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ENERGY LOSS OF MUONS IN THE ENERGY RANGE 1–10000 GeV

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ABSTRACT

A summary is given of the most recent formulae for the cross-sections contributing to the energy loss of muons in matter, notably due to electromagnetic interactions (ionization, bremsstrahlung and electron-pair production) and nuclear interactions. Computed energy losses dE/dx are tabulated for muons with energy between 1 GeV and 10,000 GeV in a number of materials commonly used in high-energy physics experiments. In comparaison with earlier tables, these show deviations that grow with energy and amount to several per cent at 200 GeV muon energy.

CONTENTS

1. INTRODUCTION

Over the past 20 years, considerable progress has been achieved in the theoretical understanding of electromagnetic and nuclear interactions of muons with matter. Historically, these calculations have been stimulated mostly by cosmic-ray physics. The construction of massive muon detectors at accelerators, designed mainly to study deep inelastic muon and charged-current neutrino interactions, has revived interest in precise calculations of the energy loss of muons in the energy range of several hundred GeV.

The well-known dE/dx tables compiled by Richard-Serre in 1971 [1] have long served as a standard reference for the stopping power of relativistic muons. Since then, progress has been made mainly in evaluating the cross-sections of radiative processes and in the determination of material constants which are relevant to the calculation of ionization losses. These improvements start to be of practical importance at presently accessible energies and will be substantial for the next generation of particle accelerators where detectors will have to cope with muons of several TeV energy. Therefore, we found it timely to attempt a revised compilation of the most up to date formulae and to provide experimentalists with a comprehensive set of tables of the mean energy loss (stopping power) of muons for a choice of media frequently used in high-energy physics experiments.

2. ENERGY LOSS PROCESSES

High-energy muons passing through matter lose energy due to electromagnetic processes - mainly ionization (order α^2), bremsstrahlung (order α^3), and direct pair production (order α^4) - and photonuclear interactions.

2.1 Ionization

The ionization loss of a muon of energy E is given by the well-known Bethe-Bloch formula [2]:

$$\frac{dE}{dx} = \alpha^2 2\pi N\lambda_e^2 \frac{Zm_e}{A\beta^2} \left\{ \ln \frac{2m_e\beta^2\gamma^2 E'_m}{I^2(Z)} - 2\beta^2 + \frac{1}{4}\frac{E'^2_m}{E^2} - \delta \right\},$$

where

α = 1/137.036 is the fine structure constant,

N = 6.023 x 10^{23} is Avogadro's number,

Z and A are the atomic number and the atomic weight of the traversed medium,

m_e and m_μ are the rest masses of the electron and the muon,

$\beta = p/E$, where p is the muon momentum,

$\gamma = E/m_\mu$,

λ_e = 3.8616 x 10^{-11} cm is the Compton wavelength of the electron,

I(Z) is the mean ionization potential of the medium,

E'_m is the maximum energy transferable to the electron,

$$E'_m = 2m_e \frac{p^2}{m_e^2 + m_\mu^2 + 2m_e\sqrt{p^2 + m_\mu^2}},$$

δ is the density correction.

For the density correction δ, we have used the parametrization of Sternheimer et al. [3]:

$$\delta(X) = 4.6052\, X + a\,(X_1 - X)^m + C, \qquad X_0 < X < X_1$$
$$\delta(X) = 4.6052\, X + C, \qquad X > X_1$$

where $X = \log_{10}(\beta\gamma)$. The values for X_0, X_1, a, m, C and I(Z) are taken from Refs. [3,4].

2.2 Bremsstrahlung

The cross-section for muon bremsstrahlung has first been calculated by Bethe and Heitler [5]. The main improvement to their formula was a comprehensive treatment of atomic and nuclear form factors by Petrukhin and Shestakov [6], who derived the expression:

$$\frac{d\sigma}{dv} = \alpha^3 \left(2Z\lambda_e \frac{m_e}{m_\mu}\right)^2 \frac{1}{v} \left(\frac{4}{3} - \frac{4}{3}v + v^2\right) \phi(\delta),$$

where v is the fraction of energy transferred to the photon. They suggest the following approximation for $\phi(\delta)$:

$$\phi(\delta) = \ln \frac{\frac{189 m_\mu}{m_e} Z^{-1/3}}{1 + \frac{189\sqrt{e}}{m_e}\delta Z^{-1/3}} , \qquad Z < 10$$

$$\phi(\delta) = \ln \frac{\frac{2}{3}\frac{189 m_\mu}{m_e} Z^{-2/3}}{1 + \frac{189\sqrt{e}}{m_e}\delta Z^{-1/3}} , \qquad Z > 10$$

where $\delta = m_\mu^2 v/2E(1-v)$ is the minimum momentum transfer to the nucleus and $e = 2.718$. All other variables have the same meaning as defined in Section 2.1.

The mean energy loss

$$\frac{dE}{dx} = E\frac{N}{A}\int_{v_{min}}^{v_{max}} v \frac{d\sigma}{dv} dv$$

can be calculated analytically by solving the integral between $v_{min} = 0$ and $v_{max} = 1 - \frac{3}{4}\sqrt{e}\,(m_\mu/E)Z^{1/3}$. To account for bremsstrahlung losses on atomic electrons, we have replaced Z^2 by $Z(Z+1)$ [7].

2.3 Direct electron pair production

Based on a rigorous QED calculation performed by Kelner and Kotov [7], Kokoulin and Petrukhin have given a convenient parametrization of the direct pair production cross-section in the form [8]

$$\frac{d^2\sigma}{dv d\rho} = \alpha^4 \frac{2}{3\pi}(Z\lambda_e)^2 \frac{1-v}{v}\left(\phi_e + \frac{m_e^2}{m_\mu^2}\phi_\mu\right),$$

where $\rho = (E^+-E^-)/(E^++E^-)$ is the asymmetry parameter of the electron-positron pair. The terms ϕ_e and ϕ_μ correspond to different QED diagrams and contain also corrections for atomic and nuclear form factors. Their explicit form is given in the Appendix. Their interference term has been estimated to be negligible [7].

The energy loss was calculated by numerical integration of the twofold integral:

$$\frac{dE}{dx} = 2E\,\frac{N}{A} \int_{v_{min}}^{v_{max}} v \int_0^{\rho_{max}} \frac{d^2\sigma}{dv d\rho}\, d\rho dv$$

Again, to take into account the influence of the atomic electrons, we have replaced Z^2 by $Z(Z+1)$ [7].

2.4 Nuclear Interaction

The photonuclear interaction of high-energy muons is theoretically much less understood than the purely electromagnetic processes. Several models have been developed, mainly to describe cosmic-ray data [9]. Accelerator measurements of the γp and γA cross-section are now available up to $\sim$ 200 GeV [10] and allow the parameters of models describing real photonuclear scattering to be adjusted. Here we use the formula evaluated by Bezrukov and Bugaev in the framework of the vector dominance model [11]. It describes well the behaviour of $\sigma_{\gamma A}$ as a function of the photon energy and also has been confirmed by cosmic-ray measurements [12]. Furthermore, it is consistent with the results of other calculations [9,13] on the 30% level. The explicit expression is given in the Appendix. The energy loss dE/dx was calculated by numerical integration.

3. OTHER CONTRIBUTIONS TO THE ENERGY LOSS

3.1 Higher Order Contributions to the Ionization

Contributions of the order of α^3 to the ionization energy loss were first calculated using a static Coulomb approximation [14], which should be valid up to several GeV. They amount to 0.3% of the total ionization loss. For the extreme relativistic case, the approach of Eriksson et al. [15] points to an increasing contribution of α^3 corrections to the μe elastic cross-section. A recent measurement of the muon energy loss at energies of $\sim$ 100 GeV [16] indicates that there is room for additional contributions of about 1%.

At even higher energies, the contribution of the ionization to the total energy loss decreases rapidly, dropping, for example, to only 3% for 10 TeV muons in iron, such that higher order corrections are likely to be negligible. For a quantitative calculation of the α^3 contributions to the ionization, an exact cross-section formula is still missing.

3.2 Muon Pair Production

The contribution of direct muon pair production to the energy loss has been estimated using the cross-section given in Ref. [8] and replacing m_e by m_μ. In the energy region under consideration it does not exceed 0.01% of the total energy loss for any material.

4. RESULTS

4.1 Elements

The total energy loss for a single element was calculated by summing up the individual contributions:

$$\frac{dE}{dx} = \left(\frac{dE}{dx}\right)_i + \left(\frac{dE}{dx}\right)_b + \left(\frac{dE}{dx}\right)_p + \left(\frac{dE}{dx}\right)_n ,$$

where i denotes ionization, b bremsstrahlung, p pair production, and n nuclear interactions. Table 1 summarizes the material constants of the elements for which the energy loss has been calculated. For illustration, the contributions of the individual processes are shown for hydrogen, iron, and uranium in Figs. 1a-1c and in Table 2. While the ionization losses reach a constant value, the radiative contributions grow approximately linearly with the energy and are the dominant contribution in the very high energy regime.

In Table 3, energy losses dE/dx are tabulated for muon energies in the range 1-10000 GeV. The energy intervals chosen allow linear interpolation with a precision of about 3×10^{-3}. A recent measurement of the energy loss of muons in iron and in a carbon-boron mixture, for muon energies between 50 and 120 GeV, indicates that these calculations are correct to 1% in this energy range [16].

4.2 Compounds

The energy loss in compounds was determined in two steps. First, the ionization losses were calculated using the material parameters given in Table 4. In a second step, the radiative losses were calculated for each element separately and then added according to

$$\frac{dE}{dx}^{rad} = \sum_j k_j \left(\frac{dE}{dx}\right)_j^{rad} ,$$

where j runs over all elements and k_j is the weight proportion of the j-th element in the compound. For a molecule with molecular weight A_m the weight proportion of the element j with an atomic weight A_j is

$$k_j = \frac{nA_j}{A_m} ,$$

where n is the number of atoms j in the molecule. The energy losses in several compounds are listed as a function of the energy in Table 5.

5. CONCLUSIONS

We believe that the present compilation reflects the latest state of the art in the theoretical and phenomenological treatment of muon-energy loss. In the energy range accessible with present-day accelerators, the differences from earlier calculations based on simpler analytical estimates do not exceed several per cent. On the energy scale set by the next generation of particle accelerators, however, the improvement - which is mainly due to a refined treatment of the radiative processes - may well be substantial.

It is important to realize that, for muon energies beyond $\sim$ 100 GeV and heavy materials, the contribution of the stochastic radiative processes becomes important and eventually dominates the total energy loss. In this regime, the description of the energy loss by a single mean value may become inappropriate or even misleading for detailed detector design and precise data analysis since typical massive detectors - i.e. solid iron spectrometers or beam dumps - often absorb muons which lose a substantial fraction of their energy before they are detected. We have therefore developed a Monte Carlo package for the statistical simulation of muon energy loss according to the same cross-section formulae which we have used for the present tables [17].

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APPENDIX

Cross-section formulae

1. Direct pair production

$$\frac{d\sigma}{dv d\rho} = \alpha^4 \frac{2}{3\pi} (Z\lambda_e)^2 \frac{1-v}{v} \left[\phi_e + \left(\frac{m_e}{m_\mu}\right)^2 \phi_\mu \right]$$

$$\phi_e = \left\{ \left[(2+\rho^2)(1+\beta) + \xi(3+\rho^2) \right] \ln (1+1/\xi) + \frac{1-\rho^2-\beta}{1+\xi} - (3+\rho^2) \right\} L_e$$

$$\phi_\mu = \left\{ \left[(1+\rho^2)(1+\tfrac{3}{2}\beta) - \frac{1}{\xi}(1+2\beta)(1-\rho^2) \right] \ln (1+\xi) + \frac{\xi(1-\rho^2-\beta)}{1+\xi} + \right.$$
$$\left. + (1+2\beta)(1-\rho^2) \right\} L_\mu$$

$$L_e = \ln \frac{RZ^{-1/3}\sqrt{(1+\xi)(1+Y_e)}}{1 + \dfrac{2m_e \sqrt{e} RZ^{-1/3} (1+\xi)(1+Y_e)}{Ev(1-\rho^2)}} -$$
$$- \frac{1}{2} \ln \left[1+\left(\frac{3}{2} \frac{m_e}{m_\mu} Z^{1/3}\right)^2 (1+\xi)(1+Y_e)\right]$$

$$L_\mu = \ln \frac{\dfrac{2}{3} \dfrac{m_\mu}{m_e} RZ^{-2/3}}{1 + \dfrac{2m_e \sqrt{e} RZ^{-1/3} (1+\xi)(1+Y_\mu)}{Ev(1-\rho^2)}}$$

$$Y_e = \frac{5 - \rho^2 + 4\beta(1+\rho^2)}{2(1+3\beta) \ln (3+1/\xi) - \rho^2 - 2\beta(2-\rho^2)}$$

$$Y_\mu = \frac{4 + \rho^2 + 3\beta(1+\rho^2)}{(1+\rho^2)(\tfrac{3}{2} + 2\beta) \ln (3+\xi) + 1 - \tfrac{3}{2} \rho^2}$$

$$\beta = \frac{v^2}{2(1-v)} , \qquad \xi = \left(\frac{m_\mu v}{2m_e}\right)^2 \frac{1-\rho^2}{1-v}$$

$$\rho = \frac{E^+ - E^-}{E^+ + E^-} , \qquad v = \frac{E^+ + E^-}{E} .$$

The integration limits are:

$$\frac{4m_e}{E} < v < 1 - \frac{3\sqrt{e}m_\mu}{4E} Z^{1/3}$$

$$0. < |\rho| < \left(1- \frac{6m_\mu^2}{E^2(1-v)}\right)\sqrt{1 - \frac{4m_e}{Ev}} ,$$

where

E^+ and E^- are the energies of the positron and the electron,

R = 189 is the value of the radiation logarithm,

e = 2.718

All other variables have the same meaning as defined in Section 2.1.

2. Nuclear interaction

$$\frac{d\sigma}{dv} = \frac{\alpha}{2\pi} A\sigma_{\gamma N} v \left\{ \frac{3}{4} G(x) \left[\kappa \ln \left(1 + \frac{m_1^2}{t}\right) - \frac{\kappa m_1^2}{m_1^2+t} - \frac{2m_\mu^2}{t}\right] + \right.$$

$$+ \frac{1}{4}\left[\kappa \ln\left(1+ \frac{m_2^2}{t}\right) - \frac{2m_\mu^2}{t}\right] +$$

$$\left. + \frac{m_\mu^2}{2t}\left[\frac{3}{4} G(x) \frac{m_1^2}{m_1^2+t} + \frac{1}{4} \frac{m_2^2}{t} \ln\left(1+ \frac{t}{m_2^2}\right)\right]\right\} ,$$

where

$$G(x) = \frac{3}{x^3}\left(\frac{x^2}{2} - 1 + e^{-x} (1+x)\right), \qquad x = 0.00282 A^{1/3} \sigma_{\gamma N}(\varepsilon)$$

$$\sigma_{\gamma N}(\varepsilon) = 114.3 + 1.647 \ln^2 (0.0213 \varepsilon)$$

$$t = \frac{m_\mu^2 v^2}{1-v} , \quad \kappa = 1 - \frac{2}{v} + \frac{2}{v^2}$$

$$m_1^2 = 0.54 \text{ GeV}^2$$

$$m_2^2 = 1.8 \text{ GeV}^2 ,$$

ϵ being the photon energy in GeV and $\sigma_{\gamma N}$ the total photonuclear cross-section on nucleons in μb. All other variables have the same meaning as defined in the previous sections.

