

Update to ESTAR, PSTAR, and ASTAR Databases

A result of Report 90 (ICRU, 2014) of the International Commission on Radiation Units and Measurements (ICRU)^a has been to update stopping powers and ranges of electrons, positrons, protons, and alpha particles in three materials: air (dry, at sea level), graphite, and liquid water. This addendum to the ESTAR, PSTAR, and ASTAR databases provides these updated results, but only in a non-interactive set of computer-readable tables. The ICRU Report considered also stopping powers and ranges of carbon ions in these three materials, and these results are included also.

^a This Report was released in 2016; the members of the Report Committee were S. M. Seltzer (Co-Chairman), J. M. Fernández-Varea (Co-Chairman), P. Andreo, P. M. Bergstrom Jr., D. T. Burns, I. Krajcar Bronić, C. K. Ross, and F. Salvat.

The methods underlying the calculations, as detailed in ICRU Report 90, are basically the same as those used earlier, but with differences listed below.

- The key parameter in Bethe's theory of charged-particle electronic (collision) stopping power, *i.e.*, the mean excitation energy, I , was thoroughly reviewed, with the results: $I = 85.7$ eV for air (no change from previous recommendation), $I = 81$ eV for graphite (previous recommendation was 78 eV), and $I = 78$ eV for liquid water (previous recommendation was 75 eV).
- The density-effect correction, δ , for the electronic (collision) stopping powers in graphite assumes a mass density of $\rho = 2.25$ g cm⁻³ rather than $\rho = 1.7$ g cm⁻³, and assumes there is one conduction electron rather than two.
- The radiative stopping powers, S_{rad} , for electrons and positrons are now taken from Seltzer and Berger (1986), which are slightly different from the somewhat more preliminary results of Seltzer and Berger (1985).
- The low-energy electronic (collision) stopping powers for protons in graphite are taken from the measured results of Nečas *et al.* (1993) rather than those used in ICRU Report 49 (ICRU, 1993).

The tables use the following symbols:

T , kinetic energy of the charged particle

S_{el} , electronic (collision) stopping power

S_{rad} , radiative stopping power (given here for electrons and positrons)

S_{nuc} , nuclear stopping power (given here for protons, alpha particles, and carbon ions)

S_{tot} , total stopping power

r_0 , csda range of the charged particle

Y , radiation yield (given here for electrons and positrons)

δ , density-effect correction

Additional References

ICRU (1993). International Commission on Radiation Units and Measurements. *Stopping Power and Ranges for Protons and Alpha Particles*, ICRU Report 49 (International Commission on Radiation Units and Measurements, Bethesda, MD).

ICRU (2014). International Commission on Radiation Units and Measurements. *ICRU Report 90, Key Data for Ionizing-Radiation Dosimetry: Measurement Standards and Applications*. ICRU Report 90, *J. ICRU* **14** (Oxford University Press, Oxford).

Nečas, V., Käferböck, W., Rössler, W., and Bauer, P. (1993). “Electronic stopping of hydrogen ions in graphite and amorphous carbon,” *Nucl. Instrum. Meth. B* **80–81**, 41–44.

Seltzer, S. M., and Berger, M. J. (1986). “Bremsstrahlung energy spectra from electrons with kinetic energy 1 keV–10 GeV incident on screened nuclei and orbital electrons of neutral atoms with $Z = 1–100$,” *At. Data Nucl. Data Tables* **35**, 345–418.

Appendix A: New Tabular Data

Table A.1. Electrons in air, $I = 85.7$ eV, $\rho = 0.0012$ g cm⁻³.

T MeV	S_{el}/ρ	S_{rad}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Y	δ
0.0010	1.025E+02	2.883E-03	1.025E+02	4.879E-06	1.407E-05	0.000E+00
0.0015	7.903E+01	3.171E-03	7.904E+01	1.049E-05	2.077E-05	0.000E+00
0.0020	6.501E+01	3.351E-03	6.502E+01	1.750E-05	2.705E-05	0.000E+00
0.0030	4.879E+01	3.562E-03	4.879E+01	3.547E-05	3.883E-05	0.000E+00
0.0040	3.954E+01	3.679E-03	3.954E+01	5.839E-05	4.991E-05	0.000E+00
0.0050	3.348E+01	3.752E-03	3.349E+01	8.598E-05	6.045E-05	0.000E+00
0.0060	2.918E+01	3.801E-03	2.919E+01	1.181E-04	7.058E-05	0.000E+00
0.0080	2.344E+01	3.858E-03	2.345E+01	1.950E-04	8.983E-05	0.000E+00
0.0100	1.975E+01	3.889E-03	1.976E+01	2.884E-04	1.080E-04	0.000E+00
0.0150	1.444E+01	3.919E-03	1.445E+01	5.886E-04	1.502E-04	0.000E+00
0.0200	1.157E+01	3.933E-03	1.158E+01	9.781E-04	1.891E-04	0.000E+00
0.0300	8.491E+00	3.958E-03	8.495E+00	2.002E-03	2.607E-04	0.000E+00
0.0400	6.848E+00	3.981E-03	6.852E+00	3.322E-03	3.266E-04	0.000E+00
0.0500	5.818E+00	4.006E-03	5.822E+00	4.912E-03	3.883E-04	0.000E+00
0.0600	5.110E+00	4.039E-03	5.114E+00	6.750E-03	4.468E-04	0.000E+00
0.0800	4.197E+00	4.116E-03	4.201E+00	1.110E-02	5.566E-04	0.000E+00
0.1000	3.633E+00	4.205E-03	3.637E+00	1.623E-02	6.591E-04	0.000E+00
0.1500	2.861E+00	4.463E-03	2.865E+00	3.193E-02	8.930E-04	0.000E+00
0.2000	2.469E+00	4.759E-03	2.474E+00	5.082E-02	1.105E-03	0.000E+00
0.3000	2.084E+00	5.463E-03	2.089E+00	9.528E-02	1.494E-03	0.000E+00
0.4000	1.902E+00	6.283E-03	1.908E+00	1.456E-01	1.859E-03	0.000E+00
0.5000	1.802E+00	7.194E-03	1.809E+00	1.995E-01	2.214E-03	0.000E+00
0.6000	1.743E+00	8.181E-03	1.751E+00	2.558E-01	2.566E-03	0.000E+00
0.8000	1.683E+00	1.033E-02	1.694E+00	3.723E-01	3.270E-03	0.000E+00
1.0000	1.661E+00	1.267E-02	1.674E+00	4.912E-01	3.982E-03	0.000E+00
1.5000	1.661E+00	1.919E-02	1.680E+00	7.901E-01	5.815E-03	0.000E+00
2.0000	1.684E+00	2.644E-02	1.711E+00	1.085E+00	7.718E-03	0.000E+00
3.0000	1.740E+00	4.247E-02	1.782E+00	1.658E+00	1.168E-02	0.000E+00
4.0000	1.790E+00	5.994E-02	1.850E+00	2.208E+00	1.579E-02	0.000E+00
5.0000	1.833E+00	7.841E-02	1.911E+00	2.740E+00	1.997E-02	0.000E+00
6.0000	1.870E+00	9.762E-02	1.968E+00	3.255E+00	2.420E-02	0.000E+00
8.0000	1.931E+00	1.378E-01	2.068E+00	4.246E+00	3.268E-02	0.000E+00
10.0000	1.979E+00	1.796E-01	2.159E+00	5.192E+00	4.114E-02	0.000E+00
15.0000	2.069E+00	2.891E-01	2.359E+00	7.405E+00	6.181E-02	0.000E+00
20.0000	2.134E+00	4.032E-01	2.537E+00	9.447E+00	8.161E-02	0.000E+00
30.0000	2.226E+00	6.394E-01	2.865E+00	1.315E+01	1.184E-01	7.556E-03
40.0000	2.282E+00	8.825E-01	3.164E+00	1.647E+01	1.517E-01	1.375E-01
50.0000	2.319E+00	1.130E+00	3.449E+00	1.949E+01	1.821E-01	3.188E-01
60.0000	2.347E+00	1.381E+00	3.728E+00	2.228E+01	2.100E-01	5.024E-01
80.0000	2.387E+00	1.890E+00	4.277E+00	2.729E+01	2.594E-01	8.360E-01
100.0000	2.417E+00	2.405E+00	4.822E+00	3.169E+01	3.018E-01	1.120E+00
150.0000	2.468E+00	3.713E+00	6.181E+00	4.082E+01	3.857E-01	1.669E+00
200.0000	2.502E+00	5.035E+00	7.538E+00	4.814E+01	4.484E-01	2.078E+00
300.0000	2.550E+00	7.698E+00	1.025E+01	5.947E+01	5.368E-01	2.674E+00
400.0000	2.582E+00	1.037E+01	1.296E+01	6.813E+01	5.971E-01	3.116E+00
500.0000	2.606E+00	1.306E+01	1.566E+01	7.514E+01	6.413E-01	3.471E+00
600.0000	2.625E+00	1.575E+01	1.837E+01	8.103E+01	6.754E-01	3.772E+00
800.0000	2.653E+00	2.114E+01	2.380E+01	9.056E+01	7.251E-01	4.266E+00
1000.0000	2.674E+00	2.655E+01	2.922E+01	9.813E+01	7.599E-01	4.667E+00

Table A.2. Electrons in graphite, $I = 81 \text{ eV}$, $\rho = 2.265 \text{ g cm}^{-3}$.

