

ICRM Gamma Spectrometry Working Group

Workshop

Paris, Laboratoire National d'Essais

23 -24 February 2009

Methods used at ENEA for computing the coincidence summing corrections

P. De Felice

ENEA – National Institute for Ionising Radiation Metrology

defelice@casaccia.enea.it

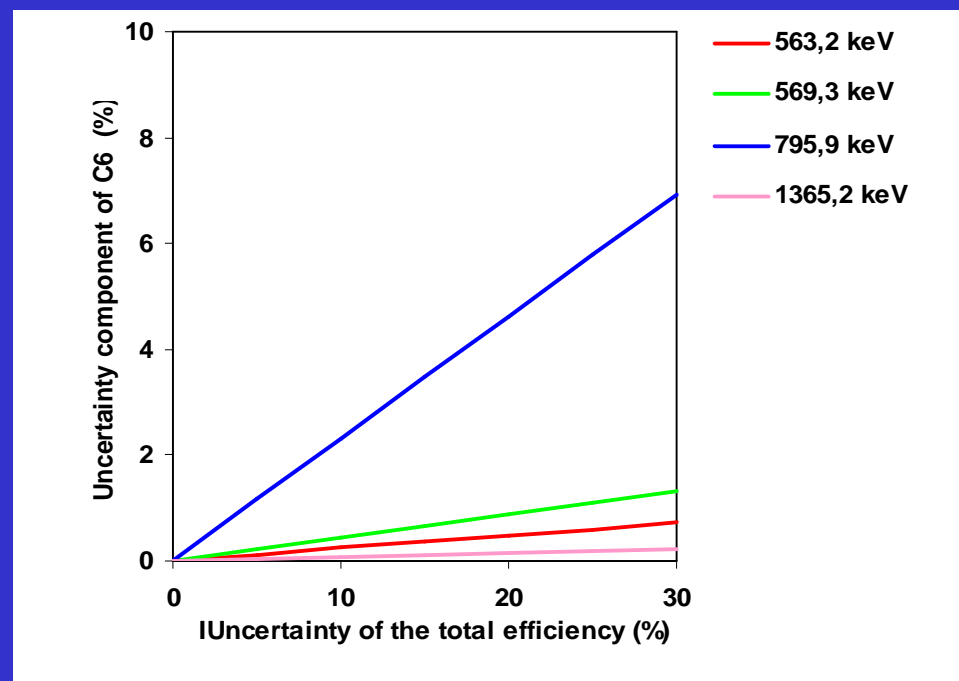
UNCERTAINTY PROPAGATION

The uncertainty of the total efficiency, ε_t , is propagated to C_i by the usual error propagation law

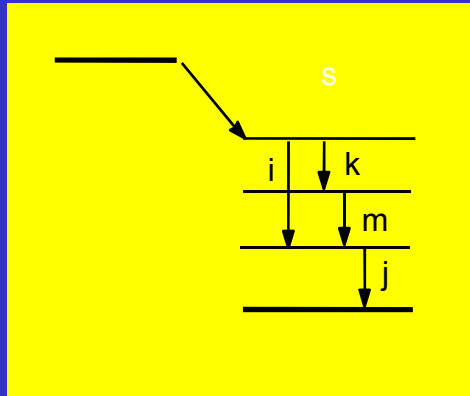
Input uncertainties are "compressed" by partial derivatives and the output uncertainties of C_i are notably reduced

Example: Point source on detector window, 604.7 keV, ^{134}Cs .

Photon N.	Photon energy (keV)
4	563.2
5	569.3
6	604.7
7	795.9
11	365.2 (569+796)



N. 1 – “Analytical” method (basic approach)



$$n_i = AI_{\gamma_i} \varepsilon_i C_i$$

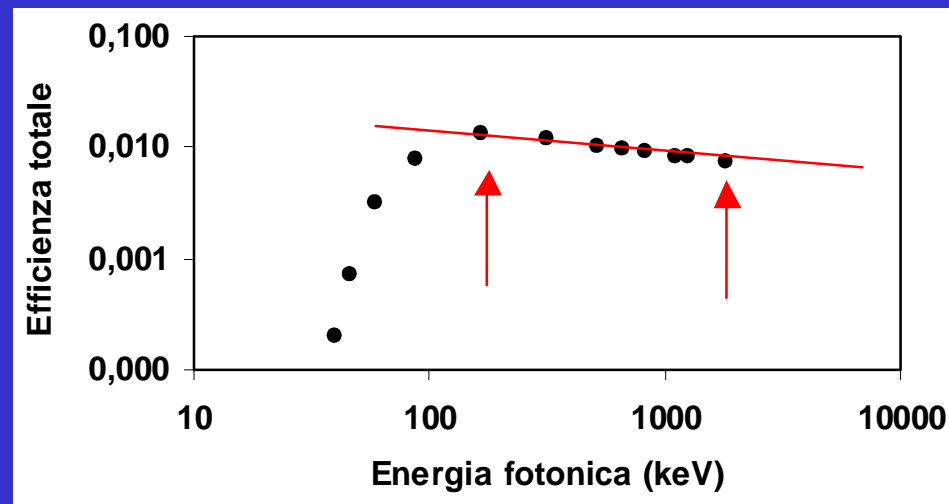
$$C_i = \left[1 + \frac{\sum_{k,m} P_{t_{km}} P_k P_m \varepsilon_k \varepsilon_m}{I_{\gamma_i} \varepsilon_i} \right] \left[1 - \frac{\sum_j P_{t_{ij}} P_i P_j \varepsilon_{t_j}}{I_{\gamma_i}} \right]$$

