Prospects of the COMPASS Hadron Program with Charged Kaonic Final States

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The COMPASS experiment at CERN took data with a 190 GeV/c negative hadron beam on a fixed proton target in 2008. These data provide an opportunity to search for mesons with exotic J^{PC} and for glueballs. A first glance on the ongoing analyses is presented. This includes the discussion of kaonic final states produced by incoming pions or kaons. The available statistics of the 2008 data allow an improved study of centrally produced resonances compared to previous experiments. Preliminary results on resonances in the kaonic final states are shown and discussed. The analysis of charged kaonic final states serves as an important cross-check of the ongoing neutral kaonic final state studies. In particular, we discuss prominent $KK\pi$ resonances which preferentially decay via $K^*(890)$ and the exclusive $\phi\pi$ production. Partial wave analyses of these final states are planned.

1. Introduction

The data collected in the COMPASS hadron run of 2008 allow high statistics studies of kaonic channels in diffractive and central production [1]. Previous work on centrally produced K^+K^- systems at 450 GeV/c by the WA102 collaboration resulted in a $q\bar{q}$ (q = u, d, s) and glueball mixing scheme for the 0^{++} states observed at 980, 1370, 1500, and 1710 MeV/c^2 [2].

The COMPASS data provide an opportunity to search for mesons with exotic J^{PC} quantum number combinations and glueballs and to study the previously found candidates in detail. Centrally produced kaonic systems are interesting for the production of glueballs as they are considered to be glue-rich, preferred due to chirality arguments [3]. The starting point of the presented analysis was the search for resonances which decay into $\phi\pi$. Therefore we will focus on charged kaonic final states in this paper.

2. Discussion of preliminary results

The analyzed data sample is based on the reaction of an incoming hadron beam with an energy of 191 GeV on a fixed proton target. The incoming beam consists of a mixture of several particles, i.e. $\pi^-(93\%)$, $K^-(2.5\%)$, $\mu^-(3\%)$, $p-(0.6\%)$ and $e^-(0.1\%)$. Hence it can be assumed that the dominating process is due to $\pi^- p$ reactions. In addition, the CEDAR (ChErenkov Differential counter with Achromatic Ring focus) detectors, which are placed before the COMPASS target, can be used to select a specific beam particle, e.g. kaons.

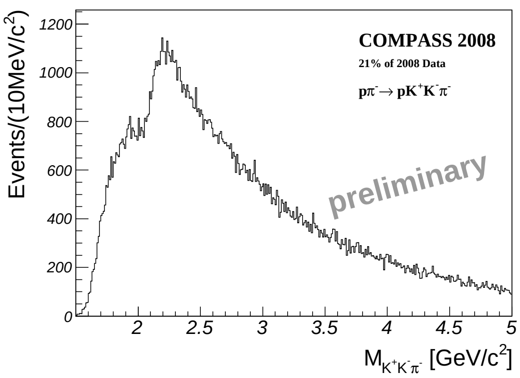

Figure 1. $K^+K^-\pi$ invariant mass spectrum.

The charged kaonic final state signature for selection is given by the reaction $\pi p \to p K^+ K^- \pi^-$. For the signal selection we require one unique reconstructed primary vertex in the event with three outgoing tracks and a (-,-,+) reconstructed charge assignment.

The dominating background to the charged kaonic final state is a purely pionic process, i.e. $\pi p \to p \pi^+ \pi^- \pi^-$. Due to the overwhelming cross-section of the pionic final states, an additional decay particle identification has to be used. Hence we require that one negatively charged track with a momentum smaller than $30\,GeV$ has to be identified as kaon by the COMPASS RICH detector. The relatively low momentum threshold ensures a clean suppression of pions.

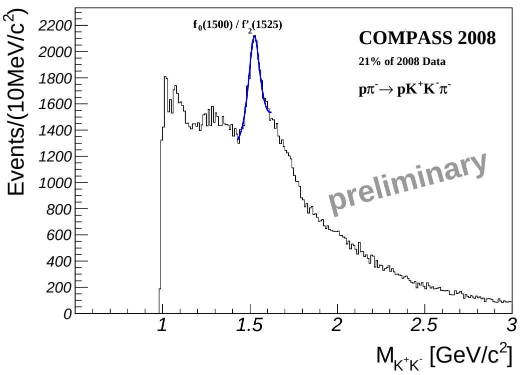

Figure 2. K^+K^- invariant mass spectrum in a mass range of 0.5 and $3.0\,GeV/c^2$.

Since we expect two kaons in the final state due to strangeness conservation, this guarantees a unique assignment of particle masses to the reconstructed tracks. To ensure the exclusivity of the event, i.e. that all final state particles have been detected and reconstructed, it is required that the energy sum of all outgoing tracks must be close to the incoming beam energy, i.e. $|191\,GeV - E_{tot}| < 5\,GeV$. In addition, the opening angle ϕ in the transverse plane to the incident beam between the recoil proton track and the vector sum of the outgoing particles has to fulfill $|\pi - \phi| < 0.2$. The three body invariant mass spectra is shown in Figure 1.

