Summary from the ALMERA technical visit on coincidence summing and geometry correction in gamma ray spectrometry

Rajdeep Sidhu

Basic facts

- 19 – 23 July 2010 at Seibersdorf
- 40 participants from 20 countries
- 6 lecturers:

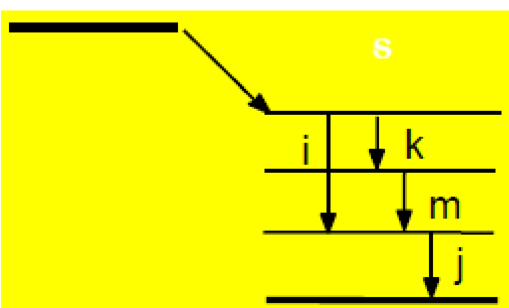
Octavian Sima
Pierino De Felice
Marie-Christine Lepy
Tim Vidmar
Iolanda Osvath
Alessia Ceccatelli

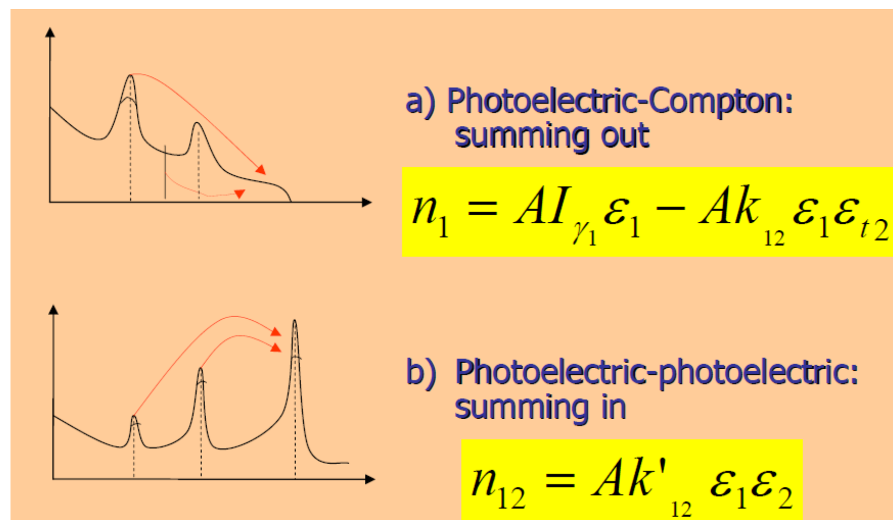
Topics

- True coincidence summing correction
- Geometry correction
- Self absorption corrections
- (Decision threshold and detection limit)

True coincidence summing

- Energy from two or more gammas is released within the resolving time of the detector electronics
- True coincidence vs random coincidence
- Summing in
- Summing out



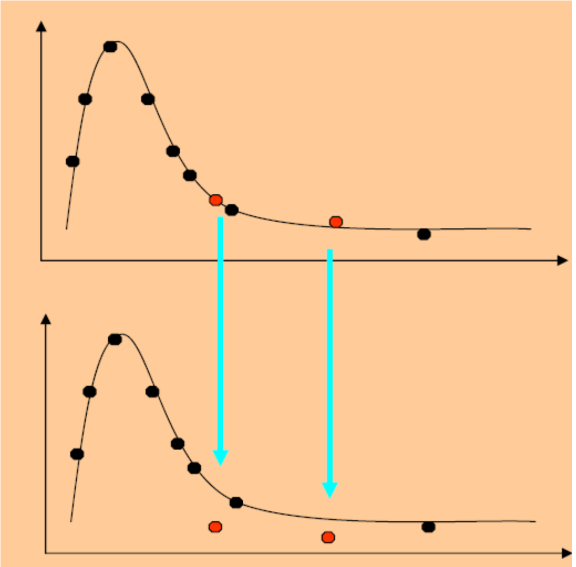


True coincidence

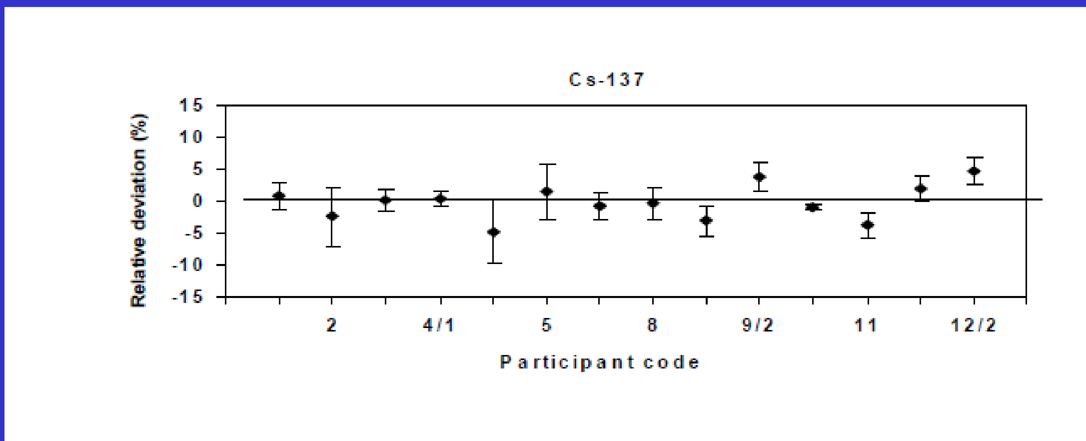
- Higher distance between source and detector gives lower coincidence summing
- Random coincidence: more probable at higher activities
- Ture coincidence: not dependante on activity level
- Coincidence also due to simultaneous detection of x-rays (Pb X-rays) anhilation photones etc. together with gamma

