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Study of the $\eta \to \pi^+\pi^-\pi^0$ decay in p – p collisions with WASA-at-COSY

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Abstract. Study of the $\eta \to \pi^+\pi^-\pi^0$ decay allows for precise tests of the C parity conservation, makes possible to set constraints on the u and d as well as s and d quark mass ratios and can be used for a verification of the predictions of the Chiral Perturbation Theory (ChPT). The WASA-at-COSY collaboration has accumulated the world largest numbers of η mesons produced in $p-d$ and $p-p$ collisions. This report includes preliminary results of the ongoing analysis of the $\eta \to \pi^+\pi^-\pi^0$ decay from $p-p$ data which were collected during 8 weeks of the COSY beam time in 2010 in Forschungszentrum Jülich with more than 10^8 η mesons produced.

1 Introduction

The $\eta \to \pi^+\pi^-\pi^0$ decay, being one of the main η-meson decay channels, is forbidden by the G parity conservation. Since the electromagnetic contribution to this decay is very small [1], it proceeds predominantly via isospin violating processes resulting from the difference between the u and d quark masses. Therefore, study of this decay makes it possible to set constraints on the u and d as well as s and d quark mass ratios. Study of the $\eta \to \pi^+\pi^-\pi^0$ decay is also of high interest for precise tests of the C parity conservation [2][3][4]. It can be also used for a verification of the predictions of the Chiral Perturbation Theory (ChPT)[5]. The $\eta \to \pi^+\pi^-\pi^0$ decay was measured with high statistics (Dalitz Plot comprising $1.3 \cdot 10^6$ events) by the KLOE collaboration [2]. Their results show a deviation from ChPT predictions and no evidence for C parity viotation. The WASA-at-COSY collaboration conducts analogical studies in experimental runs with η-meson produced in $p-d$ and $p-p$ collisions with even higher statistics. This report presents preliminary results of the ongoing analysis of the $\eta \to \pi^+\pi^-\pi^0$ decay from $p-p$ data which were collected during 8 weeks of the COSY beam time in 2010 with more than 10^8 η's produced.

2 Data analysis

During the experiment the momentum of the proton beam was fixed to 2.142 GeV/c which corresponds to an excess energy Q=55 MeV with respect to the threshold of the η meson production. The two outgoing protons from the $pp \to pp\eta$ reaction were registered in the Forward Detector of the WASA-at-COSY facility. The three pions originating from the $\eta \to \pi^+\pi^-\pi^0$ decay were measured in the Central Detector. Requirement of one positive, one negative, at least two neutral tracks in the Central Detector and two tracks in the Forward Detector were used in the analysis and also there were put appropriate time conditions on time differences between registered particles. The π^0 mesons were identified on the basis of the two decay gammas (two gamma candidates which invariant mass is the closest to the π^0mass) detected in the Electromagnetic Calorimeter (see left panel of Fig. 1). The charged pions were identified using the $\Delta E - p$ method, where the energy loss ΔE was measured in the

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Plastic Scintillator Barrel and the momentum p was registered using the information from the Mini Drift Chamber (see right panel of Fig. 1).

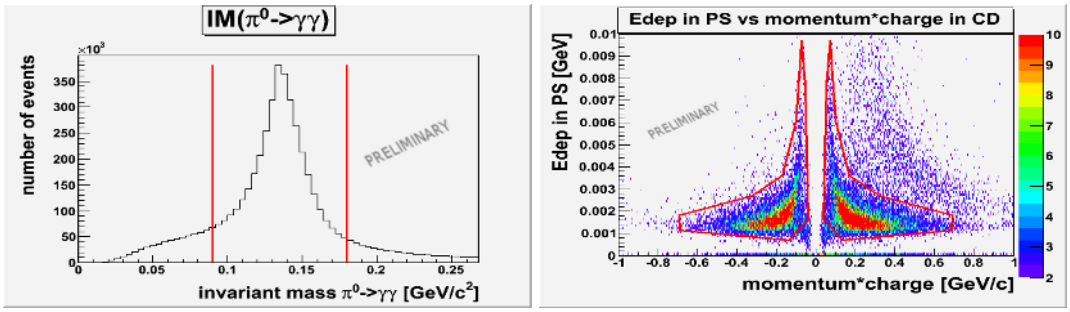

Fig. 1. Invariant mass of two photons with the cut for the π^0 identification (left). Energy loss in the Plastic Scintillator Barrel versus momentum multiplied with charge with a cut for the charged pions identification (right).

The protons in the Forward Detector were identified by the $\Delta E - E$ method with a "banana" cut on the energy deposit in all layers of the Forward Range Hodoscope (FRH) versus energy deposit in the first layer of the FRH (see left panel of Fig. 2). To further suppress the background an additional condition was applied that the missing mass squared of $pp\pi^0$ has to be larger than zero and the missing mass squared of $pp\pi^+\pi^-$ has to be larger than 0.003 GeV^2/c^4. It is presented in the right panel of Fig. 2.

