Particle production at high energy. I. Geometrical orientated simulation of hadron-hadron collisions below 250 GeV/*c*

Chia C. Shih and Jing-ye Zhang
Department of Physics, University of Tennessee, Knoxville, Tennessee 37996-1200
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Using an eikonal formulation a phenomenological representation is constructed which simulates multiparticle production processes initiated by hadron-hadron collisions from threshold to 250 GeV/c laboratory momentum. Essential features examined include the multiplicity distribution, rapidity distribution, and transverse momentum distribution with a bias in rapidity. A specific technique is developed to ensure that conservation of energy momentum and conservation of charge is maintained for individual events. This event generator can be used directly as part of a kernel of a more complicated event generator describing heavy-ion collisions based on geometrically orientated hadronic cascading processes. [S0556-2813(97)00501-3]

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In the past decade various models of internuclear cascades have demonstrated the importance and usefulness of hadronic cascading processes in relativistic heavy-ion collisions (RHIC's) [1]. Since these effects are usually implemented numerically in terms of Monte Carlo simulations, there is a need to simultaneously keeping track of many dynamically interacting entities. It is therefore desirable to develop an efficient algorithm to build an event generator for the basic binary collisions to be used as the building blocks for internuclear cascading processes. Many-body effects can then be introduced systematically to the more involved nucleus-nucleus (AB) systems. To serve this purpose, an event generator should yield statistical predictions consistent with experimental data for both small and large systems. It should also possesses the space-time characteristics of colliding hadrons, as the geometry of the finite spatial extension of the constitutional hadrons plays an important role in heavy-ion collisions. When such a model is adapted to the internuclear cascading hadronic subprocesses, its predications can provide an interesting reference in detecting nontrivial multihadronic dynamical phenomena. For instance, it may be used to provide a useful background calculation against subhadronic quark-gluon interactions.

In the present approach, we shall treat individual hadrons as the basic entities of interaction. Prior to any interaction, energy momentum is transferred along straight line trajectories of hadrons. During any binary collision, hadronic interactions are responsible for any abrupt change of momentum associated with the straight line trajectories originating in a space-time regions, which are essentially confined to a very local space-time region. A detailed assessment of the hadron-based Monte Carlo simulation presented here is not only intended to provide an interesting set of background calculations in the absence of any signature of the quark-gluon plasma, but also to provide the building blocks of a simple Monte Carlo algorithm for relativistic heavy-ion collisions [2]. A more microscopic consideration at the level of QCD dynamics would involve quarks and gluons. As long as the local interaction is a meaningful concept and the time ordering of binaries is of interest, various considerations of the technique of our Monte Carlo simulations shall still be relevant.

To establish a geometrically orientated model for a hadron-hadron (hh) collisions, we visualize a configuration in which the center of mass (c.m.) of two hadrons possesses an impact parameter b. Convolution of all possible values of b is evaluated for a comparison with experimental data such as the measured experimental total inelastic cross sections $\sigma_{\mathrm{in}}(hh)$ at a given laboratory momentum q given by [3]

$$\sigma_{\mathrm{in}}(pp,q)=33.74+239.q^{-4.33}-26.9q^{-1.21}+0.245\ln^2 q -1.59\ln q, \tag{1}$$

$$\sigma_{\mathrm{in}}(p\pi,q)=-12.4+40.4q^{-0.28}-11.2q^{-1.67} -0.180\ln^2 q+5.21\ln q. \tag{2}$$

To deconvolute the impact parameter b dependence, we assume that $\sigma_{\mathrm{in}}(hh)$ obeys geometrical scaling and use an eikonal function $\Omega(R)$ to project out the b dependence for pp and $p\pi$ collisions [4], i.e.,

$$\sigma_{\mathrm{in}}(hh,q)=\int db^2(1-e^{-2\Omega})\equiv\int db^2\sigma_{\mathrm{in}}(hh,q,b), \tag{3}$$

$$\sigma_{\mathrm{tot}}(hh,q)=2\int b^2(1-e^{-\Omega}),$$

with a Gaussian approximation given by Ref. [4] for the total cross section σ_{tot} and inelastic cross sections σ_{in} in relation to multiplicity fluctuations:

$$1-e^{-\Omega}=Ae^{-(2A-A^2/2)R^2},\quad A=0.68,\qquad R=b/b_0(q), \tag{4}$$

$$\sigma_{\mathrm{in}}(hh,q)\equiv\pi b_0^2 q.$$

For the $\sigma_{\mathrm{in}}(\pi\pi)$ collision which is not measured directly, a simple factorized expression is used as an approximation so that

$$\sigma_{\mathrm{in}}(\pi\pi,q)=\sigma_{\mathrm{in}}(p\pi,q)^2/\sigma_{\mathrm{in}}(pp,q). \tag{5}$$

The above geometrical cross section formulas simulate stochastically the probability of the occurrence of a hadron-hadron collision for any given impact parameter b of the initial state configuration.

