UNIVERSITY OF CALIFORNIA, LOS ANGELES

UCLA

BERKELEY · DAVIS · IRVINE · LOS ANGELES · RIVERSIDE · SAN DIEGO · SAN FRANCISCO · SANTA BARBARA · SANTA CRUZ

OFFICE OF THE CHANCELLOR
LOS ANGELES, CALIFORNIA 90024

December 7, 1983

John H. Frye, III, Chairman
Administrative Judge
Atomic Safety and Licensing Bd.
U.S. Nuclear Regulatory Comm.
Washington, D.C. 20555

Dr. Emmeth A. Luebke
Administrative Judge
Atomic Safety and Licensing Bd.
U.S. Nuclear Regulatory Comm.
Washington, D.C. 20555

Glenn O. Bright
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

In the Matter of
THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
(UCLA Research Reactor)
Docket No. 50-142
(Proposed Renewal of Facility License)

Re: Neutron Transport Calculations Requested by CBG

Dear Administrative Judges:

Enclosed are the raw data underlying the neutron transport calculations of Mr. Ostrander which were described in connection with the Wigner energy calculation in University's rebuttal testimony. This material was requested by CBG in Mr. Hirsch's letter of November 18, 1983.

Also enclosed is Mr. Ostrander's "Correction" to those calculations. The relevant effect of the correction is to change the reported result of the "Monte Carlo" calculation of the percentage of fission neutron energy deposited in the graphite (and fuel region) from 15% (and 85%) to 19% (and 81%). A separate correction is made to the uncollided flux calculation which changes the reported result from 85% to 71%; however, this calculation does not directly enter any of the analyses nor is it relied upon by any of University's witnesses. (In this regard, I note that I inadvertently over-stated the significance of these corrections on page 18 of "University's Response to CBG's Objections to Rebuttal Testimony", dated December 2, 1983: the only significant changes are the change in the reported percentage of fission neutron energy absorbed in the water, which is noted at several places in University's rebuttal testimony, from 85% to 81%; and the change from 15% to 19% for the percentage of fission neutron energy deposited in the graphite which enters into the last step of the Wigner energy calculation.)

DS03

We had intended to respond to CBG's request by reproducing the computer code listing and data for the Monte Carlo calculation with further explanations in a more presentable form, but because of CBG's insistence that the calculations be presented now, we have abandoned that time-consuming effort.

Very truly yours,

William H. Cormier

Enclosures

cc: Service List

C O R R E C T I O N T O

THE DISTRIBUTION OF FISSION NEUTRON ENERGY DEPOSITION BETWEEN FUEL REGIONS AND GRAPHITE IN AN ARGONAUT RESEARCH REACTOR

BY

N.C. OSTRANDER

Two calculations were performed to determine the percentage of fission neutron energy deposited in the fuel region and graphite of an Argonaut research reactor. The first calculation was based on a model of the "uncollided flux" which reached the graphite. The second calculation utilized a detailed "Monte Carlo" method which traced the paths and energy deposition of individual neutrons. As previously reported, the Monte Carlo calculation yielded the result that approximately 85% of the fission neutron energy was deposited in the fuel region and only 15% was deposited in the graphite. This result was stated to be consistent with the result obtained based on the "uncollided flux" model calculation. Two corrections are to be noted.

The Uncollided Flux Calculation

The model of the uncollided flux used and previously reported yields the fraction of the fission neutrons which reach the center graphite

island at high energy. That fraction is approximately 15%. However, an approximately equal fraction reaches the graphite reflector opposite the center island. As a result, the total fraction of fission neutrons which reach the graphite at high energy is approximately 29%. As previously reported, the result failed to properly account for the "mirror image" symmetry of the calculational model.

The Monte Carlo Calculation

The Monte Carlo calculation is not affected by the correction made in the uncollided flux calculation. However, verification of the calculation disclosed that of the population of 45 neutrons whose paths were traced, only 19 of the neutrons initially started in the direction of the graphite while 24 of the neutrons moved toward the interior of the fuel box. The initial directions of two of the neutrons could not be ascertained. Although the initial directions were determined by means of a random number sub-routine in the program, the selection produced an obvious bias in the procedure which could have affected the results.

In order to remove the bias, eliminate the two neutrons of uncertain initial direction, and to improve the statistics by providing a more uniform sampling of the initial directions, thirteen neutrons of the initial population have been discarded and eighteen new neutron samples were run to provide a population of 50 neutrons. Of the discarded

neutrons, only three had reached the graphite and that sub-population deposited only 5.7% of its total energy in the graphite.

For the new population of 50 neutrons, the estimate of energy deposition in the graphite is 19%, instead of approximately 15% as previously reported, and, accordingly, 81% of the energy is deposited is the fuel region.

Comparison of the Two Calculations

The Monte Carlo calculation indicates that about 34% of the fast neutrons enter the graphite above 0.8 mev. The corrected uncollided flux model suggests 29%. The 34% of the fast neutrons that enter the graphite transport an average energy of 1.88 mev per neutron to the graphite. However, these neutrons rarely stay in the graphite and much of their energy is ultimately deposited in the fuel box. The Monte Carlo calculation demonstrates that an average net deposition of 0.94 mev per fast neutron (greater than 0.8 mev) occurs in the graphite. In other words, the uncollided flux does not deposit the entirety of its energy in the graphite, but more nearly 50% of its energy. The other source of energy deposited in the graphite is due to a small fraction (approximately 10%) of the population that occasionally migrate into the graphite but at much lower average energy levels.

Thus, there is a relationship between the uncollided flux and the energy deposition in graphite, but it cannot be interpreted without more

precise information concerning the energy deposition due to the flux and the lower energy neutrons which are responsible for a small contribution to the total energy deposited in the graphite. These factors cannot be accounted for the calculation based on the uncollided flux model, but they are accounted for in the Monte Carlo calculation.

I. Uncollided Flux Integral

II. Monte Carlo: Program and Results

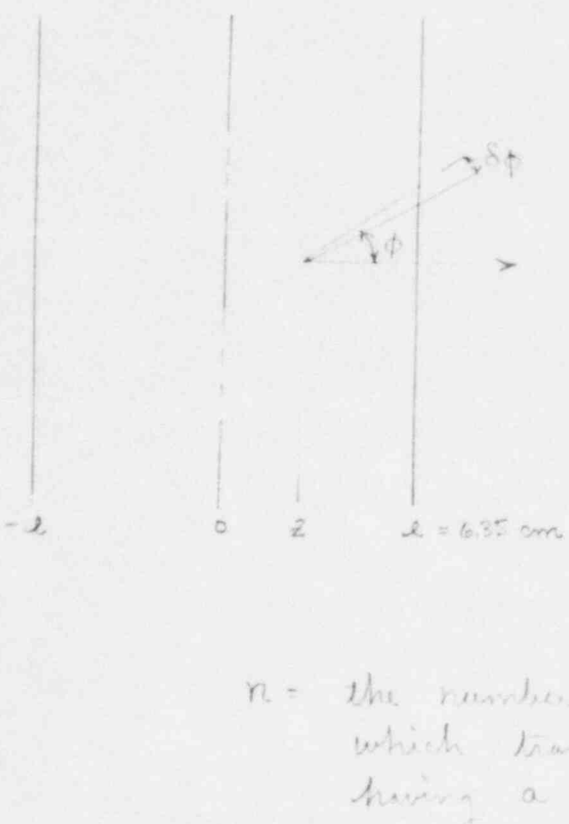
The Uncollided Flux Integral

Fuel Box Composition (by volume) al : H_2O = 0.34 : 0.66

Component	atoms/cm^3	2 Mev σ_s (barns)	Σ_s (cm^{-1})	Σ_s	%
H	4.37×10^{22}	2.90	0.127	0.127	59
O	2.18×10^{22}	1.40	0.030	0.088	41
al	2.05×10^{22}	2.82	0.058		
			0.215	0.215	100

(Source: BNL-325, see Monte Carlo calculation, p. 5)

Fission neutrons are born at an average density of N per cm^3. The geometry is that of a solid bounded by two planes (x-y) that are of infinite extent.



In the region δz at z, the fission neutron density is $N \cdot \delta z$ per square cm.

The neutrons are emitted isotropically and the fission neutron density is

$$\delta n = \frac{N}{4\pi}\, \delta z \cdot d\theta \cdot \sin\phi \, d\phi$$

The integration over the azimuthal angle θ is just a multiplication by 2π and

n = the number of neutrons per square cm which transit the plane $z = l$ without having a collision in the fuel box.

$$n = \frac{N}{2} \int_{\phi=0}^{\pi/2} \int_{z=-l}^{l} e^{-(l-z)\Sigma_s/\cos\phi} \, dz \, \sin\phi \, d\phi$$

Note that if $\Sigma_s = 0$, $n = Nl$, and half of the fission neutrons cross the plane $z = l$, the other half cross the plane $z = -l$.

uncollided flux (cont)

Let $\cos\phi = \mu$ and $x = l - z$. The integral becomes

$$n = \frac{N}{2} \int_{\mu=0}^{1} \int_{x=0}^{2l} e^{-x\Sigma_s/\mu}\, dx\, d\mu$$

$$= \frac{N}{2\Sigma_s} \int_{\mu=0}^{1} \left(1 - e^{-2l\Sigma_s/\mu}\right) \mu\, d\mu$$

$$= \frac{N}{2\Sigma_s} \left[\frac{1}{2} - \int_{\mu=0}^{1} e^{-2l\Sigma_s} \right.$$

with the substitution $y = 1/\mu$, the remaining integral is found to be the exponential integral, E_3.

$$E_3(2l\Sigma_s) = \int_1^\infty e^{-2l\Sigma_s y} \frac{dy}{y^3}$$

$$n = \frac{N}{2\Sigma_s}\left[\frac{1}{2} - E_3(2l\Sigma_s)\right]$$

with $l = 6.35$ and $\Sigma_s = 0.215$, $2l\Sigma_s = 2.73$ (See Handbook of Mathematical Functions (Abramowitz and Stegun, editors), U.S. Dept. Commerce, AMS 55, June 1964, p. 228 eq. 5.1.4 and p. 248 for tables).
$E_3(2.73) \simeq 0.0123$. neglecting E_3 relative to 0.5

$$n = \frac{N}{4\Sigma_s}$$

The total fission neutrons generated per square cm of fuel box surface is $2Nl$ and hence the fraction which has first collisions with graphite in the region $z > l$ is

$$f = \frac{n}{2Nl} = \frac{1}{8l\Sigma_s} = 0.0916$$

correction - see next page.

