ISOCS / LabSOCS

Calibration software for Gamma Spectroscopy

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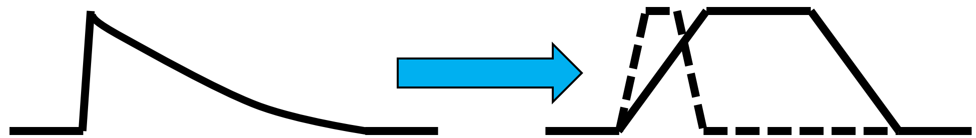
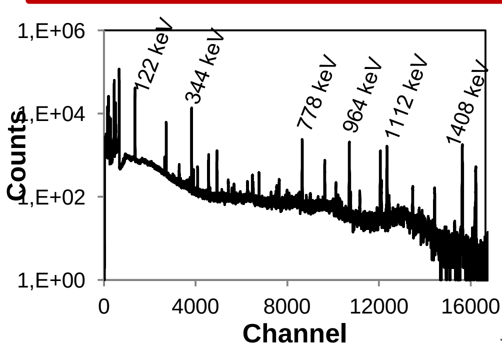
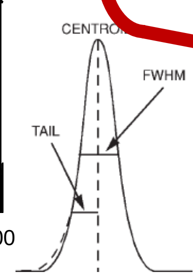
Setting up a detector for measurement

- **Setup Hardware**
  - **Peak Shaping Parameters**
    - Rise Time
    - Flat Top
  - **Pole-zero**
  - **Number of Channels**
  - **Signal Gain**

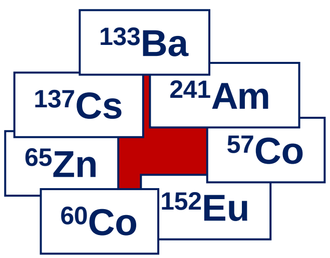


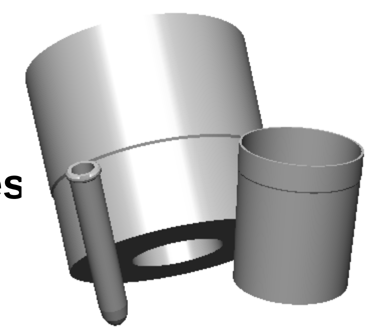
- **Setup Software**
  - **Energy Calibration**
  - **Shape Calibration**
  - **Efficiency Calibration**





- **Select Sources**
  - **Energy Range**
  - **Half-life**
  - **Cascade effects**
  - **Activity**
- **Select Geometries**
  - **Beakers**
  - **Vials**
- **Pay $$$ for these sources**





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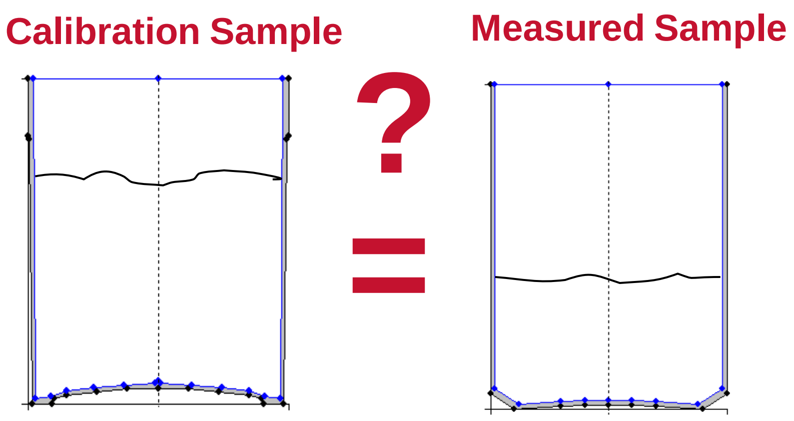
Source-based Efficiency Calibrations

- **Cost of Source-based Calibration**
  - **Purchase of Sources**
  - **Replacement of Sources**
  - **Disposal of Sources**
  - **Licensing for Sources**
  - **Calibration Program**
  - **Sample Preparation**

Time consuming



- **What if you can't make the sample match the calibration**
  - **Not enough material**
  - **Unusual material composition**
  - **Locked in sealed container**

Corrections required

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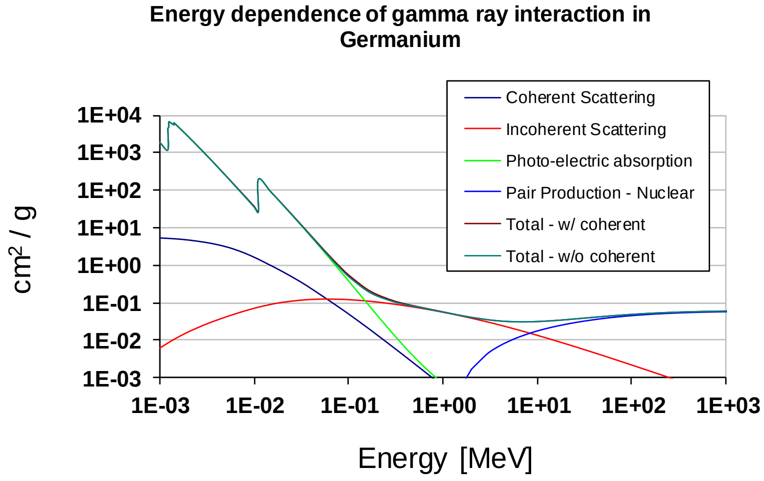
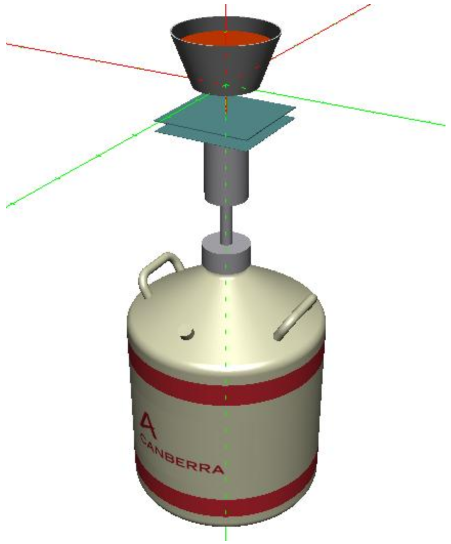
Gamma-ray Interactions in Material

- **Gamma-ray Interactions are very well understood.**
  - Photoelectric absorption
  - Compton Scattering
  - Pair Production





- We can exploit this knowledge to create efficiency responses based on the physical parameters of the geometry.
- Use mathematical models to accurately compute the transport of gamma-rays through these geometries.

