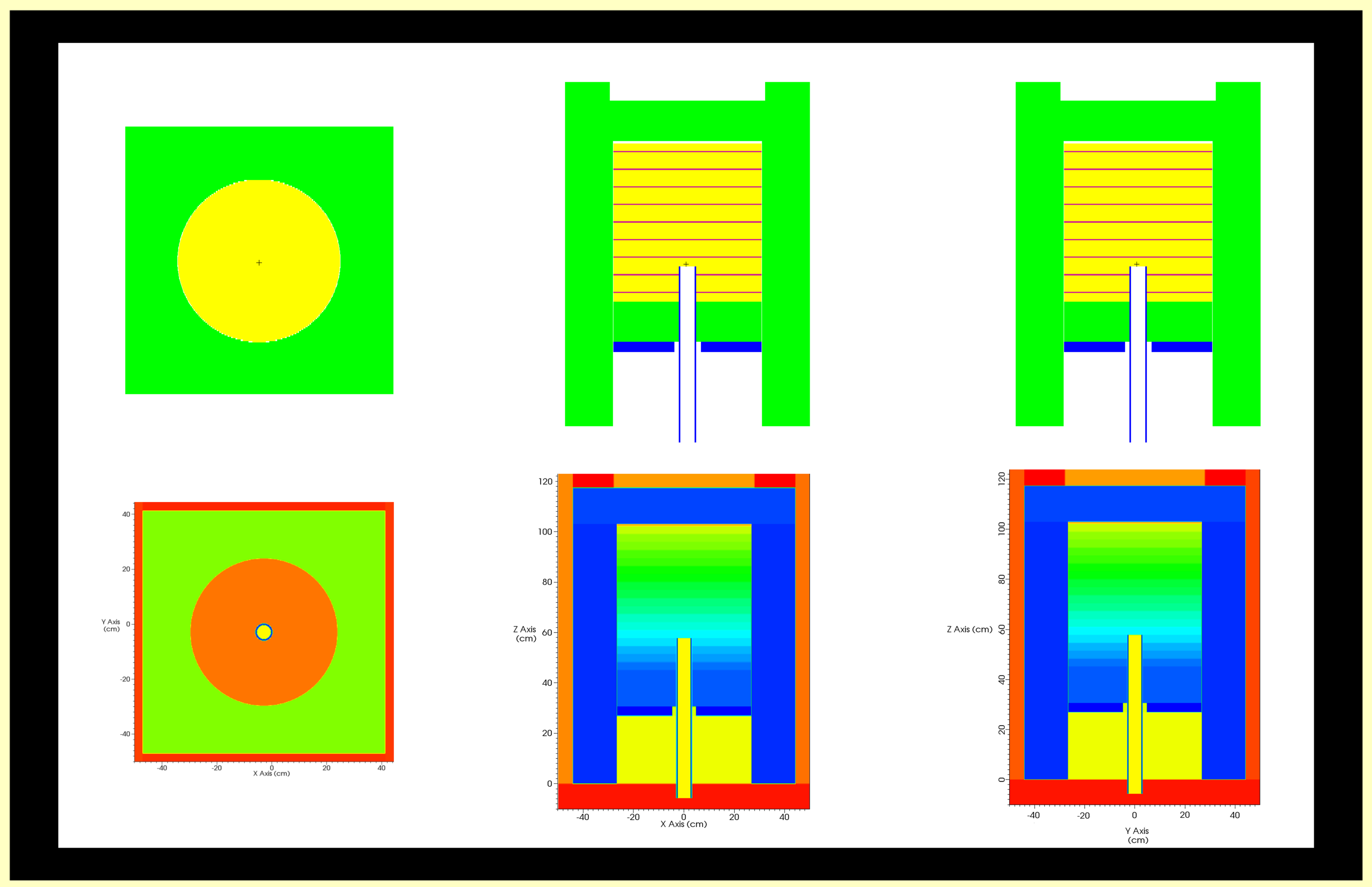

Fig. 1: From left to right, XY-plane, XZ-plane, and YZ-plane slices of geometry from the zeus2 criticality problem using MCNP5 with its plotter (top) and Mercury with VisIt (bottom)

Methods:

Three tests were devised for assessing the translation's correctness:

