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DIRECTION DE LA RECHERCHE TECHNOLOGIQUE

^{124}Sb - ACTIVITY MEASUREMENT AND DETERMINATION OF PHOTON EMISSION INTENSITIES

par

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«^{124}Sb – Mesure de l'activité et détermination des intensités photoniques»

Résumé - La traçabilité de l'antimoine 124, en terme de mesure d'activité, est très limitée. Les valeurs, venant de laboratoires internationaux de métrologie, contribuant au Système International de Référence sont au nombre de trois. Deux laboratoires ont utilisé la méthode 4πβ-γ de mesure en coïncidence, le troisième un détecteur NaI cristal puit. Les deux premiers résultats sont en accord, mais le troisième diffère de 2 %. Diverses hypothèses ont été évoquées pour expliquer cette divergence parmi lesquelles la cohérence du schéma de désintégration. Par ailleurs, ce radionucléide émet des rayonnements gamma de haute énergie et donc pourrait être utilisé pour l'étalonnage en rendement des détecteurs gamma, si les intensités d'émission sont bien connues. Ces remarques ont conduit à proposer un exercice international de mesure de l'activité et des intensités photoniques. Cet exercice, dirigé par le CEA/List-LNE/LNHB, a été enregistré comme projet Euromet 907. Il a été demandé aux participants de mesurer l'activité d'une solution d'antimoine 124 fournie par le LNHB à l'aide de toutes les méthodes disponibles dans leur laboratoire, dans le but de confirmer ou non l'existence d'un problème lié à une, ou plusieurs, techniques de mesure. De plus, les participants ont été sollicités pour mesurer les intensités des émissions photoniques émises lors de la désintégration. Ces résultats ont été comparés avec les valeurs disponibles dans la littérature et un nouveau schéma de décroissance est proposé. Huit laboratoires nationaux de métrologie ont participé à cet exercice

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«^{124}Sb – Activity measurement and determination of photon emission intensities »

Abstract - The international traceability of antimony 124, in term of activity, is very limited. The results of ^{124}Sb activity measurements sent to the SIR (BIPM – International System of Reference, BIPM.RI(II)-K1.Sb-124.) are scarce. Up to now, only three laboratories have contributed. Two of them carried out measurements using the 4πβ-γ coincidence counting technique and the third one using the 4πγ method with a well-type crystal detector. The first two results are in agreement but the last one differs significantly from them, by 2 %. The decay scheme consistency cannot be excluded when trying to explain those discrepancies. In other respects, this nuclide emits high-energy gamma rays, and then could be selected as a valuable standard radionuclide for the calibration of gamma-ray detectors in that energy range, given well known photon intensities. Those considerations led to the proposal of an international exercise and to the realisation of this Euromet project, registered as project n° 907, coordinated by CEA/List-LNE/LNHB. The first part of this exercise was dedicated to activity measurements and to their comparison. For this purpose, participants were asked to make use of all the direct measurement techniques available in their laboratory in order to confirm or not the existence of possible biases specific to some measuring methods. In addition, this exercise offered the opportunity of improving the uncertainties of the gamma-ray intensities. Then, participants were asked, in the second part of the exercise, to carry out X-ray and gamma-ray intensity measurements. These results have been compared to previous published values and new decay scheme data are proposed. Eight international laboratories participated in this exercise.

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- Rapport CEA-R-6222 -

CEA Saclay
Direction de la Recherche Technologique
Laboratoire d'Intégration des Systèmes et des Technologies
Département des Technologies du Capteur et du Signal
Laboratoire National Henri Becquerel

^{124}Sb – ACTIVITY MEASUREMENT AND DETERMINATION OF PHOTON EMISSION INTENSITIES

par

Marie-Martine Bé, B. Chauvenet,
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- Juillet 2009 -

^{124}Sb – Activity measurement and determination of photon emission intensities

Part A – Euromet 907 Results

Part B – ^{124}Sb Decay data evaluation

^{124}Sb – Activity measurement and determination of photon emission intensities

Part A – Euromet 907 Results

1. Introduction

^{124}Sb is a fission product. As such, this radionuclide has to be taken into account in the management of short-lived wastes of nuclear industry. This radionuclide can be used also as a tracer in industry because of its high-energy high-intensity photon emissions (603, 723, 1691 keV) and its relatively short half-life (60,2 d).

The international traceability of this radionuclide is very limited. The results of ^{124}Sb activity measurements sent to the SIR (BIPM – International System of Reference, BIPM.RI(II)-K1.Sb-124.) are scarce. Up to now, only three laboratories have contributed. Two of them carried out measurements using the 4πβ-γ coincidence counting technique and the third one using the 4πγ method with a well-type crystal detector. The first two results are in agreement but the last one differs significantly from them, by 2 %, [C. Michotte *et al.* 2006 *Metrologia* **43**, Tech. Suppl. 06007]. The decay scheme consistency cannot be excluded when trying to explain those discrepancies.

On the other hand, this nuclide emits high-energy gamma rays, and then could be selected as a valuable standard radionuclide for the calibration of gamma-ray detectors in that energy range, given well known photon intensities.

Those considerations led to the proposal of an international exercise and to the realisation of this Euromet project, registered as project n° 907, coordinated by LNE-LNHB. The first part of this exercise was dedicated to activity measurements and to their comparison. For this purpose, participants were asked to make use of all the direct measurement techniques available in their laboratory in order to confirm or not the existence of possible biases specific to some measuring methods. In addition, this exercise offered the opportunity of improving the uncertainties of the gamma-ray intensities. Then, participants were asked, in the second part of the exercise, to carry out x-ray and gamma-ray intensity measurements.

In the following sections, the participants in the Euromet project 907 will be referred to as E907-*n*, where *n* is a serial number.

2. Decay scheme of antimony 124

^{124}Sb disintegrates through β^- transitions to excited levels in ^{124}Te. The total energy (Q) released to reach the ^{124}Te ground state level amounts to 2904 keV. The decay scheme is rather complex, as it includes more than 25 β^- transitions and about 70 γ transitions with energies spread between 148 keV and 2807 keV. However, only about a tenth of them have probabilities greater than 1 %. A simplified decay scheme is shown below. For a comprehensive decay scheme, see the “Decay Data Evaluation” part of this report.

In order to get comparable activity measurement results, participants were recommended to use the same nuclear decay data, *i.e.* the evaluated data published in Nuclear Data Sheets (NDS) 80,4 in 1997. This evaluation was based on γ-ray intensity values measured from 1984 to 1990. All these measurements were carried out relatively to the most intense γ-ray line of energy 602 keV, taken as the reference line.

In this exercise, the participants were asked to give their results in terms of both absolute values and relative values referred to the 602 keV line.

The ^{124}Sb half-life value adopted for the exercise was 60,20 (3) d.

