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SPANDY—A MONTE CARLO PROGRAM FOR GAS TARGET SCATTERING GEOMETRY

by

Nelson Jarmie, J. H. Jett,
A. C. Niethammer

ABSTRACT

A Monte Carlo computer program is presented that simulates a two-slit gas target scattering geometry. The program is useful in estimating effects due to finite geometry and multiple scattering in the target foil. Details of the program are presented and experience with a specific example is discussed.

INTRODUCTION

A gas target with two slits is used to define the scattering geometry in many experiments in nuclear and particle physics. The yield of the scattering experiment depends on the "geometry factor" G , which is basically a function of the slit sizes and distances. This factor has been calculated for a variety of approximations, including finite slit sizes, finite beam, and a divergent beam.¹⁻⁵ The formulas depend on the detailed shape of the scattering cross section. In the usual case, calculations are made to second order and involve the angular slope $\sigma'(\theta) = d\sigma/d\theta$ and curvature $\sigma''(\theta) = d^2\sigma/d\theta^2$ of the differential cross section.

Recently, the role of multiple scattering of particles in the exit foil of the gas target has become potentially important.⁶ Where there is a large angular curvature in the nuclear cross section, the particles scattered out of the detection line may not be compensated for by those scattering in.^{7,8} Essentially, the multiple scattering in the foil contributes to the angular width of the detection system, but the effect is difficult to calculate analytically or numerically because of the complicated geometry.

We have written a Monte Carlo type of program (see Appendix A) to estimate this effect. The program may also be used to compute detection geometries not covered by Refs. 1-5 and to check the accuracy of their formulas. Formulas for the multiple scattering corrections in thin *solid* targets are known^{9,10} and are compared with our results. In many cases, including the experiment¹¹ that inspired this work, the solid target formula gives a sufficiently accurate correction for the gas target geometry.

METHOD

The program simulates the progressive three-dimensional history of a scattering experiment (see Fig. 1). The position and divergence of a single beam particle are specified by four random numbers; the position of the nuclear scattering point along the beam is specified by a fifth random number. A polar and an azimuthal scattering direction are calculated using an assumed angular distribution together with random numbers six and seven. A Gaussian multiple scattering distribution is assumed at the target

Fig. 1.

Schematic (not to scale) of simulated history of a scattering experiment. Dashed arrow exemplifies the path of an undetected particle.

foil, where two more random numbers are used to specify a new flight direction. Tests are then made to determine whether the particle has passed successfully through both slits (is detected). The various transformations in the particle's flight path are made by consistent use of direction cosines.

The above sequence is run many times until the desired statistical accuracy is obtained (or until one runs out of computer time) for a given set of constraints—slit sizes, multiple scattering angle, etc. The history of each particle is recorded—scattering angle, multiple scattering angle, position in passing through the slits, etc.—and tables and plots of the resulting spectra are produced. This procedure is followed for all particles as well as for just the detected particles. The spread of energy from the different pathlengths is also recorded.

RESTRICTIONS

The program has few restrictions. At present, the program assumes a parallel beam. The energy calculation assumes a simple elastic scattering.

PROGRAM STRUCTURE

Frequent comment cards in the listing (Appendix A) indicate the details of the calculation. The program consists of a main program SPANDY and four subprograms EVALF, SINP, BINTAB, and SIMPSON.

SPANDY has three sections: (1) preliminary, (2) main loop, and (3) output. The *preliminary* section reads the input information and calculates various constants to be used in the main loop. In particular, it computes a cumulative distribution function (CDF) from the nuclear scattering angular distribution supplied by the user in EVALF. The CDF is used with a random number to choose a scattering direction. The *main loop* makes the calculation described in METHOD. It is written as efficiently as possible because most of the computing time is spent there. The *output* computes certain final averages and prints and plots the results.

EVALF contains the analytic form of the angular distribution of the nuclear scattering.

SINP is used to print the input data.

BINTAB tabulates the particle histories.

SIMPSN is a Simpson integration routine called by SPANDY in the calculation of the CDF.

INPUT

All input is in millimeters, MeV, and degrees. The input cards and formats are as follows (details are mentioned in the program listing):

Card 1 (8A10) Title

Card 2 (8I10)

NS number of source particles
KNTRL determines plot and table production
NSIGTRL reserved for future angular distribution options

Card 3 (7E10.3)

AO half-height of beam
BO half-width of beam

Card 4 (7E10.3)

Z1 beginning of target acceptance region
Z2 end of target acceptance region
ZC origin of target center
(The values on card 4 are usually measured from a nominal point, such as the front foil of the gas target.)

Card 5 (7E10.3)

THD nominal angle of slit system with respect to the beam
DELTHD ($\pm$) polar scattering acceptance range
PHIM minimum azimuthal angle acceptance range
PHIX maximum azimuthal angle acceptance range
THRMS RMS multiple scattering angle in target foil

Card 6 (7E10.3)

EO initial beam energy
DEDX stopping power of beam in target gas (MeV/mm)
DEDX2 stopping power of scattered particle in gas
DEFOIL energy loss of exit particle in target foil (MeV)

ELOSS plot limit for beam energy losses
ELOSD plot limit for detected particle energy loss

Card 7 (7E10.3)

B1 half-width of first slit
B2 half-width of second slit
L2 half-height of second slit
R1 distance from target center to first slit
R0 distance from target center to second slit

Card 8 (7E10.3) The following are limits for tables and plots:

XSTMIN minimum width limit for both slits
XSTMAX maximum width limit for both slits
YSTMIN minimum height limit
YSTMAX maximum height limit

In addition, the program must be changed to determine the initial random number and the formula for the angular distribution in EVALF. Details concerning the computer are given in Appendix B.

OUTPUT

All input information is printed (see Appendix C). Some diagnostic information may be printed, depending on the branching in the program. If called for, the distribution history tables are printed (Appendix D). The final results are printed (see example in Appendix E). Also printed are the mean angles of the successfully detected particles. The last random number is given to permit a continuation, if desired.

PHILOSOPHY OF PROGRAM OPERATION

As with all Monte Carlo programs, there is a trade-off between running time and accuracy. The acceptance ranges in Cards 4 and 5 must be large enough to insure that all possible detected events are physically allowed. However, as the ranges get larger, there will be more "wasted" trials and more inefficient running. Proper acceptances must be chosen by trial and error—the distribution tables are helpful here. The tabulation should then be turned off for long statistics runs because it slows the main loop considerably.

EXPERIENCE AND EXAMPLE

In Appendix C are listed the parameters of the most difficult case for which the program has been used. The experiment simulated is the nuclear reaction ${}^4\text{He}(t, \alpha){}^3\text{H}$ at 9.844 MeV. The detected alpha particles scattered at 30° have a large multiple scattering in the target foil (1.6°). This scattering occurs near a deep minimum in the angular distribution and a serious noncompensation effect results. The formula calculated in EVALF is

$$\sigma(\theta) = 10 + 2(\theta - 30)^2 \text{ mb/sr},$$

which closely simulates the actual data.¹¹ One of the major problems is to estimate the shape of the angular distribution to be used in the program.

The efficiency of the simulation is such that only about 1 in 3000 source particles is "detected." The program was run with 3.5×10^7 source particles each for the case where the multiple scattering angle was 1.6° or 0.0° . About 4 h of CDC-7600 central processor time was used. The resulting increase of detected particles for 1.6° over those for 0.0° was $25.8 \pm 1.2\%$. The solid target correction formula

$$1/4 (\text{THRMS})^2 (\sigma''/\sigma)$$

predicts a ratio increase of 25.6%. Thus the program gives a large correction and shows that the solid target formula gives a good approximation for the correction in this case.

Problems not involving losses due to multiple scattering are more efficient and consume significantly less computer time.

FUTURE IMPROVEMENTS

The following improvements could be made in the code:

1. Allowance for a divergent beam.
2. Significant reduction in running time. Sophisticated reprogramming in machine or assembly languages has not been attempted.
3. Installation of a more general, yet accurate, way of choosing the angular form of the scattering distribution.

4. Adaptation to a scattering distribution dependent on both the azimuthal and polar angles so that asymmetry measurements in nuclear scattering could be studied.

