Title
Evidence for a New Isotope of Potassium

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Publication Date
1948-07-15

UNIVERSITY OF CALIFORNIA

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BERKELEY, CALIFORNIA

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EVIDENCE FOR A NEW ISOTOPE OF POTASSIUM*

Roy Overstreet, Louis Jacobson, and P. R. Stout

College of Agriculture

University of California

July 1, 1948

*The authors are indebted to the staff of the 60-inch Cyclotron, University of California, for performing the bombardments with helium ions.

This document is based on work performed under Contract No. W-7405-eng-48-A-I for the Atomic Energy Commission.

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Physics-General

EVIDENCE FOR A NEW ISOTOPE OF POTASSIUM

Roy Overstreet*, Louis Jacobson**, and P. R. Stout***

July 1, 1948

ABSTRACT

A study of the potassium isotopes produced by the bombardment of argon with helium ions reveals the presence of a hitherto unknown isotope with a 22.4 hour half-life. The new potassium isotope has two beta components of approximately .25 Mev and .8 Mev maximum energies. A gamma component is present of roughly 0.4 Mev energy. The evidence strongly suggests that the isotope in question is K^{43} produced by the reaction A^{40} (α, p) K^{43}.

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Introduction: In a recent communication by two of the authors (1) it was shown that bombardment of argon with 40 Mev helium ions resulted in the production of radio-potassium in exceptionally high yields (about one millicurie per micro-ampere-hour). This bombardment subsequently has proven to be a very satisfactory method for the production of radioactive carrier free potassium, particularly for use as a tracer in the biological and agricultural sciences. Moreover, the apparatus used (See Fig. 1) which was designed by M. T. Webb of the Crocker Radiation Laboratory may be employed for the bombardment of other gases with protons, deuterons or helium ions. The reaction is carried out in a bell-jar constructed of 2S commercially pure aluminum so as to contain the beam and through which a slow stream of argon gas continuously flows. The outlet tube for the gas is approximately 20 feet in length and the end of the tube is immersed in a beaker of water. Also the outlet tube contains a glass wool plug adjacent to the bell-jar. The rate of gas flow and length of outlet tube are adjusted so as to prevent air being sucked back into the bell-jar as a result of cooling due to momentary interruptions in the beam from sparking of the deflector, etc. The major portion of the radio-potassium settles out on the walls of the bell-jar and the remainder is caught in the glass wool plug in the gas outlet. Following the bombardment, the walls of the bell-jar and the glass wool plug are treated with warm distilled water. In this manner an essentially pure preparation of carrier free radio-potassium is obtained that can be used without further purification in most instances. However, it will be shown in the following sections that this preparation contains more than one long-lived isotope of potassium.

Purification of Radio-potassium: In order to identify chemically the radioactivity produced by the above method the preparation was carried through a series of chemical separations.

To a water solution of the potassium preparation 10 mg. each of the following carriers was added in the form of soluble salts: Zn, Cu, Na, K, Rb, Cs, Ca, Ba, and Sr.

The Cu was precipitated with H_2S in acid solution and Zn with H_2S in neutral solution. No activity was carried down with the CuS and ZnS precipitates. This indicated the absence of essentially all elements except those behaving as anions and the alkali and alkaline earth groups.

The elements K, Rb and Cs were precipitated as the perchlorates. Only a trace of activity was found in the filtrate which probably was due to the slight solubility of $KClO_4$. The perchlorate precipitate was recrystallized 15 times in the presence of Na, Ca, Ba and Sr carriers. There was no detectable change in the specific activity of the perchlorate precipitate. It was, therefore, evident that all of the activity was associated with the K, Rb and Cs fraction.

