BOOK40R

Notes:

Blank pages: inside cover sheets, 2-4, 6, 7, 24, 29, 30, 32, 34, 37-158, 5 sheets (part of book and unnumbered), inside back cover sheets

-page 8 has 4 small pieces of paper glued
-page 9 has graph sheet (big) glued to it
-page 23 has 2 small pieces of paper glued

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August 10, 1999

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Account Book

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Hydrogen (Proton) Recoil Proportional COUNTER FOR NEUTRON SPECTRA MEASUREMENTS

CONTENTS

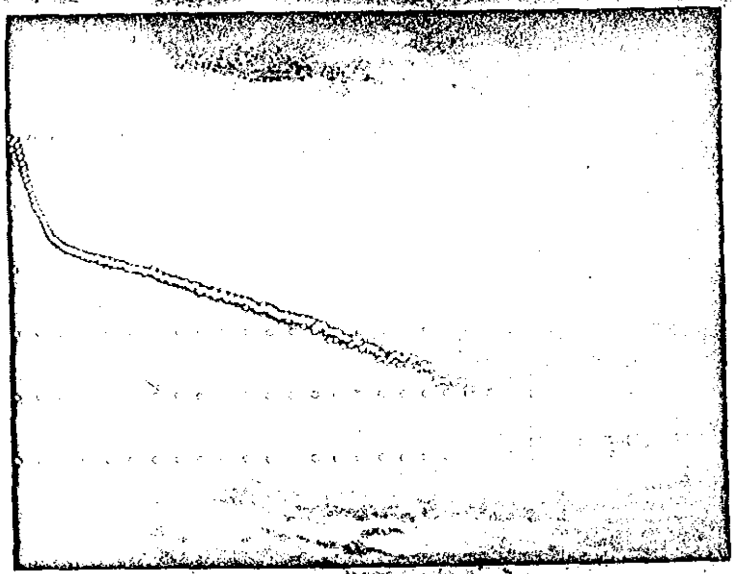
References

E.F. BENNETT, Fast Neutron Spectroscopy by Proton Recoil Proportional ~~Cou~~ Counting, NSE Ms No. 58-65 (R)

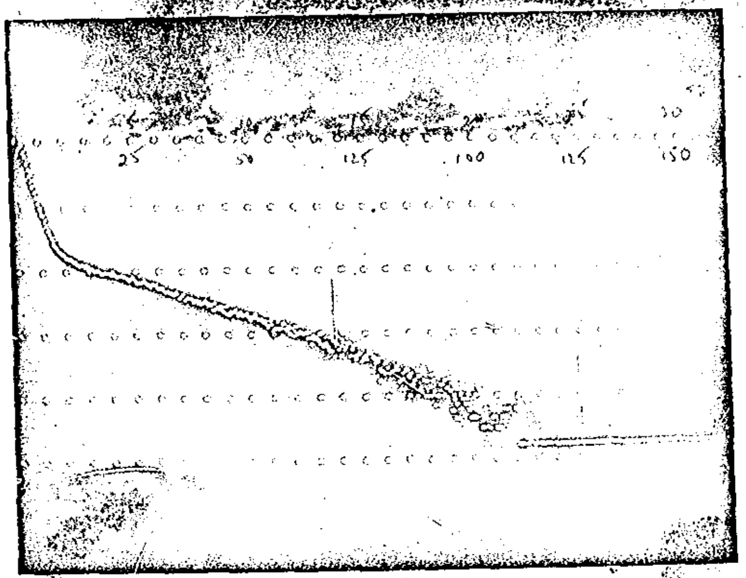
" , Neutron Spectrum Measurement in a Fast Critical Assembly. NSE Ms No. 36-66.

" , A Modified Cascode Preamplifier for Proportional Counters. ARGONNE REPORT - UNNUMBERED.

