**Dependence of the excess energy distribution for the quasi-free $pn \to pn\eta'$ reaction on the deuteron wave function model**

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The $\eta$ and $\eta'$ meson production in the collisions of protons with neutrons will be measured by the COSY-11 collaboration in March 2002 [1] using a COSY proton beam and a deutron cluster target. The experimental aim is to determine the total cross section for the reactions $pn \to pn\eta$ and $pn \to pn\eta'$ as a function of the excess energy Q. A simultaneous measurement of the fast neutron and proton as well as the slow backwards flying spectator proton will allow to identify the reaction and to determine the excess energy for each event. However, in order to extract the total cross section from the number of identified reactions at a given Q value, the knowledge of the geometrical acceptance and efficiency of the detection system alone will not be sufficient. It will require an assumption of the nucleon momentum distribution in the target deuteron. There exist several models that describe the distribution of the nucleon momentum inside the deuteron [2–6]. In order to estimate the systematical uncertainty of the cross section determination due to the choice of the model a Monte-Carlo simulation of the quasi-free $pn \to pn\eta'$ reaction for Paris and CD-Bonn potentials have been performed. For the calculations the S- and D-wave components of the deuteron wave function were parametrized analytically in the momentum space according to the prescription given in reference [2]:

$$\frac{\psi_0(p)}{p} = \sqrt{\frac{2}{\pi}} \sum_{j=1}^{n} \frac{C_j}{p^2+m_j^2} \;;\; \frac{\psi_2(p)}{p} = \sqrt{\frac{2}{\pi}} \sum_{j=1}^{n} \frac{D_j}{p^2+m_j^2} \quad (1)$$

where the coefficients $C_j$ and $D_j$ can be found in [2] and [3] for the Paris and CD-Bonn potential, respectively. By means of the above equations the probability density of finding a nucleon with a Fermi momentum p inside a deuteron (see fig. 1) can be expressed as: $f(p) = p^2[(\psi_0)^2 + (\psi_2)^2]$, where the parameters $C_j$ and $D_j$ were chosen such that $\int_0^\infty f(p)dp = 1$ .

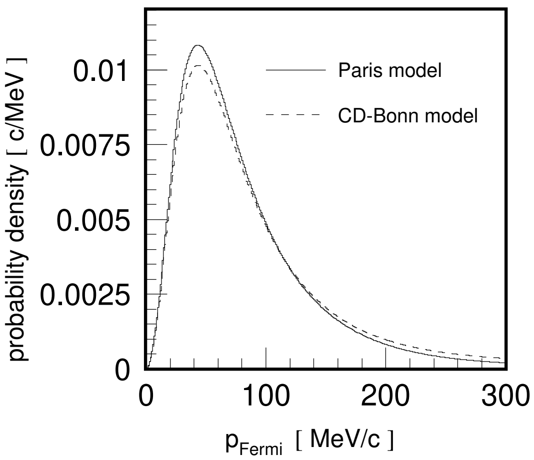


Fig. 1: Momentum distribution inside the deuteron as obtained for Paris (full line) and CD–Bonn (dotted line) potentials.

In the experiment, only spectators with total momenta up to 130 MeV/c will be registered [1]. In this momentum range the Fermi momentum distributions deduced from Paris and CD-Bonn potentials differ no more than by $\sim 6\%$. The resulting systematical error for the total cross section energy dependence originating from the choice of the deuteron potential may be estimated from the difference between solid and dashed line shown in Figure 2. In the performed simulations of the $pd \to p_{sp}pn\eta'$ reaction, it was assumed that the proton from a deuteron does not take part in the reaction and is on it mass shell at the moment of interaction. Thus in the framework of this impulse approximation the spectator proton is a physical particle and due to the energy and momentum conservation the reacting neutron is off its mass shell.

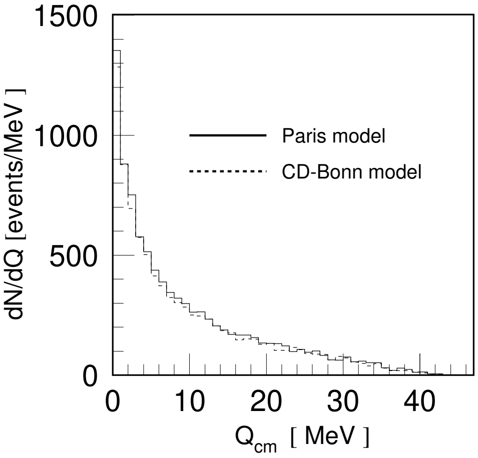


Fig. 2: Distribution of the excess energy $Q_{cm}$ for the quasi-free $pn \to pn\eta'$ reaction as simulated with the COSY-11 detection system at a beam momentum of $p_{beam} = 3.350$ GeV/c. Calculations have been performed assuming the target diameter equal to 0.9 cm, and standart deviations of 0.2 cm and 0.4 cm for the horizontal and vertical beam spread, respectively. The distance between the centre of spectator detector's pad and the centre of target was assumed to be $\Delta Z_{SD} = -3.4$ cm [7]. The neutron detector was set at the distance of 430 cm from the target. The figure shows the number of reconstructed events per 1 MeV bin out of $5 \cdot 10^6$ generated $pd \to p_{sp}pn\eta'$ reactions.

Summarizing: The uncertainty, originating from the differences between the CD-Bonn and Paris potentials, in the correction factor ($F(Q) = dN/dQ \,/\, 5 \cdot 10^6$) necessary for the determination of the total cross section from a data, amounts to about 4 % only.

**References:**

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