CRITICAL DESIGN REVIEW 4/26/69

BBRC

DAWSON | GARIN | KRIMIGIS
MANNY GREEN | KOHL
EARL GRAY | GLAZIER
FRANK MANDERS

PROGRAM STATUS - DAWSON (PROTO - 24 DEC)

① DECISION ON GOLD ABSORBER & SCINTILLATOR

② PERMISSION TO CONTACT APL ON NONSTANDARD PARTS, EG. SLIGHTLY OUT OF TOLERANCE

STOGSDILL - LIGHT COLLECTION ON SCINTILLATOR. & TUBE NOISE ~ 25×10^{-14} COUL AT 1500 VOLTS
5×10^5

E.S. CALCS. MIN. IONIZING ~ 3×10^{-13}

RCA 7151 ~ 5×10^5 1200 - 1500 VOLTS.

<u>OBJECTIVE</u> - TO SET ΔE = 100 KEV
WITH 35 KEV
E.E.S. - POSSIBLE BUT ONLY JUST.

REPORT ON ACTION ITEMS

1. Scint. to be painted in & out 1-2 then water soluble pilot

2. SILICONE SPONGE ON GOLD ABSORBER - silicon tape + RTV 60

3. Gold abs. to be hard mounted by pins S.MK. AVOID VOIDS IN GOLD (MAY MOLD PINS ON THE SLUG)

4. D-3 mounted? 0 VOLTS FWD
~1μ DEAD LAYER
+ SURF ~ 200μ DEAD & CHGS. WITH TIME UNDER BIAS.

5. VENTING - use 1/4" tapped hole 1/4" 20 threads + safety wire

SILASTIC TAPE WILL BE RELIEVED

7.) SPACER - VESBEL SPACER .090 x .085
THREE POSTS.

8.) D-3 PIN.

9.) N.A.

10.) YES.

11.) YES.

12.) ROUND BACK CORNER OF SCINT CU,

13.) YES.

14.) YES.

15.) YES

16.)

LOOK AT NICKEL FOIL HOLDER ARE
INC. THICKNESS TO .064"?

17, 18, YES.

MANDERS: RESONANCE IN Z AXIS ALONG
SCINTILLATOR. REQUIRES PRELO
→ USE CuBe RATHER THAN ALUMINUM.

6/4/70

AFTERNOON

KOHL: DETECTORS 5 GM SCINTS (PROTO GRADE)
ORDERED MORE 22 MAY PILOT M
G.M. TUBES - 506213's REDUNDANT.
LND's - 705 KRYPTON
704's

A.P.L. – progress meeting 6/18/70

schedule accelerator time for proj 15
L.R.C. accelerator time ?
→ IPA. action.

Kohl - PMT - decision to be made.

SEC. 8 AUG 1 — DATA REQUIREMENTS.
D. WILLIAMS

6/24/70 Arranging accelerator time at L.R.C.

telecom Ralph Krone —
Inst Dev Div. J. J. Singh

N.A.S.A. 700 - MeV synchro-cyclotron
4 MeV dynamitron
+ lin accelerator

6/4/70

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schedule accelerator time for July 15
L.R.C. accelerator time ?
→ IPO. action

Kohl - PMT - decision to be made

SEC. 8 Aug 1 - DATA REQUIREMENTS
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Inst dev div. J. J. Singh

N.A.S.A. 700 - MeV synchrocyclotron
4 MeV dynamatron
+ lin accelerator

1/25/70 FACILITIES:

ENERGY RANGE 350 GeV 600

CURRENT: 0.1 Ma no trouble

ENERGY SPREAD -

PURITY -

TARGET AREA -

TIME AVAILABLE -

Space Rad. Lab. NASA ... 3816 ext (

Dr. Siegel, Robert Direct

→ William & Mary * 877-92.. Newport N

Air Force — (E.G.G.)

Prime time difficult

Parasitic time

wn 60 MeV absorbers
(½cm × 10")

$10^{10} - 10^{12}$ p
(10^{5} cm²
→ diffuse be

1" dia. sma

(S. MARDER)
No CHARGE

> Scheduled through Sept.
Procedure to apply –
Request to L.R.C.

Newport News – to Route 64 to
Airport E. Va 143
11970 Jeff. Ave
Any time Tues. or Wed. –

6/26/70 INITIAL CALIBRATION REQUIREME

SYNCHRO-CYCLOTRON AT SPACE RAD. EFFECTS

ENERGY AVAILABLE 60 to 600 MeV

1. PET FOREGROUND CHANNELS TO MEASURE absolute efficiency WITH SCINTILLATOR ON & OFF
   - P9 $50 \leq E_p \leq 100$ MeV
   - P10 $100 \leq E_p \leq 170$ MeV (set by tungsten penetrat
   - P11 $170 \leq E_p \leq 500$ MeV

   EXPECTED EDGE [illegible]

2. SCINTILLATOR $E_p \gtrsim 50$ MeV

3. CHECK INELASTIC CONTRIBUTION TO ALPHA RATES IN ALL DETECTORS

   channels.

