

**Software ModeXR for Quality Control
of Radiation Processing**

User Manual

The program ModeXR consideration

The program **ModeXR** was designed specially for simulation of industrial radiation processes and calculation of the absorbed dose distribution within products irradiated by scanned X-ray (bremsstrahlung) beams on industrial radiation-technological lines (RTL) that is based on the pulsed or continuous type of electron accelerators in the energy range from 0.1 to 50 MeV .

A source of electron beam, a scanner, the X-ray converter with the cooling system, a conveyor line, an irradiated product and a package are considered in uniform self-consistent geometrical and physical models.

The software **ModeXR** provides the end-user with data sets in the graphic and tabular form for the X-ray energy spectrum generated in an X-ray converter, a dose distribution value, a temperature distribution within the objects irradiated by a scanned X-ray beam with energy from 0.1 up to 50 MeV.

The ModeXR contains a set of tool means for the comparative analysis of the obtained data for absorbed dose of X-ray beams. Service blocks of the program, in reporting forms, give the user the necessary and sufficient information for decision-making at:

- the choice of optimum conditions, parameters and operating modes of the radiation facility;
- the configuration of the irradiated objects with taking into consideration of features irradiated materials;
- the organizations of a dosimetric control during materials processing;
- the confirmation of a correctness (verification) of results of the carried out irradiation.

The feature of the software ModeXR is unique high running speed of calculation schemes.

It is reached due to :

- The use of a forced method for process of producing X-ray on each step of design of electron track in a construction of the X-ray converter.
- The automatic choice of self-consistent parameters is used for simulation of an electron - photon shower. The choice is based on determination a minimum machine time for obtaining given accuracy.

These parameters are the following: cutoff energy for modeling of an electron track, threshold energy of catastrophic electron-electron collisions, cutoff

energy for modeling of a photon track, threshold angle of grouping electron collisions for modeling of scattering.

- The use of both a simple estimation (collision method) and the special estimation (method of crossing area) for the dose calculation.

At implementation of the simulation MC methods the specially designed schemes which allow to reduce a running time for receiving of the end results in about hundreds time were applied.

The software **ModeXR** works on platform Windows98/Me/NT/XP/2000. The software has intuitively clear interface of the end-users. Language of the interface - English. Demo versions are accessible on request.

The software **ModeXR** takes into account the features of two modifications of geometrical model for system of EB scanning with vertical ModeXR-v and horizontal ModeXR-h locations.

Input data for the program **ModeXR** are the following:

- **Parameters of electron beam**: average beam current, or pulse duration and repetition frequency in pulsed accelerators, electron energy spectrum, beam diameter and spatial distribution of the beam intensity.

- **Parameters of scanning system**: modes of operation, the triangular or non-diverging irradiation treatment field in target material; form of current in magnet of scanning system; repetition frequency of scanning; angular distribution of electron beam at the outlet of a scanning system; parameters of the exit window for electron beam.

- **Parameters of the X-ray converter with cooling system**: geometrical characteristics of the X-ray converter with cooling system, thickness of plates (layers) and cooling agent, materials composition, distance between exit window and X-ray converter.

- **Parameters of conveyor line**: speed and geometrical characteristics of the line.

- **Parameters of irradiated product**: geometrical characteristics of the irradiated product; elemental composition of the target material and weight concentrations of component; material and size of the covering for irradiated product.

- **Regimes of irradiation**: one- and two-sided irradiation.

Some problem tasks of the program **ModeXR** are as follows:

- calculation of the different construction variants of X-ray converter with cooling system on its conversion efficiency from electron beam to X-rays versus materials composition and thickness of converter plates and cooling agent;
- calculation of the optimum thickness of the converter plates;
- simulation of the X-ray energy spectrum;
- simulation of the absorbed dose and temperature distribution within irradiated products,
 - calculation of the optimum product thickness at double treatment of the irradiated materials from opposite sides, and dose uniformity ratio;
 - calculation of the X-ray utilization efficiency in the irradiated products, electron beam power utilization, and
 - calculation of other important characteristics of X-ray-product interaction for economic evaluation of X-ray processing.

Geometrical models of radiation facility with X-ray converter and moving conveyor for simulation X-ray processing

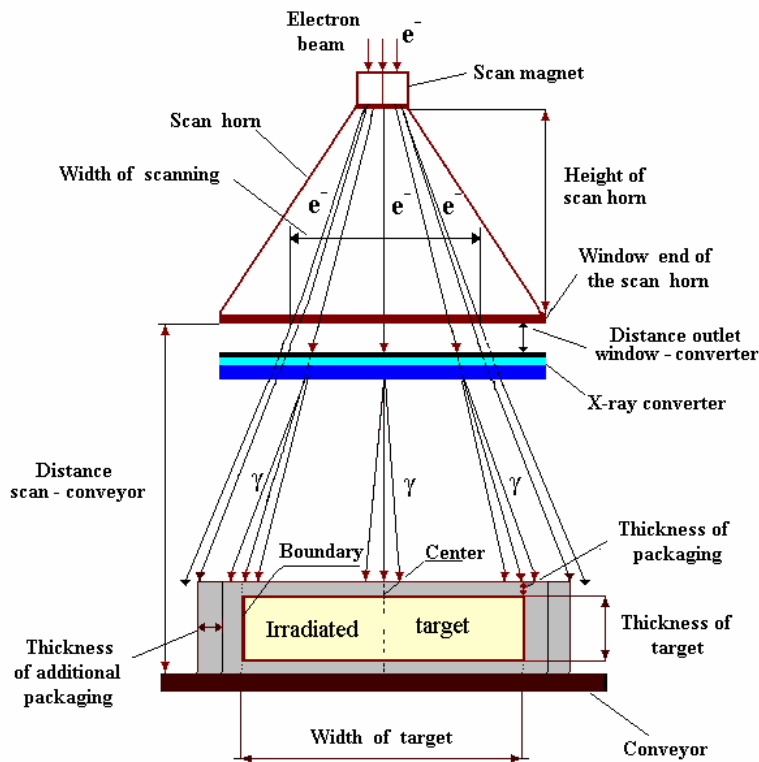


Fig.1. Scheme of radiation facility with X-ray converter, cooling system and moving conveyor for triangular scanned EB.

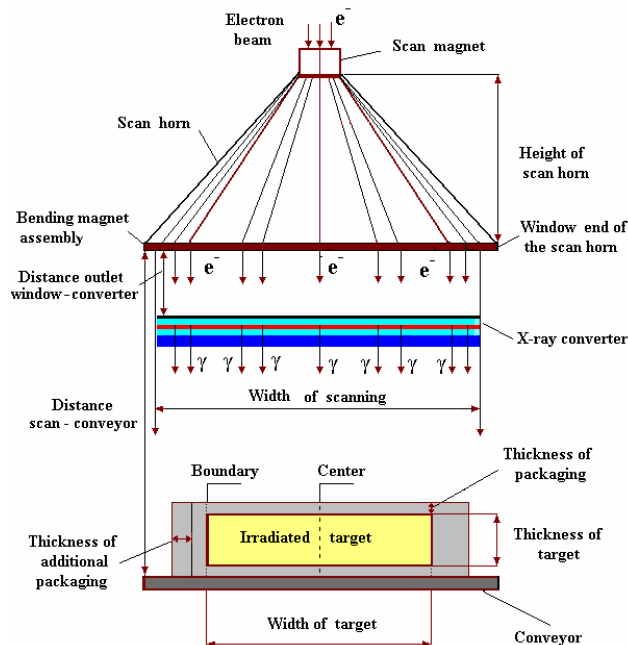


Fig.2. Scheme of radiation facility with X-ray converter, cooling system and moving conveyor for non-diverging (parallel ray) scanned EB.

