SHORT COMMUNICATION

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The study of ^{101}Mo decay

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The decay of ^{101}Mo to levels in ^{101}Tc has been studied using the three-parameter (γ-γ-t) coincidence system of HpGe-HpGe detectors. According to the coincidence data, the decay scheme was modified. The positions of 221.80, 318.00, 377.90, 452.50, 515.42, 1011.05 and 1759.72 keV transitions have been arranged again, the transition positions of 104.70, 105.95 and 774.15 keV gamma-rays have been assigned for the first time, the positions of 169.00, 590.91, 980.52 and 1431.68 keV transitions have been reconfirmed, the 1508.01 keV gamma-ray was observed simultaneously for the first time and its transition position has been assigned. The β-intensities and the values of log ft of most levels were calculated.

Introduction

The ^{101}Mo nucleus has high decay energies and complicated decay γ-ray spectra, many of them were in doublets or triplets. A present decay scheme of ^{101}Mo was built mainly according to the single spectra measurement by HAMMED et al.[1] in 1993 and the γ-γ coincidences measurement by WRIGHT et al.[2] in 1975. It should be pointed out that many γ-rays which belong to the decay of ^{101}Mo were not placed in level sheme.[1–3] The nuclear structure of ^{101}Tc which is daughter of ^{101}Mo was studied using the ^{101}Mo(^{3}He, pnγ) reaction in 1997 by SAVAGE et al.[4] the experiments included γ-ray excitation functions, γ-ray angular distributions, and γ-γ coincidences measurement. The results were interpreted using a particle-rotor model. By careful analyzing of the decay scheme of ^{101}Mo proposed by HAMMED et al.[1] and the level scheme for ^{101}Tc proposed by SAVAGE et al.,[4] it can be found that there are some discrepancies. For example, the 515.42 keV γ-ray is placed between the level at 1122.04 keV and the level at 606.46 keV in Reference 1 meanwhile the 515.1 keV γ-ray is placed between the level at 515.16 keV and the ground state in Reference 4. These discrepancies has motivated us to use the coincidence technique of HpGe detectors to reexamine ^{101}Mo decay.

Experimental and results

The radioactive sources of ^{101}Mo were produced by neutron irradiation of 1 mg targets of metallic ^{100}Mo isotopically enriched to 99.2% via the reaction ^{100}Mo(n, γ)^{101}Mo. The neutron beam, whose energy was ~6 MeV, was produced from irradiation of ^{9}Be using 16 MeV, 5 μA deuterium,[5] which was produced by the K = 40 Cyclotron in Shanghai Institute of Nuclear Research and passed through a 20 μm thick Havar film. The only detectable contaminants in the sources were ^{99}Mo ($T_{1/2}$ = 2.75 d) and ^{97}Z ($T_{1/2}$ = 16.9 h), which were formed from the reactions ^{100}Mo(n, 2n)^{99}Mo and ^{100}Mo(n, α)^{97}Zr, respectively. Due to the difference in half-life, a short-term irradiation of ^{100}Mo can be used to produce sufficient interference-free activity for the determination of the decay of ^{101}Mo. There can also be found some γ-rays from the decay of ^{101}Tc, the daughter of ^{101}Mo.

A series of coincidence measurements were carried out in order to establish the relation among the γ-rays observed. The experiments were performed with the three-parameter γ-γ-t data acquistion system composed of two HpGe detectors. One of the detectors is a coaxial detector of 115 cm^{3} n type HpGe with 0.5 mm berylllum absorbing layer in front of the crystal, and energy resolution is 1.9 keV at FWHM for 1332 keV, γ-ray of ^{60}Co. The other is a coaxial detector of 232 cm^{3} HpGe. The FWHM is 2.0 keV at 1332 keV. The experiments are carried out for 20 times, the irradiation time and measurement time is selected 30 and 45 minutes, respectively. The $1\cdot10^{7}$ coincidence events were recorded in event by event mode. Figure 1 shows the coincidence γ-ray spectra gated on 211.98, and (590.10+590.91) keV photopeaks. Table 1 lists the new coincidence relations observed.

