MASTER

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SCINTILLATION SPECTROMETRY

GAMMA-RAY SPECTRUM CATALOGUE

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SCINTILLATION SPECTROMETRY

GAMMA-RAY SPECTRUM CATALOGUE

2ND EDITION
VOLUME 2 OF 2

BY

R. L. HEATH

PHILLIPS
PETROLEUM
COMPANY

Atomic Energy Division

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Idaho Operations Office

U. S. ATOMIC ENERGY COMMISSION

COMPILATION OF GAMMA-RAY SPECTRA

Element	Isotope	Half-Life	Detector	Energy Scale	Plate Number	Method of Production
Beryllium	7	53 day	3"x3"-2	1 keV/PHU(Cs)	4-7-1	Li ⁷ (p,n)
Sodium	22	2.6 yr	3"x3"-2	1 keV/PHU(Cs)	11-22-2	Na ²³ (n,2n)
	24	15 hr	3"x3"-2	2 keV/PHU(Cs)	11-24-1	Na ²³ (n,γ)
	24	15 hr	3"x3"-2	1 keV/PHU(Cs)	11-24-2	Na ²³ (n,γ)
Magnesium	27	9.5 min	3"x3"-2	1 keV/PHU(Cs)	12-27-1	Mg ²⁶ (n,γ)
	28	21.3 hr	3"x3"-2	≈2 keV/PHU	12-28(13-28)-1	Mg ²⁶ (2n,γ)
	with Al ²⁸	2.3 min				
Aluminum	28	2.3 min	3"x3"-2	1 keV/PHU(Cs)	13-28-2	Al ²⁷ (n,γ)
	29	6.6 min	3"x3"-2	1 keV/PHU(Cs)	13-29-1	Si ²⁹ (n,p)
Silicon	31	2.62 hr	3"x3"-2	1 keV/PHU(Cs)	14-31-1	Si ³⁰ (n,γ)
Phosphorus	32	14.3 day	3"x3"-2	1 keV/PHU(Cs)	15-32-1	P ³¹ (n,γ)
Sulfur	37	5.1 min	3"x3"-2	2 keV/PHU(Cs)	16-37-2	S ³⁶ (n,γ)
Chlorine	34m	32.4 min	3"x3"-3	2 keV/PHU(Cs)	17-34m(17-34)-1	Cl ³⁵ (γ,n)
	with Cl ³⁴	1.6 sec				
	38	38 min	3"x3"-2	1 keV/PHU(Cs)	17-38-2	Cl ³⁷ (n,γ)
Argon	41	1.83 hr	3"x3"-2	1 keV/PHU(Cs)	18-41-1	A ⁴⁰ (n,γ)
Potassium	38	7.7 min	3"x3"-3	1 keV/PHU(Cs)	19-38-1	K ³⁹ (γ,n)
	38	7.7 min	3"x3"-3	2 keV/PHU(Cs)	19-38-2	K ³⁹ (γ,n)
Potassium	40	1.27x10 ⁹ yr	3"x3"-2	1 keV/PHU(Cs)	19-40-1	nat.
	42	12.4 hr	3"x3"-2	1 keV/PHU(Cs)	19-42-2	K ⁴¹ (n,γ)
Calcium	47	4.5 day	3"x3"-2	1 keV/PHU(Cs)	20-47-1	Ti ⁵⁰ (n,α)
	49	8.7 min	3"x3"-2	2 keV/PHU(Cs)	20-49-1	Ca ⁴⁸ (n,γ)
Scandium	44m	2.4 day	3"x3"-2	1 keV/PHU(Cs)	21-44m(21-44)-1	Sc ⁴⁵ (γ,n)
	with Sc ⁴⁴	4 hr				
	44m	2.4 day	3"x3"-3	2 keV/PHU(Cs)	21-44m(21-44)-2	Sc ⁴⁵ (γ,n)
	with Sc ⁴⁴	4 hr				
	46	85 day	3"x3"-2	1 keV/PHU(Cs)	21-46-1	Sc ⁴⁵ (n,γ)
	47	3.4 day	3"x3"-2	1 keV/PHU(Cs)	21-47-1	Ti ⁴⁷ (n,p)
	47	3.4 day	3"x3"-2	0.5 keV/PHU(Cs)	21-47-2	Ti ⁴⁷ (n,p)
Titanium	48	14 hr	3"x3"-2	1 keV/PHU(Cs)	21-48-2	Ti ⁴⁸ (n,p)
	44	≈10 ⁸ yr	3"x3"-2	1 keV/PHU(Cs)	22-44(21-44)-1	Sc ⁴⁵ (p,2n)
	with Sc ⁴⁴	3.9 hr				
	45	3.08 hr	3"x3"-2	1 keV/PHU(Cs)	22-45-1	Ti ⁴⁶ (γ,n)
Vanadium	51	5.8 min	3"x3"-2	1 keV/PHU(Cs)	22-51-1	Ti ⁵¹ (n,γ)
	48	16 day	3"x3"-2	1 keV/PHU(Cs)	23-48-1	Ti ⁴⁸ (p,n)
Chromium	52	3.77 min	3"x3"-2	1 keV/PHU(Cs)	23-52-2	V ⁵¹ (n,γ)
	49	42 min	3"x3"-24	1 keV/PHU(Cs)	24-49-1	Cr ⁵⁰ (γ,n)
	51	27.8 day	3"x3"-2	1 keV/PHU(Cs)	24-51-1	Cr ⁵⁰ (n,γ)
Manganese	55	3.5 min	3"x3"-2	1 keV/PHU(Cs)	24-55-1	Cr ⁵⁴ (n,γ)
	52	5.7 day	3"x3"-2	1 keV/PHU(Cs)	25-52-1	Cr ⁵² (p,n)
	54	314 day	3"x3"-2	1 keV/PHU(Cs)	25-54-2	Cr ⁵⁴ (p,n)
Iron	56	2.58 hr	3"x3"-2	1 keV/PHU(Cs)	25-56-2	Mn ⁵⁵ (n,γ)
	53	9 min	3"x3"-2	1 keV/PHU(Cs)	26-53-1	Fe ⁵⁴ (γ,n)
Cobalt	59	45 day	3"x3"-2	1 keV/PHU(Cs)	26-59-2	Fe ⁵⁸ (n,γ)
	57	267 day	3"x3"-2	0.5 keV/PHU(Cs)	27-57-1	Fe ⁵⁷ (p,n)
	57	267 day	3"x3"-2	0.25 keV/PHU(Cs)	27-57-2	Fe ⁵⁷ (p,n)

