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STUDY OF THE REACTION $\bar{p}p \to \Delta^{\pm\pm}(1232) + X$ AT 22.4 GeV/c

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Батюня Б.В. и др. E1 - 12297

Изучение реакции $\bar{p}p \to \Delta^{\pm\pm}(1232)+X$ при 22,4 ГэВ/с

В статье приводятся инклюзивные и полуинклюзивные сечения образования изобары $\Delta^{\pm\pm}$ во всей кинематической области.

Распределения по x и y^* (для $\Delta^{--}(1232)$ производилось отражение относительно точки $x = y^* = 0$) имеют продолжение в переднюю полусферу. Вклад $\Delta^{\pm\pm}(1232)$ не зависит от топологии. Среднее значение поперечного импульса изобары $\langle P_T \rangle$ равно 0,43 ±0,10 ГэВ/с, а наклон P_T^2-распределения равен 4,3±1,0 (ГэВ/с)^2.

Элемент спиновой матрицы плотности ρ_{33} равен 0,20± 0,07, что может говорить о применимости модели однопионного обмена с поглощением.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

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Batyuna B.V. et al. E1 - 12297

Study of the Reaction $\bar{p}p \to \Delta^{\pm\pm}(1232)+X$ at 22.4 GeV/c

We present inclusive and semi-inclusive cross sections for $\Delta^{\pm\pm}(1232)$ production in the entire kinematical region. The x and y^* distributions (for $\Delta^{--}(1232)$ reflected about $X = y^* = 0$) extend into forward hemisphere. The fraction of $\Delta^{\pm\pm}(1232)$ production seems to be constant as a function of topology. The average transverse momentum is 0.43 ± 0.10 GeV/c and the slope of the P_T^2 distributions is -4.3 ± 1.0 (GeV/c)^2. The spin density matrix element ρ_{33} is 0.20 ± 0.07 favouring the absorptive OPE model.

The investigation has been performed at the Laboratory of High Energies, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna 1979

1. INTRODUCTION

In this paper we study $\Delta^{++}(1232)$ and $\Delta^{--}(1232)$ production in $\bar{p}p$ reactions at 22.4 GeV/c in a truly inclusive way without applying any cuts to the data, which enables us to study the $\Delta^{\pm\pm}$ production close to the central region. Recently $\Delta^{\pm\pm}$ has been also studied in this way in other experiments /1-3/.

The data used in this analysis consist of ~8200 events with charged multiplicity 4 or higher. Experimental details have been given elsewhere /4,5/. To calculate the $(p^{\pm}\pi^{\pm})$ mass distributions, we assume that each positive (negative) particle is in turn a proton (antiproton) in the case when the proton was not identified by ionization ($P_{lab} \geq 1.5$ GeV/c), and thus make all the possible combinations. We assume that wrong combinations enter into the background. We get some justification for this assumption from the events with identified protons. We have reassigned the protons as pions and assumed each true pion in turn to be a proton. The mass distribution thus calculated does not make any contribution to the Δ^{++} signal. Generating the Δ^{++} signal by the Monte-Carlo method and reassigning the proton and pion masses give an effective mass distribution without any resonance structure.

Consistency checks of the CP-invariance of $\Delta^{++}(1232)$ and $\Delta^{--}(1232)$ have been done throughout the work.

In our earlier work /6/ only events with protons identified by ionization were used for the inclusive distributions. Cuts were applied to the $(P\pi^+)$ mass distribution and the momentum transfer. Thus this investigation was limited to the peripherally produced Δ^{++} (1232).

2. RESONANCE FITTING

To obtain cross sections for $\Delta^{\pm\pm}$ (1232), the following procedure was applied. The expression

$$f = \frac{\beta_1 \phi_1}{I_1} + \frac{\beta_2 \phi_2}{I_2} + \frac{(1-\beta_1-\beta_2)}{I_3} BW\phi_3 \qquad (1)$$

was fitted to the $(p^\pm\pi^\pm)$ mass distribution in the region 1.08 GeV $\leq M(p^\pm\pi^\pm) \leq$ 1.80 GeV. Here β's are free parameters and I's are normalization integrals. The background ϕ_1 is assumed to have the hehaviour as the phase space term ϕ_3 and for $i = 1,2$.

