



Radiological Toolbox (v3.0)

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Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission



US-NRC RAMP Users' Meeting

Radiological Toolbox 3.0 Workshop

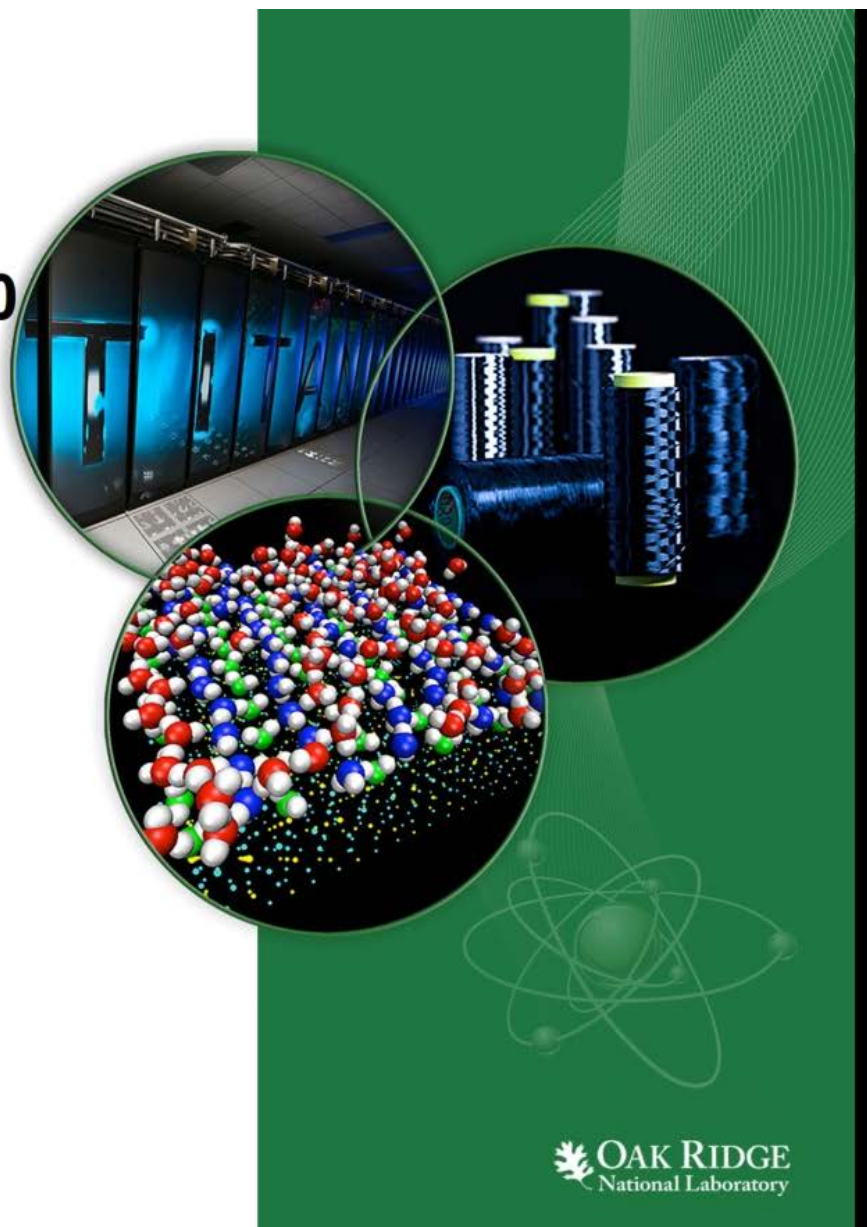
Shaheen Dewji

Center for Radiation
Protection Knowledge

Oak Ridge National
Laboratory

17-21 October 2016

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Timelines

- This “Toolbox” is existed for years....
- 2003 – NRC contracted ORNL to shape it.
- 2007 – Radiological Toolbox V2 issued.
- 2013 – Radiological Toolbox V3 issued with NUREG/CR-7166, the user’s manual.



What's in The Latest



Radiological Toolbox User's Guide

Manuscript Completed: April 2013
Date Published: May 2013

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NRC Job V6088

Office of Nuclear Regulatory Research

NUREG/CR-7166
ORNL/TM-2013/16

- **Rad-Toolbox V3.0 (April 2013)**
 - Windows 7 and OS 64-bit compatible
 - Code is 27 MB in size and one click to install.
 - TRM certified for NRC workstations
 - *Forum: Look for your feedback*
- **User's Manual (May 2013)**
 - In color and PDF searchable
 - References are up to date
 - Built-in under "View-Manual" tab



ABSTRACT: NUREG/CR-7166

“Toolbox” software developed by ORNL for USNRC is designed to provide electronic access to the vast and varied data...These data represent physical, chemical, anatomical, physiological, and mathematical parameters detailed in various handbooks... This release has been tested on Windows 7...The nuclear decay data has been updated, thermal neutron capture cross sections, and cancer risk coefficients.



Something You Should Know

- Abstract and acknowledgement
- The software can be removed by clicking on the **unins000.exe** that resides in the Toolbox folder
- User's Guide, PDF: Can be highlighted or add note...
- Knowing bugs: The decay chain graphics have not been tested for all potential parent nuclides.
- The default units of the original data are used.
- Runtime Error '3051' has been received. Your input and feedback are welcome.
- A note of caution in Page 9.



Must Know the Basic!

- <http://www.hps1.org/aahp/abhp/exams/formulas.pdf>

$$A = \lambda N$$

$$T_{1/2}^p = \frac{0.693}{\lambda_p}$$

$$A(t) = A_0 e^{-\lambda t}$$

$$\frac{1}{T_{1/2}^e} = \frac{1}{T_{1/2}^p} + \frac{1}{T_{1/2}^b}$$

$$X_2 = X_1 \frac{d_1^2}{d_2^2}$$

$$SA(\text{Ci} / \text{g}) = \frac{1.129 \times 10^{13}}{T_{1/2}^p(\text{s}) \text{ AtomicMass}}$$

$$\dot{X}(d) = A \frac{\Gamma}{d^2}$$



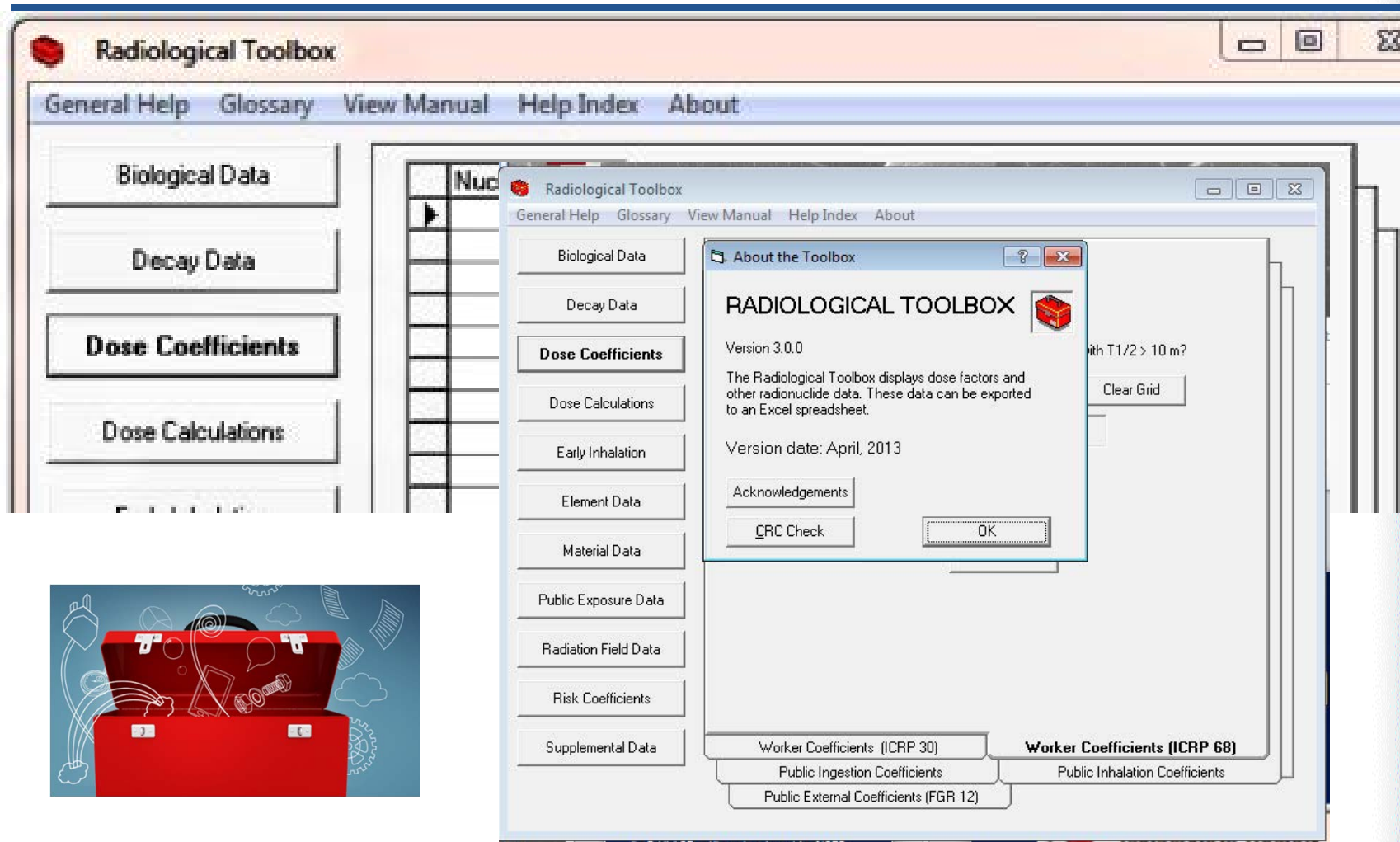
HP Constants

Useful Constants and Conversions

Avogadro's number	$6.023 \times 10^{23} \text{ mol}^{-1}$
Planck's constant	$6.625 \times 10^{-34} \text{ J s}$
volume of ideal gas (STP)	22.4 L mol^{-1}
charge (e^{-1})	$1.602 \times 10^{-19} \text{ C}$
roentgen (STP)	$2.58 \times 10^{-4} \text{ C kg}^{-1}$
1 MeV	$1.602 \times 10^{-13} \text{ J}$
1 atm	760 mm Hg
w	$33.7 \text{ eV ion pair}^{-1}$
rad	$6.242 \times 10^7 \text{ MeV g}^{-1}$
1 m ³	1000 L
1 ft ³	28.32 L
universal gas constant (R)	$8.32 \times 10^7 \text{ erg } ^\circ\text{C}^{-1} \text{ g}^{-1} \text{ mol}^{-1}$
standard temperature	0°C
standard pressure	1 atm
1 barn (b)	10^{-24} cm^2



Menu Bar (About)





Menu Bar (View Manual)

Radiological Toolbox User's Guide

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The authors acknowledge:

- The International Commission on Radiological Protection (ICRP) for granting permission to extract the inhalation and ingestion dose coefficients from "The ICRP Database of Dose Coefficients: Worker and Members of the Public" CD. In addition, the nuclear decay data of ICRP Publication 107,



Menu Bar (Glossary)

The screenshot displays the 'Radiological Toolbox' software interface. On the left, a vertical menu bar lists various data and calculation options: Biological Data, Decay Data, Dose Coefficients, Dose Calculations, Early Inhalation, Element Data, Material Data, and Public Exposure Data. The 'Glossary' option is highlighted. To the right of this menu, there are sections for 'Units, Constants, Conversion Factors' (with a 'SI Units' button), 'International Nuclear and Radiological' (with a 'Display' button), 'Formulas' (with a 'Display' button and 'Bateman Equations' selected), and 'Web Pages' (with a 'Display' button and 'ICRP' selected). Overlaid on the right side of the interface is an 'HTML Help' window. This window has a title bar with standard window controls and a toolbar with 'Hide', 'Back', 'Forward', and 'Print' buttons. The main content area of the help window is titled 'Glossary' in blue. It contains a list of topics, each preceded by a question mark icon, including: independent kinetics of daughter products, internal exposure, ionizing radiation, in utero exposure, in vivo, isotope, kerma, LET, lethality fraction, life table, linear model, linear dose-effect relationship, lifetime risk coefficient, LRC, linear-quadratic model, linear-quadratic model, low dose, low dose rate, minimal latency period, mortality rate, MIRD, morbidity, multiplicative transport model, NCHS, NCRP, and neutron. To the right of the list, a cartoon character of a man in a green hat and blue shirt is holding a large yellow sheet of paper. Below the character are five colored dots (red, blue, green, yellow, purple) arranged vertically. The text on the right side of the help window reads: 'This glossary is based on that of Federal Guidance Report 13 with liberties to accommodate the restricted format of help files. Click on the topic of interest.'



HOMework 1

The following 7 questions and solutions were designed and provided by Dr. Sami Sherbini, SL at RES/DSA.

Calculate committed effective dose from repair work in areas where the airborne concentration of ^{60}Co (Type W) is $4 \times 10^3 \text{ Bq m}^{-3}$. The work will be remaining in this for 2.5 hours. What are the results from using ICRP-26 and ICRP-60 dose coefficients (Sv/Bq)?

*Click Dose Coefficients tab.
Click Worker Coefficients (ICRP 30) tab.
Click Select Units and choose Sv/Bq (this is the default).
Enter Co and select Co60 from the Nuclide drop down menu.*

*Select the Inhalation button for intake mode.
Click the Display tab.
Read off the dose coefficients for Type W:
 $8.94\text{E-}9 \text{ Sv/Bq}$ for ICRP 26
 $8.92\text{E-}9 \text{ Sv/Bq}$ for ICRP 60
The coefficients show that for ^{60}Co , there is little difference between ICRP26 and ICRP 60.*

*Click OK to close the Dose Coefficient window.
Click the Biological Data tab.
Under the ICRP-89 Reference Values tab, select Respiratory Functions from the drop-down menu.
Click ICRP89 Data tab.*

*Select Ventilation (L Exercise) from the drop-down menu.
Read the rate of $1.3 \text{ m}^3/\text{hr}$ for a female worker.

Committed effective dose = $8.92\text{E-}9 \text{ (Sv/Bq)} \times 1.3 \text{ (m}^3/\text{hr)} \times 2.5 \text{ (hr)} \times 4 \times 10^5 \text{ (Bq/m}^3\text{)} = 11.6 \text{ mSv}$
= 1.16 rem*



HOMework 2

The concentration of ^{131}I in air (Type F) in an unrestricted area is $3\text{E}2 \text{ Bq m}^{-3}$. Assuming this concentration to remain constant over a period of one year, and using ICRP-60 data, what is the dose coefficients ratio in this case for a 1 year-old and an adult? What would be the effective dose to the child and to the adult as a result of the 1 year exposure? What is the ratio??

Click Dose Coefficients tab, the Public Inhalation Coefficients, he select ^{131}I from the drop-down nuclide menu, the 1 year old button from the age menu, then Display.