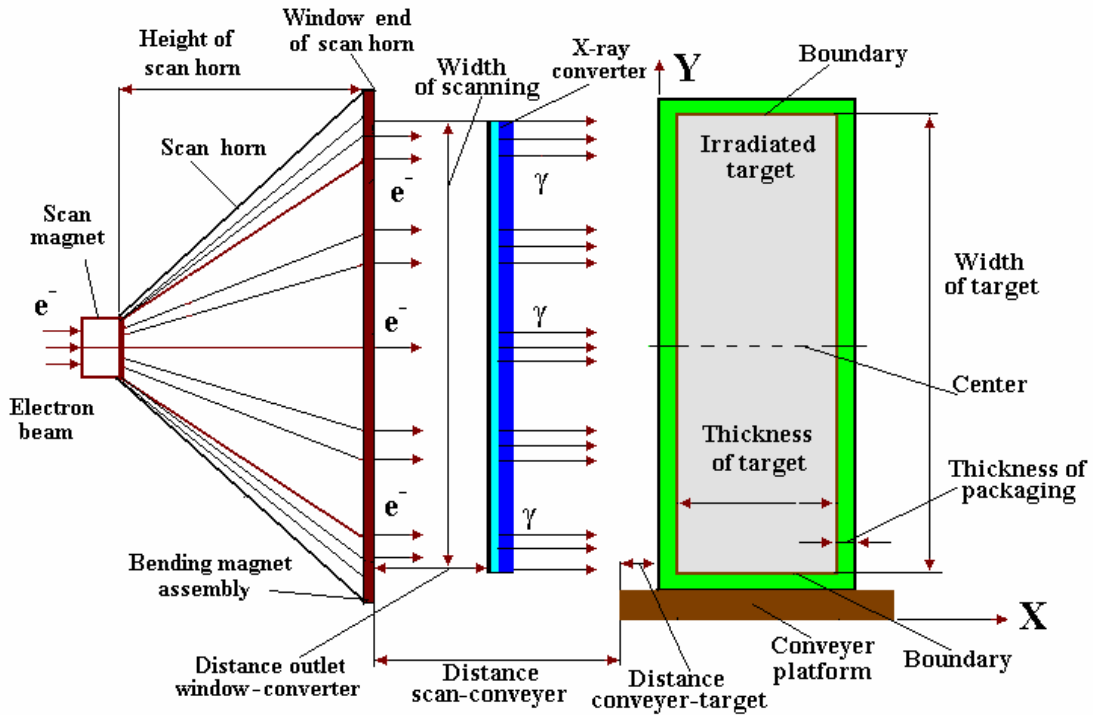


Fig.3. Scheme of radiation facility with X-ray converter, cooling system and moving conveyor for non-diverging (parallel ray) scanned EB.

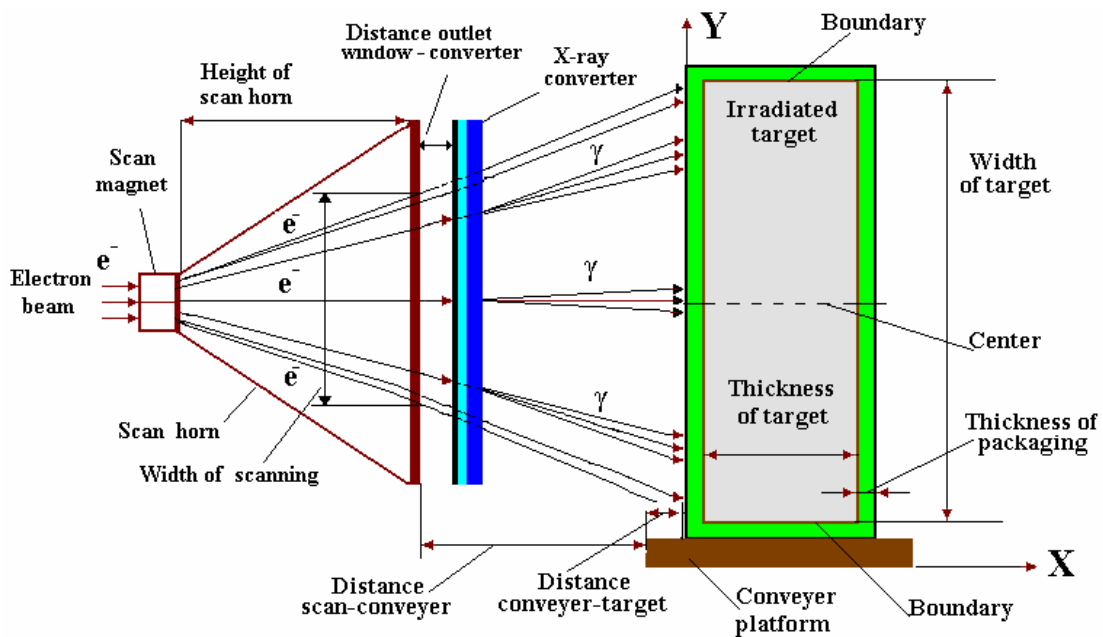


Fig.4. Scheme of radiation facility with X-ray converter, cooling system and moving conveyor for triangular scanned EB.

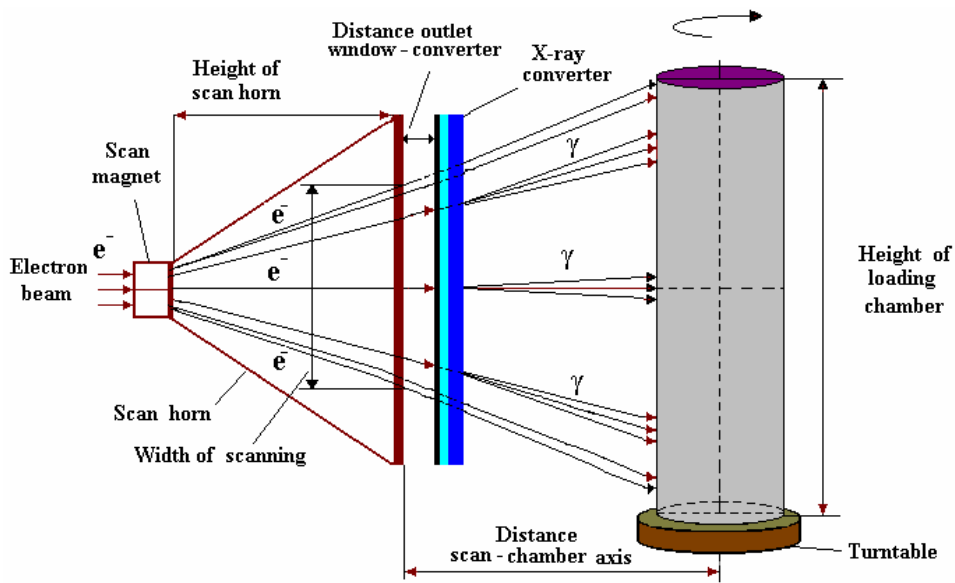


Fig.5. Scheme of X-ray irradiator with turntable loading chamber for triangular scanned EB.

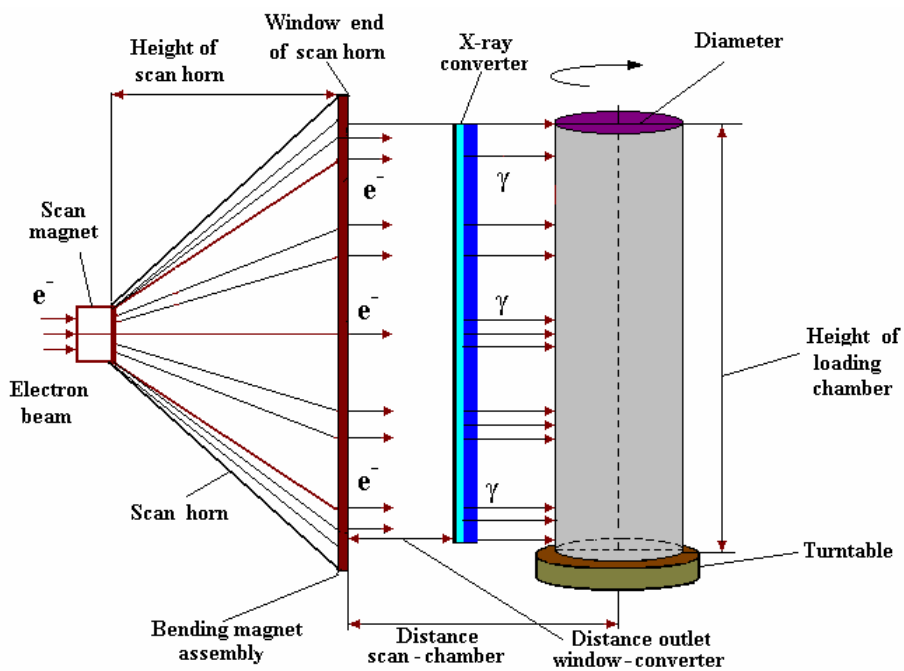


Fig. 6. Schemes for X-ray irradiator with turntable loading chamber for non-diverging (parallel ray) scanned EB.

