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Deep inelastic collision followed by disassembly in the reaction ^{136}Xe + ^{209}Bi at $E_{\rm lab}/A = 28.2$ MeV

J. P. Bondorf and C. H. Dasso
The Niels Bohr Institute, Blegdamsvej 17, 2100 Copenhagen, Denmark

R. Donangelo
Instituto de Fisica, Universidade Federal do Rio de Janeiro, 21945 Rio de Janeiro, Brazil

G. Pollarolo
Dipartimento di Fisica Teorica dell', Universita di Torino and Istituto Nazionale di Fisica Nucleare, Torino, Italy

H. Schulz and K. Sneppen
The Niels Bohr Institute, Blegdamsvej 17, 2100 Copenhagen, Denmark
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We show that a major part of the neutron and charged-fragment multiplicity distributions measured in the collision of ^{136}Xe on ^{209}Bi at an incident energy of $28.2A$ MeV can be reproduced by assuming that the colliding nuclei decay independently after a highly dissipative process.

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Recently [1] we have presented results of a model calculation which show that the decay pattern of the collisions of ^{40}Ar on ^{232}Th at incident energies between 27 and $77A$ MeV [2] and ^{208}Pb on ^{197}Au at an energy of $29A$ MeV [3] can be understood by assuming that most of the reaction cross section is associated with the binary collision process. This implies that even the highest multiplicity events do not necessarily originate from the disintegration of a large compound nuclear system, but rather from the individual decay of the colliding partners.

This reaction scenario has been confirmed recently by exclusive measurements performed by Lott *et al.* with a combination of 4π neutron and 4π charged-particle detectors [4]. The data suggest that even rather central collisions may be dominated by events in which the identity of a projectilelike and a targetlike fragment is well preserved. This situation is very interesting from a theoretical point of view and calls for further studies on the validity of such interpretation at still higher bombarding energies.

Here we perform the model calculations outlined in Ref. [1] for the reaction investigated in Ref. [4] and show that the trends of the neutron and charged-particle distributions for $28.2A$ MeV ^{136}Xe on ^{209}Bi are also compatible with a predominantly binary collision process. As in Ref. [1] the dynamical aspects of the collision are described using the TORINO heavy-ion reaction code [6] which yields the distribution of the dissipated energy in both collision partners. The disintegration of the highly excited systems is calculated with the Copenhagen statistical multifragmentation model which first determines the primordial distribution of fragments after the prompt breakup and then follows their subsequent decay [5].

In Fig. 1 we display the kinetic-energy loss as a function of the impact parameter and the probability distribution of excitation energies for the projectilelike and tar-

