Availability and Use of the CD-ROMS on Models and Dose Coefficients

Eye-opener 08 IRPA 10 Congress Hiroshima May 17, 2000

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IRPA10.01

Availability and Use of the CD-ROMs on Models and Dose Coefficients Title

Thank you

- IRPA 10 Program Committee
 for the kind invitation to present this eye-opener lecture
- Dr. Herwig Paretzke for search for sponsers of my travel
- Federal Office for Radiation Protection (BfS) for support in the preparation of these slides

- My Son Ingo

for permission to spend a week of vacation here

- To You

to attend this eye-opener lecture

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Availability and Use of the CD-ROMs on Models and Dose Coefficients Acknowledgement

Please Excuse Me

- the selection of the software presented here is incomplete
 I acknowledge that there may be software even better as the
 software mentioned here.
- my assessment of software here is subjective to some extent

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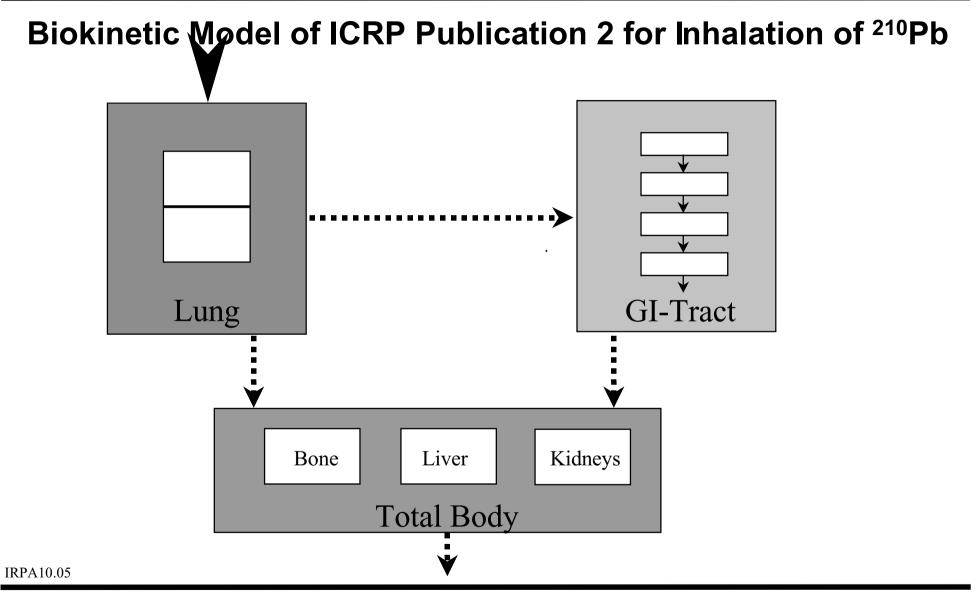
Availability and Use of the CD-ROMs on Models and Dose Coefficients Apologies

Contents

- 1. Interactions models / software ICRP 2 / 30 / 56ff.
- 2. Who needs which software ? Regulators / Students / Members of Measurement Agencies / Researchers
- 3. Different kinds of software Publications / Education and Basic Informations, Basic Calculations / Researchers' Tools
- 4. Risks of software Errors / Misuse
- 5. Conclusions / Look to the Future

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Availability and Use of the CD-ROMs on Models and Dose Coefficients Contents



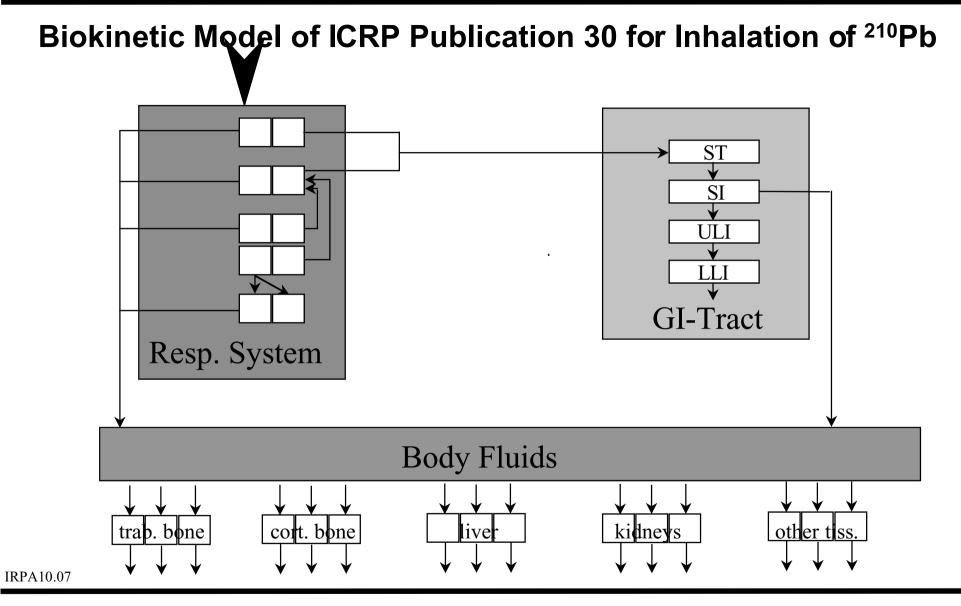
Availability and Use of the CD-ROMs on Models and Dose Coefficients 1.1.1 ICRP 2 - Biokinetic Model

Dosimetric Model of ICRP Publication 2

- Only source organs are considered as target organs.
- No cross-fire is considered for penetrating radiation.
- Target organs are considered as spheres with an effective radius (for example 30 cm for total body).

