SOURCE PROFILE ANALYSIS FOR THE ITER FIRST WALL/SHIELD MODULE 13

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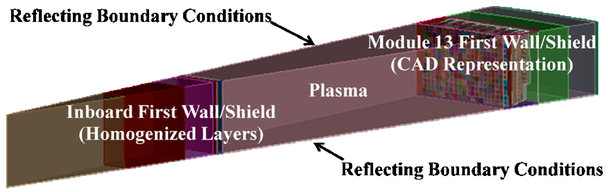


DAG-MCNPX Simulation Parameters

- Mesh Tallies: 3 mm x 3 mm x 3 mm by material in entire First Wall/Shield module
- Source: Uniform 14.1 MeV neutron source between the inboard and outboard first walls
- Materials: Homogenized layers on the inboard side, CAD model on outboard side with material composition specified by ITER IO
- Run Time: 40 million histories simulated in 78 computer-weeks on 12 parallel Quad Core 3 GHz Intel Xeon processors
- Statistical Error: Maximum of 5% in the First Wall, 30% at the back of the shield block

PROBLEM: Module 13 hybrid geometry does not have an accurate angular neutron source distribution at the first wall.

- **Reflective boundaries simulate an infinite source in the z-direction.**
- **This caused a more tangential angular distribution of the source neutrons incident on the First Wall.**
- **Tangential neutrons cause an overestimation of nuclear heating in the first wall.**

SOLUTION: Write Surface Source

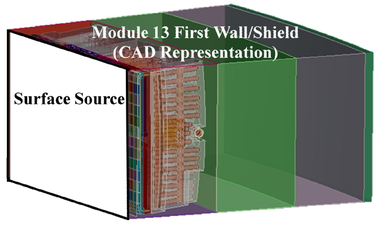
- **An extra surface was inserted into the ITER CAD geometry directly in front of Module 13.**
- **All particles crossing the surface were recorded in location, angle, and energy.**

DAG-MCNPX Simulation Parameters

- Source: Detailed 14.1 MeV neutron source distribution provided by the ITER IO
- Materials: Homogenized layers with material composition specified by ITER IO
- Run Time: 250 million histories simulated in 3.85 computer-weeks on 2.66/3.20 GHz Intel processors resulted in 14.5 million surface source crossings

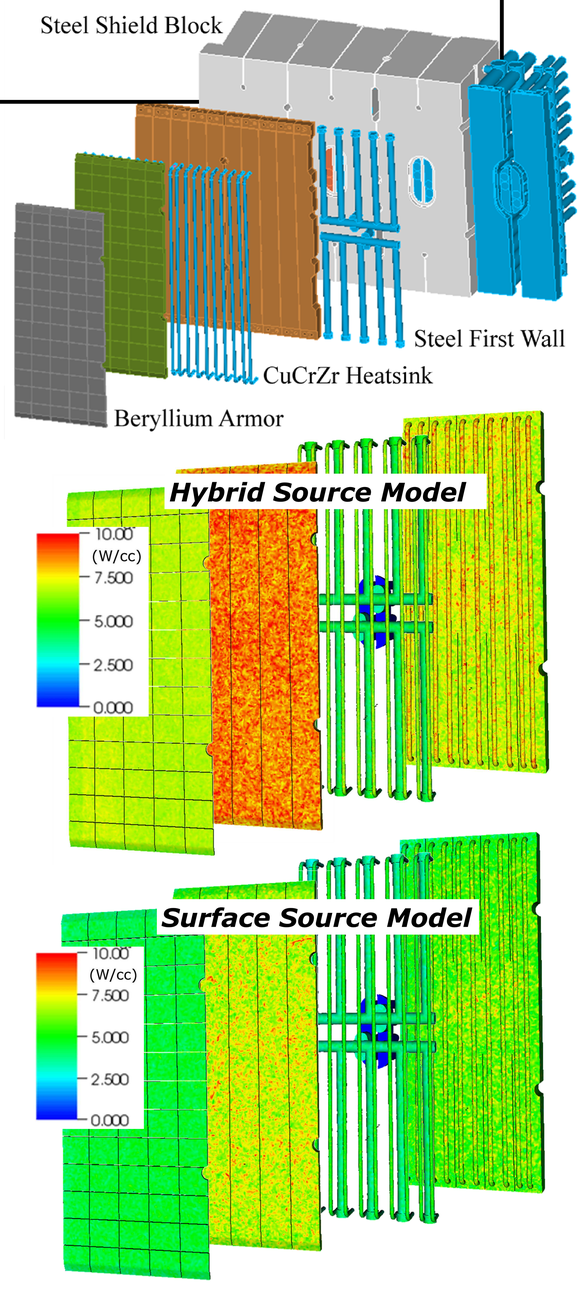
SOLUTION: Read Surface Source

- **A corresponding surface was inserted into the Module 13 CAD geometry directly in front of the First Wall.**
- **Particles are "born" on this surface with the location, angle, and energy that was recorded in the 3D ITER model.**
- **Neighboring modules were simulated with reflecting surfaces in the poloidal and toroidal directions.**