A1	A4 $\overline{A5}$ $\overline{B1}$
A2	A5 $\overline{B1}$
A4	B6 $\overline{B7}$ $\overline{C1}$
A5	B7 $\overline{C1}$
A7	C5 $\overline{B6}$
Z1	A6 $\overline{B1}$
Z2	A7 $\overline{B1}$

4. upper thresholds of gm tubes for protons

5. ΔE vs E curves for elements of pet.

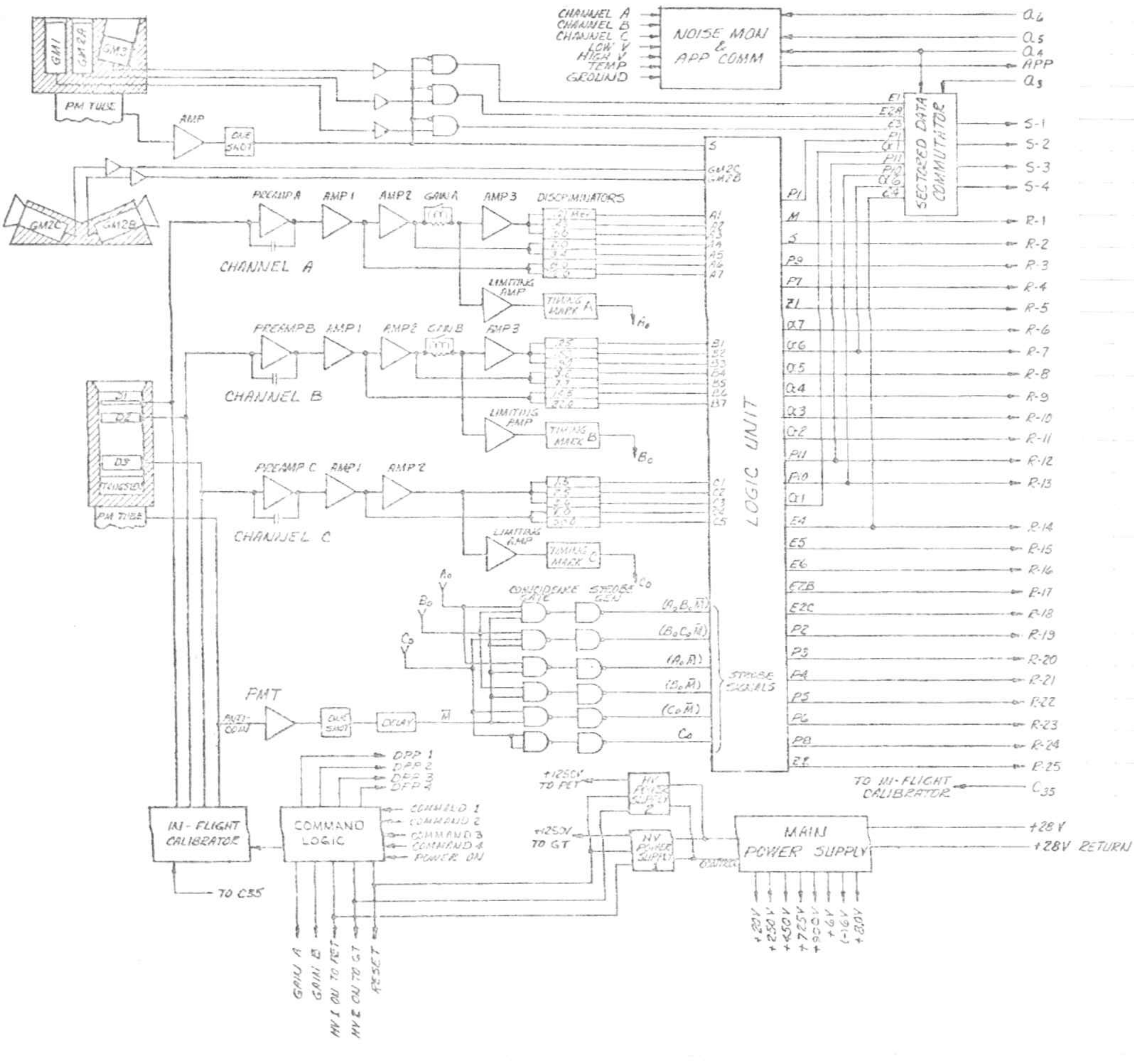
6. verify effectiveness of –

TS

LAB

FLUX DYNAMIC RANGE = 10^5 to 10^{12} /cm^2 sec

BLOCK DIAGRAMS & INFO TAKEN FROM JAN. 1970
6/26/70



RSION OF EXPT. REQ. DOCUMENT BY P.E. CASH

Detector Designation	Detector Type	Particle Type	Channel Designation	Energy Interval	Geometric Factor cm^2 sr	Dynamic Range $(cm^2 \text{ sec sr})^{-1}$	Signal Name
T roton-Electron lescope)	Solid State Detectors and anticoincidence plastic scintillators	Electrons	E4	$0.2 \le E_e \le 2.5$ Mev	0.956	$0 - 10^6$	R-14, APL-S3*
			E5	$0.4 \le E_e \le 2.5$	0.956		R-15
			E6	$0.7 \le E_e \le 2.5$	0.956		R-16
		Protons	P1	$0.3 \le E_p \le 0.5$ Mev	2.5		APL-S3*
			P2	$0.5 \le E_p \le 0.9$	2.5		R-19
			P3	$0.9 \le E_p \le 1.9$	2.5		R-20
			P4	$1.9 \le E_p \le 3.9$	0.956		R-21
			P5	$3.9 \le E_p \le 8.0$	0.956		R-22
			P6	$8.0 \le E_p \le 14.0$	0.956		R-23
			P7	$14.0 \le E_p \le 30$	0.956		R-4
			P8	$30 \le E_p \le 50$	0.956		R-24
			P9	$50 \le E_p \le 100$	0.956		R-3