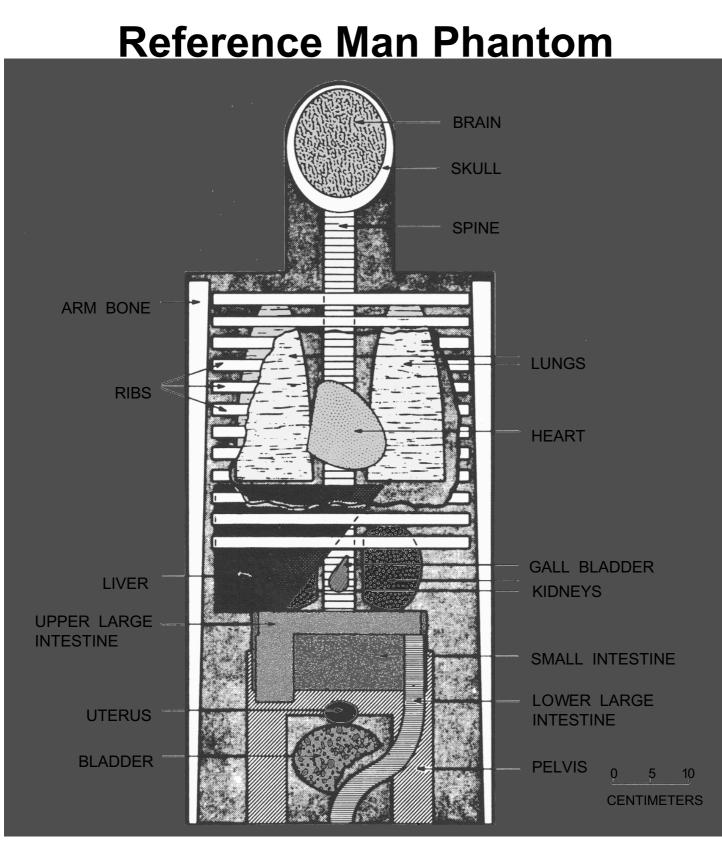
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Availability and Use of the CD-ROMs on Models and Dose Coefficients 1.1.2 ICRP 2 - Dosimetric Model



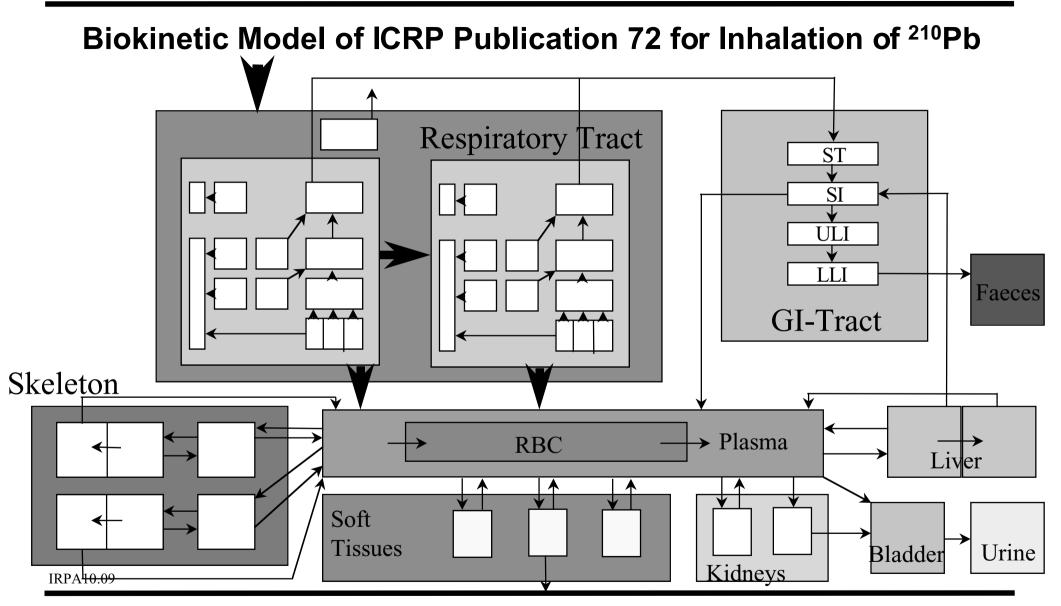
Availability and Use of the CD-ROMs on Models and Dose Coefficients 1.2.1 ICRP 30 - Biokinetic Model