Read the dose coefficients:

Child (1-y) = $7.2\text{E}-8 \text{ Sv/Bq}$

Adult (>17) = $7.4\text{E}-9 \text{ Sv/Bq}$

*Ratio of dose coefficients (child/Adult) = $7.2\text{E}-8/7.4\text{E}-9$
= 9.7*

Click Biological Data, ICRP-89 Reference Values, Respiratory Function, Ventilation, Light Exercise:

Child = $0.35 \text{ m}^3/\text{hr}$

Adult = $1.5 \text{ m}^3/\text{hr}$

The annual doses are:

Child: $D = 7.2\text{E}-8 \text{ (Sv/Bq)} \times 300 \text{ (Bq/m}^3) \times 0.35 \text{ (m}^3/\text{hr)} \times 8760 \text{ hr/yr)} = 0.066 \text{ Sv/yr}$

Adult: $D = 7.4\text{E}-9 \text{ (Sv/Bq)} \times 300 \text{ (Bq/m}^3) \times 1.50 \text{ (m}^3/\text{hr)} \times 8760 \text{ (hr/yr)} = 0.029 \text{ Sv/yr}$

*Ratio of annual dose rates (Child/Adult) =
 $0.066/0.029 = 2.3$*

Although the ratio of dose coefficients is 9.7, the ratio of annual doses is 2.3. The reason for this difference in ratios is the difference in breathing rates.



HOMework 3

A worker is suspected of having inhaled airborne ^{134}Cs (Type F) and was asked to collect a 24-h urine sample. The sample was collected 950 mL, 5 days following the suspected intake incident, and showed an activity of 50 Bq mL^{-1} . What is the estimated intake, and the effective dose? Which is the critical organ from the intake and does it overexpose by US regulations?

Click the Biological data tab.

In the Bioassay Data tab, select ^{134}Cs and select Type F and click Display.

In the E_Urine(t) column select the row corresponding to 5 days and read the value $5.43\text{E-}3$. This is the urine excretion fraction for that time post-intake.

Intake = $(50 \text{ (Bq/ml)} \times 900 \text{ (ml)}) / 5.43\text{E-}3 = 8.29\text{E}6 \text{ Bq}$

From the Dose Coefficient tab, inhalation of Type F ^{134}Cs , ICRP-68 worker data, the effective dose coefficient is $9.6\text{E-}9 \text{ Sv/Bq}$. Hence, Committed effective dose = $9.6\text{E-}9 \text{ (Sv/Bq)} \times 8.29\text{E}6 \text{ (Bq)} = 0.08 \text{ Sv}$.

Using the limit of 0.5 Sv for any organ, and an intake of $8.29\text{E}6 \text{ Bq}$, any organ with a dose coefficient greater than $0.5 / 8.29\text{E}6 = 6.0\text{E-}8 \text{ Sv/Bq}$ will exceed the limit. A review of the dose coefficient table shows that none of the organs exceeds that dose.



HOMework 4

What is the mean energy and the end-point energy of the spectrum emitted by ^{32}P ? What is the CSDA range, gm cm^{-2} of electrons with this end-point energy in leaded glass? What fraction of the beta energy is going to be converted to bremsstrahlung radiation?

*Click the Decay Data tab.
Select the ICRP-107 Data tab.
Select ^{32}P from the Nuclide drop-down menu.
Select the Beat Spectrum button.
Click Display. The average and end-point energies are shown at the top of the beta spectrum.
End-point = 1.7106 MeV
Average = 0.695 MeV
Close the Decay Data tab and Click the Material Data tab.*

*Select the Electron Data tab.
Select Glass, Lead from the material drop-down menu.
Check the CSDA Range and the Yield buttons.
Click Display. Read the CSDA and Yield:*

	CSDA	Yield
for 1.75 MeV	1.32	.78E-2

The values at 1.75 MeV may be considered close enough, or interpolation may be used between values at 1.50 and 1.75 MeV. Ans: CSDA = 1.32 gm/cm^2 and Yield = 7.8%



HOMework 5

What fraction of a 1E3 Bq of ^{58}Co aerosol (Type S, 5 μm AMAD) is exhaled immediately after the inhalation intake? What fraction of the intake will deposit in the thoracic and extra-thoracic regions? What will be the 24-h urine content would be expected when the sample is collected 10 days post-intake?

Click the Biological Data tab.

In Biokinetic Models, select Lung Model and click Display.

Click the Default Regional Deposition highlighted text. In the table under AMAD = 5 microns, add the fractions deposited in the ET, BB, and BB and AI regions. The results are:

Deposition in ET = 73.76%; in BB = 1.78%; in bb = 1.09%; in AI = 5.32%; and Total Deposition = 81.93%. Amount exhaled = 18.1%

Note: ET1 corresponds to the nasal mucus in a nose breather. According to the table, about 34% of the 5 micron aerosol is deposited there. Therefore, if a nose swab is taken, a qualitative idea of the possible intake is probably more than about three times the activity on the swab, depending on how much of the nasal deposit is collected on the swab.

Next, click Biological Data, select ^{58}Co , Type S in Bioassay Data, and click display. Under E_Urine, in the row corresponding to 10 days, read 2.53E-4.

Activity expected in the 24-hour urine sample is:

Urine activity = $1,000 \times 2.53\text{E-}4 = 0.253 \text{ Bq}$.

This type of calculation is helpful to determine whether the available urine counting protocol and equipment are capable of measuring this level of activity in the sample, given the methods used on site for routine bioassay intervals amounts of urine collected per sample, for example, a 24-hour sample or a "grab" sample. The grab sample is taken from one voiding and therefore usually contains much less activity than a 24-hour sample, and so required greater measurement capabilities to detect a given minimum intake level.



HOMework 6

What is the air kerma rate free-in-air at a location where the $8E-2$ MeV photon fluence is $2.24E8 \text{ cm}^{-2}$? What are the effective dose rates resulting from exposure to this beam when incident on the body in the AP and PA directions at that location? What is the rate if the radiation is isotropic?

*Click the Radiation Field Data tab.
Select the Operational quantities button.
Click Display.*

The air kerma column at 0.08 MeV shows a kerma rate of 3.69 pGy-cm^2 . This unit may be interpreted as pGy per photon/cm² or the kerma per unit fluence.

*The kerma rate corresponding to the $2.24E8$ fluence is:
 $K = 2.24E8 \times 3.69 = 8.27E8 \text{ pGy} = 0.827 \text{ mGy}$*

Click on the AP button on the same tab and read the effective dose coefficient (Sv/Gy) for AP, PA, and ISO incidence at 0.08 MeV are : AP = 1.433; PA = 1.019, and ISO = 0.749

The dose rates are:

@ E(AP) = $0.827 \text{ (mGy/s)} \times 1.433 \text{ (Sv/Gy)} \times 0.001 \text{ (Gy/mGy)} = 0.0012 \text{ mSv/s} = 4.27 \text{ Sv/hr}$

@ E(PA) = $0.827 \text{ (mGy/s)} \times 1.019 \text{ (Sv/Gy)} \times 0.001 \text{ (Gy/mGy)} = 0.00084 \text{ mSv/s} = 3.03 \text{ Sv/hr}$

@ E(ISO) = $0.827 \text{ (mGy/s)} \times 0.749 \text{ (Sv/Gy)} \times 0.001 \text{ (Gy/mGy)} = 0.00062 \text{ mSv/s} = 2.23 \text{ Sv/hr}$



HOMework 7

What is the annual risk resulting from continuous submersion in ^{85}Kr cloud environment at a constant concentration of $1\text{E}3 \text{ Bq m}^{-3}$?

Click the Risk Coefficients button.

Select Xe-133 from the Nuclides list.

Click display. The risk coefficients are:

Mortality = $6.59\text{E-}17 \text{ m}^3/\text{Bq-s}$

Morbidity = $9.86\text{E-}17 \text{ m}^3/\text{Bq-s}$

The integrated duration of exposure is:

$X = 1\text{E}3 (\text{Bq}/\text{m}^3) \times 8760 (\text{h}/\text{y}) \times 3600 (\text{s}/\text{h}) = 3.154\text{E}10 (\text{Bq-s}/\text{m}^3)$

Mortality risk = $6.59\text{E-}17 (\text{m}^3/\text{Bq-s}) \times 3.154\text{E}10 (\text{Bq-s}/\text{m}^3) = 2\text{E-}6$

Morbidity risk = $9.86\text{E-}17 (\text{m}^3/\text{Bq-s}) \times 3.154\text{E}10 (\text{Bq-s}/\text{m}^3) = 3\text{E-}6$



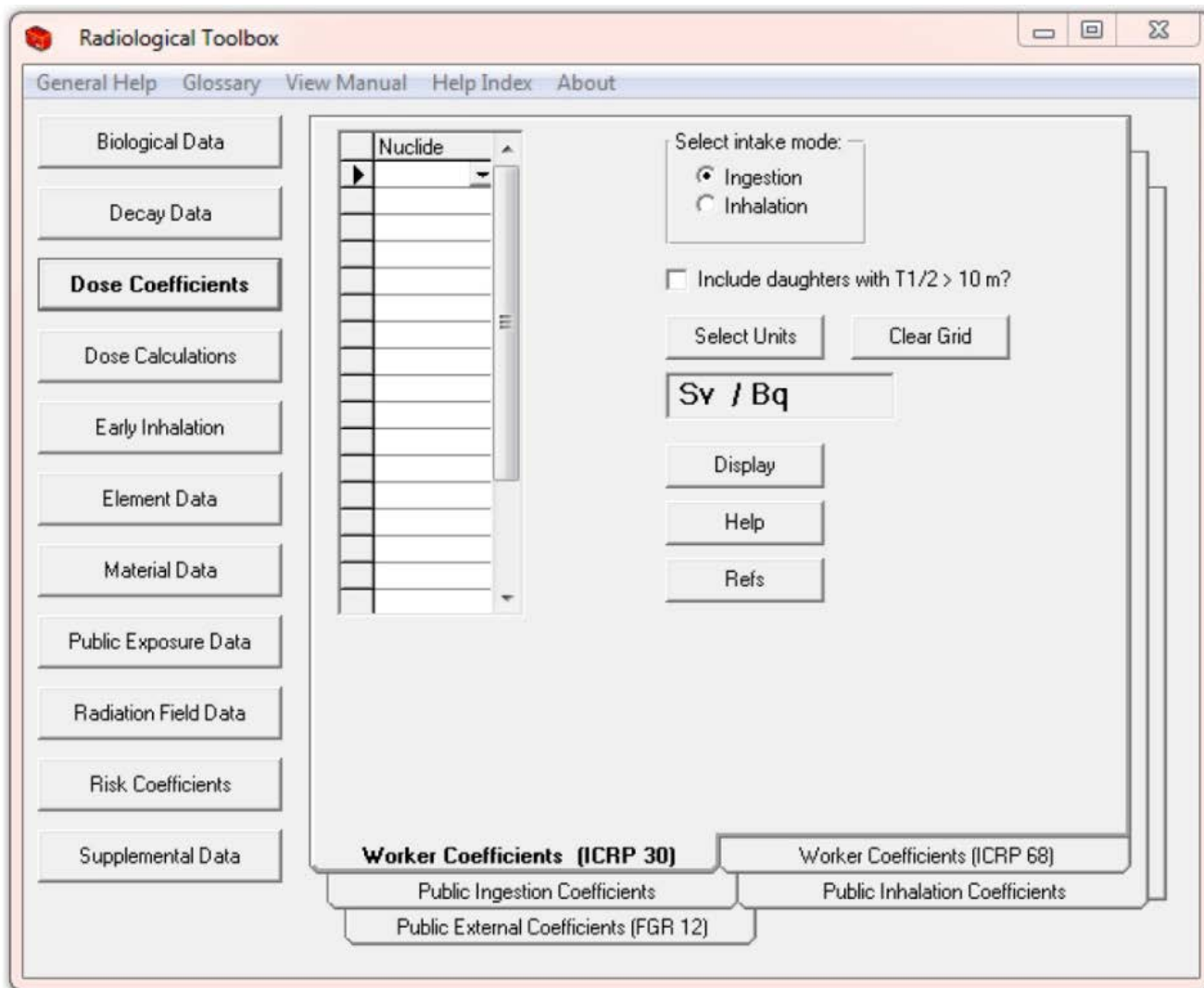
Toolbox's Data Collections

Table 1.1. General Description of the Radiological Toolbox Data Elements

Data Collections	Description of Data Collection
Biological Data	Biokinetic models, reference anatomical data, bioassay data, and summary information on radiation health effects
Decay Data	Detailed information on the radiations emitted by radionuclides and members of serial decay chains
Dose Coefficients	Internal dose coefficients for intakes of radionuclides by workers and members of the public and external dose coefficients for members of the public exposed to radionuclides external to the body
Dose Calculation	Calculation of dose for worker or member of the public exposed to a radionuclide mixture
Early Inhalation	Absorbed dose coefficient integrated over a user-specific time period following an inhalation intake
Element Data	Radiation interaction coefficients with elements for alpha, electron, photon, and neutron radiations
Material Data	Radiation interaction coefficients with materials for alpha, electron, photon, and neutron radiations
Public Exposure Data	Summary information on radiation exposures to natural background radiation and from medical exposure
Radiation Field Data	Organ doses for workers resulting from idealized photon and neutron radiation fields
Risk Coefficients	Nuclide-specific risk coefficients for public exposure
Supplemental Data	Collection of reference information ranging from SI units to numerical limits on the activity content of radionuclides in transport

