A Sample Assay Geometry for a Wide Range of Gamma Spectroscopy Sample Types and Volumes with a Single Efficiency Calibration and Still Achieve Reasonable Accuracy

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1 INTRODUCTION

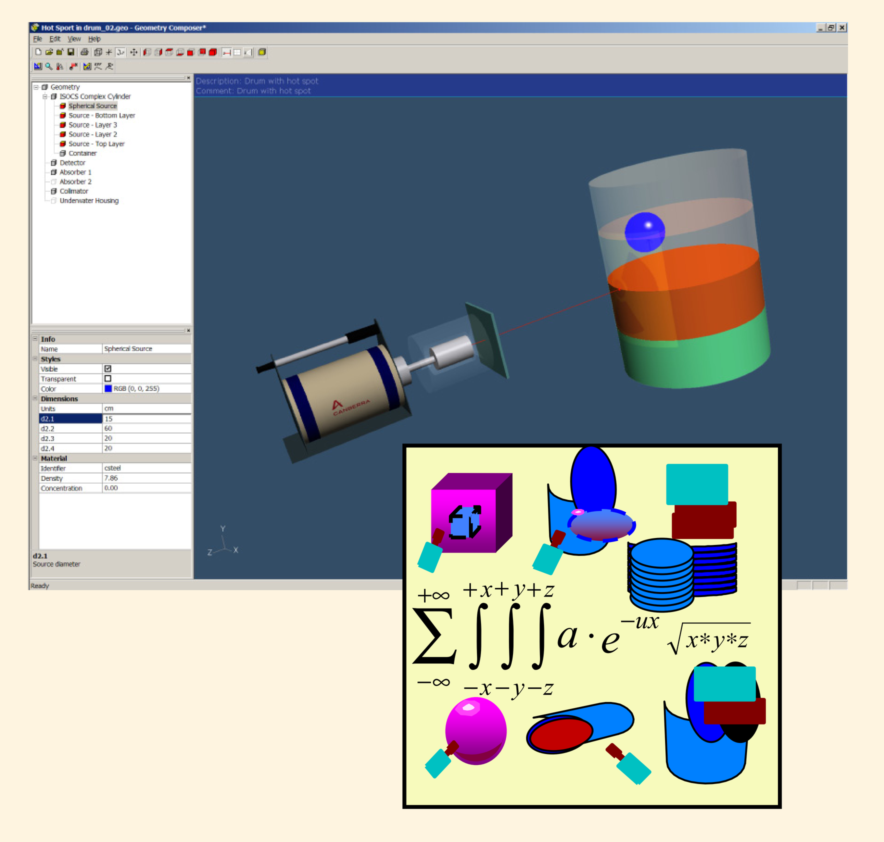
- **Conventional "Laboratory Quality" gamma spectroscopy is capable of achieving very high quality accurate results**
- **But there are many situations that do not demand this high quality**
  - emergency response samples
  - samples from the initial and operational phases of decontamination projects
  - environmental remediation samples from the initial and operational phases
  - samples where regulatory compliance is not the primary purpose
  - samples which are expected to be well above or well below a decision value
- **For these situations, the important items frequently are:**
  - getting the result quickly
  - minimal sample preparation time and labor
  - ability to easily handle a wide range of sample types
  - ability to easily handle wide range of sample sizes
  - minimal time spent preparing or choosing multiple efficiency calibrations

