

# Errata and Addenda for ICRU Report 73, Stopping of Ions Heavier than Helium

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## 1 Errors and misprints in ICRU Report 73 (2005)

- Page 24, footnote 8; the last line should read: ‘*cf.* footnote 23 on page 44.’
- Page 25, footnote 9 should read: ‘*Cf.* footnote 4 on page 15.’
- Page 46, footnote 26 should read: ‘For symbol  $\gamma$ , see footnote 4 on page 15.’
- Page 91, footnote 34 should read: ‘Concerning  $\gamma$  the reader is reminded of footnote 4 on page 15.’
- Page 96, first paragraph of Section 5.3.2: Replace the second and third sentence by ‘ $\gamma^2$  is assumed to be independent of  $Z_2$  and the state of aggregation and found by interpolation between experimental data for  $Z_2 = 6, 13, 28, 47$  and  $79$ , while the underlying proton stopping forces are interpolated separately for solid and gaseous materials.’

## 2 Revised tables

### 2.1 Nylon

The column for fluorine ions in nylon, type 6 and type 6/6, inadvertently lists the data for chlorine ions. The corrected table is shown in Appendix A. This table replaces p. 204 in ICRU Report 73.

### 2.2 Water

The fundamental material parameter governing stopping data in ICRU Reports 37 and 49 is the mean excitation energy  $I$ , whereas the PASS code by Sigmund and Schinner (2000) underlying the stopping data in Report 73 uses as input data a series of discrete-model oscillator-strength spectra derived from oscillator-strength distributions compiled for atomic and molecular gases. However, these data do imply mean excitation energies. The oscillator-strength spectrum used in Report 73 for liquid water gives an  $I$ -value of 67.2 eV (compared to 75.0 eV in ICRU Reports 37 and 49), and the corresponding value for water vapor is 75.5 eV (compared to 71.6 eV in ICRU Reports 37 and 49). Clearly the  $I$ -value of liquid water must be higher than that of water vapor.

The ICRU currently has a Report Committee on Key Data for Measurement Standards in the Dosimetry of Ionizing Radiation, which among other issues is tasked with recommending an  $I$ -value for liquid water. While a generally accepted value has not yet been established, it seems prudent in the meantime to review the procedure and, where appropriate, to replace the results for water in ICRU Report 73 with new results based on  $I$ -values more consistent with current information.

Calculations have been performed with the PASS code of Sigmund and Schinner (2000). Apart from revised input parameters for the valence shell, the applied procedure and input are identical with the one applied previously in ICRU Report 73.

### 2.2.1 Stopping in liquid water

The oscillator-strength spectrum of liquid water has been studied extensively, *cf.* literature quoted by Emfietzoglou *et al.* (2008). As far as the  $I$ -value is concerned, it was decided to rely on recent measurements of Schardt *et al.* (2008) with 100-400 MeV/u protons, Li, C and O ions. In this velocity regime,  $I$  is the only material parameter entering the analysis, which led to a tentative value of  $I = 78$  eV. In view of the importance of reliable stopping data for liquid water it was found appropriate to make an exception to the overall strategy of ICRU Report 73 and to employ input based on stopping data.

Table 1 shows the adopted oscillator-strength spectrum, which was determined in the following manner:

- For the 1s and 2s shells, the  $I$ -values and oscillator strengths adopted for atomic and molecular oxygen in ICRU Report 73 were employed.
- For the valence shell, the oscillator strength is determined by the sum rule, and the  $h\omega$ -value is found by enforcing a predetermined total  $I$ -value of 78.0 eV.

Table 1: Revised sub-shell oscillator strengths  $f$ , excitation energies  $h\omega$ , and ionization energies  $U$  used in new calculations for liquid water and water vapor by the PASS code.

Shell		$Z_2 f$	$h\omega / \text{eV}$	$U / \text{eV}$
Water vapor, $I = 69.1$ eV				
1	0	1.802	965.1	538.2
2	0	1.849	129.85	28.7
2	1	6.348	27.21	12.017
Liquid water, $I = 78.0$ eV				
1	0	1.802	965.1	538.2
2	0	1.849	129.85	28.7
2	1	6.348	34.81	13.618

Revised stopping tables are shown in Appendix B and replace pp. 232-233 in ICRU Report 73. Relative deviations from the original data amount to  $\sim 1.5\%$  at 1000 MeV/u, less than 5% at 1 MeV/u, and up to  $\sim 15\%$  at 0.025 MeV/u.

### 2.2.2 Stopping in water vapor

A reevaluation of the tables of Berkowitz (2002) has led to a set of oscillator strengths implying  $I = 69.1$  eV. This is somewhat smaller than the value of  $I = 72.0$  eV derived by Kamakura *et al.* (2006) from the same data. Appendix C lists stopping tables evaluated with input data shown in Table 1. Appendix C replaces pp. 234-235 in ICRU Report 73. The relative differences between the revised and the original stopping forces amounts to less than 1% at 1000 MeV/u, to up to 3% at 1 MeV/u, and up to 8% at 0.025 MeV/u. These figures lie within the error bars in the respective velocity regimes.

### 2.2.3 Ranges in liquid water

Ranges in liquid water were reevaluated on the basis of the stopping forces in appendix B. Revised range data are tabulated in appendix D, which replaces pp. 236-237.

## References

- Berkowitz, J. (2002). *Atomic and molecular photoabsorption. Absolute total cross sections* (Academic Press, San Diego).
- Emfietzoglou, D., Abril, I., Garcia-Molina, R., Petsalakis, I. D., Nikjoo, H., Kyriakou, I., and Pathak, A. (2008). "Semi-empirical dielectric descriptions of the Bethe surface of the valence bands of condensed water," *Nucl. Instrum. Methods B* 266, 1154–1161.
- ICRU (2005). International Commission on Radiation Units and Measurements, *Stopping of ions heavier than helium*, ICRU Report 73, *J. ICRU* 5(1) (Oxford University Press, Oxford).
- Kamakura, S., Sakamoto, N., Ogawa, H., Tsuchida, H., and Inokuti, M. (2006). "Mean excitation energies for the stopping power of atoms and molecules evaluated from oscillator-strength spectra," *J. Appl. Phys.* 100, 064905.
- Schardt, D., Steidl, P., Krämer, M., Weber, U., Parodi, K., and Brons, S. (2008). "Precision Bragg-curve measurements for light-ion beams in water," *GSI Scientific Report 2007*, 2008-1, 373–373 (GSI-Gesellschaft f. Schwerionenforschung, Darmstadt, Germany), URL <http://www.gsi.de/informationen/wti/library/scientificreport2007/PAPERS/RADIATION-BIOPHYSICS-19.pdf>.
- Sigmund, P., and Schinner, A. (2000). "Binary stopping theory for swift heavy ions," *Europ. Phys. J. D* 12, 425–434.