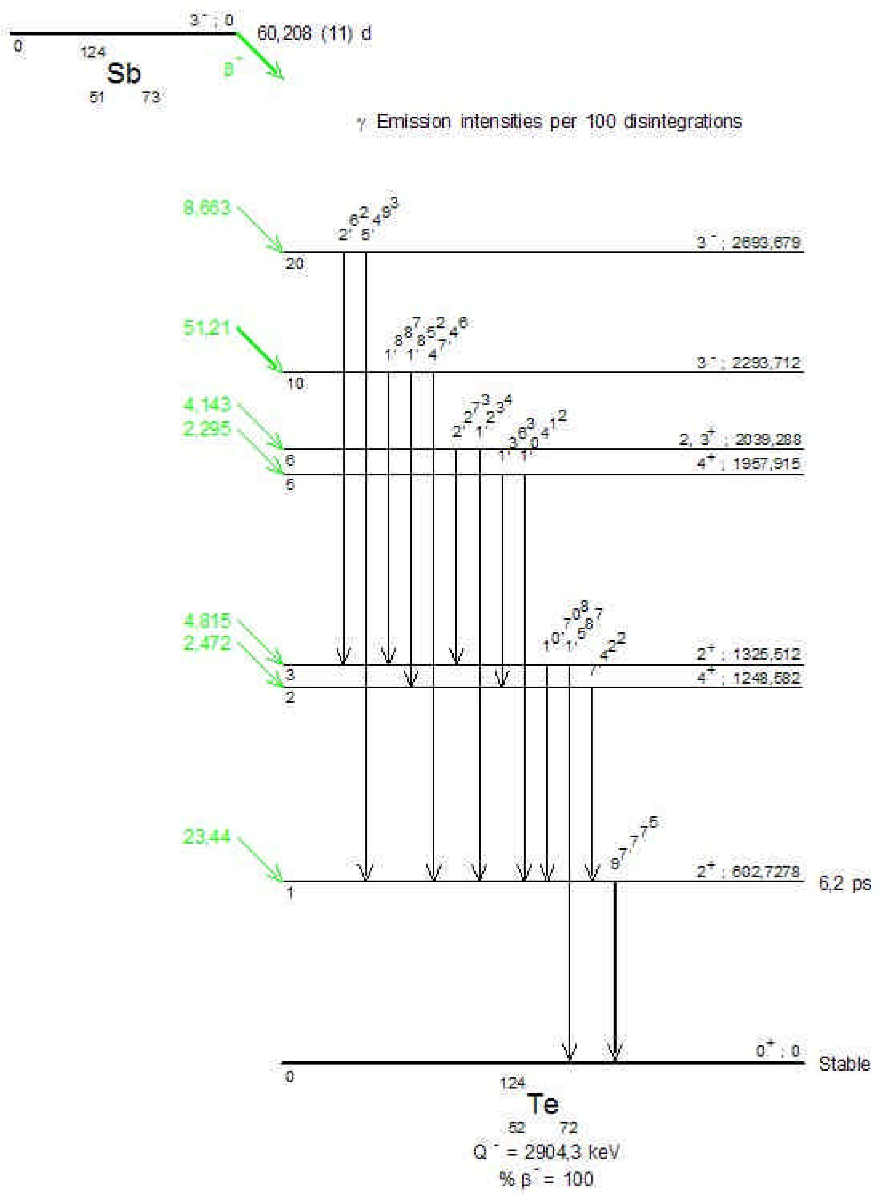

Figure 2.1. Simplified decay scheme of ^{124}Sb

3. Programme and procedure

3.1. General description

Ampoules of ^{124}Sb solution were prepared and sent to the participants by the end of February 2007. They were accompanied with a description of the presently adopted decay scheme data, a short note describing the solution (see Appendix A1) and a questionnaire (see Appendix A2).

The results had to be sent to LNE-LNHB, with the completed questionnaire. The participants were requested to determine their uncertainties according to the rules expressed in the “Guide to the expression of uncertainty in measurement” (GUM, 1993). The results included the following items:

- standardization of the ^{124}Sb solution, for which participating laboratories had to describe the techniques using the questionnaire;

- half-life measurements, enabling, using various methods, to detect possible impurities in the solution; when available, these results could be used to determine the half-life value with a better accuracy;
- measurements of photon emission intensities for gamma- and K x-rays, for which participants were invited to give their results in terms of both absolute and relative values.

In addition, participants were requested to search for impurities in the solution at the receipt of the ampoule and two months later.

The last participant results were received at LNE-LNHB in March 2008.

Activity measurements and possible SIR submission

The participants were asked to report in the questionnaire the main characteristics of the equipment(s) used, the measurement method(s), the procedure(s) and main correction factors, the results and associated uncertainties, etc.

LNE-LNHB intended to send its own activity measurement result for submission to the SIR for establishing the traceability of the comparison exercise to the KCDB. Two ampoules of the solution were then delivered to the BIPM.

An ampoule of the same solution was sent to each participant (see next paragraph).

Then, each laboratory had the opportunity:

- to send an ampoule and the associated activity value to the BIPM for SIR submission and direct contribution to the KCRV (Key Comparison Reference value) of ^{124}Sb;
- to participate in the KCDB (Key Comparison Data Base) *via* the LNE-LNHB SIR result.

Measurements of x- and gamma photon emission intensities

The participants had to return, on the same questionnaire, a description of the main experimental details, of the peak analysis method and the results for the measured x- and γ-ray emissions. They were asked to give their results in terms of both absolute values and relative values referred to the 602 keV line.

It is worth noting that the absolute values measured by the participants depended on their activity measurement result, contrary to the relative ones only depending on their spectrometric measurements.

All the results were requested to be quoted at the reference time, March 1, 2007, 0 h UTC.

3.2. Properties of the distributed solution

The radioactive solution of ^{124}Sb was prepared by LNE-LNHB. Its activity concentration was of about 1,56 MBq.g^{-1} (March 1, 2007, 12 h UTC). The solution was hydrochloric (2 mol.L^{-1}) with a $SbCl_3$ carrier concentration of 23µg.g^{-1}. Each ampoule was filled with 5 ml of radioactive solution.

The participants were informed about a problem of antimony volatility observed by LNE-LNHB during the process of preparation of solid sources. Then the following advice was written on the form “Characteristics of the radioactive solution” sent to the participants.

“During the preparation of solid sources, a problem of volatility with ^{124}Sb was encountered. To try to solve it, we followed the procedure:

1) a weighed deposit of radioactive solution of ^{124}Sb was made for each solid source,

2) a drop with an equivalent mass of 2,5 mol.L^{-1} NaOH was added on each deposit.

The purpose was to precipitate the element antimony as insoluble oxychlorides (SbOCl, …).”

The homogeneity of the batch of ampoules was checked using an ionisation chamber. Ten ampoules (Volume 5mL) were prepared, each of them was measured 10 times, the experimental standard deviation of the measurement results was 0,02 %, which confirmed the excellent homogeneity of the batch.

3.3. Impurity checks

Purity tests of the initial solution were achieved using x- and gamma-ray spectrometry (coaxial HPGe ~ 100 cm^3 and planar HPGe). ^{125}Sb, ^{125}Te^m and ^{122}Sb were more specifically scrutinized.

A first series of measurements was carried out using both detectors at the date of February 9, 2007. The acquisition time was 250 000 seconds. No impurities were found, and detection limits were determined:

- ^{125}Sb: A(^{125}Sb) / A(^{124}Sb) = 4 10^{-4} Bq/Bq,
- ^{122}Sb: A(^{122}Sb) / A(^{124}Sb) = 2 10^{-4} Bq/Bq,
- ^{125}Te^{m}: A(^{125}Te^{m}) / A(^{124}Sb) = 10^{-3} Bq/Bq.

A second series of measurements was undertaken on July 6, 2007, under the same conditions, which confirmed the previous measurements and the absence of gamma-emitting impurities.

When reported, these results were confirmed by the participants. Nevertheless, participant 5 identified ^{125}Sb as an impurity, whose quantity was found between the decision and detection limits, *i.e.* 0,03 kBq/g (2 10^{-5} Bq/Bq) and 0,05 kBq/g (3,5 10^{-5} Bq/Bq) respectively.

3.4. List of participating laboratories

Table 3.1. List of participants

EUROMET 907 : ^{124}Sb			
Laboratory	Address	Persons involved in the measurements	Contact email address
CMI	Czech Metrological Institute Radiova 1, CZ 10200 Praha 10, Czech Republic	P. Dryak, J. Sochorovà, P. Kovar, P. Auerbach	pdryak@cmi.cz
IFIN-HH	“Horia Hulubei” National Institute of Physics and Nuclear Engineering P.O. Box MG-6 Bucharest, Romania	A. Luca (γ-ray spectrometry), M. Sahagia and A.C. Wätjen, (4πβ–γ CC and sources preparation)	aluca@ifin.nipne.ro msahagia@ifin.nipne.ro cristina.watjen@nipne.ro
IRA-METAS	Rue du Grand-Pré 1 CH - 1007 Lausanne	C. Bailat, Y. Nedjadi, P. String	Claude.bailat@chuv.ch
IRD-LNMRI	Laboratorio Nacional de Metrologia das Radiaçoes Ionizantes Av. Salvador Allende s/n° Recreio Rio de Janeiro, Brazil	A. Iwahara, M.C.M de Oliveira, J.U. Delgado, C.J. da Silva	delgado@ird.gov.br
IRMM	Institute for Reference Material and Measurements Retieseweg 111, 2440 Geel, Belgium	T. Altzitzoglou, S. Pommé, R. Van Ammel, G. Sibbens, J. Paepen, J. Camps	Timotheos.altzitzoglou@cec.europa.eu, stefaan.pomme@ec.europa.eu
LNE-LNHB	Laboratoire National Henri Becquerel CEA 91191 Gif-sur-Yvette Cedex, France	C. Bobin (4πβ–γ CC) M.C. Lépy (γ- spectrometry) M.N. Amiot (IC) T. Branger (sources preparation)	mm.be@cea.f christophe.bobin@cea.fr marie-christine.lepy@cea.fr
NPL	National Physical Laboratory Queens Road Teddington, Middlesex, TW11 OLW, U.K.	L. Johansson, L. Keightley, A. Stroak	lena.johansson@npl.co.uk ; lynsey.keightley@npl.co.uk
PTB	Physikalisch Technische Bundesanstalt Bundesallee 100 38 116 Braunschweig, Germany	K. Kossert (LSC) O. Nähle (4πβ–γ CC) O. Ott, R. Dersch (γ-spectrometry)	Karsten.Kossert@ptb.de

4. Activity measurements

4.1. Methods

Following the recommendations, most participants used several methods to measure the activity of ^{124}Sb. The eight participants thus sent a total of 18 individual measurement results.

