FERMILAB-PUB-73-119-E

Wydaje Instytut Fizyki Jądrowej

Nakład 690 egz., Objętość ark. wyd. 0,5, Ark. druk. 0,8, Data złożenia maszynopisu przez autora 7.VII.1973 r. Oddano do dr 12.VII.1973 r., Druk ukończono w sierpniu 1973 r., SP-09/250/6, Zam. 202/73

MULTIPLICITY DISTRIBUTIONS IN PROTON-NUCLEUS COLLISIONS AT 67 AND 200 GeV

ROZKŁADY KROTNOSCI W ZDERZENIACH PROTON-JADRO PRZY 67 I 200 GeV

РАСПРЕДЕЛЕНИЯ ПО МНОЖЕСТВЕННОСТИ ДЛЯ ВЗАИМО - ДЕЙСТВИЙ ПРОТОН - ЯДРО ПРИ 67 И 200 Гэв

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To be submitted for publication in "Physics Letters"

Cracow
July, 1973

New data concerning multiplicities in collisions of 67 and 200 GeV protons in emulsion are presented. Various parameters of multiplicity distributions in collisions of protons with nuclei of photographic emulsion at primary energies between a few and about 1000 GeV are compared with p-p collisions.

Zostały przedstawione nowe dane dotyczące krotności cząstek generowanych w zderzeniach protonów o energii 67 i 200 GeV z jądrami emulsji fotograficznej.Porównano różne parametry rozkładów krotności dla zderzeń protonów z protonami i z jądrami w granicach energii pierwotnej od kilku do około 1000 GeV.

Сообщаются новые результаты касающиеся множественности частиц генерированных во взаимодействиях протонов с энергией 67 и 200 Гэв с ядрами фотоэмульсии. Сравниваются разные параметры распределений по множественности для взаимодействий протонов с протонами и с ядрами для первичной энергии в области от нескольких Гэв до ок. 1000 Гэв.

The purpose of this note is to present some regularities observed in the multiplicity distributions of charged particles produced in collisions of protons with nuclei of photographic emulsion in the wide energy range of the primary proton from a few to about 1000 GeV.

Photographic emulsion is a composite target in which a majority of collisions /about 75%/ occur with such heavy nuclei as Ag and Br. Collisions with light nuclei C, N, or O are also frequent /about 21%/. On the other hand , elementary collisions with hydrogen occur only in about 4% of cases. Therefore photographic emulsion is the detector of choice for the study of collisions with nuclei. Another unique advantage offered by this detector is its sensitivity to slow particles from the disintegration of the target nucleus. The size /number N_h of the so-called heavily ionizing particles/ of the so-called star accompanying the collision vertex, gives information about the excitation of the target nucleus. No other detector is able to give such detailed information about the kind of disintegration of the target. It seems that photographic emulsion method is a suitable technique for the study of high energy collisions with nuclei. We tried to use some of these advantages in the present investigation.

The stacks of Ilford G-5 and NIKFI BR-2 emulsions were exposed to the NAL 200 GeV proton beam in September 1972 and to the Serpukhov 67 GeV proton beam in June 1971. Pellicles were oriented parallel to the beams so that the length of beam tracks was many centimetres per single pellicle. In an alongthe-track scanning the interactions were systematically collected. The obtained mean paths of about 34 cm was treated only as a check of the completeness of our scanning. Samples collected in this way have a natural composition of all topological cross-sections. For each event the number of heavily ionizing particles N_h, and of relativistic charged particles n_s were carefully counted. Table I gives the numbers of events found in these scannings as well as corresponding data for similar samples obtained at different energies in other experiments [1,2,3,4/]. Also other parameters used in Figures of the present paper are included. Events with a single relativistic track emitted at an angle less than 7 mrad at 67 GeV and less than 2.3 mrad at 200 GeV were excluded from our samples as elastic scatterings.

Fig.1 shows the multiplicity distributions for 200 GeV and for 67 GeV.

