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HIJET*

A Monte Carlo Event Generator for P-Nucleus and Nucleus-Nucleus Collisions

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HIJET is a Monte Carlo event generator which simulates high energy reactions with nuclear beams and targets. It is patterned after the widely-used ISAJET program[1], and uses the ISAJET generator for the individual nucleon-nucleon collisions.

HIJET is designed to reproduce, at least qualitatively, the known features of high energy proton-nucleus and nucleus-nucleus interaction data. Based on a very simple ansatz, the program gives quite a good representation of the main features of particle production and has been used by several groups as an aid in the design of detector systems for heavy ion experiments. It must be used with care however, since it is at best an extremely crude model for the nuclear physics of these interactions.

The HIJET algorithm for a proton colliding with a nucleus of mass A is illustrated in Fig. 1. The target nucleons are uniformly distributed within a sphere of radius $A^{1/3}$ fm. The projectile proton enters the target nucleus and collides with one of these nucleons after penetrating a distance chosen according to an interaction mean free path $\lambda = 1.6$ fm. This proton-nucleon collision is generated using ISAJET. All of the dynamics at the nucleon-nucleon level is determined by ISAJET. Following this collision only the leading baryon is allowed to reinteract in the nucleus; all other secondary particles are immediately placed in the P-nucleus final state without further interaction. The leading baryon may re-interact in the nuclear volume, with

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the same value of λ and the new four-momentum. Note that ISAJET, and therefore HIJET, is a high energy program designed to work at energies well above the threshold for multiparticle production. It gives reasonable results at AGS energies, but even here should be used with caution. It is not valid at lower energies. The ability of this simple model to reproduce the main features of high energy data is shown in Figs. 2 and 3. The average multiplicity of charged particles as a function of A and the rapidity distributions are quite accurately represented. Here, the p-p and p-Pb data are from Ref. 2, and the p-Ar and p-Xe data are from Ref. 3. Agreement of similar quality is found at 100 GeV/c, and the spectrum of final-state protons at large x is in good agreement with the data of Ref. 4. For large A the multiplicity distributions are narrower than seen in the data, an indication that such a model will not reproduce the strong fluctuations seen in real hadronic interactions.

The agreement with proton-nucleus data is good enough to warrant extending the model to nucleus-nucleus interactions. This is done in straightforward fashion by treating the projectile nucleus, of mass B, as a sphere of radius $B^{1/3}$ containing B nucleons each of which interacts independently with the target nucleus in the manner described above. The program keeps track of the four-momenta of struck target nucleons, as a function of position in the target nucleus, so that incident projectile nucleons may collide with target nucleons which are recoiling from a previous collision. In this way momentum and energy are exactly conserved in the overall nucleus-nucleus collision.

There is not, of course, a great body of data available with which to compare the predictions for high energy collisions of nuclei. Where comparisons are possible, the results have been encouraging. Figure 4 shows the HIJET model compared with α-α data[5] from the CERN ISR. The multiplicity distribution agrees well with this rather limited sample of data. Figure 5 shows quite a striking result. Here the data are from a single event recorded by the JACEE cosmic ray experiment.[5] The HIJET result, which is averaged over many events, is in quite good agreement, underestimating the multiplicity by ~ 20%. This gives us confidence that the trends exhibited by HIJET can be taken as a reasonable guide as we go to very high energy collisions with heavy nuclei.

In summary, HIJET is a means for approximating the behavior of high energy p-nucleus and nucleus-nucleus collisions. It is a tool for examining plausible background events in experiments which search for new phenomena. Its main features are:

- Good agreement is found with measured data for average multiplicities, rapidity distributions, and leading proton spectra in high energy collisions.

- The dynamics at the nucleon-nucleon level are taken to be the same as for high energy hadron-hadron interactions as given by the ISAJET code.

- Momentum and energy are globally conserved, rigorously, in each event.

The HIJET predictions for RHIC collisions have been used by several of the groups at this workshop. Figure 6 shows the rapidity spectrum for colliding beams of gold ions at c.m. energy of 100 + 100 GeV/amu.

