Beam Time Request for Measurements of the Reaction $pp \to ppK^+K^-$ at Threshold

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20 Sept. 1996

Abstract

During three days of measurements of the reaction $pp \to ppK^+K^-$ at an access energy of 6 MeV above threshold in April 96 we collected five background-free events of the kaon pair production. Since then the luminosity in our experiment was increased by a factor of 20. In order to measure the production cross section at five beam momenta near threshold we request two weeks of the COSY beam-time in the first half of 1997.

1 First Experimental Results

Measurement of the reaction $pp \to ppK^+K^-$ near threshold is of high interest, since it should deliver information about interaction of two kaons at small relative momenta. This in turn should help to answer the question about the nature of the $f_0(975)$ meson, which according to some recent models is not a standard $q\overline{q}$ state but a $K\overline{K}$ molecule [1, 2]. In our proposal, accepted by the PAC during the spring 96 meeting, we proposed to perform a kinematically complete measurements of the reaction $pp \to ppK^+K^-$ for a few beam momenta near threshold with the use of the COSY-11 facility [3]. We have been granted two weeks of the COSY beam time which, according to the beam time schedule, we will use for our measurements in October and December this year.

In the mean time, we have analysed the data from our preliminary measurements of the reaction $pp \to ppK^+K^-$ in October 95 and April 96. For the data analysis we preselected events with three tracks in the drift chambers, which were used to measure trajectories of positively charged reaction products deflected in the COSY dipol magnet towards the center of the ring. In this way we required that the tracks of two scattered protons and of positively charged kaon K^+ were measured. Tracing of particle trajectories in the magnetic field of the dipol magnet back to the target allowed us to determine momentum vectors of particles at the target place. The time of flight measured with the use of the scintillation hodoscopes and the knowledge of the reconstructed particle momenta enabled the mass identification using the relation:

$$m = |\vec{p}|/(\beta \cdot \gamma). \quad (1)$$

An example of a $pp \to ppK^+K^-$ event with reconstructed tracks of two protons and of positively charged kaon is shown in fig. 1. Indicated is also the response of the Si-pad detector, which was mounted inside the dipol gap, to negatively charged kaon. In the data analysis we did not require a coincidence with the Si-pad detector, since it would reduce the number of reconstructed events by a factor of about 3 due to additional limitation in the acceptance introduced by this detector.

The longest run lasting three days was performed for the beam momentum of 3.321 GeV/c corresponding to an excess energy of 6 MeV above threshold. The obtained distribution of the square of the invariant mass m_X of positively charged ejectiles measured in coincidence with two protons, is presented in the upper part of fig. 2 as a function of the missing mass of two protons. Next to a large number of events with m_X close to the pion mass, there are well separated events with m_X grouped around the kaon mass. The relatively large scatter of m_X is due to limited accuracy of the time of flight measurements which were used to determine this mass. Presently we are working on an improvement for better mass resolution. Events identified as cases of K^+ production (as shown between dashed lines in fig. 2) were then used to calculate the missing mass of the ppK^+ subsystem. Five events, with a positively charged kaon measured in the detection system and with the missing mass of the ppK^+ subsystem equal to the kaon mass, have been identified as the kaon-pair production events (see lower part of fig. 2).

Measurements of the same duration, but performed below the reaction threshold, show no events in the K^+K^- region as one can see it in fig. 3. The observed five events lead to first estimate of the cross section to be in the order of 150 pb.

2 Beam Request

The present results are very encouraging, since they proof our capability of measuring the kaon pair production in the proton-proton scattering near threshold. They enable us also to estimate the beam time needed in planned measurements which is of great importance in view of lack of experimental cross sections in the threshold region, and, to the best of our knowledge, lack of theoretical predictions as well.

Our capability of performing measurements with good statistics has substantially improved, as compared with our last measurements in April 96, since the luminosity in the experiment was increased by a factor of about 20. This was possible due to the following improvements:

- number of protons stored in the COSY ring increased from $0.8 \cdot 10^{10}$ to $2.0 \cdot 10^{10}$,
- density of the target increased from $5 \cdot 10^{13}$ to $1.5 \cdot 10^{14}$ atoms/cm^2,
- the beam-target overlap increased by a factor of 3 due to the new beam optics developed specially for the COSY-11 experiment.

