AVERAGE CHARGED PARTICLE MULTIPLICITY AND TOPOLOGICAL CROSS SECTIONS IN 50 GeV/*c* AND 69 GeV/*c* pp INTERACTIONS

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In an exposure of the chamber Mirabelle at the Serpukhov accelerator, 1 943 interactions at 50 GeV/*c* and 8 959 at 69 GeV/*c* have been observed. Topological cross sections and charged multiplicity distributions are presented. The average charged multiplicities found are respectively 5.32 ± 0.13 and 5.89 ± 0.07.

As part of the study of proton–proton interactions at 50 and 69 GeV/*c*, we have determined charged particle multiplicity distributions and topological cross-sections. Preliminary results based on a partial sample have been given [1]. Recently similar data have been published at 205 GeV/*c* [2]. The hydrogen bubble chamber Mirabelle was exposed to a proton beam from an internal target in the Serpukhov accelerator with no contamination. Mirabelle has the shape of a horizontal cylinder, 4.7 meter long and 1.8 meter diameter, viewed by eight cameras and operated at a magnetic field of 21 kG. A total of 8 000 pictures at 69 GeV/*c* and a smaller sample of 2 000 pictures at 50 GeV/*c* were scanned twice for all interactions, in a 2.6 meter long fiducial volume. The latter were accepted only if the number of entering tracks was higher than 1, in order to define a beam direction, and lower than 8, with an average of 4. Our criteria excluded frames where an interaction took place in the beam entry window and pictures of poor quality. All events not recorded with the same topology for both scannings were reexamined on the table by physicists; the scanning efficiency after two scannings was over 99% for all topologies and did not depend on the event position in the chamber; however two prong events with a short proton were lost in all cases and the two prong scanned topology was not used in the subsequent analysis. The final sample included 8 959 events at 69 GeV/*c* and 1 943 events at 50 GeV/*c*; even obvious Dalitz pairs were included in the charged prong count. The corresponding correction was computed assuming a production of respectively 2.15 and 2.42 neutral pions per event at 50 GeV/*c* and 69 GeV/*c*, irrespective of topology; the actual increase of the number of neutral pions with the number of charged ones, observed in our experiment, affects this correction only slightly; no correction was applied for Λ or K° decaying near the vertex, nor a fortiori for electron pairs. The number of recorded interactions actually induced by fast protons coming from a undetected elastic collision in the chamber was estimated from a Monte Carlo calculation. All those corrections were found to be of the order of the statistical errors. Beam tracks were counted in both scannings and it was also checked that the projected angular distributions of interacting and non interacting tracks were the same.

Table 1
Topological cross-sections at the two momenta 50 and 69 GeV/c

	50 GeV/c			69 GeV/c		
	number of events		cross section	number of events		cross section
	observed	corrected	(mb)	observed	corrected	(mb)
2 prongs inelastic	–	–	5.97 ± 0.88	–	–	4.84 ± 0.42
4 prongs inelastic	490	486.7	9.40 ± 0.47	2 121	2 112.1	8.63 ± 0.21
6 prongs inelastic	416	414.4	7.99 ± 0.43	1 938	1 935.3	7.90 ± 0.20
8 prongs inelastic	264	260.6	5.02 ± 0.33	1 343	1 328.0	5.42 ± 0.16
10 prongs inelastic	109	105.7	2.03 ± 0.20	690	672.9	2.75 ± 0.11
12 prongs inelastic	27	25.2	0.48 ± 0.10	320	311.8	1.27 ± 0.07
14 prongs inelastic	11	10.6	0.20 ± 0.06	102	96.5	0.39 ± 0.04
16 prongs inelastic	1	0.8	0.01 ± 0.02	28	26.1	0.11 ± 0.02
18 prongs inelastic	0	–	–	4	3.36	0.01 ± 0.01
Total observed cross section			37.74 ± 1.18			36.68 ± 0.53
Cross section for 4 to 18 prongs			25.15 ± 0.75			26.48 ± 0.30
Number of primaries	6 362			29 965		

Table 1 shows the observed and corrected numbers of events for all topologies and the topological cross-sections; the latter were determined using a hydrogen density of 62.2 ± 0.6 gr/ℓ, the error corresponding to variations of chamber conditions during the runs. The inelastic two prong values σ_2 of table 1 were obtained by subtracting from the total cross-sections at 50 and 60 GeV/c [3], the elastic one, 6.9 ± 0.2 at 50 GeV/c or 7.0 ± 0.2 at 69 GeV/c [4] and the cross-section for more than two prongs from table 1. The charged multiplicities are $\langle n_{ch}\rangle = 5.32 \pm 0.13$ at 50 GeV/c and 5.89 ± 0.07 at 69 GeV/c; the dispersions

$$D = \langle n_{ch}^2\rangle - \langle n_{ch}\rangle^2$$

being respectively 2.58 ± 0.05 and 2.89 ± 0.03.