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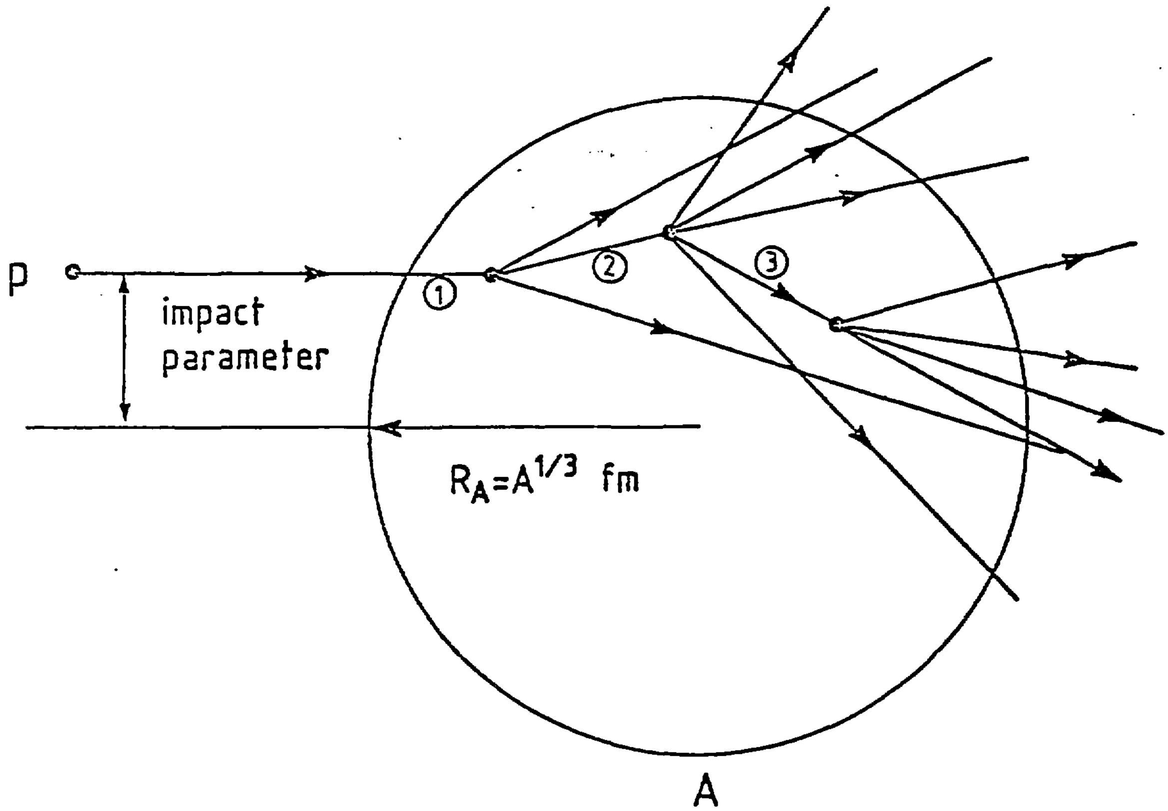

Figure 1. Schematic representation of a proton-nucleus collision in HIJET.

