Radiological Toolbox (v3.0)

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

US-NRC RAMP Users' Meeting

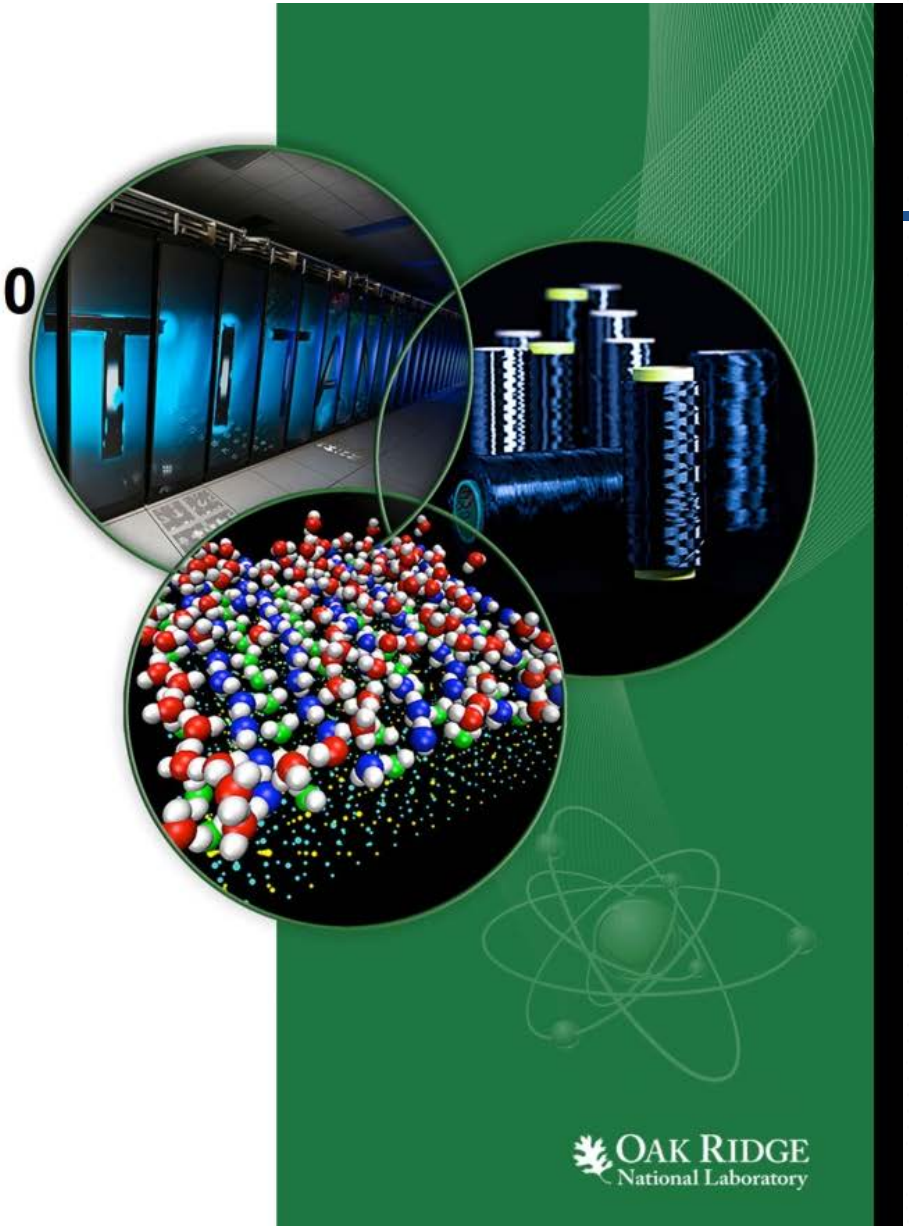
Radiological Toolbox 3.0 Workshop

Shaheen Dewji

Center for Radiation Protection Knowledge

Oak Ridge National Laboratory

17-21 October 2016



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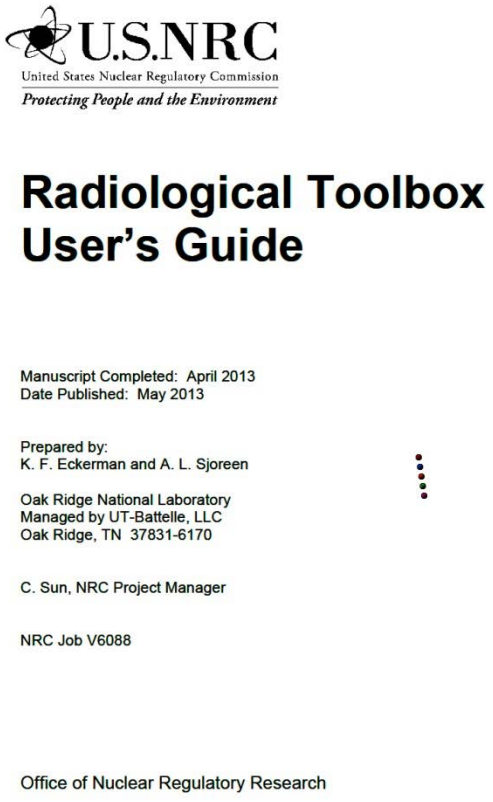
Timelines

- 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


U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Radiological Toolbox User's Guide

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

Manuscript Completed: April 2013
Date Published: May 2013

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NRC Job V6088

Office of Nuclear Regulatory Research

- **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

$$A = \lambda N$$

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

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

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

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

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

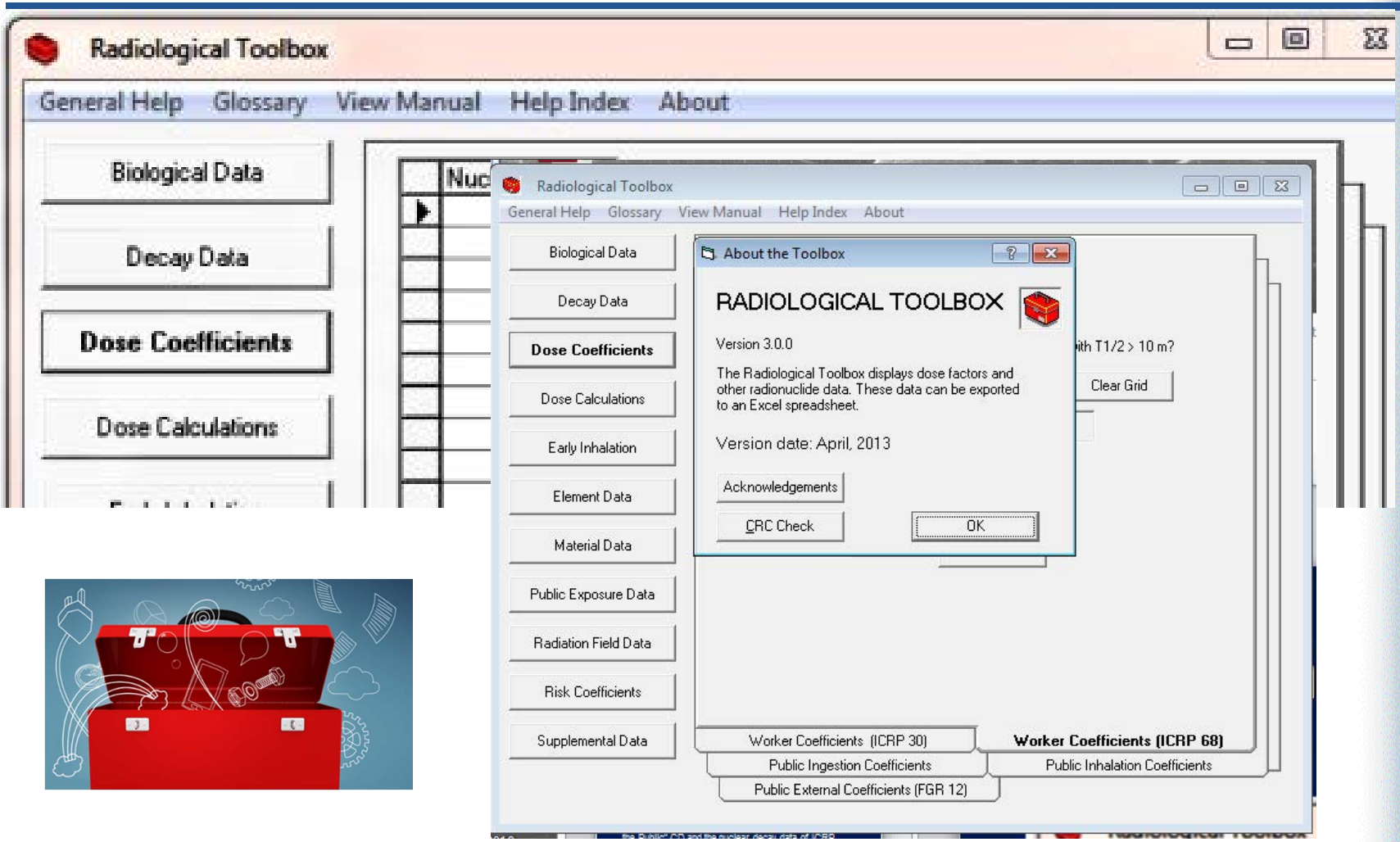
$$\dot{X}(d) = A \frac{\Gamma}{d^2}$$

HP Constants

Useful Constants and Conversions

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

Menu Bar (About)



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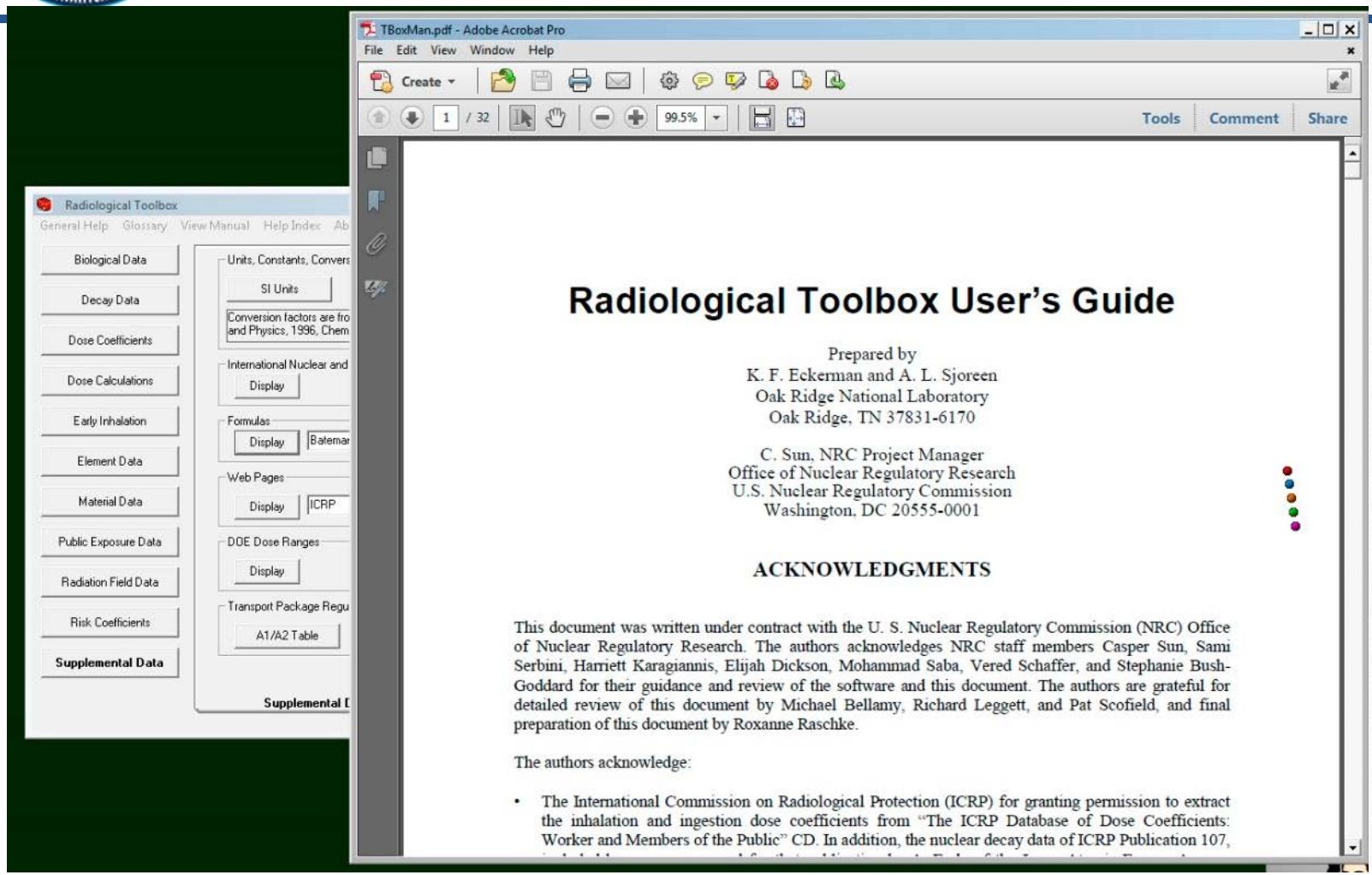
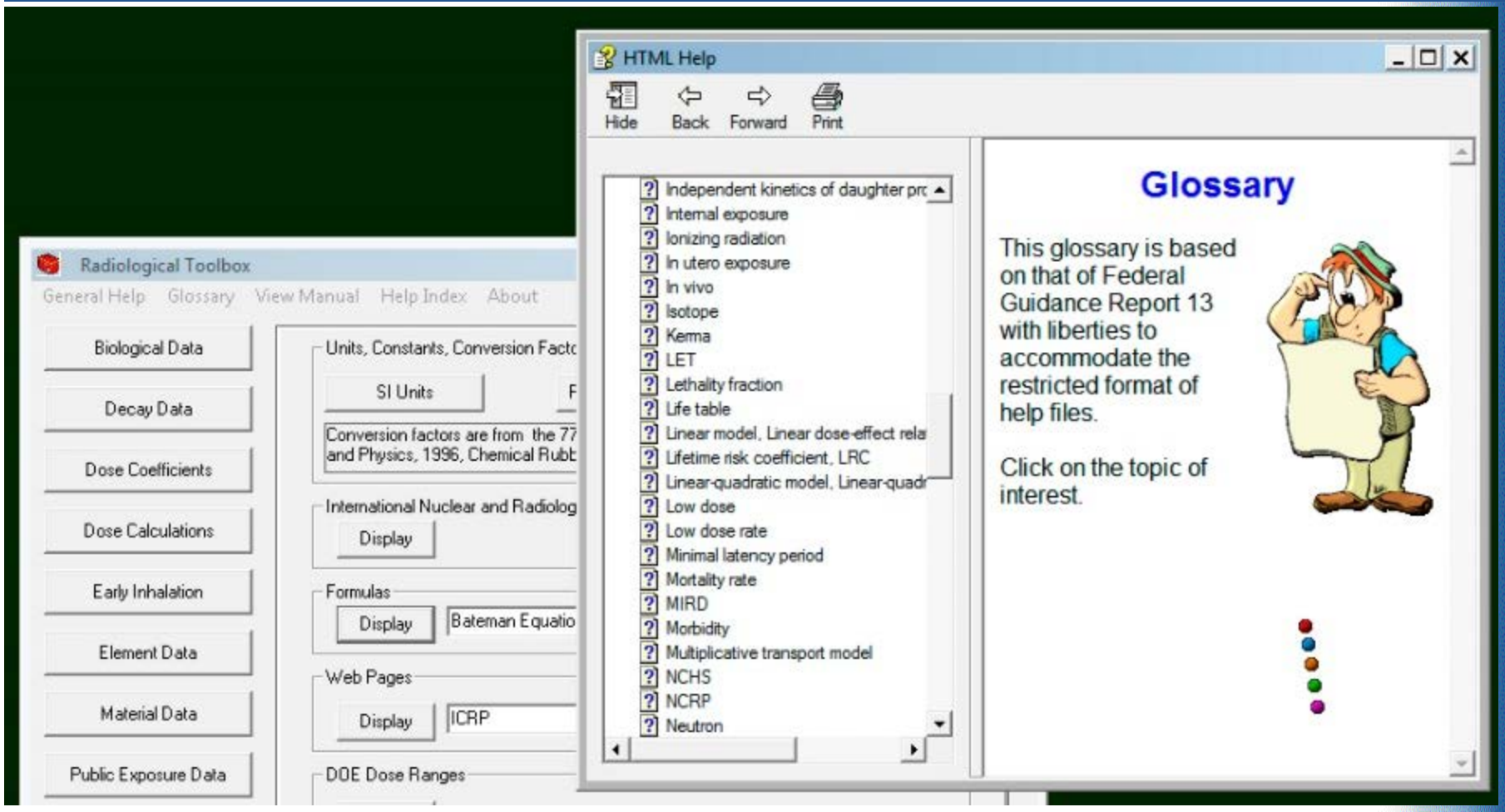


Menu Bar (Glossary)



