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Hadronic decays of the ω meson

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Abstract. The WASA detector at COSY have measured the ω meson in the reaction channel p + d → ^{3}He + ω. With this data we aim to study two hadronic decays of the ω meson, $\omega \to \pi^+ \pi^- \pi^0$ and $\omega \to \pi^+ \pi^-$. The goal for the $\pi^+\pi^-\pi^0$ study is to extract a Dalitz plot of the final state pions. An high statistics Dalitz plot would enable tests of theoretical predictions for the decay mechanism. The goal for the $\pi^+\pi^-$ study is to perform an independent verification of the branching ratio.

1 Motivation

The first measurement of the Dalitz plot for the $\omega \to \pi^+\pi^-\pi^0$ decay channel was used to determine the spin and parity of the ω particle by observing the P-wave state of the pions, [1]. Calculations have been performed which includes higher order corrections to the decay mechanism and final state interactions, [2][3]. The resulting density distributions on the Dalitz plot differs noticeably from simple P-wave calculations. Previous experimental measurements are of limited statistics and are therefore not useful in more detailed studies. This raises our interest to produce a high statistics Dalitz plot.

This isospin breaking decay of $\omega \to \pi^+\pi^-$ have an $\omega - \rho^0$ interference, due to the same $\pi^+\pi^-$ final state. When the vector mesons are produced in e^+e^- collisions, their amplitudes add mainly coherently resulting in a strong interference. Experiments using this production method is the main contribution to the measured $\omega \to \pi^+\pi^-$ branching ratio, [4]. In hadronic production, such as the WASA-at-COSY experiment, the amplitudes add mainly incoherent and a clearer separation of the ω and ρ final states is possible.

2 Searching for the ω - analysis overview

The ω was produced using a proton beam on a stationary deuteron target in the reaction p + d → ^{3}He + ω. Two different kinetic energies for the proton were used, 1.45 GeV and 1.5 GeV.

^{3}He stops in the forward part of the WASA detector. This allows for an easy separation of ^{3}He from protons and deuterons using their energy deposition in subsequent detector layers, i.e. the $\triangle$E$\triangle$E technique. This particle identification method is due to that energy loss patterns depends not only on incoming energy but also charge and mass. Figure 1 shows an illustration of the $\triangle$E$\triangle$E technique and a full schematic layout of the WASA detector. The central part of the detector has a near 4π coverage and allows for detection of both charged particles and photons. This makes exclusive measurements of all decay channels of ω possible.

Signal selection in data begins with choosing events based on the amount of tracks reconstructed in the central part of the detector. For the $\omega \to \pi^+\pi^-\pi^0$ events, we require the data events to contain

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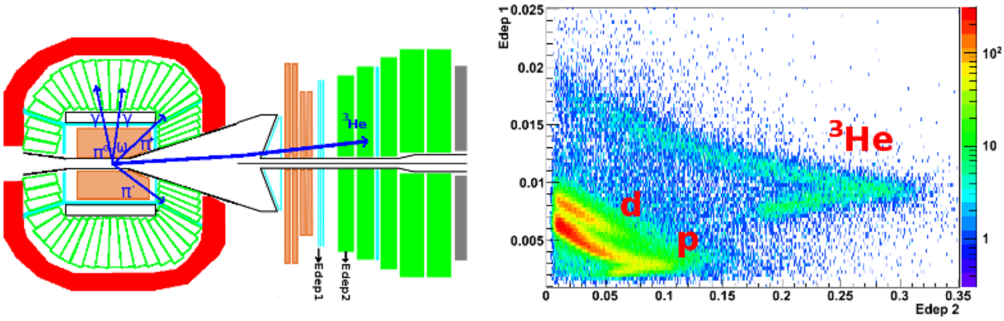

Fig. 1. Left: A schematic picture of the WASA detector with typical particle trajectories drawn. The short-lived decay particles are detected in the central part while the recoiling ^{3}He are detected in the forward part. Right: The energy deposit in one layer of the forward detector versus the energy deposit in a subsequent layer. Three bands are visible due to protons, deuterons and ^{3}He.

exactly two charged tracks and two neutral. While for the $\omega \to \pi^+\pi^-$ events, the requirement is exactly two charged tracks and no neutral tracks detected. This track selection is intended to single out the final state particles of the desired decay channels. But since there are other reactions with same final state and also a possible contamination from reactions with similar final state, further analysis steps are required. From the reconstructed final state particles one can produce combination of their 4-vectors. One example is the invariant mass of the pions, IM($\pi^+\pi^-\pi^0$) and IM($\pi^+\pi^-$). These distributions would peak at the m_ω value for signal data, while for background data one typically has a shifted or broader distribution. Cuts in distributions like these reduces the contribution from background reactions. The amount of signal events is identified in the missing mass distribution of the incoming proton and deuteron and recoiling ^{3}He. Here the signal events peak at m_ω while the background events contribute to a polynomial shaped distribution.