Granting that an interaction has occurred with a specific b, we further assume that after a collision the probability distribution of the rapidity of each hadron follows the dependence

$$p(y)dy=(2-\alpha)(e^{y_{\max}}-1)^{\alpha-2}e^{y}(e^{y}-1)^{1-\alpha}dy,\qquad 0\leqslant y\leqslant y_{\max} \tag{6}$$

where

$$\alpha=\alpha_0 e^{-\alpha_1 b}. \tag{7}$$

Here, the rapidity value y is calculated in the center-of-momentum frame of the two colliding protons. $y_{\max}=\frac{1}{2}\ln\,[(E+|\vec{p}_L|)/(E-|\vec{p}_L|)]$ is the incident value of the rapidity of either incoming hadron. The parameters α_0 together with α_1 control the shape of the profile of $p(y)$. It covers a wide range of behavior from those strongly peaking at $y=y_{\max}$ to those peaking at $y=0$, and is reasonably flexible. For the leading particle spectrum we expected our Monte Carlo simulation to favor a peripheral distribution. Indeed the values of α_0 and α_1, being used as free variables, eventually settle down to a region of the parameter space with which $p(y)$ is peaked toward the peripheral region as expected. The overall Convolution of $p(y)$ in b is also consistent with the experimental leading particle spectrum [8]. With the same impact parameter b shared by both colliding hadrons, the energy loss of the opposing hadrons is positively correlated.

In conjunction with the y distribution, after a collision each hadron also acquires a transverse momentum $\vec{p}_t$ perpendicular to the rapidity axis. While its specific direction in the perpendicular plane is being randomly assigned, its magnitude $p_t=|\vec{p}_t|$ follows closely the experimental distribution of the inclusive measurements in $P+P\rightarrow\pi+X$ [1], and is given by

$$f_{\rm inc}(p_t)\sim e^{-4.1p_t^2}\,(p_t\leqslant 0.81\ \ {\rm GeV}/c)$$
$$\sim 2.5e^{-4.4p_t}\quad (0.81\ \ {\rm GeV}/c<p_t<2.4\ \ {\rm GeV}/c). \tag{8}$$

Knowing the initial and final state momentum vectors of the colliding hadrons, we move on to construct simulations of the stochastic emission of secondary pions. Here an emitted pion, with a random charge assignment, is allowed to carry a rapidity value up to its kinematic limit $y_{j,\max}$ along either longitudinal direction of $\vec{p}_j$ ($j=1,2$) of the initial colliding hadrons. The probability distribution $f(y_\pi,j)$ of the rapidity y_π of the secondary pions is given a universal form

$$f_y(y_\pi,j)=C_j(2-\beta)(e^{\lambda y_{j,\max}}-1)^{\beta-2}e^{\lambda y_\pi}\times(e^{\lambda y_\pi}-1)^{1-\beta}dy_\pi, \tag{9}$$

$$C_j=y_{j,\max}/\sum_k y_{k,\max},\quad y_\pi\leqslant y_{j,\max},\quad j\leqslant j_{\max}=2.$$

This distribution is in the same form as that used for the scattered protons but with a scaled rapidity variable $\lambda\ \ y_\pi$. Its overall shape is dictated by a new parameter β in analogy to the variable α for the protons in Eq. (5). We adapted this form for the same reason of convenience in Monte Carlo simulations as before. For the domain of parameter space used later on in this analysis, $f_y(y_\pi,j)$ are much flatter than the hadron spectrum $p(y)$ given before. We further assume that the overall probability of secondary particle production along the jth direction of the incident particle is proportional to the length of the allowed rapidity space $y_{j,\max}$. Thus the shape of all the y_π distributions is controlled by two overall parameters β and λ. Associated with this longitudinal momentum distribution, the transverse-momentum distribution $p_t=|\vec{p}_t|$ is given by

$$f_\pi(p_t)\sim e^{-6.2p_t}\quad (p_t\leqslant 0.81\ \ {\rm GeV}/c)$$
$$\sim 0.5326e^{-5.3p_t}\quad (0.81\ \ {\rm GeV}/c<p_t<2.4\ \ {\rm GeV}/c). \tag{10}$$