T MeV	S_{el}/ρ	S_{rad}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Y	δ
0.00100	1.048E+02	2.507E-03	1.048E+02	4.772E-06	1.197E-05	2.470E-04
0.00150	8.057E+01	2.715E-03	8.057E+01	1.027E-05	1.760E-05	3.719E-04
0.00200	6.617E+01	2.836E-03	6.617E+01	1.716E-05	2.278E-05	4.978E-04
0.00300	4.956E+01	2.969E-03	4.957E+01	3.483E-05	3.235E-05	7.522E-04
0.00400	4.012E+01	3.037E-03	4.012E+01	5.740E-05	4.123E-05	1.010E-03
0.00500	3.395E+01	3.077E-03	3.395E+01	8.461E-05	4.963E-05	1.272E-03
0.00600	2.958E+01	3.101E-03	2.958E+01	1.162E-04	5.766E-05	1.537E-03
0.00800	2.374E+01	3.128E-03	2.374E+01	1.923E-04	7.286E-05	2.079E-03
0.01000	1.999E+01	3.142E-03	1.999E+01	2.845E-04	8.720E-05	2.634E-03
0.01500	1.460E+01	3.152E-03	1.461E+01	5.813E-04	1.204E-04	4.085E-03
0.02000	1.169E+01	3.164E-03	1.169E+01	9.668E-04	1.512E-04	5.622E-03
0.03000	8.572E+00	3.181E-03	8.575E+00	1.980E-03	2.080E-04	8.946E-03
0.04000	6.908E+00	3.200E-03	6.911E+00	3.289E-03	2.604E-04	1.259E-02
0.05000	5.866E+00	3.227E-03	5.869E+00	4.866E-03	3.097E-04	1.654E-02
0.06000	5.150E+00	3.256E-03	5.153E+00	6.690E-03	3.566E-04	2.079E-02
0.08000	4.226E+00	3.324E-03	4.229E+00	1.101E-02	4.449E-04	3.011E-02
0.10000	3.654E+00	3.400E-03	3.657E+00	1.611E-02	5.277E-04	4.047E-02
0.15000	2.871E+00	3.619E-03	2.875E+00	3.174E-02	7.175E-04	7.039E-02
0.20000	2.473E+00	3.871E-03	2.476E+00	5.059E-02	8.913E-04	1.052E-01
0.30000	2.076E+00	4.462E-03	2.081E+00	9.513E-02	1.213E-03	1.847E-01
0.40000	1.886E+00	5.148E-03	1.891E+00	1.458E-01	1.518E-03	2.708E-01
0.50000	1.778E+00	5.911E-03	1.784E+00	2.004E-01	1.818E-03	3.580E-01
0.60000	1.712E+00	6.734E-03	1.718E+00	2.576E-01	2.117E-03	4.438E-01
0.80000	1.640E+00	8.533E-03	1.648E+00	3.767E-01	2.724E-03	6.075E-01
1.00000	1.606E+00	1.050E-02	1.617E+00	4.994E-01	3.345E-03	7.593E-01
1.50000	1.582E+00	1.596E-02	1.598E+00	8.113E-01	4.970E-03	1.090E+00
2.00000	1.586E+00	2.204E-02	1.608E+00	1.124E+00	6.686E-03	1.364E+00
3.00000	1.609E+00	3.552E-02	1.645E+00	1.739E+00	1.033E-02	1.798E+00
4.00000	1.634E+00	5.023E-02	1.684E+00	2.339E+00	1.417E-02	2.136E+00
5.00000	1.656E+00	6.582E-02	1.722E+00	2.927E+00	1.814E-02	2.414E+00
6.00000	1.675E+00	8.203E-02	1.757E+00	3.501E+00	2.219E-02	2.653E+00
8.00000	1.706E+00	1.160E-01	1.822E+00	4.619E+00	3.043E-02	3.051E+00
10.00000	1.729E+00	1.514E-01	1.881E+00	5.699E+00	3.876E-02	3.381E+00
15.00000	1.770E+00	2.442E-01	2.014E+00	8.266E+00	5.953E-02	4.033E+00
20.00000	1.797E+00	3.410E-01	2.138E+00	1.067E+01	7.980E-02	4.533E+00
30.00000	1.832E+00	5.419E-01	2.374E+00	1.511E+01	1.181E-01	5.279E+00
40.00000	1.856E+00	7.489E-01	2.605E+00	1.913E+01	1.533E-01	5.828E+00
50.00000	1.874E+00	9.599E-01	2.834E+00	2.281E+01	1.854E-01	6.260E+00
60.00000	1.888E+00	1.174E+00	3.062E+00	2.620E+01	2.147E-01	6.616E+00
80.00000	1.911E+00	1.608E+00	3.519E+00	3.229E+01	2.665E-01	7.183E+00
100.00000	1.928E+00	2.048E+00	3.977E+00	3.764E+01	3.106E-01	7.624E+00
150.00000	1.960E+00	3.166E+00	5.125E+00	4.868E+01	3.972E-01	8.429E+00
200.00000	1.982E+00	4.296E+00	6.278E+00	5.748E+01	4.612E-01	9.002E+00
300.00000	2.013E+00	6.574E+00	8.587E+00	7.105E+01	5.505E-01	9.811E+00
400.00000	2.035E+00	8.863E+00	1.090E+01	8.136E+01	6.107E-01	1.039E+01
500.00000	2.052E+00	1.116E+01	1.321E+01	8.968E+01	6.545E-01	1.083E+01
600.00000	2.066E+00	1.346E+01	1.553E+01	9.665E+01	6.882E-01	1.119E+01
800.00000	2.089E+00	1.809E+01	2.017E+01	1.079E+02	7.369E-01	1.177E+01
1000.00000	2.106E+00	2.272E+01	2.482E+01	1.168E+02	7.708E-01	1.222E+01

Table A.3. Electrons in liquid water, $I = 78 \text{ eV}$, $\rho = 0.998 \text{ g cm}^{-3}$.

T MeV	S_{el}/ρ	S_{rad}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Y	δ
0.0010	1.181E+02	2.830E-03	1.181E+02	4.235E-06	1.199E-05	0.000E+00
0.0015	9.063E+01	3.122E-03	9.063E+01	9.118E-06	1.774E-05	0.000E+00
0.0020	7.436E+01	3.307E-03	7.436E+01	1.524E-05	2.318E-05	0.000E+00
0.0030	5.563E+01	3.530E-03	5.564E+01	3.098E-05	3.348E-05	0.000E+00
0.0040	4.500E+01	3.657E-03	4.500E+01	5.110E-05	4.322E-05	0.000E+00
0.0050	3.806E+01	3.737E-03	3.807E+01	7.536E-05	5.253E-05	0.000E+00
0.0060	3.315E+01	3.791E-03	3.315E+01	1.036E-04	6.149E-05	0.000E+00
0.0080	2.659E+01	3.855E-03	2.660E+01	1.714E-04	7.858E-05	0.000E+00
0.0100	2.239E+01	3.890E-03	2.239E+01	2.537E-04	9.476E-05	0.000E+00
0.0150	1.635E+01	3.928E-03	1.635E+01	5.189E-04	1.324E-04	0.000E+00
0.0200	1.308E+01	3.939E-03	1.309E+01	8.632E-04	1.670E-04	0.000E+00
0.0300	9.591E+00	3.965E-03	9.595E+00	1.769E-03	2.307E-04	0.000E+00
0.0400	7.729E+00	3.987E-03	7.733E+00	2.939E-03	2.893E-04	0.000E+00
0.0500	6.564E+00	4.011E-03	6.568E+00	4.348E-03	3.442E-04	0.000E+00
0.0600	5.763E+00	4.044E-03	5.767E+00	5.978E-03	3.962E-04	0.000E+00
0.0800	4.731E+00	4.122E-03	4.735E+00	9.833E-03	4.939E-04	0.000E+00
0.1000	4.093E+00	4.211E-03	4.097E+00	1.439E-02	5.851E-04	0.000E+00
0.1500	3.221E+00	4.471E-03	3.226E+00	2.833E-02	7.936E-04	0.000E+00
0.2000	2.779E+00	4.771E-03	2.784E+00	4.512E-02	9.831E-04	0.000E+00
0.3000	2.344E+00	5.482E-03	2.349E+00	8.464E-02	1.331E-03	0.000E+00
0.4000	2.138E+00	6.309E-03	2.144E+00	1.294E-01	1.657E-03	0.000E+00
0.5000	2.025E+00	7.228E-03	2.032E+00	1.774E-01	1.976E-03	0.000E+00
0.6000	1.956E+00	8.221E-03	1.965E+00	2.275E-01	2.291E-03	1.501E-02
0.8000	1.880E+00	1.039E-02	1.891E+00	3.315E-01	2.927E-03	1.005E-01
1.0000	1.845E+00	1.276E-02	1.858E+00	4.384E-01	3.577E-03	2.086E-01
1.5000	1.819E+00	1.934E-02	1.838E+00	7.096E-01	5.275E-03	4.982E-01
2.0000	1.821E+00	2.666E-02	1.848E+00	9.811E-01	7.071E-03	7.703E-01
3.0000	1.844E+00	4.286E-02	1.887E+00	1.517E+00	1.089E-02	1.231E+00
4.0000	1.869E+00	6.056E-02	1.929E+00	2.041E+00	1.493E-02	1.601E+00
5.0000	1.891E+00	7.922E-02	1.970E+00	2.554E+00	1.910E-02	1.906E+00
6.0000	1.910E+00	9.865E-02	2.008E+00	3.057E+00	2.336E-02	2.165E+00
8.0000	1.942E+00	1.392E-01	2.081E+00	4.035E+00	3.203E-02	2.589E+00
10.0000	1.967E+00	1.816E-01	2.148E+00	4.980E+00	4.077E-02	2.928E+00
15.0000	2.013E+00	2.924E-01	2.305E+00	7.226E+00	6.248E-02	3.567E+00
20.0000	2.045E+00	4.079E-01	2.453E+00	9.327E+00	8.357E-02	4.039E+00
30.0000	2.088E+00	6.472E-01	2.736E+00	1.318E+01	1.232E-01	4.734E+00
40.0000	2.117E+00	8.936E-01	3.011E+00	1.667E+01	1.592E-01	5.252E+00
50.0000	2.139E+00	1.145E+00	3.284E+00	1.985E+01	1.920E-01	5.665E+00
60.0000	2.156E+00	1.399E+00	3.555E+00	2.277E+01	2.220E-01	6.010E+00
80.0000	2.182E+00	1.914E+00	4.097E+00	2.801E+01	2.745E-01	6.563E+00
100.0000	2.202E+00	2.437E+00	4.640E+00	3.259E+01	3.190E-01	6.998E+00
150.0000	2.238E+00	3.763E+00	6.001E+00	4.204E+01	4.061E-01	7.796E+00
200.0000	2.263E+00	5.103E+00	7.366E+00	4.955E+01	4.701E-01	8.367E+00
300.0000	2.298E+00	7.802E+00	1.010E+01	6.110E+01	5.590E-01	9.173E+00
400.0000	2.322E+00	1.051E+01	1.284E+01	6.986E+01	6.186E-01	9.747E+00
500.0000	2.341E+00	1.323E+01	1.558E+01	7.692E+01	6.620E-01	1.019E+01
600.0000	2.357E+00	1.596E+01	1.832E+01	8.284E+01	6.951E-01	1.056E+01
800.0000	2.382E+00	2.143E+01	2.381E+01	9.239E+01	7.431E-01	1.113E+01
1000.0000	2.401E+00	2.691E+01	2.931E+01	9.994E+01	7.764E-01	1.158E+01

Table A.4. Positrons in air, $I = 85.7$ eV, $\rho = 0.0012$ g cm⁻³.