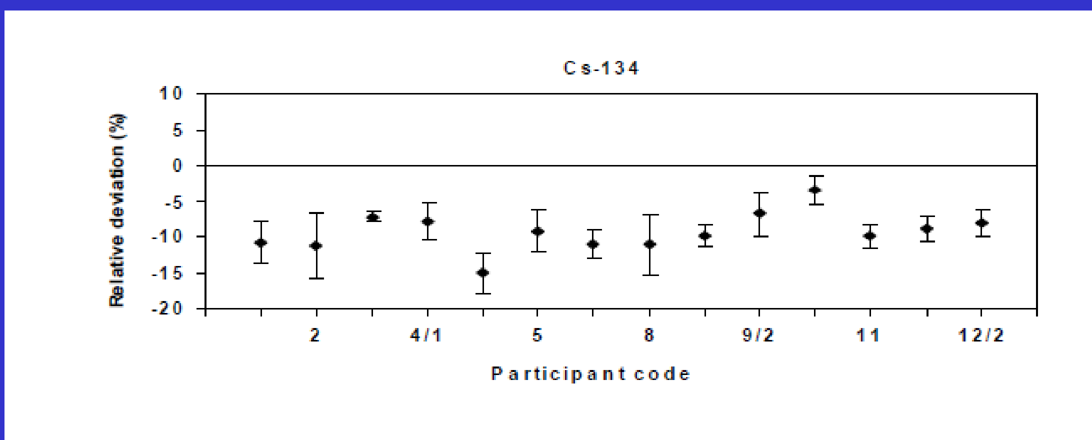
Truce coincidence summing

- Dependant on:
  - Decay scheme parameters
  - Source characteristics and geometry
  - Source to detector distance
  - Detector characteristics and geometry
  - Shielding characteristics
  - ?



Coincidence-summing:
a common source of systematic errors in gamma-spectrometry





Example:
Italian gamma-spectrometry proficiency test (1998)

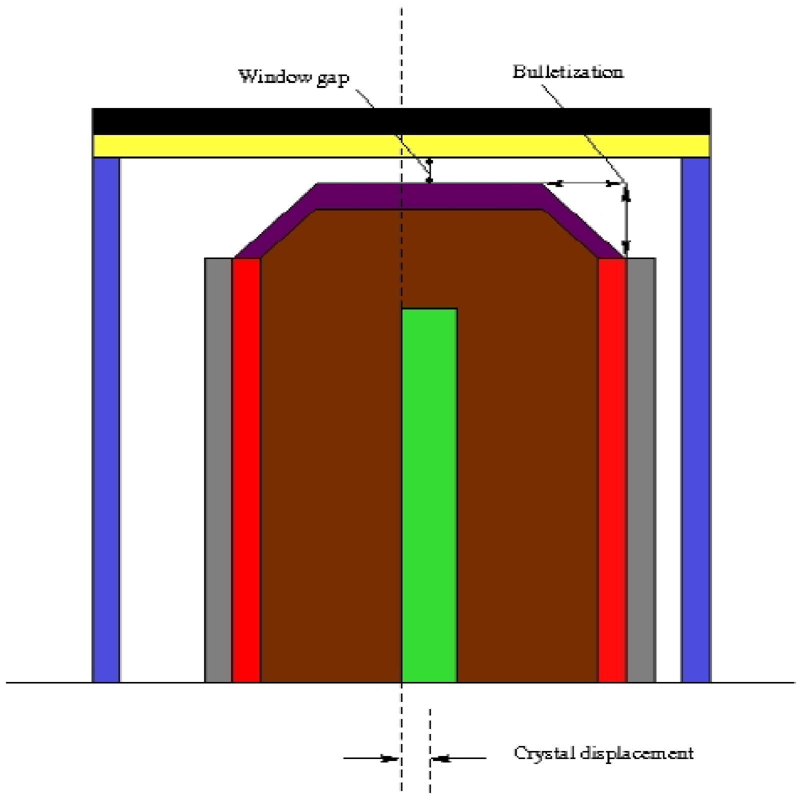
CCCC and EFFTRAN

- http://ol.ijs.si/~vidmar/

Detector

Add Comment:

Crystal diameter (including the side dead layer)	74,00	mm
Crystal length (including the top dead layer)	83,50	mm
Crystal displacement (see sketch)	0,00	mm
Bulletization (see sketch - the side, NOT the diagonal)	0,00	mm
Top dead layer	0,50	mm
Side dead layer	0,50	mm
Cavity length	70,50	mm
Cavity diameter	10,00	mm



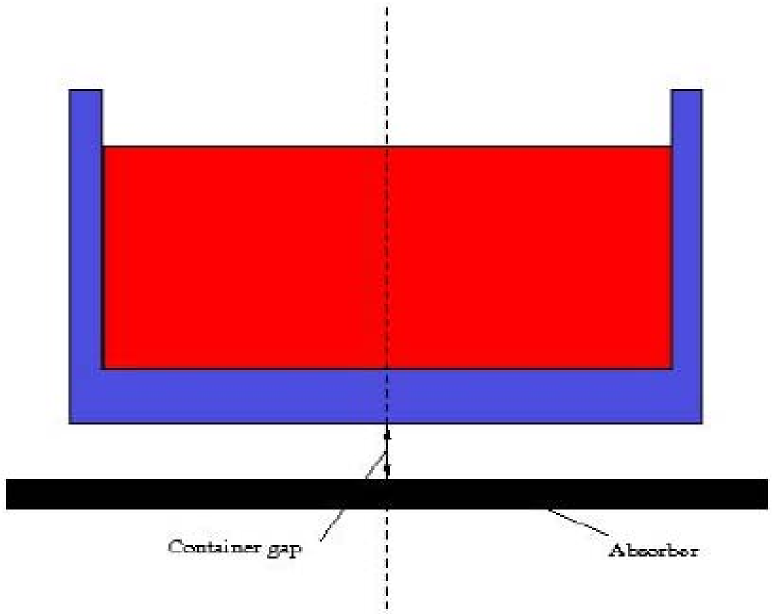
Housing diameter	80,00	mm
Housing thickness	1,50	mm
Housing material	aluminium	
Housing density	2,70	g/ccm
Window thickness	1,50	mm
Window gap (see sketch)	6,41	mm
Window material	aluminium	
Window density	2,70	g/ccm
Holder thickness	0,80	mm
Holder material	aluminium	
Holder density	2,70	g/ccm
Absorber thickness	3,00	mm
Absorber material	aluminium	
Absorber density	2,70	g/ccm