How to get results. Software ModeXR.

Introduction

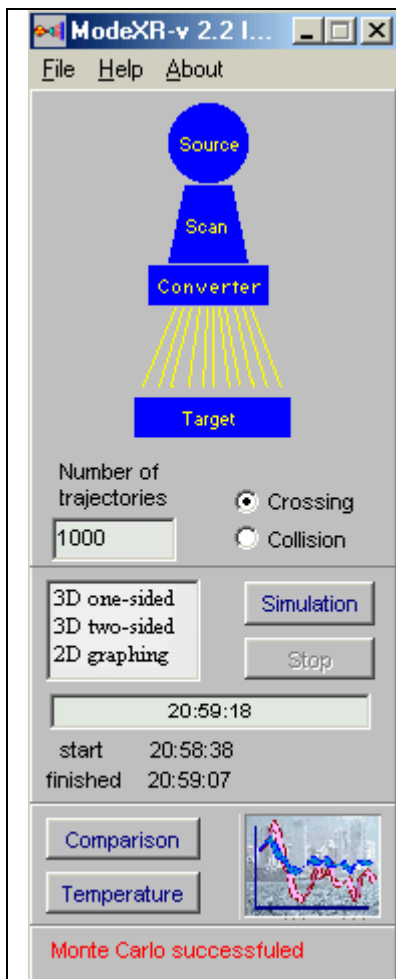


Fig.1. The main form of the **Software ModeXR**

ModeXR consists from three thematic modules and service blocks. (See Fig.1). Every module carries out own specific function, but all blocks are interrelated.

- “**Monte Carlo**” (MC) simulation module is intended for exact calculations of an **X-ray absorbed dose** in an **irradiated target**.
- “**Comparison**” module is intended for scientific analysis and comparison calculated and prepared experimental data for the **2D dose distributions**.
- **Temperature** module is intended for analysis of the temperature fields during heating and cooling of an irradiated volume.

For work with **software ModeXR** -

- Click the "File" then "Open configuration", then select "irradiating system" and load the file "Test.rts".
- Again click the "File" then "Open configuration", then select , "irradiated target" and load the file " Test.rtt".
- Again click the "File" then "Open configuration", then select, "converter" and load the file " Test.rtc".

Note. Only after download " Test.rts", " Test.rtt" and " Test.rtc" files, user can change all characteristics of X-ray facility and irradiated target for simulation X-ray processing.

If all input data are saved, color of the scheme item changes to blue.

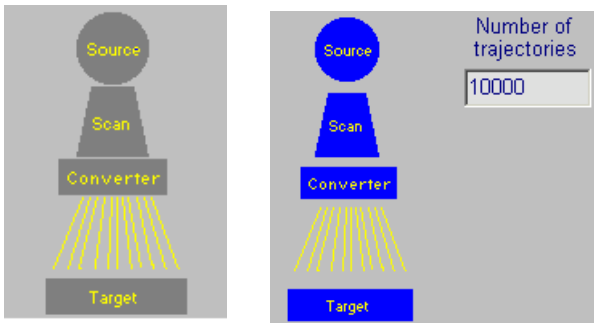
- Enter the "Number of trajectories" and
- Click the button "Simulation".

At this point the **Software ModeXR** shows starting time and defines time required for calculation.

- Click "Stop" to interrupt your calculation and reenter data.
 - When MC simulation will be ended successfully, the list of results modes will be opened.
- You can select item and work with results.

Input data

1. Source



• Click “**Source**” in the Scheme of **MC Module**. (See Fig.1.1. a).

The main form for **Source** – Electron Accelerator parameters will be opened. (See Fig.1.2).

Fig.1.1. a, b. Scheme of MC Module

Energy	Insens.
8,000	0,000
10,000	1,000
10,800	0,000

Angle	Insens.
0,000	1,000
6,000	1,000

Fig.1. 2. The main form of “**Source**” for input data and correction of an Electron Accelerator parameters.

Beam current

The frame **Beam current** contains some fields.

There are two regimes for input data: “**Pulsed regime**” and “**Average current**”.

- Click the “**Pulsed regime**” by a tick, to work with **Pulsed regime data**.
- Enter the values **Impulse current in A**, **Impulse time in msec**, **Repetition frequency in Hz**.
- Delete a tick from window “**Pulsed regime**”, to work with “**Average current**” mode.

- **Enter** the value of **Average current in mA**.

Fields for **EB energy** are placed into the frame **Spectrum**.

- **Click** the field "**MonoEnergy**" with a tick, to work with **MonoEnergy** mode.
- **Enter** a value of the **Energy**.

EB energy spectrum

- **Click** the field "**Spectrum**" with a tick, to work with **EB energy spectrum** mode.
- **Enter** a rows number in the table, **Click button "Correct table"**.
- **Enter** or edit table data.

A left mouse button allows to insert a row in the table or delete selected row. When rows number is changed by left mouse button, the field **N rows** will change accordingly. At this point **Energy** field will be inaccessible.

Angular spread

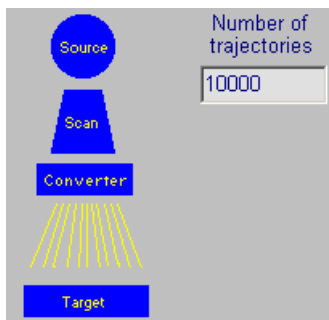
- **Click** the field **MonoDirect** by a tick, to work with **MonoDirect** mode.
The target will be irradiated with non-divergent scanned electron beam.
- **Click** the field **Angular spread** by a tick, to work with **Angular spread** mode.
- **Enter** a rows number in the table, **Click button "Correct table"**.
- **Enter** or edit table data for the beam angle spread.

You work with this table by analogy with the table of EB energy spectrum.

- **Enter** data of space spread, to work with the frame **Space spread**.
- **Click** the field "**Point beam**" by a tick, to work with **Point beam** mode.
- **Click** the field "**Distributive beam**" by a tick, to work with **space spread** mode.
- **Enter** data of **Beam diameter** in cm and **Full width on half maximum** in cm.
- **Click** the button "**Save data and close this window**".

Image of "**Source**" in the Scheme of Monte Carlo Module change into blue color. (See Fig.1.1. b).

2. Scanner



- Click “**Scan**” in the Scheme of Monte Carlo Module. (See Fig.2.1). The main form for **Scanner** and **Conveyer** parameters will be opened. See Fig.2.2.
- Enter the values of **Speed** in **cm/sec** and **Width** in **cm** in the frame **Conveyer**.
- Enter the values of **Frequency** in **Hz** and **Height** of scan horn in **cm** in the frame **Scanning horn**.

Fig.2.1. Scheme of MC Module

The screenshot shows the 'Scanning system' parameter form. It is divided into several sections:

- Conveyor:** Speed (cm/sec) set to 1, Width (cm) set to 100.
- Scanning horn:** Frequency (Hz) set to 3, Height (cm) set to 100.
- Regimes of scanning:** Checkboxes for 'Non-diverging beam' (unchecked) and 'Triangular scanning' (checked). Below are checkboxes for 'Default mode' (unchecked) and 'Custom mode' (checked).
- Geometry:** Distance scan-conveyor (cm) set to 60, Width of scanning (cm) set to 50, X displacement (cm) set to 10, and Y displacement (cm) set to -5.
- Regimes of scanning (table):** A table with 'N Rows' set to 3. The table has columns 'Time' and 'Current'.

Time	Current
0	-1
1	0
2	1

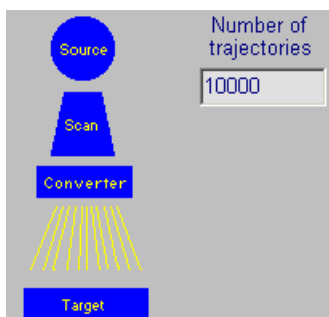
 A 'Correct table' button is located next to the 'N Rows' field. At the bottom right, there is a 'Save data and close this window' button.

Fig.2.2. The main form for the **Scanner** and **Conveyer** parameters.

- Enter the values of **Distance scan-conveyor** in **cm** and **Width of scanning** in **cm** in the frame **Geometry**.
- Enter the value “**X angle of target**” in degree.
The target will be placed on moving conveyer under **inclination angle X** (in **direction of EB scanning**) relatively axis of incident electron beam.
- Click the field “**Non-divergent beam**” by a tick, to work with **parallel ray** scanned electron beam.
The target will be irradiated with non-divergent scanned electron beam.
- Click the field “**Triangular scanning**” by a tick, to work with **triangular** scanned electron beam.
The target will be irradiated with triangular scanned electron beam.
- Click the window “**Default mode**” by a tick, to work with **linear time-current curve** in scan magnet (saw-tooth form of current).