The perchlorates of K, Rb and Cs were then converted to the nitrites by precipitation of the elements with cobaltinitrite, fusing with $NaNO_2$, and filtering off the cobalt oxides. Rb and Cs were separated from K in the nitrite solution by precipitation with bismuth subnitrate. The Rb and Cs were subsequently separated from each other by precipitation of the Cs with antimony chloride (2). Each of the three fractions were examined for activity. The Cs fraction was inactive. Approximately 97% of the activity was associated with the K fraction. The remainder of the activity was in the Rb fraction. However, since the decay rate and energy distribution of this activity was identical to that of the activity in the K fraction, and also since the separation of Rb from K is known to be not entirely complete, we can definitely attribute the small Rb activity to co-precipitated K.

The above chemical separations were carried out both on a newly bombarded sample and on an aged sample (200 hours). The distribution of activity was identical in both cases. The chemical separations indicate that no detectable activity of half-life more than a few minutes other then potassium is deposited on the walls of the bell-jar in this bombardment or arose from the bombarded areas of the bell-jar itself.

Decay Measurements: Although the potassium preparation has been shown to be very pure chemically, the decay curve does not show the 12.4 hour period characteristic of K^{42} (3). For example, the activity, when purified as described above, has at 5.5 hours after bombardment a half-life of 14.8 hours and at 150 to 350 hours after bombardment a half-life of 22.4 hours. The decay curve for the purified preparation is given in Figure 2.

An analysis of the curve of Figure 2 clearly indicates the existence of an unknown isotope of K with a half-life of 22.4 hours in addition to the 12.4 hour period of K^{42}. The new isotope accounts for approximately 22% of the total initial potassium activity as measured with a Lauritsen electroscope. The air gap plus the electroscope window was equivalent to 5 milligrams per square centimeter of aluminum.

Magnetic Spectrograph Measurements: Examination of the purified potassium preparation in a magnetic spectrograph with a field strength of 2400 gauss showed no evidence of positron emission. Three beta components of the following maximum energies were obtained: .24 Mev, .81 Mev, and 3.5 Mev. The 3.5 Mev component evidently corresponds to the 3.58 Mev beta particles reported for K^{42} (3). On standing, this component disappeared in a manner consistent with a 12.4 hour half-life, leaving the .25 Mev and the .81 Mev components. A magnetic spectrogram taken approximately 24 hours after bombardment is given in Figure 3.

Al and Pb absorption curves: The Al and Pb absorption curves for the purified preparation taken 210 hours after bombardment are given in Figure 4. The Al curve shows a soft beta component with a range of about 60 mg/cm^2 which is equivalent to a maximum energy of .24 Mev. The curve also shows a beta component with a range of roughly 300 mg/cm^2 or a maximum energy in the neighborhood of 0.8 Mev.

The Pb absorption curve, although it does not permit an accurate estimation, indicates a gamma component with a half-value thickness of about 3.5 gm/cm^2 or an energy of 0.4 Mev. A comparison of the beta to gamma ratio taken for a sample 5.5 hours after bombardment with that calculated from Figure 4 (210 hours after bombardment) indicates that this gamma component must be due to the new isotope.

Isotope Assignment: A study of the possible isotopes resulting from the bombardment of argon with alpha particles favors the assignment of K^{43} to the 22.4 hour potassium isotope. The reaction would be $A^{40}(\alpha,p)K^{43}$. This choice is further substantiated by the fact that the new isotope is a beta emitter.

ACKNOWLEDGMENTS

The authors wish to thank Professors J. G. Hamilton and Glenn T. Seaborg for valuable criticism and suggestions.

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(3). Kai Siegbahn, Ark. f. mat., astr. o. fysik, 34B, No. 4, 1, (1947).