The number f should be doubled to include the uncollided flux in the reflector

$$f_1 = \frac{1}{4 \ell \Sigma_s} = 0.183$$

The probability of a collision with a heavy atom is the probability of non-escape (1-0.183 = 0.187) times the probability that the collision is with O or Al instead of H.

$$f_3 = 0.817 \left(\frac{\Sigma_O + \Sigma_{Al}}{\Sigma_s} \right) = 0.817 \left(\frac{0.088}{0.215} \right)$$

$$= 0.334$$

The probability of n such events followed by escape is f_3^n and the probability that the neutron escapes after 1, 2, 3 ... N such events is

$$F = f_1 \left(1 + f_3 + f_3^2 + \cdots f_3^N \right)$$

$$= \frac{f_1 \left(1 - f_3^{N+1} \right)}{1 - f_3} \rightarrow \frac{f_1}{1 - f_3}$$

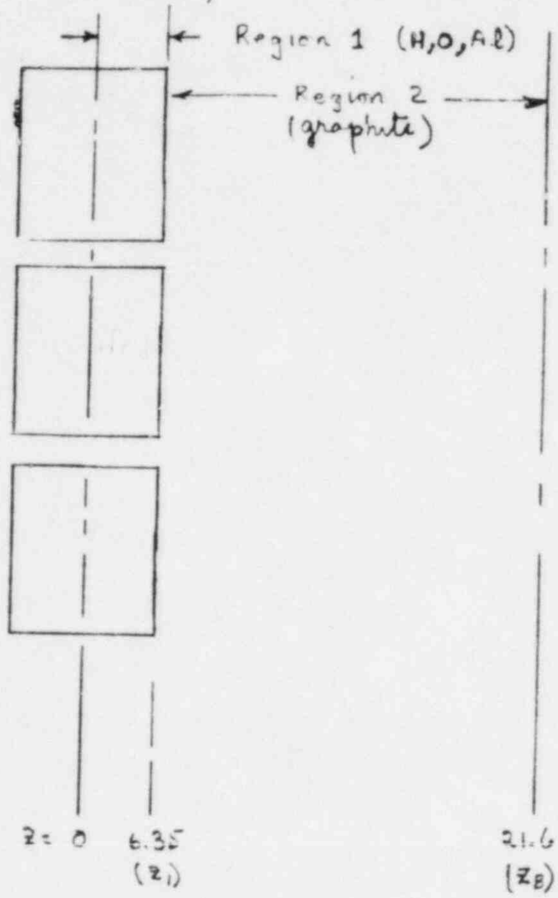
$$= \frac{0.183}{1 - 0.334} = 0.28$$

A Monte Carlo Calculation of Energy Deposition in graphite by Fast Neutrons

The computer program is written for a Hewlett-Packard, HP-41CV, with an extended Function/memory module. The latter is an unessential convenience for register manipulation and data storage. The idealized one dimensional geometry of the UCLA reactor is shown in Figure 1. The attached program, notes, and results are indexed here for convenience.

	page	Lab. Note., pg
Fig. 1 Geometry	2	2
Program "MC"	3	59
Program "Σ"	4	60
Cross Section Data	5	4
Program "REF"	6	34, 35
REF/SIJ logic	7	5
Program "SCN"	8	61
Program "SCAT"	9	45
Direction Cosines	10, 11	31, 32
Program "SHOW"	12	62
Program "UZ"	12	62
Register Assignments	13	58
Results (1st 45 neutrons)	14-28	39-44, 47-5[illegible]
summary of results (45 neutrons)	28	55
Results (next 12 neutrons)	29-34	63-68
statistical Summary	35	69
statistics (neutrons that enter graphite)	36	70
Initial values (z, cos ψ)	37	71

Geometry



Planes $z = 0$ and $z = z_B$ are assumed to be planes of symmetry and treated as reflecting boundaries.

FIGURE 1

Monte Carlo Program (Rev 11-20-83) (12-05-83)

Main (master) Program

```
01  LBL "MC"
02  "MCΣ D"
03  000.000
04  SEEKPTA
05  037.077
06  GETRX
07  072.005002
08  REGMOVE
09  LBL 01
10  069.002002
11  REGMOVE
12  074.016004
13  REGMOVE
14  0
15  STO 01
16  "ZO = "
17  PROMPT
18  STO 13
19  XEQ "UZ"      (p. 62)
20  STO 09
21  x^2          }
22  1            }
23  -            } These steps
24  CHS          } are wasted,
25  SQRT         } R10 is never
26  STO 10       } recalled in this context
27  LBL "NEXT"
28  LBL 02
29  XEQ "Σ"       (p. 60)
30  LBL "Z"
31  XEQ "UZ"      (p. 62)
32  RCL 08
33  LN
34  CHS
35  34
36  RCL 02
37  +
38  X<>Y
39  RCL IND Y
40  ÷
41  RCL 09
42  *
43  RCL 13
44  +
45  STO 14
46  XEQ "REF"     (p. 5, 35)
47  XEQ "SCN"     (p. 61)
48  XEQ "SCAT"    (p. 31, 32, 45)
49  XEQ "SHOW"    (p. 62)
50  0.1
51  RCL 16
52  X>Y ?
53  GTO 02
54  GTO 01
55  END
```

Steps 19 - 26 replaced with: 12-5-83

```
19  "DC"
20  PROMPT
21  STO 09
22  1
23  +
24  2
25  ÷
26  STO 08
27  STOP          Note RN
```

Σ (cross sections)

Page 60

```
01  LBL "Σ"
02  30
03  STO 29
04  0.1
05  RCL 16      E(n)
06  x > y ?
07  GTO 03      E(n) is > 0.10
08  0
09  GTO 06      E(n) is < 0.10
10  LBL 03

11  0.3
12  RCL 16      E(n)
13  x > y ?
14  GTO 04      E(n) > 0.3
15  8
16  GTO 06      0.1 < E(n) < 0.3
17  LBL 04
18  1
19  RCL 16      E(n)
20  x > y ?

21  GTO 05      E(n) > 1.0
22  16
23  GTO 06      1.0 < E(n)
24  LBL 05
25  24
26  LBL 06
27  35.00002
28  +
29  STO 30
30  8

31  +
32  1000
33  ÷
34  ST+ 30
35  LBL 07
36  ISG 30
37  GTO 08
38  GTO 09
39  LBL 08
40  1

41  ST+ 29
42  RCL 16
43  RCL ■ 30
44  y^x
45  RCL 30
46  1
47  +
48  x <> y
49  RCL ■ y
50  *                 Σi

51  STO ■ 29
52  GTO 07
53  LBL 09
54  RCL 34
55  STO 36            Σc = Σ2
56  RCL 31            ΣH
57  RCL 32            ΣO
58  +                 ΣH + ΣO
59  STO 34
60  RCL 33

61  +                 Σ1
62  STO 35
63  END
```

at step 26, the x register contains one of the following numbers: 0, 8, 16, 24.

CROSS SECTIONS

Microscopic Cross Sections From the "Brown Book"
BNL - 325 (1958)

E (mev)	H	O	Al	C
	cross sections, barns			
0.03	17	3.5	1.2	4.60
0.1	12.6	3.5	3.6	4.50
0.3	7.93	3.5	3.6	3.60
1.0	4.25	3.[illegible]	3.4	2.60
3.0	2.27	[illegible].8	2.55	1.45

macroscopic cross sections (cm^{-1})

E(mev)	H	O	Al	C
0.03	0.7526	0.0775	0.0244	0.3692
0.1	0.5578	"	0.0733	0.3612
0.3	0.3511	"	0.0733	0.2390
1.0	0.1881	"	0.0692	0.2087
3.0	0.100[illegible]	0.0117	[illegible].0519	0.1164

These are fitted with an equation $\Sigma_s = aE^b$.

E	H		O		Al		C		
	b	a	b	a	b	a	b	a	
0.03 - 0.10	-0.249	0.3144	0	0.0775	0.914	0.6014	-0.018	0.3465	44
0.10 - 0.30	-0.421	0.2115	0	0.0775	0	0.0733	-0.203	0.2265	[illegible]
0.30 - 1.00	-0.518	0.1881	0	0.0775	-0.048	0.0692	-0.270	0.2087	[illegible]
1.0 - 3.0	-0.571	0.1881	-1.344	0.0775	-0.262	0.0692	-0.531	0.2087	[illegible]

The values are stored in registers 37 thru 68 by row.

E	Register Allocation					
0.03 - 0.10	R_{37}	R_{38}	R_{39}	...	R_{44}	in sequence b, a, b, a
0.10 - 0.30	R_{45}	R_{46}				"
0.30 - 1.00	R_{53}					"
1.00 - 3.0	R_{61}	R_{62}	R_{63}	....	R_{68}	"

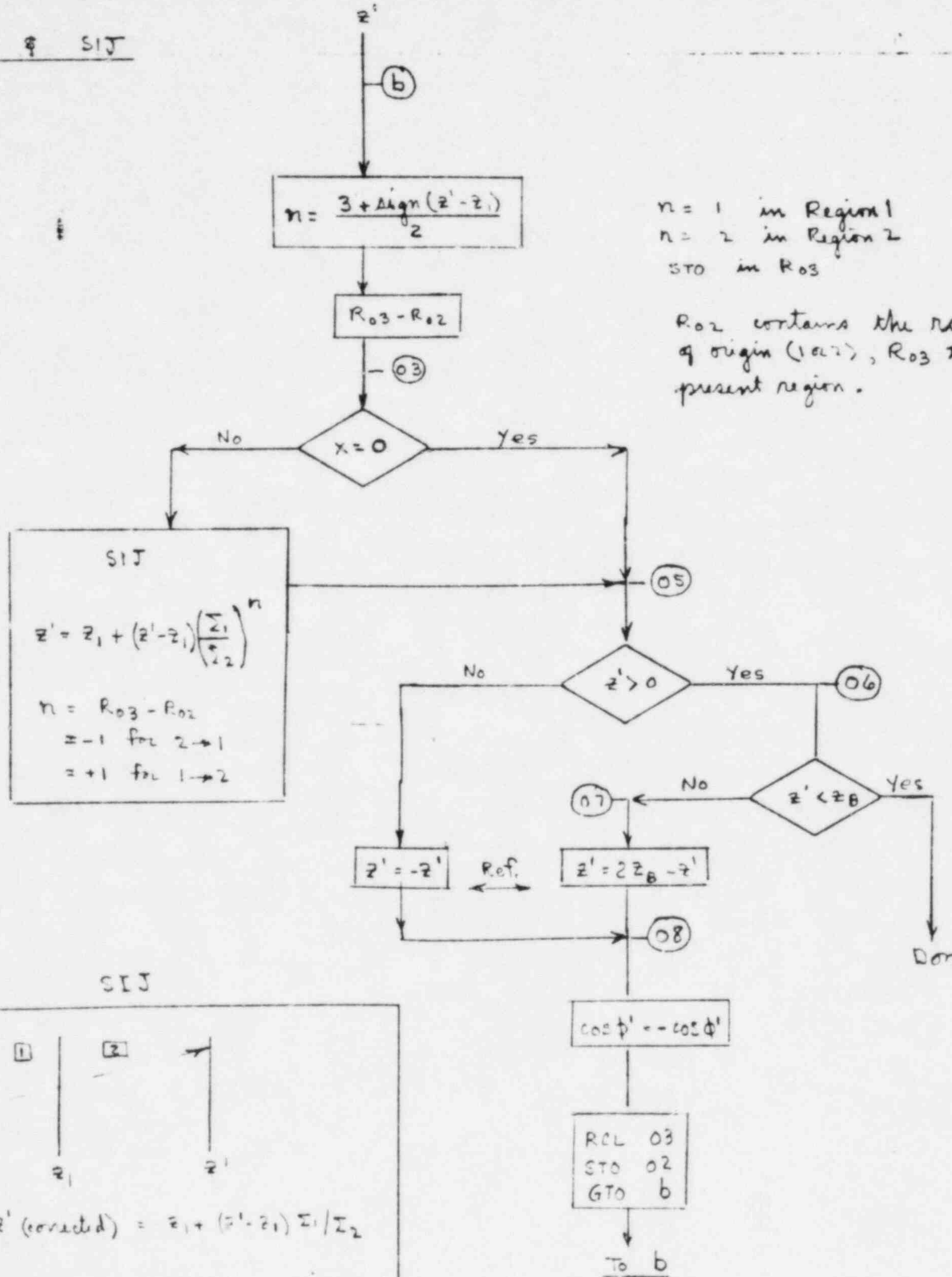
For a given E, a block of eight registers is treated sequentially, calculating Σ_H, Σ_o, Σ_{al}, Σ_c, $\Sigma_H + \Sigma_o$, $\Sigma_1 = \Sigma_H + \Sigma_o + \Sigma_{al}$, and $\Sigma_2 = \Sigma_g$

REF / SIJ (Reflect - convert)

This is the same scheme illustrated on page 5.

