ICRM-GSWG
Coincidence Summing Action

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Methods applied at ISPESL

Two methods, both based on **the same analytical equation** for the correction factors:

- **Semi-empirical Method: combination of empirical approach and matrix approach**

- **Simplyfied Procedure (De Felice et al., 2000)**

Semi-empirical Method – 1/2

If **1/Ci is the correction factor**, the equations for calculating **Ci** have been written in matrix form by Semkow et al.(1990). With some modifications (De Felice et al., 2000), we have:

Summing in Summing out

$$C_i = \left[1 + \frac{\sum_{k,m} P_{t_{km}} P_k P_m \varepsilon_k \varepsilon_m}{I_{\gamma_i} \varepsilon_i}\right]\left[1 - \frac{\sum_{j} P_{t_{ij}} P_i P_j \varepsilon_{t_j}}{I_{\gamma_i}}\right]$$

$\mathbf{Pt_{km}}$, $\mathbf{Pt_{ij}}$ = probabilities per decay that the coincidence transitions k and m, or i and j, occur

$\mathbf{P_k}$, $\mathbf{P_m}$, $\mathbf{P_i}$, $\mathbf{P_j}$ = probabilities that in each transition the respective photons γ_k, γ_m, γ_i, γ_j will be emitted

$\boldsymbol{\varepsilon_k}$, $\boldsymbol{\varepsilon_m}$, $\boldsymbol{\varepsilon_i}$ = FEP efficiencies for the photons γ_k, γ_m, γ_i

$\boldsymbol{\varepsilon t_j}$ = total efficiency for a generic photon γ_j.

Semi-empirical Method – 2/2

Summing in Summing out

$$C_i = \left[1 + \frac{\sum_{k,m} P_{t_{km}} P_k P_m \varepsilon_k \varepsilon_m}{I_{\gamma_i} \varepsilon_i} \right] \left[1 - \frac{\sum_{j} P_{t_{ij}} P_i P_j \varepsilon_{t_j}}{I_{\gamma_i}} \right]$$

$\mathbf{Pt_{km}}$
$\mathbf{Pt_{ij}}$ ⇒ obtained **combining the various transition probabilities** for each nuclear level involved in the coincidence process

$\boldsymbol{\varepsilon_k}$, $\boldsymbol{\varepsilon_m}$, $\boldsymbol{\varepsilon_i}$, $\boldsymbol{\varepsilon t_j}$ ⇒ obtained by **fitting the experimental data** (spectra analysis) provided by CEA

Simplyfied Method - 1/2

Summing in Summing out

$$C_i = \left[1 + \frac{\sum_{k,m} P_{t_{km}} P_k P_m \varepsilon_k \varepsilon_m}{I_{\gamma_i} \varepsilon_i} \right] \left[1 - \frac{\sum_{j} P_{t_{ij}} P_i P_j \varepsilon_{t_j}}{I_{\gamma_i}} \right]$$

$\mathbf{Pt_{km}}$
$\mathbf{Pt_{ij}}$ ⇒ obtained **combining the various transition probabilities** for each nuclear level involved in the coincidence process

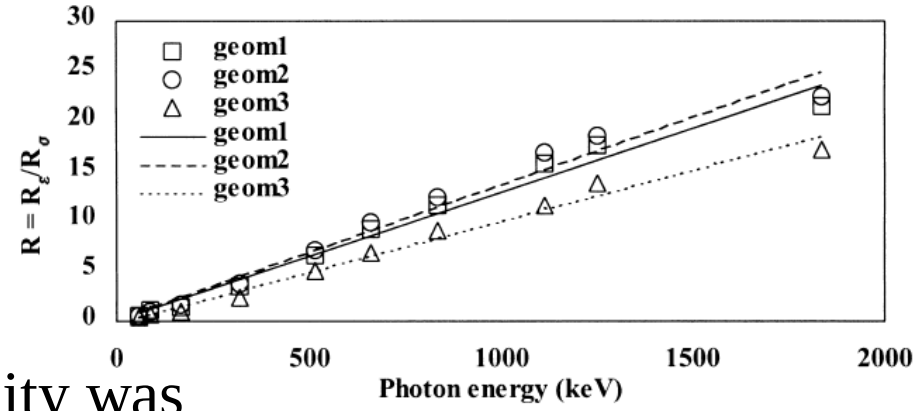
ε_k, ε_m, ε_i ⇒ obtained by **fitting the experimental data** (spectra analys) provided by CEA

εt_j ⇒ obtained, for each energy value, using **<u>just one experimental point</u>** (<u>single source of a monoenergetic radionuclide</u>)

Simplyfied Method - 2/2

$$\varepsilon_{t_j} = \frac{\varepsilon_j}{K R_\sigma E_\gamma}$$

De Felice et al. Applied Radiation and Isotopes 52 (2000)



$$K = R / E_\gamma$$

a simple proportionality was observed between R and Eγ

$$R = R_\varepsilon / R_\sigma$$

Rε = peak-to-total efficiency ratio
Rσ = photoelectric-to-total cross section (in germanium) ratio

In each measurement geometry, **<u>the slope K was calculated only for the ^{137}Cs at 662 keV</u>**.

General criteria applied

Coincidences considered:

- γ - γ
- γ - Xk_{α} (internal conversion)
- γ - Xk_{α} (electron capture decay – Sm branch)

Coincidences neglected:

- triple coincidences
- X - X
- X – γ
- γ – annihilation photon at 511 keV

Selection criteria applied

Some **photon selection criteria** were applied at ^{152}**Eu**

⇒ simplyfied decay scheme

If γ_i are the photons to which correction must be applied and γ_j are the photons which contribute to that correction:

- Summing-out effect: for each γ_i photon with an emission probability $I\gamma_i$, only coincidences with γ_j having an emission probability $\mathbf{I\gamma_j \geq 10\ \%\ I\gamma_i}$ were considered.

- Summing-in effect: only couples γ_k, γ_m where at least one of the two photons has $\mathbf{I\gamma \geq 10\ \%\ I\gamma_i}$ were considered.

References

[1] M. Korun and R. Martini *Coincidence summing in gamma and X-ray spectrometry* Nucl. Instrum. and Methods in Phys. Res. A 325 (1993) 478-484

[2] T.M. Semkow, G. Mehmood, P. Parekh, M. Virgil *Coincidence summing in gamma-ray spectroscopy* Nucl. Instrum. and Methods in Phys. Res. A 290 (1990) 437-444

[3] R.G. Helmer, R.J. Gehrke *Calculation of coincidence summing corrections for a specific small soil sample geometry* Proceedings of the symposium on advances in alpha-, beta- and Gamma-Spectrometry, St Petersburg, Russia, Sept. 1996

[4] Pierino De Felice, Paola Angelini, Aldo Fazio and Roberto Biagini *Fast procedures for coincidence-summing correction in γ-ray spectrometry* Applied Radiation and Isotopes 52 (2000) 745-752

[5] Pierino De Felice, Paola Angelini, Aldo Fazio and Marco Capogni *A national campaign for coincidence-summing correction in γ-ray spectrometry* Applied Radiation and Isotopes 56 (2002) 117-123


ThankYou