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# Possible Complementary Cosmic-Ray Systems: Nuclei and Antinuclei

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## Contents

## Introduction

The nuclear force has been the subject of a tremendous research effort for most of this century. So much progress has been made that researchers are now examining the quark content and their effects in both many-body and in two-body nucleon-nucleon ($NN$) interactions. Paralleling this research, but on a different tack, are studies of the nucleon-antinucleon ($N\bar{N}$) interaction and studies of the nuclear force involving the antinucleon. The aim of this paper is to continue to combine (and add to) all that we know about the nuclear force with what we know about cosmic-ray bombardment of a space vehicle. Earlier work has led the way and it is because of this pioneering effort (ref. 1) that we are able to present this study of possible antinuclei in cosmic rays. All studies indicate that antinuclear interactions with matter are more absorptive than their normal nuclear counterparts (ref. 2). If a significant abundance of antinuclei are found in the cosmic-ray spectrum, then shielding against them will be necessary. Even though many antiprotons and one antitriton have been observed in the cosmic-ray spectrum, it is highly speculative to assume that heavier antinuclei exist. On the other hand, these experiments were performed within the protection of Earth's atmosphere on balloon flights and may not reflect the actual abundance in space. The theoretical understanding of the nuclear force is rather advanced if we think in terms of nucleons and pions. By treating the $NN$ and $N\bar{N}$ systems as complementary, as we do in this work, one sees the possibility for the existence of heavier antinuclei. Indeed, we can make predictions. To practice more precision, one would also like to include quarks in our theory of complementarity; however, this is beyond the scope of the present work. Our motivation for the present work is based on the degree of clarity and success that the meson exchange framework provides for the $NN$ interaction.

This paper is divided into five main sections. The first section contains a brief discussion on the meson exchange framework of the $NN$ interaction. The second contains a brief discussion on the existing meson exchange description of the $N\bar{N}$ interaction. In the third section, we discuss the nucleus-nucleus interaction sometimes referred to as heavy ion scattering. The fourth section contains discussion of the little understood antinucleus-nucleus interaction. It is also in this section that we present new cross-section results and interpret them in terms of lengthy space missions. In the next section we briefly touch upon radiation damage to living tissue inflicted by a nucleus or antinucleus. The reader who is not interested in the details of the background information and theoretical justifications found in the next three sections is encouraged to go directly to the section entitled "The Antinucleus-Nucleus Interaction." Within the conclusion, we strongly urge that cosmic-ray experiments be undertaken to search for antinuclei of all $Z$ and that these experiments be conducted as far away from the Earth's protective atmosphere and magnetosphere as possible. We also suggest that production rates for antideuterons and antitritons be determined in laboratory accelerator experiments.

## The $NN$ Interaction

In this section we provide an overview of the theoretical situation of the $NN$ interaction. We also, of course, consider experimental findings. This section and the next two sections serve as background material for our arguments on the antinucleus-nucleus model presented in this paper.

In the meson theory of the nuclear force, the pion is said to be the mediator and one thinks of a bare nucleon surrounded by a cloud of pions. A dynamical model of two nucleons interacting with each other via their meson clouds has, thus, been developed. The scenario is straightforward. At large distances the two nucleons interact by the exchange of a single pion—the one-pion exchange process. This is illustrated in figure 1(a). As the spatial separation between nucleons decreases, they exchange more pions. This thinking leads to two-pion exchanges, three-pion exchanges, etc., as illustrated in figures 1(b) and 1(c). The reader must beware that vertex contributions such as is shown in figure 2 are, in general, not explicitly calculated but rather included in the interpretation of the nucleon structure function. We will return to this point later.

Within this scenario, a connection between the number of meson exchanges and the nucleons' separation distance emerges naturally. Furthermore, by considering the diagrams of figures 1 and 2 as Feynman diagrams, one can cast this scenario into a potential model framework (ref. 3).

This is a common sense picture, in principle. However, there are some serious difficulties to deal with in practice. For example, when one constructs a total $NN$ potential from the sum of meson exchanges, the series does not converge as the relative separation $r$ goes to zero because the $\pi NN$ coupling constant is determined to be about 14. Another difficulty which arises is in the calculation of exchanges other than one pion; they are technically difficult and particularly challenging when the exchanged pions interact with each other while in flight (ref. 3). These diagrams are commonly referred to as "correlated graphs" and are shown in figure 3.

The reader must not be misled into thinking that these difficulties cannot be overcome because they most certainly can be. The most sophisticated and well known is the Paris potential (ref. 4). Less sophisticated one-boson exchange potentials (OBEP) are very tractable in obtaining solutions and uncovering the essential dynamics. In configuration space, a typical OBEP can be written

$$V_{\rm tot}(r) = V_\pi(r) + V_\sigma(r) + V_\rho(r) + V_\omega(r) \qquad (1)$$

$$\left.\begin{aligned} V_\pi &= \tau_1\tau_2\left(\sigma_1\sigma_2 V_\sigma^\pi + S_{12}V_T^\pi\right) \\ V_\sigma &= -\left(V_o^\sigma + \mathbf{L}\cdot\mathbf{S}V_{LS}^\sigma + Q_{12}V_{LS2}^\sigma\right) \\ V_\rho &= \tau_1\tau_2\left(V_o^\rho + \sigma_1\sigma_2 V_\sigma^\rho - S_{12}V_T^\rho - \mathbf{L}\cdot\mathbf{S}V_{LS}^\rho + Q_{12}V_{LS2}^\rho\right) \\ V_\omega &= V_o^\omega + \sigma_1\sigma_2 V_\sigma^\omega - S_{12}V_T^\omega - \mathbf{L}\cdot\mathbf{S}V_{LS}^\omega + Q_{12}V_{LS2}^\omega \end{aligned}\right\} \qquad (2)$$

and where

$$\left.\begin{aligned} V_o^{\rho,\omega} &= G\left[(1+\beta k)^2 + \frac{\beta}{2}\right]F_o(x) \\ V_o^\sigma &= G\left(1-\frac{\beta}{2}\right)F_o(x) \\ V_\sigma^{\rho,\omega} &= 2\beta G\left[(1+k)^2 + \frac{\beta k^2}{2}\right]\frac{F_o(x)}{3} \\ V_\sigma^\pi &= \beta G\frac{F_o(x)}{3} \\ V_T^{\rho,\omega} &= \beta G\left[(1+k) + \frac{\beta k^2}{2}\right]\frac{F_T(x)}{3} \\ V_T^\pi &= \beta G\frac{F_T(x)}{3} \\ V_{LS}^{\rho,\omega} &= 6\beta G\left(1+\frac{4k}{3}+\beta k^2\right)F_{LS}(x) \\ V_{LS}^\sigma &= 2\beta G F_{LS}(x) \\ V_{LS2}^{\rho,\omega} &= \beta^2 G\left(1+8k+8k^2\right)F_{LS2}(x) \\ V_{LS2}^\sigma &= \beta^2 G F_{LS2}(x) \end{aligned}\right\} \qquad (3a)$$

with

$$\left.\begin{aligned} G &= \mu\frac{g^2}{4\pi} \quad \beta = \frac{\mu}{2M} \\ k &= \frac{f}{g} \quad x = \mu r \\ F_o(x) &= \frac{e^{-x}}{x} \\ F_{LS}(x) &= F_o(x)\left(\frac{1}{x}+\frac{1}{x^2}\right) \\ F_T(x) &= F_o(x)\left(1+\frac{3}{x}+\frac{3}{x^2}\right) \\ F_{LS2}(x) &= \frac{F_T(x)}{x^2} \end{aligned}\right\} \qquad (3b)$$

Equation (1) is a phenomenological representation of the exact pion graphs of figures 1 through 3. By this we mean that the two-pion exchange graphs are represented by $V_\sigma$ and $V_\rho$ which are the potentials due to a single "fictitious $\sigma$-meson" exchange and a single $\rho$-meson exchange, respectively. Other meson exchanges such as $\eta$ and $\delta$ are often added to give better agreement with empirically determined $NN$ phase shifts. For the three-pion exchange, all graphs are represented by the exchange of a single $\omega$-meson; occasionally the exchange of an $A_1$-meson is added in, for example. The number and type of mesons included in OBEP's depend quite sensitively on the theoretical framework and the amount of freedom one allows for parameter determination. In any case, the four mesons appearing in equation (1) are universally accepted as minimum ingredients. The "fictitious $\sigma$" is fictitious because it has the quantum numbers of the $\epsilon$ meson ($J^{\pi c} = 0^{++}$) but with a variable mass typically far lower than the $\epsilon$ mass. Such a particle has never been observed but is responsible for the $NN$ intermediate range attraction. This phenomenological $\sigma$-particle represents the two-pion exchange when the two pions are in a relative $J = 0$ state. The $\rho$-meson represents the two pions when they are in a relative $J = 1$ state. Many arguments suggest that the dominant three-pion contribution comes from the three pions in a relative $J = 1$ state; hence the $\omega$-meson (refs. 3 and 4). Much of the repulsive core is attributed to the $\omega$-meson exchange.

Even though our experience in fitting $\pi\pi$ phase shifts, $NN$ phase shifts and deuteron data suggest certain limits on the values of OBE coupling constants and masses—one still has freedom of choice. Thus, the coupling constants and masses of the OBE, save OPEP (one-pion exchange potential), are parameters of the theory. By employing dispersion theoretical techniques, the more sophisticated Paris potential group is able to calculate $J = 0$ and 1 two-pion contributions without the use of explicit $\sigma$- and $\rho$-potentials as found in equation (1) (ref. 4).

Form factors or structure functions must be included; otherwise singularities appear in $V(r)$ as $r \to 0$. The physical interpretation of this form factor is that the nucleon is not pointlike. This has been well-known for years. One such analytic form for this structure function is

$$f(\Lambda) = \frac{\Lambda^2 - \mu^2}{\Lambda^2 - t} \qquad (4)$$

where $\mu$ is the mass of the exchanged boson, $t$ is the 4-momentum transfer squared, and $\Lambda$ is an adjustable form factor mass. One multiplies $f(\Lambda)$ times the corresponding Feynman diagram and then transforms the entire expression into position space. Equation (1) represents the potential without form factors and for the purposes of discussion for the present work, equation (1) is all that is needed.

Figure 4 illustrates the role that the four mesons of equation (1) play in, say, the deuteron's channel. The deuteron is the only bound state of the $NN$ system.

All in all there are many demonstrations showing how very well the meson exchange theory works for the $NN$ interaction and for many-body interactions. Reference 4 is a nonrelativistic theory. For a relativistic $NN$ theory, see references 5 and 6.

## The $N\bar{N}$ Interaction

In the previous section, a rather broad overview of meson exchange theory for the $NN$ interaction was given. In this section, we apply that overview to the elastic part of the $N\bar{N}$ interaction and make comparisons with the $NN$ interaction. We also address the large, yet not so well-understood, inelastic $N\bar{N}$ interaction.

Once again we begin with meson exchange theory; and, in analogy with the charge conjugation operation which takes electron-electron scattering to electron-position scattering, we obtain an elastic $N\bar{N}$ potential by $G$-parity transforming the $NN$ potential (ref. 7). Put quite simply, the $G$-parity transformation changes the sign of $NN$ potentials which arise from an odd number of pions being exchanged. Thus, in the model of equation (1), only $V_\pi$ and $V_\omega$ change overall signs:

$$V_{\text{tot}}(r) = -V_\pi(r) + V_\sigma(r) + V_\rho(r) - V_\omega(r) \qquad (5)$$

This means, for example, that the repulsive core attributed to the $\omega$-meson in figure 4 is now deeply attractive as illustrated in figure 5. This gives a quantitative justification for the strong attraction observed between an antinucleon and a nucleon. One can make comparative arguments of the $NN$ and $N\bar{N}$ systems for any isospin, spin, and angular momentum channel (partial wave) simply by using equations (1), (2), and (5). The beauty of this procedure lies in the determination of which component(s) of the potential, either $NN$ or $N\bar{N}$, dominate the interaction for a given partial wave and at a given distance. This means that one can discuss coherences and supercoherences of spin-spin, spin-orbit, tensor, and quadratic spin-orbit forces in various partial wave channels of the $NN$ and $N\bar{N}$ interactions. A clear description of this model-independent study has been put forth by Buck, Dover, and Richard (ref. 7) and more recently by Dover (ref. 8).

In no way should one believe that the arguments presented above fully describe the $N\bar{N}$ interaction. Certainly the long range and perhaps the intermediate range can be treated as we have, but unlike the $NN$ interaction, the annihilation is very strong for $N\bar{N}$ even at low energies (see figs. 6 and 7) or, equivalently, for relative separations of $r < 1$ fm. It is this strong annihilation in the $N\bar{N}$ interaction which has no apparent counterpart in the $NN$ system through meson exchange theory.[1] It is speculated that the solution of interpreting the $NN$ and $N\bar{N}$ systems as purely complementary, or at least treating them on the same footing, can be found in the physics of quarks. As stated above, these ideas about quarks are beyond the scope of the present work; however, we can state that there is much discussion within the physics community focused on the $NN$ interaction as six quarks and the $N\bar{N}$ interaction as being three quarks and three antiquarks and/or as two quarks and two antiquarks (ref. 9). The number of quark-antiquark pairs in the $N\bar{N}$ system may be a function of energy. At any rate, the state of the art at this writing is to add an imaginary partial wave dependent potential (in nuclear physics it is more generally known as "velocity dependence") to the G-parity transformed $NN$ potential to explain the very strong $N\bar{N}$ absorption:

$$W(r) = \left\{ g_c\,(1 + f_c T_L) + g_{ss}\,(1 + f_{ss} T_L)\,\sigma_1\sigma_2 + g_T S_{12} + \frac{g_{LS}}{4M^2}\mathbf{L}\cdot\mathbf{S}\frac{1}{r}\frac{d}{dr} \right\} \frac{K_o(2Mr)}{r} \qquad (6)$$

where $g_c$, $g_{ss}$, $g_T$, $g_L$, $f_c$, and $f_{ss}$ are parameters and $K_o$ is a modified Bessel function, $T_L$ is the lab energy (refs. 10 and 11). Thus, the full complex potential used to describe the $N\bar{N}$ system is

$$V(r) = V_{\text{tot}}(r) - iW(r) \qquad (7)$$

The number of adjustable parameters can obviously be adversely commented on; however, we have yet to devise a better scheme. We will, therefore, hold back any further comments on the form of equation (7) and accept the fact, for the moment, that it produces very good cross-section results.

Our motivations for discussing the $NN$ and $N\bar{N}$ interactions in a unified way is propelled by our notion of the symmetry of nuclear forces. As will be shown in the subsequent sections of this paper, we apply and test this notion of symmetry to many-body interactions, in particular, heavy ion reaction. However, before pressing on to the next section, we would like to comment that no matter how one theoretically treats the $NN$ and $N\bar{N}$ systems, the experimental results speak for themselves. Figures 6

[1] Note that because the $N\bar{N}$ system has net baryon number equal to zero, there is no Pauli principle (see ref. 7).

and 7 illustrate the cross-section data for $PP$ and $P\bar{P}$, respectively. Since

$$\sigma_{\text{in}} = \sigma_{\text{tot}} - \sigma_{\text{cl}} \tag{8}$$

one observes that $P\bar{P}$ has a much larger inelastic channel than does $PP$ for the energies shown. We use these cross-section data and non-meson theory in the next two sections to obtain theoretical results. We have focused on meson theory in this section and the previous section in order to help guide our thinking for the many-body problem. For many researchers, meson theory has been very useful in the understanding of many-body systems since for many calculations of nuclear matter, for example, a two-body $NN$ potential is employed (refs. 12 and 13).

## The Nucleus-Nucleus Interaction

It is in this section that ion-ion scattering is addressed. The two-body $NN$ interaction does not enter into our heavy ion formalism in the form of a potential but rather in the form of $NN$ cross-sectional data. The advantages of using the $NN$ data are that (1) theoretical uncertainties of various $NN$ models are minimized and (2) we can obtain the degree of accuracy and predictive powers required for discussions of biological systems as is pointed out in the section on radiation damage. The main disadvantage in this approach is the inability to describe spin dependences adequately, thereby softening our accuracy and predictive powers (e.g., differential cross section). Yet, as we show, the accuracy which we obtain for nucleus-nucleus total and absorptive cross sections is remarkably good compared with empirical data.

The theoretical development has been extensively reported elsewhere. In a recent NASA Reference Publication (ref. 1) tables of nuclear cross sections for galactic cosmic rays are calculated and the optical model employed is outlined. For the purpose of consolidation, we briefly describe the model here.

The heart of the calculation is the constituent-averaged energy-dependent two-body $NN$ transition amplitude

$$\tilde{t}(e,\mathbf{y}) = \left(\frac{e}{M}\right)^{1/2} \sigma(e)[\alpha(e)+i][2\pi B(e)]^{-3/2} \exp\left[\frac{-y^2}{2B(e)}\right] \tag{9}$$

where $\sigma(e)$ is the empirical $NN$ total cross as a function of the center-of-mass kinetic energy $e$; $\alpha(e)$ is the ratio of elastic to inelastic empirical cross sections; $B(e)$ is the experimentally determined energy-dependent slope parameter; and $\mathbf{y}$ is the relative position vector of the $NN$ system. One of the end results is the calculation of the ion-ion absorptive cross section which is given in the Eikonal approximation by

$$\sigma_{\text{abs}} = 2\pi \int_0^\infty \{1 - \exp[-2\text{Im}\chi(\mathbf{b})]\}\, b\, db \tag{10}$$

where

$$\chi(\mathbf{b}) = -\frac{1}{2k}\int_{-\infty}^{\infty} dz \left\{ \frac{2MA_P^2A_T^2}{A_P + A_T} \times \int d^3\xi_T \rho_T(\xi_T) \int d^3y \rho_P(\mathbf{b}+\mathbf{z}+\mathbf{y}+\xi_T) \times \tilde{t}(e,\mathbf{y})[1-\tilde{C}(\mathbf{y})] \right\} \tag{11}$$

The $A_P$ and $A_T$ are projectile and target atomic masses, respectively. The $\rho_T$ and $\rho_P$ are the target and projectile nuclear densities, respectively, and $\xi_T$ is a collection of constituent relative coordinates for the target nucleus. Further, $\mathbf{b}$ is the impact parameter, $\mathbf{z}$ is the position vector of the projectile in the beam direction, $\tilde{C}$ is a correlation function which takes into account the Pauli principle and $k$ is the projectile momentum. Once an adequate correlation function and the nuclear densities have been determined, one need only call upon empirical $NN$ cross-sectional data to calculate $\sigma_{\text{abs}}$. As is stated in reference 1, agreement with empirical nucleon-nucleus, deuteron-nucleus and nucleus-nucleus absorptive cross sections is obtained to within 3 percent for energies between 80 MeV/nucleon and 22.5 GeV/nucleon. Heavy and light nuclei in this energy range have been detected in the cosmic-ray spectrum.

## The Antinucleus-Nucleus Interaction

We now come to the main results of this paper which have been reported, in part, elsewhere (ref. 14).[2] The thrust of this section is to fold nucleus-nucleus scattering together with antinucleus-nucleus scattering in a parallel way as $NN$ and $N\bar{N}$ are done. In short, we introduce a technique to formulate heavy ion physics with antinucleons and calculate cross sections.

We are motivated by the strong absorption found in the $N\bar{N}$ interaction and we want to study effects of many $N\bar{N}$ pairs annihilating in matter. We are also motivated by the obvious symmetry displayed in the two-body transition amplitude of equation (9). By replacing the $NN$ empirical cross sections and the slope parameter with the corresponding $N\bar{N}$ quantities, antinucleus-nucleus cross sections can be

[2] Note that refs. 1 and 14 are nonrelativistic formulations.

calculated, provided that an appropriate non-Pauli blocking correlation function is inserted. In these first antinucleus-nucleus calculations we take $\tilde{C} = 0$ and change the overall sign of the projectile antinuclear charge density. Of course, antiprotons are readily produced in the lab at CERN and Brookhaven and are seen in the cosmic-ray spectrum (ref. 15). Because of the large $P\bar{P}$ annihilation, absorptive $\bar{P}$-nucleus cross sections are expected to be larger than $P$-nucleus absorptive cross sections. Indeed, we find this to be true (see figs. 8 and 9). What about heavier antinuclei? Well, recently antideuterons have been produced in the lab at DESY (ref. 16) and a single antitriton event was reported in a cosmic-ray balloon experiment (ref. 17). The existence of these small antinulei are encouraging from the standpoint of our theoretical framework presented in this paper. However, there are those who would say that the existence of large quantities of antinuclei is not possible. This point we prefer not to argue with, but rather take the stand that until very recently all of our cosmic-ray data have come from balloon experiments within the atmosphere. Obviously, our atmosphere is a major protective shield against cosmic rays, meteors, etc., and cosmic antinuclei, if they exist, would not be able to travel very deep into our atmosphere before being absorbed. Thus, it would not be surprising to find that the abundances of antinuclei would change at distances further away from Earth's surface. There will be more discussion on this subject in the next section.

Our goal in this section is merely to outline calculations of heavy ion cross sections involving antinuclei as projectiles. The only data that we have to compare with our theoretical results come from $\bar{P} - {}^{12}\mathrm{C}$, $\bar{P} - \mathrm{A}\ell$, $\bar{P} - \mathrm{Cu}$, and $\bar{P} - \mathrm{Pb}$ (refs. 18 to 20). Illustrated in figures 8 and 9 are our $\sigma_{\mathrm{abs}}$ predictions along with the experimental $\bar{P}$ data. The reader can very quickly verify that agreement is well within 15 percent. Theoretical predictions for energies higher than 400 MeV/nucleon can be found in table 1. Antideuteron and other antinucleus-nucleus cross sections (total and absorptive) can be found in tables 1 through 26. In each case we have employed the $N\bar{N}$ cross-sectional data and slope parameter (see figs. 7 and 10). We have assumed no Pauli principle in the $N\bar{N}$ interaction, and since we have not incorporated correlations (i.e., $\tilde{C} = 0$), our results are not exact. The reader is reminded, once again, that the only cross-section data that we are aware of is for $\bar{P}$-nucleus scattering.

## Radiation Damage

Why do we need to study nuclear physics with $\bar{P}$, $\bar{d}$, and other antinuclei? The answer is simple: because of the strong absorption, the antinuclei deposit larger amounts of nuclear energy in a volume of matter than do their nuclei counterparts. This is clear from $\bar{P}$-nucleus and $P$-nucleus studies; one need only look at the relative sizes of the cross sections. From this, we speculate that antinuclei are potentially much more destructive to living tissue than their normal ion partners.

The production of antiprotons in the lab (e.g., CERN, Fermilab, and Brookhaven) has become quite commonplace. Beams made of antiprotons are easily constructed and utilized in scattering experiments. Numerous antiprotons have been detected in the cosmic-ray spectrum through experiments flown on atmospheric balloons. Reports on $\bar{d}$ and $\bar{t}$ production in the lab have been published (refs. 21 to 24), but no beams have yet been generated. There has only been one $\bar{t}$ event observed in the cosmic-ray spectrum (ref. 17) and we are not aware of anti-alpha particles being found in cosmic rays; a reason for this may be that there has not yet been a serious effort to look for antinuclei of $Z > 1$. However, manned space flights to various locations outside of Earth's protective atmosphere and magnetosphere (and Mars' atmosphere, for that matter) generate the need to know how to shield from cosmic antiprotons and other cosmic antinuclei. We recognize that presently all abundance measurements and calculations for antinuclei are orders of magnitude smaller than their nuclei counterparts. For example, the cosmic $\bar{P}$ to $P$ abundance ratio is on the order of $10^{-4}$, while higher $Z$ abundances may be far less.

Cosmic antinuclei when compared with cosmic nuclei have the possibility of depositing substantially larger amounts of energy into living tissue by way of microlesions. The only calculation involving antinuclei which we are aware of employs an ion transport theory that calculates the linear energy transport (LET) of annihilation products from an antiproton annihilation event in living tissue (refs. 25 to 27). Figure 11 illustrates the LET spectrum of annihilation products for two nuclear temperatures.

## Conclusion

We have presented a broad overview of strong interaction physics with nucleons and antinucleons. In particular, we have focused on the nucleon-nucleon, nucleon-antinucleon, nucleus-nucleus, and nucleus-antinucleus interactions and their interrelationships. We showed how to obtain a nucleon-antinucleon potential from the meson exchange description of the nucleon-nucleon potential and we showed how to obtain nucleus-antinucleus cross sections from a theoretical heavy ion optical model. For the first time, theoretical absorptive and total cross sections for

antinucleus-nucleus scattering have been presented for antinuclei having charge $|Z| > 1$ and mass number $A > 2$. Biological effects, as in the formation of microlesions, were very briefly discussed and our concern about adequate shielding of astronauts from cosmic rays (particularly very energetic heavy nuclei or heavy antinuclei) during deep and lengthy space flights has been expressed. The existence of antinuclei with $A > 3$ has not yet been established. We, therefore, strongly urge that a space-based experiment (not a balloon flight) to gather data on cosmic antinuclei be undertaken.