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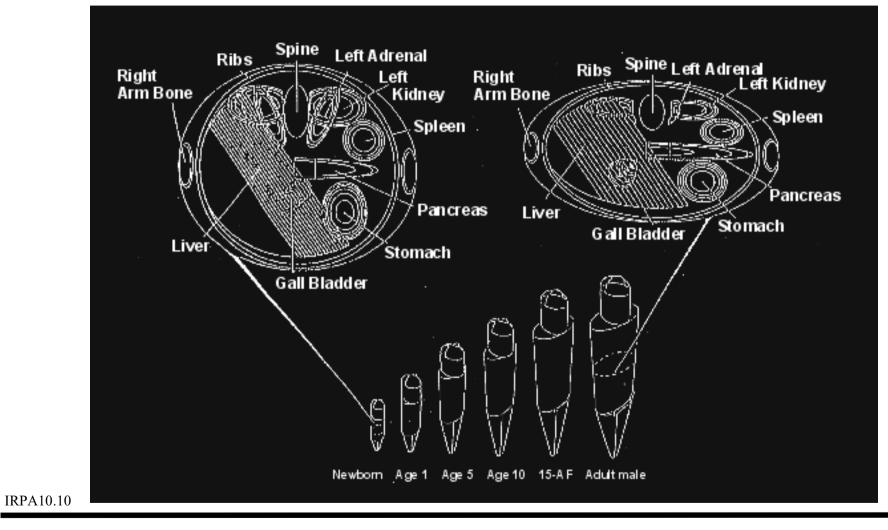
Availability and Use of the CD-ROMs on Models and Dose Coefficients 1.2.2 ICRP 30 - Dosimetric Model



Availability and Use of the CD-ROMs on Models and Dose Coefficients1.3.1ICRP 72 - Biokinetic Model

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The Reference Family Phantoms Used in ICRP Publications 56ff .



Availability and Use of the CD-ROMs on Models and Dose Coefficients 1.3.2 ICRP 72 - Dosimetric Model

Forthcoming Model Developments by ICRP

- Doses to embryo and foetus after activity intake by the mother
- Transfer of activity to mother s milk
- A new biokinetic and dosimetric model for the human alimentary tract
- Further physiologically based biokinetic models during the revision of Publication 30

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Availability and Use of the CD-ROMs on Models and Dose Coefficients1.4Further Developments

Who Needs Which Software?

Scientists active in research in internal dosimetry (who develop models)

data base tools, model development tools, highly sophisticated computational tools

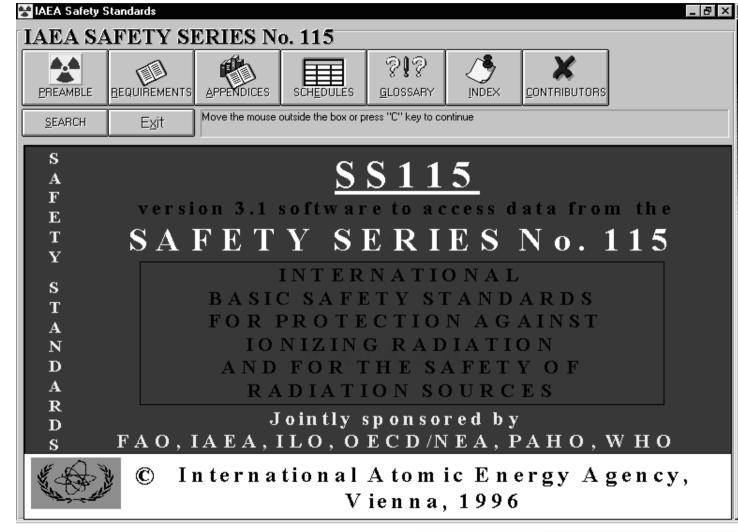
- Members of measurement agencies or nuclear medicine departments (who apply models) basic calculational tools, administrative tools
- Students (who learn models) basic informations, educational tools
- Regulators (who must have an idea of models) dose coefficients, electronic versions of standard documents

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Availability and Use of the CD-ROMs on Models and Dose Coefficients

2. Who needs which software?

The Electronic Version of the IAEA Basic Safety Standards



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Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.1 Electronic documents

The Electronic Version of the IAEA Basic Safety Standards

- The whole text and all tables of the IAEA Basic Safety Series No. 115 can be selected via the list of contents and can be displayed.
- It includes a search function for several topics.
- Parts can be printed and copied to other documents.
 A disadvantage is that for example the copy of dose coefficients includes Tabs and cannot be used directly as an input to other programs
- Comments and bookmarks can be included.