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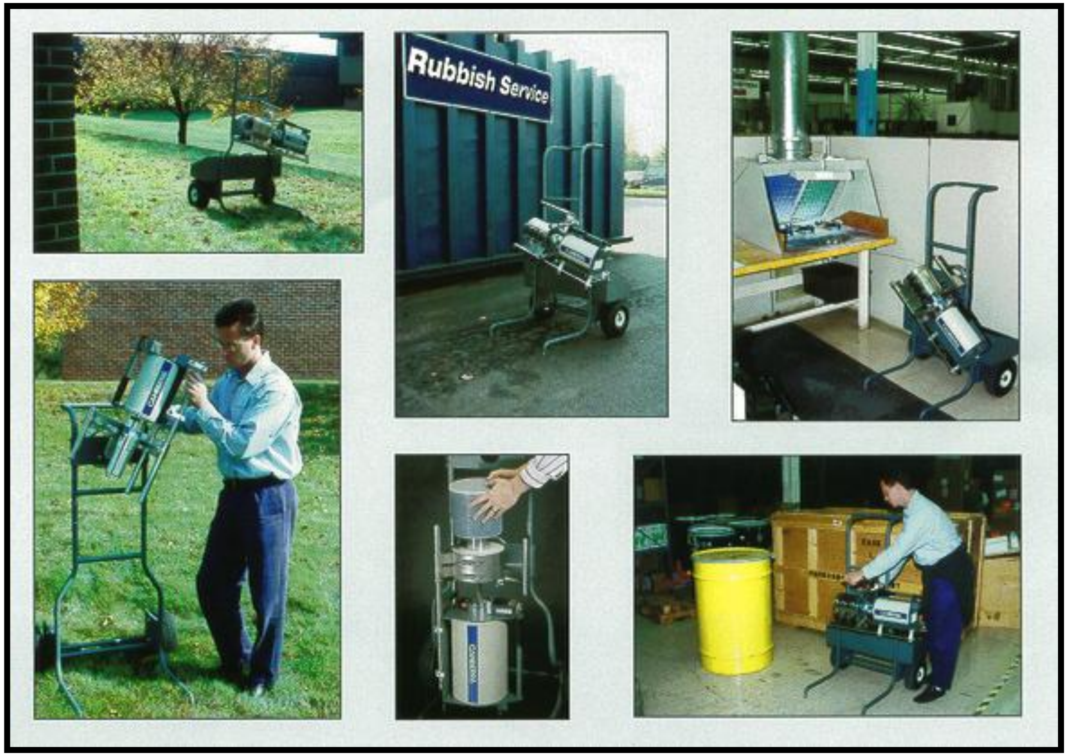
Field (In-Situ) measurements



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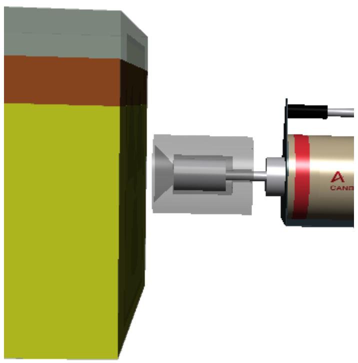
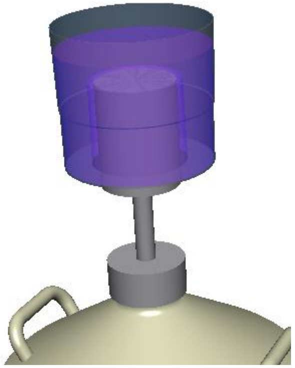
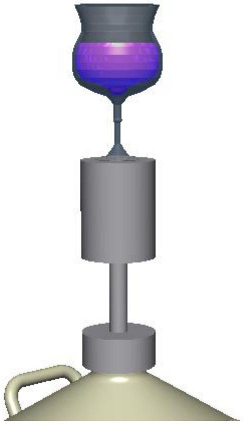
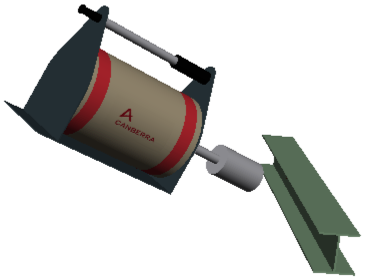
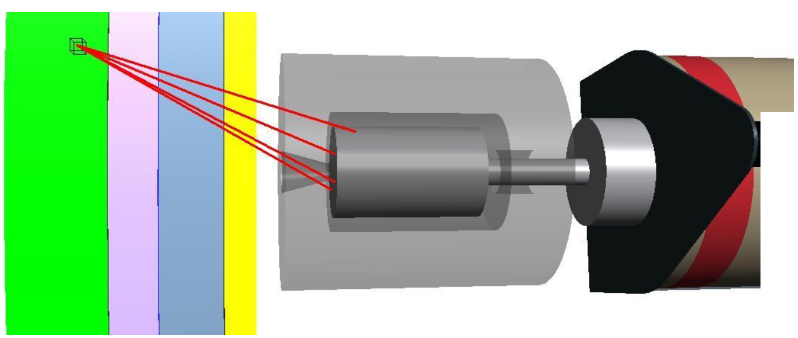
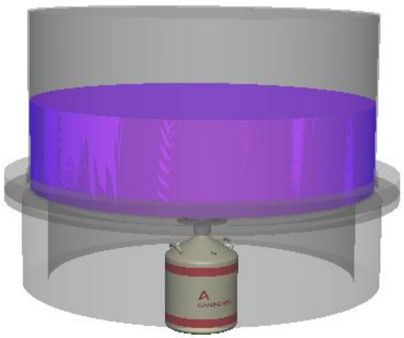
Modeling of Laboratory Samples

- **How to handle varieties of samples and containers?**

ISOCS/LabSOCS:
A Generalized Efficiency Computation Method

- ISOCS/LabSOCS method is designed to quickly and accurately compute efficiencies for a wide range of geometries.
- Relies on a factory characterization of the intrinsic efficiency response of the detector.
- Does not require that the customer have a large inventory of calibration sources (although nominal sources for quality control tracking is highly recommended).

