

Manual for simulation of EB processing

Software ModeCEB

Software ModeCEB

was designed specially for predictions of the electron dose distribution in multi-layer circular objects such as wire, cable, tubing, pipes, flexible hose, etc..

The simulation of the absorbed dose distribution formation in multi-layer circular objects at one-, two-, and four-sided irradiation with a scanned electron beam on a moving conveyer were performed by Monte Carlo method with utilization of the software **ModeCEB**.

The program **ModeCEB** was designed for simulation of the electron dose distribution in multi-layer circular objects irradiated by scanned EB in the electron energy range from 0.1 to 25 MeV. The self-consistent physical and geometrical models of the program **ModeCEB** include in detail the features of electron beam transport in the circular objects related with its surface irregularity such as convexity, concavity and roundness of inner and outer layers.

The software ModeCEB provides to end-user in the graphical and tabular form a data set with a dose profile of electrons in multi-layer circular objects along azimuth angle and along radius tube (cable) at one-, two-, and four-sided irradiation with a scanned electron beam on a moving conveyer.

Differential and integral characteristics of an irradiation process are simulated with a Monte Carlo method, as statistical estimations of simulation results of processes of electron interaction with target materials, within range of electron energy from 0.1 up to 25 MeV.

The features of the simulation of irradiation process by the ModeCEB program are the following:

- unique high running speed of calculation schemes due to use of specially developed algorithm on the basis of a method of translation of an electron trajectory;**
- special method for statistical estimation of electron beam dose;**
- an adaptive choice of free parameters of modeling on the basis of semiempirical model.**

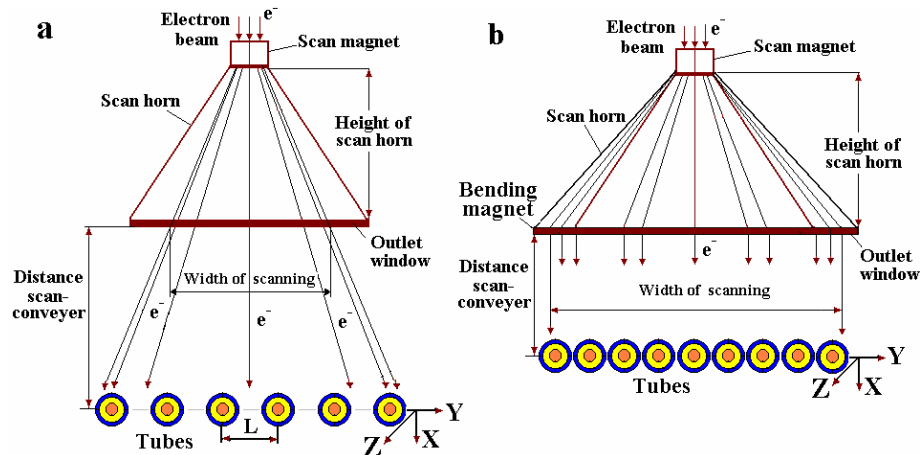
Algorithms and calculation schemes are based on results of scientific researches of authors in the field of development the non-traditional methods of Monte Carlo for simulation processes of transport of electron and photon radiation in multi-layer circular objects.

Software ModeCEB works on platform Windows98/Me/NT/XP/2000.

It has intuitively clear interface for the end-user.

Interface language - English.

Geometrical models of EB radiation facility for irradiation of set of tubes or cables.



Figs. 1 (a), (b). The geometrical models for typical radiation facility with one EB irradiator that are used for one- or two-sided irradiation of tubes and cables.

Axis X – EB incidence. Axis Y – EB scanning. Axis Z – conveyer movement.

Models in Fig.1(a) provides triangular regime of scanning, in Fig. 1 (b) – non-divergent (parallel ray) regime of scanning.