In addition, according to the in-beam gamma experimental results given by SAVAGE et al.,[4] we assign the spin and parity of the levels at 500.43, 515.250, 533.55, 616.20, 622.06, 669.80, 711.205, 1188.04, 1319.57 keV are 5/2^{-}, 5/2^{+}, 7/2^{+}, 3/2^{-}, 1/2^{-}, 3/2^{-}, 3/2^{-}(5/2^{-}), 3/2^{+}, 5/2^{+}, 3/2^{-}, 5/2^{-}, 3/2^{+}, 5/2^{+}, respectively.

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Table 1. New γ-γ coincidence relations of ^{101}Mo decay obtained from coincidence spectra

Gate, keV	Coincident γ-rays, keV	Placement, keV
80.92	105.95, 318.00	394.77-288.45, 606.46-288.45
195.93	515.42	515.250-0.0
211.98	169.0	669.80-500.43
221.80	80.92, 105.95, 378.99, 571.62	288.45-207.517, 394.77-288.45, 394.77-15.602, 1188.04-616.20
333.61	1508.01	2129.83-622.06
408.69	774.15, 1431.68	1962.326-1188.04, 2047.72-616.20
510.21+512.83+514.1+515.42	195.93	711.205-515.25
566.62	452.5	2047.72-1594.65
590.10+590.91	104.70	711.205-606.46
606.8+608.34	104.70	711.205-606.46
642.71	590.91	606.46-15.602
774.15+775.8	980.52	1188.04-207.517
869.7+871.08	1011.05	1897.97-886.7
877.39	1011.05	1897.97-886.7
980.52	774.15	1962.326-1188.04
1011.05+1012.47	871.08,877.39	886.70-15.602,886.70-9.32
1249.4+1251.10	104.70	711.205-606.46
1346.09	221.80	616.20-394.77
1530.3+1532.49	515.42	515.250-0.0
1662.49	377.9	2056.83-1678.09
1754.90+1759.72	80.92	288.45-207.517