They were invited to give their individual results for each method they used and their adopted final value. When a participant used several methods, his final value was either the average of all the different results obtained or of a selection of some of them, or the result of the method in which he was the most confident. Some results were thus eliminated by some participants, because of an unexplained discrepancy when compared to others.

The details are given in Table 4.1. Each line lists a measurement method, the number of participants who used it, the identification numbers of those participants, and the identification numbers of the participants who included that method in their final value.

It is worth noting that all participants carried out measurements with the 4π β(PC,PPC)-γ coincidence or anti-coincidence method and included it in their final value.

Table 4.1. Activity measurement methods used by participants

Method	Number of results	Participants using the method (*serial number*)	Participants using the method in their final result (*serial number*)
4π β(PC,PPC)-γ coincidences or anti-coincidences	8	1-2-3-4-5-6-7-8	1-2-3-4-5-6-7-8
4π β(LS)-γ coincidences	2	2-3	2
CIEMAT/NIST liquid scintillation counting	2	5-8	5
4πγ NaI(Tl) counting	3	1-3-8	8
4πγ CsI(Tl) counting	1	8	8
Well-type ionization chamber	2	1-3	-

4.2. Source preparation

In addition to the pilot laboratory, three participants gave some information about antimony volatility related to source preparation.

Participant E907-1 reported experimental evidence that the recommended procedure was not sufficient to completely avoid Sb emanation, possibly because of the difficulty of fully homogenizing $SbCl_3$ and NaOH by drop addition onto the source support. Instead, they diluted the original solution with an aqueous solution containing NaOH and chelating agent EDTA, after which no emanation could be detected. Such a problem was not encountered by the pilot laboratory when testing the procedure.

Participant E907-5 observed a bad quality of samples (low efficiency and changes of the appearance of samples) when applying the recommended procedure. Thus, many attempts were made to improve the sample preparation. Some techniques showed evidence of antimony evaporation during source preparation. Finally a technique was applied in which the original solution and tartaric acid were used in a light-protected metal-free environment. No antimony evaporation was observed applying that technique.

Participant E907-6 followed the recommended procedure: after preparing the sources by drop deposition of an aliquot of the original solution onto VYNS films, a drop of NaOH in concentration 2,5 mol/L of approximate equal mass was added. The effect was the reduction of the beta detection efficiency down to 0,70 – 0,80. These sources were used in reporting the result. Sources with lower NaOH concentrations *i.e*. 0,25 mol/L and 0,025 mol/L were also prepared. The effect was to obtain better efficiencies, 0,85 and 0,92 respectively, but the loss of mass was more than 0,5 %; consequently, these results were not used.

4.3. Results

The results obtained for all methods are reported in Table 4.2 and Figure 4.1. This leads to an unweighted mean value of 1451 (12) kBq/g.

The following sections focus on the results obtained for each method in more details.

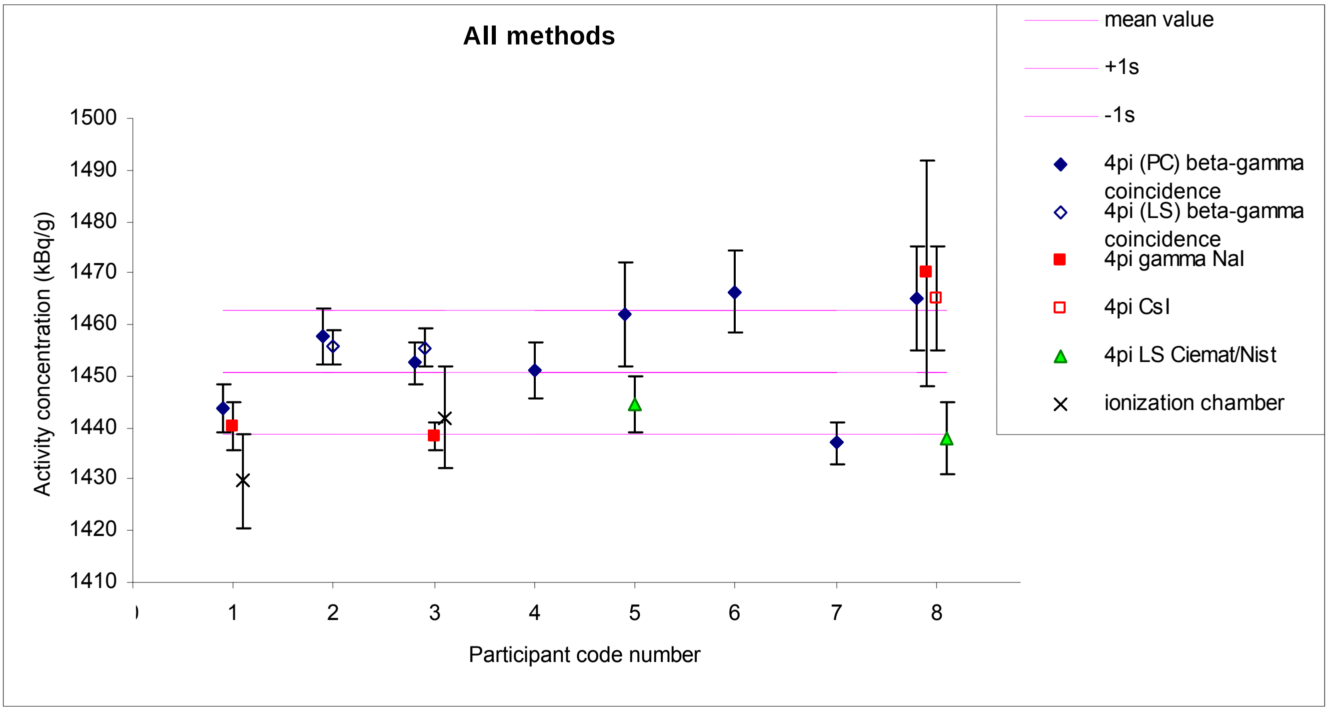

Figure 4.1. Measurement results for all methods

Table 4.2.Results for all the methods used by participants

Participant n°	Methods	Activity concentration (kBq/g)	Standard uncertainty (kBq/g)
1	4π(PC)β–γ 4πγ(NaI) Ionization chamber	1443,6 1440,2 1429,6	4,7 4,8 9,2
2	4π(PC)β–γ 4π(LS)β–γ	1457,6 1455,6	5,5 3,3
3	4π(PC)β–γ 4π(LS)β–γ 4πγ(NaI) Ionization chamber	1452,5 1455,5 1438,4 1442	4,1 3,7 2,8 10
4	4π(PC)β–γ	1451,1	5,4
5	4π(PC)β–γ Ciemat/Nist(LS)	1461,9 1444,6	10.1 5,4
6	4π(PC)β–γ	1466,4	8,1
7	4π(PC)β–γ	1437	4,2
8	4π(PC)β–γ 4πγ(NaI) 4π(CsI) Ciemat/Nist(LS)	1465 1470 1465 1438	10 22 10 7

4π b-g **coincidence or anti-coincidence measurements**

4π β-γ coincidence or anti-coincidence measurements using a proportional counter in the beta channel were carried out by all participants. In addition, two participants (2 and 3) made measurements using a liquid scintillation counter in that channel. The results are presented in Figure 4.2. In that figure, the mean value (1454,4 kBq/g) is the unweighted mean value of the 4π(PC)β-γ results and the standard deviation (10,4 kBq/g or 0,72 %) corresponds to the distribution of those results. Only one participant in eight is an outlier within the one standard uncertainty limits. The two 4π(LS) β-γ results are shown for comparison purpose; they look quite consistent with other results.

