BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York

ACCELERATOR DEPARTMENT
Informal Report

MASTER

MONTE CARLO MODEL FOR MULTIPARTICLE PRODUCTION

D.E. Lyon, Jr.

November 24, 1971

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Accelerator Department
BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York

CRISP 71-45
ISABELLE PROJECT
BNL 16817

INTERSECTING STORAGE ACCELERATOR NOTES

MONTE CARLO MODEL FOR MULTIPARTICLE PRODUCTION

Donald E. Lyon, Jr.*
November 24, 1971

ABSTRACT

A Monte Carlo calculation based on the multi-peripheral model of Chew and Pignotti, is used to produce $d^2N/dpd\Omega$ distributions at energies up to a laboratory energy of 80,000 GeV. The momentum distribution employed is

$$d^3N \propto f(x,s) e^{-bp_T^2} d^3p/E.$$

The calculations produce scaling longitudinal momentum distributions that compare well with data that exist up to 1500 GeV; laboratory energy.

* Present address: University of Michigan, Ann Arbor, Michigan

Rather than be constrained by any one model, high energy events have been generated with a Monte Carlo calculation that incorporated the general features of the models of Chew and Pignotti¹, and Feynman². Specifically, it was assumed that:

a) In addition to the original particles, the high energy interactions tend to shed rho mesons.

b) The center of mass momentum distribution of the rho mesons is given by

$$d^3N \propto g(x,s) e^{-ap_T^2} d^3p/E,$$

where E is the total energy of a secondary, $x = 2p_L s^{-1/2}$, p_L is the longitudinal momentum, p_T the transverse momentum, and s is the square of the total center of mass energy. The function g (x,s) describes the effects of the kinematical constraints whose form is determined by conservation of momentum and energy.

c) The number of rho's emitted at fixed s is described by a Poisson distribution whose average value is given by a constant times $\ln(E_0/m)$, where E_0 is total laboratory energy of the incident particle and m is its mass.

d) The charges of the final state particles (rho's and nucleons) result as if the rho's were produced multi-peripherally via π meson (I = 1) exchange.

-2-

Since the rho mesons decay essentially to two pions, the momentum distribution of the pions that result will be given by

$$d^3N \propto f(x,s) e^{-bp_T^2} d^3p/E$$

and the average number of pions emitted will also vary as $k \ln(E_0/m)$. The value of b was chosen to correspond to $\langle |p_T| \rangle = .35$ GeV, and the value of k was 1.51 .

The generation procedure begins by selecting the number of rho's from a Poisson distribution, the transverse momenta for the rho's and nucleons from $e^{-ap_T^2}$ such that $\Sigma p_T = 0$, and the longitudinal momenta for the rho's from $1/E$. The equations of conservation of momentum and energy are then used to solve for the remaining two longitudinal momenta of the final state nucleons. There is frequently no solution as the rho's have taken too much energy ($g(x,s)$ is ignored during generation). In this case a smaller value of the longitudinal momentum for the rho with the largest $|p_L|$ is generated, again from $1/E$, and the process is repeated until a solution is obtained where one nucleon goes forward and one backward (in the c.m.). The rho mesons are then allowed to decay into two pions.

-3-

The process produces an $f(x,s)$ (for the pion distribution) that is independent of s and that varies approximately as e^{-8x^2} . There also results a scaling nucleon momentum distribution that varies approximately as $10x$ for $0.05 \leq x \leq 0.85$. The inelasticity is also energy independent and has the value 0.53. It should be noted that a comparison of the predictions for inclusive particle spectra between detailed multiperipheral model calculations and the more empirical Monte Carlo calculations presented here, showed negligible differences.

Comments:

Previous comparisons of data to the multiperipheral model have served as a guide to the selection of details of this Monte Carlo calculation.^{3,4} For example, an analysis of the angular distributions indicated the need for particle correlations (rho's, nucleon resonances, etc.) in order to avoid structure in the angular distributions and to improve the model predictions regarding charged multiplicity distributions at fixed s . Some of these refinements have been incorporated in this Monte Carlo calculation, resulting in general improvement in the agreement of model predictions with data; particularly with the charged multiplicity and angular distributions.

It may be noted that the earlier comparisons with data had been made using a similar Monte Carlo calculation analagous to a multiperipheral model wherein rho and omega mesons were exchanged and single pions produced.⁴ This led to two important differences in the distributions as compared with the data: the number distributions were narrower (corresponding to Poisson statistics for single pions rather than pion pairs), and the angular distributions had "ears" or peaks at extremes of $\log \tan \theta$ which corresponded to the final state protons. The pure $I = 1$ exchange results in a larger probability that the final state nucleon is a neutron than the $I = 0,1$ mixture, and consequently suppresses the effect of the nucleons in charged particle distributions; resulting in better agreement with data.

REFERENCES

1. G.F. Chew and A. Pignotti. Phys. Rev. 176, 2112 (1968).
2. R.P. Feynman. High Energy Collisions - Third International Conference, edited by C.N. Yang (Gordon and Breach, New York, 1969).
3. L.W. Jones, A.E. Bussian, G.D. DeMeester, B.W. Loo, D.E. Lyon, P.V. Ramana Murthy, R.F. Roth, J.G. Learned, F.E. Mills, D.D. Reeder, K.N. Erickson, and B. Cork. Phys. Rev. Letters 25, 1679 (1970).
4. D.E. Lyon, A.E. Bussian, G.D. DeMeester, L.W. Jones, B.W. Loss, P.V. Ramana Murthy, R.F. Roth, F.E. Mills, J.G. Learned, D.D. Reeder, K.N. Erickson, B. Cork, and C. Risk. Phys. Rev. Letters 26, 728 (1971).

P-P at 1000 GeV (21.67 GeV per proton CM)

P-P at 10000 GeV (68.5 GeV per proton CM)

P-P at 1000 GeV (21.67 GeV per proton CM)

P-P at 80000 GeV (193.73 GeV per proton CM)

P-P at 1000 GeV (21.67 GeV per proton CM)

P-P at 80000 GeV (193.73 GeV per proton CM)

P-P at 1000 GeV (21.67 GeV per proton CM)

P-P at 80000 GeV (193.73 GeV per proton CM)