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STUDY OF THE NNη' PRODUCTION WITH COSY-11*

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We describe a new high precision measurement of the production cross section for the η' meson in proton–proton collisions $\sigma_{pp\to pp\eta'}$ for five beam momenta at low access energy region Q conducted at the COSY-11 detection system together with an updated results of all other previous measurements of $\sigma_{pp\to pp\eta'}$ at COSY-11.

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1. Introduction

Recently, the increased interest in the properties of the η and η' meson can be observed due to extensive experimental search of the η and η' bound states performed *e.g.* at COSY [1–6], ELSA [7], GSI [8, 9], JINR [10], JPARC [11, 12], LPI [13], and MAMI [14, 15] as well as intensive theoretical investigations *e.g.* [16–28].

Properties of η' in nuclear medium are related with the effects of $U_A(1)$ anomaly at finite density [17, 19, 20, 29], which is reflected in the large mass of the η' meson compared to the masses of the other members of the pseudoscalar meson nonet [30, 31], and with the η–η' mixing [19, 32].

COSY-11 experiment [33, 34] has provided already an important data for these studies [35–38], with the most precise direct measurement of the total width of the η' meson $\Gamma_{\eta'}$ [39, 40], and the first rough estimation of the η'–N interaction from the excitation function of the cross section for the $pp \to pp\eta'$ reaction [41]. Here, we describe an analysis of the data used

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earlier for $\Gamma_{\eta'}$ determination in view of the extraction of the production cross section for the η' meson $\sigma_{pp\to pp\eta'}$ in proton–proton collisions and an update of the $\sigma_{pp\to pp\eta'}$ values presented previously [35–37].

2. Experiment

In the reported measurement, the η' meson was produced in proton–proton collisions reaction and its mass was reconstructed based on the momentum vectors of protons taking part in the $pp \to pp\eta'$ reaction which was measured at five different beam momenta using the COSY-11 detector setup [33, 34] installed at the Cooler Synchrotron COSY [42] in Research Centre Jülich. The schematic view of the COSY-11 detector setup is presented in Fig. 1.

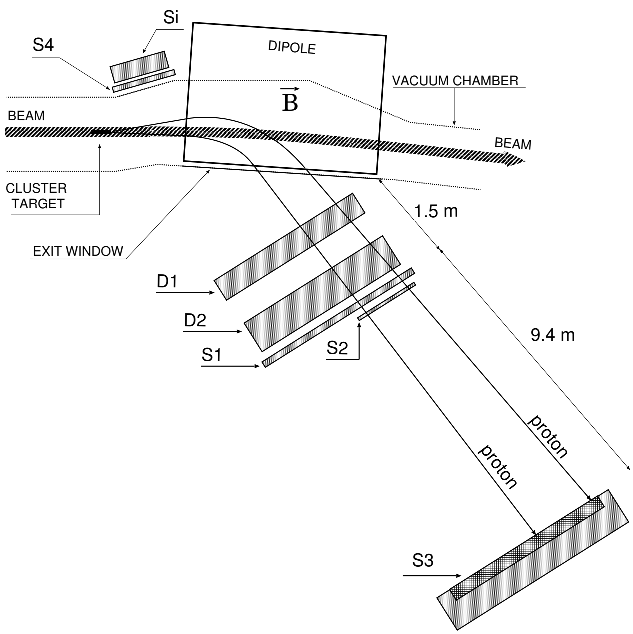

Fig. 1. Schematic view of the COSY-11 detector setup (top view). S1, S2, S3 and S4 denote scintillator detectors, D1 and D2 indicate drift chambers and Si stands for the silicon-pad detector.

The collision of a proton from the beam with a proton cluster target may cause an η'-meson creation. In that case, all outgoing nucleons have been registered by the COSY-11 detectors, whereas for the η'-meson identification the missing mass technique was applied. The COSY beam momentum and the dedicated zero degree COSY-11 facility enabled the measurement at an excess energy down the fraction of an MeV above the kinematic threshold for the η'-meson production. Modification of the COSY-11 target system allowed to decrease effective beam momentum spread and, therefore, enabled precise determination of the access energy Q with the precision of 0.10 MeV. Good control of the systematic uncertainties was possible due to measurement performed at five different values of Q and monitoring of the beam and target properties [43]. On the other hand, the achieved missing mass resolution in the order of the total width of the η' meson itself [40] improved significantly the η' production cross section measurement. The number of registered η' mesons was obtained from the missing mass spectra for each Q value and corrected for the detector geometrical acceptance and registration efficiency. The luminosity value was determined using comparison of the cross section of $pp \to pp$ reaction determined by the EDDA Collaboration [44] and the number of registered elastically scattered protons.

