

VISIPLAN

3D ALARA planning tool

Version 3.0

A 3D-ALARA planning tool for routine work and interventions in an environment with risk of external exposure.

User's Guide

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1. Introduction

The application of the ALARA-planning for work and interventions in a nuclear environment is difficult. The environments in which the work has to be performed is generally complex, making the assessment and analysis of the work difficult.

VISIPLAN 3D ALARA planning is a new calculational tool developed to facilitate the planning of the work based on 3D-geometrical, material and radiological information. The dose calculations are based on a point-kernel method with a build-up correction.

2. The VISIPLAN methodology.

Different stages can be determined in the ALARA-analysis of an intervention or a routine work in an environment with risk of external exposure, they are:

- The information gathering and model building stage
- The general analysis stage
- The detailed planning stage
- The follow-up stage

The aim of the VISIPLAN software is to provide a tool to streamline these stages.

2.1. Information gathering and model building stage.

A first step in the VISIPLAN approach is the gathering of information about the working area. This information includes the geometry, the materials and the radioactive sources of the work area.

Geometrical information.

The geometrical model can be build from technical drawings or can be obtained through rendering techniques such as laser scanners, or photogrammetry.

Material information

Material information is gathered from technical drawings, technical reports and from experts on-site with a knowledge of the site history.

Radiological information.

Radiological information is gathered from dose measurements or from detailed information about the sources used on the site.

Measurements can be performed with the VISIRAD system (under development) and further completed and analysed with information about the history of the site.

The VISIRAD dose mapping system will be equipped with an easy interface to the VISIPLAN program which makes it possible to determine source strengths with a source inference technique.

2.2. General analysis stage.

In this stage different maps of the radiation environment are produced for the different working areas. A first analyses of the problem can be performed based on these maps. Different shielding configurations can be introduced in the model and analysed on their effectiveness. The geometry's in VISIPLAN are stored in a Take structure. A Take is defined as a fixed environment of geometry, materials and sources. Changes to the basic geometry are stored in sequential Takes. This method allows a clear overview on the different geometry changes possible in a project.

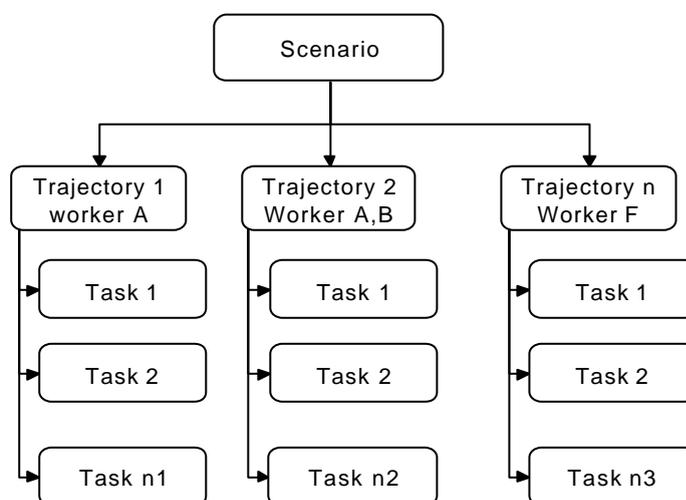
2.3. The detailed planning stage

Detailed trajectories for the workers consisting of a sequence of tasks to be performed are defined in a 3D virtual environment. These trajectories are analysed based on work duration, dose account and influence of the radiological and geometrical configuration.

Information about the type of work, work description and work duration is gathered from the knowledge of experienced workers.

Based on the analysis a selection of the most suited trajectories is performed.

Finally a complete work scenario is put together consisting of a set of trajectories for the different workers.



Different scenarios can be built in this way. Comparison of the scenarios can then lead to the selection of the most adequate way to perform the work.