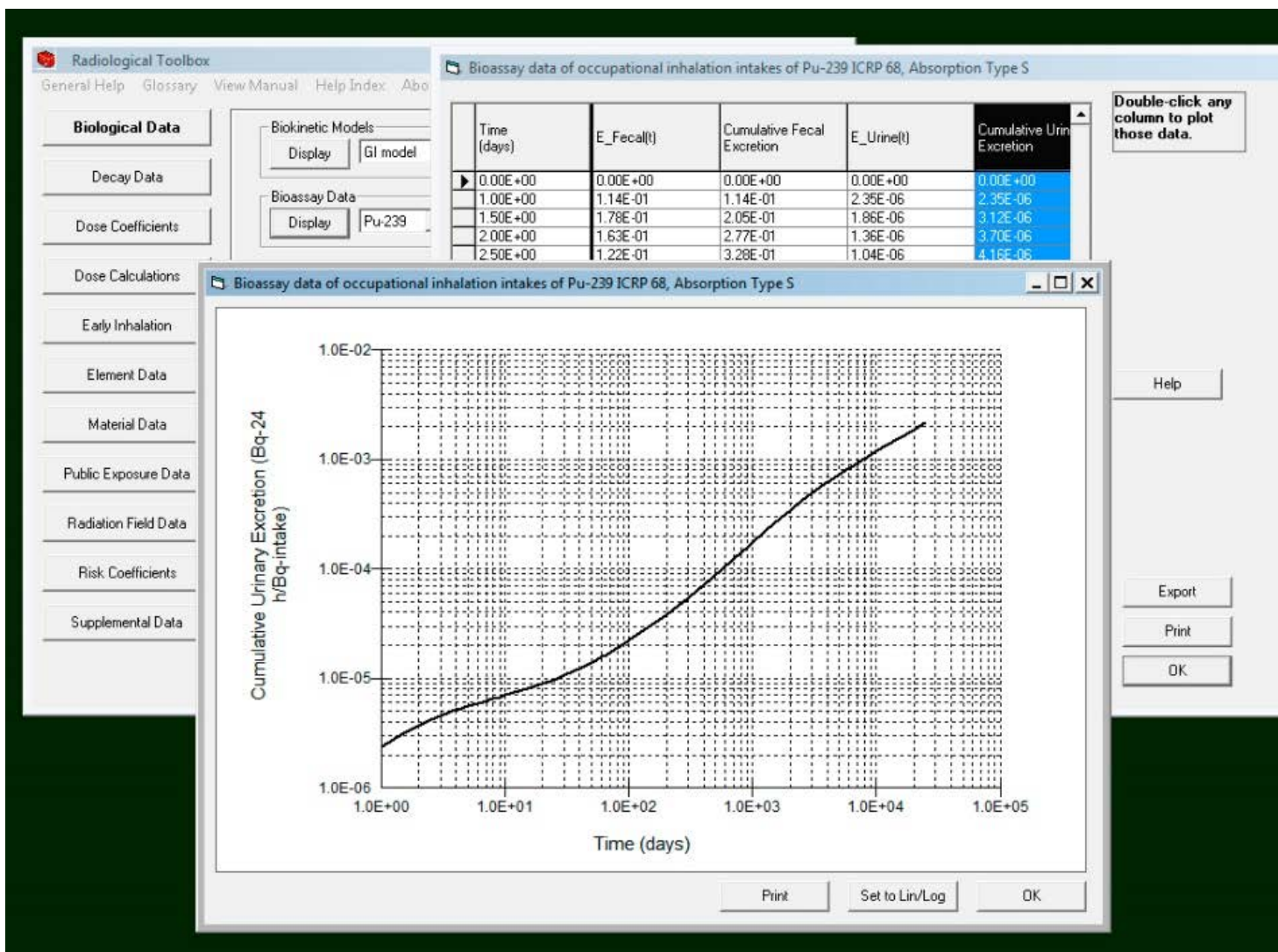


Rad-Toolbox 11 Database



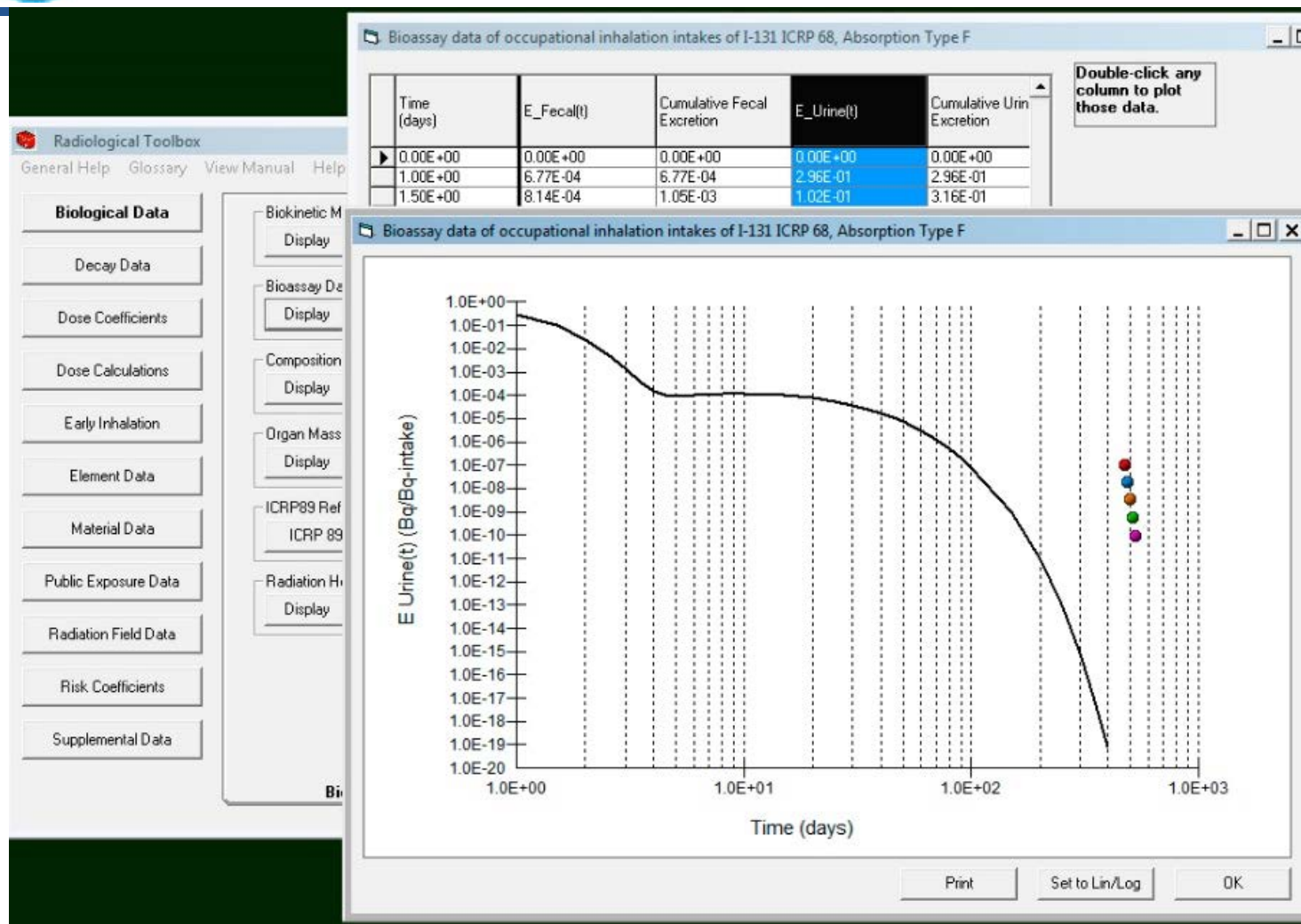


(1) Biological Data



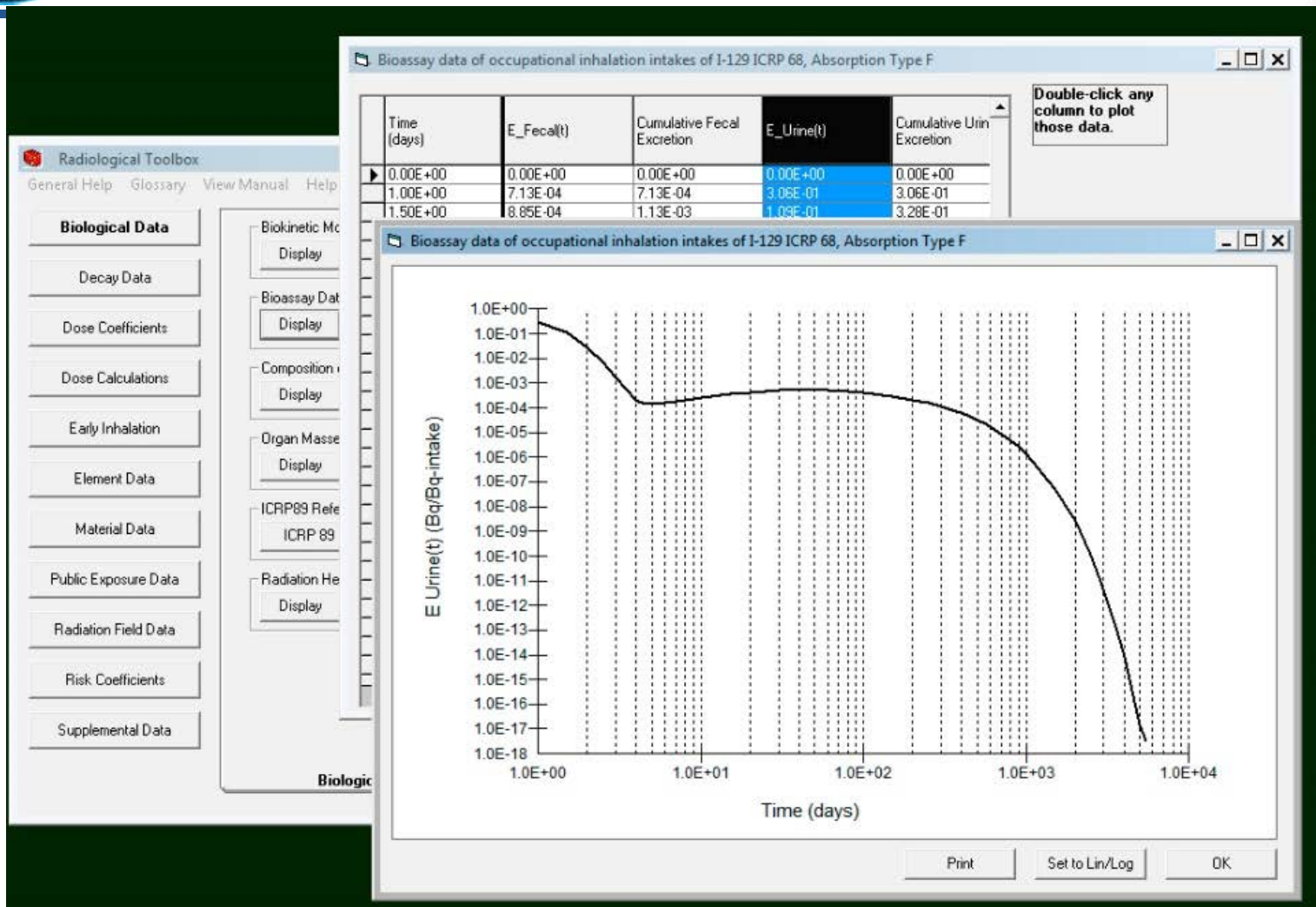


(1) I-131





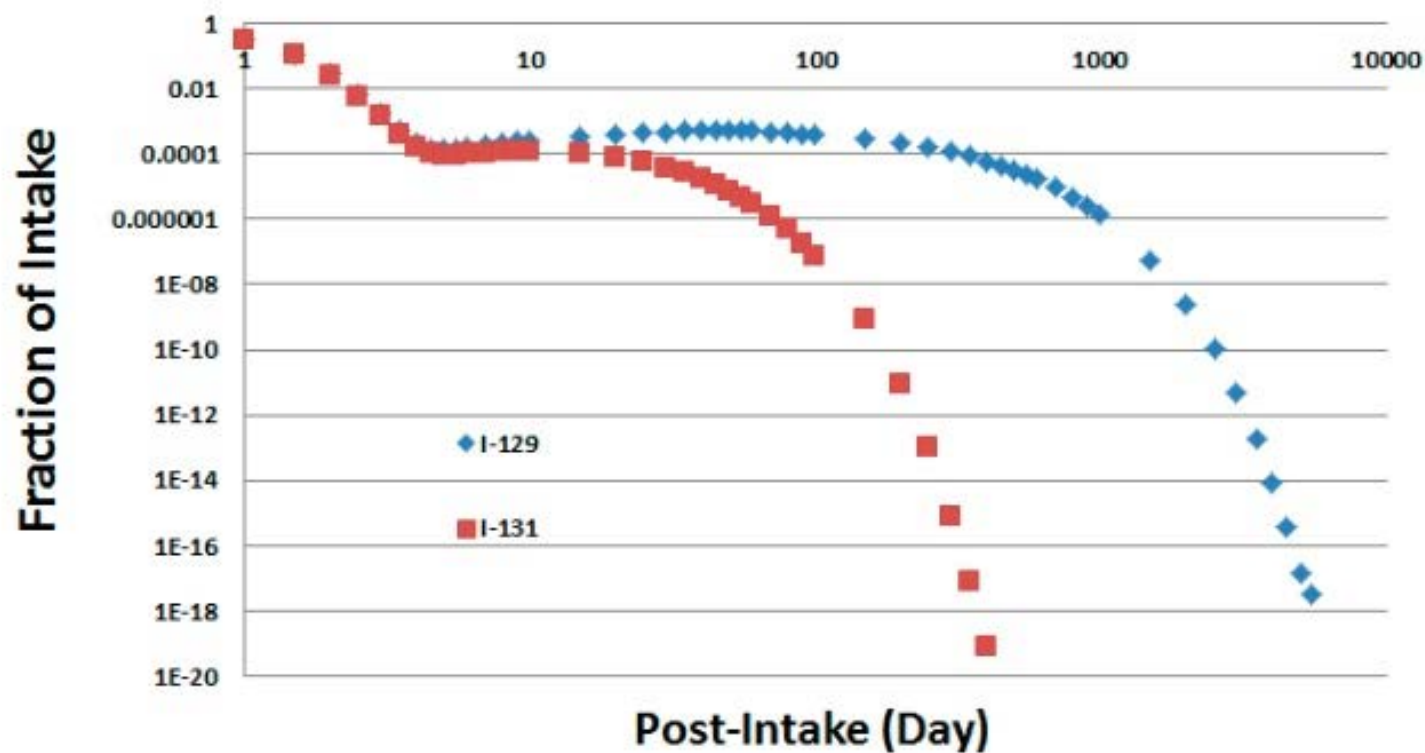
(1) I-129





(1) Bioassay Application

24-h Urine Excretion Function





(2) Decay Data

Radiological Toolbox

General Help Glossary View Manual Help Index About

Biological Data

Decay Data

Dose Coefficients

Dose Calculations

Early Inhalation

Element Data

Material Data

Public Exposure Data

Radiation Field Data

Risk Coefficients

Supplemental Data

Nuclide: **Ac-223**

Select type of data:

- ☒ Energy-Intensity Data
- ☐ Beta Spectrum
- ☐ Decay Chain Table
- ☐ Decay Chain Graphic
- ☐ Activity
- ☐ Summary

Select Units

(Specific Activity)

Units: **Bq / kg**

Select level of E * I data to display

- ☐ > 20% of all (E*I)
- ☐ > 10% of all (E*I)
- ☐ > 1% of all (E*I)
- ☐ > 0.1% of all (E*I)
- ☒ all radiations

