92-69

сообщения
объединенного
института
ядерных
исследований
дубна

E1-92-69

Z.Strugalski, M.Sultanov*

CHARACTERISTICS OF THE PION PRODUCTION AND NUCLEON EMISSION PROCESSES IN PION-CARBON NUCLEAR COLLISIONS AT 40 GeV/c

*SamSU, Uzbekistan

1992

Стругальски З., Султанов М. E1-92-69

Характеристики процессов рождения пионов и испускания протонов в пион-углерод ядерных столкновениях при импульсе 40 ГэВ/с

Описаны экспериментальные результаты, полученные при исследованиях столкновений пионов с ядрами углерода. Импульсные и энергетические спектры протонов, испущенных из ядра-мишени, не зависят от интенсивности продукции пионов в изучаемых столкновениях.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна 1992

Strugalski Z., Sultanov M. E1-92-69

Characteristics of the Pion Production and Nucleon Emission Processes in Pion-Carbon Nuclear Collisions at 40 GeV/c

Experimental data on pion-carbon nucleus collisions are presented. The momentum and energy spectra of protons emitted from the target nucleus do not depend on the intensity of the pion production in the collisions.

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

Communication of the Joint Institute for Nuclear Research. Dubna 1992

1. INTRODUCTION

The aim of this work has been to gain insight in the physics of the nucleon emission and pion production processes in hadron-nucleus collisions. This publication is the second one in a series of our works/1/ in which experimental data on hadron-$^{12}C_6$ nucleus collisions are presented. The data were collected using the 2 meter long propane bubble chamber of the Joint Institute for Nuclear Research exposed to 40 GeV/c momentum pion beams from the Serpukhov Institute of High Energy Physics accelerator. We used to present the experimental characteristics of the outcome in the pion-$^{12}C_6$ nucleus collisions in a special manner, the physical motivation for such a presentation is given in our former work/1/.

2. EXPERIMENTAL PROCEDURE

The methodical questions concerning the expositions of the chamber and the analysis of the photographs are discussed in the former works/1-4/. Here, additional information on questions is given.

All the secondary electrically charged particles, if not the protons with the momenta within the values interval 0.15 GeV/c ÷ 0.7 GeV/c in the lab system, were considered to be pions. In this case, the admixture of the protons among the positively charged secondaries amounts about 15% and the admixture of the K^{+-} mesons and Σ^{+-} hyperons is not larger than 4-5%/3,4/.

3. EXPERIMENTAL DATA

For this work, 7577 Pi^-+ $^{12}C_6$ nuclear collisions were selected, according to the standard criteria/1,5,6/. In the sample of the selected and analysed collision events, the interactions of the incident pions with quasi-free nucleons on the periphery of the $^{12}C_6$ nuclei were excluded.

The distributions $N(n_p)$ of the multiplicities n_p of the emitted protons in dependence on the multiplicity n_{pi} of the ejected pions, and the distributions $N(n_{pi})$ of the ejected pions multiplicities n_{pi} in dependence on the multiplicity n_p of the emitted protons are presented below; the distributions in fact represent the distributions of the proton emission intensities and of the pion ejection intensities correspondingly/1/. Moreover, the momentum spectra of the emitted protons in dependence on the ejection intensity of the produced pions and the momentum spectra of the produced pions in dependence on the intensity of the emitted protons in the events under analysis were constructed. Important characteristics of the collision processes are contained in the energy spectra of the emitted protons and of the ejected pions in the classes of events with various numbers of protons n_p emitted in collisions and with various numbers n_{pi} of the pions created in the reactions. The distributions of the emission angles of the protons and of the ejection angles of the created pions are considered to be of mostly important value as well. All these characteristics are presented in figs. 1 - 12. The characteristics of the distributions in figs 1 - 12 are presented in tables I - XII.

4. DISCUSSION AND RESULTS

The following results should be emphasized here:

1. The mean number of the emitted protons equals to

$$\langle n_p \rangle_{exp} \simeq \frac{Z}{A} \langle\lambda\rangle \cdot \pi D_o^2 = 1.8;$$

where $\langle\lambda\rangle$ in nucleon/S is the mean thickness of the intranuclear matter layer involved in the pion-carbon nucleus collisions, D_o is the nuclear interaction range.

2. The momentum and kinetic energy spectra, and angular distributions of the emitted protons do not depend on the pion production intensity, when the intensity is not larger than 8.

3. The kinetic energy mean value of the emitted protons is near to the pion rest mass value; it has been emphasized in our former works with the xenon bubble chambers.

4. There are indications that at least two separate groups of the produced pion multiplicities appeare (Fig.4).

Experimental results obtained here do not contradict the picture of the hadron-nucleus collision process, presented by one of the authors (Z.S.) in his former works as prompted experimentally.

Table I. Characteristics of the distributions shown in fig.1

n_{Pi}	N_{ev}	$\langle n_p \rangle$	s.d.	skewness	kurtosis
≥0	3586	1.82	1.14	0.9179	0.9223
0	88	2.00	0.52	0.0472	-1.8441
1	122	1.71	0.89	1.0835	1.7522
2	199	2.00	1.09	0.5248	-0.1566
3	368	1.65	0.92	0.7496	0.4080
4	362	1.74	1.23	1.1123	0.8108
5	342	1.81	1.28	1.4360	2.7237
6	360	1.88	1.22	0.7681	0.1268
7	342	1.80	1.16	0.9852	1.0313
8	364	1.76	1.20	0.9137	0.7193

Table II. Characteristics of the distributions shown in fig.2

n_{Pi}	Σn_p	$\langle P_{tot} \rangle$	s.d.	skewness	kurtosis
≥0	10776	0.303	0.175	1.0822	1.1185
0	73	0.314	0.146	1.4592	2.6342
1	331	0.310	0.136	1.4462	2.6926
2	538	0.306	0.146	1.6173	3.2254
3	805	0.300	0.142	1.6160	3.5355
4	1011	0.317	0.151	1.4357	2.5744
5	1204	0.319	0.151	1.2870	1.7482
6	1201	0.326	0.156	1.3227	1.6942
7	1098	0.322	0.151	1.3024	1.7454
8	1071	0.318	0.147	1.2145	1.5160