- Click the window “**Custom mode**” by a tick, to work with the **nonlinear time-current curve**.
 - **Enter** a rows number of the table.
 - Click the button “**Correct table**” and work as well as with tables for an electrons source. The values of **time** and **current** are dimensionless.
 - Click the button “**Save data and close this window**”.
- Image of “**Scan**” in the scheme of MC Module change into **blue color**.

3. Converter



- Click “**Converter**” in the Scheme of Monte Carlo Module. The main form for **Converter** parameters will be opened. See Fig.2.

Fig.3.1. Scheme of MC Module

The screenshot shows a software window titled "Input data for a Bremsstrahlung radiation (ModeXR)". It contains several input fields and a table. The "Input characteristics for dosimetry" section includes:

- Distance between converter and scan: 1
- Film width: 5
- Film length: 25
- Number of splittings on width: 10
- Number of splittings on length: 50

 Below this is a table with 5 columns (Layer 1 to Layer 5) and 4 rows (Thickness [cm], Density [g/cm3], Material, Layer). The "Material" row is expanded to show Z and W values for each layer.

Elements	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5					
Thickness [cm]	0.1	1	0.1							
Density [g/cm3]	19.3	1	7.8							
Material	Z	W	Z	W	Z	W	Z	W	Z	W
Layer	74	1	1	2	26	1				
			8	16						

At the bottom of the window is a button labeled "Save data and close this window".

Fig.3.2. The main form for data input and correction of the **Converter parameters.**

X-ray converter has multi-layer structure. The numbers of flat layers are in the range from 1 to 5.

The functions of layers are as follows:

- 1st plate has function as **X-ray converter plate**,

- 2nd and another plates have functions as **cooling agent** and
- **backing plate** for absorbing of electron beam.

- **Click** on layer 1 or 2 or 3 or 4 or 5.

In this point the column of corresponding layer will be activated and in the **Layer** field will be shown the layer number that will be corrected. Instead you can type the layer number in **Layer** field.

- **Enter** for this layer material: **Thickness** layer, **Density**, atomic number **Z**, and **W** ("weight part").
- **Enter Z** and **W** for each element of compound and mixtures .
- **Enter** values of **Distance between converter and scan in cm**.
- For clear data in selected layer, **enter** layer number in the **Layer** field and click the **Clear layer**

Input characteristics for film dosimetry

- The window for X-ray converter input data has an additional option **Input characteristics for dosimetry** . See Fig.3.3.

Fig.3.3. Window "Input characteristics for dosimetry".

This option is intended for entering data of geometrical characteristics for a thin film layer located near the surface of target irradiated with scanned X-ray beam.

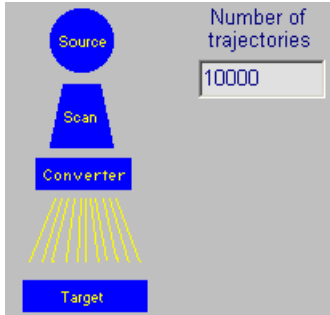
- **Film width** is the 1/2 width of film in a direction of the conveyer motion,
- **Film length** - the 1/2 length of film in a direction of electron beam scanning.
- The material of a film layer equal to material of an irradiated target in case of absence of a cover box, or to material of a cover box if it is present.
- **The film layer is used for simulation of X-ray dose rate distribution (kGy/sec) on the surface of target/cover box irradiated with scanned X-ray beam.**
- To work with **Input characteristics for dosimetry**, enter the values data: **Film width in cm, Film length in cm, and Number of splittings "on width" and "on length"**.

- **Click** the button **"Save data and close this window"**.

Image of **"Converter"** in the Scheme of MC Module change into **blue color**.

4. Target

4.1. Input data for Target and Cover



- Click “**Target**” in the Scheme of MC Module (See Fig.4.1).

The form for entering of **input data** for irradiated **Target (Irradiation object)** and **Packing materials (Cover)** will be opened (See Fig.4.2).

Fig.4.1. Scheme of MC Module

The screenshot shows a software window titled 'Target' with two main sections: 'Irradiation object' and 'Cover of irradiation object'.
Irradiation object section:
 - Density (g/cm³): 1
 - Thickness (cm): 50
 - Width (cm): 50
 - Material list: Polyethylene, Polystyrene, Polymethylmethacrylat, Carbon, Birchwood, Cellulose (highlighted), Soft Tissue, Water, Teflon, Aluminum, Iron, Another material.
 - Radio buttons: List, Table.
 - Rows: 3
 - Table:

A number	W part
1	10
6	72
8	80

Cover of irradiation object section:
 - Density (g/cm³): 7.8
 - Cover thickness (cm): 0.1
 - Additional cover (cm): 0
 - Radio buttons: List, Table, Opened cover.
 - Button: Correct table for a cover
 - Rows: 1
 - Table:

A number	W part
26	1.00

 At the bottom right, there is a button labeled 'Save data and close this window'.

Fig.4.2. The form for entering of **input data** for an irradiated **Target (Irradiation object)** and **Packing materials (Cover)**.

4.2. Target model

Figs.4. 3 (a), (b), (c), and (d) demonstrate the different models for irradiated target within package which are used by the ModeXR programs for simulation X ray processing.

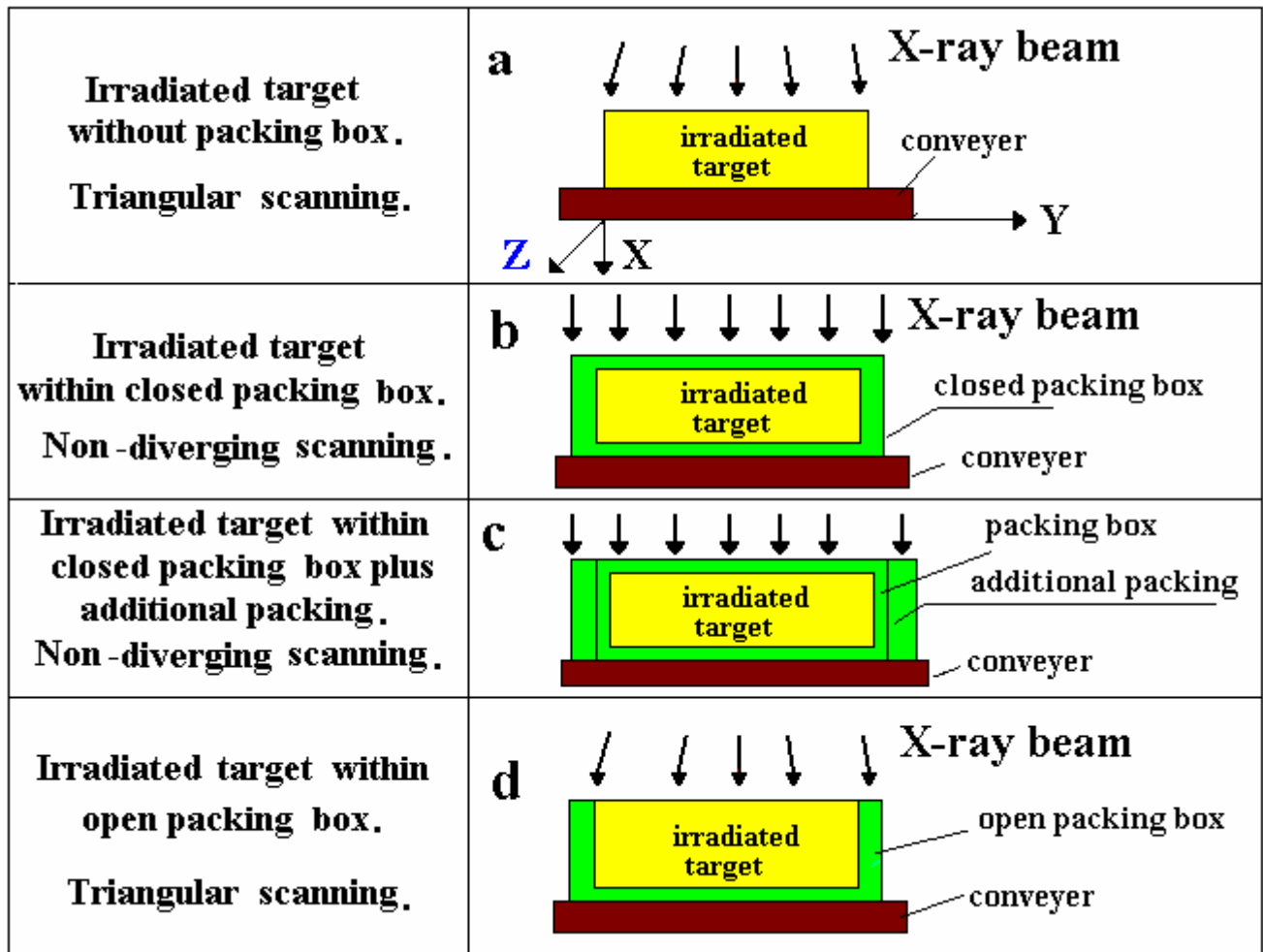


Fig.4.3. Geometrical models of irradiated targets and packing placed on moving conveyer and irradiated with X ray beams.

