ORTEC®

ANGLE V3.0

Advanced Efficiency Calibration Software for High Purity Germanium Gamma-Ray Detectors

Calibrate all your gamma-spectrometry systems with one software tool!
Geometrically identical standards no longer required!

- Generate efficiency calibrations for new geometries instantly; no new standards needed.
- Never again wait for delivery of new standards.
- Applies to a wide range of detectors and container types.
- Highly accurate, typically to a few percent.
- Reduces disposal costs of old radioactive standards.
- Universal: use with any or all of your HPGe detectors regardless of the vendor!
- "Efficiency transfer" principle: the best combination of absolute and relative methods.
- No expensive and time-consuming detector "factory characterization".
- Simple to use, transparent and verifiable by the user: results traceable to traceable standards.

Version 3.0 is the latest version of ANGLE software which has evolved over more than 16 years of development and testing. The new version incorporates many user suggestions for improvement. Generally speaking, ANGLE solves the familiar counting room problem of needing an appropriate efficiency calibration with which to analyze a sample, but not having an identical or "replicate" traceable standard from which to determine that calibration.

Based on a technique called "efficiency transfer" or "ET", ANGLE calculates a transfer function between the absolute efficiency data for the detector-sample-matrix geometry which is experimentally known (the "reference geometry") and the new detector-sample geometry (the "sample").

The "semi-empirical" approach used in ANGLE differs from absolute methods, in that rather than start with a Monte Carlo model of the detector and then correct the model via measurement (or "characterization"), ANGLE starts from a measured calibration which is then "transferred" to the new geometry by calculation of the transfer function. Different from absolute methods, small errors in, for example, the assumed thickness of a detector dead layer will tend to self cancel in the ANGLE method, whereas in absolute methods they do not. Obviously, the more closely the calibration source resembles the sample, the better the ANGLE result.[1] As the sample gets more and more similar to the reference, the ET result converges on the reference, which is a good "boundary condition" for the method.

[1]The most common or "replicate standard" method can be referred to as the relative method. So-called "absolute" methods may rely purely on detector and sample physical data with no "reality check" by use of a standard. Many studies have shown the non-ideal behaviour of HPGe detectors due to areas of crystal defect or errors in physical data. The actual efficiency is not the same for "identical" detectors for these reasons. Also detector response may change over time, for example, because of dead layer lithium diffusion into the crystal. Absolute methods always require checking with real world sources.

ANGLE V3.0

- Improved user interface.
- User input is "remembered".
- Self teaching.
- Multiple Reference sources may be used, and results compared.
- Short computation times, typically seconds.
- Direct transfer of data to/from ORTEC GammaVision.

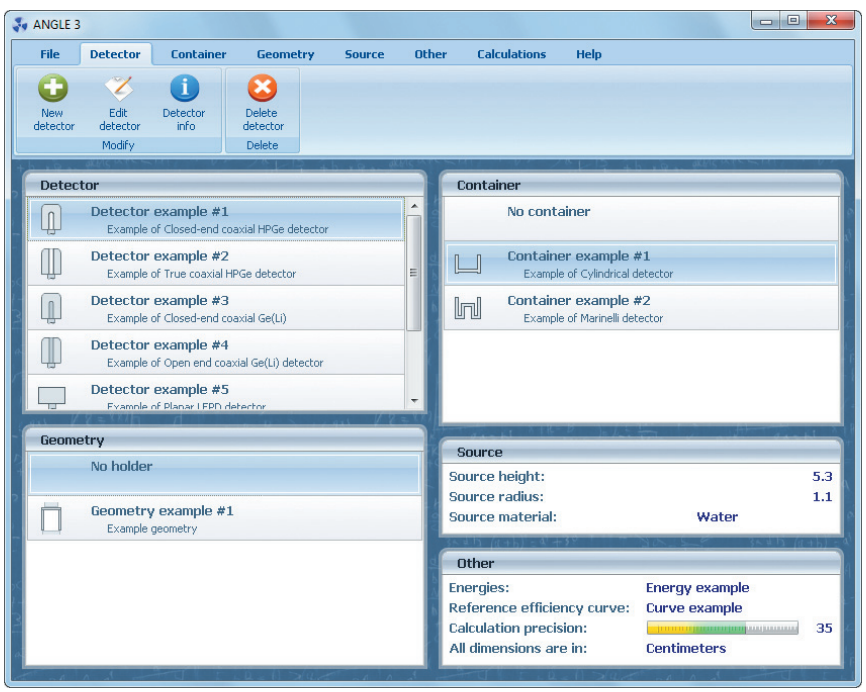
Version 3.0 of ANGLE incorporates a greatly improved user interface. User input is "remembered" so that with repeated use the user and the software defaults become more "in tune". All input and output for all detectors can be displayed on a single screen.