Table III. Characteristics of the distributions shown in fig.3

n_{Pi}	Σn_p	$\langle P_{lon} \rangle$	s.d.	skewness	kurtosis
≥0	10810	0.099	0.200	0.5131	0.9280
0	73	0.091	0.168	1.2025	3.4584
1	331	0.056	0.188	0.5031	1.6433
2	538	0.102	0.200	0.4478	1.3222
3	806	0.087	0.190	0.6048	1.1778
4	1012	0.093	0.209	0.4468	0.7814
5	1206	0.098	0.208	0.4970	0.8982
6	1201	0.106	0.213	0.4946	0.8455
7	1099	0.094	0.213	0.5206	0.9548
8	1072	0.095	0.199	0.4162	0.9681

Table IV. Characteristics of the distributions shown in fig.4

n_{Pi}	$\sum n_p$	$< P_{tr} >$	s.d.	skewness	kurtosis
≥ 0	10801	0.216	0.159	1.2751	1.9515
0	73	0.255	0.129	1.0798	2.0894
1	331	0.249	0.120	1.1238	2.6405
2	538	0.227	0.119	1.2480	2.6815
3	806	0.231	0.122	1.3987	3.6418
4	1012	0.237	0.126	1.3290	3.0315
5	1206	0.241	0.127	1.1945	1.9914
6	1204	0.243	0.125	1.1431	1.7403
7	1099	0.243	0.123	1.1296	2.0242
8	1072	0.244	0.126	1.1770	2.5398

Table V. Characteristics of the distributions shown in fig.5

n_{Pi}	$\sum n_p$	$< E_k >$	s.d.	skewness	kurtosis
≥ 0	73	0.059	0.059	2.5338	8.0168
1	331	0.057	0.055	2.5137	8.3065
2	538	0.057	0.060	2.6327	8.6672
3	806	0.055	0.059	3.0159	12.4417
4	1011	0.060	0.062	2.5829	8.8709
5	1206	0.062	0.064	2.4474	8.0907
6	1201	0.065	0.064	2.1392	5.1377
7	1099	0.063	0.063	2.2745	6.6757
8	1072	0.062	0.060	2.2105	6.5737

Table VI. Characteristics of the distributions shown in fig.6

n_{Pi}	$\sum n_p$	$< \cos\theta >$	s.d.	skewness	kurtosis
≥0	10815	0.2487	0.5890	-0.5521	-0.8506
0	73	0.2104	0.4837	-0.5600	-0.3588
1	331	0.1527	0.5098	-0.1648	-0.9278
2	538	0.2660	0.5360	-0.5392	-0.8338
3	806	0.2263	0.5288	-0.4164	-0.8481
4	1013	0.2285	0.5462	-0.5209	-0.7521
5	1206	0.2371	0.5362	-0.4775	-0.8148
6	1204	0.2548	0.5323	-0.5516	-0.6946
7	1099	0.2166	0.5429	-0.4571	-0.8459
8	1072	0.2381	0.5229	-0.4765	-0.7657

Table VII. Characteristics of the distributions shown in fig.7

n_p	N_{ev}	$< n_{Pi} >$	s.d.	skewness	kurtosis
≥0	3574	7.14	3.72	0.7056	0.8929
0	252	12.66	2.75	1.1986	1.1509
1	459	9.77	4.99	-0.2937	-0.2748
2	400	9.41	5.16	-0.1149	-0.6723
3	160	9.28	4.78	-0.1629	-1.4175
4	73	8.35	4.17	0.2262	-1.0914
5	28	7.96	3.02	0.4220	-0.5735

Table VIII. Characteristics of the distributions shown in fig.8

n_p	N_{Pi}	$< P_{tot} >$	s.d.	skewness	kurtosis
≥0	41706	1.25	1.00	0.9452	-0.0532
0	5943	0.96	0.98	0.9799	0.0403
1	7919	1.23	0.97	1.0237	0.1476
2	5636	1.20	0.96	1.0287	0.1394
3	3058	1.17	0.96	1.1169	0.3972
4	1350	1.15	0.96	1.1298	0.3969
5	390	1.20	1.02	0.9735	-0.1091

Table IX. Characteristics of the distributions shown in fig.9

n_p	N_{Pi}	$< P_{lon} >$	s.d.	skewness	kurtosis
≥0	38395	0.95	0.82	0.7276	-0.4180
0	5506	0.97	0.80	0.7361	-0.3696
1	7351	0.94	0.80	0.7683	-0.3189
2	5267	0.92	0.81	0.7903	-0.3068
3	2860	0.88	0.79	0.8410	-0.2094
4	1264	0.87	0.79	0.8951	-0.0688
5	358	0.89	0.84	0.8462	-0.4219

Table X. Characteristics of the distributions shown in fig.10

n_p	N_{Pi}	$< P_{tr} >$	s.d.	skewness	kurtosis
≥ 0	53781	0.33	0.32	2.3560	9.8798
0	7068	0.36	0.29	2.6807	15.3892
1	9516	0.36	0.31	2.8309	16.3275
2	6840	0.36	0.29	2.1570	8.6440
3	3681	0.36	0.29	2.5168	14.7945
4	1652	0.37	0.31	2.6932	14.0877
5	490	0.36	0.30	2.0698	7.0520

Table XI. Characteristics of the distributions shown in fig.11

n_p	N_{Pi}	$< E_k >$	s.d.	skewness	kurtosis
0	5232	0.86	0.65	0.7694	-0.4138
1	6990	0.84	0.65	0.7868	-0.4097
2	4996	0.82	0.65	0.8367	-0.3371
3	2742	0.80	0.65	0.8700	-0.2888
4	1212	0.79	0.64	0.9064	-0.1635
5	343	0.80	0.70	0.9086	-0.3725

Table XII. Characteristics of the distributions shown in fig.12

n_p	N_{Pi}	$< \cos\theta >$	s.d.	skewness	kurtosis
≥ 0	53666	0.8227	0.3393	-3.2949	11.2350
0	7077	0.8274	0.3056	-3.2599	11.3662
1	9522	0.8152	0.3239	-3.0462	9.6158
2	6842	0.7996	0.3494	-2.8728	8.2279
3	3682	0.7960	0.3477	-2.8124	7.9062
4	1653	0.7978	0.3486	-2.9747	9.0386
5	490	0.7917	0.3558	-2.8612	8.4308