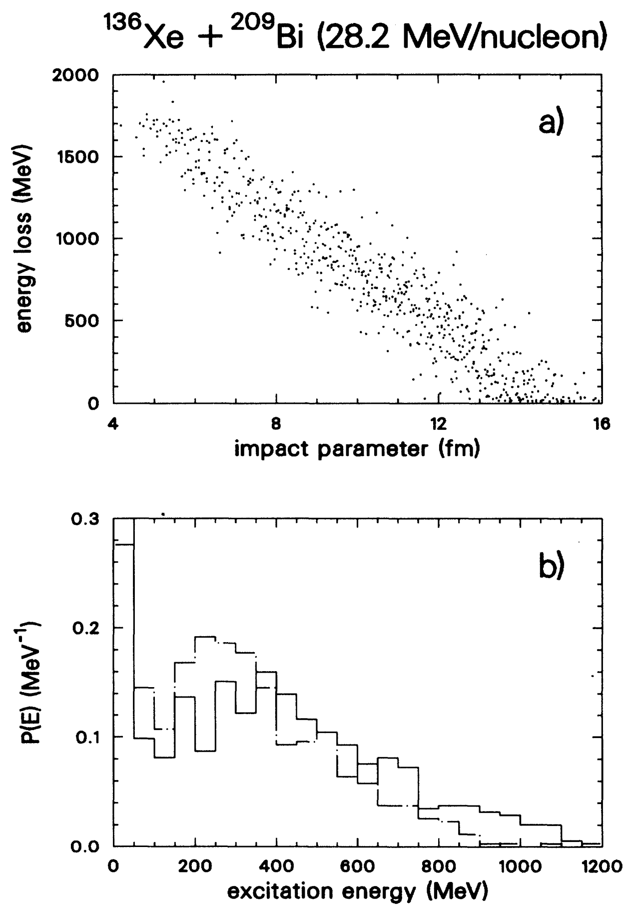

FIG. 1. (a) Kinetic-energy loss as a function of the impact parameter. (b) Distribution of excitation energies for the projectilelike (dot-dashed) and targetlike (full line) colliding systems.

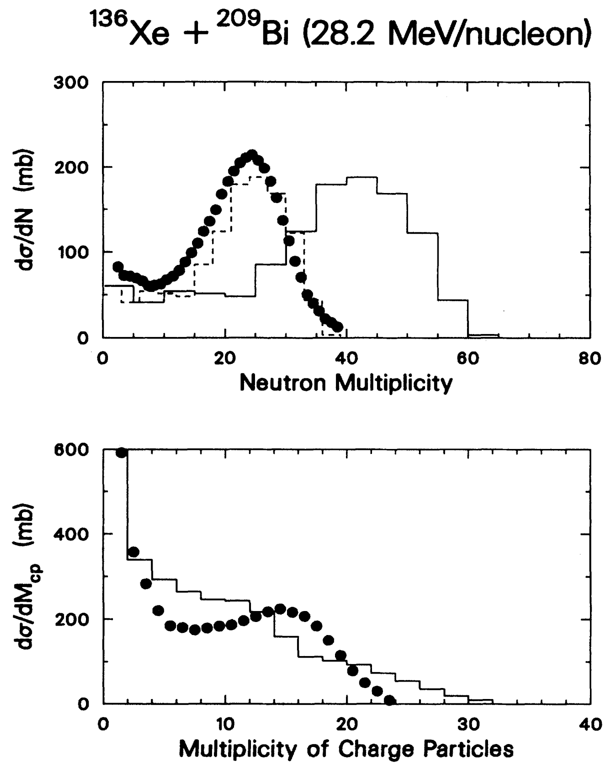

FIG. 2. Neutron (a) and charged-particle (b) multiplicities for the reaction of 28 A MeV ^{136}Xe on ^{209}Bi. The dots represent the experimental results of Ref. [4]. The dashed histogram in (a) takes into account a neutron detection efficiency of 60%.

getlike systems in a collection of simulated events. We note that the fluctuations of the excitation energy with the impact parameter are quite large and that the functions $P(E)$ extend to excitation energies sufficiently high to crack the colliding nuclei into many small fragments.

The multiplicity distributions of neutrons and charged particles are given in Fig. 2. The theoretical cross sections (full-drawn histograms) incorporate no adjustable parameters to fit the data and, in particular, have not been corrected to take into account experimental limitations. Using a neutron detection efficiency of $\approx 60\%$, as quoted in Ref. [4], yields the dashed histogram in Fig. 2(a), which agrees well with the measurement. A similar, simple scaling for the charged-particle distribution is not possible because of the wide diversity of mass partitions that feed the histogram bins. The correspondence between theory and experiment appears to be, in any case, not as close as in the neutron case. There is experimental indication for a bump at a multiplicity of about 15 charged particles which is not present in our results. This structure could be associated with the decay of a composite system formed in very central collisions. We recall that about 15% of the reaction cross section—corresponding to these events—cannot be reliably ascribed by our formulation [1].

The inferred predominance of binarylike events up to about 30 MeV per nucleon underscores how such processes can still be relevant at an intermediate-energy domain. To shed further light on these issues the importance of performing experiments like the one reported in Ref. [4] for a variety of systems and at even higher beam energies cannot be overemphasized.

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