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AN INVESTIGATION OF ASSOCIATIVE MULTIPLICITY IN THE REACTION $\bar{p}p \to p$ (SLOW) + X AT 22.4 GeV/c

Alma-Ata - Dubna - Helsinki - Kosice - Moscow - Prague Collaboration

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Батюня Б.В. и др.

E1 - 12117

Исследование ассоциативной множественности в реакции $\bar{p}p \to p$ (медл.)+ X при 22,4 ГэВ/с

В работе исследуется поведение ассоциативной множественности как функции недостающей массы к идентифицированному протону в реакции $\bar{p}p \to p$(медл.) + X при 22,4 ГэВ/с. Показан различный характер поведения ассоциативной множественности для дифракционных ($M_X^2/s \leq 0{,}1$) и недифракционных событий. В рамках двухкомпонентной модели качественно объяснено поведение отношения $\langle n(M_X^2)\rangle/D$ как функции M_X^2.

При использовании масштабной переменной

$$z' = (n_{ch} - 1 - \alpha)/(\langle n(M_X^2)\rangle - \alpha), \quad \alpha = -1{,}04$$

для всех значений M_X^2 был получен аналог скейлинга KNO в системе X. Отмечается подобие реакций $\bar{p}p \to p$(медл) + X и $pp \to p$(медл.) + X.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1979

Batyunya B.V. et al.

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An Investigation of Associative Multiplicity in the Reaction $\bar{p}p \to p$(slow)+ X at 22.4 GeV/c

The associative multiplicity as a function of the missing mass squared to the identified proton in the reaction $\bar{p}p \to p$(slow) + X at 22.4 GeV/c is studied. A different behaviour of the associative multiplicity for diffraction ($M_X^2/s \leq 0.1$) and nondiffraction events is observed. The M_X^2 dependence of the ratio $\langle n(M_X^2)\rangle/D$ is qualitatively explained on the basis of the two-component model.

An analogue of KNO scaling in the system X is obtained for all values of M_X^2 with the help of the scaling variable.

$$z' = (n_{ch} - 1 - \alpha)/(\langle n(M_X^2)\rangle - \alpha), \quad \alpha = -1.04\,.$$

A similar behaviour of the reactions $\bar{p}p \to p$(slow) + X and $pp \to p$(slow)+ X is pointed out.

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

Preprint of the Joint Institute for Nuclear Research. Dubna 1979

1. The associative characteristics of recoil system X to identified particle c in the reaction $aN \to c + X$ have been extensively studied for various particles a and c [1].

In this paper we study the reaction

$$\bar{p}p \longrightarrow p\,(slow) + X \qquad (1)$$

at 22.4 *GeV/c*. About 21 000 inelastic events were used in this analysis. Protons with a laboratory momentum of $\lesssim$ 1.5 *GeV/c* were identified by ionization thus yielding about 5 600 events of the type (1). The questions concerning the separation of elastic events, the corrections for losses of inelastic 2-prong events with slow recoil protons, etc., have been analyzed in ref. [2].

2. The average charged multiplicity of system X is defined through the topological (inclusive) differential cross sections $d\sigma_n / dM_X^2 (d\sigma / dM_X^2)$ of reaction (1),

$$\langle n(M_X^2)\rangle = \sum_n (n-1)\, d\sigma_n / dM_X^2 \,/\, d\sigma / dM_X^2 \,, \qquad (2)$$

as a function of the missing mass squared M_X^2 to the identified proton. In *fig. 1* we compare the M_X^2/s dependence of $\langle n(M_X^2)\rangle$ both for the reaction (1) and the reaction $pp \longrightarrow p(slow) + X$ at 19 *GeV/c* [9]. We have fitted our data points by the logarithmic expression

$$\langle n(M_X^2)\rangle = a + b\,\ell n(M_X^2 / M_0^2)\,, \qquad M_0 = 1\ GeV^2, \qquad (3)$$

