Strangeness Production in the Reaction $pp \to ppK^+K^-$ close to Threshold

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While low lying pseudoscalar, vector and tensor mesons are described successfully as $q\overline{q}$ states on the basis of the quark model, the present understanding of scalar mesons appears still to be uncertain.

A study of the reaction $pp \to ppK^+K^-$ is especially motivated by the discussion on the nature of the scalar resonances $f_0\,(980)$ and $a_0\,(980)$ in view of their affiliation to the scalar nonet. A $qq\overline{qq}$ state within a nonet derived from colour–hyperfine interactions [1], a simple $q\overline{q}$ structure [2] and a $K\overline{K}$ molecule structure [3] have been suggested in case of the $f_0\,(980)$.

A recent analysis [4] in the framework of the Jülich meson exchange model for $\pi\pi$ and $\pi\eta$ scattering concludes the f_0 to be a $K\overline{K}$ bound state originating from the strong $K\overline{K}$ interaction generated by vector meson exchange. The threshold behaviour of the $\pi\pi \to K\overline{K}$ cross section is shown to be sensitive to the strength of the $K\overline{K}$ interaction.

Thus, a measurement of the excitation function of K^+K^- production in the proton proton interaction should reveal valuable information on the magnitude of the $K\overline{K}$ interaction and, consequently, on the structure of the scalar resonances in the $K\overline{K}$ threshold region.

In April 1996 data on the reaction $pp \to ppK^+K^-$ have been taken at the COSY–11 facility at a beam momentum of 3.321 GeV/c, corresponding to an excess energy of 6.1 MeV above threshold (p_{beam}^{thresh} = 3.3016 GeV/c). A run for background investigation was done at 3.294 GeV/c, i.e. below threshold.

Particles are identified by a momentum determination, via tracing back trajectories measured by two drift chamber stacks (D1,D2) in the dipole field to the target position, in combination with a time–of–flight measurement between the scintillation hodoscopes S1 or S2 and the large area scintillation wall S3. A detailed description of the detection system is given in [5].

Preselecting two proton final states, the time of the production in the target is intrinsically provided and an indirect time–of–flight measurement between the target location and the "start" hodoscope S1 for a third charged particle not hitting the stop scintillator S3 can be applied. Thus, the indirect time–of–flight method allows a particle identification for the third positively charged ejectile including its three–momentum from the reconstruction in the dipole field.

The invariant mass of the third track is plotted versus the missing mass in the identified (pp) system in figure 1. Candidates of positively charged kaons are well separated from a dominant pionic background (fig. 1). Figure 2 shows the reconstructed invariant K^+ mass versus the missing mass in the (ppK^+) subsystem, i.e. the mass of the fourth unmeasured ejectile Y, resulting in a total of 5 identified $pp \to ppK^+K^-$ events out of a three day run. The large scattering of the invariant mass of the third charged ejectile is due to the inaccuracy of the indirect time–of–flight measurement which is presently being improved. In comparison with a measurement below threshold of similar integrated luminosity the (ppK^+K^-) identification nonetheless proves to be free of background. An exemplary reconstructed $pp \to ppK^+K^-$ event including the response of a silicon pad detection system mounted inside the

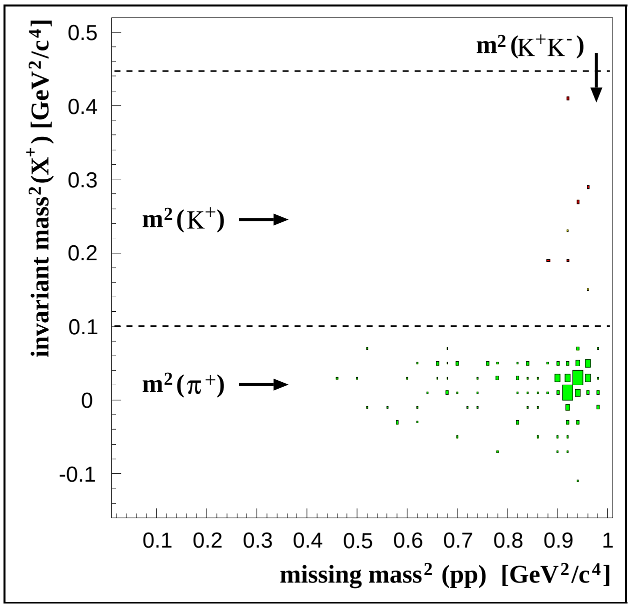

Figure 1: Squared invariant mass of particle X in $pp \to ppXY$ events versus the squared missing mass of the associated (pp) system.