In a measurement at the excess energy of 6 MeV we can now expect about 40 K^+K^- events per day. In order to determine the energy dependence of the production cross section we want to perform measurements for 4 momenta above and one momentum below threshold. Proposed momentum settings and the beam time needed, estimated from the measured counting rate under assumption of an energy independent cross section, are listed in table. 1. Altogether we would need 45 days of the COSY beam to performe the measurements. From these 45 days 14 days have been allocated already for the second half of 1996. Out of the remaining 31 days we would like to ask for 14 days in the first half of 1997 to continue the measurements.

p_{beam} [GeV/c]	excess energy [MeV]	acceptance[a] [%]	counts[b] [1/day]	required counts	required time [days]
3.295	-2.0	-	-	-	3
3.305	1.0	85.5	174	500	3
3.308	2.0	57.4	117	500	4
3.324	7.0	16.2	33	500	15
3.330	9.0	12.2	25	500	20
					$\sum = 45$

[a] for the detection of two protons and the kaon K^+

[b] assuming an energy independent cross section

Table 1: Proposed beam settings for the study of $pp \rightarrow ppK^+K^-$ close to threshold and required beam time.

References

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

[2] G. Janssen, B. C. Pearce, K. Holinde, J. Speth, Report KFA-IKP(TH)-1994-40

[3] S. Brauksiepe at el., Nucl. Instr. and Meth. **A 376**(1996)397

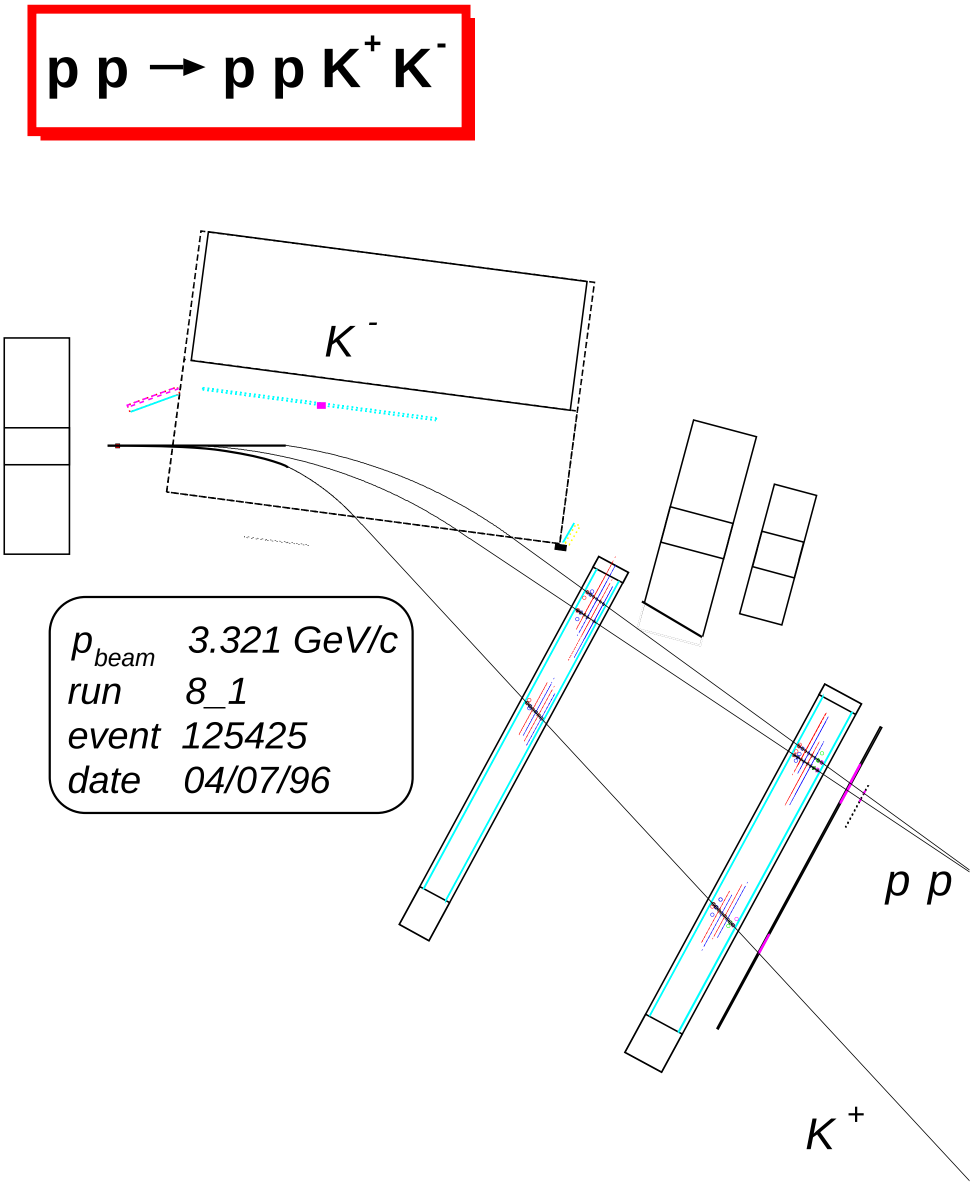

Figure 1: An example of a reconstructed $pp \to ppK^+K^-$ event.