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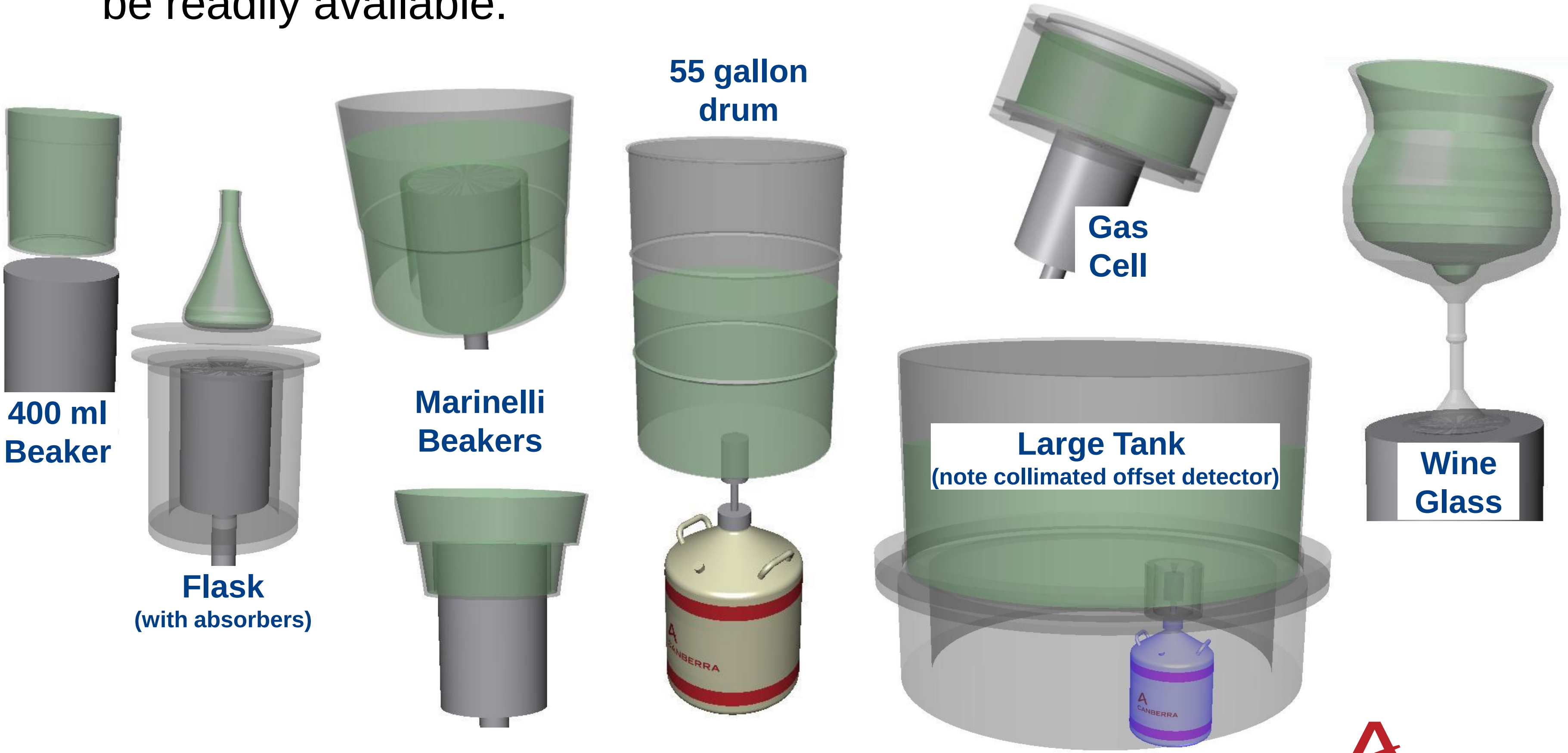
Regulatory Acceptance of Modeling Approaches

- **"*Calibration of Germanium Detectors for In-Situ Gamma-ray Measurements*", N42.28-2002 American National Standards Institute, Inc., 1430 Broadway, New York 10018.**
  "One such application [of Monte Carlo Methods] *is the calculation of the efficiency or response function for an HPGe detector. Using this approach, detectors can be calibrated for a variety of applications using models and simulations."*
- **"*Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste*", U.S. Nuclear Regulatory Commission Guide 1.21 rev. 2 (June 2009):**
  "The use of NIST-traceable sources combined with mathematical efficiency calibrations may be applied to instrumentation used for radiochemical analysis (e.g., gamma spectroscopy systems) if employing a method provided by the instrument manufacturer."
- **"*A Good Practice Guide for the use of Modelling Codes in Non Destructive Assay of Nuclear Materials*", ESARDA Bulletin No. 42 (November 2009) 26.**
- **[Proposed revision of N42.14-1999. In committee]**
  "*Calibration and Use of Germanium Spectrometers for the Measurement of Gamma-Ray Emission Rates of Radionuclides*", N42.14-201x American National Standards Institute, Inc., 1430 Broadway, New York 10018:
  "The following approaches may be considered for the calibration of the detector efficiency:
  - *a) Measurement of a standardization coefficient for a specific gamma ray and radionuclide by direct comparison with a standard source of known activity;*
  - *b) Measurement of the full-energy peak efficiency as a function of energy;*
  - *c) Calculation of the peak efficiency as a function of energy with the use of Monte Carlo or other calculation techniques."*

