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SPINS OF CESIUM-127, CESIUM-129, AND CESIUM-130

William A. Nierenberg, Howard A. Shugart, Henry B. Silsbee,
and Robert J. Sunderland

August 3, 1956

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Abstract

The spins of three neutron-deficient radioactive isotopes of cesium have been measured by atomic beam methods. The results are: for 6-hour Cs^{127}, $I = 1/2$; for 31-hour Cs^{129}, $I = 1/2$; for 30-minute Cs^{130}, $I = 1$.

SPINS OF CESIUM-127, CESIUM-129, AND CESIUM-130*

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Experimental Method

The isotopes Cs^{127} (6 hour),[1,4] Cs^{129} (31 hour),[1] and Cs^{130} (30 minutes)[2,3,4] were produced in the Berkeley 60-inch cyclotron by (α, kn) reactions on iodine. About 5 mg of CsI carrier was added to a solution of the BaI_2 target material; then the barium was eliminated by precipitation of its carbonate, and the excess iodine was sublimed off as NH_4I. The resulting CsI was transferred to an atomic-beam oven and reduced by heating with calcium to form a beam of atomic cesium. The beam could be obtained in a little more than an hour after the end of the bombardment.

The I^{127} (α, n) Cs^{130} reaction could be relatively enhanced by using short bombardments and placing aluminum foils in front of the target material to cut the α-beam energy to a point where the I^{127}(α, 2n)Cs^{129} cross section would be low but the Cs^{130} yield would be reasonably high.

Similarly the I^{127}(α, 4n)Cs^{127} production could be favored by using a target so thin that the α beam left the back of the material before the I^{127}(α, 2n)Cs^{129} cross section became high. This was important, because Cs^{127} does not K-capture with high probability,[1] and hence the x-ray counters are relatively inefficient for this isotope.

The spins of the three isotopes were investigated in an atomic-beam resonance apparatus by techniques previously described.[5]

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Cesium-130 Results

Table I compares the counting rates obtained at conditions appropriate to several integral spin values. The rates have been corrected for counter background, extrapolated to a common time, and normalized for variations in beam intensity (as indicated by the resonance height observed for the carrier isotope).

Table I

Counting rates for Cs^{130}, integral spin values					
Spin value	0	1	2	3	4
Counting rate (arbitrary units)	-14 ± 7	100 ± 13	7 ± 5	14 ± 6	9 ± 3

There is a clear indication that I = 1. This was confirmed by a repetition of the experiment.

Figure 1 compares the decay of the I = 1 sample with that of a sample of the full beam (obtained by turning off the deflecting fields and removing the stop). The full-beam sample shows the 30-minute Cs^{130} component superimposed on a 31-hour Cs^{129} background. The I = 1 sample shows a marked enrichment of the 30-minute activity, indicating that Cs^{130} is responsible for the I = 1 signal.

Cesium-127 and Cesium-129 Results

Table II gives the results of a search at half-integral spin values.

Table II

Counting rates for Cs^{127} and Cs^{129}, half-integral spin values

Spin value	1/2	3/2	5/2	7/2	9/2
Counting rate (arbitrary units)	100 ± 1.3	1.4 ± .2	1.9 ± .2	1.8 ± .2	1.4 ± .2

A significant signal appears only for $I = 1/2$.

In Fig. 2 the decay of the $I = 1/2$ sample is compared with that of the full beam. It is clear that both the 6-hour Cs^{127} and the 31-hour Cs^{129} are present in both samples and in the same ratio. The same result has been obtained in other runs in which the relative amounts of the two isotopes were appreciably different. The conclusion is that both Cs^{127} and Cs^{129} have $I = 1/2$.

Remarks

The measured spin, $I = 1$, for Cs^{130} agrees with the prediction by Smith, Mitchell, and Caird[3] deduced from the decay scheme, and--as they point out--it is consistent with a shell-model picture of an unpaired $(d_{5/2})$ proton coupled with a $(d_{3/2})$ neutron.

A ground-state spin of 1/2 for either Cs^{127} or Cs^{129} is hard to fit into the shell picture. If the spin is due to a single proton it must occupy an $(s_{1/2})$ state, which is presumed to lie at the top of the shell,[6] while the $(g_{7/2})$ and $(d_{5/2})$ levels at the bottom of the shell are available. Furthermore, no coupling scheme with the five protons outside the closed shell at $Z = 50$, all in the $(g_{7/2})$ level or all in the $(d_{5/2})$ level, can give $I = 1/2$; nor can three protons

in one of these levels and a canceling pair in the other give $I = 1/2$. Five protons in the $(h_{11/2})$ level can produce $I = 1/2$, but coupling to such a low spin value seems unlikely. It is conceivable but improbable that the neutrons contribute to the spin.

The most likely possibility seems to be that the observed properties are those of an isomeric state rather than the ground state.

