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THE pd $\rightarrow$ ^{3}Heω REACTION

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Abstract

ω production in pd $\rightarrow$ ^{3}Heω has been studied with the WASA detector at two beam energies, $T_p = 1360$ MeV and $T_p =$ 1450 MeV. Angular distributions have been reconstructed and compared with results from calculations using a two-step model. There is a qualitative agreement between data and theory at $T_p = 1360$ MeV but a disagreement at extreme angles at $T_p = 1450$ MeV.

1 Introduction

A study of the pd $\rightarrow$ ^{3}Heω reaction, with focus on the full angular distribution, is currently being carried out by the CELSIUS/WASA collaboration. Data were taken at two beam energies, $T_p = 1360$ MeV and $T_p = 1450$ MeV, corresponding to excess energies of 17 MeV and 64 MeV, respectively. This reaction has been studied near the kinematic threshold before [1-3], but [1] only lead to preliminary results, [2] remains unpublished and the correctness of the data interpretation in [3] has been questioned [4].

On the theoretical side, production of η, ω, ϕ and η' in pd $\rightarrow$ ^{3}HeX were studied in, e.g., [5] and [6]. However, no attempts to calculate the full angular distribution have been made until now, when the ongoing experimental investigation has raised an interest for the reaction.

2 Analysis of the WASA data

The data in this work were taken with the WASA detector [7] in Uppsala, Sweden, using a proton beam impinging on a deuterium pellet target [8]. The ^{3}He's were identified by the $\Delta E/E$-method as described in [9] and [10]. We focus on the $\omega \rightarrow \pi^+\pi^-\pi^0$ decay channel ($BR = 89.1\%$). The selection

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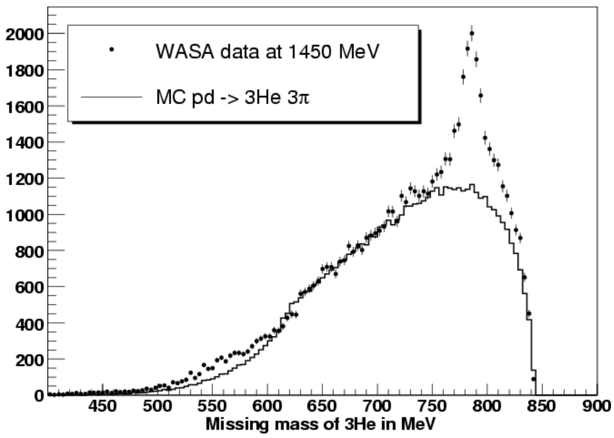

Figure 1: 1450 MeV data (dots) with cuts optimized for $\omega \rightarrow \pi^+\pi^-\pi^0$ and simulated $\pi^+\pi^-\pi^0$ data (line).

criteria are described in [10]. The constraints given there give an acceptance of 39% at $T_p = 1450$ MeV while it is 36% at $T_p = 1360$ MeV. In Fig. 1 and 2, the ^{3}He missing mass distributions at both energies are shown. The major part of the background comes from pion production in pd $\rightarrow$ ^{3}He$\pi^+\pi^-\pi^0$, but also from overlapping events and beam halo interacting with either rest gas or the beam pipe.

The aim of this work is to reconstruct the differential cross section as a function of $\cos\theta^*_\omega$. The procedure is described in [10] and [11]. At $T_p = 1450$ MeV, the normalization is performed using the SPES3 point at $\cos\theta^*_\omega = -0.65$ [2]. The resulting angular distribution is shown in Fig 3.

The analysis of the 1360 MeV data is more difficult. Firstly, ω has a finite width ($\Gamma = 8.44$ MeV), which close to threshold means that $\omega's$ with high mass cannot be produced, giving an asymmetric ω peak. Secondly, the background fitting is more difficult since the background continuum ends under the ω peak(see Fig 2). Thirdly, the signal-to-background ratio is small. The statistical and systematical uncertainties are thus significantly larger at 1360 MeV, which is clear from Fig 4. The angular distribution at $T_p = 1360$ MeV is very preliminary and the normalization arbitrary.