Table 2 lists the Mueller [5] correlation parameters for negative secondary particles†. The low values of f_2^- suggest that a Poisson distribution on charged pairs (Wang model 1) accidentally fits the data in our energy range.

In figures 1 and 2, $\langle n_{ch}\rangle$ and F_2^- from table 2 are compared with other values based on topological cross-sections from references [2], [6–12]. The fitted curves on these figures are based on data at 18 GeV/c

† The K^- contamination in negative tracks amounts to several percent; it should be kept in mind that our values are not those for negative pions.

Table 2
Correlation parameters for negative particles

momentum	f_2^-	f_3^-	F_2^-	F_3^-
50 GeV/c	0.01 ± 0.09	−0.30 ± 0.16	2.76 ± 0.14	4.30 ± 0.37
69 GeV/c	0.15 ± 0.06	−0.33 ± 0.11	3.92 ± 0.09	7.88 ± 0.28

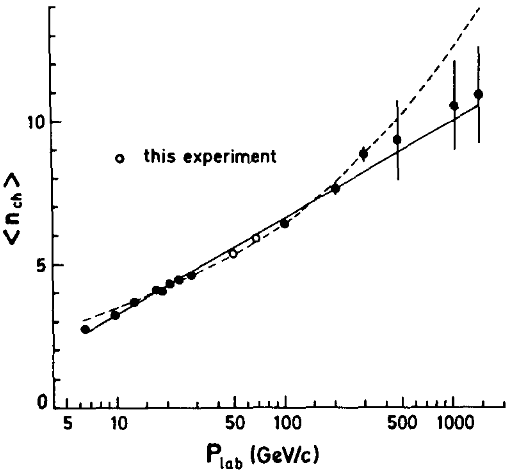

Fig. 1. Mean number of charged particles per inelastic pp interaction as a function of laboratory momentum. The solid curve is $-1.38 + 1.50 \log s$ and the dashed curves is $1.47\, s^{0.28}$; see text.

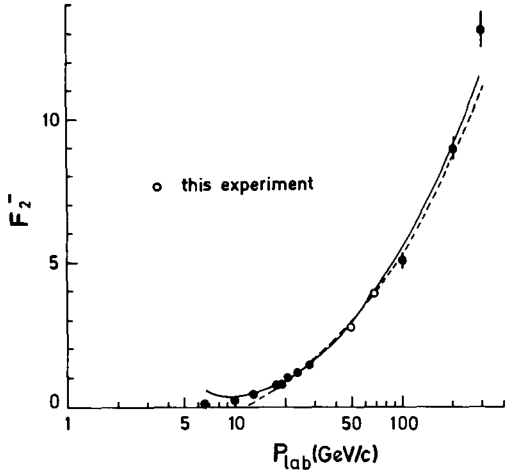

Fig. 2. $F_2^- = \langle n_-(n_- - 1)\rangle$ per inelastic pp interaction as a function of laboratory momentum. The solid curve is $9.09 - 5.82 \log s + 0.98 (\log s)^2$. The dashed curve is $-2.76 + 0.58 = \sqrt{s}$; see text.

[8], 19 GeV/c [9], 21, 24, 28.5 GeV/c [8], 103 GeV/c [10], 205 GeV/c [2], 303 GeV/c [11] and this experiment.

The average charged multiplicity variation does not disagree with the popular predictions.

$$\langle n_{ch}\rangle = a\, s^b$$

or $\langle n_{ch}\rangle = a + b \log s$.

Experimental values of F_2^- are equally consistent with the currently predicted energy variations

$$F_2^- = a + b\sqrt{s}$$

$$F_2^- = a + b \log s + c(\log s)^2.$$

We conclude that the available data behaviour for $\langle n_{ch}\rangle$ or F_2^- are insufficient to distinguish between multiperipheral or diffractive models below 300 GeV.

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