MENU 2007
11th International Conference
on Meson-Nucleon Physics and
the Structure of the Nucleon
September10-14, 2007
IKP, Forschungzentrum Jülich, Germany

HIGH-STATISTICS η PRODUCTION IN PROTON-PROTON COLLISIONS AT Q=72 MeV

H. Pettersson[1] for the CELSIUS/WASA collaboration
Department of Nuclear and Particle Physics[2]
Uppsala University
Uppsala, Sweden

Abstract

The production of η mesons at an excess energy of Q=72 MeV has been studied in the reaction pp→pp(η)$\gamma\gamma$. Preliminary angular distributions and projections of invariant masses are presented. Deviations from phase space behavior is observed, indicating the presence of different partial waves.

1 Introduction

Meson production experiments give us the possibility to study the interaction between nucleons and short-lived mesons. The interactions between the final state particles are expected to show up as a non-homogeneous population in some regions of the Dalitz plots. The large mass of the mesons produced and the corresponding large momentum transfer make meson production experiments a way of probing the short-range part of the nucleon-nucleon interaction. An additional motivation for η production experiments is the strong coupling of the η to the N*(1535) resonance close to threshold. Successful modelling of the production mechanism of η could therefore lead to information on this resonance.

There are previous near-threshold measurements of η production in proton-proton collisions at CM excess energies of Q=15 MeV [1], 15.5 MeV [2], 16 and 37.6 MeV [3] and 41 MeV [1]. The measurement at 37.6 MeV, performed at CELSIUS, showed some anisotropy in the scattering angle of the η in the CM system, whereas the measurement at 41 MeV, performed at COSY using a detector with higher acceptance, is consistent with isotropy.

[1]Dept. of Nuclear and Particle Physics, Uppsala University
[2]Box 535, 751 21 Uppsala, Sweden

We would like to investigate the presence of higher partial waves in the pp→ppη reaction. Thanks to an energy upgrade of the CELSIUS storage ring, WASA can add one data point in the region where the onset of higher partial waves is expected [4]. The WASA detector also has much higher acceptance than the one used in Ref. [3].

In this context, it is interesting to consider the results from the DISTO collaboration, who have measured differential cross sections at higher excess energies [5]. At their lowest excess energy (324 MeV) they observe an isotropy where the η is produced preferentially perpendicular to the beam. The isotropy weakens with energy and vanishes at their highest energy (554 MeV). In their studies of the momentum differential cross sections, the authors see the influence of the $N^*(1535)$, but no need for other partial waves than s-wave to explain their data.

2 Analysis

The data was taken in December 2003 with the WASA detector [6] and the η was detected through its decay into 2γ. This decay was chosen because of its high branching ratio and clear signature and as a means to cross-check the study of the $\eta \to 3\pi^0$ decay (the same trigger was used). The trigger required at least two charged particles in the forward detector, and no charged particles in the central detector. Furthermore, the deposited energy in the calorimeter had to exceed a certain threshold. A veto on hits in the forward veto hodoscope [6] was applied in order to cut down background from pion production.

To select the $\eta \to 2\gamma$ events in the off-line analysis, we required two tracks with precise angular information in the forward detector and exactly two hit clusters from photons in the calorimeter. The invariant mass of the two photons was required to be above 450 MeV, and the missing mass of the two protons was required to be between 525 and 575 MeV. The geometric acceptance of the WASA setup for this four-particle final state is about 43%, and the reconstruction efficiency for the signal reaction as determined from a Monte Carlo simulation of the detectors is around 10 %. While no kinematical fitting was used, momentum balance was imposed by the requirement that the η momenta as reconstructed from the two photons and from the two protons be within 28 degrees of each other, and that the invariant mass squared of the difference between the four-vectors be less than 0.02 GeV^2. From comparison with signal and background (assumed to consist of non-resonant $2\pi^0$-production) Monte Carlo, the fraction of background in the data is estimated to 15-30 %.

3 Results

The preliminary distributions shown are based on a sample of $167{\cdot}10^3$ events. The acceptance has been determined by passing generated events with phase space weights through a GEANT3 [7] simulation of the detector. Only statistical errors are shown as the magnitude of the systematical errors has not yet been determined.

