BOOK67R

Notes:
" 1970 Chem Tech Log DWM"

Blank pages: page opposite page 1, 1, 4, 6, 8, 10, 12, 14, 18, 22, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 68, 70, 72, 74, 76, 78, 80, 84, 88, 90, 92, 94, 102, 104, 106, 108, 110, 114, 118-150, 152, inside back cover sheets

-pages 20 & 21 has 1 sheet glued each
-pages 28 & 29 has 1 sheet glued each
-page 47 has 1 small sheet taped
-page 66 has 1 small graph taped
-page 98 has 1 half sheet taped
-page 112 has 1 graph sheet

Scanned by:
Sheila Finch
RSICC /Oak Ridge National Lab.
August 23, 1999

Anderson
688

SHAW'S
PIONEERS SINCE 1831

Account Book

No. S 149

NO UNITS

Journal . . . .

Ledger, Single Entry . .

Ledger, Double Entry .

Record Ruled (27 Lines)

Made in 150, and 300 Pages

MADE IN U. S. A.

TO REORDER, SPECIFY NUMBER, RULING AND THICKNESS INDICATED ON BACKBONE OF THIS BOOK.

June 23, 1970 DWM, ADC, JTT, JTM present.

Summary of Discussions with JP Nichols on Nondestructive Assay of Fissile Material.

Chem Tech Div. has responsibility for

1) Waste Material Storage in Salt Mine
   Primary Design for Federal Repository of Waste Materials
2) LMFBR Fuel Reprocessing
3) HTGR " "
4) LWBR " " (^{233}U)

Desirable to be able to analyze nondestructively

1) Irradiated Fuel Elements
2) Process stream
3) Waste Materials

Waste Repository materials of 2 types

a) High Level Wastes which contain fission products. Will be in sealed 6 to 24 in diameter cylinders 10 ft long
b) Low Level Wastes at present mostly α contaminated wastes (from TRU) 55 gal drums

Items under b) will be stored for the next few years until Salt Mine ready.

DWM

Barrels are limited only by heat generation and criticality problem -- no maximum upper limit on ^{235}U or ^{239}Pu has been placed; however one of approx 5g of fissile / ft^3 may.

5g × 8 ft^3 = 400 g per bbl.

Heat generation ~0.01 watts / ft^3 from long lived - f.p. or α radiation. This will probably char paper and plastic; temperature limit has been set to be . (I do not recall value) (nor do my notes have the number)

Criticality problem --

ATMX RR car filled with BBL must be subcrit.

9 × 9 × 50 ft ≈ 4050 ft^3

3 × 5 × 28 = 420 bbls; must subcrit.

Crush conditions for Train Wreck!

Storage Facility for α wastes including Rocky Flats

150,000 ft^3 -- must be sub crit!

DWM

The efforts of Keepin et al at LASL and the work of GGA at San Diego on Fissionable Materials Safeguards was discussed at some length. The extension of these efforts to the nondestructive assay of irradiated fissile materials may be a very difficult problem. JPN believes that if either group has the capability of assaying the waste barrels, we should duplicate their efforts and learn how so that similar eqpt can be installed at ORNL! JPN will support CEF -- 1 Man year + 25 k$ to 50 k$ for eqpt for this next fiscal year. It was emphasized that this amount of money would not allow us to buy the necessary electronics, but only to study the problem and make a proposal for the next course of action.

DWM

From JTT array calculations
1000 Bare units in 24" birdcage
5.97 kg of ^{239}Pu metal
(6-26 10^6 units of 1.6 kg Pu are crit, from JTT.)
From JTT Calculations on Barrels with foamglas or Vermiculite + ~10% safety factor
5.7 kg for 1000 unit
6.3 kg for 100 units

DWM

Perhaps calculations should be made on barrels for optimum H/Pu and C/Pu ratios.

This could be done in spherical geometry which has equal volume and S.S. thickness equal to barrel weight as a series of k_∞ calculations.

DWM

June 24, 70

Assume one has a ^{252}Cf Source of strength 1×10^{10} n/sec or 4.27 mg

Assume Irradiation time = 10 sec

$St = 1 \times 10^{11}$

Assume Solid angle @ 1m = $1/1.256 \times 10^{5}$ cm^{2}

Fast Fluence $= \phi t = 0.8 \times 10^{6}$

Assume 10 g sample $\sigma_f \approx 2$ b

$$\text{Induced Fissions} = \phi t \times n \times \sigma_f$$

$$= 80 \times 10^{6} \times \frac{10}{240} \times 0.6 \times 2$$

$$= 4 \times 10^{4}$$

Prompt Neutrons for $\nu = 3$, 1.2×10^{5}

Total Delayed Neutron (D/P = 0.004)

$= 4.8 \times 10^{2}$

If Counting Eff = 0.05

Total Counts = 24.

In order to collect many events, source will have to be cycled 10 sec in 10 sec out perhaps 1000 times.

2. Assume one has LMFBR Fuel in Barrel

Source strength (Bkgnd) = 5×10^2 n/sec g

Assume 10 g of Pu ... Total Background Rate 5×10^3 n/sec

Assume 10 sec delayed neutron collection time

Total Background 5×10^4 n

If Signal to Background Ratio is 10

Delayed Neutrons = 5×10^5 n

Delayed / Prompt Ratio ~ .005

Prompt Neutrons = 1×10^8 n

Induced Fissions ($\nu = 3$) = 3.3×10^7

Assume 14. MeV irradiation $\sigma_f = 2.5$ for ^{239}Pu and ^{240}Pu

τ_i = irradiation time

$$\text{Fissions} = \phi t_i \times \frac{10g}{240} \times .6 \times 2.5b$$

$$\phi t_i = 3.3 \times 10^7 \times \frac{40}{2.5} = 5.28 \times 10^8 \text{ n/cm}^2$$

Assume Solid Angle @ 1m $\rightarrow$ $1.25_{66} \times 10^5$ cm²

$$\phi = \frac{S}{A} \rightarrow S = \phi A$$

$$S t_i = 5.28 \times 10^8 \times 1.25_{66} \times 10^5 = 6.6_3 \times 10^{13}$$

If τ_i = 10 sec

$S = 6.6_3 \times 10^{12}$ n/sec !

June 25, 1970

Method for making analyses of Irradiated Fuel Element From an LMFBR.

Use critical experiment with Fuel Element in center -- Nuclear Test Gage type of measurement. Such an experiment could be calibrated with dummy elements, ~~and since~~ Power levels need only to be large enough to over ride source. Special gamma compensated instrumentation is required. Multiplication measurements may be sensitive enough.

Measurements of two types can be made.

1. In the center of a thermal column such as target region of HFIR which will emphasize thermal fission ~~of~~ ^{239}Pu and absorption in ^{240}Pu

2. In a much faster spectrum, perhaps a fast reactor spectrum which may then give a measure of Total Pu rather than a difference of ^{239}Pu and ^{240}Pu

$$\text{Thermal } \rho = A\,^{239}Pu - B\,^{240}Pu$$

$$\text{Fast } \rho = C\,^{239}Pu + D\,^{240}Pu$$

In a fast spectrum ^{240}Pu ~~also~~ will fission and contribute ⊕ to the reactivity.

a facility such as the RMF and/or ARMF (Advanced Reactivity Measuring Facility may be required)

July 14, 1970 Re Telephone J P Nichols

JPN is preparing a budget request for the development of a waste drum "interrogator" or "assay machine" to be built and operational by the end of 1974!

He is sending over some write-up or proposals as well as descriptive reports on Los Alamos (Keepin) portable interrogator trailer, cost estimate etc. For FY 1971, he is suggesting 2 man years + $50000 for eqpt. Whether or not his request will be approved is yet to be ascertained!

DWMagnuson

JPN does not want to involve either I&C or the Anal Chem. (who have developed a leached hull monitor based on pulsed neutron interrogation and delayed neutrons) but wants to give full responsibility to us here in 9213†! (I do not understand)

Many questions still unanswered

1. Can Pu samples be brought into 9213?
2. Specifications for monitor not complete only generalized, what drum content what fissile isotopes, what gamma sources what neutron sources.
3. Electronics support by whom?
4. Barrels per day?
5. Analysis cost per barrel? Upper limit?

10 g of ^{235}U

$$\frac{dN}{dt} = .60248\times10^{24}\ \frac{10}{235} \times \frac{2.196\times10^{-8}}{7.13\times10^{8}} = .007896\times10^{8} = .790\times10^{6}\ \gamma/sec$$

$$Eff = 6.25\times10^{-4} \times 6 = 3.75\times10^{-3}$$

$$2.96\times10^{3}\ ct/sec$$

Assume 3X3 XTL at a distance of 1m

$$\frac{\text{Solid angle}}{\text{Eff.}} = \frac{\pi\, 3.81^2}{4\pi \times 10^4} = 3.629\times10^{-4}$$

July 21, 1971

Neutron source strength monitor for spontaneous fission

$^{240}Pu \rightarrow t_{1/2}(SF) = 1.32 \times 10^{11}$ yr $\lambda = \frac{2.196 \times 10^{-8}}{1.32 \times 10^{11}} = 1.66_4 \times 10^{-19}$

$\frac{1}{240} \times .60248 \times 10^{24} \times 1.66_4 \times 10^{-19} = .00418 \times 10^{5}$

$= 418$ fiss/sec g $\times 2.07 = 865$ n/sec g

$\sim 31\%$ $^{240}Pu \rightarrow 268$ n/sec/g   10 g $\rightarrow$ 2680 n/sec

Coincidence Detectors $\sim 8\%$ sp. f (α,n) ~ 2510   Total ~ 5×10^{3}/g

~~$.08 \times .65 \times 865 = 2.16$ ct/sec g × fract solid angle~~

~~If Eff. ~1%~~

~~$= .0865$ ct/sec g × fract solid angle~~

10 g of Pu   5000 n/sec

Assume "Barrel" is sphere having 30 cm rad.

Surface area $= 4\pi r^2 = 11,309.76$ cm^2

Space Detector Area $= 2 \times 30 \times 30 = 1800$ cm^2

Eff ~ 10%

Neutron counting rate

$C.R = 5 \times 10^{3} \times 10^{-1} \times \frac{30^2}{4\pi\, 30^2} = \frac{500}{12.5} = 40 \frac{ct}{sec}$

10g of ^{239}Pu $\lambda = \frac{2.196 \times 10^{-8}}{2.436 \times 10^{5}} = 9.015 \times 10^{-14}$

$\frac{dN}{dt} = \frac{10}{239} \times .60248 \times 10^{+24} \times 9.015 \times 10^{-14} = \frac{5.4}{24} \times 10^{10} = 2.273 \times 10^{9}$

Solid angle for 3×3 XTL NaI(Tl) $= \frac{\pi\ 1.5_{in}^2}{4\pi\ 30_{in}^2}$

$= \frac{1}{1600} = .000625$

× 6 detectors

$.003.75 \times 10^{-3} \times 2.273 \times 10^{9} = 8.522 \times 10^{6} \frac{cts}{sec}$

6 Detector Response Locations $\begin{cases}(\pm 1, 0, 0),\\ (0, \pm 1, 0),\\ (0, 0, \pm 1)\end{cases}$

$$\text{Det Resp} = \sum_{i=1}^{6} \frac{1}{r_i^2}$$

$r_1^2 = (x-1)^2 + y^2 + z^2$ $\quad 0 \geq x \geq 1$

$r_2^2 = (x+1)^2 + y^2 + z^2$ $\quad 0 \geq y \geq 1$

$r_3^2 = x^2 + (y-1)^2 + z^2$ $\quad 0 \geq z \geq 1$

$r_4^2 = x^2 + (y+1)^2 + z^2$

$r_5^2 = x^2 + y^2 + (z-1)^2$

$r_6^2 = x^2 + y^2 + (z+1)^2$

Programmed on Wang Tapes for $x \geq .6$

$(.8, .8, .8) \rightarrow 2.936$ $\quad y \geq .6$

$(.8, 0, 0) \rightarrow 27.748$ $\quad z \geq .8$

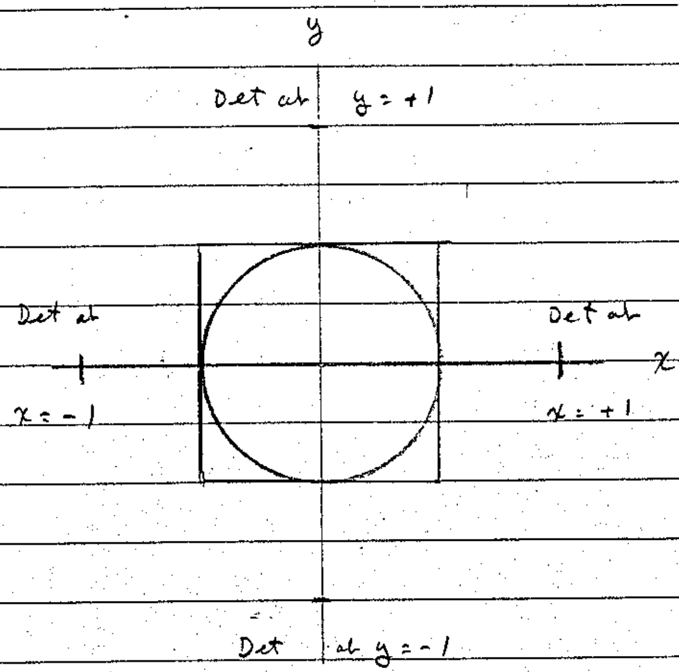
Response tabulated on next pages 20-21.