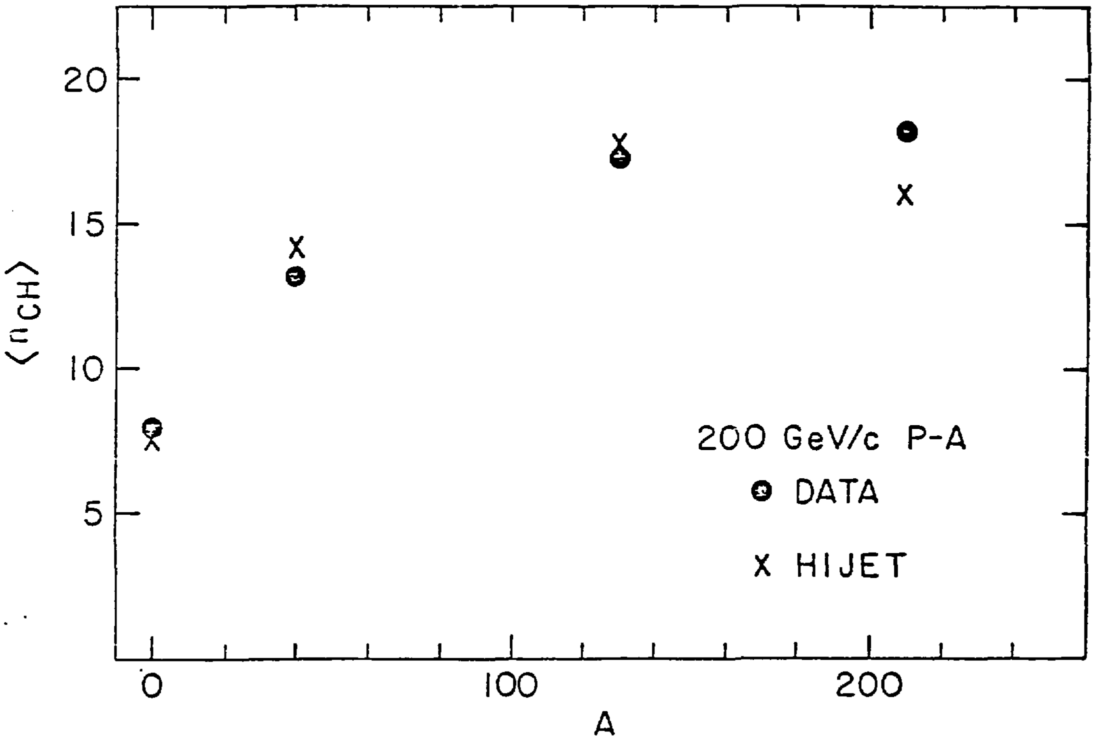

Figure 2. The mean charged particle multiplicity for proton-nucleus collisions as a function of the mass of the target nucleus. HIJET points are compared with data from Refs. 2 and 3. (For the p-Pb only tracks with $\beta >$ .85 are included, to agree with the experimental acceptance.)

