Fusion of neutron-rich radioactive ^{132}Sn and ^{134}Sn with ^{64}Ni

The heaviest elements are produced in laboratories by fusion of two nuclei. Because of the large Coulomb repulsion, the production rate is extremely low. The first obstacle encountered in fusion is the Coulomb barrier generated by the two interacting nuclei. Having overcome the barrier, there are several paths that the amalgamating system can take and only one of which leads to the formation of compound nucleus (heavy element). The compound nucleus has a large probability of fissioning, breaking into large fragments, due to the Coulomb repulsion. If the compound nucleus does not undergo fission, it would evaporate light particles to reduce its excitation energies becoming a evaporation residue. The understanding of fusion processes is essential for using accelerators to synthesize the heaviest elements.

The use of neutron-rich radioactive nuclear beams is expected to enhance the production rate in heavy element synthesis. The excess neutrons in such nuclei will reduce the Coulomb barrier. The coupling to reactions with considerable strengths due to the large neutron excess is predicted to further enhance the fusion rate. The compound nucleus formed in such reactions would be less likely to fission and have a longer lifetime. If the heaviest elements were produced by neutron-rich radioactive beams, the long-lived heavy nuclei would improve the study of the physics and chemistry of these nuclei.

In the Holifield Radioactive Ion Beam Facility, neutron-rich radioactive beams are produced in moderate intensities. It provides an excellent opportunity for us to learn if and how neutron excess influences fusion processes. We have studied fusion reactions using neutron-rich radioactive ^{132,134}Sn beams on a ^{64}Ni target. Our measured evaporation residue yield are compared with fusion of stable $^{112-124}$Sn on ^{64}Ni in Fig. 1. The yield for producing evaporation residues of the same mass is higher in reactions with more neutron-rich Sn. This suggests that the heavy element production rate would be larger in neutron-rich radioactive beam induced reactions. Furthermore, the evaporation residues produced in ^{132,134}Sn induced reactions cannot be reached with stable Sn. Neutron-rich radioactive beams are required to synthesize new neutron-rich isotopes of heavy elements.

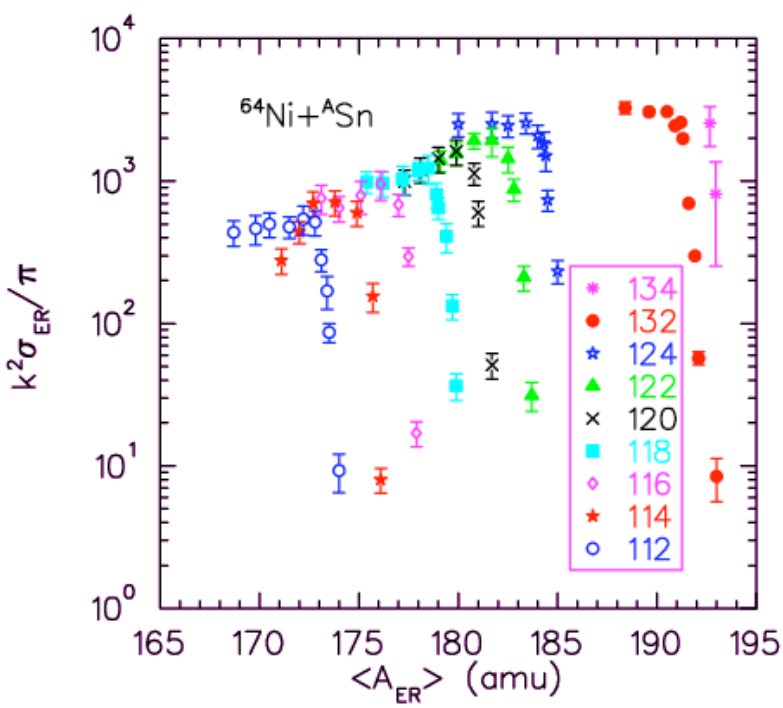

Fig. 1: Measured evaporation residue yields for $^{112-124,132,134}$Sn on ^{64}Ni as a function of calculated mass.