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COMPARISON OF CALCULATED RADIOCHEMICAL CROSS SECTIONS WITH EXPERIMENTAL RESULTS FOR INCIDENT PROTONS AND π^- MESONS IN THE 50- TO 400-MeV REGION: EFFECT OF VARYING A FEW NUCLEAR PARAMETERS IN THE CALCULATIONS

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OAK RIDGE NATIONAL LABORATORY
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APRIL 1968

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Hugo W. Bertini

Abstract

Comparisons are made between theoretical predictions and experimental data for several (p,xpyn) reactions involving C, Al, Cu, and U and for the (π^-,π^-n) reaction in carbon. Interaction energies range from about 50 to 400 MeV. The theoretical model employs the two-step cascade-evaporation mechanism and includes the effect of the diffuse nuclear surface. The comparisons for the proton-initiated reactions indicate that agreement to within about 40% can be expected when the reaction cross section is about 100 mb, but the values can differ by factors of 5 or more when the cross section is about 10 mb. The agreement for the (π^-,π^-n) reaction on carbon was fair. This reaction can be used for the measurement of the real part of the optical-model potential, and the method for doing so is described. The effects of the diffuse nuclear surface in conjunction with changes in the nuclear radius on the (p,pn) reaction are discussed. Finally, results are given for the dependence of the (p,xpyn) cross sections on the transition energy used in the calculation between the cascade and evaporation processes. A tabulation of calculated and experimental cross sections, which includes all those used in this study, is attached as an appendix.

I. Introduction

Four aspects related to the prediction of radiochemical cross sections will be discussed in this paper. The first is the accuracy of the calculated (p,xpyn) cross sections when the cascade-evaporation model is employed. The energy range considered is from about 50 to 400 MeV. The second is the relationship between the nuclear size and density distribution to the predicted (p,pn) cross section in carbon. The third is a discussion of the $^{12}C(\pi^-,\pi^-n)^{11}C$ reaction in the 50- to 300-MeV energy

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region, which includes a comparison with experiment and a possible ramification attributable to the energy dependence of this cross section. The fourth is the effect of the theoretical transition energy between the cascade and the evaporation on the calculated cross sections.

The two-step cascade-evaporation mechanism is employed in the theoretical calculation of these cross sections. The details are given elsewhere.[1] The most important difference between these calculations and those undertaken previously[2] is that a diffuse nuclear surface is included. The evaporation program that was used in this report was modified[3] from that used in the previous work.[1] The pertinent modification is the inclusion of recently published binding energies[4] in the program.

II. (p,xpyn) Reactions

The (p,xpyn) reactions that were selected to test the accuracy of the calculations were those in which x and y were small, that is, one or so, and those in which they were relatively large. The targets selected span the periodic table. Those reactions were used for which an energy dependence could be determined.

Much of the earlier experimental cross-section data have been compiled and renormalized by Bruninx. In some of the figures discussed below, his CERN reports[5] are cited rather than those of the original workers in order to make comparisons with data that are consistently normalized to the monitor reaction, $^{27}Al(p,3pn)^{24}Na$. There apparently was a wide variation in the monitor values at the time the early work was performed.

The comparison between the experimental data and theoretical predictions are illustrated in Figs. 1 through 8. The agreement illustrated in Fig. 8 for the (p,3p9n) reaction in uranium is misleading. Many of the reactions in heavy elements result from fission, which is not taken into account in the calculation. Therefore, many of the predicted reaction cross sections in this mass region can be in considerable error.

On the basis of Figs. 1 through 8, however, one can say that in general the predictions from the calculation will be within about 40%

of the measured reaction cross sections when the cross sections themselves are about 100 mb, but they may differ from the measured values by factors of 5 or more when the cross sections are about 10 mb or smaller.

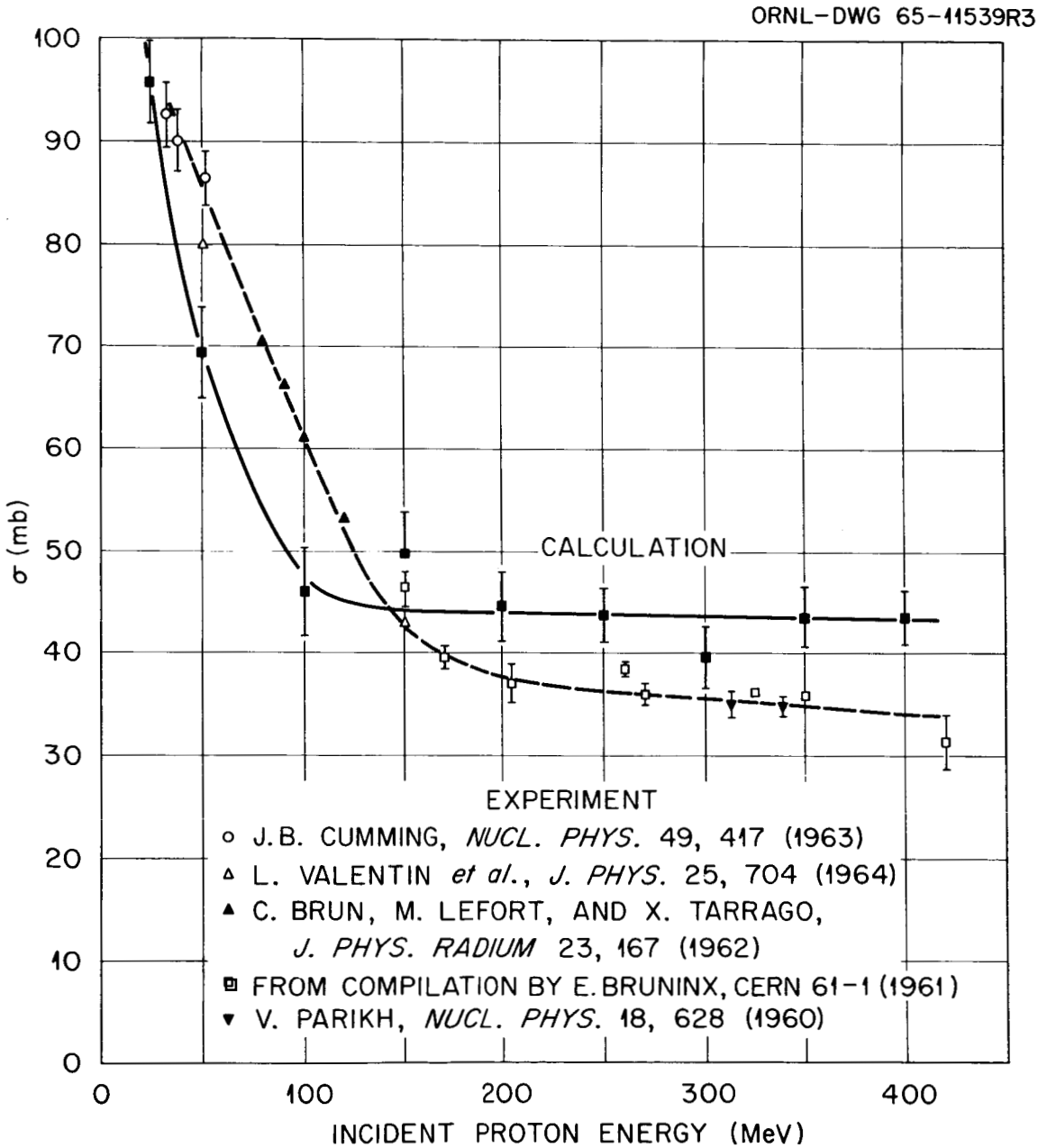

Fig. 1. Cross Section for the $^{12}C(p,pn)^{11}C$ Reaction vs Incident Proton Energy.

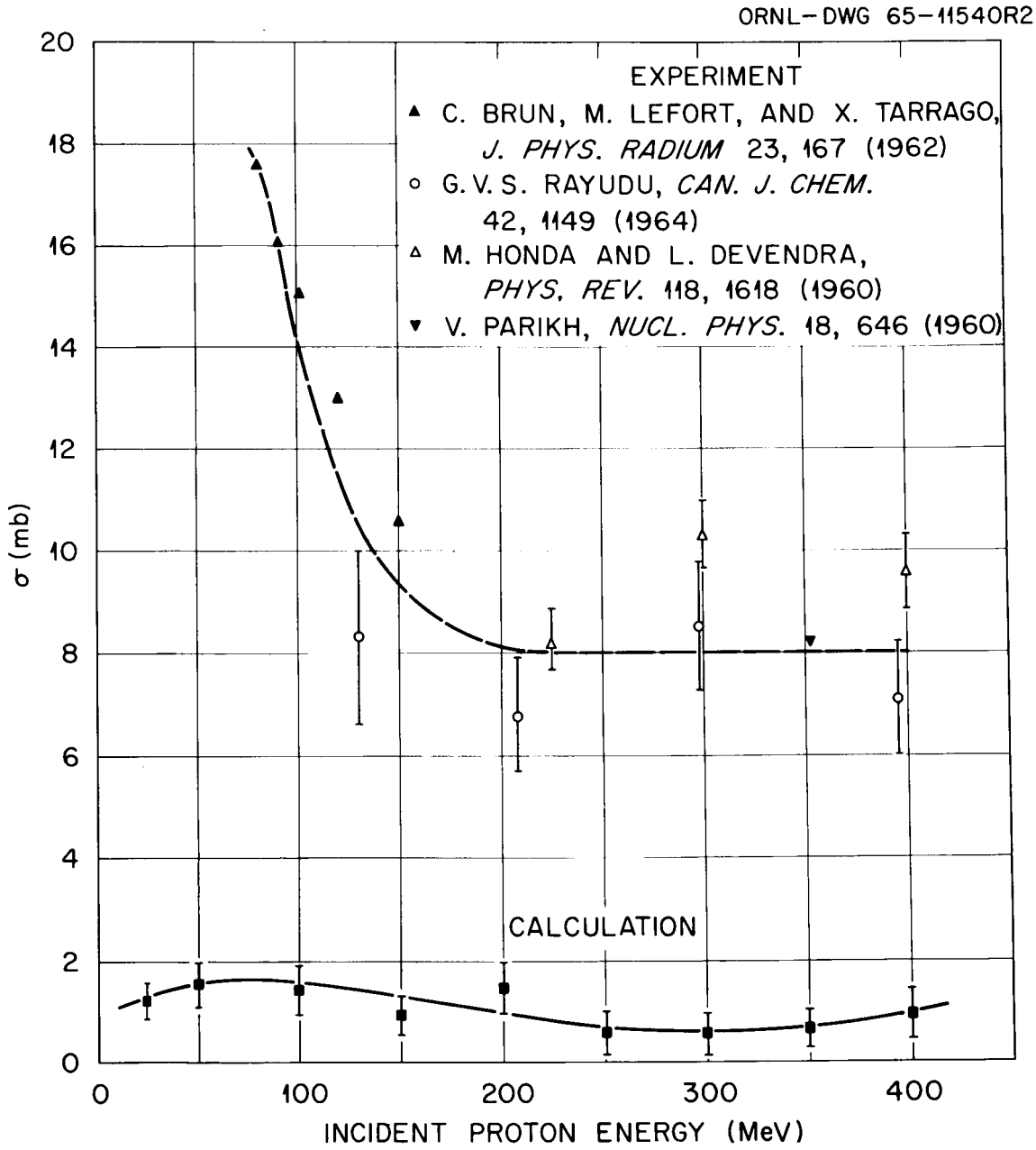

Fig. 2. Cross Section for the $^{12}C(p,3p3n)^{7}Be$ Reaction vs Incident Proton Energy.

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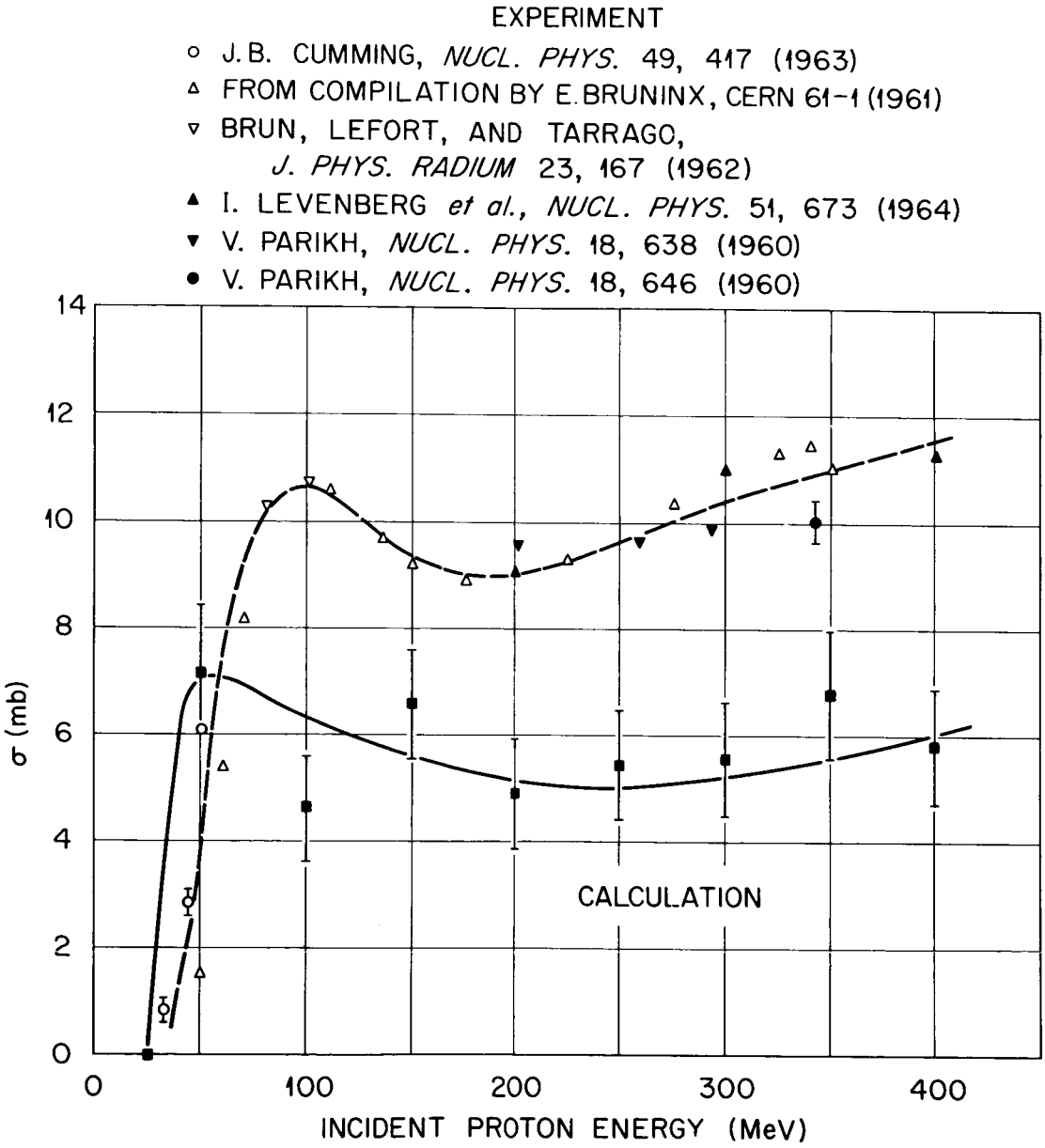

Fig. 3. Cross Section for the $^{27}Al(p,3pn)^{24}Na$ Reaction vs Incident Proton Energy.

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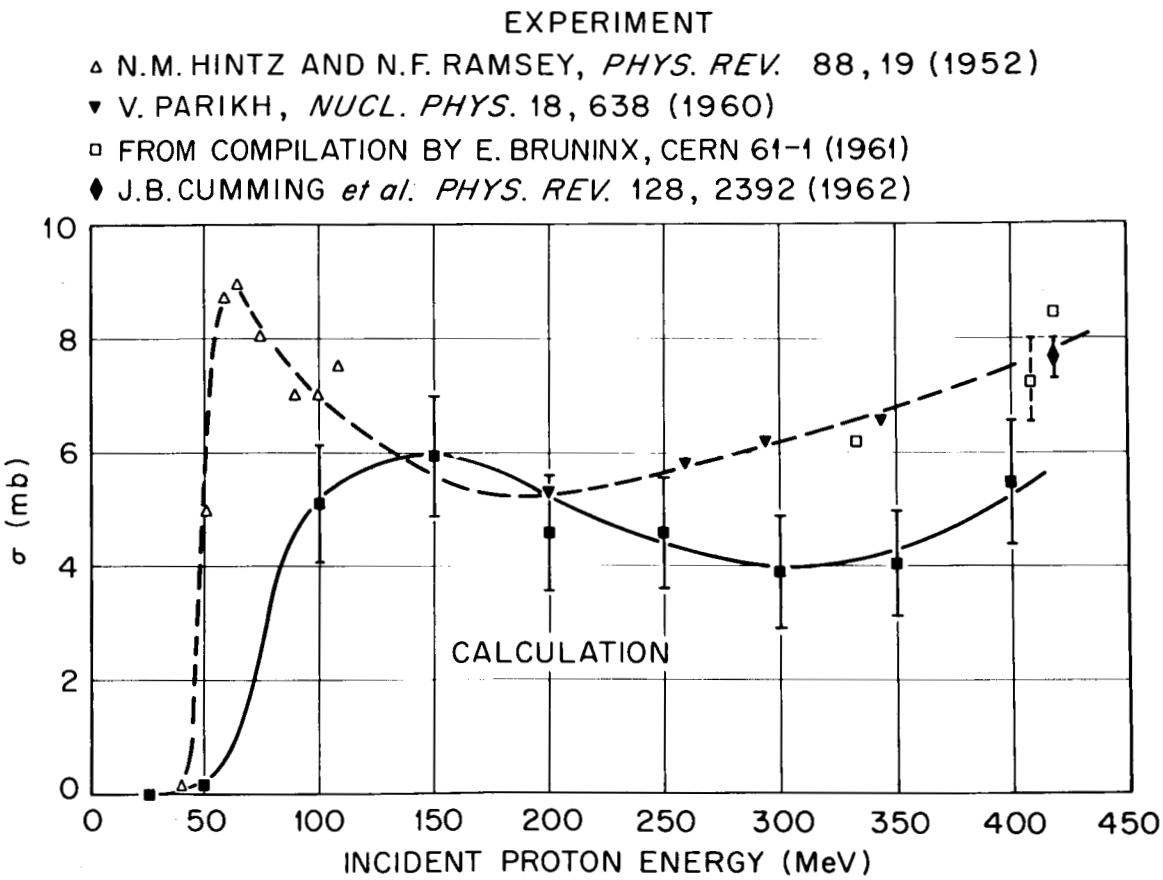

Fig. 4. Cross Section for the $^{27}Al(p,5p5n)^{18}F$ Reaction vs Incident Proton Energy.