HOMEWORK 1

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

Calculate committed effective does from repair work in areas where the airborne concentration of ^{60}Co (Type W) is $4x10^{3}$ Bqm^{-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:* *8.94E-9 Sv/Bq for ICRP 26* *8.92E-9 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 m^3/hr for a female worker.* *Committed effective dose = 8.92E-9 (Sv/Bq) x 1.3 (m^3/hr) x 2.5 (hr) x $4x10^5$ (Bq/m^3) = 11.6 mSv = 1.16 rem*

HOMEWORK 2

The concentration of ^{131}I in air (Type F) in an unrestricted area is 3E2 Bqm^{-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) = 7.2E-8 Sv/Bq* *Adult (>17) = 7.4E-9 Sv/Bq* *Raito of dose coefficients (child/Adult) = 7.2E-8/7.4E-9 = 9.7* *Click Biological Data, ICRP-89 Reference Values, Respiratory Function, Ventilation, Light Exercise:* *Child = 0.35 m^3/hr* *Adult = 1.5 m^3/hr*	*The annual doses are:* *Child: D = 7.2E-8 (Sv/Bq) x 300 (Bq/m^3) x 0.35 (m^3/hr) x 8760 hr/yr) = 0.066 Sv/yr* *Adult: D = 7.4E-9 (Sv/Bq) x 300 (Bq/m^3) x 1.50 (m^3/hr) x 8760 (hr/yr) = 0.029 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 5.43E-3.
This is the urine excretion fraction for that time post-intake.
Intake = (50 (Bq/ml) x 900 (ml))/5.43E-3 = 8.29E6 Bq

From the Dose Coefficient tab, inhalation of Type F ^{134}Cs, ICRP-68 worker data, the effective dose coefficient is 9.6E-9 Sv/Bq. Hence, Committed effective dose = 9.6E-9 (Sv/Bq) x 8.29E6 (Bq) = 0.08 Sv.
Using the limit of 0.5 Sv for any organ, and an intake of 8.29E6 Bq, any organ with a dose coefficient greater than 0.5/8.29E6 = 6.0E-8 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 <u>mean energy</u> and the <u>end-point energy</u> of the spectrum emitted by ^{32}P? What is the <u>CSDA</u> 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 lings 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 x 2.53E-4 = 0.253 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 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/cm^2 or the kerma per unit fluence.* *The kerma rate corresponding to the 2.24E8 fluence is:* *K = 2.24E8 x 3.69 = 8.27E8 pGy = 0.827 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 (mGy/s) x 1.433 (Sv/Gy) * 0.001 (Gy/mGy) = 0.0012 mSv/s = = 4.27 Sv/hr* *@ E(PA) = 0.827 (mGy/s) x 1.019 (Sv/Gy) x 0.001 (Gy/mGy) = 0.00084 mSv/s = 3.03 Sv/hr* *@ E(ISO) = 0.827(mGy/s) x 0.749 (Sv/Gy) x 0.001 (Gy/mGy) = 0.00062 mSv/s = 2.23 Sv/hr*

HOMEWORK 7

What is the annual risk resulting from continuous submersion in ^{85}Kr cloud environment at a constant concentration of 1E3 Bq m^{-3}?

Click the Risk Coefficients button.
Select Xe-133 from the Nuclides list.
Click display. The risk coefficients are:
Mortality = 6.59E-17 m^3/Bq-s
Morbidity = 9.86E-17 m^3/Bq-s

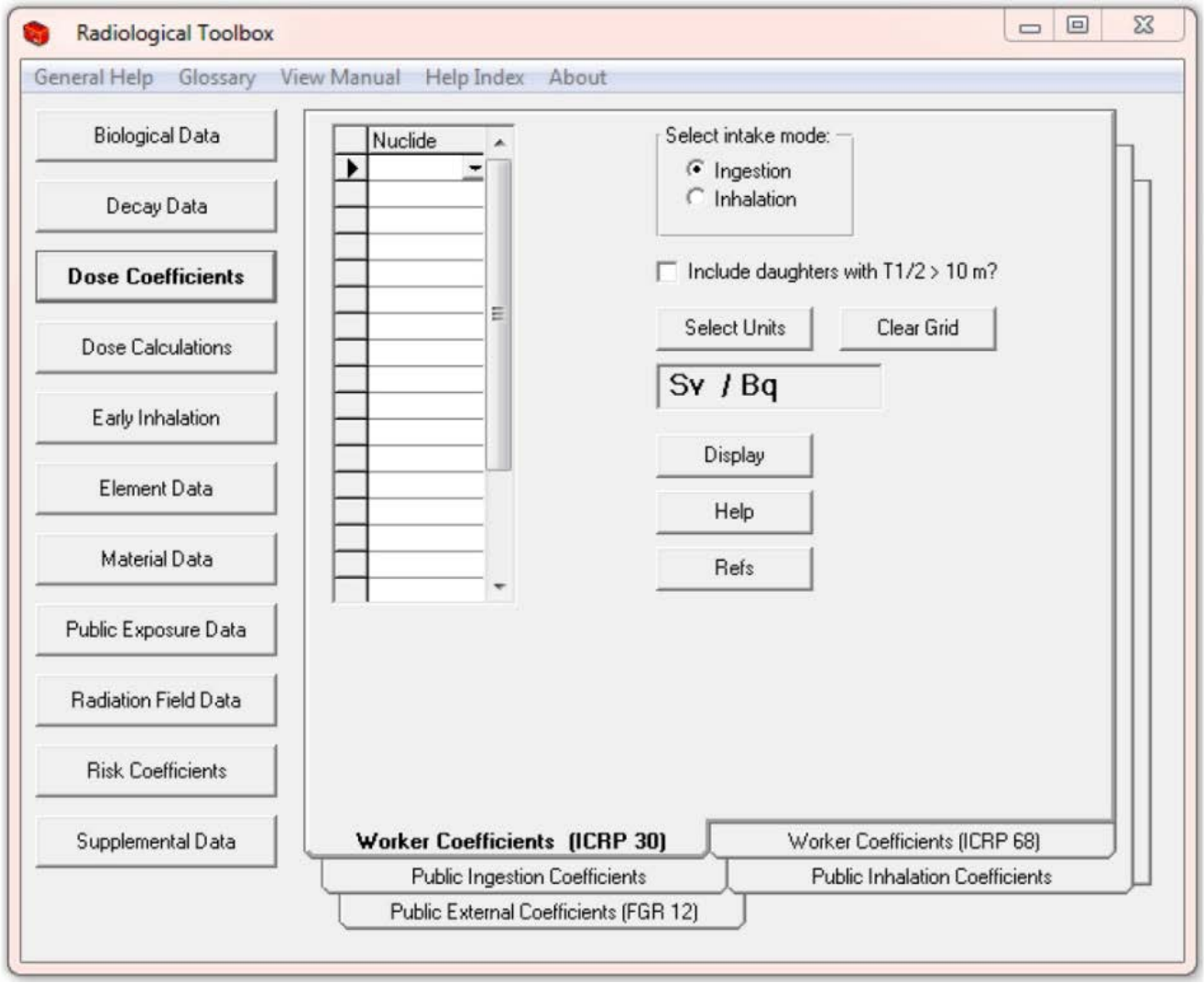
The integrated duration of exposure is:
X = 1E3 (Bq/m^3) x 8760 (h/y) x 3600 (s/h) = 3.154E10 (Bq-s/m^3)
Mortality risk = 6.59E-17 (m^3/Bq-s) x 3.154E10 (Bq-s/m^3) = 2E-6
Morbidity risk = 9.86E-17 (m^3/Bq-s) x 3.154E10 (Bq-s/m^3) = 3E-6

Toolbox's Data Collections

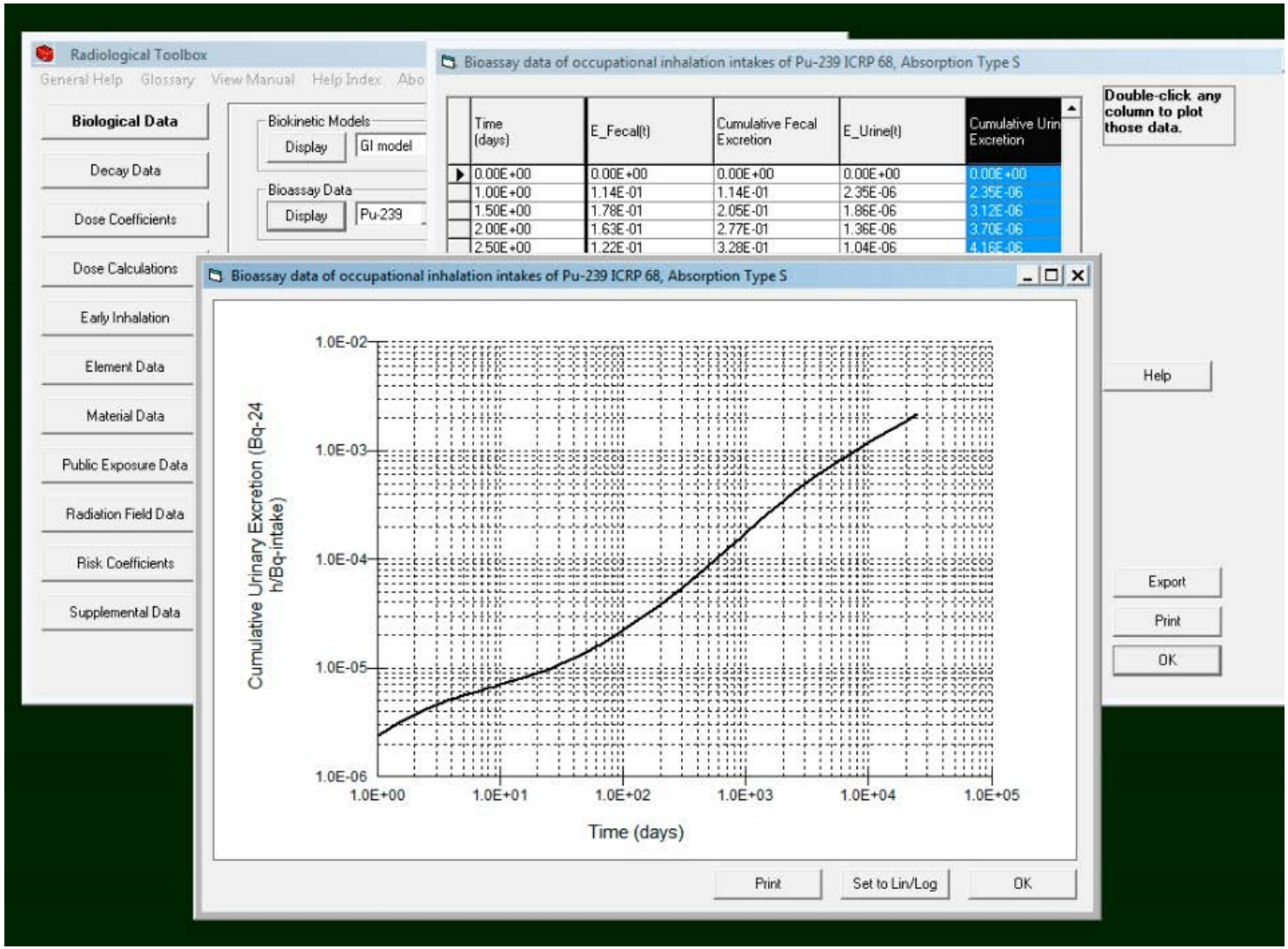
Table 1.1. General Description of the Radiological Toolbox Data Elements

