PhotonExcel Add-in

USER’S GUIDE

CONTENTS

1.0 Introduction 4
2.0 Structure and Functions 4
3.0 General Functionality (Physics Tab) 6
3.1 General Data Input Rules 7
3.2 Specific Input Rules for the Decay Routine 8
3.3 Creating MCNP SDef Files 10
4.0 General Functionality (Formulas Tab) 12
4.1 Physics Constants 12
4.2 Lookup and Reference 12
5.0 Calculation Examples 12
5.1 Example A Dose Rate Calculation 12
5.2 Example B Shielding Replicate the co60example.xlsm See Web Site 16
6.0 Installation Instructions for Windows 21
7.0 Appendicies 23
7.1 Appendix A : List of Built-in Absorbing Compounds 23

1.0 INTRODUCTION

The purpose of PhotonExcel add-in is to provide a simple interface between Excel and users for calculation of photon (gamma & X-ray) emission from any radioactive source. A simple interface provides users with a fast way to insert data on gamma/X-ray lines (energies & probabilities) and the physical constants into Excel for conducting calculation in dosimetry and shielding using all of the tools Excel has to offer. This add-in also allows users to quickly obtain such characteristics as activity, specific doses, decay products, attenuation and absorption coefficient for the selected element or compound.

It creates an additional Excel Tab called 'Physics':

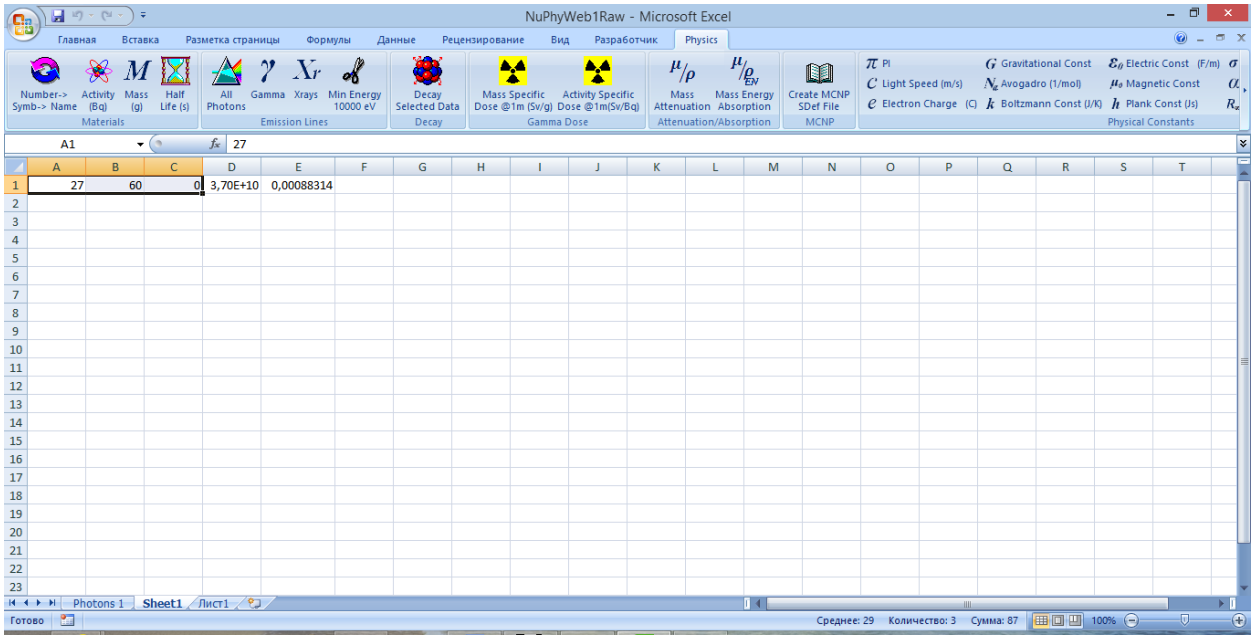
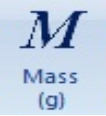


Figure 1 Selection of Physics Tab in Excel

2.0 STRUCTURE AND FUNCTIONS

The functions of each button (from left to right) are as follows:

	This button cycles between atomic number, element symbol and element name of any chemical element from the Periodic Table
	Calculates an activity in Becquerels from a mass in grams
	Converts a mass in grams to an activity in Becquerels.

Half Life (s)	Provides the half-life in seconds
All Photons	Provides all emission lines (gamma+X-rays) of the selected element, i.e. energies in eV and probability in part fraction
Gamma	Provides gamma emission lines of the selected element, i.e. energies in eV and probability in part fraction
Xrays	Provides X-ray emission lines of the selected element, i.e. energies in eV and probability in part fraction
Min Energy 10000 eV	Defines the minimum energy to be considered in photon spectrum
Decay Selected Data	Calculates the decay products of the selected isotope over selected time period
Mass Specific Dose @1m (Sv/g)	Calculates the mass specific dose of the selected element at 1m in $Sv(gh)^{-1}$
Activity Specific Dose @1m(Sv/Bq)	Calculates the activity specific dose of the selected element at 1m in $Sv(Bqh)^{-1}$
μ/ρ Mass Attenuation	Calculates mass attenuation coefficient for the selected element or compound in cm^2g^{-1}
μ/ρ_{EN} Mass Energy Absorption	Calculates mass energy absorption coefficient for the selected element or compound in cm^2g^{-1}
Load Table	Loads the table of build-up factors into the program's memory
Get Build Up	Retrieves an interpolated value of build-up factor B(E,μd)
Create MCNP SDef File	Create a file suitable for input to MCNP program
π PI	Inserts the mathematical constant π = 3.141592654

C Light Speed (m/s)	Inserts the physical constant Speed of Light C = 3E+08 m/s
e Electron Charge (C)	Inserts the physical constant of Electron Charge e = 1.60218E-19C
G Gravitational Const	Inserts the Gravitational constant G = 6.67384E-11 Nm^2kg^{-2}
N_A Avogadro (1/mol)	Inserts the Avogadro constant N_A = 6.02214E+23 mol^{-1}
k Boltzmann Const (J/K)	Inserts the Boltzmann constant k = 1.38066E-23 J/K
ε_0 Electric Const (F/m)	Inserts the Electric constant ε_0 = 8.85419E-12 Fm^{-1}
μ_0 Magnetic Const	Inserts the Magnetic constant μ_0 = 1.25664E-06 H m^{-1}
h Plank Const (Js)	Inserts the Plank constant h = 6.62608E-34 Js
σ Stefan-Boltzmann	Inserts the Stefan–Boltzmann constant σ = 5.67037E-08 W/m^2K^{-4}
α Fine Structure	Inserts the fine-structure constant α = 0.007297353
R_∞ Rydberg (1/m)	Inserts the Rydberg constant R_∞ = 10973731.57 m^{-1}
u Atomic Mass (kg)	Inserts the Atomic Mass constant u = 1.66054E-27 kg
m_p Proton Mass (kg)	Inserts the physical constant of Proton Mass m_p = 1.67262E-27 kg
m_e Electron Mass (kg)	Inserts the Electron Mass constant m_e = 9.10938E-31 kg

3.0 GENERAL FUNCTIONALITY (PHYSICS TAB)

Data input to the functions is most easily done by selecting a row of cells and clicking on the relevant button in the Physics tab. Different function buttons require differing number of cells to be selected. Buttons requiring one cell selection include all physical constants, the “Number-Symb-Name” function and the minimum energy function. The other function buttons require more than one cell to be selected. The data input information required must be placed in cells on the left-hand side and answer/ result of calculation will be placed on the far right column of your selection.

Figures 2 & 3 show screen shots depicting the action of selecting data and then inserting a function. In this case Uranium 238 with isomeric state 0 is the isotope, the data quantity is 1, clicking the Activity Button performs the calculation of deriving the activity in Becquerels for an input quantity of 1 gram. Figure 3 shows the answer in cell “F1” following the button click. The answer was inserted incell “F1” because “F1” was the far right hand cell of the initial data selection shown in figure 2.

