ORTEC®

ANGLE 3.0

Semiconductor Detector Efficiency Calculations

User Guide

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ANGLE 3

Semiconductor Detector Efficiency Calculations

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Introduction

Theoretical

In any gamma-spectrometric measurement with semiconductor detectors, the task of **converting number of counts** – collected by multichannel analyzer (MCA) in a full gamma-energy peak – **into the activity of the sample/source** cannot be avoided. There are, in principle, three approaches to this issue: relative, absolute and semi-empirical.

Relative method is more accurate, but less flexible to changing experimental conditions, while absolute ones (e.g. Monte Carlo) are beautifully exact and flexible, but often too demanding when extent and accuracy of required input data are concerned.

Semi-empirical approach takes advantage of positive attributes of both relative and absolute methodologies, simultaneously minimizing their drawbacks. This comes to the determination of full-energy peak efficiency (ε_p), an energy dependent characteristic of the detector for the given counting arrangement. Semi-empirical methods commonly consist of two parts: experimental (producing one kind or another of reference efficiency characteristic of the detector) and relative-to-this calculation of ε_p. Inflexibility of the relative method is avoided in this way, as well as the demand for many physical parameters needed in absolute calculations.

Numerous variations exist within semi-empirical approach, with emphases either to the experimental or to the computational part. It is important to note that only simultaneous differential treatment of

- gamma-attenuation,
- counting geometry and
- detector response

is essentially justified. Attempting to separately calculating these three physical phenomena, generally leads to (over)simplifications, which further require complex corrections with limited success.

This fact is transformed into the concept of the **effective solid angle** ($\overline{\Omega}$) – a calculated value incorporating the three components, and closely related to the detection efficiency. Assuming that the virtual peak-to-total ratio is an intrinsic characteristic of the detector crystal (depending on gamma energy only), leads to ε_p being proportional to $\overline{\Omega}$. The detection efficiency is then found as:

$$\varepsilon_p = \varepsilon_{p,ref} \, (\overline{\Omega} \, / \, \overline{\Omega}_{ref})$$

which is further the basis of the **"efficiency transfer" principle**. Efficiency transfer factor (ET) is thus the ratio of the actual to reference efficiency at a given gamma-energy.

The ET approach is extremely useful, offering:

- practically unlimited flexibility in sample type and size, matrix composition, detector choice and source detector counting arrangement and
- cancelling out much of the impact of input data uncertainties (especially those of the detector) on final ε_p calculation result.

This implicit latter "ET error compensation" gives to ET an important advantage over purely mathematical (Monte Carlo) efficiency calculation approaches.

Therefore, in order to apply this method the following should be known:

- **reference efficiency curve**, usually obtained by counting calibrated source(s) at reference geometry(ies) and covering gamma-energies in the region of interest; some effort should be put in this phase to reach accurate ε_p vs. E_γ function, but it pays off in further exploitation;
- **geometrical and compositional data** about the source, detector, and all intercepting layers (for the latter e.g. source container and holder, detector end-cap and housing, dead layers, etc.) and
- **gamma-attenuation coefficients** for all materials involved (normally a data file in the computer program).

Software

ANGLE software is computer program which performs these calculations. In its various forms, ANGLE has been in use for 15 years now in numerous gamma-spectrometry based analytical laboratories worldwide.

The program can be applied to practically all situations encountered in gamma-laboratory practice: point, disc, cylindrical or Marinelli samples, small and large, of any matrix composition. No standards are required, but a start-up "**reference efficiency curve**" (**REC**) should be obtained ("once for ever") by measuring a calibrated source at some reference counting geometry. Calibration sources should cover gamma-energy region of analytical interest (e.g. 50-3000keV). It is suggested that calibrated sources with low certified uncertainties (not exceeding 1.5%-2.5%) are used to obtain as many calibration points (efficiencies vs. gamma-energies) as possible for the energy range mentioned. This non-negligible initial effort is largely paid back in future exploitation, since well accurate reference efficiency curve is the basis for accurate ANGLE application.

One REC per detector is enough, in principle. It is recommended to construct it by counting a number of calibrated point sources at a large distance from the detector (e.g. 20-30 cm), avoiding true coincidences and matrix effects. Also, absolutely calibrated point sources are often certified to better accuracy than voluminous ones. It is generally more prudent to use several single-nuclide sources, than a single multi-nuclide one.

However, in order to additionally exploit the ET error-compensation effect, one might consider constructing more RECs for the same detector. For instance, the same point source(s) counted at large distance could also be counted on the detector top, yielding another REC. Calibrated cylindrical and Marinelli sources could produce additional RECs.

In ideal case, using any of several RECs in ε_p calculations would produce the same result for the actual sample, i.e. result should be independent on the choice of REC. Given the fact all input data (detector, source, geometry) are inaccurate to some extent, choosing a "**likely**" **REC** for the actual sample/geometry should eventually produce better (more accurate) results, due to larger ET error compensation. In other words, if the REC sample/geometry is closer to the actual sample, results are likely to be better. This in itself is a measure of the accuracy of the various sample and detector

parameter choices – if two RECs produce results which are close, the implication is that both sample/geometry and detector are well characterized.

ANGLE 3 allows multiple RECs to be employed for a given detector, so that varying of REC can be one of the elements in the optimization of gamma-spectrometry analytical procedure.

In short, ANGLE software is characterized by:

- broad application range, covering the vast majority of situations encountered in gamma spectrometry practice;
- high accuracy (uncertainties of calculated detector efficiencies are of the order of a few percent – usually less than from other uncertainty sources in the measurement), based upon the concept of the ET and effective solid angle calculations;
- easy data manipulation with friendly and intuitive graphical user interface;
- short computation times of the order of seconds on standard PCs (normaly not more than a minute even for the most complex calculations);
- flexibility in respect with changing input parameters, which enables easy estimation of the impact of a particular parameter on the detection efficiency and, related to this
- teaching/training aspect (e.g. in gamma spectrometry courses), since practically all parameters characterizing the detection process are found therein, systematically grouped and easy to follow and understand;
- no need for "factory characterization" of the detector – ANGLE can be used with any HPGE detector; when necessary, the detector performance is easily re-validated without intervention from the vendor;
- possibility to expand, so as to meet changing users' counting conditions/requirements[1];
- possibility to accommodate other ET methods for efficiency calculations[1].

[1] Subject to request to the developers

Built-in help system

At any moment an in built help system is available by simply pressing the **F1** key. The Help System is context sensitive, meaning that the help provided by the system is dependent on the specific action being performed at the specific time help is requested (E.g. by pressing **F1** key while entering detector data, help for detector data entry will be displayed).

Help contents can be displayed by choosing the ANGLE main menu option "**Help**" and then option "**Help contents**" (Figure 1).

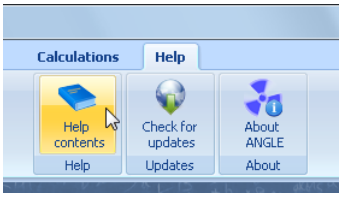

Figure 1 Help contents menu item

Data entry

In order to perform calculations with ANGLE, parameters for the specific measurement must be defined. The Basic process starts with entry of the data defining the detector, container and geometry used for calculation.

All information is logically divided into one of five groups:

- **Detector** – contains information about all detectors defined in ANGLE. Each detector is represented with its name and description. Detector images in the left-hand part of the list represent one of six possible detector types.
- **Container** – contains information about all containers (beakers) defined in ANGLE. Each container is represented with its name and description. Container images in the left-hand part of the list represent one of two possible container types. "No container" option is at the top of the list.
- **Geometry** – contains information about all geometries defined in ANGLE. "Geometry" here means defining the geometrical positioning of the source vs. the detector, including source support ("holder"). Each geometry is represented with its name and description. Images in the left-hand part of the list represents one of three possible geometry types (for well detector, for Marinelli geometry or for other detector/geometry types). "No holder" option is at the top of the list.
- **Source** – this group contains information about the radiation source used for calculations (height, radius and material).
- **Other** – contains four remaining, uncategorized, calculation parameters: energies-of-interest set, reference efficiency curve, calculation precision and units (centimeters/inches).