01	LBL	"REF	
02	LBL	6	
03	RCL	14	
04	RCL	05	
05	−		
06	SIGN		
07	3		
08	+		
09	2		
10	÷		
11	STO	03	Region of Scat.
12	RCL	02	Region of Orig.
13	−		
14	X = 0 ?		
15	GTO	05	same region
16	LBL	SIJ	
17	RCL	35	Σ_1
18	RCL	36	Σ_2
19	÷		Σ_1/Σ_2
20	X<>Y		n, Σ_1/Σ_2
21	y^x		$(\Sigma_1/\Sigma_2)^n$
22	RCL	14	z'
23	RCL	05	z_1
24	−		$z' - z_1$
25	*		$(z' - z_1)(\Sigma_1/\Sigma_2)^n$
26	RCL	05	
27	+		
28	STO	14	corrected z'
29	LBL	05	
30	RCL	14	
31	X ≥ 0 ?		
32	GTO	06	
33	CHS		
34	STO	14	
35	GTO	08	
36	LBL	06	
37	RCL	06	z_B
38	RCL	14	z'
39	−		$z_B - z'$
40	X ≥ 0 ?		
41	GTO	09	
42	LBL	07	
43	RCL	06	
44	+		
45	STO	14	$2z_B - z'$
46	LBL	08	
47	-1		
48	ST*	09	reverse dir.
49	αRα		
50	AVIEW		note reflect (R).
51	STOP		
52	GTO	6	
53	LBL	09	
54	RCL	03	
55	STO	02	
56	RCL	14	
57	STO	13	
58	RTN		
59	END		Done

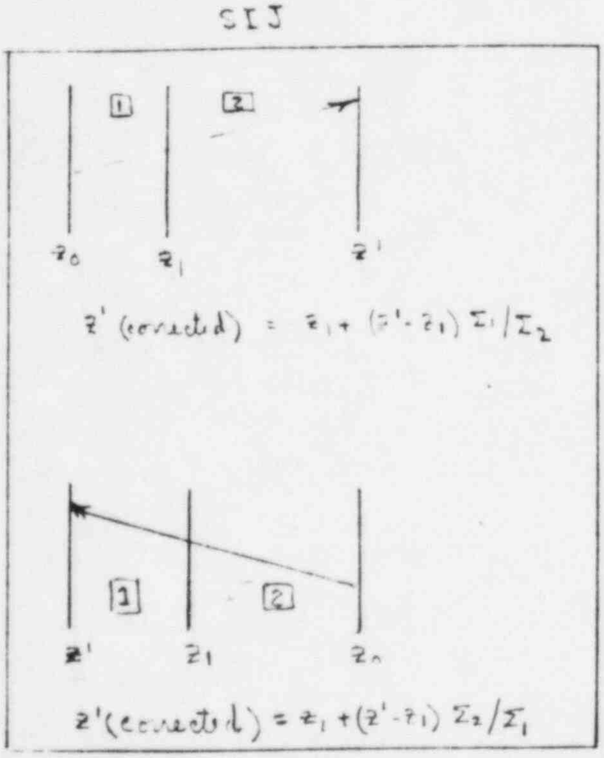
REF & SIJ



n = 1 in Region 1
n = 2 in Region 2
STO in R_{03}

R_{02} contains the region of origin (1 or 2), R_{03} the present region.

SIJ



SCN (identify scatterer; H, O, Al, or C. If the neutron is in Region 2, the scatterer is C, otherwise a decision is required).

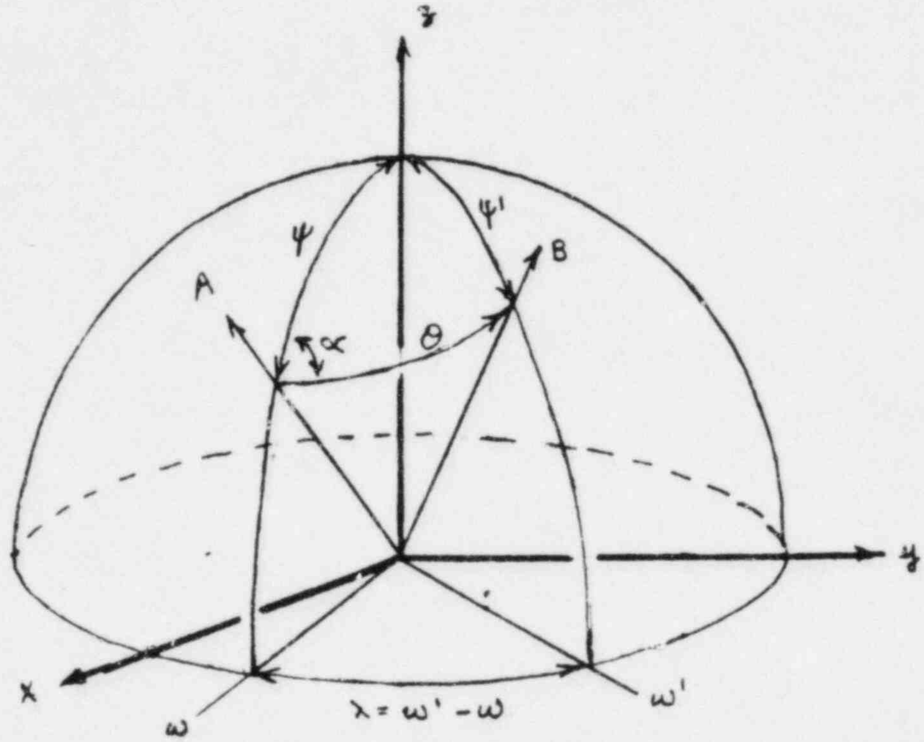
```
LBL "SCN"
RCL 02
2
x = y ?
GTO 03        (graphite)
XEQ UZ
RCL 31
RCL 35
÷
RCL 08        0 < N_i < 1

x > y ?       N_i > Σ_H/Σ_1 ?
GTO 01        yes, not H
"H = 1"       no, it is H
ASTO 00
1
GTO 04
LBL 01
RCL 34        Σ_H + Σ_O
RCL 35        Σ_1
÷

RCL 08
x > y ?       N > (Σ_H + Σ_O)/Σ_1
GTO 02        yes, Not O
"O = 16"
ASTO 00
16
GTO 04
LBL 02
"Al = 27
ASTO 00
27
GTO 04
LBL 03
"C = 12"
ASTO 00
12
LBL 04
STO 04        A = 1 or 12
END           or 16 or 27
```

SCAT (Scatter, Energy and new $\cos\psi$)

01	LBL	SCAT	
02	XEQ	UZ	$\cos\phi$
03	RCL	07	
04	RCL	04	A
05	*		$A\cos\phi$
06	2		
07	*		$2A\cos\phi$
08	1		
09	+		$1+2A\cos\phi$
10	RCL	04	A
11	X^2		A^2
12	+		
13	STO	15	$1+A^2+2A\cdot\cos\phi$
14	1		
15	RCL	04	A
16	+		$1+A$
17	X^2		$(1+A)^2$
18	÷		E/E_0 (p.32)
19	RCL	16	E_0
20	*		E
21	STO	17	E
22	RCL	16	E_0
23	−		
24	RCL	02	Region (1 or 2)
25	17		
26	+		
27	X<>Y		
28	ST+	IND Y	Accumulate ΔE
29	RCL	17	
30	STO	16	New E
31	LBL	THETA	
32	RCL	07	$\cos\phi$
33	RCL	04	A
34	*		$A\cos\phi$
35	1		
36	+		
37	RCL	15	
38	SQRT		
39	÷		$\cos\theta$
40	STO	10	$\cos\theta$ (p.31)
41	XEQ	UZ	(for azimuth)
42	180		
43	*		(α = azim. deg)
44	COS		$\cos\alpha$ (p.32)
45	1		
46	RCL	10	$\cos\theta$
47	X^2		
48	−		
49	1		
50	RCL	09	$\cos\psi$
51	X^2		
52	−		
53	*		
54	SQRT		$\sin\theta\sin\psi$
55	*		$\sin\theta\sin\psi\cos\alpha$
56	RCL	10	$\cos\theta$
57	RCL	09	$\cos\psi$
58	*		
59	+		$\cos\psi'$ (new)
60	STO	09	
61	END		

(Steps 44–60: calculates new $\cos\psi$ in the stack.)

THREE DIMENSIONAL SCATTERING



The neutron, initially moving in direction A, is scattered through polar angle θ at azimuth α into direction B. The direction cosines:

Before scattering	After scattering
$u_x = \sin\psi \cos\omega$	$u'_x = \sin\psi' \cos\omega'$
$u_y = \sin\psi \sin\omega$	$u'_y = \sin\psi' \sin\omega'$
$u_z = \cos\psi$	$u'_z = \cos\psi'$

For isotropic scattering in a center-of-mass coordinate system, let $\cos\phi$ be the polar angle uniformly distributed, $-1 < \cos\phi < 1$, and α will be uniformly distributed $-\pi < \alpha < \pi$. With A representing the mass of the scattering nucleus, the polar scattering angle in the laboratory coordinate system is

$$\cos\theta = \frac{1 + A\cos\phi}{\sqrt{A^2 + 1 + 2A\cos\phi}}$$

The post scattering direction cosines, in terms of the scattering angles θ and α are calculated by:

$$u_z = \cos\psi' = \cos\psi\cos\theta + \sin\psi\sin\theta\cos\alpha$$

$$\sin\lambda = \sin\theta \cdot \sin\alpha / \sin\psi'$$

$$\cos\lambda = (\cos\theta - \cos\psi\cos\psi') / \sin\psi\sin\psi'$$

$$\sin\omega' = \sin(\omega+\lambda) = \sin\omega\cos\lambda + \cos\omega\sin\lambda$$
$$\cos\omega' = \cos(\omega+\lambda) = \cos\omega\cos\lambda - \sin\omega\sin\lambda$$

The u_x' and u_y' direction cosines can be calculated from these components. However, we shall track only the motion in z and need only u_z. Note that $0 < \psi' < \pi$, $\sin\psi' \geq 0$, and hence

$$\sin\psi' = \sqrt{1-\cos^2\psi'}$$

The procedure is to choose a random number N from a uniformly distributed population, $-1 < N < 1$ and

$$\cos\phi = N$$

$$\cos\theta = \frac{1 + A \cdot N}{\sqrt{1+A^2+2AN}}$$

$$\sin\theta = \frac{A\sqrt{1-N^2}}{\sqrt{1+A^2+2AN}} = \sqrt{1-\cos^2\theta} \geq 0$$

$$\cos\psi' = \cos\psi\cos\theta + \sin\psi\sin\theta\cos\alpha$$

were α is a random number uniformly distributed over $-\pi, \pi$ (or $-180, 180$ deg).

