Abstract

The WASA detector is a multi–purpose detection system designed to investigate the production of mesons and their decays at the CELSIUS hadron storage ring. Together with a unique target system that provides small frozen hydrogen or deuterium spheres, it is optimized to measure all final state particles in hadron–hadron collisions due to its near to 4π solid angle coverage in the laboratory system and to cope with high luminosities up to 10^{32} $\text{cm}^{-2}\text{s}^{-1}$.

In this work, the analysis of data taken during the commissioning phase of the CELSIUS/WASA experiment is described. Experimental data taken in November, 2001 and in the time period from December, 2002 till December, 2003 are analyzed.

The analysis of the former data set focuses on the continuation of the physics program from the preceding experiments at the IUCF in Bloomington, Indiana [R^+93, Roh94] and the PROMICE/WASA experiment [Gre99, G^+00].

In both works, precise measurements of the reaction $pd \rightarrow pd\pi^0$ in the near threshold region were carried out. The data were compared to predictions from [MN93] that describes the pion production in the dp system by a quasifree process involving the nucleon–nucleon reaction $pn \rightarrow d\pi^0$. It turned out that the phenomenological Spectator Model alone failed to describe the experimental distribution over the whole energy range measured and that so–called coherent mechanisms involving all three nucleons had to be added to the model description. Similar result were shown in [Gre99, G^+02] for the bremsstrahlung process $dp \rightarrow dp\gamma$, which had never been measured before in the given energy range.

The measurement discussed here has been intended to put the results from [G^+00, G^+02] on firmer ground, since the detector acceptance has not only increased but is sensitive to phase space regions not accessible in the previous experiment. Indeed, the previous results for the Spectator Model contribution are confirmed in this thesis for both reactions. However, limited statistics do not allow an improvement of the previous quantitative conclusions. Apparently, the deuteron beam with an energy of $T_d = 560$ MeV suffered from the beam–target–interaction with the hydrogen pellets, resulting in a rather low deuteron beam life time and large beam heating which caused high background conditions. Furthermore, a simultaneously measured, well–known reaction has not been available for calibration purposes, luminosity determination and estimation of systematic errors.

To address the open questions about the actual performance of the WASA detector, the examination of the second data set is presented. To circumvent the intricatenesses involved with a low energy deuteron beam, data with a

high energy proton beam of $T_p = 1.36$ GeV are chosen. The generation and selection of the elastic proton–proton scattering is discussed in detail. The gained data samples are then used to check the efficiency and acceptance of the WASA detector and to diagnose the beam and target performance by determining the vertex position and the luminosity. The calculated vertex position shows a small shift in all three coordinates which is not in agreement with the nominal vertex position within the given errors. The luminosity is determined with a systematical error of less then 5%. In the time period investigated, it increased about a factor of seven, reaching $6 \cdot 10^{30}$ cm^{-2}s^{-1} in December, 2003.

References

[G$^+$00] J. Greiff et al., *Pion production in $dp \to dN\pi$*, Phys. Rev. C **62**, 064002 (2000).

[G$^+$02] J. Greiff et al., *Quasifree bremsstrahlung in the $dp \to dp\gamma$ reaction above the pion production threshold*, Phys. Rev. C **65**, 034009 (2002).

[Gre99] J. Greiff, *Investigation of Inelastic Reactions in Deuteron Proton Collisions Between T_d = 437 and 559 MeV Using the PROMICE/WASA Detector at CELSIUS*, PhD thesis, Universität Hamburg, Institut für Experimentalphysik, 1999.

[MN93] H. O. Meyer and J. A. Niskanen, *Quasifree pion production in the three nucleon system*, Phys. Rev. C **47**, 2474–2480 (1993).

[R$^+$93] H. Rohdjess et al., *Total cross-section for $p + d \to p + d + \pi^0$ close to threshold*, Phys. Rev. Lett. **70**, 2864–2867 (1993).

[Roh94] H. Rohdjeß, *Pion Production in pd Reactions Close to Threshold*, PhD thesis, Universität Hamburg, Institut für Experimentalphysik, 1994.