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## Symbols

| | |
|---|---|
| $A_P, A_T$ | atomic mass number of projectile or target |
| $B(e)$ | slope parameter, fm$^2$ |
| $\mathbf{b}$ | impact parameter vector, fm |
| $\tilde{C}$ | correlation function |
| $c$ | charge conjugation; also speed of light |
| $\bar{d}$ | symbol for antideuteron |
| $e$ | center-of-mass kinetic energy, MeV |
| $f$ | anamolous moment |
| $f(\Lambda)$ | form factor |
| $g^2/4\pi$ | meson-nucleon-nucleon coupling constant |
| $J$ | total angular momentum |
| $K_o$ | modified Bessel function |
| $\mathbf{L}$ | orbital angular momentum |
| $M$ | nucleon mass, MeV |
| $N,\ \bar{N}$ | symbol for a nucleon and an antinucleon |
| $P,\ \bar{P}$ | symbol for a proton and an antiproton |
| $Q_{12}$ | quadratic spin-orbit operator |
| $r$ | internucleon separation distance, fm |
| $\mathbf{S}$ | nuclear spin |
| $S_{12}$ | tensor force operator |
| $T_L$ | lab energy of $\bar{N}$, MeV |
| $t$ | 4-momentum transfer squared, MeV$^2$ |
| $\tilde{t}(e,\mathbf{y})$ | two-body transition amplitude |
| $V(r)$ | nucleon-nucleon potential, MeV |
| $V_{\rm tot}$ | total potential, MeV |
| $V_o^{\rho,\omega,\sigma}$ | central potentials defined in eq. (3a), MeV |
| $V_\sigma^{\rho,\omega,\pi}$ | spin-spin potentials defined in eq. (3a), MeV |
| $V_T^{\rho,\omega,\pi}$ | tensor potentials defined in eq. (3a), MeV |
| $V_{LS}^{\rho,\omega,\sigma}$ | spin-orbit potentials defined in eq. (3a), MeV |
| $V_{LS2}^{\rho,\omega,\sigma}$ | quadratic spin-orbit potentials defined in eq. (3a), MeV |
| $V_\pi$ | pi-meson potential defined in eq. (2), MeV |
| $V_\sigma$ | sigma-meson potential defined in eq. (2), MeV |
| $V_\rho$ | rho-meson potential defined in eq. (2), MeV |
| $V_\omega$ | omega-meson potential defined in eq. (2), MeV |
| $W(r)$ | $N\bar{N}$ absorptive potential defined in eq. (6), MeV |
| $\mathbf{y}$ | relative position vector of two body system, fm |
| $Z$ | number of protons in the nucleus |
| $\mathbf{z}$ | projectile position vector in beam direction, fm |
| $\alpha(e)$ | ratio of elastic to inelastic cross sections |
| $\delta$ | symbol for delta-meson |
| $\eta$ | symbol for eta-meson |
| $\Lambda$ | form factor mass, MeV |
| $\mu$ | exchanged particle mass, MeV |
| $\boldsymbol{\xi}_T$ | collection of constituent relative coordinates for target nucleus, fm |
| $\pi$ | symbol for pion; also orbital parity; also universal constant |
| $\rho_P, \rho_T$ | projectile or target nuclear densities, fm$^{-3}$ |
| $\boldsymbol{\sigma}_i$ | Pauli spin matrix of $i$th nucleon |
| $\sigma$ | cross section, mb |
| $\sigma_{\rm in}$ | inelastic $N\bar{N}$ cross section, mb |
| $\sigma_{\rm el}$ | elastic $N\bar{N}$ cross section, mb |
| $\sigma_{\rm tot}$ | total $N\bar{N}$ cross section, mb |
| $\sigma_{\rm abs}$ | absorptive cross section |
| $\boldsymbol{\tau}_i$ | isospin matrix of $i$th nucleon |

Table 1. Total Cross Sections (millibarns) for Antiproton Projectiles

| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | U | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 522. | 1007. | 1230. | 1536. | 1943. | 2267. | 2373. | 2390. | 3037. | 3664. | 4552. |
| 75. | 466. | 920. | 1130. | 1427. | 1816. | 2132. | 2239. | 2274. | 2893. | 3496. | 4372. |
| 100. | 431. | 864. | 1065. | 1356. | 1733. | 2045. | 2151. | 2198. | 2798. | 3386. | 4254. |
| 125. | 403. | 820. | 1014. | 1301. | 1668. | 1975. | 2082. | 2136. | 2722. | 3298. | 4159. |
| 150. | 387. | 793. | 984. | 1267. | 1629. | 1934. | 2041. | 2101. | 2678. | 3246. | 4103. |
| 175. | 371. | 768. | 954. | 1235. | 1591. | 1893. | 1999. | 2064. | 2633. | 3193. | 4046. |
| 200. | 360. | 749. | 933. | 1211. | 1563. | 1863. | 1970. | 2038. | 2601. | 3156. | 4005. |
| 225. | 348. | 731. | 911. | 1187. | 1535. | 1833. | 1940. | 2010. | 2567. | 3117. | 3963. |
| 250. | 340. | 717. | 895. | 1169. | 1514. | 1811. | 1917. | 1990. | 2543. | 3089. | 3932. |
| 275. | 332. | 704. | 880. | 1152. | 1495. | 1790. | 1896. | 1971. | 2520. | 3062. | 3903. |
| 300. | 326. | 694. | 868. | 1139. | 1479. | 1773. | 1879. | 1957. | 2501. | 3040. | 3879. |
| 350. | 315. | 675. | 846. | 1114. | 1450. | 1742. | 1848. | 1929. | 2467. | 3000. | 3836. |
| 400. | 306. | 659. | 828. | 1094. | 1426. | 1717. | 1823. | 1906. | 2439. | 2968. | 3801. |
| 500. | 292. | 636. | 800. | 1064. | 1390. | 1678. | 1784. | 1872. | 2397. | 2918. | 3747. |
| 600. | 283. | 620. | 781. | 1042. | 1364. | 1650. | 1756. | 1848. | 2367. | 2883. | 3709. |
| 700. | 275. | 606. | 764. | 1023. | 1342. | 1627. | 1733. | 1827. | 2341. | 2852. | 3676. |
| 800. | 268. | 594. | 750. | 1007. | 1323. | 1606. | 1712. | 1808. | 2318. | 2826. | 3647. |
| 900. | 263. | 584. | 738. | 995. | 1308. | 1590. | 1696. | 1794. | 2300. | 2805. | 3624. |
| 1000. | 258. | 576. | 728. | 983. | 1295. | 1575. | 1681. | 1782. | 2285. | 2786. | 3604. |
| 1250. | 250. | 560. | 709. | 962. | 1269. | 1548. | 1654. | 1759. | 2256. | 2752. | 3567. |
| 1500. | 243. | 547. | 693. | 944. | 1248. | 1525. | 1631. | 1738. | 2230. | 2722. | 3534. |
| 1750. | 237. | 536. | 680. | 929. | 1229. | 1505. | 1611. | 1720. | 2208. | 2696. | 3506. |
| 2000. | 233. | 528. | 671. | 919. | 1217. | 1492. | 1598. | 1709. | 2194. | 2679. | 3488. |
| 2500. | 227. | 516. | 655. | 901. | 1196. | 1469. | 1576. | 1691. | 2170. | 2650. | 3457. |
| 3000. | 223. | 506. | 643. | 888. | 1179. | 1452. | 1558. | 1676. | 2151. | 2627. | 3433. |
| 3500. | 219. | 498. | 633. | 876. | 1166. | 1437. | 1544. | 1663. | 2135. | 2608. | 3412. |
| 4000. | 215. | 491. | 625. | 867. | 1154. | 1424. | 1531. | 1652. | 2121. | 2591. | 3394. |
| 5000. | 210. | 479. | 610. | 850. | 1134. | 1402. | 1509. | 1633. | 2098. | 2563. | 3363. |
| 6000. | 205. | 470. | 598. | 836. | 1117. | 1384. | 1491. | 1617. | 2077. | 2539. | 3337. |
| 7000. | 201. | 461. | 588. | 824. | 1102. | 1368. | 1474. | 1603. | 2059. | 2517. | 3314. |
| 8000. | 198. | 453. | 578. | 813. | 1088. | 1353. | 1459. | 1590. | 2043. | 2497. | 3292. |
| 9000. | 194. | 446. | 569. | 802. | 1075. | 1338. | 1445. | 1577. | 2027. | 2478. | 3271. |
| 10000. | 191. | 439. | 560. | 792. | 1063. | 1325. | 1431. | 1565. | 2011. | 2460. | 3251. |
| 12500. | 183. | 423. | 540. | 768. | 1033. | 1292. | 1398. | 1535. | 1974. | 2416. | 3202. |
| 15000. | 176. | 407. | 520. | 744. | 1003. | 1259. | 1365. | 1504. | 1936. | 2370. | 3152. |
| 17500. | 176. | 407. | 520. | 744. | 1003. | 1259. | 1365. | 1504. | 1936. | 2370. | 3152. |
| 20000. | 176. | 407. | 520. | 744. | 1003. | 1259. | 1365. | 1504. | 1936. | 2370. | 3152. |
| 22500. | 176. | 407. | 520. | 744. | 1003. | 1259. | 1365. | 1504. | 1936. | 2370. | 3152. |

Table 2. Absorptive Cross Sections (millibarns) for Antiproton Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BK | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 311. | 592. | 724. | 884. | 1115. | 1280. | 1325. | 1284. | 1653. | 2007. | 2450. |
| 75. | 282. | 548. | 673. | 828. | 1051. | 1212. | 1257. | 1227. | 1581. | 1923. | 2361. |
| 100. | 264. | 520. | 641. | 793. | 1009. | 1167. | 1214. | 1191. | 1535. | 1869. | 2303. |
| 125. | 249. | 497. | 615. | 764. | 975. | 1132. | 1179. | 1161. | 1498. | 1825. | 2256. |
| 150. | 241. | 485. | 600. | 748. | 956. | 1112. | 1159. | 1144. | 1476. | 1799. | 2229. |
| 175. | 233. | 472. | 585. | 731. | 936. | 1091. | 1138. | 1127. | 1454. | 1773. | 2201. |
| 200. | 227. | 462. | 574. | 720. | 922. | 1076. | 1124. | 1115. | 1439. | 1755. | 2182. |
| 225. | 221. | 453. | 563. | 707. | 908. | 1061. | 1109. | 1102. | 1423. | 1736. | 2162. |
| 250. | 217. | 446. | 555. | 698. | 897. | 1050. | 1098. | 1093. | 1411. | 1722. | 2147. |
| 275. | 212. | 439. | 547. | 690. | 887. | 1040. | 1087. | 1084. | 1400. | 1709. | 2133. |
| 300. | 209. | 434. | 541. | 683. | 880. | 1031. | 1079. | 1077. | 1391. | 1698. | 2121. |
| 350. | 203. | 424. | 530. | 671. | 865. | 1016. | 1064. | 1064. | 1375. | 1679. | 2101. |
| 400. | 199. | 417. | 521. | 661. | 853. | 1003. | 1051. | 1054. | 1361. | 1663. | 2084. |
| 500. | 192. | 405. | 507. | 646. | 835. | 984. | 1032. | 1039. | 1342. | 1639. | 2059. |
| 600. | 187. | 397. | 497. | 636. | 823. | 971. | 1020. | 1028. | 1328. | 1623. | 2042. |
| 700. | 183. | 390. | 489. | 627. | 812. | 960. | 1008. | 1019. | 1316. | 1609. | 2026. |
| 800. | 179. | 384. | 482. | 619. | 802. | 950. | 998. | 1011. | 1306. | 1596. | 2013. |
| 900. | 177. | 379. | 477. | 613. | 795. | 942. | 991. | 1005. | 1298. | 1586. | 2003. |
| 1000. | 174. | 375. | 472. | 607. | 789. | 935. | 984. | 1000. | 1291. | 1578. | 1994. |
| 1250. | 170. | 368. | 463. | 598. | 777. | 923. | 972. | 991. | 1278. | 1562. | 1978. |
| 1500. | 166. | 361. | 455. | 589. | 766. | 912. | 962. | 982. | 1267. | 1549. | 1963. |
| 1750. | 163. | 356. | 448. | 582. | 758. | 903. | 952. | 974. | 1257. | 1537. | 1951. |
| 2000. | 161. | 352. | 444. | 577. | 752. | 897. | 947. | 970. | 1251. | 1530. | 1943. |
| 2500. | 158. | 347. | 437. | 570. | 743. | 887. | 937. | 963. | 1242. | 1518. | 1931. |
| 3000. | 156. | 342. | 431. | 564. | 735. | 880. | 930. | 958. | 1234. | 1508. | 1921. |
| 3500. | 154. | 338. | 427. | 559. | 729. | 873. | 924. | 953. | 1228. | 1500. | 1913. |
| 4000. | 152. | 335. | 423. | 554. | 724. | 868. | 918. | 949. | 1222. | 1493. | 1906. |
| 5000. | 149. | 329. | 416. | 547. | 715. | 858. | 909. | 942. | 1213. | 1482. | 1894. |
| 6000. | 147. | 325. | 410. | 541. | 708. | 851. | 902. | 937. | 1205. | 1472. | 1883. |
| 7000. | 145. | 321. | 405. | 535. | 701. | 844. | 895. | 931. | 1198. | 1463. | 1874. |
| 8000. | 143. | 317. | 400. | 530. | 695. | 837. | 889. | 927. | 1192. | 1455. | 1866. |
| 9000. | 141. | 313. | 396. | 526. | 689. | 831. | 883. | 922. | 1185. | 1447. | 1858. |
| 10000. | 139. | 310. | 392. | 521. | 683. | 825. | 877. | 918. | 1180. | 1440. | 1851. |
| 12500. | 135. | 302. | 382. | 510. | 670. | 811. | 863. | 907. | 1165. | 1423. | 1832. |
| 15000. | 131. | 294. | 372. | 499. | 657. | 797. | 850. | 896. | 1151. | 1405. | 1814. |
| 17500. | 131. | 294. | 372. | 499. | 657. | 797. | 850. | 896. | 1151. | 1405. | 1814. |
| 20000. | 131. | 294. | 372. | 499. | 657. | 797. | 850. | 896. | 1151. | 1405. | 1814. |
| 22500. | 131. | 294. | 372. | 499. | 657. | 797. | 850. | 896. | 1151. | 1405. | 1814. |

Table 3. Total Cross Sections (millibarns) for Antideuteron Projectiles

| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 931. | 1606. | 1890. | 2312. | 2615. | 3228. | 3373. | 3499. | 4216. | 4920. | 5990. |
| 75. | 838. | 1482. | 1753. | 2163. | 2649. | 3052. | 3196. | 3327. | 4022. | 4706. | 5757. |
| 100. | 779. | 1403. | 1666. | 2068. | 2542. | 2938. | 3081. | 3215. | 3896. | 4566. | 5606. |
| 125. | 734. | 1341. | 1598. | 1993. | 2458. | 2849. | 2991. | 3127. | 3796. | 4456. | 5486. |
| 150. | 706. | 1303. | 1556. | 1947. | 2406. | 2794. | 2935. | 3073. | 3736. | 4389. | 5412. |
| 175. | 680. | 1267. | 1516. | 1903. | 2357. | 2741. | 2882. | 3021. | 3677. | 4323. | 5341. |
| 200. | 661. | 1240. | 1486. | 1871. | 2320. | 2702. | 2842. | 2983. | 3633. | 4275. | 5288. |
| 225. | 642. | 1214. | 1457. | 1839. | 2284. | 2664. | 2803. | 2944. | 3590. | 4227. | 5236. |
| 250. | 628. | 1194. | 1435. | 1814. | 2256. | 2635. | 2774. | 2915. | 3557. | 4191. | 5196. |
| 275. | 615. | 1176. | 1415. | 1792. | 2231. | 2607. | 2746. | 2888. | 3527. | 4157. | 5159. |
| 300. | 604. | 1161. | 1398. | 1773. | 2210. | 2585. | 2723. | 2867. | 3502. | 4129. | 5129. |
| 350. | 585. | 1133. | 1367. | 1739. | 2172. | 2544. | 2682. | 2827. | 3457. | 4079. | 5074. |
| 400. | 570. | 1111. | 1342. | 1712. | 2141. | 2511. | 2649. | 2794. | 3420. | 4038. | 5029. |
| 500. | 546. | 1077. | 1304. | 1670. | 2093. | 2460. | 2598. | 2745. | 3363. | 3974. | 4960. |
| 600. | 529. | 1052. | 1276. | 1639. | 2058. | 2423. | 2560. | 2709. | 3322. | 3928. | 4910. |
| 700. | 515. | 1031. | 1252. | 1613. | 2028. | 2392. | 2529. | 2679. | 3288. | 3889. | 4867. |
| 800. | 503. | 1013. | 1232. | 1591. | 2003. | 2365. | 2501. | 2652. | 3257. | 3855. | 4830. |
| 900. | 493. | 999. | 1215. | 1573. | 1983. | 2343. | 2480. | 2632. | 3233. | 3828. | 4801. |
| 1000. | 484. | 986. | 1201. | 1557. | 1964. | 2324. | 2460. | 2613. | 3212. | 3805. | 4775. |
| 1250. | 468. | 962. | 1173. | 1527. | 1930. | 2288. | 2424. | 2579. | 3172. | 3759. | 4726. |
| 1500. | 455. | 941. | 1150. | 1502. | 1901. | 2257. | 2393. | 2549. | 3138. | 3721. | 4684. |
| 1750. | 444. | 925. | 1131. | 1481. | 1877. | 2231. | 2367. | 2524. | 3110. | 3689. | 4649. |
| 2000. | 436. | 912. | 1117. | 1466. | 1860. | 2213. | 2349. | 2507. | 3090. | 3666. | 4625. |
| 2500. | 424. | 893. | 1095. | 1441. | 1832. | 2183. | 2319. | 2480. | 3057. | 3629. | 4585. |
| 3000. | 414. | 877. | 1077. | 1422. | 1809. | 2160. | 2295. | 2458. | 3032. | 3600. | 4553. |
| 3500. | 406. | 864. | 1062. | 1406. | 1791. | 2140. | 2275. | 2439. | 3010. | 3575. | 4526. |
| 4000. | 399. | 853. | 1049. | 1392. | 1775. | 2123. | 2258. | 2423. | 2992. | 3554. | 4504. |
| 5000. | 387. | 835. | 1028. | 1368. | 1748. | 2094. | 2230. | 2396. | 2960. | 3519. | 4465. |
| 6000. | 378. | 819. | 1010. | 1349. | 1725. | 2070. | 2206. | 2374. | 2934. | 3489. | 4432. |
| 7000. | 370. | 805. | 994. | 1331. | 1705. | 2049. | 2184. | 2354. | 2911. | 3462. | 4404. |
| 8000. | 362. | 793. | 980. | 1315. | 1687. | 2030. | 2165. | 2335. | 2889. | 3438. | 4377. |
| 9000. | 355. | 781. | 966. | 1300. | 1670. | 2011. | 2146. | 2318. | 2869. | 3415. | 4352. |
| 10000. | 349. | 770. | 953. | 1286. | 1653. | 1994. | 2129. | 2301. | 2850. | 3393. | 4328. |
| 12500. | 333. | 744. | 922. | 1252. | 1614. | 1952. | 2086. | 2261. | 2803. | 3340. | 4270. |
| 15000. | 318. | 718. | 892. | 1218. | 1575. | 1910. | 2044. | 2221. | 2756. | 3287. | 4212. |
| 17500. | 318. | 718. | 892. | 1218. | 1575. | 1910. | 2044. | 2221. | 2756. | 3287. | 4212. |
| 20000. | 318. | 718. | 892. | 1218. | 1575. | 1910. | 2044. | 2221. | 2756. | 3287. | 4212. |
| 22500. | 318. | 718. | 892. | 1218. | 1575. | 1910. | 2044. | 2221. | 2756. | 3287. | 4212. |

Table 4. Absorptive Cross Sections (millibarns) for Antideuteron Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 585. | 959. | 1120. | 1342. | 1620. | 1833. | 1902. | 1941. | 2333. | 2719. | 3266. |
| 75. | 536. | 895. | 1050. | 1266. | 1535. | 1743. | 1812. | 1855. | 2236. | 2611. | 3149. |
| 100. | 504. | 854. | 1004. | 1216. | 1480. | 1685. | 1754. | 1799. | 2172. | 2540. | 3074. |
| 125. | 480. | 822. | 969. | 1177. | 1436. | 1639. | 1707. | 1754. | 2122. | 2485. | 3013. |
| 150. | 465. | 802. | 947. | 1154. | 1410. | 1611. | 1680. | 1727. | 2092. | 2451. | 2977. |
| 175. | 451. | 783. | 926. | 1131. | 1384. | 1584. | 1652. | 1701. | 2062. | 2418. | 2941. |
| 200. | 440. | 769. | 911. | 1114. | 1365. | 1565. | 1632. | 1682. | 2040. | 2394. | 2916. |
| 225. | 430. | 755. | 896. | 1098. | 1347. | 1545. | 1612. | 1663. | 2019. | 2370. | 2889. |
| 250. | 422. | 745. | 884. | 1085. | 1332. | 1530. | 1597. | 1648. | 2002. | 2352. | 2870. |
| 275. | 415. | 735. | 873. | 1074. | 1319. | 1516. | 1583. | 1635. | 1987. | 2334. | 2851. |
| 300. | 409. | 727. | 865. | 1064. | 1308. | 1505. | 1572. | 1624. | 1974. | 2321. | 2836. |
| 350. | 399. | 713. | 849. | 1047. | 1289. | 1484. | 1551. | 1604. | 1952. | 2295. | 2809. |
| 400. | 390. | 702. | 836. | 1033. | 1273. | 1467. | 1534. | 1588. | 1933. | 2275. | 2787. |
| 500. | 377. | 684. | 816. | 1011. | 1249. | 1441. | 1509. | 1563. | 1905. | 2244. | 2753. |
| 600. | 368. | 671. | 802. | 996. | 1231. | 1423. | 1490. | 1546. | 1886. | 2221. | 2729. |
| 700. | 360. | 661. | 790. | 983. | 1216. | 1408. | 1475. | 1531. | 1869. | 2202. | 2708. |
| 800. | 354. | 651. | 780. | 971. | 1203. | 1394. | 1461. | 1518. | 1854. | 2185. | 2690. |
| 900. | 348. | 644. | 772. | 963. | 1193. | 1383. | 1450. | 1506. | 1842. | 2172. | 2676. |
| 1000. | 344. | 637. | 764. | 955. | 1184. | 1374. | 1441. | 1499. | 1832. | 2161. | 2664. |
| 1250. | 335. | 625. | 751. | 940. | 1167. | 1356. | 1423. | 1483. | 1813. | 2139. | 2641. |
| 1500. | 328. | 615. | 739. | 927. | 1153. | 1341. | 1408. | 1469. | 1797. | 2121. | 2621. |
| 1750. | 321. | 606. | 729. | 917. | 1141. | 1328. | 1395. | 1457. | 1783. | 2105. | 2604. |
| 2000. | 317. | 600. | 723. | 909. | 1133. | 1319. | 1387. | 1449. | 1773. | 2094. | 2592. |
| 2500. | 310. | 591. | 712. | 898. | 1119. | 1305. | 1373. | 1436. | 1758. | 2077. | 2574. |
| 3000. | 305. | 583. | 703. | 888. | 1108. | 1294. | 1361. | 1426. | 1747. | 2064. | 2560. |
| 3500. | 300. | 577. | 696. | 881. | 1100. | 1285. | 1352. | 1418. | 1737. | 2052. | 2548. |
| 4000. | 296. | 571. | 690. | 874. | 1092. | 1277. | 1344. | 1410. | 1728. | 2042. | 2537. |
| 5000. | 290. | 562. | 679. | 863. | 1079. | 1263. | 1331. | 1398. | 1714. | 2026. | 2520. |
| 6000. | 284. | 555. | 671. | 854. | 1068. | 1252. | 1320. | 1388. | 1702. | 2012. | 2505. |
| 7000. | 280. | 548. | 663. | 845. | 1059. | 1242. | 1310. | 1379. | 1691. | 2000. | 2492. |
| 8000. | 275. | 541. | 656. | 838. | 1050. | 1233. | 1301. | 1370. | 1681. | 1989. | 2480. |
| 9000. | 271. | 536. | 649. | 831. | 1042. | 1224. | 1292. | 1363. | 1672. | 1978. | 2469. |
| 10000. | 267. | 530. | 643. | 824. | 1034. | 1216. | 1284. | 1355. | 1663. | 1968. | 2458. |
| 12500. | 258. | 517. | 628. | 807. | 1015. | 1197. | 1264. | 1337. | 1642. | 1944. | 2432. |
| 15000. | 249. | 503. | 613. | 791. | 997. | 1177. | 1245. | 1319. | 1621. | 1920. | 2406. |
| 17500. | 249. | 503. | 613. | 791. | 997. | 1177. | 1245. | 1319. | 1621. | 1920. | 2406. |
| 20000. | 249. | 503. | 613. | 791. | 997. | 1177. | 1245. | 1319. | 1621. | 1920. | 2406. |
| 22500. | 249. | 503. | 613. | 791. | 997. | 1177. | 1245. | 1319. | 1621. | 1920. | 2406. |