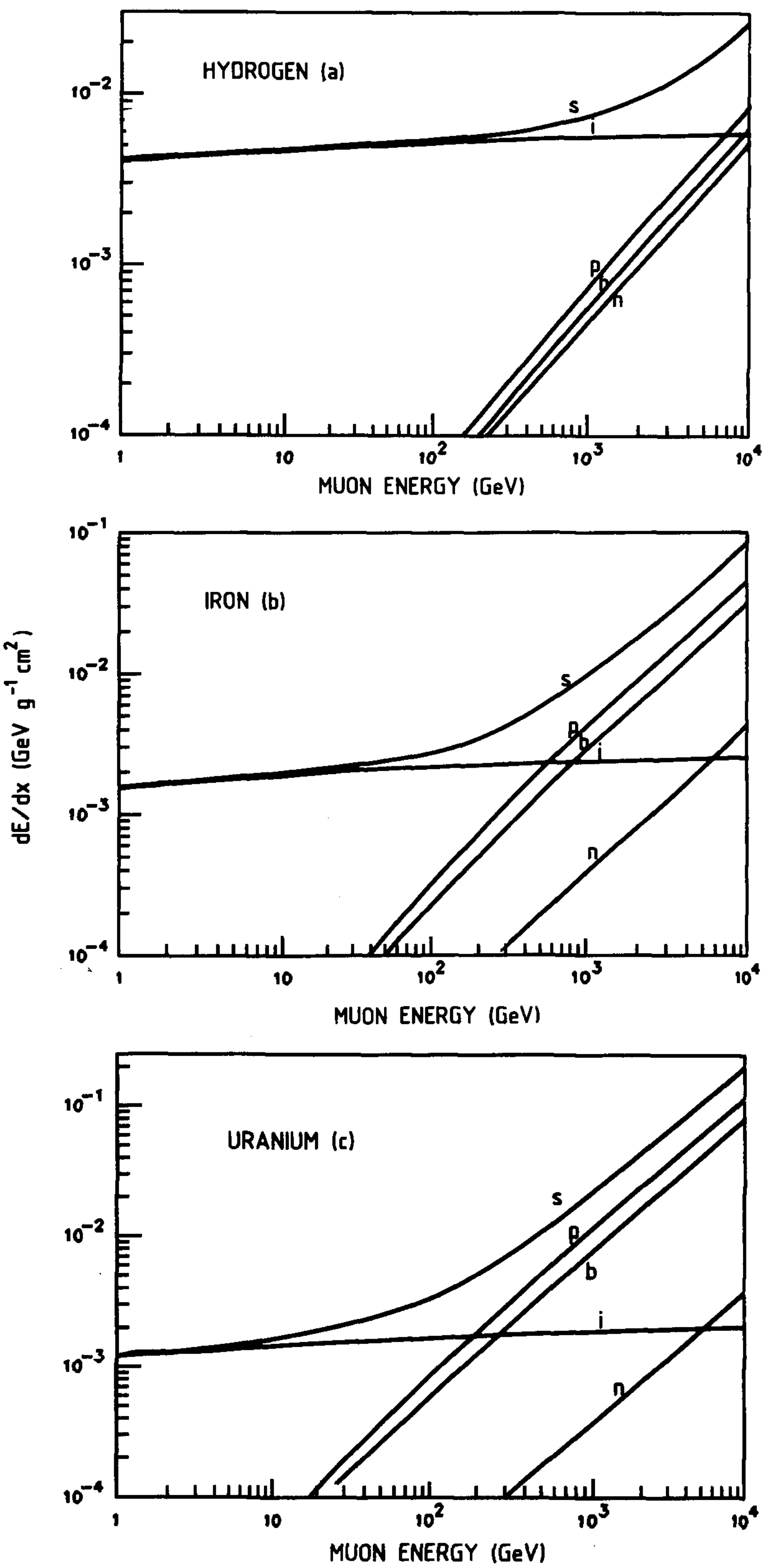

Fig. 1 Contributions to the energy loss from ionization (i), bremsstrahlung (b), pair production (p), nuclear interaction (n), and their sum (s) as functions of the energy in hydrogen (a), iron (b), and uranium (c).

Table 1

List of elements and their material parameters

Material	Density (g/cm^3)	Z	A	I (eV)	Density correction constants -C	X_0	X_1	a	m
Hydrogen	.063	1.	1.008	21.8	3.263	.476	1.922	.135	5.625
Deuterium	.140	1.	2.014	21.8	2.942	.200	2.000	.347	3.000
Helium	.125	2.	4.003	41.8	4.517	.473	2.000	.657	3.000
Lithium	.534	3.	6.940	40.0	3.122	.130	1.640	.951	2.499
Beryllium	1.848	4.	9.012	63.7	2.785	.059	1.692	.804	2.434
Boron	2.370	5.	10.810	76.0	2.848	.031	1.969	.562	2.451
Carbon	2.265	6.	12.011	78.0	2.868	-.018	2.342	.261	2.870
Nitrogen	.808	7.	14.007	82.0	3.998	.304	2.000	.533	3.000
Oxygen	1.140	8.	15.999	95.0	3.948	.287	2.000	.523	3.000
Fluorine	1.108	9.	18.998	115.0	4.413	.200	3.000	.159	3.000
Neon	1.207	10.	20.170	137.0	4.632	.200	3.000	.169	3.000
Sodium	.971	11.	22.990	149.0	5.053	.288	3.196	.078	3.645
Magnesium	1.740	12.	24.305	156.0	4.530	.150	3.067	.082	3.617
Aluminium	2.699	13.	26.982	166.0	4.240	.171	3.013	.080	3.635
Silicon	2.330	14.	28.086	173.0	4.435	.201	2.872	.149	3.255
Sulphur	2.000	16.	32.060	180.0	4.666	.158	2.716	.340	2.646
Chlorine	1.560	17.	35.453	174.0	4.887	.200	3.000	.181	3.000
Argon	1.393	18.	39.948	188.0	5.217	.201	3.000	.196	3.000
Potassium	.862	19.	39.098	190.0	5.642	.385	3.172	.198	2.923
Calcium	1.550	20.	40.080	191.0	5.040	.323	3.119	.156	3.075
Chromium	7.180	24.	51.996	257.0	4.178	.034	3.045	.154	2.990
Manganese	7.440	25.	54.938	272.0	4.270	.045	3.107	.150	2.980
Iron	7.874	26.	55.847	286.0	4.291	-.001	3.153	.147	2.963
Nickel	8.902	28.	58.710	311.0	4.312	-.057	3.185	.165	2.843
Copper	8.960	29.	63.546	322.0	4.419	-.025	3.279	.143	2.904
Zinc	7.133	30.	65.380	330.0	4.691	.005	3.367	.147	2.865
Germanium	5.323	32.	72.590	350.0	5.141	.338	3.610	.072	3.331
Bromine	3.120	35.	79.904	343.0	5.641	.339	3.000	.217	3.000
Tin	7.310	50.	118.690	488.0	5.534	.288	3.296	.187	2.858
Iodine	4.930	53.	126.905	491.0	5.949	.055	3.260	.238	2.728
Barium	3.500	56.	137.330	491.0	6.315	.419	3.455	.183	2.891
Tungsten	19.300	74.	183.850	727.0	5.406	.217	3.496	.155	2.845
Lead	11.350	82.	207.200	823.0	6.202	.378	3.807	.094	3.161
Bismuth	9.747	83.	208.980	823.0	6.351	.415	3.825	.094	3.167
Uranium	18.950	92.	238.029	890.0	5.869	.226	3.372	.197	2.817

Table 2

Energy loss from ionization, bremsstrahlung, pair production, and nuclear interaction as a function of the muon energy for hydrogen, iron, and uranium.

a) *dE/dx composition for hydrogen (GeV g^{-1} cm^2)*

E (GeV)	Ionization	Brems-strahlung	Pair production	Nuclear interaction	Total
1	.4171 10^{-2}	.1741 10^{-6}	.2917 10^{-7}	.5375 10^{-6}	.4171 10^{-2}
5	.4593 10^{-2}	.1368 10^{-5}	.8077 10^{-6}	.2735 10^{-5}	.4598 10^{-2}
10	.4766 10^{-2}	.3173 10^{-5}	.2416 10^{-5}	.5221 10^{-5}	.4776 10^{-2}
15	.4860 10^{-2}	.5142 10^{-5}	.4383 10^{-5}	.7624 10^{-5}	.4878 10^{-2}
20	.4924 10^{-2}	.7217 10^{-5}	.6586 10^{-5}	.9985 10^{-5}	.4948 10^{-2}
30	.5010 10^{-2}	.1158 10^{-4}	.1147 10^{-4}	.1464 10^{-4}	.5047 10^{-2}
40	.5067 10^{-2}	.1615 10^{-4}	.1682 10^{-4}	.1924 10^{-4}	.5119 10^{-2}
50	.5110 10^{-2}	.2087 10^{-4}	.2249 10^{-4}	.2380 10^{-4}	.5177 10^{-2}
60	.5144 10^{-2}	.2571 10^{-4}	.2842 10^{-4}	.2835 10^{-4}	.5226 10^{-2}
70	.5172 10^{-2}	.3065 10^{-4}	.3455 10^{-4}	.3289 10^{-4}	.5270 10^{-2}
80	.5196 10^{-2}	.3566 10^{-4}	.4086 10^{-4}	.3742 10^{-4}	.5310 10^{-2}
90	.5217 10^{-2}	.4075 10^{-4}	.4731 10^{-4}	.4195 10^{-4}	.5347 10^{-2}
100	.5235 10^{-2}	.4589 10^{-4}	.5389 10^{-4}	.4647 10^{-4}	.5381 10^{-2}
120	.5266 10^{-2}	.5635 10^{-4}	.6737 10^{-4}	.5552 10^{-4}	.5446 10^{-2}
140	.5293 10^{-2}	.6698 10^{-4}	.8120 10^{-4}	.6457 10^{-4}	.5505 10^{-2}
160	.5315 10^{-2}	.7776 10^{-4}	.9533 10^{-4}	.7363 10^{-4}	.5562 10^{-2}
180	.5334 10^{-2}	.8868 10^{-4}	.1097 10^{-3}	.8270 10^{-4}	.5615 10^{-2}
200	.5352 10^{-2}	.9970 10^{-4}	.1243 10^{-3}	.9178 10^{-4}	.5668 10^{-2}
220	.5367 10^{-2}	.1108 10^{-3}	.1390 10^{-3}	.1009 10^{-3}	.5718 10^{-2}
240	.5381 10^{-2}	.1220 10^{-3}	.1539 10^{-3}	.1100 10^{-3}	.5767 10^{-2}
260	.5394 10^{-2}	.1333 10^{-3}	.1690 10^{-3}	.1191 10^{-3}	.5816 10^{-2}
280	.5406 10^{-2}	.1447 10^{-3}	.1842 10^{-3}	.1283 10^{-3}	.5863 10^{-2}
300	.5417 10^{-2}	.1561 10^{-3}	.1995 10^{-3}	.1374 10^{-3}	.5910 10^{-2}
350	.5442 10^{-2}	.1850 10^{-3}	.2381 10^{-3}	.1604 10^{-3}	.6026 10^{-2}
400	.5463 10^{-2}	.2142 10^{-3}	.2773 10^{-3}	.1835 10^{-3}	.6138 10^{-2}
450	.5482 10^{-2}	.2436 10^{-3}	.3169 10^{-3}	.2067 10^{-3}	.6249 10^{-2}
500	.5498 10^{-2}	.2733 10^{-3}	.3568 10^{-3}	.2299 10^{-3}	.6358 10^{-2}
600	.5527 10^{-2}	.3332 10^{-3}	.4376 10^{-3}	.2768 10^{-3}	.6575 10^{-2}
700	.5551 10^{-2}	.3938 10^{-3}	.5192 10^{-3}	.3239 10^{-3}	.6788 10^{-2}
800	.5572 10^{-2}	.4550 10^{-3}	.6016 10^{-3}	.3714 10^{-3}	.7000 10^{-2}
900	.5590 10^{-2}	.5166 10^{-3}	.6846 10^{-3}	.4192 10^{-3}	.7210 10^{-2}
1000	.5606 10^{-2}	.5786 10^{-3}	.7680 10^{-3}	.4672 10^{-3}	.7420 10^{-2}
1500	.5669 10^{-2}	.8928 10^{-3}	.1190 10^{-2}	.7111 10^{-3}	.8463 10^{-2}
2000	.5713 10^{-2}	.1212 10^{-2}	.1618 10^{-2}	.9603 10^{-3}	.9504 10^{-2}
3000	.5776 10^{-2}	.1860 10^{-2}	.2483 10^{-2}	.1471 10^{-2}	.1159 10^{-1}
4000	.5820 10^{-2}	.2514 10^{-2}	.3354 10^{-2}	.1995 10^{-2}	.1368 10^{-1}
5000	.5854 10^{-2}	.3174 10^{-2}	.4229 10^{-2}	.2529 10^{-2}	.1579 10^{-1}
6000	.5882 10^{-2}	.3837 10^{-2}	.5107 10^{-2}	.3072 10^{-2}	.1790 10^{-1}
7000	.5905 10^{-2}	.4502 10^{-2}	.5987 10^{-2}	.3623 10^{-2}	.2002 10^{-1}
8000	.5926 10^{-2}	.5170 10^{-2}	.6869 10^{-2}	.4180 10^{-2}	.2214 10^{-1}
9000	.5943 10^{-2}	.5839 10^{-2}	.7751 10^{-2}	.4744 10^{-2}	.2428 10^{-1}
10000	.5960 10^{-2}	.6509 10^{-2}	.8635 10^{-2}	.5314 10^{-2}	.2642 10^{-1}

Table 2 (cont'd)