These five principal data groups are arranged in the **main ANGLE window** as shown in Figure 2.

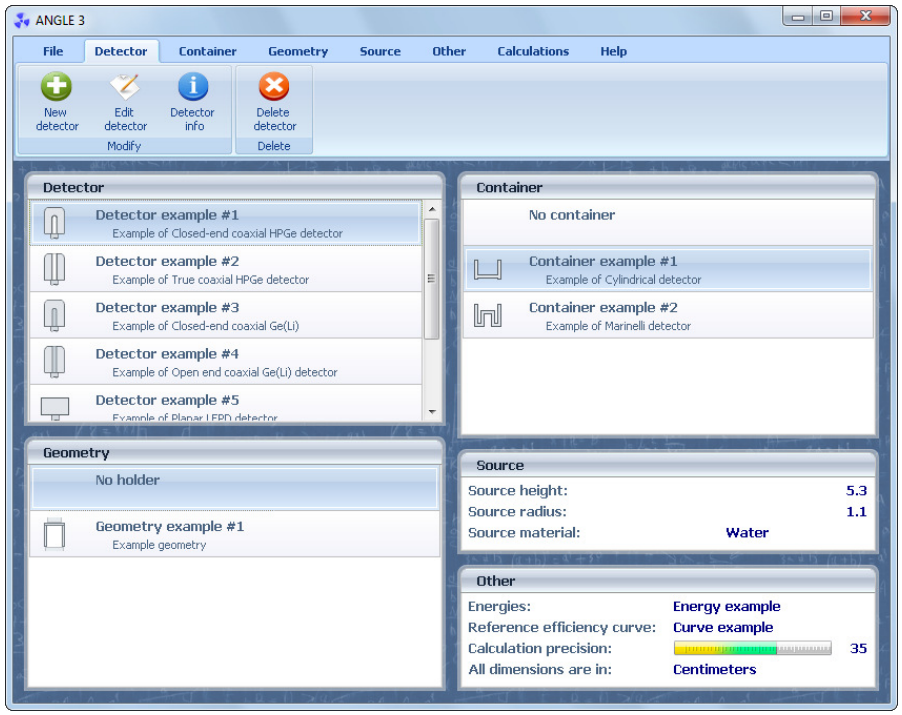

Figure 2 ANGLE main window

Since version 3, "ribbon" menu is introduced, replacing classic program menu. This makes ANGLE usage faster and easier, while maintaining the same menu structure as before.

Data entry for detector, container and geometry can be done in two ways. The first is by choosing the option "**New...**" from appropriate main menu item (Figure 3). The second way is by right-clicking the appropriate list and choosing the option "**New...**" from pop-up menu (Figure 4).

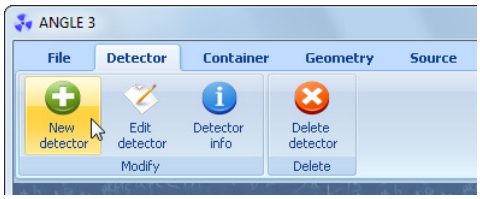

Figure 3 Entering new detector using main menu

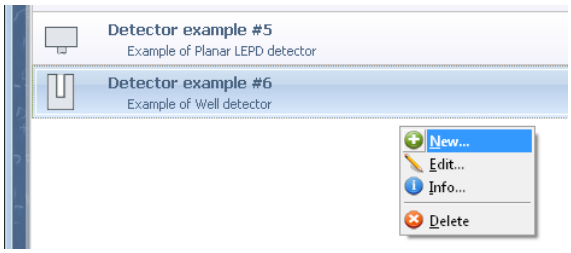

Figure 4 Entering new detector using pop-up menu

When entering the data, such as detector data, moving between text fields can be done by pressing **Tab** or **Enter** key. In this way the data entry is much faster, especially when using the numeric keyboard.

All dimensions are expressed in **centimeters** (cm) by default. ANGLE supports inches, as well. Switching between these two dimension units can be done by clicking on the appropriate option in the **Other** group of the main window of the ANGLE.

Detector data entry

First, the detector name and type are to be chosen. There are six detector types available (Figure 5):

- Closed-end coaxial HPGe
- True coaxial HPGe
- Closed-end coaxial Ge(Li)
- Open end coaxial Ge(Li)
- Planar LEPD
- Well

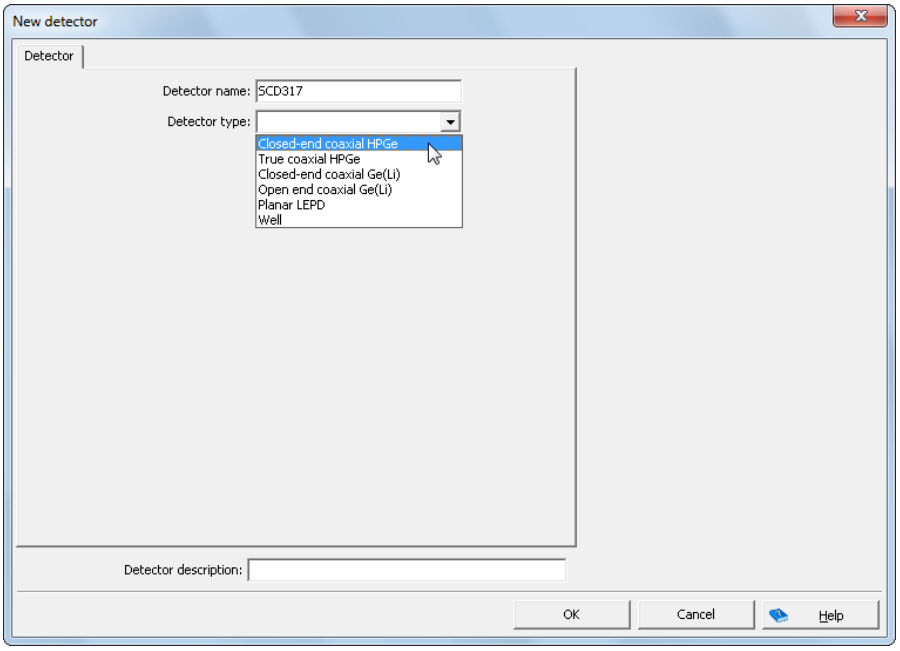

Figure 5 Choosing the detector type

After the detector type is chosen, data fields appropriate for that detector are shown. Data fields are divided into six groups (four in case of well detectors), each one represented by one tab:

- **Detector** (data for the detector crystal)
- **End-cap window**[2] (data for the end-cap window, if any)
- **Antimicrophonic shield** (data for the antimicrophonic shield, if any)
- **End-cap** (detector end-cap data)
- **Vacuum** (data about the vacuum between the end-cap and detector crystal)
- **Housing**[2] (detector housing data)

At the right-hand side of the window, schematic drawing is shown, representing the data which is currently entered. While entering the dimensions, a red dimension line is showed on the illustration indicating the required dimension (Figure 6).