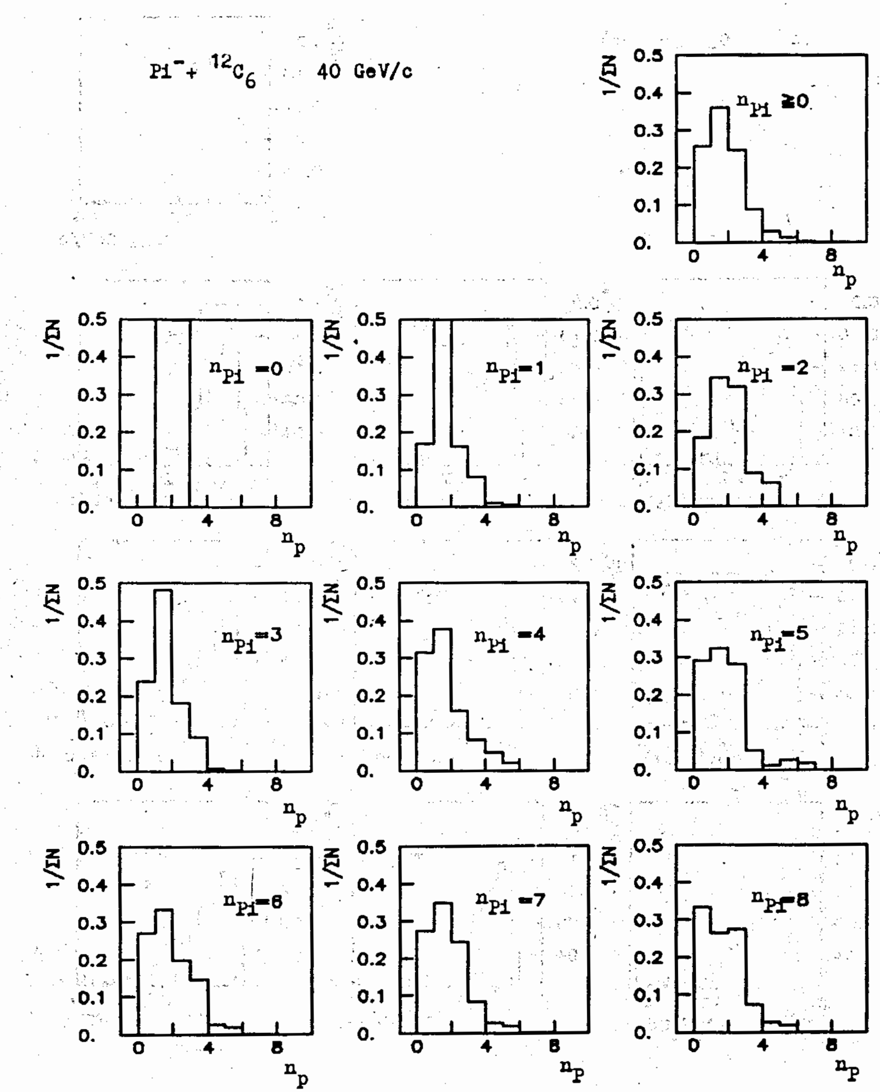

Fig.1. Emitted protons multiplicity n_p distributions $N(n_p) = 1/\Sigma N$, in samples of collision events with various multiplicities n_{Pi} of ejected charged pions

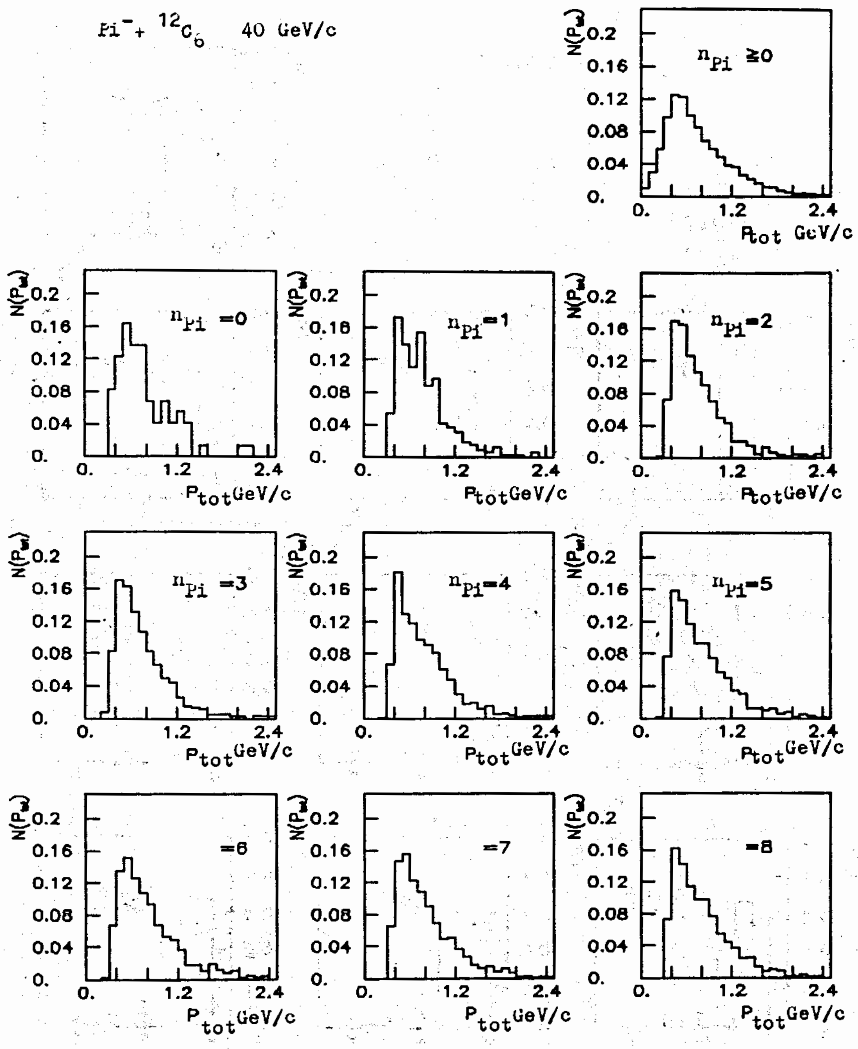

Fig.2. Emitted protons total momenta P_{tot} distributions $N(P_{tot})$, in events with various multiplicities n_{pi} of ejected charged pions

