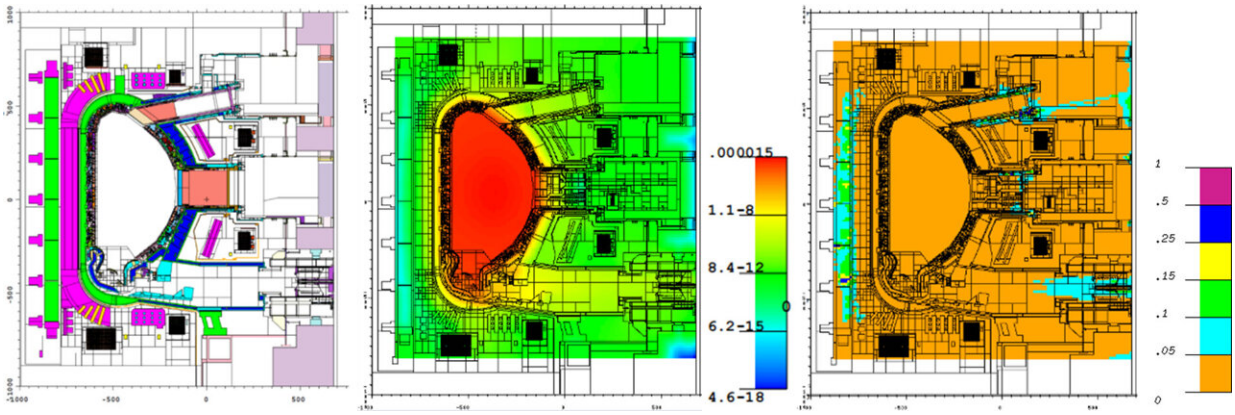
Novel method to accelerate neutron transport calculations

July 21 2022, by Zhang Nannan



Geometry configuration of the ITER C-model (left), normalized neutron flux maps (middle) and relative error maps (right) calculated by OTF method. Credit: Wang Guohe

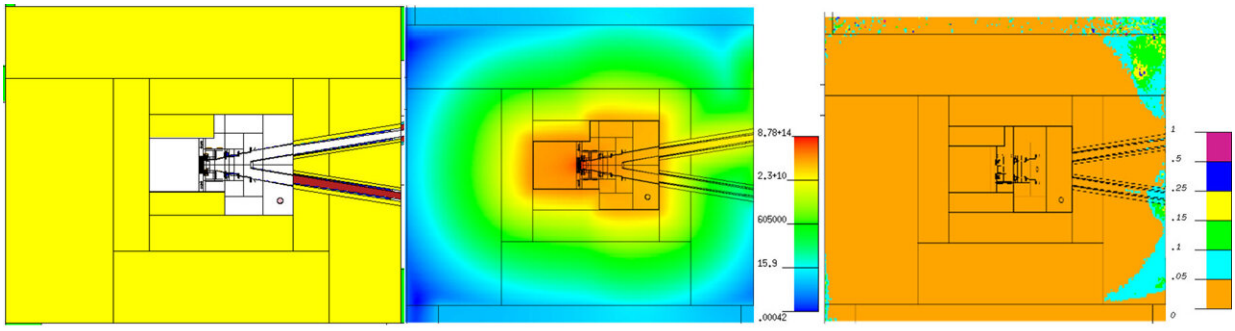
Dr. Zheng Yu from the Hefei Institutes of Physical Science of Chinese Academy of Sciences, in cooperation with researchers from the Karlsruhe Institute of Technology of Germany, has proposed a new method to accelerate the Monte Carlo large-scale shielding simulation.

The new global variance reduction method, also called On The Fly (OTF), makes the Monte Carlo (MC) codes applicable for shielding analyses of large-scale and complex fusion reactors. Relevant results have been published in *Nuclear Fusion*.

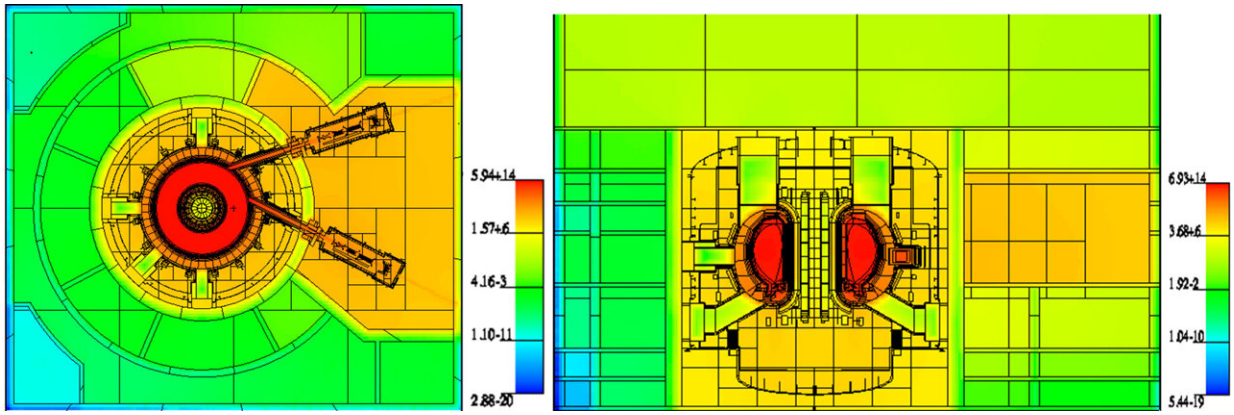
MC is one of the most accurate computation methods in the field of nuclear analysis for fusion and fission reactors. However, the shielding calculation of the fusion device using Monte Carlo transport codes is still challenging due to the complexity and heavy shielding of fusion reactors. The slow convergence rate of the MC method rendering in analog simulations is prohibitively costly in computational time.

The researchers introduced a new idea to update the weight window along the transport process in this method. They also proposed an innovative solution based on automatic dynamic adjustment of the upper bounds of weight window, which addressed the problem that has plagued the neutronics particle transport calculation of MC for a long time.

When they applied the OTF method to the nuclear analysis of International Thermonuclear Experimental Reactor (ITER) and the International Fusion Materials Irradiation Facility-DEMO-oriented Neutron Source IFMIF-DONES Accelerator, remarkable acceleration effects were achieved.



Geometry configuration of IFMIF-DONES (left), normalized neutron flux maps (middle) and relative error maps (right) calculated by OTF method. Credit: Wang Guohe



Neutron flux distribution of horizontal cut (left) and vertical cut (right) calculated by OTF method. Credit: Wang Guohe

Compared with the Automated Variance Reduction Generator (ADVANTG) variance reduction method developed by Oak Ridge National Laboratory, the acceleration effect of OTF method is 13 to 20 times that of ADVANTG.

In addition, OTF also serves for the global radiation field calculation of Chinese Fusion Engineering Testing Reactor, which provides an important basis for evaluating the safe operation of key components such as magnets and vacuum vessels under nuclear irradiation.

More information: Yu Zheng et al, Improvements of the on-the-fly MC variance reduction technique with dynamic WW upper bounds, *Nuclear Fusion* (2022). DOI: 10.1088/1741-4326/ac75fc

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