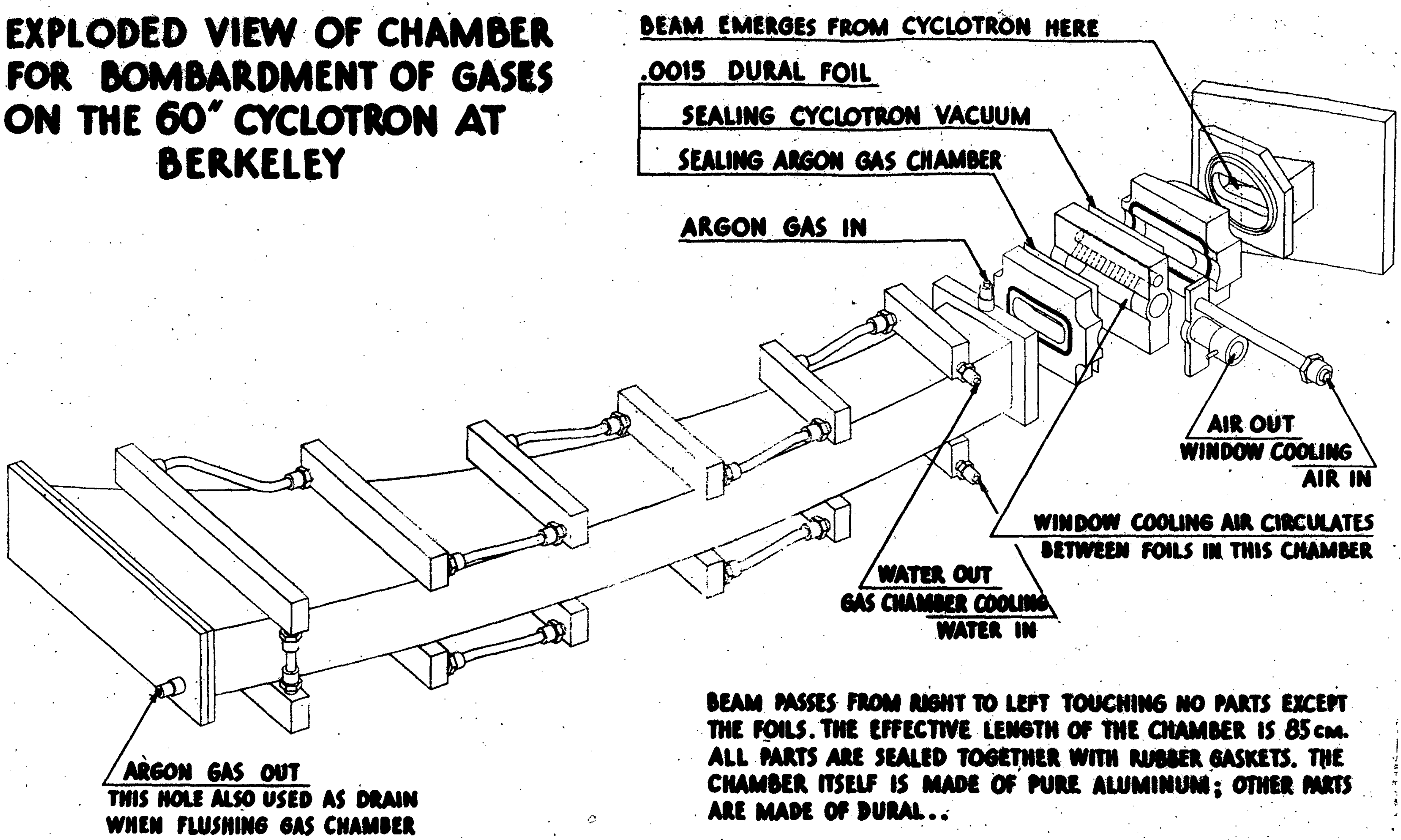
EXPLODED VIEW OF CHAMBER FOR BOMBARDMENT OF GASES ON THE 60" CYCLOTRON AT BERKELEY
BEAM EMERGES FROM CYCLOTRON HERE
.0015 DURAL FOIL
SEALING CYCLOTRON VACUUM
SEALING ARGON GAS CHAMBER
ARGON GAS IN
AIR OUT
WINDOW COOLING
AIR IN
WINDOW COOLING AIR CIRCULATES BETWEEN FOILS IN THIS CHAMBER
WATER OUT
GAS CHAMBER COOLING
WATER IN
ARGON GAS OUT
THIS HOLE ALSO USED AS DRAIN WHEN FLUSHING GAS CHAMBER
BEAM PASSES FROM RIGHT TO LEFT TOUCHING NO PARTS EXCEPT THE FOILS. THE EFFECTIVE LENGTH OF THE CHAMBER IS 85 cm. ALL PARTS ARE SEALED TOGETHER WITH RUBBER GASKETS. THE CHAMBER ITSELF IS MADE OF PURE ALUMINUM; OTHER PARTS ARE MADE OF DURAL..

