

## On the different Clusterization algorithms and their role to study event-by-event correlations among fragments

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### Introduction

Dynamical models saw tremendous growth in understanding multifragmentation [1], but what causes a highly excited system formed during energetic nucleus-nucleus collisions to break into several intermediate mass fragments still remains an open question. To study the origin of the fragments, one needs to identify them. One of the most widely used approaches is based on the spatial correlation among nucleons [2]. This has proven to be quite successful in explaining the experimental data of fragmentation, in particular, in the energy domain of 50 to 150 MeV/nucleon [3]. On the other hand, certain disagreement between experimental measurements and theoretical predictions has been observed at higher incident energy and for mildly excited systems. This has led to the development of complicated Simulated Annealing Clusterization Algorithm (SACA) [4] which is based on the metropolis procedure and is capable of detecting the fragments at an early stage of a reaction [5].

The SACA method is based on the concept of energy minimization of the system to find the most bound configuration of fragments. This algorithm has been able to explain the ALADiN data for the reactions of  $^{197}\text{Au}+^{197}\text{Au}$  having energies ranging between 35 MeV/nucleon to 1000 MeV/nucleon and for all impact parameters [6]. But its limited use in fragment identification is because of its large computational time. In all the comparisons of SACA with experimental data, one has used the average properties for e.g., av-

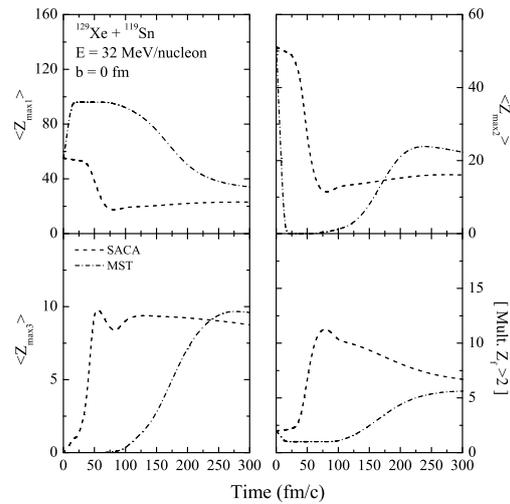


FIG. 1: The mean charge of the first, second, third largest fragments and multiplicity of the fragments with charge  $[Z_f > 2]$  as a function of time for the central reactions of  $^{129}\text{Xe}+^{119}\text{Sn}$  reaction at an incident energy of 32 MeV/nucleon. Results are shown here are for SACA (dashed lines) and MST algorithms (dash-dotted lines).

erage size of the largest fragment, multiplicities of the light charge particles, intermediate mass fragments and charge distribution only. With the advancement in the experimental measurements, the predictability of the model parameters and the secondary algorithms has to be tested to a deeper level. In the present study, to check the compatibility of n-body dynamical model, we have compared our calculations using SACA and MST methods with experimental observations based on event-by-event correlations among fragments.

### Results and discussion

We have simulated the central reactions of  $^{129}\text{Xe}+^{119}\text{Sn}$  at an incident energy of

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32 MeV/nucleon using a soft equation of state and energy-dependent nucleon-nucleon cross section. Fragments are identified from the phase space generated by the primary model quantum molecular dynamics (QMD) [7] model using SACA and MST methods. In Fig. 1, we have shown the time evolution of the average charge of the first, second, third largest fragments and multiplicity of the fragments with  $Z_f > 2$ . At the initial time, when system is in compression stage, MST (dash-dotted lines) detects one big fragment with size equal to the mass of projectile and target. With the advancement in the time, the system expands due to pressure gradient, causing the largest fragment to break into other fragments, therefore, the second and third largest fragments can be detected. The multiplicity of the other fragments also starts to increase. The fragment structures saturates at around 300 fm/c, which we took as freeze out time for the MST method. On the other hand, SACA (dashed lines) can identify the fragment structures much earlier in time when the system is still in compressional phase ( $\sim 60$  fm/c).

In Fig. 2, we have compared our predictions using SACA (open circles) and MST (open triangles) methods with the experimental data [8] (solid lines) on average charge distribution and distribution of the first, second and third largest fragments averaged over the events. It is observed that MST method can give consistent results qualitatively for charge distribution, distribution of first and second largest fragments, but fails completely to explain the measured trends for distribution of third largest fragment. Whereas, SACA not only explains the experimental trends for all the quantities qualitatively but also quantitatively to a great extent. Thus with the SACA method, we are able to explain the charge partition of fragments event-by-event. It is important to mention here that this is the first time that any dynamical model is able to explain the charge correlations on event-by-event basis.

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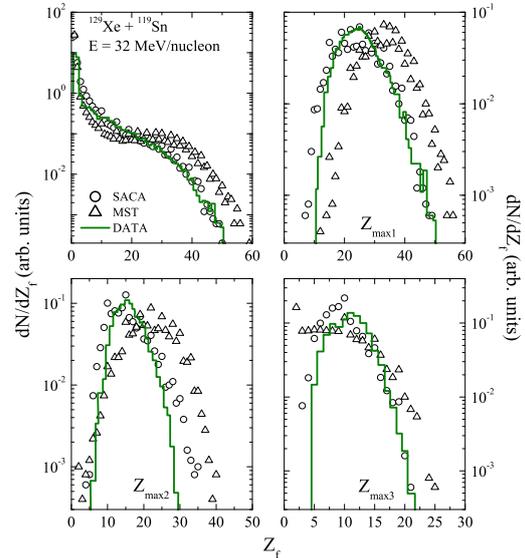


FIG. 2: The charge distribution, distribution of first, second and third largest fragments for the central reactions of  $^{129}\text{Xe} + ^{119}\text{Sn}$  at an incident energy of 32 MeV/nucleon. Results are shown here for SACA (open circles) and MST (open triangles) approaches (preliminary results). Experimental data is represented by solid lines and is been extracted from Ref. [8].

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