- Visualization – Visual comparison of geometries using MCNP's plotter and the VisIt visualization tool
- Volume – Cell by cell comparison of MCNP volumes with calculated Mercury volumes
- Track Length – Comparison of mean cell track lengths with void cells to remove physical dependencies

Results:

In general, results of all three validation tests indicate that the translator correctly translated the MCNP5 geometry to Mercury

Visual inspection of corresponding planar slices (Fig. 1, Left) reveals no discernable differences between the original MCNP5 geometry and the translated Mercury geometry

Initial cell volume calculations in Mercury show some variation when compared with cell volume calculations in MCNP5 (Fig. 2, Right)

Cell volumes calculated in MCNP5 and Mercury have an average relative error of 17.5%

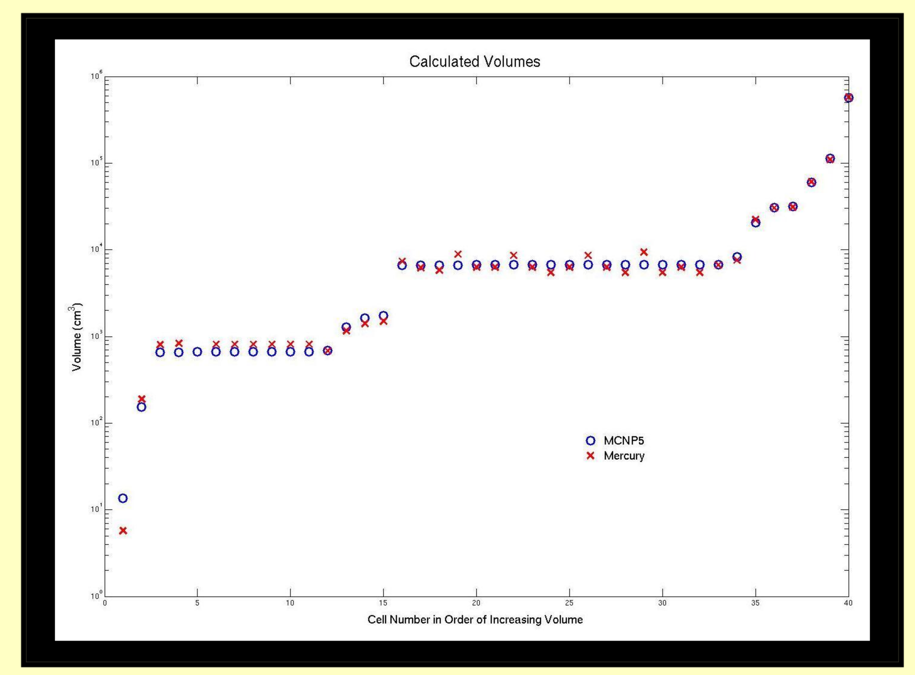

Fig. 2: Calculated cell volumes for corresponding MCNP5 and Mercury cells

Cell by cell comparison of the mean particle track lengths calculated by each code offers the strongest evidence of a correct translation

Mean particle track length calculations for corresponding cells (Fig. 3, Right) agree with a maximum relative error of .3% and a mean relative error of .06%

