Measurement of the $pp \to pp\eta'$ reaction aiming at determination of the natural width of the η' meson

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The physics of the η' meson receives an increasing interest in view of the forthcoming measurements planned e.g. at the COSY, DAϕNE-2 and MAMI-C facilities where the η' will be produced in hadron-hadron, e^+-e^-, and γ-hadron reactions, respectively. Therefore, the precise determination of the natural width of the η' meson ($\Gamma_{\eta'}$) will have an impact on the physics results which will be derived from future measurements of detector setups like: WASA-at-COSY [1] and KLOE [2].

Among previous experiments the one performed by the NIMROD collaboration extracted the width of the η' meson with the smallest error: $\Gamma_{\eta'} = 0.28 \pm 0.1$ MeV/c^2 [3]. Based on many years of experience gained with the COSY-11 apparatus and thorough simulations we have established that at the COSY-11 facility, combined with the excellent features of the COSY proton beam, the natural width of η' can be determined with at least five times better precision. This will be due to an about three times better experimental resolution, larger statistics, larger signal to background ratio, and finally due to a simultaneous use of two independent methods for the derivation of the width of the η' meson. The $\Gamma_{\eta'}$ will be derived directly from the missing mass distribution of the $pp \to ppX$ reaction and also from the shape of the excitation function.

In May 2006 the COSY Programme Advisory Committee has recommended the realisation of a corresponding proposal [5] and the measurement of the $pp \to pp\eta'$ reaction was conducted by the COSY-11 collaboration in October 2006. In the experiment five discret values of beam momentum were used: 3211, 3213, 3214, 3218 and 3224 MeV/c, where the threshold beam momentum is equal to 3208.3 MeV/c. In order to improve the experimental resolution of the four-momentum determination of the registered particles and in order to decrease the spread of the momentum of the beam protons reacting with the target two major changes have been applied to the COSY-11 setup. Namely, the spatial resolution of the measurement of the particle track coordinates in the drift chambers was improved by increasing the supply voltage up to the maximum allowed value and also the dimensions of the target in the direction perpendicular to the COSY beam was decreased from 9 to $\approx$1 mm (rectangular 9×1 mm instead of circular target).

In order to control the systematical uncertainties each of the crucial parameters (like target dimesions or beam momentum spread) were monitored by at least two independend methods [5].

The received mean luminosity equals to $1.4 \cdot 10^{30}$ s^{-1}cm^{-2} resulting in an integrated luminosity of 1.3 pb^{-1}. This is smaller than the expected 3.6 pb^{-1} used for the estimations in the proposal [5] because of a reduction in the beam time (almost 5 days breakdown in COSY operation) and because of a 30% smaller luminosity.

An online analysis has revealed a signal originating from the production of the η' meson at each of the investigated beam momenta (see Fig. 1). The obtained width of the η' peak in the missing mass spectra (FWHM) equals to approximatly 0.5 MeV/c^2. Thus, already online spectra show that the achieved mass resolution is at least three times better than reached at the best of the previous measurements. Although such a resolution is already comparable with the expected value of the width of the η' meson, it is still broader than expected but we are confident to improve it in the off-line analysis.

Probably, the broadening was due to changes of the beam optics which caused variations of the beam momentum value at the interaction region on the 10^{-4} level. In order to enable an off-line correction of these variations we have monitored various parameters which could influence the beam conditions like current in the COSY dipoles, temperature of the cooling water of the magnets, air temperature, humidity and barometric pressure inside COSY tunnel. Independently it will be possible to correct the variation of the beam momentum based on the distribution of the elasticaly scattered protons measured simultaneously with the $pp \to pp\eta'$ reaction.

The off-line analysis of the data is in progress.

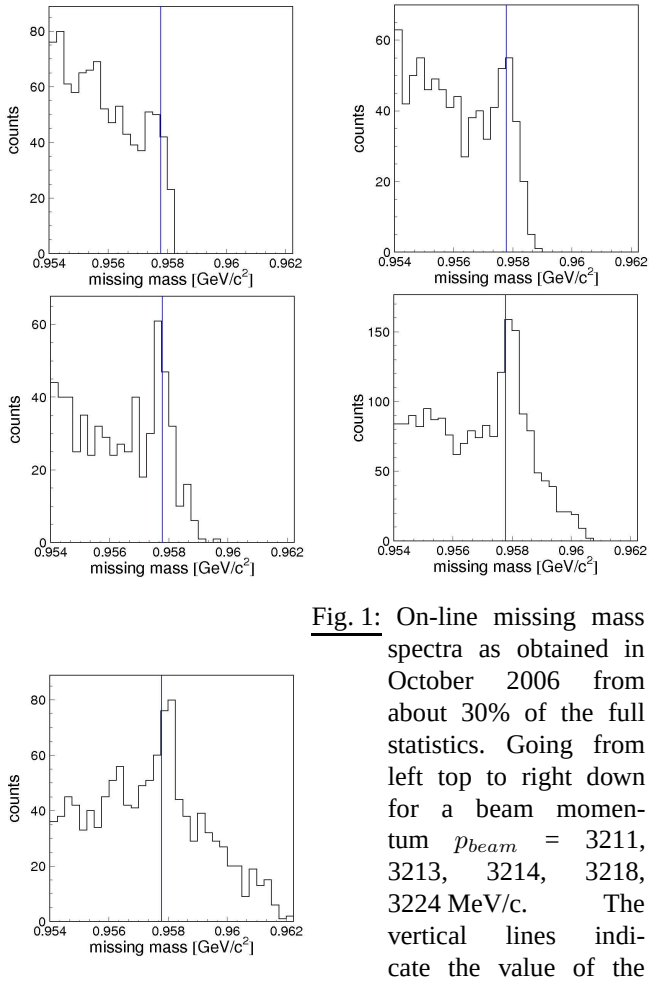

Fig. 1: On-line missing mass spectra as obtained in October 2006 from about 30% of the full statistics. Going from left top to right down for a beam momentum p_{beam} = 3211, 3213, 3214, 3218, 3224 MeV/c. The vertical lines indicate the value of the mass of the η' meson ($m_{\eta'}$ = 957.78 MeV/c^2)

References:

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