APPLICABILITY OF COOLANT MATERIALS IN HYBRID FISSION-FUSION NUCLEAR REACTORS

J. L. GERVASONI, M. PETACCIA,

J.A. GARCIA GALLARDO.

Centro Atómico Bariloche
Comisión Nacional de Energía Atómica (CNEA), Argentina.
Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina.

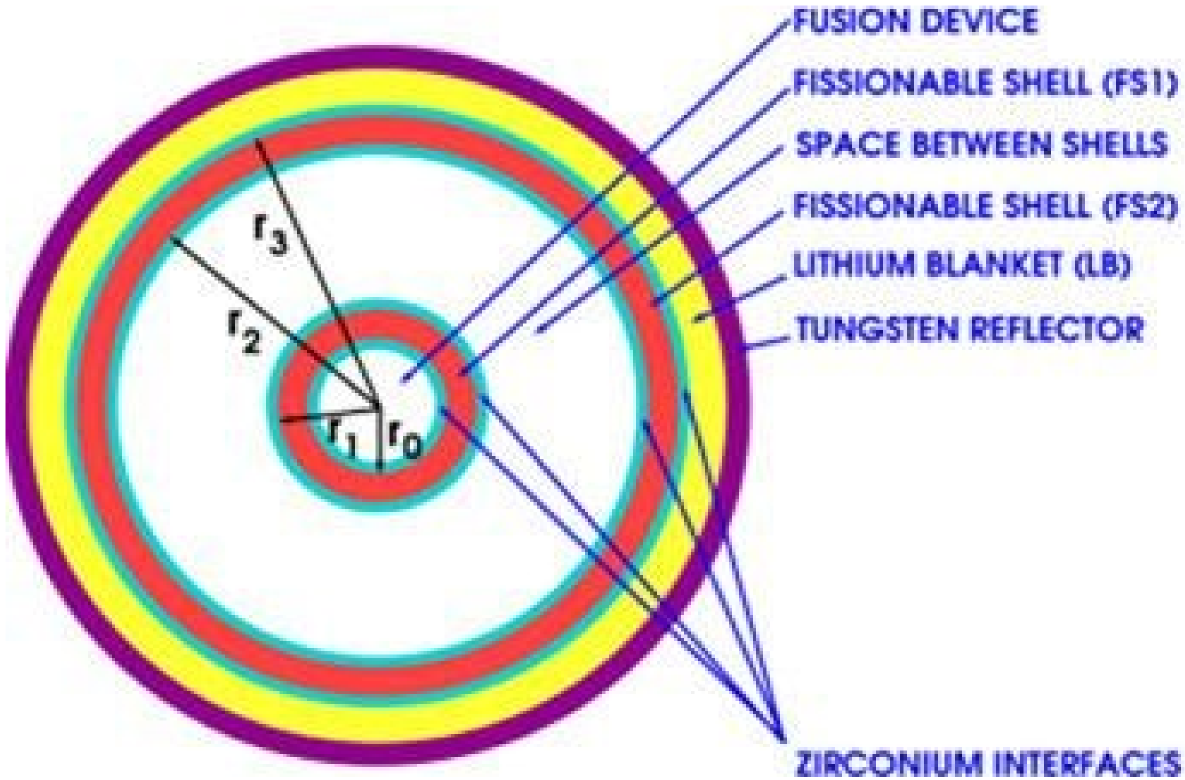
Fusion-Fission collaboration team

With all humility, Fusion tells Fission:

"I will be your servant and help you destroy toxic waste while producing energy."