Notes:

Sample

Add comment:

Sample filling height (without the container)	0,01	mm
Sample material	aluminium	
Sample density	1,00	g/cmm
Container diametre	2,00	mm
Containier bottom thickness	0,01	mm
Container side wall thickness	0,01	mm
Container material	aluminium	
Container density	1,05	g/ccm
Container gap (see sketch)	2,00	mm



Notes:

Correction factors

E [keV]	Factor
CO-60	
8	1,185
347	1,381
826	1,410
1173	1,183
1332	1,188
2159	0,847
2506	0,000
Y-88	
2	1,374
14	1,389
484	1,400
511	1,169
851	1,401
898	1,169
1382	1,163
1836	1,189
2734	0,105

Calculate

Nuclide(s)

- ☐ BE-7
- ☐ NA-22
- ☐ NA-24
- ☐ AL-26
- ☐ K-40
- ☐ K-42

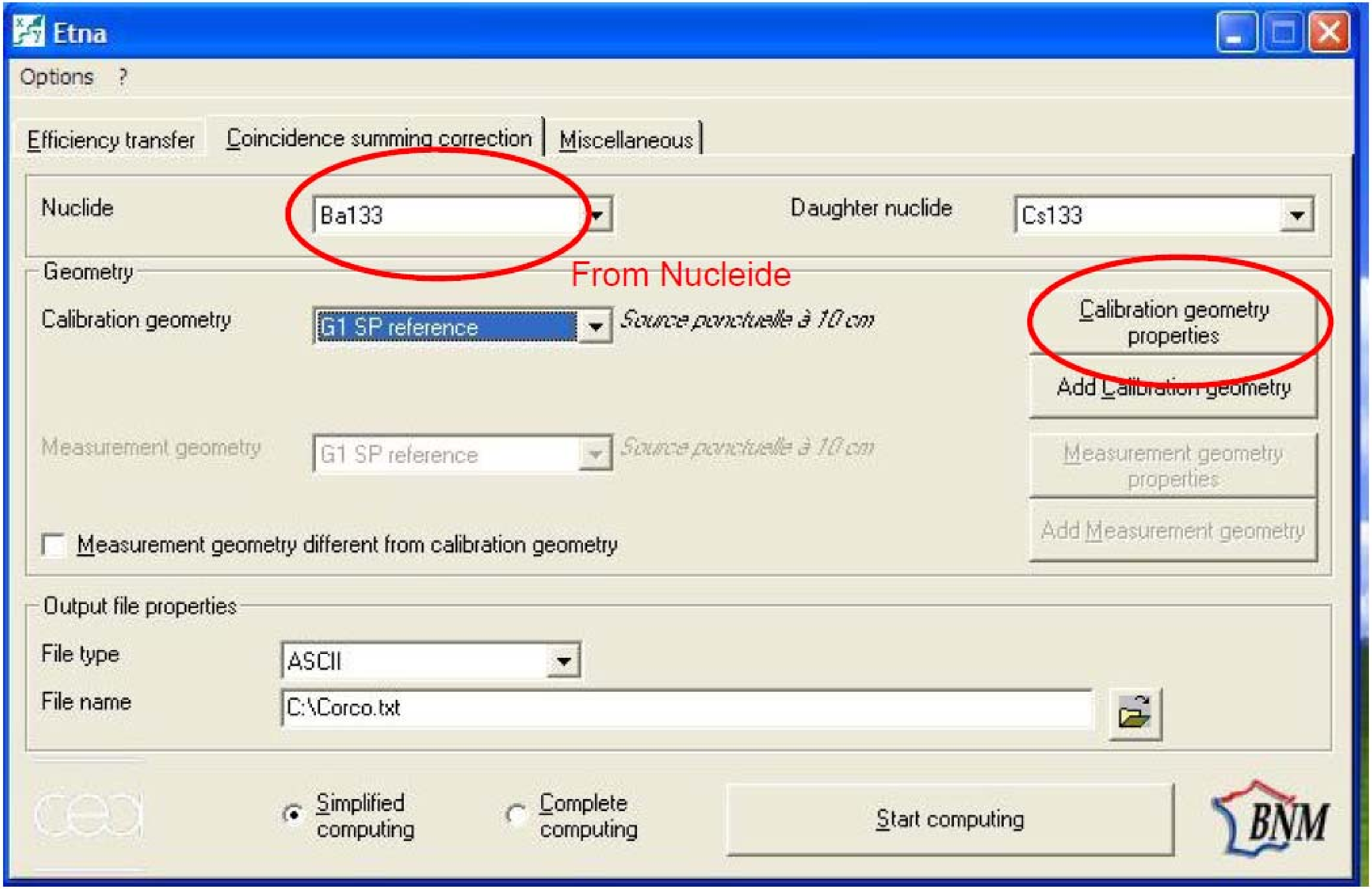
Notes:

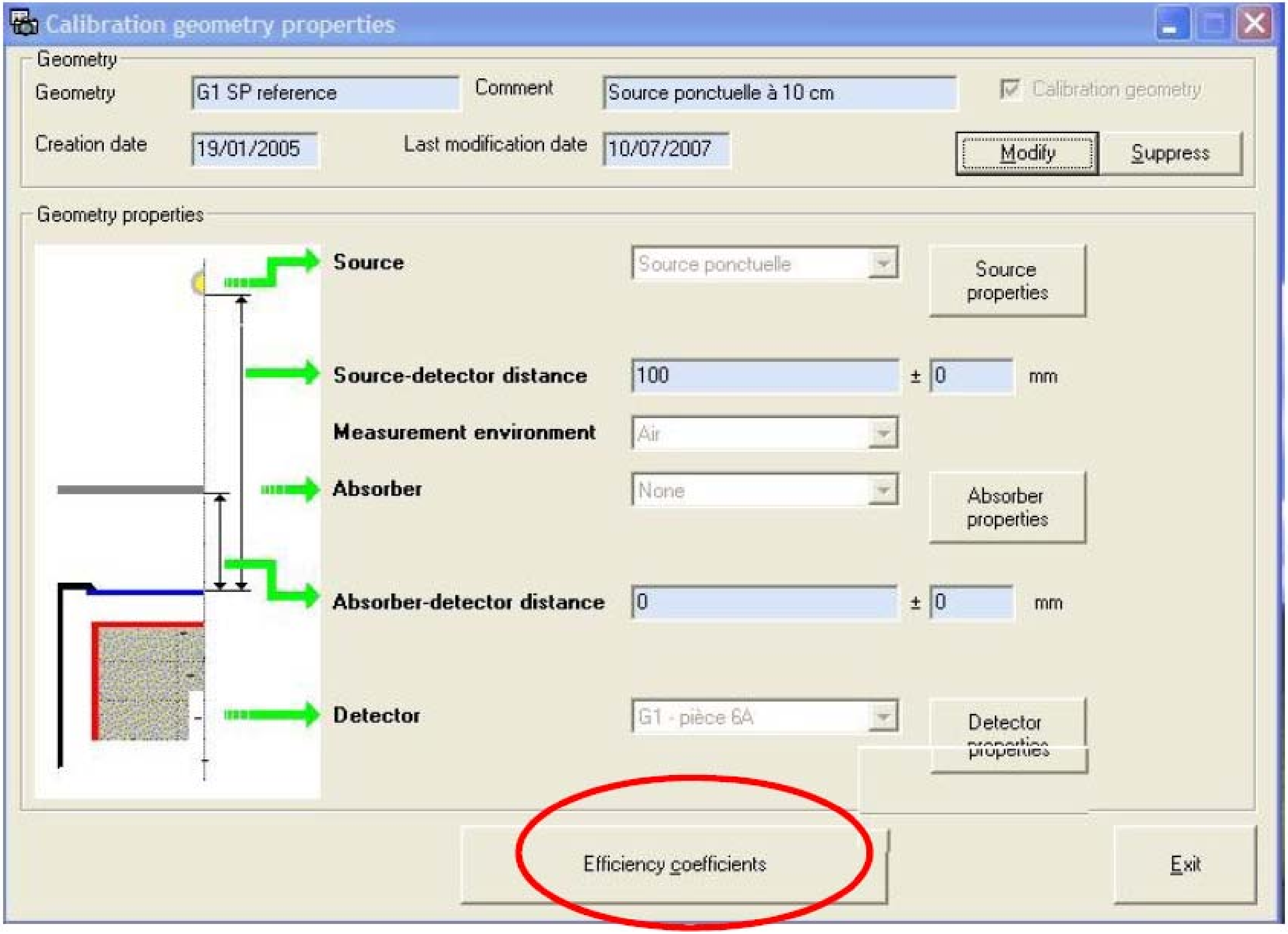
ETNA

- Efficiency Transfer for Nuclide Activity measurement
- Software for computing efficiency transfer and coincidence summing corrections
- Developed at the Laboratoire National Henri Becquerel and available upon request

ETNA

- ETNA requires:
  - Decay scheme (Nucleide database)
  - FEP and total efficiency for at least one source-to-detector geometry


Etna
Options ?
Efficiency transfer
Coincidence summing correction
Miscellaneous
Nuclide
Ba133
Daughter nuclide
Cs133
From Nucleide
Geometry
Calibration geometry
G1 SP reference
Source ponctuelle à 10 cm
Calibration geometry properties
Add Calibration geometry
Measurement geometry
G1 SP reference
Source ponctuelle à 10 cm
Measurement geometry properties
Add Measurement geometry
Measurement geometry different from calibration geometry
Output file properties
File type
ASCII
File name
C:\Corco.txt
Simplified computing
Complete computing
Start computing
BNM


Calibration geometry properties
Geometry
Geometry
G1 SP reference
Comment
Source ponctuelle à 10 cm
Calibration geometry
Creation date
19/01/2005
Last modification date
10/07/2007
Modify
Suppress
Geometry properties
Source
Source ponctuelle
Source properties
Source-detector distance
100
± 0
mm
Measurement environment
Air
Absorber
None
Absorber properties
Absorber-detector distance
0
± 0
mm
Detector
G1 - pièce 6A
Detector properties
Efficiency coefficients
Exit

