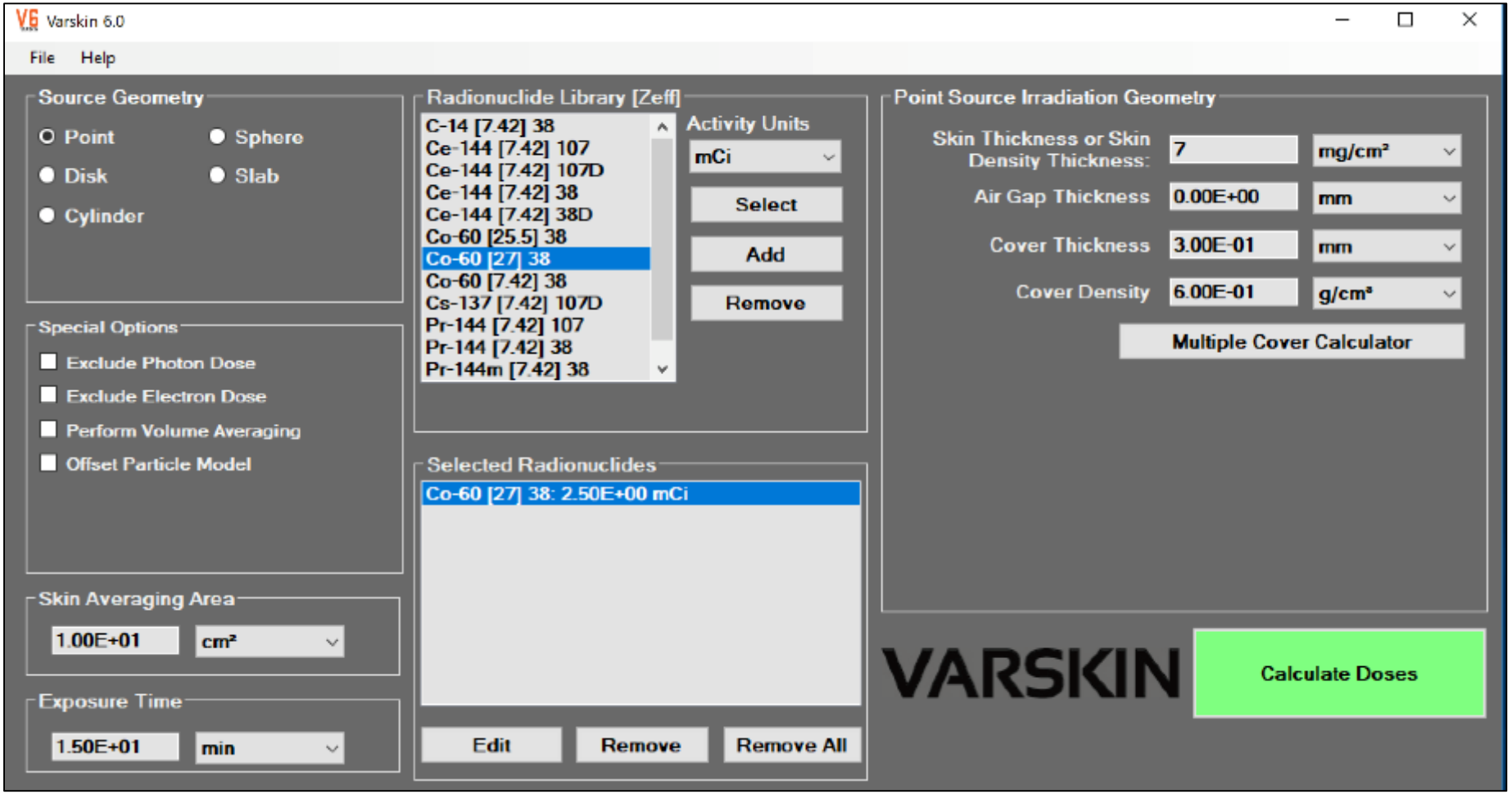
VARSKIN 6

EXAMPLES

Scenario #1

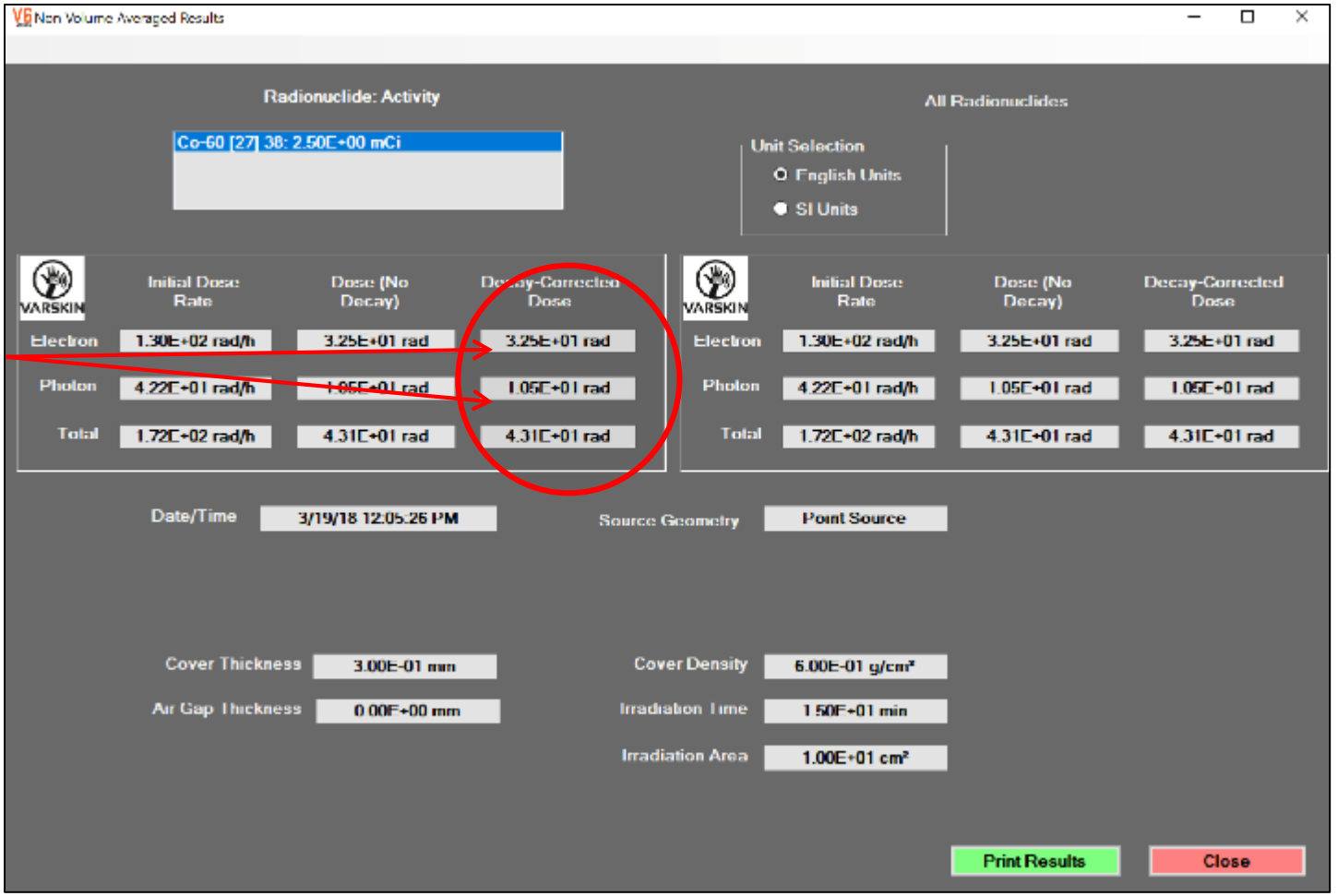
- Radiation worker in reactor containment
- ^{60}Co hot particle (2.5 mCi; 15 min) on gloved hand
- 50 μm @ 8.3 g/cm^3 (Z=27)
- 80 x 70 μm
- Glove characteristics: 0.3 mm and 0.6 g/cm^3
- Initially, point-source geometry
- Then, refine for more realism …

Point source



results

Note β/γ contribution

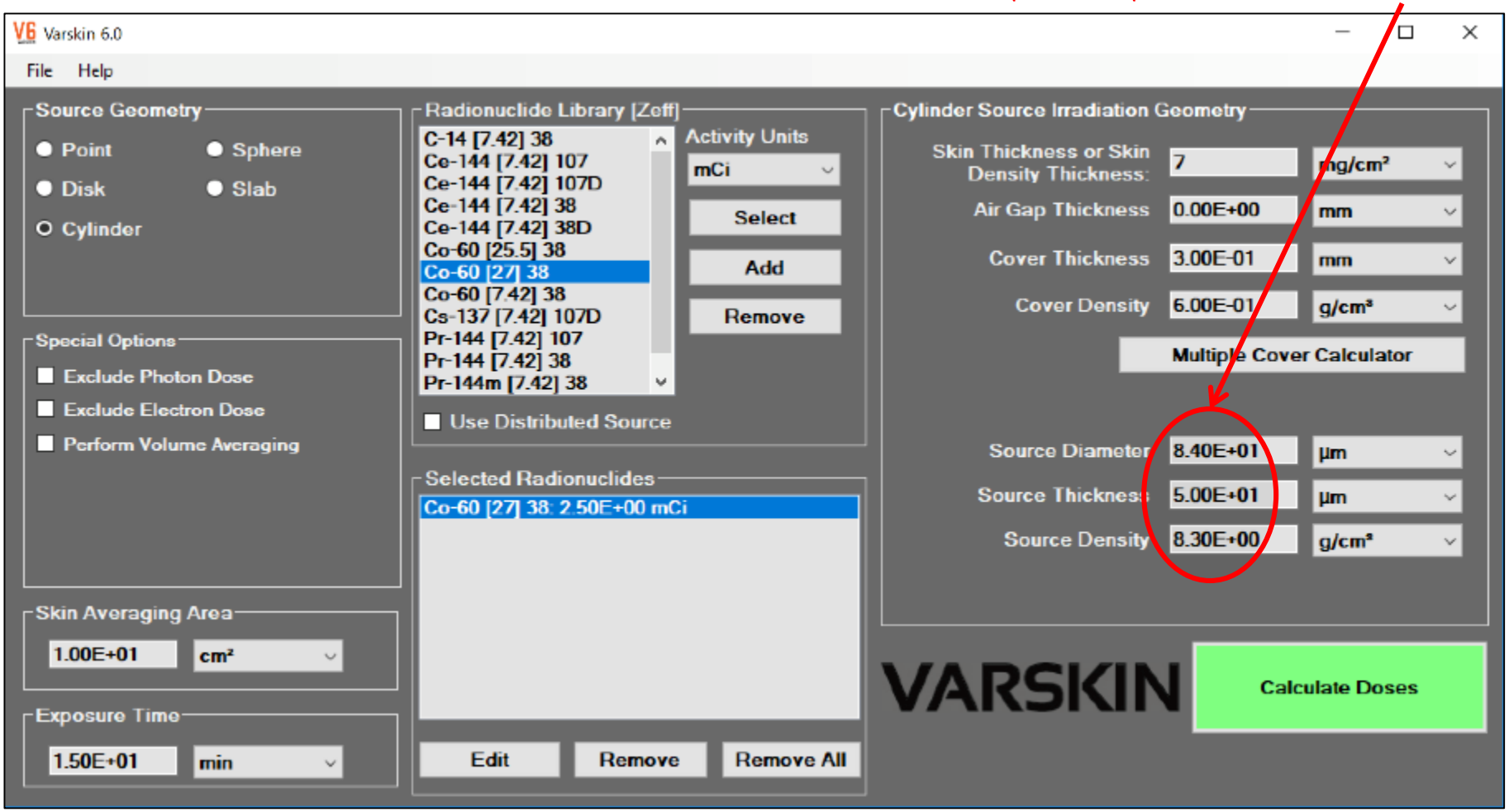


summary

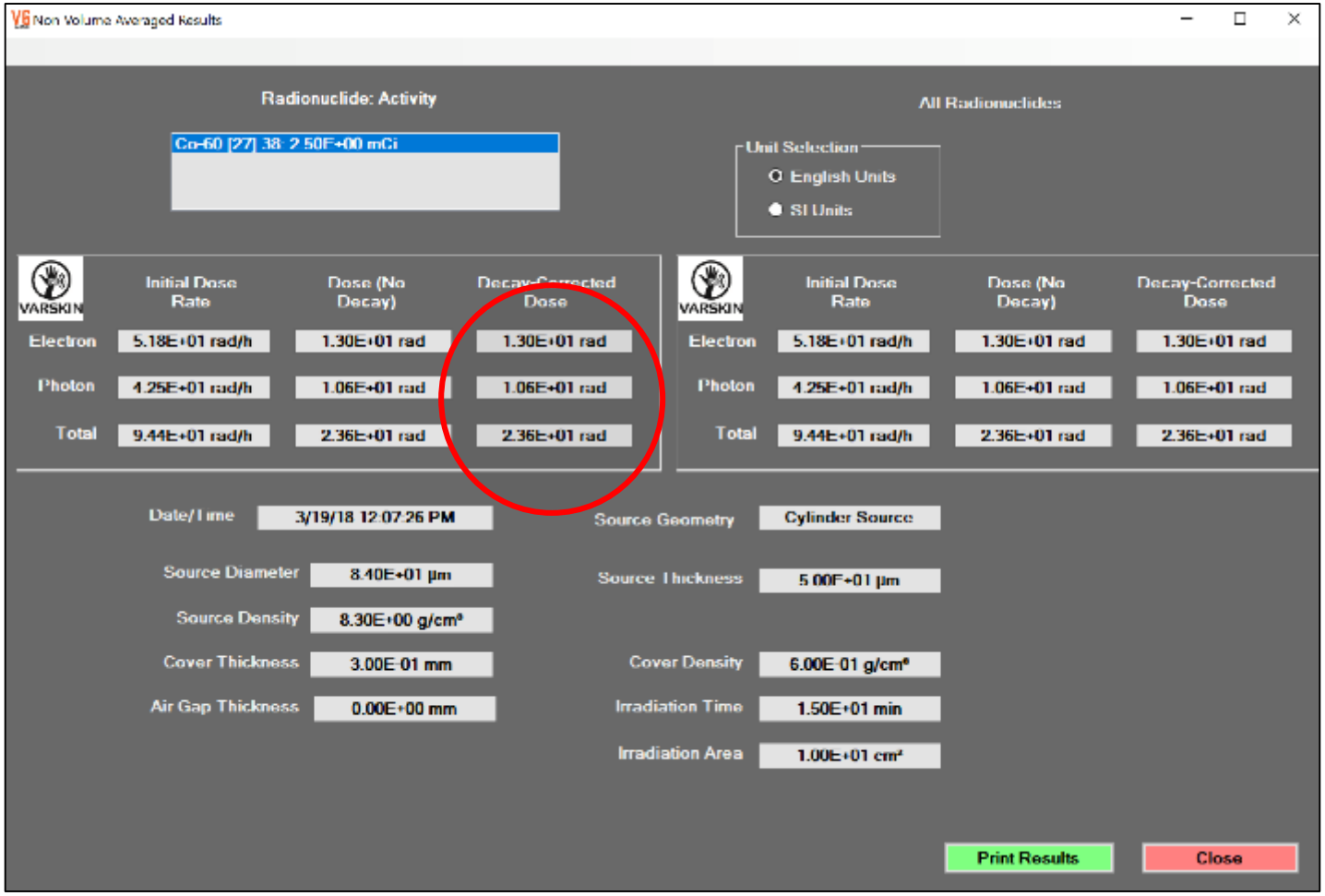
	Beta Dose	Photon Dose	Total Dose (rad)
Point Source	32.5	10.5	43.1
Cylindrical Equivalent			
Deep Dose			

Cylindrical equivalent source

$$d = 2\sqrt{\frac{X \cdot Y}{\pi}} = 2\sqrt{\frac{80\mu m \cdot 70\mu m}{\pi}} = 84\ \mu m$$



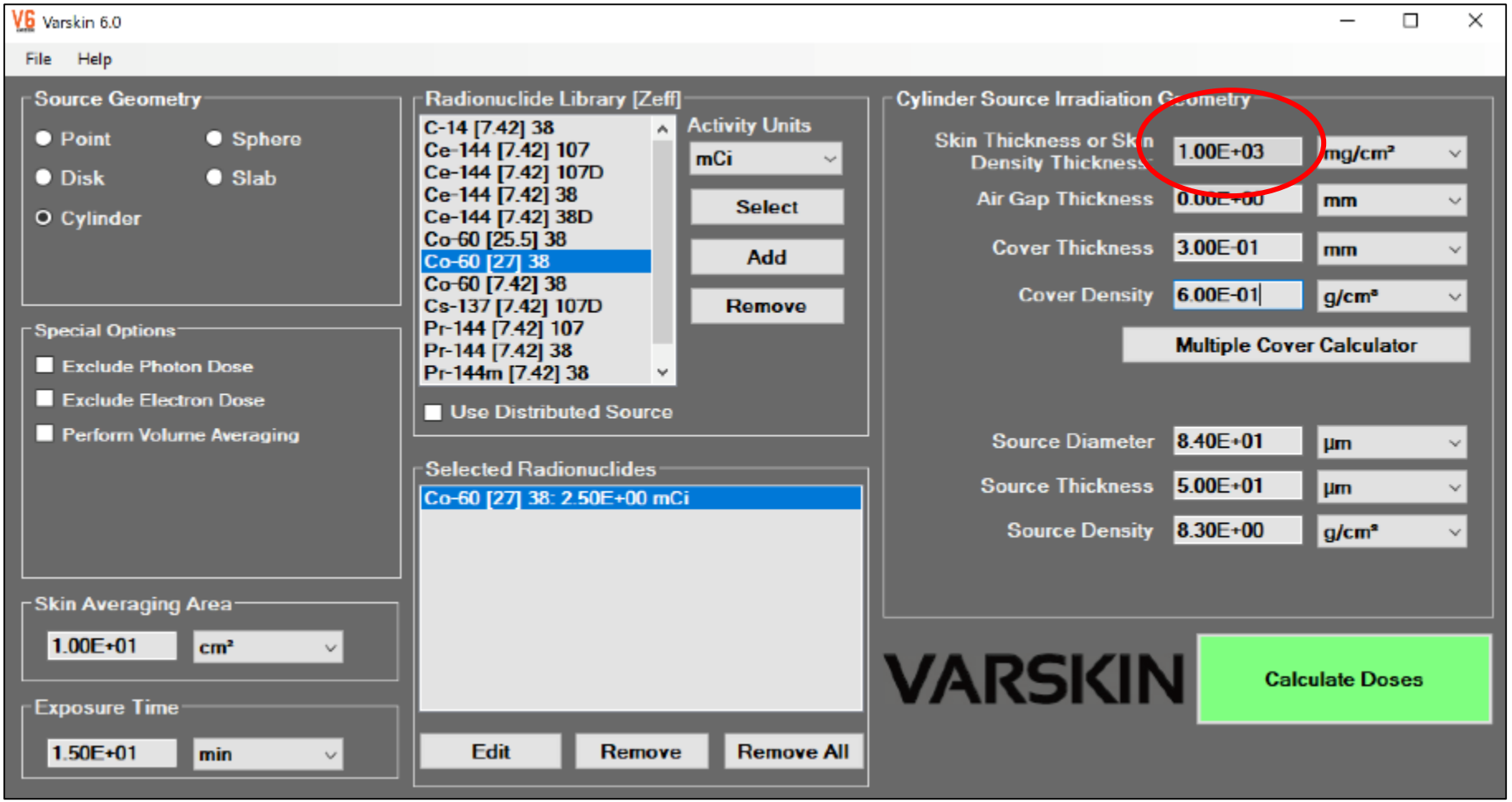
results


Non Volume Averaged Results
Radionuclide: Activity
Co-60 [27] 38.2.50E+00 mCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
5.18E+01 rad/h
1.30E+01 rad
1.30E+01 rad
Photon
4.25E+01 rad/h
1.06E+01 rad
1.06E+01 rad
Total
9.44E+01 rad/h
2.36E+01 rad
2.36E+01 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
5.18E+01 rad/h
1.30E+01 rad
1.30E+01 rad
Photon
4.25E+01 rad/h
1.06E+01 rad
1.06E+01 rad
Total
9.44E+01 rad/h
2.36E+01 rad
2.36E+01 rad
Date/Time
3/19/18 12:07:26 PM
Source Geometry
Cylinder Source
Source Diameter
8.40E+01 µm
Source Thickness
5.00E+01 µm
Source Density
8.30E+00 g/cm³
Cover Thickness
3.00E-01 mm
Cover Density
6.00E-01 g/cm³
Air Gap Thickness
0.00E+00 mm
Irradiation Time
1.50E+01 min
Irradiation Area
1.00E+01 cm²
Print Results
Close

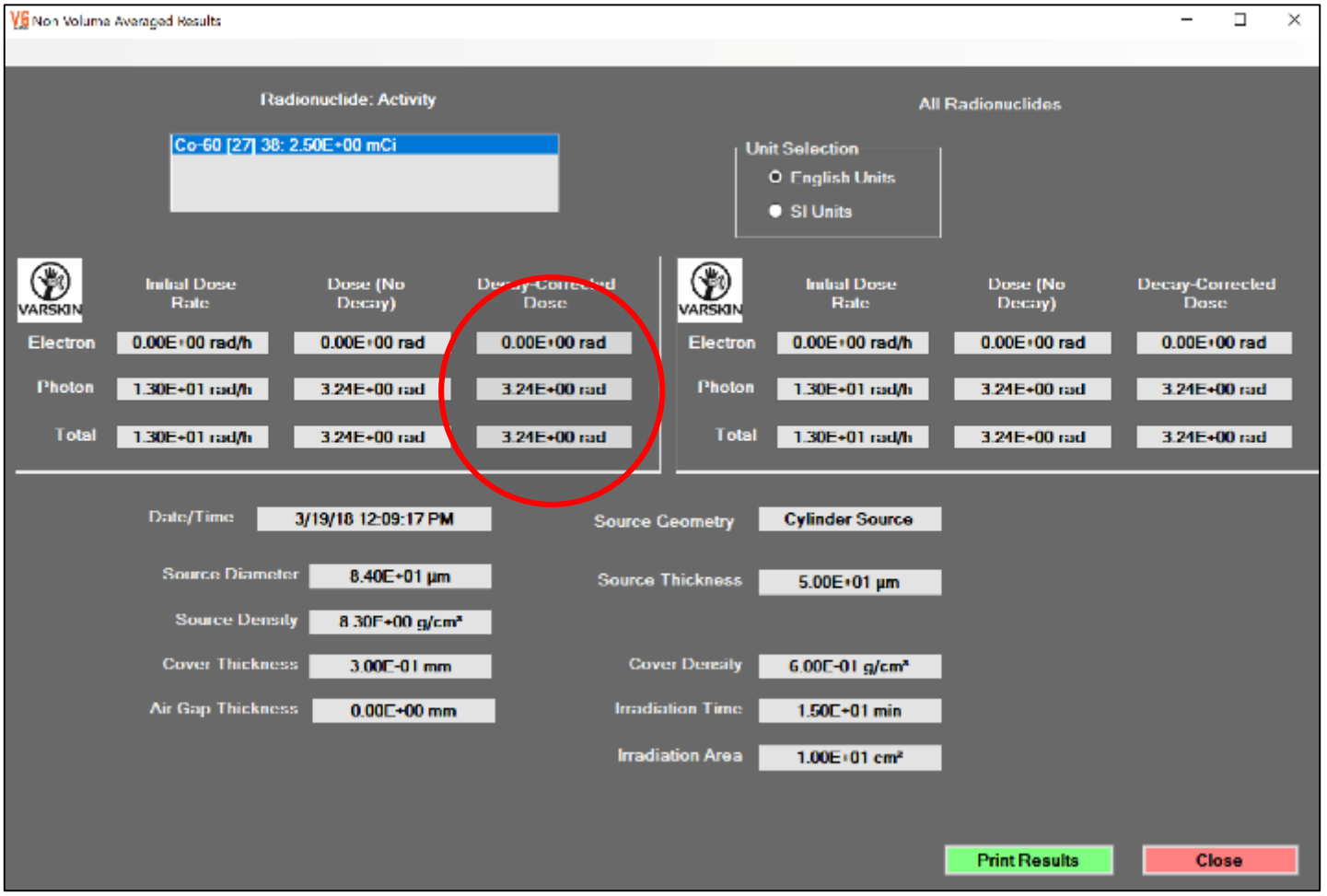
summary

	Beta Dose	Photon Dose	Total Dose (rad)
Point Source	32.5	10.5	43.1
Cylindrical Equivalent	13.0	10.6	23.6
Deep Dose			