Fig.2 shows the energy dependence of the average multiplicity $\langle n_s \rangle$ in collisions with emulsion nuclei compared with the data concerning $\langle n_{ch} \rangle$ for p-p collisions from HBC experiments. Emulsion data are also shown separately for two extreme groups with $N_h \leq 1$ and $N_h > 8$. A strong correlation between N_h and $\langle n_s \rangle$ /increasing with energy/ can be seen. At low energies the $\langle n_s \rangle$ for emulsion data are smaller than the $\langle n_{ch} \rangle$ for p-p data. This may be attributed to differences in targets and techniques.

Interesting speculative works [6/] were stimulated recently by the observations of new empirical regularities in the multiplicity distributions for p-p interactions [7/]. In wide limits of the primary proton energy there exists a linear

relation between the average charged multiplicity $\langle n_{ch} \rangle$ and the dispersion of the multiplicity distribution $D=/\langle n_{ch}{}^2 \rangle - \langle n_{ch} \rangle^2/^{1/2}$: $D= 0.585/\langle n_{ch} \rangle -1/$.

In connection with this we compared in Fig.3 our data for p-Em collisions with this relation. The increase in D with $\langle n_s \rangle$ is faster for our nuclear data than for p-p collisions and seems to be also linear in the limits of the present statistical errors. However, as seen in Fig.4, the division of our data into groups with various N_h shows that the increase in D with $\langle n_s \rangle$ is in the group with $N_h \leq 1$ similar to that in p-p collisions, while for higher N_h it starts to be slower. This is particularly clear in the group with $N_h > 8$ which contains entirely collisions with Ag and Br nuclei which became highly excitated by the impact of the primary proton, and constitute about 50% of all collisions with Ag and Br nuclei.

Acknowledgements

We are much indebted for the possibilities of emulsion exposures at the highest energy accelerators: for 200 GeV exposure, to the staff of the National Accelerator Laboratory at Batavia, in particular to Professor R.R. Wilson, Dr.L. Voyvodic, and Dr.J.R. Sanford; for 67 GeV exposure, to the staff of the Institute of High Energy at Serpukhov, in particular to Professor Yu.D. Prokoshkin and Dr.S. Denisov. We also thank Dr. H.H. Heckman from UCLRL at Berkeley and Dr.S.I. Lubomilov from the Joint Institute for Nuclear Reseach at Dubna for excellent processing of our emulsions. The work done by our scanning team in Cracow is gratefully acknowledged.

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Captions for Figures:

Fig.1 Multiplicity distributions in collisions of 200 GeV and 67 GeV protons with emulsion nuclei. Shadowed areas correspond to coherent interactions [5] which were rejected from our samples.

Fig.2 Energy dependence of the average charged multiplicity for collisions of protons with emulsion nuclei. Solid lines are to guide the eye only. The dashed p-p line is based on G. Giacomelli's report, Proc. of the Batavia Conference 1972, Vol.3, p.218.

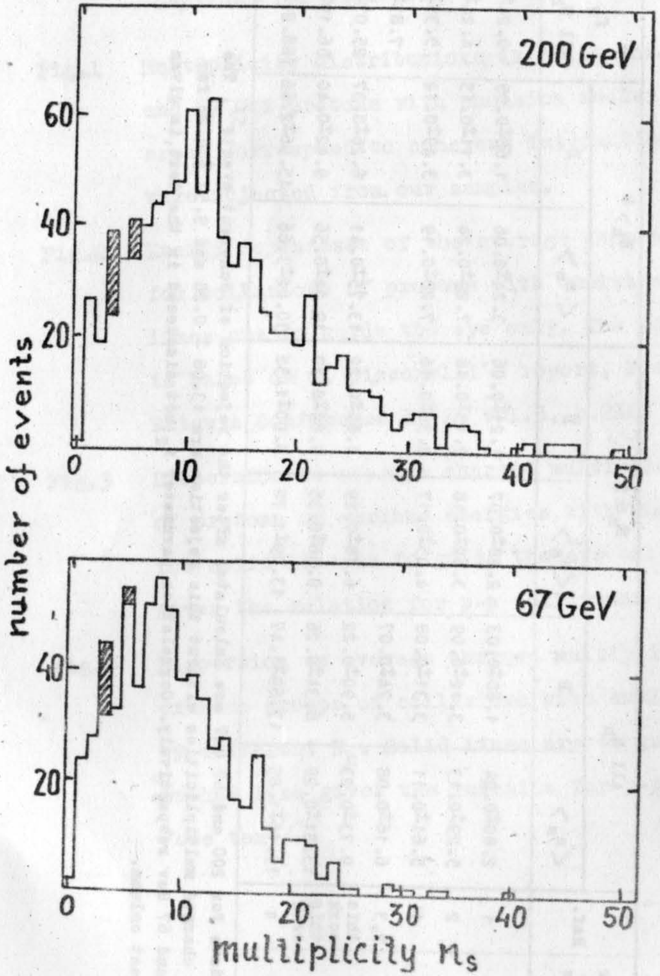
Fig.3 Dispersion vs average charged multiplicity for collisions of protons of various energies with emulsion nuclei. The solid line is to guide the eye only. Dashed line gives the relation for p-p collisions /see text/.

