Low-Threshold Proton-Recoil Detectors for nELBE

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Part of Diploma thesis R. Beyer

For experiments with neutrons at the new neutron time-of-flight source (nELBE) [1] at FZD, and at the existing bremsstrahlung facility [2] fast plastic-scintillation detectors with relatively high efficiency also for neutrons with kinetic energies below 100 keV have been developed [3].

The detectors are made from strips of EJ-200 and have a detection area of 1000 x 42 mm^2 and thicknesses of 11 or 22 mm. In order to determine the position of the detection reaction and to improve the signal to noise ratio, the scintillators are read out in coincidence by two Hamamatsu R2059-01 PMTs, one at each end. A dedicated VMEbus-based data acquisition (DAQ) setup was assembled. Two 32-channel QDCs (CAEN V792) integrate the analog signals of both PMTs to obtain the light output signal. One TDC (CAEN V1190A) is used to determine the timing information. The timing signals are delivered by CFDs (CFT5386), which are an inhouse development being optimized for the signals of the scintillator material used. The start for the time-of-flight (ToF) measurement is given by a reference signal (e.g. the timing signal of the ELBE accelerator). To obtain a low neutron detection threshold, the PMTs are operated at highest gain ($\sim 2{\cdot}10^7$) while the CFD threshold is set to about 50 mV, resulting in a trigger level just below the single-photo-electron peak (SEP) of the PMTs. By adjusting the trigger threshold relative to the SEP, one can set a quite stable and well reproduceable detection threshold [3].

From measurements with a collimated ^{90}Sr electron source one obtains a position resolution of about 5.3 cm (FWHM) and a time resolution of of about 670 ps (FWHM). For neutrons with a kinetic energy of 1 MeV and a flight path of 4 m this time resolution causes an energy resolution of less than $\Delta E/E =$ 0.5 %. The efficiency of the detectors has been determined at Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, with quasi-monoenergetic neutron fields from (p,n) reactions on ^{3}H or ^{7}Li [4]. The neutron yield is monitored by well-calibrated neutron counters [5]. In Fig. 1 the measured ToF spectra taken with one detector and a neutron energy of 73 keV are shown. In the upper panel the comparison of the time-of-flight spectra measured with and without a polyethylene shadow bar is shown. Both measurements have been normalised to the same neutron fluence. The width of the ToF peak is dominated by the energy loss of the proton beam inside the target which was simulated with the Monte-Carlo program TARGET [6]. The background subtracted spectrum is shown in the lower panel of Fig. 1 for comparison with the simulated spectrum. Even the background of scattered neutrons can be reproduced reasonably well. Six plastic scintillation detectors were calibrated at five different neutron energies E_n: 24, 73, 150, 560 and 1200 keV. The results of the efficiency determination are plotted in Fig. 2. The main result is, that for neutrons with a kinetic energy of only 24 keV, efficiencies of about ten percent were obtained for all detectors.

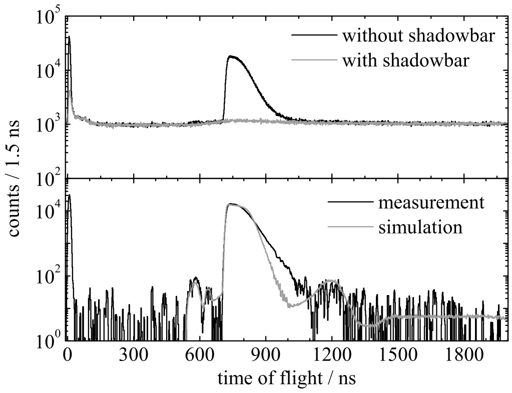

Fig. 1 *Measured ToF spectra for one detector at $E_n =$ 73 keV (see text).*

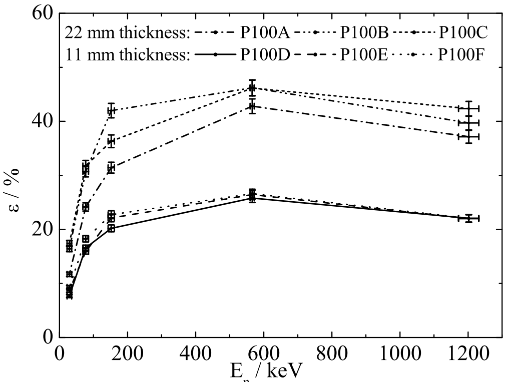

Fig. 2 *Measured intrinsic neutron-detection efficiency for 6 different detectors. The efficiency may vary due to different light collection efficiencies.*

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