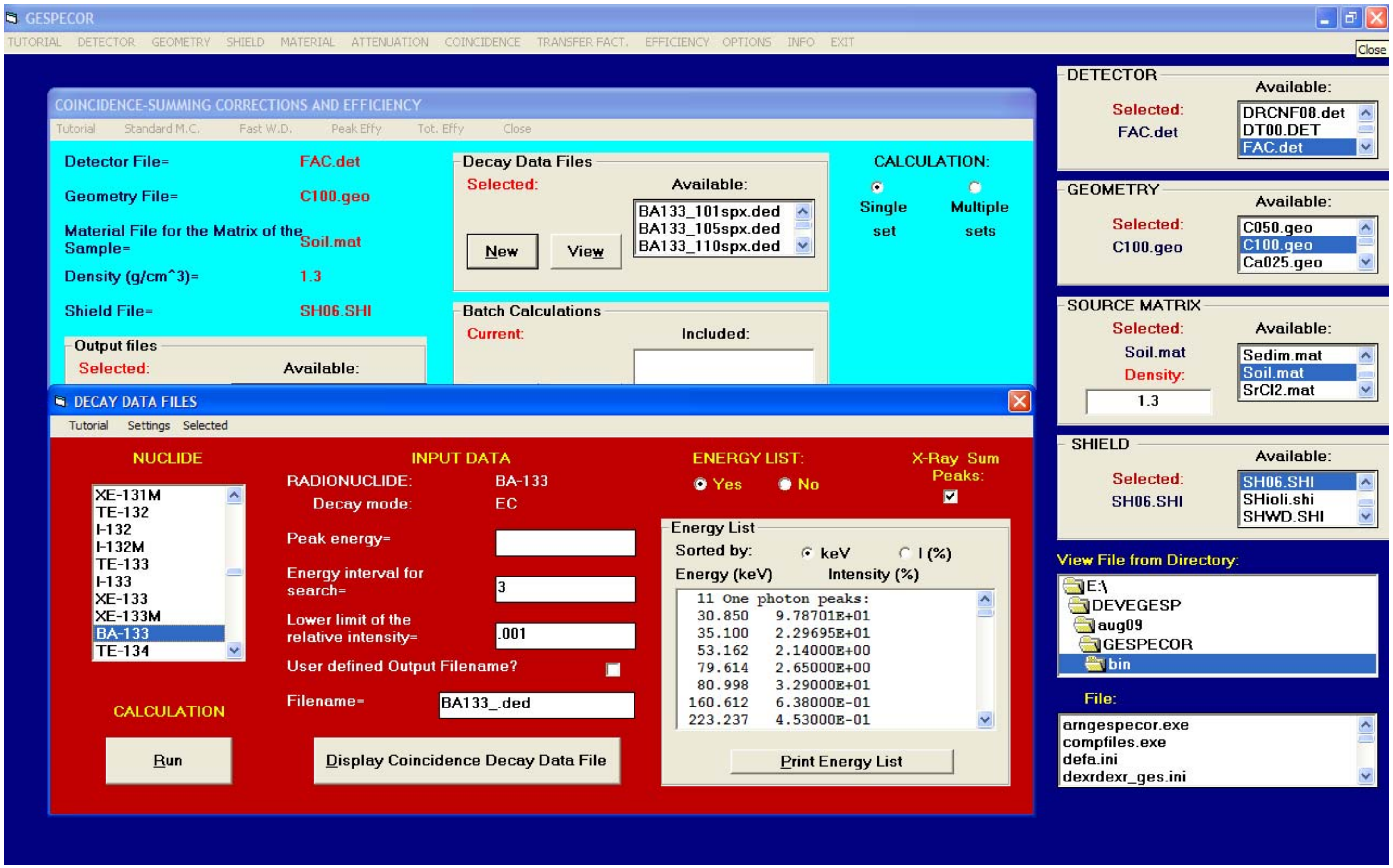
Results

- dimanche 22 février 2009
- ETNA ________________________________ Version 5.5 Rev 51
- Filename :C:\Documents and Settings\ML118236\Bureau\Workshop_ICRM\Presentations\ETNA\test_ETNA
- dimanche 22 février 2009
- Processing identification : Coincidence summing correction (simplified computing)
- Nuclide :Ba133
- Daughter nuclide :Cs133
- Half-life threshold :0,000001 s
- Calibration geometry : G1 SP reference (Source ponctuelle à 10 cm)
- Calibration source :Source ponctuelle
- Calibration source - detector distance :100 mm
- Calibration absorber :None
- Calibration absorber - detector distance :0 mm
- Measurement geometry :Calibration geometry
- Detector :G1 - pièce 6A
- Results :
- Error codes : 0 0
- X-ray correction : 01,015880

Starting level	Arrival level	Energy (keV)	Gamma-gamma correction	Gamma-X correction	Total correction
004	003	00053,162	01,013962	01,010219	01,024324
002	001	00079,614	01,015207	01,012325	01,027720
001	000	00080,998	01,011478	01,007984	01,019554
002	000	00160,612	00,993490	01,007235	01,000678
003	002	00223,237	01,009461	01,019791	01,029439
004	002	00276,399	01,008560	01,015827	01,024522
003	001	00302,851	01,005028	01,015414	01,020519
004	001	00356,013	01,003565	01,011468	01,015074
003	000	00383,849	00,991597	01,010308	01,001818

