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Radiological Toolbox

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

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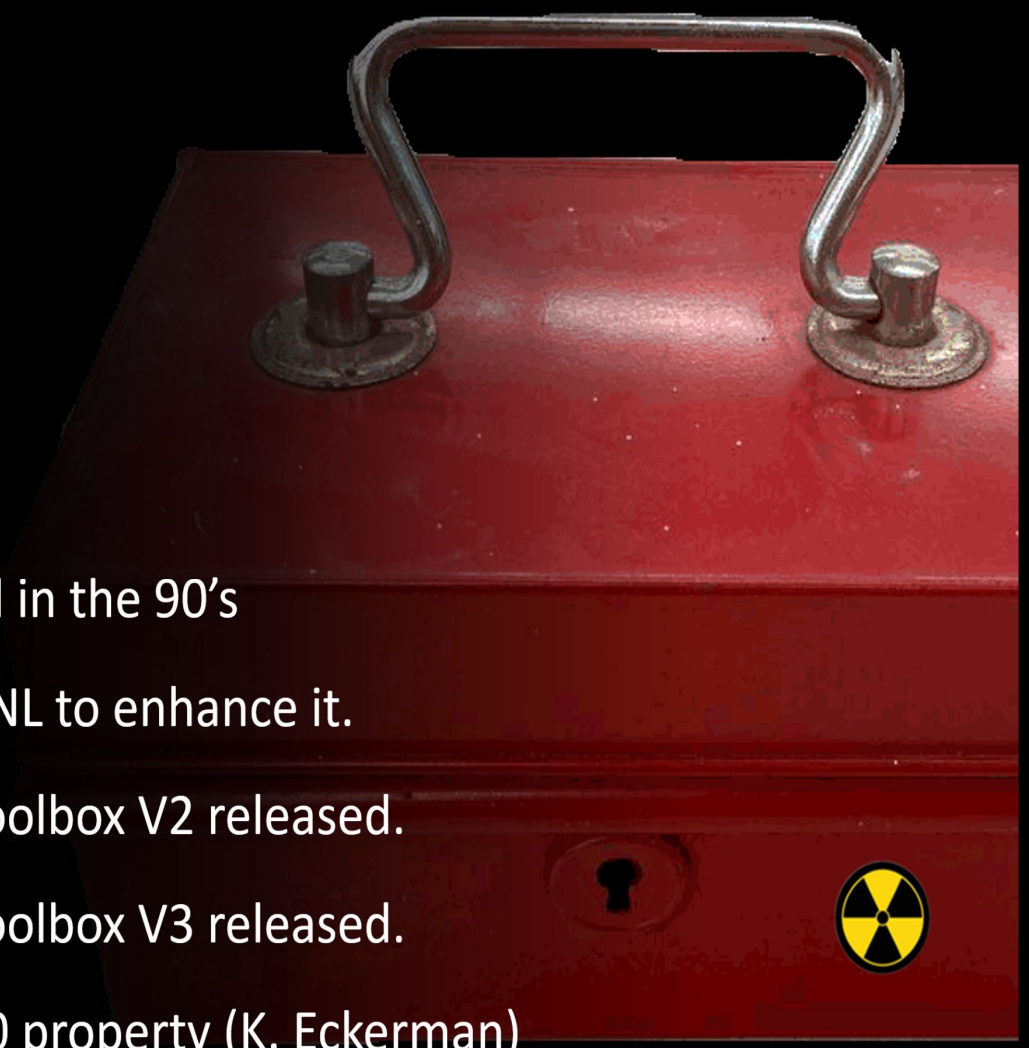
Fall 2020 USERS GROUP Virtual Meeting

Timelines



- “Rad-Toolbox” existed in the 90’s
- 2003 – NRC funds ORNL to enhance it.
- 2007 – Radiological Toolbox V2 released.
- 2013 – Radiological Toolbox V3 released.
- 2019 – Update Pu-240 property (K. Eckerman)

What's in the code?

- **Rad-Toolbox V3.0 (April 2013)**
  - Windows 7 & 10
  - TRM ready for NRC workstations
  - Code has 27 MB in one file.
- **User's Manual (May 2013)**
  - K.F. Eckerman and A.L. Sjoreen
  - In color and PDF searchable
  - References are up to date
  - Built-in under "View-Manual" tab

Something You Should Know about NUREG/CR-7166

- Abstract and acknowledgement
- Ch.3. How to access Rad-Toolbox features
- User's Guide, PDF: Can be highlighted or add your notes …
- 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 10.
- The software can be removed by clicking on the unins000.exe that resides in the Toolbox folder

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Must Know the Basic!

$$A = \lambda N$$

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

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

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

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

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

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

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

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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

