Coincidence-summing
General considerations

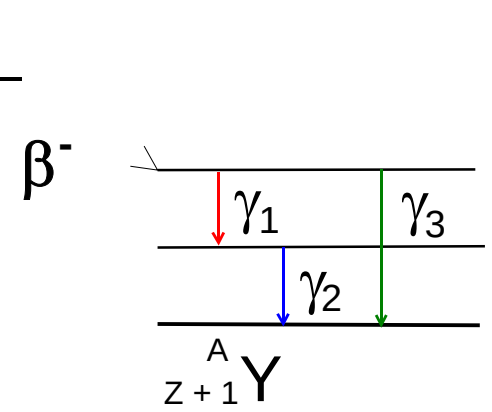
Observation : Change of the relative peak intensities when changing the source-to-detector distance

Explanation : Complex decay scheme
Close geometry
Lifetimes of nuclear levels << charge collection time in detectors (some µs)

Also refered as « true coincidence », « cascade summing »
Not to be mixed with pile-up

General principle

- 1972-1975 : Andreev, Mc Callum rise the problem
- Numerical method requiring FEP and total efficiency
- 1979-1983: Development of specific codes:
- KORSUM (PTB)
- CORCO (LNHB) -> ETNA
- Extension to volume sources



$$C_1 = \frac{1}{1 - P_{12} \cdot \varepsilon_{T2}}$$

$$C_2 = \frac{1}{1 - P_{21} \cdot \varepsilon_{T1}}$$

$$C_3 = \frac{1}{\left(1 + \frac{I_{\gamma 1}}{I_{\gamma 3}} \cdot \frac{\varepsilon_{P1} \cdot \varepsilon_{P2}}{\varepsilon_{P3}} \cdot P_{12}\right)}$$

P_{12} : probability for emitting γ_2 simultaneaously with γ_1
ε_{Pi} : FEP efficiency for energy E_i
ε_{Ti} : Total efficiency for energy E_i

Major problems

- Computing the FEP and total efficiency for different source-to-detector distance, especially for volume sources….

- Taking into account the decay scheme, including electron capture, beta+ decay, emission of X-rays, …

20 years later …

- Monte Carlo : IRA (using GEANT) (1992)
  - apparent FEP efficiency: ε_a
  - True FEP efficiency: ε
  - Correction factor: $\varepsilon/\varepsilon_a$
- Other developpements with mixture of Monte Carlo (for computing efficiencies) and numerical computation of the correction factor
- Practical applications
  - Empirical methods using monoenergetic radionuclides to establish corrective factors
  - Matrix approach
  - LS (linear-to-square) curve

Coincidence-summing at ICRM

- 1980 : action – Leader Jedlowszky - Report OMH
  - Enquiry with the objective of preparing a «Guide» …
  - 17 participants
    - CSC used by 15 participants
    - Program supplied by 4 participants
- 2001 : proposition for a comparison
  - Enquiry : 24 possible participants !
- 2005 : Interest inquiry on ICRM actions
  - (10 high + 3 medium) / 13 replies …
- ICRM 2007 : shall we start the action ? YES
  - End 2007 : Interest enquiry : 17 positive replies
  - February 2008 : Proposal sent to participants
  - August 2008 : Sending of experimental data
  - January 15, 2009 : Dead line for results