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

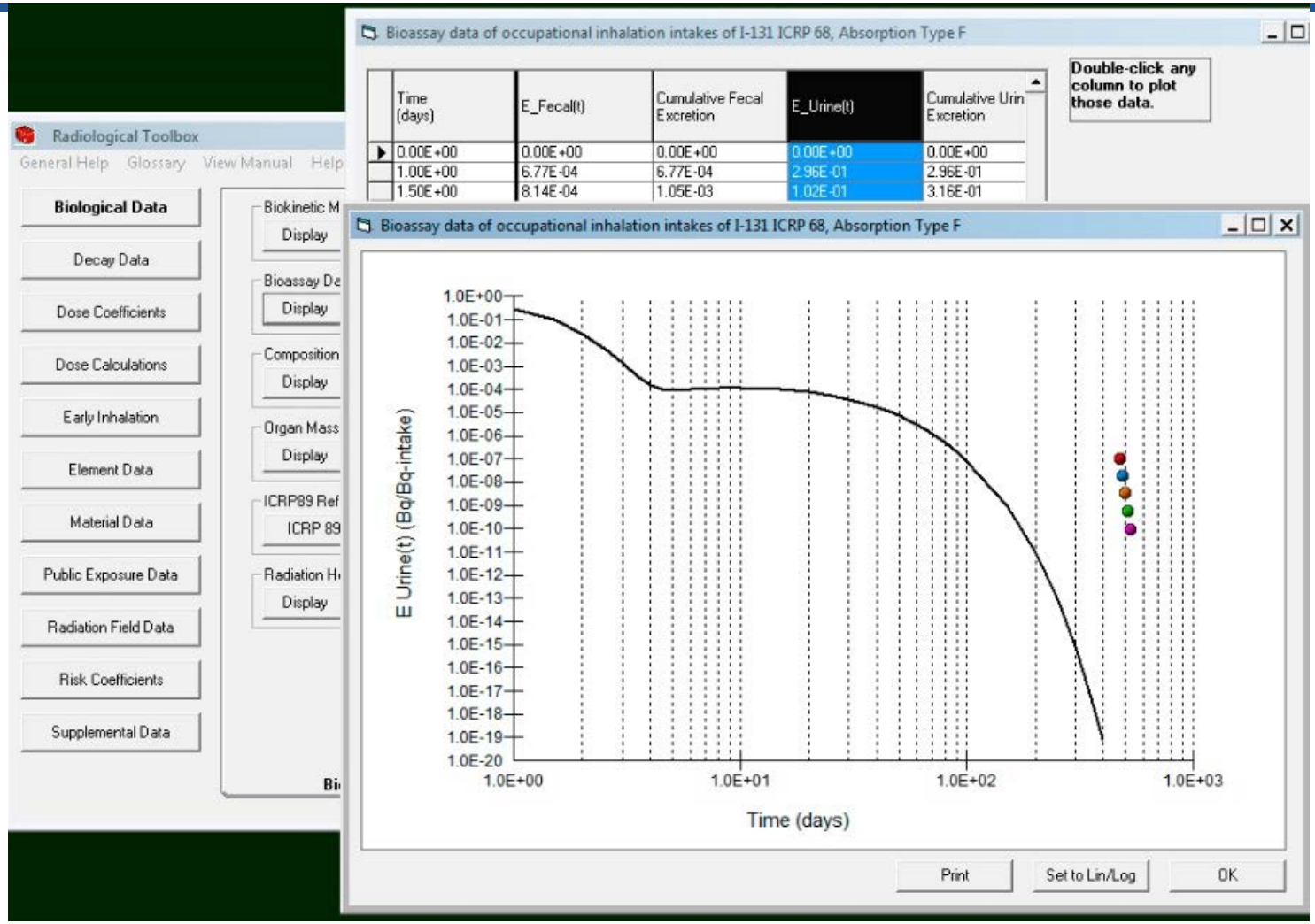
Rad-Toolbox 11 Database



(1) Biological Data



(1) I-131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Dose Calculations
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Element Data
Material Data
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Bioassay data of occupational inhalation intakes of I-131 ICRP 68, Absorption Type F
Time (days)
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Cumulative Fecal Excretion
E_Urine(t)
Cumulative Urin Excretion
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1.00E+00 6.77E-04 6.77E-04 2.96E-01 2.96E-01
1.50E+00 8.14E-04 1.05E-03 1.02E-01 3.16E-01
Bioassay data of occupational inhalation intakes of I-131 ICRP 68, Absorption Type F
E Urine(t) (Bq/Bq-intake)
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
1.0E-09
1.0E-10
1.0E-11
1.0E-12
1.0E-13
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1.0E-19
1.0E-20
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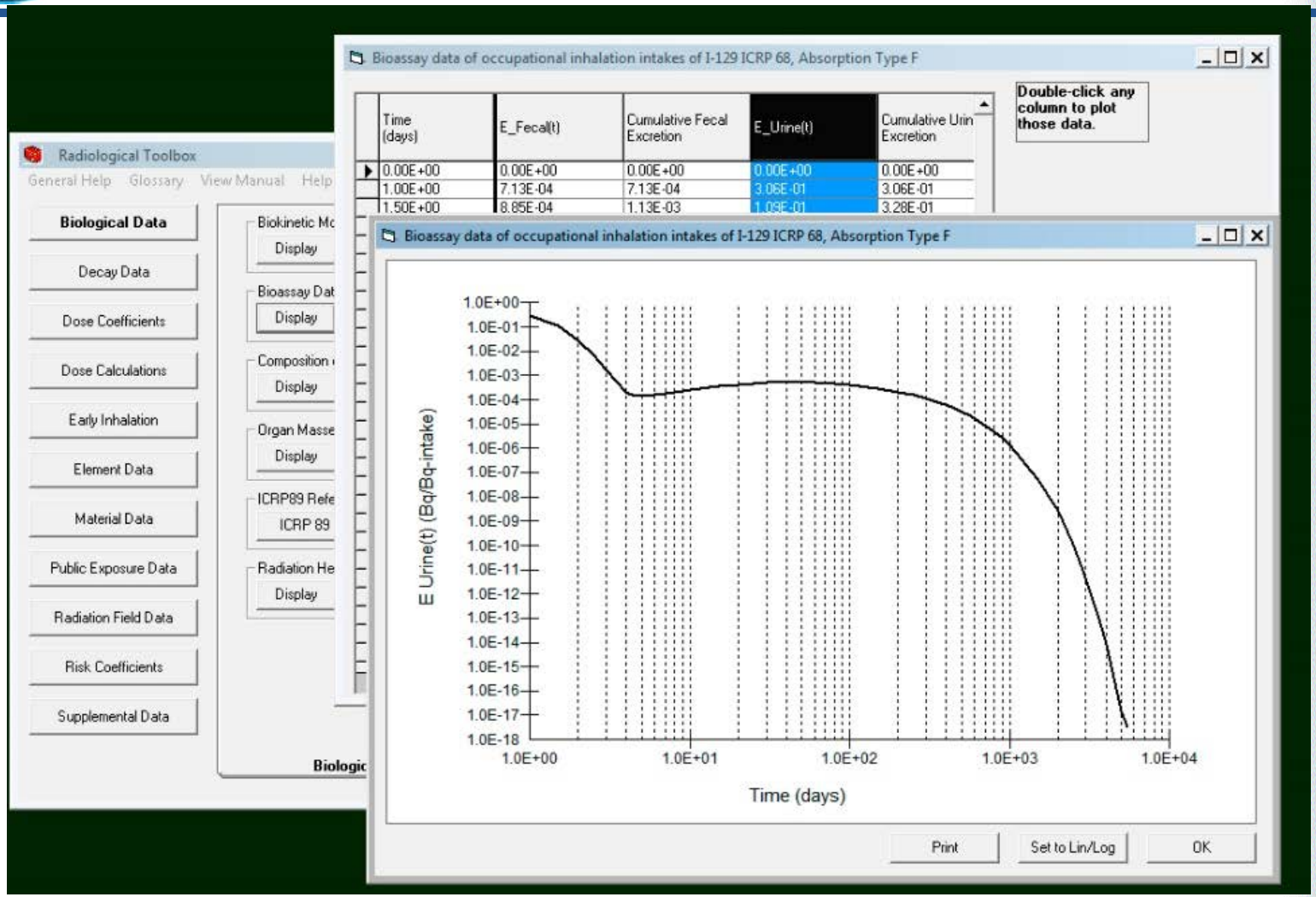
1.0E+03
Time (days)
Print
Set to Lin/Log
OK

(1) I-129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Bioassay data of occupational inhalation intakes of I-129 ICRP 68, Absorption Type F
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E_Fecal(t)
Cumulative Fecal Excretion
E_Urine(t)
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1.50E+00 8.85E-04 1.13E-03 3.28E-01
Bioassay data of occupational inhalation intakes of I-129 ICRP 68, Absorption Type F
E Urine(t) (Bq/Bq-intake)
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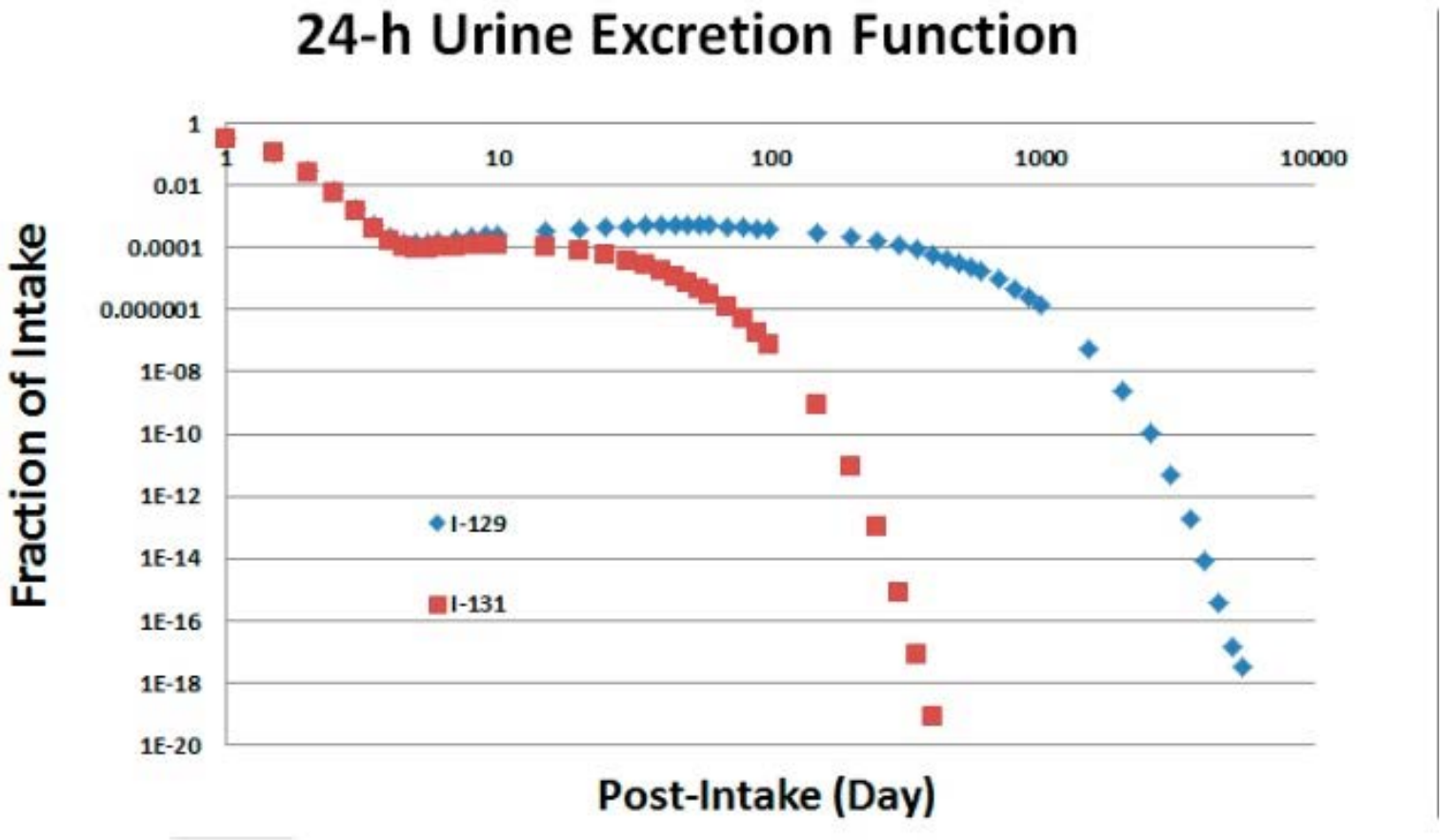
Time (days)
Print
Set to Lin/Log
OK

(1) Bioassay Application



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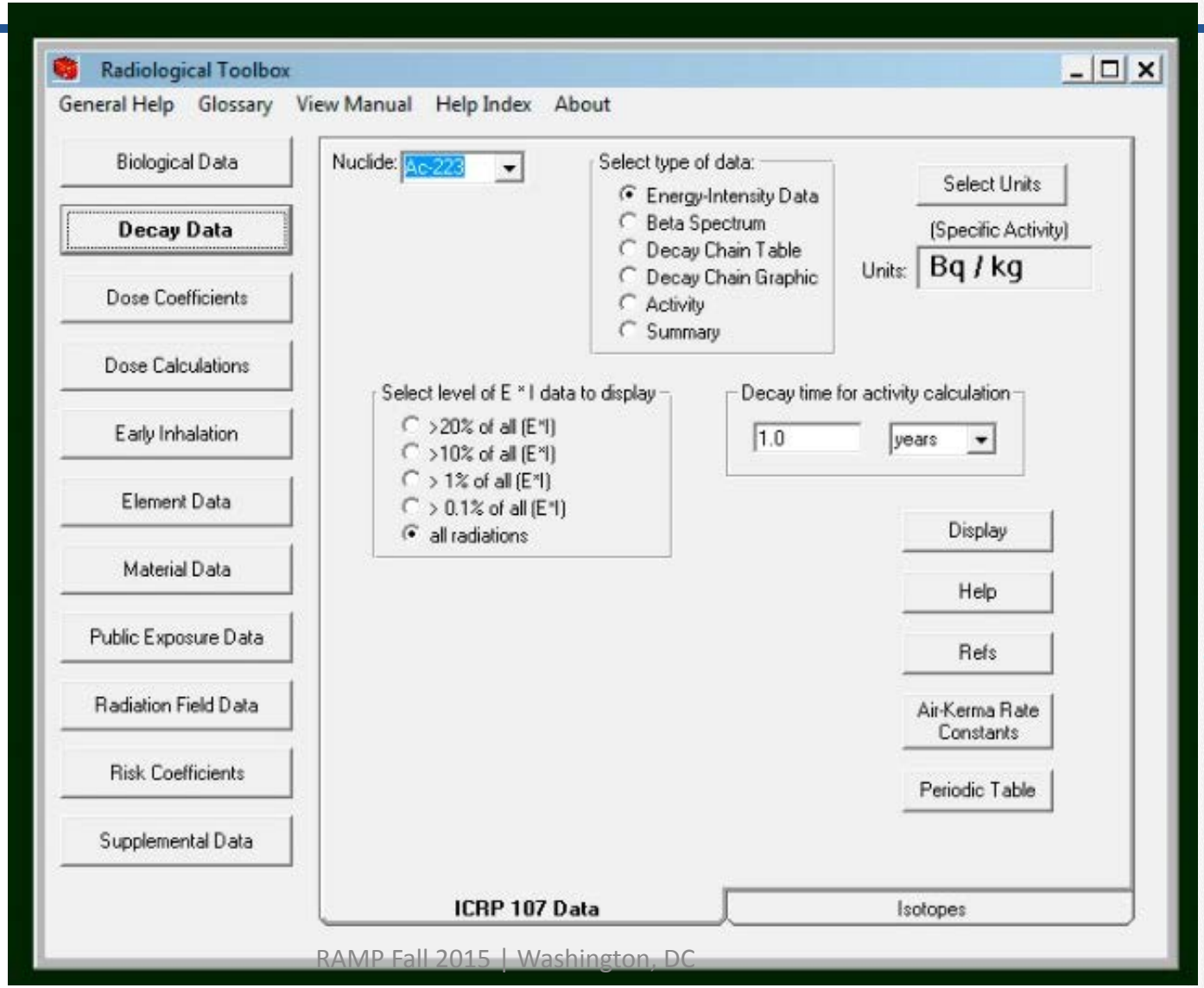
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Nuclide: Ac-223
Select type of data:
Energy-Intensity Data
Beta Spectrum
Decay Chain Table
Decay Chain Graphic
Activity
Summary
Select Units
(Specific Activity)
Units: Bq / kg
Select level of E * I data to display
>20% of all (E*I)
>10% of all (E*I)
> 1% of all (E*I)
> 0.1% of all (E*I)
all radiations
Decay time for activity calculation
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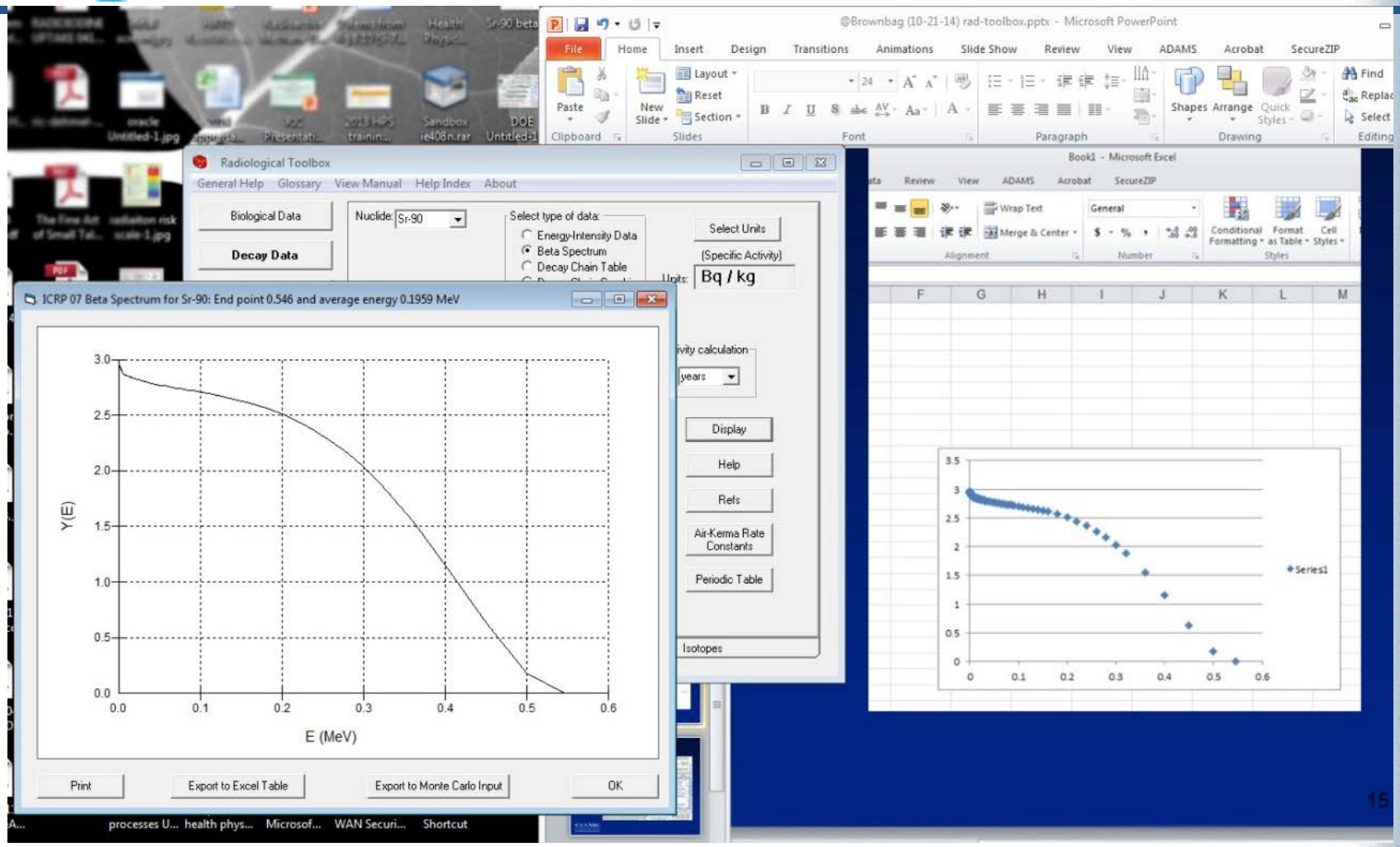
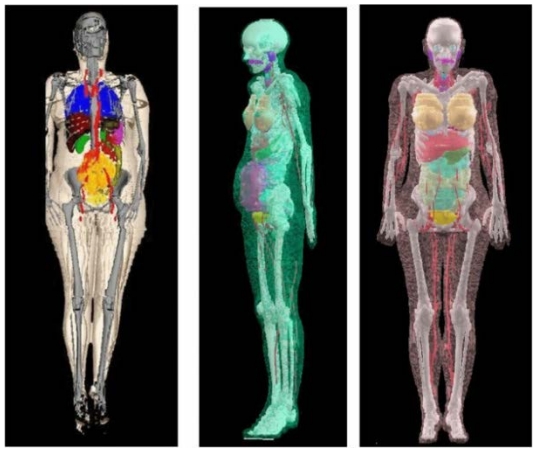
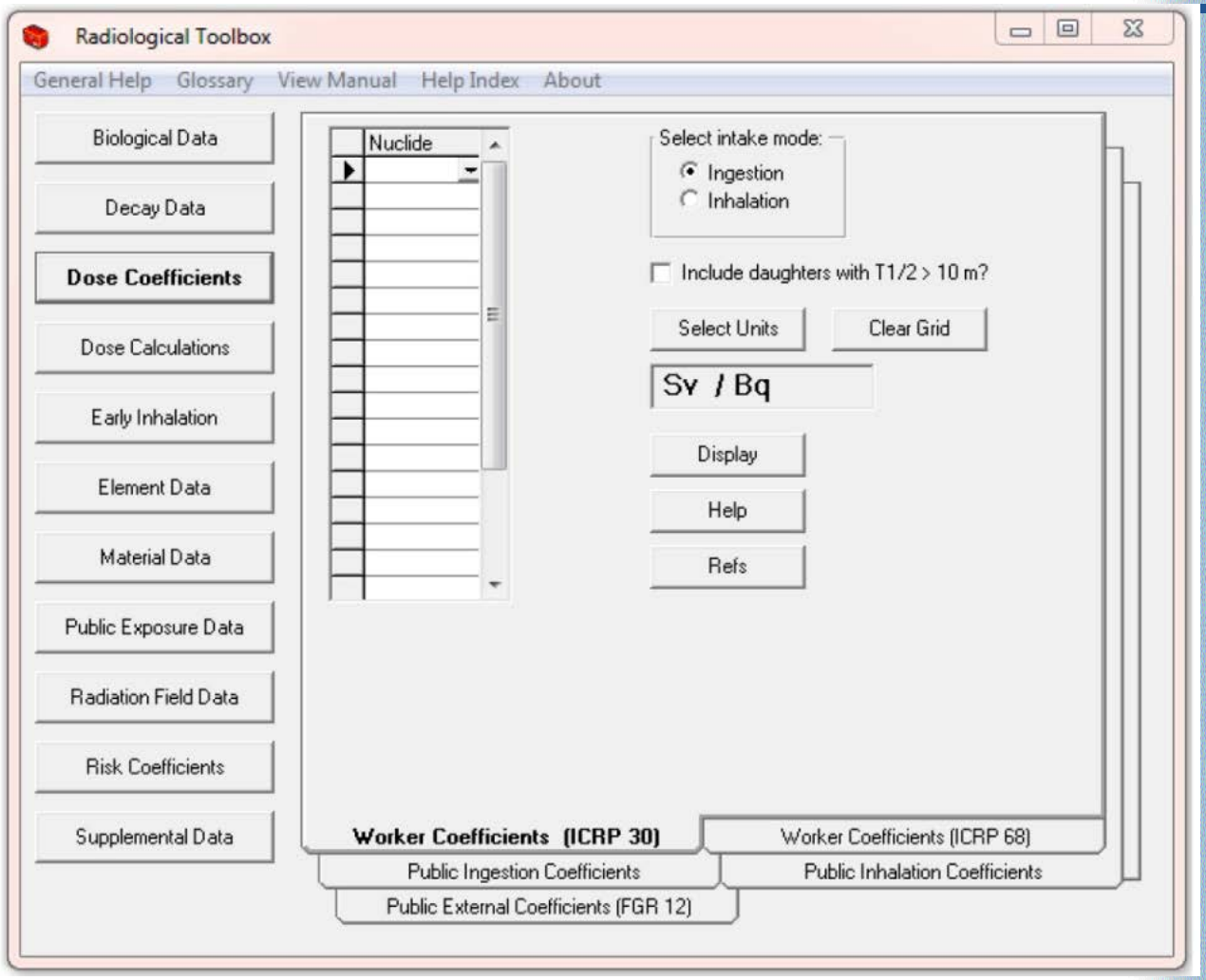
Air-Kerma Rate Constants
Periodic Table
ICRP 107 Data
Isotopes

