



# Training course DOSE DATAMED 2

Effective dose estimate  
in **general radiography**





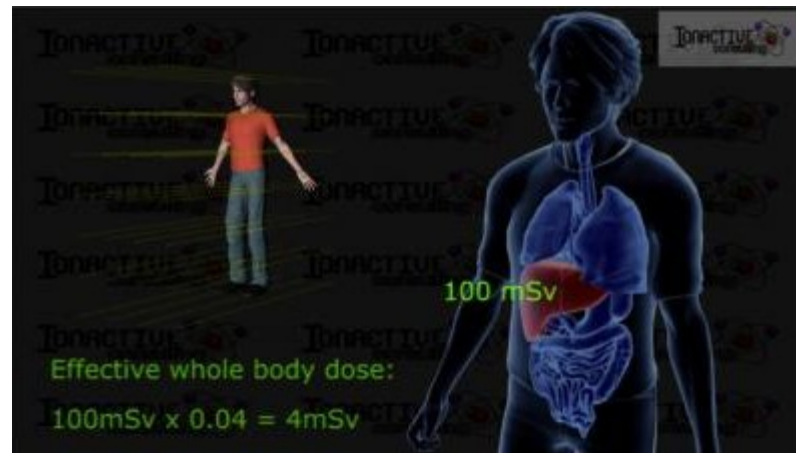
# Effective dose

- Defined by ICRP – Publication 60, 1990  
Publication 103, 2007
- Requires knowledge of dose in several organs and tissues
- Determined applying computational dosimetry techniques



# Effective dose

- Conversion coefficients relating organ



# Calculation of effective dose

- Centre for Devices and Radiological Health, USA  
**Handbook CDRH 89-8031**, Rosenstein 1988:  
**Selected tissue doses for projections  
common  
in diagnostic radiology (Adults)**

based on the hermaphrodite MIRD-5 phantom  
with added female breasts

provides tissue **dose-conversion coefficients**  
for a variety of radiographic projections  
for reference adult **male** and **female patients**

similar handbooks for paediatric radiology,  
mammography and fluoroscopy

# Calculation of effective dose

- National Research Centre for Environment and Health (GSF), Germany  
**GSF-Bericht 11/90**, Drexler et al. 1990:  
**The calculation of dose from external photon exposures using reference human phantoms and MC methods**

based on the hermaphrodite MIRD-5 phantom

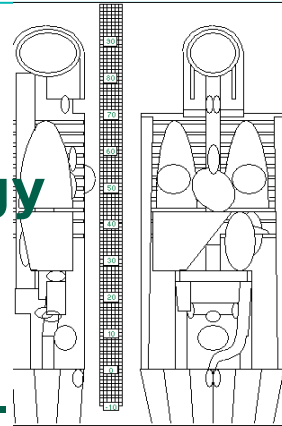
provides tissue **dose-conversion coefficients**  
for a variety of radiographic examinations  
incl. pregnant women  
for gender specific **ADAM** and **EVA phantoms**

similar reports for paediatric radiology and CT



# Calculation of effective dose

- Health Protection Agency (formerly NRPB), UK  
**NRPB-R262 and -SR262**, Hart et al. 1994:  
**Estimation of effective dose in diagnostic radiology  
from ESD and DAP measurements**



based on the hermaphrodite Cristy's phantom with mod.

provides **coefficients relating dose to ESD** and **DAP**  
for a variety of radiographic examinations  
for **hermaphrodite phantom**

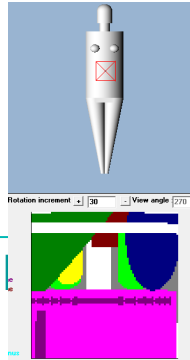
similar reports for paediatric radiology and CT

# Calculation of effective dose

- Radiation and Nuclear Safety Authority (STUK), Finland  
**PCXMC**, Tapiovaara et al. 1997:  
**A PC based MC program for calculating patient doses in medical x-ray examinations**

based on the hermaphrodite Cristy's phantoms with mod.

calculates **organ doses and effective dose**  
**from IAK, KAP, exposure, exposure-area product or mAs**  
allows user's choice of patient's age, height and weight