Table 5. Total Cross Sections (millibarns) for Antihelium Projectiles

| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 992. | 1680. | 1990. | 2389. | 2926. | 3312. | 3427. | 3429. | 4206. | 4974. | 5985. |
| 75. | 910. | 1568. | 1865. | 2253. | 2771. | 3150. | 3265. | 3280. | 4033. | 4777. | 5776. |
| 100. | 857. | 1496. | 1784. | 2165. | 2671. | 3045. | 3160. | 3182. | 3920. | 4650. | 5639. |
| 125. | 815. | 1439. | 1721. | 2096. | 2592. | 2962. | 3076. | 3104. | 3830. | 4548. | 5529. |
| 150. | 791. | 1406. | 1683. | 2052. | 2545. | 2912. | 3027. | 3059. | 3777. | 4487. | 5465. |
| 175. | 767. | 1372. | 1645. | 2014. | 2498. | 2863. | 2978. | 3013. | 3723. | 4427. | 5400. |
| 200. | 750. | 1348. | 1619. | 1984. | 2464. | 2828. | 2942. | 2981. | 3685. | 4384. | 5354. |
| 225. | 732. | 1324. | 1591. | 1954. | 2430. | 2792. | 2906. | 2947. | 3646. | 4340. | 5306. |
| 250. | 719. | 1306. | 1571. | 1932. | 2405. | 2765. | 2879. | 2922. | 3617. | 4307. | 5271. |
| 275. | 707. | 1289. | 1552. | 1911. | 2381. | 2740. | 2854. | 2898. | 3590. | 4276. | 5237. |
| 300. | 698. | 1275. | 1537. | 1895. | 2362. | 2719. | 2834. | 2880. | 3568. | 4251. | 5211. |
| 350. | 680. | 1251. | 1509. | 1864. | 2326. | 2682. | 2797. | 2846. | 3528. | 4205. | 5162. |
| 400. | 666. | 1231. | 1487. | 1839. | 2298. | 2652. | 2767. | 2818. | 3496. | 4169. | 5122. |
| 500. | 645. | 1200. | 1452. | 1802. | 2255. | 2607. | 2722. | 2776. | 3447. | 4112. | 5062. |
| 600. | 630. | 1179. | 1428. | 1775. | 2224. | 2575. | 2690. | 2748. | 3413. | 4073. | 5020. |
| 700. | 618. | 1161. | 1408. | 1753. | 2198. | 2547. | 2662. | 2723. | 3383. | 4039. | 4984. |
| 800. | 606. | 1145. | 1389. | 1733. | 2175. | 2523. | 2638. | 2700. | 3357. | 4009. | 4952. |
| 900. | 598. | 1133. | 1376. | 1718. | 2157. | 2504. | 2620. | 2684. | 3338. | 3986. | 4928. |
| 1000. | 591. | 1122. | 1363. | 1704. | 2141. | 2488. | 2603. | 2669. | 3320. | 3966. | 4906. |
| 1250. | 577. | 1102. | 1340. | 1679. | 2112. | 2457. | 2573. | 2643. | 3288. | 3929. | 4866. |
| 1500. | 565. | 1085. | 1321. | 1658. | 2087. | 2431. | 2547. | 2619. | 3260. | 3896. | 4832. |
| 1750. | 555. | 1070. | 1304. | 1639. | 2066. | 2409. | 2525. | 2599. | 3236. | 3868. | 4802. |
| 2000. | 549. | 1061. | 1293. | 1627. | 2052. | 2394. | 2510. | 2586. | 3221. | 3851. | 4783. |
| 2500. | 539. | 1046. | 1275. | 1608. | 2029. | 2370. | 2487. | 2567. | 3196. | 3822. | 4753. |
| 3000. | 531. | 1033. | 1261. | 1593. | 2011. | 2351. | 2469. | 2551. | 3177. | 3799. | 4728. |
| 3500. | 524. | 1023. | 1249. | 1580. | 1996. | 2336. | 2453. | 2538. | 3161. | 3780. | 4708. |
| 4000. | 518. | 1014. | 1239. | 1569. | 1983. | 2322. | 2440. | 2526. | 3147. | 3763. | 4691. |
| 5000. | 509. | 1000. | 1222. | 1551. | 1961. | 2300. | 2418. | 2507. | 3123. | 3735. | 4662. |
| 6000. | 500. | 987. | 1207. | 1535. | 1943. | 2281. | 2399. | 2491. | 3103. | 3712. | 4637. |
| 7000. | 493. | 976. | 1195. | 1521. | 1927. | 2264. | 2383. | 2477. | 3086. | 3691. | 4615. |
| 8000. | 487. | 966. | 1183. | 1509. | 1912. | 2248. | 2367. | 2463. | 3070. | 3672. | 4595. |
| 9000. | 480. | 957. | 1172. | 1497. | 1898. | 2234. | 2353. | 2451. | 3055. | 3655. | 4577. |
| 10000. | 475. | 948. | 1162. | 1486. | 1885. | 2220. | 2339. | 2439. | 3040. | 3638. | 4559. |
| 12500. | 461. | 927. | 1137. | 1459. | 1853. | 2187. | 2307. | 2410. | 3005. | 3597. | 4515. |
| 15000. | 447. | 905. | 1112. | 1432. | 1822. | 2154. | 2274. | 2382. | 2971. | 3556. | 4472. |
| 17500. | 447. | 905. | 1112. | 1432. | 1822. | 2154. | 2274. | 2382. | 2971. | 3556. | 4472. |
| 20000. | 447. | 905. | 1112. | 1432. | 1822. | 2154. | 2274. | 2382. | 2971. | 3556. | 4472. |
| 22500. | 447. | 905. | 1112. | 1432. | 1822. | 2154. | 2274. | 2382. | 2971. | 3556. | 4472. |

Table 6. Absorptive Cross Sections (millibarns) for Antihelium Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 579. | 957. | 1130. | 1343. | 1641. | 1836. | 1886. | 1851. | 2277. | 2698. | 3205. |
| 75. | 536. | 900. | 1067. | 1273. | 1561. | 1753. | 1804. | 1776. | 2189. | 2598. | 3100. |
| 100. | 509. | 863. | 1025. | 1228. | 1509. | 1699. | 1750. | 1727. | 2132. | 2533. | 3032. |
| 125. | 487. | 833. | 992. | 1192. | 1468. | 1656. | 1707. | 1688. | 2086. | 2482. | 2976. |
| 150. | 474. | 816. | 973. | 1171. | 1444. | 1631. | 1683. | 1666. | 2060. | 2451. | 2944. |
| 175. | 462. | 799. | 954. | 1150. | 1420. | 1606. | 1657. | 1643. | 2033. | 2421. | 2912. |
| 200. | 453. | 787. | 940. | 1135. | 1402. | 1588. | 1640. | 1627. | 2014. | 2399. | 2889. |
| 225. | 444. | 774. | 926. | 1119. | 1385. | 1569. | 1621. | 1610. | 1994. | 2376. | 2865. |
| 250. | 437. | 765. | 916. | 1108. | 1371. | 1556. | 1607. | 1597. | 1980. | 2360. | 2847. |
| 275. | 431. | 756. | 906. | 1097. | 1359. | 1543. | 1595. | 1586. | 1966. | 2344. | 2831. |
| 300. | 426. | 750. | 898. | 1089. | 1349. | 1533. | 1585. | 1577. | 1955. | 2332. | 2817. |
| 350. | 416. | 737. | 884. | 1073. | 1331. | 1514. | 1566. | 1560. | 1935. | 2309. | 2793. |
| 400. | 409. | 727. | 872. | 1060. | 1317. | 1498. | 1551. | 1546. | 1919. | 2290. | 2773. |
| 500. | 398. | 711. | 855. | 1041. | 1294. | 1475. | 1528. | 1525. | 1895. | 2262. | 2743. |
| 600. | 391. | 701. | 843. | 1028. | 1279. | 1459. | 1512. | 1511. | 1878. | 2243. | 2723. |
| 700. | 384. | 691. | 832. | 1016. | 1266. | 1445. | 1498. | 1499. | 1864. | 2226. | 2705. |
| 800. | 378. | 683. | 823. | 1006. | 1254. | 1433. | 1486. | 1488. | 1851. | 2211. | 2689. |
| 900. | 374. | 677. | 816. | 999. | 1245. | 1424. | 1477. | 1480. | 1841. | 2200. | 2678. |
| 1000. | 370. | 672. | 810. | 992. | 1237. | 1415. | 1469. | 1473. | 1832. | 2190. | 2667. |
| 1250. | 363. | 662. | 799. | 980. | 1222. | 1400. | 1454. | 1461. | 1817. | 2171. | 2648. |
| 1500. | 357. | 653. | 789. | 969. | 1210. | 1387. | 1441. | 1449. | 1803. | 2155. | 2631. |
| 1750. | 352. | 646. | 781. | 959. | 1199. | 1376. | 1430. | 1439. | 1791. | 2142. | 2616. |
| 2000. | 349. | 641. | 775. | 954. | 1192. | 1369. | 1423. | 1434. | 1784. | 2133. | 2608. |
| 2500. | 344. | 634. | 767. | 944. | 1181. | 1357. | 1412. | 1424. | 1773. | 2119. | 2593. |
| 3000. | 340. | 628. | 760. | 937. | 1172. | 1348. | 1403. | 1417. | 1764. | 2108. | 2582. |
| 3500. | 337. | 623. | 754. | 931. | 1165. | 1341. | 1395. | 1411. | 1756. | 2099. | 2573. |
| 4000. | 334. | 619. | 749. | 925. | 1158. | 1334. | 1389. | 1406. | 1750. | 2092. | 2565. |
| 5000. | 329. | 612. | 741. | 917. | 1148. | 1323. | 1379. | 1397. | 1739. | 2078. | 2551. |
| 6000. | 325. | 606. | 734. | 909. | 1139. | 1314. | 1370. | 1390. | 1730. | 2067. | 2540. |
| 7000. | 322. | 601. | 728. | 903. | 1131. | 1306. | 1362. | 1383. | 1721. | 2058. | 2530. |
| 8000. | 319. | 596. | 723. | 897. | 1124. | 1299. | 1355. | 1377. | 1714. | 2049. | 2520. |
| 9000. | 316. | 592. | 718. | 891. | 1117. | 1292. | 1348. | 1371. | 1707. | 2040. | 2512. |
| 10000. | 313. | 587. | 713. | 885. | 1111. | 1285. | 1341. | 1366. | 1700. | 2032. | 2503. |
| 12500. | 306. | 577. | 701. | 873. | 1095. | 1269. | 1326. | 1353. | 1684. | 2013. | 2483. |
| 15000. | 299. | 567. | 689. | 860. | 1080. | 1253. | 1310. | 1340. | 1668. | 1994. | 2463. |
| 17500. | 299. | 567. | 689. | 860. | 1080. | 1253. | 1310. | 1340. | 1668. | 1994. | 2463. |
| 20000. | 299. | 567. | 689. | 860. | 1080. | 1253. | 1310. | 1340. | 1668. | 1994. | 2463. |
| 22500. | 299. | 567. | 689. | 860. | 1080. | 1253. | 1310. | 1340. | 1668. | 1994. | 2463. |

Table 7. Total Cross Sections (millibarns) for Antilithium Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 1484. | 2327. | 2687. | 3171. | 3784. | 4238. | 4381. | 4446. | 5295. | 6129. | 7279. |
| 75. | 1373. | 2187. | 2534. | 3007. | 3601. | 4047. | 4190. | 4264. | 5090. | 5902. | 7037. |
| 100. | 1302. | 2096. | 2435. | 2900. | 3483. | 3923. | 4065. | 4144. | 4956. | 5754. | 6878. |
| 125. | 1246. | 2025. | 2357. | 2816. | 3389. | 3825. | 3967. | 4049. | 4849. | 5637. | 6752. |
| 150. | 1212. | 1982. | 2310. | 2766. | 3333. | 3766. | 3908. | 3993. | 4786. | 5566. | 6677. |
| 175. | 1180. | 1940. | 2265. | 2716. | 3277. | 3708. | 3849. | 3937. | 4723. | 5497. | 6602. |
| 200. | 1156. | 1910. | 2231. | 2680. | 3237. | 3666. | 3807. | 3897. | 4677. | 5446. | 6548. |
| 225. | 1133. | 1879. | 2198. | 2644. | 3197. | 3624. | 3765. | 3855. | 4631. | 5395. | 6493. |
| 250. | 1115. | 1856. | 2173. | 2617. | 3166. | 3592. | 3732. | 3825. | 4596. | 5357. | 6451. |
| 275. | 1099. | 1835. | 2149. | 2591. | 3138. | 3562. | 3703. | 3796. | 4564. | 5321. | 6413. |
| 300. | 1085. | 1818. | 2130. | 2571. | 3115. | 3538. | 3678. | 3773. | 4538. | 5292. | 6382. |
| 350. | 1061. | 1786. | 2096. | 2533. | 3073. | 3494. | 3634. | 3731. | 4490. | 5239. | 6325. |
| 400. | 1041. | 1761. | 2068. | 2503. | 3039. | 3458. | 3598. | 3696. | 4451. | 5196. | 6279. |
| 500. | 1012. | 1722. | 2025. | 2456. | 2986. | 3403. | 3543. | 3644. | 4392. | 5130. | 6208. |
| 600. | 990. | 1694. | 1994. | 2423. | 2949. | 3364. | 3504. | 3608. | 4351. | 5083. | 6158. |
| 700. | 972. | 1670. | 1968. | 2395. | 2917. | 3331. | 3471. | 3576. | 4315. | 5043. | 6115. |
| 800. | 957. | 1650. | 1945. | 2370. | 2889. | 3301. | 3442. | 3549. | 4283. | 5008. | 6077. |
| 900. | 944. | 1634. | 1927. | 2351. | 2868. | 3279. | 3419. | 3528. | 4259. | 4981. | 6049. |
| 1000. | 934. | 1619. | 1911. | 2334. | 2848. | 3259. | 3399. | 3509. | 4238. | 4956. | 6023. |
| 1250. | 913. | 1593. | 1882. | 2302. | 2812. | 3221. | 3362. | 3474. | 4198. | 4911. | 5975. |
| 1500. | 896. | 1570. | 1857. | 2275. | 2782. | 3189. | 3330. | 3444. | 4164. | 4873. | 5934. |
| 1750. | 882. | 1551. | 1835. | 2252. | 2756. | 3162. | 3303. | 3419. | 4134. | 4840. | 5898. |
| 2000. | 872. | 1538. | 1821. | 2237. | 2738. | 3144. | 3285. | 3402. | 4115. | 4818. | 5875. |
| 2500. | 856. | 1517. | 1797. | 2211. | 2710. | 3114. | 3255. | 3376. | 4084. | 4783. | 5838. |
| 3000. | 843. | 1500. | 1779. | 2192. | 2687. | 3091. | 3232. | 3355. | 4060. | 4755. | 5808. |
| 3500. | 833. | 1486. | 1763. | 2175. | 2668. | 3071. | 3213. | 3337. | 4039. | 4731. | 5784. |
| 4000. | 824. | 1475. | 1750. | 2161. | 2652. | 3054. | 3196. | 3322. | 4022. | 4711. | 5762. |
| 5000. | 808. | 1455. | 1728. | 2137. | 2625. | 3026. | 3168. | 3296. | 3992. | 4677. | 5727. |
| 6000. | 796. | 1438. | 1709. | 2117. | 2602. | 3002. | 3145. | 3275. | 3967. | 4649. | 5697. |
| 7000. | 785. | 1423. | 1692. | 2099. | 2582. | 2981. | 3124. | 3256. | 3945. | 4624. | 5670. |
| 8000. | 774. | 1409. | 1677. | 2083. | 2563. | 2962. | 3105. | 3238. | 3925. | 4601. | 5645. |
| 9000. | 765. | 1397. | 1663. | 2068. | 2546. | 2944. | 3087. | 3222. | 3906. | 4579. | 5623. |
| 10000. | 755. | 1384. | 1649. | 2053. | 2530. | 2927. | 3070. | 3206. | 3888. | 4559. | 5601. |
| 12500. | 734. | 1355. | 1617. | 2018. | 2490. | 2886. | 3029. | 3169. | 3844. | 4509. | 5548. |
| 15000. | 712. | 1326. | 1584. | 1984. | 2451. | 2845. | 2988. | 3131. | 3800. | 4460. | 5495. |
| 17500. | 712. | 1326. | 1584. | 1984. | 2451. | 2845. | 2988. | 3131. | 3800. | 4460. | 5495. |
| 20000. | 712. | 1326. | 1584. | 1984. | 2451. | 2845. | 2988. | 3131. | 3800. | 4460. | 5495. |
| 22500. | 712. | 1326. | 1584. | 1984. | 2451. | 2845. | 2988. | 3131. | 3800. | 4460. | 5495. |

Table 8. Absorptive Cross Sections (millibarns) for Antilithium Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 868. | 1324. | 1522. | 1776. | 2110. | 2341. | 2407. | 2409. | 2868. | 3320. | 3902. |
| 75. | 811. | 1252. | 1444. | 1692. | 2017. | 2244. | 2310. | 2318. | 2765. | 3206. | 3781. |
| 100. | 774. | 1206. | 1393. | 1638. | 1956. | 2181. | 2247. | 2258. | 2698. | 3131. | 3701. |
| 125. | 745. | 1169. | 1353. | 1594. | 1908. | 2131. | 2197. | 2210. | 2644. | 3072. | 3638. |
| 150. | 728. | 1147. | 1329. | 1569. | 1879. | 2101. | 2167. | 2183. | 2613. | 3037. | 3601. |
| 175. | 711. | 1125. | 1305. | 1543. | 1851. | 2071. | 2137. | 2154. | 2581. | 3001. | 3563. |
| 200. | 698. | 1110. | 1289. | 1525. | 1830. | 2050. | 2116. | 2134. | 2558. | 2976. | 3536. |
| 225. | 686. | 1094. | 1271. | 1506. | 1809. | 2028. | 2094. | 2114. | 2535. | 2950. | 3508. |
| 250. | 677. | 1082. | 1258. | 1492. | 1794. | 2012. | 2078. | 2098. | 2517. | 2931. | 3488. |
| 275. | 668. | 1071. | 1246. | 1479. | 1779. | 1996. | 2063. | 2084. | 2501. | 2913. | 3469. |
| 300. | 661. | 1063. | 1237. | 1469. | 1767. | 1984. | 2050. | 2073. | 2488. | 2898. | 3453. |
| 350. | 649. | 1046. | 1219. | 1450. | 1746. | 1962. | 2028. | 2051. | 2464. | 2872. | 3425. |
| 400. | 639. | 1033. | 1205. | 1434. | 1728. | 1944. | 2010. | 2034. | 2445. | 2850. | 3402. |
| 500. | 623. | 1013. | 1183. | 1410. | 1702. | 1916. | 1982. | 2009. | 2415. | 2817. | 3367. |
| 600. | 612. | 1000. | 1167. | 1394. | 1683. | 1896. | 1963. | 1991. | 2395. | 2794. | 3342. |
| 700. | 603. | 988. | 1154. | 1379. | 1667. | 1880. | 1946. | 1975. | 2377. | 2774. | 3321. |
| 800. | 595. | 977. | 1143. | 1367. | 1653. | 1865. | 1932. | 1962. | 2362. | 2756. | 3303. |
| 900. | 589. | 969. | 1134. | 1357. | 1642. | 1854. | 1921. | 1951. | 2350. | 2743. | 3289. |
| 1000. | 583. | 962. | 1126. | 1349. | 1632. | 1844. | 1911. | 1942. | 2339. | 2731. | 3276. |
| 1250. | 573. | 949. | 1111. | 1333. | 1614. | 1825. | 1892. | 1926. | 2320. | 2709. | 3253. |
| 1500. | 565. | 937. | 1099. | 1319. | 1599. | 1809. | 1876. | 1911. | 2303. | 2690. | 3233. |
| 1750. | 557. | 928. | 1088. | 1308. | 1586. | 1796. | 1863. | 1898. | 2289. | 2674. | 3216. |
| 2000. | 552. | 921. | 1081. | 1300. | 1577. | 1787. | 1854. | 1891. | 2280. | 2664. | 3205. |
| 2500. | 544. | 911. | 1070. | 1288. | 1563. | 1772. | 1840. | 1878. | 2265. | 2647. | 3187. |
| 3000. | 538. | 903. | 1060. | 1279. | 1552. | 1761. | 1829. | 1868. | 2253. | 2633. | 3173. |
| 3500. | 533. | 897. | 1053. | 1271. | 1543. | 1752. | 1820. | 1860. | 2244. | 2622. | 3162. |
| 4000. | 529. | 891. | 1047. | 1264. | 1535. | 1743. | 1812. | 1853. | 2235. | 2613. | 3152. |
| 5000. | 521. | 881. | 1036. | 1252. | 1522. | 1730. | 1798. | 1841. | 2221. | 2597. | 3135. |
| 6000. | 515. | 873. | 1027. | 1242. | 1511. | 1718. | 1787. | 1831. | 2210. | 2583. | 3121. |
| 7000. | 510. | 866. | 1019. | 1234. | 1501. | 1708. | 1777. | 1822. | 2199. | 2571. | 3108. |
| 8000. | 505. | 859. | 1011. | 1226. | 1492. | 1699. | 1768. | 1814. | 2190. | 2560. | 3097. |
| 9000. | 500. | 853. | 1004. | 1219. | 1484. | 1690. | 1759. | 1806. | 2181. | 2550. | 3086. |
| 10000. | 496. | 847. | 998. | 1212. | 1476. | 1682. | 1751. | 1799. | 2172. | 2540. | 3075. |
| 12500. | 485. | 833. | 982. | 1195. | 1456. | 1662. | 1732. | 1782. | 2152. | 2516. | 3051. |
| 15000. | 474. | 819. | 966. | 1178. | 1437. | 1642. | 1712. | 1764. | 2131. | 2493. | 3026. |
| 17500. | 474. | 819. | 966. | 1178. | 1437. | 1642. | 1712. | 1764. | 2131. | 2493. | 3026. |
| 20000. | 474. | 819. | 966. | 1178. | 1437. | 1642. | 1712. | 1764. | 2131. | 2493. | 3026. |
| 22500. | 474. | 819. | 966. | 1178. | 1437. | 1642. | 1712. | 1764. | 2131. | 2493. | 3026. |

Table 9. Total Cross Sections (millibarns) for Antiberyllium Projectiles

| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 1643. | 2530. | 2908. | 3411. | 4051. | 4517. | 4661. | 4716. | 5597. | 6461. | 7635. |
| 75. | 1527. | 2385. | 2750. | 3241. | 3863. | 4321. | 4465. | 4530. | 5388. | 6230. | 7389. |
| 100. | 1453. | 2291. | 2648. | 3132. | 3741. | 4194. | 4338. | 4408. | 5251. | 6079. | 7228. |
| 125. | 1394. | 2217. | 2567. | 3045. | 3644. | 4093. | 4236. | 4310. | 5142. | 5959. | 7099. |
| 150. | 1359. | 2172. | 2519. | 2992. | 3586. | 4033. | 4176. | 4253. | 5077. | 5887. | 7023. |
| 175. | 1325. | 2129. | 2471. | 2941. | 3529. | 3973. | 4116. | 4195. | 5012. | 5816. | 6946. |
| 200. | 1300. | 2097. | 2437. | 2904. | 3487. | 3930. | 4073. | 4154. | 4966. | 5764. | 6892. |
| 225. | 1275. | 2065. | 2402. | 2867. | 3446. | 3886. | 4029. | 4112. | 4919. | 5712. | 6836. |
| 250. | 1256. | 2042. | 2376. | 2838. | 3414. | 3853. | 3996. | 4081. | 4883. | 5673. | 6794. |
| 275. | 1239. | 2019. | 2352. | 2812. | 3385. | 3822. | 3965. | 4051. | 4850. | 5637. | 6754. |
| 300. | 1225. | 2001. | 2332. | 2791. | 3361. | 3798. | 3940. | 4028. | 4824. | 5607. | 6723. |
| 350. | 1199. | 1969. | 2296. | 2752. | 3318. | 3752. | 3895. | 3984. | 4775. | 5553. | 6665. |
| 400. | 1178. | 1942. | 2267. | 2721. | 3283. | 3715. | 3858. | 3949. | 4735. | 5509. | 6618. |
| 500. | 1147. | 1901. | 2222. | 2673. | 3229. | 3659. | 3802. | 3896. | 4675. | 5442. | 6546. |
| 600. | 1125. | 1873. | 2191. | 2638. | 3191. | 3619. | 3762. | 3859. | 4633. | 5394. | 6495. |
| 700. | 1106. | 1848. | 2163. | 2609. | 3158. | 3585. | 3728. | 3827. | 4596. | 5353. | 6452. |
| 800. | 1089. | 1827. | 2140. | 2584. | 3129. | 3555. | 3698. | 3798. | 4564. | 5317. | 6413. |
| 900. | 1076. | 1810. | 2121. | 2564. | 3107. | 3532. | 3675. | 3777. | 4539. | 5290. | 6384. |
| 1000. | 1065. | 1795. | 2105. | 2546. | 3087. | 3511. | 3654. | 3758. | 4517. | 5265. | 6358. |
| 1250. | 1043. | 1768. | 2074. | 2514. | 3050. | 3473. | 3616. | 3723. | 4477. | 5220. | 6310. |
| 1500. | 1025. | 1744. | 2048. | 2486. | 3018. | 3440. | 3583. | 3692. | 4442. | 5180. | 6268. |
| 1750. | 1010. | 1724. | 2026. | 2462. | 2992. | 3412. | 3555. | 3666. | 4412. | 5147. | 6232. |
| 2000. | 999. | 1711. | 2011. | 2446. | 2974. | 3393. | 3537. | 3649. | 4393. | 5125. | 6209. |
| 2500. | 982. | 1689. | 1987. | 2420. | 2944. | 3363. | 3507. | 3622. | 4362. | 5089. | 6171. |
| 3000. | 969. | 1672. | 1968. | 2400. | 2921. | 3339. | 3484. | 3601. | 4337. | 5061. | 6142. |
| 3500. | 958. | 1657. | 1952. | 2383. | 2902. | 3319. | 3464. | 3583. | 4316. | 5037. | 6117. |
| 4000. | 948. | 1645. | 1938. | 2368. | 2885. | 3302. | 3447. | 3568. | 4298. | 5017. | 6095. |
| 5000. | 932. | 1624. | 1915. | 2344. | 2858. | 3273. | 3418. | 3542. | 4268. | 4982. | 6059. |
| 6000. | 919. | 1607. | 1896. | 2323. | 2834. | 3249. | 3394. | 3520. | 4243. | 4954. | 6029. |
| 7000. | 907. | 1591. | 1879. | 2305. | 2814. | 3228. | 3373. | 3501. | 4221. | 4928. | 6002. |
| 8000. | 896. | 1577. | 1863. | 2289. | 2795. | 3208. | 3354. | 3483. | 4200. | 4905. | 5978. |
| 9000. | 886. | 1564. | 1849. | 2273. | 2777. | 3190. | 3336. | 3467. | 4181. | 4883. | 5955. |
| 10000. | 876. | 1552. | 1834. | 2258. | 2760. | 3172. | 3318. | 3451. | 4162. | 4862. | 5933. |
| 12500. | 852. | 1521. | 1801. | 2222. | 2720. | 3130. | 3277. | 3413. | 4118. | 4812. | 5879. |
| 15000. | 829. | 1491. | 1767. | 2187. | 2679. | 3089. | 3235. | 3375. | 4074. | 4762. | 5827. |
| 17500. | 829. | 1491. | 1767. | 2187. | 2679. | 3089. | 3235. | 3375. | 4074. | 4762. | 5827. |
| 20000. | 829. | 1491. | 1767. | 2187. | 2679. | 3089. | 3235. | 3375. | 4074. | 4762. | 5827. |
| 22500. | 829. | 1491. | 1767. | 2187. | 2679. | 3089. | 3235. | 3375. | 4074. | 4762. | 5827. |