			P10	$100 \le E_p \le 170$	0.956		R-13, APL-S4*
			P11	$170 \le E_p \le 500$	0.956		R-12, APL-S4*
		Alphas	A1	$2.0 \le E_\alpha \le 3.6$ Mev	0.956		APL-S4*
			A2	$3.6 \le E_\alpha \le 7$	0.956		R-11
			A3	$7 \le E_\alpha \le 17$	0.956		R-10
			A4	$17 \le E_\alpha \le 32$	0.956		R-9
			A5	$32 \le E_\alpha \le 60$	0.956		R-8
			A6	$60 \le E_\alpha \le 120$	0.956		R-7, APL-S4*
			A7	$120 \le E_\alpha \le 200$	0.956		R-6
		Integral Protons and Alphas	M	$E > 50$ Mev/Nucleon ($9\ cm^2$)			R-1
		Particles with $3 \le Z \le 5$	Z1	$E > 8$ Mev	2.5		R-5
		$6 \le Z \le 8$	Z2	$E > 32$ Mev	2.5		R-25
·1	705 GM Tube	Electrons	E1	$E_e > 15$ keV	0.02	$10 - 10^8$	APL-S1
		Protons		$E_p > 250$ keV	0.02	$10 - 10^8$	
		X-Rays		$2 < \lambda < 10$Å			
·2A ·2B ·2C	~~6213~~ 704 LND ~~GM~~ Tube (3)	Electrons	E2A E2B	$E_e > 45$ keV	0.03	$10 - 10^8$	APL-S2*
		Protons	E2C	$E_p > 500$ keV	0.03	$10 - 10^8$	R-17
		X-Rays		$2 < \lambda < 10$Å			R-18
·3	LND-L1887A GM Tube (foil)	Electrons	E3	$E_e > 120$ keV	0.03	$10 - 10^8$	APL-S2*
		Protons		$E_p > 2800$ keV	0.03	$10 - 10^8$	
		X-Rays		$2 < \lambda < 10$Å			
	Scintillator	Integral Protons and Alphas	S	$E > 50$ Mev/Nucleon ($6\ cm^2$)			R-2

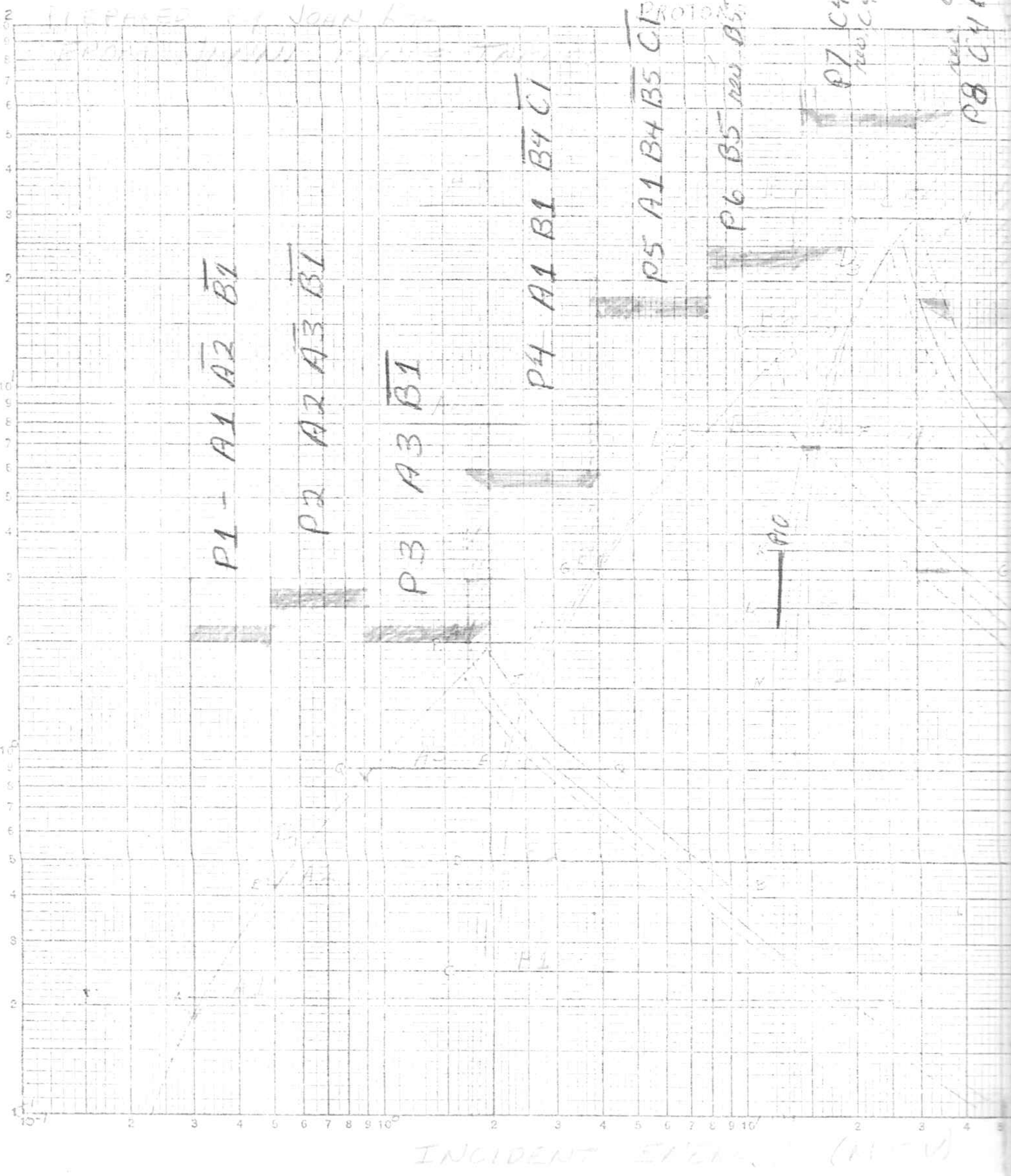
tes signals that are subcommutated into these words

