An Adjustable Neutron Absorber for the Fission Fragment Accelerator

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A central part of the Munich fission fragment accelerator [1] is the target-ion source unit, which will be located in the SR-6 beam tube in in-pile position at a distance of about 60 cm from the core axis. This corresponds to a non-perturbed neutron flux of $\approx 1.5 \cdot 10^{14}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$.

According to the present design, the target will be a porous graphite cylinder, impregnated with $^{235}\mathrm{U\,C_2}$ and placed within a Re-container, which is directly attached to one of three foreseen types of ion sources:

- a surface ion source for alkali and earth alkali elements
- a laser ion source, which is appropriate for many metals and is element selective
- a FEBIAD source for noble gases

In order to ensure a fast diffusion of the fission products out of the graphite into the ion source, the target must be kept at high temperatures, usually between 2200 and 2600 K. The available neutron flux is sufficiently high to achieve this temperature solely by nuclear heating in the target. In combination with an optimized radiation cooling, this concept allows maximum fission rates and thus beam intensities. On the other hand, this makes it highly desirable to be able to vary the neutron flux at the target position, not only to compensate for the burn-up of the fissile material, but also to adjust the target temperature to a somewhat lower value, which can be used to reduce unwanted surface ionization in a laser ion source.

Therefore an adjustable neutron absorber has been designed as an elaborate compromise due to the following partially conflicting requirements:

- Effective decrease of the neutron flux at the target position with only minor consequences on other experimental positions within the reactor and on the reactivity of the reactor itself. This calls for a "compact" design.
- No hindrance to the heat exchange between the beam tube and the surrounding heavy water and no hindrance at all to the exchange between target and beam tube. This limits the compactness of the absorber and in particular prevents a placement inside the beam tube.
- Possibility to remove the reaction heat which is eventually generated in the absorber itself, assuming only natural convection in the reflector tank.
- No excessive production of long living activity.

This results in the absorber geometry shown in fig. 1: It is a finned zircalloy ring that surrounds the SR-6 beam tube at the target position on a length of 10 cm. The finns are filled with a 5 wt.-% aqueous $\mathrm{B(OH)_3}$ solution which acts as neutron absorber and allows to reduce the neutron flux and thus the power released in the target by 40 %, which is sufficient to compensate the burn-up of 150 days of operation or to reduce the target temperature by $\approx 300\,\mathrm{K}$.

The adjustment of the absorption efficiency can be done by varying the absorber level, as a maximum vertical asymmetry of the power distribution in the target of 7 % is acceptable. The axial power distribution is governed by effects due to the target fixation and the materials used in the ion source.

In the central part, several oblong holes are cut into the absorber cavity to allow convection around the hot region of the beam tube, as the source releases about 3 kW. Due to the finns, the absorber surface is sufficiently increased to evacuate ≈8 kW by natural convection without the risk of boiling boric acid. The power released in a completely filled absorber is half of this value. The power density in the absorber reaches values up to $11\,\mathrm{W/cm^3}$, which limits the layer thickness to 3–4 mm. Other neutron absorber materials could offer better thermal conditions, but boric acid has the unique advantage not to produce long living activity.

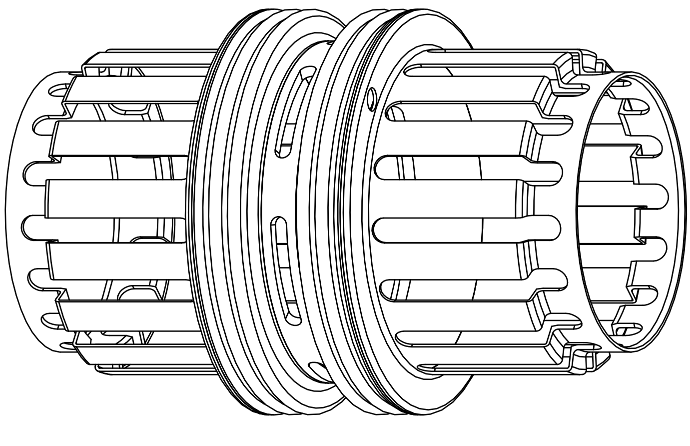

Fig. 1: The neutron absorber, including the support structure for fixation on the SR-6 beam tube. Only the two rings are filled with boric acid.

References

[1] D. Habs *et al.*, Proc. Int. Workshop on Research with Fission Fragments (1994) 18