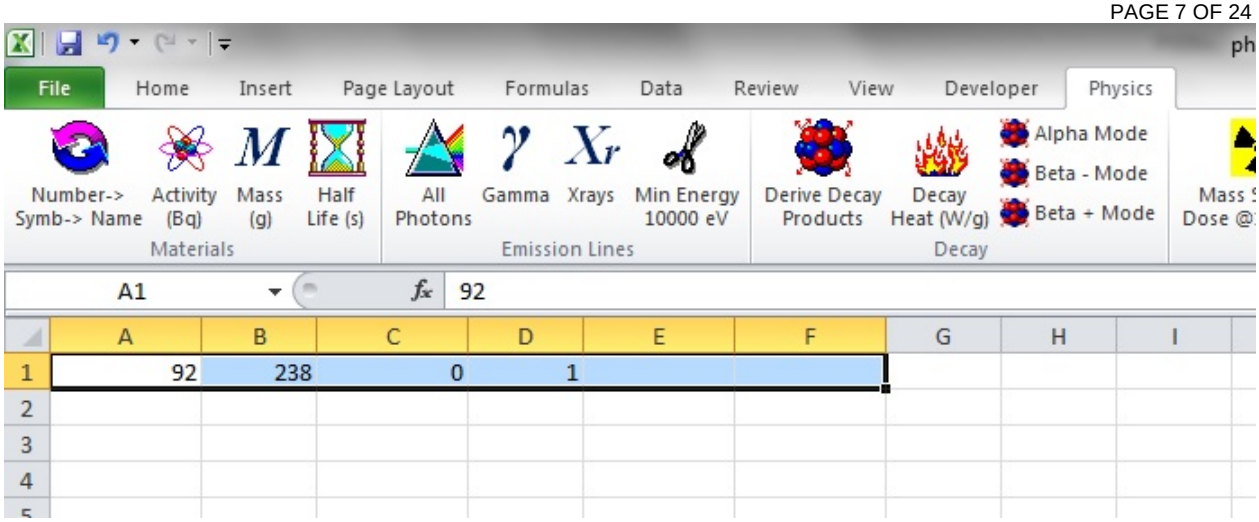


Figure 2 Example of Data Selection Before Pressing the Function Button

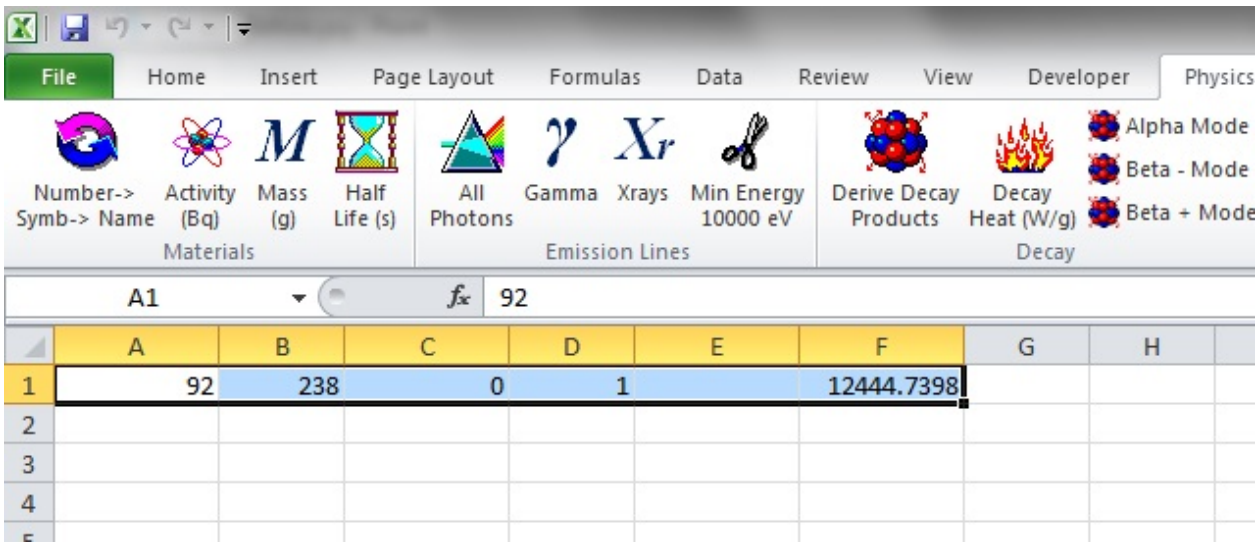


Figure 3 Screen Shot After Clicking on the Activity Button.

3.1 General Data Input Rules

Select a Data Input Block
The left hand column in the selection must contain an element number, symbol or name.
The next column on the left must contain the atomic mass.
The third column on the left should contain isomer information or remain blank.
The fourth column should contain an quantity data such as mass (g) or activity (Bq).
The result will be placed in the far right hand column selected.
For complex data types (emission lines, decay products etc) the result will be presented in a new worksheet.

3.2 Specific Input Rules for the Decay Routine

The “Derive Decay Products” routine has special data input rules. For this function a two line data input selection is required. Figure 4 shows an example of data input to calculate the decay products of Uranium 238 (Isomer 0) from a period starting in 1000s up to an end period of 1E+18 seconds or 3E+10 years. The results will be displayed in a new worksheet, decay product will be displayed in columns with ten lines of decay data (Number of Lines Input = 10). Output will displayed as mass in grams (Data Type Input = 1).

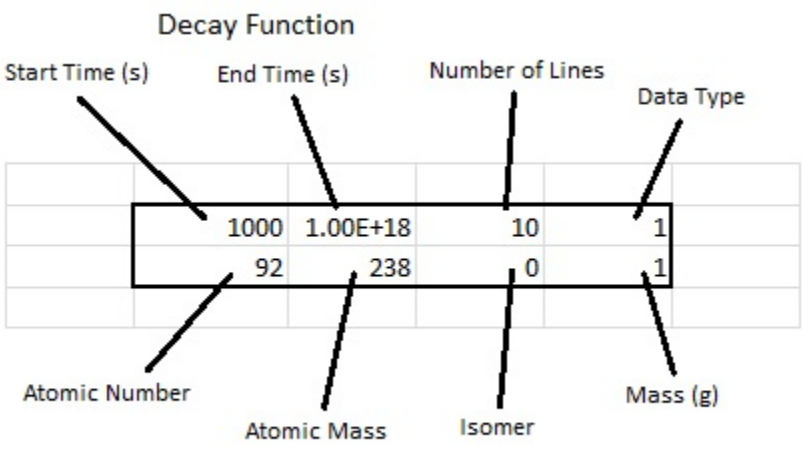
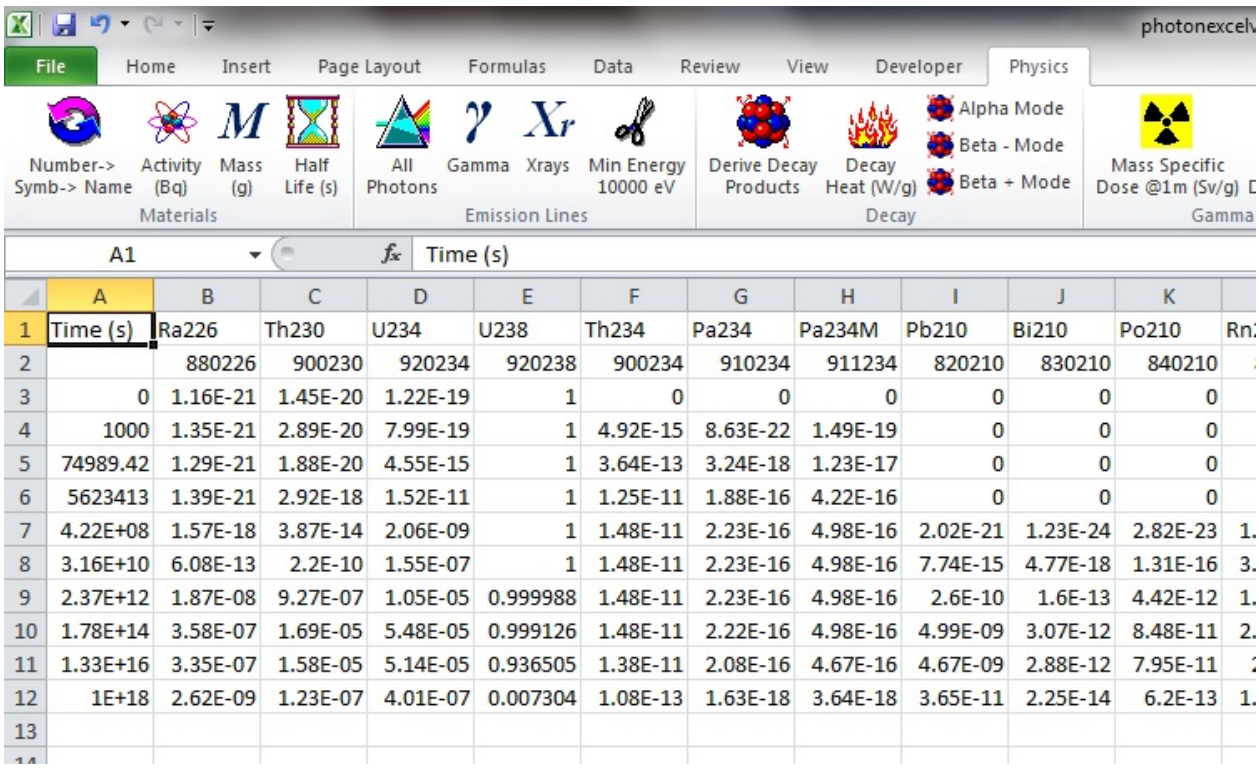


Figure 4 Decay Function Data Input



	A	B	C	D	E	F	G	H	I	J	K
1	Time (s)	Ra226	Th230	U234	U238	Th234	Pa234	Pa234M	Pb210	Bi210	Po210
2		880226	900230	920234	920238	900234	910234	911234	820210	830210	840210
3	0	1.16E-21	1.45E-20	1.22E-19	1	0	0	0	0	0	0
4	1000	1.35E-21	2.89E-20	7.99E-19	1	4.92E-15	8.63E-22	1.49E-19	0	0	0
5	74989.42	1.29E-21	1.88E-20	4.55E-15	1	3.64E-13	3.24E-18	1.23E-17	0	0	0
6	5623413	1.39E-21	2.92E-18	1.52E-11	1	1.25E-11	1.88E-16	4.22E-16	0	0	0
7	4.22E+08	1.57E-18	3.87E-14	2.06E-09	1	1.48E-11	2.23E-16	4.98E-16	2.02E-21	1.23E-24	2.82E-23
8	3.16E+10	6.08E-13	2.2E-10	1.55E-07	1	1.48E-11	2.23E-16	4.98E-16	7.74E-15	4.77E-18	1.31E-16
9	2.37E+12	1.87E-08	9.27E-07	1.05E-05	0.999988	1.48E-11	2.23E-16	4.98E-16	2.6E-10	1.6E-13	4.42E-12
10	1.78E+14	3.58E-07	1.69E-05	5.48E-05	0.999126	1.48E-11	2.22E-16	4.98E-16	4.99E-09	3.07E-12	8.48E-11
11	1.33E+16	3.35E-07	1.58E-05	5.14E-05	0.936505	1.38E-11	2.08E-16	4.67E-16	4.67E-09	2.88E-12	7.95E-11
12	1E+18	2.62E-09	1.23E-07	4.01E-07	0.007304	1.08E-13	1.63E-18	3.64E-18	3.65E-11	2.25E-14	6.2E-13
13											

Figure 5 Result of the Decay Function (Number of Lines = 10)

Should the “Number of Lines” input value be set to 1 then the results format is slightly different with only the final value being displayed in a set of rows. See example of this mode in figure 6.