Deep dose


Varskin 6.0
File
Help
Source Geometry
Point
Sphere
Disk
Slab
Cylinder
Special Options
Exclude Photon Dose
Exclude Electron Dose
Perform Volume Averaging
Skin Averaging Area
1.00E+01
cm²
Exposure Time
1.50E+01
min
Radionuclide Library [Zeff]
C-14 [7.42] 38
Ce-144 [7.42] 107
Ce-144 [7.42] 107D
Ce-144 [7.42] 38
Ce-144 [7.42] 38D
Co-60 [25.5] 38
Co-60 [27] 38
Co-60 [7.42] 38
Cs-137 [7.42] 107D
Pr-144 [7.42] 107
Pr-144 [7.42] 38
Pr-144m [7.42] 38
Activity Units
mCi
Select
Add
Remove
Use Distributed Source
Selected Radionuclides
Co-60 [27] 38: 2.50E+00 mCi
Edit
Remove
Remove All
Cylinder Source Irradiation Geometry
Skin Thickness or Skin Density Thickness
1.00E+03
mg/cm²
Air Gap Thickness
0.00E+00
mm
Cover Thickness
3.00E-01
mm
Cover Density
6.00E-01
g/cm³
Multiple Cover Calculator
Source Diameter
8.40E+01
µm
Source Thickness
5.00E+01
µm
Source Density
8.30E+00
g/cm³
VARSKIN
Calculate Doses

results

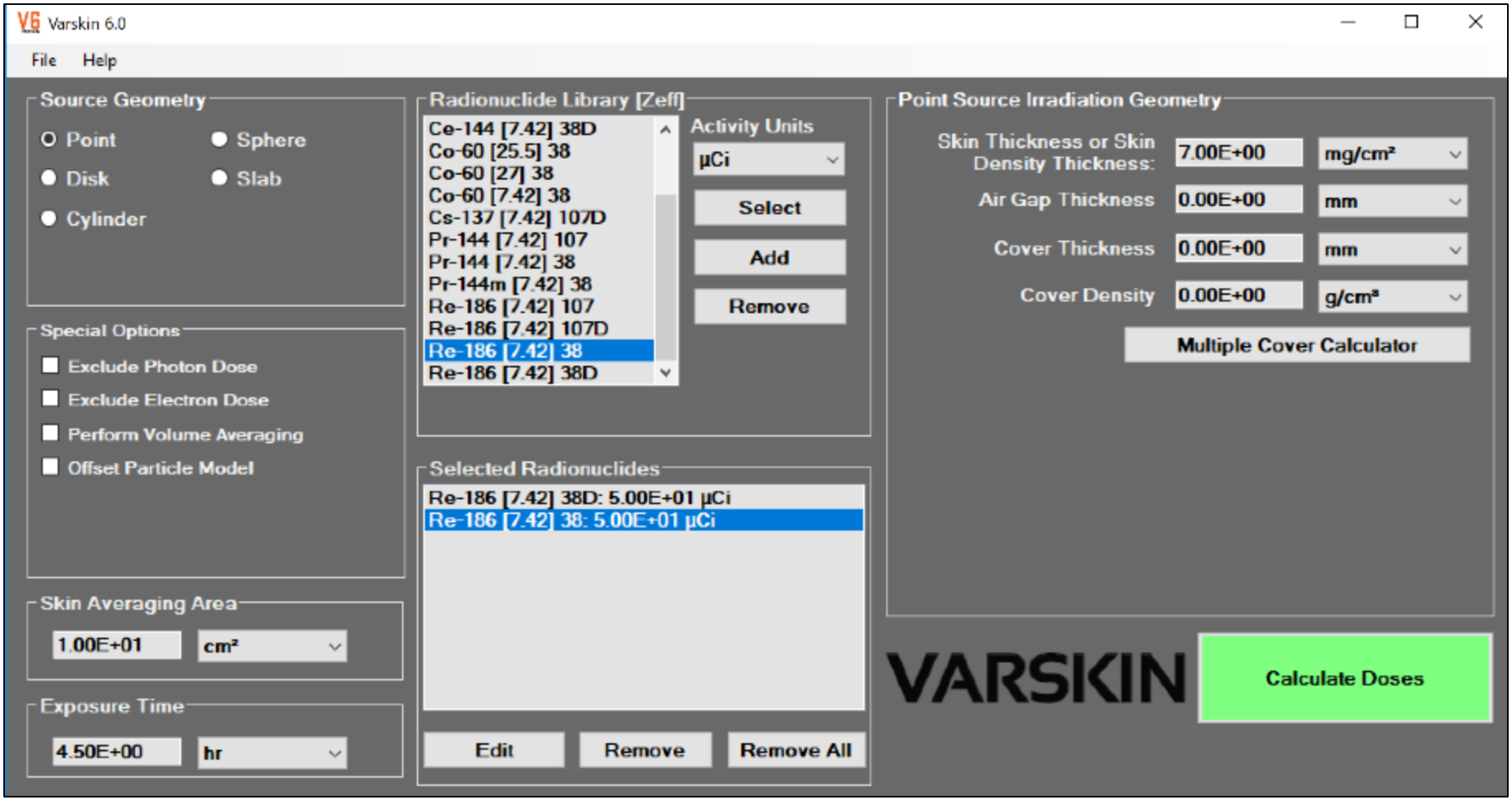

Non Volume Averaged Results
Radionuclide: Activity
Co-60 [27] 38: 2.50E+00 mCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 0.00E+00 rad/h 0.00E+00 rad 0.00E+00 rad
Photon 1.30E+01 rad/h 3.24E+00 rad 3.24E+00 rad
Total 1.30E+01 rad/h 3.24E+00 rad 3.24E+00 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 0.00E+00 rad/h 0.00E+00 rad 0.00E+00 rad
Photon 1.30E+01 rad/h 3.24E+00 rad 3.24E+00 rad
Total 1.30E+01 rad/h 3.24E+00 rad 3.24E+00 rad
Date/Time 3/19/18 12:09:17 PM
Source Geometry Cylinder Source
Source Diameter 8.40E+01 µm
Source Thickness 5.00E+01 µm
Source Density 8.30E+00 g/cm³
Cover Thickness 3.00E-01 mm
Cover Density 6.00E-01 g/cm³
Air Gap Thickness 0.00E+00 mm
Irradiation Time 1.50E+01 min
Irradiation Area 1.00E+01 cm²
Print Results
Close

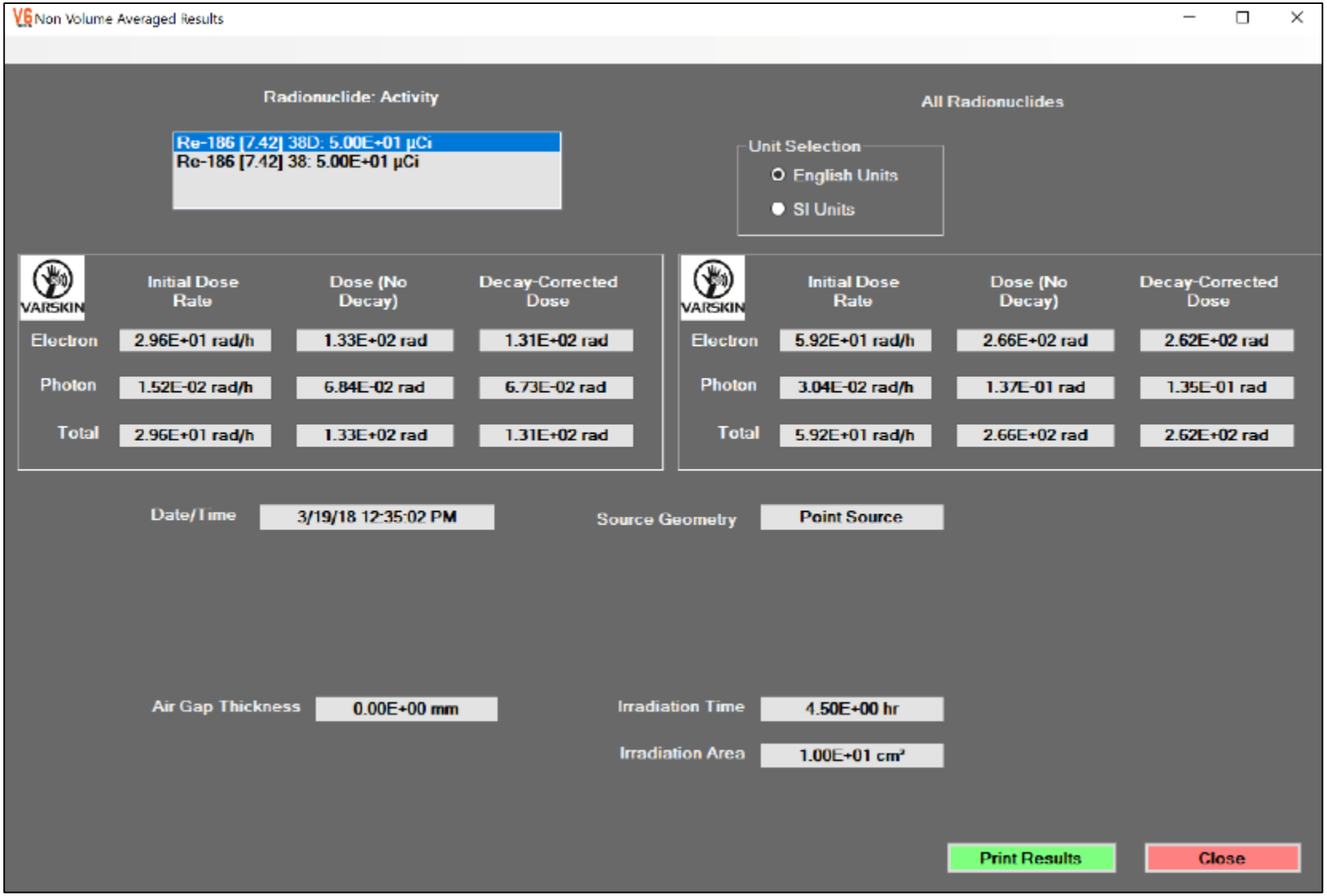
summary

	Beta Dose	Photon Dose	Total Dose (rad)
Point Source	32.5	10.5	43.1
Cylindrical Equivalent	13.0	10.6	23.6
Deep Dose	0	3.24	3.24

Scenario #2

- Nuclear medicine technician
- 10 μCi/mL of ^{186}Re (decays to ^{186}Os and ^{186}W)
- Unknown to tech, 5 mL spills on lab coat
- 50 cm^2 circular shape
- 4.5 hr exposure
- Initially,
  - point-source geometry
  - source in contact with the skin
- Then, refine for more realism
  - coat thickness of 0.4 mm, and density of 0.9 g/cm^3


Varskin 6.0
File
Help
Source Geometry
Point
Sphere
Disk
Slab
Cylinder
Special Options
Exclude Photon Dose
Exclude Electron Dose
Perform Volume Averaging
Offset Particle Model
Skin Averaging Area
1.00E+01
cm²
Exposure Time
4.50E+00
hr
Radionuclide Library [Zeff]
Ce-144 [7.42] 38D
Co-60 [25.5] 38
Co-60 [27] 38
Co-60 [7.42] 38
Cs-137 [7.42] 107D
Pr-144 [7.42] 107
Pr-144 [7.42] 38
Pr-144m [7.42] 38
Re-186 [7.42] 107
Re-186 [7.42] 107D
Re-186 [7.42] 38
Re-186 [7.42] 38D
Activity Units
µCi
Select
Add
Remove
Selected Radionuclides
Re-186 [7.42] 38D: 5.00E+01 µCi
Re-186 [7.42] 38: 5.00E+01 µCi
Edit
Remove
Remove All
Point Source Irradiation Geometry
Skin Thickness or Skin Density Thickness:
7.00E+00
mg/cm²
Air Gap Thickness
0.00E+00
mm
Cover Thickness
0.00E+00
mm
Cover Density
0.00E+00
g/cm³
Multiple Cover Calculator
VARSKIN
Calculate Doses


Non Volume Averaged Results
Radionuclide: Activity
Re-186 [7.42] 38D: 5.00E+01 µCi
Re-186 [7.42] 38: 5.00E+01 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
2.96E+01 rad/h
1.33E+02 rad
1.31E+02 rad
Photon
1.52E-02 rad/h
6.84E-02 rad
6.73E-02 rad
Total
2.96E+01 rad/h
1.33E+02 rad
1.31E+02 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
5.92E+01 rad/h
2.66E+02 rad
2.62E+02 rad
Photon
3.04E-02 rad/h
1.37E-01 rad
1.35E-01 rad
Total
5.92E+01 rad/h
2.66E+02 rad
2.62E+02 rad
Date/Time
3/19/18 12:35:02 PM
Source Geometry
Point Source
Air Gap Thickness
0.00E+00 mm
Irradiation Time
4.50E+00 hr
Irradiation Area
1.00E+01 cm²
Print Results
Close

summary

	Beta Dose	Photon Dose	Total Dose (rad)
Point on Skin	131	0.0673	131
Disk on Skin			
Disk on Coat			
Cylinder in Cloth			

summary

	Beta Dose	Photon Dose	Total Dose (rad)
Point on Skin	131	0.0673	131
Disk on Skin	26.2	0.0149	26.2
Disk on Coat			
Cylinder in Cloth			

summary

	Beta Dose	Photon Dose	Total Dose (rad)
Point on Skin	131	0.0673	131
Disk on Skin	26.2	0.0149	26.2
Disk on Coat	9.21	0.0110	9.23
Cylinder in Cloth			

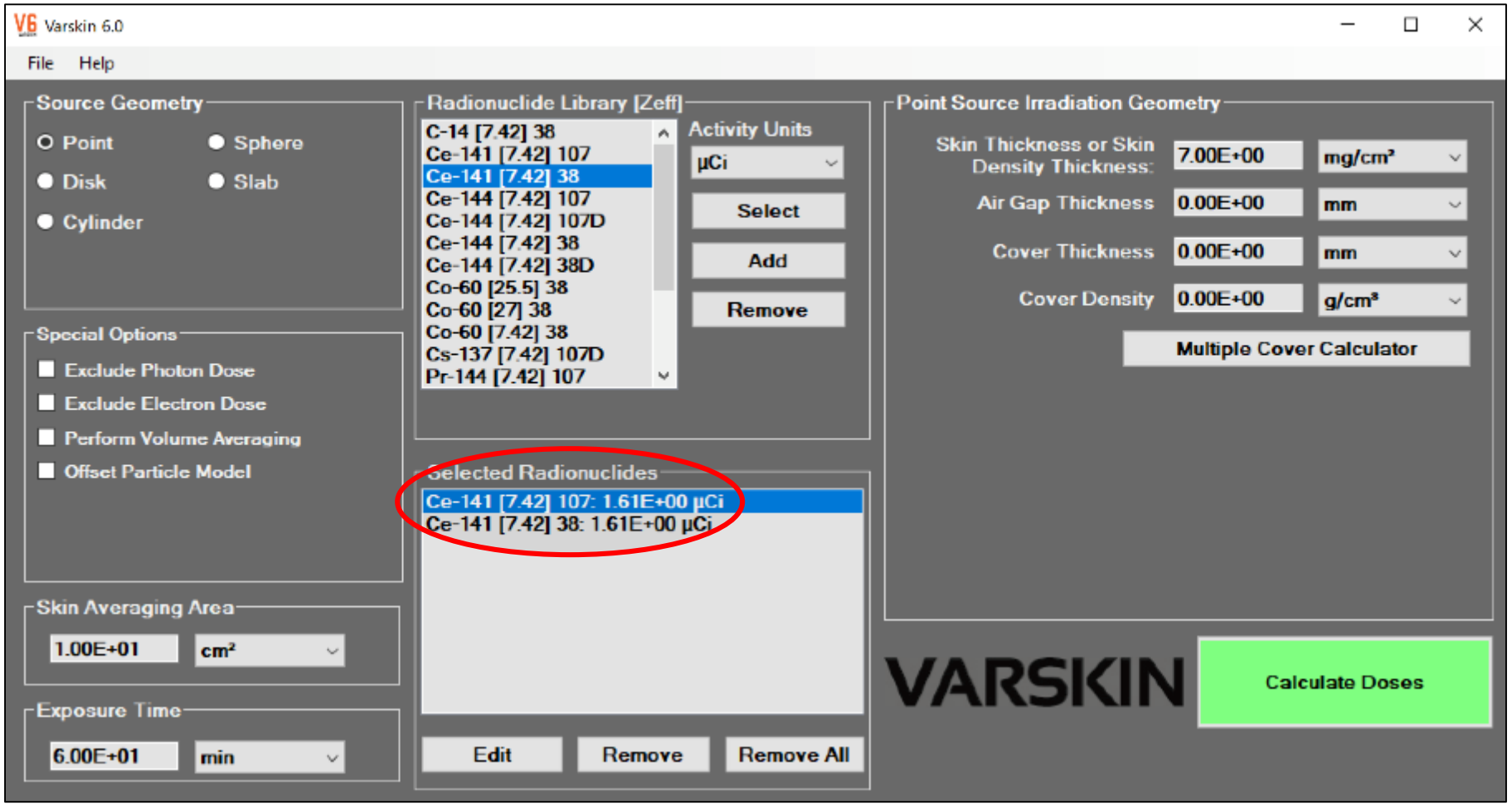
summary

	Beta Dose	Photon Dose	Total Dose (rad)
Point on Skin	131	0.0673	131
Disk on Skin	26.2	0.0149	26.2
Disk on Coat	9.21	0.0110	9.23
Cylinder in Cloth	16.9	0.0126	16.9

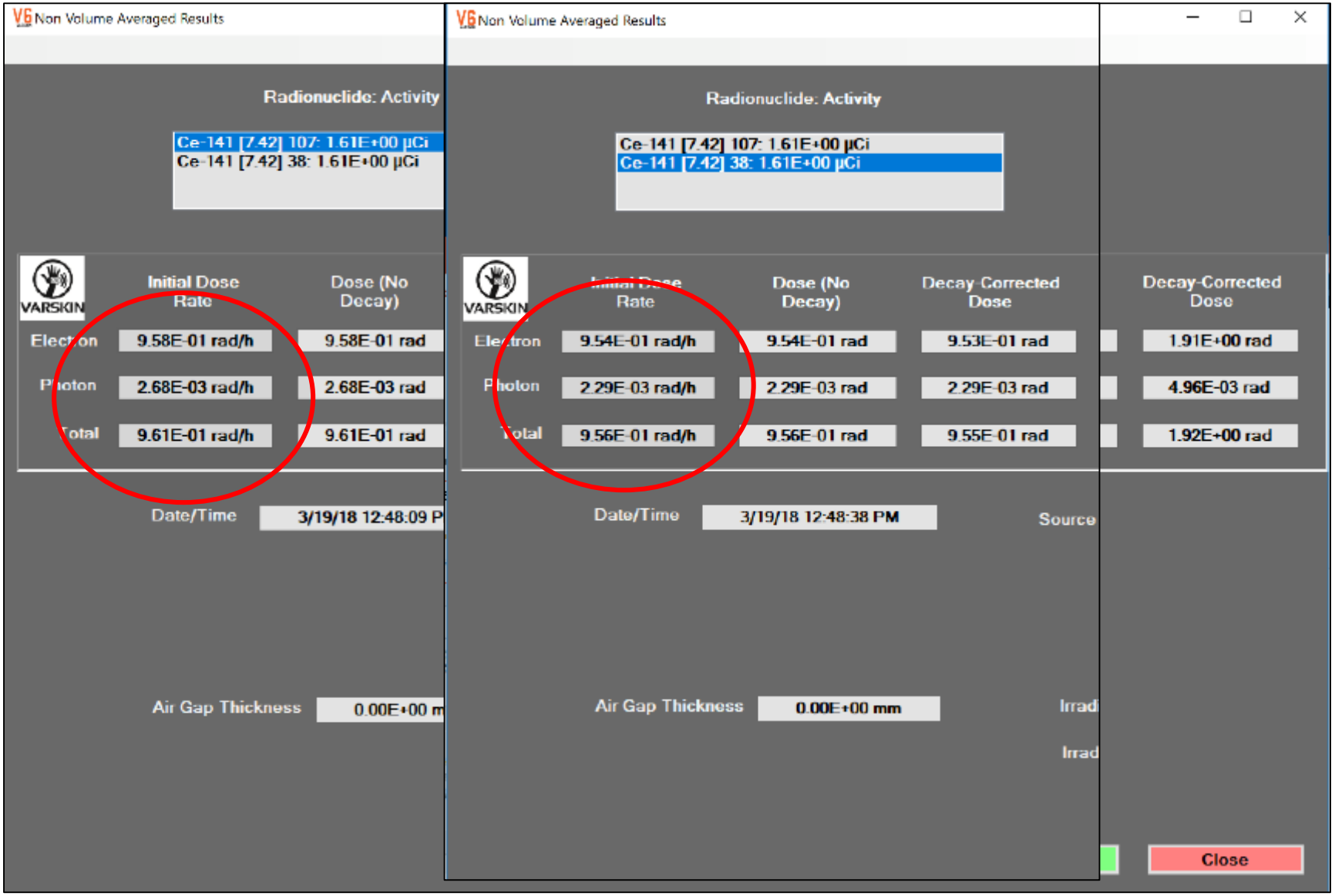
scenario #3

- Dose rate from general contamination
- ^{141}Ce directly on the skin
  - with concentration (0.25 μCi/cm^2)
- 1” x 1” contamination area
- Exposure to 1.61 μCi liquid source
- As before, point-source geometry for a bounding estimate
- … then refine for more realism …