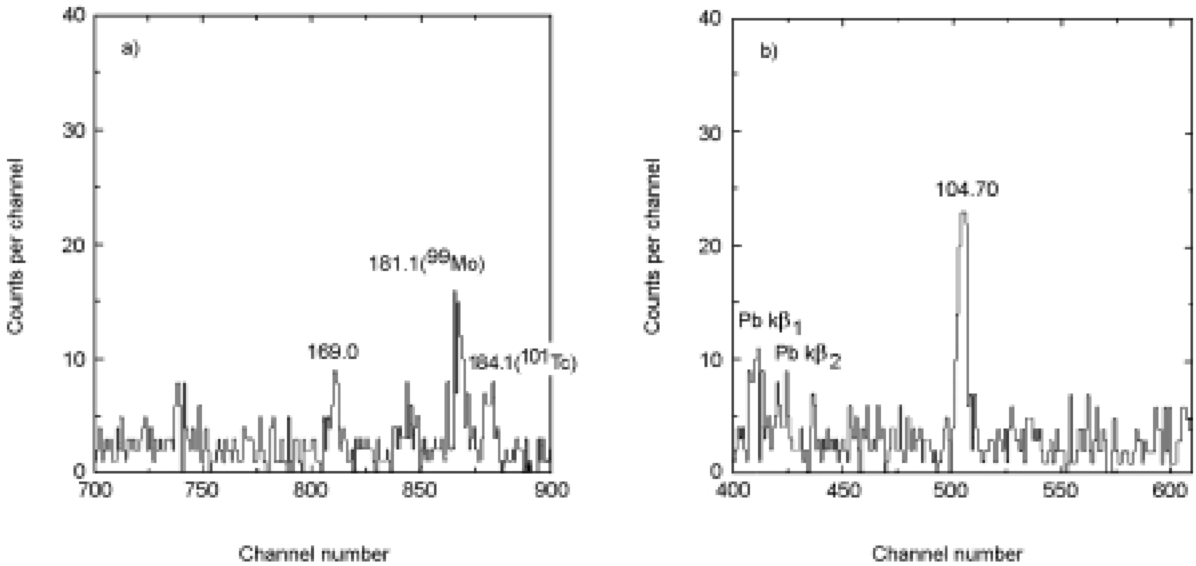