T MeV	S_{el}/ρ	S_{rad}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Y	δ
0.0010	1.235E+02	9.936E-04	1.235E+02	4.047E-06	4.021E-06	0.000E+00
0.0015	9.305E+01	1.210E-03	9.305E+01	8.765E-06	6.180E-06	0.000E+00
0.0020	7.551E+01	1.372E-03	7.551E+01	1.477E-05	8.527E-06	0.000E+00
0.0030	5.576E+01	1.606E-03	5.577E+01	3.038E-05	1.350E-05	0.000E+00
0.0040	4.475E+01	1.774E-03	4.475E+01	5.054E-05	1.868E-05	0.000E+00
0.0050	3.764E+01	1.904E-03	3.764E+01	7.501E-05	2.397E-05	0.000E+00
0.0060	3.264E+01	2.009E-03	3.264E+01	1.036E-04	2.932E-05	0.000E+00
0.0080	2.601E+01	2.173E-03	2.602E+01	1.728E-04	4.012E-05	0.000E+00
0.0100	2.179E+01	2.297E-03	2.180E+01	2.571E-04	5.099E-05	0.000E+00
0.0150	1.578E+01	2.513E-03	1.579E+01	5.308E-04	7.812E-05	0.000E+00
0.0200	1.256E+01	2.664E-03	1.256E+01	8.887E-04	1.050E-04	0.000E+00
0.0300	9.125E+00	2.880E-03	9.128E+00	1.837E-03	1.580E-04	0.000E+00
0.0400	7.306E+00	3.035E-03	7.309E+00	3.071E-03	2.100E-04	0.000E+00
0.0500	6.171E+00	3.157E-03	6.174E+00	4.566E-03	2.607E-04	0.000E+00
0.0600	5.393E+00	3.265E-03	5.396E+00	6.304E-03	3.103E-04	0.000E+00
0.0800	4.393E+00	3.452E-03	4.396E+00	1.044E-02	4.067E-04	0.000E+00
0.1000	3.776E+00	3.617E-03	3.780E+00	1.537E-02	4.997E-04	0.000E+00
0.1500	2.935E+00	3.991E-03	2.939E+00	3.058E-02	7.200E-04	0.000E+00
0.2000	2.510E+00	4.350E-03	2.514E+00	4.909E-02	9.265E-04	0.000E+00
0.3000	2.091E+00	5.111E-03	2.096E+00	9.316E-02	1.313E-03	0.000E+00
0.4000	1.893E+00	5.950E-03	1.899E+00	1.435E-01	1.681E-03	0.000E+00
0.5000	1.784E+00	6.862E-03	1.791E+00	1.979E-01	2.041E-03	0.000E+00
0.6000	1.719E+00	7.840E-03	1.727E+00	2.548E-01	2.399E-03	0.000E+00
0.8000	1.652E+00	9.959E-03	1.662E+00	3.732E-01	3.115E-03	0.000E+00
1.0000	1.626E+00	1.227E-02	1.638E+00	4.946E-01	3.839E-03	0.000E+00
1.5000	1.621E+00	1.867E-02	1.639E+00	8.005E-01	5.700E-03	0.000E+00
2.0000	1.642E+00	2.581E-02	1.668E+00	1.103E+00	7.630E-03	0.000E+00
3.0000	1.695E+00	4.163E-02	1.737E+00	1.691E+00	1.165E-02	0.000E+00
4.0000	1.744E+00	5.892E-02	1.803E+00	2.256E+00	1.582E-02	0.000E+00
5.0000	1.786E+00	7.722E-02	1.863E+00	2.801E+00	2.007E-02	0.000E+00
6.0000	1.823E+00	9.630E-02	1.919E+00	3.330E+00	2.436E-02	0.000E+00
8.0000	1.883E+00	1.363E-01	2.019E+00	4.345E+00	3.299E-02	0.000E+00
10.0000	1.931E+00	1.780E-01	2.109E+00	5.314E+00	4.159E-02	0.000E+00
15.0000	2.020E+00	2.873E-01	2.308E+00	7.578E+00	6.263E-02	0.000E+00
20.0000	2.085E+00	4.014E-01	2.486E+00	9.664E+00	8.278E-02	0.000E+00
30.0000	2.176E+00	6.379E-01	2.814E+00	1.344E+01	1.202E-01	7.556E-03
40.0000	2.232E+00	8.816E-01	3.114E+00	1.681E+01	1.540E-01	1.375E-01
50.0000	2.269E+00	1.130E+00	3.399E+00	1.988E+01	1.849E-01	3.188E-01
60.0000	2.297E+00	1.383E+00	3.680E+00	2.271E+01	2.132E-01	5.024E-01
80.0000	2.337E+00	1.897E+00	4.234E+00	2.777E+01	2.632E-01	8.360E-01
100.0000	2.367E+00	2.419E+00	4.786E+00	3.221E+01	3.061E-01	1.120E+00
150.0000	2.418E+00	3.750E+00	6.168E+00	4.139E+01	3.910E-01	1.669E+00
200.0000	2.452E+00	5.102E+00	7.555E+00	4.871E+01	4.542E-01	2.078E+00
300.0000	2.500E+00	7.841E+00	1.034E+01	5.997E+01	5.431E-01	2.674E+00
400.0000	2.532E+00	1.061E+01	1.314E+01	6.853E+01	6.035E-01	3.116E+00
500.0000	2.556E+00	1.340E+01	1.595E+01	7.543E+01	6.477E-01	3.471E+00
600.0000	2.575E+00	1.620E+01	1.877E+01	8.120E+01	6.817E-01	3.772E+00
800.0000	2.603E+00	2.184E+01	2.444E+01	9.051E+01	7.312E-01	4.266E+00
1000.0000	2.624E+00	2.752E+01	3.014E+01	9.787E+01	7.657E-01	4.667E+00

Table A.5. Positrons in graphite, $I = 81$ eV, $\rho = 2.265$ g cm⁻³.

T MeV	S_{el}/ρ	S_{rad}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Y	δ
0.00100	1.258E+02	9.929E-04	1.258E+02	3.973E-06	3.945E-06	2.470E-04
0.00150	9.460E+01	1.183E-03	9.460E+01	8.610E-06	6.025E-06	3.719E-04
0.00200	7.667E+01	1.322E-03	7.667E+01	1.452E-05	8.235E-06	4.978E-04
0.00300	5.654E+01	1.517E-03	5.655E+01	2.991E-05	1.283E-05	7.522E-04
0.00400	4.533E+01	1.655E-03	4.534E+01	4.980E-05	1.754E-05	1.010E-03
0.00500	3.811E+01	1.760E-03	3.811E+01	7.396E-05	2.230E-05	1.272E-03
0.00600	3.303E+01	1.844E-03	3.303E+01	1.022E-04	2.708E-05	1.537E-03
0.00800	2.631E+01	1.974E-03	2.631E+01	1.706E-04	3.667E-05	2.079E-03
0.01000	2.203E+01	2.071E-03	2.203E+01	2.540E-04	4.624E-05	2.634E-03
0.01500	1.594E+01	2.241E-03	1.594E+01	5.248E-04	6.994E-05	4.085E-03
0.02000	1.268E+01	2.364E-03	1.268E+01	8.792E-04	9.334E-05	5.622E-03
0.03000	9.206E+00	2.533E-03	9.208E+00	1.819E-03	1.393E-04	8.946E-03
0.04000	7.366E+00	2.655E-03	7.369E+00	3.042E-03	1.839E-04	1.259E-02
0.05000	6.219E+00	2.754E-03	6.222E+00	4.526E-03	2.275E-04	1.654E-02
0.06000	5.432E+00	2.840E-03	5.435E+00	6.251E-03	2.700E-04	2.079E-02
0.08000	4.421E+00	2.989E-03	4.424E+00	1.036E-02	3.525E-04	3.011E-02
0.10000	3.797E+00	3.119E-03	3.800E+00	1.526E-02	4.317E-04	4.047E-02
0.15000	2.945E+00	3.420E-03	2.949E+00	3.040E-02	6.188E-04	7.039E-02
0.20000	2.513E+00	3.713E-03	2.516E+00	4.888E-02	7.938E-04	1.052E-01
0.30000	2.083E+00	4.342E-03	2.088E+00	9.301E-02	1.122E-03	1.847E-01
0.40000	1.877E+00	5.041E-03	1.882E+00	1.437E-01	1.436E-03	2.708E-01
0.50000	1.760E+00	5.804E-03	1.766E+00	1.987E-01	1.746E-03	3.580E-01
0.60000	1.688E+00	6.623E-03	1.694E+00	2.566E-01	2.054E-03	4.438E-01
0.80000	1.609E+00	8.405E-03	1.617E+00	3.778E-01	2.678E-03	6.075E-01
1.00000	1.571E+00	1.034E-02	1.581E+00	5.030E-01	3.315E-03	7.593E-01
1.50000	1.542E+00	1.574E-02	1.558E+00	8.225E-01	4.977E-03	1.090E+00
2.00000	1.543E+00	2.175E-02	1.565E+00	1.143E+00	6.730E-03	1.364E+00
3.00000	1.564E+00	3.507E-02	1.599E+00	1.776E+00	1.044E-02	1.798E+00
4.00000	1.588E+00	4.964E-02	1.638E+00	2.393E+00	1.436E-02	2.136E+00
5.00000	1.609E+00	6.512E-02	1.674E+00	2.997E+00	1.841E-02	2.414E+00
6.00000	1.628E+00	8.124E-02	1.709E+00	3.588E+00	2.254E-02	2.653E+00
8.00000	1.658E+00	1.150E-01	1.773E+00	4.737E+00	3.096E-02	3.051E+00
10.00000	1.681E+00	1.503E-01	1.831E+00	5.847E+00	3.946E-02	3.381E+00
15.00000	1.721E+00	2.430E-01	1.964E+00	8.481E+00	6.068E-02	4.033E+00
20.00000	1.747E+00	3.396E-01	2.087E+00	1.095E+01	8.137E-02	4.533E+00
30.00000	1.782E+00	5.406E-01	2.323E+00	1.549E+01	1.205E-01	5.279E+00
40.00000	1.806E+00	7.483E-01	2.554E+00	1.959E+01	1.562E-01	5.828E+00
50.00000	1.824E+00	9.605E-01	2.784E+00	2.334E+01	1.889E-01	6.260E+00
60.00000	1.838E+00	1.176E+00	3.015E+00	2.679E+01	2.188E-01	6.616E+00
80.00000	1.861E+00	1.616E+00	3.477E+00	3.296E+01	2.714E-01	7.183E+00
100.00000	1.878E+00	2.063E+00	3.941E+00	3.836E+01	3.161E-01	7.624E+00
150.00000	1.910E+00	3.204E+00	5.113E+00	4.947E+01	4.038E-01	8.429E+00
200.00000	1.932E+00	4.365E+00	6.297E+00	5.827E+01	4.684E-01	9.002E+00
300.00000	1.963E+00	6.720E+00	8.683E+00	7.174E+01	5.581E-01	9.811E+00
400.00000	1.985E+00	9.104E+00	1.109E+01	8.191E+01	6.184E-01	1.039E+01
500.00000	2.002E+00	1.151E+01	1.351E+01	9.007E+01	6.622E-01	1.083E+01
600.00000	2.016E+00	1.392E+01	1.594E+01	9.687E+01	6.957E-01	1.119E+01
800.00000	2.038E+00	1.880E+01	2.083E+01	1.078E+02	7.441E-01	1.177E+01
1000.00000	2.055E+00	2.370E+01	2.576E+01	1.164E+02	7.776E-01	1.222E+01

Table A.6. Positrons in liquid water, $I = 78$ eV, $\rho = 0.998$ g cm⁻³.