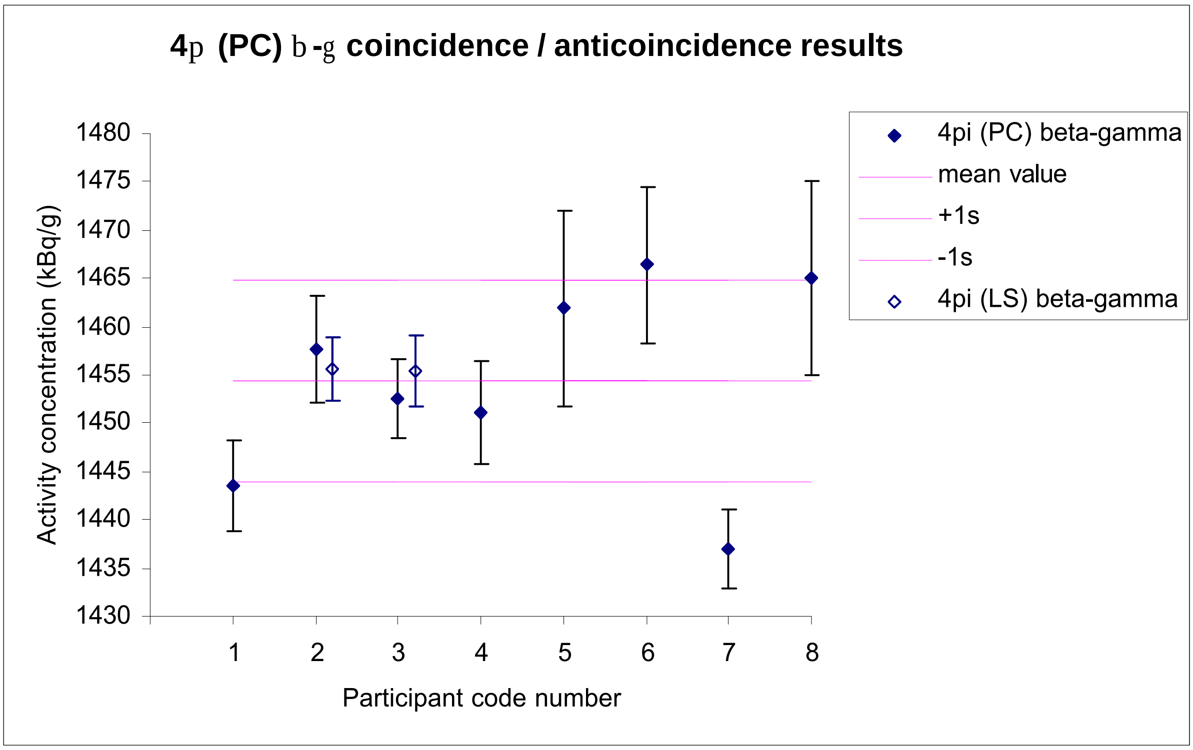

Figure 4.2. 4p b-g coincidence or anti-coincidence measurement results

The participant laboratories which carried out both coincidence and anticoincidence measurements with a proportional counter and a liquid scintillation detector in the beta channel got very close results. This observation is of particular interest since there was an identified problem of antimony volatility which should have a different impact on solid point sources and liquid scintillation sources. This effect could be a potential source of dispersion of the results, independently from any other origin, and thus cause confusion in comparing the results of the different measurement methods.

The maximum beta detection efficiency achieved as reported by participants spread from 70 % to 98 % for solid point sources, and from 90 % to 98 % for liquid scintillation sources. Participant 3 reported that the adding of NaOH lowered by about 5 to 10 % the beta detection efficiency of solid sources due to additional self absorption.

In order to control the antimony evaporation observed during the production process of his solid sources, participant 5 measured repeatedly some sources over a period of 8 months. An increase of the activity result was observed which could not be explained by the detected impurity (^{125}Sb) alone, which was measured at the ampoule reception with a detection limit of 0,05 kBq/g (see section 3.3). So, that participant introduced two uncertainty components, one of 0,20 % for impurities, and one of 0,58 % for source stability, due to possible changes of source properties due to environmental influences, which is predominant in his uncertainty budget. To our knowledge, no other participant made that control over a similar period of time.

From the 4π β-γ coincidence or anti-coincidence measurements, it can be concluded that this set of results is consistent.

4π-g **NaI and 4**p **CsI measurements**

Three participants (1, 3 and 8) carried out 4π-γ measurements using a well-type NaI(Tl) crystal detector and one (8) using also a 2×2π CsI crystal detector. The results are presented in Figure 4.3. In that figure, the mean value (1450 kBq/g) is the unweighted mean of the 4π-γ NaI results and the standard deviation (18 kBq/g, or 1,22 %) corresponds to the distribution of those results. The 4π CsI result is added for comparison purpose.

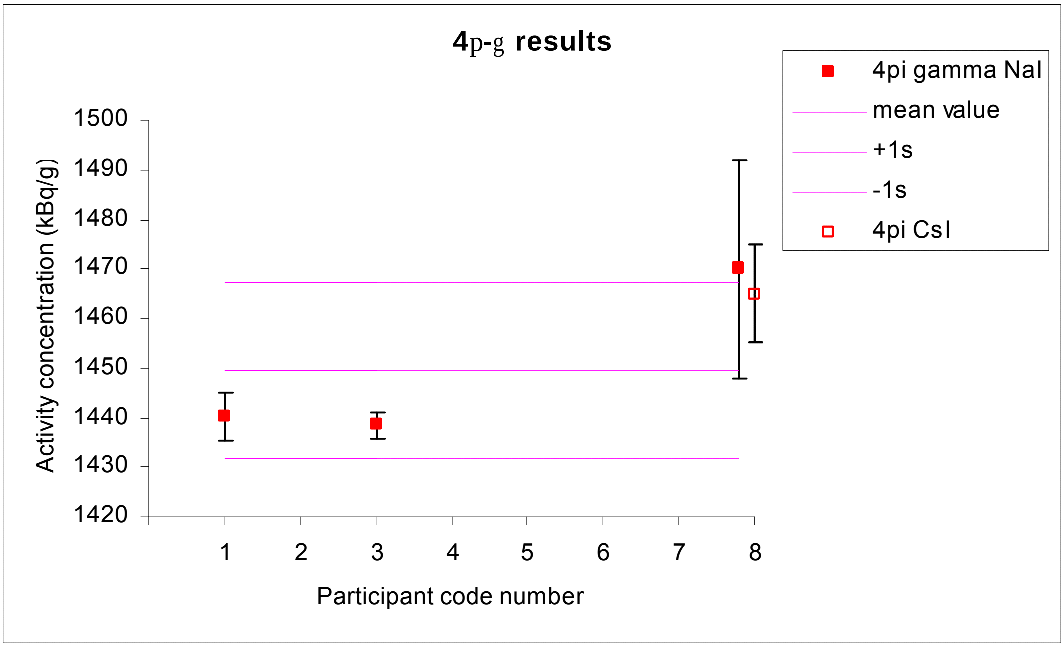

Figure 4.3. 4p-g NaI and 4p CsI measurement results

The reported maximum ^{124}Sb detection efficiencies were respectively 0,895, 0,956 and 0,91 for participants 1, 3 and 8. For participant 8, the predominant uncertainty component came from efficiency calculation (1,5 %); a substantial component of this uncertainty concerned the contribution of high-energy beta radiation which is particularly abundant in the decay of ^{124}Sb, when working out the efficiency curve by using a Monte Carlo code. The reported detection efficiency of the 4π CsI detector was 1, with an uncertainty of efficiency calculation of 0,6 %. It can be noted that since that efficiency value is maximal, any change of that quantity can only be a reduction and then leads to an increase of the activity concentration.

The results obtained surround those obtained with coincidence counting. In spite of their high value, the results of participant 8 are consistent with coincidence results, considering their large uncertainties. The results of participants 1 and 3 are in agreement but are low compared to coincidence measurement results. Participant 1 carried out measurements both with solid point sources and liquid sources in sealed glass scintillation vials filled with 14 mL Ultima Gold. The results reported for the two types of sources were in good agreement, demonstrating no loss of activity. Considering its uncertainty, the value of participant 3 is inconsistent with his coincidence result and the mean value of all coincidence results.

Liquid scintillation (Ciemat-Nist) measurements

Two participants (5 and 8) carried out measurements using the Ciemat-Nist method. Their results are respectively 1444,6 (54) kBq/g and 1438 (7) kBq/g. These results are consistent with each other, but are low compared to those obtained by coincidence counting (see Fig. 4.1). However, the number of results is too small to get a significant conclusion about a possible trend resulting from the method itself. Participant 5 gave some details on the efficiency calculation, taking into account the seven most dominant beta branches and twenty seven gamma transitions, and cascades with one beta and up to four gammas in coincidence. Decay data were successively taken from "Nucléide-CD" (2005) and from Nuclear Data Sheets (NDS) 80,4 (1997), leading to an activity larger by about 0,055 % with "Nucléide". Participant 8 included the 13 most dominant beta decay branches and twenty five gamma-ray transitions and cascades with one beta and up to four gamma-rays in coincidence, with decay data taken from NDS (1997).