FIG. 1

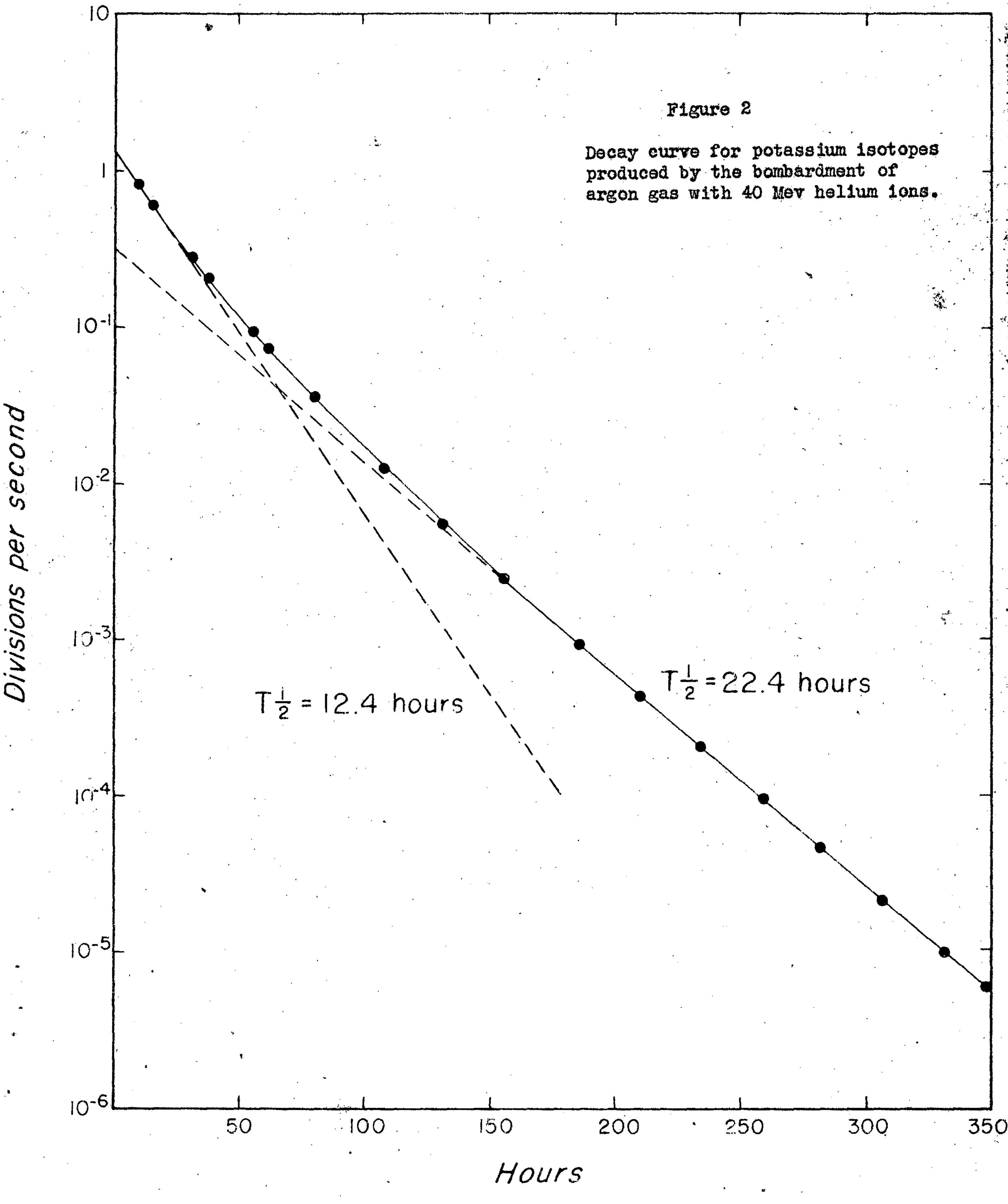

Figure 2

Decay curve for potassium isotopes produced by the bombardment of argon gas with 40 Mev helium ions.