Table 10. Absorptive Cross Sections (millibarns) for Antiberyllium Projectiles

| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | U | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 952. | 1429. | 1636. | 1900. | 2246. | 2485. | 2550. | 2546. | 3021. | 3489. | 4082. |
| 75. | 892. | 1355. | 1556. | 1814. | 2152. | 2385. | 2451. | 2453. | 2916. | 3373. | 3959. |
| 100. | 854. | 1307. | 1503. | 1757. | 2089. | 2320. | 2386. | 2392. | 2848. | 3297. | 3878. |
| 125. | 823. | 1269. | 1462. | 1713. | 2040. | 2269. | 2335. | 2343. | 2793. | 3236. | 3813. |
| 150. | 805. | 1246. | 1437. | 1686. | 2010. | 2238. | 2304. | 2315. | 2761. | 3200. | 3776. |
| 175. | 788. | 1224. | 1413. | 1660. | 1981. | 2207. | 2274. | 2286. | 2728. | 3164. | 3737. |
| 200. | 775. | 1208. | 1395. | 1641. | 1960. | 2185. | 2252. | 2265. | 2705. | 3138. | 3710. |
| 225. | 762. | 1192. | 1378. | 1622. | 1939. | 2163. | 2230. | 2244. | 2681. | 3112. | 3682. |
| 250. | 752. | 1179. | 1364. | 1607. | 1922. | 2146. | 2213. | 2228. | 2663. | 3092. | 3661. |
| 275. | 743. | 1168. | 1352. | 1594. | 1907. | 2131. | 2198. | 2214. | 2647. | 3074. | 3641. |
| 300. | 736. | 1159. | 1342. | 1583. | 1895. | 2118. | 2185. | 2202. | 2633. | 3059. | 3626. |
| 350. | 723. | 1142. | 1324. | 1563. | 1873. | 2095. | 2162. | 2180. | 2609. | 3032. | 3597. |
| 400. | 712. | 1129. | 1309. | 1547. | 1855. | 2077. | 2144. | 2163. | 2589. | 3010. | 3573. |
| 500. | 696. | 1108. | 1286. | 1523. | 1828. | 2048. | 2115. | 2137. | 2559. | 2976. | 3538. |
| 600. | 685. | 1094. | 1270. | 1506. | 1809. | 2028. | 2095. | 2119. | 2538. | 2953. | 3513. |
| 700. | 675. | 1081. | 1257. | 1491. | 1792. | 2011. | 2078. | 2103. | 2520. | 2932. | 3492. |
| 800. | 666. | 1070. | 1245. | 1478. | 1777. | 1996. | 2063. | 2089. | 2504. | 2914. | 3473. |
| 900. | 660. | 1062. | 1235. | 1468. | 1766. | 1984. | 2052. | 2078. | 2492. | 2901. | 3459. |
| 1000. | 654. | 1054. | 1227. | 1460. | 1756. | 1974. | 2042. | 2069. | 2482. | 2889. | 3446. |
| 1250. | 644. | 1041. | 1212. | 1443. | 1738. | 1955. | 2023. | 2052. | 2462. | 2866. | 3422. |
| 1500. | 634. | 1029. | 1199. | 1429. | 1722. | 1939. | 2007. | 2037. | 2445. | 2847. | 3402. |
| 1750. | 627. | 1019. | 1188. | 1418. | 1709. | 1925. | 1993. | 2024. | 2430. | 2830. | 3384. |
| 2000. | 622. | 1013. | 1181. | 1410. | 1700. | 1916. | 1984. | 2017. | 2421. | 2820. | 3374. |
| 2500. | 614. | 1002. | 1169. | 1397. | 1686. | 1901. | 1970. | 2004. | 2406. | 2803. | 3356. |
| 3000. | 607. | 994. | 1160. | 1387. | 1674. | 1890. | 1958. | 1994. | 2394. | 2789. | 3342. |
| 3500. | 602. | 987. | 1152. | 1379. | 1665. | 1880. | 1949. | 1986. | 2385. | 2778. | 3330. |
| 4000. | 597. | 981. | 1146. | 1372. | 1657. | 1872. | 1941. | 1978. | 2376. | 2768. | 3320. |
| 5000. | 589. | 971. | 1135. | 1360. | 1643. | 1858. | 1927. | 1966. | 2362. | 2752. | 3303. |
| 6000. | 583. | 963. | 1126. | 1350. | 1632. | 1846. | 1916. | 1956. | 2350. | 2738. | 3289. |
| 7000. | 577. | 955. | 1117. | 1342. | 1622. | 1836. | 1906. | 1947. | 2340. | 2726. | 3276. |
| 8000. | 572. | 949. | 1110. | 1334. | 1613. | 1826. | 1896. | 1939. | 2330. | 2715. | 3265. |
| 9000. | 567. | 942. | 1102. | 1326. | 1604. | 1818. | 1888. | 1931. | 2321. | 2705. | 3254. |
| 10000. | 562. | 936. | 1096. | 1319. | 1596. | 1809. | 1879. | 1924. | 2312. | 2695. | 3243. |
| 12500. | 551. | 922. | 1079. | 1302. | 1576. | 1789. | 1859. | 1906. | 2291. | 2671. | 3218. |
| 15000. | 540. | 907. | 1063. | 1284. | 1557. | 1769. | 1840. | 1888. | 2271. | 2647. | 3194. |
| 17500. | 540. | 907. | 1063. | 1284. | 1557. | 1769. | 1840. | 1888. | 2271. | 2647. | 3194. |
| 20000. | 540. | 907. | 1063. | 1284. | 1557. | 1769. | 1840. | 1888. | 2271. | 2647. | 3194. |
| 22500. | 540. | 907. | 1063. | 1284. | 1557. | 1769. | 1840. | 1888. | 2271. | 2647. | 3194. |

Table 11. Total Cross Sections (millibarns) for Antiboron Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 1660. | 2550. | 2936. | 3436. | 4087. | 4546. | 4680. | 4699. | 5598. | 6482. | 7639. |
| 75. | 1547. | 2409. | 2781. | 3269. | 3901. | 4353. | 4488. | 4518. | 5393. | 6255. | 7398. |
| 100. | 1474. | 2317. | 2681. | 3161. | 3781. | 4228. | 4362. | 4399. | 5259. | 6106. | 7240. |
| 125. | 1417. | 2244. | 2601. | 3075. | 3686. | 4128. | 4263. | 4304. | 5152. | 5988. | 7114. |
| 150. | 1383. | 2201. | 2554. | 3024. | 3629. | 4069. | 4203. | 4249. | 5090. | 5918. | 7039. |
| 175. | 1350. | 2158. | 2507. | 2974. | 3572. | 4010. | 4144. | 4193. | 5026. | 5848. | 6964. |
| 200. | 1326. | 2127. | 2473. | 2937. | 3531. | 3967. | 4102. | 4153. | 4981. | 5797. | 6911. |
| 225. | 1301. | 2096. | 2439. | 2900. | 3490. | 3924. | 4059. | 4112. | 4935. | 5746. | 6856. |
| 250. | 1283. | 2073. | 2414. | 2873. | 3459. | 3892. | 4027. | 4081. | 4900. | 5707. | 6815. |
| 275. | 1266. | 2051. | 2390. | 2847. | 3430. | 3862. | 3997. | 4053. | 4868. | 5671. | 6776. |
| 300. | 1252. | 2033. | 2371. | 2826. | 3407. | 3837. | 3972. | 4030. | 4842. | 5642. | 6746. |
| 350. | 1228. | 2001. | 2335. | 2788. | 3365. | 3793. | 3928. | 3988. | 4794. | 5589. | 6689. |
| 400. | 1208. | 1975. | 2307. | 2757. | 3330. | 3757. | 3892. | 3954. | 4756. | 5546. | 6643. |
| 500. | 1177. | 1936. | 2264. | 2710. | 3277. | 3702. | 3837. | 3903. | 4697. | 5481. | 6573. |
| 600. | 1156. | 1908. | 2233. | 2677. | 3240. | 3663. | 3798. | 3867. | 4656. | 5435. | 6524. |
| 700. | 1137. | 1884. | 2207. | 2649. | 3208. | 3630. | 3765. | 3836. | 4621. | 5395. | 6482. |
| 800. | 1121. | 1863. | 2183. | 2624. | 3179. | 3600. | 3736. | 3809. | 4590. | 5360. | 6445. |
| 900. | 1109. | 1847. | 2166. | 2605. | 3158. | 3578. | 3714. | 3789. | 4566. | 5333. | 6417. |
| 1000. | 1098. | 1833. | 2150. | 2588. | 3138. | 3558. | 3694. | 3770. | 4545. | 5309. | 6391. |
| 1250. | 1078. | 1807. | 2121. | 2557. | 3103. | 3521. | 3657. | 3737. | 4506. | 5265. | 6345. |
| 1500. | 1060. | 1784. | 2096. | 2529. | 3072. | 3489. | 3625. | 3708. | 4473. | 5227. | 6305. |
| 1750. | 1046. | 1765. | 2074. | 2506. | 3046. | 3462. | 3598. | 3683. | 4444. | 5195. | 6270. |
| 2000. | 1036. | 1752. | 2060. | 2491. | 3029. | 3444. | 3581. | 3667. | 4426. | 5174. | 6248. |
| 2500. | 1020. | 1732. | 2037. | 2467. | 3000. | 3415. | 3552. | 3642. | 4396. | 5140. | 6213. |
| 3000. | 1008. | 1715. | 2019. | 2447. | 2978. | 3392. | 3530. | 3622. | 4373. | 5113. | 6185. |
| 3500. | 998. | 1702. | 2004. | 2431. | 2960. | 3373. | 3511. | 3605. | 4353. | 5090. | 6161. |
| 4000. | 989. | 1690. | 1991. | 2417. | 2944. | 3357. | 3495. | 3591. | 4336. | 5071. | 6141. |
| 5000. | 974. | 1671. | 1969. | 2394. | 2917. | 3329. | 3468. | 3567. | 4308. | 5038. | 6107. |
| 6000. | 961. | 1654. | 1951. | 2375. | 2895. | 3306. | 3445. | 3547. | 4284. | 5011. | 6078. |
| 7000. | 950. | 1640. | 1934. | 2357. | 2875. | 3286. | 3425. | 3529. | 4263. | 4987. | 6053. |
| 8000. | 940. | 1627. | 1920. | 2342. | 2857. | 3267. | 3407. | 3512. | 4244. | 4965. | 6030. |
| 9000. | 930. | 1614. | 1906. | 2327. | 2840. | 3250. | 3390. | 3497. | 4226. | 4944. | 6008. |
| 10000. | 921. | 1602. | 1892. | 2313. | 2824. | 3233. | 3373. | 3482. | 4206. | 4924. | 5987. |
| 12500. | 899. | 1574. | 1860. | 2279. | 2785. | 3193. | 3333. | 3447. | 4167. | 4876. | 5937. |
| 15000. | 878. | 1545. | 1829. | 2245. | 2747. | 3153. | 3294. | 3411. | 4125. | 4829. | 5887. |
| 17500. | 878. | 1545. | 1829. | 2245. | 2747. | 3153. | 3294. | 3411. | 4125. | 4829. | 5887. |
| 20000. | 878. | 1545. | 1829. | 2245. | 2747. | 3153. | 3294. | 3411. | 4125. | 4829. | 5887. |
| 22500. | 878. | 1545. | 1829. | 2245. | 2747. | 3153. | 3294. | 3411. | 4125. | 4829. | 5887. |

Table 12. Absorptive Cross Sections (millibarns) for Antiboron Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 950. | 1430. | 1640. | 1904. | 2259. | 2491. | 2551. | 2526. | 3011. | 3490. | 4072. |
| 75. | 892. | 1357. | 1562. | 1819. | 2164. | 2392. | 2453. | 2435. | 2908. | 3375. | 3951. |
| 100. | 855. | 1310. | 1510. | 1764. | 2102. | 2328. | 2390. | 2376. | 2841. | 3300. | 3872. |
| 125. | 825. | 1273. | 1470. | 1720. | 2053. | 2278. | 2339. | 2328. | 2787. | 3240. | 3808. |
| 150. | 808. | 1251. | 1446. | 1694. | 2024. | 2247. | 2309. | 2301. | 2752. | 3205. | 3771. |
| 175. | 791. | 1229. | 1422. | 1668. | 1995. | 2217. | 2279. | 2272. | 2724. | 3170. | 3734. |
| 200. | 779. | 1214. | 1405. | 1649. | 1974. | 2196. | 2257. | 2253. | 2701. | 3144. | 3707. |
| 225. | 766. | 1198. | 1387. | 1630. | 1953. | 2174. | 2235. | 2232. | 2677. | 3118. | 3679. |
| 250. | 757. | 1186. | 1374. | 1616. | 1937. | 2157. | 2219. | 2217. | 2660. | 3099. | 3659. |
| 275. | 748. | 1174. | 1362. | 1603. | 1922. | 2142. | 2204. | 2202. | 2644. | 3081. | 3640. |
| 300. | 741. | 1166. | 1352. | 1592. | 1910. | 2130. | 2192. | 2191. | 2631. | 3066. | 3624. |
| 350. | 728. | 1149. | 1334. | 1573. | 1889. | 2107. | 2169. | 2170. | 2607. | 3039. | 3596. |
| 400. | 718. | 1136. | 1320. | 1557. | 1871. | 2089. | 2151. | 2153. | 2588. | 3018. | 3573. |
| 500. | 702. | 1116. | 1298. | 1533. | 1844. | 2061. | 2123. | 2128. | 2559. | 2985. | 3539. |
| 600. | 691. | 1102. | 1282. | 1517. | 1825. | 2041. | 2104. | 2110. | 2539. | 2962. | 3515. |
| 700. | 682. | 1090. | 1269. | 1503. | 1809. | 2024. | 2087. | 2095. | 2521. | 2942. | 3494. |
| 800. | 674. | 1080. | 1257. | 1490. | 1795. | 2010. | 2073. | 2082. | 2506. | 2925. | 3475. |
| 900. | 668. | 1072. | 1249. | 1480. | 1784. | 1998. | 2062. | 2072. | 2494. | 2911. | 3462. |
| 1000. | 662. | 1064. | 1241. | 1472. | 1774. | 1988. | 2052. | 2063. | 2484. | 2900. | 3449. |
| 1250. | 652. | 1052. | 1226. | 1456. | 1756. | 1970. | 2034. | 2047. | 2465. | 2878. | 3427. |
| 1500. | 643. | 1040. | 1214. | 1443. | 1741. | 1954. | 2018. | 2033. | 2448. | 2859. | 3407. |
| 1750. | 636. | 1030. | 1203. | 1431. | 1727. | 1940. | 2004. | 2020. | 2434. | 2843. | 3390. |
| 2000. | 631. | 1024. | 1196. | 1424. | 1719. | 1932. | 1996. | 2013. | 2425. | 2833. | 3380. |
| 2500. | 624. | 1015. | 1185. | 1412. | 1705. | 1918. | 1982. | 2001. | 2411. | 2817. | 3363. |
| 3000. | 618. | 1007. | 1176. | 1402. | 1694. | 1907. | 1971. | 1992. | 2400. | 2804. | 3349. |
| 3500. | 613. | 1000. | 1169. | 1394. | 1685. | 1897. | 1962. | 1984. | 2391. | 2793. | 3338. |
| 4000. | 609. | 995. | 1163. | 1388. | 1677. | 1889. | 1955. | 1977. | 2383. | 2784. | 3328. |
| 5000. | 601. | 985. | 1152. | 1376. | 1664. | 1876. | 1941. | 1966. | 2369. | 2768. | 3312. |
| 6000. | 595. | 977. | 1143. | 1367. | 1654. | 1865. | 1931. | 1956. | 2358. | 2755. | 3299. |
| 7000. | 590. | 970. | 1136. | 1358. | 1644. | 1855. | 1921. | 1948. | 2348. | 2743. | 3287. |
| 8000. | 585. | 964. | 1128. | 1351. | 1635. | 1846. | 1912. | 1940. | 2339. | 2733. | 3276. |
| 9000. | 581. | 958. | 1122. | 1344. | 1627. | 1837. | 1904. | 1933. | 2330. | 2723. | 3266. |
| 10000. | 576. | 952. | 1115. | 1337. | 1619. | 1829. | 1896. | 1926. | 2322. | 2713. | 3256. |
| 12500. | 566. | 939. | 1100. | 1320. | 1600. | 1810. | 1877. | 1910. | 2303. | 2690. | 3232. |
| 15000. | 555. | 925. | 1085. | 1304. | 1581. | 1791. | 1858. | 1893. | 2283. | 2668. | 3209. |
| 17500. | 555. | 925. | 1085. | 1304. | 1581. | 1791. | 1858. | 1893. | 2283. | 2668. | 3209. |
| 20000. | 555. | 925. | 1085. | 1304. | 1581. | 1791. | 1858. | 1893. | 2283. | 2668. | 3209. |
| 22500. | 555. | 925. | 1085. | 1304. | 1581. | 1791. | 1858. | 1893. | 2283. | 2668. | 3209. |

Table 13. Total Cross Sections (millibarns) for Anticarbon Projectiles

| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 1679. | 2576. | 2965. | 3465. | 4124. | 4581. | 4711. | 4714. | 5623. | 6518. | 7670. |
| 75. | 1568. | 2435. | 2811. | 3300. | 3939. | 4388. | 4520. | 4534. | 5420. | 6292. | 7431. |
| 100. | 1495. | 2343. | 2711. | 3192. | 3818. | 4263. | 4395. | 4417. | 5287. | 6144. | 7274. |
| 125. | 1438. | 2271. | 2632. | 3106. | 3723. | 4164. | 4296. | 4323. | 5181. | 6026. | 7148. |
| 150. | 1405. | 2228. | 2585. | 3056. | 3666. | 4105. | 4237. | 4269. | 5119. | 5957. | 7075. |
| 175. | 1371. | 2185. | 2539. | 3005. | 3610. | 4046. | 4178. | 4213. | 5056. | 5887. | 7000. |
| 200. | 1348. | 2155. | 2505. | 2969. | 3569. | 4004. | 4136. | 4174. | 5011. | 5837. | 6947. |
| 225. | 1323. | 2123. | 2471. | 2932. | 3528. | 3961. | 4093. | 4133. | 4965. | 5786. | 6892. |
| 250. | 1305. | 2100. | 2445. | 2905. | 3497. | 3929. | 4061. | 4103. | 4931. | 5747. | 6852. |
| 275. | 1288. | 2079. | 2422. | 2879. | 3469. | 3899. | 4031. | 4074. | 4899. | 5712. | 6814. |
| 300. | 1275. | 2061. | 2403. | 2859. | 3445. | 3875. | 4007. | 4052. | 4873. | 5683. | 6783. |
| 350. | 1250. | 2029. | 2368. | 2821. | 3403. | 3830. | 3963. | 4011. | 4826. | 5630. | 6727. |
| 400. | 1230. | 2004. | 2339. | 2790. | 3368. | 3795. | 3927. | 3977. | 4788. | 5587. | 6681. |
| 500. | 1200. | 1964. | 2296. | 2743. | 3316. | 3740. | 3872. | 3926. | 4730. | 5522. | 6612. |
| 600. | 1179. | 1937. | 2266. | 2711. | 3279. | 3701. | 3834. | 3891. | 4689. | 5476. | 6564. |
| 700. | 1161. | 1913. | 2240. | 2683. | 3247. | 3668. | 3801. | 3861. | 4654. | 5437. | 6522. |
| 800. | 1145. | 1893. | 2217. | 2658. | 3219. | 3639. | 3772. | 3834. | 4623. | 5402. | 6485. |
| 900. | 1133. | 1877. | 2199. | 2639. | 3197. | 3617. | 3750. | 3814. | 4600. | 5376. | 6458. |
| 1000. | 1122. | 1863. | 2183. | 2622. | 3178. | 3597. | 3730. | 3796. | 4579. | 5352. | 6433. |
| 1250. | 1102. | 1837. | 2154. | 2591. | 3143. | 3560. | 3694. | 3764. | 4541. | 5309. | 6387. |
| 1500. | 1085. | 1814. | 2130. | 2564. | 3112. | 3528. | 3663. | 3735. | 4508. | 5271. | 6347. |
| 1750. | 1070. | 1795. | 2108. | 2541. | 3086. | 3501. | 3636. | 3710. | 4480. | 5239. | 6313. |
| 2000. | 1060. | 1783. | 2094. | 2526. | 3069. | 3484. | 3619. | 3695. | 4462. | 5218. | 6292. |
| 2500. | 1045. | 1762. | 2072. | 2502. | 3041. | 3455. | 3591. | 3670. | 4433. | 5185. | 6257. |
| 3000. | 1033. | 1746. | 2054. | 2483. | 3019. | 3433. | 3569. | 3651. | 4410. | 5158. | 6229. |
| 3500. | 1023. | 1733. | 2039. | 2467. | 3001. | 3414. | 3550. | 3635. | 4391. | 5136. | 6206. |
| 4000. | 1014. | 1722. | 2026. | 2453. | 2986. | 3398. | 3535. | 3621. | 4374. | 5117. | 6186. |
| 5000. | 999. | 1703. | 2005. | 2431. | 2959. | 3371. | 3508. | 3597. | 4347. | 5085. | 6153. |
| 6000. | 987. | 1686. | 1987. | 2411. | 2937. | 3348. | 3486. | 3578. | 4323. | 5058. | 6125. |
| 7000. | 976. | 1672. | 1971. | 2394. | 2918. | 3328. | 3466. | 3560. | 4303. | 5035. | 6100. |
| 8000. | 966. | 1659. | 1956. | 2379. | 2900. | 3310. | 3448. | 3544. | 4284. | 5013. | 6077. |
| 9000. | 957. | 1647. | 1942. | 2364. | 2883. | 3293. | 3431. | 3529. | 4266. | 4992. | 6056. |
| 10000. | 948. | 1635. | 1929. | 2350. | 2867. | 3276. | 3415. | 3515. | 4249. | 4973. | 6036. |
| 12500. | 926. | 1607. | 1898. | 2317. | 2829. | 3237. | 3376. | 3480. | 4208. | 4926. | 5987. |
| 15000. | 905. | 1579. | 1866. | 2283. | 2791. | 3197. | 3337. | 3446. | 4168. | 4880. | 5938. |
| 17500. | 905. | 1579. | 1866. | 2283. | 2791. | 3197. | 3337. | 3446. | 4168. | 4880. | 5938. |
| 20000. | 905. | 1579. | 1866. | 2283. | 2791. | 3197. | 3337. | 3446. | 4168. | 4880. | 5938. |
| 22500. | 905. | 1579. | 1866. | 2283. | 2791. | 3197. | 3337. | 3446. | 4168. | 4880. | 5938. |