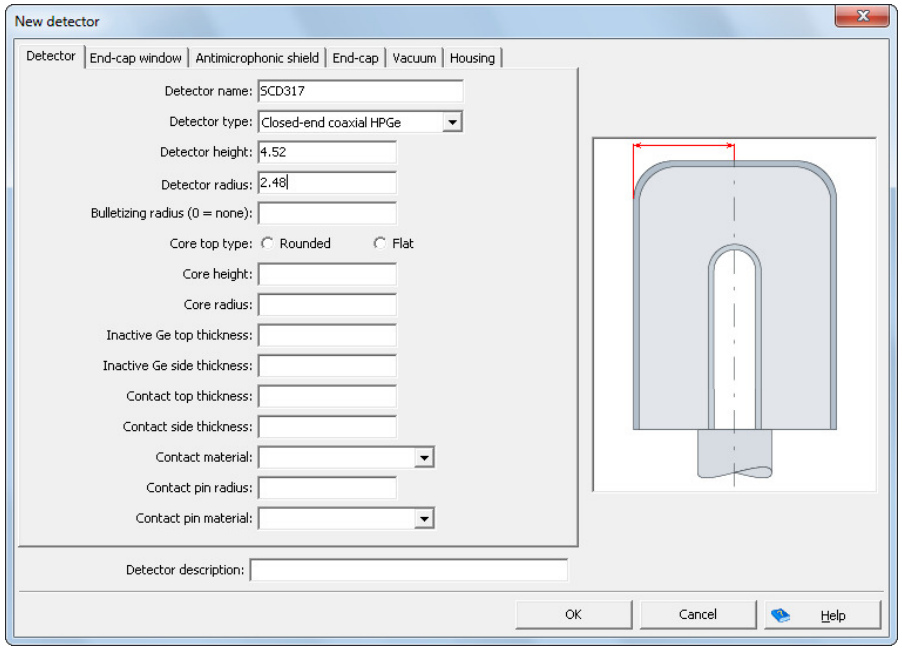

Figure 6 Detector data entry

[2] This group does not exist for well-type detectors.

By pressing **Enter** key, while cursor is in the last field of one group/tab (e.g. *Contact pin material* field in the *Detector* tab), the next group/tab will be displayed automatically, so data entry can be continued without the need to select the next tab and data field. In other words, pressing Enter key after each data entry is the easiest way to continue entering and/or editing.

Materials (i.e. material chemical composition) can be chosen from the appropriate drop-down list (Figure 7). In the drop-down list the most common materials for the given items are shown (for example, common materials for Contact material is gold, but it may also be aluminum, or something else…).

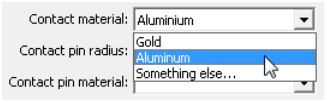

Figure 7 Choosing the material

If the desired material cannot be found on the list, clicking on "**Something else...**" any other material can be defined. More about the entering of new materials later in the "**Defining custom materials**" section.

Real numbers can be entered in exponential form, as well. For example, $5.43 \cdot 10^{-3}$ can be entered in two ways: as **0.00543** or **5.43E-3**. This is very useful when entering very small numbers, for example **1E-7** ($1 \cdot 10^{-7}$), which is more convenient than **0.0000001**.

The end-cap tab contains, besides the information about detector end-cap thicknesses and material, information about end-cap coating layers, if any. Up to two coating layers are supported. Each coating layer can be of different material and its thicknesses can be defined separately for end-cap top and side.

If **end-cap window** and/or **antimicrophonic shield** exist, i.e. if the check boxes are checked in appropriate groups, the additional fields will be displayed, so their dimensions and materials can be defined.

Depending on whether antimicrophonic shield exists or not, the number of fields needed to be entered under **Vacuum** tab will be different.

Container data entry

Similar to the detector data entry, there are two different container types:

- Cylindrical
- Marinelli

Depending on the container type chosen, the number of data fields to be entered will vary. Fields for cylindrical container type are shown on Figure 8.

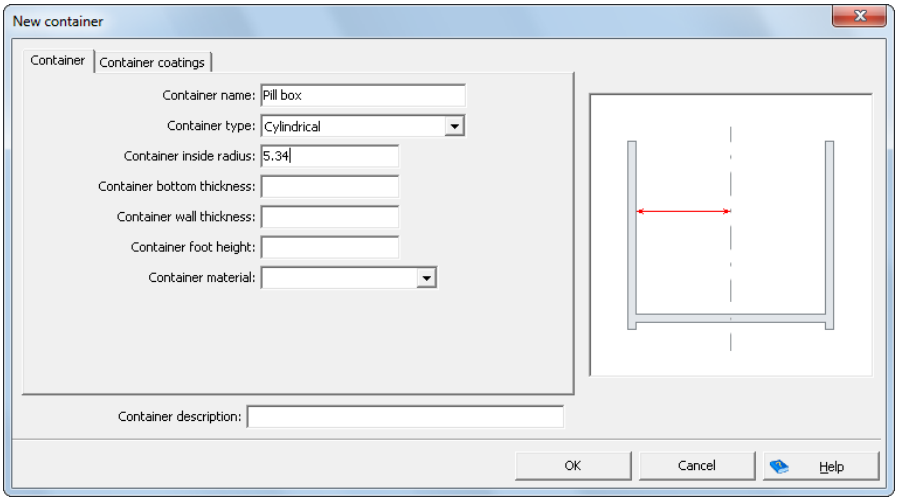

Figure 8 Container data entry

If the source is not in a container (e.g. stand-alone pill sources), then container data do not have to be entered. **No container** option is to be used instead.

The first tab contains the information about the container itself, while the second tab contains the information about container coating layers. Up to two coating layers are supported. Each coating layer can be of different material and its thicknesses can be defined separately for container side and bottom(s).

Depending on whether antimicrophonic shield exists or not, the number of fields needed to be entered under **Vacuum** tab will be different.

Geometry data entry

Geometry defines the source/container holder (support) and additional intercepting layers (if any).

For practical reasons, when well detectors are chosen, no possibility for source holder is offered (i.e. only intercepting layers can be defined). The same is valid when a Marinelli container is chosen (regardless of the detector type).

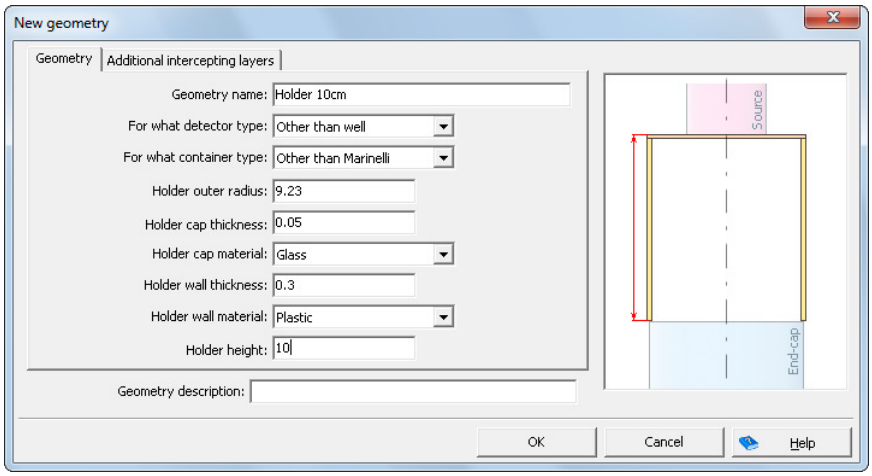

Figure 9 Geometry data entry

If there is no holder and there are no additional intercepting layers (e.g. source/container is placed on the detector top), then geometry data do not have to be entered. **No holder** option is to be used instead.

Additional intercepting layers (between the detector and the source) are, for instance, thin protective plastic foils. Maximal number of additional intercepting layers that can be entered is five. Every additional intercepting layer is defined by its top and side thickness and material (Figure 10).

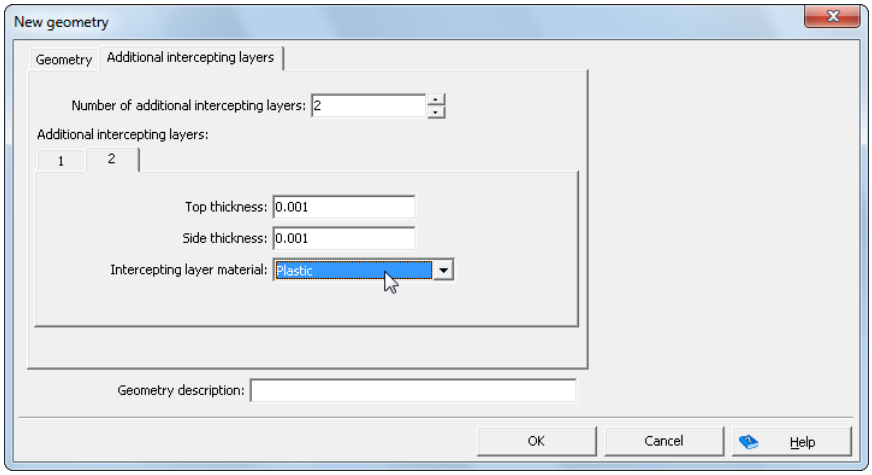

Figure 10 Additional intercepting layers entry

Source data entry

The source is defined by its height, radius and material. Height and radius can be changed by simply clicking the appropriate option in **Source** group in the main ANGLE window and entering the new value (Figure 11).