3 Model calculations

A theoretical study of this reaction has been carried out using a two-step model (see diagram and details in [12]). The T-matrix for this mechanism, which favors sharing of the large momentum transfer ($\sim$ 1 GeV at both

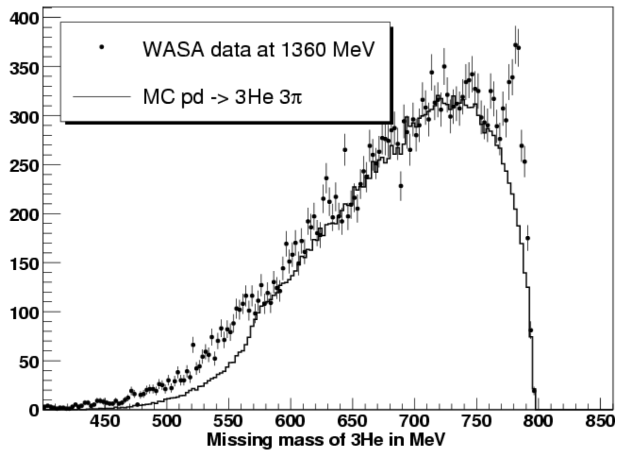

Figure 2: 1360 MeV data (dots) with cuts optimized for $\omega \to \pi^+\pi^-\pi^0$ and simulated $\pi^+\pi^-\pi^0$ data (line).

energies), can be written as

$$\langle|T_{pd\to{}^3He\omega}|\rangle = i\frac{3}{2}\frac{d\mathbf{P_1}}{(2\pi)^3}\frac{d\mathbf{P_2}}{(2\pi)^3}\sum_{int\,m's}\langle pn|d\rangle\frac{\langle|T_{pp\to\pi d}|\rangle}{K_\pi^2-m_\pi^2+i\epsilon}\langle|T_{\pi n\to\omega p}|\rangle\langle{}^3He|pd\rangle.$$

All the inputs for these calculations except the $\pi N \to \omega N$ T-matrix have been taken as in [13]. The $\pi N \to \omega N$ sub-process has been written in terms of the Giessen model [14], where it was shown that the reaction cross section could be explained well including up to l=3 partial waves, hinting towards importance of multiple resonances also in ω production in pd collisions. Hence, the calculations in this work also include all partial waves up to l=3. The result of the calculations performed in the plane wave approach, at T_p = 1450 MeV and 1360 MeV, is shown in Fig 3 (with the preliminary data from [10]) and 4, respectively. The figures also show the contribution of various partial waves to the cross sections. The results from the two-step model and the data at T_p = 1450 MeV clearly disagree at extreme angles. The addition of higher partial waves does not seem to change the shape of the distribution drastically though it does seem to be essential to reproduce the magnitude of the cross section. The result of the calculations at T_p = 1360 MeV looks, qualitatively, in agreement with the behavior of the − yet very preliminary − data. On the theoretical front, adding the ω − ^{3}He final state interaction to this model and further exploration of this reaction using different models for the production mechanism is in progress.