Availability and Use of the CD-ROMs on Models and Dose Coefficients3.1Electronic documents

ICRP Database of Dose Coefficients (1)

	onuclide Radio	onuclide (e	g Co-60): H-3	Subject(s) Ages at intake: Adult 15 year old
Ζ	Element	Symbol A		Adult Worker 10 year old
	Hydrogen	Н	3 12.35y	Public 5 year old
	Beryllium	Be	7 53.3d	Jahaha Dauta(a)
	Beryllium	Be	10 1.6E6y	Intake Route(s)
	Carbon	C	11 20.38m	Aerosol size (AMAD): 0.03 microns 0.1 microns
	Carbon	C	14 5730y	■ Ingestion 0.1 microns 0.3 microns
9	Fluorine	F	18 109.77m 🖵	✓ Inhalation
		1 day) Five O Custom	All With wT Custom Custom
		7 days 30 days 1 year		Bone Surface Brain

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Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.2 Dose Coefficients

ICRP Database of Dose Coefficients (2)

- contains all dose coefficients of ICRP Publication 68 (Workers) and ICRP Publication 72 (Members of the Public) including organ doses

Also doses to regions of the respiratory tract can be selected.

- for inhalation 10 different AMADs can be selected (from 1 nm to 10 m)
- 10 different integration periods from 1 d to the age of 70 y (or 50 y integration period for adults) can be selected

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Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.2 Dose Coefficients

ICRP Database of Dose Coefficients (3)

- includes text of ICRP Publications 68 and 72 with search function and all the functionality of electronic documents (copy, print, comments, bookmarks)
- includes biokinetic models for all elements
- results can be saved as ASCII file and printed however only results of 1 radionuclide

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Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.2 Dose Coefficients

ICRP Database of Dose Coefficients (4)

- results are ICRP approved

many quality assurance procedures within the ICRP Task Group on Dose Calculations

- version 2.0 will also run under Windows NT
- will be followed by a similar CD-ROM with dose coefficients for embryo and foetus after activity intake by the mother (many intake scenarios, several organs, doses in utero and after birth)

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Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.2 Dose Coefficients

Radiation Decay Data (1)

🐟 Radiation	Decau		_			
<u>File E</u> dit <u>S</u> e		arch Heln				
Te-127 Te-127m		Th-2	232			Periodic Table
Te-129 Te-129m		Elemen	t Name:	Thorium		
Te-131		Atomic I	Number:	90		
Te-131m		Mass N	umber:	232		
Te-132 Te-133		Atomic I	Maee'	232.038		
Te-133m		Half Life		1.4E+0004	Million	Years
Te-134 Th-226		DAUGH	ITER PRODU	JCTS		
Th-227 Th-228		1.	Ra-228	Radium	ı	100% ^{or}
Th-229 Th-230						l s
Th-231		EMISSI	ON PRODUC	TS		
Th-232 Th-233		1.	Number o	f Alphas	3	Show List
Th-233 Th-234		2.	Number o	fBetas		Show List
Ti-44		3.	Number o	fPositrons		Show List
Ti-45		4.		f Electrons	5	Show List
Ti-51 Tl-200					-	
TI-200	•	5.	Number o	I Photons	3	Show List
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This is an example of a windows-based freeware program by Charles Hacker (Australia)

Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.3 Basic Informations

Radiation Decay Data (2)

 It gives radiation data (decay chain, half-life, energies and probabilities for various kinds of emissions) for 497 radionuclides.

based on data from ORNL

- Results can be printed and copied to the clipboard.
- It has a search function for radionuclides with gamma emissions within a given energy range.

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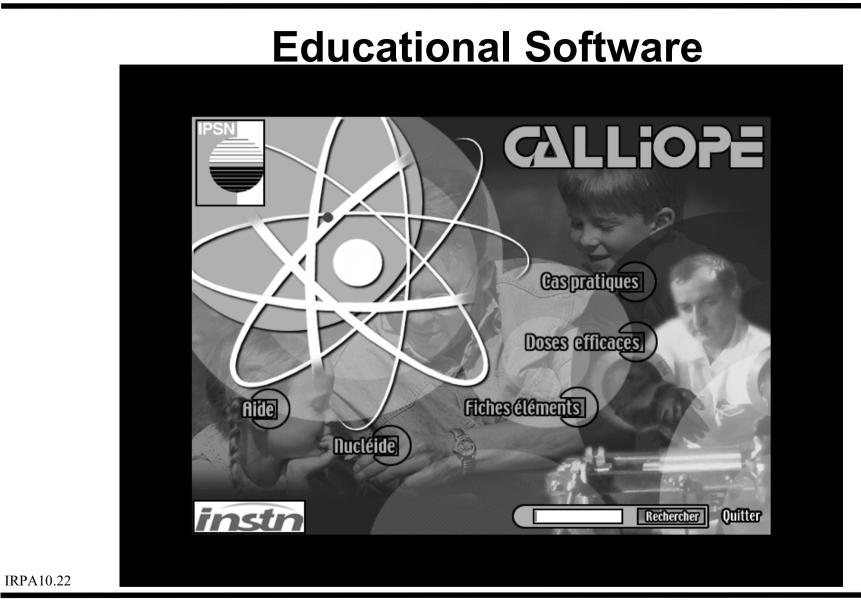
Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.3 Basic Informations

Radiation Decay Data (3)

- There are similar tools within the ORNL DCAL package.
- They give all information of ICRP Publication 38 including beta spectra.
- With the SEECAL code also SEE values for all source and target pairs of the reference family can be calculated.
- The version I know is a menue driven DOS program.