Table 14. Absorptive Cross Sections (millibarns) for Anticarbon Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 956. | 1439. | 1652. | 1916. | 2275. | 2505. | 2563. | 2528. | 3019. | 3504. | 4083. |
| 75. | 899. | 1367. | 1573. | 1831. | 2180. | 2407. | 2466. | 2438. | 2917. | 3390. | 3963. |
| 100. | 862. | 1320. | 1523. | 1776. | 2118. | 2344. | 2402. | 2379. | 2850. | 3315. | 3884. |
| 125. | 833. | 1283. | 1482. | 1732. | 2069. | 2293. | 2352. | 2332. | 2797. | 3256. | 3821. |
| 150. | 816. | 1262. | 1458. | 1707. | 2040. | 2263. | 2322. | 2305. | 2766. | 3221. | 3784. |
| 175. | 799. | 1240. | 1434. | 1681. | 2011. | 2233. | 2292. | 2277. | 2734. | 3185. | 3747. |
| 200. | 786. | 1224. | 1417. | 1662. | 1991. | 2211. | 2271. | 2258. | 2712. | 3160. | 3720. |
| 225. | 774. | 1208. | 1400. | 1643. | 1970. | 2189. | 2249. | 2237. | 2688. | 3134. | 3693. |
| 250. | 765. | 1196. | 1387. | 1629. | 1954. | 2173. | 2233. | 2222. | 2671. | 3115. | 3673. |
| 275. | 756. | 1185. | 1375. | 1616. | 1939. | 2158. | 2218. | 2208. | 2655. | 3097. | 3653. |
| 300. | 749. | 1177. | 1365. | 1606. | 1927. | 2145. | 2205. | 2197. | 2642. | 3082. | 3638. |
| 350. | 736. | 1160. | 1347. | 1586. | 1905. | 2123. | 2183. | 2176. | 2618. | 3056. | 3610. |
| 400. | 726. | 1147. | 1333. | 1571. | 1888. | 2105. | 2165. | 2160. | 2599. | 3034. | 3587. |
| 500. | 711. | 1127. | 1311. | 1547. | 1861. | 2077. | 2137. | 2135. | 2570. | 3002. | 3553. |
| 600. | 700. | 1114. | 1296. | 1531. | 1842. | 2058. | 2118. | 2118. | 2551. | 2979. | 3529. |
| 700. | 691. | 1102. | 1283. | 1516. | 1826. | 2041. | 2102. | 2103. | 2533. | 2959. | 3509. |
| 800. | 683. | 1091. | 1271. | 1504. | 1812. | 2026. | 2087. | 2089. | 2518. | 2942. | 3491. |
| 900. | 677. | 1083. | 1262. | 1494. | 1801. | 2015. | 2076. | 2079. | 2507. | 2929. | 3477. |
| 1000. | 671. | 1076. | 1255. | 1486. | 1791. | 2005. | 2067. | 2071. | 2496. | 2917. | 3465. |
| 1250. | 662. | 1064. | 1240. | 1471. | 1774. | 1987. | 2049. | 2055. | 2478. | 2896. | 3443. |
| 1500. | 653. | 1052. | 1228. | 1457. | 1758. | 1971. | 2033. | 2041. | 2461. | 2877. | 3423. |
| 1750. | 646. | 1043. | 1217. | 1445. | 1745. | 1957. | 2020. | 2029. | 2447. | 2861. | 3406. |
| 2000. | 641. | 1037. | 1210. | 1438. | 1737. | 1949. | 2011. | 2022. | 2439. | 2851. | 3396. |
| 2500. | 634. | 1027. | 1200. | 1427. | 1723. | 1935. | 1998. | 2010. | 2425. | 2835. | 3379. |
| 3000. | 628. | 1019. | 1191. | 1417. | 1712. | 1924. | 1987. | 2001. | 2414. | 2822. | 3366. |
| 3500. | 623. | 1013. | 1184. | 1410. | 1703. | 1915. | 1978. | 1994. | 2405. | 2812. | 3355. |
| 4000. | 619. | 1008. | 1178. | 1403. | 1696. | 1907. | 1971. | 1987. | 2397. | 2803. | 3346. |
| 5000. | 612. | 998. | 1167. | 1392. | 1683. | 1894. | 1958. | 1976. | 2384. | 2787. | 3330. |
| 6000. | 606. | 991. | 1159. | 1382. | 1672. | 1883. | 1947. | 1967. | 2373. | 2774. | 3317. |
| 7000. | 601. | 984. | 1151. | 1374. | 1663. | 1873. | 1938. | 1959. | 2363. | 2763. | 3305. |
| 8000. | 596. | 978. | 1144. | 1367. | 1654. | 1864. | 1929. | 1951. | 2354. | 2753. | 3294. |
| 9000. | 591. | 972. | 1137. | 1360. | 1646. | 1856. | 1921. | 1944. | 2346. | 2743. | 3284. |
| 10000. | 587. | 966. | 1131. | 1353. | 1638. | 1848. | 1913. | 1937. | 2338. | 2733. | 3275. |
| 12500. | 577. | 953. | 1116. | 1337. | 1619. | 1829. | 1894. | 1921. | 2319. | 2711. | 3252. |
| 15000. | 567. | 939. | 1101. | 1321. | 1601. | 1810. | 1876. | 1905. | 2300. | 2689. | 3229. |
| 17500. | 567. | 939. | 1101. | 1321. | 1601. | 1810. | 1876. | 1905. | 2300. | 2689. | 3229. |
| 20000. | 567. | 939. | 1101. | 1321. | 1601. | 1810. | 1876. | 1905. | 2300. | 2689. | 3229. |
| 22500. | 567. | 939. | 1101. | 1321. | 1601. | 1810. | 1876. | 1905. | 2300. | 2689. | 3229. |

Table 15. Total Cross Sections (millibarns) for Antinitrogen Projectiles

| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 1817. | 2749. | 3152. | 3670. | 4348. | 4818. | 4953. | 4960. | 5890. | 6804. | 7983. |
| 75. | 1700. | 2603. | 2993. | 3499. | 4157. | 4620. | 4756. | 4775. | 5681. | 6572. | 7738. |
| 100. | 1624. | 2508. | 2889. | 3387. | 4034. | 4492. | 4627. | 4654. | 5545. | 6421. | 7577. |
| 125. | 1564. | 2432. | 2807. | 3299. | 3936. | 4390. | 4525. | 4556. | 5435. | 6300. | 7449. |
| 150. | 1529. | 2388. | 2758. | 3247. | 3877. | 4329. | 4464. | 4500. | 5371. | 6229. | 7373. |
| 175. | 1493. | 2343. | 2710. | 3195. | 3819. | 4268. | 4404. | 4442. | 5306. | 6157. | 7297. |
| 200. | 1468. | 2312. | 2675. | 3157. | 3777. | 4225. | 4361. | 4402. | 5260. | 6106. | 7242. |
| 225. | 1443. | 2279. | 2640. | 3119. | 3735. | 4180. | 4316. | 4360. | 5213. | 6053. | 7186. |
| 250. | 1424. | 2255. | 2614. | 3091. | 3703. | 4147. | 4283. | 4329. | 5178. | 6014. | 7145. |
| 275. | 1406. | 2233. | 2589. | 3064. | 3673. | 4116. | 4252. | 4299. | 5145. | 5977. | 7105. |
| 300. | 1392. | 2214. | 2569. | 3043. | 3649. | 4091. | 4227. | 4276. | 5118. | 5948. | 7074. |
| 350. | 1366. | 2181. | 2533. | 3003. | 3605. | 4046. | 4182. | 4233. | 5070. | 5894. | 7017. |
| 400. | 1345. | 2154. | 2503. | 2972. | 3570. | 4009. | 4145. | 4198. | 5030. | 5850. | 6970. |
| 500. | 1313. | 2114. | 2458. | 2923. | 3515. | 3952. | 4089. | 4146. | 4970. | 5783. | 6899. |
| 600. | 1291. | 2085. | 2427. | 2889. | 3477. | 3912. | 4049. | 4110. | 4929. | 5736. | 6849. |
| 700. | 1271. | 2060. | 2400. | 2860. | 3444. | 3878. | 4015. | 4078. | 4893. | 5696. | 6807. |
| 800. | 1254. | 2039. | 2376. | 2834. | 3415. | 3848. | 3985. | 4050. | 4861. | 5660. | 6769. |
| 900. | 1242. | 2022. | 2358. | 2815. | 3393. | 3825. | 3963. | 4030. | 4837. | 5633. | 6740. |
| 1000. | 1230. | 2007. | 2341. | 2797. | 3373. | 3805. | 3942. | 4011. | 4815. | 5608. | 6714. |
| 1250. | 1209. | 1980. | 2311. | 2765. | 3336. | 3767. | 3905. | 3977. | 4776. | 5564. | 6668. |
| 1500. | 1191. | 1957. | 2285. | 2737. | 3305. | 3734. | 3872. | 3947. | 4742. | 5525. | 6627. |
| 1750. | 1175. | 1937. | 2263. | 2713. | 3278. | 3706. | 3845. | 3921. | 4713. | 5492. | 6592. |
| 2000. | 1165. | 1924. | 2249. | 2698. | 3260. | 3688. | 3827. | 3906. | 4694. | 5471. | 6570. |
| 2500. | 1149. | 1903. | 2225. | 2673. | 3231. | 3659. | 3798. | 3880. | 4664. | 5436. | 6534. |
| 3000. | 1136. | 1886. | 2206. | 2653. | 3209. | 3635. | 3775. | 3860. | 4640. | 5409. | 6505. |
| 3500. | 1125. | 1872. | 2191. | 2636. | 3190. | 3616. | 3756. | 3843. | 4621. | 5386. | 6482. |
| 4000. | 1116. | 1860. | 2178. | 2622. | 3174. | 3599. | 3740. | 3829. | 4604. | 5366. | 6461. |
| 5000. | 1100. | 1840. | 2155. | 2598. | 3146. | 3571. | 3712. | 3804. | 4575. | 5334. | 6427. |
| 6000. | 1087. | 1823. | 2136. | 2578. | 3124. | 3548. | 3689. | 3784. | 4551. | 5306. | 6398. |
| 7000. | 1076. | 1808. | 2120. | 2561. | 3104. | 3527. | 3669. | 3766. | 4530. | 5282. | 6373. |
| 8000. | 1065. | 1794. | 2105. | 2544. | 3085. | 3508. | 3650. | 3749. | 4510. | 5259. | 6349. |
| 9000. | 1055. | 1782. | 2090. | 2529. | 3068. | 3490. | 3632. | 3734. | 4492. | 5238. | 6327. |
| 10000. | 1045. | 1769. | 2077. | 2515. | 3051. | 3473. | 3616. | 3719. | 4474. | 5218. | 6306. |
| 12500. | 1023. | 1740. | 2044. | 2480. | 3012. | 3432. | 3575. | 3683. | 4432. | 5170. | 6256. |
| 15000. | 1000. | 1711. | 2011. | 2445. | 2972. | 3392. | 3535. | 3647. | 4390. | 5122. | 6206. |
| 17500. | 1000. | 1711. | 2011. | 2445. | 2972. | 3392. | 3535. | 3647. | 4390. | 5122. | 6206. |
| 20000. | 1000. | 1711. | 2011. | 2445. | 2972. | 3392. | 3535. | 3647. | 4390. | 5122. | 6206. |
| 22500. | 1000. | 1711. | 2011. | 2445. | 2972. | 3392. | 3535. | 3647. | 4390. | 5122. | 6206. |

Table 16. Absorptive Cross Sections (millibarns) for Antinitrogen Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 1032. | 1533. | 1752. | 2025. | 2394. | 2631. | 2691. | 2659. | 3160. | 3655. | 4247. |
| 75. | 972. | 1456. | 1671. | 1938. | 2297. | 2530. | 2591. | 2566. | 3055. | 3538. | 4124. |
| 100. | 934. | 1410. | 1618. | 1881. | 2233. | 2465. | 2526. | 2505. | 2986. | 3461. | 4043. |
| 125. | 903. | 1371. | 1576. | 1836. | 2183. | 2413. | 2474. | 2456. | 2931. | 3400. | 3979. |
| 150. | 885. | 1349. | 1552. | 1809. | 2153. | 2382. | 2443. | 2429. | 2899. | 3364. | 3941. |
| 175. | 867. | 1326. | 1527. | 1782. | 2123. | 2351. | 2412. | 2400. | 2867. | 3328. | 3903. |
| 200. | 854. | 1310. | 1509. | 1763. | 2102. | 2329. | 2390. | 2380. | 2844. | 3302. | 3876. |
| 225. | 841. | 1293. | 1491. | 1744. | 2080. | 2306. | 2368. | 2358. | 2820. | 3275. | 3847. |
| 250. | 831. | 1281. | 1478. | 1729. | 2064. | 2289. | 2351. | 2343. | 2802. | 3256. | 3827. |
| 275. | 822. | 1269. | 1465. | 1716. | 2048. | 2273. | 2335. | 2328. | 2785. | 3237. | 3807. |
| 300. | 815. | 1260. | 1455. | 1705. | 2036. | 2261. | 2323. | 2317. | 2772. | 3222. | 3791. |
| 350. | 801. | 1243. | 1437. | 1685. | 2014. | 2238. | 2300. | 2295. | 2748. | 3195. | 3763. |
| 400. | 791. | 1230. | 1422. | 1669. | 1995. | 2219. | 2281. | 2278. | 2728. | 3173. | 3739. |
| 500. | 774. | 1209. | 1399. | 1644. | 1968. | 2190. | 2253. | 2252. | 2698. | 3139. | 3704. |
| 600. | 763. | 1195. | 1383. | 1627. | 1948. | 2170. | 2233. | 2234. | 2678. | 3116. | 3680. |
| 700. | 753. | 1182. | 1370. | 1612. | 1932. | 2153. | 2216. | 2219. | 2660. | 3096. | 3659. |
| 800. | 745. | 1171. | 1358. | 1599. | 1917. | 2138. | 2201. | 2205. | 2644. | 3078. | 3640. |
| 900. | 738. | 1163. | 1349. | 1589. | 1906. | 2126. | 2190. | 2195. | 2632. | 3065. | 3626. |
| 1000. | 733. | 1156. | 1340. | 1581. | 1896. | 2116. | 2180. | 2186. | 2622. | 3053. | 3613. |
| 1250. | 722. | 1142. | 1326. | 1565. | 1878. | 2097. | 2161. | 2169. | 2603. | 3031. | 3591. |
| 1500. | 713. | 1131. | 1313. | 1551. | 1862. | 2081. | 2145. | 2155. | 2586. | 3012. | 3570. |
| 1750. | 705. | 1121. | 1302. | 1539. | 1848. | 2067. | 2131. | 2142. | 2571. | 2995. | 3553. |
| 2000. | 700. | 1114. | 1295. | 1531. | 1839. | 2058. | 2123. | 2135. | 2562. | 2985. | 3543. |
| 2500. | 693. | 1104. | 1283. | 1519. | 1825. | 2044. | 2109. | 2123. | 2548. | 2968. | 3526. |
| 3000. | 686. | 1096. | 1274. | 1509. | 1814. | 2032. | 2098. | 2113. | 2537. | 2955. | 3512. |
| 3500. | 681. | 1089. | 1267. | 1501. | 1805. | 2023. | 2088. | 2105. | 2527. | 2944. | 3501. |
| 4000. | 677. | 1084. | 1260. | 1494. | 1797. | 2015. | 2081. | 2099. | 2519. | 2935. | 3491. |
| 5000. | 669. | 1074. | 1250. | 1483. | 1784. | 2001. | 2067. | 2087. | 2506. | 2919. | 3475. |
| 6000. | 663. | 1066. | 1241. | 1473. | 1772. | 1990. | 2056. | 2077. | 2494. | 2906. | 3461. |
| 7000. | 658. | 1059. | 1232. | 1464. | 1763. | 1980. | 2046. | 2069. | 2484. | 2894. | 3449. |
| 8000. | 653. | 1052. | 1225. | 1457. | 1754. | 1971. | 2037. | 2061. | 2475. | 2883. | 3438. |
| 9000. | 648. | 1046. | 1218. | 1449. | 1745. | 1962. | 2029. | 2054. | 2466. | 2873. | 3427. |
| 10000. | 643. | 1040. | 1212. | 1442. | 1737. | 1954. | 2021. | 2047. | 2458. | 2863. | 3417. |
| 12500. | 632. | 1026. | 1196. | 1425. | 1718. | 1934. | 2001. | 2030. | 2438. | 2840. | 3394. |
| 15000. | 622. | 1012. | 1180. | 1409. | 1699. | 1914. | 1982. | 2013. | 2418. | 2817. | 3370. |
| 17500. | 622. | 1012. | 1180. | 1409. | 1699. | 1914. | 1982. | 2013. | 2418. | 2817. | 3370. |
| 20000. | 622. | 1012. | 1180. | 1409. | 1699. | 1914. | 1982. | 2013. | 2418. | 2817. | 3370. |
| 22500. | 622. | 1012. | 1180. | 1409. | 1699. | 1914. | 1982. | 2013. | 2418. | 2817. | 3370. |

Table 17. Total Cross Sections (millibarns) for Antioxygen Projectiles

| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 1985. | 2959. | 3376. | 3915. | 4613. | 5101. | 5242. | 5261. | 6212. | 7146. | 8359. |
| 75. | 1860. | 2805. | 3209. | 3736. | 4416. | 4896. | 5038. | 5068. | 5996. | 6907. | 8106. |
| 100. | 1780. | 2706. | 3101. | 3621. | 4288. | 4763. | 4905. | 4942. | 5854. | 6751. | 7941. |
| 125. | 1716. | 2627. | 3016. | 3529. | 4186. | 4657. | 4799. | 4840. | 5741. | 6626. | 7808. |
| 150. | 1679. | 2580. | 2969. | 3474. | 4125. | 4594. | 4736. | 4782. | 5675. | 6552. | 7730. |
| 175. | 1642. | 2533. | 2914. | 3420. | 4065. | 4531. | 4673. | 4722. | 5608. | 6478. | 7651. |
| 200. | 1615. | 2500. | 2878. | 3381. | 4021. | 4486. | 4628. | 4680. | 5560. | 6425. | 7595. |
| 225. | 1588. | 2466. | 2841. | 3341. | 3977. | 4440. | 4582. | 4636. | 5511. | 6371. | 7537. |
| 250. | 1567. | 2441. | 2813. | 3311. | 3944. | 4406. | 4548. | 4603. | 5474. | 6330. | 7494. |
| 275. | 1549. | 2417. | 2788. | 3284. | 3913. | 4373. | 4516. | 4573. | 5440. | 6293. | 7454. |
| 300. | 1533. | 2398. | 2767. | 3261. | 3888. | 4348. | 4490. | 4548. | 5413. | 6262. | 7422. |
| 350. | 1506. | 2363. | 2729. | 3220. | 3843. | 4300. | 4443. | 4504. | 5362. | 6206. | 7362. |
| 400. | 1483. | 2335. | 2698. | 3187. | 3806. | 4262. | 4404. | 4467. | 5321. | 6161. | 7314. |
| 500. | 1449. | 2292. | 2651. | 3136. | 3749. | 4203. | 4346. | 4413. | 5259. | 6091. | 7241. |
| 600. | 1425. | 2261. | 2618. | 3101. | 3709. | 4162. | 4305. | 4375. | 5216. | 6043. | 7189. |
| 700. | 1405. | 2235. | 2589. | 3070. | 3675. | 4126. | 4269. | 4342. | 5178. | 6001. | 7145. |
| 800. | 1386. | 2213. | 2564. | 3043. | 3645. | 4095. | 4238. | 4312. | 5145. | 5964. | 7106. |
| 900. | 1373. | 2195. | 2545. | 3023. | 3622. | 4071. | 4214. | 4291. | 5120. | 5936. | 7076. |
| 1000. | 1360. | 2179. | 2528. | 3004. | 3601. | 4049. | 4193. | 4271. | 5098. | 5911. | 7050. |
| 1250. | 1338. | 2151. | 2496. | 2970. | 3563. | 4010. | 4154. | 4236. | 5057. | 5864. | 7001. |
| 1500. | 1318. | 2126. | 2468. | 2941. | 3530. | 3976. | 4120. | 4204. | 5021. | 5824. | 6959. |
| 1750. | 1301. | 2105. | 2445. | 2916. | 3502. | 3947. | 4091. | 4177. | 4991. | 5790. | 6922. |
| 2000. | 1290. | 2091. | 2430. | 2900. | 3483. | 3928. | 4073. | 4161. | 4971. | 5768. | 6899. |
| 2500. | 1273. | 2068. | 2405. | 2873. | 3453. | 3897. | 4042. | 4134. | 4940. | 5732. | 6862. |
| 3000. | 1258. | 2051. | 2385. | 2853. | 3429. | 3872. | 4018. | 4112. | 4915. | 5703. | 6832. |
| 3500. | 1247. | 2036. | 2369. | 2835. | 3410. | 3852. | 3998. | 4095. | 4894. | 5680. | 6808. |
| 4000. | 1237. | 2023. | 2355. | 2820. | 3393. | 3835. | 3981. | 4079. | 4876. | 5659. | 6786. |
| 5000. | 1220. | 2002. | 2331. | 2795. | 3364. | 3805. | 3952. | 4054. | 4846. | 5625. | 6751. |
| 6000. | 1205. | 1984. | 2311. | 2774. | 3340. | 3781. | 3928. | 4032. | 4821. | 5596. | 6721. |
| 7000. | 1193. | 1968. | 2293. | 2755. | 3319. | 3759. | 3907. | 4013. | 4799. | 5571. | 6694. |
| 8000. | 1181. | 1953. | 2277. | 2738. | 3300. | 3739. | 3887. | 3995. | 4778. | 5548. | 6670. |
| 9000. | 1170. | 1939. | 2262. | 2722. | 3281. | 3721. | 3869. | 3979. | 4759. | 5526. | 6647. |
| 10000. | 1160. | 1926. | 2248. | 2707. | 3264. | 3703. | 3851. | 3963. | 4741. | 5505. | 6625. |
| 12500. | 1135. | 1895. | 2213. | 2670. | 3223. | 3660. | 3809. | 3925. | 4697. | 5455. | 6572. |
| 15000. | 1110. | 1864. | 2178. | 2634. | 3181. | 3617. | 3767. | 3887. | 4653. | 5405. | 6520. |
| 17500. | 1110. | 1864. | 2178. | 2634. | 3181. | 3617. | 3767. | 3887. | 4653. | 5405. | 6520. |
| 20000. | 1110. | 1864. | 2178. | 2634. | 3181. | 3617. | 3767. | 3887. | 4653. | 5405. | 6520. |
| 22500. | 1110. | 1864. | 2178. | 2634. | 3181. | 3617. | 3767. | 3887. | 4653. | 5405. | 6520. |

Table 18. Absorptive Cross Sections (millibarns) for Antioxygen Projectiles

| ENERGY MEV/AMU | HE | C | U | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 1126. | 1647. | 1874. | 2157. | 2536. | 2782. | 2845. | 2819. | 3331. | 3835. | 4445. |
| 75. | 1063. | 1569. | 1789. | 2066. | 2435. | 2677. | 2741. | 2723. | 3222. | 3714. | 4318. |
| 100. | 1022. | 1518. | 1734. | 2007. | 2369. | 2610. | 2674. | 2660. | 3151. | 3636. | 4235. |
| 125. | 989. | 1478. | 1691. | 1960. | 2317. | 2556. | 2620. | 2609. | 3094. | 3573. | 4169. |
| 150. | 970. | 1454. | 1665. | 1932. | 2286. | 2524. | 2588. | 2580. | 3061. | 3536. | 4130. |
| 175. | 951. | 1431. | 1639. | 1905. | 2255. | 2492. | 2557. | 2550. | 3027. | 3498. | 4090. |
| 200. | 937. | 1414. | 1620. | 1885. | 2233. | 2469. | 2534. | 2529. | 3003. | 3472. | 4062. |
| 225. | 923. | 1396. | 1602. | 1864. | 2211. | 2445. | 2511. | 2507. | 2979. | 3444. | 4033. |
| 250. | 913. | 1383. | 1588. | 1849. | 2194. | 2428. | 2493. | 2490. | 2960. | 3424. | 4012. |
| 275. | 903. | 1371. | 1574. | 1835. | 2178. | 2412. | 2477. | 2475. | 2943. | 3405. | 3992. |
| 300. | 895. | 1362. | 1564. | 1824. | 2165. | 2398. | 2464. | 2463. | 2929. | 3389. | 3976. |
| 350. | 881. | 1344. | 1545. | 1803. | 2142. | 2374. | 2440. | 2441. | 2904. | 3361. | 3946. |
| 400. | 870. | 1330. | 1529. | 1786. | 2123. | 2355. | 2421. | 2423. | 2884. | 3338. | 3922. |
| 500. | 852. | 1308. | 1505. | 1760. | 2094. | 2325. | 2391. | 2396. | 2853. | 3304. | 3885. |
| 600. | 840. | 1293. | 1489. | 1743. | 2074. | 2305. | 2371. | 2377. | 2831. | 3280. | 3860. |
| 700. | 830. | 1280. | 1474. | 1727. | 2057. | 2287. | 2353. | 2361. | 2813. | 3259. | 3838. |
| 800. | 821. | 1268. | 1462. | 1713. | 2042. | 2271. | 2337. | 2346. | 2796. | 3240. | 3819. |
| 900. | 814. | 1259. | 1452. | 1703. | 2030. | 2259. | 2326. | 2336. | 2784. | 3226. | 3805. |
| 1000. | 808. | 1252. | 1443. | 1694. | 2020. | 2248. | 2315. | 2326. | 2773. | 3214. | 3791. |
| 1250. | 797. | 1237. | 1428. | 1677. | 2001. | 2229. | 2296. | 2309. | 2753. | 3191. | 3768. |
| 1500. | 787. | 1225. | 1414. | 1663. | 1984. | 2212. | 2279. | 2294. | 2736. | 3171. | 3747. |
| 1750. | 778. | 1214. | 1403. | 1650. | 1970. | 2197. | 2265. | 2281. | 2721. | 3154. | 3729. |
| 2000. | 773. | 1208. | 1395. | 1642. | 1961. | 2188. | 2256. | 2273. | 2711. | 3144. | 3718. |
| 2500. | 765. | 1197. | 1383. | 1629. | 1946. | 2173. | 2241. | 2260. | 2696. | 3126. | 3700. |
| 3000. | 758. | 1188. | 1374. | 1619. | 1934. | 2161. | 2229. | 2250. | 2684. | 3113. | 3686. |
| 3500. | 752. | 1181. | 1366. | 1611. | 1925. | 2151. | 2220. | 2242. | 2675. | 3101. | 3675. |
| 4000. | 748. | 1175. | 1359. | 1603. | 1916. | 2143. | 2211. | 2234. | 2666. | 3091. | 3664. |
| 5000. | 739. | 1165. | 1348. | 1591. | 1902. | 2128. | 2198. | 2222. | 2652. | 3075. | 3648. |
| 6000. | 733. | 1156. | 1338. | 1581. | 1891. | 2116. | 2186. | 2212. | 2640. | 3061. | 3633. |
| 7000. | 727. | 1149. | 1330. | 1572. | 1880. | 2106. | 2176. | 2203. | 2629. | 3049. | 3621. |
| 8000. | 721. | 1142. | 1322. | 1564. | 1871. | 2096. | 2166. | 2195. | 2620. | 3038. | 3609. |
| 9000. | 716. | 1135. | 1314. | 1556. | 1862. | 2087. | 2157. | 2187. | 2610. | 3027. | 3598. |
| 10000. | 711. | 1129. | 1307. | 1548. | 1854. | 2079. | 2149. | 2180. | 2602. | 3017. | 3588. |
| 12500. | 699. | 1114. | 1291. | 1531. | 1833. | 2058. | 2129. | 2162. | 2581. | 2993. | 3563. |
| 15000. | 687. | 1099. | 1274. | 1513. | 1813. | 2037. | 2108. | 2144. | 2560. | 2969. | 3538. |
| 17500. | 687. | 1099. | 1274. | 1513. | 1813. | 2037. | 2108. | 2144. | 2560. | 2969. | 3538. |
| 20000. | 687. | 1099. | 1274. | 1513. | 1813. | 2037. | 2108. | 2144. | 2560. | 2969. | 3538. |
| 22500. | 687. | 1099. | 1274. | 1513. | 1813. | 2037. | 2108. | 2144. | 2560. | 2969. | 3538. |

