The half-life of ^{27}P

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The motivation to study the lifetime of ^{27}P arose from an experiment done earlier, the β-delayed proton and gamma study of ^{27}P, which led to the observation of previously unobserved beta-delayed gamma rays and levels in the ^{27}Si daughter. In order to produce useful log *ft* calculations for these new beta transitions, a value for the ^{27}P half-life is required that is more precise than the current value of 260 (80) ms [1], which is uncertain to ±30%. Ours was a quick experiment, without sufficient statistics for a true 0.1% precision result of the type normally done with this experimental setup. However, we acquired enough data to greatly improve the current half-life value.

A primary beam of ^{28}Si at 40 MeV/u from the K500 superconducting cyclotron at TAMU impinged upon a hydrogen gas target kept at liquid nitrogen temperature (77 K) and a pressure of 2 atm. The desired ^{27}P was then separated out with the MARS spectrometer, producing a beam at the focal plane with a rate of 7.63 evts/nC (191pps) and about 93 % purity. Fig. 1 shows the optimal production results achieved with the coffin slits at ±1.0 cm (a momentum spread of about ±0.7%).

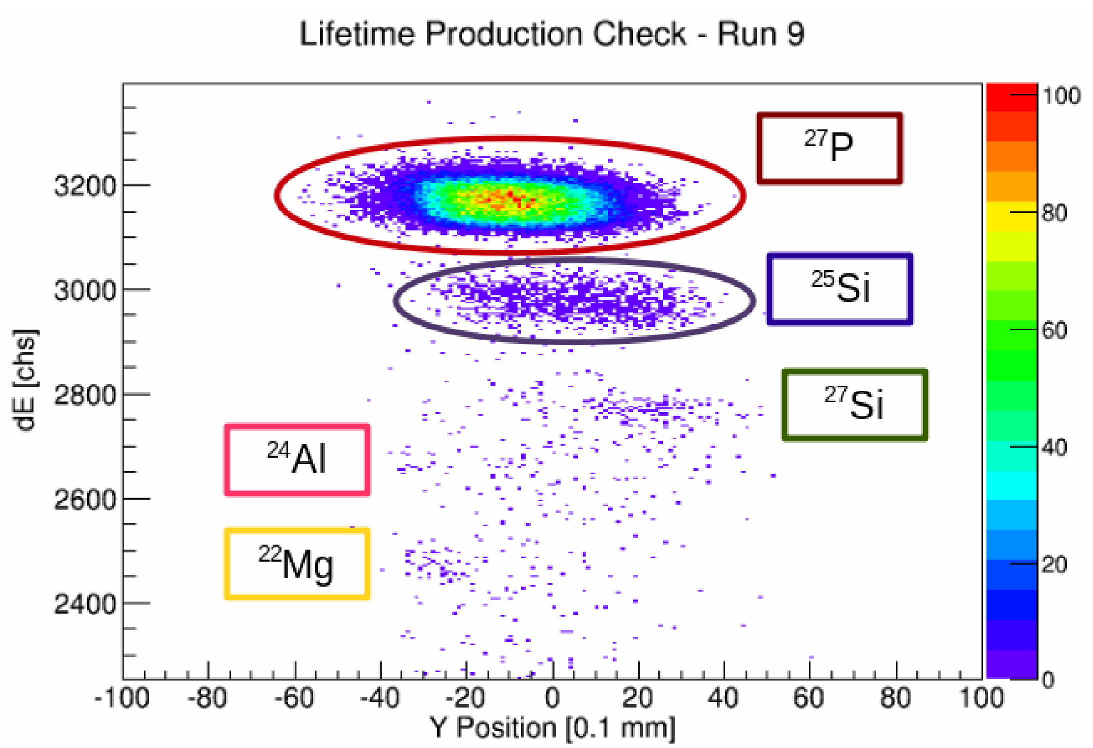

FIG. 1. Production check done with a position-sensitive silicon detector at the focal plane of MARS, recorded at the end of the lifetime experiment.

The measurement was done using the Precision On-Line Decay Facility, which is located at the end of the MARS beam line [2, 3]. A 50.8-μm-thick Kapton widow allowed the separated beam to pass out of the chamber, into air and through a 300 μm BC-404 plastic scintillator (to count the heavy ions), through a 17.25 mil Al degrader and one "dummy" tape (76.2 μm aluminized Mylar) before being implanted into the movable 76.2-μm aluminized Mylar tape. After a collection time of 0.52 sec, the beam was turned off and the tape was quickly moved (normally in 68 ms) to a position between two halves of a 4π proportional gas counter, where the β-particles were detected and recorded during a 3 second time period. This collect-move-record cycle was repeated until sufficient statistics had been accumulated.

Fig. 2 shows the setup at the back end of MARS. Note that the gas counter was moved as close as possible to the exit window to accommodate the short half-life involved in this study; this was also the reason for using a short continuous loop of tape instead of the usual reel-to-reel configuration. In separate runs, the gas counter was operated at three different biases (2600, 2700 and 2800 V), which were all within the detector's proportional region, and with three different discriminator voltages (150, 200 and 250 mV). These parameter changes are routinely done with this equipment to test that there is no systematic dependence on these parameters.

