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The (d,p) reaction on ^{132}Sn: First complete determination of single-neutron excitations outside of doubly magic ^{132}Sn

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Over the decades, there have been many attempt to identify the single-neutron excitations outside of ^{132}Sn, with beta decay being a common approach. ISOLDE played a key role in identifying a subset of these states in the 90s [1]. A measurement of the ^{132}Sn(d,p) reaction, the ideal tool to probe these single-particle excitations, has been considered a flagship measurement, often used to motivate the development of the current and next generation radioactive ion beam facilities and equipment. To date, the (presumed) unbound $i_{13/2}$ excitation has not been observed, only estimated [2].
In 2010, a pioneering measurement of this reaction was carried out at Oak Ridge National Laboratory [3] at a beam energy of 4.77 MeV/u using a barrel-like array of silicon detectors. The measurement revealed for the first time the single-particle strength of the levels corresponding to the $f_{7/2}$, $p_{3/2}$, $p_{1/2}$ and $f_{5/2}$ orbitals. These states appear to carry all the single-particle strength, confirming the doubly magic nature of ^{132}Sn. However, due to the low beam energy, below barrier in the outgoing channel for all bar the ground state, the high-j states were not populated or, in the case of the $h_{9/2}$ excitation, could not be observed due to low resolution. Higher beam energy and the high resolution made possible by the solenoidal-spectrometer technique are is essential for such a measurement. Indeed, the development of the solenoidal spectrometer concept was motivated largely by an eventual measurement of the ^{132}Sn(d,p)^{133}Sn reaction [4]. Thus, ISOLDE and ISS offer a unique opportunity to completely map out the single-neutron excitations outside of ^{132}Sn, with a beam energy that makes it just possible.
For heavy systems, the performance of the ISS has been emphatically demonstrated in its inaugural year, with a study of the ^{206}Hg(d,p) reaction at 7.4 MeV/u, revealing for the first time the single-neutron structure outside of $N = 126$ [5]. Other facilities (Argonne, FRIB), may have slightly higher beam energy, but in the next 2-5 years, are unlikely to have comparable intensity and purity Sn beams.
For this measurement, we have assumed a beam energy of 8.5 MeV/u with an intensity of 1×10^5 particles per second or greater. The purity, if better than 90% is tolerable from past experience. At 2 T, the outgoing protons are dispersed across the whole array, taking advantage of the new ISS Si array. Recoil detection will be necessary, limiting the statistics slightly.
Furthermore, we can also consider the prospect of pushing for a measurement of the ^{134}Te(d,p) reaction, which would complete our knowledge the evolution of these single-neutron excitations from Sn to Sm, as the $g_{7/2}$ and $d_{5/2}$ protons fill the core up to the $Z = 64$ sub-shell at Gd.

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