The CM η scattering angle shown in figure 1 is non-isotropic, which implies the presence of higher partial waves, as does the distribution in $\cos\theta_p^{pp}$ seen in figure 2. In the invariant mass squared of the two protons (figure 3)

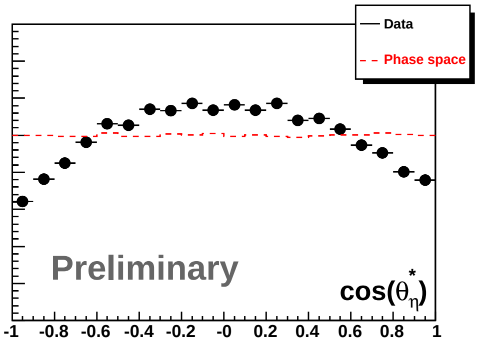

Figure 1: Differential cross section (in arbitrary units) as a function of the η scattering angle in the CM system.

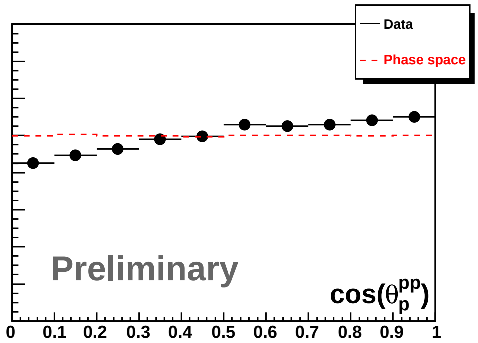

Figure 2: Differential cross section (in arbitrary units) as a function of the proton scattering angle in the proton-proton system.

a small effect of the proton-proton final state interaction (FSI) is barely visible around 3.54 GeV^2. The enhancement over phase space around 3.7 GeV^2 has also been observed at COSY [1], and could be explained by proton-proton P wave [8]. Isolating any effect of the proton-η FSI from the effect of higher partial waves in the invariant mass squared of one proton and the η (figure 4) requires further analysis.

4 Conclusions

Differential cross section of the pp$\rightarrow$ppη reaction have been measured at Q=72 MeV. The $\cos\theta_\eta^*$-distribution and the $\cos\theta_p^{pp}$-distribution both show deviations from isotropy, indicating the presence of higher partial waves. To separate the contributions from higher waves from proton-η FSI, further measurements with polarized protons are desirable *e.g.*by WASA at COSY.

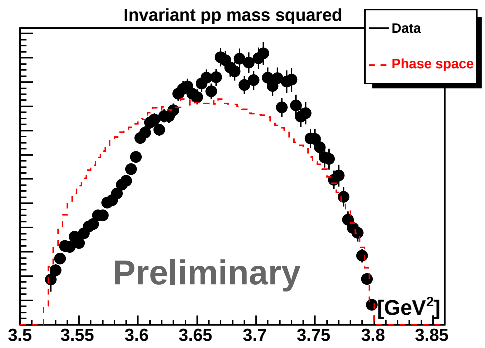

Figure 3: Differential cross section (in arbitrary units) as a function of the pp invariant mass squared.

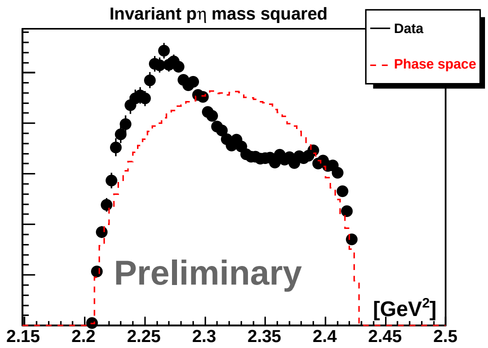

Figure 4: Differential cross section (in arbitrary units) as a function of the pη invariant mass squared.

Acknowledgments

This contribution is dedicated to the memory of David Duniec.

References

[1] M. Abdel-Bary *et al.* [COSY-TOF Collab.], *Eur. Phys. J. A* **16**, 127 (2003).

[2] P. Moskal *et al.*, *Phys. Rev. C* **69**, 025203 (2004).

[3] H. Calén *et al.*, *Phys. Lett. B* **458**, 190 (1999).

[4] P. Moskal, *Hadronic interaction of η and η' mesons with protons* (Wydawnictwo uniwersytetu Jagiellońskiego, Cracow, 2004).

[5] F. Balestra *et al.* [DISTO Collab.], *Phys. Rev. C* **69**, 064003 (2004)

[6] J. Zabierowski *et al.*, The CELSIUS/WASA Detector Facility, in *Eta Physics Handbook* (*Physica Scripta* **T99** 2002).

[7] R. Brun *et al.*, GEANT. CERN DD/EE/84-1

[8] K. Nakayama *et al.*, *Phys. Rev. C* **68**, 045201 (2003)