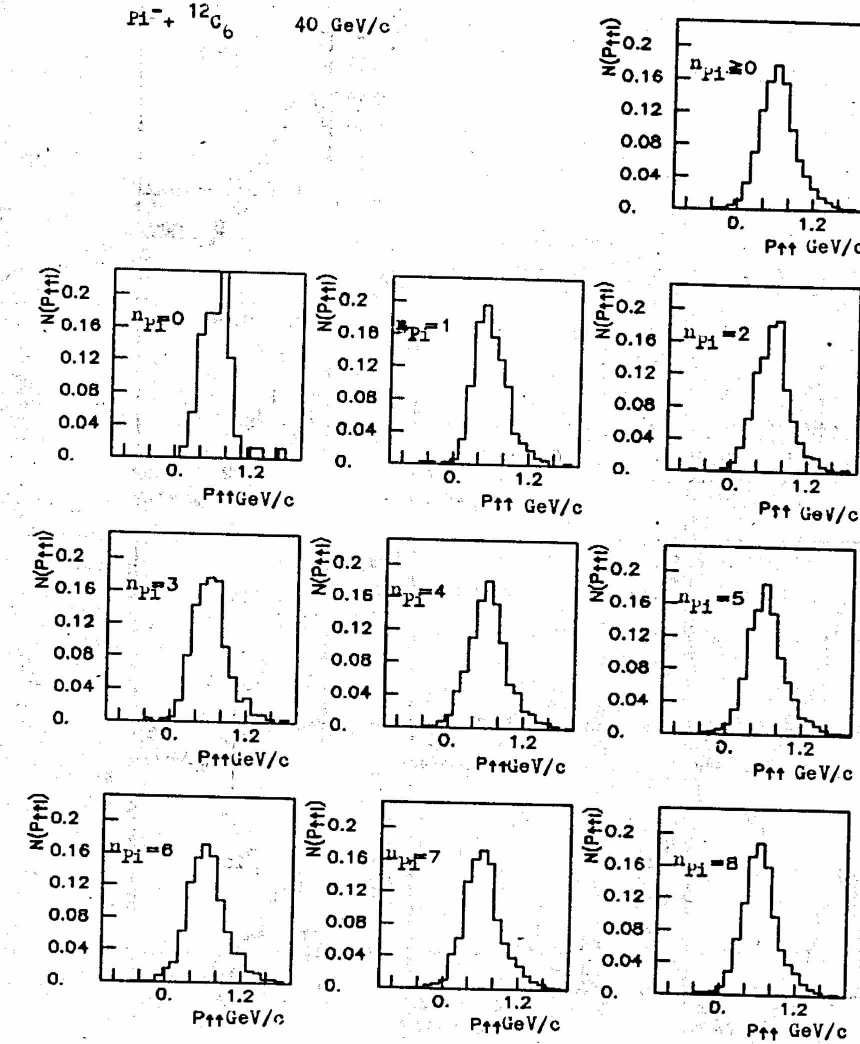

Fig.3. Emitted protons longitudinal momenta P_{lon} distributions $N(P_{\uparrow\uparrow}) = N(P_{lon})$ in events with various multiplicities n_{pi} of the ejected charged pions

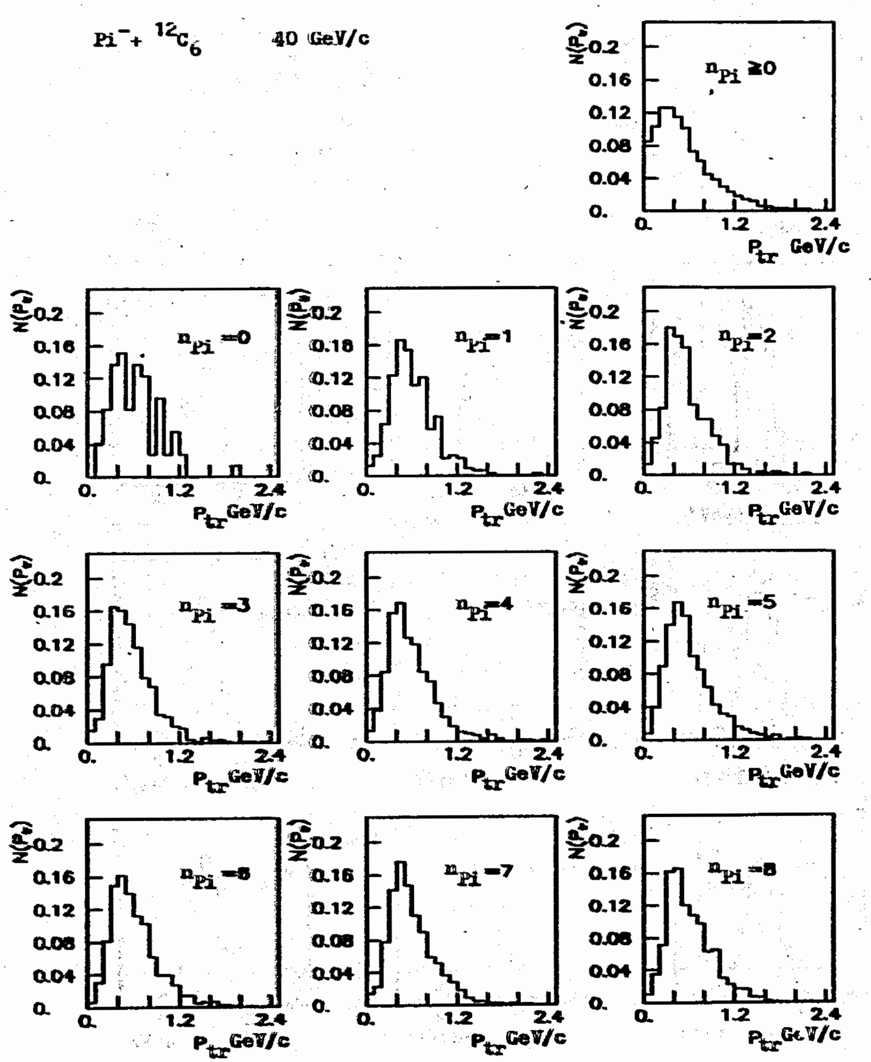

Fig.4. Emitted protons transversal momenta P_{tr} distributions $N(P_{tr})$ in events with various multiplicities n_{Pi} of the ejected pions