Table 19. Total Cross Sections (millibarns) for Antineon Projectiles

| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 2122. | 3132. | 3564. | 4119. | 4842. | 5338. | 5479. | 5489. | 6466. | 7426. | 8657. |
| 75. | 1994. | 2975. | 3394. | 3937. | 4640. | 5129. | 5271. | 5291. | 6245. | 7182. | 8400. |
| 100. | 1911. | 2873. | 3283. | 3818. | 4508. | 4993. | 5135. | 5162. | 6101. | 7023. | 8231. |
| 125. | 1845. | 2792. | 3196. | 3724. | 4405. | 4885. | 5027. | 5059. | 5986. | 6896. | 8096. |
| 150. | 1807. | 2744. | 3143. | 3668. | 4342. | 4820. | 4962. | 4999. | 5918. | 6821. | 8017. |
| 175. | 1768. | 2696. | 3092. | 3613. | 4281. | 4756. | 4898. | 4938. | 5850. | 6746. | 7937. |
| 200. | 1741. | 2662. | 3054. | 3573. | 4236. | 4710. | 4852. | 4895. | 5801. | 6692. | 7880. |
| 225. | 1713. | 2627. | 3017. | 3532. | 4191. | 4663. | 4805. | 4850. | 5751. | 6637. | 7821. |
| 250. | 1692. | 2601. | 2988. | 3502. | 4157. | 4628. | 4770. | 4817. | 5714. | 6595. | 7778. |
| 275. | 1673. | 2576. | 2962. | 3473. | 4126. | 4595. | 4738. | 4785. | 5679. | 6557. | 7737. |
| 300. | 1657. | 2557. | 2941. | 3450. | 4100. | 4569. | 4711. | 4761. | 5651. | 6526. | 7704. |
| 350. | 1628. | 2521. | 2902. | 3408. | 4054. | 4520. | 4663. | 4715. | 5599. | 6469. | 7643. |
| 400. | 1605. | 2492. | 2870. | 3374. | 4016. | 4481. | 4624. | 4678. | 5558. | 6423. | 7594. |
| 500. | 1570. | 2448. | 2822. | 3323. | 3958. | 4421. | 4564. | 4622. | 5494. | 6352. | 7520. |
| 600. | 1546. | 2417. | 2788. | 3286. | 3917. | 4379. | 4522. | 4583. | 5450. | 6303. | 7468. |
| 700. | 1524. | 2390. | 2759. | 3255. | 3882. | 4343. | 4486. | 4550. | 5412. | 6260. | 7423. |
| 800. | 1506. | 2367. | 2733. | 3227. | 3851. | 4311. | 4454. | 4520. | 5379. | 6222. | 7383. |
| 900. | 1492. | 2349. | 2714. | 3206. | 3828. | 4286. | 4430. | 4498. | 5353. | 6194. | 7353. |
| 1000. | 1479. | 2333. | 2696. | 3188. | 3806. | 4264. | 4409. | 4478. | 5330. | 6168. | 7326. |
| 1250. | 1456. | 2304. | 2664. | 3153. | 3767. | 4224. | 4369. | 4442. | 5289. | 6121. | 7277. |
| 1500. | 1436. | 2278. | 2636. | 3123. | 3734. | 4190. | 4335. | 4410. | 5253. | 6081. | 7234. |
| 1750. | 1418. | 2257. | 2612. | 3098. | 3705. | 4160. | 4305. | 4383. | 5221. | 6046. | 7197. |
| 2000. | 1407. | 2243. | 2596. | 3081. | 3686. | 4141. | 4286. | 4366. | 5202. | 6023. | 7174. |
| 2500. | 1389. | 2220. | 2571. | 3054. | 3656. | 4109. | 4256. | 4338. | 5170. | 5987. | 7136. |
| 3000. | 1375. | 2202. | 2551. | 3033. | 3632. | 4085. | 4231. | 4317. | 5145. | 5958. | 7106. |
| 3500. | 1363. | 2187. | 2535. | 3015. | 3612. | 4064. | 4211. | 4299. | 5124. | 5934. | 7081. |
| 4000. | 1353. | 2174. | 2520. | 3000. | 3594. | 4046. | 4194. | 4283. | 5106. | 5914. | 7060. |
| 5000. | 1335. | 2152. | 2496. | 2975. | 3565. | 4017. | 4164. | 4257. | 5076. | 5879. | 7024. |
| 6000. | 1321. | 2134. | 2476. | 2953. | 3541. | 3992. | 4140. | 4235. | 5050. | 5850. | 6994. |
| 7000. | 1308. | 2118. | 2458. | 2934. | 3520. | 3970. | 4118. | 4216. | 5028. | 5824. | 6967. |
| 8000. | 1296. | 2103. | 2442. | 2917. | 3500. | 3950. | 4098. | 4198. | 5007. | 5801. | 6942. |
| 9000. | 1285. | 2089. | 2426. | 2901. | 3482. | 3931. | 4080. | 4181. | 4988. | 5779. | 6919. |
| 10000. | 1274. | 2076. | 2412. | 2885. | 3464. | 3913. | 4062. | 4166. | 4969. | 5758. | 6897. |
| 12500. | 1249. | 2044. | 2377. | 2848. | 3422. | 3869. | 4019. | 4127. | 4925. | 5707. | 6844. |
| 15000. | 1224. | 2012. | 2342. | 2811. | 3380. | 3826. | 3977. | 4089. | 4881. | 5657. | 6792. |
| 17500. | 1224. | 2012. | 2342. | 2811. | 3380. | 3826. | 3977. | 4089. | 4881. | 5657. | 6792. |
| 20000. | 1224. | 2012. | 2342. | 2811. | 3380. | 3826. | 3977. | 4089. | 4881. | 5657. | 6792. |
| 22500. | 1224. | 2012. | 2342. | 2811. | 3380. | 3826. | 3977. | 4089. | 4881. | 5657. | 6792. |

Table 20. Absorptive Cross Sections (millibarns) for Antineon Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 1199. | 1738. | 1972. | 2265. | 2656. | 2906. | 2969. | 2941. | 3465. | 3981. | 4601. |
| 75. | 1133. | 1658. | 1889. | 2171. | 2552. | 2799. | 2863. | 2841. | 3353. | 3858. | 4472. |
| 100. | 1091. | 1606. | 1829. | 2111. | 2485. | 2730. | 2794. | 2777. | 3280. | 3777. | 4387. |
| 125. | 1057. | 1564. | 1784. | 2062. | 2432. | 2674. | 2739. | 2724. | 3222. | 3713. | 4319. |
| 150. | 1037. | 1540. | 1758. | 2034. | 2400. | 2642. | 2707. | 2694. | 3188. | 3675. | 4279. |
| 175. | 1018. | 1515. | 1731. | 2005. | 2368. | 2609. | 2674. | 2663. | 3154. | 3637. | 4239. |
| 200. | 1003. | 1498. | 1712. | 1985. | 2345. | 2586. | 2651. | 2642. | 3129. | 3610. | 4210. |
| 225. | 989. | 1480. | 1693. | 1964. | 2322. | 2562. | 2627. | 2619. | 3104. | 3582. | 4181. |
| 250. | 978. | 1467. | 1679. | 1949. | 2305. | 2544. | 2609. | 2603. | 3085. | 3561. | 4159. |
| 275. | 968. | 1454. | 1665. | 1934. | 2289. | 2527. | 2592. | 2587. | 3067. | 3542. | 4138. |
| 300. | 960. | 1445. | 1654. | 1923. | 2276. | 2514. | 2579. | 2574. | 3053. | 3526. | 4122. |
| 350. | 946. | 1426. | 1634. | 1901. | 2252. | 2489. | 2555. | 2552. | 3028. | 3497. | 4091. |
| 400. | 934. | 1412. | 1618. | 1884. | 2233. | 2469. | 2535. | 2533. | 3007. | 3474. | 4067. |
| 500. | 916. | 1389. | 1594. | 1858. | 2203. | 2439. | 2505. | 2505. | 2975. | 3439. | 4030. |
| 600. | 904. | 1374. | 1577. | 1839. | 2183. | 2418. | 2484. | 2486. | 2953. | 3414. | 4004. |
| 700. | 893. | 1360. | 1562. | 1824. | 2165. | 2399. | 2466. | 2470. | 2934. | 3393. | 3982. |
| 800. | 883. | 1348. | 1549. | 1810. | 2149. | 2383. | 2450. | 2455. | 2917. | 3374. | 3962. |
| 900. | 876. | 1340. | 1540. | 1799. | 2137. | 2371. | 2438. | 2444. | 2905. | 3360. | 3947. |
| 1000. | 870. | 1332. | 1531. | 1790. | 2127. | 2360. | 2427. | 2434. | 2894. | 3347. | 3934. |
| 1250. | 859. | 1317. | 1515. | 1772. | 2107. | 2340. | 2407. | 2416. | 2873. | 3324. | 3910. |
| 1500. | 848. | 1304. | 1501. | 1757. | 2090. | 2323. | 2390. | 2401. | 2855. | 3304. | 3889. |
| 1750. | 840. | 1294. | 1489. | 1745. | 2076. | 2308. | 2375. | 2387. | 2840. | 3286. | 3870. |
| 2000. | 834. | 1287. | 1482. | 1736. | 2067. | 2298. | 2366. | 2379. | 2830. | 3275. | 3859. |
| 2500. | 826. | 1276. | 1469. | 1723. | 2051. | 2283. | 2351. | 2366. | 2815. | 3258. | 3841. |
| 3000. | 819. | 1267. | 1460. | 1713. | 2040. | 2271. | 2339. | 2356. | 2803. | 3244. | 3827. |
| 3500. | 813. | 1260. | 1452. | 1704. | 2030. | 2261. | 2330. | 2347. | 2793. | 3232. | 3815. |
| 4000. | 808. | 1253. | 1445. | 1697. | 2021. | 2252. | 2321. | 2340. | 2784. | 3222. | 3805. |
| 5000. | 800. | 1243. | 1433. | 1684. | 2007. | 2238. | 2307. | 2327. | 2770. | 3205. | 3787. |
| 6000. | 793. | 1234. | 1423. | 1674. | 1995. | 2225. | 2295. | 2317. | 2758. | 3191. | 3773. |
| 7000. | 787. | 1226. | 1415. | 1665. | 1985. | 2215. | 2285. | 2308. | 2747. | 3179. | 3760. |
| 8000. | 781. | 1219. | 1407. | 1656. | 1975. | 2205. | 2275. | 2299. | 2737. | 3168. | 3748. |
| 9000. | 776. | 1213. | 1399. | 1648. | 1966. | 2196. | 2266. | 2291. | 2728. | 3157. | 3737. |
| 10000. | 771. | 1206. | 1392. | 1641. | 1957. | 2187. | 2257. | 2284. | 2719. | 3147. | 3727. |
| 12500. | 759. | 1191. | 1375. | 1623. | 1937. | 2166. | 2237. | 2266. | 2698. | 3122. | 3702. |
| 15000. | 747. | 1176. | 1358. | 1605. | 1916. | 2145. | 2216. | 2248. | 2676. | 3098. | 3677. |
| 17500. | 747. | 1176. | 1358. | 1605. | 1916. | 2145. | 2216. | 2248. | 2676. | 3098. | 3677. |
| 20000. | 747. | 1176. | 1358. | 1605. | 1916. | 2145. | 2216. | 2248. | 2676. | 3098. | 3677. |
| 22500. | 747. | 1176. | 1358. | 1605. | 1916. | 2145. | 2216. | 2248. | 2676. | 3098. | 3677. |

Table 21. Total Cross Sections (millibarns) for Antialuminum Projectiles

| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 2372. | 3441. | 3897. | 4477. | 5236. | 5748. | 5890. | 5884. | 6905. | 7905. | 9168. |
| 75. | 2238. | 3277. | 3720. | 4288. | 5027. | 5532. | 5675. | 5681. | 6678. | 7655. | 8904. |
| 100. | 2151. | 3170. | 3605. | 4165. | 4891. | 5391. | 5535. | 5548. | 6529. | 7492. | 8732. |
| 125. | 2082. | 3086. | 3513. | 4067. | 4783. | 5280. | 5423. | 5442. | 6411. | 7362. | 8594. |
| 150. | 2041. | 3036. | 3459. | 4009. | 4719. | 5213. | 5357. | 5380. | 6341. | 7284. | 8512. |
| 175. | 2001. | 2986. | 3405. | 3951. | 4655. | 5147. | 5291. | 5317. | 6271. | 7207. | 8430. |
| 200. | 1972. | 2950. | 3366. | 3910. | 4609. | 5099. | 5243. | 5273. | 6221. | 7152. | 8372. |
| 225. | 1942. | 2914. | 3327. | 3868. | 4562. | 5051. | 5195. | 5226. | 6169. | 7095. | 8312. |
| 250. | 1920. | 2886. | 3298. | 3836. | 4527. | 5014. | 5159. | 5192. | 6131. | 7053. | 8267. |
| 275. | 1899. | 2861. | 3270. | 3806. | 4494. | 4980. | 5125. | 5160. | 6095. | 7013. | 8225. |
| 300. | 1883. | 2841. | 3248. | 3783. | 4468. | 4953. | 5097. | 5135. | 6066. | 6981. | 8192. |
| 350. | 1853. | 2803. | 3207. | 3739. | 4420. | 4903. | 5048. | 5088. | 6014. | 6923. | 8130. |
| 400. | 1828. | 2773. | 3174. | 3704. | 4380. | 4862. | 5007. | 5050. | 5971. | 6875. | 8080. |
| 500. | 1791. | 2727. | 3124. | 3650. | 4320. | 4800. | 4946. | 4992. | 5906. | 6803. | 8004. |
| 600. | 1765. | 2694. | 3089. | 3612. | 4278. | 4757. | 4903. | 4953. | 5861. | 6753. | 7951. |
| 700. | 1743. | 2667. | 3059. | 3580. | 4242. | 4720. | 4865. | 4918. | 5822. | 6709. | 7905. |
| 800. | 1723. | 2642. | 3032. | 3551. | 4210. | 4686. | 4832. | 4887. | 5787. | 6670. | 7864. |
| 900. | 1708. | 2624. | 3012. | 3529. | 4185. | 4661. | 4808. | 4865. | 5761. | 6641. | 7833. |
| 1000. | 1695. | 2607. | 2993. | 3510. | 4164. | 4639. | 4785. | 4844. | 5738. | 6615. | 7806. |
| 1250. | 1670. | 2576. | 2960. | 3474. | 4123. | 4597. | 4745. | 4807. | 5695. | 6567. | 7756. |
| 1500. | 1649. | 2550. | 2931. | 3443. | 4089. | 4562. | 4709. | 4775. | 5658. | 6525. | 7712. |
| 1750. | 1631. | 2527. | 2906. | 3417. | 4059. | 4531. | 4679. | 4746. | 5626. | 6489. | 7675. |
| 2000. | 1619. | 2513. | 2890. | 3400. | 4040. | 4511. | 4659. | 4729. | 5606. | 6467. | 7651. |
| 2500. | 1600. | 2489. | 2864. | 3372. | 4008. | 4479. | 4628. | 4701. | 5574. | 6430. | 7613. |
| 3000. | 1585. | 2470. | 2843. | 3350. | 3983. | 4454. | 4603. | 4679. | 5548. | 6400. | 7582. |
| 3500. | 1572. | 2454. | 2826. | 3332. | 3963. | 4433. | 4582. | 4661. | 5527. | 6376. | 7557. |
| 4000. | 1562. | 2441. | 2811. | 3316. | 3945. | 4415. | 4565. | 4645. | 5508. | 6355. | 7535. |
| 5000. | 1543. | 2418. | 2786. | 3290. | 3915. | 4384. | 4535. | 4619. | 5478. | 6320. | 7499. |
| 6000. | 1528. | 2399. | 2765. | 3267. | 3890. | 4358. | 4510. | 4596. | 5452. | 6290. | 7468. |
| 7000. | 1515. | 2383. | 2747. | 3248. | 3868. | 4336. | 4487. | 4577. | 5429. | 6264. | 7441. |
| 8000. | 1502. | 2367. | 2730. | 3230. | 3848. | 4315. | 4467. | 4559. | 5408. | 6240. | 7416. |
| 9000. | 1491. | 2353. | 2714. | 3213. | 3829. | 4296. | 4448. | 4542. | 5388. | 6218. | 7393. |
| 10000. | 1479. | 2339. | 2699. | 3197. | 3811. | 4277. | 4430. | 4525. | 5369. | 6196. | 7371. |
| 12500. | 1453. | 2306. | 2662. | 3159. | 3767. | 4233. | 4386. | 4486. | 5324. | 6145. | 7317. |
| 15000. | 1426. | 2273. | 2626. | 3121. | 3724. | 4189. | 4343. | 4448. | 5279. | 6094. | 7264. |
| 17500. | 1426. | 2273. | 2626. | 3121. | 3724. | 4189. | 4343. | 4448. | 5279. | 6094. | 7264. |
| 20000. | 1426. | 2273. | 2626. | 3121. | 3724. | 4189. | 4343. | 4448. | 5279. | 6094. | 7264. |
| 22500. | 1426. | 2273. | 2626. | 3121. | 3724. | 4189. | 4343. | 4448. | 5279. | 6094. | 7264. |

Table 22. Absorptive Cross Sections (millibarns) for Antialuminum Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 1329. | 1897. | 2143. | 2449. | 2859. | 3117. | 3180. | 3142. | 3688. | 4226. | 4860. |
| 75. | 1261. | 1814. | 2054. | 2353. | 2752. | 3007. | 3071. | 3040. | 3573. | 4099. | 4728. |
| 100. | 1216. | 1760. | 1995. | 2290. | 2683. | 2935. | 2999. | 2973. | 3499. | 4017. | 4641. |
| 125. | 1181. | 1716. | 1948. | 2240. | 2628. | 2878. | 2943. | 2919. | 3439. | 3951. | 4571. |
| 150. | 1160. | 1691. | 1921. | 2210. | 2595. | 2844. | 2909. | 2888. | 3404. | 3912. | 4531. |
| 175. | 1139. | 1666. | 1894. | 2181. | 2562. | 2810. | 2876. | 2857. | 3368. | 3873. | 4490. |
| 200. | 1124. | 1648. | 1874. | 2160. | 2538. | 2786. | 2852. | 2834. | 3343. | 3845. | 4460. |
| 225. | 1109. | 1629. | 1854. | 2138. | 2514. | 2761. | 2827. | 2811. | 3317. | 3816. | 4430. |
| 250. | 1098. | 1615. | 1839. | 2122. | 2497. | 2743. | 2809. | 2794. | 3298. | 3795. | 4408. |
| 275. | 1087. | 1602. | 1825. | 2107. | 2480. | 2726. | 2791. | 2778. | 3280. | 3775. | 4386. |
| 300. | 1079. | 1592. | 1814. | 2095. | 2466. | 2712. | 2778. | 2765. | 3266. | 3759. | 4370. |
| 350. | 1064. | 1573. | 1793. | 2073. | 2442. | 2686. | 2752. | 2742. | 3239. | 3729. | 4339. |
| 400. | 1051. | 1558. | 1776. | 2055. | 2422. | 2666. | 2732. | 2723. | 3218. | 3705. | 4314. |
| 500. | 1032. | 1534. | 1751. | 2027. | 2391. | 2634. | 2701. | 2694. | 3185. | 3669. | 4276. |
| 600. | 1019. | 1518. | 1733. | 2008. | 2370. | 2613. | 2679. | 2674. | 3163. | 3644. | 4250. |
| 700. | 1008. | 1504. | 1718. | 1992. | 2352. | 2594. | 2661. | 2657. | 3143. | 3622. | 4227. |
| 800. | 998. | 1492. | 1705. | 1977. | 2335. | 2577. | 2644. | 2642. | 3126. | 3603. | 4206. |
| 900. | 991. | 1483. | 1695. | 1967. | 2323. | 2565. | 2632. | 2631. | 3113. | 3588. | 4191. |
| 1000. | 984. | 1474. | 1685. | 1957. | 2312. | 2553. | 2621. | 2621. | 3102. | 3575. | 4178. |
| 1250. | 972. | 1459. | 1669. | 1939. | 2292. | 2533. | 2601. | 2603. | 3081. | 3552. | 4153. |
| 1500. | 961. | 1446. | 1655. | 1923. | 2274. | 2515. | 2583. | 2587. | 3062. | 3531. | 4132. |
| 1750. | 952. | 1435. | 1642. | 1910. | 2259. | 2499. | 2568. | 2573. | 3046. | 3513. | 4113. |
| 2000. | 947. | 1428. | 1634. | 1902. | 2250. | 2490. | 2558. | 2565. | 3037. | 3502. | 4102. |
| 2500. | 937. | 1416. | 1622. | 1888. | 2234. | 2474. | 2543. | 2551. | 3021. | 3484. | 4083. |
| 3000. | 930. | 1407. | 1612. | 1878. | 2222. | 2461. | 2531. | 2541. | 3009. | 3470. | 4069. |
| 3500. | 924. | 1400. | 1603. | 1869. | 2212. | 2451. | 2521. | 2532. | 2999. | 3458. | 4057. |
| 4000. | 919. | 1393. | 1596. | 1861. | 2203. | 2442. | 2512. | 2524. | 2990. | 3448. | 4046. |
| 5000. | 910. | 1382. | 1584. | 1848. | 2188. | 2427. | 2498. | 2512. | 2975. | 3431. | 4029. |
| 6000. | 903. | 1373. | 1574. | 1837. | 2176. | 2415. | 2485. | 2501. | 2963. | 3416. | 4014. |
| 7000. | 897. | 1365. | 1565. | 1828. | 2165. | 2404. | 2475. | 2492. | 2952. | 3404. | 4001. |
| 8000. | 891. | 1358. | 1557. | 1819. | 2155. | 2394. | 2465. | 2483. | 2942. | 3392. | 3989. |
| 9000. | 885. | 1351. | 1549. | 1811. | 2146. | 2384. | 2456. | 2475. | 2932. | 3381. | 3978. |
| 10000. | 880. | 1344. | 1542. | 1803. | 2137. | 2375. | 2447. | 2467. | 2923. | 3371. | 3967. |
| 12500. | 867. | 1328. | 1525. | 1784. | 2116. | 2354. | 2426. | 2449. | 2902. | 3346. | 3942. |
| 15000. | 855. | 1313. | 1507. | 1766. | 2095. | 2332. | 2405. | 2431. | 2880. | 3321. | 3916. |
| 17500. | 855. | 1313. | 1507. | 1766. | 2095. | 2332. | 2405. | 2431. | 2880. | 3321. | 3916. |
| 20000. | 855. | 1313. | 1507. | 1766. | 2095. | 2332. | 2405. | 2431. | 2880. | 3321. | 3916. |
| 22500. | 855. | 1313. | 1507. | 1766. | 2095. | 2332. | 2405. | 2431. | 2880. | 3321. | 3916. |

