BOOK63R

Notes:
"West Cell Pulsing by DWM" on spine

Blank pages: inside front cover sheets, 1, 2, 12, 18, 38, 58, 64, 66, 68, 78, 88, 118, 122, 170, 174, 176, 182-298, inside back cover sheets

-pages 15, 16(2), 17, 24, 29, 108, 109, each has 1 sheet glued down
-page 25 has 1 index card glued down
-page 94 has 3 long thin sheets glued down
-page 96 has graph glued down
-page 97 has big sheet glued down
-page 98 has graph glued down
-page 104 has sheet glued down
-page 129 has graph sheet taped down
-page 133 has 7 long thin sheets glued down and 1 long sheet not attached between pages 132/133
-pages 134 & 135 has 1 graph sheet attached to each
-page 150 has graph sheet glued down
-following pages have (#) of small photos attached to each page: 151 (4), 152 (1), 153 (1), 155 (1), 156 (2)
-page 154 has 1 graph attached
-page 164 has card and small piece of dosimetry film clipped at top
-page 168 has 1 graph sheet attached
-page 181 has 2 long thin sheets attached

Scanned by:
Sheila Finch
RSICC /Oak Ridge National Lab.
August 20, 1999

October 15, 1961

Measurement of Decay Constant for Polyethylene Cylinders in various geometric arrangements of Cylinders Source and Detector.

If the boron loaded liq. scintillator pulse higher than the Ra γ source are used, only fast neutrons are counted, Therefore all pulses slightly greater than noise are used. A preliminary decay curve gave λ = 6200 sec^{-1} 1/4 min ony only.

PNM-1. Acc 145kv 1.02ma 15μa Curnt 200μs 320 CPS
TMC CH 10μs Delay 2 BKG 16 DISC 1.5
DET NE-311 1500V HP40A + HP460B
Source pos (R, Z/2)
Det (R 180°, Z/2)
Fill ch 16 To ~capacity of memory. Neutron pulse over at ch 9.
No Cadmium on Polyethylene #1 24 1/2 o.d. x 10 9/16 in Ht.

PNM-2 Source (R, 0, Z/2) 10 9/16 x 24 1/2 o.d #1
Detector (0, 180°, 0)

PNM-3 Same as above + 37 mil Cd, 3" o.d hole for det.
PNM-4 Repeat No 3.
PNM-5 Repeat 1 w. Cd. 1"x5" slot for detector.

PNM-6 Repeat 5 ~~[illegible]~~
(yield of target is down? by a factor of 4)

2^{30} PM After PNM-6, turned off HV observed source which was very blue. No leak, therefore assume that vinyl seal is still outgassing solvent. Leave solenoid on all night and some gas flow. Source still blue at 8^{15} AM increase flow of D_2 – OK.

Oct-16 PNM-~~6~~7 Surround back side of NE 311 with 0.037 in cadmium.

The plot of the above indicated more room return or a poorer exp when background subtracted

Built 16 x 24 x 24 house around target w. 4 x 4 x 16 central hole for beam tube.

PNM-8 Source r = 0 z = 0, det r = 0 z = Z
PNM-9 " r = 0 z = 0 det r = R z = Z/2
Burst 200 μs
PNM-10 Burst = 100 μs

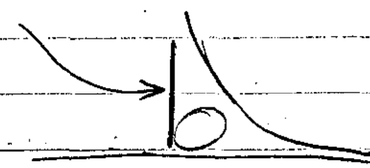
PNM-11 Burst 100 μs remove all Cd and $(CH_2)_n$ around target good decay

Install 2" od BF3 counter on r = R
PH ~ 4 cm on 100 v gain #1 1/.1 x 100 #2 1.1 x 200
PNM-12 Burst = 100 μs, poor decay curve
-13

PNM-13 Detector at z = Z center on face
1/4 Mcm
PNM-14 1/2 Mcm same as 13

Attempts to find source of extra neutrons
that are time dependent.
① BF3 Counter on Dif Plates place
② " " On plate between table
③ " " On floor by fixed Table
④ " " On plate between tables
with polyethylene cylinder rolled away.
Conc. Room return is the culprit

PNM-15 Cd area on 36 x 36 in x .037 in. on BF3 counter
PNM-16 " " " " 2 " "
PNM-17 add Cd shield



Oct 17 added ½ Boral below Poly cyl. PNM-18
Remove Boral PNM-19
Remove Poly cyl from fixed Table PNM-20
Covered Counters with ~0.025 PNM-21
Moved counters so that they do not
protrude beyond poly PNM-22
add .037 mil Cd between Counters and Poly -23
Pulse Poly #1 ~3 μa 24
" " 1.13 ma ~11 μa 25

.73
4.00 μa $11 \times \frac{3125}{200} = 172$ μa
loss of 228 μa ?

BF3 Counters | Scope

#1 1100v read Y-100370 1.1X50 2cm@1X8

#2 " 0.6X50 (100v ~ 4in

PHS	C1	C2	
200	8110	41 x256+50	
400	3770	18	+24
300	6690	30	186
150	9130	46	216
100	9740	49	87
50	10200	50	14

Counters covered with 25 mil Cd again

PNM-26 PHS = 50

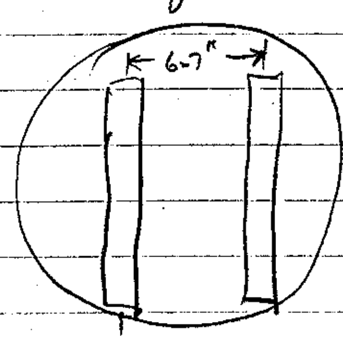
-27 PHS = 200

PNM-28 Counters on flat surface 3μa Z = Z

29 Higher count rate ~11μa

Acc not stable over cycle of data coll.

Counters placed on flat surface



$\sigma_t(H) = 0.7\,b$ @ 14 Mev S.G = 0.92

$\sigma_t(C) = 1.3\,b$

$$\Sigma_t = \frac{\overset{2.7}{(1.3 + 2 \times 0.7)}\ .6025\ \ .92}{14} = \frac{1.49}{14} = 0.106$$

$$\lambda = \frac{1}{\Sigma_t} = 9.43 \text{ cm}$$

$$H \text{ density} = \frac{.6025}{14} \times .92 \times 2 =$$

	BKG	DELAY	CH	Total Cycles	IC-4	Burst μS	Rep RATE (CPS)	Target μa	Power Sup Ma	KV
PNM-30	16	8	10	357111	5×10^{-12}	100	350	—		
31	8	16	10	242887	1×10^{-11}	100	330	4		
32	8	16	10	247603	"	"	"	3½	0.85	747
33	8	16	10	275610	"	"	"	"	"	"
34	8	16	10	291226	1×10^{-11}	"	"	"	"	"
35	8	16	10		5×10^{-12}	"	"	2	.77	"
36	8	2	10		3×10^{-11}	"	"	11	1.20	150
37	8	2	10		1.6×10^{-11}	"	"	10	1.10	150
38	8	2	10		8×10^{-12}	"	"	3½	.85	150

The decay of the 20⅝ in high cylinder is ap

Pulse a stack of poly ethylene 6 wide x 16 in long x

	BKG	DELAY	CH	Total Cycles	IC-4	Burst μS	Rep RATE (CPS)	Target μa	Power Sup Ma	KV
39	8	2	10			100	330			
40	8	2	10		1.0×10^{-12}	100	330			

Pulsing Room a

	BKG	DELAY	CH	Total Cycles	IC-4	Burst μS	Rep RATE (CPS)	Target μa	Power Sup Ma	KV
41	2	2	1280	3139	6×10^{-12}	2560	10			
41			640	11542	"	1280	20			
41			320	21167	"	640	40			
41			160	37063	"	320	80			
42			80	59302	"	160	150			
42			40	100713	"	80	280			
42			40	100000	"	80	230			
42			20	"	"	"	"			
	43		20	"	"	"	"			

Pulse 3 H_2O filled 5 liter plasticoyl or bo

	BKG	DELAY	CH	Total Cycles	IC-4	Burst μS	Rep RATE (CPS)	Target μa	Power Sup Ma	KV
44	2	2	10	300000	2.8×10^{-12}	100	330	~1	.77	150
45	2	2	10	300000	1.1×10^{-12}	100	330	~—	.73	150
46	2	16	10	297567	1.3×10^{-12}	100	330		.74	150
47	2	16	10	290158	8.0×10^{-12}	"	"			

Source

#1 Poly Cyl. 24 1/2 " x 10 9/16 in.

#2 " "

#3 " "

#4 " "

#4

#4 + #3 counters $z = Z$

#4 + #3 Counters at $r = R$

#4 + #3 Ne 311 @ $r = R$, $z = Z/2$

approx the same or faster than one cylinder

x 24 in high on center of 6 x 24 face det, on 18 x 24 face

#6 x 24 x 18 $\lambda \approx 6637$

2 BF3 counters with cd on table top - no poly,

only Counters 8' above target

4th quarter

3rd "

2 " } PN M-41

1st "

~~4nd~~ " } ~~PNM-42~~

~~3st~~ "

2nd

1st Counter Covered with Cd

Table Top. " " " "

~~bottles.~~

source = DET DET

9 bottle =

"

~~single 52 bottles~~ Detectors moved to Det.

	Bkg	Delay	Ch	Cycles	IC-4	Burst	Rep Rate	Targ pos	ma	KV
PNM 48	2	16	10	301000	6×10^{-12}	100	330	—	—	—
49	2	16	10	300000	8×10^{-12}	"	"			
50	"	"	"	300.000	2×10^{-12}	"	"			
51	"	"	"		2.2	"	"			
52	"	"	"	600000	1.15×10^{-12}	"	"			
				October 23, 1962						
53	"	"	"	600000	2.1×10^{-11}	"	"	10	1.06	147
54	"	"	"	427865	2.8×10^{-12}	"	"	~	—	147
55	"	"	"	600000	3.5×10^{-12}	"	"			
56					3×10^{-12}					
57				300000	1.0×10^{-11}					

1 5l bottle
3 5l bottles =
"
" detectors w.o. Cd.
3 5l bottle 1" BF_3 in center of array 1050v

3 5l bottles 3/8" od BF_3
" 2" BF_3 w. Cd on top =
" 2" BF_3 w. Cd on top =
" Source ~4" above ℄ of 3 bottles
Det on top of 2
2ea 2" BF_3 on side of Bottles

October 24, 1962

Summary to date.

① Preliminary work with large polyethylene cylinders gave poor results with either Ne 311 scintillator (Boron loaded liquid) or with BF_3 counters. The leakage from a 24 in od 12 in hi cylinder is very small and the source intensity was high. The background under these conditions is larger and show some time dependence which can be attributed to room return — 65 ch × 20 μs = 1.3 ms. Further investigations with BF_3 counters in the center of the room and covering w. cadmium removed the peak.

② work with the small water filled lucite cylinders 5 l. bottles 8 in o.d and 7½ in. high showed a dependence of decay period on source and target location. Background in this instance was unimportant. Discussions with E. Silver pointed out that in any large block of moderator where $B^2 < 0.01$ the modes are not separated very much. that is the $v\Sigma_a$ term in the expression $\lambda = v\Sigma_a + DB^2$ is dominant. This means that the spatial separation of the modes is real and since the λ's are close one really is never on the fundamental and it is difficult to tell

$$e^{-\bar{\lambda}t} \text{ from } \tfrac{1}{2}e^{-\lambda_1 t} + \tfrac{1}{2}e^{-\lambda_2 t}$$

when λ_1 and λ_2 are close.

Two other things were discussed with E Silver. ① Our lack of background when pulsing H_2O which he found in his systems (and reported in annual ORNL -) and which he attributed to N^{16} gammas giving a photo neutron source in the deuterium of natural water.
② The observation of the increased background when 2ea $2\frac{7}{8}$ in $\times$ 30 $\times$ $\frac{1}{4}$ boral was inserted into the 3 $\times$ 3 boxes below the assembly ($\sim$ 3 in from counters)

It is concluded from this preliminary survey that interactions of loosely coupled systems - that is in units where $v\Sigma_a$ is dominant for the decay of the individual pieces - cannot be measured with thermal neutrons. However, these same size units when filled with uranium solutions the fast leakage now can make these same systems coupled more strongly and there may be some hope of determining the lifetime dependence at critical on density of interacting units or on size of assembly.

Buckling of 8 in. i.d by $7\frac{1}{2}$ high units could be measured when filled with heavy water. Here, $v\Sigma_a \approx 0$ and DB^2 would be dominant.

Preliminary calculations for measurement of
λ_c as a function of concentration

Buckling calc. for 15 in. o.d. cylinder and estimates of H/x for system critical, $B_r^2 = \left(\frac{2.405}{19.05}\right)^2 = 15.94 \times 10^{-3}$

vol / in = 2.896 l / in.

Volume ~~liter~~	z (in.)	z (cm)	B_z	B_z^2 ($\times 10^3$)	B^2 ($\times 10^3$)	$1 + M^2B^2$	H/x
17.38	6	15.24	.2061	42.48	58.42	2.75	
20.27	7	17.78	.1767	31.22	47.36	2.42	
23.17	8	20.32	.1546	23.90	39.84	2.195	
28.96	10	25.4	.1237	15.30	31.24	1.937	~150
43.44	15						
57.92	20	50.8	.06184	3.82	19.76	1.593	~620
86.88	30	71.2					
115.84	40	101.6	.03092	0.96	16.90	1.507	~760
173.76	60	152.4	.02061	.4243	16.36	1.491	~800
231.68	~80	203.2	.01546 ~~.00785~~	0.24	16.18	1.485	
	∞				15.94	1.478	~820

For height variations of from 7–8 in, the minimum height in max conc. to ~70 cm, the H/x varies from ~50 to ~700.

An estimate of the lifetime l is $\frac{1}{v\Sigma_a}$ for inf. thermal system. For finite systems

$$l = \frac{1}{v\Sigma_a + DB^2} = \frac{1}{v\Sigma_a(1 + L^2B^2)}$$

In the two group approx., the slowing down time is un important.

$$l = \frac{1}{v \Sigma_a (1 + L^2 B^2)}$$ for these ~~options~~ solns.

the diff lengths are very short. Hence an approx value of l as a function of hydrogen & uranium density can be calculated. This should not be valid for conc. solutions but will give a range of values to be expected.

Total U g/liter	.301 x	Fractional H density	N_H $.6025 \times .99704 \times \frac{2.016}{18.016} =$ .06722 x10^24	$\Sigma_a(H)$ $\sigma = .332$	$N(U^{235})$ $\frac{.932 \times .6025}{235.21}$ =.002 3874	$\Sigma_a(U^{235})$ $\sigma = .682$ b.
15	.00452	.99548	.06692	.022 22	35.81 x10^18	.024 42
20	.00602	.99398	.06682	.022 18	44.74	.030 51
25	.007525	.99247	.06671	.022 15	59.68	.040 70
30	.00903	.99097	.06661	.022 11	71.62	.048 84
40	.01204	.98796	.06641	.022 05	95.49 695	.065 12
50	.01505	.98495	.06621	.021 98	119.36 555	.081 40
75	.02258	.97742	.06570	.021 81	179.04 367	.122 11
100	.0301	.9699	.06520	.021 65	238.74 273	.162 82
120	.0361	.9639	.06479	.021 51	286.47	.195 37
150	.04515	.9548	.06418	.021 31	358.08	.244 21
200	.0602	.9398	.06317	.020 97	477.44	.325 61
250	.07525	.92475	.06216	.020 64	596.80	.407 02
300	.0903	.9097	.06115	.020 30	716.16	.488 42
400	.1204	.8796	.05913	.019 63	954.88	.651 23
500	.1505	.8595	.05778	.019 18	1193.61	.814 04
600	.1806	.8194	.05508	.018 28	1432.33	.976 85
700	.2107	.7893	.05306	.017 62	1671.05	1.139 66
800	.2408	.7592	.05103	.016 94	1909.77	1.302 46
1000	.301	.699	.04699	.015 60	2387.4	1.628 21

The lifetimes vary from 3 to 110 μs

λ_c ~~which~~ $(\lambda_c = \beta_{eff}/\ell)$ varies from 2,333 to 64 cps.

Therefore if the measured decay constant is greater than 2330, it should be subcritical!

However the concentration solution systems will have an appreciable fraction of the fissions occuring at higher energies than thermal and therefore the lifetime will be shorter than the simple calculations indicate.

	Σ_{at}	$\ell = \frac{1}{.8862\, v\Sigma_a}$ $\beta = .71$	$\lambda = \frac{\beta}{\ell}$
		230.[illegible]	30.8
2	.046 64	110.0	64.5
1	.052 69	[illegible]7.34	71.9
0	.062 8[illegible]	81.60	87.0
4	.070 9[illegible]	72.29	98.2
2	.087 1[illegible]	58.84	120.7
0	.103 3[illegible]	49.[illegible]	143.1
1	.149 92	35.[illegible]	200.6
2	.184 47	27.[illegible]	255.4
7	.216 88	23.[illegible]	300
1	.265 52	19.[illegible]	367
1	.346 58	14.80	480
12	.427 64	11.99	592
12	.508 72	10.08	657
3	.670 86	7.65	928
4	.833 22	6.15	1154
5	.995 13	5.15	1379
6	1.157 28	4.43	1603
16	1.319 40	3.89	1825
21	1.643 80	3.12	2276

Estimates of changes in decay constant with size of system.

For thermal energies 2200 m/sec (.025 eV)

$\frac{1}{v} = 4.5_{45}\ \mu sec/cm$

for 2.5 ev $\frac{1}{v} \rightarrow 0.45_{45}\ \mu sec/cm$

250 ev $\frac{1}{v} \rightarrow 0.0454_{5}\ \mu sec/cm$

.25 kev $\frac{1}{v} \rightarrow 45.45$ nanosec/cm

25 kev $\frac{1}{v} \rightarrow 4.54_{545}$ n sec/cm

2,500 kev = 2.5 Mev $\frac{1}{v} \rightarrow 0.45_{45}$ n sec/cm

400 kev $\frac{1}{v} \rightarrow 1.136_{36}$ n sec/cm

Therefore for arrays where most of the leakage is in the prompt range the transit time for neutrons interacting may be unimportant. However, there are a few neutrons whose transit times are appreciable, and these can change λ.

Design of a Neutron Shield for Accelerator Target to Reduce Room Return

Nov 12-13, 1962

14 Mev Cross Sections

	H	D	Li	Be	B	C	N	O	Fe	Al
σ_T	0.7	0.8	1.45	1.55	1.45	1.4	01	1.65	2.6 barns.	1.7b
MW	1	2	6.95		10.82			16		
σ (th)	.332	.00046	71.	.01	755	.0034	1.88	<.0002		

HBO_3 MW = 61.84 $\rho = 1.435$

$$\text{Mol. density} = \frac{1.435}{61.84} \times .6025 \times 10^{24} = 0.01399 \times 10^{24}$$

$$\Sigma_T = .01399(\overset{7.1}{x}.7 + 1.45 + 3 \times 1.65) = 0.09933$$

$$\Sigma_a(th) = \cancel{.01399} \; .01399\,(.332 + 755 + 3 \times .0) = 10.57$$

LiH MW = 7.95 $\rho = 0.82$

$$\text{Mol density} = \frac{0.82}{7.95} \times .6025 \times 10^{24} = 0.06214 \times 10^{24}$$

$$\Sigma_T = 0.06214\,(0.7 + 1.45) = 0.1336$$

$$\Sigma_a(th) \quad .06214\,(71.33) = 4.43$$

Li_2CO_3 MW = 73.89 $\rho = 2.11$

$$\text{Mol density} = \frac{2.11}{73.89} \times .6025 \times 10^{24} = 0.01720 \times 10^{24}$$

$$\Sigma_T(14\,Mev) = 0.0172\,(2 \times 1.45 \overset{9.25}{+} 1.4 + 3 \times 1.65) = \cancel{0.0}\; 0.1591$$

$$\Sigma_a(th) = 0.0172\,(142) = 2.443$$

CH_2 MW = 18 $\rho = .93$

$$\text{Mol density} = \frac{0.93}{18} \times .6025 \times 10^{24} = 0.03112$$

$$\Sigma_T(14\,Mev) = .03112\,(1.4 + \overset{2.8}{2 \times .7}) = 0.08714$$

$$\Sigma_a(th) \quad .0311\,(.664) = .02066$$

Al 27 2.7 = .06025 $\Sigma_{14\,Mev} = 0.1024$

Iron MW. 55.85 $\rho = 7.88$ Mol den. = 0.0850 $\Sigma = 0.221$

An enriched LiH shield ~~would~~ be the best.
It has about the same hydrogen content as CH_2.
(0.06214 vs .06224) but $\Sigma_a(th)$ = .06214 X 950 = 59.03
even larger than HBO_3.

Comparison of 50% CH_2 50% absorber powders

	Σ_t (14)	Σ_a (th)	Total H density
Li_2CO_3	.1232	1.232	.0311 $\times 10^{24}$
HBO_3	.0933	5.295	.0381 $\times 10^{24}$

Experimentally 290 g of paraffin was used to mix 2# (908 g) of HBO_3. Resulted in very little settling

$290/.93 + 908/1.435 = 1573$

$\frac{1497.7}{1573} = \frac{290}{.93} + \frac{908}{1.435}$

$312 + 633 = 945$

$33\% + 67\% = 100\%$

This is about the limit, without excess settling

For 33.3% CH_2 and 66.7% HBO_3

Σ_T (14 Mev) = ~~0.07648~~ 0.09516 $\quad \lambda_t = 10.5$ cm

Σ_a (thermal) = 7.05 $\quad$ 8 in → 1.935 MFP

H Density = 0.03007 $\times 10^{24}$ $\quad e^{-2x} = 0.1444$ or 14.4% transmission

For annulus 20 in o.d. 4 in i.d. and 15 in. high

$\pi(10^2 - 2^2)15 = 4524 \text{ in}^3 = 74,147 \text{ cm}^3$

$\frac{1}{3} \times .93 \times 74147 = 22986$ gm = 50.7 lbs.

$\frac{2}{3} \times 1.435 \times 74147 = 70934$ gm = 156.4 lbs.

Such a design was submitted to Tunnell to get fabricated.

Buckling Measurements of Arrays

Since there is an abundant supply of graphite blocks 3 × 3 × 12 in. (AGHT) in storage, it might be useful to pulse arrays of these units

11-21-62 (Blocks are $2\frac{7}{8} \times 2\frac{7}{8} \times 12''$) ~1536 + 20 blocks total.

		B^2
12 × 12 × 12	B^2 = 0.01062 × 3	= 0.03186
12 × 18 × 18	.01062 + 2 × .00472	= 0.02006
24 × 18 × 18	.002660 + .00944	= 0.01210
24 × 24 × 24	3 × .00266	= 0.00798
24 × 30 × 30 ~~30 × 24 × 24~~		
30 × 30 × 30	3 × .001700	= 0.00510
36 × 36 × 36	3 × .001180	= 0.00354
48 × 48 × 48	3 × .000664	= 0.00199

Glasstone & Edlund p 127 D (Graphite) = 0.903

$vD = 2.200 \times 10^5 \times 0.903 = 1.987 \times 10^5 = 198{,}700 \text{ sec}^{-1}$

Beckurts = 189,200

$\lambda(12) =$ 6331. (6028)
$\lambda(24) =$ 1586. (1510)
$\lambda(36) =$ 703. (670)

Therefore arrays of 27 ea $1 ft^3$ will have decay constants

If $\sigma_a = .0037$ $v\Sigma_a = 68 \text{ sec}^{-1}$ ranging from 703 to 6331 sec^{-1}.

HEAVY WATER

8 in o.d × $7\frac{1}{2}$ in. hi

$$B^2 = \frac{\pi^2}{(7.5 \times 2.54)^2} + \frac{2.405^2}{4 \times 2.54} = .1649^2 + .2367^2$$

19.05 .2719

$= .08322$ $B^2(L=\infty) = .05603$

If $vD = 0.80 \times 2.2 \times 10^5 = 1.76 \times 10^5$ (G&E)

$\lambda = 14647.$ $v\Sigma_a \approx 0$

$\lambda(L=\infty) = 9861.$

Ideally these cylinders should be larger but the same size that J.T. Thomas has used is feasible. A preliminary design has been submitted to Tunnell to have made to be filled with D_2O.

Macroscopic Abs. Cross section of BF_3 counters filled to a pressure of 40 cm Hg

$$\frac{40}{76}\ \frac{\times .6025 \times 10^{24}}{22414} = (1.415 \times 10^{-5}) \times 10^{24}$$

$96\%\ {}^{10}BF_3$, $\sigma(B10) = 3840$

$$\sum (BF_3) = 1.415 \times 10^{-5} \times .96 \times 3840 = 5.216 \times 10^{-2} = .05216$$

approx. 5.2% absorption per cm of path.

A counter of this type ~~used~~ used where a collimated beam traverses the length would have to be 44 cm long for 96% absorption — 88 cm long for 99% absorption or 132 cm long for 99.9% absorption.

For a 1 in. o.d. counter average path unknown but for radial directed neutrons path ~ 2.5 cm

$\Sigma x = 0.1304$ Transmission $= e^{-\Sigma x} = .878$

abs $= 1 - e^{-\Sigma x} = .122$ or 12.2%

Accelerator - Dose and Hazard from 14 Mev. neutrons

If RBE for 14 Mev neutrons = RBE for 2 Mev
then a flux of 19 n/cm²/sec gives an
exposure of 10 mrads/week or
100 mrem/week

$19 \times 40 \times 3600 = 2.736 \times 10^6$ n/cm²/week

At a distance of 1 foot and max yield of 4×10^{10} neut/sec
which is rarely achieved if not impossible
yield gives a flux of

$$\frac{4 \times 10^{10}}{4\pi\,(30.48)^2} = 3.42 \times 10^6 \ n/cm^2/sec$$

and the weekly dose is obtained in 0.8 sec
at 10 ft the " " " " 80 sec
at 30 ft the " " " " 720 sec or ~~13~~ 12 min

Use of the Neutron Shield gives an attn factor of 1/7
(see p 20) and then at 10 ft 80 is increased to 560 sec.
If Accelerator is drawing only 60 μa, then 5600 sec
6 μa then 56000 sec

under this latter condition, one could be in the room
for 2 days! (See next page)

From these considerations it is obvious
that when pulsing subcritical systems there
is no need for the red light to be on if
entry to cell is barred in other ways.

DW Magnuson Nov 13, 1962

Distance From Target (feet)	Exposure Time for Weekly Dose (sec)		
	Beam Current (μa		
	600	60	6
	without shield		
1	0.8	8.	80.
3	7.2	72.	720.
10	80.	800.	8000.
30	720.	7200.	72000.
	With Shield (Factor of $\frac{1}{7}$)		
1	5.6	56.	560.
3	50.4	504.	5040.
10	560.	5600.	56000.
30	5040.	50400.	504000.

$UO_2(NO_3)_2$ critical data in 12 in cylinder.

H/x	U density	Meas Crit Ht in	Bott Corr.	Crit Vol l	Total U	CRIT Mass
59.03	0.4127	9.99	+.15	19.559	8.072	7.47
91.7	0.2792	9.78		19.157	5.349	4.95
117.5	0.2237	9.69		18.982	4.246	3.93
191.6	0.1411	10.52		20.584	2.904	2.69

$\pi r^2 = 728.70\ cm^2$ if $r = 15.23$ cm some doubt

B^2

Nov. 1962

Discussed with P. Wood, C. Williams and F. Miller the dead time corrections for the TMC 211 76 μsec dead time and for counter dead time corrections. This code is being written.