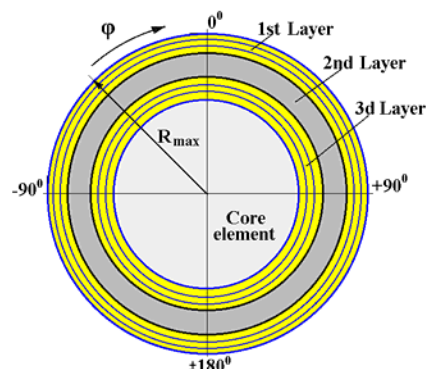


Fig. 2. Model of tube with four-layers structure.

The 2-D dose distribution in an irradiated tube is represented as function of two coordinates:

the azimuth angle φ in the range from -180° up to $+180^{\circ}$,
and radius tube R in the range from 0 to R_{\max} - maximal value of tube's radius (see Fig.2).

Absorbed dose distribution as function of an azimuth angle φ characterize **circumferential dose distribution** for certain sub-layer located on the fixed value of tube radius.

Absorbed dose distribution as function of radius tube R characterize dose distribution in different sub-layers at fixed azimuth angle on the circumference.

Parameters simulation for the set of tubing are the following:

- the number tubes in the set are in the range from 1 to 20;
- the number layers in each tube are in the range from 1 to 4;
- the number sub-layers in each layer are in the range from 1 to 30;
- the averaging dose interval over an azimuth angle on the circumference can be installed as 2.5° (144 points) or 5° (72 points).
- the averaging dose over radius in each layer is carried out on the thickness sub-layer.

Software ModeCEB. How to get results.

Introduction

Software ModeCEB is intended for predictions of the electron dose distribution in multi-layer circular objects such as wire, cable, tubing, pipes, flexible hose, etc. irradiated with scanned electron beam, EB.

Input Data

To work with software ModeCEB -

- Click the "File" then "Load configuration", then select "Irradiating system" and load the file "Test.rts". See Fig.1.

The frames "Scanning system" and "Model options" will be opened. See Fig.2.

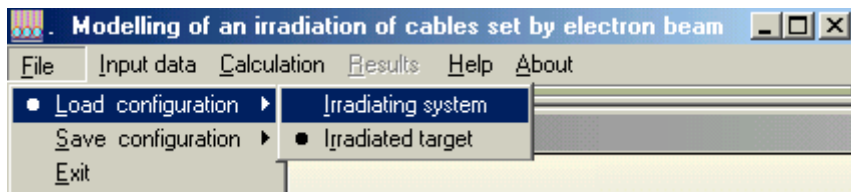


Fig.1. Main form of the Software ModeCEB

- Again click the "File" then "Load configuration", then select, "Irradiated target" and load the file " Test.rtt".

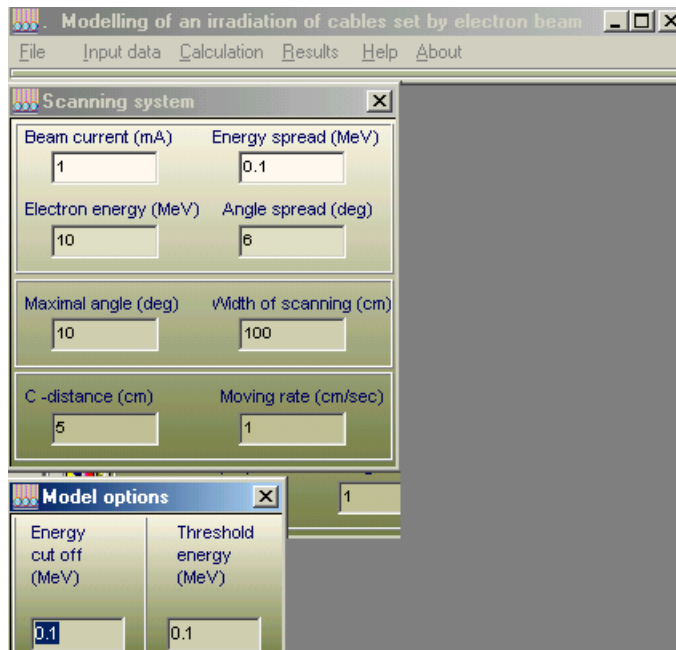


Fig.2. Frames "Scanning system" and "Model options" to enter input data for EB radiation facility.

