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PHOTOPRODUCTION OF η'-MESONS WITH SAPHIR*

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The η' production was studied by searching for 5-track events from the decay chain $\gamma\mathrm{p} \to \mathrm{p}\eta' \to \mathrm{p}\pi^+\pi^-\eta$ (43.7%) $\to \mathrm{p}2\pi^+2\pi^-\pi^0/\gamma$(23.2%/4.78%) having a total decay probability of 10.1% for the π^0 branch. From this decay with only one neutral particle much less background is expected than from the 3-track decays of the $\gamma\mathrm{p} \to \mathrm{p}\eta'$ reaction, namely $\to \mathrm{p}\pi^+\pi^-\eta(\to 2\pi^0/2\gamma)$ or the decay $\mathrm{p}\eta' \to \mathrm{p}\rho\gamma \to \mathrm{p}\pi^+\pi^-\gamma$.

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1. Observed decay modes, existing data, and motivation

The present data stem from beam-times in January and April 1997 using the SAPHIR detector at ELSA and the new tagging facility TOPAS II which provided tagged photons between $0.9 \leq \mathrm{E}_\gamma \leq 2.6$ GeV at an electron beam energy of 2.8 GeV. SAPHIR is a 4π-detector for mass and momentum analysis of charged particles (for details see [2]). Here, we present our results on η'-photoproduction with a fifteen-fold higher statistics than the previous experiments. In fact, data on photoproduction of η'-mesons on the nucleon are very scarce. The ABBHHM-collaboration [3] in 1968 reports on about 11 events from investigating bubble-chamber tracks with an untagged γ-beam. Using tagged photons another experiment at DESY in 1976 [4] found approximately 7 η' candidates with a streamer chamber setup.

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2. Data selection and proton missing mass distribution

The analysis of the 1997 runs led to the following results: From 6×10^6 hadronic events 36.000 show 5 tracks with one common vertex inside the target, $\sum Q_i = +1$, and $E_\gamma \geq E_{\text{thr}}(\pi^+\pi^-\eta)$. We further cut in the product of the 4 probabilities that

i) an assumed particle type is not rejected by TOF (probability = 0 or 1),

ii) the invariant mass of $\pi^+\pi^-\pi^0$ is compatible with the η–mass,

iii) the missing mass of $\text{p}\pi^+\pi^-$ is compatible with the η–mass, and

iv) the momenta of $\pi^+,\ \pi^-,\ \pi^0$ in the rest frame of the found η are smaller than the allowed maximum momentum leaving 3750 events.

With this technique checked by Monte Carlo studies only a small fraction of η' is lost. 330 events remain above background at the η'-mass. After kinematical fits with 2 constraints on the π^+, π^-, π^0 system with fixed η-mass and strict conservation of the total energy ($E_{\text{in}} = E_{\text{out}}$) and an anti-cut on $\eta \rightarrow \pi^+\pi^-\gamma$ in order to reduce background we finally obtain 250 good η' events (*cf.* Fig. 1). Clearly, the process $\gamma\text{p} \rightarrow \text{p}\eta' \ \rightarrow \text{p}\pi^+\pi^-\eta$ is observed at rather low background **not** using the η'-mass in the analysis!

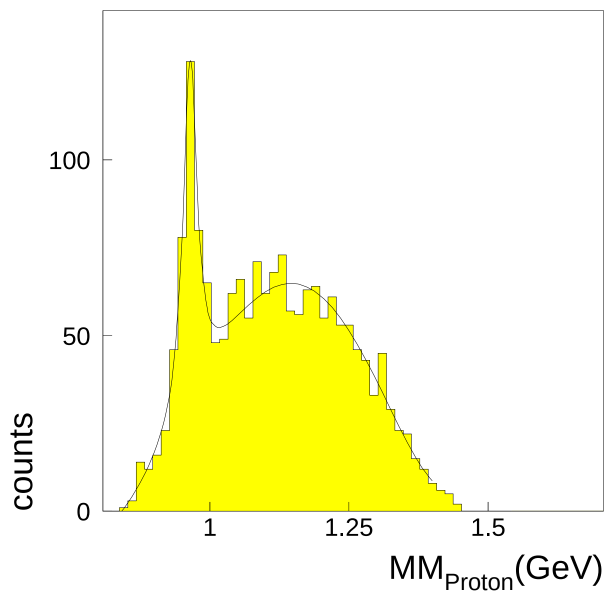

Fig. 1. Final proton missing mass distribution after 2Cfit.