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.3Basic Informations



Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.4 Educational Software

CALLIOPE (1)

- new educational software by IPSN in French language with audio/video animation
- partly presenting basic information / dose coefficients and the sub-program Nucl ide, partly presenting examples how to calculate doses in specific situations

Availability and Use of the CD-ROMs on Models and Dose Coefficients3.4Educational Software

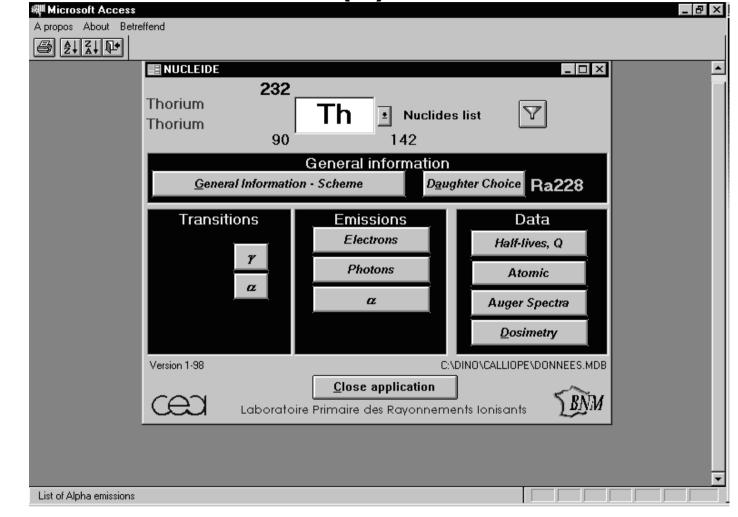
CALLIOPE (2) - Basic Informations

- effective dose coefficients for workers and members of the public due to ICRP Publications 68 and 72 due to format problems some inaccuracies in exceptional cases
- for some elements/radionuclides description of the biokinetic model, possible medical intervention, information on absorption Types and f₁, in which ICRP Publication the models are defined, and methods of measurement (including detection limit)

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.4Educational Software

CALLIOPE (3) - Nucl ide



Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.4 Educational Software

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CALLIOPE (4) - Nucl ide

- computerized form of Table de Radionucl ides " by BNM-CEA/LPRI, edited in international co-operation
- data for 75 radionuclides
- not consistent with ICRP Publication 38
- contains many details including uncertainties
- extended search function (besides energies also halflives, mass number and probabilities)

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.4Educational Software

CALLIOPE (5) - practical cases

Several example calculations of intake and doses from measurement values

- with ICRP models and without ICRP models (integration method)

- chronic and acute intake
- with and without knowledge of time of intake

The selection of the example is the only possible interaction by the user.

This software was designed to accompany lectures and the examples are partly difficult do understand without accompanying declarations

Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.4 Educational Software

MIRDOSE3 (1)

MIRDOSE 3.1 - Input Form		
<u>F</u> ile <u>H</u> elp		
Elements Nuclides	Phantoms	
Aluminum		
Antimony Argon	□ + Adult (70 kg)	🗖 Adult Female - Nonpregnant
Arsenic	□ + 15-year-old (57 kg)	□ i 3-month Pregnant Woman
Barium	□ + 10-year-old (32 kg)	_
Beryllium	□ 5-year-old (19 kg)	□ 6-month Pregnant Woman
Bismuth Bromine	□ 1-year-old (9.8 kg)	🔲 9-month Pregnant Woman
Cadmium 🔽	□ Newborn (3.4 kg)	_
Residence Times (hr)		
Adrenals	🗌 🗌 Kidneys	Testes
🗖 🗖 Brain	Liver	🗖 Thymus
🗖 🗖 Breasts	🗖 Lungs	🗖 Thyroid
Gallbladder Contents	Muscle	🗖 Urin. Bl. Contents
LLI Contents	🗌 🗌 Ovaries	Uterus
SI Contents	Pancreas	Fetus
Stomach Contents	Red Marrow	Placenta
	Cortical Bone	🗖 Total Body
Heart Contents	Trabecular Bone	
🗌 🗌 Heart Wall	Spleen	Use ICRP 30 GI tract model? Yes
Select All Clear All		Use Dynamic Bladder Model? Yes
- Nodule Module	Control F	Panel
Report	Self-dose S-value:	ulate Doses S-Value Table
Sphere Size:	Label for	Program Output:
Sphere Diameter:		

A standard software to calculate doses in nuclear medicine

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Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.5.1 Basic Calculations - MIRDOSE3

MIRDOSE3 (2)

- Input residence times in source regions (in h)
- it calculates residence times in urinary bladder and in the GI tract due to the dynamic bladder model and the GI tract model of ICRP 30

does not consider delay in the transfer to the GI tract, i.e. may be overestimation

- calculates doses for many radionuclides for 6 age groups and also for pregnant females
- calculates S-values for nodules

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.5.1Basic Calculations - MIRDOSE3