The post-collision Energy (Soodak & Campbell, Pg. 6, Eq 3-2)

$$\frac{E}{E_0} = \frac{1 + A^2 + 2A\cos\phi}{(1+A)^2} \qquad A = M/m$$

SHOW (Display Output)

```
01  LBL   "SHOW"
02  BEEP
03  1
04  ST+    01
05  VIEW   01    collision No.
06  STOP
07  VIEW   00    A = A
08  STOP
09  VIEW   18    E1
10  STOP

11  VIEW   19    E2
12  STOP
13  VIEW   13    Z
14  STOP
15  RCL    09    cos ψ'
16  ACOS         ψ'
17  STOP
18  VIEW   16    E(n)
19  STOP
20  VIEW   08    N

21  STOP
22  EXEQ  "UZ"
23  END
```

UZ (generates Random Numbers)

```
01  LBL   "UZ"
02  RCL    08         Ni
03  23
04  *
05  ↑
06  INT
07  10^8
08  ÷
09  −
10  FRC               0 < Ni+1 < 1

11  STO    08
12  2
13  *
14  1
15  −
16  STO    07
17  END
```

Monte Carlo Program (11-20-83)

Register Assignments

R_{00}	⋮	R_{70}	Region (initially)			
R_{01}	n, collision no	R_{71}	0	(initially)		
R_{02}	Region of origin, 1 or 2	R_{72}	6.35	boundary		
R_{03}	Region of event, 1 or 2	R_{73}	21.6	boundary		
R_{04}	A = Scat. Mass (1,12,16,27)	R_{74}	2	$E(n=0)$	Reg. 1	
R_{05}	$z_1 =$ 6.35 cm	R_{75}	2	$E(n=0)$	Reg. 2	
R_{06}	$z_B =$ 21.6 cm	R_{76}	0	0	ΔE_1	
R_{07}	$\cos\phi$	R_{77}	0	0	ΔE_2	
R_{08}	N					
R_{09}	$\cos\psi$					

R_{10} $\cos\theta$
R_{11} Not used
R_{12} Not used
R_{13} z
R_{14} z'
R_{15} $1 + A^2 + 2A\cos\phi$
R_{16} E_0
R_{17} E
R_{18} ΔE_1
R_{19} ΔE_2

R_{20} - R_{28} Not used
R_{29} Indir. Address (in "Σ")

R_{30} ISG (in "Σ")
R_{31} Σ_H
R_{32} Σ_O
R_{33} Σ_{Al}
R_{34} $\Sigma_C = \Sigma_H + \Sigma_O$
R_{35} $\Sigma_1 = \Sigma_H + \Sigma_O + \Sigma_{Al}$
R_{36} $\Sigma_2 = \Sigma_c$
R_{37} - R_{68} constants for $\Sigma(E)$
R_{69} 1 Region (initially)

E_0 - 2 MeV (Here and there Page No 53)

	z_0	N_i	n	A	ΔE_1	ΔE_2	z	ψ	E
1	5.715	0.490	1	27	-0.251	0.000	2.37	98	1.749
		0.621	2	16	-0.559		1.67	67	1.441
		0.521	3	16	-0.599		1.69	86	1.401
		0.297	4	1	-1.529		1.74	82	0.471
		0.383	5	1	-1.740		1.81	74	0.260
		0.073	6	1	-1.807		2.01	101	0.193
		0.418	7	1	-1.890		1.84	128	0.110
		0.636	8	1	-1.982		1.44	110	0.018
					-2.000	0.000			
2	4.445	0.617	1	1	-0.168	0.000	2.90	142	1.832
		0.684	2	16	-0.380		1.80	126	1.620
		0.177	3 R	16	-0.610		4.48	91	1.390
		0.007	4	27	-0.618		4.37	111	1.382
		0.235	5	1	-1.562		3.15	93	0.438
		0.732	6	1	-1.587		3.13	91	0.413
		0.923	7	1	-1.750		3.08	121	0.250
		0.917	8	1	-1.875		0.79	76	0.125
		0.067	9	1	-1.948		1.02	56	0.052
		0.894	10	1	-1.967		1.43	21	0.033
		0.952	11	1	-1.990		1.55	51	0.010
					-2.000	0.000			
3	3.175	0.803	1	27	-0.167		3.10	149	1.833
		0.918	2 R	1	-1.837		5.26	102	0.163
		0.389	3	1	-1.856		5.24	99	0.144
		0.157	4	1	-1.931		5.11	133	0.069
		0.532	5	1	-1.977		3.79	77	0.023
					-2.000	0.000			
4	1.905	0.407	1	27	-0.197		0.36	26	1.803
		0.575	2	1	-0.844		6.29	44	1.156
		0.750	3	12	"	-0.127	11.49	109	1.029
		0.101	4	12		-0.355	9.70	130	0.801
		0.031	5	12		-0.540	8.68	36	0.617
		0.374	6	12		-0.549	10.38	51	0.608
		0.827	7	12		-0.650	20.90	44	0.507
		0.520	8	12		-0.665	21.04	11	0.491
		0.531	9 R	12		-0.671	16.21	167	0.486
		0.081	10	12		-0.691	15.65	128	0.465
		0.614	11	12		-0.692	10.75	130	0.464
		0.787	12	1	-1.053	-0.692	5.49	98	0.255
		0.635	13	16	-1.055	-0.692	5.36	110	0.253

	z_0	N_i	n	A	ΔE_1	ΔE_2	z	4	E
	1.905	0.138	14	1	-1.208	-0.692	4.23	127	0.090
		0.163	15	1	-1.262	"	4.00	102	0.046
		0.685	16	1	-1.301	"	3.93	60	0.007
					-1.308	-0.692			
5	0.635	0.369	1R	27	-0.232	0.000	1.63	83	1.768
		0.640	2	1	-1.523		1.82	100	0.477
		0.204	3	16	-1.577		1.66	62	0.423
		0.329	4	1	-1.641		2.23	40	0.359
		0.481	5	12	-1.641	-0.060	7.13	65	0.298
		0.393	6	12	"	-0.080	12.04	62	0.279
		0.702	7	12	"	-0.151	15.23	124	0.207
		0.195	8	12	"	-0.155	13.91	96	0.203
		0.465	9	12		-0.205	13.79	71	0.154
		0.304	10	12		-0.246	19.84	133	0.112
		0.061	11	12		-0.268	18.08	56	0.090
		0.338	12	12		-0.292	18.46	119	0.066
		0.255	13	12		-0.293	18.27	111	0.065
		0.716	14	12		-0.296	17.54	114	0.062
		0.214	15	12		-0.311	17.45	37	0.048
		0.387	16	12		-0.311	17.66	59	0.047
		0.015	17	12		-0.324	19.14	155	0.035
		0.958	18	12		-0.328	9.78	121	0.030
		0.976	19	12	-1.641	-0.333	8.66	126	0.025
					-1.641	-0.359			
6	5.715	0.878	1	1	-0.742	0.000	3.13	91	1.258
		0.464	2	1	-1.086	"	3.09	84	0.914
		0.710	3	1	-1.239	"	3.46	96	0.761
		0.164	4	1	-1.683	"	3.38	53	0.317
		0.575	5	1	-1.885	"	5.25	42	0.115
		0.353	6	12	"	-0.016	8.94	95	0.099
		0.792	7	12	"	-0.022	8.55	119	0.093
		0.157	8	12	"	-0.025	7.87	85	0.090
		0.441	9	12	"	-0.043	8.35	81	0.072
		0.917	10	12	"	-0.056	8.66		0.059
		0.563	11	12	"	-0.057	8.78	48	0.058
		0.853	12	12	"	-0.073	9.69	138	0.042
		0.066	13	12	"	-0.076	8.32	146	0.039
		0.890	14	12	"	-0.078	6.62	107	0.037
		0.589	15	1	-1.919	-0.078	6.25	134	0.003
					-1.919	-0.081			

	z_0	N_i	n	A	ΔE_1	ΔE_2	z	ψ	E
7	4.445	0.866	1	12	0.000	-0.073	13.89	71	1.927
		0.040	2	12	0.000	-0.403	14.05	130	1.597
		0.138	3	12	"	-0.434	7.01	104	1.566
		0.439	4	1	-0.222	"	4.58	102	1.344
		0.743	5	1	-0.477	"	2.80	85	1.090
		0.641	6	27	-0.483	"	2.88	108	1.023
		0.0[illegible]1	7	16	-0.714	"	1.48	91	0.853
		0.893	8	1	-0.721	"	1.45	93	0.846
		0.814	9	16	-0.747	"	1.40	86	0.819
		0.725	10	16	-0.802	"	1.47	145	0.764
		0.048	11 R	16	-0.937	"	3.45	110	0.630
		0.714	12	27	-0.957	"	2.70	59	0.609
		0.567	13	12	"	-0.581	6.92	79	0.462
		0.405	14	12	"	-0.656	7.75	128	0.387
		0.855	15	12	"	-0.729	6.83	65	0.314
		0.693	16	12	"	-0.763	6.92	89	0.280
		0.228	17	12	"	-0.797	6.99	66	0.246
		0.317	18	12	"	-0.814	8.62	46	0.229
		0.356	19	12	"	-0.852	12.37		0.191
		6.564	20	12	"	-0.890	12.43		0.153
		0.026	21	12	"	-0.892	11.01	134	0.151
		0.575	22	12	"	-0.936	7.85	62	0.113
		0.761	23	12	"	-0.947	8.78	46	0.095
		0.395	24	12	"	-0.948	13.46	51	0.095
		0.943	25	12	"	-0.956	14.12	70	0.087
		0.734	26	12	"	-0.97[illegible]	14.24	96	0.072
		0.760	27	12	"	-0.9[illegible]3	14.01	90	0.070
		0.715	28	12	"	-0.[illegible]86	13.99	149	0.056
		0.932	29	12	"	0.988	12.01	118	0.055
		0.600	30	12	"	-0.997	11.73	148	0.046
		0.030	31	12	"	-1.009	10.89	57	0.033
		0.961	32	12	-0.957	-1.015	14.20	107	0.028
					-0.957	-1.043			
8	3.175	0.800	1	27	-0.135	0.000	0.04	73	1.865
		0.700	2	1	-0.143		3.10	76	1.857
		0.903	3	1	-1.285		3.22	108	0.715
		0.853	4	1	-1.703		2.82	61	0.297
		0.553	5	16	-1.758		3.15	81	0.242
		0.626	6	27	-1.782		3.40	72	0.218
		0.685	7	1	-1.813		3.55	76	0.187
		[illegible]	8	1	[illegible]				