Robert N. LARSEN, Nanosecond Pulse Stretcher ARGONNE <u>Preprint</u> unnumbered,

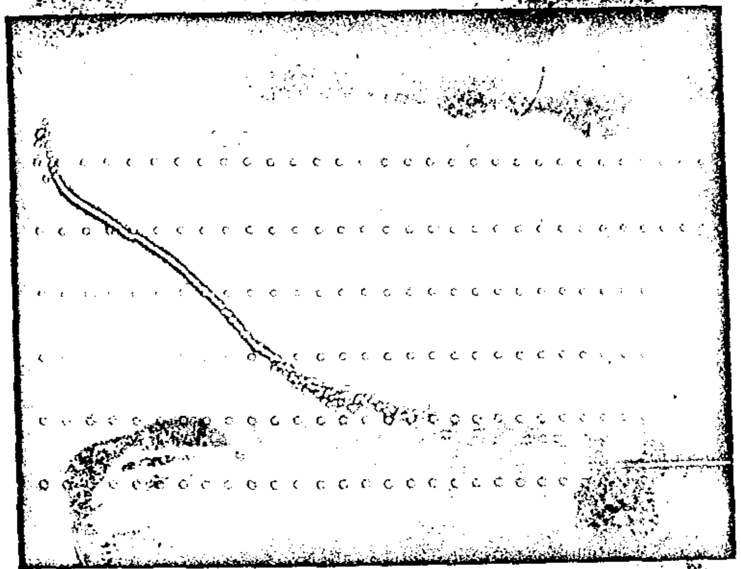


V = 3500 .... 6" hole next to Source

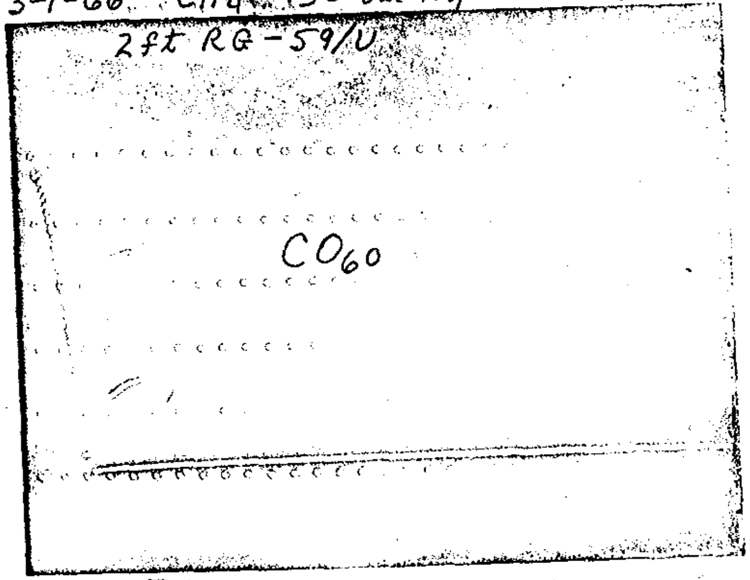


V = 3500 2" hole next to Source

3-1-66. CH4 - 150 cm Hg G-2 BW-5
2 ft RG-59/U



V = 3300

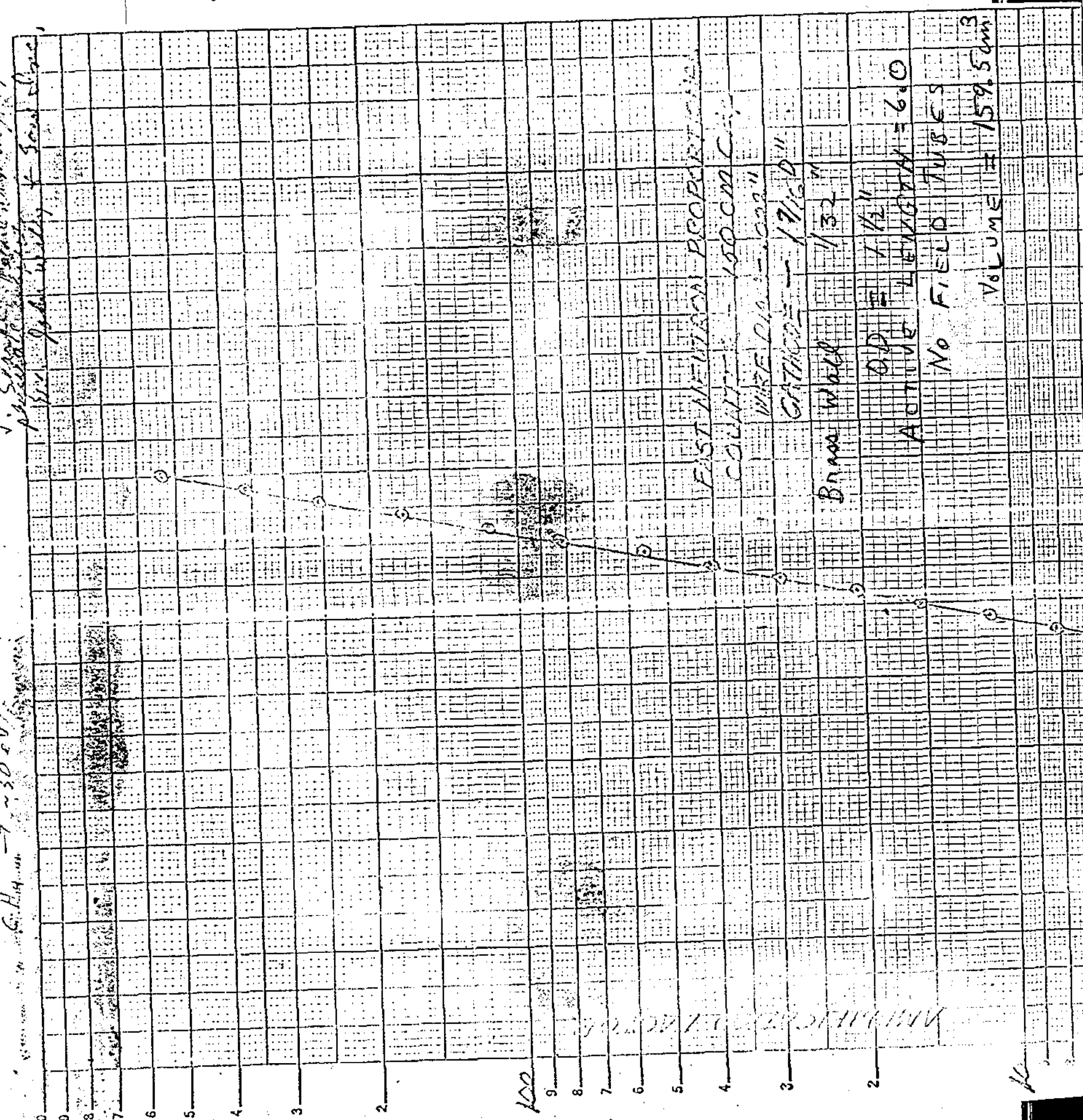


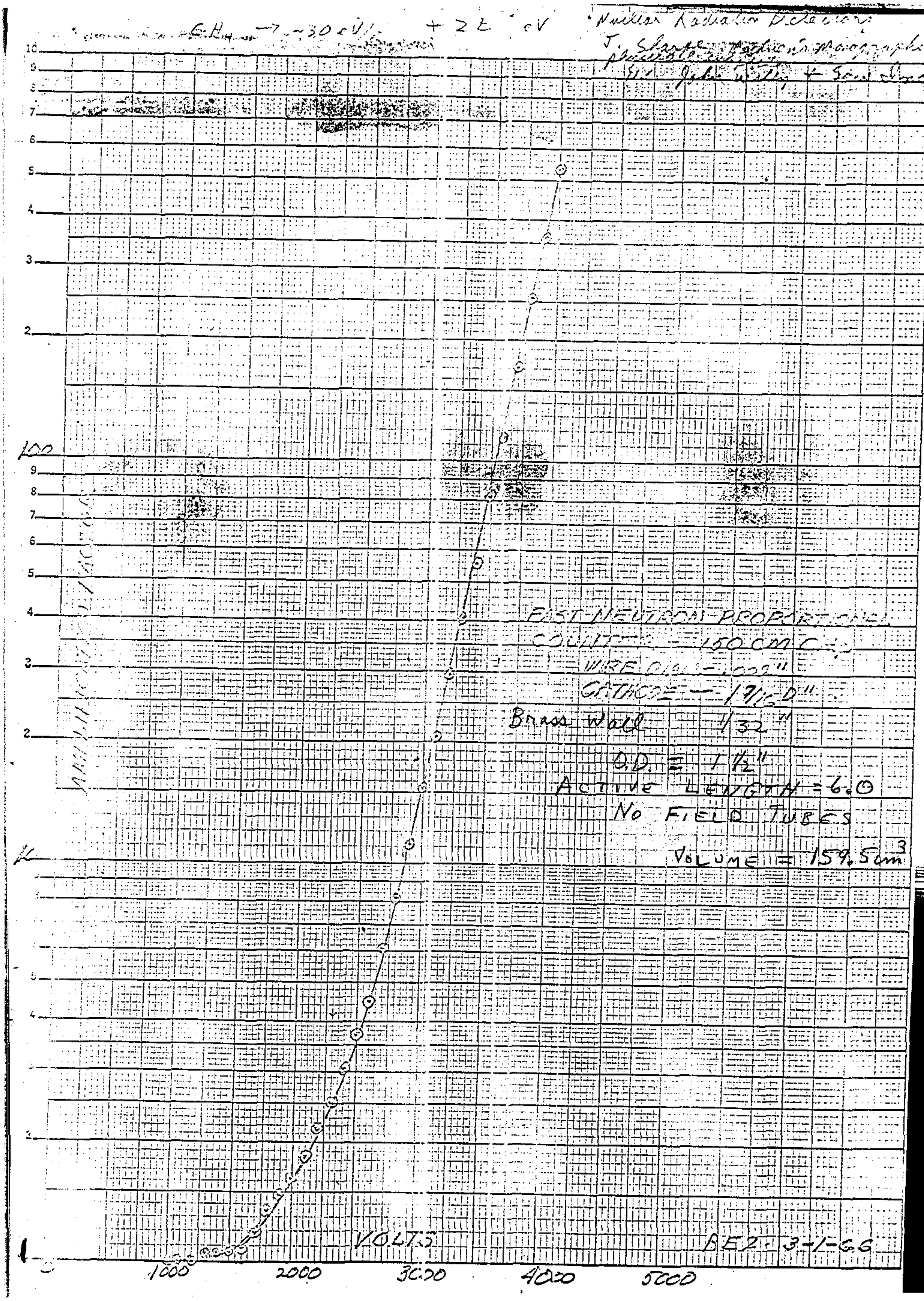
V = 3400

Taken with DD-2 and Voltage Sens. Preamp. (TENNELEC)

FAST NEUTRON PROPORTIONAL COUNTER

fabricated for V.V. Verbinski by R.E. Zedler





FAST NEUTRON PROPORTIONAL COUNTER
fabricated for V.V. Verbinski by R.E. Zedler

19 Oct. At $V = 3500$ $A = \sim 90$, If 1 Mev recoil proton loses 30 ev per ion pair, pulse consist of $3.3 \times 10^4 \times 90$ $= 3 \times 10^6$ electrons. Therefore Verbinski's pulse height distribution may be distorted -- Bennett states that one gets into space charge effects for electron collections per pulse of $\sim 10^6$ and he tries to limit this to 10^5. However, his counter has 1 mil anode wire.

Zedler's has 2 mil " ".

At $V = 2500$ $A = \sim 3.5$ $\times 3.3 \times 10^4 = 1.2 \times 10^5$

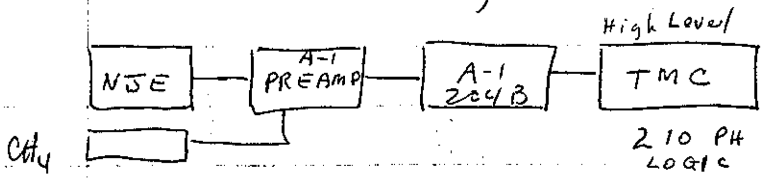
Need P.S. range greater than NJE — 0-2.5 kV.

Drift Velocities for CH_4 [@ $E/p = 0.1$] $v \approx 1$ cm/μsec

~~Electric Field $V \sim \frac{1}{r}$ $E = \int V dr$~~

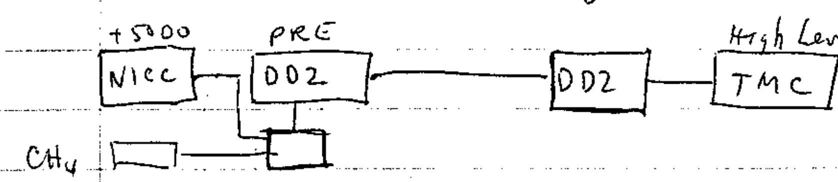
~~$E = K \ln r + C$~~

Summary of Preliminary Experiments with electronics in Bldg 9213.