## Appendix A: Revised stopping tables for nylon

Material: Nylon, type 6 and type 6/6								
Ion:	Li	Be	B	C	N	O	F	Ne
$(E/A_1)/\text{MeV}$	$[-dE/(\rho d\ell)] / (\text{MeV cm}^2 \text{mg}^{-1})$							
0.025	2.784E+00	3.441E+00	3.957E+00	4.362E+00	4.740E+00	5.063E+00	5.314E+00	5.543E+00
0.030	3.026E+00	3.767E+00	4.361E+00	4.834E+00	5.265E+00	5.635E+00	5.926E+00	6.188E+00
0.040	3.417E+00	4.322E+00	5.063E+00	5.668E+00	6.205E+00	6.671E+00	7.042E+00	7.373E+00
0.050	3.703E+00	4.765E+00	5.649E+00	6.385E+00	7.026E+00	7.587E+00	8.040E+00	8.442E+00
0.060	3.906E+00	5.110E+00	6.133E+00	6.997E+00	7.747E+00	8.405E+00	8.940E+00	9.413E+00
0.070	4.047E+00	5.374E+00	6.524E+00	7.514E+00	8.374E+00	9.133E+00	9.753E+00	1.030E+01
0.080	4.141E+00	5.570E+00	6.834E+00	7.942E+00	8.912E+00	9.773E+00	1.048E+01	1.111E+01
0.090	4.202E+00	5.714E+00	7.078E+00	8.292E+00	9.367E+00	1.033E+01	1.113E+01	1.184E+01
0.100	4.238E+00	5.818E+00	7.266E+00	8.576E+00	9.748E+00	1.081E+01	1.170E+01	1.249E+01
0.15	4.231E+00	6.004E+00	7.715E+00	9.344E+00	1.087E+01	1.230E+01	1.356E+01	1.473E+01
0.20	4.103E+00	5.951E+00	7.782E+00	9.568E+00	1.129E+01	1.294E+01	1.443E+01	1.584E+01
0.25	3.948E+00	5.822E+00	7.711E+00	9.581E+00	1.141E+01	1.320E+01	1.483E+01	1.640E+01
0.30	3.790E+00	5.666E+00	7.583E+00	9.501E+00	1.140E+01	1.327E+01	1.499E+01	1.666E+01
0.40	3.492E+00	5.341E+00	7.270E+00	9.227E+00	1.119E+01	1.316E+01	1.498E+01	1.677E+01
0.50	3.230E+00	5.031E+00	6.941E+00	8.903E+00	1.089E+01	1.291E+01	1.478E+01	1.663E+01
0.60	3.001E+00	4.746E+00	6.625E+00	8.573E+00	1.057E+01	1.260E+01	1.450E+01	1.638E+01
0.70	2.801E+00	4.487E+00	6.327E+00	8.253E+00	1.024E+01	1.227E+01	1.419E+01	1.608E+01
0.80	2.625E+00	4.252E+00	6.050E+00	7.947E+00	9.915E+00	1.195E+01	1.386E+01	1.576E+01
0.90	2.469E+00	4.039E+00	5.792E+00	7.657E+00	9.604E+00	1.162E+01	1.353E+01	1.544E+01
1.00	2.331E+00	3.845E+00	5.554E+00	7.384E+00	9.307E+00	1.131E+01	1.321E+01	1.511E+01
1.5	1.821E+00	3.096E+00	4.592E+00	6.245E+00	8.022E+00	9.911E+00	1.173E+01	1.356E+01
2.0	1.496E+00	2.589E+00	3.905E+00	5.394E+00	7.024E+00	8.784E+00	1.050E+01	1.225E+01
2.5	1.272E+00	2.225E+00	3.395E+00	4.741E+00	6.237E+00	7.871E+00	9.488E+00	1.115E+01
3.0	1.108E+00	1.952E+00	3.001E+00	4.226E+00	5.602E+00	7.122E+00	8.644E+00	1.022E+01
4.0	8.863E-01	1.571E+00	2.438E+00	3.470E+00	4.650E+00	5.972E+00	7.325E+00	8.743E+00
5.0	7.423E-01	1.319E+00	2.057E+00	2.944E+00	3.971E+00	5.136E+00	6.347E+00	7.630E+00
6.0	6.413E-01	1.140E+00	1.782E+00	2.559E+00	3.466E+00	4.503E+00	5.597E+00	6.764E+00
7.0	5.662E-01	1.007E+00	1.575E+00	2.266E+00	3.077E+00	4.009E+00	5.005E+00	6.074E+00
8.0	5.082E-01	9.035E-01	1.413E+00	2.036E+00	2.769E+00	3.615E+00	4.527E+00	5.512E+00
9.0	4.618E-01	8.208E-01	1.284E+00	1.850E+00	2.519E+00	3.293E+00	4.133E+00	5.046E+00
10.0	4.239E-01	7.532E-01	1.178E+00	1.698E+00	2.313E+00	3.025E+00	3.805E+00	4.655E+00
15	3.045E-01	5.407E-01	8.445E-01	1.217E+00	1.657E+00	2.169E+00	2.741E+00	3.372E+00
20	2.406E-01	4.274E-01	6.672E-01	9.604E-01	1.308E+00	1.710E+00	2.163E+00	2.666E+00
25	2.005E-01	3.562E-01	5.561E-01	8.002E-01	1.089E+00	1.423E+00	1.800E+00	2.220E+00
30	1.729E-01	3.071E-01	4.795E-01	6.899E-01	9.385E-01	1.226E+00	1.551E+00	1.913E+00
40	1.369E-01	2.434E-01	3.800E-01	5.469E-01	7.439E-01	9.713E-01	1.229E+00	1.516E+00
50	1.145E-01	2.035E-01	3.179E-01	4.576E-01	6.225E-01	8.127E-01	1.028E+00	1.269E+00
60	9.911E-02	1.762E-01	2.753E-01	3.963E-01	5.392E-01	7.039E-01	8.905E-01	1.099E+00
70	8.786E-02	1.562E-01	2.441E-01	3.514E-01	4.782E-01	6.244E-01	7.900E-01	9.749E-01
80	7.926E-02	1.409E-01	2.202E-01	3.171E-01	4.316E-01	5.636E-01	7.131E-01	8.801E-01
90	7.246E-02	1.289E-01	2.014E-01	2.900E-01	3.947E-01	5.155E-01	6.523E-01	8.052E-01
100	6.695E-02	1.191E-01	1.861E-01	2.680E-01	3.648E-01	4.765E-01	6.030E-01	7.444E-01
150	4.999E-02	8.892E-02	1.390E-01	2.002E-01	2.726E-01	3.562E-01	4.509E-01	5.568E-01
200	4.124E-02	7.336E-02	1.147E-01	1.652E-01	2.250E-01	2.940E-01	3.723E-01	4.599E-01
250	3.590E-02	6.387E-02	9.986E-02	1.439E-01	1.960E-01	2.561E-01	3.243E-01	4.006E-01
300	3.232E-02	5.750E-02	8.990E-02	1.295E-01	1.765E-01	2.306E-01	2.921E-01	3.608E-01
400	2.784E-02	4.954E-02	7.746E-02	1.116E-01	1.521E-01	1.988E-01	2.518E-01	3.111E-01
500	2.519E-02	4.483E-02	7.010E-02	1.010E-01	1.376E-01	1.799E-01	2.279E-01	2.816E-01
600	2.347E-02	4.176E-02	6.532E-02	9.414E-02	1.282E-01	1.677E-01	2.124E-01	2.624E-01
700	2.229E-02	3.965E-02	6.202E-02	8.939E-02	1.218E-01	1.592E-01	2.017E-01	2.492E-01
800	2.143E-02	3.814E-02	5.965E-02	8.597E-02	1.171E-01	1.531E-01	1.940E-01	2.397E-01
900	2.080E-02	3.702E-02	5.790E-02	8.345E-02	1.137E-01	1.486E-01	1.883E-01	2.327E-01
1000	2.032E-02	3.616E-02	5.656E-02	8.152E-02	1.111E-01	1.452E-01	1.840E-01	2.273E-01