1. Input data of irradiation facility

- Click “Input data” in the Main form of the Software ModeCEB (See Fig.1.)
- Click “Scanning system” in the frame “Input data”.

The frame “Scanning system” will be opened.

- Enter the value of the EB current in mA in the window “Beam current”.
- Enter the value of the electron Energy in MeV in the window “Energy”.
- Enter the value of the electron Energy spread in MeV.
- Enter the value of the “Angle spread” in degree.
- Enter the value of the “Maximal angle” in degree.
- Enter the value of the “Width of scanning” in cm.
- Enter the value of the “C- distance” between the center line of adjacent tubes in cm.
- Enter the value of the “Moving rate” of conveyer line in cm/sec.

2. Model options

Options are intended for:

- optimization of simulation regimes,
- scientific research of transport irradiation through heterogeneous targets.

- Click “Input data” in the Main form of the Software ModeCEB (See Fig.1.)
- Click “Model options” in the frame “Input data”.

Then to choice and click “Automatic” or “Manual”.

The frame “Model options” will be opened.

In the default mode “Automatic” of the Software ModeCEB work, all simulation parameters are working in an optimal automatic regimes which were installed in the physical, operational and in calculation models of the Software.

All Options parameters can be changed only in regime “Manual parameters”.

- Change of simulation parameters “Electron energy cut off” and “Threshold energy” can be used for scientific researches of transport irradiation through heterogeneous targets.

3. Input data for Target

- Click “Input data” in the Main form of the Software ModeCEB (See Fig.1.)
- Click “Target” in the frame “Input data”.

The frame “Target” will be opened. (See Fig.3)

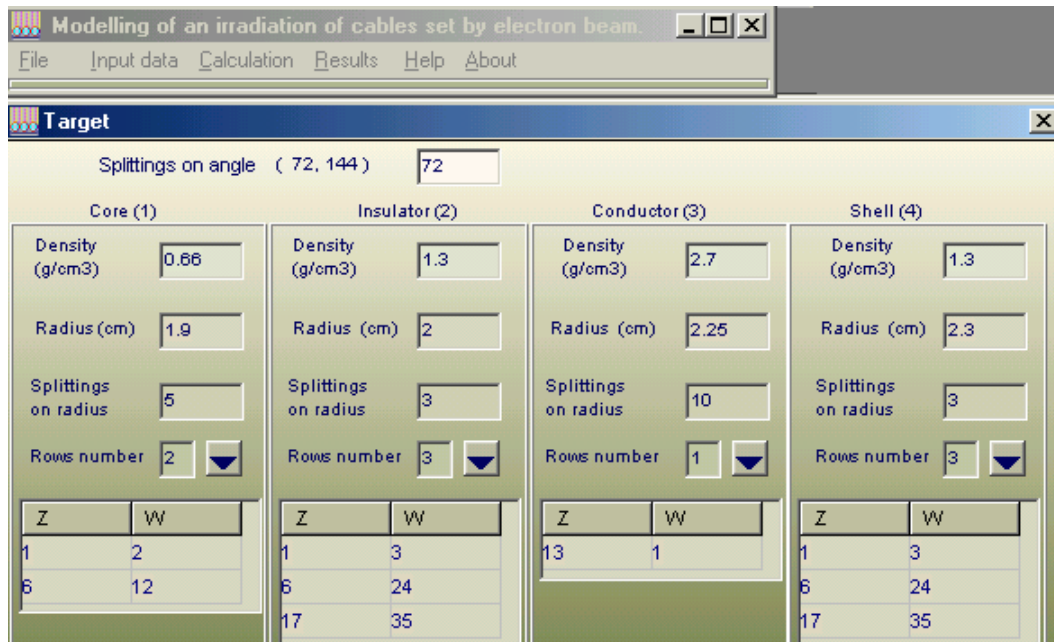


Fig.3. Frame “Target” to enter input data for set tubes/cables irradiated with EB.