- :
- CEA\LNHB ____________________________________ BNM

GESPECOR



GESPECOR
TUTORIAL DETECTOR GEOMETRY SHIELD MATERIAL ATTENUATION COINCIDENCE TRANSFER FACT. EFFICIENCY OPTIONS INFO EXIT
Close
COINCIDENCE-SUMMING CORRECTIONS AND EFFICIENCY
Tutorial Standard M.C. Fast W.D. Peak Effy Tot. Effy Close
Detector File= FAC.det
Geometry File= C100.geo
Material File for the Matrix of the Sample= Soil.mat
Density (g/cm^3)= 1.3
Shield File= SH06.SHI
Output files
Selected:
Available:
Decay Data Files
Selected:
Available:
BA133_101spx.ded
BA133_105spx.ded
BA133_110spx.ded
New
View
CALCULATION:
Single set
Multiple sets
Batch Calculations
Current:
Included:
DECAY DATA FILES
Tutorial Settings Selected
NUCLIDE
XE-131M
TE-132
I-132
I-132M
TE-133
I-133
XE-133
XE-133M
BA-133
TE-134
INPUT DATA
RADIONUCLIDE: BA-133
Decay mode: EC
Peak energy=
Energy interval for search= 3
Lower limit of the relative intensity= .001
User defined Output Filename?
Filename= BA133_.ded
ENERGY LIST:
Yes
No
X-Ray Sum Peaks:
Energy List
Sorted by: keV I (%)
Energy (keV) Intensity (%)
11 One photon peaks:
30.850 9.78701E+01
35.100 2.29695E+01
53.162 2.14000E+00
79.614 2.65000E+00
80.998 3.29000E+01
160.612 6.38000E-01
223.237 4.53000E-01
CALCULATION
Run
Display Coincidence Decay Data File
Print Energy List
DETECTOR
Available:
Selected:
FAC.det
DRCNF08.det
DT00.DET
FAC.det
GEOMETRY
Available:
Selected:
C100.geo
C050.geo
C100.geo
Ca025.geo
SOURCE MATRIX
Selected:
Available:
Soil.mat
Density:
1.3
Sedim.mat
Soil.mat
SrCl2.mat
SHIELD
Available:
Selected:
SH06.SHI
SH06.SHI
SHioli.shi
SHWD.SHI
View File from Directory:
E:\
DEVEGESP
aug09
GESPECOR
bin
File:
arngespecor.exe
compfiles.exe
defa.ini
dexrdexr_ges.ini

Simplified semi-emperical methods

- ”*Fast procedures for coincidence-summing correction in gamma-ray spectrometry*”, Pierino et al, Applied Radiation and Isotopes 52 (2000) 745-752
- Three different approximate procedures
  - Linear interpolation (log-log plot) between two efficiency points
  - Constant peak-to-total efficiency ratios
  - Efficiency-to-cross section ratios

Geometry and self absorption correction

- EFFTRAN
- ETNA
- GESPECOR
- LABSOCS
- PENELOPE
- ….

- Individual calibration for each geometry in use
- Direct transmission method for self absorption correction

EFFTRAN

- Computational tool for gamma-ray spectrometry. The user provides measured full-energy-peak efficiencies for a standard source and the code calculates the efficiency values for a source of a different size, composition and density.

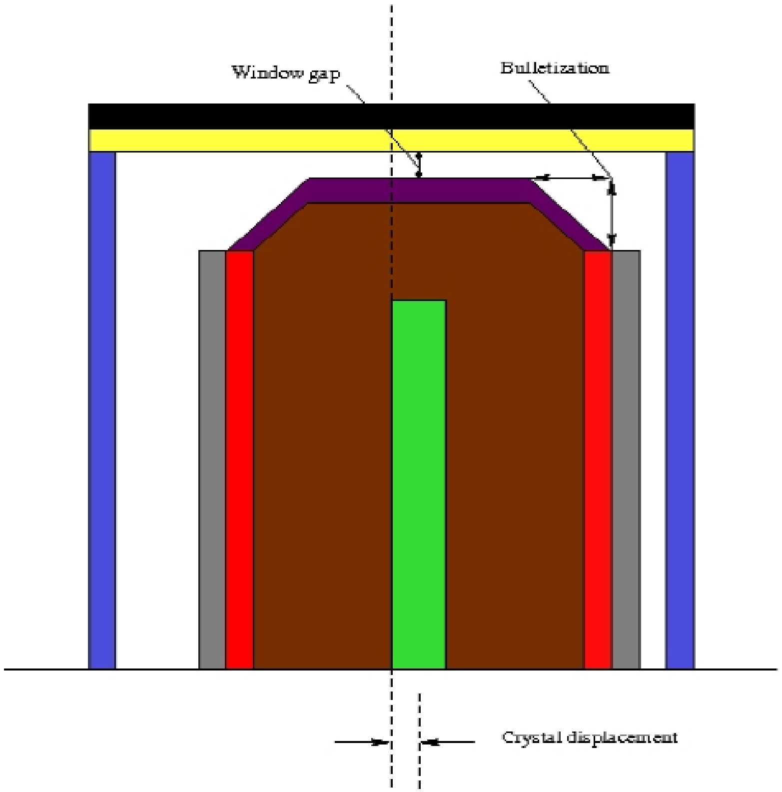
- The user must also specify the parameters of the detector, the standard and the sample models (dimensions, materials, densities).

Detector

Add comment:

Crystal diameter (including the side dead layer)	60,00	mm
Crystal length (including the top dead layer)	60,00	mm
Crystal displacement (see sketch)	0,00	mm
Bulletization (see sketch - the side, NOT the diagonal)	0,00	mm
Top dead layer	1,00	mm
Side dead layer	1,00	mm
Cavity length	40,00	mm
Cavity diameter	10,00	mm

Housing diameter	80,00	mm
Housing thickness	1,00	mm
Housing material	aluminium	
Housing density	2,70	g/ccm
Window thickness	1,00	mm
Window gap (see sketch)	5,00	mm
Window material	aluminium	
Window density	2,70	g/ccm
Holder thickness	1,00	mm
Holder material	aluminium	
Holder density	2,70	g/ccm
Absorber thickness	0,00	mm
Absorber material	aluminium	
Absorber density	0,00	g/ccm