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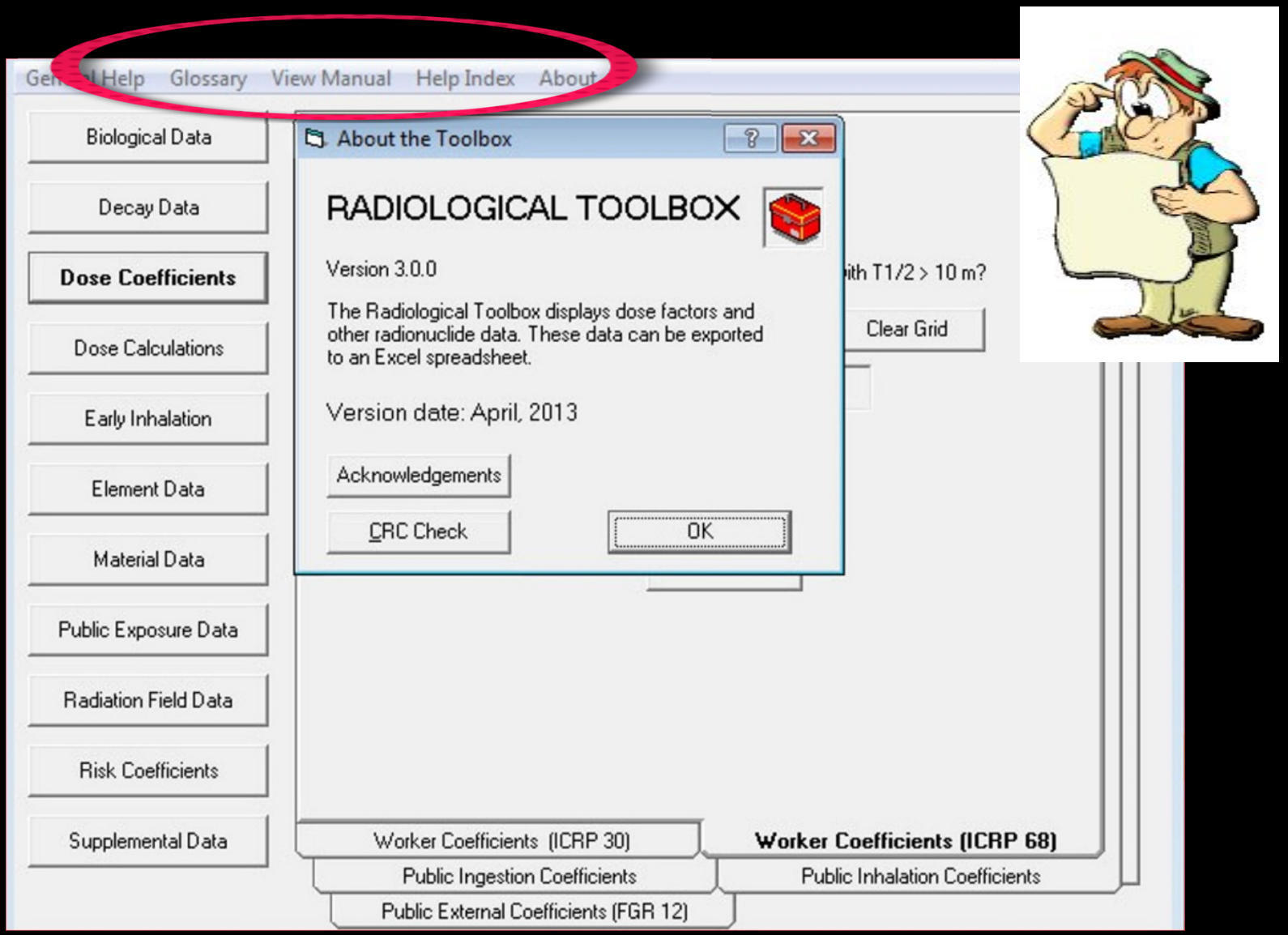
ABOUT: Menu-Bar



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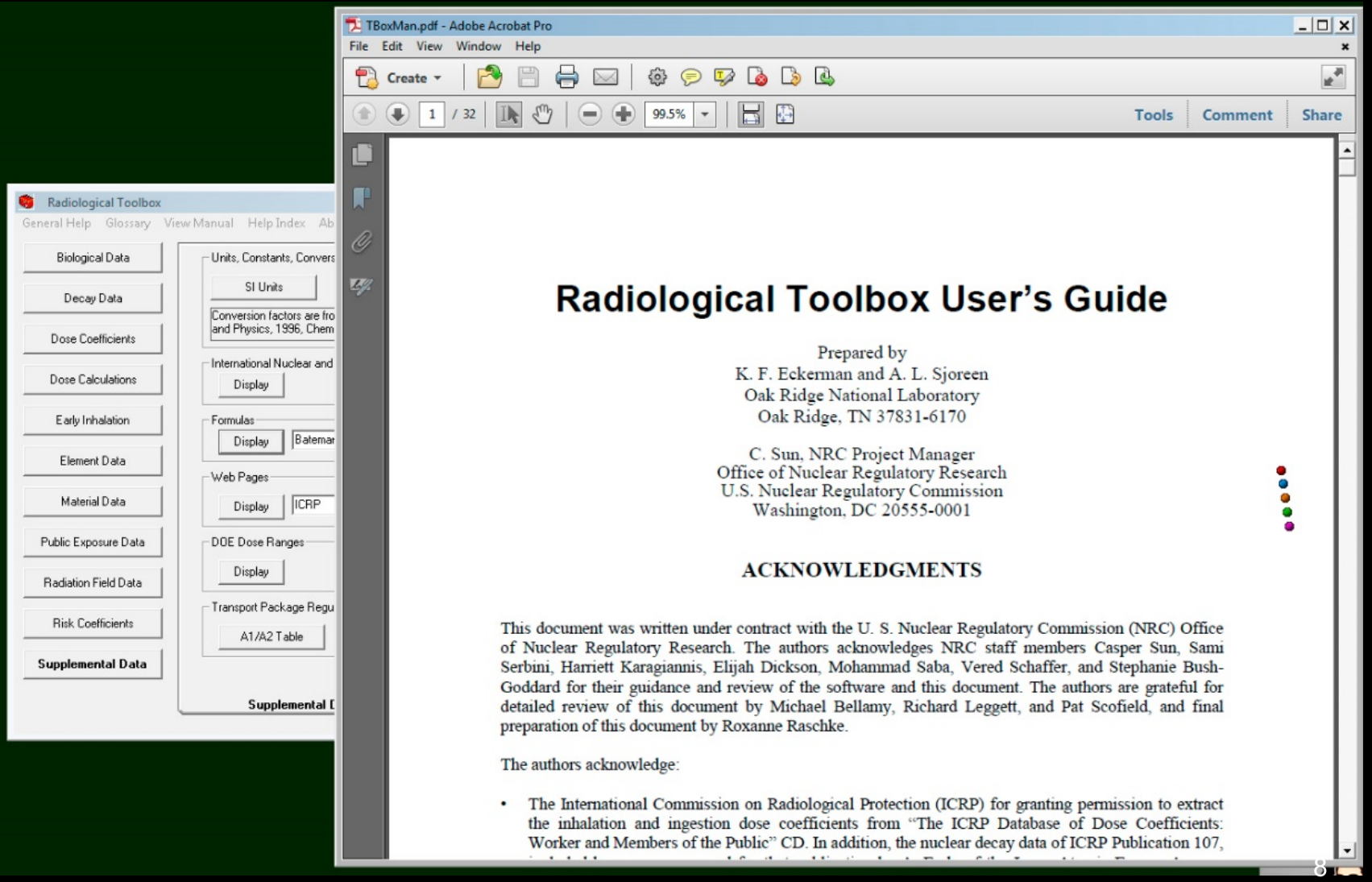
Menu Bar has …