## Appendix B: Revised stopping tables for liquid water

Material: Liquid water								
Ion:	Li	Be	B	C	N	O	F	Ne
$(E/A_1)/\text{MeV}$	$[-dE/(\rho d\ell)] / (\text{MeV cm}^2 \text{mg}^{-1})$							
0.025	2.319E+00	2.872E+00	3.292E+00	3.604E+00	3.882E+00	4.122E+00	4.295E+00	4.451E+00
0.030	2.520E+00	3.144E+00	3.632E+00	4.004E+00	4.328E+00	4.606E+00	4.811E+00	4.991E+00
0.040	2.854E+00	3.610E+00	4.223E+00	4.713E+00	5.131E+00	5.495E+00	5.768E+00	6.004E+00
0.050	3.116E+00	3.997E+00	4.724E+00	5.325E+00	5.837E+00	6.287E+00	6.634E+00	6.934E+00
0.060	3.320E+00	4.317E+00	5.154E+00	5.860E+00	6.463E+00	6.998E+00	7.420E+00	7.785E+00
0.070	3.476E+00	4.579E+00	5.522E+00	6.329E+00	7.021E+00	7.639E+00	8.134E+00	8.566E+00
0.080	3.591E+00	4.790E+00	5.832E+00	6.736E+00	7.517E+00	8.218E+00	8.786E+00	9.284E+00
0.090	3.676E+00	4.957E+00	6.091E+00	7.088E+00	7.955E+00	8.737E+00	9.379E+00	9.944E+00
0.100	3.735E+00	5.087E+00	6.304E+00	7.387E+00	8.338E+00	9.201E+00	9.915E+00	1.055E+01
0.15	3.813E+00	5.387E+00	6.889E+00	8.299E+00	9.594E+00	1.081E+01	1.186E+01	1.281E+01
0.20	3.735E+00	5.403E+00	7.045E+00	8.635E+00	1.015E+01	1.160E+01	1.289E+01	1.410E+01
0.25	3.613E+00	5.319E+00	7.031E+00	8.719E+00	1.036E+01	1.196E+01	1.341E+01	1.479E+01
0.30	3.482E+00	5.197E+00	6.945E+00	8.688E+00	1.040E+01	1.210E+01	1.365E+01	1.515E+01
0.40	3.226E+00	4.924E+00	6.693E+00	8.485E+00	1.028E+01	1.208E+01	1.375E+01	1.538E+01
0.50	2.995E+00	4.655E+00	6.413E+00	8.216E+00	1.004E+01	1.189E+01	1.362E+01	1.532E+01
0.60	2.791E+00	4.404E+00	6.137E+00	7.933E+00	9.768E+00	1.164E+01	1.340E+01	1.514E+01
0.70	2.611E+00	4.173E+00	5.875E+00	7.653E+00	9.485E+00	1.136E+01	1.314E+01	1.490E+01
0.80	2.452E+00	3.963E+00	5.628E+00	7.384E+00	9.204E+00	1.108E+01	1.286E+01	1.463E+01
0.90	2.310E+00	3.771E+00	5.398E+00	7.127E+00	8.930E+00	1.080E+01	1.257E+01	1.435E+01
1.00	2.184E+00	3.596E+00	5.184E+00	6.884E+00	8.667E+00	1.052E+01	1.229E+01	1.406E+01
1.5	1.715E+00	2.912E+00	4.312E+00	5.857E+00	7.517E+00	9.279E+00	1.098E+01	1.271E+01
2.0	1.414E+00	2.444E+00	3.683E+00	5.081E+00	6.613E+00	8.262E+00	9.880E+00	1.153E+01
2.5	1.205E+00	2.106E+00	3.211E+00	4.481E+00	5.892E+00	7.431E+00	8.960E+00	1.053E+01
3.0	1.053E+00	1.852E+00	2.846E+00	4.004E+00	5.308E+00	6.743E+00	8.187E+00	9.682E+00
4.0	8.442E-01	1.496E+00	2.320E+00	3.301E+00	4.423E+00	5.679E+00	6.969E+00	8.321E+00
5.0	7.086E-01	1.259E+00	1.962E+00	2.808E+00	3.788E+00	4.898E+00	6.057E+00	7.285E+00
6.0	6.132E-01	1.090E+00	1.703E+00	2.446E+00	3.314E+00	4.305E+00	5.354E+00	6.474E+00
7.0	5.421E-01	9.639E-01	1.507E+00	2.169E+00	2.947E+00	3.839E+00	4.795E+00	5.823E+00
8.0	4.871E-01	8.659E-01	1.354E+00	1.951E+00	2.655E+00	3.466E+00	4.343E+00	5.292E+00
9.0	4.431E-01	7.874E-01	1.232E+00	1.775E+00	2.418E+00	3.161E+00	3.970E+00	4.850E+00
10.0	4.070E-01	7.231E-01	1.131E+00	1.630E+00	2.222E+00	2.907E+00	3.658E+00	4.478E+00
15	2.931E-01	5.205E-01	8.131E-01	1.171E+00	1.597E+00	2.090E+00	2.642E+00	3.252E+00
20	2.321E-01	4.121E-01	6.434E-01	9.263E-01	1.261E+00	1.650E+00	2.088E+00	2.575E+00
25	1.936E-01	3.439E-01	5.369E-01	7.727E-01	1.052E+00	1.375E+00	1.739E+00	2.146E+00
30	1.671E-01	2.968E-01	4.634E-01	6.668E-01	9.072E-01	1.185E+00	1.499E+00	1.850E+00
40	1.325E-01	2.355E-01	3.678E-01	5.293E-01	7.200E-01	9.400E-01	1.189E+00	1.468E+00
50	1.109E-01	1.972E-01	3.080E-01	4.433E-01	6.031E-01	7.873E-01	9.960E-01	1.229E+00
60	9.608E-02	1.708E-01	2.668E-01	3.842E-01	5.227E-01	6.824E-01	8.634E-01	1.065E+00
70	8.522E-02	1.515E-01	2.367E-01	3.409E-01	4.638E-01	6.057E-01	7.663E-01	9.458E-01
80	7.692E-02	1.368E-01	2.137E-01	3.077E-01	4.188E-01	5.469E-01	6.921E-01	8.542E-01
90	7.035E-02	1.251E-01	1.955E-01	2.815E-01	3.832E-01	5.005E-01	6.333E-01	7.818E-01
100	6.503E-02	1.156E-01	1.807E-01	2.603E-01	3.543E-01	4.628E-01	5.857E-01	7.230E-01
150	4.862E-02	8.647E-02	1.352E-01	1.947E-01	2.652E-01	3.464E-01	4.386E-01	5.416E-01
200	4.014E-02	7.140E-02	1.116E-01	1.608E-01	2.190E-01	2.862E-01	3.624E-01	4.476E-01
250	3.496E-02	6.220E-02	9.726E-02	1.401E-01	1.909E-01	2.495E-01	3.159E-01	3.902E-01
300	3.149E-02	5.602E-02	8.760E-02	1.262E-01	1.719E-01	2.247E-01	2.846E-01	3.516E-01
400	2.715E-02	4.830E-02	7.554E-02	1.089E-01	1.483E-01	1.938E-01	2.455E-01	3.034E-01
500	2.458E-02	4.373E-02	6.840E-02	9.858E-02	1.343E-01	1.756E-01	2.224E-01	2.748E-01
600	2.291E-02	4.077E-02	6.376E-02	9.189E-02	1.252E-01	1.637E-01	2.073E-01	2.562E-01
700	2.176E-02	3.872E-02	6.056E-02	8.729E-02	1.189E-01	1.555E-01	1.970E-01	2.434E-01
800	2.094E-02	3.726E-02	5.827E-02	8.399E-02	1.144E-01	1.496E-01	1.895E-01	2.342E-01
900	2.033E-02	3.617E-02	5.657E-02	8.155E-02	1.111E-01	1.453E-01	1.840E-01	2.274E-01
1000	1.986E-02	3.535E-02	5.528E-02	7.968E-02	1.086E-01	1.419E-01	1.798E-01	2.222E-01