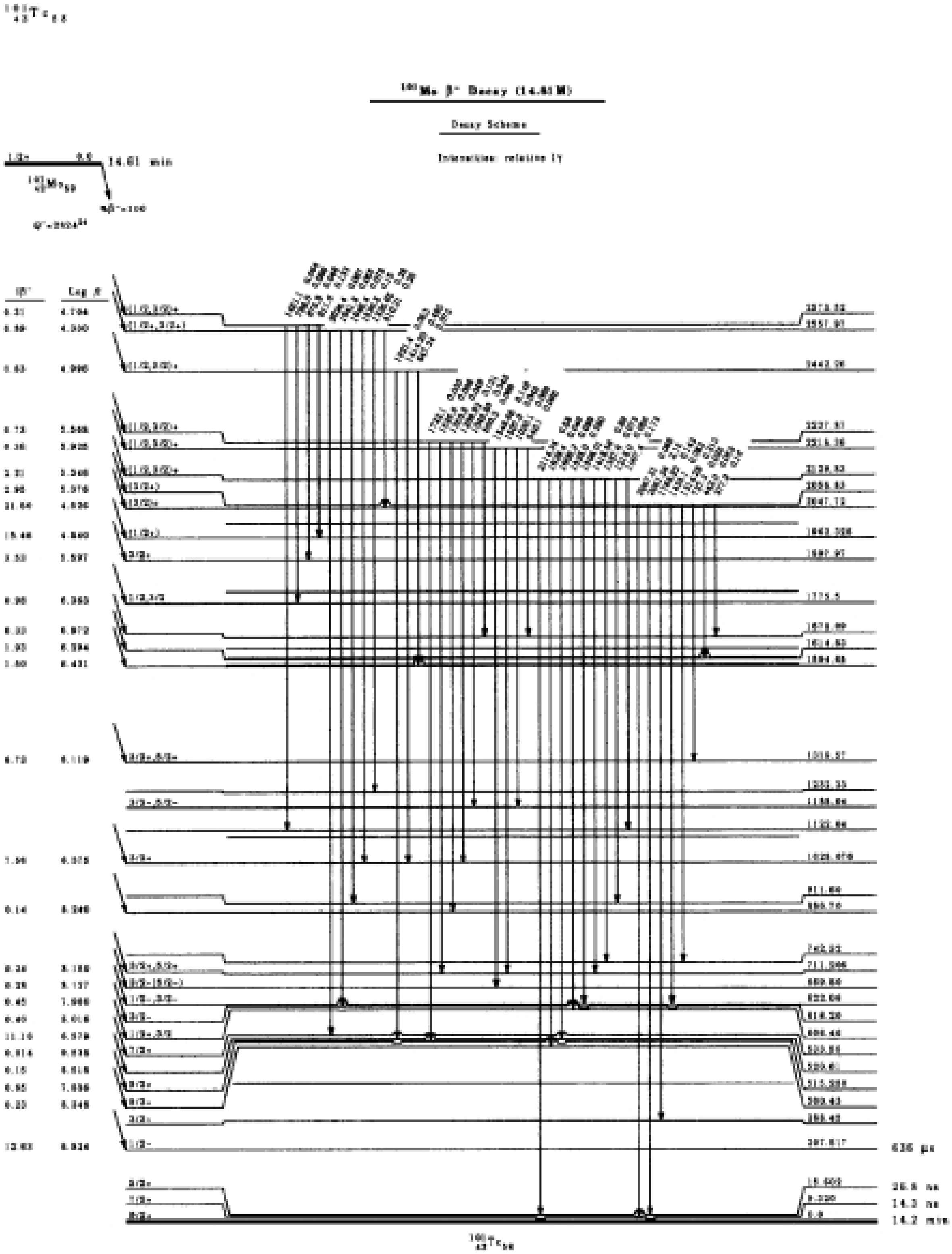
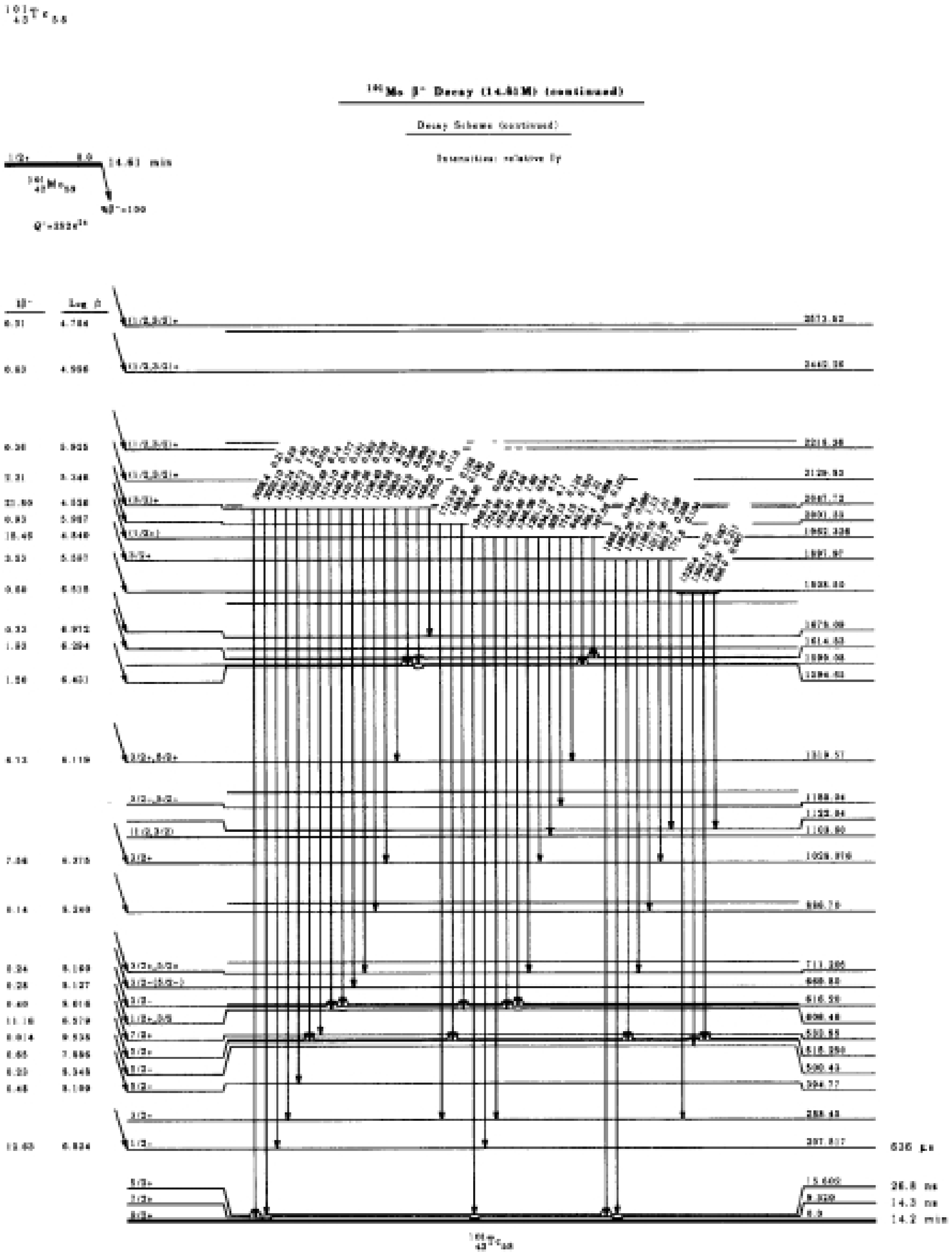