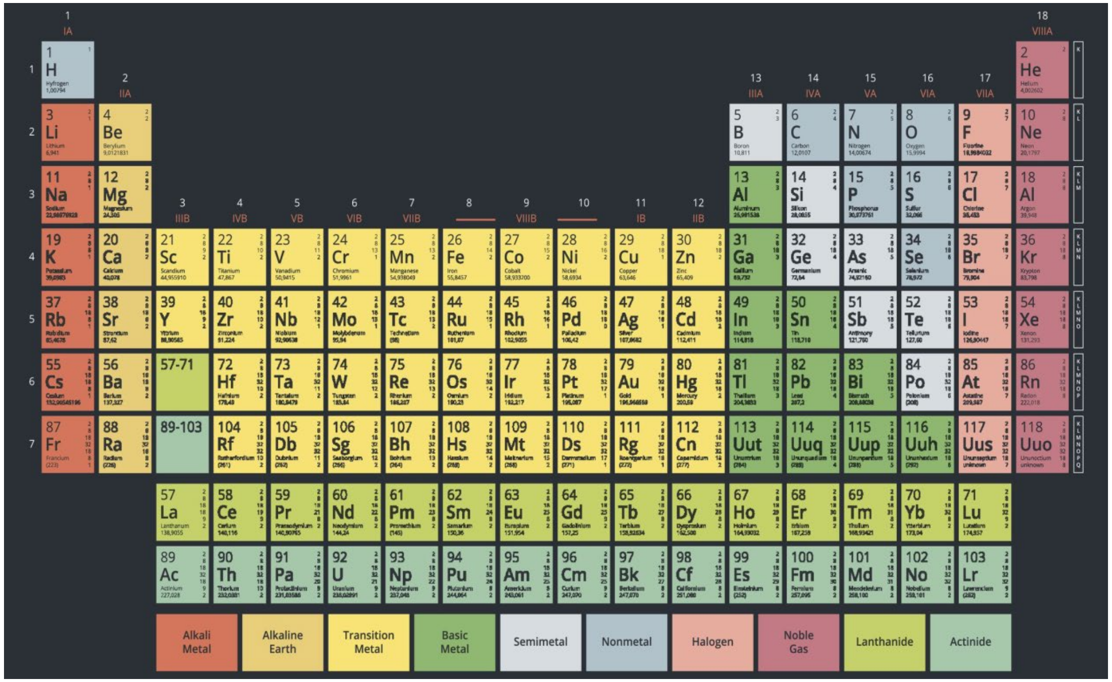
S. Mahajan (Institute for Fusion Studies, Univ. of Texas - Austin, USA), cited in T. Feder: *Need for clean energy, waste transmutation revives interest in hybrid fusion–fission reactor*, Physics Today, July 2009, page 24.

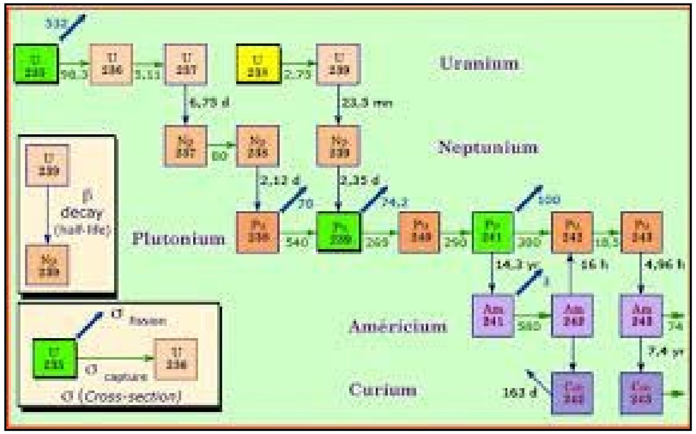
Concentric model for an FUSION-FISSION HYBRID REACTOR (FFHR)



GARCIA-GALLARDO, J.A., GIMENEZ, M.A.N., GERVASONI, J.L., "Nuclear properties of Tungsten under 14 MeV neutron irradiation for fusion-fission hybrid reactors", Annals of Nuclear Energy 147 (2020) 107739.

Minor actinides!