① With RT = 5μsec TMC not triggered properly
② With RT = 0.8μsec, not certain all charge is collected
③ Noise levels on system high -- ~ ripple on gain settings of 16 of same magnitude as pulses.
④ Reproducibility questionable.
⑤ With 10^5 Pu Be source, recoil proton pulses observed @ 2500 v. (Gain ~ 3.5) A-1 gain 16 RT = 0.8
most pulses stored before. An apparent dist of pulses greater than expected through out 256 channels -- may be noise.
⑥ Pulse output preamp appears to be less than 1μs Rise @ 2500 v.

Changed to DD-2 amp and 5000 volt supply



① Noise observed when 3M print copy machine cycles.
② Noise adds pulses when TMC started only if DD2 is connected.
③ Gamma source pulse from 5mc Cs^{137} are smaller than the largest neutron pulses

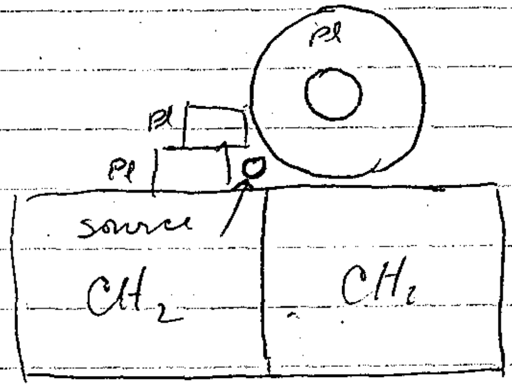
④ With V=4000 ~30 counts in all high channels in 10' count, Bkg count ~0. Perhaps is more noise rather than neutron pulses.

⑤. Count Dist. does not resemble Verbinski's data, source probably different!

⑥ Noise disappears after $4^{\underline{30}}$

⑦ PuBe source energy is too high
Calc peaks @ 1.5, 4 and 7 MeV with neutrons up to 10-11 MeV.

Oct 25, 66 ① Wrapped counter sensitive volume with 4 mil U^{235} foil surrounded with 2 1/8 ID x 5 3/4 OD plastic (plexiglas). Placed Pu Be source outside annulus of plexiglas



② Repeated counts with Pu-Be source with ~2" lead broadside and on end and w.o. lead.

③ No real diff in p.H. dist noted.

Range 1mev Protons in H_2 = 1.3 cm @ 160 cm Hg
1 MeV in CH_4 = 1.1 cm "
1.4 MeV Protons in CH_4 = 2.0 cm "
1.5 MeV " " " = 3.1 cm "

Carbon recoils expend 40% more energy per ion pair formed than proton recoils.

$\sigma(C) = 2.6$
$\sigma(H) = 4.3$

$\frac{H \text{ recoils}}{C \text{ recoil}}$ $\frac{4.3}{2.6} \times 4 = 1.65 \times 4 = 6.6$

∴ Carbon recoils ~ 13.6%
a sizeable low energy correction

Range at 800 cm Hg = 1.1 cm
(~10+ atmos)

Vol I Fast Neutron Phys.
"from 20 kev up to 3.0 MeV an amplification not greater than 30 nor less than 10 will be required."

B

a) ~~A > 10~~ If A > 10 pulse ht independent of position in counter.
b) for 20 kev energy noise in ampe corres

(glass)

Oct 26, 64 Thorngate ORNL Health Physics Div — 270

questions Bennett's pulse discrimination technique as one which separates protons from gammas. As a result of a computed program, they found a strong dependence of pulse rise time as a function of track orientation with respect to the wire anode. ranging from tens to hundreds of nanoseconds. Differentiating (150 ns.) selects only those with rise times less than 150. (It was not made clear to me why gammas or electrons give pulses with long rise times.) Pulses parallel have short R.T. Pulses ⊥ have long Rise Times. He also questioned the neutron spectra unscrambling technique used by Bennett, preferring one like the computerized one of Burrus & all used at Tower and Bulk Shielding Facilities.

He is going to look into neutron energy or spectra measurements with prop. counters, looking in particular at the pulse discrimination method and trying to improve the electronics in general. Blosser will work with him.

(Henry exp. with 14 MeV neutrons in Nevada will have priority!)

27 Oct

For neutron spectra measurements above 1 MeV, the proton recoil (in liquid scintillators) method, Verbinski et al could be set up immediately essentially duplicating their eqpt.

For measurements below 1 MeV, we need a complete new set up including

① Proton recoil proportional counters

a) large to minimize end & wall corrections

b) avoid methane if possible to avoid correction for carbon recoils, range in H_2 greater than CH_4

c) high pressure hydrogen to shorten proton range (also minimizing end and wall corrections.

d) Anode wire uniformity .001 vs .002

② High Voltage Supply

a) Digital type for accurate reproducibility of voltage settings.

b) 8 - ~~4~~000 for 0.002 anode
less for 0.001 anode

③ Amplifiers and Preamp.

a) Low Noise and High Gain
Noise of DD-2 reduced x 100
Gain of DD-2 probably adequate

b) L. A. in PHA CN-110 may be used with adequate gain in preamps.
To be matched!

c) DD-2 Gain 20 Gas Amp ~ 10
Pu Be Source, ~~pulses~~ high level input
pulses stored as high as Ch. 80
perhaps 10 MeV. No peak observed
at 7 MeV or 4 MeV. ∴ END and
Wall corrections must be severe
for these proton ranges!
To observe 10 keV neutrons overall
gain probably should be 10^3 higher
gas amp of ~~500 could~~ 100 to 500 (except for saturation effects in counter for high energy work)
could be used and main amplifier
gain 2× to 10× higher than (20 DD2) used.
~~2× higher than (20 DD2)~~

④ Low Energy neutron Source
Li-α-n peaks at 200 keV with neutrons
up to 1 MeV.
N_2 calibration reaction ~~gas~~ with thermal neutrons
$N(n_{th}, p) C^{14}$ 615 keV proton
resolution obtained by Bennett as low as 5%
means of counter acceptance (on $N(n,p)C^{14}$)

27 Oct Telephone Verbinski re fast neutron proton recoil liquid scintillator NE 213 with pulse shape disc. ckt.

① Base location of components very important recommend duplicating their arrangement exactly.