Element	Isotope	Half-Life	Detector	Energy Scale	Plate Number	Method of Production
Cobalt	58	70 day	3"x3"-2	1 keV/PHU(Cs)	27-58-1	Ni ⁵⁸ (n,p)
	60m	10.5 min	3"x3"-2	1 keV/PHU(Cs)	27-60m-1	Co ⁵⁹ (n,γ)
	60	5.27 yr	3"x3"-2	1 keV/PHU(Cs)	27-60-1	Co ⁵⁹ (n,γ)
	61	3.3 hr	3"x3"-2	0.5 keV/PHU(Cs)	27-61-1	Ni ⁶¹ (n,p)
Nickel	57	36 hr	3"x3"-2	1 keV/PHU(Cs)	28-57-1	Ni ⁵⁸ (γ,n)
	65	2.65 hr	3"x3"-2	1 keV/PHU(Cs)	28-65-2	Ni ⁶⁴ (n,γ)
Copper	61	3.3 hr	3"x3"-3	1 keV/PHU(Cs)	29-61-1	Cu ⁶³ (γ,2n)
	62	9.9 min	3"x3"-3	1 keV/PHU(Cs)	29-62-1	Cu ⁶³ (γ,n)
	64	12.9 hr	3"x3"-2	1 keV/PHU(Cs)	29-64-1	Cu ⁶³ (n,γ)
	66	5.1 min	3"x3"-2	1 keV/PHU(Cs)	29-66-1	Cu ⁶⁵ (n,γ)
	67	61 hr	3"x3"-2	1 keV/PHU(Cs)	29-67-1	Zn ⁶⁸ (γ,p)
Zinc	63	38 min	3"x3"-3	1 keV/PHU(Cs)	30-63-1	Zn ⁶⁴ (γ,n)
	65	245 day	3"x3"-2	1 keV/PHU(Cs)	30-65-2	Zn ⁶⁴ (n,γ)
	69m	14 hr	3"x3"-2	1 keV/PHU(Cs)	30-69m(30-69)-1	Zn ⁶⁸ (n,γ)
	with Zn ⁶⁹	55 min				
	69m	14 hr	3"x3"-2	0.5 keV/PHU(Cs)	30-69m(30-69)-2	Zn ⁶⁸ (n,γ)
	with Zn ⁶⁹	55 min				
Gallium	67	78 hr	3"x3"-2	1 keV/PHU(Cs)	31-67-1	Ga ⁶⁹ (γ,2n)
	67	78 hr	3"x3"-2	0.5 keV/PHU(Cs)	31-67-2	Ga ⁶⁹ (γ,2n)
	68	68 min	3"x3"-2	1 keV/PHU(Cs)	31-68-1	Ga ⁶⁹ (γ,n)
	70	21 min	3"x3"-2	1 keV/PHU(Cs)	31-70-1	Ga ⁶⁹ (n,γ)
	72	14.1 hr	3"x3"-2	1 keV/PHU(Cs)	31-72-1	Ga ⁷¹ (n,γ)
Germanium	69	40 hr	3"x3"-2	1 keV/PHU(Cs)	32-69-1	Ge ⁷⁰ (γ,n)
	75	82 min	3"x3"-2	1 keV/PHU(Cs)	32-75-1	Ge ⁷⁴ (n,γ)
	75	82 min	3"x3"-2	0.5 keV/PHU(Cs)	32-75-2	Ge ⁷⁴ (n,γ)
	77m	54 sec	3"x3"-2	0.5 keV/PHU(Cs)	32-77m-1	Ge ⁷⁶ (n,γ)
	77	11 hr	3"x3"-2	1 keV/PHU(Cs)	32-77-1	Ge ⁷⁶ (n,γ)
Arsenic	72	26 hr	3"x3"-2	1 keV/PHU(Cs)	33-72-1	Ge ⁷² (p,n)
	74	18 day	3"x3"-2	1 keV/PHU(Cs)	33-74-1	As ⁷⁵ (γ,n)
	76	26.5 hr	3"x3"-2	1 keV/PHU(Cs)	33-76-2	As ⁷⁵ (n,γ)
	77	39 hr	3"x3"-2	1 keV/PHU(Cs)	33-77-2	Ge ⁷⁶ (n,γ,β)
Selenium	73	7.1 hr	3"x3"-2	1 keV/PHU(Cs)	34-73-1	Se ⁷⁴ (γ,n)
	75	120 day	3"x3"-2	1 keV/PHU(Cs)	34-75-1	Se ⁷⁴ (n,γ)
	75	120 day	3"x3"-2	0.5 keV/PHU(Cs)	34-75-2	Se ⁷⁴ (n,γ)
	81m	61 min	3"x3"-2	1 keV/PHU(Cs)	34-81m(34-81)-1	Se ⁸⁰ (n,γ)
Bromine	with Se ⁸¹	18 min				
	77	58 hr	3"x3"-2	1 keV/PHU(Cs)	35-77-1	Br ⁷⁹ (γ,2n)
	80	18 min	3"x3"-2	1 keV/PHU(Cs)	35-80-1	Br ⁷⁹ (n,γ)
Krypton	82	36 hr	3"x3"-2	1 keV/PHU(Cs)	35-82-1	Br ⁸¹ (n,γ)
	85m	4.4 hr	3"x3"-2	1 keV/PHU(Cs)	36-85m-1	Kr ⁸⁴ (n,γ)
	85	10.4 yr	3"x3"-2	1 keV/PHU(Cs)	36-85-1	Kr ⁸⁴ (n,γ)
Rubidium	84m	21 min	3"x3"-3	1 keV/PHU(Cs)	37-84m-1	Rb ⁸⁵ (γ,n)
	86	18.7 day	3"x3"-2	1 keV/PHU(Cs)	37-86-1	Rb ⁸⁵ (n,γ)
	88	18 min	3"x3"-2	1 keV/PHU(Cs)	37-88-1	Rb ⁸⁷ (n,γ)
	88	18 min	3"x3"-2	2 keV/PHU(Cs)	37-88-2	Rb ⁸⁷ (n,γ)
	89	15 min	3"x3"-2	1 keV/PHU(Cs)	37-89-1	U ²³⁵ (n,f)
	89	15 min	3"x3"-2	2 keV/PHU(Cs)	37-89-2	U ²³⁵ (n,f)
	90	2.9 min	3"x3"-2	≈ 2 keV/PHU	37-90-1	U ²³⁵ (n,f)
Strontium	85m	70 min	3"x3"-2	0.5 keV/PHU(Cs)	38-85m-1	Sr ⁸⁴ (n,γ)
	85	64 day	3"x3"-2	1 keV/PHU(Cs)	38-85-2	Rb ⁸⁵ (p,n)