The above parametrization is typical of any longitudinal phase space model in which light cone variables are not used [5]. The dramatic distinction between the longitudinal and the transverse axes is consistent with the traditional hydrodynamical-thermodynamical approaches in the treatment of particle production at high energies [6]. We have chosen the above parametrization for the convenience in numerical simulations; their detail forms have no distinct advantage over other reasonable choices. The above information is sufficient to construct a Monte Carlo event generator for a statistical description of the dynamics of the multihadron production when the secondary particles are restricted to π only with k and $\bar{p}$ production being neglected. Equations (1)–(9) then control all the relevant relative distributions with a few tunable parameters for their general shapes. The overall normalizations are also fixed with no additional degrees of freedom left. However, a straightforward simulation of the above distributions will not guarantee that each event generated by such a simulation will satisfy the conservation of energy momentum and baryon number. As we shall discuss later baryon and energy momentum considerations can be imposed with the resultant relative distributions only slightly modified. The corrections for the ensemble averages are also not severe. Occasionally there are simulations where the last assignment according to Eqs. (1)–(9) represents a substantial fraction of energy momentum. In such cases, without any correction, the unbalanced energy momentum may create a fictitious contribution to that event.

As long as the number of secondary pions produced in each event is large and an ensemble average of many simulated events is used, the central-limit theorem naturally ensures a compensation of statistical fluctuation among various events. The Monte Carlo average can be used to compare with data. As indicated above, a more rigorous consideration is, however, needed to use this event generator to represent individual events. There are essentially two concerns. The first is the requirement of the conservation of the overall energy and momentum, which can be badly violated in individual events. The second is the conservation of charge. Both of these requirements impose a global correlation among all final state secondaries. There are also additional correlations due to the dynamics of strong interactions. In the present paper we shall only address questions related to the requirements of global conservation laws and ignore all other local correlations [7]. We shall project our simulations to the charged final states for the comparison with experimental data. Our simulations shall include the lower energy region as it shall be used for internucleus cascades during a nucleus-nucleus collision.

Having in mind the construction of an event generator as part of the kernel of hadron based hadron-nucleus and nucleus-nucleus collisions, we first use the statistical requirements and construct a simulation in the absence of any consideration of the conservation laws. Using this set of values as the first approximation, we then construct a specific algorithm to restore the conservation of energy and momentum for each event. With the modification kept to a minimum, the ensemble average of various quantities shall be essentially the same as those given by the input first approximation.

We start in a reference frame where the total momentum of the incident particles is zero. The energy ω_j and the momentum $\vec{p_j}$ of the secondaries particles repeatedly generated by the event generator ($j=3,4,\ldots$) are recorded in this reference frame according to the statistical formulation discussed earlier (with $j=1,2$ being the rescattered hadrons). The procedure of secondary particle pion generation continues until the addition of the newest pion (with $j=n$) has exceeded the total available energy W, i.e.,

$$\sum_{j=1}^{n-1} \omega_j < W < \sum_{j}^{n} \omega_j . \tag{11}$$

At this point the total momentum of the secondaries and the two scattered hadrons is typically small, we can therefore spread this unbalanced momentum given by

$$\delta\vec{p} = \sum_{j=1}^{n} \vec{p}_j \tag{12}$$

uniformly to all the particles. Thus at this second this step we have created a new set of energy momenta,

$$\vec{p}_j^{[1]} = \vec{p}_j - \frac{1}{n}\delta\vec{p}, \qquad j=1,\ldots,n, \tag{13}$$

which are typically fairly close to the original values generated during the first step by the event generator. After this modification of the momenta of the secondary particles, the total energy of the final state particles is not yet equal to the available energy W. In order to achieve this, we now introduce an overall scaling factor ν to the transverse momentum $\vec{p}_t$ of all the particles, i.e.,

$$\vec{p}_{t,j}^{[2]} = \nu \vec{p}_{t,j}^{[1]}, \qquad j=1,\ldots,n, \tag{14}$$

so that the total linear momentum remains zero. The value of ν is then determined by the requirement that the total energy of secondaries be equal to the required total energy W. Since value of ν is usually very close to 1, the modified simulation remains similar to the original one. The specific value of ν can be iteratively determined without requiring a prolonged computational time.