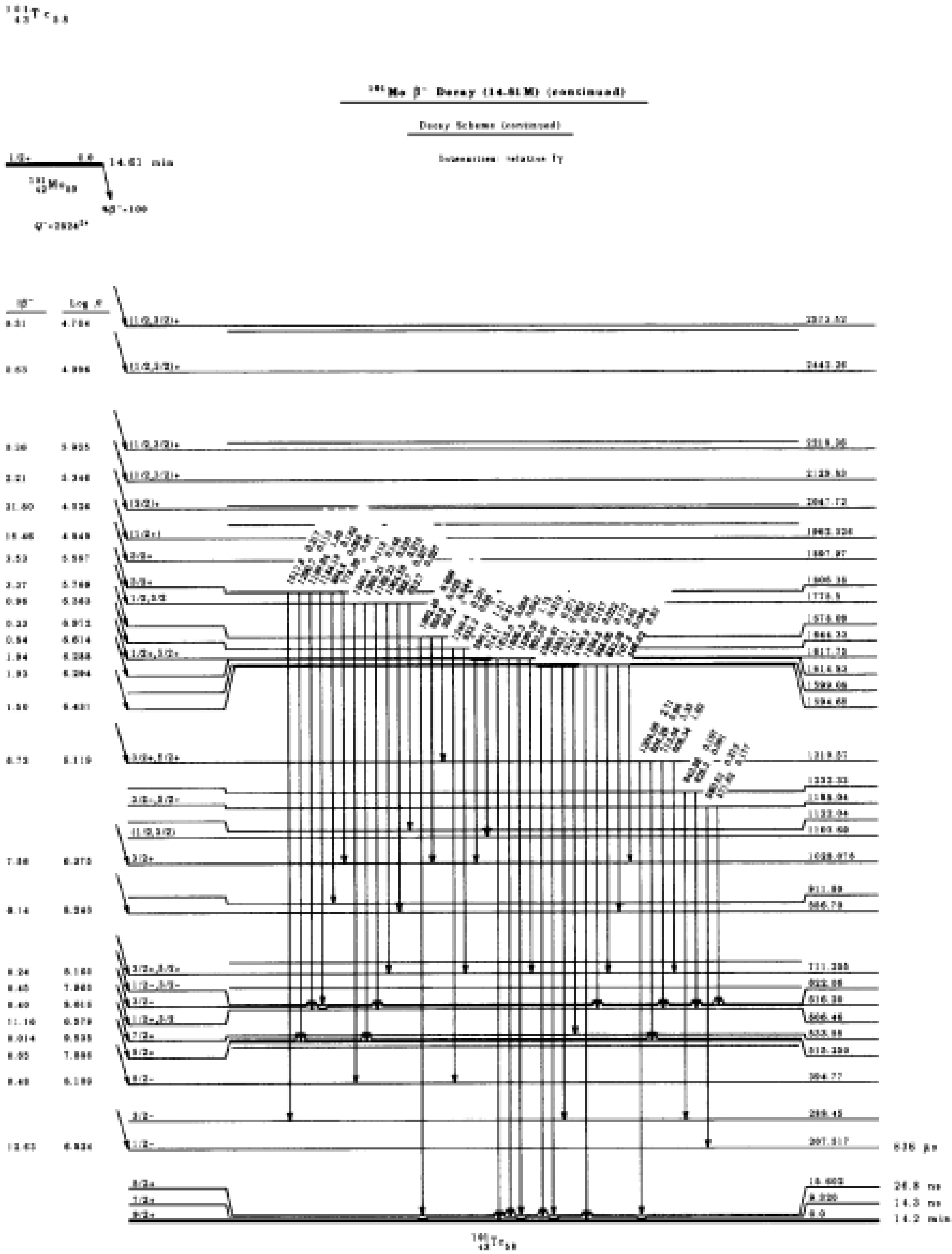