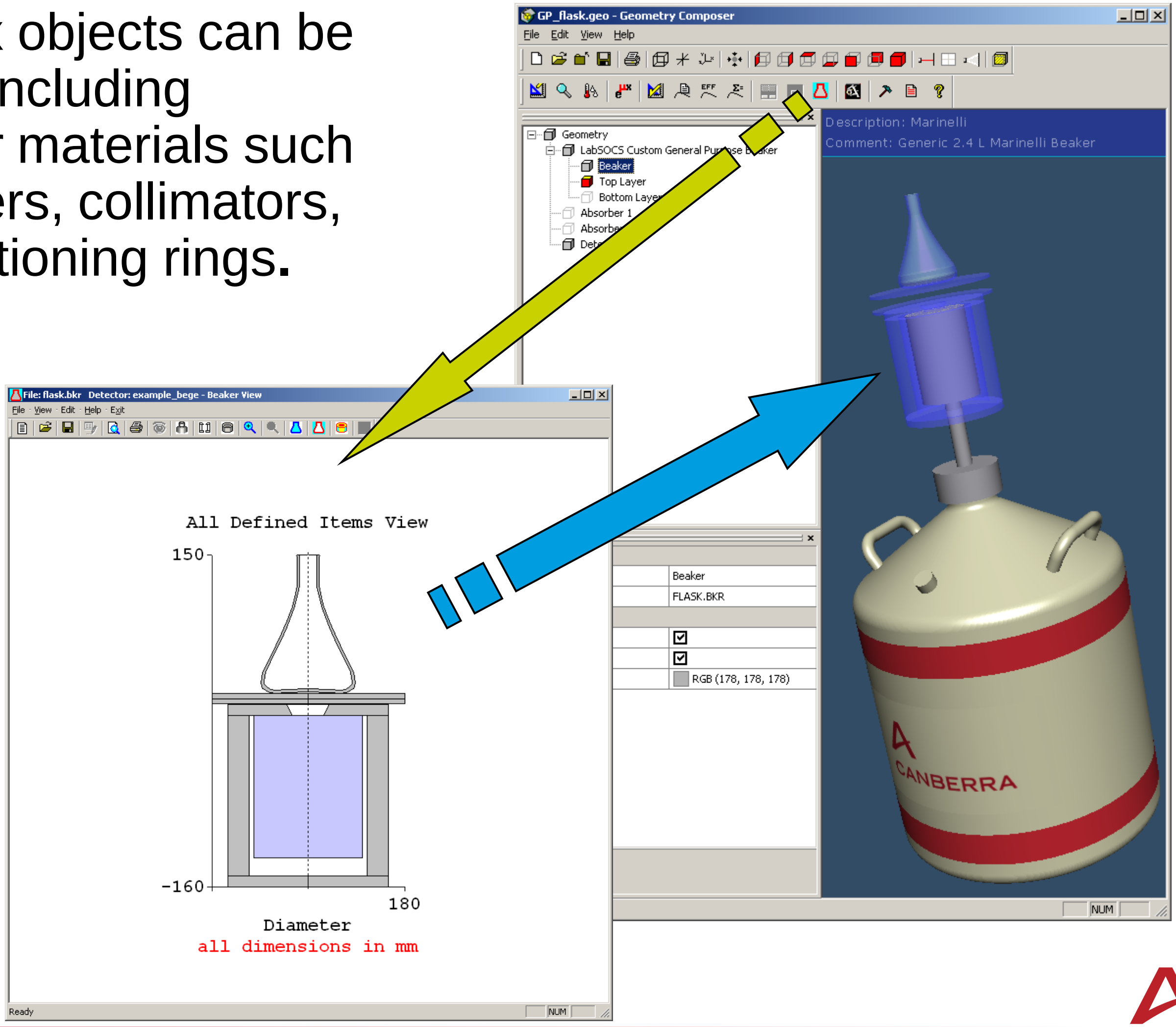
Flexibility of Modeling

- With modeling, it is possible to rapidly produce geometries that represent many usual shapes for which source standards may not be readily available.



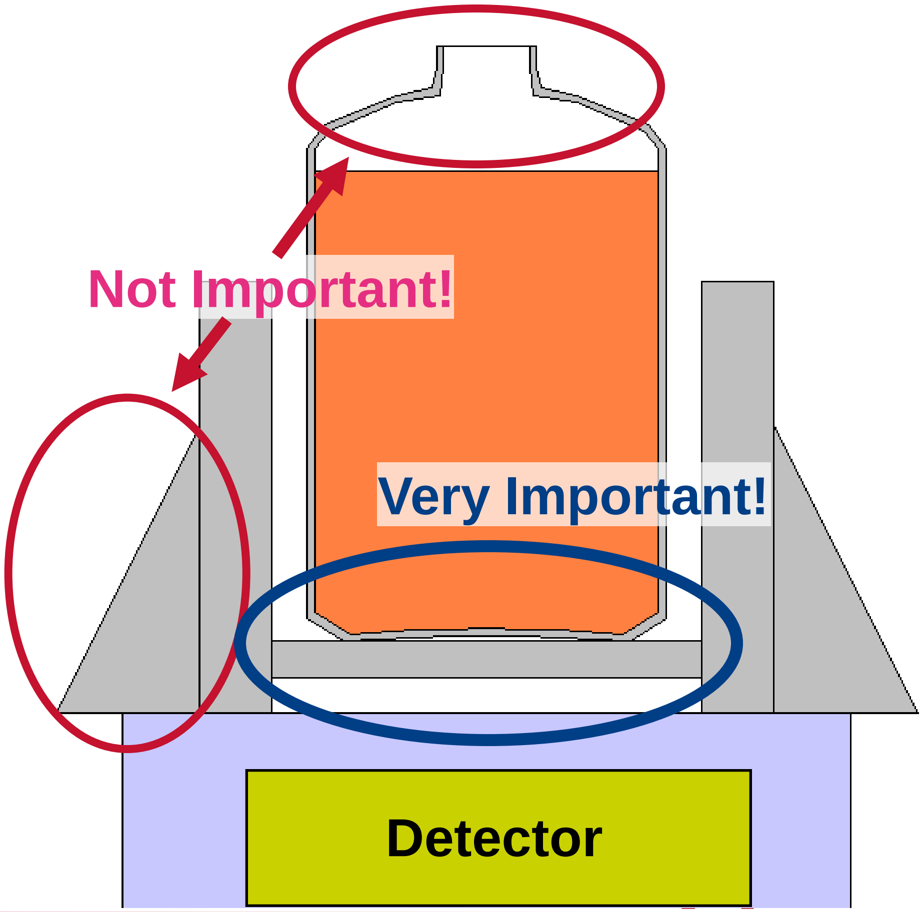
Include Features Beyond just the Sample

- Complex objects can be created including absorber materials such as spacers, collimators, and positioning rings.



A Word of Caution

- While mathematical modeling is a significant time and cost saver compared to source-based calibrations, care must still be taken to model the geometry to an appropriately accurate level.
- Not all regions are equally important.
- Some critical parameters are:
  - Distance from Sample to Detector
  - Attenuation of gamma-rays by intervening materials



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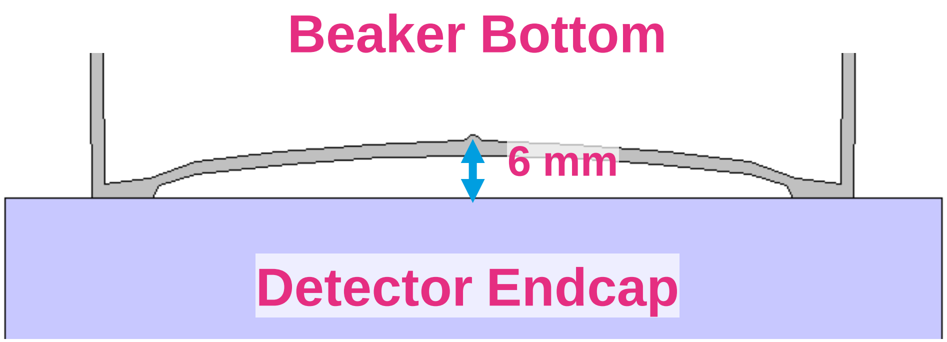
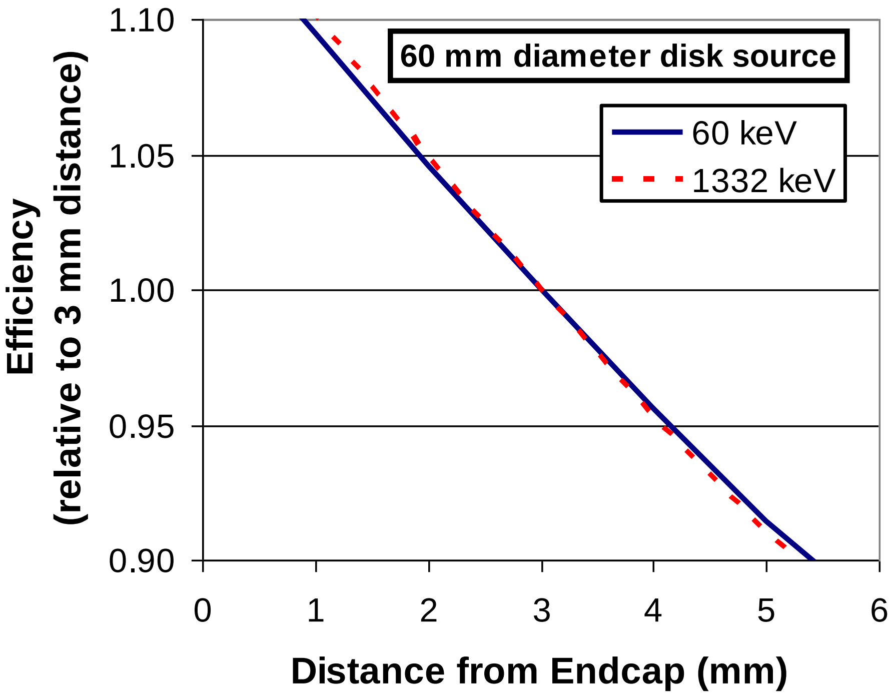
Sensitivity of Distance

