International Journal of Modern Physics A
Vol. 20, Nos. 2 & 3 (2005) 690–692

World Scientific
www.worldscientific.com

η AND η' PHOTOPRODUCTION OFF THE NUCLEON

MARTIN KOTULLA
For the CBELSA/TAPS Collaboration
Department of Physics and Astronomy, University of Basel, CH-4056 Basel, Switzerland

We have measured the reaction $\gamma p \to \eta' p$ from threshold up to 2.6 GeV incident beam energy using the Crystal Barrel and TAPS detectors at the ELSA accelerator. At present the knowledge about the resonance contribution to this process is very limited. Our measurement is a significant improvement of the data basis. We will present preliminary results.

Keywords: Meson photoproduction; resonances.

1. Introduction

Most baryon structure calculations predict many excited states of the nucleon in the mass region around w=2 GeV. Experimentally observed is only a small number of states and it is important to understand whether this discrepancy is only due to experimental bias or related to the effective degrees of freedom of the nucleon. An important aspect in this discussion is the limitation of the data basis. Resonances which favorably decay into a scarce explored decay channel can easily be overlooked. Therefore, it is important to study alternative decay channels. Of particular interest is the reduction of the model dependence of a partial wave analysis in the threshold region, where only a few partial waves contribute. The best example is the investigation of η photoproduction which is completely dominated by the $S_{11}(1535)$ and has enormously contributed to the study of the properties of this resonance[1]. The η' photoproduction might open a similar possibility. So far, only low statistics measurements for η' photoproduction were available from old bubble chamber experiments[2,3] and a newer measurement by the SAPHIR collaboration[4]. The angular distribution of the latter experiment shows a strongly forward peaking and was interpreted by an interference of a S_{11} and a P_{11} resonance with pole positions between 1.89 to 2.18 GeV and 1.89 to 2.05 GeV, respectively. However, this interpretation is not unique. Sibirtsev *et al.*[5] reproduce the data with a $\rho, \omega - t$ channel exchange in combination with the subthreshold $S_{11}(1535)$ excitation. Chiang *et al.*[6] have developed a Reggeized model for η and η' photoproduction and interprete the SAPHIR data by a strong Regge contribution interfering with an S_{11} resonance around 1950 MeV and a possible further contribution from an P_{11} or P_{13}

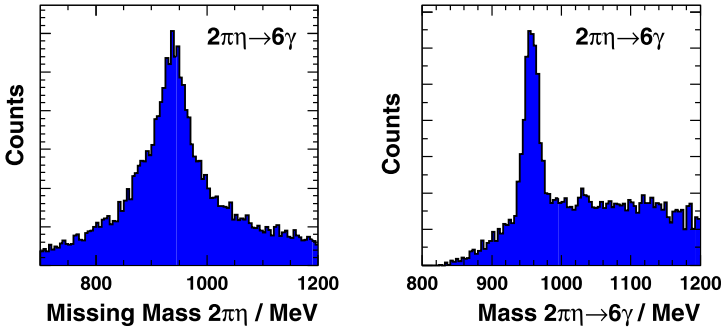

Fig. 1. Left: The missing mass of the $2\pi^0\eta$ final state indicating the missing proton. Right: Invariant mass of the $2\pi^0\eta$ showing a clear η' signal.

with poles close to 1950 MeV. A much more precise data set is very desirable to discriminate between the different interpretations.

2. Experimental Setup and preliminary Results

The data was measured at the tagged photon beam of ELSA at the University of Bonn. Electrons were extracted at energies of 3.2 GeV, covering photon energies up to 3 GeV. A 5 cm long liquid H_2 or D_2 target with 3 cm diameter was used. The Crystal Barrel detector[7] composing of 1290 CsI(Tl) crystals was covering angles between 30° and 165°. Charged particles were identified in a 3-layers scintillating fiber detector of cylindrical shape positioned around the target. The TAPS calorimeter[8] composed of 528 BaF_2 detectors individually equipped thin plastic detectors for detecting charged particles was covering the forward region up to 30°.

The $\gamma p \to \eta' p$ reaction channel was identified by measuring the 4-momenta of the η' mesons, whereas the proton was not detected. The η' meson was detected via its $2\pi^0\eta \to 6\gamma$ or 10γ decay channel and identified in a standard invariant mass analysis from the measured photon momenta. After applying a cut on the missing mass (compare Fig. 1 left hand side) the invariant mass of the $2\pi^0\eta$ system (compare Fig. 1 right hand side) was used to measure the yield of $\gamma p \to \eta' p$ events. Therefore, for each bin of incident energy and angle the η' rate was estimated and corrected for the detection efficiency. The cross section was deduced from the rate of the η' events, the photon beam flux, the branching ratio of the η' decay into 6 or 10 photons, and the detector and analysis efficiency. The geometrical detector acceptance and the analysis efficiency due to cuts and thresholds were obtained using the GEANT3 code. Hence, the shown cross sections are arbitrarily scaled to the SAPHIR data.

Fig. 2 shows the preliminary angular distributions of the η' meson in the CM frame for two different incident beam energies. The shape of the angular distributions is compared to the SAPHIR results[4]. In addition the calculation of Chiang et al.[6] is shown where the S_{11} plus Reggeized t-channel result is given by the solid

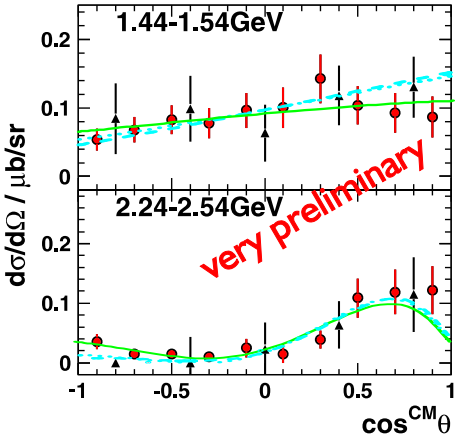

Fig. 2. Arbitrarily scaled angular distribution of the η' meson in the CM frame in comparison to the SAPHIR data for two bins of incident beam energy.

line, and the result with an additional P_{11} (P_{13}) is indicated by the dashed (dotted) line.

Acknowledgments

The presented data are part of the results of the experimental program of the CBELSA/TAPS collaboration. We thank the accelerator group of ELSA as well as many other scientists and technicians of the at the University of Bonn. This work was supported by Schweizerischer Nationalfond.

References

1. B. Krusche, S. Schadmand, *Prog. Part. Nucl. Phys.* **51**, 399 (2003).
2. ABBHHM-collaboration, *Phys. Rev.* **175**, 1669 (1968).
3. W. Strucinski *et al.*, *Nucl. Phys. B* **108**, 45 (1976).
4. R. Ploetzke *et al.*, *Phys. Lett. B* **444**, 555 (1998).
5. A. Sibirtsev *et al.*, *nucl-th/0303044*.
6. W-T. Chiang *et al.*, *Phys. Rev. C* **68**, 045202 (2003).
7. E. Aker *et al.* [Crystal Barrel Collaboration], *Nucl. Instr. Meth. A* **321**, 69 (1992).
8. R. Novotny *et al.*, *IEEE Trans. Nucl. Sci.* **38**, 378 (1991).