ACKNOWLEDGMENT

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APPENDIX A

SPANDY PROGRAM LIST

LASL Identification
No. LP-0754

C	SPANDY IS A MONTE CARLO PROGRAM THAT MOCKS UP A GAS TARGET GEOMETRY	SPANDY	2
C	AND ALLOWS TESTS FOR FINITE BEAM, FINITE SLIT SIZES, MULTIPLE	SPANDY	3
C	SCATTERING IN THE TARGET FOIL, AND THE SHAPE OF THE CROSS SECTION,	SPANDY	4
C	ALL INPUT IN DEGREES, MILLIMETERS, AND MEV.	SPANDY	5
C	WRITTEN BY JIM JETT, ANNE NIETHAMMER, AND BILL JARMIE.	SPANDY	6
C	AT PRESENT (6/76), BEAM DIVERGENCE IS NOT BUILT IN.	SPANDY	7
C		SPANDY	8
C		SPANDY	9
C	PROGRAM SPANDY(INP,OUT,FILM,FSET10=INP,FSET9=OUT,FSET12=FILM)	SPANDY	10
2	REAL LL,L1,L2,L3	SPANDY	11
2	REAL NORMX,NORMY,NORMZ,NORMP	SPANDY	12
2	REAL LOC1,LOC2,LOC3,LOC4,LOC5,LOC6,LOC7,LOC8,LOC9,LOC10	SPANDY	13
2	DIMENSION TITLE(6),XTITLE(50)	SPANDY	14
2	DIMENSIONX(50),Y(50),TOP(2),AS(50),BS(50),CS(50),O2X(50),TABTHS(3)	SPANDY	15
2	COMMON/DEN1/BIN1(50),BIN2(50),BIN3(50),BIN4(50),BIN5(50),BIN6(50),	SPANDY	16
2	BIN7(50),BIN8(50),BIN9(50),BIN10(50)	SPANDY	17
2	COMMON/ANNE/LOC1(50),LOC2(50),LOC3(50),LOC4(50),LOC5(50),LOC6(50),	SPANDY	18
2	LOC7(50),LOC8(50),LOC9(50),LOC10(50)	SPANDY	19
2	COMMON/RON/KNTRL,DTOR,RTOD,H1,H2,H3,H4,H5,H6,H7,H8,H9,H10	SPANDY	20
2	COMMON/BILL/XSTMIN,XSTMAX,YSTMIN,YSTMAX	SPANDY	21
2	DIMENSION LABX1(4),LABX2(4),LABX3(4),LABX4(4),LABX5(4),LABX6(4),	SPANDY	22
2	LABX7(4),LABX8(4),LABX9(4),LABX10(4)	SPANDY	23
	DATA LABX1/31MPOLAR SCATTERING ANGLE, DEGREES/	SPANDY	24
	DATA LABX2/35MAZIMUTHAL SCATTERING ANGLE, DEGREES/	SPANDY	25
	DATA LABX3/34HZ-AXIS NUCLEAR SCATTERING INTERVAL/	SPANDY	26
	DATA LABX4/30MPOLAR MULTIPLE SCATTER CORRECTION, DEG./	SPANDY	27
	DATA LABX5/10HX-AXIS, FIRST SLIT/	SPANDY	28
	DATA LABX6/10HY-AXIS, FIRST SLIT/	SPANDY	29
	DATA LABX7/10HX-AXIS, SECOND SLIT/	SPANDY	30
	DATA LABX8/10HY-AXIS, SECOND SLIT/	SPANDY	31
	DATA LABX9/25HENERGY AT SCATTERING, MEV/	SPANDY	32
2	DATA LABX10/24HENERGY AT DETECTION, MEV/	SPANDY	33
	EXTERNAL EVALF	SPANDY	34
C***	READ FORMATS	SPANDY	35
1	FORMAT(8A10)	SPANDY	36
2	FORMAT(7E10,3)	SPANDY	37
3	FORMAT(8I10)	SPANDY	38
C***	PRINT FORMATS	SPANDY	39
8	FORMAT(1H1,/,10X,0BEGIN MONTE CARLO CALCULATIONS0///)	SPANDY	40
9	FORMAT(1H1)	SPANDY	41
10	FORMAT(1H1,8A10/)	SPANDY	42
11	FORMAT(1P7E10,5)	SPANDY	43
12	FORMAT(0 LOWER AND UPPER INTEGRATION LIMITS00 2E10,50 DEGREES0/)	SPANDY	44
13	FORMAT(0 VALUES OF THS VS, INTEGRAL0/)	SPANDY	45
14	FORMAT(0 RANF00 E12,5,6X,0TABTHS(1)00E12,5/)	SPANDY	46
15	FORMAT(0 STEP SIZE00 E10,4/)	SPANDY	47
16	FORMAT(2E20,5)	SPANDY	48
17	FORMAT(0 NORMALIZED TABLE0/)	SPANDY	49
18	FORMAT(0 NORMALIZATION OF DIRECTION COSINES004E20,4//)	SPANDY	50
19	FORMAT(1X,0TIMINT00 1PE13,4/)	SPANDY	51
20	FORMAT(6E20,5)	SPANDY	52
21	FORMAT(0 COORDINATES OF SCATTERED PARTICLE003E12,5//	SPANDY	53
10	DIRECTION COSINES003E12,5,0 XT00F0,1/)	SPANDY	54
22	FORMAT(0 NCOL002,4X,0ENTRY FOIL PARAMETERS 004E12,5//)	SPANDY	55
23	FORMAT(000 ERROR, POLAR ANGLE OUT OF ACCEPTANCE REGION0//)	SPANDY	56
24	FORMAT(0 RANF00E12,5,6X,0POLAR ANGLE00E12,50 DEGREES0//)	SPANDY	57
25	FORMAT(000 ERROR, AZIMUTHAL ANGLE OUT OF ACCEPTANCE REGION0//)	SPANDY	58
26	FORMAT(000 AZIMUTHAL ANGLE00E12,50 DEGREES0//)	SPANDY	59
27	FORMAT(000 ERROR, NEGATIVE DISTANCE ROOT0/)	SPANDY	60
28	FORMAT(0 COORDINATES OF FOIL EXIT POINT003E12,5,0 DT0F00E12,5//)	SPANDY	61
29	FORMAT(0 MULTIPLE SCATTERING CORRECTIONS FOR RG003E12,50 RADIANS0)	SPANDY	62
30	FORMAT(0 COORDINATES OF TARGET EXIT PT, M,R,TO THD00 3E12,5//)	SPANDY	63
31	FORMAT(0 DIRECTION COSINES M,R,TO THD004E12,5//)	SPANDY	64
32	FORMAT(0 X AND Y COORDINATES AT FIRST SLIT002E12,5//)	SPANDY	65
33	FORMAT(0 X AND Y COORDINATES AT SECOND SLIT002E12,5//)	SPANDY	66
34	FORMAT(0 D100E12,5,0 E1800E12,5//)	SPANDY	67
35	FORMAT(0 E1A00E12,5,0 D200E12,5,0 E2A00E12,5//)	SPANDY	68
36	FORMAT(0 NUMBER OF SOURCE PARTICLES 00 15//)	SPANDY	69


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37 FORMAT( * RESULTS ARE AS FOLLOWS=,5X,ACTUAL NUMBER OF SOURCE PART SPANDY 71
1ICLES= ,110/5X,NUMBER OF PARTICLES TRAPPED BY SLIT1= ,110/5X,PA SPANDY 72
2RTICLES THROUGH SLIT1 BUT NOT SLIT2=,110/5X,NUMBER OF DETECTED PAR SPANDY 73
3TTICLES RESULTING=,10/5X, SPANDY 74
38 FORMAT(12E20,5) SPANDY 75
39 FORMAT(1H1,/,30X,RA10) SPANDY 76
40 FORMAT(33X,KNTRL=,12, * ALL PARTICLES TABULATED=) SPANDY 77
41 FORMAT(2X,VARIABLE= 9X,THSCAT=,6X,PHISCAT=,6X,ZSCAT=,6X, SPANDY 78
1,THMSCAT=,7X,XS1=,9X,YS1=,9X,XS2=,9X,YS2=,9X,E1A=,9X, SPANDY 79
2,EAD=) SPANDY 80
42 FORMAT(2X,PLOT MESH=,5X,1P1NF12,3) SPANDY 81
43 FORMAT(2X,PLOT RANGE=,4X,10(F6,2, * F5,2) SPANDY 82
44 FORMAT(2X,BIN(=,12)=,6X,10(F6,8,4X)) SPANDY 83
45 FORMAT(33X,KNTRL=,12, * DETECTED PARTICLES TABULATED=) SPANDY 84
46 FORMAT(85X,DATE=,A10, * JOBNAME= ,A10) SPANDY 85
47 FORMAT( * AVERAGE POLAR ANGLE= *F7,2, * +- *F5,2, * DEG/* AVERAGE A SPANDY 86
121MUTH ANGLE= *F7,2, * +- *F5,2, * DEG/* RMS MULTIPLE SCATT ANGLE= SPANDY 87
2*F6,2, * DEG,(SHOULD CHECK INPUT)=) SPANDY 88
48 FORMAT(1H0, * LAST RANDOM NUMBER (TO CONTINUE RUN)= *F25,10//) SPANDY 89
C SPANDY 90
C FOR REGULAR START LEAVE R=0,0 SPANDY 91
C R=0,0 INITIATES THE REGULAR RANDOM NUMBER SEQUENCE WITH THE BUILT-IN SPANDY 92
C SEED. TO CONTINUE FROM A PREVIOUS RUN USE THE LAST RANDOM NUMBER SPANDY 93
C PRINTED ON THE PREVIOUS RUN AS FOLLOWS-- INSERT TWO CARDS SPANDY 94
C R=,XXXXXX WHERE XXXXXX IS LAST RANDOM NUMBER FROM PREVIOUS RUN SPANDY 95
C DUMMY=,RANF(R) SPANDY 96
C THESE CARDS MUST BE FOLLOWED BY R= 0,0 SPANDY 97
2 R=.763655394338950799 MOD1 1
3 DUMMY=,RANF(R) MOD1 2
6 R=0,0 SPANDY 98
C SET UP OVERTIME PROTECTION SPANDY 99
6 NTIME=0 SPANDY 100
C GET TIME LIMIT FROM JOB CARD IN SECONDS SPANDY 101
7 CALL GETO(4LKTLN,LIMTIME) SPANDY 102
11 TIMELIM=LIMTIME*27,5E-9 SPANDY 103
C SPANDY 104
C MOD1 3
C MOD1 4
C MOD1 5
14 000 CONTINUE SPANDY 105
14 READ 1,TITLE SPANDY 106
22 IF(EOF,10)430,802 SPANDY 107
25 002 CONTINUE SPANDY 108
25 READ 3,NS,KNTRL,NSIGTRL SPANDY 109
C NS =NOMINAL NUMBER OF TRIES, NSIGTRL CHOOSES SCATTERING INPUT OPTION SPANDY 110
C KNTRL=1, NO PLOT OUTPUT, SPANDY 111
C =2, PLOT OUTPUT FOR DETECTED PARTICLES ONLY, SPANDY 112
C =3, PLOT OUTPUT FOR DETECTED AND ALL SOURCE PARTICLES, SPANDY 113
C READ SQUARE INPUT APERTURE HALF-WIDTH,HT, ALL INPUT IN MM MOD1 6
37 READ 2,A0,80 SPANDY 115
C READ INPUT GEOMETRY FOR SYSTEM,(Z2-Z1)DEFINES Z-AXIS ACCEPTANCE SPANDY 116
C REGION FOR SCATTER, ZC IS THE ORIGIN OF COORDINATE SYSTEM, SPANDY 117
C ZC FROM FRONT FOIL TO TARGET CENTER SPANDY 118
47 READ 2, Z1,Z2,ZC SPANDY 119
61 ZAA=Z2-Z1 SPANDY 120
C THD IS THE FIXED POLAR ANGLE MEASURED FROM THE Z-AXIS TO THE AXIS SPANDY 121
C OF THE DETECTOR, PHIM AND PHIX,THE MIN AND MAX AZIMUTHAL ANGLE, SPANDY 122
C THRS IS THE POLAR ANGLE MULTIPLE SCATTER ROOT MEAN SQUARE, IN DEG. SPANDY 123
63 READ 2,THD,DELTHD,PHIM,PHIX,THRS SPANDY 124
C INPUT INITIAL ENERGY AND ENERGY RELATED PARAMETERS IN MEV, SPANDY 125
C ELOSS AND ELOSD ARE THE MINIMUM ENERGIES ALLOWED FOR SCATTER SPANDY 126
C AND DETECTION, AND ARE USED IN THE PLOTTING ROUTINE. SPANDY 127
101 READ 2,E0,DEDX,DEDX2,DEFOIL,ELOSS,ELOSD SPANDY 128
C INPUT GEOMETRY FOR COLLIMATING SLITS IN MM SPANDY 129
C B1 IS THE HALF-WIDTH OF THE FIRST SLIT, B2 OF THE REAR SLIT, SPANDY 130
C L2 IS REAR SLIT HALF-HEIGHT, R1 IS THE DISTANCE FROM TARGET CENTER SPANDY 131
C TO FIRST SLIT, R0 FROM TARGET CENTER TO REAR SLIT. SPANDY 132
C RT IS THE TARGET RADIUS (REMEMBER FOIL BULGE) SPANDY 133
121 READ 2,B1,B2,L2,R1,R0,RT SPANDY 134
C READ IN PLOT LIMITS FOR SLITS SPANDY 135
141 READ 2,XSTHIN,XSTMAX,YSTHIN,YSTMAX SPANDY 136
C INITIALIZE COUNTERS AND CONSTANTS USED IN CODE. SPANDY 137
155 PI=3.14159265 SPANDY 138
155 THOP1=6.26310531 SPANDY 139
155 DTOR=0.0174533 SPANDY 140
155 RTOD=57.29578 SPANDY 141
155 EPS=1.E-06 SPANDY 142
155 NP=50 SPANDY 143
155 NR=NP-1 SPANDY 144
155 NCOL=0 SPANDY 145
155 NTRPSL1=0 SPANDY 146
155 NTSINT=0 SPANDY 147