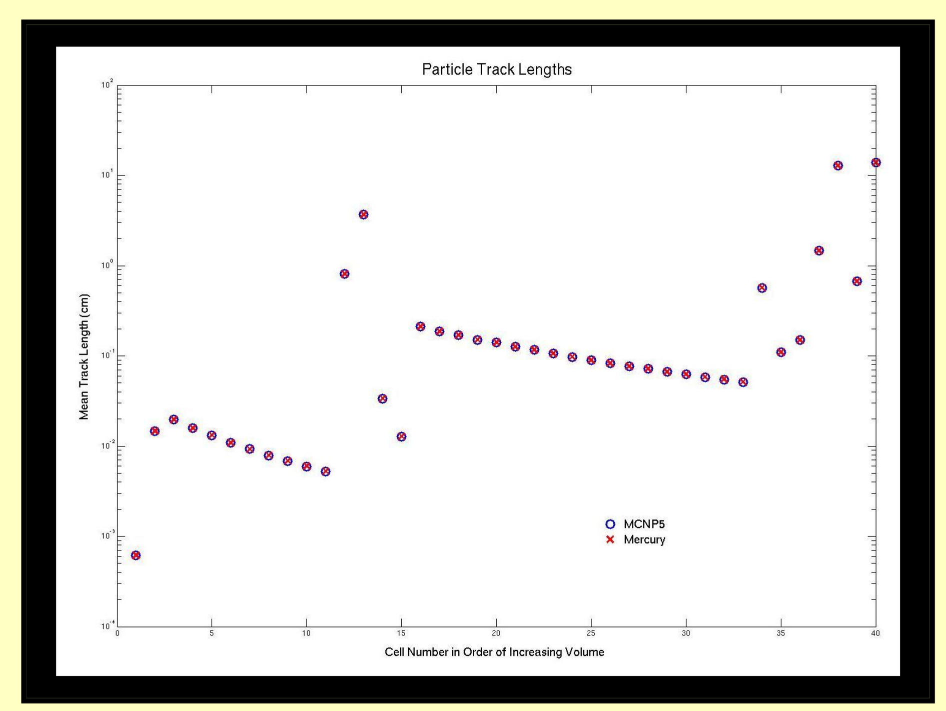

Fig. 3: Mean particle track lengths for corresponding MCNP5 and Mercury cells

Discussion:

While all other results validate the geometry translation from MCNP5 to Mercury, there is an uncomfortably large relative error in the calculated cell volumes between the two codes — likely due to error in Mercury's calculation of cell volumes rather than an error in the translation.

Fig. 4 shows that as mesh resolution and mesh refinement are increased, Mercury's calculated cell volumes converge to their expected values, and the mean relative error is reduced to a minimum observed value of 2.7%.

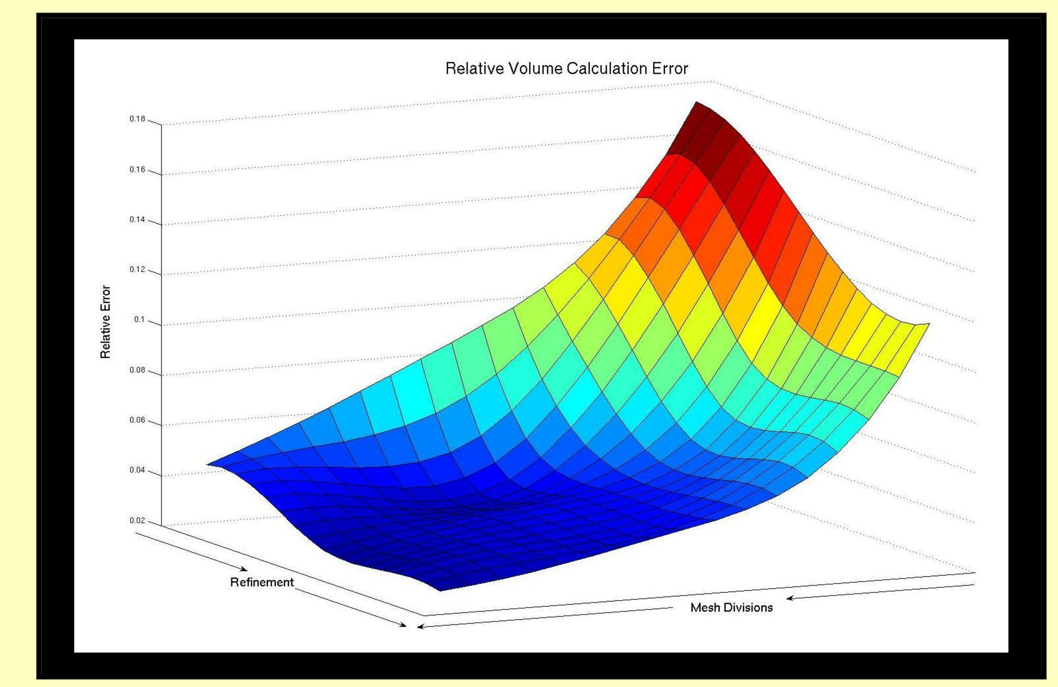

Fig. 4: Relative error in Mercury volume calculations

Note: For the purposes of our validation tests, a few minor changes were made to the original MCNP5 input and some hand modifications were made to the translated Mercury input to accommodate code differences.

Future Work:

We plan to continue validation testing by translating and assessing additional inputs including more complicated geometries that make use of lattices and universes. Translation capabilities may also be expanded beyond geometry to include other input data such as source and tally specifications.

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