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ABSOLUTE CROSS SECTIONS AND ANALYZING POWERS
OF THE REACTION $pp \rightarrow d \pi^+$ BETWEEN 1.3 AND 2.4 GeV**

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MEASUREMENTS OF ANGULAR DISTRIBUTIONS OF ABSOLUTE CROSS SECTIONS AND ANALYZING POWERS OF THE REACTION $\bar{p}p \rightarrow d\pi^+$ BETWEEN 1.3 AND 2.4 GeV

J. YONNET, R. ABEGG^{*,**}, M. BOIVIN, A. BOUDARD^{*}, G. BRUGE^{*},
P. COUVERT^{*}, G. GAILLARD^{***}, M. GARÇON^{*}, L.G. GREENIAUS^{****},
D.A. HUTCHEON^{**}, C. KERBOUL^{*} and B. MAYER^{*}

CEN-Saclay, Laboratoire National Saturne, F-91191 Gif sur Yvette Cedex, France

^{*}CEN Saclay, DPhN/SEPN, F-91191 Gif sur Yvette Cedex, France

^{**}TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C. V6T 2A3, Canada

^{***}Université de Genève, DPNC, CH-1211 Geneva, Switzerland

^{****}University of Alberta, Dept. of Physics, Edmonton, Alberta T6G 2J1, Canada

Résumé - Nous avons mesuré les distributions angulaires des sections efficaces absolues, des pouvoirs d'analyse et des coefficients de transfert de spin K_{nn} de la réaction $\bar{p}p \rightarrow d\pi^+$ pour 6 énergies incidentes du proton entre 1.3 et 2.4 GeV. La première phase de l'analyse concernant les distributions angulaires des A_{y0} et des sections efficaces absolues est achevée. Les distributions de A_{y0} présentées en fonction de \sqrt{s} pour t ou u égaux à zéro ou pour θ_π (c.m.) égal à 90° confirment le phénomène résonnant vu dans une précédente expérience. Dans cette même représentation, nous montrons pour la première fois un comportement non monotone de la section efficace (pour $t = 0$) autour de $\sqrt{s} = 2700$ MeV.

Abstract - We have measured angular distributions of absolute cross sections, analyzing powers and the spin transfer parameters K_{nn} of the reaction $\bar{p}p \rightarrow d\pi^+$ at 6 incident proton energies between 1.3 and 2.4 GeV. In a first phase the data were analyzed to obtain angular distributions of absolute cross sections and analyzing powers A_{y0} . Distributions of A_{y0} where the Mandelstam parameters t or u are equal to zero or the angle θ_π (c.m.) equals 90° as a function of \sqrt{s} confirm the resonance like behaviour suggested by an earlier experiment. For the first time deviations from a smooth behaviour are also found in the \sqrt{s} distribution (at $t = 0$) of the absolute cross section.

1 - INTRODUCTION

For the fundamental reaction $pp \rightarrow d\pi^+$ the data can be divided into two regions in energy of the incident proton: below 800 MeV where the data are relatively abundant and above 800 MeV where data are scarce. To extend dramatically the data set of $pp \rightarrow d\pi^+$ we have measured angular distributions of absolute cross sections, analyzing powers, spin transfer parameter K_{nn} and the polarization of the deuteron. The interest in spin observables at a few GeV stems also from the fact that earlier experiments found resonance like structures around $\sqrt{s} = 2.7$ GeV in excitation functions of the spin correlation parameters C_{LL} /1/ and C_{NN} /2/ in pp elastic scattering around θ (c.m.) = 90° . A bump was also observed /3/ in the difference between the total cross section for antiparallel and parallel longitudinal spin states around 2.7 GeV. Structures were also observed /4/ in the analyzing power A_{y0} of the reaction $pp \rightarrow d\pi^+$ in the same energy region. Such resonances are predicted by a model by Lomon et al. /5/. A first phase of the analysis resulted in angular distributions of absolute cross sections and analyzing powers at 6 energies between 1.3 and 2.4 GeV which are presented here.

2 - EXPERIMENTAL METHODS

To study the polarization observables of the reaction $\bar{p}p \rightarrow d\pi^+$ a polarized proton beam of intensity $(2 - 5)10^{10}$ protons per pulse was extracted from the synchrotron SATURNE II. The protons were incident onto a 4 or 10 cm thick liquid hydrogen target. The reaction products were momentum analyzed in the magnetic spectrometer system SPES 4. Momentum analysis together with time of flight information allowed the unambiguous identification of the reaction deuterons. The polarization of the incident proton beam was continuously monitored by an in beam polarimeter and varied between 70 and 80 % depending on the extracted energy. The number of particles was monitored by a secondary electron emission monitor and calibrated by the use of the carbon activation method.