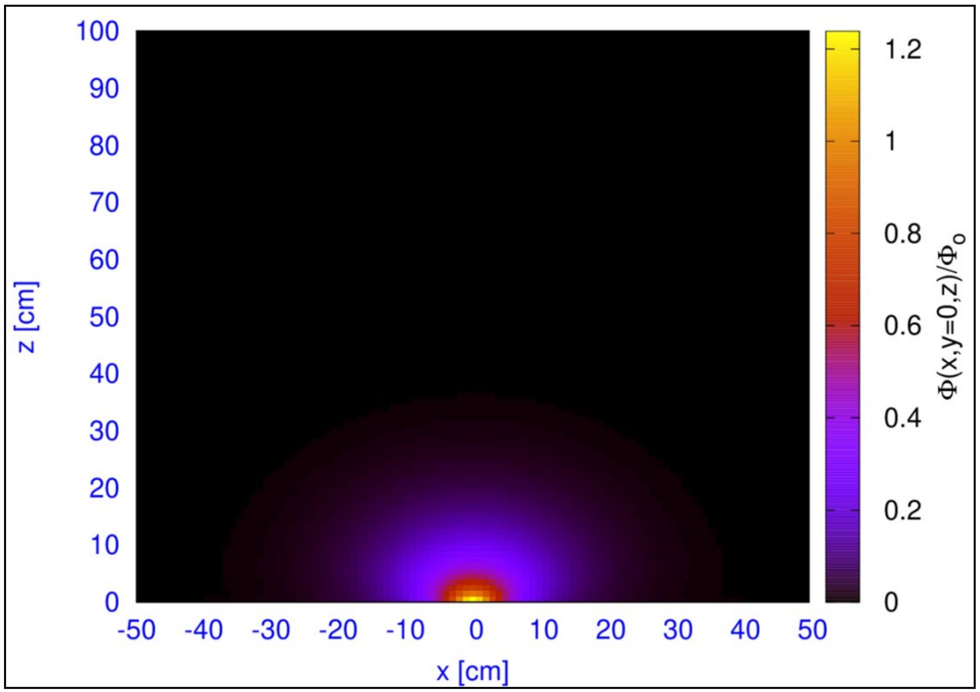




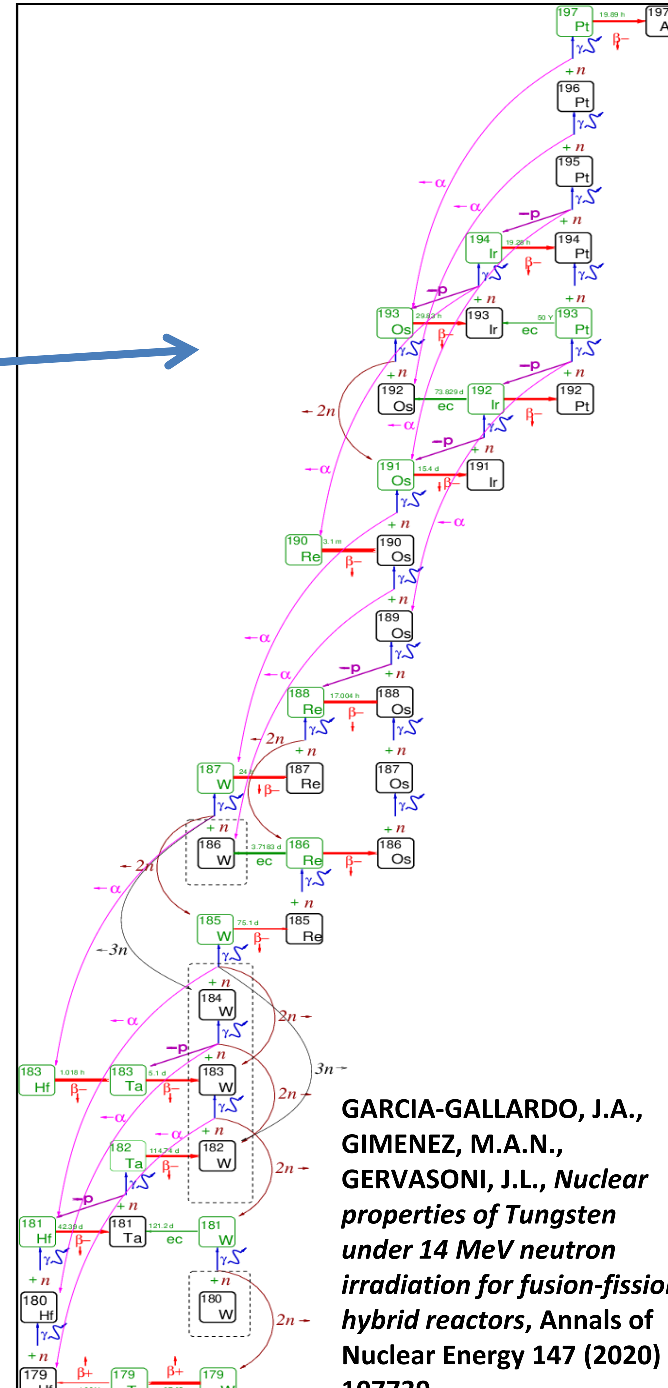
Properties of W

Free from minor actinides!:

W transmutation cycle under 14 MeV neutron irradiation.
Dashed lines enclose initial isotopes present in natural W.
Stable isotopes are in bold boxes.