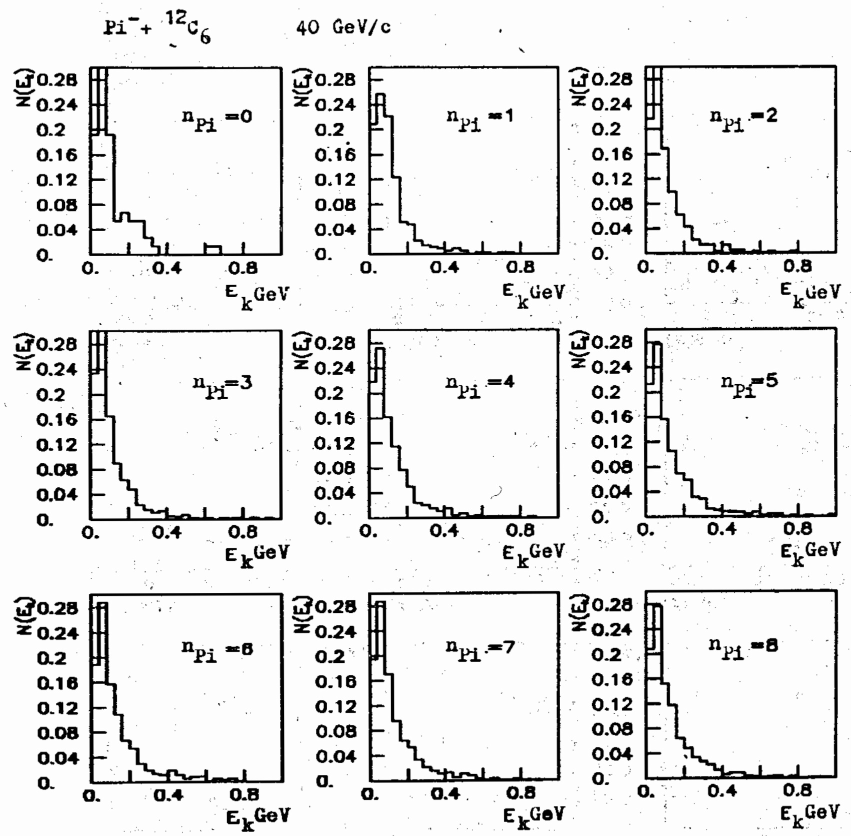

Fig.5. Emitted protons kinetic energy E_k distributions $N(E_k)$ in events with various multiplicities n_{Pi} of the ejected pions

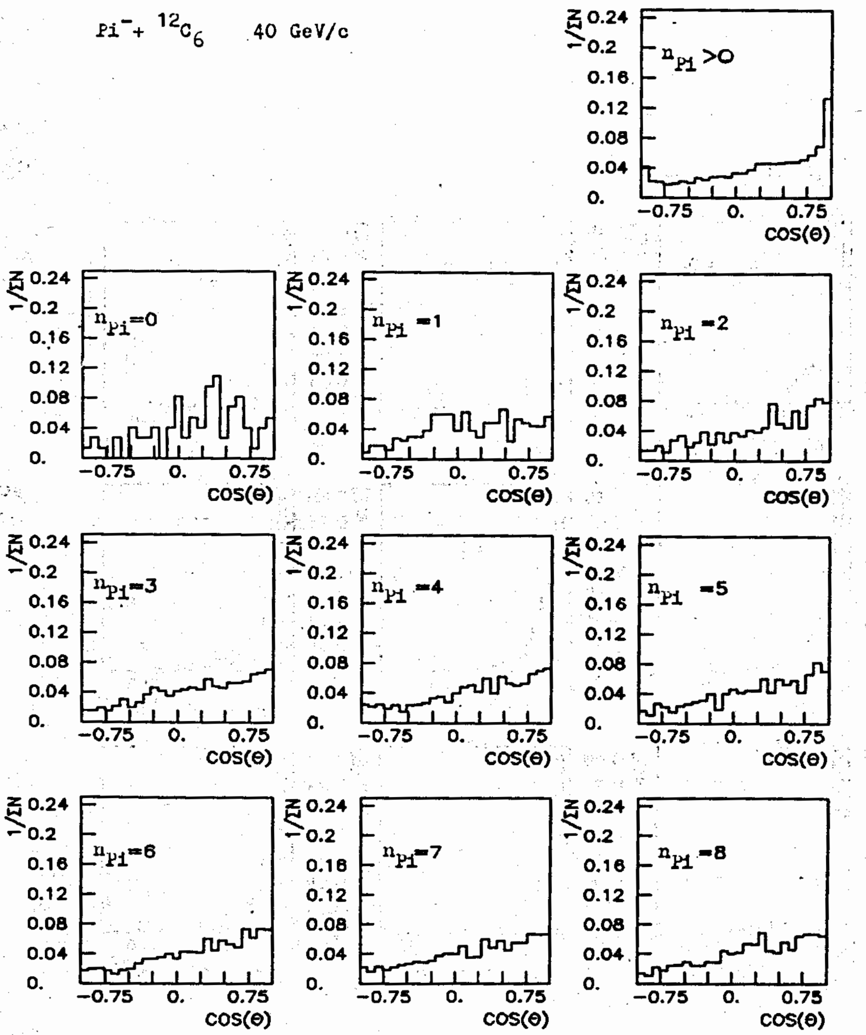

Fig.6. Emitted protons emission angle Θ distributions $N(\cos\Theta) = 1/\Sigma N$ in events with various multiplicities n_{Pi} of the ejected pions

