Development of a method to determine the polarization of the ANKE storage cell target

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Commissioning of the ABS and the storage cell [1] at ANKE includes investigations of the atomic hydrogen density distribution in the cell and the nucleon polarization. The $pp \to d\pi^+$ process with detection of both secondaries was chosen for this aim, and a simulation has been performed to find the optimum conditions for the measurement [2]. At a proton beam energy of 600 MeV and deflection angle of 9.2°, the jet polarization can be determined with an accuracy (RMS) of 4% after 5 hours of data taking at a luminosity of $4 \times 10^{28}\mathrm{cm}^{-2}\mathrm{s}^{-1}$. The polarization would be measured by detecting both particles in the ANKE Forward Detector at $\Theta_\pi^{cm} = 17 - 22°$, while monitoring of the luminosity will be done with pions at 0°, which go to the Positive Detector.

The $pp \to d\pi^+$ events can be identified via reconstructed momenta, the arrival time difference and the energy loss in the scintillation counters. Trajectories of both particles together with their arrival times allow, with the use of kinematical constraints, to reconstruct the coordinates of the interaction point. This is accomplished by minimizing the following expression:

$$\chi^2 = \Sigma \frac{(\Delta w)_i^2}{(\sigma^2 w)_i} + \mathrm{HW} \cdot \Sigma(\Delta \mathrm{P})_\mathrm{i}^2 + \Sigma \frac{(\Delta \mathrm{TOF})_\mathrm{i}^2}{(\sigma^2 \mathrm{TOF})_\mathrm{i}},$$

where the first term includes the deviations of the trajectories in the MWPCs, the second one is the kinematical term, applied with a "heavy weight" HW. ΔTOF was calculated as $\Delta\mathrm{TOF} = \tau(\vec{\mathrm{p}}, \mathrm{l}, \mathrm{m}) - \mathrm{TDC} \cdot \mathrm{channel}$, where $\tau(p, l, m)$ is the TOF from the vertex, calculated from the particle momentum, trajectory length and the mass assumed, and $TDC \cdot channel$ is the measured arrival time. This procedure provides a measurement of the gas density distribution inside the cell and a separation of the background $d\pi^+$–pairs originating from the rest gas in the target and magnet chambers. An appropriate software for the vertex reconstruction has been developed.

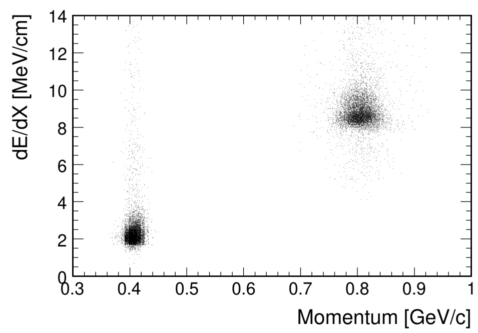

Fig. 1: Identification of $d\pi^+$ by energy loss.

The method was tested during a beam time in November 2005 [3]. A calibration run with a point-like CH_2 strip target allowed to tune the $d\pi^+$ events separation and confirmed that the obtained detector acceptance corresponds to the simulated one. The data showed that the resolution of the reconstructed vertex coordinate is $\sigma_z = 3.6$ cm longitudinally and $\sigma_x = 0.8$ cm transversely. These values have been obtained with the use of the FD MWPC only; the inclusion of the newly built MWDC into the analysis should improve σ_x up to ≈ 0.5 cm.

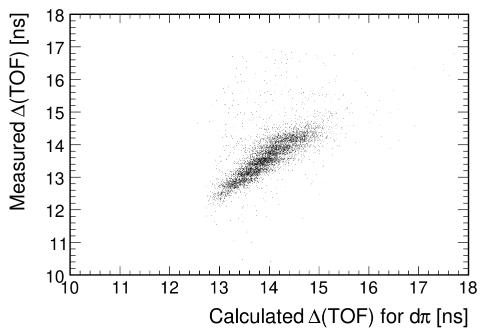

Fig. 2: Identification of $d\pi^+$ by TOF.

The $d\pi^+$ pairs are well separated due to the high deuteron energy loss, as shown in Fig. 1. In Fig. 2, the comparison of the measured arrival time difference with the one calculated for pion and deuteron masses is shown for the storage cell data. The large ΔTOF of $d\pi^+$ pairs allows to identify them practically without dilution from pairs of other particles. The distribution of coordinates in Fig. 3, obtained with the storage cell, shows the events produced inside the cell as well as the background. The origin in the figure corresponds to the ABS jet position and the x and y coordinates follow the positions of the COSY beam.

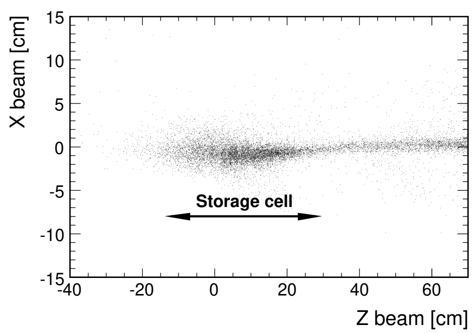

Fig. 3: Reconstructed vertex coordinates for the cell measurement.

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References:

[1] Commissioning and Initial Research with the Polarized Gas Target at ANKE. COSY Proposal #146.

[2] S. Dymov et al, Simulation of ABS polarization measurement in Week 47, 2005. ANKE internal report.

[3] K. Grigoryev et al, Storage cell tests and commissioning of the Polarized Internal Gas Target. IKP Annual report, 2005.