	z	N_i	n	A	ΔE_1	ΔE_2	z	φ	E
	cont	0.770	8	1	-1.821	0.000	3.70	87	0.179
		0.921	9	1	-1.927	"	3.83	41	0.073
		0.447	10	1	-1.984	0.000	5.15	97	0.016
					-2.000	0.000			
9	1.905	0.902	1	1	-1.079	0.000	2.05	30	0.921
		0.590	2	27	-1.096	"	3.56	67	0.904
		0.892	3	16	-1.280	"	4.26	138	0.720
		0.895	4	1	-1.891	"	3.18	71	0.109
		0.475	5	1	-1.941	"	3.21	29	0.059
		0.506	6	1	-1.958	"	3.75	10	0.042
		0.447	7	1	-1.979	0.000	5.33	43	0.021
					-2.000				
10	0.635	0.301	1	1	-0.280	0.000	3.87	40	1.728
		0.780	2	16	-0.594	"	4.06	167	1.406
		0.014	3 R	1	-1.397	"	0.18	59	0.603
		0.875	4	27	-1.478	"	2.97	109	0.522
		0.385	5	1	-1.565	"	2.83	117	0.435
		0.186	6	1	-1.632	"	1.49	95	0.368
		0.441	7	1	-1.755	"	1.12	76	0.245
		0.342	8	27	-1.759	"	1.19	102	0.241
		0.142	9	27	-1.787	"	0.65	47	0.213
		0.386	10	1	-1.900	"	0.81	68	0.100
		0.779	11	1	-1.935	"	0.86	103	0.065
		0.043	12	1	-1.958	"	0.85	80	0.042
		0.646	13	1	-1.962	"	0.89	95	0.038
		0.073	14	1	-1.986	"	0.85	44	0.014
					-2.000				

Summary 1st 10 neutrons, 20 mev

$\Sigma \Delta E_1 =$	17.716	mev	88.6%
$\Sigma \Delta E_2 =$	2.118	mev	10.6%
Remaing K.E.	0.165	mev	0.8%
	19.999		

number of collisions = 137

lethargy = ln (2/0.00835) = 2.495

$\bar{n}$ = 137/10 13.7

$\bar{\xi}$ = 0.57

For the next set, add XEQ UZ prior to .RTN1 in "SHOW". Purpose – to further isolate successive cycles.
The first N is 0.53391624

	z_0	N	n	A	ΔE_1	ΔE_2	z	ψ	E
11	5.715	0.534	1	1	-0.694	0.000	4.04	152	1.306
		0.020	2	27	-0.753	"	0.65	85	1.247
		0.442	3	1	-0.814	"	0.72	94	1.186
		0.870	4	1	-1.179	"	0.18	123	0.821
		0.919	5R	1	-1.262	"	1.39	52	0.738
		0.693	6	1	-1.803	"	2.77	99	0.197
		0.129	7	1	-1.942	"	2.13	102	0.058
		0.773	8	1	-1.968	"	1.67	60	0.032
		0.512	9	1	-1.975	0.000	1.76	39	0.025
					-2.000	0.000			
12	4.445	0.405	1	1	-1.618	0.000	4.47	45	0.382
		0.394	2	1	-1.845	"	6.18	37	0.155
		0.358	3	12	-1.845	-0.015	7.89	101	0.140
		0.077	4	12	"	-0.043	7.85	128	0.113
		0.123	5	12	"	-0.045	7.60	100	0.111
		0.467	6	12	"	-0.063	7.59	32	0.092
		0.411	7	12	"	-0.081	9.25	97	0.074
		0.287	8	12	"	-0.082	8.38	96	0.074
		0.262	9	12	"	-0.091	8.34	158	0.064
		0.940	10	16	-1.851	-0.091	5.99	106	0.058
		0.796	11	16	-1.861	"	5.45		0.048
		0.602	12	12	-1.861	-0.100	7.58	68	0.039
		0.511	13	12	"	-0.107	8.49	34	0.032
		—	14	12	-1.861	-0.110	14.35	26	0.029
					-1.861	-0.139			
13	3.175	0.503	1	27	-0.158	0.000	2.96	117	1.842
		0.838	2	1	-0.613	"	0.55	103	1.387
		0.313	3	27	-0.776	"	0.29	52	1.224
		0.363	4	1	-1.952	"	0.34	121	0.048
		0.908	5R	1	-1.998	"	0.93	135	0.002
					-2.000	0.000			
14	1.905	0.033	1	1	-0.342	0.000	1.55	131	1.658
		0.062	2	1	-1.360	"	0.76	148	0.640
		0.883	3R	16	-1.395	"	2.33	58	0.605
		0.272	4	27	-1.424	"	2.33	124	0.576
		0.936	5	1	-1.615	"	2.23	98	0.385 (c

	z_0	N	n	A	ΔE_1	ΔE_2	z	ψ	E
	cont.	0.365	6	1	-1.642	0.060	1.33	85	0.358
		0.431	7	1	-1.935	"	2.29	106	0.065
		0.193	8	1	-1.998	0.000	1.77	73	0.007
					-2.000	0.000			
15	0.635	0.319	1	1	-1.116	0.000	4.54	85	0.884
		0.168	2	27	-1.124	"	4.54	57	0.876
		0.451	3	1	-1.169	"	6.30	63	0.831
		0.813	4	12	-1.169	-0.049	9.12	86	0.782
		0.199	5	12	"	-0.229	10.02	53	0.602
		0.392	6	12	"	-0.310	11.56	123	0.521
		0.104	7	12	"	-0.312	7.09	117	0.519
		0.677	8	1	-1.525	-0.312	4.95	106	0.163
		0.245	9	1	-1.636	"	4.58	83	0.052
		0.308	10	1	-1.680	-0.312	4.64	21	0.008
					-1.688	-0.312			

Summary. 1st 15 neuts, 30 mev

	1st 5	2nd 5	3rd 5	Total	
ΔE_1	8.891	8.825	9.507	27.223	90.7%
ΔE_2	1.025	1.093	0.422	2.540	8.5%
Residual	0.083	0.082	0.071	0.236	0.8%
	9.999	10.000	10.000	29.999	100.0%

Total no of collisions: 183

ave lethergy from 2 mev = $\ln(30/0.236) = 4.845$

$\bar{\xi}$ = lethergy per collision (183/15 = 12.2 coll/neut)

= 0.397

we had $\bar{\xi} = 0.408$ for the isotropic case with 40 neutrons.

Programs ENER & SLC combined into one program named SCAT. Minor modifications required in MC and SCN. 7-8-83

	z_0	N	n	A	ΔE_1	ΔE_2	z	ψ	E
16	5.715	0.950	1	H	-1.103	0.000	1.53	84	0.897
		0.321	2	H	-1.854	"	1.59	88	0.146
		0.751	3	H	-1.956	"	1.63	144	0.044
					-2.000	0.000			—
17	5.715	0.550	1	Al	-0.124	0.000	5.79	41	1.876
		0.615	2	C	-0.124	-0.085	16.02	45	1.790
		0.310	3^R	C	"	-0.401	20.44	76	1.474
		0.721	4	C	"	-0.557	21.08	28	1.318
		0.419	5^R	C	"	-0.563	20.64	143	1.313
		0.658	6	C	"	-0.916	7.00	48	0.960
		0.232	7	C	"	-1.021	7.50	100	0.855
		—	8	C	"	-1.082	7.35	118	0.794
		0.182	9	Al	-0.128	"	3.12	115	0.790
		0.240	10	H	-0.529	"	0.40	90	0.389
		0.328	11	O	-0.611	"	0.41	113	0.307
		0.086	12^R	Al	-0.627	"	0.42	21	0.291
		0.442	13	Al	-0.652	"	0.99	84	0.266
		0.566	14	O	-0.710	"	1.24	82	0.208
		0.410	15	H	-0.804	"	1.35	44	0.114
		0.558	16	H	-0.908	"	1.42	111	0.010
					-0.918	-1.082			—
18	5.715	0.300	1	C	0.000	-0.511	7.38	120	1.489
		0.299	2	Al	-0.130	"	4.40	25	1.359
		0.442	3	O	-0.367	"	4.92	137	1.122
		0.869	4	I	-1.301	"	3.78	134	0.188
		0.857	5	I	-1.484	"	3.04	58	0.005
					-1.489	-0.511			—
19	5.715	0.700	1	Al	-0.083	0.000	1.23	148	1.917
		0.055	2^R	C	"	-0.260	10.69	114	1.657
		0.031	3	C	"	-0.632	9.66	99	1.285
		0.827	4	C	"	-0.838	9.26	167	1.079
		0.788	5	C	"	-1.039	7.29	88	0.878
		0.928	6	C	"	-1.203	7.76	122	0.714
		0.841	7	C	"	-1.247	7.53	171	0.670
		0.025	8^R	Al	-0.104	-1.247	3.36	61	0.649
		0.860	9	O	-0.138		3.43	7	0.615
		0.488	10	C	-0.138	-1.392	13.99	133	0.470

(cont)

	z_0	N	n	A	ΔE_1	ΔE_2	z	ψ	E
	5.715 (cont)	0.963	11	C	-0.138	-1.396	9.87	142	0.465
		0.151	12	C	"	-1.518	9.45	57	0.343
		0.798	13	C		-1.587	9.60	130	0.275
		0.848	14	C		-1.651	8.97	103	0.210
		0.016	15	C		-1.677	8.63	157	0.185
		0.067	16	O	-0.162	"	5.42	79	0.161
		0.710	17	O	-0.184	"	5.72	153	0.139
		–	18	H	-0.309		3.76	93	0.014
					-0.323	-1.677			
20	5.715	0.150	1	H	-1.701	0.000	5.23	35	0.299
		0.440	2	H	-1.784	"	5.32	17	0.216
		0.584	3	H	-1.906	"	5.64	66	0.094
					-2.000	0.000			–
21	5.715	0.850	1	Al	-0.042	0.000	5.92	40	1.958
		0.495	2^R	C		-0.441	15.84	67	1.517
		0.753	3	C		-0.855	21.59	136	1.103
		0.933	4	C		-1.092	19.85	25	0.866
		0.557?	5^R	C		-1.165	21.19	123	0.793
		0.199	6	C		-1.249	14.65	55	0.709
		0.450	7	C		-1.258	14.77	74	0.700
		–	8	C		-1.264	16.37	63	0.694
		0.371	9	C		-1.278	17.68	41	0.680
		0.403	10	C		-1.405	20.28	107	0.553
		0.776	11	C		-1.446	19.67	158	0.512
		0.048	12	C		-1.466	14.61	138	0.492
		0.774	13	C		-1.598	13.17	22	0.360
		0.410	14	C		-1.695	13.31	161	0.263
		0.121	15	H	-0.178	-1.695	3.19	146	0.127
		0.118	16	O	-0.201	"	2.63	52	0.104
		0.298	17	O	-0.203		2.81	47	0.102
		0.685	18	Al	-0.207		3.37	68	0.098
					-0.305	-1.695			