Material: Liquid water								
Ion:	Na	Mg	Al	Si	P	S	CL	Ar
$(E/A_1)/\text{MeV}$	$[-dE/(\rho d\ell)] / (\text{MeV cm}^2 \text{mg}^{-1})$							
0.025	4.591E+00	4.754E+00	4.911E+00	5.070E+00	5.262E+00	5.413E+00	5.617E+00	5.716E+00
0.030	5.155E+00	5.318E+00	5.486E+00	5.653E+00	5.854E+00	6.019E+00	6.231E+00	6.339E+00
0.040	6.224E+00	6.396E+00	6.585E+00	6.770E+00	6.987E+00	7.176E+00	7.398E+00	7.520E+00
0.050	7.220E+00	7.414E+00	7.630E+00	7.838E+00	8.074E+00	8.287E+00	8.521E+00	8.653E+00
0.060	8.144E+00	8.366E+00	8.619E+00	8.856E+00	9.119E+00	9.360E+00	9.610E+00	9.753E+00
0.070	8.998E+00	9.255E+00	9.551E+00	9.823E+00	1.012E+01	1.039E+01	1.066E+01	1.082E+01
0.080	9.791E+00	1.009E+01	1.043E+01	1.074E+01	1.107E+01	1.137E+01	1.167E+01	1.185E+01
0.090	1.053E+01	1.086E+01	1.125E+01	1.160E+01	1.196E+01	1.231E+01	1.263E+01	1.284E+01
0.100	1.121E+01	1.158E+01	1.202E+01	1.241E+01	1.282E+01	1.320E+01	1.355E+01	1.378E+01
0.15	1.385E+01	1.446E+01	1.515E+01	1.577E+01	1.640E+01	1.699E+01	1.752E+01	1.790E+01
0.20	1.545E+01	1.628E+01	1.723E+01	1.809E+01	1.895E+01	1.976E+01	2.050E+01	2.107E+01
0.25	1.638E+01	1.737E+01	1.853E+01	1.959E+01	2.066E+01	2.168E+01	2.262E+01	2.338E+01
0.30	1.692E+01	1.802E+01	1.933E+01	2.055E+01	2.178E+01	2.298E+01	2.408E+01	2.500E+01
0.40	1.737E+01	1.860E+01	2.011E+01	2.154E+01	2.299E+01	2.443E+01	2.577E+01	2.693E+01
0.50	1.744E+01	1.873E+01	2.035E+01	2.190E+01	2.350E+01	2.509E+01	2.658E+01	2.789E+01
0.60	1.734E+01	1.865E+01	2.035E+01	2.198E+01	2.367E+01	2.536E+01	2.695E+01	2.836E+01
0.70	1.716E+01	1.848E+01	2.022E+01	2.190E+01	2.366E+01	2.542E+01	2.708E+01	2.856E+01
0.80	1.693E+01	1.825E+01	2.002E+01	2.173E+01	2.354E+01	2.535E+01	2.707E+01	2.859E+01
0.90	1.668E+01	1.799E+01	1.979E+01	2.151E+01	2.336E+01	2.521E+01	2.696E+01	2.852E+01
1.00	1.641E+01	1.772E+01	1.952E+01	2.127E+01	2.313E+01	2.501E+01	2.679E+01	2.838E+01
1.5	1.505E+01	1.631E+01	1.812E+01	1.988E+01	2.179E+01	2.373E+01	2.558E+01	2.723E+01
2.0	1.380E+01	1.503E+01	1.680E+01	1.853E+01	2.043E+01	2.237E+01	2.421E+01	2.587E+01
2.5	1.271E+01	1.390E+01	1.561E+01	1.730E+01	1.916E+01	2.107E+01	2.290E+01	2.454E+01
3.0	1.175E+01	1.291E+01	1.457E+01	1.620E+01	1.802E+01	1.989E+01	2.169E+01	2.330E+01
4.0	1.019E+01	1.128E+01	1.282E+01	1.435E+01	1.607E+01	1.784E+01	1.955E+01	2.110E+01
5.0	8.967E+00	9.998E+00	1.143E+01	1.287E+01	1.447E+01	1.615E+01	1.777E+01	1.926E+01
6.0	7.996E+00	8.973E+00	1.031E+01	1.165E+01	1.316E+01	1.473E+01	1.627E+01	1.769E+01
7.0	7.207E+00	8.134E+00	9.377E+00	1.064E+01	1.205E+01	1.354E+01	1.500E+01	1.635E+01
8.0	6.556E+00	7.438E+00	8.600E+00	9.788E+00	1.111E+01	1.252E+01	1.390E+01	1.519E+01
9.0	6.011E+00	6.851E+00	7.941E+00	9.061E+00	1.031E+01	1.164E+01	1.295E+01	1.418E+01
10.0	5.549E+00	6.350E+00	7.376E+00	8.434E+00	9.615E+00	1.087E+01	1.212E+01	1.330E+01
15	4.015E+00	4.663E+00	5.450E+00	6.276E+00	7.192E+00	8.173E+00	9.169E+00	1.014E+01
20	3.164E+00	3.705E+00	4.342E+00	5.017E+00	5.761E+00	6.562E+00	7.385E+00	8.202E+00
25	2.626E+00	3.092E+00	3.627E+00	4.198E+00	4.825E+00	5.500E+00	6.200E+00	6.906E+00
30	2.257E+00	2.666E+00	3.129E+00	3.625E+00	4.167E+00	4.751E+00	5.360E+00	5.982E+00
40	1.783E+00	2.114E+00	2.481E+00	2.876E+00	3.305E+00	3.767E+00	4.254E+00	4.757E+00
50	1.490E+00	1.770E+00	2.077E+00	2.408E+00	2.766E+00	3.151E+00	3.559E+00	3.984E+00
60	1.291E+00	1.534E+00	1.800E+00	2.087E+00	2.397E+00	2.729E+00	3.082E+00	3.452E+00
70	1.145E+00	1.361E+00	1.598E+00	1.852E+00	2.127E+00	2.422E+00	2.734E+00	3.064E+00
80	1.034E+00	1.230E+00	1.443E+00	1.673E+00	1.922E+00	2.187E+00	2.469E+00	2.767E+00
90	9.462E-01	1.126E+00	1.321E+00	1.532E+00	1.760E+00	2.001E+00	2.260E+00	2.532E+00
100	8.750E-01	1.041E+00	1.222E+00	1.417E+00	1.626E+00	1.851E+00	2.090E+00	2.343E+00
150	6.555E-01	7.802E-01	9.158E-01	1.062E+00	1.220E+00	1.388E+00	1.567E+00	1.757E+00
200	5.419E-01	6.451E-01	7.574E-01	8.787E-01	1.009E+00	1.149E+00	1.297E+00	1.455E+00
250	4.724E-01	5.625E-01	6.605E-01	7.664E-01	8.803E-01	1.002E+00	1.132E+00	1.269E+00
300	4.257E-01	5.070E-01	5.954E-01	6.909E-01	7.936E-01	9.035E-01	1.021E+00	1.145E+00
400	3.673E-01	4.375E-01	5.138E-01	5.964E-01	6.851E-01	7.801E-01	8.813E-01	9.887E-01
500	3.328E-01	3.963E-01	4.655E-01	5.404E-01	6.208E-01	7.070E-01	7.987E-01	8.962E-01
600	3.103E-01	3.696E-01	4.341E-01	5.039E-01	5.790E-01	6.594E-01	7.450E-01	8.360E-01
700	2.948E-01	3.511E-01	4.125E-01	4.788E-01	5.502E-01	6.266E-01	7.080E-01	7.945E-01
800	2.836E-01	3.379E-01	3.969E-01	4.608E-01	5.295E-01	6.030E-01	6.814E-01	7.646E-01
900	2.754E-01	3.281E-01	3.854E-01	4.475E-01	5.142E-01	5.856E-01	6.617E-01	7.426E-01
1000	2.692E-01	3.206E-01	3.767E-01	4.373E-01	5.025E-01	5.723E-01	6.467E-01	7.258E-01

