EXCLUSIVE MEASUREMENT OF $pp \to pp\pi^+\pi^-$ AT CELSIUS* **

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With the PROMICE/WASA detector setup at CELSIUS the reaction $pp \to NN\pi\pi$ has been measured in the energy range from 650 to 775 MeV. These data constitute the first exclusive high-statistics measurements on a pure hydrogen target, supplying both differential and integral cross sections. Most of the differential spectra for $pp \to pp\pi^-\pi^+$ are close to phase space predictions (including NN final-state interaction) identifying the production via $N^*(1440) \to N(\pi\pi)_{I=L=0}$ as the dominant process. However, the measured $M_{\pi^+\pi^-}$-spectrum is strikingly different from phase space simulation pointing to the importance of other processes in this reaction. Possible contributions from dibaryon resonances are discussed.

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1. Introduction

The 2π-production in the basic reaction $NN \to NN\pi\pi$ offers a variety of aspects concerning both the dynamics of the total system and its subsystems $\pi\pi, NN, \pi N, \pi\pi N$ and πNN. Apart from small non-resonant chiral contributions the 2π-production process is dominated by excitation of one or both participating nucleons. Since a single Δ excitation leads to the emission of only one pion, the lowest order contributed by the Δ mechanism is the simultaneous Δ excitation in both nucleons. Since this $\Delta\Delta$ process needs higher energies for its excitation than the excitation of $N^*(1440)$ in one of the participating nucleons, the latter is expected to dominate this reaction at low energies. For this reason 2π-production offers the unique possibility to investigate the yet rather poorly known Roper resonance in more detail.

Here we report specifically on the $pp \to pp\pi^-\pi^+$ measurement from the 1996 run at $T_p = 750$ MeV with the PROMICE/WASA detector setup [1] at CELSIUS. This measurement had been carried out to increase substantially the statistics accumulated by us in 1995 at the same energy, in order to obtain high quality data on differential spectra, in particular on the invariant $pp\pi$-mass spectrum $M_{pp\pi^-}$. In the previous data a narrow excursion on the 3σ level had been observed which was tentatively interpretated as a possible signal of the hitherto hypothetical πNN resonance d' [2,3].

2. Results

Fig. 1 shows a selection of differential spectra obtained from the 1996 run [4]. The data are compared with MC simulations assuming pure phase space (shaded histograms) or phase space including proton-proton final-state interaction (solid histogram curves). The latter clearly improves very much the description of the data for M_{pp}, on the other hand it has only tiny effects in the other spectra of Fig. 1. In particular, it cannot improve the poor description of the data in the proton-proton missing mass MM_{pp}, which is equivalent to $M_{\pi^-\pi^+}$. Qualitatively the observed discrepancy is similar to that observed [5] by MOMO in $pd \to {}^3\mathrm{He}\,\pi^-\pi^+$ at comparable energy. The reason for these discrepancies are not clear yet. According to calculations [6] performed by the Valencia group the cause of the observed discrepancy could be in the interference of the amplitudes $pp \to pN^* \to pp(\pi^-\pi^+)_{I=\ell=0}$, which corresponds to our MC-simulations shown in Fig. 1, and $pp \to pN^* \to p\Delta\pi \to pp\pi^-\pi^+$. If so this reaction could be a good means to determine the branching ratio of these N^* decays with high precision.

The invariant πNN mass spectra MM_{π^+}, equivalent to $M_{pp\pi^-}$, and $M_{pp\pi^+}$ show no narrow structures of significance. In particular there is no longer a narrow peak in MM_{π^+} at 2.06 GeV which was seen in the evaluation [2] of the 1995 data. This implies that a possible d' production cross