in an interval of $4 \lesssim M_X^2 \lesssim 22\ GeV^2$ and by the power law

$$\langle n(M_X^2)\rangle = a_1 + b_1 \sqrt{M_X^2} \qquad (4)$$

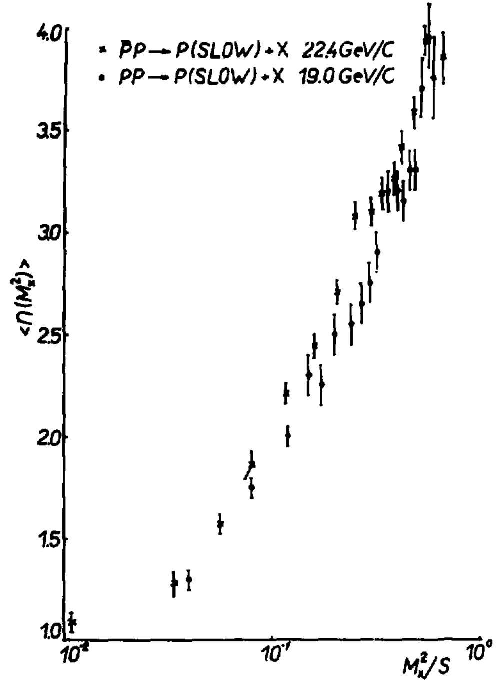

Fig. 1. The average charged multiplicity $<n(M_X^2)>$ *of system X as a function of* M_X^2/s *for the reactions* $\bar{p}p \longrightarrow p(\text{slow}) + X$ *(22.4 GeV/c) and* $pp \longrightarrow p(\text{slow}) + X$ *(19 GeV/c)*[9].

in the diffraction region ($M_X^2 < 4$ GeV^2), as suggested by multiperipheral models (see, e.g., ref.[3]) and by the fragmentation model "NOVA", incorporating cluster production[4], respectively. The fitted parameters are shown in *table 1* together with similar parameters for the reaction $pp \longrightarrow p(\text{slow}) + X$.

3. In *fig. 2* we show the M_X^2 -dependence of the ratio $<n(M_X^2)>/D$, where

$$D = (<n^2(M_X^2)> - <n(M_X^2)>^2)^{1/2} . \tag{5}$$

A clear dip structure seen for $2 \lesssim M_X^2 \lesssim 4$ GeV^2 can be explained, e.g., due to overlapping of two different mechanisms

Table 1

The parameters in eqs. (3), (4) and corresponding

$\chi^2/ND \cdot pp(102-405)$ [8], $pp(36)$ [10].

Reaction momentum (GeV/c)	a	b	χ^2/ND	a_1	b_1	χ^2/ND
$\bar{p}p$ (22.4)	0.69±0.11	0.94±0.05	7.8/7	0.63±0.09	0.61±0.06	5/2
pp (36)	0.78±0.45	0.85±0.16	1.4/5	0.66±0.18	0.55±0.13	0.3/1
pp (102-405)	-0.55±0.39	1.37±0.09	-	0.71±0.17	0.72±0.07	-

in the diffraction region. In such a two-component model [5] the dispersion can be written in the form

$$D = (\beta_1 D_1^2 + \beta_2 D_2^2 + \beta_1 \beta_1 (<n_1(M_X^2)> - <n_2(M_X^2)>)^2)^{1/2}, \quad (6)$$

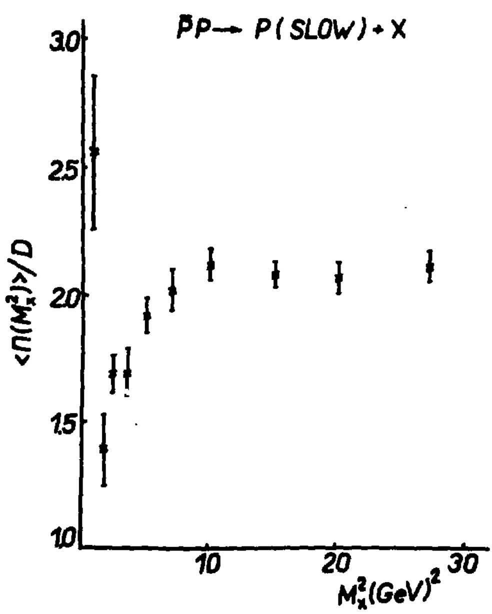

Fig. 2. The M_X^2-dependence of the ratio $<n(M_X^2)>/D$.

