Study of the eta meson production with the polarised proton beam

M. Hodana[a,b], P. Moskal[a,b], I. Ozerianska[a] for the WASA-at-COSY collaboration

One of the interesting unsolved problem as regards the $\vec{p}p \to pp\eta$ reaction is the difficulty in reproducing the pp invariant mass distributions [1, 2, 3, 4]. Calculations which include NN FSI and $N\eta$ FSI do not match existing data [2]. To explain the unexpected shape of the distribution, possibility of higher partial-waves is considered. Taking into account a P-wave contribution one could reproduce the pp invariant mass distribution but not the close to threshold cross section dependencies [5]. To solve this discrepancy, a D_{13} resonance has been included [6] in the calculations. However, the data collected so far are insufficient for the unambiguous extraction of the S-wave or P-wave contributions.

Polarisation observables can probe interference terms between various partial amplitudes even if they are negligible for the spin averaged distributions. Therefore, for better understanding of the η meson production process, relative magnitudes from the partial waves contributions must be well established.

Up to now there are only three measurements of the analysing power for the $\vec{p}p \to pp\eta$ reaction which have been performed with low statistics and the determined value of analysing power is essentially consistent with zero [7, 8, 9] within large error bars of about ± 0.15.

Therefore in November 2010, the azimuthally symmetric WASA detector and the polarised proton beam of COSY, have been used [12] to collect a high statistics sample of $\vec{p}p \to pp\eta$ reactions in order to determine the analysing power as a function of the invariant mass spectra of the two particle subsystems and subsequently to perform the partial wave decomposition with an accuracy by far better than resulting from measurements of the distributions of the spin averaged cross sections.

For the determination of the analysing power of the η meson at a given value of the polar and azimuthal angle, it is required to measure left-right asymmetry of yields of the η meson, in the frame turned by the ϕ angle with respect to the laboratory coordinate system.

The large acceptance of the WASA detector allows to determine asymmetry of the η meson production as a function of the polar and azimuthal angle. The whole angular range is covered even at excess energies far from the threshold.

The measurement of the $\vec{p}p \to pp\eta$ reaction was carried out for two beam momenta of 2.026 GeV/c and 2.188 GeV/c, corresponding to excess energies of 15 MeV and 72 MeV. 118 hours of effective data taking included 74 hours with polarisation of 70% for the lower beam momentum and 44 hours with polarisation of 60% for the higher beam momentum. Vertically polarised proton beam, was stored and accelerated in the COSY ring. Direction of the polarisation was flipped from cycle to cycle. Protons from the $p\vec{p} \to pp\eta$ reaction, were registered in the Forward Detector and photons coming from the η decay channels were detected in the electromagnetic calorimeter. Both, the invariant mass of the decay products and the missing mass of two outgoing protons, are used for the identification of the η meson.

Determination of the beam polarisation and control of the systematics is achieved by measuring asymmetries for elastically scattered protons. Angular range of elastic scattered protons amounts to $60° - 85°$. In this range, analysing power for Q = 15 MeV and Q = 72 MeV is within 0.27 - 0.36 [10].

Average luminosity was estimated using trigger which requires at least one hit in the Central Plastic Barrel together with at least one hit in the Forward Plastic Barrel. For this trigger, prescaling factor was set to 600. With an assumption that 350 kHz [11] corresponds to the luminosity of $10^{31} cm^{-2}s^{-1}$, the achieved averaged luminosity amounts to $1.7 \cdot 10^{30} cm^{-2}s^{-1}$ and $2.3 \cdot 10^{30} cm^{-2}s^{-1}$ for the beam momentum of 2.026 GeV/c and 2.188 GeV/c, respectively. The main trigger used in the experiment required at least one matching track in Forward Trigger Hodoscope, Forward Window Counter and Forward Range Hodoscope in coincidence with at least two neutral groups in calorimeter. Cross sections for the $pp \to pp\eta$ reaction amounts to about $1 \cdot 10^3$nb for Q = 15 MeV and $5 \cdot 10^3$ nb for Q = 72 MeV, respectively [2]. Geometrical acceptance (Acc) together with expected number of $\eta \to \gamma\gamma$ and $\eta \to 3\pi^0$ events are given in Table 1.

Q [Mev/c]	P [MeV/c]	σ_{tot} [mb]	Acc	$N_{\eta\to\gamma\gamma}$	$N_{\eta\to 3\pi^0}$
15	2026	10^3	0.55	99708	81661
72	2188	$5*10^3$	0.63	447789	375558

Table 1: Estimation of the number of produced eta mesons corrected for the geometrical acceptance of the detector system

The expected result should shed a light on the still not explained origin of structures in the invariant mass distributions observed independently by the TOF [1], COSY-11 [2, 4], and CELSIUS/WASA [3] collaborations.

We acknowledge support by the FFE grants from the Research Center Jülich.

References:

[1] M. Abdel-Bary et al., Eur. Phys. J. **A16** (2003) 127.
[2] P. Moskal et al., Phys. Rev. **C 69** (2004) 025203.
[3] H.Petrn et al., Phys. Rev. C 82 (2010) 055206
[4] P. Moskal et al., Eur. Phys. J. **A43** (2010) 131.
[5] K. Nakayama et al., Phys. Rev. C **68** (2003) 045201.
[6] K. Nakayama, SLAC eConf C070910
[7] R. Czyżykiewicz et al., Phys.Rev.Lett. **98** (2007) 122003.
[8] P. Winter et al., Eur. Phys. J. **A18** (2003) 355.
[9] F. Balestra et al. Phys. Rev. **C69** (2004) 064003.
[10] W. Scobel, *Nucl.Phys.News 11N4:21-26* (2001).
[11] H. Calén, priv. com. (2010).
[12] P. Moskal, M. Hodana, e-Print: arXiv:1101.5486

[a] M. Smoluchowski Institute of Physics, Jagiellonian University, 30-059 Cracow, Poland
[b] IKP, Forschungszentrum Jülich, D-52425 Jülich, Germany