Electromagnetic transition form factor of the η meson with WASA-at-COSY

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Introduction

The aim of this work is to measure the transition form factor of the η meson. The transition form factor describes the internal structure of a particle. The determination of the transition form factor of the η meson is possible through the $\eta \rightarrow \gamma\gamma^* \rightarrow \gamma e^+e^-$ Dalitz decay. This decay is special as it incorporates only one meson hence the transition from factor describes the structure of this meson. The squared four-mometum of γ^* is equal to the mass square of $e^{\pm}$. When a particle is point-like then the decay rate can be calculated within QED using equation(1) [1].

$$\frac{d\Gamma(\eta \rightarrow \gamma e^+ e^-)}{dq^2 \cdot \Gamma(\eta \rightarrow \gamma\gamma)} = \frac{2\alpha}{3\pi}[1 - \frac{4m_e^2}{q^2}]^{1/2}[1 + \frac{2m_e^2}{q^2}]\frac{1}{q^2}[1 - \frac{q^2}{m_\eta^2}]^3 \quad (1)$$

Where m_e stands for lepton mass, m_η is the mass of the eta meson and q^2 is the squared four-momentum of $e^{\pm}$.

However, the complex structure of the particle modifies the decay rate. The transition form factor is determined by comparing the experimental lepton-antilepton invariant mass distribution with QED.

WASA-at-COSY Experiment

A large data sample of pp→ppη ($10^9\eta$) has been collected in 2008, 2010 and 2012 at WASA-at-COSY experimental setup. The high intensity proton beam provided by COoler SYnchrotron (COSY) at Forschungzentrum Juelich in combination with a high density pellet target of the WASA detector enable to achieve high luminosities which is required for the study of rare decays. WASA is a nearly 4π detector setup [2] in which recoil protons are detected with the forward detector which covers 3-18 degrees in the polar angle and neutral and charged decay products of the η meson are identified with the central part of the detector which covers 20-169 degrees.

Analysis

η mesons were produced in proton-proton reactions at a beam energy of T_p=1.4 GeV. Data collected in 2010 have been used in this study. The identification of recoil protons has been done in the forward part of the detector using the △E-E method, △E is the enrgy deposited by protons in the layers of Forward Range Hodoscope. Charged decay particles $e^{\pm}$ of the produced η meson are identified in the central part of the detector using the △E-P method. Energy information is provided by the electromagnetic calorimeter and momentum information by the mini drift chamber of the central detector. The missing mass technique is used to tag the η mesons, as shown in Fig.1. kinematic conditions have been implemented in the data analysis to identify all final state particles and to supress the background. Approximately 29000 η candidates have been reconstructed from the γe^+e^- channel after the background subtraction. A 4^{th} order polynomial multiplied with the phase space of multipion production pp→pp$\pi^+\pi^-\pi^0$ has been used to fit background. It is seen in simulation studies that 8.4% background still would contribute from the competing decay channels as $\eta \rightarrow \gamma\gamma$, $\eta \rightarrow \gamma\pi^+\pi^-$, and $\eta \rightarrow \pi^0\pi^+\pi^-$ inside the peak region. Table 1 presents the background contribution from each competing decay channel. $\eta \rightarrow \gamma\gamma$ contributes as a background for this reaction if one of the photons interacts with the beampipe material and converts into $e^{\pm}$ pair. $\eta \rightarrow \gamma\pi^+\pi^-$ channel is sim-

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ilar to the signal channel therefore it satisfies the selection criteria as there are two oppositely charged tracks and one neutral track in the central detector. In $\eta \to \pi^0\pi^+\pi^-$ channel, π^0 decays into two photons and if one photon failed to register in the detector then this channel also satisfy the selection criteria. The invariant mass of e^+e^- is promising, a good agreement between the simulation and data is seen. A detailed comparison of simulation and data has been performed in order to ensure the realistic scenario of the simulations.

TABLE I: Background contribution from competing η decay cannels.

Channel	Background contribution (%)
$\eta \to \gamma\gamma$	6.6
$\eta \to \gamma\pi^+\pi^-$	0.63
$\eta \to \pi^0\pi^+\pi^-$	1.2

Outlook

The background inside the peak region has to be subtracted. Branching ratio of $\eta \to \gamma e^+e^-$ has to be cross-checked. Finally, kinematic fitting will be implemented in order to suppress the background. This work aims at a precise measurement of η transition form factor.

Acknowledgments

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References

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