Figure 11 Changing the source height

Source height can be equal to zero ("disk sources"). Also, both source height and radius can be equal to zero, in case of "point sources".

When one container is selected, the source radius parameter automatically changes to its inner radius, but this value can be changed manually in case of cylindrical or no container. This way, the source with smaller radius than container inner radius can be defined (e.g. pill sources).

If a Marinelli container is selected, source radius cannot be entered/changed – it is equal to the container inner radius.

Source material can be changed by clicking "**Source material**" label and choosing adequate option from pop-up menu (Figure 12). For more details see "**Defining custom materials"** section.

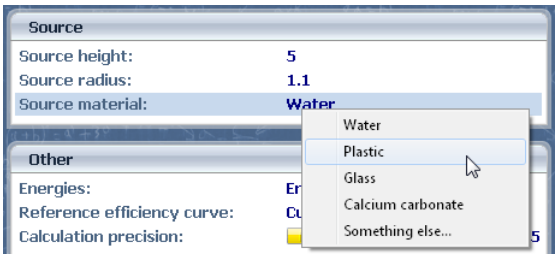

Figure 12 Choosing the source material

Reference efficiency curves

The key thing for efficiency calculations is the reference efficiency curve (REC). By clicking the "**Reference efficiency curve**" option in the **Other** group of the main ANGLE window, the pop-up menu will appear (Figure 13).

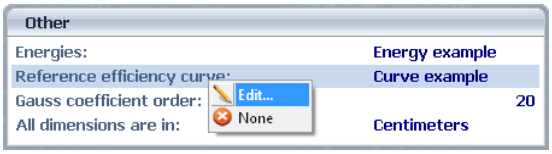

Figure 13 Reference efficiency curve pop-up menu options

Obtaining reliable reference efficiency curve is crucial for successful ANGLE utilization: all ANGLE results for a given detector will be relative to REC with error propagation factor = 1 (that is to say 100% of the uncertainty in the REC is added in quadrature to the other sources of uncertainty).

Investment of care in determining the REC will always pay off!

First option ("**Edit...**") is for entering, changing and loading already saved curves. The later option ("**None**") turns off the reference curve.

If the reference efficiency curve is not specified, efficiencies will not (can not) be calculated! Only effective solid angles will be calculated in this case.

When defining a reference efficiency curve (Figure 14), several groups of parameters must be entered:

- Experimental points
- Interpolation regions
- Detector name
- Reference container data
- Reference geometry data

- Source data
- Reference curve name and description.

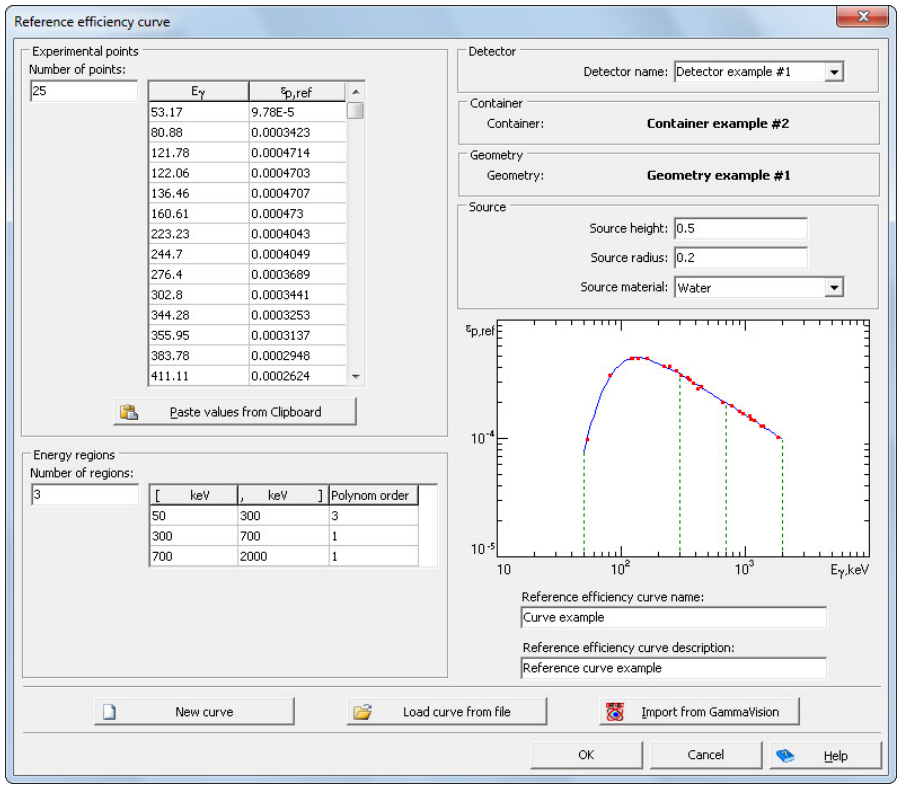

Figure 14 Defining the reference efficiency curve

After confirming the entry by clicking the "**OK**" button, user can choose whether the curve data will be saved to file or not.

By clicking the "**New curve**" button all data are cleared and user can enter data for a new reference efficiency curve.

Previously saved reference efficiency curve can be loaded from file by clicking "**Load curve from file**" button.

Entering the curve data

First, experimental points data must be entered – the number of points and appropriate number of energy–efficiency pairs. The entered points will be automatically drawn on the log-log diagram in the right-hand part of the window.

Experimental points can be easily transferred from another application simply by copying the values and pasting it using the "**Paste values from Clipboard**" button.

The reference efficiency curve represents the curve fitted through the experimental points. In order to have the best fit possible, the interpolation can be divided into intervals with different polynomial orders.

It is possible to use zero value for polynomial order. In this case experimental points will be connected with non-interpolated line.

The intervals are defined by energy pairs (in *keV*) and polynomial order for that interval.

Although ANGLE supports polynomial fitting up to order of 6, it is recommendable to divide energy region of interest into several segments and fit each of them with polynomials of lower order (not more than order 3).

The intervals are represented on the diagram with green dashed lines.

When interpolating the reference efficiency curve ANGLE takes one closest point from the neighboring intervals in order to create smoother curve.

It is possible to define a new container and/or geometry, or to choose one of already existing containers/geometries.

For example, after clicking on **Container** option, a pop-up window with the following options will be displayed (Figure 15):

- **Define** – new reference container "from scratch"

- **Edit** – change the current reference container
- **Info** – information about the reference container
- **No container** – no reference container
- **Select container** – select one of existing containers defined in ANGLE

Reference geometry allows usage of holder on top of Well detector for point sources. Nevertheless, reference calibration is best with source placed in the well, as will be the samples.

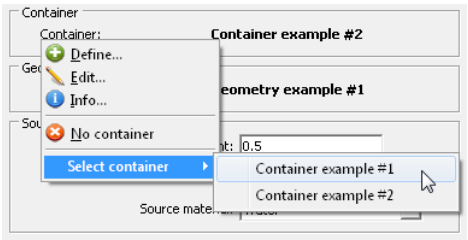

Figure 15 Defining reference container

One REC per detector is enough, in principle. It is recommended to construct it by counting a number of calibrated point sources at a large distance from the detector (e.g. 20–30 cm), avoiding true coincidences and matrix effects. Also, absolutely calibrated point sources are often certified to better accuracy than voluminous ones. It is generally more prudent to use several single-nuclide sources, than a single multi-nuclide one.