3 The ω signal in data

The $\omega \to \pi^+\pi^-\pi^0$ decay is the main decay channel of ω with a branching ratio of 89.2%, [4]. Using track selections and analysis cuts, as exemplified in section 2, reveal already a strong signal peak in experimental data. Figure 2 displays this peak located at the m_ω in the missing mass distribution. These plots are made on ~50% of the total available data. The signal sample can easily be increased by modification to the analysis steps, such as relaxing the track selection conditions.

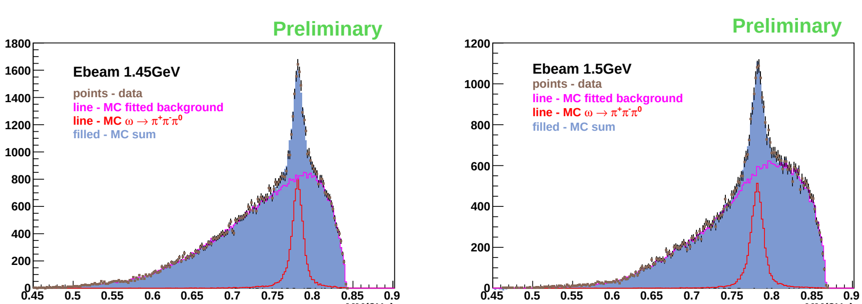

Fig. 2. The resulting missing mass distributions in the analysis on $\omega \to \pi^+\pi^-\pi^0$. Left: Plot based on data taken with a kinetic energy at 1.45 GeV for the beam protons. Right: Plot based on data taken with 1.5 GeV kinetic beam energy.

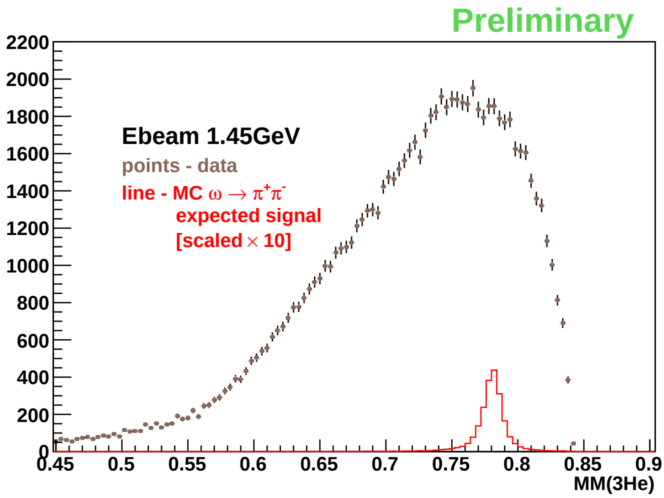

Fig. 3. The preliminary missing mass distribution in the analysis on $\omega \rightarrow \pi^+\pi^-$. Due to the background, the expected Monte Carlo simulated signal peak has been scaled with factor 10 to make it visible. The distribution is based on data taken with 1.45 GeV kinetic beam energy.

In the analysis of the $\omega \rightarrow \pi^+\pi^-$ decay we are faced with the challenge of reducing the background from p + d $\rightarrow$ ^{3}He + π^+ + π^- reactions. The branching ratio for the $\omega \rightarrow \pi^+\pi^-$ channel is 1.53% [4] which calls for a more refined analysis in order to clearly see a signal peak from experimental data. Figure 3 shows the preliminary missing mass distribution of the incoming proton and deuteron and recoiling ^{3}He. Also shown in the figure is a scaled signal peak demonstrating what is expected from Monte Carlo simulated data. The expected amount of $\omega \rightarrow \pi^+\pi^-$ events in this peak is estimated from the $\omega \rightarrow \pi^+\pi^-\pi^0$ analysis.

4 Outlook

Using the WASA detector at COSY we have collected a clean data sample of the $\omega \rightarrow \pi^+\pi^-\pi^0$ reaction. Remaining work include tuning the analysis to achieve a sample as large as possible. The resulting Dalitz plot distribution will be obtained through bin-wise background subtraction and acceptance correction.

For the $\omega \rightarrow \pi^+\pi^-$ analysis, further signal selection is in progress. Another analysis step would be to perform kinematical fitting of the initial and final state variables. This will help improving the signal to background ratio.

References

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