(2) Sr-90 Beta Spec.

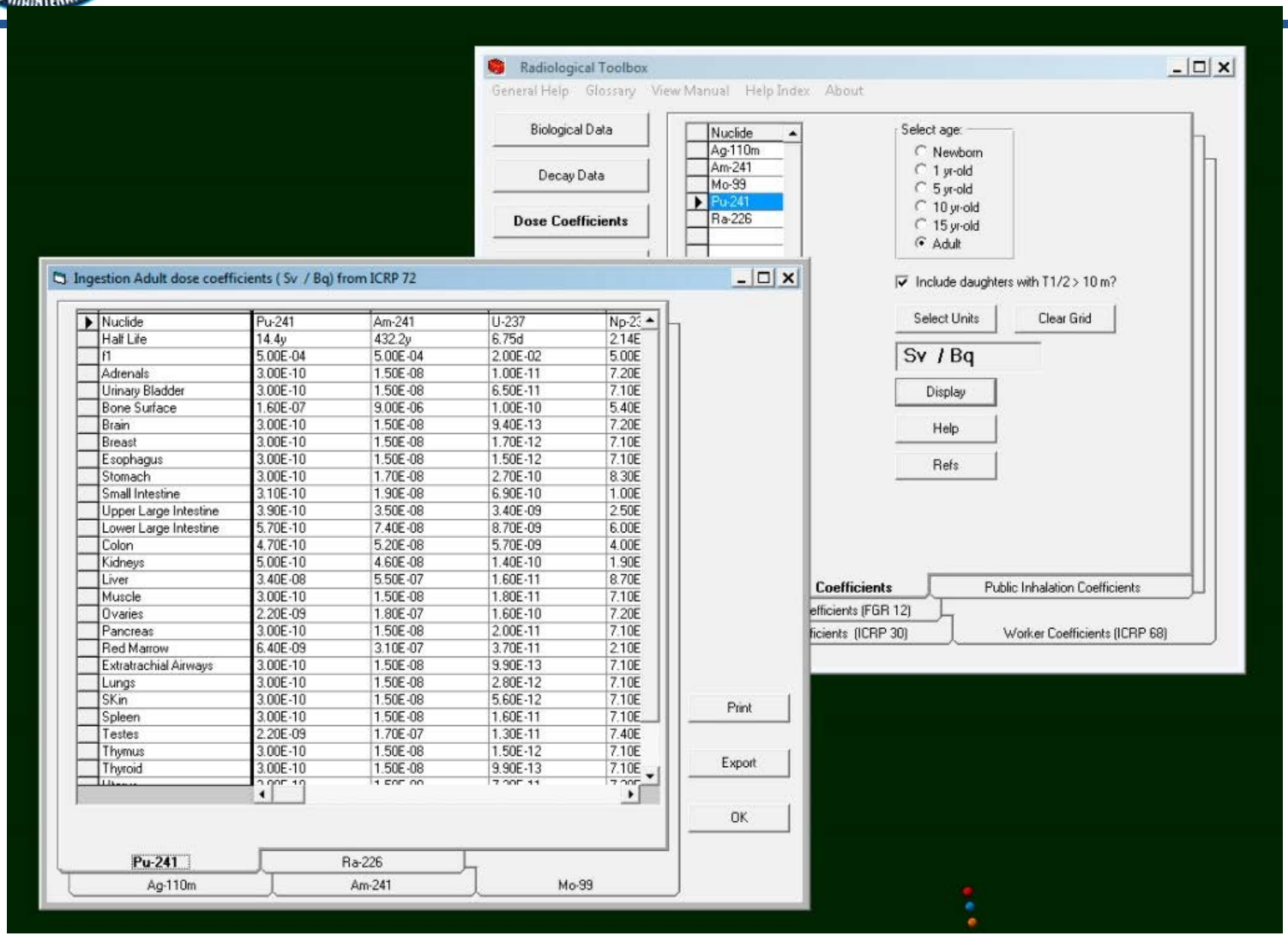


(3) Dose Coefficients



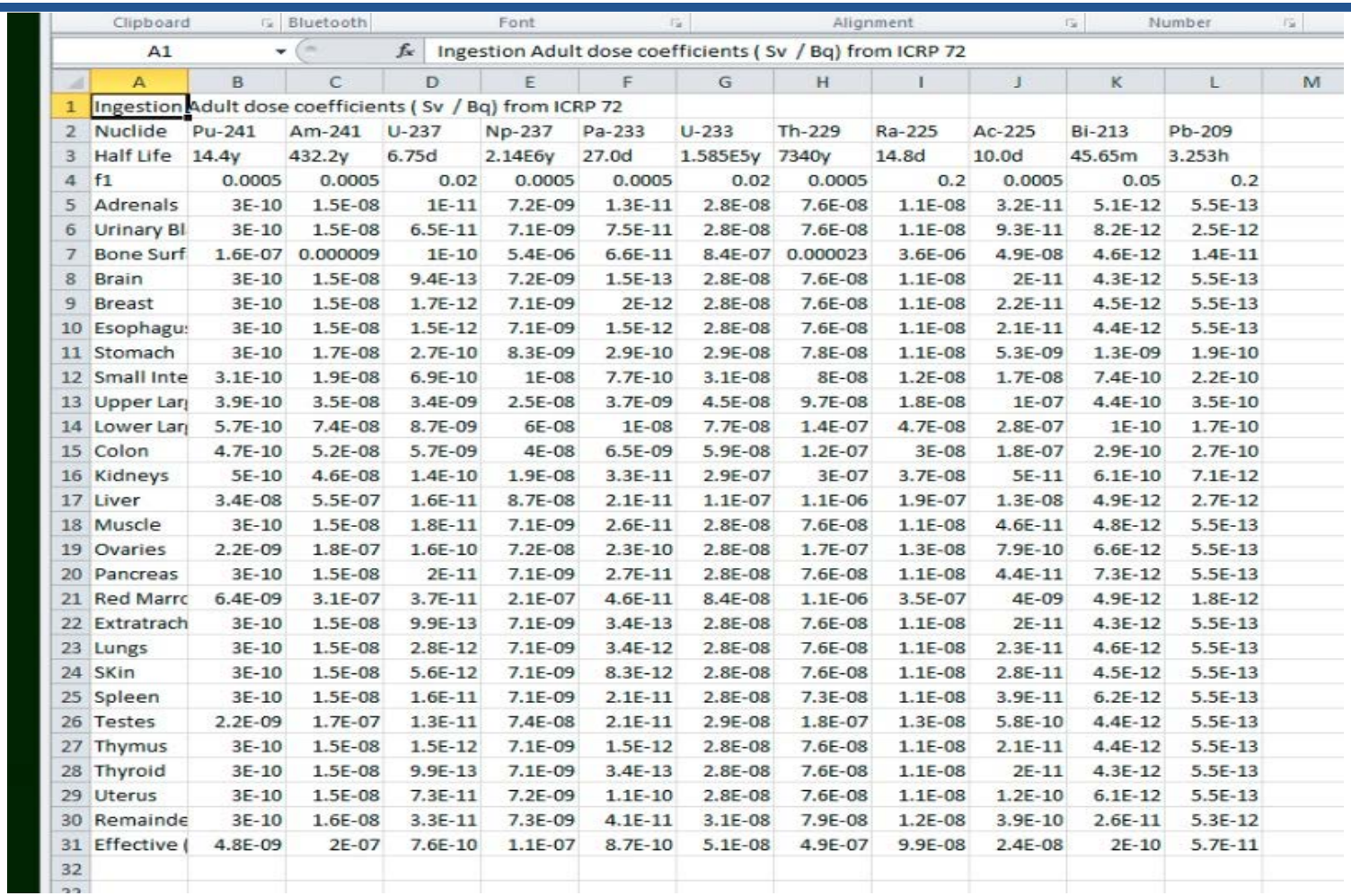


(3) Pu-241; Adult



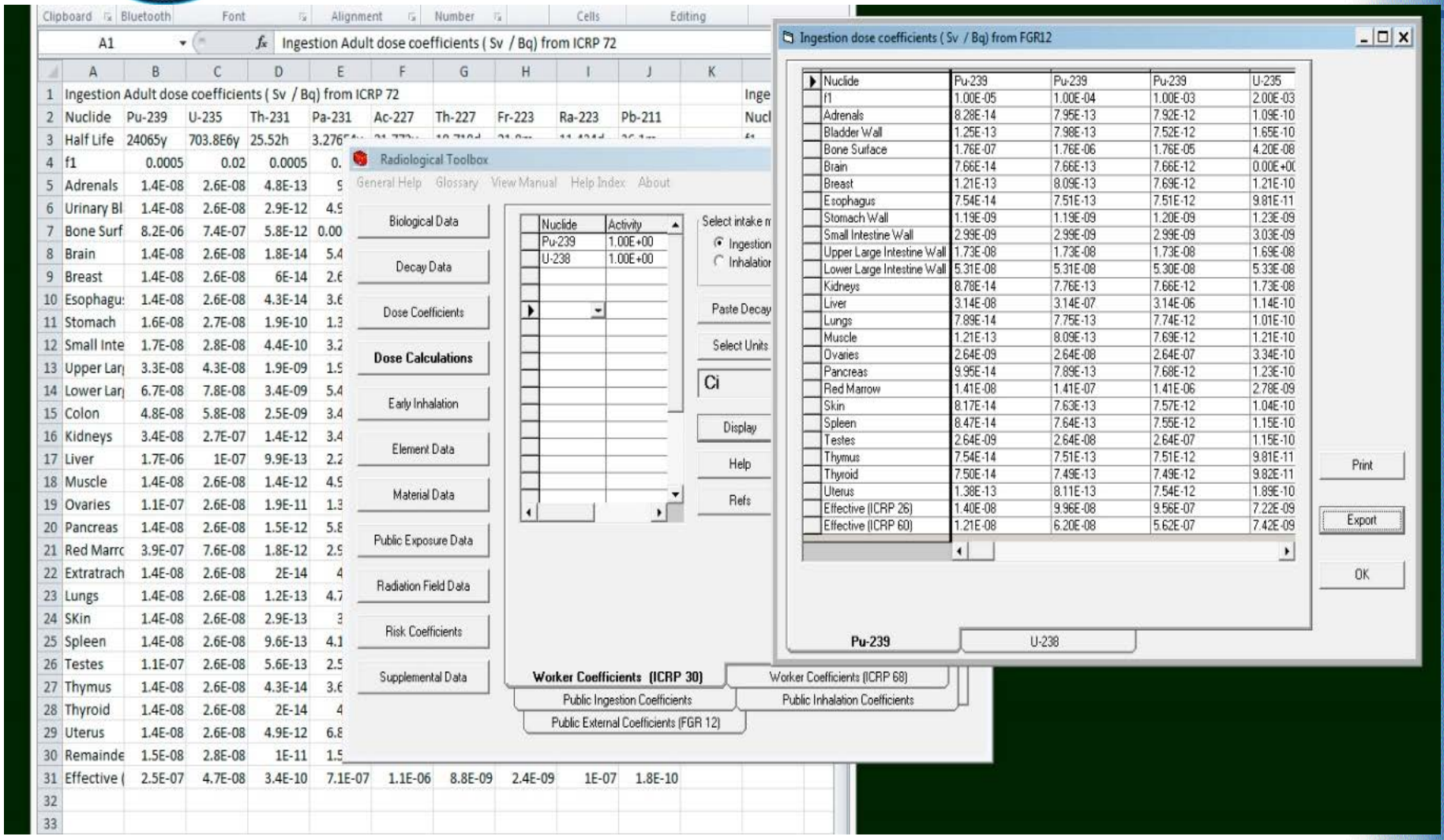
Nuclide	Pu-241	Am-241	U-237	Np-23
Half Life	14.4y	432.2y	6.75d	2.14E
f1	5.00E-04	5.00E-04	2.00E-02	5.00E
Adrenals	3.00E-10	1.50E-08	1.00E-11	7.20E
Urinary Bladder	3.00E-10	1.50E-08	6.50E-11	7.10E
Bone Surface	1.60E-07	9.00E-06	1.00E-10	5.40E
Brain	3.00E-10	1.50E-08	9.40E-13	7.20E
Breast	3.00E-10	1.50E-08	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
Extratrachial 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

(3) Pu-241

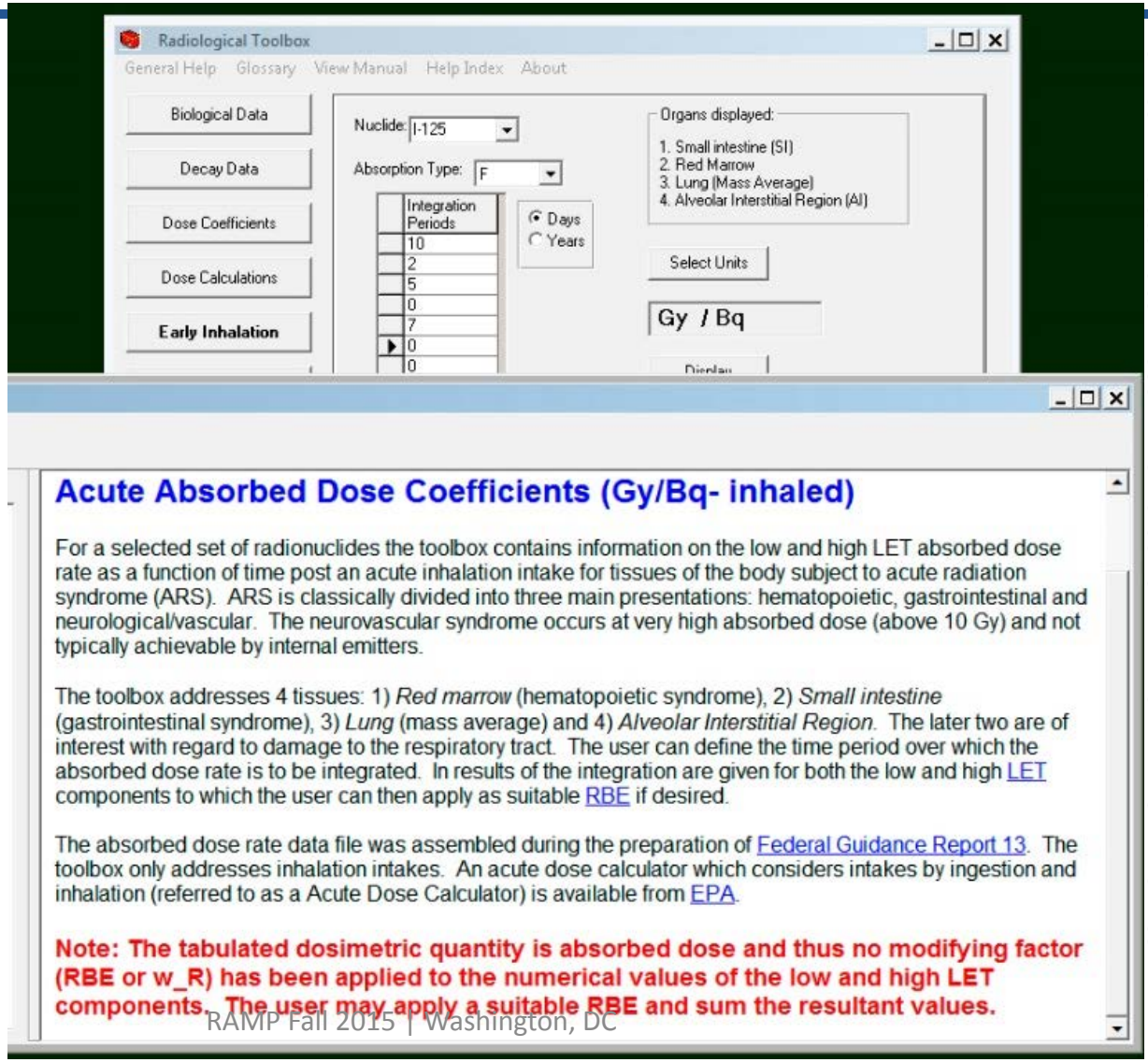


	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Ingestion Adult dose coefficients (Sv / Bq) from ICRP 72												
2	Nuclide	Pu-241	Am-241	U-237	Np-237	Pa-233	U-233	Th-229	Ra-225	Ac-225	Bi-213	Pb-209	
3	Half Life	14.4y	432.2y	6.75d	2.14E6y	27.0d	1.585E5y	7340y	14.8d	10.0d	45.65m	3.253h	
4	f1	0.0005	0.0005	0.02	0.0005	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 Marrc	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													