# Calculation of effective dose

According RP 154 (EC, 2008):

- There is **sufficient agreement** between the 4 publications, any of them can be used
- NRPB coefficients – for larger number of examinations and exposure conditions
- If not possible to derive conversion coefficients matched to the practice in a country – NRPB coefficients are the preferred choice





# Approaches

- Use of effective dose values from **other countries** with similar healthcare settings
- Use of effective dose values from **small local surveys** in the same country - extrapolation
- Determination of effective dose from **representative national survey**
  - number and choice of hospitals and rooms - to reflect all variations in clinical practice, types of equipment, radiographic techniques, exposure parameters etc.
  - measuring doses of at least 10 (preferably 20) average size patients (e.g.  $70 \pm 20$  kg)

# Approaches - national survey

For each examination type and projection:

- Mean for the survey dose quantity  
ESAK/KAP \*conversion coefficient
- Typical effective dose for each department and  
mean for whole sample from survey
- Effective dose for each patient (PCXMC) and  
mean for whole sample from survey



# Our experience

- PCXMC - determination of effective dose for individual adult patients

Necessary data:

- type of examination, projection
- patient age, height and weight
- focus-skin distance, beam height and width
- x-ray spectrum: kVp, filtration, anode angle
- patient dose data: IAK, KAP...