	A	B	C	D	E
1	Element Number	Mass Number	Isomer	Mass	
2	80	206	0	4.81658E-25	
3	81	206	0	1.72273E-23	
4	82	206	0	0.992694835	
5	82	208	0	2.97808E-13	
6	82	209	0	8.49944E-24	
7	83	209	0	1.38977E-08	
8	81	210	0	8.08725E-22	
9	82	210	0	3.64576E-11	
10	83	210	0	2.24537E-14	
11	84	210	0	6.19799E-13	
12	82	214	0	8.33443E-17	
13	83	214	0	6.18986E-17	
14	84	214	0	8.51584E-24	
15	84	218	0	9.6425E-18	
16	85	218	0	1.65892E-23	
17	86	222	0	1.71258E-14	
18	88	226	0	2.61579E-09	
19	90	230	0	1.23236E-07	
20	90	234	0	1.07938E-13	
21	91	234	0	1.62542E-18	
22	91	234	1	3.639E-18	
23	92	234	0	4.00536E-07	
24	92	238	0	0.007304084	
25					
26					

Figure 6 Result of the Decay Function in Alternative Output Format (Number of Lines = 1).

The decay routine can accept more than one isotope as an input hence a mixture of substance can be decayed. Figure 7 gives an example of the input selection for a mixture that contains both uranium and thorium isotopes.

Specifically: 10 grams of Uranium 238, 2 grams of Uranium 235, 1.2 grams of Thorium 230 and 1.5 grams of Thorium 234.

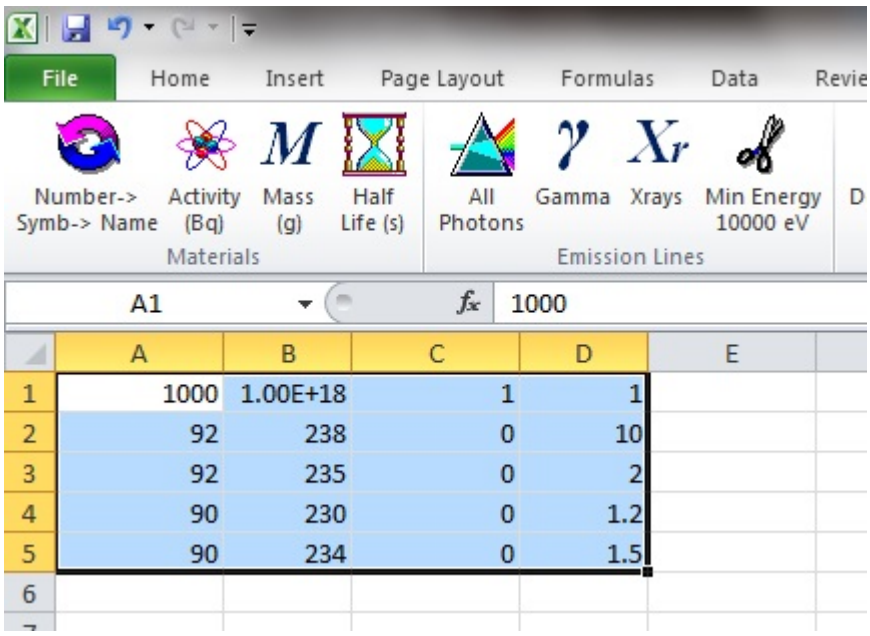


Figure 7 Input of a mixture for the decay routine.

3.3 Creating MCNP SDef Files

Rules are similar to the general rules for data input. Select the input isotope data, most left column for element number, the next column on the right for atomic number the next for isomer number and finally the quantity that should be presented in grams. Figure 8 shows an input selection example for a mixture of 3 grams of Cs-134 and 2 grams of Co-60.

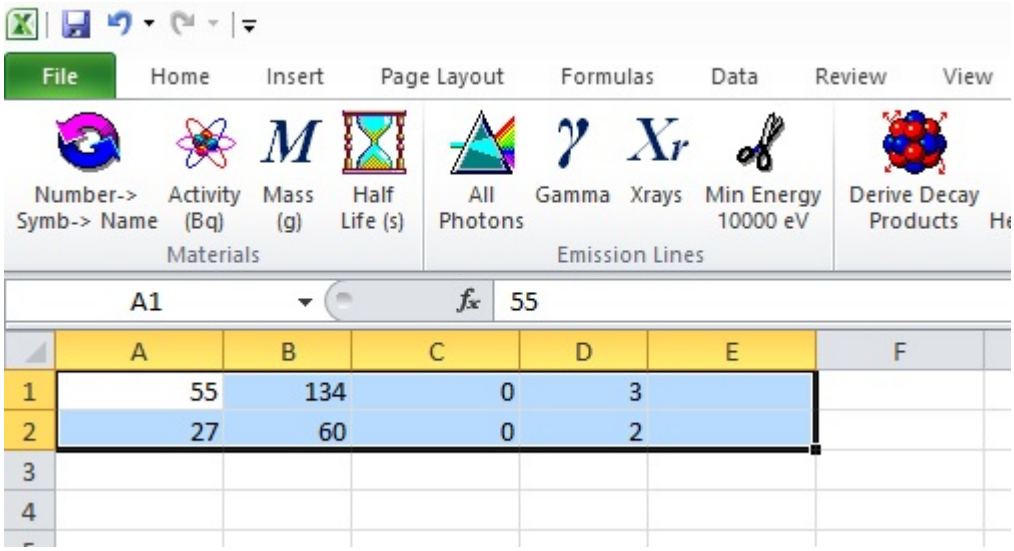


Figure 8 Input Selection for MCNP Sdef Creation

After selecting the input data, press the “Create MCNP SDef File” button in the Physics Tab. The file is created and a “Save File” dialog box is opened to allow the naming of the mcnp output file. Figure 9 shows the screen following clicking on the mcnp button, note the mcnp weighting is placed in the far right hand column of the data selection. Type in the file name and click save as usual windows file saving procedure. The file is created as a text file making it easy for the MCNP SDef code to be copied and paste into MCNP input text files. The output file includes a record of the isotope mixtures and the photon energy list. The actual SDef code is included at the end of the file following the isotope record.

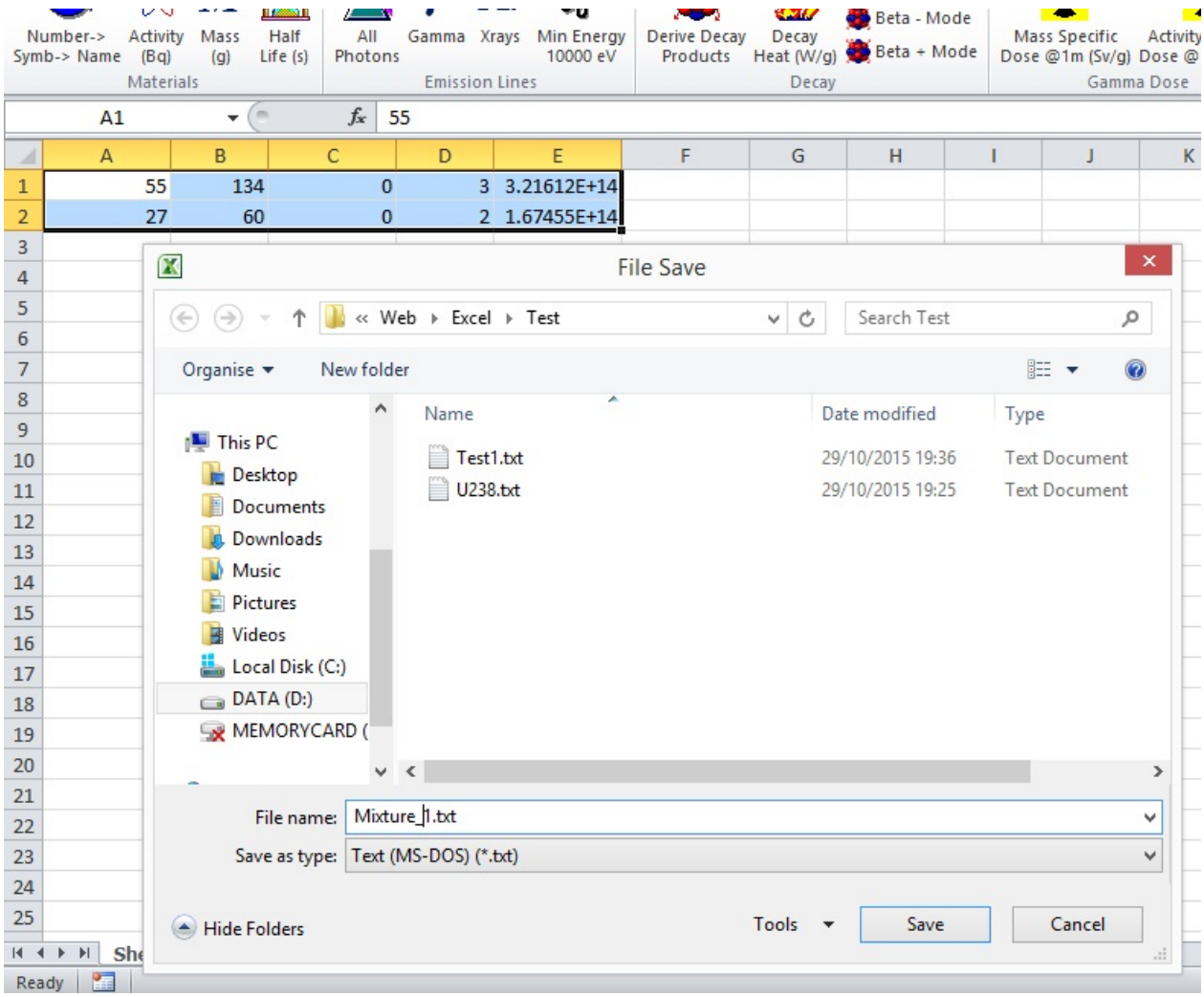


Figure 9 Creating MCNP SDef text files

4.0 GENERAL FUNCTIONALITY (FORMULAS TAB)

4.1 Physics Constants

From version 3 onwards some physics functions are included in the Formulas Tab of the Excel spreadsheet. The Physics constants are available via a constants button in a new Physics Group. Just click on the constants button to get a drop-down list of the constants available.