RANGE - ENERGY CALCULATIONS IMP H & J

DET A = 40 µ VERTICAL 43.4 OBLIQUE (22.7°)

B = 1000 µ VERTICAL 1084 "

C = 3000 µ VERTICAL 3251 "



USE JANNI AFWL-TR 65-150

STOPS [illegible]

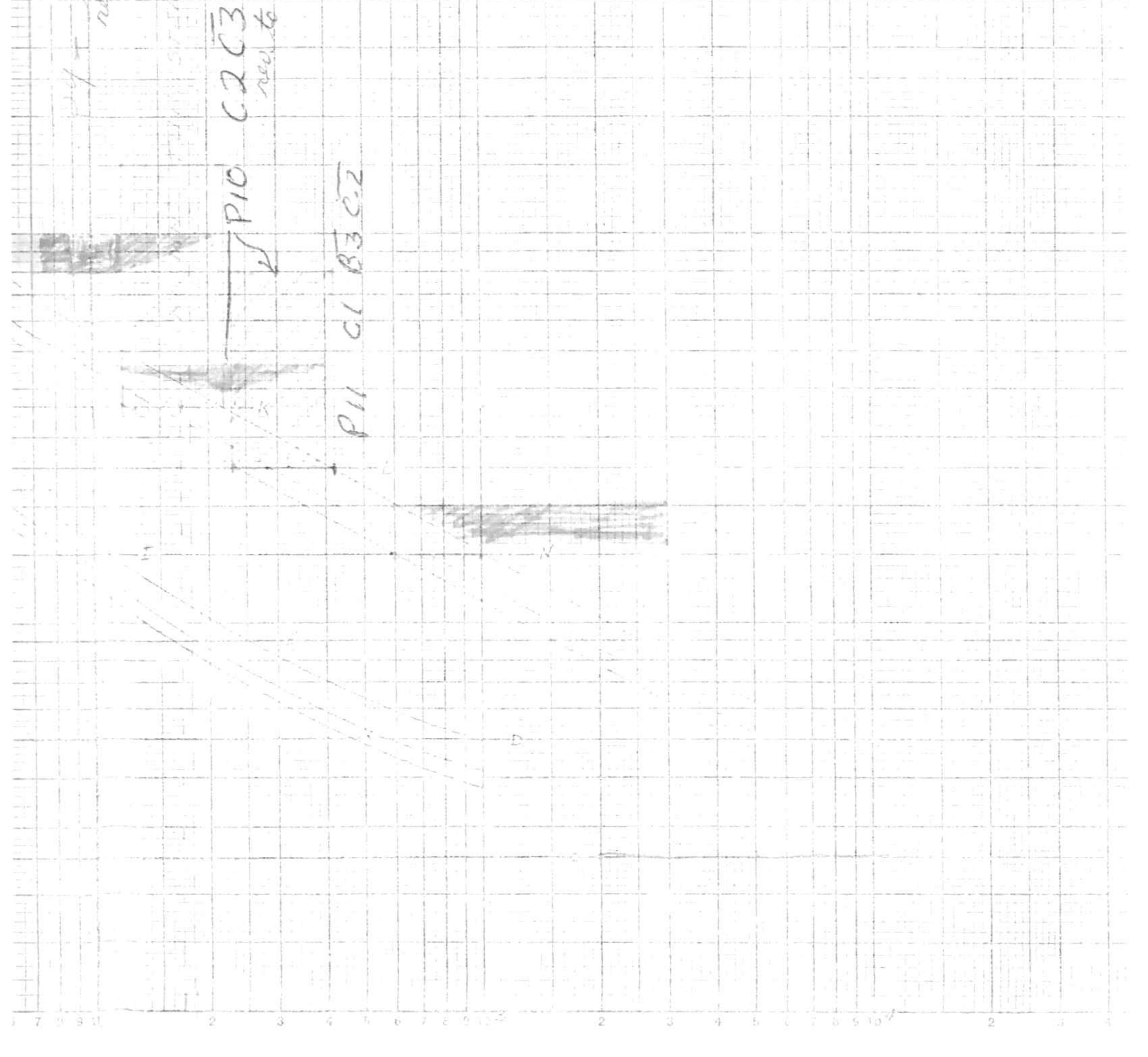
1040μ STOPS ~12.3 MEV (VERTICAL)

