N-Z equilibration in target-like and projectile-like fragments

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Recent work has shown N-Z equilibration follows first-order kinetics within projectile-like fragments (PLF*) in symmetric ^{70}Zn, ^{64}Zn, and ^{64}Ni reaction systems at 35A MeV. Due to the angular distribution indicative of a timescale of PLF* decay much shorter than its rotational period, the angle of rotation was used as a surrogate for time. We propose future experiments to examine the N-Z equilibration within the target-like fragments (TLF*) and PLF*.

Constrained Molecular Dynamics (CoMD) simulations were performed for ^{40,48}Ca+^{40}Ca reaction systems at 10A and 15A MeV and for ^{64,70}Zn+^{40}Ca reaction systems at 10A MeV. For each reaction system with the exception of ^{48}Ca+^{40}Ca at 10A MeV, 10,000 events were analyzed. For each event, fragments were sorted based on atomic number. Fragments were sorted into two categories: fusion events and binary decay. Fusion events are considered events where the largest fragment had an atomic number of Z≥30 for ^{40,48}Ca+^{40}Ca and Z≥40 for ^{64,70}Zn+^{40}Ca and the second fragment has a Z<10. For the ^{40,48}Ca+^{40}Ca reaction systems at 15A MeV, approx. 15% of all events were fusion events. The number of fusion events was 18-20% for the reaction systems at 10A MeV. For the binary decay events, the two biggest fragments were required to have a Z>10. The TLF* was designated as the fragment with the smaller velocity in the laboratory frame; the PLF* has a greater velocity. The average multiplicity for each reaction system, with the exception of the ^{48}Ca+^{40}Ca at 10A MeV, was six. The ^{48}Ca+^{40}Ca reaction system had an average multiplicity of five. However, the width of the distribution was greatest for the

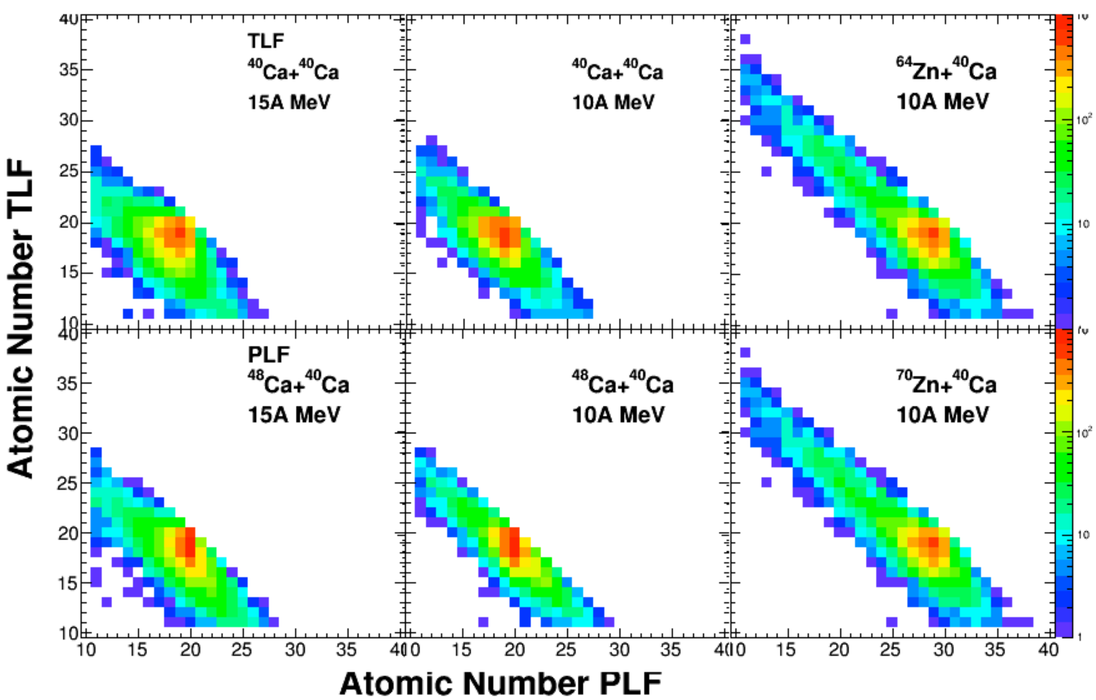

FIG. 1. The atomic number of the TLF* and the PLF* for all six reaction system. The neutron-poor systems are on the top row and the neutron-rich systems are on the bottom row. The largest yield corresponds to loss of 1-2 protons per fragment.

^{40,48}Ca+^{40}Ca reaction system at 15A MeV. The maximum for this system was 18. The ^{40,48}Ca+^{40}Ca reaction system at 10A MeV has the smallest width and a maximum multiplicity of 14. The composition of the fragments was examined as seen in Fig. 1. The largest yield for each reaction system corresponded to loss of 1-2 protons per TLF* and PLF*. The spread in the Zn+^{40}Ca reaction is due to the 10 proton difference between Zn (Z=30) and Ca (Z=20). A similar trend was observed for the mass of the TLF* and PLF*. The yield was peaked on a loss of 3-4 nucleons.