~~Oct~~ Nov. 19, 1962

Attempts to collect data at high counting rates for 211 dead time corrections revealed a malfunctioning TMC unit. TMC drops channels on 4 and 8 μs only channel widths. Called Arciola and he is sending three cards on consignment 8015, 8016, and 8018.

Gated clock waveform
Signal storage binary } seem abnormal with
Memory core binary

random input and OK with one count per sweep delayed from the start trigger.

Dwm.

Nov 21, 1962

Cards 8015, 8016 and/or 8018 did not correct the trouble! ~~Don Davidson~~

Nov 28, 1962

Don Davidson, TMC, replaced card 8018 with a new design (Q-1 is now a faster transistor and all germanium diodes are faster too 1N995 instead of 1N281. This apparently improved the system and not as many channels added counts or lost counts. Adjustments of the address current did not change the results of some dropped channels. D.D. showed some trouble with one of the ~~memory~~ arithmetic binaries in the CN-110 and interchanged the 2^7 ? with the 2^{16} binary card. Supposedly, this trouble disappeared.

Dec 3, 1962 -

Pulsed Space reactor at Critical. (No leaks developed on morning on Thurs Nov 29. Pump started on Fri. and well pumped down by Monday A.M. Accelerator shut down

Dec 4, 1962

acc. moved to West End and set up. pump started

Dec 5, 1962

Ready for pulsing 27 bottle array but plumbing difficulties preventing any action until late after noon

27 unit Assembly on period of 234 sec

7080	
9234	x10
12004	
15695	
19881	
25873	
32874	
42093	
53260	
68195	
85843	
107354	
134130	
164656	

1" BF_3 counter @ 1500 V DD-2 gain 1.1 x 5 200 loader + PHS output to RG 114 To X 82415 decade scaler. Counts Taken for 45 sec, off for reading & reset for 15 sec. A plot of this data shows dead time of 7.3 μsec. Later found that pulse of 3 v is not adequate for scaler also on 6 Ω ~, scaler counts 5/4 X as many counts as 60 ~. Therefore this is N.G.

See NB 5604 Int #2
p 239 Exp 68 B

PNS-1 12-6-62

Pulsing critical array of (27) 5 liter bottles
Large, wide cadmium sheet on iron blade
lowered between 1 & 2 rows of bottles

2 in NE-102 XTL @ 1350 V. −154.1 ± 1.5
1 HP 460A Max
1 HP 460B Lin. Pulse ~ 4 v. max
TMC CH 320 μs Bkg 4 Delay 2 Mem 1/1 Disc 2
ACC 142 KV 0.75 MA press 1.5 × 10^{-5} mm Hg
10 CPS Burst 1600 μs. Neutron absorber
blade inserted after 100 cycles or bursts.
(Notebook 5604 p 240 Exp 68 C)
Crit Before slightly super after < 1 ¢

PN-S-2 Same except Disc set at 3
crit before and after −154.7 ± 1.5

PNS-3 1" BF3 Counter (200 Ω + 100 ft RG-114
+ 200 Ω @ 1700 v NJ Q C P.S. 2 ea HP 460A 1/ea HP 460B
Pulse size max 8 v. (width ~ .2 μs total
most of pulse over in 0.05 μsec.

−153.4 ± 1.5

−153.9 ± 1.0

12-10-62

on 12-7, Tried replacing cards 8015 and 8016 in T.O.F. 211 with the new ones sent by Arcinolo. No improvement noted. Analyzer now has a new 8018 card that D. Davidson installed when he was here on Nov 30.

DWM

Dead Time Corrections for
Time of Flight Logic and
for Counter Losses.

Dead Time in T.O.F - 211.

The TMC Model 211 Time of flight Logic Unit has a dead time of 16 μsec following each count received at the signal input. There is additional dead time because the analyzer waits until the end of a channel before it starts to store the count in the proper time channel Therefore, the counts in preceding channels as well as the channel under consideration contribute to the dead time losses. The Model 211 unit has time channels selectable from 0.25 to 64 μsec For channels longer than 16 μsec the analyzer must be advanced a fraction of a channel after the storage of a pulse, and for channels 16 μsec and shorter the analyzer must be advanced an integral number of channels.

The dead time in a channel, i, of width Δt due to counts C_i arriving while that channel is open for n times is $C_i \Delta t/2$ since the counts are approx. random over the time interval Δt. (See p. 34 for the case of decay during time Δt.) The dead time in this channel due to counts arriving in preceding channels is

$$\underset{\text{from preceding counts}}{\text{dead time}} = \sum_{k=1}^{k=j} C_{i-k} \times \Delta t$$

where $j = \dfrac{16\,\mu sec}{\Delta t}$

the total dead time is

$$t_i = \left(\sum_{k=1}^{k=j} C_{i-k} + \frac{C_i}{2} \right) \Delta t$$

$$C_{i-k} = 0 \quad \text{when} \quad i-k \leq 0$$

If $\Delta t = 32$ or $64\,\mu sec$, the dead time in channel i is

$$t_i = j\,C_{i-1} + \frac{C_i}{2}$$

where j is now less than 1 $j = \dfrac{16}{\Delta t}$

The fractional dead time is

$$f_i = \frac{t_i}{n \Delta t}$$

The corrected counts C_i' is given by

$$C_i' = C_i (1 + f_i)$$

If detectors are used which have additional dead times, corrections must be made for these losses. This correction factor is given simply by the relation

$$C_i^{\circ} = (1 + \tau C_i' / n\Delta t) C_i'$$

where τ is the electronic counter dead time.

These corrections have been programmed by P. B. Wood to precede the least squares calculation under "Dead Time Corrections Problem No 3527

Dead time in channel i for constant count rate.

Dead time after count at time t is $(t_i - t)$

$$C_i = \int_{t_{i-1}}^{t_i} N_0 e^{-\lambda t}\,dt \rightarrow N_0 \Delta t \text{ if } \lambda \rightarrow 0$$

$$\text{Total dead time} = \int_{t_{i-1}}^{t_i} N_0 (t_i - t)\,dt = N_0 \left[t_i t - \frac{t^2}{2} \right]_{t_{i-1}}^{t_i}$$

$$= N_0 \left[t_i^2 - \frac{t_i^2}{2} - t_i t_{i-1} + \frac{t_{i-1}^2}{2} \right]$$

$$= N_0 \left[\frac{(t_i - t_{i-1})^2}{2} \right] = N_0 \Delta t \frac{\Delta t}{2} = C_i \frac{\Delta t}{2}$$

Dead time for count rate varying decay.

$$C_i = \int_{t_{i-1}}^{t_i} N_0 e^{-\lambda t}\,dt = \frac{N_0}{-\lambda}\left(e^{-\lambda t_i} - e^{-\lambda t_{i-1}} \right)$$

$$C_i = N_0 e^{-\lambda t_{i-1}} \left[\frac{1 - e^{-\lambda \Delta t}}{\lambda} \right] \rightarrow \frac{+\lambda \Delta t/_1 - \lambda^2 \Delta t^2/_2 + \lambda^3 \Delta t^3/_6}{\lambda}$$

$$C_i = N_0 e^{-\lambda t_{i-1}} (\Delta t) \left(1 - \frac{\lambda \Delta t}{2} + \frac{\lambda^2 \Delta t^2}{6} - \frac{\lambda^3 \Delta t^3}{24} \right)$$

$$\text{Dead time} = \int_{t_{i-1}}^{t} N_0 e^{-\lambda t} (t_i - t)\,dt = N_0 \left[\frac{t_i}{-\lambda} e^{-\lambda t} + \frac{e^{-\lambda t}}{\lambda^2} (\lambda t + 1) \right]_{t_{i-1}}^{t_i}$$

$$\text{Dead Time} = N_0\left[\frac{t_i}{-\lambda}e^{-\lambda t_i} + \frac{e^{-\lambda t_i}}{\lambda^2}(\lambda t_i+1) + \frac{t_i}{\lambda}e^{-\lambda t_{i-1}} - \frac{e^{-\lambda t_{i-1}}}{\lambda^2}(\lambda t_{i-1}+1)\right]$$

$$= N_0\left[\cancel{\frac{t_i}{-\lambda}e^{-\lambda t_i}} + \cancel{\frac{t_i e^{-\lambda t_i}}{\lambda}} + \frac{e^{-\lambda t_i}}{\lambda^2} + \frac{t_i}{\lambda}e^{-\lambda t_{i-1}} - \frac{t_{i-1}}{\lambda}e^{-\lambda t_{i-1}} - \frac{e^{-\lambda t_{i-1}}}{\lambda^2}\right]$$

$$= N_0\left[\frac{1}{\lambda^2}\left(e^{-\lambda t_i} - e^{-\lambda t_{i-1}}\right) + \frac{e^{-\lambda t_{i-1}}}{\lambda}\left(t_i - t_{i-1}\right)\right]$$

$$= \frac{N_0 e^{-\lambda t_{i-1}}}{\lambda^2}\left[\cancel{1}\left(e^{-\lambda\Delta t} - 1\right) + \lambda\Delta t\right]$$

$$= \frac{N_0 e^{-\lambda t_{i-1}}}{\lambda^2}\left[\cancel{1} - \cancel{\lambda\Delta t} + \frac{\lambda^2\Delta t^2}{2} - \frac{\lambda^3\Delta t^3}{6} + \frac{\lambda^4\Delta t^4}{24} \cdots \cancel{-1} + \cancel{\lambda\Delta t}\right]$$

$$= \frac{N_0 e^{-\lambda t_{i-1}}}{\lambda^2}\left[\frac{\lambda^2\Delta t^2}{2} - \frac{\lambda^3\Delta t^3}{6} + \frac{\lambda^4\Delta t^4}{24} - \frac{\lambda^5\Delta t^5}{120}\right]$$

Dead time per count $= T/C_i$

$$= \frac{\dfrac{N_0 e^{-\lambda t_{i-1}}}{\cancel{\lambda^2}}\left[\dfrac{\lambda^2\Delta t^2}{2} - \dfrac{\lambda^3\Delta t^3}{6} + \dfrac{\lambda^4\Delta t^4}{24}\right]}{N_0 e^{-\lambda t_{i-1}}\,\dfrac{\Delta t}{1}\left(1 - \dfrac{\lambda\Delta t}{2} + \dfrac{\lambda^2\Delta t^2}{6}\right)}$$

$$= \frac{\dfrac{\Delta t}{2}\left(1 - \dfrac{\lambda\Delta t}{3} + \dfrac{\lambda^2\Delta t^2}{12}\right) - \dfrac{\lambda^3\Delta t^3}{60}}{\left(1 - \dfrac{\lambda\Delta t}{2} + \dfrac{\lambda^2\Delta t^2}{6} - \dfrac{\lambda^3\Delta t^3}{24}\right.}$$

$$1 + \frac{\lambda\Delta t}{6} - \frac{\lambda^3\Delta t^3}{360}$$

$$1 - \frac{\lambda\Delta t}{3} + \frac{\lambda^2\Delta t^2}{12} - \frac{\lambda^3\Delta t^3}{60} \;\Big)\; 1 - \frac{\lambda\Delta t}{2} + \frac{\lambda^2\Delta t^2}{6} - \frac{\lambda^3\Delta t^3}{24}$$

$$\frac{\lambda\Delta t}{6} - \frac{\lambda^2\Delta t^2}{12} + \frac{\cancel{3}}{\cancel{120}\;40}\lambda^3\Delta t^3$$

$$\frac{\lambda\Delta t}{6} - \frac{\lambda^2\Delta t^2}{12} + \frac{\lambda^3\Delta t^3}{36} - \frac{\lambda^4\Delta t^4}{144}$$

$$-\frac{1}{360}\lambda^3\Delta t^3 + \text{——}$$

Dead Time per Count $= \frac{\Delta t}{2}\left(1 + \frac{\lambda\Delta t}{6}\right)$

If the counting rate is 10,000 counts/sec

or $\frac{C_i}{n\Delta t} = 10,000$ counts/sec

~~then~~ $f_i = \frac{C_i\,\Delta t/2}{n\Delta t} = 10000\,\frac{\Delta t}{2} = .08$ for 16μsec Δt

$= .00125$ for $1/4\mu$sec Δt

For $f_i = .0125$ with $1/4$ μsec Δt

count rate can be 100,000.

12-12-62
We need a printing scaler for measuring periods since the two RIDL units are inoperative. One way to get one economically would be to get a new logic unit for the TMC-110. The Model 214 Multi scaler - it sorts counts in time channels of 0.001, 0.01, 0.1 and 1.0 sec plus external time advances. If we would cascade 2 ea Atomic (256) scalers, and count 60 ~ then the scale factors of 16, 64, 256, 1024, 4096 16,384 & 65,536 yield time channels of 0.267, 1.067, 4.267, 17.067, 68.267, 273.067 & 1092.267 seconds. This is adequate to measure any period of interest in the critical facility using pulse techniques.

12-13-62 Ordered 214 Plug in Unit.

" 1ea 1" o.d by 8 1/4 in. RSN-75

" 1ea 5/16" o.d by 1" in 5' probe RSN-105S

4-9-63
O^{3^2} cd
on 20" and 12" cylinders

12/19/62

Set up 2 in NE-102 so that @ 1350 v HP-460A full gain HP-460B linear, TMC DISC @ 2½ essentially no counts from Co^{60} gamma rays ~~but~~ Pulse height less than 1v as measured with 543A scope with A channel. Pu-Be source gives pulses up to 2-2½ volts.

12/20/62

Set up for flux traverse in 20" cylinder using Min BF on control drive 219 Preamp 204 amps at 0.2μs rise time gain x64 PHS @ 5. Neutron pulses 10-25 volts in amplitude and ~ 1½ μs wide on output of 204.

Using B.A. model 136 scaler with 4Kc second decade and hence dead time ~25μs Hence for 1% losses CR should be less than 400cps or 24 kct/MIN

		σ		
17 pt.	$B2 = 0.3156 \pm$	0.0026	Central	7 in.
15	$0.3175 \pm$	0.0023	Central	6.11 in
12	$0.3186 \pm$	0.0020	"	5.31 in

$B2 = 0.3186 \pm 0.006 \text{ in}^{-1} = 0.125_4$

$B_2^2 = 0.01573$

$\tilde{h} = 9.86$ in

$h = 7.66$

2.22 in x2.54 = 5.64 cm

		Dig level	
Dec 21	2" detector on side of 20 in diam cylinder	4.02 -.16	=3.86
	centered 2 1/4" above bottom (outside)	4.54	4.38
		4.93	4.77
	2" det now 3 1/4 above bottom	5.425	5.27
	"	5.71	5.56
	"	6.03	5.87
	"	6.31	6.15
	"	6.61	6.45
	"	6.89	6.73
	"	"	"
	"	7.17	7.01
	"	7.50	7.34
	"	7.61	7.45
	"	7.71	7.55
	Critical Position	7.775	7.62
	2" det below, rt angle to target	4.00	3.84
	"	5.05	4.89
	"	6.01	5.85
Jan 5, 63			
	"	4.04	3.88
		5.04	4.88
		6.04	5.88
		6.59	6.43
		6.59	"
		6.59	"
		7.04	6.88
		7.04	"

	CH WIDTH	DELAY	BKG	DISC	~~BURST~~ WIDTH MEM	REP RATE	BURST WIDTH	
PNS-4	10	16	8	2½	1/4	600	100	148KV .87MA 8μa −10700 ± 100
5	"	"	"	"	"	"	"	" .92 10μa ± 70
6	"	"	"	"	"	"	"	" .93 10μa
7	"	"	"	"	"	"	"	" " "
8	"	"	"	"	1/2	300	"	149 .94 5μa
9	"	"	"	"	"	"	"	150 .85 3μa
10	"	"	"	"	"	"	"	" " "
11	20	8	"	"	"	200	100	" .83 2μa
12	"	"	"	"	"	200	150	" " "
13	"	"	"	"	"	"	"	" " "
14	40	8	8	2½	1/2	130	200	150 .83 2μa
15	80	8	8	2½	1/2	~~400~~ 73	400	150 .78 1μa
16	160	4	8	2½	1/2	38	800	150 .76 >1μa
17	320	4	8	2½	1/2	20	1600	150 .75 >1μa
								8.75 38.50 47.25
18	10	16	8	2½	1/4	600	100	150 .83 5μa } # 8.75
19	10	16	8	2½	1/4	600	100	150 .80 4μa
20	10	16	8	2½	1/2	300	100	150 .80 2μa
21	10	16	8	2½	1/2	300	100	150 .88 4μa
22	10	16	8	2½	1/2	300	100	150 .84 3μa
23	10	16	8	2½	1/2	300	100	150 .79 2μa
24	10	16	8	2½	1/2	300	100	150 .79 2μa
25	20	8	8	2½	1/2	220	100	150 .79 ~~2μa~~
26	40	4	8	2½	1/2	130	100	150 .79 ~~2μa~~
27	40	4	8	2½	1/2	130	100	" "
28	40	8	8	2½	1/2	130	200	" "

		Soln Ht	
		7.40 −.16	= 7.24
		7.58	7.42
		7.68	7.50
		7.72	" = 7.56
	+ crit	7.77	
	− "	7.76	

1-7-63

BF3 Counter RSN-75 in center of soup.
2000 V 3 ea 460A 1 ea 460B ~6v pulses on scope

4.065	= 3.905
4.065	= 3.905
5.005	= 4.845
5.985	= 5.825
6.54	6.38
7.015	6.855
7.29	7.13
7.495	7.335

1-8-63

Set up TMC - TOF - 211 for use at
+ sync signal from EP-110A (Same pulse that
3+v pulse needed to trip 211 unit
Use 2 ea HP 460A with RSN-75 @ 2000 V

	4.08 −.16	= 3.92
		"
		"
	7.01	6.85
Crit with	7.51	7.35
counter 7.895	7.61	7.45
.16 7.735	7.71 7.795	7.55 7.635

PN.
3.50
14.00
350
14.75
8/
t

	CH WIDTH	DELAY	BKG	DISC	MEM	REP Rate	BURST WIDTH
PNS-29	80	8	8	2½	1	39	300
3.50 / 14.00 30	80	8	8	2½	1	20	300
31	160	8	8	2½	1	10	300
32	160	8	8	2½	1	10	400

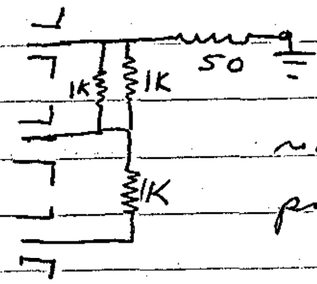
Correct pulse rep period.

	CH WIDTH	DELAY	BKG	DISC	MEM	REP Rate	BURST WIDTH
33	10	16	8	2½	1/4	600	100
34	10	32	8	2½	1/4	550	100
350 / 1475 35	10	16	8	2½	1/4	600	100
36	20	16	8	2½	1/4	400	150
37	40	16	8	2½	1/4	230	250
38	80	16	8	2½	1/4	120	450
39	160	16	8	2½	1/4	64	600
40	320	16	8	2½	1/4	35	1000

8 μsec channel widths. Use Attn box to attn

Hai) turns on accelerator)

+3v



~40

~10:1 attn

pulse now

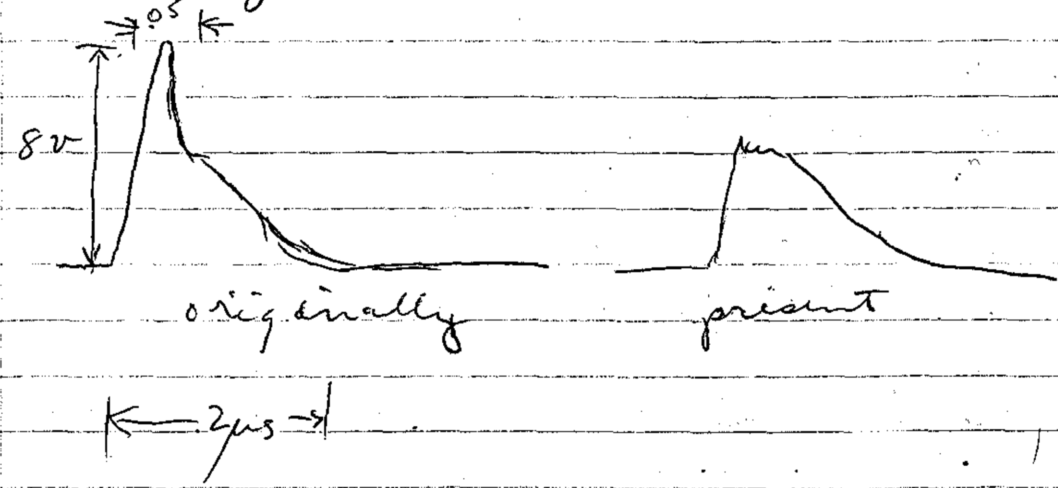
	CH WIDTH	DELAY	BKG	Gain	MEM	REP Rate	BURST WIDTH
211							
41	8	0	X	32	1/2	800	30
42	4	0		32	1	800	30
43	10	2	2	2½	1/4	700	30
44	80	2	2	2½	1/4	150	300
45	160	2	2	2½	1/4	80	500
46	"	"	"	"	1/2	40	500
7.635 47 48	"	"	"	"	"	"	"

1~~2~~/9/63

RSN-7S counter was connected to DD-2 amplifier and a pulse height distribution was observed in the TMC-210 logic unit. The characteristics of the counter have changed!

1~~2~~/10/63

RSN-7S + 2000V + 3ea HP460A + 1ea 460B now yield pulses of ~ 4v. Setting PHS disc on TMC down to ~1 eliminates nearly all background counts. Pulse shape below.



There were also some strange effects noted when DD-2 amp was used with short pulse trigger. These disappeared when long delay trigger was used, or when L.A. in TMC was used.

1/~~2~~/10/63
Reedy and Connors have reworked ~ 3 control drive bearings, and have the thimble in which the safety will move mounted in the 20 in vessel. (It worked in the clean 12 in vessel.) ~~and~~

1/~~2~~/1~~1~~/63
After determining crit pos., 50 mc/sec from ion source was observed in the signal from the BF-3 and HP amp. blocking the TMC.

The 1/2 thick Ne102 with 6810 PM @ 1050 volts 1ea HP 460A and 460B give pulses on scope ~ 4 v. With disc @ 2 1/2, no counts with Acc off.

PNS - 49 Critical HT 8.34 ($16 = 8.18$) Control In 0.06 (Out {6.60, 6.58})
Ch 320 μs Delay 8 Bkg 8 Disc 2 1/2 Mem 1/2
Burst 1000 μs Rep Rate 18 cps 150 kv .80 ma
Total cycles 7000 Slightly Sub Crit after pulsing ~ -975 sec or 1.7 ¢

	C R	Sol Ht		
Jan. 11, 1963 Crit	6.59	8.34	-16	8.18
w. thimble	6.45	8.215		8.055
for Safety	6.35	8.12		7.96
	6.24	8.04		7.88
	6.03	7.80		7.64
	5.53	7.30		7.14
Jan 14, 1963, C.R - 6.60 -06				
6.59 -07		8.34		8.18
	5.53	7.30		7.14
	5.03	6.80_5		6.645
	4.53	6.29		6.13
	"	"		"
	3.53	5.29_5		5.135
	2.53	4.30		4.14

Solution sampled for Analyses

Reg A-181 corrected mg U/g	59.325
Density @ 24	1.0830
Sp Gr	1.0859
mg U/ml	64.25

Isotopic Analyses

P

	Ch	Delay	Blg	Disc	Mem	Burst	Rep	
PNS-50	160	8	8	2½	½	1000	38	
51	80	8	8	2½	½	400	73	
52	80	8	8	2½	½	400	73	
53	80	8	8	2½	½	400	73	
54	40	16	8	2½	½	250	125	
Pulsing		at Critical						After pulsing Subcritty 0.36 ¢
55	320	8	8	2½	½	1500	18	
56	40	8	8	1¼	½	250	110	
57	20	16	8	1¼	½	150	210	
		1 ea	460	[illegible]	HP		HV	= 1050
58	16	0	TOF	Gain 32	1/1	100	200	
59	16	0		32	1/1	100	200	
60	8	0		32	1/1	100	400	
61	4	0		32	1/1	40	800	

1/18/63 12 in. diam S.S. vessel
Critical height 16.30₅ on 1/16/63.
liq. level zero at 00.00.

1/18/63 Pulsing 12 in diam S.S. vessel
unperturbed by thimbles or counters.

	EXP No.	Ch Width μs	Delay	Bkg	Disc	Mem	Burst μs	Rep Rate	Ht Sol	Ht
1-18	PNS-62	10	16	8	1 1/4	1/2	100	330	8.00	7.94
	63	10	16	8	1 1/4	1/2	100	250	8.99	8.93
	64	10	16	16	1 1/4	1/2	100	200	10.00	9.94
	65	20	16	16	1 1/4	1/2	200	100	11.00	10.94
	66	20	16	16	1 1/4	1/2	200	100	12.00	11.94
	67	40	16	16	1 1/4	1/2	500	50	13.01	12.95
	68	40	16	16	1 1/4	1/2	500	50	14.01	13.95
	69	80	8	16	1 1/4	1/2	500	30	15.00	14.94
	70	80	8	16	1 1/4	1/2	500	20	15.25	15.19
	71	160	8	16	1 1/4	1/2	800	10	15.505	15.45
	72	160	8	16	1 1/4	1/2	800	10	15.76	15.70
	73	160	8	8	1 1/4	1/2	800	10	16.005	15.95
	74	160	8	8	1 1/4	1/2	800	5	16.15	16.09
	Critical Height after Pulsing								16.365	16.31

Manometer zero Correction
determined to be .060

Source on Side 5" up from bottom
Detector 1/2 Ne 102 5" at RTANGLE
PM @ 1050 HP 460 A + HP 461 B.

74
73
94
94
.94
.95
3.95
4.94
5.19
15.45
15.70
15.95
16.09
16.31

1/21/63 Pulsing 12 in od Vessel

BF-3 @ 1500 V (RSN-75) DD-2 @ 1.1 X 50

0.5 μs delay line dead time ~ 1.2 μs. PHS-Neg + HP-460B

Counter located @ ~100° from target on side of 12 in cyl. bottom of counter even with bottom of vessel.