- The target on a conveyer line was represented as a parallelepiped unlimited on length along a motion of the conveyer (axis Z). X-ray beam scans along axis Y.
- The material of the target is homogeneous.
- The target can be located on the conveyer platform **with/without packing box.**
- The target on moving conveyer can be oriented in parallel or under arbitrary angle in respect to electron beam axis in plane of scanning XY or in plane of conveyer travel XZ

4.3. Input data for Target size and Target materials

- Enter the **"Width of target"** in cm (left up corner in the **"Target"** frame) (See Fig.4.2).
- Enter the **"Thickness"** in cm.
- Enter the **"Density of materials"** in g/cm^3 .
- Select a **material** for the **"Target"** from the **"List of material"** (right up corner in the **"Target"** frame). The **atomic number Z** and the **atomic weight W** of the material appear in the corresponding boxes.
- Select the button **"Another material"** for materials not given in the **"List of material"**.
- Enter the values of **Z** and **W** for **another material**.
- To enter the values of **Z** and **W** for **compounds and mixtures**, Click the window **"Table"** (right up corner in the **"Target"** frame) (See Fig.4.2). The frame **"Correct table for object"** will be opened (See Fig.4. 4).

A number	W part
1	8.6
7	16.4
8	68
13	7

- Enter the necessary number **N constituent elements** for compounds and mixtures in window **"Rows"**.
- Click the button **"Correct table for object"**. The table with **N** rows will be opened.
- Enter the **atomic number Z_i** and the **atomic weight W_i** for **i^{th} constituent elements**.

Fig.4.4. Frame **"Correct table for object"**.

4.4. Input data for cover size and cover materials

- Enter characteristics for the **"Cover Box"**: **"Cover thickness"** in cm, **"Additional cover thickness"** in cm, and **"Density of cover materials"** in g/cm^3 .

Note. In the case of **cover thickness = 0**, the target has not a **Cover Box**.

- Select a **material** for **cover materials** from the **"List of material"** (right down corner in the **"Target"** frame).

The **atomic number Z** and the **atomic weight W** of the material appear in the corresponding boxes.

- Enter the values of **Z** and **W** for materials not given in the **"List of material"**. The selection button changes to **"Another material"**.

- Target can be irradiated by incident **X-ray beam** either in **closed or open** (Click the window "**Opened cover**") **Cover Box**. (See Fig.4.2).
 - **Click** the button "**Save data and close this window**".
- Image of "**Target**" in the Scheme of MC Module change into **blue color**.

4.5. Start calculation

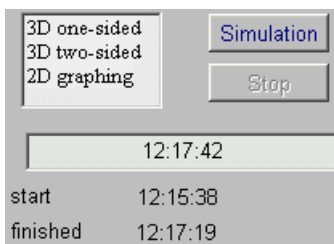
After loading all input data for EB radiation facility and irradiated target,

- **Enter** the "**Number of trajectories**".
- **Select** the mode of calculations "**Crossing**" or "**Collision**". (Default mode is "**Crossing**").
- **Click** the button "**Simulation**".



The **Software ModeXR** will show starting time and define time required for calculation. (See Fig.4.5).

Fig.4.5. Frame simulation.



- **Click** "**Stop**" to interrupt calculation and reenter data.
- When MC simulation will be ended, the list of results will be opened.

You can select item and work with results. (See Fig.4.6).

Fig.4.6. Frame with simulation results.

5. Output data.

5.1. MC module.

After finish **Simulation**, **Select** the result in the frame "**simulation results**" (See Fig.4.6).

There are **three variants** for selection:

- **Select** "**2D graphing**" - The form "**Dose plots**" after MC simulation will be opened (see Fig.5.1.).

There are data:

- for analysis of the **2D X-ray absorbed dose distributions** for irradiated target with package **under one/two-sided** in graphical and tabular forms.
- for analysis of the X-ray spectrum from X-ray converter.
- **Select “3D one-sided”** - The form **“one-sided dose map”** after MC simulation with **3D view** of the **X-ray absorbed dose distribution** for irradiated target with package irradiated **under one-sided** in graphical and tabular forms will be opened (see Fig.5.2 a).
- **Select “3D two-sided”** - The form **“two-sided dose map”** after MC simulation with **3D view** of the **X-ray absorbed dose distribution** for irradiated target with package irradiated **under two-sided** in graphical and tabular forms will be opened (see Fig.5.2 b).

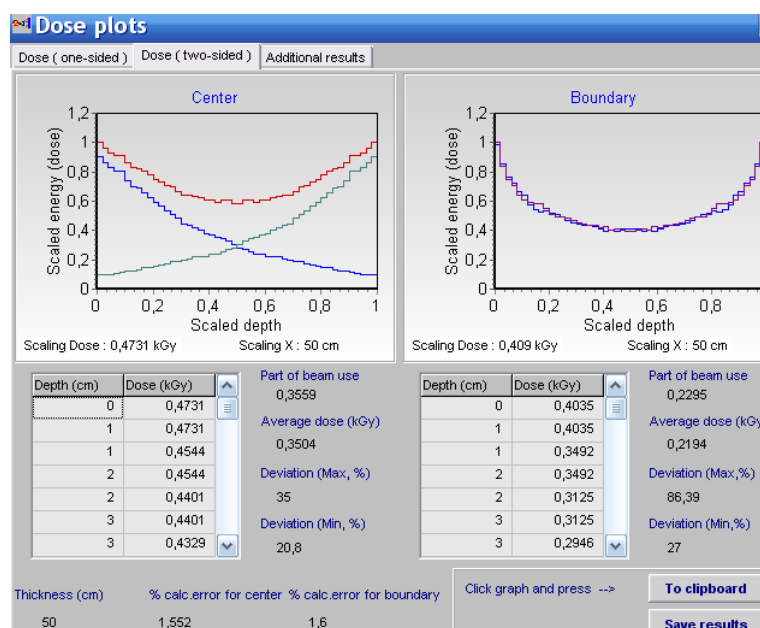


Fig.5.1. 2D view of the absorbed dose distributions under two-sided irradiated target with package in graphical and tabular forms.
Left graph - **2D depth dose distribution** in the target **Center**.
Right graphs - **2D depth dose distributions** near the **Boundary** of the irradiated object with packing material.
Blue curve near the boundary from **left side**, **violet curve** near the boundary from **right side** in direction of EB scanning.

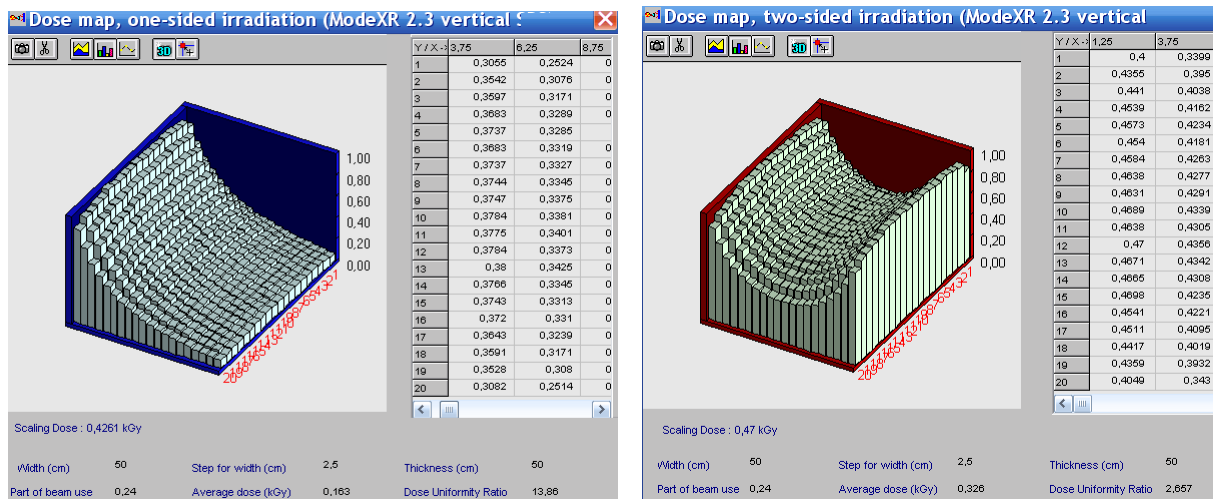


Fig.5.2 a, b. 3D view of the absorbed dose distribution for irradiated target with package.

