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Updated Charged-Particle Multiplicity Distribution from 205 GeV/c Proton-Proton Interactions*

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The charged-particle multiplicity distribution in 205 GeV/c proton-proton interactions is presented. In addition, the total diffractive contributions to each charged multiplicity are estimated assuming a factorizable Pomeron.

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The purpose of this paper is to present the final results on the topological cross sections for 205 GeV/c pp interactions, as observed in a 50,000 picture exposure of the 30-inch hydrogen bubble chamber at the National Accelerator Laboratory. The number of scanned events has been increased by over a factor of three from our original publication, [1] significantly reducing the errors for the rare high multiplicity events. The two-prong topology, where one must separate out and correct the elastic scattering events, [2] has been treated in greater detail than in our original publication. Also, we are now able to determine the contribution of the diffractive component to each charged-particle multiplicity.

The detailed evaluation of the two-prong elastic and inelastic cross sections is discussed in Ref. 2. For events with four or more charged prongs, the scanning efficiency was $98.7 \pm 1.0\%$. The topological cross sections have been corrected using the average number of neutral kaons, lambdas, and neutral pions per inelastic event as a function of the charged multiplicity. [3] From the measured decay length distributions of the strange particles, it is estimated that 10% of them are not observed because of their short decay path. Appropriate corrections to the numbers of events are then made for each charged multiplicity. A similar correction was made for the inclusion of Dalitz decays of the neutral pions as charged prongs. These corrections tend to slightly reduce the mean number of charged prongs. Only 0.2% of events were found to have an odd number of prongs; these were assigned to the next higher even-prong topology. Corrections

for secondary interactions and γ-conversions near the primary vertex were also negligible. As is evident from Table I, all of these corrections are small, being at most equal to the statistical errors.

Table I and Fig. 1 display the new topological cross sections as a function of charged multiplicity normalized to a total cross section of 39 ± 1 mb, which is obtained from our measurement and other published values at neighboring energies.[4, 5] Our measured elastic cross section is 6.92 ± 0.44 mb,[2] which yields a total inelastic cross section of 32.1 ± 1.1 mb. Even though the two-prong inelastic cross section is somewhat smaller than the previous value, all of these cross sections are consistent with those of Ref. 1. Various moments of the multiplicity distribution are displayed in Table II; the quoted errors are substantially less than those of the original publication primarily due to the reduction in the error on the two-prong inelastic cross section.

We have estimated the single diffractive component in the topological cross sections of Table I from measurements of the events with a visually recognizable slow proton[6] and of the two-[2] and four-prong events.[7] These references should be consulted for the exact cuts which were used to define diffractive events. Weighted means have been used for those cross sections estimated in both Refs. 6 and 7. Assuming that diffractive production proceeds through the exchange of a factorizable Pomeron, the double diffractive contributions have been calculated. No single diffractive contribution is

visible as a low mass peak in events with eight or more charged prongs;[6] furthermore, the high multiplicity double diffractive components, as deduced using factorization, are found to be negligibly small. The total diffractive components are estimated to be 79 ± 10%, 43 ± 4%, and 10 ± 3% for the inelastic two-, four- and six-prongs, respectively, where the errors include the uncertainty in background estimation. The "diffractive" multiplicity distribution is indicated by the dashed line in Fig. 1, and has a mean value of 3.50 ± 0.09.[8] The diffractive cross sections are given in Table I; the moments of the negative particle multiplicities are presented separately for the diffractive and non-diffractive components in Table II.

References

1. G. Charlton et al., Phys. Rev. Letters 29, 515 (1973).

2. "Analysis of Two-Prong Events in pp Interactions at 205 GeV/c: Separation of Elastic and Inelastic Events," S. Barish et al., Argonne Report ANL/HEP 7337 (submitted for publication in Phys. Rev. D).

3. "Characteristics of V^0 and γ Production in pp Interactions," D. Colley et al., ANL/HEP 7362 (to be published).

4. U. Amaldi et al., Phys. Letters 44B, 112 (1973).

5. S. R. Amendolia et al., Phys. Letters 44B, 119 (1973).

6. S. J. Barish et al., Phys. Rev. Letters 31, 1080 (1973).

7. "Diffraction Dissociation in Four-Prong Proton-Proton Interactions at 205 GeV/c," M. Derrick et al., Argonne Report ANL/HEP 7356 (to be published).

8. Similar separations have been reported for other high energy experiments:

   (a) "Evidence for a Diffractive Component in Multiparticle Production at 102 GeV," C. M. Bromberg et al., University of Rochester Report No. 416.

   (b) F. T. Dao et al., Phys. Letters 45B, 402 (1973).

Figure Captions

Fig. 1 Charged multiplicity distribution for 205 GeV/c pp interactions. The solid line represents the total inelastic topological cross section distribution, and the dashed lines the total diffractive component. The elastic contribution to the two-prong topology is also indicated.