3 - ANALYSIS AND RESULTS

A Monte-Carlo program was used to simulate the geometry of SPES 4 and revealed that for certain geometries particles were lost in SPES 4. Using these calculations as a guide absolute cross sections were determined in a momentum region where no losses occurred. Complete angular distributions of the absolute cross section were thus obtained at 1.3, 1.6, 1.7, 1.88, 2.1 and 2.4 GeV. A typical distribution of the cross section as a function of the center of mass angle of the pion $\theta_\pi(\text{c.m.})$ is shown in figure 1. Since the distribution is symmetric about 90° cross sections which were measured at large angles are shown at their composite forward angles. The statistical errors are smaller than the dot size. The systematic uncertainty is estimated to be 3 % due to the uncertainty of the thicknesses of the liquid hydrogen targets and the uncertainties of the monitors. The background varied with angle and was carefully subtracted. Background, events, efficiencies and dead time were determined separately for each spin state of the incident proton beam. These two cross sections were then averaged to yield the absolute cross section for that particular $\theta_\pi(\text{c.m.})$. A careful study of the cases where particles were lost in SPES 4 showed that for the determination of A_{y0} the losses did not affect the result and therefore, for statistical reasons, a wider bite in momentum was used. As a result some of the angles for the A_{y0} data differ slightly from the ones of the corresponding cross sections. Complete angular distributions of A_{y0} were determined for 1.3, 1.88, 2.1 and 2.4 GeV and a typical example is shown in figure 2 for 1.88 GeV. Partial distributions were obtained at 1.6 and 1.7 GeV to complement the large angle data of an earlier experiment /4/. At each energy the value of A_{y0} at $t = 0$ (and $u = 0$) was obtained (through interpolation if necessary) and the resulting distribution as a function of \sqrt{s} is shown in figure 3 which also includes the values from the previous experiment /4/. The new data strongly support the suggestion of the earlier experiment of a pronounced maximum around 2.75 GeV. The same procedure was applied for the first time to absolute cross sections and the distribution (fig. 4) as a function of \sqrt{s} shows a shoulder around 2.65 GeV. Similar structures are confirmed by distribution of A_{y0} when $\theta_\pi(\text{c.m.}) = 90^\circ$ or $u = 0$.

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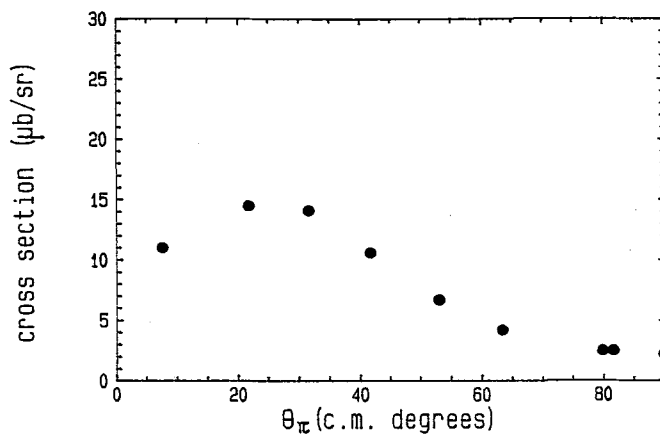


Fig. 1 - Angular distribution of the absolute cross section as a function of the pion c.m. angle θ at $T_p = 1880$ MeV.

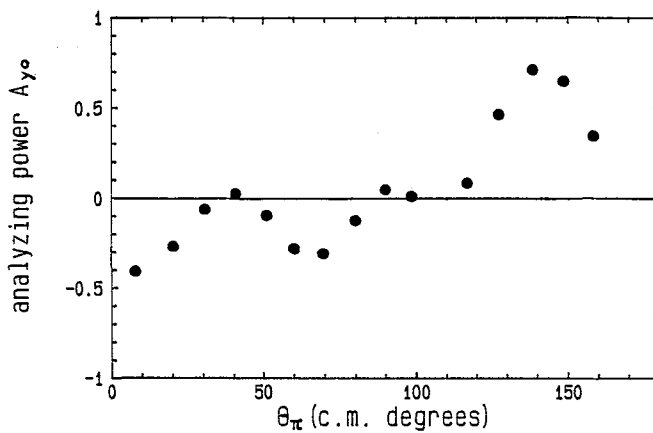


Fig. 2 - Angular distribution of the analyzing power A_{y0} as a function of the pion c.m. angle θ at $T_p = 1880$ MeV.

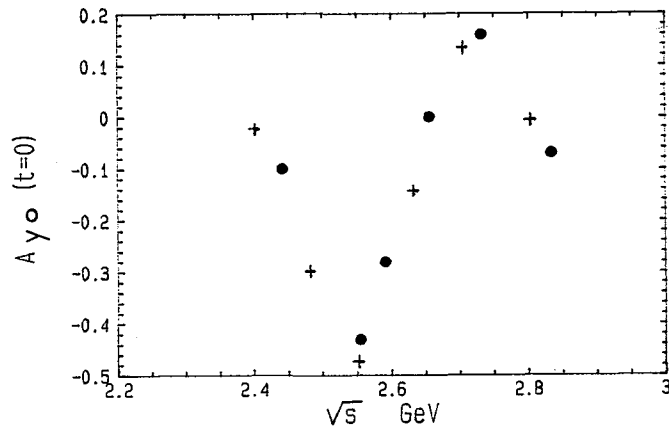


Fig. 3 - Analyzing power A_{y_0} for $t = 0$ as a function of \sqrt{s} . • present experiment (typical statistical error : 0.01), + data from ref. 4 (typical error : ~ 0.02).

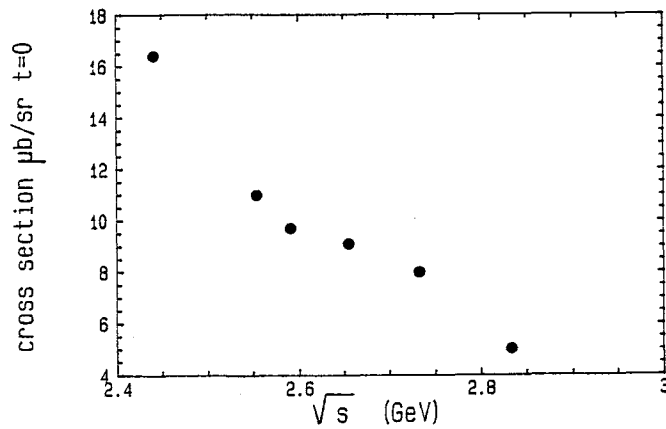


Fig. 4 - Absolute cross section (typical statistical error : ~ 0.15) for $t = 0$ as a function of \sqrt{s} showing a shoulder around 2.65 GeV.