	Channel width (μs)	Delay	Bkg	Disc	Mem	Burst μs	Rep Rate CPS		Manom Sol HT		
PNS-75	10	16	8	2½	½	80	300		8.03		
76	20	8	8	2½	½	80	220		10.05		
77	20	8	8	2½	½	80	220		12.04		
78	40	8	8	2½	½	200	80		14.06		
79	80	8	8	2½	½	500	20		15.56		
80	160	8	8	2½	½	1000	10		15.855		
81	160	8	8	2½	½	1000	5		16.14		
1-24-63 82	160	8	8	2½	1	1000	18		16.30		Crit
83	160	8	4	4.0	1	1000	10		16.15		
84	160	8	8	4.0	1	1000	15		16.00		
85	160	8	8	4.0	½	1000	25		15.85		
86	160	8	8	4.0	½	1000	30		15.70		
									Crit	Ht.	
2-5-63 87	320	8	4	2½	½	700	18			Crit in 20 in.	X
88	320	8	4	2½	½	700	18		7.985		X

460B

rit

20 in.	X1.005	Slight Subcool Flat Safety in Sings. Center on Side of vessel
	X1.015	" "

1/22/63

Set up 214 Multiscaler with Atomic scalers counting 60 ~ to get pulses every 15 sec scale of 256. this was used to trigger the channel advance. Pulses from the BF3 @ 1500 with Neg PHS signal attenuated with (box) by ~ 10. 214 gain 1.0 X2

EXT Channel advanced by 60 ~/256 or 4.2667 sec

	Beck	ORNL	Aver	Counter
MS-214-1	506.3	499.8	503	519.3
2	198.4	187.5		192.7 ~~[illegible]~~
3	195.6 ~~217.3~~	185.4		203.8
4	200.6	195.6		NG

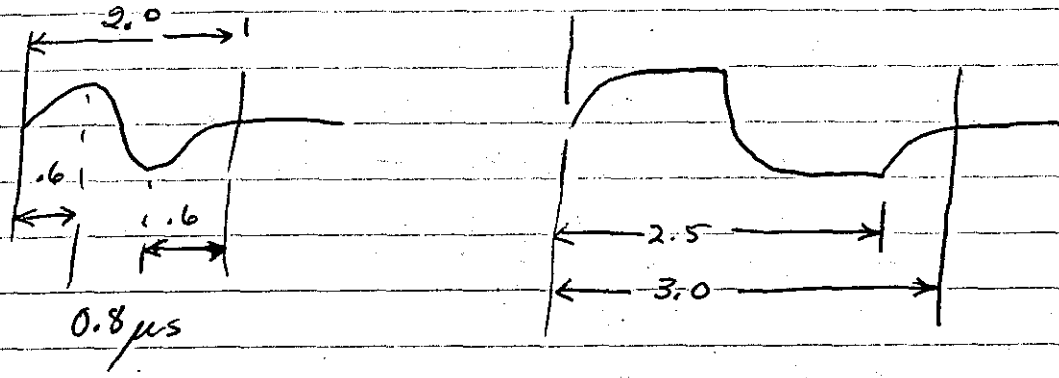
1/25/63

Vertical Flux Traverse in 12 in. cyl.

1/23/63

ERR & DWM — measured dead time of PHS section of 0.5 μs delay line DD-2 amp $\tau = 1.35\ \mu s$ when amp skipped every other pulse. $\tau = 1.25$ on DD-2 with regular delay line of 1.2 μs.

0.5 μs   1.2 μs



PHS section drawing shows some pulses that are 1.4 μs long, therefore the measured dead time is reasonable.

1/24/63

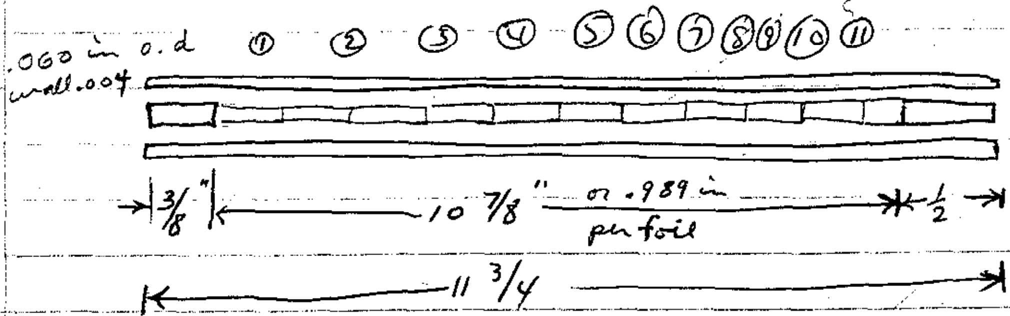
Set up for pulsing at Critical   Safety in soup no thimble

BF3 (RSN-75) on outside of 12 in vessel @ 1600 V, use 200 Ω term on RG-114 ends between DD-2 amp (gain 50 X1.1) on Pos PAS, at Input to TMC-212 pulse is 1.5 v and less than 1/2 μs wide. Disc can be set at 4.0 without reducing count rate. see page 50 for conditions.

Crit ht = 16.30

1/28/63

FOIL Preparation for Radial Traverse in 12 in cyl.



Foils ① – ⑪ of .042 gold wire, weighed and within ± 1/2 % (.372 – .375)
Ends sealed with polyethylene tape and doped with red glyptal.

Foil ⑫ at bottom of 4' tube and will be used to determine power level for foil irradiation

$\#2/\#3 = .9811$ $\quad \frac{1}{.9811} = 1.0193$ (ΔE:1000, E:75)

1/29/63

Suspended #2 bare U^{235} and #3 Cd Covered .025 Cd +3/4 and – 3/4 in. from ℄ of crit solution in 12 in. diam cyl., ℄ = 8.15 in.

Cd Ratio 16.14, corrected $\times \frac{.94}{.79} = 19.2$

1/29/63

Reedy and Connors have made ~ 25 ea ~~#~~ .064 o d × ~~.500~~ 490 ± .001 ~~wire~~ gold wire foils

1/30/61

Foil Exposure for 1 hr @ ORNL log N = .1 x 10⁻⁸.
11 ea 1 in x .040 gold wires ① - ⑪. Use ⑥ as normalizer
Crit height with Foils 16.56
− .21
16.35

1/30/61 Checked out of RSN-1055 5/16" od counter. @ 1500 gain x16 x1 RT 0.2 μs

PHS	x16	x32
5	79 752	83 691
10	69 711	78,859
15	54 049	
20	37 994	68,518
25		
30		

1/30 Install 18 ea foils #13 − #30 in .060 SS
Total foil length 17 29/32 average .995 in
Foil 13 at top foil 30 at Bottom, bottom sealed with tape and Red Glyptal.
Tip at bottom at 994.94, lower to 992.90. selsyn reading, irradiated for 1 hr @ .1 (10^{-8}) on ORNL log N on 31, contd Feb 1, 1963 [signature]

2-4-63

gold wire traverse using
0.49 × .064 od foils
~~A-1, A-2~~, Foils used from top to bottom
A-3, A-4, A-5, A-6, A-7, A-8 A-9
B-1, B-2, B-3, B-4, B-5, B-6, B-7
B-8, B-9, A-1, A-2

A-3, 4, 5 and ~~A-1~~, A-2 not used
in the curve fitting.

called
PNS - 89

Crit Ht = 7.69 in.

2-5-63

Pulsing at critical in 20" cylinder

Crit Ht 7.985 − .35 = 7.635

PNS-87 See p. 50 X 1.005

using flat safety in scrap.

criticality check before, during, and after pulsing, 0, 0, −1369 sec → −1.0 ¢

PNS-88 repeat pulsing at critical.

after PNS-88, system @ −695 sec period

= 1.25 x 10^{-4} = −1.95 ¢

Average sub crit −1.5 ¢, correction factor = 1.015

2-6-63

Exposed Gold Foil Wires 1.000 x .040 od for Radial Flux Traverse. @ 0.1 log N (ORNL)

≈ 19¾" S.S. tube .060 od x .004 contains

3/8 in spacer 19 wires + 7/16 in spacer.

2-6-63

Aligned log N recorders so that pen traces were parallel to lines ~~that~~ when chart motor off and pen made to go up an down scale,

DWM

2-12-63

An experiment is planned to measure the time distribution of neutrons as a function of axial position using RSN-105S counter. These data will be normalized using RSN-7S counter below the assembly. (This position may have to be adjusted for optimum counting rate.

RSN-105S	RSN-7S on C-1
Nuclear Inst @ 1500	B-A PS @ 1700
DD-2 0.7 X 50	A-1, 0.2 μs R.T.
PHS 100	Gain 1 X 32
Pulses ~ 10-80 volt	ORNL Decade Scaler (500 KC)
very few counts <10 in 210000 cycles x 10 μsec.	Pulses ~ 10-50 v with most at 40 v.

Tip of counter

		Ch	Delay	Bkg	Disc	Burst	Rep Rate	RSN 105 POS	Norm
2-13-63	PNS-92	10	2	2	2 1/2	100	370	10.80	200070
	93							12.80	200070
	94	Removed Term Res after acc scram							
	94							10.80	200060
	95							8.5	200040
	96							8.9	210080 ✓
	97							9.3	200030
	98							9.8	200060
	99							10.3	230050 86950 ✓
	100							11.3	200060
	101							11.8	200060
	102							12.3	200070
	103							13.3	200040
	104							13.8	200070
	105							14.3	200090
	106							12.8	200060
	107							8.8	191700 (1.0433)
	108							10.8	200110
2-14-63	109	10	2	2	2 1/2	100	700	8.5	200090
	110							10.5	200070
	111							10.9	200100
	112							11.3	200160
	113							11.7	200120
	114							12.1	200120
	115							12.5	200060
	116							8.9	200090
	117							9.3	200060
	118							9.1	200130
	119							10.1	200090

Solution Height = 8.31 − .31 = 8.00 in.

at least 1 arc no scram No Trip of P.S

at least 1 arc no scram " " " "

n... system while printing

1 arc − no scram " " " "

1 arc − no scram " " " "

1 arc − no scram − No trip of P.S

Solution height = 6.31 − .31 = 6.00 in.

		RSN 105 pos	Norm.
2-14-63	PNS-92		
	120	8.9	200130
	121	12.1	200090

2-14-63

additional flux traverse in 12 in diam cyl at sol ht of 16.52 - .31 = 16.21

PNS-127 using RSN-1055 and improved B-A scalers (200KC)

2-21-63

Flux Traverse in 30 in diam Alum Cylinder at sol Ht of 7.43

zero .62 with

Bottom dish full of sol. 6.81

est + .15

~~6.96 sol Ht~~

7.43

Measured zero 0.55

6.88

2-25-63 Summary of Crit Ht data

	30" mod	Sol. Ht	Zero	Crit Ht
2-21-63	30"	7.43	.55	6.88
2-18		7.45	(-.62+.07)	6.90
2-14	12" w. RSN-105	16.52	.31	16.21
2-7	20" w.o. Cd	7.98	.30	
2-7	20" w.o. Cd	7.98	.30	7.68
2-7	20" w. Cd	7.96	.30	7.66
2-5	20" (pulsing @ crit)	7.99	.36	7.63
2-4	20" (w. gold) axial flux	8.07	.36	7.71
2-1	12" w. o Cd	16.59	.21	
	w. Cd	16.41	.21	16.20
1-31	12" Axial gold	16.50	(.21)	16.29
1-30	12" Radial gold	16.47	.21	16.26
1-29	12" gold + U^{235}	16.31	.21	16.11
	12" U^{235} + Cd U^{235}	16.54	.21	16.33
1-25	12" 1/4 Counter	16.295 → 16.42 16.36	(.06)	16.24
1-24	12" Pulse @ Crit	16.295	(.06)	16.24
		16.30	(.06)	16.24
1-18	12"	16.365	.06	16.30
1/15	12"	16.305	0 0	16.31
1/14	20" with 5.5 Th	8.34	(.14)	8.20
1/11	20" with 5.5 Th	8.33		8.19
		8.335		8.20
12/20 12/18	20" 1/4" Counter	7.81 7.82	.14	7.67 7.68

5/2/58 Calibration of 12 in cylinder S.S.

$R = 5.985$ in $D = 11.97$, $R = 15.206$ cm

Area 726.4 cm^2

Calibration of Alum Sphere

14.42 in $\rightarrow$ 25.684 liters

Reedy & Fox and Cronin

Annual Report

20 in S.S. cylinder has 10.0 in Rad

25.4 cm rad

2026.8 cm^2 area

Mar 1, 1963

Modified TMC logic Unit 214 so that the PHA section is bypassed. Signal input on remote start BNC. see 214 ckt diagram for detail.

Dw M

March 6, 1963

Irr. 2" Silver foil in paraffin plastic house

11^{56} 50 μa on target
12^{00} 50 μa off

Not big enough silver foil or not enough neutrons at foil. There is also an activity of half life ~37 sec which is probably Ag^{110}
$t_{1/2}$ = 22 sec γ = .656 Mev
Ag^{109m}, $t_{1/2}$ = 40 sec γ = .09 mev, with PHS at 100, (Cs Pk at 240) the DD2 amp cuts out all energies below $\frac{.66}{2.4}$ = ~.3 mev.

Al^{28} has gamma energy of 1.8 mev, 2.3 min half life. Irradiate for 4 min at 150 μa beam current a 2 7/8 x 2 7/8 x 1/4 2S alum piece. gain x 1.1 x .5, cobalt peaks below 450
PHS = 500

Half life of 85 sec measured instead of 2.3 MIN!
Do not understand

Al^{28} γ = 1.78 Mev

March 7, 1963

Irradiate

4e 1/4 x 2 7/8 x 2 7/8 with
100 μa of beam on Target, 14 Mev neutron irradiation for 10 MIN.
4.2667 sec channels (60 cycle x $\frac{1}{256}$)

Channel 9 started 1 Min after end of irradiation
8 x 4 = 32 sec
∴ Channel 1 started 28 sec after irradiation
22 3 overflows.

Ch around 48 NG
131 1 overflow
258 = Ch 255 therefore 3 reg before scaler (TMC) started time channels.

Ch 341 started second set of data
596 = 255
690 = Ch 1 for third set of data
(256 stored in Ch 2)
945 = Chan 255

Recorded PH spectrum after 3rd set
5' true time Baseline 15.
Recorded Cs + Co for calib.

(PHS = 300 on DD-2, Cs $\lesssim$ 240 ∴ 300 ~ .80 Mev

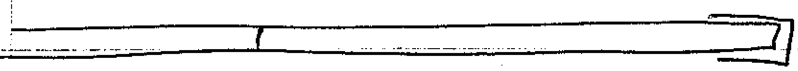
3-13-63
Measured bottom thicknesses
12" SS = 3/8 in
20" SS = 1/2 in.

Measured wall thicknesses
12" = 0.070 in
20" = 0.067 in

Cal thick .032 in.

3-13-63

Foils prepared for flux traverse in 30" cyl.



A-5, 6, 7, 8, 9, B-1, 2 3 4 5 6 7 8 9 — ~~1~~ ea foil

crit ht was 6.88 in. — .49 X .064 o.d.

Mg — Bottom in .100 od S.S. Tube.

3-14-63 Irr at log (RRN2) N = 0.1 for 1 hr

(Cu-12) Sol Ht 7.50 - 55 = 6.95 in.

3-15-63

Burst 150 μs Reprate 360

TMC 10 μs x2 Bkg x~~2~~ delay 1/2 Mem

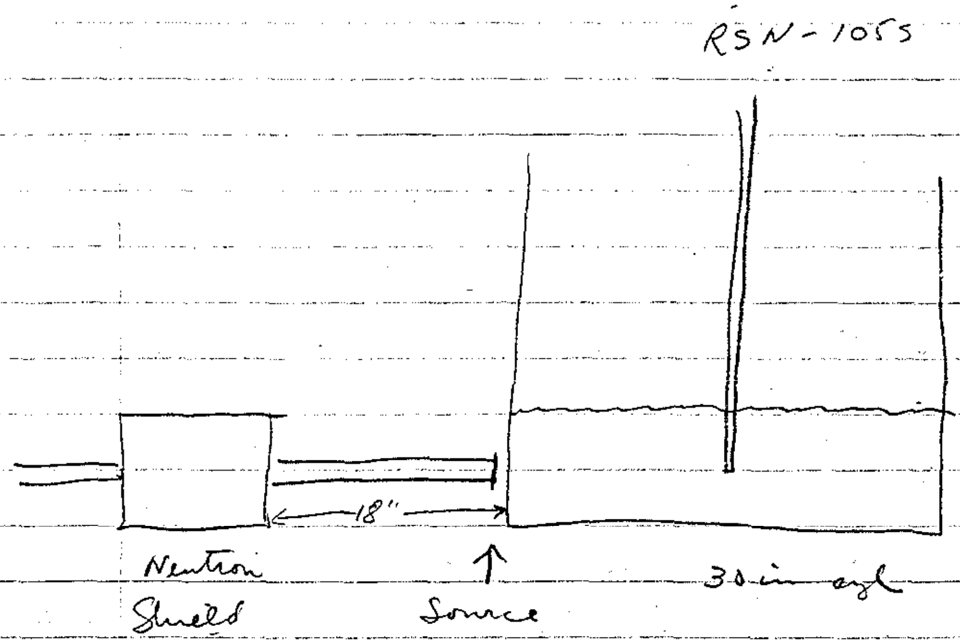
Acc 14+ target current, Beam 1.07 MA

147 kv — Solution height 6.20 − .55 = 5.65 in.

RSN-1055 Counter on Bottom = 15.58,

PNS-123	Counter = 15.80	Norm 500,080
124	16.40	"
125	17.00	500,080
126	17.6	500,070
127	18.1	"
128	18.7	500 070
129	~~19.3~~ 19.03	500 060
130	→ 19.30 .9901	505080
131	18.4	3-16-63 ~ 500090
132	16.1	~ 500080

Pulsing 30 in cyl at 5.65 in height of sol with traversing counter @ 1500 VDC DD2 0.5 μs delay gain 1.1 X 50


RSN-1055
18"
Neutron
Shield
Source
30 in cyl

3-18-63 Summary

The flux traverses taken in the 12.0 in. vessel ~~a~~ cylinder at critical and the flux traverses at the sub-critical heights of 6 in and 8 in. were used to establish the variation of $\tilde{z}-z$ as a fn. of z. There was a change from 2.54 in. at critical to 1.83 in at the 6 in sd. height.

Since the 20 in vessel was used before this scheme of buckling measurements was devised, ~~only~~ buckling was measured only at delayed critical. If a variation in $\tilde{z}-z$ similar to that measured in the 12.0 vessel is assumed, then bucklings can be calculated for all of the subcritical pulsing data and a plot of λ vs B^2 compared for the 12 and 20 in vessels. There is apparent agreement between these data even though the $\tilde{z}-z$ values seem inconsistent at d.c.

12 in. vessel	16 in height	$\tilde{z}-z$	= 2.54
20 in vessel	7.6 in "	$\tilde{z}-z$	= 2.18
Subcrit 12 in ves	~ 7.6 in "	$\tilde{z}-z$	= 1.94
Difference in bottom thickness .125 in.			.24
12.0	t = 3/8 in		.12
20.0	t = 1/2 in		.12

There is still 0.12 in difference unexplained.

The 3 in. pipe on bottom should be worth more on the 12 in vessel - this increases the discrepancy.

These measurements taken so far must be all considered only indicative of the results to be expected when better vessels are used. They also point toward the use of only spherical vessels where calculations are much simpler. On Feb. 19, a set of specifications for spheres was set down as follows

1. Sphere diameters shall cover the 8" to 20 in size range in 10 – 15 approx. equal size intervals
2. The deviation ~~from~~ spherical of measured outside diameters shall be less than
   a. $\pm \frac{1}{400}$ the average sphere diameter
   b. $\pm \frac{1}{200}$ the average " "
3. The wall thickness shall be determined by the thickness required to support the ~~[illegible]~~ vessel when filled with a liquid S.G = 2 and shall be the next larger standard gauge thickness. The supporting area shall be a band between 30° and 40° latitude on the lower hemisphere.
4. Each sphere shall have top and bottom axial ports welded to the sphere and aligned within $\pm \frac{1}{2}°$. The o. d. of these ports shall be the standard tubing size closest to 1/12 the sphere diameter. The ~~tubing~~ wall thickness of the tubing and sphere shall be nearly the same gauge. The ports shall be 1 sphere diam long. A stainless steel rod, three sphere diam long shall be provided to extend thru each sphere to keep ports aligned.

If these sphere can be obtained, the following measurements are proposed.

1. Get smallest sphere critical with most concentrated solution.
   a. Flux traverse
   b. Decay constant.
2. Measure decay constant several smaller spheres as a function of counter position to get buckling and decay constant of each.

3. Select next larger sphere. At k_c, measure
   a. flux traverse
   b. Decay constant

4. Measure buckling and decay constant in several smaller spheres.

Repeat above measurements as a function of concentration.

3-20-63

The ~~6.96~~ 5.80 l sphere (i.d ~~8.35~~ 8.78) was set up so that the RSN-105 S counter could make an axial traverse while pulsing. RSN-7S was used to normalize

RSN-7S @ 1750 v (B.A.PS) 204B X1 x32 0.2 μs RT Disc = 10.

RSN-105S @ 1500v (NICC P.S) DD2 x1 x ~~50~~ 20 PHS = 100

+ pulse 200 Ω RG-114 (100 ft) 200 Ω at 2-3 volt pulse input to TMC.

(1000 full scale)

ACCELERATOR 147KV 1.0 MA 8 μa 50 μsec @ 700 cps

TMC 10 μs Bkg x2 Delay x2 Disc 2 1/2 Memory 1/4.

	~~Nos~~ Counter Pos	Norm Counts	Sol (2 in i.Wck)
PNS-133	25.00	70018	
134	.50	70016	13.1
135	26.00	70023	
136	.50	70007	
137	27.00	70015	
138	.50	70018	
139	28.00	70015	
140	.50	70005	12.95
141	29.00	70013	
142	.50	70014	
143	30.00	70006	
144	.50	70012	
145	31.00	70011	
146	.50	70020	
147	32.00	70016	
148	.50	70045	
149	26.00	70025	

March 27, 1963

Filled sphere with H_2O

Bottle Gross H_2O 19.75

Tare 2.65

H_2O 17.10

Upper Spout 24 in long × 1 3/8 in i.d.
lower spout 30 in long × 3/4 in i.d.

$$\frac{17.10}{.997644} = 17.15\ l$$

$$\frac{\pi d^2}{4} l = \frac{3.14 \times \overset{1.89}{1.375^2} \times 24}{4} = 35.64\ in^3 = \overset{\times 16.39}{584.}$$

$$\frac{\pi d^2 l}{4} = \frac{3.14 \times .75^2 \times 30}{4} = 13.25 = \underline{217}$$

801.

17.10
80
16.30

Orig Calib was 16.438 and some (2 layers) glyptal has been added.

(12.436 in) hemisphere meas.

~12.5 in sphere.

$$\frac{4}{3}\pi r^3 = 16.30\ l$$

$$r^3 = \frac{16300}{1.33\pi} = 3891$$

$$r = 15.73\ cm = 6.193\ in.$$

$$\text{If } d = \frac{.36}{16.09}$$

$B = .19525$ $B^2 = .03812$

the 12 in sphere was set up, and top port was bent back ~ 1/2 in. and plumbed. RSN-105S counter was set up to traverse the center of the sphere. Sphere Volume ~~19.35~~ l.
16.30 ? 6-24-63

Sphere was filled with H_2O !
Counter at Midplane = 29.70 in.
See page 72 for data on counters Acc Mu = .90
100 μs Burst
@ 700 cps

~~PBN~~	Counter position	Normalizing Counts,
PNS-150	29.70	50016
151	30.70	~~4~~9011
152	31.70	50507
153	32.70	50013
154	32.20	50016
155	28.70	50009
156	27.70	50008
157	26.70	50014
158	25.70	50020

These data are not useful because ~~the~~ the plot of channel 20 vs pos. of each of these does not make a smooth curve of the expected shape of sin Br/Br.

Checked counters, everything OK. Changed ~~HV~~ volts to RSN-75 now to 1800, gain the same. Changed volts to RSN-105S to 1550, gain the same. PHS on RSN-75 = 15. PHS on RSN-105 = 100.

Accelerator current = 0.94 ma (increased some)

		Counter Pos	Norm. Counts	
PNS –	159 –	24.70	~~500~~ 51516	✓
	160	26.70	50013	10 μa
	161	32.20	50015	
	162	30.70	50025	
	163	23.70	50026	
	164	24.20	50108	
	165	25.70	50034	
	166	27.70	50015	
	167	28.70	50010	
	168	29.70	50014	
	169	31.70	50019	
	170	27.70	50013	(lower power Spec)

March 26, 1963

Data data near center are not good exponentials when plotted on semi log paper. a trial run at a lower pulse amplitude (~~1~~0.3 of 3-25-63 data) yielded a decay constant of 5234 sec^{-1} instead of 6060 sec measured on 3-25-63. Not understood!

	Pos	Norm.	
PNS-17~~1~~	27.70	60610	(Norm moved closer)
172	29.70	60016	
173	31.70	60014	
174	32.70	60019	
175	30.70	60026	
176	28.70	60024	
177	26.70	60017	
178	25.70	60009	
179	24.70	60135	
180	23.70	60016	

Background variable on above runs, Turning off ion source restores acc. to norm. background.
An arc will sometimes induce high bkg

Check Focus supply = 9.6 Kv at Max
5.8 Max less 10 turns
4.8 = .48 kv/turn.

Operated acc at varying pressures, and could not duplicate varying bkg conditions. Apparent higher target/beam current ratio at pressures < 1 x 10^{-5} mostly

March 27, 1963

Since background conditions have improved and since the accelerator seems to be functioning, attempt will be made to get more data.

Moved normalizing counter RSN7S to equatorial plane diametrical opposite source. Two preliminary runs with the RSN-105S counter near midplane gave decay constants of $\approx 5617\ sec^{-1}$. Expected value calculated from Gelbard and Davis

$\omega_0 = 4876, \quad D_0 = 38080, \quad C = 3003$

give $\lambda = -6360.$

$B^2\ (12.5''\ \text{sphere}) = \left(\frac{\pi}{6.25 \times 2.54}\right)^2 = \left(\frac{\pi}{15.9}\right)^2 = .1976^2$

$= .0390$

$\lambda = 4876 + 38080\ B^2 - 3003\ B^4$

$= 4876 + 1485 - 5 \qquad = 6356\ sec^{-1}$

Background counts $= 32/2 = 16.$

$= 32/2 = 16$

Peak counts 17,311 in 300000 cycles or 3 sec.

C.R = < 6000 cts/sec

RSN-7S @ 1800 V 204 gain 1X32 PHS 15, most pulses 40V.

RSN-105S @ 1550 DD2 1.1X20 PHS 100, most pulses > 20V

Input to TMC + PHS output +4v.

ACC ~80 μa Total Beam 150 kv .85 ma 680 cps

75 μs Burst

TMC 10 μs Bkg X2 Delay X2 Disc 2 1/2 Mem 1/4

target current ~6 μa total 100 μa

	Counter Pos	Norm. Counts	
PNS – 181	27.7	10 00 18	Very Poor
182	28.7	10 00 15	Normalization
183	29.7	100031	when Calc
184	30.7	100043	B2 values
185	31.7	100045	
186	32.7	10 0029	plotted vs.
187	32.2	10 0044	Counter Position
188	26.7	100038	4-25-63
189	25.7	10 0066	
190	24.7	10 0033	
191	23.7	100051	
192	23.2	105031	

Increase beam current to maximum obtainable (250 – 300 ua) 1.15 ma 20 μa Beam

		Cycles (no norm counts)		
193	27.7	500000	75 μs	1/4 Memory
194	27.7	500000	(14 μa) 150 μs	1/2 Mem
195	27.7	500000	(14 μa) 300 μs	1/2 Mem.

See p. 77 for sphere vol calib.