As for coincidence measurements, participant 5 noticed evidence of a significant increase of activity over a period of ten months of measurements, then he added two uncertainty components, one of 0,20 % for impurities, and one of 0,05 % for sample stability. Participant 8 measured his sources 17 times over a period of seven months. Some of those sources needed 5-6 days after preparation to become stable. Then they were mostly stable (to better than 0,1 - 0,2 %) for a period of 75 days, after which the count rate started to increase. An uncertainty component of 0,2 % for sample stability was added.

Well-type ionization chamber measurements

Two participants (1 and 3) carried out measurements of the ^{124}Sb solution in glass ampoules using a pressurized well-type ionization chamber. The chamber of participant 1 (Centronics IG11/A20) was filled with argon at 2 MPa, and the chamber of participant 3 (Vinten 671) with nitrogen at 1 MPa. Both participants determined the response of their instrument by computation from semi-empirical efficiency curves, obtained from Monte Carlo calculation and primary standard solutions. Participant 3 pointed out that the response to beta particles was obtained from an experimental curve obtained with pure beta-emitters; the contribution of beta particles to the response of the chamber was less than 1 % for ^{124}Sb.

The results are 1429,6 (92) kBq/g and 1442 (10) kBq/g for participants 1 and 3, respectively. Participant 1 gave in addition a result obtained using the data of "NDS" instead of "Nucléide" (1422,8 (62) kBq/g), the difference is of about 0,5 %.

These two results are consistent within the uncertainty limits and, for both participants, they are consistent with their respective coincidence measurement values (see Table 4.2 and Fig. 4.1).

Final results

Each participant was asked to select his final activity concentration value from his individual results. This value was considered as his reference value for the activity comparison, and the one to be used by him to derive absolute photon intensities. Those reference values are presented in Table 4.3 and Figure 4.4.

Table 4.3. Final results of participants

Participant n°	Procedure / choice of participant	Activity concentration (kBq/g)	Relative standard uncertainty (%)	Comments
1	4π(PC)β–γ	1443,6	0,32	4πγ and ionization chamber not selected
2	Weighted mean of 4π(PC)β–γ + 4π(LS)β–γ	1456,1	0,38	Adoption of uncertainty budget of 4π(PC)β–γ
3	4π(PC)β–γ	1452,5	0,28	4π(LS)β–γ and ionization chamber not selected; 4πγ considered as an outlier
4	4π(PC)β–γ	1451,1	0,37	Single method used
5	Unweighted mean of 4π(PC)β–γ + Ciemat/Nist(LS)	1453,3	0,60	Uncertainty enlarged to take account of the discrepancy between the two methods
6	4π(PC)β–γ	1466,4	0,55	Single method used
7	4π(PC)β–γ	1437	0,29	Single method used
8	Weighted mean (internal variance) of 4π(PC)β–γ + 4πγ(NaI)+ 4π(CsI)	1465	0,48	Ciemat/Nist LS not selected, interpreted as an outlier

The unweighted mean value obtained with those results is 1453 (10) kBq/g, the associated relative standard deviation of the distribution is 0,68 %. This value remains close to the general mean value (1451 (12) kBq/g) and to the mean value of coincidence counting results (1454,4 (10,4) kBq/g), this latter method being the predominant one for that exercise.

Participant 1 selected only his 4π(PC)β–γ coincidence result.

Participant 3 did the same choice. For supporting that choice, he considered that the very good agreement obtained using the coincidence method with two different types of sources, solid and liquid, should remove doubts about source stability. The 4πγ result was discarded because of unexplained discrepancy at this stage. A possible source of error could be the underestimation of the contribution of high-energy beta particles which is particularly abundant in the decay of ^{124}Sb, when working out the efficiency curve by using a Monte Carlo code.

Participant 5 observed some inconsistency between his 4π(PC)β-γ coincidence and Ciemat/Nist LS results. Suspecting unknown systematic effects, he adopted the unweighted mean of the two values, with an enlarged uncertainty.

Participant 8 adopted the weighted mean of three methods, excluding the discrepant Ciemat/Nist LS result. No explanation for this discrepancy was found at the deadline of the exercise.

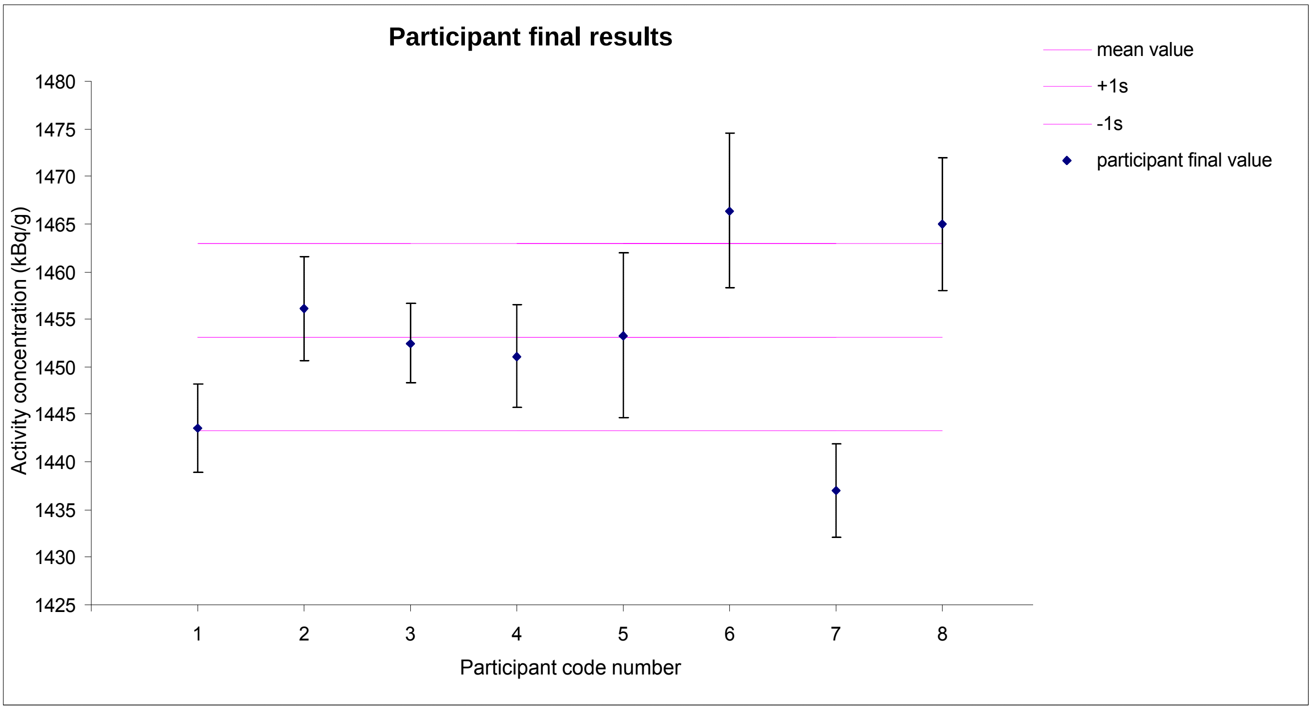

Figure 4.4. Final results given by participants

4.4 Findings for the activity measurements

In spite of some lack of detailed information given in some questionnaires, several points come to light:

- When preparing solid sources, several laboratories noticed antimony volatility and tried to deal with it.
- The results of the 4π β-γ coincidence measurements are consistent (except one outlier). There was a very good agreement between measurements made with solid point sources and liquid scintillation sources.
- The results obtained by means of other methods (4π-γ, ionisation chambers and LSC) are in general consistent with each other but lower than the coincidence results, except for participant 8 with larger uncertainties (Fig. 4.3). Participant 3 mentioned for his 4π-γ result a possible underestimation of high-energy beta emissions when calculating the detector response.
- When simulations by means of Monte Carlo calculations as well as LSC efficiency calculations were done using various sets of decay data, no significant differences in the computed results were observed.

5. Half-life measurement

Participant 8 carried out the half-life measurement of ^{124}Sb by means of a well-type ionization chamber. The decay of the source was followed during 240 days, *i.e.* about four half-lives. The chamber main characteristics are described in Table 5.1.