We shall now concentrate on our algorithm for the conservation of charge. We first use the fact that the dynamics of strong interactions is independent of charge. In the present model we therefore treat both proton and neutron as nondistinguishable baryons. During the first step of the simulation, the event generator creates secondary particles with specific energy momentum but without any assignment of individual charges. The next step is to assign charges to the secondary particles. Notice that if the final state charges were chosen randomly among all possibilities of positive, negative, and neutral assignments, the total charge of the secondaries would likely be small but not zero. While the statistical ensemble average is zero, there is no guarantee that it holds for individual events. Nevertheless, under our assumption of the dominance of strong interactions, the production of meson π^+ and π^- should always comes in pairs. Within any given total number of secondaries, $\langle n_t \rangle$, we assume charge independence of the strong interaction and impose the condition that the average number of pions $\langle n_+ \rangle = \langle n_- \rangle = \langle n_0 \rangle$. Our problem is therefore reduced to the consideration of the distribution of the number of charged pairs. In this paper, we have simply assumed a Gaussian distribution for the number of pairs with the width of distribution proportional to the average total number of particles produced. There is therefore a built-in fluctuation between the number of $\pi^\pm$ and π^0 from event to event. Within each event, a specific assignment for individual charges remains random among all secondary pions. Thus charge conservation is imposed at the global level without any additional restriction on local correlation and charge compensation.[1]

Using this generator, we have created a variety of samples. The resultant phenomenological representations are given in the figures below. Parameters used in the above formula are determined through a simultaneous analysis of several aspects of hh collisions. Our choice of $\alpha_0=1.4$ and $\alpha_1=0.5$ leads to a y distribution of the scattered hadrons sharply peaked toward the peripheral region. The result of a convolution in b is also consistent with the experimental leading particle spectrum [8]. On the other hand, a choice of $\beta=2.1$ and $\lambda=-0.325$ gives a rather flat y_π distribution for the secondary pions.

Figure 1 gives the global parameter of the average charge multiplicity $\langle n_{\mathrm{ch}} \rangle$ and its associated relative dispersion $\sigma_2 = (\langle n_{\mathrm{ch}}^2 \rangle / \langle n_{\mathrm{ch}} \rangle^2 - 1)^{1/2}$ as a function of the incident momentum from 12 to 250 GeV/c [9]. While the ensemble averages of the individual simulation events are slightly higher

[1]Given a value of $n_t = n_+ + n_- + n_0$, and $n_+ = n_-$, we construct a Gaussian distribution with $\langle n_+ \rangle = \langle n_- \rangle = \langle n_0 \rangle = \frac{1}{3}\langle n_t \rangle$, and $\sigma_\pm = (\langle n_+^2 \rangle - \langle n_+ \rangle^2)^{1/2} = \frac{1}{12} n_t$. When n_t is small, a minor adjustment is needed. For example, with $n_t=1$, the produced pion must be neutral in charge. With $n_t=3$, the available configurations are $[+,-,0]$ and $[0,0,0]$. As long as the chance of $[0,0,0\,]$ production is not zero, $\langle n_+ \rangle$ would be always less than $\langle n_0 \rangle$. For this special case, we have made an exceptional assumption of an equal relative probability between the charge configuration $[+,-,0]$ and $[0,0,0]$.

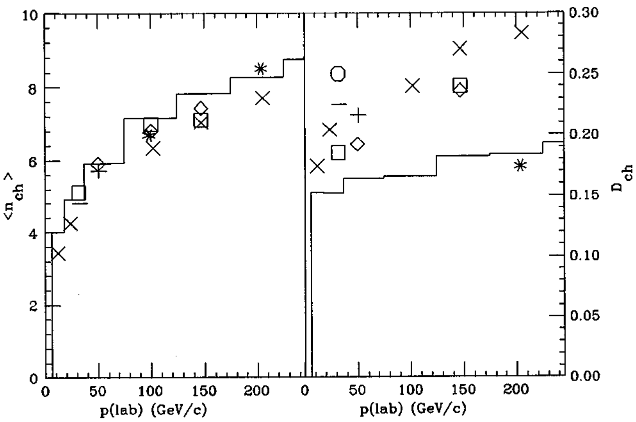

FIG. 1. Average $\langle n_{\mathrm{ch}}\rangle$ and $D_{\mathrm{ch}}=\sqrt{\langle n_{\mathrm{ch}}^2\rangle-\langle n_{\mathrm{ch}}\rangle^2}$ as a function of laboratory momentum. Data $\times$ for pp, $\diamond$ for π^+p, $\square$ for k^+p, $\bigcirc$ for $\overline{p}p$, $+$ for π^-p, $-$ for k^-p, and * for pp(NSD) from Ref. [9].

