Training course
DOSE DATAMED 2

Effective dose estimate
in **general radiography**

NCRRP
Simona Avramova-Cholakova

Effective dose

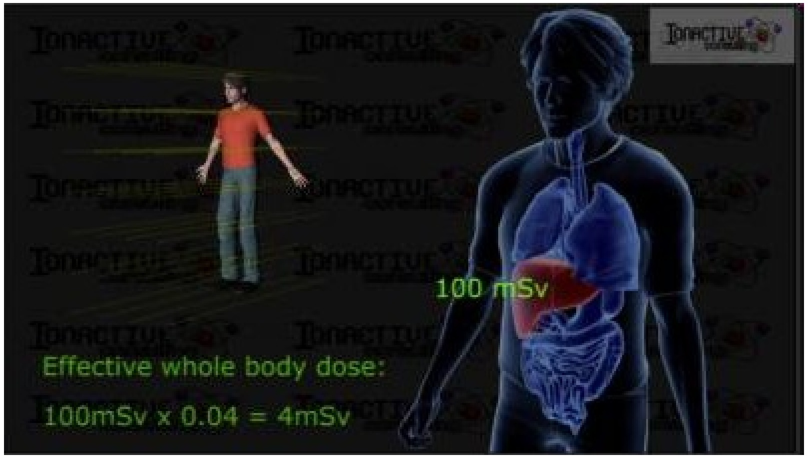
- Defined by ICRP – Publication 60, 1990
  Publication 103, 2007

- 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

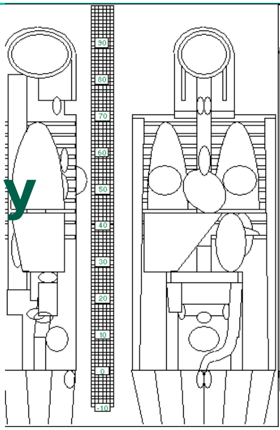
- National Research Centre for Environment and Health (GSF), Germany
  GSF-Bericht 11/90, Drexler et al. 1990:
  The calculation of dose from external photon exposures using reference human phantoms and MC methods

  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**

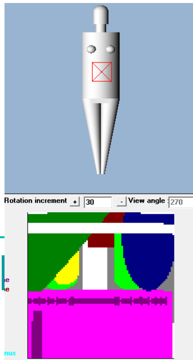
  similar reports for paediatric radiology and CT

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 ± 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 wi
  - x-ray spectrum: kVp, filtration, anode angle
  - patient dose data: IAK, KAP…