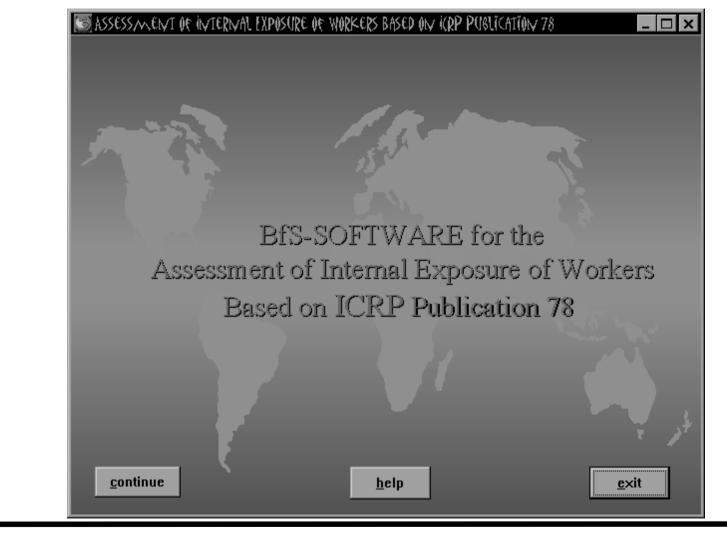
MIRDOSE3 (3)

- Input form can be saved and retrieved
- In the output also the main contributors to the dose are displayed
- Output form can be printed and saved as an ASCII file
- Tables with S-values can be displayed, saved and printed

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.5.1Basic Calculations - MIRDOSE3

Software accompanying ICRP Publication 78 (1)



Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.5.2 Basic Calculations - ICRP78

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Software accompanying ICRP Publication 78 (2)

- is being produced by BfS at the moment ICRP does not want to publish interactive software
- contains the radionuclide-specific data of ICRP Publication 78 (including Tables and graphs)
- can calculate the values of the retention and excretion functions for any times after (the beginning) of an acute or chronic intake
- can calculate intake and dose (organ doses and effective dose) from measurement values
 it is, however, restricted to the ICRP 78 models, but for 2 different AMADs (1)

it is, however, restricted to the ICRP 78 models, but for 2 different AMADs (1 $_{\rm IRPA10.32}$ and 5 m)

Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.5.2 Basic Calculations - ICRP78

Software accompanying ICRP Publication 78 (3)

Please Select	:				date of i	intake	24/3/00
Radionuclide	Th-232	. 🗖	Measurem. Excre				
	11-202		date 27.03.2000	days	Measure. 3,E-2	Std.dev.	Infake
D 1 (T 1		⊣ ⊢́	29.03.2000	3	1,8E-2	*	1,5E4 1,3E4
Path of Intake	Inhalation	- I	04.04.2000	11	2,2E-2	*	2,5E4
			15.04.2000	22	8,E-3	*	1,2E4
Туре	S	• *					
Measurement	Urine	-	st estimate of inta			,6E4 2 Inhalation	
Measurement	Urine	-	easurement Excr	etion [B	'q/d] Th-232	2 Inhalation	
Measurement Intake pattern	Urine acute	-		etion [B	'q/d] Th-232	2 Inhalation	
		-	easurement Excr Measuremen	etion [B	'q/d] Th-232	2 Inhalation	
		-	easurement Excr Measuremen	etion [B	'q/d] Th-232	2 Inhalation	
	acute	-	easurement Excr Measuremen 0.1 0.01	etion [B t Excret	:q/d] Th-23 2 tion [Bq/d] '	2 Inhalation Th-232 Inh	alation ₹
	acute	-	easurement Excr Measuremen 0.1 0.01	etion [B It Excret 7	'q/d] Th-232	2 Inhalation Th-232 Inh 5 20	

Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.5.2 Basic Calculations - ICRP78

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Software accompanying ICRP Publication 78 (4)

- graphic display of retention and excretion functions (together with measurement values)
- can calculate number of days between time of (begin of) intake and time of measurement
- can save input and output data in ASCII and LUDEP format

Availability and Use of the CD-ROMs on Models and Dose Coefficients3.5.2Basic Calculations - ICRP78

Software Package INCOR (1)

- Software Package for Data Administration and Calculation of Intake as well as Effective Dose for Measured Incorporated Radionuclides in Humans
- it assists both administration and analysis of data due to the German regulations

Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.5.3 Basic Calculations - INCOR

Software Package INCOR (2)

- Data base for administration of personal data and measurement results
- calculation of intake and effective dose due to the reference method
- use of ICRP models if reference method does not apply
- dose calculation with the integration method
- test of suitability of models

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.5.3Basic Calculations - INCOR