3. Results

Since $\sigma_{pp\to pp\eta'}$ measured at COSY-11 was obtained with the luminosity determination based on the EDDA data available at that time [45], we updated these numbers accordingly to superseded data [44]. COSY-11 measurement at $Q = 16.4$ MeV [38] was already reported with new EDDA data [44], whereas SPESIII [46] and DISTO [47] used different techniques for luminosity determination. The experimental data presented at Fig. 2

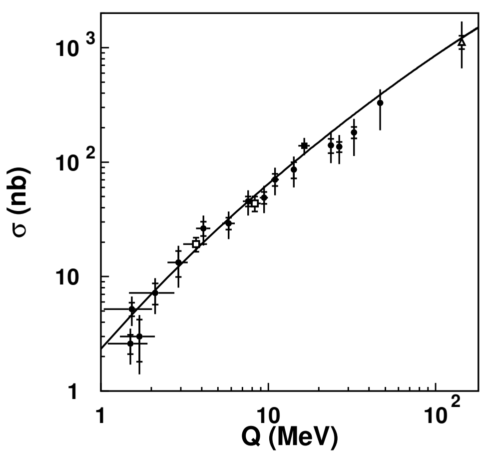

Fig. 2. Total cross section for the η'-meson production in the proton–proton collision as a function of the access energy Q for the $pp \to pp\eta'$ reaction measured at: COSY-11 (solid circles — updated values of [35–37], solid square — measurement [38] with usage of EDDA 2004 data [44]), SPESIII (open squares) [46] and DISTO (open triangle) [47]. The solid line shows parametrization of the experimental data using formula (1).

are compared to the analytical parametrization derived by Fäldt and Wilkin [48, 49] which takes into account final state interaction of the protons

$$\sigma_{pp\to pp\eta'}(Q) = C\frac{Q^2}{m_p p_{\mathrm{LAB}}}\frac{1}{\left(1+\sqrt{1+\frac{Q}{\epsilon}}\right)^2}, \quad (1)$$

where Q denotes the excess energy, p_{LAB} beam momentum, m_p proton mass. The parameters $\epsilon = 0.75^{+0.20}_{-0.15}$ MeV and $C = 45^{+10}_{-9}$ mb denote the Coulomb distortion and constant factor, respectively, and have been determined by fitting this formula to the experimental data. Values of $pp \to pp\eta'$ cross sections determined at COSY-11 are gathered in Table I apart from the new measurement reported here, which is still in the final stage of the analysis.

TABLE I

Updated values of production cross sections for the η' meson in proton–proton collisions measured at COSY-11 detector [35–38] with statistical and systematic uncertainties, respectively.

Q [MeV]	$\sigma_{pp\to pp\eta'}$ [nb]
1.5 ± 0.4	2.6 ± 0.5 ± 0.4
1.53 ± 0.49	5.2 ± 0.7 ± 0.8
1.7 ± 0.4	3.0 ± 1.2 ± 0.5
2.11 ± 0.64	7.2 ± 1.5 ± 1.1
2.9 ± 0.4	13.3 ± 3.4 ± 2.0
4.1 ± 0.4	26.4 ± 3.8 ± 4.0
5.80 ± 0.50	29.2 ± 3.5 ± 4.4
7.57 ± 0.51	45.5 ± 4.5 ± 6.8
9.42 ± 0.53	49.0 ± 5.9 ± 7.4
10.98 ± 0.56	70.5 ± 8.6 ± 11
14.21 ± 0.57	86 ± 14 ± 13
16.4 ± 1.3	139 ± 3 ± 21
23.64 ± 0.64	146 ± 20 ± 22
26.5 ± 1.0	136 ± 14 $^{+22}_{-26}$
32.5 ± 1.0	182 ± 21 $^{+36}_{-48}$
46.6 ± 1.0	329 ± 18 $^{+85}_{-122}$

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