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 ≈ 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. At the end of the storage tube a neutron buffer volume will be installed to improve the maximum UCN density in the attached experiments. By opening a valve at the end of the buffer volume, which is already in the experimental hall, up to $5 \cdot 10^8$ 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 2002 the technical layout of all parts of the Mini-D_2 source and its supplying systems was finished. A multiple-barrier concept against basin water loss and for secure inclusion of D_2 has been implemented in the design. Some important parts of the barriers have been successfully tested, for example the double walled membrane bellows between the inpile cryostat and the end plate of the beam tube SR-4. Another critical part of the barriers is the neutron exit window, which consists of three thin Al foils stabilized by a special grid. Thickness and layout of the grid have been adapted to withstand the expected mechanical stress.

Shielding simulations with MCNP have been performed to find out if the required protection against radiation can be achieved. Due to the results, the design of some parts of the Mini-D_2 source has been changed. Most important, an intermediate cryostat has been added. This allows on the one hand to change the beam direction horizontally and vertically, and on the other hand to insert more concrete shielding to block the direct view to the reactor core. Simulations with the new shielding show that the maximum radiation dose stays below the required limit.

Major efforts have been reached in the commissioning of the D_2 gas system. The safety vessel containing all parts of the system has been manufactured and was certified by the safety authorities. Nearly all parts of the gas system, multiple valves, tubes, sensors, vacuum pumps and a mass spectrometer, are now assembled and mounted inside the vessel. A SIMATIC S7-400 SPS-system to control and observe these parts has been programmed. In the nearest future the SPS will start operation.

Calculations based on the neutron diffusion theory showed, that a buffer volume added to the UCN-storage tube of about the same size as the experimental volume will improve the maximum UCN density in the experiment. Therefore a buffer volume of about 100 l has been embedded in the Mini-D_2 concept. The buffer is located near the end of the storage tube. According to calculations, a maximum neutron density of $5500/\text{cm}^3$ in the experiment will be reached with this configuration. Hence up to $5 \cdot 10^8$ UCN can be supplied to an attached experimental setup every few minutes.

To increase experience in freezing out D_2, a test croystat has been developed and is currently built. UCN production with this test cryostat connected to the D_2 gas system will take place at the TRIGA reactor of the Mainz University. These tests can give valuable hints on the moderation of neutrons with a solid deuterium converter.

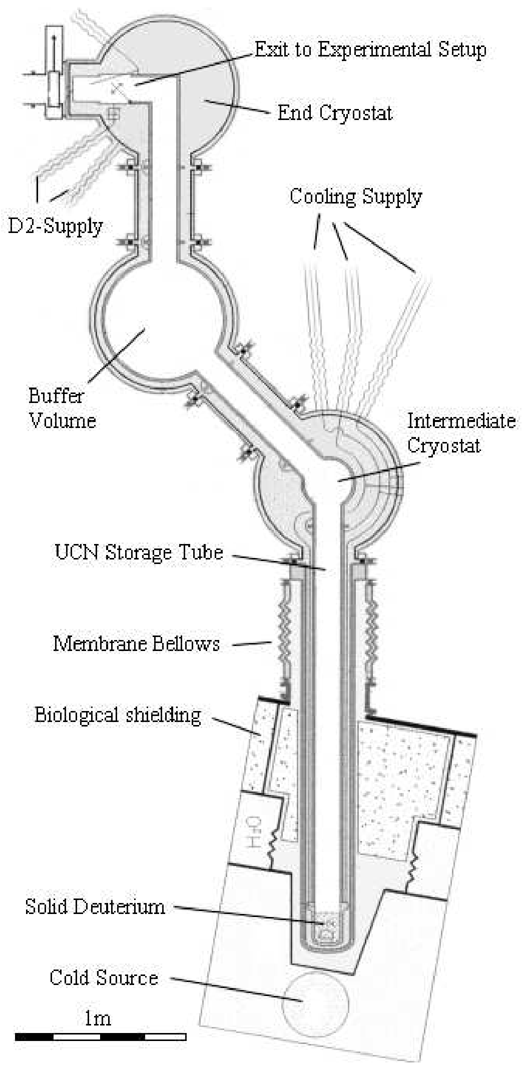

Fig. 1: The Mini-D_2 source inside of the SR-4 beamtube (schematic).

References

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