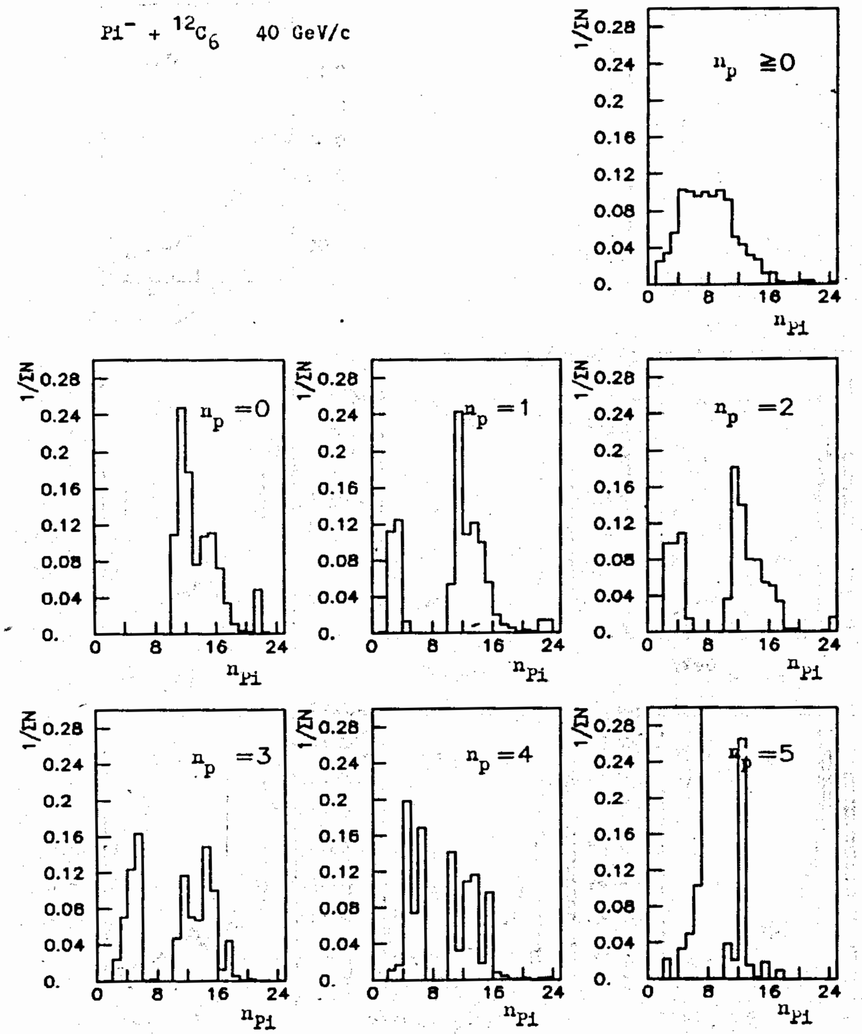

Fig.7. Ejected pions multiplicity n_{Pi} distributions $N(n_{Pi}) = 1/\Sigma N$ in events with various multiplicities n_p of the emitted protons

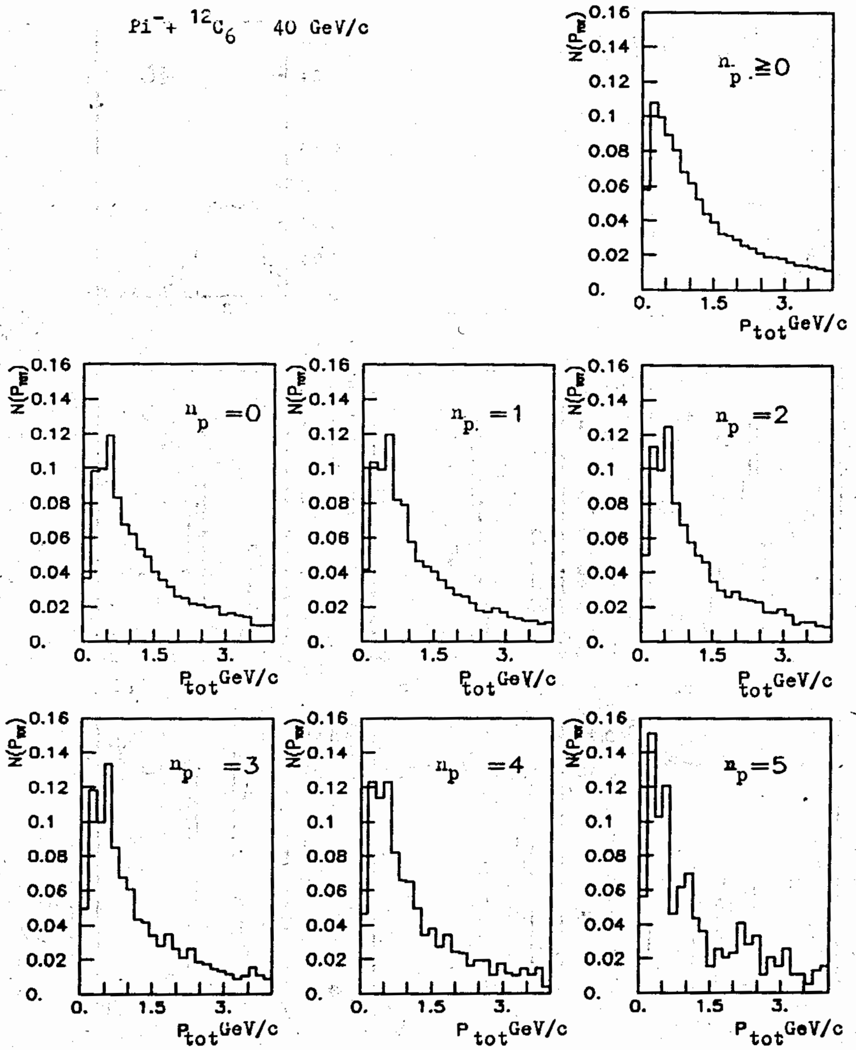

Fig.8. Ejected pions total momentum P_{tot} distributions $N(P_{tot}) = 1/\Sigma N$ in events with various multiplicities n_p of the emitted protons