The semi-empirical efficiency transfer method has now been extended to allow multiple (different) reference geometry sources to be used. In other words ANGLE V3.0 calibrations may be based on other than point source reference calibrations. For example, if available, a one liter marinelli beaker standard can be used to generate a two liter marinelli calibration. This improves accuracy and greatly adds to the assurance that the generated calibration is valid, because it can be checked by using different reference standards. Validation of the calibrations can be carried out at point of use, not in a manufacturers test facility.

ANGLE V3.0 in Use

The main window is clear, informative and logically organized into five groups.

In order to explain these five groupings, a step-by-step explanation of how to set up ANGLE V3.0 and generate a calibration follows. Most typically, some of the data (for example, data on a specific detector, or on a source container) will already have been entered previously, so that there may be fewer steps required than actually given here.



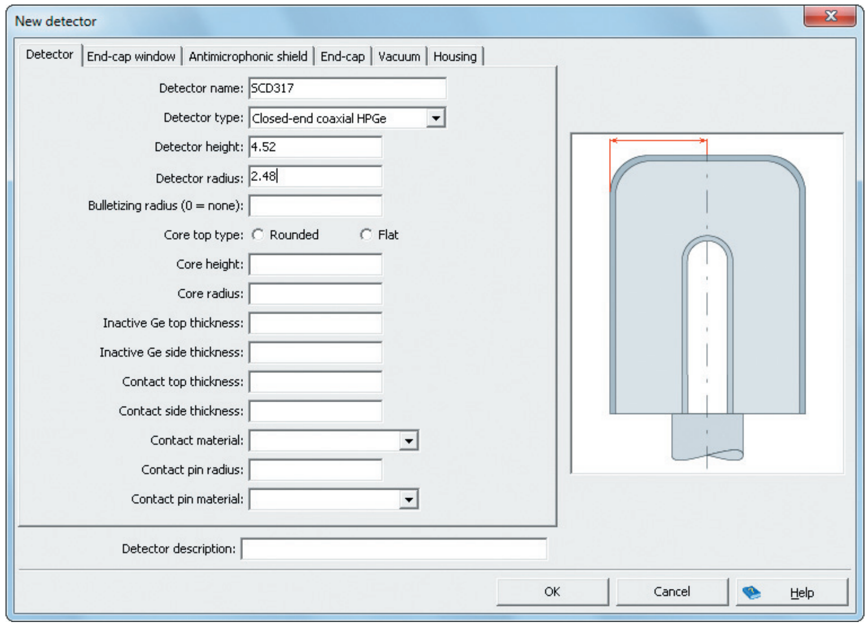
Step 1

Entry of Detector data.

Detector templates are supplied ready to take the physical data for the detector in use. The following Germanium detector types are supported:

- Closed end coaxial HPGe
- True coaxial HPGe
- Closed end coaxial Ge(Li)
- Open end coaxial Ge(Li)
- Planar (GLP)
- GWL (well type)

Usually the data for the specific detectors on the system will already be present. This is a one time only exercise.

