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Studying neutron-rich ^{18}N in fusion-evaporation reactions*

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Light neutron-rich nuclei provide an excellent opportunity to study the changes in nuclear shell structure that occur with increasing neutron number and are an important testing ground for shell model theories. Probably one of the most striking examples of shell modification is the occurrence of intruder ground states, which signal an inversion of the normal shell ordering. Intruder ground states are observed around ^{32}Mg (Z=10-12), "the island of inversion", and in ^{11}Be. An analogous situation appears in the Z=2 He isotopes, where the intrusion of sd excitations in p-shell configurations becomes important in the heavy helium isotopes. Finally, for Z=8, recent data on ^{20}O [1] show a reduction in the p-sd shell gap with increasing neutron number. It remains an open question whether the observed diminishing of the p-sd shell gap is restricted to O and F isotopes or extends also to neighboring nuclei.

Here, we report preliminary results on ^{18}N (Z=7), which is sufficiently far from stability to exhibit modified shell structure and yet still within the reach of stable beam facilities utilizing state-of-the art detector systems. ^{18}N was produced in the $^{9}Be(^{11}B,2p)^{18}N$ reaction at the 88" Cyclotron at LBNL and studied using the LIBERACE-STARS detector array – an array of large area segmented silicon detectors (E-ΔE) and six HPGe Clover detectors. This experiment was the first to use a fusion-evaporation reaction to populate ^{18}N. Previous information on the excited states of ^{18}N came from ^{18}C beta-decay [2] and charge-exchange reactions [3]. These are highly selective reactions and the fusion-evaporation reaction used here can provide a more comprehensive picture of the excitation spectrum. The beam energy of 50 MeV was chosen to optimize the cross section for the evaporation of 2 protons while simultaneously suppressing the evaporation of additional neutrons in conjunction with the 2p channel. The two proton tag cleanly selects the weak (sub milli-barn) ^{18}N products. A natural lead catcher foil was mounted between the target and Silicon detectors (3 cm distance) to detect gamma-rays emitted from long lived ($t_{1/2} < 1$ μs) states.

The ^{18}N γ-ray spectrum is shown in figure 1 and a preliminary level scheme in figure 2. New transitions were observed at 628 and 155 keV. The 628 and 114 keV transitions are shown to be in coincidence. The origin of the 298 keV line is currently being investigated. In ref. [2] a lifetime of > 600 ns was assigned to the first excited state at 114 keV. However, from our measurement we estimate a lifetime value of < 30 ns for this state; far shorter than the value of > 600 ns given from the beta decay experiment.

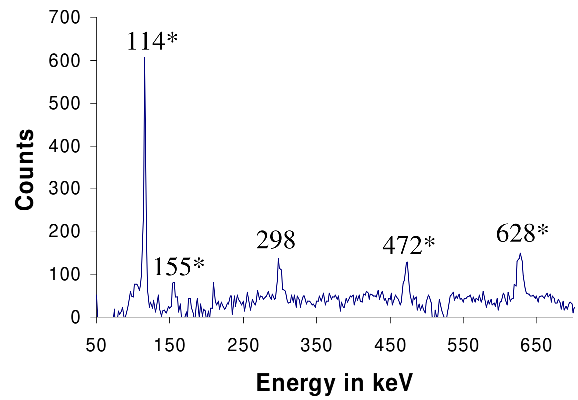

FIG. 1: Gamma-ray spectrum gated on the requirement of two protons hits in the silicon detectors. The contribution from random events has been subtracted. Transitions labeled with an asterisk are identified with ^{18}N events. The gamma-rays at 155 and 628 keV have been observed for the first time.

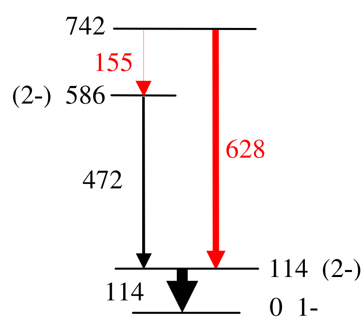

FIG. 2: Preliminary low-excitation energy level structure in ^{18}N. The widths of the transitions indicate the relative intensities normalized with respect to the 114 keV line. The transitions in red have been observed for the first time.

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