Transition Form Factor of the η' meson

Ankhi Roy[1,*]
(for the WASA-at-COSY collaboration)
[1] *Department of Physics, Indian Institute of Technology Bombay and Department of Physics, Indian Institute of Technology Indore*

Introduction

The strong force described by Quantum Chromodynamics is responsible for binding coloured quarks and gluons to colourless hadrons. However, at large distances or small momentum transfers it becomes complex due to large coupling constant and strong nonlinearity. Thus in turn leads to confinement of quarks annd gluons inside the hadrons and chiral symmetry breaking and is a region of very rich phenomenology. A deeper understanding of the structure and dynamics of hadrons as well as their excitation spectrum could provide valuable insight into both confinement and chiral symmetry breaking. One of the ways to investigate the confinement would be to study the transition form factor of pseudoscalar mesons. In this paper we report the simulation studies carried out to investigate the transition form factor of the η' meson through its Dalitz decay, $\eta' \rightarrow e^+e^-\gamma$. The square of the invariant mass of the lepton pair is equal to the four momentum transfer squared ($q^2 = m^2_{l^+l^-}$) in such decays. Therefore, one can use this channel to investigate the transition form factor of the η' meson as a function of the square of the four momentum transfer, (F(q^2)). The transition form factor F(q^2) is determined by comparing the experimental measured mass spectrum of lepton pairs decay with the theoretically calculated mass spectrum for point like particles [1]

$$\frac{d\Gamma}{dq^2} = \frac{d\Gamma}{dq^2}|_{QED} \mid F(q^2) \mid$$

Experimental Setup

A test run to investiagte the feasibility of producing η' mesons with a proton beam of momentum 3.3 GeV/c has been performed with the WASA detector at the COSY accelerator facility in Juelich, Germany. COSY is a cooler synchrotron and storage ring using polarized and unpolarized proton and deuteron beams. WASA operates as an internal experiment using a pellet-target system which provides frozen hydrogen and deuterium pellets. The WASA detector [2] can be divided into two parts, namely the Forward Detector and Central Detector. The Forward detector detects scattered projectiles and recoil particles like protons. It has five layers of Forward Range hodoscopes to measure the deposited energy of recoil particles. The Central Detector consists of an Electromagnetic Calorimeter of CsI(Na) crystals to identify photons, a Plastic Scintillator Barrel, and a Mini Drift Chamber. The Central Detector can detect various decay particles of different mesons - photons, electrons and charged pions. The Mini Drift Chamber is used for determining the particle momenta.

Analysis

We have started simulations to identify the decay particles of the channel $pp \rightarrow pp\eta' \rightarrow e^+e^-\gamma pp$ with a proton beam of momentum 3.3 GeV/c and to optimize the selection criteria to reduce background from other channels. In the analysis we identify two protons, one electron, one positron and one photon. Events with two charged particles in the Forward Detector and two charge tracks in the Central Detector and one neutral track in the Central Detector have been preselected from the data set.

The kinetic energy of a final state proton is

*Electronic address: ankhi@phy.iitb.ac.in

reconstructed from the deposited energy in the different Forward Range Hodoscope planes. The kinetic energy of protons below 300 MeV which are stopped in the detector is determined from the deposited energy with small resolution. However, the error of energy reconstruction of protons above 300 MeV deteriorates with increasing proton energy.

Thus the four vector reconstruction of two protons above 300 MeV is not possible using the kinetic energy information from the Forward Detector in its present form. The four vector reconstruction of two protons is absolutely necessary for the missing mass analysis of two protons which produce a peak at the η' mass region (958 MeV). It is a very powerful tool to reduce background.

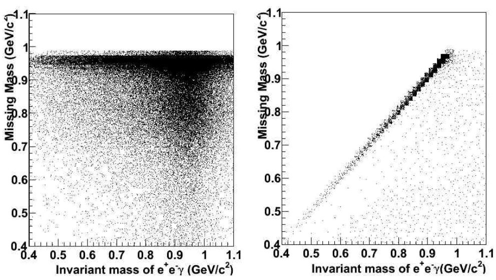

FIG. 1: Invariant mass versus missing mass of $e^+e^-\gamma$ before fitting (left panel) and after fitting (right panel) from the simulation.

To overcome this problem, we have implemented the kinematic fitting technique with $pp \to ppe^+e^-\gamma$ hypothesis, where the kinetic energies of two protons are undetermined parameters. We have supplied the experimentally measured kinetic energy, theta and phi angles for each final state partcile except the kinetic energies of two protons as input for the kinematic fitting. The errors of each measured quantity are also supplied as input for the fitting. Since the energy, theta and phi resolution of each particle is not constant over their entire range, an error parametrization for each variable has been produced.

After implementing kinematic fitting, we have an improved mass resolution of η' mesons from 40 MeV to 9 MeV. Figure 1 shows the invariant mass versus missing mass plot before and after fitting. However, the proton's kinetic energy calculation from the kinematic fitting is not improved significantly. Simulations of channels contributing to the background have been started and will be reported.

Acknowledgments

This work has been supported through Fast Track Project for the Young Scientist by the Department of Science and Technology (DST), India.

References

[1] L. G. Landsberg, Phys. Rept. 128, 301 (1985)

[2] The WASA-at-COSY collaboration Proposal for the Wide Angle Shower Apparatus (WASA)at COSY-Juelich "$WASAatCOSY''$, Juelich 2004.