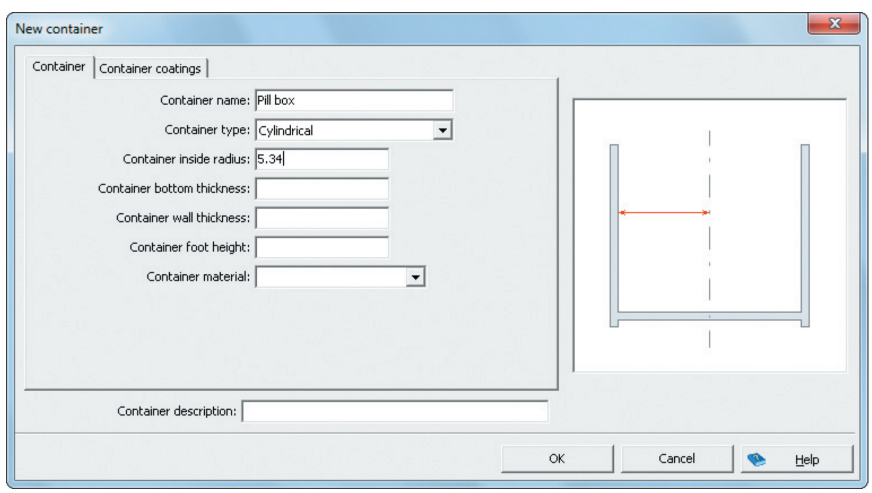


Steps 2, 3 and 4 which follow are completed once for the reference: container-geometry-source and once for the "sample": container-geometry-source, ("sample" is the unknown efficiency being calculated). First the reference data are entered and saved and then the sample data are entered. Once the reference data are entered and saved, further sample geometries are calculated as needed. ANGLE supports unlimited numbers of reference and sample geometries.

Step 2

Entry of Container data.

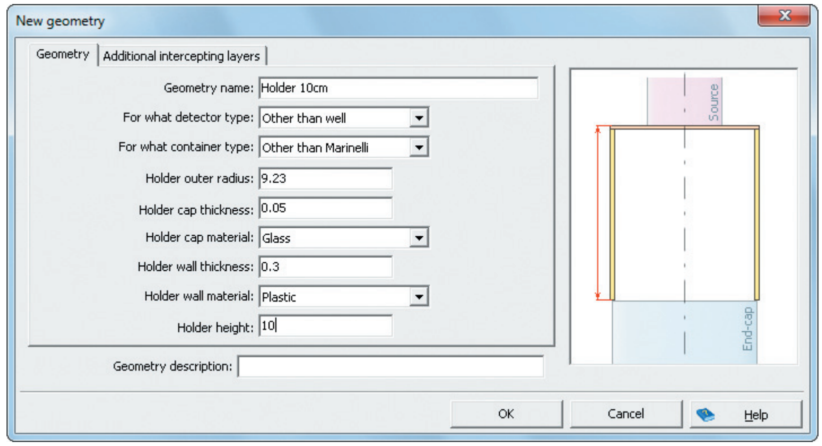
Container templates exist for Cylindrical and Marinelli configurations, and the "no container" option can deal with point sources or filters. The Cylindrical can also be used for Point (or quasi-point) and disc (or quasi-disc, e.g. air filters) sources by entering height and/or radius as zero.



Step 3

Entry of Geometry information.

The Geometry information screen also utilizes the graphical display to make data entry simple. ANGLE V3.0 includes materials databases to make data entry simple. Up to five layers of intercepting absorbing material can be included.

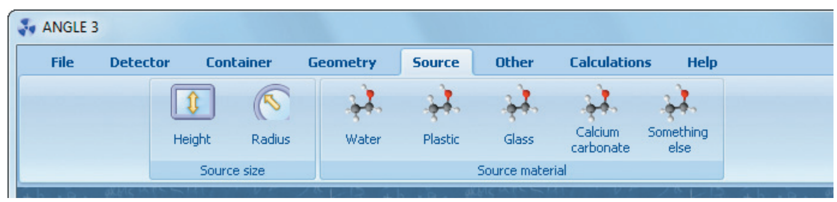


Step 4

Entry of Source information.

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.

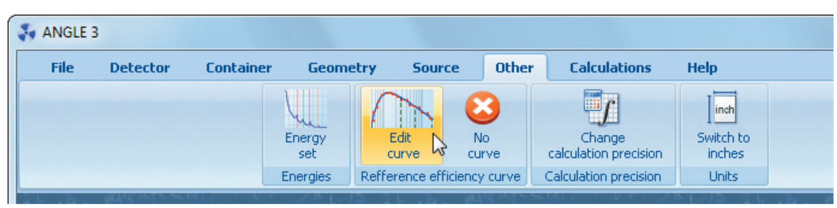
Steps 2, 3, and 4 are carried out first for the reference, and the data saved and then repeated for the sample.