Decay time for activity calculation

1.0 years

Display

Help

Refs

Air-Kerma Rate Constants

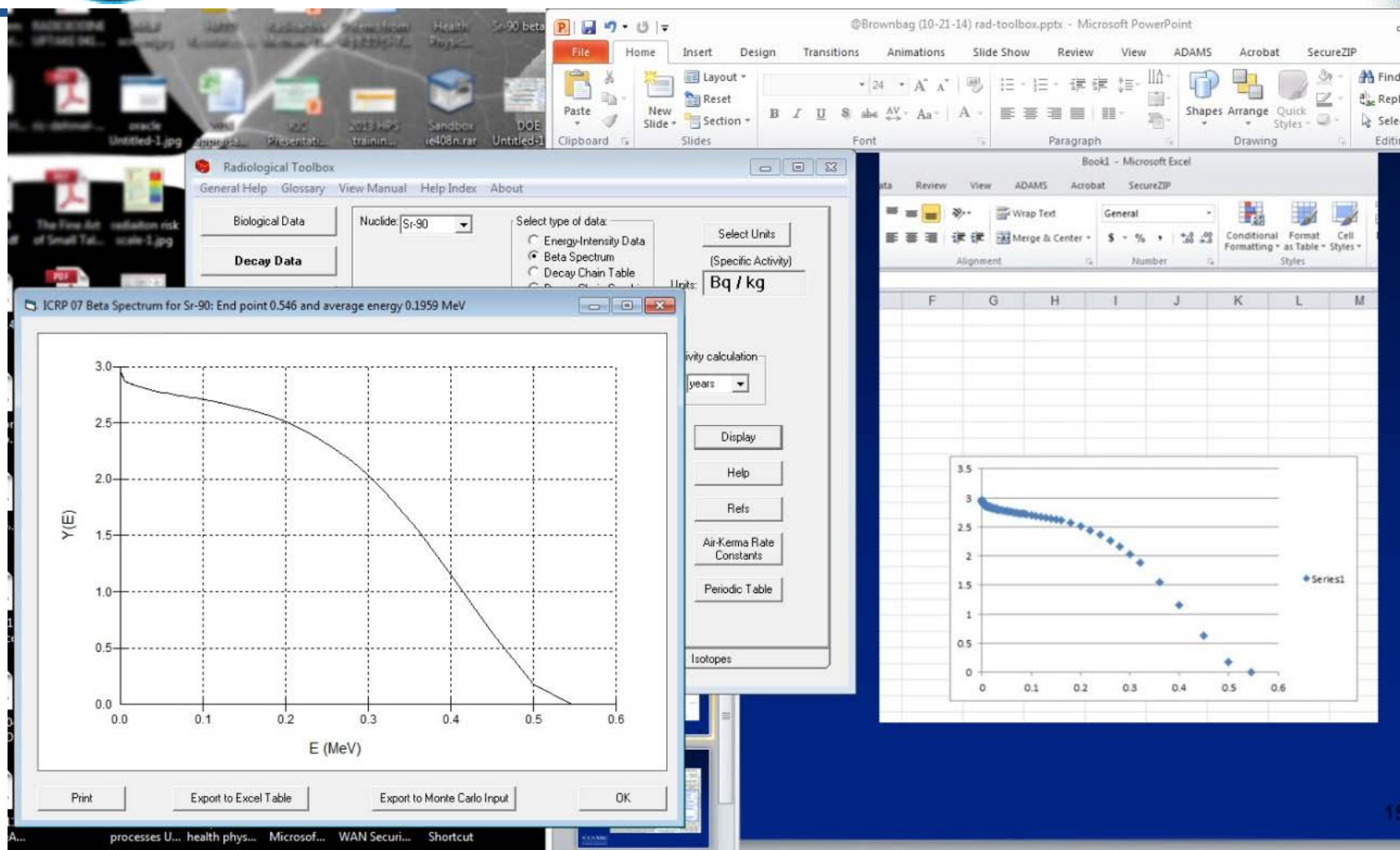
Periodic Table

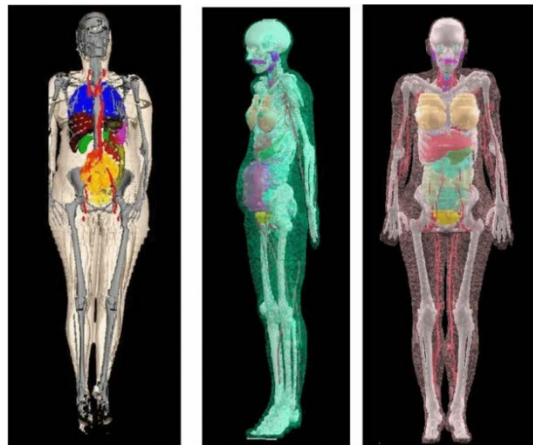
ICRP 107 Data

Isotopes



(2) Sr-90 Beta Spec.







(3) Pu-241; Adult

Radiological Toolbox

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Biological Data
Decay Data
Dose Coefficients

Nuclide
Ag-110m
Am-241
Mo-99
Pu-241
Ra-226

Select age:
☐ Newborn
☐ 1 yr-old
☐ 5 yr-old
☐ 10 yr-old
☐ 15 yr-old
☒ Adult

☒ Include daughters with T1/2 > 10 m?

Select Units
Clear Grid

Sv / Bq

Display
Help
Refs

Coefficients
 Public Inhalation Coefficients
 coefficients (FGR 12)
 coefficients (ICRP 30)
 Worker Coefficients (ICRP 68)

Print
Export
OK

Ingestion Adult dose coefficients (Sv / Bq) from ICRP 72

Nuclide	Pu-241	Am-241	U-237	Np-237
Half Life	14.4y	432.2y	6.75d	2.14E
f1	5.00E-04	5.00E-04	2.00E-02	5.00E
Adrenals	3.00E-10	1.50E-08	1.00E-11	7.20E
Urinary Bladder	3.00E-10	1.50E-08	6.50E-11	7.10E
Bone Surface	1.60E-07	9.00E-06	1.00E-10	5.40E
Brain	3.00E-10	1.50E-08	9.40E-13	7.20E
Breast	3.00E-10	1.50E-08	1.70E-12	7.10E
Esophagus	3.00E-10	1.50E-08	1.50E-12	7.10E
Stomach	3.00E-10	1.70E-08	2.70E-10	8.30E
Small Intestine	3.10E-10	1.90E-08	6.90E-10	1.00E
Upper Large Intestine	3.90E-10	3.50E-08	3.40E-09	2.50E
Lower Large Intestine	5.70E-10	7.40E-08	8.70E-09	6.00E
Colon	4.70E-10	5.20E-08	5.70E-09	4.00E
Kidneys	5.00E-10	4.60E-08	1.40E-10	1.90E
Liver	3.40E-08	5.50E-07	1.60E-11	8.70E
Muscle	3.00E-10	1.50E-08	1.80E-11	7.10E
Ovaries	2.20E-09	1.80E-07	1.60E-10	7.20E
Pancreas	3.00E-10	1.50E-08	2.00E-11	7.10E
Red Marrow	6.40E-09	3.10E-07	3.70E-11	2.10E
Extratracheal Airways	3.00E-10	1.50E-08	9.90E-13	7.10E
Lungs	3.00E-10	1.50E-08	2.80E-12	7.10E
SKin	3.00E-10	1.50E-08	5.60E-12	7.10E
Spleen	3.00E-10	1.50E-08	1.60E-11	7.10E
Testes	2.20E-09	1.70E-07	1.30E-11	7.40E
Thymus	3.00E-10	1.50E-08	1.50E-12	7.10E
Thyroid	3.00E-10	1.50E-08	9.90E-13	7.10E
Uterus	3.00E-10	1.50E-08	7.00E-11	7.20E

Pu-241 Ag-110m Ra-226 Am-241 Mo-99



(3) Pu-241

Clipboard		Bluetooth		Font		Alignment		Number					
A1		Ingestion Adult dose coefficients (Sv / Bq) from ICRP 72											
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Ingestion	Adult dose coefficients (Sv / Bq) from ICRP 72											
2	Nuclide	Pu-241	Am-241	U-237	Np-237	Pa-233	U-233	Th-229	Ra-225	Ac-225	Bi-213	Pb-209	
3	Half Life	14.4y	432.2y	6.75d	2.14E6y	27.0d	1.585E5y	7340y	14.8d	10.0d	45.65m	3.253h	
4	f1	0.0005	0.0005	0.02	0.0005	0.0005	0.02	0.0005	0.2	0.0005	0.05	0.2	
5	Adrenals	3E-10	1.5E-08	1E-11	7.2E-09	1.3E-11	2.8E-08	7.6E-08	1.1E-08	3.2E-11	5.1E-12	5.5E-13	
6	Urinary Bl	3E-10	1.5E-08	6.5E-11	7.1E-09	7.5E-11	2.8E-08	7.6E-08	1.1E-08	9.3E-11	8.2E-12	2.5E-12	
7	Bone Surf	1.6E-07	0.000009	1E-10	5.4E-06	6.6E-11	8.4E-07	0.000023	3.6E-06	4.9E-08	4.6E-12	1.4E-11	
8	Brain	3E-10	1.5E-08	9.4E-13	7.2E-09	1.5E-13	2.8E-08	7.6E-08	1.1E-08	2E-11	4.3E-12	5.5E-13	
9	Breast	3E-10	1.5E-08	1.7E-12	7.1E-09	2E-12	2.8E-08	7.6E-08	1.1E-08	2.2E-11	4.5E-12	5.5E-13	
10	Esophagu:	3E-10	1.5E-08	1.5E-12	7.1E-09	1.5E-12	2.8E-08	7.6E-08	1.1E-08	2.1E-11	4.4E-12	5.5E-13	
11	Stomach	3E-10	1.7E-08	2.7E-10	8.3E-09	2.9E-10	2.9E-08	7.8E-08	1.1E-08	5.3E-09	1.3E-09	1.9E-10	
12	Small Inte	3.1E-10	1.9E-08	6.9E-10	1E-08	7.7E-10	3.1E-08	8E-08	1.2E-08	1.7E-08	7.4E-10	2.2E-10	
13	Upper Lar	3.9E-10	3.5E-08	3.4E-09	2.5E-08	3.7E-09	4.5E-08	9.7E-08	1.8E-08	1E-07	4.4E-10	3.5E-10	
14	Lower Lar	5.7E-10	7.4E-08	8.7E-09	6E-08	1E-08	7.7E-08	1.4E-07	4.7E-08	2.8E-07	1E-10	1.7E-10	
15	Colon	4.7E-10	5.2E-08	5.7E-09	4E-08	6.5E-09	5.9E-08	1.2E-07	3E-08	1.8E-07	2.9E-10	2.7E-10	
16	Kidneys	5E-10	4.6E-08	1.4E-10	1.9E-08	3.3E-11	2.9E-07	3E-07	3.7E-08	5E-11	6.1E-10	7.1E-12	
17	Liver	3.4E-08	5.5E-07	1.6E-11	8.7E-08	2.1E-11	1.1E-07	1.1E-06	1.9E-07	1.3E-08	4.9E-12	2.7E-12	
18	Muscle	3E-10	1.5E-08	1.8E-11	7.1E-09	2.6E-11	2.8E-08	7.6E-08	1.1E-08	4.6E-11	4.8E-12	5.5E-13	
19	Ovaries	2.2E-09	1.8E-07	1.6E-10	7.2E-08	2.3E-10	2.8E-08	1.7E-07	1.3E-08	7.9E-10	6.6E-12	5.5E-13	
20	Pancreas	3E-10	1.5E-08	2E-11	7.1E-09	2.7E-11	2.8E-08	7.6E-08	1.1E-08	4.4E-11	7.3E-12	5.5E-13	
21	Red Marr	6.4E-09	3.1E-07	3.7E-11	2.1E-07	4.6E-11	8.4E-08	1.1E-06	3.5E-07	4E-09	4.9E-12	1.8E-12	
22	Extratrach	3E-10	1.5E-08	9.9E-13	7.1E-09	3.4E-13	2.8E-08	7.6E-08	1.1E-08	2E-11	4.3E-12	5.5E-13	
23	Lungs	3E-10	1.5E-08	2.8E-12	7.1E-09	3.4E-12	2.8E-08	7.6E-08	1.1E-08	2.3E-11	4.6E-12	5.5E-13	
24	SKin	3E-10	1.5E-08	5.6E-12	7.1E-09	8.3E-12	2.8E-08	7.6E-08	1.1E-08	2.8E-11	4.5E-12	5.5E-13	
25	Spleen	3E-10	1.5E-08	1.6E-11	7.1E-09	2.1E-11	2.8E-08	7.3E-08	1.1E-08	3.9E-11	6.2E-12	5.5E-13	
26	Testes	2.2E-09	1.7E-07	1.3E-11	7.4E-08	2.1E-11	2.9E-08	1.8E-07	1.3E-08	5.8E-10	4.4E-12	5.5E-13	
27	Thymus	3E-10	1.5E-08	1.5E-12	7.1E-09	1.5E-12	2.8E-08	7.6E-08	1.1E-08	2.1E-11	4.4E-12	5.5E-13	
28	Thyroid	3E-10	1.5E-08	9.9E-13	7.1E-09	3.4E-13	2.8E-08	7.6E-08	1.1E-08	2E-11	4.3E-12	5.5E-13	
29	Uterus	3E-10	1.5E-08	7.3E-11	7.2E-09	1.1E-10	2.8E-08	7.6E-08	1.1E-08	1.2E-10	6.1E-12	5.5E-13	
30	Remainde	3E-10	1.6E-08	3.3E-11	7.3E-09	4.1E-11	3.1E-08	7.9E-08	1.2E-08	3.9E-10	2.6E-11	5.3E-12	
31	Effective (	4.8E-09	2E-07	7.6E-10	1.1E-07	8.7E-10	5.1E-08	4.9E-07	9.9E-08	2.4E-08	2E-10	5.7E-11	
32													
33													



(4) Dose Calculations

Clipboard Bluetooth Font Alignment Number Cells Editing

A1 Ingestion Adult dose coefficients (Sv / Bq) from ICRP 72

	A	B	C	D	E	F	G	H	I	J	K
1	Ingestion Adult dose coefficients (Sv / Bq) from ICRP 72										
2	Nuclide	Pu-239	U-235	Th-231	Pa-231	Ac-227	Th-227	Fr-223	Ra-223	Pb-211	Nucl
3	Half Life	24065y	703.8E6y	25.52h	3.276E4y	21.77y	4.75E4y	21.8m	11.43d	36.1m	HL
4	f1	0.0005	0.02	0.0005	0.	Radiological Toolbox					
5	Adrenals	1.4E-08	2.6E-08	4.8E-13	9	General Help Glossary View Manual Help Index About					
6	Urinary Bl	1.4E-08	2.6E-08	2.9E-12	4.9	Biological Data					
7	Bone Surf	8.2E-06	7.4E-07	5.8E-12	0.00	Decay Data					
8	Brain	1.4E-08	2.6E-08	1.8E-14	5.4	Dose Coefficients					
9	Breast	1.4E-08	2.6E-08	6E-14	2.6	Dose Calculations					
10	Esophagus	1.4E-08	2.6E-08	4.3E-14	3.6	Early Inhalation					
11	Stomach	1.6E-08	2.7E-08	1.9E-10	1.3	Element Data					
12	Small Inte	1.7E-08	2.8E-08	4.4E-10	3.2	Material Data					
13	Upper Lar	3.3E-08	4.3E-08	1.9E-09	1.5	Public Exposure Data					
14	Lower Lar	6.7E-08	7.8E-08	3.4E-09	5.4	Radiation Field Data					
15	Colon	4.8E-08	5.8E-08	2.5E-09	3.4	Risk Coefficients					
16	Kidneys	3.4E-08	2.7E-07	1.4E-12	3.4	Supplemental Data					
17	Liver	1.7E-06	1E-07	9.9E-13	2.2						
18	Muscle	1.4E-08	2.6E-08	1.4E-12	4.5						
19	Ovaries	1.1E-07	2.6E-08	1.9E-11	1.3						
20	Pancreas	1.4E-08	2.6E-08	1.5E-12	5.8						
21	Red Marro	3.9E-07	7.6E-08	1.8E-12	2.9						
22	Extratrach	1.4E-08	2.6E-08	2E-14	4						
23	Lungs	1.4E-08	2.6E-08	1.2E-13	4.7						
24	SKin	1.4E-08	2.6E-08	2.9E-13	3						
25	Spleen	1.4E-08	2.6E-08	9.6E-13	4.1						
26	Testes	1.1E-07	2.6E-08	5.6E-13	2.5						
27	Thymus	1.4E-08	2.6E-08	4.3E-14	3.6						
28	Thyroid	1.4E-08	2.6E-08	2E-14	4						
29	Uterus	1.4E-08	2.6E-08	4.9E-12	6.8						
30	Remainde	1.5E-08	2.8E-08	1E-11	1.5						
31	Effective (	2.5E-07	4.7E-08	3.4E-10	7.1E-07	1.1E-06	8.8E-09	2.4E-09	1E-07	1.8E-10	
32											
33											