# Our experience

- PCXMC - determination of effective dose for individual adult patients

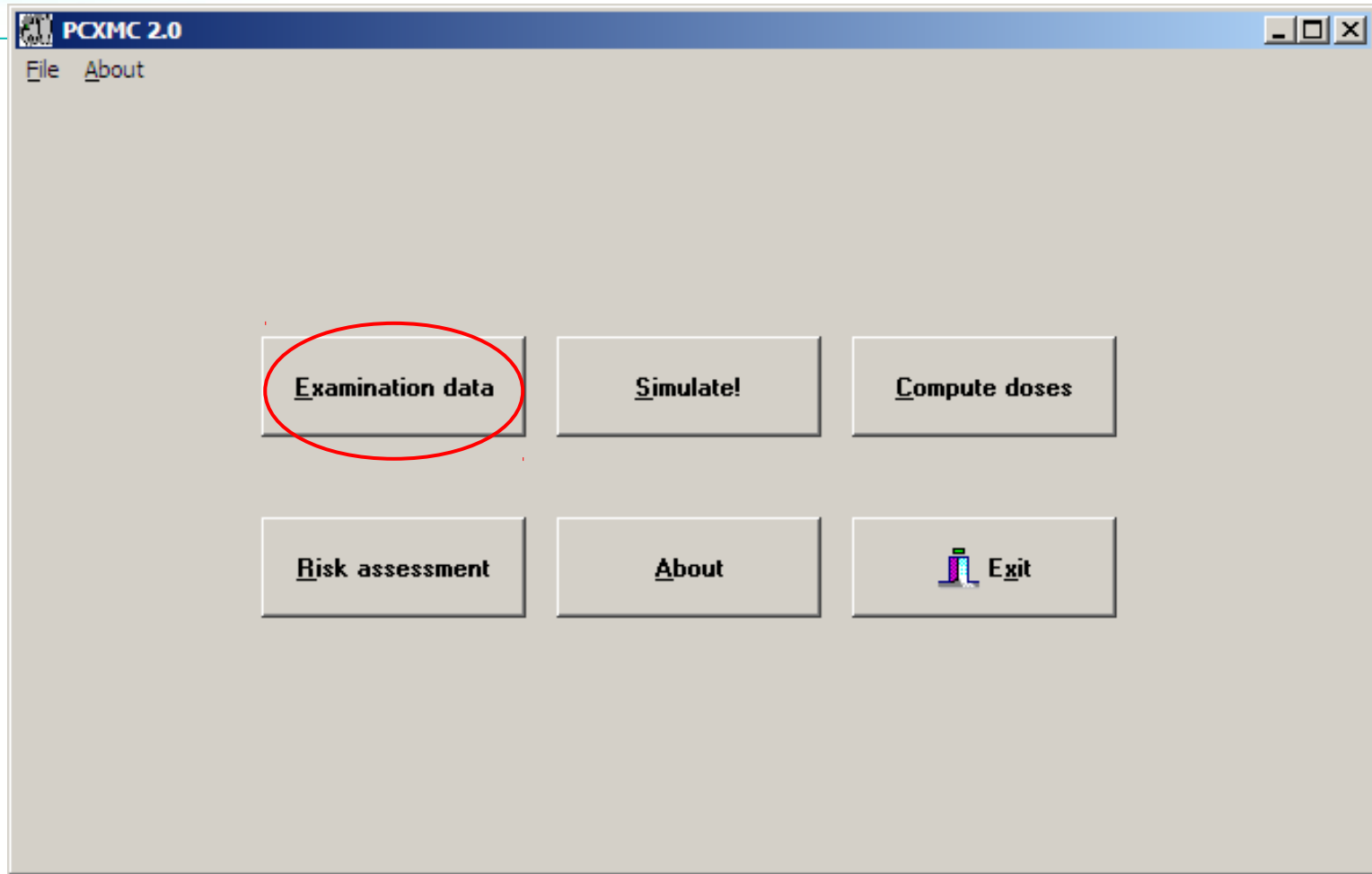


National survey:

- 46 x-ray units, 1600 patients (weight 50-100 kg)
  - skull, chest, lumbar spine, pelvis, urography
- > standard data sheets in each room
  - > standard measurement procedures for each physicist

# Our experience

- Patient dose data:
  - radiation output and exposure data – the method of choice for this survey
  - KAP – where available – supplementary data
  - TLD – in some cases
  - combinations
- › Calculation of effective dose for each patient
- › Comparison of our conv. coeff. with NRPB – good coincidence
- Good enough approach to take mean value of ESAK/KAP and apply standard conv. coeff.



File

Header text

Phantom data

Age:  0  1  5  10  15  Adult

Phantom height  Phantom mass   Arms in phantom

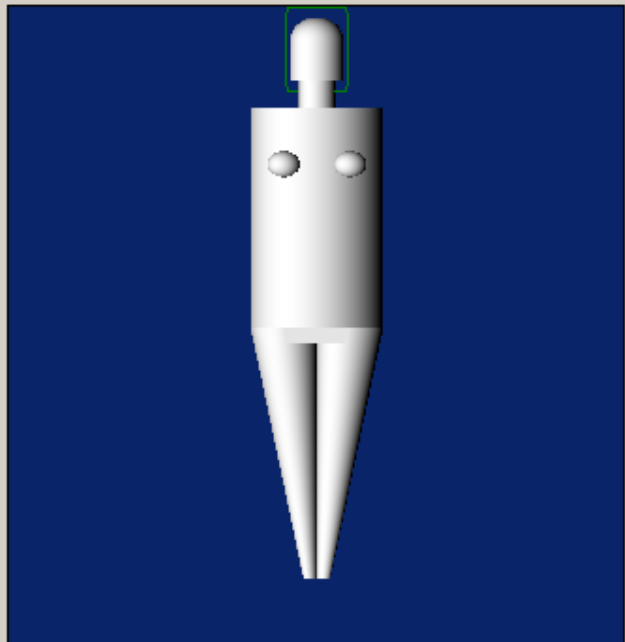
Standard: 178.6 Standard: 73.2

Geometry data for the x-ray beam

FSD	Beam width	Beam height	Xref	Yref	Zref
<input type="text" value="87.00"/>	<input type="text" value="18.00"/>	<input type="text" value="24.00"/>	<input type="text" value="0.0000"/>	<input type="text" value="0.0000"/>	<input type="text" value="84.0000"/>

Projection angle  Cranio-caudal angle   
 LATR=180 AP=270 (pos) Cranial X-ray tube  
 LATL=0 PA=90 (neg) Caudal X-ray tube