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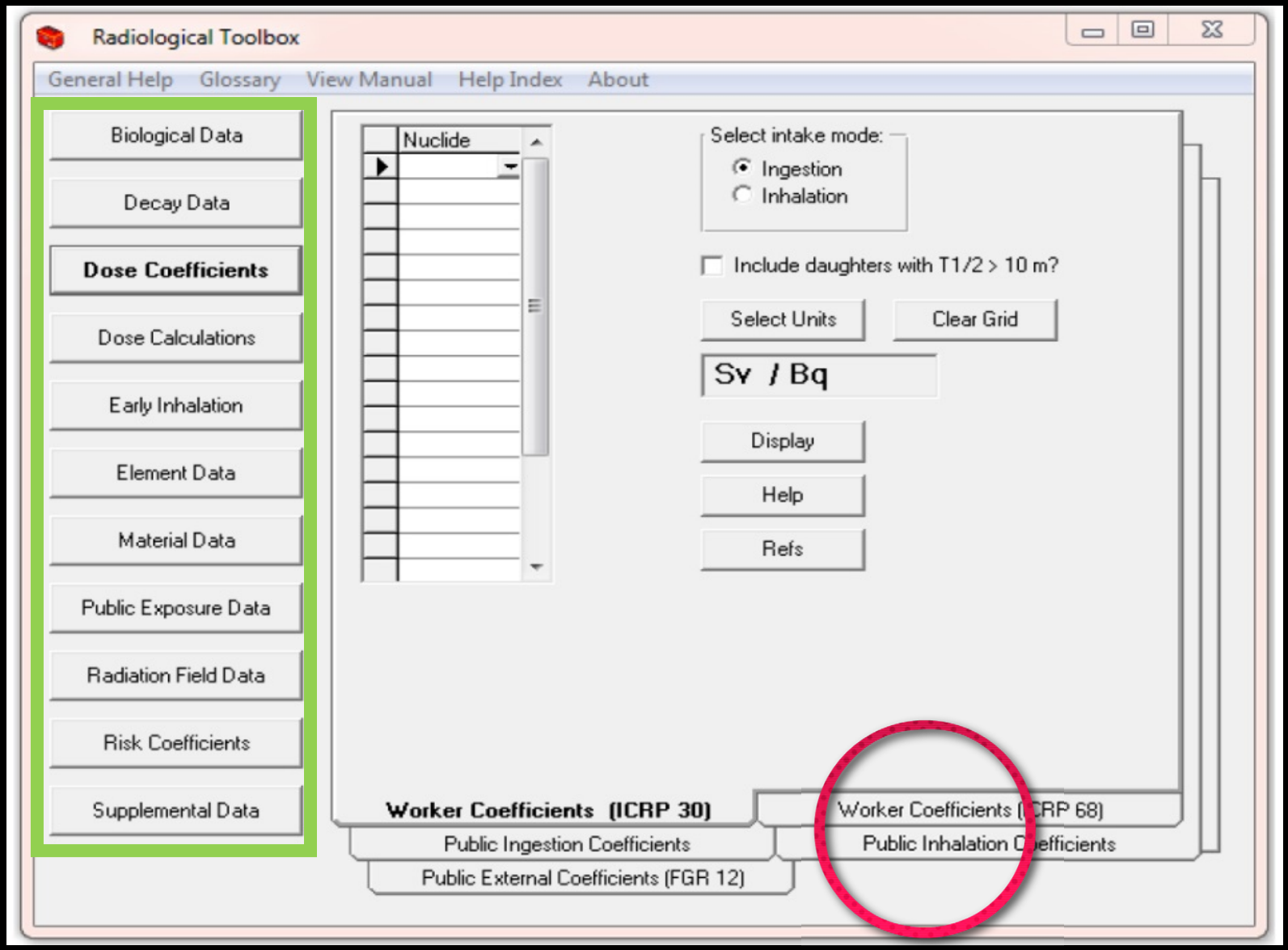
HOME-PAGE



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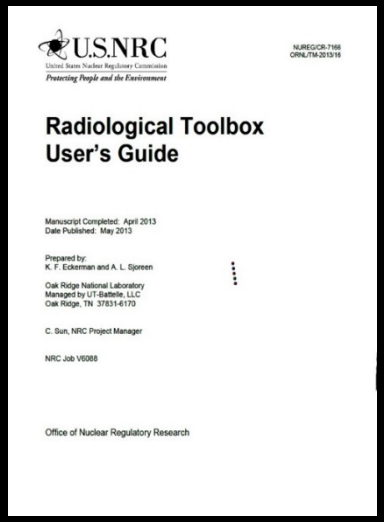
The 11 Databases (db)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NUREG/CR-7166
ORNL/TM-2013/16

Radiological Toolbox User's Guide

Manuscript Completed: April 2013
Date Published: May 2013

Prepared by:
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Oak Ridge National Laboratory
Managed by UT-Battelle, LLC
Oak Ridge, TN 37831-6170