Point source



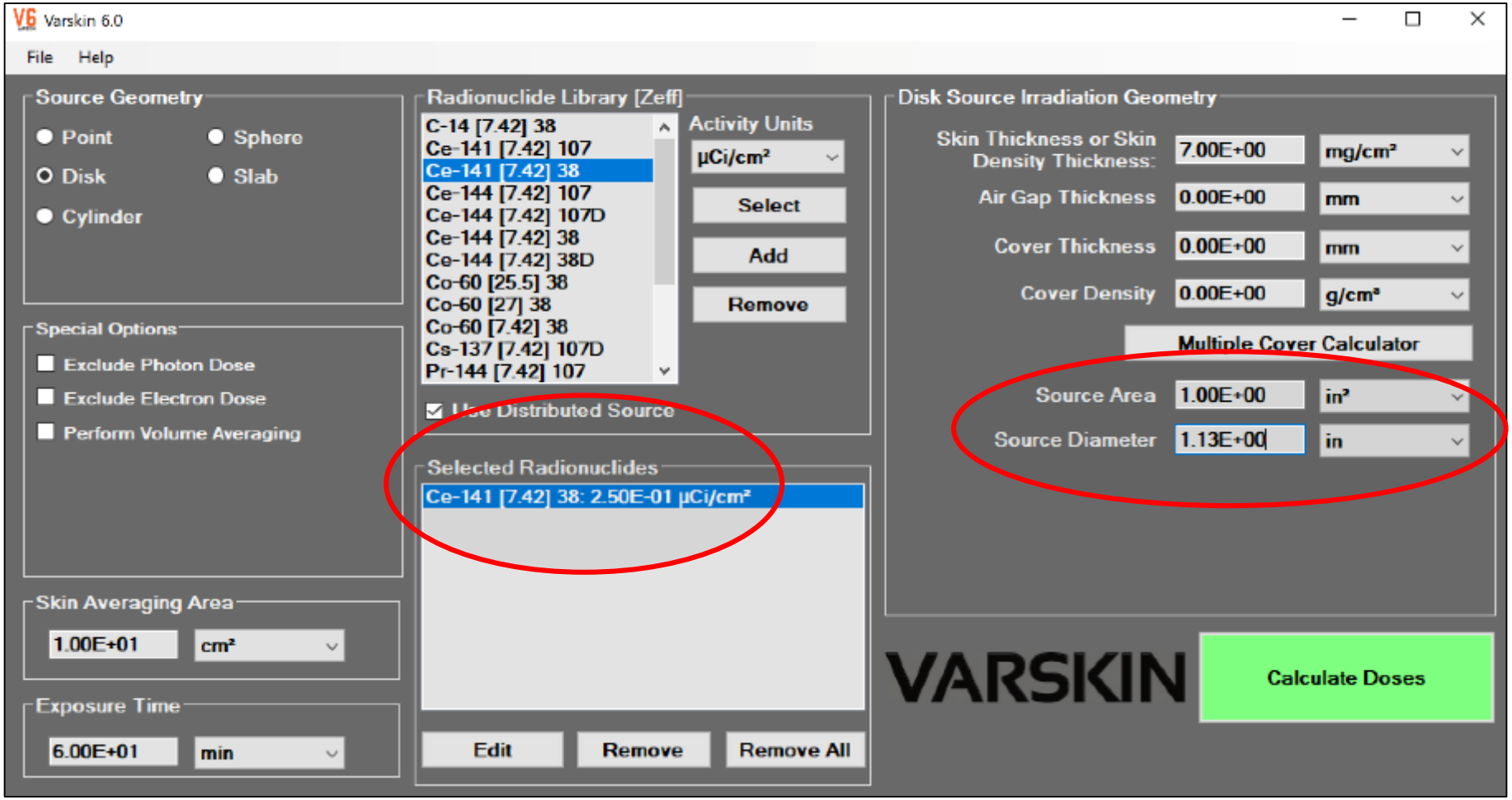
results


V6 Non Volume Averaged Results
Radionuclide: Activity
Ce-141 [7.42] 107: 1.61E+00 µCi
Ce-141 [7.42] 38: 1.61E+00 µCi
VARSKIN
Initial Dose Rate
Dose (No Decay)
Electron 9.58E-01 rad/h 9.58E-01 rad
Photon 2.68E-03 rad/h 2.68E-03 rad
Total 9.61E-01 rad/h 9.61E-01 rad
Date/Time 3/19/18 12:48:09 P
Air Gap Thickness 0.00E+00 m
V6 Non Volume Averaged Results
Radionuclide: Activity
Ce-141 [7.42] 107: 1.61E+00 µCi
Ce-141 [7.42] 38: 1.61E+00 µCi
VARSKIN
Dose (No Decay)
Decay-Corrected Dose
Decay-Corrected Dose
Electron 9.54E-01 rad/h 9.54E-01 rad 9.53E-01 rad 1.91E+00 rad
Photon 2.29E-03 rad/h 2.29E-03 rad 2.29E-03 rad 4.96E-03 rad
Total 9.56E-01 rad/h 9.56E-01 rad 9.55E-01 rad 1.92E+00 rad
Date/Time 3/19/18 12:48:38 PM
Source
Air Gap Thickness 0.00E+00 mm
Irrad
Irrad
Close

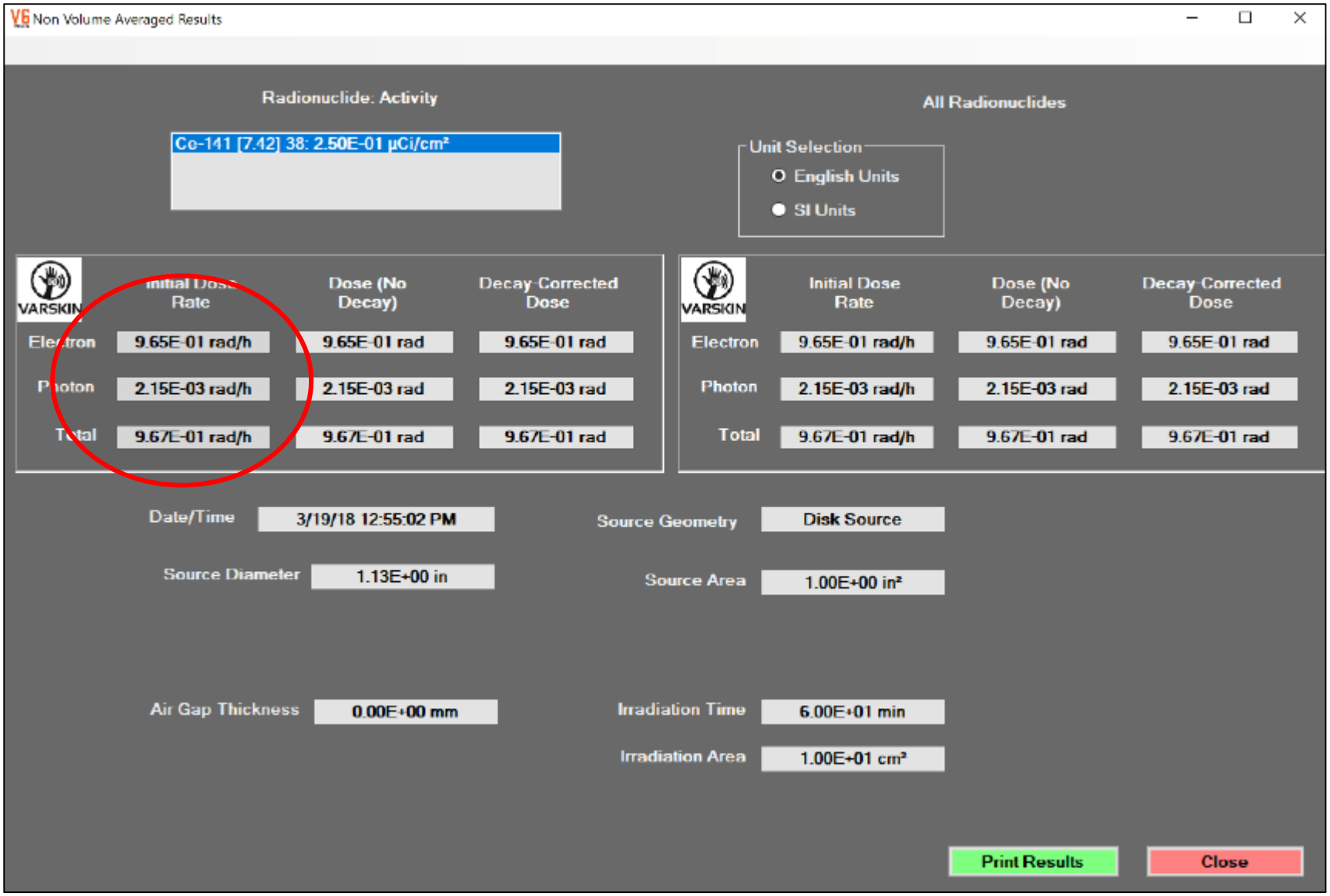
summary

1” x 1”	Beta Dose Rate	Photon Dose Rate	Total Dose Rate (rad/hr)
Point Source	0.954	0.00229	0.956
2D Disk Source			
Water Slab Source			
Air Slab Source			
Water Slab (1 cm^2)			

2D Disk source



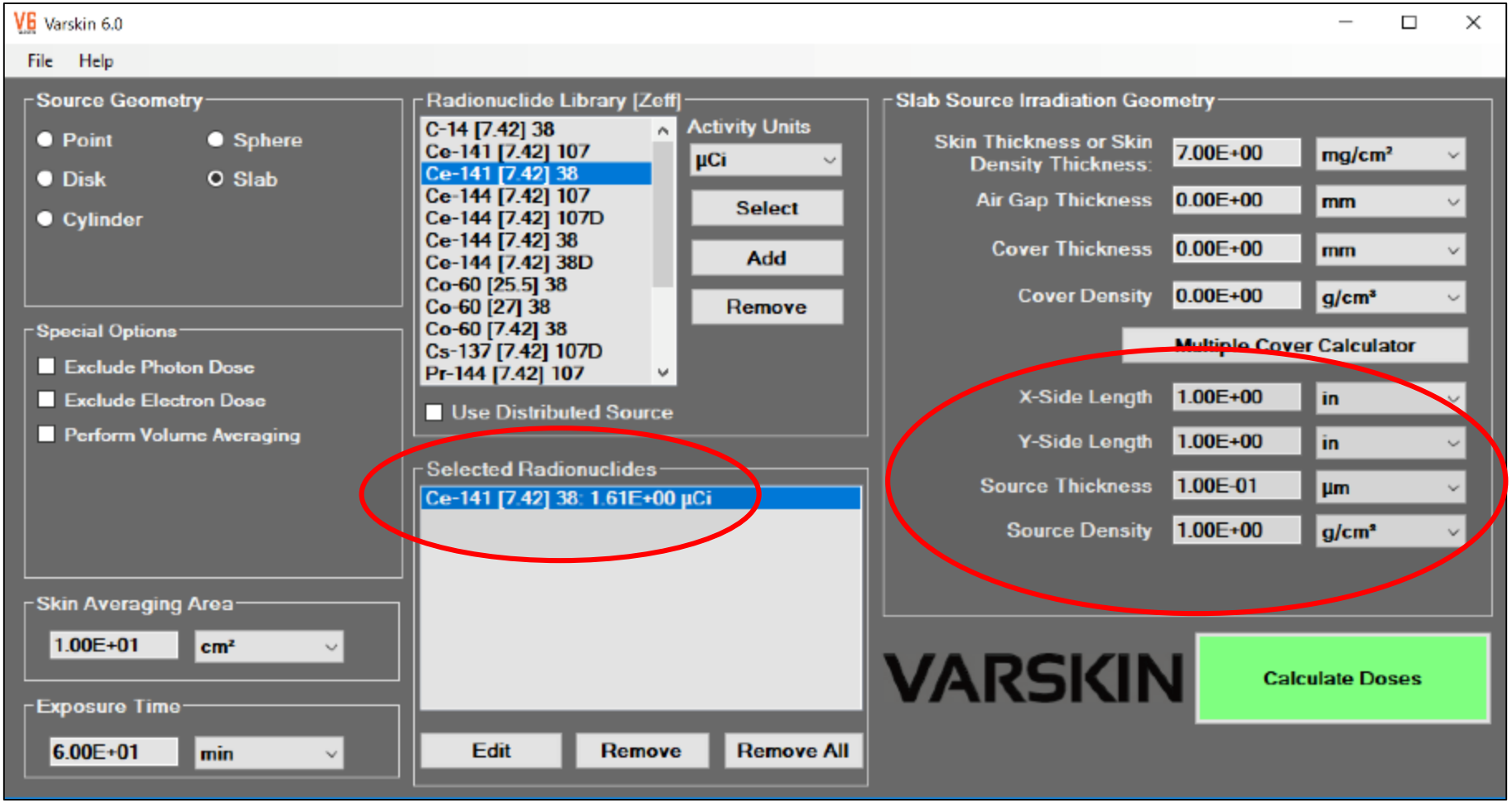
results


V6 Non Volume Averaged Results
Radionuclide: Activity
Co-141 [7.42] 38: 2.50E-01 µCi/cm²
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 9.65E-01 rad/h 9.65E-01 rad 9.65E-01 rad
Photon 2.15E-03 rad/h 2.15E-03 rad 2.15E-03 rad
Total 9.67E-01 rad/h 9.67E-01 rad 9.67E-01 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 9.65E-01 rad/h 9.65E-01 rad 9.65E-01 rad
Photon 2.15E-03 rad/h 2.15E-03 rad 2.15E-03 rad
Total 9.67E-01 rad/h 9.67E-01 rad 9.67E-01 rad
Date/Time 3/19/18 12:55:02 PM
Source Geometry Disk Source
Source Diameter 1.13E+00 in
Source Area 1.00E+00 in²
Air Gap Thickness 0.00E+00 mm
Irradiation Time 6.00E+01 min
Irradiation Area 1.00E+01 cm²
Print Results
Close

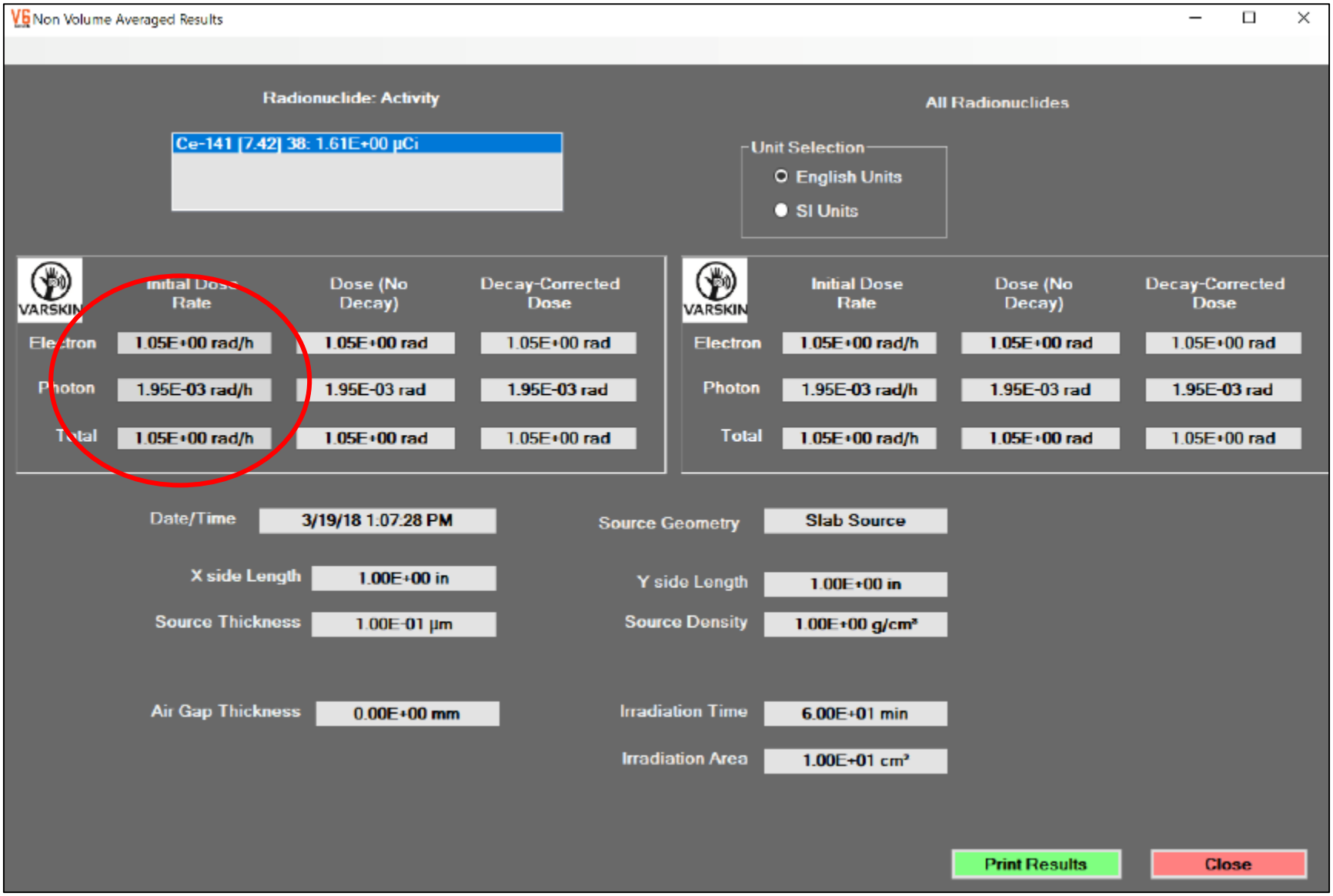
summary

1” x 1”	Beta Dose Rate	Photon Dose Rate	Total Dose Rate (rad/hr)
Point Source	0.954	0.00229	0.956
2D Disk Source	0.965	0.00215	0.967
Water Slab Source			
Air Slab Source			
Water Slab (1 cm^2)			

Slab source


Varskin 6.0
File
Help
Source Geometry
Point
Sphere
Disk
Slab
Cylinder
Special Options
Exclude Photon Dose
Exclude Electron Dose
Perform Volume Averaging
Skin Averaging Area
1.00E+01
cm²
Exposure Time
6.00E+01
min
Radionuclide Library [Zeff]
C-14 [7.42] 38
Co-141 [7.42] 107
Ce-141 [7.42] 38
Ce-144 [7.42] 107
Ce-144 [7.42] 107D
Ce-144 [7.42] 38
Ce-144 [7.42] 38D
Co-60 [25.5] 38
Co-60 [27] 38
Co-60 [7.42] 38
Cs-137 [7.42] 107D
Pr-144 [7.42] 107
Activity Units
µCi
Select
Add
Remove
Use Distributed Source
Selected Radionuclides
Ce-141 [7.42] 38: 1.61E+00 µCi
Edit
Remove
Remove All
Slab Source Irradiation Geometry
Skin Thickness or Skin Density Thickness:
7.00E+00
mg/cm²
Air Gap Thickness
0.00E+00
mm
Cover Thickness
0.00E+00
mm
Cover Density
0.00E+00
g/cm³
Multiple Cover Calculator
X-Side Length
1.00E+00
in
Y-Side Length
1.00E+00
in
Source Thickness
1.00E-01
µm
Source Density
1.00E+00
g/cm³
VARSKIN
Calculate Doses

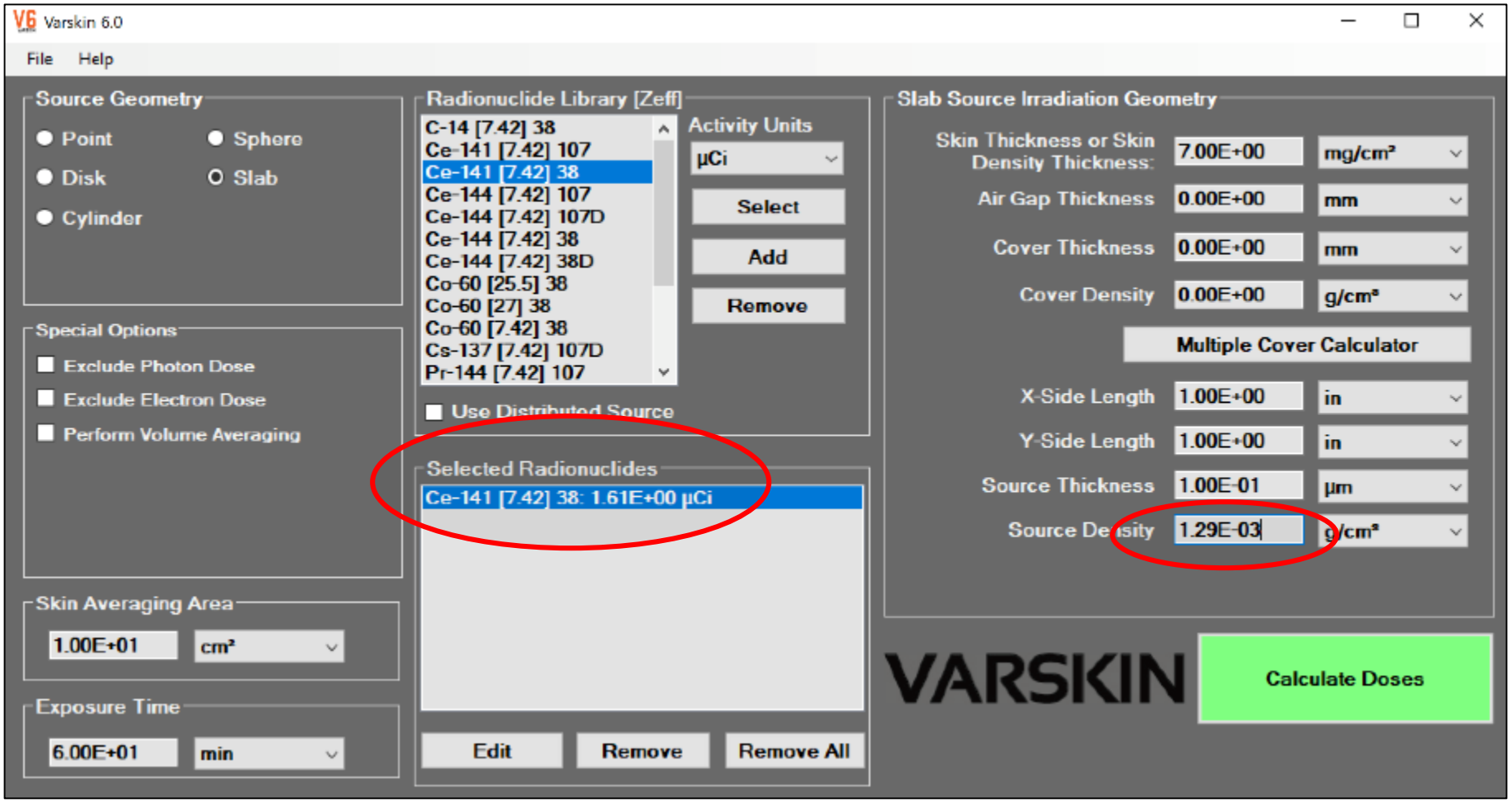
results


V6 Non Volume Averaged Results
Radionuclide: Activity
Ce-141 [7.42] 38: 1.61E+00 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 1.05E+00 rad/h 1.05E+00 rad 1.05E+00 rad
Photon 1.95E-03 rad/h 1.95E-03 rad 1.95E-03 rad
Total 1.05E+00 rad/h 1.05E+00 rad 1.05E+00 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 1.05E+00 rad/h 1.05E+00 rad 1.05E+00 rad
Photon 1.95E-03 rad/h 1.95E-03 rad 1.95E-03 rad
Total 1.05E+00 rad/h 1.05E+00 rad 1.05E+00 rad
Date/Time 3/19/18 1.07.28 PM
Source Geometry Slab Source
X side Length 1.00E+00 in
Y side Length 1.00E+00 in
Source Thickness 1.00E-01 µm
Source Density 1.00E+00 g/cm³
Air Gap Thickness 0.00E+00 mm
Irradiation Time 6.00E+01 min
Irradiation Area 1.00E+01 cm²
Print Results
Close