2.4. The follow up stage

The graphs and task lists produced in the detailed planning stage make it possible to perform a thorough follow up of the dose account during the work. This is achieved through comparison of the predicted and the received dose. Large deviations between both are an indication that risks which were not foreseen in the planning stage are present on the work floor. An

appropriate answer and new prognoses can then be formulated based on new measurements and an adaptation of the model including the detected risks.

3. Using VISIPLAN.

This section gives a description of the different tools available in VISIPLAN and their use in the planning of your project. The tools allow a quick and efficient way to perform the different tasks in the VISIPLAN methodology. A command is printed in bold and italic with the menu group name followed by the specific command name.

3.1. General

Installing the program

The program is installed on your hard disk by running the setup program on your VISIPLAN CD-rom.

Starting the program.

Clicking the VISIPLAN program name in the program file selection (Windows 95) starts the program. This action is followed by the display of the VISIPLAN start-up screen. Press the start button to enter the program. You can stop the program with the *File Exit* command

Program screen interface.

The graphical user interface of VISIPLAN has the following components:

The menu bar

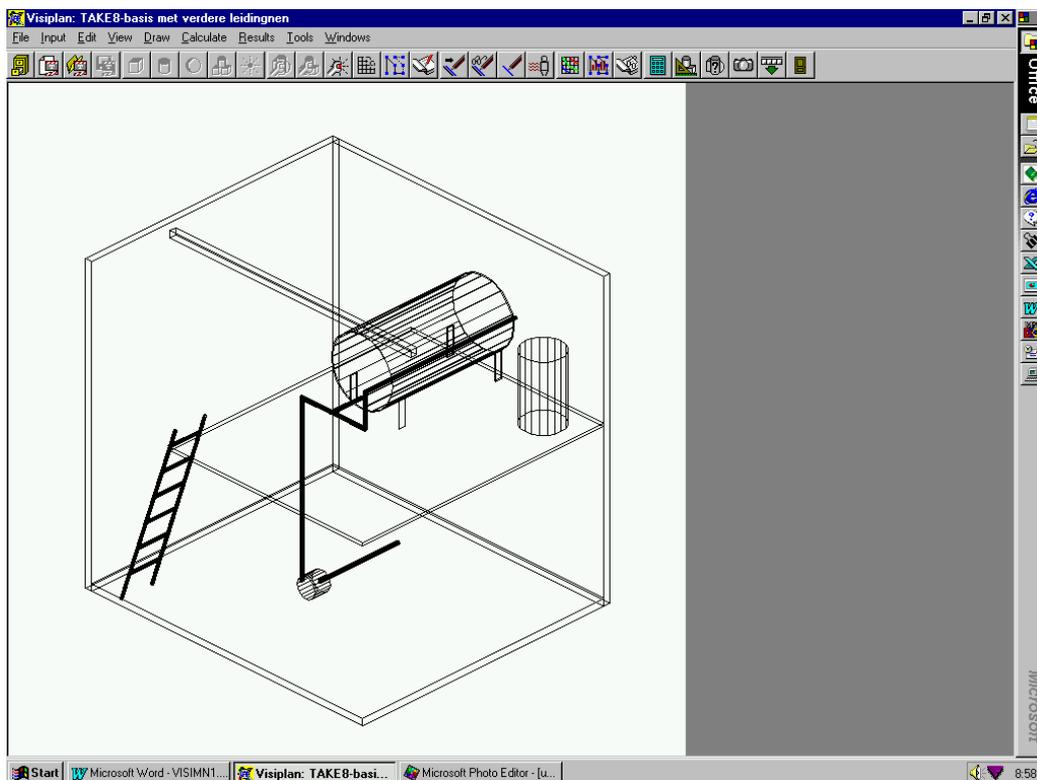
Enables you to select the different commands of the program.

The main graphical area

Displays the current Take in a draw mode selected by the user.

The Tool bar

Gives a shortcut to the frequently used commands.



The Take structure of VISIPLAN

The dose rate in an environment is dependent on geometry, materials and source data a change in any of these will result in a dose rate change. Therefore we implemented what we call the Take structure in VISIPLAN.