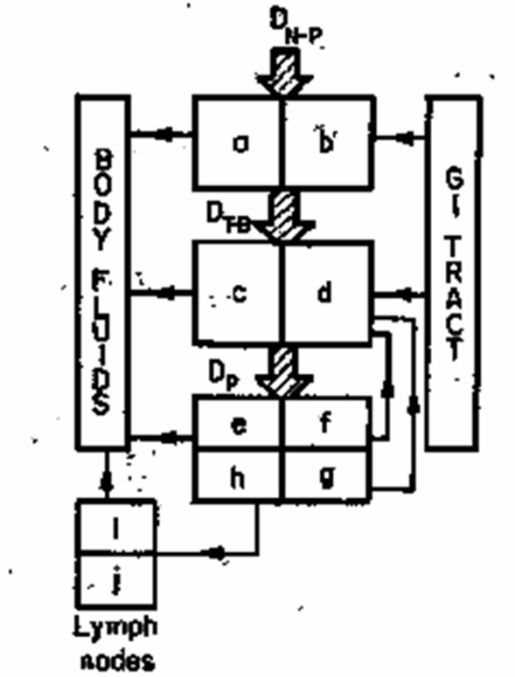
(4) Dose Calculations

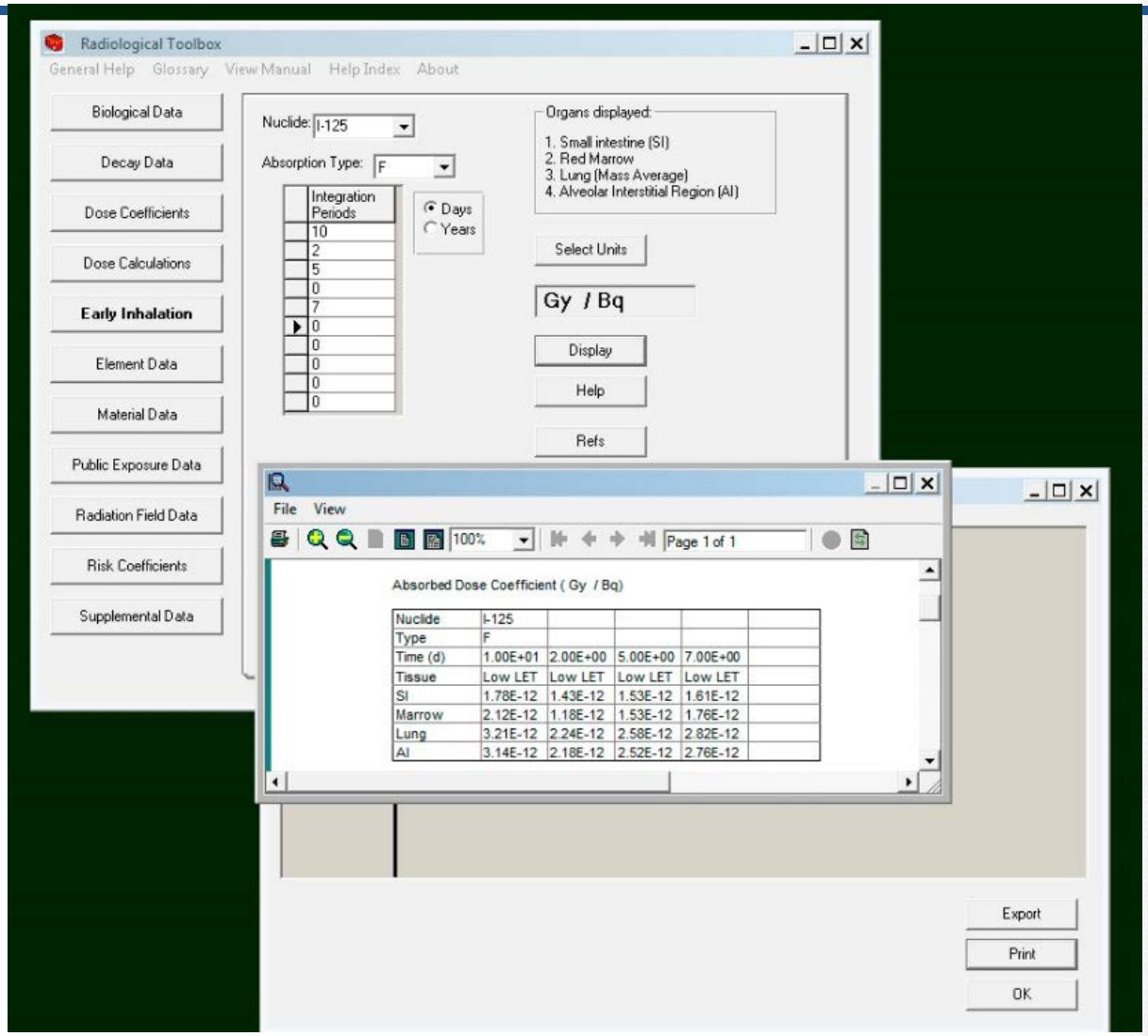


(5) Early Inhalation



(5) I-125


D_{N-P}
a
b
BODY FLUIDS
GI TRACT
D_{FB}
c
d
D_P
e
f
h
g
l
i
Lymph nodes


Radiological Toolbox
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About
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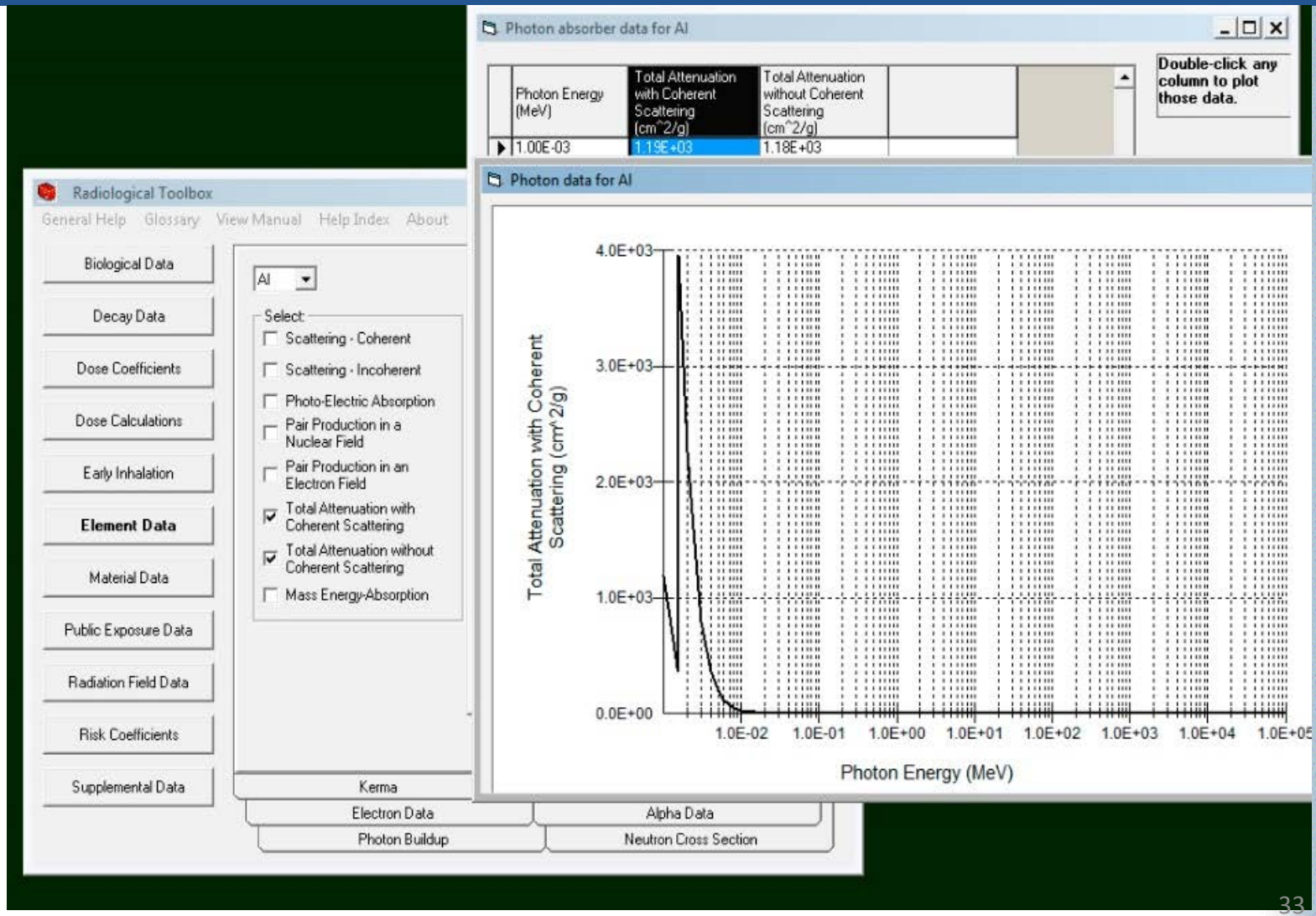
Dose Calculations
Early Inhalation
Element Data
Material Data
Public Exposure Data
Radiation Field Data
Risk Coefficients
Supplemental Data
Nuclide: I-125
Absorption Type: F
Integration Periods
10
2
5
0
7
0
0
0
0
Days
Years
Organs displayed:
1. Small intestine (SI)
2. Red Marrow
3. Lung (Mass Average)
4. Alveolar Interstitial Region (AI)
Select Units
Gy / Bq
Display
Help
Refs
File
View
100%
Page 1 of 1
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

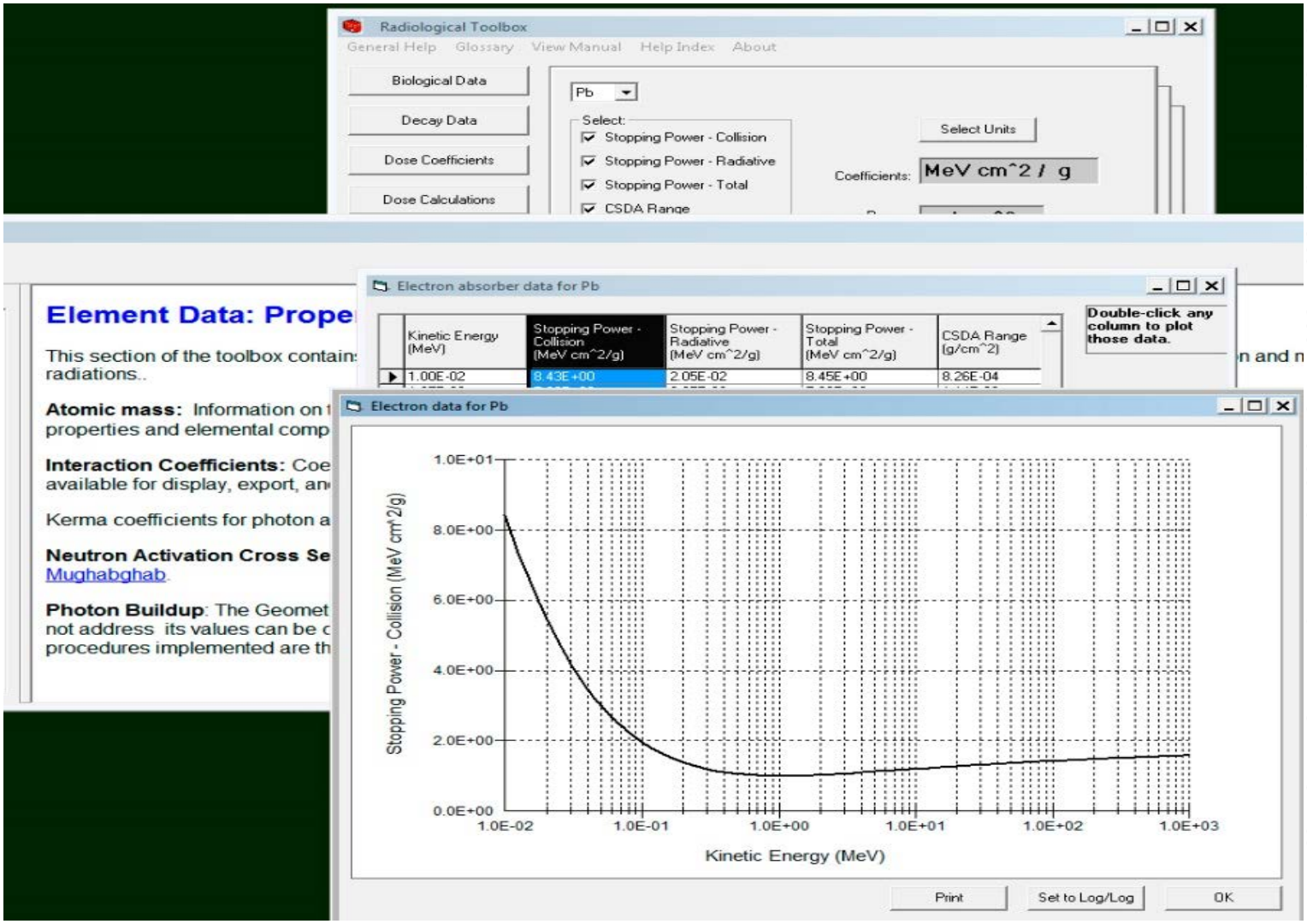
(6) Element Data (Al)



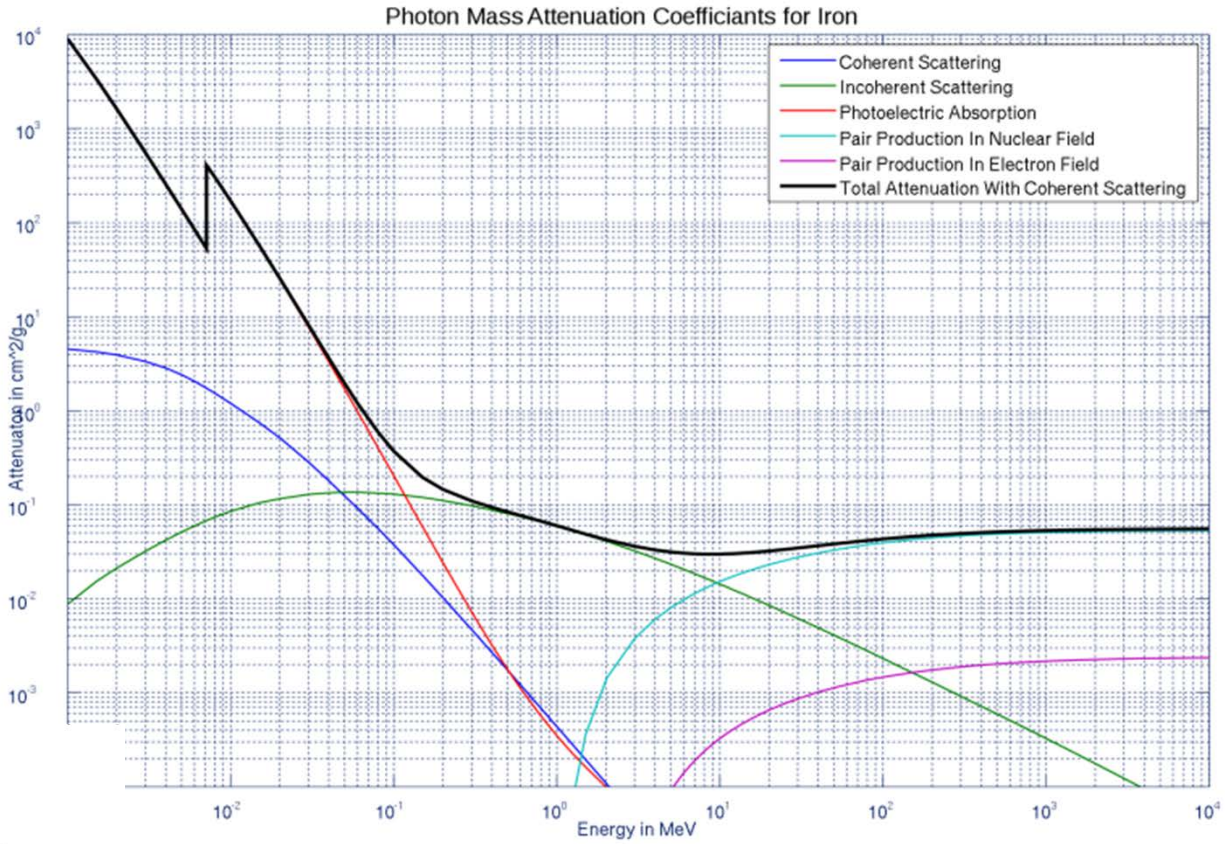
Element Data
(Credit from ORNL)

