High precision half-life measurement of ^{29}P

P.D. Shidling, J.C. Hardy, V.E. Iacob, V. Kolhinen, D. McClain, D. Melconian, N. Morgan, A. Ozmetin, H.I. Park, B.T. Roeder, and B. Schroeder

Precision measurements of the correlation parameters and *ft* values of β-decaying nuclei continue to improve our understanding of the fundamental symmetries of the weak interaction and allow to test predictions of the standard model. One way to probe the standard model is to determine the precise value of V_{ud}, the up-down element of the Cabbibo-Kobayashi-Maskawa (CKM) matrix, and test whether or not it is unitary as expected. Mixed Fermi and Gamow-Teller transitions between $T = \frac{1}{2}$ mirror nuclei (^{19}Ne, ^{21}Na, ^{29}P, ^{35}Ar, ^{37}K) have also been considered for determining the value of V_{ud} [1]. They are mediated by both the vector and axial-vector component fo the weak interaction. Thus the extraction of V_{ud}, from one fo these transitions requires the measurement of ft value and any one of the angular-correlation coefficients. The decay of ^{29}P is one of the five cases used to determine V_{ud}. The relatively large uncertainty of its contribution is dominated by the precision of ρ, the ratio of Gamow-Teller to Fermi matrix elements, which was obtained from a $\pm 12\%$ measurement of the beta asymmetry parameter, A_β [2]. The ft value [3] is known much better, to $\pm 0.4\%$, with the largest contribution to its uncertainty being the lifetime of the decay. The aim of the present work is to improve the lifetime of ^{29}P so that it no longer dominates the uncertainty in the deduced ft value.

^{29}P was produced via the p (^{30}Si, 2n) ^{29}P reaction in inverse kinematics at a primary beam energy

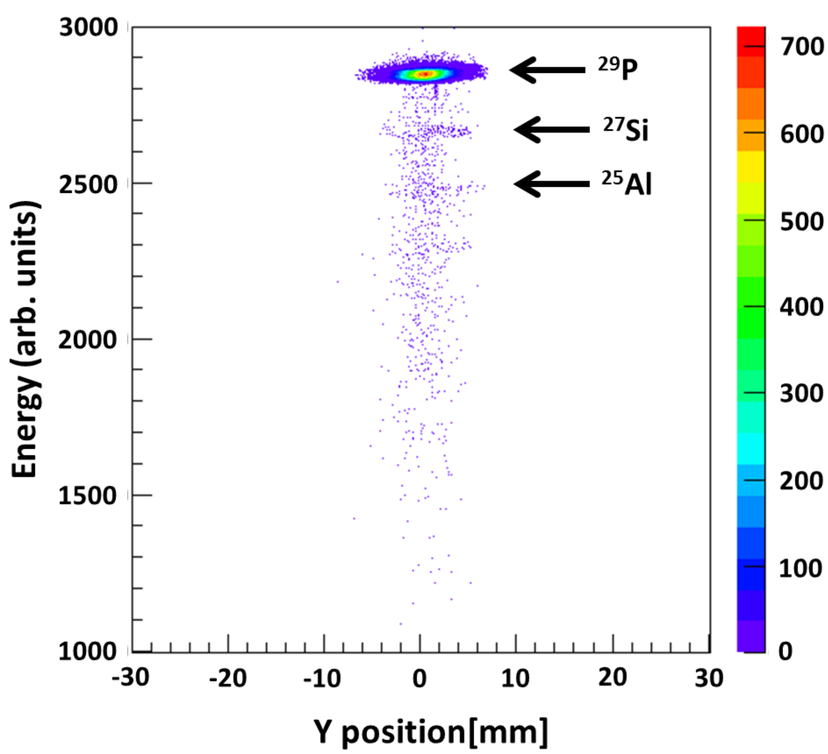

FIG. 1. Two-dimensional plot of energy-loss versus position in the PSSD at the MARS focal plane after the spectrometer had been optimized for ^{29}P production.

of 24 MeV/u. The Momentum Achromatic Recoil Spectrometer (MARS) was used to produce a secondary beam of ^{29}P with a purity of 99.5%. The impurity level of ^{27}Si and ^{25}Al at the exit of MARS were at the 0.1% level. Fig. 1 shows a typical two-dimensional plot of energy-loss vs position as obtained with the position-sensitive silicon detector (PSSD) in the MARS focal plane.

The secondary beam exited the vacuum system through a Kapton foil and then passed through a thick plastic scintillator, a series of Al degraders and eventually implanted in the center of an Al-Mylar tape. The combination of m/q selectivity in MARS and range selectivity in the degrader led to implanted ^{29}P samples that were greater than 99.9% pure. Each source of ^{29}P was prepared by implantation of the ^{29}P into a section of aluminized Mylar tape for 8.4 s. The beam was then turned off and our tape-transport system moved the sample in 180 ms to a well-shielded detector station consisting of a high efficiency 4π proportional gas counter. The decay positrons were then observed for 84 s, which is equal to twenty half-lives of ^{29}P. This cycle was repeated until the desired statistics had been accumulated. The total data set was divided into several runs with different settings of the experimental parameters: bias voltage, discriminator threshold, dominant dead-times. A background measurement was also recorded for which all conditions were the same as for normal data taking except that the tape-move feature was disabled. The analysis is in progress to extract the precise half-life with an associated error budget.

[1] O. Naviliat-Cuncic and N. Severijns, Phys. Rev. Lett. **102**, 142302 (2009).

[2] G.S. Masson and P.A. Quin, Phys. Rev. C **42**, 1110 (1990).

[3] N. Severijns, M. Tandecki, T. Phalet, and I.S. Towner, Phys. Rev. C **78**, 055501 (2008).