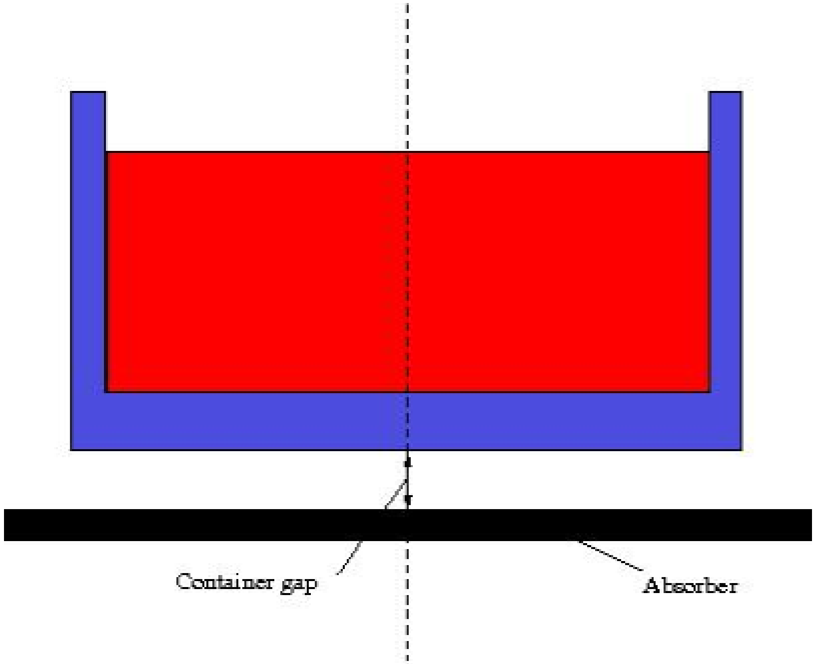


Notes:

Standard

Add comment:

Standard filling height (without the container)	19,00	mm
Standard material	aluminium	
Standard density	1,00	g/cmm
Container diameter	60,00	mm
Containier bottom thickness	1,00	mm
Container side wall thickness	1,00	mm
Container material	aluminium	
Container density	1,05	g/ccm
Container gap (see sketch)	0,00	mm

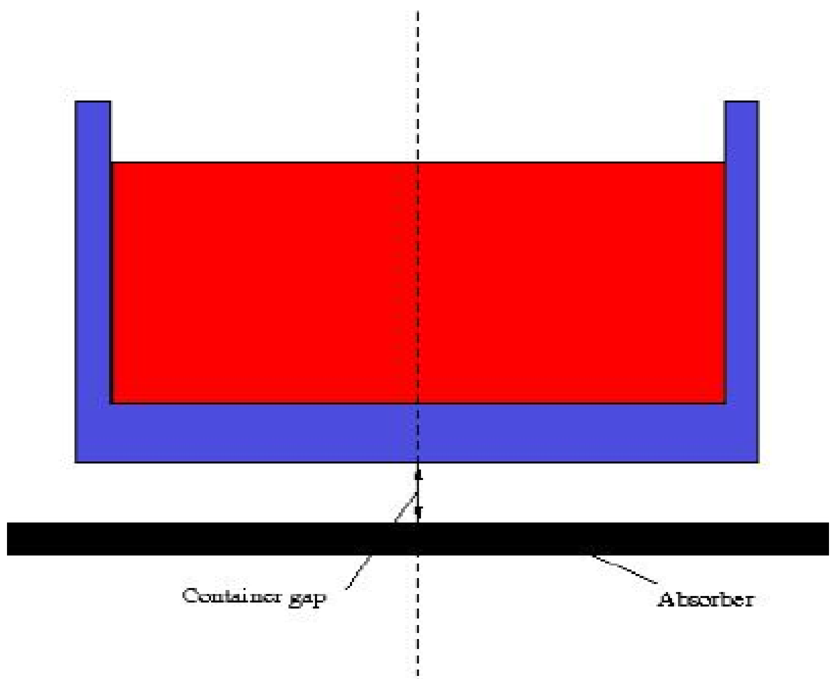


Notes:

Sample

Add comment:

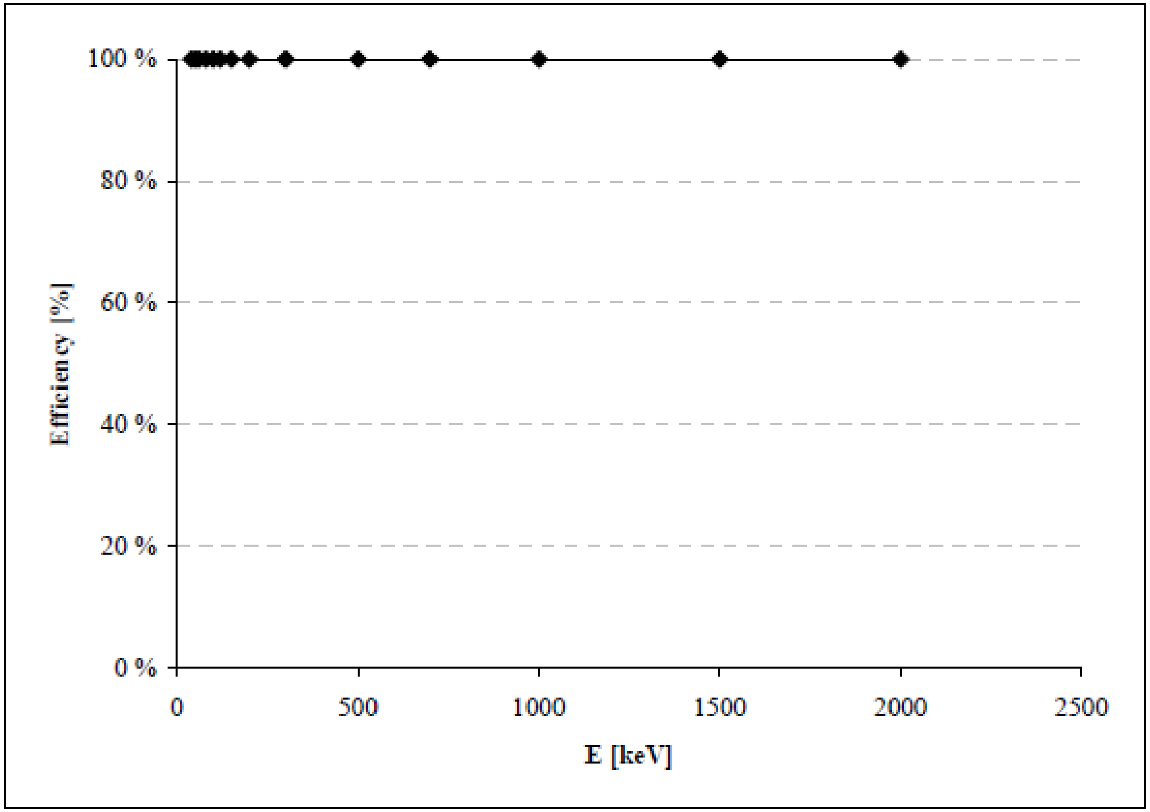
Sample filling height (without the container)	39,00	mm
Sample material	aluminium	
Sample density	1,40	g/cmm
Container diameter	90,00	mm
Containier bottom thickness	1,00	mm
Container side wall thickness	1,00	mm
Container material	aluminium	
Container density	1,05	g/ccm
Container gap (see sketch)	0,00	mm