$$\phi_i \simeq (M(p^\pm\pi^\pm) - M_\pi - M_p)^{\alpha_i} \cdot e^{a_i M(p^\pm\pi^\pm)} , \qquad (2)$$

where α_i and a_i are free parameters. The background ϕ_2 is introduced to account for the reflection of the true $\Delta^{\pm\pm}$ signal when assigning wrong masses to the true proton (antiproton) and pion. The background term, which has been investigated in Monte-Carlo events, has a behaviour that differs significantly from ϕ_1 (i.e. $\alpha_2 \neq \alpha_1$ and $a_2 \neq a_1$). BW stands for the usual p-wave Breit-Wigner with the width

$$\Gamma = \Gamma_0 \left(\frac{q}{q_0}\right)^3 \frac{\rho \cdot M(p^\pm\pi^\pm)}{p \cdot M_{\Delta^{\pm\pm}}} . \qquad (3)$$

Here q and q_0 are the decay momenta in the resonance rest system and in the central position of the resonance rest system, respectively, and

$$\rho(M) = (M_\pi^2 + q^2)^{-1} . \qquad (4)$$

The mass spectra were fitted using fixed values for a mass of $M_{\Delta^{\pm\pm}} = 1232$ MeV and a width of $\Gamma_0 = 115$ MeV. Different inclusive $\Delta^{\pm\pm}$ spectra were obtained by fitting, for each bin, expression (1) to the corresponding $(p^\pm\pi^\pm)$ mass distribution.

In fig. 1 we present the total $(p^\pm\pi^\pm)$ mass distribution. The curves show the result of the fit of expression (1) $(X^2/ND = 18/11)$. As obtained from this fit, the total inclusive cross section for $\Delta^{\pm\pm}$ (1232) production is 8.0 ± 1.0 mb.

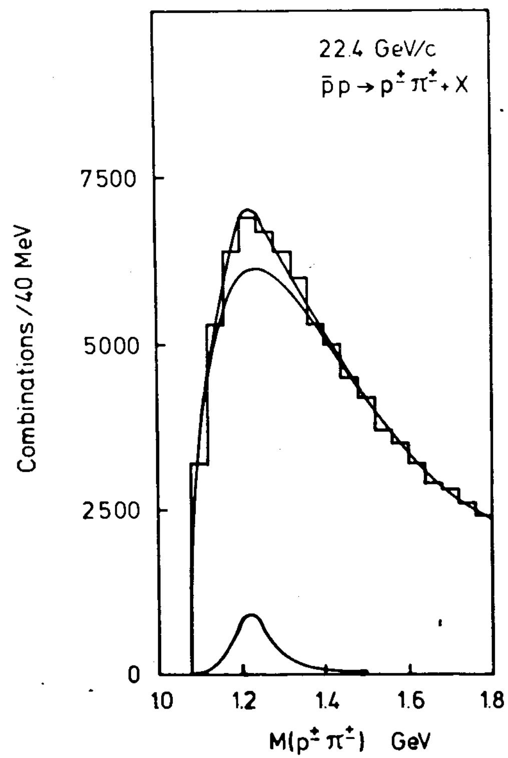

Fig.1. $(p^\pm\pi^\pm)$ mass distribution.The upper curve shows the best fit to the data (eq.(1)), the middle curve represents the background and the bottom curve, the p-wave Breit-Wigner.

3. TOPOLOGICAL CROSS SECTIONS FOR $\Delta^{\pm\pm}(1232)$ PRODUCTION

At Fermilab energies Δ^{++} production is seen in significant amounts for all topologies [7]. In the table the cross section for $\Delta^{\pm\pm}$ production

Table

Topological cross sections for $\Delta^{\pm\pm}(1232)$

Prong	$\sigma(\Delta^{\pm\pm})$mb	$\sigma(n_{ch})$mb [2]	$\sigma(\Delta^{\pm\pm})/\sigma(n_{ch})$
4	4.2±0.4	14.17±0.32	0.30±0.03
6	2.8±0.4	9.45±0.24	0.30±0.04
8	1.4±0.4	4.25±0.15	0.33±0.09
10	0.6±0.4	1.42±0.08	0.42±0.28
12	0.0±0.1	0.24±0.03	< 0.4
Σ	9.0±0.8	29.53±0.44	0.30±0.03

is given together with the total cross section as a function of topology. The ration $\sigma(\Delta^{\pm\pm})/\sigma(n_{ch})$ seems to be constant within errors. It has been noted that in meson-proton reactions at 16 GeV/c [1] the fraction of Δ^{++} production increases with topology. However, as we know that a great amount of our high multiplicity cross section is due to annihilation, we do not expect to see such a feature.