## Appendix C: Revised stopping tables for water vapor

Material: Water vapor								
Ion:	Li	Be	B	C	N	O	F	Ne
$(E/A_1)/\text{MeV}$	$[-dE/(\rho d\ell)] / (\text{MeV cm}^2 \text{mg}^{-1})$							
0.025	2.576E+00	3.181E+00	3.641E+00	3.982E+00	4.285E+00	4.544E+00	4.733E+00	4.905E+00
0.030	2.795E+00	3.480E+00	4.016E+00	4.426E+00	4.781E+00	5.085E+00	5.309E+00	5.509E+00
0.040	3.155E+00	3.989E+00	4.664E+00	5.206E+00	5.668E+00	6.069E+00	6.372E+00	6.637E+00
0.050	3.430E+00	4.403E+00	5.207E+00	5.872E+00	6.440E+00	6.937E+00	7.325E+00	7.661E+00
0.060	3.637E+00	4.737E+00	5.664E+00	6.446E+00	7.116E+00	7.708E+00	8.180E+00	8.591E+00
0.070	3.790E+00	5.003E+00	6.045E+00	6.939E+00	7.709E+00	8.395E+00	8.950E+00	9.435E+00
0.080	3.899E+00	5.211E+00	6.359E+00	7.359E+00	8.226E+00	9.005E+00	9.642E+00	1.020E+01
0.090	3.975E+00	5.372E+00	6.615E+00	7.714E+00	8.675E+00	9.543E+00	1.026E+01	1.090E+01
0.100	4.026E+00	5.494E+00	6.822E+00	8.011E+00	9.060E+00	1.002E+01	1.082E+01	1.153E+01
0.15	4.065E+00	5.749E+00	7.359E+00	8.875E+00	1.028E+01	1.159E+01	1.274E+01	1.380E+01
0.20	3.959E+00	5.729E+00	7.473E+00	9.165E+00	1.078E+01	1.233E+01	1.372E+01	1.503E+01
0.25	3.816E+00	5.617E+00	7.427E+00	9.212E+00	1.095E+01	1.264E+01	1.419E+01	1.567E+01
0.30	3.666E+00	5.473E+00	7.313E+00	9.151E+00	1.096E+01	1.275E+01	1.439E+01	1.598E+01
0.40	3.381E+00	5.163E+00	7.019E+00	8.899E+00	1.078E+01	1.267E+01	1.443E+01	1.615E+01
0.50	3.129E+00	4.866E+00	6.705E+00	8.592E+00	1.050E+01	1.244E+01	1.425E+01	1.604E+01
0.60	2.909E+00	4.592E+00	6.402E+00	8.277E+00	1.019E+01	1.215E+01	1.399E+01	1.581E+01
0.70	2.716E+00	4.343E+00	6.116E+00	7.970E+00	9.879E+00	1.184E+01	1.369E+01	1.553E+01
0.80	2.546E+00	4.117E+00	5.850E+00	7.677E+00	9.571E+00	1.152E+01	1.338E+01	1.522E+01
0.90	2.396E+00	3.913E+00	5.603E+00	7.400E+00	9.274E+00	1.122E+01	1.307E+01	1.491E+01
1.00	2.263E+00	3.726E+00	5.374E+00	7.139E+00	8.990E+00	1.092E+01	1.276E+01	1.460E+01
1.5	1.770E+00	3.005E+00	4.452E+00	6.048E+00	7.764E+00	9.585E+00	1.135E+01	1.314E+01
2.0	1.456E+00	2.517E+00	3.792E+00	5.234E+00	6.812E+00	8.511E+00	1.018E+01	1.189E+01
2.5	1.239E+00	2.166E+00	3.301E+00	4.607E+00	6.059E+00	7.641E+00	9.217E+00	1.084E+01
3.0	1.081E+00	1.902E+00	2.923E+00	4.112E+00	5.451E+00	6.925E+00	8.411E+00	9.950E+00
4.0	8.658E-01	1.534E+00	2.379E+00	3.384E+00	4.534E+00	5.821E+00	7.145E+00	8.534E+00
5.0	7.260E-01	1.290E+00	2.010E+00	2.876E+00	3.879E+00	5.015E+00	6.203E+00	7.462E+00
6.0	6.277E-01	1.116E+00	1.743E+00	2.503E+00	3.391E+00	4.404E+00	5.478E+00	6.625E+00
7.0	5.546E-01	9.861E-01	1.542E+00	2.218E+00	3.013E+00	3.926E+00	4.903E+00	5.955E+00
8.0	4.980E-01	8.853E-01	1.385E+00	1.995E+00	2.714E+00	3.543E+00	4.439E+00	5.409E+00
9.0	4.528E-01	8.047E-01	1.259E+00	1.814E+00	2.470E+00	3.229E+00	4.056E+00	4.955E+00
10.0	4.158E-01	7.388E-01	1.155E+00	1.665E+00	2.269E+00	2.969E+00	3.736E+00	4.573E+00
15	2.990E-01	5.311E-01	8.295E-01	1.195E+00	1.629E+00	2.132E+00	2.695E+00	3.317E+00
20	2.366E-01	4.201E-01	6.559E-01	9.442E-01	1.286E+00	1.682E+00	2.128E+00	2.624E+00
25	1.973E-01	3.504E-01	5.470E-01	7.871E-01	1.071E+00	1.400E+00	1.772E+00	2.186E+00
30	1.701E-01	3.022E-01	4.718E-01	6.789E-01	9.237E-01	1.207E+00	1.527E+00	1.884E+00
40	1.348E-01	2.396E-01	3.742E-01	5.385E-01	7.325E-01	9.565E-01	1.210E+00	1.493E+00
50	1.128E-01	2.005E-01	3.132E-01	4.508E-01	6.133E-01	8.007E-01	1.013E+00	1.250E+00
60	9.767E-02	1.736E-01	2.713E-01	3.905E-01	5.313E-01	6.937E-01	8.777E-01	1.083E+00
70	8.660E-02	1.540E-01	2.406E-01	3.464E-01	4.714E-01	6.155E-01	7.788E-01	9.611E-01
80	7.814E-02	1.389E-01	2.171E-01	3.126E-01	4.255E-01	5.557E-01	7.031E-01	8.678E-01
90	7.146E-02	1.271E-01	1.986E-01	2.860E-01	3.892E-01	5.084E-01	6.433E-01	7.941E-01
100	6.604E-02	1.174E-01	1.835E-01	2.643E-01	3.598E-01	4.700E-01	5.948E-01	7.342E-01
150	4.934E-02	8.775E-02	1.372E-01	1.976E-01	2.691E-01	3.516E-01	4.451E-01	5.496E-01
200	4.072E-02	7.243E-02	1.132E-01	1.632E-01	2.222E-01	2.903E-01	3.676E-01	4.541E-01
250	3.546E-02	6.308E-02	9.862E-02	1.421E-01	1.936E-01	2.530E-01	3.203E-01	3.957E-01
300	3.193E-02	5.680E-02	8.881E-02	1.280E-01	1.743E-01	2.278E-01	2.886E-01	3.565E-01
400	2.751E-02	4.895E-02	7.655E-02	1.103E-01	1.503E-01	1.964E-01	2.488E-01	3.074E-01
500	2.490E-02	4.431E-02	6.929E-02	9.987E-02	1.361E-01	1.779E-01	2.253E-01	2.784E-01
600	2.321E-02	4.129E-02	6.458E-02	9.308E-02	1.268E-01	1.658E-01	2.100E-01	2.595E-01
700	2.204E-02	3.921E-02	6.133E-02	8.840E-02	1.204E-01	1.574E-01	1.995E-01	2.465E-01
800	2.120E-02	3.772E-02	5.900E-02	8.504E-02	1.159E-01	1.515E-01	1.919E-01	2.371E-01
900	2.058E-02	3.662E-02	5.727E-02	8.255E-02	1.125E-01	1.470E-01	1.863E-01	2.302E-01
1000	2.011E-02	3.578E-02	5.596E-02	8.065E-02	1.099E-01	1.437E-01	1.820E-01	2.249E-01