- **Select** the value of splitting on angle **72 or 144 points**.
- **Enter** the selected value into window **“Splittings on angle”**. (Right up corner of frame **“Target”**)
- **Enter characteristics of Core element: Density** in g/cm³, **Radius** in cm, **Splittings on radius** in the range from 1 to 30.
- **Enter** the values of the **atomic number Z** and the **atomic weight W** for the material/compound of the **Core element**.
- **Enter characteristics for Insulator, Conductor and Shell analogously to Core element**.
- **Click** the button **“Calculation”** in the **Main form of the Software ModeCEB** (See Fig.1.). **The frame “Calculation” will be opened.** (See Fig.4 a, b)

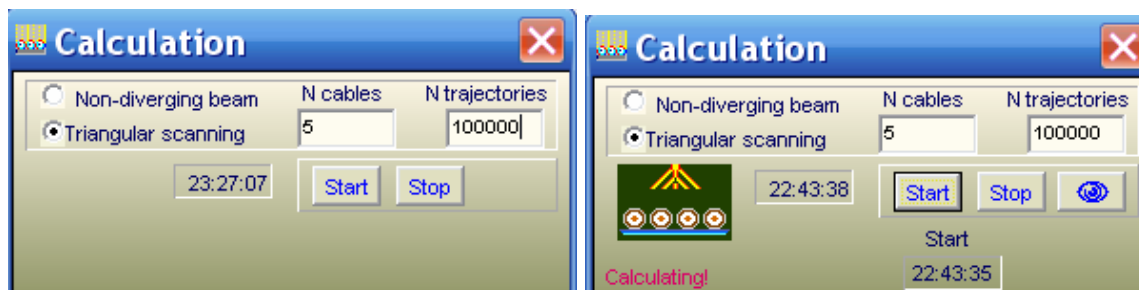


Fig.4 a, b. Frames “Calculation”.

- View for enter input parameters.**
- View in time calculation.**

- To select regime of scanning, Click by a tick the field “Non-diverging beam” or “Triangular scanning”.
- Enter into window “N cables” the number of cables/tubes in the set in the range from 1 to 20.
- Enter the “Number of trajectories” and Click the button “Start”.
The button with “Eye” will appear.
- Click the button “Eye”. The Table with all input data will be open. (See Fig.5)

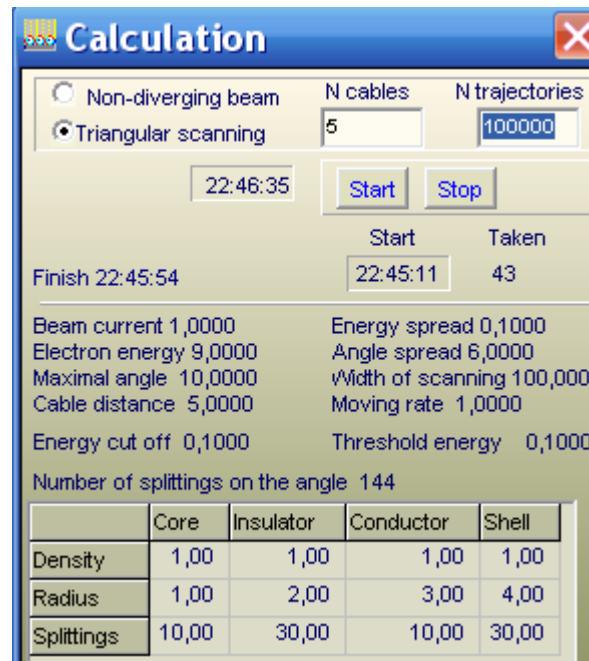


Fig.5. Frame “Calculation” with Table of input data.

- The Software ModeCEB will show starting time and define time required for calculation.
- Click "Stop" to interrupt calculation and reenter data.
- When MC simulation will be ended, you can work with results.

4. Output Data

4.1. 2D dose distribution analysis.