Ingestion dose coefficients (Sv / Bq) from ICRP 72

Nuclide	Pu-239	U-235	Th-231	Pa-231	Ac-227	Th-227	Fr-223	Ra-223	Pb-211
f1	0.0005	0.02	0.0005	0.					
Adrenals	1.4E-08	2.6E-08	4.8E-13	9					
Urinary Bl	1.4E-08	2.6E-08	2.9E-12	4.9					
Bone Surf	8.2E-06	7.4E-07	5.8E-12	0.00					
Brain	1.4E-08	2.6E-08	1.8E-14	5.4					
Breast	1.4E-08	2.6E-08	6E-14	2.6					
Esophagus	1.4E-08	2.6E-08	4.3E-14	3.6					
Stomach	1.6E-08	2.7E-08	1.9E-10	1.3					
Small Inte	1.7E-08	2.8E-08	4.4E-10	3.2					
Upper Lar	3.3E-08	4.3E-08	1.9E-09	1.5					
Lower Lar	6.7E-08	7.8E-08	3.4E-09	5.4					
Colon	4.8E-08	5.8E-08	2.5E-09	3.4					
Kidneys	3.4E-08	2.7E-07	1.4E-12	3.4					
Liver	1.7E-06	1E-07	9.9E-13	2.2					
Muscle	1.4E-08	2.6E-08	1.4E-12	4.5					
Ovaries	1.1E-07	2.6E-08	1.9E-11	1.3					
Pancreas	1.4E-08	2.6E-08	1.5E-12	5.8					
Red Marrow	3.9E-07	7.6E-08	1.8E-12	2.9					
Extratrach	1.4E-08	2.6E-08	2E-14	4					
Lungs	1.4E-08	2.6E-08	1.2E-13	4.7					
SKin	1.4E-08	2.6E-08	2.9E-13	3					
Spleen	1.4E-08	2.6E-08	9.6E-13	4.1					
Testes	1.1E-07	2.6E-08	5.6E-13	2.5					
Thymus	1.4E-08	2.6E-08	4.3E-14	3.6					
Thyroid	1.4E-08	2.6E-08	2E-14	4					
Uterus	1.4E-08	2.6E-08	4.9E-12	6.8					
Remainder	1.5E-08	2.8E-08	1E-11	1.5					
Effective (ICRP 26)	2.5E-07	4.7E-08	3.4E-10	7.1E-07	1.1E-06	8.8E-09	2.4E-09	1E-07	1.8E-10
Effective (ICRP 60)	2.5E-07	4.7E-08	3.4E-10	7.1E-07	1.1E-06	8.8E-09	2.4E-09	1E-07	1.8E-10

Ingestion dose coefficients (Sv / Bq) from ICRP 72

Nuclide	Pu-239	U-235	Th-231	Pa-231	Ac-227	Th-227	Fr-223	Ra-223	Pb-211
f1	1.00E-05	1.00E-04	1.00E-03	2.00E-03					
Adrenals	8.28E-14	7.92E-13	7.92E-12	1.09E-10					
Bladder Wall	1.25E-13	7.98E-13	7.52E-12	1.65E-10					
Bone Surface	1.76E-07	1.76E-06	1.76E-05	4.20E-08					
Brain	7.66E-14	7.66E-13	7.66E-12	0.00E+00					
Breast	1.21E-13	8.09E-13	7.69E-12	1.21E-10					
Esophagus	7.54E-14	7.51E-13	7.51E-12	9.81E-11					
Stomach Wall	1.19E-09	1.19E-09	1.20E-09	1.23E-09					
Small Intestine Wall	2.99E-09	2.99E-09	2.99E-09	3.03E-09					
Upper Large Intestine Wall	1.73E-08	1.73E-08	1.73E-08	1.69E-08					
Lower Large Intestine Wall	5.31E-08	5.31E-08	5.30E-08	5.33E-08					
Kidneys	8.78E-14	7.76E-13	7.66E-12	1.73E-08					
Liver	3.14E-08	3.14E-07	3.14E-06	1.14E-10					
Lungs	7.89E-14	7.75E-13	7.74E-12	1.01E-10					
Muscle	1.21E-13	8.09E-13	7.69E-12	1.21E-10					
Ovaries	2.64E-09	2.64E-08	2.64E-07	3.34E-10					
Pancreas	9.95E-14	7.89E-13	7.68E-12	1.23E-10					
Red Marrow	1.41E-08	1.41E-07	1.41E-06	2.78E-09					
Skin	8.17E-14	7.63E-13	7.57E-12	1.04E-10					
Spleen	8.47E-14	7.64E-13	7.55E-12	1.15E-10					
Testes	2.64E-09	2.64E-08	2.64E-07	1.15E-10					
Thymus	7.54E-14	7.51E-13	7.51E-12	9.81E-11					
Thyroid	7.50E-14	7.49E-13	7.49E-12	9.82E-11					
Uterus	1.38E-13	8.11E-13	7.54E-12	1.89E-10					
Effective (ICRP 26)	1.40E-08	9.96E-08	9.56E-07	7.22E-09					
Effective (ICRP 60)	1.21E-08	6.20E-08	5.62E-07	7.42E-09					

Worker Coefficients (ICRP 30)

Public Ingestion Coefficients

Public External Coefficients (FGR 12)

Worker Coefficients (ICRP 68)

Public Inhalation Coefficients

Print

Export

OK



(5) Early Inhalation



5-9 October 2015

Biological Data

Decay Data

Dose Coefficients

Dose Calculations

Early Inhalation

Nuclide: I-125

Absorption Type: F

Integration Periods

10

2

5

0

7

0

0

Days

Years

Organs displayed:

1. Small intestine (SI)

2. Red Marrow

3. Lung (Mass Average)

4. Alveolar Interstitial Region (AI)

Select Units

Gy / Bq

Display

Acute Absorbed Dose Coefficients (Gy/Bq- inhaled)

For a selected set of radionuclides the toolbox contains information on the low and high LET absorbed dose rate as a function of time post an acute inhalation intake for tissues of the body subject to acute radiation syndrome (ARS). ARS is classically divided into three main presentations: hematopoietic, gastrointestinal and neurological/vascular. The neurovascular syndrome occurs at very high absorbed dose (above 10 Gy) and not typically achievable by internal emitters.

The toolbox addresses 4 tissues: 1) *Red marrow* (hematopoietic syndrome), 2) *Small intestine* (gastrointestinal syndrome), 3) *Lung* (mass average) and 4) *Alveolar Interstitial Region*. The later two are of interest with regard to damage to the respiratory tract. The user can define the time period over which the absorbed dose rate is to be integrated. In results of the integration are given for both the low and high [LET](#) components to which the user can then apply as suitable [RBE](#) if desired.

The absorbed dose rate data file was assembled during the preparation of [Federal Guidance Report 13](#). The toolbox only addresses inhalation intakes. An acute dose calculator which considers intakes by ingestion and inhalation (referred to as a Acute Dose Calculator) is available from [EPA](#).

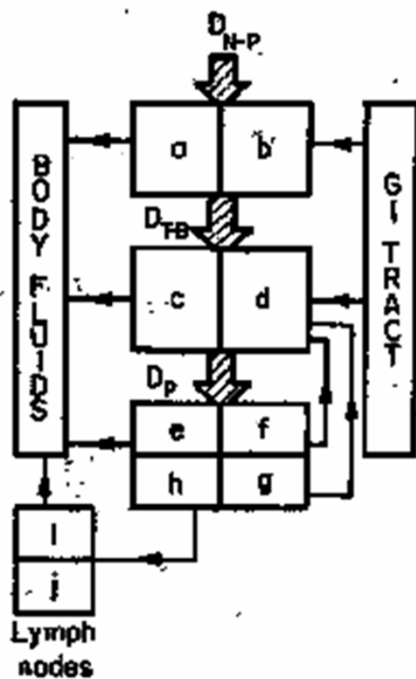
Note: The tabulated dosimetric quantity is absorbed dose and thus no modifying factor (RBE or w_R) has been applied to the numerical values of the low and high LET components. The user may apply a suitable RBE and sum the resultant values.

RAMP Fall 2015 | Washington, DC

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(5) I-125



Radiological Toolbox

General Help | Glossary | View Manual | Help Index | About

Biological Data
Decay Data
Dose Coefficients
Dose Calculations
Early Inhalation
Element Data
Material Data
Public Exposure Data
Radiation Field Data
Risk Coefficients
Supplemental Data

Nuclide: I-125
Absorption Type: F

Integration Periods: 10, 2, 5, 0, 7, 0, 0, 0, 0, 0

Days
Years

Organs displayed:
1. Small intestine (SI)
2. Red Marrow
3. Lung (Mass Average)
4. Alveolar Interstitial Region (AI)

Select Units
Gy / Bq
Display
Help
Refs

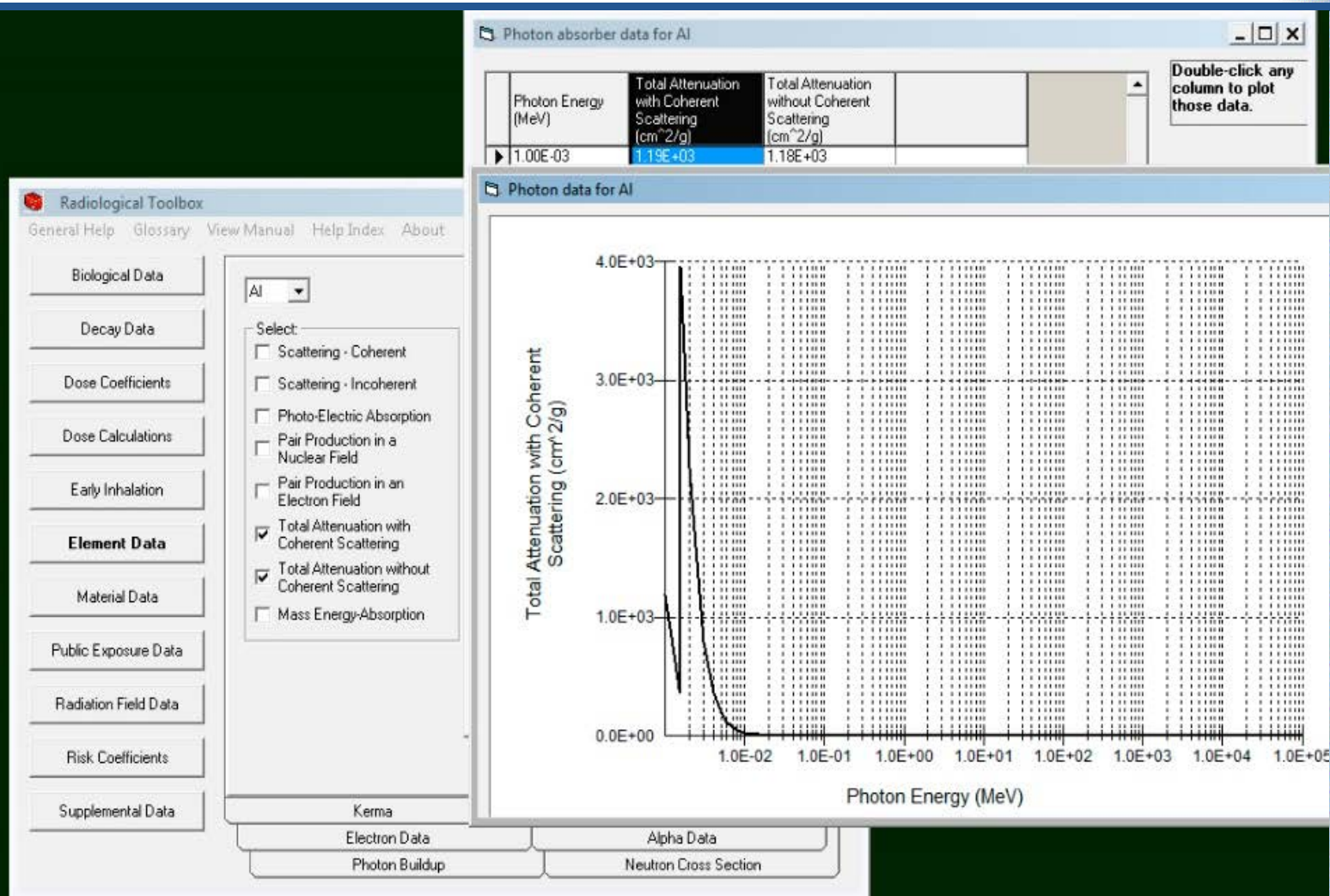
Absorbed Dose Coefficient (Gy / Bq)

Nuclide	I-125				
Type	F				
Time (d)	1.00E+01	2.00E+00	5.00E+00	7.00E+00	
Tissue	Low LET	Low LET	Low LET	Low LET	
SI	1.78E-12	1.43E-12	1.53E-12	1.61E-12	
Marrow	2.12E-12	1.18E-12	1.53E-12	1.76E-12	
Lung	3.21E-12	2.24E-12	2.58E-12	2.82E-12	
AI	3.14E-12	2.18E-12	2.52E-12	2.76E-12	

Export
Print
OK



(6) Element Data (Al)





Element Data (Credit from ORNL)

- Interaction coefficients for alpha, electron, photon, and neutron radiations in elemental absorbers.
 - Not available for every element or for each radiation type
 - Can be plotted
- Geometric progression form of the photon buildup factors from ANSI Standard 6.4
 - 0.015 and 15 MeV at distances ranging from 0.5 to 60 MFP
 - The photon and neutron kerma coefficients were taken from KERMAL, RSICC package DLC-143
- Atomic mass and isotopic abundance data
 - 16th edition of the Chart of the Nuclides
- Can be exported to EXCEL



(6) Element Data (Pb)

Radiological Toolbox
General Help Glossary View Manual Help Index About

Biological Data
Decay Data
Dose Coefficients
Dose Calculations

Pb

Select:
☒ Stopping Power - Collision
☒ Stopping Power - Radiative
☒ Stopping Power - Total
☒ CSDA Range

Select Units
Coefficients: MeV cm² / g

Element Data: Properties

This section of the toolbox contains data for various types of radiations.

Atomic mass: Information on the atomic mass and elemental composition of an element.

Interaction Coefficients: Coefficients for the interaction of radiation with matter, available for display, export, and calculation.

Kerma coefficients for photon and neutron: Coefficients for the calculation of Kerma (Kinetic Energy Released in Material) for photons and neutrons.

Neutron Activation Cross Sections: Cross sections for neutron activation reactions, available from the [Mughabghab](#) database.

Photon Buildup: The Geometric Factor (GF) and Buildup Factor (BF) are not addressed; their values can be calculated using the procedures implemented in the software.

Electron absorber data for Pb

Kinetic Energy (MeV)	Stopping Power - Collision (MeV cm ² /g)	Stopping Power - Radiative (MeV cm ² /g)	Stopping Power - Total (MeV cm ² /g)	CSDA Range (g/cm ²)
1.00E-02	8.43E+00	2.05E-02	8.45E+00	8.26E-04

Double-click any column to plot those data.