② Linear signal uses Tennelec Voltage Sens. preamps, ± polarity and DD-2 amplifier (cannot use DD-2 preamp because polarity of pulse is wrong.

③ Delayed 2 μs using HH 2000 cable to P.H.A.

(pol for neutron effects in counter for high energy recoil)

③ Anode signal – preamp a white cathode triode cathode follower to a Mod A-8 Coincidence ckt – (timing with what other pulse?)

④ Selected 6810A photo tubes give better perf. Photo cathode sens. 80 – 120 μa/lumen. See V. McKay I&C.

Selected therefore RCA 7265 for purchase with NE-213, 2 in x 2 in Scintillators

31 Oct 66 Roher & Magnuson discussed details of Neutron Spectra Meas. with V. Verbinski. affirmed other discussions. Acquired reports and wiring Diagrams

2 Nov 66 If light pulse from Stilbene (RSI, 32, 666)

$$I(t,E) = \alpha(E)e^{-t/6.2} + \beta(E)e^{-t/370}$$

t = ns

$$\text{total light output} = \int_0^\infty \alpha(E)e^{-t/6.2}\,dt + \int_0^\infty \beta(E)e^{-t/6.2}\,dt$$

$$= 6.2\,\alpha(E) + 370\,\beta(E)$$

For protons of a few MeV $\beta/\alpha \approx 0.021$

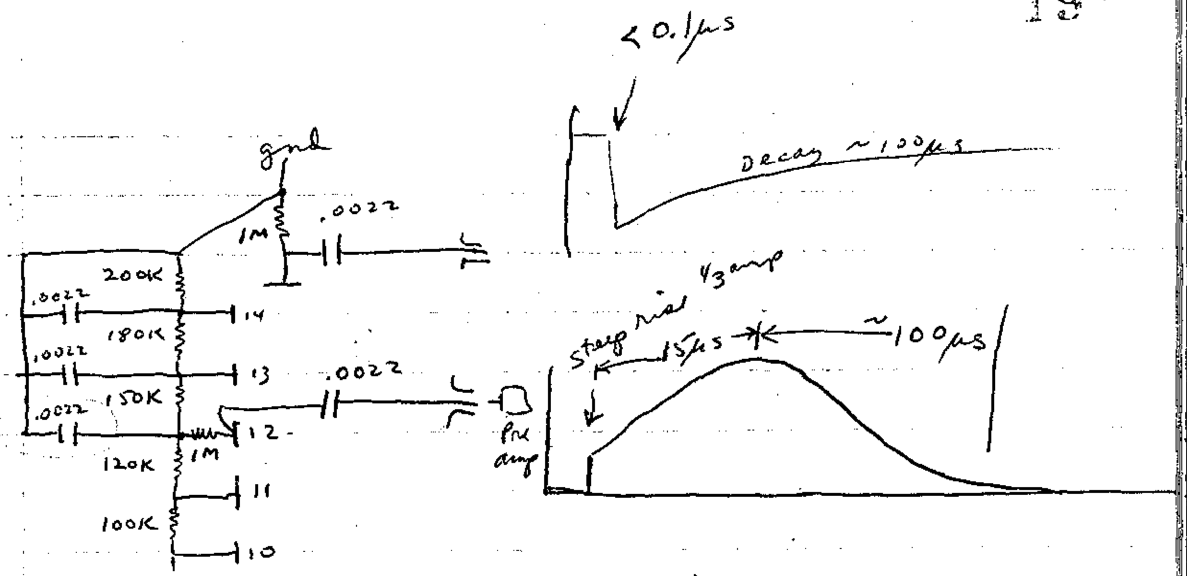
electrons 0.011

$$\text{Ratio } \frac{\text{fast}}{\text{slow}} = \frac{6.2}{370 \times .021} = \frac{6.2}{7.43} \text{ for protons} = .83$$