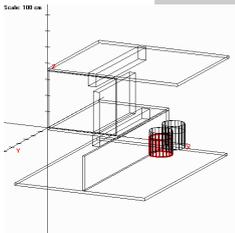
The geometrical, material and sources data of a simulated environment are stored in a Take (refer to a Take in a movie), a Take is a fixed situation of these components at a certain moment. A change in the geometry, materials and sources information will automatically result in the creation of a new Take. Projects that involve a change in the environment can then be described by a sequence of Takes. The Take structure is an important feature to keep a clear view on the results of the dose calculation in these different environments.

The menu bar structure

The menu bar structure is given below. The commands are grouped based on their use in the program.

Command group	Use	Commands
File	All file operations	New Database Open Database Database Maintenance New Take Load Take Save Take Exit
Input	Input of different data objects relative to a Take.	Box Cylinder Sphere Structure Sources

Edit	Editing and definition of the different data objects	<ul style="list-style-type: none"> Measured Dose rate sets Volumes <ul style="list-style-type: none"> Single volumes Structures Sources Trajectories Grids Source Sensitivity analysis file Scenario's Measured dose rate sets Source mixtures Material Mixtures Volume Sequence Work areas Update Source strengths
View	Viewing the properties of the different object related to a Take	<ul style="list-style-type: none"> Volumes Sources Source Spectrum Build-up factors Attenuation coeff. Measured Dose rates
Draw	Commands related to the 3D-wire-frame representation.	<ul style="list-style-type: none"> Redraw Saved view New view
Calculate	Commands related to calculations	<ul style="list-style-type: none"> Dose rate Source Strengths
Results	Commands to display and examine results	<ul style="list-style-type: none"> Trajectories Grids Scenario Scenario Comparison
Tools	Commands related to support tools	<ul style="list-style-type: none"> Calculator Geometry Check MDR merge Dose maps Structure Design Toolbar



3.2. Tools for the information gathering and model building stage.

In this stage you need to collect and store the geometry and source data in the Take structure of the project database.

3.2.1. Creating and handling a project database.

Creating a new project database

A new project database is created using the *File New Database* command from the menu bar. A Windows file interface is presented on the screen that allows you to choose the filename and the directory for the new database.

The project database will include the different Takes and results of calculations associated with them. The command only creates the database with the appropriate database structure it does not activate the database for use in VISIPLAN.

Activating a project database

The project database is activated for use in VISIPLAN by the *File Open Database* command. A Windows file interface is presented on the screen allowing the selection of the database.

Activating a Take as the current Take

Once the project database is activated you can activate a Take. The activated Take is defined as the current Take. The last Take you worked on remains in the *current Take* status even when you exit VISIPLAN. So if you are in the development of geometry and a source distribution and you have not finished yet you can leave the program without losing the information. You can exit the program without the need to save the unfinished Take. After restarting the program you can reactivate the unfinished Take by selecting *File Load Take* with the "Use current Take" option.

Activating a New Take

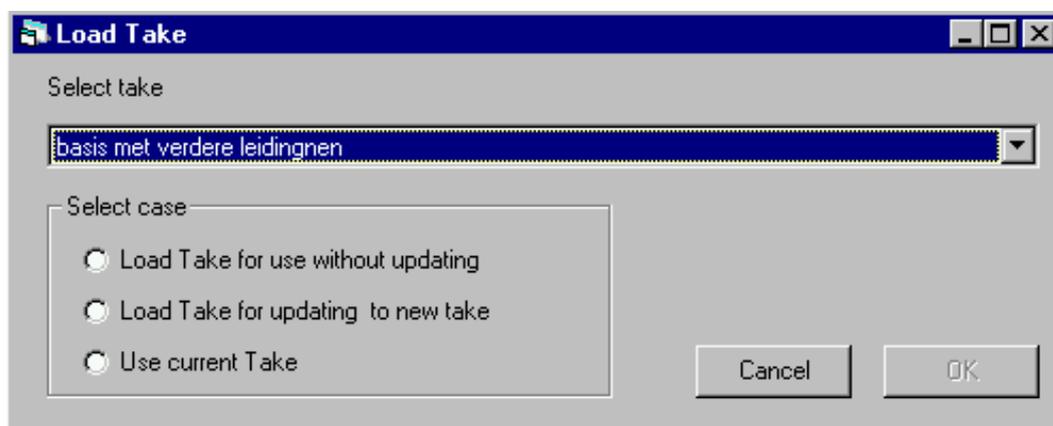
If you want to create a Take, which is not based on an existing one, use the *File New Take* command. This will delete the last active Take from the current Take status and give you an empty geometry and source table.