Our experience

- PCXMC - determination of effective dose for individual adult patients

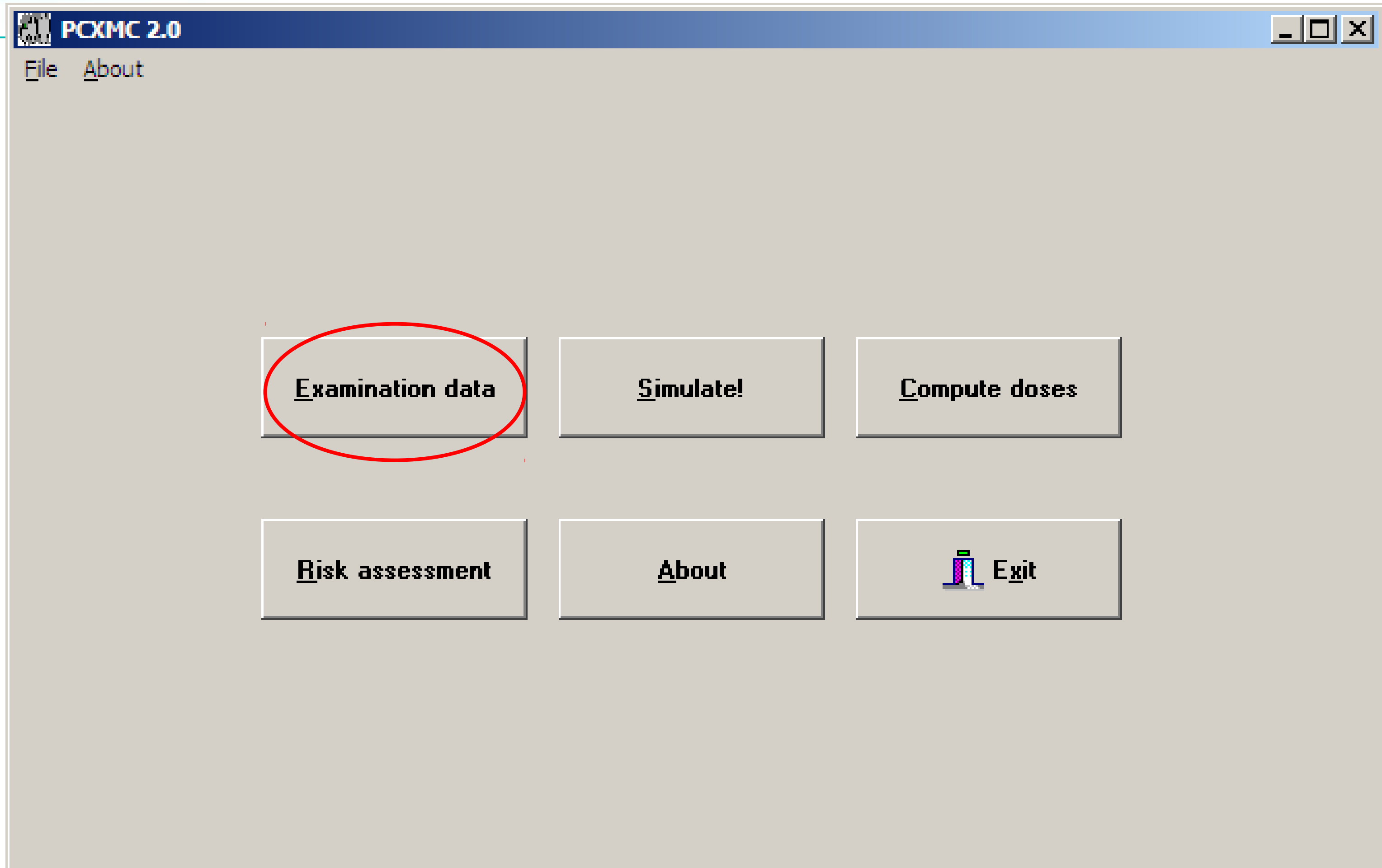
  National survey:
  - 46 x-ray units, 1600 patients (weight 50-100 kg)
  - skull, chest, lumbar spine, pelvis, urography

