Phenomenological analysis of near-threshold production of π^0, η, and η' mesons in proton-proton collisions.

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A comparative study of the production of mesons with significantly different masses encounters the difficulty of finding a proper variable at which the observed cross sections can be compared. In case of $pp \to ppX$ reactions a total cross section is an integral over phase space, weighted by the square of the transition matrix element and normalized to the incoming flux factor [1]. Therefore we propose the volume of the available phase space for the produced particles [2] as a variable suited to compare the cross sections. Figure 1 shows the yield of π^0, η, and η' meson production in the proton-proton interaction as a function of the available space phase volume. The yield is defined as the cross section multiplied by the corresponding flux factor, and divided by the ISI reduction factor accounting for the repulsive interactions of protons in the initial state [3]. Hence, the chosen dimensionless quantity $\frac{\sigma \cdot F}{ISI}$, depends on the primary production amplitude M_0 and on the final state interaction among the produced particles only. Thus, the observed differences in the production yield for the different mesons, as shown in Figure 1, indicate directly the difference in the primary production dynamics convoluted with the interactions in the exit channel. The data [4] for π^0, η, and η' meson production are grouped on parallel lines indicating a dependence according to the power low: $\frac{\sigma \cdot F}{ISI} = \alpha * V_{phs}^{0.61}$. A similar behaviour was also found when plotting the data versus the maximum center-of-mass momentum of the produced meson normalized to its mass [5]. The dynamics of the $pp \to ppX$ reaction would be independent of the produced meson, all the data points in Figure 1 would lay on the same line.

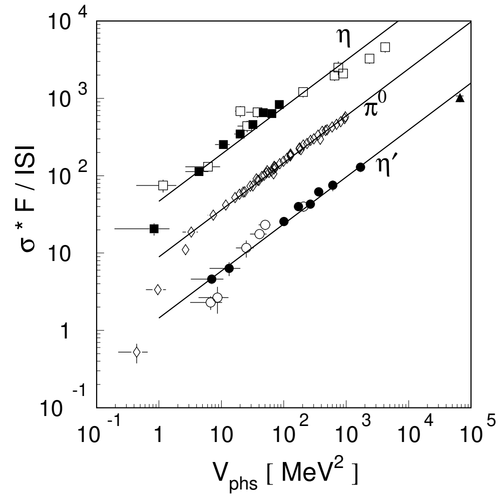

Figure 1: Yield defined in text for the reactions $pp \to pp\eta$ (squares), $pp \to pp\pi^0$ (diamonds), and $pp \to pp\eta'$ (circles,triangle) [4], The filled squares and circles indicate recent COSY - 11 results.

Assuming that the production amplitude factorizes into an energy independent primary production amplitude $|M_0|$ and the FSI and ISI factors we derived from the experimental data the $|M_0|$ values for each discussed meson [2]. Further we normalized the obtained $|M_0^\eta|$ and $|M_0^{\eta'}|$ to the $|M_0^{\pi^0}|$. These ratios, presented in Figure 2, are independent of the prescription used for the proton-proton interaction. The increasing strenth of the ratio $|M_0^\eta|/|M_0^{\pi^0}|$ at low V_{phs} (Figure 2b) indicates a much stronger η-proton FSI than the π^0-proton one. Note, however, that the ratio for the η' meson is constant over the phase space range considered (Figure 2b). This allows us to conclude that the η'-proton interaction is in the order of or weaker than the π^0-proton one.

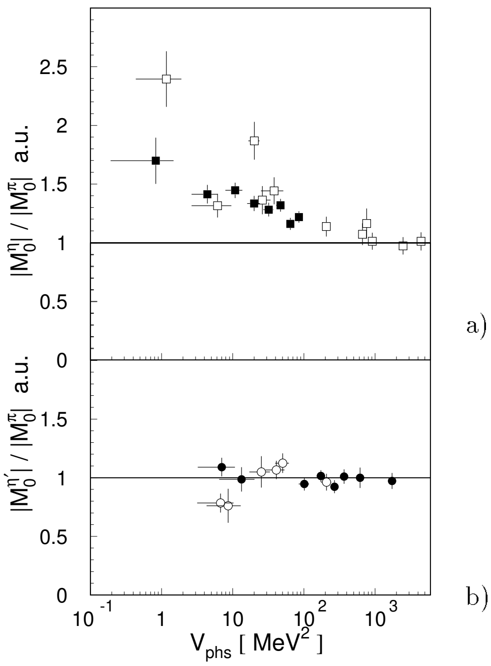

Figure 2: The ratios of a) $|M_0^\eta|/|M_0^{\pi^0}|$ and b) $|M_0^{\eta'}|/|M_0^{\pi^0}|$ extracted from the data, assuming the pp-FSI enhancement factor of reference [6]

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