b) *dE/dx composition for iron (GeV g^{-1} cm^2)*

E (GeV)	Ionization	Brems-strahlung	Pair production	Nuclear interaction	Total
1	.1560 10^{-2}	.5837 10^{-6}	.1777 10^{-6}	.4145 10^{-6}	.1561 10^{-2}
5	.1827 10^{-2}	.5683 10^{-5}	.5007 10^{-5}	.2192 10^{-5}	.1840 10^{-2}
10	.1925 10^{-2}	.1397 10^{-4}	.1492 10^{-4}	.4229 10^{-5}	.1958 10^{-2}
15	.1976 10^{-2}	.2326 10^{-4}	.2695 10^{-4}	.6210 10^{-5}	.2032 10^{-2}
20	.2009 10^{-2}	.3318 10^{-4}	.4033 10^{-4}	.8161 10^{-5}	.2091 10^{-2}
30	.2053 10^{-2}	.5431 10^{-4}	.6977 10^{-4}	.1202 10^{-4}	.2189 10^{-2}
40	.2081 10^{-2}	.7663 10^{-4}	.1016 10^{-3}	.1583 10^{-4}	.2275 10^{-2}
50	.2102 10^{-2}	.9981 10^{-4}	.1352 10^{-3}	.1963 10^{-4}	.2357 10^{-2}
60	.2118 10^{-2}	.1237 10^{-3}	.1700 10^{-3}	.2342 10^{-4}	.2436 10^{-2}
70	.2132 10^{-2}	.1480 10^{-3}	.2058 10^{-3}	.2720 10^{-4}	.2513 10^{-2}
80	.2143 10^{-2}	.1729 10^{-3}	.2423 10^{-3}	.3097 10^{-4}	.2590 10^{-2}
90	.2153 10^{-2}	.1981 10^{-3}	.2796 10^{-3}	.3474 10^{-4}	.2666 10^{-2}
100	.2162 10^{-2}	.2236 10^{-3}	.3174 10^{-3}	.3851 10^{-4}	.2741 10^{-2}
120	.2177 10^{-2}	.2756 10^{-3}	.3944 10^{-3}	.4605 10^{-4}	.2893 10^{-2}
140	.2189 10^{-2}	.3285 10^{-3}	.4730 10^{-3}	.5359 10^{-4}	.3044 10^{-2}
160	.2199 10^{-2}	.3822 10^{-3}	.5527 10^{-3}	.6114 10^{-4}	.3195 10^{-2}
180	.2209 10^{-2}	.4365 10^{-3}	.6334 10^{-3}	.6870 10^{-4}	.3347 10^{-2}
200	.2217 10^{-2}	.4915 10^{-3}	.7149 10^{-3}	.7627 10^{-4}	.3499 10^{-2}
220	.2224 10^{-2}	.5469 10^{-3}	.7971 10^{-3}	.8385 10^{-4}	.3652 10^{-2}
240	.2231 10^{-2}	.6027 10^{-3}	.8799 10^{-3}	.9144 10^{-4}	.3805 10^{-2}
260	.2237 10^{-2}	.6590 10^{-3}	.9632 10^{-3}	.9904 10^{-4}	.3958 10^{-2}
280	.2242 10^{-2}	.7156 10^{-3}	.1047 10^{-2}	.1067 10^{-3}	.4112 10^{-2}
300	.2248 10^{-2}	.7725 10^{-3}	.1131 10^{-2}	.1143 10^{-3}	.4265 10^{-2}
350	.2259 10^{-2}	.9161 10^{-3}	.1343 10^{-2}	.1334 10^{-3}	.4652 10^{-2}
400	.2269 10^{-2}	.1061 10^{-2}	.1557 10^{-2}	.1526 10^{-3}	.5040 10^{-2}
450	.2278 10^{-2}	.1208 10^{-2}	.1772 10^{-2}	.1719 10^{-3}	.5429 10^{-2}
500	.2286 10^{-2}	.1355 10^{-2}	.1989 10^{-2}	.1912 10^{-3}	.5821 10^{-2}
600	.2299 10^{-2}	.1652 10^{-2}	.2425 10^{-2}	.2301 10^{-3}	.6607 10^{-2}
700	.2310 10^{-2}	.1953 10^{-2}	.2863 10^{-2}	.2692 10^{-3}	.7395 10^{-2}
800	.2320 10^{-2}	.2256 10^{-2}	.3305 10^{-2}	.3085 10^{-3}	.8189 10^{-2}
900	.2329 10^{-2}	.2560 10^{-2}	.3748 10^{-2}	.3480 10^{-3}	.8985 10^{-2}
1000	.2336 10^{-2}	.2866 10^{-2}	.4192 10^{-2}	.3878 10^{-3}	.9782 10^{-2}
1500	.2366 10^{-2}	.4415 10^{-2}	.6430 10^{-2}	.5891 10^{-3}	.1380 10^{-1}
2000	.2386 10^{-2}	.5982 10^{-2}	.8684 10^{-2}	.7940 10^{-3}	.1785 10^{-1}
3000	.2416 10^{-2}	.9150 10^{-2}	.1322 10^{-1}	.1213 10^{-2}	.2600 10^{-1}
4000	.2436 10^{-2}	.1234 10^{-1}	.1777 10^{-1}	.1640 10^{-2}	.3419 10^{-1}
5000	.2452 10^{-2}	.1555 10^{-1}	.2233 10^{-1}	.2075 10^{-2}	.4241 10^{-1}
6000	.2465 10^{-2}	.1877 10^{-1}	.2690 10^{-1}	.2516 10^{-2}	.5065 10^{-1}
7000	.2476 10^{-2}	.2200 10^{-1}	.3148 10^{-1}	.2962 10^{-2}	.5892 10^{-1}
8000	.2486 10^{-2}	.2524 10^{-1}	.3606 10^{-1}	.3412 10^{-2}	.6719 10^{-1}
9000	.2494 10^{-2}	.2847 10^{-1}	.4064 10^{-1}	.3867 10^{-2}	.7548 10^{-1}
10000	.2502 10^{-2}	.3172 10^{-1}	.4523 10^{-1}	.4326 10^{-2}	.8377 10^{-1}

Table 2 (cont'd)

c) *dE/dx composition for uranium (GeV g^{-1} cm^2)*

E (GeV)	Ionization	Brems-strahlung	Pair production	Nuclear interaction	Total
1	.1203 10^{-2}	.1319 10^{-5}	.4918 10^{-6}	.3576 10^{-6}	.1205 10^{-2}
5	.1452 10^{-2}	.1392 10^{-4}	.1405 10^{-4}	.1917 10^{-5}	.1481 10^{-2}
10	.1541 10^{-2}	.3500 10^{-4}	.4175 10^{-4}	.3713 10^{-5}	.1621 10^{-2}
15	.1587 10^{-2}	.5887 10^{-4}	.7522 10^{-4}	.5463 10^{-5}	.1727 10^{-2}
20	.1618 10^{-2}	.8448 10^{-4}	.1123 10^{-3}	.7190 10^{-5}	.1822 10^{-2}
30	.1657 10^{-2}	.1392 10^{-3}	.1933 10^{-3}	.1060 10^{-4}	.2000 10^{-2}
40	.1682 10^{-2}	.1972 10^{-3}	.2806 10^{-3}	.1399 10^{-4}	.2174 10^{-2}
50	.1701 10^{-2}	.2575 10^{-3}	.3720 10^{-3}	.1736 10^{-4}	.2348 10^{-2}
60	.1715 10^{-2}	.3196 10^{-3}	.4666 10^{-3}	.2071 10^{-4}	.2522 10^{-2}
70	.1727 10^{-2}	.3832 10^{-3}	.5636 10^{-3}	.2407 10^{-4}	.2698 10^{-2}
80	.1737 10^{-2}	.4479 10^{-3}	.6624 10^{-3}	.2742 10^{-4}	.2875 10^{-2}
90	.1745 10^{-2}	.5136 10^{-3}	.7629 10^{-3}	.3076 10^{-4}	.3053 10^{-2}
100	.1753 10^{-2}	.5802 10^{-3}	.8647 10^{-3}	.3411 10^{-4}	.3232 10^{-2}
120	.1766 10^{-2}	.7156 10^{-3}	.1071 10^{-2}	.4080 10^{-4}	.3593 10^{-2}
140	.1776 10^{-2}	.8535 10^{-3}	.1282 10^{-2}	.4750 10^{-4}	.3959 10^{-2}
160	.1785 10^{-2}	.9934 10^{-3}	.1495 10^{-2}	.5420 10^{-4}	.4327 10^{-2}
180	.1792 10^{-2}	.1135 10^{-2}	.1710 10^{-2}	.6091 10^{-4}	.4698 10^{-2}
200	.1799 10^{-2}	.1278 10^{-2}	.1927 10^{-2}	.6763 10^{-4}	.5072 10^{-2}
220	.1805 10^{-2}	.1422 10^{-2}	.2146 10^{-2}	.7436 10^{-4}	.5448 10^{-2}
240	.1811 10^{-2}	.1568 10^{-2}	.2366 10^{-2}	.8110 10^{-4}	.5826 10^{-2}
260	.1816 10^{-2}	.1714 10^{-2}	.2587 10^{-2}	.8785 10^{-4}	.6205 10^{-2}
280	.1821 10^{-2}	.1861 10^{-2}	.2809 10^{-2}	.9461 10^{-4}	.6585 10^{-2}
300	.1825 10^{-2}	.2009 10^{-2}	.3032 10^{-2}	.1014 10^{-3}	.6968 10^{-2}
350	.1834 10^{-2}	.2383 10^{-2}	.3593 10^{-2}	.1184 10^{-3}	.7928 10^{-2}
400	.1843 10^{-2}	.2759 10^{-2}	.4158 10^{-2}	.1354 10^{-3}	.8896 10^{-2}
450	.1850 10^{-2}	.3139 10^{-2}	.4726 10^{-2}	.1525 10^{-3}	.9868 10^{-2}
500	.1856 10^{-2}	.3522 10^{-2}	.5297 10^{-2}	.1696 10^{-3}	.1085 10^{-1}
600	.1868 10^{-2}	.4294 10^{-2}	.6445 10^{-2}	.2041 10^{-3}	.1281 10^{-1}
700	.1877 10^{-2}	.5072 10^{-2}	.7599 10^{-2}	.2387 10^{-3}	.1479 10^{-1}
800	.1885 10^{-2}	.5856 10^{-2}	.8758 10^{-2}	.2736 10^{-3}	.1677 10^{-1}
900	.1892 10^{-2}	.6644 10^{-2}	.9921 10^{-2}	.3086 10^{-3}	.1877 10^{-1}
1000	.1898 10^{-2}	.7436 10^{-2}	.1109 10^{-1}	.3438 10^{-3}	.2077 10^{-1}
1500	.1923 10^{-2}	.1144 10^{-1}	.1695 10^{-1}	.5218 10^{-3}	.3083 10^{-1}
2000	.1940 10^{-2}	.1548 10^{-1}	.2284 10^{-1}	.7029 10^{-3}	.4096 10^{-1}
3000	.1964 10^{-2}	.2364 10^{-1}	.3469 10^{-1}	.1072 10^{-2}	.6136 10^{-1}
4000	.1981 10^{-2}	.3185 10^{-1}	.4657 10^{-1}	.1449 10^{-2}	.8185 10^{-1}
5000	.1995 10^{-2}	.4010 10^{-1}	.5848 10^{-1}	.1831 10^{-2}	.1024
6000	.2006 10^{-2}	.4837 10^{-1}	.7040 10^{-1}	.2219 10^{-2}	.1230
7000	.2015 10^{-2}	.5666 10^{-1}	.8233 10^{-1}	.2611 10^{-2}	.1436
8000	.2023 10^{-2}	.6496 10^{-1}	.9427 10^{-1}	.3007 10^{-2}	.1643
9000	.2030 10^{-2}	.7327 10^{-1}	.1062	.3406 10^{-2}	.1849
10000	.2036 10^{-2}	.8159 10^{-1}	.1182	.3808 10^{-2}	.2056

Table 3

Energy loss in elements as a function of the muon energy ($GeV\ g^{-1}\ cm^2$)

E (GeV)	Hydrogen (liquid)	Deuterium (liquid)	Helium (liquid)	Lithium	Beryllium
1	$.4171\ 10^{-2}$	$.2042\ 10^{-2}$	$.2050\ 10^{-2}$	$.1710\ 10^{-2}$	$.1668\ 10^{-2}$
2	$.4352\ 10^{-2}$	$.2145\ 10^{-2}$	$.2171\ 10^{-2}$	$.1803\ 10^{-2}$	$.1763\ 10^{-2}$
4	$.4538\ 10^{-2}$	$.2246\ 10^{-2}$	$.2280\ 10^{-2}$	$.1889\ 10^{-2}$	$.1853\ 10^{-2}$
6	$.4645\ 10^{-2}$	$.2301\ 10^{-2}$	$.2337\ 10^{-2}$	$.1937\ 10^{-2}$	$.1903\ 10^{-2}$
8	$.4720\ 10^{-2}$	$.2339\ 10^{-2}$	$.2376\ 10^{-2}$	$.1970\ 10^{-2}$	$.1937\ 10^{-2}$
10	$.4776\ 10^{-2}$	$.2368\ 10^{-2}$	$.2406\ 10^{-2}$	$.1996\ 10^{-2}$	$.1964\ 10^{-2}$
15	$.4878\ 10^{-2}$	$.2420\ 10^{-2}$	$.2459\ 10^{-2}$	$.2043\ 10^{-2}$	$.2013\ 10^{-2}$
20	$.4948\ 10^{-2}$	$.2457\ 10^{-2}$	$.2496\ 10^{-2}$	$.2077\ 10^{-2}$	$.2049\ 10^{-2}$
30	$.5047\ 10^{-2}$	$.2508\ 10^{-2}$	$.2551\ 10^{-2}$	$.2126\ 10^{-2}$	$.2101\ 10^{-2}$
40	$.5119\ 10^{-2}$	$.2547\ 10^{-2}$	$.2591\ 10^{-2}$	$.2164\ 10^{-2}$	$.2142\ 10^{-2}$
50	$.5177\ 10^{-2}$	$.2578\ 10^{-2}$	$.2625\ 10^{-2}$	$.2196\ 10^{-2}$	$.2177\ 10^{-2}$
60	$.5226\ 10^{-2}$	$.2605\ 10^{-2}$	$.2655\ 10^{-2}$	$.2224\ 10^{-2}$	$.2208\ 10^{-2}$
70	$.5270\ 10^{-2}$	$.2629\ 10^{-2}$	$.2682\ 10^{-2}$	$.2250\ 10^{-2}$	$.2237\ 10^{-2}$
80	$.5310\ 10^{-2}$	$.2651\ 10^{-2}$	$.2706\ 10^{-2}$	$.2275\ 10^{-2}$	$.2265\ 10^{-2}$
90	$.5347\ 10^{-2}$	$.2671\ 10^{-2}$	$.2730\ 10^{-2}$	$.2298\ 10^{-2}$	$.2291\ 10^{-2}$
100	$.5381\ 10^{-2}$	$.2691\ 10^{-2}$	$.2752\ 10^{-2}$	$.2320\ 10^{-2}$	$.2316\ 10^{-2}$
120	$.5446\ 10^{-2}$	$.2728\ 10^{-2}$	$.2795\ 10^{-2}$	$.2363\ 10^{-2}$	$.2365\ 10^{-2}$
140	$.5505\ 10^{-2}$	$.2762\ 10^{-2}$	$.2835\ 10^{-2}$	$.2404\ 10^{-2}$	$.2411\ 10^{-2}$
160	$.5562\ 10^{-2}$	$.2794\ 10^{-2}$	$.2873\ 10^{-2}$	$.2443\ 10^{-2}$	$.2457\ 10^{-2}$
180	$.5615\ 10^{-2}$	$.2826\ 10^{-2}$	$.2911\ 10^{-2}$	$.2482\ 10^{-2}$	$.2501\ 10^{-2}$
200	$.5668\ 10^{-2}$	$.2856\ 10^{-2}$	$.2947\ 10^{-2}$	$.2520\ 10^{-2}$	$.2545\ 10^{-2}$
220	$.5718\ 10^{-2}$	$.2886\ 10^{-2}$	$.2983\ 10^{-2}$	$.2557\ 10^{-2}$	$.2589\ 10^{-2}$
240	$.5767\ 10^{-2}$	$.2915\ 10^{-2}$	$.3018\ 10^{-2}$	$.2594\ 10^{-2}$	$.2632\ 10^{-2}$
260	$.5816\ 10^{-2}$	$.2944\ 10^{-2}$	$.3053\ 10^{-2}$	$.2631\ 10^{-2}$	$.2675\ 10^{-2}$
280	$.5863\ 10^{-2}$	$.2972\ 10^{-2}$	$.3088\ 10^{-2}$	$.2667\ 10^{-2}$	$.2717\ 10^{-2}$
300	$.5910\ 10^{-2}$	$.3000\ 10^{-2}$	$.3122\ 10^{-2}$	$.2703\ 10^{-2}$	$.2759\ 10^{-2}$
350	$.6026\ 10^{-2}$	$.3069\ 10^{-2}$	$.3206\ 10^{-2}$	$.2792\ 10^{-2}$	$.2864\ 10^{-2}$
400	$.6138\ 10^{-2}$	$.3136\ 10^{-2}$	$.3290\ 10^{-2}$	$.2881\ 10^{-2}$	$.2969\ 10^{-2}$
450	$.6249\ 10^{-2}$	$.3203\ 10^{-2}$	$.3373\ 10^{-2}$	$.2969\ 10^{-2}$	$.3073\ 10^{-2}$
500	$.6358\ 10^{-2}$	$.3269\ 10^{-2}$	$.3455\ 10^{-2}$	$.3057\ 10^{-2}$	$.3177\ 10^{-2}$
600	$.6575\ 10^{-2}$	$.3400\ 10^{-2}$	$.3618\ 10^{-2}$	$.3232\ 10^{-2}$	$.3383\ 10^{-2}$
700	$.6788\ 10^{-2}$	$.3529\ 10^{-2}$	$.3781\ 10^{-2}$	$.3406\ 10^{-2}$	$.3590\ 10^{-2}$
800	$.7000\ 10^{-2}$	$.3658\ 10^{-2}$	$.3943\ 10^{-2}$	$.3581\ 10^{-2}$	$.3797\ 10^{-2}$
900	$.7210\ 10^{-2}$	$.3787\ 10^{-2}$	$.4105\ 10^{-2}$	$.3755\ 10^{-2}$	$.4003\ 10^{-2}$
1000	$.7420\ 10^{-2}$	$.3915\ 10^{-2}$	$.4267\ 10^{-2}$	$.3929\ 10^{-2}$	$.4210\ 10^{-2}$
1500	$.8463\ 10^{-2}$	$.4555\ 10^{-2}$	$.5075\ 10^{-2}$	$.4802\ 10^{-2}$	$.5247\ 10^{-2}$
2000	$.9504\ 10^{-2}$	$.5196\ 10^{-2}$	$.5886\ 10^{-2}$	$.5678\ 10^{-2}$	$.6289\ 10^{-2}$
3000	$.1159\ 10^{-1}$	$.6485\ 10^{-2}$	$.7517\ 10^{-2}$	$.7443\ 10^{-2}$	$.8387\ 10^{-2}$
4000	$.1368\ 10^{-1}$	$.7785\ 10^{-2}$	$.9161\ 10^{-2}$	$.9222\ 10^{-2}$	$.1050\ 10^{-1}$
5000	$.1579\ 10^{-1}$	$.9095\ 10^{-2}$	$.1082\ 10^{-1}$	$.1101\ 10^{-1}$	$.1263\ 10^{-1}$
6000	$.1790\ 10^{-1}$	$.1041\ 10^{-1}$	$.1248\ 10^{-1}$	$.1281\ 10^{-1}$	$.1476\ 10^{-1}$
7000	$.2002\ 10^{-1}$	$.1174\ 10^{-1}$	$.1415\ 10^{-1}$	$.1462\ 10^{-1}$	$.1690\ 10^{-1}$
8000	$.2214\ 10^{-1}$	$.1307\ 10^{-1}$	$.1583\ 10^{-1}$	$.1643\ 10^{-1}$	$.1905\ 10^{-1}$
9000	$.2428\ 10^{-1}$	$.1441\ 10^{-1}$	$.1751\ 10^{-1}$	$.1825\ 10^{-1}$	$.2121\ 10^{-1}$
10000	$.2642\ 10^{-1}$	$.1575\ 10^{-1}$	$.1920\ 10^{-1}$	$.2008\ 10^{-1}$	$.2337\ 10^{-1}$