T MeV	S_{el}/ρ	S_{rad}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Y	δ
0.0010	1.415E+02	1.012E-03	1.415E+02	3.534E-06	3.575E-06	0.000E+00
0.0015	1.062E+02	1.219E-03	1.062E+02	7.661E-06	5.481E-06	0.000E+00
0.0020	8.603E+01	1.377E-03	8.603E+01	1.293E-05	7.543E-06	0.000E+00
0.0030	6.339E+01	1.608E-03	6.339E+01	2.665E-05	1.192E-05	0.000E+00
0.0040	5.080E+01	1.775E-03	5.080E+01	4.440E-05	1.647E-05	0.000E+00
0.0050	4.268E+01	1.904E-03	4.269E+01	6.597E-05	2.113E-05	0.000E+00
0.0060	3.699E+01	2.009E-03	3.699E+01	9.121E-05	2.585E-05	0.000E+00
0.0080	2.945E+01	2.172E-03	2.945E+01	1.523E-04	3.539E-05	0.000E+00
0.0100	2.466E+01	2.297E-03	2.466E+01	2.268E-04	4.501E-05	0.000E+00
0.0150	1.784E+01	2.516E-03	1.784E+01	4.689E-04	6.907E-05	0.000E+00
0.0200	1.418E+01	2.665E-03	1.418E+01	7.857E-04	9.294E-05	0.000E+00
0.0300	1.030E+01	2.881E-03	1.030E+01	1.626E-03	1.400E-04	0.000E+00
0.0400	8.239E+00	3.036E-03	8.242E+00	2.720E-03	1.861E-04	0.000E+00
0.0500	6.956E+00	3.158E-03	6.959E+00	4.046E-03	2.311E-04	0.000E+00
0.0600	6.077E+00	3.266E-03	6.081E+00	5.588E-03	2.752E-04	0.000E+00
0.0800	4.948E+00	3.455E-03	4.951E+00	9.261E-03	3.609E-04	0.000E+00
0.1000	4.252E+00	3.621E-03	4.256E+00	1.364E-02	4.437E-04	0.000E+00
0.1500	3.303E+00	4.000E-03	3.307E+00	2.715E-02	6.401E-04	0.000E+00
0.2000	2.824E+00	4.363E-03	2.828E+00	4.360E-02	8.244E-04	0.000E+00
0.3000	2.352E+00	5.132E-03	2.357E+00	8.278E-02	1.170E-03	0.000E+00
0.4000	2.128E+00	5.978E-03	2.134E+00	1.276E-01	1.500E-03	0.000E+00
0.5000	2.005E+00	6.896E-03	2.012E+00	1.760E-01	1.823E-03	0.000E+00
0.6000	1.930E+00	7.879E-03	1.938E+00	2.267E-01	2.143E-03	1.501E-02
0.8000	1.846E+00	1.002E-02	1.856E+00	3.324E-01	2.789E-03	1.005E-01
1.0000	1.806E+00	1.234E-02	1.818E+00	4.414E-01	3.448E-03	2.086E-01
1.5000	1.774E+00	1.881E-02	1.793E+00	7.191E-01	5.170E-03	4.982E-01
2.0000	1.774E+00	2.601E-02	1.800E+00	9.976E-01	6.990E-03	7.703E-01
3.0000	1.794E+00	4.198E-02	1.836E+00	1.548E+00	1.086E-02	1.231E+00
4.0000	1.817E+00	5.947E-02	1.877E+00	2.087E+00	1.496E-02	1.601E+00
5.0000	1.838E+00	7.795E-02	1.916E+00	2.614E+00	1.920E-02	1.906E+00
6.0000	1.857E+00	9.722E-02	1.954E+00	3.131E+00	2.354E-02	2.165E+00
8.0000	1.888E+00	1.376E-01	2.026E+00	4.136E+00	3.236E-02	2.589E+00
10.0000	1.913E+00	1.798E-01	2.093E+00	5.107E+00	4.128E-02	2.928E+00
15.0000	1.958E+00	2.905E-01	2.249E+00	7.410E+00	6.345E-02	3.567E+00
20.0000	1.990E+00	4.061E-01	2.396E+00	9.563E+00	8.498E-02	4.039E+00
30.0000	2.033E+00	6.462E-01	2.679E+00	1.351E+01	1.254E-01	4.734E+00
40.0000	2.062E+00	8.937E-01	2.956E+00	1.706E+01	1.622E-01	5.252E+00
50.0000	2.084E+00	1.146E+00	3.230E+00	2.029E+01	1.956E-01	5.665E+00
60.0000	2.101E+00	1.403E+00	3.504E+00	2.327E+01	2.261E-01	6.010E+00
80.0000	2.127E+00	1.925E+00	4.052E+00	2.857E+01	2.794E-01	6.563E+00
100.0000	2.147E+00	2.456E+00	4.603E+00	3.320E+01	3.246E-01	6.998E+00
150.0000	2.182E+00	3.810E+00	5.992E+00	4.269E+01	4.127E-01	7.796E+00
200.0000	2.207E+00	5.185E+00	7.392E+00	5.019E+01	4.772E-01	8.367E+00
300.0000	2.242E+00	7.974E+00	1.022E+01	6.165E+01	5.665E-01	9.173E+00
400.0000	2.266E+00	1.079E+01	1.306E+01	7.029E+01	6.262E-01	9.747E+00
500.0000	2.286E+00	1.364E+01	1.592E+01	7.721E+01	6.694E-01	1.019E+01
600.0000	2.301E+00	1.649E+01	1.880E+01	8.299E+01	7.025E-01	1.056E+01
800.0000	2.326E+00	2.225E+01	2.457E+01	9.227E+01	7.500E-01	1.113E+01
1000.0000	2.345E+00	2.804E+01	3.039E+01	9.957E+01	7.830E-01	1.158E+01

Table A.7. Protons in air, $I = 85.7$ eV, $\rho = 0.0012$ g cm⁻³.

T MeV	S_{el}/ρ	S_{nuc}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Detour factor
0.0010	1.197E+02	2.163E+01	1.413E+02	9.857E-06	0.3304
0.0015	1.467E+02	1.840E+01	1.651E+02	1.310E-05	0.3760
0.0020	1.693E+02	1.614E+01	1.854E+02	1.595E-05	0.4123
0.0030	2.074E+02	1.314E+01	2.205E+02	2.088E-05	0.4674
0.0040	2.395E+02	1.120E+01	2.507E+02	2.512E-05	0.5084
0.0050	2.678E+02	9.825E+00	2.776E+02	2.891E-05	0.5406
0.0060	2.933E+02	8.786E+00	3.021E+02	3.236E-05	0.5669
0.0080	3.387E+02	7.310E+00	3.460E+02	3.853E-05	0.6078
0.0100	3.787E+02	6.300E+00	3.850E+02	4.400E-05	0.6387
0.0150	4.504E+02	4.751E+00	4.552E+02	5.588E-05	0.6923
0.0200	5.067E+02	3.858E+00	5.106E+02	6.623E-05	0.7281
0.0300	5.905E+02	2.848E+00	5.933E+02	8.430E-05	0.7743
0.0400	6.483E+02	2.282E+00	6.506E+02	1.003E-04	0.8041
0.0500	6.877E+02	1.917E+00	6.896E+02	1.152E-04	0.8256
0.0600	7.132E+02	1.659E+00	7.149E+02	1.295E-04	0.8420
0.0800	7.341E+02	1.316E+00	7.354E+02	1.569E-04	0.8664
0.1000	7.290E+02	1.098E+00	7.301E+02	1.842E-04	0.8839
0.1500	6.672E+02	7.861E-01	6.680E+02	2.554E-04	0.9133
0.2000	5.922E+02	6.183E-01	5.928E+02	3.349E-04	0.9320
0.3000	4.765E+02	4.390E-01	4.770E+02	5.240E-04	0.9544
0.4000	4.012E+02	3.435E-01	4.016E+02	7.536E-04	0.9668
0.5000	3.498E+02	2.836E-01	3.501E+02	1.021E-03	0.9743
0.6000	3.121E+02	2.423E-01	3.123E+02	1.324E-03	0.9793
0.8000	2.587E+02	1.885E-01	2.589E+02	2.031E-03	0.9852
1.0000	2.227E+02	1.548E-01	2.229E+02	2.867E-03	0.9886
1.5000	1.682E+02	1.080E-01	1.683E+02	5.479E-03	0.9926
2.0000	1.370E+02	8.340E-02	1.371E+02	8.792E-03	0.9943
3.0000	1.017E+02	5.778E-02	1.018E+02	1.737E-02	0.9959
4.0000	8.192E+01	4.444E-02	8.197E+01	2.839E-02	0.9966
5.0000	6.905E+01	3.621E-02	6.909E+01	4.173E-02	0.9969
6.0000	5.994E+01	3.061E-02	5.997E+01	5.731E-02	0.9972
8.0000	4.781E+01	2.345E-02	4.783E+01	9.493E-02	0.9975
10.0000	4.004E+01	1.905E-02	4.006E+01	1.408E-01	0.9976
15.0000	2.892E+01	1.304E-02	2.894E+01	2.899E-01	0.9979
20.0000	2.293E+01	9.953E-03	2.294E+01	4.855E-01	0.9980
30.0000	1.652E+01	6.790E-03	1.653E+01	1.007E+00	0.9981
40.0000	1.312E+01	5.173E-03	1.312E+01	1.691E+00	0.9982
50.0000	1.098E+01	4.187E-03	1.099E+01	2.528E+00	0.9983
60.0000	9.514E+00	3.523E-03	9.518E+00	3.509E+00	0.9983
80.0000	7.618E+00	2.681E-03	7.620E+00	5.876E+00	0.9984
100.0000	6.441E+00	2.169E-03	6.443E+00	8.744E+00	0.9985
150.0000	4.815E+00	1.475E-03	4.816E+00	1.786E+01	0.9986
200.0000	3.975E+00	1.122E-03	3.976E+00	2.937E+01	0.9986
300.0000	3.117E+00	7.631E-04	3.118E+00	5.816E+01	0.9987
400.0000	2.686E+00	5.806E-04	2.687E+00	9.293E+01	0.9988
500.0000	2.431E+00	4.697E-04	2.431E+00	1.322E+02	0.9989
600.0000	2.265E+00	3.951E-04	2.266E+00	1.749E+02	0.9990
800.0000	2.069E+00	3.009E-04	2.069E+00	2.677E+02	0.9990
1000.0000	1.962E+00	2.436E-04	1.963E+00	3.672E+02	0.9991
1500.0000	1.850E+00	1.661E-04	1.850E+00	6.311E+02	0.9992
2000.0000	1.820E+00	1.267E-04	1.820E+00	9.041E+02	0.9993
3000.0000	1.828E+00	8.655E-05	1.828E+00	1.454E+03	0.9994
4000.0000	1.861E+00	6.608E-05	1.861E+00	1.996E+03	0.9995
5000.0000	1.898E+00	5.362E-05	1.898E+00	2.528E+03	0.9996
6000.0000	1.934E+00	4.520E-05	1.934E+00	3.050E+03	0.9996
8000.0000	1.998E+00	3.453E-05	1.998E+00	4.067E+03	0.9997
10000.0000	2.052E+00	2.803E-05	2.053E+00	5.054E+03	0.9997

