IAEA.org
International Atomic Energy Agency

3.1
Geometry corrections –
Efficiency Transfer

Tim Vidmar

IJS

Jozef Stefan Institute, Ljubljana,Slovenia

Moens theorem

- Virtual peak-to-total ratio independent of the sample for a given gamma-ray energy
- Virtual efficiencies do not take scattering into account
- Virtual peak efficiency equivalent to the usual full-energy-peak efficiency
- Virtual total efficiency can only be calculated (except for a point source)
- $P_1/T_1 = P_2/T_2$ for two different samples 1 and 2

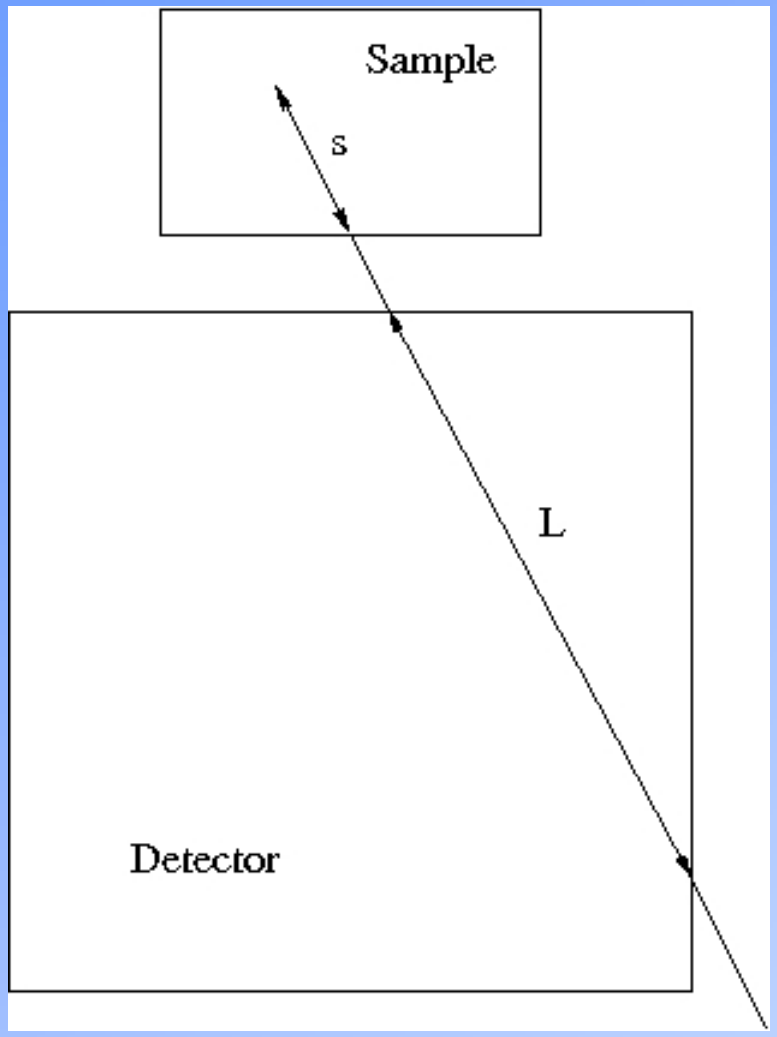
Moens theorem

- $P/T = (\tau+\kappa\sigma)/\mu$
  - τ = photo-effect absorption coefficient
  - σ = Compton absorption coefficient
  - μ = Total absorption coefficient
  - κ κ = percentage of Compton scattered gamma-rays which eventually end up in the full-energy peak (do not escape)
- κ can be shown to be independent of the source position
- T.Vidmar, A. Likar On the invariability of the total-to-peakratio in gamma-ray spectrometry. Applied Radiation and Isotopes 60 (2004) 191–195
- Moens theorem not valid for planar detectors!

The Method

- $P_2 = P_1 (T_2/T_1)$
- P_1 measured, Reference sample (calibrated standard)
- T_2 and T_1 calculated
- P_2 efficiency for the desired (analyzed) sample
- In the calculated ratio (T_2/T_1) many inaccuracies of the detector model cancel out!
- Detector data can be taken from the manufacturers sheet
- Simultaneous "correction" for geometry and self absorption
- Alternative: $P_2 = P_1 (\varepsilon_2/\varepsilon_1)$
  - ε_2, ε_1 full-energy-peak efficiencies → Monte Carlo simulation

The Method



Absorption:

$F = \exp(-\mu_s s)\ \exp(-\mu_w w)\ \ldots$

Interaction:

$R = 1\text{-}\exp(-\mu_{Ge} L)$

Registration:

$p_i = F_i\, R_i$

Efficiency:

$T = (1/N) \sum p_i$

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 Moens method
  - 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

The Originators

- Moens, L., De Donder, J., Xi-lei, L., De Corte, F., De Wispelaere, A., Simonits, A., Hoste, J., 1981. Calculation of the absolute peak efficiency of gamma-ray detectors for different counting geometries. Nuclear Instruments and Methods in Physics Research, 187, 451-472.
- Point-source reference measurements
- Sensitivity study
  - Method very sensitive to the detector diameter!
  - Otherwise quite robust
  - Sensitivity increases with decreasing energy