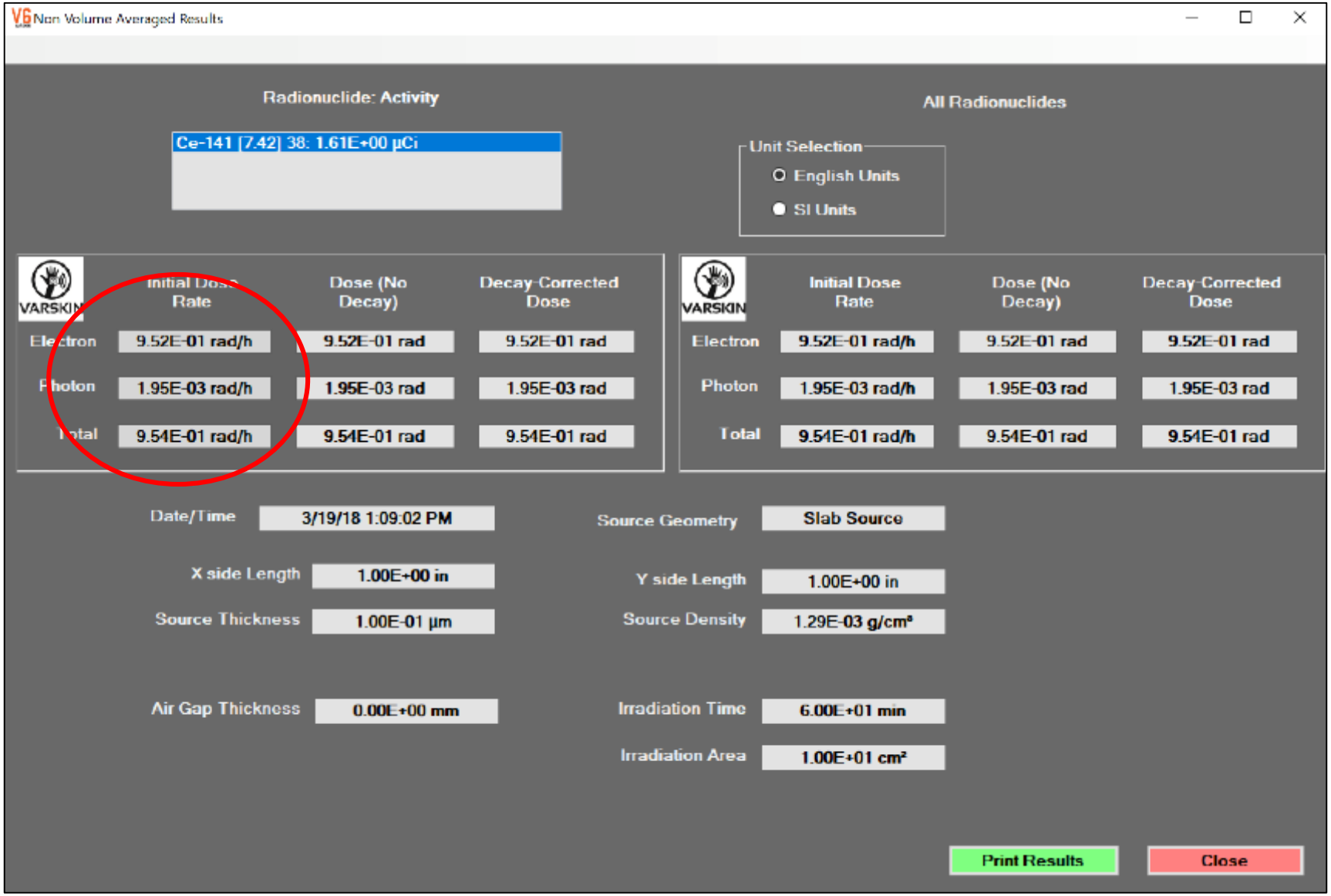
summary

1” x 1”	Beta Dose Rate	Photon Dose Rate	Total Dose Rate (rad/hr)
Point Source	0.954	0.00229	0.956
2D Disk Source	0.965	0.00215	0.967
Water Slab Source	1.05	0.00195	1.05
Air Slab Source			
Water Slab (1 cm^2)			

Slab source (low density)



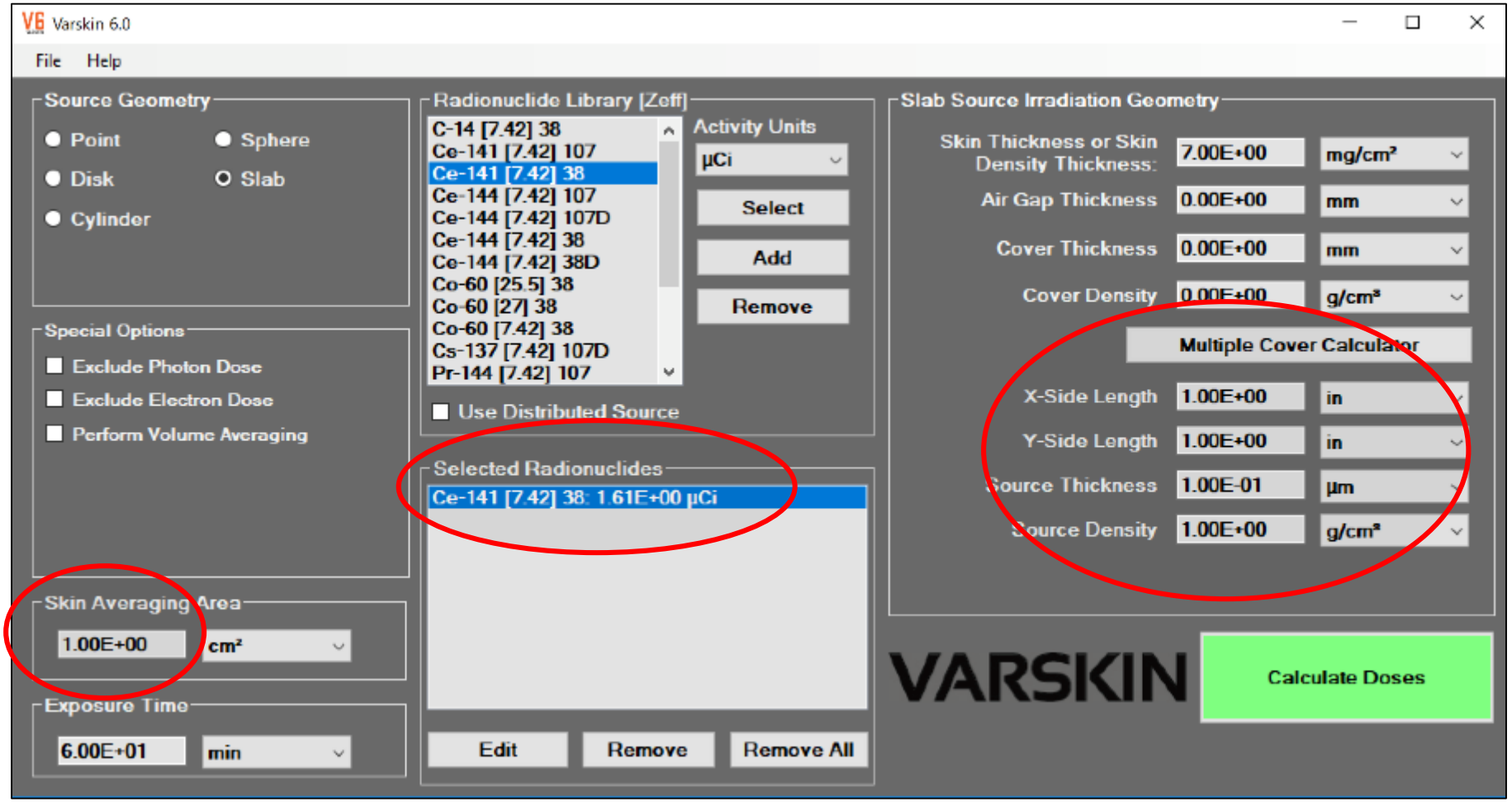
results


Non Volume Averaged Results
Radionuclide: Activity
Ce-141 [7.42] 38: 1.61E+00 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
9.52E-01 rad/h
9.52E-01 rad
9.52E-01 rad
Photon
1.95E-03 rad/h
1.95E-03 rad
1.95E-03 rad
Total
9.54E-01 rad/h
9.54E-01 rad
9.54E-01 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
9.52E-01 rad/h
9.52E-01 rad
9.52E-01 rad
Photon
1.95E-03 rad/h
1.95E-03 rad
1.95E-03 rad
Total
9.54E-01 rad/h
9.54E-01 rad
9.54E-01 rad
Date/Time
3/19/18 1:09:02 PM
Source Geometry
Slab Source
X side Length
1.00E+00 in
Y side Length
1.00E+00 in
Source Thickness
1.00E-01 µm
Source Density
1.29E-03 g/cm³
Air Gap Thickness
0.00E+00 mm
Irradiation Time
6.00E+01 min
Irradiation Area
1.00E+01 cm²
Print Results
Close

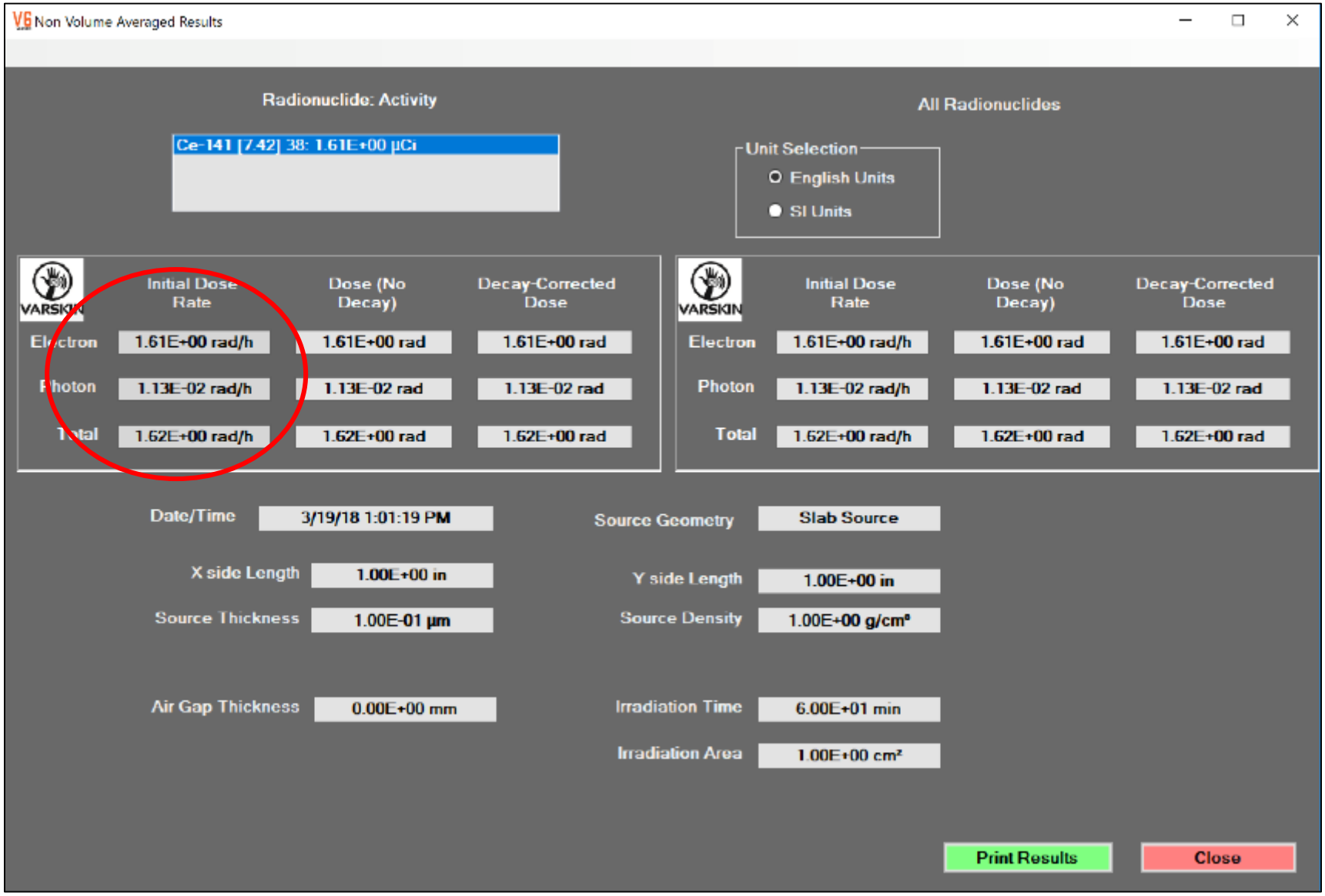
summary

1” x 1”	Beta Dose Rate	Photon Dose Rate	Total Dose Rate (rad/hr)
Point Source	0.954	0.00229	0.956
2D Disk Source	0.965	0.00215	0.967
Water Slab Source	1.05	0.00195	1.05
Air Slab Source	0.952	0.00195	0.954
Water Slab (1 cm^2)			

Slab source (1 cm^2)



results


Non Volume Averaged Results
Radionuclide: Activity
Ce-141 [7.42] 38: 1.61E+00 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
1.61E+00 rad/h
1.61E+00 rad
1.61E+00 rad
Photon
1.13E-02 rad/h
1.13E-02 rad
1.13E-02 rad
Total
1.62E+00 rad/h
1.62E+00 rad
1.62E+00 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
1.61E+00 rad/h
1.61E+00 rad
1.61E+00 rad
Photon
1.13E-02 rad/h
1.13E-02 rad
1.13E-02 rad
Total
1.62E+00 rad/h
1.62E+00 rad
1.62E+00 rad
Date/Time
3/19/18 1:01:19 PM
Source Geometry
Slab Source
X side Length
1.00E+00 in
Y side Length
1.00E+00 in
Source Thickness
1.00E-01 µm
Source Density
1.00E+00 g/cm³
Air Gap Thickness
0.00E+00 mm
Irradiation Time
6.00E+01 min
Irradiation Area
1.00E+00 cm²
Print Results
Close

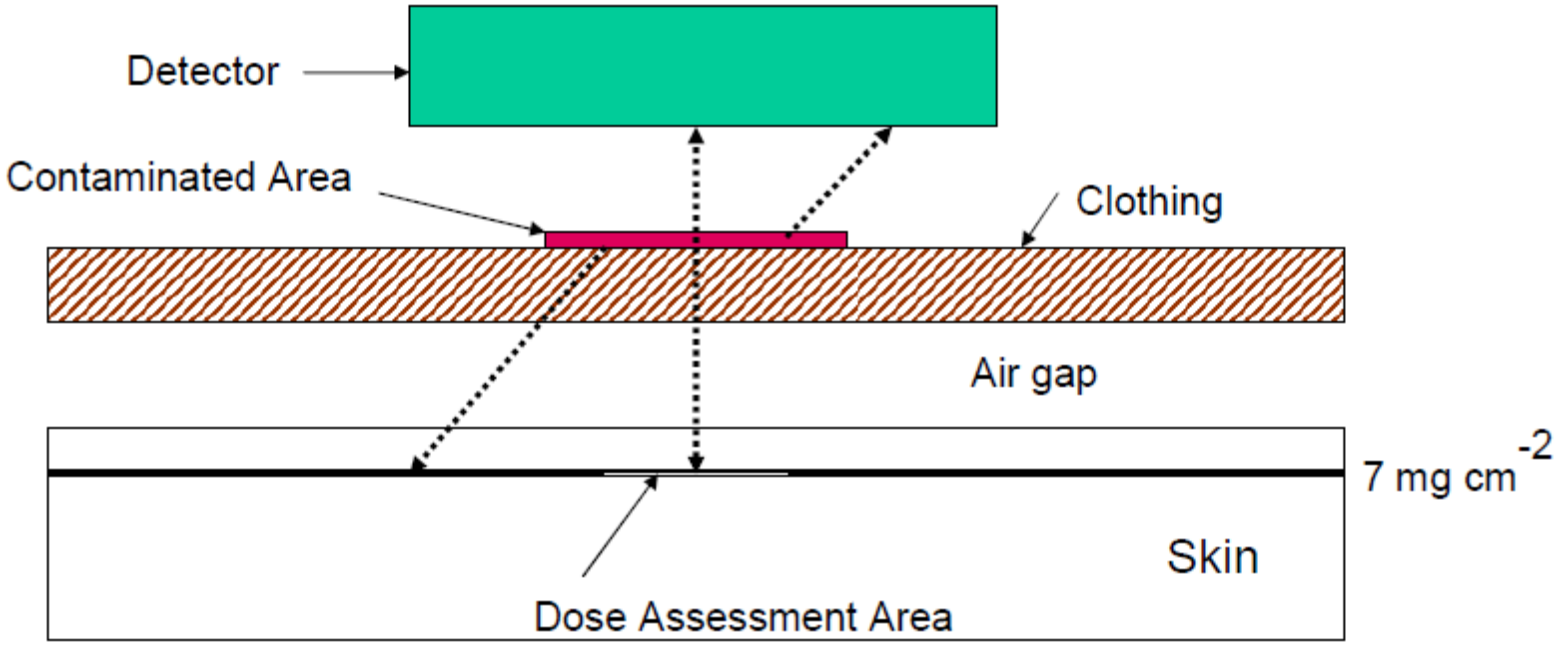
summary

1” x 1”	Beta Dose Rate	Photon Dose Rate	Total Dose Rate (rad/hr)
Point Source	0.954	0.00229	0.956
2D Disk Source	0.965	0.00215	0.967
Water Slab Source	1.05	0.00195	1.05
Air Slab Source	0.952	0.00195	0.954
Water Slab (1 cm^2)	1.61	0.0113	1.62

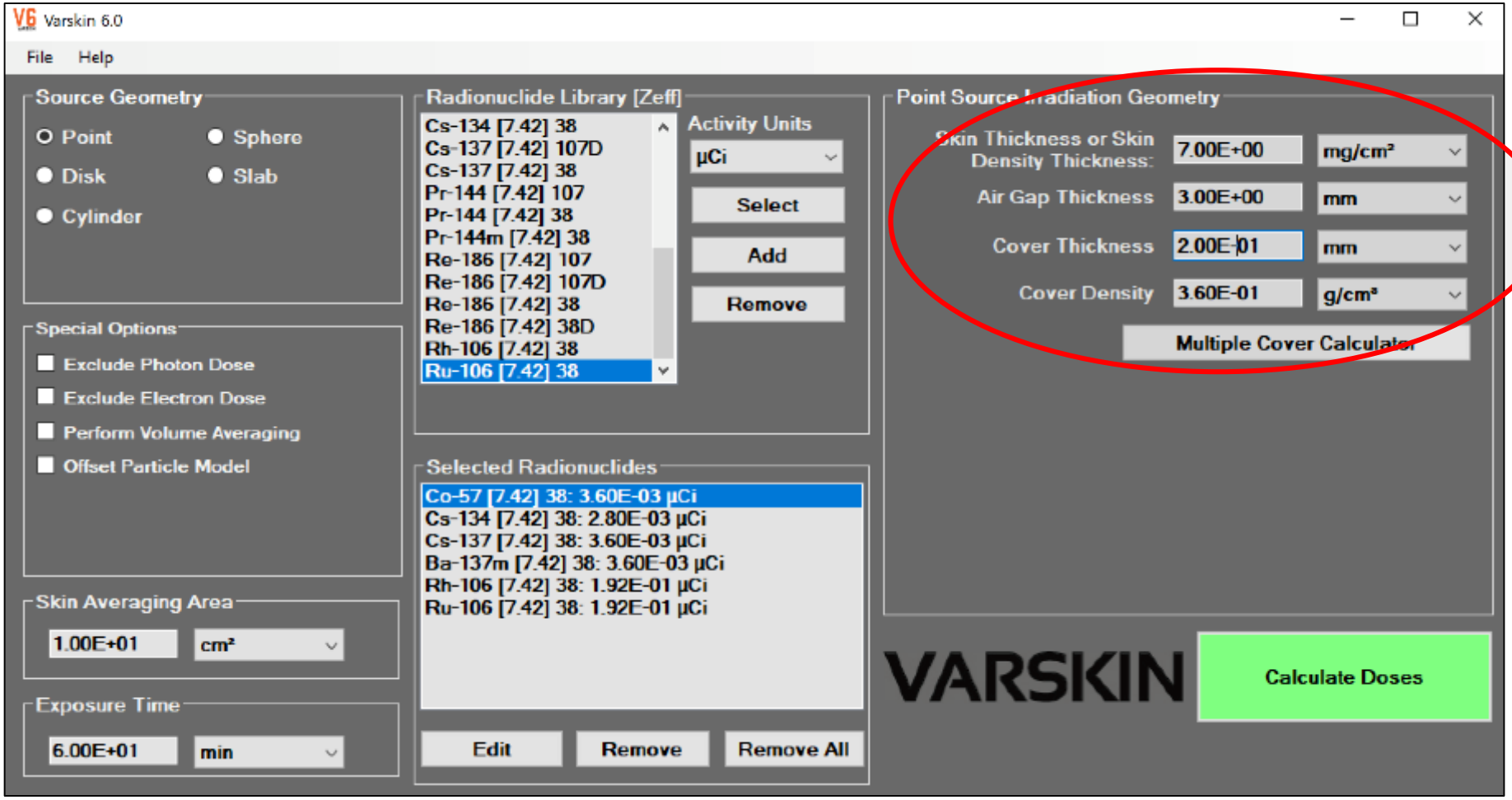
scenario #4

- Particle (not captured) on plastic lab coat
  - will assume 3 mm air gap (very arbitrary)
  - coat thickness of 0.20 mm, and density of 0.36 g/cm^3
- Source measurements indicate:
  - 0.0036 μCi of Co-57
  - 0.1920 μCi of Ru-106 (Rh-106)
  - 0.0028 μCi of Cs-134
  - 0.0036 μCi of Cs-137 (Ba-137m)
- Modeled as a point source
- Interested in a beta and gamma depth-dose profile