Activating without changing the Take

A Take can be made active to perform dose calculations on trajectories or grids. In that case you will select the *File Load Take* command with the "load Take without updating" option. The selected Take will be put in the current Take status with the restriction that no changes can be made to the geometry and the sources. The only exception to this is the number of random sampling points for volume sources. This parameter can be changed to increase the accuracy of the calculations within a Take.

Activating to change a Take

You can select a Take with the aim to change the geometry or the sources and store it as a new Take. In order to do so select the *File Load Take* command with the "load Take for updating to new Take" option.



Saving a Take

The current Take is saved by using the ***File Save Take*** command. This operation should Take place only when the complete Take definition is finished. This means that the geometry and the source data must be completed. Once a Take is saved it cannot be changed and resaved as the same Take. A change of the Take will automatically result in the creation of a new Take. This method is used to exclude the possibility that a Take (geometry, materials and sources) used for earlier calculation would be changed. An unfinished Take definition can be left in the current Take status on leaving the program. The current Take is saved in the project database for further development. Takes that were saved but were not finished or have become obsolete can be removed later with the ***File Database Maintenance*** tool.

3.2.2. Input of geometry and material information

Standard geometry input

Input of the volumes and the materials can be done with the ***Input menu***.

The ***Input menu*** allows the selection of a rectangular, cylindrical or spherical volume with the ***Input Box, Input Cylinder, Input Sphere*** commands. The ***Input Structures*** command allows you to enter a previously defined combination of volumes, called a *structure*, into the Take description. This command can be used to introduce recurring structures at different positions.

With every volume you need to associate a material. The materials are selected from the material drop-down box in the input forms of the ***Input*** commands. The materials available in the program are given below. Entering a relative density different from one in the input forms can change the density of the materials.

Materials	Density (g/cm ³)
Air	0.00122
Aluminium	2.702
Carbon	2.25
Concrete	2.35

Iron	7.86
Lead	11.34
Leadglass	4.36
Nickel	8.8
Tin	6.52
Tungsten	19.3
Uranium	18.7
Water	1
Zirconium	6.44

The use of nested volumes

Volumes can be nested, this means that a volume or part of a volume can overlap another volume or part of another volume. However care must be taken in the sequence of the volume definition. The material in the overlapping region will always be the first material that was defined in that region of space.

A tool is provided in order to be able to change the sequence of the volumes. The tool is selected with the *Edit Volume Sequence* command.

Creating mixed materials

In some cases a material in a volume is best defined as a combination of different materials. The mixture has to be created before it can be selected in the material drop-down box from the input volumes form.

The *Edit material mixture* form makes it possible to create and edit these mixtures. The materials can only be created through the combination of the standard materials available in VISIPLAN.

Input of source information

The data about the sources can be entered in the Take description through *the Input sources* command. The source isotope and the source strength are stored in the Take description. The source geometry's available are point, line, box, cylinder and sphere. The source isotope is selected from a list in the isotope drop-down box. This list contains a set of single isotopes but can also contain a list of custom made isotope mixtures or source spectra created before the selection in the list.