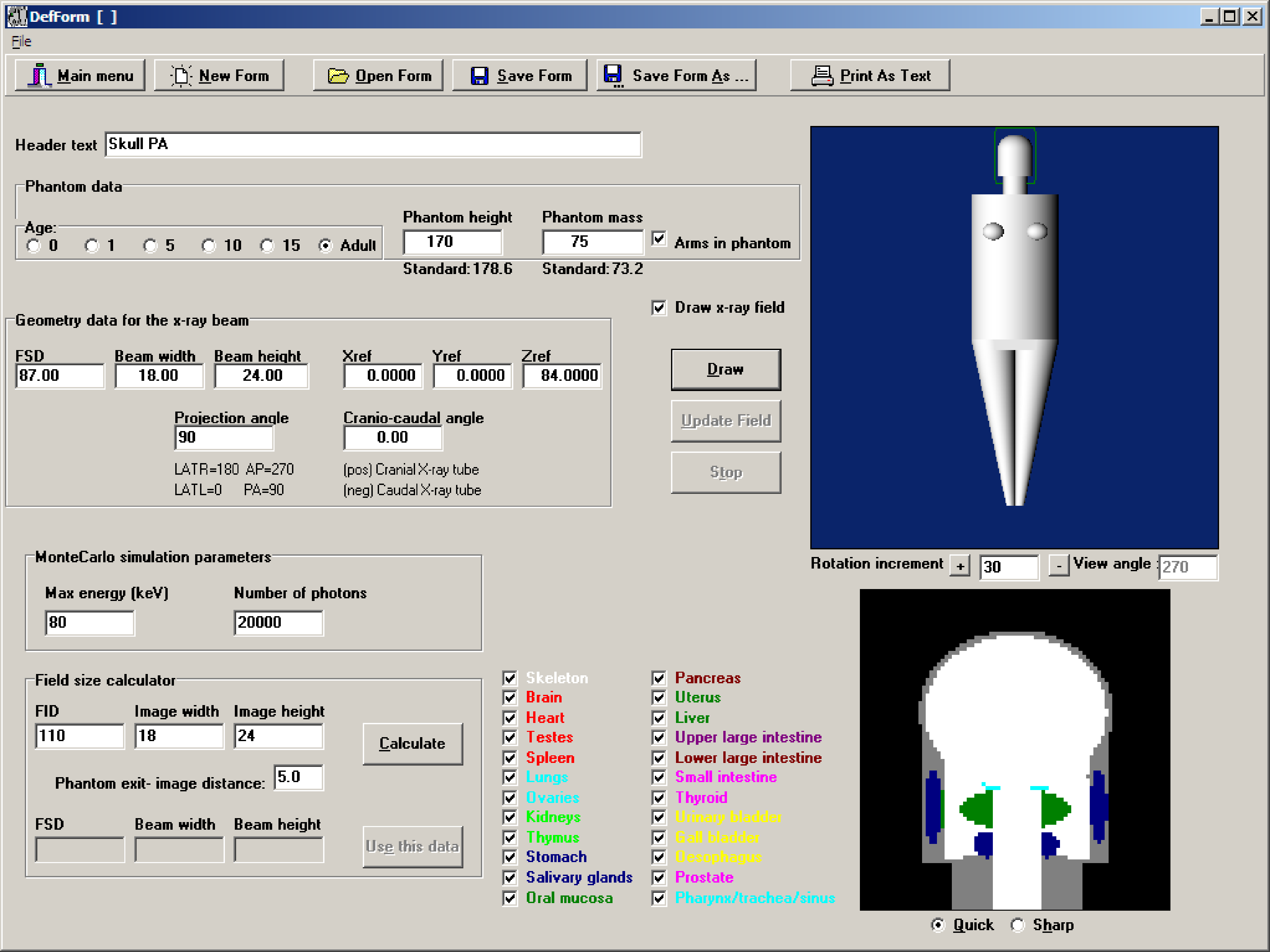
  › standard data sheets in each room
  › standard measurement procedures for each physicist