Table 5.1. Details on ionization chamber and measurement conditions

IONIZATION CHAMBER DESCRIPTION	
Producer and type	Centronic IG12/A20
Shape (U-shape, cylindrical)	cylindrical, re-entrant tube
Gas nature	Argon
Gas pressure	2 MPa
Well diameter	50,8 mm
Thickness of the wall of the well	0,8 mm
IC external diameter	184 mm
IC height	427 mm
Material of the wall of the well	Steel
Material of the electrodes	Aluminium
Thickness of lead shielding	50 mm
CURRENT MEASUREMENT	
Reference of the electrometer	Keithley 6517A in voltage mode, using NPL current integrator and IRMM stable air capacitor (shielded in 50 mm lead)
Current measurements relative to a long-lived reference source (Y/N)	No
MEASUREMENT DATA	
Typical current pA	222 pA at reference date
Background current pA	0,05 pA
IC response pA/MBq	N.A.
Typical integration time	28 s at the beginning 334 s at the end of measurement campaign
Number of measurements	Source: 10138 Background: 5811

Data treatment

One raw data point corresponds to one charge cycle of the feedback capacitor from 0 to 9 V. This raw data is corrected for background, impurities and decay during the integration time, to obtain the activity of the source at the beginning of the charge cycle. The background is considered constant over the measurement campaign, and the decay correction is applied using a preliminary half-life of 60,20 (3) days. The data are limited to 240 days, after which the uncertainty of the background becomes too important. Raw data points due to instrument malfunctioning are also rejected, leaving 10138 points. These are averaged, day-by-day, yielding 46 data points for fitting. A least-squares fit is applied to determine the half-life, weighting the data points with the inverse of the variances (?^{2}=0,955). Residuals after the fit are shown in Figure 5.1.

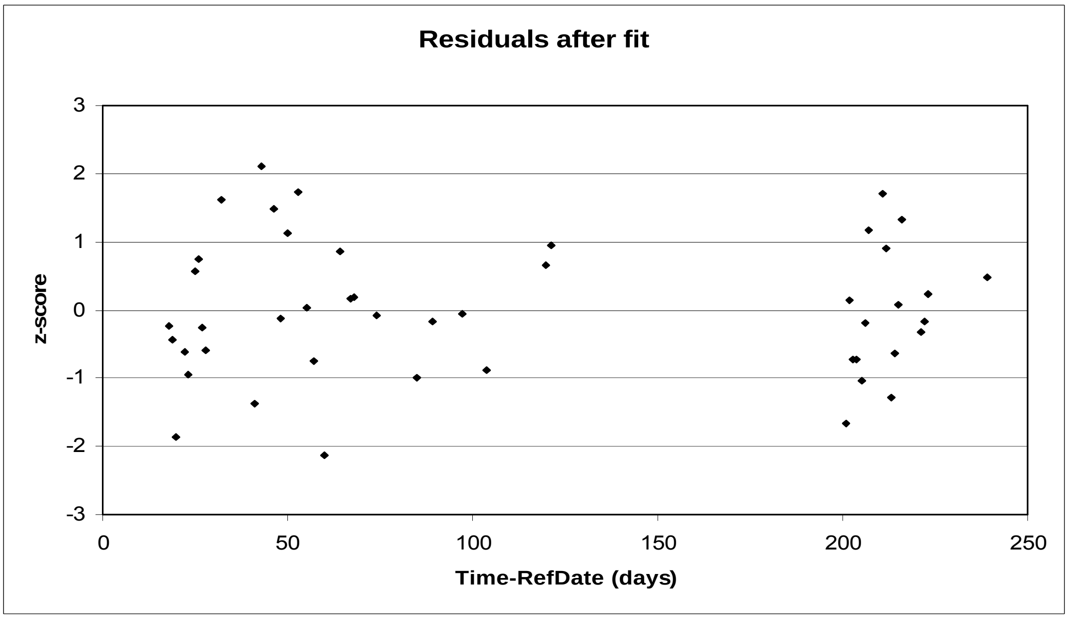

Figure 5.1. Residuals from the least-square fitting of experimental points

Uncertainty budget

Table 5.2 lists all the uncertainty components which were taken into account to calculate the combined standard uncertainty of the half-life. The calculation of the individual uncertainty contributions is done using the variance propagation formula:

$$\frac{s_{T_{1/2}}}{T_{1/2}} \approx \frac{2}{l T} \sqrt{\frac{2}{n+1}} \frac{s_A}{A}$$

in which T is the duration of the measurement campaign (240 days), and n corresponds with the frequency of the uncertainty component (n = 1 for low-frequency components).

Table 5.2. Uncertainty budget of the ^{124}Sb half-life measurement

Process	**Uncertainty on *A* (relative ´ 10^{-4})**	***n***	**Propagation factor**	**Uncertainty of $T_{1/2}$ (relative ´ 10^{-4})**
Background, systematic component	1,9	1	0,78	1,5
Medium term instability	1,0	1	0,78	0,78
Ampoule repositioning	2,1	56	0,15	0,32
Long term instability	0,40	1	0,78	0,31
Background, random component	9,6	5811	0,015	0,14
Impurities	0,18	1	0,78	0,14
High frequency instability	2,4	10138	0,011	0,026
Statistical nature of decay	0,94	10138	0,011	0,010
Time measurement	0,36	10138	0,011	0,004
Preliminary decay correction	$4{,}5 \times 10^{-6}$	10138	0,011	5×10^{-8}
	Standard combined uncertainty ($\times 10^{-4}$)			**1,8**

The final result is **60,212 (11) d**. This value is in very good agreement with the one recommended for that exercise.

6. Photon emission intensities determination

Six participants carried out measurements of the γ-ray emission intensities. As recommended, they sent their results both in absolute and relative values, the most intense line (602 keV) being the reference. Only three of those participants measured x-ray emission intensities.

6.1. Experimental arrangements

The γ-ray emission intensities were measured by the six participants with a coaxial-type germanium detector (HPGe). The x-ray emission intensities were measured by the three participants with a planar HPGe. The main features of the experimental arrangements are listed in Table A.1 "Instrumentation - general characteristics, geometry arrangements" of Appendix A3.

6.2. Efficiency calibration and analysis procedure

The list of radionuclides and their x- and γ– rays which were used as standards by participants to determine the full-peak efficiency calibration curve of their detectors are detailed in Table A.2 (Appendix A3). Since ^{124}Sb emits gamma rays in a large energy range from 148 keV to 2800 keV, the "traditional" efficiency curve of the HPGe gamma detectors had to be extended.

Participants 2 and 6 used point sources emitting gamma photons up to 1408 keV. Participant 6 thus sent results for gamma lines of energies up to 1918 keV only.

Participants 3 and 5 used point sources emitting up to 3 MeV (^{56}Co) and 2,7 MeV (^{88}Y) respectively.

Participants 7 and 8 used a Monte Carlo calculation method combined with experimental results from point sources, up to 2615 keV (^{232}Th (^{208}Tl)) and 1332 keV (^{60}Co) respectively.

It is noteworthy that participant 7 used a Monte Carlo simulation method to work out the efficiency curve of his detector and claimed an efficiency uncertainty in the range 0,15 - 0,25 %. This is, at least, two times lower than those of the other participants.

A short description of the efficiency interpolation peak analysis method is given in Table A.3 (Appendix A3). Most participants carried out peak analyses using a software provided by a manufacturer and, often, they finalised or made an analysis more specific with their own calculations. Participants 2 and 7 did not give clear explanations of the peak analysis method they used.

The main applied corrections were due to the coincidence summing effect, pile-up and dead-time losses. Some numerical examples are given in Tables 6.1 and additional details in Table A.4 (Appendix A3). In most cases, the calibration of the spectrometer and the measurement of Sb-124 sources were carried out with the same geometry arrangement, so that the absorption and self-absorption effects were included in the efficiency calibration.

Table 6.1. Main corrections applied to photon intensity measurements

Code number	***E907- 3***		***E907- 5***		***E907- 7***		***E907- 8***	
Detector	HP-Ge (100 cm^3)		HP-Ge (127 cm^3)		HP-Ge (180 cm^3)		HP-Ge (360 cm^3)	
Source-to-detector distance	12,5 cm		18,5 cm		25 cm		12 cm	
Gamma ray	Summing effect	Pile-up	Summing effect	Pile-up & dead time	Summing effect	Pile-up	Summing effect	Pile-up & dead time
602,7 keV	1,02	-	1,003	1,01	1,003	1	1,0014	1,022
1690,9 keV	-	-	1,004	1,01	1,0035	1	1,0066	1,022
2293,7 kev	0,18	-	0,333	1,01	0,35	1	1	1,022

6.3. Uncertainties

The participants were asked to give detailed uncertainty budgets. The main components are summarized in tables below for the two most intense emissions taken as examples.

a) 602-keV photon emission

The main components of the uncertainty come from the peak detection efficiency and from the activity value.

The combined standard uncertainties determined by the participants are in the range 0,3 % - 1,5 %.

Table 6.2. Uncertainty budget of the photon emission intensity results for the 602-keV line, in %.