4.2 Lookup and Reference

From version 3 onwards some physics functions are included in the Formulas Tab of the Excel spreadsheet. Some of the functions that require data input, such as isotope information, are listed in the “Lookup and Reference” section of the function library. Click on the Lookup & Reference button and select the required function from the drop-down list. Fill in the data input boxes as in the usual Excel function method.

5.0 CALCULATION EXAMPLES

5.1 Example A Dose Rate Calculation

Find the equivalent gamma dose rate from 1 MBq of Co-60 at 1 metre.

We will use the following formula for a gamma dose:

$$\frac{dH}{dT}(\mu Sv/h) = (5.77 \cdot 10^{-4}) \cdot \frac{A}{4\pi R^2} \cdot \sum_i E_i(keV) \cdot P_i \cdot (\frac{\mu}{\rho})_i^{tis} \qquad [1]$$

where A is the activity of the source, R is the distance in cm, E_i and P_i the gamma emission energy and emission probability per disintegration respectively; $(\mu t/\rho)^{tis}$ is the absorption coefficient for tissues. The summation must include all emission lines.

1. Type element symbol ‘Co’ in the cell A1 (or atomic number ‘27’, or element name ‘Cobalt’) and press Enter;

2. Enter ‘60’ in the B1 cell;
3. Enter the isomeric state in C1, in this example there is no isomeric state and C1 can be left blank;

4. Drag cursor to select 2 cells (in case of isomer 3 Cells) A1+B1(+C1) together and press 'All photons' button

5. A new worksheet 'Photons 1' will be opened consisting the six gamma energies in eV in the column B and their emission probabilities in the column C;

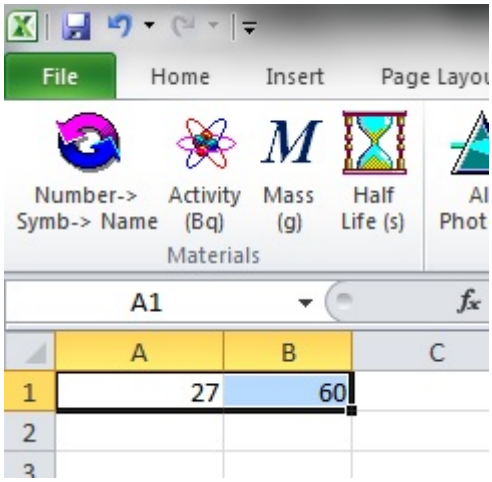


Figure 10 "Sheet 1" : Steps 1 – 4

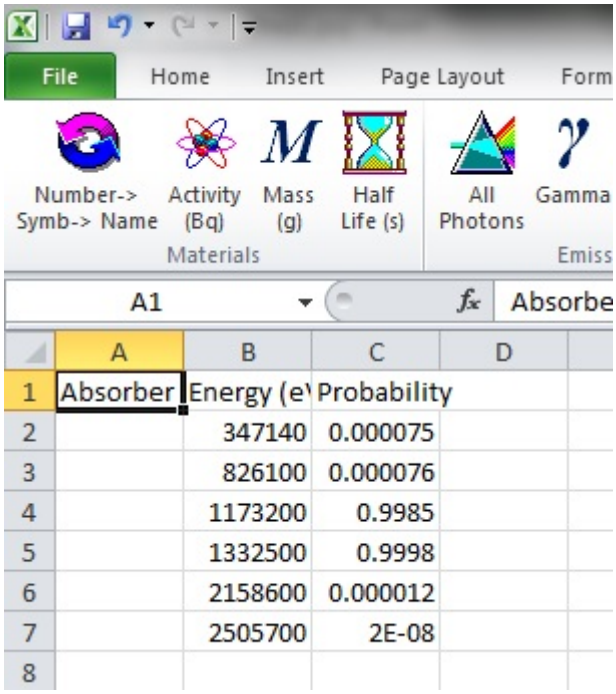
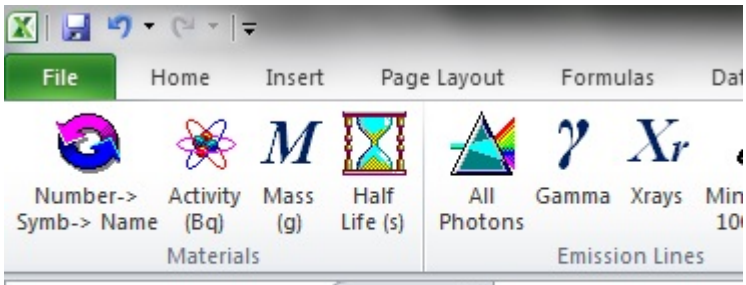


Figure 11 "Photons 1" : Step 5

6. Enter an absorbing material 'tissue' in the column A

7. Select the cells from A2 to D7 and press 'Mass energy absorption' button

Column D will show tissue absorption coefficients in cm^2g^{-1};



	A	B	C	D	E
1	Absorber	Energy (e'	Probability		
2	Tissue	347140	0.000075	0.032048	
3	Tissue	826100	0.000076	0.031621	
4	Tissue	1173200	0.9985	0.029763	
5	Tissue	1332500	0.9998	0.028921	
6	Tissue	2158600	0.000012	0.025176	
7	Tissue	2505700	2E-08	0.023946	
8					
9					

Figure 12 “Photons 1” : Steps 6 & 7

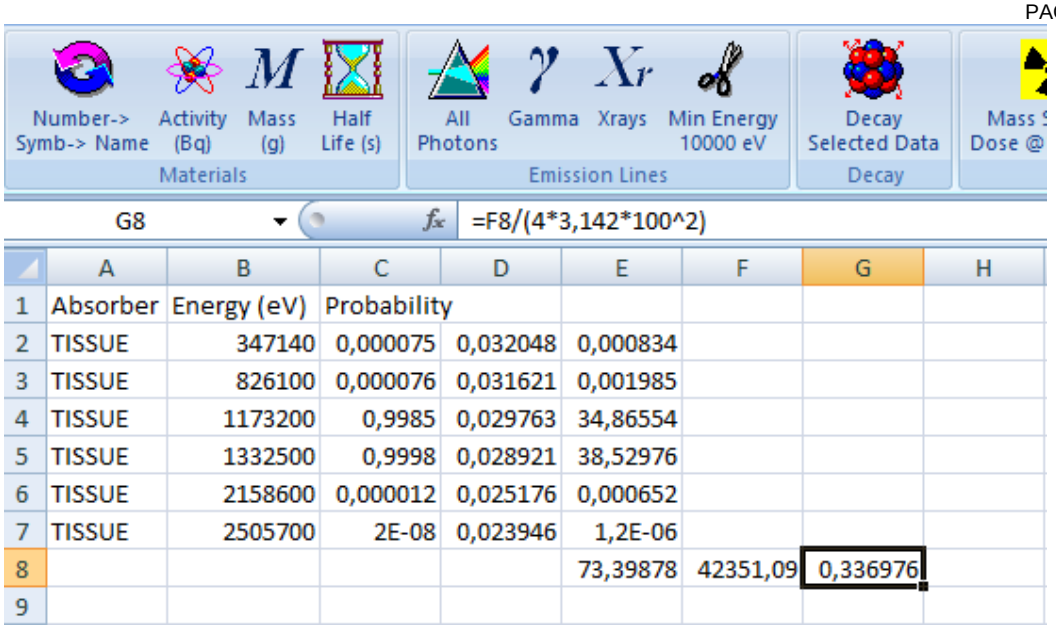
8. In E column write a formula ‘=B2*C2*D2/1000’ to find a term under the sign of summation;

9. Sum the data in E column and place an answer at E8 cell;

10. Multiply the result of summation by activity A=10^6 Bq and coefficient 5.77e-4 and place an answer at F8 cell: ‘=E8*1000000*0,000577’

11. Finally divide by $4\pi R^2$; where R=100 cm and place the result in cell G8: ‘=F8/(4*3,142*100^2)’.

The result is 0.337 μSv/h



	A	B	C	D	E	F	G	H
1	Absorber	Energy (eV)	Probability					
2	TISSUE	347140	0,000075	0,032048	0,000834			
3	TISSUE	826100	0,000076	0,031621	0,001985			
4	TISSUE	1173200	0,9985	0,029763	34,86554			
5	TISSUE	1332500	0,9998	0,028921	38,52976			
6	TISSUE	2158600	0,000012	0,025176	0,000652			
7	TISSUE	2505700	2E-08	0,023946	1,2E-06			
8					73,39878	42351,09	0,336976	
9								

Figure 13 “Photons 1” : Steps 8 - 11

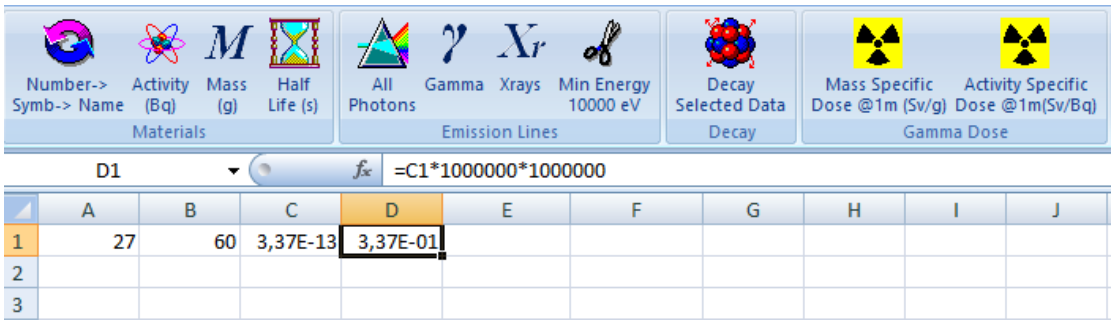
There is another **short** way of calculation of the gamma dose rate.