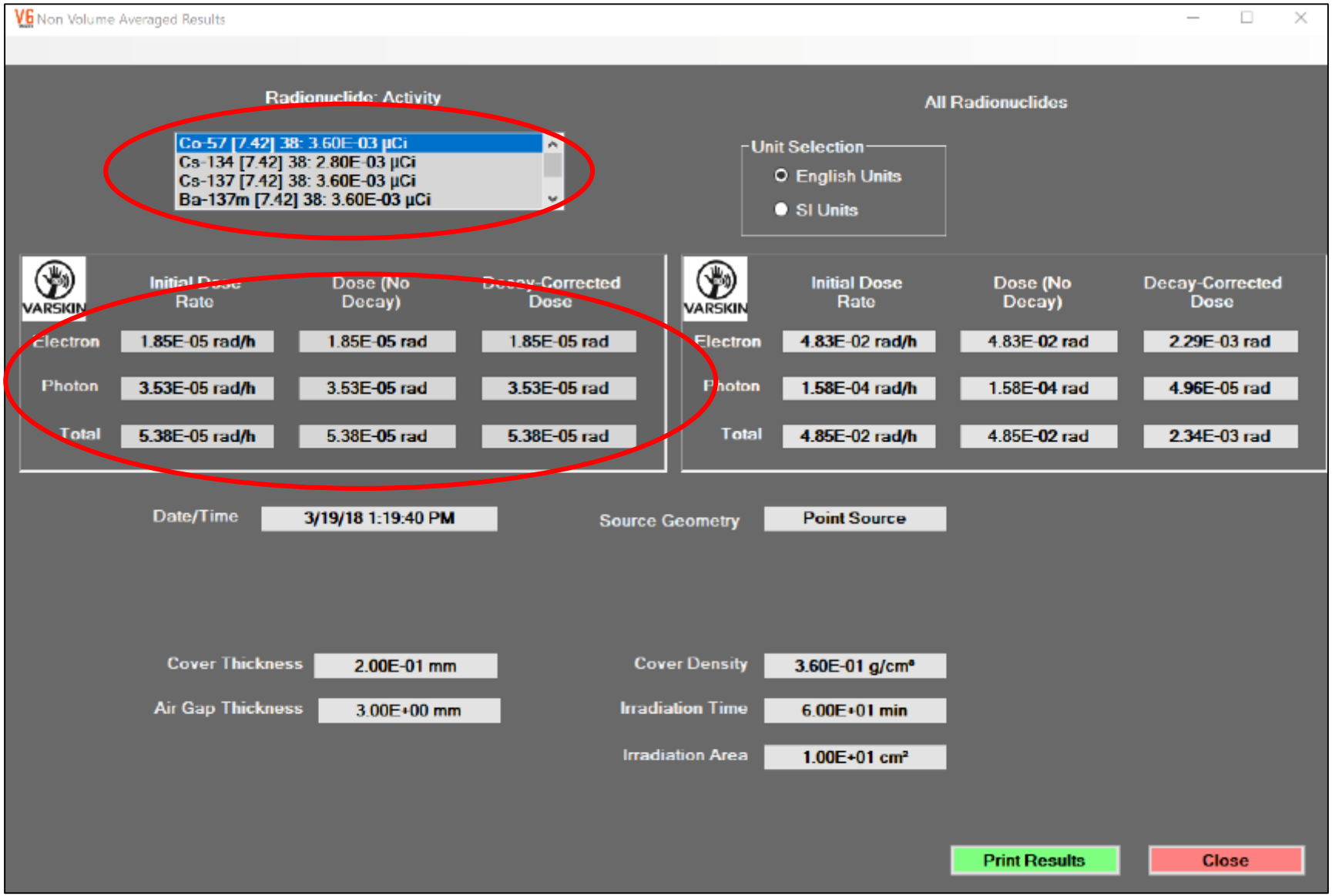
Beta activity determination



Varskin input



results

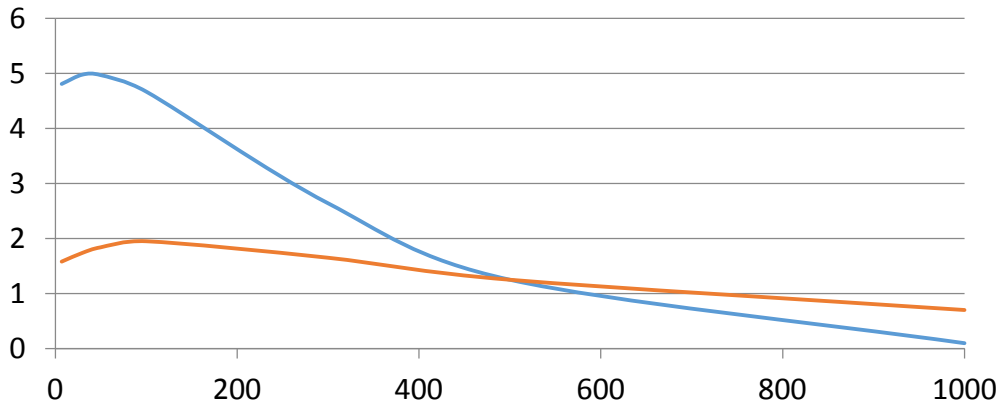

V6 Non Volume Averaged Results
Radionuclide: Activity
Co-57 [7.42] 38: 3.60E-03 µCi
Cs-134 [7.42] 38: 2.80E-03 µCi
Cs-137 [7.42] 38: 3.60E-03 µCi
Ba-137m [7.42] 38: 3.60E-03 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 1.85E-05 rad/h 1.85E-05 rad 1.85E-05 rad
Photon 3.53E-05 rad/h 3.53E-05 rad 3.53E-05 rad
Total 5.38E-05 rad/h 5.38E-05 rad 5.38E-05 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 4.83E-02 rad/h 4.83E-02 rad 2.29E-03 rad
Photon 1.58E-04 rad/h 1.58E-04 rad 4.96E-05 rad
Total 4.85E-02 rad/h 4.85E-02 rad 2.34E-03 rad
Date/Time 3/19/18 1:19:40 PM
Source Geometry Point Source
Cover Thickness 2.00E-01 mm
Air Gap Thickness 3.00E+00 mm
Cover Density 3.60E-01 g/cm³
Irradiation Time 6.00E+01 min
Irradiation Area 1.00E+01 cm²
Print Results
Close

Results by nuclide

@ 7 mg/cm^2	Beta Dose Rate	Photon Dose Rate	Total Dose Rate (rad/hr)
Co-57	1.85E-5	3.53E-5	5.38E-5
Ru-106	0	0	0
Rh-106	4.65E-2	1.04E-4	4.66E-2
Cs-134	6.41E-4	1.27E-5	6.54E-4
Cs-137	1.06E-3	0	1.06E-3
Ba-137m	1.02E-4	6.49E-6	1.09E-4
TOTAL	**4.83E-2**	**1.58E-4**	**4.85E-2**

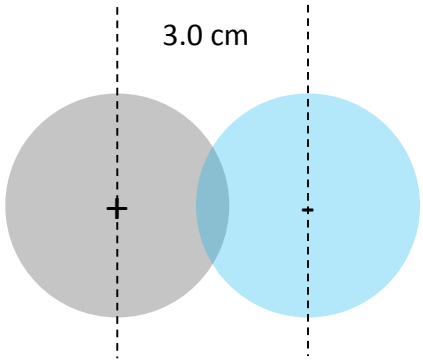
Results by depth

	Beta Dose Rate	Photon Dose Rate	Total Dose Rate (rad/hr)
7 mg/cm^2	4.83E-2	1.58E-4	4.85E-2
30	5.00E-2	1.74E-4	5.01E-2
50	4.98E-2	1.84E-4	5.00E-2
100	4.67E-2	1.95E-4	4.69E-2
300	2.64E-2	1.65E-4	2.66E-2
500	1.25E-2	1.25E-4	1.27E-2
1000	9.68E-4	7.00E-5	1.04E-3

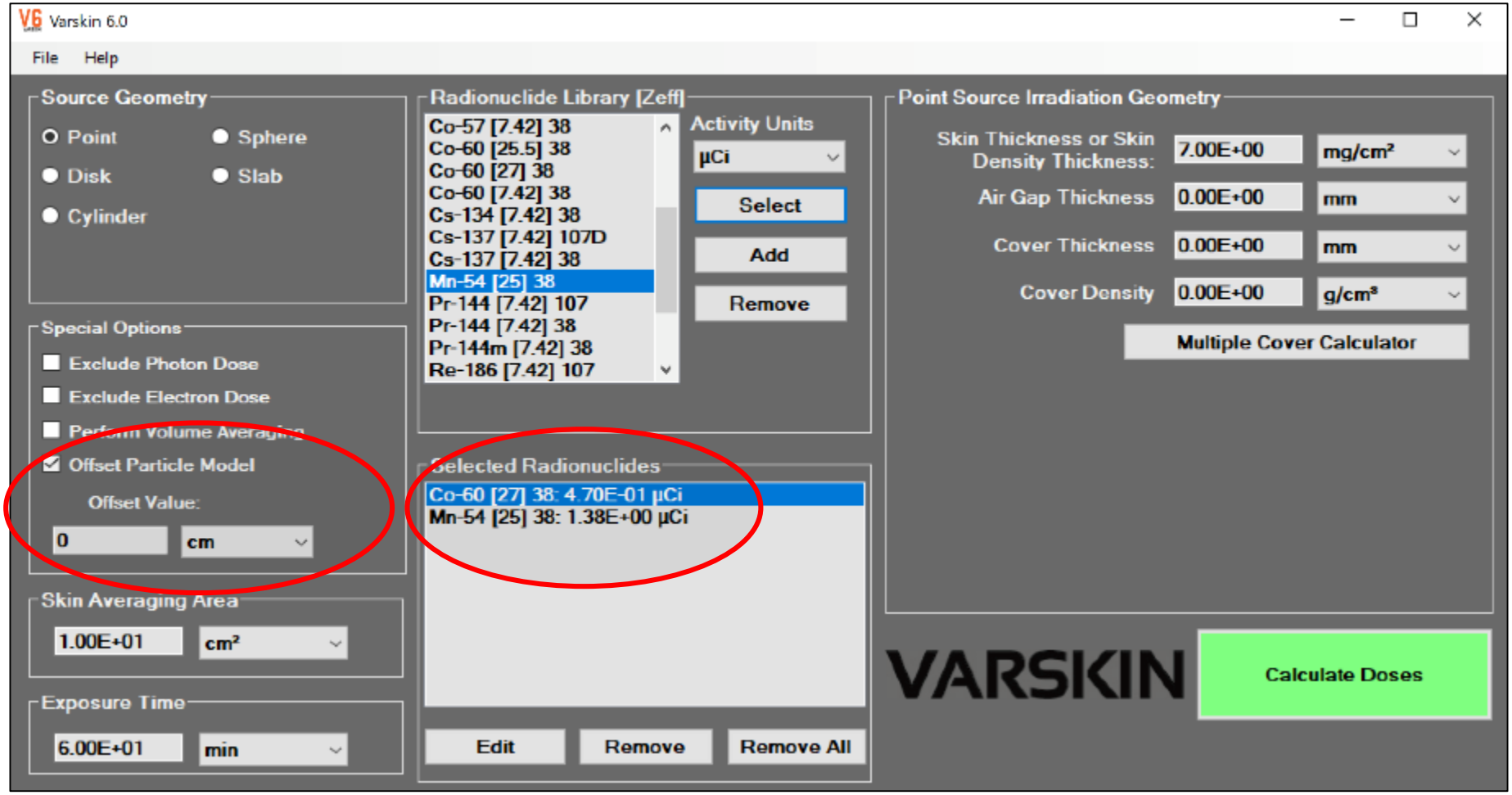


scenario #5 (offset model)

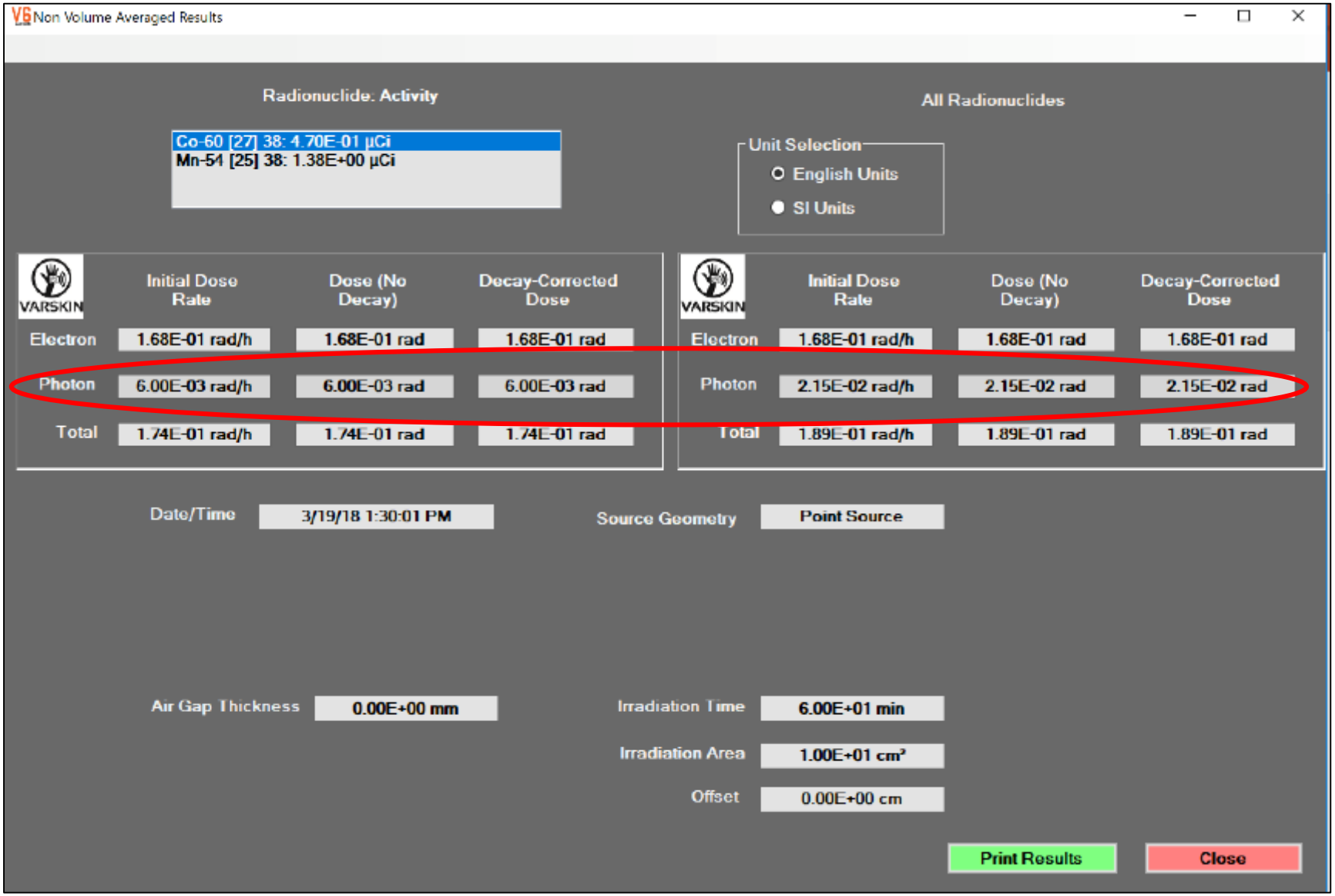
- Two particles on skin
  - separated by 3.0 cm
- Particle #1:
  - 1.38 μCi of Mn-54 (Z=25)
- Particle #2:
  - 0.471 μCi of Co-60 (Z=27)
- Modeled as two offset point sources
- Offset model only works for photon dosimetry
- Need maximum dose rate to 10 cm^2 disk @ 7 mg/cm^2



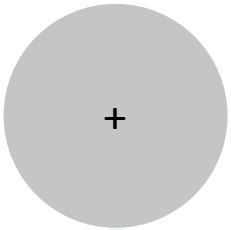
Point source input



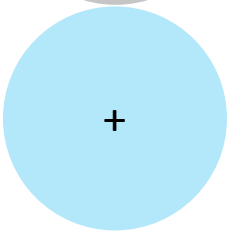
results


Non Volume Averaged Results
Radionuclide. Activity
Co-60 [27] 38: 4.70E-01 µCi
Mn-54 [25] 38: 1.38E+00 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 1.68E-01 rad/h 1.68E-01 rad 1.68E-01 rad
Photon 6.00E-03 rad/h 6.00E-03 rad 6.00E-03 rad
Total 1.74E-01 rad/h 1.74E-01 rad 1.74E-01 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 1.68E-01 rad/h 1.68E-01 rad 1.68E-01 rad
Photon 2.15E-02 rad/h 2.15E-02 rad 2.15E-02 rad
Total 1.89E-01 rad/h 1.89E-01 rad 1.89E-01 rad
Date/Time 3/19/18 1:30:01 PM
Source Geometry Point Source
Air Gap Thickness 0.00E+00 mm
Irradiation Time 6.00E+01 min
Irradiation Area 1.00E+01 cm²
Offset 0.00E+00 cm
Print Results
Close

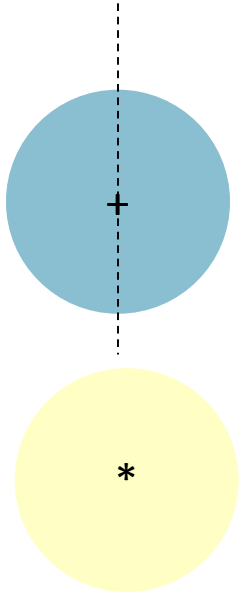
Photon dose rate from each source



Mn-54
15.5 mrad/hr

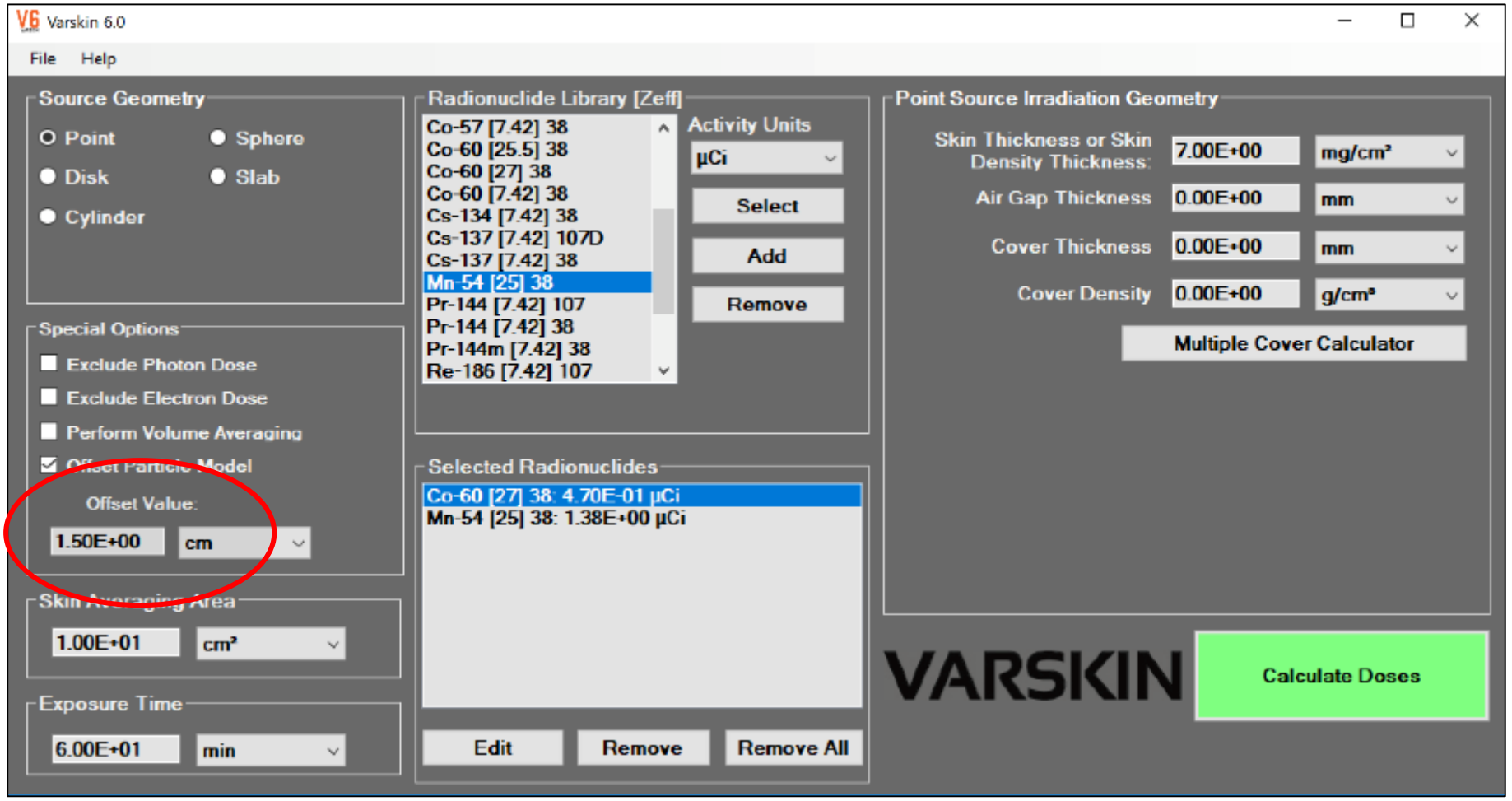


Co-60
6.00 mrad/hr

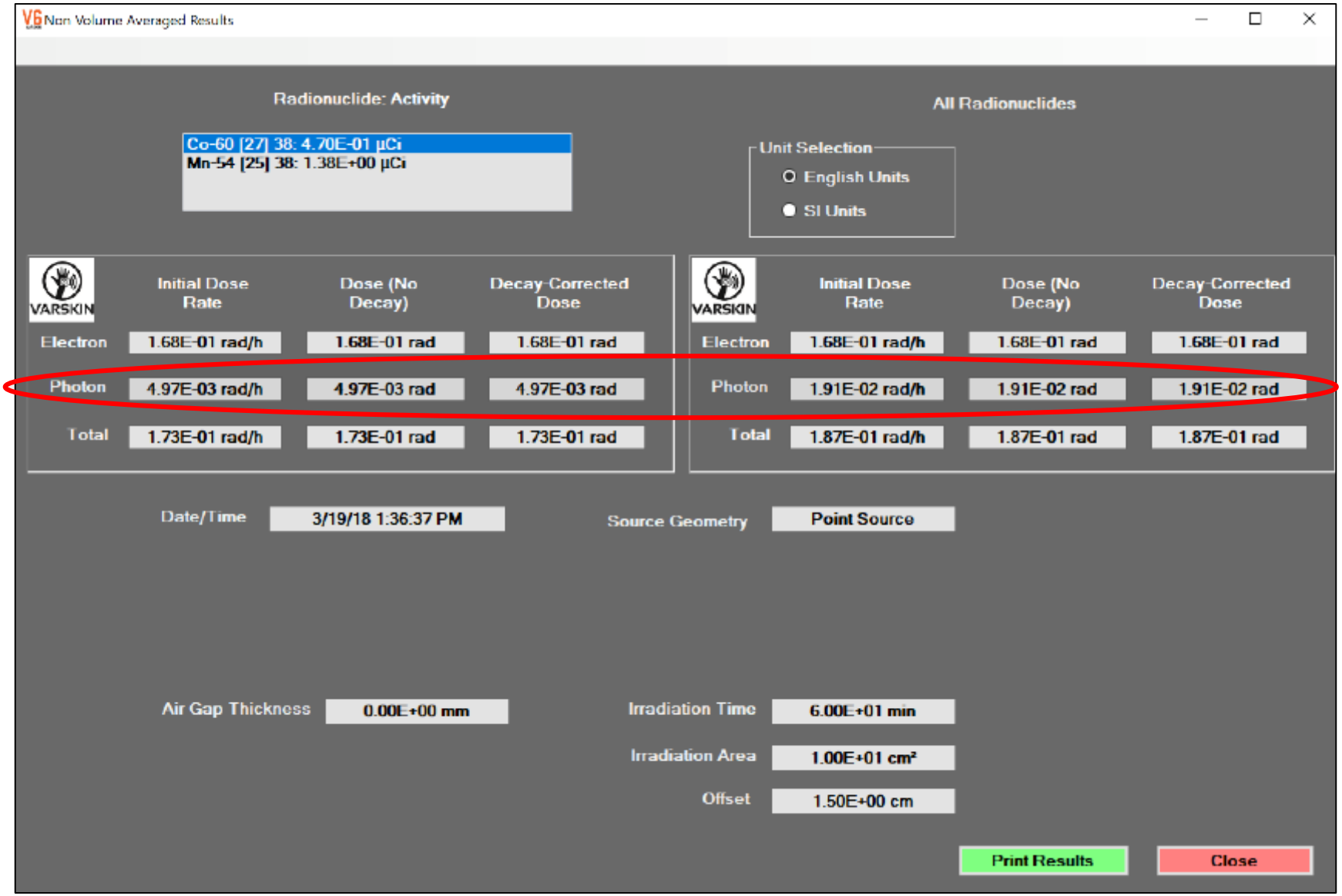


Where do we place a single averaging disk in order to maximize dose?