Element	Isotope	Half-Life	Detector	Energy Scale	Plate Number	Method of Production
Strontium	87m	2.8 hr	3"x3"-2	1 keV/PHU(Cs)	38-87m-1	Sr ⁸⁰ (n,γ)
	87m	2.8 hr	3"x3"-2	0.5 keV/PHU(Cs)	38-87m-2	Sr ⁸⁶ (n,γ)
	91	9.7 hr	3"x3"-2	1 keV/PHU(Cs)	38-91-2	U ²³⁵ (n,f)
	92	2.7 hr	3"x3"-2	1 keV/PHU(Cs)	38-92-1	U ²³⁵ (n,f)
Yttrium	86	15 hr	3"x3"-2	1 keV/PHU(Cs)	39-86-1	Sr ⁸⁶ (p,n)
	88	105 day	3"x3"-2	2 keV/PHU(Cs)	39-88-1	Sr ⁸⁸ (p,n)
	88	105 day	3"x3"-2	1 keV/PHU(Cs)	39-88-2	Sr ⁸⁸ (p,n)
	90m	3.14 hr	3"x3"-2	1 keV/PHU(Cs)	39-90m-1	Zr ⁹⁰ (n,p)
	91m	50 min	3"x3"-2	1 keV/PHU(Cs)	39-91m-2	U ²³⁵ (n,f)
	91	59 day	3"x3"-2	1 keV/PHU(Cs)	39-91-2	U ²³⁵ (n,f)
	92	3.6 hr	3"x3"-2	1 keV/PHU(Cs)	39-92-1	U ²³⁵ (n,f)
	93	10.1 hr	3"x3"-2	1 keV/PHU(Cs)	39-93-1	U ²³⁵ (n,f)
	94	17 min	3"x3"-2	≈ 4 keV/PHU	39-94-1	U ²³⁵ (n,f)
Zirconium	89m	4.4 min	3"x3"-3	1 keV/PHU(Cs)	40-89m-1	Zr ⁹⁰ (γ,n)
	89	79 hr	3"x3"-3	1 keV/PHU(Cs)	40-89-1	Zr ⁹⁰ (γ,n)
	95	65 day	3"x3"-2	1 keV/PHU(Cs)	40-95-2	U ²³⁵ (n,f)
	95	65 day	3"x3"-2	1 keV/PHU(Cs)	40-95(41-95)-2	U ²³⁵ (n,f)
	with Nb ⁹⁵	35 day				
	97	17 hr	3"x3"-2	1 keV/PHU(Cs)	40-97-2	Zr ⁹⁶ (n,γ)
	with Nb ^{97m}	60 sec				
	97	17 hr	3"x3"-2	1 keV/PHU(Cs)	40-97(41-97)-1	Zr ⁹⁶ (n,γ)
	with Nb ⁹⁷	74 min				
Niobium	92	10 day	3"x3"-2	1 keV/PHU(Cs)	41-92-1	Nb ⁹³ (γ,n)
	94m	6.6 min	3"x3"-2	1 keV/PHU(Cs)	41-94m-1	Nb ⁹³ (n,γ)
	94	2x10 ⁴ yr	3"x3"-2	1 keV/PHU(Cs)	41-94-2	Nb ⁹³ (n,γ)
	95	35 day	3"x3"-2	1 keV/PHU(Cs)	41-95-2	U ²³⁵ (n,f)
	97m	60 sec	3"x3"-2	1 keV/PHU(Cs)	41-97m-1	Zr ⁹⁶ (n,γ,β)
	97	74 min	3"x3"-2	1 keV/PHU(Cs)	41-97-1	Zr ⁹⁶ (n,γ,β)
Molybdenum	91	16 min	3"x3"-2	1 keV/PHU(Cs)	42-91-1	Mo ⁹² (γ,n)
	99	66 hr	3"x3"-2	≈ 1 keV/PHU	42-99-1	Mo ⁹⁸ (n,γ)
	99	66 hr	3"x3"-2	1 keV/PHU(Cs)	42-99(43-99m)-1	Mo ⁹⁸ (n,γ)
	with Tc ^{99m}	6 hr				
	101	14.6 min	3"x3"-2	1 keV/PHU(Cs)	42-101-1	Mo ¹⁰⁰ (n,γ)
Technecium	95m	60 day	3"x3"-2	1 keV/PHU(Cs)	43-95m(43-95)-1	Ru ⁹⁶ (γ,n,K)
	with Tc ⁹⁵	20 hr				
	95	20 hr	3"x3"-3	1 keV/PHU(Cs)	43-95-1	Ru ⁹⁶ (γ,n,K)
	96	4.3 day	3"x3"-2	1 keV/PHU(Cs)	43-96-1	Mo ⁹⁸ (p,n)
	99	2.1x10 ⁵ yr	3"x3"-2	1 keV/PHU(Cs)	43-99-1	U ²³⁵ (n,f)
Ruthenium	101	14 min	3"x3"-2	1 keV/PHU(Cs)	43-101-1	Mo ¹⁰⁰ (n,γ,β)
	95	1.7 hr	3"x3"-3	1 keV/PHU(Cs)	44-95-1	Ru ⁹⁶ (γ,n)
	97	2.9 day	3"x3"-2	1 keV/PHU(Cs)	44-97-1	Ru ⁹⁶ (n,γ)
	103	40 day	3"x3"-2	1 keV/PHU(Cs)	44-103-1	Ru ¹⁰² (n,γ)
	105	4.45 hr	3"x3"-2	1 keV/PHU(Cs)	44-105-1	Ru ¹⁰⁴ (n,γ)
	106	1.0 yr	3"x3"-2	1 keV/PHU(Cs)	44-106(45-106)-3	U ²³⁵ (n,f)
Rhodium	with Rh ¹⁰⁶	30 sec				
	101m	4.7 day	3"x3"-2	1 keV/PHU(Cs)	45-101m-1	Rh ¹⁰³ (γ,2n)
	104m	4.4 min	3"x3"-2	≈ 0.5 keV/PHU	45-104m-1	Rh ¹⁰³ (n,γ)
	with Rh ¹⁰⁴	42 sec				
Palladium	105m	42 sec	3"x3"-2	≈ 0.5 keV/PHU	45-105m-1	Ru ¹⁰⁴ (n,γ,β)
	109	13.6 hr	3"x3"-2	0.5 keV/PHU(Cs)	46-109-1	Pd ¹⁰⁸ (n,γ)
Silver	105	40 day	3"x3"-2	1 keV/PHU(Cs)	47-105-1	Ag ¹⁰⁷ (γ,2n)