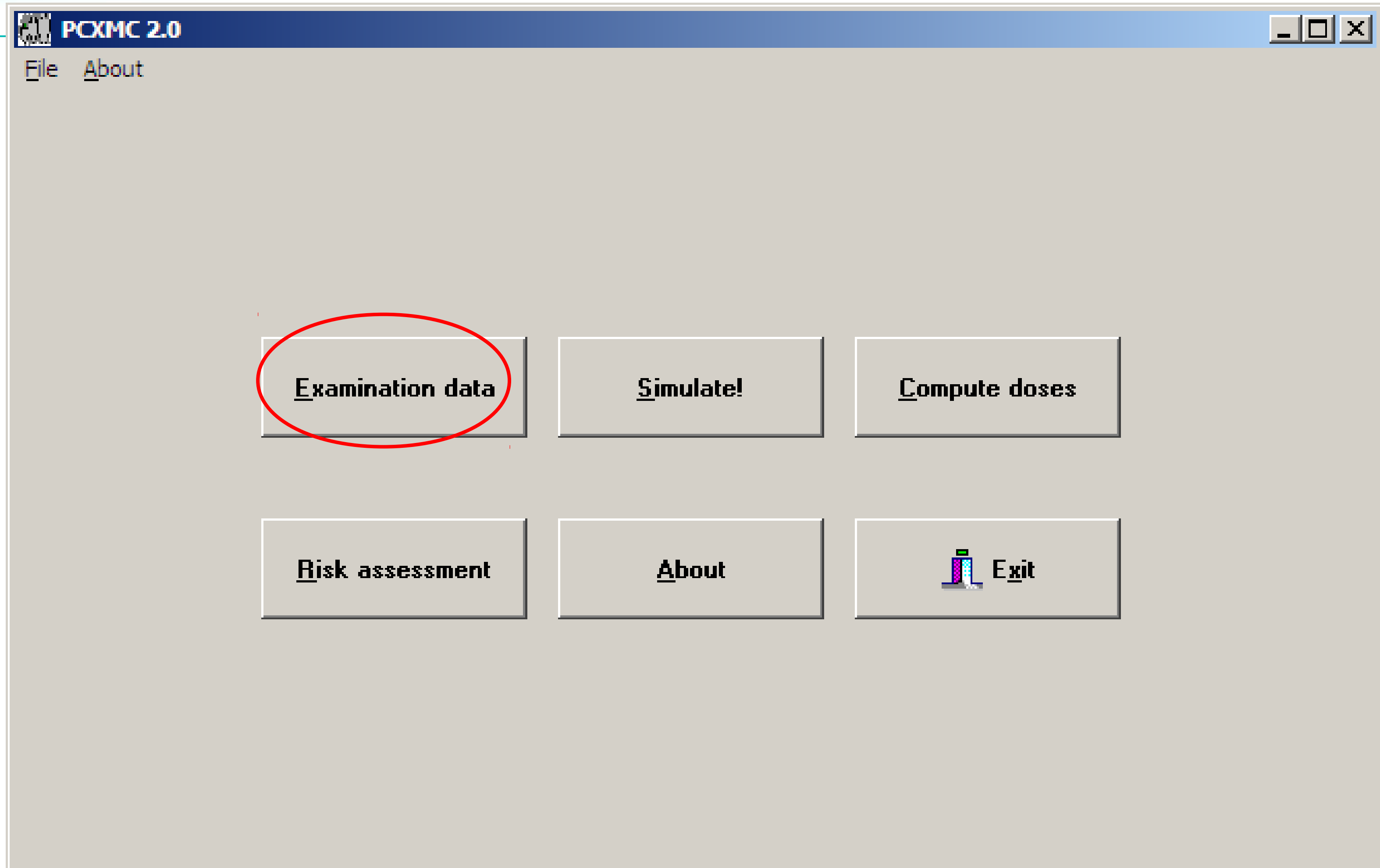
Our experience

- 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.


PCXMC 2.0
File
About
Examination data
Simulate!
Compute doses
Risk assessment
About
Exit