Creating isotope mixtures or source spectra.

Isotope mixtures are created with the *Edit isotope mixture* command. Selecting the required isotopes together with their source strength in a list creates the mixture.

A source spectrum is created by giving the number or the relative number of photons emitted per disintegration in a standard energy bin. The standard energy bins in VISIPLAN are given below.

0.015		0.15		1.5		15	MeV
0.02		0.2		2			
0.03		0.3		3			
0.04	MeV	0.4	MeV	4	MeV		
0.05		0.5		5			
0.06		0.6		6			
0.08		0.8		8			
0.1		1.		10			

Displaying and examining the created Take.

The current Take is always displayed on the screen as a wire-frame model.

The way in which this is done depends on the drawing parameters you have selected from the draw menu. The draw menu consists of three commands ***Draw Redraw***, ***Draw Saved view*** and ***Draw new view***.

Draw new view allows you to change the drawing parameters and to define the saved view. It also makes it possible to include or exclude certain objects from the display.

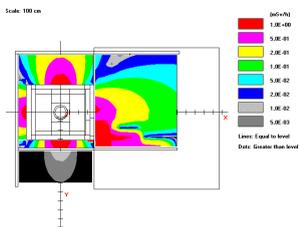
Draw Redraw refreshes the wire-frame model on the screen using the current draw parameters and the current situation of the Take definition. The ***Draw saved view*** allows you to switch to a set of preferred drawing parameters saved earlier.

The geometry of the Take can be examined with the ***Tools Check geometry*** command. This command allows performing cuts along the x-, y- and z-plane of your geometry enabling you to check if all the materials of the primitive volumes are defined correctly. It is recommended to perform this check before definitively saving your Take. In order to appreciate your geometry in a more realistic way we have provided the ***Tools photo command***. With this command a picture is rendered based on the outer surfaces of the geometry and the materials according to the current draw parameter settings.

Determining the source strengths from a measured dose rate set

Source strengths can be determined from a set of measured dose rates in the working area. The measured dose rate (MDR) set can be entered in the program with the ***Input Measured Dose Rate sets*** command. This command allows input from keyboard or from file. Once the MDR set is defined in the program you can display it on the geometry with the ***View Measured Dose rates*** command.

The source strengths calculation is done in two steps. In the first step you need to calculate the dose rates at the positions of the measurements of the set using the defined source strengths in the Take. This is done with ***Calculate Dose rate*** with the ***MDR set*** option. Once this information is available you can calculate the source strengths with the ***Calculate Source strengths*** command. This command will perform several iterations to improve the fit of the source strengths in order to achieve a good agreement between measured and calculated dose rates at the MDR set positions. The results of the calculation are saved in a Source Sensitivity Analysis set with the same name as the MDR set. When the user is satisfied with the result he can use the ***Update Source Strengths*** command to change the source strengths of the Take to the values calculated with the MDR set.



3.3. Tools for the general analysis stage.

In this stage you should get a general idea of the dose hazards and the way you can reduce them through shielding or source strength reducing methods. Several tools are available to assist you.

Creating dose information in selected area's

Based on the geometry and source information of a Take you can now create dose maps. In order to do so you first need to create grids to perform the calculations. The

grids are created and changed with the *Edit grid* command. Once the grids are created you can perform dose calculations with the *Calculate dose rate* command.

Calculating a dose distribution on a grid.

The dose rates are calculated using the *Calculate dose rate* command.

The *Calculate dose rate* form allows you to select the required grid and also to select the appropriate build-up factor to perform the point-kernel calculation. The selection of the build-up factor must be done with due consideration. In order to assist you in the selection you can display the build-up factors defined in the software with the *View build-up factors* command.

The flux to dose conversion factors available are the rotational ones from ICRP 51 (1987). Other conversion factors will become available in later versions of the program.

Displaying the calculated dose maps.