Ref.: P. De Felice et al., ARI, 52 (2000) 745.

- Summing-in and summing-out taken into account;
- X-ray coincidences taken into account;
- Triple coincidences neglected;
- Experimental efficiencies obtained by LNHB data;
- ε efficiencies interpolated by two linear relationships in log-log plot with 130 keV knee;
- ε_t obtained by some single-photon nuclides, Co-60 and Y-88 with corrections;
- $\varepsilon_t = \varepsilon$ for $E < 130$ keV;
- Photon i and j with $I_j/I_i > 0.1$ were taken into account;
- Nuclear and atomic data supplied by comparison organisers.

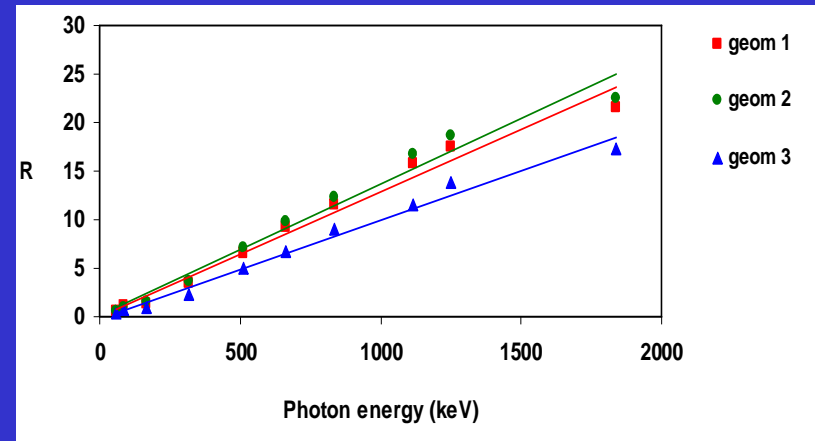
N. 2 – “Two points” method

- $E < 130 \text{ keV}$: $\varepsilon_t = \varepsilon$;
- $E > 130 \text{ keV}$: ε_t obtained by linear interpolation (log-log scale) between two points (Co-60 and Cs-137).



N. 3 – “Efficiency to cross section ratio” method

$$R = \frac{\varepsilon_i / \varepsilon_{t_i}}{\sigma_i / \sigma_{t_i}} = k E_\gamma$$