Table 3 (cont'd)

E (GeV)	Boron	Carbon	Nitrogen (liquid)	Oxygen (liquid)	Fluorine (liquid)
1	$.1703\ 10^{-2}$	$.1830\ 10^{-2}$	$.1916\ 10^{-2}$	$.1891\ 10^{-2}$	$.1742\ 10^{-2}$
2	$.1807\ 10^{-2}$	$.1943\ 10^{-2}$	$.2032\ 10^{-2}$	$.2007\ 10^{-2}$	$.1862\ 10^{-2}$
4	$.1907\ 10^{-2}$	$.2053\ 10^{-2}$	$.2139\ 10^{-2}$	$.2114\ 10^{-2}$	$.1979\ 10^{-2}$
6	$.1962\ 10^{-2}$	$.2113\ 10^{-2}$	$.2198\ 10^{-2}$	$.2173\ 10^{-2}$	$.2044\ 10^{-2}$
8	$.1999\ 10^{-2}$	$.2155\ 10^{-2}$	$.2238\ 10^{-2}$	$.2214\ 10^{-2}$	$.2088\ 10^{-2}$
10	$.2027\ 10^{-2}$	$.2187\ 10^{-2}$	$.2269\ 10^{-2}$	$.2246\ 10^{-2}$	$.2122\ 10^{-2}$
15	$.2079\ 10^{-2}$	$.2245\ 10^{-2}$	$.2327\ 10^{-2}$	$.2304\ 10^{-2}$	$.2184\ 10^{-2}$
20	$.2117\ 10^{-2}$	$.2287\ 10^{-2}$	$.2370\ 10^{-2}$	$.2348\ 10^{-2}$	$.2230\ 10^{-2}$
30	$.2174\ 10^{-2}$	$.2350\ 10^{-2}$	$.2436\ 10^{-2}$	$.2416\ 10^{-2}$	$.2299\ 10^{-2}$
40	$.2218\ 10^{-2}$	$.2400\ 10^{-2}$	$.2488\ 10^{-2}$	$.2471\ 10^{-2}$	$.2355\ 10^{-2}$
50	$.2257\ 10^{-2}$	$.2444\ 10^{-2}$	$.2534\ 10^{-2}$	$.2520\ 10^{-2}$	$.2404\ 10^{-2}$
60	$.2292\ 10^{-2}$	$.2484\ 10^{-2}$	$.2577\ 10^{-2}$	$.2565\ 10^{-2}$	$.2449\ 10^{-2}$
70	$.2324\ 10^{-2}$	$.2521\ 10^{-2}$	$.2617\ 10^{-2}$	$.2607\ 10^{-2}$	$.2492\ 10^{-2}$
80	$.2355\ 10^{-2}$	$.2557\ 10^{-2}$	$.2655\ 10^{-2}$	$.2648\ 10^{-2}$	$.2534\ 10^{-2}$
90	$.2385\ 10^{-2}$	$.2591\ 10^{-2}$	$.2692\ 10^{-2}$	$.2688\ 10^{-2}$	$.2575\ 10^{-2}$
100	$.2413\ 10^{-2}$	$.2624\ 10^{-2}$	$.2728\ 10^{-2}$	$.2727\ 10^{-2}$	$.2614\ 10^{-2}$
120	$.2469\ 10^{-2}$	$.2689\ 10^{-2}$	$.2799\ 10^{-2}$	$.2803\ 10^{-2}$	$.2692\ 10^{-2}$
140	$.2522\ 10^{-2}$	$.2752\ 10^{-2}$	$.2868\ 10^{-2}$	$.2878\ 10^{-2}$	$.2768\ 10^{-2}$
160	$.2575\ 10^{-2}$	$.2814\ 10^{-2}$	$.2935\ 10^{-2}$	$.2951\ 10^{-2}$	$.2844\ 10^{-2}$
180	$.2626\ 10^{-2}$	$.2875\ 10^{-2}$	$.3002\ 10^{-2}$	$.3024\ 10^{-2}$	$.2919\ 10^{-2}$
200	$.2677\ 10^{-2}$	$.2935\ 10^{-2}$	$.3068\ 10^{-2}$	$.3096\ 10^{-2}$	$.2993\ 10^{-2}$
220	$.2728\ 10^{-2}$	$.2995\ 10^{-2}$	$.3134\ 10^{-2}$	$.3168\ 10^{-2}$	$.3067\ 10^{-2}$
240	$.2778\ 10^{-2}$	$.3055\ 10^{-2}$	$.3200\ 10^{-2}$	$.3239\ 10^{-2}$	$.3141\ 10^{-2}$
260	$.2828\ 10^{-2}$	$.3114\ 10^{-2}$	$.3265\ 10^{-2}$	$.3311\ 10^{-2}$	$.3215\ 10^{-2}$
280	$.2877\ 10^{-2}$	$.3173\ 10^{-2}$	$.3330\ 10^{-2}$	$.3382\ 10^{-2}$	$.3288\ 10^{-2}$
300	$.2927\ 10^{-2}$	$.3232\ 10^{-2}$	$.3395\ 10^{-2}$	$.3453\ 10^{-2}$	$.3362\ 10^{-2}$
350	$.3050\ 10^{-2}$	$.3379\ 10^{-2}$	$.3557\ 10^{-2}$	$.3630\ 10^{-2}$	$.3545\ 10^{-2}$
400	$.3172\ 10^{-2}$	$.3525\ 10^{-2}$	$.3719\ 10^{-2}$	$.3808\ 10^{-2}$	$.3729\ 10^{-2}$
450	$.3294\ 10^{-2}$	$.3671\ 10^{-2}$	$.3880\ 10^{-2}$	$.3985\ 10^{-2}$	$.3912\ 10^{-2}$
500	$.3416\ 10^{-2}$	$.3816\ 10^{-2}$	$.4042\ 10^{-2}$	$.4162\ 10^{-2}$	$.4096\ 10^{-2}$
600	$.3659\ 10^{-2}$	$.4108\ 10^{-2}$	$.4365\ 10^{-2}$	$.4517\ 10^{-2}$	$.4464\ 10^{-2}$
700	$.3903\ 10^{-2}$	$.4399\ 10^{-2}$	$.4688\ 10^{-2}$	$.4872\ 10^{-2}$	$.4832\ 10^{-2}$
800	$.4146\ 10^{-2}$	$.4691\ 10^{-2}$	$.5012\ 10^{-2}$	$.5229\ 10^{-2}$	$.5202\ 10^{-2}$
900	$.4390\ 10^{-2}$	$.4983\ 10^{-2}$	$.5336\ 10^{-2}$	$.5585\ 10^{-2}$	$.5572\ 10^{-2}$
1000	$.4633\ 10^{-2}$	$.5276\ 10^{-2}$	$.5661\ 10^{-2}$	$.5942\ 10^{-2}$	$.5943\ 10^{-2}$
1500	$.5857\ 10^{-2}$	$.6744\ 10^{-2}$	$.7293\ 10^{-2}$	$.7737\ 10^{-2}$	$.7807\ 10^{-2}$
2000	$.7088\ 10^{-2}$	$.8220\ 10^{-2}$	$.8934\ 10^{-2}$	$.9542\ 10^{-2}$	$.9683\ 10^{-2}$
3000	$.9564\ 10^{-2}$	$.1119\ 10^{-1}$	$.1224\ 10^{-1}$	$.1318\ 10^{-1}$	$.1346\ 10^{-1}$
4000	$.1206\ 10^{-1}$	$.1418\ 10^{-1}$	$.1556\ 10^{-1}$	$.1683\ 10^{-1}$	$.1726\ 10^{-1}$
5000	$.1456\ 10^{-1}$	$.1719\ 10^{-1}$	$.1890\ 10^{-1}$	$.2051\ 10^{-1}$	$.2108\ 10^{-1}$
6000	$.1708\ 10^{-1}$	$.2020\ 10^{-1}$	$.2225\ 10^{-1}$	$.2419\ 10^{-1}$	$.2490\ 10^{-1}$
7000	$.1961\ 10^{-1}$	$.2323\ 10^{-1}$	$.2561\ 10^{-1}$	$.2789\ 10^{-1}$	$.2874\ 10^{-1}$
8000	$.2214\ 10^{-1}$	$.2626\ 10^{-1}$	$.2898\ 10^{-1}$	$.3159\ 10^{-1}$	$.3259\ 10^{-1}$
9000	$.2468\ 10^{-1}$	$.2930\ 10^{-1}$	$.3236\ 10^{-1}$	$.3530\ 10^{-1}$	$.3645\ 10^{-1}$
10000	$.2723\ 10^{-1}$	$.3235\ 10^{-1}$	$.3574\ 10^{-1}$	$.3903\ 10^{-1}$	$.4030\ 10^{-1}$

Table 3 (cont'd)

E (GeV)	Neon (liquid)	Sodium	Magnesium	Aluminium	Silicon
1	$.1807\ 10^{-2}$	$.1761\ 10^{-2}$	$.1789\ 10^{-2}$	$.1723\ 10^{-2}$	$.1781\ 10^{-2}$
2	$.1935\ 10^{-2}$	$.1888\ 10^{-2}$	$.1914\ 10^{-2}$	$.1843\ 10^{-2}$	$.1909\ 10^{-2}$
4	$.2059\ 10^{-2}$	$.2008\ 10^{-2}$	$.2034\ 10^{-2}$	$.1958\ 10^{-2}$	$.2031\ 10^{-2}$
6	$.2127\ 10^{-2}$	$.2074\ 10^{-2}$	$.2100\ 10^{-2}$	$.2022\ 10^{-2}$	$.2098\ 10^{-2}$
8	$.2174\ 10^{-2}$	$.2119\ 10^{-2}$	$.2145\ 10^{-2}$	$.2066\ 10^{-2}$	$.2145\ 10^{-2}$
10	$.2210\ 10^{-2}$	$.2154\ 10^{-2}$	$.2181\ 10^{-2}$	$.2100\ 10^{-2}$	$.2181\ 10^{-2}$
15	$.2275\ 10^{-2}$	$.2217\ 10^{-2}$	$.2245\ 10^{-2}$	$.2163\ 10^{-2}$	$.2248\ 10^{-2}$
20	$.2322\ 10^{-2}$	$.2263\ 10^{-2}$	$.2293\ 10^{-2}$	$.2211\ 10^{-2}$	$.2298\ 10^{-2}$
30	$.2395\ 10^{-2}$	$.2335\ 10^{-2}$	$.2368\ 10^{-2}$	$.2285\ 10^{-2}$	$.2377\ 10^{-2}$
40	$.2453\ 10^{-2}$	$.2393\ 10^{-2}$	$.2430\ 10^{-2}$	$.2348\ 10^{-2}$	$.2444\ 10^{-2}$
50	$.2505\ 10^{-2}$	$.2445\ 10^{-2}$	$.2485\ 10^{-2}$	$.2404\ 10^{-2}$	$.2504\ 10^{-2}$
60	$.2553\ 10^{-2}$	$.2494\ 10^{-2}$	$.2537\ 10^{-2}$	$.2457\ 10^{-2}$	$.2561\ 10^{-2}$
70	$.2598\ 10^{-2}$	$.2540\ 10^{-2}$	$.2587\ 10^{-2}$	$.2508\ 10^{-2}$	$.2616\ 10^{-2}$
80	$.2642\ 10^{-2}$	$.2585\ 10^{-2}$	$.2636\ 10^{-2}$	$.2558\ 10^{-2}$	$.2670\ 10^{-2}$
90	$.2685\ 10^{-2}$	$.2629\ 10^{-2}$	$.2683\ 10^{-2}$	$.2606\ 10^{-2}$	$.2722\ 10^{-2}$
100	$.2727\ 10^{-2}$	$.2672\ 10^{-2}$	$.2730\ 10^{-2}$	$.2655\ 10^{-2}$	$.2775\ 10^{-2}$
120	$.2809\ 10^{-2}$	$.2756\ 10^{-2}$	$.2822\ 10^{-2}$	$.2749\ 10^{-2}$	$.2877\ 10^{-2}$
140	$.2890\ 10^{-2}$	$.2840\ 10^{-2}$	$.2913\ 10^{-2}$	$.2843\ 10^{-2}$	$.2979\ 10^{-2}$
160	$.2970\ 10^{-2}$	$.2922\ 10^{-2}$	$.3003\ 10^{-2}$	$.2936\ 10^{-2}$	$.3080\ 10^{-2}$
180	$.3050\ 10^{-2}$	$.3004\ 10^{-2}$	$.3093\ 10^{-2}$	$.3029\ 10^{-2}$	$.3181\ 10^{-2}$
200	$.3129\ 10^{-2}$	$.3086\ 10^{-2}$	$.3182\ 10^{-2}$	$.3121\ 10^{-2}$	$.3282\ 10^{-2}$
220	$.3208\ 10^{-2}$	$.3168\ 10^{-2}$	$.3271\ 10^{-2}$	$.3214\ 10^{-2}$	$.3382\ 10^{-2}$
240	$.3286\ 10^{-2}$	$.3249\ 10^{-2}$	$.3360\ 10^{-2}$	$.3306\ 10^{-2}$	$.3483\ 10^{-2}$
260	$.3365\ 10^{-2}$	$.3330\ 10^{-2}$	$.3449\ 10^{-2}$	$.3398\ 10^{-2}$	$.3583\ 10^{-2}$
280	$.3443\ 10^{-2}$	$.3411\ 10^{-2}$	$.3538\ 10^{-2}$	$.3490\ 10^{-2}$	$.3684\ 10^{-2}$
300	$.3522\ 10^{-2}$	$.3493\ 10^{-2}$	$.3627\ 10^{-2}$	$.3583\ 10^{-2}$	$.3785\ 10^{-2}$
350	$.3718\ 10^{-2}$	$.3696\ 10^{-2}$	$.3849\ 10^{-2}$	$.3814\ 10^{-2}$	$.4036\ 10^{-2}$
400	$.3914\ 10^{-2}$	$.3899\ 10^{-2}$	$.4072\ 10^{-2}$	$.4045\ 10^{-2}$	$.4289\ 10^{-2}$
450	$.4110\ 10^{-2}$	$.4102\ 10^{-2}$	$.4295\ 10^{-2}$	$.4277\ 10^{-2}$	$.4542\ 10^{-2}$
500	$.4306\ 10^{-2}$	$.4306\ 10^{-2}$	$.4519\ 10^{-2}$	$.4509\ 10^{-2}$	$.4795\ 10^{-2}$
600	$.4699\ 10^{-2}$	$.4714\ 10^{-2}$	$.4967\ 10^{-2}$	$.4974\ 10^{-2}$	$.5304\ 10^{-2}$
700	$.5094\ 10^{-2}$	$.5124\ 10^{-2}$	$.5417\ 10^{-2}$	$.5442\ 10^{-2}$	$.5815\ 10^{-2}$
800	$.5489\ 10^{-2}$	$.5535\ 10^{-2}$	$.5868\ 10^{-2}$	$.5911\ 10^{-2}$	$.6326\ 10^{-2}$
900	$.5885\ 10^{-2}$	$.5946\ 10^{-2}$	$.6320\ 10^{-2}$	$.6380\ 10^{-2}$	$.6840\ 10^{-2}$
1000	$.6282\ 10^{-2}$	$.6359\ 10^{-2}$	$.6773\ 10^{-2}$	$.6852\ 10^{-2}$	$.7356\ 10^{-2}$
1500	$.8279\ 10^{-2}$	$.8433\ 10^{-2}$	$.9053\ 10^{-2}$	$.9222\ 10^{-2}$	$.9946\ 10^{-2}$
2000	$.1029\ 10^{-1}$	$.1052\ 10^{-1}$	$.1135\ 10^{-1}$	$.1161\ 10^{-1}$	$.1255\ 10^{-1}$
3000	$.1434\ 10^{-1}$	$.1473\ 10^{-1}$	$.1597\ 10^{-1}$	$.1642\ 10^{-1}$	$.1781\ 10^{-1}$
4000	$.1841\ 10^{-1}$	$.1896\ 10^{-1}$	$.2062\ 10^{-1}$	$.2125\ 10^{-1}$	$.2309\ 10^{-1}$
5000	$.2250\ 10^{-1}$	$.2322\ 10^{-1}$	$.2530\ 10^{-1}$	$.2611\ 10^{-1}$	$.2840\ 10^{-1}$
6000	$.2660\ 10^{-1}$	$.2748\ 10^{-1}$	$.2998\ 10^{-1}$	$.3098\ 10^{-1}$	$.3372\ 10^{-1}$
7000	$.3072\ 10^{-1}$	$.3176\ 10^{-1}$	$.3467\ 10^{-1}$	$.3587\ 10^{-1}$	$.3905\ 10^{-1}$
8000	$.3485\ 10^{-1}$	$.3605\ 10^{-1}$	$.3938\ 10^{-1}$	$.4076\ 10^{-1}$	$.4440\ 10^{-1}$
9000	$.3898\ 10^{-1}$	$.4034\ 10^{-1}$	$.4409\ 10^{-1}$	$.4566\ 10^{-1}$	$.4976\ 10^{-1}$
10000	$.4312\ 10^{-1}$	$.4464\ 10^{-1}$	$.4882\ 10^{-1}$	$.5057\ 10^{-1}$	$.5512\ 10^{-1}$