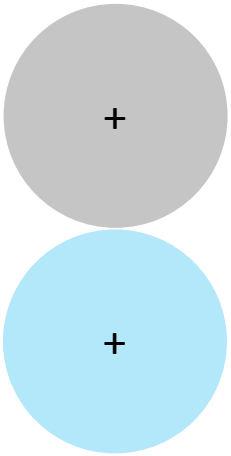
Offset particle model input



results

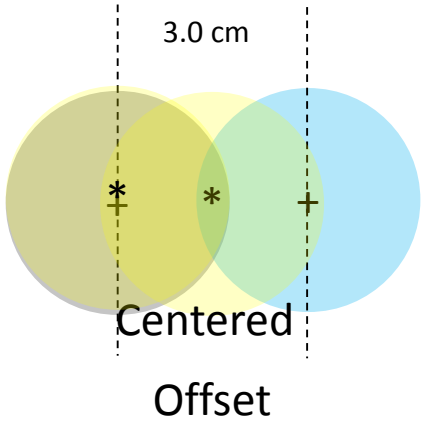

Non Volume Averaged Results
Radionuclide: Activity
Co-60 [27] 38: 4.70E-01 µCi
Mn-54 [25] 38: 1.38E+00 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 1.68E-01 rad/h 1.68E-01 rad 1.68E-01 rad
Photon 4.97E-03 rad/h 4.97E-03 rad 4.97E-03 rad
Total 1.73E-01 rad/h 1.73E-01 rad 1.73E-01 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 1.68E-01 rad/h 1.68E-01 rad 1.68E-01 rad
Photon 1.91E-02 rad/h 1.91E-02 rad 1.91E-02 rad
Total 1.87E-01 rad/h 1.87E-01 rad 1.87E-01 rad
Date/Time 3/19/18 1:36:37 PM
Source Geometry Point Source
Air Gap Thickness 0.00E+00 mm
Irradiation Time 6.00E+01 min
Irradiation Area 1.00E+01 cm²
Offset 1.50E+00 cm
Print Results
Close

Dose to single averaging disk



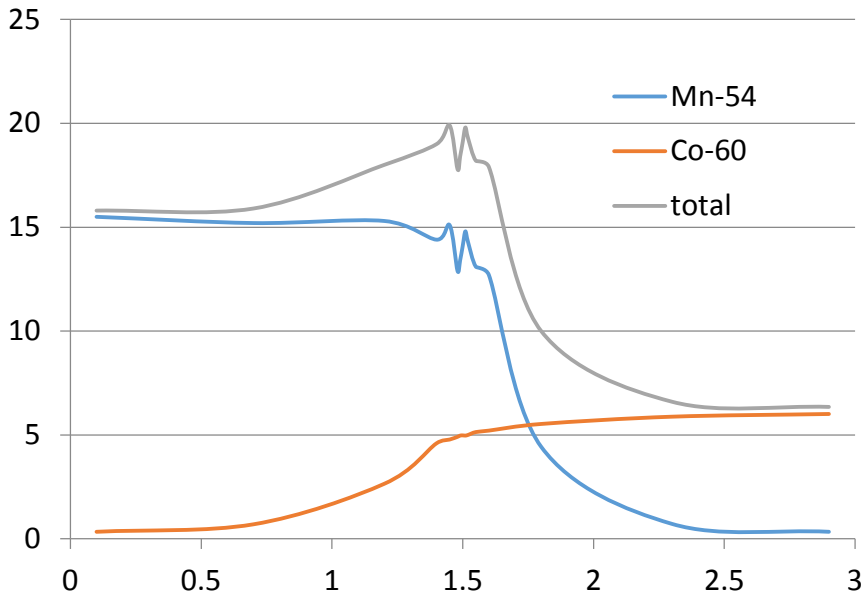
Mn-54
14.1 mrad/hr

Co-60
4.97 mrad/hr



Placement to maximize photon dose

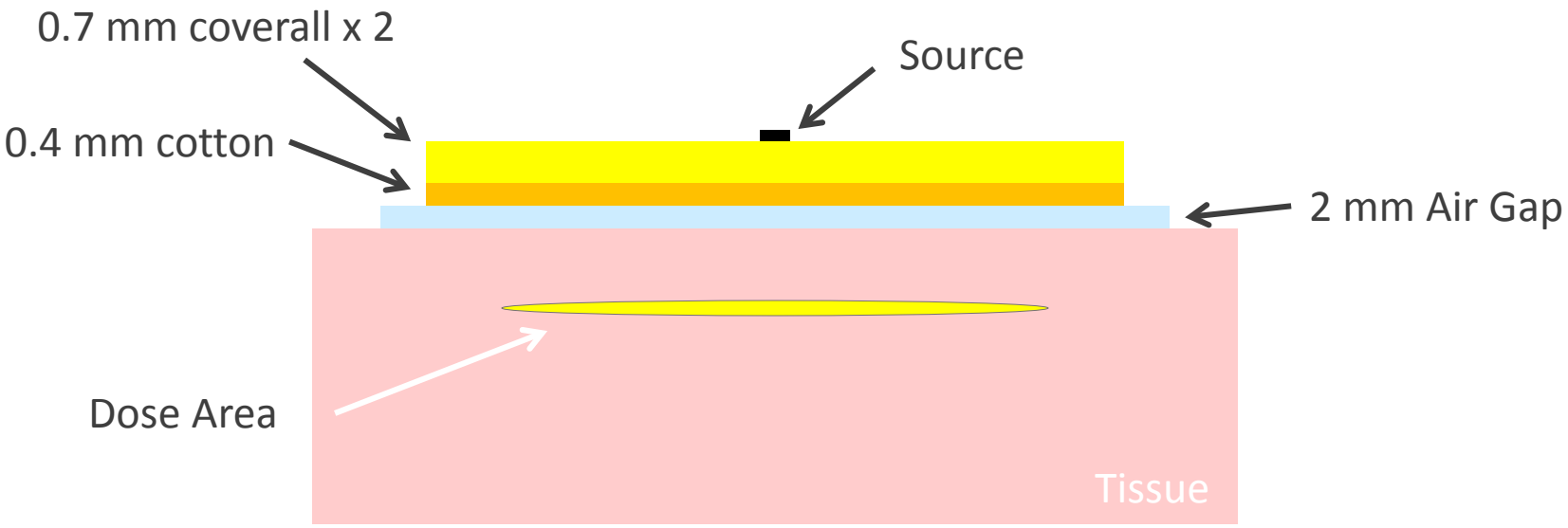
Dose Rate (mrad/hr)	Mn-54	Co-60	Total
Each on-axis (stacked)	15.5	6.00	21.5
0.1 cm from Mn-54	15.5	0.34	15.8
0.7 cm	15.2	0.70	15.9
1.2 cm	15.3	2.65	18.0
1.4 cm	14.4	4.60	19.0
1.45 cm	15.1	4.78	19.9
1.48 cm	12.9	4.91	17.8
1.49 cm	13.4	4.97	18.4
1.5 cm (centered)	14.1	4.97	19.1
1.51 cm	14.8	4.97	19.8
1.52 cm	14.3	5.00	19.3
1.55 cm	13.1	5.14	18.2
1.6 cm	12.7	5.21	17.9
1.8 cm	4.43	5.53	10.0
2.3 cm	0.72	5.88	6.60
2.9 cm (0.1 cm from Co-60)	0.34	6.00	6.35



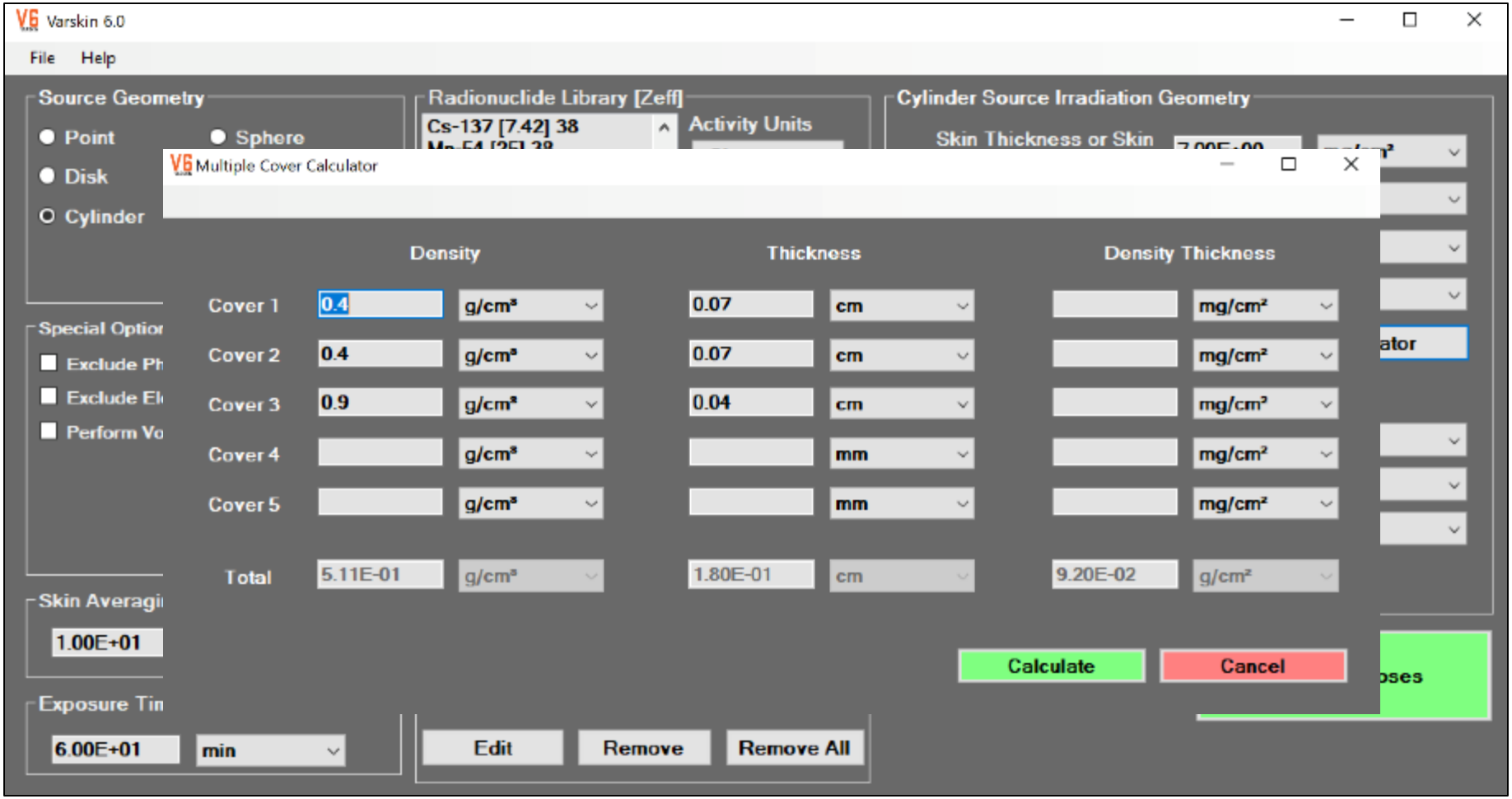
scenario #6 (multiple cover)

- Using the Multiple Cover Calculator
- Hot particle imbedded in two layers of coveralls (0.7 mm; 0.4 g/cm^3), and one heavy cotton shirt (assumed similar to cloth lab coat; 0.4 mm; 0.9 g/cm^3)
- Assume air gap of 1.5 mm + 0.5 mm between coveralls and cotton shirt
- Sr-90 in equilibrium with daughter
- 1.3 μCi in iron (Z=26; 7.87 g/cm^3), cylindrical source, 20 μm diameter x 40 μm length
- Depth-dose profile to 100 mg/cm^2

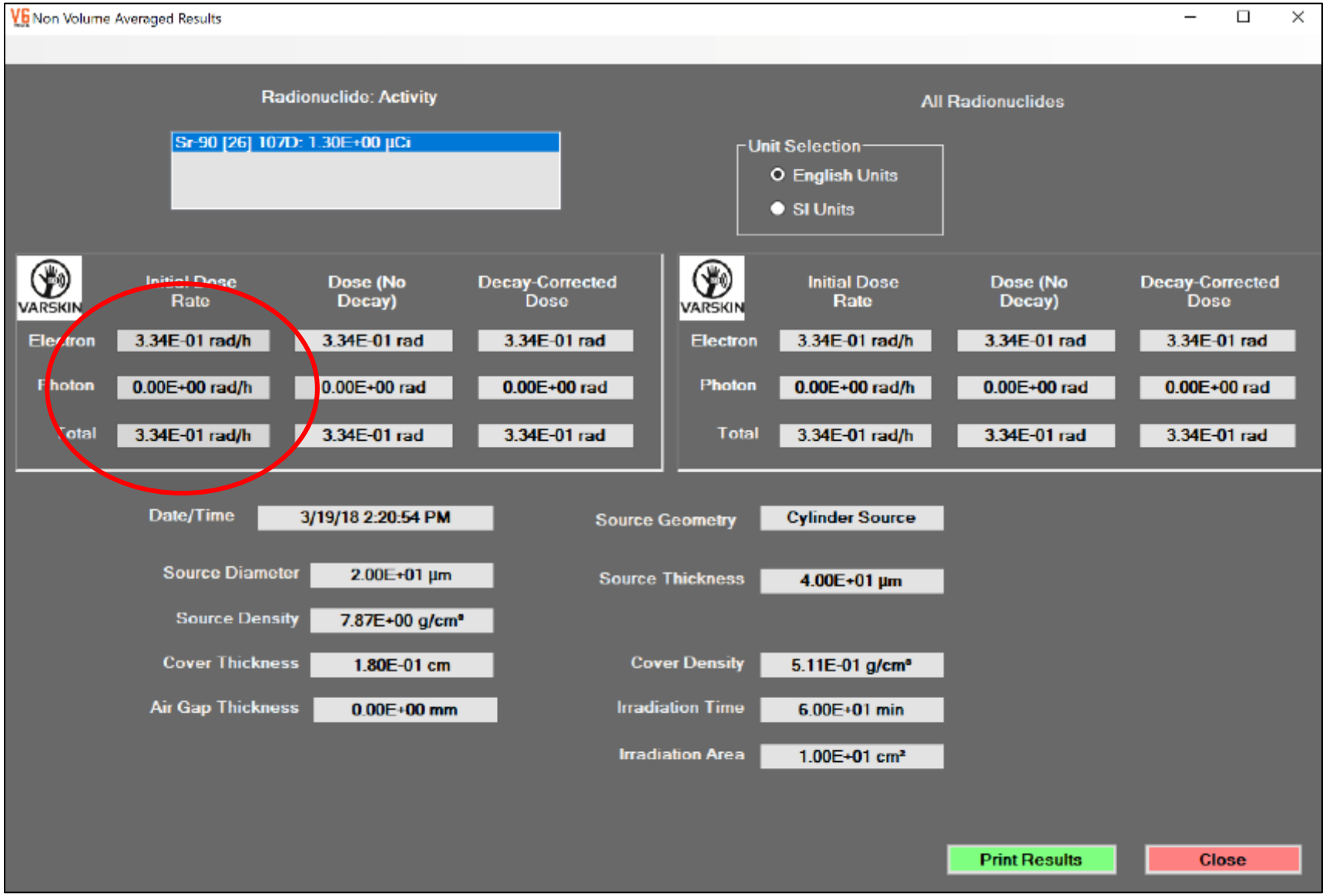
Cover model


0.7 mm coverall x 2
0.4 mm cotton
Source
2 mm Air Gap
Dose Area
Tissue

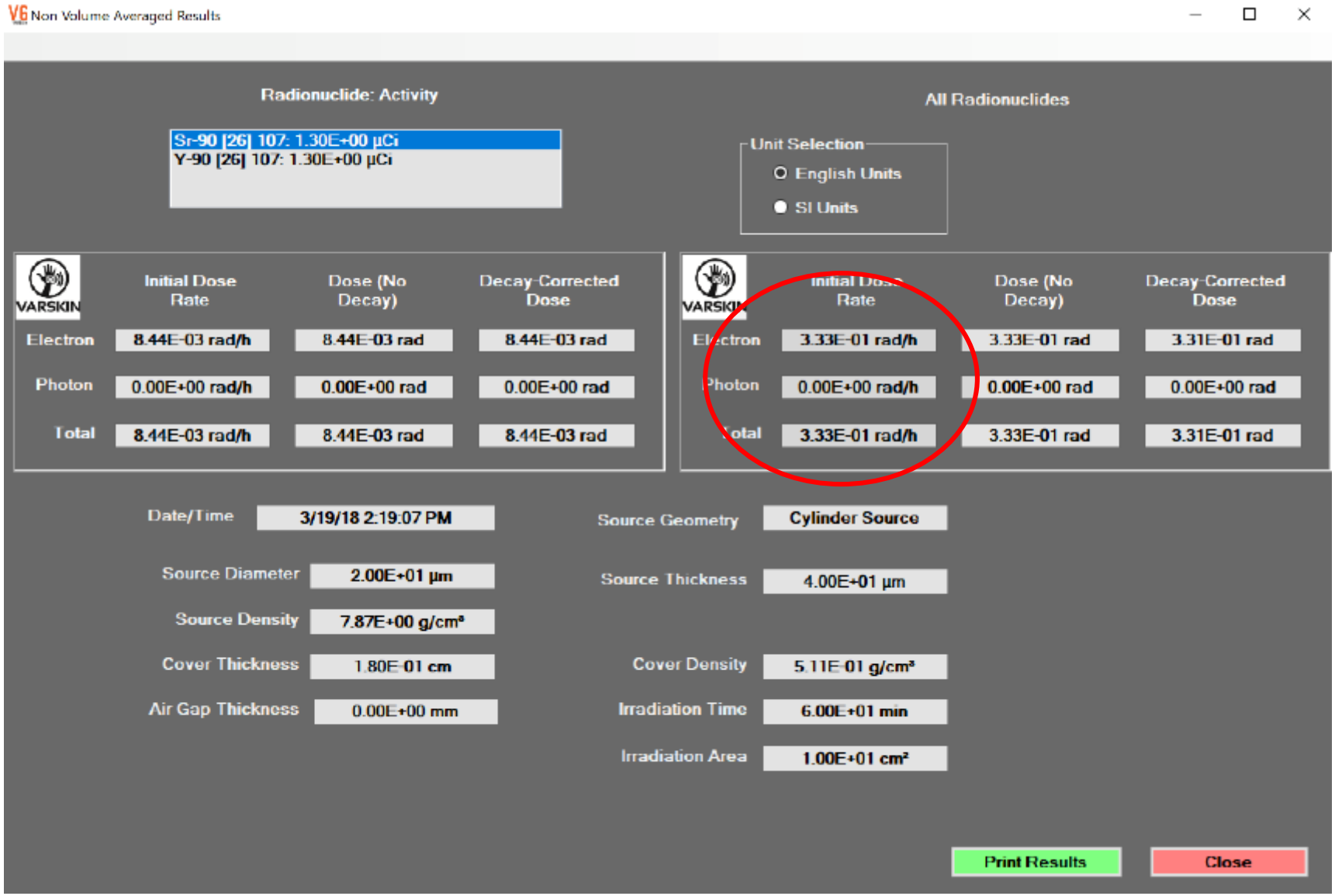
Multiple cover input



results


Non Volume Averaged Results
Radionuclide: Activity
Sr-90 [26] 107D: 1.30E+00 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 3.34E-01 rad/h 3.34E-01 rad 3.34E-01 rad
Photon 0.00E+00 rad/h 0.00E+00 rad 0.00E+00 rad
Total 3.34E-01 rad/h 3.34E-01 rad 3.34E-01 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 3.34E-01 rad/h 3.34E-01 rad 3.34E-01 rad
Photon 0.00E+00 rad/h 0.00E+00 rad 0.00E+00 rad
Total 3.34E-01 rad/h 3.34E-01 rad 3.34E-01 rad
Date/Time 3/19/18 2:20:54 PM
Source Geometry Cylinder Source
Source Diameter 2.00E+01 µm
Source Thickness 4.00E+01 µm
Source Density 7.87E+00 g/cm³
Cover Thickness 1.80E-01 cm
Cover Density 5.11E-01 g/cm³
Air Gap Thickness 0.00E+00 mm
Irradiation Time 6.00E+01 min
Irradiation Area 1.00E+01 cm²
Print Results
Close

