Neutron velocity distribution from a solid deuterium ultracold neutron source.

I.Altarev [3], M. Daum[4], A.Frei [3], E.Gutsmiedl [3], G.Hampel[1], F.J.Hartmann [3], W.Heil [2], A. Knecht[4], J.V.Kratz[1], Th.Lauer[1], M. Meier[4], S.Paul [3], U. Schmidt[5], Y.Sobolev [1,2], N.Wiehl[1], G. Zsigmond[4]

[1] Institut für Kernchemie, Universität Mainz, D-55099 Mainz, Germany; [2] Institut für Physik, Universität Mainz, D-55099 Mainz, Germany; [3] Physik Department E18, Technische Universität München, D-85748 Garching, Germany; [4] Paul-Scherrer-Institut, Villigen, Switzerland, [5]Physikalisches Institut, Ruprecht-Karls-Universität, Heidelberg, Germany

We have determined for the first time the velocity distribution of neutrons from a solid deuterium UCN source at the TRIGA Mark II reactor of Mainz University using a chopper and the time-of-flight method [1]. The measured time-of-flight distribution is shown in Fig. 1.

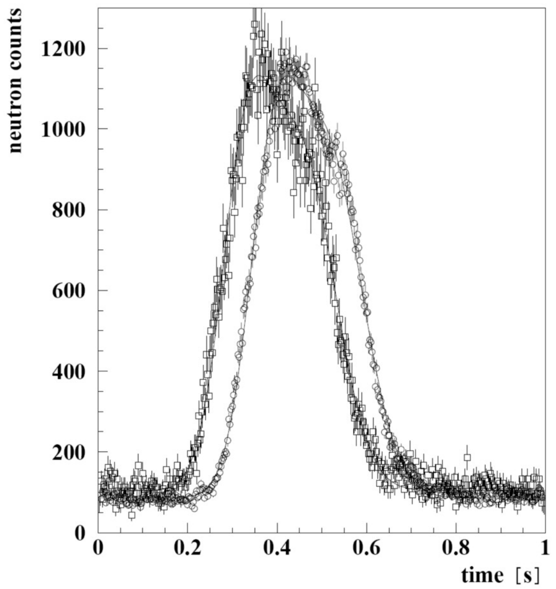

Fig.1: Time-of-flight spectra for a flight path of 1.616 m. The converter volume was 4 mole, the chopper frequencies were 1.00 Hz (open squares) and 0.75 Hz (open circles). The solid line is a fit (two Gaussians) for the parameterization of the data. The horizontal shift of the two spectra is due to an electronic offset.

The velocity distribution is obtained in several steps:
(a) The data were fitted by two Gaussians in order to obtain smooth functions before the deconvolution, see Fig. 1.
(b) The background was subtracted.
(c) In the next step, the time offsets, $\delta t(\upsilon_i)$, of the chopper corresponding to the two respective frequencies υ_i were subtracted.
(d)The spectra were deconvoluted with the resolution function of the chopper [1].
The data represent the neutron event distribution dN/dt. In order to obtain a velocity distribution dN/dv parallel to the guide axis, we performed the following steps:
(i) we multiplied the data with the derivative $dt/dv = t^2/d$, where d is the flight path;
(ii) we converted the TOF axis to $v = d/t$.
The absolute velocity spectrum of UCN is shown in Fig. 2:
(1) The neutron spectrum rises sharply above 4.5 m/s. After transport in an 8 m stainless-steel neutron guide, the distribution has a maximum around 7 m/s, and decreases approximately exponentially above this velocity.
(2) The yield of neutrons with velocities below 4.5 m/s is very small and can be explained by diffuse, i.e. non-specular, scattering where the neutron guide can also be considered as an UCN storage chamber.
(3) The number of storable neutrons in an experiment can be increased considerably (by a factor ~2) by placing the corresponding experimental setup about 1 m above the UCN guide from the reactor.
(4) It is demonstrated that the new superthermal neutron source with a solid deuterium UCN converter provides also 'very cold neutrons' for experiments with velocities 7 m/s $< v_n < \sim 25$ m/s and are so far only available at the ILL in Grenoble.

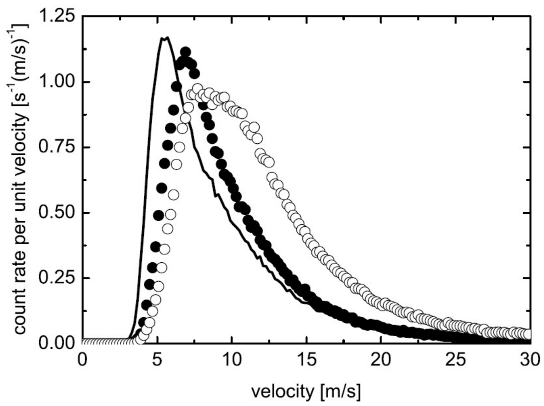

Fig.2: Neutron velocity distribution from the solid deuterium ultracold neutron source at TRIGA Mainz. Full dots: data from the optimized 4 mole source. The line represents the velocity component parallel to the neutron beam axis. Open circles: data from the (not optimized) 6.1 mole source

[1]. P. Fierlinger et al., NIMA 557, 572 (2006).