A Prototype of 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. 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 $5 \cdot 10^5$ UCN/cm^{2}s. More details on the Mini-D_2 UCN source are given in an internal report [1].

In the year 2005 a test setup to study UCN production has been taken into operation at the pulsed TRIGA-reactor at the University of Mainz. This setup consists of all the essential parts for producing UCN in the same geometry as it will later be in the Mini-D_2 source, such as the UCN converter filled with solid deuterium, the UCN storage tube, the deuterium gas system and the electrical controlling and measuring system. With this setup one is able to measure the different effects wich have influence on the UCN production, such as the para-D_2 to ortho-D_2 ratio in the converter or the temperature of the converter. Also systematic studies of different loss factors in storing the UCN or by transporting them through the storage tube can be done. Furthermore different types of UCN detectors can be installed in this setup and their efficiency can be measured. For the technical side boundary conditions are demanding. High vacuum, very clean system, very low temperatures together with big gradients (from 5 K to 300 K) made the technical realization on the one hand difficult, but gave on the other hand the opportunity to study the technical feasibility of many components of the Mini-D_2 source with the test prototype. After some optimization processes this resulted in a redesign of some parts of the setup, such as the UCN storage tube and the converter.

The test setup has been installed in the tangential beam tube "C" of the TRIGA reactor in Mainz. UCN are produced there by reactor pulses of 250 MW_{th} for 30 ms. At the present state more then 200 pulses on the D_2 converter have been performed. Until now mainly the UCN count rate depending on the amount of frozen D_2 has been measured. Therefore a Si pin diode covered with ^{6}LiF has been used as UCN detector. A typical energy spectrum of this detector is shown in plot 1. The number of counted UCN at different amounts of frozen D_2 normalized to the reactor pulse energy is shown in plot 2. Hereby the large variations in the count rate come from different temperatures of the frozen D_2.

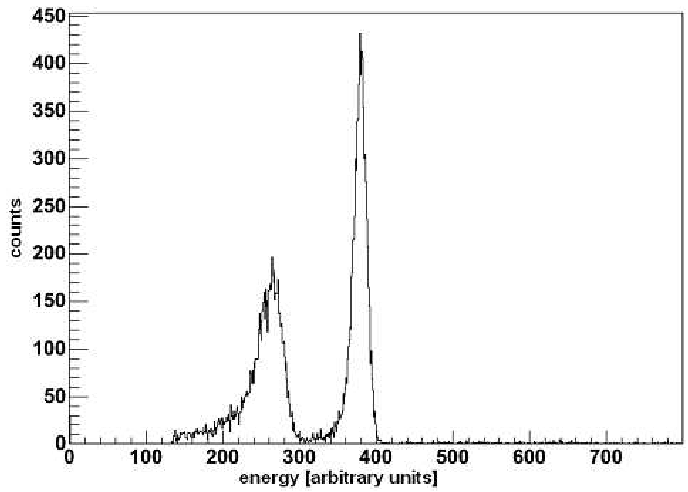

Fig. 1: Energy spectrum of the UCN detector. The conversion reaction is $^6\text{Li} + \text{n} \rightarrow \alpha + \text{t} + 4.78$ MeV.

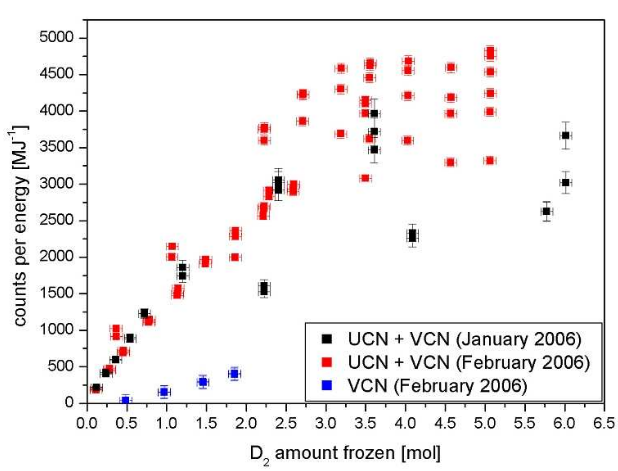

Fig. 2: Number of UCN counted at different amounts of frozen D_2.

The test measurements in Mainz gave already valuable hints on the conversion of neutrons with a solid deuterium converter. In the following weeks and months the systematic studies on the prototype will continue. These results will be taken into account for the Mini-D_2 setup at the FRM-II.

References

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