Fig.4 Dispersion vs average charged multiplicity for two extreme groups of collisions with emulsion characterized by different N_h. Solid lines are to guide the eye only. Dashed line gives the relation for p-p collisions /see text/.

Table I

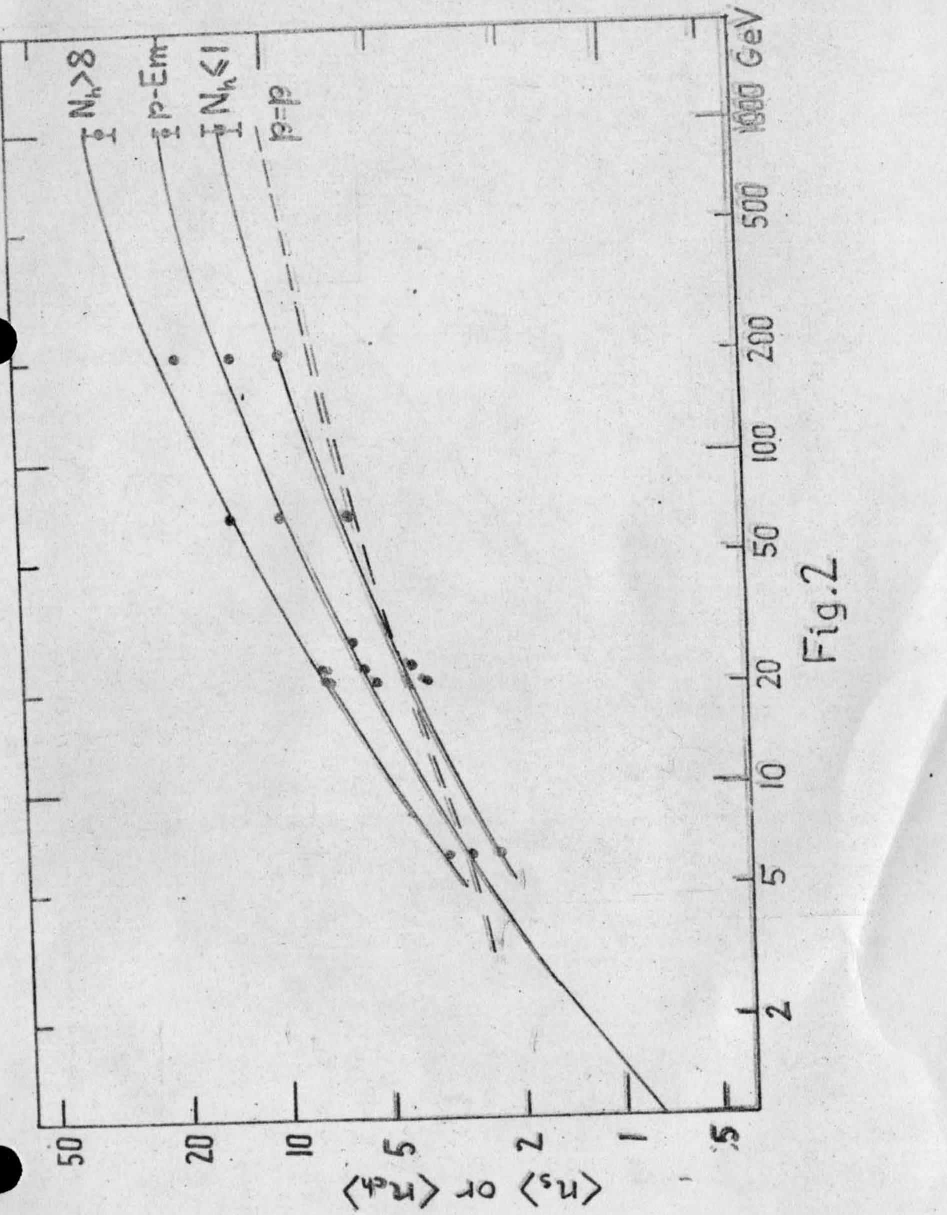
primary proton energy GeV	Number of events	Ref.	All N_h		$N_h \leq 1$		$N_h > 8$		f_2
			$\langle n_s \rangle$	D	$\langle n_s \rangle$	D	$\langle n_s \rangle$	D	All N_h
6.2	1769	1	2.80±0.04	1.60±0.03	2.28±0.07	1.21±0.06	3.24±0.06	1.66±0.05	-0.24±0.09
20.5	551	2	5.29±0.13	3.12±0.09	3.62±0.18	2.13±0.16	7.29±0.24	3.11±0.15	4.24±0.52
22.5	892	1	5.61±0.11	3.31±0.08	4.05±0.17	2.38±0.16	7.28±0.19	3.49±0.12	5.35±0.49
27	2165	2,3	6.16±0.08	3.74±0.07					7.83±0.47
67	657	this work	9.73±0.23	5.90±0.22	6.18±0.29	3.65±0.22	13.75±0.41	6.26±0.37	25.07±2.47
200	876	this work	13.31±0.28	8.34±0.26	9.56±0.35	4.89±0.30	19.34±0.56	9.42±0.40	56.19±4.09
1000	55	4	19:16±1.85	13.69±1.47	13.09±1.78	5.90±1.32	30.82±3.66	15.06±2.66	168.21±38.90