Draw x-ray field



Rotation increment  View angle

MonteCarlo simulation parameters

Max energy (keV)  Number of photons

Field size calculator

FID  Image width  Image height

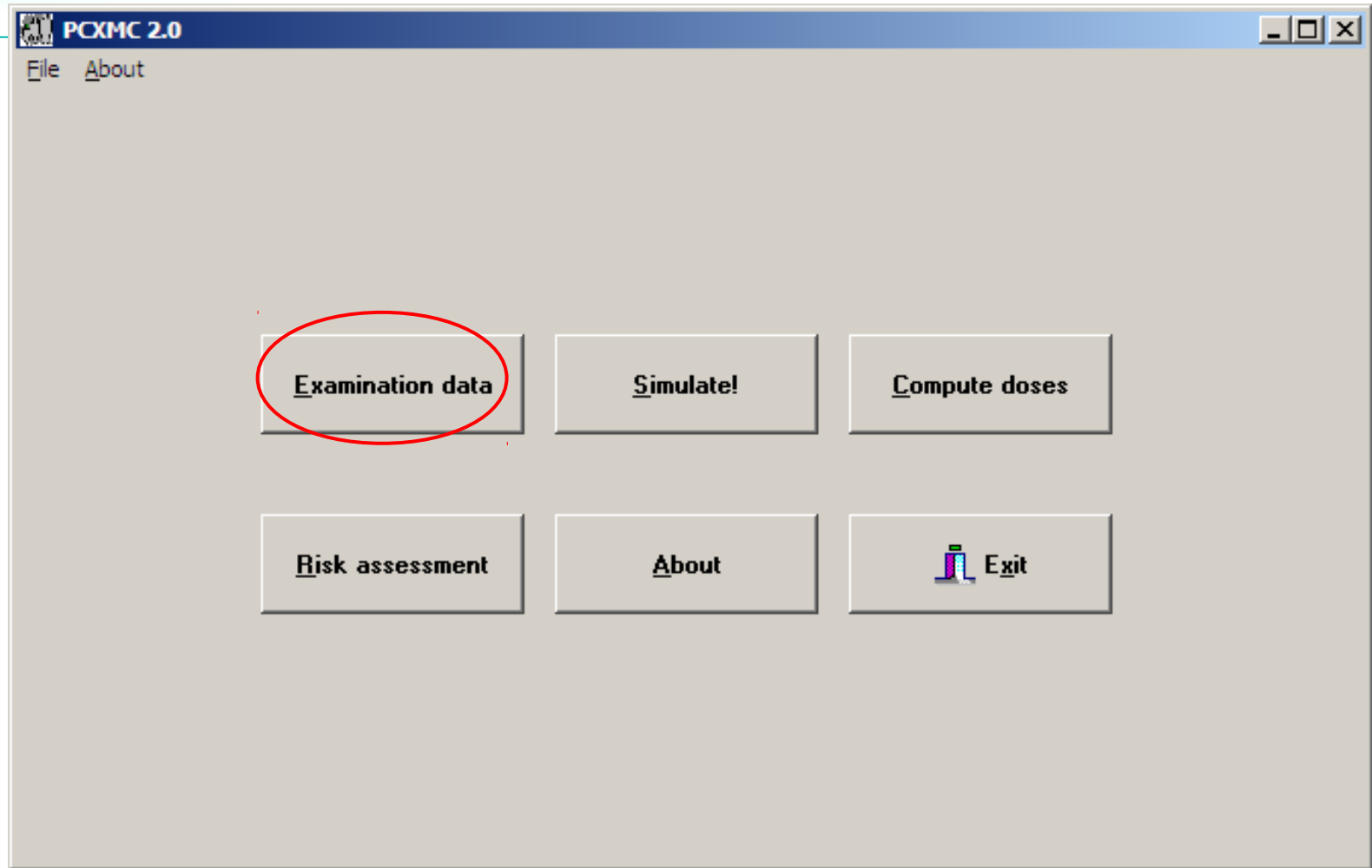
Phantom exit- image distance:

FSD  Beam width  Beam height

- Skeleton
- Brain
- Heart
- Testes
- Spleen
- Lungs
- Ovaries
- Kidneys
- Thymus
- Stomach
- Salivary glands
- Oral mucosa
- Pancreas
- Uterus
- Liver
- Upper large intestine
- Lower large intestine
- Small intestine
- Thyroid
- Urinary bladder
- Gall bladder
- Desophagus
- Prostate
- Pharynx/trachea/sinus