Material: Water vapor								
Ion:	Na	Mg	Al	Si	P	S	CL	Ar
$(E/A_1)/\text{MeV}$	$[-dE/(\rho d\ell)] / (\text{MeV cm}^2 \text{mg}^{-1})$							
0.025	5.061E+00	5.237E+00	5.409E+00	5.581E+00	5.789E+00	5.958E+00	6.177E+00	6.290E+00
0.030	5.692E+00	5.870E+00	6.053E+00	6.236E+00	6.455E+00	6.638E+00	6.866E+00	6.991E+00
0.040	6.882E+00	7.076E+00	7.285E+00	7.489E+00	7.726E+00	7.936E+00	8.177E+00	8.317E+00
0.050	7.981E+00	8.204E+00	8.447E+00	8.679E+00	8.939E+00	9.176E+00	9.432E+00	9.584E+00
0.060	8.990E+00	9.249E+00	9.535E+00	9.803E+00	1.010E+01	1.036E+01	1.064E+01	1.081E+01
0.070	9.915E+00	1.022E+01	1.055E+01	1.086E+01	1.119E+01	1.149E+01	1.179E+01	1.198E+01
0.080	1.077E+01	1.111E+01	1.150E+01	1.185E+01	1.222E+01	1.256E+01	1.289E+01	1.310E+01
0.090	1.154E+01	1.194E+01	1.238E+01	1.277E+01	1.318E+01	1.357E+01	1.393E+01	1.417E+01
0.100	1.226E+01	1.270E+01	1.319E+01	1.364E+01	1.409E+01	1.452E+01	1.492E+01	1.519E+01
0.15	1.492E+01	1.562E+01	1.640E+01	1.711E+01	1.781E+01	1.847E+01	1.907E+01	1.952E+01
0.20	1.648E+01	1.740E+01	1.844E+01	1.939E+01	2.033E+01	2.124E+01	2.205E+01	2.271E+01
0.25	1.735E+01	1.844E+01	1.969E+01	2.084E+01	2.199E+01	2.310E+01	2.412E+01	2.497E+01
0.30	1.784E+01	1.903E+01	2.043E+01	2.174E+01	2.306E+01	2.434E+01	2.553E+01	2.654E+01
0.40	1.822E+01	1.954E+01	2.114E+01	2.265E+01	2.419E+01	2.571E+01	2.713E+01	2.837E+01
0.50	1.824E+01	1.961E+01	2.132E+01	2.295E+01	2.463E+01	2.630E+01	2.787E+01	2.926E+01
0.60	1.810E+01	1.949E+01	2.127E+01	2.297E+01	2.475E+01	2.652E+01	2.818E+01	2.967E+01
0.70	1.787E+01	1.927E+01	2.109E+01	2.285E+01	2.469E+01	2.653E+01	2.826E+01	2.982E+01
0.80	1.761E+01	1.900E+01	2.086E+01	2.264E+01	2.452E+01	2.641E+01	2.820E+01	2.980E+01
0.90	1.732E+01	1.871E+01	2.058E+01	2.238E+01	2.430E+01	2.623E+01	2.805E+01	2.969E+01
1.00	1.702E+01	1.840E+01	2.028E+01	2.210E+01	2.404E+01	2.600E+01	2.785E+01	2.951E+01
1.5	1.554E+01	1.688E+01	1.875E+01	2.058E+01	2.256E+01	2.457E+01	2.648E+01	2.820E+01
2.0	1.422E+01	1.550E+01	1.733E+01	1.912E+01	2.109E+01	2.309E+01	2.500E+01	2.672E+01
2.5	1.306E+01	1.431E+01	1.608E+01	1.782E+01	1.974E+01	2.171E+01	2.360E+01	2.530E+01
3.0	1.207E+01	1.327E+01	1.498E+01	1.667E+01	1.854E+01	2.046E+01	2.231E+01	2.398E+01
4.0	1.044E+01	1.157E+01	1.315E+01	1.473E+01	1.649E+01	1.831E+01	2.007E+01	2.167E+01
5.0	9.177E+00	1.024E+01	1.171E+01	1.319E+01	1.483E+01	1.655E+01	1.822E+01	1.974E+01
6.0	8.176E+00	9.184E+00	1.055E+01	1.193E+01	1.347E+01	1.508E+01	1.666E+01	1.811E+01
7.0	7.365E+00	8.319E+00	9.591E+00	1.088E+01	1.233E+01	1.385E+01	1.534E+01	1.673E+01
8.0	6.696E+00	7.602E+00	8.791E+00	1.001E+01	1.136E+01	1.279E+01	1.421E+01	1.553E+01
9.0	6.137E+00	6.999E+00	8.113E+00	9.258E+00	1.054E+01	1.189E+01	1.323E+01	1.449E+01
10.0	5.664E+00	6.485E+00	7.533E+00	8.614E+00	9.819E+00	1.110E+01	1.238E+01	1.359E+01
15	4.094E+00	4.755E+00	5.558E+00	6.401E+00	7.334E+00	8.334E+00	9.350E+00	1.034E+01
20	3.223E+00	3.776E+00	4.425E+00	5.113E+00	5.871E+00	6.686E+00	7.525E+00	8.358E+00
25	2.675E+00	3.149E+00	3.694E+00	4.276E+00	4.914E+00	5.601E+00	6.314E+00	7.033E+00
30	2.298E+00	2.714E+00	3.186E+00	3.690E+00	4.242E+00	4.836E+00	5.457E+00	6.090E+00
40	1.814E+00	2.150E+00	2.524E+00	2.926E+00	3.363E+00	3.833E+00	4.327E+00	4.840E+00
50	1.516E+00	1.800E+00	2.112E+00	2.449E+00	2.813E+00	3.205E+00	3.619E+00	4.051E+00
60	1.312E+00	1.559E+00	1.830E+00	2.121E+00	2.436E+00	2.774E+00	3.133E+00	3.509E+00
70	1.164E+00	1.383E+00	1.623E+00	1.882E+00	2.161E+00	2.461E+00	2.779E+00	3.113E+00
80	1.050E+00	1.249E+00	1.466E+00	1.700E+00	1.952E+00	2.222E+00	2.508E+00	2.811E+00
90	9.610E-01	1.143E+00	1.342E+00	1.556E+00	1.786E+00	2.033E+00	2.295E+00	2.572E+00
100	8.886E-01	1.057E+00	1.241E+00	1.439E+00	1.652E+00	1.880E+00	2.122E+00	2.379E+00
150	6.652E-01	7.918E-01	9.294E-01	1.078E+00	1.238E+00	1.409E+00	1.591E+00	1.783E+00
200	5.496E-01	6.544E-01	7.683E-01	8.913E-01	1.024E+00	1.165E+00	1.316E+00	1.475E+00
250	4.791E-01	5.704E-01	6.698E-01	7.772E-01	8.926E-01	1.016E+00	1.148E+00	1.287E+00
300	4.316E-01	5.140E-01	6.036E-01	7.004E-01	8.045E-01	9.159E-01	1.035E+00	1.161E+00
400	3.722E-01	4.433E-01	5.207E-01	6.043E-01	6.943E-01	7.905E-01	8.930E-01	1.002E+00
500	3.371E-01	4.015E-01	4.716E-01	5.474E-01	6.289E-01	7.162E-01	8.091E-01	9.078E-01
600	3.143E-01	3.743E-01	4.397E-01	5.104E-01	5.864E-01	6.678E-01	7.545E-01	8.467E-01
700	2.985E-01	3.556E-01	4.177E-01	4.849E-01	5.571E-01	6.344E-01	7.169E-01	8.044E-01
800	2.872E-01	3.421E-01	4.019E-01	4.665E-01	5.360E-01	6.105E-01	6.898E-01	7.741E-01
900	2.788E-01	3.321E-01	3.902E-01	4.529E-01	5.205E-01	5.927E-01	6.698E-01	7.516E-01
1000	2.724E-01	3.245E-01	3.812E-01	4.426E-01	5.086E-01	5.792E-01	6.545E-01	7.345E-01