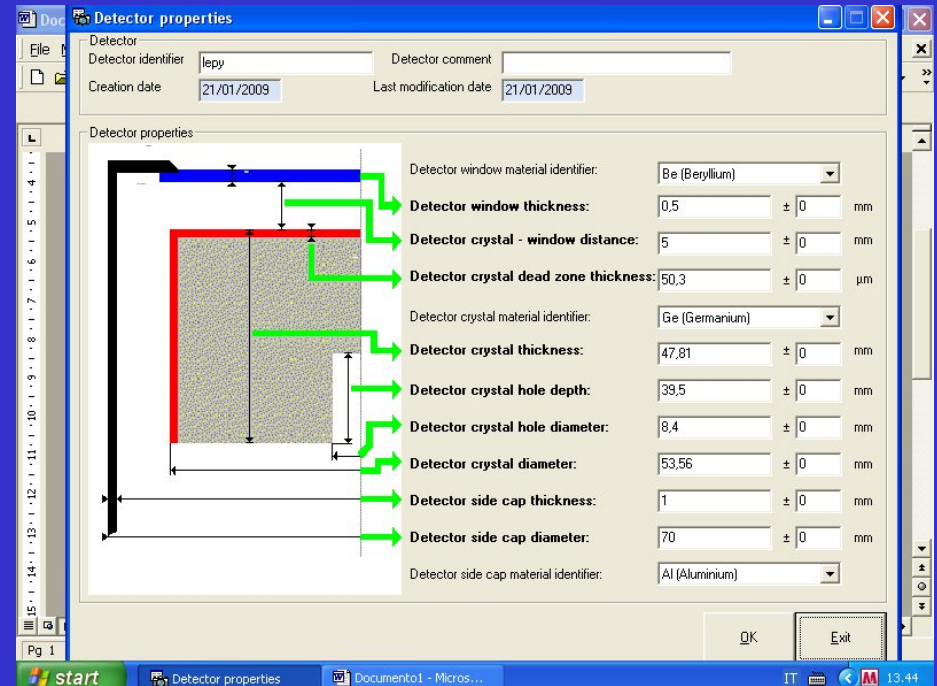
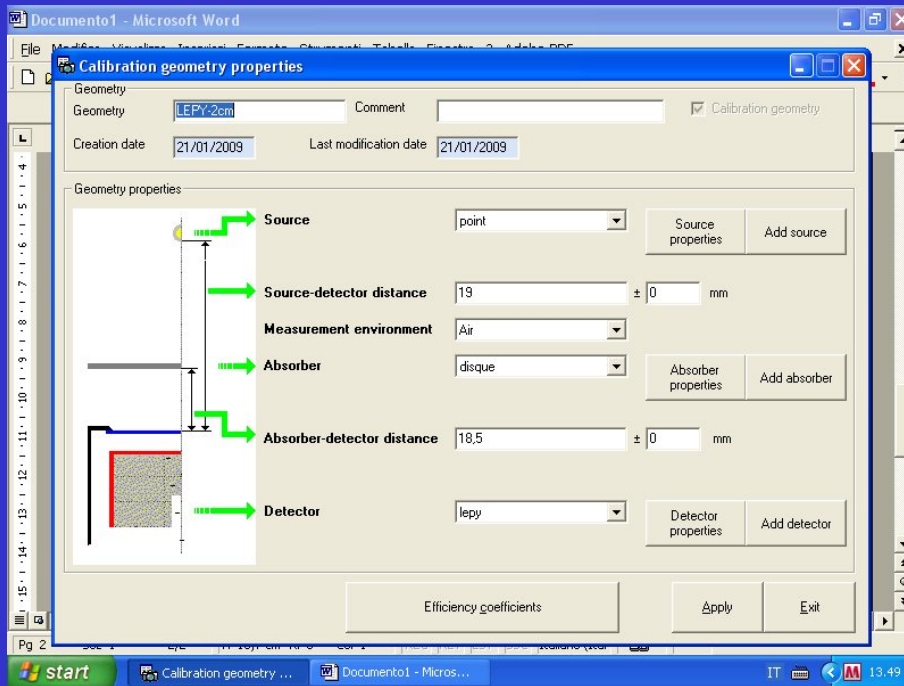


- $E < 130$ keV: $\varepsilon_t = \varepsilon$;
- Assumption of a constant relation between the peak-to-total efficiency ratios and the photoelectric-to-total cross-section ratios;
- Constant, k , determined by Cs-137.

