Diffractive Pion Dissociation at COMPASS ◇

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COMPASS is a large-acceptance high-resolution spectrometer at the SPS at CERN. The experiment explores questions on the structure of strongly interacting particles. The TUM group has played a leading role in the development of high-resolution tracking detectors (GEM, PixelGEM, silicon tracker), fast readout electronics and data acquisition software. The work on which we report here is part of the ongoing efforts to understand the meson spectrum and the search for exotic hadrons.

In addition to constituent $q\overline{q}'$ pair configurations four-quark states or gluonic excitations are also expected to contribute to the meson spectrum. The most promising way to identify such QCD-exotic meson candidates is the search for spin-parity quantum number combinations that are forbidden in the constituent quark model e.g.: $J^{PC} = 0^{--}, 0^{+-}, 1^{-+}, \ldots$.

First studies of diffractive reactions of 190 GeV/c π^- on a 3 mm lead target were carried out by COMPASS during a pilot run of a few days of data taking in 2004. The $\pi^-\pi^-\pi^+$ final state was chosen because the disputed $\pi_1(1600)$ meson with exotic quantum numbers $J^{PC} = 1^{-+}$ had previously been reported in this channel [1,2,3].

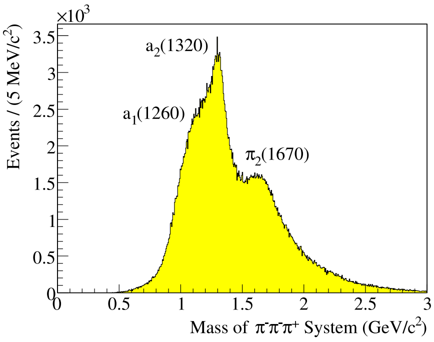

Fig. 1: Invariant mass of the 3π system for $0.1\ \mathrm{GeV}^2/c^2 < t' < 1.0\ \mathrm{GeV}^2/c^2$.

A sample of 420 000 events in the momentum transfer range $0.1\ \mathrm{GeV}^2/c^2 < t' < 1.0\ \mathrm{GeV}^2/c^2$ has been analysed. Figure 1 shows the invariant mass of the corresponding events. The well-known resonances $a_1(1260)$, $a_2(1320)$, and $\pi_2(1670)$ are clearly visible.

In order to separate the contributions of a total of 42 different quantum states to the spectrum a partial wave analysis (PWA) of this data set was performed. The extended likelihood analysis also takes into account the spectrometer acceptance through a phase-space Monte Carlo simulation of the apparatus. Figure 2 shows the intensities of the major components as well as of the exotic 1^{-+} wave.

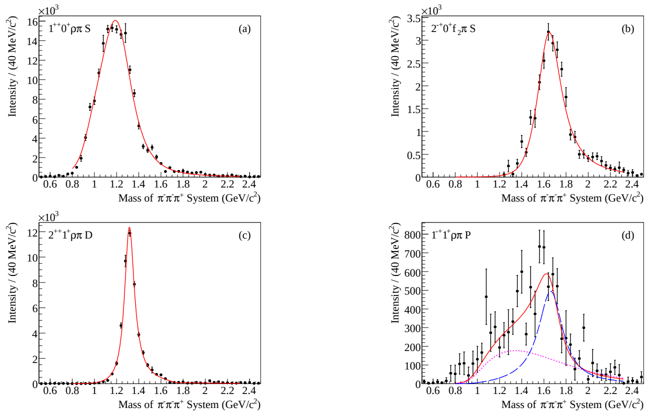

Fig. 2: Intensities of major waves $1^{++}0^+\ \rho\pi\ S$ (a), $2^{-+}0^+\ f_2\pi\ S$ (b), and $2^{++}1^+\ \rho\pi\ D$ (c), as well as the intensity of the exotic wave $1^{-+}1^+\ \rho\pi\ P$ (d). The lines represent the result of the mass-dependent fit.

We then use a relativistic Breit-Wigner fit (with coherent background) taking into account wave intensities and interference terms to extract the resonance parameters of the observed states (red lines in figure 2). The results obtained with this method are given in Table 1.

Resonance	Mass (MeV/c^2)	Width (MeV/c^2)	Channel
$a_1(1260)$	$1255 \pm 6^{+7}_{-17}$	$367 \pm 9^{+28}_{-25}$	$1^{++}0^+\ \rho\pi\ S$
$a_2(1320)$	$1321 \pm 1^{+0}_{-7}$	$110 \pm 2^{+2}_{-15}$	$2^{++}1^+\ \rho\pi\ D$
$\pi_1(1600)$	$1660 \pm 10^{+0}_{-64}$	$269 \pm 21^{+42}_{-64}$	$1^{-+}1^+\ \rho\pi\ P$
$\pi_2(1670)$	$1658 \pm 3^{+24}_{-8}$	$271 \pm 9^{+22}_{-24}$	$2^{-+}0^+\ f_2\pi\ S$

Table 1: Resonance masses and total widths for the specified decay channel of the major waves. The first uncertainty corresponds to the statistical error, the asymmetric second one to the systematic error.

Due to the excellent acceptance of the COMPASS spectrometer the exotic 1^{-+} signal has clearly been established in the $\rho\pi$ decay mode.

In 2008 up to two orders of magnitude more statistics have been recorded using a liquid hydrogen target and an upgraded spectrometer. This data is currently being analysed.

References

[1] G.S. Adams *et al.*, (E825), Phys.Rev.Lett **81** (1998) 5760
[2] S.U. Chung *et al.* Phys. Rev. **D65** (2002) 072001
[3] Y. Khokhlov (VES), Nucl. Phys. **A663** (2000) 596

◇ This work is supported by the the German Bundesministerium für Bildung und Forschung, the Maier-Leibnitz-Labor der LMU und TU München, and the DFG cluster of excellence emOrigin and Structure of the Universe.