Table A.8. Protons in graphite, $I = 81$ eV, $\rho = 2.265$ g cm⁻³.

T MeV	S_{el}/ρ	S_{nuc}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Detour factor
0.0010	1.185E+02	2.514E+01	1.436E+02	8.186E-06	0.3727
0.0015	1.451E+02	2.106E+01	1.662E+02	1.092E-05	0.4211
0.0020	1.676E+02	1.829E+01	1.859E+02	1.331E-05	0.4588
0.0030	2.053E+02	1.469E+01	2.200E+02	1.742E-05	0.5147
0.0040	2.370E+02	1.241E+01	2.494E+02	2.098E-05	0.5557
0.0050	2.650E+02	1.081E+01	2.758E+02	2.421E-05	0.5877
0.0060	2.903E+02	9.618E+00	2.999E+02	2.718E-05	0.6136
0.0080	3.352E+02	7.943E+00	3.431E+02	3.254E-05	0.6534
0.0100	3.748E+02	6.810E+00	3.816E+02	3.739E-05	0.6832
0.0150	4.353E+02	5.094E+00	4.404E+02	4.812E-05	0.7343
0.0200	4.811E+02	4.115E+00	4.852E+02	5.763E-05	0.7677
0.0300	5.503E+02	3.019E+00	5.533E+02	7.457E-05	0.8102
0.0400	6.110E+02	2.411E+00	6.134E+02	8.985E-05	0.8371
0.0500	6.630E+02	2.019E+00	6.650E+02	1.040E-04	0.8559
0.0600	6.976E+02	1.744E+00	6.993E+02	1.175E-04	0.8702
0.0800	7.267E+02	1.380E+00	7.281E+02	1.433E-04	0.8908
0.1000	7.266E+02	1.149E+00	7.277E+02	1.688E-04	0.9055
0.1500	6.712E+02	8.200E-01	6.720E+02	2.353E-04	0.9298
0.2000	5.986E+02	6.436E-01	5.992E+02	3.097E-04	0.9451
0.3000	4.833E+02	4.559E-01	4.837E+02	4.928E-04	0.9635
0.4000	4.071E+02	3.561E-01	4.075E+02	7.190E-04	0.9736
0.5000	3.546E+02	2.937E-01	3.549E+02	9.828E-04	0.9797
0.6000	3.159E+02	2.505E-01	3.161E+02	1.282E-03	0.9836
0.8000	2.624E+02	1.943E-01	2.626E+02	1.980E-03	0.9884
1.0000	2.261E+02	1.594E-01	2.263E+02	2.803E-03	0.9910
1.5000	1.711E+02	1.108E-01	1.712E+02	5.373E-03	0.9941
2.0000	1.394E+02	8.541E-02	1.395E+02	8.628E-03	0.9955
3.0000	1.035E+02	5.901E-02	1.036E+02	1.706E-02	0.9967
4.0000	8.326E+01	4.529E-02	8.330E+01	2.789E-02	0.9972
5.0000	7.010E+01	3.685E-02	7.014E+01	4.103E-02	0.9975
6.0000	6.081E+01	3.112E-02	6.084E+01	5.638E-02	0.9977
8.0000	4.845E+01	2.380E-02	4.847E+01	9.348E-02	0.9980
10.0000	4.055E+01	1.932E-02	4.057E+01	1.388E-01	0.9981
15.0000	2.925E+01	1.320E-02	2.926E+01	2.861E-01	0.9983
20.0000	2.317E+01	1.006E-02	2.318E+01	4.796E-01	0.9984
30.0000	1.668E+01	6.858E-03	1.669E+01	9.960E-01	0.9985
40.0000	1.323E+01	5.221E-03	1.324E+01	1.674E+00	0.9986
50.0000	1.107E+01	4.225E-03	1.108E+01	2.504E+00	0.9986
60.0000	9.591E+00	3.553E-03	9.595E+00	3.477E+00	0.9987
80.0000	7.675E+00	2.703E-03	7.678E+00	5.826E+00	0.9987
100.0000	6.486E+00	2.186E-03	6.488E+00	8.673E+00	0.9988
150.0000	4.843E+00	1.486E-03	4.845E+00	1.773E+01	0.9988
200.0000	3.994E+00	1.130E-03	3.995E+00	2.917E+01	0.9989
300.0000	3.125E+00	7.686E-04	3.126E+00	5.786E+01	0.9990
400.0000	2.687E+00	5.847E-04	2.688E+00	9.257E+01	0.9990
500.0000	2.426E+00	4.730E-04	2.427E+00	1.319E+02	0.9991
600.0000	2.255E+00	3.979E-04	2.256E+00	1.747E+02	0.9991
800.0000	2.050E+00	3.029E-04	2.050E+00	2.681E+02	0.9992
1000.0000	1.936E+00	2.453E-04	1.936E+00	3.688E+02	0.9993
1500.0000	1.806E+00	1.672E-04	1.806E+00	6.378E+02	0.9994
2000.0000	1.760E+00	1.275E-04	1.761E+00	9.188E+02	0.9995
3000.0000	1.744E+00	8.710E-05	1.744E+00	1.491E+03	0.9995
4000.0000	1.756E+00	6.650E-05	1.756E+00	2.063E+03	0.9996
5000.0000	1.775E+00	5.395E-05	1.775E+00	2.629E+03	0.9997
6000.0000	1.796E+00	4.548E-05	1.796E+00	3.189E+03	0.9997
8000.0000	1.834E+00	3.474E-05	1.834E+00	4.291E+03	0.9997
10000.0000	1.868E+00	2.820E-05	1.868E+00	5.371E+03	0.9998

Table A.9. Protons in liquid water, $I = 78 \text{ eV}$, $\rho = 0.998 \text{ g cm}^{-3}$.

T MeV	S_{el}/ρ	S_{nuc}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Detour factor
0.0010	1.337E+02	4.315E+01	1.769E+02	6.319E-06	0.4555
0.0015	1.638E+02	3.460E+01	1.984E+02	8.969E-06	0.4906
0.0020	1.891E+02	2.927E+01	2.184E+02	1.137E-05	0.5197
0.0030	2.316E+02	2.281E+01	2.544E+02	1.560E-05	0.5647
0.0040	2.675E+02	1.894E+01	2.864E+02	1.930E-05	0.5986
0.0050	2.990E+02	1.631E+01	3.153E+02	2.262E-05	0.6254
0.0060	3.276E+02	1.439E+01	3.420E+02	2.567E-05	0.6473
0.0080	3.782E+02	1.175E+01	3.900E+02	3.113E-05	0.6813
0.0100	4.229E+02	1.000E+01	4.329E+02	3.599E-05	0.7070
0.0150	5.036E+02	7.400E+00	5.110E+02	4.657E-05	0.7514
0.0200	5.673E+02	5.939E+00	5.732E+02	5.578E-05	0.7808
0.0300	6.628E+02	4.325E+00	6.671E+02	7.187E-05	0.8187
0.0400	7.290E+02	3.437E+00	7.324E+02	8.613E-05	0.8429
0.0500	7.740E+02	2.870E+00	7.769E+02	9.935E-05	0.8602
0.0600	8.026E+02	2.473E+00	8.051E+02	1.120E-04	0.8735
0.0800	8.241E+02	1.951E+00	8.261E+02	1.364E-04	0.8931
0.1000	8.145E+02	1.620E+00	8.161E+02	1.607E-04	0.9073
0.1500	7.360E+02	1.152E+00	7.372E+02	2.249E-04	0.9310
0.2000	6.585E+02	9.016E-01	6.594E+02	2.967E-04	0.9460
0.3000	5.435E+02	6.351E-01	5.441E+02	4.645E-04	0.9635
0.4000	4.643E+02	4.928E-01	4.648E+02	6.640E-04	0.9731
0.5000	4.065E+02	4.043E-01	4.069E+02	8.945E-04	0.9790
0.6000	3.624E+02	3.438E-01	3.627E+02	1.155E-03	0.9829
0.8000	2.997E+02	2.658E-01	3.000E+02	1.765E-03	0.9877
1.0000	2.574E+02	2.173E-01	2.577E+02	2.487E-03	0.9905
1.5000	1.934E+02	1.504E-01	1.936E+02	4.753E-03	0.9938
2.0000	1.569E+02	1.157E-01	1.570E+02	7.639E-03	0.9952
3.0000	1.160E+02	7.972E-02	1.161E+02	1.514E-02	0.9965
4.0000	9.319E+01	6.113E-02	9.325E+01	2.482E-02	0.9971
5.0000	7.842E+01	4.970E-02	7.847E+01	3.656E-02	0.9974
6.0000	6.801E+01	4.195E-02	6.805E+01	5.028E-02	0.9976
8.0000	5.417E+01	3.208E-02	5.420E+01	8.346E-02	0.9978
10.0000	4.532E+01	2.603E-02	4.535E+01	1.240E-01	0.9980
15.0000	3.269E+01	1.778E-02	3.271E+01	2.558E-01	0.9982
20.0000	2.589E+01	1.356E-02	2.591E+01	4.289E-01	0.9983
30.0000	1.864E+01	9.239E-03	1.865E+01	8.910E-01	0.9984
40.0000	1.479E+01	7.034E-03	1.479E+01	1.498E+00	0.9985
50.0000	1.238E+01	5.691E-03	1.238E+01	2.240E+00	0.9985
60.0000	1.072E+01	4.786E-03	1.072E+01	3.111E+00	0.9986
80.0000	8.578E+00	3.641E-03	8.581E+00	5.212E+00	0.9986
100.0000	7.250E+00	2.944E-03	7.253E+00	7.759E+00	0.9987
150.0000	5.417E+00	2.001E-03	5.419E+00	1.586E+01	0.9987
200.0000	4.470E+00	1.522E-03	4.471E+00	2.609E+01	0.9988
300.0000	3.504E+00	1.035E-03	3.505E+00	5.170E+01	0.9989
400.0000	3.018E+00	7.870E-04	3.019E+00	8.263E+01	0.9990
500.0000	2.731E+00	6.367E-04	2.732E+00	1.176E+02	0.9990
600.0000	2.544E+00	5.355E-04	2.545E+00	1.556E+02	0.9991
800.0000	2.323E+00	4.076E-04	2.324E+00	2.382E+02	0.9992
1000.0000	2.203E+00	3.300E-04	2.204E+00	3.268E+02	0.9992
1500.0000	2.065E+00	2.249E-04	2.065E+00	5.625E+02	0.9993
2000.0000	2.017E+00	1.715E-04	2.017E+00	8.079E+02	0.9994
3000.0000	1.998E+00	1.171E-04	1.998E+00	1.307E+03	0.9995
4000.0000	2.010E+00	8.939E-05	2.010E+00	1.806E+03	0.9996
5000.0000	2.029E+00	7.251E-05	2.030E+00	2.302E+03	0.9996
6000.0000	2.050E+00	6.112E-05	2.050E+00	2.792E+03	0.9997
8000.0000	2.090E+00	4.669E-05	2.090E+00	3.758E+03	0.9997
10000.0000	2.124E+00	3.788E-05	2.125E+00	4.707E+03	0.9998