## Appendix D: Revised range tables for liquid water

Material: Liquid water								
Ion:	Li	Be	B	C	N	O	F	Ne
$(E/A_1)/\text{MeV}$	$[\rho R(E) - \rho R(E)] / (\text{mg cm}^{-2})$							
0.025	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.030	1.436E-02	1.501E-02	1.565E-02	1.583E-02	1.711E-02	1.839E-02	2.093E-02	2.145E-02
0.040	4.029E-02	4.182E-02	4.334E-02	4.358E-02	4.694E-02	5.031E-02	5.715E-02	5.847E-02
0.050	6.358E-02	6.558E-02	6.758E-02	6.760E-02	7.259E-02	7.760E-02	8.793E-02	8.983E-02
0.060	8.516E-02	8.729E-02	8.951E-02	8.913E-02	9.542E-02	1.018E-01	1.151E-01	1.174E-01
0.070	1.056E-01	1.076E-01	1.098E-01	1.089E-01	1.162E-01	1.237E-01	1.395E-01	1.421E-01
0.080	1.252E-01	1.268E-01	1.288E-01	1.273E-01	1.355E-01	1.439E-01	1.620E-01	1.647E-01
0.090	1.443E-01	1.453E-01	1.470E-01	1.447E-01	1.536E-01	1.628E-01	1.830E-01	1.858E-01
0.100	1.631E-01	1.633E-01	1.644E-01	1.613E-01	1.709E-01	1.806E-01	2.027E-01	2.055E-01
0.15	2.550E-01	2.494E-01	2.465E-01	2.381E-01	2.494E-01	2.611E-01	2.906E-01	2.927E-01
0.20	3.470E-01	3.329E-01	3.241E-01	3.090E-01	3.204E-01	3.326E-01	3.675E-01	3.679E-01
0.25	4.414E-01	4.170E-01	4.009E-01	3.783E-01	3.887E-01	4.005E-01	4.398E-01	4.378E-01
0.30	5.393E-01	5.027E-01	4.783E-01	4.473E-01	4.562E-01	4.671E-01	5.100E-01	5.052E-01
0.40	7.465E-01	6.809E-01	6.369E-01	5.872E-01	5.916E-01	5.994E-01	6.487E-01	6.374E-01
0.50	9.699E-01	8.692E-01	8.020E-01	7.310E-01	7.295E-01	7.329E-01	7.875E-01	7.689E-01
0.60	1.210E+00	1.068E+00	9.743E-01	8.798E-01	8.710E-01	8.690E-01	9.282E-01	9.014E-01
0.70	1.467E+00	1.279E+00	1.154E+00	1.034E+00	1.017E+00	1.008E+00	1.071E+00	1.036E+00
0.80	1.742E+00	1.500E+00	1.342E+00	1.194E+00	1.166E+00	1.151E+00	1.218E+00	1.173E+00
0.90	2.033E+00	1.733E+00	1.539E+00	1.359E+00	1.321E+00	1.297E+00	1.367E+00	1.312E+00
1.00	2.342E+00	1.978E+00	1.743E+00	1.531E+00	1.480E+00	1.447E+00	1.520E+00	1.454E+00
1.5	4.148E+00	3.379E+00	2.891E+00	2.480E+00	2.350E+00	2.258E+00	2.339E+00	2.210E+00
2.0	6.386E+00	5.074E+00	4.252E+00	3.583E+00	3.345E+00	3.173E+00	3.252E+00	3.045E+00
2.5	9.053E+00	7.066E+00	5.828E+00	4.844E+00	4.469E+00	4.196E+00	4.263E+00	3.962E+00
3.0	1.214E+01	9.352E+00	7.619E+00	6.264E+00	5.723E+00	5.327E+00	5.373E+00	4.962E+00
4.0	1.955E+01	1.480E+01	1.185E+01	9.584E+00	8.626E+00	7.922E+00	7.896E+00	7.217E+00
5.0	2.855E+01	2.139E+01	1.693E+01	1.354E+01	1.206E+01	1.096E+01	1.083E+01	9.815E+00
6.0	3.911E+01	2.910E+01	2.286E+01	1.814E+01	1.602E+01	1.446E+01	1.417E+01	1.276E+01
7.0	5.117E+01	3.791E+01	2.962E+01	2.336E+01	2.051E+01	1.840E+01	1.793E+01	1.605E+01
8.0	6.469E+01	4.779E+01	3.720E+01	2.921E+01	2.553E+01	2.279E+01	2.209E+01	1.969E+01
9.0	7.964E+01	5.872E+01	4.558E+01	3.567E+01	3.106E+01	2.763E+01	2.667E+01	2.368E+01
10.0	9.600E+01	7.067E+01	5.475E+01	4.274E+01	3.711E+01	3.291E+01	3.166E+01	2.801E+01
15	1.978E+02	1.451E+02	1.119E+02	8.679E+01	7.480E+01	6.580E+01	6.262E+01	5.480E+01
20	3.317E+02	2.431E+02	1.871E+02	1.448E+02	1.245E+02	1.092E+02	1.033E+02	8.991E+01
25	4.961E+02	3.632E+02	2.795E+02	2.161E+02	1.856E+02	1.625E+02	1.534E+02	1.330E+02
30	6.895E+02	5.046E+02	3.882E+02	3.000E+02	2.575E+02	2.254E+02	2.124E+02	1.838E+02
40	1.159E+03	8.478E+02	6.518E+02	5.036E+02	4.319E+02	3.780E+02	3.556E+02	3.071E+02
50	1.734E+03	1.268E+03	9.743E+02	7.525E+02	6.454E+02	5.647E+02	5.309E+02	4.580E+02
60	2.407E+03	1.760E+03	1.352E+03	1.044E+03	8.955E+02	7.835E+02	7.363E+02	6.348E+02
70	3.176E+03	2.321E+03	1.783E+03	1.377E+03	1.180E+03	1.033E+03	9.702E+02	8.362E+02
80	4.034E+03	2.948E+03	2.265E+03	1.748E+03	1.499E+03	1.311E+03	1.231E+03	1.061E+03
90	4.978E+03	3.638E+03	2.794E+03	2.157E+03	1.849E+03	1.617E+03	1.519E+03	1.308E+03
100	6.005E+03	4.388E+03	3.370E+03	2.601E+03	2.229E+03	1.950E+03	1.831E+03	1.577E+03
150	1.224E+04	8.941E+03	6.865E+03	5.296E+03	4.538E+03	3.969E+03	3.725E+03	3.207E+03
200	2.013E+04	1.470E+04	1.129E+04	8.705E+03	7.458E+03	6.521E+03	6.118E+03	5.265E+03
250	2.942E+04	2.148E+04	1.649E+04	1.272E+04	1.089E+04	9.522E+03	8.932E+03	7.686E+03
300	3.989E+04	2.912E+04	2.235E+04	1.724E+04	1.476E+04	1.290E+04	1.210E+04	1.041E+04
400	6.368E+04	4.650E+04	3.568E+04	2.751E+04	2.356E+04	2.059E+04	1.931E+04	1.661E+04
500	9.058E+04	6.613E+04	5.074E+04	3.912E+04	3.350E+04	2.927E+04	2.745E+04	2.361E+04
600	1.198E+05	8.748E+04	6.712E+04	5.175E+04	4.431E+04	3.872E+04	3.630E+04	3.122E+04
700	1.509E+05	1.102E+05	8.452E+04	6.516E+04	5.579E+04	4.875E+04	4.571E+04	3.931E+04
800	1.834E+05	1.339E+05	1.027E+05	7.919E+04	6.780E+04	5.925E+04	5.554E+04	4.776E+04
900	2.171E+05	1.585E+05	1.216E+05	9.371E+04	8.022E+04	7.010E+04	6.572E+04	5.651E+04
1000	2.516E+05	1.837E+05	1.409E+05	1.086E+05	9.298E+04	8.124E+04	7.616E+04	6.549E+04

