Progress Report on 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 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 are small compared to those in the D_2 converter. Then a UCN density of $\approx 10^4/\text{cm}^3$ 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 continuous mode, the source will provide a UCN flux of about $5 \cdot 10^3$ UCN/cm^{2}s. More details on the Mini-D_2 UCN source are given in an internal report [1].

In the year 2001 the work on the design of the source was continued to bring forward the procedure of approval by the technical safety authorities (TÜV). The barriers against water loss of the reactor were set in agreement with the authorities, as well as the planned measures to prevent explosion of the deuterium gas. The classifications concerning the nuclear relevance of all parts of the source. The maximum pressure limits of the different sectors were matched.

Based on these agreements a preliminary approval of the deuterium gas system and the vacuum system - both inside a common vessel - was achieved, and the construction of the vessel was recently started. All valves, vacuum sensors, pressure probes and other instruments of these systems are in the laboratory and will be installed in near future. The para / ortho deuterium converter, which is part of the deuterium gas system, was manufactured and is under commissioning. In order to control all sensors of the deuterium converter a SIMATIC S7-400 SPS-system was taken into operation successfully.

An important part of the water barrier is the pair of membrane bellows between the inpile-cryostat and the end plate of the beam tube SR-4, which allows the extraction of the inpile-cryostat from the high radiation region by 1.8 m, if the source is not in operation. Three of in total 15 sectors of the membrane bellows were manufactured and tested under real pressure conditions. Up to now 1500 complete cycles were run without any signs of fatigue. Rupture tests will be made at the end of these test runs.

The UCN-windows at the exit of the UCN-storage tube, which consist of thin aluminum foils between two supporting grids, are crucial elements of the deuterium barrier. Extensive rupture tests were made with different foils of various thickness and several types of grids.

A manufacturer was found for the production of the double-walled UCN-storage tube by extrusion. Some welding tests of the thin walled tubes were made. The technology of sputtering beryllium on aluminum surfaces was elaborated. Measurements of the loss factor of impinging UCNs at ILL gave encouraging results.

For the test cryostat for measurements of the UCN production rate at the pulsed TRIGA reactor at the University Mainz a neutron valve between the storage volume and the UCN guide tube was constructed (see Fig.1). The funding of this project was approved in March 2002.

Theoretical investigations of the effects of ionizing radiation on the para content of solid deuterium predict a temperature dependent equilibrium between para production during the recombination of atoms and conversion to the ortho-state, catalyzed by D-atoms. For the conditions expected in the Mini-D_2 source an acceptable para concentration of $6 \cdot 10^{-3}$ is predicted [2].

Calculations based on neutron diffusion theory showed, that a buffer volume added to the UCN-storage tube of about the same size as the experimental volume could be very helpful to improve the maximum UCN-density in the experiment. Presently work is going on for the proper matching of the source and representative experiments.

First calculations of the radiation dose in the experimental hall outside the Mini-D_2 source by F. Grünauer (FRM-II) gave valuable hints for modifications of the shielding.

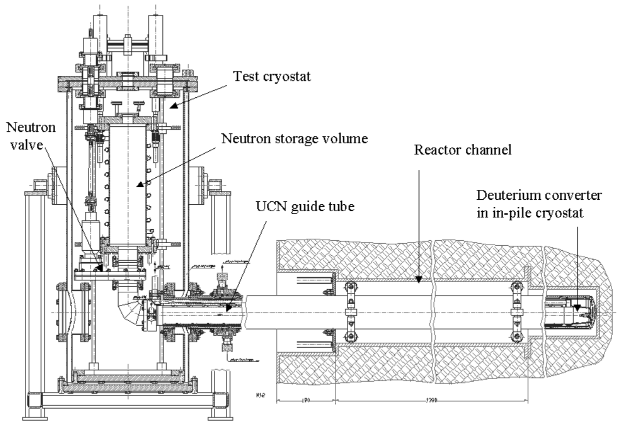

Fig. 1: Vertical cross section of the test facility

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References

[1] I. Altarev, F.J. Hartmann, S. Paul, W. Schott, and U. Trinks, Internal Report TUM-E18, Oct 2000
[2] S. Gröger, diploma thesis, TU München, 2001