PION PRODUCTION FROM $dp \to dN\pi$-REACTIONS WITH DEUTERON BEAMS AT CELSIUS*

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The reactions $dp \to dp\pi^o$ and $dp \to dn\pi^+$ have been measured at CELSIUS with deuteron beam energies between 436 MeV and 558 MeV. The observed energy and angular distributions show contributions of comparable size from different production mechanisms like quasi-free $NN \to d\pi$ and a 3-nucleon $dN \to dN\pi$ production mechanism.

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1. Introduction

Pion-production in the *pd*-system is of particular interest, because it is the simplest one to study the influence of a multinuclear environment on a hypothetical quasi-free $NN \to NN\pi$-process. Excitation functions $\sigma_{pd\to pd\pi^0}(T_p)$ with projectile protons of energies between the $3N$ and $2N$ thresholds for π^o production could be described as quasi-free $pn \to d\pi^0$-interaction plus a spectator-proton, whereas the observed energy-spectra indicated substantial contributions from other reaction mechanisms [1,2].

Recently the option of the CELSIUS-accelerator to store cooled deuteron-beams has been used to study the reactions $dp \to dp\pi^0$ and $dp \to dn\pi^+$ at energies between $T_d = 436$ MeV and $T_d = 558$ MeV, corresponding to pion momenta $\eta = p^{\pi}_{\mathrm{c.m.max}}/m_\pi c$ ranging from 0.3 to 0.9 [3].

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2. Experimental setup

The WASA/PROMICE detector [4] allowed to cover a large fraction of the accessible phase-space, which is necessary for more detailed investigations of production mechanisms. In particular the usage of the CELSIUS *deuteron beam* gives access to the phase space region at which a spectator proton (neutron) in the case of π^0 (π^+) production from the interaction of the target proton with the neutron (proton) of the projectile can be expected [5].

The events are identified by a kinematically complete measurement of the outgoing charged particles and a reconstruction of the missing mass of the neutral particle. Therefore the charged particles have to be identified by E/dE-measurements in the Forward Detector. For the π^+-identification the delayed pulse from the myon-decay has been used as further constraint. Figure 1 shows the results for identified events at $T_d = 558$ MeV.

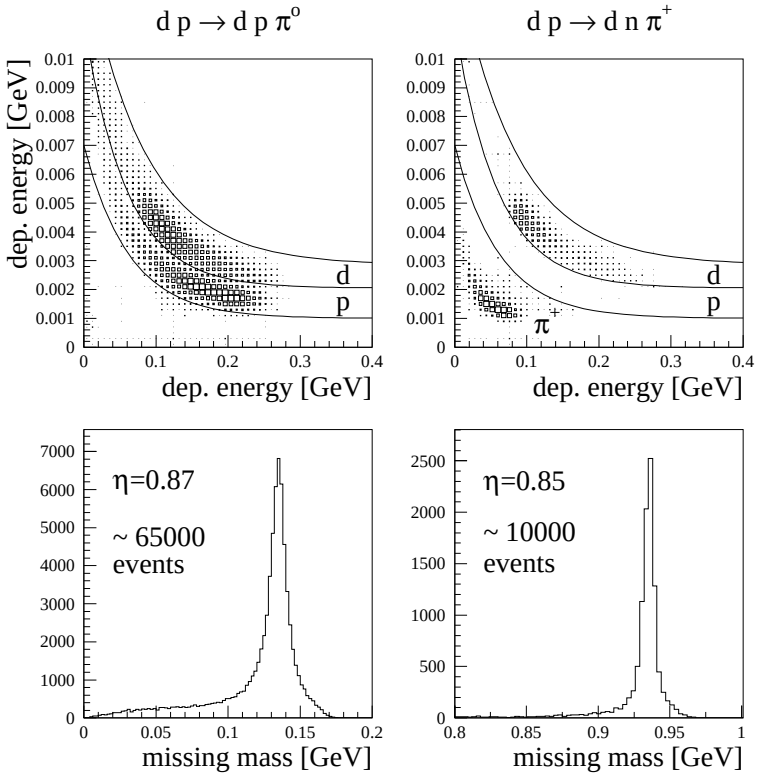

Fig. 1. *ΔE versus. E* plots and missing-mass distributions for selected events at $T_d = 558$ MeV.