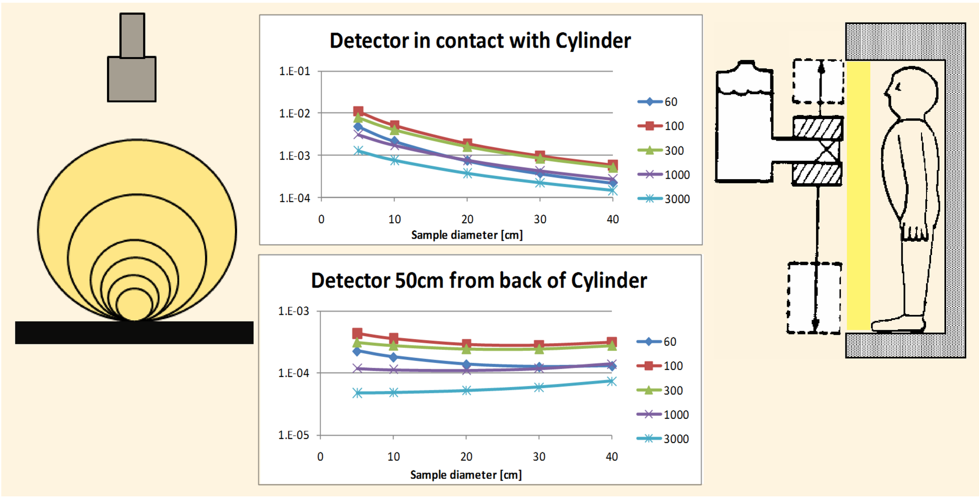
2 PROBLEM

- **With conventional "laboratory quality" gamma spectroscopy using radioactive sources**
  - Calibrations usually done in advance
    - Difficult to quickly adapt to new situations
  - Calibrations usually done for a few convenient matrices, e.g. water
    - Estimations done to convert to proper density
  - Calibrations usually done for a few different sample geometries
    - Labor and time must be spent to make the sample fit those geometries

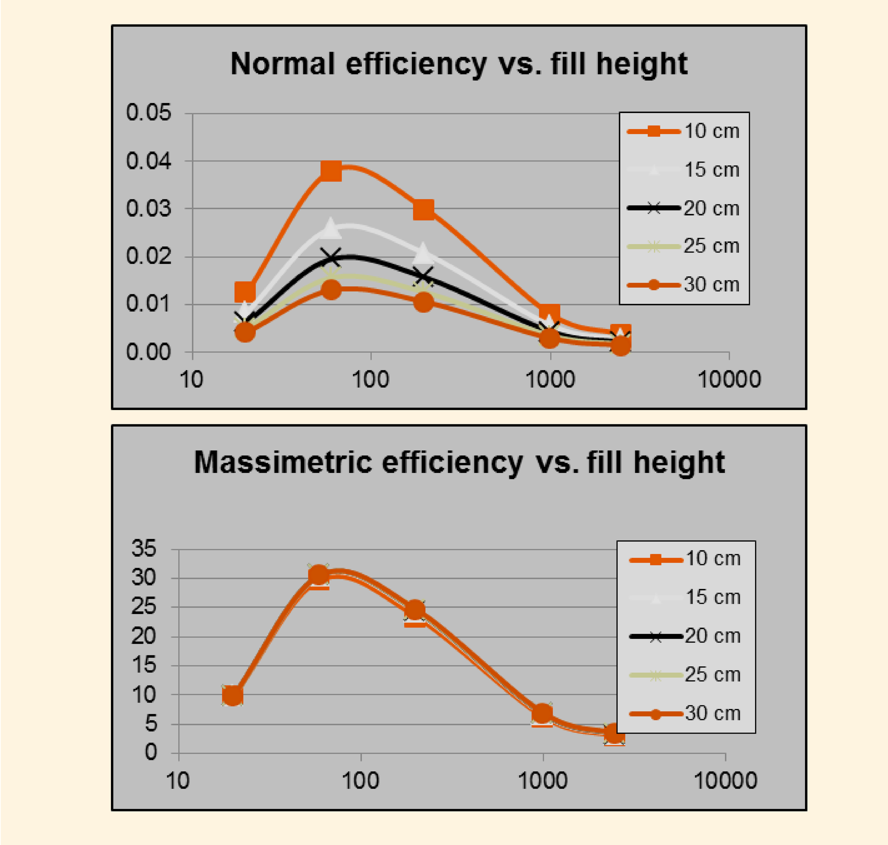
3 METHODS AND SOLUTIONS

- **Use mathematical calibrations, instead of radioactive sources**
  - They are very quick to do and allow new situations to be easily accommodated
  - They work with any matrix and any density
    - Concrete, steel, soil, air, vegetation, wood
  - ISOCS, a CANBERRA product, is widely accepted, and very versatile
  - Using these requires some skill by the operator for correct use