C. Sun, NRC Project Manager

NRC Job V6088

Office of Nuclear Regulatory Research

#	db collection	db Description (Table 1.1 from NUREG/CR-7166)
1	Biological Data	Biokinetic models, reference anatomical data, bioassay data, and summary information on radiation health effects
2	Decay Data	Detailed information on the radiations emitted by radionuclides and members of serial decay chains
3	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
4	Dose Calculation	Calculation of dose for worker or member of the public exposed to a radionuclide mixture
5	Early Inhalation	Absorbed dose coefficient integrated over a user-specific time period following an inhalation intake
6	Element Data	Radiation interaction coefficients with elements for alpha, electron, photon, and neutron radiations
7	Material Data	Radiation interaction coefficients with materials for alpha, electron, photon, and neutron radiations
8	Public Exposure	Summary information on radiation exposures to natural background radiation and from medical exposure
9	Radiation Field	Organ doses for workers resulting from idealized photon and neutron radiation fields
10	Risk Coefficients	Nuclide-specific risk coefficients for public exposure
11	Supplemental	Collection of reference information ranging from SI units to numerical limits on the activity content of radionuclides in transport

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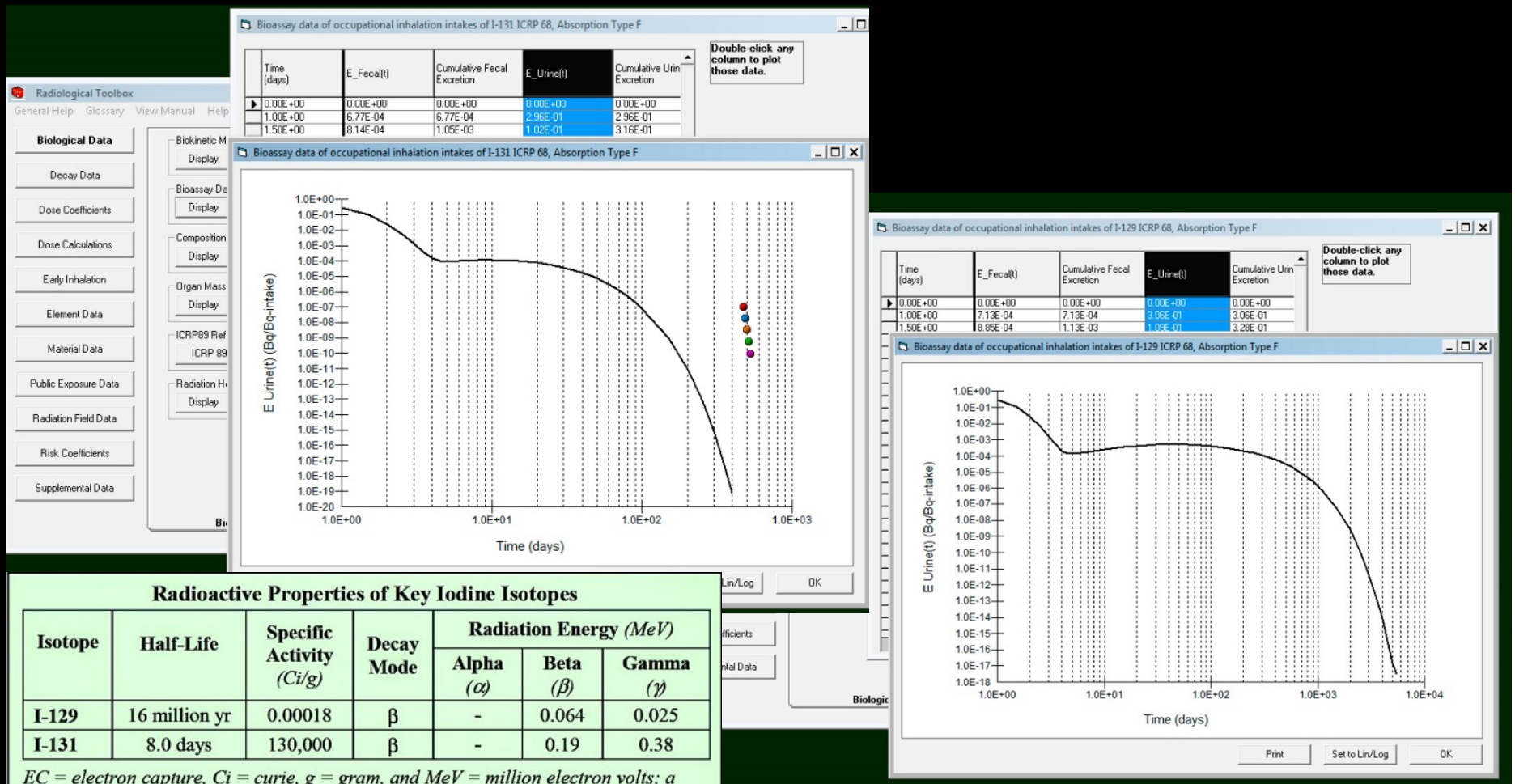
(db1) Biological Database: I-131 and I-129 Excretions



Radioactive Properties of Key Iodine Isotopes

Isotope	Half-Life	Specific Activity *(Ci/g)*	Decay Mode	Radiation Energy *(MeV)*		
				Alpha *(α)*	Beta *(β)*	Gamma *(γ)*
I-129	16 million yr	0.00018	β	-	0.064	0.025
I-131	8.0 days	130,000	β	-	0.19	0.38

EC = electron capture, Ci = curie, g = gram, and MeV = million electron volts; a dash means the entry is not applicable. (See the companion fact sheet on Radioactive Properties, Internal Distribution, and Risk Coefficients for an explanation of terms and interpretation of radiation energies.) Values are given to two significant figures.

