STUDY OF THE $\eta \to e^+e^-\gamma$ DECAY

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1.1 Introduction

Since the η meson is a short-lived, neutral particle, it is not possible to investigate its structure via the classical method of particle scattering. To learn about its quark wave function, one studies the decay processes of this meson, in which a pair of photons is produced, at least one of them being virtual. The virtual photons have a non-zero mass and convert into lepton-antilepton pairs. The squared four-momentum transferred by the virtual photon corresponds to the squared invariant mass of the created lepton-antilepton pair. Therefore, information about the quarks' spatial distribution inside the meson can be achieved from the lepton-antilepton invariant mass distributions by comparison of empirical results with predictions, based on the assumption that the meson is a point-like particle. The latter can be obtained from the theory of Quantum Electrodynamics. The deviation from the expected behaviour in the leptonic mass spectrum expose the inner structure of the meson. This deviation is characterized by a form factor. It is currently not possible to precisely predict the dependence of the form factor on the four-momentum transferred by the virtual photon in the framework of Quantum Chromodynamics. Therefore, to perform calculations, assumptions about the dynamics of the investigated decay are needed.

The knowledge of the form factors is also important in studies of the muon anomalous magnetic moment, $a_\mu = (g_\mu - 2)/2$, which is the most precise test of the Standard Model and, as well, may be an excellent probe of new physics. The theoretical error of calculation of a_μ is dominated by hadronic corrections and therefore limited by the accuracy of their determination. At present, the discrepancy between the a_μ prediction based on the Standard Model [1] and its experimental value is $(28.7 \pm 8.0) \cdot 10^{-10}$ (3.6σ) [2].

The aim of the data analysis is the investigation of the electromagnetic structure of the η meson by determining the transition form factor using the $\eta \to e^+e^-\gamma$ decay mode. The probability of creation of a dielectron pair in considered decay is proportional to the probability of emission of a virtual photon with a time-like four-momentum. The square of this four-momentum vector is equal to the square of the mass of created e^+e^- pair. By studying the probability of given decay as a function of the dilepton pair mass, one obtains information about the hadron-photon transition and hence about the electromagnetic structure of decaying neutral meson [3].

1.2 Current status of the analysis

Data were collected using the $pd \to {}^3He\,\eta$ reaction at proton beam momentum of 1.69 GeV/c. The experiment was performed using the WASA-at-COSY detector [4] in November 2008. Data collected during 4 weeks, yielded approximately 10 million η mesons tagged by the ${}^3He$ ions measured in the Forward Detector.

The event selection in the Central Detector aims at choosing the decay channel of interest. We demand (i) that two tracks corresponding to oppositely charged particles are reconstructed and, (ii) that at least one neutral particle was registered and, (iii) that the signals are correlated in time with signals observed in the Forward Detector within a 12 ns and a 31 ns window for charged and neutral tracks, respectively. The energy deposited by a neutral particle (E_γ) is demanded to drop linearly with increasing opening angle with the nearest charged particle (Ω) starting from 100 MeV for $\Omega = 0°$ and having $E_\gamma = 0$ MeV for $\Omega = 180°$. Additionally, in the η centre of mass system, there has to be only one such neutral candidate, forming with a lepton pair a $\Delta\phi$ angle in the range from 60° to 300°. The identification of electrons is achieved using energy-momentum plot as shown in Fig. 1.1 (right). An additional restriction is imposed on the missing mass of the

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