# TIME SCALES AND DYNAMICS OF $^3$He-INDUCED MULTIFRAGMENTATION

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The time scale and breakup dynamics of multifragmentation reactions between 1.8 to 4.8-GeV $^3$He ions and Ag or Au targets have been investigated through angular correlations between intermediate mass fragments (IMF). Data were taken with the ISiS $4\pi$ detector array[1] at the Laboratoire National Saturne in Saclay (E228). Earlier papers have reported results on energy deposition and fragment multiplicity, charge and kinetic energy distributions.[2]

Fragment correlation functions have been calculated in terms of the ratio of coincident ($Y_{12}$) to single-particle ($Y_1 \cdot Y_2$) yields:

$$R = const\left[\frac{Y_{12}(p_1 p_2)}{Y_1(p_1)Y_2(p_2)}\right] - 1 \qquad (1)$$

where $p_1$ and $p_2$ are the IMF laboratory momenta. Here we assume $A_i = 2Z_i$ in calculating the momenta, $p_i$, from kinetic energy spectra. The normalization constant is fixed by the requirement that R = 0 for large relative momenta, which should correspond to uncorrelated events.

Correlation functions for small relative angles are sensitive to the breakup time scale. In Fig. 1, the correlation functions for the 4.8-GeV $^3$He + Ag, Au reactions are shown as a function of the reduced velocity of fragment pairs, $v_{red} = (p_1/m_1 - p_2/m_2)/(Z_1 + Z_2)^{1/2}$. Three different gates on deposition energy are shown – gauged here by the number of thermalized charged particles ($M_{th}$) detected in the reaction. The suppression of coincidence yield at small reduced velocities scales with collision violence ($M_{th}$) and reflects the Coulomb repulsion experienced by fragments with similar velocities. The suppression of the correlation function for the largest $M_{th}$ events is large relative to heavy ion results[3] and implies very short time scales for breakup of the most highly excited residues: $\lesssim$30 fm/c for Ag and $\lesssim$50 fm/c for Au.

Large-angle relative velocity correlations probe the breakup dynamics of the system. Fig. 2 presents large-angle correlations for the 4.8-GeV $^3$He + Au reactions in terms of the relative velocity of fragment pairs with identical charge, where $v_{rel} = (\vec{p}_1/m_1 + \vec{p}_2/m_2)$. Large relative velocities imply emission from a hot source near normal nuclear density, while lower values are associated with a cooler/more dilute system. These data have been compared with two model calculations, the expanding, evaporating source (EES)[4] and

## IMF Correlation with Thermal Multiplicity Gates

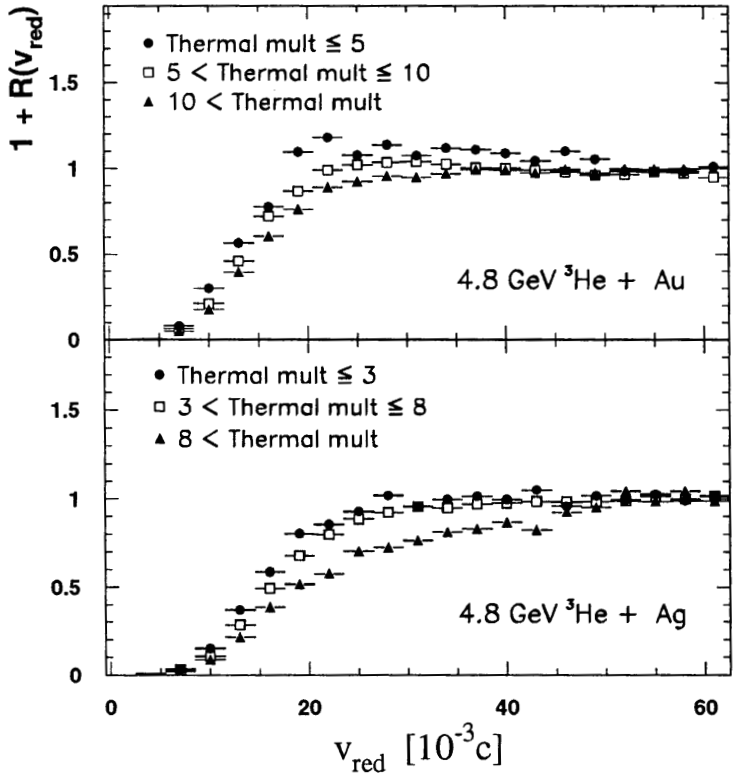


Figure 1. Small-angle, reduced velocity correlation functions for 4.8-GeV $^3$He + Ag, Au as a function of event thermal multiplicity, as indicated on the figure.

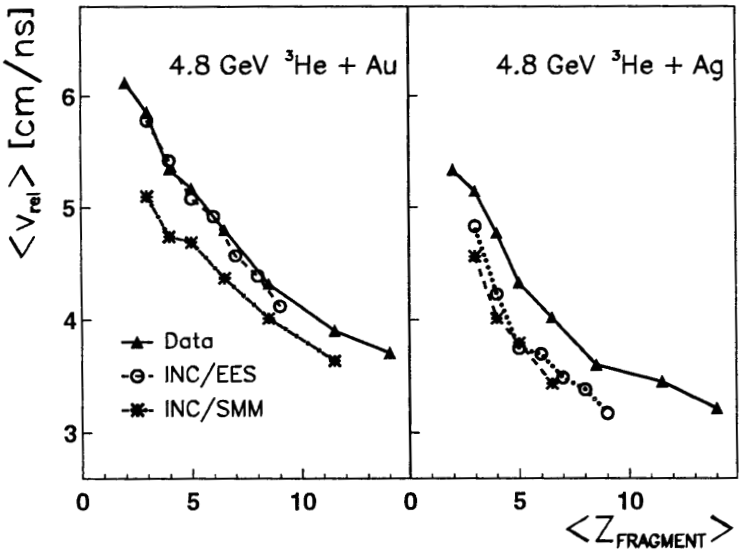


Figure 2. Large-angle average relative velocities for identical Z fragments emitted in 4.8-GeV $^3$He + Au reactions. The data (triangles) are compared with the INC/SMM model (squares) and the INC/EES model (circles).

statistical multifragmentation (SMM)[5] models, both of which use identical intra-nuclear cascade code input to define the excitation energy of the fragmenting residues.[6] Generally, good agreement is found with the EES model, which involves sequential fragment

emission from an expanding source, followed by breakup of residues excited to high temperatures (T $\gtrsim$12 MeV). The SMM model gives a reasonable description of the data for fragments with Z > 6, but under-predicts the lower Z correlations. These results suggest that multifragmentation induced by light ions is a time-dependent phenomenon in which light fragments are preferentially emitted from a hot, expanding source, followed by rapid multi-body disintegration for the hottest systems.


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3. D. Fox *et al.*, Phys. Rev. C **47**, R421 (1993).
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## MULTIFRAGMENTATION IN THE 5.0- TO 14.6-GeV/c $\pi^-$, p + $^{197}$Au REACTIONS


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Excitation functions for charged-particle emission in the 6.0- to 14.6-GeV/c p + $^{197}$Au and 5.0- to 9.2-GeV/c $\pi^-$ + $^{197}$Au reactions have been measured with the ISiS $4\pi$ detector array at the Brookhaven AGS (E900). For these secondary beams, we associate protons with the positive beam and $\pi^-$ with the negative beam from the AGS production target.