Beta-Delayed Proton Decay of ^{27}P

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The decays of the A=4n+3, T_Z=-3/2 series nuclei, with their large beta-decay Q values, offer an opportunity to study Gamow-Teller transition strengths up to high excitation energies. The known members of this series in the sd shell, ^{23}Al, ^{27}P, ^{31}Cl and ^{35}K, all exhibit beta-delayed proton branches. In 1995 we published a βp study of ^{23}Al utilizing our low threshold particle detector telescopes [1]. This work has now been extended to ^{27}P and ^{31}Cl [2].

The isotope ^{27}P (Q_{EC}=11.6 MeV) was produced via the ^{28}Si(p,2n) reaction with 45 MeV protons from the 88" cyclotron impacting on a series of thin natural silicon targets. Radioactive product nuclei recoiled out of the target foils, were thermalized in helium and were swept away on potassium chloride aerosols. These aerosols were transported through a thin capillary and deposited on a collection spot in the detector station. The transport time in this setup was approximately 200 ms, comparable to the ^{27}P halflife of 260±80 ms. The collection point was located on a slowly rotating wheel to reduce the buildup of longer-lived radionuclides.

The deposition spot was observed by two low-energy particle detection telescopes, each consisting of two gas ΔE detectors backed by a single 300 μm silicon detector for measuring the particle energy. The thin ΔE's allow the separation of protons from alpha and beta events. The use of two ΔE's further suppresses beta contamination of the identified proton spectrum, necessary in the high beta fluxes typical of helium-jet experiments. These gas detectors are thinner than existing silicon ΔE's, leading to a lower detection threshold. In this experiment protons were detectable down to about 240 keV with an energy resolution of approximately 30 keV. This improves on the best previous measurement of ^{27}P [3] where the all-silicon detector telescopes had a low-energy threshold of 700 keV and a resolution of 75 keV.

The measured proton spectrum after a 290 mC bombardment is shown in the accompanying figure. Four lines were identified as belonging to ^{27}P, the lower two of which were not seen previously. A partial decay scheme is inset in the figure. Contamination from the beta-delayed proton decay of ^{28}P, produced via the ^{28}Si(p,n) reaction, was studied through a separate bombardment at E_p = 28 MeV, which is below the ^{27}P production threshold. Energy and detection efficiency calibrations were based on the ^{28}P transitions in addition to those from the well-known βp emitter ^{25}Si which was produced via proton bombardment of an aluminum target. The total beta-delayed proton branch of ^{27}P was estimated to be 0.07%.

The measured Gamow-Teller strengths were compared with predictions obtained from shell-model calculations. While a portion of the expected strength was positively identified, a more complete comparison awaits a βγ measurement of the ^{27}P decay below the proton threshold.

1. R. J. Tighe *et al.*, Phys. Rev. **C52** (1995) R2298.
2. T. J. Ognibene *et al.*, Phys. Rev. **C54** (1996) 1098.
3. J. Äystö *et al.*, Phys. Rev. **C32** (1985) 1700.