DWM Aug 17, 70

The calculated response may be useful for a detector system surrounding a waste barrel. If the detectors are located a barrel diameter from the center (H=D equilateral barrel) responses are ± 20% except on and near the axes and far from the origin.

If the barrel is located in a differing medium such as CH_2 or H_2O, the calculated responses will be much different and probably more linear. If barrel radius and half height are 0.4, then range is 5.7 to 6.7, or $\sim(6.2 \pm \frac{0.5}{6.2})$ or ± 8%, most between 6.0 and 6.4 (28 out of 35).

x y z	Response		x y z	Response		x y z	Response	
0 0 0	6.000	1						
.1	6.021	6						
.2	6.103	6						
.3	6.302	6						
.4	6.736	6						
.5	7.644	6						
.6	9.582	6						
0 .1 .1	6.039	12	.1 .1 .1	6.053	8			
.2	6.109	24	.2	6.113	24			
.3	6.287	24	.3	6.270	24			
.4	6.681	24	.4	6.627	24			
.5	7.504	"	.5	7.374	24			
.6	9.223	"	.6	8.904	24			
0 .2 .2	6.144	12	.1 .2 .2	6.140	24	.2 .2 .2	6.140	8
.3	6.258	24	.3	6.237	48	.3	6.191	24
.4	6.542	24	.4	6.492	48	.4	6.363	24
.5	7.151	"	.5	7.043	"	.5	6.766	"
.6	8.369	24	.6	8.135	"	.6	7.555	
0 .3 .3	6.267	12	.1 .3 .3	6.237	24	.2 .3 .3	6.162	24
.4	6.389	24	.4	6.340	48	.4	6.213	48
.5	6.728	"	.5	6.644	"	.5	6.421	
.6	7.421	"	.6	7.266	48	.6	6.829	
0 .4 .4	6.305	12	.1 .4 .4	6.251	24	.2 .4 .4	6.107	24
.5	6.364		.5	6.294		.5	6.106	
.6	6.628		.6	6.526		.6	6.252	
0 .5 .5	6.133		.1 .5 .5	6.067		.2 .5 .5	5.884	
.6	6.060		.6	5.984		.6	5.777	
0 .6 .6	5.694		.1 .6 .6	5.628		.2 .6 .6	5.445	



Barrel $x = y = z = \pm.5$ $x = y = z = \pm.4$

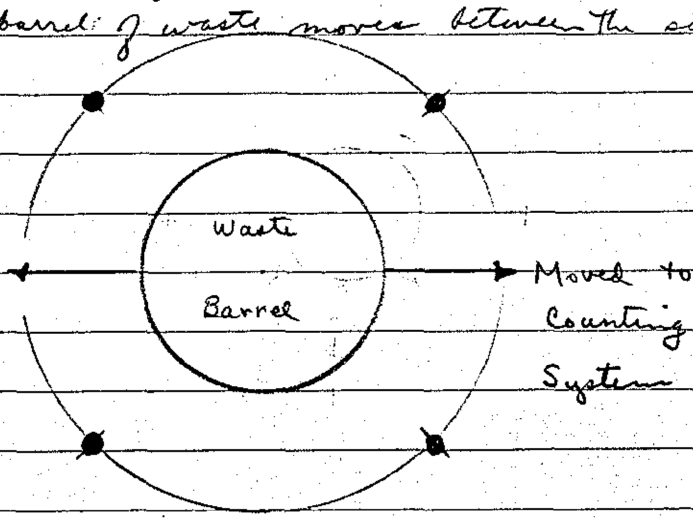
Resp 5.0 to 7.6   Resp. 5.7 to 6.8

(729 cells size = ±.45, ±.45 ±.45)

Average value for cube (±.4, ±.4 ±.4) $= \frac{4564.296}{729} = 6.261$

x	y	z	Response	x	y	z	Response	x	y	z	Response	x	y	z	Response
.3	.3	.3	6.082												
		.4	6.053												
		.5	6.132												
		.6	6.368												
.3	.4	.4	5.916	.4	.4	.4	5.7288								
		.5	5.851			.5	5.585								
		.6	5.887			.6	5.510								
.3	.5	.5	5.629	.4	.5	.5	5.351	.5	.5	.5	5.091				
		.6	5.488			.6	5.171			.6	4.867				
.3	.6	.6	5.185	.4	.6	.6	4.890	.5	.6	.6	4.596	.6	.6	.6	4.324

Similarly an irradiation facility can be constructed using six ^{252}Cf sources at $\pm X$, $\pm Y$ and $\pm Z$, and the barrel of waste moves between the source



Counting System must be remote from the 6 sources

If system is in H_2O, then the source-barrel distance should be optimized to produce the required spectrum. If fast neutron irradiation is preferred, then the sources and barrel should be in a large cavity.

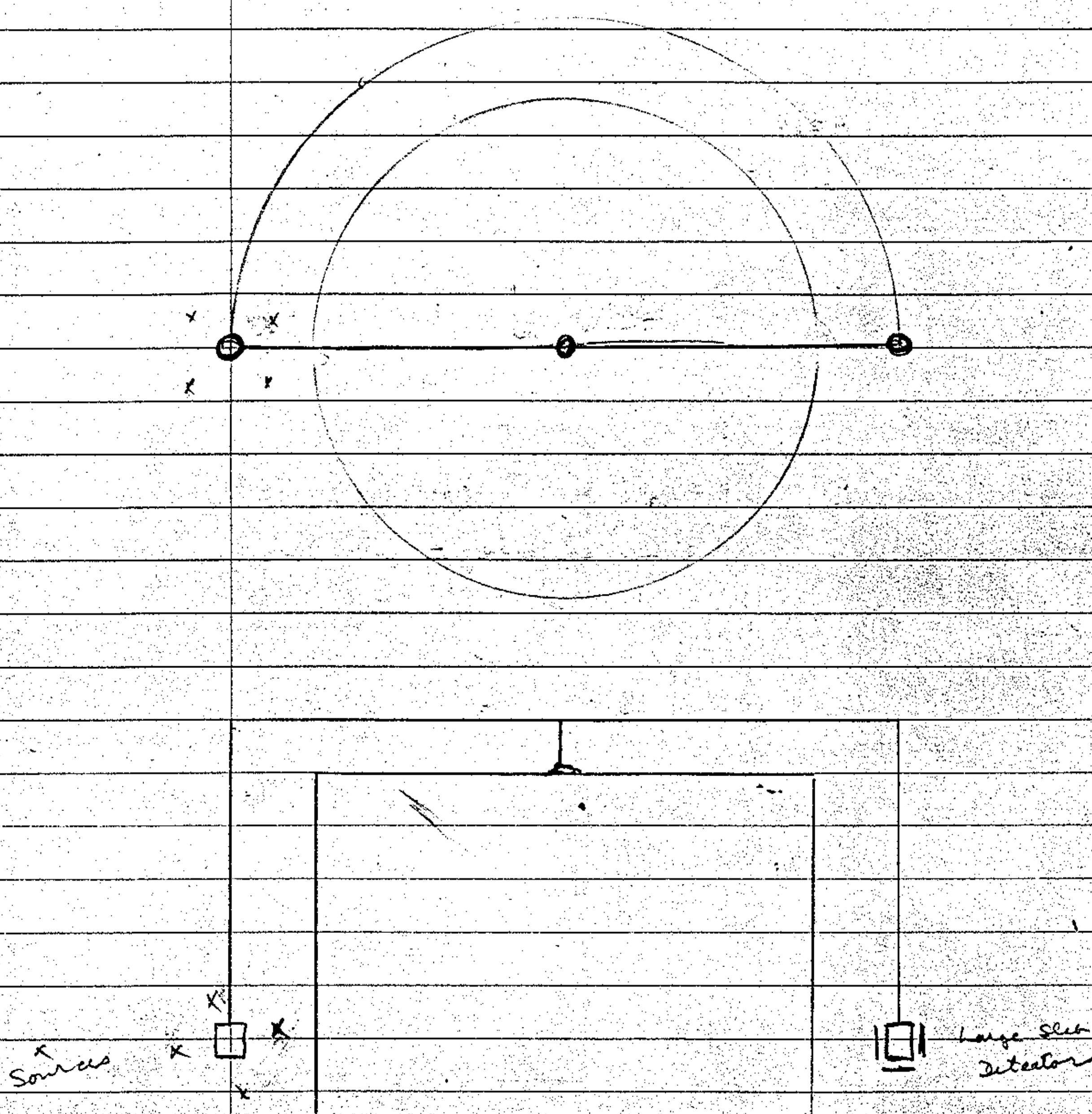
Shielding between sources & counting system should reduce the flux to less than $1\ n/cm^2 sec$

Assume 6 sources each at 50cm from the origin

Total strength = 10^{10} n/sec cm² or 4.27 mg

or 0.71 mg (710 μg) per source.

Central flux is $\frac{10^{10} n/sec}{4\pi\, 50^2} = \frac{10^{10}}{\pi \times 10^4} = 0.3183 \times 10^6\ n/sec\ cm^2$


Sources
Large Slab
Detector

assume fast flux = 3.18×10^5 n/sec cm²

assume 10 g of ^{235}U, $\sigma_f \approx 1.5$

Fission rate = $N \sigma \phi$ = $\frac{10}{235} \times .60248 \times 1.5 \times 3.18 \times 10^5$

= $.0256 \times 1.5 \times 3.15 \times 10^5$ =

.0064
2.5
64
64
32
160

= 1.223×10^4 fiss/sec

Delayed neutron / Fiss = .016

= 1.95×10^2 delayed/sec

Assume 10 sec irrad.

= 1.95×10^3 delayed/per irr.

If counting is long ~100 sec

Counter efficiency surrounding barrel must be ~ 1.0%

= 19.5 delayed neutrons per irradiation

Irradiation repeated 100 x
Cycles
Total Counts = 1950.

