First observation of ^{20}B and ^{21}B[†]

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It is well established that the shell structure of the nucleus, that leads to an enhanced stability for systems with "magic" numbers of protons (Z) and/or neutrons (N) of 2, 8, 20... is modified as the limits of particle stability, or driplines, are approached. Neutron numbers between 8 and 20 correspond to the filling of the *sd*-shell neutron single-particle orbitals. Approaching the driplines, the energies of these orbitals evolve, leading for example to the disappearance of the $N = 20$ magic number for $Z = 10$–12 and to the appearance of new shell closures at $N = 14$, 16 in the oxygen isotopes. In this respect, the most neutron-rich boron isotopes, which lie below doubly-magic ^{22,24}O and straddle the neutron dripline, are of considerable interest.

After removing one or two nucleons from secondary beams of ^{22}N and ^{22}C, produced at the RIBF of the RIKEN Nishina Center, with a carbon reaction target, beam-velocity ^{19}B fragments and neutrons were detected in the forward direction using the SAMURAI setup including the NEBULA neutron array. The relative energy between the ^{19}B fragment and the first detected neutron is shown in Fig. 1. A prominent resonance-like structure was observed at about 2.5 MeV above the one-neutron decay threshold (Fig. 1) that, guided by theoretical considerations, has been identified as the 1^-, 2^- ground-state doublet of ^{20}B, with energies $E_r = 1.56 \pm 0.15$ and 2.50 ± 0.09 MeV. A weaker higher-lying peak was also observed at 4.86 ± 0.25 MeV.

The data acquired for ^{21}B in the ^{19}B plus one- (Fig. 1) and two-neutron channels were consistent with the population of a resonance 2.47 ± 0.19 MeV above the two-neutron emission threshold, and thus tentatively assigned to be the expected $3/2^-$ ground state. These results allowed the first determinations to be made of the ground-state masses of ^{20,21}B, which are in agreement with the extrapolations of the most recent atomic-mass evaluations taking into account the ^{19}B, ^{22}C and ^{23}N mass measurements. In this spirit, the present ^{20,21}B masses will permit mass-surface extrapolations in this region to be made with improved precision and further from stability. In addition, ^{21}B was found to exhibit direct two-neutron decay.

The identification and first spectroscopy of ^{20,21}B opens the way to the exploration of structure and correlations beyond the dripline below ^{24}O. In particular, improvements in secondary-beam intensities and neutron detection should permit *n*-*n* correlations in the decay of ^{21}B to be investigated and its first excited state to be located. This, coupled with work underway to investigate the excited states of ^{22}C, will provide direct insights into the $N = 16$ shell closure beyond the neutron dripline as well as stringent tests of a new generation of *ab initio* and related theoretical models.

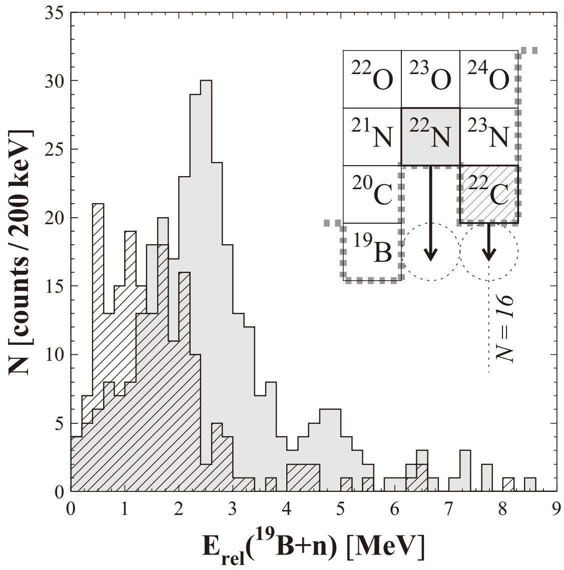

Fig. 1. Relative energy spectrum of ^{19}B+n events following proton-removal from ^{22}N (gray) and ^{22}C (hatched histogram). The gray dotted line in the inset delineates the neutron dripline.

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