Code Number	**Relative standard uncertainties (%)**						
	Counting statistics	**Peak area**	**Efficiency**	**Correction factor**	**Others**	**Source activity**	**Combined standard uncertainty**
2	0,3	0,1	0,6	< 0,2	~ 0,2	0,4	**0,72**
3	0,6		0,5	0,1	0,3	0,28	**0,87**
5	0,034	0,061	0,20	0,038		0,65	**0,68**
6	0,22		0,98			0,55	**1,14**
7	0,1	0,2	0,07	0,05	0,01	0,25	**0,3**
8	0,05	0,1	1,2	0,7	0,3	0,5	**1,5**

b) 1690-keV photon emission

The following table gives an example for a γ- ray emission intensity given both in absolute and relative values with respective uncertainties.

The standard combined uncertainties determined by the participants are in the range 0,4 % - 2,4 %.

Table 6.3. Uncertainty budget of the photon emission intensity results for the 1690-keV line, in %.

Code Number	**Relative standard uncertainties (%)**							
	Counting statistics	**Peak area**	**Efficiency**	**Correction factor**	**Others**	**Combined standard uncertainty on relative value**	**Source activity**	**Combined standard uncertainty**
2	0,3	0,1	2	< 0,2	~ 0,2	2,4	0,4	**2,4**
3	0,6		0,5	0,1	0,3	1,2	0,28	**0,87**
5	0,075	0,061	0,36	0,038		0,43	0,65	**0,75**
6	0,5		1,6			1,9	0,55	**1,9**
7	0,1	0,2	0,17	0,05	0,01	0,37	0,25	**0,4**
8	0,01		1,6	0,8	0,3	1,13	0,5	**1,9**

c) X-ray emissions

The combined standard uncertainties reported by the participants are in the range 5 - 20 %, the main component coming from the detector efficiency.

Table 6.4. Uncertainty budget of the photon emission intensity results for the $K\alpha$ x-ray emissions, in %.

Code Number	Relative standard uncertainties (%)						
	Counting statistics	**Peak area**	**Efficiency**	**Correction factor**	**Others + weighting**	**Source activity**	**Combined standard uncertainty**
2							21
3	0,56		0,8			0,28	1,3
8	0,13	0,28	2,5	0,6	0,3	0,5	4,3

6.4. Statistical treatment of data

When the same measurement technique was applied by several participants, a weighted average, a_w, was calculated using the combined uncertainties of the individual values as weights.

For n independent values a_i, each with a combined standard uncertainty u_{ci}, a weight p_i proportional to the inverse of the square of the individual standard uncertainty u_{ci} can be assigned to each value.

$$a_w = \frac{\sum_{i=1}^{n} p_i a_i}{\sum_{i=1}^{n} p_i} \quad ,$$

where the weights are $p_i = 1/u_{c_i}^2$.

Internal and external uncertainties can be assigned to the weighted mean value. The square root of the internal variance $s^2{}_{\text{int}}(a_w)$ is the expected uncertainty of the mean, based on the individual *a priori* variances $u_{c_i}^2$ and the application of the propagation law of uncertainty.

$$s_{\text{int}}(a_w) = \left[\sum_i \left(1/u_{c_i}^2\right)\right]^{-1/2}$$

The external uncertainty is given by the formula,

$$s_{ext}(a_w) = \left[\frac{\sum_i (a_i - a_w)^2 / u_{c_i}^2}{(n-1)\sum 1/u_{c_i}^2}\right]^{1/2} .$$

The external variance $s_{\text{ext}}^2(a_w)$ takes the scatter of the data into account, and is based on the amount by which each result a_i deviates from the mean, measured as a fraction of each given uncertainty u_{c_i}.

A measure of the consistency of the data is given by the ratio,

$$s_{ext} / s_{\text{int}} = \sqrt{c^2/(n-1)} \ .$$

If this ratio is significantly greater than unity, at least one of the input data surely has an underestimated standard uncertainty value u_{c_i} which should be increased.

6.5. Results of g- ray intensity measurements

The participants were asked to measure all the photon emission intensities, the weak as well as the intense lines, in order to improve the decay scheme data, some of the weakest lines having been observed in the past without any confirmation since.

All the measured values of photon emission intensities published in the literature are given relative to the 602-keV line; this is why the participants were requested to send their results both in absolute values, *i.e*. per 100 % Sb-124 disintegrations and in relative values, the 602-keV γ-ray line being taken as the reference line. This was thus intended to make possible the comparison of the Euromet 907 results with the other available results and to give a better statistical treatment of the data when working out the decay scheme evaluation.

In general, for the most intense lines, the results sent by the participants were in good agreement. The set of data, for the two most intense lines are detailed below. Figures 6.1 and 6.2 give the diagram for the 602- and 1690-keV lines. For a comprehensive statistical study of all sets of data, see Part B – ^{124}Sb Decay Data Evaluation.

a) 602-keV photon-emission absolute intensity

Despite the relatively large dispersion of activity measurement results, the set of photon emission absolute intensity data is consistent, with a reduced c^2 of 0,1.

The value of participant 6 was found to be an outlier, based on Chauvenet’s criterion.

The value given by participant 7 amounts to 58 % of the total statistical weight, because the associated uncertainty is significantly lower than the uncertainties given by the other participants, due to an uncertainty of the calibration efficiency of 0,07 % and an uncertainty on the activity value of 0,25 % ; both seem optimistic.

Nevertheless, since the single (UWM) and weighted means (WM) are close to each other and the set of data is consistent, the weighted mean is adopted as reference.

Table 6.5. Results for the 602-keV photon-emission absolute intensity

Participant	**I_{abs602} (%)**	**u_c**	
E907- 2	97,5	0,7	
E907- 3	97,8	0,9	
E907- 5	97,6	0,7	
E907- 6	91	1	
E907- 7	97,84	0,34	
E907- 8	98,1	1,5	
Chi2	0,1		c^2 / (n-1)
Chi2 criterion	3,3		
UWM	97,787		Unweighted mean
WM	97,769		Weighted mean
u_c (int)	0,26		Internal uncertainty
u_c (ext)	0,07		External uncertainty
Adopted	**97,77**	**0,26**	

b) 1690-keV photon-emission absolute intensity

The second line in terms of emission intensity is the 1690 keV γ-ray. The spread of the values is larger than for the 602 keV line. However, ignoring the value of participant 6, the set of the five remaining data is consistent with a reduced c^2 of 2,2. The value of participant 7 amounts to 65 % of the total statistical weight.

Table 6.6. Results for the 1690-*keV photon-emission absolute intensity*

Participant	**$I_{abs1690}$ (%)**	**u_c**
E907- 2	45,56	1,09
E907- 3	47,04	0,40
E907- 5	47,10	0,35
E907- 6	44,70	0,77
E907- 7	47,65	0,18
E907- 8	46,03	0,87
Chi2	2,2	
Chi2 criterion	3,3	
UWM	46,676	
WM	47,392	
u_c (int)	0,15	
u_c (ext)	0,22	
Adopted	**47,39**	**0,22**

c) Diagrams for the 602- , 722- , 1690- , and 2090-keV lines

From Figures 6.1, 6.2, 6.3 and 6.4, it appears that the spread of the results is greater for the gamma lines of high energy, namely 1690 and 2090 keV, than for those of lower energy. This could be due to difficulties in the detector efficiency calibration at high energy; as already mentioned, only three participants (3, 5, 7) used standard point sources with energies greater than 1400 keV.