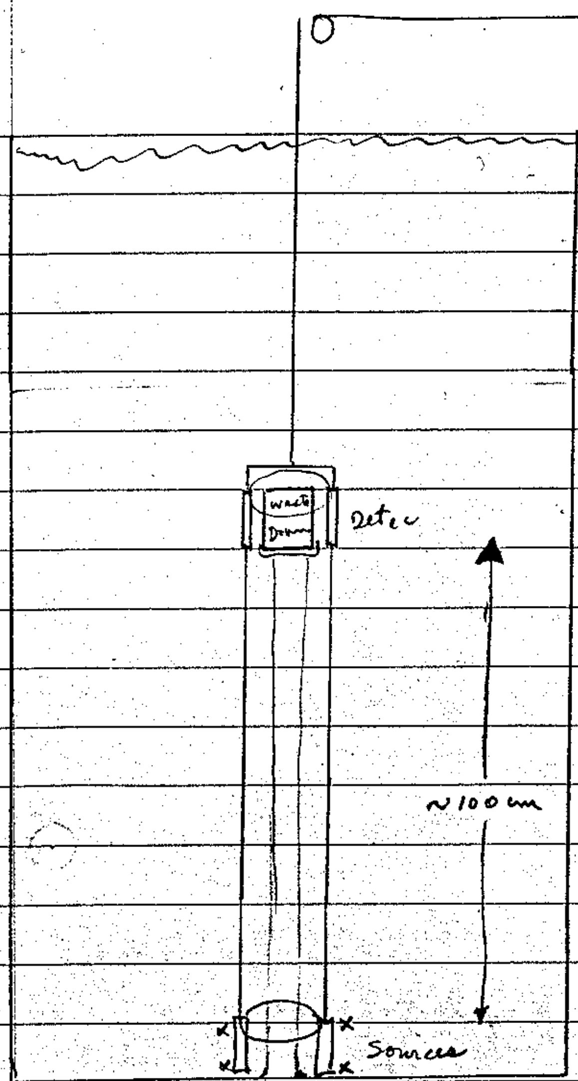
If Counter Eff can be increased to 10%
then total counts = 19500

Cycles reduced to 20

Total Count = 4000

Fast neutron irradiation is feasible but slow

Calculations should be made for the flux inside a cavity for various moderator and heavy reflector arrangements to maximize the thermal flux at the barrel location



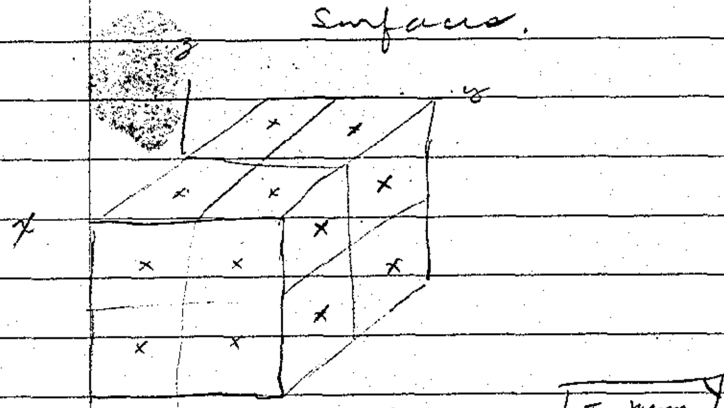
Neutron atten

		for 10^{10}
@ 10 cm	.003	$\phi = 3 \times 10^{7}$
20 cm	3×10^{-4}	3×10^{6}
30 cm	3×10^{-5}	3×10^{5}
40 cm	3×10^{-6}	3×10^{4}
50 cm	3×10^{-7}	3×10^{3}
60		3×10^{2}
70		3.0
80		3
90		0.3
100		0.03

Assume 8 mg ^{252}Cf $= 8 \times 10^{-3} \times 2.34 \times 10^{12}$

$= 1.872 \times 10^{10}$ n/sec

Detectors or Sources Dist. on Surfaces.



24 sources [Too many]

$r_1^2 = (x-2)^2 + (y-1)^2 + (z-1)^2$

$r_2^2 = (x-2)^2 + (y-1)^2 + (z+1)^2$

$r_3^2 = (x-2)^2 + (y+1)^2 + (z-1)^2$

$r_4^2 = (x-2)^2 + (y+1)^2 + (z+1)^2$

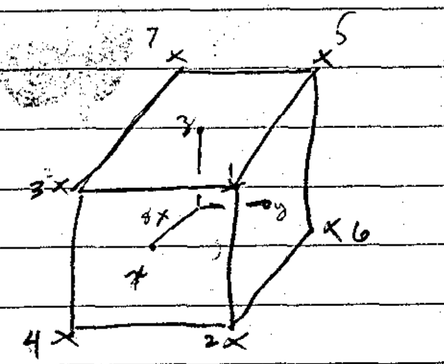
$r_5^2 = (x+2) + (y-1)^2 + (z-1)^2$

$r_6^2 = (x+2) + (y-1)^2 + (z+1)^2$

$r_7^2 = (x+2) + (y+1)^2 + (z-1)^2$

$r_8^2 = (x+2) + (y+1)^2 + (z+1)^2$

Detectors or Sources at corners



8 sources

$r_1^2 = (x-1)^2 + (y-1)^2 + (z-1)^2$

$(x-1)^2 + (y-1)^2 + (z+1)^2$

$(x-1)^2 + (y+1)^2 + (z-1)^2$

$(x-1)^2 + (y+1)^2 + (z+1)^2$

$(x+1)^2 + (y-1)^2 + (z-1)^2$

$(x+1)^2 + (y-1)^2 + (z+1)^2$

$(x+1)^2 + (y+1)^2 + (z-1)^2$

$(x+1)^2 + (y+1)^2 + (z+1)^2$

x y z	8 Detector Response	St. wt	x y z	8 Detector Response	st. wt.
0 0 0	2.66667	1	.1 .1 .1	2.67587	8
.1	2.66959	6	.2	2.68505	24
.2	2.67794	6	.3	2.69890	24
.3	2.69044	6	.4	2.71525	24
.4	2.70502	6	.5	2.73126	24
.5	2.71895	6	.6	2.74354	
.6	2.72904	6			
			.1 .2 .2	2.69552	24
0 .1 .1	2.67266	12	.3	2.71143	48
.2	2.68141	24	.4	2.73051	48
.3	2.69456	24	.5	2.74973	48
.4	2.70999	24	.6	2.76541	48
.5	2.72492	24			
.6	2.73606	24	.1 .3 .3	2.73068	24
			.4	2.75419	48
0 .2 .2	2.69136	12	.5	2.77863	48
.3	2.70642	24	.6	2.79989	48
.4	2.72439	24			
.5	2.74227	24	.1 .4 .4	2.78363	24
.6	2.75653	24	.5	2.81508	48
			.6	2.84388	48
0 .3 .3	2.72458	12			
.4	2.74664	24	.1 .5 .5	2.85492	24
.5	2.76932	24	.6	2.89281	48
.6	2.78866	24			
			.1 .6 .6	2.94064	24
0 .4 .4	2.77411	12			
.5	2.80318	24			
.6	2.82934	24			
			.2 .2 .2	2.70753	8
0 .5 .5	2.83983	12	.3	2.72594	24
.6	2.87412	24	.4	2.74837	24
			.5	2.77156	24
0 .6 .6	2.91722	12	.6	2.79152	24

x y z	δ Detector Response	St. wt.	x y z	δ Detector Response	St. wt.
.2 .3 .3	2.748 44	24	.4 .5 .5	3.077 59	24
.4	2.776 36	48	.6	3.176 72	48
.5	2.806 11	48			
.6	2.833 19	48	.4 .6 .6	3.309 61	24
.2 .4 .4	2.811 71	24			
.5	2.850 44	48			
.6	2.887 33	48	.5 .5 .5	3.203 97	8
			.6	3.345 32	24
.2 .5 .5	2.900 12	24			
.6	2.949 17	48	.5 .6 .6	3.541 21	24
.2 .6 .6	3.011 91	24			
			.6 .6 .6	3.823 39	8
.3 .3 .3	2.776 30	8			
.4	2.811 54	24			
.5	2.850 22	24			
.6	2.887 16	24			
.3 .4 .4	2.856 89	24			
.5	2.908 05	48			
.6	2.959 00	48		Average Value	
				(±.4, ±.4, ±.4 Case)	
.3 .5 .5	2.974 90	24		1995,37281/729	
.6	3.043 81	48		= 2.737 14	
.3 .6 .6	3.133 74	24		For (±.5, ±.5, ±.5)	
				3703,43703/1331	
				= 2.782 45	
.4 .4 .4	2.916 33	8			
.5	2.985 36	24			
.6	3.056 95	24			

August 20, 1970

Discussed with J T Thomas the feasibility of using arrays of easily contrived units (subcritical) to obtain single unit critical mass, size, etc information. Confidence in single unit calculations is markedly increased if calculations can "reproduce" an experimental array of that same material.

Materials of interest.

1. Fully enriched
   Oxides at various densities and low moderation values. XTLS of $UO_2(NO_3)\cdot 6H_2O$ could also be used
2. Low enrichment and intermediate enrichment
   Oxides
   UNH

Such a scheme would reduce fabrication and preparation costs if a process stream can be tapped.

Technique would be to make 27 vessels of a size which 8 could be made critical with very small spacing. Both Bare and Reflected 8 and 27 unit critical spacings would be determined. If materials can be compacted, vibropak or pressed to uniform, it would be preferred. However, loose powder could also be used.

DWM.

August 24, 1970

Telephone conversation with Rod Walton.

Los Alamos Passive Gamma Analysis Systems

1. Attenuation - Rotation for Pu

8 NaI Detectors (8 barrel Segments

100 μc ^{22}Na attenuation measurements

in Transmission

Results 1 gram ± 10%

With everything ganged, measurements not

segmented 1 gram ±10% in 2 or 3 MIN

2. Collimation - Rotation Method for Pu

for attenuation factors up to 100

across barrell!

Los Alamos Passive Neutron Analysis

for ^{240}Pu Spontaneous Fission

lower limit of 1 - 10 grams of Pu

(^{240}Pu content probably 5 to 10%) DWM

DW Magnuson

Sigma II Clearance for Los Alamos requested .

Taxi @ 8[10] TA-35 (Tensite) Bldg 27

Los Alamos Inn.

Bramblett - Photo Fission 88-714-293-5000 FTS operator

Gozani GA → 453-1000

Costello Bramblett Ext 486

Verbinski 1616

E. Anderson Spectrum Analysis Code

Lukens activation analysis.

AI - Shubert Country Squire

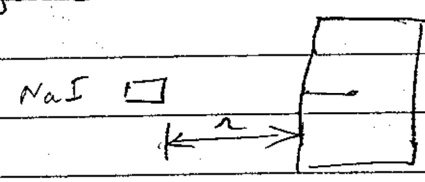
7631 Topanga Canyon RD

Santa Susana

Whitey Thorpe

Passive Analysis Detection of ^{239}Pu 385 - 414

55 gal Drums



±15%   rotate

a) correcting for $\frac{1}{r^2}$

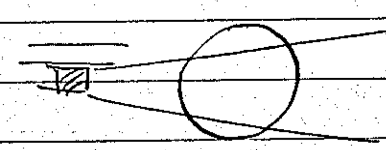
b) " for attn

One modification

Barrell assay ~ 1 per 10'

Use Collimators

use 8 detectors for detecting regions of diff. attn



Change angle

as a function of attn

with Attenuations up to 20.

Use Source To measure attn factors

GeLi has resolution - and

S.F. Neutrons must know ^{240}Pu assay

1. 2 gal drum
2.

τ die away time
or slowing down time

$\frac{Acc}{Tru} = \frac{Source}{\tau}$

$\pm 5\%$ for

Trick needed — for neutron efficiency
add a nanogram of ^{252}Cf.

Trace Detection

UCRL-50007 Joe Tenney from Livermore
-69-1
-69-2 20 KeV L xrays from ^{239}Pu or ^{241}Am 60 keV
-69-3

~ 5" ~ $\frac{1}{16}$ or $\frac{1}{8}$" NaI xtl

Used on waste water discharge to Sewage.
will detect 0.1 the tolerance for water

TA-18 1.30 Badge office

None work in high radiation fields

35% MTR measured @ 20 000 R Lead cask

Fissile content of high

Pulse 50% Count 50% to maximize cts/time.

Yield Technique 14 MeV

tailor spectrum to differentiate ^{238}U ^{232}Th from ^{235}U, ^{239}Pu

Kinetics Response

Short Pulse vs Long Count.

^3He Counter not gated off

Preamp gated off during Beam Pulse.

Use fast neutron interrogation for 2-3% ^{235}U

use ^{238}U and ^{235}U

1 gram min detection in Pipe filled barrel

±15%

For ^{235}U only, using tailoring assemblie for neutron flux

2½ MA KAMAN 200 keV.