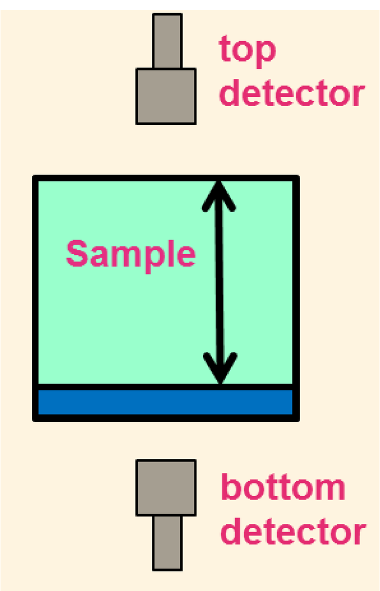
- Massimetric efficiency calibration
  - Efficiency is the product of normal efficiency x mass of sample – i.e. counts per gamma per gram
  - Once sample thickness is above a certain value, the efficiency is constant
  - Example here shows normal and massimetric efficiency for bottle of water at energies from 20 to 1500 keV
    - Bottle on top of detector
    - Water filled from 10 to 30cm
  - Massimetric efficiency almost constant for all fill heights
  - Result automatically in activity/gram without weighing the sample



- **Use special geometries that are relatively invariant with sample type and volume**
  - Count variable size samples with detector at a constant distance from opposite side of sample
    - As sample size increases two competing effects
      - Bigger samples are closer to the detector, and higher efficiency
      - Bigger samples have more self-absorption, and lower efficiency
    - Efficiency relatively constant with increasing sample size
    - Same result for both spheres and cylinders
      - This geometry used in FastScan Whole Body Counters
      - One calibration for all sized people – see poster 2488744

4 COMPUTATIONAL EXPERIMENT DESIGN

- **Experiment performed to determine best sample-detector geometry**
  - Sample chamber is 40cm diameter cylinder
  - Detector position choices are top or bottom – which is best ?
  - Calibration choices are normal or massimetric – which is best?
  - ISOCS Uncertainty Estimator feature used to compute relative standard deviation with variable sample parameters
  - ***Experiment 1***
    - Sample matrix was water
    - Sample amount was random variable, all values from 5-40cm equally probable
    - Both detector choices and both calibration methods tried



  - ***Experiment 2***
    - Sample matrix was random variable, with all the following equally probable
      - Dry soil, cellulose, sand, concrete, mineralized soil, aluminum, plastic, 75%soil+25% iron
    - Sample amount was random variable, all values from 5-40 cm equally probable
    - Sample density was random variable, all values from 0.5-2.0 g/cc equally probable
    - Both detector choices and both calibration methods tried

5 RESULT AND CONCLUSION

- **Experiment 1 results – constant sample type, variable sample amount**
  - Top detector best with normal calibration
  - Bottom detector best with massimetric calibration
  - Bottom detector and massimetric calibration a little bit better, and since no weighing of the sample is required, is the preferred method.
  - Standard deviation <15% due to calibration uncertainty

Det Loc'n	Fill Height	Fill Matrix	Density	Cal Type	20 keV	60 keV	200 keV	1000 keV	2500 keV
Top	5-40	Water	1	Normal	23	11	10	15	20
Bottom	5-40	Water	1	Mass	1	5	8	14	17

- **Experiment 2 results – variable sample type, variable density, and variable amount**
  - Top detector best with normal calibration
  - Bottom detector best with massimetric calibration
  - Bottom detector and massimetric calibration a little bit better, and since no weighing of the sample is required, is the preferred method.
  - Standard deviation <30% due to calibration uncertainty

Det Loc'n	Fill Height	Fill Matrix	Density	Cal Type	20 keV	60 keV	200 keV	1000 keV	2500 keV
Top	5-40	Many	0.5-2.0	Normal	89	39	30	25	25
Bottom	5-40	Many	0.5-2.0	Mass	109	24	13	21	27

- **Conclusion**
  - Best sample geometry is with detector on the bottom
  - Best calibration method is Massimetric calibrations
  - Results with a standard deviation of <30% can be obtained with no sample preparation, and with a wide range of sample types and sample amounts

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