Element	Isotope	Half-Life	Detector	Energy Scale	Plate Number	Method of Production
Silver	106m	8.3 day	3"x3"-2	1 keV/PHU(Cs)	47-106m-1	Ag ¹⁰⁷ (γ,n)
	106	24 min	3"x3"-3	1 keV/PHU(Cs)	47-106-1	Ag ¹⁰⁷ (γ,n)
	108m	>5 yr	3"x3"-2	1 keV/PHU(Cs)	47-108m-1	Ag ¹⁰⁷ (n,γ)
	108	2.4 min	3"x3"-2	1 keV/PHU(Cs)	47-108-1	Ag ¹⁰⁷ (n,γ)
	110m	250 day	3"x3"-2	1 keV/PHU(Cs)	47-110m-2	Ag ¹⁰⁹ (n,γ)
	110	24 sec	3"x3"-2	1 keV/PHU(Cs)	47-110-1	Ag ¹⁰⁹ (n,γ)
	111	7.5 day	3"x3"-2	≈1 keV/PHU	47-111-1	Pd ¹¹⁰ (n,γ,β)
Cadmium	109	1.3 yr	3"x3"-2	0.5 keV/PHU(Cs)	48-109-1	Cd ¹⁰⁸ (n,γ)
	115m	43 day	3"x3"-3	1 keV/PHU(Cs)	48-115m-1	Cd ¹¹⁴ (n,γ)
	115	2.3 day	3"x3"-2	1 keV/PHU(Cs)	48-115(49-115m)-2	Cd ¹¹⁴ (n,γ)
	with In ^{115m}	4.5 hr				
Indium	111	2.8 day	3"x3"-2	0.5 keV/PHU(Cs)	49-111-1	In ¹¹³ (γ,2n)
	112m	21 min	3"x3"-3	1 keV/PHU(Cs)	49-112m(49-112)-1	In ¹¹³ (γ,n)
	with In ¹¹²	14 min				
	113m	1.7 hr	3"x3"-2	1 keV/PHU(Cs)	49-113m-1	Sn ¹¹² (n,γ,β)
	114m	49 day	3"x3"-2	1 keV/PHU(Cs)	49-114m-1	In ¹¹³ (n,γ)
	115m	4.5 hr	3"x3"-2	0.5 keV/PHU(Cs)	49-115m-2	Cd ¹¹⁴ (n,γ,β)
	116m	54 min	3"x3"-2	1 keV/PHU(Cs)	49-116m-1	In ¹¹⁵ (n,γ)
Tin	113	118 day	3"x3"-2	1 keV/PHU(Cs)	50-113(49-113m)-1	Sn ¹¹² (n,γ)
	with In ^{113m}	1.7 hr				
	125m	9.7 min	3"x3"-2	1 keV/PHU(Cs)	50-125m-1	Sn ¹²⁴ (n,γ)
	125	9.4 day	3"x3"-2	1 keV/PHU(Cs)	50-125-1	U ²³⁵ (n,f)
Antimony	120m	5.8 day	3"x3"-2	1 keV/PHU(Cs)	51-120m-1	Sb ¹²¹ (γ,n)
	120	16 min	3"x3"-24	1 keV/PHU(Cs)	51-120-1	Sb ¹²¹ (γ,n)
	122m	3.4 min	3"x3"-2	0.5 keV/PHU(Cs)	51-122m-1	Sb ¹²¹ (n,γ)
	122	2.8 day	3"x3"-2	1 keV/PHU(Cs)	51-122-2	Sb ¹²¹ (n,γ)
	124	60 day	3"x3"-2	1 keV/PHU(Cs)	51-124-2	Sb ¹²³ (n,γ)
	125	2.7 yr	3"x3"-2	1 keV/PHU(Cs)	51-125(52-125m)-1	U ²³⁵ (n,f)
	with Te ^{125m}	58 day				
	125	2.7 yr	3"x3"-2	1 keV/PHU(Cs)	51-125-2	U ²³⁵ (n,f)
	129	4.2 hr	3"x3"-2	≈2 keV/PHU	51-129-1	U ²³⁵ (n,f)
Tellurium	125m	58 day	3"x3"-2	0.5 keV/PHU(Cs)	52-125m-1	Te ¹²⁴ (n,γ)
	132	78 hr	3"x3"-2	1 keV/PHU(Cs)	52-132-1	U ²³⁵ (n,f)
	132	78 hr	3"x3"-2	1 keV/PHU(Cs)	52-132(53-132)-1	U ²³⁵ (n,f)
	with I ¹³²	2.3 hr				
Iodine	124	4.5 day	3"x3"-2	≈2 keV/PHU	53-124-1	Te ¹²⁴ (p,n)
	126	13.2 day	3"x3"-2	1 keV/PHU(Cs)	53-126-1	I ¹²⁷ (γ,n)
	128	25 min	3"x3"-2	1 keV/PHU(Cs)	53-128-1	I ¹²⁷ (n,γ)
	130	12.5 hr	3"x3"-2	1 keV/PHU(Cs)	53-130-1	Te ¹³⁰ (p,n)
	131	8 day	3"x3"-2	1 keV/PHU(Cs)	53-131-2	U ²³⁵ (n,f)
	132	2.3 hr	3"x3"-2	1 keV/PHU(Cs)	53-132-2	U ²³⁵ (n,f)
	133	20.8 hr	3"x3"-2	1 keV/PHU(Cs)	53-133-2	U ²³⁵ (n,f)
	134	53 min	3"x3"-2	1 keV/PHU(Cs)	53-134-1	U ²³⁵ (n,f)
	135	6.7 hr	3"x3"-2	1 keV/PHU(Cs)	53-135-1	U ²³⁵ (n,f)
Xenon	125	18 hr	3"x3"-2	0.5 keV/PHU(Cs)	54-125-1	Xe ¹²⁴ (n,γ)
	133	5.3 day	3"x3"-2	0.5 keV/PHU(Cs)	54-133-1	U ²³⁵ (n,f)
	135	9.2 hr	3"x3"-2	1 keV/PHU(Cs)	54-135-1	U ²³⁵ (n,f)
Cesium	132	6.5 day	3"x3"-2	1 keV/PHU(Cs)	55-132-1	Cs ¹³³ (γ,n)
	134m	2.9 hr	3"x3"-2	1 keV/PHU(Cs)	55-134m-1	Cs ¹³³ (n,γ)
	134m	2.9 hr	3"x3"-2	0.5 keV/PHU(Cs)	55-134m-2	Cs ¹³³ (n,γ)
	134	2.1 yr	3"x3"-2	1 keV/PHU(Cs)	55-134-1	Cs ¹³³ (n,γ)