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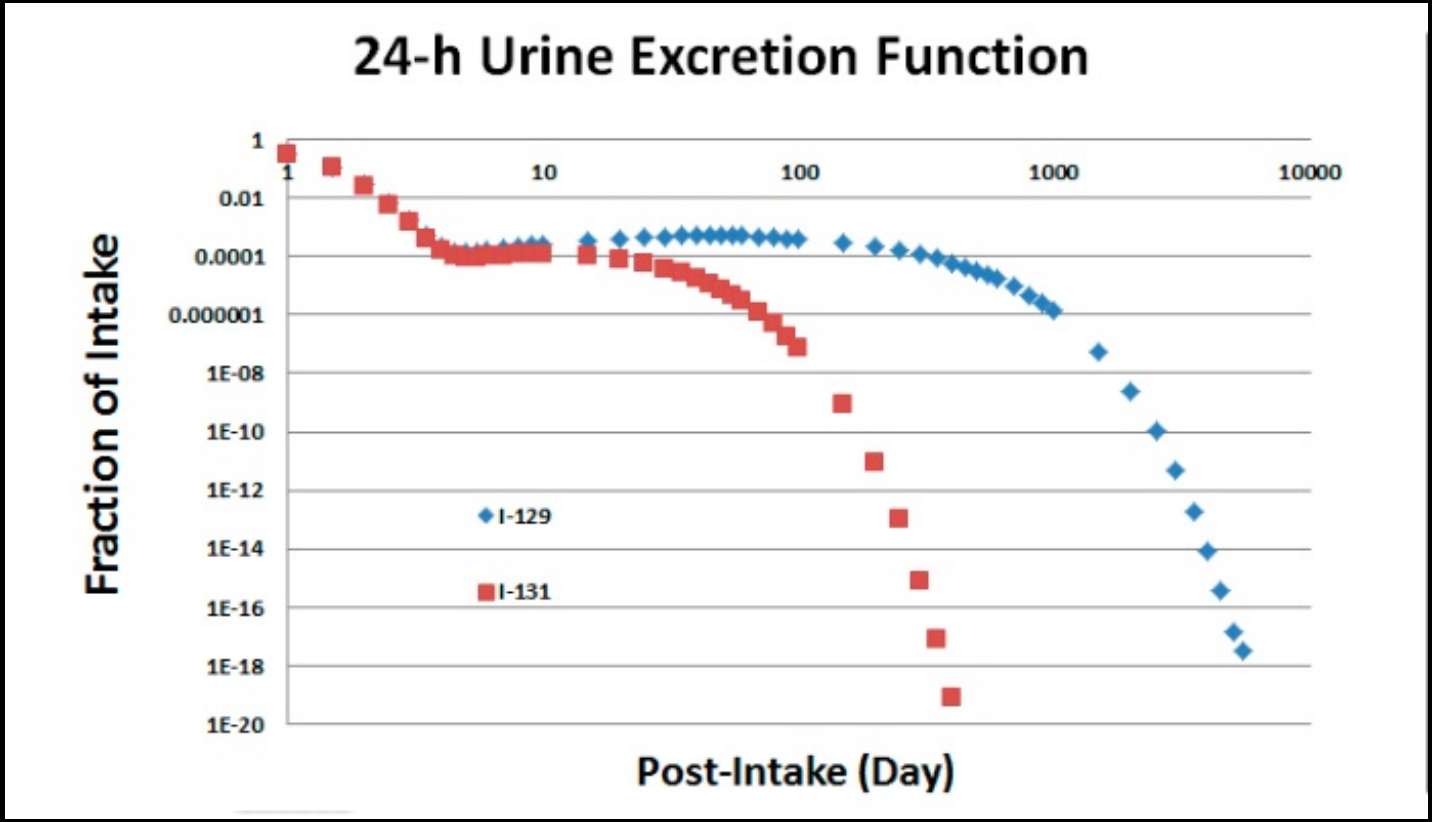
Excel plot of Toolbox exported data for "Urine Bioassay Interpretations"



“Positive” Bioassay!

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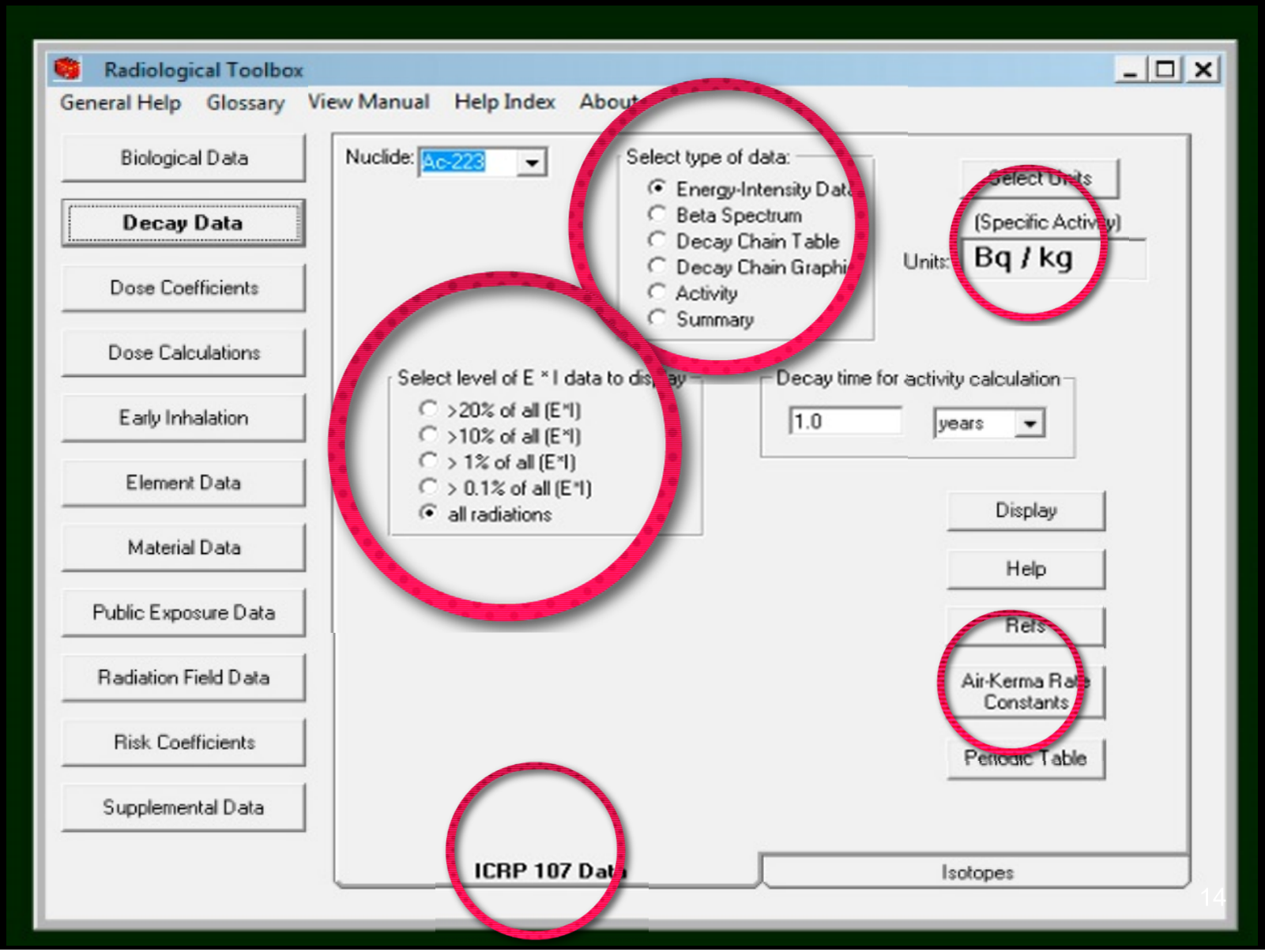
(db2) Decay Database