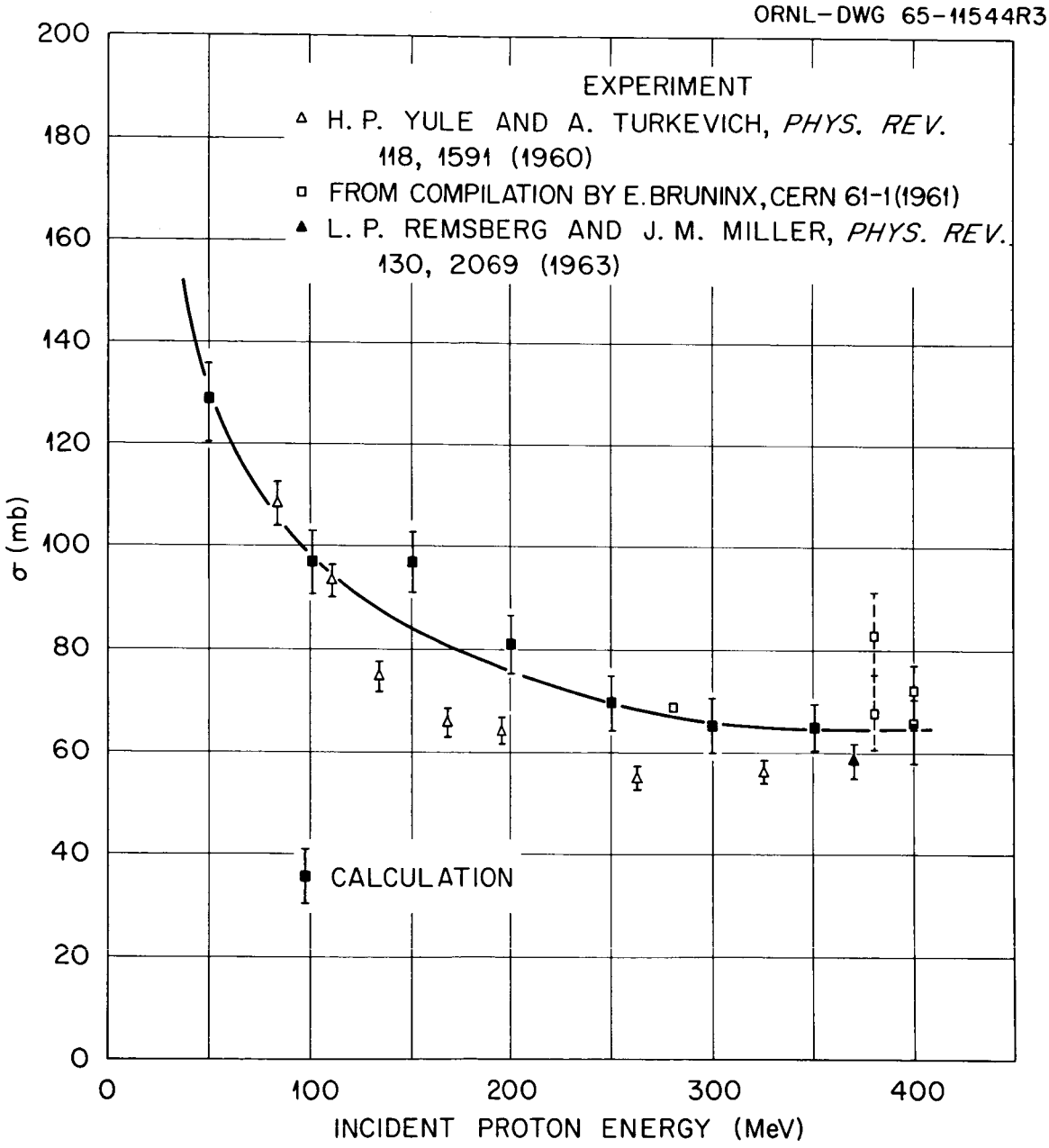

Fig. 5. Cross Section for the $^{65}Cu(p,pn)^{64}Cu$ Reaction vs Incident Proton Energy.

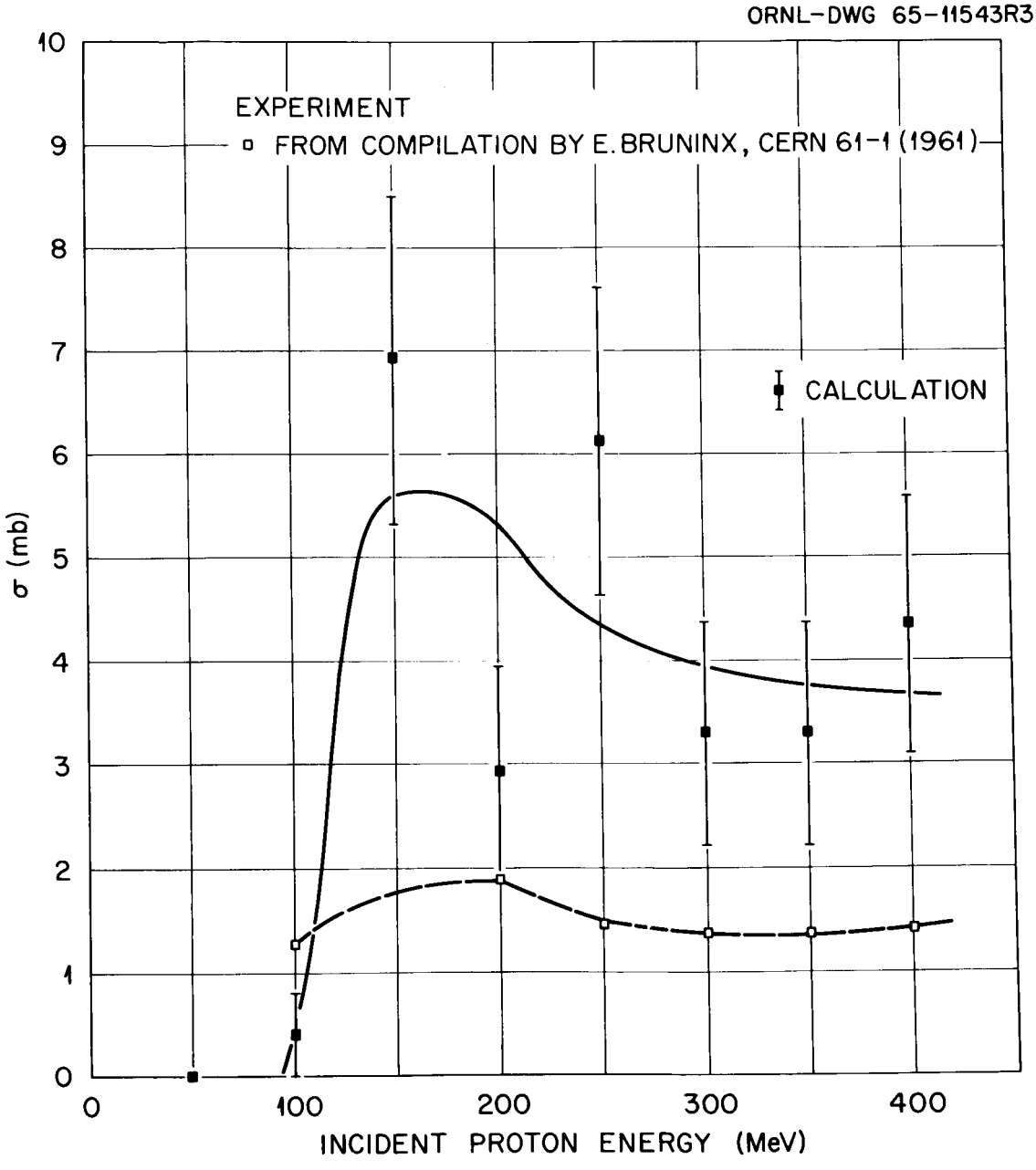

Fig. 6. Cross Section for the $^{65}Cu(p,2p7n)^{57}Ni$ Reaction vs Incident Proton Energy.

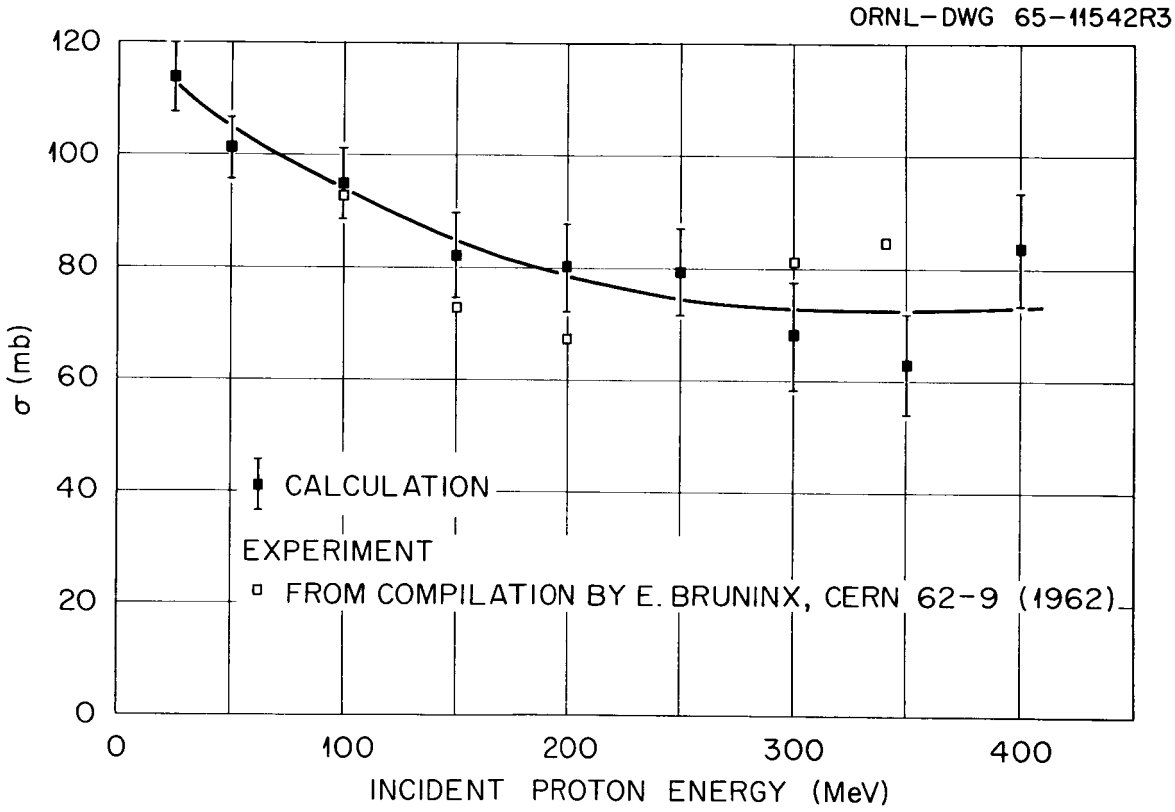

Fig. 7. Cross Section for the $^{238}U(p,pn)^{237}U$ Reaction vs Incident Proton Energy.

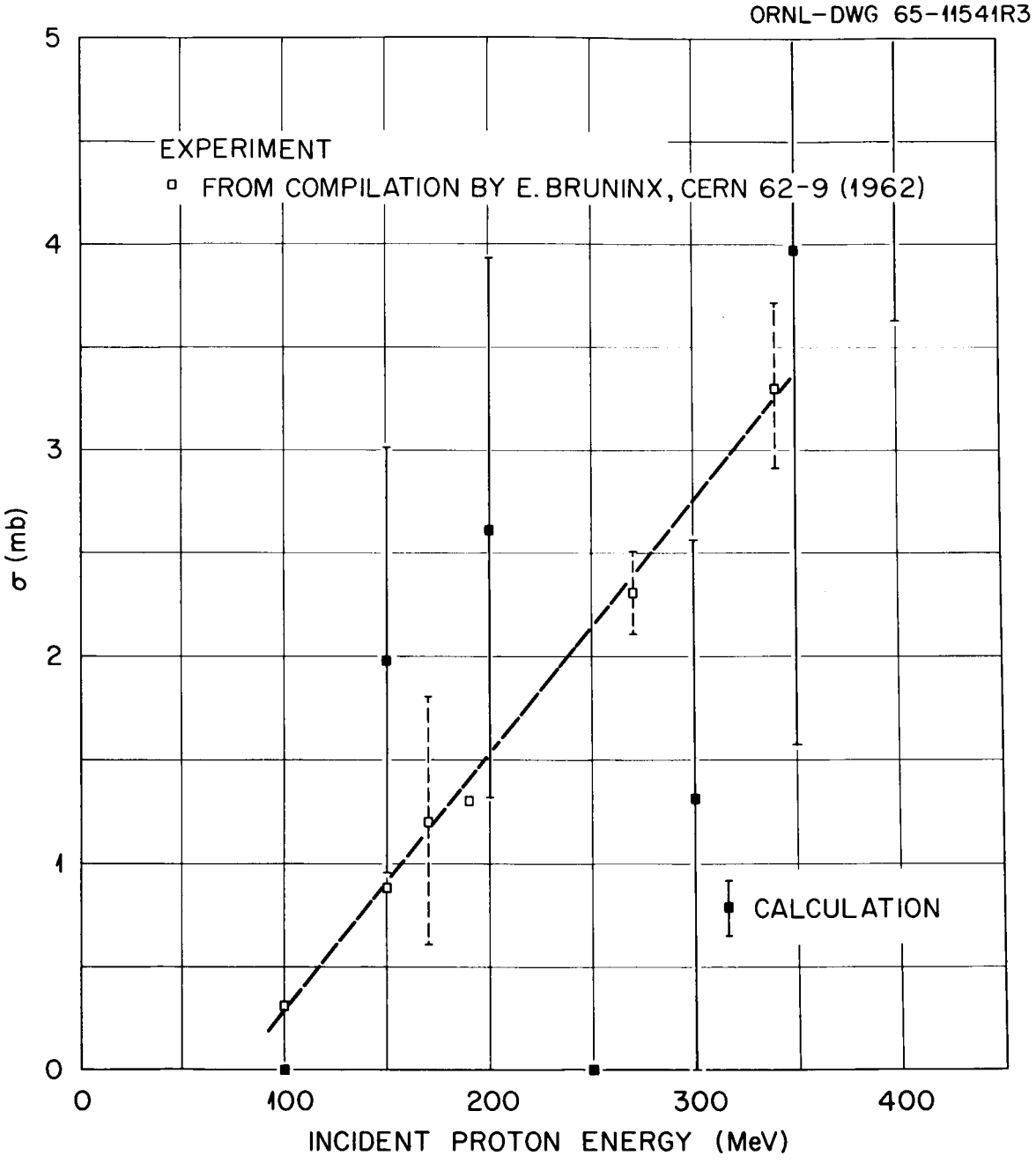

Fig. 8. Cross Section for the $^{238}U(p,3p9n)^{227}Th$ Reaction vs Incident Proton Energy.

III. Effect of Nuclear Size and Density Distribution on the (p,pn) Cross Section of a Light Element

The discrepancies observed[6,7] between experiment and the calculations of Metropolis et al.[2] were attributed to the lack of a diffuse nuclear surface in the nuclear model used in the calculations. This effect has been investigated for medium- and heavyweight elements,[1] and the investigation will now be extended to a lightweight element, carbon.

All but one of the nuclear radii and density distributions that were used are illustrated in Fig. 9, and the results for all of the distributions are given in Table 1. The small-radius, uniform density distribution is that employed by Metropolis et al.[2] The root-mean-square (rms) radius, uniform density distribution (not illustrated), with a radius of 3.58 F, has the same rms radius as Hofstadter's curve illustrated in Fig. 9. The configuration with the medium-radius, nonuniform density distribution best approximates Hofstadter's distribution; that is, it accounts for the diffuse nuclear surface, and it is the one used in all cases where the configuration is not specified. Hence, the configurations with the medium-radius, nonuniform distribution and rms, uniform distribution have essentially the same rms radius.

The discrepancies between the results using the small-radius nuclear configurations and experiment are considerably reduced by the use of the medium-radius, nonuniform configuration. The results from the rms-radius, uniform configuration are significantly smaller than those using the medium-radius, nonuniform configuration, but not as small as those from the small-radius, uniform configuration.

An examination of the data in Table 1 reveals that the discrepancy can be reduced by simply increasing the size of the nucleus while keeping the density distribution uniform; therefore, it is difficult to attribute the reduction of the discrepancy solely to the diffuseness of the nuclear surface.

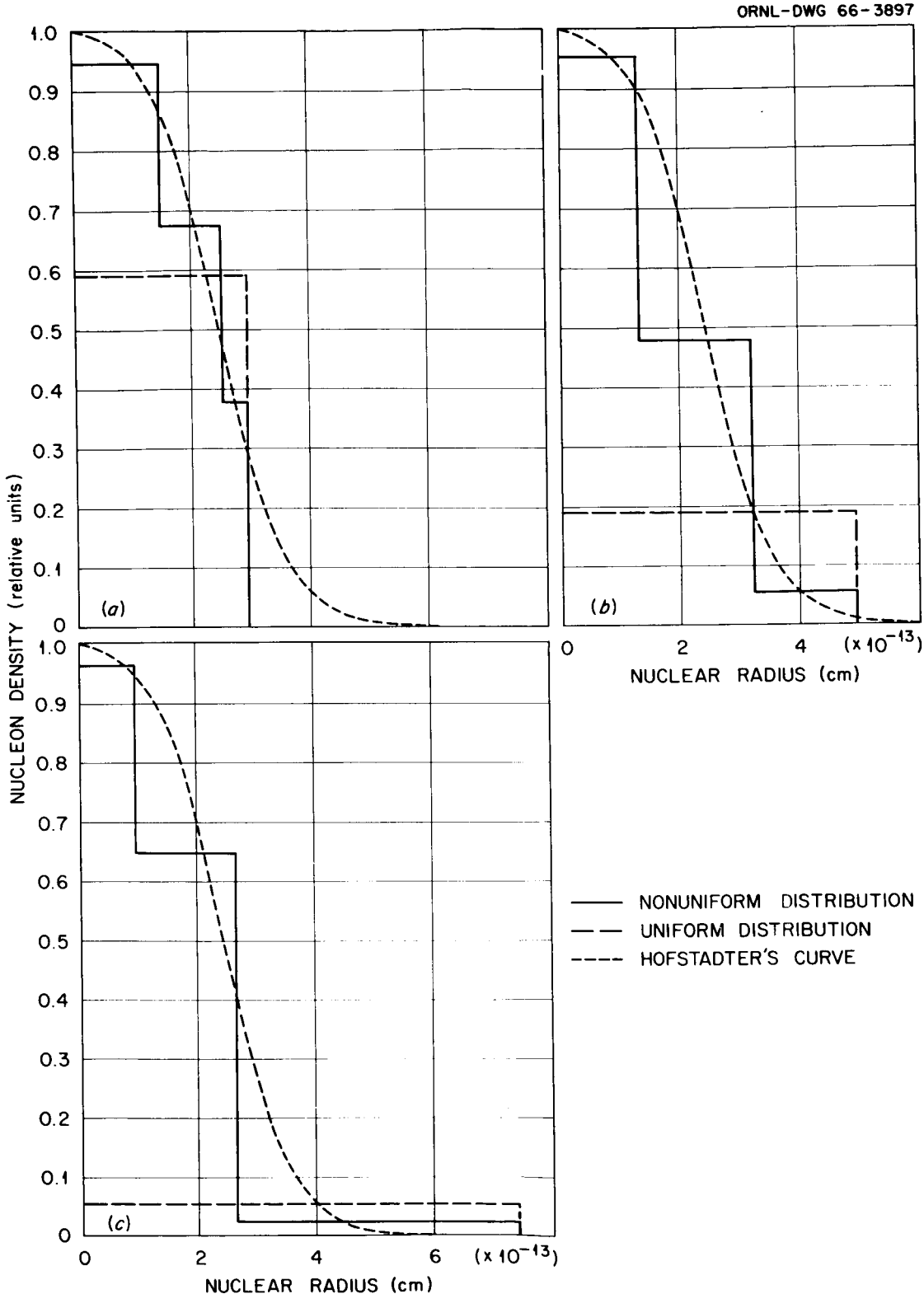

Fig. 9. Various Nucleon Density Distributions Assumed for the Carbon Nucleus; (a) Small Nuclear Radius, (b) Medium Nuclear Radius, (c) Large Nuclear Radius. [For Hofstadter's curve see Rev. Mod. Phys. 28, 214 (1956).]