Table I

Topological Cross Sections

Number of Charged Prongs	Scanned Events	Corrected Events	Topological Cross Section (mb)	Total Diffractive Cross Section (mb)
2	1969	----------	9.77 ± 0.40	----------
Elastic	----	----------	6.92 ± 0.44	----------
Inelastic	----	----------	2.85 ± 0.26	2.26 ± 0.19
4	1348	1396 ± 41	5.91 ± 0.28	2.56 ± 0.15
6	1580	1629 ± 46	6.89 ± 0.32	0.76 ± 0.17
8	1334	1354 ± 42	5.73 ± 0.28	0.04 ± 0.02
10	1064	1077 ± 39	4.56 ± 0.24	~ 0
12	774	763 ± 32	3.23 ± 0.18	
14	397	373 ± 23	1.58 ± 0.11	
16	210	200 ± 16	0.846 ± 0.075	
18	86	79.2 ± 9.9	0.335 ± 0.044	
20	31	28.6 ± 5.7	0.121 ± 0.025	
22	13	12.4 ± 3.7	0.053 ± 0.016	
24	3	2.7 ± 1.8	0.012 ± 0.008	
26	1	1 ± 1	0.004 ± 0.004	
Total	8810	----------	39.0 ± 1.0	
Inelastic	----	----------	32.1 ± 1.1	5.64 ± 0.30

Table II

Moments of the Multiplicity Distribution

Moments	All Prongs	Negative Prongs Only		
		All Events	Non-Diffractive	Diffractive
$\langle n \rangle$	7.68 ± 0.07	2.84 ± 0.04	3.28 ± 0.06	0.75 ± 0.05
$\langle n(n-1) \rangle$	65.8 ± 1.2	8.86 ± 0.20	10.7 ± 0.3	0.34 ± 0.06
$\langle n(n-1)(n-2) \rangle$	620 ± 16	29.1 ± 1.0	35.2 ± 1.4	0.13 ± 0.03
$f_2 \equiv \langle n(n-1) \rangle - \langle n \rangle^2$	6.89 ± 0.35	0.80 ± 0.09	-0.10 ± 0.16	-0.22 ± 0.04
$f_3 \equiv \langle n(n-1)(n-2) \rangle - 3\langle n(n-1) \rangle \langle n \rangle + 2\langle n \rangle^3$	8.6 ± 2.1	-0.63 ± 0.26	0.9 ± 0.5	0.20 ± 0.06

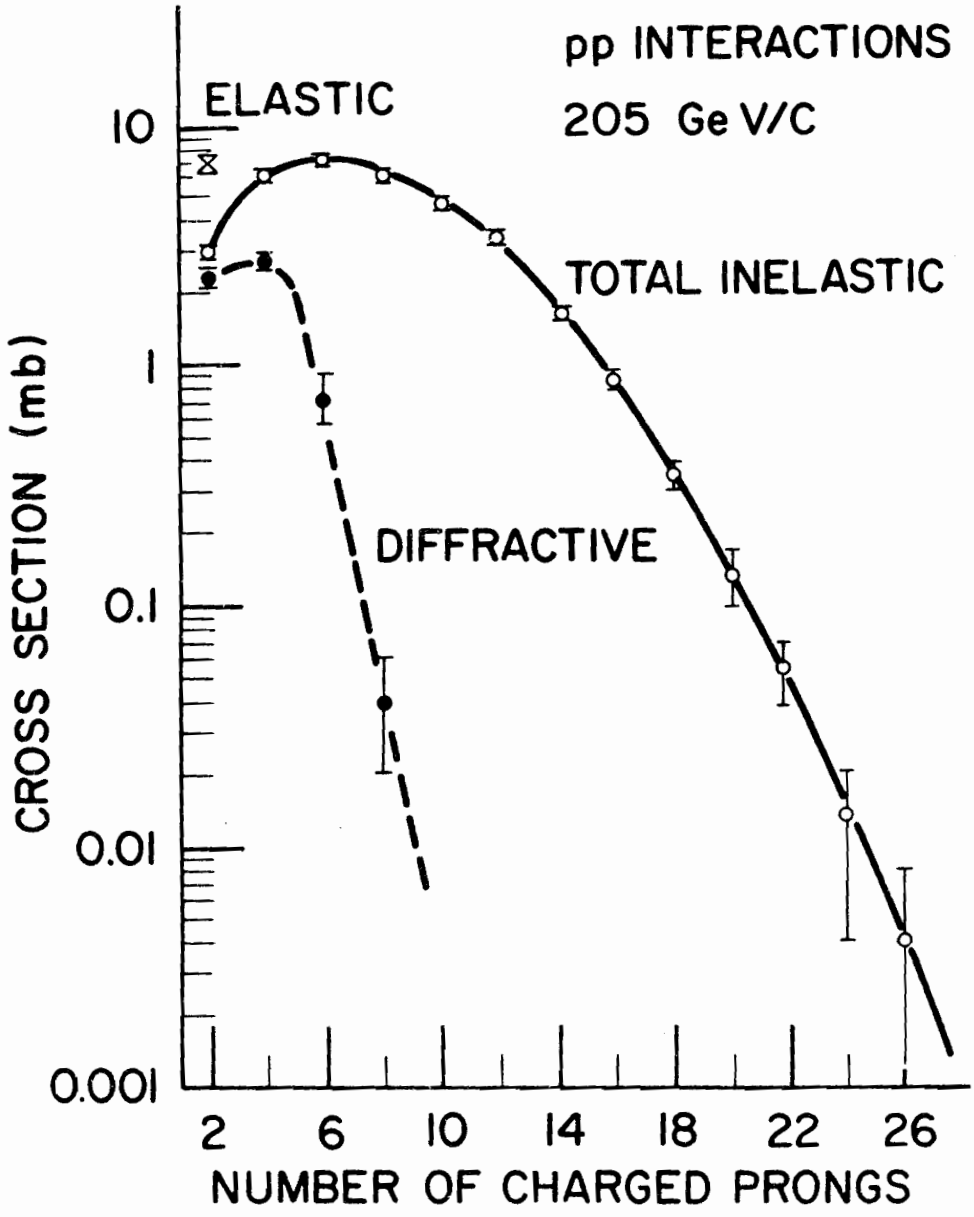

FIG. 1 CHARGED MULTIPLICITY DISTRIBUTION