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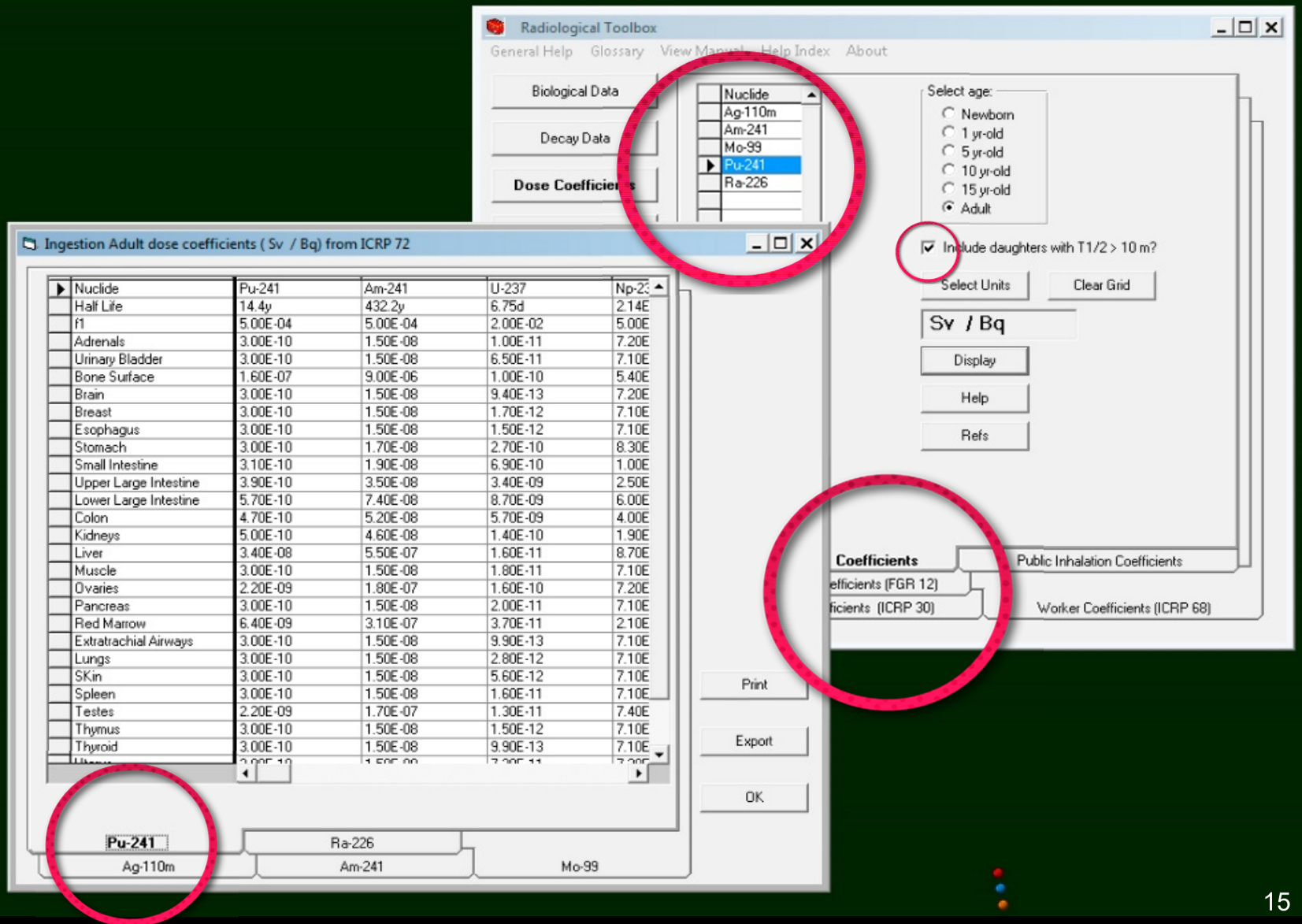
(db3) DC for Pu-241 (a)



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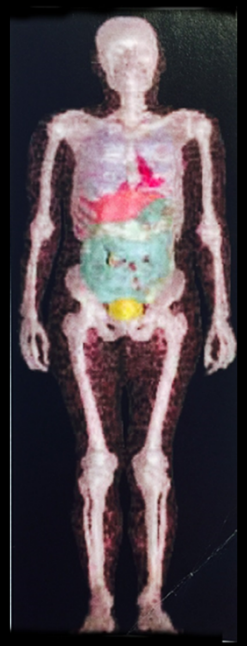
DC for Pu-241 (b)

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 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 (	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													