Element	Isotope	Half-Life		Detector	Energy Scale	Plate Number	Method of Production
Cesium	136	13	day	3"x3"-2	1 keV/PHU(Cs)	55-136-1	U ²³⁵ (n,f)
	137	30	yr	3"x3"-2	1 keV/PHU(Cs)	55-137-1	U ²³⁵ (n,f)
	138	32	min	3"x3"-2	1 keV/PHU(Cs)	55-138-1	U ²³⁵ (n,f)
	139	9.5	min	3"x3"-2	1 keV/PHU(Cs)	55-139-1	U ²³⁵ (n,f)
Barium	131	11.5	day	3"x3"-2	≈ 1 keV/PHU	56-131-1	Ba ¹³⁰ (n,γ)
	133	7.5	yr	3"x3"-2	1 keV/PHU(Cs)	56-133-1	Ba ¹³² (n,γ)
	133	7.5	yr	3"x3"-2	0.5 keV/PHU(Cs)	56-133-2	Ba ¹³² (n,γ)
	139	83	min	3"x3"-2	1 keV/PHU(Cs)	56-139-1	Ba ¹³⁸ (n,γ)
	140	12.8	day	3"x3"-2	1 keV/PHU(Cs)	56-140-1	U ²³⁵ (n,f)
	140 with La ¹⁴⁰	12.8 40	day hr	3"x3"-2	1 keV/PHU(Cs)	56-140(57-140)-2	U ²³⁵ (n,f)
Lanthanum	136	9.5	min	3"x3"-3	1 keV/PHU(Cs)	57-136-1	La ¹³⁹ (γ,3n)
	140	40.2	hr	3"x3"-2	1 keV/PHU(Cs)	57-140-1	La ¹³⁹ (n,γ)
	142	87	min	3"x3"-2	≈ 4 keV/PHU	57-142-2	U ²³⁵ (n,f)
Cerium	139	140	day	3"x3"-2	1 keV/PHU(Cs)	58-139-1	La ¹³⁹ (p,n)
	139	140	day	3"x3"-2	0.5 keV/PHU(Cs)	58-139-2	La ¹³⁹ (p,n)
	141	32.5	day	3"x3"-2	1 keV/PHU(Cs)	58-141-1	Ce ¹⁴⁰ (n,γ)
	141	32.5	day	3"x3"-2	0.5 keV/PHU(Cs)	58-141-2	Ce ¹⁴⁰ (n,γ)
	143	33	hr	3"x3"-2	1 keV/PHU(Cs)	58-143-1	Ce ¹⁴² (n,γ)
	143	33	hr	3"x3"-2	0.5 keV/PHU(Cs)	58-143-2	Ce ¹⁴² (n,γ)
	144 with Pr ¹⁴⁴	284 17	day min	3"x3"-2	1 keV/PHU(Cs)	58-144(59-144)-1	U ²³⁵ (n,f)
Praseodymium	139	4.5	hr	3"x3"-3	1 keV/PHU(Cs)	59-139-1	Pr ¹⁴¹ (γ,2n)
	142	19.2	hr	3"x3"-2	1 keV/PHU(Cs)	59-142-1	Pr ¹⁴¹ (n,γ)
	143	13.7	day	3"x3"-2	1 keV/PHU(Cs)	59-143-1	Ce ¹⁴² (n,γ,β)
	145	5.9	hr	3"x3"-2	1 keV/PHU(Cs)	59-145-1	U ²³⁵ (n,f)
Neodymium	141	2.4	hr	3"x3"-3	1 keV/PHU(Cs)	60-141-1	Nd ¹⁴² (γ,n)
	147	11.1	day	3"x3"-2	1 keV/PHU(Cs)	60-147-1	Nd ¹⁴⁶ (n,γ)
	147	11.1	day	3"x3"-2	0.5 keV/PHU(Cs)	60-147-2	Nd ¹⁴⁶ (n,γ)
	149	1.9	hr	3"x3"-2	0.5 keV/PHU(Cs)	60-149-1	Nd ¹⁴⁸ (n,γ)
	151	12	min	3"x3"-2	1 keV/PHU(Cs)	60-151-1	Nd ¹⁵⁰ (n,γ)
Promethium	147	2.5	yr	3"x3"-2	1 keV/PHU(Cs)	61-147-1	Nd ¹⁴⁶ (n,γ,β)
	148m	41	day	3"x3"-2	1 keV/PHU(Cs)	61-148m(61-148)-1	Sm ¹⁴⁸ (n,p)
	148	5.4	day	3"x3"-2	1 keV/PHU(Cs)	61-148-1	Sm ¹⁴⁸ (n,p)
	151	28.4	hr	3"x3"-2	1 keV/PHU(Cs)	61-151-1	Nd ¹⁵⁰ (n,γ,β)
Samarium	153	46.7	hr	3"x3"-2	0.5 keV/PHU(Cs)	62-153-1	Sm ¹⁵² (n,γ)
	155	25	min	3"x3"-2	≈ 0.5 keV/PHU	62-155-1	Sm ¹⁵⁴ (n,γ)
Europium	152m	9.3	hr	3"x3"-2	1 keV/PHU(Cs)	63-152m-1	Eu ¹⁵¹ (n,γ)
	155	1.7	yr	3"x3"-2	0.5 keV/PHU(Cs)	63-155-1	U ²³⁵ (n,f)
	156	15	day	3"x3"-2	1 keV/PHU(Cs)	63-156-1	Sm ¹⁵⁴ (n,γ,β,n,γ)
	157	15	hr	3"x3"-2	1 keV/PHU(Cs)	63-157-1	U ²³⁵ (n,f)
Gadolinium	153	200	day	3"x3"-2	0.5 keV/PHU(Cs)	64-153-1	Cd ¹⁵² (n,γ)
	159	18	hr	3"x3"-2	1 keV/PHU(Cs)	64-159-1	Gd ¹⁵⁸ (n,γ)
	159	18	hr	3"x3"-2	0.5 keV/PHU(Cs)	64-159-2	Gd ¹⁵⁸ (n,γ)
	161	3.7	min	3"x3"-2	≈ 1 keV/PHU	64-161-1	Gd ¹⁶⁰ (n,γ)
Terbium	160	73	day	3"x3"-2	1 keV/PHU(Cs)	65-160-2	Tb ¹⁵⁹ (n,γ)
Dysprosium	165m	75	sec	3"x3"-2	1 keV/PHU(Cs)	66-165m-1	Dy ¹⁶⁴ (n,γ)
	165	2.3	hr	3"x3"-2	1 keV/PHU(Cs)	66-165-1	Dy ¹⁶⁴ (n,γ)
Holmium	164	37	min	3"x3"-3	0.5 keV/PHU(Cs)	67-164-1	Ho ¹⁶⁵ (γ,n)