$$= \frac{6.2}{370 \times .011} = \frac{6.2}{4.07} \text{ for electrons } 1.52$$

proton $\frac{\text{slow}}{\text{fast}} = 1.20$

electron $\frac{\text{slow}}{\text{fast}} = 0.66$



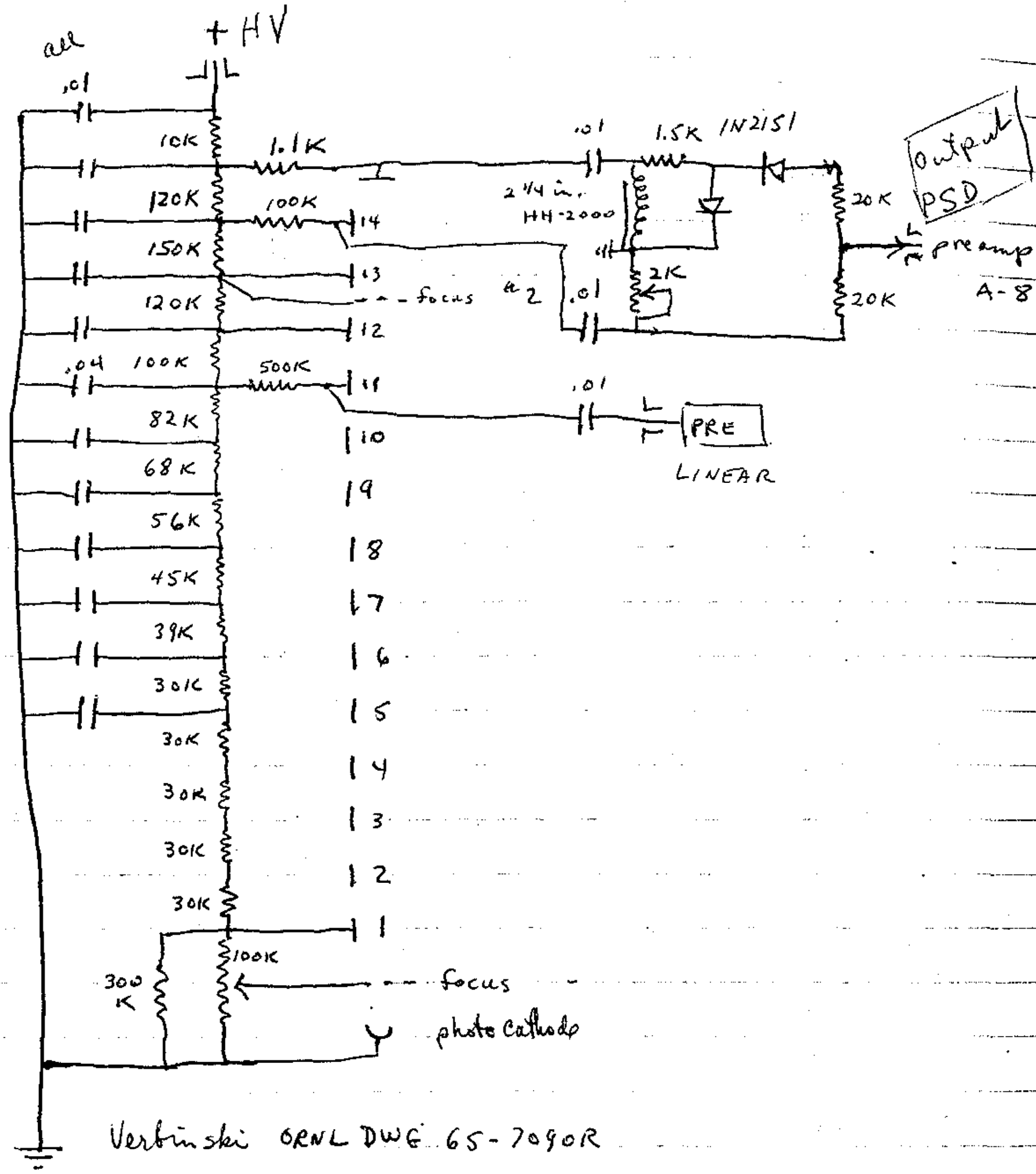
ETC 1-9 same as 10. (100K)

1st attempt to see the signal on Dynode 12 using an PM base with above values of Voltage divider the pulse shape is unexplained. Attempts to modify the 15 μs part of pulse were unsuccessful. Voltages on voltage divider seemed normal when checked with VOM, ~~Increased~~ add 0.0047 with 0.0022 Mfd cond — no change

Added 0.01 " to Dynode 11 — no change

Tripled cable length on input to preamp — no change.

[signature] 15 Nov

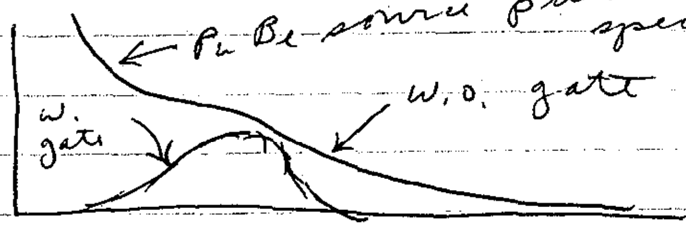


Verbinski ORNL DWG 65-7090R

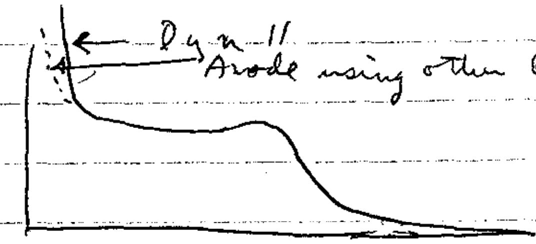
ER Rohrer wired a PM base ala Verbinski.
Signal observed at preamp input observed as a fn of setting of 2K pot using Co^{60} gamma rays. Although the pulses from NE 102 do not have visible

pul
D
reamp
A-8

amounts of slow component, it must be present to get the cancellation effects observed at preamp input. A range of + and − pulses were observed with decay times of a few microseconds. Varying the 2K pot changed the ratio of these + and − pulses as well as amplitudes. Using a setting of the 2K pot which minimized the pulses on [PSD], Neutron pulse spectra were run on The TMC with and without a coincidence gate from the [PSD]



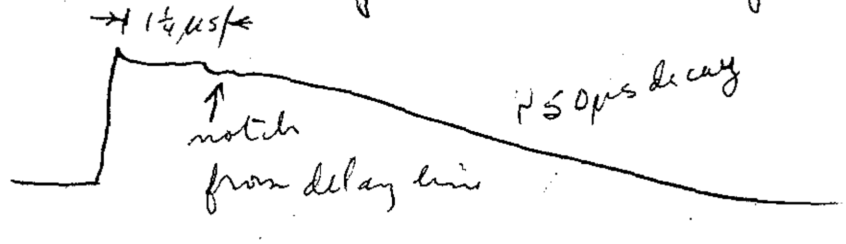
The spectra from Co^{60} on NE-102 does resemble Verbinski's data on 213, however 213 has a sharper cut off. Co^{60} spectra recorded from Dyn 11 and TMC L.A. seems to have much more noise or low energy pulses!