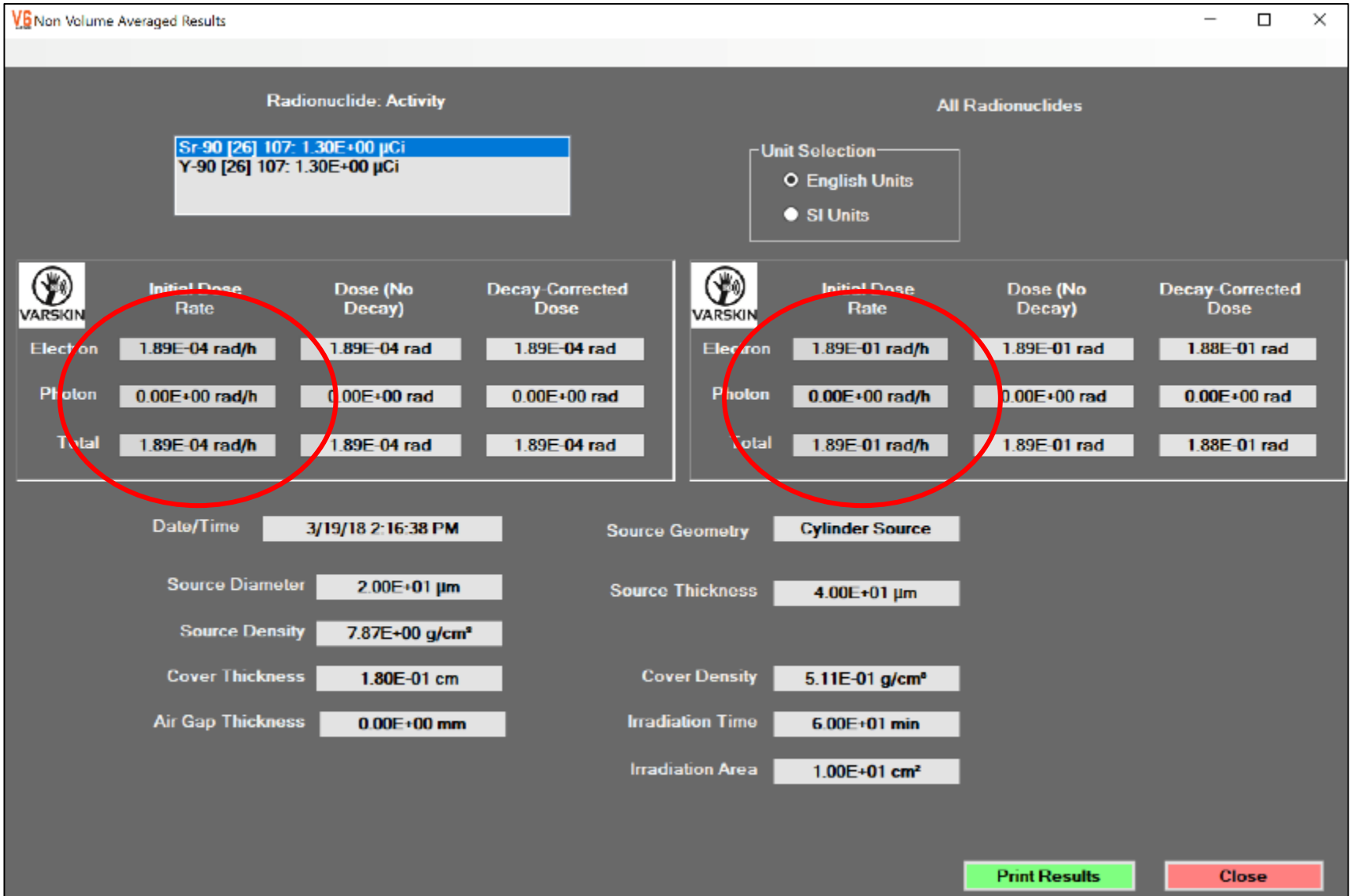
results


Non Volume Averaged Results
Radionuclide: Activity
Sr-90 [26] 107: 1.30E+00 µCi
Y-90 [26] 107: 1.30E+00 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 8.44E-03 rad/h 8.44E-03 rad 8.44E-03 rad
Photon 0.00E+00 rad/h 0.00E+00 rad 0.00E+00 rad
Total 8.44E-03 rad/h 8.44E-03 rad 8.44E-03 rad
VARSKIN
Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 3.33E-01 rad/h 3.33E-01 rad 3.31E-01 rad
Photon 0.00E+00 rad/h 0.00E+00 rad 0.00E+00 rad
Total 3.33E-01 rad/h 3.33E-01 rad 3.31E-01 rad
Date/Time 3/19/18 2:19:07 PM
Source Geometry Cylinder Source
Source Diameter 2.00E+01 µm
Source Thickness 4.00E+01 µm
Source Density 7.87E+00 g/cm³
Cover Thickness 1.80E-01 cm
Cover Density 5.11E-01 g/cm³
Air Gap Thickness 0.00E+00 mm
Irradiation Time 6.00E+01 min
Irradiation Area 1.00E+01 cm²
Print Results
Close

Depth-dose summary

	Total Dose (mrad/hr)
7 mg/cm^2	334
10	326
20	304
30	285
50	252
100	189

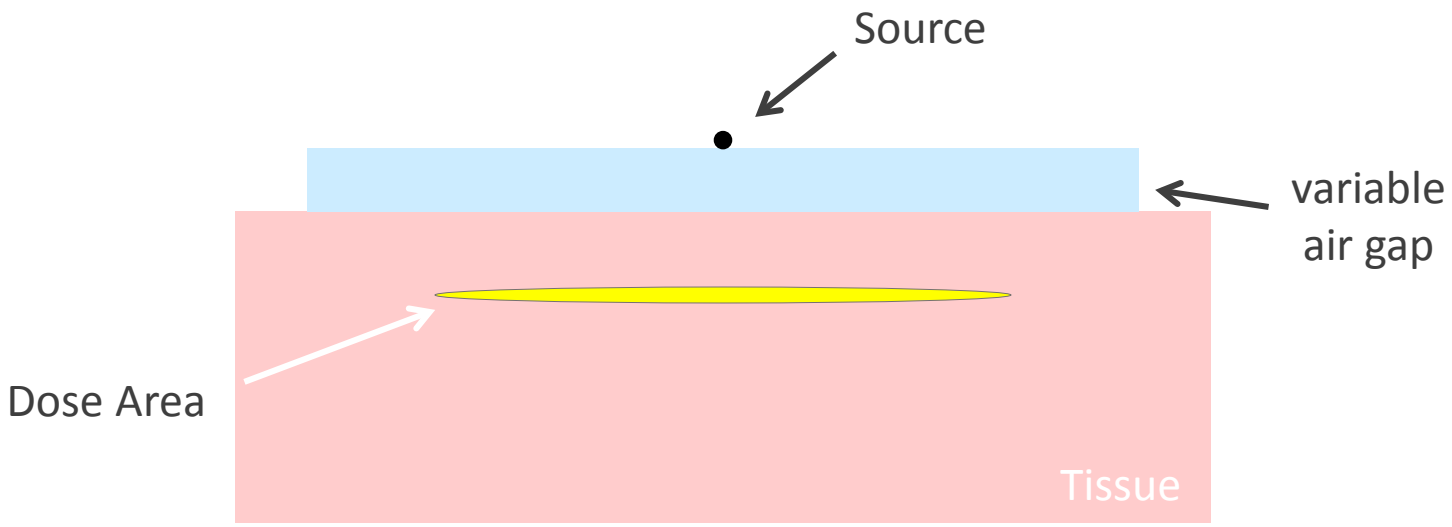
results


Non Volume Averaged Results
Radionuclide: Activity
Sr-90 [26] 107: 1.30E+00 µCi
Y-90 [26] 107: 1.30E+00 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay Corrected Dose
Electron 1.89E-04 rad/h 1.89E-04 rad 1.89E-04 rad
Photon 0.00E+00 rad/h 0.00E+00 rad 0.00E+00 rad
Total 1.89E-04 rad/h 1.89E-04 rad 1.89E-04 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay Corrected Dose
Electron 1.89E-01 rad/h 1.89E-01 rad 1.88E-01 rad
Photon 0.00E+00 rad/h 0.00E+00 rad 0.00E+00 rad
Total 1.89E-01 rad/h 1.89E-01 rad 1.88E-01 rad
Date/Time 3/19/18 2:16:38 PM
Source Geometry Cylinder Source
Source Diameter 2.00E+01 µm
Source Thickness 4.00E+01 µm
Source Density 7.87E+00 g/cm³
Cover Thickness 1.80E-01 cm
Cover Density 5.11E-01 g/cm³
Air Gap Thickness 0.00E+00 mm
Irradiation Time 6.00E+01 min
Irradiation Area 1.00E+01 cm²
Print Results
Close

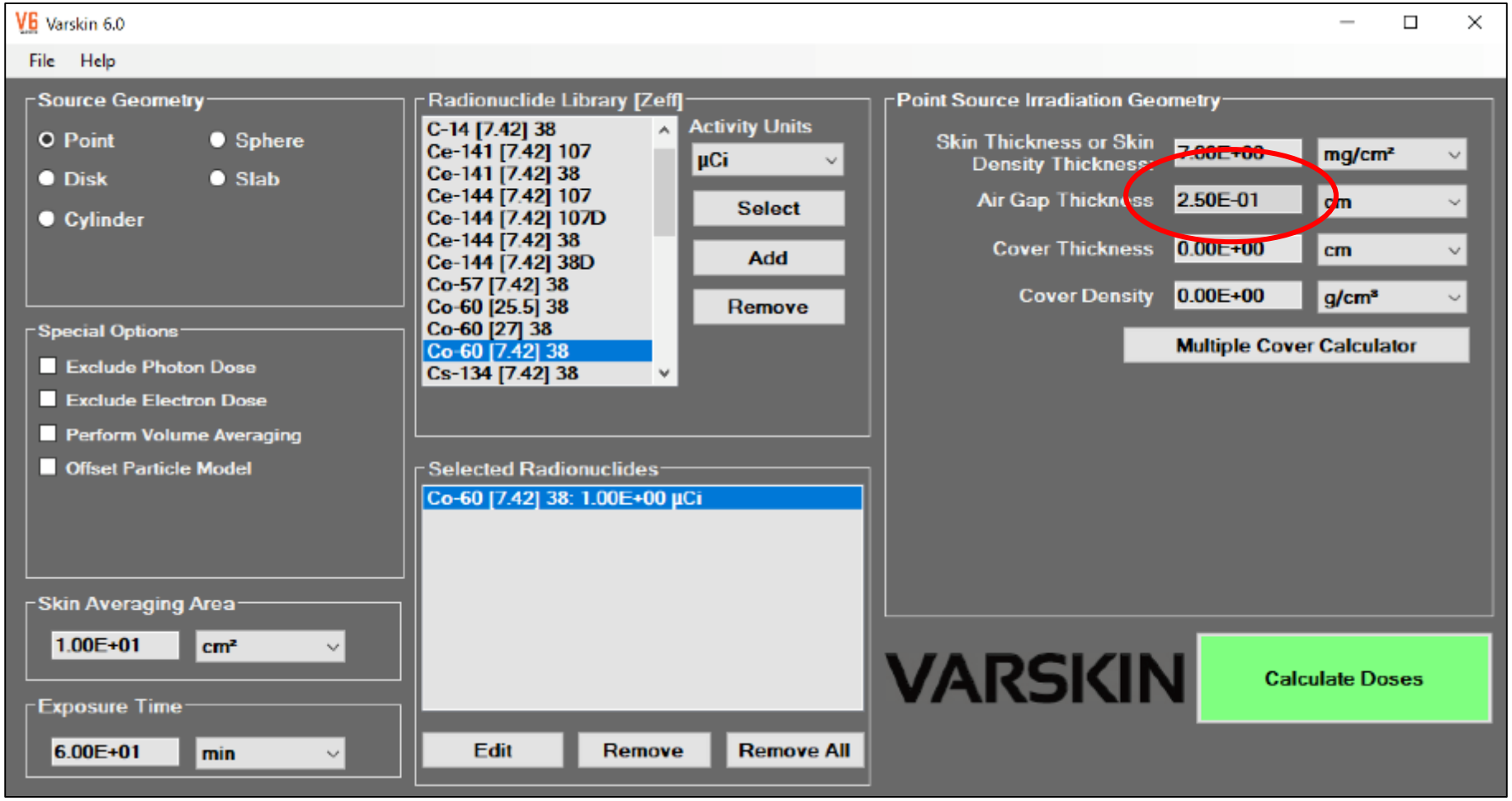
scenario #7 (air gap)

- Using the Air Gap Model
- Co-60 point source (1 μCi)
- 10 cm^2 averaging area
- Tissue depth of 7 mg/cm^2
- How does dose vary with an air gap of zero to 5 cm?

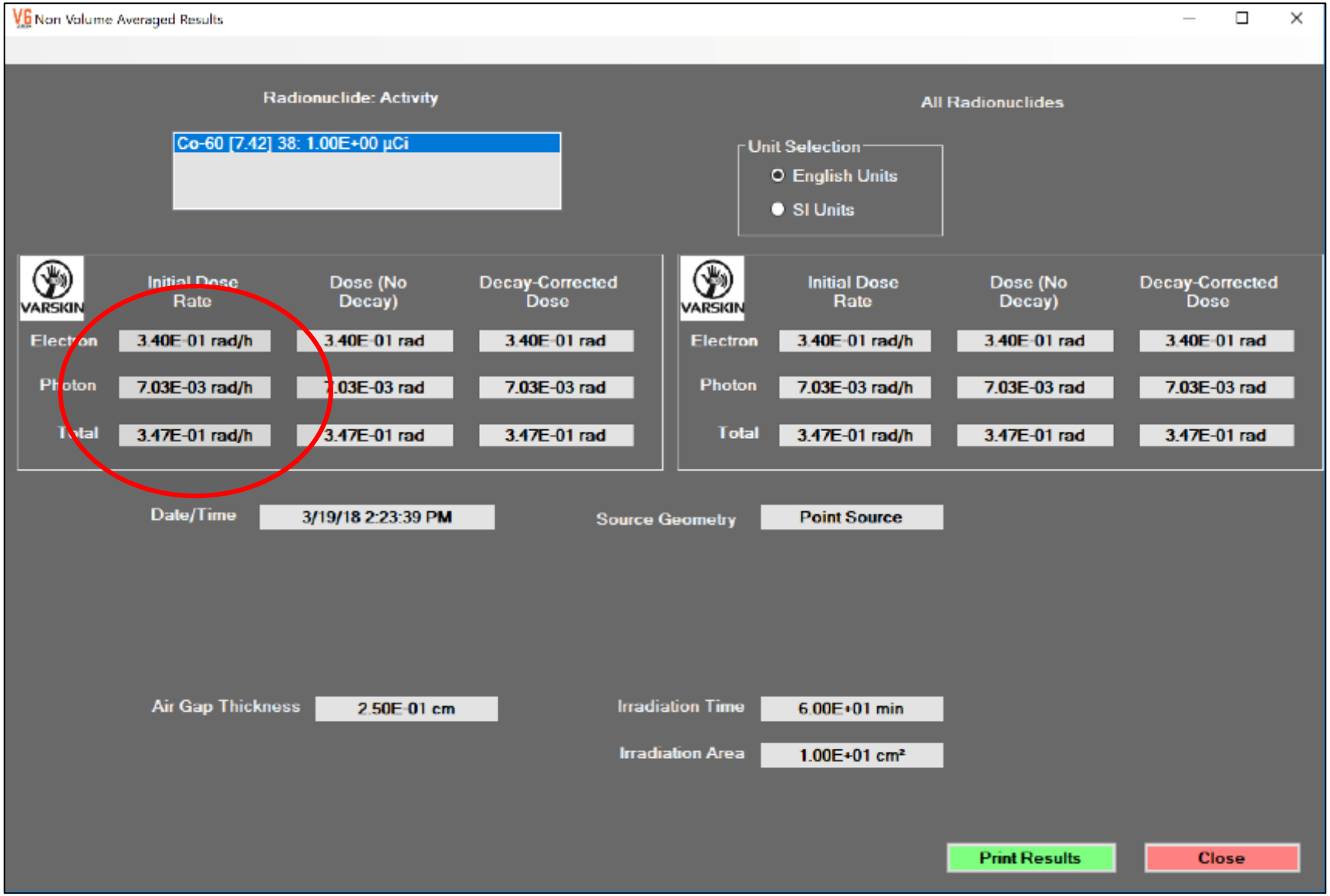
Air gap model



Air gap model input

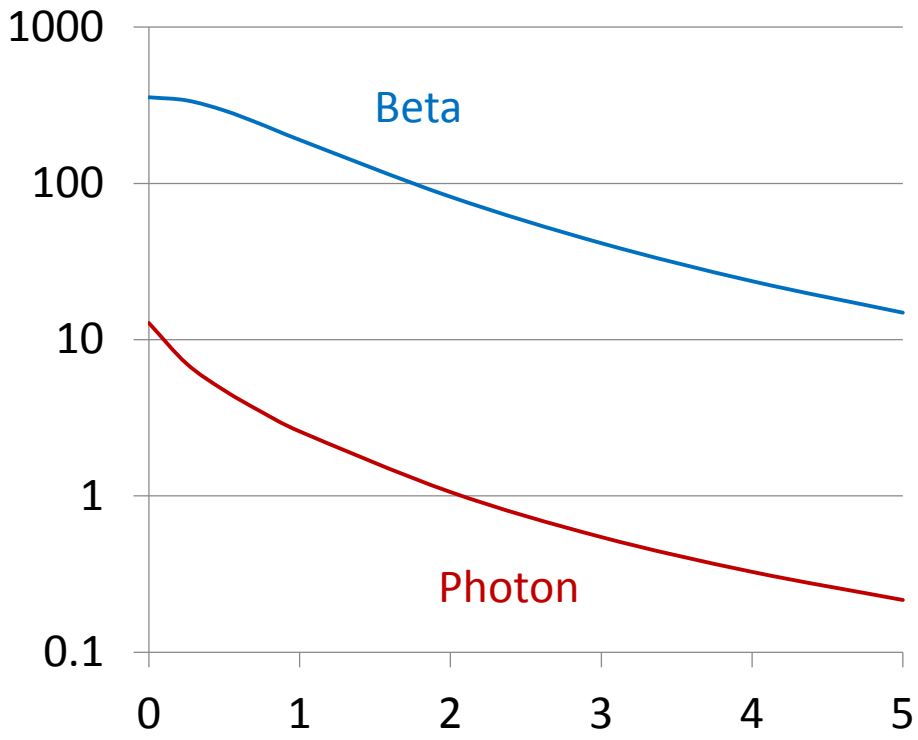


results


Non Volume Averaged Results
Radionuclide: Activity
Co-60 [7.42] 38: 1.00E+00 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
3.40E-01 rad/h
3.40E-01 rad
3.40E-01 rad
Photon
7.03E-03 rad/h
7.03E-03 rad
7.03E-03 rad
Total
3.47E-01 rad/h
3.47E-01 rad
3.47E-01 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
3.40E-01 rad/h
3.40E-01 rad
3.40E-01 rad
Photon
7.03E-03 rad/h
7.03E-03 rad
7.03E-03 rad
Total
3.47E-01 rad/h
3.47E-01 rad
3.47E-01 rad
Date/Time
3/19/18 2:23:39 PM
Source Geometry
Point Source
Air Gap Thickness
2.50E-01 cm
Irradiation Time
6.00E+01 min
Irradiation Area
1.00E+01 cm²
Print Results
Close

Air gap impact on dose

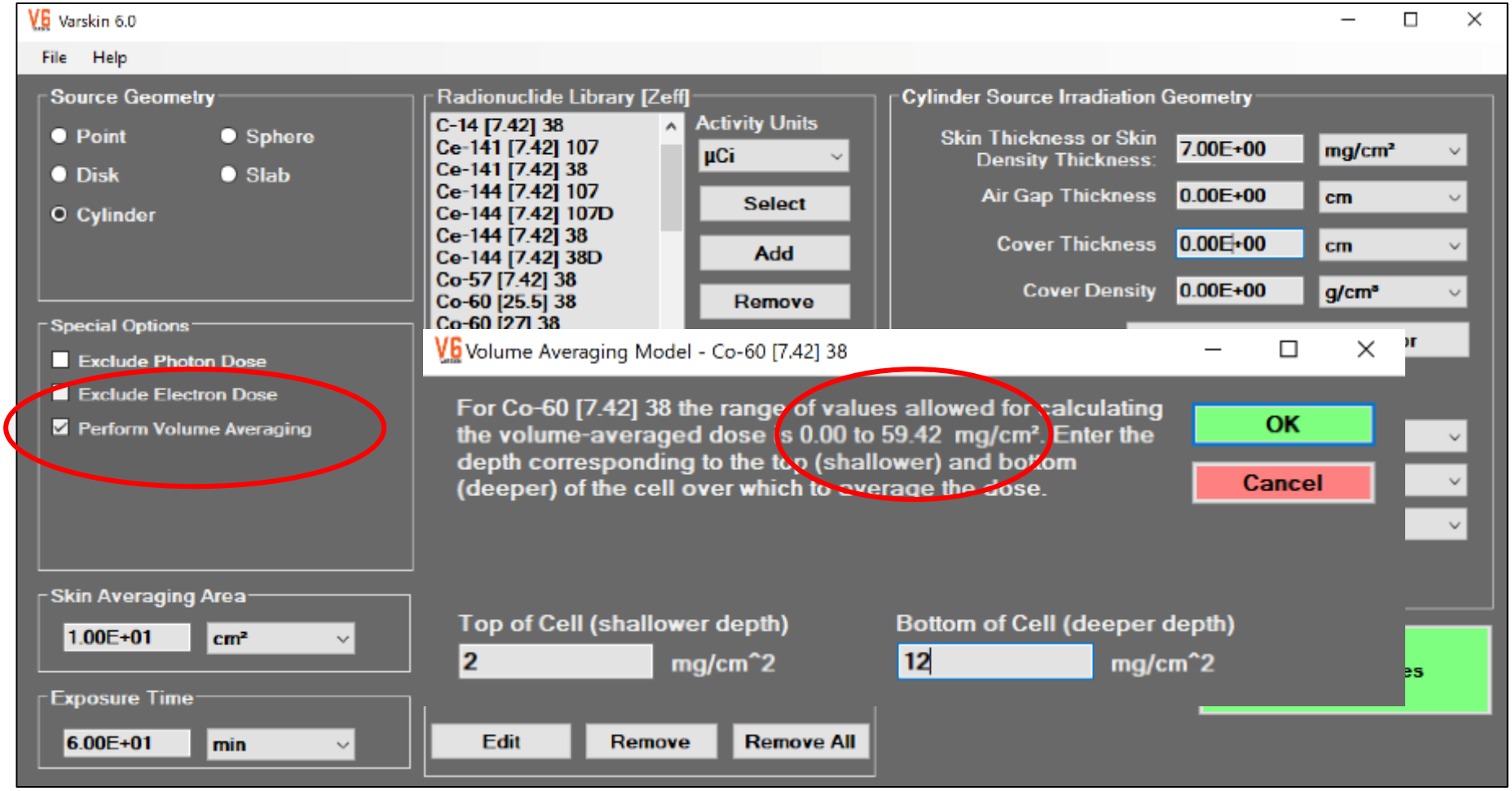
Air Gap (cm)	Beta	Photon	Total
0	356	12.8	369
0.25	340	7.03	347
0.50	293	4.74	298
0.75	238	3.44	241
1	190	2.59	192
2	82.2	1.06	83.3
3	41.5	0.546	42.0
4	23.7	0.327	24.1
5	14.9	0.216	15.1



scenario #8

- 1 μCi of Co-60 on skin
- 3D source
- With photon dose calculations
- With volume averaging (beta and gamma)
- For the purpose of examining run times and picking reasonable volume