DAG-MCNPX Simulation Parameters

- Mesh Tallies: 3 mm x 3 mm x 3 mm by material in the First Wall
- Source: Surface source recorded in 3D ITER model
- Materials: CAD model with material composition specified by ITER IO
- Run Time: 14.5 million histories simulated in 18.96 computer-weeks on 2.66/3.20 GHz Intel processors
- Statistical Error: Maximum of 11% in the First Wall



RESULTS: Hybrid Approach vs. Surface Source Approach

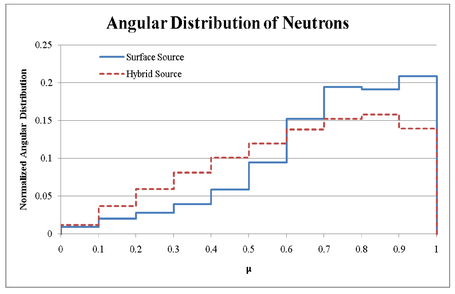
	Surface Source	Hybrid Source
Total Neutrons [neutrons/s]	6.64×10^{17}	8.77×10^{17}
Average Energy of Neutrons [MeV]	7.37	5.87
Total Gamma Photons [photons/s]	2.61×10^{17}	3.32×10^{17}
Average Energy of Gamma Photons [MeV]	1.48	1.33

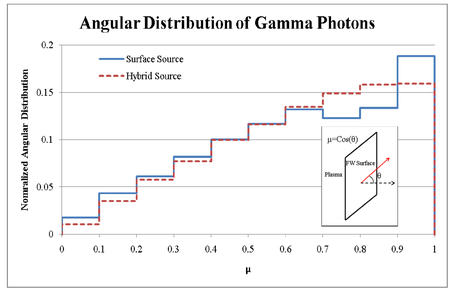
Average Energy and Number of Incident Particles

- The hybrid source overestimates the number of neutrons and gamma photons incident on the First Wall.
  - This is because the geometry of the hybrid model creates tangential source particles which result in additional reflection into the chamber.
- The average energy of particles in the hybrid model is lower, suggesting softer neutron and gamma photon spectra.

Angular Distribution of Neutrons and Gamma Photons

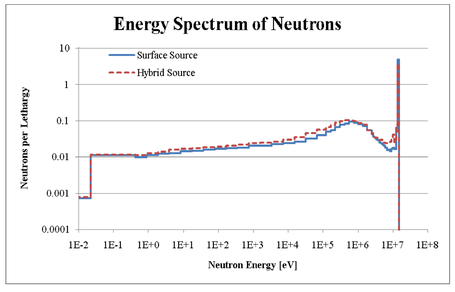
- Angular distributions are normalized to one neutron or gamma photon incident on Module 13.
- As expected the Cylindrical Hybrid Model exaggerates the component of neutrons tangential to the First Wall.
- Differences in the gamma photon angular distribution are more subtle than in the neutron angular distribution because all photons are secondary particles that originate from other First Wall/Shield Modules.

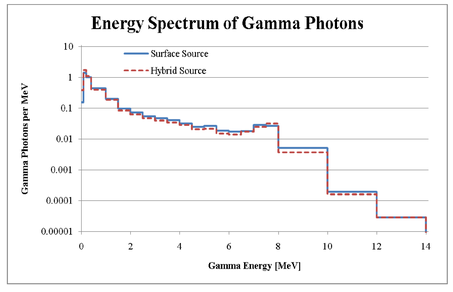




Energy Distribution of Neutrons and Gamma Photons

- The high energy peak is due to uncollided 14.1 MeV fusion source neutrons.





Nuclear Heating in the First Wall

- Nuclear heating was calculated on cylindrical mesh tallies.
- Structured mesh tallies then were interpolated onto conformal tetrahedral mesh for CFD.
- Using VisIt visualization suite from LLNL, nuclear heating data was visualized.
- The hybrid source was found to overestimate nuclear heating in the first wall by as much as 63%.

CONCLUSIONS

- **Simulation accuracy was increased using DAG-MCNPX's surface source feature.**
- **The hybrid source overestimated the total number and underestimated the average energy of particles incident on the First Wall.**
- **The hybrid source was found to overestimate nuclear heating as much as 63% in the First Wall.**

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