Invariant mass distributions for the $pp \to pp\eta$ reaction at Q = 10 MeV

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The earlier high statistics measurements of the $pp \to pp\eta$ reaction from the COSY-11 [1] and TOF groups [2]revealed that there exist significant enhancements in the invariant mass distributions of pp and $p\eta$ subsystems at higher values of proton-proton invariant mass and lower values of the proton-η invariant mass. One of the plausible explanations for these enhancements could be an influence of the proton-η interaction [**?**, 3]. If this is the case one could use such observables for the estimation of the strength of this interaction. However, the observed invariant mass distributions could be also plausibly explained by contributions of higher partial waves [4, 5] or by an energy dependence of the primary production amplitude [6]. Therefore, in order to verify the correctness of the proposed explanations it is of importance to investigate the dependence of the strength of the enhancements as a function of the excess energy. To this end we performed an analysis of the proton-proton and proton-η invariant mass distributions at the excess energy of Q = 10 MeV which is significantly closer to the threshold with respect to the previous studies. Although the original experiment at Q = 10 MeV has been devoted to the investigations of the analysing power for the $pp \to pp\eta$ reaction [8] and has been performed with a vertically polarised proton beam, the data enable also the determination of the spin averaged observables after appropriate offline "depolarisation" of the beam. In the discussed experiment the direction of the polarisation was being flipped from cycle to cycle. Hence, for the so called "spin up cycles" we define the spin up polarisation as:

$$P^{\uparrow} = \frac{\sum_{i=up} n_{+,i} - \sum_{i=up} n_{-,i}}{\sum_{i=up} n_{+,i} + \sum_{i=up} n_{-,i}}, \quad (1)$$

and analogously for "spin down cycles" the spin down polarisation reads:

$$P^{\downarrow} = \frac{\sum_{i=dn} n_{-,i} - \sum_{i=dn} n_{+,i}}{\sum_{i=dn} n_{-,i} + \sum_{i=dn} n_{+,i}}, \quad (2)$$

where, $n_{+,i}$ and $n_{-,i}$ denote the number of protons in the i^{th} cycle, in spin up and down state, respectively. The beam can be effectively depolarized e.g. by assigning to the events in spin up cycles the weights w which can be derived from the following requirement [9]:

$$w \cdot \sum_{i=up} n_{+,i} + \sum_{i=dn} n_{+,i} - (w \cdot \sum_{i=up} n_{-,i} + \sum_{i=dn} n_{-,i}) = 0. \quad (3)$$

Thus, combining eqs. 1 and 2 with eq. 3 we obtain the following formula for the value of w:

$$w = \frac{P^{\downarrow}}{P^{\uparrow}} \cdot \frac{\sum_{i=dn} n_{-,i} + \sum_{i=dn} n_{+,i}}{\sum_{i=up} n_{+,i} + \sum_{i=up} n_{-,i}} = \frac{P^{\downarrow}}{P^{\uparrow}} \cdot \frac{L^{\downarrow}}{L^{\uparrow}} = \frac{P^{\downarrow}}{P^{\uparrow}} \cdot \frac{1}{L_{rel}} \quad (4)$$

where $L_{rel} := \frac{L^{\uparrow}}{L^{\downarrow}}$ denotes the relative luminosity for the spin up and down cycles. For the description of the relative motion of the protons and the η meson we have divided the range of s_{pp} and $s_{p\eta}$ into 20 bins. For each bin of these variables we have determined the spectrum of the square of the missing mass. Analogoues spectra were simulated for the $pp \to pp\eta$ reaction and for the background channels. The simulated events were analysed with the same program

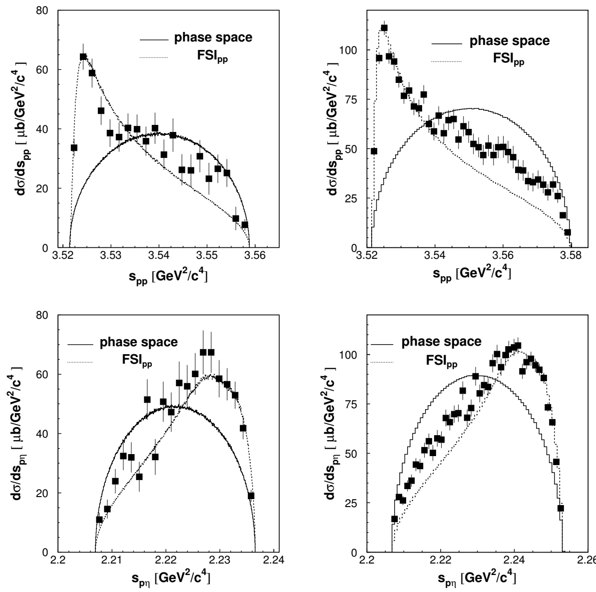

Fig. 1: Distributions of the square of the proton-proton and proton-η invariant masses as measured at Q = 10 MeV (left) and Q = 15.5 MeV (right). Solid lines represent the homogeneous phase-space distributions, while the dotted lines are the theoretical predictions taking into account the $^1S_0$ proton-proton final state interaction.

as the experimental data. The results on the differential cross sections for the $pp \to pp\eta$ reaction as a function of the square of the proton-proton and proton-η invariant masses are presented in the left part of Figure 1. They are compared with the differential cross sections measured at the excess energy of Q = 15.5 MeV [1], displayed in the right part of Figure 1. The total cross section evaluated as an integral of the s_{pp} distribution equals to $\sigma = 1.27 \pm 0.04 \pm 0.13\ \mu$b, where the first error is the statistical and the second the systematic one. This result is in line with the previous measurements performed independently by various experimental groups and was accepted for publication in the European Physical Journal A [9].

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