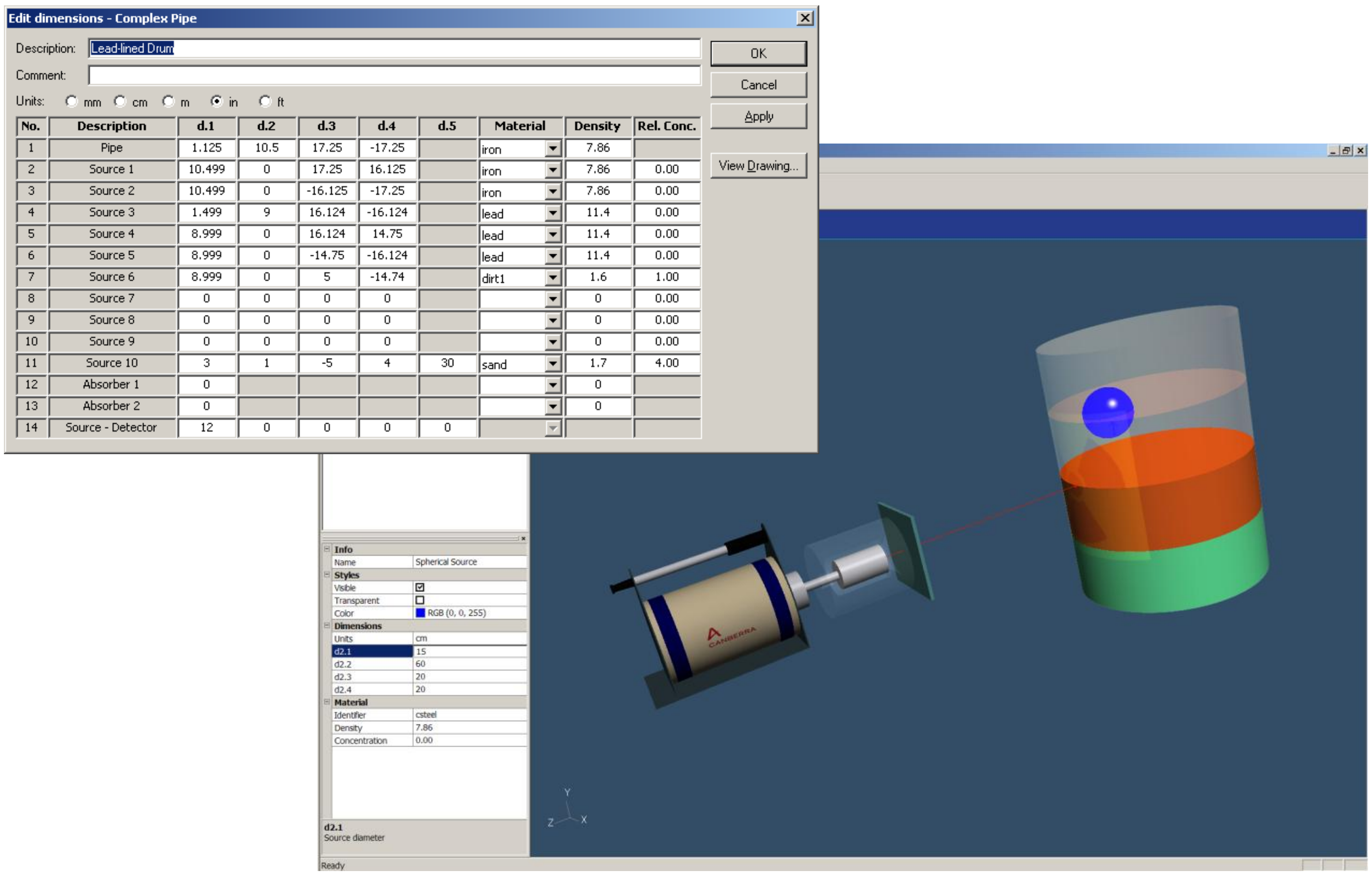
- The efficiency for sources close to the detector are very sensitive to the position of the source.
- As a general rule of thumb: 1 mm ≈ 5% change in efficiency for close geometries.
- Many beakers have complicated bases and an "effective distance" may not be clear.
- Also note: Reference source standards in epoxy matrices may deform beaker (from Rxn heat) thus changing the geometry.
- Direct modeling of beaker base provides accurate description of the container.





3D Interactive Geometry Composer

- ***Powerful 3D visualization provides immediate feedback for faster geometry development***

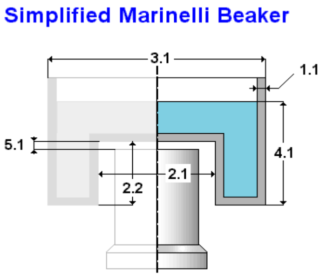


No.	Description	d.1	d.2	d.3	d.4	d.5	Material	Density	Rel. Conc.
1	Pipe	1.125	10.5	17.25	-17.25		iron	7.86	
2	Source 1	10.499	0	17.25	16.125		iron	7.86	0.00
3	Source 2	10.499	0	-16.125	-17.25		iron	7.86	0.00
4	Source 3	1.499	9	16.124	-16.124		lead	11.4	0.00
5	Source 4	8.999	0	16.124	14.75		lead	11.4	0.00
6	Source 5	8.999	0	-14.75	-16.124		lead	11.4	0.00
7	Source 6	8.999	0	5	-14.74		dirt1	1.6	1.00
8	Source 7	0	0	0	0			0	0.00
9	Source 8	0	0	0	0			0	0.00
10	Source 9	0	0	0	0			0	0.00
11	Source 10	3	1	-5	4	30	sand	1.7	4.00
12	Absorber 1	0						0	
13	Absorber 2	0						0	
14	Source - Detector	12	0	0	0	0			