- Click the button “**Results**” in the **Main form of the Software ModeCEB**. (See Fig.1.). The frame “**View and comparison**” will be opened. (See Fig.6)

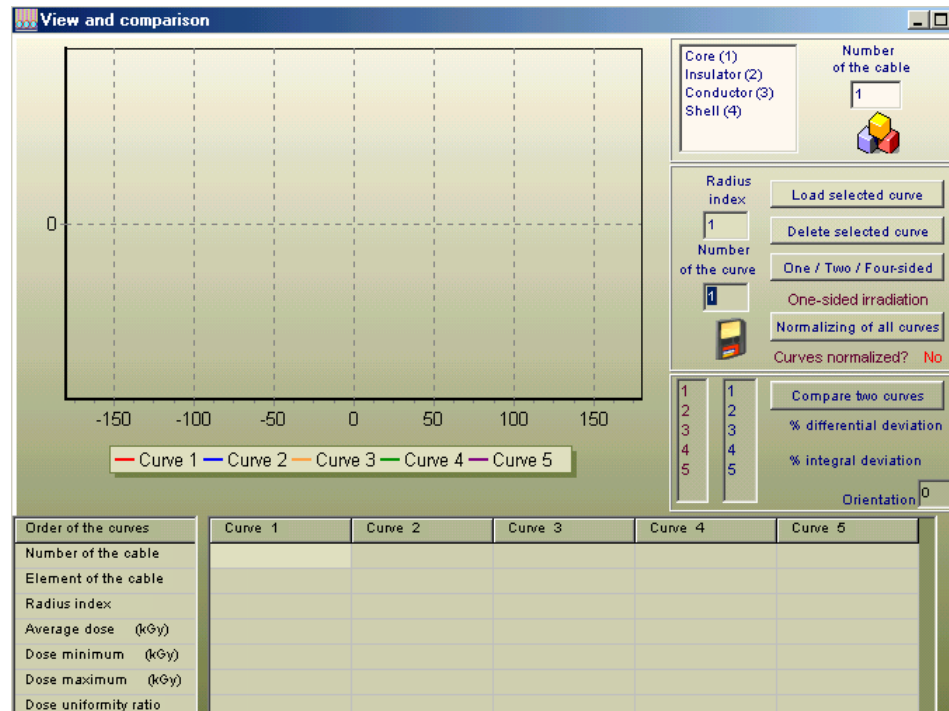


Fig.6. The frame “View and comparison”.

- Enter the “**Number of cable**” for which you will made analysis of simulation results. See Fig.6 - Right up corner.
 - To select the cable construction element, Click by a tick the **Core, Insulator, Conductor or Shell**. See Fig.6 - Right up corner.
 - Enter the “**Radius index**” for selected construction element of the cable in accordance with **splitting** of the element in the frame **Target**.
 - Click with cursor the any of 5 columns of the **Table** in the bottom part of the form the “**View and comparison**”. The 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 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 the **2D dose distributions** in the graph area. See Fig.7.

• The **2-D dose distribution** in an irradiated tube is represented as function of two coordinates - of the azimuth angle φ in the range from -180° up to $+180^\circ$, and radius tube R in the range from 0 to R_{\max} - maximal value of tube's radius. Absorbed dose distribution as function of an azimuth angle φ characterize circumferential dose distribution for certain sub-layer located on fixed value of tube radius.

Absorbed dose distribution as function of radius tube R characterize dose distribution in different sub-layers at fixed azimuth angle on the circumference.

• Click the button **“One/Two/Four-sided”**. The graphs for the **2D dose distribution curves** at one, two or four-sided irradiation of cables/tubes will be appeared in the graph area. See Figs.7, 8,9.