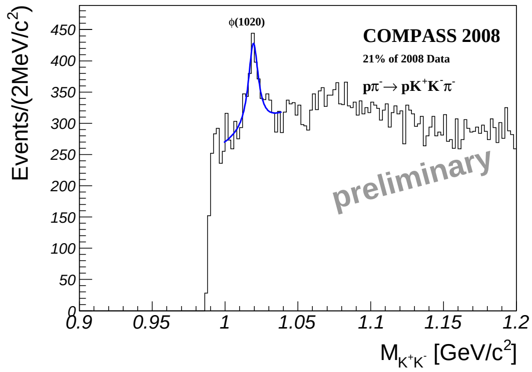

Figure 3. K^+K^- invariant mass spectrum in a mass range of 0.9 and $1.2\,GeV/c^2$.

The invariant mass spectra for K^+K^- invariant masses in the selected sample are shown in Figure 2 and 3 for different invariant mass regions, respectively. In Figure 2, the $f_0(1270)$ resonance can be seen. Moreover, a peak at $1.5\,GeV/c^2$ is observed, which could be assigned to the $f_0(1500)$ and $f_2'(1525)$ resonances. A final answer can only be given by a detailed partial wave analysis. The $f_0(1500)$ is of special interest for further studies as it is often referred in the literature as a glueball candidate. It has been checked that this resonance is not a simple reflection of another resonance which decays into a pionic final state.

Kinematic reflections of three pion final states could mimic the observed peaks, when falsely identifying a pion as kaon. A further possible background comes from the kaon contribution in the incoming beam, as the assumption of two kaons in the final state does not hold anymore. These effects have been carefully studied and taken into account.

The $\phi(1020)$ meson is clearly visible in Figure 3. The current analysis suggests that a large fraction of the $\phi(1020)$ is produced by the kaonic content of the incoming beam. This confirms the expectation that the production of the ϕ is strongly suppressed due to the OZI-rule. A detailed study is ongoing as a $\phi\pi$ decay mode is a promising decay channel of exotic meson candidates [4].

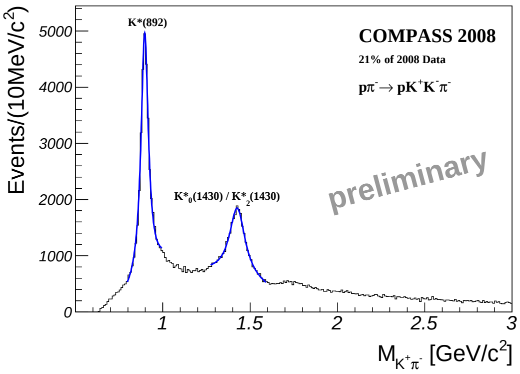

Figure 4. $K^+\pi^-$ invariant mass spectrum for selected events .

The $K^+\pi^-$ invariant mass spectra of the selected sample is shown in Figure 4. We observe a clean signature of the $K^*(892)$. Moreover, we see a resonance peak around $1.4\,GeV$. This is most probably the $K_2^*(1430)$ but could also have admixtures of the $K_0^*(1430)$ and $K^*(1410)$ resonances. The third peak in the spectrum around $1.7\,GeV$ could be due to $K^*(1680)$ or $K_3^*(1780)$. A final conclusion can only be drawn after a detailed partial wave analysis.

We observe a similar invariant mass spectrum in the neutral kaonic final states, i.e. $\pi p \to p\pi K_S^0 K_S^0$. In order to select a neutral kaon in a reconstructed event, we require a secondary vertex with two outgoing oppositely charged tracks which are assumed to be pions. It is further required that the invariant mass of the two pion tracks is close to $498\,MeV$. Such a selection does not depend on the COMPASS RICH detector and its corresponding limited acceptance. Therefore a different phase space region is covered by the study of the neutral kaonic final states and hence can be used for independent cross-checks of the presented analysis.

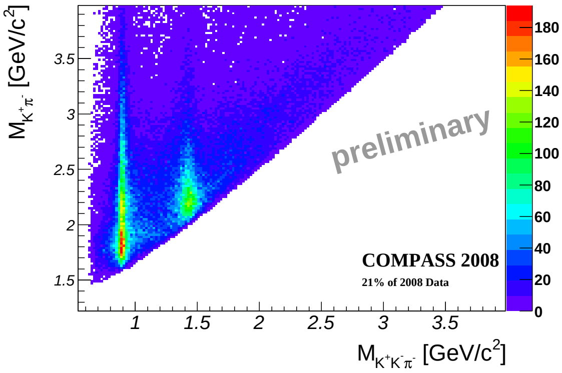

Figure 5. $K^+K^-\pi^-$ vs. $K^+\pi^-$ invariant mass spectrum for selected events .

The selected $K^+\pi^-$ invariant mass vs. the three body invariant mass is shown in Figure 5. The bump at the three body invariant $KK\pi$ mass between $2.0 - 2.5\,GeV/c^2$ for $K^+\pi^-$ masses between $1.4 - 1.5\,GeV/c^2$ a seems to be a purely kinematic effect, i.e. by adding the kaon mass of the third particle to the $K\pi$ invariant mass.

The situation is different for the 3-body decay into $K^*(890)K$ where we observe a more complex spectrum with a possible resonance at $\sim 2.2\,GeV/c^2$. This stimulates questions concerning the reaction mechanism and its nature and will be subject to further studies.

3. Conclusion

Several resonances in the charged and neutral decay channel have observed in data during the 2008 run at COMPASS. Special attention was drawn to searches for mesons with a $\phi\pi$ decay mode.

Moreover, interesting structures in the $K^*(890)K$ decay channel have been found. The presented results are based only on a small fraction of the available statistics. The full available statistics will be significantly larger compared to the previous *WA102* experiment. This is a very promising basis for further partial wave analyses.

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