Coalescence and Chemical Equilibrium in Multifragmentation at Intermediate Energies

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In November, 1999 and April, 2000 the TAMU NIMROD detector, a 4B charged particle array inside a 4B neutron calorimeter, was used to carry out a series of experiments designed to explore the mechanisms of light cluster and intermediate mass fragment emission in multi-fragmentation reactions induced by intermediate energy heavy ion projectiles on medium and heavy mass targets. Reactions studied to date include.

26 A MeV $^{40}Ar + ^{92}Mo$

26,35,47 A MeV $^{22}Ne + ^{117}Sn$

26,35,47 A MeV $^{64}Zn + ^{92}Mo$

35 A MeV $^{54}Fe + ^{100}Mo$

40 A MeV $^{40}Ar + ^{112}Sn$

40, 55 A MeV $^{27}Al + ^{124}Sn$

47 A MeV $^{64}Zn + ^{48}Ti$

47 A MeV $^{64}Zn + ^{159}Tb$

47 A MeV $^{64}Zn + ^{197}Au$.

Analyses of earlier experiments performed with our more limited CsI ball system led to the development of coalescence model based techniques for characterizing hot expanded multi-fragmenting nuclei at freeze-out [1]. This more extensive set of measurements was selected to probe the impact parameter, excitation energy, mass and isospin dependencies of the dynamic evolution and equilibration processes.

The NIMROD array, in addition to providing much more complete geometric coverage, has lower detection thresholds, a larger dynamic range for light charged particle detection and allows isotopic identification at least to Z=10. These features are illustrated in Figures 1-4 which depict on line raw data obtained with the ionization chambers, Si detectors and CsI detectors.

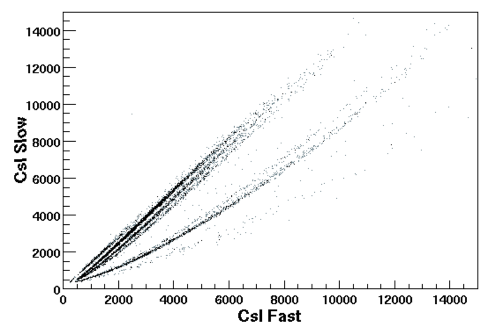

Figure 1. Result of the pulse-shape analysis of the CsI signal. The Slow component versus the fast shows the different light particles (p, d, t, ^{3}He and a) discrimination.

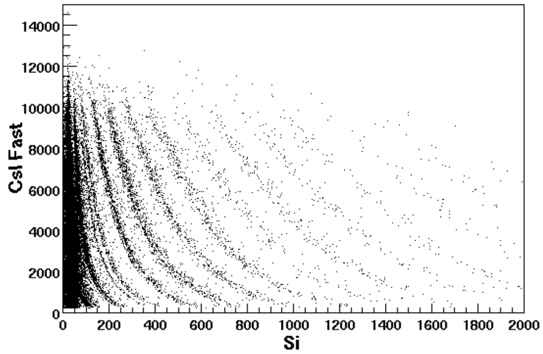

Figure 2: Fast component of the CsI Signal versus Si.

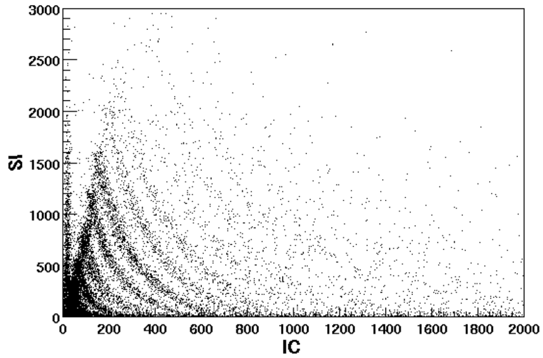

Figure 3: Silicon detector (300 :m) versus Ionization Chamber (IC).

In Figure 5 the event by event correlation between neutron multiplicity and charged particle multiplicity observed for the ^{64}Zn(47 A MeV)+^{92}Mo reaction is shown.

To further refine these measurements, we borrowed five discrete neutron detectors from the Belgian-French DEMON array [2-3] and used them to make simultaneous measurements of the neutron spectra. Although the NIMROD environment is not ideal for neutron spectral measurements, the strong neutron absorption of the neutron calorimeter removes a large fraction of the scattered neutrons. It appears that with the help of GEANT simulations to evaluate attenuation and scattering effects valid neutroon spectra and multiplicities can be obtained. These data will be particularly valuable in excitation energy

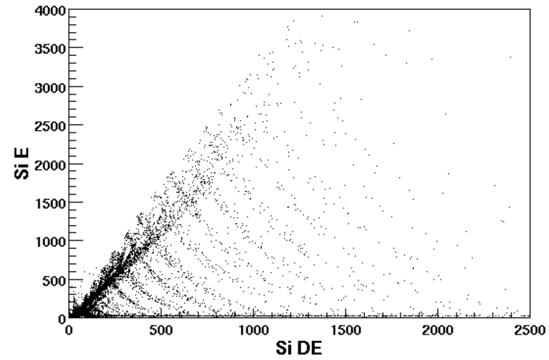

Figure 4: Silicon)E (150 :m)-E (500 :m) Telescope.

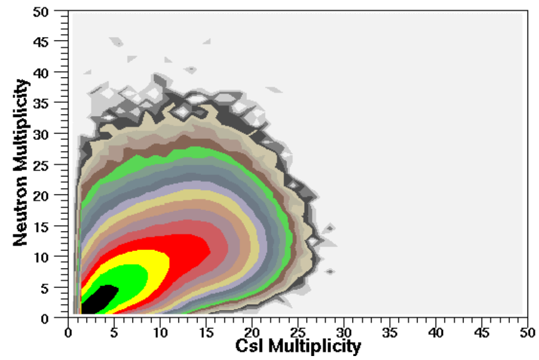

Figure 5: Two-dimensional plot of the neutron multiplicity (neutron ball) versus the charged particle multiplicity (CsI).

determinations and in refining our coalescence model treatments.

The complete analyses of these experiments are now underway. Initially they are focused on distinguishing dynamical and statistical mechanisms of light cluster and intermediate mass fragment emission in order to probe the evolution of the hot composite systems formed and establish the degree of thermal and chemical equilibrium achieved.

References

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