Two-pion production at CELSIUS-WASA and the quest for the nature of σ meson and Roper resonance

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The two-pion production in proton-proton collisions has been measured at CELSIUS in the energy range T_p = 775 - 1360 MeV using the WASA 4π detector with hydrogen pellet target. The WASA detector containing magnetic field, tracking detectors and calorimeter, allows the detection of both charged and neutral particles. The channels $pp\pi^+\pi^-, pp\pi^0\pi^0$ and $d\pi^+\pi^0$ have been measured exclusively with 4 overconstraints.

Our first exclusive $pp\pi^+\pi^-$ data taken at PROMICE/WASA near threshold have been shown [1] to be in agreement with the process proceeding via the Roper resonance as predicted by calculations of the Valencia group [2]. Within this ansatz the branching of $N^* \to \Delta\pi$ and $N^* \to N(\pi\pi)_{I=l=0}$ has been determined [3] assuming the scalar-isoscalar pion pair not to be correlated dynamically. Alternatively, the data are equally well described by $\pi\pi$ rescattering leading to a dynamic formation of the σ meson without invoking explicitely excitation and decay of the Roper resonance. In particular no Δ excitation is needed in this case. The implications on the nature of the Roper resonance will be discussed.

With increasing incident energies, however, the agreement of the Valencia prediction with the new data in $pp\pi^+\pi^-$ and $pp\pi^0\pi^0$ channels gets worse and finally at variance for $T_p > 1$ GeV. Rather at the highest energies the data in these channels are consistent with the formation of a $(\Delta\Delta)_{0^+}$ configuration, i.e., a very particular dibaryonic configuration. This is in contrast to the Valencia calculations, where the $\Delta\Delta$ system is assumed to be produced in all possible spin combinations. In addition the $M_{\pi^0\pi^0}$ spectra for $T_p \geq 1$ GeV exhibit some enhancement near threshold which is not yet understood.

Preliminary data analyses exist for the $d\pi^+\pi^0$ channel at $T_p = 1100$ MeV. In this isovector channel the data are consistent with the onset of ρ production.

[1] Brodowski et al. PRL **88** 192301 (2002); PRC **67** 052202 (2003)

[2] L. Alvarez-Ruso et al., Nucl. Phys. **A633**, 519 (1998)

[3] J. Pätzold et al., Phys. Rev. **C67**, 052202(R) (2003)

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