Table 1. Cross Section for the $^{12}C(p,pn)^{11}C$ Reaction and for the Total Nonelastic Scattering as a Function of Proton Energy and Nuclear Configuration

Proton Energy (MeV)	Nuclear Configuration	(p,pn) Cross Sections (mb)		Calculated Nonelastic Cross Sections (mb)	Ratio of Calculated Values
		Calculated	Experimental[a]		
50	small, uniform	21 ± 1	86	200	0.11
	small, nonuniform	23 ± 1		193	0.12
	rms, uniform	36 ± 2		279	0.13
	medium, uniform	79 ± 3		443	0.18
	medium, nonuniform[b]	69 ± 3		349	0.20
	large, uniform	186 ± 8		692	0.27
	large, nonuniform	136 ± 7		487	0.28
400	small, uniform	11 ± 0.8	34	180	0.061
	small, nonuniform	11 ± 0.8		172	0.070
	rms, uniform	24 ± 1		211	0.11
	medium, uniform	66 ± 3		255	0.26
	medium, nonuniform[b]	43 ± 3		233	0.18
	large, uniform	118 ± 6		315	0.37
	large, nonuniform	60 ± 5		236	0.25

[a]Values taken from curve drawn through experimental points in Fig. 1.

[b]Standard nuclear configuration adopted for most calculations.

IV. The $^{12}C(\pi^-,\pi^-n)^{11}C$ Reaction

The $^{12}C(\pi^-,\pi^-n)^{11}C$ reaction cross section was calculated for several pion energies, and the results are compared with experiment in Fig. 10. The general agreement between the experimental results and those for the standard configuration is fair. There is significant improvement over the results using the small-radius configurations.

These data are interesting because it may be possible to determine the real part of the optical-model potential by their use. The reason is as follows: the shape of the cross-section curve has a peak at an energy in the vicinity of the energy of the peak of the free-particle $\pi^+ + p$ (or $\pi^- + n$) cross section. This strongly implies that the $^{12}C(\pi^-,\pi^-n)^{11}C$ reaction occurs predominantly through the direct interaction of the incident π^- with a loosely bound neutron followed by the subsequent emission of both the pion and the neutron without further collisions. The neutron must be loosely bound and the pion and neutron must escape without further collisions, because both conditions cause the excitation energy of the residual nucleus to be small. The residual nucleus must be left with little excitation energy after the pion and neutron escape; otherwise, it will evaporate a particle and the final nucleus will not be ^{11}C.

Assuming that the reaction is dominated by this direct "knockout" process, one would expect the reaction to occur with the greatest probability at an interaction energy that corresponds to the peak in the free-particle $\pi^- + n$ (i.e., $\pi^+ + p$) cross section (about 190 MeV). If the optical-model potential is real, negative, and about 25 MeV as analysis indicates,[8] then in order for the interaction energy to average about 190 MeV the incident particle energy must be about 165 MeV, since the pion will gain energy as it enters the nucleus, where it experiences the effect of the nuclear forces.

The trend in this direction for the calculated data which include the potential for pions is visible in Fig. 10. The errors associated with the experimental data are too large to allow the peak in the cross section to be located with sufficient accuracy to determine the strength of the potential. However, other experiments might be performed with this as a goal which could corroborate the optical-model analysis using

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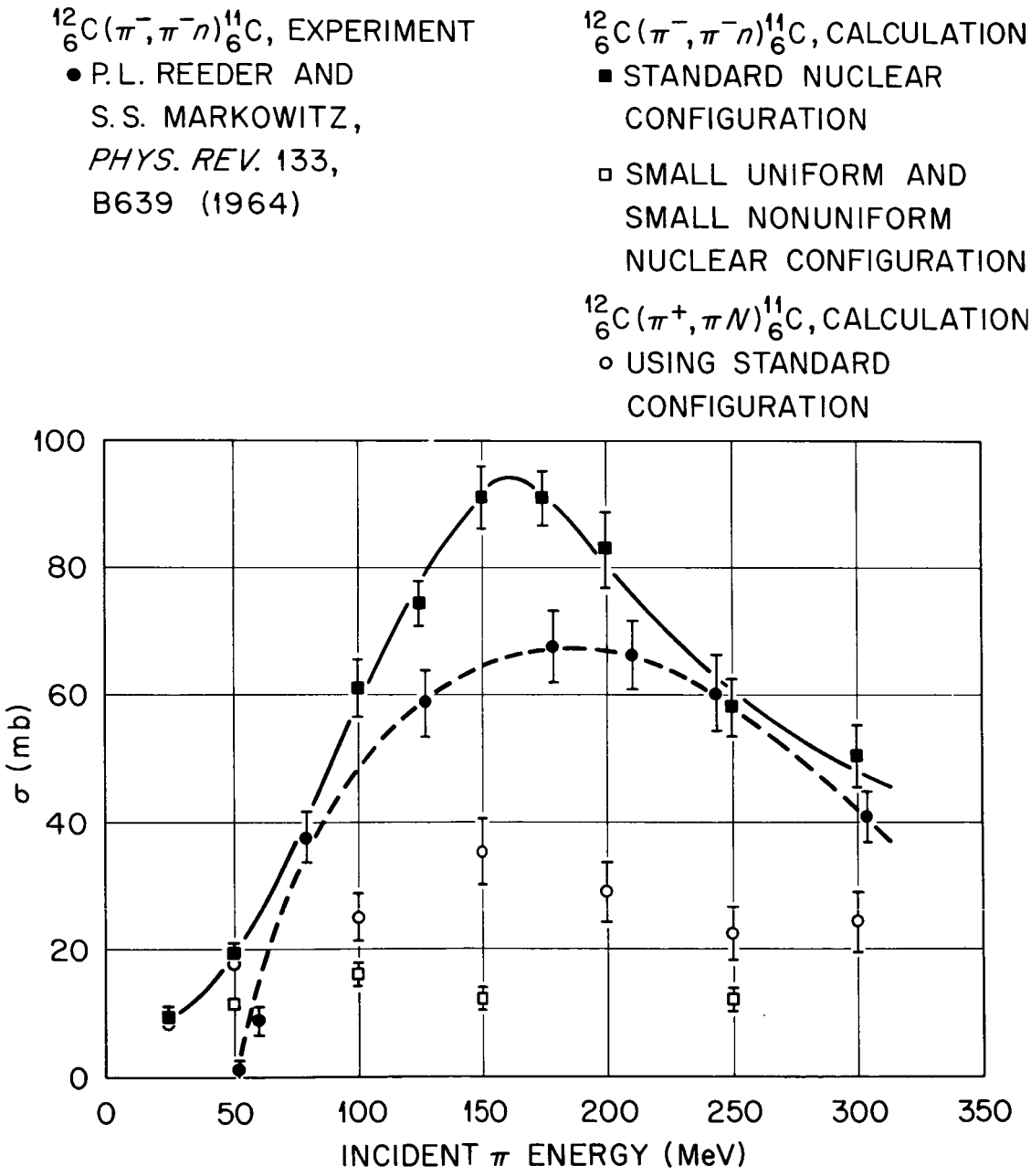

Fig. 10. Cross Section for the $^{12}C(\pi^-,\pi^-n)^{11}C$ Reaction vs Incident Pion Energy.

a completely different reaction. An increase in the accuracy of the experiments from about 10 to 5% or less should be sufficient.

The calculated cross section for the $^{12}C(\pi^+,\pi N)^{11}C$ reaction is illustrated in Fig. 10 also. It is smaller than the calculated $^{12}C(\pi^-,\pi^-n)^{11}C$ reaction by factors that are entirely consistent with the direct knockout assumption; that is, the cross sections for these reactions are reflections of the π-nucleon free-particle cross sections. Hence, these very detailed cascade-plus-evaporation calculations confirm the results obtained from the crude method employed by Wilkinson and shed no light on the anomolous experimental behavior of these cross sections;[9] that is, the measurements indicate that they have the same values.

V. Energy of Transition from Cascade to Evaporation

One of the most arbitrary decisions that must be made in the cascade-evaporation calculations is the determination of the transition energy separating the cascade phase from the evaporation. This energy is usually taken to be about the size of the Coulomb potential at the surface of the nucleus.[1,2] However, at these energies the de Broglie wavelength is about 1 F, the same size as the internucleon distances within the nucleus, and therefore one is well beyond the limits of validity of the cascade calculation.

The results from an investigation of the effects of a variation of this transition energy, or cascade cutoff energy, on the radiochemical cross sections are illustrated in Tables 2 through 5. As expected, the calculated (p,pn) cross sections generally decrease with increasing cutoff energy, but there is no trend clearly visible in the reactions in which many particles are emitted. In the latter cases the trends may be masked by the poor statistics. It is interesting to note that for the reactions considered the most consistent agreement is obtained using the cutoff energies of 10 MeV or less, that is, about the size of the Coulomb potential.

Table 2. Cross Section for the $^{12}C(p,pn)^{11}C$ and $^{12}C(p,3p3n)^{7}Be$ Reactions as a Function of Proton Energy and Cutoff Energy

Reaction	Proton Energy (MeV)	Reaction Cross Sections (mb)				
		Calculated Results[a] at Various Cutoff Energies (MeV)				Experimental Value[c]
		0.87[b]	10	30	50	
$^{12}C(p,pn)^{11}C$	100	47 ± 3	44 ± 2	25 ± 2	15 ± 1	61
	400	43 ± 3	36 ± 2	30 ± 2	24 ± 2	34
$^{12}C(p,3p3n)^{7}Be$	100	1.4 ± 0.4	1.2 ± 0.4	1.2 ± 0.4	1.4 ± 0.4	14
	400	1.1 ± 0.4	1.6 ± 0.4	0.31 ± 0.2	0.62 ± 0.3	8

[a]The errors indicated are statistical. They represent a 68% confidence interval.

[b]Cutoff energy normally used for carbon.

[c]Values taken from curves drawn through experimental points in Figs. 1 and 2.

Table 3. Cross Section for the $^{27}Al(p,3pn)^{24}Na$ and $^{27}Al(p,5p5n)^{18}F$ Reactions as a Function of Proton Energy and Cutoff Energy

Reaction	Proton Energy (MeV)	Reaction Cross Sections (mb)								
		Calculated Results[a] at Various Cutoff Energies (MeV)								Experimental Value[c]
		1.64[b]	5	10	15	20	30	40	50	
$^{27}Al(p,3pn)^{24}Na$	100	4.7 ± 1.0	4.5 ± 1.0	4.9 ± 1.0	4.3 ± 1.0	7.0 ± 1.2	4.7 ± 1.0	6.8 ± 1.2	3.1 ± 0.8	10.6
	400	5.8 ± 1.1	4.9 ± 1.0	6.8 ± 1.2	4.9 ± 1.0	5.1 ± 1.0	3.9 ± 0.9	3.7 ± 0.9	5.1 ± 1.0	11.6
$^{27}Al(p,5p5n)^{18}F$	100	5.1 ± 1.0	4.5 ± 1.0	1.9 ± 0.6	3.3 ± 0.8	2.9 ± 0.8	4.5 ± 1.0	4.5 ± 1.0	7.8 ± 1.3	7.0
	400	5.6 ± 1.1	6.0 ± 1.1	5.6 ± 1.1	4.9 ± 1.0	4.9 ± 1.0	4.3 ± 1.0	6.8 ± 1.2	8.0 ± 1.3	7.2

[a]The errors indicated are statistical. They represent a 68% confidence interval.

[b]Cutoff energy normally used for aluminum.

[c]Values taken from curves drawn through experimental points in Figs. 3 and 4.

Table 4. Cross Section for the $^{65}Cu(p,pn)^{64}Cu$ and $^{65}Cu(p,2p7n)^{57}Ni$ Reactions as a Function of Proton Energy and Cutoff Energy

Reaction	Proton Energy (MeV)	Reaction Cross Sections (mb)								
		Calculated Results[a] at Various Cutoff Energies (MeV)								Experimental Value[c]
		3.07[b]	5	10	15	20	30	40	50	
$^{65}Cu(p,pn)^{64}Cu$	100	97 ± 5	100 ± 5	92 ± 5	85 ± 5	73 ± 5	68 ± 4	44 ± 4	54 ± 4	98
	400	66 ± 4	68 ± 4	66 ± 4	72 ± 5	65 ± 4	59 ± 4	48 ± 4	52 ± 4	67
$^{65}Cu(p,2p7n)^{57}Ni$	100	0.4 ± 0.4	1.8 ± 0.7	2.0 ± 0.8	2.3 ± 0.8	5.0 ± 1.2	2.9 ± 0.9	3.8 ± 1.1	5.3 ± 1.2	1.3
	400	4.4 ± 1.1	4.1 ± 1.1	5.5 ± 1.3	3.5 ± 1.0	2.6 ± 0.9	3.5 ± 1.0	5.3 ± 1.2	4.1 ± 1.1	1.4

[a]The errors indicated are statistical. They represent a 68% confidence interval.

[b]Cutoff energy normally used for copper.

[c]Values taken from single curve in Fig. 5 and from curve drawn through experimental points in Fig. 6.

Table 5. Cross Section for the $^{238}U(p,pn)^{237}U$ and $^{238}U(p,3p9n)^{227}Th$ Reactions as a Function of Proton Energy and Cutoff Energy

Reaction	Proton Energy (MeV)	Reaction Cross Sections (mb)					
		Calculated Results[a] at Various Cutoff Energies (MeV)					Experimental Value[c]
		7.25[b]	10	15	25	50	
$^{238}U(p,pn)^{237}U$	100	95 ± 7	84 ± 7	74 ± 6	57 ± 6	30 ± 4	94
	400	83 ± 7	70 ± 6	77 ± 6	69 ± 6	47 ± 5	73
$^{238}U(p,3p9n)^{227}Th$	100	0	0	0	0	0	0.3
	400	6.6 ± 2.0	3.2 ± 1.3	1.6 ± 0.9	1.6 ± 0.9	0.5 ± 0.5	4

[a]The errors indicated are statistical. They represent a 68% confidence interval.

[b]Cutoff energy normally used for uranium.

[c]Values taken from curves in Figs. 7 and 8.

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Appendix

This appendix presents a tabulation of available experimental cross sections with which the calculations could be compared, as well as the calculated cross sections themselves. Those data for which some dependence could be determined were used as a basis for the conclusions presented in the text.

The numbers given in parentheses in column 5 were obtained with a version of the evaporation code that is different from that described in the text. This version is described in ref. 1 below. It differs from the one described in the text in that estimated masses (particularly for N or Z $\leqq$ 10) were used rather than measured masses, and ^{8}Be breakup was not included. The estimated masses compared quite well with the measured masses;[2] therefore the difference between these versions is quite small for A > 8. All other values in this column were obtained with the unmodified version.[3]

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INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	BE(9, 4)	BE(7, 4)	150.0	0.91		
P	BE(9, 4)	BE(7, 4)	155.0		8.8 + 0.5	1
P	BE(9, 4)	BE(7, 4)	350.0	0.71		
P	BE(9, 4)	BE(7, 4)	352.0		12.0 + 0.48	2
P	C(12, 6)	C(11, 6)	20.7		38.0 + 1.3	3
P	C(12, 6)	C(11, 6)	21.1		32.9 + 1.1	3
P	C(12, 6)	C(11, 6)	25.0	112.0 (96.0)		
P	C(12, 6)	C(11, 6)	50.0	76.0 (70.0)	80.0 + 5.0	4
P	C(12, 6)	C(11, 6)	50.5		86.4 + 2.6	3
P	C(12, 6)	C(11, 6)	100.0	52.0 (48.0)	61.0	5
P	C(12, 6)	C(11, 6)	100.0		62.0	4
P	C(12, 6)	C(11, 6)	150.0	52.0 (49.0)	43.0	4
P	C(12, 6)	C(11, 6)	150.0		45.0	5
P	C(12, 6)	C(11, 6)	150.0		46.2 + 1.4	6
P	C(12, 6)	C(11, 6)	200.0	48.0 (45.0)		
P	C(12, 6)	C(11, 6)	202.0		38.3	7
P	C(12, 6)	C(11, 6)	250.0	45.0 (44.0)		
P	C(12, 6)	C(11, 6)	252.0		36.3	7
P	C(12, 6)	C(11, 6)	300.0	41.0 (39.0)		
P	C(12, 6)	C(11, 6)	302.0		34.7	7
P	C(12, 6)	C(11, 6)	350.0	43.0 (43.0)	36.0 + 0.7	6
P	C(12, 6)	C(11, 6)	383.0		31.6 + 1.01	2
P	C(12, 6)	C(11, 6)	400.0	46.0 (43.0)		
P	C(12, 6)	C(11, 6)	420.0		31.2 + 2.8	6
P	C(12, 6)	C(10, 6)	150.0	1.6 (2.2)		
P	C(12, 6)	C(10, 6)	155.0		2.6 + 0.3	1
P	C(12, 6)	C(10, 6)	350.0	0.77 (2.5)		
P	C(12, 6)	C(10, 6)	365.0		3.55	6
P	C(12, 6)	C(10, 6)	400.0	0.31 (3.7)		
P	C(12, 6)	C(10, 6)	420.0		3.30	6
P	C(12, 6)	BE(10, 4)	200.0	2.8 (1.9)		
P	C(12, 6)	BE(10, 4)	220.0		1.8 + 0.6	8
P	C(12, 6)	BE(7, 4)	100.0	4.8 (2.9)	15.0	5
P	C(12, 6)	BE(7, 4)	150.0	5.4 (2.6)	10.5	5
P	C(12, 6)	BE(7, 4)	200.0	4.8 (1.4)		
P	C(12, 6)	BE(7, 4)	208.0		6.8 + 1.05	9
P	C(12, 6)	BE(7, 4)	300.0	3.56 (0.93)	10.3 + 0.7	10
P	C(12, 6)	BE(7, 4)	350.0	3.7 (1.6)		
P	C(12, 6)	BE(7, 4)	352.0		8.3	2
P	C(12, 6)	BE(7, 4)	400.0	3.9 (1.6)	9.6 + 0.7	10
P	C(12, 6)	LI(8, 3)	340.0		0.70 + 0.20	6
P	C(12, 6)	LI(8, 3)	350.0	0.46 (0.31)		
P	N(14, 7)	O(14, 8)	150.0	2.9		
P	N(14, 7)	O(14, 8)	155.0		0.075 + 0.01	1
P	N(14, 7)	N(13, 7)	25.0	56.0	40.0	11
P	N(14, 7)	N(13, 7)	50.0	37.0	22.0	4
P	N(14, 7)	N(13, 7)	100.0	33.0	12.0	4
P	N(14, 7)	N(13, 7)	150.0	26.0	8.0	4
P	N(14, 7)	N(13, 7)	400.0	27.0	5.6	6
P	N(14, 7)	C(11, 6)	25.0	2.4	43.0	4
P	N(14, 7)	C(11, 6)	50.0	12.0	18.5	4
P	N(14, 7)	C(11, 6)	100.0	8.1	17.2	4
P	N(14, 7)	C(11, 6)	150.0	7.3	16.3	4
P	N(14, 7)	C(11, 6)	400.0	6.4		
P	N(14, 7)	C(11, 6)	420.0		22.6	6