Electron data for Pb

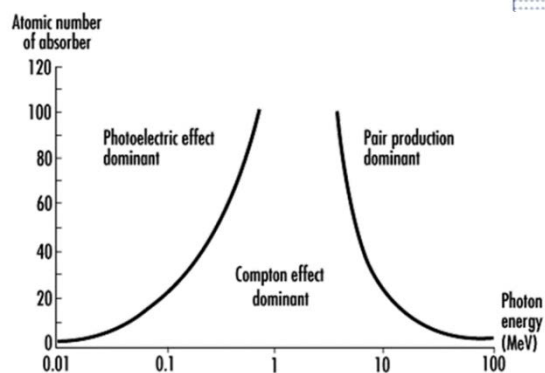
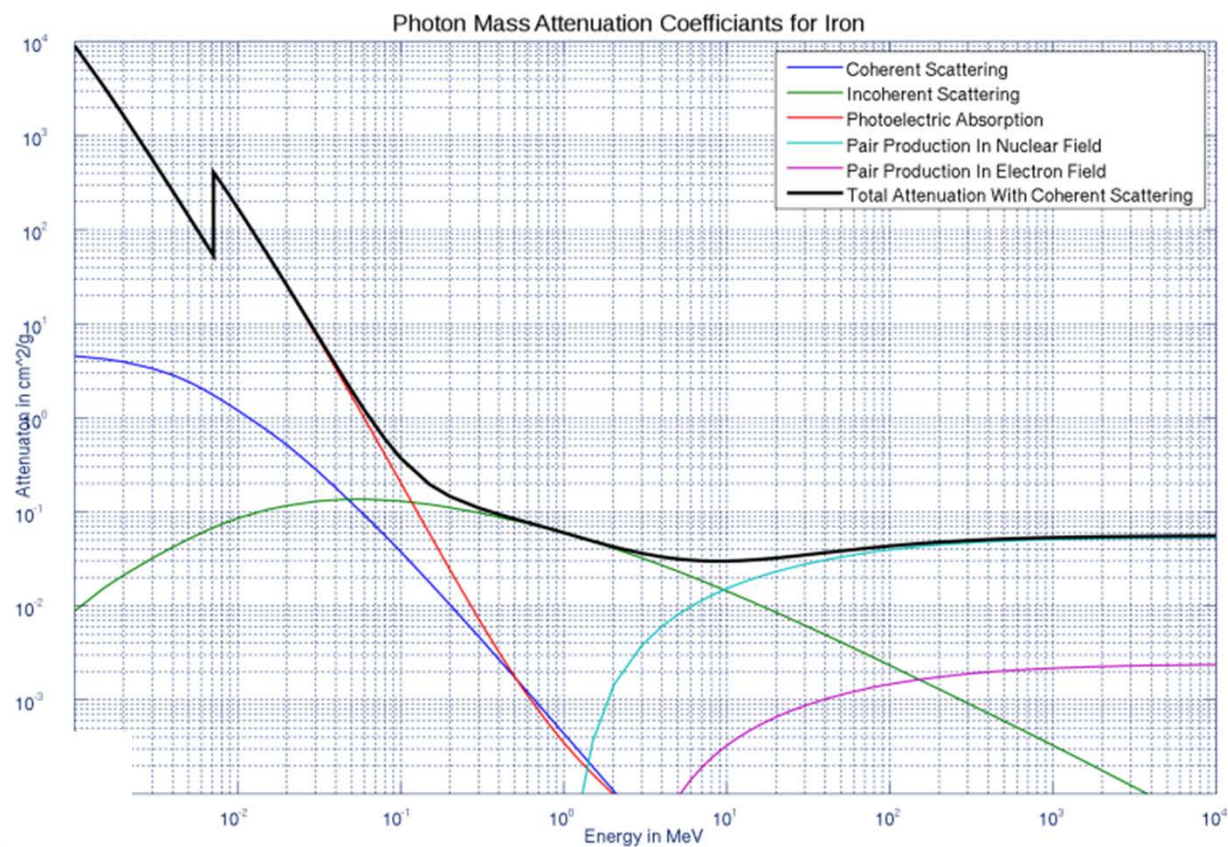
Stopping Power - Collision (MeV cm²/g)

Kinetic Energy (MeV)

Print Set to Log/Log OK

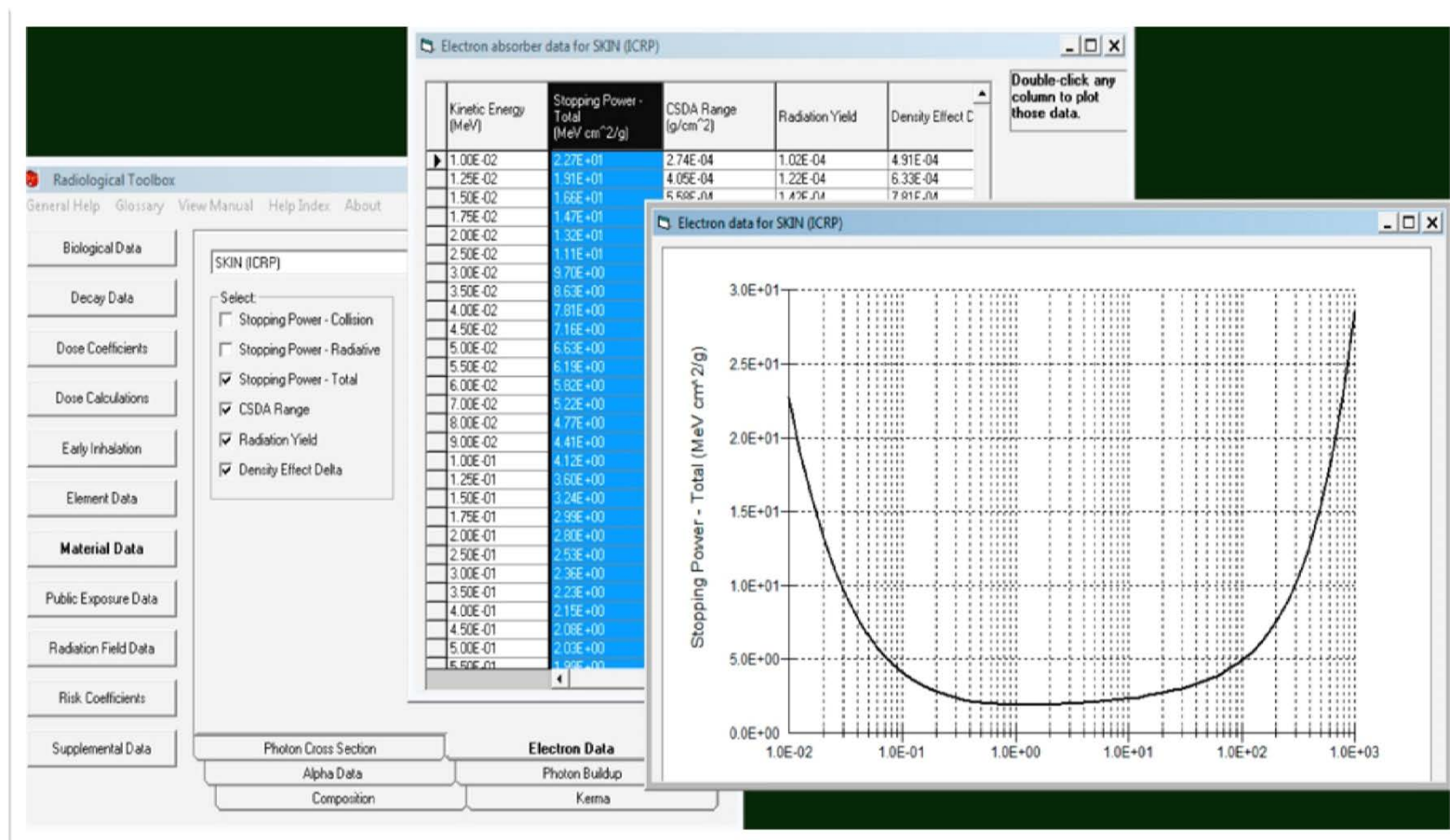


(6) Element Data (Fe)





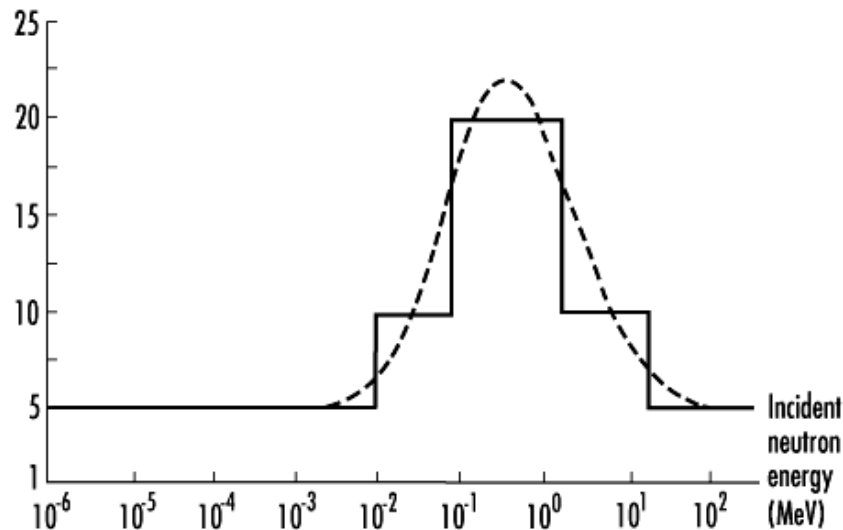
(7) Material Data (Skin)





(7) Neutron “ w_R ”

Radiation
weighting
factors

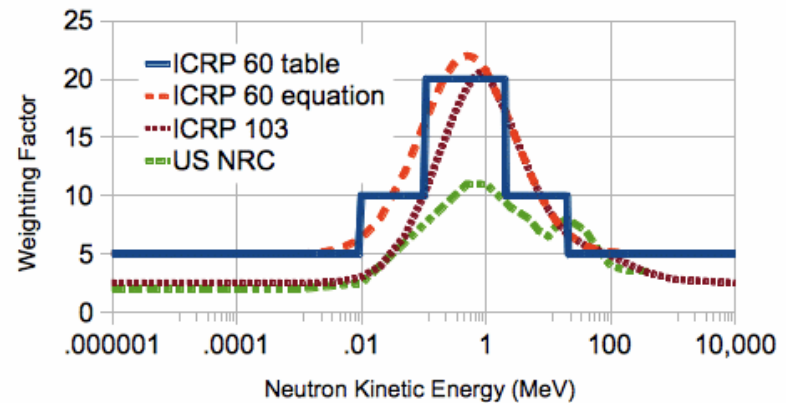


$$w_R = \begin{cases} 2.5 + 18.2e^{-[\ln(E_n)]^2/6}, & E_n < 1 \text{ MeV} \\ 5.0 + 17.0e^{-[\ln(2E_n)]^2/6}, & 1 \text{ MeV} \leq E_n \leq 50 \text{ MeV} \\ 2.5 + 3.25e^{-[\ln(0.04E_n)]^2/6}, & E_n > 50 \text{ MeV} \end{cases}$$

ICRP 60 Radiation Weighting Factors

Radiation type and energy	Weighting Factor w_R
Photons, all energies	1
Electrons, all energies	1
Neutrons, energy < 10 keV	5
10 - 100 keV	10
100 - 2000 keV	20
2 - 20 MeV	10
> 20 MeV	5
Protons, energy > 2 MeV	5
Alpha, fission fragments	20

Radiation Weighting Factors for Neutrons





(8) Public Exposure Data

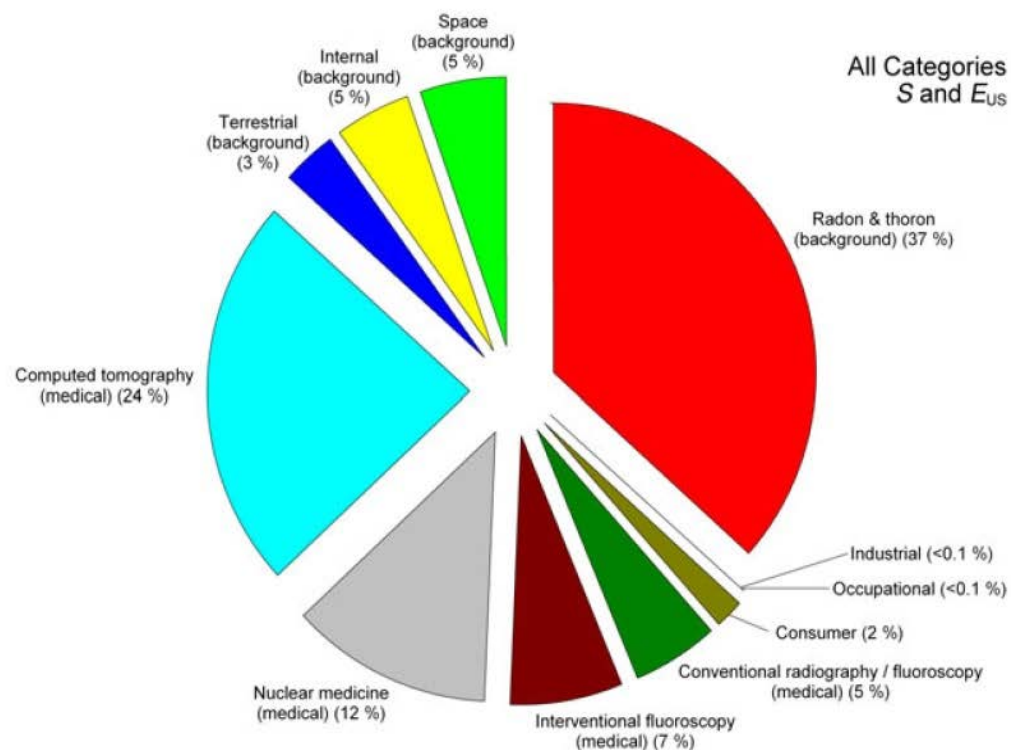
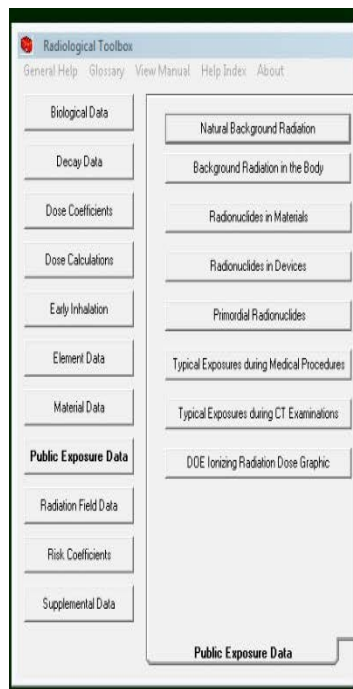


Fig. 1.1. Percent contribution of various sources of exposure to the total collective effective dose (1,870,000 person-Sv) and the total effective dose per individual in the U.S. population (6.2 mSv) for 2006. Percent values have been rounded to the nearest 1 %, except for those <1 % [see Table 1.1 for the values of S (person-sievert) and E_{US} (millisievert)].