Notes:

Standard Efficiency

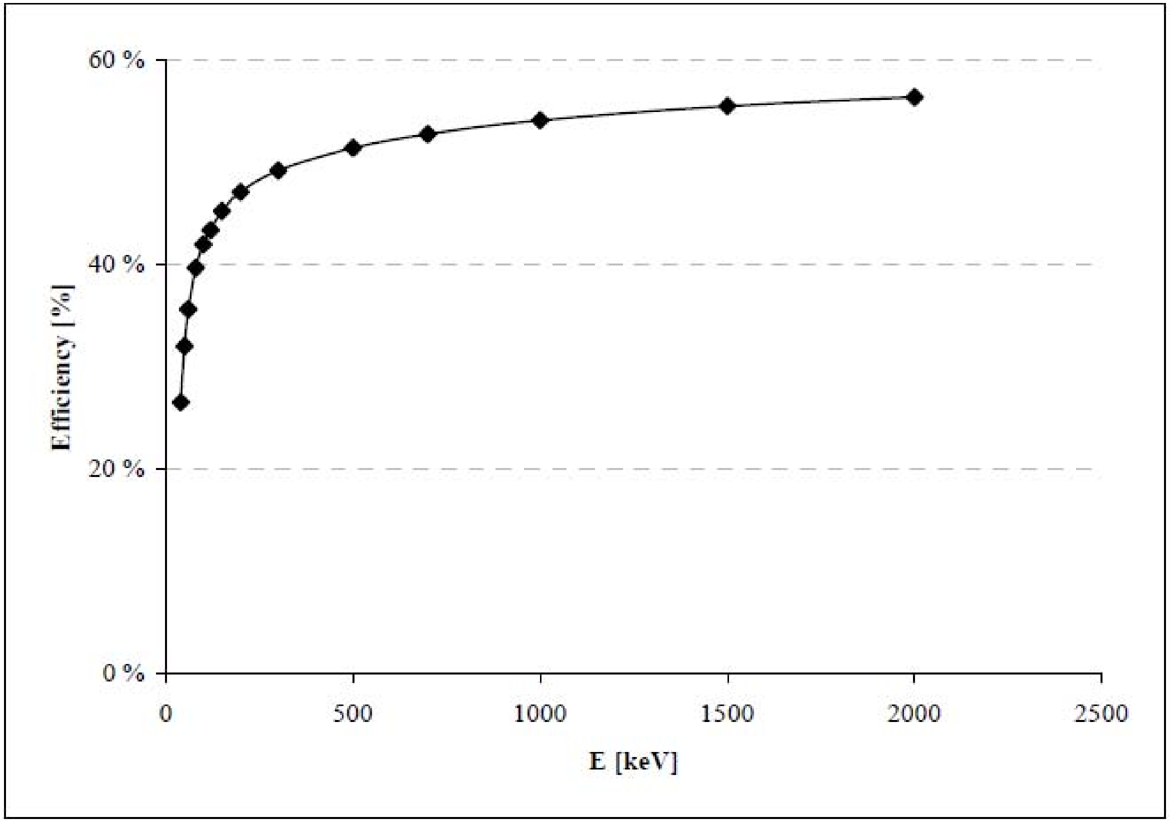
E [keV]	Efficiency [%]
40	100,00 %
50	100,00 %
60	100,00 %
80	100,00 %
100	100,00 %
120	100,00 %
150	100,00 %
200	100,00 %
300	100,00 %
500	100,00 %
700	100,00 %
1000	100,00 %
1500	100,00 %
2000	100,00 %



Sample Efficiency

Calculate

E [keV]	Efficiency [%]
40	26,53 %
50	32,04 %
60	35,66 %
80	39,69 %
100	41,98 %
120	43,39 %
150	45,25 %
200	47,12 %
300	49,22 %
500	51,43 %
700	52,77 %
1000	54,11 %
1500	55,53 %
2000	56,39 %



ICRM Gamma-Ray Spectrometry Working Group

- http://www.nucleide.org/ICRM_GSWG.htm

- Meeting reports
- Workshop presentations
- Gamma-Ray Spectrometry Forum

GammaWiki

- https://www.gr.is/wiki/GammaWiki
- https://www.gr.is/wiki/GammaWiki/index.php/TCScorrections

Thank you!