Arrows : reactions and decays.

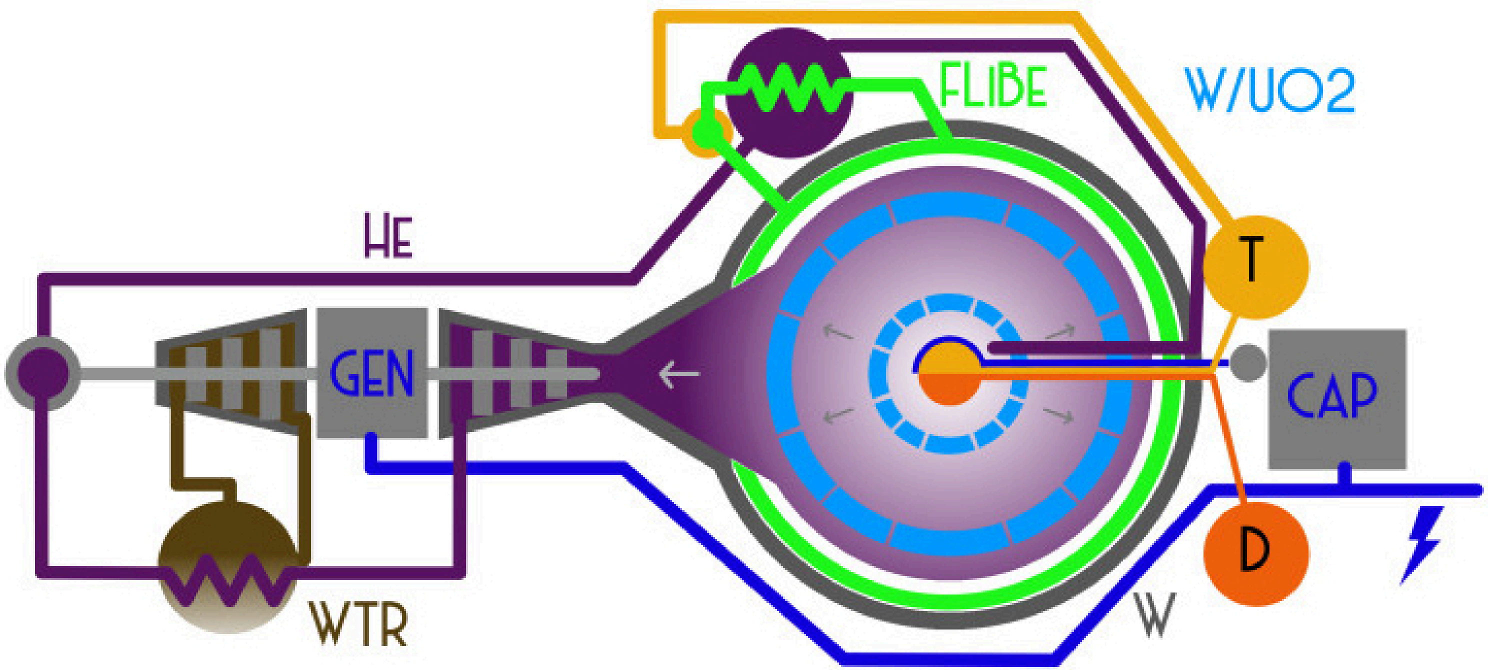


Normalized total neutron flux inside a 1 block of solid Tungsten. As the shading becomes brighter, the net neutron flux is more intense. The plane of the cutaway (y = 0) contains the axis of the beam, which enters in (0,0,0).