- a) under one-sided irradiated target,
- b) under two-sided irradiated target.

- Additional information related to absorbed dose distributions are presented in this form:
 - Dose uniformity ratio
 - Average dose
 - Dose minimum
 - Dose maximum
 - Statistical uncertainty
 - Part of beam use.

5.2. Output Data for X-ray spectrum

- Click the button "Additional results" in the form "Dose distributions after MC simulation" (see Fig.5.1).
- The form with X-ray spectrum generated with 5 MeV electron beam in Tantalum converter (see Fig.3.2) in graphical and tabular form will be opened (see Fig.5.3).

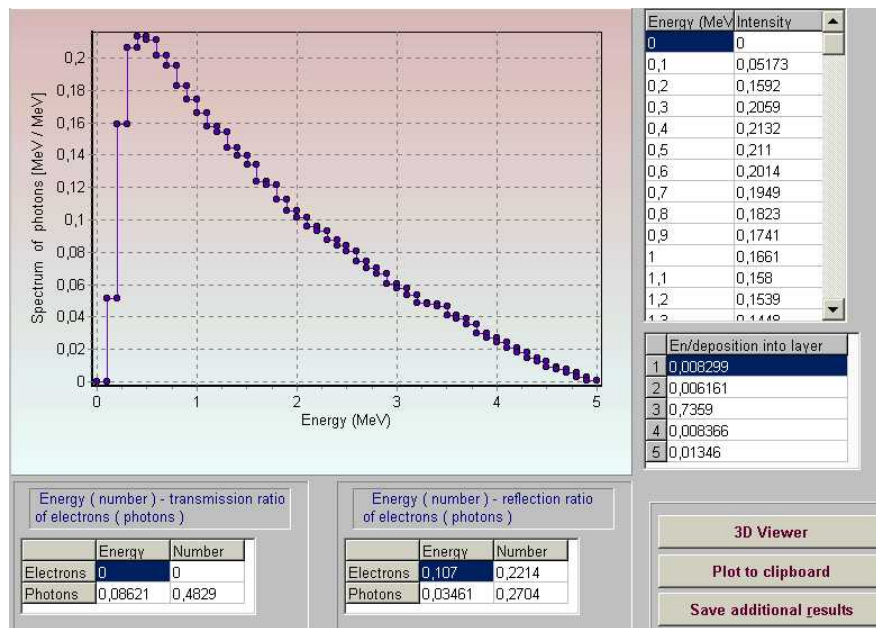


Fig.5.3. X-ray spectrum generated with 5 MeV electron beam in Tangsten converter. The X-ray yield in the forward direction for 5 MeV electron is 8.62%.

Additional results:

- Energy transmission ratio of incident electrons into energy of photons/electrons.
- Energy reflection ratio for photons/electrons.
- Energy deposition in each layers of converter construction.

6. Analysis and comparison of simulation results

Module “**Comparison**” is intended for the scientific analysis and comparison of calculated and experimental data of 2D absorbed dose distributions in the target irradiated with X-ray beam.

- Click the button “**Comparison**” in the Main form of the **Software ModeXR** (See Fig.1). The form of “**Comparison of calculated curves**” will be opened for analysis of calculated and experimental data of 2D absorbed dose distributions in an irradiated target (See Fig.6.1).
- Click the button “**One-sided/Two-sided**”. The graphs for the **2D dose distribution curves** at **one- or two-sided** irradiation of target will be appeared in the graph area. (See Fig.6.1).

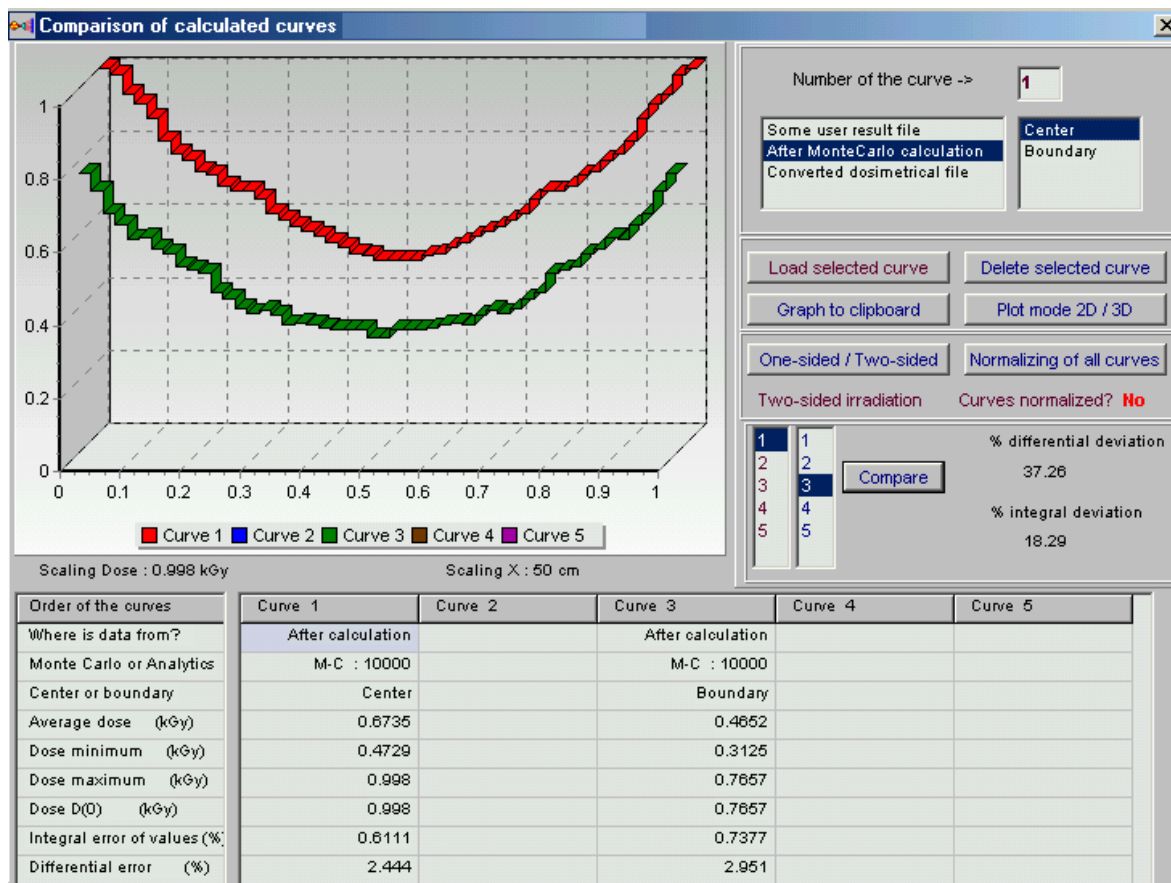


Fig.6.1. The form of "Comparison of calculated curves".

Example of 2D X-ray dose distributions in two-sided irradiated target.

Curve 1 – X-ray dose distribution in the center of irradiated target.

Curve 2 – X-ray dose distribution near the boundary of irradiated target with packing material.

The analysis can be carried out with **current calculated data**, **data calculated before** and **dosimetric experimental data**.

- **Choose** for analysis the calculated curve in the frame under the window **"Number of the curve"**. For that, **click** the chosen curve with cursor.

There are the following variants of curves for the choice:

1. **"Some user result file"**- it is simulation results of the X-ray 2D dose distributions which were previously stored in the files.
2. **"After Monte Carlo calculation"** – it is the results of current **Monte Carlo** calculation of the X-ray dose distributions in the target.
3. **"Converted dosimetric file"** – it is results with dosimetric experimental data which were prepared and saved after processing of dosimetric films with the Dosimetry module.