March 28, 1963

$12\frac{1}{2}''$ Sphere filled $UO_2(NO_3)_2$ solution

Normalized Decay vs Position

~~PNS~~	Counter Position	Norm Counts
PNS - 196	27.70	100030
197	28.70	100029
198	29.70	100019
199	30.70	100039
200	31.70	100014
201	32.70	100025
202	32.20	100032
203	26.70	100033
204	25.70	100014
205	24.70	100019
206	23.70	100025
207	23.20	100034
208	27.20	100020
209	28.20	100028
210	29.20	100009
211	30.2	100023
212	31.2	100049

April 1
RSN-75
1700 v gain 1.1 x 50. Not pulses > 20 V. PHS = 100
4-2-63
Pulsing 14.375 in sphere at critical.
using 1 in. od S.S rod for reducing React.

Pulse at critical PNS-213 ~160 Mem
800 μs Burst 41 cps 500 cycles Delay x2
between inserting 1" SS rod. 12.29 in
starting in solution ~ .27 in.
~ Crit before and after -125 Usec on Beck logN
No correction needed < -3000 sec on Keith logN
Sol Ht 17.38 − 3.94 = 13.44 in. (h = 1.01)
Air Vol = $\frac{1}{3}\pi h^2(3r-h) = \frac{\pi}{3} \times 1.0201 (20.665) = 22.075\ in^3 \rightarrow 362\ cm^3$

4-10-63
Analysis from J. R Wilson 4-3-63 A-196

		mg U/g	Density a 25	SG
11002	40-1	60.83	1.0847	1.0880
11003	40-3	60.76	1.0846	1.0879

∴ mg U/ml = 65.98
" " = 65.90 > 65.94 1.0263
p46 64.25

H₂O disp = 1 − .06594 × .301 = 1 − .01985
= .98015 × .99704 @ 25°C
= $\frac{.97725 \times .6025 \times 10^{24}}{18.016}$ = .03268 × 10^{24}

see p 91

U^{234} = .
U^{235} = .9
U^{238} = .

Sphere Calib 3-10-63

Top Port Botton Port
1.357 i.d. .884
~~.884~~ long
24 - 5/8 (Not full (18 in - 1/4" cork)

2 l
2 l 6.5 l fills to within 2" of top
.485
.485
.495
.504

Top port vol
$.7854 \; 1.357^2 \times 22 = 31.82 \text{ in}^3$
Bottom port vol
$.7854 \; .884^2 \times 17.75 = \underline{10.89}$
$42.71 \text{ in}^3 = .700 \; l$

Sphere Volume = 6.50 - .70 = 5.80 l
$\frac{4}{3}\pi r^3 = 5.80 \times 10^3$
$r^3 = 1384.6$
$r = 11.15$ cm $d = 22.30$ cm
4.39 in 8.78 in

Machined I.D. 8.784!

3-10-63

25 l sphere

Top port 1.735 id × (24 − 1 in)
bottom .884 × 12

Total volume 26.91 cc — wall thickness

Top port = 54.38 in^3
bottom 7.36

61.74 in^3 × 16.39 = 1012 cc

Sphere Volume = 25.90 liters

r^3 = 6,183.
r = 18,354
d = 36.71 cm or 14.45 in.

Critical volume equiv. sphere

25.90
.36

25.54 l r^3 = 6097.2
r = 18.269 cm → 7.1925 in
d = 36.538 d = 14.395 in

extrapolated δ = 2.08 cm

$$B^2 = \left(\frac{\pi}{20.35}\right)^2 = .1544^2 = .02384$$

4-25-63 out diameter meas. $14\frac{17}{32}$ in ± 1/32
$14\frac{1}{2}$ + $\frac{1}{32}$, ~~1/64~~, $\frac{1}{32}$, 1/32, 1/32, 1/32.
$14\frac{1}{2}$ + 1/64, 0, 1/16, 1/16, 1/16, 1/16 at 90°

April 16, 1963

Corrections for finite length of counter or foil wires in flux distribution measurements

Slab Geometry $\quad \varphi = \cos Bx \, dx$

compare $\left[\cos B \frac{x_1 + x_2}{2}\right](x_2 - x_1)$ with $\frac{1}{B}\left[\sin Bx_2 - \sin Bx_1\right]$

Let $B = 1$

x/π	sin	cos	$.1\pi \cos \bar{x}$		Ratio
0	.0	1	.31416	31286	1.00415
.05	.15643	.98769	.31029	.30902	1.00410
.10	.30902	.95106	.29878	.29756	1.00410
.15	.45399	.89101	27982 ~~.25416~~	.27877	1.00412
.20	.58779	.80902	25416 ~~18446~~	.25312	1.00410
.25	.70711	.70711	22215 ~~.04708~~	.22123	1.00415
.30			18466	.18390	1.00413
.35			14263	.14204	1.00415
.40			.09708	.09668	1.00413
.45			.04914	.04894	1.00408
.50			0	0	1.000

Therefore the correction is almost a constant factor except near $\pi/2$ in this idealized calculation and should be even more constant for more foil points and not significant for even fewer foils.

Similar estimation for Bessel function.
using 3 point Interpolation.

x	J_0		
0	1.0		
.1	.9975	.9958	1.0018
.2	.9900		
.3	.9776	.9760	1.0016
.4	.9604	x	
.5	.9385	.9370	1.0016
.6	.9120	~~.8798~~	
.7	.8812	.8798	1.0016
.8	.8463		
.9	.8075	8064	1.0014
1.0	.7652		
1.1	.7196	7186	1.0014
1.2	.6711		
1.3	.6201	6194	1.0011
1.4	.5669		
1.5	.5118	5114	1.0007
1.6	.4554		
1.7	.3980	.3978	1.0005
1.8	.3400		
1.9	.2818	.2819	.9996
2.0	.2239		
2.1	.1666	1670	.9976
2.2	.1104		
23	0555	0561	.9893
2.4	0025		

No appreciable error is introduced except at the extreme boundary where counting data is <u>not</u> used.

Summary of Chem Analysis

		mg U/g	density	gm U/ml		
1-14-63	X-10	.059325	1.0830	.06425		
1-25	X-12	.059500	1.0853	.06458		
2-7	X-10	.05995	1.0831	.06493		
		.05865	1.0831	.06352	av 4	06459
	Repeat	.05990	"	.06488	3	06494
	Alone	.06003	"	06502	2	06495
4-3	X-10	06083	1.0847	06598		
		06076	1.0846	06590	.06594	

Isotopic analysis	593196	593197	av
W	1.00	0.98	.99
X	92.43	92.45	92.44
U	.56	.55	.55
Q	6.01	6.02	6.02
			100

U^{234}	0.017 $\times 10^{20}$	atoms/cm^3	
235	1.563 $\times 10^{20}$	"	60.95 g U^{235}/liter
236	0.009 $\times 10^{20}$	"	
238	0.101 $\times 10^{20}$	"	
H	653.4 $\times 10^{20}$	"	
N	3.39 $\times 10^{20}$	"	
O	340.3 $\times 10^{20}$	"	

Delayed Neutron Fraction subracted from fission spectrum used by Kinney and Mikolas in Sn Calc.

Group	Energy (Mev)	Fraction of Neutrons
3		.000698
4		.002697
5		.002394
6		.000613

June 10, 1963

Set up to investigate the effects of room return

Accelerator @ 145 kv 0.87 ma 7½-8 μa target current 800 μsec burst 80 cps

TMC - 160 μsec x2 bkg x2 delay 2½ disc 1/4 Mem.

Detector BF_3 @ 1600 max pulse > 50 volts
(RSN-75) min pulse ~ 15-20 volts
PHS 100

Input to TMC +4 volt.

DD-2 with 0.5 μsec dlay line

Collected counts for 20,000 bursts
or $\times 160 \times 10^{-6}$ = 3.2 sec in each channel

with 14 in cube of paraffin with Cd and Boral interleaved counts were collected in analyzer
(1) (2) counter located on east edge of cube (near S wall)
(3) " " " west edge of cube (away from S wall)
(4) " " " 3 ft from edge of stack on east edge of rack. 1427 peak counts ch 5 — ch 20 — 300
(5) Removed 14 in cube of paraffin peak counts 757 in ch 7.

(6) Counter moved to west edge of rack pk in ch 4 567
(7) " " to center of room pk in ch 4 668
(8) " " 6" from wall near S. water window pk ch 4 2254
(9) Cd cover on counter pk ch 4 387 ch 10 25, ch 20, 12, ch 30, 3.

It must be concluded that room return using a bare counter is not influencing the results, especially when the counter is cadmium covered, and when the counter is immersed in the solution.

(1)

Counter near window

dry to $CH_2 + Cl$

	20000
1	76 -Bkg
2	59177
3	59310
4	58397
5	18225
6	3143
7	928
8	594
9	448
10	434
11	367
12	296
13	269
14	202
15	194
16	176
17	143
18	137
19	124
20	105
21	108
22	114
23	97
24	86
25	91
26	99
27	77
28	78
29	77
30	72
31	61
32	60
33	57
34	69
35	63
36	50
37	41
38	44
39	43
40	52
41	52
42	56
43	41
44	52
45	53
46	45
47	38
48	43
49	33
50	34
51	37
52	36
53	41
54	36
55	25
56	34
57	24
58	30
59	35
60	34
61	31
62	36
63	31
64	25

(7)

Counter in Center of Room

	20000
1	78
2	504
3	619
4	668
5	533
6	459
7	347
8	327
9	303
10	284
11	324
12	344
13	347
14	328
15	266
16	294
17	249
18	292
19	273
20	265
21	231
22	210
23	213
24	201
25	200
26	199
27	192
28	153
29	162
30	142
31	140
32	152
33	117
34	119
35	135
36	131
37	84
38	107
39	119
40	101
41	83
42	84
43	97
44	87
45	86
46	88
47	73
48	70
49	84
50	60
51	74
52	68
53	56
54	65
55	67
56	68
57	62
58	58
59	56
60	59
61	48
62	48
63	65
64	55

(9)

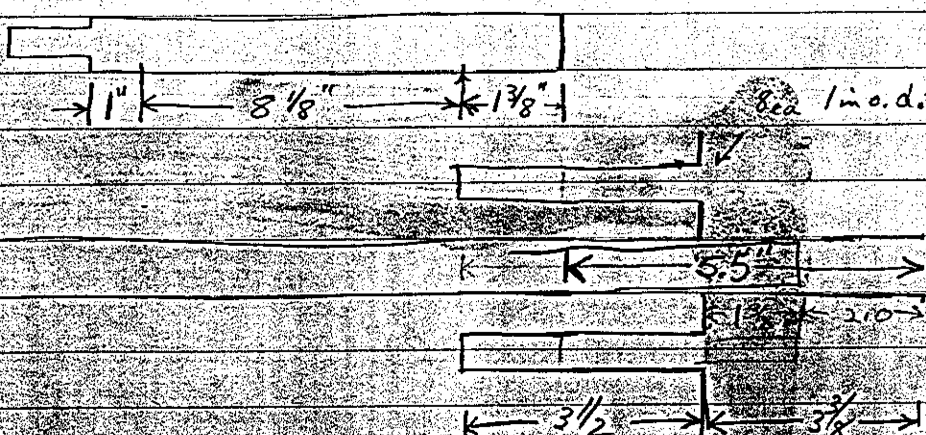
Cd-covered counter on wall.

	20000
1	11
2	343
3	349
4	387
5	132
6	80
7	63
8	42
9	35
10	25
11	23
12	15
13	15
14	15
15	13
16	16
17	8
18	8
19	11
20	12
21	6
22	4
23	10
24	10
25	6
26	5
27	5
28	10
29	6
30	3
31	8
32	4
33	5
34	5
35	7
36	5
37	3
38	4
39	3
40	3
41	2
42	3
43	1
44	4
45	3
46	3
47	5
48	2
49	2
50	4
51	2
52	4
53	4
54	5
55	5
56	5
57	4
58	4
59	3
60	3
61	2
62	3
63	1
64	3

4×10^4

6/11/63

Calibration of long counter using 1" od × $8\frac{1}{8}$" sens length
RSN-75 counter @ 1700 gain on DD-2 ≈ 50 × 1.1
Pulses 20 – 50 volts (500 kc scaler used)



M-226 7.50×10^6 Pu
M-227 7.96×10^6
PN-563 8/18/61 → 2.37×10^7 63 d [illegible]

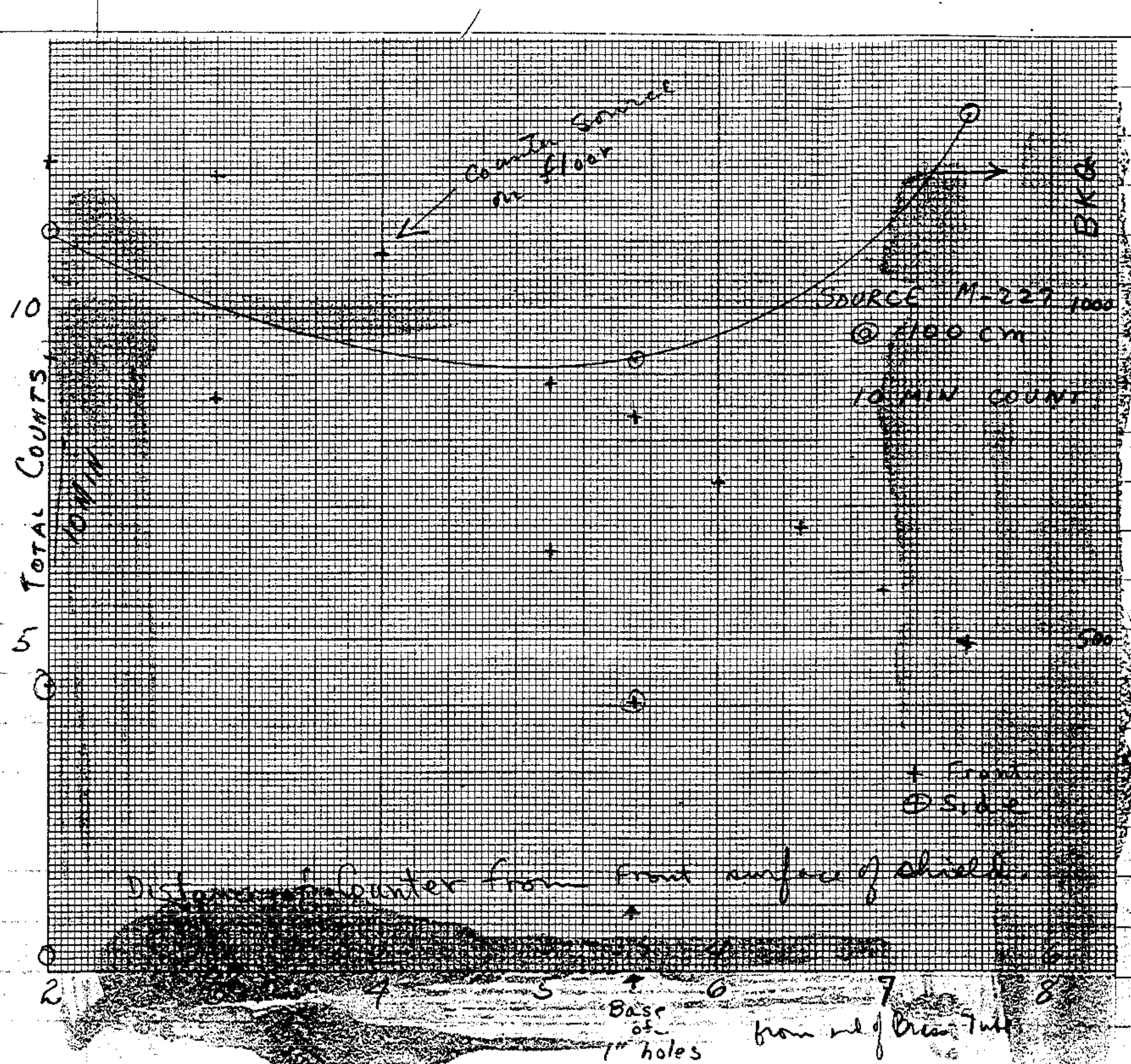
$$e^{-\frac{.693}{t_{1/2}} \times t} = e^{-.693 \times [illegible]} \rightarrow [illegible] = e^{-.512}$$

$$2.3 \times 10^6 \times .7125 = 1.65 \times 10^6 \text{ neut/sec}$$

PHS	Counts/2 MIN
100	17050
200	16320
300	14110
50	17450
75	17160
125	17180
100	17270

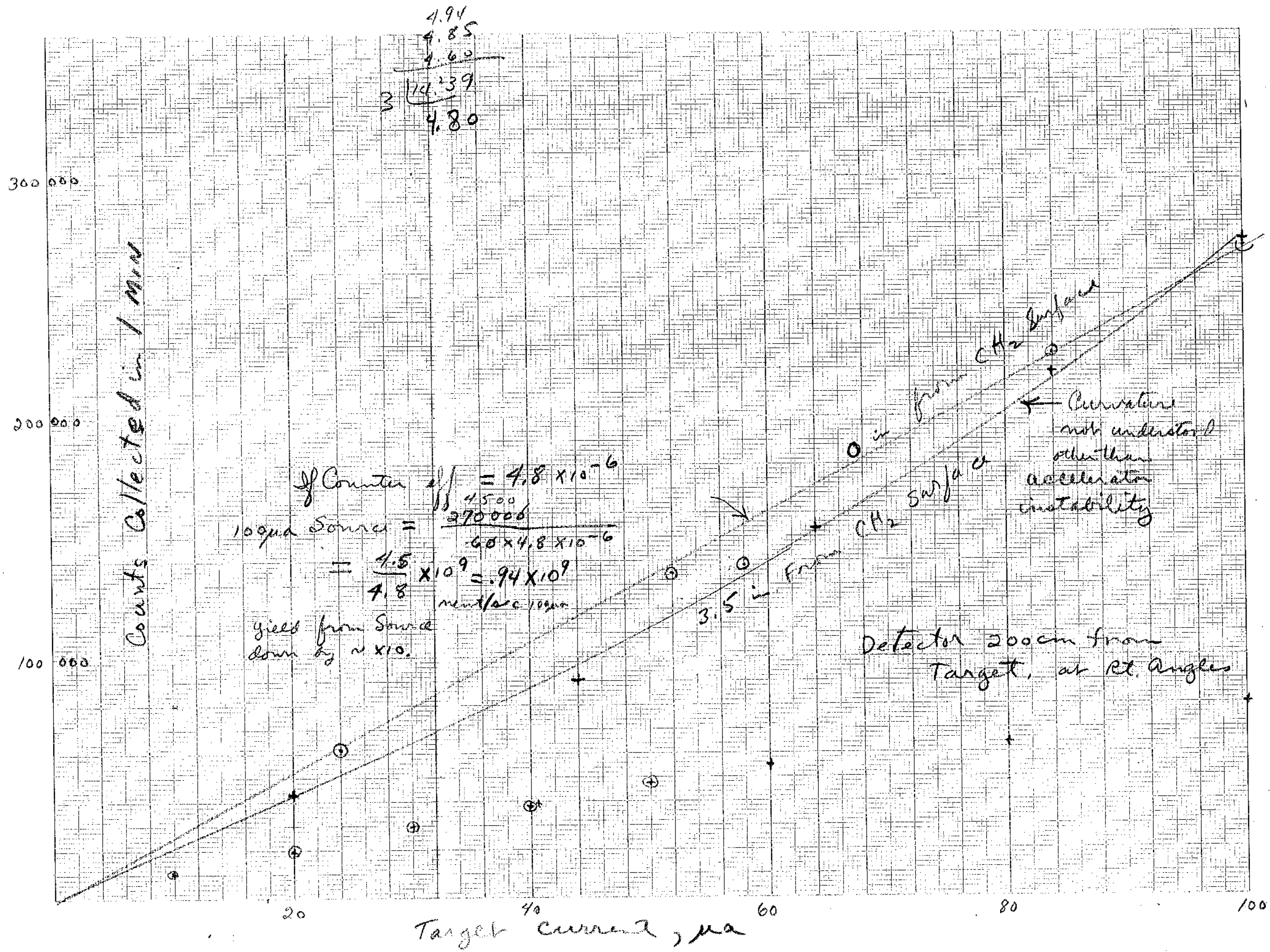
Set PHS @ 100. HV = 1700 (N/CC)
DD2 1.1 × 50

See page 97 for calib data



Counter Source on floor
SOURCE M-227
@ 100 cm
10 MIN COUNT
BKG
1000
500
10
5
0
TOTAL COUNTS
10 MIN
+ Front
⊕ Side
Counter from front surface of shield
2
4
5
6
7
8
Base of 1" holes

	Source NO	DISTANCE (cm)	DIRECTION	Counter	Distance from end of Brass Tube LOCATION (in.)	Active Volume from Front (in.)	Count TIME (MIN)	Total COUNTS		Ct/sec	Cts/MIN / neutron/sec	Cts / neutron	neut / counts	4×10⁴ … [illegible]	= 2×10⁴ ×600 : @2 m	neut/sec 6.2×10⁷ neut/10 MIN 0.3×10⁷ neut/10 MIN	
	M-227	100	FRONT	RSN-75	5	3.0	10	88580	87630								
	(7.96×10⁶)	"	"	[illegible]	6	4.0		73660									
				[illegible]	5.5	3.5		83620	8[illegible]								
					6.5	4.5		66690									
					7.0	5		57310									
					7.5	5.5		47480									
					4.0	2		108320	107300								
					3.0	1		120180	119100								
					2.0	0		121900	120780								
		100	SIDE		2.0	0		43200	42080								
					5.5	3.5		40600	39680								
		200	FRONT		5.5	3.5		25900	24980								
					2.0	0		37150	36030								
			Bkg		5.5	0	20	1840	920						neut/sec		
					2.0	3.5	"	2230	1120								
					7.5	5.5	"	2580	1290								
	M-227	200	FRONT	RSN-75	5.5	3.5	10	22910	21990	36.65	2.76×10^{-4}	4.604×10^{-6}	$.2172\times10^{6}$	3.62×10^{3}		neut/sec/μa	
				4' off floor	2.0	0	10	33710	32590	54.32	4.09×10^{-4}	6.824×10^{-6}		2.445×10^{3}			
145 hr	Acc 100 μa	"			5.5	3.5	1'	272830							$.988\times10^{9}$	$.388\times10^{7}$	
	84 μa				5.5	"	1'	218400							.791	.941	
	64 μa				5.5	"	1'	154410							.559	.873	
	44 μa				5.5	"	1'	90690							.328	.745	
	20 μa				5.5	"	1'	43270							.157	.785	
	24 μa				2.0	0	1'	62420							.153	.638	
	52 μa				"	"	"	134960							.330	.635	
	84 μa				"	"	"	226050							.553	.658	
	100 μa				"	"	"	270070		2700 cts/μa		(4500 [illegible]/sec)			.66	.660	
lower press	58 μa				"	"	"	138300				1.4×10^{-6} [illegible]		[illegible]	.3381	.583	
	M-226	200	Front		2.0	0	10	33320	32200	53.67		7.156×10^{-6}					
	7.50×10⁶				5.5	3.5	10	22730	21810	36.35		4.847					
	PN-563	200	Front		2.0	0	10	5900	4980	8.30		5.03×10^{-6}					
	1.65×10⁶				5.5	3.5	10	3860	2740	4.57		2.77					



4.94
4.85
4.60
3 | 14.39
4.80
300 000
200 000
100 000
Counts Collected in 1 Min
20
40
60
80
100
Target current, μa
0 in from CH2 surface
3.5 in from CH2 surface
← Curvature not understood other than accelerator instability
If Counter eff = 4.8 x 10^-6
100 μa Source = 270 000 / 60 x 4.8 x 10^-6
= 4.5/4.8 x 10^9 = .94 x 10^9 neut/sec 100 μa
yield from Source down by ~ x10.
Detector 200 cm from Target, at Rt. Angles

With 1" o.d × 8 1/8 in. long RSN-7S counter 3.5 in from front surface of paraffin; the long counter efficiency at 200 cm distance is
4.60×10^{-6} from M-227
4.85×10^{-6} M-226
4.73×10^{-6} cts/ment @ 200 cm
Cu. PW-563 — 2.77×10^{-6} cts/ment @ 200 cm

Assuming same eff at 14 Mev (See Graves & Davis PR 97, 1205 1955) 4500 ct/sec
Accelerator source at 100 μa was 0.951×10^9 or 1.62×10^9 with Pu and Po Calibration!
Should be at least 6.7×10^9 for good target.

June 12, 1963

Background count counter @ 3.5 from front surface
30690 in 92 min. or 334 per MIN
3340 per 10 MIN

N.B. M-226 and M-227 in room in NW corner and probably contribute to the above Bkg making it higher than previously measured.

June 18, 1963

Adjusted concentration of solution (by dilution) so that 14.45 in i.d. sphere is slightly super critical when filled several inches in top spout.

1 in. o.d. SS control shows no change in reactor period when lowered to within 3/4 of sphere top selsyn reading of 19.55. insert to 7.38 to reduce react. when pulsing.

BF_3 with ½ circumference covered with cd. to reduce rem. return

Reactor Period #1 before pulsing } 25.0 25.1 } 8.22

repeat #2 " " 23.9 23.6 178.5 sec

2.17x10

3.394

Period after pulsed 28.0 29.0 } 9.475 div. sec

#2 after pulsing 28.0 28.7

sec Keith 205.8 sec

1.93

3.024

PNS-214

Ace 147 KV 0.74 Ma 1.0×10^{-5} mm Hg ~0 Target current

Burst 800 μsec @ 43 cps.

BF_3 RSN-75 at 90° to target mounted vertically

@ 1700 v. DD2 gain @ 50 x1.1 PHS = 100

TMC 160 μs ch width x2 delay x2 bkg 2.5 DISC

½ Mem.

Pulse for 200 cycles, insert control rod from 19.55 to 7.38, complete cycle requires 2 MIN., Total pulse cycles 10 000 or 100 MIN of operation for 50 cycles.

$-220.8 \pm 1.1 \times 1.032 = -227.9 \pm 1.1$

Samples taken for Chemical Analyses
June 25, 1963

	density	Analysis mg/g	
	1.0839	59.89	
	1.0837	59.87	
	1.0838	× 59.88	= 64.90 g/liter or mg/ml

	Analysis		mg/ml		atoms/cm³
4	0099	→	.64	→	1.65×10^{18}
5	.9244	→	59.99	→	153.77×10^{18}
6	,0055		.36	→	.92
8	,0602		3.91	→	9.90
			64.90		166.24×10^{18}
N					332.48
O					997.44
					1329.92
					32612
					340.12

O
H $f = 1 - .301 \times 64.90 \times 10^{-3} = 1 - .01953 = .98047 \times .99704$

$$= \frac{.97757 \times .6025}{18.016} = .032692 \times 10^{20} \times 2$$

H $= 653.84 \times 10^{+20}$

R = 18.35 cm
Δl = 0.15 cm.

1. calculate k
2. " crit Rad
3. " k_0 for 2
4. " α for 2

June 18, 1963

Set up for flux traverse in 14.45 i d sphere with RSN-105 S counter @1500 v. PHS @ 150 gain @ 50 x 1.1. Bkg ~ 1 ct/sec

Counted background for ~16 hours

6-19-63

Bkg Ch = 320 μs x 256 x 570 000 cycles

= 46 694.4 sec to collect 23815 counts

or .51 ct/sec.

