Half-Life of ^{23}Al

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We report elsewhere on the decay scheme of ^{23}Al, and its application to nuclear astrophysics [1]. As with any β decay, the spin-parity of this nucleus and of the states in its β-decay daughter, ^{23}Mg, determine the properties of the observed β transitions between them. In fact, these spins and parities can be determined (or at least limited) by the *ft* values measured for the connecting β transitions. To extract accurate *ft*-values, however, we need not only precise branching-ratios but also an accurate half-life for the parent nucleus. The measurement reported here was prompted by the poor precision of the currently accepted [2] half-life of ^{23}Al, $t_{1/2}$=0.470(30) s.

Since ^{23}Al decays by β-delayed proton emission as well as by β-delayed γ rays, and both resulting daughter nuclei are themselves radioactive, a measurement of decay positrons with our standard proportional gas-counter [3] involves too many inseparable activities to yield a reliable result for ^{23}Al. Instead, we measured off-beam β-γ coincidences as a function of time using our fast tape-transport system – and analyzed the decay of those γ rays uniquely associated with ^{23}Al.

We used a ^{24}Mg primary beam at 48*A* MeV from the cyclotron impinging on a liquid-nitrogen cooled hydrogen target pressurized to 1.5 atm. The recoiling ^{23}Al ions were separated from the other ejectiles by the MARS spectrograph (see Ref. [1]), yielding a radioactive beam at the exit of MARS with a purity of about 99% and an intensity of about 4000 pps. The ^{23}Al nuclei at 39*A* MeV were then extracted into air, passed through a thin (0.3mm) plastic scintillator and a stack of aluminum degraders, and finally were implanted into the aluminized mylar tape of our fast tape transport system. We collected activity for 1s, then switched off the beam and moved the activity 90 cm in 180ms to the center of a detection system, located in a well shielded region. There, β singles and β-γ coincidences were obtained from a HPGe detector and a BC-404 plastic scintillator located on opposite sides of the collected sample; these data were taken for 3.2s and each recorded event was tagged with the time elapsed since the beginning of the detection period. The collect-move-detect cycles were then repeated until sufficient statistics had been accumulated.

In the off-line analysis, we selected only the most intense γ-ray peaks in the ^{23}Al decay (those at 451 and 1600 keV) and generated a net decay spectrum by subtracting from the time-spectrum associated with the peak of a given γ-ray, the corresponding background observed on either side of the peak. In Fig. 1 we present the net decay spectrum containing a total of about 1.3×10^5 events in the sum of the 451 and 1600-keV peaks. While the selection of the ^{23}Al decay events by their γ-ray energies simplifies the analysis significantly, the very different dead-time corrections in the β, γ and β-γ coincidence channels require a detailed analysis, especially since the total decay-rates in the β and γ detectors are not proportional to the decay rate of ^{23}Al. This can be easily observed in Fig. 1, where the scaled-down total γ-rate (solid line) obviously contains contributions from decays with longer half-lives than that of ^{23}Al.

Our preliminary result is $t_{1/2}$ (^{23}Al) = 447(4) s; this is consistent with the previously accepted value of 0.470(30) [2], but is significantly more accurate.

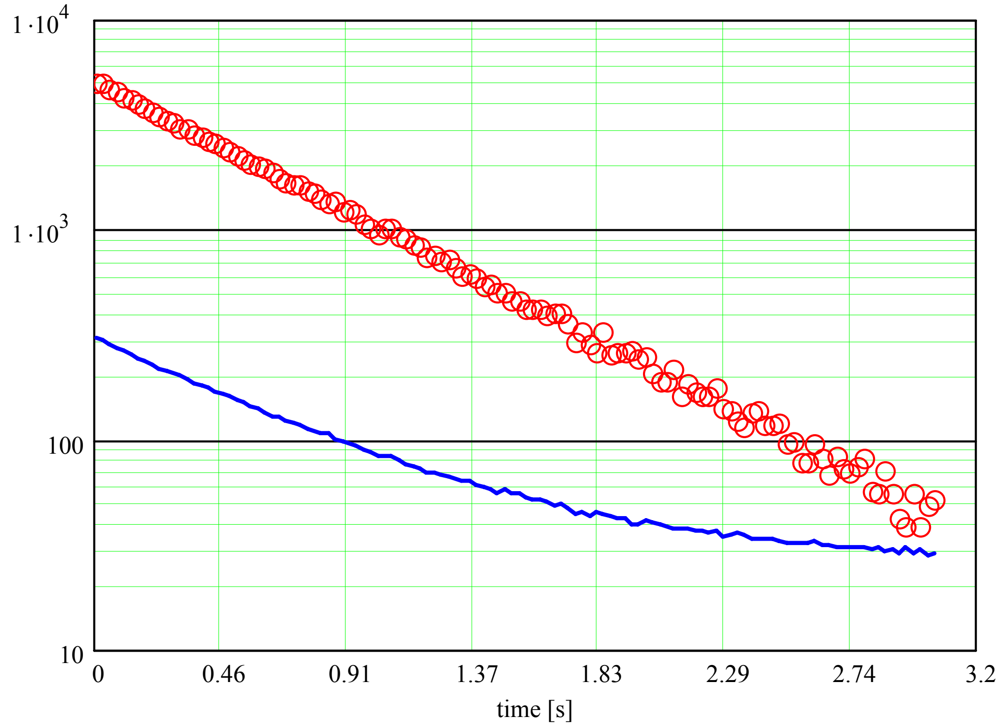

Figure 1. Net versus total γ-spectra observed in the decay of ^{23}Al. Open circles represent the net decay spectrum of ^{23}Al as observed in β–γ coincidences; only the two most intense γ-rays (451 and 1600 keV) were used in the selection; the spectrum contains about 1.3×10^5 events. The solid line represents a scaled-down total γ-spectrum containing contributions from ^{23}Al and its several descendents, all of which are radioactive and generate γ-rays.

[1] L. Trache *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2005-2006), p.I-8.

[2] P.M. Endt**,** Nucl. Phys. **A521,** 1 (1990).

[3] V.E. Iacob *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2005-2006), p.I-31.