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155	INIT=0	SPANDY	148
155	C LIMITS ON PHI AND THETA, THE SCATTERING ANGLES IN THE GAS,	SPANDY	149
155	THTSM=THD+DELTHD	SPANDY	150
155	THTSX=THD+DELTHD	SPANDY	151
	C PRELIMINARY DEFINITIONS FOR MULTIPLE SCATTERING,	SPANDY	152
155	LX=10	SPANDY	153
155	FLX=FLOAT(LX)	SPANDY	154
155	TEMPH=FLX/2.0	SPANDY	155
200	STDEV=SQRT(FLX/12.0)	SPANDY	156
	C DEFINE MINIMUM AND MAXIMUM RANGE FOR POLAR MULTIPLE SCATTERING, IN DEG	SPANDY	157
205	STH=THRMS/STDEV	SPANDY	158
205	THMSMIN=0.0	SPANDY	159
205	THMSMAX=5.5*STH	SPANDY	160
	C CONVERT TO RADIANs,	SPANDY	161
205	THRMS=THRMS*DTOR	SPANDY	162
205	STH=THRMS/STDEV	SPANDY	163
	C***CALL THE SUBROUTINE THAT PRINTS OUT INPUT DATA,	SPANDY	164
213	CALL SING(TITLE,THSM,THTSX,PHIM,PHIX,EQ,DEOX,DEOX2,DEFOIL,	SPANDY	165
	1THRMS,ZAA,RT,R1,B1,R0,B2,L2,KNTRL,THD,DELTHD,NS,NSIGTRL)	SPANDY	166
	C COMPUTE PRELIMINARIES FOR FIRST SCATTERING,	SPANDY	167
241	THDR=THD*DTOR	SPANDY	168
243	COST=COS(THDR)	SPANDY	169
245	SINT=3IN(THDR)	SPANDY	170
	C SET UP THE GIVEN SCATTERING POLAR ANGLE DISTRIBUTION FOR RANDOM	SPANDY	171
	C INTERPOLATION BY INTEGRATING THE DISTRIBUTION FUNCTION OVER THE SOLID	SPANDY	172
	C ANGLE,	SPANDY	173
250	LL=THTSX	SPANDY	174
250	UL=THTSX	SPANDY	175
	C SOLVE THE INDEFINITE INTEGRAL FOR VALUES OF THS IN ACCEPTANCE REGION	SPANDY	176
	C CONSTRUCT TABLES OF THS VS. INTEGRAL FOR USE IN SPLINE INTERPOLATION	SPANDY	177
	C CHANGE INTEGRATION LIMITS TO RADIANs,	SPANDY	178
250	LL=LL*DTOR	SPANDY	179
250	UL=UL*DTOR	SPANDY	180
250	HTHS=(UL-LL)/NR	SPANDY	181
257	DO 100 INC=1,NP	SPANDY	182
262	K=INC-1	SPANDY	183
262	THS=(LL+K*HTHS)	SPANDY	184
262	X(INC)=THS	SPANDY	185
267	Y(INC)=SIMP8N(EVALF,LL,THS,EPB)	SPANDY	186
274	100 CONTINUE	SPANDY	187
276	DO 101 I=1,50	SPANDY	188
303	X(I)=X(I)*RTOD	SPANDY	189
303	101 CONTINUE	SPANDY	190
	C NORMALIZE THE C.D.F., DIVIDE Y(INC) BY THE TOTAL INTEGRAL,	SPANDY	191
305	DO 110 INC=1,NP	SPANDY	192
312	110 Y(INC)=Y(INC)/Y(NP)	SPANDY	193
	C SET UP CONSTANTS NEEDED FOR SPLINE INTERPOLATION,	SPANDY	194
314	IJ=1	SPANDY	195
314	TOP(1)=5	SPANDY	196
314	TOP(2)=5	SPANDY	197
317	CALL SPL101(NP,Y,X,DRX,TOP,IJ,45,88,CS)	SPANDY	198
	C SET UP CONSTANTS FOR PLOT ROUTINE IF KNTRL=2 OR 3,	SPANDY	199
330	IF(KNTRL,EQ,2,OR,KNTRL,EQ,3)CALL BINTAB(THTSX,0.,THTSX,PHIM,0.,	SPANDY	200
	1PHIX,Z1,ZC,0.,Z2,0.,0.,THMSMAX,0.,0.,0.,0.,ELOSS,0.,ELOSS,0.,EOI)	SPANDY	201
	C	MOD1	7
	C	MOD1	8
	C START PARTICLES BOMBARDING TARGET, BEGIN MONTE CARLO RANDOMIZATION	SPANDY	202
	C	SPANDY	203
	C START LOOP	SPANDY	204
	C	SPANDY	205
366	500 CONTINUE	SPANDY	206
	C OVERTIME PROTECTION, TESTS EVERY 100 LOOPS AND LEAVES 10 SECONDS	SPANDY	207
366	NTIME=NTIME+1	SPANDY	208
370	IF(NTIME-100)501,502,502	SPANDY	209
372	502 CALL SECOND(TIMINT)	SPANDY	210
374	NTIME=0	SPANDY	211
375	IF(TIMINT-YINFLIM+10.)501,700,700	SPANDY	212
401	501 CONTINUE	SPANDY	213
	C RANDOMLY SELECT COORDINATES OF ENTRANCE POINT IN THE FOIL,X0,Y0,Z0=0.	SPANDY	214
	C ASSUME THE PARTICLE DIRECTION PARALLEL TO THE Z-AXIS, DEFINE THE	SPANDY	215
	C DIRECTION COSINES OF ENTRY,	SPANDY	216
401	IF(NCOL,GE,N3) GO TO 700	SPANDY	217
424	NCOL=NCOL+1	SPANDY	218
	C TEMPORARY BYPASS OF DIVERGENT BEAM CALCULATIONS	MOD1	9
405	IF(NS,GE,1)GOTO503	MOD1	10
	C	MOD1	11
407	X0=80*(2.*RANF(R)-1.)	SPANDY	219
414	Y0=80*(2.*RANF(R)-1.)	SPANDY	220
422	Z0=0.	SPANDY	221
422	UX=0.	SPANDY	222
422	UY=0.	SPANDY	223
422	UZ=1.	SPANDY	224

	C	FORCE SCATTERING IN THE INTERVAL (Z1,Z2),CHOOSE Z3 RANDOMLY,	SPANDY	225
	C	Z1=Z3*Z2,	SPANDY	226
425		Z3=(Z2-Z1)*RANF(R)+Z1	SPANDY	227
	C	COMPUTE THE X AND Y COORDINATES OF THE SCATTERING LOCATION,	SPANDY	228
433		X3=(Z3-Z0)/UZ*UX+X0	SPANDY	229
433		Y3=(Z3-Z0)/UZ*UY+Y0	SPANDY	230
	C	COMPUTE PRELIMINARIES FOR NUCLEAR SCATTERING, ROTATE THE Z-AXIS	SPANDY	231
	C	ALONG THE DIRECTION OF MOTION, CALCULATE THE NEW DIRECTION COSINES	SPANDY	232
	C	IN THE PROTON SYSTEM,	SPANDY	233
	C	THE Z-PRIME DIRECTION COSINES ARE UX,UY,UX,	SPANDY	234
433		AZ=UX	SPANDY	235
433		BZ=UY	SPANDY	236
433		CZ=UZ	SPANDY	237
	C	THE X-PRIME AXIS IS PARALLEL TO THE TARGET X-Z PLANE, THE X-AXIS IS	SPANDY	238
	C	CROSSED INTO Z,	SPANDY	239
445		TEMP=1./OSQRT(CZ**2-AZ**2)	SPANDY	240
453		AX=CZ*TEMP	SPANDY	241
453		BX=B*TEMP	SPANDY	242
453		CX=AZ*TEMP	SPANDY	243
	C	THE Y-PRIME AXIS IS ZPRIME CROSS X-PRIME	SPANDY	244
453		AY=-AZ*BZ*TEMP	SPANDY	245
453		BY=(AZ**2+CZ**2)*TEMP	SPANDY	246
453		CY=-CZ*BZ*TEMP	SPANDY	247
	C	EARLY CODE HAD DIRECTION COSINE NORMALIZATION CHECK HERE	SPANDY	248
	C		SPANDY	249
465		5MS CONTINUE	MOD1	12
	C	TEMPORARY VALUES FOR BEAM WITH NO WIDTH OR DIVERGENCE	MOD1	13
465		Y3=0,BSX3=0,BSAZ=0,BSBZ=0,BSXZ=1,BSAX=1,BSBX=0,BSX=0,0	MOD1	14
474		AY=0,BSBY=1,BSY=0,0	MOD1	15
	C	CHOOSE RANDOM SCATTERING POINT IN TARGET IN GIVEN RANGE	MOD1	16
477		Z3=(Z2-Z1)*RANF(R)+Z1	MOD1	17
	C		MOD1	18
	C	BEGIN COMPUTATION FOR NUCLEAR SCATTERING	MOD1	19
	C	CHOOSE POLAR ANGLE THS BY INTERPOLATING RANDOMLY FROM THE	SPANDY	231
	C	GIVEN SCATTERING DISTRIBUTION, (THD-DELTHD)LE(THS)LE(THD+DELTHD),	SPANDY	232
504		FRN=RANF(R)	SPANDY	233
507		CALL SPL1D2(NP,Y,X,D2X,IJ,FRN,TABTHS)	SPANDY	234
516		THS=TABTHS(IJ)	SPANDY	235
517		IF(THS.LT.(THD-DELTHD).OR.THG.GT.(THD+DELTHD)) PRINT 23	SPANDY	236
	C	CHOOSE AZIMUTHAL SCATTERING ANGLE, PHIM*PHIS*PHIX,	SPAN	237
534		PHIS=PHIM*(PHIX-PHIM)*RANF(R)	SPA.	238
541		IF(PHIS.LT.PHIM.OR.PHIS.GT.PHIX) PRINT 25	SPAN	239
	C	COMPUTE DIRECTION COSINES OF THE SCATTERED PARTICLE WITH RESPECT TO	SPANDY	240
	C	PRIME SYSTEM, I.E., THE DIRECTION COSINES OF THE SCATTERED PROTON	SPANDY	241
	C	IN THE PROTON SYSTEM.	SPANDY	242
	C	CONVERT THS AND PHIS TO RADIANS.	SPANDY	243
554		PHIS=PHIS*DTOR	SPANDY	244
554		THS=THS*DTOR	SPANDY	245
557		CALL QSNCS(THS,XT,CP)	SPANDY	246
561		CALL QSNCS(PHIS,OP,AP)	SPANDY	247
566		AP=AP*XT	SPANDY	248
566		BP=BP*XT	SPANDY	249
	C	EARLY CODE HAD DIRECTION COSINE NORMALIZATION CHECK HERE	SPANDY	250
	C	TRANSFORM BACK TO THE ORIGINAL HYDROGEN TARGET SYSTEM.	SPANDY	251
566		UX=AX*AP+AY*BP+AZ*CP	SPANDY	252
566		UY=BX*AP+BY*BP+BZ*CP	SPANDY	253
566		UZ=CX*AP+CY*BP+CZ*CP	SPANDY	254
566		XT=UX**2+UY**2+UZ**2	SPANDY	255
	C	SIX NECESSARY PROTON SCATTER PARAMETERS HAVE BEEN COMPUTED, X3,Y3,	SPANDY	256
	C	Z3 ARE POSITION COORDINATES AND UX,UY,UZ ARE THE DIRECTION COSINES	SPANDY	257
	C	WITH RESPECT TO HYDROGEN TARGET SYSTEM, CENTER AT ZC,	SPANDY	258
	C	TRANSLATE CENTER OF COORDINATE SYSTEM TO CENTER OF TARGET SYSTEM,	SPANDY	259
566		Z3=Z3-ZC	SPANDY	260
	C	COMPUTE THE COORDINATES OF THE TARGET FOIL EXIT POINT,	SPANDY	261
	C	SOLVE A QUADRATIC EQUATION TO FIND DTOF, THE DISTANCE FROM POINT OF	SPANDY	262
	C	SCATTER TO FOIL.	SPANDY	263
566		TEMA=UX**2+UZ**2	SPANDY	264
566		TEMB=UX*X3+UZ*Z3	SPANDY	265
566		TEMC=X3**2+Z3**2-RT**2	SPANDY	266
	C	ARE THE DISTANCE ROOTS COMPLEX	SPANDY	267
566		ARG=TEMB**2-TEMA*TEMC	SPANDY	268
626		IF(ARG.LT.0.0) PRINT 27	SPANDY	269
634		DTOF=(OSQRT(TEMB**2-TEMA*TEMC)-TEMB)/TEMA	SPANDY	270
	C	COMPUTE COORDINATES OF FOIL EXIT POINT, WITH RESPECT TO TARGET,	SPANDY	271
644		X4=X3+UX*DTOF	SPANDY	272
644		Y4=Y3+UY*DTOF	SPANDY	273
644		Z4=Z3+UZ*DTOF	SPANDY	274
	C	COMPUTE PRELIMINARIES FOR MULTIPLE SCATTER IN FOIL, ASSUME ALL	SPANDY	275
	C	PARTICLES SEE THE SAME THICKNESS OF FOIL, AGAIN ASSUME Z-AXIS ALONG	SPANDY	276
	C	THE DIRECTION OF MOTION, CALCULATE DIRECTION COSINES SAME AS FOR	SPANDY	277
	C	NUCLEAR SCATTER.	SPANDY	278
644		AZ2=UX	SPANDY	279