DefForm [ ]
File
Main menu
New Form
Open Form
Save Form
Save Form As ...
Print As Text
Header text
Skull PA
Phantom data
Age:
0
1
5
10
15
Adult
Phantom height
170
Standard: 178.6
Phantom mass
75
Standard: 73.2
Arms in phantom
Draw x-ray field
Geometry data for the x-ray beam
FSD
87.00
Beam width
18.00
Beam height
24.00
Xref
0.0000
Yref
0.0000
Zref
84.0000
Projection angle
90
LATR=180 AP=270
LATL=0 PA=90
Cranio-caudal angle
0.00
(pos) Cranial X-ray tube
(neg) Caudal X-ray tube
Draw
Update Field
Stop
Rotation increment
+
30
-
View angle
270
MonteCarlo simulation parameters
Max energy (keV)
80
Number of photons
20000
Field size calculator
FID
110
Image width
18
Image height
24
Calculate
Phantom exit- image distance:
5.0
FSD
Beam width
Beam height
Use this data
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
Oesophagus
Prostate
Pharynx/trachea/sinus
Quick
Sharp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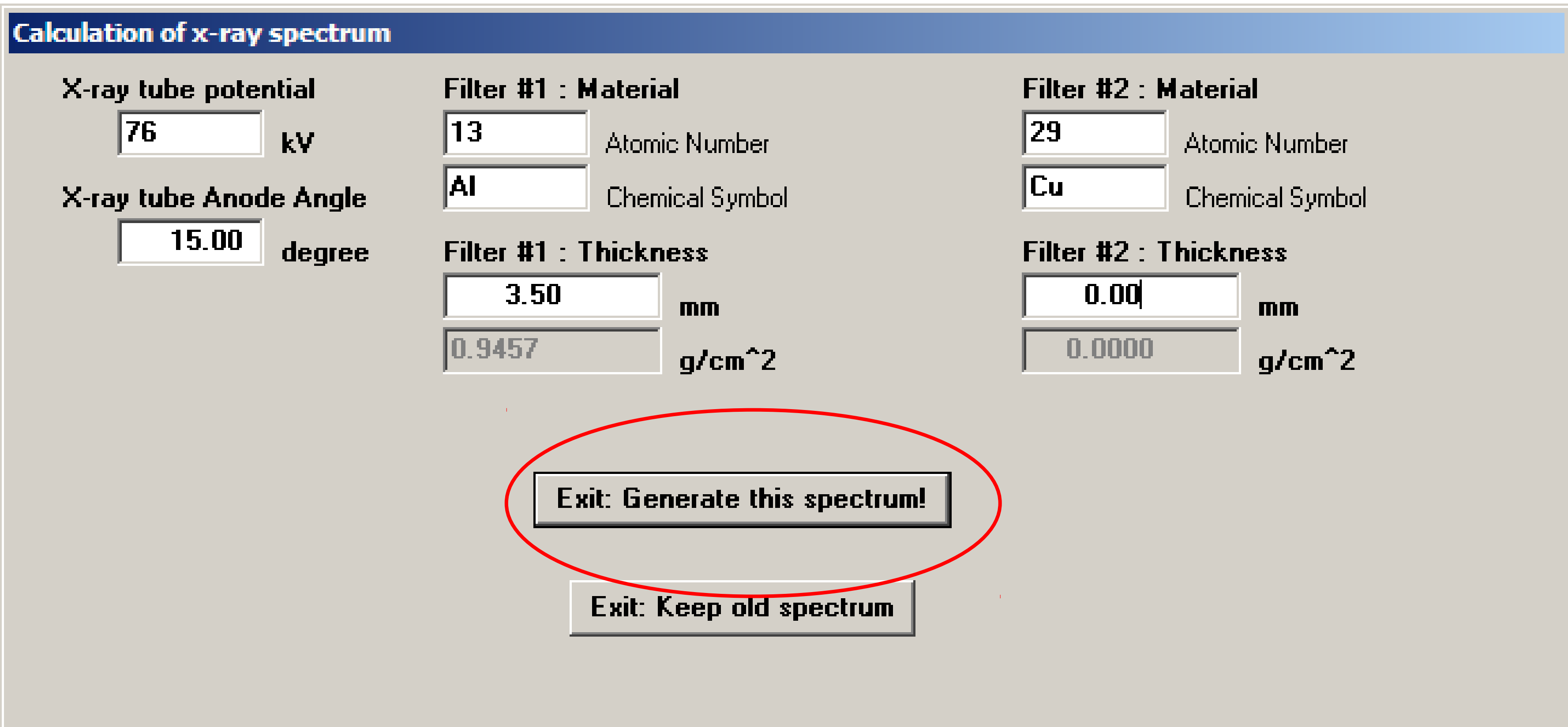