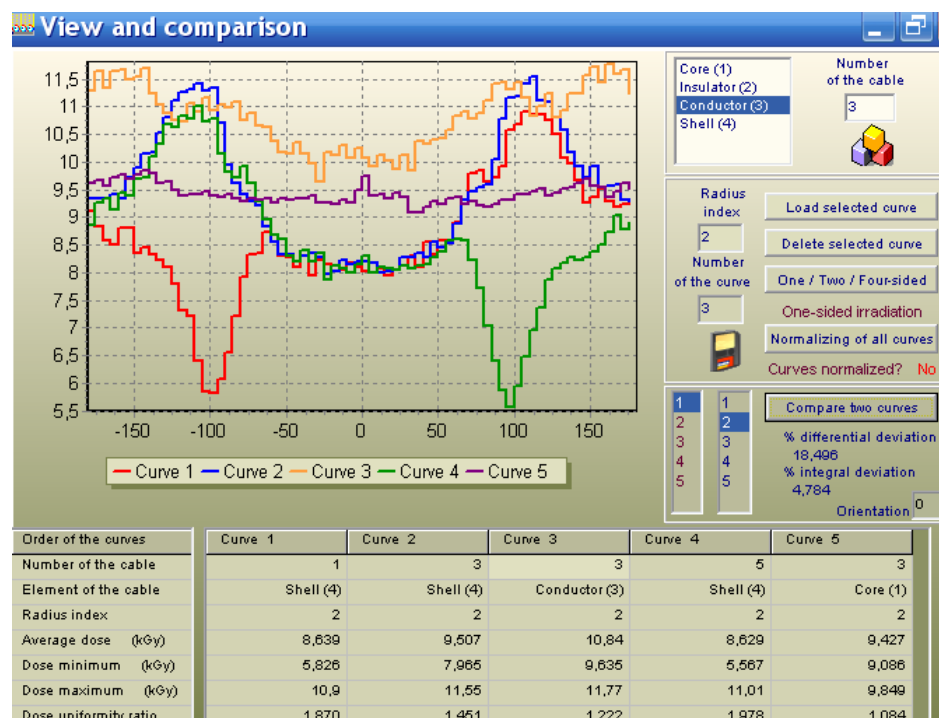


Fig.7. 2D view of the absorbed dose distribution in some sub-layers. One-sided irradiation.

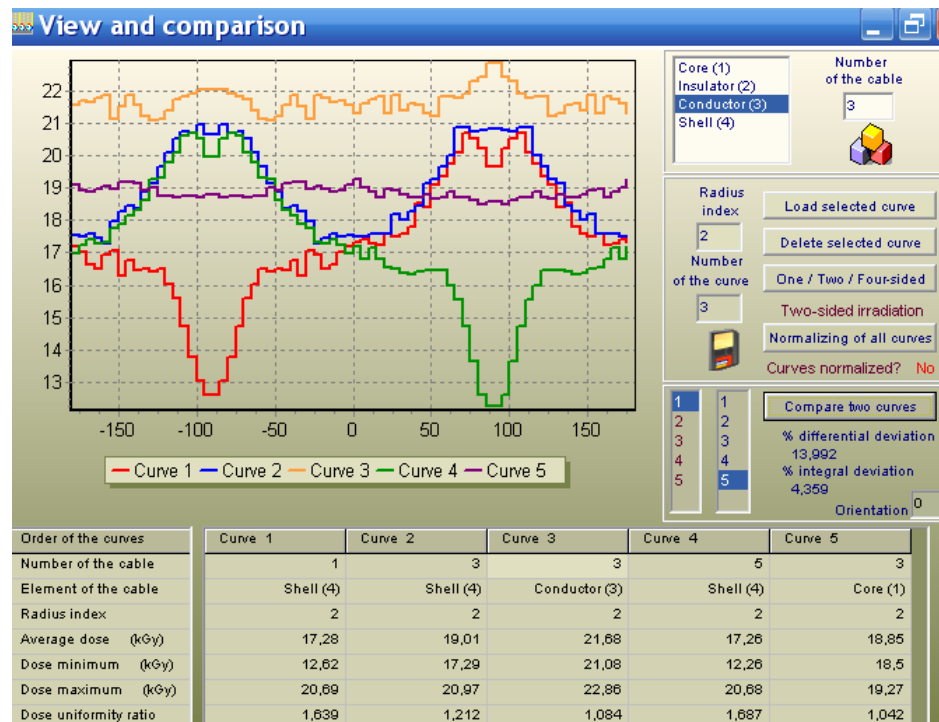


Fig.8. 2D view of the absorbed dose distribution in some sub-layers.
Two-sided irradiation.