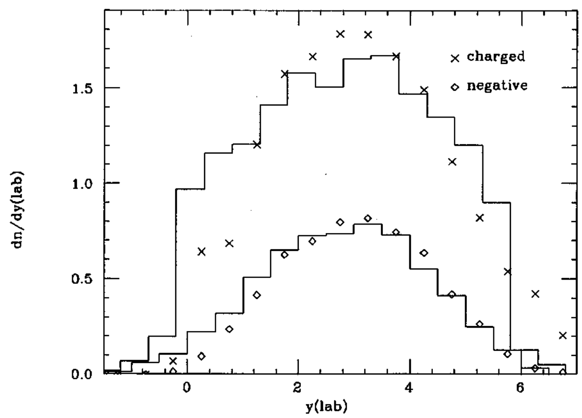

FIG. 2. Inclusive distributions of pp for charged particles dn_{ch}/dy (upper histogram) and negatively charged particles dn_-/dy (lower histogram) at 200 GeV/c. Data $\times$ for all charge and $\diamond$ for negative charge from Ref. [21].

than the corresponding data, our model gives a relative dispersion roughly 20% too low at lower energies. This is a reflection of the fact that our model has not phenomenologically incorporated many secondary effects such as resonance production, single-diffractive, charge exchange cross sections, dynamical correlations [10,11], and many others effects, many of them emphasizing somewhat different regions of the final state configuration. It is reasonable to anticipate that our statistical formulation would tend to underestimate the dispersion of the observed experimental data at lower energies. The main fluctuation of our simulation comes from the impact parameter distributions, Eqs. (1)–(5), and the stopping power distributions, Eqs. (6)–(9). The latter are most appropriate only for the consideration of hadrons passing through an effect medium. Another intrinsic cause of a larger fluctuation may come from QCD substructures and fluctuations as have demonstrated effectively the usefulness of perturbative QCD and mini-jets [10,11]. Other causes may also come from quantum mechanical chaoticity, coherence, and other hadronic final state interactions. It is possible to introduce two-particle correlations as part of the input in addition to the correlations inherent in the accumulative impacts and clustering (AIC) model. Such an approach, however, may become frivolous when correlations are energy dependent due to the onset of certain dynamics, such as hard or semihard processes. Thus the simplicity of the AIC model should be viewed as the simplicity in dynamics. Potential shortcomings of this approach in the high energy region should be more appropriately improved upon through further modifications of the underlying dynamics instead of substantial superficial expansions of phenomenological parametrizations.

Figure 2 gives the inclusive rapidity distribution dn_{ch}/dy (upper histogram) and dn_-/dy (lower histogram) for hh collisions at 200 GeV/c. Our simulated distribution is symmetrically with respect to the center-of-mass value of the rapidity $y_{\mathrm{c.m.}}=3$. It possesses a slightly higher shoulder in the target peripheral region ($y\sim 0$) and slightly narrower shoulder in the peripheral projectile region than the experimental data. Such a discrepancy is entirely normal, as our simulation has not included any experimental bias in the peripheral region of the target and the projectile. For the total charge n_{ch} distribution, the simulation is also slightly too high at the center where $y=y_{\mathrm{c.m.}}$, while the agreement for the inclusive rapidity distribution of negative hadrons is much better. Since our slowing-down process does not change the identity of the incoming hadrons, it is again natural to accept the current level of agreement until charge exchange cross sections are implemented into the event generator at a later time.