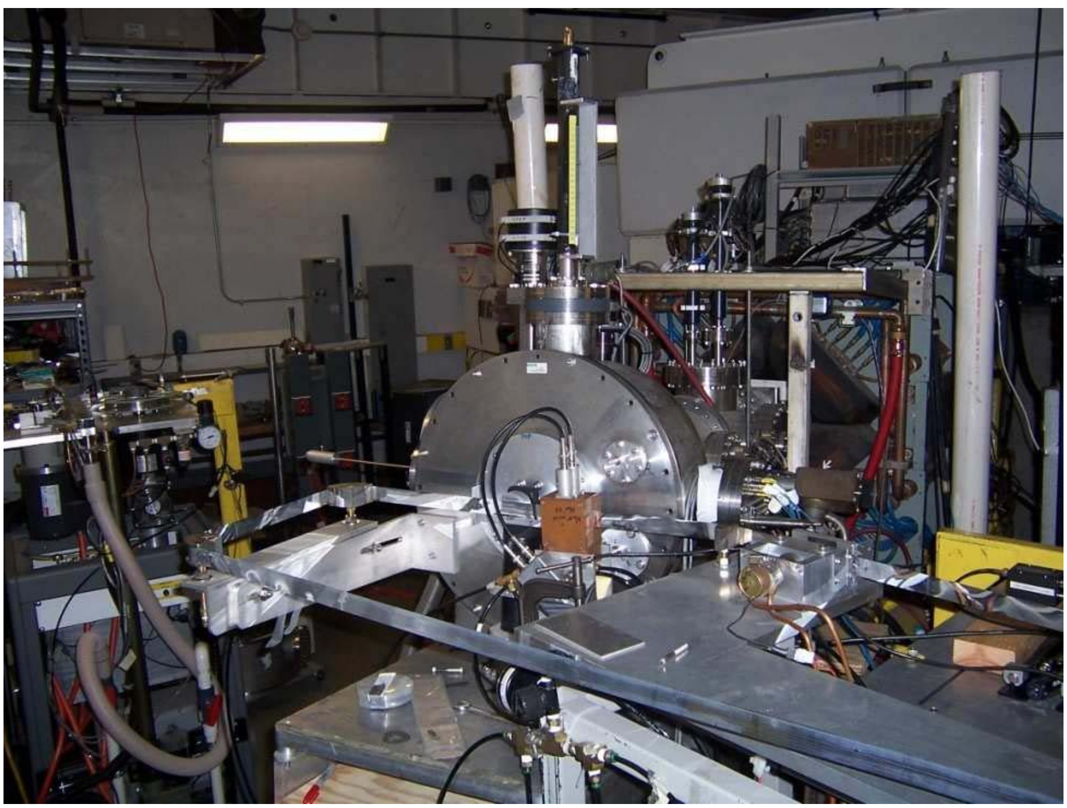

FIG. 2. The tape transport system setup at the back end of MARS.

SRIM ion-range calculations [4] together with the beam composition measured at the focal plane of MARS (see Fig. 1) were used to determine the composition of the sample actually collected on the tape. Of the four impurity beams identified in Fig. 1, only ^{24}Al [$t_{1/2}$ = 2.053 (4) s] is collected on the tape and it constitutes a mere 0.2 % of the total sample. ^{25}Si and ^{22}Mg both punch through the tape, and ^{27}Si is stopped in the degraders and never reaches the tape.

The first step in the analysis process has been to check that all data files are consistent with one another and that each event's header numbers are an accurate representation of the data listed. Three output files were obtained for each run; the heavy ion event file, the MCA event file and the MCB event file. The MBA and MCB files contain the same primary data but recorded with different pre-selected dead times. Within each of the 22 runs, any cycle that displayed significant variations between the three files was discarded. This resulted in less than 0.15% of the collected data being thrown out. Fig. 3 shows a preliminary representation of the total data recorded, on which we have placed a calculated decay spectrum for ^{27}P and the growth-and-decay spectrum for its daughter, ^{27}Si. The analysis is still in progress.

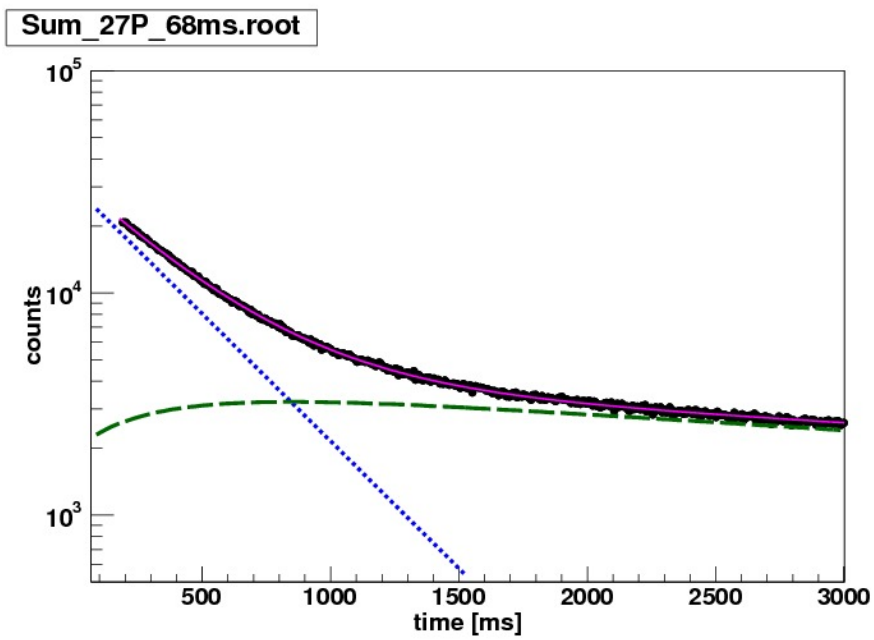

FIG. 3. Preliminary data from the measurement are shown in black. The calculated contributions from the parent (blue line) and daughter (green line) are also shown. No impurities have been taken into account at this point.

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