1127μ STOPS ~12.? MEV (OBLIQUE)

4040μ STOPS ~ 27.0 MEV (VERTICAL)

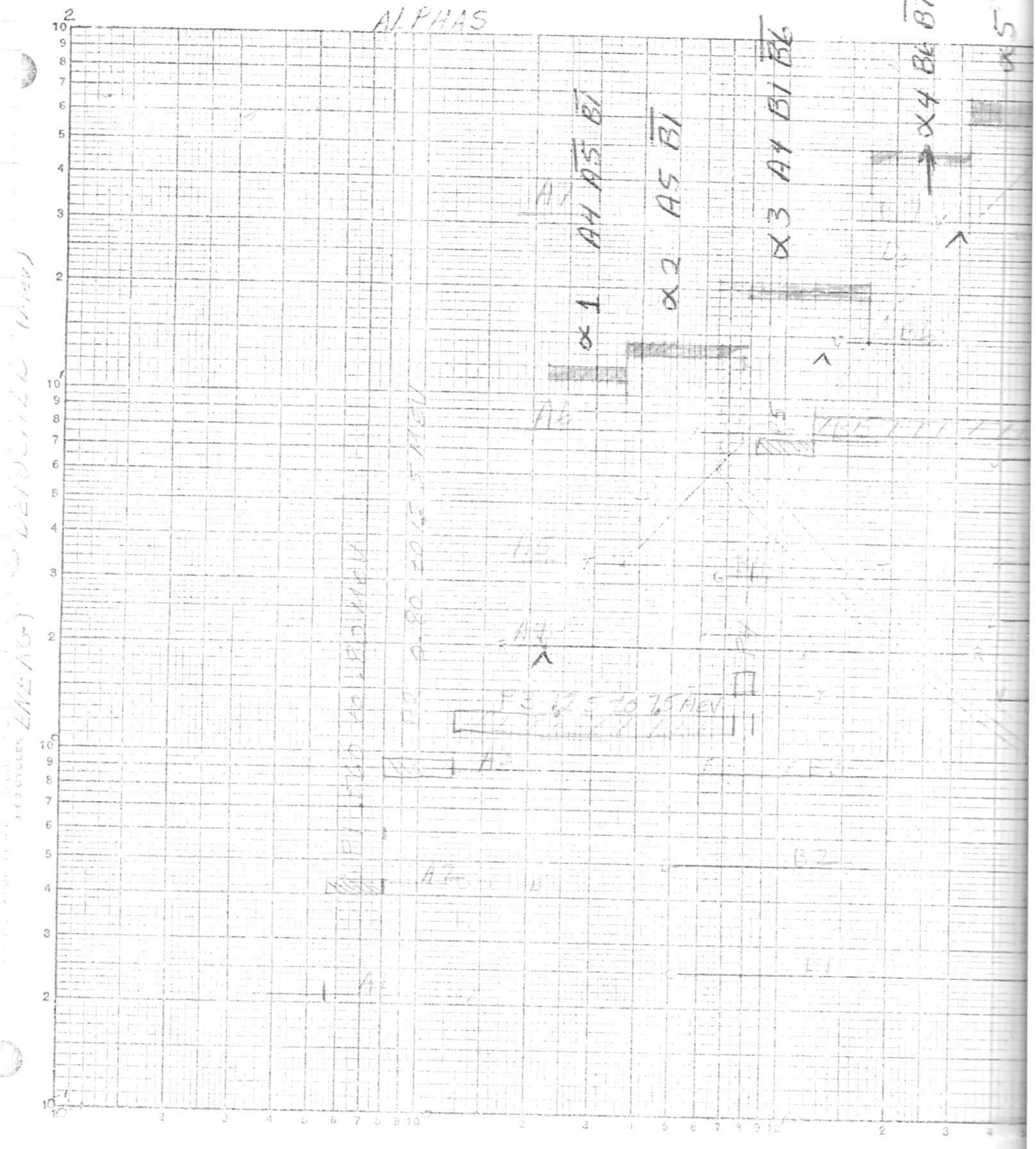
4378μ STOPS ~ 28.0 MEV (OBLIQUE)

	[illegible]	[illegible]	[illegible]
D_1	40μ	37μ	45.?μ
D_2	1040	920	1110
D_3	3800	2700	