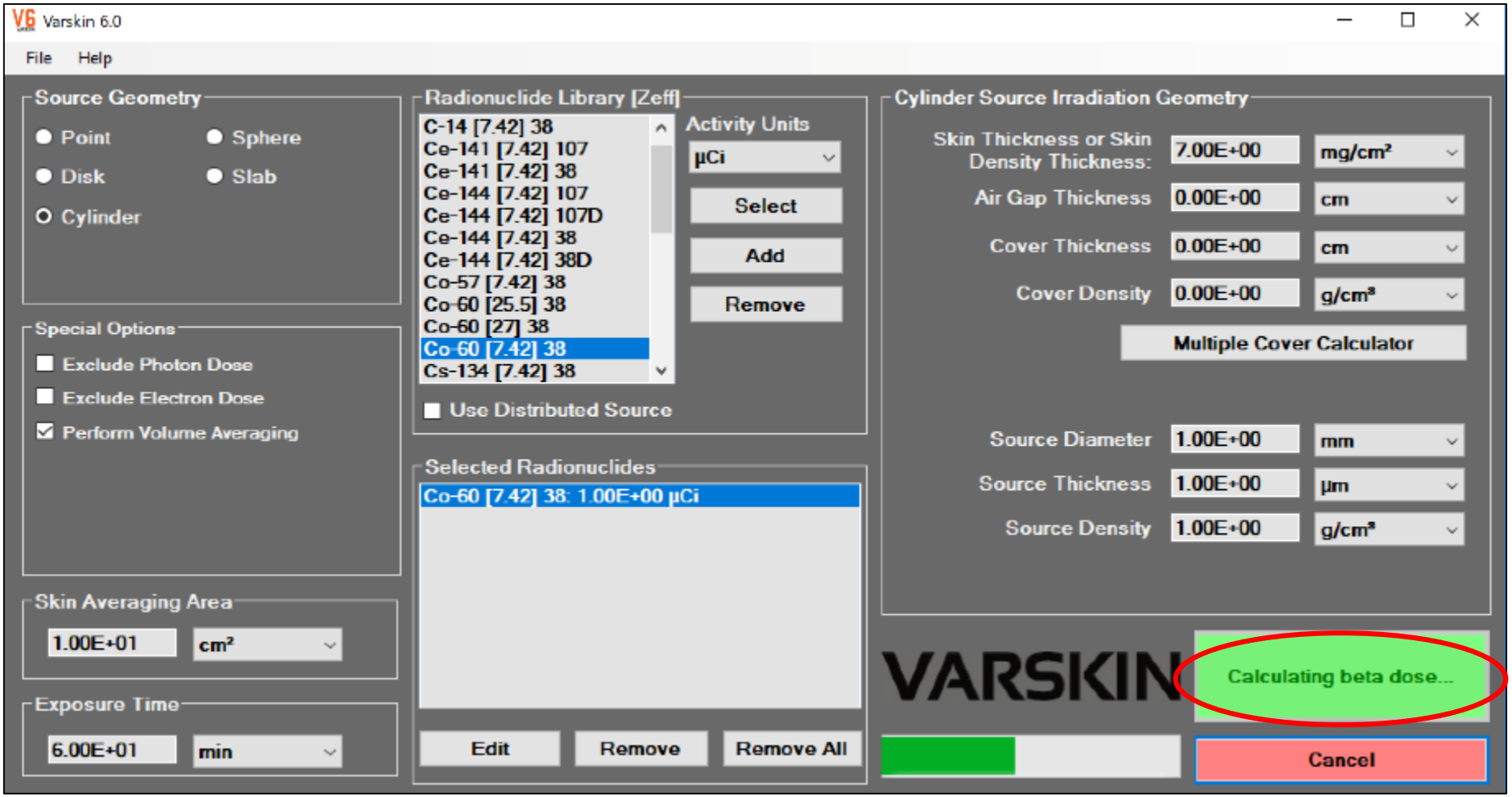
3D source and Volume averaging



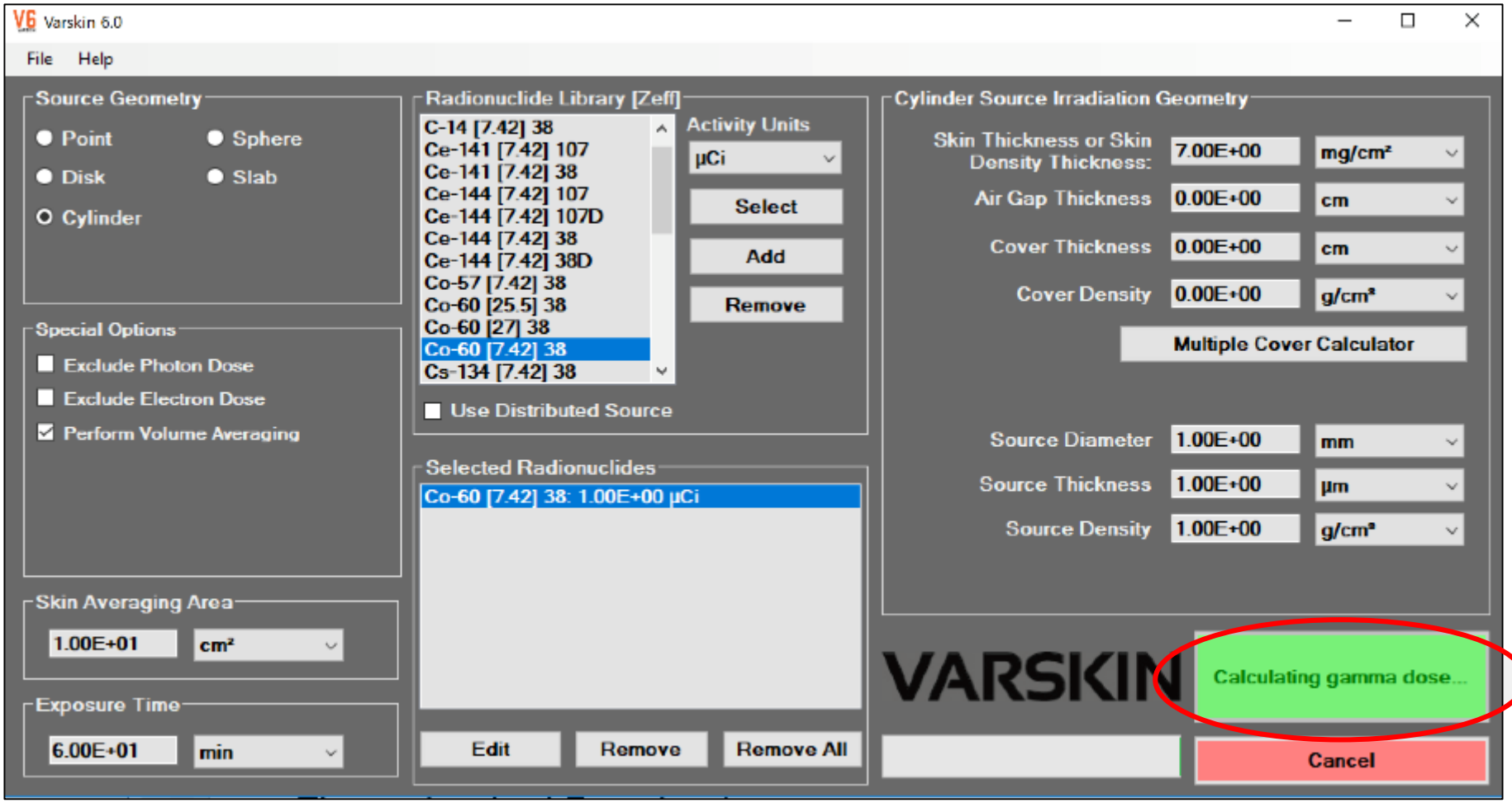
Maximum volume averaging depth

	Max Beta Energy (keV)	Max Depth (mg/cm^2)
Co-60	318	59.09
Cs-137	514	163.8
Cs-134	658	186.2
Ba-140	1020	295.3
Y-91	1540	604.4

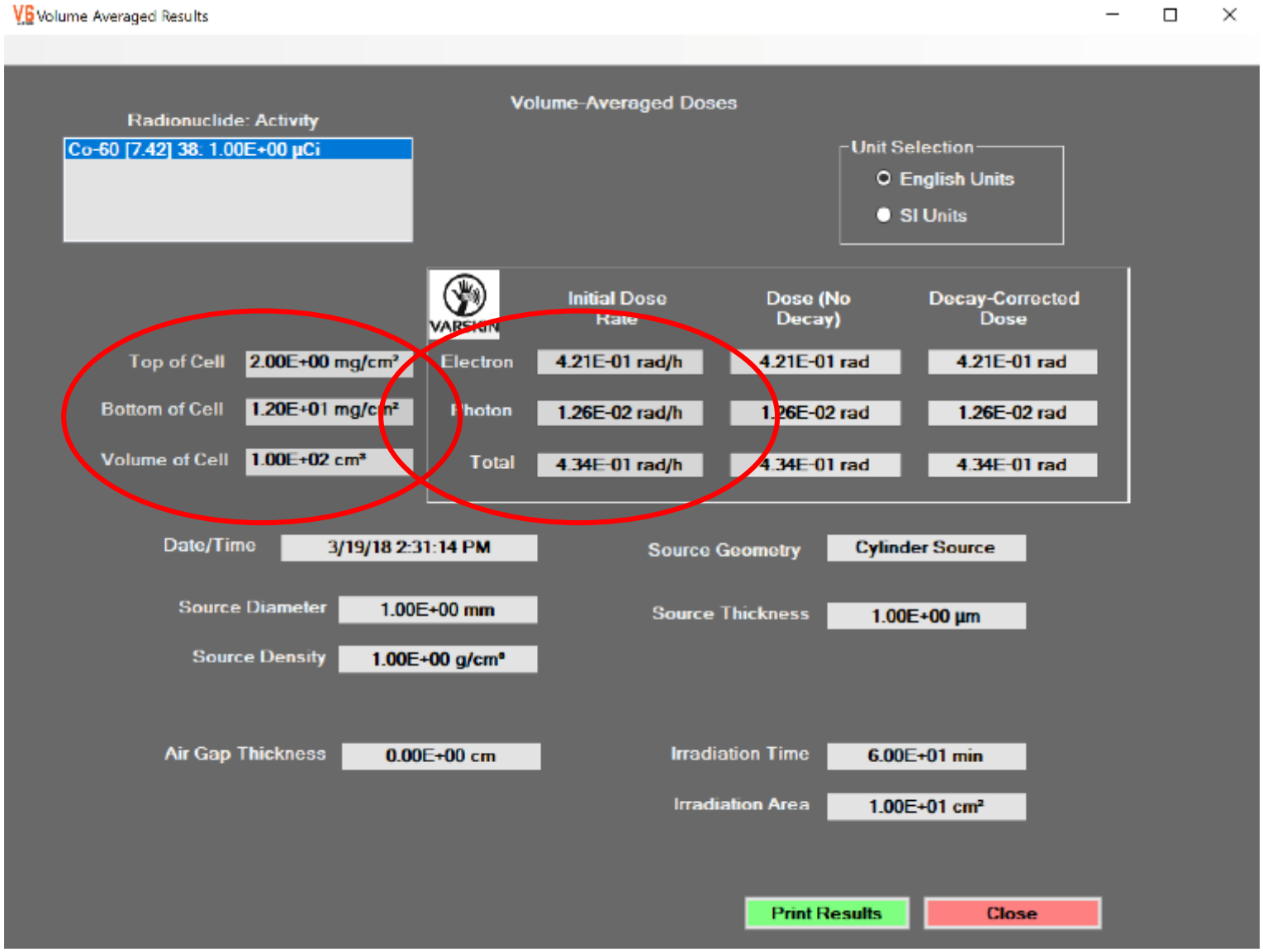
Calculating beta dose



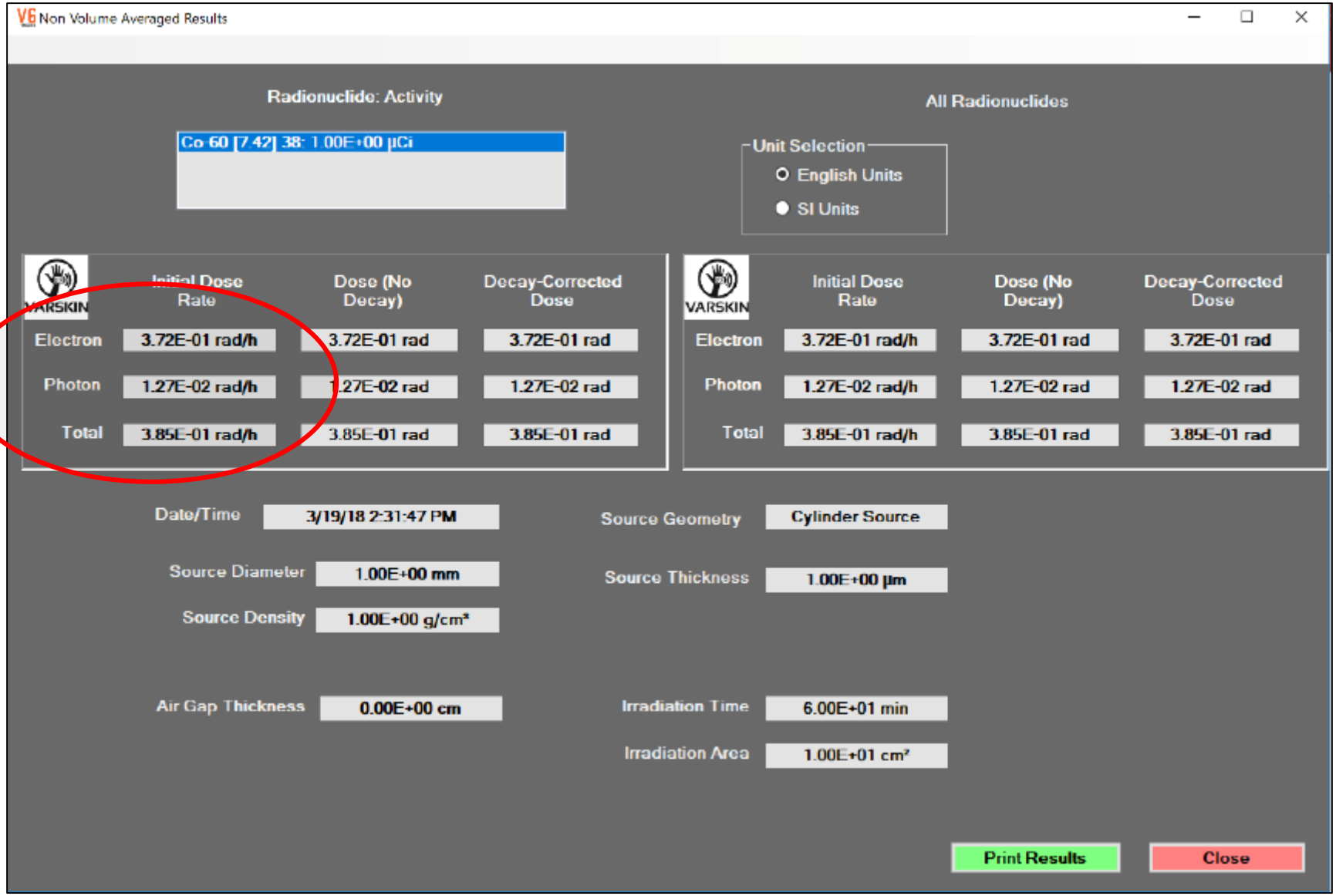
Calculating gamma dose



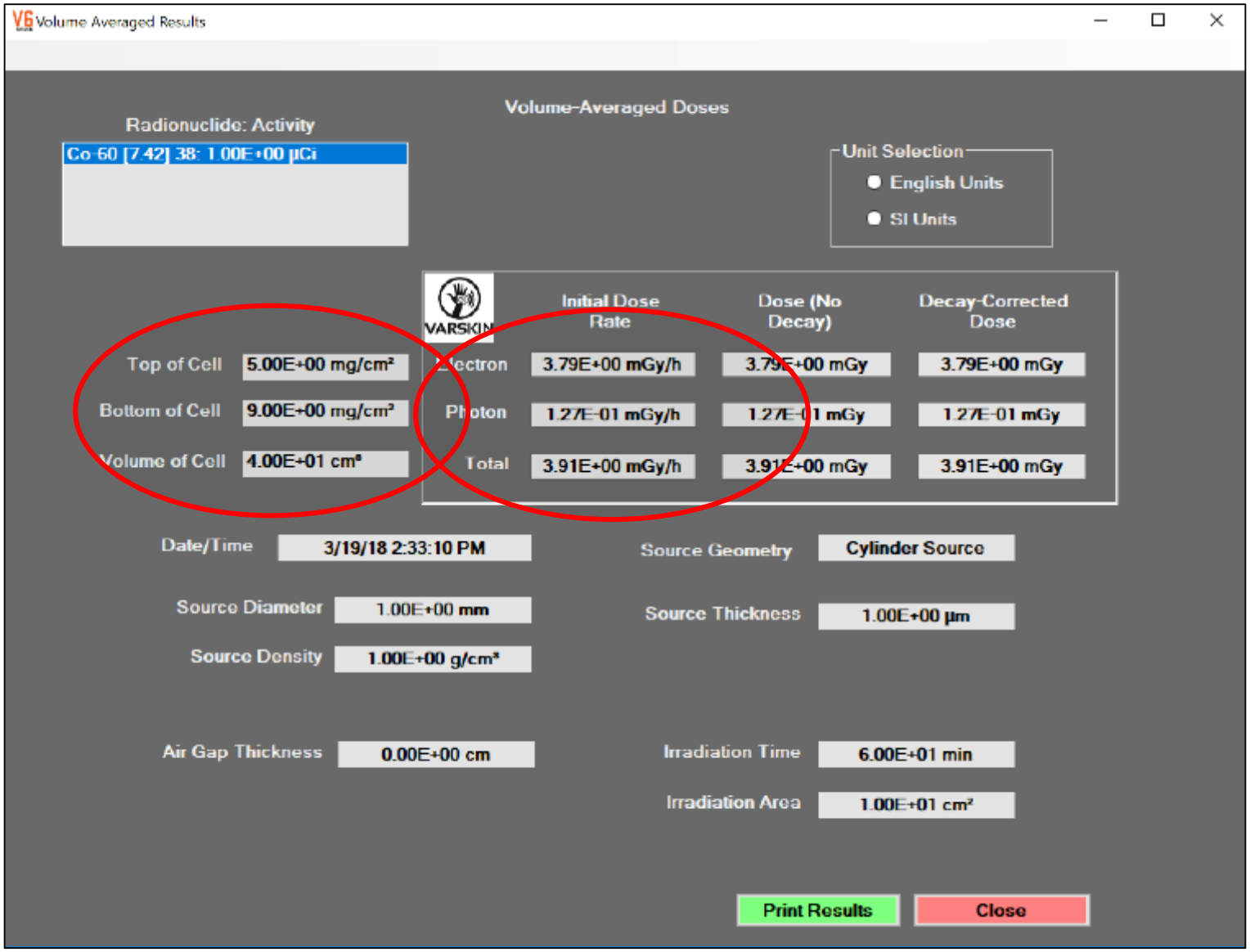
results


V6 Volume Averaged Results
Volume-Averaged Doses
Radionuclide: Activity
Co-60 [7.42] 38. 1.00E+00 µCi
Unit Selection
English Units
SI Units
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Top of Cell
2.00E+00 mg/cm²
Bottom of Cell
1.20E+01 mg/cm²
Volume of Cell
1.00E+02 cm³
Electron
4.21E-01 rad/h
4.21E-01 rad
4.21E-01 rad
Photon
1.26E-02 rad/h
1.26E-02 rad
1.26E-02 rad
Total
4.34E-01 rad/h
4.34E-01 rad
4.34E-01 rad
Date/Time
3/19/18 2:31:14 PM
Source Geometry
Cylinder Source
Source Diameter
1.00E+00 mm
Source Thickness
1.00E+00 µm
Source Density
1.00E+00 g/cm³
Air Gap Thickness
0.00E+00 cm
Irradiation Time
6.00E+01 min
Irradiation Area
1.00E+01 cm²
Print Results
Close

results


Non Volume Averaged Results
Radionuclide: Activity
Co 60 [7.42] 38: 1.00E+00 µCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
3.72E-01 rad/h
3.72E-01 rad
3.72E-01 rad
Photon
1.27E-02 rad/h
1.27E-02 rad
1.27E-02 rad
Total
3.85E-01 rad/h
3.85E-01 rad
3.85E-01 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
3.72E-01 rad/h
3.72E-01 rad
3.72E-01 rad
Photon
1.27E-02 rad/h
1.27E-02 rad
1.27E-02 rad
Total
3.85E-01 rad/h
3.85E-01 rad
3.85E-01 rad
Date/Time
3/19/18 2:31:47 PM
Source Geometry
Cylinder Source
Source Diameter
1.00E+00 mm
Source Thickness
1.00E+00 µm
Source Density
1.00E+00 g/cm³
Air Gap Thickness
0.00E+00 cm
Irradiation Time
6.00E+01 min
Irradiation Area
1.00E+01 cm²
Print Results
Close

results


Volume Averaged Results
Volume-Averaged Doses
Radionuclide: Activity
Co-60 [7.42] 38: 1.00E+00 µCi
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Top of Cell
5.00E+00 mg/cm²
Bottom of Cell
9.00E+00 mg/cm²
Volume of Cell
4.00E+01 cm³
Electron
3.79E+00 mGy/h
3.79E+00 mGy
3.79E+00 mGy
Photon
1.27E-01 mGy/h
1.27E-01 mGy
1.27E-01 mGy
Total
3.91E+00 mGy/h
3.91E+00 mGy
3.91E+00 mGy
Date/Time
3/19/18 2:33:10 PM
Source Geometry
Cylinder Source
Source Diameter
1.00E+00 mm
Source Thickness
1.00E+00 µm
Source Density
1.00E+00 g/cm³
Air Gap Thickness
0.00E+00 cm
Irradiation Time
6.00E+01 min
Irradiation Area
1.00E+01 cm²
Print Results
Close