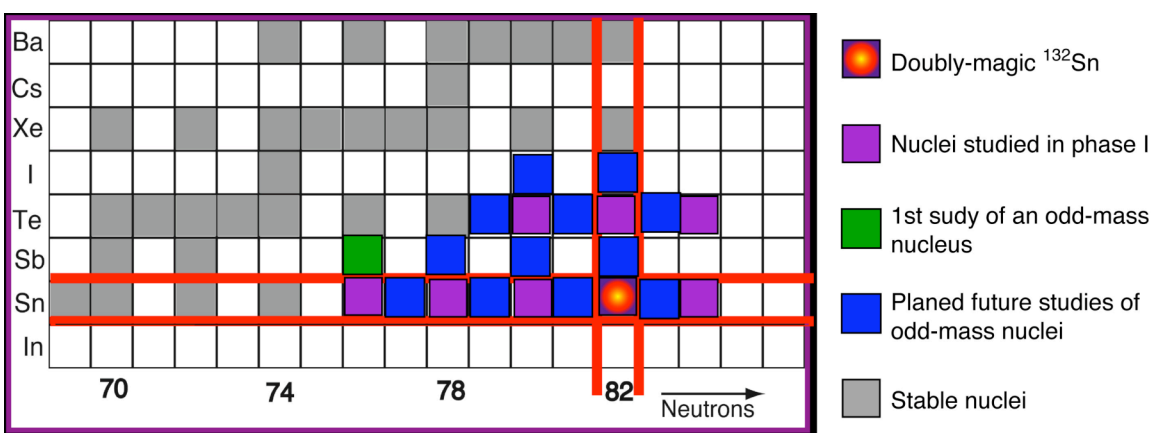
Probing Structures of Exotic Nuclei in the Vicinity of Doubly-Magic ^{132}Sn

Nuclei, similar to atomic systems, manifest shell-like structures that are completed when the number of protons or neutrons corresponds to certain values, called “magic numbers.” Nuclei that have both their neutron and proton numbers equal to one of the magic numbers are called "doubly magic", and are especially tightly bound together. Studies of these doubly-magic nuclei and their neighbors provide a wealth of information about the properties of the “single” protons and neutrons that surround the magic cores. Experimental information about these “single particles” such as their energies, moments, as well as the interactions among them provide the most crucial input to our theoretical models. Two of the best examples of doubly-magic nuclei are the well-studied stable ^{208}Pb, and ^{132}Sn, which is unstable and (until recently) poorly studied. The situation, changed dramatically when unique beams of reaccelerated ^{132}Sn and its neighbors became available at the HRIBF. In the past few years, we have used these beams to glean unique and vitally important information about the shell structure in this region. For example, when these energetic nuclei pass stationary target nuclei at close distances, they undergo a transition from their lowest energy level (ground state) to higher (excited) states. By studying the properties of the characteristic gamma rays, which are emitted when the nucleus of interest returns to its ground state, we can learn about the electric and magnetic moments of the excited state, its shape or composition, and how much its properties resemble those of the ground state. These studies, referred to as Coulomb excitation, have been carried out for many radioactive nuclei in the ^{132}Sn region that have even numbers of protons and neutrons. We plan to extend these pioneering studies to nuclei with an odd-number of nucleons in the near future. We are also improving our experimental techniques to be able to study exotic nuclei that lie farther from stability and are, hence, produced with smaller intensities. Furthermore, we will expand our complementary “transfer” experiments, in which a proton or neutron is transferred from/to the radioactive ion beam to synthesize a neighboring nucleus. By studying the probability that these processes take place, one can gain additional information about the complexities of “shell” structure around ^{132}Sn.



A partial chart of nuclei in the vicinity of the “doubly-magic” ^{132}Sn, showing nuclei of interest for Coulomb excitation and transfer studies at HRIBF. Each box corresponds to a

nucleus identified by neutron number (N) and proton number (Z). “Magic” numbers at N=82 and Z=50 (Sn) are indicated by heavy red lines which intersect at ^{132}Sn.