However, in order to additionally exploit the **ET error-compensation effect**, one might consider constructing **more RECs for the same detector**. For instance, the same point source(s) counted at large distance could also be counted on the detector top, yielding another REC. Calibrated cylindrical and Marinelli sources could produce additional RECs. During exploitation, choosing a REC geometry similar to the actual sample geometry should eventually produce better (more accurate) results – due to larger ET error-compensation.

Importing curve from ORTEC GammaVision

The reference efficiency curve can also be imported directly from ORTEC's **GammaVision-32** software by clicking the "**Import from GammaVision**" button.

GammaVision files that can be imported into ANGLE have **.EFT** extension.

Defining custom materials

Whenever a material is to be chosen (for source, container, intercepting layers, detector elements, etc), ANGLE offers a list of common materials for the particular case. If none of them is adequate, material can be entered manually or loaded from a previously saved material file. This is done by choosing "**Something else...**" option from material drop-down list (Figure 7), i.e. pop-up menu (Figure 12). After this, the material entry window is shown. Material can be entered in three ways, which can be chosen by appropriate buttons at the top of the form:

- As a mixture of elements
- As a compound
- As a mixture of compounds

When entering the material as a mixture of elements, the number of elements, element symbols and percentages, material density and material name has to be entered (Figure 16).

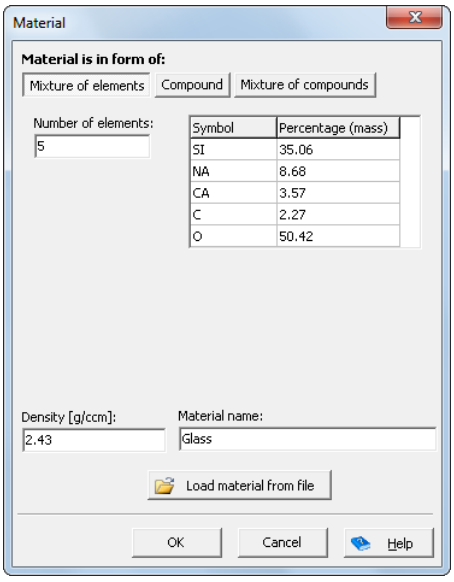

Figure 16 Entering the material as a mixture of elements

When entering the material as a compound, the number of elements, element symbols and number of atoms, material density and material name has to be entered (Figure 17).

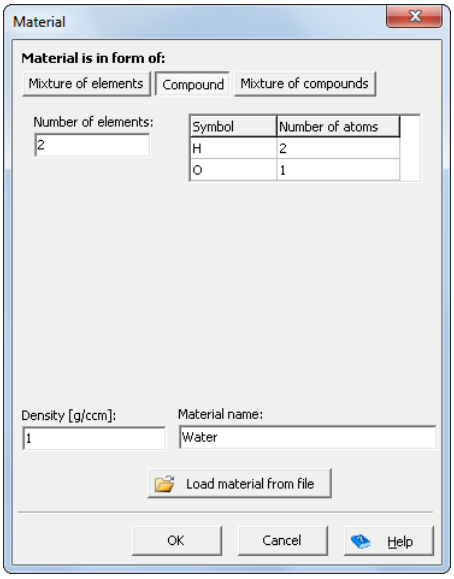

Figure 17 Entering the material as a compound

The third way of defining a custom material is a mixture of compounds. First, the number of compounds is entered. Next, each compound is defined, as well as its share (in percents) in the material (Figure 18). Finally, a material density and name must be entered.

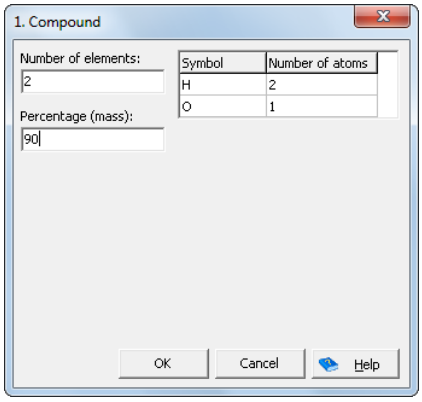

Figure 18 Entering one compound of a mixture of compounds

When all material data is entered, after a click on the "**OK**" button the user will be asked if the material should be saved to disk, for further use.

Knowing material composition as good as possible contributes to the accuracy of calculated results. However, baring in mind it goes about gamma-atenuation, it is not necessary to know the exact material composition, particularly not materials in trace quantities.

Loading already saved material

In material entry dialog box there is a "**Load material from file**" button. After clicking on that button user can choose the file with material which was previously saved.

Defining energy sets

In order to perform the calculation, a set of energies must be defined. Set of energies represent chosen gamma-energies at which ANGLE will calculate effective solid angles and full energy peak efficiencies, which is the ultimate goal of the software. By clicking "**Energies**" option from the **Other** group, the energy set dialog will be shown (Figure 19).

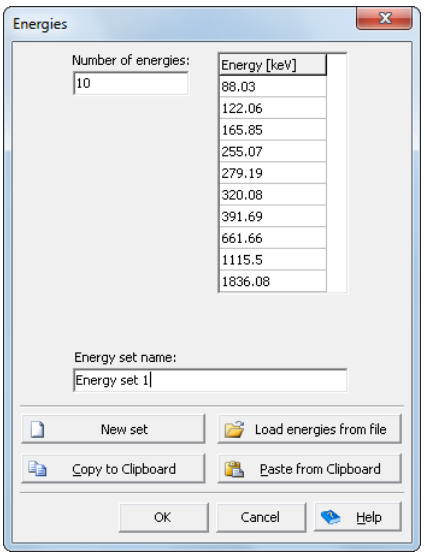

Figure 19 Defining the energy set

The dialog will automatically display the current energy set. The user can change the set, enter a completely new set, or load a previously saved set from disk.

When entering a new set of energies, the user should click on a "**New set**" button. Then, the number of energies has to be entered and energies (in *keV*). Finally, an energy set name should be assigned.

The whole energy set can be copied or pasted from Clipboard using "**Copy to Clipboard**" and "**Paste from Clipboard**" buttons, respectively.

After clicking the "**OK**" button the user will be prompted if the energy set should be saved to a file for future use.

Loading already saved energy set

Similar to material loading, there is a "**Load energies from file**" button. After clicking that button user can choose the file with energies which was previously saved.

Calculation precision

During the calculations, ANGLE performs numerical integration over the source volume and detector surface which is "visible" by the source. Precision is defined by specifying the so called Gauss coefficient order. Higher coefficient values result in higher precision, but longer calculations times. For large sources, the use of higher calculation precisions should be particularly considered.

ANGLE allows calculation precision values between 10 and 50. Recommended values, which will cover most cases, are between 25 and 35. The selected calculation precision is displayed in **Other** group, both numerically and graphically (Figure 20).

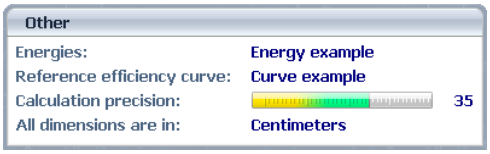

Figure 20 Other group

To change the calculation precision, click the "**Calculation precision**" option in the **Other** group, or choose menu option "**Other**" and then option "**Change calculation precision**". In the calculation precision dialog simply drag the slider to the desired position and click "**OK**" button (Figure 21).

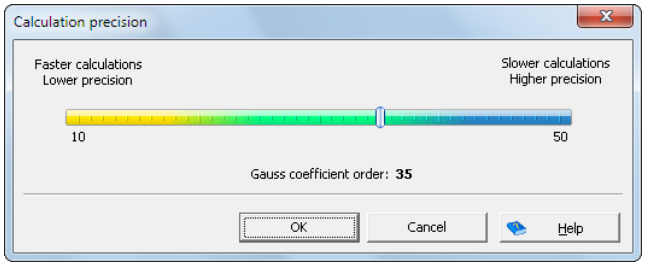

Figure 21 Calculation precision dialog

Dimensions

ANGLE supports both centimeters and inches as dimension units. Switching between these two dimension units can be done by clicking on the "**All dimensions are in**" option in the **Other** group of the main window of ANGLE.

