Estimate of the multimeson background for measurement of the η' decays with WASA-at-COSY

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The η' mesons for the rare decay studies with the WASA detector will be produced in the $pp \to pp\eta'$ reaction near the threshold. The identification of the $pp \to pp\eta'$ process will be performed by means of the missing mass of the two outgoing protons measured in the Forward Range Hodoscope (FRH). One of the sources of the background originates from multimeson (mainly 2π and 3π) production. For the decay channels with similar particles in the final state this background is crucial for the determination of systematical and statistical uncertainty. The background will appear as a continuum under the η' peak in the missing mass distribution.
The upper limit of the background can be estimated using the COSY-11 measurements of the $pp \to ppX$ reaction near the threshold for the production of the η' meson [1]. We have extracted differential cross section $\rho_B \equiv \frac{d\sigma_B}{dm}\Big|_{m=m_{\eta'}}$ for the production of the multimeson system with the invariant mass corresponding to the mass of the η' meson according to the formula:

$$\rho_B = \frac{N_B}{N_S}\frac{\sigma_{\eta'}^{tot}}{\Delta m}, \qquad (1)$$

where N_B number of measured background events, N_S number of registered $pp \to pp\eta'$ events, $\sigma_{\eta'}^{tot}$ is the total cross section for the η' meson production and Δm is the width of the signal. Table 1 shows the derived values of the ρ_B as a function of Q (center-of-mass excess energy for the $pp \to pp\eta'$ reaction), with corresponding statistical and systematical errors [2].

Q [MeV]	ρ_B [nb/MeV]	$\Delta\rho_B(stat)$ [nb/MeV]	$\Delta\rho_B(syst)$ [nb/MeV]
1.53	1.04	0.14	0.2
4.10	7.0	1.1	1.1
5.80	13.4	1.2	2.0
7.60	18.2	1.6	2.8
9.42	32.3	3.6	4.9
10.98	32.7	3.2	4.9
14.21	60	11	9.0
15.50	85	2.4	13
23.64	117	17	17
46.60	322	16	48

Table 1: Differential cross section for multipion production extracted form the COSY-11 data [1]

A satisfactory description of the Q dependence of ρ_B was obtained by a function of the following form:

$$\rho_B(Q) = \alpha(Q/Q_0)^\beta \qquad (2)$$

where Q_0=1 MeV and the parameters α and β were estimated to be $\alpha = 0.64 \pm 0.14$ nb/MeV and $\beta = 1.662 \pm 0.081$. The extracted values of ρ_B with the superimposed fit are shown in Fig. 1.
The established differential cross section can be treated as an upper limit for the expected background from $pp \to pp\pi^+\pi^-\pi^0$ for the η' decay into $\pi^+\pi^-\pi^0$. The signal to background ratio expected for the WASA detector could be then

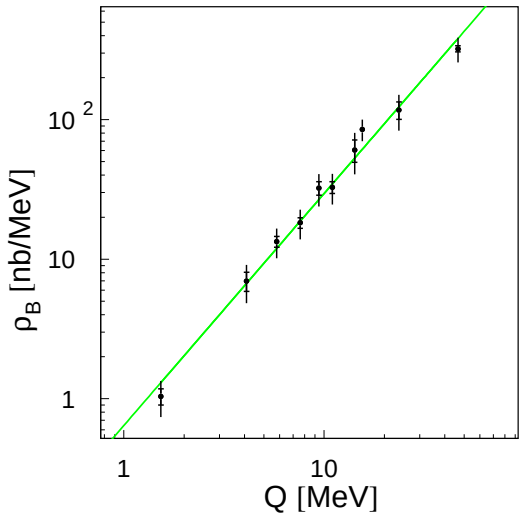

Fig. 1: Inclusive differential cross section for multipion production derived from the COSY-11 data [1]. Line – the function (2) fitted to the data.

calculated from ρ_B using formula (1) by replacing Δm by the WASA detector missing mass resolution and the cross section $\sigma_{\eta'}^{tot}$ by the product $\sigma_{\eta'}^{tot} \times BR(\eta' \to \pi^+\pi^-\pi^0)$.
By that means we can compute values of the expected continuum background as a function of the excess energy near the η' threshold. The value is an important ingredient for the preparation of the η' meson decays experiments at WASA-at-COSY and the estimates of the expected uncertainties and necessary duration of the experiments [3].

References:

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