Table 3 (cont'd)

E (GeV)	Sulphur	Chlorine (liquid)	Argon (liquid)	Potassium	Calcium
1	$.1774\ 10^{-2}$	$.1724\ 10^{-2}$	$.1623\ 10^{-2}$	$.1754\ 10^{-2}$	$.1781\ 10^{-2}$
2	$.1907\ 10^{-2}$	$.1851\ 10^{-2}$	$.1746\ 10^{-2}$	$.1892\ 10^{-2}$	$.1916\ 10^{-2}$
4	$.2035\ 10^{-2}$	$.1974\ 10^{-2}$	$.1864\ 10^{-2}$	$.2025\ 10^{-2}$	$.2047\ 10^{-2}$
6	$.2106\ 10^{-2}$	$.2043\ 10^{-2}$	$.1930\ 10^{-2}$	$.2099\ 10^{-2}$	$.2120\ 10^{-2}$
8	$.2156\ 10^{-2}$	$.2090\ 10^{-2}$	$.1976\ 10^{-2}$	$.2151\ 10^{-2}$	$.2171\ 10^{-2}$
10	$.2194\ 10^{-2}$	$.2127\ 10^{-2}$	$.2011\ 10^{-2}$	$.2191\ 10^{-2}$	$.2211\ 10^{-2}$
15	$.2264\ 10^{-2}$	$.2196\ 10^{-2}$	$.2077\ 10^{-2}$	$.2265\ 10^{-2}$	$.2286\ 10^{-2}$
20	$.2317\ 10^{-2}$	$.2248\ 10^{-2}$	$.2128\ 10^{-2}$	$.2322\ 10^{-2}$	$.2344\ 10^{-2}$
30	$.2401\ 10^{-2}$	$.2332\ 10^{-2}$	$.2208\ 10^{-2}$	$.2412\ 10^{-2}$	$.2437\ 10^{-2}$
40	$.2472\ 10^{-2}$	$.2403\ 10^{-2}$	$.2277\ 10^{-2}$	$.2489\ 10^{-2}$	$.2517\ 10^{-2}$
50	$.2537\ 10^{-2}$	$.2468\ 10^{-2}$	$.2340\ 10^{-2}$	$.2560\ 10^{-2}$	$.2591\ 10^{-2}$
60	$.2598\ 10^{-2}$	$.2529\ 10^{-2}$	$.2400\ 10^{-2}$	$.2627\ 10^{-2}$	$.2662\ 10^{-2}$
70	$.2658\ 10^{-2}$	$.2589\ 10^{-2}$	$.2459\ 10^{-2}$	$.2692\ 10^{-2}$	$.2731\ 10^{-2}$
80	$.2716\ 10^{-2}$	$.2648\ 10^{-2}$	$.2516\ 10^{-2}$	$.2757\ 10^{-2}$	$.2799\ 10^{-2}$
90	$.2774\ 10^{-2}$	$.2705\ 10^{-2}$	$.2573\ 10^{-2}$	$.2820\ 10^{-2}$	$.2866\ 10^{-2}$
100	$.2831\ 10^{-2}$	$.2763\ 10^{-2}$	$.2629\ 10^{-2}$	$.2883\ 10^{-2}$	$.2933\ 10^{-2}$
120	$.2944\ 10^{-2}$	$.2876\ 10^{-2}$	$.2741\ 10^{-2}$	$.3007\ 10^{-2}$	$.3065\ 10^{-2}$
140	$.3056\ 10^{-2}$	$.2989\ 10^{-2}$	$.2851\ 10^{-2}$	$.3131\ 10^{-2}$	$.3197\ 10^{-2}$
160	$.3167\ 10^{-2}$	$.3101\ 10^{-2}$	$.2962\ 10^{-2}$	$.3255\ 10^{-2}$	$.3329\ 10^{-2}$
180	$.3279\ 10^{-2}$	$.3213\ 10^{-2}$	$.3073\ 10^{-2}$	$.3378\ 10^{-2}$	$.3461\ 10^{-2}$
200	$.3390\ 10^{-2}$	$.3325\ 10^{-2}$	$.3183\ 10^{-2}$	$.3502\ 10^{-2}$	$.3593\ 10^{-2}$
220	$.3501\ 10^{-2}$	$.3438\ 10^{-2}$	$.3293\ 10^{-2}$	$.3626\ 10^{-2}$	$.3725\ 10^{-2}$
240	$.3612\ 10^{-2}$	$.3550\ 10^{-2}$	$.3404\ 10^{-2}$	$.3750\ 10^{-2}$	$.3857\ 10^{-2}$
260	$.3724\ 10^{-2}$	$.3662\ 10^{-2}$	$.3515\ 10^{-2}$	$.3874\ 10^{-2}$	$.3990\ 10^{-2}$
280	$.3835\ 10^{-2}$	$.3775\ 10^{-2}$	$.3626\ 10^{-2}$	$.3998\ 10^{-2}$	$.4122\ 10^{-2}$
300	$.3947\ 10^{-2}$	$.3887\ 10^{-2}$	$.3737\ 10^{-2}$	$.4122\ 10^{-2}$	$.4255\ 10^{-2}$
350	$.4226\ 10^{-2}$	$.4170\ 10^{-2}$	$.4015\ 10^{-2}$	$.4434\ 10^{-2}$	$.4589\ 10^{-2}$
400	$.4506\ 10^{-2}$	$.4453\ 10^{-2}$	$.4295\ 10^{-2}$	$.4747\ 10^{-2}$	$.4922\ 10^{-2}$
450	$.4787\ 10^{-2}$	$.4736\ 10^{-2}$	$.4575\ 10^{-2}$	$.5062\ 10^{-2}$	$.5259\ 10^{-2}$
500	$.5069\ 10^{-2}$	$.5021\ 10^{-2}$	$.4856\ 10^{-2}$	$.5376\ 10^{-2}$	$.5595\ 10^{-2}$
600	$.5634\ 10^{-2}$	$.5593\ 10^{-2}$	$.5420\ 10^{-2}$	$.6008\ 10^{-2}$	$.6271\ 10^{-2}$
700	$.6201\ 10^{-2}$	$.6166\ 10^{-2}$	$.5986\ 10^{-2}$	$.6644\ 10^{-2}$	$.6950\ 10^{-2}$
800	$.6771\ 10^{-2}$	$.6742\ 10^{-2}$	$.6555\ 10^{-2}$	$.7282\ 10^{-2}$	$.7631\ 10^{-2}$
900	$.7342\ 10^{-2}$	$.7319\ 10^{-2}$	$.7125\ 10^{-2}$	$.7921\ 10^{-2}$	$.8315\ 10^{-2}$
1000	$.7914\ 10^{-2}$	$.7898\ 10^{-2}$	$.7698\ 10^{-2}$	$.8563\ 10^{-2}$	$.9002\ 10^{-2}$
1500	$.1080\ 10^{-1}$	$.1081\ 10^{-1}$	$.1058\ 10^{-1}$	$.1179\ 10^{-1}$	$.1245\ 10^{-1}$
2000	$.1370\ 10^{-1}$	$.1375\ 10^{-1}$	$.1348\ 10^{-1}$	$.1504\ 10^{-1}$	$.1593\ 10^{-1}$
3000	$.1954\ 10^{-1}$	$.1966\ 10^{-1}$	$.1932\ 10^{-1}$	$.2159\ 10^{-1}$	$.2293\ 10^{-1}$
4000	$.2542\ 10^{-1}$	$.2560\ 10^{-1}$	$.2519\ 10^{-1}$	$.2818\ 10^{-1}$	$.2997\ 10^{-1}$
5000	$.3132\ 10^{-1}$	$.3157\ 10^{-1}$	$.3109\ 10^{-1}$	$.3479\ 10^{-1}$	$.3704\ 10^{-1}$
6000	$.3725\ 10^{-1}$	$.3756\ 10^{-1}$	$.3700\ 10^{-1}$	$.4141\ 10^{-1}$	$.4413\ 10^{-1}$
7000	$.4318\ 10^{-1}$	$.4355\ 10^{-1}$	$.4293\ 10^{-1}$	$.4806\ 10^{-1}$	$.5122\ 10^{-1}$
8000	$.4912\ 10^{-1}$	$.4957\ 10^{-1}$	$.4887\ 10^{-1}$	$.5472\ 10^{-1}$	$.5834\ 10^{-1}$
9000	$.5507\ 10^{-1}$	$.5559\ 10^{-1}$	$.5481\ 10^{-1}$	$.6138\ 10^{-1}$	$.6546\ 10^{-1}$
10000	$.6103\ 10^{-1}$	$.6161\ 10^{-1}$	$.6077\ 10^{-1}$	$.6805\ 10^{-1}$	$.7259\ 10^{-1}$

Table 3 (cont'd)