Calculations

Calculations can be performed after defining all requested input parameters (from 5 main groups), i.e.:

- selecting appropriate detector, container and geometry from the lists,
- defining the source and
- all information in Other group.

Calculations from current data are performed by choosing the appropriate option from the "**Calculations**" main menu group (Figure 22).

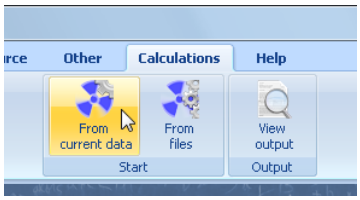

Figure 22 Starting the calculation

Before calculations start ANGLE checks all input values for possible incompatibilities. If there is one or more incompatibilities in input parameters, such as container not compatible with the detector (for example when using well detector with Marinelli container), the error message will be shown and calculations will not be performed (Figure 23).

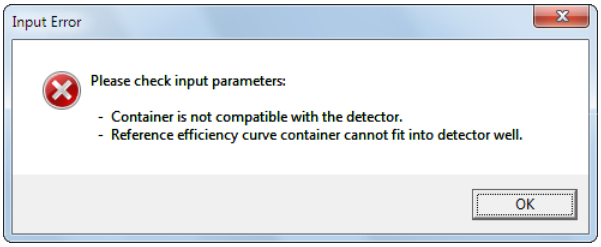

Figure 23 Error in input parameters message box

After testing the input parameters ANGLE asks for a name of the file where the output results will be saved and the calculations begins. While calculating, ANGLE displays calculation information, as shown in Figure 24.

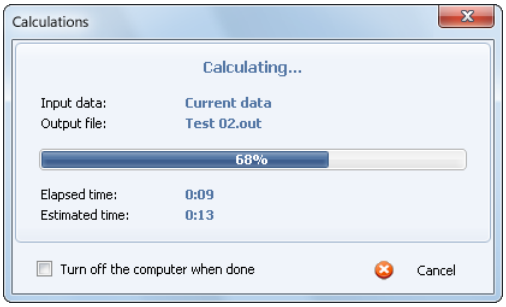

Figure 24 Calculations information box

First line shows the input parameters source – "Current data" or the name of the input file (more about the input files in the following chapter). Second line shows the name of the output file. In the central part of the calculations information box there is a progress bar, showing the completion progress in percents. Finally, the total calculation time and the estimated time for the calculation are shown.

Calculations can be canceled anytime by clicking the "**Cancel**" button

Option "**Turn off the computer when done**" will, if checked, automatically shut down the computer after the calculations are finished. This is useful for time consuming calculations (e.g. long batch jobs), where computers are left unattended to finish calculations. Once all calculations are finished, the shut down dialog will be displayed (Figure 25):

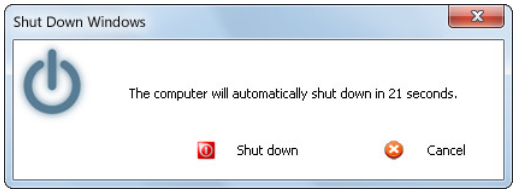

Figure 25 Automatic shut down dialog

Shut down dialog will start 30-seconds countdown, after which the shut down procedure will be initiated. During this period it is possible to cancel the shut down, or even force it before the timer reaches zero.

After the calculations are finished, the results are shown. Output files contain all input parameters, so they can be reviewed anytime later (Figure 26).

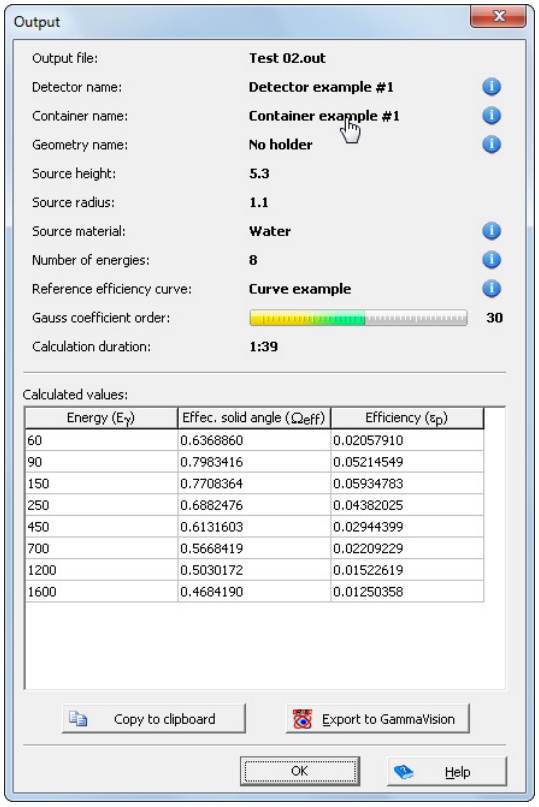

Figure 26 Output results window

In order to see the complete data for some item (container, for example), the appropriate option should be clicked.

The input parameters containing more information can be recognized by "info" button at the right-hand side. Also, the cursor changes its shape to a pointed hand when moving over these parameters (Figure 26).

Calculated values are shown in the lower part of the window, in form of a table. Values for effective solid angle ($\overline{\Omega}_{eff}$) and efficiency (ε_p) are shown for each energy from the given energy set.

The ε_p values will be calculated only if the reference efficiency curve is defined. Otherwise, only $\overline{\Omega}_{eff}$ values are calculated.

Output results can be copied to clipboard by clicking the "**Copy to clipboard**" button, so they can be pasted to some other program, for example to spreadsheet or word processor application.

Calculation results can be reviewed anytime later. By choosing the "**View Output...**" option from the "**Calculation**" main menu (Figure 27) output files can be selected and appropriate results will be displayed (Figure 27).

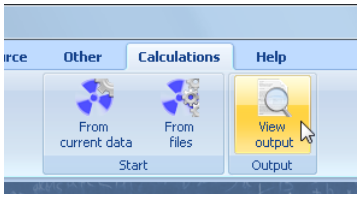

Figure 27 Viewing output files

It is possible to select more than output file (Figure 28):

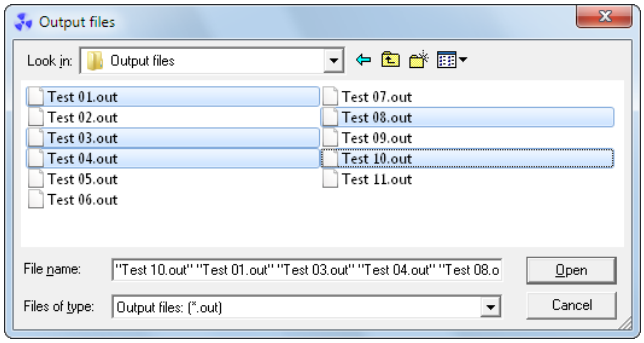

Figure 28 Selecting multiple output files

For selecting the multiple files use any of the following standard Windows procedures (or their combination):

- By clicking the file name while holding keyboard **Ctrl** key will select/deselect that file.
- By clicking one file name and clicking on another file name while holding down **Shift** key, all files between them will be selected, too.
- By pressing **Ctrl+A** key combination all files will be selected.

Output results window in this case will have a list of output files in the left-hand part of the window (Figure 29). By clicking a name of a file, the results from that file will be displayed in the right-hand part of the window. This option is useful when comparing the results of calculations or when transferring the results to another application.

