NEUTRONIC MODELLING IN SUPPORT OF THE Irradiation Programmes

Background

Irradiation experiments are generally conducted to determine some specific characteristics of the concerned fuels and structural materials under well defined irradiation conditions. For the determination of the latter the BR2 division has an autonomous reactor physics cell and has implemented the required computational tools. The major tool used is a three-dimensional full-scale Monte Carlo model of the BR2 reactor developed under MCNP-4C for the simulation of irradiation conditions.

Objectives

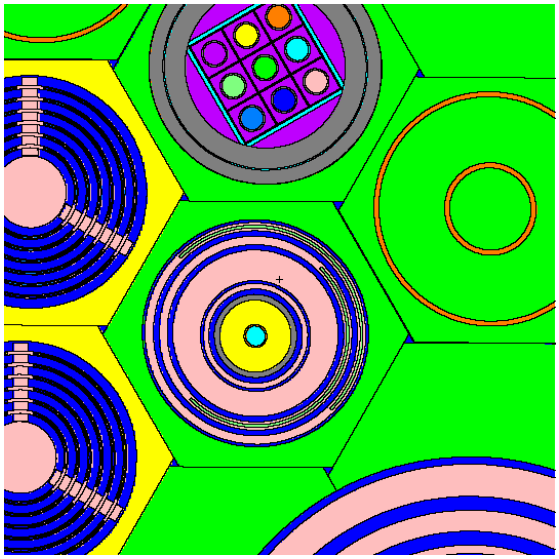
- to evaluate and adjust previsonnal irradiation conditions by adjustments of the environment, differential rod positions, axial and azimuthal positioning of the samples, global power level, ...;
- to deliver reliable, well defined irradiation condition and fluence data during and after irradiation;
- to assist the designer of new irradiation devices by simulations and neutronic optimisations of design options;
- to provide computational support to related projects as a way to valorise the capabilities that the BR2 reactor can offer.

Principal results

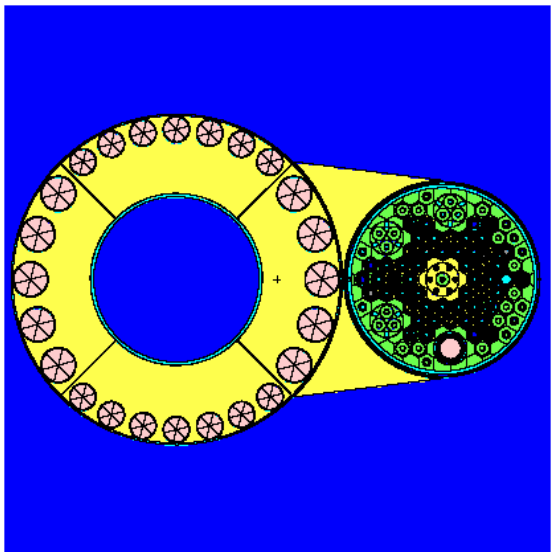
The major evaluations conducted during 2004 are:

Ongoing Irradiation Programs:

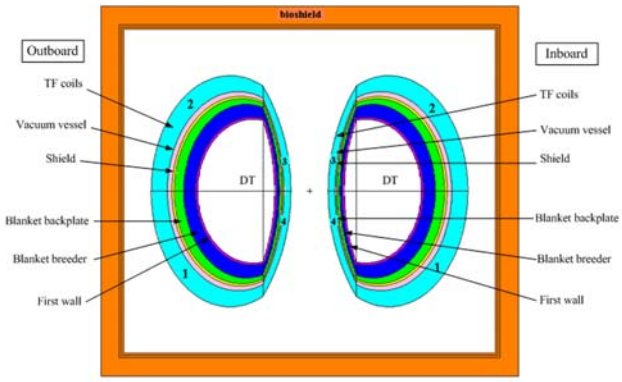
- OMICO: calculation of the power distribution in the experimental MOX fuel rods to allow for online absolute LHGR measurements.
- UMo MTR fuel development: recalculation of the irradiation history of various fuel plates in the dedicated FUTURE irradiation device; determination of detailed burn-up distributions; comparison with the results of the latest dosimetrical measurements.
- U_3Si_2 MTR fuel qualification at high heat fluxes: preparation and follow-up of an irradiation programme of advanced MTR fuel U_3Si_2 fuel plates inserted as the outer ring in a 6NG standard BR2 fuel element.
- optimization of the Mo-99 production yields in the PRF-type devices for various target geometries and loading schemes.