E (GeV)	Chromium	Manganese	Iron	Nickel	Copper
1	$.1563\ 10^{-2}$	$.1534\ 10^{-2}$	$.1561\ 10^{-2}$	$.1581\ 10^{-2}$	$.1512\ 10^{-2}$
2	$.1682\ 10^{-2}$	$.1653\ 10^{-2}$	$.1682\ 10^{-2}$	$.1706\ 10^{-2}$	$.1633\ 10^{-2}$
4	$.1799\ 10^{-2}$	$.1769\ 10^{-2}$	$.1802\ 10^{-2}$	$.1831\ 10^{-2}$	$.1752\ 10^{-2}$
6	$.1865\ 10^{-2}$	$.1835\ 10^{-2}$	$.1870\ 10^{-2}$	$.1902\ 10^{-2}$	$.1821\ 10^{-2}$
8	$.1913\ 10^{-2}$	$.1883\ 10^{-2}$	$.1919\ 10^{-2}$	$.1953\ 10^{-2}$	$.1870\ 10^{-2}$
10	$.1950\ 10^{-2}$	$.1920\ 10^{-2}$	$.1958\ 10^{-2}$	$.1993\ 10^{-2}$	$.1909\ 10^{-2}$
15	$.2021\ 10^{-2}$	$.1991\ 10^{-2}$	$.2032\ 10^{-2}$	$.2072\ 10^{-2}$	$.1986\ 10^{-2}$
20	$.2077\ 10^{-2}$	$.2048\ 10^{-2}$	$.2091\ 10^{-2}$	$.2134\ 10^{-2}$	$.2046\ 10^{-2}$
30	$.2170\ 10^{-2}$	$.2141\ 10^{-2}$	$.2189\ 10^{-2}$	$.2239\ 10^{-2}$	$.2148\ 10^{-2}$
40	$.2251\ 10^{-2}$	$.2224\ 10^{-2}$	$.2275\ 10^{-2}$	$.2331\ 10^{-2}$	$.2240\ 10^{-2}$
50	$.2328\ 10^{-2}$	$.2302\ 10^{-2}$	$.2357\ 10^{-2}$	$.2419\ 10^{-2}$	$.2326\ 10^{-2}$
60	$.2402\ 10^{-2}$	$.2377\ 10^{-2}$	$.2436\ 10^{-2}$	$.2504\ 10^{-2}$	$.2409\ 10^{-2}$
70	$.2474\ 10^{-2}$	$.2450\ 10^{-2}$	$.2513\ 10^{-2}$	$.2588\ 10^{-2}$	$.2492\ 10^{-2}$
80	$.2546\ 10^{-2}$	$.2523\ 10^{-2}$	$.2590\ 10^{-2}$	$.2671\ 10^{-2}$	$.2573\ 10^{-2}$
90	$.2617\ 10^{-2}$	$.2596\ 10^{-2}$	$.2666\ 10^{-2}$	$.2753\ 10^{-2}$	$.2655\ 10^{-2}$
100	$.2688\ 10^{-2}$	$.2668\ 10^{-2}$	$.2741\ 10^{-2}$	$.2835\ 10^{-2}$	$.2736\ 10^{-2}$
120	$.2829\ 10^{-2}$	$.2811\ 10^{-2}$	$.2893\ 10^{-2}$	$.2999\ 10^{-2}$	$.2897\ 10^{-2}$
140	$.2970\ 10^{-2}$	$.2955\ 10^{-2}$	$.3044\ 10^{-2}$	$.3164\ 10^{-2}$	$.3059\ 10^{-2}$
160	$.3111\ 10^{-2}$	$.3098\ 10^{-2}$	$.3195\ 10^{-2}$	$.3328\ 10^{-2}$	$.3221\ 10^{-2}$
180	$.3252\ 10^{-2}$	$.3242\ 10^{-2}$	$.3347\ 10^{-2}$	$.3493\ 10^{-2}$	$.3384\ 10^{-2}$
200	$.3394\ 10^{-2}$	$.3386\ 10^{-2}$	$.3499\ 10^{-2}$	$.3658\ 10^{-2}$	$.3547\ 10^{-2}$
220	$.3535\ 10^{-2}$	$.3531\ 10^{-2}$	$.3652\ 10^{-2}$	$.3824\ 10^{-2}$	$.3711\ 10^{-2}$
240	$.3678\ 10^{-2}$	$.3676\ 10^{-2}$	$.3805\ 10^{-2}$	$.3990\ 10^{-2}$	$.3875\ 10^{-2}$
260	$.3820\ 10^{-2}$	$.3821\ 10^{-2}$	$.3958\ 10^{-2}$	$.4157\ 10^{-2}$	$.4039\ 10^{-2}$
280	$.3963\ 10^{-2}$	$.3967\ 10^{-2}$	$.4112\ 10^{-2}$	$.4324\ 10^{-2}$	$.4204\ 10^{-2}$
300	$.4105\ 10^{-2}$	$.4113\ 10^{-2}$	$.4265\ 10^{-2}$	$.4491\ 10^{-2}$	$.4370\ 10^{-2}$
350	$.4465\ 10^{-2}$	$.4479\ 10^{-2}$	$.4652\ 10^{-2}$	$.4912\ 10^{-2}$	$.4784\ 10^{-2}$
400	$.4825\ 10^{-2}$	$.4846\ 10^{-2}$	$.5040\ 10^{-2}$	$.5334\ 10^{-2}$	$.5202\ 10^{-2}$
450	$.5187\ 10^{-2}$	$.5215\ 10^{-2}$	$.5429\ 10^{-2}$	$.5759\ 10^{-2}$	$.5620\ 10^{-2}$
500	$.5549\ 10^{-2}$	$.5586\ 10^{-2}$	$.5821\ 10^{-2}$	$.6184\ 10^{-2}$	$.6041\ 10^{-2}$
600	$.6278\ 10^{-2}$	$.6330\ 10^{-2}$	$.6607\ 10^{-2}$	$.7039\ 10^{-2}$	$.6886\ 10^{-2}$
700	$.7011\ 10^{-2}$	$.7077\ 10^{-2}$	$.7395\ 10^{-2}$	$.7899\ 10^{-2}$	$.7735\ 10^{-2}$
800	$.7747\ 10^{-2}$	$.7828\ 10^{-2}$	$.8189\ 10^{-2}$	$.8763\ 10^{-2}$	$.8588\ 10^{-2}$
900	$.8485\ 10^{-2}$	$.8582\ 10^{-2}$	$.8985\ 10^{-2}$	$.9629\ 10^{-2}$	$.9443\ 10^{-2}$
1000	$.9226\ 10^{-2}$	$.9338\ 10^{-2}$	$.9782\ 10^{-2}$	$.1050\ 10^{-1}$	$.1030\ 10^{-1}$
1500	$.1295\ 10^{-1}$	$.1314\ 10^{-1}$	$.1380\ 10^{-1}$	$.1487\ 10^{-1}$	$.1462\ 10^{-1}$
2000	$.1671\ 10^{-1}$	$.1697\ 10^{-1}$	$.1785\ 10^{-1}$	$.1928\ 10^{-1}$	$.1898\ 10^{-1}$
3000	$.2427\ 10^{-1}$	$.2469\ 10^{-1}$	$.2600\ 10^{-1}$	$.2815\ 10^{-1}$	$.2775\ 10^{-1}$
4000	$.3187\ 10^{-1}$	$.3245\ 10^{-1}$	$.3419\ 10^{-1}$	$.3708\ 10^{-1}$	$.3656\ 10^{-1}$
5000	$.3950\ 10^{-1}$	$.4024\ 10^{-1}$	$.4241\ 10^{-1}$	$.4603\ 10^{-1}$	$.4540\ 10^{-1}$
6000	$.4715\ 10^{-1}$	$.4805\ 10^{-1}$	$.5065\ 10^{-1}$	$.5502\ 10^{-1}$	$.5426\ 10^{-1}$
7000	$.5481\ 10^{-1}$	$.5587\ 10^{-1}$	$.5892\ 10^{-1}$	$.6401\ 10^{-1}$	$.6315\ 10^{-1}$
8000	$.6249\ 10^{-1}$	$.6371\ 10^{-1}$	$.6719\ 10^{-1}$	$.7302\ 10^{-1}$	$.7205\ 10^{-1}$
9000	$.7018\ 10^{-1}$	$.7156\ 10^{-1}$	$.7548\ 10^{-1}$	$.8204\ 10^{-1}$	$.8096\ 10^{-1}$
10000	$.7788\ 10^{-1}$	$.7941\ 10^{-1}$	$.8377\ 10^{-1}$	$.9108\ 10^{-1}$	$.8987\ 10^{-1}$

Table 3 (cont'd)

E (GeV)	Zinc	Germanium	Bromine (liquid)	Tin	Iodine
1	.1524 10^{-2}	.1485 10^{-2}	.1514 10^{-2}	.1385 10^{-2}	.1387 10^{-2}
2	.1648 10^{-2}	.1606 10^{-2}	.1639 10^{-2}	.1507 10^{-2}	.1510 10^{-2}
4	.1770 10^{-2}	.1725 10^{-2}	.1760 10^{-2}	.1627 10^{-2}	.1633 10^{-2}
6	.1841 10^{-2}	.1793 10^{-2}	.1829 10^{-2}	.1698 10^{-2}	.1705 10^{-2}
8	.1891 10^{-2}	.1842 10^{-2}	.1878 10^{-2}	.1750 10^{-2}	.1759 10^{-2}
10	.1932 10^{-2}	.1881 10^{-2}	.1917 10^{-2}	.1793 10^{-2}	.1802 10^{-2}
15	.2010 10^{-2}	.1957 10^{-2}	.1994 10^{-2}	.1879 10^{-2}	.1891 10^{-2}
20	.2072 10^{-2}	.2019 10^{-2}	.2057 10^{-2}	.1952 10^{-2}	.1966 10^{-2}
30	.2178 10^{-2}	.2123 10^{-2}	.2164 10^{-2}	.2081 10^{-2}	.2099 10^{-2}
40	.2272 10^{-2}	.2217 10^{-2}	.2261 10^{-2}	.2201 10^{-2}	.2224 10^{-2}
50	.2361 10^{-2}	.2306 10^{-2}	.2354 10^{-2}	.2319 10^{-2}	.2346 10^{-2}
60	.2447 10^{-2}	.2393 10^{-2}	.2446 10^{-2}	.2435 10^{-2}	.2466 10^{-2}
70	.2532 10^{-2}	.2479 10^{-2}	.2536 10^{-2}	.2550 10^{-2}	.2586 10^{-2}
80	.2617 10^{-2}	.2564 10^{-2}	.2627 10^{-2}	.2666 10^{-2}	.2706 10^{-2}
90	.2700 10^{-2}	.2649 10^{-2}	.2717 10^{-2}	.2781 10^{-2}	.2827 10^{-2}
100	.2784 10^{-2}	.2734 10^{-2}	.2807 10^{-2}	.2897 10^{-2}	.2947 10^{-2}
120	.2951 10^{-2}	.2903 10^{-2}	.2987 10^{-2}	.3131 10^{-2}	.3190 10^{-2}
140	.3118 10^{-2}	.3073 10^{-2}	.3168 10^{-2}	.3365 10^{-2}	.3435 10^{-2}
160	.3286 10^{-2}	.3243 10^{-2}	.3350 10^{-2}	.3601 10^{-2}	.3681 10^{-2}
180	.3454 10^{-2}	.3413 10^{-2}	.3532 10^{-2}	.3839 10^{-2}	.3928 10^{-2}
200	.3623 10^{-2}	.3584 10^{-2}	.3715 10^{-2}	.4077 10^{-2}	.4177 10^{-2}
220	.3792 10^{-2}	.3756 10^{-2}	.3899 10^{-2}	.4317 10^{-2}	.4427 10^{-2}
240	.3962 10^{-2}	.3928 10^{-2}	.4083 10^{-2}	.4557 10^{-2}	.4678 10^{-2}
260	.4132 10^{-2}	.4101 10^{-2}	.4269 10^{-2}	.4799 10^{-2}	.4930 10^{-2}
280	.4302 10^{-2}	.4274 10^{-2}	.4454 10^{-2}	.5041 10^{-2}	.5183 10^{-2}
300	.4474 10^{-2}	.4448 10^{-2}	.4640 10^{-2}	.5285 10^{-2}	.5436 10^{-2}
350	.4903 10^{-2}	.4884 10^{-2}	.5108 10^{-2}	.5897 10^{-2}	.6074 10^{-2}
400	.5334 10^{-2}	.5322 10^{-2}	.5577 10^{-2}	.6511 10^{-2}	.6715 10^{-2}
450	.5767 10^{-2}	.5763 10^{-2}	.6050 10^{-2}	.7129 10^{-2}	.7360 10^{-2}
500	.6201 10^{-2}	.6204 10^{-2}	.6523 10^{-2}	.7750 10^{-2}	.8008 10^{-2}
600	.7075 10^{-2}	.7092 10^{-2}	.7476 10^{-2}	.8998 10^{-2}	.9310 10^{-2}
700	.7953 10^{-2}	.7984 10^{-2}	.8434 10^{-2}	.1025 10^{-1}	.1062 10^{-1}
800	.8836 10^{-2}	.8881 10^{-2}	.9396 10^{-2}	.1151 10^{-1}	.1194 10^{-1}
900	.9721 10^{-2}	.9781 10^{-2}	.1036 10^{-1}	.1278 10^{-1}	.1326 10^{-1}
1000	.1061 10^{-1}	.1068 10^{-1}	.1133 10^{-1}	.1405 10^{-1}	.1458 10^{-1}
1500	.1508 10^{-1}	.1523 10^{-1}	.1620 10^{-1}	.2044 10^{-1}	.2126 10^{-1}
2000	.1958 10^{-1}	.1981 10^{-1}	.2111 10^{-1}	.2688 10^{-1}	.2797 10^{-1}
3000	.2865 10^{-1}	.2902 10^{-1}	.3101 10^{-1}	.3984 10^{-1}	.4150 10^{-1}
4000	.3777 10^{-1}	.3829 10^{-1}	.4095 10^{-1}	.5287 10^{-1}	.5508 10^{-1}
5000	.4692 10^{-1}	.4759 10^{-1}	.5093 10^{-1}	.6594 10^{-1}	.6872 10^{-1}
6000	.5609 10^{-1}	.5692 10^{-1}	.6092 10^{-1}	.7904 10^{-1}	.8238 10^{-1}
7000	.6527 10^{-1}	.6626 10^{-1}	.7095 10^{-1}	.9216 10^{-1}	.9608 10^{-1}
8000	.7448 10^{-1}	.7561 10^{-1}	.8097 10^{-1}	.1053	.1098
9000	.8370 10^{-1}	.8498 10^{-1}	.9102 10^{-1}	.1184	.1235
10000	.9292 10^{-1}	.9435 10^{-1}	.1011	.1316	.1372

Table 3 (cont'd)

E (GeV)	Barium	Tungsten	Lead	Bismuth	Uranium
1	.1361 10^{-2}	.1261 10^{-2}	.1251 10^{-2}	.1260 10^{-2}	.1205 10^{-2}
2	.1486 10^{-2}	.1377 10^{-2}	.1372 10^{-2}	.1383 10^{-2}	.1322 10^{-2}
4	.1609 10^{-2}	.1496 10^{-2}	.1494 10^{-2}	.1506 10^{-2}	.1442 10^{-2}
6	.1682 10^{-2}	.1568 10^{-2}	.1569 10^{-2}	.1582 10^{-2}	.1515 10^{-2}
8	.1735 10^{-2}	.1623 10^{-2}	.1626 10^{-2}	.1639 10^{-2}	.1572 10^{-2}
10	.1779 10^{-2}	.1670 10^{-2}	.1674 10^{-2}	.1688 10^{-2}	.1621 10^{-2}
15	.1869 10^{-2}	.1768 10^{-2}	.1777 10^{-2}	.1792 10^{-2}	.1727 10^{-2}
20	.1945 10^{-2}	.1854 10^{-2}	.1868 10^{-2}	.1885 10^{-2}	.1822 10^{-2}
30	.2081 10^{-2}	.2014 10^{-2}	.2037 10^{-2}	.2056 10^{-2}	.2000 10^{-2}
40	.2208 10^{-2}	.2167 10^{-2}	.2201 10^{-2}	.2222 10^{-2}	.2174 10^{-2}
50	.2332 10^{-2}	.2319 10^{-2}	.2364 10^{-2}	.2387 10^{-2}	.2348 10^{-2}
60	.2455 10^{-2}	.2471 10^{-2}	.2527 10^{-2}	.2552 10^{-2}	.2522 10^{-2}
70	.2578 10^{-2}	.2624 10^{-2}	.2690 10^{-2}	.2718 10^{-2}	.2698 10^{-2}
80	.2701 10^{-2}	.2777 10^{-2}	.2855 10^{-2}	.2885 10^{-2}	.2875 10^{-2}
90	.2825 10^{-2}	.2930 10^{-2}	.3020 10^{-2}	.3053 10^{-2}	.3053 10^{-2}
100	.2948 10^{-2}	.3085 10^{-2}	.3186 10^{-2}	.3221 10^{-2}	.3232 10^{-2}
120	.3197 10^{-2}	.3397 10^{-2}	.3521 10^{-2}	.3561 10^{-2}	.3593 10^{-2}
140	.3448 10^{-2}	.3712 10^{-2}	.3860 10^{-2}	.3905 10^{-2}	.3959 10^{-2}
160	.3700 10^{-2}	.4028 10^{-2}	.4201 10^{-2}	.4250 10^{-2}	.4327 10^{-2}
180	.3953 10^{-2}	.4347 10^{-2}	.4545 10^{-2}	.4598 10^{-2}	.4698 10^{-2}
200	.4208 10^{-2}	.4668 10^{-2}	.4890 10^{-2}	.4949 10^{-2}	.5072 10^{-2}
220	.4464 10^{-2}	.4991 10^{-2}	.5238 10^{-2}	.5302 10^{-2}	.5448 10^{-2}
240	.4722 10^{-2}	.5315 10^{-2}	.5586 10^{-2}	.5656 10^{-2}	.5826 10^{-2}
260	.4980 10^{-2}	.5640 10^{-2}	.5937 10^{-2}	.6012 10^{-2}	.6205 10^{-2}
280	.5240 10^{-2}	.5967 10^{-2}	.6290 10^{-2}	.6369 10^{-2}	.6585 10^{-2}
300	.5499 10^{-2}	.6295 10^{-2}	.6643 10^{-2}	.6728 10^{-2}	.6968 10^{-2}
350	.6153 10^{-2}	.7120 10^{-2}	.7531 10^{-2}	.7628 10^{-2}	.7928 10^{-2}
400	.6811 10^{-2}	.7949 10^{-2}	.8425 10^{-2}	.8535 10^{-2}	.8896 10^{-2}
450	.7471 10^{-2}	.8783 10^{-2}	.9323 10^{-2}	.9446 10^{-2}	.9868 10^{-2}
500	.8135 10^{-2}	.9621 10^{-2}	.1023 10^{-1}	.1036 10^{-1}	.1085 10^{-1}
600	.9471 10^{-2}	.1131 10^{-1}	.1204 10^{-1}	.1220 10^{-1}	.1281 10^{-1}
700	.1081 10^{-1}	.1300 10^{-1}	.1387 10^{-1}	.1406 10^{-1}	.1479 10^{-1}
800	.1216 10^{-1}	.1470 10^{-1}	.1570 10^{-1}	.1592 10^{-1}	.1677 10^{-1}
900	.1352 10^{-1}	.1641 10^{-1}	.1754 10^{-1}	.1778 10^{-1}	.1877 10^{-1}
1000	.1487 10^{-1}	.1813 10^{-1}	.1939 10^{-1}	.1966 10^{-1}	.2077 10^{-1}
1500	.2171 10^{-1}	.2676 10^{-1}	.2869 10^{-1}	.2909 10^{-1}	.3083 10^{-1}
2000	.2861 10^{-1}	.3546 10^{-1}	.3806 10^{-1}	.3860 10^{-1}	.4096 10^{-1}
3000	.4247 10^{-1}	.5295 10^{-1}	.5691 10^{-1}	.5772 10^{-1}	.6136 10^{-1}
4000	.5641 10^{-1}	.7054 10^{-1}	.7584 10^{-1}	.7692 10^{-1}	.8185 10^{-1}
5000	.7038 10^{-1}	.8817 10^{-1}	.9484 10^{-1}	.9619 10^{-1}	.1024
6000	.8439 10^{-1}	.1058	.1139	.1155	.1230
7000	.9842 10^{-1}	.1235	.1329	.1348	.1436
8000	.1125	.1412	.1520	.1542	.1643
9000	.1265	.1590	.1711	.1735	.1849
10000	.1406	.1768	.1902	.1929	.2056