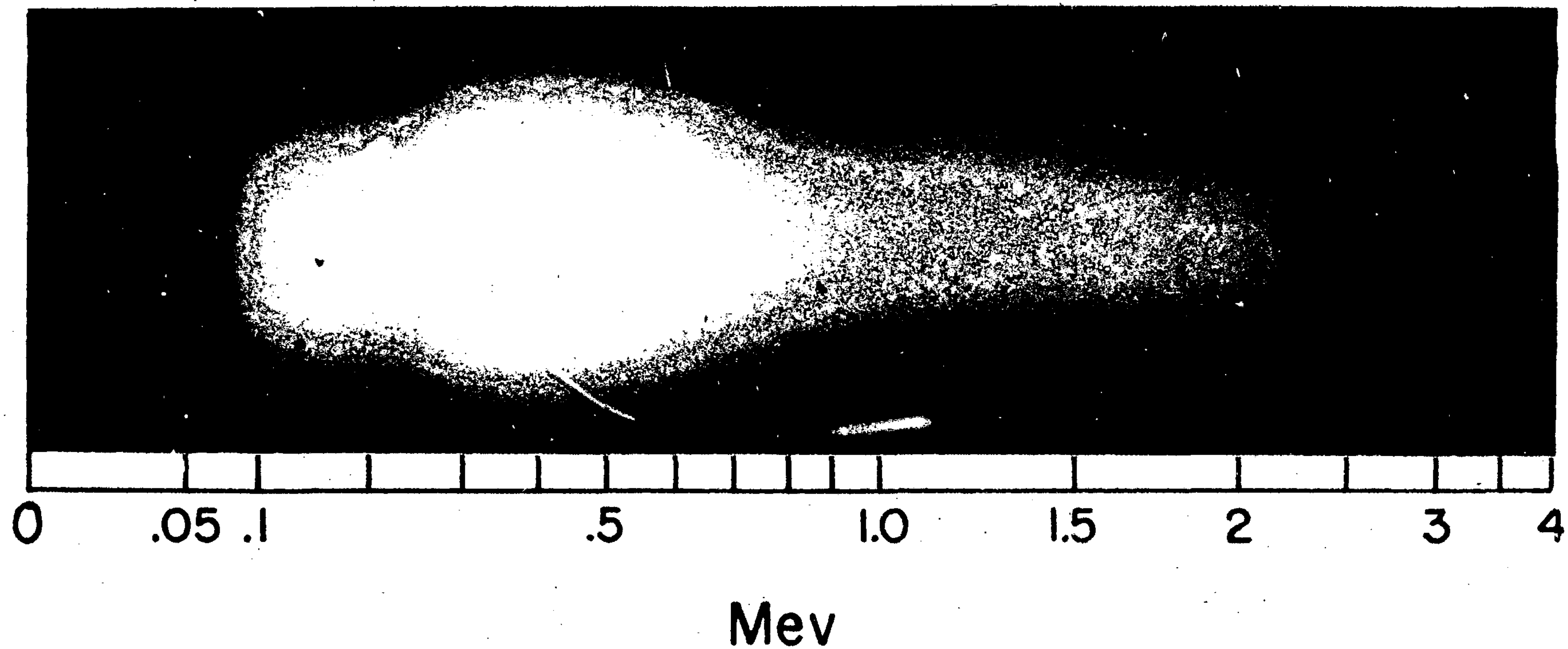

Figure 3

Beta spectrogram of the energy groups of radioactive potassium formed by helium ion bombardment of argon. Spectrogram taken approximately 24 hours after bombardment.