Σ ΔE's, 6 samples at z_0 = 5.715

ΔE_1	ΔE_2
7.035	4.965

	z_0	N	n	A	ΔE_1	ΔE_2	z	ψ	E
22	4.445	0.430	1	C	0.000	-0.108	7.59	33	1.897
		0.629	2	C	"	-0.339	10.18	105	1.661
		0.093	3	O	-0.031	-0.339	6.12	136	1.629
		0.037	4	H	-1.393	-0.339	3.72	113	0.267
		0.774	5	O	-1.431	"	2.82	90	0.229
		0.236	6	H	-1.612	"	2.82	130	0.049
					-1.661	-0.339			
23	4.445	0.570	1	H	-1.263	0.000	2.14	89	0.737
		0.473	2	O	-1.370		2.18	114	0.629
		0.818	3	H	-1.968	0.000	2.14	122	0.032
					2.000	0.000			
24	4.445	0.290	1	H	-0.222	0.000	5.86	52	1.778
		0.451	2	C	-0.222	-0.309	6.74	142	1.469
		0.927	3	Al	-0.410	-0.309	4.85	29	1.281
		0.640	4	C	"	-0.540	7.39	75	1.051
		0.429	5	C	"	-0.821	7.64	97	0.769
		0.288	6	C	"	-1.001	7.10	131	0.589
		0.071	7	H	-0.675	-1.001	5.74	98	0.324
		0.630	8	H	-0.839		5.22	66	0.160
		0.376	9	C	-0.839	-1.017	7.53	106	0.145
		0.162	10	C	"	-1.057	7.45	60	0.105
		0.629	11	C	"	-1.076	7.56	77	0.085
					-0.924	-1.076			
25	4.445	0.710	1	H	-1.784	0.000	3.61	39	0.216
		0.484	2	H	-1.882		5.89	15	0.118
		0.563	3	Al	-1.894		5.89	129	0.106
		0.894	4	H	-1.930		5.65	123	0.070
					-2.000	0.000			
26	4.445	0.160	1	O	-0.195	0.000	5.19	124	1.805
		0.870	2^R	O	-0.501		1.27	68	1.499
		0.423	3	H	-1.005		1.96	71	0.995
		0.258	4	Al	-1.016		3.02	74	0.984
		0.250	5	H	-1.501		3.86	53	0.499
		0.649	6	Al	-1.534		4.79	136	0.466
		0.958	7	H	-1.722		4.53	119	0.278
		0.721	8	H	-1.937		3.87	120	0.063
					-2.000	0.000			

	z_0	N	n	A	ΔE_1	ΔE_2	z	ψ	E
27	4.445	0.840	1	H	1.125	0.000	2.73	151	0.875
		0.066	2	H	-1.772		2.41	91	0.208
		0.469	3	O	-1.827		2.36	58	0.173
		0.353	4	H	-1.896		2.58	78	0.104
		0.814	5	H	-1.958		2.84	40	0.042
					-2.000	0.000			

Σ ΔE's, 6 samples
@ z_0 = 4.445 — 10.585 — 1.415

Initial N's

z_0 = 5.715	0.15	0.30	0.45	0.55	0.70	0.85
4.445	0.16	0.29	0.43	0.57	0.71	0.84
3.175	0.14	0.28	0.42	0.58	0.72	0.86
1.905	0.11	0.27	0.41	0.59	0.73	0.89
0.635	0.08	0.25	0.417	0.583	0.75	0.92

	z_0	N	n	A	ΔE_1	ΔE_2	z	ψ	E
8	3.175	0.140	1^R	H	-0.521	0.000	4.16	87	1.479
		0.011	2	O	-0.781		4.21	90	1.219
		0.745	3	Al	-0.914		4.15	83	1.086
		0.726	4	H	-0.987		4.24	68	1.013
		0.469	5	C		-0.112	7.80	134	0.902
		0.068	6	O	-1.115		1.89	92	0.773
		0.205	7	H	-1.459		1.80	97	0.429
		0.772	8	Al	-1.485		1.54	72	0.403
		0.698	9	H	-1.730		4.60	123	0.158
		0.028	10	H	-1.842	-0.112	4.39	114	0.047
					-1.888	-0.112			
9	3.175	0.280	1	H	-0.430		3.98	77	1.570
		0.060	2	H	-1.003		4.61	50	0.997
		0.603	3	C		-0.024	9.96	81	0.973
		0.013	4	C		-0.256	12.14	78	0.741
		0.684	5	C		-0.367	14.69	160	0.631
		0.960	6	C		-0.537	13.73	46	0.460
		0.050	7	C		-0.659	17.78	103	0.338
		0.568	8	C		-0.670	17.26	71	0.327
		0.414	9	C		-0.697	20.19	103	0.300

	z_0	N	n	R	ΔE_1	ΔE_2	z	ψ	E
	3.175	0.177	10	C	-1.003	-0.715	19.95	64	0.283
	(cont)	0.392	11	C		-0.735	21.39	120	0.262
		0.032	12	C		-0.768	20.93	127	0.229
		0.851	13	C		-0.769	20.80	112	0.228
		0.545	14	C		-0.819	19.95	74	0.178
		0.269	15	C		-0.850	20.73	158	0.147
		0.941	16	C		-0.892	19.73	30	0.105
		0.051	17	C	-1.003	-0.921	20.07	147	0.076
					-1.003	-0.997			
30	3.175	0.420	1	H	-1.562	0.000	5.73	132	0.438
		0.033	2	H	-1.729		4.47	125	0.271
		0.235	3	Al	-1.743		2.18	120	0.257
		0.177	4	H	-1.795		1.28	97	0.205
		0.407	5	O	-1.831		0.91	72	0.169
		0.705	6	H	-1.896		1.07	98	0.104
		-	7	H	-1.967		0.64	89	0.033
					-2.000	0.000			
31	3.175	0.580	1	Al	-0.061	0.000	2.88	145	1.939
		0.903	2	Al	-0.100		0.38	112	1.900
		0.657	3^R	H	-1.468		0.12	23	0.532
		0.434	4	Al	-1.489		0.82	51	0.511
		0.657	5	H	-1.636		1.65	38	0.364
		0.354	6	H	-1.951		3.89	100	0.049
					-2.000	0.000			
32	3.175	0.720	1	H	-0.964	0.000	3.25	120	1.036
		0.914	2	H	-1.937		1.52	56	0.063
					-2.000	0.000			
33	3.175	0.860	1	O	-0.329	0.000	3.34	155	1.671
		0.925	2^R	H	-1.553		4.15	75	0.447
		0.147	3	H	-1.692		4.26	101	0.308
		0.885	4	H	-1.818		3.82	68	0.182
		0.595	5	H	-1.845		4.03	45	0.155
		0.490	6	O	-1.861		5.02	37	0.137
		0.525	7	H	-1.937		5.44	11	0.063
					-2.000	0.000			

ΣΔE's to sample at $z_0 = 3.175$ — 10.891 — 1.109

	z_n	N	n	A	ΔE_1	ΔE_2	Z	ψ	E
4	1.905	0.110	1	H	-0.981	0.000	2.37	81	1.019
		0.723	2	O	-1.057		2.79	94	0.943
		0.228	3	H	-1.511		2.71	132	0.489
		0.927	4	H	-1.537		1.56	134	0.463
		0.797	5	H	-1.810		0.80	86	0.190
		0.446	6	Al	1.830		1.02	63	0.170
		0.346	7	H	-1.994		2.47	103	0.006
					-2.000	0.000			
5	1.905	0.270	1	H	-1.862	0.000	1.40	60	0.138
		0.593	2	H	-1.876		1.96	50	0.124
		0.651	3	O	-1.898		3.14	129	0.102
		0.185	4	Al	-1.900		2.97	164	0.100
		0.047	5	O	-1.902		2.96	160	0.098
					-2.000	0.000			
6	1.905	0.410	1	H	-0.382		1.83	77	1.618
		0.604	2	H	-1.831		2.88	37	0.169
		0.396	3	O	-1.854		4.34	129	0.146
		0.910	4	H	-1.883		3.86	103	0.117
		0.516	5	H	-1.884		2.93	99	0.116
		0.664	6	H	-1.889		2.62	111	0.111
		0.018	7	H	-1.955		2.10	94	0.045
					-2.000	0.000			
7	1.905	0.590	1	H	-1.623	0.000	3.34	60	0.377
		0.332	2	O	-1.676		3.82	42	0.324
		0.496	3	H	-1.835		4.79	47	0.165
		0.700	4	H	-1.881		5.56	19	0.119
		0.548	5	H	-1.890		6.01	11	0.110
		0.395	6	C	-1.890	-0.004	6.56	45	0.106
		0.792	7	C		-0.013	11.71	48	0.097
					-1.890	0.110			
8	1.905	0.730	1	C	0.000	-0.051	6.85	84	1.949
		0.928	2	C		-0.353	6.93	16	1.647
		0.460	3	C		-0.565	15.49	66	1.435
		0.576	4	C		-0.799	16.28	107	1.201
		0.796	5	C		-0.917	16.18	172	1.083
		0.017	6	C		-1.145	15.04	74	0.855
		0.998	7	C		-1.311	17.53	106	0.689
		0.217	8	C		-1.413	17.45	148	0.587
		0.082	9	C		-1.458	15.63	114	0.542

	z_0	N	n	A	ΔE_1	ΔE_2	z	Ψ	E(n)
	1.905	0.740	10	C	0.000	-1.569	14.95	19	0.431
	(cont)	0.443	11	C		-1.607	17.39	76	0.393
		0.860	12	C		-1.632	17.40	82	0.368
		0.750	13	C		-1.637	17.50	100	0.363
		0.088	14	C		-1.733	17.09	57	0.267
			15	C		-1.792	21.39	176	0.208
		0.991	16	C		-1.792	19.03	179	0.208
		0.956	17	C		-1.792	16.67	176	0.208
		0.940	18	C		-1.838	12.47	64	0.162
		0.047	19	C		-1.876	15.63	91	0.124
		0.302	20	C		-1.895	15.60	47	0.105
			21	C		-1.916	21.11	151	0.084
					0.000	-2.000			
39	1.905	0.890	1	O	-0.227	0.000	1.85	104	1.773
		0.213	2	H	-0.561		1.20	90	1.439
		0.664	3	H	-1.457		1.24	71	0.543
		0.684	4	O	-1.508		1.59	80	0.492
		0.267	5	O	-1.562		2.32	40	0.438
		0.612	6	H	-1.773		2.64	79	0.227
		0.892	7	H	-1.956		2.66	23	0.044
					-2.000	0.000			