Use HP 460 B and long cable to C₂ BA scaler g. C_3 channel used w 1" RCL counter under sphere @1500 v. pulses ~75 v max PHS = 20 v on 204B L.A. C-1 scaler for norm count of 20k

Traverse data fitted to SIN BR/BR (SIN - 31)

June 19, 1963

B-1 = 325000. ± 800

B 2 = 0.39120 ± .0011

B 3 = -25.782 ± .011

June ~~19~~ 21, 1963

Checked stability of C_3 counting channel

Po-Be source 1" O d RCL counter + (CH_2)

1 MIN counts

	24796	On for about 15 MIN only.
	27508	
~ 11^{30}	27676	
	lunch	
12^{53}	27196	Counting statistics $\pm\sqrt{N} = \pm 165$.
5	27110	95% ~ ±330.
7	27405	
9	27642	
101	26541 ←	
2½	27010	
4	27426	
5½	27398	
8½	26629 ←	
12½	25826 ←	
14½	27425	
16	27608	

Timer no longer works —

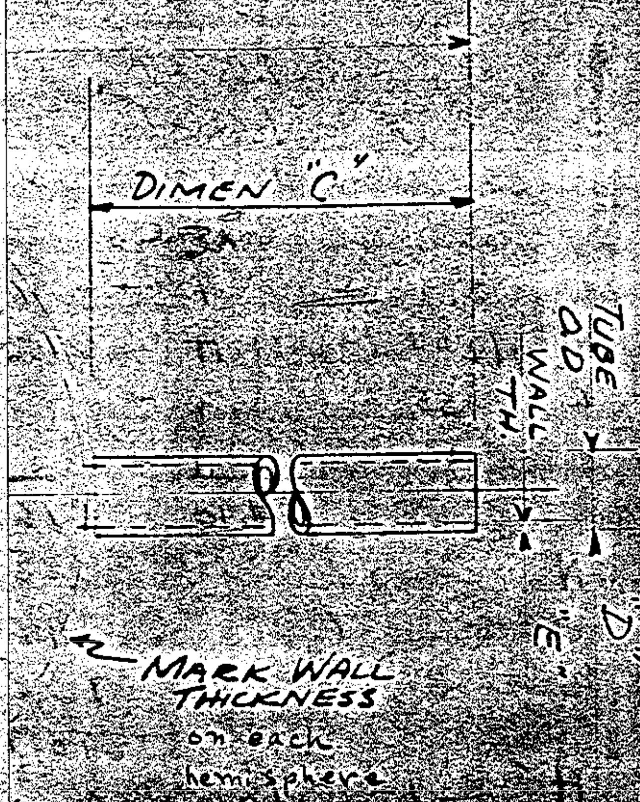
N.B. B.A. P.S. @ 1500 V plugged into unreg power.

Atomic 204B L.A. " " " "

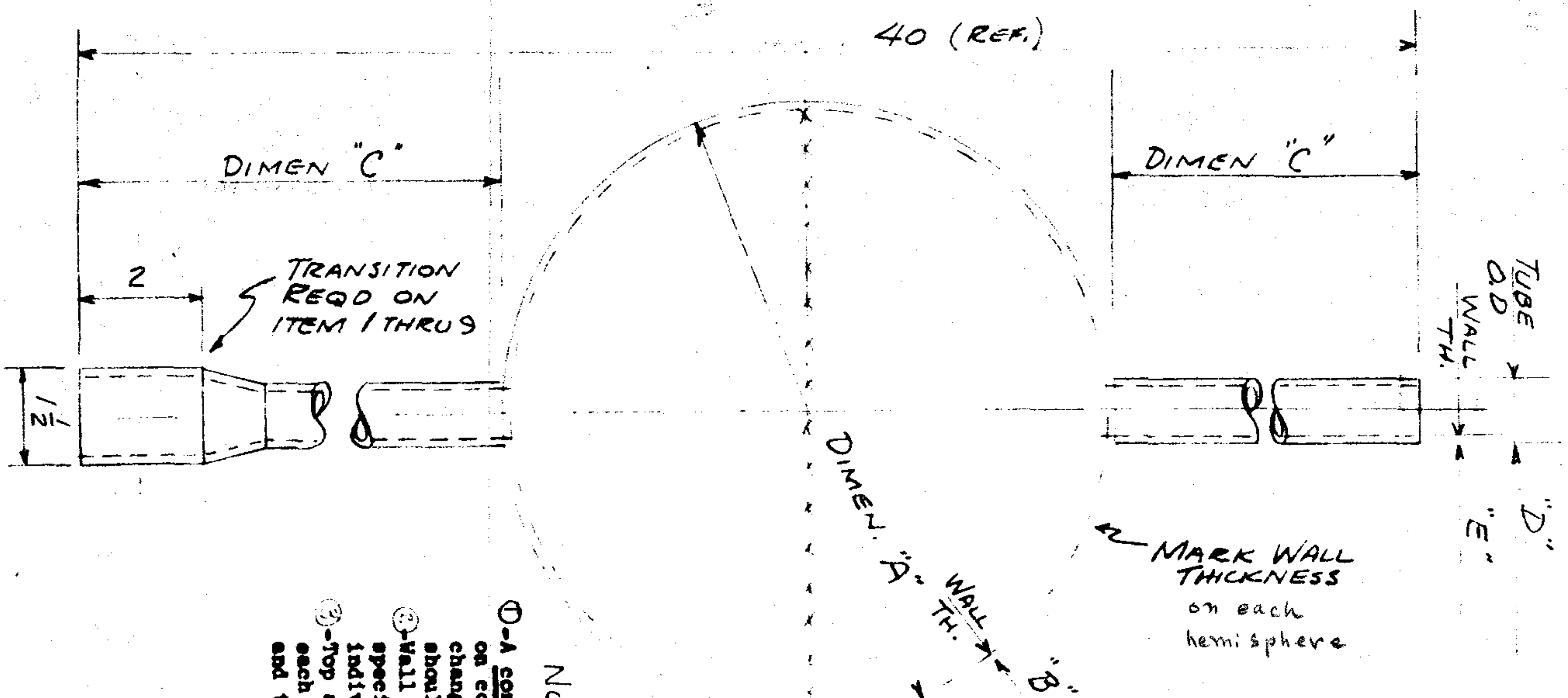
DWM.

Friday June 21, 1963

Sketch of Spheres submitted by Tunnell to 9212 for suggestions and comments.



ALL CKNESS "B"	TUBE LENGTH "C"	TUBE O.D. "D"	TUBE WALL THICKNESS "E"
50	10	3/4	.049
50	15½	3/4	.049
50	15	3/4	.049
50	14½	1	.065
50	14	1	.065
65	13½	1	.065
65	13	1¼	.065
65	12½	1¼	.065
65	12	1¼	.065
65	11½	1½	.065
80	11	1½	.065
80	10½	1½	.065
80	10	1½	.065



NOTES:-

1. A constant spherical radius is required on completed units. Any dimensional changes due to weld shrinkage or distortion should be compensated for.
2. Wall thicknesses can vary ±.010 from that specified but must be constant for each individual sphere.
3. Top and bottom tubes must be in line with each other and the center lines of sphere and tubes shall intersect.

ITEM No	SPHERE DIAMETER "A"	WALL THICKNESS "B"	TUBE LENGTH "C"	TUBE O.D. "D"	TUBE WALL THICKNESS "E"
1	8 ± .020	.050	16	3/4	.049
2	9 ± .023	.050	15 1/2	3/4	.049
3	10 ± .025	.050	15	3/4	.049
4	11 ± .027	.050	14 1/2	1	.065
5	12 ± .030	.050	14	1	.065
6	13 ± .033	.065	13 1/2	1	.065
7	14 ± .035	.065	13	1 1/4	.065
8	15 ± .038	.065	12 1/2	1 1/4	.065
9	16 ± .040	.065	12	1 1/4	.065
10	17 ± .043	.065	11 1/2	1 1/2	.065
11	18 ± .045	.080	11	1 1/2	.065
12	19 ± .048	.080	10 1/2	1 1/2	.065
13	20 ± .050	.080	10	1 1/2	.065

June 25, 1963

DSN. Calculation of 14.45 in dian sphere to J. Knight, see 101.

July 3, 1963

DSN Calculations desired for above sphere coated with Linsey Mix and/or Cd and H_2O reflected, however no cross section available for Gd or Sm. Whitesides is investigating. The following calc will be made of k values

	1. Sphere + alum	+ 1 cm H_2O	.9941 / 1.0302
	2. " "	+ 2 cm H_2O	1.0595
	3. " "	+ 3 cm H_2O	1.0822
1.34 cm	4. " "	+ 0.08 cm Cd + ∞ H_2O	1.0408
1.39 cm	5. " "	+ x cm (Gd + Sm) + ∞ H_2O	1.0424
	6. " "	+ ∞ H_2O	1.0296

Purpose of calculations is to evaluate effect of (Gd + Sm) coating which was put on Rover fuel element dissolver. See p 111 for X section comments.

Dwh

Discussed with JTM & ADC proposals for L.A. bursts triggering a critical assembly. Discussion centered around type of bursts, multiplication, burst shape etc. Perhaps C.W. source could be used to observe pulse shapes obtained on multiplying systems.

G.A. Linear accelerator @ 100 ma for 5 μsec @ 25 Mev delivers 5×10^{10} neutrons/pulse with Pb ~~target~~ or Bi target

~~Stepkey~~

July 12,

J. L. Russell of GA visited on 7-11 and 7-12 to discuss feasability of getting a fast metal multiplying assembly moved to San Diego to check out design considerations of an Acc Pulsed Fast Assembly to produce bursts of 0.1 to 10 μs.

Preliminary design

1. new L.A. to get 3×10^{18} n/sec
2. U^{233} has short lifetime ~~and~~ which governs the α or T achievable.
3. U^{233} has better neutron yield when used as target

$$\frac{U^{235}}{U^{238}} \simeq 1.4 \quad \frac{U^{233}}{U^{238}} \simeq 2.0$$

@ 40 Mev electron energy

0.083 ± 20% neutrons/electron

Present machine @ 0.4 amp @ 30 Mev U^{238} target

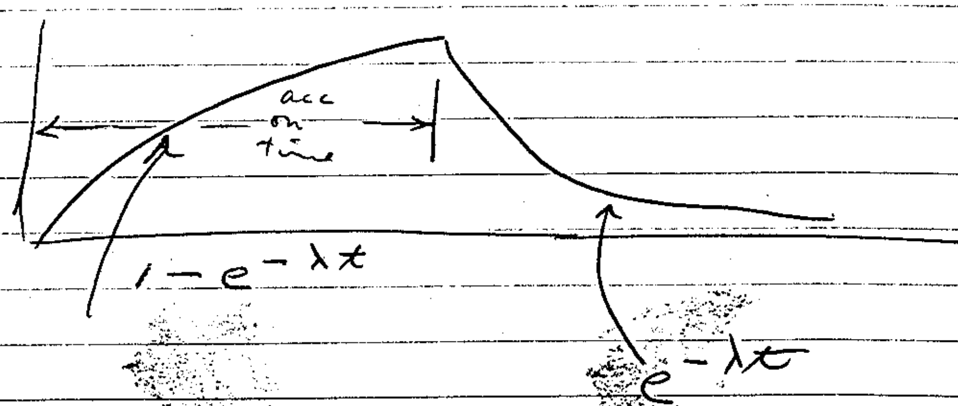
$\sim 0.7 \times 10^{17}$

$[0.4 \times 6.12 \times 10^{18} \times .030 = 7.35 \times 10^{16}]$

Experiments desired

1. Measure Burst shapes at various multiplications at low power
2. Measure neutron yield / electron
   Check multiplication of Uranium
3. Measure spectrum
4. Measure surface motions under burst conditions
   ~ 1° temp rise or less.
5. Threshold detector calibrations, Burst detector calibrations etc.

Burst widths produced will be no shorter than the accelerator on time nor any shorter than the prompt neutron decay period. at high prompt multiplication, pulse will approx,



the above curve.

For 1st approx., let λ = acc on time and then for burst widths of and decay periods of

10 μs gives	$\Delta k = .000544$,	$M = 1840$. for U^{235}
1 μs	$\Delta k = .00544$	$M = 184.$ "
0.1 μs	$\Delta k = .0544$	$M = 18.4$ "

Since the $\Delta k = 1 - k_p$, the 1st two are above delayed critical! See next pages for calc.

α and Multiplication of U^{233} and U^{235} Fast Metal Assemblies

Calculated Delayed Critical (Russell)

$l(235) = 5.44 \times 10^{-9}$

$l(233) = 2.86 \times 10^{-9}$

Δk	k	$M = \frac{1}{1-k}$	$\alpha(235) = \frac{\Delta k}{l}$	$T = \frac{1}{\alpha}$	$\alpha(233)$	$T = \frac{1}{\alpha}$
.5	.5	2	91.9 $\times 10^{6}$		175.	
.4	.6	2.5	73.5		140.	
.3	.7	3.33	55.1		105.	
.2	.8	5	36.8		70.0	
.15	.85	6.67	27.6		52.5	
.1	.9	10	18.4		35.0	.0286
.08	.92	12.5	14.7		28.0	.0333
.06	.94	16.7	11.03		21.0	.0445
.05	.95	20	9.19		17.5	.0572
.04	.96	25	7.35		14.0	.0715
.03	.97	33.3	5.51		10.5	.0953
.02	.98	50.	3.68		7.0	.143
.01	.99	100.	1.84	← U^{235} Delayed Crit	3.5	.286
.005	.995	200.	.92		1.75	.572
.003	.997	333.3	.55		1.05	.953
.002	.998	500.	.37	← U-233	0.70	1.43
.0544	.9456	18.4	10.00 $\times 10^{6}$	0.1 $\times 10^{-6}$		
.0286	.9714	35.0			10.0 $\times 10^{6}$	0.1 $\times 10^{-6}$
.0066	.9934	151.5	1.21 $\times 10^{6}$	0.824 $\times 10^{-6}$		
.00194	.99806	515.5			0.678 $\times 10^{6}$	1.47 $\times 10^{-6}$

$T = \frac{1}{\alpha}$	U^{233} $\ell = 2.86 \times 10^{-9}$ (calc)			U^{235} $\ell = 5.44 \times 10^{-9}$ (calc)	
	$\Delta k = \frac{\ell}{T}$ $\Sigma\beta = 0.00259$ $\beta_{eff} \approx 0.0027$	M		$\Delta k = \frac{\ell}{T}$ $\beta_{eff} = 0.0066$	M
0.1×10^{-6}	.0286	35.	subcrit	.0544	18.4
0.2	.0143	70.		.0272	36.8
0.4	.0072	140.		.0136	73.6
0.8	.0036	280.		.0068	147.2
1.0	.00286	350.	← delayed crit →	.00544	184.
2.0	.00143	700.	prompt crit	.00272	368.
4.0	.00072	1400.		.00136	736.
8.0	.00036	2800		.00068	1472.
10.0	.000286	3500		.000544	1840

The Fast Assembly improves the yield of the Accelerator by its Fast Multiplication $\frac{1}{1 - K_p}$!

($M(U^{233}) > M(U^{235})$ for same T)

In the region of prompt critical it can help by getting the power level up before there is time for thermal expansion and make the prompt critical bursts sharper. Russell has shown this by calculations using Livermore's Coron code.

~~Results of DSN Calculations using~~

July 24, 1963

Cross sections by DWM & GAM [redacted] for calculations on p 105 for reflected sphere with Cd and Linay mix

	Energy	Cd	Sm	Gd	GAM I Sm	GAM I Gd	GAM II Sm	GAM II Gd
14	4 - 1.0 ev	99.	379.	173.	276.3	90.4	283.1	101.9
15	.1 - .4 ev	4035.	3268.	4313.				
16	thermal	3038.	9176.	36600.				

σ_{2200}

g

.886 $g\sigma = \sigma_{th}$

However the following were actually used

σ	Cd	Sm	Gd
14	60.	579.	265.
15	3000.	3268.	4313.
16	3000.	10354.	41299.

It is believed that the above error is minor since the poison layers are so black anyway!

DWM

Discussed with ADC the design of an experiment to show this effect similar to Hanford's exp with Pu spheres.

1. Slab geometry more closely resembles Rover dissolver
2. But requires more reflector
3. Less Rigid, ~~tot~~
4. ~~Ex~~ If x only dimension are ~150 cm then 1 dim calc can be used.

5. Cylindrical geometry, with ≥ > 150 cm could be used with a moderate amt of reflector materials

6. Spherical Geom. requires most careful machining & preparation of matl.

7. Slab Geometry easiest to get Matls of const.

Purpose of experiment is to evaluate the use of ~~[illegible]~~ Lindsay mix and cadmium as neutron poison between vessels and reflector.

July 31, 1963

Recommended to A.D.C. that we not make any S.S. sphere until pulsing completed at another concentration!

Y-12 can make hemispheres ≈20 for $3000

welding was very expensive.

WCT suggested making a sphere by letting Met. X-10 weld them without specification but let them practice!

[signature]

Aug 1, 1963

Considerations at reduced density

If all cross sections are reduced by a factor of 2 size must be increased by a factor of two in order to have the same leakage in both systems

$M_1 = \rho_1 V_1$ $\qquad \frac{V_1}{V_2} = \left(\frac{r_1}{r_2}\right)^3 = \frac{1}{8} = \left(\frac{\rho_2}{\rho_1}\right)^3$

$M_2 = \rho_2 V_2$

$\frac{\rho_1}{\rho_2} = \frac{r_2}{r_1}$

$$\frac{M_1}{M_2} = \frac{\rho_1}{\rho_2}\frac{V_1}{V_2} = \left(\frac{\rho_2}{\rho_1}\right)^2$$

Lifetime would be doubled for system of reduced density.

Estimate of lifetime change for the 27 unit array of 5l bottles.

Unit cell volume $(8.0 + .95)\left[.7854\,(7.5+.95)^2\right]$

$= 8.95 \times 8.45^2 \times .785 \times 16.39 = 10.474$ liters

$\frac{10.474}{5} = 2.095$

$\sqrt[3]{2.095} = 1.280$. Therefore, lifetime should change by this factor.

$$\alpha(\text{unit cell}) = \frac{\alpha(\text{sphere})}{1.280} = \frac{234.6}{1.28} = 183.3$$

for $H/X = 424$ and reflecting plastic

Since the measured value was 152.9, this difference is due to differences in moderation from plastic boxes.

Assume unit cell including plastic ($H/x = 507$)

$$8.0 \times 7.5^2 \times .7854 \times 16.39 = 5.793 \text{ liters}$$

$$\frac{10.474}{5.793} = 1.8080$$

$$\sqrt[3]{1.808} = 1.218$$

$$\alpha = 153.9 \times 1.218 = \overset{187.5}{\cancel{186.2}} \quad @ \ H/x = 507$$

Flux peaking in the cells and streaming between the units will ~~not~~ make the above considerations (based on uniform density changes) in error.

For an approximate lifetime $l = \frac{1}{.886\, v \Sigma_a}$ see p 16

$l = 39.8$ @ $H/x = 424$

$l = 46.0$ @ $H/x = 507$ $\quad l/l = \frac{46.0}{39.8} = 1.156$

$$\alpha(507) = \frac{\alpha(424)}{1.156} = \frac{234.6}{1.156} = 202.9$$

compared to ~~[illegible]~~ est. value of ~~186.2~~ 187.5 within ~~[illegible]~~ 8.2%

Dixon

Aug 1, 1963

Aug 6, 1963

Discussed application of pulsed neutron measurements to fuel element shipping casks with Schappert and Callihan. Schappert is writing a memo about design of casks including multiplication meas. and poss. inclusion of pulsed neutron meas. a la Silver.

DWM

Aug 6., 1963

Hammond proposed to ADC J.T.M. and DWM a method for measuring Doppler coefficients in power reactors. For Pu "breeders" ~~as~~ PuO_2 in UO_2

1. Put reactor mockup on a fast period to heat up according to power distribution

2. Some time later pulse again to and/or determine shape of power burst.

GE now building a power reactor, SEFOR,
(Southwest Exp. Fast Oxide Reactor)
for Southwest Atomic Energy Asso., Karlsruhe, & AEC.

DWM

If Doppler effect is positive, then the first step above is unsafe! And the second is unnecessary. It is possible to get the same information from the behavior of step 1

Spec Heat — Specific Heat cal/g

ThO_2	0.0571 @ 0°C	0.0589 @ 50°C
U_3O_8	0.0671 @ 0°C	0.0750 @ 50°C
$U(\alpha)$	0.0275 @ 0°C	0.02919 @ 100°C
	0.03135 @ 200°C	0.03681 @ 400°C
	0.04521 @ 600°C	

If Crit Mass = 400 kg PuO_2 and radius ~ 60 cm

Total = 2000 kg ($PuO_2 + UO_2$) = 2.0×10^6 g

If $\overline{\Delta T} = 100°C$

$\Delta H \approx .06 \times 2 \times 10^6 \times 100° = 1.2 \times 10^7$ Cal

~~Average Power~~ = $4.185 \times 10^7 \times 1.2 \times 10^7 = 5.02 \times 10^{14}$ ergs

1.5927×10^{-12} ergs/ev — 200 MEV = 3.18×10^{-4} = 1 fiss

$$\frac{5.02 \times 10^{14}}{3.18 \times 10^{-4}} = 1.58 \times 10^{18} \text{ fissions}$$

lifetime = $\frac{60}{\sim 6.28}\, l = .30 \times 10^{-8} = 2.866 \times 10^{-8}$ sec

ρ = 15.66
C.M = 16.28 kg
V = 1.040 l
r^3 = 278.3
r = 6.285
Jezebel.

September 17, 1963

Hammond proposed to EP Blizard, AD Callihan, JT Mihalczo and DW Magnuson some calculations concerning a fast reactor which would be pulsed to measure its Doppler coefficient.

Core Vol 3000 liter — 50% Na, 17% S.S., 33% $UO_2 - PuO_2$ ($\sim$ 15% Pu)

l^* 5×10^{-7} sec

β .003

$n_0 = 10^{-2}$ watts

$C_\Theta = \Delta k/°C = -1 \times 10^{-5} \sim 1/3$ ¢/°C

$H = 6.8 \times 10^6$ joules/°C Total

3.3×10^6 " Fuel

1000 l of Fuel
$H = 3.3 \times 10^3$ joules/liter
$= 3.3$ joule/cc
.33 joule/g
.0789 cal/g

$C = \frac{\Delta k}{joule} = \frac{C_\Theta}{H} = 3.3 \times 10^{-12}$

For 500°C heating total Energy

$E = 1.5 \times 10^9$ joules ($\times 3 \times 10^{10} = 4.5 \times 19$ fissions)

Since react = 0 at peak of ~~reactivity~~ power transient and if transient is symmetrical

$\rho_p^{(¢)} = \frac{1}{\beta}\frac{E}{2} \times C_\Theta = 83¢$ (

$\frac{1.5 \times 10^9}{2} \times 3.3 \times 10^{-12} / .003 = 83¢$

also $\rho_p^{(¢)} = \frac{\Delta t}{2} \times C_\Theta = \frac{500}{2} \times \frac{1}{3} = 83¢$

Hammond quoting Keen?

Ramp rate should be $> \frac{A^2}{2l^* \ln \frac{n}{n_0}}$ $\rightarrow$ \$67/sec

$t = 12.4$ ms

Since one starts from delayed critical $A = 1.83$

Ramp rate must be \$148/sec

to add 1.83 in less than 12.4 ms

Another mode of operation would be to operate on a much slower ramp and let it pulse several times. Hammond presented some numbers which showed that it would pulse twice in 0.1 sec for a reasonable ramp rate of $/17/sec. for ~ 0.1 sec.

Hammond estimated that 0.5×10^6 dollars would build a facility, and 0.25×10^6 dollars per year would run it.

Mihalczo suggested that we could start immediately on 238+235 mixtures without building a facility to check out the method. (Hammond wasn't very interested in this system)

Hammond will submit a letter from him to Wensch of AEC (for review by Silver and Mihalczo) outlining his proposal.

The reactivity of 83¢ above prompt critical will have to be approached gradually

a) by oscillator measurements
b) or by having a driver region of known neg. prompt react coeff and a small region of test elements which region eventually becomes the whole core.
c) or other positive shutdown mechanisms must be included.

Hammond objected to the Phillips proposal for a Sport type test systems with a central cavity by saying that it doesn't measure what is wanted by the reactor safety people, but yet it is part of his safety system under 6) in the approach to the final experiment.

Hammond also quoted calculations of PBX a molten plutonium core reflected by nickel which pulsed 17 times during a ramp reactivity addition. (There must have been many dollars in the ramp, >34 DWM)

DWM

10-28-63 12.4 in sphere. full more than #/ subcut

Tip of RSN-1055 near bottom 51.61 lower limit

upper limit 39.26

1500+ volt N/CC on RSN-1055 12.35 in Travel

DD-2 X 50 (.5 μsec delay) Pulses ~ 20-60v PHS = 150

Input to TMC +4v (200 Ω on both ends of RG 114)

Input to scaler -20 PHS on Y140343 -10v

1" RCL 1681 + 45B preamp + 204B 123800

X16. RT 0.2 — PHS @ 20

Pulse ~ 20-60v HV = 1500 BA 318 123871

Long line 460A (75Ω term) Gain set for -20v pulse to scaler

$\frac{37000}{300}$ = 123 cts/sec

Acc 148 kv .81 ma ~ 2 μa. 240 cps 200 μs burst

TMC Ch 20 μs Bly x2 Delay x2 ½ Memory Disc 2½

Changed Acc to 140 kv after PNS-218

	Counter Pos	Normalizing x10	Pulses on Cycles	Peak
PNS-215	46.5	10006	123 746	29206
216	47.5	10005	188 115	
217	48.5	10004	267 176 should be 167 176	
218	46.5 pk Acc.	10003	172 278	24432
219	49.5	10007	77 562	23288
220	49.5	10005	84 852	2278
221	49.5	10004	120 382	20466
~~222~~	.5			
~~223~~	.5			
~~224~~	.5			
~~225~~	.5			

There seems to be a ~~good~~ thick layer of carbon on the target. The beam current on target during 219-221 was 4 to 5 μa and the neutron yield decreased during each of the runs.

The background changed from ~3600 - 219
to 3300 - 220
to 2900 - 221

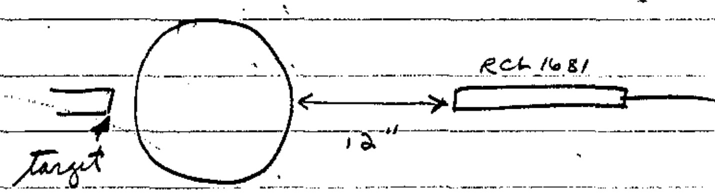
and the number of pulses for constant normalizer increased from 77562 to - 84852 to 120382 resp.

The only conclusion is that the flux inside is not proportional to flux outside. Therefore, the accelerator must be changing.

1st The beam on - off ratio must be changing so that the peak to Bkg ratio keeps improving

2nd. The background from beam deflection must be increasing because the normalizer sees more neutrons on successive runs

10-29 Pulsing 12.4 in sphere full H/X ≈ 65
Norm counter 180° from source.



