Diffractive dissociation into $K_s K^{\pm} \pi^{\mp} \pi^{-}$ final states

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The COMPASS fixed-target experiment at CERN/SPS is dedicated to the study of hadron structure and spectroscopy, especially the search for spin-exotic states. After having started to study the existence of the spin-exotic $\pi_1(1600)$ resonance in the 2004 pilot-run data, the new 2008/09 data will enable us to further clarify the situation. Apart from the $\pi_1(1600)$ resonance, also a spin-exotic $\pi_1(2000)$ was reported in the past in the $f_1(1285)\pi$ decay channel by the E852/BNL experiment, however, this state still lacks confirmation. We present a first event selection of the diffractively produced $(K\overline{K}\pi\pi)^-$ system showing clean $f_1(1285)$ and $f_1(1420)$ resonances at competing statistics. A partial-wave analysis started on $f_1(1285)\pi$ and $f_1(1420)\pi$ decay channels will further complete the search for spin-exotics in the 2008/09 COMPASS data.

1 Introduction

One important part of the COMPASS physics programme is the search for new states, in particular the search for spin-exotic states and glueballs. COMPASS has started to contribute to the puzzle of the existence of spin-exotic mesons with the published 2004 pilot-run data, showing a significant production strength for an exotic $J^{PC} = 1^{-+}$ state at $1.66\,\mathrm{GeV}/c^2$ [1]. The high-statistics 2008/09 data sets, covering almost all decay channels reported in the past, will further clarify the situation. Apart from the spin-exotic $\pi_1(1600)$ resonance observed in various decay channels and experiments, also a spin-exotic $\pi_1(2000)$ candidate was reported in the past by the E852 experiment at BNL in the $f_1(1285)\pi$ decay channel [2,3]. This state, however, still requires confirmation.

In this paper, we present the event selection of the diffractively produced $(K\overline{K}\pi\pi)^-$ system showing clean $f_1(1285)$ and $f_1(1420)$ signals competitive with the BNL/E852 data. The accessible mass range is extended beyond $2\,\mathrm{GeV}/c^2$. The started partial-wave analysis (PWA) of the $f_1(1285)\pi$ and $f_1(1420)\pi$ systems will further complete the search for spin-exotics in the 2008/09 COMPASS data. A PWA of the $(K\overline{K}\pi\pi)^-$ system will on the one hand complement previous searches in the $f_1\pi$-channel, on the other hand it will be the first PWA of the $f_1(1420)\pi$ system.

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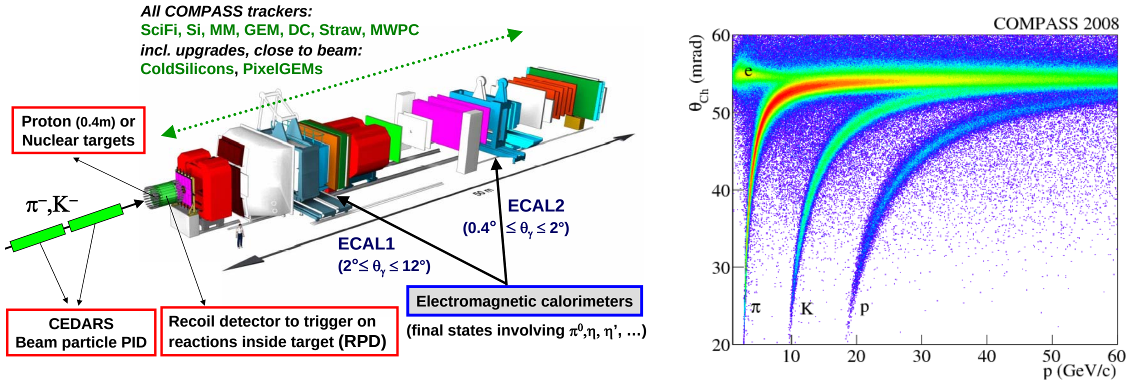

Figure 1: *(Left)* Sketch of the two-stage COMPASS spectrometer. *(Right)* Measured Cherenkov angle using RICH-1 versus particle momentum. Three bands appear corresponding to the different masses of pions, kaons, and (anti-)protons; some additional contribution from δ-electrons is present at low masses and angles.