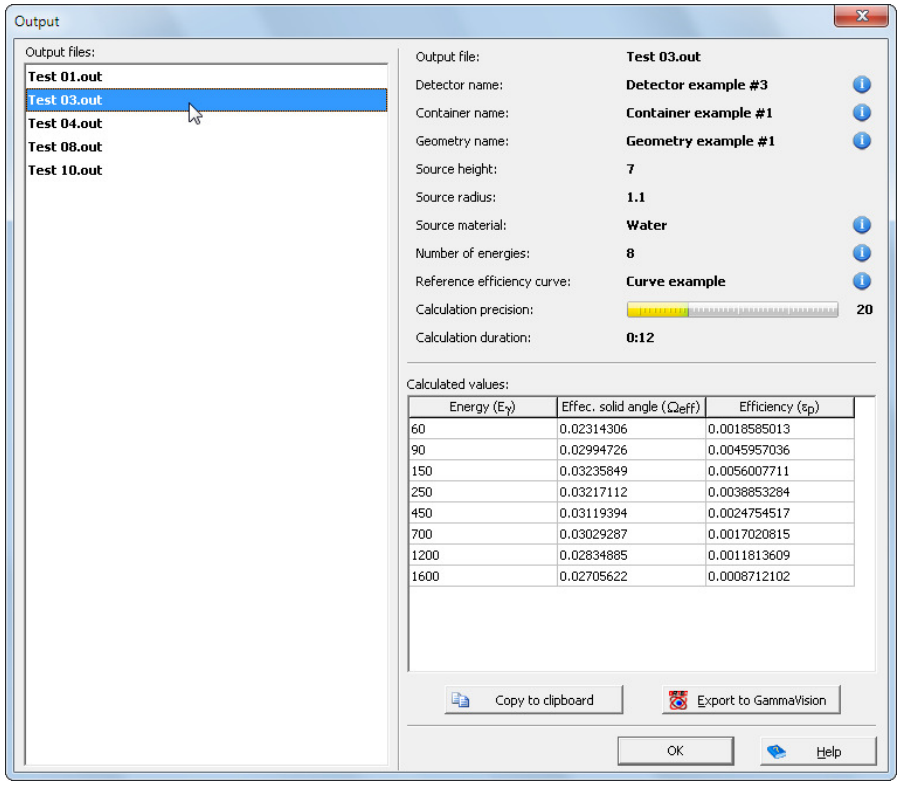

Figure 29 Multiple output results window

Exporting to ORTEC GammaVision

Calculation results can also be exported to **ORTEC GammaVission** format, simply by clicking on "**Export to GammaVision**" button (Figure 26).

Export to **GammaVision** will be possible only in case when efficiencies are calculated, i.e. when reference efficiency curve is defined. Otherwise, "**Export to GammaVision**" button will be disabled.

Saving input parameters

All input parameters can be saved to a file. This is convenient in several cases:

- When calculations will not be performed immediately.
- For preparing the calculations which will be performed on another computer.
- For preparing the inpus for multiple calculations at the same time (batch jobs).

Input file can be saved by choosing the item "**Save as**" from main menu option "**File**" (Figure 30), or by pressing **Ctrl+S** key combination on keyboard.

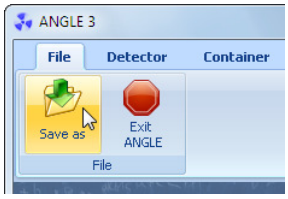

Figure 30 Saving the input parameters

Before saving ANGLE checks all input values for possible incompatibilities. If there is an incompatibility in input parameters, such as invalid detector-container combination (for example when using well detector with Marinelli container), the error message will be shown and calculations will not be performed (Figure 23).

Calculations from saved files

Calculations from one or more saved files can be performed by choosing the appropriate option from the "**Calculations**" main menu item (Figure 31).

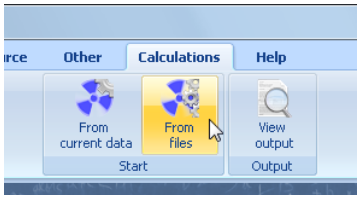

Figure 31 Starting calculations from saved files

After choosing one or more previously saved input files the calculation begins. Output file names will have the same name as input files (except for the extension, which will be ".out" instead of ".sav"). The calculation information box will be displayed, similar to the one for the calculations of current data. In case of multiple input files, additional information will be showed in the information box – progress bar and elapsed time for the overall process (Figure 32).

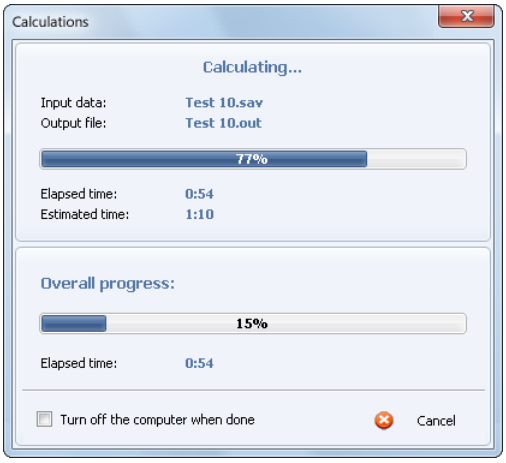

Figure 32 Calculations information box for multiple calculations

Output files will have the same names as the input ones. If output files with the same names exist they will be overwritten without warning.

After the calculations are finished, the output results will be automatically displayed for all selected files, except in case when automatic computer shut down is requested.

Software registration

After the installation ANGLE works in **demo mode**. In this mode the software is fully functional, except the calculations cannot be performed. After obtaining ANGLE it must be registered in order to unlock the calculations.

Each time you reinstall your computer ANGLE must be registered in order to be fully operational. **The number of registration for each copy of ANGLE is limited to three registrations per one year. Do not disclose serial number to other parties to prevent yourself being unable to register your copy when needed.**

Registration form can be opened simply by clicking on "**Register ANGLE 3**" option from the "**Help**" main menu item (Figure 33).

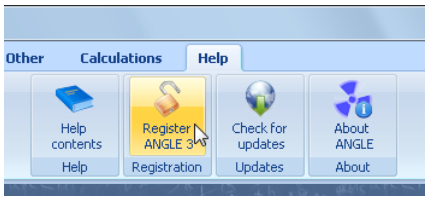

Figure 33 Registration menu item

The registration form consists of the following fields (Figure 34):

- **Name**
- **Company**
- **Address** (two lines)

- **City**
- **ZIP/postal code**
- **Country**
- **Telephone**
- **e-mail**
- **Serial number**
- **Authorization key**

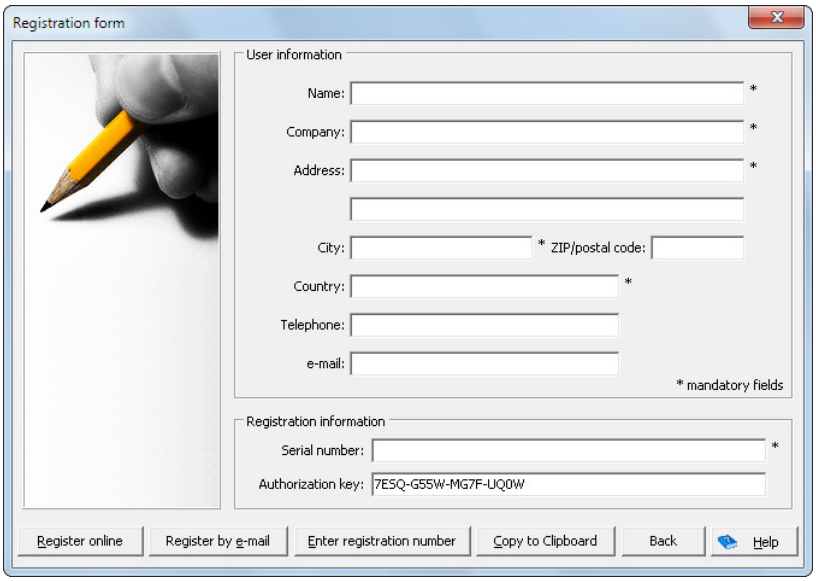

Figure 34 The registration form

Mandatory fields are marked with the asterisk ("*").

The **Serial number** field must be populated with valid ANGLE serial number obtained from the software distributor.

Authorization key is calculated by ANGLE and it cannot be modified.