Comparison of methods for coincidence summing corrections

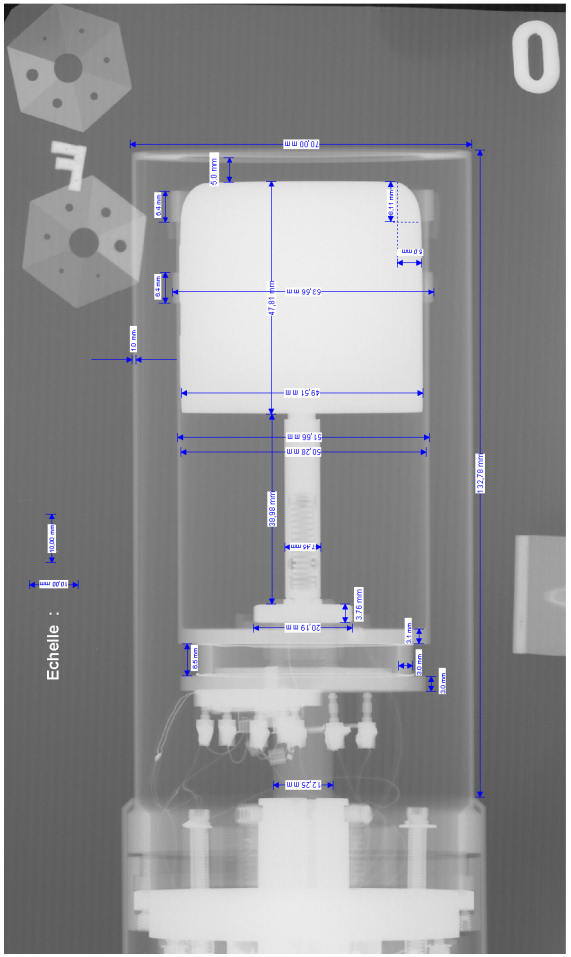
- 18 participating laboratories
- About 26 series of results per energy
- About 12 different methods
  - ENEA (3)
  - ETNA (4)
  - GEANT4 (1)
  - GESPECOR (4)
  - KORSUM (4)
  - LABSOCS (1)
  - Monte Carlo (1)
  - Recursive algorithm (1)
  - Semiempirical (1)
  - Simplified (1)
  - Sinkko-Aaltonen (1)
  - Truecoinc (2)
  - …

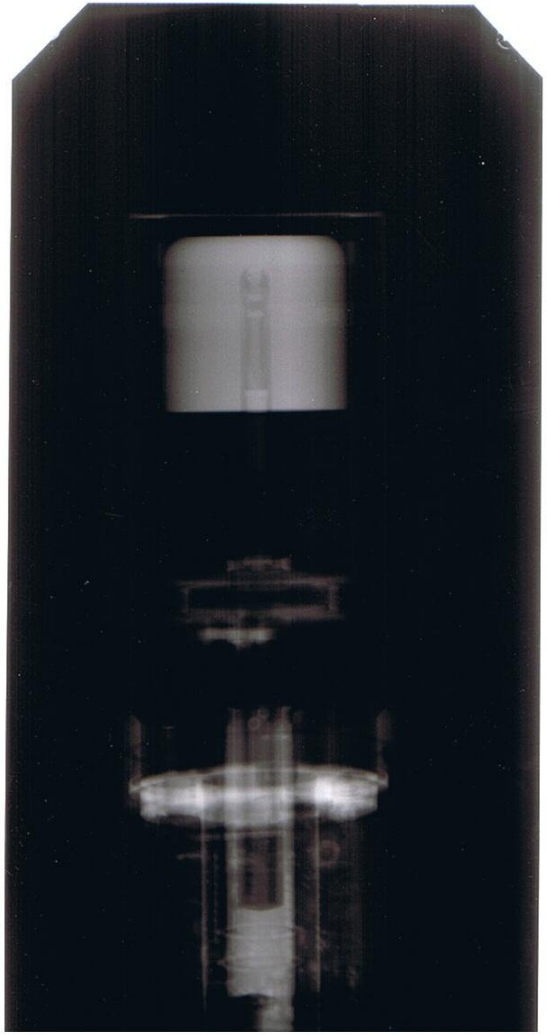
Data provided to participants

- Experimental conditions
  - HPGe detector
  - Point sources at different distances
- Experimental spectra
- Nuclear decay data