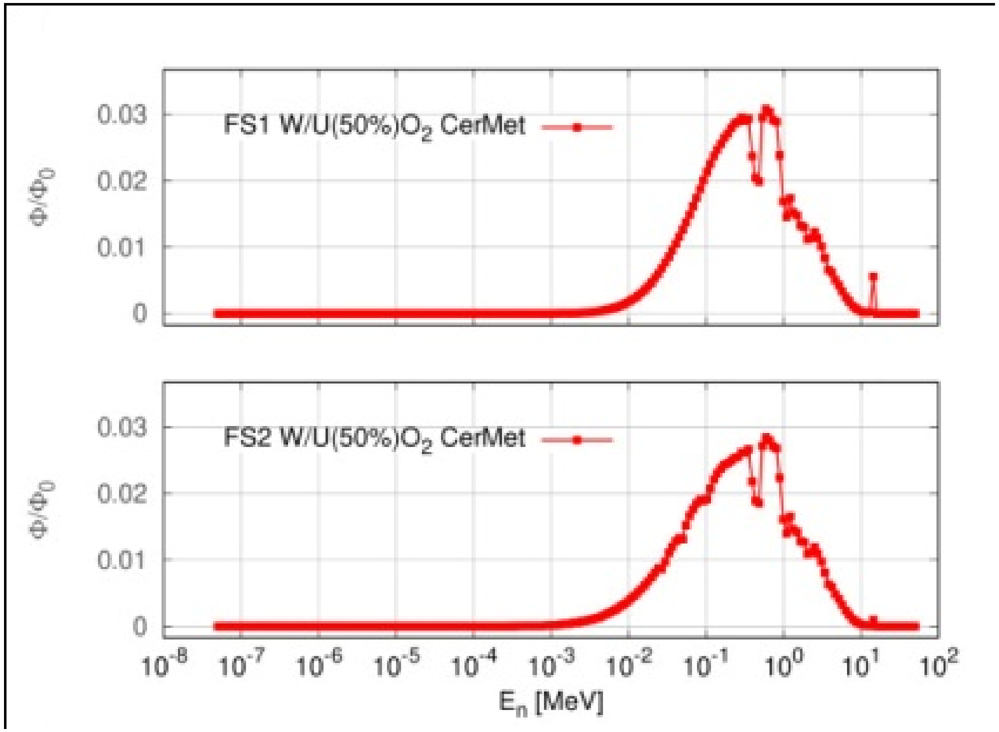
GARCIA-GALLARDO, J.A., GIMENEZ, M.A.N., GERVASONI, J.L., *Nuclear properties of Tungsten under 14 MeV neutron irradiation for fusion-fission hybrid reactors*, Annals of Nuclear Energy 147 (2020) 107739.

What is Cermet?



- SONG, J., AN, W., WU, Y., TIAN, W., “Neutronics and Thermal Hydraulics Analysis of a Conceptual Ultra-High Temperature MHD Cermet Fuel Core for Nuclear Electric Propulsion”. Front. Energy Res., 6 (2018) https://doi.org/10.3389/fenrg.2018.00029.
- HICKMAN, R., and BROADWAY, J., “Hot Hydrogen Testing of Tungsten-Uranium Dioxide (W-UO2) CERMET Fuel Materials for Nuclear Thermal Propulsion”, NASA Technical Reports Server. https://ntrs.nasa.gov/citations/20140012459 (2014).