	K
ε/σ 2 cm	0,0102207
ε/σ 5 cm	0,0099135
ε/σ 10 cm	0,0094897

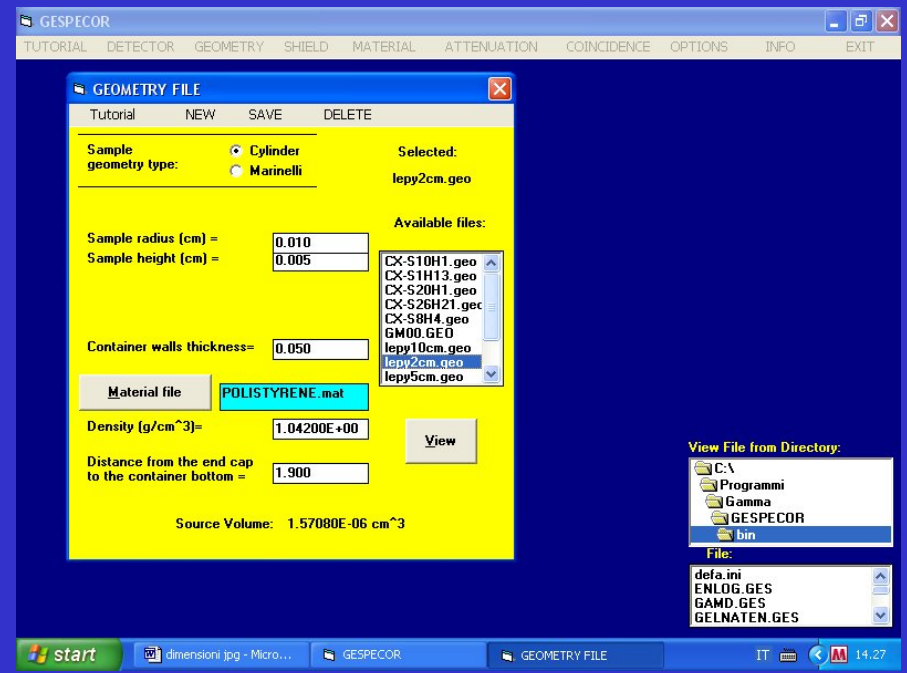
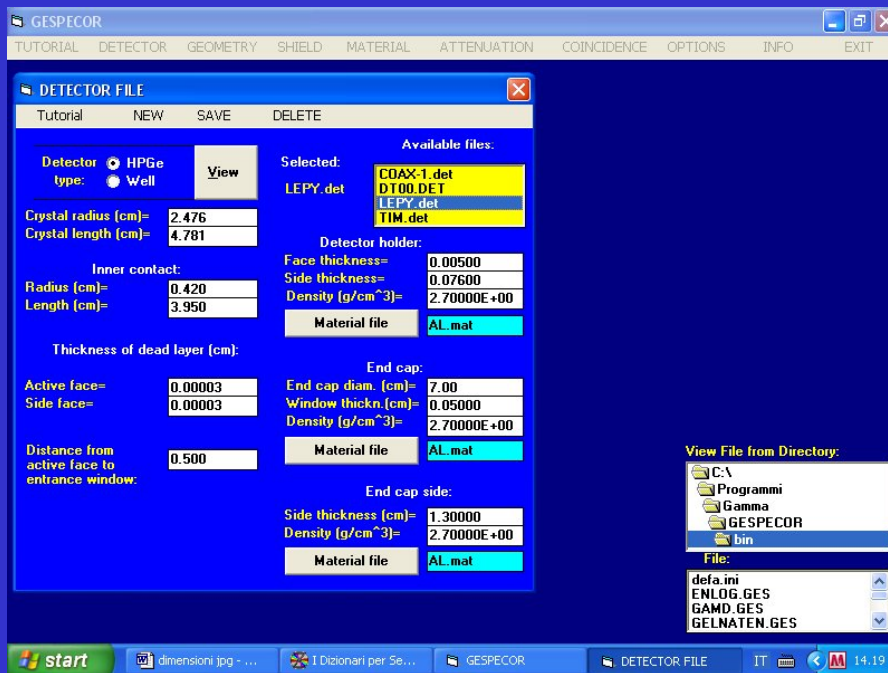
N. 4 – “ETNA” method

- Corrective factors computed by ETNA (5.5 rev 51) program;
- Efficiency values and photon selection criteria calculated as in Method N. 1;
- Nuclear and atomic data taken from ETNA data base;
- Detector dimensions taken from LNHB radiographies.



N. 5 – “GESPECOR” method

- Corrective factors computed by GESPECOR 3.0 program;
- Efficiency values and photon selection criteria calculated as in Method N. 1;
- Nuclear and atomic data taken from GESPECOR data base;
- Detector dimensions taken from LNHB radiographies.



N. 6 – “MONTE CARLO” method

(performed by M. Capogni)

- Corrective factors computed by GEANT 3.21 program;
- Corrective factors obtained from simulated efficiencies ratios (single-photon nuclide to nuclide of interest);
- Number of starting events simulated: between 107 and 108;
- Energy cut-off for electrons and photons: 10 keV;
- Nuclear and atomic data supplied by comparison organisers (LNHB);
- Detector data taken from LNHB radiographies as in Method N. 5 (GESPECOR).

UNCERTAINTIES

- Calculated only for Method N. 1
- Source of uncertainties: efficiency calibration (5%), nuclear data (1%).

Energy keV	Corrective factor at 10 cm	Corrective factor at 5 cm	Corrective factor at 2 cm
242.8	1.02305	1.06226	1.18212
326.5	1.02972	1.08140	1.24619
475.3	1.02173	1.05874	1.17037
563.2	1.02326	1.06290	1.18409
569.3	1.02297	1.06203	1.18138
604.7	1.01371	1.03638	1.10186
795.8	1.01416	1.03785	1.10573
801.9	1.02164	1.05849	1.16958
1038.6	1.00510	1.01320	1.03257
1167.9	0.98896	0.97069	0.92043
1365.2	0.98088	0.95056	0.87420

Energy keV	Comb. St. Unc.(%) at 10 cm	Comb. St. Unc. (%) at 5 cm	Comb. St. Unc. (%) at 2 cm
242.8	0,12%	0,34%	1,10%
326.5	0,16%	0,45%	1,56%
475.3	0,11%	0,32%	1,02%
563.2	0,12%	0,34%	1,11%
569.3	0,12%	0,34%	1,09%
604.7	0,07%	0,19%	0,57%
795.8	0,07%	0,20%	0,60%
801.9	0,11%	0,32%	1,01%
1038.6	0,07%	0,19%	0,53%
1167.9	0,12%	0,31%	0,78%
1365.2	0,16%	0,41%	0,94%

Thank you