Element	Isotope	Half-Life		Detector	Energy Scale	Plate Number	Method of Production
Lead	212	10.6	hr	3"x3"-2	1 keV/PHU(Cs)	82-212-1	Th ²²⁸ decay
Bismuth	205	15	day	3"x3"-2	1 keV/PHU(Cs)	83-205-2	Pb ²⁰⁸ (p,2n)
	207	28	yr	3"x3"-2	1 keV/PHU(Cs)	83-207-2	Pb ²⁰⁷ (p,n)
	212	60	min	3"x3"-2	1 keV/PHU(Cs)	83-212-1	Th ²²⁸ decay
Radium	226	1620	yrs	3"x3"-2	≈2 keV/PHU	88-226-1	nat.
with daughters							
Thorium	228	1.91	yr	3"x3"-2	1 keV/PHU(Cs)	90-228-1	Th decay
with daughters							
with daughters							
with daughters							
with daughters							
with daughters							
Protactinium	231	34,000	yr	3"x3"-2	≈1 keV/PHU	91-231-1	nat.
	233	27	day	3"x3"-2	0.5 keV/PHU(Cs)	91-233-1	Th ²³² (n,γ,β)
	233	27	day	3"x3"-2	1 keV/PHU(Cs)	91-233-2	Th ²³² (n,γ,β)
Uranium	235	1.1x10 ⁸	yr	3"x3"-2	0.5 keV/PHU(Cs)	92-235-1	nat.
	237	6.7	day	3"x3"-2	0.5 keV/PHU(Cs)	92-237-1	Pu ²⁴¹ decay
	239	23.5	min	3"x3"-2	0.5 keV/PHU(Cs)	92-239-1	U ²³⁸ (n,γ)
Uranium ore				3"x3"-2	≈2 keV/PHU	92-(ore)-1	nat.
Neptunium	239	2.35	day	3"x3"-2	0.5 keV/PHU(Cs)	93-239-2	U ²³⁸ (n,γ,β)