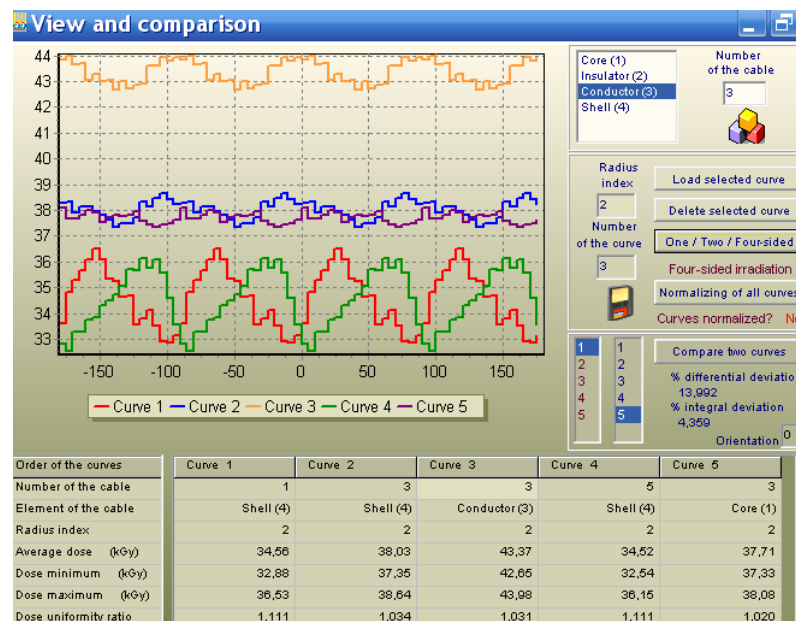


Fig.9. 2D view of the absorbed dose distribution in some sub-layers.
Four-sided irradiation.

You can “Delete selected curves” and make “Normalizing of all curves”.
See Figs.7, 8, 9.

- To do this, Click corresponding buttons in the frame “View and comparison”.

- The function of button "**Compare two curves**" (right down side in the "**View and comparison**" 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.
- To do this, **choose** the numbers of 2 compared curves and **click** the button "**Compare two curves**". See Figs.7, 8,9.

4.3. 3D dose map analysis.

- Enter the "**Number of cable**" for which you will made analysis of simulation results. See Fig.6 - Right blue corner.
- Select the cable construction element, Click by a tick the **Core, Insulator, Conductor or Sell**. See Fig.10
- Click the button "**Fig. 3 cubes**". See Fig.10

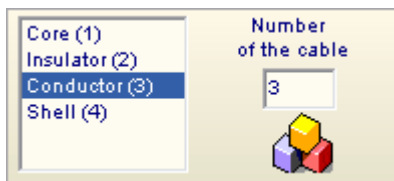


Fig.10. Frame for selection of the cable construction element.

The frame "**Dose map**" with **3D dose distribution** for selected the cable construction element will be opened. (See Fig.11 a, b.)