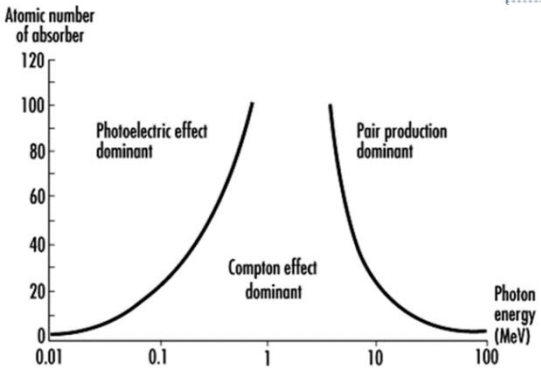
- Interaction coefficients for alpha, electron, photon, and neutron radiations in elemental absorbers.
  - Not available for every element or for each radiation type
  - Can be plotted
- Geometric progression form of the photon buildup factors from ANSI Standard 6.4
  - 0.015 and 15 MeV at distances 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)

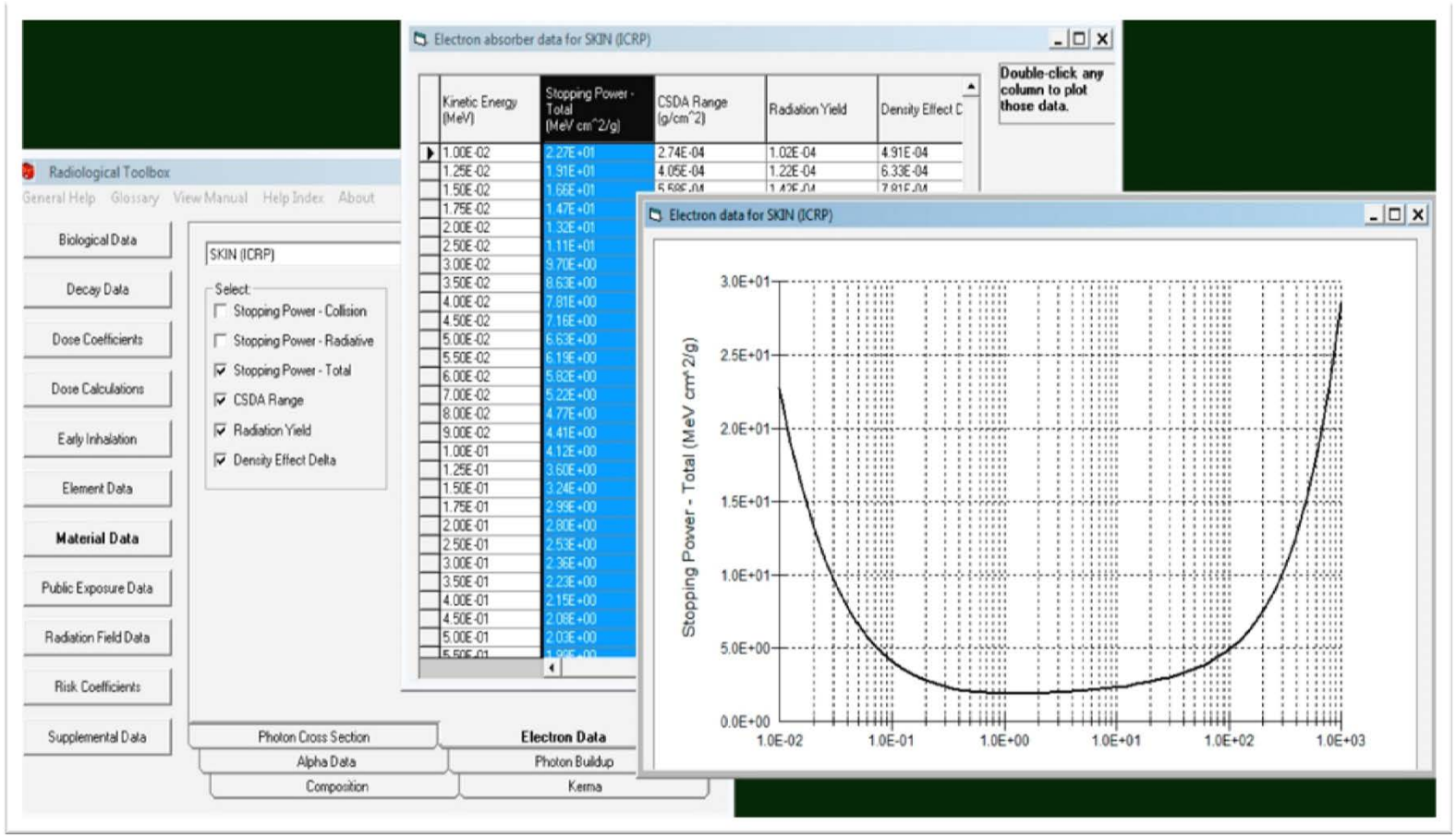


(6) Element Data (Fe)

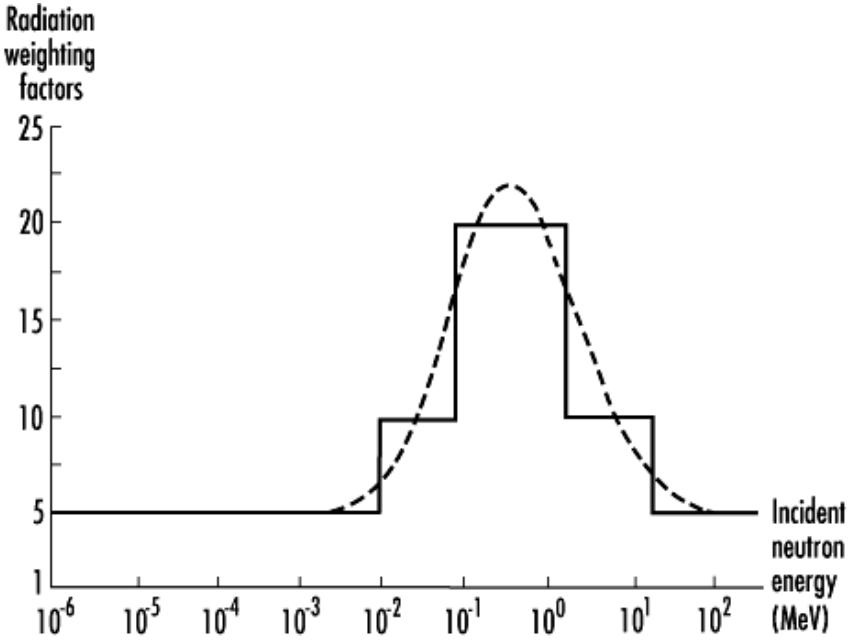




(7) Material Data (Skin)

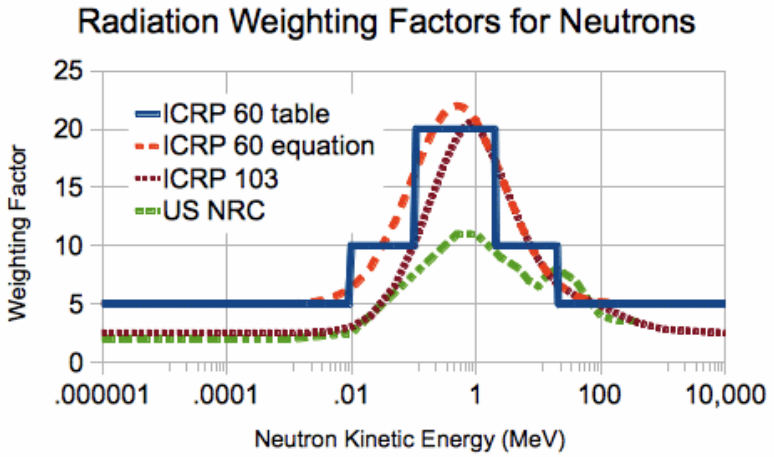


(7) Neutron "w_R"

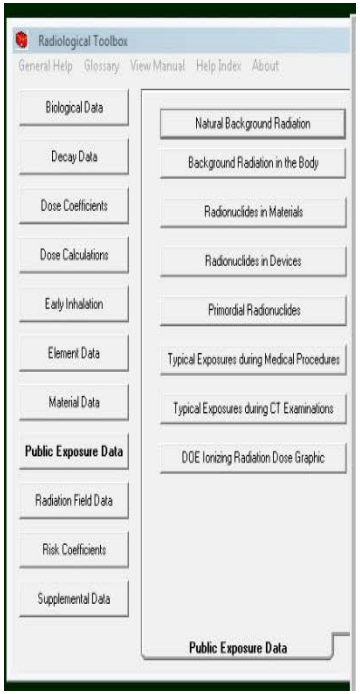


ICRP 60 Radiation Weighting Factors	
Radiation type and energy	**Weighting Factor w_R**
Photons, all energies	1
Electrons, all energies	1
Neutrons, energy < 10 keV	5
10 - 100 keV	10
100 - 2000 keV	20
2 - 20 MeV	10
> 20 MeV	5
Protons, energy > 2 MeV	5
Alpha, fission fragments	20

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



(8) Public Exposure Data



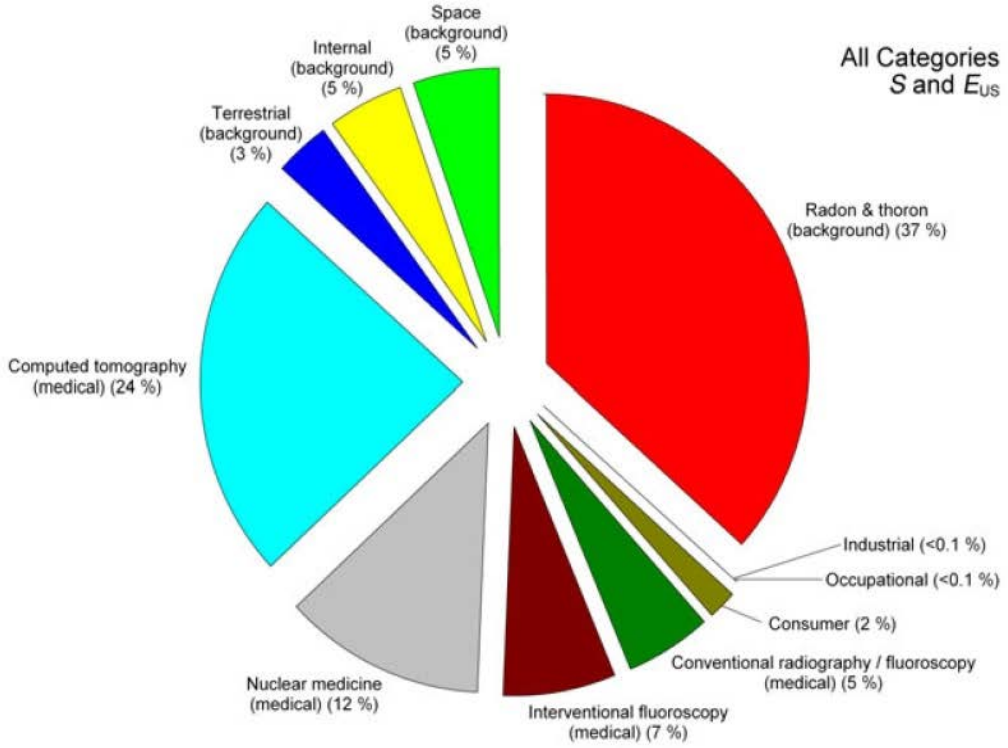
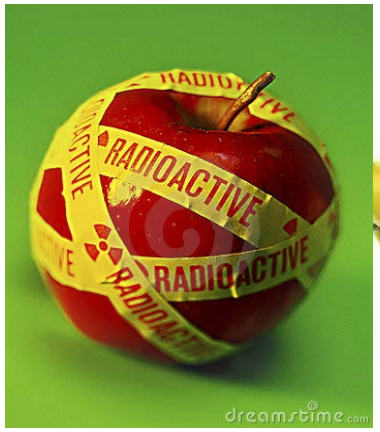


Fig. 1.1. Percent contribution of various sources of exposure to the total collective effective dose (1,870,000 person-Sv) and the total effective dose per individual in the U.S. population (6.2 mSv) for 2006. Percent values have been rounded to the nearest 1 %, except for those <1 % [see Table 1.1 for 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)**
Barna	3520	1
Brazil nuts	5600	1000-7000
Carrots	3400	0.6 - 2
Potatoes	3400	1 - 2.5
Beer	390	-
Redmeat	3000	0.5
Lima beans	4640	2 -5
Drinking water	-	0 - 0.17