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	N(14, 7)	C(10, 6)	150.0	0.65		
P	N(14, 7)	C(10, 6)	155.0		1.6 + 0.3	1
P	N(14, 7)	BE(7, 4)	150.0	1.5		
P	N(14, 7)	BE(7, 4)	155.0		6.5 + 1.0	1
P	N(14, 7)	LI(8, 3)	340.0		0.55 + 0.16	6
P	N(14, 7)	LI(8, 3)	350.0	0.33		
P	O(16, 8)	O(15, 8)	25.0	128.0	25.0	12
P	O(16, 8)	O(15, 8)	50.0	68.0	69.0	4
P	O(16, 8)	O(15, 8)	100.0	54.90	59.0	4
P	O(16, 8)	O(15, 8)	150.0	55.0	42.0	4
P	O(16, 8)	O(15, 8)	350.0	40.0		
P	O(16, 8)	O(15, 8)	362.0		20.2 + 2.02	2
P	O(16, 8)	O(15, 8)	400.0	48.0		
P	O(, 8)	O(15, 8)	420.0		30.7	6
P	O(16, 8)	O(14, 8)	150.0	3.9		
P	O(16, 8)	O(14, 8)	155.0		0.9 + 0.1	1
P	O(16, 8)	N(13, 7)	25.0	0.68	19.0	4
P	O(16, 8)	N(13, 7)	25.0		18.0	12
P	O(16, 8)	N(13, 7)	50.0	11.0	3.5	4
P	O(16, 8)	N(13, 7)	100.0	5.80	5.0	4
P	O(16, 8)	N(13, 7)	150.0	4.60	5.0	4
P	O(16, 8)	N(13, 7)	150.0		4.5	12
P	O(16, 8)	N(13, 7)	350.0	5.5		
P	O(16, 8)	N(13, 7)	362.0		1.0 + 0.41	2
P	O(16, 8)	N(13, 7)	400.0	3.8		
P	O(, 8)	N(13, 7)	420.0		14.0 + 3.5	6
P	O(, 8)	N(13, 7)	420.0		6.5	6
P	O(16, 8)	C(11, 6)	25.0	0.17		
P	O(16, 8)	C(11, 6)	35.0		2.5 + 0.8	12
P	O(16, 8)	C(11, 6)	50.0	4.6		
P	O(16, 8)	C(11, 6)	51.0		13.0 + 0.7	12
P	O(16, 8)	C(11, 6)	95.0		15.2 + 0.7	12
P	O(16, 8)	C(11, 6)	100.0	4.4		
P	O(16, 8)	C(11, 6)	150.0	2.5	11.5 + 0.5	12
P	O(16, 8)	C(11, 6)	350.0	3.4		
P	O(16, 8)	C(11, 6)	362.0		13.6 + 1.632	2
P	O(16, 8)	C(11, 6)	400.0	2.9		
P	O(, 8)	C(11, 6)	420.0		31.0 + 7.75	6
P	O(, 8)	C(11, 6)	420.0		8.4	6
P	O(16, 8)	C(10, 6)	150.0	0.51		
P	O(16, 8)	C(10, 6)	155.0		1.0 + 0.2	1
P	O(16, 8)	C(10, 6)	400.0	0.17		
P	O(, 8)	C(10, 6)	420.0		6.1	6
P	O(16, 8)	BE(7, 4)	50.0	0.68		
P	O(16, 8)	BE(7, 4)	52.0		2.0 + 0.5	12
P	O(16, 8)	BE(7, 4)	100.0	0.85		
P	O(16, 8)	BE(7, 4)	110.0		5.0 + 1.2	12
P	O(16, 8)	BE(7, 4)	150.0	0.85	3.8 + 1.0	12
P	O(16, 8)	BE(7, 4)	200.0	0.34		
P	O(, 8)	BE(7, 4)	208.0		4.89 + 1.22	9
P	O(, 8)	BE(7, 4)	297.0		6.54 + 1.63	9
P	O(16, 8)	BE(7, 4)	300.0	0.51		
P	O(, 8)	BE(7, 4)	396.0		7.47 + 1.87	9
P	O(16, 8)	BE(7, 4)	400.0	0.34		
P	O(16, 8)	LI(7, 3)	150.0	0.17		

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	O(16, 8)	LI(7, 3)	156.0		14.0	13
P	O(16, 8)	LI(6, 3)	150.0	0.68		
P	O(16, 8)	LI(6, 3)	155.0		12.C + 4.0	14
P	O(16, 8)	LI(6, 3)	156.0		9.8 + 1.4	13
P	AL(27, 13)	MG(27, 12)	130.0		C.C86 + 0.CC4	15
P	AL(27, 13)	MG(27, 12)	150.0	0.0 (0.0)		
P	AL(27, 13)	MG(27, 12)	200.0	0.0 (0.0)	0.081 + .C4C	15
P	AL(27, 13)	MG(27, 12)	240.0		C.C94 + .CC3	15
P	AL(27, 13)	MG(27, 12)	250.0	0.0 (0.0)		
P	AL(27, 13)	MG(27, 12)	280.0		C.143 + 0.CC7	15
P	AL(27, 13)	MG(27, 12)	300.0	0.0 (0.0)		
P	AL(27, 13)	MG(27, 12)	320.0		C.155 + .CC12	15
P	AL(27, 13)	MG(27, 12)	380.0		0.164 +.C16	15
P	AL(27, 13)	MG(27, 12)	400.0	0.0 (0.0)		
P	AL(27, 13)	NA(24, 11)	25.0	0.0 (0.0)		
P	AL(27, 13)	NA(24, 11)	37.4		0.8 + 0.2	3
P	AL(27, 13)	NA(24, 11)	50.0	9.5 (12.0)	1.52	6
P	AL(27, 13)	NA(24, 11)	50.1		6.1 + 0.2	3
P	AL(27, 13)	NA(24, 11)	50.6		6.5 + 0.2	3
P	AL(27, 13)	NA(24, 11)	100.0	6.8 (9.7)	1C.8	5
P	AL(27, 13)	NA(24, 11)	150.0	3.3 (7.8)	9.2	6
P	AL(27, 13)	NA(24, 11)	150.0		9.6	5
P	AL(27, 13)	NA(24, 11)	200.0	3.5 (6.8)	9.1	16
P	AL(27, 13)	NA(24, 11)	200.0		9.2	6
P	AL(27, 13)	NA(24, 11)	250.0	4.1 (8.6)	9.9	6
P	AL(27, 13)	NA(24, 11)	300.0	3.3 (8.2)	11.0	16
P	AL(27, 13)	NA(24, 11)	300.0		11.2	6
P	AL(27, 13)	NA(24, 11)	350.0	3.9 (11.0)	11.2	6
P	AL(27, 13)	NA(24, 11)	350.0		11.1 + C.2	6
P	AL(27, 13)	NA(24, 11)	400.0	3.7 (9.5)	11.3	16
P	AL(27, 13)	NA(23, 11)	150.0	28.0 (41.0)		
P	AL(27, 13)	NA(23, 11)	155.0		23.0	17
P	AL(27, 13)	NA(22, 11)	25.0	0.0 (0.0)		
P	AL(27, 13)	NA(22, 11)	29.7		2.4 + 0.2	3
P	AL(27, 13)	NA(22, 11)	50.0	13.0 (18.0)		
P	AL(27, 13)	NA(22, 11)	50.1		38.4 + 1.0	3
P	AL(27, 13)	NA(22, 11)	50.6		36.4 + 3.6	3
P	AL(27, 13)	NA(22, 11)	100.0	40.0 (45.0)	21.5	5
P	AL(27, 13)	NA(22, 11)	150.0	23.0 (30.0)	18.0	5
P	AL(27, 13)	NA(22, 11)	335.0		13.6	6
P	AL(27, 13)	NA(22, 11)	350.0	21.0 (26.0)		
P	AL(27, 13)	F(18, 9)	100.0	2.06	7.C	
P	AL(27, 13)	F(18, 9)	200.0	1.7 (3.9)		
P	AL(27, 13)	F(18, 9)	202.0		5.38	7
P	AL(27, 13)	F(18, 9)	250.0	1.4 (4.3)		
P	AL(27, 13)	F(18, 9)	259.0		5.85	7
P	AL(27, 13)	F(18, 9)	294.0		6.18	7
P	AL(27, 13)	F(18, 9)	300.0	1.6 (3.3)		
P	AL(27, 13)	F(18, 9)	342.0		6.46	7
P	AL(27, 13)	F(18, 9)	342.0		6.8 + 0.68	2
P	AL(27, 13)	F(18, 9)	350.0	2.9 (5.6)		
P	AL(27, 13)	F(18, 9)	400.0	2.5 (4.9)		
P	AL(27, 13)	F(18, 9)	410.0		7.2 + .72	6
P	AL(27, 13)	N(13, 7)	400.0	0.2 (1.0)		
P	AL(27, 13)	N(13, 7)	410.0		C.78	6

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	AL(27, 13)	C(11, 6)	335.0		2.1	6
P	AL(27, 13)	C(11, 6)	350.0	0.0 (0.0)		
P	AL(27, 13)	C(11, 6)	400.0	0.4		
P	AL(27, 13)	C(11, 6)	410.0		3.0	6
P	AL(27, 13)	BE(7, 4)	335.0		1.6	6
P	AL(27, 13)	BE(7, 4)	350.0	0.0 (0.0)		
P	CR(50, 24)	CR(49, 24)	350.0	13.0		
P	CR(50, 24)	CR(49, 24)	370.0		48.2 + 2.9	18
P	CR(52, 24)	MN(52, 25)	150.0	20.0		
P	CR(52, 24)	MN(52, 25)	155.0		3.9 + 0.6	11
P	CR(52, 24)	MN(52, 25)	350.0	9.3		
P	CR(52, 24)	MN(52, 25)	370.0		1.43	18
P	CR(52, 24)	MN(52, 25)	370.0		1.46	18
P	CR(52, 24)	MN(52, 25)	370.0		1.45 + 0.10	18
P	CR(52, 24)	MN(51, 25)	350.0	3.32		
P	CR(52, 24)	MN(51, 25)	370.0		0.86	18
P	CR(52, 24)	MN(51, 25)	370.0		0.80	18
P	CR(52, 24)	MN(51, 25)	370.0		0.83 + 0.07	18
P	CR(52, 24)	CR(51, 24)	350.0	60.47		
P	CR(52, 24)	CR(51, 24)	370.0		59.2 + 4.5	18
P	CR(52, 24)	CR(49, 24)	350.0	12.63		
P	CR(52, 24)	CR(49, 24)	370.0		5.6	18
P	CR(52, 24)	CR(49, 24)	370.0		6.2	18
P	CR(52, 24)	CR(49, 24)	370.0		5.9 + 0.6	18
P	FE(54, 26)	FE(53, 26)	400.0	5.14	48.0	6
P	FE(54, 26)	FE(53, 26)	400.0		45.0	6
P	FE(56, 26)	CO(56, 27)	100.0	19.18		
P	FE(56, 26)	CO(56, 27)	150.0		1.6 + 0.3	4
P	FE(56, 26)	CO(56, 27)	200.0	9.59		
P	FE(56, 26)	CO(56, 27)	340.0		0.24	6
P	FE(56, 26)	CO(56, 27)	370.0		.91	18
P	FE(56, 26)	CO(56, 27)	370.0		.95	18
P	FE(56, 26)	CO(56, 27)	370.0		.90	18
P	FE(56, 26)	CO(56, 27)	370.0		.92 + 0.06	18
P	FE(56, 26)	CO(56, 27)	400.0	6.51		
P	FE(56, 26)	CO(55, 27)	100.0	8.91		
P	FE(56, 26)	CO(55, 27)	150.0		1.7 + 0.4	4
P	FE(56, 26)	CO(55, 27)	200.0	5.14		
P	FE(56, 26)	CO(55, 27)	370.0		0.76	18
P	FE(56, 26)	CO(55, 27)	370.0		0.79	18
P	FE(56, 26)	CO(55, 27)	370.0		0.76	18
P	FE(56, 26)	CO(55, 27)	370.0		.77 + 0.08	18
P	FE(56, 26)	CO(55, 27)	400.0	3.77		
P	FE(56, 26)	FE(55, 26)	100.0	111.67		
P	FE(56, 26)	FE(55, 26)	150.0		110.0 + 10.0	4
P	FE(56, 26)	FE(55, 26)	200.0	95.57		
P	FE(56, 26)	FE(55, 26)	370.0		63.9 + 3.8	18
P	FE(56, 26)	FE(55, 26)	400.0	78.10		
P	FE(56, 26)	FE(53, 26)	100.0	11.99		
P	FE(56, 26)	FE(53, 26)	150.0		30.0 + 2.0	4
P	FE(56, 26)	FE(53, 26)	200.0	8.56		
P	FE(56, 26)	FE(52, 26)	100.0	2.40		
P	FE(56, 26)	FE(52, 26)	150.0		5.2 + 1.4	4
P	FE(56, 26)	FE(52, 26)	200.0	1.37		
P	FE(56, 26)	FE(52, 26)	340.0		0.68	6

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	FE(56, 26)	FE(52, 26)	400.0	0.0		
P	FE(56, 26)	MN(56, 25)	100.0	0.0		
P	FE(56, 26)	MN(56, 25)	150.0		0.7 + 0.2	4
P	FE(56, 26)	MN(56, 25)	200.0	0.0		
P	FE(56, 26)	MN(56, 25)	340.0		0.59	6
P	FE(56, 26)	MN(56, 25)	400.0	0.0		
P	FE(56, 26)	MN(54, 25)	100.0	43.50		
P	FE(56, 26)	MN(54, 25)	150.0		36.0 + 16.0	4
P	FE(56, 26)	MN(54, 25)	200.0	44.19		
P	FE(56, 26)	MN(54, 25)	340.0		12.0	6
P	FE(56, 26)	MN(54, 25)	400.0	41.45		
P	FE(56, 26)	MN(52, 25)	100.0	72.28		
P	FE(56, 26)	MN(52, 25)	150.0		14.0 + 3.0	4
P	FE(56, 26)	MN(52, 25)	200.0	46.93		
P	FE(56, 26)	MN(52, 25)	340.0		12.9	6
P	FE(56, 26)	MN(52, 25)	400.0	31.17		
P	FE(56, 26)	MN(51, 25)	100.0	24.32		
P	FE(56, 26)	MN(51, 25)	150.0		5.8 + 1.2	4
P	FE(56, 26)	MN(51, 25)	200.0	14.04		
P	FE(56, 26)	MN(51, 25)	340.0		4.0	6
P	FE(56, 26)	MN(51, 25)	400.0	7.88		
P	FE(56, 26)	CR(51, 24)	100.0	79.81		
P	FE(56, 26)	CR(51, 24)	150.0		63.0 + 19.0	4
P	FE(56, 26)	CR(51, 24)	200.0	46.24		
P	FE(56, 26)	CR(51, 24)	340.0		41.0	6
P	FE(56, 26)	CR(51, 24)	400.0	39.39		
P	FE(56, 26)	CR(49, 24)	100.0	6.85		
P	FE(56, 26)	CR(49, 24)	150.0		6.1 + 1.7	4
P	FE(56, 26)	CR(49, 24)	200.0	11.65		
P	FE(56, 26)	CR(49, 24)	340.0		4.8	6
P	FE(56, 26)	CR(49, 24)	400.0	10.96		
P	FE(56, 26)	CR(48, 24)	100.0	0.0		
P	FE(56, 26)	CR(48, 24)	150.0		0.5 + 0.1	4
P	FE(56, 26)	CR(48, 24)	200.0	0.0		
P	FE(56, 26)	CR(48, 24)	340.0		0.80	6
P	FE(56, 26)	CR(48, 24)	400.0	0.34		
P	FE(56, 26)	V(49, 23)	100.0	15.07		
P	FE(56, 26)	V(49, 23)	150.0		33.0 + 5.0	4
P	FE(56, 26)	V(49, 23)	200.0	22.95		
P	FE(56, 26)	V(49, 23)	340.0		31.0	6
P	FE(56, 26)	V(49, 23)	400.0	28.43		
P	FE(56, 26)	V(48, 23)	100.0	11.30		
P	FE(56, 26)	V(48, 23)	150.0		15.0 + 2.0	4
P	FE(56, 26)	V(48, 23)	200.0	25.35		
P	FE(56, 26)	V(48, 23)	340.0		10.3	6
P	FE(56, 26)	V(48, 23)	400.0	36.99		
P	FE(56, 26)	V(47, 23)	100.0	2.06		
P	FE(56, 26)	V(47, 23)	150.0		5.9 + 1.9	4
P	FE(56, 26)	V(47, 23)	200.0	8.56		
P	FE(56, 26)	V(47, 23)	340.0		2.4	6
P	FE(56, 26)	V(47, 23)	400.0	8.22		
P	FE(56, 26)	TI(45, 22)	100.0	0.0		
P	FE(56, 26)	TI(45, 22)	150.0		4.5 + 1.0	4
P	FE(56, 26)	TI(45, 22)	200.0	6.85		
P	FE(56, 26)	TI(45, 22)	340.0		3.7	6

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	FE(56, 26)	TI(45, 22)	400.0	5.14		
P	FE(56, 26)	SC(48, 21)	340.0		0.45	6
P	FE(56, 26)	SC(48, 21)	400.0	0.0		
P	FE(56, 26)	SC(47, 21)	100.0	0.0		
P	FE(56, 26)	SC(47, 21)	150.0		0.7 + 0.2	4
P	FE(56, 26)	SC(47, 21)	200.0	1.37		
P	FE(56, 26)	SC(47, 21)	340.0		0.84	6
P	FE(56, 26)	SC(47, 21)	400.0	2.40		
P	FE(56, 26)	SC(46, 21)	100.0	0.34		
P	FE(56, 26)	SC(46, 21)	150.0		3.0 + 0.6	4
P	FE(56, 26)	SC(46, 21)	200.0	4.80		
P	FE(56, 26)	SC(46, 21)	340.0		3.20	6
P	FE(56, 26)	SC(46, 21)	400.0	5.82		
P	FE(56, 26)	SC(44, 21)	100.0	0.0		
P	FE(56, 26)	SC(44, 21)	150.0		5.9 + 0.4	4
P	FE(56, 26)	SC(44, 21)	200.0	9.59		
P	FE(56, 26)	SC(44, 21)	340.0		2.60	6
P	FE(56, 26)	SC(44, 21)	400.0	12.33		
P	FE(56, 26)	SC(43, 21)	100.0	0.0		
P	FE(56, 26)	SC(43, 21)	150.0		2.5 + 0.2	4
P	FE(56, 26)	SC(43, 21)	200.0	4.45		
P	FE(56, 26)	SC(, 21)	340.0		2.0	6
P	FE(56, 26)	SC(43, 21)	400.0	7.54		
P	FE(56, 26)	CA(47, 20)	100.0	0.0		
P	FE(56, 26)	CA(47, 20)	150.0		0.007 + 0.002	4
P	FE(56, 26)	CA(47, 20)	200.0	0.0		
P	FE(56, 26)	CA(47, 20)	340.0		0.007	6
P	FE(56, 26)	CA(47, 20)	400.0	0.0		
P	FE(56, 26)	CA(45, 20)	100.0	0.0		
P	FE(56, 26)	CA(45, 20)	150.0		0.36 + 0.06	4
P	FE(56, 26)	CA(45, 20)	200.0	0.0		
P	FE(56, 26)	CA(45, 20)	340.0		0.56	6
P	FE(56, 26)	CA(45, 20)	400.0	0.69		
P	FE(56, 26)	K(43, 19)	100.0	0.0		
P	FE(56, 26)	K(43, 19)	150.0		0.11 + 0.04	4
P	FE(56, 26)	K(43, 19)	200.0	0.0		
P	FE(56, 26)	K(43, 19)	340.0		0.4	6
P	FE(56, 26)	K(43, 19)	400.0	0.69		
P	FE(56, 26)	K(42, 19)	100.0	0.0		
P	FE(56, 26)	K(42, 19)	150.0		0.25 + 0.05	4
P	FE(56, 26)	K(42, 19)	200.0	0.34		
P	FE(56, 26)	K(42, 19)	340.0		0.7	6
P	FE(56, 26)	K(42, 19)	400.0	1.03		
P	FE(56, 26)	CL(39, 17)	100.0	0.0		
P	FE(56, 26)	CL(39, 17)	150.0		0.024 + .008	4
P	FE(56, 26)	CL(39, 17)	200.0	0.0		
P	FE(56, 26)	CL(39, 17)	340.0		0.045	6
P	FE(56, 26)	CL(39, 17)	400.0	0.0		
P	FE(56, 26)	CL(38, 17)	340.0		0.17	6
P	FE(56, 26)	CL(38, 17)	400.0	0.34		
P	FE(56, 26)	CL(34, 17)	100.0	0.0		
P	FE(56, 26)	CL(34, 17)	150.0		0.11 + 0.03	4
P	FE(56, 26)	CL(34, 17)	200.0	0.0		
P	FE(56, 26)	CL(34, 17)	340.0		0.11	6
P	FE(56, 26)	CL(34, 17)	400.0	0.69		

