# Cross section angular dependences of the $pp \to \{pp\}_s\pi^0$ reaction at several energies in the $\Delta(1232)$ excitation region*

D. Tsirkov[1], S. Dymov[1,2], V. Komarov[1] for the ANKE collaboration

The study of the reaction $pp \to \{pp\}_s\pi^0$ at intermediate energies at ANKE [1, 2] has shown that the forward cross section energy dependence exhibits a clear peak associated with the $\Delta(1232)$ resonance excitation.
We approximated the cross section angular dependences with the following function:

$$d\sigma/d\Omega = d\sigma_0/d\Omega \left(1 + k \sin^2\theta_{pp}^{\rm cm}\right), \qquad (1)$$

where $d\sigma_0/d\Omega$ represents the cross section at zero angle of the proton pair $\theta_{pp}^{\rm cm} = 0$ and $k$ — the angular slope.
Further studies revealed that the slope $k$ is very sensitive to small uncertainties in ANKE positioning for the data collected at the beam energies of 500, 550 and 700 MeV [2], in contrast to the forward cross section $d\sigma_0/d\Omega$, that is relatively stable. The precision of the standard ANKE geometry tuning procedure is not enough to decrease the systematical error of the slope sufficiently. It has been found that the geometry correction parameters are strongly correlated and no more than one of them can be fitted. For further study the tunings of either the target position or the angle of the ANKE platform were used in addition to the original untuned geometry.
The slope $k$ is so unstable because the reconstructed polar angle of the proton pair $\theta_{pp}^{\rm cm}$ depends much on the geometry corrections and a significant migration of the events in the angular distribution occurs when we apply small changes in the ANKE positioning. In attempt to counter this effect the data analysis software using a kinematical fit for the event reconstruction has been developed.

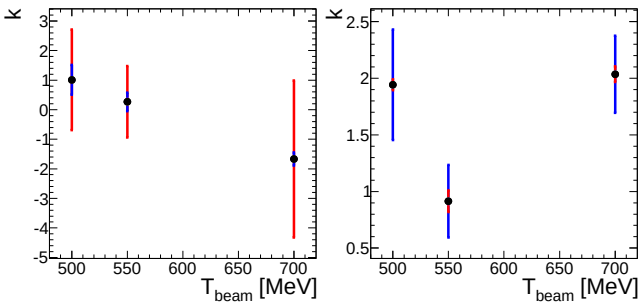


Fig. 1: Comparison of the statistical errors (marked blue) and the systematics from the geometrical uncertainties (marked red) for the parameter $k$. On the left are the results for the old procedure utilized in [2], on the right — the new procedure decribed here.

The impact of this procedure on the uncertainties in $\theta_{pp}^{\rm cm}$ reconstruction was studied in the following way: a simulation has been done in which chamber hits were generated using some set of geometry corrections and then the events were reconstructed using the untuned ANKE geometry. That has shown that without the kinematical fit an average difference between the original and reconstructed angles changes smoothly from $\sim -1°$ at small angles to $\sim +3°$ when approaching the end of the acceptance ($\sim 30°$). With the kinematical fit the precision of $\theta_{pp}^{\rm cm}$ reconstruction is about 2.5 times better and average deviations do not exceed $\pm 0.7°$ even near the edges of the acceptance.
Analysis of the experimental data for $\vec{p}p \to \{pp\}_s\pi^0$ with different geometry tunings shows that use of a kinematical fit strongly stabilyses the slope parameter $k$, as can be seen in fig. 1. The new results for the cross section, obtained with the procedure decribed here, are shown in fig. 2.

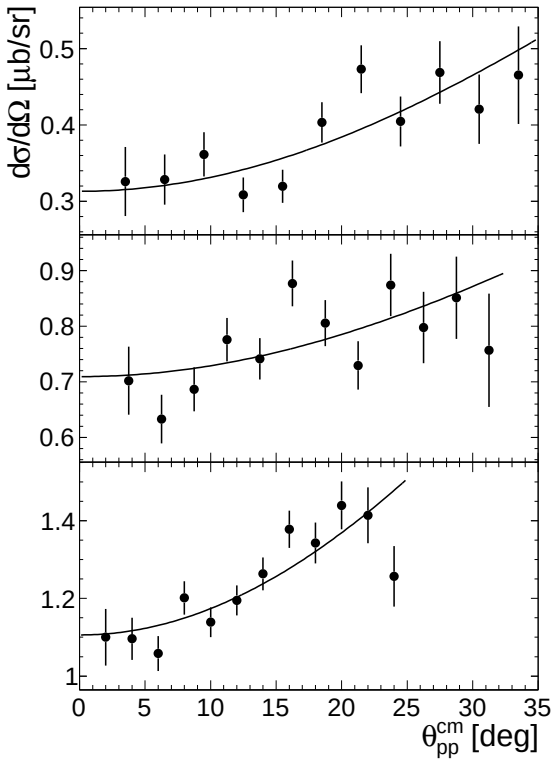


Fig. 2: The cross section angular dependences for the $\vec{p}p \to \{pp\}_s\pi^0$ data at the 500, 550 and 700 MeV beam energies, the lines represent fits with equation (1).

Besides the ANKE forward detector, employed in obtaining the presented results, the positive side detector collected some data as well. If these data would be processed, the available acceptance could be extended to cover the polar angles up to 90°, providing the full cross section angular dependence.

**References:**

[1] V. Kurbatov *et al.*, Phys. Lett. B **661** (2008) 22
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[1] LNP JINR, RU-141980 Dubna, Russia
[2] Phys. Inst. II, UEN, D-91058 Erlangen, Germany
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