The $^{33}S(p, \gamma)^{34}Cl$ experiment

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In the late summer of 2018 we conducted a $^{33}S(p, \gamma)^{34}Cl$ experiment at the University of Notre Dame to investigate the effect that weak γ-ray transitions potentially have on the superallowed β decay of ^{34}Ar, the parent nucleus of ^{34}Cl. Our focus was on a determination of the gamma-branching of the 666-keV level populated in ^{34}Cl. A possible weak 519-keV γ-ray from this level can affect the ^{34}Ar superallowed branching-ratio result, for which we seek 0.1 % precision in order to obtain an *ft* value that can contribute meaningfully to the determination of V_{ud}, the up-down quark-mixing element of the Cabibbo-Kobayashi-Maskawa matrix.

For our two-week measurement we used the Notre Dame Sta. ANA, 5-MV single-ended electrostatic accelerator to produce a proton beam with an energy-spread of less than 1 keV. The accelerated beam was sent through a 90-degree dipole magnet to the 5U solid-target line, where a ^{33}S target was installed at the center of the compact germanium-detector array GEORGINA, which consists of 5 detectors, each with a relative γ-ray efficiency of 100%. The proton beam energy was chosen to be 1072 keV based on resonance-energy scans that determined which one resulted in maximum population of the 666-keV state in ^{34}Cl. During the experiment, the beam current varied between 6.0 and 10.0 μA.

We energy-calibrated the detectors with ^{7}Be, ^{60}Co, ^{137}Cs, ^{133}Ba, and ^{152}Eu sources before and after the $^{33}S(p, \gamma)^{34}Cl$ experiment. These sources provided us with twenty well-known γ-ray peaks covering the energy range from 120 keV to 1400 keV, and therefore our energy calibration for all five Ge detectors could be well established in the region of our interest between 500 keV and 700 keV. The efficiency calibration was done for each individual Ge detector with the ^{60}Co, ^{137}Cs, and ^{152}Eu sources. On the one hand, the ^{60}Co and ^{137}Cs sources have simple decay schemes that permit clean determination of the detectors' efficiencies. The complexity of the decay scheme for ^{152}Eu (to ^{152}Sm by electron capture and to ^{152}Gd via positron emission), on the other hand, led us to use only the 122-keV, 344-keV, 779-keV, and 1112-keV γ-rays and their respective sum peaks at 1234 keV (122+1112) and 1123-keV (344+779) to anchor our efficiency calibration. We have now obtained a well-defined efficiency curve to determine the ratio of the 519-keV to 666-keV γ-ray.

Currently we are developing an analysis program for the very big data set we recorded. It is written in the framework of the ROOT [1]. The results from this measurement will allow us to complete the precise analysis of the superallowed branching ratio for ^{34}Ar.

[1] R. Brun and F. Rademakers, Nucl. Instrum. Methods Phys. Res. **A389**, 81 (1997); http://-root.cern.ch/).