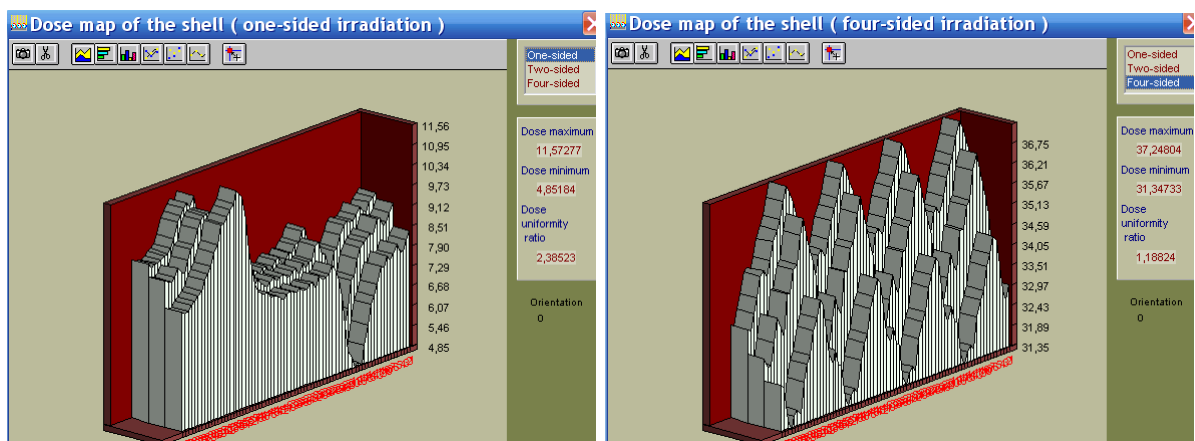


Fig.11 a, b. 3D view of the absorbed dose distribution in all sub-layers for the "**Shell layer**". a) **One-sided** irradiation. b) **Four-sided** irradiation.

- You can **copy** the results of MC calculation of the **2D dose distributions** in tabular form for **each sub-layer** irradiated at one-, two-, or four-sided.

- To do this, **Select** sub-layer in the window **“Radius index”**, **Enter** **“Number of the curve”**, **Select** regime irradiation **One/Two/Four-sided**, **Click** the button **“Fig. Diskette”**. See Fig.12.

Results of MC calculation of the **2D dose distributions** will be saved as **“*.txt”** file.

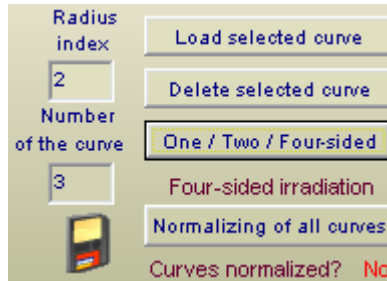
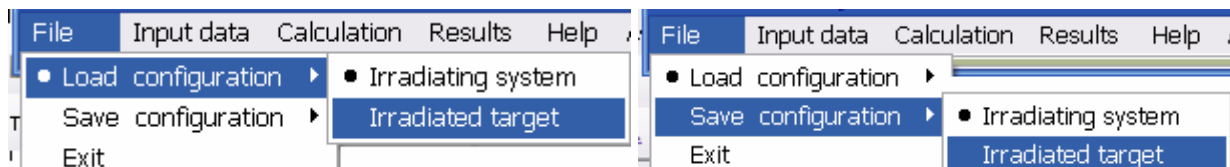


Fig.12. Frame for selection of the sub-layer and regimes irradiation.

5. Service blocks

The Software ModeCEB has **block to save and open input data** about configuration of irradiation process. To save formed input data you need to open the **File** in the **Software ModeCEB** master menu. In opening menu list you choose item **Save configuration**, enter file name and save input data for MC calculations. If you want to continue calculation that you made earlier and saved data configuration, you need click **File** in the **Software ModeCEB** master menu and choose item **Open configuration** from list.



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

- The viewer **“View and comparison”** with **2D absorbed dose distributions** in graphical and tabular forms for selected sub-layers for cables/tubes construction elements (**Core, Insulator, Conductor, Shell**).

This viewer is intended for showing of the plots with **2D absorbed dose distributions as function of an azimuth angle φ** . The plot characterize

circumferential dose distribution for certain sub-layer located on fixed value of tube radius.

- The viewer **“Dose Map”** is used for analysis of **3D view of dose distribution** in the cables/tubes layers and sub-layers.

“Dose Map” is viewer for showing **3D view of the dose distributions** in graphical and tubular forms for the selected layers and sub-layers.

- You can save calculated result in tubular forms on hard disk as file **“*.txt”** 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.