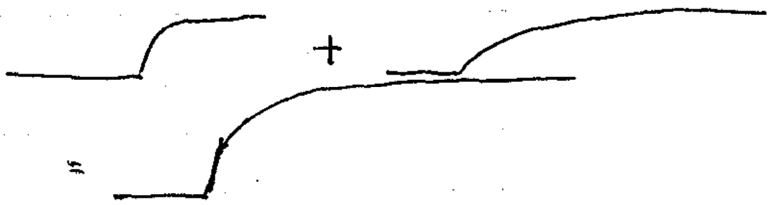
However, the copying machine in counting room may be source of these extra noise pulses!

17 Nov 1966

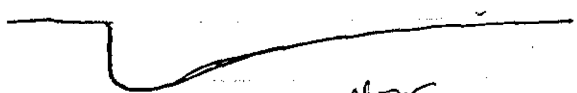
Pulse from Dynode 11 ∅ pre amp DD-2 was fed to LA TMC set for + pulses. This arrangement was not ideal because the delay line in DD-2 put a notch in the pulse. Actual pulse



was not clean. Initial overshoot also not explained. Shape should be



if slow and fast component are equal.
On ~~Dynode~~ Anode one could see some



rounding due to ~~fast~~ slow component ~~or other~~ pulse distortion effects not understood!
Pulse shape described on p19 not understood.

Dec 12, 1966

Mounted NE-213 #4006 (Vert. Mount Style) on RCA 7265 No. 10141

Observed to be very noisy -- possibility of high dark current or decay of scint. which were both exposed to light. (HV base)

11^{00} ~~0.70 M.V. for 40K counts in Bkg ch.~~ Base 50 + HV

12^{00} (Base allows light thru.

Retaped base of PM Tube 7265.

also Mounted NE-213 # 4007 (Horiz Mount) on RCA 7265 No 10 349. Covered with Al Foil and Black Tape.

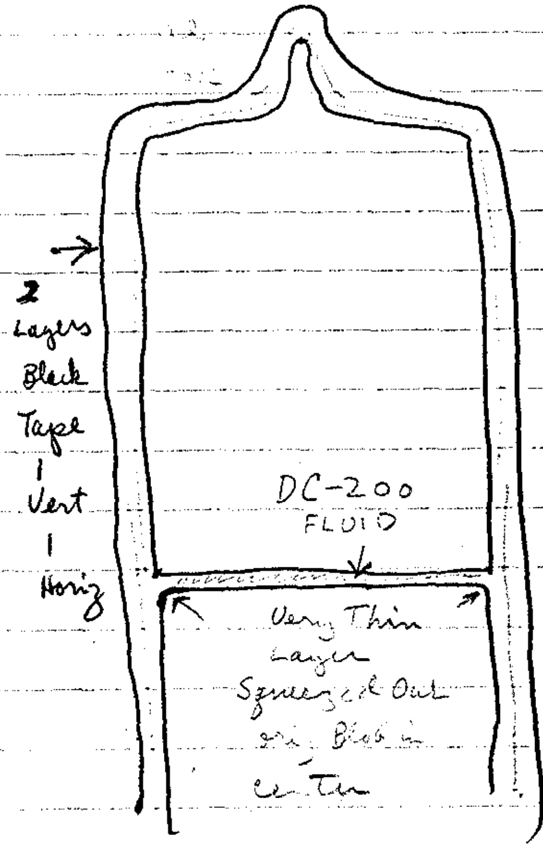
TEST DATA

TYPE	7265
SERIAL No	Z10141
CATHODE SENS	160. µA/L
CATHODE RED SENSITIVITY	.54 µA
ANODE SENS.	18500. A/L
@	2400 V
DARK CURRENT	.050 µA
@	1000 A/L

TEST CONDITIONS BASED ON TUBE BULLETIN DATED 9-58 AND REV. DATED 8-63

RCA

Form No. TL2343-4



TEST DATA

TYPE	7265
SERIAL No	Z10349
CATHODE SENS	160. µA/L
CATHODE RED SENSITIVITY	.42 µA
ANODE SENS.	7200. A/L
@	2400 V
DARK CURRENT	.092 µA
@	1000 A/L

.092x10^{-9}

TEST CONDITIONS BASED ON TUBE BULLETIN DATED 9-58 AND REV. DATED 8-63

RCA

Form No. TL2343-4

Recorded spectrum from ^{60}Co and Pu Be source

①	4006	@-1250V	DD-2 gain	1.0×1.0	^{60}Co	Hi Level Input
②	4006	@-1250	"	0.4×1.0	Pu-Be	from anode
③	4007	@-1250	"	1.0×1.0	^{60}Co	
④	4007	@-1250	"	0.4×0.5	Pu Be	

Using PM base for -HV supply

⑤	4006	@+1950 V	TMC-gain	64×1.0	^{60}Co	Low level TMC+ (from 11th dynode)
⑥	4006	@+1950 V	"	16×1.0	PuBe	
⑦	4007	@+1950 V	"	"	PuBe	
⑧	4007	@+1950	"	64×1.0	^{60}Co	
⑨	4007	@+1950	"	16×1.0	PuBe +2 in. Pb	
⑩	4007	@+1950	"	32×0.75	Po-Be	
⑪	4006	@+1950	"	32×0.75	Po-Be	
⑫	4007	@+1950	"	32×0.75	Po-Be with new Term on Preamp box	

To be complete, Temple is developing two other methods for pulse shape discrimination

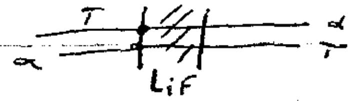
1. Essentially the system Ortec borrowed from ORNL
   Time to zero crossover is different for γ and p. called TAC system
2. Pulse amplitude / Tail amplitude — Ratio measured electronically
   Neutron (proton recoil) pulse has ~ 20% of slow light
   gamma (electron) pulse has ~ 5% of slow light
   depends on a gate not having a pedestal.

anti log [log (Pulse integration) − log (tail integration)] separates events into 2 groups. log device must have large dynamic range.