3. Differential and total cross sections

The background of the η'-peak was subtracted for each of the 8 bins in energy and of respective 5 bins in $\cos\Theta^*$ where Θ^* reflects the angle between the outgoing η' and the direction of the γ-beam. The experimental event rates were corrected for the Monte Carlo determined acceptance and reconstruction efficiency (in total 2.5%) and were normalized to the incoming photon flux that was derived by comparing the simultaneously measured event rate from γp reactions leading to 3 charged particles with corresponding well known energy dependent cross sections [3]. The resulting total cross section is presented in Fig. 2 (•). Only statistical errors are shown. The deduced yields well agree with those of the ABBHHM [3] ($\times$) and AHHM [4] ($\circ$) groups. The measured angular distributions were analysed according to

$$d\sigma/d\Omega = q^*_{\eta'}/k^*_\gamma(A + B\cos\Theta^* + C\cos^2\Theta^*)\,. \tag{1}$$

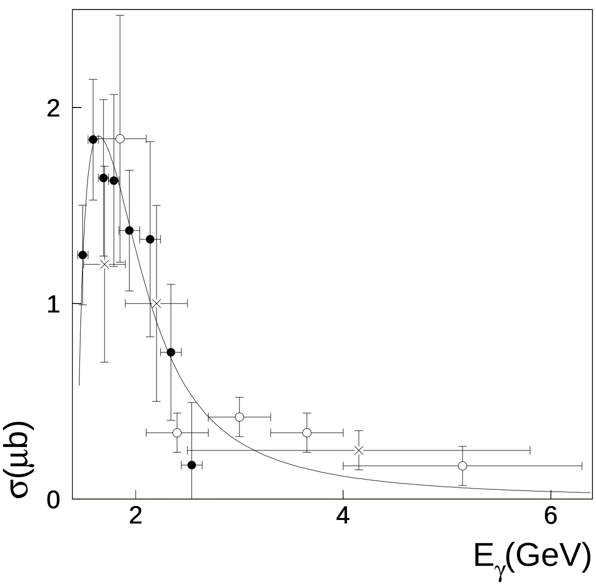

Fig. 2. Measured η' photoproduction cross section, for symbols see text.

The fits were consistent with $C \approx 0$, the experimental values of A and B with respective error bars are displayed in Fig. 3. The strong rise and fall of the total yield near the η'-threshold suggest that the Born terms and ρ– and ω–exchange in the t-channel should be neglected since their contributions would rather rise with energy. On the other hand, the strongly forward

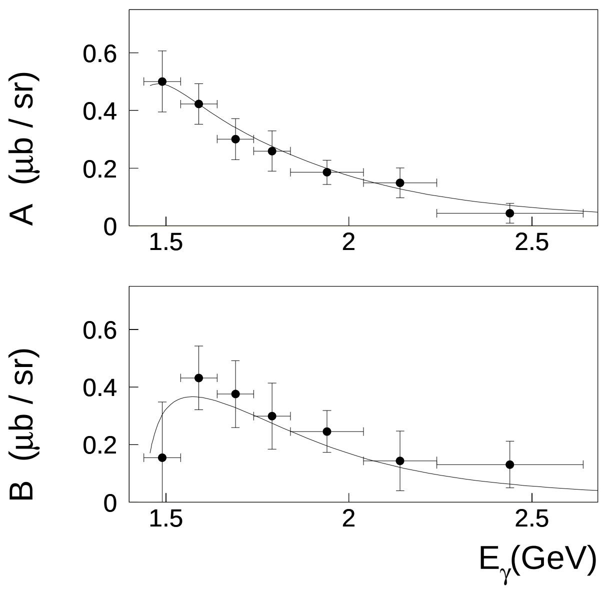

Fig. 3. Extracted A- and B-term of (1) as a function of E_γ and corresponding 2-Breit–Wigner resonance best-fit according (2) & (3).

peaked cross sections require at least two interfering resonances. We made the simplest ansatz with two Breit–Wigner resonances identifying them by a E_{0+} and a M_{1-} transition. They correspond to amplitudes of S_{11} and P_{11} resonances, respectively. The parameters A and B are defined by:

$$A \;=\; |E_{0+}|^2 + |M_{1-}|^2\,, \tag{2}$$

and

$$B \;=\; -2 \cdot \mathrm{Re}(E^*_{0+} \cdot M_{1-})\,. \tag{3}$$

From the 2-resonance best-fit mass, width and helicity coupling parameter of each resonance are obtained, namely $\mathrm{mass}_{S_{11}}$ of (1.89 ± 0.02) GeV with a width of (0.32±0.12) GeV and $\mathit{\Gamma}^p_{1/2} = (1.4 \pm 0.3)10^{-3}$ $\mathrm{GeV}^{-1/2}$ and $\mathrm{mass}_{P_{11}}$ of (2.04 ± 0.06) GeV with a width of (0.52±0.28) GeV and $\mathit{\Gamma}^p_{1/2} = (-2.8 \pm 0.6)10^{-3}$ $\mathrm{GeV}^{-1/2}$. It is worth to note that the data are compatible with the $S_{11}(2090)$ and $P_{11}(2100)$ resonances of the Baryon Particle Listings of Ref. [5] though other interpretations are not yet excluded.

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