ANGLE 4
Advanced Gamma Spectroscopy Efficiency Calibration Software

“Compatible, Efficient, and Defendable Calibrations for Gamma Spectroscopy Applications.”
ANGLE is an advanced efficiency calculation application for High Purity Germanium and Sodium Iodide detectors based on the concept of Efficiency Transfer. This method combines the measured efficiency of a known reference configuration and solid angle models to derive the efficiency for different containers, sample materials, and sample positions. This semi-empirical approach is more accurate than pure mathematical models due to large errors that can be imposed by detector characteristics that are not precisely known – such as crystal defects, contact thickness, and dead layers – as these errors cancel out in the reference efficiency measurement. And, since the Reference Efficiency can be determined from any standard source, there is no need for complex and costly factory characterization of the detector.

WHY ANGLE?

<table>
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<th>Compatibility</th>
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<tr>
<td>• All 32-bit and 64-bit versions of Windows from Windows 95 to Windows 10</td>
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<tr>
<td>• Multiple Language: English, French, Spanish, Russian, Chinese, Japanese - and growing!</td>
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<tr>
<td>• High Purity Germanium and Sodium Iodide Detector Types</td>
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<td>• Modeling for most common laboratory measurement containers</td>
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<table>
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<tr>
<th>Process Efficiency</th>
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<tr>
<td>• No Factory Detector Characterization Necessary</td>
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<td>• Import and Export ORTEC and Canberra file formats</td>
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<td>• Command line scripting and XML Data files for automation and application integration</td>
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<td>• Rapid modeling using Container, Geometry, and Source Matrix configurations</td>
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<th>Defendable Results</th>
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<td>• Comprehensive Reporting of Efficiency Calculation Model</td>
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<td>• Actual and Relative Efficiency Method provides Calibration Standard Traceability</td>
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<td>• Graphical Display of model</td>
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<td>• High Accuracy with Extensive Comparison Testing</td>
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New Features in ANGLE 4!

**New!** Modeling for Cylinder and Well Sodium Iodide Detectors in addition to Germanium

**New!** Multi-Language Support which is easily extended to additional languages

**New!** Comprehensive and Summary Modeling Reports for validation and record retention

**New!** Graphical Display of Model and Calculated vs Reference Efficiency curves

**New!** Geometry Correction Files to maintain traceability and calibration uncertainty in GammaVision analysis

**New!** Command Line Operation and XML File Format for automation and integration with other applications

**New!** Import and Export any parameter from Efficiency Calculation Parameter or Results files

**New!** Discrete Reference Efficiency eliminates the curve fit error at specific energies of interest

**New!** Enhanced User Interface for a more intuitive user experience

**New!** Demo Detectors to evaluate and perform training with no registration required
ANGLE 4 Overview

Detector, Container, Matrix, and Position Models

- **Detector**: GEM40-I3S-SS-P42871A
- **Container**: Example Marinelli, the example of a Marinelli container
- **Source**: 1L Marinelli (132g)
  - Source volume: 1.640 l
  - Source material: Water

Reference Configuration and Measured Efficiency

- **Geometry**: 1 In Stand-Off
  - 1 inch Stand-off for small containers
  - 2 In Stand-Off

Calculated Efficiency

- **Output file**: 55-P42871A-20ml-Vial-1 to 1 Marinelli (W)_Ex
- **Detector name**: GEM40-I3S-SS-P42871A
- **Container name**: 1L Marinelli (132g)
- **Geometry**: No holder
- **Source height**: 99 mm
- **Source radius**: 70.5 mm
- **Source volume**: 1.640 l
- **Source material**: Water
- **Number of energies**: 25
- **Reference efficiency curve**: 55-P42871A-20ml-Vial-1 1 inch
- **Calculation precision**: 55 Calculations duration: 0.12

Calculated values:

- **Energy (E)**: 0.0036064, 0.0065406, 0.0101010, 0.0146614
- **Effective solid angle (E)**: 0.0001135, 0.0003461, 0.0009405, 0.0017061
- **Efficiency (E)**: 0.0001135, 0.0003461, 0.0009405, 0.0017061

Summary:

- **Number of energies**: 25
- **Calculation duration**: 0.12
The Detector Model defines the physical construction of the detector. The input parameters are dependent on the detector type which may be Germanium or Sodium Iodide in Coaxial, Planar, or Well configurations. A graphic display of each model helps validate the appropriate detector type in the configuration process. Some parameters, such as the Inactive material thickness and the Contact thickness, are usually not precisely known for each detector so nominal values are typically used. These minor deviations are typically inconsequential with the Efficiency Transfer calculation method implemented in ANGLE because the minor error in transmission cancels out in the Reference and Target solid angle models. This is one of the significant advantages of Efficiency Transfer over modeling alone. And, if the detector response is affected by changes to any of these parameters, then a new Reference calibration can be generated with standard sources in the lab instead of having to return the detector to the factory for an expensive and time consuming characterization.

Detector Types:
- HPGe: Closed or open end coaxial, Planar, and Well
- Ge(Li): Closed or open end coaxial
- NaI: Cylinder and Well

Detector Types:
**Container and Source Model**

Containers define the physical holders of source or sample material, and Sources define the actual material within the container. Containers and Sources are defined independently in ANGLE to simplify the process of establishing different combinations of material and volume in each container. Common materials are pre-defined for Containers and Sources, and additional materials can easily be added based on user-defined compounds or mixtures.

**Container Types:**
- Marinelli
- Cylinder to define Point Source, Filter Paper, Disk, Charcoal Cartridge, and Bottles

**Geometry Model**

The Geometry defines the relative position of the Container to the Detector including any sample holders that may be used and up to five additional absorbing layers between the detector and the container. Common materials for sample holders and absorbers and pre-defined, and additional materials are easily added by the user.
Reference Efficiency Calibration

ANGLE eliminates complex, expensive, and time consuming detector characterization because the Reference Calibration can be determined by direct measurement of a known source within the lab. Optimally, the Reference Calibration is determined using a source/geometry that is similar to the one being modeled in order to minimize uncertainty in the modeled efficiency; however, any source/geometry can be used as the reference when modeling any other source/geometry with good results when all of the detector and source/geometry configuration parameters are well known.

The Reference Energy/Efficiency pairs can be manually entered into ANGLE, or imported from either ORTEC's GammaVision Efficiency Tables or Canberra's CAM files. A calibration curve is then generated using up to a 6-order logarithmic polynomial function over each of up to ten different energy regions to optimize the calibration fit. Alternatively, the reference Energy/Efficiency pairs can exclude the fit function in order to calculate the modeled efficiency for only the input energy points without any uncertainty imposed by using a fit function. The choice to use a fit function or discrete energy/efficiency pairs is largely determined by how the extrapolated efficiency calibration will be used. In many cases, the extensive calibration fit algorithms in ANGLE can achieve a much more precise calibration fit than is possible with other spectroscopy applications.
Calculated Efficiency

ANGLE uses an Efficiency Transfer method, which is a semi-empirical approach comprised of experimental evidence (i.e. measured efficiency of a known reference source) and mathematical comparison of effective solid angle modeling for the reference and target configurations. The precision of the effective solid angle models is based on the number of integration segments over the source volume and detector surface visible to the source, and is easily adjustable to optimize calibration accuracy versus calculation time.

The derived efficiency data can be comprised of the same energy points used in the reference calibration or user-defined energy points derived by ANGLE’s robust fitting algorithms. These Energy/Efficiency pairs can then be used to generate efficiency calibrations in standard gamma spectroscopy applications. A Geometry correction file can also be generated for use in ORTEC’s GammaVision application so that the final analysis results retain traceability to the Reference calibration while applying the necessary efficiency corrections to the derived geometry configuration.

Detailed and Summary reports of the reference and derived efficiency calibrations and their associated configurations are also available for verification and record retention.
## Ordering Information

<table>
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<tr>
<th>Model</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANGLE-BW</td>
<td>Advanced Gamma Spectroscopy Efficiency Calibration Software</td>
</tr>
<tr>
<td>ANGLE-UW</td>
<td>Update from ANGLE-B32 (Version 2 or 3) to ANGLE-BW (Version 4)</td>
</tr>
<tr>
<td>ANGLE-GW</td>
<td>Additional Hard Copy Documentation for ANGLE</td>
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## References

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


Specifications subject to change 060916