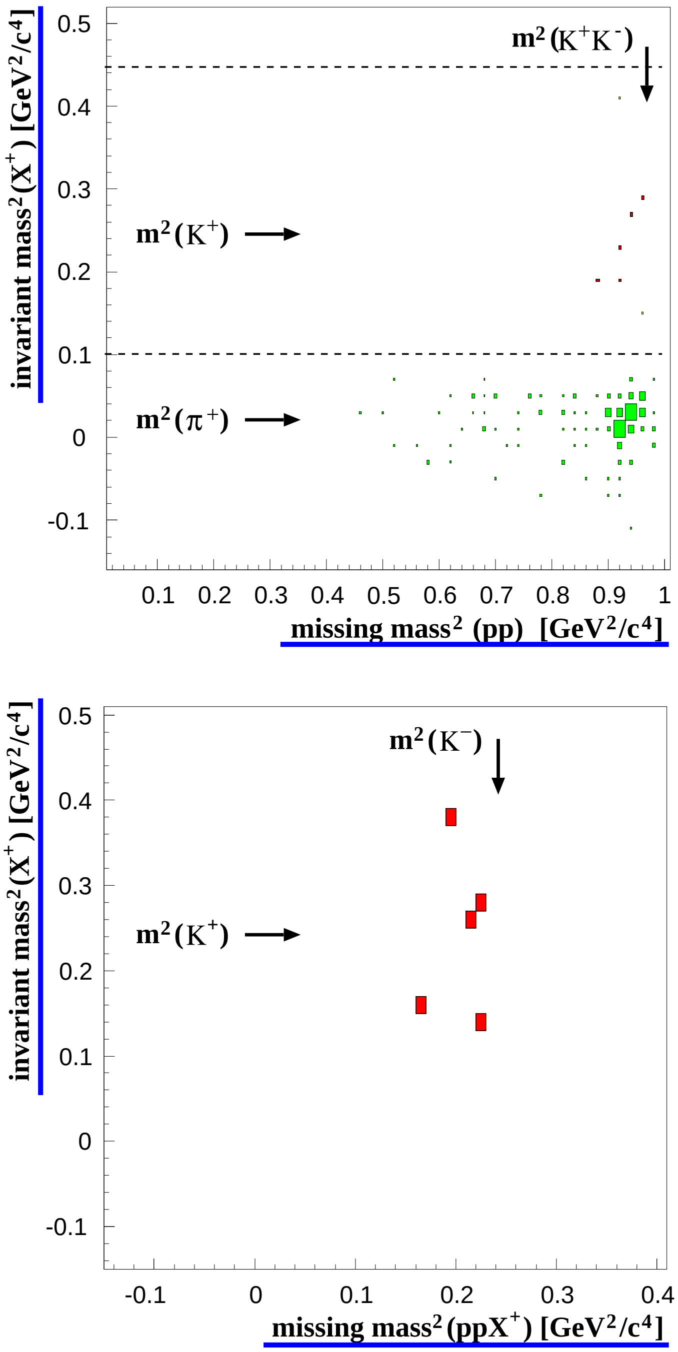

Figure 2: Invariant mass squared of particle measured in coincidence with two protons as a function of the missing mass squared of the proton-proton system (upper part) and as a function of the missing mass squared of the proton-proton-kaon