4. INCLUSIVE SPECTRA

The Feynman x and c.m. rapidity distributions are shown in figs. 2a and b. For Δ^{--} the distributions are reflectrd about $x=y^*=0$. We notice that there is $\Delta^{\pm\pm}$ production also in the central

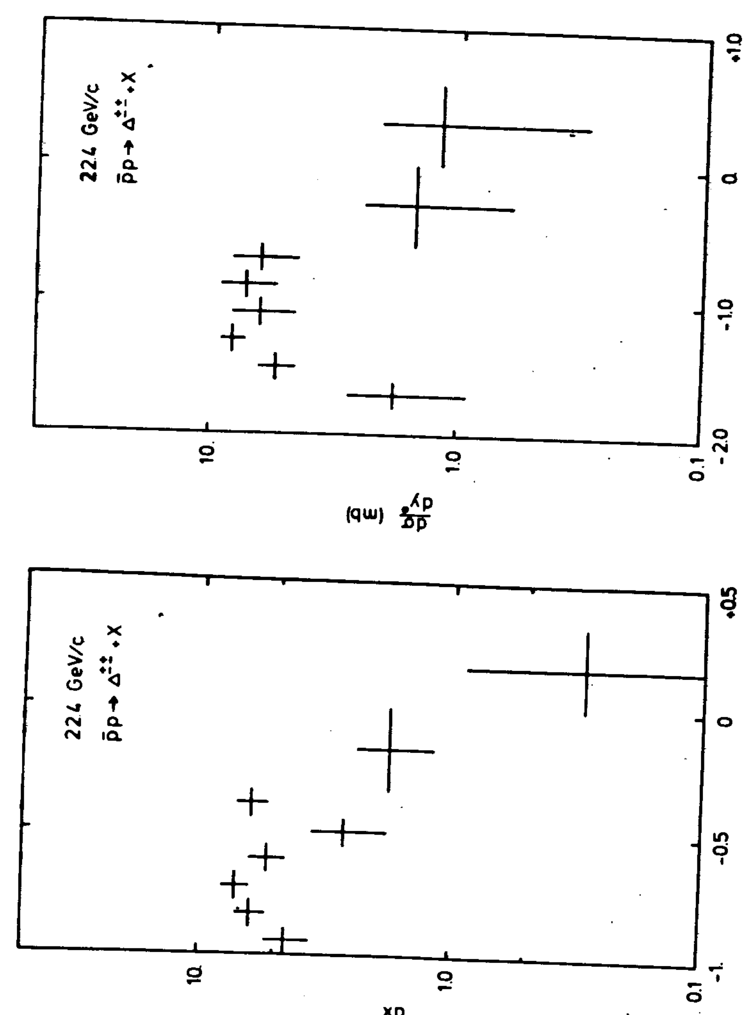

Fig.2. a) x distribution (reflected about x=0 for Δ^{--}),
b) y* distribution (reflected about y*=0 for Δ^{--}).

region. The forward production of Δ^{++} seen in negative meson-proton reactions [1] may well agree with our results, although our limited statistics makes it difficult to draw any definite conclusions.

The P_T^2 distribution is shown in fig. 3. The slope is -4.3 ± 1.0 $(GeV/c)^{-2}$. This value is in

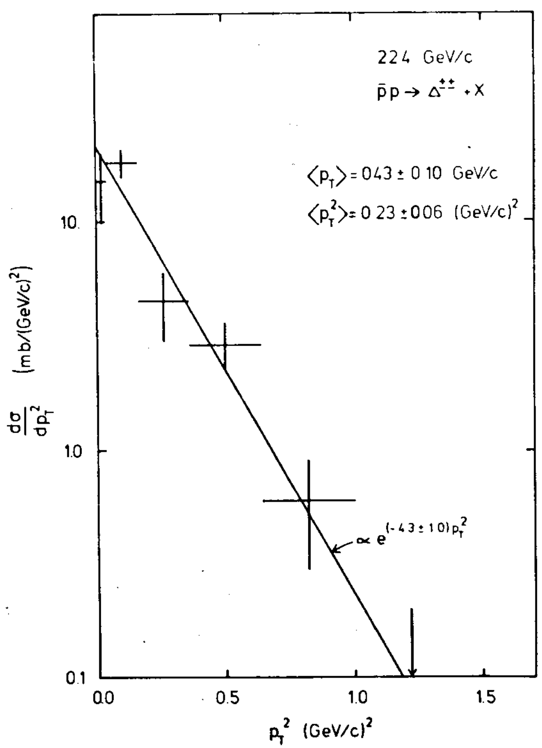

Fig.3. Transverse momentum squared distrubution.

agreement with the values given in ref. [8] for inclusive Δ^{++} production and with the universal value for inclusive vector meson production [9]. Extrapolating the slope towards high P_T^2, we calculate the average transverse momentum $\langle P_T \rangle = 0.43 \pm 0.10$ GeV/c, which is surprisingly large

if the usual assumption that $\Delta^{\pm\pm}$ should be peripherally produced is correct. The average transverse momentum squared is $\langle P_T^2 \rangle = 0.23 \pm 0.06 (GeV/c)^2$. In ref. [1] the peak in the P_T^2 distribution was seen for small values of P_T^2. We do not see such an effect.