644	BZ2=UY	SPANDY	300
644	CZ2=UZ	SPANDY	301
656	TEMP2=1./DSORT(AZ2**2+CZ2**2)	SPANDY	302
664	AX2=CZ2*TEMP2	SPANDY	303
664	BX2=0.0	SPANDY	304
664	CX2=AZ2*TEMP2	SPANDY	305
664	AY2=AZ2*BZ2*TEMP2	SPANDY	306
664	BY2=(AZ2**2+CZ2**2)*TEMP2	SPANDY	307
664	CY2=CZ2*BZ2*TEMP2	SPANDY	308
	C EARLY CODE HAD DIRECTION COSINE NORMALIZATION CHECK HERE	SPANDY	309
	C	SPANDY	310
	C INTRODUCE A CHANGE IN DIRECTION DUE TO MULTIPLE SCATTERING.	SPANDY	311
	C COMPUTE MULTIPLE SCATTERING POLAR ANGLE THMS.	SPANDY	312
	C GENERATE A GAUSSIAN VARIATE.	SPANDY	313
664	RG=0.0	SPANDY	314
677	DO 120 LQ=1,LX	SPANDY	315
700	120 RG=RG+RANF(R)	SPANDY	316
706	RG=ABS(RG+TEMPH)	SPANDY	317
706	THMS=RG+STH	SPANDY	318
711	PHMS=THMS*PI+RANF(R)	SPANDY	319
	C CALCULATE DIRECTION COSINES AFTER MULTIPLE SCATTER IN PROTON SYSTEM.	SPANDY	320
715	CALL QSNCS(THMS,XT,CP2)	SPANDY	321
717	CALL QSNCS(PHMS,SP2,AP2)	SPANDY	322
724	AP2=AP2*XT	SPANDY	323
724	BP2=BP2*XT	SPANDY	324
	C EARLY CODE HAD DIRECTION COSINE NORMALIZATION CHECK HERE	SPANDY	325
	C TRANSFORM BACK TO ORIGINAL HYDROGEN TARGET SYSTEM.	SPANDY	326
724	UX=AX2*AP2+AY2*BP2+AZ2*CP2	SPANDY	327
724	UY=BX2*AP2+BY2*BP2+BZ2*CP2	SPANDY	328
724	UZ=CX2*AP2+CY2*BP2+CZ2*CP2	SPANDY	329
724	XT=UX**2+UY**2+UZ**2	SPANDY	330
	C MULTIPLE SCATTERING CORRECTION PARAMETERS IN FOIL; X4,Y4,Z4,UX,UY,UZ.	SPANDY	331
	C COMPUTE COORDINATES OF THE TARGET EXIT POINT WITH RESPECT TO THD,	SPANDY	332
	C WITH TRANSLATION (0,0,R1) IN THE NEW SYSTEM,	SPANDY	333
724	X4P3=COST*X4+SINT*Z4	SPANDY	334
724	Y4P3=Y4	SPANDY	335
724	Z4P3=SINT*X4+COST*Z4-R1	SPANDY	336
	C FIND THE NEW DIRECTION COSINES WITH RESPECT TO THD.	SPANDY	337
724	ATHD=UX	SPANDY	338
724	BTHD=UY	SPANDY	339
724	CTHD=UZ	SPANDY	340
724	AP3=COST*ATHD+SINT*CTHD	SPANDY	341
724	BP3=BTHD	SPANDY	342
724	CP3=SINT*ATHD+COST*CTHD	SPANDY	343
	C EARLY CODE HAD DIRECTION COSINE NORMALIZATION CHECK HERE	SPANDY	344
	C	SPANDY	345
	C COMPUTE NEW X AND Y COORDINATES AT THE FIRST SLIT.	SPANDY	346
724	XT=ABS(Z4P3)/CP3	SPANDY	347
724	XS1=XT*AP3+X4P3	SPANDY	348
724	YS1=XT*BP3+Y4P3	SPANDY	349
	C TEST TO SEE IF PARTICLE GETS THROUGH FIRST SLIT.	SPANDY	350
1003	IF(ABS(XS1).LE.01)GO TO 200	SPANDY	351
1007	NTRPSL1=NTRPSL1+1	SPANDY	352
	C THIS BRANCH IN THE CODE TABULATES PARAMETERS FOR PLOT OUTPUT	SPANDY	353
	C DEPENDING ON THE INPUT VALUE OF KNTRL.	SPANDY	354
1010	GO TO(400,400,401)KNTRL	SPANDY	355
1017	401 CALL ALLPART (THSM,THS,THSX,PHIN,PHIS,PHIX,Z1,ZC,Z3,Z2,THMSHIN,	SPANDY	356
	1THMS,THMSMAX,XS1,YS1,1111,.0,0,EL00S,0,0,EL00D,0,0,EO)	SPANDY	357
1046	400 CONTINUE	SPANDY	358
	C THIS BRANCH DID NOT GO THROUGH FIRST SLIT.	SPANDY	359
1046	GO TO 500	SPANDY	360
1047	200 CONTINUE	SPANDY	361
	C IF THIS POINT IS REACHED, THE PROTON IS A CANDIDATE FOR DETECTION.	SPANDY	362
	C AGAIN, FIND COORDINATES OF THE TARGET EXIT POINT WITH RESPECT TO THD,	SPANDY	363
	C WITH TRANSLATION (0,0,R0) IN THE NEW SYSTEM, SAME DIRECTION COSINES.	SPANDY	364
1047	X4P4=X4P3	SPANDY	365
1047	Y4P4=Y4P3	SPANDY	366
1047	Z4P4=SINT*X4+COST*Z4-R0	SPANDY	367
	C COMPUTE NEW X AND Y COORDINATES AT THE SECOND SLIT.	SPANDY	368
1047	YT=ABS(Z4P4)/CP3	SPANDY	369
1047	XS2=YT*AP3+X4P4	SPANDY	370
1047	YS2=YT*BP3+Y4P4	SPANDY	371
1047	GO TO (402,402,403)KNTRL	SPANDY	372
1076	403 CALL ALLPART (THSM,THS,THSX,PHIN,PHIS,PHIX,Z1,ZC,Z3,Z2,THMSHIN,	SPANDY	373
	1THMS,THMSMAX,XS1,YS1,XS2,YS2,EL00S,0,0,EL00D,0,0,EO)	SPANDY	374
1125	402 CONTINUE	SPANDY	375
	C CHECK TO SEE IF PROTON GETS THROUGH SECOND SLIT.	SPANDY	376
1125	IF(ABS(XS2).LE.02.AND.ABS(YS2).LE.02) GO TO 300	SPANDY	377
1141	NTRINT2=NTRINT2+1	SPANDY	378
1142	GO TO 500	SPANDY	379
	C PARTICLE HAS BEEN DETECTED.	SPANDY	380
1143	300 INIT = INIT + 1	SPANDY	381