Table 23. Total Cross Sections (millibarns) for Antiargon Projectiles

| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 2894. | 4075. | 4570. | 5207. | 6024. | 6578. | 6734. | 6749. | 7830. | 8887. | 10234. |
| 75. | 2742. | 3893. | 4376. | 5000. | 5797. | 6344. | 6501. | 6527. | 7584. | 8619. | 9952. |
| 100. | 2643. | 3775. | 4250. | 4865. | 5650. | 6192. | 6349. | 6382. | 7424. | 8443. | 9767. |
| 125. | 2565. | 3682. | 4149. | 4758. | 5533. | 6071. | 6228. | 6265. | 7296. | 8304. | 9619. |
| 150. | 2519. | 3626. | 4089. | 4694. | 5463. | 5999. | 6156. | 6197. | 7220. | 8221. | 9532. |
| 175. | 2473. | 3571. | 4030. | 4631. | 5394. | 5927. | 6084. | 6129. | 7144. | 8138. | 9444. |
| 200. | 2440. | 3531. | 3987. | 4585. | 5343. | 5875. | 6033. | 6080. | 7090. | 8078. | 9382. |
| 225. | 2407. | 3491. | 3944. | 4539. | 5293. | 5823. | 5980. | 6029. | 7034. | 8017. | 9317. |
| 250. | 2381. | 3460. | 3911. | 4505. | 5255. | 5783. | 5941. | 5992. | 6992. | 7972. | 9269. |
| 275. | 2358. | 3432. | 3881. | 4472. | 5219. | 5746. | 5904. | 5957. | 6954. | 7929. | 9224. |
| 300. | 2339. | 3409. | 3857. | 4446. | 5190. | 5717. | 5875. | 5929. | 6922. | 7895. | 9188. |
| 350. | 2305. | 3368. | 3812. | 4398. | 5137. | 5662. | 5820. | 5877. | 6865. | 7832. | 9122. |
| 400. | 2277. | 3334. | 3775. | 4359. | 5095. | 5618. | 5776. | 5835. | 6819. | 7781. | 9068. |
| 500. | 2234. | 3283. | 3720. | 4300. | 5029. | 5551. | 5709. | 5772. | 6748. | 7703. | 8986. |
| 600. | 2204. | 3246. | 3681. | 4258. | 4983. | 5503. | 5662. | 5728. | 6699. | 7648. | 8928. |
| 700. | 2179. | 3215. | 3647. | 4223. | 4943. | 5462. | 5622. | 5690. | 6656. | 7601. | 8879. |
| 800. | 2156. | 3188. | 3617. | 4191. | 4908. | 5426. | 5586. | 5656. | 6618. | 7559. | 8835. |
| 900. | 2139. | 3167. | 3595. | 4167. | 4882. | 5399. | 5558. | 5631. | 6590. | 7528. | 8802. |
| 1000. | 2123. | 3148. | 3574. | 4145. | 4858. | 5374. | 5534. | 5608. | 6564. | 7499. | 8772. |
| 1250. | 2095. | 3114. | 3537. | 4106. | 4813. | 5329. | 5489. | 5567. | 6518. | 7447. | 8718. |
| 1500. | 2070. | 3084. | 3505. | 4071. | 4775. | 5289. | 5450. | 5531. | 6477. | 7402. | 8671. |
| 1750. | 2049. | 3059. | 3477. | 4042. | 4743. | 5256. | 5417. | 5500. | 6442. | 7364. | 8630. |
| 2000. | 2036. | 3042. | 3459. | 4023. | 4721. | 5234. | 5396. | 5480. | 6420. | 7339. | 8604. |
| 2500. | 2014. | 3015. | 3430. | 3992. | 4687. | 5199. | 5361. | 5449. | 6384. | 7298. | 8563. |
| 3000. | 1996. | 2994. | 3406. | 3967. | 4659. | 5171. | 5334. | 5424. | 6356. | 7266. | 8529. |
| 3500. | 1981. | 2976. | 3387. | 3947. | 4636. | 5148. | 5311. | 5404. | 6333. | 7240. | 8502. |
| 4000. | 1969. | 2961. | 3371. | 3930. | 4617. | 5128. | 5291. | 5386. | 6312. | 7217. | 8478. |
| 5000. | 1947. | 2935. | 3343. | 3900. | 4584. | 5094. | 5258. | 5356. | 6278. | 7179. | 8439. |
| 6000. | 1930. | 2914. | 3319. | 3875. | 4556. | 5066. | 5231. | 5331. | 6250. | 7146. | 8405. |
| 7000. | 1914. | 2895. | 3299. | 3854. | 4532. | 5041. | 5206. | 5309. | 6224. | 7118. | 8376. |
| 8000. | 1899. | 2878. | 3280. | 3834. | 4510. | 5018. | 5184. | 5289. | 6201. | 7092. | 8349. |
| 9000. | 1886. | 2861. | 3262. | 3815. | 4489. | 4997. | 5163. | 5270. | 6180. | 7068. | 8323. |
| 10000. | 1873. | 2846. | 3245. | 3797. | 4469. | 4977. | 5143. | 5252. | 6159. | 7044. | 8299. |
| 12500. | 1842. | 2808. | 3204. | 3754. | 4421. | 4928. | 5094. | 5208. | 6109. | 6988. | 8241. |
| 15000. | 1811. | 2771. | 3164. | 3712. | 4374. | 4879. | 5047. | 5165. | 6060. | 6933. | 8183. |
| 17500. | 1811. | 2771. | 3164. | 3712. | 4374. | 4879. | 5047. | 5165. | 6060. | 6933. | 8183. |
| 20000. | 1811. | 2771. | 3164. | 3712. | 4374. | 4879. | 5047. | 5165. | 6060. | 6933. | 8183. |
| 22500. | 1811. | 2771. | 3164. | 3712. | 4374. | 4879. | 5047. | 5165. | 6060. | 6933. | 8183. |

Table 24. Absorptive Cross Sections (millibarns) for Antiargon Projectiles

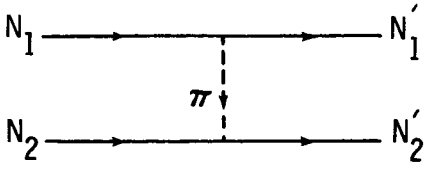
| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 1614. | 2238. | 2504. | 2837. | 3276. | 3555. | 3625. | 3600. | 4175. | 4741. | 5419. |
| 75. | 1537. | 2146. | 2405. | 2732. | 3161. | 3436. | 3507. | 3488. | 4052. | 4605. | 5277. |
| 100. | 1486. | 2086. | 2341. | 2663. | 3086. | 3359. | 3430. | 3415. | 3971. | 4517. | 5184. |
| 125. | 1446. | 2038. | 2290. | 2609. | 3026. | 3297. | 3369. | 3357. | 3906. | 4446. | 5110. |
| 150. | 1423. | 2010. | 2260. | 2576. | 2990. | 3260. | 3333. | 3323. | 3868. | 4404. | 5066. |
| 175. | 1399. | 1982. | 2229. | 2544. | 2955. | 3224. | 3296. | 3288. | 3830. | 4362. | 5022. |
| 200. | 1382. | 1962. | 2208. | 2521. | 2929. | 3198. | 3270. | 3264. | 3803. | 4332. | 4991. |
| 225. | 1365. | 1941. | 2185. | 2497. | 2903. | 3171. | 3243. | 3238. | 3774. | 4302. | 4958. |
| 250. | 1352. | 1926. | 2169. | 2480. | 2884. | 3151. | 3224. | 3219. | 3753. | 4279. | 4934. |
| 275. | 1340. | 1911. | 2154. | 2463. | 2865. | 3132. | 3205. | 3202. | 3734. | 4257. | 4911. |
| 300. | 1331. | 1900. | 2141. | 2450. | 2851. | 3117. | 3190. | 3188. | 3718. | 4240. | 4893. |
| 350. | 1313. | 1879. | 2118. | 2425. | 2824. | 3090. | 3163. | 3162. | 3689. | 4208. | 4860. |
| 400. | 1299. | 1861. | 2100. | 2406. | 2802. | 3067. | 3140. | 3141. | 3666. | 4182. | 4833. |
| 500. | 1277. | 1835. | 2072. | 2376. | 2769. | 3033. | 3107. | 3109. | 3631. | 4143. | 4792. |
| 600. | 1263. | 1817. | 2052. | 2355. | 2746. | 3009. | 3083. | 3088. | 3606. | 4116. | 4764. |
| 700. | 1250. | 1802. | 2036. | 2337. | 2726. | 2989. | 3063. | 3069. | 3585. | 4093. | 4739. |
| 800. | 1238. | 1788. | 2021. | 2321. | 2708. | 2971. | 3045. | 3052. | 3566. | 4072. | 4718. |
| 900. | 1230. | 1778. | 2009. | 2309. | 2695. | 2957. | 3031. | 3039. | 3552. | 4056. | 4701. |
| 1000. | 1222. | 1768. | 1999. | 2298. | 2682. | 2944. | 3019. | 3028. | 3540. | 4042. | 4686. |
| 1250. | 1208. | 1751. | 1981. | 2278. | 2660. | 2922. | 2997. | 3008. | 3517. | 4016. | 4660. |
| 1500. | 1196. | 1736. | 1965. | 2261. | 2641. | 2902. | 2977. | 2990. | 3497. | 3994. | 4637. |
| 1750. | 1185. | 1724. | 1951. | 2246. | 2625. | 2886. | 2961. | 2975. | 3479. | 3975. | 4616. |
| 2000. | 1179. | 1716. | 1942. | 2237. | 2614. | 2875. | 2950. | 2965. | 3469. | 3962. | 4604. |
| 2500. | 1168. | 1703. | 1928. | 2222. | 2597. | 2858. | 2933. | 2951. | 3451. | 3943. | 4584. |
| 3000. | 1159. | 1692. | 1917. | 2210. | 2584. | 2844. | 2920. | 2939. | 3438. | 3927. | 4568. |
| 3500. | 1152. | 1684. | 1907. | 2200. | 2573. | 2832. | 2909. | 2929. | 3426. | 3914. | 4555. |
| 4000. | 1146. | 1676. | 1899. | 2191. | 2563. | 2823. | 2899. | 2920. | 3417. | 3903. | 4543. |
| 5000. | 1136. | 1664. | 1886. | 2177. | 2547. | 2806. | 2883. | 2906. | 3400. | 3885. | 4524. |
| 6000. | 1128. | 1654. | 1875. | 2165. | 2533. | 2793. | 2870. | 2894. | 3386. | 3869. | 4508. |
| 7000. | 1120. | 1645. | 1865. | 2154. | 2521. | 2780. | 2858. | 2883. | 3374. | 3855. | 4494. |
| 8000. | 1113. | 1636. | 1855. | 2145. | 2510. | 2769. | 2847. | 2874. | 3363. | 3843. | 4481. |
| 9000. | 1107. | 1628. | 1847. | 2136. | 2500. | 2759. | 2837. | 2865. | 3353. | 3831. | 4469. |
| 10000. | 1100. | 1621. | 1839. | 2127. | 2490. | 2749. | 2827. | 2856. | 3343. | 3819. | 4457. |
| 12500. | 1086. | 1603. | 1819. | 2106. | 2467. | 2725. | 2804. | 2835. | 3319. | 3792. | 4429. |
| 15000. | 1071. | 1585. | 1799. | 2085. | 2444. | 2701. | 2781. | 2814. | 3295. | 3766. | 4401. |
| 17500. | 1071. | 1585. | 1799. | 2085. | 2444. | 2701. | 2781. | 2814. | 3295. | 3766. | 4401. |
| 20000. | 1071. | 1585. | 1799. | 2085. | 2444. | 2701. | 2781. | 2814. | 3295. | 3766. | 4401. |
| 22500. | 1071. | 1585. | 1799. | 2085. | 2444. | 2701. | 2781. | 2814. | 3295. | 3766. | 4401. |

Table 25. Total Cross Sections (millibarns) for Anti-Iron Projectiles

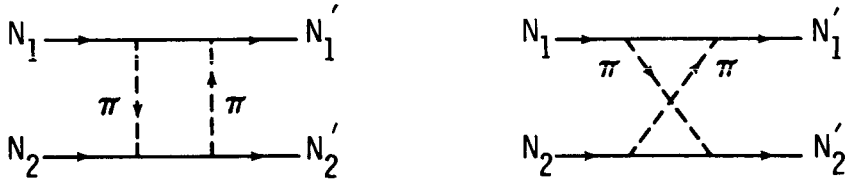
| ENERGY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
| 50. | 3285. | 4540. | 5068. | 5736. | 6602. | 7175. | 7331. | 7318. | 8458. | 9572. | 10956. |
| 75. | 3125. | 4351. | 4866. | 5521. | 6367. | 6933. | 7090. | 7090. | 8206. | 9297. | 10667. |
| 100. | 3021. | 4228. | 4734. | 5381. | 6214. | 6775. | 6933. | 6941. | 8041. | 9117. | 10478. |
| 125. | 2939. | 4130. | 4629. | 5270. | 6092. | 6650. | 6807. | 6821. | 7909. | 8973. | 10327. |
| 150. | 2890. | 4072. | 4567. | 5203. | 6019. | 6575. | 6733. | 6752. | 7832. | 8887. | 10238. |
| 175. | 2842. | 4014. | 4505. | 5137. | 5947. | 6501. | 6659. | 6681. | 7753. | 8802. | 10148. |
| 200. | 2807. | 3972. | 4460. | 5090. | 5895. | 6447. | 6606. | 6631. | 7698. | 8741. | 10083. |
| 225. | 2771. | 3930. | 4415. | 5042. | 5842. | 6393. | 6551. | 6578. | 7640. | 8678. | 10017. |
| 250. | 2745. | 3898. | 4381. | 5006. | 5803. | 6352. | 6511. | 6540. | 7598. | 8631. | 9968. |
| 275. | 2720. | 3869. | 4349. | 4972. | 5766. | 6314. | 6473. | 6504. | 7557. | 8587. | 9922. |
| 300. | 2700. | 3845. | 4324. | 4945. | 5736. | 6283. | 6442. | 6475. | 7525. | 8552. | 9885. |
| 350. | 2664. | 3801. | 4277. | 4895. | 5681. | 6226. | 6386. | 6422. | 7467. | 8487. | 9817. |
| 400. | 2634. | 3766. | 4239. | 4854. | 5636. | 6181. | 6340. | 6379. | 7419. | 8435. | 9762. |
| 500. | 2589. | 3712. | 4181. | 4793. | 5568. | 6111. | 6271. | 6314. | 7346. | 8355. | 9678. |
| 600. | 2558. | 3675. | 4140. | 4749. | 5520. | 6062. | 6222. | 6269. | 7296. | 8299. | 9620. |
| 700. | 2531. | 3642. | 4105. | 4712. | 5479. | 6019. | 6181. | 6230. | 7252. | 8250. | 9569. |
| 800. | 2507. | 3613. | 4074. | 4679. | 5443. | 5982. | 6143. | 6196. | 7213. | 8208. | 9525. |
| 900. | 2489. | 3592. | 4051. | 4654. | 5415. | 5954. | 6116. | 6170. | 7184. | 8175. | 9491. |
| 1000. | 2472. | 3572. | 4029. | 4632. | 5390. | 5928. | 6090. | 6147. | 7158. | 8146. | 9461. |
| 1250. | 2442. | 3536. | 3991. | 4591. | 5344. | 5882. | 6044. | 6105. | 7111. | 8093. | 9406. |
| 1500. | 2417. | 3505. | 3957. | 4555. | 5305. | 5841. | 6004. | 6068. | 7069. | 8047. | 9357. |
| 1750. | 2394. | 3479. | 3928. | 4525. | 5271. | 5807. | 5970. | 6036. | 7033. | 8007. | 9316. |
| 2000. | 2380. | 3462. | 3910. | 4505. | 5249. | 5784. | 5948. | 6017. | 7011. | 7982. | 9290. |
| 2500. | 2357. | 3434. | 3879. | 4473. | 5214. | 5748. | 5913. | 5985. | 6975. | 7941. | 9248. |
| 3000. | 2338. | 3412. | 3855. | 4448. | 5185. | 5719. | 5885. | 5960. | 6946. | 7909. | 9215. |
| 3500. | 2323. | 3393. | 3836. | 4427. | 5162. | 5696. | 5861. | 5939. | 6922. | 7882. | 9187. |
| 4000. | 2310. | 3378. | 3818. | 4409. | 5142. | 5675. | 5841. | 5921. | 6902. | 7858. | 9163. |
| 5000. | 2288. | 3351. | 3790. | 4379. | 5108. | 5641. | 5808. | 5891. | 6868. | 7820. | 9123. |
| 6000. | 2269. | 3329. | 3765. | 4353. | 5079. | 5612. | 5779. | 5866. | 6839. | 7787. | 9089. |
| 7000. | 2252. | 3309. | 3744. | 4331. | 5054. | 5586. | 5754. | 5844. | 6813. | 7758. | 9060. |
| 8000. | 2237. | 3291. | 3724. | 4310. | 5031. | 5563. | 5732. | 5823. | 6790. | 7732. | 9032. |
| 9000. | 2223. | 3274. | 3706. | 4291. | 5010. | 5541. | 5710. | 5804. | 6768. | 7707. | 9007. |
| 10000. | 2209. | 3258. | 3688. | 4272. | 4989. | 5520. | 5690. | 5786. | 6747. | 7683. | 8982. |
| 12500. | 2177. | 3219. | 3646. | 4228. | 4940. | 5470. | 5640. | 5741. | 6696. | 7626. | 8924. |
| 15000. | 2144. | 3181. | 3604. | 4185. | 4891. | 5420. | 5592. | 5698. | 6646. | 7570. | 8866. |
| 17500. | 2144. | 3181. | 3604. | 4185. | 4891. | 5420. | 5592. | 5698. | 6646. | 7570. | 8866. |
| 20000. | 2144. | 3181. | 3604. | 4185. | 4891. | 5420. | 5592. | 5698. | 6646. | 7570. | 8866. |
| 22500. | 2144. | 3181. | 3604. | 4185. | 4891. | 5420. | 5592. | 5698. | 6646. | 7570. | 8866. |

Table 26. Absorptive Cross Sections (millibarns) for Anti-Iron Projectiles

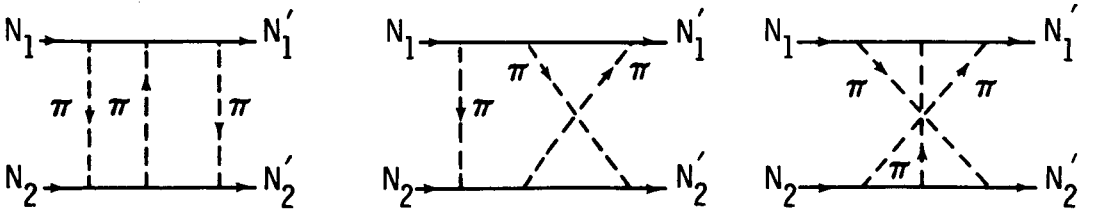
| ENERGY MEV/AMU | HE | C | O | AL | AR | FE | CU | BR | AG | BA | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | 1814. | 2475. | 2757. | 3107. | 3572. | 3859. | 3928. | 3886. | 4492. | 5088. | 5782. |
| 75. | 1733. | 2379. | 2655. | 2998. | 3422. | 3736. | 3807. | 3771. | 4365. | 4949. | 5637. |
| 100. | 1680. | 2317. | 2588. | 2927. | 3374. | 3656. | 3727. | 3696. | 4282. | 4858. | 5542. |
| 125. | 1638. | 2267. | 2535. | 2870. | 3312. | 3592. | 3663. | 3636. | 4215. | 4785. | 5466. |
| 150. | 1613. | 2238. | 2503. | 2837. | 3272. | 3555. | 3626. | 3601. | 4177. | 4742. | 5421. |
| 175. | 1588. | 2208. | 2472. | 2803. | 3238. | 3517. | 3588. | 3566. | 4137. | 4699. | 5376. |
| 200. | 1571. | 2187. | 2449. | 2779. | 3212. | 3490. | 3561. | 3541. | 4109. | 4668. | 5344. |
| 225. | 1553. | 2166. | 2426. | 2754. | 3185. | 3462. | 3534. | 3514. | 4080. | 4636. | 5311. |
| 250. | 1539. | 2150. | 2409. | 2736. | 3165. | 3441. | 3513. | 3495. | 4059. | 4613. | 5286. |
| 275. | 1527. | 2135. | 2393. | 2719. | 3146. | 3422. | 3494. | 3477. | 4039. | 4591. | 5263. |
| 300. | 1517. | 2123. | 2380. | 2705. | 3131. | 3406. | 3479. | 3463. | 4023. | 4573. | 5245. |
| 350. | 1498. | 2101. | 2357. | 2680. | 3103. | 3378. | 3450. | 3436. | 3993. | 4540. | 5210. |
| 400. | 1483. | 2083. | 2337. | 2659. | 3080. | 3355. | 3427. | 3414. | 3969. | 4514. | 5183. |
| 500. | 1461. | 2056. | 2308. | 2628. | 3046. | 3319. | 3392. | 3382. | 3933. | 4474. | 5141. |
| 600. | 1445. | 2037. | 2288. | 2607. | 3022. | 3295. | 3368. | 3360. | 3908. | 4446. | 5112. |
| 700. | 1431. | 2021. | 2271. | 2588. | 3001. | 3274. | 3347. | 3341. | 3886. | 4422. | 5087. |
| 800. | 1419. | 2006. | 2255. | 2571. | 2983. | 3255. | 3329. | 3323. | 3867. | 4400. | 5065. |
| 900. | 1410. | 1996. | 2243. | 2559. | 2969. | 3241. | 3315. | 3311. | 3853. | 4384. | 5048. |
| 1000. | 1402. | 1986. | 2233. | 2548. | 2956. | 3226. | 3302. | 3299. | 3840. | 4370. | 5033. |
| 1250. | 1388. | 1968. | 2214. | 2527. | 2933. | 3205. | 3280. | 3279. | 3816. | 4344. | 5006. |
| 1500. | 1375. | 1953. | 2197. | 2509. | 2914. | 3184. | 3260. | 3261. | 3796. | 4321. | 4983. |
| 1750. | 1364. | 1940. | 2183. | 2494. | 2897. | 3167. | 3242. | 3245. | 3778. | 4301. | 4962. |
| 2000. | 1357. | 1931. | 2174. | 2485. | 2886. | 3156. | 3232. | 3235. | 3767. | 4289. | 4949. |
| 2500. | 1346. | 1918. | 2159. | 2469. | 2868. | 3138. | 3215. | 3220. | 3750. | 4269. | 4929. |
| 3000. | 1337. | 1908. | 2148. | 2457. | 2854. | 3124. | 3201. | 3208. | 3736. | 4253. | 4913. |
| 3500. | 1330. | 1899. | 2138. | 2446. | 2843. | 3113. | 3190. | 3198. | 3725. | 4240. | 4900. |
| 4000. | 1324. | 1891. | 2130. | 2438. | 2833. | 3103. | 3180. | 3190. | 3715. | 4229. | 4888. |
| 5000. | 1313. | 1878. | 2116. | 2423. | 2816. | 3086. | 3163. | 3176. | 3698. | 4210. | 4869. |
| 6000. | 1304. | 1868. | 2104. | 2411. | 2802. | 3072. | 3150. | 3163. | 3684. | 4194. | 4853. |
| 7000. | 1296. | 1858. | 2094. | 2400. | 2790. | 3059. | 3138. | 3153. | 3672. | 4180. | 4838. |
| 8000. | 1289. | 1850. | 2085. | 2390. | 2779. | 3048. | 3126. | 3143. | 3661. | 4167. | 4825. |
| 9000. | 1282. | 1842. | 2076. | 2380. | 2768. | 3037. | 3116. | 3134. | 3650. | 4155. | 4813. |
| 10000. | 1276. | 1834. | 2067. | 2371. | 2758. | 3027. | 3106. | 3125. | 3640. | 4143. | 4801. |
| 12500. | 1261. | 1815. | 2047. | 2350. | 2734. | 3003. | 3082. | 3104. | 3616. | 4116. | 4773. |
| 15000. | 1245. | 1797. | 2027. | 2329. | 2710. | 2979. | 3059. | 3083. | 3592. | 4089. | 4745. |
| 17500. | 1245. | 1797. | 2027. | 2329. | 2710. | 2979. | 3059. | 3083. | 3592. | 4089. | 4745. |
| 20000. | 1245. | 1797. | 2027. | 2329. | 2710. | 2979. | 3059. | 3083. | 3592. | 4089. | 4745. |
| 22500. | 1245. | 1797. | 2027. | 2329. | 2710. | 2979. | 3059. | 3083. | 3592. | 4089. | 4745. |




(a) One-pion exchange potential (OPEP).




(b) Two-pion exchange potentials (TPEP).




(c) Some three-pion exchange potentials.

Figure 1. Meson exchange potentials.

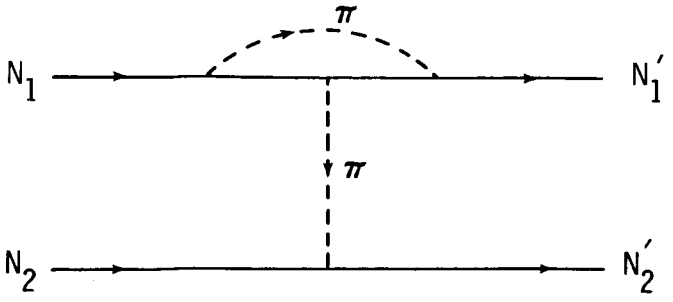
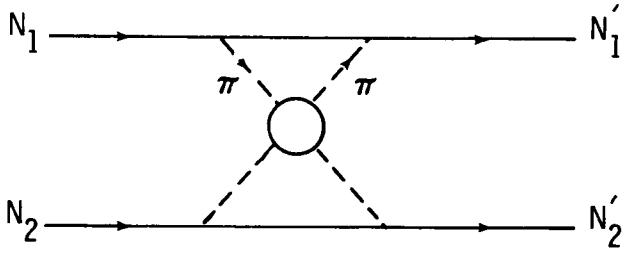
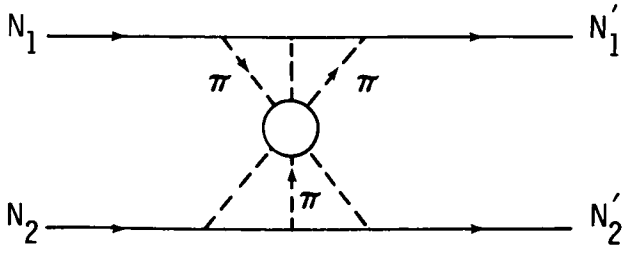



Figure 2. Two-pion vertex contribution.




(a) Two pions.




(b) Three pions.

Figure 3. Correlated pion exchange potentials.