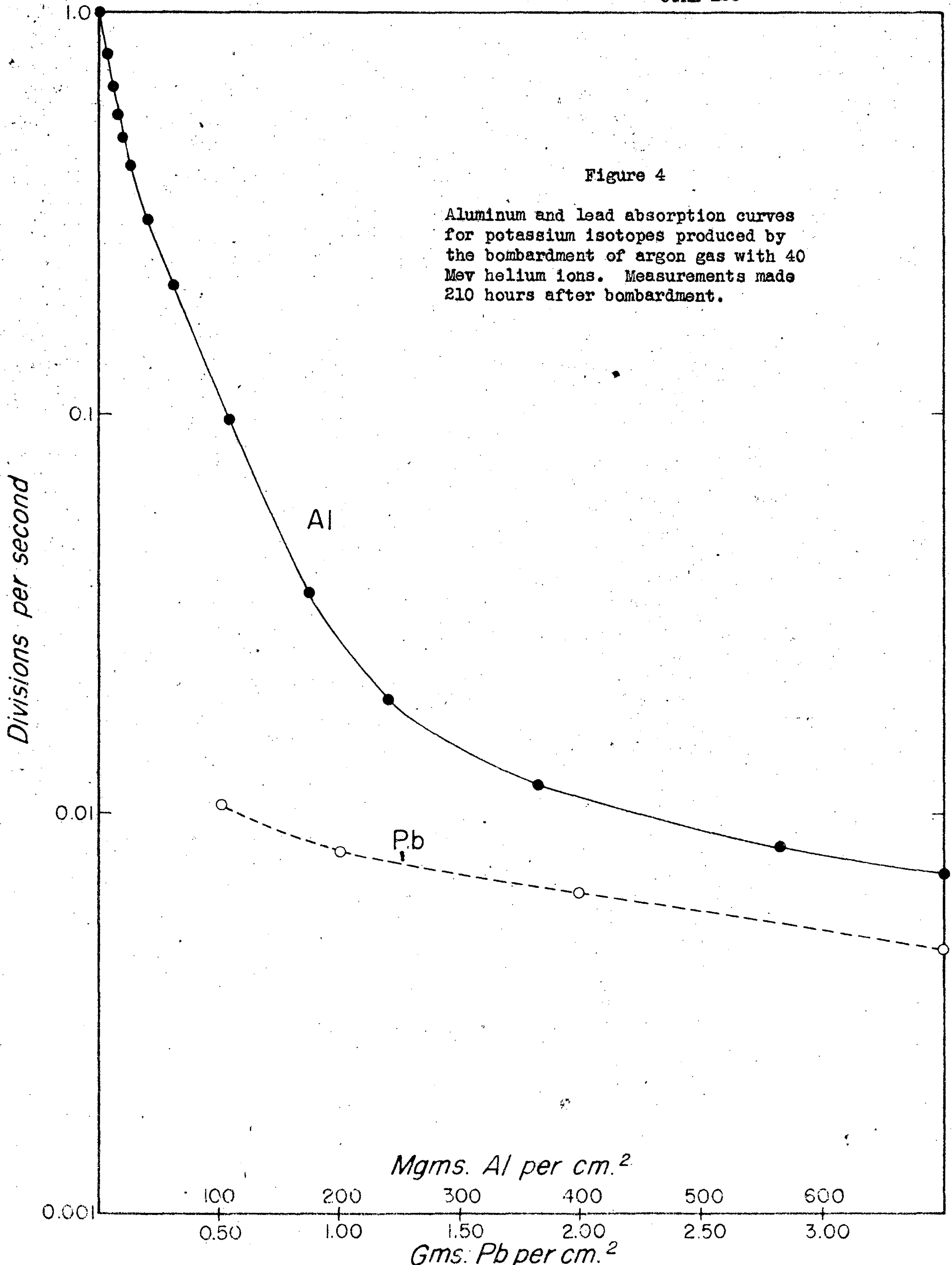

Figure 4

Aluminum and lead absorption curves for potassium isotopes produced by the bombardment of argon gas with 40 Mev helium ions. Measurements made 210 hours after bombardment.