~25K$ DC model ~17K$

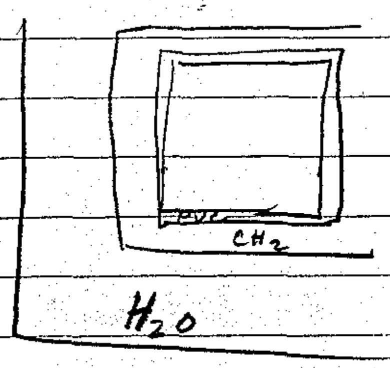
Accelen 2.5×10^{10} n/sec 1000 hrs tube life $1300 replacement

Traps

1. $^{17}O(n,p)^{17}N$ reactions do give delayed neutrons
   4 sec activity threshold at 11 MeV

   4-6 inches of lead reduces neutron energy below 14 MeV

2. Decoupling shielding from cavity
   PVC + Boron ~ 1/2" thick
   Transformer oil 6-8 inch
   30 in water

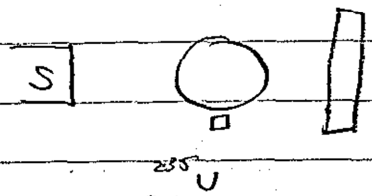


3: Oxygen in sample may interfere

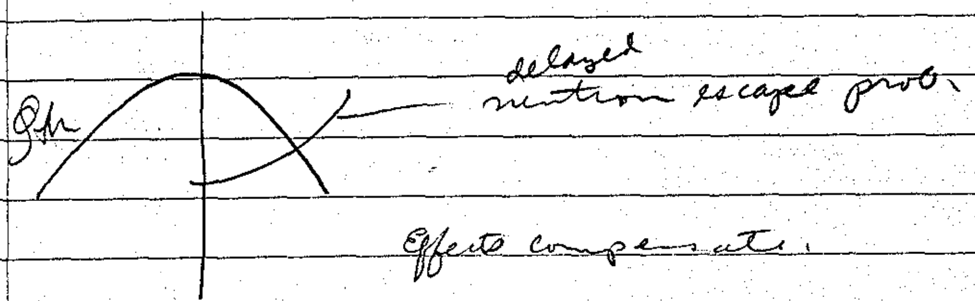
   $^{16}O(n,p)^{16}N$ with 7 MeV gamma ray

   a 5" NaI XTL can monitor Oxy content of sample.

Dome measurements



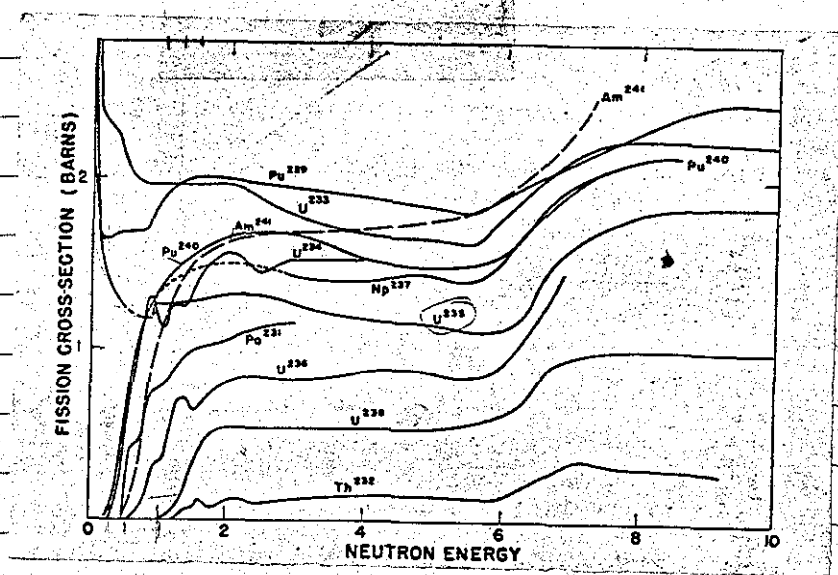
Fission Det. measures fission rate at edge and measures effect of matrix material.



Effects compensate.

.3 CH_2 vol fraction or less

Request Distribution thru. Gen Groves



Raddy Walton

R&D

Prototype Development

operate mobile Lab. (Field

LASL Housekeeping

DP site design ^{240}Pu coincidence counter

30 gallon drum for Plutonium Prod.

Non destructive Verification Lab.

U-Al mixture

1.001 MeV γ in ^{238}U can be used for passive

.700

Active

Neutron Interrogation

Fissile vs Fertile threshold energy

Matrix independence by having a fission monitor

Discrimination ratios for energy.

Photon Interrogation

Passive

Pu ~ 7×10^4 γ/gm sec in 385 - 414 group

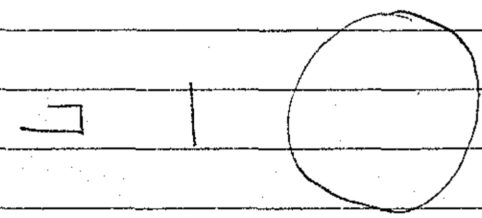
Pu 500 f/gm ^{240}Pu sec

Spark Scanning for Fission Fragment Tracks
in Plastic Foils
Neil L. Lark
(Niels Bohr Inst. Univ. of Copenhagen
Denmark

On leave from Raymond College
Univ. of the Pacific
Stockton, Calif.

25000 with Pulsing Accelerator, Inc.

Slab Detector
2 Banks
Fission Detectors



Lou Dohen Rocky Flats

Standard Barrels
containing various

S.F. Barrell Counter

'71 Budget $1 × 10^6$

Totals 65–70

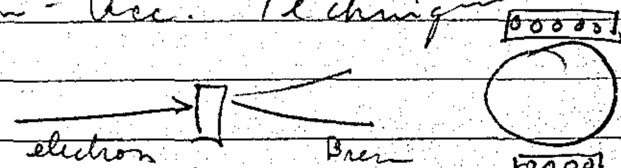
Rundquist, David
Naliboff, Davis

Request Crowson -- Get on GGA Dist.

1. Photon-induced reactions for difficult part of Waste Drum
2. Various Neutron Sources
   56 Be 4 - 24 μg Cf (2 × 10^2)

Passive
NaI
GeLi

Electron - Acc. Technique



Waste Drum must be scanned because of inhomogeneity

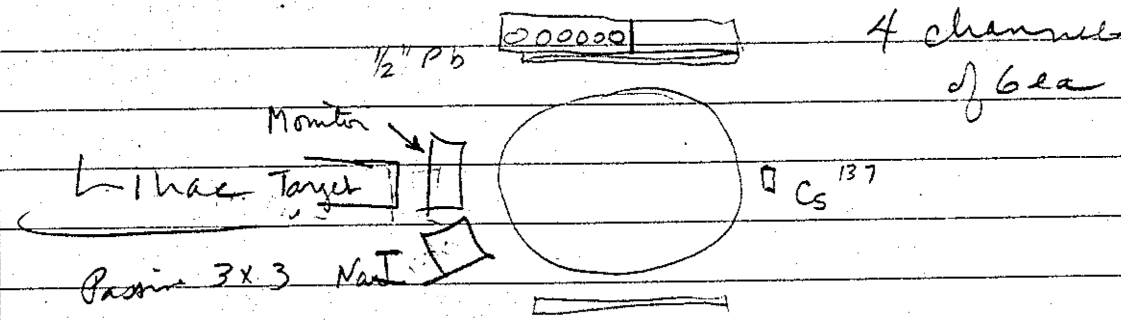
Target Strahlung, peaked forward easily Shielded

Look for prompt and delayed.

@ 5.5 MeV

ELRON ELECTRONICS, N.J. for PM Tubes and pulse shape disc.

Barrel Rotates elevates translates



24 ea 2 in. BF_3 for Linac operation
in polyethylene

Used only for Delayed Neutrons

gate off electronics 75 μsec
with gamma flash cancellation — 2 detectors + 2 − add all four
gateoff 10-15 μsec
100 μsec decay or die away

Beam Pulse 2 μsec 180 pps

Naliboff

Dave Rundquist

Sept 18, JPN & V DeCarlo,

Telephone call from Roddy Walton Sept 23 ± 1 day

L.A. is going to build a Scrap Plutonium Barrel Tester which will detect sub gram quantities of (5% ^{240}Pu) Pu (95). (For Merriman Pu Recovery Opn)

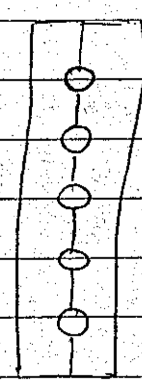
a) For 30 gal Drums

b) 78 counters in Hexagon array and on Top & Bottom, assumed to be 2" BF_3, similar to previous assembly for counting ^{240}Pu.

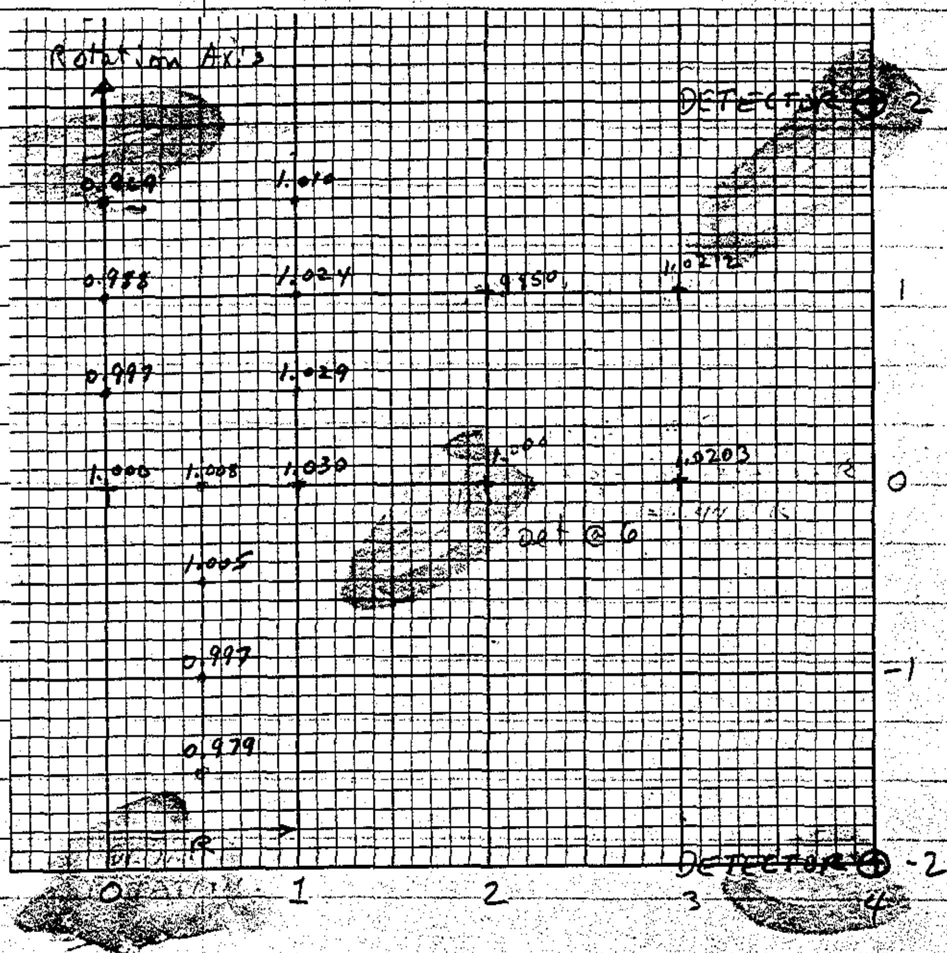
c) Polyethylene Slabs - grooved and then assembled around counters.

d) Will have engineering drawing in a few weeks.

c) Shielding not discussed.