Material: Liquid water								
Ion:	Na	Mg	Al	Si	P	S	CL	Ar
$(E/A_1)/\text{MeV}$	$[\rho R(E) - \rho R(E)] / (\text{mg cm}^{-2})$							
0.025	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.030	2.367E-02	2.422E-02	2.603E-02	2.627E-02	2.795E-02	2.813E-02	3.000E-02	3.323E-02
0.040	6.443E-02	6.608E-02	7.111E-02	7.186E-02	7.657E-02	7.710E-02	8.241E-02	9.129E-02
0.050	9.882E-02	1.015E-01	1.093E-01	1.105E-01	1.179E-01	1.188E-01	1.272E-01	1.409E-01
0.060	1.289E-01	1.324E-01	1.426E-01	1.443E-01	1.541E-01	1.553E-01	1.664E-01	1.845E-01
0.070	1.557E-01	1.601E-01	1.724E-01	1.744E-01	1.864E-01	1.878E-01	2.015E-01	2.234E-01
0.080	1.803E-01	1.853E-01	1.995E-01	2.018E-01	2.157E-01	2.173E-01	2.333E-01	2.588E-01
0.090	2.029E-01	2.085E-01	2.244E-01	2.270E-01	2.426E-01	2.445E-01	2.625E-01	2.912E-01
0.100	2.241E-01	2.302E-01	2.476E-01	2.504E-01	2.676E-01	2.696E-01	2.897E-01	3.212E-01
0.15	3.169E-01	3.247E-01	3.483E-01	3.515E-01	3.753E-01	3.776E-01	4.057E-01	4.495E-01
0.20	3.956E-01	4.041E-01	4.319E-01	4.349E-01	4.634E-01	4.653E-01	4.995E-01	5.527E-01
0.25	4.679E-01	4.764E-01	5.075E-01	5.095E-01	5.418E-01	5.429E-01	5.819E-01	6.428E-01
0.30	5.369E-01	5.452E-01	5.788E-01	5.795E-01	6.148E-01	6.147E-01	6.579E-01	7.255E-01
0.40	6.711E-01	6.780E-01	7.157E-01	7.131E-01	7.533E-01	7.501E-01	8.004E-01	8.795E-01
0.50	8.031E-01	8.083E-01	8.490E-01	8.424E-01	8.865E-01	8.796E-01	9.358E-01	1.025E+00
0.60	9.353E-01	9.383E-01	9.816E-01	9.704E-01	1.018E+00	1.007E+00	1.068E+00	1.167E+00
0.70	1.069E+00	1.069E+00	1.115E+00	1.098E+00	1.149E+00	1.133E+00	1.200E+00	1.308E+00
0.80	1.203E+00	1.202E+00	1.249E+00	1.227E+00	1.280E+00	1.259E+00	1.330E+00	1.448E+00
0.90	1.340E+00	1.336E+00	1.384E+00	1.357E+00	1.412E+00	1.386E+00	1.462E+00	1.587E+00
1.00	1.479E+00	1.472E+00	1.522E+00	1.488E+00	1.545E+00	1.514E+00	1.594E+00	1.728E+00
1.5	2.212E+00	2.188E+00	2.239E+00	2.172E+00	2.235E+00	2.172E+00	2.271E+00	2.447E+00
2.0	3.010E+00	2.965E+00	3.013E+00	2.904E+00	2.970E+00	2.868E+00	2.984E+00	3.199E+00
2.5	3.879E+00	3.807E+00	3.847E+00	3.689E+00	3.753E+00	3.607E+00	3.737E+00	3.992E+00
3.0	4.820E+00	4.715E+00	4.742E+00	4.528E+00	4.587E+00	4.390E+00	4.532E+00	4.828E+00
4.0	6.927E+00	6.735E+00	6.721E+00	6.373E+00	6.410E+00	6.095E+00	6.256E+00	6.632E+00
5.0	9.337E+00	9.029E+00	8.954E+00	8.443E+00	8.444E+00	7.987E+00	8.160E+00	8.616E+00
6.0	1.206E+01	1.160E+01	1.144E+01	1.074E+01	1.069E+01	1.007E+01	1.025E+01	1.078E+01
7.0	1.509E+01	1.445E+01	1.419E+01	1.327E+01	1.315E+01	1.234E+01	1.252E+01	1.313E+01
8.0	1.844E+01	1.758E+01	1.720E+01	1.602E+01	1.583E+01	1.481E+01	1.498E+01	1.567E+01
9.0	2.210E+01	2.099E+01	2.047E+01	1.900E+01	1.873E+01	1.746E+01	1.762E+01	1.839E+01
10.0	2.609E+01	2.467E+01	2.399E+01	2.222E+01	2.184E+01	2.032E+01	2.045E+01	2.130E+01
15	5.076E+01	4.728E+01	4.552E+01	4.173E+01	4.066E+01	3.750E+01	3.743E+01	3.867E+01
20	8.324E+01	7.672E+01	7.343E+01	6.692E+01	6.487E+01	5.953E+01	5.910E+01	6.069E+01
25	1.233E+02	1.128E+02	1.076E+02	9.764E+01	9.436E+01	8.632E+01	8.540E+01	8.733E+01
30	1.706E+02	1.552E+02	1.477E+02	1.337E+02	1.290E+02	1.178E+02	1.162E+02	1.185E+02
40	2.860E+02	2.584E+02	2.452E+02	2.213E+02	2.130E+02	1.941E+02	1.910E+02	1.939E+02
50	4.276E+02	3.846E+02	3.646E+02	3.285E+02	3.159E+02	2.875E+02	2.825E+02	2.860E+02
60	5.938E+02	5.325E+02	5.045E+02	4.541E+02	4.365E+02	3.971E+02	3.898E+02	3.940E+02
70	7.832E+02	7.011E+02	6.639E+02	5.972E+02	5.739E+02	5.221E+02	5.121E+02	5.170E+02
80	9.948E+02	8.893E+02	8.418E+02	7.569E+02	7.273E+02	6.616E+02	6.488E+02	6.544E+02
90	1.227E+03	1.096E+03	1.038E+03	9.326E+02	8.959E+02	8.150E+02	7.990E+02	8.055E+02
100	1.480E+03	1.321E+03	1.250E+03	1.123E+03	1.079E+03	9.818E+02	9.623E+02	9.696E+02
150	3.014E+03	2.684E+03	2.539E+03	2.280E+03	2.190E+03	1.992E+03	1.952E+03	1.964E+03
200	4.952E+03	4.405E+03	4.166E+03	3.740E+03	3.592E+03	3.268E+03	3.201E+03	3.219E+03
250	7.229E+03	6.428E+03	6.078E+03	5.455E+03	5.239E+03	4.766E+03	4.667E+03	4.693E+03
300	9.795E+03	8.707E+03	8.232E+03	7.388E+03	7.095E+03	6.453E+03	6.319E+03	6.352E+03
400	1.562E+04	1.388E+04	1.312E+04	1.177E+04	1.131E+04	1.028E+04	1.007E+04	1.012E+04
500	2.221E+04	1.973E+04	1.865E+04	1.673E+04	1.606E+04	1.461E+04	1.430E+04	1.437E+04
600	2.937E+04	2.609E+04	2.465E+04	2.211E+04	2.123E+04	1.930E+04	1.890E+04	1.898E+04
700	3.697E+04	3.284E+04	3.103E+04	2.783E+04	2.672E+04	2.429E+04	2.378E+04	2.389E+04
800	4.492E+04	3.990E+04	3.770E+04	3.381E+04	3.246E+04	2.951E+04	2.889E+04	2.901E+04
900	5.315E+04	4.720E+04	4.460E+04	4.000E+04	3.840E+04	3.491E+04	3.417E+04	3.432E+04
1000	6.160E+04	5.469E+04	5.168E+04	4.635E+04	4.449E+04	4.045E+04	3.959E+04	3.976E+04