Determination of Q_β for the Gamow-Teller decay of ^{100}Sn and ^{98}Cd

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The heaviest self-conjugate doubly magic nucleus ^{100}Sn is known to have the largest Gamow-Teller decay strength $B(GT)$ of all nuclei.[1)] A precise determination of $B(GT)$ is needed to test the robustness of the $N = Z = 50$ shell closure suggested by shell model calculations. This implies the importance of measuring the β-decay endpoint energy Q_β of ^{100}Sn with better precision. An experiment to study the superallowed Gamow-Teller decay of ^{100}Sn was performed at the RIBF facility of RIKEN Nishina Center in June 2013. ^{100}Sn and a large cocktail of neutron-deficient isotopes down to $N = Z - 2$ were produced by fragmenting a 345 MeV/u ^{124}Xe beam with intensities up to 36 pnA on a 4 mm ^{9}Be target. The nuclei of interest were separated and identified through BigRIPS and the ZeroDegree spectrometer, before being implanted into one of the three double-sided silicon strip detectors (DSSD) of WAS3ABi. The DSSDs were complemented by 10 single-sided silicon strip detectors in a closed-stack geometry for Q_β measurement at maximum efficiency in the downstream direction. WAS3ABi was surrounded by 84 HPGe and 18 $LaBr_3$ detectors of the γ-ray spectrometer EURICA. Thus, gating on the γ-ray transitions of the daughter nuclei results in a high purity of the β^+ energy spectrum. The accurate measurement of the total β^+ energy using WAS3ABi was hindered by processes such as bremsstrahlung, annihilation-in-flight, and particle escape. Hence, neither the measured endpoint nor the experimental distribution of the measured energies could directly be used to determine the Q_β-value. Therefore, Geant4 simulations of the WAS3ABi geometry and physics processes were used to study the detector response and determine the endpoint energy[2)]. For each trial, Q_β was used as the input parameter and positrons were generated in the WAS3ABi geometry to form a simulated energy spectrum. Then, it was compared to the experimental energy spectrum by a χ^2-test. The experimental Q_β resulted in the minimum $\chi^2_{\rm min}$. The uncertainty of χ^2 originating in the simulations is obtained by performing 30 simulations for each trial energy (see Fig. 1). In order to verify this method, the β-decay of ^{98}Cd into the 1691-keV state in ^{98}Ag[3)] was studied (see Fig. 1). The minimum $\chi^2_{\rm min}$ is obtained by $Q_\beta = 2750 \pm 36$ keV, which agrees well with the literature value of 2717(40) keV[4)]. Analysis for Q_β of ^{100}Sn is ongoing, and it will be finalized soon.

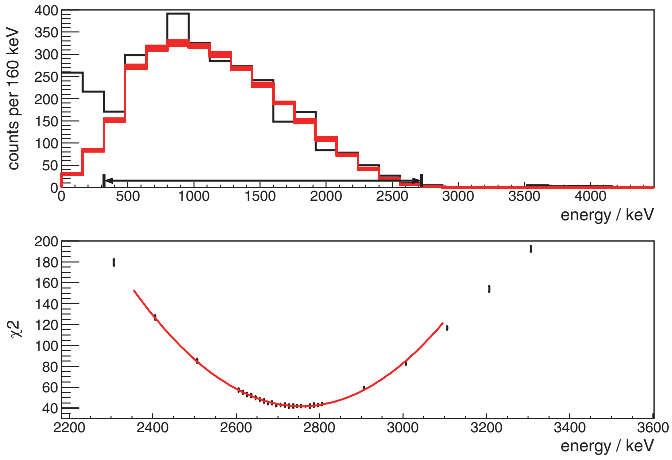

Fig. 1. Complete energy deposit in the experiment (black) of decay products after the implantation of ^{98}Cd nuclei coincident with γ-rays at $E_\gamma = 1176 \pm 2$ keV and 30 simulated spectra (red) of positrons at $Q_\beta = 2737$ keV. The arrow denotes the range of comparison. A parabolic fit yields $\chi^2_{\rm min}$ at $Q_\beta = 2750 \pm 36$ keV.

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