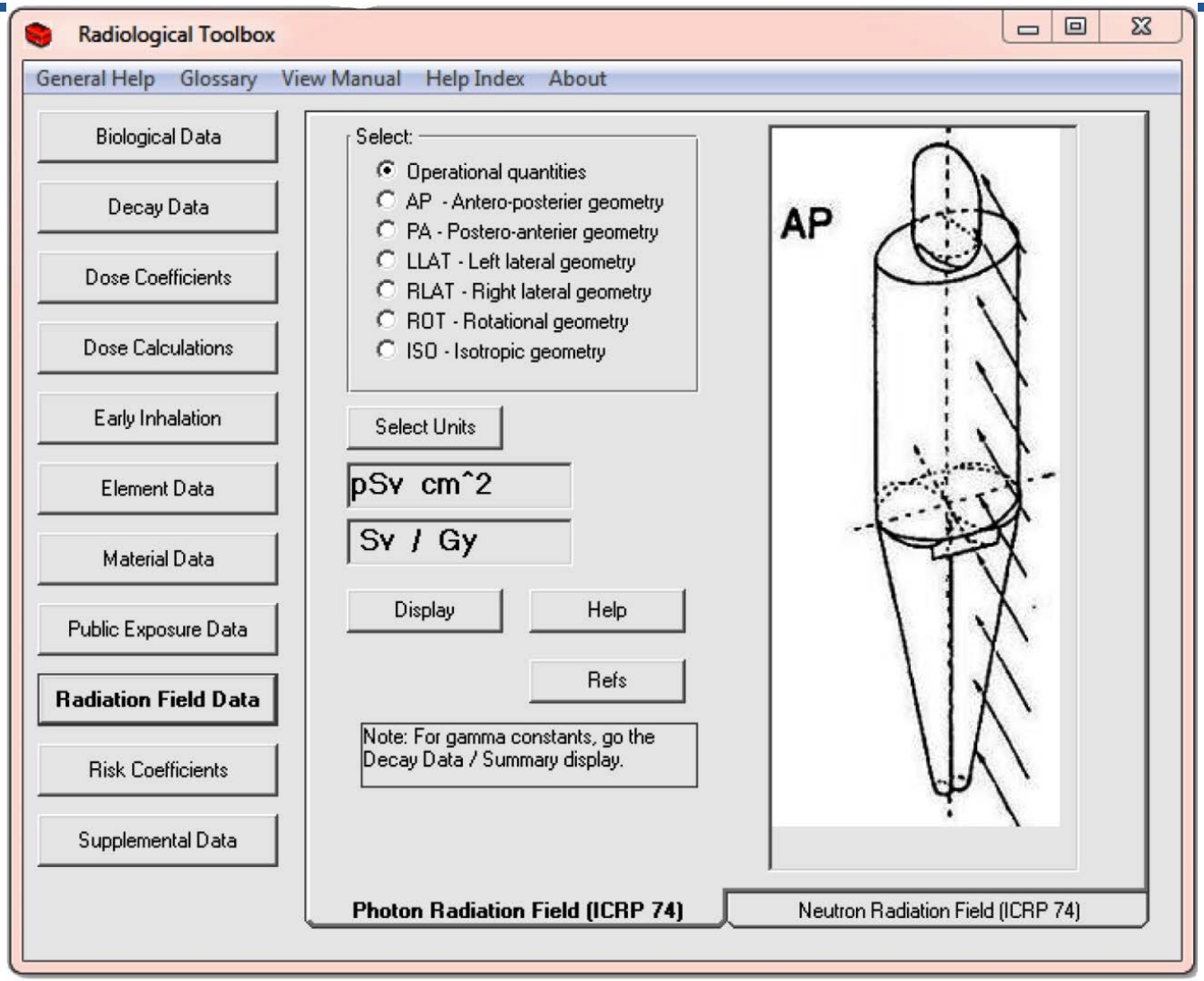
(8) Medical Exposures

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

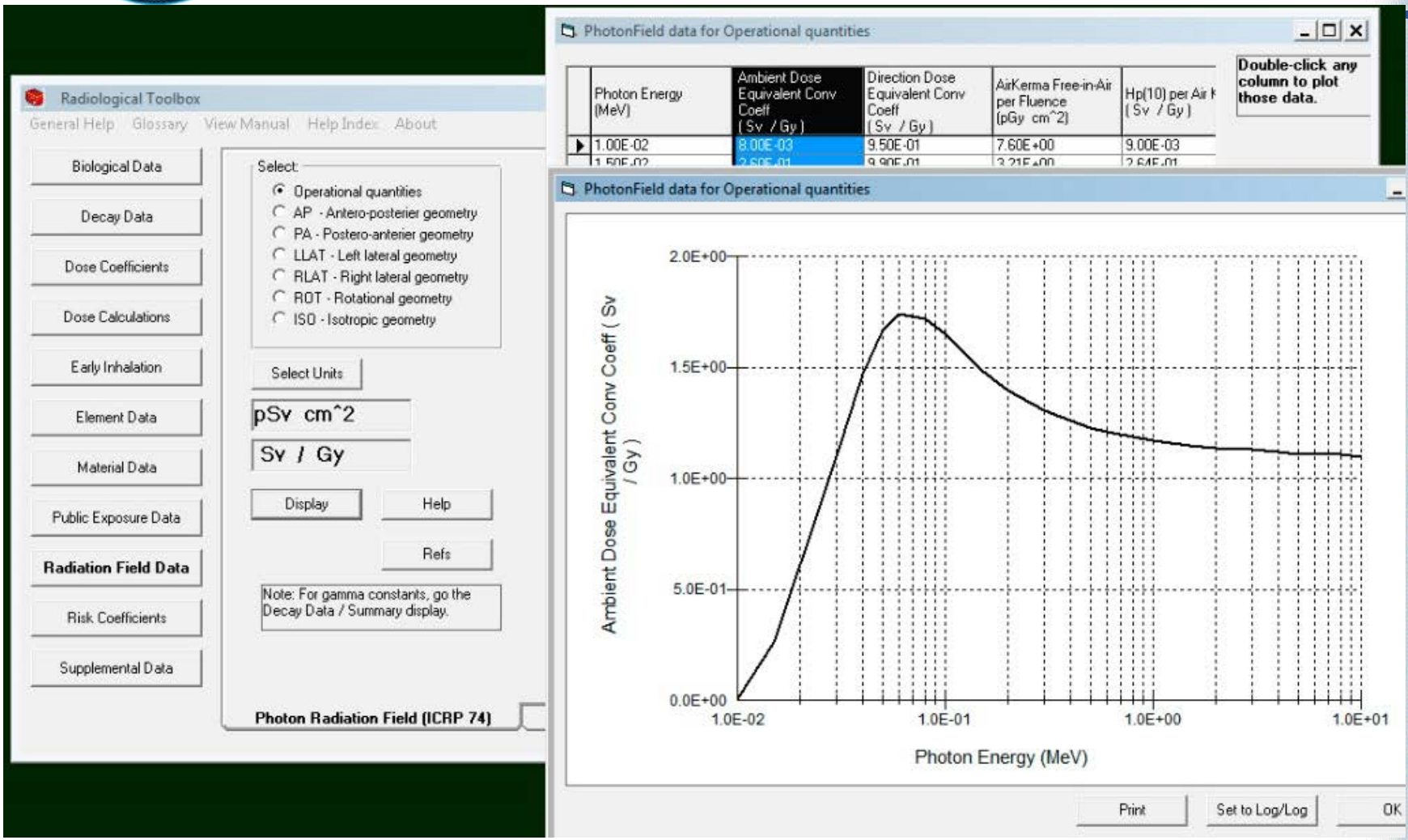
Computed tomography examinations

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

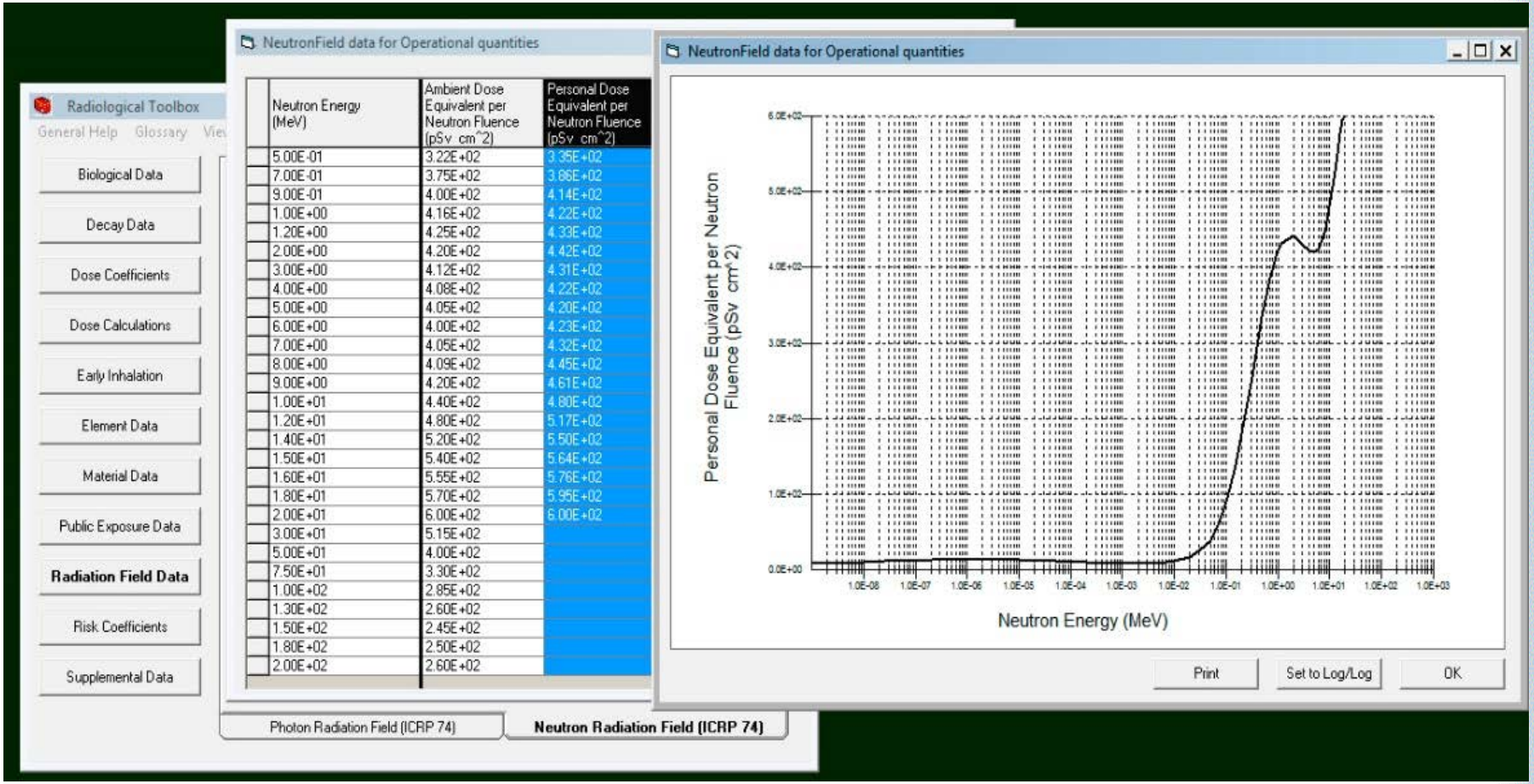
(9) Radiation Field Data



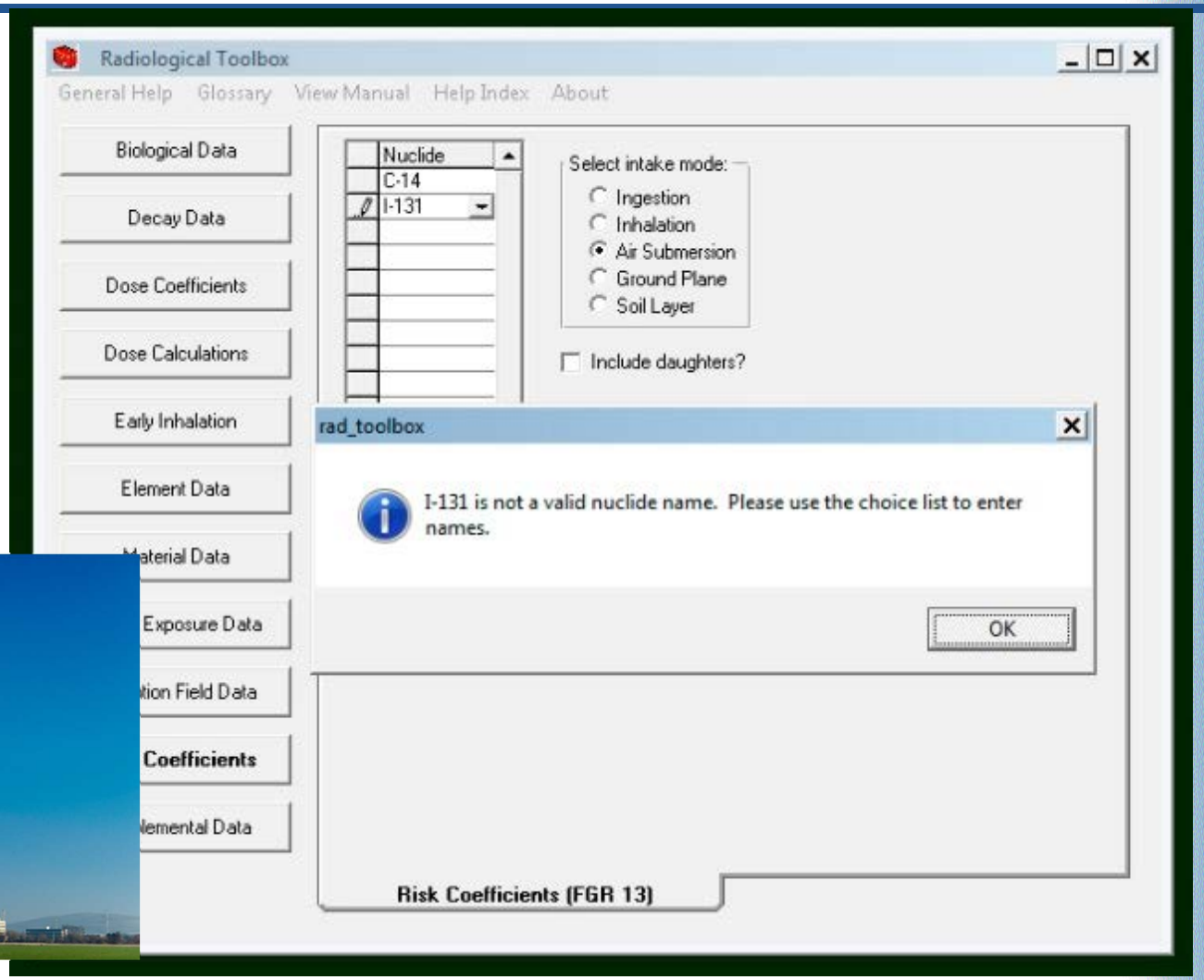
(9) Operational (γ)



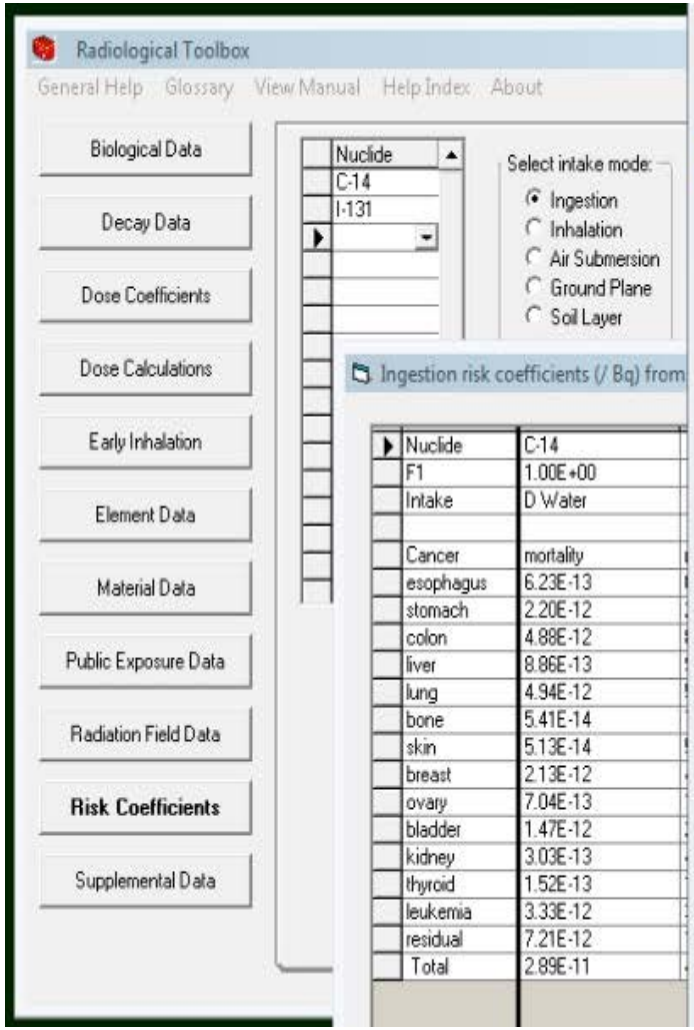
(9) Operational (n)



(10) Risk Coefficients



(10) C-14 and I-131



Workbook Views | Zoom | Window

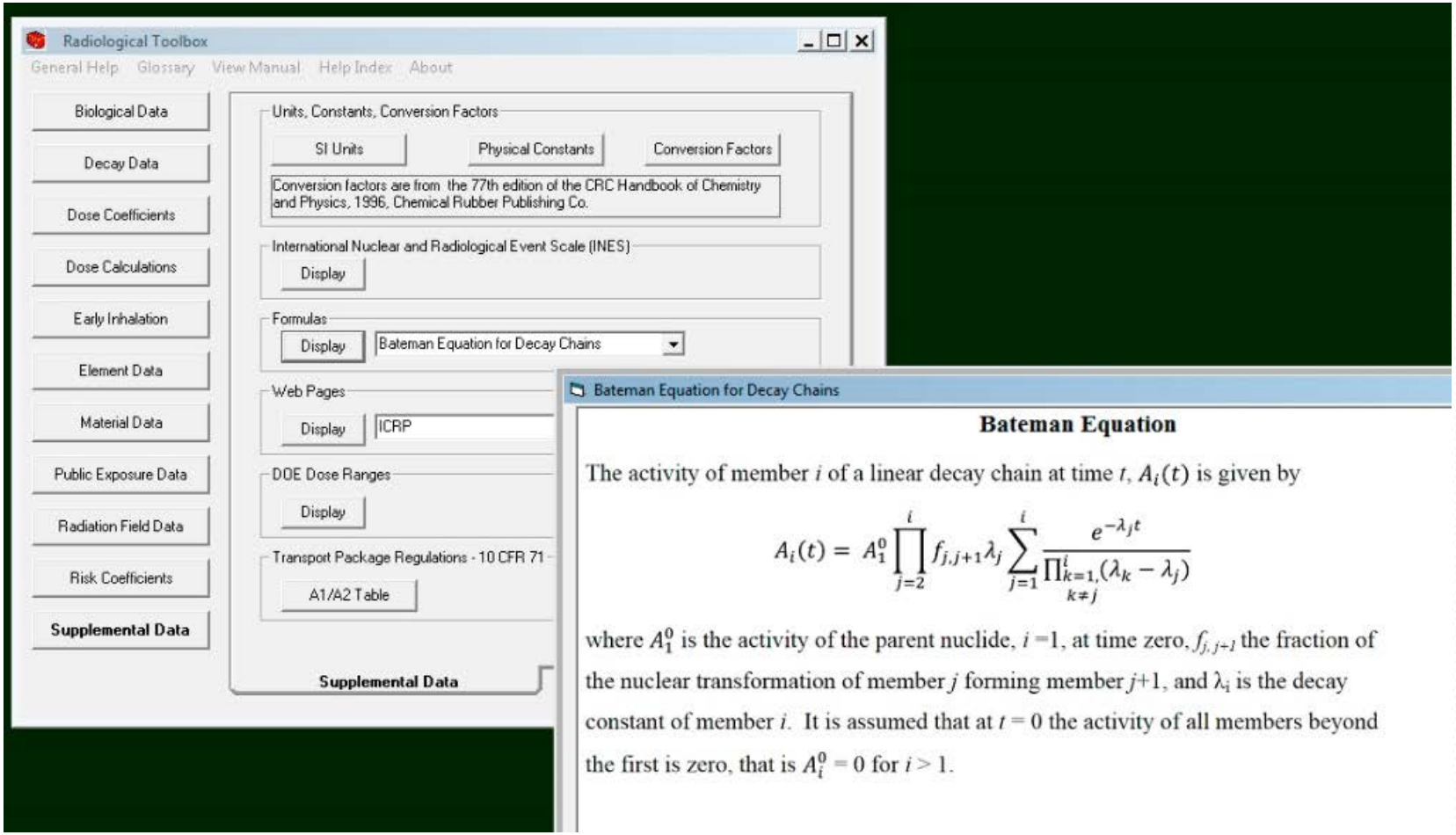
A1 — Ingestion risk coefficients (/ Bq) from FGR 13

