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Study of the polarization degree for the $\overrightarrow{p}p \to pp\eta$ measurement with WASA

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Abstract Understanding of the production processes of the η meson will strongly rely on the precise determination of spin observables. So far these observables have been determined only for few excess energies and with low statistics (Winter et al. Eur. Phys. J. **A18**, 355, 2003; Czyzykiewicz et al. Phys. Rev. Lett. **98**, 122003, 2007; Balestra et al. Phys. Rev. **C69**, 064003, 2004). In the year 2010 WASA detector was used for the measurement of the $\overrightarrow{p}p \to pp\eta$ reaction with the polarized proton beam of COSY (Moskal and Hodana J. Phys. Conf. Ser **295**, 012080, 2011). The measurement was done for the excess energy of Q = 15 MeV and Q = 72 MeV. In total about 10^6 events corresponding to the $\overrightarrow{p}p \to pp\eta$ reaction have been collected.

Keywords Analyzing power · Polarization

1 Introduction

Protons from the $\overrightarrow{p}p \to pp\eta$ reaction are registered in the forward part of the detector and photons from the η meson decays are detected in the Electromagnetic Calorimeter of the central part. Simultaneously to the $\overrightarrow{p}p \to pp\eta$ reaction, elastically scattered protons were registered. In the case of the $\overrightarrow{p}p \to pp$ reaction, one proton is registered in the Forward Detector and the other in the Central Detector.

In order to control effects caused by potential asymmetries in the detector setup, the spin of the proton beam was flipped from cycle to cycle. The degree of polarization was

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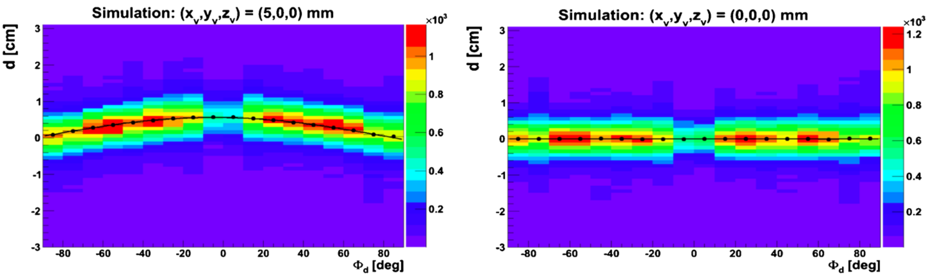

Fig. 1 Simulated distributions of $d(\phi_d)$ made for vertex position (x_v, y_v, z_v) = (0, 0, 0) (*right plot*) and (x_v, y_v, z_v) = (5,0,0) mm (*left plot*). Points show positions of the mean of the d-distributions for given ranges of ϕ_d

determined based on the elastic scattering $\overrightarrow{p}\, p \to pp$ for which values of analyzing power have been determined by the EDDA experiment [5]. After identification of events corresponding to elastically scattered protons, number of $\overrightarrow{p}\, p \to pp$ events for each angular bin, N(θ, φ), was determined. The polarization, P, can be written as:

$$P \equiv \frac{1}{A_y} \cdot \epsilon(N(\theta,\varphi), N(\theta,\varphi+\pi)), \quad (1)$$

where ϵ is the asymmetry .

In practice the polarization of the COSY beam can depend on the spin orientation. Therefore, it is determined for both spin orientations separately. The polarization measured in the experiment for unpolarized beam deviates slightly from zero.

The probable source of the systematic uncertainty in the determination of the polarization might be originating from the possible misalignment of the beam and/or target position.

Detailed estimation of the systematics uncertainties for the determination of the polarization degree with the WASA detector was described in reference [6].

One of the method to determine the vertex position is to study the coplanarity, C, as a function of proton's azimuthal angle. Coplanarity is defined as:

$$C = \frac{(\widehat{p_1} \times \widehat{p_2}) \cdot \widehat{p}_{beam}}{|\,(\widehat{p_1} \times \widehat{p_2})\,| \cdot |\,\widehat{p}_{beam}\,|}, \quad (2)$$

where $\widehat{p_1}$ and $\widehat{p_2}$ denote momenta of scattered protons, and $\widehat{p}_{beam}$ is the beam momentum.

Another method to determine the shift of the reaction vertex is to extract coordinates x_v, y_v and z_v. For this new variables d and ϕ_d are introduced, where d is the distance [7], ϕ_d is the azimuthal (Fig. 1) angle between d and the x -axis. We find x_v and y_v using formula:

$$d(\phi_d) = x_v \cdot cos(\phi_d) + y_v \cdot sin(\phi_d), \quad (3)$$

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