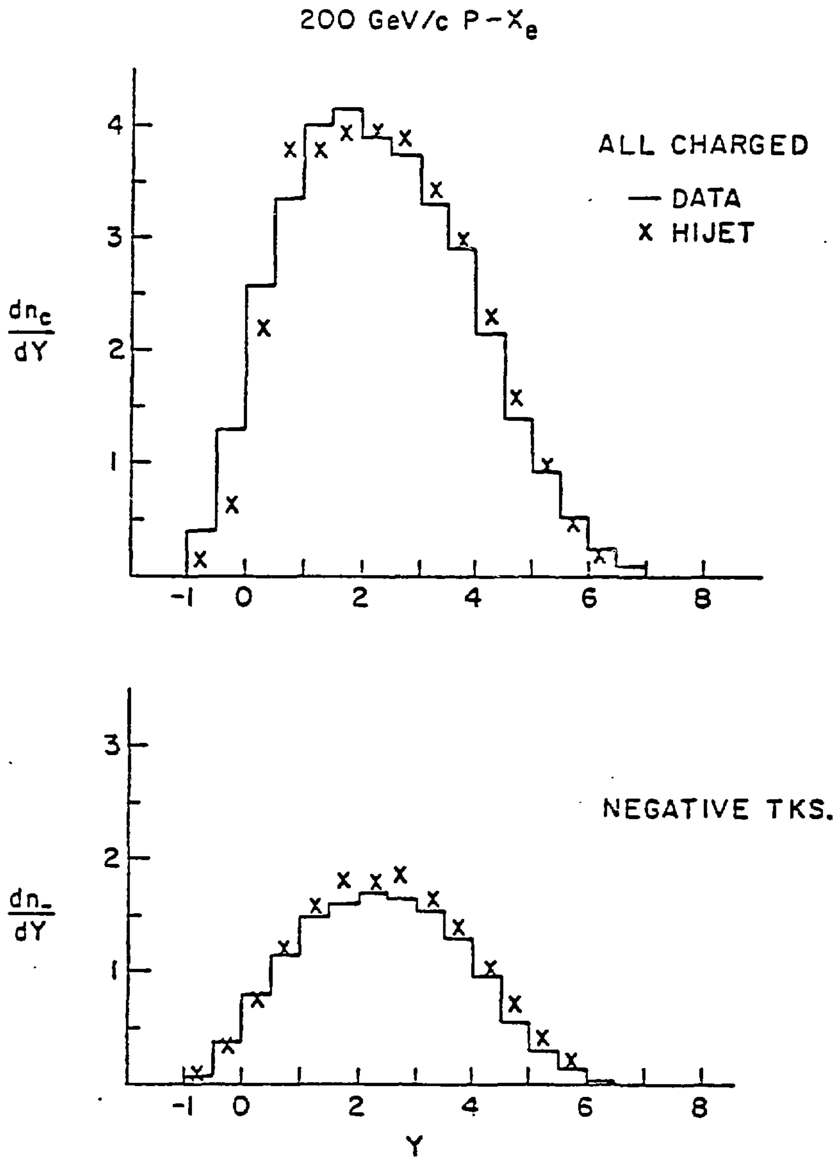

Figure 3. The charged particle rapidity spectrum for 200 GeV proton-xenon collisions. The data are from Ref. 3.