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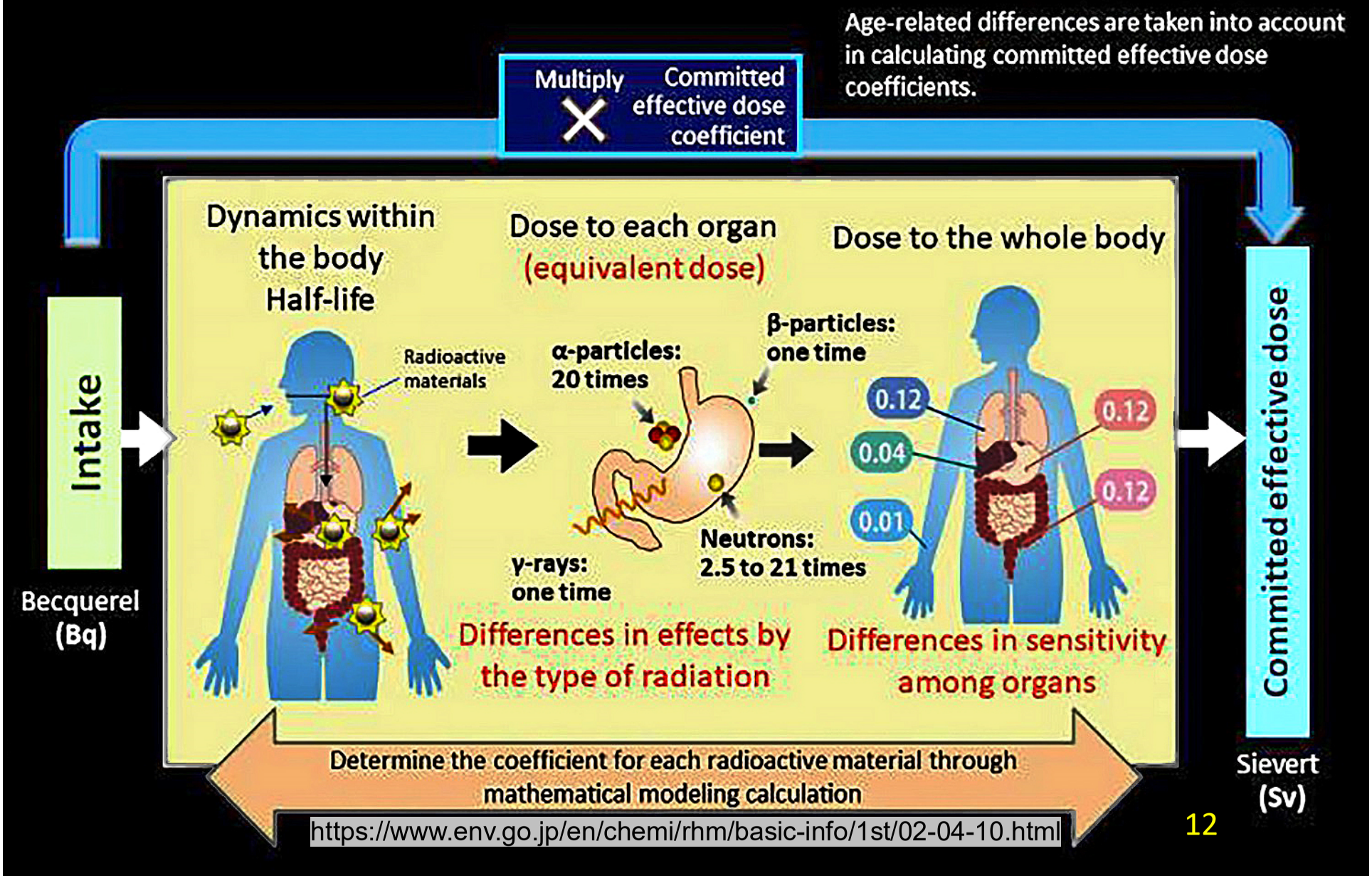
Primer for db (4)



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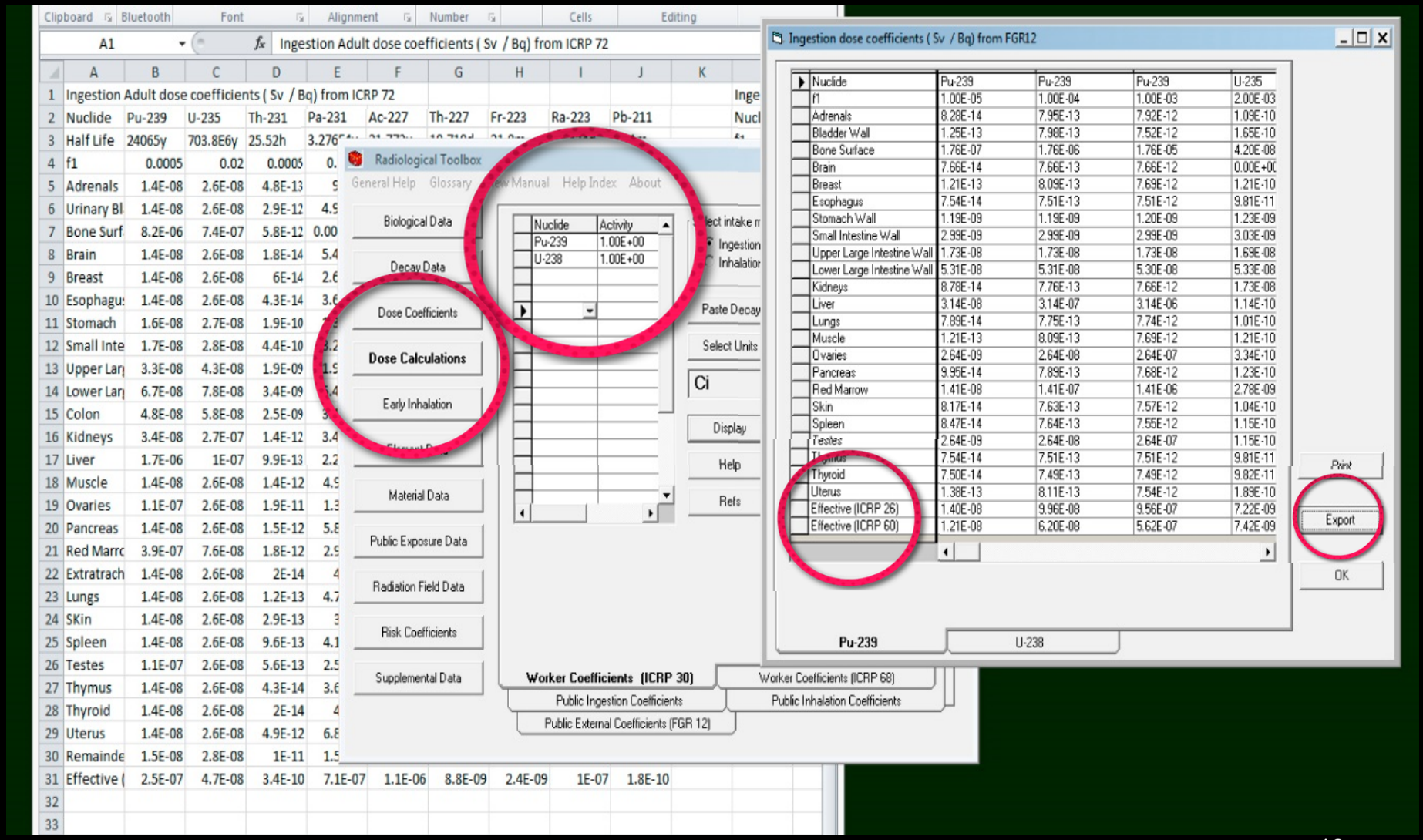
(db4) Dose Calculations