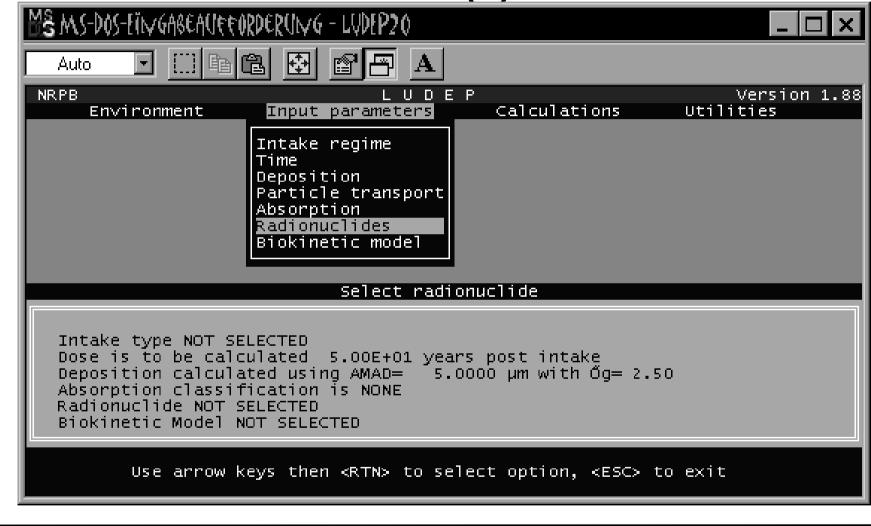
LUDEP (1)

- DOS-based program developed parallel with the new ICRP respiratory tract model (Publication 66)
- very flexible with a very comfortable user-interface
- calculates deposition in the respiratory tract, doses per (unit) intake, or intake and doses from measurement values

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.6.1Sophisticated Computational Tools - LUDEP

LUDEP (2)



Availability and Use of the CD-ROMs on Models and Dose Coefficients3.6.1Sophisticated Computational Tools - LUDEP

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LUDEP (3)

- very efficient tool to calculate respiratory tract deposition values for all possible parameter selections
- selection of any mechanical transport and absorption parameters for the respiratory tract
- selection of all kinds of systemic biokinetic parameters however only based on ICRP 30 model structure, no specific consideration of daughter nuclides
- calculation of SEE values, numbers of transformations, organ and effective doses

also doses to respiratory tract regions, however only for adults

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.6.1Sophisticated Computational Tools - LUDEP

LUDEP (4)

- various possibilities to calculate intake and doses from measurement data by fitting the measurement values by bioassay functions
- indication of the quality of the fit no indication of the reasons for a bad fit

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.6.1Sophisticated Computational Tools - LUDEP

ICRP DOCAL Tools (1)

The calculations for ICRP Publications are performed within the Task Group on Dose Calculations (DOCAL) with several independently written codes:

- DCAL from ORNL (USA)
- PLEIADES from NRPB (UK)
- DOSAGE from BfS (Germany)
- IDSS from URPI (Ukraine)

By intercomparison of the results a very efficient quality assurance of results is obtained.

Availability and Use of the CD-ROMs on Models and Dose Coefficients3.6.2Sophisticated Computational Tools - DOCAL

ICRP DOCAL Tools (2)

All these codes can calculate

- age-dependent dose coefficients (with continuous change of biokinetic and dosimetric parameters) with any firstorder biokinetic model and with consideration of independent daughter kinetics
- age-dependent retention and excretion functions for various intake functions
- doses to embryo and foetus after activity intake by the mother with compartment models as well as with the generic model based on activity concentration data

and they are extended due to new requirements. IRPA10.42

Availability and Use of the CD-ROMs on Models and Dose Coefficients3.6.2Sophisticated Computational Tools - DOCAL

ICRP DOCAL Tools (3)

- PLEIADES and DOSAGE are only development tools for use by NRPB and BfS and are not avilable outside these institutions; however, calculation results can be requested

user interface is not suitable for distribution

- Versions of DCAL and IDSS are intended to be commercially available

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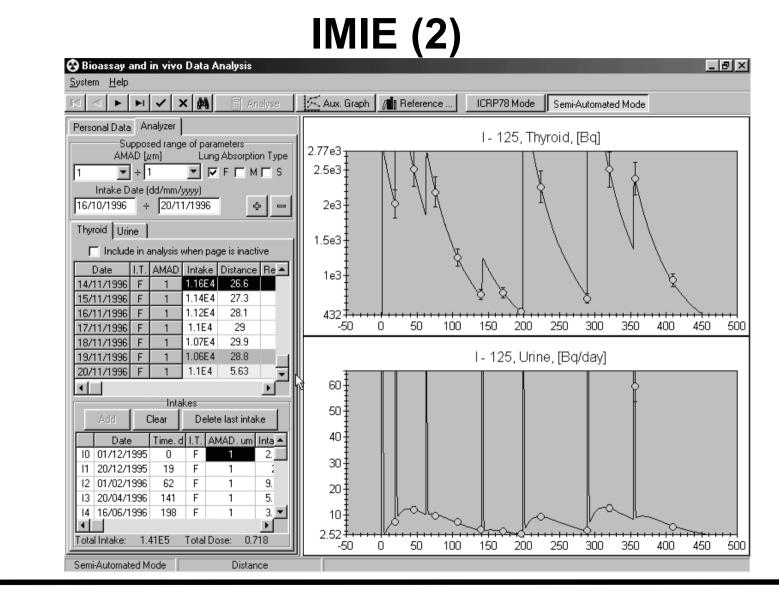
Availability and Use of the CD-ROMs on Models and Dose Coefficients3.6.2Sophisticated Computational Tools - DOCAL