[Bennett has used similar]

Nov 6, 1967

On Nov 5 ERR & Dwm discussed measuring neutron spectra with T. Love and W. Zobel. They are improving the Verbinski system. They state that the NE-213 is good down to 200-300 keV and perhaps 100 keV by careful attention to details — Temple believes that one could get lower perhaps 30 keV with the LiF sandwich again considerable development using extremely thin LiF "radiators". Energy loss differences between ^4_2He and T recoils limit the resolution. Also suggested was the ^3He spectrometer in which the recoil



~~px~~ part is detected in a sandwich detector. None of the methods are really suitable for reactor spectra.

We also discussed Bennett's (ANL) work with hydrogen filled prop. counters. Temple was not at all familiar, but from results published he was of the opinion that the method was promising.

Later I called RK Abele, Counting Lab to inquire if they had done anything on hydrogen recoil counters since last year. He informed me that Muckenthaler and Clifford, Tran, Neut Phys Div !!! were ordering immediately, if not sooner, six spherical H_2 filled proton recoil counters from 20th Century Elect. Eng. for this purpose. Benjamin of Harwell had calibrated counters filled with 1, 3, and 10 atm of H_2 and these calibration data have been (or will be furnished) and the computer unscrambling based on these data will also be sent.

Further conversation with Muckenthaler revealed that Thorngate of H.P. did some work for them over the last year but he wasn't interested in building a system but wanted to make a research project out of it. Probably related to the problem of pulse rise time with recoil direction, position etc when compared to an electron. They are using the Harwell system because it works! at or least worked for Benjamin et all at Harwell. (Blosser & Thorngate accomplished little in the past year, see p 14)

Feb 2, 68 Conversations with Blosser last Nov Dec indicated that the TAC systems resolve n - γ pulses well, but the relationships vary with amplifier settings, with voltage on counter, etc and each system must be investigated separately to find the correct settings to get good n-γ discrimination

12-14-67

Check out of parallel plate Fission Counters.
Pulse height distributions measured (1962) show poor resolution of fragment recoil. Counters refilled by Zeidler, but not checked since.

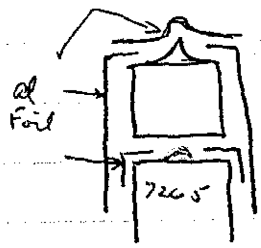
FC-9	^{235}U =	$\frac{\#9}{\#10}$ = ~1.060		meas ratio = 1.04 OK 12-14-67	
FC-10	^{235}U =			"	
		M. Ratio	C. Ratio		
13	^{234}U =	.957	~1.24	21% EXT to zero	
14	^{234}U =			16% EXT to zero	
11	^{236}U =	1.042	.85	9.7%	EXT to 0
12	^{236}U =			4% EXT "	to 0
7	^{238}U =			– %	" " "
8	^{238}U =	N G			
		M. Ratio	C. Ratio		
17	^{237}Np = 1.7 mg	.810	.699	1%	Small extrap to 0 pulse
18	^{237}Np = 2.1 mg			2%	

See Rafferty notebooks for details since calibration were done with neutrons from 2% blocks
1/4" o.d. fission counters 235-3 & 238-2 measured essentially the same fission ratio as the parallel plate counters did.

Have concluded that the uranium foils are not good, mass do not agree! Thickness may vary considerably to give rise to small pulses.

Febr 7, 1968

Upon T. Love's recommendation NE-213 were un-mounted to remove the "plastic" white reflective coating on the glass vials. He recommended putting crinkled Al foil next to glass. He also recommended putting an aperture on the photo tube. Used a 1 3/8" i. d. hole in Al foil on end of photo tube base. Reassembled and covered with black electrician tape.



Vert. Mount 4006 on 7265 Serial No Z10141

Horiz " 4007 on 7265 " " Z 10349 Red Dow Corning 200, Discussion with Jere Nichols Re phone on Aug 21, 69

Subject

Material Analysis of fuel elements using delayed neutrons ala Keepin.

To be able to confirm that an irradiated fuel element contains more ^{233}U than that which was loaded into it.

a. Accuracy needed less than ± 1%
probably ± 0.1%

b. Source strength of fuel element from
(α, n), (γ, n) etc, large $> 10^8$

Assume irradiation by pulsed reactor or ORELA

During 100 sec count time, ~90-95% of all delayed neutrons are emitted.

Background then $100 \times 10^8 = 10^{10}$

Delayed neutrons should be $\sim 10^{13}$

Prompt neutrons $\beta = 0.2$ $\sim 5 \times 10^{15}$

fissions $\sim 2 \times 10^{15}$ — $\frac{3.1 \times 10^{10} \text{ fiss}}{\text{watt sec}}$

watt seconds $\sim 0.6 \times 10^5$

0.06 MWsec

If burst is produced in ORELA, 0.1% absorbed in fuel element

ORELA Burst Size $\sim 2 \times 10^{18}$ required.

For LMFBR & LWR see program ORNL CF 69-3-34

Pu source strengths ~ 5-8 $\times 10^5$ n/sec kg Pu

Outer Fuel element has 7.69 kg fissile ~ 6×10^6 n/sec

Count for 100 sec source strength = 6×10^8 background

Total delayed × 100 = 6×10^{10} 100:1 Sig/Bkg

Total prompt × 500 = 3×10^{13}

Total fissions ≈ 1×10^{13}

Total neutrons in irradiation burst × 1000

≈ 1×10^{16}

If total fissions are 1×10^{14}

sig/Bkg increased to $\frac{1000}{1}$