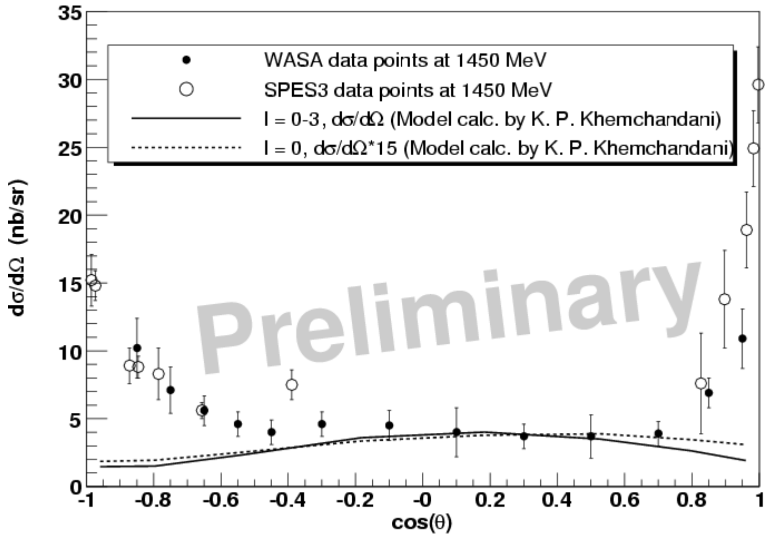

Figure 3: The WASA data points at T_p = 1450 MeV (black), the SPES3 data (white) from [2] and the model calculations given in Section 3. The error bars represent statistical and systematic uncertainties.

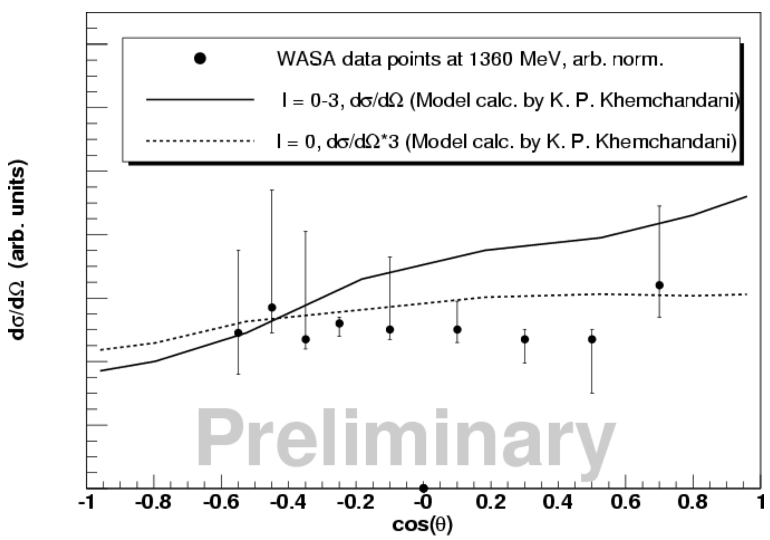

Figure 4: The new WASA data points at T_p = 1360 MeV, arbitrarily normalized, along with the model calculations described in Section 3.

References

[1] F. Plouin in *Production and Decay of Light Mesons*, ed. P. Fleury (World Scientific, Singapore, 1988), p. 114.

[2] T. Kirchner, Ph. D. thesis. (IPN Orsay, France, 1993).

[3] R. Wurzinger *et al.*, *Phys. Rev.* **C 51**, R443 (1995).

[4] C. Hanhart and A. Kudryavtsev *Eur. Phys. J* **A 6**, p. 325 (1999).

[5] G. Fäldt and C. Wilkin, *Phys. Lett.* **B 354**, p. 20 (1995).

[6] L.A. Kondratyuk *et al. Acta Phys. Pol.* **B 27**, p. 2977 (1996).

[7] J. Zabierowski *et al.*, *Physica Scripta* **T 99**, p. 159 (2002).

[8] C. Ekström *et al.*, *Physica Scripta* **T 99**, p. 169 (2002).

[9] K. Schönning *et al.*, *Acta Phys. Slov.* **56-3**, p. 299 (2006).

[10] K. Schönning *et al.* in *Proc. from the 2nd Int. η MesonNet Workshop* eds. M. Jacewicz and B. Höistad, 0710.1809v1[nucl-ex](2007).

[11] K. Schönning *et al.*, *Nucl. Phys.* **A 790**, p. 319c (2007).

[12] K. P. Khemchandani in *Proc. from the 2nd Int. η MesonNet Workshop* eds. M. Jacewicz and B. Höistad, 0710.1809v1[nucl-ex] (2007).

[13] K. P. Khemchandani, N. G. Kelkar and B. K. Jain, *Nucl. Phys.* **A 708**, p. 312 (2002); *ibid Phys. Rev.* **C68**, p. 064610.

[14] V. Shklyar *et al. Phys. Rev. C* **71**, p. 055206 (2005).