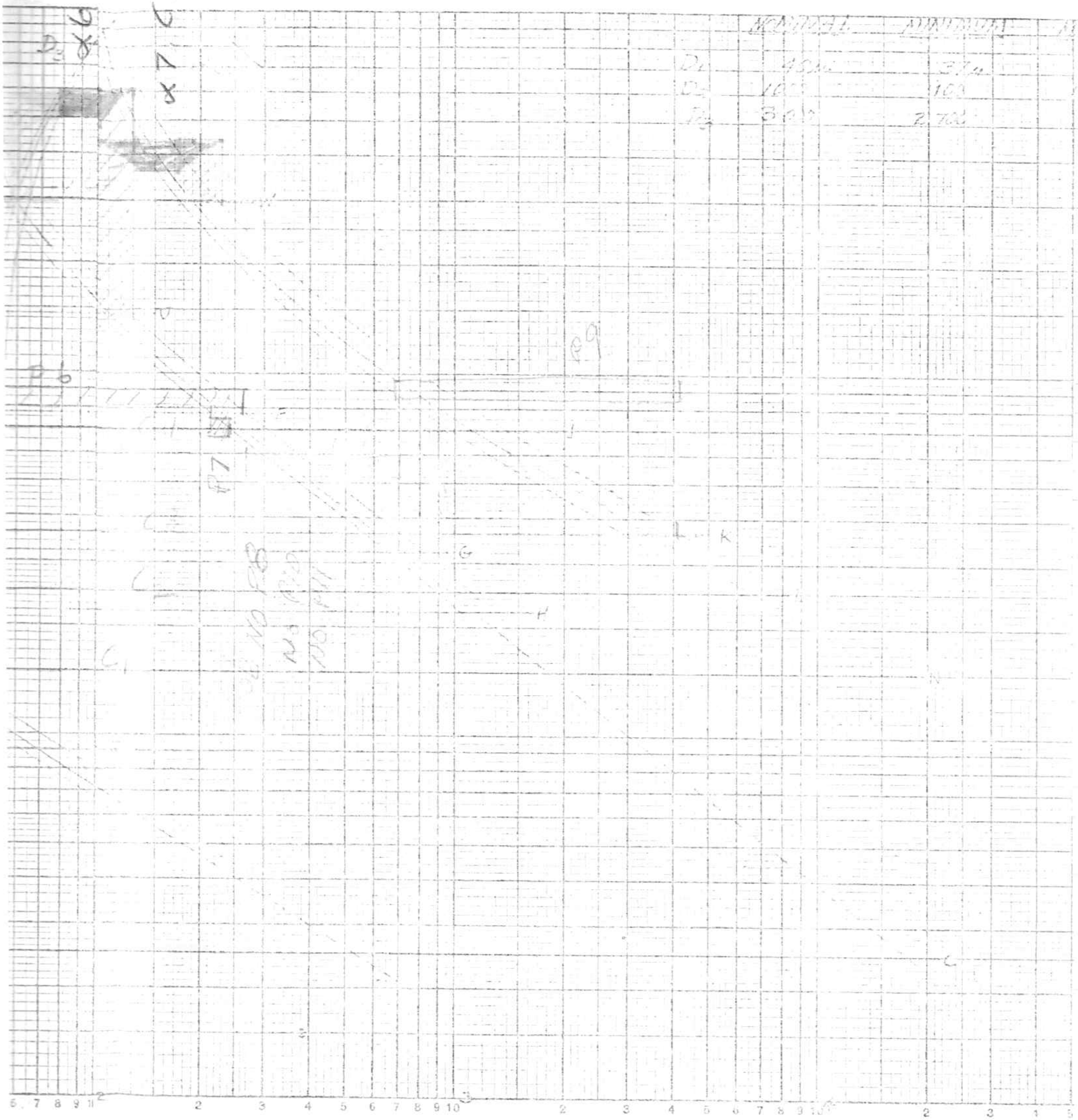
revised to B7 C1 A2 M

revised to B6 B7 C1 A0 M



C5 B6 → revised to C5 $\overline{B6}$ B4 $\bar{M}$

x6 x7 C5 $\overline{B6}$



6/29/70 PATH LENGTH STRAGGLING (protons)

R.M. Sternheimer, Phys Rev 117, 485-488, 1960.

– see also Janni, range tables

Suppose we know ϵ or σ due to

ⓐ discrete energy loss

& ⓑ changes in path length

we want to know the spread of ΔE expected

R_0 entry range E_0 = [illegible] energy

R_1 exit range E_1 = exit energy

Suppose $R_0 = R_0 \pm \sigma_0$

$R_1' = R_1 \pm \sigma_1$

Now $\Delta E = E(R_0) - E(R_1)$ average

$$E_{TOT} = \sum_{i=1}^{n} \Delta E_i$$

assume σ's add in root mean square

$$\Delta R = R_0 - R_1 = t$$

$$\sigma_{\Delta R}^2 + \sigma_1^2 = \sigma_0^2$$

$$\sigma_{\Delta R}^2 = \sigma_0^2 - \sigma_1^2 = \epsilon_0^2 R_0^2 - \epsilon_1^2 R_1^2$$

considering [illegible] MeV proton in a 1,000 μ detector:

$\Delta E \sim 1.5$ meV $\epsilon_0 = \epsilon_1 = 0.012$.

$$\sigma_{\Delta R}^2 = 1.44 \times 10^{-4} (R_0^2 - R_1^2) = 1.44 \times 10^{-4} (R_0 - R_1)(R_0 + R_1)$$

dispersion of apparent path length in detector

$$\frac{\sigma_{\Delta R}^2}{(R_0 - R_1)^2} = \frac{1.44 \times 10^{-4}}{} \frac{R_0 + R_1}{R_0 - R_1} =$$

$R_0 \cong R_1 \cong 4152\,\mu$.