$\frac{78}{6} = 13$


Rotation Axis
DETECTOR 2
DETECTOR -2
Det @ 0
0.969
0.988
0.997
1.000
1.008
1.005
0.997
0.979
1.020
1.024
1.029
1.030
.9850
1.0212
1.0203
1
0
-1
2
-2
0
1
2
3
4

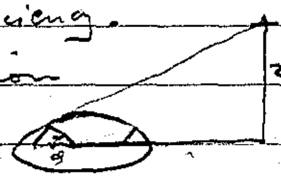
Drum Counting System

a, Two Detectors

b. Rotation of Drum

c. No collimation To reduce efficiency.

Solution of Geometry Problem for rotation



$$\rho^2 = x^2 + y^2 + z^2$$

$$z = Z$$

$$y = R\sin\varphi \qquad \rho^2 = (X^2 + 2RX\cos\varphi + R^2\cos^2\varphi + R^2\sin^2\varphi + Z^2)$$

$$x = X + R\cos\varphi \qquad \rho^2 = (X^2 + R^2 + Z^2)\left(1 + \frac{2RX}{X^2+R^2+Z^2}\cos\varphi\right)$$

$$\widehat{\frac{1}{\rho^2}} = \int_0^{2\pi} \frac{d\varphi}{\rho^2} \Big/ \int_0^{2\pi} d\varphi \qquad = b\,(1 \pm a\cos\varphi)$$

$$= \frac{1}{2\pi b}\int_0^{2\pi} \frac{d\varphi}{(1 + a\cos\varphi)} = \frac{1}{2\pi b}\left(\frac{2\pi}{\sqrt{1-a^2}}\right)$$

Choose $R = 1$, $X = 4$, $Z = \pm 2$ with origin at Drum center

R	X	Z_1	Z_2	Response		
0	4	2	2	1.00000	0 6 2 2	1.0000
0	4	1.5	2.5	.99738		
0	4	1	3	.98924	0 6 1 3	.9850
0	4	0.5	3.5	.96937		
0.5	4	2	2	1.00750	0.5 6 2 2	[illegible]
0.5	4	1.5	2.5	1.00528		
0.5	4	1	3	0.99706	0.5 6 1 3	1.0[illegible]11
0.5	4	0.5	3.5	0.97908		
1	4	2	2	1.03005	1 6 2 2	1.0203
1	4	1.5	2.5	1.02922		
1	4	1	3	1.02440	1 6 1 3	1.[illegible]
1	4	0.5	3.5	1.00977		

DWM Oct 27, 70

$^{232}U \sim 7 \times 10^{-6}$ $t_{1/2} = 74$ years

$^{235}U \sim .97$ $t_{1/2} = 1.62 \times 10^{5}$ years

$^{235}U \sim$ $t_{1/2} = 7.13 \times 10^{8}$ years

$$\frac{\frac{dN}{dt}(232)}{\frac{dN}{dt}(235)} = \frac{7.13 \times 10^{8} y}{7.4 y \times 10^{1}} \times 7 \times 10^{-6} = 67.4$$

Assume 35% branching ratio for ^{208}Tl

Reduced detector efficiency for 2.6 MeV vs .185 keV [illegible]

$67.4 \times .35 = 23.6$

Assume 1 g of ^{233}U

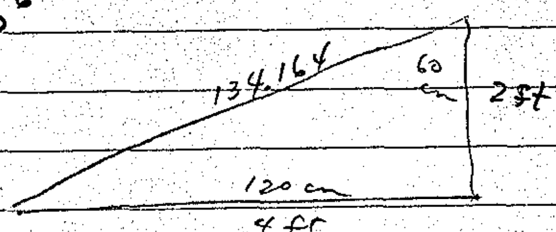
7×10^{-6} g of ^{232}U

$$\frac{dN}{dt}(232) = \lambda N = \frac{2.196 \times 10^{-8}}{.74 \times 10^{2}} \times \frac{7 \times 10^{-6} \times .6025 \times 10^{24}}{.232 \times 10^{2}}$$

$= 5.39 \times 10^{6}$

$\times .35$

$$\frac{dN}{dt}(^{280}Tl) = 1.89 \times 10^{6}$$



Detector solid angle

$$\begin{array}{r} 14400 \\ 3600 \\ \hline 18000 \end{array}$$

XTL area $4\pi r^2 = 2.26 \times 10^{5}$

$$\frac{\pi r^2}{4\pi r^2} = \frac{\pi\, 3.81^2}{4\pi 1.8 \times 10^{4}} = \frac{14.516}{7.2 \times 10^{4}} = 2.016 \times 10^{-4}$$ Fractional S.A

$\times 2 = 4.032 \times 10^{-4}$

Assume Detector Efficiency for 3x3 @ 2.6 MeV
= .23 (Peak/Total Ratio)

$1.89 \times 10^{6} \times 4.032 \times 10^{-4} \times .23$

Estimated Count Rate = 1.75×10^{2} cts/sec

10 M in counts ⟶ 1.05×10^{5} counts

this is adequate statistics for 100% of equilibrium of decay

For 10% of equilibrium 0.3 year after processing 1.05×10^{4} counts – 10 min,

It remains to be seen how other gamma emission interferes with this analysis.

Probably must use ^{233}U standard having same ^{232} content and processed at same time to follow the equilibrium.

Oct 30, 1970

Set up TMC-CN-110 256 pHA with 3x3 NaI, NJE PS @1000V, linear amp input at gain 64 and 32 To "look" at and record spectra from ^{233}U, ^{235}U, and ^{239}Pu at 1 meter. Checkout with ^{137}Cs and ^{60}Co, spectra OK. Door Open.

	Isotope	Peak Energy	Counts - Bkg (10 Min)	Counts/g
M 229	^{239}Pu (8.0g)	~385	126 893	15 860
HFIR 015127	^{235}U (19.8g)	~185	73 087	3691
Calutron	^{233}U (.101g)	~105	277 235	109 800

@ 20cm ≈ 2.5₂₅ @1m

smaller peaks @ 240

335

475

1450

No detectable pk @ 2.615 MeV in 50 Min counting runs

DWM

Nov 3 11:00 AM	^{233}U (9.551g)	2.615 MeV	8096	847.7

^{233}U from Hanford Shipment #4 (arrived Nov 2) Bldg 3019

2-2-5

Batch or Lot No. Drum 61

347.5 mg U/ml Sp G = 1.492

98.333 wt% fissile Vol 0.02795 l → 9.7126 g U

Gross 54.5

Tare 12.7

Net 41.7 g

9.551 g ^{233}U

A comparison of the spectra from the Calutron sample and the Hanford #4 shipment sample (age)

Nov 10, 1970 ch 10' Bkg

9.551 g ^{233}U (171-210) 12,974-77 = 12897

^{60}Co (1.33 MeV) set at Ch 133, Baseline = 0.0

^{233}U counting → Baseline ~~set~~ to 2.00 ~67 ch.

2.615 peak @ 187+57 = 2.54 (Non-linear)

$(171\text{-}210)\ \dfrac{131{,}235 - 767}{100\text{ MIN}} = 130468 \rightarrow 1366/10\text{ MIN}$

$\dfrac{1366}{848} = 1.61_1$ $\dfrac{22\text{ day}}{15\text{ days}}$ $\dfrac{.65}{.39} = 1.66_7$

$\dfrac{23}{16}$ $\dfrac{.69}{.43} = 1.604$

therefore, the age ~~at on~~ Nov. 3 was ~ 16 days

0 age on Oct 18.

" Oak Ridge Concrete has 4.03×10^{-5} atom/barn/cm

^{40}K 4.03×10^{19} atoms/cm^3

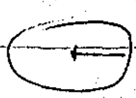
$\lambda = \dfrac{2.196 \times 10^{-8}}{1.3 \times 10^{9}\text{ yr}} = 1.689 \times 10^{-17}$ $\times .000118$ $\dfrac{K^{40}}{K_{total}}$

$N = \dfrac{4.03 \times 10^{19}}{}$

$\dfrac{dN}{dt} = 6.807 \times 10^{2}$ $\times 600 = 4.08 \times 10^{5}/10\text{MIN}$

$\times 1.18 \times 10^{-4}$

48.1 cts/10MIN

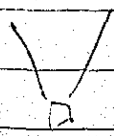


Solid Angle $= \dfrac{3.81^2 \times \pi}{10\text{ ft} \times 30.48 \times 4\pi} = .0125^2 \times 4 = 6.25 \times 10^{-4}$

Ceiling area × 10 cm thick $= (5 \times 30.48)^2 \times 10$

$= 2.32 \times 10^{5}$

× 1 cm thick $= 2.32 \times 10^{4}$



Count Rate for 10 MIN $= 4.08 \times 10^{5} \times 6.25 \times 10^{-4} \times 2.32 \times 10^{4} = 5.916 \times 10^{6}$

$\times 1.18 \times 10^{-4} = 698.$

Observed $\frac{3400}{60 \times 100\ MIN}$ Counts in peak @ 1.42

or 340 counts / 10 MIN   Observed rate is expected!

Portland Cement Concrete has 0.0079 g K/cm

$\times 1.18 \times 10^{-4} = 9.322 \times 10^{-7}$ g of $^{40}K/cm^3$

$\times \frac{.6024 \times 10^{24}}{4.0 \times 10^{1}} = 1.404 \times 10^{16}$ atom/cm^3

$\lambda = \frac{2.196 \times 10^{-8}}{1.3 \times 10^{9}} = 1.689 \times 10^{-17}$

$\lambda N = 0.2372$ dis/sec./cm^3

Nov 17, 1970 ^{233}U 9.551 g Sample

Total Area in peak (171 - 210) 180,381 100'

− 767 Bkg

179,614

1881 cts/g (10 min)

Extrap to zero on 23 oct

less 5 day delay (Calc Transition time to linear rise.

~ Separation day 18 oct = day zero.

[signature]

Nov 24, 1970   Peak area (171-210) 228785 100'

− 767

228018

or 2387.4 cts/g (10 min)

Dec 1, 1970   287007

− 767

286240 → 2997. cts/g/10 Min

Dec 8 327 264 171-210
767
3265. cts/Min 341,85 cts/MIN/g

Dec 15 391 900
767
391 1,33 / 9.551 = 409.52 cts/MIN/g

171-210 370 183
767
369 4.16 / 9.551 = 386.8 cts/min/g

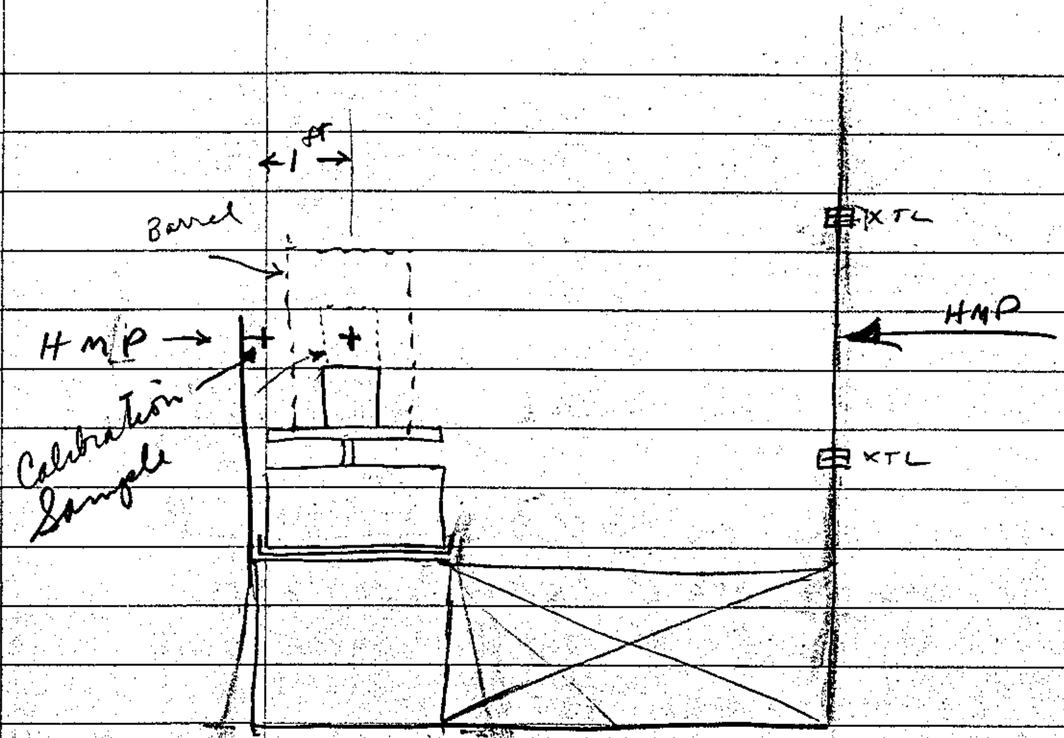
Dec. 31 165-210 529 903 100 MIN (434 Bkg 50 MIN)
Bkg ~868 5290 3.5 / 9.551 = 554.