IMIE (1)

- On the basis of IDSS URPI (Kiev, Ukraine) develops the IMIE (Individual Monitoring of the Internal Exposure) code for retrospective dosimetry
- It offers a wide range of analysis of measurement data together with an administrative tool
- It has an interactive user interface with graphical tools for presentation and analysis with the choice of automatic (on the basis of ICRP78 methods), semi-automatic or manual evaluation

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.6.3Sophisticated Computational Tools - IMIE



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Availability and Use of the CD-ROMs on Models and Dose Coefficients 3.6.3 Sophisticated Computational Tools - IMIE

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Radionuclide Biokinetic Database (1)

- developed by an EULEP-EURADOS action group to collate and analyse information from the scientific literature on the biokinetic results of experimental studies
- it is planned to use it for the revision of ICRP Publications 30/54
- based on ACCESS
- Changes are only included by the Database Manager (at present Mike Bailey, NRPB)

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.7.1Distribution of latest information - Database

Radionuclide Biokinetic Database (2)

It contains information on

- radionuclide, chemical and physical properties
- the experiment in vivo/in vitro etc.
- species including further conditions age, fasting / non-fasting etc.
- results (also as spreadsheet)

- comments

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.7.1Distribution of latest information - Database

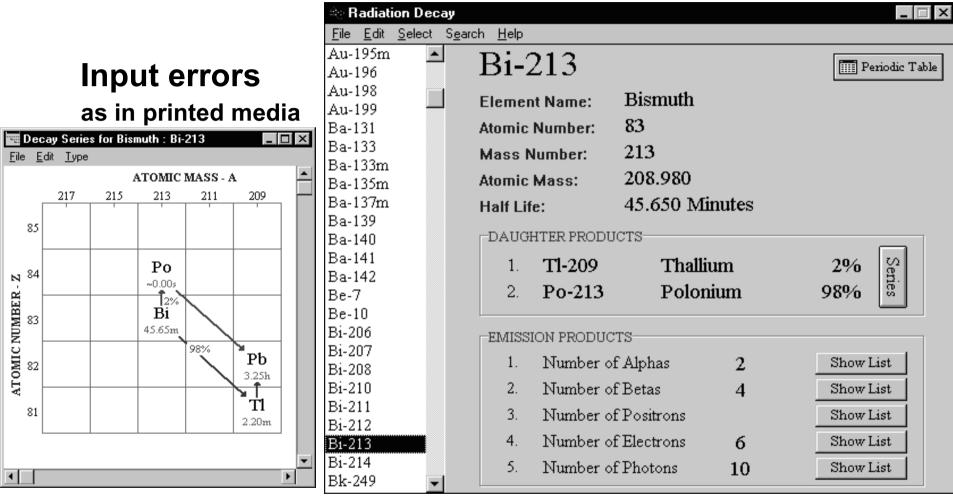
ICRP goes Internet

- Draft reports can be downloaded and commented
- Interim reports will be posted on the web Radiopharmaceuticals additional to those in Publication 80
- Supplements and updates of reports will be given Errata

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Availability and Use of the CD-ROMs on Models and Dose Coefficients3.7.2Distribution of latest information - Internet

Risks of Software (1)



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4.1 **Risks - Input errors**

Risks of Software (2)

Implementation Problems

- Some results of MIRDOSE3 are wrong if in the Windows settings not USA are selected as country
- MIRDOSE3 does not consider gamma radiation if it is implemented under Windows NT

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Availability and Use of the CD-ROMs on Models and Dose Coefficients4.2Risks of Software - Implementation Problems

Risks of Software (3)

Misuse of software

- Optimisation of results in any direction
- generally use of interactive software without sufficient knowledge of internal dosimetry

Availability and Use of the CD-ROMs on Models and Dose Coefficients4.3Risks of Software - Misuse

Risks of Software (4)

Wrong authority of software

- Statements like due to the software XY ...

In the use of MIRDOSE3 the input is more important and more sensitive to the results than what is done by the program.

In the Third European Intercomparison Exercise on Internal Dose Assessment doses assessed with the same program (LUDEP) were different by a factor of almost 50.

The software is only giving results due of the underlying models and assumptions

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Availability and Use of the CD-ROMs on Models and Dose Coefficients
4.4 Risks of Software - Wrong authority

CONCLUSIONS (1)

- Model development should take into account the availability of qualified software to be able to make realistic predictions
- To make complicated models applicable the user should be provided with appropriate software

Availability and Use of the CD-ROMs on Models and Dose Coefficients

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5. Conclusions

CONCLUSIONS (2)

Such as there are generally acknowledged models (ICRP) there should also be generally acknowledged certified software available.

Who can produce it?

- It should be taken into account that different users have different needs; therefore different kinds of software are needed.
- However, it would be helpful to have links between these software packages which facilitate the transition from one to another.

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5. Conclusions

Final Remark

The quality of results depends more on the quality of the user than on the quality of the software

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5. Conclusions