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Efficiency Transfer

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Introduction

- Samples may vary in size, composition and density
- Preparation of standards time consuming and costly
- Can we use a computational approach?
- Efficiency transfer – "transfer" of the efficiency of a standard to another sample

The method

Efficiency transfer:

- Standard different from the measured sample
- Activity of a given radionuclide in the sample is determined by considering the sample efficiency

$$A = \frac{N}{tI\varepsilon}$$

- The sample efficiency is obtained from the efficiency of the standard

$$\varepsilon = \varepsilon_0 \left(\overline{\varepsilon} / \overline{\varepsilon}_0 \right)$$

- The two efficiencies $\overline{\varepsilon}$ and $\overline{\varepsilon}_0$ must be computed!

The method

Efficiency transfer:

- $\overline{\varepsilon}$ is the computed efficiency of the sample
- $\overline{\varepsilon}_0$ is the computed efficiency of the standard
- $\overline{\varepsilon}$ and $\overline{\varepsilon}_0$ are correlated!

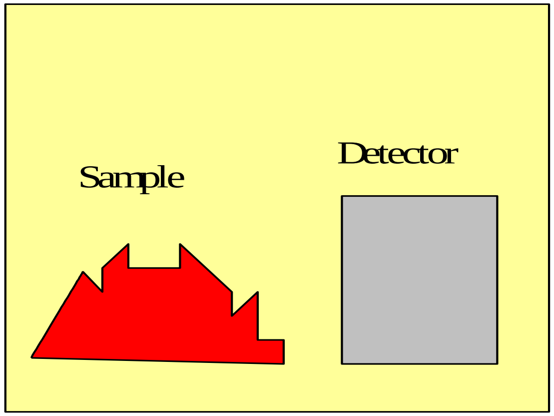
The method

Efficiency transfer:

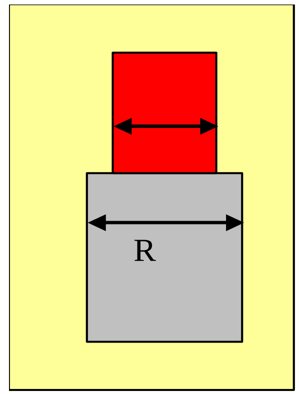
- Imperfection in the detector model cancel out to a large extent
- But it is only true if the standard and the sample have a sufficiently similar geometry!

From calibration to measurement

Sample and measurement instrument



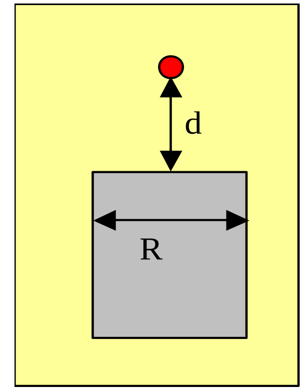
Measurement geometry



$$\varepsilon_0 = \frac{N_0}{A_0 t_0 I_0}$$

$$k = \frac{\bar{\varepsilon}}{\bar{\varepsilon}_0}$$

Calibration geometry



$$\varepsilon = k\varepsilon_0$$

Sample treatment

- Grinding
- Homogenization
- Weighing
- Preparation of measurement geometry

Efficiency transfer

- Detector characterization
- Sample characterization
- Measurement of a standard
- Calculation of the efficiency transfer factor

A study

- M-C. Lepy et al., EUROMET Action 428: Transfer of Ge detector efficiency calibration from point source geometry to other sources
- Various approaches
  - Direct Monte Carlo with and without optimization
  - Efficiency transfer with Monte Carlo efficiencies
  - Efficiency transfer with the computation of virtual total efficiencies
  - Semi-empirical methods
- Point-to-point, point-to-extended and extended-to-extended source transfers
- Efficiency transfer found to be much more consistent and reliable than direct calculation
- Transfer with peak efficiencies (involves Monte Carlo calculations) best
- Accuracy sufficient for environmental measurements, especially for self-absorption correction

Another study

- Tim Vidmar, Branko Vodenik, Marijan Necemer, Applied Radiation and Isotopes, 68 (2010) 2352–2354
- Water solution samples with known activities: Am-241, Cd-109, Ce-139, Sn-113, Co-57, Cr-51, Sr-85, Co-60 and Y-88
- Point source measurements
- Transfer from point source to the extended samples failed
- Efficiency transfer between extended sources accurate to within a couple of percent

Comparison of efficiency transfer codes

- Codes were compared to each other for a set of well defined detector and sample geometries
- No reference to experimental data
- All the codes were found equivalent to each other
- Testing Efficiency Transfer Codes for Equivalence.

  T. Vidmar et al., Applied Radiation and Isotopes, 68 (2010) 355-359.

Characteristics of the method

- Standards still required - but only a few!
- The efficiency of the measured sample is calculated
- The measured sample can differ from the standard – but not too much !
  - Size –> geometry correction
  - Density –> density correction
  - Composition
  - Any given combination of these
- Calculation can only be done with a computer
- Models of the detector and the sample are required
- The method is robust, accurate enough and reliable