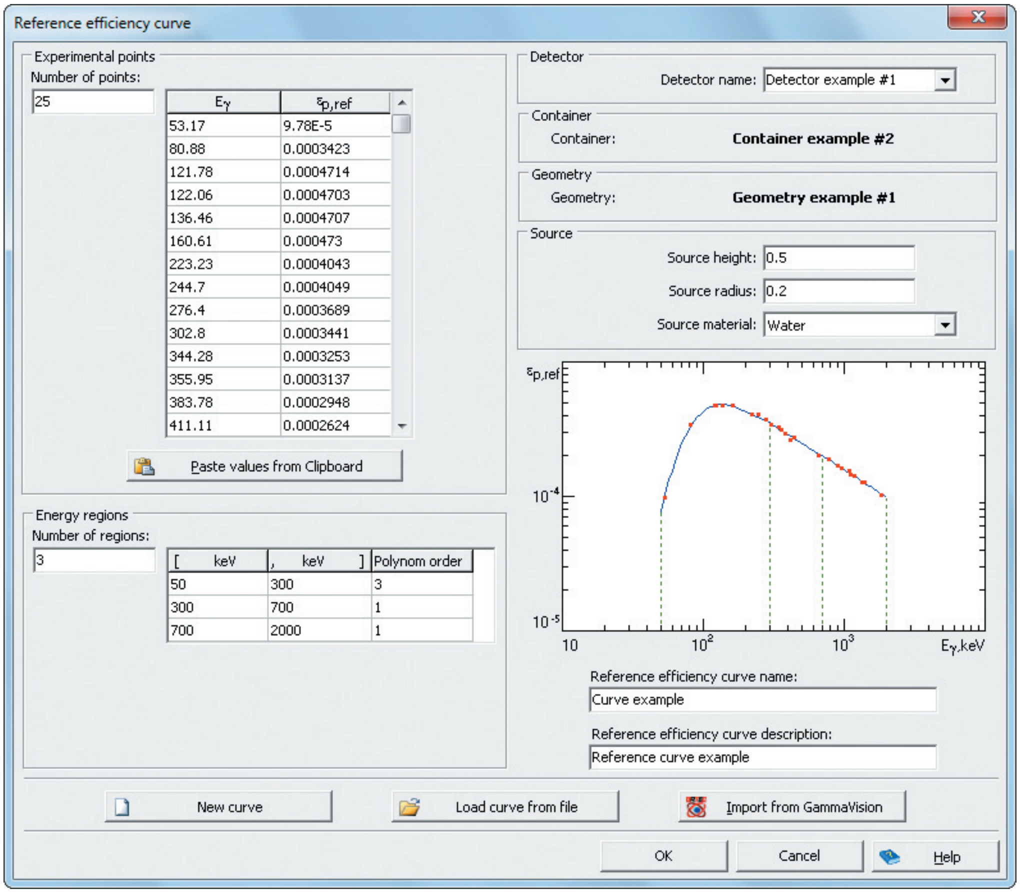


Step 5

Creation of Reference Efficiency data. (“Other” window on main screen).

Here the efficiency data points (experimental values) and the relevant detector, reference container, reference source, and reference geometry are combined. The measured reference efficiency points are easily imported from GammaVision by a single mouse click.

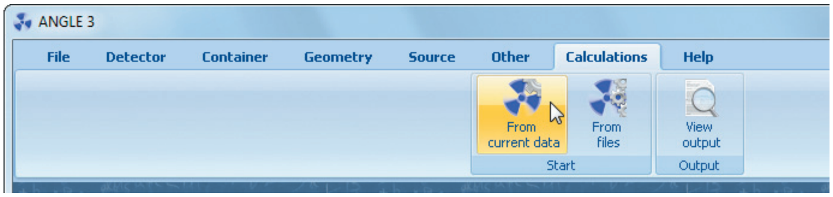




Step 6

Calculating the new Sample calibration.

Clicking the “from current data set” item will result in the efficiency curve data entered about the reference standard being “adjusted” to reflect the parameters entered for the sample geometry.



The new calibration may then be exported to GammaVision. . .   it’s that simple!

Accuracy

The method, which is referred to as a “semi empirical” method, is highly accurate because it is based on experimentally determined reference geometry data. The calibration accuracy is limited by the accuracy to which the physical data for the sample and the detector are known, given the condition that a reliable source of accurately known activity is used for the reference.

There are many factors that can affect the accuracy of the results. However, with the correct entry of the information about the detector, container, geometry and source, and with a reliable reference calibration source, routine applications can expect 3–4% accuracy.