Table A.10. Alpha particles in air, $I = 85.7$ eV, $\rho = 0.0012$ g cm⁻³.

T MeV	S_{ei}/ρ	S_{nuc}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Detour factor
0.0010	8.750E+01	1.340E+02	2.215E+02	5.377E-06	0.3767
0.0015	1.086E+02	1.256E+02	2.342E+02	7.562E-06	0.4012
0.0020	1.267E+02	1.178E+02	2.445E+02	9.651E-06	0.4220
0.0030	1.573E+02	1.049E+02	2.622E+02	1.360E-05	0.4558
0.0040	1.835E+02	9.494E+01	2.784E+02	1.730E-05	0.4830
0.0050	2.067E+02	8.698E+01	2.937E+02	2.079E-05	0.5058
0.0060	2.279E+02	8.047E+01	3.084E+02	2.411E-05	0.5255
0.0080	2.659E+02	7.036E+01	3.363E+02	3.032E-05	0.5580
0.0100	2.996E+02	6.283E+01	3.624E+02	3.605E-05	0.5841
0.0150	3.723E+02	5.018E+01	4.225E+02	4.879E-05	0.6327
0.0200	4.343E+02	4.220E+01	4.765E+02	5.992E-05	0.6670
0.0300	5.395E+02	3.250E+01	5.720E+02	7.900E-05	0.7136
0.0400	6.290E+02	2.672E+01	6.557E+02	9.530E-05	0.7447
0.0500	7.081E+02	2.284E+01	7.309E+02	1.097E-04	0.7674
0.0600	7.798E+02	2.002E+01	7.998E+02	1.228E-04	0.7850
0.0800	9.068E+02	1.619E+01	9.230E+02	1.460E-04	0.8107
0.1000	1.018E+03	1.368E+01	1.032E+03	1.665E-04	0.8289
0.1500	1.247E+03	9.991E+00	1.257E+03	2.101E-04	0.8585
0.2000	1.429E+03	7.956E+00	1.437E+03	2.472E-04	0.8768
0.3000	1.693E+03	5.736E+00	1.699E+03	3.108E-04	0.8993
0.4000	1.861E+03	4.531E+00	1.866E+03	3.667E-04	0.9134
0.5000	1.961E+03	3.767E+00	1.965E+03	4.188E-04	0.9234
0.6000	2.008E+03	3.235E+00	2.011E+03	4.690E-04	0.9310
0.8000	2.002E+03	2.540E+00	2.005E+03	5.682E-04	0.9424
1.0000	1.922E+03	2.103E+00	1.924E+03	6.698E-04	0.9507
1.5000	1.626E+03	1.487E+00	1.627E+03	9.518E-04	0.9647
2.0000	1.381E+03	1.160E+00	1.383E+03	1.286E-03	0.9735
3.0000	1.071E+03	8.157E-01	1.072E+03	2.115E-03	0.9834
4.0000	8.858E+02	6.341E-01	8.864E+02	3.147E-03	0.9885
5.0000	7.606E+02	5.211E-01	7.611E+02	4.368E-03	0.9915
6.0000	6.696E+02	4.436E-01	6.700E+02	5.772E-03	0.9934
8.0000	5.453E+02	3.437E-01	5.456E+02	9.101E-03	0.9955
10.0000	4.634E+02	2.817E-01	4.637E+02	1.309E-02	0.9967
15.0000	3.423E+02	1.959E-01	3.425E+02	2.581E-02	0.9980
20.0000	2.747E+02	1.511E-01	2.748E+02	4.222E-02	0.9985
30.0000	2.001E+02	1.045E-01	2.002E+02	8.546E-02	0.9990
40.0000	1.593E+02	8.026E-02	1.593E+02	1.419E-01	0.9992
50.0000	1.332E+02	6.533E-02	1.333E+02	2.108E-01	0.9993
60.0000	1.150E+02	5.516E-02	1.151E+02	2.918E-01	0.9993
80.0000	9.119E+01	4.215E-02	9.123E+01	4.885E-01	0.9994
100.0000	7.614E+01	3.418E-02	7.618E+01	7.295E-01	0.9994
150.0000	5.493E+01	2.324E-02	5.496E+01	1.514E+00	0.9995
200.0000	4.369E+01	1.763E-02	4.370E+01	2.543E+00	0.9995
300.0000	3.184E+01	1.191E-02	3.185E+01	5.265E+00	0.9996
400.0000	2.563E+01	8.987E-03	2.564E+01	8.791E+00	0.9996
500.0000	2.179E+01	7.219E-03	2.179E+01	1.304E+01	0.9996
600.0000	1.917E+01	6.034E-03	1.917E+01	1.795E+01	0.9996
800.0000	1.583E+01	4.533E-03	1.583E+01	2.951E+01	0.9996
1000.0000	1.379E+01	3.635E-03	1.379E+01	4.310E+01	0.9997

Table A.11. Alpha particles in graphite, $I = 81$ eV, $\rho = 2.265$ g cm⁻³.

T MeV	S_{el}/ρ	S_{nuc}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Detour factor
0.0010	1.923E+02	1.557E+02	3.480E+02	3.630E-06	0.4644
0.0015	2.289E+02	1.441E+02	3.730E+02	5.010E-06	0.4941
0.0020	2.590E+02	1.340E+02	3.930E+02	6.315E-06	0.5185
0.0030	3.083E+02	1.179E+02	4.262E+02	8.755E-06	0.5565
0.0040	3.489E+02	1.058E+02	4.547E+02	1.102E-05	0.5856
0.0050	3.840E+02	9.627E+01	4.803E+02	1.316E-05	0.6091
0.0060	4.153E+02	8.860E+01	5.039E+02	1.520E-05	0.6288
0.0080	4.699E+02	7.685E+01	5.468E+02	1.900E-05	0.6602
0.0100	5.170E+02	6.822E+01	5.852E+02	2.253E-05	0.6846
0.0150	6.151E+02	5.395E+01	6.690E+02	3.050E-05	0.7280
0.0200	6.955E+02	4.509E+01	7.406E+02	3.760E-05	0.7575
0.0300	8.262E+02	3.446E+01	8.607E+02	5.008E-05	0.7963
0.0400	9.327E+02	2.820E+01	9.609E+02	6.105E-05	0.8213
0.0500	1.024E+03	2.402E+01	1.048E+03	7.100E-05	0.8393
0.0600	1.104E+03	2.101E+01	1.125E+03	8.021E-05	0.8530
0.0800	1.240E+03	1.693E+01	1.257E+03	9.699E-05	0.8727
0.1000	1.354E+03	1.427E+01	1.368E+03	1.122E-04	0.8866
0.1500	1.574E+03	1.038E+01	1.584E+03	1.460E-04	0.9087
0.2000	1.731E+03	8.249E+00	1.739E+03	1.760E-04	0.9222
0.3000	1.929E+03	5.931E+00	1.935E+03	2.302E-04	0.9385
0.4000	2.027E+03	4.677E+00	2.032E+03	2.805E-04	0.9485
0.5000	2.063E+03	3.884E+00	2.067E+03	3.292E-04	0.9555
0.6000	2.060E+03	3.333E+00	2.063E+03	3.776E-04	0.9608
0.8000	1.993E+03	2.613E+00	1.996E+03	4.759E-04	0.9683
1.0000	1.891E+03	2.161E+00	1.893E+03	5.788E-04	0.9736
1.5000	1.615E+03	1.526E+00	1.616E+03	8.644E-04	0.9818
2.0000	1.387E+03	1.189E+00	1.388E+03	1.199E-03	0.9865
3.0000	1.085E+03	8.350E-01	1.086E+03	2.021E-03	0.9916
4.0000	8.982E+02	6.486E-01	8.988E+02	3.038E-03	0.9941
5.0000	7.720E+02	5.327E-01	7.725E+02	4.242E-03	0.9956
6.0000	6.804E+02	4.532E-01	6.808E+02	5.624E-03	0.9965
8.0000	5.544E+02	3.509E-01	5.547E+02	8.899E-03	0.9976
10.0000	4.712E+02	2.874E-01	4.715E+02	1.282E-02	0.9981
15.0000	3.478E+02	1.996E-01	3.480E+02	2.533E-02	0.9988
20.0000	2.788E+02	1.538E-01	2.789E+02	4.149E-02	0.9991
30.0000	2.028E+02	1.062E-01	2.029E+02	8.414E-02	0.9993
40.0000	1.612E+02	8.149E-02	1.613E+02	1.398E-01	0.9994
50.0000	1.348E+02	6.626E-02	1.348E+02	2.079E-01	0.9995
60.0000	1.163E+02	5.588E-02	1.164E+02	2.880E-01	0.9995
80.0000	9.214E+01	4.266E-02	9.218E+01	4.826E-01	0.9995
100.0000	7.689E+01	3.455E-02	7.693E+01	7.212E-01	0.9996
150.0000	5.543E+01	2.344E-02	5.545E+01	1.499E+00	0.9996
200.0000	4.405E+01	1.776E-02	4.407E+01	2.518E+00	0.9996
300.0000	3.209E+01	1.198E-02	3.210E+01	5.219E+00	0.9996
400.0000	2.581E+01	9.027E-03	2.582E+01	8.720E+00	0.9997
500.0000	2.193E+01	7.251E-03	2.193E+01	1.294E+01	0.9997
600.0000	1.928E+01	6.049E-03	1.929E+01	1.782E+01	0.9997
800.0000	1.591E+01	4.548E-03	1.591E+01	2.932E+01	0.9997
1000.0000	1.384E+01	3.643E-03	1.385E+01	4.285E+01	0.9997