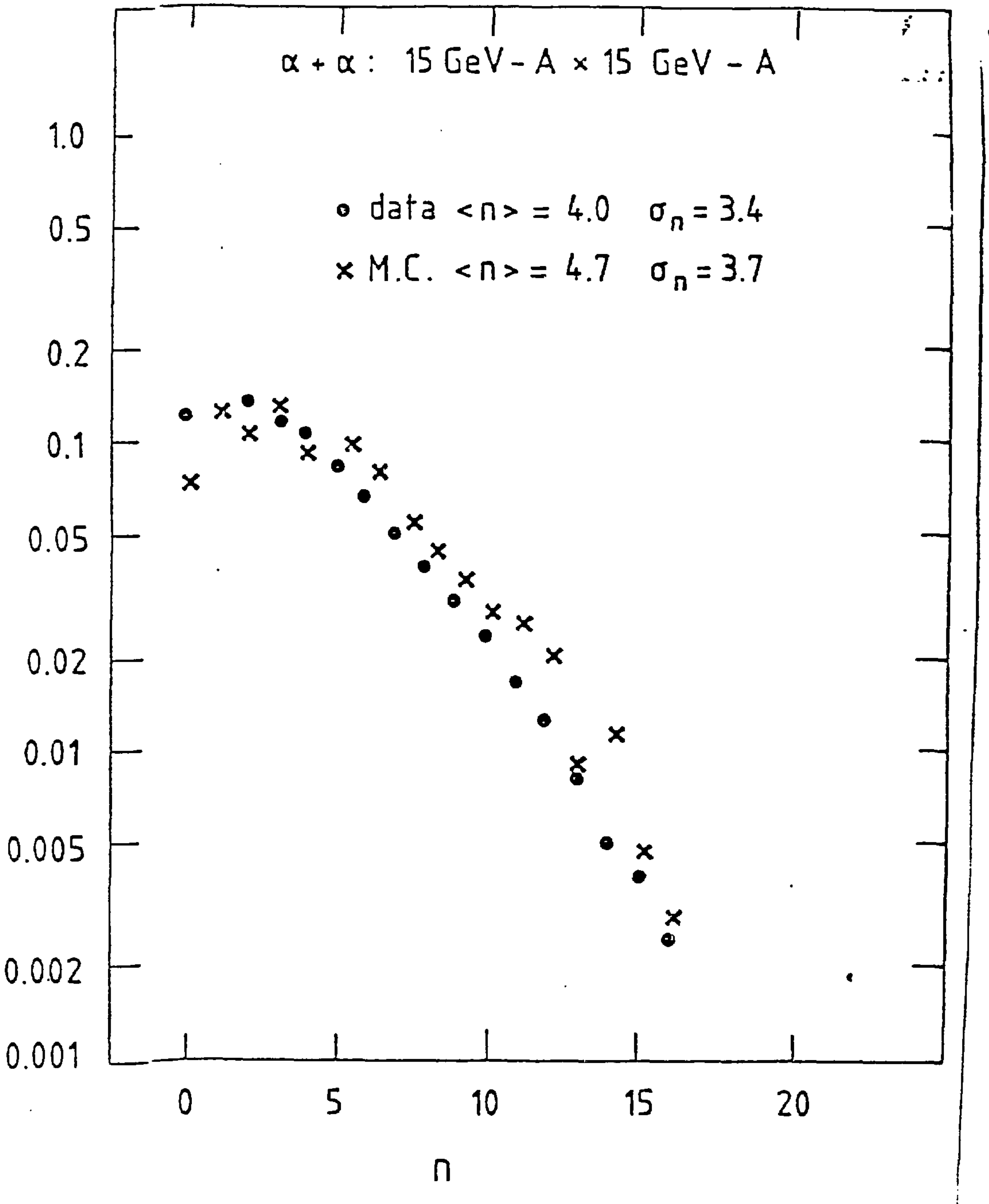

Figure 4. Multiplicity distribution for charged particles produced near central rapidity in α-α interactions at the CERN ISR (Ref. 5).

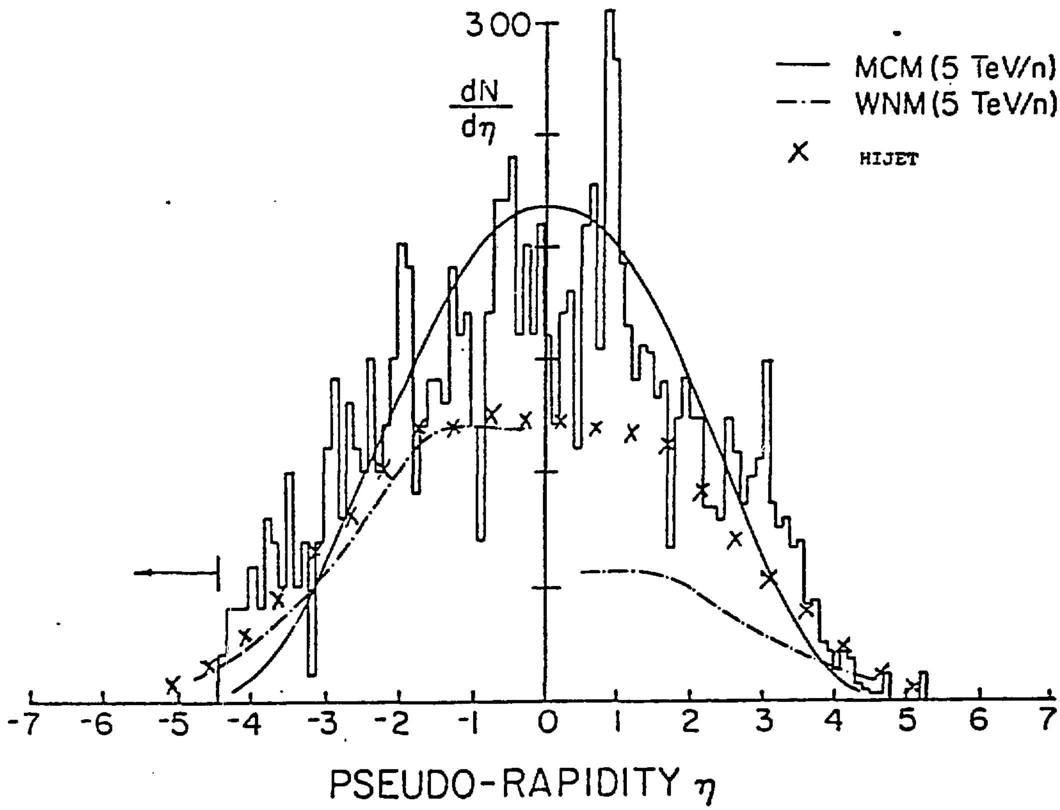

Figure 5. A high energy event from the JACEE cosmic ray sample (Ref. 6). The projectile nucleus is silicon, with an estimated energy of 5000 GeV/amu, interacting in photographic emulsion. There are 1015 charged tracks. The HIJET calculation is for central collisions of silicon on silver at this energy. The smooth curves are model calculations presented by the authors of Ref. 6.

