Near-Threshold Production of ω Mesons in the pn → dω Reaction

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The first measurement of the $pn \to d\omega$ total cross section has been achieved at mean excess energies of $Q \approx 28$ and 57 MeV by using the forward array of the ANKE spectrometer and a silicon telescope placed close to the target. The cross sections lie above those measured for $pp \to pp\omega$ but significantly below theoretical predictions.

The comparison of the cross sections for meson production in proton-proton and proton-neutron collisions test theoretical models describing the production mechanisms. For η production the observed ratio $R = \sigma_{tot}(pn \to pn\eta)/\sigma_{tot}(pp \to pp\eta) \approx 6.5$ [1] is generally attributed to isovector dominance in model calculations based on meson exchange [2]. It is therefore interesting to investigate whether a similar isospin dependence is found also for the ω, the next heavier isoscalar meson. Relatively few experiments were performed for the $pp \to pp\omega$ [3, 4] reaction, and no data whatsoever are available in proton-neutron collisions.

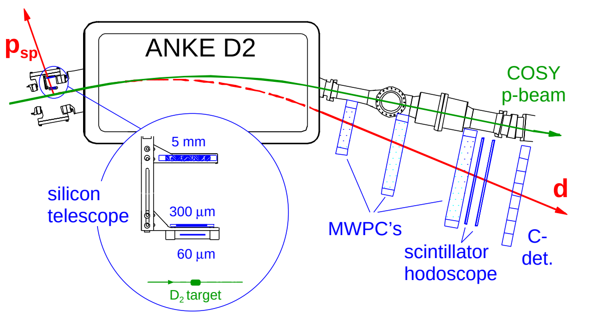

Fig. 1: Top view of the detector set-up at ANKE used for the detection of the slow recoil proton "p_{sp}" and a fast deuteron "d" from the reaction $pd \to p_{sp}d\omega$. Magnified is the silicon telescope used for the spectator detection.

The $pn \to d\omega$ reaction was studied in the $pd \to p_{sp}d\omega$ reaction at four proton beam momenta between 2.6 and 2.9 GeV/c at ANKE (Fig. 1). A deuterium cluster-jet target was used as an effective neutron target, detecting the recoil protons (p_{sp}), which have momenta of about 80 MeV/c, in a silicon telescope placed close to the target [5]. These recoil protons can be treated as "spectators" that influence the reaction only through their modification of the kinematics. By varying the angle and momentum of the spectator protons, a certain range in excess energy Q is selected experimentally. This range is used to extract results in pn collisions for the corresponding Q values. The deuterons emitted at angles below 8° with momenta around 2 GeV/c were detected in the forward system of the ANKE spectrometer. Inclined Čerenkov counters in combination with two layers of scintillation counters enabled us to identify these deuterons despite a two orders of magnitude higher proton background [5]. Their momenta were reconstructed using the information from two multi-wire proportional chambers. The $pn \to d\omega$ reaction was then identified *via* the missing mass technique. In order to normalise the data, the absolute luminosity was determined by pd elastic scattering, employing the possibility to identify slow deuterons simultaneously in the silicon telescope [5].

Measurements of $pp \to pp\omega$ at SATURNE [3] show there to be a strong contribution from multi-pion production below the ω peak in the missing mass spectrum. This can only be reliably estimated by comparing data above and below the ω threshold. We used experimental data at 2.6, 2.7, 2.8 and 2.9 GeV/c beam momentum, which correspond to mean Q values in $pn \to d\omega$ of -40, -5, 28 and 57 MeV respectively. At the highest energy, there is clear evidence for an ω peak, whereas at 2.8 GeV/c the residual ω signal depends much more sensitively upon the background description. The cross sections σ for $pn \to d\omega$ are extracted to be $(2.6 \pm 1.6 \pm 2.3)\,\mu$b at $Q = (28^{+16}_{-20})$ MeV and $(9.0 \pm 3.2^{+3.6}_{-2.5})\,\mu$b at $Q = (57^{+21}_{-15})$ MeV, where the uncertainty in Q reflects the total width of the bin. The first error in σ is statistical and the second systematic. The fact, that the cross sections are significantly smaller than theoretical predictions, suggests that the reaction mechanism for ω production differs from that for the η, possibly implying a relatively larger contribution from isoscalar meson exchange. Measurements with higher precision in both Q and in cross section have been performed in August 2003 and are currently under analysis.

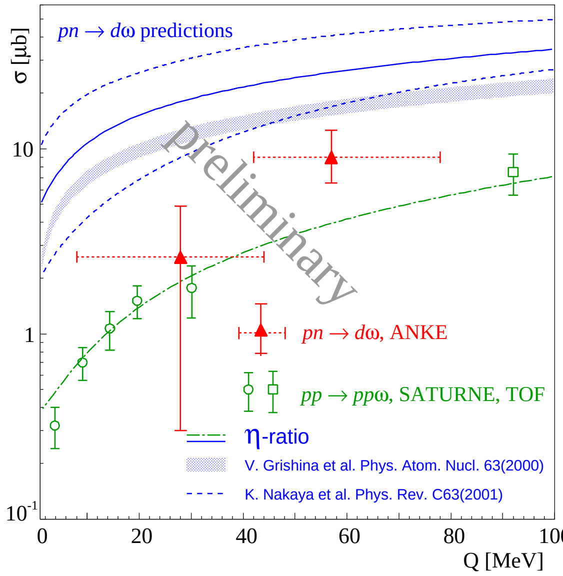

Fig. 2: Total cross sections for ω-production. The $pp \to pp\omega$ data are taken from SATURNE [3] (open circles) and COSY-TOF [4] (open square), whereas our two $pn \to d\omega$ points are given by the closed triangles. Only the systematic errors are shown as the statistical errors are smaller. The horizontal bars indicate the width of the Q ranges. The dot-dashed curve is the semi-phenomenological fit given in Ref. [3] to the $pp \to pp\omega$ results taking the ω width into account. If the ratio for $d\omega$ to $pp\omega$ were similar to that for η production [1], one would then obtain the solid curve, which predicts a $pn \to d\omega$ cross section of over 25 µb at 57 MeV. The predictions of the Jülich group depend upon the relative contributions of exchange and production current terms and lie between the two dashed curves [6]. The only other published estimate [7] is shown by the shaded area.

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Supported by DFG, Russian Ac. of Science, and FZ-Jülich.