Σ ΔE's, 6 samples at z_0 = 1.905 — ΔE_1: 9.890, ΔE_2: 2.110

	z_0	N	n	A	ΔE_1	ΔE_2	z	Ψ	E(n)
40	0.635	0.080	1	H	-1.440	0.000	4.24	21	0.560
		0.435	2	C		-0.027	15.53	62	0.533
		0.118	3	C		-0.131	17.49	138	0.428
		0.123	4	C		-0.136	11.62	144	0.424
		0.170	5	C		-0.241	11.50	74	0.319
		0.878	6	C		-0.263	13.05	59	0.296
		0.325	7	C		-0.306	13.53	85	0.253
		0.260	8	C		-0.312	13.72	74	0.248
		0.317	9	C		-0.326	13.86	80	0.233
		0.250	10	C		-0.353	15.10	77	0.207
		0.720	11	C		-0.377	15.15	4	0.182
		0.510	12	C		-0.391	15.18	61	0.169
		0.014	13	C		-0.391	16.41	50	0.168
		0.592	14	C		-0.425	16.57	69	0.134
		0.600	15	C		-0.439	18.21	94	0.120
		0.787	16	C		-0.458	17.81	36	0.102

	z_0	N	n	A	ΔE_1	ΔE_2	z	ψ	E
	0.635	0.600	17	C	-1.440	-0.478	19.22	76	0.081
	(cont)				-1.440	-0.560			
41	0.635	0.250	1	Al	-0.207	0.000	3.86	99	1.793
		0.738	2	H	-0.443		2.86	120	1.557
		0.973	3	H	-0.873		2.20	96	1.127
		0.653	4	H	-1.007		1.52	97	0.993
		0.266	5	H	-1.524		1.39	143	0.476
		0.015	6	H	-1.792		0.85	162	0.208
		0.060	7^R	Al	-1.797		0.26	34	0.203
		0.564	8	H	-1.878		1.19	67	0.122
		0.864	9	H	-1.959		2.44	68	0.041
					-2.000	0.000			
42	0.635	0.417	1	O	-0.135	0.000	1.08	143	1.865
		0.004	2^R	O	-0.439		4.66	144	1.561
		0.083	3	H	-1.301		4.28	114	0.699
		0.297	4	H	-1.579		4.29	129	0.421
			5	O	-1.604		1.70	172	0.396
		0.992	6^R	C	-1.604	-0.110	17.70	153	0.287
		0.618	7	C		-0.143	16.51	90	0.254
		0.654	8	C		-0.187	16.51	135	0.209
		0.877	9	C		-0.204	16.04	95	0.192
		0.316	10	C		-0.220	15.58	56	0.176
		0.373	11	C		-0.257	18.14	143	0.139
		0.886	12	C		-0.260	16.78	116	0.136
		0.446	13	C		-0.283	16.62	131	0.113
		0.101	14	C	-1.604	-0.304	13.51	53	0.093
					-1.604	-0.396			
43	0.635	0.583	1^R	H	-1.397	0.000	0.13	130	0.603
		0.931	2^R	H	-1.874		0.35	87	0.126
		0.809	3	H	-1.943		0.35	71	0.057
					-2.000	0.000			
44	0.635	0.750	1^R	H	-0.504		0.03	72	1.496
		0.202	2	H	-1.095		0.43	107	0.905
		0.919	3^R	H	-1.844		1.13	136	0.156
		0.958	4	H	-1.900		0.93	135	0.100
		0.798	5^R	H	-1.956		1.47	93	0.044
					-2.000	0.000			

	z_0	N	n	A	ΔE_1	ΔE_2	z	ψ	E
45	0.6[illegible]	0.820	1^R	H	-1.257	0.000	0.81	18	0.743
		0.550	2	O	-1.333		0.83	75	0.667
		0.318	3	Al	-1.378		1.74	54	0.622
		0.648	4	H	-1.530		1.90	34	0.470
		0.394	5	H	-1.710		3.88	61	0.290
		0.173	6	H	-1.928		4.19	69	0.072
					-2.000	0.000			

$\Sigma \Delta E$'s, 6 samples from z_0 = 0.635   11.044   0.956

Summary 45 neutrons:

	z_0	ΔE_f	ΔE_c
9 from	0.635	16.373	1.627
9 from	1.905	15.198	2.802
9 from	3.175	16.891	1.109
9 from	4.445	15.403	2.597
9 from	5.715	12.954	5.046
TOTAL		76.819	13.181

OF the 2×45 = 90 mev of the 45 neutrons,
85.4% is deposited in the fuel or water,
14.6% is deposited in the graphite.

---

of the 45 neutrons, 36 passed the lower energy cut-off in the H-O-Al, and 9 in the graphite. 36/45 = 0.800

---

46 Z_0 = 5.715 DC_0 = 0.460

	N	n	A	ΔE_1	ΔE_2	Z	ψ (cos ψ)	E
46	0.730	1	H	-0.180		6.22	0.199	1.820
	0.928	2	H	-1.163		6.32	0.775	0.837
	0.576	3	C	-1.163	-0.101	8.44	0.174	0.736
	0.248	4	C		-0.143	9.10	0.353	0.693
	0.302	5	C		-0.337	9.75	-0.147	0.500
	0.382	6	C		-0.337	9.66	-0.218	0.499
	0.963	7	C		-0.448	7.96	-0.733	0.382
	0.997	8	H	-1.204		6.13	-0.513	0.348
	0.597	9	H	-1.321		5.81	-0.324	0.231
	0.280	10	H	-1.392		4.85	-0.605	0.159
	0.860	11	O	-1.401		4.84	-0.316	0.151
	0.253	12	H	-1.548		4.82	0.879	0.003
				1.552	-0.448			

47 Z_0 = 5.715 DC_0 = 0.604

N	n	A	ΔE_1	ΔE_2	Z	ψ	E
0.202	1	C	0.000	-0.421	8.78	-0.914	1.579
0.934	2	Al	-0.177		5.10	-0.436	1.402
0.308	3	H	-1.221		4.90	-0.712	0.357
0.859	4	H	-1.345		3.97	-0.958	0.234
0.062	5	H	-1.378		3.16	-0.886	0.201
0.747	6 R	H	-1.559		1.31	+0.299	0.020
			-1.579	-0.421			

48 Z_0 - 4.445 DC_0 = 0.170

N	n	A	ΔE_1	ΔE_2	Z	ψ	E
0.585	1	H	-0.610	0.000	5.07	-0.400	1.390
0.983	2	H	-1.631		2.67	-0.805	0.369
0.112	3	H	-1.921		0.39	-0.786	0.079
			-2.000				

49 is missing see pg 68

50 Z_0 = 4.445 DC_0 - 0.534

N	n	A	ΔE_1	ΔE_2	Z	ψ	E
0.767	1	Al	-0.251	0.000	5.55	-0.910	1.749
0.045	2	O	-0.297		4.31	-0.668	1.703
0.290	3	H	-1.373		0.27	+0.170	0.627
0.461	4	Al	-1.376		1.66	+0.432	0.624
0.435	5	H	-1.473		3.10	+0.697	0.527
0.409	6	H	-1.779		4.28	0.826	0.221
0.630							

RN	N	A	ΔE_1	ΔE_2	z	cos ψ	En
0.630	7	C	-1.779	-0.030	6.96	-0.433	0.191
0.042	8	H	-1.928	-0.030	5.93	-0.966	0.042
			-1.770	-0.030			

51 z_0 = 4.445 DC_0 = -0.534

RN	N	A	ΔE_1	ΔE_2	z	cos ψ	En
0.233	1	H	-0.178	0.000	1.90	0.751	1.822
0.952	2	H	-1.985	0.000	1.13	-0.278	0.015
			-2.000	0.000			

52 z_0 = 4.445 DC_0 = -0.840

RN	N	A	ΔE_1	ΔE_2	z	cos ψ	En
0.080	1	H	-1.280	0.000	3.76	-0.423	0.720
0.280	2^R	H	-1.402		3.61	+0.111	0.598
0.118	3	H	-1.926		3.89	-0.418	0.074
			-2.000	0.000			

53 z_0 = 3.175 DC_0 = -0.120

RN	N	A	ΔE_1	ΔE_2	z	cos ψ	En
0.440	1	Al	-0.143		1.99	-0.963	1.857
0.039	2^R	O	-0.525		0.91	-0.720	1.475
0.648	3	O	-0.794		0.87	-0.055	1.206
0.074	4	Al	-0.875		0.65	-0.256	1.125
0.791	5^R	H	-1.284		0.28	0.568	0.716
0.643	6	O	-1.332		4.28	-0.422	0.668
0.930	7	H	-1.502		4.10	-0.655	0.498
0.141	8	H	-1.705		2.52	-0.154	0.295
0.621	9	H	-1.805		2.29	-0.195	0.195
0.231	10	H	-1.987		1.36	-0.786	0.013
			-2.000				

.218
6·1

54 z_0 = 3.175 DC_0 = 0.218

RN	N	A	ΔE_1	ΔE_2	z	cos ψ	En
0.609	1	C	0.000	-0.477	9.12	0.084	1.523
0.703	2	C		-0.693	9.20	0.997	1.307
0.488	3	C		-0.771	9.50	0.603	1.229
0.175	4	C		-1.035	10.43	0.292	0.965
0.606	5	C		-1.282	11.20	0.005	0.718
0.310	6	C		-1.485	11.24	-0.120	0.515
0.111							

→ Next Page

H	n	A	ΔE_1	ΔE_2	z	cos ψ	E
0.111	7	C	0.000	-1.609	10.97	0.749	0.391
0.426	8	C		-1.703	13.24	0.016	0.297
0.523	9	C		-1.740	13.29	-0.515	0.260
0.839	10	C		-1.774	12.61	0.243	0.226
0.684	11	C		-1.837	15.08	0.053	0.163
0.457	12	C		-1.839	15.08	-0.083	0.161
0.801	13	C		-1.878	15.06	0.672	0.122
	14	C		-1.902	15.85	-0.755	0.098
			0.000	-2.000			

55 z_0 = 3.175 DC_0 = $\overline{0.840}$ should have been 0.734 See pg 68

H	n	A	ΔE_1	ΔE_2	z	cos ψ	E
0.920	1	C	0.000	-0.182	12.29	0.673	1.818
	5	C	0.000	-1.121	11.96		0.879
0.397	10	C	0.000	-1.573	11.10	0.521	0.427
0.143	15	C	0.000	-1.753	10.24	-0.389	0.247
	19	H	-0.094	-1.822	6.29	-0.478	0.083
			~~-0.178~~	~~-1.822~~			

56 z_0 = 3.175 DC_0 = $-\overline{0.840}$ should have been 0.734 See pg 68

H	n	A	ΔE_1	ΔE_2	z	cos ψ	E
0.080	1	H	-1.280	0.000	2.49	-0.423	0.720
0.220	2^R	H	-1.402		4.88	0.111	0.598
0.118	3	H	-1.926		5.16	-0.418	0.074
			-2.000	0.000			

57 z_0 = 1.905 DC_0 = +0.278

H	n	A	ΔE_1	ΔE_2	z	cos ψ	E
0.639	1	H	-0.574	0.000	2.37	0.646	1.426
0.397	2	C	-0.574	-0.050	8.02	0.234	1.376
	5			-0.755	11.10	-0.435	0.671
0.088	10	H	-0.591	-0.947	6.80	-0.787	0.462
0.189	11	H	-0.792		3.11	-0.993	0.261
0.975	12	H	-0.820		2.46	-0.905	0.233
0.567	13	H	-0.976		2.01	-0.229	0.077
			-1.053	-0.947			