Quick  Sharp







## Calculation of x-ray spectrum

X-ray tube potential

kV

X-ray tube Anode Angle

degree

Filter #1 : Material

Atomic Number

Chemical Symbol

Filter #1 : Thickness

mm

g/cm<sup>2</sup>

Filter #2 : Material

Atomic Number

Chemical Symbol

Filter #2 : Thickness

mm

g/cm<sup>2</sup>





**Patient input dose**

Input dose value:  
 mGy

Incident air kerma value used in calculations:  
 mGy

[Corresponds to about 44.3mAs]

Input dose quantity and unit:

- Incident air kerma (mGy)
- Dose-Area Product (mGycm<sup>2</sup>)
- Entrance exposure (mR)
- Exposure -Area Product (Rcm<sup>2</sup>)
- Current -Time Product (mAs)

[Input dose quantities are for measurements without BSF]



Main menu

Change X-ray Spectrum

Open MC data for dose calculation



Print



Save As ...

X-ray tube potential: 76 kV      Filtration: 3.5 mm Al + 0 mm Cu  
 Anode angle: 15 deg

File: C:\simona\My Documents on D\Work related\Instalacionni programi\PCXMC\Probi\SkullPA.en2  
 Skull PA Phantom: Adult , Arms included. Simulation: Photons/Energy level: 20000 Maximum energy: 80 keV  
 Projection angle (LATL=0,PA=90,LATR=180,AP=270): 90.000 Obl. angle: 0.000  
 Field width: 18.00 cm and height: 24.00 cm FSD: 87.000 cm Ref.point (x,y,z[cm]): ( 0.000, 0.000, 84.000)  
 Phantom height: 170.000 cm and mass: 75.000 kg Scaling factors sx(=sy): 1.038 and sz: 0.952  
 Incident air kerma:..... 2.150 mGy Tube voltage: 76 kV Filter:.....3.5 mm Al + 0 mm Cu

Organs	Dose (mGy)	Error (%)	Organs	Dose (mGy)	Error (%)
Active bone marrow	0.061514	0.5	(Scapulae)	0.010409	13.1
Adrenals	0.000104	94.5	(Clavicles)	0.065534	11.7
Brain	0.466461	1.2	(Ribs)	0.008264	7.4
Breasts	0.000779	33.4	(Upper arm bones)	0.011181	10.0
Colon (Large intestine)	0.000004	94.5	(Middle arm bones)	0.000730	44.7
(Upper large intestine)	0.000008	94.5	(Lower arm bones)	0.000000	NA
(Lower large intestine)	0.000000	NA	(Pelvis)	0.000000	NA
Extrathoracic airways	0.194200	7.6	(Upper leg bones)	0.000000	NA
Gall bladder	0.000000	NA	(Middle leg bones)	0.000000	NA
Heart	0.000482	27.5	(Lower leg bones)	0.000000	NA
Kidneys	0.000005	100.0	Skin	0.107879	1.1
Liver	0.000133	31.9	Small intestine	0.000000	NA
Lungs	0.005458	6.1	Spleen	0.000680	44.5
Lymph nodes	0.109677	2.4	Stomach	0.000307	62.5
Muscle	0.027893	0.5	Testicles	0.000000	NA
Desophaqus	0.004156	32.2	Thymus	0.002391	49.7
Oral mucosa	0.313963	5.3	Thyroid	0.070377	12.2
Ovaries	0.000000	NA	Urinary bladder	0.000000	NA
Pancreas	0.000339	67.3	Uterus	0.000000	NA
Prostate	0.000000	NA			
Salivary glands	0.959532	2.4	Average dose in total body	0.070432	0.3
Skeleton	0.284885	0.5	Effective dose ICRP60 (mSv)	0.028110	1.6
(Skull)	1.690681	0.6	Effective dose ICRP103 (mSv)	0.035339	1.3
(Upper Spine)	1.620876	1.2			
(Middle Spine)	0.011954	8.5			
(Lower Spine)	0.000002	100.0	Abs. energy fraction (%)	40.679462	



# Our experience

- Patient dose data:
  - radiation output and exposure data – the method of choice
  - KAP – where available – supplementary data
  - TLD – in some cases
  - combinations
- › Calculation of effective dose for each patient
- › **Calculation of mean value of the effective doses for all patients and for given type of examination**