There are two ways to register ANGLE:

- **Online registration**
- **Registration by e-mail**

If the computer is connected to the Internet, registration can be completed in a few seconds simply by clicking the "**Register online**" button.

The second method of registering is by e-mail. By clicking on "**Register by e-mail**", ANGLE will automatically create an e-mail for you with all registration parameters. After receiving your mail we will send you back the unique registration number which will unlock your copy of the software. To enter received registration number click the "**Enter registration number**" button and enter the registration button you received (Figure 35).

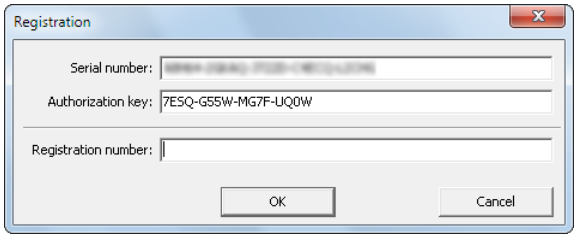

Figure 35 Registration number entry

We suggest you copy the received registration number and paste it to the appropriate field, in order to avoid typing mistakes.

Registration information can be copied to Clipboard by clicking the "**Copy to Clipboard**" button and pasted to other application (e.g. text editor). This can be convenient when sending the registration information from another computer.

Updating ANGLE

ANGLE has built-in automatic updating function. To check if there is an update for ANGLE available choose the "**Check For Updates**" option from the "**Help**" main menu item (Figure 36).

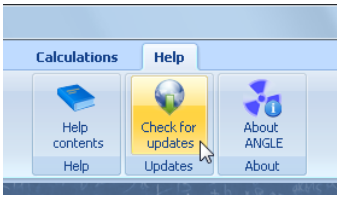

Figure 36 Update menu item

To be able to check for updates and to download them the computer must be connected to the Internet.

ANGLE update dialog will be displayed (Figure 37). By clicking on "**Check for updates**" button, ANGLE will contact the update server over the Internet and check if there are updates available. If yes, updates will be automatically downloaded and installed.

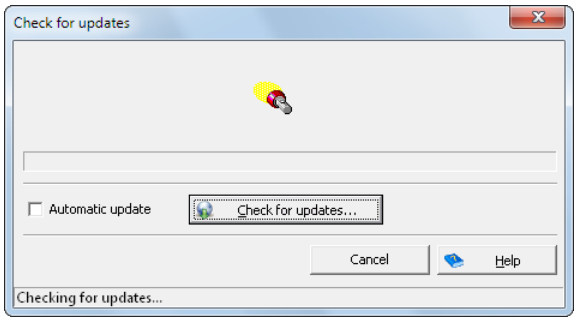

Figure 37 The update dialog

Security software, such as antivirus or firewall may interfere and not allow ANGLE to update. Please contact your system administrator to resolve this issue.

By checking the "**Automatic update**" check box, ANGLE will automatically check for updates on every program start.

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[7] P. Vukotic, N. Mihaljevic, S. Jovanovic, S. Dapcevic, F. Boreli, J. Radioanal. Nucl. Chem., 218 (1997) 21.

[8] K. Abbas, F. Simonelli, F. D'Alberti, M. Forte, M.F. Stroosnijder, Appl. Rad. Isot. 56 (2002) 703.

Appendix A: Creating GammaVision-32 Calibration (.CLB) Files

These instructions are for GammaVision-32 version 6.08/6.09. If using another version of GammaVision, refer to the corresponding *Software User's Manual* for instructions on creating efficiency calibrations.

ANGLE's EXPORT tool will automatically transfer the energy/efficiency pairs generated by ANGLE to the .EFT file format required by ORTEC's GammaVision-32 Gamma-Ray Spectrum Analysis and MCA Emulator software (A66-B32). Once the .EFT file is created, you can use GammaVision to create the calibration (.CLB) files.

Export the .EFT file from ANGLE to GammaVision, saving it in the **Spectra** directory indicated on the Directory tab under GammaVision's **File/ Settings...** command (the default location is C:/User).

Start GammaVision-32 and recall the spectrum used to generate the Reference curve.

On the menu bar, select **Calibrate/Efficiency...**. This will open the efficiency calibration graph, table, and dialog shown in Fig. 38.

If an efficiency calibrated already exists for this spectrum, destroy it by clicking on the upper-left icon of the the Efficiency Calibration dialog and selecting **Destroy**, as shown in Fig. 39.

Next, click on the **Merge...** button in the Efficiency Calibration dialog and select the .EFT file you imported from ANGLE.

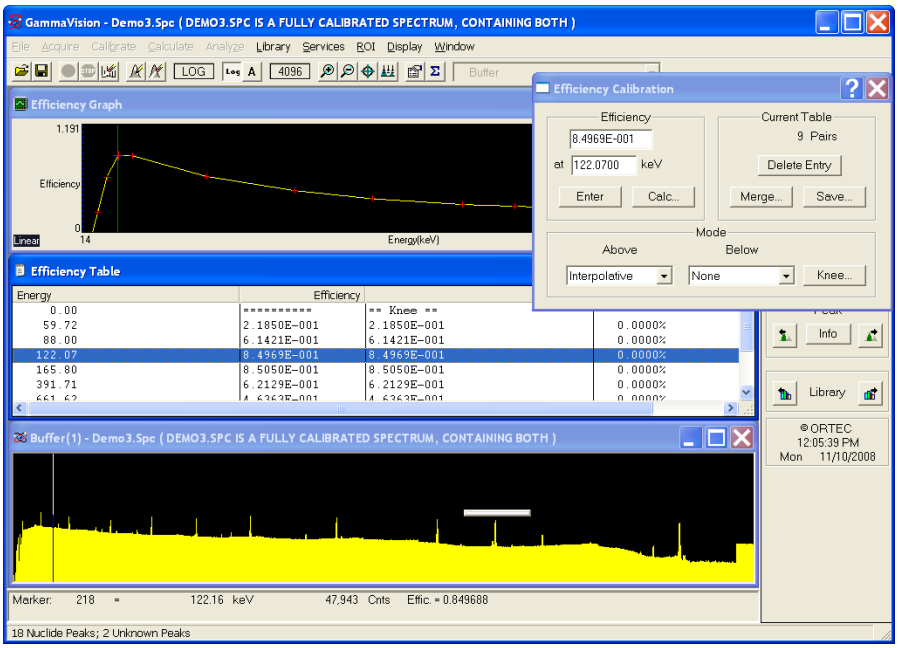

Figure 38 Efficiency calibration graph, table, and dialog.

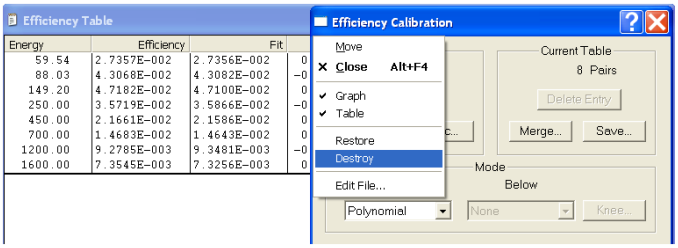

Figure 39 Destroy the existing efficiency calibration, if one exists.

The **Interpolative** calibration fit type will be displayed. To change the fit type, select from the **Above** droplist in the **Mode** section of the Efficiency Calibration dialog. When the desired calibration results are obtained, click on the dialog's upper-right Close (X) box.

Finally, save this calibration to disk by selecting **Calibrate/Save Calibration...** (Fig. 40) from the GammaVision menu bar, and entering the

desired file name. This will save the .CLB file for future recall. This file will contain both the energy and efficiency calibration data.

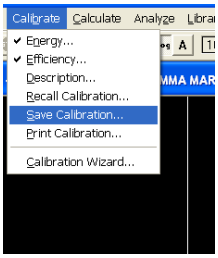

Figure 40 Save the new calibration and spectrum in a .CLB file.

For more detailed information on GammaVision's calibration features and capabilities, refer to the *Software User's Manual*.