1145	GO TO (410,411,411)KNTRL	SPANDY	362
1154	411 CONTINUE	SPANDY	363
	C ENERGY LOSS CALCULATIONS, CALCULATED ONLY IF A PROTON HAS BEEN	SPANDY	364
	C DETECTED. FIRST COMPUTE ENERGY LOSS IN TARGET BEFORE SCATTER,	SPANDY	365
1154	D1=0.5*ORT((X0-X3)**2+(Y0-Y3)**2+(Z0-Z3)**2)	SPANDY	366
1165	E1B=E10-D1*DEDX	SPANDY	367
	C ENERGY LOSS AFTER SCATTER.	SPANDY	368
1170	E1A=E1B+COS(THS)**2	SPANDY	369
1174	D2=0.5*ORT((X3-X4)**2+(Y3-Y4)**2+(Z3-Z4)**2)	SPANDY	370
1206	E2A=E1A-D2*DEDX2	SPANDY	371
1206	EAD=E2A*DEFOIL	SPANDY	372
1212	CALL DETECT (THTSM,THTSX,PHIM,PHIS,PHIX,Z1,ZC,Z3,Z2,THMBSIN,	SPANDY	373
	1THMS,THMSMAX,KC,XS1,XS2,Y52,ELOSS,E1B,ELOSSD,EAD,EO)	SPANDY	374
1240	410 CONTINUE	SPANDY	375
1240	GO TO 500	SPANDY	376
	C	SPANDY	377
	C	SPANDY	378
	C FINAL OUTPUT FOLLOWS	SPANDY	379
1241	700 PRINT 37,NCOL,NTRPSL1,NTSINT2,INIT	SPANDY	380
	C CALCULATE AVERAGES AND STANDARD DEVIATIONS OF THE AVERAGE OF	SPANDY	381
	C THETA AND PHIS---THDAVG AND THAVSD PHIAVG AND PHIAVSD	SPANDY	382
	C FROM THE DETECTED PARTICLES DISTRIBUTION.	SPANDY	383
	C ALSO CALC RMS MULTIPLE SCATT ANGLE THMSSD, FROM ALLPARTICLES	SPANDY	384
1255	THDAVG=0.	SPANDY	385
1255	THAVSD=0.	SPANDY	386
1255	PHIAVG=0.	SPANDY	387
1255	THMSSD=0.	SPANDY	388
1255	PHIAVSD=0.	SPANDY	389
1260	DO 701 I=1,NP	SPANDY	390
1267	PHIAVG=PHIAVG+8*IN2(I)*(PHIM+(I-.5)*H2)	SPANDY	391
1267	701 THDAVG=THDAVG+8*IN1(I)*(THTSM+(I-.5)*H1)	SPANDY	392
1302	PHIAVG=PHIAVG/INIT	SPANDY	393
1302	THDAVG=THDAVG/INIT	SPANDY	394
1305	DO 702 I=1,NP	SPANDY	395
1314	THMSSD=THMSSD+LOC4(I)*(THMBSIN+(I-.5)*H4)**2	SPANDY	396
1314	PHIAVSD=PHIAVSD+8*IN2(I)*(PHIM+(I-.5)*H2-PHIAVG)**2	SPANDY	397
1314	702 THAVSD=THAVSD+8*IN1(I)*(THTSM+(I-.5)*H1-THDAVG)**2	SPANDY	398
1343	PHIAVSD=(PHIAVSD/INIT*(INIT-1))**0.5	SPANDY	399
1343	THAVSD=(THAVSD/INIT*(INIT-1))**0.5	SPANDY	400
1343	THMSSD=(THMSSD/NCOL)**0.5	SPANDY	401
1362	PRINT 47,THDAVG,THAVSD,PHIAVG,PHIAVSD,THMSSD	SPANDY	402
	C	SPANDY	403
	C SAVE AND PRINT LAST RANDOM NUMBER TO CONTINUE THIS RUN, IF DESIRED.	SPANDY	404
1400	R=R1.	SPANDY	405
1401	RANLAST=RANF(R)	SPANDY	406
1404	PRINT 48,RANLAST	SPANDY	407
1411	CALL GETQ(4LKJBN,JOBNAME)	SPANDY	408
1413	CALL DATE1(DATE)	SPANDY	409
1415	GO TO(420,421,421)KNTRL	SPANDY	410
1424	421 CONTINUE	SPANDY	411
	C TABULATE TABLE OF ABBCTSSAB DEPENDING ON KNTRL.	SPANDY	412
1424	NB=49	SPANDY	413
1424	XTBLE(1)=1.	SPANDY	414
1427	DO 130 J=1,NB	SPANDY	415
1435	K=J+1	SPANDY	416
1435	130 XTBLE(K)=XTBLE(J)+1.	SPANDY	417
	C INITIALIZE CONSTANTS FOR OUTPUT	SPANDY	418
1441	ZLX=Z1-ZC	SPANDY	419
1441	ZRX=Z2-ZC	SPANDY	420
1445	GO TO (420,431,432)KNTRL	SPANDY	421
1454	432 CONTINUE	SPANDY	422
1454	PRINT 39,TITLE	SPANDY	423
1462	PRINT 46,DATE,JOBNAME	SPANDY	424
1472	PRINT 40,KNTRL	SPANDY	425
1500	PRINT 41	SPANDY	426
1504	PRINT 42,H1,H2,H3,H4,H5,H6,H7,H8,H9,H10	SPANDY	427
1534	PRINT 43,THTSM,THTSX,PHIM,PHIX,ZLX,ZRX,THMBSIN,THMSMAX,XSTMIN,	SPANDY	428
	1XSTMAX,YSTMIN,YSTMAX,XSTMIN,XSTMAX,YSTMIN,YSTMAX,ELOSSD,EO,	SPANDY	429
	2ELOSSD,EO	SPANDY	430
1610	DO 140 I=1,50	SPANDY	431
1612	PRINT 44,(I,LOC1(I),LOC2(I),LOC3(I),LOC4(I),LOC5(I),LOC6(I),	SPANDY	432
	1LOC7(I),LOC8(I),LOC9(I),LOC10(I))	SPANDY	433
1655	140 CONTINUE	SPANDY	434
1657	CALL PLOJB(XTBLE,LOC1,50,1,-1,778,-1,0,0,LABX1,31,0,0,0,0)	SPANDY	435
1676	CALL PLOJB(XTBLE,LOC2,50,1,-1,778,-1,0,0,LABX2,35,0,0,0,0)	SPANDY	436
1715	CALL PLOJB(XTBLE,LOC3,50,1,-1,778,-1,0,0,LABX3,34,0,0,0,0)	SPANDY	437
1734	CALL PLOJB(XTBLE,LOC4,50,1,-1,778,-1,0,0,LABX4,38,0,0,0,0)	SPANDY	438
1753	CALL PLOJB(XTBLE,LOC5,50,1,-1,778,-1,0,0,LABX5,18,0,0,0,0)	SPANDY	439
1772	CALL PLOJB(XTBLE,LOC6,50,1,-1,778,-1,0,0,LABX6,18,0,0,0,0)	SPANDY	440
2011	CALL PLOJB(XTBLE,LOC7,50,1,-1,778,-1,0,0,LABX7,19,0,0,0,0)	SPANDY	441
2030	CALL PLOJB(XTBLE,LOC8,50,1,-1,778,-1,0,0,LABX8,19,0,0,0,0)	SPANDY	442
2047	CALL PLOJB(XTBLE,LOC9,50,1,-1,778,-1,0,0,LABX9,25,0,0,0,0)	SPANDY	443

2866	CALL PLOJB(XTBLE,LOC10,50,1,-1,770,-1,0,0,LABX10,24,0,0,0,0)	SPANDY	464
2105	431 CONTINUE	SPANDY	465
2105	PRINT 30,TITLE	SPANDY	466
2113	PRINT 46,DATE,JOBNAME	SPANDY	467
2123	PRINT 45,XNTRL	SPANDY	468
2131	PRINT 41	SPANDY	469
2135	PRINT 42,M1,M2,M3,M4,M5,M6,M7,M8,M9,M10	SPANDY	470
2165	PRINT 43,THSM,YHSM,PHIM,PHIX,ZLX,ZRX,THSMIN,THSMAX,XSTMIN, IXSMAX,YSTMIN,YSMAX,XSTMIN,XBTMAX,YSTMIN,YBTMAX,ELOSS,EO, ZELOSS,EO	SPANDY	471
2241	DO 150 I=1,50	SPANDY	472
2243	PRINT 44,(I,BIN1(I),BIN2(I),BIN3(I),BIN4(I),BIN5(I),BIN6(I), BIN7(I),BIN8(I),BIN9(I),BIN10(I))	SPANDY	473
2306	150 CONTINUE	SPANDY	474
2310	CALL PLOJB(XTBLE,BIN1,50,1,-1,470,-1,0,0,LABX1,31,0,0,0,0)	SPANDY	475
2327	CALL PLOJB(XTBLE,BIN2,50,1,-1,470,-1,0,0,LABX2,35,0,0,0,0)	SPANDY	476
2346	CALL PLOJB(XTBLE,BIN3,50,1,-1,470,-1,0,0,LABX3,30,0,0,0,0)	SPANDY	477
2365	CALL PLOJB(XTBLE,BIN4,50,1,-1,470,-1,0,0,LABX4,30,0,0,0,0)	SPANDY	478
2404	CALL PLOJB(XTBLE,BIN5,50,1,-1,470,-1,0,0,LABX5,10,0,0,0,0)	SPANDY	479
2423	CALL PLOJB(XTBLE,BIN6,50,1,-1,470,-1,0,0,LABX6,10,0,0,0,0)	SPANDY	480
2442	CALL PLOJB(XTBLE,BIN7,50,1,-1,470,-1,0,0,LABX7,19,0,0,0,0)	SPANDY	481
2461	CALL PLOJB(XTBLE,BIN8,50,1,-1,470,-1,0,0,LABX8,14,0,0,0,0)	SPANDY	482
2500	CALL PLOJB(XTBLE,BIN9,50,1,-1,470,-1,0,0,LABX9,25,0,0,0,0)	SPANDY	483
2517	CALL PLOJB(XTBLE,BIN10,50,1,-1,470,-1,0,0,LABX10,24,0,0,0,0)	SPANDY	484
2536	426 CONTINUE	SPANDY	485
2536	CALL SECOND(TIMINT)	SPANDY	486
2540	TIMINT=TIMINT/60.	SPANDY	487
2542	PRINT 19,TIMINT	SPANDY	488
2547	GO TO 800	SPANDY	489
2550	430 STOP	SPANDY	490
2552	END	SPANDY	491

	FUNCTION EVALF(X)	SPANDY	495
C	THIS FUNCTION SUPPLIES AN ANALYTIC SHAPE TO THE CROSS SECTION	SPANDY	496
C	TAKE CARE ALL TERMS ARE IN CONSISTENT UNITS, RADIANS OR DEGREES	MOD1	20
C	TIGHT PARABOLA MOCKS 9.844 MEV AT 30 DEG	MOD1	21
3	EVALF=10.0+2.0*(X-57.3-30.0)**2	MOD1	22
10	RETURN	SPANDY	500
11	END	SPANDY	501

	SUBROUTINE SINP(TITLE,THSMIN,THSMAX,PHISMN,PHISMAX,ENGO,DEDX1, 1DEDX2,DEFOIL,THRMS,ZAXIS,TARRAD,DTOS1,HWS1,DTOS2,HWS2,HHS2,KNTRL, 2THDET,DELTHDE,NS,NSIGTRL)	SPANDY	502
		SPANDY	503
		SPANDY	504
C	C***ROUTINE SINP PRINTS OUT SPANDY INPUT.	MOD1	23
C		MOD1	24
		MOD1	25
36	DIMENSION TITLE(6)	SPANDY	506
36	THRMS=THRMS*57.29578	SPANDY	507
C	PRINT TITLE AND LIMITS ON POLAR AND AZIMUTHAL SCATTERING ANGLES.	SPANDY	508
40	PRINT 1	SPANDY	509
43	CALL GETQ(4LKJBN,JOBNAME)	SPANDY	510
45	CALL DATE1(DATE)	SPANDY	511
47	PRINT 11,DATE,JOBNAME	SPANDY	512
62	PRINT 2,TITLE	SPANDY	513
74	PRINT 10,NS,KNTRL,NSIGTRL	SPANDY	514
111	PRINT 9,THDET,DELTHDE	SPANDY	515
124	PRINT 3,THSMIN,THSMAX,PHISMN,PHISMAX	SPANDY	516
C	INCIDENT PARTICLE ENERGY AND ENERGY LOSS PARAMETER OUTPUT,	SPANDY	517
143	PRINT 4,ENGO,DEDX1,DEDX2,DEFOIL	SPANDY	518
162	PRINT 5,ENGO,THRMS	SPANDY	519
C	INITIAL SOURCE APERTURE GEOMETRY.	SPANDY	520
175	PRINT 6	SPANDY	521
C	TARGET PARAMETERS.	SPANDY	522
204	PRINT 7,ZAXIS,TARRAD	SPANDY	523
C	SLIT GEOMETRY, ALL OUTPUT IN MILLIMETERS.	SPANDY	524
217	PRINT 8,DTOS1,HWS1,DTOS2,HWS2,HHS2	SPANDY	525
240	THRMS=THRMS*.0174533	SPANDY	526
C	C***VARIABLE KNTRL DETERMINES SPANDY OUTPUT,	SPANDY	527
	1 FORMAT(IH1)	SPANDY	528
	2 FORMAT(///,20X,A10///)	SPANDY	529
	3 FORMAT(5X,*NUCLEAR SCATTERING ANGLE PARAMETERS-- POLAR AN	SPANDY	530
	1GLE,*F6,2,*THS*F6,2,* DEG,*//40X,*AZIMUTHAL ANGLE,*F6,2,*PHIS*	SPANDY	531
	2F5,2,* DEG,*///)	SPANDY	532
	4 FORMAT(5X,*INCIDENT PARTICLE-- ENERGY=F7,3* MEV*//20X,*ENERGY	SPANDY	533
	1LOSS, DEDX1=1PE10,3,4X,*DEDX2=E10,3,1X*MEV/MM*,6X,*DEFOIL=E10,	SPANDY	534
	23,* MEV*///)	SPANDY	535
	5 FORMAT(5X,*MULTIPLE SCATTERING RMS POLAR ANGLE FOR FO=F6,3* MEV	SPANDY	536
	1=1PE10,3* DEG,*///)	SPANDY	537
	6 FORMAT(5X,*TEMPORARY SOURCE OUTPUT RECORD*///)	SPANDY	538
	7 FORMAT(5X,*TARGET-- LENGTH OF Z-AXIS SCATTERING REGION=F6,2	SPANDY	539
	1* MM,*6X,*TARGET RADIUS=F6,3* MM,*///)	SPANDY	540
	8 FORMAT(5X,*FIRST SLIT-- DISTANCE FROM TARGET CENTER TO FIRST SLI	SPANDY	541
	1T=F6,3,6X,*HALF-WIDTH=F9,6* MM,*//	SPANDY	542
	2 *//SECOND SLIT-- DISTANCE FROM TARGET CENTER TO SECOND SL	SPANDY	543
	3IT=F10,5,6X,*HALF-WIDTH=F9,6,6X,*HALF-HEIGHT=F9,6* MM,*///)	SPANDY	544
	9 FORMAT(5X,*DETECTOR PARAMETERS-- FIXED POLAR ANGLE=F6,2,* DEG.	SPANDY	545
	1*,6X,*DELTHD=F6,2,* DEG,*///)	SPANDY	546
	10 FORMAT(3X,*INITIAL NUMBER OF SOURCE PARTICLES=I10,6X,*PLOT KNTRL=	SPANDY	547
	1*13,6X,*DISTRIBUTION TYPE, NSIGTRL=I3///)	SPANDY	548
	11 FORMAT(85X,*DATE=,A10,* JOBNAME= ,A10)	SPANDY	549
246	RETURN	SPANDY	550
247	END	SPANDY	551