Jan 6 168-210 275180 50'
(pk 186.5) 430
274750 → 5495. /MIN = 575.3 /g min

Jan 19, 168-210 319,559 51
peak 186.5 430
319.1 x 2 x / 9.551 = 668.2 cts/g Min

Feb 9 168-210 407 955
430
407 520 x2 = 815 040 / 9.551 = 853.36 ct/g min

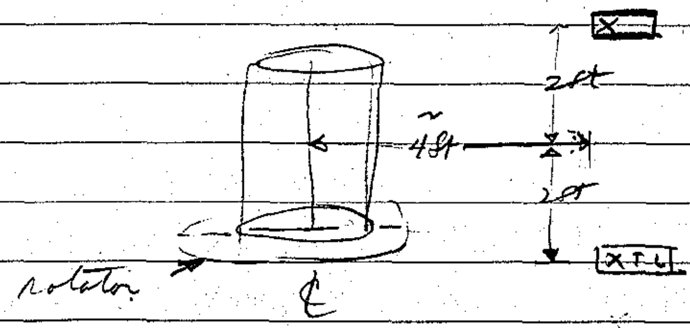
Feb 17 Baseline 3 gain x32 1.00 29-64
10' - 83 295 - 101 = 8319.4 → 871.05 ct/MIN g


1 ft
Barrel
HMP
Calibration Sample
XTL
HMP
XTL

February 16, 1971

On Friday Feb 12, 1971 discussed with J P Nichols and Victor di Carlo the development of a Waste monitor for ^{233}U scrap. at Erwin. It was assumed that the scrap was in barrels.

My proposal was to use 2 detectors and a barrel rotator



Need samples having ^{232}U content and age equal to Erwin scrap for developing standards

Need Barrel rotator.

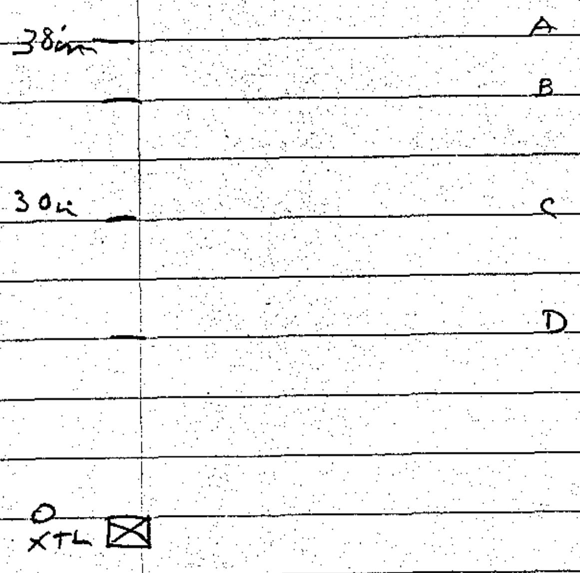
[signature]

Feb 17, 1971

Set up 3x3 XTL Multichannel Analyzer with 1/4 Mem such that with Base line at 3.00 (100 ch) peak for ^{60}Co @ 1.33 MeV was at channel 33. change gain from X64 to X32. 2.614 MeV, ^{208}Tl now at channel 40

Gap	Counts 10 MIN (29-64)
Air	83424 - 101
1" of Plexiglass	74880 - 101
~~1 7/16" of Plexiglass~~	
2" Plexiglas	66915 - 101
1" Pb.	26808 - 101
7.2 cm Wood	75386 - 101
3 7/16" Plexiglass	56317 - 101
Air	83167 - 101
Background 101	

arrangement for simulated Barrel atten and

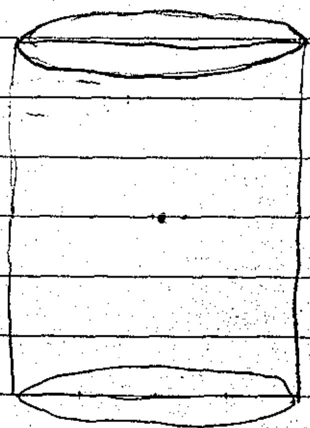


Source atten meas outside B Bl.
Source on 38 in - outside BBl
Source on 30 in. inside BBl
Plastic on B and D simulate absorption around Source in BBL

141 cts/sec

~~226~~ 00

600



A	B	C	D	Counts in 10 Min
Source	—	—	—	84652 − 101 = 84551
Source	1″	—	1″	67473 − 101 = 67372
Source	2″	—	2″	53742 − 101 = 53641
—	—	Source	—	132834 − 101 = 132733
—	1″	Source	1″	117751 − 101 = 117650
—	2″	Source	2″	105933 − 101 = 105832

	$\frac{N_0}{N}$	$e^{\mu x} = \frac{N_0}{N}$	$\log \frac{N_0}{N} = \mu x$	$\frac{\mu x}{2}$	$e^{\frac{\mu x}{2}}$
1″	1.254987		.22712	.11356	1.1203
2″	1.576238		.45504	.22752	1.2555

Source at 30 in.

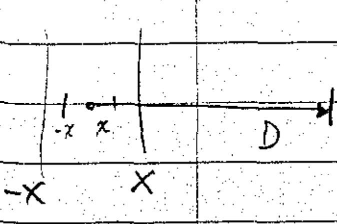
1″ $N_1 \times e^{\frac{\mu x}{2}}$ = 131 803 compared to 132 732

2″ $N_2 \times e^{\frac{\mu_2 x}{2}}$ = 132 870 " " 132723

This simulated barrel attenuation is amenable to evaluation by putting the known source outside the barrel. For inhomogeneous conditions the accuracy will probably be affected and barrel rotation may not average properly.

For slabs

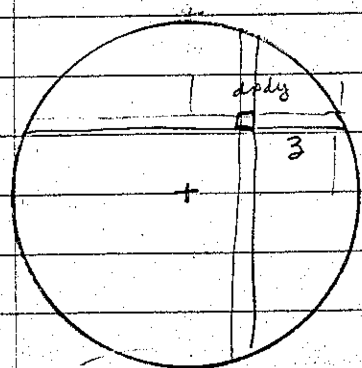
$$dV \times \left[\frac{e^{-\mu(X-x)}}{(D-x)^2} + \frac{e^{-\mu(X+x)}}{(D+x)^2}\right] = dV e^{-\mu X}\left[\frac{e^{\mu x}}{(D-x)^2} + \frac{e^{-\mu x}}{(D+x)^2}\right]$$



$$= \frac{dV e^{-\mu X}}{D^2}\left[\frac{D^2}{(D-x)^2} e^{\mu x} + \frac{D^2 e^{-\mu x}}{(D+x)^2}\right]$$

For x = 0, [ ] = 2

Average value of the attenuation length for material homogeneously distributed in a barrel



$$\bar{z} = \frac{\iint dx\,dy\; z}{\iint dx\,dy}$$

$$= \frac{\int_{-R}^{+R} dy \int_{-\sqrt{R^2-y^2}}^{\sqrt{R^2-y^2}} dx \left(\sqrt{R^2-y^2} - x\right)}{\pi R^2}$$

$$= \frac{1}{\pi R^2} \int_{-R}^{R} dy \int_{-\sqrt{R^2-y^2}}^{\sqrt{R^2-y^2}} \left(\sqrt{R^2-y^2}\, dx - x\, dx\right) \rightarrow \left[(R^2-y^2)^{1/2}\left[x\right] - \left[\frac{x^2}{2}\right]\right]_{-(R^2-y^2)^{1/2}}^{+\sqrt{R^2-y^2}}$$

$$= \frac{1}{\pi R^2} \int_{-R}^{R} dy\, (R^2-y^2)^{1/2} \times \left[2(R^2-y^2)^{1/2}\right]$$

$$= \frac{1}{\pi R^2} \int_{-R}^{R} dy \left[2(R^2-y^2)\right] = \frac{2}{\pi R^2}\left[R^2 y - \frac{y^3}{3}\right]_{-R}^{R}$$

$$= \frac{2}{\pi R^2}\left[\left(R^3 - \frac{R^3}{3}\right) - \left(-R^3 + \frac{R^3}{3}\right)\right]$$

$$= \frac{8}{3\pi} R = 0.8488\, R$$

$$\bar{z} = 0.4244\, D$$

Feb 25, 1971

Additional thoughts and work on ^{235}U waste monitor

1. Checked out 2 NaI crystals — from V. DeCarlo
   1. No good
   2. Poor Resolution — Can't use either
   3. Bases OK with our 3×3 on Dumont 6363 tube.
2. Proposed to J R Parrott that we set up over in 3019 and make measurements on anything and everything that he has. Essentially do this under field conditions
3. V. deCarlo will order 2 turntables
   one for 2000 lbs 48 in diam. 1 RPM
   one 350 lbs 12 in diam. 3 RPM

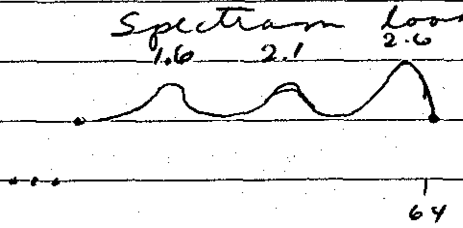
4. ~~Set up~~ The spectrum of ^{208}Tl from 2.614 MeV gamma includes a single escape @ 2.103 MeV and a double escape @ 1.592 MeV

With the 3×3 XTL, integrating over all three one includes 3× as many counts.

5. Using a 1×1 XTL is not satisfactory at all -- too small efficiency for the peak.

6. Adjusted Gain and Baseline for only 1/4 Memory so that
Channel 4 at energy ~.255 below double escape and channel 64 at 2.164 + .255.

Spectrum looks like below



Base line @ 1.80
Peak @ Ch 47.5

Advantage of above set up is not as sensitive to PM drifts as previous and includes 3 x as many counts. Background is larger, but less than 1/3 % for 9.55 g @ 38 in.

DWM

March 1, 1971

On comparison of ^{60}Co spectrum, ~2.50 MeV sum peak occurs within a channel of the supposedly high peak of ^{208}Tl @ 2.614 in ^{233}U sample.
~21.5 (~~??~~ keV per channel) whereas it should have been ~~4?~~ 5 1/4 channels higher.

DWM

March 3, 1971

Set up Multichannel Analyzer at 3019

Peaked @ Baseline 1.80 ^{233}U peak at ch~ 58

Distance 10 × 1.414 × 9 + 8 + 8

1.5 + 127.26 + 16 = 143.26 in.

1.5

144.76 in. → 367.69 cm

1st Bird. 98767 98857

1ST + 2nd Bird

2nd + 1st Bird

2nd Bird

Couldn't find 2nd Birdcage

Work terminated

DWM

98812 × 13.52 = 1335906. 1.3359×10^6 @ 1m

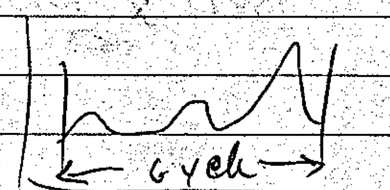
1.33×10^4/g @ 1m

~ 100 g sample $2.66 \times 10^3 \frac{ct}{min\,g}$ @ 1m

Distance To face of XJL
63 1/2 in
Total 65 in.
Distance to point beyond
Bird cage
78 1/2 in.
Total 80 in.

