Study of the superallowed β-decay of ^{100}Sn

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An experiment for studying the superallowed Gamow-Teller decay of the doubly magic nucleus ^{100}Sn was performed in June 2013 at the high-resolution separator BigRIPS of the RIBF at the RIKEN Nishina Center. The β-decay of a $g_{9/2}$-proton in ^{100}Sn to a $g_{7/2}$-neutron in ^{100}In shows the smallest log(ft) = $2.62^{+0.13}_{-0.11}$ value in the nuclear chart. The Gamow-Teller strength $B_{GT} = 9.1^{+2.6}_{-3.0}$, as deduced from the last experiment at GSI[1]. This value is consistent with the results of B_{GT} calculations as derived from LSSM calculations. However, the uncertainties in the extracted B_{GT} are still dominated by statistics. In particular, the contribution of the β-decay end-point energy $E_{\beta,max}$ amounts to 85% of the B_{GT} uncertainty. In the present experiment, a 4 mm Be target was bombarded with a ^{124}Xe beam of 345 MeV/u at intensities up to 36.4 pnA to produce ^{100}Sn by fragmentation. In total, 2525 ^{100}Sn ions (Fig. 1) were identified during 8.5 days of beamtime. This exceeds the number obtained in the previous experiment at GSI[1] by nearly a factor of 10, and the uncertainties in B_{GT} are expected to be improved by more than a factor of 2. Furthermore, a number of nuclides towards the proton dripline have been newly identified (see Čeliković et al.[2]) and significantly higher statistics for N=Z and N=Z-1 isotopes have been obtained.

In order to observe β- and γ-decays, ^{100}Sn and most of the neighboring nuclei (see Fig. 1) were implanted into the WAS3ABi detector, which is a closed stack consisting of three highly segmented silicon detectors of 1 mm thickness each surrounded by 84 Ge- and 18 LaBr-detectors of the 4π-γ-spectrometer EURICA. This WAS3ABi detector array is expanded by a stack of 10 silicon detectors of the same thickness in order to measure the total energy of the decay positrons accurately. Since $E_{\beta,max} = 3.29 \pm 0.20$ MeV is rather small[1], the decay positrons are stopped in the silicon stack, enabling a high-precision measurement in order to determine $E_{\beta,max}$. We find correlated β-decays by considering decay events occurring within a time window t_C and active detector volume around the implantation. Thus, we can determine the half-lives of β-decays. From β-delayed γ-decays, using the largest data sample on ^{100}Sn, we will be able to distinguish between two scenarios for the β-delayed γ-cascades to confirm a dominantly populated 1^+ state in ^{100}In after β-decay. Furthermore, we are looking for a 6^+ isomeric state in ^{100}Sn, as predicted by Grawe et al.[3] based on LSSM calculations.

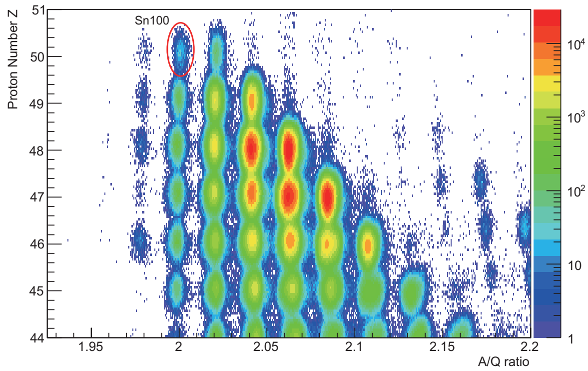

Fig. 1. figure
PID plot in the region of ^{100}Sn. The total number of identified ^{100}Sn nuclei is 2525 (red encircled region).

After a preliminary energy calibration of the WAS3ABi detectors, one of the most challenging tasks is to determine systematic uncertainties in the β-decay end-point energy $E_{\beta,max}$ and β-half-life $T_{1/2}$. A small (systematic) error in these quantities affects the B_{GT}, resulting in a large relative uncertainty. Since ^{100}Sn has a long half-life, the background contribution on this measurement is also studied in detail to minimize these systematic uncertainties.

First results indicate a good agreement with known values[1] of both quantities $T_{1/2}(^{100}\mathrm{Sn})$ and $E_{\beta,max}(^{100}\mathrm{Sn})$.

References
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