FFHR: Neutron Spectra for different shells



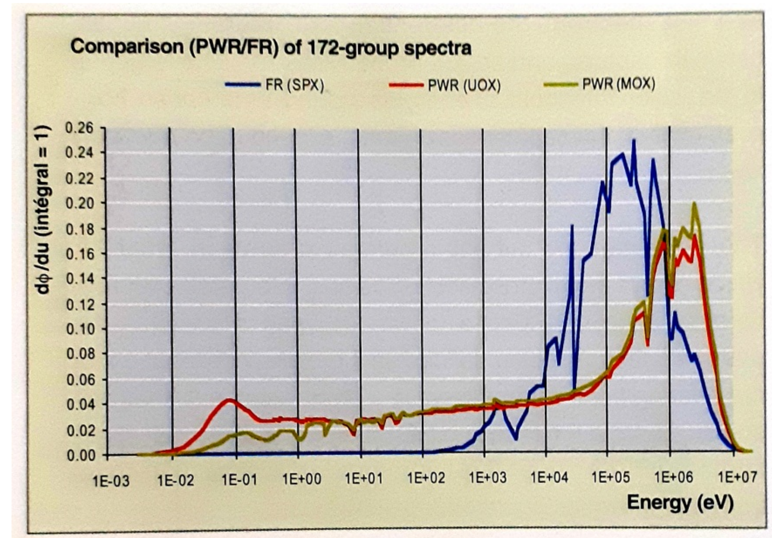
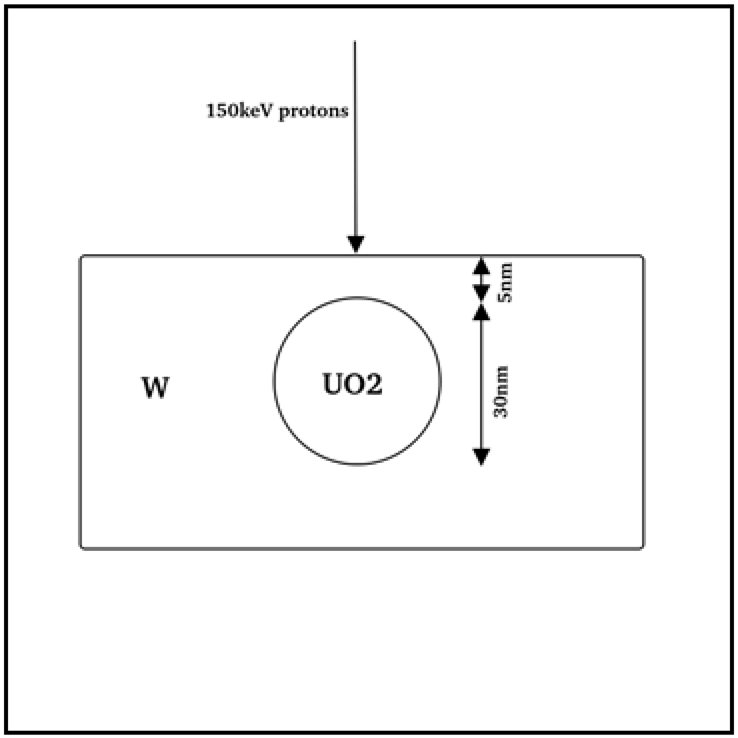
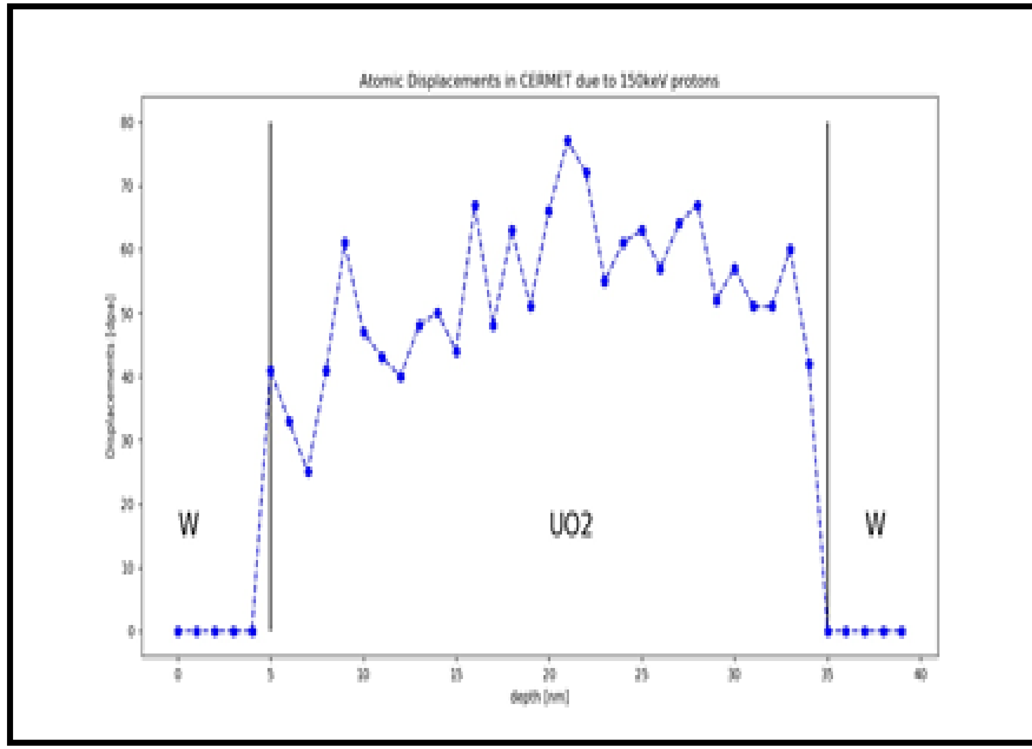