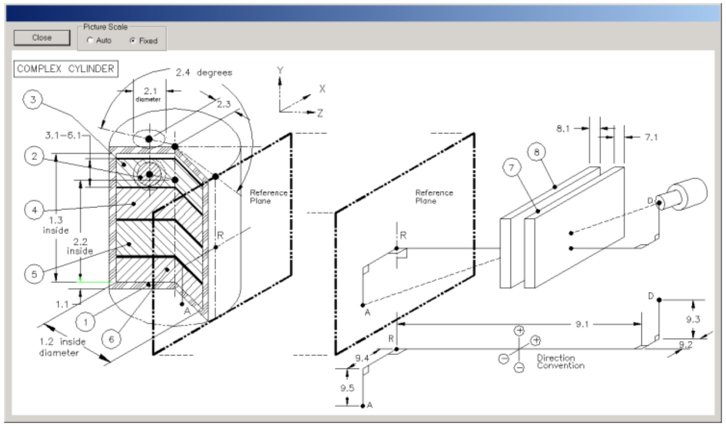
- **Detectors, "basic" Collimators, and Templates are rendered in the 3D virtual space.**
- **Data entry is fundamentally similar to the present geometry composer (although not identical).**

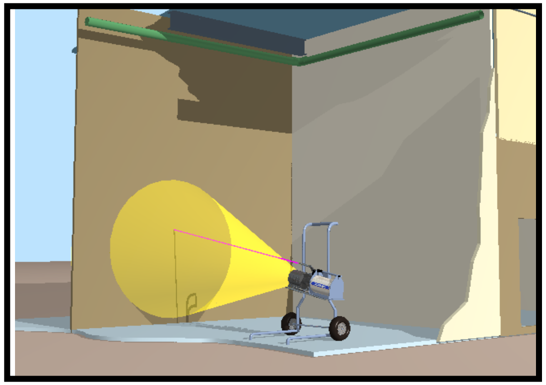
Templates - sample shape

- Many standard sample geometries are available for LabSOCS
  - Box, Cylinder, Sphere, Beaker, Marinelly beaker…
- Beaker editor for complex shape (cylindrically symmetric)

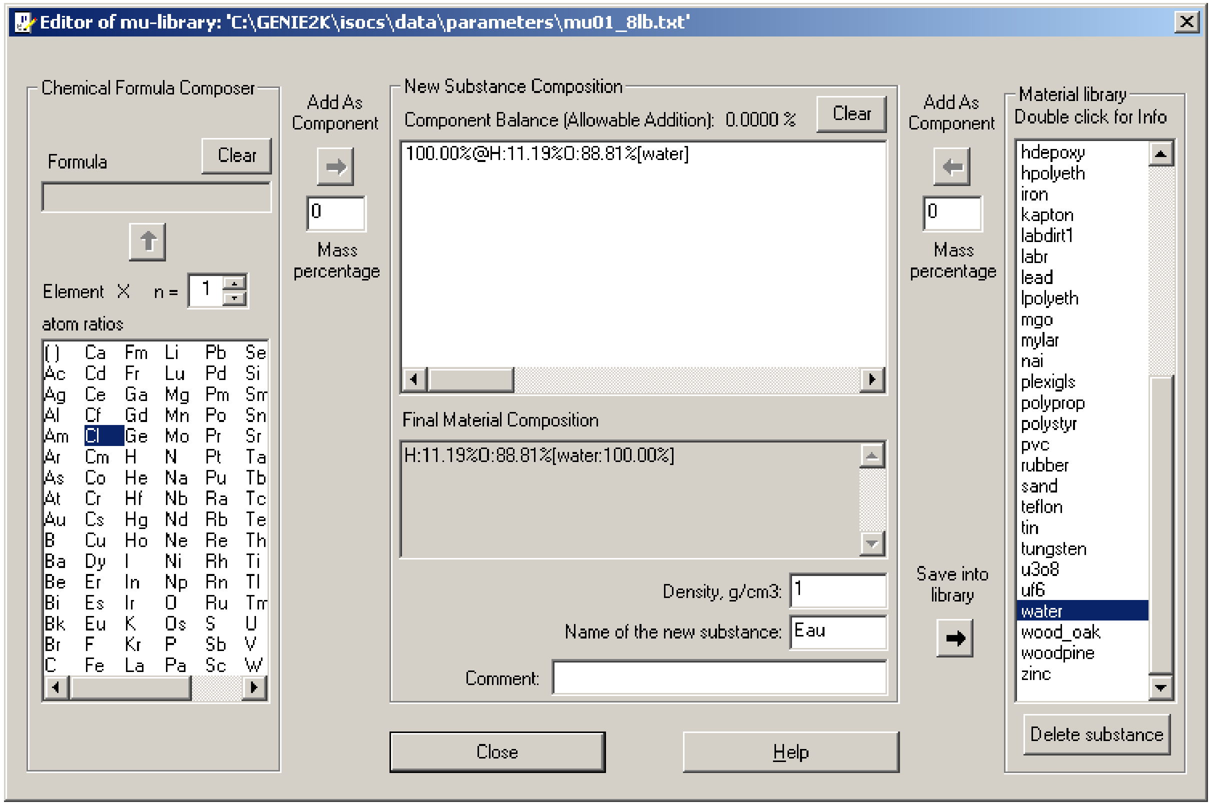


- Many templates are also available for ISOCS
  - Drum, Container, Pipe, Box, surface measurement…
  - With collimator, housing, or without