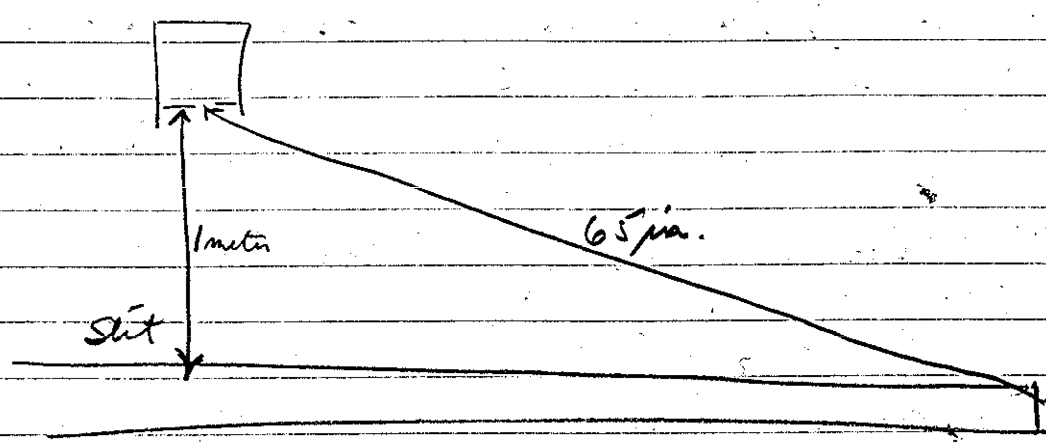
	Norm Count	Pk (7)	(15)	Background
X_1	4002	21272	14768	~3500
X_2	4002	20620	13921	3100
X_3	4004	21115	14519	3350
X_4	4802	$\frac{24300}{1.2}$ = 20250	$\frac{16543}{1.2}$ = 13786	$\frac{3900}{1.2}$ = 3250

Evidence from previous pulsing of this sphere when water filled that the target was very much better at that time. Adequate counts were obtained with reversing counter with total beam current of ~ < 100 μa.

Set up long counter at 200 cm from target RSW-75 5.5 in from end of brass tube. Pulses ~35 volts, PHS on 204B @ 20.

Count Time	Source	Total Counts	
10'	M-227 @ 200 cm	23901	> 18943 cts
10'	Bkg	4958	600 = 32 cts/sec
(M-43 in same drive ~1 yd away)			
1'	10 μa	10650	47000 / 50
1'	20 μa	19330	
1'	30 μa	29390	940 cts/MIN μa / 60
1'	40 μa	38550	16 cts/sec/μa
1'	50 μa	47670	

Count time	Source	Total Counts
1'	20μa	20840
1'	40μa	39370
1'	60μa	54940
1'	80μa	68790
1'	100μa	81150
1'	100μa total Pulse 60	53930
1'	100μa " Pulse 50	42850
1'	100μa " 20	16350
1'	20μa —	15300
1'	20μa —	16280



100μa on target, current deflected onto slit.

1'	100μa on Slit	575
1'	Bkg	186
2'	M-227	14492 − 331 = 14161/2 = 7081 ct/Min
20'	Bkg	3311/20 = 166.

409

It must be concluded that the source from beam current impinging on the slits is very small compared to the source on target.

$$\frac{\frac{409}{7081}}{\frac{81150}{1894}} = \frac{409}{81150} \times \frac{1894}{7081} = \frac{1}{200} \times 4 = \frac{1}{50}$$

For duty cycles of 2%, this source is as large as the target but since it is 47" from the target it has reduced importance because of the $\frac{1}{r^2}$ dependency

Previously the normalizing counter was ~12" below the sphere with the deflected beam source ~5'

For 200 μs burst and 240 cps rep rate

duty cycle is 200/4000 = 5%

$$\frac{\text{Bkg}}{\text{Target}} \quad \frac{1^2}{25^2} \times \frac{.95}{.05050} = \frac{.01}{25} \times \frac{.95}{.050} = \frac{.95}{62.5} = \frac{1}{64}$$

It seems that this slit background can't be the source of our trouble. It must be related to beam quality changing with time so that yield from target on and off change.

Background ratio with Long Counter 1 meter from target.

1'	50 μa	133910	$\sim 10^3$
3'	50 μa deflected	1267 433	1
3'	Bkg	848	
		419/3	140/134 $\times 10^3$

Moved Source drive.

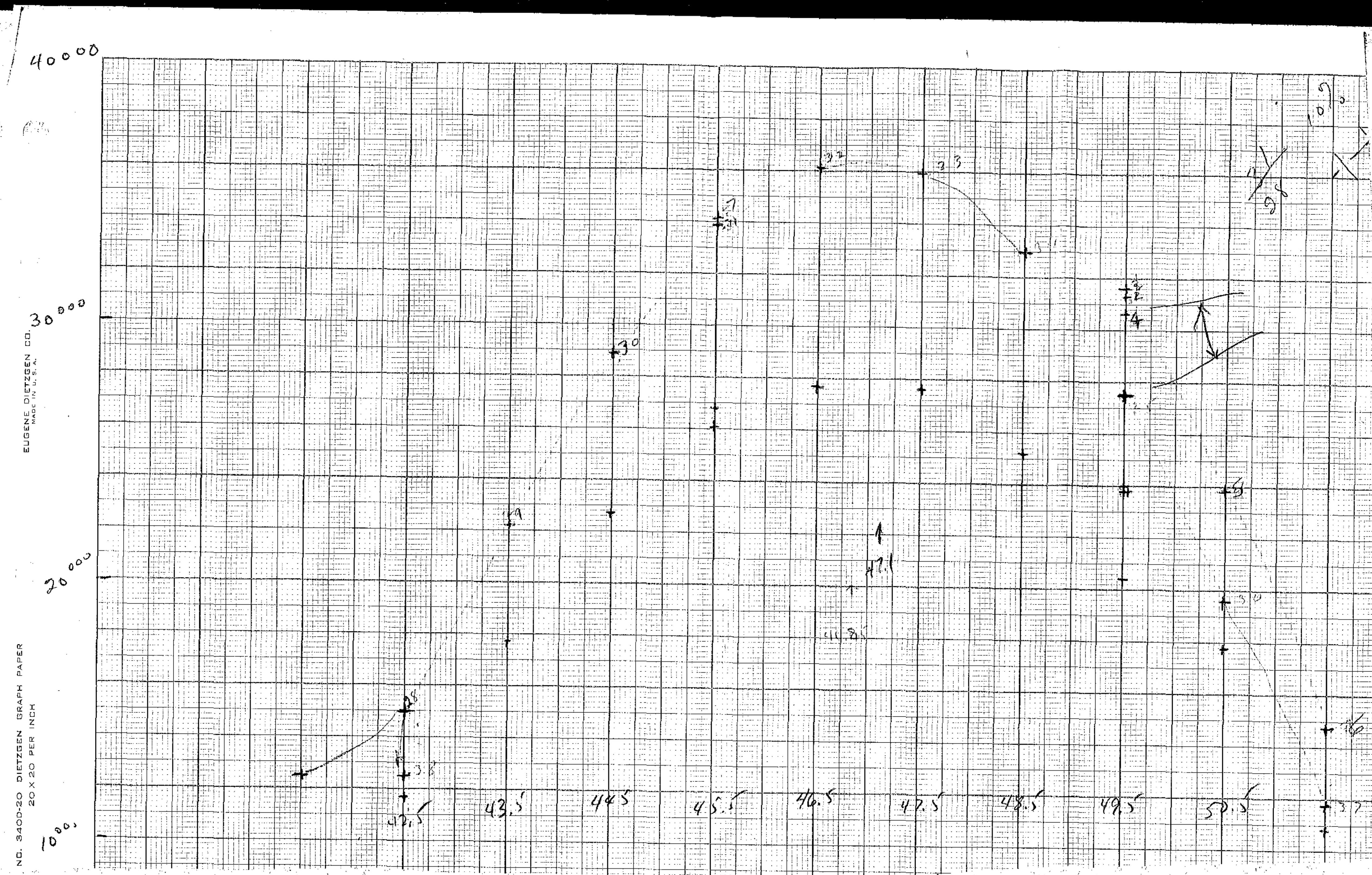
5 MIN Bkg 781 1,56
1 MIN 50 μa Target 159 060
5 MIN 50 μa deflected 1746 − Bkg = 765/5 = 155
50 μa after

Bkg ratio ~ 10^{-3}

Probably needs clean target and clean source

Oct 31 New Source Target #-47 (1c) installed with
new water jacket T-102.
Nov 1 Pump to 2×10^{-6} — Add liq N_2 pump to < 10^{-7}

Acc 140 kv 71 μa 71 μa Target 200 μsec burst 240 cps
Det RSN-105S, 1500v DD2 ×50×1.1 PHS 100 cps · 5 μsec Delay line
TMC 20 μsec, ×2 delay ×2 Bkg 2.5 disc 1/2 memory


40000
30000
20000
10000
42.5
43.5
44.5
45.5
46.5
47.5
48.5
49.5
50.5
EUGENE DIETZGEN CO.
MADE IN U.S.A.
NO. 3400-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH

November 1, 1963

Pulsing 13.4 in sphere filled with ~~390~~ ~3?? g/l solution subcritical

	Counter Pos	Normalizing (X10)
RNS 222	49.5	100060
223	49.5	100050
224	49.5	100050
225	50.5	100070
226	51.5	100050
227	45.5	100060
228	42.5	100060
229	43.5	100050
230	44.5	100050
231	45.5	100050
232	46.5	100040
233	47.5	100030
234	48.5	100030
235	49.5	100080
236	50.5	100030
237	51.5	100030
238	~~41.5~~ 42.5	100040

Analyses 10-10 11-7 255.52 256.63 Dec 24, 1963 390.3 g/liter

Evidence of counter changing efficiency

11/1/63 M-227 Source

14:20	Bkg.		Tot Counts
	10 MIN		202560
14:50	10 MIN		202020
3:50	10 MIN		202860

Normalizing counter not unstable with source!

5'	1520	23590
5'	1600	28110
1'	1500	4350

Nov. 4, 1963

1	1500	4620
2'	1500	8850

Increased gain to x100 x1.1 PHS on DDZ = 150

1'	1500	9172
1'	1500	8797

Change to 460BR Amp. Scaler PHS = 15 (Pulser = 302)

1'	1500	7479
1'	1500	7669
1'	1500	7907
1'	1500	7824
1'	1500	7778
2'	1500	15353/2 = 7676
1'	1500	7826
1'	1600	12612
1'	1600	12360
1'	1600	12406
1'	1400	4822
1'	1400	4905
1'	1400	4901

1'	1300	4694, 4457, 4593
2'	1200	8218/2 4109
2'	1350	9487/2 4743

Set gain 50 x1.0

	1'	1520	4603, 4438, 4330
100	1'	1400	4291
	1'	1500	4519
	1'	1600	5389

Nov 5, 1963 gain 100 x1.1

11'	1350	51875/11 = 4716
30'	1350	139879/30 = 4663

Signal Input to TMC from DD-2 ~+4 volts.
Signal Input to Scaler from HP460B +20v <0.3μs wide
PHS on Scaler begins counting @+1.5v
Input to 460B +3.5v ~.3μsec Set at +1.5v.

Nov 5, 1963

with Traversing counter at 47.0 (near middle) (sphere)
and H.V = 1350 Gain @ 100 x1.1. Accelerator used for
constant source

Beck log N	Count Time	Norm Count	14 Mem TMC Bkg x32 @ 20μs	Cycles (35 cps)	Count Ratio
.013	2'	6960	15867	42829	~~2.160~~ 2.280
.013	5'	16977	36662	106842	~~2.32~~ 2.160
		16366	37987	106954	2.321
		16537	37882	107006	2.291
		16662	37845		2.271
		15989	36124		2.259
		15952	36685		2.299
		16340	37230		2.278
		16110	36701		2.278
		15823	36467		2.305

Use RSN-75 and M-227 in paraffin
DD-2 + 460B and 500kc scaler (use 1400 mid in plateau)
Gain 100 x1.1 Use electric Timer.

1' 40190, 40360, 40240, 40260, 40890
40410, 40410, 40110, 40260.

Using Analyzer with 80 μs Ch. Bkg x64 and 10000 cycles

Bkg Ch
34454
33000
34591
34448
30810
36026

Instability?!

	10000
1	34454
2	555
3	563
4	501
9	541

	10000
1	33000
2	492
1	579
	10000
1	34591
2	568
3	511
	10000
1	34448
2	502
3	564
	1109

	10000
1	30810
2	504
3	459
4	470
5	1608
6	1537
7	1536
8	1612
9	1571
10	1559
11	1629
12	1611
13	1653
14	1549
15	1570
16	1533
17	1617
18	1503
	10000
1	36026
2	552
	569

Use Analyzer Bkg × 2 40 μsec Ch. M227 in $(CH_{2}-)_n$
CR ≈ 4000 c/sec H.V. = 1400 RSN-725 DD2 gain 100×1.1

stability fairly good

	1	2	3	4	5	6	7
2	0	0	0	0	0	0	0
1	63213	63188	62895	62753	62533	62914	63203
2	31625	32009	31629	31474	31385	31555	31582
3	31538	31791	31790	31752	31994	31558	31708
4	32115	31563	31843	31259	31531	31504	31827
5	31829	31996	31563	31526	31577	31338	31860
6	31683	31838	31448	31749	31487	31483	31864
7	31985	31617	31237	31559	31784	31865	31711
8	31785	32170	31748	31451	31454	31623	31923
9	31756	32021	31639	31484	31530	31248	31783
10	31715	31478	31746	31530	31584	31294	31937
11	31920	32085	31527	31100	31640	31302	31700
12	31663	32049	31540	31501	31441	31597	31575
13	31970	32028	31454	31413	31601	31420	31836
14	31709	32050	31424	31372	31823	31933	31942
15	31642	32168	31932	31645	31709	31595	31517
16	31892	31745	31384	31207	31421	31404	31932
17	32041	31909	31246	31610	31387	31457	31561
18	32211	31754	31689	31322	31832	31695	31688
19	31853	31973	31403	31434	31510	31829	31231
20	31488	31798	31695	31597	31670	31784	31828
21	32133	31953	31647	31692	31649	31798	31712
22	32290	32065	31646	31815	31716	31653	31988
23	32106	32183	31502	31388	31944	31628	31678
24	31629	32075	31574	31470	31743	31630	31688
25	31522	32205	31654	31611	31446	31549	31906
26	31761	31319	31517	31260	31346	31323	31479
27	32087	32016	31504	31099	31658	31769	31598
28	31906	32049	31630	31430	31591	31622	31625
29	32057	31795	31798	31434	31247	31338	31724
30	31933	31769	31556	31093	31920	31830	31506
31	32074	31808	32015	31413	31385	31480	31869
32	31751	32234	31601	31797	31838	31497	31880
33	32028	31838	31328	31555	31809	31526	31805
34	31912	32025	31691	31842	31563	31493	31913
35	31575	31892	31394	31637	31459	31733	31682
36	31854	32078	31689	31750	31651	31491	31817
37	31914	31926	31589	31386	31487	31802	31976
38	31627	31705	31596	31595	31741	31502	31560
39	32068	32179	31809	31751	31808	31473	31620
40	31653	32118	31784	31522	31491	31743	31759
41	31320	32097	31744	31611	31346	31728	31517
42	31848	32089	31546	31517	31735	31716	31955
43	31560	31919	31606	31339	31561	31756	31776
44	31298	31963	31679	31499	31804	31554	31798
45	31881	32164	31756	31354	31277	31906	31826
46	32145	31758	31448	31419	31393	31463	31790
47	31609	31914	31525	31524	31606	31794	31825
48	32030	31517	31516	31459	31601	31677	31795
49	31634	32064	31464	31549	31526	31881	31792
50	31724	31865	31467	31688	31336	31483	32217
51	31888	31805	31400	31402	31513	31512	31731
52	32106	32168	31783	31546	31548	31528	31726
53	31749	31914	31548	31471	31638	31318	31817
54	31583	31815	31180	31484	31452	32149	31967
55	32091	32123	31546	30960	31478	31447	31944
56	31949	32149	31276	31507	31460	31358	31663
57	31610	31738	31182	31548	31081	31837	31578
58	32172	32146	31385	31371	31832	31772	31651
59	32011	31587	31777	31427	31505	31557	31752
60	31794	31509	31609	31532	31591	31634	31790
61	32007	31882	31458	31311	31838	31700	31503
62	32091	32052	31503	31597	31881	31510	31613
63	31946	31790	31283	31531	31376	31525	31964
64	31936	31823	31701	31340	31661	31672	32036

$\frac{200000}{280} \approx 700$ sec
≈ 12 MIN

Nov 5, 1963

Set up small RSN-105 S in $(CH_2-)_n$ with M-226 and M-227 with Hamner PS. Determine plateau for DD-2 gain of 100x1.1 and PHS of 150. 50000 cycles x 20μs @ 480 cps

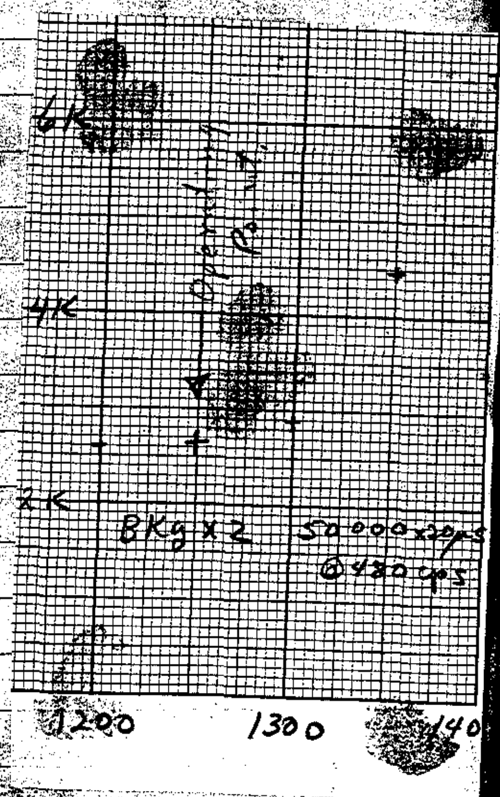
Volts	Bkg x2
1350	4467
1400	6598
1300	2890
1200	2613
1250	2631

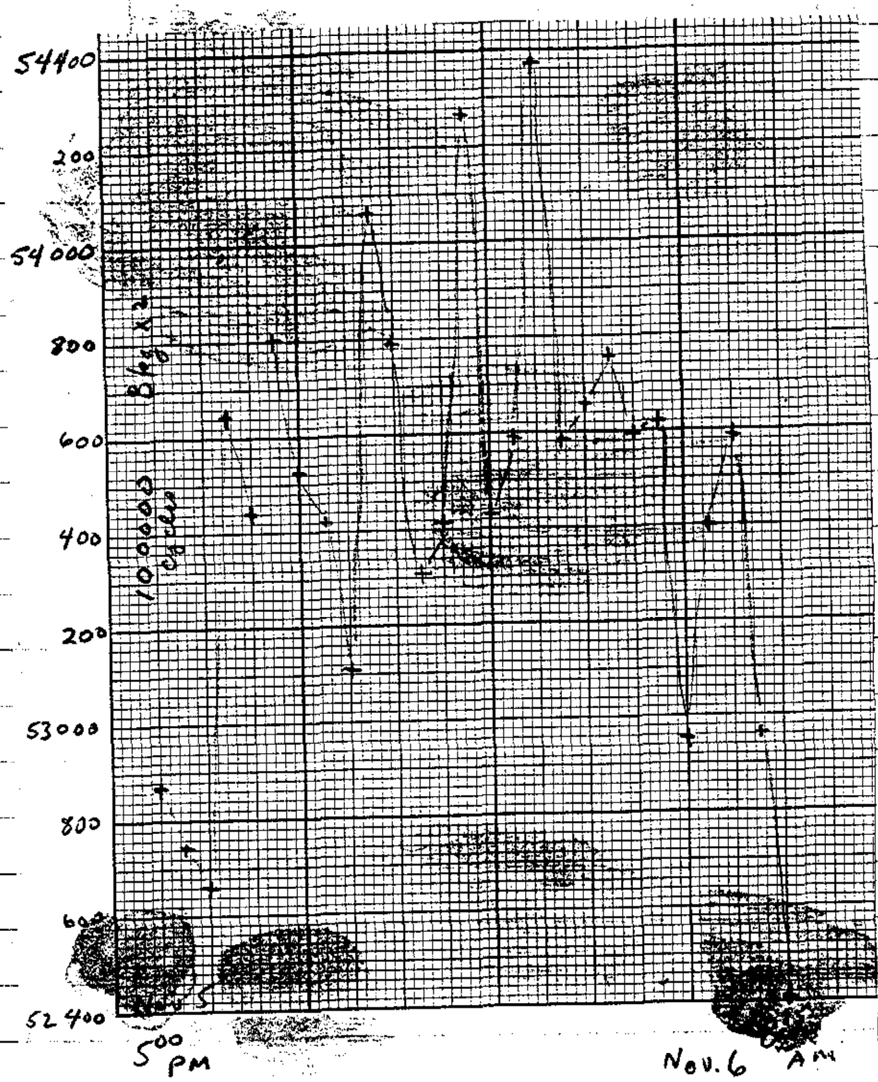
Use 1250 V. setting on Hamner with D.D2 @ 100x1.

Set up TMC on fully automatic with destructive readout for overnight run; Ch 20μs delay x2 Bkg x2 disc 2.5 pulse input from DD-2 + ~4v. Total cycles 1000 000 @ 480 cps ~2000 sec ~ 33'. St.W. Time 36+ min per cycle.

Total cts in Bkg in successive runs

52866	54064	53660
52746	3789	755
52659	311	594
53642	417	623
439	4268	2955
801	3433	3400
523	591	599
422	4374	2963
110	3581	2406





Plot of counts in Bkg channel for each of the runs (overnite Nov 5-6)

Nov 6, 1963

Filled 12.4" sphere with soup with counter reassembled in sphere H.V. Hammer @ 1250 DD2 gain 100 x1.1 PHS 150
TMC 20 μs X2 Bky X2 delay 2.5 disc. 1/2 Mlam
Acc 145 KV 1.2x10^-6 mm Hg 0.75 ma 20 μs @ 240 cps
390 g/l

	Counter Pos	Counter Normalizing	Beck log N	Ch 10	Temp °C
PNS-239	47.0	200230	.11	47170	
240	47.0	200170		48314	
241	47.0	200100		47383	
242	48.0	200130		45306	
243	49.0	200750		39971	
244	50.0	200160		30796	24.3
245	51.0	200140 (Cy 116438)		21125	24.7
246	51.5	200110		15940	24.5
247	47.0	200170		46318	24.6
248	42.5	200130		16222	23.6
249	43.0	200190		21098	24.8
250	44.0	201820		29520	23.7
251	45.0	200180		36765	24.7
252	46.0	200130		41891	23.8
253	47.0	200170		43946	24.1
	49.5				
	51.0				
	43.5				

These data show a drift of — a nonreproducibility between 239 and 253 of ~ 10%

a detector sensitive only to 14 Mev neutrons during burst may improve normalization. Following scheme tried using Ne-102 gated with EP-210A

PM-6810A + $\frac{1}{4}$" x 2" o.d. NE-102 @ 1025 v. C3 2048 @ 2x1.6

RT = 0.2 μsec PHS = 30 (~30v) Pulses up to 60, occ. 80v.

HP-460B (linear) to 500 Kc Dec. Scaler PHS = 7.5 No counts = 15

+ Gate output EP-210A to stop SW (UHF con.) w-

POS @ 6 (~~40-50v~~ 38v gate) gates scaler for 200 μsec.

ACC 145KV 800μs @ 240CPS

TMC 20μs Bkg x 2 Delay x 2 ½ Mem Disc 2½

	Counter Pos	Scaler Norm	Log n-Bub	Counts in Ch 10	Temp. °C
PNS-254	47.0	80020	.105	46850	24.9
255	47.0	80170		49140	23.4
256	47.0	80040		51594	

Stability Check with gate

Observed that the time constant of the RC net (.001 x 39K) prevented all of the pulses that occurred during the 200 μsec gate from being counted. Therefore the gate was clipped on the grid of the tube directed as a temporary condition. The amplitude of the gate was adjusted carefully, and the setting of the size from EP 210A was critical. Five Runs were made for stability check, one between 3 & 4 discarded because of arcing!

		(Norm)	Bkg	Tot. cycles		10
$\frac{1}{4}$" Ne 102	①	33030	8869	112195	9.1	32509
~14-15 from	②	33010	8745	114600	9.3	32337
target	③	33010	9035	122462	9.9	33504
	④	33020	8771	118767	9.5	32535
	⑤	33020	9582	131468	10.6	34279

1942

Nov. 7, 1963

Continue additional meas using NE-102 norm.
Moved detector to 12° from Target, lowered PHS
on 2048 to 20.

12.386 in sphere 16.30 l 15.73 cm

	Normal	Counter Pos	Back log N.	
PNS-257	200150	47.0	.11	46610
258	200060	47.0	.11	46307 — Full Target current for 10-15"
			Accelerator arced	
259	220140	47.0		50227/11 = 45661
260	200070	48.5		
261	200080	50.0		
262	200110	51.5		
263	200170	51.5		
264	200230	50.0		
265	200170	48.5		
266	200210	47.0		
267	200170	45.5		
268	200170	44.		
269	200130	42.5		
270	200160	42.5		
271	298400	44		
272	200180	44		
273	200230 ~~200230~~	45.5		
274	200180	47.0		

Setup for pulsing 8.78 in sphere

Nov 8, 1963

Hammer 1250 - RSN - 105 S in 8.78 in. sphere
DO2 amp @ 100 X1.1 PHS = 150 - 4 volts on Terminated
200 Ω line, Atten box used
with ext 200 Ω. Term.

1000 1000 1000 1000 50

TOF - 211 Gain on TMC = 4 in order to count
~~all~~ pulses in analyzer. 2 μsec Ch
1/2 Memory. Acc 142 kv 0.94 ma 8 μa target
10 μsec burst @ 3300 cps.

Normalizer 1/4" NE-102 ~ ~~2~~ 3' below Target Hammer = 1025 v
PHS = 20 204B @ gain X2 X1, 0.2 μsec RT - Term line - pulse
amplified by 460 BR to + pulse PHS ≥ 15 no
counts in 500 KC Scaler. PHS = 7.5.
When counts observed on scope synched by acc on pulse
no counts were ~~ob~~ observed in region between
bursts. Therefore ~~a~~ 14 mev neutrons only
are counted by norm. (Previously, Pu Be
source neutrons were not counted at
these operating conditions).

All runs on next page at 2 μsec channel
L.C oscillator. 0 delay Time gain X4

	Counter	Norm x10	Cycles	
PNS-275	55.0	3~~4~~00060	3282116	1 acc arc added 1 Reg to scaler
276	58.0	3~~7~~00090	3270191	
277	57.0	300090	3184842	
278	56.0	300100	3240989	
279	55.0	300100	3352934	
280	54.0	300110	3499070	
281	53.0	300090	3196669	
282	52	300110	3384572	
283	52	3~~4~~00090	3613627	1 acc arc
284	53	300120	3346054	
285	54	300080	3599097	
286	55	300080	3443476	
287	56	300100	3398584	
288	57	300070	3486242	
289	58	300110	3529547	

#55 Nov 12, 1963

Density 1.5262 g/ml

256.63 mg/g

Nov 11, 1963

Set up 12 in 55. cylinder to pulse at delayed critical to mess l/β. with flat blade safety on air cyl.