	SUBROUTINE BINTAB(THSMIN,THSCAT,THSMAX,PHISMIN,PHISCAT,PHISMAX,	SPANDY	552
	IZL,ZC,ZSCAT,ZR,THSMIN,THMS,THSMAX,XS1,YS1,XS2,YS2,ELOSS,EIO,	SPANDY	553
	ZELOSD,EAD,E0)	SPANDY	554
36	REAL LOC1,LOC2,LOC3,LOC4,LOC5,LOC6,LOC7,LOC8,LOC9,LOC10	SPANDY	555
	C SUBROUTINE BINTAB TABULATES THE ORDINATES FOR PLOT ROUTINE.	SPANDY	556
36	COMMON/DEN1/BIN1(50),BIN2(50),BIN3(50),BIN4(50),BIN5(50),BIN6(50),	SPANDY	557
	BIN7(50),BIN8(50),BIN9(50),BIN10(50)	SPANDY	558
36	COMMON/ANNE/LOC1(50),LOC2(50),LOC3(50),LOC4(50),LOC5(50),LOC6(50),	SPANDY	559
	LOC7(50),LOC8(50),LOC9(50),LOC10(50)	SPANDY	560
36	COMMON/ROD/KNTRL,DTOR,RTOD,H1,H2,H3,H4,H5,H6,H7,H8,H9,H10	SPANDY	561
36	COMMON/BILL/XSTMIN,XSTMAX,YSTMIN,YSTMAX	SPANDY	562
	C CLEAR ARRAYS PRIOR TO PARTICLE TABULATION.	SPANDY	563
36	DO 100 J=1,50	SPANDY	564
44	BIN1(J)=0.0	SPANDY	565
44	BIN2(J)=0.0	SPANDY	566
44	BIN3(J)=0.0	SPANDY	567
44	BIN4(J)=0.0	SPANDY	568
44	BIN5(J)=0.0	SPANDY	569
44	BIN6(J)=0.0	SPANDY	570
44	BIN7(J)=0.0	SPANDY	571
44	BIN8(J)=0.0	SPANDY	572
44	BIN9(J)=0.0	SPANDY	573
44	BIN10(J)=0.0	SPANDY	574
44	LOC1(J)=0.0	SPANDY	575
44	LOC2(J)=0.0	SPANDY	576
44	LOC3(J)=0.0	SPANDY	577
44	LOC4(J)=0.0	SPANDY	578
44	LOC5(J)=0.0	SPANDY	579
44	LOC6(J)=0.0	SPANDY	580
44	LOC7(J)=0.0	SPANDY	581
44	LOC8(J)=0.0	SPANDY	582
44	LOC9(J)=0.0	SPANDY	583
44	LOC10(J)=0.0	SPANDY	584
	C INITIALIZE CONSTANTS USED IN TABULATION, FOR EACH VARIABLE TO BE	SPANDY	585
	C PLOTTED.	SPANDY	586
62	PNB=50.	SPANDY	587
62	DIFF=THSMAX-THSMIN	SPANDY	588
62	H1=DIFF/PNB	SPANDY	589
62	DIFF=PHISMAX-PHISMIN	SPANDY	590
62	H2=DIFF/PNB	SPANDY	591
62	ZLX=ZL-ZC	SPANDY	592
62	ZRX=ZR-ZC	SPANDY	593
62	DIFF=ZRX-ZLX	SPANDY	594
62	H3=DIFF/PNB	SPANDY	595
62	DIFF=THSMAX-THSMIN	SPANDY	596
62	H4=DIFF/PNB	SPANDY	597
102	IF(H4,E0,0.0) H4=0.01	SPANDY	598
107	DIFF=XSTMAX-XSTMIN	SPANDY	599
107	H5=DIFF/PNB	SPANDY	600
107	DIFF=YSTMAX-YSTMIN	SPANDY	601
107	H6=DIFF/PNB	SPANDY	602
107	H7=H5	SPANDY	603
107	H8=H6	SPANDY	604
107	DIFF=E0-ELOSS	SPANDY	605
107	H9=DIFF/PNB	SPANDY	606
107	DIFF=E0-ELOSD	SPANDY	607
107	H10=DIFF/PNB	SPANDY	608
126	RETURN	SPANDY	609
127	ENTRY DETECT	SPANDY	610
231	THSCAT=THSCAT+RTOD	SPANDY	611
231	PHISCAT=PHISCAT+RTOD	SPANDY	612
231	THMS=THMS+RTOD	SPANDY	613
231	NR=(THSCAT-THSMIN)/H1+1.	SPANDY	614
231	BIN1(NR)=BIN1(NR)+1.	SPANDY	615
231	NR=(PHISCAT-PHISMIN)/H2+1.	SPANDY	616
231	BIN2(NR)=BIN2(NR)+1.	SPANDY	617
231	NR=(ZSCAT-ZLX)/H3+1.	SPANDY	618
231	BIN3(NR)=BIN3(NR)+1.	SPANDY	619
231	NR=(THMS-THSMIN)/H4+1.	SPANDY	620
231	BIN4(NR)=BIN4(NR)+1.	SPANDY	621
231	NR=(XS1-XSTMIN)/H5+1.	SPANDY	622
274	IF(NR,LT,1)NR=1	SPANDY	623
300	IF(NR,GT,50)NR=50	SPANDY	624
304	BIN5(NR)=BIN5(NR)+1.	SPANDY	625
304	NR=(YS1-YSTMIN)/H6+1.	SPANDY	626
313	IF(NR,LT,1)NR=1	SPANDY	627
317	IF(NR,GT,50)NR=50	SPANDY	628
323	BIN6(NR)=BIN6(NR)+1.	SPANDY	629
323	NR=(XS2-XSTMIN)/H7+1.	SPANDY	630
332	IF(NR,LT,1)NR=1	SPANDY	631

336	IF(NR.GT.50)NR=50	SPANDY	632
342	BIN7(NR)=BIN7(NR)+1.	SPANDY	633
342	NR=(YS2-YSTMIN)/H8+1.	SPANDY	634
351	IF(NR.LT.1)NR=1	SPANDY	635
355	IF(NR.GT.50)NR=50	SPANDY	636
361	BIN8(NR)=BIN8(NR)+1.	SPANDY	637
361	NR=(E18-ELOSS)/H9+1.	SPANDY	638
370	IF(NR.LT.1)NR=1	SPANDY	639
374	BIN9(NR)=BIN9(NR)+1.	SPANDY	640
374	NR=(EAD-ELOSSD)/H10+1.	SPANDY	641
403	IF(NR.LT.1)NR=1	SPANDY	642
407	BIN10(NR)=BIN10(NR)+1.	SPANDY	643
407	THSCAT=THSCAT+DTOR	SPANDY	644
407	PHISCAT=PHISCAT+DTOR	SPANDY	645
407	THMS=THMS+DTOR	SPANDY	646
416	RETURN	SPANDY	647
416	ENTRY ALLPART	SPANDY	648
520	THSCAT=THSCAT+RTOD	SPANDY	649
520	PHISCAT=PHISCAT+RTOD	SPANDY	650
520	THMS=THMS+RTOD	SPANDY	651
520	NR=(THSCAT-THSMIN)/H1+1.	SPANDY	652
520	LOC1(NR)=LOC1(NR)+1.	SPANDY	653
520	NR=(PHISCAT-PHISMIN)/H2+1.	SPANDY	654
520	LOC2(NR)=LOC2(NR)+1.	SPANDY	655
520	NR=(ZSCAT-ZLX)/H3+1.	SPANDY	656
520	LOC3(NR)=LOC3(NR)+1.	SPANDY	657
520	NR=(THMS-THSMIN)/H4+1.	SPANDY	658
520	LOC4(NR)=LOC4(NR)+1.	SPANDY	659
520	NR=(XS1-XSTMIN)/H5+1.	SPANDY	660
563	IF(NR.LT.1)NR=1	SPANDY	661
567	IF(NR.GT.50)NR=50	SPANDY	662
573	LOC5(NR)=LOC5(NR)+1.	SPANDY	663
573	NR=(YS1-YSTMIN)/H6+1.	SPANDY	664
602	IF(NR.LT.1)NR=1	SPANDY	665
606	IF(NR.GT.50)NR=50	SPANDY	666
612	LOC6(NR)=LOC6(NR)+1.	SPANDY	667
615	IF(XS2.EQ.1111.)GO TO 101	SPANDY	668
620	NR=(XS2-XSTMIN)/H7+1.	SPANDY	669
623	IF(NR.LT.1)NR=1	SPANDY	670
627	IF(NR.GT.50)NR=50	SPANDY	671
633	LOC7(NR)=LOC7(NR)+1.	SPANDY	672
633	NR=(YS2-YSTMIN)/H8+1.	SPANDY	673
642	IF(NR.LT.1)NR=1	SPANDY	674
646	IF(NR.GT.50)NR=50	SPANDY	675
652	LOC8(NR)=LOC8(NR)+1.	SPANDY	676
655	101 CONTINUE	SPANDY	677
655	NR=(E18-ELOSS)/H9+1.	SPANDY	678
662	IF(NR.LT.1)NR=1	SPANDY	679
666	LOC9(NR)=LOC9(NR)+1.	SPANDY	680
666	NR=(EAD-ELOSSD)/H10+1.	SPANDY	681
675	IF(NR.LT.1)NR=1	SPANDY	682
701	LOC10(NR)=LOC10(NR)+1.	SPANDY	683
701	THSCAT=THSCAT+DTOR	SPANDY	684
701	PHISCAT=PHISCAT+DTOR	SPANDY	685
701	THMS=THMS+DTOR	SPANDY	686
707	RETURN	SPANDY	687
710	END	SPANDY	688