A measurement of the hyperfine structure may throw light on the problem. Preliminary results indicate that the hyperfine splitting for both isotopes is in the neighborhood of 8000 to 9000 Mc.

If protons give a ground-state spin of 1/2 for Cs^{127} and Cs^{129}, then the observed spin of 1 for Cs^{130} may be due to these protons coupled to an $(s_{1/2})$ neutron. Again a measurement of the hyperfine structure would be useful.

This work was done under the auspices of the U.S. Atomic Energy Commission.

References

1. Fink, Reynolds, and Templeton, Phys. Rev. 77, 614 (1950).
2. Risser and Smith, private communication from Lark-Horowitz cited by Hollander, Perlman, and Seaborg, Revs. Modern Phys. 25, 469 (1953).
3. Smith, Mitchell, and Caird, Phys. Rev. 87, 454 (1952).
4. Mathur and Hyde, Phys. Rev. 95, 708 (1954).
5. Hobson, et al., Phys. Rev. (to be published)
6. Mayer and Jensen, Elementary Theory of Nuclear Shell Structure, Wiley, New York, 1955.

Legends

Fig. 1. Decay of I = 1 sample (Cs^{130}).

Fig. 2. Decay of I = 1/2 sample (Cs^{127} and Cs^{129}).

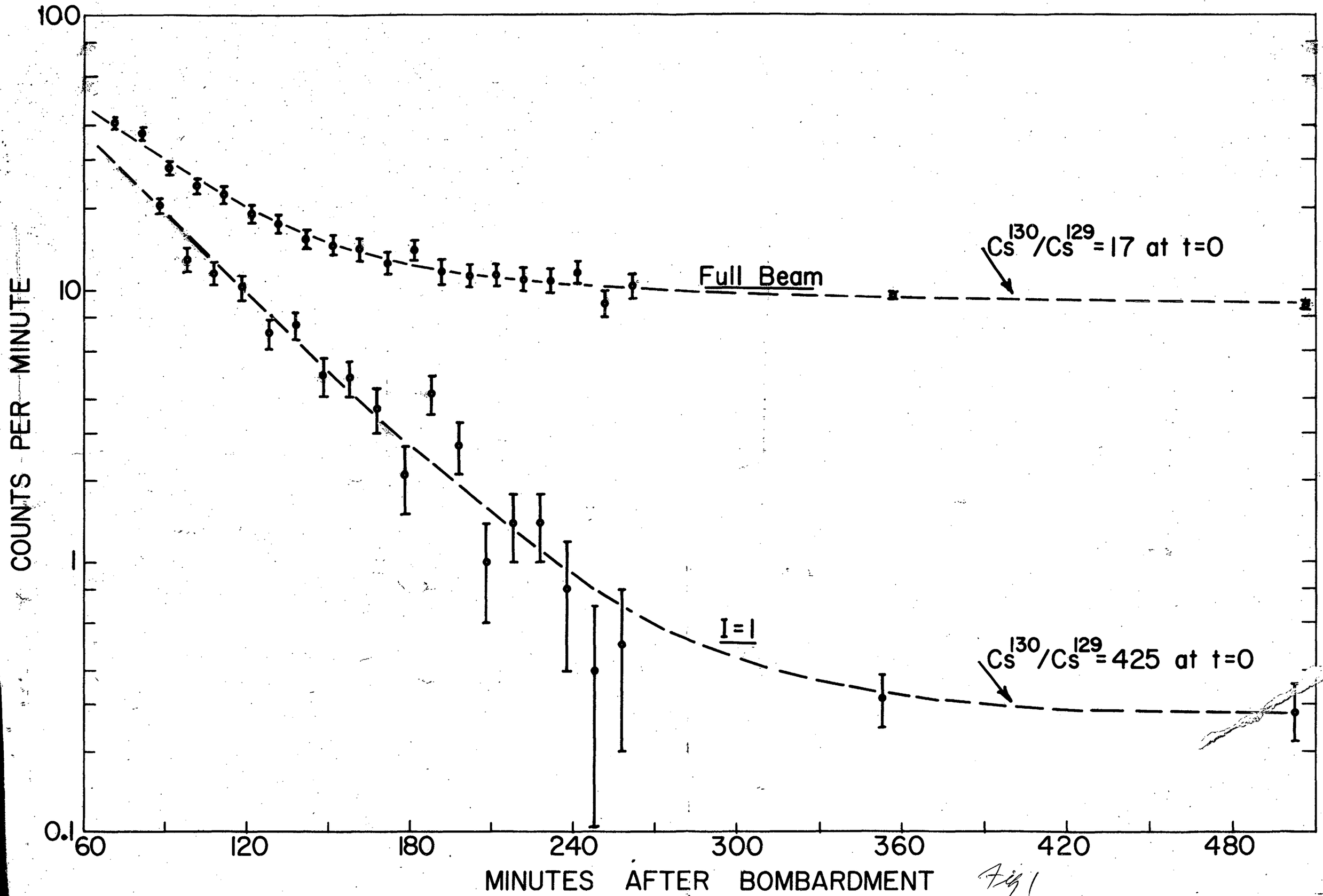
100
10
1
0.1
COUNTS PER MINUTE
60
120
180
240
300
360
420
480
MINUTES AFTER BOMBARDMENT
Full Beam
I=1
Cs^{130}/Cs^{129}=17 at t=0
Cs^{130}/Cs^{129}=425 at t=0