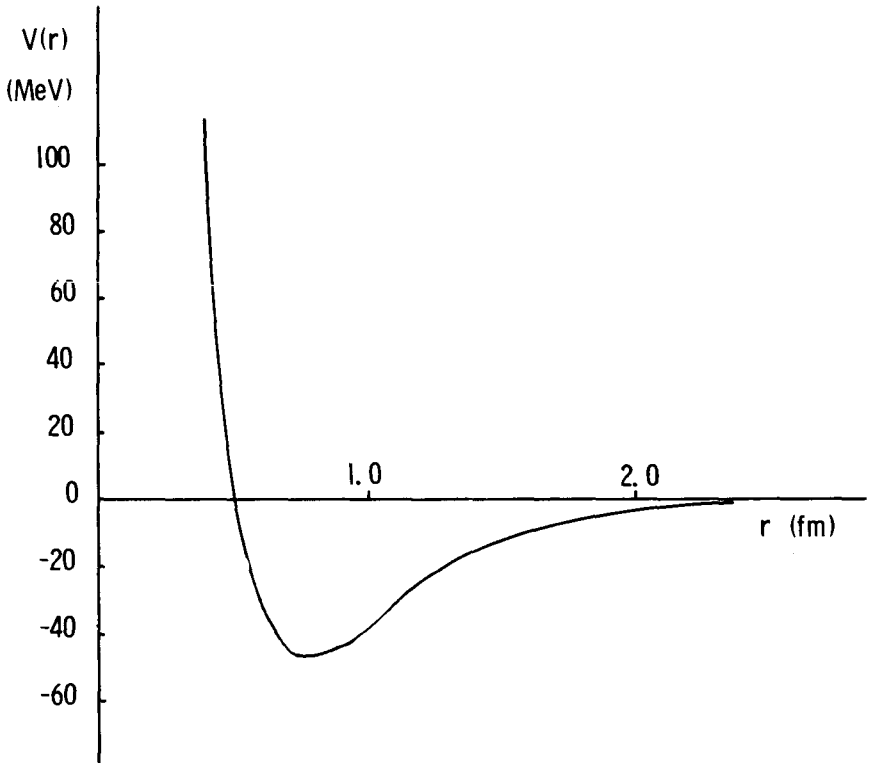



Figure 4. Total $NN$ potential in the deuteron's channel.

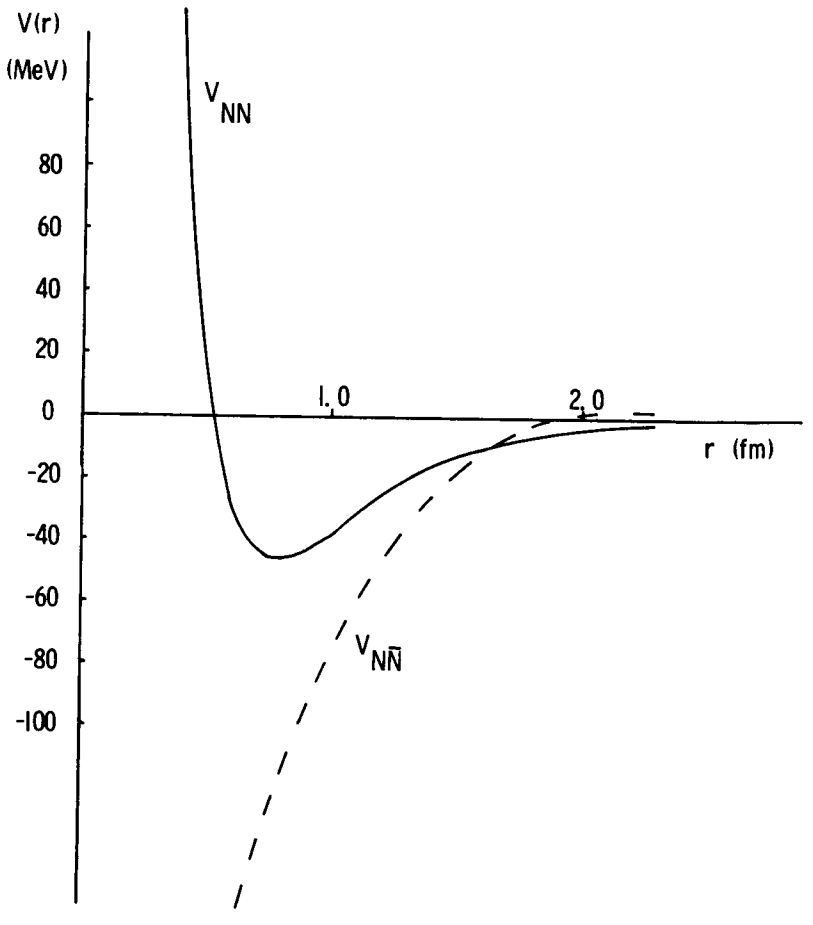



Figure 5. Total $NN$ potential (solid curve, from fig. 4) and G-parity transformation of $NN$ potential (dashed curve) to obtain $N\bar{N}$ potential.

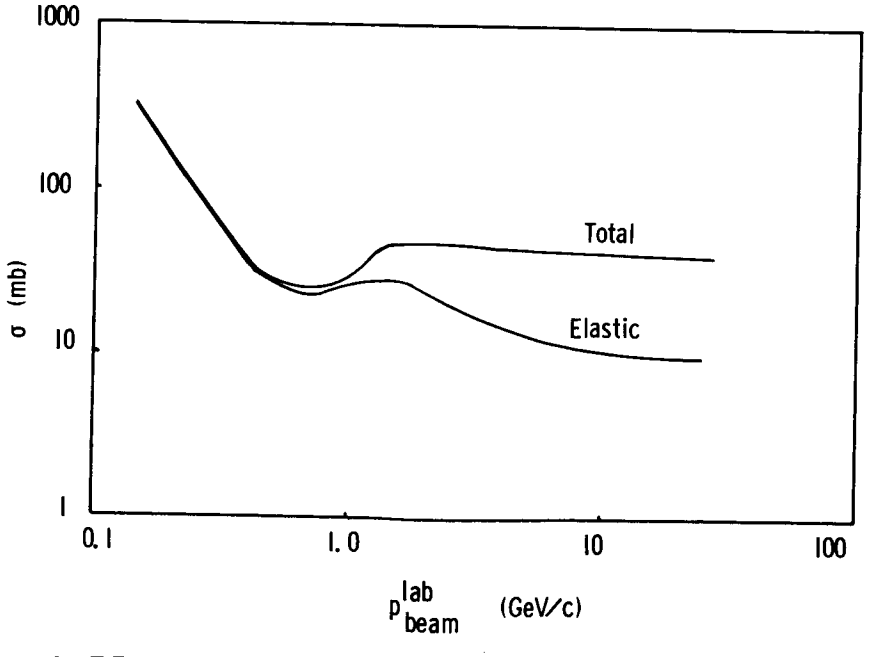



Figure 6. $PP$ cross sections as function of laboratory projectile momentum.

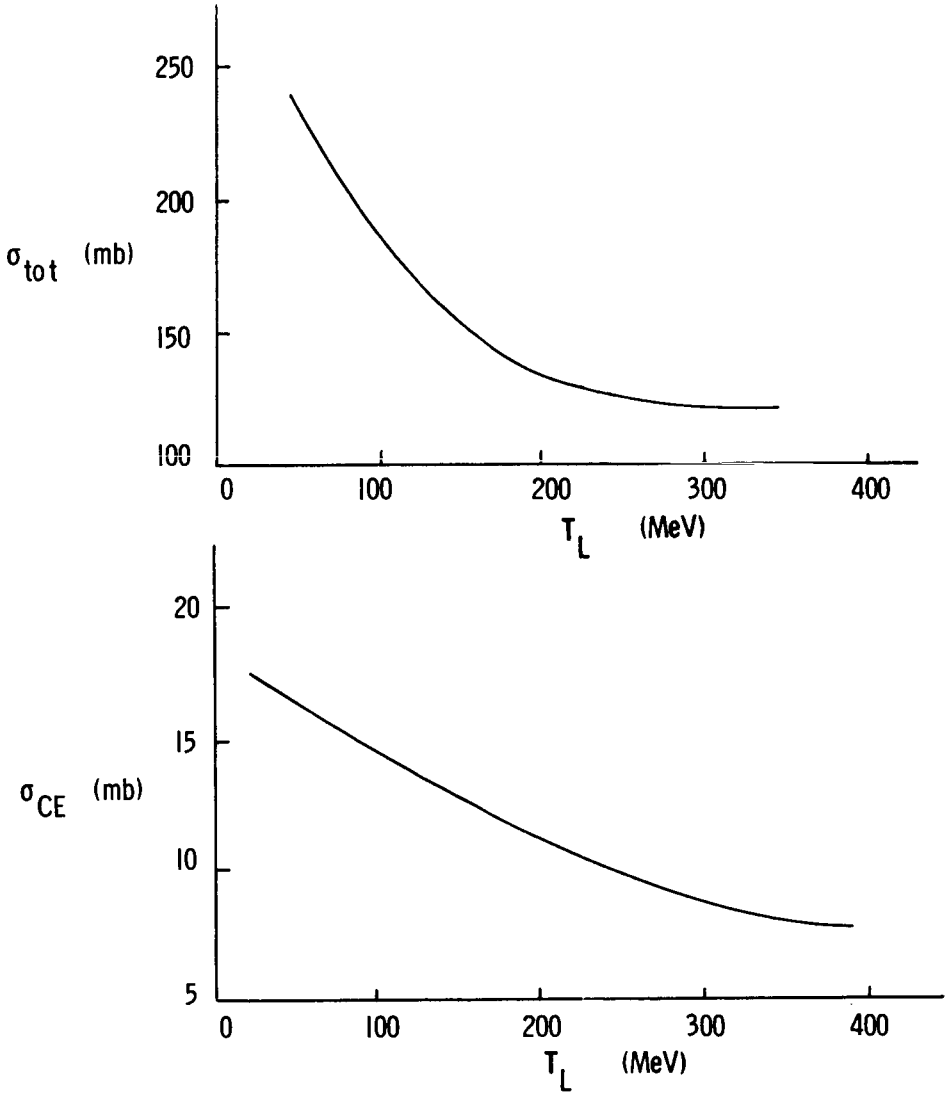



Figure 7. $P\bar{P}$ total and charge exchange cross sections. The inelastic cross section is approximately $(1/2)\sigma_{\text{tot}}$ for the energies shown.

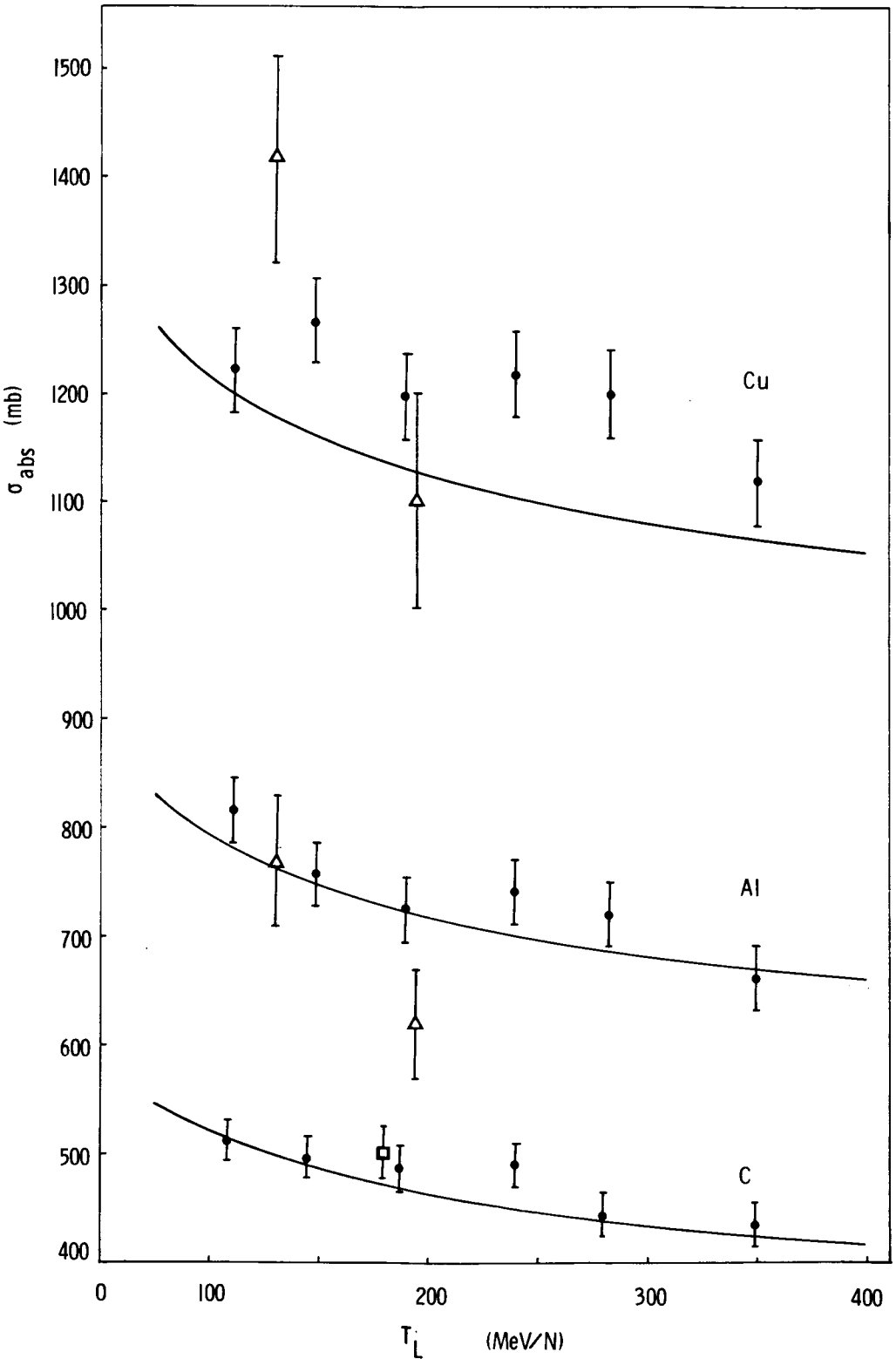



Figure 8. $\bar{P}$-Nucleus absorptive cross sections. Data shown are from references 18 to 20.

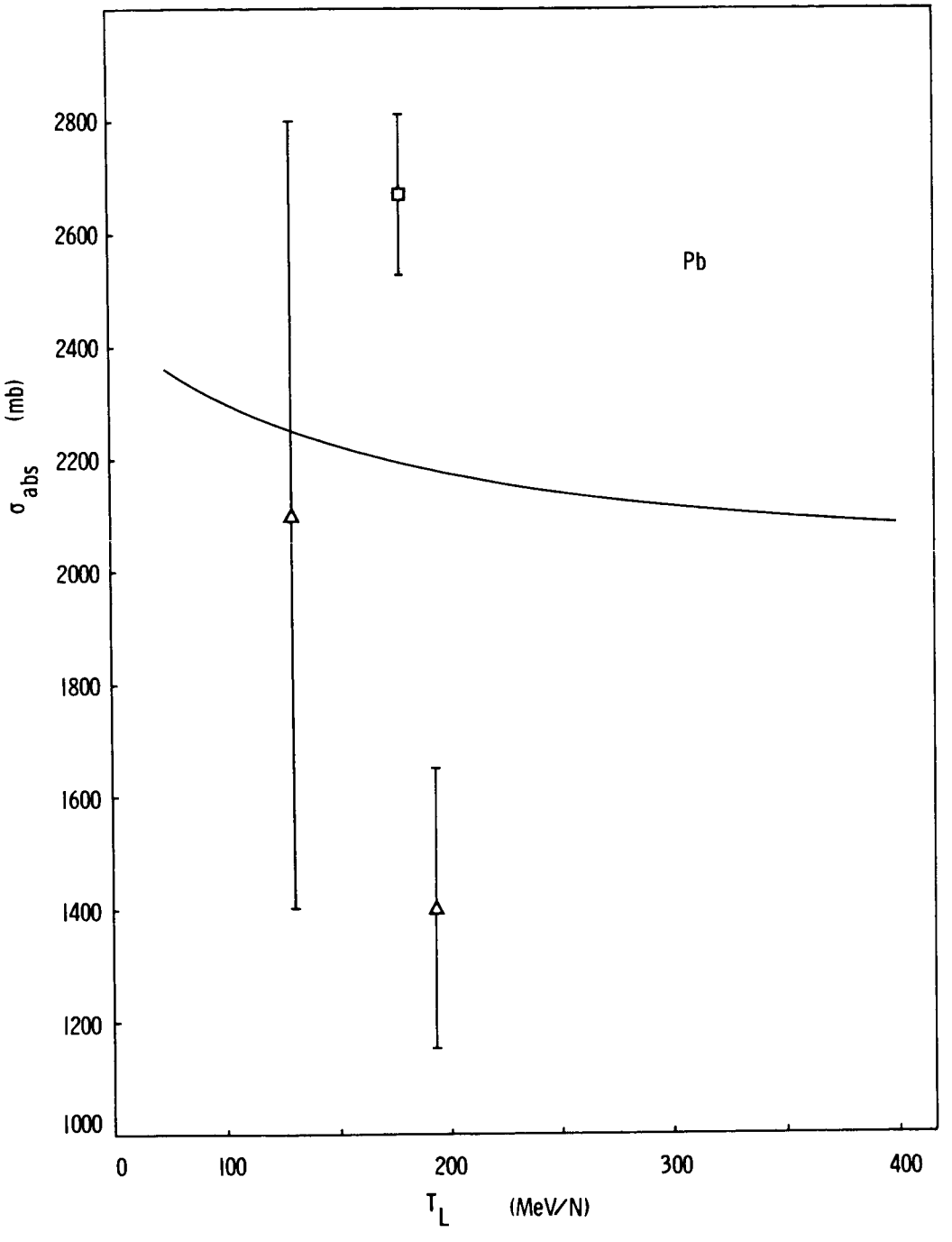



Figure 9. $\bar{P}$-$Pb$ absorptive cross section. Data shown are from references 18 to 20.

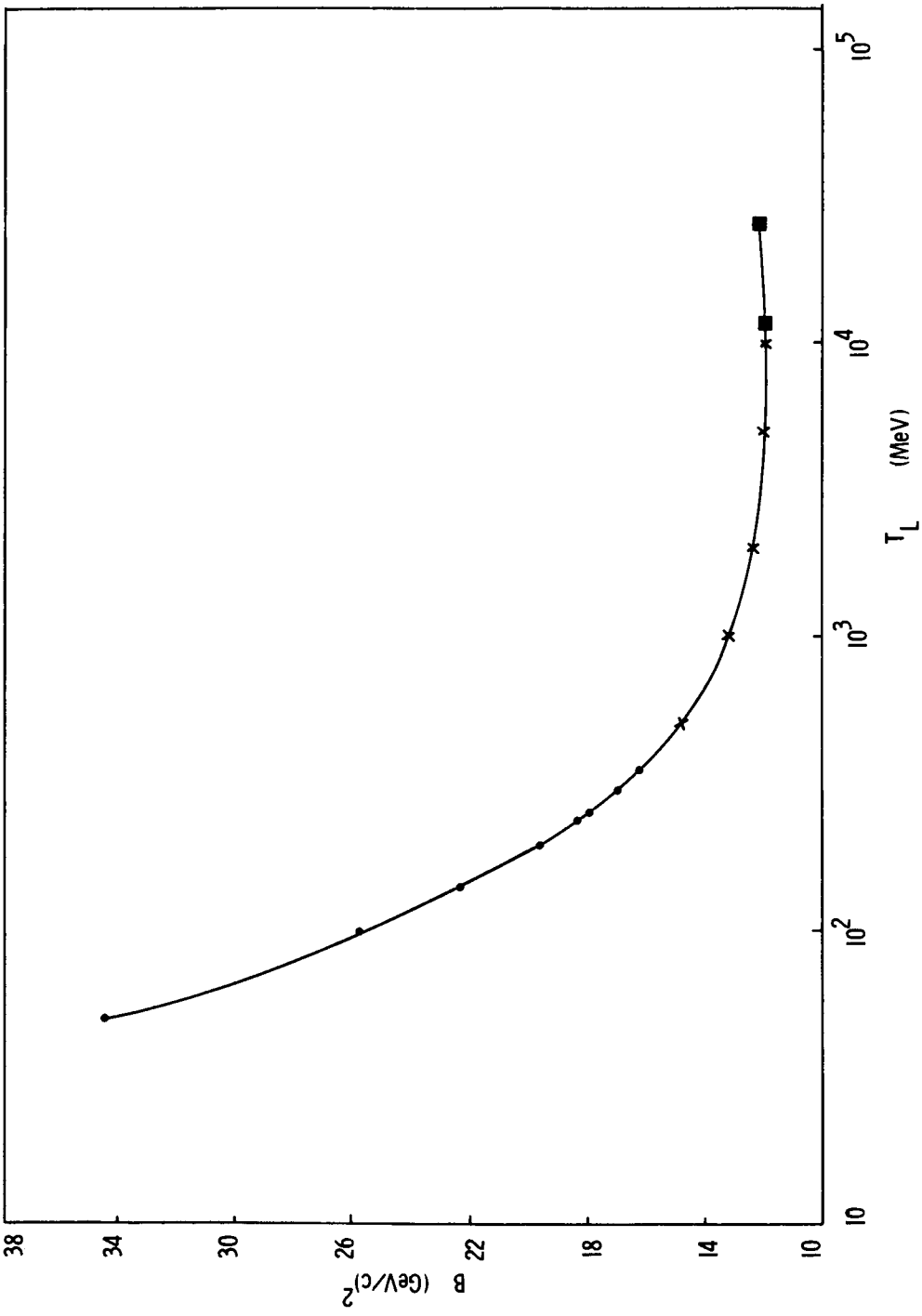



Figure 10. $N\bar{N}$ slope parameter.

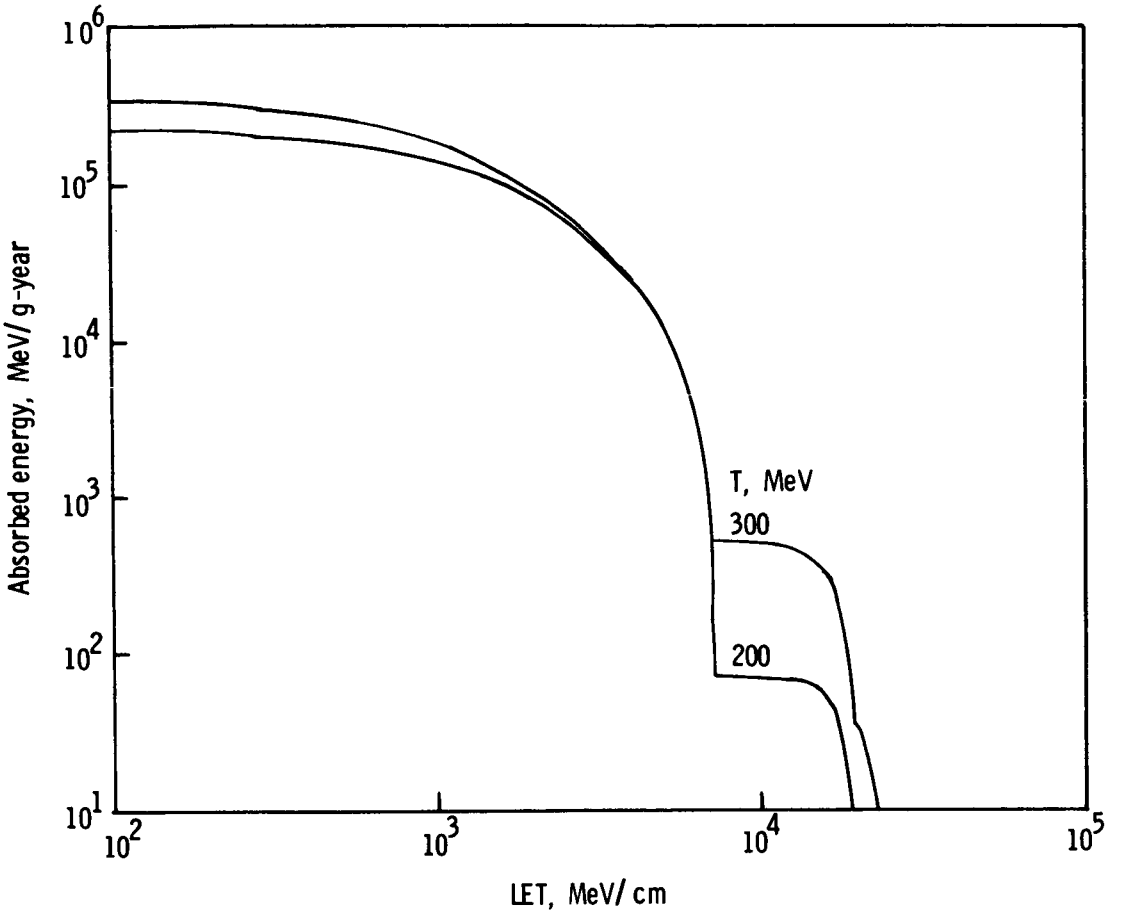



Figure 11. Linear energy transport (LET) spectrum of annihilation products for temperatures of 200 and 300 MeV.

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15. Supplementary Notes

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John W. Norbury: University of Idaho, Moscow, Idaho.

16. Abstract

Arguments are presented for the possible existence of antinuclei of charge $|Z| > 2$ and particularly galactic cosmic antinuclei. Theoretical antinucleus-nucleus optical model cross sections are calculated and presented for the first time. A brief review of the nucleon-antinucleon interaction is also presented and its connection with the antinucleus-nucleus interaction is made. The predicted cross sections are smooth and show no structure. Finally, the findings are tied together with the formation of microlesions in living tissue.

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