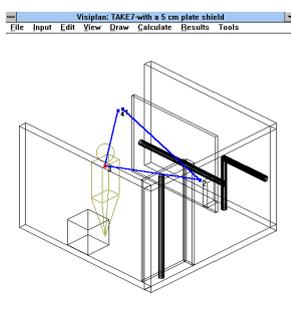
The calculated dose maps can be displayed with the *Results grids* command. The results of the calculation are displayed as isolines or coloured dots on top of the geometry. This can be done for every set of drawing parameters. A dose pattern can be shown only when the drawing parameters are set to a projection on the x-, y- or z-plane.

The dose rate at every position within the active grid can be displayed by clicking the position on the screen. The contribution of every source to the dose rate is also displayed. This function is only available for a x-, y- or z-projection of the geometry. The tool is useful to examine doses and dose contribution in specific work area's. The displayed dose contributions can help you to chose the appropriate shielding solution. The typical size of a man can be displayed on the screen at the cursor position by pressing the right mouse button.

Once you have examined the dose maps of the working area and you have pin-pointed the risk area's you can change your geometry by introducing shielding material. The new geometry will then be saved in a new Take. Use the command *File Load Take* with the option *load Take for updating to a new Take* in order to change your geometry. You can then recalculated the dose distribution on the grid defined in the earlier Take. However before doing so you have to *show and edit the grid* in the new Take with the *Edit grid* command. This action associates a new results table to this grid specific for the new Take. The results of a dose calculation are always attributed to a specific Take. Several calculations in several Takes can be done in order to compare different shielding options.

The effect of reducing source strengths (by chemical cleaning or rinsing) can be investigated in the first Take with the use of the Source Sensitivity Analysis file. This file is defined with the *Edit Source sensitivity analysis file* command. In this file a matrix is stored with a multiplication factor for each source defined in the Take. These factors can be changed to examine the effect of the source strength changes.

The influence of a change in source strength on the dose distribution can be examined by selection of the appropriate SSA set in the *Results grids* command form.



3.4. Tools for the detailed analysis stage.

In this stage you will calculate the dose uptake for every worker involved in the project. In order to do so you have to go through two major steps. The first is the definition and calculation of trajectories. The second will be to associate the workers to a specific trajectory or trajectories. The latter is done in the scenario definition.

A trajectory is defined as a sequence of tasks each including a task description, task duration and task position. The results of a trajectory dose calculation are always associated with a specific Take. So if the geometry changes during a sequence of tasks you need to define several trajectories one for each set of tasks performed in a specific geometry and source distribution. Changes, which only involve the source strengths, can be examined using the SSA sets.

A scenario is defined as a set of trajectories each connected to a worker or a group of workers. Special tools are available to create and edit scenarios. The results of the calculations provide information on individual and collective doses.

Calculating dose and dose rates on a trajectory.

Before you can start your calculations you first have to define your trajectories. This is done with the ***Edit trajectory*** command. Using this command you can define, in the current Take, a sequence of tasks, with a task position, task description and a task duration. Once this is done you can calculate the trajectory with the ***Calculate dose*** command with the *trajectory* option selected. Again the selection of the build-up factor must be performed with due care.

The results of the calculations can be examined with the ***Result Trajectory*** command. The results contain information down to task level and even down to the contribution of each source.

Creating scenario's and examining scenario results

Once you have calculated a set of trajectories in one or in several Takes you can start building your scenario's. A scenario can be defined or changed with the ***Edit Scenario*** command. This command allows you to group different trajectories connected to a worker or a group of workers from different Takes in order to achieve a global view of the dose uptake of the planned project.

The scenario results can be displayed with the ***Results Scenario*** command. The display involves results concerning the individual and collective dose. The display dose per worker allows an overview of the dose distribution in your work force.

The collective dose information can also be displayed as a function of trajectory. This display allows the detection of trajectories with a high dose burden.



Comparing several scenario's.

A good ALARA approach requires the comparison of different work scenarios. In order to fulfil this need we provided the ***Results Compare scenario's*** command.