ANGLE Simplified Methodology

ANGLE relies on the concept of “Effective Solid ANGLE”: The absolute detector crystal photopeak efficiency for the sample ε_p is related to that for a reference standard $\varepsilon_{p,ref}$ by:

$$\varepsilon_p = \varepsilon_{p,ref} \frac{\bar{\Omega}}{\bar{\Omega}_{ref}}$$

Where the $\bar{\Omega}$ factors are the “effective solid angle” factors for sample and reference (“ref”). The effective solid angle is a “catch-all” term which takes account of sample/reference geometry, and gamma attenuation in all intercepting layers between radionuclide and active detector crystal, in the sample and in the detector itself. If $\varepsilon_{p,ref}$ is obtained by a calibration measurement of the reference source and the $\bar{\Omega}$ factors are calculable from the physical data of detector, reference and sample, ε_p may be calculated and be used to determine the actual activities in the sample.

Determination of the $\bar{\Omega}$ effective solid angle factors for reference and sample are the challenge!

Below is an example of the mathematics applicable to a Marinelli geometry.

$$\begin{aligned}
\bar{\Omega} &= \int\limits_{(V_1+V_2),S_1} d\bar{\Omega} + \int\limits_{V_2,S_2} d\bar{\Omega} + \int\limits_{V_3,S_1} d\bar{\Omega} + \int\limits_{(V_3+V_4),S_2} d\bar{\Omega} + \int\limits_{V_5,(S_2+S_3)} d\bar{\Omega} = \\
&= \frac{4}{r_o^2 L + \left(r_o^2 - r_\phi^2\right) L_\phi} \int_0^L (d+l)\,dl \int_0^{r_o} r\,dr \int_0^{\pi} d\varphi \int_0^{R_o} \frac{F_{att} \cdot F_{eff} \cdot R\,dR}{\left[R^2 - 2Rr\cos\varphi + r^2 + (d+l)^2\right]^{3/2}} + \\
&+ \frac{4R_o}{r_o^2 L + \left(r_o^2 - r_\phi^2\right) L_\phi} \int_0^L dl \int_{R_o}^{r_o} r\,dr \int_0^{\varphi_o} d\varphi \int_{-H}^{0} \frac{F_{att} \cdot F_{eff} \cdot \left(r\cos\varphi - R_o\right) dh}{\left[R_o^2 - 2R_o r\cos\varphi + r^2 + (d+l-h)^2\right]^{3/2}} + \\
&+ \frac{4}{r_o^2 L + \left(r_o^2 - r_\phi^2\right) L_\phi} \int_0^d l\,dl \int_{r_\phi}^{r_o} r\,dr \int_0^{\pi} d\varphi \int_0^{R_o} \frac{F_{att} \cdot F_{eff} \cdot R\,dR}{\left(R^2 - 2Rr\cos\varphi + r^2 + l^2\right)^{3/2}} + \\
&+ \frac{4R_o}{r_o^2 L + \left(r_o^2 - r_\phi^2\right) L_\phi} \int_{d-L\phi}^{d} dl \int_{r_\phi}^{r_o} r\,dr \int_0^{\varphi_o} d\varphi \int_{-H}^{0} \frac{F_{att} \cdot F_{eff} \cdot \left(r\cos\varphi - R_o\right) dh}{\left[R_o^2 - 2R_o r\cos\varphi + r^2 + (l-h)^2\right]^{3/2}} + \\
&+ \frac{-4}{r_o^2 L + \left(r_o^2 - r_\phi^2\right) L_\phi} \int_{d-L\phi}^{-H} (l+H)\,dl \int_{r_\phi}^{r_o} r\,dr \int_0^{\pi} d\varphi \int_0^{R_o} \frac{F_{att} \cdot F_{eff} \cdot R\,dR}{\left[R^2 - 2Rr\cos\varphi + r^2 + (l+H)^2\right]^{3/2}}
\end{aligned}$$

ANGLE V3.0 “protects” the user from the complexity of these calculations making efficiency transfer calculations simple to perform through its user-friendly graphical user interface.

Would you like to know more about ANGLE? Visit the ANGLE website at www.dlabac.com/angle.

Prerequisites

Windows 2000/XP/Vista.

Detailed detector dimensional and material information. (Contact the detector manufacturer.)

Detailed container dimensional and material information. (Contact the container manufacturer.)

Ordering Information

Model	Description
ANGLE-B32	Advanced Efficiency Calibration software for HPGe detectors.
ANGLE-G32	Documentation for ANGLE-B32.
ANGLE-U32	Update for ANGLE-B32.

References

References 1 and 2 are highly recommended to the interested reader.

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