Monte-Carlo simulations of the ultra-cold neutron transport in the test solid deuterium source at channel C of the TRIGA Mainz.

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At the beginning of 2006, ultra-cold neutrons (UCN) were obtained for the first time at the prototype UCN-source of the research reactor TRIGA Mainz [1]. The source is located at the tangential beam port C of the reactor. During 2007 many improvements were carried out to optimize the production and extraction of UCN. Finally, up to 200000 very- and ultra-cold neutrons were detected at 10 MJ reactor pulses [2]. Even more UCN are expected with the installation of a newly designed source at the radial beam port D in summer 2008. One significant improvement will be the higher neutron flux at this position directly in front of the reactor core.

The source is based on a solid deuterium converter from which UCN are transported via a 5.5 m neutron guide to the detector. The efficient extraction of UCN from the converter and the transport via the neutron guides is a crucial factor. Therefore, we carried out Monte-Carlo simulations of the UCN-transmission from the source to the experiment.

In these calculations, the following model was used: Solid deuterium in form of a cylinder of diameter 66 mm and thickness *d* is located next to the reactor core in a straight cylindrical stainless steel neutron guide with a length of 3.5 m. The neutron guide is separated after a distance of 3.5 m from the converter by an aluminum foil (0.1mm thickness). Downstream follows the experimental part of the neutron guide containing bends of 45 and 90 degree as shown in Fig. 1:

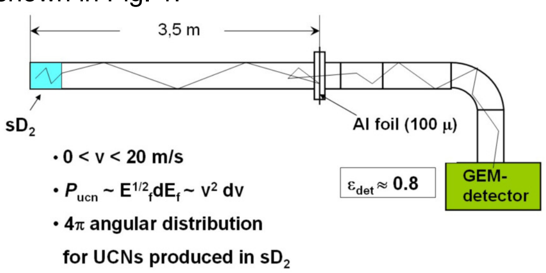

Fig. 1: Schematic view of the setup for the MC simulation.

The production rate of UCN was obtained in accordance with [3] using MCNP calculations of the neutron flux at the converter position. UCN losses in deuterium were simulated using the mean free loss length for slow neutrons as parameter and also taking into account the wall-potential of solid deuterium which can reflect neutrons back inside the converter. For the calculation of the propagation of neutrons through the neutron guide, the influence of gravity and the dependence of different neutron guide parameters, such as diffuse reflection and losses of neutrons per collision due to absorption, were taken into account. The transmission through the separating aluminum foil as well as through the detector aluminum entrance window was simulated directly for each incident angle of entering neutrons using the known wall-potential of aluminum for reflection and refraction and neutron capture cross-section for losses. The comparison between the simulated and measured Time-of-Flight spectra after the reactor pulse is shown in Fig. 2:

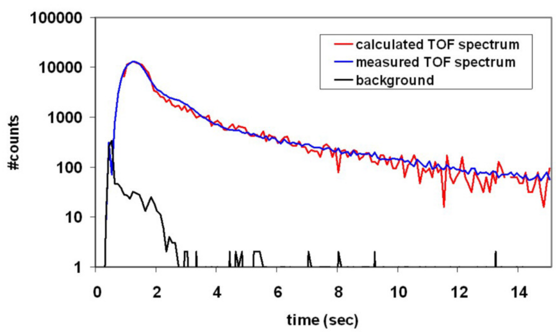

Fig. 2: Simulated and measured Time-of-Flight spectra of very- and ultra-cold neutrons after the reactor pulse.

As final result we obtained a UCN-transmission of only 25 – 30% for velocities smaller than 6 m/s. This shows the necessity to further improve the extraction and transmission of the UCN by polishing of the neutron guides and coating with materials of higher wall-potentials like Nickel or Diamond-like-Carbon.

1. I.Altarev et. al., Jahresbericht Inst. f. Kernchemie 2005
2. A.Frei et al., Eur.Phys.J.A34,119–127(2007)
3. Z.Ch.Yu et al., Z.Phys. B62, 137-142 (1986)