Investigation of Diffractive Pion Dissociation at COMPASS ◇

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1. Introduction

COMPASS [1] is a fixed-target experiment at the CERN SPS, which investigates the structure and spectroscopy of hadrons. Since 2002, several years of data taking with a muon beam and a polarized target have been completed, mostly to study the spin structure of the nucleon. In 2004, also a first run with a 190 GeV/c π^- beam took place using nuclear targets. Diffractive dissociation reactions in COMPASS provide clean access to meson resonances with masses below 2.5 GeV/c^2, where candidates for spin-exotic states (e.g. 1^{-+}) have been discussed in the past [2,3]. Such states have quantum numbers forbidden in the $q\bar{q}$ model and would be a direct hint for systems with gluonic degrees of freedom like hybrids or glueballs. Within a few days of data taking, a competitive number of diffractive events from a lead target with $\pi^-\pi^-\pi^+$ final states were recorded. The covered range in momentum transfer t extends from 0 to a few GeV$^2/c^2$ allowing to study resonance production in different regimes.

2. Diffractive Dissociation

In analogy to black disc scattering in optics, strongly interacting particles can undergo a very peripheral scattering off a target with a characteristic diffraction pattern in momentum transfer t [4]. The reaction is mediated mostly by a Regge-exchange and happens such that the target stays intact. If in addition the beam particle is excited to some resonance X one speaks of diffractive dissociation. In COMPASS this process is investigated by looking at exclusive $\pi^-\pi^-\pi^+$ final states, where the three pions are a result of the decay of the state X.

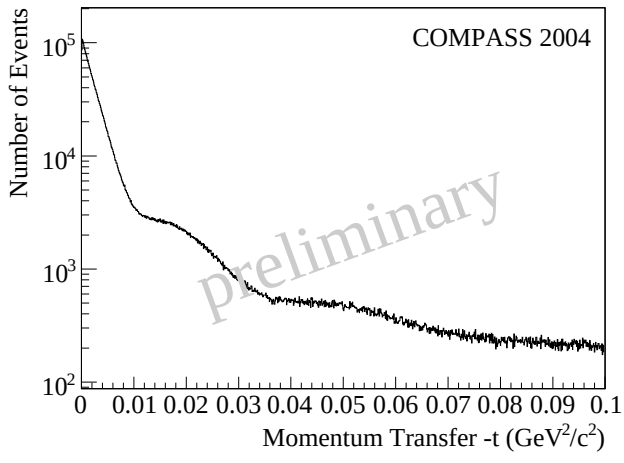

Fig. 1: Diffraction of pions on lead nuclei at COMPASS.

With lead targets, in 2004 the diffraction could either take place on the lead nucleus as a whole or on individual nucleons inside the nuclei, depending on the momentum transfer t. Figure 1 shows part of the t distribution corresponding to the scattering off lead nuclei. The diffractive nature of the process is evident by the presence of a steeply falling exponential with a slope depending on the redius of the nucleus, followed by several minima and maxima.

3. Meson Production and Search for Exotic Spin States

The potential of the diffractively produced $\pi^-\pi^-\pi^+$ final state events regarding meson spectroscopy in COMPASS can already be demonstrated by plotting their invariant mass. Figure 2 presents mass spectra corresponding to different ranges in momentum transfer t. Most of the $\sim$ 4 000 000 events have a t below 10^{-2} GeV$^2/c^2$, but also $\sim$ 400 000 events were recorded with t larger than 0.1 GeV$^2/c^2$. From their mass spectrum the production of the three well-known resonances $a_1(1260)$, $a_2(1320)$ and $\pi_2(1670)$ is apparent.

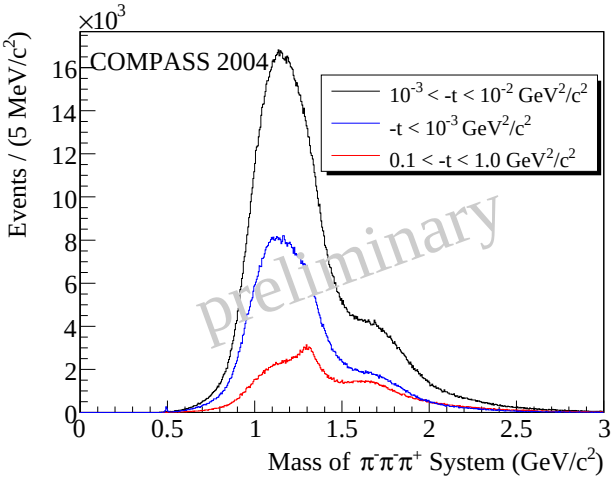

Fig. 2: t-dependent, diffractive resonance production at COMPASS.

Comparing to the experiments mentioned in the introduction, a search for spin exotic states is feasible with this data set. Currently a partial wave analysis for both "high-t" and "low-t" regions is ongoing. To collect more statistics especially in the "high-t" region, COMPASS will continue to take diffractive dissociation data in 2008, switching to a liquid hydrogen target.

References

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