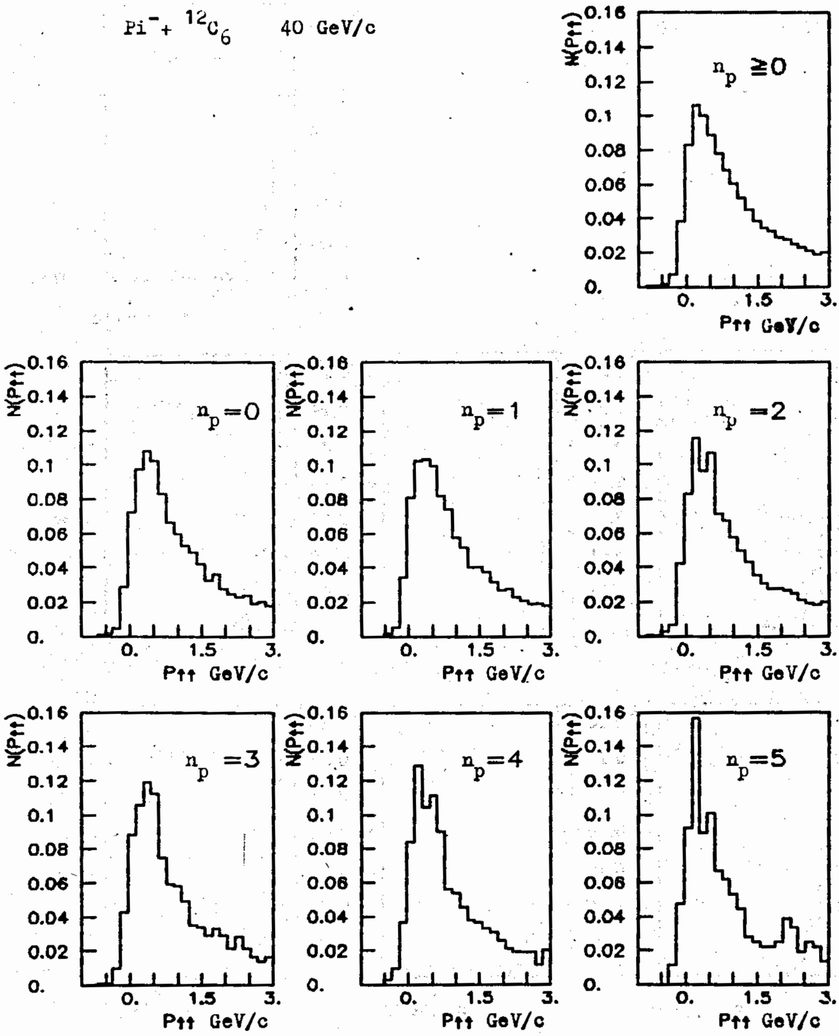

Fig.9. Ejected pions longitudinal momenta $P_{lon} = P_{\uparrow\uparrow}$ distributions $N(P_{\uparrow\uparrow}) = 1/\Sigma N$ in events with various multiplicity n_p of the emitted protons

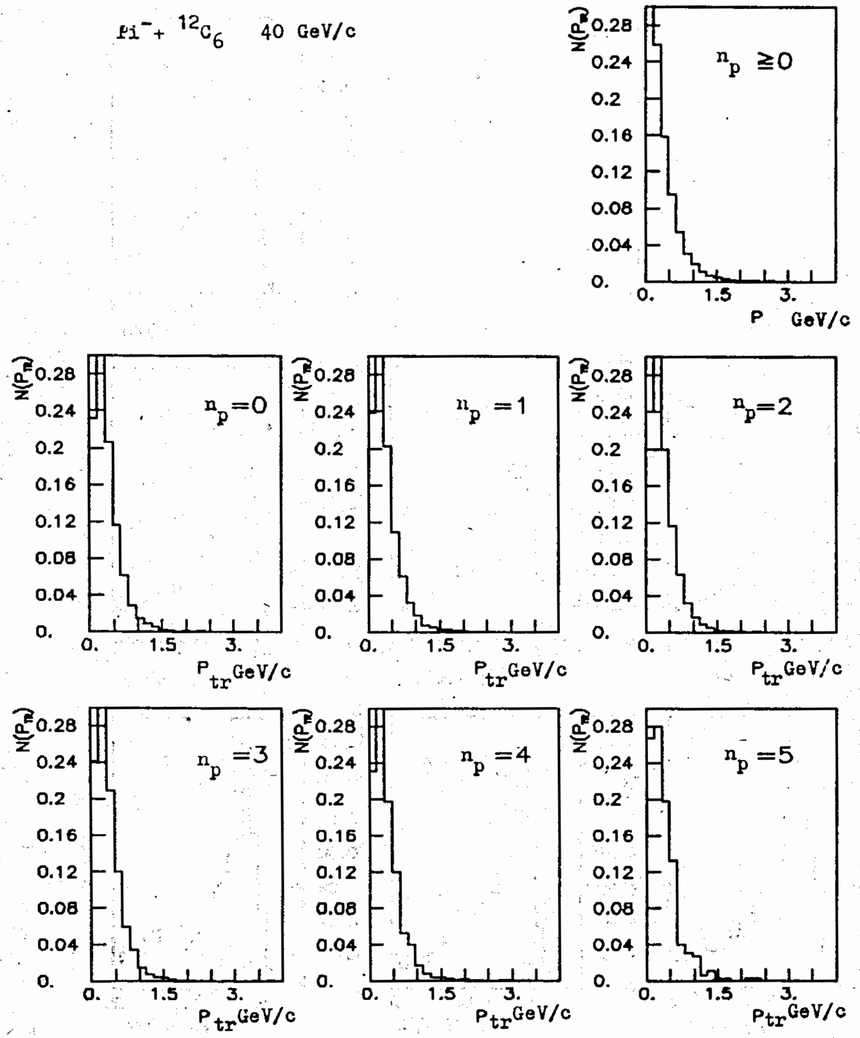

Fig.10. Ejected pions transversal momenta P_{tr} distributions $N(P_{tr})$ in events with various muliplicities n_p of the emitted protons