Live Time

Baseline 1.80
Counting 2.614
Single escape 2.1
Double escape 1.5
} peaks



March 8, 1971 — DWM ee

Counting at 3019

Sample		Count Time		Integrate		Printout Tape No	Dist	
Bkg		5		6441		#1	65"	In Birdcage
Bkg		5		10374		2	65"	Samples in Rm
Bkg		5		7526		3	65"	Samples 20 ft away
~~Bkg~~		5		—		4	65"	Memory
DWM		5	5331.1	50917	19.551	5	65"	In Birdcage
0.54g	#1	5		5108		6	65"	"
3.89g	#2	5		26300		7	65"	"
18.95	#3	5		106248		8	65"	"
18.60	#4	5		105336		9	65"	"
18.70	#5	5	5657.4	106273		10	65"	"
18.76	#6	5	count/g	106514		11	65"	"
18.77	#7	5		106154		12	65"	"
	#7	5		54809		13	80"	Behind Bird Horiz (Bottle)
	6	"		54632		14	"	" " "
	5	"		60200 ~~59272~~		15	"	" Vert
	4	"		59272		16	"	" "
	3	"		59814		17	"	" "
	~~2~~	~~"~~		~~X~~		~~18~~	~~"~~	~~" "~~
	~~1~~	~~"~~		~~X~~		~~19~~	~~"~~	~~" "~~
	~~#6 + #7~~	~~"~~				~~20~~		~~7 inside 6 behind~~
	#7	"		60817		13A	80"	Beh. Bird Vert!
	6	"		60901		14A	80"	Behind Bird Vert!

UNH Solution from U-6
for Testing by D. W. Magnuson

3-4-71
ALB
CWM
RGN

B.C. -102-5204

SpG 1.3501

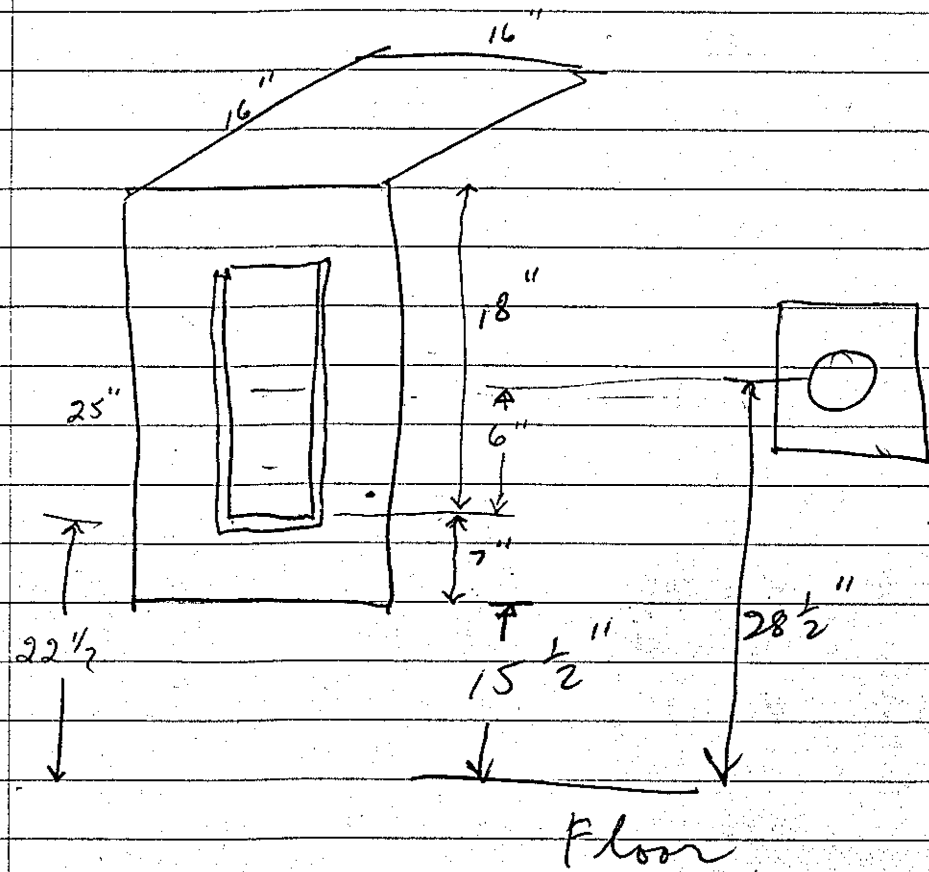
Bottle No.	Gross, g.	Tare, g.	Net, g.	^{233}U (g)	Vol (l)
1	36.55	33.55	3.00	.54	.0022
2	55.00	33.70	21.30	3.87	.01578
3	137.70	33.95	103.75	18.95	.07685
4	135.60	33.70	101.90	18.60	.07548
5	136.55	34.10	102.45	18.70	.07588
6	136.45	33.70	102.75	18.76	.07611
7	144.50	41.70	102.80	18.77	.07614
			u 99.78	98.21	

Sample	count Time	Int. Counts	Printout No	Dist	
~~1~~	~~5~~			~~80"~~	~~No Birdcage~~
~~2~~					
3	5	83580	24	80"	No Bird
4	5	82719	25	"	"
5	5	82547	26	"	"
6	5	82663	27	"	"
7	5	84014	28	"	"
~~6+7~~					
6+7	5	206 848	18	65"	In Birdcage ~~[illegible]~~
5+6+7	5	307 120	19	"	" " ⊥ to XTL
4+5+6+7	5	409 481	20	"	In Bird in plane ⊥
3+4+5+6+7	5	515 509	21	"	"
1+2+3+4+5+6+7	5	546 244	22	"	"
5+6+7	5	294 043	19 A	65"	In Bird in line with XTL
1+((2 3 4 5 6))	5	516 507	22 A	65"	Closepack in Bird #1 on top
#6 (65") + 7 (80")	5	165 546	23	65" 80"	In Bird Out behind Bird

Sample	Time	Counts				
7	5	127 024	29	65"	No Bird	Ch 8-9 dropping or not adding
6	5	~~189 423~~ 125 935	30	"	"	
5	5	124 382	31	"	"	
4	5	125 201	32	"	"	
3	5	125 562	33	"	"	

Wiggled cards in TMC CN-110, OK

3	5	127 145	33A	"	"


16"
16"
18"
25"
6"
7"
22 1/2
15 1/2"
28 1/2"
Floor

Sample	Count Time	Int. Counts	Output Tape No	Dist.	
3	5'	127191	33B	65"	No Bird
	Adjust Hi Voltage (Inc 1/2 div)				
3	5'	127681	33C		

		Distance	Count	
3-15-71	#3, 4, 5, 6, 7 from U-6		Bkg 7423 > 7440	
	for Std 93.78g ^{233}U		7457	
	8.5 ppm age ~150d			
	Std	148.5 in	133713	126273
	Unknown + St		325926	318486
	Unk 6M-30-48	138.0 in	251112	243672

(12.9g 39ppm

Shipped ORNL

Returned

Age ~2000d

Calibration factor = 1200.78

Attn factor = $(0.5925)^{1/2} = 0.7697$

Age Factor = $\frac{3.28}{.52} = 6.31$

^{232}U conten $39/8.5 = 4.59$

28.96

$$\frac{243672}{1200.2 \times 28.96} = 7.01\,g$$

vs 12.9 g

April ~~8~~ 7, 1971

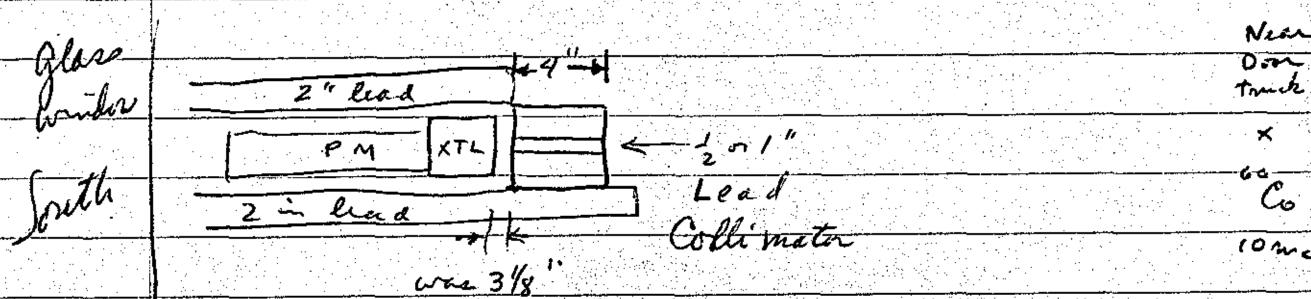
CC drilled a ½" hole in a 4×4×4 lead brick
and a 1" " " another " " "
to make collimators. The 10 mc ^{60}Co source
was placed 28' 4" from the surface of the 3×3
NaI detector. Integrate over both peaks @ 1.17 & 1.33 MeV

	Count Rate		Bkg			
No Coll.	215035	−	916	=	214 119	cts/min
1" Coll	30683	−	876	=	29 807	"
½" Coll	09082	−	845	=	8 237	"

There was no apparent loss in resolution or shift in peak heights. Conclude that collimators and/or distance can be used to decrease sensitivity of the 3×3 NaI detector

	area Ratios		Counts Ratios	
areas of XTL	36	9	26.0	7.2
1"	4		3.6	
½	1		1	

DWM
April 8, 1971



Linear Abs coeff for Lead @ 2.6 MeV = 0.48 cm^{-1}

For 4 in = 10.16 cm

μx = 4.88 $e^{-\mu x}$ = .00762

June 1, 1971

Moved Counting Analysis System to Bldg 3019 for demonstration of method to Bartel on June 2, 71

Baseline 180

Gain (HV) adjusted so that upper edge of 2.6 MeV line is in channel 64, peak channel ~ 60. (57) but all three 1.6, 2.1, 2.6 lines are accepted in 64 channels.

DWM CC.

June 2, 1971

Letter to Brooksbank on Thorium Interference with ^{233}U – ^{208}Tl Analysis.

July 21, 1971

Discussions with S D Snyder in June indicated that the NDT section M&C Div was interested in developing a neutron scanning device similar to the x ray inspection machines that have been developed. The HFIR fuel plate scanner is an example of the latter, and it is believed that no neutron inspection machines have been conceived. The interest of M&C in neutron radiography is merely to have available a facility but not to do much development work. My suggestions for using critical assemblies and flux traps ~~and the reactor~~ for neutron sources was appealing to him because they could be made dry. We could not produce ~~reach~~ the ~~fluxes~~ neutron fluxes in a C.A that a reactor could produce, but having a source only for neutron radiographs ~~that~~ has many advantages.

Considerations of the fluxes that could be produced by fixed ^{252}Cf sources.