At 200 GeV/c our calculation leads to $\langle p_t\rangle=440$ MeV for all the final state charged particles including the final state protons. This value can be estimated through the input values of 510 MeV for the transverse momentum of the scattered protons [Eq. (7)] and 370 MeV for the transverse momentum of the secondary pions [Eq. (9)], leading to a value of $\langle p_t\rangle$ for all charges:

$$\langle p_t\rangle_{\mathrm{all}}=[2\langle p_t\rangle_{\mathrm{proton}}+(\langle n_{\mathrm{ch}}\rangle-2)\langle p_t\rangle_{\mathrm{pion}}]/\langle n_{\mathrm{ch}}\rangle.$$

We also present in Fig. 3 a more detailed comparison of the

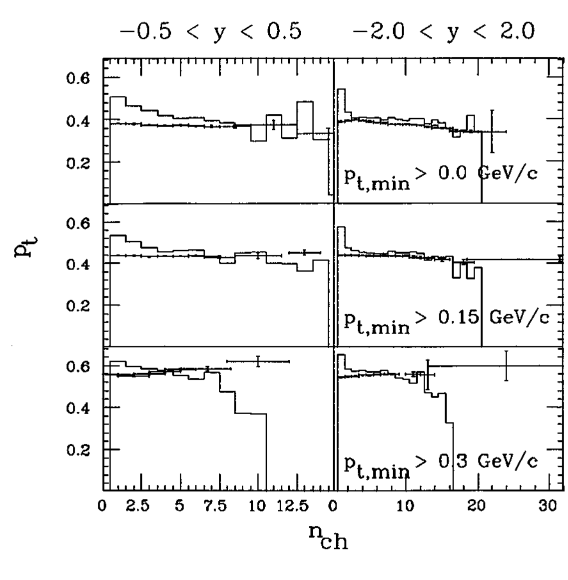

FIG. 3. Average $\langle p_t\rangle$ for charged particles as a function of n_{ch} with various cuts in rapidity y. Data from Ref. [22].

average $\langle p_t \rangle$ at a slightly higher energy of 250 GeV/c. There the average value of the transverse momentum, $\langle p_t \rangle$, has been analyzed experimentally for a variety values of rapidity window and charge multiplicity n_{ch}. It demonstrates that, unlike at higher collider energy, a distribution for p_t with a factorized y dependence can indeed reproduce the $\langle p_t \rangle$ data in most situations at the lower energy of 250 GeV/c. In Fig. 3, the main disagreement is in the region of very small n_{ch}. For example, with $n_{\mathrm{ch}}=1$, the singly produced pion has to balance the transverse momentum of the scattered proton. Consequently it takes on a larger p_t of the scattered proton. In the present paper, we have also not allowed an impact parameter b and n_{ch} dependence on the transverse momentum p_t. A more involved model with such a dependence tends to lift the average p_t for high multiplicity events.

Part of the merit of our model is the simplicity of the formulation. Considerable flexibility of our model still exists for a more realistic parametrization in the future. For example, the impact parameter dependence in our model is rather simple. It only deals with the center of mass of the hadron as a whole. One of the natural generalizations is to fold this with the impact parameter distributions of the partonic structures [11]. Sublevel distributions at least as broad as Possionian distributions shall be needed [12]. Hadrons are then no longer treated as the kernel of interaction. While additional complications may be a necessity, it introduces yet another layer of parametrization, with its associated advantages and uncertainties (such as nonperturbativeness, duality, and K factors). At the hadronic level, more detailed considerations such as charge exchange interaction, factorization of $\pi\pi$ cross sections in Eq. (4), transverse momentum p_t and impact parameter b dependence, production of the k mesons, and leading particle effects may also be incorporated. The specific form of the dependence in rapidity and transverse momentum as in Eqs. (5)–(9) is adopted for its convenience in numerical simulations. There are no intrinsic advantages in this form, and other reasonable parametrizations are clearly acceptable. None of these changes, however, will alter the rationale of our consideration for the conservation laws.