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	FE(56, 26)	S(35, 16)	100.0	0.0		
P	FE(56, 26)	S(35, 16)	150.0		0.18 + 0.09	4
P	FE(56, 26)	S(35, 16)	200.0	0.0		
P	FE(56, 26)	S(35, 16)	340.0		0.23	6
P	FE(56, 26)	S(35, 16)	400.0	0.34		
P	FE(56, 26)	P(33, 15)	100.0	0.0		
P	FE(56, 26)	P(33, 15)	150.0		0.065 + 0.032	4
P	FE(56, 26)	P(33, 15)	200.0	0.0		
P	FE(56, 26)	P(32, 15)	100.0	0.0		
P	FE(56, 26)	P(32, 15)	150.0		0.2 + 0.1	4
P	FE(56, 26)	P(32, 15)	200.0	0.0		
P	FE(56, 26)	P(32, 15)	340.0		0.044	6
P	FE(56, 26)	P(32, 15)	400.0	0.0		
P	FE(56, 26)	SI(31, 14)	100.0	0.0		
P	FE(56, 26)	SI(31, 14)	150.0		0.026 + 0.013	4
P	FE(56, 26)	SI(31, 14)	200.0	0.0		
P	FE(56, 26)	SI(31, 14)	340.0		0.12	6
P	FE(56, 26)	SI(31, 14)	400.0	0.0		
P	FE(56, 26)	MG(28, 12)	100.0	0.0		
P	FE(56, 26)	MG(28, 12)	150.0		0.005 + 0.001	4
P	FE(56, 26)	MG(28, 12)	200.0	0.0		
P	FE(56, 26)	NA(24, 11)	100.0	0.0		
P	FE(56, 26)	NA(24, 11)	150.0		0.065 + 0.011	4
P	FE(56, 26)	NA(24, 11)	200.0	0.0		
P	FE(56, 26)	NA(24, 11)	340.0		0.026	6
P	FE(56, 26)	NA(24, 11)	400.0	0.0		
P	FE(56, 26)	NA(22, 11)	100.0	0.0		
P	FE(56, 26)	NA(22, 11)	150.0		0.03 + 0.01	4
P	FE(56, 26)	NA(22, 11)	200.0	0.0		
P	FE(56, 26)	NA(22, 11)	340.0		0.02	6
P	FE(56, 26)	NA(22, 11)	400.0	0.0		
P	FE(56, 26)	F(18, 9)	100.0	0.0		
P	FE(56, 26)	F(18, 9)	150.0		0.014 + 0.003	4
P	FE(56, 26)	F(18, 9)	200.0	0.0		
P	FE(56, 26)	C(11, 6)	100.0	0.0		
P	FE(56, 26)	C(11, 6)	150.0		0.04 + 0.01	4
P	FE(56, 26)	C(11, 6)	200.0	0.0		
P	FE(56, 26)	BE(7, 4)	100.0	0.0		
P	FE(56, 26)	BE(7, 4)	150.0		0.23 + 0.03	4
P	FE(56, 26)	BE(7, 4)	200.0	0.0		
P	CU(65, 29)	ZN(65, 30)	45.0		41.0 + 6.0	19
P	CU(65, 29)	ZN(65, 30)	50.0	38.28		
P	CU(65, 29)	ZN(65, 30)	100.0	17.50	17.0 + 3.0	19
P	CU(65, 29)	ZN(65, 30)	143.0		14.0 + 2.0	19
P	CU(65, 29)	ZN(65, 30)	150.0	15.7		
P	CU(65, 29)	CU(64, 29)	90.0		126.0 + 32.0	20
P	CU(65, 29)	CU(64, 29)	100.0	97.69		
P	CU(65, 29)	CU(64, 29)	110.0		93.6 + 3.7	21
P	CU(65, 29)	CU(64, 29)	134.0		74.6 + 2.9	21
P	CU(65, 29)	CU(64, 29)	150.0	93.32		
P	CU(65, 29)	CU(64, 29)	168.0		65.8 + 2.6	21
P	CU(65, 29)	CU(64, 29)	196.0		64.3 + 2.5	21
P	CU(65, 29)	CU(64, 29)	200.0	79.83		
P	CU(65, 29)	CU(64, 29)	250.0	0.0		
P	CU(65, 29)	CU(64, 29)	263.0		55.0 + 2.1	21

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	CU(65, 29)	CU(64, 29)	280.0		69.0	6
P	CU(65, 29)	CU(64, 29)	300.0	64.89		
P	CU(65, 29)	CU(64, 29)	330.0		55.9 + 2.2	21
P	CU(65, 29)	CU(64, 29)	350.0	67.07		
P	CU(65, 29)	CU(64, 29)	370.0		58.6 + 3.3	18
P	CU(65, 29)	CU(64, 29)	400.0	66.71	73.0 + 7.3	6
P	CU(65, 29)	CU(64, 29)	400.0		67.0 + 6.7	6
P	CU(65, 29)	NI(65, 28)	100.0	0.0	0.006	6
P	CU(65, 29)	NI(65, 28)	200.0	0.0	0.009	6
P	CU(65, 29)	NI(65, 28)	250.0	0.0	0.021	6
P	CU(65, 29)	NI(65, 28)	300.0	0.0	0.032	6
P	CU(65, 29)	NI(65, 28)	350.0	0.0	0.056	6
P	CU(65, 29)	NI(65, 28)	400.0	0.0	0.078	6
P	CU(65, 29)	NI(57, 28)	100.0	2.55	1.3	6
P	CU(65, 29)	NI(57, 28)	200.0	6.93	1.9	6
P	CU(65, 29)	NI(57, 28)	200.0		1.8	6
P	CU(65, 29)	NI(57, 28)	250.0	5.83	1.4	6
P	CU(65, 29)	NI(57, 28)	250.0		1.5	6
P	CU(65, 29)	NI(57, 28)	300.0	2.92	1.5	6
P	CU(65, 29)	NI(57, 28)	300.0		1.3	6
P	CU(65, 29)	NI(57, 28)	350.0	4.37	1.4	6
P	CU(65, 29)	NI(57, 28)	400.0	4.74	1.4	6
P	CU(65, 29)	NI(57, 28)	400.0		1.4	6
P	TE(130, 52)	TE(129, 52)	50.0	120.89		
P	TE(130, 52)	TE(129, 52)	60.0		59.0 + 4.0	22
P	TE(130, 52)	TE(129, 52)	60.0		66.0 + 2.0	22
P	TE(130, 52)	TE(129, 52)	60.0		125.0 + 4.0	22
P	TE(130, 52)	TE(129, 52)	100.0	88.31		
P	TE(130, 52)	TE(129, 52)	120.0		55.0 + 4.0	22
P	TE(130, 52)	TE(129, 52)	120.0		70.0 + 5.0	22
P	TE(130, 52)	TE(129, 52)	120.0		126.0 + 6.0	22
P	TE(130, 52)	TE(129, 52)	150.0	80.46		
P	TE(130, 52)	TE(129, 52)	180.0		33.0 + 3.0	22
P	TE(130, 52)	TE(129, 52)	180.0		43.0 + 2.0	22
P	TE(130, 52)	TE(129, 52)	180.0		76.0 + 4.0	22
P	TE(130, 52)	SB(129, 51)	50.0	10.99		
P	TE(130, 52)	SB(129, 51)	60.0		9.9 + 0.5	22
P	TE(130, 52)	SB(129, 51)	100.0	17.66		
P	TE(130, 52)	SB(129, 51)	120.0		7.2 + 0.4	22
P	TE(130, 52)	SB(129, 51)	150.0	24.73		
P	TE(130, 52)	SB(129, 51)	180.0		12.3 + 0.6	22
P	I(127, 53)	I(126, 53)	80.0	102.86		
P	I(127, 53)	I(126, 53)	100.0		126.0 + 26.0	23
P	I(127, 53)	I(125, 53)	80.0	70.40		
P	I(127, 53)	I(125, 53)	100.0		100.0 + 26.0	23
P	I(127, 53)	I(124, 53)	80.0	73.53		
P	I(127, 53)	I(124, 53)	100.0		50.0 + 7.0	23
P	I(127, 53)	I(123, 53)	80.0	79.39		
P	I(127, 53)	I(123, 53)	100.0		44.0 + 11.0	23
P	I(127, 53)	I(121, 53)	80.0	179.52		
P	I(127, 53)	I(121, 53)	100.0		105.0 + 16.0	23
P	I(127, 53)	I(120, 53)	80.0	9.39		
P	I(127, 53)	I(120, 53)	100.0		8.9 + 3.6	23
P	CE(142, 58)	CE(141, 58)	50.0	123.49		
P	CE(142, 58)	CE(141, 58)	60.0		114.0 + 12.0	24

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	CE(142, 58)	CE(141, 58)	100.0	100.70		
P	CE(142, 58)	CE(141, 58)	120.0		98.2 + 17.0	24
P	CE(142, 58)	CE(141, 58)	200.0	90.98	68.9 + 3.4	24
P	CE(142, 58)	CE(141, 58)	233.0		65.5 + 3.8	24
P	CE(142, 58)	CE(141, 58)	250.0	91.33		
P	CE(142, 58)	CE(141, 58)	350.0	68.15		
P	CE(142, 58)	CE(141, 58)	370.0		79.0 + 7.9	25
P	CE(142, 58)	CE(141, 58)	400.0	81.10	86.2 + 1.6	23
P	CE(142, 58)	LA(141, 57)	50.0	9.41		
P	CE(142, 58)	LA(141, 57)	60.0		9.2 + 2.0	24
P	CE(142, 58)	LA(141, 57)	100.0	18.91		
P	CE(142, 58)	LA(141, 57)	120.0		11.8 + 4.0	24
P	CE(142, 58)	LA(141, 57)	200.0	27.60	15.5 + 6.0	24
P	CE(142, 58)	LA(141, 57)	233.0		19.6 + 7.0	24
P	CE(142, 58)	LA(141, 57)	250.0	32.03		
P	CE(142, 58)	LA(141, 57)	350.0	41.57		
P	CE(142, 58)	LA(141, 57)	370.0		20.0 + 2.3	25
P	CE(142, 58)	LA(141, 57)	400.0	36.80	54.4 + 4.6	23
P	W(186, 74)	TA(185, 73)	130.0		2.98 + 0.48	26
P	W(186, 74)	TA(185, 73)	150.0	21.48		
P	W(186, 74)	TA(185, 73)	200.0	27.87		
P	W(186, 74)	TA(185, 73)	210.0		5.55	26
P	W(186, 74)	TA(185, 73)	300.0	19.74	5.48	26
P	W(186, 74)	TA(185, 73)	400.0	39.48	6.93 + 1.74	26
P	W(186, 74)	HF(184, 72)	130.0		0.243 + 0.033	26
P	W(186, 74)	HF(184, 72)	150.0	0.58		
P	W(186, 74)	HF(184, 72)	200.0	1.55		
P	W(186, 74)	HF(184, 72)	210.0		0.144 + 0.001	26
P	W(186, 74)	HF(184, 72)	400.0	3.48	0.316 + 0.065	26
P	PB(206, 82)	BI(205, 83)	50.0	73.27		
P	PB(206, 82)	BI(205, 83)	52.5		150.0 + 22.5	23
P	PB(206, 82)	BI(203, 83)	50.0	171.09		
P	PB(206, 82)	BI(203, 83)	52.5		470.0 + 70.5	23
P	PB(206, 82)	BI(202, 83)	50.0	582.45		
P	PB(206, 82)	BI(202, 83)	52.5		590.0 + 88.5	23
P	PB(206, 82)	BI(201, 83)	50.0	410.54		
P	PB(206, 82)	BI(201, 83)	52.5		260.0 + 39.0	23
P	PB(206, 82)	BI(200, 83)	50.0	0.0		
P	PB(206, 82)	BI(200, 83)	63.8		180.0 + 27.0	23
P	PB(206, 82)	GA(73, 31)	390.0		1.2 + 0.36	23
P	PB(206, 82)	GA(73, 31)	400.0	0.0		
P	PB(206, 82)	GA(72, 31)	390.0		0.56 + 0.168	23
P	PB(206, 82)	GA(72, 31)	400.0	0.0		
P	PB(206, 82)	GA(67, 31)	390.0		0.013 + 0.0039	23
P	PB(206, 82)	GA(67, 31)	400.0	0.0		
P	PB(206, 82)	P(32, 15)	390.0		0.01 + 0.003	23
P	PB(206, 82)	P(32, 15)	400.0	0.0		
P	PB(206, 82)	MG(28, 12)	390.0		0.001 + 0.0003	23
P	PB(206, 82)	MG(28, 12)	400.0	0.0		
P	PB(206, 82)	NA(24, 11)	390.0		0.03 + 0.009	23
P	PB(206, 82)	NA(24, 11)	400.0	0.0		
P	BI(209, 83)	PO(209, 84)	135.0		20.0 + 5.0	27
P	BI(209, 83)	PO(209, 84)	155.0	18.50		
P	BI(209, 83)	PO(208, 84)	135.0		37.0 + 7.0	27
P	BI(209, 83)	PO(208, 84)	155.0	28.37		

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	BI(209, 83)	PO(207, 84)	50.0	104.24		
P	BI(209, 83)	PO(207, 84)	50.4		80.0 + 12.0	23
P	BI(209, 83)	PO(206, 84)	135.0		59.0 + 6.0	27
P	BI(209, 83)	PO(206, 84)	155.0	26.52		
P	BI(209, 83)	PO(206, 84)	380.0		7.7 + 5.6	23
P	BI(209, 83)	PO(206, 84)	400.0	9.65		
P	BI(209, 83)	PO(206, 84)	412.0		2.0	23
P	BI(209, 83)	PO(205, 84)	50.0	770.38		
P	BI(209, 83)	PO(205, 84)	50.4		800.0 + 120.0	23
P	BI(209, 83)	PO(205, 84)	59.7		450.0 + 67.50	23
P	BI(209, 83)	PO(205, 84)	65.0	131.38		
P	BI(209, 83)	PO(205, 84)	135.0		72.5 + 7.5	27
P	BI(209, 83)	PO(205, 84)	155.0	33.92		
P	BI(209, 83)	PO(205, 84)	380.0		12.9 + 9.4	23
P	BI(209, 83)	PO(205, 84)	400.0	11.58		
P	BI(209, 83)	PO(205, 84)	412.0		0.4	23
P	BI(209, 83)	PO(204, 84)	50.0	210.33		
P	BI(209, 83)	PO(204, 84)	50.4		210.0 + 31.50	23
P	BI(209, 83)	PO(204, 84)	65.0	383.03		
P	BI(209, 83)	PO(204, 84)	66.3		470.0 + 70.50	23
P	BI(209, 83)	PO(204, 84)	74.9		450.0 + 67.50	23
P	BI(209, 83)	PO(204, 84)	77.0	148.65		
P	BI(209, 83)	PO(204, 84)	135.0		71.5 + 3.5	27
P	BI(209, 83)	PO(204, 84)	155.0	25.91		
P	BI(209, 83)	PO(204, 84)	380.0		8.9 + 6.5	23
P	BI(209, 83)	PO(204, 84)	400.0	8.36		
P	BI(209, 83)	PO(204, 84)	412.0		1.6	23
P	BI(209, 83)	PO(203, 84)	59.7		90.0 + 13.5	23
P	BI(209, 83)	PO(203, 84)	65.0	377.48		
P	BI(209, 83)	PO(203, 84)	66.3		390.0 + 58.50	23
P	BI(209, 83)	PO(203, 84)	74.9		490.0 + 73.50	23
P	BI(209, 83)	PO(203, 84)	77.0	270.16		
P	BI(209, 83)	PO(203, 84)	79.9		390.0 + 58.5	23
P	BI(209, 83)	PO(203, 84)	83.7		360.0 + 54.0	23
P	BI(209, 83)	PO(203, 84)	90.0	84.50		
P	BI(209, 83)	PO(203, 84)	135.0		69.5 + 5.5	27
P	BI(209, 83)	PO(203, 84)	155.0	33.92		
P	BI(209, 83)	PO(203, 84)	380.0		12.5 + 9.1	23
P	BI(209, 83)	PO(203, 84)	400.0	13.51		
P	BI(209, 83)	PO(203, 84)	412.0		0.39	23
P	BI(209, 83)	PO(202, 84)	135.0		71.0 + 5.0	27
P	BI(209, 83)	PO(202, 84)	155.0	30.22		
P	BI(209, 83)	PO(202, 84)	380.0		5.2 + 3.8	23
P	BI(209, 83)	PO(202, 84)	400.0	9.65		
P	BI(209, 83)	PO(202, 84)	412.0		0.78	23
P	BI(209, 83)	PO(201, 84)	135.0		80.0 + 8.0	27
P	BI(209, 83)	PO(201, 84)	155.0	28.37		
P	BI(209, 83)	PO(201, 84)	380.0		13.3 + 9.7	23
P	BI(209, 83)	PO(201, 84)	400.0	7.72		
P	BI(209, 83)	PO(200, 84)	135.0		90.0 + 4.0	27
P	BI(209, 83)	PO(200, 84)	155.0	38.86		
P	BI(209, 83)	PO(200, 84)	380.0		10.0 + 7.3	23
P	BI(209, 83)	PO(200, 84)	400.0	5.79		
P	BI(209, 83)	BI(207, 83)	380.0		15.7 + 3.6	23
P	BI(209, 83)	BI(207, 83)	400.0	45.02		