The COMPASS two-stage spectrometer [4] at the CERN SPS features charged particle tracking and good coverage by electromagnetic calorimetry for both stages (Fig. 1). The fixed liquid hydrogen target is surrounded by a recoil proton detector (RPD) included in the trigger. Moreover, a Ring Imaging Cherenkov (RICH) detector in the first stage allows for final state particle identification (PID). A good separation of pions from kaons allows for final state PID and hence the study of kaonic final states. Two Cherenkov Differential counters with Achromatic Ring focus (CEDAR) upstream of the target are used to identify the incoming beam particle. Not only kaon diffraction, tagging the kaon contribution in the negative hadron beam (96.8 % π^-, 2.4 % K^-, 0.8 % $\overline{p}$) can thus be studied, cf. [5], but also production of strangeness with the pion beam, see also [6, 7]. The COMPASS data recorded with 190 GeV/c hadron beams in 2008/09 provide excellent opportunity for simultaneous observation of new states in various decay modes within the same experiment, see also [8–10].

2 First glimpse on the diffractively produced $(K\overline{K}\pi)^0$ system

The $(K\overline{K}\pi\pi)^-$ events are selected from the full 2008 data set taken with negatively charged pion beam. Exactly one reconstructed primary vertex inside the target volume is required for each event. Further, three outgoing charged tracks (two negative, one positive) were required, resulting in two types of final states: *(a)* $K_s K^+ \pi^- \pi^-$ and *(b)* $K_s K^- \pi^+ \pi^-$. The K^0s are identified by requiring the invariant mass of the pion pair from the reconstructed V^0 decay (after anticut on Λ and $\overline{\Lambda}$) to be within ± 20 MeV/c^2 with respect to the PDG mass. Only events with exactly one K^0 candidate are accepted. By PID of the $K^\pm$ with the RICH detector (using the likelihood ratio of the Kaon assumption over others), the two types are separated, remaining particles are assumed to be pions. The beam energy is determined by the total momentum of the outgoing system. In order to select exclusive

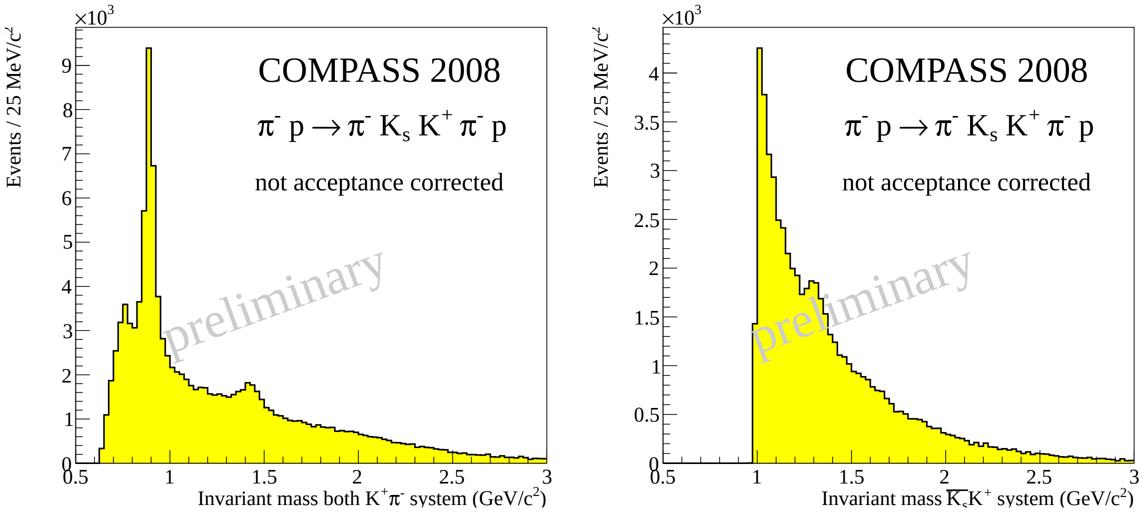

Figure 2: Exemplary sub mass spectra shown for event type (a) (similar for (b)). *Left:* The $(K\pi)^0$ subsystem features a clean $K^*(892)$ peak and some contribution from $K^*_{0,2}(1430)$. *Right:* The $(K\overline{K})$ subsystem shows a clean $a_0(980)$ peak at threshold and some $a_2(1320)$ contribution.

