Reactions of Fe and Ni at Intermediate Energies

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In recent years much attention has been paid, both experimentally and theoretically, to the isospin of a reacting system and its effect on the reaction mechanism [1-4]. The three main reaction systems studied including ^{58}Fe + ^{58}Fe, ^{58}Fe + ^{58}Ni, ^{58}Ni + ^{58}Fe, and ^{58}Ni + ^{58}Ni at energies of 35 and 45 MeV were chosen to minimize the effects of size on the reaction. The neutron to proton ratio of the systems ranges from 1.3 to 1.07, respectively. The fragments were detected using the 4π multidetector NIMROD. Neutron multiplicities, N_n, and charged particle multiplicities, N_c, as well as the isotopic composition of the fragments was studied.

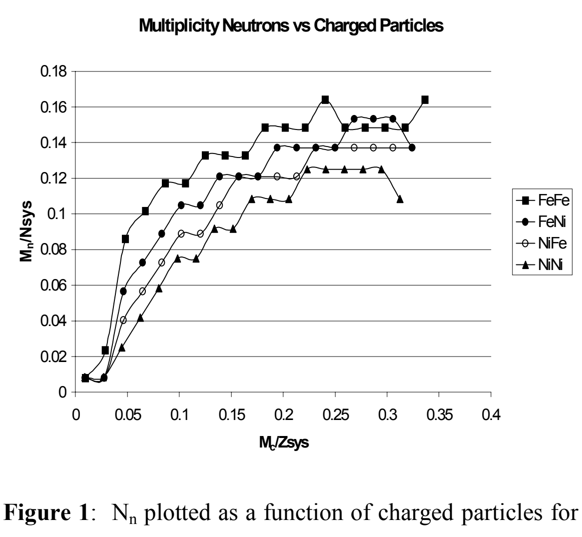

Figure 1: N_n plotted as a function of charged particles for the four different reaction systems. The errors in M_n/N_{sys} are estimated to be no greater than 0.008 units

Plots of the N_n versus the N_c were created for each reaction system. From these plots the most probable value of N_n is calculated as a function of N_c and is displayed for all the reaction systems in figure 1.

The neutron multiplicities are normalized by dividing by the total number of neutrons contained in the system, the same was done for the charged particles.

From the graph it can be seen that the more neutron rich systems preferentially give off more neutrons, in concordance with the results of Dempsey and Kunde[5,6]. Additionally, the plots of the multiplicity of neutrons versus charged particles are extremely important in event selection where events were characterized by their respective impact parameters.

The isotopic composition of the fragments is determined for the elements boron, carbon, and nitrogen. Unless otherwise specified all isotope ratios are calculated from the ring 67 data, at lab angles between 15.3 and 27.8 degrees.

For the following analysis, different cuts on the neutron multiplicity are made. While a stricter determination of the centrality of the collision could be achieved through the use of cuts on both neutron and charged particle multiplicity for the present purposes the neutron cut was sufficient. The three different cuts were for neutron multiplicities above 10, all multiplicities, and multiplicities below 6. These cuts allowed for the most violent collisions, all collisions, and the most peripheral collisions to be selected respectively (figure 2). An apparent trend is that the more neutron rich the system is, the more neutron rich isotopes are formed. The second interesting feature is that if the results for the different cuts are plotted for each reaction system it can be seen that the lower the multiplicity, the more neutron rich isotopes are produced.

This can be understood in the following manner. The lower the multiplicity of the reaction the more peripheral it is. Particles that are emitted from these reactions could be coming from a neck-

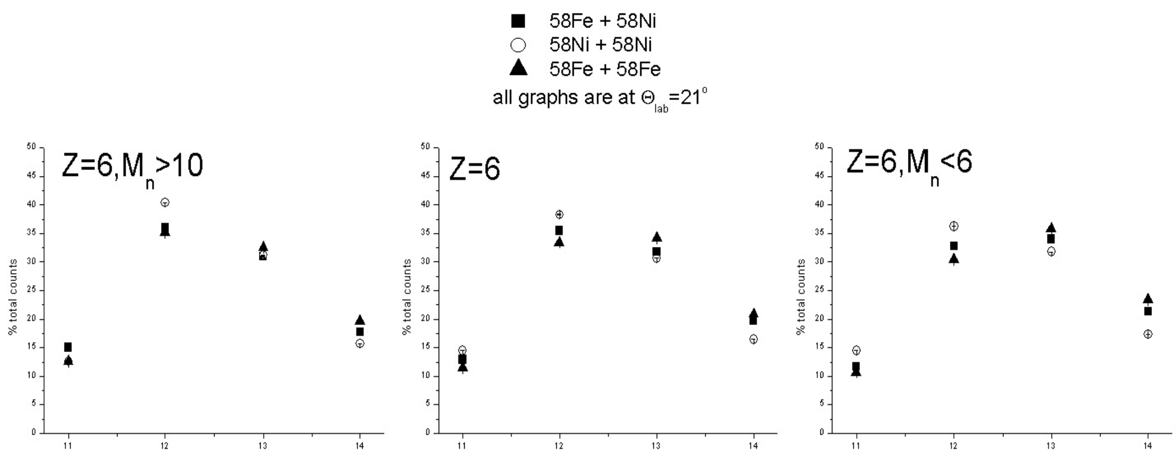

Figure 2: Isotopic distribution of carbon fragments from the three different reactions at energies 45 MeV for central (left), inclusive (middle), and peripheral (right) collisions.

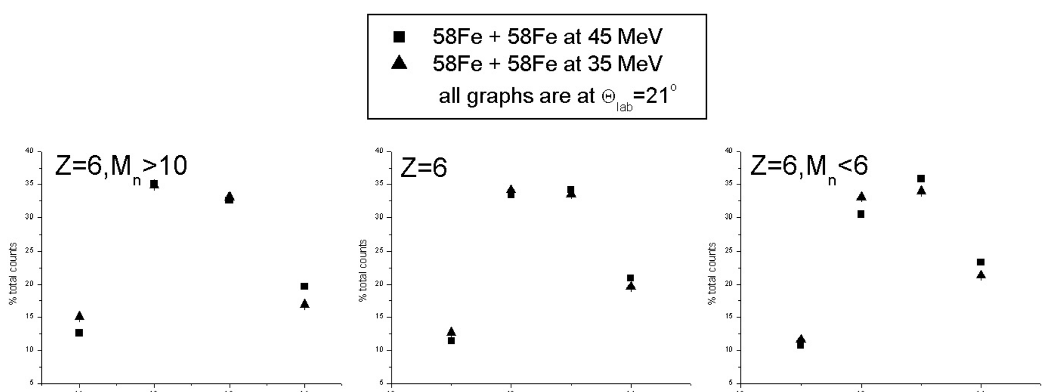

Figure 3: Isotopic distribution of carbon fragments from the reactions of $^{58}Fe + ^{58}Fe$ at energies of 35 MeV/nucleon (circles) and 45 MeV/nucleon (squares) for central (left), inclusive (middle), and peripheral (right) collisions.

like region, which is predicted to be more neutron rich than the surrounding nuclear material [6].

The system was also analyzed for the effect of incident energy (figure 3) on the isotopic fragments.

In summary the reaction of different systems of ^{58}Fe and ^{58}Ni were studied at 35 and 45 MeV/nucleon to try and gain insight into the effect of isospin on the reaction. From neutron and charged particle multiplicities the more neutron rich the system is the more neutrons are given off during the reaction even after correcting for the number of neutrons available. The isotopic analysis included the dependence of the fragment distribution on the neutron multiplicity, the detection angle and the incident beam energy.

References

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