3. First results

The statistics at the highest projectile energies are good enough to compare the measured energy and angular distributions with a GEANT Monte Carlo simulation based upon different model calculations. A quasi free NN process $Np \to d\pi$ which is described with the invariant matrix-element [6]

$$\propto |\Phi_d(\kappa)|^2 \frac{d\sigma_{pN\to d\pi}}{d\Omega_{q_\pi^*}}(\eta^*)\,, \tag{1}$$

is compared with a partial wave parametrisation for an assumed $Nd \to Nd\pi$-process where

$$\propto |\vec{p}_{Nd} \cdot (A + B\cos(\Theta_N))|^{2L_{Nd}} |\vec{q}|^{2l_\pi} \tag{2}$$

is used. Here $\vec{p}_{Nd}$ is the nucleon-momentum within the Nd-system and $\vec{q}$ the pion momentum with respect to it. In addition a Watson–Migdal approximation for the final state interaction at $L_{Nd} = 0$ has been applied.

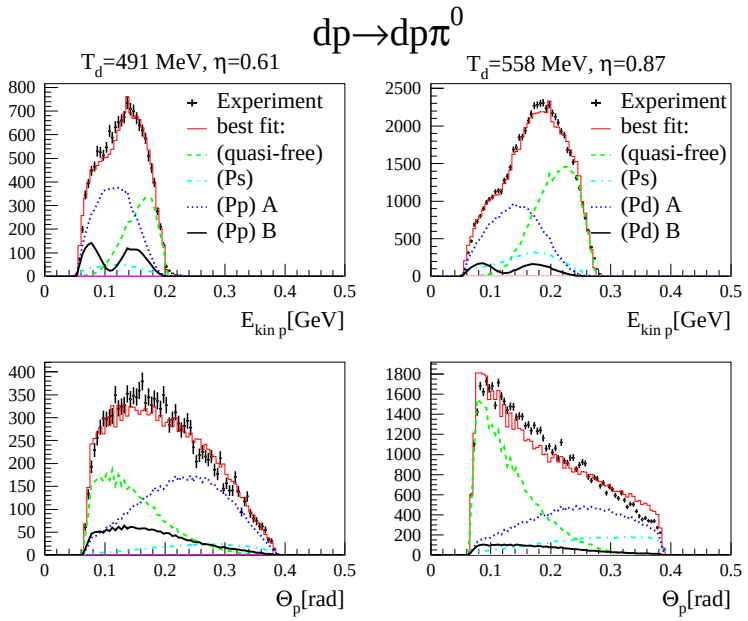

Fig. 2. Proton energy and angular distributions in comparison with different model calculations. The left column shows distributions for $dp \to dp\pi^0$ at $T_d = 491$ MeV and the right column at $T_d = 558$ MeV. The separate contributions to the best fit are also shown.

Figure 2 shows this preliminary comparison at two energies. Partial waves up to $L_{Nd}l_\pi = Pd$ have been included in the Monte Carlo. One

can clearly see, that neither the quasi-free NN-process nor the assumed nucleon–nucleus parametrisations alone describe the experimental data. In particular the protons at large angles cannot be pure spectators. However, an incoherent superposition (best fit) with comparable contributions from both mechanisms leads to a good agreement. At the highest energy the quasi-free process accounts for more than fifty percent of the cross section but becomes less important at lower energies.

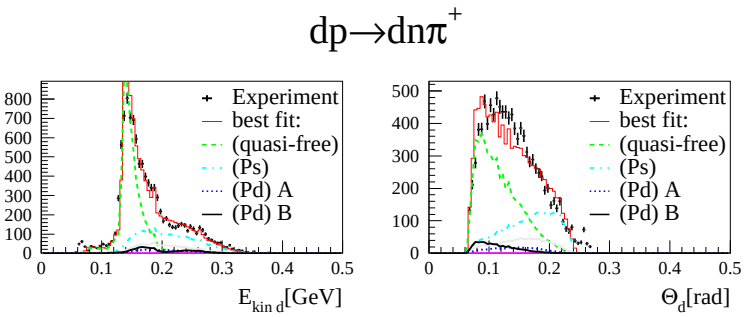

Fig. 3. Deuteron energy and angular distributions for $dp \to dn\pi^+$ at $T_d = 558$ MeV corresponding to $\eta = 0.85$

A similar excess over the prediction of the quasi-free mechanism can be observed for the deuterons from $dp \to dn\pi^+$ at high energies and angles (figure 3), respectively, indicating that the neutron must have participated in the interaction.

REFERENCES

[1] H. Rohdjeß *et al.*, *Phys. Rev. Lett.* **70**, 2864 (1993).
[2] H. Rohdjeß, PhD Thesis, Hamburg 1994.
[3] Experiment CA40 at CELSIUS (TSL Uppsala 1996,1997).
[4] R. Bilger *et al.*, *Acta Phys. Pol.* **29**, 2981 (1998).
[5] J. Greiff *et al.*, *Acta Phys. Pol.* **B27**, 2965 (1997).
[6] H.O. Meyer, J.A. Niskanen, *Phys. Rev.* **C47**, 2474 (1993).