(8) Basic NORM

Natural Occurring Radionuclides in Body		
Nuclide	Mass	Activity
Uranium	90 μg	1.1 Bq
Thorium	30 μg	0.11 Bq
Potassium 40	17 mg	4.4 kBq
Radium	31 pg	1.1 Bq
Carbon 14	22 ng	3.7 kBq
Tritium	0.06 pg	23 Bq
Polonium	0.2 pg	37 Bq



Radionuclides in Oceans	
Nuclide	Concentration
Uranium	33 mBq/L
Potassium 40	11 Bq/L
Tritium	0.6 mBq/L
Carbon 14	5 mBq/L
Rubidium 87	1.1 mBq/L

Radionuclides in Food		
Food	K-40 (pCi/kg)	Ra-226 (pCi/kg)
Banana	3520	1
Brazil nuts	5600	1000-7000
Carrots	3400	0.6 - 2
Potatoes	3400	1 - 2.5
Beer	390	-
Red meat	3000	0.5
Lima beans	4640	2 - 5
Drinking water	-	0 - 0.17



(8) Medical Exposures

Dose from Medical Diagnostic Procedures		
Procedure	Dose (rem)	Dose (mSv)
Chest x-ray (1 film)	0.01	0.1
Dental x-ray	0.16	1.6
Mammogram	0.25	2.5
Lumbosacral spine	0.32	3.2
Bone scan (Tc-99m)	0.44	4.4
Cardiac (Tc-99m)	0.75	7.5
Cranial CT	5	50
GI fluoroscopy (barium)	8.5	85
Spiral CT	3-10	30 - 100



Computed tomography examinations

Effective dose per CT scans	
Examination	Dose (mSv)
Head	2
Chest	7
Abdomen/pelvis	10
Extremity	0.1
CT angiography: heart	20
CT angiography: head	5
Spine	10
Interventional	0.1
Whole-body screening	10
Calcium scoring	2
Cardiac	20
Virtual colonography	10
Miscellaneous	5



(9) Radiation Field Data

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Biological Data

Decay Data

Dose Coefficients

Dose Calculations

Early Inhalation

Element Data

Material Data

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Risk Coefficients

Supplemental Data

Select:

- ☒ Operational quantities
- ☐ AP - Antero-posterior geometry
- ☐ PA - Postero-anterior geometry
- ☐ LLAT - Left lateral geometry
- ☐ RLAT - Right lateral geometry
- ☐ ROT - Rotational geometry
- ☐ ISO - Isotropic geometry

Select Units

pSv cm²

Sv / Gy

Display Help

Refs

Note: For gamma constants, go the Decay Data / Summary display.

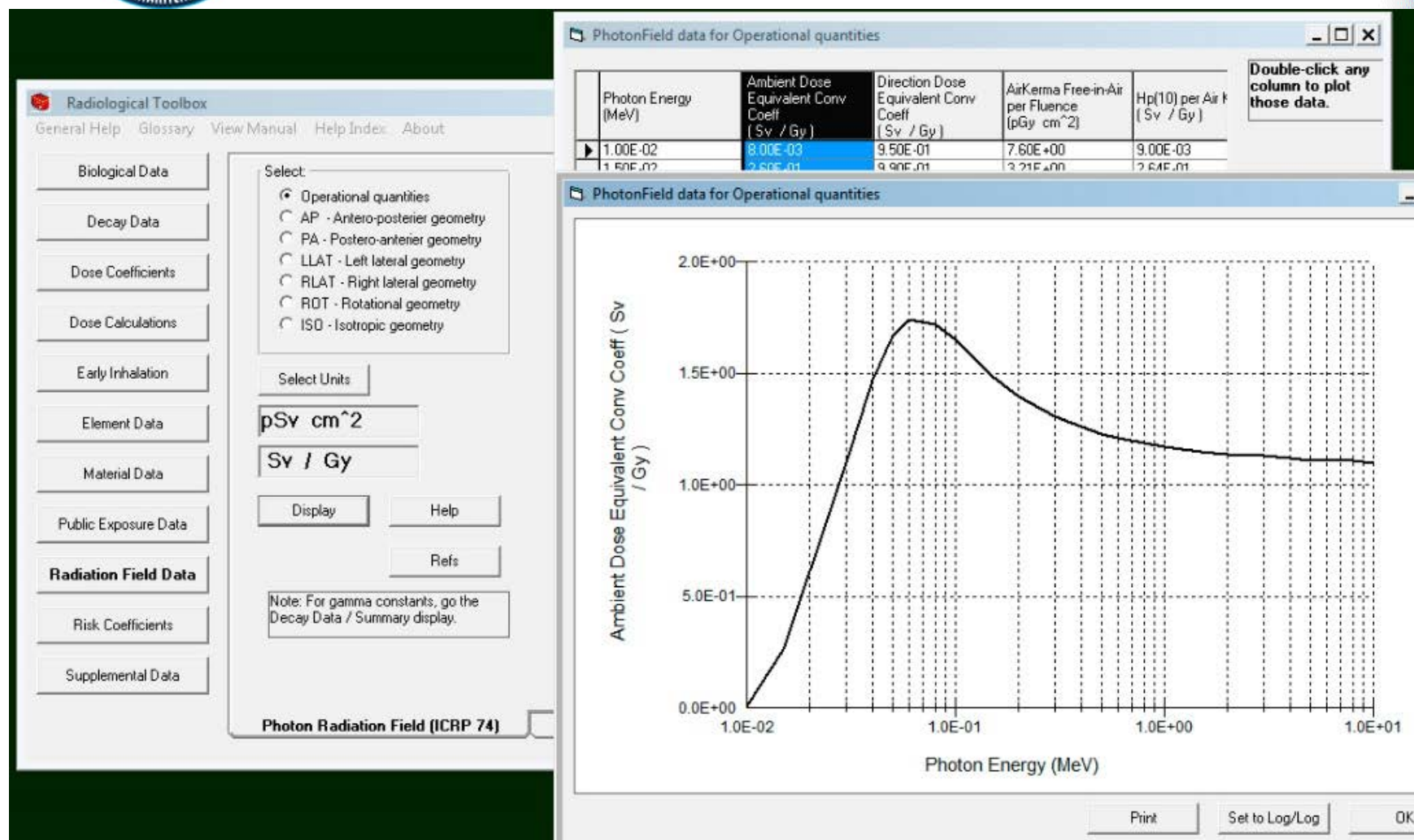
Photon Radiation Field (ICRP 74)

Neutron Radiation Field (ICRP 74)

AP

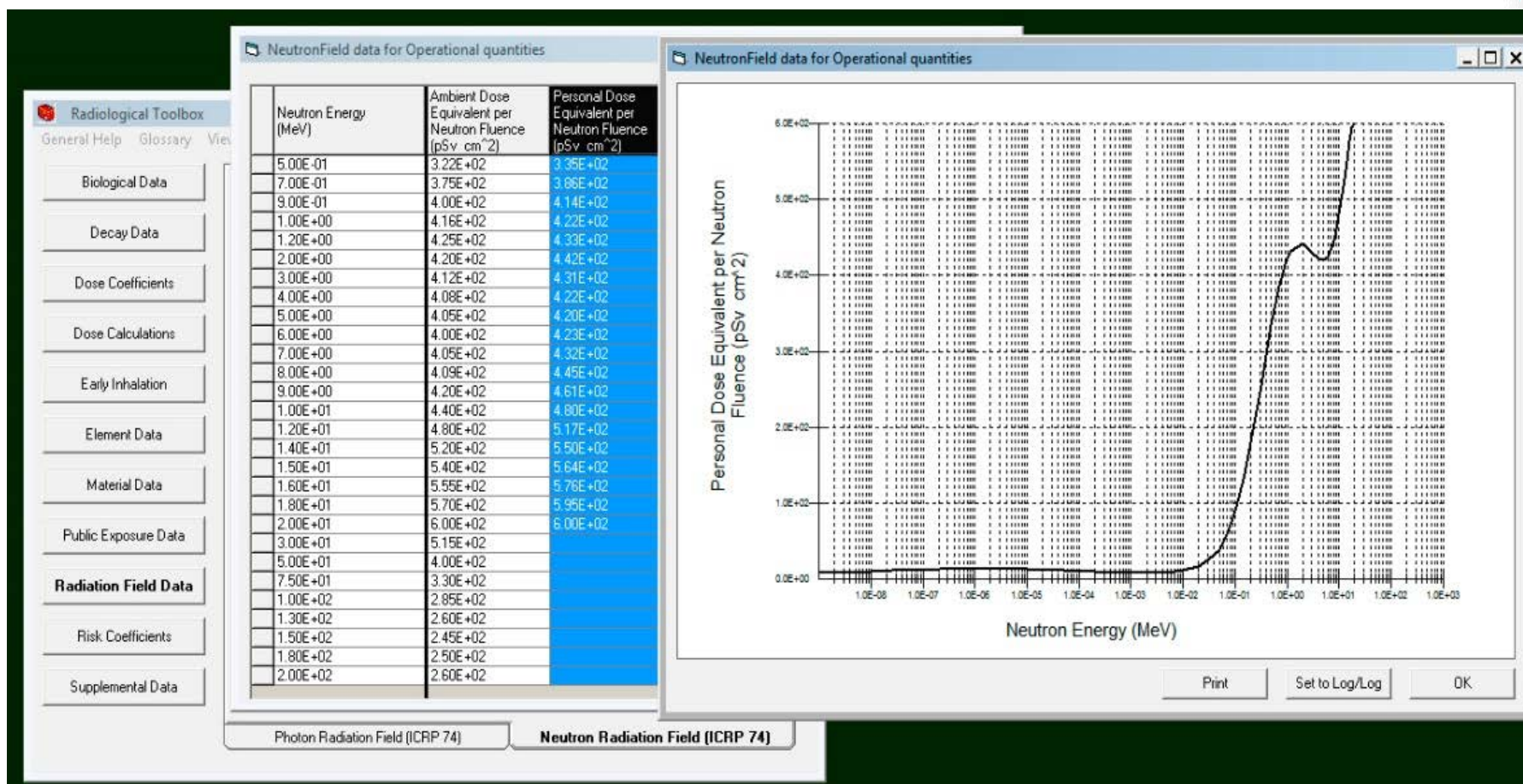


(9) Operational (γ)



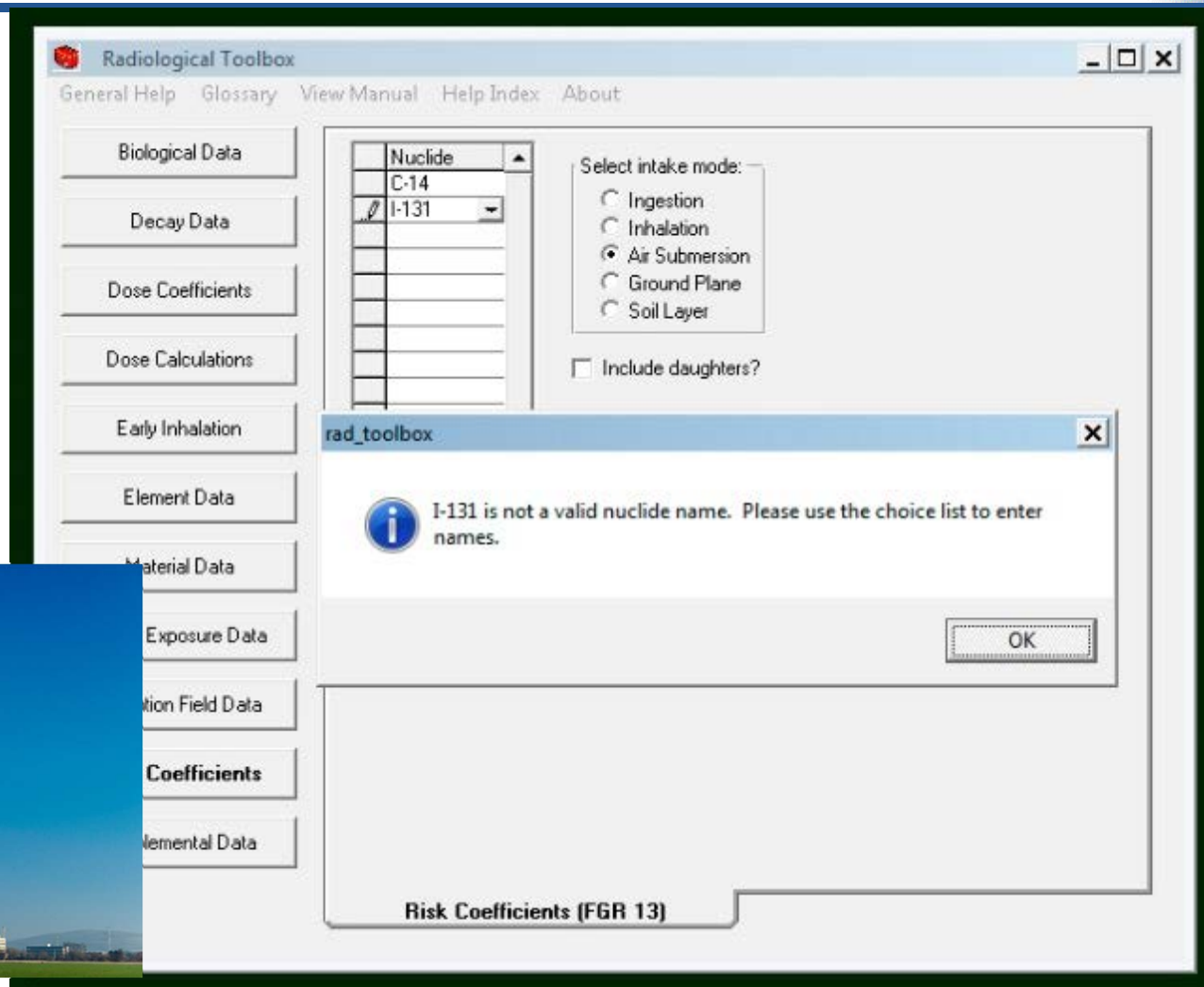


(9) Operational (n)





(10) Risk Coefficients





(10) C-14 and I-131

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Nuclide: C-14, I-131
 Select intake mode:
☒ Ingestion
☐ Inhalation
☐ Air Submersion
☐ Ground Plane
☐ Soil Layer

Ingestion risk coefficients (/ Bq) from

Nuclide	C-14
F1	1.00E+00
Intake	D Water
Cancer	mortality
esophagus	6.23E-13
stomach	2.20E-12
colon	4.88E-12
liver	8.86E-13
lung	4.94E-12
bone	5.41E-14
skin	5.13E-14
breast	2.13E-12
ovary	7.04E-13
bladder	1.47E-12
kidney	3.03E-13
thyroid	1.52E-13
leukemia	3.33E-12
residual	7.21E-12
Total	2.89E-11