$R_2 - R_1 = 1000\,\mu$.

$$\frac{\delta E}{\Delta E} = \left\{ 1.44 \cdot 2 \cdot \frac{4152}{1000} \right\}^{1/2} 10^{-2}$$

$$\frac{\delta E}{\Delta E} = 3.5\ \%$$

...ed in the same manner as in the previous calculations of the density effect for the ionization loss.[12] The effective excitation potentials I_n for the various

... 1.16 at 100 Mev, and 1.11 at 200 Mev.

R. M. Sternheimer, Phys Rev. 117, 485–488, 1960

III. RESULTS

The results of the calculations are given in Tables I and II. For the calculations for protons (Table I), the

TABLE I. Values of the percentage range straggling ϵ_p for protons in Be, C, Al, Cu, Pb, and air.

T_p (Mev)	$T/\mu c^2$	Be	C	Al	Cu	Pb	Air
2	0.00213	1.704	1.867	1.968	2.293	2.659	1.981
4	0.00426	1.550	1.631	1.814	2.030	2.331	1.679
6	0.00640	1.469	1.526	1.720	1.875	2.187	1.564
8	0.00853	1.419	1.466	1.649	1.779	2.079	1.498
10	0.01066	1.382	1.424	1.597	1.749	1.994	1.452
15	0.01599	1.322	1.357	1.507	1.667	1.865	1.376
20	0.02132	1.286	1.315	1.450	1.609	1.828	1.335
25	0.02665	1.259	1.285	1.408	1.562	1.783	1.304
30	0.03198	1.238	1.263	1.377	1.526	1.742	1.280
40	0.0426	1.206	1.230	1.330	1.468	1.674	1.244
50	0.0533	1.183	1.203	1.297	1.425	1.619	1.218
60	0.0640	1.165	1.183	1.271	1.390	1.574	1.197
70	0.0746	1.149	1.166	1.249	1.363	1.536	1.180
80	0.0853	1.135	1.152	1.231	1.339	1.505	1.165
100	0.1066	1.112	1.128	1.201	1.300	1.464	1.141
120	0.1279	1.094	1.109	1.178	1.271	1.431	1.121
140	0.1493	1.078	1.093	1.157	1.245	1.401	1.104
160	0.1706	1.065	1.078	1.140	1.225	1.376	1.087
200	0.2132	1.041	1.054	1.112	1.190	1.333	1.060
250	0.2665	1.017	1.029	1.084	1.155	1.289	1.036
300	0.3198	0.997	1.009	1.060	1.127	1.254	1.016
350	0.373	0.980	0.991	1.040	1.104	1.225	0.999
400	0.426	0.966	0.976	1.023	1.085	1.200	0.984
500	0.533	0.942	0.952	0.996	1.052	1.160	0.959
600	0.640	0.924	0.932	0.974	1.028	1.127	0.939
800	0.853	0.897	0.904	0.943	0.991	1.081	0.909
1000	1.066	0.879	0.886	0.921	0.966	1.049	0.889
1500	1.599	0.856	0.862	0.891	0.928	1.002	0.860
2000	2.132	0.850	0.855	0.882	0.915	0.981	0.850
2500	2.665	0.853	0.857	0.882	0.913	0.973	0.849
3000	3.198	0.860	0.864	0.888	0.917	0.972	0.853
4000	4.26	0.881	0.884	0.907	0.933	0.982	0.869
5000	5.33	0.907	0.910	0.931	0.957	1.000	0.889
7000	7.46	0.964	0.965	0.985	1.010	1.047	0.935
10 000	10.66	1.048	1.049	1.067	1.092	1.122	1.005
15 000	15.99	1.178	1.179	1.195	1.220	1.244	1.115
20 000	21.32	1.295	1.295	1.311	1.336	1.357	1.214
25 000	26.65	1.401	1.401	1.416	1.442	1.460	1.304
30 000	31.98	1.499	1.498	1.512	1.540	1.555	1.384
40 000	42.63	1.674	1.674	1.686	1.716	1.727	1.508
60 000	63.95	1.969	1.968	1.979	2.013	2.018	1.772
80 000	85.27	2.214	2.212	2.223	2.260	2.262	1.983
100 000	106.6	2.426	2.425	2.435	2.475	2.475	2.168

TABLE II. Values of the percentage range straggling ϵ_μ for μ mesons in Be, C, Al, Cu, Pb, and air.

