The $\omega \to \pi^+\pi^-\pi^0$ Dalitz plot analysis with WASA-at-COSY

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Introduction

The ω meson, along with the ρ and ϕ vector mesons, plays a key role in the electromagnetic interaction of hadrons. At low energy QCD where the perturbative approach was impossible, the Vector Meson Domenance (VMD) model proved remarkably successful in the description of electromagnetic form factors and decays of hadrons. [1].

The VMD predicted the $\pi^+\pi^-\pi^0$ decay of the ω as proceeding via an intermediate ρ meson [2]. More recent calculations were based on a counting scheme for flavor-SU(3) systems of Goldstone bosons and light vector mesons [3]. The importance of the $\pi\pi$ interaction was also considered [4]. However, the expected deviations from the VMD were small.

The decay mechanism of the $\omega \to \pi^+\pi^-\pi^0$ decay (branching ratio ∼89%) was intended to study using a Dalitz plot analysis. The density distribution in the Dalitz plot provides a tool to test theoretical predictions of the decay mechanism of the three body decay.

Experimental facility

A *pp* collision reaction at beam energies of 2.06 GeV and 2.54 GeV were used to produce ω with the WASA-at-COSY experiment [5]. The proton beam was provided by the cooler synchrotron COSY. WASA, a nearly 4π detector system, designed to detect scattered particles like p in the forward part; and decay products of mesons like $\gamma, \pi^\pm, e^\pm$ were detected in the central part.

Analysis

The analysis was performed for the $pp \to pp\pi^+\pi^-\pi^0$ reaction at T_p=2.06 GeV.

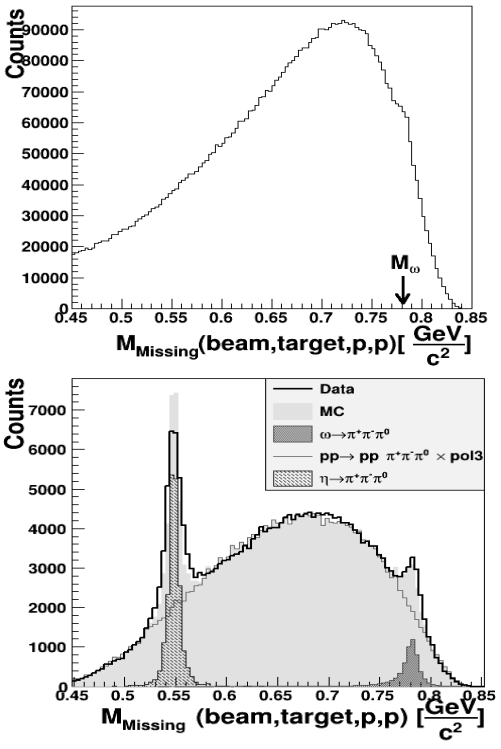

FIG. 1: The missing mass of beam, target and the *pp* system before (upper) and after (lower) applying the kinematic fit.

Protons were identified and reconstructed in the forward part of the WASA detector using a $\Delta E/E$ method [5]. A $\Delta E/P$ method, using deposited energy (ΔE) in the thin plastic scintillator and momentum (P) from the drift chamber, was used to identify $\pi^\pm$ in the central part of the WASA detector. The π^0 was reconstructed out of electromagnetic showers in the calorimeter of the WASA detector fulfilling the condition $|M_{\gamma\gamma} - M_{\pi^0}| <$ 35 MeV/c^2.

After all final state particles being identified

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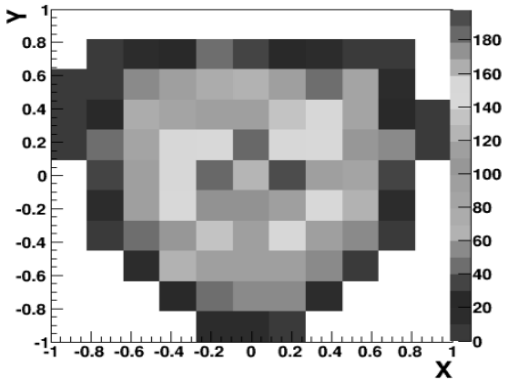

FIG. 2: The bin-wise background subtracted and not efficiency corrected Dalitz plot for $\omega \to 3\pi$.

and reconstructed the data showed large background contributions from multi-pion productions. As the $\pi^+\pi^-$ production background lies mainly on negative values of the square of the missing mass of beam, target, *pp* and the π^+ π^- system, on cutting it below 2 MeV/c^2 could remove the $\pi^+\pi^-$ production background. As shown in the upper plot in figure 1, the missing mass of beam, target and the *pp* system showed no clear signal of the ω, but just a shoulder around the M_ω. This suggested a small ω signal buried under the huge multi-pion background.

In order to improve an overall detector resolution and to remove background to some extent, a kinematic fit routine was implemented. The kinematic fit was performed for the $pp \to pp\ \pi^+\pi^-\gamma\gamma$ hypothesis with the $\pi^0 \to \gamma\gamma$ as an additional constraint. After the kinematic fit clear signals of η and ω were seen in the missing mass plot as shown in the lower plot in figure 1.

The data could explain by the Monte Carlo simulation considering $\omega \to \pi^+\pi^-\pi^0$, $pp \to pp\pi^+\pi^-\pi^0$ (direct 3π), $\eta \to \pi^+\pi^-\pi^0$ and $\eta \to \pi^+\pi^-\gamma$ reactions. The line shape of the direct 3π distribution was modified by multiplying it with the third order polynomial in order to explain the line shape of the direct 3π background of the data. In the data $\sim$5600 event candidates of the $\omega \to \pi^+\pi^-\pi^0$ were reconstructed.

In the Dalitz plot, dynamics of the three body decay was explained by two variables, $X = \sqrt{3}(T_{\pi^+} - T_{\pi^-})/Q_\omega$ and $Y = 3\,T_{\pi^0}/Q_\omega - 1$, where the T_π's were the pions kinetic energy, $Q_\omega = T_{\pi^+} + T_{\pi^-} + T_{\pi^0}$. In order to get $\omega \to 3\pi$ events in each X-Y bin, bin-wise background subtraction was done using the missing mass of beam, target and the *pp* system. The resulting Dalitz plot is shown in figure 2, which was not corrected for efficiency.

Now next steps are to obtain the efficiency corrected Dalitz plot and to calculate Dalitz plot parameters. We also plan to analyze the data set of the higher beam energy and then to combine all data sets to improve statistics.

Acknowledgments

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