In our phenomenological construction of the event generator, several important features of high energy processes have been ignored. One of the factors is local correlations of different kinds. Existing data indicate that the momentum and charge balance typically observe a compensation within one unit of rapidity [13]. In our representation, such correlations have been diluted to an overall global domain. For a hadron-hadron collision without the presence of other nuclear matter, a final state interaction is included phenomenologically in the effective cross sections of the secondary particle production. Glauber's and various other formulations for off-mass-shell multiple scatterings are therefore bypassed [4]. Similarly semilocal correlations associated with a resonance production and other many-body interactions are ignored to avoid double counting of any kind. In other words, the present formulation does not provide deep insight into the underlying dynamics other than a specific geometrical interpretation of the cross section and cluster formation. There are clearly potential limits to our approach. Since without any QCD structures and/or quantum statistics an overemphasis of eventwise fluctuations in hadron-hadron collisions may lead to interpretations of dubious physical implication, we have been restraining ourselves from demanding too much until further physical considerations are implemented. Until the time when a comprehensive numerical algorithm that includes all important nonperturbative effects becomes available, it remains an issue as to how sensitive the effects of second order fluctuations would be in comparison with that of the first order interaction cross sections for a typical evaluation of the background of RHIC physics. Detailed features of correlations and a more profound understanding of the space-time evolution beyond classical trajectories are therefore not addressed in the simple statistical formulation presented in this paper.

Our event generator possesses several distinct features that can be naturally adapted to the environment of nucleus-nucleus collision processes. First of all, prior to any interaction the center of mass of each colliding hadron is unambiguously identified with a unique spatial geometry of an impact parameter b. A space-time trajectory for such an extended object can be easily visualized. Second, the characteristics of the slowing-down hadron losing energy through an effective medium is established by a proper description of the statistical profile of the phenomenology. To avoid successive parametrization and as a first approximation, we have extended the same stopping power formulation to the more extensive heavy-ion environment. In such a formulation the energy loss of a hadron is statistically dictated by its own energy, and the total energy-momentum loss of a binary collision is the convolution of two independent distributions. Thus the computational simulation time of our algorithm depends linearly, instead of quadratically, on the number of interacting hadrons. Third, the balancing of energy momentum and total charge conservation can be imposed at any stage of a hadronic interaction in a controlled manner [14]. In one extreme, one may impose conservation laws only on the final state of the secondaries when all strong interactions cease. There is then no real need for a conservation requirement during the subprocesses. Successive interactions may be compensatory to each other, leading to essentially an inequality constraint at each stage of the cascade. In the other extreme, conservation requirements are imposed on every stage of the secondary cascade. Quantum-mechanical off-shell effects are then absent. The strong requirement of such stagewise local compensation shall be partially diluted in the case of RHIC's, where we shall introduce cluster formation in our algorithm. The Monte Carlo simulation is then a compromise between the above two extreme cases. Many-body correlations in our algorithm are, however, different from the inherent hadronic intensity correlation of the generalized Hambury-Brown-Twist effects [15].

The construction of the present event generator is strongly inspired by its adaptability to the construction of a hadron-based nuclear cascade simulation process. It is commonly known that although QCD structures of hadronic matter manifest themselves in many ways beyond on-shell phenomena, often such effects may also be interpreted by statistical descriptions of hot hadronic matter. So far it has been rather difficult to differentiate various fundamentally different dynamics at the level of experimental data available at the present time. Topics related to intermittency addressing self-similar cascading mechanisms in hadron production [16] can also be operating from a origin both in a quark gluon plasma or in hot hadron matter. Our model is readily generalized to include more explicitly a temperature dependence, but a quark gluon plasma cannot be easily be treated by localized partonic energy momentum and is therefore complementary to the model presented here.

One of the very powerful phenomenological techniques to distinguish various dynamics is to examine critically the basic formulation of correlation analysis. Phenomenological formations such as a wavelet analysis may lead to an in depth analysis of various correlation integrals [16]. Dynamics driven by the correlation can then be analyzed [17]. Model analyses for quantum coherence [18] and for intermittency [19] also share the desire to understand the dynamics of RHIC's without involving heavily detailed modeling. Our present model departs from such approaches in spirit. It is built on a simple yet specific dynamical mode of space-time evolution so that a statistical description of the RHIC physics can be obtained for global distributions. Since the goal of this study is not to create an ambitious model to explain all essential features of hadronic collisions at high energies, there are no intrinsic advantages to the specific forms of parametrization adopted. While other reasonable forms are acceptable, they will not alter the rationale of our evaluation of the conservation laws and the associated Monte Carlo algorithm for the geometrical orientated simulations.

This paper is the starting point of our second study where the space-time ordering of the subnuclear cascades are formatted in a more concise manner [20]. There, the analyses of nucleon-nucleus and nucleus-nucleus collisions are evaluated simultaneously. The phenomenological parametrization established in this paper for hh processes shall be adapted without any adjustment. Thus a coherent representation is presented to include the circumstance of nucleon-nucleon collisions as well.

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