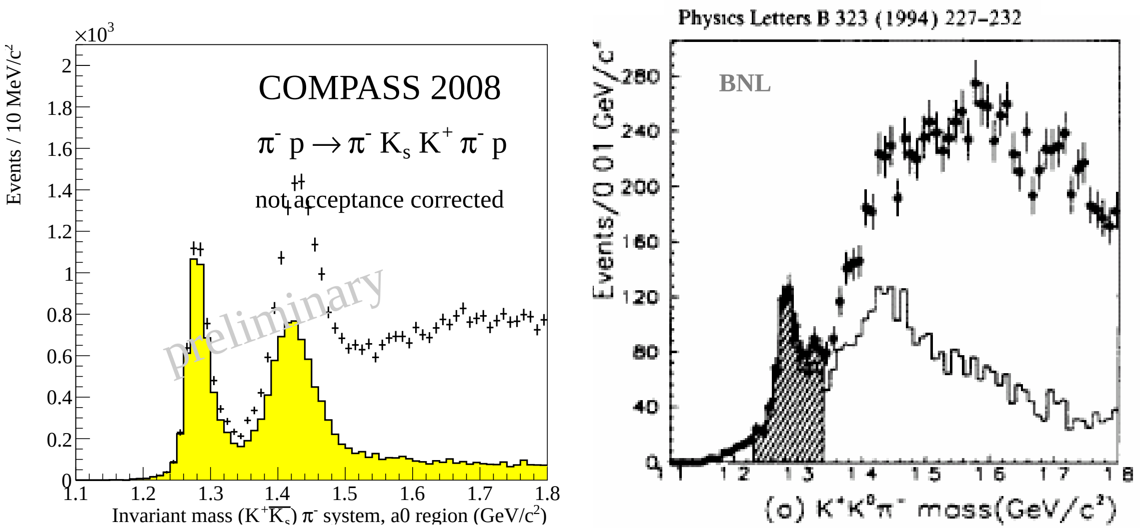

Figure 3: *Left:* The $(K\overline{K}\pi)^0$ subsystem, showing clean $f_1(1285)$ and $f_1(1420)$ peaks before (dots) and after (line) an additional restriction of the $K\overline{K}$ mass to the $a_0(980)$ region. *Right:* Comparing the similar plot published by BNL/E852 [2], the COMPASS statistics exceeds the one analysed by E852 by a factor of 10 (or a factor of about 20, taking into account also the 2009 data with negative pion beam). Not only the observed $f_1(1285)$ but also the $f_1(1420)$ are nearly background free as compared to BNL/E852 [2].

events, two main cuts are applied consistently in terms of $\pm 2\,\sigma$ of each distribution: On the calculated beam energy ($\pm 2\,\mathrm{GeV}/c^2$), and on the azimuthal angle anti-correlation ($\pm 0.3\,\mathrm{rad}$) of the recoil proton (measured with the RPD) and the outgoing system (measured with the spectrometer). To get a first glimpse on the isobars to be included for the PWA, the mass spectra of the different subsystems have been studied. In Fig. 2, the $(K\pi)^0$ and the $(K\overline{K})$ subsystems are exemplary shown, featuring clean $K^*(892)$ and $a_0(980)$ peaks, also contributions from $K^*_{0,2}(1430)$ and $a_2(1320)$ are present. The $(K\overline{K}\pi)^0$ subsystem (Fig. 3) is of particular interest, as a spin-exotic 1^{-+} resonance was reported in the $f_1(1285)\pi$ decay channel. It features clean $f_1(1285)$ and $f_1(1420)$ peaks. Even though an η contribution cannot be excluded, a first mass-independent PWA indicate contributions from $\eta(1405)$ and $\eta(1295)$ to be minor, consistent with the observation by E852 [3]. Further isobars obviously to be included are: $K\pi$ and KK s-wave contributions and, for event type *(b)* only, $\rho(770)$, $f_1(1270)$, and $f_0(600)$ or σ (corresponding mass spectra not shown).

3 Conclusions and summary

The COMPASS hadron data taken in 2008/09 will allow us to contribute solving the puzzle of light spin-exotic mesons, even extending the region to higher masses beyond $2\,\mathrm{GeV}/c^2$. We presented a first selection of $K_s K^{\pm}\pi^{\mp}\pi^-$ events, verifying our feasibility to study not only the diffractively produced $f_1(1285)\pi$ at competing statistics but also the $f_1(1420)\pi$ system. In the former decay mode, apart from the $\pi_1(1600)$, a second spin-exotic $J^{PC} = 1^{-+}$ resonance at $2\,\mathrm{GeV}/c^2$, the $\pi_1(2000)$, was reported in the past by one experiment [3], whereas the latter has never been studied before.

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