336	IF(NR,GT,50)NR=50	SPANDY	632
342	BIN7(NR)=BIN7(NR)+1.	SPANDY	633
342	NR=(YS2-YSTMN)/H4+1.	SPANDY	634
351	IF(NR,LT,1)NR=1	SPANDY	635
355	IF(NR,GT,50)NR=50	SPANDY	636
361	BIN8(NR)=BIN8(NR)+1.	SPANDY	637
361	NR=(E18-ELOSS)/H9+1.	SPANDY	638
370	IF(NR,LT,1)NR=1	SPANDY	639
374	BIN9(NR)=BIN9(NR)+1.	SPANDY	640
374	NR=(EAD-ELOSD)/H10+1.	SPANDY	641
403	IF(NR,LT,1)NR=1	SPANDY	642
407	BIN10(NR)=BIN10(NR)+1.	SPANDY	643
407	THSCAT=THSCAT+DTOR	SPANDY	644
407	PHISCAT=PHISCAT+DTOR	SPANDY	645
407	THMS=THMS+DTOR	SPANDY	646
416	RETURN	SPANDY	647
416	ENTRY ALLPART	SPANDY	648
520	THSCAT=THSCAT+RTDD	SPANDY	649
520	PHISCAT=PHISCAT+RTOD	SPANDY	650
520	THMS=THMS+RTOD	SPANDY	651
520	NR=(THSCAT-THSMIN)/H1+1.	SPANDY	652
520	LOC1(NR)=LOC1(NR)+1.	SPANDY	653
520	NR=(PHISCAT-PHISHIN)/H2+1.	SPANDY	654
520	LOC2(NR)=LOC2(NR)+1.	SPANDY	655
520	NR=(ZSCAT-ZLX)/H3+1.	SPANDY	656
520	LOC3(NR)=LOC3(NR)+1.	SPANDY	657
520	NR=(THMS-THSMIN)/H4+1.	SPANDY	658
520	LOC4(NR)=LOC4(NR)+1.	SPANDY	659
520	NR=(XS1-XSTMN)/H5+1.	SPANDY	660
563	IF(NR,LT,1)NR=1	SPANDY	661
567	IF(NR,GT,50)NR=50	SPANDY	662
573	LOC5(NR)=LOC5(NR)+1.	SPANDY	663
573	NR=(YS1-YSTMN)/H6+1.	SPANDY	664
602	IF(NR,LT,1)NR=1	SPANDY	665
606	IF(NR,GT,50)NR=50	SPANDY	666
612	LOC6(NR)=LOC6(NR)+1.	SPANDY	667
615	IF(XS2,EQ,1111.)GO TO 101	SPANDY	668
620	NR=(XS2-XSTMN)/H7+1.	SPANDY	669
623	IF(NR,LT,1)NR=1	SPANDY	670
627	IF(NR,GT,50)NR=50	SPANDY	671
633	LOC7(NR)=LOC7(NR)+1.	SPANDY	672
633	NR=(YS2-YSTMN)/H8+1.	SPANDY	673
642	IF(NR,LT,1)NR=1	SPANDY	674
646	IF(NR,GT,50)NR=50	SPANDY	675
652	LOC8(NR)=LOC8(NR)+1.	SPANDY	676
655	101 CONTINUE	SPANDY	677
655	NR=(E18-ELOSS)/H9+1.	SPANDY	678
662	IF(NR,LT,1)NR=1	SPANDY	679
666	LOC9(NR)=LOC9(NR)+1.	SPANDY	680
666	NR=(EAD-ELOSD)/H10+1.	SPANDY	681
675	IF(NR,LT,1)NR=1	SPANDY	682
701	LOC10(NR)=LOC10(NR)+1.	SPANDY	683
701	THSCAT=THSCAT+DTOR	SPANDY	684
701	PHISCAT=PHISCAT+DTOR	SPANDY	685
701	THMS=THMS+DTOR	SPANDY	686
707	RETURN	SPANDY	687
710	END	SPANDY	688

	FUNCTION SIMPSN(ARG,Y1,Y2,FERR)	SPANDY	689
	SIMPSN INTEGRATION ROUTINE WRITTEN AS FORTRAN IV FUNCTION J.SMITH	SPANDY	690
12	C DIMENSION F2I(20),FMT(20),F3T(20),F4T(20),F8T(20),	SPANDY	691
	IDXT(20),X1T(20),X2T(20),ART(20),EPS7(20),ES2T(20),	SPANDY	692
	ES3T(20),LEG(20),SUM1(20),SUM2(20)	SPANDY	693
	C INITIAL SET-UP	SPANDY	694
12	A=Y1	SPANDY	695
12	EP8=FERR	SPANDY	696
12	B=Y2	SPANDY	697
12	DA=B-A	SPANDY	698
16	FA=ARG(A)	SPANDY	699
27	FM=4.*ARG((A+B)*.5)	SPANDY	700
44	F8=ARG(B)	SPANDY	701
56	AREA=1.0	SPANDY	702
56	EST=1.0	SPANDY	703
56	L=1	SPANDY	704
	C BEGIN SIMPSON	SPANDY	705
63	1 DX=DA/3.	SPANDY	706
63	X1=A+DX	SPANDY	707
63	X2=X1+DX	SPANDY	708
67	F1=4.*ARG(A+.5*DX)	SPANDY	709
104	F2=ARG(X1)	SPANDY	710
116	F3=ARG(X2)	SPANDY	711
127	F4=4.*ARG(A+2.5*DX)	SPANDY	712
145	DX6=DX/6.	SPANDY	713
145	EST1=(FA+F1+F2)*DX6	SPANDY	714
145	EST2=(F2+FM+F3)*DX6	SPANDY	715
145	EST3=(F3+F4+F8)*DX6	SPANDY	716
145	AREA=AREA-ABS(EST)+ABS(EST1)+ABS(EST2)+ABS(EST3)	SPANDY	717
145	SUM=EST1+EST2+EST3	SPANDY	718
	C TEST FOR CONVERGENCE	SPANDY	719
172	IF(ABS(EST-SUM)-EP8*AREA)2,2,3	SPANDY	720
177	2 IF(EST-1.0)6,3,6	SPANDY	721
202	3 IF(L-20)5,6,6	SPANDY	722
205	5 L=L+1	SPANDY	723
205	LEG(L)=3	SPANDY	724
	C STORE PARAMETERS FOR SIMPSON II AND III	SPANDY	725
205	F2T(L)=F2	SPANDY	726
205	FMT(L)=FM	SPANDY	727
205	F3T(L)=F3	SPANDY	728
205	F4T(L)=F4	SPANDY	729
205	F8T(L)=F8	SPANDY	730
205	DXT(L)=DX	SPANDY	731
205	X1T(L)=X1	SPANDY	732
205	X2T(L)=X2	SPANDY	733
205	ART(L)=AREA	SPANDY	734
205	EPST(L)=EP8/1.7	SPANDY	735
205	ES2T(L)=EST2	SPANDY	736
205	ES3T(L)=EST3	SPANDY	737
	C RETURN TO SIMPSON I	SPANDY	738
205	DA=DX	SPANDY	739
205	FM=F1	SPANDY	740
205	F8=F2	SPANDY	741
205	EST=EST1	SPANDY	742
205	EP8=EPST(L)	SPANDY	743
250	GO TO 1	SPANDY	744
250	6 IF(LEG(L)-2)9,0,7	SPANDY	745
250	7 SUM1(L)=SUM	SPANDY	746
254	LEG(L)=2	SPANDY	747
	C RETURN TO SIMPSON II	SPANDY	748
254	A=X1T(L)	SPANDY	749
254	DA=DXT(L)	SPANDY	750
254	FA=F2T(L)	SPANDY	751
254	FM=FMT(L)	SPANDY	752
254	F8=F3T(L)	SPANDY	753
254	AREA=ART(L)	SPANDY	754
254	EST=ES2T(L)	SPANDY	755
254	EP8=EPST(L)	SPANDY	756
273	GO TO 1	SPANDY	757
274	8 SUM2(L)=SUM	SPANDY	758
274	LEG(L)=1	SPANDY	759
	C RETURN TO SIMPSON III	SPANDY	760
274	A=X2T(L)	SPANDY	761
274	DA=DXT(L)	SPANDY	762
274	FA=F3T(L)	SPANDY	763
274	FM=F4T(L)	SPANDY	764
274	F8=F8T(L)	SPANDY	765
274	AREA=ART(L)	SPANDY	766
274	EST=ES3T(L)	SPANDY	767
274	EP8=EPST(L)	SPANDY	768

```

313      GO TO 1
313      * SUM=SUM1(L)+SUM2(L)+SUM
313      L=L-1
317      IF(L-1)11,11,6
321 11 SIMPON = SUM
323      RETURN
323      END

```

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SPANDY 769
SPANDY 770
SPANDY 771
SPANDY 772
SPANDY 773
SPANDY 774
SPANDY 775

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APPENDIX B
OPERATING SPECIFICATIONS

Computer: CDC-7600

Magnetic tapes: none

Installation: Los Alamos

Number of cards in program: 794

Operation system or monitor: CROS 2.79

Card punching code: 026

Programming language: FORTRAN-IV

Stored at present in Los Alamos on photostore AX-X1107 Version 4

High-speed storage required: 31000 words (execution); 68000 words (compilation)

(AC = P14ANNE) as an UPDATE file.