Use 1/2" NE-102 6810A Hammer @ 1350V
HP460A - HP460B. Max Pulse ~ 4 V.
with Pu-Be Source.
Acc 145 kv .72 ma 71 μa target 300 μs @ 115 cps
TMC 20 μsec Bkg x 2 Delay x 2 Div. 4 Full Mem
Just critical before Pulsing
PNS Pulse for 1000 pulses, Insert blade
Complete cycles in 1 1/2 MIN.
PNS-290 Crit Ht 9.50 IN. - .15
Period after -358.5 sec or -4.07 ¢
Shut down for lunch
N 12^40 Just Crit ical before pulsing (+4463 sec) +0.20
PNS-291 Crit Ht 9.51 in
Period after -870 sec or -1.56 ¢
Change level 1.27 .63
Period before +1375 sec or +0.92 ¢
PNS-292 Crit Ht 9.515
Period after -875 sec -1.56
-0.64/2 - 0.32

Drain Soln and Refill to

Change H/X to ~ 90

Nov 12 Crit Ht found to be lowered by ~.22 in (HT = 9.28 in. on probe)

Nov 13

PNS-293 Critical Height in Cylinder 9.29 - .15 zero = 9.14

Same Cond as PNS-290-1-2. (40000 cycles

Period before ∞ 0 ¢

" after 598 = -2.32 ¢

-1.16 ¢

Shutdown for lunch (Soln not drained but safety inserted

Period before + 1400 sec → 0.908 ¢

PNS-294 " after ∞ 0 9.31 - .15

0.454 ¢

Acc 500 μs @ 75

TMC Ch 40 μsec

PNS-295 ∞ Period Before 0 ¢ Ht 9.31 - .15

-950 -1.43 ¢

0.72 ¢

Solution sampled #60

204.59 mg U/g

Density 1.3740 g/ml

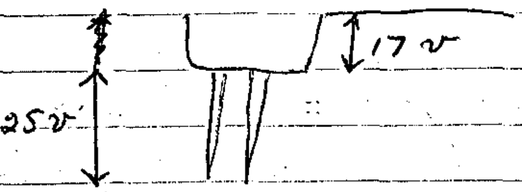
Nov 14, 1963

Set up for pulsing 8.78 in sphere at $H/\chi \approx 90$

Use TOF @ 2 μsec channels, set up as on p 139

ERR has built new input with gate.

EP gate signal set at 6. Input to scaler



PHS on scaler set at 25
no counts w.o. counts.

RSN-105S traversing counter Hammer @ 1250 V. DD-2 100 × 1.1

PHS-150 (Term line to Attn to TMC input - gain 4)

TMC - TOF - 211 @ 2 μsec Ch. 1/2 Memory.

Acc 140 kv 10 μa 0.88 mai 3300 cps 20 μs burst

EP-210 A + gate output 6. to gate input of 500 kc Scaler

Normalizer 1/4" NE 102 PM - on floor below Acc target

204 B gain X 2 X 1 0.2 μsec RT (Hammer 1175V @ 1025)

PHS = 30 long cable term X 100 Ω to HP 460 BR

linear to signal input of gate Tube ckt on scaler.

Nov 14, 1963

8.78 in sphere $H/X \approx 90$

	Norm	Counter Pos	Cycles
PNS-296	1000150	52.0	3389692
297	1000130	53.0	3195755
298	1002740	54.0	3215765
299	1000180	55.0	3205790
300	1000240	56.0	3218247
301	1000170	57.0	3288347
302	1000280	58.0	3213437
303	1100220	58.0	3021216
304	1000240	57.0	3064270
305	1000310	56.0	3029322
306	1000220	55.0	3070285
307	1000180	54.0	3139687
308	1000300	53.0	3145522
309	1000230	52.0	3089633

11-20-63 Examination of decay constants measured in 8.78 in sphere show room return or extra neutron in the decay curve. P 146-etc are attempts to find difficulty. Decay curves of PNS-257-274 in 12.4 in sphere are not 1 exp + const. Previous series PNS-222-238 are each good decay curves but normalization poor. Both sets show changes in value of decay constant with counter position since counter is worth ~17¢ and system is about 84¢ subcritical when counter inserted and 65 with counter almost removed. Since 12.4 sphere was critical at $H/X \sim 90$ no traverse was taken in this sphere at this concentration, and troubles cannot be traced.

Nov. 15, 1963
System changed to 12.4 in sphere. H/X ≅ 90
super critical by 18.3¢ (42.4 sec period)
Control fully inserted for PNS 310 – 311 – 312
Also Critical with counter inserted to within 21 in of bottom
~~PNS-310~~ 1/2" NE-102 PM6810 at RT ANGLES TO
Target @1250 ~~[illegible]~~ HP 460A HP460B DISC
@ 2 on TMC input 10 μsec Ch Bkg X 2
Relay X 2 Mem 1/1. Acc 140 KV @ 80 MA
Target 2 μa (prob. 200 μs x)
PNS-310 6000 cycles
311 6000 "
PNS-312 12000 " lower count rate × ½

Nov 18, 1963 Pulse near critical in sphere
2 Periods meas on Beck UL and Keithley 420
Average of 4 = +681 sec = +1.82¢ C.R = 26.00 Sol ~16.07

PNS-313 Ch = 40 μs Burst 500 μs @ 75 cps (See above for details)
Pulse for 500 cycles, Insert 1" Control from
26.00 to 16.95 and repeat 20000 total cycles
+572 sec 2.15¢ av k_{ex} = 1.98₅ cents
314 30000 cycles
+506 2.44¢ k_{ex} = 2.28¢

Nov 19, 1963

Random Count taken with Scint $\frac{1}{2}$-11 NE 102 @ 1350 V and M-226 or M227 source at ~ 5 inch. Channel 20 μs.

Bkg Ct × 2 = 65536 max in ch. 42 = 33225

Min in ch 56 32357

868 or 2.3%

av 32791

20 Ch. above 33000 cts.

$\sigma = \frac{1}{\sqrt{N}} = \frac{1}{181} = .00553$ $\sqrt{N} = 181$

If av counts is 32768 ± 181, .67 ~~of half~~ of channels should be between 32587 and 32949. With 20 channels above 33000, this is consistent with Statistics.

181 × 2.3 = 416.5 ; × 2 = 833 vs 868.

∴ There seems to be no channel width anomaly that could affect the measurement of decay constants.

Setup 2 μsec channel on TOF - 211 with Scintillator input gain to × 8 (w.o HP 460 B) collect random count.

Average channel 30264 $\sqrt{N} = 174$

Max	2	30950	99	30705
Min	3	29782	13	29798

$\frac{1168}{4.6} = 254$ $\frac{907}{4.6} = 197$

∴ Channel widths are within Statistics

Measure fast neutron background ratio

$\sim \frac{50000}{66} \approx < 900$ pulsing 20 μsec
2 μsec ch

Measure background accelerator off.
only 7.69 counts/channel

> No reflected, or moderated neutrons detected by fast neutron detector.

Nov 20, 1963

Measure decay constant with NE-102 fast neutron detector ~~on~~ outside edge of 8.78 sphere at rt angles to target.

Accelerator arced — leaked and much trouble see repair book

Nov. 21, 1963
Accelerator 20 μsec @ 3300 cps pres ~ 10^{-5}
Target at 8.78 in sphere equator
1/2" NE102 at Rt angles PM-6810 @ 1310 Hammer 200-Ω
HP460A (no 200-Ω on cables to 460A) to Input 211
with 200-Ω. ~~gain x~~
TMC 211 gain X4 (Ra gamma source counts
only a few at this setting)
Trig pulse from + Delayed output @ 3 w 7'8" HH1600
(1 μsec/ft) Scope delay measured ~ 8.5 μsec.
Time analyser starts ~ 8 μsec after
neutron pulse.

Background ratio using the NE-102 fast neutron
(and gamma) detector was not very good
and the extra background occuring ~ 100 μsec
after the burst did not show up. Pk was Ch2 = 42,489
Bkg 5800

Subtracted bkg without pulsing Bkg reduced to 5000
for same no. of cycles with
beam deflected (initial pulse cable disconnected)
∴ Most of the bkg is not neutrons from target but
either neutrons or gamma rays after burst.
prob. the latter since BF_3 counters give
reduced bkg ratios.

Set up BF_3 counter RSN-75 vertically
at rt angles to target. Hammer @ 1500 V.
DD2 @ 100X1 pulses ~ 40 volts. PHS @ 150.
Neg output (200-Ω) 100' Rg114 (200-Ω) To 211 @ gain X1

using same delay line or trigger pulse from p.s.
delayed output (7.8 μsec after acc off)
Plot of results shows same extra
background as found in the traverse
with RSV-105 S.

DWJr

~~Stop~~

Nov 22, 1963.

Possible source of this extra background
is a delayed neutron group in the 100 μsec
range, that arises from a precursor
that must grow in with a half life
of approx 20 – 40 μsec. in order to
reach a maximum in ~100 μsec.

DWJr

Nov 22, 1963

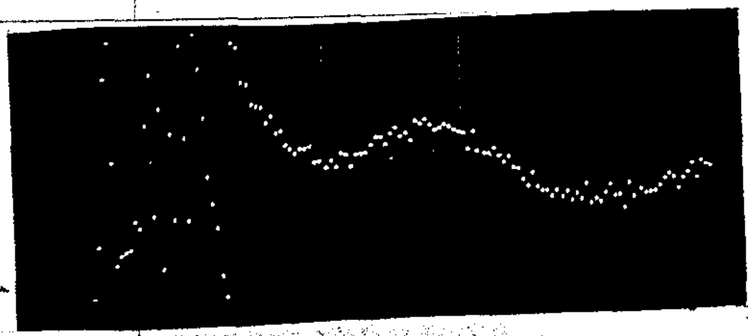
Repeat BF_3 run with counter on
west side of sphere instead of east side.
EXTRA background peak see p 150

Placed counter between SS cylinders
make run at same power level as
with counter on west side. Cd. removed.
3x higher than run near sphere! but constant.

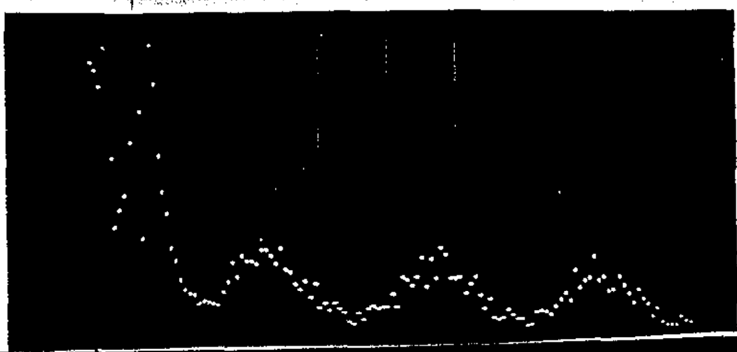
Counter back ~~to west side~~ under sphere, pulse with
solution half full. see picture.

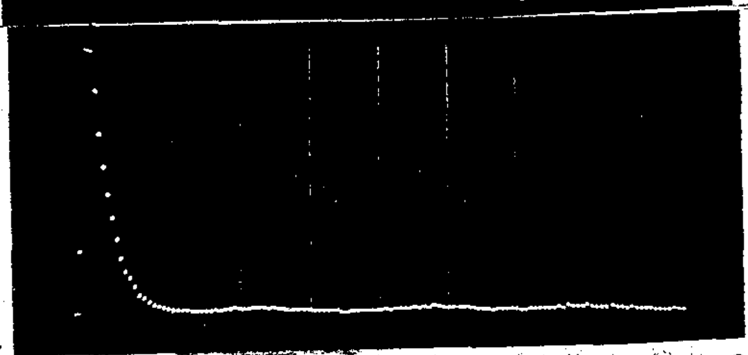
Counter below 4 μs Time chan
x1 Sol Ht 5.97 See pictures ~~and~~ sol Ht 3.57 4 μs 1.00000 cycles


S(HT' 5.47
Counts below
S(HT ~13
Sol 9.50 wh. fuel
No 22, RSN 75 on Wet.
Channel No. (2kcs wide)
20
30
40
50
60
70
80
90

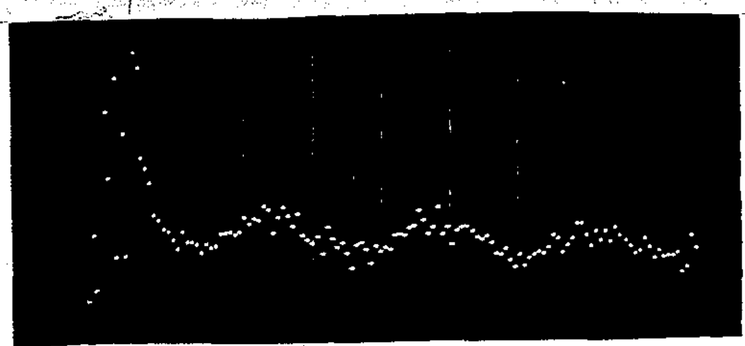


2 μs channels
Sol Ht @ 5.47
1/2 Mem.
10 μa Target
3200



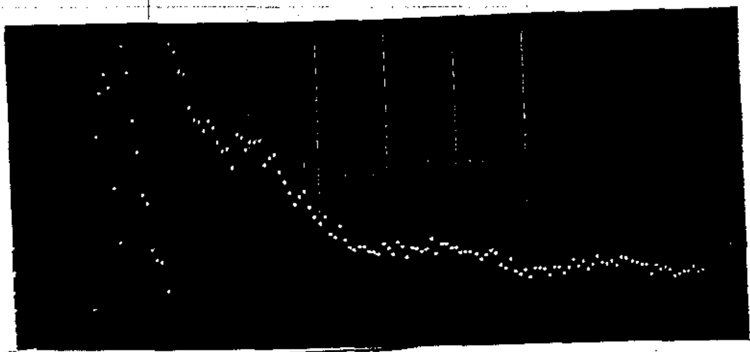


4 μs channels
Sol Ht 5.47
1/2 Mem
Same data
5 μa
1500 cps
38 × 4 = 152 μsec.
$\frac{72 \times 4}{2} = 144 \mu s$



4 μsec
Solution Height
3.49
1/2 Mem
5 μa
1500 cps

With M-226 or 227 source and TAC-211 @ 4 μsec
background is Constant! High Volt off Ion Source off.



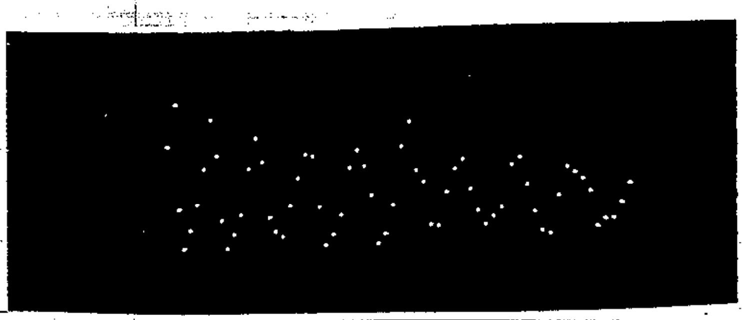
4μs channel
Plastic under Counter
no solution in sphere
Accelerator ~ 5μa
1500 cps. 20μs burst
Still evidence of peaks.

Moved counter near Target add sol to 5.5 in
(No record)
(No decay) otherwise (drain solution)
Same as above.
Peaks about same amplitude

Same effect noted with Pulsed Neutron Logic 212
On both 1/4 memory and 1/2 memory
although the peaks in the last 3/4 of
the memory were not as pronounced.
With 100 μs pulse, peaks in bkg were still there
with 200 μs pulse " " " " " "

With 5kv P.S. (deflecting pulsed beam onto target)
turned off, background although reduced was uniform.

Nov. 26, Found excessive ripple in deflection P.S.
but this was due to method of meas. gnd to +
(P.S. not grounded) In shop ERR found
High Voltage arcing in ~~supply~~ cable lead with spikes.
Essential no trouble w. Supply itself!



Nov. 26 Data taken with
Pulsed Neutron Logic 212 @ 10 μsec
30 μsec Burst @ 650 cps
RSN-75 counter near
Target. 7 pks between 5 & 8
~140 μsec or 7.14 kc/sec.

Nov. 27, 1963 Late PM 11-26-63 acc developed
leak, found fans off! P.S. replaced
but no change in time dependent background.

Deflection supply Ripple ~7-8v/6000 = 0.13%
H.V. Acc Supply Ripple w. 10kv on 1st plate $\frac{25v}{10kv}$ = .25%

Voltage spikes 3×5×100 = 1500 V. on plates of
Deflection Supply @ 5000K with damped sine wave
following! of ~100-150 μsec wide!

4^{00} PM Found Focus supply fuse blown!

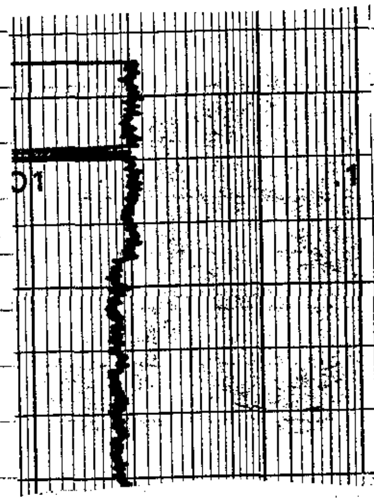
Theory: that the diffuse unfocused beam
was charging plates and periodically
arced over — must ground one side!

Nov 29, 1963
With Acc functioning properly 7kc in bkg remains
no clue as to cause
Deflection Supply ~ ~~[illegible]~~ Ripple pk to pk ~ 10/6000 = .16%
Beam Pulse caused voltage increase of ~10v.!

Dec 2, 1963

Ripple in Deflection Supply ~ 9v at 6000v
But now Beam makes ~ 5-10v negative pulse
on Deflection supply voltage! see p 153.

No Ripple or 60 cycle variation of neutron
production when pulsed at 60 cycles and 300 μsec
burst width.



Bty variation not found using scint or
fission counters, FC-7-8.
Prepare to measure decay using these
fission counters.

Dec 2, 1963

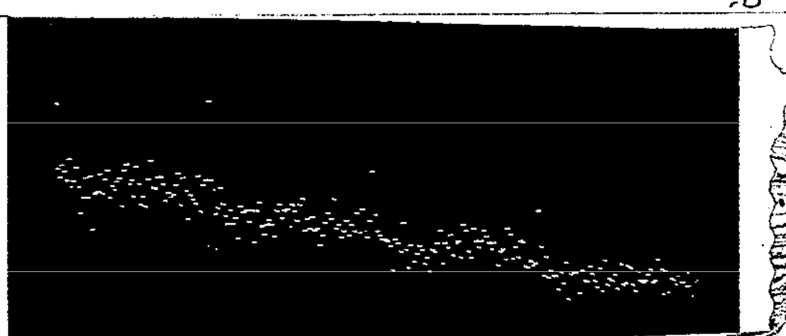
With FC-7-8 U^{235} counter mounted at right angle to target. 8 μa on target 13 8 kv 0.95 MA 30 μs burst @ 3300 cps TMC - 211 AH 1500 @ 2 μsec ch. Trigger delayed ~ 8 μs from sync output (should have been from the final pulse delayed an additional 24 μsec) Count rate not enough to accumulate enough data for pulsing and getting accurate decay constants. W.O pulsing ~ 96 μa on target.

Dec 3, 1963

Changed from DD-2 amp to 204-B amp.
Set Hamner Y-117540 @ 1700v gain 1 x 64 RT 0.2 μs.
PHS = 20 Pulse approx 60v on scope
No cyclic background found under pulsing conditions of 650 cps 30 μsec wide beam current ~ .8 — .95

1/4 mem	press < 1×10^{-5} mm	beam ~ .95	20000 cycles
2/4 "	" $1^{+} \times 10^{-5}$ "	beam ~ .9	"
3/4		.85	"
4/4		.8	"

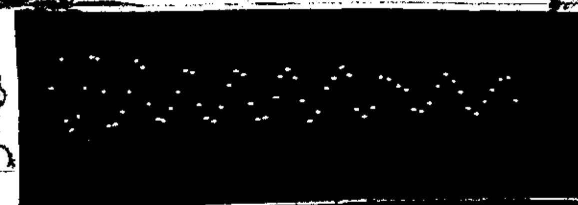
Counts in each channel are less than 128



1/4 2/4 3/4 4/4

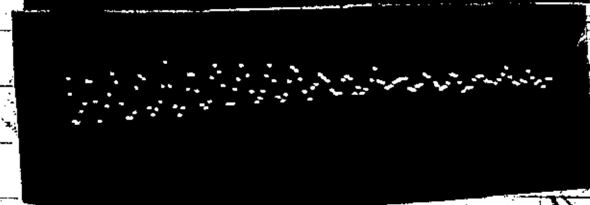
Dec 3, 1963

Set up original system



1/4 memory

10 μsec channels



1/2 memory

Used Hamner 117540 @1600

~~Return~~

Set up DD-2 with 1.2 μsec delay lines and @1600
the above effect not found! with Hamner 117540
or with Hamner 118.714 @1500

∴ Trouble has been located and due
to defective ? DD-2 amplifier
which had 0.5 μsec delay lines

Measured Dead time of DD-2 = 3.0 μsec

3 μsec → ← on scope.

DEC 3, 1963

PNS-315 2500000 cycles

Acc 145 kv Def. 6 KV Beam 0.85 Tor 5 ma

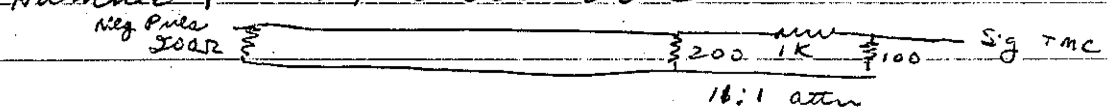
3300 cps 20 μsec, delay trigger to

TMC-211 by 8 μsec from final pulse

with HH 1500 delay line.

TMC-211 gain x2 Ch. 2 μsec, RSN-75 Coaxial

at Rt angles to Target Hamner Y-118714 @ 1500 DD-2 1.1 x 100



600 PNS-316 at half counting rate 5.0x10⁶ cycles.

1500 Beam 0.80 Ma

Install RSN-105 S counter in sphere

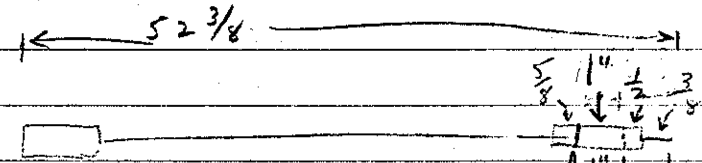
0000 = tip at bottom of sphere.

Raise to 3.3 in. Pulses ~ 80 v max

PHS ≐ 20 v

PNS-317 at same settings on acc as PNS-316

318 at twice the counting rate.



Dec 4, 1963

Set up new RSN-105-S M2 E-1151

(with 1/8" lead tube to counter) for use with traversing and pulsing. Counter OK Use DD-2 with 3 μsec pulse. Gain 1.1 X 50 (Hamner @ 1500 v) PHS @ 100

Acc 1 mx10⁻⁵ mm Hg 141 kv 0.80 MA 3 μa 3300 cps 2 μsec pulse

RSN-105 S is 52 in long.

Dec 4, 1963

Normalizer 1/4" scintillator on floor below @ 1025 v
204-B @ 1 x 2 pHS @ 30 v. (0.2 μs RT)
502 kc scaler gated on for duration of pulse
only pulses from scint greater than 30 v
some as large as 40. are accepted during
accelerator neutron burst of 20 μsec. @ 3300 cps
Delayed output pulse, further delay by 8 μsec
triggers TMC 211 gain X2 Neg output
from Counter DD2 attenuated by 11 to 1.
Beckman log N reads .03! Normalizer Scint may drift!

	Counter Position	Normalizer	
PNS-319	0.00	6.0009	1 arc. 2926706
320	1.00	60021	3196913
321	2.00	60015	3091301
322	3.00	60016	2966486
323	4.00	60016	2921918
324	5.00	60021	2806237
325	6.00	60012	2823588
326	6.00	60016	2731678
327	5.00	60014	2763621
328	4.00	60017	2750483
329	3.00	60042	2680622
330	2.00	5 60013	2213509
331	1.00	60023	3062411
~~332~~	~~6.00~~		

Dec 5, 1963

Repeat traverse of 12-4-63 – Log N = .05

	Pos. (in)"	Norm	
PNS-332	0.50	60024	2250564
333	0.50	60016	2169547
334	1.50	60022	2077274
335	2.50	60029	2371571
336	3.50	60017	2306876
337	4.50	60019	2286301
338	5.50	60014	2271838
339	6.50	60036	2223413
340	6.50	60016	2127846
341	5.50	60017	2167960
342	4.50	60018	2301110
343	3.50	60019	2334380
344	2.50	60008	2281435
345	1.50	60004	2272395
346	0.50	60029	2230797

Set up in 12.4" sphere, pulse at critical again on Dec 6.
(see p. 145.)

Dec 5 Excess k in 12.4 sphere with C.R at 26.0
+1.1¢

Pulse w 1/4 Mev neut ~5 v max.
" " fiss neut ~3 v max

Dec 6, 1963

Repaired EP-110A by tube replacement!

With rod at 26.0 in.
React before pulsing + 3.9 ¢ (+296 sec)
PNS-347 Pulsing at critical 150 kv 0.75 MA @ 72 cps
Burst - 750 μsec TMC Chan 40 μsec Bkg x 2
Delay x 2 DISC 3 Memory 1/1.
½" Scin @ 1250 HP46A - 460B - Fission Neut
pulses 3 v (14 mev 5 v)
Pulse for 500 cycles, then insert 1" SS rod
from 26.0 to 16.95 in

React after pulsing 4.85 ¢ av 4.4 ¢

Dec 11, 1963 2 PM

Check pulses from Scint 1/2" NE-102 with PuBe source pulses up to 3 V. essentially no change since 12-6-63

Dec 12, 1963 Pulsing at critical with sphere full, no control. Control at 33.37 (as in above song)

Reactivity = 0.0 ¢ (was +2 ¢ on Dec 10)

Acc 145 kv 0.75 ma > 1μ target 500 μs burst @ 72 cps

TMC 40 μsec channel Bkg x2 Delay x2 Disc 3 Mem 1/1

Det 1/2" Ne 102 @ 1250 V. AP 460A + 460B

PNS-348

React after pulsing 1.4 ¢ av 0.7 ¢

Insert 1" od SS control pulse for worth of control.

PNS-349 40μs 500 μs 135 cps 1/2 Memory

PNS-350 40μs " " "

PNS-351 20μs 300 μs 110 cps 1/2 Mem.

PNS-352 40μs 500 μs 135 cps 1/1 mem

Repeat pulsing at end

Init period 1.7 ¢

Final period 2.2 ¢

av 1.95 ¢

Dec 13, 1963

Set up RSN-105 S M2 in 12.~~44~~ 39 in sphere
for traverse at critical DD-2 amp. @ 1.1 × 50 PHS = 100
Hammer @ 1500 Pulses ~10 — 50 volts.

Norm.
Use RSN-75 ~3 in from sphere @ 1700 V
gain ~~204~~ 204 B ~~X32~~ pulse 20 – 80 volts
PHS set at 15.
Acc. used to set power up after each run.

TRAVERSE

POSITION	COUNTER	for 50K on NORM.
32.05	47283	-2.58 ¢
33.05	74 872	-3.88
34.05	99 043	-4.95
35.05	117 500	-5.45
36.05	131 079	-6.10
37.05	134 605	-6.19
38.05	131 091	-4.40
39.05	118 340	-4.15
40.05	99 053	-2.20
41.05	74 931	-1.04
42.05	47 811	Crit

Solution Sampled!