Table A.12. Alpha particles in liquid water, $I = 78$ eV, $\rho = 0.998$ g cm⁻³.

T MeV	S_{el}/ρ	S_{nuc}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²	Detour factor
0.0010	9.891E+01	2.282E+02	3.271E+02	3.273E-06	0.5212
0.0015	1.228E+02	2.078E+02	3.306E+02	4.789E-06	0.5364
0.0020	1.431E+02	1.912E+02	3.343E+02	6.294E-06	0.5501
0.0030	1.776E+02	1.660E+02	3.436E+02	9.247E-06	0.5737
0.0040	2.069E+02	1.477E+02	3.546E+02	1.211E-05	0.5934
0.0050	2.330E+02	1.336E+02	3.666E+02	1.489E-05	0.6102
0.0060	2.568E+02	1.225E+02	3.793E+02	1.757E-05	0.6250
0.0080	2.993E+02	1.056E+02	4.049E+02	2.267E-05	0.6497
0.0100	3.370E+02	9.341E+01	4.304E+02	2.746E-05	0.6700
0.0150	4.181E+02	7.347E+01	4.916E+02	3.831E-05	0.7080
0.0200	4.871E+02	6.123E+01	5.483E+02	4.793E-05	0.7352
0.0300	6.039E+02	4.665E+01	6.506E+02	6.462E-05	0.7724
0.0400	7.030E+02	3.811E+01	7.411E+02	7.900E-05	0.7973
0.0500	7.905E+02	3.242E+01	8.229E+02	9.179E-05	0.8155
0.0600	8.696E+02	2.834E+01	8.979E+02	1.034E-04	0.8296
0.0800	1.009E+03	2.281E+01	1.032E+03	1.241E-04	0.8503
0.1000	1.131E+03	1.921E+01	1.150E+03	1.425E-04	0.8649
0.1500	1.383E+03	1.397E+01	1.397E+03	1.817E-04	0.8886
0.2000	1.582E+03	1.109E+01	1.593E+03	2.151E-04	0.9032
0.3000	1.873E+03	7.969E+00	1.881E+03	2.725E-04	0.9212
0.4000	2.062E+03	6.282E+00	2.068E+03	3.230E-04	0.9323
0.5000	2.178E+03	5.214E+00	2.183E+03	3.699E-04	0.9402
0.6000	2.240E+03	4.473E+00	2.244E+03	4.150E-04	0.9462
0.8000	2.256E+03	3.506E+00	2.260E+03	5.034E-04	0.9551
1.0000	2.190E+03	2.898E+00	2.193E+03	5.931E-04	0.9615
1.5000	1.877E+03	2.045E+00	1.879E+03	8.385E-04	0.9722
2.0000	1.599E+03	1.594E+00	1.600E+03	1.128E-03	0.9789
3.0000	1.239E+03	1.119E+00	1.240E+03	1.844E-03	0.9867
4.0000	1.021E+03	8.686E-01	1.022E+03	2.737E-03	0.9907
5.0000	8.747E+02	7.132E-01	8.754E+02	3.798E-03	0.9931
6.0000	7.687E+02	6.066E-01	7.693E+02	5.020E-03	0.9946
8.0000	6.239E+02	4.694E-01	6.243E+02	7.924E-03	0.9963
10.0000	5.290E+02	3.844E-01	5.294E+02	1.142E-02	0.9973
15.0000	3.894E+02	2.667E-01	3.896E+02	2.258E-02	0.9983
20.0000	3.118E+02	2.054E-01	3.121E+02	3.702E-02	0.9988
30.0000	2.267E+02	1.417E-01	2.269E+02	7.514E-02	0.9992
40.0000	1.802E+02	1.087E-01	1.803E+02	1.250E-01	0.9993
50.0000	1.506E+02	8.833E-02	1.507E+02	1.859E-01	0.9991
60.0000	1.300E+02	7.448E-02	1.301E+02	2.575E-01	0.9994
80.0000	1.030E+02	5.679E-02	1.030E+02	4.317E-01	0.9995
100.0000	8.593E+01	4.598E-02	8.597E+01	6.452E-01	0.9995
150.0000	6.194E+01	3.121E-02	6.197E+01	1.341E+00	0.9996
200.0000	4.923E+01	2.362E-02	4.925E+01	2.253E+00	0.9996
300.0000	3.586E+01	1.593E-02	3.587E+01	4.670E+00	0.9996
400.0000	2.885E+01	1.201E-02	2.886E+01	7.802E+00	0.9996
500.0000	2.452E+01	9.637E-03	2.453E+01	1.158E+01	0.9997
600.0000	2.156E+01	8.053E-03	2.157E+01	1.594E+01	0.9997
800.0000	1.780E+01	6.052E-03	1.781E+01	2.622E+01	0.9997
1000.0000	1.550E+01	4.848E-03	1.551E+01	3.830E+01	0.9997

Table A.13. Carbon ions in air, $I = 85.7$ eV, $\rho = 0.0012$ g cm⁻³.

T MeV	S_{el}/ρ	S_{nuc}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	$\rho r_0 \rho$ g cm ⁻²
0.0010	1.188E+02	7.394E+02	8.582E+02	5.826E-07
0.0015	1.475E+02	7.705E+02	9.180E+02	1.141E-06
0.0020	1.720E+02	7.815E+02	9.535E+02	1.675E-06
0.0030	2.135E+02	7.794E+02	9.929E+02	2.700E-06
0.0040	2.504E+02	7.647E+02	1.015E+03	3.695E-06
0.0050	2.801E+02	7.460E+02	1.026E+03	4.675E-06
0.0060	3.091E+02	7.263E+02	1.035E+03	5.645E-06
0.0080	3.605E+02	6.881E+02	1.049E+03	7.563E-06
0.0100	4.061E+02	6.530E+02	1.059E+03	9.461E-06
0.0150	5.045E+02	5.801E+02	1.085E+03	1.413E-05
0.0200	5.885E+02	5.241E+02	1.113E+03	1.868E-05
0.0300	7.312E+02	4.431E+02	1.174E+03	2.743E-05
0.0400	8.530E+02	3.869E+02	1.240E+03	3.572E-05
0.0500	9.614E+02	3.451E+02	1.306E+03	4.357E-05
0.0600	1.060E+03	3.125E+02	1.373E+03	5.104E-05
0.0800	1.237E+03	2.646E+02	1.502E+03	6.496E-05
0.1000	1.394E+03	2.309E+02	1.625E+03	7.776E-05
0.1500	1.733E+03	1.776E+02	1.911E+03	1.061E-04
0.2000	2.023E+03	1.458E+02	2.169E+03	1.306E-04
0.3000	2.517E+03	1.091E+02	2.626E+03	1.723E-04
0.4000	2.939E+03	8.819E+01	3.027E+03	2.077E-04
0.5000	3.312E+03	7.446E+01	3.387E+03	2.389E-04
0.6000	3.648E+03	6.470E+01	3.713E+03	2.671E-04
0.8000	4.235E+03	5.165E+01	4.286E+03	3.170E-04
1.0000	4.727E+03	4.325E+01	4.771E+03	3.612E-04
1.5000	5.637E+03	3.117E+01	5.668E+03	4.566E-04
2.0000	6.191E+03	2.461E+01	6.215E+03	5.405E-04
3.0000	6.631E+03	1.757E+01	6.648E+03	6.947E-04
4.0000	6.573E+03	1.379E+01	6.586E+03	8.452E-04
5.0000	6.379E+03	1.141E+01	6.390E+03	9.993E-04
6.0000	6.178E+03	9.765E+00	6.188E+03	1.158E-03
8.0000	5.822E+03	7.630E+00	5.830E+03	1.491E-03
10.0000	5.525E+03	6.291E+00	5.531E+03	1.844E-03
15.0000	4.915E+03	4.423E+00	4.920E+03	2.804E-03
20.0000	4.425E+03	3.438E+00	4.428E+03	3.877E-03
30.0000	3.679E+03	2.404E+00	3.681E+03	6.363E-03
40.0000	3.155E+03	1.863E+00	3.157E+03	9.306E-03
50.0000	2.754E+03	1.527E+00	2.755E+03	1.270E-02
60.0000	2.425E+03	1.297E+00	2.426E+03	1.658E-02
80.0000	1.948E+03	1.001E+00	1.949E+03	2.584E-02
100.0000	1.639E+03	8.183E-01	1.639E+03	3.707E-02
150.0000	1.191E+03	5.656E-01	1.191E+03	7.338E-02
200.0000	9.467E+02	4.344E-01	9.471E+02	1.208E-01
300.0000	6.839E+02	2.984E-01	6.842E+02	2.469E-01
400.0000	5.430E+02	2.279E-01	5.433E+02	4.122E-01
500.0000	4.545E+02	1.848E-01	4.547E+02	6.144E-01
600.0000	3.935E+02	1.555E-01	3.936E+02	8.515E-01
800.0000	3.143E+02	1.181E-01	3.145E+02	1.424E+00
1000.0000	2.651E+02	9.524E-02	2.652E+02	2.120E+00
1500.0000	1.967E+02	6.436E-02	1.968E+02	4.343E+00
2000.0000	1.612E+02	4.853E-02	1.612E+02	7.171E+00
3000.0000	1.247E+02	3.258E-02	1.247E+02	1.432E+01
4000.0000	1.062E+02	2.448E-02	1.062E+02	2.307E+01
5000.0000	9.506E+01	1.962E-02	9.508E+01	3.306E+01
6000.0000	8.777E+01	1.637E-02	8.779E+01	4.403E+01
8000.0000	7.896E+01	1.230E-02	7.897E+01	6.817E+01
10000.0000	7.402E+01	9.842E-03	7.403E+01	9.440E+01

Table A.14. Carbon ions in graphite, $I = 81$ eV, $\rho = 2.265$ g cm⁻³.