1. Repeat steps 1-3

2. Drag cursor to select 3 cells (in case of isomer 4 sells) A1+B1+C1(+D1) together and press ‘Activity Specific Dose’ button

3. The result gives the activity at 1 metre in Sv / (Bq*h) in the cell C1.

4. To account for 1 MBq and to change Sv to μSv we multiply by 1.e12 and place a result into D1 cell.



	A	B	C	D	E	F	G	H	I	J
1	27	60	3,37E-13	3,37E-01						
2										
3										

Figure 14 “Sheet 1” : Using the “Activity Specific Dose” Button.

5.2 Example B Shielding Replicate the co60example.xlsm See Web Site

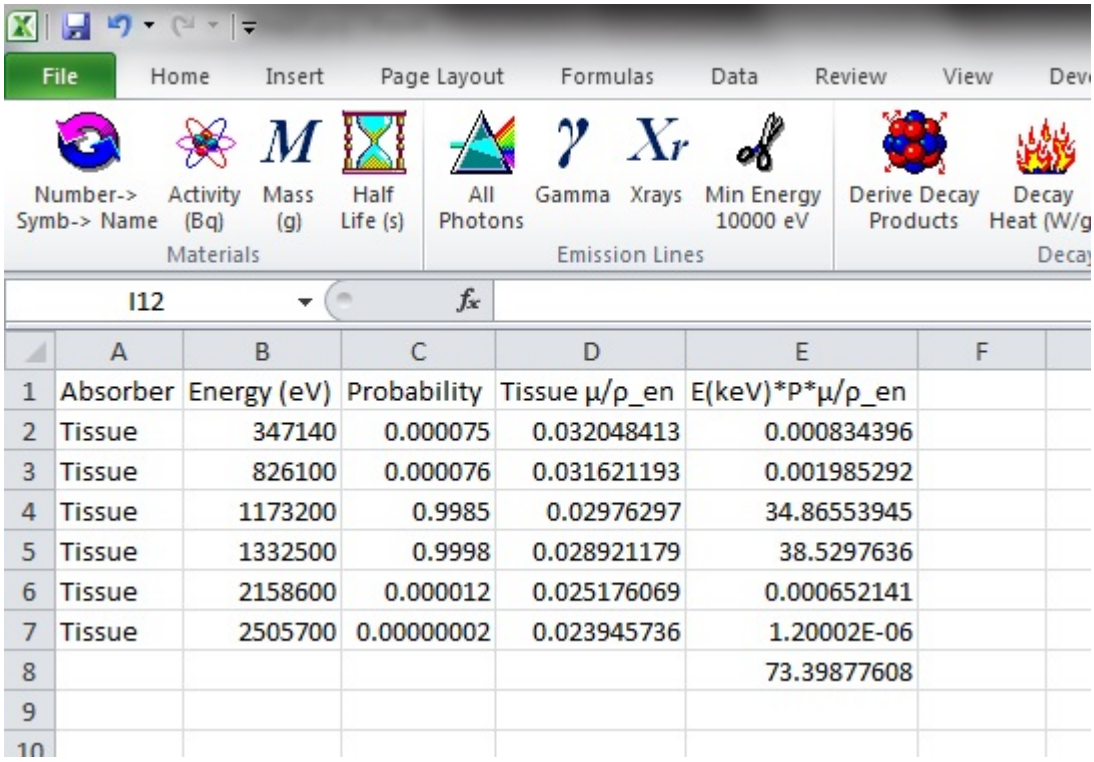
Based on the previous calculations, find the dose rate from the same source of Co-60 at 100 cm distance, when 3 cm thick lead shield is added between the source and detector.

$$\frac{dH}{dT}(\mu Sv/h) = (5.77\cdot 10^{-4})\cdot\frac{A}{4\pi R^2}\cdot\sum_i E_i(keV)\cdot P_i\cdot B_i\cdot e^{-(\mu/\rho)_i^{shield}\cdot(\rho d)}\cdot(\frac{\mu}{\rho})_i^{tis} \quad [2]$$

This formula has additional terms under summation sign:

build-up factor B(μd) as a function of mean free path μd, where d=3 cm is shield thickness and μ is attenuation coefficient.

1. Repeat steps 1-9 from Example A & Type Column Titles in cells D1 & E1.



	A	B	C	D	E	F
1	Absorber	Energy (eV)	Probability	Tissue μ/ρ_en	E(keV)*P*μ/ρ_en	
2	Tissue	347140	0.000075	0.032048413	0.000834396	
3	Tissue	826100	0.000076	0.031621193	0.001985292	
4	Tissue	1173200	0.9985	0.02976297	34.86553945	
5	Tissue	1332500	0.9998	0.028921179	38.5297636	
6	Tissue	2158600	0.000012	0.025176069	0.000652141	
7	Tissue	2505700	0.00000002	0.023945736	1.20002E-06	
8					73.39877608	
9						
10						

Figure 15 “Photons 1” : Example B Step 1

2. Add some shield data in Cells B11, B12 & B13, name these cells Thickness, Density & Geometry respectively, see Figure 16.