Material editor



- **Easy to create:**
  - New element
  - List of currently used elements

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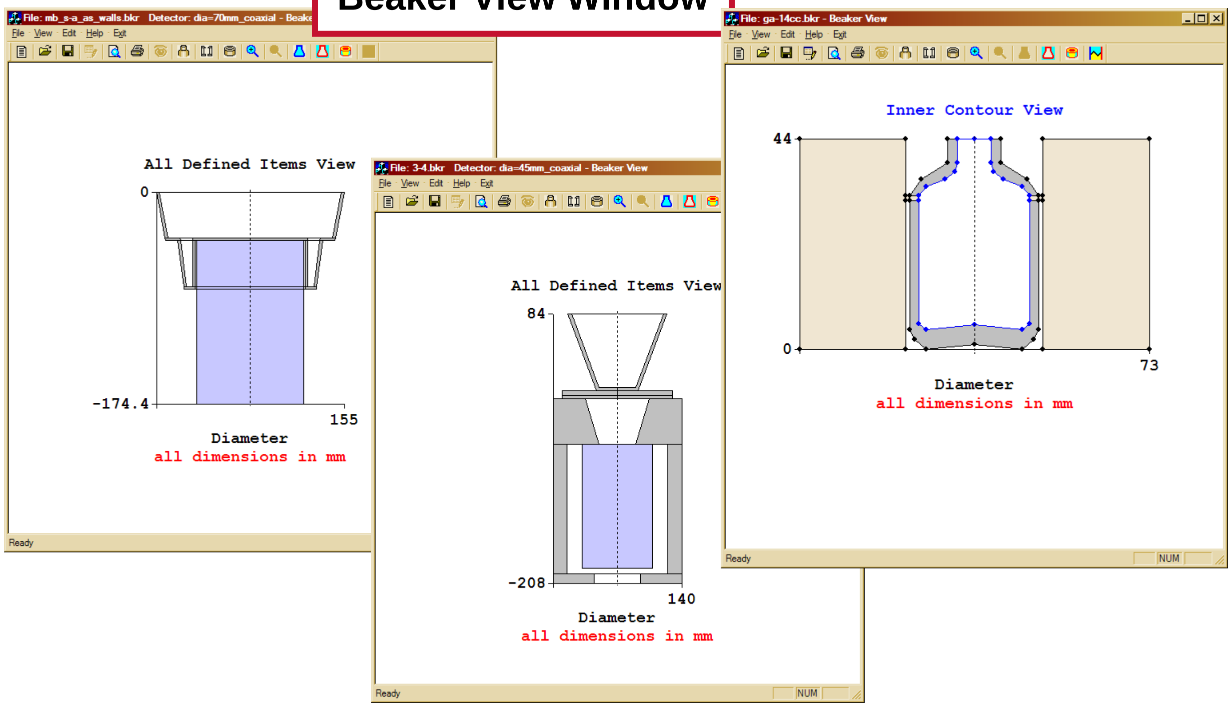
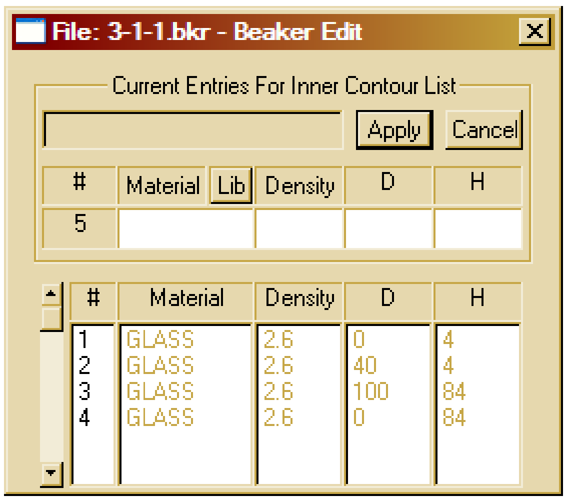
LabSOCS Beaker Editor

- Used to create the *.bkr files for the complex beaker template in LabSOCS
- Simplifies creating of the complex beaker geometries by providing a visual output
- Created geometry may consist of boundaries for different materials, shields and collimators with a variety of shapes

Beaker View Window



Beaker Edit Window



Geometry report

Geometry Composer Report

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Date: Thursday, May 05, 2011 - 17:26:09
Description: SG15 à 5c0 + support complet
Comment:
File Name: C:\Genie2k\CAMFILES\Cattenom12\CAT2 SG15 det1.geo
Software: LabSOCS
Template: SIMPLIFIED_BEAKER, Version: Custom Beaker (sg15catsupport2.BKR)
Detector: b11084
Environment: Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
Integration: Convergence = 1.00%, MDRPN = 2^4 (16), CRPN = 2^4 (16)
Sample Weight: 16.3 g

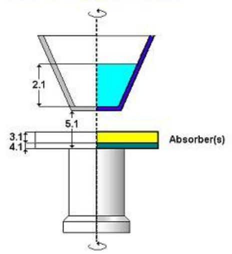
Dimensions (mm)

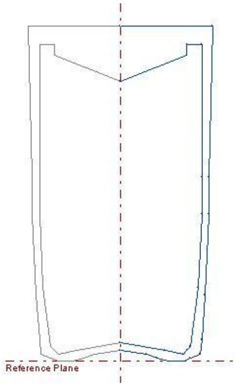
No.	Description	d.1	d.2	d.3	d.4	d.5	d.6	Material	Density
1	Beaker								
2	Sample	40.672						epoxy	1.1
3	Absorber 1								
4	Absorber 2								
5	Source - Detector	49							

List of energies for efficiency curve generation

40.0 59.5 88.0 122.1 165.9 391.7 661.7 898.0
1173.2 1332.5 1836.0

Custom Simplified Beaker





Page 1 of 2

- ISOCS / LabSOCS report
  - **All geometry parameters**
    - Dimensions
    - Materials
  - **Draw**
    - Template used
    - Final result

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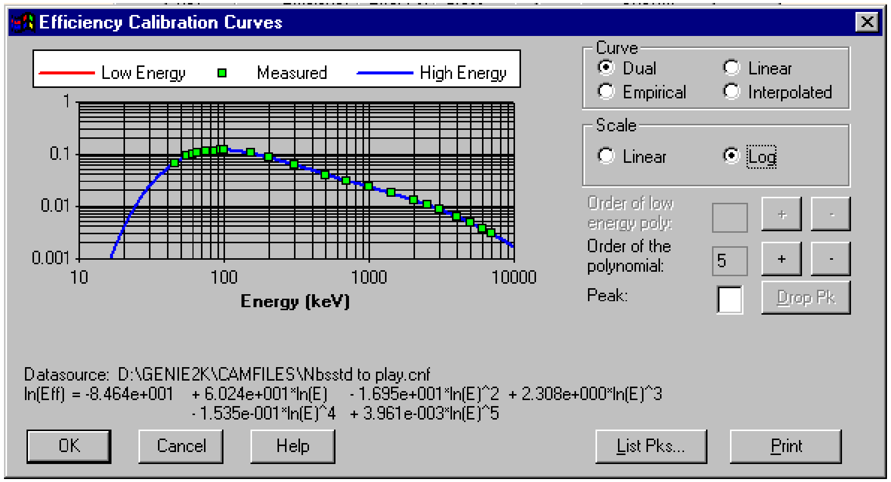
ISOCS - LabSOCS