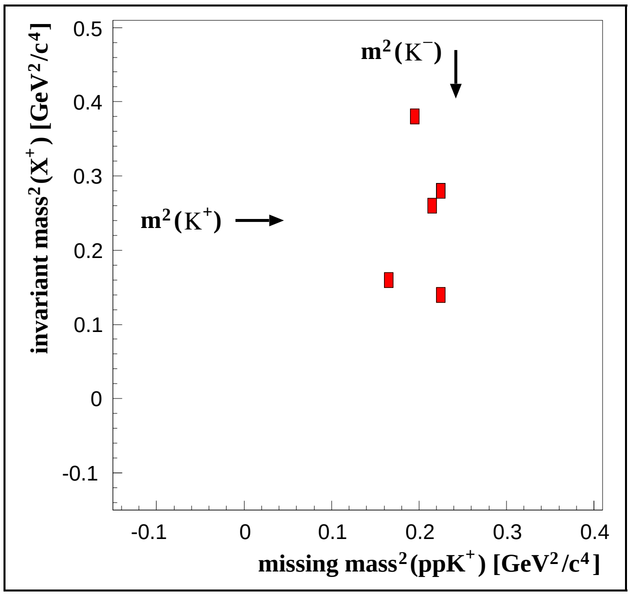

Figure 2: Squared invariant mass of particle X versus the squared missing mass of the identified (ppK^+) system.

dipole gap in agreement with a detected negatively charged kaon is displayed in figure 3.

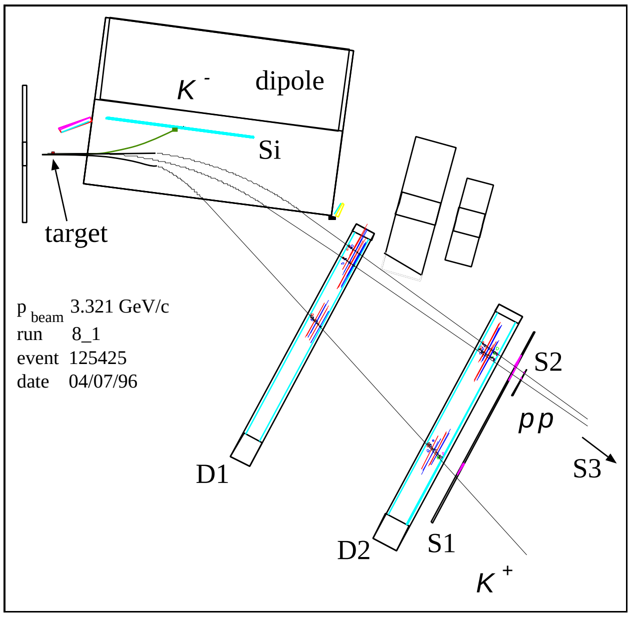

Figure 3: Exemplary $pp \to ppK^+K^-$ event with reconstructed tracks of two protons and a positively charged kaon, indicating also the response of the silicon pad detector inside the dipole gap in agreement with a detected negatively charged kaon.

An efficiency $\eta = 0.051$ for the detection of three tracks, including the possible kaon decay, has been calculated from Monte Carlo simulations. The preliminary estimate of the total cross section at 3.321 ± 0.003 GeV/c results from a present upper limit for the integrated luminosity of $L \times T \leq 180 \times 10^{33}\mathrm{cm}^{-2}$:

$$\sigma_{pp\to ppK^+K^-\ (\mathrm{Q=6.1\ MeV})} \geq 520\ \mathrm{pb}.$$

The error is estimated to be less than a factor of two and will be reduced by the normalization of simultaneously measured pp elastic scattering to forthcoming data from the EDDA experiment [6].
Data taken in December 1996 at a beam momentum of 3.333 GeV/c (10 MeV excess energy) with an improved luminosity by one order of magnitude are currently being analyzed. Further measurements closer to threshold are planned for the first half of 1997 [7].

References:

[1] R. Jaffe, Phys. Rev. D 15 (1977) 267.

[2] D. Morgan, M. R. Pennington, Phys. Rev. D 48 (1993) 1185.

[3] J. Weinstein, N. Isgur, Phys. Rev. D 41 (1990) 2236.

[4] O. Krehl, R. Rapp, J.Speth, KFA–IKP–TH–1996–09 (1996).

[5] S. Brauksiepe et al., Nucl. Instr. & Meth. A 376 (1996) 397.

[6] J. Bisplinghoff et al., Annual Report IKP–KFA 1995 (1996) 33.

[7] COSY Proposal No. 46 (1996), J. Smyrski, T. Lister (spokesmen).