All our data for 200 and 67 GeV are calculated after the rejection of coherent events [5]. The averaged charged multiplicities without this rejection are 13.08 ± 0.28 and 9.57 ± 0.23 for 200 GeV and 67 Gev respectively. Correlation parameter f_2, not discussed in the text, is given in the last column.



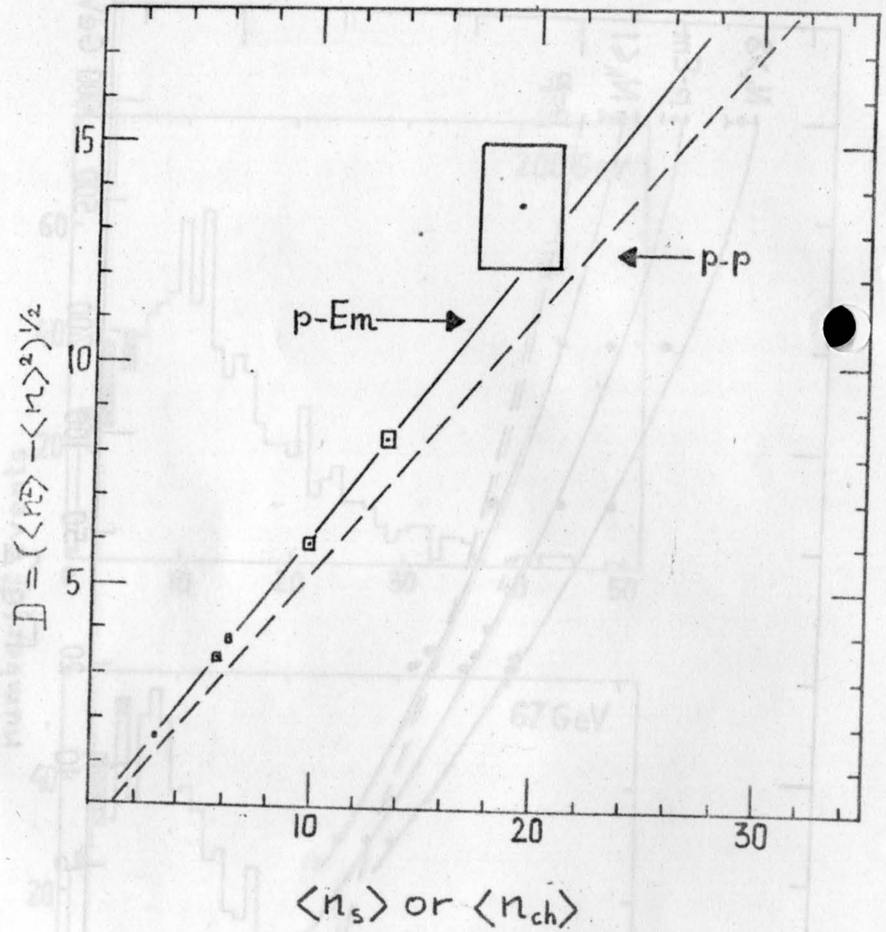
200 GeV
67 GeV
number of events
multiplicity n_s