Studies of inclusive Δ^{++} production at medium energy [1,8] suggest that there is Δ^{++} production also at large momentum transfer. In our data the t-dependence of inclusive $\Delta^{\pm\pm}$ (fig. 4) can

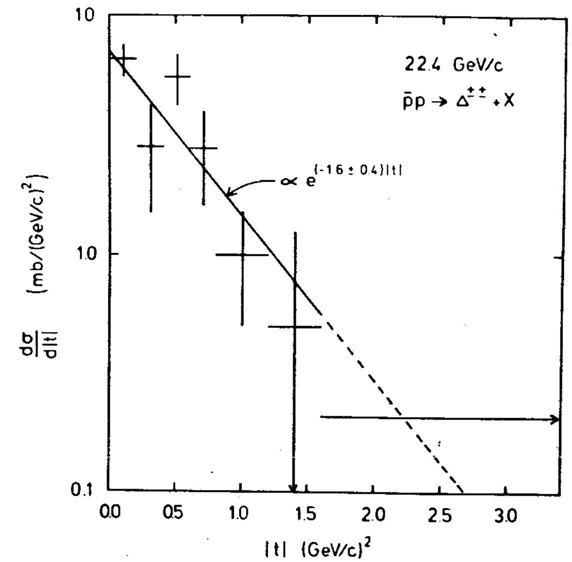

Fig.4. Four-momentum transfer distribution.

be fitted with a simple exponential for $|t| \leq 1.6$ $(GeV/c)^2$. The slope is -1.6 ± 0.4 $(GeV/c)^{-2}$. Extrapolating this slope towards higher values of $|t|$, we get the cross section b=4.5 ± 2.0 mb. However, the bin $|t| > 1.6$ $(GeV/c)^2$, when fitted by expression (1), yields the cross section 3.8 ± 1.1 mb, and thus the added total cross section equal to 7.9 ± 1.3 mb is in agreement with the result from the total inclusive mass distribution. Thus we conclude that there is a break in the slope of the t-distribution at $|t| > 1.6\ (GeV/c)^2$ and that the t-distribution for small $|t|$-values cannot be used to estimate the total cross section (compare with ref. [10]). Such a break (between 2 and 4 (GeV/c^2) in $|t|$ was noted in refs. [1,8].

The density matrix element ρ_{33} was obtained by fitting the expression $W(\cos\theta) \sim 1 + 3\cos^2\theta + 4\rho_{33}(1 - 3\cos^2\theta)$ to the polar angle distribution in the t-channel (see fig. 5). We get $\rho_{33} = 0.20 \pm 0.07$ which favours the absorptive OPE model.

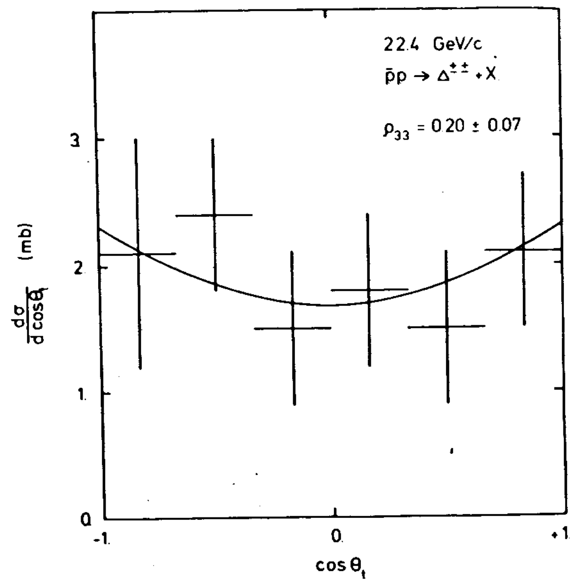

Fig.5. Distribution of the cosine of the polar angle in the t-channel frame. The curve represents the best fit of the expression $W(\cos\theta) \sim 1 + 3\cos^2\theta + 4\rho_{33}(1-3\cos^2\theta)$ to the data.

5. CONCLUSIONS

The main physics results are:

(i) Although the $\Delta^{\pm\pm}$ production is mainly "peripheral" there is an evidence for "central" $\Delta^{\pm\pm}$-production.

(ii) We have found that a substantial part of the $\Delta^{\pm\pm}$ production comes from high topologies.

(iii) The slope of the P_T^2 distrubution is in a agreement with the universal slope for inclusive isobar and vector meson production.

(iv) The Jackson angle distribution is in agreement with the prediction of the absorptive one pion exchange model.

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