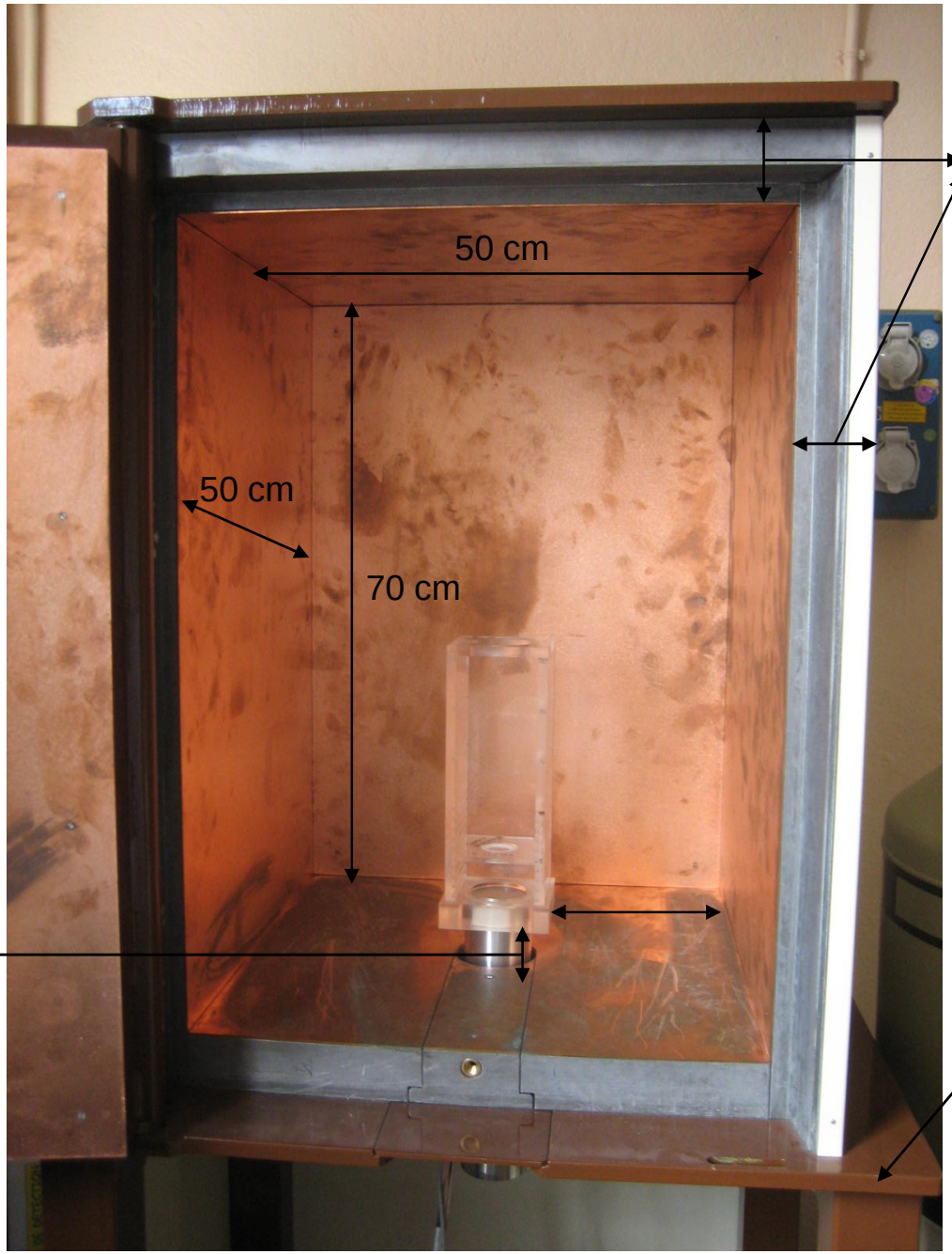
Experimental conditions : detector

- Information sheets from the detector supplier
- Radiographies





Shielding structures

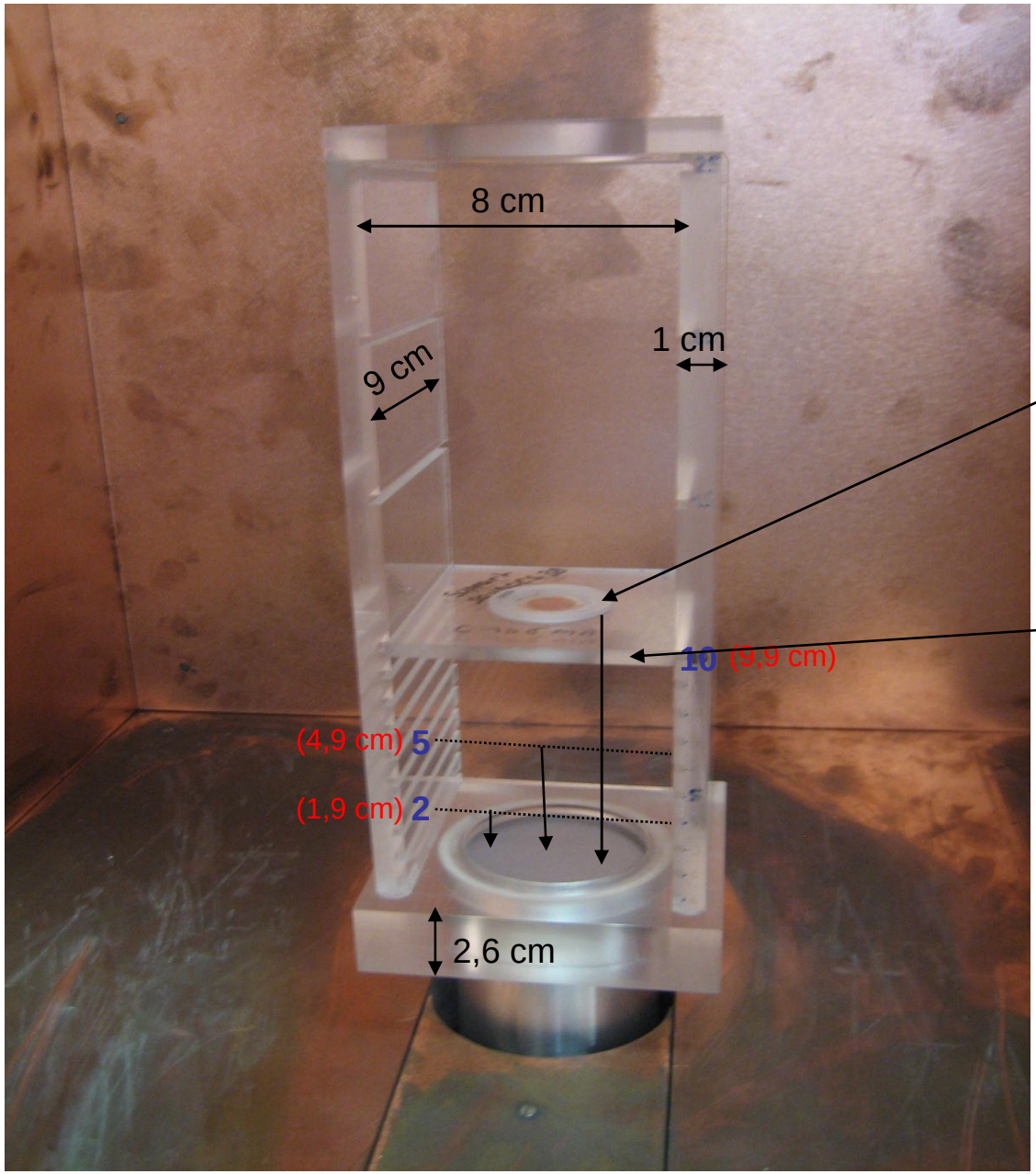


The structures of the chamber are composed of 0,2 cm Cu + 5 cm Pb thickness

Distance between the source support and the chamber : 4cm

Steel of 1,5 cm thickness on the top and below the chamber and 0,5 cm on the door