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	BI(209, 83)	BI(207, 83)	412.0		20.0	23
P	BI(209, 83)	BI(206, 83)	380.0		49.3 + 5.9	23
P	BI(209, 83)	BI(206, 83)	400.0	35.38		
P	BI(209, 83)	BI(206, 83)	412.0		16.0	23
P	BI(209, 83)	BI(205, 83)	380.0		50.0 + 7.0	23
P	BI(209, 83)	BI(205, 83)	400.0	34.09		
P	BI(209, 83)	BI(205, 83)	412.0		3.0	23
P	BI(209, 83)	BI(204, 83)	380.0		37.1 + 3.2	23
P	BI(209, 83)	BI(204, 83)	400.0	34.73		
P	BI(209, 83)	BI(204, 83)	412.0		15.0	23
P	BI(209, 83)	BI(203, 83)	380.0		47.6 + 7.6	23
P	BI(209, 83)	BI(203, 83)	400.0	30.23		
P	BI(209, 83)	BI(203, 83)	412.0		8.2	23
P	BI(209, 83)	BI(202, 83)	380.0		55.8 + 9.4	23
P	BI(209, 83)	BI(202, 83)	400.0	30.87		
P	BI(209, 83)	BI(202, 83)	412.0		18.0	23
P	BI(209, 83)	BI(201, 83)	380.0		49.6 + 4.4	23
P	BI(209, 83)	BI(201, 83)	400.0	28.94		
P	BI(209, 83)	BI(200, 83)	380.0		64.4	23
P	BI(209, 83)	BI(200, 83)	400.0	29.59		
P	BI(209, 83)	BI(199, 83)	380.0		68.6	23
P	BI(209, 83)	BI(199, 83)	400.0	27.66		
P	BI(209, 83)	BI(198, 83)	380.0		60.1	23
P	BI(209, 83)	BI(198, 83)	400.0	25.73		
P	BI(209, 83)	PB(209, 82)	400.0	0.0		
P	BI(209, 83)	PB(209, 82)	412.0		9.8	23
P	BI(209, 83)	PB(206, 82)	50.0	10.49		
P	BI(209, 83)	PB(206, 82)	56.0		27.0 + 1.0	28
P	BI(209, 83)	PB(203, 82)	380.0		14.0 + 2.7	23
P	BI(209, 83)	PB(203, 82)	400.0	12.22		
P	BI(209, 83)	PB(203, 82)	412.0		6.6	23
P	BI(209, 83)	PB(201, 82)	380.0		24.5 + 6.6	23
P	BI(209, 83)	PB(201, 82)	400.0	14.15		
P	BI(209, 83)	PB(200, 82)	380.0		7.5 + 5.0	23
P	BI(209, 83)	PB(200, 82)	400.0	22.51		
P	BI(209, 83)	PB(200, 82)	412.0		5.6	23
P	BI(209, 83)	PB(199, 82)	380.0		13.7	23
P	BI(209, 83)	PB(199, 82)	400.0	22.51		
P	BI(209, 83)	PB(198, 82)	380.0		26.9	23
P	BI(209, 83)	PB(198, 82)	400.0	18.65		
P	BI(209, 83)	PB(197, 82)	380.0		12.5	23
P	BI(209, 83)	PB(197, 82)	400.0	31.52		
P	BI(209, 83)	TL(204, 81)	400.0	0.64		
P	BI(209, 83)	TL(204, 81)	412.0		1.6	23
P	BI(209, 83)	TL(202, 81)	380.0		4.42 + 5.9	23
P	BI(209, 83)	TL(202, 81)	400.0	5.79		
P	BI(209, 83)	TL(202, 81)	412.0		0.33	23
P	BI(209, 83)	TL(201, 81)	380.0		15.1 + 3.4	23
P	BI(209, 83)	TL(201, 81)	400.0	4.50		
P	BI(209, 83)	TL(201, 81)	412.0		2.0	23
P	BI(209, 83)	TL(200, 81)	380.0		13.5 + 0.8	23
P	BI(209, 83)	TL(200, 81)	400.0	2.57		
P	BI(209, 83)	TL(200, 81)	412.0		1.0	23
P	BI(209, 83)	TL(199, 81)	380.0		2.52 + 1.37	23
P	BI(209, 83)	TL(199, 81)	400.0	2.57		

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	BI(209, 83)	TL(198, 81)	380.0		25.8 + 3.2	23
P	BI(209, 83)	TL(198, 81)	400.0	4.50		
P	BI(209, 83)	TL(196, 81)	380.0		62.5 + 18.4	23
P	BI(209, 83)	TL(196, 81)	400.0	10.93		
P	BI(209, 83)	TL(195, 81)	380.0		62.3 + 15.2	23
P	BI(209, 83)	TL(195, 81)	400.0	6.43		
P	BI(209, 83)	HG(197, 80)	380.0		4.65 + 2.83	23
P	BI(209, 83)	HG(197, 80)	400.0	1.29		
P	BI(209, 83)	HG(195, 80)	380.0		3.89 + 1.87	23
P	BI(209, 83)	HG(195, 80)	400.0	1.29		
P	BI(209, 83)	HG(194, 80)	380.0		(0.5)	23
P	BI(209, 83)	HG(194, 80)	400.0	0.0		
P	BI(209, 83)	HG(193, 80)	380.0		7.0	23
P	BI(209, 83)	HG(193, 80)	400.0	3.22		
P	BI(209, 83)	HG(192, 80)	380.0		22.0	23
P	BI(209, 83)	HG(192, 80)	400.0	5.15		
P	BI(209, 83)	HG(191, 80)	380.0		21.9	23
P	BI(209, 83)	HG(191, 80)	400.0	5.15		
P	BI(209, 83)	HG(190, 80)	380.0		39.8	23
P	BI(209, 83)	HG(190, 80)	400.0	7.72		
P	BI(209, 83)	HG(189, 80)	380.0		1.05	23
P	BI(209, 83)	HG(189, 80)	400.0	9.00		
P	BI(209, 83)	AU(196, 79)	380.0		0.46 + 0.07	23
P	BI(209, 83)	AU(196, 79)	400.0	.64		
P	BI(209, 83)	AU(194, 79)	380.0		1.30 + 0.17	23
P	BI(209, 83)	AU(194, 79)	400.0	0.0		
P	BI(209, 83)	AU(193, 79)	380.0		0.6 + 0.6	23
P	BI(209, 83)	AU(193, 79)	400.0	0.0		
P	BI(209, 83)	AU(192, 79)	380.0		14.2 + 1.3	23
P	BI(209, 83)	AU(192, 79)	400.0	.64		
P	BI(209, 83)	AU(191, 79)	380.0		17.0	23
P	BI(209, 83)	AU(191, 79)	400.0	1.29		
P	BI(209, 83)	AU(189, 79)	380.0		7.8	23
P	BI(209, 83)	AU(189, 79)	400.0	.64		
P	BI(209, 83)	PT(189, 78)	380.0		16.8	23
P	BI(209, 83)	PT(189, 78)	400.0	0.0		
P	BI(209, 83)	PT(188, 78)	380.0		20.8	23
P	BI(209, 83)	PT(188, 78)	400.0	0.0		
P	BI(209, 83)	PT(186, 78)	380.0		28.1	23
P	BI(209, 83)	PT(186, 78)	400.0	.64		
P	BI(209, 83)	CS(131, 55)	75.0		0.0023 + 0.00069	23
P	BI(209, 83)	CS(131, 55)	77.0	0.0		
P	BI(209, 83)	CS(131, 55)	155.0	0.0		
P	BI(209, 83)	CS(131, 55)	184.0		0.0027 + 0.00081	23
P	BI(209, 83)	CS(131, 55)	303.0		0.012 + 0.0036	23
P	BI(209, 83)	CS(131, 55)	400.0	0.0		
P	BI(209, 83)	CS(129, 55)	75.0		0.0028 + 0.00084	23
P	BI(209, 83)	CS(129, 55)	77.0	0.0		
P	BI(209, 83)	I(132, 53)	75.0		0.0006 + 0.00018	23
P	BI(209, 83)	I(132, 53)	77.0	0.0		
P	BI(209, 83)	I(132, 53)	90.0	0.0		
P	BI(209, 83)	I(132, 53)	120.0		0.00082 + 0.00246	23
P	BI(209, 83)	I(132, 53)	155.0	0.0		
P	BI(209, 83)	I(132, 53)	184.0		0.0026 + 0.00078	23
P	BI(209, 83)	I(132, 53)	373.0		0.012 + 0.0036	23

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	BI(209, 83)	I(132, 53)	400.0	0.0		
P	BI(209, 83)	I(130, 53)	75.0		0.00083 + 0.000249	23
P	BI(209, 83)	I(130, 53)	77.0	0.0		
P	BI(209, 83)	I(130, 53)	90.0	0.0		
P	BI(209, 83)	I(130, 53)	120.0		0.0017 + 0.00051	23
P	BI(209, 83)	I(130, 53)	155.0	0.0		
P	BI(209, 83)	I(130, 53)	184.0		0.0040 + 0.0012	23
P	BI(209, 83)	I(130, 53)	373.0		0.014 + 0.0042	23
P	BI(209, 83)	I(130, 53)	400.0	0.0		
P	BI(209, 83)	I(128, 53)	75.0		0.0012 + 0.00036	23
P	BI(209, 83)	I(128, 53)	77.0	0.0		
P	BI(209, 83)	I(128, 53)	90.0	0.0		
P	BI(209, 83)	I(128, 53)	120.0		0.0025 + 0.0075	23
P	BI(209, 83)	I(128, 53)	155.0	0.0		
P	BI(209, 83)	I(128, 53)	184.0		0.0069 + 0.0207	23
P	BI(209, 83)	I(128, 53)	373.0		0.024 + 0.072	23
P	BI(209, 83)	I(128, 53)	400.0	0.0		
P	BI(209, 83)	I(126, 53)	75.0		0.0012 + 0.00036	23
P	BI(209, 83)	I(126, 53)	77.0	0.0		
P	BI(209, 83)	I(126, 53)	90.0	0.0		
P	BI(209, 83)	I(126, 53)	120.0		0.0027 + 0.0081	23
P	BI(209, 83)	I(126, 53)	155.0	0.0		
P	BI(209, 83)	I(126, 53)	184.0		0.013 + 0.039	23
P	BI(209, 83)	I(126, 53)	373.0		0.050 + 0.015	23
P	BI(209, 83)	I(126, 53)	400.0	0.0		
P	BI(209, 83)	I(124, 53)	75.0		0.0003 + 0.0009	23
P	BI(209, 83)	I(124, 53)	77.0	0.0		
P	BI(209, 83)	I(124, 53)	90.0	0.0		
P	BI(209, 83)	I(124, 53)	120.0		0.0015 + 0.0045	23
P	BI(209, 83)	I(124, 53)	155.0	0.0		
P	BI(209, 83)	I(124, 53)	184.0		0.0065 + 0.0195	23
P	BI(209, 83)	I(124, 53)	373.0		0.031 + 0.093	23
P	BI(209, 83)	I(124, 53)	400.0	0.0		
P	BI(209, 83)	SN(115, 50)	75.0		0.12 + 0.36	23
P	BI(209, 83)	SN(115, 50)	77.0	0.0		
P	BI(209, 83)	SN(115, 50)	155.0	0.0		
P	BI(209, 83)	SN(115, 50)	192.0		2.5 + 0.75	23
P	BI(209, 83)	IN(114, 49)	75.0		0.0044 + 0.0132	23
P	BI(209, 83)	IN(114, 49)	77.0	0.0		
P	BI(209, 83)	IN(114, 49)	90.0	0.0		
P	BI(209, 83)	IN(114, 49)	120.0		0.13 + 0.39	23
P	BI(209, 83)	IN(114, 49)	155.0	0.0		
P	BI(209, 83)	IN(114, 49)	184.0		0.32 + 0.96	23
P	BI(209, 83)	IN(114, 49)	373.0		4.9 + 1.47	23
P	BI(209, 83)	IN(114, 49)	400.0	0.0		
P	BI(209, 83)	IN(111, 49)	75.0		0.12 + 0.036	23
P	BI(209, 83)	IN(111, 49)	77.0	0.0		
P	BI(209, 83)	IN(111, 49)	155.0	0.0		
P	BI(209, 83)	IN(111, 49)	192.0		1.2 + 0.36	23
P	BI(209, 83)	AG(113, 47)	75.0		0.28 + 0.084	23
P	BI(209, 83)	AG(113, 47)	77.0	0.0		
P	BI(209, 83)	AG(113, 47)	90.0	0.0		
P	BI(209, 83)	AG(113, 47)	120.0		1.5 + 0.45	23
P	BI(209, 83)	AG(113, 47)	155.0	0.0		
P	BI(209, 83)	AG(113, 47)	184.0		1.7 + 0.51	23

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	BI(209, 83)	AG(113, 47)	373.0		1.1 + 0.33	23
P	BI(209, 83)	AG(113, 47)	400.0	0.0		
P	BI(209, 83)	AG(112, 47)	75.0		0.12 + 0.036	23
P	BI(209, 83)	AG(112, 47)	77.0	0.0		
P	BI(209, 83)	AG(112, 47)	90.0	0.0		
P	BI(209, 83)	AG(112, 47)	120.0		0.69 + 0.207	23
P	BI(209, 83)	AG(112, 47)	155.0	0.0		
P	BI(209, 83)	AG(112, 47)	184.0		0.89 + 0.267	23
P	BI(209, 83)	AG(112, 47)	373.0		1.9 + 0.57	23
P	BI(209, 83)	AG(112, 47)	400.0	0.0		
P	BI(209, 83)	AG(111, 47)	75.0		0.35 + 0.105	23
P	BI(209, 83)	AG(111, 47)	77.0	0.0		
P	BI(209, 83)	AG(111, 47)	90.0	0.0		
P	BI(209, 83)	AG(111, 47)	120.0		1.7 + 0.51	23
P	BI(209, 83)	AG(111, 47)	155.0	0.0		
P	BI(209, 83)	AG(111, 47)	184.0		2.4 + 0.72	23
P	BI(209, 83)	AG(111, 47)	373.0		3.1 + 0.93	23
P	BI(209, 83)	AG(111, 47)	400.0	0.0		
P	BI(209, 83)	PD(112, 46)	155.0	0.0		
P	BI(209, 83)	PD(112, 46)	192.0		0.12 + 0.036	23
P	BI(209, 83)	PD(109, 46)	155.0	0.0		
P	BI(209, 83)	PD(109, 46)	192.0		0.48 + 0.144	23
P	BI(209, 83)	PD(103, 46)	155.0	0.0		
P	BI(209, 83)	PD(103, 46)	192.0		0.009 + 0.0027	23
P	BI(209, 83)	PD(100, 46)	155.0	0.0		
P	BI(209, 83)	PD(100, 46)	192.0		0.016 + 0.0048	23
P	BI(209, 83)	NB(96, 41)	75.0		0.026 + 0.0078	23
P	BI(209, 83)	NB(96, 41)	77.0	0.0		
P	BI(209, 83)	NB(96, 41)	90.0	0.0		
P	BI(209, 83)	NB(96, 41)	120.0		0.70 + 0.21	23
P	BI(209, 83)	NB(96, 41)	155.0	0.0		
P	BI(209, 83)	NB(96, 41)	184.0		2.3 + 0.69	23
P	BI(209, 83)	NB(96, 41)	373.0		4.1 + 1.23	23
P	BI(209, 83)	NB(96, 41)	400.0	0.0		
P	BI(209, 83)	NB(95, 41)	75.0		0.017 + 0.0051	23
P	BI(209, 83)	NB(95, 41)	75.0		0.012 + 0.0036	23
P	BI(209, 83)	NB(95, 41)	77.0	0.0		
P	BI(209, 83)	NB(95, 41)	90.0	0.0		
P	BI(209, 83)	NB(95, 41)	120.0		0.14 + 0.042	23
P	BI(209, 83)	NB(95, 41)	120.0		0.079 + 0.0237	23
P	BI(209, 83)	NB(95, 41)	155.0	0.0		
P	BI(209, 83)	NB(95, 41)	184.0		0.9 + 0.27	23
P	BI(209, 83)	NB(95, 41)	184.0		0.45 + 0.135	23
P	BI(209, 83)	NB(95, 41)	373.0		2.7 + 0.81	23
P	BI(209, 83)	NB(95, 41)	373.0		0.81 + 0.243	23
P	BI(209, 83)	NB(95, 41)	400.0	0.0		
P	BI(209, 83)	RB(86, 37)	155.0	0.0		
P	BI(209, 83)	RB(86, 37)	184.0		0.053 + 0.0159	23
P	BI(209, 83)	BR(84, 35)	75.0		0.023 + 0.0069	23
P	BI(209, 83)	BR(84, 35)	77.0	0.0		
P	BI(209, 83)	BR(84, 35)	90.0	0.0		
P	BI(209, 83)	BR(84, 35)	120.0		0.19 + 0.057	23
P	BI(209, 83)	BR(83, 35)	75.0		0.034 + 0.0102	23
P	BI(209, 83)	BR(83, 35)	77.0	0.0		
P	BI(209, 83)	BR(83, 35)	90.0	0.0		

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	BI(209, 83)	BR(83, 35)	120.0		0.45 + 0.135	23
P	BI(209, 83)	BR(83, 35)	155.0	0.0		
P	BI(209, 83)	BR(83, 35)	184.0		0.98 + 0.294	23
P	BI(209, 83)	BR(83, 35)	373.0		1.6 + 0.48	23
P	BI(209, 83)	BR(83, 35)	400.0	0.0		
P	BI(209, 83)	BR(82, 35)	75.0		0.0033 + 0.00099	23
P	BI(209, 83)	BR(82, 35)	77.0	0.0		
P	BI(209, 83)	BR(82, 35)	90.0	0.0		
P	BI(209, 83)	BR(82, 35)	120.0		0.13 + 0.039	23
P	BI(209, 83)	BR(82, 35)	155.0	0.0		
P	BI(209, 83)	BR(82, 35)	184.0		0.76 + 0.228	23
P	BI(209, 83)	BR(82, 35)	373.0		1.5 + 0.45	23
P	BI(209, 83)	BR(82, 35)	400.0	0.0		
P	BI(209, 83)	BR(80, 35)	155.0	0.0		
P	BI(209, 83)	BR(80, 35)	184.0		0.63 + 0.189	23
P	BI(209, 83)	BR(80, 35)	373.0		1.8 + 0.54	23
P	BI(209, 83)	BR(80, 35)	400.0	0.0		
P	BI(209, 83)	AS(77, 33)	75.0		0.074 + 0.0222	23
P	BI(209, 83)	AS(77, 33)	77.0	0.0		
P	BI(209, 83)	AS(77, 33)	90.0	0.0		
P	BI(209, 83)	AS(77, 33)	120.0		0.47 + 0.141	23
P	BI(209, 83)	AS(77, 33)	155.0	0.0		
P	BI(209, 83)	AS(77, 33)	184.0		1.6 + 0.48	23
P	BI(209, 83)	AS(77, 33)	373.0		2.2 + 0.66	23
P	BI(209, 83)	AS(77, 33)	400.0	0.0		
P	BI(209, 83)	AS(76, 33)	90.0	0.0		
P	BI(209, 83)	AS(76, 33)	120.0		0.24 + 0.072	23
P	BI(209, 83)	AS(76, 33)	155.0	0.0		
P	BI(209, 83)	AS(76, 33)	184.0		0.71 + 0.213	23
P	BI(209, 83)	AS(76, 33)	373.0		2.3 + 0.69	23
P	BI(209, 83)	AS(76, 33)	400.0	0.0		
P	BI(209, 83)	AS(74, 33)	75.0		0.008 + 0.0024	23
P	BI(209, 83)	AS(74, 33)	77.0	0.0		
P	BI(209, 83)	AS(74, 33)	90.0	0.0		
P	BI(209, 83)	AS(74, 33)	120.0		0.041 + 0.0123	23
P	BI(209, 83)	AS(74, 33)	155.0	0.0		
P	BI(209, 83)	AS(74, 33)	184.0		0.19 + 0.057	23
P	BI(209, 83)	AS(74, 33)	373.0		0.69 + 0.207	23
P	BI(209, 83)	AS(74, 33)	400.0	0.0		
P	BI(209, 83)	CU(67, 29)	90.0	0.0		
P	BI(209, 83)	CU(67, 29)	120.0		0.038 + 0.0114	23
P	BI(209, 83)	CU(67, 29)	155.0	0.0		
P	BI(209, 83)	CU(67, 29)	184.0		0.12 + 0.036	23
P	BI(209, 83)	CU(67, 29)	373.0		0.41 + 0.123	23
P	BI(209, 83)	CU(67, 29)	400.0	0.0		
P	BI(209, 83)	CU(64, 29)	90.0	0.0		
P	BI(209, 83)	CU(64, 29)	120.0		0.0059 + 0.00177	23
P	BI(209, 83)	CU(64, 29)	155.0	0.0		
P	BI(209, 83)	CU(64, 29)	184.0		0.036 + 0.0108	23
P	BI(209, 83)	CU(64, 29)	373.0		0.11 + 0.033	23
P	BI(209, 83)	CU(64, 29)	400.0	0.0		
P	BI(209, 83)	CU(61, 29)	90.0	0.0		
P	BI(209, 83)	CU(61, 29)	120.0		0.0030 + 0.00090	23
P	BI(209, 83)	CU(61, 29)	155.0	0.0		
P	U(238, 92)	NP(238, 93)	340.0		0.46 + 0.05	23

