SIMPLE ANALYSIS OF THE THRESHOLD MESON PRODUCTION IN *pp* COLLISIONS *

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A phenomenological model is used to analyze the π and η meson formation in pp collisions. The aim is to describe final state interactions. Strong ηpp correlations are found at very low energies.

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The recent meson production experiments in the near-threshold reactions

$$pp \to pp\pi^o \quad \text{and} \quad pp \to pp\eta$$

present a twofold interest. The prime question is the mechanism of the momentum-energy transfer required for the meson formation. Another, simpler, question is related to the final state mesonic interactions. Here, of interest are the studies of ηpp and ηp scattering. These reactions are useful since only one partial wave is relevant in the pp system . It is $^3P_0$ in the initial and $^1S_0$ in the final state. The experimental production cross sections rise rapidly with the increasing available energy Q. Three factors contribute: the three body phase space which follows Q^2 , the Coulomb barrier that damps the cross sections in an exponential way and the quasi-deuteron state which dominates the $^1S_0$ wave in the final pp system. Once these effects are removed from the analysis, some somplicity in the π production is revealed. On the other hand, an interesting structure is discovered in the in the η production at very low energies.

Assume that the meson production is described by an operator $T(r)$ where r is the relative proton-proton coordinate. The amplitude A is then given by an integral

$$A(P,p) = \int d^3r j_o(qr/2)\psi^-_{pp}(r,p)^* T(r)\phi_{pp}(r,P) \tag{1}$$

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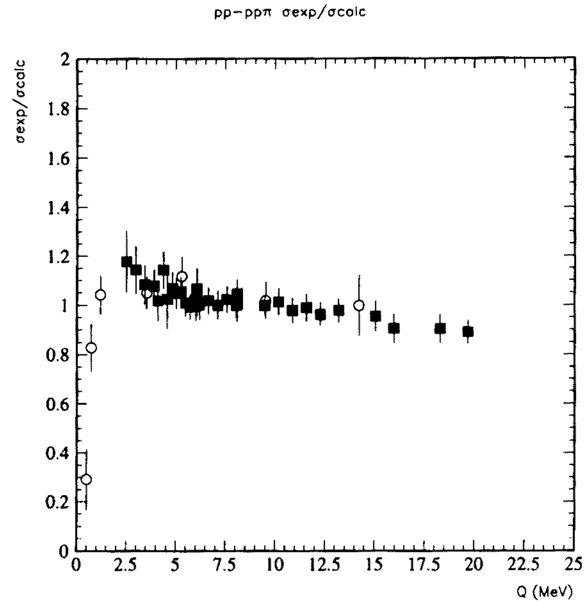

Fig. 1. The experimental [1] pion production cross section scaled by the calculated σ_o, plotted against the excess energy.

with wave functions $\phi_{pp}(r,P)$, $\psi^-_{pp}(r,p)$, j_o describing the interacting initial and final pp pairs and noninteracting final mesons. A simple form $T(r) = const * exp(-\mu r)/r(1/r + d/dr) * const$ motivated by the meson exchange models ([2]) is tried. Next, the production X-section $\sigma_o(Q)$ is calculated and used to scale the experimental one. The ratio $\sigma_{\rm exp}(Q)/\sigma_o(Q)$ for pions is shown in Fig. 1. Essentially it is a constant which we find well-independent on the parameter μ and the detailed form of $T(r)$. The actual value of this constant is a well known problem of the theory [2]. The picture changes dramatically if one turns to η production, as shown in Fig. 2. The enhancement close to threshold is due to the strong attraction in the final state. It may be described by an amplitude of the type (1) with the pp pair produced from an object of a 4 fm radius. The question arises, is that **a Borromean ηpp state?** To answer it, we have summed the final state interactions with a method used previously in the η-helium and η-deuteron interactions [4]. In order to reproduce the enhancement one needs the $\eta - p$ scattering length Re $a \geq .7$ fm, *i.e.*larger than the standard $(.3 - .5$ fm), but allowed by some analyses. The same calculation produces an η-deuteron quasibound state for Re $a \geq .8$ fm. With the uncertainties in Fig. 2 one cannot tell is the enhancement due to a Borromean system (quasi-bound state with singularity on the physical energy sheet) or a 3-body resonance

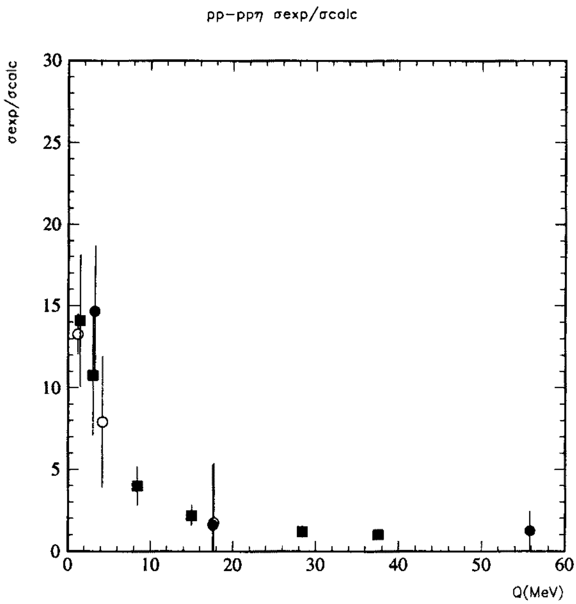

Fig. 2. The experimental [3] eta production cross section scaled by the calculated σ_o, plotted against the excess energy.

(singularity located on an unphysical sheet related to the virtual *pp* state). To elucidate the question it is useful to measure : the relative *pp* momentum distributions and the pion production cross section at and just below the η production threshold.

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