Exclusive $\omega\pi^0$ Production with 160 GeV Muons at COMPASS

M. Bettinelli, W. Dünnweber, M. Faessler, R. Geyer, J.-F. Rajotte, T. Schlüter, and A. Zvyagin

Identification of the radially excited ρ meson is debated since a long time [1]. An early photoproduction experiment [2] observed an enhancement in the $\omega\pi^0$ channel with mass around 1250 MeV and width of about 200 MeV. For spin-parity analysis it was assumed that the produced meson retains the helicity of the incoming photon (s-channel helicity conservation, SCHC). A dominant contribution with ρ quantum numbers $J^{PC} = 1^{--}$ was deduced. However, subsequent investigation with linearly polarized photons revealed a dominance of non-SCHC production of the well-known 1^{+-} meson $b_1(1250)$. From the systematics of photoproduction [3] one would expect the yield of $\rho(1250)$, as compared to b_1, to increase with photon energy.

We have performed the first study of $\omega\pi^0$ production with quasi-real photons in inelastic muon scattering. The average γ^*-nucleon c.m. energy of 13 GeV is twice that of the previous photoproduction experiments.

A data sample collected in 8 weeks of the 2004 COMPASS run was analyzed to select the exclusive process $\mu + N \rightarrow \mu' + \omega(\pi^+\pi^-\pi^0)\pi^0 + N$, with $\pi^0 \rightarrow \gamma\gamma$ and undetected recoil nucleon N (Fig. 1).

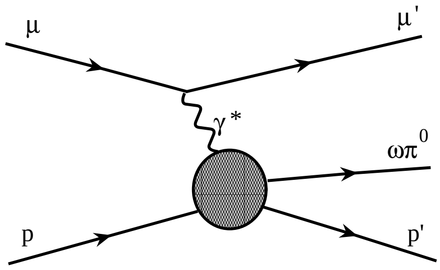

Fig. 1: Exclusive $\omega\pi^0$ production with muons.

With suitable kinematic cuts, the missing mass distribution shows a clear peak at the nucleon mass M_N, which guarantees the exclusivity of the reaction. Fig. 2 shows the $\omega\pi^0$ invariant mass spectrum, where a cut on the $\pi^+\pi^-\pi^0$ invariant mass at M_ω has been applied.

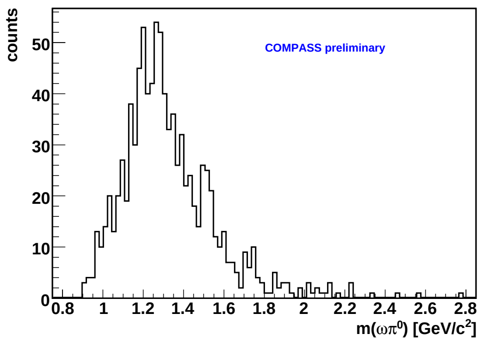

Fig. 2: Invariant mass spectrum of exclusively produced $\omega\pi^0$. The acceptance (not corrected for) decreases by 50% from 1 to 2 GeV/c^2

A peak with a mean value of about 1250 MeV and a width of about 300 MeV is observed. These features are consistent with the results of the quoted photoproduction experiments. To access non-ω background, the $\pi^+\pi^-\pi^0$ invariant mass cut was somewhat relaxed. Fig. 3 shows the 3π versus 4π invariant mass: events in the ω mass region correspond to the 4π invariant mass interval around 1250 MeV. A non-ω background contribution of 12% is present in the final sample.

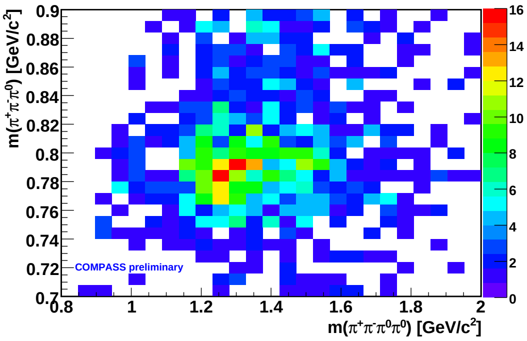

Fig. 3: 3π vs. 4π invariant mass for exclusive $\omega\pi^0$ events, showing clearly the presence of $\omega(782)$.

The kinematic distributions for the final sample are characterized by the virtual photon mass squared $Q^2 \approx 0.1$ (GeV/c^2)^2, the Bjorken scale variable $x_B \approx 10^{-3}$ and the $\omega\pi^0$ momentum in the laboratory system $\approx$ 95 GeV/c, which corresponds to $E(\gamma^*) \approx 90$ GeV. The 4-momentum transfer squared t is characterized by an exponential shape, as is typical of diffractive processes.

Three types of angular correlations are suited for spin-parity studies:
(i) the angle of the ω momentum $\vec{p}_\omega$ relative to the $\omega\pi^0$ direction (reference axis z) in the overall γ^*p c.m. system;
(ii) the angle between the vector $\vec{n}_\omega$ perpendicular to the ω decay plane (in the ω rest frame) and the z axis;
(iii) the azimuthal angle between the μ scattering plane and the "spin analyzer" $\vec{a}$. For electroproduction via quasi-real photons, one can assume linear polarization of the intermediate photon in the primary scattering plane, and adopt the corresponding angular correlation mechanism [4], according to which $\vec{a}$ is $\vec{n}_\omega \times \vec{p}_\omega$ for $J^P = 1^-$ and $\vec{n}_\omega$ for $J^P = 1^+$.

All three angular correlations are in favour of a significant 1^- contribution. For a quantitative disentanglement of 1^- and 1^+, however, also the non-SCHC production of the latter must be taken into account. In the present stage, our analysis supports models which place the first radial excitation of the ρ meson at 1250 MeV.

References

[1] A. Donnachie, Y. S. Kalashnikova, Proc. HADRON 01, AIP Conf. Proc. **619** (2002) 5
[2] D. Aston *et al.*, Phys. Lett. **92B** (1980) 211
[3] A. Donnachie, Phys. Lett. **B611** (2005) 255
[4] K. Schilling, G. Wolf, Nucl. Phys. **B61** (1973) 381