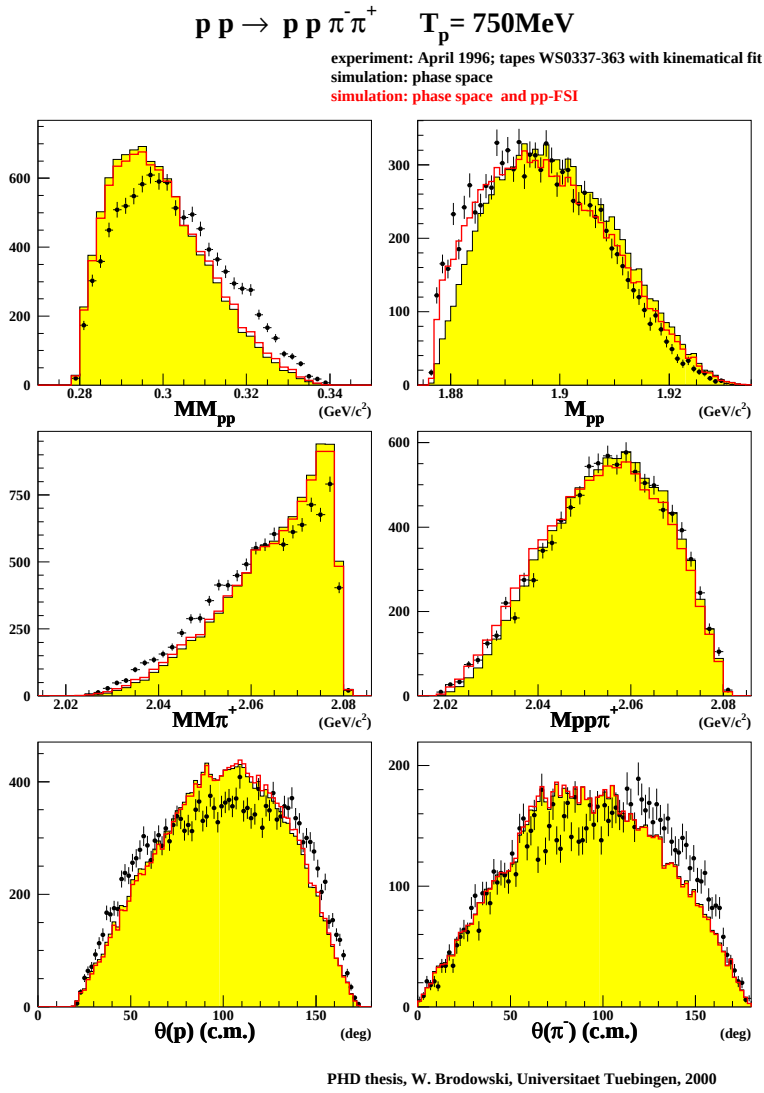

Fig. 1. Selection of differential spectra of the reaction $pp \to pp\pi^-\pi^+$ at $T_p = 750$ MeV. The data are compared to phase space MC simulations with (solid histogram curves) and without (shaded histograms) pp-FSI. (M = invariant mass, MM = missing mass).

section in $pp \to pp\pi^-\pi^+$ at 750 MeV must be smaller than 1% of the total cross section, *i.e.* smaller than 100 nb — if this resonance is lying within the mass region investigated in this measurement. The analysis of data taken at $T_p = 775$ MeV is in progress.

REFERENCES

[1] H. Calén *et al.*, *Nucl. Instrum. Methods* **A379**, 57 (1996).

[2] W. Brodowski *et al.*, *Z. Phys.* **A355**, 5 (1996).

[3] R. Bilger *et al.*, *Phys. Rev. Lett.* **71**, 42 (1993), **72**, 2972 (1994), and **79**, 3849 (1997); *Phys. Lett.* **B420**, 37 (1998), **B428**, 18 (1998) and **B443**, 77 (1998); *Phys. Rev.* **C58**, 1576 (1998).

[4] W. Brodowski, PhD thesis, Univ. Tübingen, 2000, to be published.

[5] F. Belleman *et al.*, *Phys. Rev.* **C60**, 061002 (1999).

[6] L. Alvarez-Ruso, E. Oset, E. Hernández, *Nucl. Phys.* **A633**, 519 (1998) and priv. communication.