Fig. 178. Comparison of neutron spectra, for a pressurized-water reactor, and a sodium-cooled fast reactor.

J.F. PARISOT. Treatment and recycling of spent nuclear fuel, Ed. Le Moniteur, Comisariat à l'énergie nucleaire, Saclay, (2008).

System simulated with IMPC5, where a sphere of UO2 is embedded into a Tungsten matrix

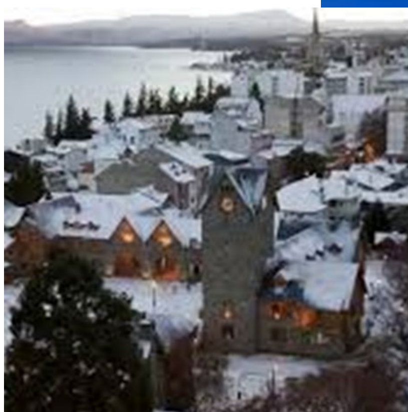


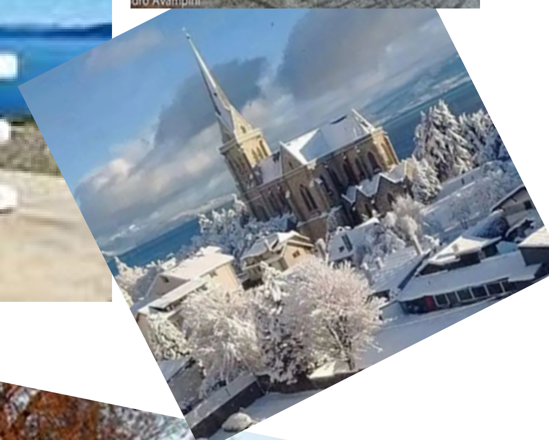


CONCLUDING REMARKS

- The cermet alloys studied here, have reasonable thermophysical properties and, from irradiation experience in fast reactors to well over 100 dpa, a substantial resistance to swelling and high temperature embrittlement. From the point of view of its behaviour with the gaseus coolant, we observe that for protons at the studied energies, there are not displacement of its atoms. Moreover, they have good compatibility with He coolants.
- But there are several difficulties open regarding the behavior of the coolant with the cermet. In particular, for these energies, we have to study the corrosion processes involve in this interaction.
- Further research would require the study of the temperature distribution around the fuel sphere, specially the properties of W as a function of T, for example, phonons, elastic constant, hardness, and so on.

Thank you for your attention





Announcement

- **Latin America Workshop and School in Nuclear fusion systems for energy production.**
- **Tentative date: 17 – 21 October 2024.**
- **Location: Centro Atómico Bariloche, Bariloche, Argentina.**