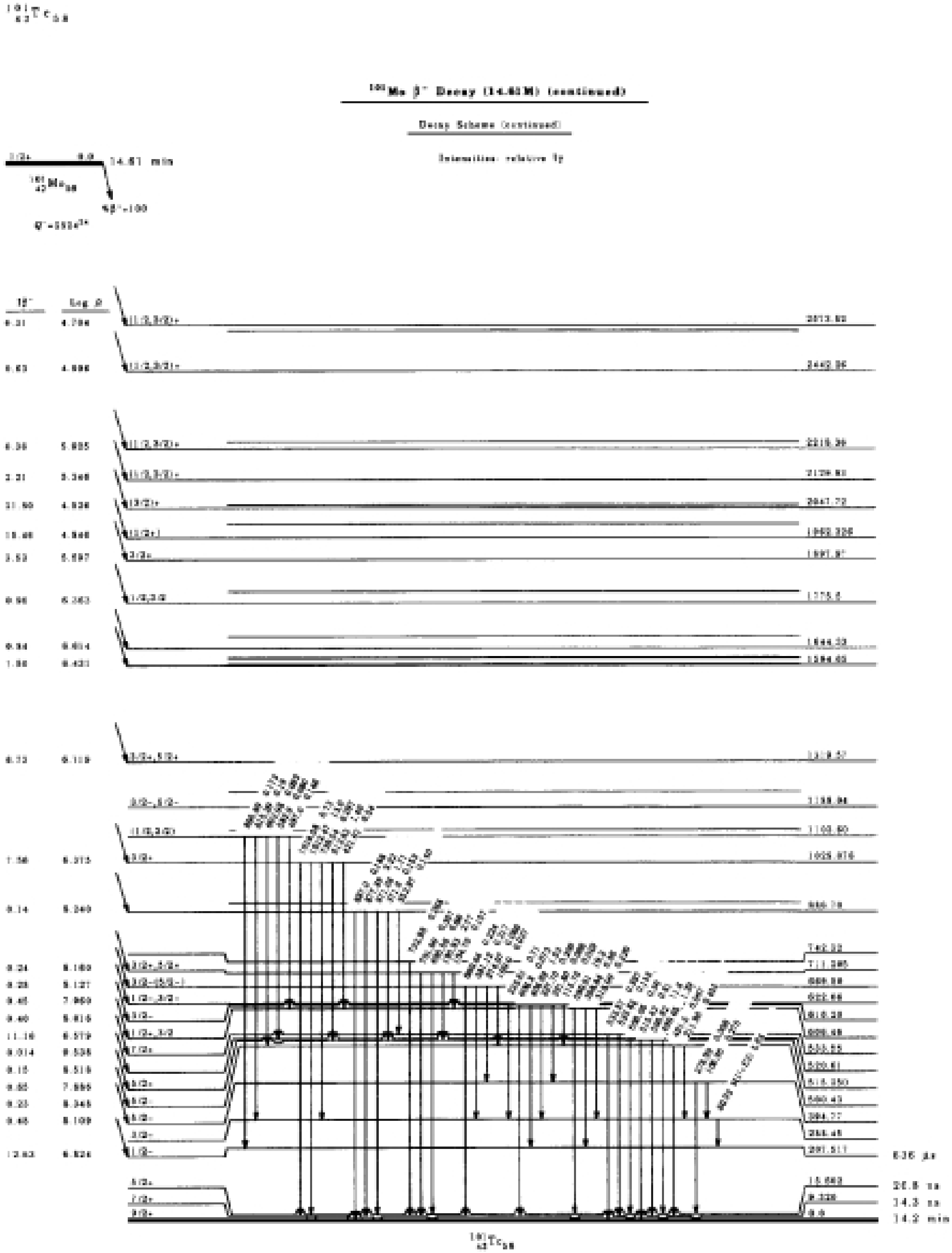


