The WASA-at-COSY missing mass resolution for η′ tagging

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The studies of the η′ meson decays are one of the main goals of the WASA-at-COSY experiment [1]. Due to cross section considerations the most appropriate way for the production of the η′ meson would be the $pp \to pp\eta'$ reaction where mesons can be tagged by means of the missing mass technique. In this report we discuss analytical parametrisations of the missing mass resolution.

The resolution of the missing mass determination can be described e.g. by one of two functions: exponential

$$f_e(\mu) = A\exp\left(B|\mu| + C\mu\right), \tag{1}$$

or asymmetric Gauss:

$$f_g(\mu) = A\exp\left(-\frac{\mu(\mu - |\mu|)}{4\alpha^2} - \frac{\mu(|\mu| + \mu)}{4\beta^2}\right) \tag{2}$$

where $\mu = mm - m_{\eta'}$, with mm denoting the value of the reconstructed mass. For a given shape of the peak $f(\mu)$ one can find the optimal value of the $\Delta\mu$ region as a value corresponding to the minimum of [2]:

$$\frac{\sqrt{\Delta\mu}}{\int_{-\Delta\mu_-}^{\Delta\mu_+} f(\mu)d\mu}, \tag{3}$$

which is expected to be around $\Delta\mu = FWHM$.

In Fig. 1 the distribution of the difference between the reconstructed and real mass of the η′ meson is shown. The superimposed lines were fitted using formulas (1) and (2). The figure indicates that due to the relatively large tails the exponential function describes the shape of the spectrum better than the Gaussian. Further on Fig. 2 shows a dependence of a missing mass resolution simulated for Q = 40 MeV, as a function of the energy resolution. The values of FWHM represented by triangles were obtained applying the formula:

$$\Delta\mu = FWHM = ln(2)\left(-\frac{1}{B+C} + \frac{1}{C-B}\right), \tag{4}$$

with parameters B and C determined by fitting expression 1 to the simulated spectra of μ. Moreover, as shown by the solid line, the observed dependence may be parametrized by:

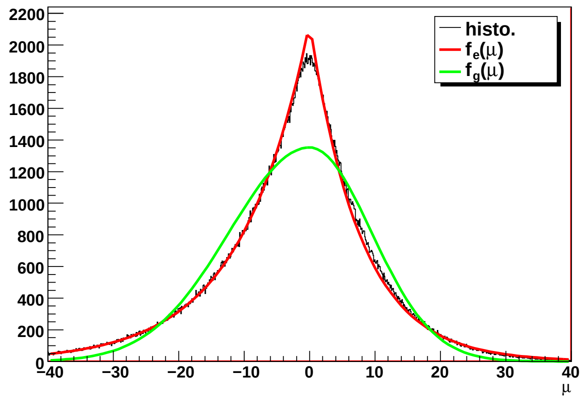

Fig. 1: Figure shows results of the Monte-Carlo simulations of the μ ditribution for excess energy Q = 40 MeV. Simulations were conducted for the $pp \to pp\eta'$ reaction using ROOT event generator whitout beam spread and including only energy resolution for registration of protons. Superimposed lines denote the fit with: exponential function $f_e(\mu)$ - red line; and asymmetric Gauss function $f_g(\mu)$ - green line.

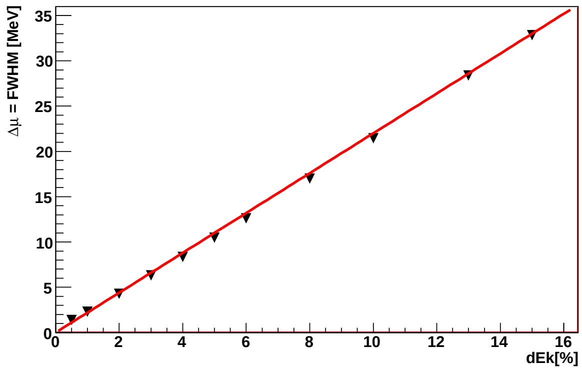

Fig. 2: The FWHM of the missing mass spectra as a function of energy resolution of protons simulated at Q = 40 MeV for the $pp \to pp\eta'$ reaction. The black triangles denote the FWHM calculated fromexpression (4), and the superimposed red line indicates parametrisation according to formula (5).

$$\Delta\mu = 11\frac{\Delta E}{E}\sqrt{Q}. \tag{5}$$

where ΔE denotes the the energy resolution of protons. The systematic and statistical errors in the evaluations of studied decay channels will depend on the precision of the missing mass reconstruction. Using the $f_e(\mu)$ function one can describe the resolution function of the missing mass in a analitical way which facilitate determining of the optimal value of the $\Delta\mu$ region.

References:

[1] H. H. Adam et al., `arXiv:nucl-ex/0411038` (2004)

[2] M. J. Zieliński, Dip. Thesis, Jagiellonian University, `arXiv:0807.0576 [hep-ex]` (2008)

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