Calculation of the matrix element for the hadronic decay $\omega \to \pi^o\pi^+\pi^-$

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Introduction

Quantum Chromodynamics (QCD) is the theory of strong interaction and the Chiral perturbation theory (ChPT) is the effective theory of QCD at low energy. There has been a lot of work and progress in field of high energy physics or so called perturbative QCD, but the scientific community has very little knowledge and understanding of particle behavior in the low energy regime or the non-perturbative QCD regime. The ChPT is a very successful theory for studying hadronic decay of hadrons, which is the smallest unit of the low energy QCD regime. In the present article we are studing the ($I^G J^P = 0^-1^-$)ω channel of the 3π system. Study of these light isoscalar vector meson holds its special importance because of the fact that they show strong coupling to the light pseudoscalars meson [1]. The aim of the present work is to develop the high precision measurement of Dalitz plot of $\omega \to \pi^o\pi^+\pi^-$ with large statistics, and to obtain the matrix elements of the decay through the general decomposition parametrization described in the text. The Jefferson Lab (Jlab) at Newport News, USA has an accelerator facility, which provides a very suitable range of energies for production and detection of mesons. We are using the "The Continuous Electron Beam Accelerator Facility (CEBAF) Large Acceptance Spectrometer (CLAS)" detector data for this study.

Experimental Setup

The CLAS experiment uses a 4 GeV electron beam hitting a gold foil(10^{-4} radiation length) produces real photons, via the bremsstrahlung process. The recoiling electrons were then analyzed using a dipole magnet and scintillator hodoscopes to tag the energy of the photons [2], and Magnetic Spectrometer at Hall B is used to separate electrons from the photon beam. Photons in the energy range from 20% to 95% of the electron beam energy were tagged and thus measured with an energy resolution of 0.1% of the electron beam energy. The physics target, which was filled with liquid hydrogen, was a 40-cm long cylinder with a radius of 2 cm. The 24 "start counter" scintillators near to interaction region were used in the event trigger and start time. The CLAS detector utilized a non-uniform toroidal magnetic field of peak strength near 1.8 T in conjunction with drift chamber tracking to determine particle momenta. Charged particles with laboratory polar angles in the range 8° to 140° could be tracked over approximately 83% of the azimuthal angle. A set of 288 scintillators placed outside of the magnetic field region was used in the event trigger and during off-line analysis in order to determine time of flight (TOF) of charged particles. The momentum resolution of the detector was, on average, about 0.5%.

Data Analysis

We are analyzing the vector meson ω from the complete decay channel: γ+p$\to$ ω+p$\to\pi^0$ + π^++π^-+p. The CLAS detector is optimized for detection of charged particles; so, two charge particles and any number of neutral particles along with the proton was added to the selection criteria of data skimming from the huge data set of CLAS. A missing mass technique is used in the analysis for reconstruction from the kinematical information of the two pion and proton. The resolution obtained is clear enough for identification of the π^o meson. In, γp$\to$pX missing mass was used to identify the photopro-

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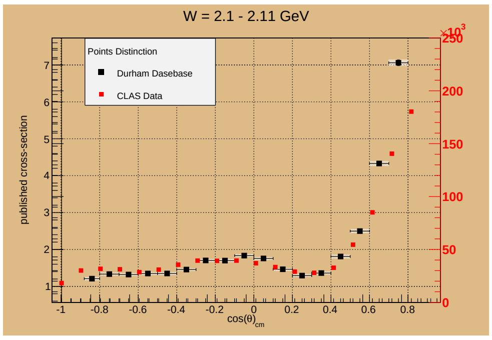

FIG. 1: Comparison of the data without beam flux and other constant quantities and previous measurements from Durham database for center of mass beam energy(W) ranging from 2.1 to 2.11 GeV in the Cos(θ) center of mass frame of η'. The black and red axis represents the Durham database[3] cross-section and present analysis axis respectively.

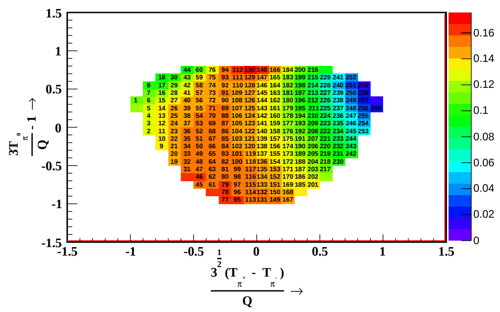

FIG. 2: The numbering and position are used in the analysis and the colour scale shows the corrosponding acceptance for the $\omega{\to}\pi^+\pi^-\pi^0$.

duced ω meson after selecting the π^o meson region. As a cross check to the analysis and Fast Monte Carlo, we have also reproduced the cross-section without the beam flux and other constant quantities, and matched with the available cross section at Durham database [3]. The Fig.1 shows a differential cross-section comparison for a small beam energy in the center of mass (W) ranging form 2.1 to 2.11 GeV. The ω events are then distributed within the Dalitz Plot, with the variables X[-1.5,1.5] and Y[-1.5,1.5] is divided into 30x30 bins. The X and Y for the decay is defined as:

$$X = \frac{\sqrt{3}(T_{\pi^+} - T_{\pi^-})}{Q},$$

$$Y = \frac{(3T_{\pi^0})}{Q} - 1.$$

Here, Q=$T\pi^+$+Tπ^-+$T\pi^o$ in the rest frame of ω meson.
Simulation of $\omega\to\pi^o\pi^+\pi^-$ in the phase space distribution through Fast Monte Carlo with 50 million events is shown in Fig.2, along with the position, numbering and corrosponding acceptance of the Dalitz plot bins used in the analysis [4].

Outlook

Once the acceptance corrected Dalitz plot is obtained, the matrix element of the decay can be expanded around the center of the corresponding Dalitz plot in order to obtain the Dalitz slope parameters:
M^2=A(1+aY+bY^2+cX+dX^2),
where a, b, c and d are real parameters and A is a normalization factor.
In some decay modes the CLAS has the world's largest dataset for analysis of light pseudoscalar mesons, so it can be further used to develop the Dalitz plot of $\eta\prime\to\pi^+\pi^-\eta$ and $\eta\to\pi^+\pi^-\pi^o$.

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