Table 4

List of coumpounds and their material parameters

Material	Density (g/cm^3)	Z/A	I (eV)	Density correction constants -C	X_0	X_1	a	m
Barium fluoride	4.830	.4221	375.9	5.412	-.010	3.387	.160	2.887
Bismuth germanate	7.100	.4207	534.1	5.741	.046	3.782	.096	3.078
Pyrex[a)]	2.230	.4971	134.0	3.971	.148	2.993	.083	3.522
Calcium carbonate	2.800	.4996	136.4	3.774	.049	3.055	.083	3.412
Concrete[b)]	2.500	.5027	135.2	3.946	.130	3.047	.075	3.547
Freon 12	1.120	.4797	143.0	4.825	.304	3.266	.080	3.463
Freon 13B1	1.500	.4567	210.5	5.356	.352	3.755	.039	3.719
Lead Glass SF5[c)]	4.080							
Lead oxide	9.530	.4032	766.7	6.216	.036	3.546	.196	2.730
Lithium fluoride	2.635	.4626	94.0	3.167	.017	2.705	.076	3.748
Lucite	1.190	.5394	74.0	3.330	.182	2.668	.114	3.384
Polyethylene	.940	.5703	57.4	3.002	.137	2.518	.121	3.429
Polystyrene	1.060	.5377	68.7	3.300	.165	2.503	.165	3.222
Propane (liquid)	.430	.5896	52.0	3.553	.286	2.657	.103	3.562
Silica aerogel[d)]	.200							
Silicon dioxide	2.320	.4993	139.2	4.003	.139	3.003	.084	3.506

Table 4 (cont'd)

Material	Density (g/cm³)	Z/A	I (eV)	Density Correction Constants -C	X_0	X_1	a	m
Sodium iodide	3.667	.4270	452.0	6.057	.120	3.592	.125	3.040
Standard rock[e)]	2.650	.5000	136.4	3.774	.049	3.055	.083	3.412
Uranium oxide	10.960	.4000	720.6	5.961	-.194	3.529	.205	2.671
Water	1.000	.5551	75.0	3.502	.240	2.800	.091	3.477

a) 80% SiO_2, 12% B_2O_3, 5% Na_2O

b) 52.9% O_2, 33.7% Si, 4.4% Ca, 3.4% Al, 1.6% Na, 1.4% Fe, 1.3% K, 1% H_2

c) 55% PbO, 38% SiO_2, 5% K_2O, 1% Na_2O

d) $n(SiO_2) + 2n(H_2O)$

e) Z = 11, A = 22. Ionization potential and density corrections as for calcium carbonate.

Table 5

Energy loss in compounds as a function of the muon energy
(GeV g^{-1} cm^2)

E (GeV)	Barium fluoride	Bismuth germanate	Pyrex	Calcium carbonate	Concrete
1	.1416 10^{-2}	.1370 10^{-2}	.1796 10^{-2}	.1785 10^{-2}	.1813 10^{-2}
2	.1536 10^{-2}	.1492 10^{-2}	.1917 10^{-2}	.1906 10^{-2}	.1934 10^{-2}
4	.1655 10^{-2}	.1615 10^{-2}	.2033 10^{-2}	.2023 10^{-2}	.2052 10^{-2}
6	.1724 10^{-2}	.1688 10^{-2}	.2098 10^{-2}	.2089 10^{-2}	.2118 10^{-2}
8	.1775 10^{-2}	.1743 10^{-2}	.2142 10^{-2}	.2135 10^{-2}	.2163 10^{-2}
10	.1816 10^{-2}	.1789 10^{-2}	.2177 10^{-2}	.2171 10^{-2}	.2198 10^{-2}
15	.1899 10^{-2}	.1883 10^{-2}	.2240 10^{-2}	.2236 10^{-2}	.2263 10^{-2}
20	.1968 10^{-2}	.1963 10^{-2}	.2287 10^{-2}	.2286 10^{-2}	.2311 10^{-2}
30	.2089 10^{-2}	.2108 10^{-2}	.2359 10^{-2}	.2363 10^{-2}	.2385 10^{-2}
40	.2201 10^{-2}	.2245 10^{-2}	.2419 10^{-2}	.2428 10^{-2}	.2447 10^{-2}
50	.2309 10^{-2}	.2380 10^{-2}	.2472 10^{-2}	.2486 10^{-2}	.2502 10^{-2}
60	.2415 10^{-2}	.2513 10^{-2}	.2521 10^{-2}	.2541 10^{-2}	.2553 10^{-2}
70	.2520 10^{-2}	.2646 10^{-2}	.2568 10^{-2}	.2593 10^{-2}	.2602 10^{-2}
80	.2626 10^{-2}	.2779 10^{-2}	.2614 10^{-2}	.2644 10^{-2}	.2649 10^{-2}
90	.2731 10^{-2}	.2913 10^{-2}	.2658 10^{-2}	.2695 10^{-2}	.2696 10^{-2}
100	.2837 10^{-2}	.3047 10^{-2}	.2702 10^{-2}	.2744 10^{-2}	.2741 10^{-2}
120	.3048 10^{-2}	.3317 10^{-2}	.2788 10^{-2}	.2841 10^{-2}	.2831 10^{-2}
140	.3261 10^{-2}	.3589 10^{-2}	.2873 10^{-2}	.2937 10^{-2}	.2920 10^{-2}
160	.3475 10^{-2}	.3861 10^{-2}	.2956 10^{-2}	.3033 10^{-2}	.3007 10^{-2}
180	.3690 10^{-2}	.4136 10^{-2}	.3039 10^{-2}	.3128 10^{-2}	.3094 10^{-2}
200	.3905 10^{-2}	.4413 10^{-2}	.3122 10^{-2}	.3222 10^{-2}	.3181 10^{-2}
220	.4122 10^{-2}	.4690 10^{-2}	.3205 10^{-2}	.3317 10^{-2}	.3267 10^{-2}
240	.4340 10^{-2}	.4969 10^{-2}	.3287 10^{-2}	.3411 10^{-2}	.3353 10^{-2}
260	.4557 10^{-2}	.5250 10^{-2}	.3369 10^{-2}	.3506 10^{-2}	.3440 10^{-2}
280	.4777 10^{-2}	.5530 10^{-2}	.3451 10^{-2}	.3600 10^{-2}	.3526 10^{-2}
300	.4996 10^{-2}	.5812 10^{-2}	.3533 10^{-2}	.3694 10^{-2}	.3612 10^{-2}
350	.5548 10^{-2}	.6520 10^{-2}	.3738 10^{-2}	.3931 10^{-2}	.3827 10^{-2}
400	.6103 10^{-2}	.7232 10^{-2}	.3943 10^{-2}	.4167 10^{-2}	.4042 10^{-2}
450	.6660 10^{-2}	.7948 10^{-2}	.4149 10^{-2}	.4404 10^{-2}	.4258 10^{-2}
500	.7220 10^{-2}	.8668 10^{-2}	.4354 10^{-2}	.4641 10^{-2}	.4473 10^{-2}
600	.8346 10^{-2}	.1011 10^{-1}	.4766 10^{-2}	.5117 10^{-2}	.4906 10^{-2}
700	.9477 10^{-2}	.1157 10^{-1}	.5179 10^{-2}	.5594 10^{-2}	.5340 10^{-2}
800	.1061 10^{-1}	.1303 10^{-1}	.5593 10^{-2}	.6073 10^{-2}	.5775 10^{-2}
900	.1175 10^{-1}	.1449 10^{-1}	.6008 10^{-2}	.6553 10^{-2}	.6211 10^{-2}
1000	.1290 10^{-1}	.1596 10^{-1}	.6423 10^{-2}	.7034 10^{-2}	.6648 10^{-2}
1500	.1866 10^{-1}	.2336 10^{-1}	.8514 10^{-2}	.9453 10^{-2}	.8845 10^{-2}
2000	.2447 10^{-1}	.3082 10^{-1}	.1062 10^{-1}	.1189 10^{-1}	.1106 10^{-1}
3000	.3614 10^{-1}	.4582 10^{-1}	.1485 10^{-1}	.1679 10^{-1}	.1551 10^{-1}
4000	.4788 10^{-1}	.6089 10^{-1}	.1912 10^{-1}	.2172 10^{-1}	.1999 10^{-1}
5000	.5966 10^{-1}	.7601 10^{-1}	.2340 10^{-1}	.2668 10^{-1}	.2448 10^{-1}
6000	.7146 10^{-1}	.9117 10^{-1}	.2769 10^{-1}	.3164 10^{-1}	.2899 10^{-1}
7000	.8328 10^{-1}	.1063	.3199 10^{-1}	.3662 10^{-1}	.3352 10^{-1}
8000	.9512 10^{-1}	.1215	.3630 10^{-1}	.4161 10^{-1}	.3805 10^{-1}
9000	.1070	.1367	.4063 10^{-1}	.4661 10^{-1}	.4259 10^{-1}
10000	.1188	.1519	.4496 10^{-1}	.5161 10^{-1}	.4714 10^{-1}

Table 5 (cont'd)

E (GeV)	Freon 12	Freon 13B1	Lead glass SF5	Lead oxide	Lithium fluoride
1	.1756 10^{-2}	.1629 10^{-2}	.1317 10^{-2}	.1280 10^{-2}	.1693 10^{-2}
2	.1880 10^{-2}	.1754 10^{-2}	.1440 10^{-2}	.1402 10^{-2}	.1796 10^{-2}
4	.2001 10^{-2}	.1874 10^{-2}	.1562 10^{-2}	.1526 10^{-2}	.1896 10^{-2}
6	.2067 10^{-2}	.1942 10^{-2}	.1633 10^{-2}	.1602 10^{-2}	.1953 10^{-2}
8	.2114 10^{-2}	.1990 10^{-2}	.1685 10^{-2}	.1659 10^{-2}	.1992 10^{-2}
10	.2149 10^{-2}	.2028 10^{-2}	.1728 10^{-2}	.1707 10^{-2}	.2022 10^{-2}
15	.2215 10^{-2}	.2099 10^{-2}	.1813 10^{-2}	.1809 10^{-2}	.2077 10^{-2}
20	.2264 10^{-2}	.2155 10^{-2}	.1884 10^{-2}	.1898 10^{-2}	.2117 10^{-2}
30	.2342 10^{-2}	.2246 10^{-2}	.2008 10^{-2}	.2061 10^{-2}	.2180 10^{-2}
40	.2406 10^{-2}	.2325 10^{-2}	.2122 10^{-2}	.2218 10^{-2}	.2230 10^{-2}
50	.2464 10^{-2}	.2398 10^{-2}	.2233 10^{-2}	.2373 10^{-2}	.2274 10^{-2}
60	.2519 10^{-2}	.2468 10^{-2}	.2342 10^{-2}	.2527 10^{-2}	.2315 10^{-2}
70	.2571 10^{-2}	.2537 10^{-2}	.2450 10^{-2}	.2682 10^{-2}	.2353 10^{-2}
80	.2622 10^{-2}	.2604 10^{-2}	.2558 10^{-2}	.2838 10^{-2}	.2390 10^{-2}
90	.2672 10^{-2}	.2671 10^{-2}	.2666 10^{-2}	.2995 10^{-2}	.2426 10^{-2}
100	.2722 10^{-2}	.2738 10^{-2}	.2774 10^{-2}	.3152 10^{-2}	.2461 10^{-2}
120	.2819 10^{-2}	.2870 10^{-2}	.2991 10^{-2}	.3469 10^{-2}	.2529 10^{-2}
140	.2915 10^{-2}	.3002 10^{-2}	.3209 10^{-2}	.3788 10^{-2}	.2596 10^{-2}
160	.3011 10^{-2}	.3133 10^{-2}	.3427 10^{-2}	.4110 10^{-2}	.2662 10^{-2}
180	.3107 10^{-2}	.3265 10^{-2}	.3647 10^{-2}	.4434 10^{-2}	.2727 10^{-2}
200	.3202 10^{-2}	.3396 10^{-2}	.3868 10^{-2}	.4760 10^{-2}	.2792 10^{-2}
220	.3297 10^{-2}	.3528 10^{-2}	.4089 10^{-2}	.5088 10^{-2}	.2856 10^{-2}
240	.3392 10^{-2}	.3660 10^{-2}	.4311 10^{-2}	.5417 10^{-2}	.2920 10^{-2}
260	.3487 10^{-2}	.3793 10^{-2}	.4534 10^{-2}	.5748 10^{-2}	.2984 10^{-2}
280	.3581 10^{-2}	.3925 10^{-2}	.4758 10^{-2}	.6080 10^{-2}	.3047 10^{-2}
300	.3676 10^{-2}	.4058 10^{-2}	.4982 10^{-2}	.6413 10^{-2}	.3111 10^{-2}
350	.3914 10^{-2}	.4391 10^{-2}	.5545 10^{-2}	.7250 10^{-2}	.3269 10^{-2}
400	.4152 10^{-2}	.4725 10^{-2}	.6111 10^{-2}	.8092 10^{-2}	.3427 10^{-2}
450	.4391 10^{-2}	.5060 10^{-2}	.6680 10^{-2}	.8939 10^{-2}	.3585 10^{-2}
500	.4630 10^{-2}	.5396 10^{-2}	.7251 10^{-2}	.9789 10^{-2}	.3743 10^{-2}
600	.5110 10^{-2}	.6072 10^{-2}	.8398 10^{-2}	.1150 10^{-1}	.4060 10^{-2}
700	.5591 10^{-2}	.6750 10^{-2}	.9552 10^{-2}	.1322 10^{-1}	.4376 10^{-2}
800	.6074 10^{-2}	.7432 10^{-2}	.1071 10^{-1}	.1495 10^{-1}	.4693 10^{-2}
900	.6558 10^{-2}	.8115 10^{-2}	.1187 10^{-1}	.1668 10^{-1}	.5011 10^{-2}
1000	.7043 10^{-2}	.8800 10^{-2}	.1304 10^{-1}	.1843 10^{-1}	.5330 10^{-2}
1500	.9483 10^{-2}	.1225 10^{-1}	.1891 10^{-1}	.2718 10^{-1}	.6928 10^{-2}
2000	.1194 10^{-1}	.1572 10^{-1}	.2482 10^{-1}	.3602 10^{-1}	.8537 10^{-2}
3000	.1689 10^{-1}	.2271 10^{-1}	.3672 10^{-1}	.5377 10^{-1}	.1178 10^{-1}
4000	.2186 10^{-1}	.2974 10^{-1}	.4868 10^{-1}	.7161 10^{-1}	.1503 10^{-1}
5000	.2686 10^{-1}	.3680 10^{-1}	.6067 10^{-1}	.8951 10^{-1}	.1831 10^{-1}
6000	.3188 10^{-1}	.4387 10^{-1}	.7269 10^{-1}	.1074	.2159 10^{-1}
7000	.3690 10^{-1}	.5096 10^{-1}	.8473 10^{-1}	.1254	.2489 10^{-1}
8000	.4194 10^{-1}	.5806 10^{-1}	.9679 10^{-1}	.1434	.2819 10^{-1}
9000	.4698 10^{-1}	.6517 10^{-1}	.1089	.1614	.3150 10^{-1}
10000	.5203 10^{-1}	.7229 10^{-1}	.1209	.1794	.3482 10^{-1}