T_μ (Mev)	Be	C	Al	Cu	Pb	Air
0.225	5.081	5.566	5.866	6.835	7.927	5.904
0.450	4.621	4.862	5.408	6.052	6.948	5.005
0.676	4.379	4.550	5.127	5.588	6.520	4.662
0.901	4.229	4.371	4.917	5.302	6.198	4.467
1.126	4.120	4.244	4.761	5.213	5.944	4.328
1.689	3.941	4.044	4.491	4.968	5.558	4.101
2.252	3.834	3.921	4.322	4.798	5.448	3.981
2.815	3.753	3.831	4.197	4.657	5.315	3.888
3.378	3.690	3.764	4.104	4.548	5.193	3.815
4.50	3.596	3.666	3.966	4.375	4.991	3.709
5.63	3.527	3.587	3.867	4.247	4.826	3.630
6.76	3.472	3.527	3.788	4.144	4.693	3.569
7.88	3.425	3.477	3.724	4.063	4.580	3.519
9.01	3.384	3.435	3.670	3.992	4.487	3.474
11.26	3.316	3.364	3.580	3.876	4.365	3.401
13.51	3.260	3.306	3.511	3.788	4.265	3.341
15.76	3.214	3.258	3.450	3.713	4.178	3.290
18.02	3.174	3.214	3.399	3.652	4.102	3.240
22.52	3.104	3.142	3.315	3.548	3.972	3.160
28.15	3.031	3.069	3.231	3.442	3.844	3.090
33.78	2.973	3.006	3.161	3.360	3.737	3.029
39.4	2.922	2.955	3.101	3.291	3.653	2.977
45.0	2.878	2.910	3.050	3.234	3.577	2.932
56.3	2.809	2.837	2.970	3.136	3.456	2.858
67.6	2.754	2.780	2.904	3.064	3.360	2.798
90.1	2.673	2.695	2.809	2.953	3.221	2.709
112.6	2.621	2.641	2.744	2.879	3.124	2.648
168.9	2.536	2.553	2.641	2.749	2.969	2.549
225.2	2.511	2.526	2.607	2.703	2.900	2.512
281.5	2.515	2.526	2.602	2.692	2.871	2.504
337.8	2.530	2.542	2.614	2.699	2.864	2.511
450	2.586	2.596	2.661	2.740	2.884	2.548
563	2.655	2.663	2.725	2.800	2.930	2.600
788	2.803	2.808	2.867	2.938	3.048	2.719
1126	3.022	3.025	3.079	3.150	3.239	2.899
1689	3.350	3.352	3.400	3.471	3.542	3.171
2252	3.633	3.635	3.679	3.753	3.812	3.408
2815	3.882	3.881	3.923	4.000	4.051	3.614
3378	4.101	4.100	4.140	4.218	4.264	3.795
4504	4.475	4.475	4.510	4.592	4.628	4.103
6756	5.044	5.041	5.072	5.163	5.183	4.565
9008	5.461	5.457	5.487	5.584	5.597	4.904
11 260	5.786	5.783	5.813	5.913	5.921	5.174

[12] R. M. Sternheimer, Phys, Rev. **88**, 851 (1952); **103**, 511 (1956).

$\epsilon = 100\,\frac{\sigma}{R}$ ← width of gaussian; R ← total range.

6/29/70 Estimate efficiency for inelastic interactions:

at 100 MeV — use Jannis total probability figures

Probability = 0.1548 for some interaction before the proton stops

we want probability/unit path length

Take representative cross section from Janni, p. 45

$\sigma(Al, 100 MeV) \simeq 0.5$ barn.

$\epsilon_{in} = \frac{\# \text{ events}}{\text{inc part}} = \sigma \cdot \# \text{ targets}$

40 micron of silicon = $\sim 2 \times 10^{20}$ atoms/cm²

$\# = 0.5 \times 10^{-24} cm^2 \cdot 2 \times 10^{20} / cm^2$

$\epsilon_{inelastic}(100 MeV) = 10^{-4}$ (40 μ detector)

1000μ detector — factor of 25 larger

$\epsilon_{inelastic}(100 MeV, 1000\mu) \sim .0025$

7/1/70 Space Radiation lab visit

① VACUUM FACILITIES? GONIOMETER

Target aera – air

patches – amphenol 70 S receptacle

50 Ω & ~~70~~ 75 Ω cable (150 ft.)
(35) (10)

T.V. monitor

std. beams – 10 minutes 877-9231

Bill Madigan — 278

7/2/70 Project meeting

TPA – call Ben Ferrer 982 5586?

Prototype – S. Gary – assembling M.B. finish today

C. Cunningham – anticoinc on M.B. by Monday – logic by Tuesday –

July 28 & 29 run time –

+

7/2/70 Ben Ferrer } 982 5586
Don Pimbucie }

Jim TRAINOR 982-6281

7/6/70 Dr. Welsh, L.R.C. ←

Run - 2 shifts 23 - 24 [illegible]
24 - 25

16 hrs straight - all Friday
[illegible] am till midnight

→ Come late Wednesday —
[illegible]

Friday 24th 8 AM till mid. —
— 1st day

→ Own [illegible]
time [illegible]

→ Dr. [illegible] ←

→ 1024 Analyzer — [illegible]

→ 400 ←

Sunday 8 AM to 12:00 PM

Friday to set up. —

→ 7 doubles (14 scalars)

check back midweek

7/1/?? Cashion, Kohl, Krumrgis, Armstrong
Detector # B : use 55 μ detector to

LRC SREL CALIBRATIONS

① PET SCINT. ON & OFF

② PET GAIN A UP & DOWN

③ PET GAIN B UP & DOWN

④ GM TUBE SCINT ON & OFF

⑤ FIDUCIAL MARKS ON PACKAGE FOR ANGLE MEASUREMENT

⑥ CHECK OUT DISC LEVELS

⑦

NC-133