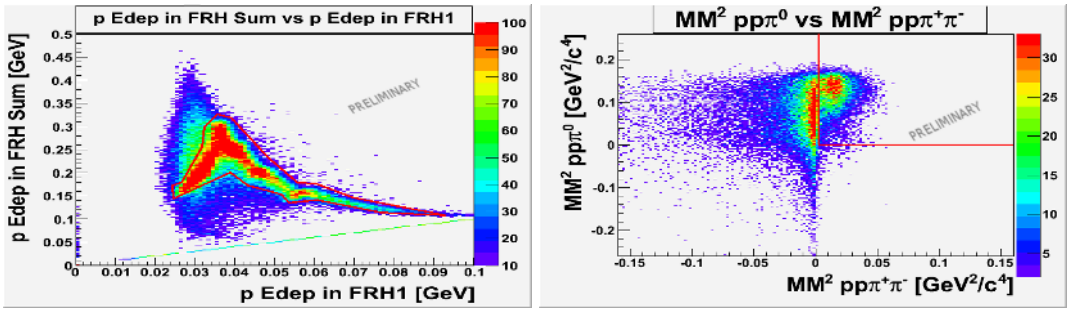

Fig. 2. Energy loss in all layers of the Forward Range Hodoscope versus energy loss in the first layer of the Forward Range Hodoscope with a "banana" cut for the protons identification (left). Missing mass squared of the $pp\pi^0$ versus missing mass squared of the $pp\pi^+\pi^-$ with a cut for the backgound reduction (right).

The $\eta \to \pi^+\pi^-\pi^0$ decay was identified on the basis of a two-dimensional plot showing the $\pi^+\pi^-\pi^0$ invariant mass versus pp missing mass (see Fig. 3). The maximum at the η mass is clearly visible. The goal of the current analysis is to build the $\pi^+\pi^-\pi^0$ Dalitz plot with the axes defined as $X = \sqrt{3}(T_+ - T_-)/Q_\eta$ and $Y = 3T_0/Q_\eta - 1$, where T_+, T_-, T_0 are the kinetic energies of π^+, π^-, π^0 in the rest frame of η and $Q_\eta = T_+ + T_- + T_0$. A preliminary version of the Dalitz plot projections on the X and Y axes are shown in Fig. 4. The experimental data (red lines) are compared with results of Monte Carlo simulations performed under assumption of a uniform distribution of events over the phase space available for the decay products (represented by the green line). Currently the errors parametrisation for the kinematical fit is being developed and after that it is planned to subtract the background under the η-peak in the missing mass spectra.

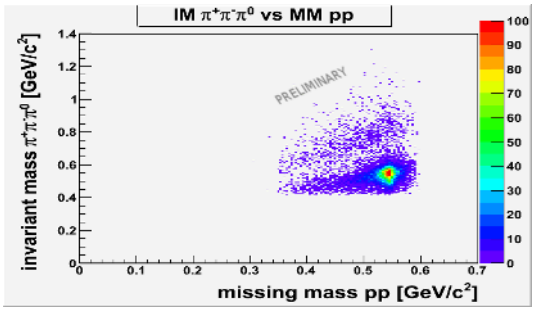

Fig. 3. Invariant mass of $\pi^+\pi^-\pi^0$ versus missing mass of pp.

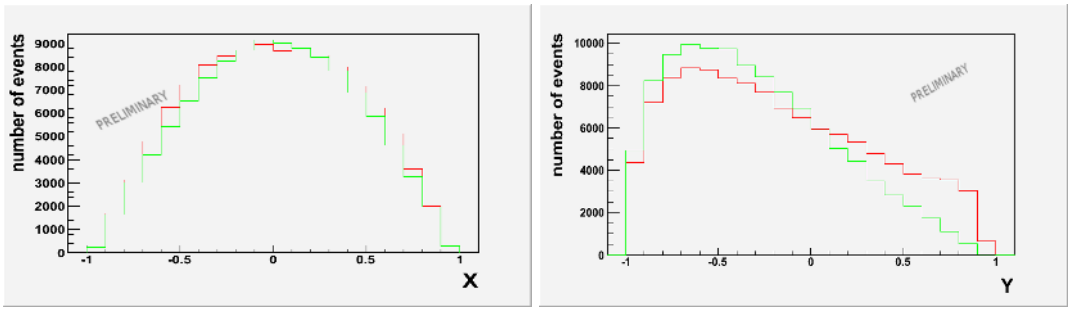

Fig. 4. Projections on the X and Y axes of the $\pi^+\pi^-\pi^0$ Dalitz plot. The green lines shows results of the Monte Carlo simulations, the red ones shows results of the pp data analysis. Background not subtracted, not corrected for acceptance.

References

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