Production of the $^1S_0$ diproton in the $pN \to pp\pi^0$ reaction in the GeV region

S. Dymov[a], V. Kurbatov[a], A. Kulikov[a], V. Komarov[a], G. Macharashvili[a], D. Tsirkov[a], and Yu. Uzikov[a]
for ANKE collaboration

Single pion production in NN collisions in the GeV region is attracting increasing attention in both theory and experiment [1, 2]. The $pp \to \{pp\}_s\pi^0$ reaction is of special interest for low excitation energy of the pp–system, $E_{pp} < 3$ MeV, when the $^1S_0$ final state dominates. Kinematically this reaction is very close to the well investigated $pp \to d\pi^+$ reaction [3]. However, the final $\{pp\}_s$–pair is an isotriplet partner of the unbound virtual deuteron, whereas the $^3S_1$–$^3D_1$ deuteron is an isosinglet. The different spin–isospin values lead to different transitions in the NN system that could significantly change the mechanism of the $pp \to \{pp\}_s\pi^0$ reaction as compared to that of $pp \to d\pi^+$. This gives us an opportunity to get more insight into the underlying meson–baryon dynamics by analyzing both reactions together. Unfortunately, experimental data on the $pp \to \{pp\}_s\pi^0$ reaction are very scarce (see Ref. [4] and references therein).

The unpolarized cross section of the $pp \to \{pp\}_s\pi^0$ reaction has recently been measured at COSY–ANKE at 0.8 GeV for diproton cm angles between 0 and 15.4° [4]. The absolute value of the measured cross section was found to be two orders of magnitude smaller than that of $pp \to d\pi^+$. Furthermore, an unusual angular dependence of the cross section was observed for this reaction. Both these peculiarities were qualitatively explained within a phenomenological model [5], which explicitly includes the Δ–isobar excitation in the intermediate state. Within this approach, a very strong energy dependence of the differential cross section and spin observables is expected below 1 GeV. This behaviour will soon be tested at COSY [6]. Here we report on the preliminary results of an analysis of data obtained at 1.1 GeV under similar conditions to those in Ref. [4].

For the analysis, events with two charged particle tracks crossing the Forward Detector of ANKE [7], were selected and the identification of the process was done on the basis of the missing–mass criterion. In total about 2000 events were obtained with $E_{pp} \leq 3$ MeV for the angular interval $0° \leq \theta \leq 21.0°$, where θ is the ejection angle of the pp system in the centre of mass of the reaction. The integral luminosity needed for normalization was found by simultaneous detecting $pp \to pp$ events and comparing the results with experimental data [8] and phase shift analysis [3] .

In Fig. 1 the differential cross section is shown as a function of $\cos^2\theta$. The fit to the linear function $a(1 + b\sin^2\theta)$ gives $a = (186.8 \pm 15.5)$ nb/sr and $b = 9.74\pm2.64$, where the errors are pure statistical. Though the measured cross section demonstrates the same type of angular dependence as at 0.8 GeV, it is a factor 3.8 lower in the forward direction [4]. This seems to be in contradiction to the main trend expected in the GeV region within the ΔN model [5].

The ratio of the $pp \to \{pp\}_s\pi^0$ and $pp \to d\pi^+$ cross sections at 1.1 GeV and angle zero is $R(\pi^0/\pi^+) = 4.5 \times 10^{-3}$, which is very close to that found at 0.8 GeV. This is also very similar to the ratio of backward diproton production in the $pd \to \{pp\}_s n$ reaction to the deuteron in $pd \to dp$ in the GeV region [9]. Using the $pp \to \{pp\}_s\pi^0$ data at 0.8 GeV [4], agreement with the experimental results on the deuteron breakup $pd \to \{pp\}_s n$ [9] and the one–pion–exchange model involving the subprocess $pN \to \{pp\}_s\pi$ was found [10], where a baryon (or Reggeon) exchange mechanism was assumed for the $pN \to \{pp\}_s\pi$ reaction. Using the present data at 1.1 GeV, one can also find [11] similar agreement with the deuteron breakup data, interpolated between 0.95 and 1.35 GeV [9]. As noted in Ref. [10], in order to distinguish between baryon exchange and Δ–isobar mechanisms it is necessary to measure the ratio of π^- and π^0 production in the $pN \to \{pp\}_s\pi$ reaction.

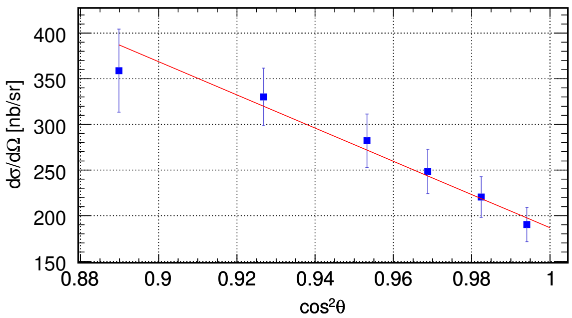

Fig. 1: The measured differential cross section of the $pp \to \{pp\}_s\pi^0$ reaction at 1.1 GeV versus $\cos^2\theta$, where θ is the angle of the momentum of the diproton system relative to direction of the beam in the cm system.

References:

[1] V. Lensky *et al.*, Eur. Phys. J. **A** 27, 37 (2006).
[2] C. Hanhart, Phys. Rep. **397** , 215 (2004)
[3] R.A. Arndt, I.I. Strakovsky, R.L. Workman, and D.V. Bugg, Phys. Rev. C **48**, 1926 (1993); http://gwdac.phys.gwu.edu
[4] S. Dymov *et al.*, Phys. Lett. B **635** (2006) 270.
[5] J.A. Niskanen, Phys. Lett. B **642**, 34 (2006).
[6] A. Kulikov *et al.*, *Measurement of the cross section and analyzing power of the* $\vec{p}p \to \{pp\}_s\pi^0$ *reaction*, COSY proposal No. 158 (2006).
[7] S. Barsov *et al.* Nucl. Instrum. Methods. A **462**, 364, (2001).
[8] F. Shimizu *et al.*, Nucl. Phys. A**3**89, 445 (1982).
[9] V.I. Komarov *et al.*, Phys. Lett. B **553** (2003) 179.
[10] Yu.N. Uzikov, J. Haidenbauer, and C. Wilkin, Phys. Rev. C **75**, 014008 (2007).
[11] Yu.N. Uzikov *et al.* (*in preparation).*

[a] Joint Institute for Nuclear Research, Dubna, Russia