where the probabilities β_i of the two processes satisfy the normalization condition $\beta_1+\beta_2=1$. The diffraction mechanism ($D=D_1$) dominates at $M_X^2 \sim 1\ GeV^2$ and the nondiffraction mechanism is responsible for $M_X^2 > 4\ GeV^2$ ($D=D_2$), while in the intermediate region the "interference" term in (6) increases the dispersion thus yielding the observed dip structure.

4. We analyse also the possibility of an analogue of KNO-scaling for the system X /6/. In *table 2* we show the normalized moments $c_q = \langle n^q(M_X^2)\rangle / \langle n(M_X^2)\rangle^q$. It is seen that c_q values are different in the diffraction ($M_X^2/s \lesssim 0.09$) and nondiffraction regions. From this it follows that the usual KNO-scaling for the system X is not valid, i.e., the function

$$\Psi(z, M_X^2) = \frac{\langle n(M_X^2)\rangle\, d\sigma_N/dM_X^2}{d\sigma/dM_X^2} \qquad (7)$$

Table 2

The normalized associative moments for various intervals of $M_X^2/s \cdot pp(205)$ /6/

M_X^2/s	c_2	c_3	c_4	Reaction momentum (GeV/c)
0. - 0.09	1.41 ± 0.02	2.71 ± 0.16	6.55 ± 0.85	$\bar{p}p$ (22.4)
	1.40 ± 0.04	2.58 ± 0.20	5.51 ± 0.82	pp (36)
	1.41 ± 0.03	2.54 ± 0.17	5.54 ± 0.69	pp (205)
0.09 - 0.18	1.26 ± 0.02	1.85 ± 0.09	3.18 ± 0.44	$\bar{p}p$ (22.4)
	1.25 ± 0.05	1.80 ± 0.19	2.90 ± 0.60	pp (36)
	1.22 ± 0.02	1.71 ± 0.06	2.66 ± 0.18	pp (205)
0.18 - 0.30	1.23 ± 0.02	1.72 ± 0.08	2.71 ± 0.18	$\bar{p}p$ (22.4)
	1.23 ± 0.04	1.71 ± 0.15	2.63 ± 0.43	pp (36)
	1.23 ± 0.02	1.77 ± 0.07	2.87 ± 0.20	pp (205)
0.30 - 0.39	1.23 ± 0.02	1.75 ± 0.04	2.76 ± 0.12	$\bar{p}p$ (22.4)
	1.27 ± 0.05	1.86 ± 0.17	3.02 ± 0.56	pp (36)
	1.23 ± 0.02	1.73 ± 0.06	2.70 ± 0.18	pp (205)
0.39 - 0.60	1.23 ± 0.02	1.74 ± 0.04	2.74 ± 0.13	$\bar{p}p$ (22.4)
	1.24 ± 0.04	1.76 ± 0.15	2.73 ± 0.47	pp (36)

essentially depends on M_X^2. To get rid of the M_X^2 dependence, we introduce the scaling variable /7/

$$z' = (n_{ch} - 1 - a)/(\langle n(M_X^2)\rangle - a) . \tag{8}$$

The parameter $a = -1.04$ in (8) is determined from the condition

$$[(\langle n(M_X^2)\rangle - a)/D]_d = [(\langle n(M_X^2)\rangle - a)/D]_{nd} . \tag{9}$$

where the l.h.s. (r.h.s.) have been calculated for $0 < M_X^2 < 4\ GeV^2$ ($4 < M_X^2 < 22\ GeV^2$). The corresponding normalized distribution $\Psi(z')$ is shown in *fig. 3* for $0 < M_X^2 < 22\ GeV^2$: The solid curve is the result of the fit:

$$\Psi(z') = (0.05 \pm 0.01) \exp[(7.78 \pm 0.59) z' - (4.17 \pm 0.58) z'^2 + (0.13 \pm 0.18) z'^3] \tag{10}$$

with $\chi^2/ND = 26/20$.