Worth of Counter 44.31 + 1.15
37.05 - 6.61
7.76

Dec 13, 1963

Set up RSN-105S M-2 in 8.78 in sphere

DD-2 @ 50×1.1 PHS @ 100 HAMNER @ 1500

TMC -211 @ 2 μs ch. Input ⊖ with 11:1 pattern Gain X2 (×1 pulses not big enough to count)

Normalizer 1/4" NE 102 @ 950 v 44B preamp 204B ×2 0.2 μs RT PHS = 4 v (should be higher). Neg pulse on cable with 200 Ω term amplified by HP 460B to signal input, gate input from EP 210 (set at 6) gate pulse ~ 20 v high on output of gate on input to scaler pulses almost 40 v high, DISC ~~on scaler~~ set at -53, at -15 it counts the gate!

Trigger pulse from delayed output pulse end of acc pulse delayed further by 8 μsec delay line HH1500.

Film on here! (Placed film on Term of Accelerator)

PNS-353	0.5	300130	Not Col
4	1.5	300110	
5	2.5	300130	
6	3.5	300110	
7	4.5		

Dec 16, 1963

PHS changed on Norm Counter from 5 to 20.
Scint moved closer to target. (21 in below)

	Position	Normalizer	
PNS - 358	3.5	2.00020	Not used
359	0.5	200060	
360	1.5	200060	
361	2.5	200090	
362	3.5	200070	
363	4.5	200080	
364	5.5	200070	
365	6.5	200060	
366	6.5	200110	
367	5.5	200080	
368	4.5	200070	
369	3.5	200090	
370	2.5	200080	
371	1.5	200050	
372	0.5	200070	

Removed film Y - 131 from Dome

Beckman log N Chart indicates accelerator was on for 5 7/8 hours for Dec 13 and Dec 16 runs. Average reading was .011 or 1.1 X 10^{-11} amp.

Changed solution come from H/x ≈ 15 to 190

LAST NAME	INITIALS	BADGE NO.
		Y131

SYMBOL			WK	YR	QTR	YR	DS	DC
24	25	26	27	29	33	35	37 - 42 (RT)	43 - 48 (RT)

FILM DOSIMETRY

☐ EDP DATA

☐ NON-RECORD

FILTER	DENSITY	READING	CALCULATION	RESULT	
W		320			
P		280			
W - P			2.5 (W - P)		
A		120	+ C		DS
C		80	C		DC

Exposed to Rear of
C-W 150KV
Linear accelerator
9213
J C Johnson

Part of exposure recieved thru back of badge

UCN-3507
(3 8-62)

Dec 17, 1963   System same I. H/x ≈ 190

	Counter Pos (in).	Norm
PNS - 373	0.5	200060
374	1.5	200110
375	2.5	200070
376	3.5	200000
377	4.5	200080
378	5.5	200090
379	6.5	228090
380	6.5	200080
381	5.5	200060
382	4.5	200060
383	3.5	200090
384	2.5	200080
385	1.5	200100
386	0.5	200060

Acc. 150 KV 0.80 ma 2 μa Target 1500 cps 40 μsec Burst
TMC - 211 TOF 4 μsec ch gain x2 1/2 memory
Detector for analyzer sig. BF_3 RSN-1055 M2
" " " Norm (gated) 1/4" NE102

Dec 18, 1963   Delay x2 Bkg x2
TMC - 212 Pulsed Neutron @ ~~40~~ 20 μs Ch. Memory 1/2 Disc 3
Acc 150 kv 0.76 MA $< 10^{-5}$ mm Hg Burst 250 μsec
220 cps

	Center Pos (in)	Norm
PMS 387	32.05	200100
388	33.05	200100
389	34.05	200120
390	35.05	200090
391	36.05	200110
392	37.05	200100
393	38.05	200080
394	39.05	200100
395	40.05	200260
396	41.05	200090
397	42.05	200100
398	42.05	200140
399	41.05	200090
400	40.05	200130
401	39.05	221770/2 = 110885
402	38.05	200140
403	37.05	200100
404	36.05	200100
405	35.05	200110
406	34.05	200160
407	33.05	200080
408	32.05	200130
409	34.05	200070
410	36.05	200070
411	38.05	200130
412	40.05	200130
413	42.05	200110

Then data on page 166 show a continuing drift of the "Traversing" counter sensitivity if one assumes that norm system is OK. The number of cycles to collect the 200 000 counts checks with observed levels on log N Beck and Keithley (.04)

Dec 19

10^{50} AM Made run at Keithley log N @ .04

		NORM	
Dec 19 - 1963 - A	37.05	200080	(Recovered some sens.)
B	37.05	200080	
C	37.05	200080	

Change PHS on DD2 to 200.

D	37.05	201190	
E	37.05	200110	

Reduce Keithley log N to 0.02

F	37.05	200040	
G	37.05	200650	

while printing put 10 μa beam on target for ~~20 sec~~

Keithley to 0.37

H	37.05	200050	K ≈ 0.03

1st ½ printed out also.

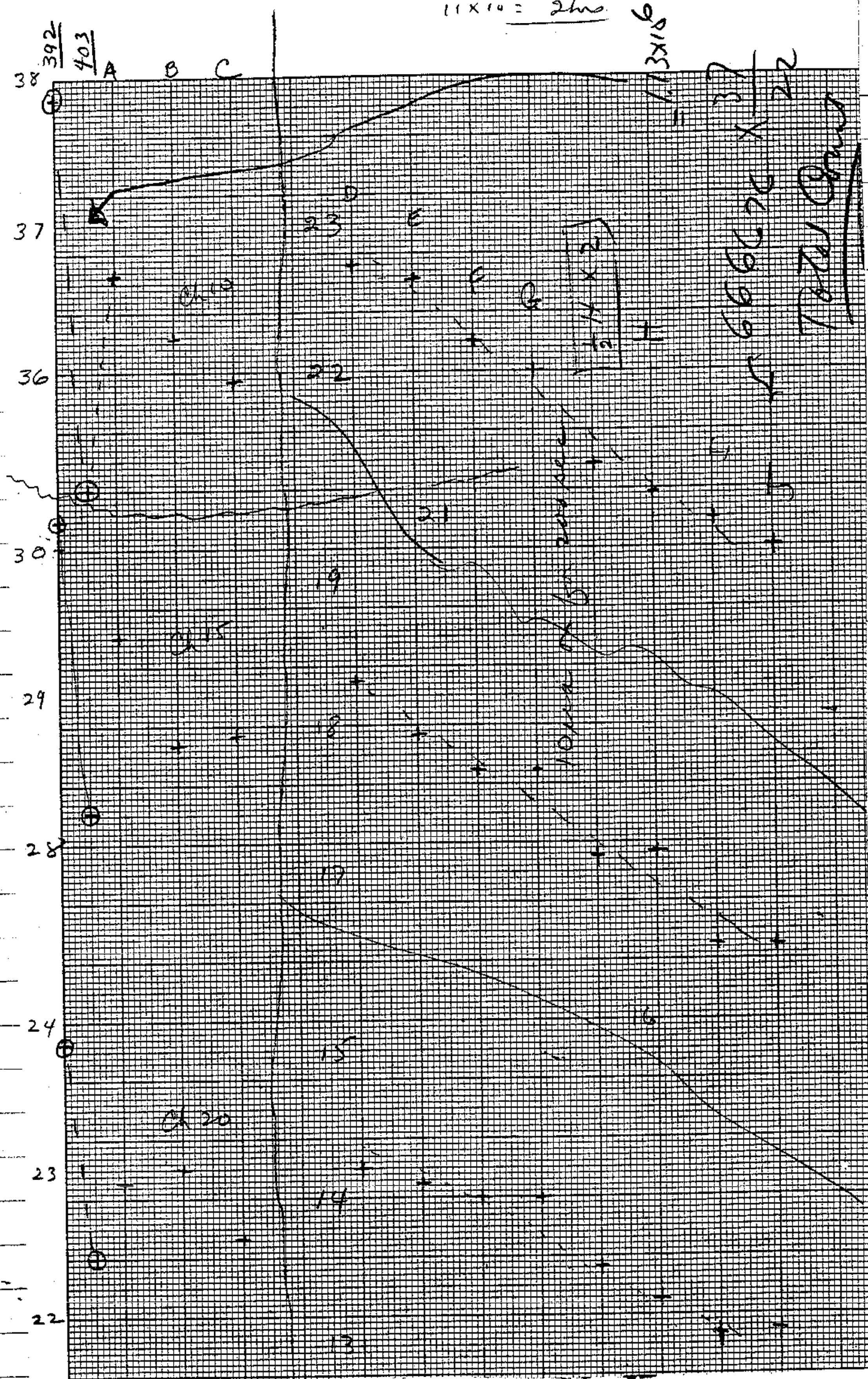
I	37.05	200010	K ≈ 0.04
J	37.05	200080	

N.B. No evidence of Temp change in solution in sphere during the runs A - J.

Run J Total Integrated count = 666 676

∴ Run A corresponds to ~1.13 × 10^6 counts

See p168 for plot of A - J


11×10 = 2hrs
A
B
C
38
37
36
30
29
28
24
23
22
D
E
F
G
23
22
21
19
18
17
16
15
14
13
Ch 10
Ch 15
Ch 20

December 20, 1963

Pulsing at critical

After preliminary runs shut down to investigate source of spikes on Keithley log N and K-1
Vibration from air cylinder and solenoid.

By following set procedure:
- air pressure on to hold safety up
- " " off safety falls under gravity
- When down air press on to hold down
- air press rev. to raise safety —

vibration reduced to a minimum

log N and K-1 also moved so that cables were not jarred.

Before PNS-414 + Period ① 3100 → .42 ¢ > +.49 ¢
+ " ② 2300 .56

PNS-414 Acc 150 kv 0.75 ma 700 μsec Burst at 80 cps TMC 80 μsec channels Bkg x 2 Delay x 2
Disc 2 3/4 Mem 1/2 300
DET 1/2" Ne 102 - 6810A @ 1250v HP 460A + 460B
Pulses ~ 4v max on scope.

Crit Height 10.04. 300 gates every 1 min.
kex(av) = +0.37 ¢

+ Period ① 2600 +.49 > +.25
± " ② ∞ 0.0

PNS-415 Kex = -0.1 ¢
period ① -.37 > -.45
period ② -.52

Chemical Analyses,

			mg U/g	Density
10-10-63	A 220 (11221) Exp #45		255.52	1.5223 @ 24°C
11-7-63	A223 (11281)	" #55	256.08 256.63	1.5242 1.5262
11-13-63	A225 (11299)	60	204.59	1.3740
12-6-63	A226 (11308)	68	203.95 203.32	1.3760 1.3780 @ 25°C

H/4 ~ 90

256.08 g/~~kg~~ → 390.32 mg/ml ~~g/l~~ ×.301 = .11749

1 − .11749 = .88251 × .99704

$= \frac{.87990 \times .6025}{18.016}$

$= 294.3 \times 10^{20}$

H = 588.6

U^{234}	390.32 × .0099 × ~~2.5742~~	=	.0995	$\times 10^{20}$
5	.9244 × 2.5633	=	9.2486	$\times 10^{20}$
6	.0055 2.5524	=	.0548	$\times 10^{20}$
8	.0602 2.5309	=	.5947	$\times 10^{20}$
	Total U		9.9976	$\times 10^{20}$
	N = 20		19.9952	

O = ~~20.0~~ 80.0 + 294.3 = 374.3

203.95 × 1.3760 = 280.64 mg/ml × .301 = .08447

1 − .08447 = .91553 × .99704 = .91282 × $\frac{6025}{18.016}$ = 305.27

H = 610.54

U^{234}	~~.0718~~	.0715
U^{235}	~~7.2334~~	6.6497
U^{236}	~~.0429~~	.0394
U^{238}	~~.4681~~	.4276
	~~7.8162~~	7.1882

O = 362.8

N = ~~15.264~~ 14.38

12 - 13

176.15 mg U/g   1.3085 density @ 25°C

243.18 g/liter or mg/ml

$\times .301 = .07320 \rightarrow 1 - .07320 = .92680$

$.99704 \times .92680 = .92406 \quad \frac{\times .6025}{18.016} = 309.03 \times 10^{20}$

H = 618.06

4	$.243.18 \times .0099 \times 2.5742 \times 10^{21}$ =	$6.\cancel{47}^{20} \times 10^{18}$
5	$\times .9244 \times 2.5633$ =	578.67
6	$\times .0055 \times 2.5524$	3.41
8	$\times .0602 \times 2.5309$	37.05
$UO_2(NO_3)_2$		615.33

$N = 2U = 1230.6 \times 10^{18}$

$O = 8U + 3.090 \times 10^{+22} = 4.923 \times 10^{21} + 3.090 \times 10^{21}$

$\underline{30.90}$

$O = 35.82 \times 10^{21}$

176.15 mg U/g → 1.3085 g/ml @ 25

230.49 g/liter

$\times .301 = .069377 \rightarrow \quad .930632$

$.99704 \times .930632 = .92787 \times \frac{.6025}{18.016} = .0310,3$

$H = 620.6 \times 10^{20}$

4	$.23049 \times .0099 = .00228$	$\times 2.5742 =$	5.87×10^{18} →	$5.87 \times 10^{6} \quad \times 10^{24}$
5	$.9244 = .21306$	633 =	546.14	5.4614×10^{8}
6	$55 = .00127$	524 =	3.24	3.24×10^{6}
8	$602 = .01388$	309 =	35.13	3.513×10^{7}
			590.38	

$N = 1180.76 \times 10^{18}$

$O = (4723.04 + 31030.) \times 10^{18} = 3.5753 \times 10^{22}$

1-2-64 #80 by phone 124.02 mg U/g

Density 1.1967 gm/ml

148.41 g/liter or mg/ml

x .301 = .04467 → .95533 x .99704 = .95250 $\frac{\times .6025}{18.016}$

= 318.54 $\times 10^{20}$

H = 637.08 $\times 10^{20}$

4 .14841 x .0099 x 2.5742 = 3.78 $\times 10^{18}$

5 .9244 x 2.5633 = 351.66

6 .0055 x 2.5524 = 2.08

8 .0602 x 2.5309 = 22.61

380.13

N = 2U = 760.26 $\times 10^{18}$

O = 8U + 3.1854 $\times 10^{22}$ = 3041.04 $\times 10^{18}$

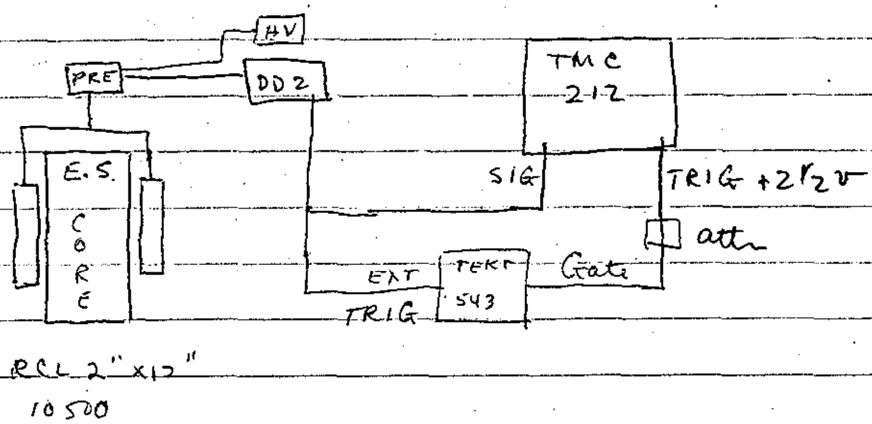
31854. $\times 10^{18}$

34.895 $\times 10^{21}$

February 13, 1964

Additional thought has been given to the measurement of Rossi-α in thermal systems. Thie in his book, "Reactor Noise" quotes the Argonne measurements and others and also shows that counter efficiencies of $\epsilon = 2\times10^{-6}$ are appropriate for fast systems but $\epsilon = 10^{-4}$ is needed for thermal systems whose lifetimes are 10 – 100 μsec. Some notes were found where previous attempts a HFIR Sol exp. yielded only slight decay. a 1/2 RCL counter was used [797 — 562] 16 μsec Ch 64 Ch Total count 6000 CPM (BF3 in soup)

Propose to use large 2" RCL Counters



ERR report that 2 counter work OK. Will try 4.

Plan to measure Rossi α in E Silver's Plate critical Exp.

DWJ

INSTRUMENT CHECK

INSTRUMENT	RANGE	TRIP		SOURCE DISTANCE	SET	START-UP RANGE
K-1	10x10^{-12}	Meter	✓	6"	—	10x10^{-12}
	"	Fast	—	"	—	"
K-2	"	Meter	—	"	—	"
	"	Fast	—	"	—	"
R-1						
R-2					—	
PM-1	700 v	Alarm	—	cont	—	500 v
PM-2	1200 v	Low	—	16"	—	900 v
	"	Alarm	—	"	—	"

LOG N CALIBRATE ✓ OPERATE ✓ SOURCE No. B-60

DUMP WELL PROBE LIGHT ______ ?

START-UP CHECK LIST

Equipment checked by AKH Personnel check by I.D.C

Instruments and safeties checked and reset by AKH

Source in checked by AKH Source No. M-43

Emergency equipment in control room checked by I.D.C

Instruments in trip circuit: K-1 K-2 PM-1 PM-2

Red light on by AKH. Time 0900

Start-up OK'd by I.D.C BWH Date 2-07-63

AKH

		Mom(cm)	Slope (cm)	E.R.
II 1 - 0930	System just crit.	11.1	58.410	.0055

		mon (cm)	Scope (cm)	Log n
0945	Drain water to →			
	System sub crit:	7.49	54.785	.002
	K2 = ~16 on 3X10^{-12} K1 = ~18 on 3X10^{-12}			

10:10 Removed all sources from room. Log n = from ~.0002 to .00065: very unstable:
K-2 = ~8 on 3X10^{-12} K-1 = ~~10~~ on 3X10^{-12}
Water ht same as 0945.

		mon (cm)	Scope (cm)
10:40	added water:	10.60	57.885

K-1 = ~10 on 3X10^{-12} K-2 = ~8 on 3X10^{-12} Log n = still unstable! ~.0015

11:00 Drain back to install another 2" counter.

		mon (cm)	Scope (cm)
11:37	System sub crit:	15.02	62.330

K-1 = ~15 on 3X10^{-12} K-2 = 10 on 3X10^{-12} Log n = .002

11:44 Removed source #M-43 from room:
K-1 = ~8 on 3X10^{-12} K-2 = 5 on 3X10^{-12} Log n = ~.0004

11:55 Drain!
12:53 Shut down:

Estimated critical ht w.o. counters was 55.80 Scope (cm)

55.8

Printed Tape	Log N	Water Level	Counter ~~TMC~~	TMC CH μsec	Scope Sweep ms/cm	
①	.0055	11.1 cm (2.6)	1942			
②	.004	10.7	" "			
③	.002	7.5	"	80	1	
④	"	7.5	"	320	5	
⑤	"	7.5	"	160	2	

Removed large M-226 (or?) from corner
" M-43 from source jig.

⑥	.0002-.0004	7.5	1942	160	2	21887
⑦	~~.001~~ "	~~[illegible]~~ "	"	640	5	
⑧	.0013	10.6	"	160	2	
⑨	"	"	"	160	5	

Install second counter on opposite side of core

⑩	~.0004	15.4	1942-1937	320	5

Moved counters out of assembly in paraffin and plastic 1-2 thick.

⑪ 1942-1937 320 5 ~10½ M in ~1002 cycles

Replace counters in assembly w. 1" plastic

⑫ 4'43" ~1002 cycles

⑬ 10' ~2007 cycles

Therefore there is a neutron source in fuel!

$Al(\alpha - n)P^{30}$

Marion and Fowler

Po α on Al

Roberts .64 n/10^6 alphas

corrected .74 n/10^6 alpha

Breen Hertz .53 n/10^6 alpha

U^{234} $T_{1/2} = 2.48 \times 10^5$ years

$= 2.48 \times 10^5 \times .365 \times 10^3 \times 24 \times .3600 \times 10^4$

$= 7.762 \times 10^{12}$ seconds

$\lambda = \frac{.693 \times 10^{-12}}{7.762} = 8.93 \times 10^{-14}$

λN per Mol $= 8.93 \times 10^{-14} \times 6.023 \times 10^{23}$

$= 5.38 \times 10^{10}$ α/mol U^{234}

$= 2.30 \times 10^8$ α/gram U^{234}

Assume 4.4 kg U in core ~ 1% U^{234}

or 44 g U^{234}

or 1.012×10^{10} α U^{234}

yield from Po α @ 5.3 - 5.4 Mev ~ .53/10^6

U^{234} α @ 4.7 estimated .3/10^6

Therefore neutron yield

$= \cancel{0.69 \times 10}$ $0.303_6 \times 10^4$

$= 3000$ n/sec

at critical M ~ 100 or 3×10^5 n/sec

Power level $= \frac{3 \times 10^5}{3 \times 10^{10} \text{ fiss/watt} \times 2.5} = 4 \times 10^{-6}$

$= 4\ \mu$ watts

Counter Sensitivity $= \frac{5 \times 10^5 \text{ n/sec}}{\cancel{1000}\ 287 \times .03 \times 10^5} = .0167$ perhaps high source much larger

⑥ Removed Sources from Room

160 µs
2 ms/cm

	21887	
1	6590	
2	2876	
3	2835	
4	2703	
5	2642	
6	2549	17
7	2383	
8	2408	
9	2291	
10	2179	
11	2185	
12	2097	12
13	2066	
14	1915	
15	1907	
16	1853	
17	1879	
18	1823	10
19	1686	
20	1805	
21	1656	
22	1671	
23	1582	
24	1631	8
25	1554	
26	1522	
27	1533	
28	1472	
29	1469	
30	1436	6
31	1428	
32	1408	
33	1379	
34	1361	
35	1282	
36	1334	5
37	1273	
38	1311	
39	1266	
40	1283	
41	1295	
42	1220	4
43	1176	
44	1194	
45	1208	
46	1171	
47	1145	
48	1044	2
49	1098	
50	1058	
51	1054	
52	1130	
53	1086	
54	1102	3
55	1139	
56	1144	
57	1140	
58	1072	
59	1105	
60	1064	2
61	1054	
62	1081	
63	1068	
64	1076	

$$\frac{1000}{.160\times 21887\times 10^{-6}} = 307 \frac{ct}{sec}$$
3.50 sec

⑩ 2 Counters

320 µs
5 ms/cm

	10000	
1	11187	
2	4947	18
3	4859	
4	4693	
5	4606	
6	4562	14
7	4339	
8	4112	
9	4072	
10	4030	9
11	3884	
12	3818	
13	3675	
14	3676	5
15	3633	
16	3591	
17	3470	
18	3302	2
19	3324	
20	3386	
21	3308	
22	3276	1
23	3284	
24	3225	
25	3274	
26	3181	
27	3128	
28	3149	
29	3196	
30	3139	
31	3068	
32	3127	
33	3193	
34	3103	
35	3206	
36	3192	
37	3105	
38	3171	
39	3090	
40	3115	
41	3033	
42	3151	
43	3097	
44	3045	
45	3140	
46	3138	
47	3092	
48	3127	
49	3178	
50	3195	
51	3224	
52	3258	
53	3202	
54	3147	
55	3042	
56	3093	
57	3055	
58	3024	
59	3032	
60	3035	
61	3200	
62	3114	
63	3168	
64	3182	

$$\frac{3182}{10^4\times 10^{-6}\times 320} = 1000 \frac{cts}{sec}$$

~~Reactivity of ⑩ must be higher because uncorrelated count is 3 × rather than~~

Bkg in ⑩ should be 4× larger than 6 if react unchanged. However, it must be lower since Bkg only 3 × No⑥.

If Bkg of 800 is subtracted from ⑥ Decay Constant of 230 sec^{-1} is obtained. Its reactivity is unknown.

Count Rate in ①
4000 cts/

9458 × 80 µsec
.756640
= 5287 ct/sec

Marion and Fowler

Po α on Al

Roberts .64 n/10^6 alphas

corrected .74 n/10^6 alpha

Breen Hertz .53 n/10^6 alpha

U^{234} $T_{1/2} = 2.48 \times 10^5$ years

$= 2.48 \times 10^5 \times .365 \times 10^3 \times 24 \times .3600 \times 10^4$

$= 7.762 \times 10^{12}$ seconds

$\lambda = \frac{.693 \times 10^{-12}}{7.762} = 8.93 \times 10^{-14}$

λN per Mol $= 8.93 \times 10^{-14} \times 6.023 \times 10^{23}$

$= 5.38 \times 10^{10}\ \alpha$/mol U^{234}

$= 2.30 \times 10^8\ \alpha$/gram U^{234}

Assume 4.4 kg U in core ~ 1% U^{234}

or 44 g U^{234}

or $1.012 \times 10^{10}\ \alpha$ U^{234}

yield from Po α @ 5.3 - 5.4 Mev ~ .53 /10^6

U^{234} α @ 4.7 estimated .3 /10^6

Therefore neutron yield

= ~~0.69 x 10~~ $0.30\frac{3}{6} \times 10^4$

= 3000 n/sec

at critical M ~ 100 or 3×10^5 n/sec

Power level $= \frac{3 \times 10^5}{3 \times 10^{10} \times 2.5 \text{ fiss/watt}} = 4 \times 10^{-6}$

= 4 μ watts

Counter Sensitivity $= \frac{5 \times 10^5 \text{ n/sec}}{\cancel{100}\ \cancel{287} \times 0^3 \times 10^5} = .0167$ perhaps high

Source must be larger

⑥ Removed Sources from Room

160 μs

2 mol/cm

	21887	
1	6590	
2	2876	
3	2835	
4	2703	
5	2642	
6	2549	19
7	2383	
8	2408	
9	2291	
10	2179	
11	2185	
12	2097	12
13	2066	
14	1915	
15	1907	
16	1853	
17	1879	
18	1823	10
19	1686	
20	1805	
21	1656	
22	1671	
23	1582	
24	1631	8
25	1554	
26	1522	
[illegible]	[illegible]	

⑩ 2 Counters

320 μs

5 mol/cm

	10000	
1	11187	
2	4947	18
3	4859	
4	4693	
5	4606	
6	4562	14
7	4339	
8	4112	
9	4072	
10	4030	9
11	3884	
12	3818	
13	3675	
14	3676	5
15	3633	
16	3591	
17	3470	
18	3302	2
19	3324	
20	3386	

$\frac{10^6}{100 \text{ cts/sec}} = 10^4$ sec

$\frac{10^4}{3600} = 3$ hrs

Reactivity of ⑩ ~~must be higher because uncorrelated count is 3 x rather than~~

Bkg in ⑩ should be 4x larger than 6 if react unchanged. However, it must be lower since Bkg only 3 x No ⑥.

If Bkg of 800 is subtracted from ⑥ Decay Constant of 230 sec^{-1} is obtained. then reactivity is unknown

Count Rate in ①

$\frac{1000 \text{ cts}/}{9458 \times 80 \mu\text{sec}}$

.756640

= 5287 ct/sec

date		Page
June 10	Pulsing CH_2 + Cd investigating room return	93

Contents