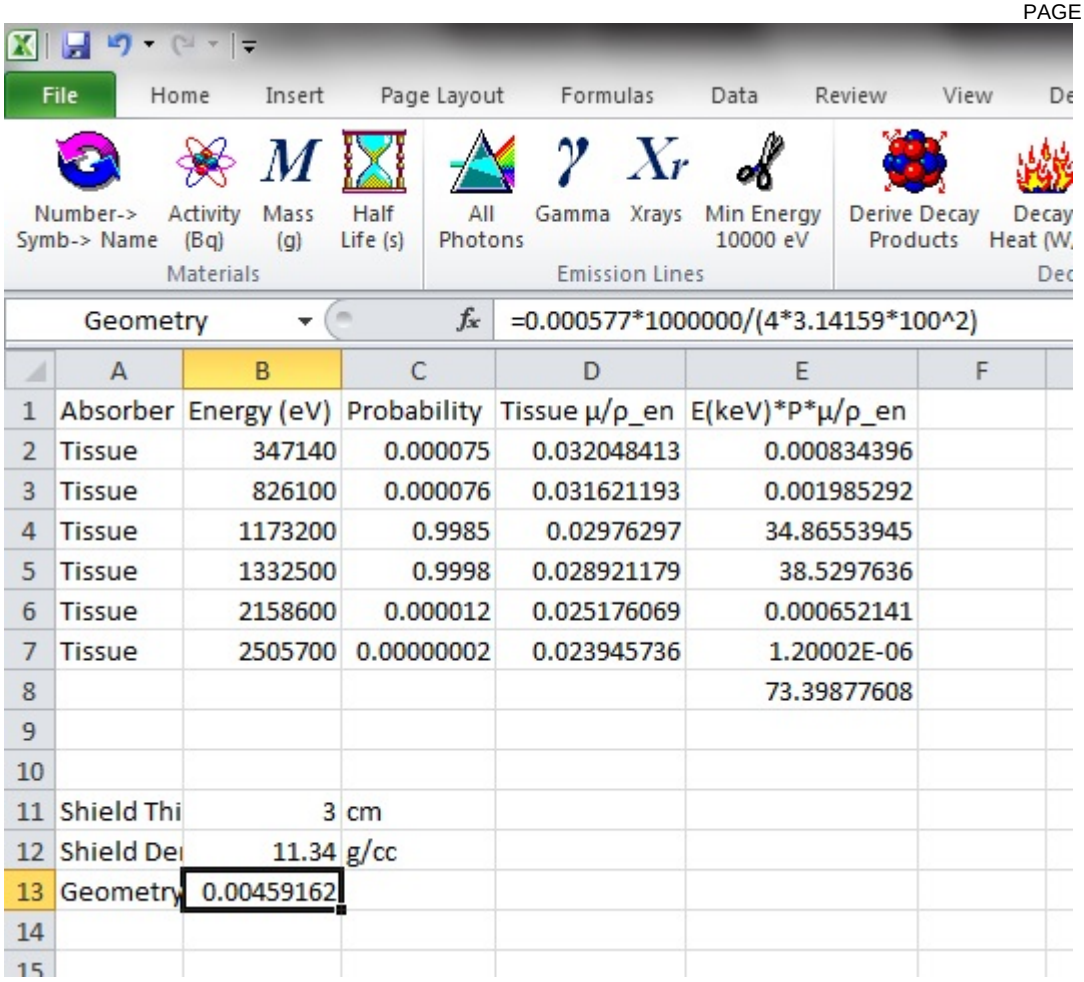


Figure 16 “Photons 1” : Step 2

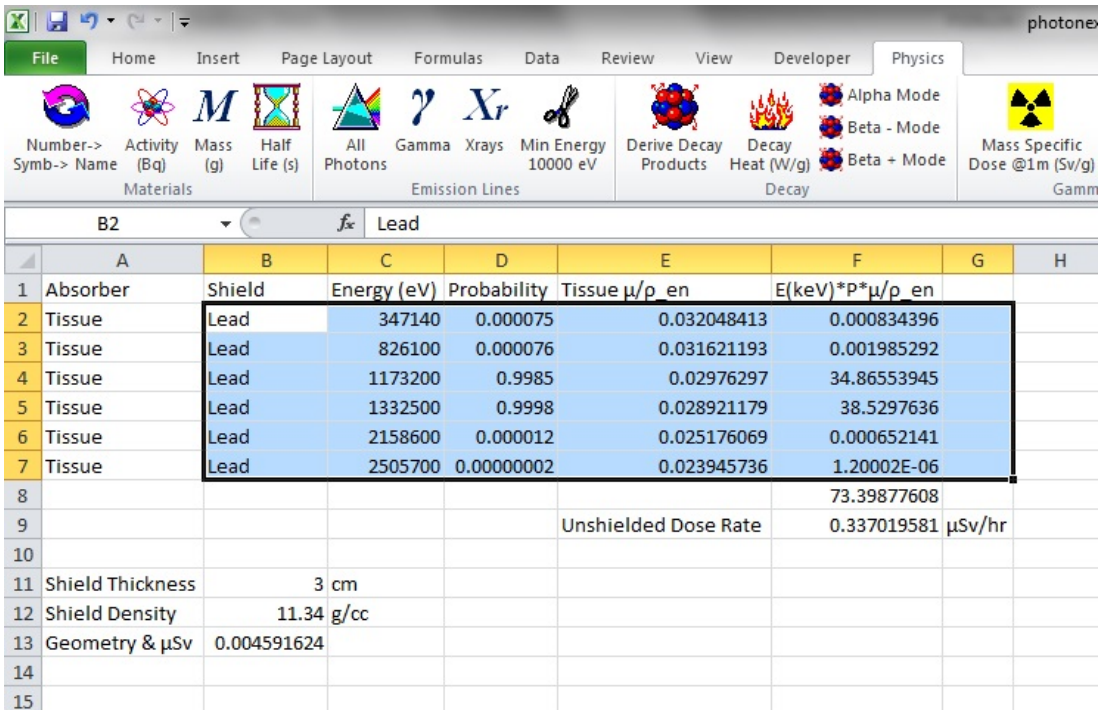


Figure 17 “Photons 1” Step 3

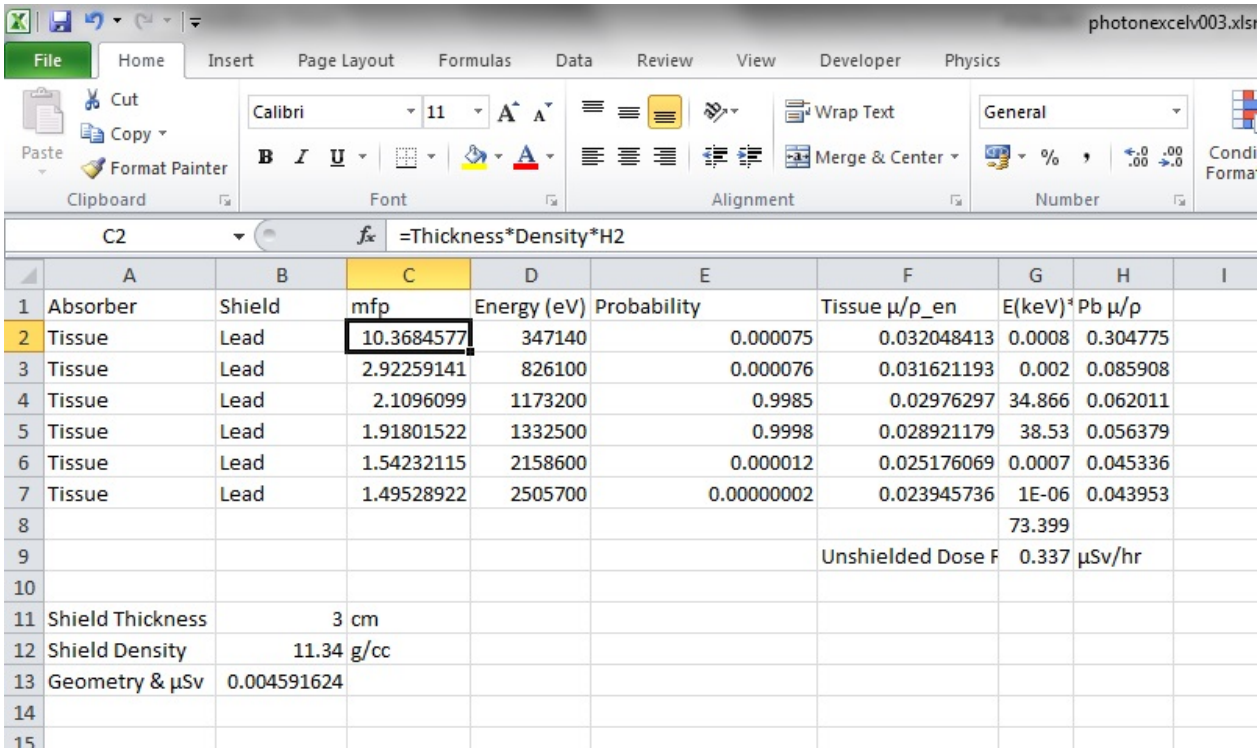
3. Place the formula “=E8*Geometry” in Cell E9, which will give the unshielded dose rate. Select Cells B1 to B10 and click “Insert” in the Home Tab to add a new column B and input a shield material name ‘lead’.

4. Select B2-G7 cells and click ‘Mass attenuation’ button

Mass attenuation coefficients will appear in column G. Place a column tile in cell G1.

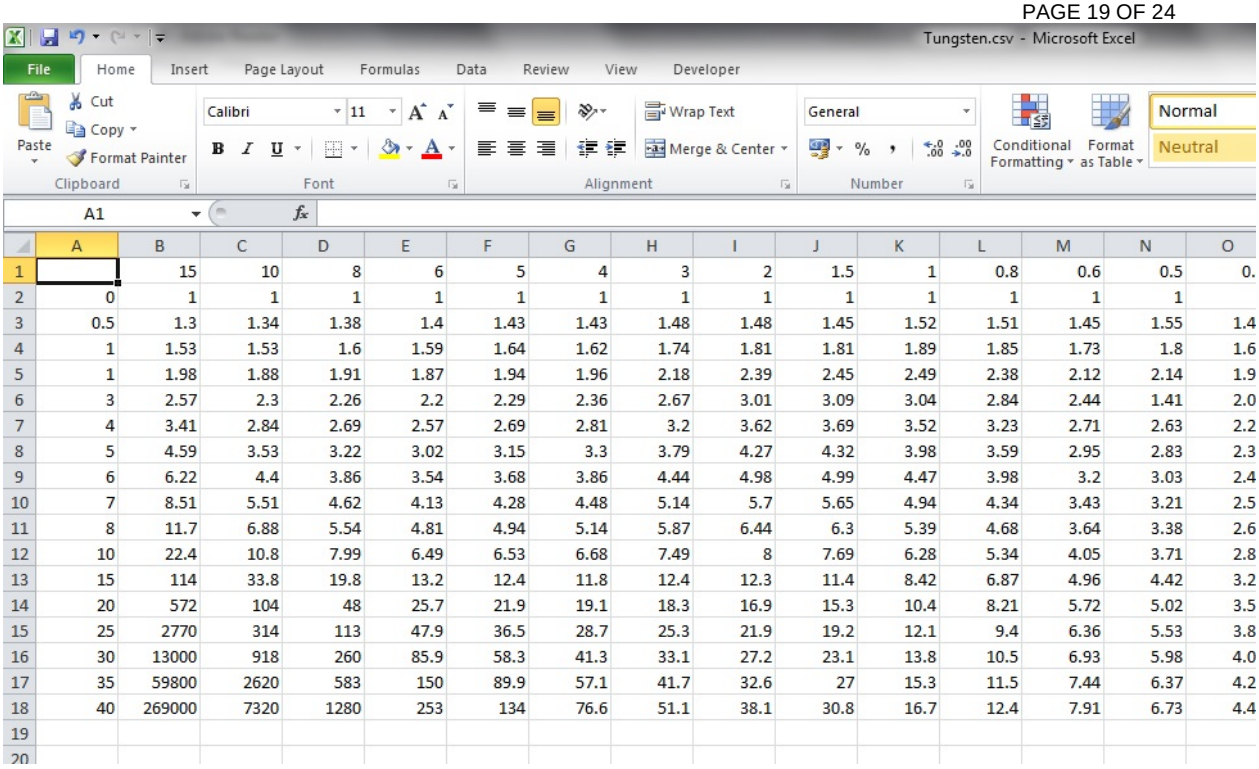
5. Select Cells C1 to C10 and click “Insert” in the Home Tab to add a new column C and calculate mean free path μd ‘= Thickness*Density*(H2 to H7)’

6. Create your own table of build-up factors for the relevant shield material in a new worksheet. The first row (from Row 1 Column B and across) should contain the energy divisions in MeV starting from the highest and working down. The first column (from Row 2 Column A and downwards) should contain the mean free path divisions starting from zero. The build-up factors are then placed into the table from Cell B2 onwards, see example figure 19. Build-up factors can be obtained from various sources on the web, including links on the Photon Excel site.



	A	B	C	D	E	F	G	H	I
1	Absorber	Shield	mfp	Energy (eV)	Probability	Tissue μ/ρ_en	E(keV)*	Pb μ/ρ	
2	Tissue	Lead	10.3684577	347140	0.000075	0.032048413	0.0008	0.304775	
3	Tissue	Lead	2.92259141	826100	0.000076	0.031621193	0.002	0.085908	
4	Tissue	Lead	2.1096099	1173200	0.9985	0.02976297	34.866	0.062011	
5	Tissue	Lead	1.91801522	1332500	0.9998	0.028921179	38.53	0.056379	
6	Tissue	Lead	1.54232115	2158600	0.000012	0.025176069	0.0007	0.045336	
7	Tissue	Lead	1.49528922	2505700	0.00000002	0.023945736	1E-06	0.043953	
8							73.399		
9						Unshielded Dose F	0.337	μSv/hr	
10									
11	Shield Thickness	3	cm						
12	Shield Density	11.34	g/cc						
13	Geometry & μSv	0.004591624							
14									
15									