- **Choose** the position of dose distribution in the **Center** or **Boundary** of irradiated target for the chosen curve of 2D dose distribution.

- **Choose** by cursor the any of 5 columns of the table in the bottom part of the form the **"Comparison of calculated curves"**. The chosen column number will be automatically entered to the window **"Number of the curve"**.

- **Click** the button **"Load selected curve"**.

The characteristics of the 2D dose distribution curve will be appeared in the chosen column. And the graph of the 2D dose distribution curve will be appeared in the graph area.

In a such way you can enter for analysis up to 5 curves of 2D dose distributions in the graph area. (See Fig.6.1).

You can **“Delete selected curves”** and make for all curves **“Normalization”**. (See Fig.6.2).

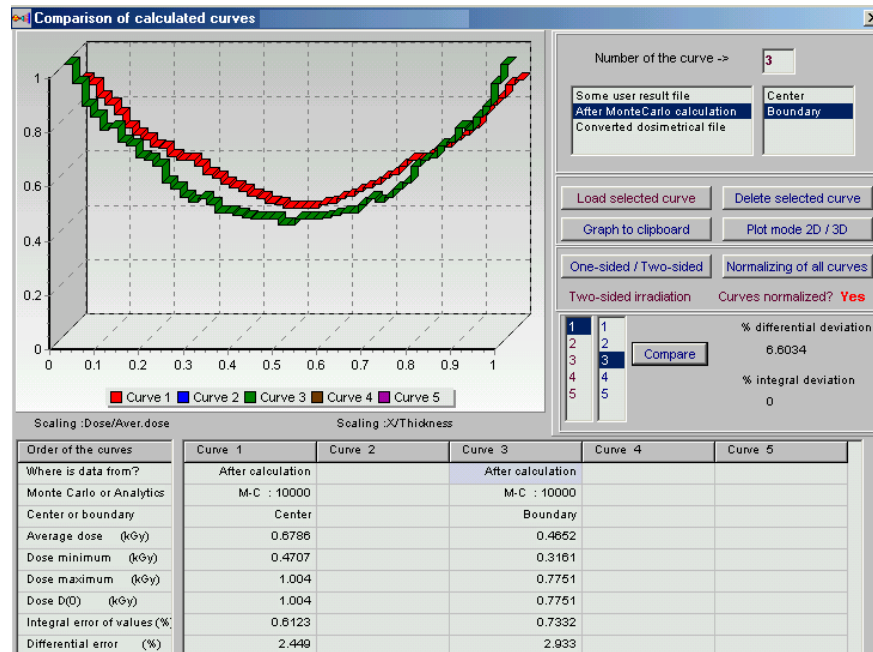


Fig.6.2. Example of “Normalization” for dose distributions presented in Fig.5.1.

- The function of button **“Compare”** (right down side in the **“Comparison of calculated curves”** frame) allows to make comparison of **2D dose distributions for 2 any curves** to obtain the values of differential and integral deviations in % between compared curves. (see Figs. 6.1. and 6.2).
 - For that, **choose** the numbers of 2 compared curves and **click** the button **“Compare”**.
 - **To copy** the results comparison into your document, **Click** the graph by right mouse button.
- Then **Click** the button **“Plot mode 2D/3D”**, if it is necessary, and then **Click** the button **“Plot to clipboard”** and **paste them** to your document.

7. Temperature module

Temperature module is intended for analysis of the temperature fields during heating and cooling of an irradiated volume.

- **Click** the button **“Temperature”** in the main form of the **Software ModeXR**,

to calculate of a temperature cooling of an irradiated target. (See Fig.1).

The main form **“Control panel for temperature calculations”** will be opened. (See Fig.7.1).

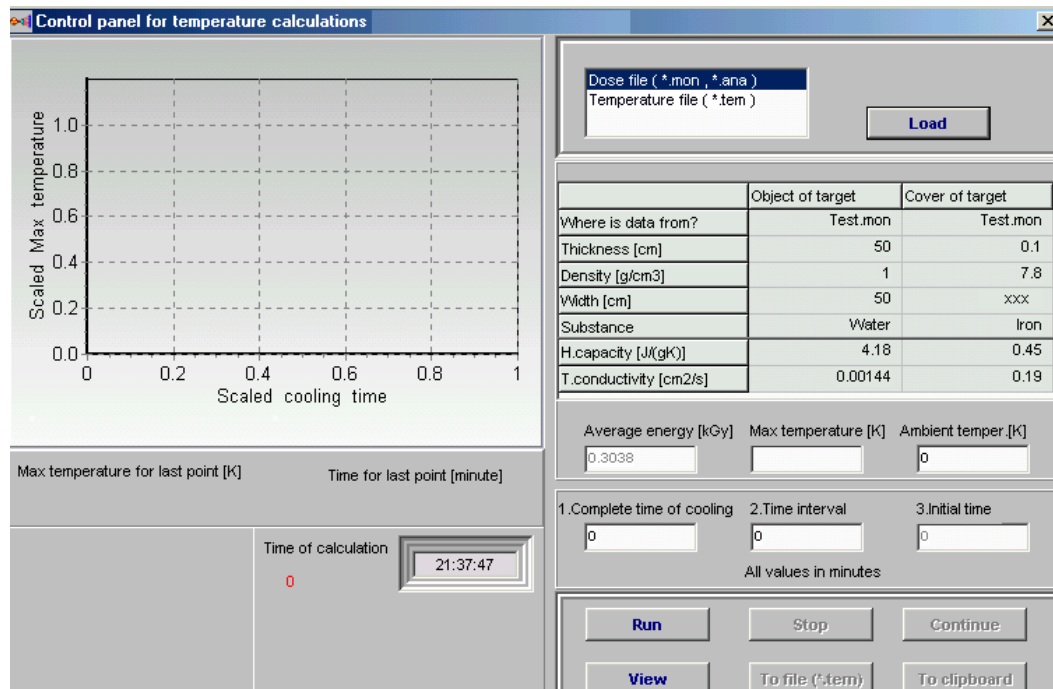


Fig.7.1. Control panel for analysis of heating and cooling of an irradiated target.

- Choose the file in the frame **“Load”**. (See Fig.7.2).

“Dose file (*.mon, *.ana)” is a file with data of current or before calculated and saved the X-ray dose distribution in an irradiated target..

“Temperature file (*.tem)” is a file with data of calculated temperature fields which were saved on the hard disk during the previously session of the **“Temperature”** module.

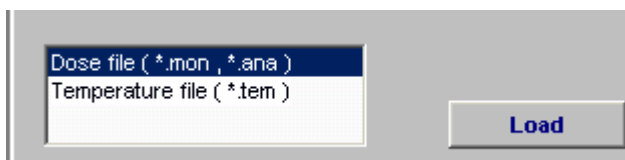


Fig.7.2. Frame “Load”.

- Click the button **“Load”** for the choose file.

The Table for chosen file will be opened with following data:

sizes, density, Heat capacity (H_c) and Temperature conductivity (T_c) for target and cover materials. (See Fig.7.3).

	Object of target	Cover of target
Where is data from?	StartL.mon	StartL.mon
Thickness [cm]	50	0.1
Density [g/cm ³]	1	7.8
Width [cm]	50	xxx
Substance	Water	Iron
H.capacity [J/(gK)]	4.18	0.45
T.conductivity [cm ² /s]	0.00144	0.19

Average energy [kGy]	Max temperature [K]	Ambient temper. [K]
<input type="text" value="0"/>	<input type="text" value="0.214"/>	<input type="text" value="0"/>

Fig.7.3. Table with characteristics of target and cover materials.

- **Enter** the value of H_c and T_c by hand for materials not given in the Table " **List of material**" in the frame "**Target**".
- **Enter** data to fields "**Complete time of cooling**" (**CTime**), "**Time interval**" (**Int**), and "**Initial time**" (**ITime**).

Note. **ITime** = 0 always, if you only begin to calculate temperature fields.

- **Enter** values to fields **CTime** and **Int** and **Press** button "**Run**".
- **Leave** **CTime** = 0 and **Int** = 0 and press the button "**Run**", if you don't know these values.
- **In** this case the expert program takes start, message window appears at the screen.
- **Click** "**Yes**".
- **When** calculation of a temperature has started , the red curve appears upon the plot and **Max Temperature**, **Cooling Time for last calculated point** for the every step. (See Fig.7.4).

