Karlsruhe Institute of Technology

Karlsruhe Institute of Technology
Institute for Neutron Physics and Reactor Technology
Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany
Internet: http://www.kit.edu
E-mail (B. Weinhorst): bastian.weinhorst@kit.edu

Comparative assessment of different approaches for the use of CAD geometry in Monte Carlo transport calculations

B. Weinhorst[1], U. Fischer[1], L. Lu[1], Y. Qiu[1], P. Wilson[2]

[1]Karlsruhe Institute of Technology. Institute for Neutron Physics and Reactor Technology *[2] University of Wisconsin-Madison, Computational Nuclear Engineering Research Group*

Objectives

- Single (unique) CAD geometry: ITER CAD benchmark model.
- Three different approaches for use of CAD geometry in MC transport calculations:

  McCad: Current standard approach, conversion of CAD geometry into MCNP representation using McCad developed at KIT.

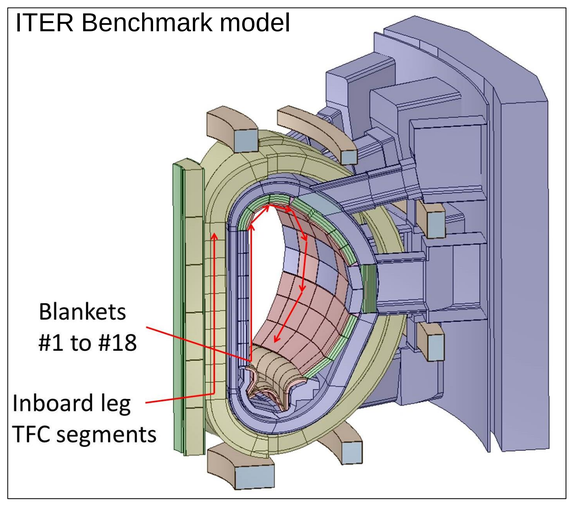
  MCNP6&TT: Using MCNP6's unstructured mesh geometry feature, meshing of CAD geometry with the tesselation-tetrahedralization (TT) approach developed at KIT.

  DAGMC: Direct particle tracking on the CAD geometry using a patched version of MCNP developed at UW-Madison.
- Comparison with respect to performance and user-friendliness:

  Installation (Installation guide, needed software, installation complexity).

  Model preparation (repairing geometry error, time needed, user expertise).

  Computation performance (calculation speed, accuracy).



	McCad	MCNP6&TT	DAGMC
Installation	 ■ Good installation guide. ■ Only one additional software package required. ■ Open Source software (except MCNP). ■ Simple installation.	 ■ New development, up to now no installation guide. ■ several software packages needed but not interdependent. ■ Open Source Software (except MCNP). ■ Moderate installation	 ■ Installation guide available, but not sufficient. ■ Interdependent software packages. Dependent on specific, older versions. Cubit and MCNP under license control. ■ Complex installation.
Model preparation	 ■ Decomposition into convertible solids. Substitution of spline surface with analytical surfaces mandatory. ■ Iterative and time intensive. ■ Extensive user expertise required.	 ■ Removing overlaps/gaps of solids. ■ Fast conversion. ■ User expertise required for optimization of meshing. ■ Tally definition difficult due to meshing of cells and surfaces.	 ■ No user guide for repairing geometrical errors. ■ Moderate speed, iterative steps required. ■ User expertise essential. ■ Tally definition very convenient, more user-friendly than standard MCNP.
Computation performance	 ■ Fastest calculation. ■ Current standard approach for MCNP calculations, chosen as reference.	 ■ Slowest calculation; speed depends mainly on mesh resolution. ■ Superimposed mesh gives large deviation for deep penetration calculations. ■ Cell tallys agree with McCad results within statistical errors.	 ■ Moderate calculation speed. ■ If model preparation done correctly, very good agreement with McCad results. ■ First wall cell tallys within 1% of McCad results.

Comparison of 14 MeV neutron flux at First Wall (FW)

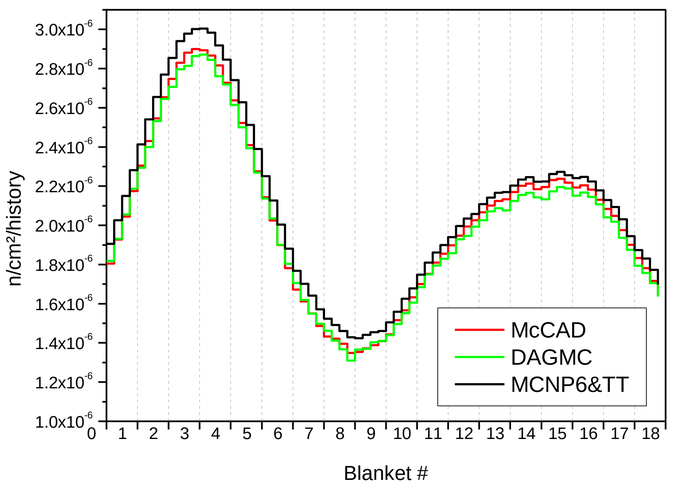
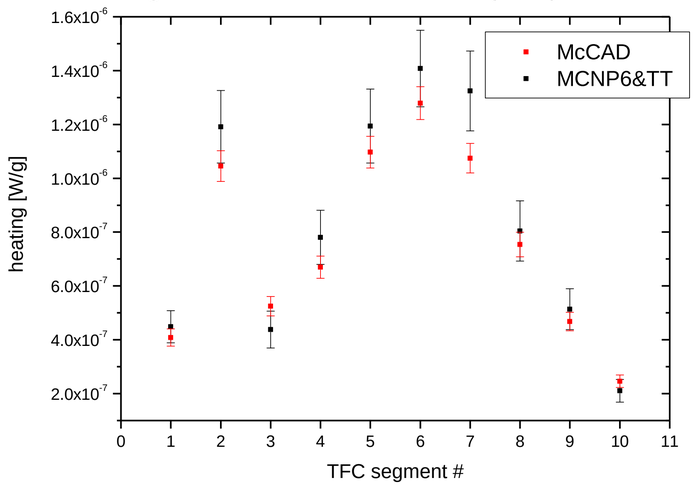


Table: Comparison of calculation performances.

	McCAD	MCNP6 & TT	DAGMC
Lost particles	4e^{-6} %	2e^{-4} %	3e^{-4} %
CPU time per 1e5 histories (voided)	23 s	550 s	134 s
CPU time per 1e5 histories	294 s	1004 s	630 s
Deviation from McCad FW 14 MeV neutron current	-	3.4 %*	1.0 %*
Deviation from McCad heating inboard TFC	-	9.8 %*	too many lost particles
Deviation from McCad Neutron flux mesh at equatorial port	-	27 %	too many lost particles

*within statistical error

Comparison of nuclear heating in the inboard leg of the Toroidal Field Coil (TFC)



Conclusions

- McCad most useful for simple models or if model preparation has to be done only once. Small changes to the geometry can be done directly in the MCNP input file.
- MCNP6&TT model preparation extremely fast and reliable. Problematic with regard to nuclear responses; for meshtally the deviation to McCad approach lager than statistical error. Statistical error in general larger than for McCad approach (same number of histories).
- DAGMC most useful for complex models that need to be changed regularly.