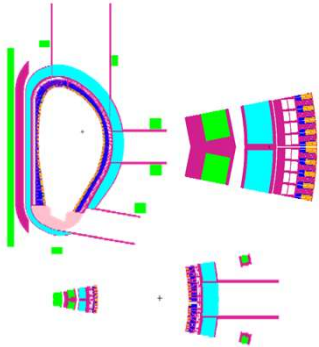


Integration of On-The-Fly Variance Reduction Method into OpenMC and Application to EU-DEMO Fusion Reactor

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INTRODUCTION

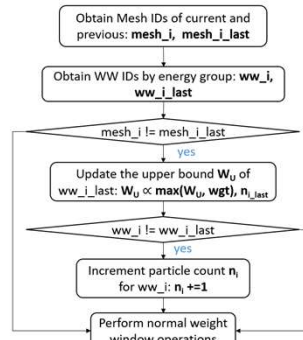


Simplified neutronics model of EU-DEMO Fusion Reactor with HCPB BB

Model parameters

- ✓ Fusion Power: 1650 MW (**5.85E20 n/s**)
- ✓ Vacuum Vessel
 - Inner and outer shell: 6 cm
 - Interlayer: 48 and 98 cm at mid-plane
- ✓ Blanket : 75 cm and 100 cm at mid-plane
- ✓ OpenMC model converted from MCNP input file with 'openmc_mcnp_adapter' and 'openmc_sdef_parser'
- ✓ Mesh tally grids size: **30 cm**
 - X: 170 ~ 1870 cm, 56 grids
 - Y: -390 ~ 390 cm, 26 grids
 - Z: -1150 ~ 1500 cm, 88grids

METHODS



Dynamically adjust the upper limit of weight window to control long-history

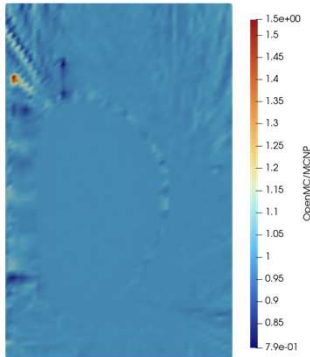
On-the-fly (OTF) Global Variance reduction

- ✓ Set weight window lower bound proportional to flux
- ✓ Iteratively update flux to refresh weight window until prescribed iteration criteria are satisfied
- ✓ **Dynamically adjust weight window upper bound** for long-history control
- ✓ Monitor weights of particles exiting each mesh cell.

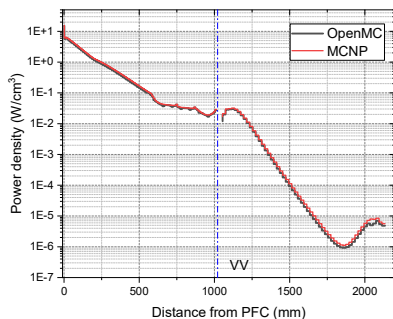
$$\begin{cases} W_{LL} = \frac{R_i}{R_{max}} \cdot m \\ W_{UL} = k \cdot W_{LL} \end{cases}$$

RESULTS

Compare to MCNP

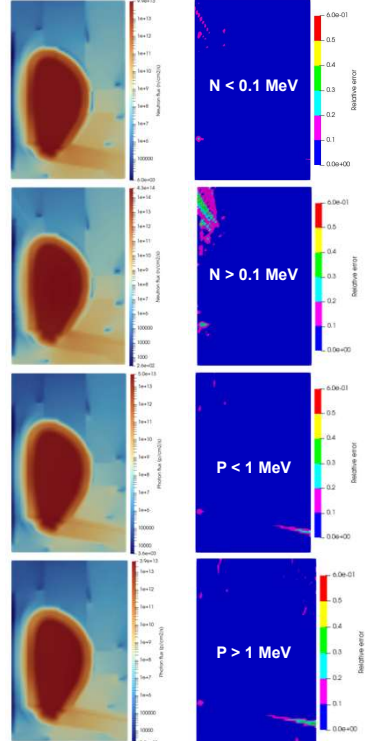


The ratio of total neutron flux



Nuclear heating along radial at the midium plane of outboard Blanket

MAP of N & P in different E group



Neutron and Photon flux and statistic error distribution

Nuclear Heat (MW)

Blanket	Divertor (homogeneous)	Vacuum Vessel	Sum
1388.301	143.6429	14.27652	1546.22

Summary

- ✓ Verify the acceleration performance
 - N & P coupled transportation
 - 2 energy group respectively: Neutron (0 ~ 0.1 ~ 20 MeV), Photon (0 ~ 1 ~ 100 MeV)
- ✓ Shielding calculation
 - Apply the OTF method to neutron-photon coupled transport, flux distributions with converged statistical errors over the entire model
- ✓ Validate the correctness
 - At the BB and front VV regions, where converged results can be obtained via analog transport, TBR equals to 1.217 with 90% enrichment of Li-6
 - At the back of VV and TFC regions, where converged results should be obtained via variance reduction method, nuclear heating of **12.65 W/m³** in the TFC steel case behind the mid-plane inboard blanket

REFERENCES

- [1] Zhou, G. et al. (2023) 'The European DEMO Helium Cooled Pebble Bed Breeding Blanket: Design Status at the Conclusion of the Pre-Concept Design Phase', Energies, 16(14):5377.
- [2] Zheng, Y. et al. (2022) 'Improvements of the on-the-fly MC variance reduction technique with dynamic WW upper bounds', Nuclear Fusion, 62(086036).

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