Source support dimensions



Measurement positions :
10 : 10,08 cm
5 : 5,08 cm
2 : 2,08 cm

Ring external diameter = 38mm

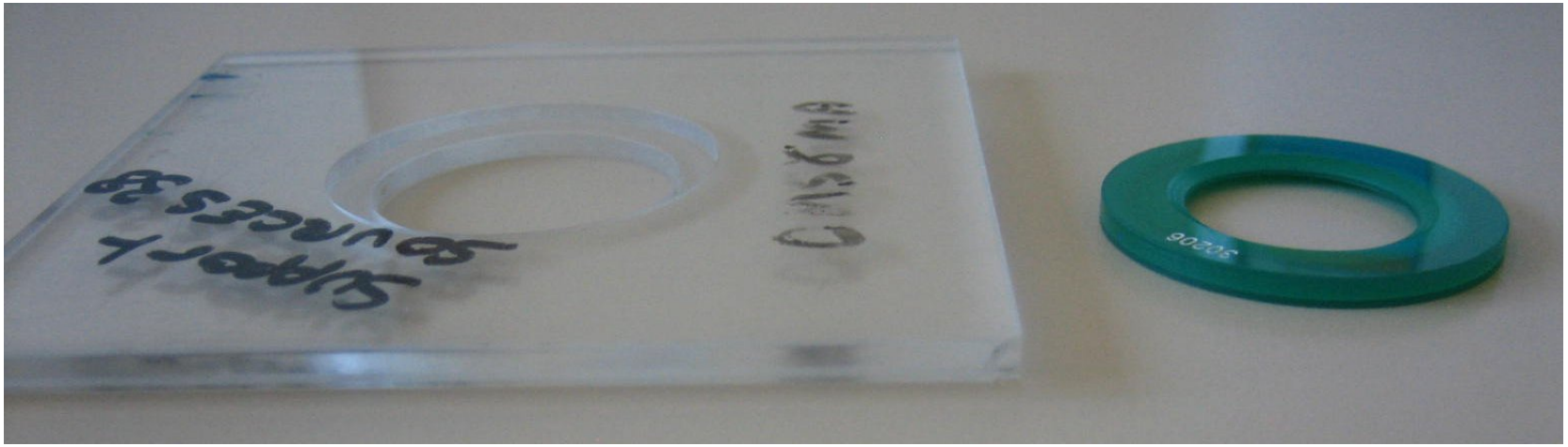
Internal diameter = 22 mm

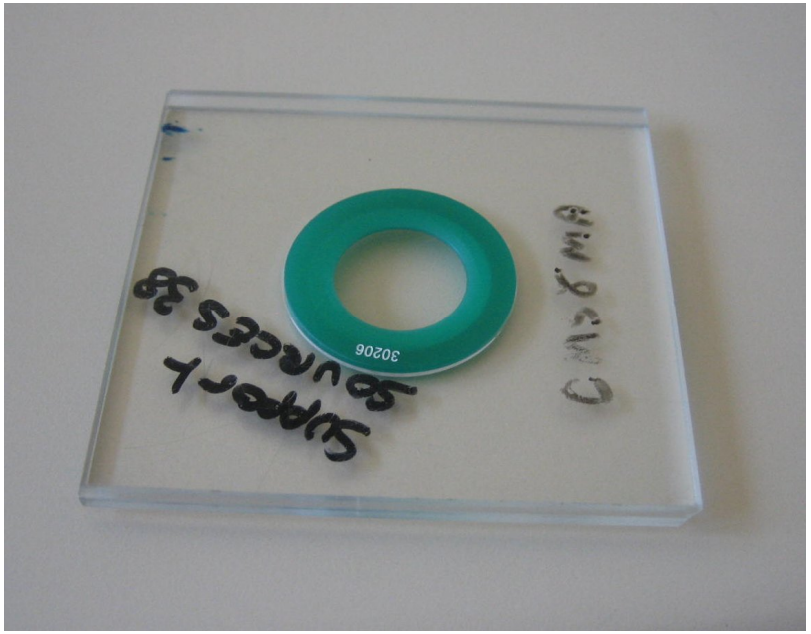
Average ring thickness 1,8 mm

Ring holder thickness = 4,5 mm

In red, distance between the source and the detector window

Experimental conditions : sources





Experimental spectra

Experimental spectra were taken at 3 source-to-detector distances (2, 5 and 10 cm)

1. “Monoenergetic “radionuclides: ^{137}Cs, ^{109}Cd, ^{54}Mn, ^{57}Co, ^{60}Co, ^{88}Y and a mixture of “monoenergetic” nuclides including (^{241}Am, ^{109}Cd, ^{57}Co, ^{60}Co, ^{139}Ce, ^{51}Cr, ^{113}Sn, ^{85}Sr, ^{137}Cs, ^{88}Y);

   Background spectrum;

   These could be used to establish the efficiency curves and also to check Monte Carlo simulation results.

2. Spectra with two multigamma sources (^{152}Eu and ^{134}Cs)

3. Complementary spectra at 25 cm (reference – negligible summing effect)

Decay data

- To assure comparable results, the decay data should be taken from the same table. According to the 3NDWG meeting of 7 September 2005, the atomic and nuclear decay data contained within Monographie BIPM-5 are recommended to ICRM members and co-workers. Recommended values are updated on the LNHB website at http://www.nucleide.org/DDEP_WG/DDEPdata.htm.

- We attached the relevant data as pdf files ; for 134Cs, as it is not yet included in the Monographie, the data are taken from the Nucléide database and a copy of the scheme and data of interest are provided in file “134CS_data.pdf” (Only the main decay towards 134Ba is considered).

Results

- The requested data are the corrective factors for ^{152}Eu and ^{134}Cs, for several energies and 3 source-to-detector distances : 10, 5 and 2 cm.

  These corrective factors should be applied to the measured net counting of each peak to obtain a “true” value (i.e. without coincidence effects).

Results form

^{134}Cs

Energy/keV	Corrective factor at 10 cm	Corrective factor at 5 cm	Corrective factor at 2 cm
242.8			
326.5			
475.3			
563.2			
569.3			
604.7			
795.8			
801.9			
1038.6			
1167.9			
1365.2			

27 energies x 3 distances X 26 series of calculations = 2106 results !