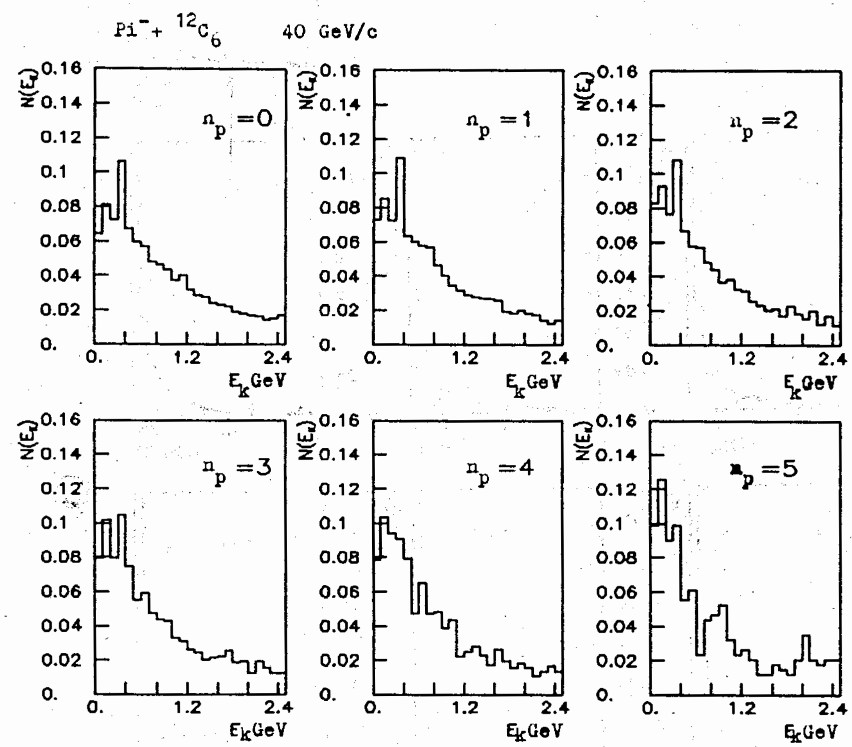

Fig.11. Ejected pions kinetic energy E_k distributions $N(E_k)$ in events with various multiplicities n_p of the emitted protons

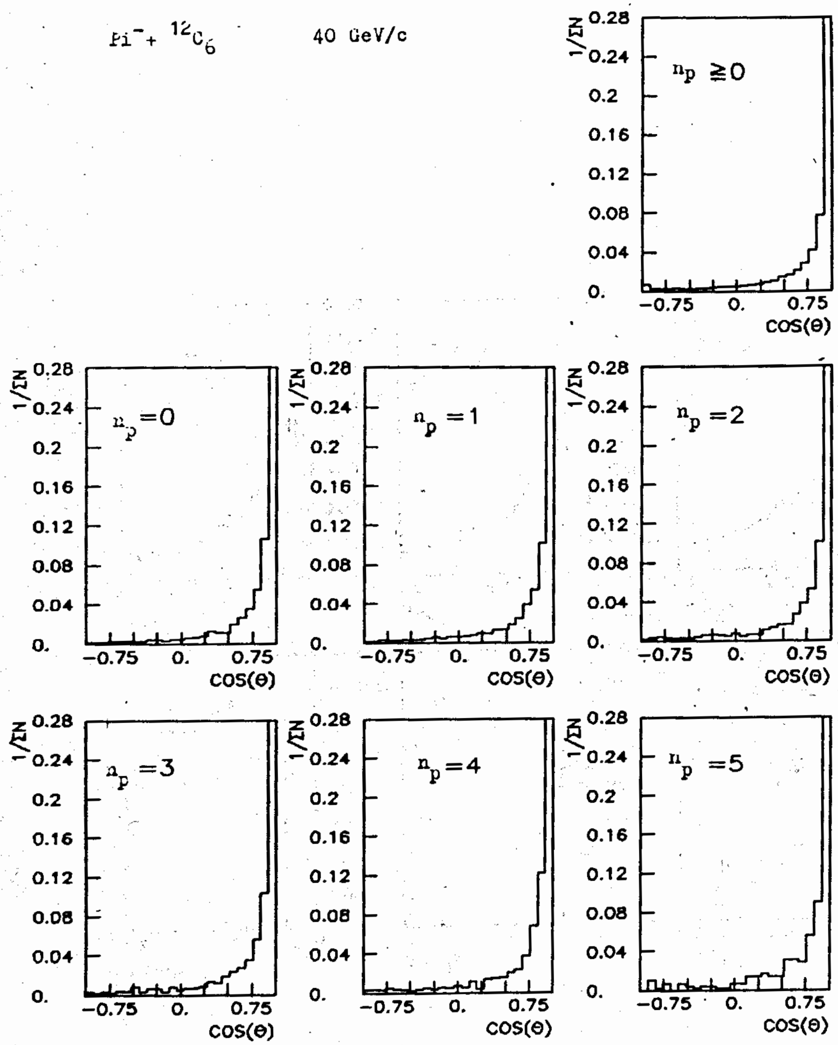

Fig.12. Ejected pions emission angle Θ distributions N(cosΘ) = 1/ΣN in events with various multiplicities n_p of the emitted protons

REFERENCES

1. Strugalski Z., Sultanov M. - JINR Comm., E1-92-68, Dubna, 1992.
2. Abdurakhimov A.U. et al. - JINR, 1-6967, Dubna, 1973.
3. Abdurakhimov A.U. et al. - Nuclear Phys. (Russian), 1973, 18, p.545.
4. Abdurakhimov A.U. et al. - Nuclear Phys. (Russian), 1971, 18, p.1251.
5. Abdurakhimov A.U. et al. - Nuclear Phys. (Russian), 1972, 16, p.583.
6. Angelov N. et al. - Nuclear Phys. (Russian), 1977, 25, p.1013.

Received by Publishing Department
on February 21, 1992.