system (lower part) obtained from three-track events at the beam momentum of 3.321 GeV/c.

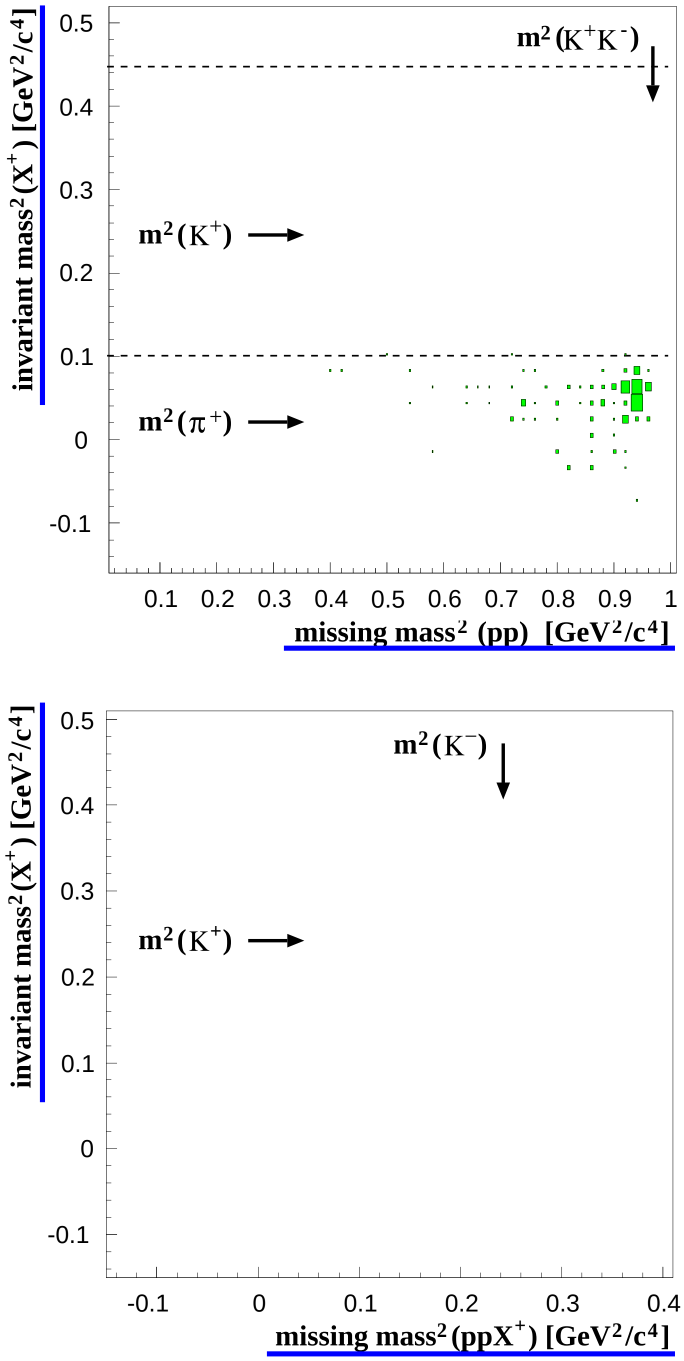

Figure 3: Results of measurements as in fig. 2 but for the beam momentum by 0.008 GeV/c smaller than the threshold momentum equal to 3.302 GeV/c