Looking at the velocity distribution, the PLF* is located above center of mass velocity (v/c=0.07 for 10A MeV reaction systems and v/c=0.09 for 15A MeV reaction systems). The velocity of the TLF* is below the center of mass velocity. The majority of the TLF* and PLF* are located at v/c=0, which is the initial velocity of the target fragment, and at the beam velocity (v/c=0.15 for 10A MeV reaction systems and v/c=0.18 for 15A MeV reaction systems), respectively.

For detector design, the energy-angle correlation was examined. The results are shown in Fig. 2. There are two areas of concentration corresponding to the different fragments. For the PLF*, the majority lies between 0-10° with the range expanding slightly for the lower energy reaction systems. The grazing angle for the reactions at 10A MeV is 9° and 6° for the 15A MeV reactions. This presents a challenge for detector design since most of the PLF* fall within the grazing angle. The PLF* also has significantly

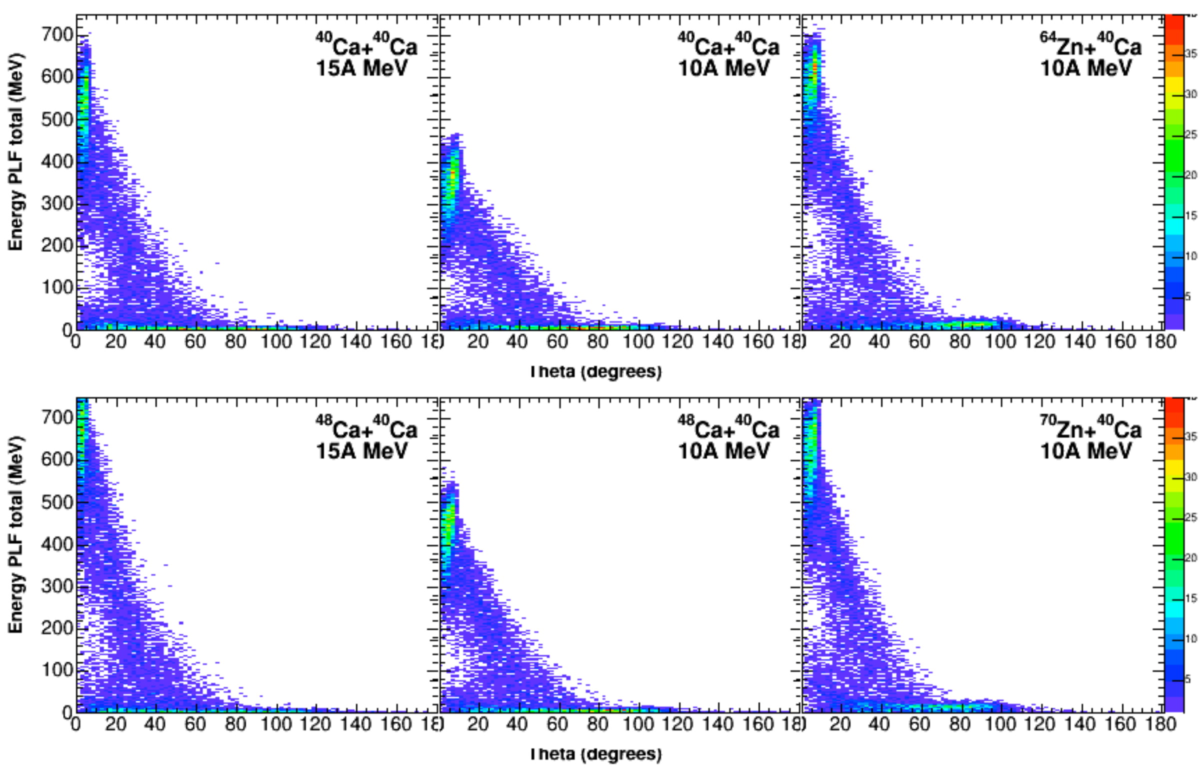

FIG. 2. Energy vs. theta. The top row corresponds to the neutron-poor reaction systems; bottom to the neutron-rich. The large concentration at high energy and small angles corresponds to the PLF*. The TLF* is located between 0-120° and under 50 MeV.

higher energy than the TLF* with energies around 9-14A MeV. The energy of the TLF* is below 10 MeV for the $^{40,48}Ca+^{40}Ca$ at 15A MeV. For the lower energy systems, the TLF* increases in energy. However, most PLF* still have an energy below 10 MeV. By changing the projectile from Ca to Zn, the energy of the TLF* was increased to 20 MeV. This increases the likelihood of detecting the TLF*.