Table 5 (cont'd)

E (GeV)	Lucite	Poly-ethylene	Poly-styrene	Propane (liquid)	Silica aerogel
1	$.2020\ 10^{-2}$	$.2165\ 10^{-2}$	$.2027\ 10^{-2}$	$.2295\ 10^{-2}$	$.1907\ 10^{-2}$
2	$.2142\ 10^{-2}$	$.2289\ 10^{-2}$	$.2147\ 10^{-2}$	$.2427\ 10^{-2}$	$.2030\ 10^{-2}$
4	$.2260\ 10^{-2}$	$.2410\ 10^{-2}$	$.2265\ 10^{-2}$	$.2556\ 10^{-2}$	$.2150\ 10^{-2}$
6	$.2326\ 10^{-2}$	$.2478\ 10^{-2}$	$.2330\ 10^{-2}$	$.2627\ 10^{-2}$	$.2216\ 10^{-2}$
8	$.2372\ 10^{-2}$	$.2524\ 10^{-2}$	$.2375\ 10^{-2}$	$.2675\ 10^{-2}$	$.2262\ 10^{-2}$
10	$.2406\ 10^{-2}$	$.2560\ 10^{-2}$	$.2409\ 10^{-2}$	$.2712\ 10^{-2}$	$.2298\ 10^{-2}$
15	$.2469\ 10^{-2}$	$.2624\ 10^{-2}$	$.2470\ 10^{-2}$	$.2779\ 10^{-2}$	$.2362\ 10^{-2}$
20	$.2514\ 10^{-2}$	$.2670\ 10^{-2}$	$.2514\ 10^{-2}$	$.2826\ 10^{-2}$	$.2410\ 10^{-2}$
30	$.2582\ 10^{-2}$	$.2738\ 10^{-2}$	$.2581\ 10^{-2}$	$.2896\ 10^{-2}$	$.2483\ 10^{-2}$
40	$.2636\ 10^{-2}$	$.2792\ 10^{-2}$	$.2633\ 10^{-2}$	$.2951\ 10^{-2}$	$.2542\ 10^{-2}$
50	$.2682\ 10^{-2}$	$.2838\ 10^{-2}$	$.2677\ 10^{-2}$	$.2997\ 10^{-2}$	$.2595\ 10^{-2}$
60	$.2724\ 10^{-2}$	$.2879\ 10^{-2}$	$.2718\ 10^{-2}$	$.3039\ 10^{-2}$	$.2644\ 10^{-2}$
70	$.2764\ 10^{-2}$	$.2917\ 10^{-2}$	$.2756\ 10^{-2}$	$.3077\ 10^{-2}$	$.2690\ 10^{-2}$
80	$.2802\ 10^{-2}$	$.2953\ 10^{-2}$	$.2792\ 10^{-2}$	$.3113\ 10^{-2}$	$.2735\ 10^{-2}$
90	$.2838\ 10^{-2}$	$.2988\ 10^{-2}$	$.2826\ 10^{-2}$	$.3148\ 10^{-2}$	$.2778\ 10^{-2}$
100	$.2873\ 10^{-2}$	$.3022\ 10^{-2}$	$.2860\ 10^{-2}$	$.3182\ 10^{-2}$	$.2821\ 10^{-2}$
120	$.2942\ 10^{-2}$	$.3086\ 10^{-2}$	$.2925\ 10^{-2}$	$.3247\ 10^{-2}$	$.2904\ 10^{-2}$
140	$.3008\ 10^{-2}$	$.3149\ 10^{-2}$	$.2987\ 10^{-2}$	$.3309\ 10^{-2}$	$.2986\ 10^{-2}$
160	$.3073\ 10^{-2}$	$.3210\ 10^{-2}$	$.3049\ 10^{-2}$	$.3370\ 10^{-2}$	$.3067\ 10^{-2}$
180	$.3137\ 10^{-2}$	$.3270\ 10^{-2}$	$.3109\ 10^{-2}$	$.3430\ 10^{-2}$	$.3147\ 10^{-2}$
200	$.3201\ 10^{-2}$	$.3329\ 10^{-2}$	$.3169\ 10^{-2}$	$.3488\ 10^{-2}$	$.3227\ 10^{-2}$
220	$.3264\ 10^{-2}$	$.3388\ 10^{-2}$	$.3228\ 10^{-2}$	$.3547\ 10^{-2}$	$.3306\ 10^{-2}$
240	$.3326\ 10^{-2}$	$.3446\ 10^{-2}$	$.3287\ 10^{-2}$	$.3604\ 10^{-2}$	$.3385\ 10^{-2}$
260	$.3389\ 10^{-2}$	$.3503\ 10^{-2}$	$.3345\ 10^{-2}$	$.3661\ 10^{-2}$	$.3464\ 10^{-2}$
280	$.3450\ 10^{-2}$	$.3561\ 10^{-2}$	$.3403\ 10^{-2}$	$.3718\ 10^{-2}$	$.3543\ 10^{-2}$
300	$.3512\ 10^{-2}$	$.3618\ 10^{-2}$	$.3461\ 10^{-2}$	$.3775\ 10^{-2}$	$.3621\ 10^{-2}$
350	$.3666\ 10^{-2}$	$.3760\ 10^{-2}$	$.3605\ 10^{-2}$	$.3916\ 10^{-2}$	$.3818\ 10^{-2}$
400	$.3820\ 10^{-2}$	$.3901\ 10^{-2}$	$.3749\ 10^{-2}$	$.4056\ 10^{-2}$	$.4014\ 10^{-2}$
450	$.3973\ 10^{-2}$	$.4042\ 10^{-2}$	$.3892\ 10^{-2}$	$.4195\ 10^{-2}$	$.4211\ 10^{-2}$
500	$.4126\ 10^{-2}$	$.4183\ 10^{-2}$	$.4035\ 10^{-2}$	$.4334\ 10^{-2}$	$.4407\ 10^{-2}$
600	$.4431\ 10^{-2}$	$.4463\ 10^{-2}$	$.4320\ 10^{-2}$	$.4612\ 10^{-2}$	$.4801\ 10^{-2}$
700	$.4737\ 10^{-2}$	$.4743\ 10^{-2}$	$.4606\ 10^{-2}$	$.4889\ 10^{-2}$	$.5196\ 10^{-2}$
800	$.5043\ 10^{-2}$	$.5024\ 10^{-2}$	$.4891\ 10^{-2}$	$.5166\ 10^{-2}$	$.5592\ 10^{-2}$
900	$.5349\ 10^{-2}$	$.5304\ 10^{-2}$	$.5178\ 10^{-2}$	$.5444\ 10^{-2}$	$.5988\ 10^{-2}$
1000	$.5655\ 10^{-2}$	$.5585\ 10^{-2}$	$.5464\ 10^{-2}$	$.5721\ 10^{-2}$	$.6385\ 10^{-2}$
1500	$.7193\ 10^{-2}$	$.6992\ 10^{-2}$	$.6899\ 10^{-2}$	$.7111\ 10^{-2}$	$.8381\ 10^{-2}$
2000	$.8740\ 10^{-2}$	$.8406\ 10^{-2}$	$.8341\ 10^{-2}$	$.8508\ 10^{-2}$	$.1039\ 10^{-1}$
3000	$.1185\ 10^{-1}$	$.1125\ 10^{-1}$	$.1124\ 10^{-1}$	$.1132\ 10^{-1}$	$.1443\ 10^{-1}$
4000	$.1498\ 10^{-1}$	$.1411\ 10^{-1}$	$.1417\ 10^{-1}$	$.1414\ 10^{-1}$	$.1850\ 10^{-1}$
5000	$.1813\ 10^{-1}$	$.1699\ 10^{-1}$	$.1710\ 10^{-1}$	$.1698\ 10^{-1}$	$.2258\ 10^{-1}$
6000	$.2129\ 10^{-1}$	$.1987\ 10^{-1}$	$.2005\ 10^{-1}$	$.1984\ 10^{-1}$	$.2668\ 10^{-1}$
7000	$.2445\ 10^{-1}$	$.2277\ 10^{-1}$	$.2300\ 10^{-1}$	$.2270\ 10^{-1}$	$.3079\ 10^{-1}$
8000	$.2763\ 10^{-1}$	$.2567\ 10^{-1}$	$.2597\ 10^{-1}$	$.2556\ 10^{-1}$	$.3490\ 10^{-1}$
9000	$.3081\ 10^{-1}$	$.2858\ 10^{-1}$	$.2893\ 10^{-1}$	$.2844\ 10^{-1}$	$.3903\ 10^{-1}$
10000	$.3400\ 10^{-1}$	$.3150\ 10^{-1}$	$.3191\ 10^{-1}$	$.3132\ 10^{-1}$	$.4317\ 10^{-1}$

Table 5 (cont'd)

E (GeV)	Silicon dioxide	Sodium iodide	Standard rock	Uranium oxide	Water
1	.1799 10^{-2}	.1431 10^{-2}	.1787 10^{-2}	.1267 10^{-2}	.2087 10^{-2}
2	.1921 10^{-2}	.1557 10^{-2}	.1907 10^{-2}	.1386 10^{-2}	.2213 10^{-2}
4	.2038 10^{-2}	.1681 10^{-2}	.2024 10^{-2}	.1508 10^{-2}	.2336 10^{-2}
6	.2103 10^{-2}	.1754 10^{-2}	.2090 10^{-2}	.1583 10^{-2}	.2405 10^{-2}
8	.2148 10^{-2}	.1807 10^{-2}	.2135 10^{-2}	.1641 10^{-2}	.2452 10^{-2}
10	.2183 10^{-2}	.1849 10^{-2}	.2170 10^{-2}	.1689 10^{-2}	.2488 10^{-2}
15	.2247 10^{-2}	.1935 10^{-2}	.2234 10^{-2}	.1792 10^{-2}	.2554 10^{-2}
20	.2295 10^{-2}	.2007 10^{-2}	.2282 10^{-2}	.1883 10^{-2}	.2602 10^{-2}
30	.2369 10^{-2}	.2132 10^{-2}	.2355 10^{-2}	.2050 10^{-2}	.2674 10^{-2}
40	.2429 10^{-2}	.2247 10^{-2}	.2416 10^{-2}	.2212 10^{-2}	.2731 10^{-2}
50	.2483 10^{-2}	.2359 10^{-2}	.2470 10^{-2}	.2372 10^{-2}	.2781 10^{-2}
60	.2534 10^{-2}	.2469 10^{-2}	.2520 10^{-2}	.2532 10^{-2}	.2826 10^{-2}
70	.2583 10^{-2}	.2578 10^{-2}	.2569 10^{-2}	.2692 10^{-2}	.2869 10^{-2}
80	.2629 10^{-2}	.2687 10^{-2}	.2615 10^{-2}	.2854 10^{-2}	.2910 10^{-2}
90	.2675 10^{-2}	.2796 10^{-2}	.2661 10^{-2}	.3016 10^{-2}	.2949 10^{-2}
100	.2720 10^{-2}	.2905 10^{-2}	.2706 10^{-2}	.3179 10^{-2}	.2988 10^{-2}
120	.2809 10^{-2}	.3124 10^{-2}	.2794 10^{-2}	.3506 10^{-2}	.3063 10^{-2}
140	.2896 10^{-2}	.3344 10^{-2}	.2881 10^{-2}	.3838 10^{-2}	.3135 10^{-2}
160	.2983 10^{-2}	.3565 10^{-2}	.2966 10^{-2}	.4172 10^{-2}	.3207 10^{-2}
180	.3069 10^{-2}	.3787 10^{-2}	.3052 10^{-2}	.4508 10^{-2}	.3278 10^{-2}
200	.3154 10^{-2}	.4011 10^{-2}	.3137 10^{-2}	.4846 10^{-2}	.3347 10^{-2}
220	.3239 10^{-2}	.4235 10^{-2}	.3222 10^{-2}	.5186 10^{-2}	.3417 10^{-2}
240	.3324 10^{-2}	.4460 10^{-2}	.3306 10^{-2}	.5527 10^{-2}	.3486 10^{-2}
260	.3409 10^{-2}	.4686 10^{-2}	.3391 10^{-2}	.5870 10^{-2}	.3555 10^{-2}
280	.3494 10^{-2}	.4912 10^{-2}	.3475 10^{-2}	.6214 10^{-2}	.3623 10^{-2}
300	.3579 10^{-2}	.5139 10^{-2}	.3560 10^{-2}	.6559 10^{-2}	.3692 10^{-2}
350	.3791 10^{-2}	.5711 10^{-2}	.3771 10^{-2}	.7427 10^{-2}	.3862 10^{-2}
400	.4004 10^{-2}	.6284 10^{-2}	.3983 10^{-2}	.8301 10^{-2}	.4032 10^{-2}
450	.4216 10^{-2}	.6862 10^{-2}	.4194 10^{-2}	.9179 10^{-2}	.4202 10^{-2}
500	.4429 10^{-2}	.7442 10^{-2}	.4406 10^{-2}	.1006 10^{-1}	.4372 10^{-2}
600	.4856 10^{-2}	.8606 10^{-2}	.4831 10^{-2}	.1184 10^{-1}	.4711 10^{-2}
700	.5284 10^{-2}	.9778 10^{-2}	.5258 10^{-2}	.1362 10^{-1}	.5050 10^{-2}
800	.5713 10^{-2}	.1095 10^{-1}	.5685 10^{-2}	.1541 10^{-1}	.5390 10^{-2}
900	.6143 10^{-2}	.1214 10^{-1}	.6113 10^{-2}	.1721 10^{-1}	.5731 10^{-2}
1000	.6574 10^{-2}	.1332 10^{-1}	.6543 10^{-2}	.1902 10^{-1}	.6071 10^{-2}
1500	.8740 10^{-2}	.1929 10^{-1}	.8702 10^{-2}	.2810 10^{-1}	.7782 10^{-2}
2000	.1092 10^{-1}	.2530 10^{-1}	.1088 10^{-1}	.3725 10^{-1}	.9502 10^{-2}
3000	.1531 10^{-1}	.3739 10^{-1}	.1525 10^{-1}	.5566 10^{-1}	.1296 10^{-1}
4000	.1973 10^{-1}	.4954 10^{-1}	.1966 10^{-1}	.7416 10^{-1}	.1644 10^{-1}
5000	.2417 10^{-1}	.6175 10^{-1}	.2408 10^{-1}	.9271 10^{-1}	.1994 10^{-1}
6000	.2862 10^{-1}	.7396 10^{-1}	.2852 10^{-1}	.1113	.2345 10^{-1}
7000	.3308 10^{-1}	.8621 10^{-1}	.3297 10^{-1}	.1299	.2697 10^{-1}
8000	.3755 10^{-1}	.9848 10^{-1}	.3743 10^{-1}	.1485	.3049 10^{-1}
9000	.4203 10^{-1}	.1107	.4190 10^{-1}	.1672	.3403 10^{-1}
10000	.4652 10^{-1}	.1230	.4637 10^{-1}	.1859	.3758 10^{-1}