Measuring β-decay strength distribution in the ^{78}Ni region using VANDLE

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The properties of nuclei away from the line of stability, revealed in the β-decay of the neutron-rich side, are crucial in understanding nuclear structure evolution and providing inputs for r-process simulations. Measurements of half-lives, one- and two-neutron emission probabilities ($P_{n,2n}$), and neutron energy spectra provide information on the β-decay strength distribution (S_β). The S_β measurement for Ga with $N > 50$, ^{83,84}Ga showed that the decay properties of the r-process isotopes near ^{78}Ni are dominated by the Gamow-Teller decay of the ^{78}Ni-core states.[1)] Through their work on ^{86,87}Ga using BRIKEN,[3)] R. Yokoyama *et al.*,[2)] demonstrated a need to consider the competition between one- and multi-neutron emissions to predict branching ratios of r-process nuclei. It also strengthened the argument for the necessity of neutron energy measurements for understanding the details of the neutron emission process. The Versatile Array of Neutron Detector at Low Energy (VANDLE)[4)] experiment at RIBF RIKEN aims to provide measurements of S_β for the decay of ^{78}Ni and neighboring nuclei using time-of-flight (ToF) based neutron spectroscopy. The isotopes of interest were produced from a 345 MeV/nucleon ∼46-particle-nA ^{238}U beam impinged on 4-mm-thick Be target by projectile fragmentation. The nuclei identified by the BigRIPS[5)] facility were supplied to the F11 focal plane, where they were implanted in a segmented-YSO based implantation detector[6)] for ∼4 days. A YSO detector consists of a segmented YSO crystal ($75 \times 75 \times 5$ mm^3) coupled to a position-sensitive photo-multiplier tube. YSO is used to establish ion-beta correlations and provides the start time of the ToF. VANDLE, consisting of EJ200 scintillator bars coupled at both ends to PMTs, provides the stop time of neutron ToF. A set of 48 medium ($3 \times 6 \times 120$ cm^3) VANDLE bars were arranged in a 100-cm radius circle with YSO at the center, as shown in Fig. 1. In addition, two HPGe clovers and (ten 3” × 3” and two 2” × 2”) LaBr$_3$ were set up in a close geometry around the YSO detector to record γ-transitions from the decays. All the signals were read using XIA Pixie-16 revF digitizers at 250 MHz and 12-bit digitization.[7)] Neutron spectra were measured for $^{78\text{–}81}$Cu isotopes to establish the role of the $N = 50$ shell gap on the β-decay properties. We show the first measurement of the neutron energy spectrum of ^{81}Cu$_{52}$ decay in Fig. 2. The spectrum indicates that neutrons with energies of 0.4–3 MeV were emitted from excited states in ^{81}Zn.

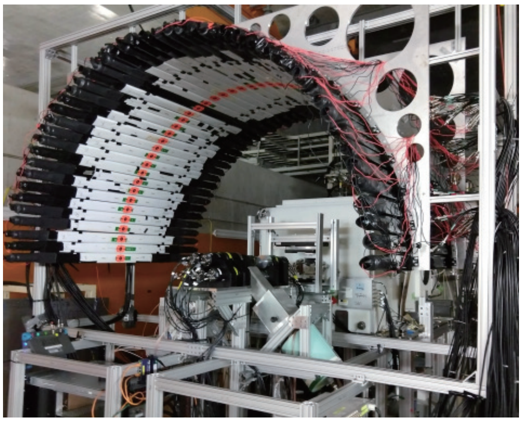

Fig. 1. VANDLE setup at the F11 focal plane of ZDS.

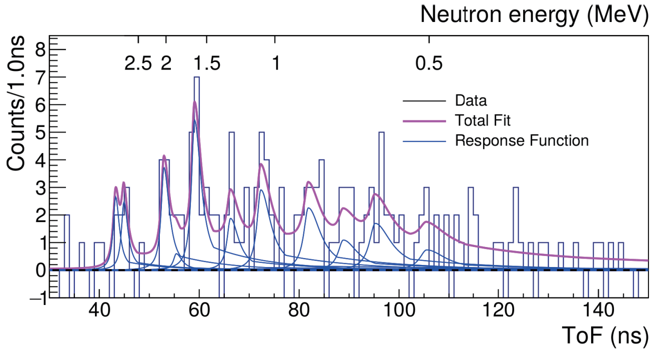

Fig. 2. Neutron energy spectrum of ^{81}Cu measured by VANDLE.

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