Figure 18 “Photons 1” : Steps 4 & 5

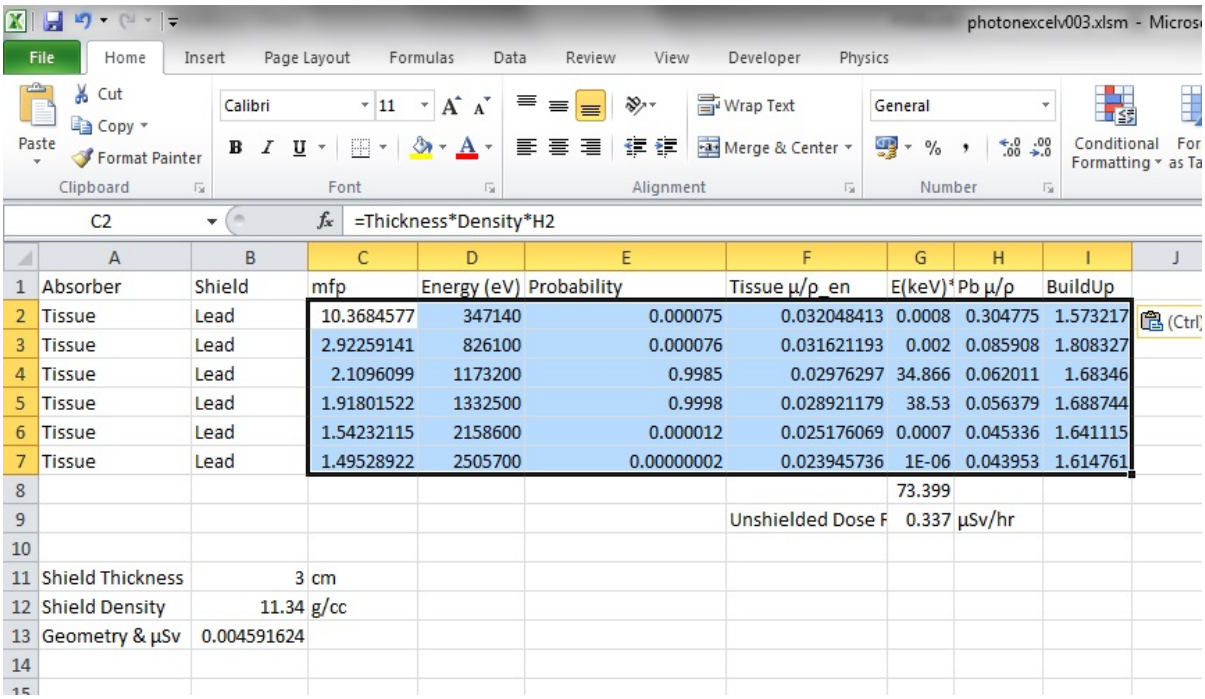


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5	0.
2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	
3	0.5	1.3	1.34	1.38	1.4	1.43	1.43	1.48	1.48	1.45	1.52	1.51	1.45	1.55	1.4
4	1	1.53	1.53	1.6	1.59	1.64	1.62	1.74	1.81	1.81	1.89	1.85	1.73	1.8	1.6
5	1	1.98	1.88	1.91	1.87	1.94	1.96	2.18	2.39	2.45	2.49	2.38	2.12	2.14	1.9
6	3	2.57	2.3	2.26	2.2	2.29	2.36	2.67	3.01	3.09	3.04	2.84	2.44	1.41	2.0
7	4	3.41	2.84	2.69	2.57	2.69	2.81	3.2	3.62	3.69	3.52	3.23	2.71	2.63	2.2
8	5	4.59	3.53	3.22	3.02	3.15	3.3	3.79	4.27	4.32	3.98	3.59	2.95	2.83	2.3
9	6	6.22	4.4	3.86	3.54	3.68	3.86	4.44	4.98	4.99	4.47	3.98	3.2	3.03	2.4
10	7	8.51	5.51	4.62	4.13	4.28	4.48	5.14	5.7	5.65	4.94	4.34	3.43	3.21	2.5
11	8	11.7	6.88	5.54	4.81	4.94	5.14	5.87	6.44	6.3	5.39	4.68	3.64	3.38	2.6
12	10	22.4	10.8	7.99	6.49	6.53	6.68	7.49	8	7.69	6.28	5.34	4.05	3.71	2.8
13	15	114	33.8	19.8	13.2	12.4	11.8	12.4	12.3	11.4	8.42	6.87	4.96	4.42	3.2
14	20	572	104	48	25.7	21.9	19.1	18.3	16.9	15.3	10.4	8.21	5.72	5.02	3.5
15	25	2770	314	113	47.9	36.5	28.7	25.3	21.9	19.2	12.1	9.4	6.36	5.53	3.8
16	30	13000	918	260	85.9	58.3	41.3	33.1	27.2	23.1	13.8	10.5	6.93	5.98	4.0
17	35	59800	2620	583	150	89.9	57.1	41.7	32.6	27	15.3	11.5	7.44	6.37	4.2
18	40	269000	7320	1280	253	134	76.6	51.1	38.1	30.8	16.7	12.4	7.91	6.73	4.4

Figure 19 “Buildup Pb” : Step 6 Example Build-Up Factor Table

7. Select all cells of the build-up table and press the button ‘Load table’ . A message informing of the correct loading of data should appear.

8. Return to your previous worksheet “Photons 1”, select cells C2-I7, and press ‘Get Build-up’ Interpolated Build-up factors will appear in column I, place title in Cell I1.



	A	B	C	D	E	F	G	H	I	J
1	Absorber	Shield	mfp	Energy (eV)	Probability	Tissue μ/ρ_en	E(keV)⁴	Pb μ/ρ	BuildUp	
2	Tissue	Lead	10.3684577	347140	0.000075	0.032048413	0.0008	0.304775	1.573217	(Ctrl)
3	Tissue	Lead	2.92259141	826100	0.000076	0.031621193	0.002	0.085908	1.808327	
4	Tissue	Lead	2.1096099	1173200	0.9985	0.02976297	34.866	0.062011	1.68346	
5	Tissue	Lead	1.91801522	1332500	0.9998	0.028921179	38.53	0.056379	1.688744	
6	Tissue	Lead	1.54232115	2158600	0.000012	0.025176069	0.0007	0.045336	1.641115	
7	Tissue	Lead	1.49528922	2505700	0.00000002	0.023945736	1E-06	0.043953	1.614761	
8							73.399			
9						Unshielded Dose F	0.337	μSv/hr		
10										
11	Shield Thickness	3	cm							
12	Shield Density	11.34	g/cc							
13	Geometry & μSv	0.004591624								
14										

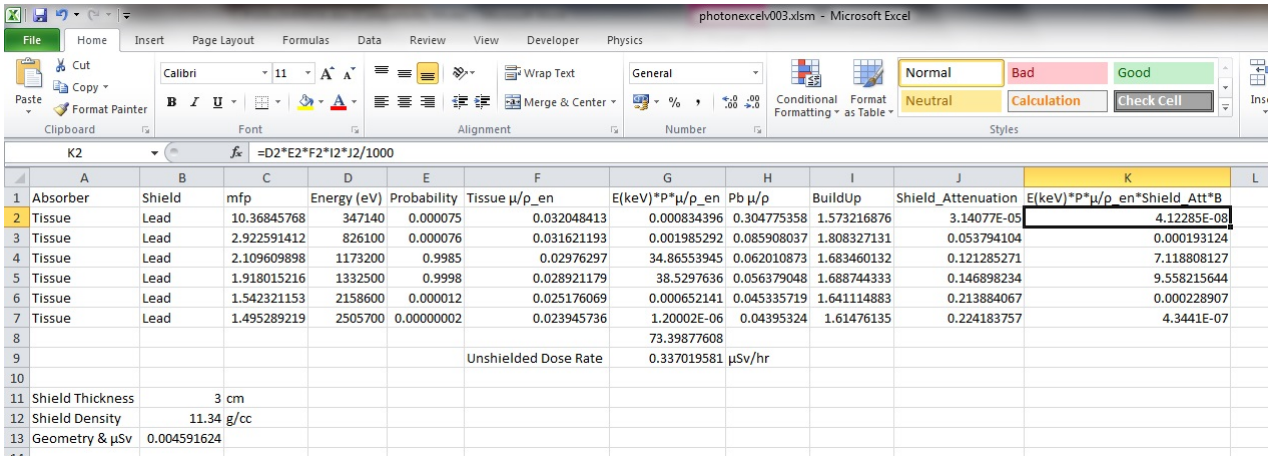
Figure 20 “Photons 1” : Steps 7 & 8

9. Calculated the Shield Attenuation = EXP(-(H2 to H7) * Density * Thickness) and place in column J.

10. Calculate the dose rate contributions columns d * e * f * I * j / 1000 and place in column K.

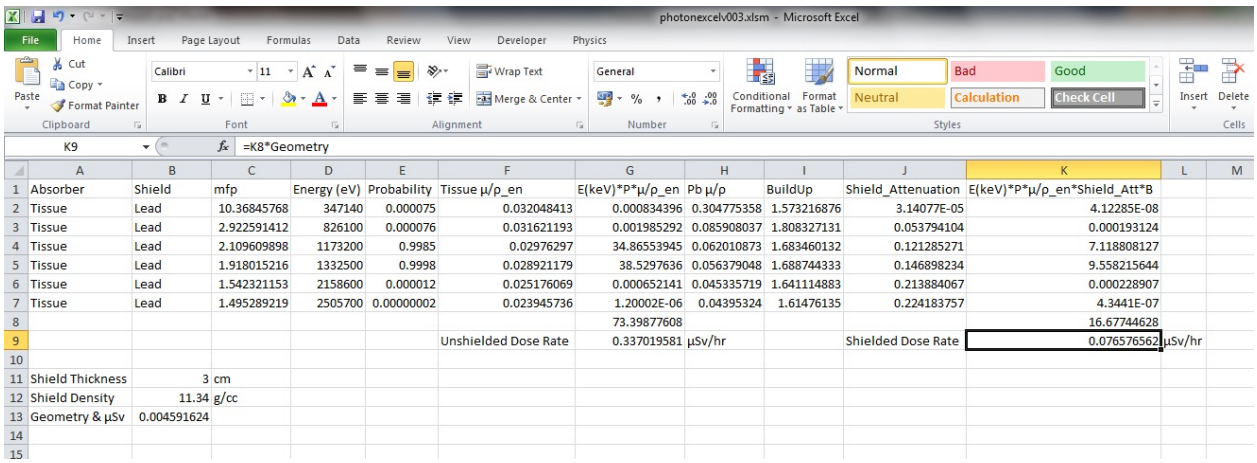
11. Sum the dose rates of column K into Cell K8

12. Multiply the summed dose rates by the geometry factor and placed in Cell K9 (K9 = K8 * Geometry). Result of shielded dose rate is produced as 0.077µSv/hr.