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	U(238, 92)	NP(238, 93)	350.0	3.94		
P	U(238, 92)	NP(236, 93)	50.0	84.04		
P	U(238, 92)	NP(236, 93)	55.0		5.0 + 1.0	29
P	U(238, 92)	NP(236, 93)	80.0		4.0 + 1.0	29
P	U(238, 92)	NP(236, 93)	100.0	40.97		
P	U(238, 92)	NP(236, 93)	120.0		2.5 + 0.5	29
P	U(238, 92)	NP(236, 93)	150.0	27.58	2.6 + 0.5	29
P	U(238, 92)	NP(236, 93)	340.0		1.7 + 0.1	23
P	U(238, 92)	NP(236, 93)	340.0		12.0	23
P	U(238, 92)	NP(236, 93)	350.0	14.44		
P	U(238, 92)	U(237, 92)	100.0	95.60	93.0	23
P	U(238, 92)	U(237, 92)	150.0	82.07	73.0	23
P	U(238, 92)	U(237, 92)	200.0	80.76	67.5	23
P	U(238, 92)	U(237, 92)	300.0	68.28	81.0	23
P	U(238, 92)	U(237, 92)	340.0		85.0	23
P	U(238, 92)	U(237, 92)	350.0	63.03		
P	U(238, 92)	U(232, 92)	340.0		(4.0)	23
P	U(238, 92)	U(232, 92)	350.0	23.64		
P	U(238, 92)	U(230, 92)	100.0	75.11	0.41 + 0.03	23
P	U(238, 92)	U(230, 92)	150.0	48.59	0.67	23
P	U(238, 92)	U(230, 92)	200.0	38.08	0.41	23
P	U(238, 92)	U(230, 92)	250.0	35.02	0.40	23
P	U(238, 92)	U(230, 92)	300.0	39.39	0.34	23
P	U(238, 92)	U(230, 92)	340.0		0.35 + 1.2	23
P	U(238, 92)	U(230, 92)	350.0	22.32		
P	U(238, 92)	U(229, 92)	100.0	78.79	0.046	23
P	U(238, 92)	U(229, 92)	150.0	51.21	0.11	23
P	U(238, 92)	U(229, 92)	200.0	45.96	0.10	23
P	U(238, 92)	U(229, 92)	250.0	45.52	0.069	23
P	U(238, 92)	U(229, 92)	300.0	30.20	0.056	23
P	U(238, 92)	U(229, 92)	340.0		0.060 + 0.005	23
P	U(238, 92)	U(229, 92)	350.0	35.45		
P	U(238, 92)	U(228, 92)	100.0	70.38	0.012	23
P	U(238, 92)	U(228, 92)	150.0	54.50	0.046	23
P	U(238, 92)	U(228, 92)	200.0	48.59	0.030	23
P	U(238, 92)	U(228, 92)	250.0	34.14	0.037	23
P	U(238, 92)	U(228, 92)	300.0	42.02	0.032	23
P	U(238, 92)	U(228, 92)	340.0		0.038 + 0.002	23
P	U(238, 92)	U(228, 92)	350.0	30.20		
P	U(238, 92)	PA(235, 91)	100.0	7.88	5.7 + 0.5	23
P	U(238, 92)	PA(235, 91)	150.0	8.54		23
P	U(238, 92)	PA(235, 91)	175.0		7.3 + 0.5	23
P	U(238, 92)	PA(235, 91)	250.0	14.01	15.1 + 0.2	23
P	U(238, 92)	PA(235, 91)	340.0		21.0 + 2.0	23
P	U(238, 92)	PA(235, 91)	350.0	2.63		
P	U(238, 92)	PA(232, 91)	340.0		8.7 + 1.0	23
P	U(238, 92)	PA(232, 91)	350.0	9.19		
P	U(238, 92)	PA(230, 91)	100.0	10.51	1.5 + 0.2	23
P	U(238, 92)	PA(230, 91)	150.0	11.16	3.7	23
P	U(238, 92)	PA(230, 91)	190.0		3.6	23
P	U(238, 92)	PA(230, 91)	200.0	13.13		
P	U(238, 92)	PA(230, 91)	250.0	10.51		
P	U(238, 92)	PA(230, 91)	270.0		4.8 + 0.4	23
P	U(238, 92)	PA(230, 91)	340.0		5.1 + 0.5	23
P	U(238, 92)	PA(230, 91)	350.0	10.51		

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	U(238, 92)	PA(228, 91)	340.0		1.7 + 0.2	23
P	U(238, 92)	PA(228, 91)	350.0	15.76		
P	U(238, 92)	PA(227, 91)	100.0	0.0	0.086	23
P	U(238, 92)	PA(227, 91)	150.0	15.10	0.30	23
P	U(238, 92)	PA(227, 91)	200.0	19.04	0.62	23
P	U(238, 92)	PA(227, 91)	250.0	18.38	0.71	23
P	U(238, 92)	PA(227, 91)	300.0	15.76	0.71	23
P	U(238, 92)	PA(227, 91)	340.0		0.71 + 0.06	23
P	U(238, 92)	PA(227, 91)	350.0	23.64		
P	U(238, 92)	TH(234, 90)	100.0	0.0	0.95 + 0.1	23
P	U(238, 92)	TH(234, 90)	150.0	0.66	1.8	23
P	U(238, 92)	TH(234, 90)	190.0		1.1	23
P	U(238, 92)	TH(234, 90)	200.0	0.66		
P	U(238, 92)	TH(234, 90)	300.0	1.31	2.5	23
P	U(238, 92)	TH(234, 90)	340.0		1.8 + 7.0	23
P	U(238, 92)	TH(234, 90)	350.0	1.31		
P	U(238, 92)	TH(231, 90)	100.0	1.05	0.50 + 0.05	23
P	U(238, 92)	TH(231, 90)	150.0	1.31	1.0	23
P	U(238, 92)	TH(231, 90)	190.0		1.1	23
P	U(238, 92)	TH(231, 90)	200.0	0.66		
P	U(238, 92)	TH(231, 90)	250.0	2.63		
P	U(238, 92)	TH(231, 90)	270.0		1.7	23
P	U(238, 92)	TH(231, 90)	340.0		2.4 + 0.1	23
P	U(238, 92)	TH(231, 90)	350.0	0.0		
P	U(238, 92)	TH(228, 90)	100.0	0.0	0.85	23
P	U(238, 92)	TH(228, 90)	150.0	1.97	0.9	23
P	U(238, 92)	TH(228, 90)	190.0		0.95	23
P	U(238, 92)	TH(228, 90)	200.0	1.31		
P	U(238, 92)	TH(228, 90)	340.0		2.9 + 0.9	23
P	U(238, 92)	TH(228, 90)	350.0	5.25		
P	U(238, 92)	TH(227, 90)	100.0	0.0	0.32 + 0.01	23
P	U(238, 92)	TH(227, 90)	150.0	1.31	0.9	23
P	U(238, 92)	TH(227, 90)	190.0		1.3	23
P	U(238, 92)	TH(227, 90)	200.0	2.63		
P	U(238, 92)	TH(227, 90)	250.0	2.63		
P	U(238, 92)	TH(227, 90)	270.0		2.3 + 0.2	23
P	U(238, 92)	TH(227, 90)	340.0		3.3 + 0.4	23
P	U(238, 92)	TH(227, 90)	350.0	3.94		
P	U(238, 92)	TH(226, 90)	340.0		2.7 + 0.2	23
P	U(238, 92)	TH(226, 90)	350.0	1.31		
P	U(238, 92)	AC(228, 89)	340.0		0.62 + 0.08	23
P	U(238, 92)	AC(228, 89)	350.0	1.31		
P	U(238, 92)	AC(226, 89)	100.0	0.0	0.021	23
P	U(238, 92)	AC(226, 89)	150.0	0.0	0.07	23
P	U(238, 92)	AC(226, 89)	190.0		0.24	23
P	U(238, 92)	AC(226, 89)	200.0	0.66		
P	U(238, 92)	AC(226, 89)	250.0	0.0		
P	U(238, 92)	AC(226, 89)	270.0		0.38	23
P	U(238, 92)	AC(226, 89)	340.0		0.54 + 0.09	23
P	U(238, 92)	AC(226, 89)	350.0	0.0		
P	U(238, 92)	AC(225, 89)	100.0	0.0	0.011	23
P	U(238, 92)	AC(225, 89)	150.0	0.0	0.009	23
P	U(238, 92)	AC(225, 89)	190.0		0.26	23
P	U(238, 92)	AC(225, 89)	200.0	0.66		
P	U(238, 92)	AC(225, 89)	250.0	0.0		

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	U(238, 92)	AC(225, 89)	270.0		0.41	23
P	U(238, 92)	AC(225, 89)	340.0		0.62 + 0.13	23
P	U(238, 92)	AC(225, 89)	350.0	1.31		
P	U(238, 92)	AC(224, 89)	340.0		1.05 + 0.05	23
P	U(238, 92)	AC(224, 89)	350.0	0.0		
P	U(238, 92)	RA(228, 88)	340.0		0.043	23
P	U(238, 92)	RA(228, 88)	350.0	0.0		
P	U(238, 92)	RA(225, 88)	340.0		0.26 + 0.02	23
P	U(238, 92)	RA(225, 88)	350.0	0.0		
P	U(238, 92)	RA(224, 88)	100.0	0.0	0.017	23
P	U(238, 92)	RA(224, 88)	150.0	0.0	0.09	23
P	U(238, 92)	RA(224, 88)	200.0	0.0	0.26	23
P	U(238, 92)	RA(224, 88)	250.0	0.0		
P	U(238, 92)	RA(224, 88)	270.0		0.44	23
P	U(238, 92)	RA(224, 88)	340.0		0.58 + 0.18	23
P	U(238, 92)	RA(224, 88)	350.0	0.0		
P	U(238, 92)	RA(224, 88)	340.0		2.8	23
P	U(238, 92)	RA(224, 88)	350.0	0.0		
P	U(238, 92)	RA(223, 88)	340.0		0.48 + 0.11	23
P	U(238, 92)	RA(223, 88)	350.0	0.0		
P	U(238, 92)	AT(210, 85)	200.0	0.0	0.08	23
P	U(238, 92)	AT(210, 85)	340.0		1.2	23
P	U(238, 92)	AT(210, 85)	350.0	0.0		
P	U(238, 92)	PO(210, 84)	200.0	0.0	0.17	23
P	U(238, 92)	PO(210, 84)	340.0		1.7	23
P	U(238, 92)	PO(210, 84)	350.0	0.0		
P	U(238, 92)	BI(210, 83)	200.0	0.0	1.1	23
P	U(238, 92)	BI(210, 83)	340.0		1.6	23
P	U(238, 92)	BI(210, 83)	350.0	0.0		
P	U(238, 92)	OS(193, 76)	340.0		0.01	23
P	U(238, 92)	OS(193, 76)	350.0	0.0		
P	U(238, 92)	YB(166, 70)	340.0		0.7	23
P	U(238, 92)	YB(166, 70)	350.0	0.0		
P	U(238, 92)	HO(166, 67)	340.0		0.05	23
P	U(238, 92)	HO(166, 67)	350.0	0.0		
P	U(238, 92)	DY(166, 66)	340.0		0.4	23
P	U(238, 92)	DY(166, 66)	350.0	0.0		
P	U(238, 92)	TB(164, 65)	150.0	0.0		
P	U(238, 92)	TB(164, 65)	170.0		0.05 + 0.02	23
P	U(238, 92)	TB(163, 65)	150.0	0.0		
P	U(238, 92)	TB(163, 65)	170.0		0.10 + 0.04	23
P	U(238, 92)	TB(161, 65)	150.0	0.0		
P	U(238, 92)	TB(161, 65)	170.0		0.3 + 0.1	23
P	U(238, 92)	TB(160, 65)	150.0	0.0		
P	U(238, 92)	TB(160, 65)	170.0		0.4 + 0.3	23
P	U(238, 92)	GD(159, 64)	150.0	0.0		
P	U(238, 92)	GD(159, 64)	170.0		0.45 + 0.10	23
P	U(238, 92)	EU(157, 63)	50.0	0.0		
P	U(238, 92)	EU(157, 63)	70.0		0.90	23
P	U(238, 92)	EU(157, 63)	100.0	0.0	0.89	23
P	U(238, 92)	EU(157, 63)	150.0	0.0	0.54	23
P	U(238, 92)	EU(157, 63)	170.0		0.50 + 0.08	23
P	U(238, 92)	EU(157, 63)	200.0	0.0	0.46	23
P	U(238, 92)	EU(157, 63)	250.0	0.0	0.47	23
P	U(238, 92)	EU(157, 63)	300.0	0.0	0.42	23

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	U(238, 92)	EU(157, 63)	340.0		0.40	23
P	U(238, 92)	EU(157, 63)	350.0	0.0		
P	U(238, 92)	EU(156, 63)	50.0	0.0		
P	U(238, 92)	EU(156, 63)	70.0		1.22	23
P	U(238, 92)	EU(156, 63)	100.0	0.0	1.31	23
P	U(238, 92)	EU(156, 63)	150.0	0.0	0.93	23
P	U(238, 92)	EU(156, 63)	200.0	0.0	0.86	23
P	U(238, 92)	EU(156, 63)	250.0	0.0	0.92	23
P	U(238, 92)	EU(156, 63)	300.0	0.0	1.12	23
P	U(238, 92)	EU(156, 63)	340.0		2.8	23
P	U(238, 92)	EU(156, 63)	340.0		1.22	23
P	U(238, 92)	EU(156, 63)	350.0	0.0		
P	U(238, 92)	SM(156, 62)	150.0	0.0		
P	U(238, 92)	SM(156, 62)	170.0		0.47 + 0.07	23
P	U(238, 92)	SM(156, 62)	340.0		1.2	23
P	U(238, 92)	SM(156, 62)	350.0	0.0		
P	U(238, 92)	SM(153, 62)	50.0	0.0		
P	U(238, 92)	SM(153, 62)	70.0		4.6	23
P	U(238, 92)	SM(153, 62)	100.0	0.0	4.4	23
P	U(238, 92)	SM(153, 62)	150.0	0.0	3.1	23
P	U(238, 92)	SM(153, 62)	200.0	0.0	2.6	23
P	U(238, 92)	SM(153, 62)	250.0	0.0	2.6	23
P	U(238, 92)	SM(153, 62)	300.0	0.0	2.4	23
P	U(238, 92)	SM(153, 62)	340.0		4.5	23
P	U(238, 92)	SM(153, 62)	340.0		2.0	23
P	U(238, 92)	SM(153, 62)	350.0	0.0		
P	U(238, 92)	PM(151, 61)	150.0	0.0		
P	U(238, 92)	PM(151, 61)	170.0		2.8 + 0.4	23
P	U(238, 92)	PM(150, 61)	150.0	0.0		
P	U(238, 92)	PM(150, 61)	170.0		1.1 + 0.3	23
P	U(238, 92)	PM(149, 61)	150.0	0.0		
P	U(238, 92)	PM(149, 61)	170.0		5.4 + 0.8	23
P	U(238, 92)	ND(149, 60)	150.0	0.0		
P	U(238, 92)	ND(149, 60)	170.0		5.6 + 0.8	23
P	U(238, 92)	ND(147, 60)	50.0	0.0		
P	U(238, 92)	ND(147, 60)	70.0		17.0	23
P	U(238, 92)	ND(147, 60)	100.0	0.0	18.0	23
P	U(238, 92)	ND(147, 60)	150.0	0.0	12.0	23
P	U(238, 92)	ND(147, 60)	200.0	0.0	11.3	23
P	U(238, 92)	ND(147, 60)	250.0	0.0	11.4	23
P	U(238, 92)	ND(147, 60)	300.0	0.0	10.8	23
P	U(238, 92)	ND(147, 60)	340.0		9.7	23
P	U(238, 92)	ND(147, 60)	340.0		33.0	23
P	U(238, 92)	ND(147, 60)	350.0	0.0		
P	U(238, 92)	ND(140, 60)	150.0	0.0	0.7	23
P	U(238, 92)	ND(140, 60)	200.0	0.0	3.4	23
P	U(238, 92)	ND(140, 60)	250.0	0.0	7.1	23
P	U(238, 92)	ND(140, 60)	300.0	0.0	13.0	23
P	U(238, 92)	ND(140, 60)	340.0		17.0	23
P	U(238, 92)	ND(140, 60)	340.0		4.2	23
P	U(238, 92)	ND(140, 60)	350.0	0.0		
P	U(238, 92)	PR(145, 59)	150.0	0.0		
P	U(238, 92)	PR(145, 59)	170.0		12.0 + 2.0	23
P	U(238, 92)	PR(143, 59)	50.0	0.0		
P	U(238, 92)	PR(143, 59)	70.0		0.36	23