Program overlaid: no

APPENDIX C

SPANDY INPUT PARAMETERS

DATE=11/08/76 JOBNAME= P27SPANSEU

ALPHA+T ALPHA DETECTED, 30 DEG, 9.844 MEV--SPANDY MONTE CARLO CORRECTIONS

INITIAL NUMBER OF SOURCE PARTICLES= 1000000 PLOT KNTRL= 3 DISTRIBUTION TYPE, NBTGTRL= 4

DETECTOR PARAMETERS-- FIXED POLAR ANGLE= 30.00 DEG, DELTHD= 4.00 DEG,

NUCLEAR SCATTERING ANGLE PARAMETERS-- POLAR ANGLE, 25.20°THG° 30.00 DEG,
AZIMUTHAL ANGLE, -0.00°PHIS° 0.00 DEG,

INCIDENT PARTICLE-- ENERGY= 9.844 MEV
ENERGY LOSS, DEDX1= 3.600E-04 DEDX2= 2.350E-03 MEV/MM DEFOIL= 7.420E-01 MEV

MULTIPLE SCATTERING RMS POLAR ANGLE FOR EQ= 9.844 MEV = 0, DEG,

TEMPORARY SOURCE OUTPUT RECORD

TARGET-- LENGTH OF Z-AXIS SCATTERING REGION= 15.00 MM, TARGET RADIUS=42.500 MM,

FIRST SLIT-- DISTANCE FROM TARGET CENTER TO FIRST SLIT=82.677 HALF-WIDTH= .57000 MM,

SECOND SLIT-- DISTANCE FROM TARGET CENTER TO SECOND SLIT= 304.91000 HALF-WIDTH= .601500 HALF-HEIGHT= 2.995000 MM,

APPENDIX D

DISTRIBUTION HISTORY

ALPHA+T ALPHA DETECTED, 30 DEG, 9.444 MEV--SPANDY MONTE CARLO CORRECTIONS

DATE=11/08/76

JOBNAME= P278PANSFU

KNTRL= 3 ALL PARTICLES TABULATED

VARIABLE	THSCAT	PHISCAT	ZSCAT	THMSCAT	XS1	YS1	XS2	YS2	E1A	EAD
PLOT MESH	1.920E-01	3.200E-01	3.000E-01	1.000E-02	5.000E-02	1.500E-01	5.000E-02	1.500E-01	2.000E-03	9.000E
PLOT RANGE	25.20, 34.80	-0.00, 0.00	-0.00, 7.00	0.00, 0.00	-1.25, 1.25	-3.75, 3.75	-1.25, 1.25	-3.75, 3.75	9.70, 9.00	5.00, 9.
BIN(1)=	65751	30900	31239	1546099	694702	200390	34063	30003	1546099	1546099
BIN(2)=	62032	31191	31020	0	3563	19966	139	263	0	0
BIN(3)=	57972	30000	30939	0	3567	20336	132	240	0	0
BIN(4)=	53931	30630	30745	0	3424	20216	154	254	0	0
BIN(5)=	49613	31150	30761	0	3464	20300	144	251	0	0
BIN(6)=	46419	31200	30795	0	3612	20163	131	271	0	0
BIN(7)=	42009	31070	30910	0	3463	20527	120	250	0	0
BIN(8)=	39005	31065	30792	0	3437	20494	111	244	0	0
BIN(9)=	36523	31073	30006	0	3402	20060	120	252	0	0
BIN(10)=	33013	31153	31007	0	3363	20237	115	209	0	0
BIN(11)=	30779	30033	31176	0	3305	20006	120	260	0	0
BIN(12)=	28617	31072	31054	0	3233	20237	119	241	0	0
BIN(13)=	26303	30005	31120	0	3331	20109	144	245	0	0
BIN(14)=	24092	30006	30975	0	3325	20275	120	256	0	0
BIN(15)=	21944	31132	31010	0	3307	20296	120	250	0	0
BIN(16)=	20291	30000	30755	0	3016	20260	150	259	0	0
BIN(17)=	18700	31029	31102	0	3303	20420	120	295	0	0
BIN(18)=	17331	30900	31037	0	3100	19909	121	255	0	0
BIN(19)=	16024	30705	31112	0	3279	20190	126	241	0	0
BIN(20)=	14799	30003	30902	0	3220	20210	116	252	0	0
BIN(21)=	14200	30009	30950	0	3235	20230	121	264	0	0
BIN(22)=	13247	30000	30930	0	3193	20201	103	247	0	0
BIN(23)=	12730	31126	31095	0	3174	20201	117	275	0	0
BIN(24)=	12694	31010	30021	0	3222	20357	112	209	0	0
BIN(25)=	12297	30637	30900	0	3109	19932	120	253	0	0
BIN(26)=	12103	31157	30913	0	3233	20053	103	261	0	0
BIN(27)=	12011	30767	30900	0	3139	20100	131	235	0	0
BIN(28)=	12964	30075	30742	0	3229	20173	123	250	0	0
BIN(29)=	13642	30603	31003	0	3105	20330	132	255	0	0
BIN(30)=	14032	30706	30050	0	3192	20072	130	247	0	0
BIN(31)=	14003	30570	30965	0	3192	20240	117	260	0	0
BIN(32)=	16107	31006	30702	0	3143	20079	132	274	0	0
BIN(33)=	17192	30921	30952	0	3171	20171	127	220	0	0
BIN(34)=	18071	31077	30792	0	3254	20070	123	269	0	0
BIN(35)=	20626	30700	31145	0	3260	20107	130	203	0	0
BIN(36)=	22179	30927	30790	0	3247	20309	130	252	0	0
BIN(37)=	23062	31000	30603	0	3279	20330	109	201	0	0
BIN(38)=	26001	30001	31126	0	3202	20250	131	264	0	0
BIN(39)=	20700	31076	30920	0	3311	20264	110	264	0	0

ALPHA+T ALPHA DETECTED, 30 DEG, 9.844 KEV--SPANDY MONTE CARLO CORRECTIONS
DATE=11/08/76 JOBNAME= P27SPAN5EU

KNTRL= 3 ALL PARTICLES TABULATED

VARIABLE	THSCAT	PHISCAT	ZSCAT	THMSCAT	XS1	YS1	XS2	YS2	E1A	EAD
PLOT MESH	1.920E-01	3.200E-01	3.000E-01	1.000E-02	5.000E-02	1.500E-01	5.000E-02	1.500E-01	2.000E-03	9.600E
PLOT RANGE	25, 20, 30, 00	-0, 00, 0, 00	-0, 00, 7, 00	0, 00, 0, 00	-1, 25, 1, 25	-3, 75, 3, 75	-1, 25, 1, 25	-3, 75, 3, 75	9, 70, 9, 00	5, 00, 9
BIN(40)*	30916	30040	31245	0	3203	20263	123	267	0	0
BIN(41)*	33750	30913	31032	0	3273	20276	154	266	0	0
BIN(42)*	36730	31035	30797	0	3251	20312	127	207	0	0
BIN(43)*	39690	31026	30857	0	3305	20164	143	235	0	0
BIN(44)*	42991	30923	31251	0	3330	19947	105	261	0	0
BIN(45)*	46192	31140	30636	0	3230	20333	124	270	0	0
BIN(46)*	49971	30760	30666	0	3390	20150	117	257	0	0
BIN(47)*	53062	30949	30906	0	3361	20031	119	250	0	0
BIN(48)*	50059	30726	30750	0	3251	20196	117	267	0	0
BIN(49)*	61072	30051	30790	0	3200	20015	102	269	0	0
BIN(50)*	66100	30950	30974	0	693007	207230	30039	30049	0	0

ALPHA+T ALPHA DETECTED,30 DEG,0.000 MEV--SPANDY MONTE CARLO CORRECTIONS
 DATE=11/28/76 JOHNAMEZ P27SPANSFU

KNTRL= 3 DETECTED PARTICLES TABULATED

VARIABLE	THSCAT	PHISCAT	ZSCAT	THMSCAT	XSI	YSI	XG2	YS2	E1A	EAD
PLOT MESH	1.020E-01	3.200E-01	1.000E-01	1.000E-01	1.000E-01	1.500E-01	5.000E-02	1.500E-01	2.000E-03	0.000E
PLOT RANGE	25.20,34.00	-0.00,0.00	-0.00,7.00	0.00,0.00	-1.25,1.25	-3.75,3.75	-1.25,1.25	-3.75,3.75	9.70,9.00	5.00,0
BIN(1)=	0	0	0	431	0	0	0	0	0	0
BIN(2)=	0	0	0	0	0	0	0	0	0	0
BIN(3)=	0	0	0	0	0	0	0	0	0	0
BIN(4)=	0	0	0	0	0	0	0	0	0	0
BIN(5)=	0	0	0	0	0	0	0	0	0	0
BIN(6)=	0	0	0	0	0	0	0	0	0	0
BIN(7)=	0	0	0	0	0	0	0	0	0	0
BIN(8)=	0	0	0	0	0	0	0	0	0	0
BIN(9)=	0	0	0	0	0	0	0	0	0	0
BIN(10)=	0	0	0	0	0	0	0	0	0	0
BIN(11)=	0	0	0	0	0	0	0	0	0	0
BIN(12)=	0	0	0	0	0	0	0	0	0	0
BIN(13)=	0	0	0	0	0	0	0	0	0	0
BIN(14)=	0	0	0	0	0	0	0	0	0	0
BIN(15)=	0	0	0	0	0	0	0	0	0	0
BIN(16)=	0	0	0	0	0	0	0	0	0	0
BIN(17)=	0	0	0	0	0	0	0	0	0	0
BIN(18)=	0	0	0	0	0	0	0	0	0	0
BIN(19)=	0	0	0	0	0	0	0	0	0	0
BIN(20)=	0	0	0	0	0	0	0	0	0	0
BIN(21)=	0	0	0	0	0	0	0	0	0	0
BIN(22)=	0	0	0	0	0	0	0	0	0	0
BIN(23)=	0	0	0	0	0	0	0	0	0	0
BIN(24)=	0	0	0	0	0	0	0	0	0	0
BIN(25)=	0	0	0	0	0	0	0	0	0	0
BIN(26)=	0	0	0	0	0	0	0	0	0	0
BIN(27)=	0	0	0	0	0	0	0	0	0	0
BIN(28)=	0	0	0	0	0	0	0	0	0	0
BIN(29)=	0	0	0	0	0	0	0	0	0	0
BIN(30)=	0	0	0	0	0	0	0	0	0	0
BIN(31)=	0	0	0	0	0	0	0	0	0	0
BIN(32)=	0	0	0	0	0	0	0	0	0	0
BIN(33)=	0	0	0	0	0	0	0	0	0	0
BIN(34)=	0	0	0	0	0	0	0	0	0	0
BIN(35)=	0	0	0	0	0	0	0	0	0	0
BIN(36)=	0	0	0	0	0	0	0	0	0	0
BIN(37)=	0	0	0	0	0	0	0	0	0	0
BIN(38)=	0	0	0	0	0	0	0	0	0	0
BIN(39)=	0	0	0	0	0	0	0	0	0	0
BIN(40)=	0	0	0	0	0	0	0	0	0	0
BIN(41)=	0	0	0	0	0	0	0	0	0	0
BIN(42)=	0	0	0	0	0	0	0	0	0	0
BIN(43)=	0	0	0	0	0	0	0	0	0	0
BIN(44)=	0	0	0	0	0	0	0	0	0	0
BIN(45)=	0	0	0	0	0	0	0	0	0	0
BIN(46)=	0	0	0	0	0	0	0	0	0	0
BIN(47)=	0	0	0	0	0	0	0	0	0	0
BIN(48)=	0	0	0	0	0	0	0	0	0	0
BIN(49)=	0	0	0	0	0	0	0	0	0	0
BIN(50)=	0	0	0	0	0	0	0	0	0	0
TIMINT=	0.000E+00									

APPENDIX E

RESULTS OF TEST RUN

RESULTS ARE AS FOLLOWS-

ACTUAL NUMBER OF SOURCE PARTICLES=	1546899
NUMBER OF PARTICLES TRAPPED BY SLIT1=	1472759
PARTICLES THROUGH SLIT1 BUT NOT SLIT2=	73789
NUMBER OF DETECTED PARTICLES RESULTING=	431

AVERAGE POLAR ANGLE= 30.00 +/- .01 DEG
AVERAGE AZIMUTH ANGLE= .03 +/- .03 DEG
RMS MULTIPLE SCATT ANGLE= .00 DEG, (SHOULD CHECK INPUT)

LAST RAN DOM NUMBER (TO CONTINUE RUN)= ,08554919843449373AE+00