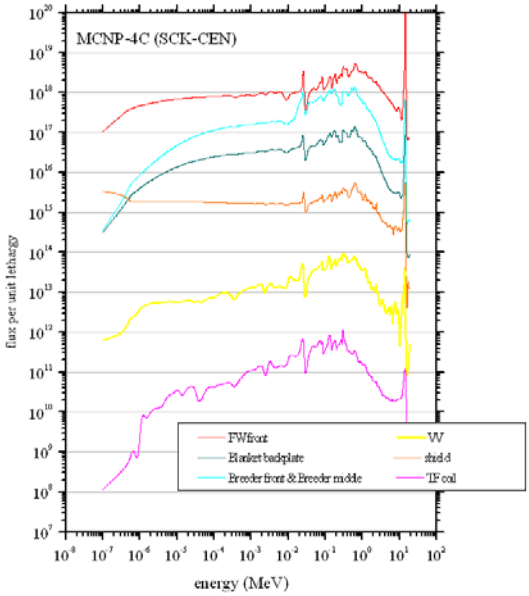
Modelling of newly proposed irradiation devices: this figure illustrates the modelling of a proposed device for power ramping on single fuel pins using various rotating absorber screens. The figure gives a cross section of the BR2 core at +30 cm above the mid-plane.



The right this figure shows the modelling of a carousel-type rotating irradiation facility located in the reactor pool outside of the BR2 vessel for Si-doping production activities.



On the left the MCNP calculation model of the tokamak building of ITER. This model has been used for the evaluation of the activation of the biological shield.



On the right the calculated neutron spectra in different parts of the tokamak of ITER

New Irradiation Devices:

- the GRIFFON project: neutronic optimisation of a pool-side facility for the irradiation of RVS samples under very demanding conditions (temperature range, dose rate, fluence homogeneity). This optimisation also concerned cooling and shielding evaluations.
- neutronic evaluations (available fluxes, spectra, deposited power, gamma heating) of various proposals for a pool-side facility for Si-doping of large ingots.
- neutronic evaluations of various proposals for the realisation of power ramps on fuel pins (e.g. rotating solid screens, asymmetrically loaded rotating devices, variable concentration of absorbing materials in the cooling water).
- Optimisation of irradiation devices containing Pb-Bi.

BR2 specific evaluations:

- detailed heat flux distributions in the standard BR2 fuel elements in function of the BR2 configuration and the burn-up in the fuel plates; evaluation of uncertainty factors.
- optimization of the BR2 fuel cycle using burnable absorbers (e.g. Cd-wires in the side-plates).

Evaluations in support of other projects:

- determination of the effective cross-sections for dosimetrical evaluations.
- Fusion: activation of the concrete in the biological shield in the present ITER design.

Future developments

- For 2005 a number of evaluations in the framework of the 2006 decennial safety reassessment of the BR2 reactor will have to be performed. This will mainly concern detailed evaluations on the poisoning of the beryllium matrix in function of various operation schemes and a detailed evaluation of the distribution of the fluences of the walls of the aluminium pressure vessel.
- Fast flux booster: increasing the fast flux in samples located in the axis of standard BR2 fuel elements by geometrical or material modifications of the inner plates of the fuel element or by introducing some fissile material close to the samples.
- Further follow-up of the OMICO-MIMAS-PV irradiation programme.
- Further investigation for the BR2-RJH-U3Si2 irradiation programme, including detailed
- Determination of the burn-up distribution.

Main contact person

Edgar Koonen: edgar.koonen@sckcen.be

Main reference

V.Kuzminov, M.Wéber, E.Koonen, *"Determination of the Linear Power in MOX Fuel Rods Irradiated at the BR2 Reactor"*, PHYSOR-2007, Chicago, April 25-29, 2004