Assume 10 mg of ^{252}Cf or 2.34×10^{10} n/sec

Measured flux per ^{252}Cf neutron = 0.013 /cm² sec

Source strength at ~~face~~ of collimator = 3×10^8 n/sec cm²

of area = 1 cm² = 3×10^8 n/sec

Assume collimator = 100 cm or $\frac{1}{r^2} = 10^{-4}$

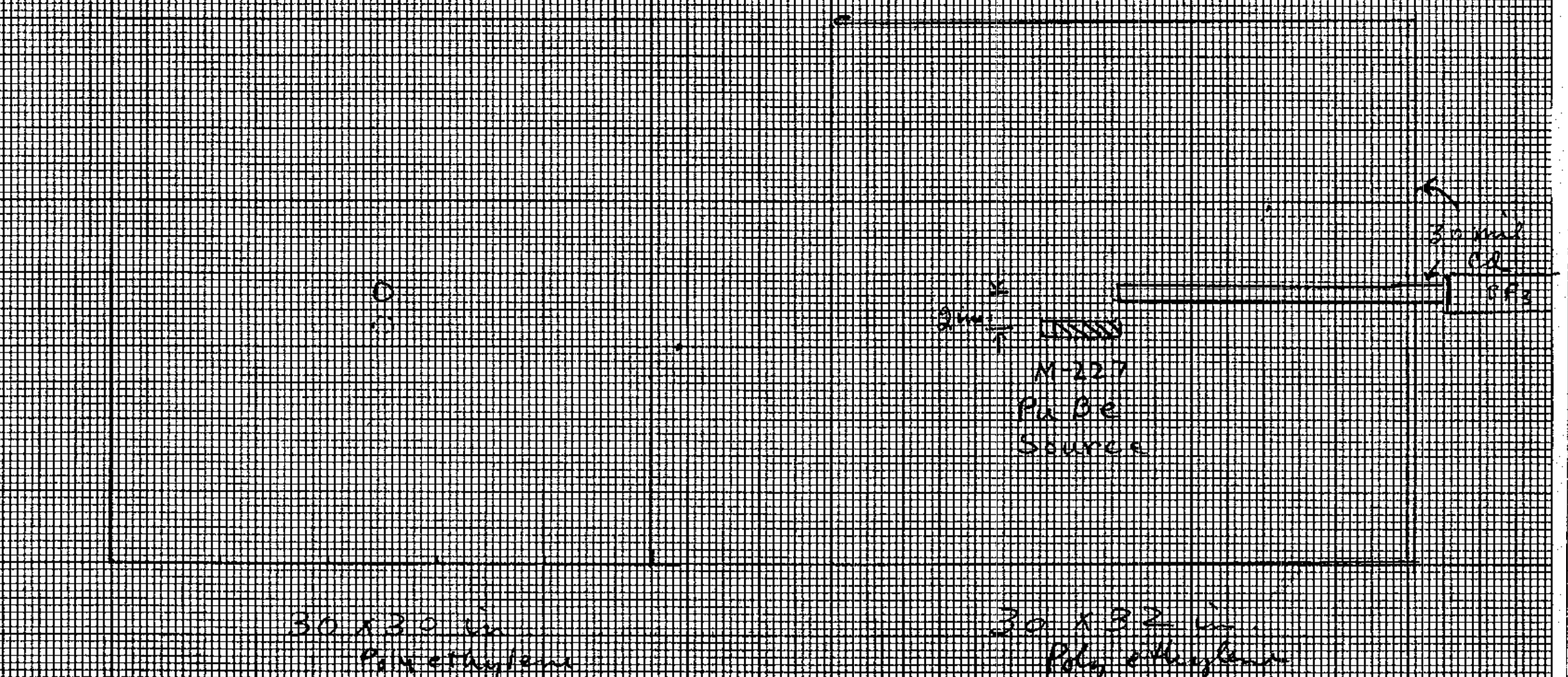
Flux at end of collimator = 3×10^4 n/sec

Statistics for pulse counting time of 1 sec = 0.6%

For an area of 1 mm^2 for the collimator ~~the flux~~ the counts rate = 300 n/sec and for an integration time of 10 sec, the statistics would be 1.8%. Such an inspection device would appear to be technically feasible. ~~and~~ Detectors such as ~~BF_3 counters and ^3He detect~~ LiCl, BF_3 and ^3He proportional counters or ^3He and LiI scintillation detectors can be obtained showing high efficiencies

A preliminary experiment has been designed to measure the flux or neutron count rate at the end of a 16 in long 1 in o d collimator which is lined with Cd. The Pu-Be source which was used to measure the peak neutron flux of 0.004 n/cm^{2}sec per source neutron will be placed ~ 4 - 5 cm away. The source will be placed near the center (2 in. off center) of a 30 x 30 x 32 assembly of $(C_2H_4)_n$ blocks into which a 16 in. hole penetrates to the vicinity of the source. A 2 in. od. $^{10}BF_3$ counter will be used to detect the emergent neutrons. Inside diam of collimator of 32 mil Cd ~ 0.9 in.

area = .6362 in^2 = 4.1 cm^2



BF_3 + PREAMP + HV @ 1300 + A/D AMP @ 16x, PHS = 30V (pulses > 50V)
+ ORNL Decade Scaler PHS @ 10 (PHS @ 5 for 60V check) – No pulses with HV @ zero.

Count rate expected to be

$8.3 \times 10^6 \times 0.004 \times 4.1 \times \frac{1}{18^2} \times 90\% = \frac{3.7 \times 10^2}{6.45\ cm^2/in^2}$

= 57.4 ct/sec or 3440 C/MIN

July 22, 1971

Observed count rate — BF_3 coaxial with Beam.

260 C/MIN
270 "
290 "
250 "
270 " — with Counter Offset 4 in. from Collimator

16,180 C/HR — Bkg 10 870 C/HR

Net 5,310 cts/hr or 1.5 cts/sec. 181 cts/MIN

Bkg Covered Counter with Cadmium 160/10 m = 16 C/MIN

Counter in front of collimator 910 /10 m = 91 C/MIN — 75 C/MIN Net

withdraw Cd Sleeve 2", moved detector 2 in back

Collimator 18", protrudes ~4" from $(CH_2)_n$ 1470 C/10 MIN
131 C/MIN

With draw Cd Sleeve to 4"	1290 c/10 M	= 113 C/MIN
3"	1460	= 130
1"	1260	→ 110

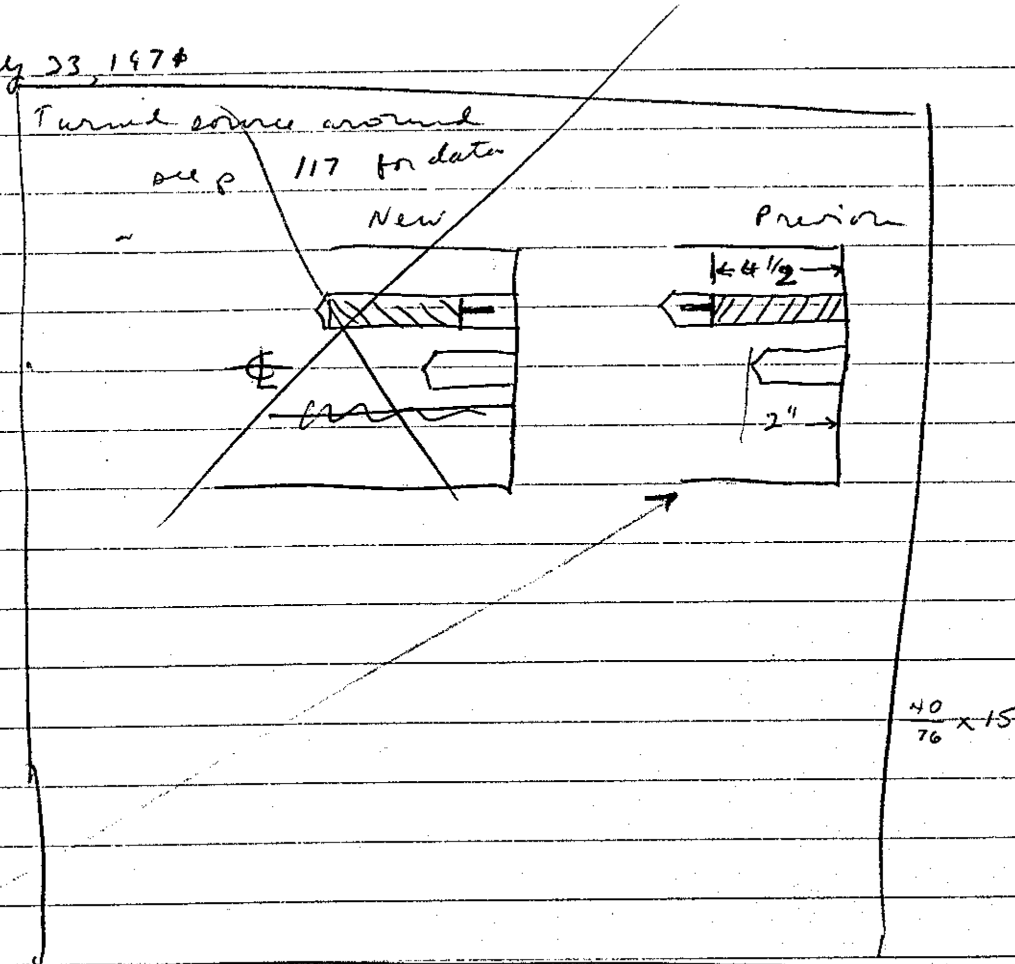
Change BF_3 Counter from # 1941 to # 1938.

1"	1250	→ 111

#1938 Ctr, With 2" dia hole 1" od in block containing source, hole 18" deep now

1"	1820	→ 166
Repeat → 2"	1770 + 1690	→ 161 + 153
3"	1840	→ 168
8"	1740	→ 158

July 23, 1970



Previous Source Position Used

Installed 1" od counter RSN-7 40cm Hg BF_3
1600 v PHS on A/D @ 2.00 most pulses
> 20 v, peak of dist ~ 50-70 volts.

Cd Position		10'	
0" (16" in hole from outer edge		2700	
	Bkg	80	= 262/MIN
0"		2790	= 271
1"		2910	→ 283
2"		2920	→ 284
3"		2940	→ 286
4"		2700	→ 262

Counter Efficencies

2.678 $\times 10^{19}$ atoms / cm^3 std atmosphere

(^{10}B) $N\sigma = .2678 \times 10^{20} \times .3840 \times 10^{-20} \times .96 = 0.098722$

For 2 in counter 12 in long 12 cm Hg

$\frac{12}{76} \times 30.48 \times .09872 = 0.4751$ $e^{-N\sigma} = .622$

$1 - e^{-N\sigma} = .378$

For 1 in counter 8 in 40 cm

$\frac{40}{76} \times 20.32 \times .098 = 1.0558$ $e^{-N\sigma} = .348$

$1 - e^{-N\sigma} = .652$

Count rate ratio for beam on axis $= \frac{.652}{.378} = 1.72_5$

$\frac{2920}{1800} \approx 1.62$

Turned Source around as described on p 115

4"	2460	→ 238
2"	2680	→ 260
1"	2540	→ 246
0"	2530	→ 245

Max. counts/sec cm² = $\frac{\frac{286}{60\times4}}{.83\times10^{7}}$ = 1.44 $\times10^{-7}$ /cm²

Observed counts/cm² n/sec at a dist of 22"

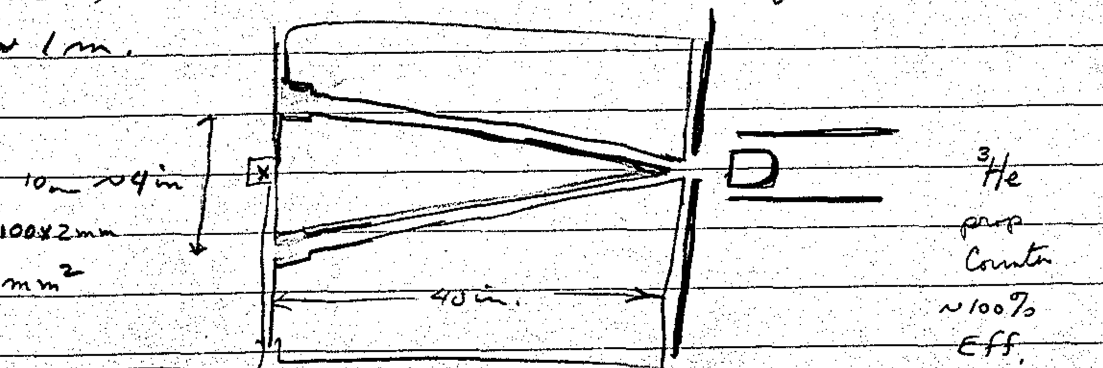
If ^{252}Cf = 2.34 $\times10^{10}$ n/sec (0.01g or 10 mg)

Count rate = 3.36 $\times10^{3}$ /cm² = 33.6 /mm²

With higher efficiency counters and smaller beam tubes (which perturb the flux much less), this can be increased to ~ 336/mm²

and 3360 /10 mm² 3.16 mm x 3.16 mm

Using a cone shaped collimator, the source area can be increased and the collimator length increased to ~ 1 m.



area = 3.14x100x2 mm
= 628 mm²

South to Ventura Freeway
West NW To Topanga Canyon