Nuclide	Pu-239	Pu-239	Pu-239	U-235
f1	1.00E-05	1.00E-04	1.00E-03	2.00E-03
Adrenals	8.28E-14	7.95E-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

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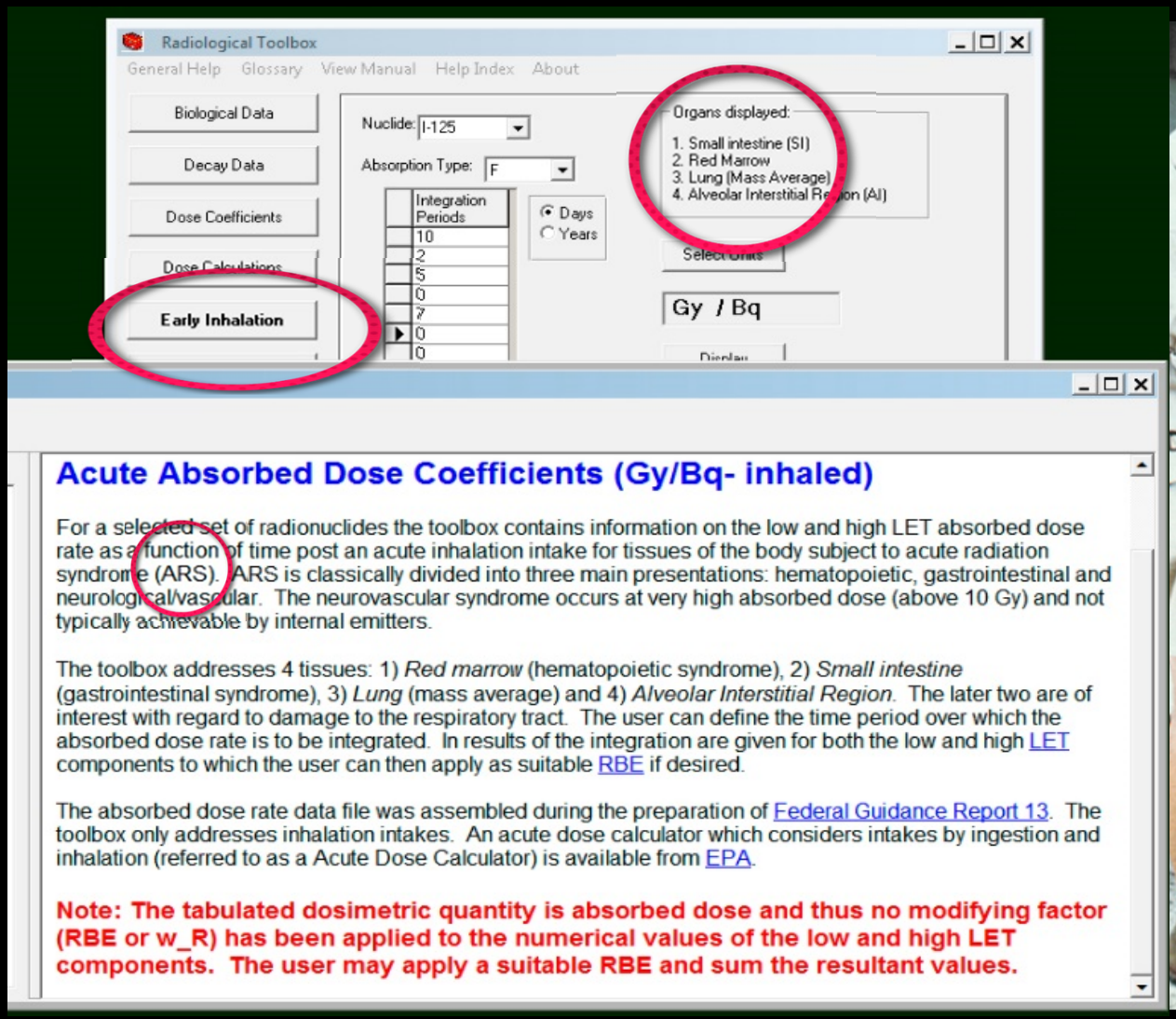
(db5) ARS: Early Inhalation



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(db5) I-125 Dose Coeff.