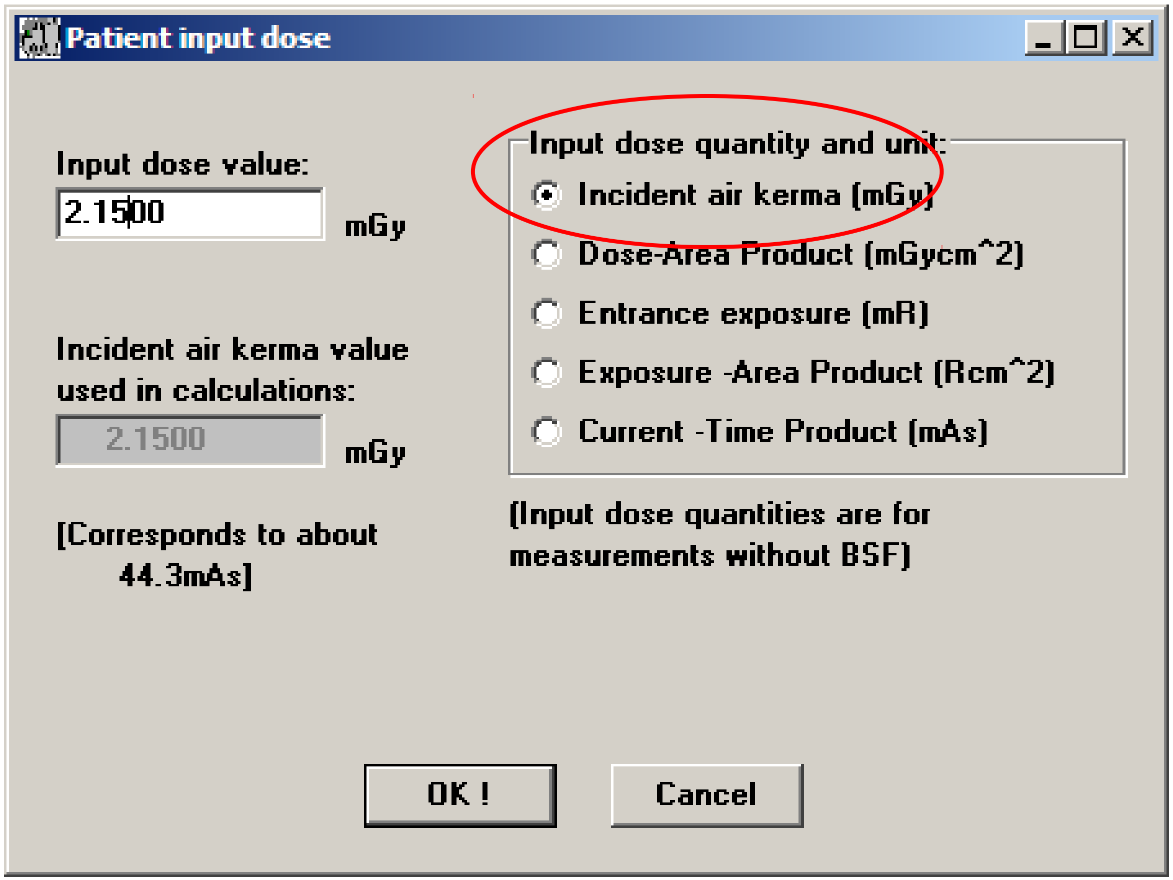

Calculation of x-ray spectrum
X-ray tube potential
76
kV
X-ray tube Anode Angle
15.00
degree
Filter #1 : Material
13
Atomic Number
Al
Chemical Symbol
Filter #1 : Thickness
3.50
mm
0.9457
g/cm^2
Filter #2 : Material
29
Atomic Number
Cu
Chemical Symbol
Filter #2 : Thickness
0.00
mm
0.0000
g/cm^2
Exit: Generate this spectrum!
Exit: Keep old spectrum


Patient input dose
Input dose value:
2.1500
mGy
Input dose quantity and unit:
Incident air kerma (mGy)
Dose-Area Product (mGycm^2)
Entrance exposure (mR)
Exposure -Area Product (Rcm^2)
Current -Time Product (mAs)
Incident air kerma value used in calculations:
2.1500
mGy
[Corresponds to about 44.3mAs]
(Input dose quantities are for measurements without BSF)
OK !
Cancel

PCXMC- Dose Calculation

File Run

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
Oesophagus	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**