N	n	A	ΔE₁	ΔE₂	Z	cos ψ	E
58 Z_0 = 1.905			DC_0 = +0.886				
0.943	1	al	-0.143	0.000	3.44	-0.432	1.857
0.060	2	H	-1.052		3.30	-0.267	0.948
0.740	3	H	-1.395		2.16	-0.004	0.605
0.691	4	al	-1.446		2.16	-0.009	0.554
0.752	5	al	-1.469		2.15	-0.830	0.531
0.066	6 R	al	-1.521		2.03	-0.478	0.479
0.802	7 R	H	-1.645		0.20	-0.029	0.355
0.029	8	H	-1.829		0.06	-0.586	0.171
0.106	9 R	H	-1.871		0.01	0.569	0.129
0.274	10	H	-1.959		0.03	0.731	0.041
			-2.000	0.000			
59 Z_0 = 1.905			DC_0 = -0.886				
0.057	1 R	H	-0.962	0.000	2.91	0.342	1.038
0.737	2	H	-1.606		3.47	0.285	0.394
0.734	3	H	-1.842		4.26	-0.027	0.158
0.205	4	H	-1.919		4.23	-0.119	0.081
			-2.000	0.000			
60 Z_0 = 0.635			DC_0 = -0.326				
0.337	1	H	-1.442	0.000	0.20	0.521	0.558
0.416	2	H	-1.560		3.26	0.226	0.440
0.147	3	H	-1.854		3.57	0.724	0.146
0.616	4	O	-1.880		3.74	-0.350	0.120
0.640	5	Al	-1.886		3.70	-0.972	0.114
—	6	H	-1.939		2.25	-0.613	0.061
			-2.000	0.000			
61 Z_0 = 0.635			DC_0 = -0.680				
0.160	1 R	O	-0.124	0.000	0.59	0.928	1.876
0.560	2 R	C	-0.124	-0.494	11.34	0.879	1.382
0.928	5	C		-0.893	16.52	-0.742	0.983

N	n	A	ΔE1	ΔE2	Z	cos ψ	En
0.175	12	C	-0.124	-1.522	7.96	-0.455	0.354
0.479	13	C		-1.535	7.24	-0.904	0.341
0.964	14	al	-0.144	-1.535	5.10	-0.298	0.321
0.199	15	H	-0.281	-1.535	4.54	-0.466	0.184
0.187	16	H	-0.352	-1.535	4.48	-0.866	0.113
0.068	17	H	-0.438	-1.535	4.39	0.009	0.027
			-0.465	-1.535			

62 $z_0 = 0.635$ $DC_0 = 0.822$

0.911	1	Al	-0.238	0.000	0.82	-0.822	1.762
0.148	2^R	H	-0.982		1.43	0.722	1.018
0.292	3	al	-1.039		2.24	0.786	0.961
0.558	4	O	-1.206		4.50	-0.927	0.794
0.967	5	H	-1.352		2.47	-0.853	0.648
0.765	6	H	-1.676		1.81	-0.233	0.324
0.498	7	H	-1.801		1.28	-0.650	0.199
0.109	8	H	-1.884		1.00	-0.023	0.116
–	9	H	-1.956		0.99	0.493	0.044
			-2.000	0.000			

63 $z_0 = 0.635$ $DC_0 = -0.822$

0.089	1^R	C	0.000	-0.522	13.36	-0.884	1.478
0.863	2	C		-0.527	9.97	-0.869	1.473
0.753	3	H	-0.255	-0.527	2.99	-0.995	1.218
0.020	4^R	O	-0.343	-0.527	0.69	0.489	1.130
0.464	5	al	-0.497	-0.527	1.62	-0.390	0.977
0.316	6^R	H	-0.880	-0.527	0.58	-0.269	0.597
0.983	7^R	O	-0.771	-0.527	0.37	0.543	0.482
0.494	8	O	-1.084	-0.527	3.09	-0.946	0.390
0.053	9	al	-1.091	-0.527	2.79	-0.845	0.382
0.863	10	H	-1.417	-0.527	2.34	0.025	0.056
			-1.473	-0.527			

N	n	A	ΔE₁	ΔE₂	z	cos ψ	E
49	z_0 = 4.4[illegible]5		DC_0 = −0.170				
0.415	1	H	−1.390	0.000	3.97	−0.912	0.610
0.014	2	H	−1.619	0.000	1.31	−0.559	0.381
0.362	3ᴿ	O	−1.634	0.	0.38	−0.219	0.366
0.002	4ᴿ	H	−1.939	———	3.42	−0.200	0.061
			−2.000	0.000			
55	z_0 = 3.175		DC_0 = 0.734				
0.867	1	O	−0.094	0.000	3.38	0.124	1.906
0.145	2	H	−0.721		3.80	0.613	1.279
0.428	3	C	−0.721	−0.225	7.94	−0.202	1054
0.772	4	C		−0.450	6.84	0.522	0.829
0.668	5	C		−0.470	8.90	−0.136	0.809
0.819	7	H	−1.292	−0.561	6.15	0.040	0.147
0.711	8	H	−1.425	−0.561	6.16	−0.342	0.014
			−1.439	−0.561			
56	z_0 = 3.175		DC_0 = −0.734				
0.133	1ᴿ	C	0.000	−0.365	6.56	−0.313	1.635
0.211	2	H	−0.127	−0.365	5.86	−0.351	1.508
0.219	3	H	−0.896		1.93	−0.174	0.739
0.267	4	O	−0.985		1.42	0.974	0.650
0.528	5	H	−1.006		6.32	0.952	0.628
0.231	6	C	−1.006	−0.459	12.04	−0.073	0.542
0.137	8	C		−0.640	10.23	−0.046	0.354
0.123	11	H	−1.043	−0.790	4.20	−0.778	0.166
0.830	12	H	−1.094		4.16	−0.995	0.116
0.996	13	H	−1.178	−0.790	3.93	−0.517	0.031
			−1.210	−0.790			

Statistical Summary

Case 1 All 63 neutrons

		ΔE_1	ΔE_2
First	45	76.819	13.181
Next	18	28.741	7.259
		105.560	20.440

Fraction in Graphite 0.162

Case 2 50 neutrons. This case was constructed by deleting 13 neutrons and adding the 18 neutrons number 46-63. The 13 that were discard were rejected because of one of the following:

a. The early results were somewhat biased in initial direction, 24 started moving into the fuel box, only 19 outward, 2 unknown.

b. The two unknown (in direction) were discarded.

c. others were paired using complementary initial direction cosines. Two that had been paired (26 and 27) fell close to another pair (24 and 25). The 50 neutrons are unbiased and more uniformly sample the z_0, $\cos\phi_0$ initial coordinates.

The 13 discards are Nos 2, 3, 5, 9, 10, 11, 12, 13, 14, 26, 27, 29, 45. These neutrons had deposited 94.3% of their energy in the fuel box. The 50 neutron summary.

$\Delta E_1 = 81.021$ 81%

$\Delta E_2 = 18.979$ 19%

NEUTRONS THAT ENTER GRAPHITE

	z_0	$(\cos\phi)_0$	E_1	ΔE	n_e	n_c
4	1.905	- 0.278	1.156	0.692	1	9
6	5.715	- 0.603	0.115	0.115	1	1
7	4.445	+ 0.840	2.000	1.043	2	3, 10
15	0.635	- 0.326	0.831	0.312	1	4
17	5.715	+ 0.300	1.876	1.082	1	7
18	5.715	+ 0.800	2.000	0.511	1	1
19	5.715	- 0.800	1.917	1.677	2	6, 6
21	5.715	- 0.100	1.958	1.695	1	13
22	4.445	+ 0.780	1.892	0.339	1	2
24	4.445	+ 0.340	1.778	1.076	3	1, 3, 3
28	3.175	- 0.560	1.013	0.112	1	1
37	1.905	0.140	0.110	0.110	1	2
38	1.905	0.580	2.000	2.000	1	21
40	0.635	0.680	0.560	0.560	1	16
42	0.635	0.182	0.396	0.396	1	9
46	5.715	0.460	0.837	0.448	1	5
47	5.715	0.604	2.000	0.421	1	1
50	4.445	0.534	0.221	0.030	1	1
54	3.175	0.218	2.000	2.000	1	14
55	3.175	0.734	1.279	0.561	1	3
56	3.175	-0.734	2.000	0.790	2	1, 3
57	1.905	0.278	1.426	0.947	1	9
61	0.635	-0.680	1.876	1.535	1	12
63	0.635	-0.822	2.000	0.527	1	2
			33.241	18.979		

24 neutrons reached graphite (48%)

			$\bar{E}_1$
7	neutrons reached graphite	from z_0 = 5.715	1.53
4	" " "	" " = 4.445	1.47
4	" " "	" " = 3.175	1.57
4	" " "	" " = 1.905	1.17
5	" " "	" " = 0.635	1.12

$\bar{E}_1$ = 1.385 mev/neutron
$\overline{\Delta E}$ = 0.783 mev/neutron

Number Entering in $\Delta E = E_1 - E_2$

ΔE =	
2.0 - 1.0	8
1.0 - 0.5	7
0.5 - 0.25	5
< 0.25	4

1. The average neutron which reaches graphite, deposits 0.783/2 = 0.392 of its birth energy in the graphite.

2. As 48% of the neutrons reach the graphite one way or another, the fraction of the total birth energy that is deposited in graphite is:

$$0.392 \times 0.48 = 0.188$$

INITIAL CONDITIONS - Direction Cosines at z_0 in $\Delta(\cos\psi) = 0.10$

	5.715	4.445	3.175	1.905	0.635
ESCRIPTION		1	2	3	4
0.0 - 0.1			~~3 -0.067~~	34/39 ± 0.060	
0.1 - 0.2	20 - 0.100 21 + 0.100	48 + 0.170 49 - 0.170	~~13 + 0.166~~ 32 + 0.120 53 - 0.12 0	36/37 ± 0.140	42/43 ± 0.180
0.2 - 0.3			8 - 0.218 54 + 0.218	4 -0.278 57 +0.278	
0.3 - 0.4	16 - 0.300 17 + 0.300	~~12 -0.350~~ 24/25 + 0.340 ~~26/27 ± 0.360~~	30/31 ± 0.320		15 - 0.326 60 - 0.326
0.4 - 0.5	1 -0.460 ~~1 -0.436~~ 46 +0.460				~~5 -0.426~~
0.5 - 0.6		50 + 0.534 51 - 0.534	28/33 ± 0.560	~~9 + 0.506~~ ~~14 0.520~~ 35/38 ± 0.580	41/45 ±0.500
0.6 - 0.7	6 - 0.603 47 + 0.604	~~2 -0.618~~			40 + 0.680 61 - 0.680
0.7 - 0.8		22 + 0.780 23 - 0.780	55 0.734 56 - 0.734		
0.8 - 0.9	18 0.800 19 - 0.800	7 + 0.840 52 - 0.840		58 + 0.886 59 - 0.886	~~10 + 0.860~~ 62 + 0.822 63 -0.822
0.9 - 1.0					
			~~29~~ ?		~~45~~ ?