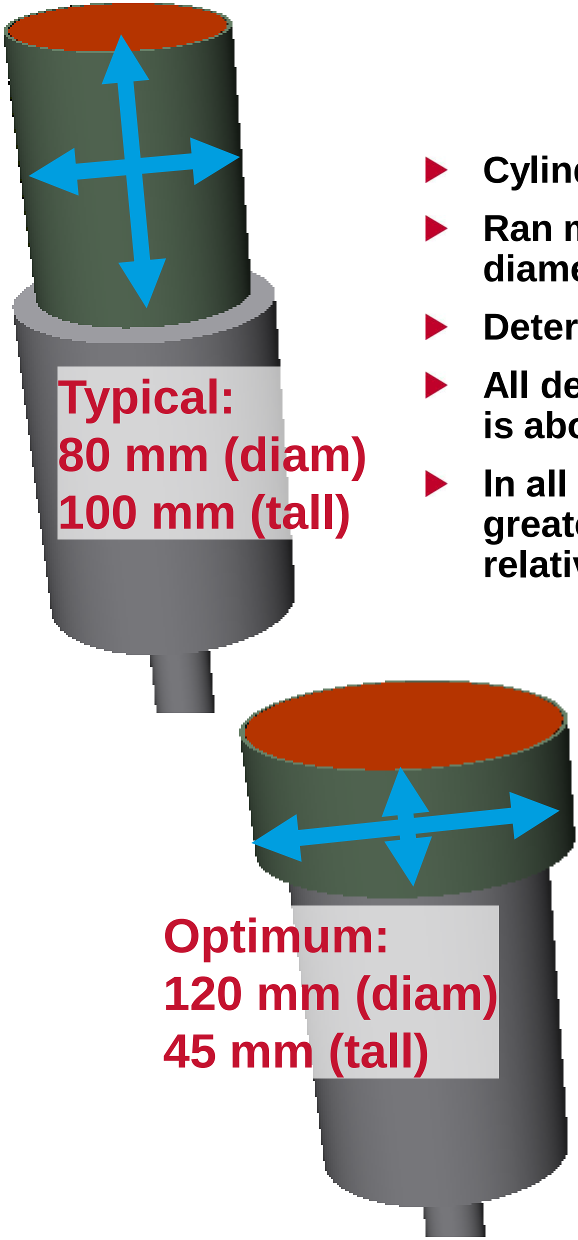
- Create an efficiency curve to calculate activities

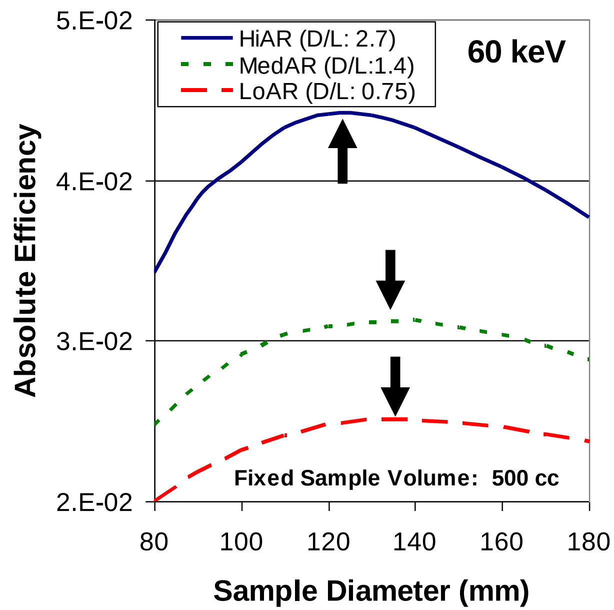


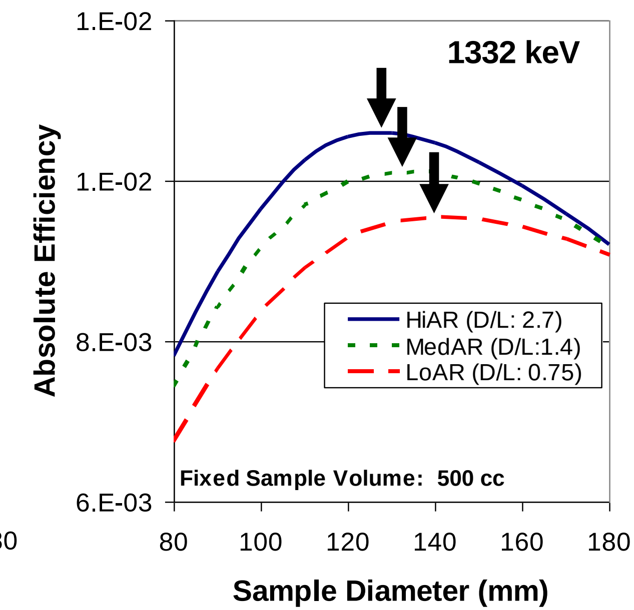
- Create a geometry file
  - **This file can be used to create a new geometry**
    - Dimensions modification
    - Materials modification
  - **Can be used to cascade summing correction**

Modeling for Sample Optimization

- Cylindrical sample with 500 cc of 1.6 g/cc Soil.
- Ran multiple efficiency computations with varying container diameter and height but with fixed sample volume.
- Determine maximum efficiency.
- All detectors have maximum efficiency when sample diameter is about 12 – 14 cm, regardless of energy.
- In all cases a high aspect ratio (e.g. BEGe’s) detector has greater efficiency than a low aspect ratio detector of similar relative efficiency.







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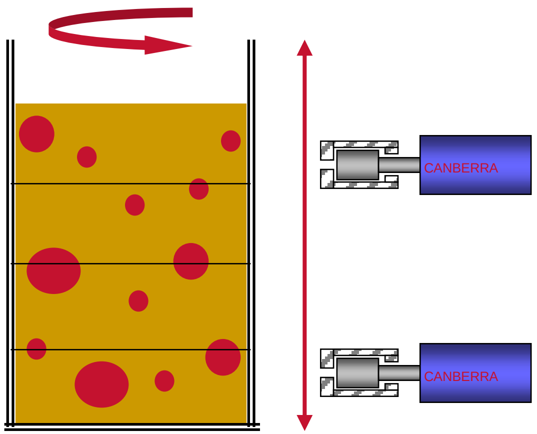
How Certain is your Measurement?

- **If you don't know all the parameters of your measurement, it is possible to use modeling techniques to estimate the uncertainty due to these "not well known" parameters.**
- **Canberra provides an ISOCS interface called the ISOCS Uncertainty Estimator (IUE) to estimate these uncertainties**



- **The IUE software**
  - **Helps the user determine which parameters to concentrate his effort in accurately determining efficiency**
  - **A structured and defendable method to quickly create the uncertainty of the efficiency calibration, and to propagate those errors to the final result**
  - **A useful investigative tool to evaluate, optimize and choose between various counting choices**
- **Different analysis modes:**
  - **Sensitivity Analysis: Determine which geometrical parameters are most important to know well (focus effort on minimization of uncertainties of important variables)**
  - **Uncertainty Analysis: Put in all known geometrical uncertainties and analyzed to determine the Total Geometric Uncertainties (more reliable accountancy)**

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Summary

- **Source-Based Efficiency**
  - **Expensive – Purchase sources/licensing**
  - **Limited – Few Number of Geometries**
  - **Labor Intensive – Make Samples Match the Calibration**
- **Mathematical Efficiency**
  - **Take Advantage of the Well-known Properties of Gamma-ray Physics**
  - **Generally Applicable**
    - In-Situ
    - Non-destructive Assay
    - Laboratory
  - **Defendable – Results are reproducible**
  - **Complex corrections -- Cascade Summing**
  - **Uncertainty Modeling**
  - **Measurement Optimization**
  - **<u>Focus on Making the Calibration Match the Sample</u>**
- **Mathematical Efficiency modeling not only saves time, but it gives a deeper understanding of the measurement and greater confidence in the results.**

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