Exclusive Measurements of the $pp \to pp\pi^+\pi^-$ Reaction and the Decay Properties of the Roper Resonance

Heinz Clement for the CELSIUS/WASA collaboration
Physikalisches Institut der Universität Tübingen, Morgenstelle 14, D-72076 Tübingen, Germany

The double pion production in NN collisions offers a variety of aspects concerning the dynamics of the total system as well as that of its subsystems $\pi\pi, NN, \pi N, \pi\pi N$ and πNN. Apart from small non-resonant chiral contributions this reaction is expected to be dominated by excitation of one or both participating nucleons [1]. Since single $\Delta(1232)P_{33}$ excitation leads to the emission of only a single pion, the excitation of $N^*(1440)P_{11}$ in one of the participating nucleons with subsequent two-pion decay has the potential to dominate at low energies. This offers the possibility to study the still rather poorly known Roper Resonance and its decay branches, which is particularly interesting if the reaction proceeds via $pp \to pp^* \to pp\sigma := pp(\pi^+\pi^-)_{I=\ell=0}$, i.e., the direct decay into the σ channel, since this branch is hard to access in other reactions.
All previous data on this reaction stem from inclusive magnetic spectrometer measurements or low-statistics bubble chamber experiments, which partly have also been inclusive. Hence, we have carried out high-statistics exclusive measurements of $pp \to pp\pi^+\pi^-$ at $T_p = 650$ - 775 MeV at the CELSIUS storage ring using the PROMICE/WASA detector setup with cluster jet H_2 target [2].
The observed total cross sections for $pp \to pp\pi^+\pi^-$ are nearly an order of magnitude lower than expected from previous inclusive measurements.
The differential cross sections reveal the direct decay of the Roper into the $N\sigma$ channel $N^* \to N\sigma$ as the by far dominant one. This process is observed to be accompanied by a 25% amplitude of a process, where the Roper resonance decays into the $\Delta\pi$ channel. This admixture implies that the branching ratio $\Gamma(N^* \to \Delta\pi)/\Gamma(N^* \to N\sigma) \approx 0.07$ is tiny in the low-energy tail of the Roper resonance considered here ($M_{N\pi\pi} = 1270$ MeV/c^2). However, since the amplitude via $\Delta\pi$ scales like momentum squared, this decay branch will get dominant at high excitation energies.

References

[1] L. Alvarez-Ruso, E. Oset and E. Hernández, Nucl. Phys. **A633** (1998) 519
[2] W. Brodowski et al., Phys. Rev. Lett. **88** (2002) 192301