Vector analyzing power of the $\vec{p}p \to \{pp\}_s\pi^0$ reaction at intermediate energies at ANKE/COSY*

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A successful ChPT analysis of the $NN \to NN\pi$ processes involving relatively high momentum transfers has only been developed in recent years [1]. The theory involves a contribution in the effective chiral Lagrangian from a so–called $(\bar{N}N)^2\pi$ contact operator, the strength of which is denoted by a low energy contact parameter d, which must be determined from experimental data. A ChPT analysis is currently focused on a set of experimental data for $pn \to \{pp\}_s\pi^-$ reaction at 353 MeV, however, the contaminations in these processes from pion d–waves are not yet included [1]. Though $(\bar{N}N)^2\pi$ does not contribute to the $pp \to \{pp\}_s\pi^0$ amplitude, the π^0 production data will provide information on the pion d–waves. It was one of the main aims for the present A_y measurement at 353 MeV.

At higher energies, in the $\Delta(1232)$ resonance region, the reaction $pp \to \{pp\}_s\pi^0$ was studied for the first time at ANKE [2]. The experiment revealed a wide peak in the energy dependence of the cross section at small angles. A consistent picture of the process is still lacking, so we have performed measurements of the cross section and A_y in the energy region 500–700 MeV where the forward cross section is maximal.

Measurements were performed in April 2009 with the ANKE spectrometer [3] at COSY-Jülich. The transversely polarized proton beam, with energies $T_p = 353$, 500, 550 and 700 MeV, interacted with the hydrogen cluster-jet target. The setup and procedure for data handling are described in detail in [2].

To start to identify the $pp \to \{pp\}_s\pi^0$ reaction, proton pairs were selected from all the registered two–track events, using the measured momenta of the both particles and their time-of-flight difference [4]. Then we applied the cut $E_{pp} < 3$ MeV to identify pairs where the $^1S_0$ state dominates.

We can reconstruct the kinematics of the $pp \to \{pp\}_sX$ process event–by–event and obtain a missing–mass spectrum. The main sources of the background are random coincidences and a signal from the $pp \to \{pp\}_s\gamma$ channel. To find the numbers of $\{pp\}_s\pi^0$ events, we fitted the M_X^2 distributions by the sum of a linear accidental background and simulated peak shapes for γ and π^0 [4]. The polarization asymmetry is given by

$$\varepsilon = \frac{N_\uparrow/L_\uparrow - N_\downarrow/L_\downarrow}{N_\uparrow/L_\uparrow + N_\downarrow/L_\downarrow}\,.$$

The analyzing power A_y is connected to it through:

$$A_y = \frac{\varepsilon}{P\,\langle\cos\phi_{pp}^{\rm cm}\rangle}\,.$$

Since the $\cos\phi_{pp}^{\rm cm}$ acceptance is concentrated near 1, essentially all the statistics collected effectively contribute to A_y.

The polarization P of the beam was evaluated using the $pp \to pp$ and $pp \to d\pi^+$ reactions detected in parallel. The two methods agreed within measurement errors and resulted in an average $P = 0.67 \pm 0.01$.

In 353 MeV case, if only waves up to $\ell = 2$ are retained, A_y must originate from a Ss:Sd interference. The cross section can be described with $a + b\cos^2\theta_{pp}^{\rm cm}$ [8]. Interpolating the CELSIUS data [5] gives the values of $a = 204\pm10$ nb/sr and $b = -112\pm23$ nb/sr. Then fitting the A_y distribution with

$$A_y = \frac{c\sin 2\theta_{pp}^{\rm cm}}{a + b\cos^2\theta_{pp}^{\rm cm}} \;[8]$$

leads to $c = 48\pm4$ nb/sr. When the results of the full model [1] are available, the current data will provide a valuable test of the theoretical approach.

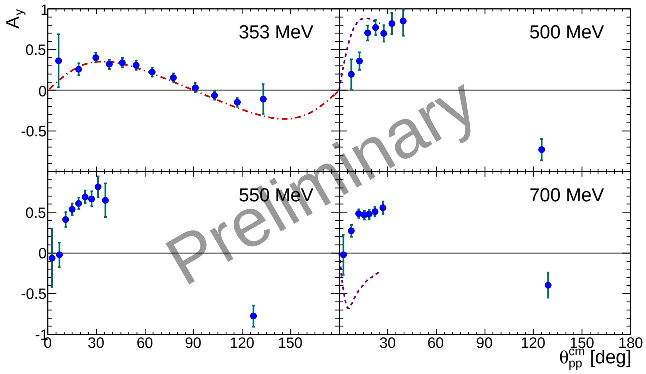

Fig. 1: Preliminary values of A_y for the $\vec{p}p \to \{pp\}_s\pi^0$ reaction at all the measured energies. The errors shown are purely statistical; the overall systematic uncertainty from the beam polarization and luminosity is about 3%. The angular uncertainty is about 5° near 90° at 353 MeV and less than 1.5° at other energies. The dash-dotted line represents the fit using CELSIUS data for the cross section [5]. The dashed line corresponds to the predictions by Niskanen [6, 7].

In the $\Delta(1232)$ region, the small angle predictions of the Niskanen model [7] approach the data at 500 MeV but are in full disagreement at 700 MeV. The reason for the disagreement in respect of both the cross section [2, 6] and analyzing power is unclear.

In order to improve the results, the setup geometry will be defined more precisely, reducing the angular uncertainty at 353 MeV from 5° to ≈ 2°. The systematic uncertainties will also be reduced by applying more precise dead-time and luminosity corrections.

References:

[1] V. Baru *et al.*, Phys. Rev. C **80** 044003 (2009).
[2] V. Kurbatov *et al.*, Phys. Lett. B **661** 22 (2008).
[3] S. Barsov *et al.*, Nucl. Instrum. Methods Phys. Res. A **462** 354 (2001).
[4] D. Tsirkov *et al.*, J. Phys. G **37** 105005 (2010).
[5] R. Bilger *et al.*, Nucl. Phys. A **693** 633 (2001).
[6] J. A. Niskanen, Phys. Lett. B **642** 34 (2006).
[7] J. A. Niskanen, private communication (2008).
[8] C. Hanhart, Phys. Rep. **397** 155 (2004).

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