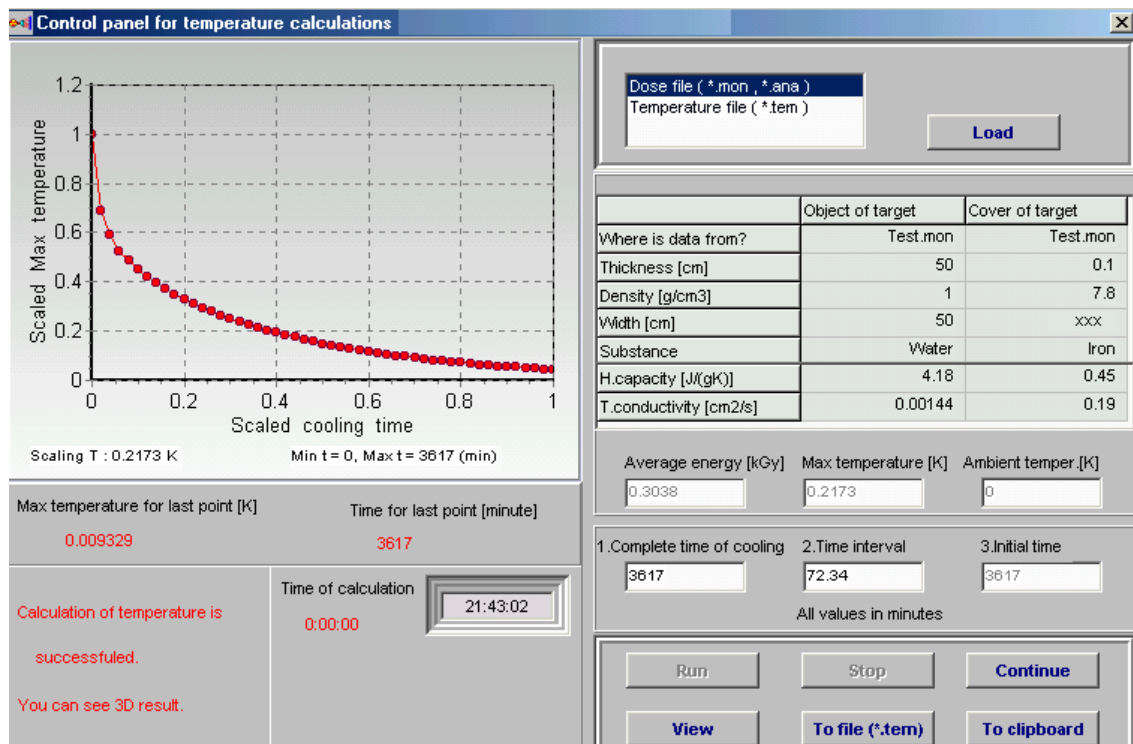


Fig.7.4. Control panel for analysis of heating and cooling of an irradiated target. End results.

- While there is calculation, the button **“Run”** is inaccessible, but the button **“Stop”** is accessible. You can stop the calculation by pressing of the **“Stop”**. At this point all other buttons of the control panel become accessible.
- If you have stopped process of the calculation, you can change values of **CTime** and **Int**, can look the temperature diagram by clicking **“View”**, can write temperature fields at this step as the temperature file (***.tem**) on the hard disk by clicking the button **“To file (*.tem)”**, can send data to clipboard by clicking the button **“To clipboard”**.
- After stop or finish of the calculation process you may change parameters and continue a temperature research by **Click** the button **“Continue”**.

Note.

There are some differences between continuation after stop and finish of calculations.

If you continue calculations after stop, a plot takes continuation from the last point which was calculated at the previous step.

If you continue calculations after finish, a plot starts from the first point.

Because a plot has **50 points** for results presentation, your one calculation session can have only **50 steps**.

If you need more steps, you have to finished the first session, to change values **CTime** and **Int** and to start the next session by **Click** the **“Continue”**.

8. Service

Main Form.

- **The Software ModeXR has options to save and open input data** related with configuration of irradiation process. (See Fig.8.1. a, b)
- **To save** formed input data you need **to open the File** in the **Software ModeXR** master menu. Then **Click “Save configuration”**. **Enter** file name and **save** input data for MC calculations.

If you want to continue calculation that you made before and saved data configuration, you need click **File** in the **Software ModeXR** master menu and choose item **“Open configuration”** from list.

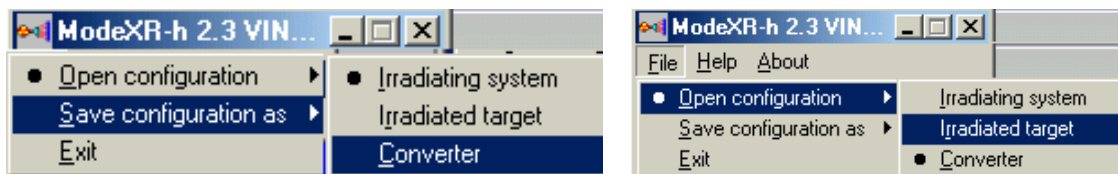


Fig.7.8 a, b. a) Frame – save configuration data.
b) Frame – open configuration data.

MC simulation module.

The Software ModeXR has some programs for visualization of calculated results. There are two viewers:

- **The viewer "Dose distributions after MC simulation" with 2D X-ray absorbed dose distributions** in graphical and tabular forms for irradiated target.

This viewer is intended for showing of the plots with **2D absorbed dose distributions** for center and boundary of the target. There are tables of calculated results and some important characteristics.

- **The viewer “Dose Map” is used for analysis of 3D view of X-ray dose distribution in the irradiated target at one-sided and 2-sided.**

“Dose Map” is viewer for presentation:

3D view of the X-ray dose distributions (Dose Map, along target thickness (axis X) and along target width (axis Y)) in graphical and tubular forms.

- **Among important characteristics:**

- Dose uniformity ratio,
- Part of X-ray beam use,
- Average X-ray absorbed dose in the target.

- **You can see diagram, data table, some important characteristics. You can turn figure of diagram and choose optimal angle, you can send figure to clipboard. At the bottom of viewers screen form there are hints about buttons actions. To exit viewer you can use button Close.**

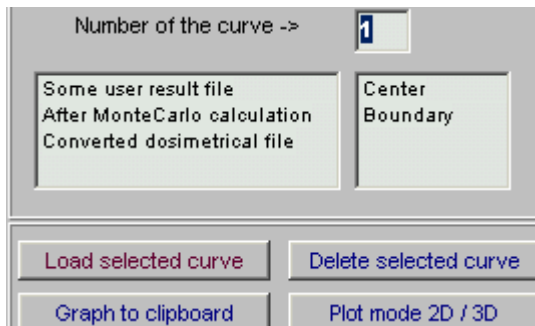
- Every page has button **To clipboard**. To send plot to clipboard you need to click on this plot and to press **To clipboard**.

- You can write calculated result on hard disk as file “*.mon” after MC calculations.

- You can **increase** some area selected on the plot to have the better sight. To do it you need to place cursor above this area. You press left mouse button (it is the left top corner of rectangle) and holding down this button, draw down rectangle around plot area. The point where you release left mouse button is right bottom corner of rectangle.

The **increasing** of selected area is a moving down cursor from left corner to right corner. The **decreasing** of the area (coming back), is a moving upwards cursor from right corner to left corner.

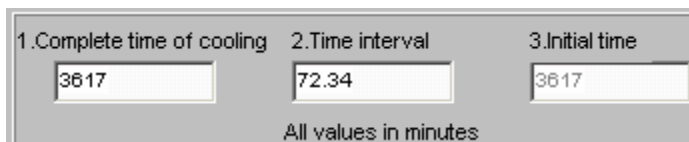
Comparison module.



You can compare results and load them from the hard disk. See Fig.8.2.

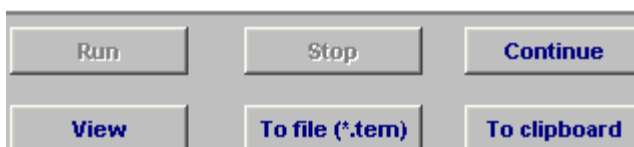
Fig.8.2.

Temperature module.



You can load data for calculations of temperature fields from hard disk. See Fig.8.3.

Fig.8.3.



You have many opportunities to work with temperature data. See Fig.8.4.

Fig.8.4.