The η meson mass determination with ANKE at COSY*

P. Goslawski[1], I. Burmeister[1], M. Mielke[1], M. Papenbrock[1], D. Schröer[1], A. Täschner[1] and A. Khoukaz[1]
and the ANKE-Collaboration

Recent measurements on the η-meson mass performed at different experimental facilities (i.e. CERN-NA48, COSY-GEM, CESR-CLEO, DAΦNE-KLOE, MAMI-Crystall Ball) resulted in very precise data but differ by up to more than eight standard deviations, i.e. $0,5\,\mathrm{MeV/c^2}$ [1]. In order to clarify this situation a high precision measurement using the ANKE spectrometer at the COoler SYnchrotron has been realized.

Using the two-body reaction $d\,p \to {}^3\mathrm{He}\,\eta$ at low excess energies the η-mass can be determined only from pure kinematics by the determination of the production threshold. Therefore, fifteen data points at fixed excess energies in the range of $Q = 1 - 15\,\mathrm{MeV}$ were investigated. The final momentum p_f of the ^{3}He-particles

$$p_f\,(s) = \frac{\sqrt{\left[s-(m_{^3\mathrm{He}}+m_\eta)^2\right]\cdot\left[s-(m_{^3\mathrm{He}}-m_\eta)^2\right]}}{2\cdot\sqrt{s}}\,,$$

measured with the ANKE spectrometer, is very sensitive on the η-mass and the total energy $\sqrt{s}$, where the latter one is completely defined by the masses of the initial particles and the momentum of the deuteron beam. For a precise determination of the production threshold both the final momenta of the ^{3}He-particles and the corresponding beam momenta have to be measured with high accuracy.

First, the beam momenta for fifteen fixed energies were determined using an artificial spin resonance. This spin resonance was induced by a horizontal rf-magnetic field of a solenoid to depolarize a vector polarized accelerator beam [2]. The depolarizing resonance frequency f_r depends on the kinematical γ-factor (i.e. the beam momentum $p = m\sqrt{\gamma^2-1}$) and the beam revolution frequency f_0 via the resonance condition:

$$f_r = (k + \gamma G)\,f_0\,,$$

where k is an integer and G the gyromagnetic anomaly of the beam particle. By measuring this two frequencies the beam momenta in the threshold range of 3.1 - 3.2 GeV/c were determined with an accuracy of $\Delta p/p < 8\cdot 10^{-5}$, i.e. with less than 250 keV/c [3].

Second, the momenta of the ^{3}He-nuclei of the reaction $d\,p \to {}^3\mathrm{He}\,\eta$ have to be determined for every energy. The reaction can be identified by an energy loss cut on the ^{3}He band and a time of flight cut. Using these two cuts the background, consisting mainly of protons and deuterons of the dp elastic scattering and the deuteron break-up, can be suppressed. The final state momentum of the ${}^3\mathrm{He}\,\eta$ channel can be visualized by plotting the transversal versus the longitudinal reconstructed momentum in the CM system, as shown in in figure 1. For a two body final state reaction, one expects a centered momentum locus with a fixed radius p_f given by the equation above. By studying carefully the momentum dependence on cos(θ) and ϕ the detector calibration can be checked and improved, which is currently in progress. The final state momentum of the ${}^3\mathrm{He}\,\eta$ channel

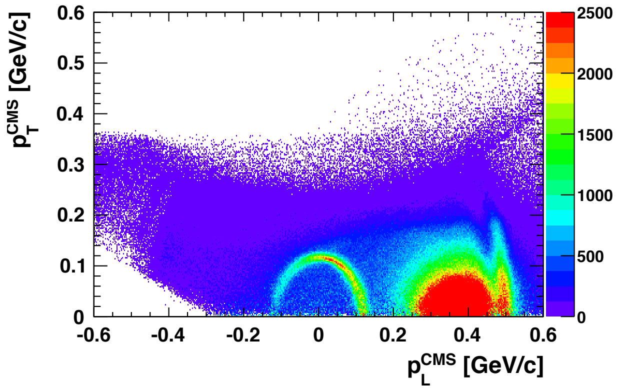

Fig. 1: Momentum plot to identify the ${}^3\mathrm{He}\,\eta$ reaction.

can be extracted as shown in figure 2. The background, originating mainly from the multi pion production and the deuteron break-up, can be described very well by sub-threshold data ($Q \approx -5\,\mathrm{MeV}$). Although currently

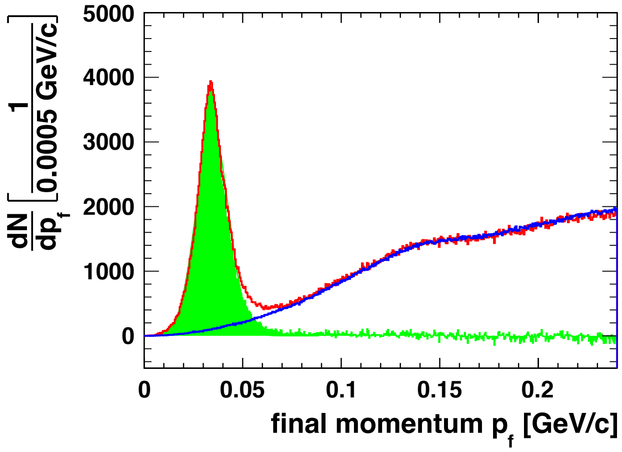

Fig. 2: Momentum p_f (red) at an excess energy of $Q \approx 0.6\,\mathrm{MeV}$, the background description (blue) and the extracted ${}^3\mathrm{He}\,\eta$ signal (green).

detailed investigation are performed on the fine calibration of the forward detector system, already now it is obvious that the accuracies of the beam momenta and the ${}^3\mathrm{He}\,\eta$ final state momenta allow for an η mass determination with the desired resolution of better than 100 keV.

References:

[1] C. Amsler et al., Phys. Lett. B **667**, 1 (2008).
[2] Ya. S. Derbenev et al., Part. Accel. 10, 177 (1980).
[3] P. Goslawski, Diploma thesis, Westfälische-Wilhelms Universität Münster (2008); P. Goslawski et al., Phys. Rev. ST Accel. Beams 13 (2010) 022803.

[1]Institut für Kernphysik, Westfälische-Wilhelms Universität Münster, 48149 Münster, Germany
*Supported by FZ Jülich FFE