Fig. 1. Coincidence spectra obtained by gating on the 211.98 and (590.10+590.91) keV peaks.
The numbers show the γ-ray energies in keV


Decay Scheme
14.61 min
14.2 min


14.61 min
636 ps
26.8 ns
14.3 ns
14.2 min


Decay Scheme (continued)
Intensities: relative Iγ


Decay Scheme (continued)
14.61 min
636 μs
14.2 min

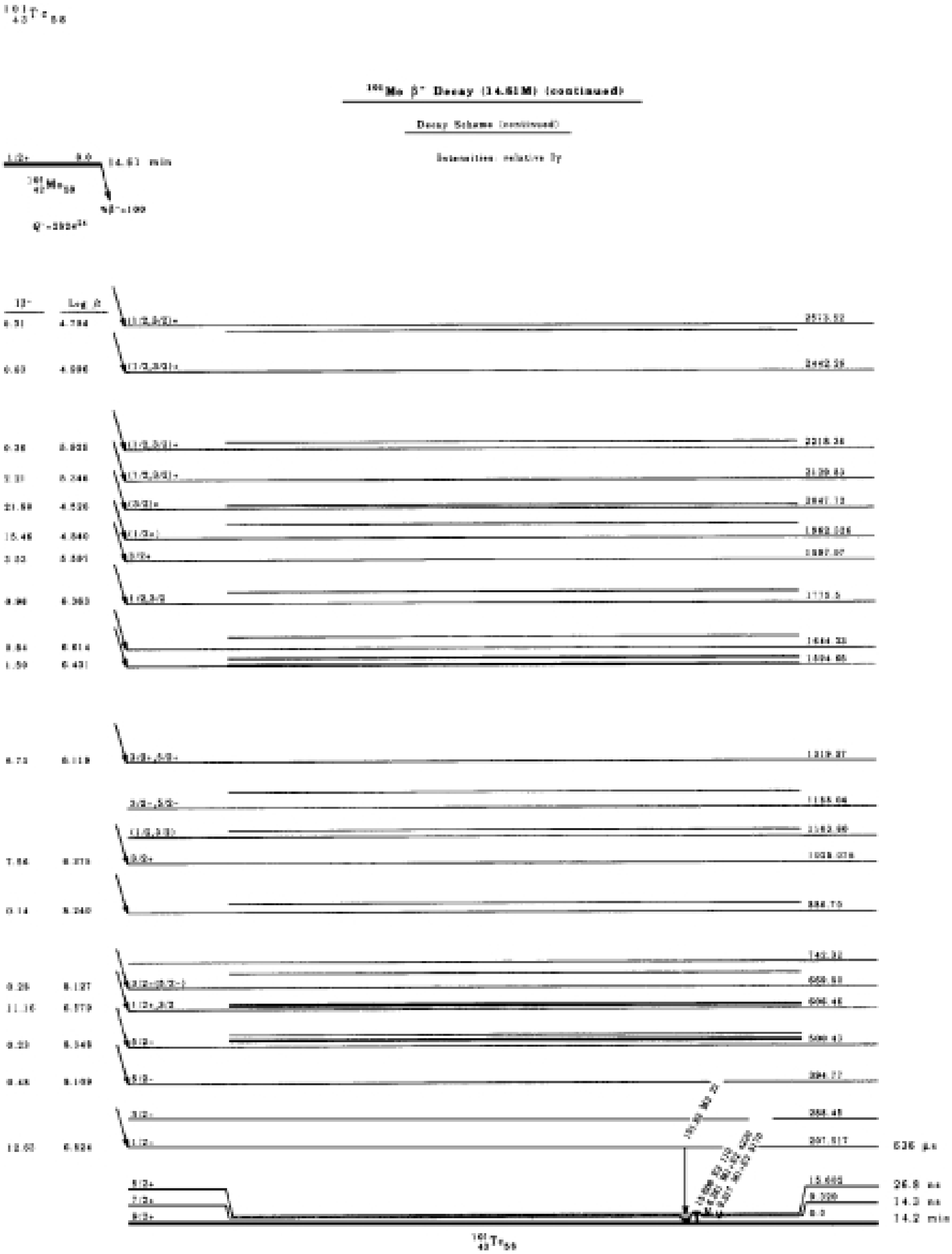


Fig. 2. Proposed decay scheme of ^{101}Mo established in this experiment

Decay scheme

The decay scheme established in this investigation of the ^{101}Mo decay is presented in Fig. 2. Absolute gamma-ray emission probabilities (P_γ) were derived from the evaluated relative emission probability by requiring that the sum of all transitions (gamma-rays plus conversion electrons) to either the ground state and the first two excited states of ^{101}Tc from higher levels should be equal to 1 (100%). This method avoids the need to include information about the 6.3 and 15.6 keV transitions of ^{101}Mo which are highly internally converted. It was also assumed that there is no direct beta decay to these levels, an assumption justified by these three spin-parity assignments. The relative intensities and energies of all γ-rays in the decay scheme were from Reference 1, and we now assign that the 515.45 keV γ-ray is the transition from the level at 515.05 keV to the ground state, and the 1759.72 keV γ-ray is the transition from the level at 2047.72 keV to the level at 288.45 keV, normalized according to Reference 1, the absolute intensity of every γ-ray should be revised, they should multiply by the factor 1.00826(100/99.181).

The intensities of the beta-branches feeding to the ^{101}Tc were determined from the transition deficits (transition intensity from a level minus the intensity to that level). we calculated the β-decay branching over again due to the change of some γ-rays, but the 1508.01 keV γ-ray was not taken into account.

The log ft values for the β-branches to the ^{101}Tc levels were calculated by using the Evaluated Nuclear Structure Data File (ENSDF) analysis and checking program offered by the National Nuclear Data Center (NNDC) at Brookhaven National Laboratory. The result is presented in the decay scheme (Fig. 2).

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