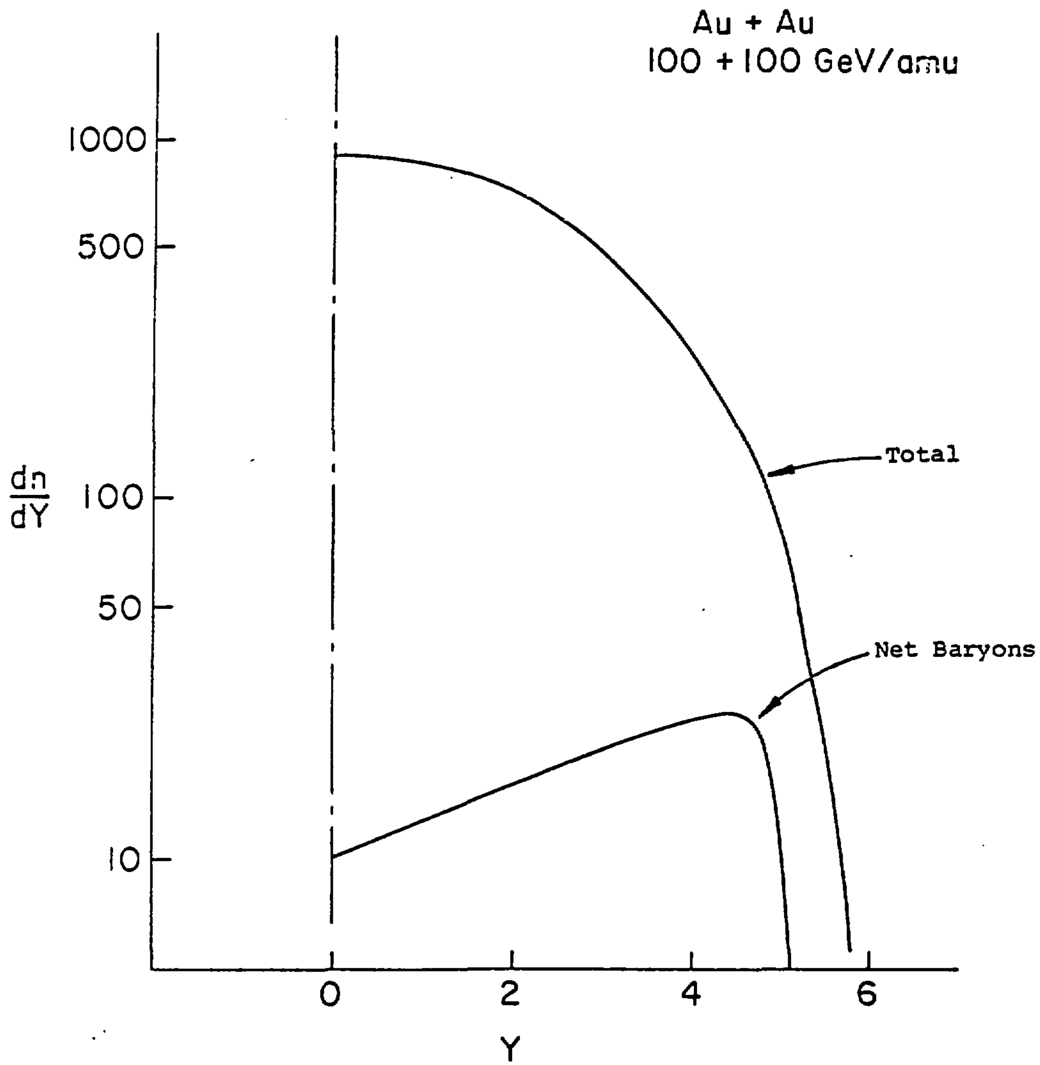

Figure 6. HIJET calculation of the rapidity spectrum in head-on collisions of gold nuclei with energy 100 GeV/amu in each of the colliding beams. (The symmetric distribution is shown for one hemisphere only. Note the log scale.) The mean charged particle multiplicity is 3300 per event.