Fig. 1



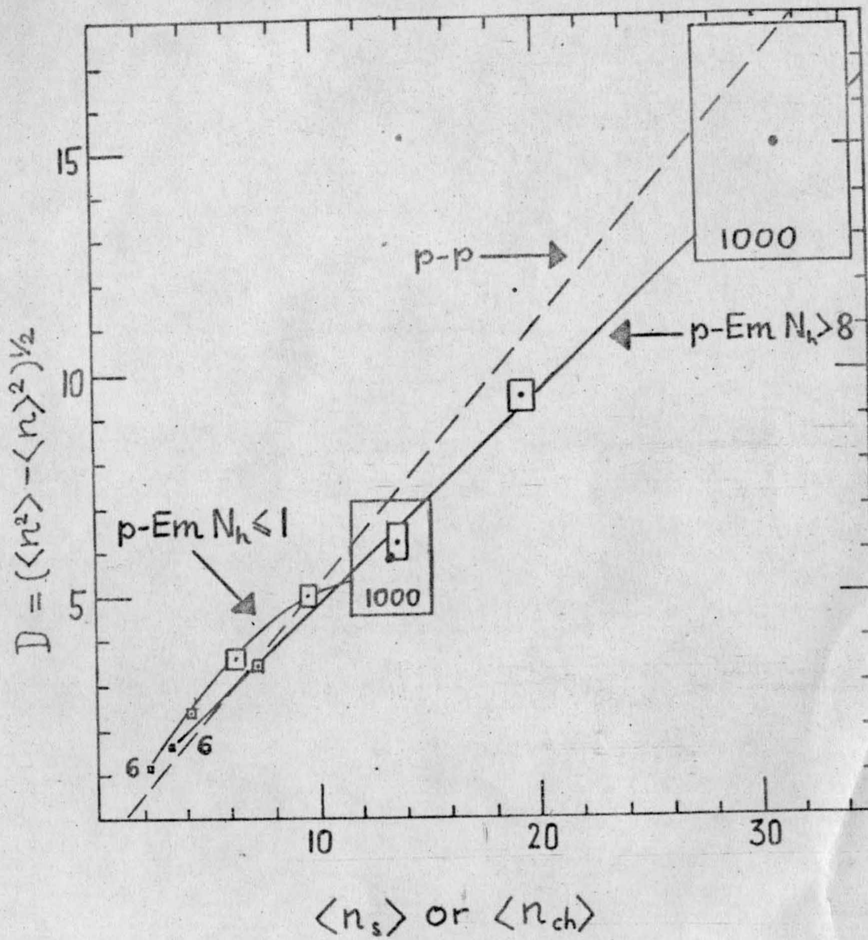
$N_h > 8$
p-Em
$N_h \leq 1$
p-p
$\langle n_s \rangle$ or $\langle n_{ch} \rangle$
1000 GeV

Fig. 2



p-Em
p-p
$D = (\langle n^2 \rangle - \langle n \rangle^2)^{1/2}$
$\langle n_s \rangle$ or $\langle n_{ch} \rangle$

Fig.3



1000
p-p
p-Em N_h>8
p-Em $N_h \leq 1$
1000
$D = (\langle n^2 \rangle - \langle n \rangle^2)^{1/2}$
$\langle n_s \rangle$ or $\langle n_{ch} \rangle$

Fig.4