Fig 1

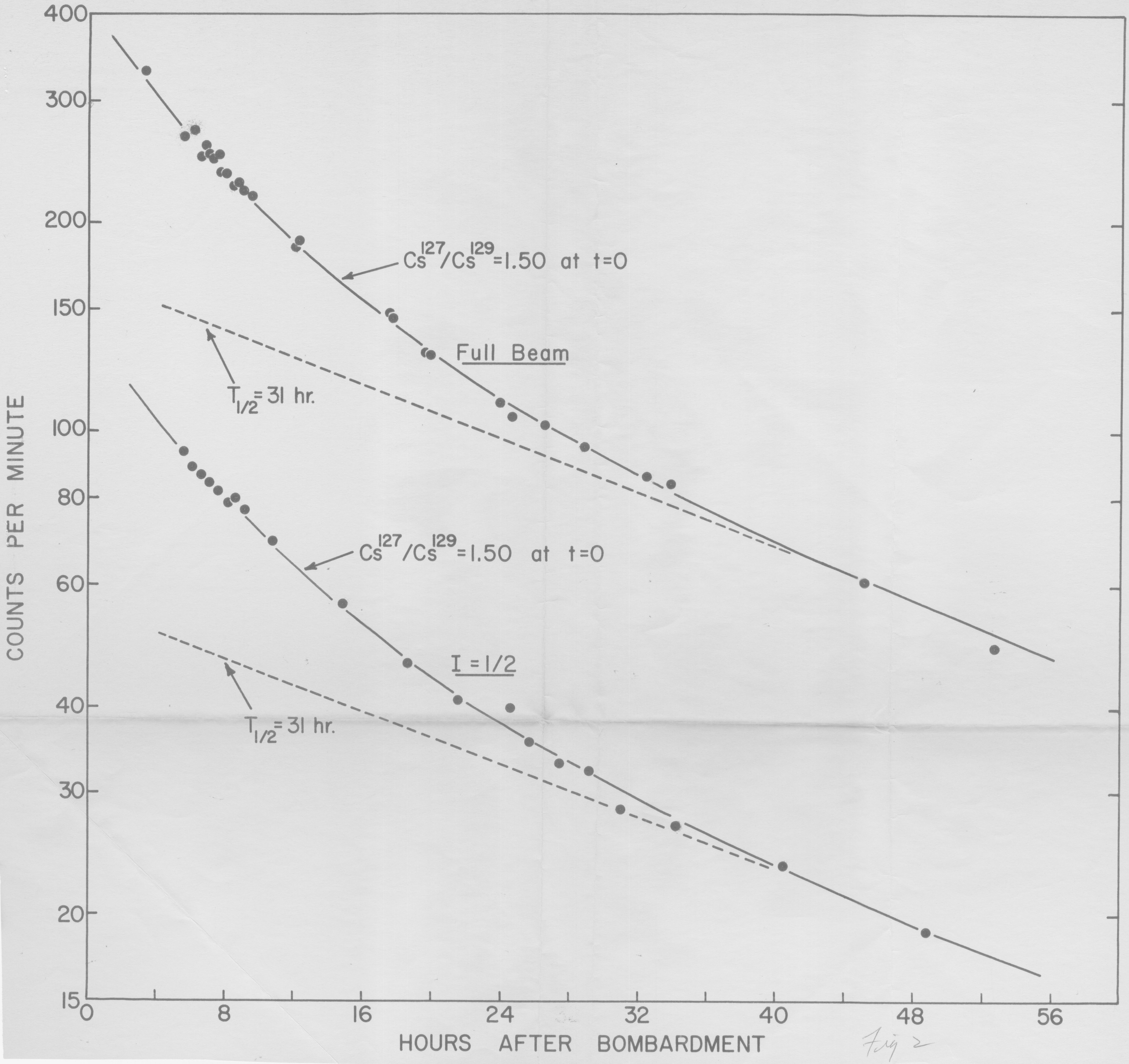
400
300
200
150
100
80
60
40
30
20
15
COUNTS PER MINUTE
0
8
16
24
32
40
48
56
HOURS AFTER BOMBARDMENT
Cs^{127}/Cs^{129}=1.50 at t=0
Full Beam
$T_{1/2}$= 31 hr.
Cs^{127}/Cs^{129}=1.50 at t=0
I = 1/2
$T_{1/2}$= 31 hr.

Fig 2