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Issued to C. Van Atta

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RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY

ENGINEERING NOTES

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SUBJECT: POLONIUM PRODUCTION BY PROTONS ON BISMUTH *

NAME: C. M. Van Atta

DATE: Revised: Nov. 9, 1950

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In LRL-1 Howard Crandall has estimated the activities of the polonium isotopes produced by protons on bismuth. These estimates are based upon the cross section data of Kelly and Segre. The following is an independent check on these estimates for MTA Mk I operating with average current of 0.050 amperes of 30 Mev protons.

No. atoms bismuth/cm^2 = $\frac{gm}{cm^2}$ x 2.87×10^{21}

Energy Range Mev	Differential Thickness gm/cm^2 Bi	Differential Thickness atoms/cm^2 Bi	Cross Section (barns) (p,2n) Po^{208}	Differential Production Atoms Po/proton Po^{208}
30-28	.233	6.70×10^{20}	0.2	1.3×10^{-4}
28-26	.221	6.34×10^{20}	0.2	1.3×10^{-4}
26-24	.210	6.03×10^{20}	0.3	1.8×10^{-4}
24-22	.196	5.62×10^{20}	0.55	3.1×10^{-4}
22-20	.185	5.31×10^{20}	0.9	4.8×10^{-4}
20-18	.171	4.91×10^{20}	1.1	5.4×10^{-4}
18-16	.158	4.53×10^{20}	1.0	4.5×10^{-4}
16-14	.145	4.16×10^{20}	0.8	3.3×10^{-4}
14-12	.131	3.76×10^{20}	0.5	1.9×10^{-4}
12-10	.116	3.33×10^{20}	0.15	0.5×10^{-4}
10-8	.101	2.90×10^{20}	0.05	0.15×10^{-4}
8-6	.085	2.45×10^{20}	-	

From the above table and from

No. of protons/day (.050 ampere) = 2.7×10^{22} ✓

the production of Po^{208} is calculated by summing from low energy up to the indicated

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proton energy. As is stated in LRL-1, the results of Kelly, Ghiorso, et al indicate for a thick target with 30 Mev protons the ratio 208/209 is 5.7 and for a thin target reducing the proton energy from 30 to 20 Mev the ratio is about 18. The figures shown for Po^{209} are chosen so as to be compatible with these observations.

The half life given for Po^{208} is 2.93 yrs. Therefore

$$\tau = 9.24 \times 10^{7} \text{ sec.}$$

and $$\lambda = 7.5 \times 10^{-9} \text{ sec}^{-1}$$

The activity of Po^{208} is then $\lambda N/3.7 \times 10^{10}$ curies. The half life of Po^{209} is so long ($\sim$200 yrs) that the activity in curies will be negligible as compared with that of Po^{208}. The following table gives the production figures for an ideal target in terms of mg/day and curies/day of Po^{208} and mg/day of Po^{209}.

If one assumes 30 Mev protons and a jacket of 0.020" stainless steel, then the loss in proton energy will be about

$$(7.8)(\text{gm/cm}^3) \times .020 \times 2.54 \times 11 \text{ (Mev/gm cm}^{-2}) = 4.3 \text{ Mev}$$

so that the production rate for 0.050 amp at 30 Mev should be about 23 mg/day or 13.6 curies/day of Po^{208} with a contamination of about 4.3 mg/day of Po^{209}.

At 30 Mev there will be about as much (p,3n) Po^{207} produced as (p,2n) Po^{208}. However, since the half life of Po^{207} is only 5.7 hours, the amount present in the target will reach an equilibrium value fairly early and its presence in the extracted product will soon disappear.

UCRL 991 REV

SUBJECT

POLONIUM PRODUCTION BY PROTONS ON BISMUTH

NAME C. M. Van Atta

DATE Revised: Nov. 9, 1950

Integrated Production from Zero Energy

up to Full Energy

Proton Energy	Atoms Po/proton Po^{208}	Atoms Po/proton Po^{209}	Atoms Po/day at .050 amp Po^{208}	Atoms Po/day at .050 amp Po^{209}	mgm Po/day at .050 amp Po^{208}	mgm Po/day at .050 amp Po^{209}	Curies Po^{208}/day at .050 amp.
	$\times 10^{-4}$	$\times 10^{-4}$	$\times 10^{19}$	$\times 10^{19}$			
8	0		0				
10	0.15		0.04		0.14		0.08
12	0.65		0.18		0.6		0.37
14	2.55		0.69		2.4		1.4
16	5.8		1.56		5.3		3.2
18	10.3	4.0	2.78		9.5		5.6
20	15.7	4.2	4.24 ✓	(1.14)	14.5	(3.9)	8.6
22	20.5	4.4	5.55	(1.19)	19.0	(4.1)	11.2
24	23.6	4.5	6.40	(1.23)	21.9	(4.2)	13.0
26	25.4	4.7	6.87	(1.26)	23.6	(4.3)	13.9
28	26.7	4.8	7.20	(1.30)	24.8	(4.5)	14.6
30	28.0	4.9	7.57 ✓	1.33	25.9	4.6	15.4

12.3×10^{-4} 6.7×10^{-4}