A set of scenario can be selected for comparison. The available results are collective dose (man.Sv), maximal individual dose (Sv), intervention time (h) and collective time (man.h). The intervention time corresponds with the wall clock time during the intervention.

Based on these parameters you can now select the most appropriate scenario for your project.



calculator

3.5. Support tools and techniques.



Structures

Scenery

MDR set merge

In this section we will describe some support tools available in the program.

The calculator.

A calculator is provided in the software to assist you during the design and the interpretation of the results. The results of a calculation with this calculator can be imported in the numerical fields of the different command input forms by simply clicking the right mouse button in the appropriate input box.

Defining work area's.

In some cases it is useful to mark a certain area of a 3D-model. This can be done when the movement of a person can only Take place in a well defined area. Work area's are just a graphical aid for the analyst. They can be defined with the *Edit Work area* command.

Entering predefined geometrical structures in a Take.

For some applications it is useful to be able to position the same objects at different positions in the geometry. This can for example be the case for a lorry filled with a set of standard 200 l drums. By using the *Tools Structure Design* command you can create one copy of a 200 l drum and store it in a database. The object ones created can then be entered several times in the Take of interest with the *Input Structures* command.

Joining MDR sets.

Measured dose rate sets can be the result of several measuring campaigns thus resulting in different measured dose rate set files. In order to have a good assessment of the source strengths it is useful to join the measured sets in a single set. This can be achieved with the *Tools MDR merge* command.

The use of scenery.

In some situation it is useful to define objects in your geometry as a kind of landmarks. In some cases you do not need to include this object in your calculation because its influence is negligible. Including them would only make the calculations longer. These kinds of objects can be defined as *scenery*. They are displayed in the geometry but they are not taken into account in the calculations. An object becomes a scenery object when the group name *scenery* is used in the *Input box*, *Input cylinder* and *Input sphere* command.

4. Main commands and functions.

A detailed description of the different commands and functions mentioned in previous section is given here. The content is structured in the same way as the menu bar.

4.1. File menu

The file menu lets you create and open the database where all the information of the project will be stored. It also gives the user the possibility to open or define "Takes".

Each of the commands is explained in the following subsections.

File

New Database

Enables to create a new database to store a new project. The file interface enables you to choose the name and the directory of the new database. This command only creates your database.



File

Open Database

Enables the opening of a database for further processing. The database has to be created before you can open it.

File

Database Maintenance

This command is only available just after opening a database and before loading a Take. The four subcommands enable the maintenance of your database. Information which has become obsolete can be removed from the database. The commands are:

Delete Take

Enables you to delete a complete Take. The names of the results calculated for the Take are displayed (trajectory, grid and scenarios). Deleting a Take used in scenario will also result in the removal of the scenario from the database. Results and scenario's related to the Take will be deleted.



Delete Grid

This command results in the removal of a grid definition and all the results calculated with this grid from the database for all Takes.

Delete Trajectory

These command results in the removal of a Trajectory definition and all the results calculated with this Trajectory from the database for all Takes and scenarios.

Delete MDR set

Removes the chosen Measured Dose Rate set from the project database.



File

New Take

This command results in the opening of a New Take to start a new problem definition (geometry, sources and materials). The interface box that appears on the screen allows the user to describe this Take. The Take numbering is done automatically by the program.



File

Load Take

Enables the user to load a previously saved Take. The load can be performed with the following options:

Load Take for use without updating

The Take is opened without the possibility to change the Take information. The Take is only used for dose calculation on grids or trajectories.

Load Take for updating to new Take

The updating or changing of a Take always results in a new Take. This can be used to introduce new materials, shielding or sources in the geometry.

Use current Take

The current Take is activated with this command. This is the last active Take in the database before the ***File Exit*** command was given.



File

Save Take

Saves the Take definition given by the user in the database. The Take has to be saved before calculations can be performed.