Element	Isotope	Half-Life		Detector	Energy Scale	Plate Number	Method of Production
Holmium	166m	10 ³	yr	3"x3"-2	1 keV/PHU(Cs)	67-166m-1	Ho ¹⁶⁵ (n,γ)
	166	27	hr	3"x3"-2	1 keV/PHU(Cs)	67-166-1	Ho ¹⁶⁵ (n,γ)
Erbium	171	7.5	hr	3"x3"-2	0.5 keV/PHU(Cs)	68-171-1	Er ¹⁷⁰ (n,γ)
Thulium	168	85	day	3"x3"-2	1 keV/PHU(Cs)	69-168-1	Tm ¹⁶⁹ (γ,n)
	170	127	day	3"x3"-2	0.5 keV/PHU(Cs)	69-170-1	Tm ¹⁶⁹ (n,γ)
	171	1.9	yr	3"x3"-2	0.5 keV/PHU(Cs)	69-171-1	Tm ¹⁶⁹ (n,γ,n,γ)
Ytterbium	169	32	day	3"x3"-2	0.5 keV/PHU(Cs)	70-169-1	Yb ¹⁶⁸ (n,γ)
	175	4.2	day	3"x3"-2	0.5 keV/PHU(Cs)	70-175-1	Yb ¹⁷⁴ (n,γ)
Lutetium	176m	3.7	hr	3"x3"-2	0.5 keV/PHU(Cs)	71-176m-1	Lu ¹⁷⁵ (n,γ)
	177	6.8	day	3"x3"-2	0.5 keV/PHU(Cs)	71-177-1	Lu ¹⁷⁶ (n,γ)
Hafnium	173	24	hr	3"x3"-3	0.5 keV/PHU(Cs)	72-173-1	Hf ¹⁷⁴ (γ,n)
	173	24	hr	3"x3"-2	1 keV/PHU(Cs)	72-173-2	Hf ¹⁷⁴ (γ,n)
	175	70	day	3"x3"-2	1 keV/PHU(Cs)	72-175-1	Hf ¹⁷⁴ (n,γ)
	175	70	day	3"x3"-2	0.5 keV/PHU(Cs)	72-175-2	Hf ¹⁷⁴ (n,γ)
	179m	19	sec	3"x3"-2	1 keV/PHU(Cs)	72-179m-1	Hf ¹⁷⁸ (n,γ)
	180m	5.5	hr	3"x3"-2	1 keV/PHU(Cs)	72-180m-1	Hf ¹⁷⁸ (n,γ)
	181	43	day	3"x3"-2	1 keV/PHU(Cs)	72-181-1	Hf ¹⁸⁰ (n,γ)
Tantalum	180m	8.1	hr	3"x3"-5	0.5 keV/PHU(Cs)	73-180m-1	Ta ¹⁸¹ (γ,n)
	182m	16	min	3"x3"-2	≈0.5 keV/PHU	73-182m-1	Ta ¹⁸¹ (n,γ)
	182	115	day	3"x3"-2	1 keV/PHU(Cs)	73-182-1	Ta ¹⁸¹ (n,γ)
	183	5.2	day	3"x3"-2	1 keV/PHU(Cs)	73-183-1	Ta ¹⁸¹ (2n,γ)
Wolfram (Tungsten)	187	24	hr	3"x3"-2	1 keV/PHU(Cs)	74-187-1	W ¹⁸⁶ (n,γ)
Rhenium	188m	18.7	min	3"x3"-2	0.5 keV/PHU(Cs)	75-188m-1	Re ¹⁸⁷ (n,γ)
