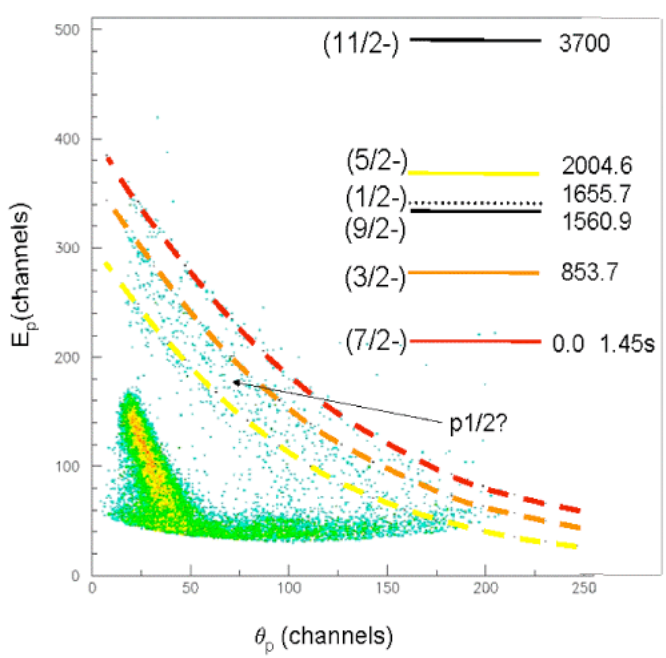
Nuclear states around the exotic doubly-magic nucleus ^{132}Sn probed at the HRIBF

Some atomic nuclei with special numbers of both protons and neutrons have unusually stable configurations. The properties of the five such naturally-occurring, "doubly-magic" nuclei have served as fundamental benchmarks in the development of the basic theory of atomic nuclei, the nuclear shell model. The production of beams of other short-lived doubly-magic nuclei at facilities like Oak Ridge National Laboratory's Holifield Radioactive Ion Beam Facility (HRIBF) is now enabling studies of nuclear configurations or "states" that test how well the shell model describes nuclei with more exotic combinations of protons and neutrons. This is especially critical to understand the origins of many of the nuclei heavier than iron that were initially formed as short-lived nuclei with a large excess of neutrons in violent supernova explosions. Unique beams of the doubly-magic nucleus ^{132}Sn, and neighboring nuclei ^{130}Sn and ^{134}Te, were produced at ORNL's HRIBF and used to study the properties of neutron states around ^{132}Sn. Neutrons were transferred from deuterium atoms in a thin foil target onto the incoming radioactive ions, and the protons left over from the deuterium were ejected from the target and then detected in large arrays of solid-state silicon detectors: the Oak Ridge Rutgers University Barrel Array (ORRUBA) and the Silicon Detector Array (SIDAR). The figure below shows the location of four of the observed neutron states. The measured properties of these nuclear states are helping us to understand how nuclear structure changes with proton and neutron number and how heavy elements are formed when stars spectacularly explode.



<u>Figure 1</u>: Observed energy versus angle for protons ejected when a neutron is removed from a deuterium atom and added to the exotic "doubly-magic" nucleus ^{132}Sn. The location of observed neutron states is indicated. The measured properties of these states are improving our understanding of how the structure of the nucleus changes with different numbers of protons and neutrons and how heavy elements are formed in exploding stars.