T MeV	S_{el}/ρ	S_{nuc}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²
0.0010	3.092E+02	8.506E+02	1.160E+03	4.311E-07
0.0015	3.701E+02	8.801E+02	1.250E+03	8.429E-07
0.0020	4.204E+02	8.877E+02	1.308E+03	1.233E-06
0.0030	5.032E+02	8.780E+02	1.381E+03	1.976E-06
0.0040	5.748E+02	8.563E+02	1.431E+03	2.686E-06
0.0050	6.302E+02	8.313E+02	1.461E+03	3.377E-06
0.0060	6.836E+02	8.063E+02	1.490E+03	4.054E-06
0.0080	7.755E+02	7.590E+02	1.534E+03	5.376E-06
0.0100	8.546E+02	7.167E+02	1.571E+03	6.664E-06
0.0150	1.019E+03	6.310E+02	1.650E+03	9.767E-06
0.0200	1.153E+03	5.666E+02	1.720E+03	1.273E-05
0.0300	1.370E+03	4.749E+02	1.845E+03	1.834E-05
0.0400	1.546E+03	4.124E+02	1.958E+03	2.360E-05
0.0500	1.696E+03	3.662E+02	2.062E+03	2.858E-05
0.0600	1.829E+03	3.305E+02	2.160E+03	3.331E-05
0.0800	2.062E+03	2.785E+02	2.340E+03	4.220E-05
0.1000	2.268E+03	2.422E+02	2.510E+03	5.045E-05
0.1500	2.719E+03	1.852E+02	2.904E+03	6.893E-05
0.2000	3.106E+03	1.516E+02	3.258E+03	8.516E-05
0.3000	3.747E+03	1.130E+02	3.860E+03	1.132E-04
0.4000	4.269E+03	9.108E+01	4.360E+03	1.376E-04
0.5000	4.709E+03	7.677E+01	4.786E+03	1.594E-04
0.6000	5.089E+03	6.663E+01	5.156E+03	1.795E-04
0.8000	5.711E+03	5.309E+01	5.764E+03	2.161E-04
1.0000	6.192E+03	4.440E+01	6.237E+03	2.494E-04
1.5000	6.973E+03	3.194E+01	7.005E+03	3.245E-04
2.0000	7.368E+03	2.519E+01	7.393E+03	3.938E-04
3.0000	7.591E+03	1.795E+01	7.609E+03	5.264E-04
4.0000	7.475E+03	1.408E+01	7.489E+03	6.585E-04
5.0000	7.227E+03	1.164E+01	7.238E+03	7.943E-04
6.0000	6.964E+03	9.958E+00	6.974E+03	9.350E-04
8.0000	6.484E+03	7.773E+00	6.492E+03	1.232E-03
10.0000	6.077E+03	6.406E+00	6.083E+03	1.551E-03
15.0000	5.278E+03	4.500E+00	5.282E+03	2.436E-03
20.0000	4.685E+03	3.495E+00	4.688E+03	3.442E-03
30.0000	3.827E+03	2.442E+00	3.830E+03	5.815E-03
40.0000	3.240E+03	1.891E+00	3.242E+03	8.662E-03
50.0000	2.801E+03	1.549E+00	2.803E+03	1.199E-02
60.0000	2.458E+03	1.315E+00	2.459E+03	1.580E-02
80.0000	1.973E+03	1.015E+00	1.974E+03	2.494E-02
100.0000	1.659E+03	8.291E-01	1.660E+03	3.604E-02
150.0000	1.204E+03	5.724E-01	1.205E+03	7.192E-02
200.0000	9.567E+02	4.393E-01	9.571E+02	1.188E-01
300.0000	6.905E+02	3.012E-01	6.908E+02	2.437E-01
400.0000	5.480E+02	2.301E-01	5.482E+02	4.075E-01
500.0000	4.585E+02	1.864E-01	4.587E+02	6.079E-01
600.0000	3.967E+02	1.566E-01	3.969E+02	8.430E-01
800.0000	3.168E+02	1.188E-01	3.169E+02	1.411E+00
1000.0000	2.670E+02	9.581E-02	2.671E+02	2.102E+00
1500.0000	1.980E+02	6.463E-02	1.980E+02	4.309E+00
2000.0000	1.621E+02	4.870E-02	1.621E+02	7.121E+00
3000.0000	1.251E+02	3.265E-02	1.252E+02	1.424E+01
4000.0000	1.064E+02	2.454E-02	1.064E+02	2.296E+01
5000.0000	9.506E+01	1.966E-02	9.508E+01	3.294E+01
6000.0000	8.759E+01	1.640E-02	8.761E+01	4.392E+01
8000.0000	7.848E+01	1.232E-02	7.849E+01	6.817E+01
10000.0000	7.322E+01	9.855E-03	7.323E+01	9.466E+01

Table A.15. Carbon ions in liquid water, $I = 78 \text{ eV}$, $\rho = 0.998 \text{ g cm}^{-3}$.

T MeV	S_{el}/ρ	S_{nuc}/ρ MeV cm ² g ⁻¹	S_{tot}/ρ	ρr_0 g cm ⁻²
0.0010	1.421E+02	1.037E+03	1.179E+03	4.241E-07
0.0015	1.773E+02	1.077E+03	1.254E+03	8.319E-07
0.0020	2.075E+02	1.090E+03	1.297E+03	1.224E-06
0.0030	2.589E+02	1.083E+03	1.342E+03	1.980E-06
0.0040	3.047E+02	1.059E+03	1.364E+03	2.718E-06
0.0050	3.416E+02	1.032E+03	1.374E+03	3.448E-06
0.0060	3.776E+02	1.003E+03	1.381E+03	4.175E-06
0.0080	4.412E+02	9.475E+02	1.389E+03	5.619E-06
0.0100	4.975E+02	8.973E+02	1.395E+03	7.056E-06
0.0150	6.183E+02	7.944E+02	1.413E+03	1.062E-05
0.0200	7.207E+02	7.160E+02	1.437E+03	1.413E-05
0.0300	8.930E+02	6.034E+02	1.496E+03	2.095E-05
0.0400	1.038E+03	5.258E+02	1.564E+03	2.749E-05
0.0500	1.166E+03	4.683E+02	1.634E+03	3.375E-05
0.0600	1.281E+03	4.236E+02	1.705E+03	3.974E-05
0.0800	1.488E+03	3.581E+02	1.847E+03	5.101E-05
0.1000	1.676E+03	3.122E+02	1.988E+03	6.144E-05
0.1500	2.099E+03	2.396E+02	2.339E+03	8.459E-05
0.2000	2.476E+03	1.966E+02	2.673E+03	1.046E-04
0.3000	3.131E+03	1.469E+02	3.278E+03	1.382E-04
0.4000	3.696E+03	1.186E+02	3.814E+03	1.664E-04
0.5000	4.198E+03	1.001E+02	4.298E+03	1.911E-04
0.6000	4.652E+03	8.697E+01	4.739E+03	2.132E-04
0.8000	5.446E+03	6.939E+01	5.515E+03	2.522E-04
1.0000	6.116E+03	5.808E+01	6.174E+03	2.864E-04
1.5000	7.364E+03	4.184E+01	7.406E+03	3.598E-04
2.0000	8.139E+03	3.302E+01	8.172E+03	4.238E-04
3.0000	8.791E+03	2.356E+01	8.815E+03	5.405E-04
4.0000	8.708E+03	1.848E+01	8.727E+03	6.540E-04
5.0000	8.372E+03	1.529E+01	8.387E+03	7.708E-04
6.0000	8.029E+03	1.309E+01	8.042E+03	8.926E-04
8.0000	7.422E+03	1.022E+01	7.433E+03	1.152E-03
10.0000	6.926E+03	8.428E+00	6.934E+03	1.430E-03
15.0000	5.980E+03	5.924E+00	5.986E+03	2.209E-03
20.0000	5.284E+03	4.603E+00	5.289E+03	3.100E-03
30.0000	4.297E+03	3.218E+00	4.300E+03	5.208E-03
40.0000	3.627E+03	2.493E+00	3.630E+03	7.749E-03
50.0000	3.134E+03	2.043E+00	3.136E+03	1.072E-02
60.0000	2.750E+03	1.735E+00	2.752E+03	1.413E-02
80.0000	2.207E+03	1.339E+00	2.208E+03	2.230E-02
100.0000	1.855E+03	1.094E+00	1.856E+03	3.222E-02
150.0000	1.346E+03	7.563E-01	1.347E+03	6.432E-02
200.0000	1.069E+03	5.806E-01	1.070E+03	1.063E-01
300.0000	7.717E+02	3.986E-01	7.721E+02	2.180E-01
400.0000	6.124E+02	3.045E-01	6.127E+02	3.646E-01
500.0000	5.123E+02	2.468E-01	5.126E+02	5.438E-01
600.0000	4.434E+02	2.076E-01	4.436E+02	7.542E-01
800.0000	3.540E+02	1.576E-01	3.542E+02	1.263E+00
1000.0000	2.984E+02	1.271E-01	2.985E+02	1.881E+00
1500.0000	2.213E+02	8.582E-02	2.214E+02	3.855E+00
2000.0000	1.813E+02	6.474E-02	1.814E+02	6.369E+00
3000.0000	1.402E+02	4.342E-02	1.402E+02	1.273E+01
4000.0000	1.193E+02	3.264E-02	1.193E+02	2.051E+01
5000.0000	1.068E+02	2.615E-02	1.068E+02	2.940E+01
6000.0000	9.860E+01	2.182E-02	9.862E+01	3.916E+01
8000.0000	8.867E+01	1.639E-02	8.869E+01	6.066E+01
10000.0000	8.311E+01	1.312E-02	8.312E+01	8.401E+01