	188	17	hr	3"x3"-2	1 keV/PHU(Cs)	75-188-1	Re ¹⁸⁷ (n,γ)
Osmium	185	94	day	3"x3"-2	1 keV/PHU(Cs)	76-185-1	Os ¹⁸⁴ (n,γ)
	191	15	day	3"x3"-2	0.5 keV/PHU(Cs)	76-191-1	Os ¹⁹⁰ (n,γ)
	193	32	hr	3"x3"-2	1 keV/PHU(Cs)	76-193-1	Os ¹⁹² (n,γ)
Iridium	192	74	day	3"x3"-2	1 keV/PHU(Cs)	77-192-1	Ir ¹⁹¹ (n,γ)
	194	19	hr	3"x3"-2	1 keV/PHU(Cs)	77-194-1	Ir ¹⁹³ (n,γ)
Platinum	195m	4.1	day	3"x3"-2	0.5 keV/PHU(Cs)	78-195m-1	Pt ¹⁹⁴ (n,γ)
	197	20	hr	3"x3"-2	0.5 keV/PHU(Cs)	78-197-1	Pt ¹⁹⁶ (n,γ)
	199	30	min	3"x3"-2	1 keV/PHU(Cs)	78-199-1	Pt ¹⁹⁸ (n,γ)
Gold	196	6.1	day	3"x3"-2	1 keV/PHU(Cs)	79-196-1	Au ¹⁹⁷ (γ,n)
	198	64.8	hr	3"x3"-2	1 keV/PHU(Cs)	79-198-1	Au ¹⁹⁷ (n,γ)
	199	3.2	day	3"x3"-2	1 keV/PHU(Cs)	79-199-1	Pt ¹⁹⁸ (n,γ,β)
	199	3.2	day	3"x3"-2	0.5 keV/PHU(Cs)	79-199-2	Pt ¹⁹⁸ (n,γ,β)
Mercury	197m	24	hr	3"x3"-2	0.5 keV/PHU(Cs)	80-197m(80-197)-1	Hg ¹⁹⁶ (n,γ)
	with Hg ¹⁹⁷	65	hr				
	197	65	hr	3"x3"-2	0.5 keV/PHU(Cs)		Hg ¹⁹⁶ (n,γ)
	203	47	day	3"x3"-2	1 keV/PHU(Cs)		Hg ²⁰² (n,γ)
Thallium	203	47	day	3"x3"-2	0.5 keV/PHU(Cs)	80-203-2	Hg ²⁰² (n,γ)
	202	12	day	3"x3"-2	1 keV/PHU(Cs)	81-202-1	Tl ²⁰³ (γ,n)
	204	3.9	yr	3"x3"-2	1 keV/PHU(Cs)	81-204-1	Tl ²⁰³ (n,γ)
Lead	208	3.1	min	3"x3"-2	1 keV/PHU(Cs)	81-208-1	Th ²²⁸ decay
	203	52	hr	3"x3"-2	1 keV/PHU(Cs)	82-203-1	Pb ²⁰⁴ (γ,n)
	204m	6/	min	3"x3"-2	1 keV/PHU(Cs)	82-204m-1	Pb ²⁰⁴ (γ,γ)
	207m	0.8	sec	3"x3"-5	1 keV/PHU(Cs)	82-207m-1	Pb ²⁰⁸ (γ,n)

Begin 5 in action.

Begin 6th section

Begin 7th section

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