Ingestion risk coefficients (/ Bq) from FGR 13									
	A	B	C	D	E	F	G	H	I
1	Ingestion risk coefficients (/ Bq) from FGR 13								
2	Nuclide	C-14		C-14		I-131		I-131	
3	F1	1.00E+00		1.00E+00		1.00E+00		1.00E+00	
4	Intake	D Water		Diet		D Water		Diet	
5									
6	Cancer	mortality	morbidity	mortality	morbidity	mortality	morbidity	mortality	morbidity
7	esophagu	6.23E-13	6.92E-13	7E-13	7.78E-13	2.22E-13	2.47E-13	2.75E-13	3.06E-13
8	stomach	2.2E-12	2.45E-12	2.93E-12	3.25E-12	1.28E-12	1.42E-12	1.75E-12	1.95E-12
9	colon	4.88E-12	8.87E-12	6.85E-12	1.25E-11	1.83E-12	3.32E-12	2.76E-12	5.01E-12
10	liver	8.86E-13	9.32E-13	9.89E-13	1.04E-12	8.67E-14	9.12E-14	1.02E-13	1.07E-13
11	lung	4.94E-12	5.2E-12	6.08E-12	6.4E-12	1.13E-12	1.18E-12	1.47E-12	1.54E-12
12	bone	5.41E-14	7.73E-14	6E-14	8.56E-14	1.3E-14	1.86E-14	1.46E-14	2.09E-14
13	skin	5.13E-14	5.13E-14	6.43E-14	6.43E-14	7.08E-15	7.08E-15	9.18E-15	9.18E-15
14	breast	2.13E-12	4.27E-12	2.86E-12	5.71E-12	3.24E-13	6.48E-13	4.58E-13	9.16E-13
15	ovary	7.04E-13	1.01E-12	7.97E-13	1.14E-12	7.46E-14	1.07E-13	8.91E-14	1.27E-13
16	bladder	1.47E-12	2.94E-12	1.58E-12	3.17E-12	2.01E-12	4.01E-12	2.18E-12	4.35E-12
17	kidney	3.03E-13	4.67E-13	3.41E-13	5.25E-13	2.76E-14	4.25E-14	3.25E-14	5.01E-14
18	thyroid	1.52E-13	1.52E-12	1.99E-13	1.99E-12	1.22E-10	1.22E-09	1.73E-10	1.73E-09
19	leukemia	3.33E-12	3.36E-12	3.62E-12	3.66E-12	6.17E-13	6.23E-13	6.83E-13	6.9E-13
20	residual	7.21E-12	1.02E-11	9.74E-12	1.37E-11	1.27E-12	1.78E-12	1.77E-12	2.49E-12
21	Total	2.89E-11	4.2E-11	3.68E-11	5.4E-11	1.31E-10	1.23E-09	1.85E-10	1.75E-09
22									
23									
24									



Risk Coefficients (Credit from ORNL)

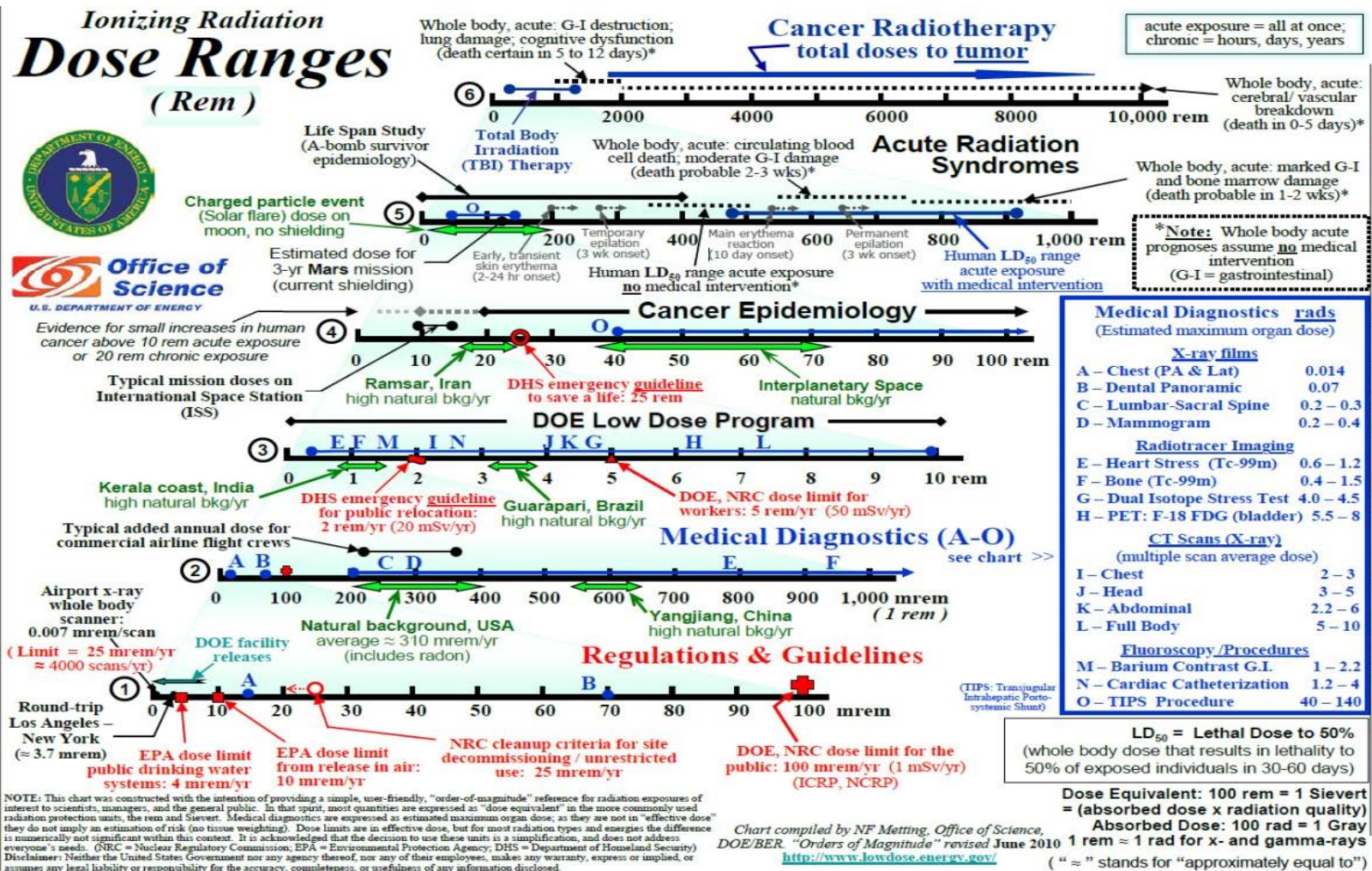
- Federal Guidance Report 13
- Average member of the US public
 - Mortality risk coefficient per unit activity inhaled or ingested for internal exposures or per unit time-integrated activity concentration in air or soil for external exposure
 - Morbidity risk coefficient is a comparable estimate of the average total risk of experiencing a radiogenic cancer, whether or not the cancer is fatal
 - Data presented for 14 cancer sites



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(11) Supplemental Data





Other Data (Credit from ORNL)

- **Radiation Field Data**
 - ICRP Publication 74/ICRU Report 57 Dose Coefficients
- **Supplemental Data**
 - SI Units
 - Physical Constants
 - Conversion Factors
 - International Nuclear and Radiological Event Scale (INES)
 - Formulas
 - Web Pages
 - DOE Dose Ranges
 - Transport Package Regulations (A1/A2 Table)



NUREG/CR-7166: Ch.3. HOW TO ACCESS RAD TOOLBOX FEATURES

- 1. Use Of The Nuclide Input Grid In Requesting Dose Coefficients**
- 2. Use Of The Choice Lists In Requesting Nuclide, Element, And Material Data**
- 3. How to Export Data**
- 4. Use The Activity Feature In Dose Calculations For A Decay Chain**
- 5. How to Define a Material and Calculate its Interaction Coefficients**
- 6. How to Generate Histogram Representation of Beta Spectra**
- 7. How to Check the Integrity of the Rad Toolbox Data Files**



educational CD Downloads

Free Educational CD Downloads

The following files are downloadable installation files for CDs of dose coefficients available here at no cost. They can be used by teachers, students, and those interested in radiological protection together with their parent ICRP Publications. Please note that while we encourage you to download and use these CDs, ICRP retains copyright and you must not edit or attempt to repackage these materials for sale.

These downloads replace ICRP [CD1](#), [CD2](#) and [CD3](#) which are now out of print. These free downloads are for Windows operating systems, including Win 7, on 32 and 64 bit machines.

ICRP Database of Dose Coefficients: Workers and Members of the Public; Ver. 3.0

Available as a Windows setup file named [ICRPDOSE_setup.exe](#).

ICRP Database of Dose Coefficients: Embryo and Fetus; Ver. 2.0

Available either as a Windows setup file named [ICRPCD2_setup.exe](#) or as a selfextracting file named [ICRPCD2_SelfExtract.exe](#).

ICRP Database of Dose Coefficients: Radionuclides in Mother's Milk; Ver. 2.0

Available either as a Windows setup file named [ICRPCD3_setup.exe](#) or as a selfextracting file named [ICRPCD3_SelfExtract.exe](#).

If the Help utility is not available for CD2 and CD3 it may be necessary to download from a program from Microsoft. See the ReadMe.txt file in the installation folder after installing these databases.

Please note that the dose coefficients in the first of the downloadable CDs listed above are the same as those in [ICRP Publication 119 "Compendium of Dose Coefficients based on ICRP Publication 60"](#). Although the downloadable CDs will be of practical use, the above-noted ICRP Publication will be the definitive and reference able compendium of these coefficients.

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Internet | Protect

Freebie:

In footnote of Page 9:
 “The numbers of nuclides differ between FGR 12 and **ICRP Publications 30, 68, and 72** as the latter set of publications **do not consider the intake of radionuclides of half-life less than 10 minutes.** The ICRP Database of Dose Coefficients: Workers and Members of the Public; Ver. 3.0 is now available as a free educational download;
<http://www.icrp.org/page.asp?id=145>.



Freebie:

NUREG-1350: ML15254A321.pdf

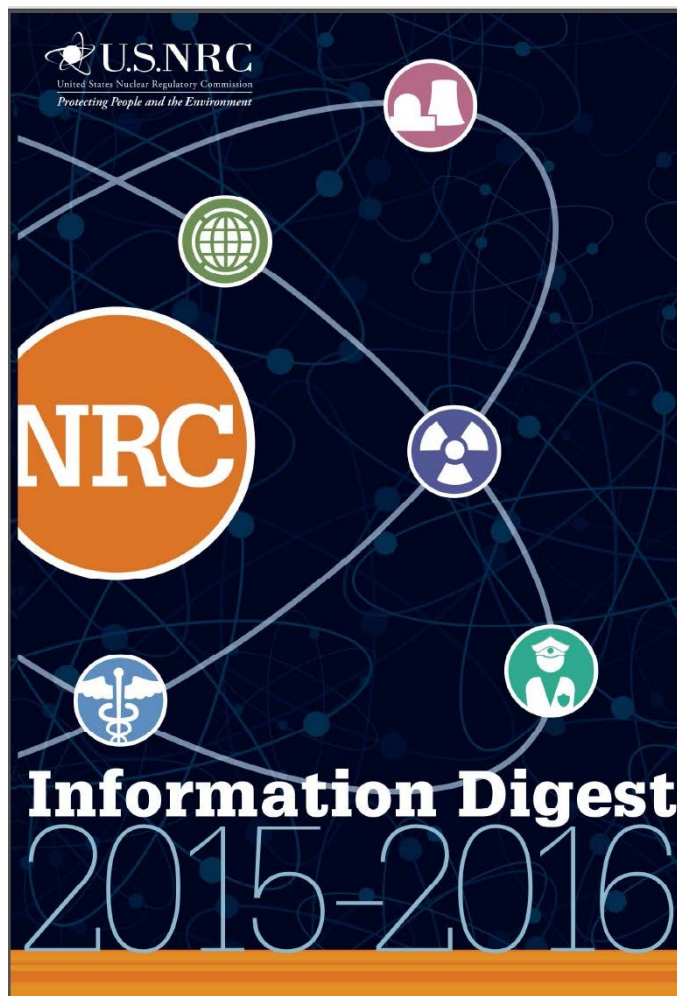
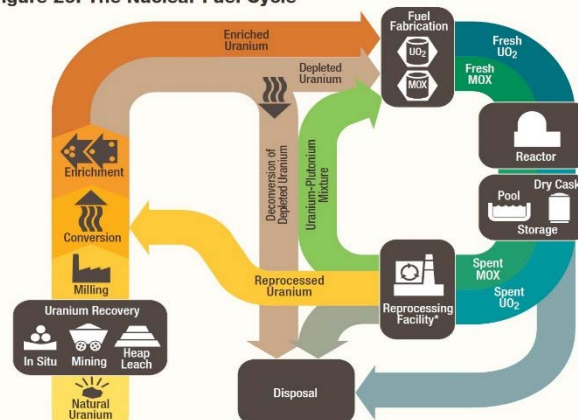


Figure 8. Nuclear Share of Electricity Generated by Country



Note: The country's short-form name is used.
Source: IAEA, Power Reactor Information System database, as of May 2015

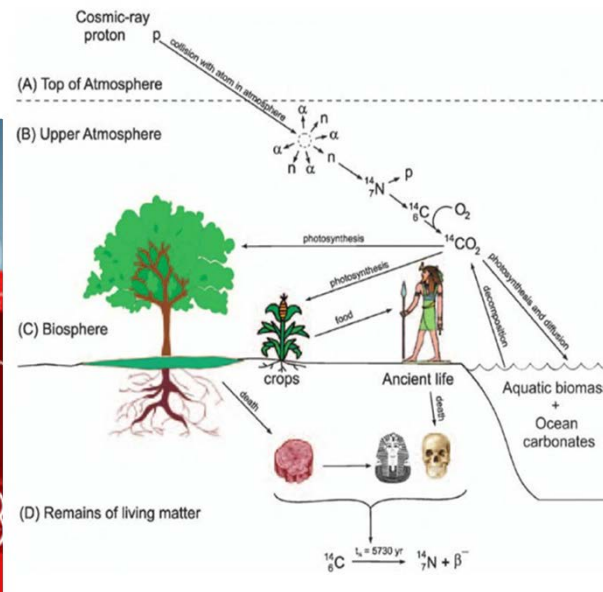
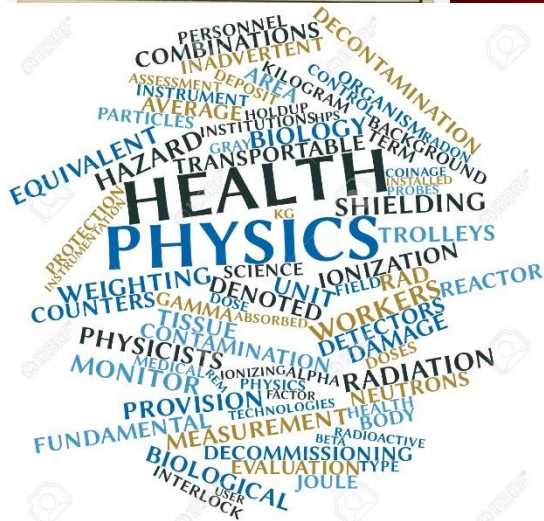
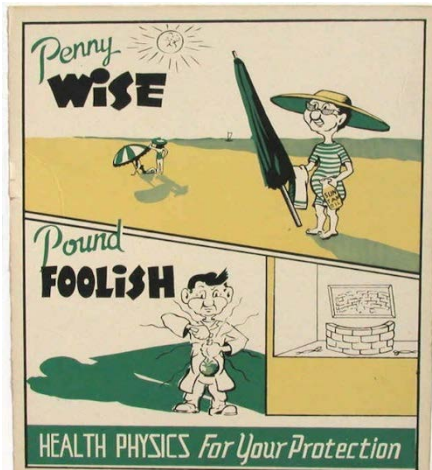
Figure 29. The Nuclear Fuel Cycle



* Reprocessing of spent nuclear fuel, including mixed-oxide (MOX) fuel is not practiced in the United States.
Note: The NRC has no regulatory role in mining uranium.



More Database?



$$C(x, y, z, t) = \frac{Q}{2\pi\mu\sigma\alpha} \cdot \exp\left(-\frac{y^2}{2\sigma_y^2}\right) \left[\exp\left(-\frac{(z-H\alpha)^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(z+H\alpha)^2}{2\sigma_z^2}\right) \right]$$

