Exclusive Measurements of the $pp \to pp\pi^+\pi^-$ Reaction Close to Threshold*

J. Pätzold[a], W. Brodowski[a], R. Bilger[a], H. Calén[b], H. Clement[a], J. Dyring[b], C. Ekström[b], K. Fransson[b], L. Gustafsson[b], S. Häggström[b], B. Höistad[b], J. Johanson[b], A. Johansson[b], T. Johansson[b], K. Kilian[c], S. Kullander[b], A. Kupść[d], P. Marciniewski[d], B. Morosov[e], A. Mörtsell, W. Oelert[c], R.J.M.Y. Ruber[b], M.G. Schepkin[f], J. Stepaniak[d], A. Sukhanov[f], A. Turowiecki[d], G.J. Wagner[a], Z. Wilhelmi[d], J. Zabierowski[g], A. Zernov[d], J. Złomańczuk[b]

[a] Tübingen – [b] Uppsala – [c] Jülich – [d] Warsaw – [e] Dubna – [f] Moscow – [g] Lódz

The reaction $NN \to NN\pi\pi$ is the basic hadronic two-pion production process, be it in NN collisions in vacuum or in the nuclear medium. This reaction offers a variety of aspects concerning the dynamics of the total system as well as that of its subsystems $\pi\pi$, NN, πN, $\pi\pi N$ and πNN. Close to threshold the reaction is expected to be dominated by the excitation of $N^*(1440)$ in one of the participating nucleons, since single Δ excitation leads to the emission of a single pion only. Hence the lowest order to which the Δ mechanism contributes is the $\Delta\Delta$ excitation, which is expected to be dominant at higher energies, or via the decay $N^* \to \Delta\pi$. All previous data on the reaction below $T_p = 900\,\mathrm{MeV}$ stem from inclusive and/or low-statistic measurements. Hence we have carried out high-statistic exclusive measurements of the $pp \to pp\pi^+\pi^-$ reaction at the CELSIUS storage ring using the PROMICE/WASA detector setup with the clusterjet H_2 target. The measurements have been carried out in the energy range $T_p = 650 - 750\,\mathrm{MeV}$.

The resulting integral cross sections turn out to be one order of magnitude lower than expected from previous measurements. Differential observables for the many one-, two- and three-particle spectra of the four-body exit channel have been obtained with good statistics at $T_p = 750\,\mathrm{MeV}$. In the invariant mass $M_{\pi^+\pi^-}$ the data are strongly enhanced towards high $\pi\pi$-masses as compared to pure phasespace. This feature is common to observations in $pd \to ^3\mathrm{He}\ \pi^+\pi^-$ [1] and $\pi^-p \to \pi^+\pi^-n$ [2]. More insight is gained by the pion angular distributions in the various subsystems. Compared to isotropic phase space the data exhibit significant forward-backward asymmetries consistent with p-wave contributions, which differ from those observed in the other reactions mentioned above and which point to a strong Δ-admixture in the reaction process and/or possibly also to ϱ-production. Both possibilities appear to be quite surprising at this low energy.

[1] F. Belleman et al., Phys. Rev. **C60**, 06 1002 (1999)
[2] A. Kermani et al., Phys. Rev. **C58**, 3419 (1998)

*supported by BMBF(06 TU 987) and DFG (European Graduate School)