	A	B	C	D	E	F	G	H	I	J	K
1	Absorber	Shield	mfp	Energy (eV)	Probability	Tissue µ/ρ_en	E(keV)*P*µ/ρ_en	Pb µ/ρ	BuildUp	Shield_Attenuation	E(keV)*P*µ/ρ_en*Shield_Att*B
2	Tissue	Lead	10.36845768	347140	0.000075	0.032048413	0.000834396	0.304775358	1.573216876	3.14077E-05	4.12285E-08
3	Tissue	Lead	2.922591412	826100	0.000076	0.031621193	0.001985292	0.085908037	1.808327131	0.053794104	0.000193124
4	Tissue	Lead	2.109609898	1173200	0.9985	0.02976297	34.86553945	0.062010873	1.683460132	0.121285271	7.118808127
5	Tissue	Lead	1.918015216	1332500	0.9998	0.028921179	38.5297636	0.056379048	1.688744333	0.146898234	9.558215644
6	Tissue	Lead	1.542321153	2158600	0.000012	0.025176069	0.000652141	0.045335719	1.641114883	0.213884067	0.000228907
7	Tissue	Lead	1.495289219	2505700	0.00000002	0.023945736	1.20002E-06	0.04395324	1.61476135	0.224183757	4.3441E-07
8							73.39877608				
9						Unshielded Dose Rate	0.337019581	µSv/hr			
10											
11	Shield Thickness	3	cm								
12	Shield Density	11.34	g/cc								
13	Geometry & µSv	0.004591624									

Figure 21 “Photons 1” : Steps 9 & 10.



	A	B	C	D	E	F	G	H	I	J	K
1	Absorber	Shield	mfp	Energy (eV)	Probability	Tissue µ/ρ_en	E(keV)*P*µ/ρ_en	Pb µ/ρ	BuildUp	Shield_Attenuation	E(keV)*P*µ/ρ_en*Shield_Att*B
2	Tissue	Lead	10.36845768	347140	0.000075	0.032048413	0.000834396	0.304775358	1.573216876	3.14077E-05	4.12285E-08
3	Tissue	Lead	2.922591412	826100	0.000076	0.031621193	0.001985292	0.085908037	1.808327131	0.053794104	0.000193124
4	Tissue	Lead	2.109609898	1173200	0.9985	0.02976297	34.86553945	0.062010873	1.683460132	0.121285271	7.118808127
5	Tissue	Lead	1.918015216	1332500	0.9998	0.028921179	38.5297636	0.056379048	1.688744333	0.146898234	9.558215644
6	Tissue	Lead	1.542321153	2158600	0.000012	0.025176069	0.000652141	0.045335719	1.641114883	0.213884067	0.000228907
7	Tissue	Lead	1.495289219	2505700	0.00000002	0.023945736	1.20002E-06	0.04395324	1.61476135	0.224183757	4.3441E-07
8							73.39877608				16.67744628
9						Unshielded Dose Rate	0.337019581	µSv/hr		Shielded Dose Rate	0.076576562 µSv/hr
10											
11	Shield Thickness	3	cm								
12	Shield Density	11.34	g/cc								
13	Geometry & µSv	0.004591624									
14											
15											

Figure 22 “Photons 1” : Final Result

6.0 INSTALLATION INSTRUCTIONS FOR WINDOWS

1. Download the Spreadsheet “Photonexcelv003.xlsm” Can be copied and used anywhere on the installation computer.

2. Download the dynamic link library “PSDExSm001.dll” and save to a temporary location.

3. Start the spreadsheet. There may be a Macros Disabled warning, You need to click on the “Enable Content” button, see fig 23

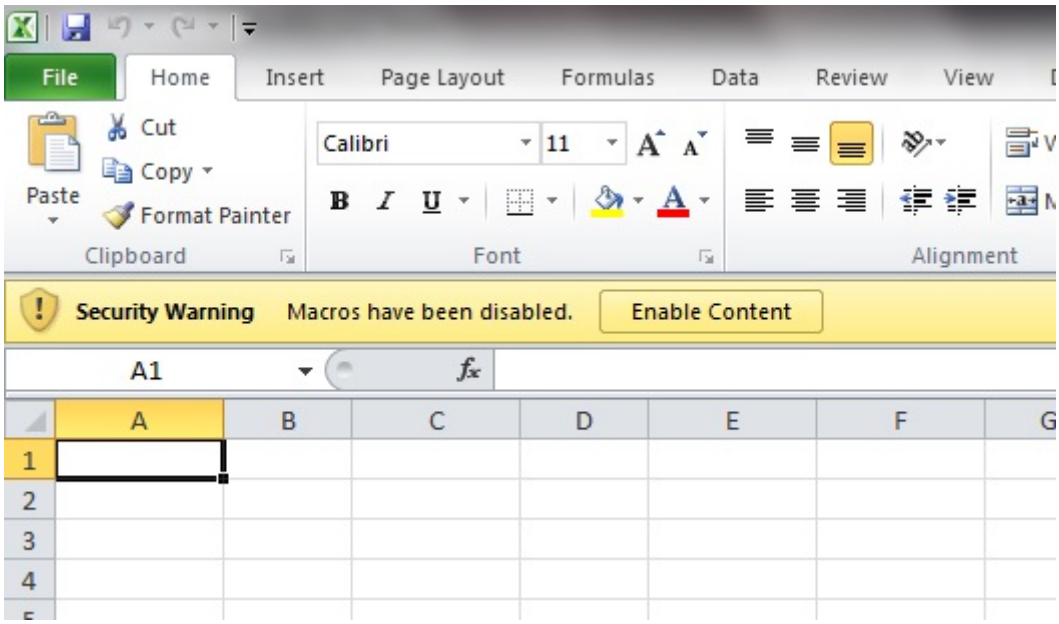


Figure 23 Macros Disabled Warning

4. The Program will give two further warnings about licensing the product and finding the dll, figures 24 & 25.

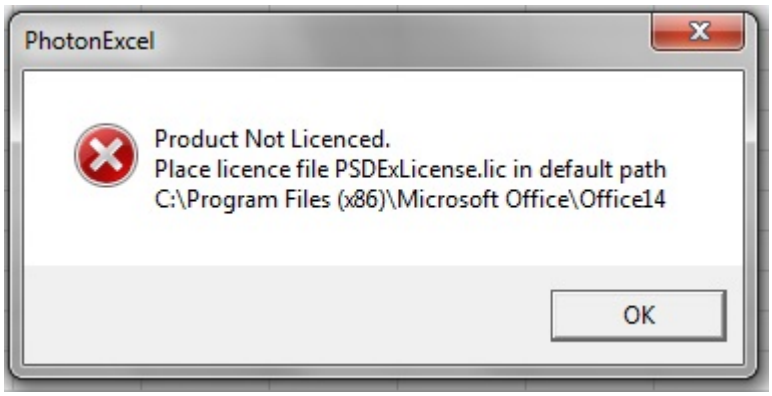


Figure 24 Product not Licensed Warning

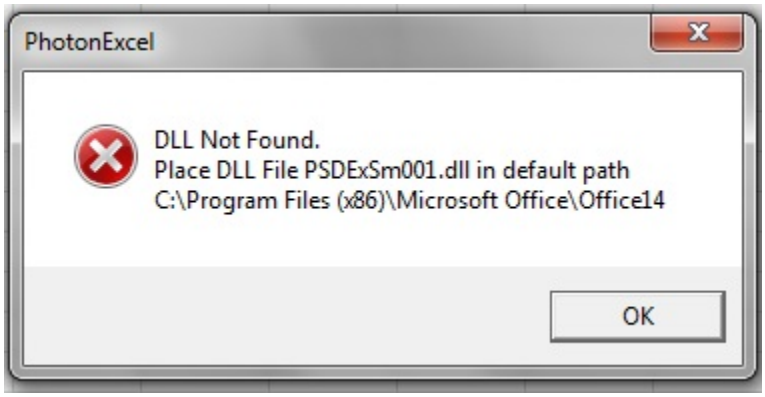


Figure 25 DLL Not Found Warning

5. The next step is to install the DLL. The DLL not found warning box also gives a location where the program is looking for the file. In figure 25 the location is C:\Program Files (x86)\Mircosoft Office\Office14\. Place the DLL file into the location advised by the warning message.

6. Restart the spreadsheet and if all is well the program will start with just one warning about licensing (Fig 24). The software should now show the Physics Tab with most functions enabled. Those functions that are disabled will require a license file.

7. To obtain a license file click on the “Get Product License” button under the Physics Tab and follow the instructions.

8. Once the license file has been obtained, it should be placed in the location advised by the warning message.

9. The Excel add-on consists in a series of routines written in the C++ language which are implemented as Windows dynamic link libraries (dll).

7.0 APPENDICIES

7.1 Appendix A : List of Built-in Absorbing Compounds

№	Name
120	"A-150 Tissue-Equivalent Plastic"
121	"Adipose Tissue"
122	"Air"
123	"Alanine"
124	"Bakelite"
125	"Blood_Whole"
126	"Bone-Equivalent Plastic"
127	"Bone_Cortical"
128	"Brain_Grey-White Matter"
129	"Breast Tissue"
130	"C-552 Air-Equivalent Plastic"
131	"Concrete_Barite"
132	"Concrete_Ordinary"
133	"Eye Lens"
134	"Gafchromic Sensor"
135	"Glass_Borosilicate"
136	"Glass_Lead"
137	"Lung Tissue"
138	"Muscle_Skeletal"
139	"Ovary"
140	"Photo Emulsion (Kodak Type AA)"
141	"Photo Emulsion (Stand_ Nucl_)"
142	"Plastic Scintillator"
143	"Polyethylene Terephthalate_Mylar"
144	"Polyethylene"
145	"Polymethyl Methacrylate"
146	"Polystyrene"
147	"Polytetrafluoroethylene_Teflon"
148	"Polyvinyl Chloride"
149	"Radiochromic Dye Film (Nylon Base)"
150	"Tissue-Equivalent Gas (Methane)"
151	"Tissue-Equivalent Gas (Propane)"
152	"Tissue_Soft (ICRU Four-Component)"
153	"Tissue_Soft (ICRU-44)"
154	"Water"