5. CONCLUSIONS

The following results have been obtained in a study of the associative multiplicities in the reaction (1).

(i) We observe striking similarity between the reactions $\bar{p}p \rightarrow p(\text{slow}) + X$ and $pp \rightarrow p(\text{slow}) + X$ for comparable energies in an interval of $0 < M_X^2/s < 0.5$. This fact is illustrated by the $\langle n(M_X^2)\rangle$ distribution in *fig. 1* and the corresponding parameters in *table 1*. Besides, in the diffraction region $M_X^2/s \lesssim 0.09$ the $\langle n(M_X^2)\rangle$ distribution is clearly independent of incident momentum (see the parameters a_1, b_1 in *table 1*).

(ii) The M_X^2 dependence of the ratio $\langle n(M_X^2)\rangle/D$ is qualitatively explained on the basis of the two-component model.

(iii) An analogue of KNO-scaling in the system X is obtained for all values of M_X^2 with the help of the scaling variable

$$z' = (n_{ch} - 1 - a)/(\langle n(M_X^2)\rangle - a), \qquad a = -1.04 .$$

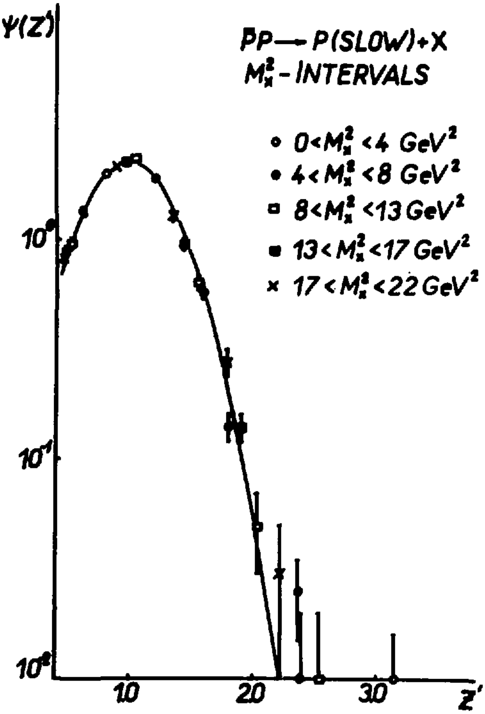

Fig. 3. The distribution $\Psi(z') = \dfrac{(\langle n(M_X^2)\rangle - a)\, d\sigma_n / dM_X^2}{d\sigma / dM_X^2}$,

$z' = (n_{ch} - 1 - a)/(\langle n(M_X^2)\rangle - a)$, $\quad a = -1.04$

in an interval of $0 < M_X^2 < 22$ *GeV*^{2} *. The solid curve is defined in eq. (10).*

REFERENCES

1. *Blobel V. et al. Nucl.Phys., 1977, B122, p.429. Zhuravleva L.I. et al. JINR, P1-10643, Dubna, 1977.*
2. *Boos E.G. et al. Nucl.Phys., 1977, B121, p.381.*
3. *Chan C.F. Phys. Rev., 1973, D8, p.179.*
4. *Berger E.L., Jacov M., Slansky R. Phys. Rev., 1972, D6, p.2580.*
5. *Van Hove L. Phys. Lett., 1973, 43B, p.65.*

6. *Barshay S. et al. Phys. Rev.Lett., 1974, v.32, p.1390.*
7. *Clifford T.S.et al. Phys. Rev.Lett., 1974, v.33, p.1239.*
8. *Whitmore J. Phys. Rep., 1974, 10C, p.274.*
9. *Boggild H. et al. Nucl.Phys., 1974, B72, p.221.*
10. *Boguslavsky I.V. et al. JINR, 1-11828, Dubna, 1978.*

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