The Mini-D_2 Source for Ultra-Cold Neutrons

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In the beam tube SR-4 of the Munich high flux reactor FRM-II a source for ultra-cold neutrons (UCN) shall be installed, the Mini-D_2 source. It has a small amount of solid D_2 at a temperature of $\approx$ 5K, being positioned inside a long evacuated tube near to the cold source. Neutrons may be down-scattered in the D_2 converter and may be stored in the tube, if their energy is less than the effective potential of the Be on the surface of the walls of this tube (250 neV). Under optimum conditions the total losses due to absorption or up-scattering in wall collisions is small compared to those in the D_2 converter. Then a UCN density of $\approx 10^4$ /cm^3 builds up in the storage tube, comparable to the density in the converter. By opening a valve at the end of the storage tube which is already in the experimental hall up to $2 \cdot 10^8$ UCN may be supplied to the experiment every few minutes. Operated in the continuous mode, the source will provide a UCN flux of about $5 \cdot 10^3$ UCN/cm^{2}s.

Fig. 1 shows a cut-away view of the SR-4 beam tube with the in-pile cryostat and part of the storage tube. Fig. 2 shows the end piece of the in-pile part of the UCN source. The storage tube is cooled to a temperature of $\approx$ 25K by helium gas, the end with the D_2 converter by supercritical helium to about 4.7K. The storage tube is inside a cryostat tube with helium gas between the double walls. The in-pile part of the cryostat tube is made of zircaloy. Outside the beam tube it is connected to the end plate by means of a pair of membrane bellows, again with helium gas between the walls. The in-pile cryostat and the pair of bellows represent the second and third barrier against water loss of the reactor.

Detailed informations on the design of the Mini-D_2 UCN source are given in an internal report [1]. In the year 2000 work was done in the following fields:

1. A report on the technical design including safety aspects was prepared and presented to the official technical safety authorities (TÜV) with the result that it will be approved in case of an official request. This request, however, will be submitted only after the third partial construction license for the reactor itself has been obtained.
2. The essential point for the safety concept is the fact, that the Mini-D_2 UCN source contains only a very small amount of deuterium (40 g). Therefore the tritium production during four years of operation will lead to a radioactivity, which still could be easily handled in case of emergency.
3. An important part of the system is the in-pile cryostat. The thickness of its inner and outer wall is 2 mm and 3 mm, respectively. Each wall is sufficiently strong to withstand even a deuterium explosion in the cryostat.
4. The maximum temperature of the in-pile cryostat was calculated to be $\leq 700^o$C even in the case of a cooling failure. The tensile strength of zircaloy ZR4 at this temperature is still sufficiently high. That determines the alloy as the only admissible material to use.
5. The final design and layout of the deuterium gas system and the cryogenic circuits were made. The vessel for the helium protected-deuterium gas handling system was ordered. The pumps for the internal vacuum system exist as well as the refrigerator for the para/ortho deuterium converter.
6. The test cryostat with double walls was manufactured. It will be used for measurements of the UCN production rate at the pulsed TRIGA reactor at the University Mainz.
7. Manufacturing the in-pile cryostat and the UCN storage tube with double walls and complete length by extrusion is an actual task. A prototype for the cell containing the solid deuterium was manufactured.
8. The main components of a SPS-system (SIMATIC S7-400) for controlling the complete Mini-D_2 UCN source are purchased.
9. A new laboratory for sputtering various metals including beryllium on components of UCN experiments was taken into operation successfully.

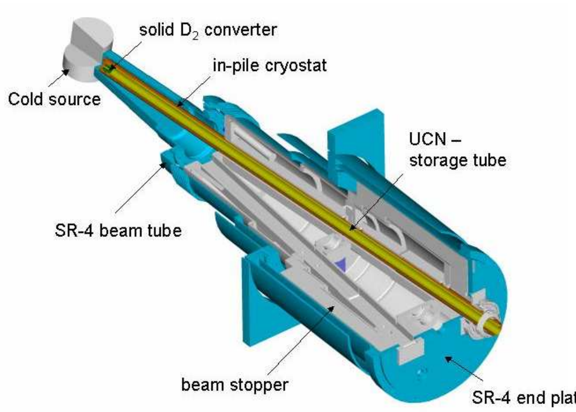

Fig. 1: Cut-away view of the SR-4 beam tube with the in-pile part of the source

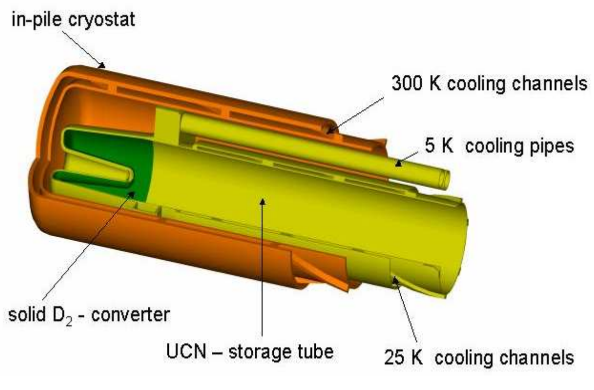

Fig. 2: Cut-away view of the source with the converter

References

[1] I. Altarev, F.J. Hartmann, S. Paul, W. Schott, U. Trinks, Internal report TUM-E18, 2000