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	U(238, 92)	PR(143, 59)	100.0	0.0	2.1	23
P	U(238, 92)	PR(143, 59)	150.0	0.0	2.0	23
P	U(238, 92)	PR(143, 59)	200.0	0.0	1.9	23
P	U(238, 92)	PR(143, 59)	250.0	0.0	2.2	23
P	U(238, 92)	PR(143, 59)	300.0	0.0	2.3	23
P	U(238, 92)	PR(143, 59)	340.0		13.0	23
P	U(238, 92)	PR(143, 59)	340.0		1.9	23
P	U(238, 92)	PR(143, 59)	350.0	0.0		
P	U(238, 92)	PR(142, 59)	150.0	0.0		
P	U(238, 92)	PR(142, 59)	170.0		1.6 + 0.2	23
P	U(238, 92)	PR(142, 59)	340.0		7.8	23
P	U(238, 92)	PR(142, 59)	350.0	0.0		
P	U(238, 92)	CE(144, 58)	50.0	0.0		
P	U(238, 92)	CE(144, 58)	70.0		30.0	23
P	U(238, 92)	CE(144, 58)	100.0	0.0	28.0	23
P	U(238, 92)	CE(144, 58)	150.0	0.0	18.0	23
P	U(238, 92)	CE(144, 58)	200.0	0.0	17.0	23
P	U(238, 92)	CE(144, 58)	340.0		14.0	23
P	U(238, 92)	CE(144, 58)	350.0	0.0		
P	U(238, 92)	CE(143, 58)	50.0	0.0		
P	U(238, 92)	CE(143, 58)	70.0		36.0	23
P	U(238, 92)	CE(143, 58)	100.0	0.0	31.0	23
P	U(238, 92)	CE(143, 58)	150.0	0.0	22.0	23
P	U(238, 92)	CE(143, 58)	200.0	0.0	21.0	23
P	U(238, 92)	CE(143, 58)	250.0	0.0	21.0	23
P	U(238, 92)	CE(143, 58)	300.0	0.0	23.0	23
P	U(238, 92)	CE(143, 58)	340.0		20.0	23
P	U(238, 92)	CE(143, 58)	350.0	0.0		
P	U(238, 92)	CE(141, 58)	50.0	0.0		
P	U(238, 92)	CE(141, 58)	70.0		49.0	23
P	U(238, 92)	CE(141, 58)	100.0	0.0	51.0	23
P	U(238, 92)	CE(141, 58)	150.0	0.0	36.0	23
P	U(238, 92)	CE(141, 58)	200.0	0.0	36.0	23
P	U(238, 92)	CE(141, 58)	340.0		31.0	23
P	U(238, 92)	CE(141, 58)	350.0	0.0		
P	U(238, 92)	LA(141, 57)	150.0	0.0		
P	U(238, 92)	LA(141, 57)	170.0		20.4 + 5.0	23
P	U(238, 92)	LA(140, 57)	50.0	0.0		
P	U(238, 92)	LA(140, 57)	70.0		8.6	23
P	U(238, 92)	LA(140, 57)	100.0	0.0	8.6	23
P	U(238, 92)	LA(140, 57)	150.0	0.0	7.9	23
P	U(238, 92)	LA(140, 57)	200.0	0.0	6.2	23
P	U(238, 92)	LA(140, 57)	250.0	0.0	7.3	23
P	U(238, 92)	LA(140, 57)	300.0	0.0	7.0	23
P	U(238, 92)	LA(140, 57)	340.0		11.0	23
P	U(238, 92)	LA(140, 57)	340.0		5.5	23
P	U(238, 92)	LA(140, 57)	350.0	0.0		
P	U(238, 92)	BA(140, 56)	150.0	0.0		
P	U(238, 92)	BA(140, 56)	170.0		21.0 + 2.0	23
P	U(238, 92)	BA(140, 56)	340.0		23.0	23
P	U(238, 92)	BA(140, 56)	350.0	0.0		
P	U(238, 92)	BA(139, 56)	150.0	0.0		
P	U(238, 92)	BA(139, 56)	170.0		25.0 + 2.0	23
P	U(238, 92)	BA(139, 56)	340.0		43.0	23
P	U(238, 92)	BA(139, 56)	350.0	0.0		

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	U(238, 92)	BA(135, 56)	150.0	0.0		
P	U(238, 92)	BA(135, 56)	170.0		6.8 + 0.9	23
P	U(238, 92)	CS(136, 55)	150.0	0.0		
P	U(238, 92)	CS(136, 55)	170.0		13.0 + 1.0	23
P	U(238, 92)	CS(136, 55)	340.0		5.9	23
P	U(238, 92)	CS(136, 55)	350.0	0.0		
P	U(238, 92)	I(134, 53)	150.0	0.0		
P	U(238, 92)	I(134, 53)	170.0		11.0 + 2.0	23
P	U(238, 92)	I(133, 53)	150.0	0.0		
P	U(238, 92)	I(133, 53)	170.0		18.0 + 2.0	23
P	U(238, 92)	I(132, 53)	150.0	0.0		
P	U(238, 92)	I(132, 53)	170.0		16.0 + 4.0	23
P	U(238, 92)	I(131, 53)	150.0	0.0		
P	U(238, 92)	I(131, 53)	170.0		31.0 + 7.0	23
P	U(238, 92)	I(131, 53)	170.0		24.0 + 2.0	23
P	U(238, 92)	I(130, 53)	150.0	0.0		
P	U(238, 92)	I(130, 53)	170.0		12.7 + 2.0	23
P	U(238, 92)	I(128, 53)	150.0	0.0		
P	U(238, 92)	I(128, 53)	170.0		9.4 + 0.2	23
P	U(238, 92)	I(126, 53)	150.0	0.0		
P	U(238, 92)	I(126, 53)	170.0		5.2 + 0.1	23
P	U(238, 92)	I(124, 53)	150.0	0.0		
P	U(238, 92)	I(124, 53)	170.0		1.1 + 0.2	23
P	U(238, 92)	TE(134, 52)	150.0	0.0		
P	U(238, 92)	TE(134, 52)	170.0		9.0 + 2.0	23
P	U(238, 92)	TE(132, 52)	150.0	0.0		
P	U(238, 92)	TE(132, 52)	170.0		19.0 + 5.0	23
P	U(238, 92)	TE(132, 52)	170.0		9.0 + 0.6	23
P	U(238, 92)	TE(131, 52)	150.0	0.0		
P	U(238, 92)	TE(131, 52)	170.0		3.0 + 1.0	23
P	U(238, 92)	TE(131, 52)	170.0		7.9 + 3.0	23
P	U(238, 92)	TE(131, 52)	340.0		5.9	23
P	U(238, 92)	TE(131, 52)	350.0	0.0		
P	U(238, 92)	SB(131, 51)	150.0	0.0		
P	U(238, 92)	SB(131, 51)	170.0		7.9 + 3.0	23
P	U(238, 92)	SB(127, 51)	150.0	0.0		
P	U(238, 92)	SB(127, 51)	170.0		19.0 + 6.0	23
P	U(238, 92)	SB(124, 51)	150.0	0.0		
P	U(238, 92)	SB(124, 51)	170.0		2.2 + 0.3	23
P	U(238, 92)	CD(115, 48)	340.0		12.0	23
P	U(238, 92)	CD(115, 48)	340.0		34.0	23
P	U(238, 92)	CD(115, 48)	350.0	0.0		
P	U(238, 92)	AG(117, 47)	340.0		48.5	23
P	U(238, 92)	AG(117, 47)	350.0	0.0		
P	U(238, 92)	AG(111, 47)	150.0	0.0		
P	U(238, 92)	AG(111, 47)	170.0		53.0 + 44.0	23
P	U(238, 92)	AG(110, 47)	150.0	0.0		
P	U(238, 92)	AG(110, 47)	170.0		2.0 + 1.0	23
P	U(238, 92)	PD(112, 46)	150.0	0.0		
P	U(238, 92)	PD(112, 46)	170.0		50.0 + 12.0	23
P	U(238, 92)	PD(112, 46)	340.0		5.2	23
P	U(238, 92)	PD(112, 46)	350.0	0.0		
P	U(238, 92)	PD(111, 46)	340.0		39.0	23
P	U(238, 92)	PD(111, 46)	350.0	0.0		
P	U(238, 92)	PD(109, 46)	340.0		4.5	23

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	U(238, 92)	PD(109, 46)	350.0	0.0		
P	U(238, 92)	RU(106, 44)	150.0	0.0		
P	U(238, 92)	RU(106, 44)	170.0		50.0 + 12.0	23
P	U(238, 92)	RU(106, 44)	340.0		52.0	23
P	U(238, 92)	RU(106, 44)	350.0	0.0		
P	U(238, 92)	RU(105, 44)	150.0	0.0		
P	U(238, 92)	RU(105, 44)	170.0		56.0 + 7.0	23
P	U(238, 92)	RU(103, 44)	150.0	0.0		
P	U(238, 92)	RU(103, 44)	170.0		43.0 + 12.0	23
P	U(238, 92)	RU(103, 44)	340.0		42.0	23
P	U(238, 92)	RU(103, 44)	350.0	0.0		
P	U(238, 92)	MO(99, 42)	50.0	0.0		
P	U(238, 92)	MO(99, 42)	70.0		71.0	23
P	U(238, 92)	MO(99, 42)	100.0	0.0	69.0	23
P	U(238, 92)	MO(99, 42)	150.0	0.0	55.0	23
P	U(238, 92)	MO(99, 42)	200.0	0.0	53.0	23
P	U(238, 92)	MO(99, 42)	250.0	0.0	58.0	23
P	U(238, 92)	MO(99, 42)	300.0	0.0	62.0	23
P	U(238, 92)	MO(99, 42)	340.0		59.0	23
P	U(238, 92)	MO(99, 42)	350.0	0.0		
P	U(238, 92)	NB(97, 41)	150.0	0.0		
P	U(238, 92)	NB(97, 41)	170.0		9.0 + 0.9	23
P	U(238, 92)	NB(96, 41)	150.0	0.0		
P	U(238, 92)	NB(96, 41)	170.0		3.8 + 0.2	23
P	U(238, 92)	NB(96, 41)	170.0		2.7 + 0.6	23
P	U(238, 92)	NB(95, 41)	150.0	0.0		
P	U(238, 92)	NB(95, 41)	170.0		0.47 + 0.06	23
P	U(238, 92)	ZR(97, 40)	150.0	0.0		
P	U(238, 92)	ZR(97, 40)	170.0		32.0 + 6.0	23
P	U(238, 92)	ZR(95, 40)	170.0		33.0 + 3.0	23
P	U(238, 92)	Y(93, 39)	100.0	0.0	49.0	23
P	U(238, 92)	Y(93, 39)	150.0	0.0	39.0	23
P	U(238, 92)	Y(93, 39)	200.0	0.0	38.0	23
P	U(238, 92)	Y(93, 39)	250.0	0.0	38.0	23
P	U(238, 92)	Y(93, 39)	300.0	0.0	38.0	23
P	U(238, 92)	Y(93, 39)	340.0		38.0	23
P	U(238, 92)	Y(93, 39)	350.0	0.0		
P	U(238, 92)	Y(92, 39)	150.0	0.0		
P	U(238, 92)	Y(92, 39)	170.0		11.9 + 2.0	23
P	U(238, 92)	Y(91, 39)	50.0	0.0		
P	U(238, 92)	Y(91, 39)	70.0		27.0	23
P	U(238, 92)	Y(91, 39)	100.0	0.0	30.0	23
P	U(238, 92)	Y(91, 39)	150.0	0.0	27.0	23
P	U(238, 92)	Y(91, 39)	200.0	0.0	26.0	23
P	U(238, 92)	Y(91, 39)	200.0	0.0	3.7	23
P	U(238, 92)	Y(91, 39)	250.0	0.0	37.0	23
P	U(238, 92)	Y(91, 39)	300.0	0.0	37.0	23
P	U(238, 92)	Y(91, 39)	340.0		32.0	23
P	U(238, 92)	Y(91, 39)	350.0	0.0		
P	U(238, 92)	Y(90, 39)	50.0	0.0		
P	U(238, 92)	Y(90, 39)	70.0		0.02	23
P	U(238, 92)	Y(90, 39)	100.0	0.0	0.11	23
P	U(238, 92)	Y(90, 39)	150.0	0.0	0.15	23
P	U(238, 92)	Y(90, 39)	250.0	0.0	3.8	23
P	U(238, 92)	Y(90, 39)	300.0	0.0	3.9	23

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	U(238, 92)	Y(90, 39)	340.0		7.2	23
P	U(238, 92)	Y(90, 39)	350.0	0.0		
P	U(238, 92)	SR(92, 38)	150.0	0.0		
P	U(238, 92)	SR(92, 38)	170.0		6.2	23
P	U(238, 92)	SR(92, 38)	340.0		40.0	23
P	U(238, 92)	SR(92, 38)	350.0	0.0		
P	U(238, 92)	SR(91, 38)	150.0	0.0		
P	U(238, 92)	SR(91, 38)	170.0		35.0 + 4.0	23
P	U(238, 92)	SR(91, 38)	340.0		38.0	23
P	U(238, 92)	SR(91, 38)	350.0	0.0		
P	U(238, 92)	SR(90, 38)	150.0	0.0		
P	U(238, 92)	SR(90, 38)	170.0		31.0 + 2.0	23
P	U(238, 92)	SR(90, 38)	170.0		23.0 + 1.0	23
P	U(238, 92)	SR(89, 38)	150.0	0.0		
P	U(238, 92)	SR(89, 38)	170.0		31.0 + 2.0	23
P	U(238, 92)	SR(89, 38)	340.0		35.0	23
P	U(238, 92)	SR(89, 38)	350.0	0.0		
P	U(238, 92)	BR(86, 37)	150.0	0.0		
P	U(238, 92)	BR(86, 37)	170.0		2.3 + 0.2	23
P	U(238, 92)	RB(86, 37)	340.0		13.8	23
P	U(238, 92)	RB(86, 37)	350.0	0.0		
P	U(238, 92)	BR(84, 35)	340.0		3.3	23
P	U(238, 92)	BR(84, 35)	350.0	0.0		
P	U(238, 92)	BR(83, 35)	150.0	0.0		
P	U(238, 92)	BR(83, 35)	170.0		5.0 + 0.9	23
P	U(238, 92)	BR(83, 35)	170.0		0.77 + 1.2	23
P	U(238, 92)	BR(83, 35)	340.0		3.8	23
P	U(238, 92)	BR(83, 35)	350.0	0.0		
P	U(238, 92)	BR(82, 35)	340.0		1.57	23
P	U(238, 92)	BR(82, 35)	350.0	0.0		
P	U(238, 92)	BR(80, 35)	340.0		0.35	23
P	U(238, 92)	BR(80, 35)	350.0	0.0		
P	U(238, 92)	SE(83, 34)	340.0		5.1	23
P	U(238, 92)	SE(83, 34)	350.0	0.0		
P	U(238, 92)	SE(81, 34)	340.0		7.5	23
P	U(238, 92)	SE(81, 34)	350.0	0.0		
P	U(238, 92)	AS(78, 33)	150.0	0.0		
P	U(238, 92)	AS(78, 33)	170.0		2.5 + 1.0	23
P	U(238, 92)	AS(77, 33)	150.0	0.0		
P	U(238, 92)	AS(77, 33)	170.0		5.2 + 0.6	23
P	U(238, 92)	AS(77, 33)	170.0		4.5 + 0.6	23
P	U(238, 92)	AS(76, 33)	150.0	0.0		
P	U(238, 92)	AS(76, 33)	170.0		0.6 + 0.2	23
P	U(238, 92)	AS(76, 33)	170.0		0.96 + 0.16	23
P	U(238, 92)	AS(76, 33)	340.0		0.21	23
P	U(238, 92)	AS(76, 33)	350.0	0.0		
P	U(238, 92)	AS(74, 33)	150.0	0.0		
P	U(238, 92)	AS(74, 33)	170.0		0.034 + 0.004	23
P	U(238, 92)	GE(78, 32)	150.0	0.0		
P	U(238, 92)	GE(78, 32)	170.0		6.7 + 2.7	23
P	U(238, 92)	GE(77, 32)	150.0	0.0		
P	U(238, 92)	GE(77, 32)	170.0		2.9 + 0.4	23
P	U(238, 92)	GE(73, 32)	150.0	0.0		
P	U(238, 92)	GE(73, 32)	170.0		1.95 + 0.12	23
P	U(238, 92)	GA(72, 32)	150.0	0.0		

INC. PART	TARGET NUCLEUS	RESIDUAL NUCLEUS	ENERGY (MEV)	SIGMA (MB) CALCULATED	SIGMA (MB) EXPERIMENT	REF
P	U(238, 92)	GA(72, 32)	170.0		0.53 + 0.06	23
P	U(238, 92)	ZN(72, 30)	340.0		2.1	23
P	U(238, 92)	ZN(72, 30)	350.0	0.0		
P	U(238, 92)	CU(67, 29)	150.0	0.0		
P	U(238, 92)	CU(67, 29)	170.0		0.96 + 0.16	23
P	U(238, 92)	CU(67, 29)	340.0		2.1	23
P	U(238, 92)	CU(67, 29)	350.0	0.0		
P	U(238, 92)	CU(64, 29)	150.0	0.0		
P	U(238, 92)	CU(64, 29)	170.0		0.026 + 0.002	23
P	U(238, 92)	NI(66, 28)	150.0	0.0		
P	U(238, 92)	NI(66, 28)	170.0		0.87 + 0.06	23
P	U(238, 92)	NI(66, 28)	340.0		0.63	23
P	U(238, 92)	NI(66, 28)	350.0	0.0		
P	U(238, 92)	NI(65, 28)	150.0	0.0		
P	U(238, 92)	NI(65, 28)	170.0		0.80 + 0.03	23
P	U(238, 92)	NI(65, 28)	340.0		0.56	23
P	U(238, 92)	NI(65, 28)	350.0	0.0		
P	U(238, 92)	FE(59, 26)	340.0		0.18	23
P	U(238, 92)	FE(59, 26)	350.0	0.0		
P	U(238, 92)	NA(24, 11)	340.0		0.05	23
P	U(238, 92)	NA(24, 11)	350.0	0.0		
N	AL(27, 13)	MG(27, 12)	350.0	3.3 (3.3)		
N	AL(27, 13)	MG(27, 12)	370.0		5.1 + 2.0	6
N	AL(27, 13)	NA(24, 11)	350.0	3.50 (12.3)		
N	AL(27, 13)	NA(24, 11)	370.0		24.4	6
N	AL(27, 13)	F(18, 9)	350.0	0.62 (4.7)		
N	AL(27, 13)	F(18, 9)	370.0		6.8 + 2.4	6
N	AL(27, 13)	N(13, 7)	350.0	0.21 (1.0)		
N	AL(27, 13)	N(13, 7)	370.0		3.2 + 2.4	6
N	AL(27, 13)	C(11, 6)	350.0	0.41 (0.0)		
N	AL(27, 13)	C(11, 6)	370.0		(3.4)	6
N	PB(206, 82)	PB(204, 82)	24.0		325.0	30
N	PB(206, 82)	PB(204, 82)	25.0	1401.89		
PI -	C(12, 6)	C(11, 6)	50.0	16.8 + 1.9		
PI -	C(12, 6)	C(11, 6)	53.0		1.0 + 1.0	31
PI -	C(12, 6)	C(11, 6)	80.0		38.0 + 4.0	31
PI -	C(12, 6)	C(11, 6)	100.0	57.08 + 3.6		
PI -	C(12, 6)	C(11, 6)	127.0		59.0 + 5.0	31
PI -	C(12, 6)	C(11, 6)	150.0	84.25 + 5.1		
PI -	C(12, 6)	C(11, 6)	179.0		68.0 + 6.0	31
PI -	C(12, 6)	C(11, 6)	200.0	72.0 + 4.7		
PI -	C(12, 6)	C(11, 6)	212.0		67.0 + 6.0	31
PI -	C(12, 6)	C(11, 6)	245.0		61.0 + 6.0	31
PI -	C(12, 6)	C(11, 6)	250.0	50.33 + 4.4		
PI -	C(12, 6)	C(11, 6)	300.0	45.30 + 4.2		
PI -	C(12, 6)	C(11, 6)	304.0		41.0 + 4.0	31

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