	A	B	C	D	E	F	G	H	I	J
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										

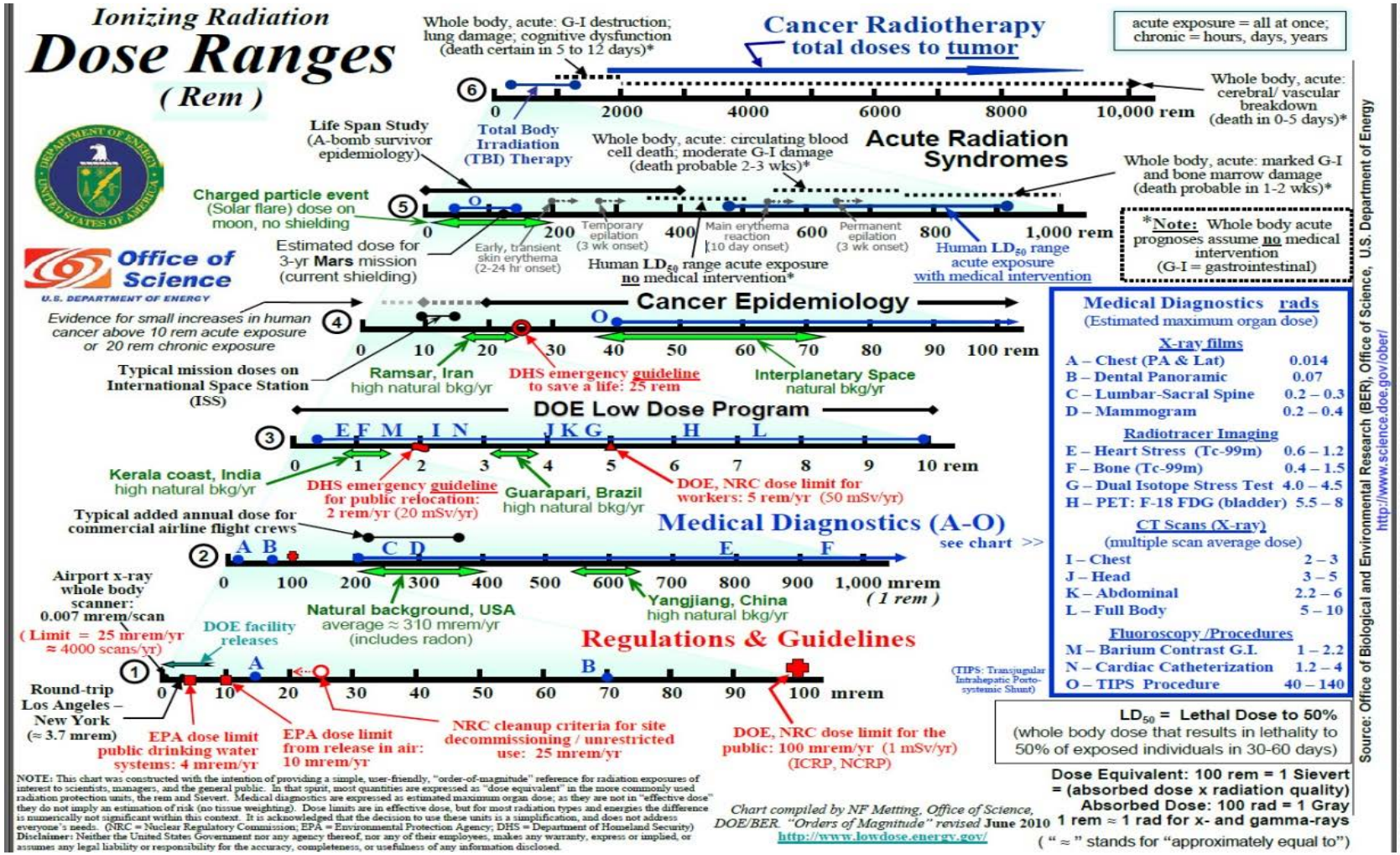
Risk Coefficients (Credit from ORNL)

- 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

(11) Supplemental Data



(11) Supplemental Data

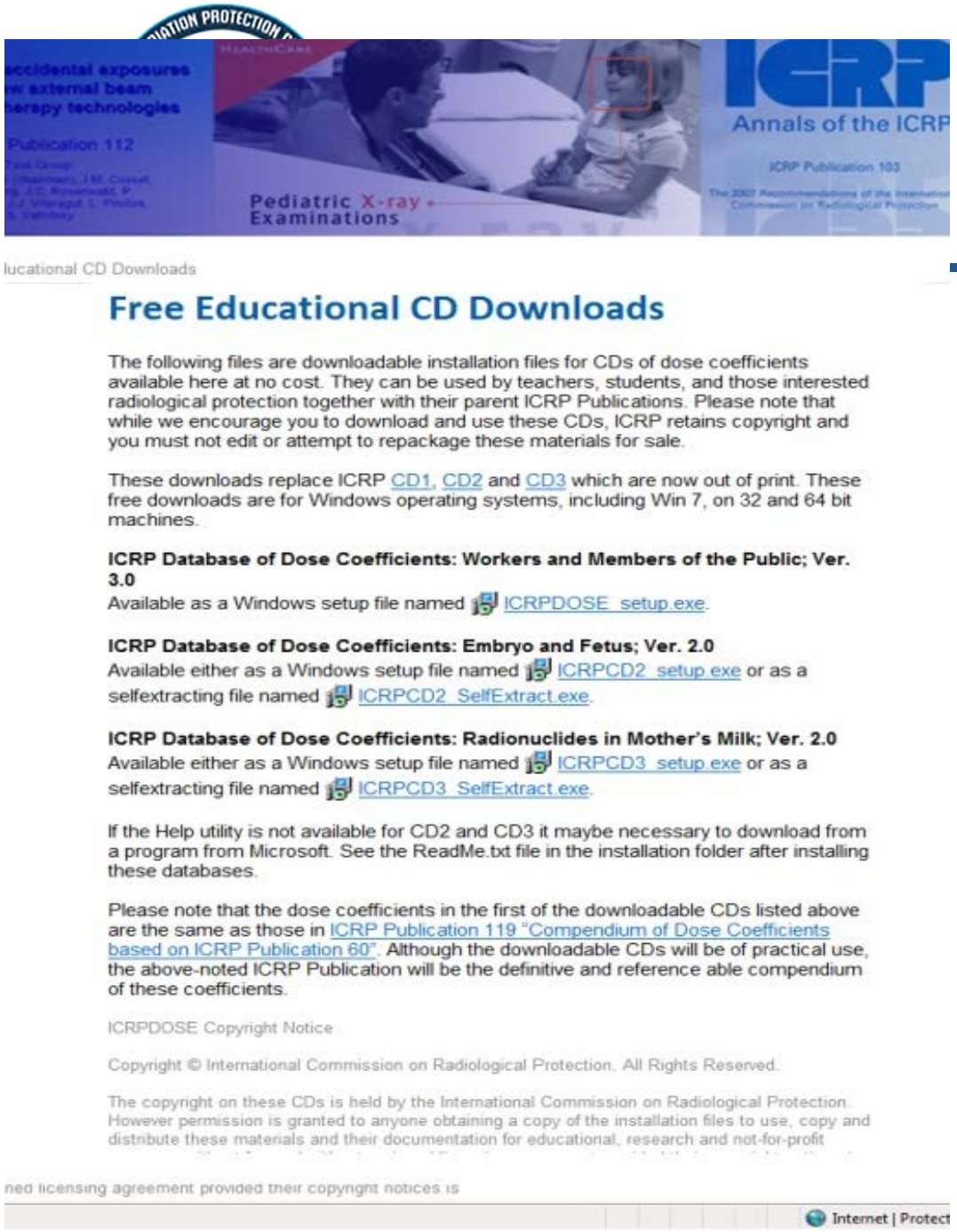


Other Data
(Credit from ORNL)

- **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

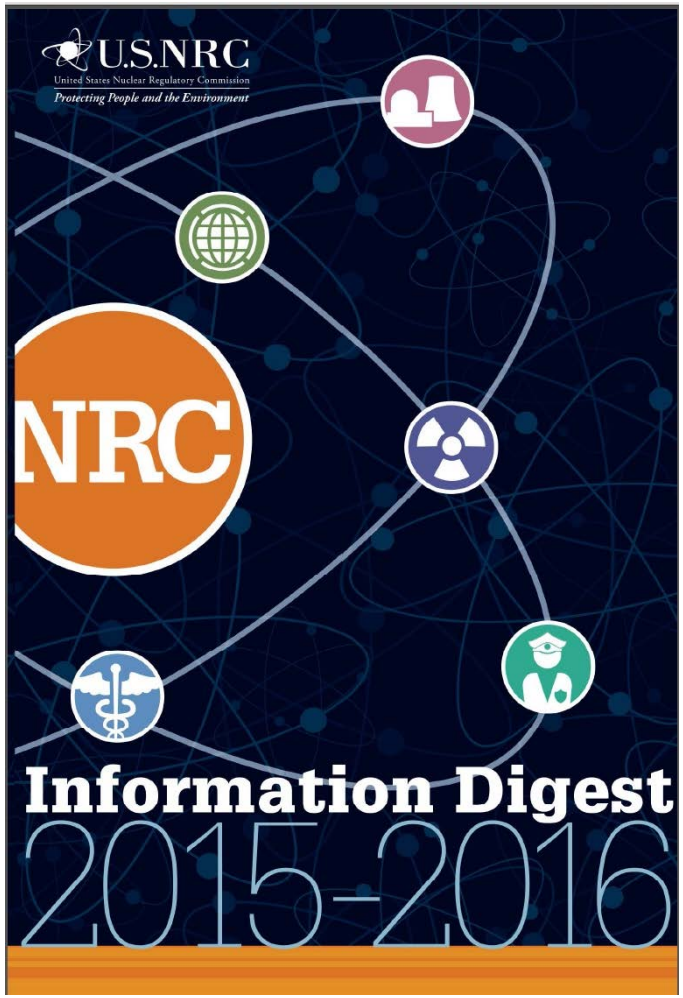


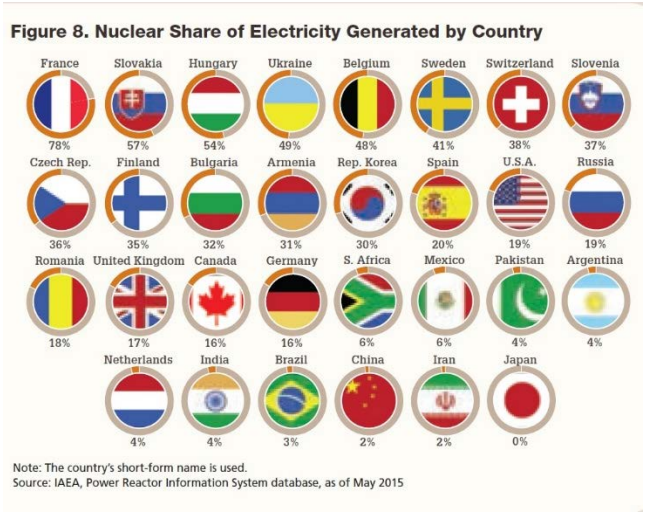
Freebie:

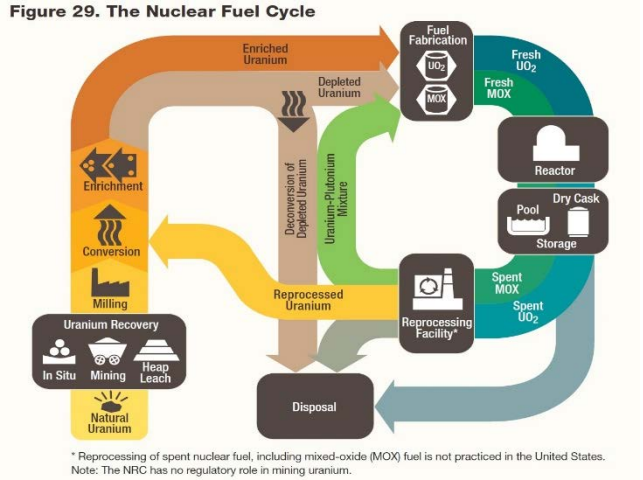
In footnote of Page 9:
"The numbers of nuclides differ between FGR 12 and **ICRP Publications 30, 68, and 72** as the latter set of publications do not consider the intake of radionuclides of **half-life less than 10 minutes.** The ICRP Database of Dose Coefficients: Workers and Members of the Public;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

Freebie:

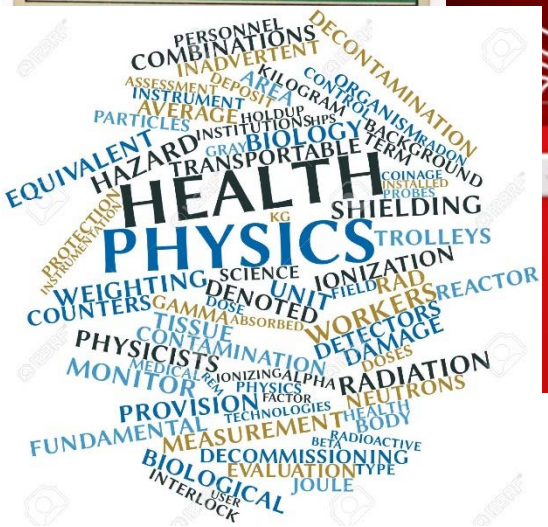
NUREG-1350: ML15254A321.pdf

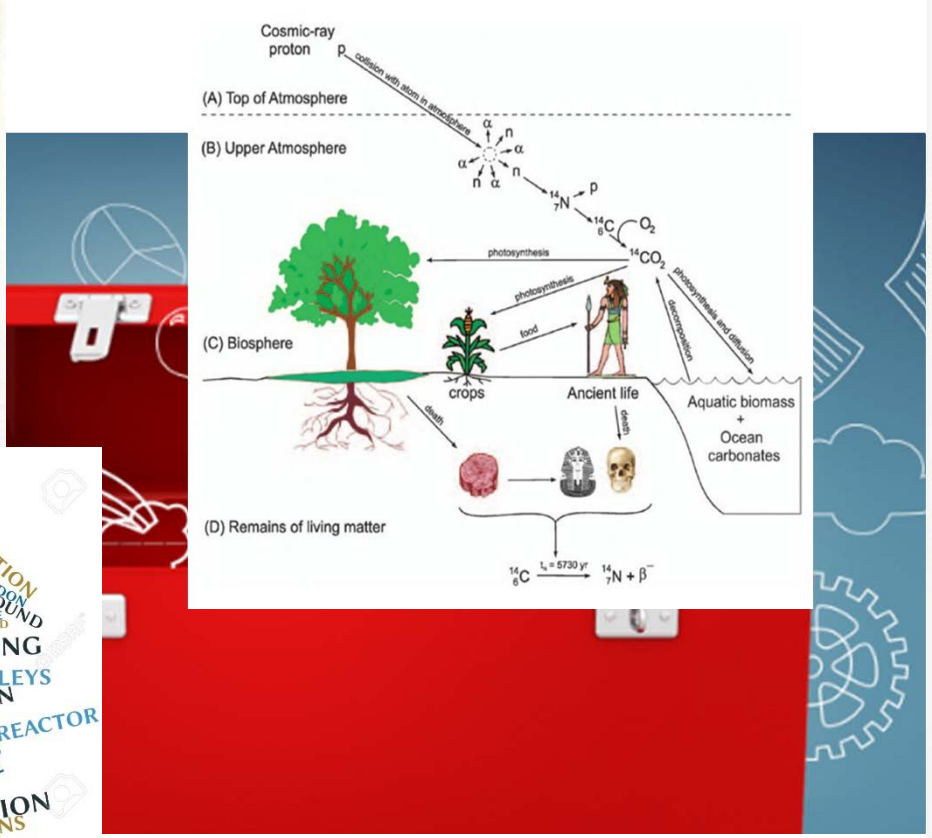






More Database?





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

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