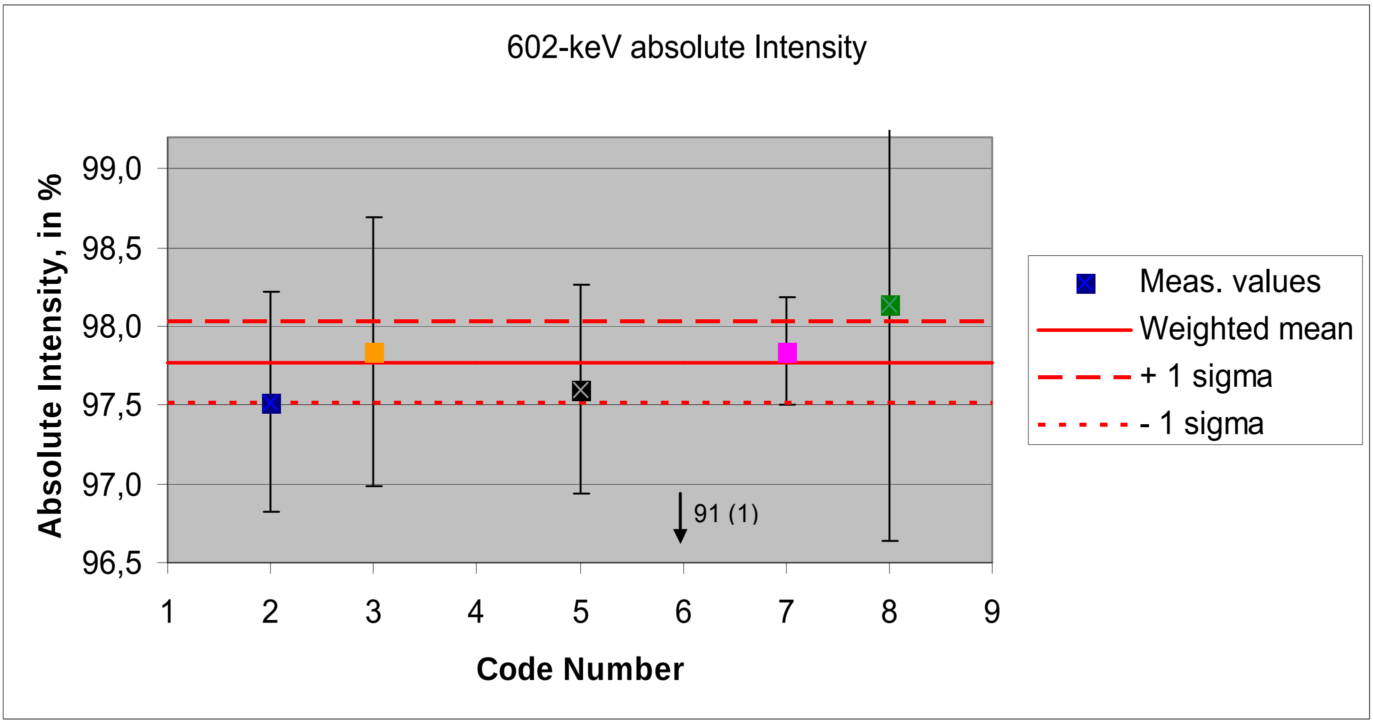

Figure 6.1. Results for the 602-keV photon-emission absolute intensity

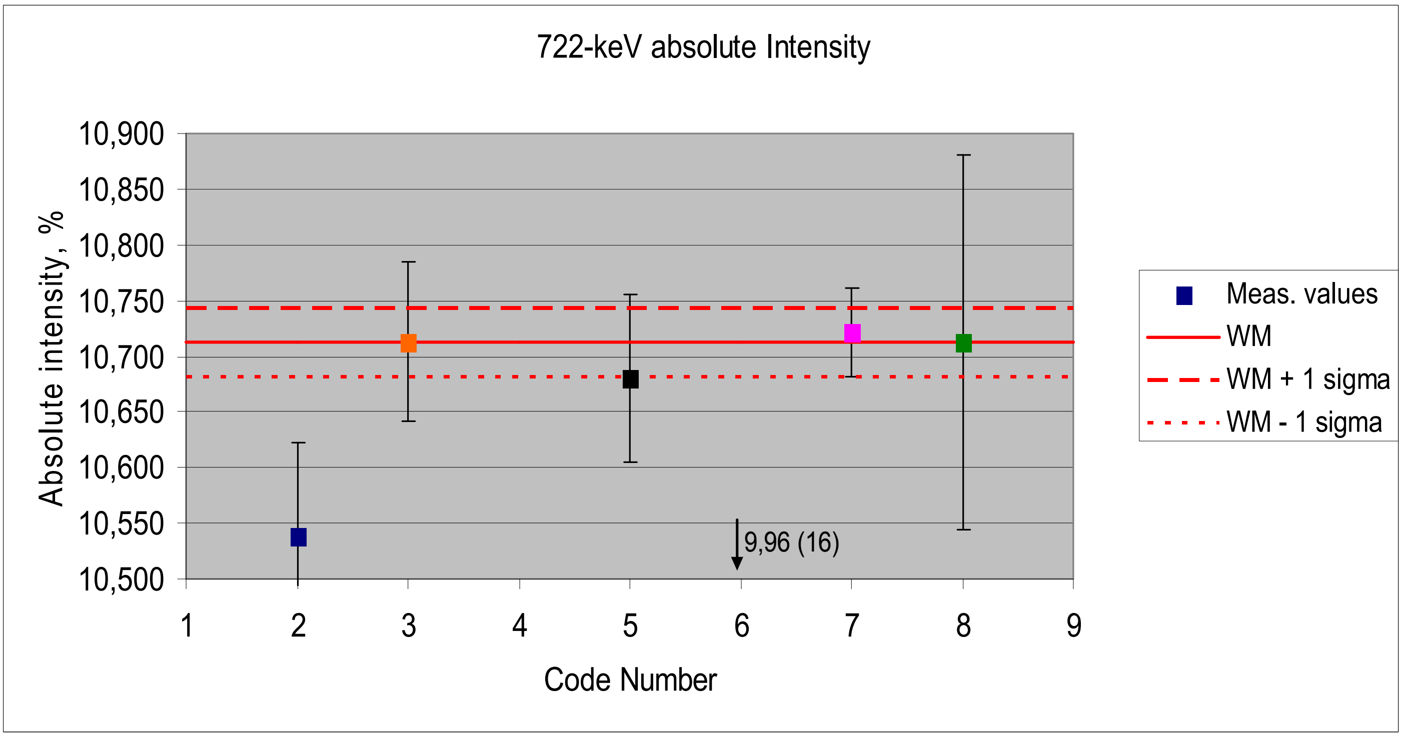

Figure 6.2. Results for the 722-keV photon-emission absolute intensity

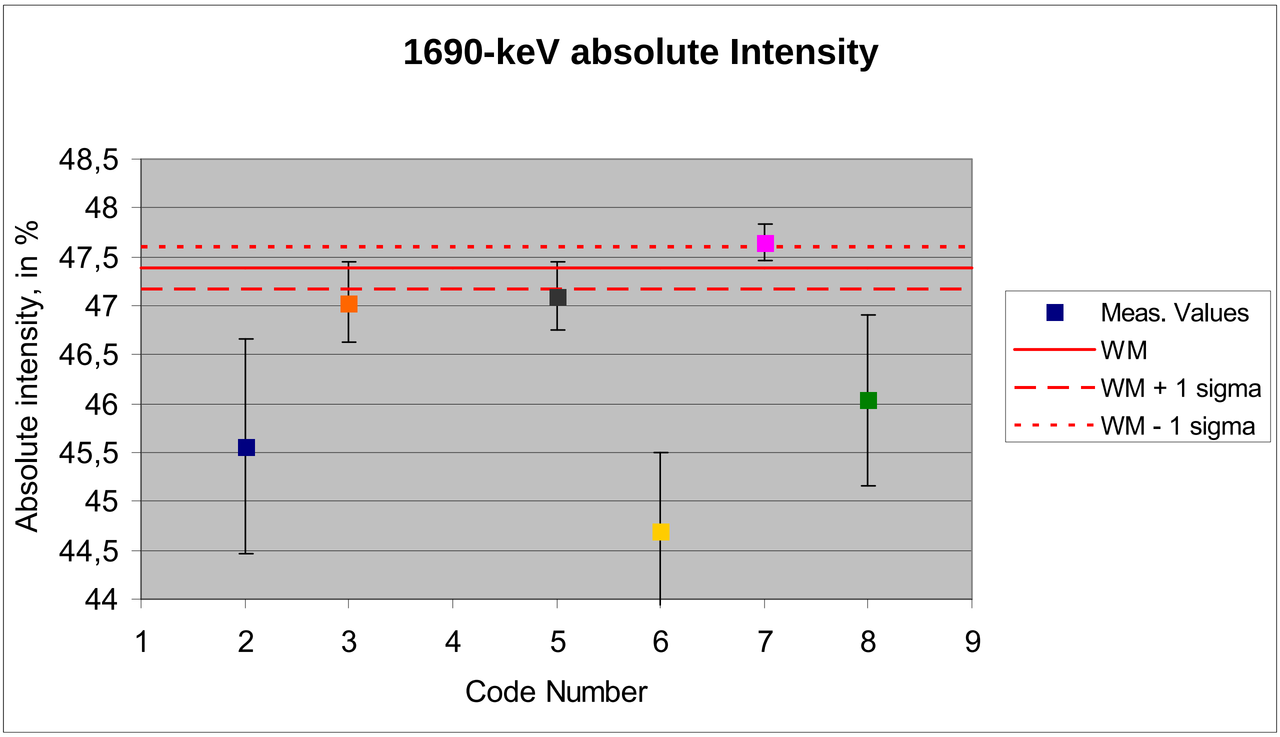

Figure 6.3. Results for the 1690-keV photon-emission absolute intensity

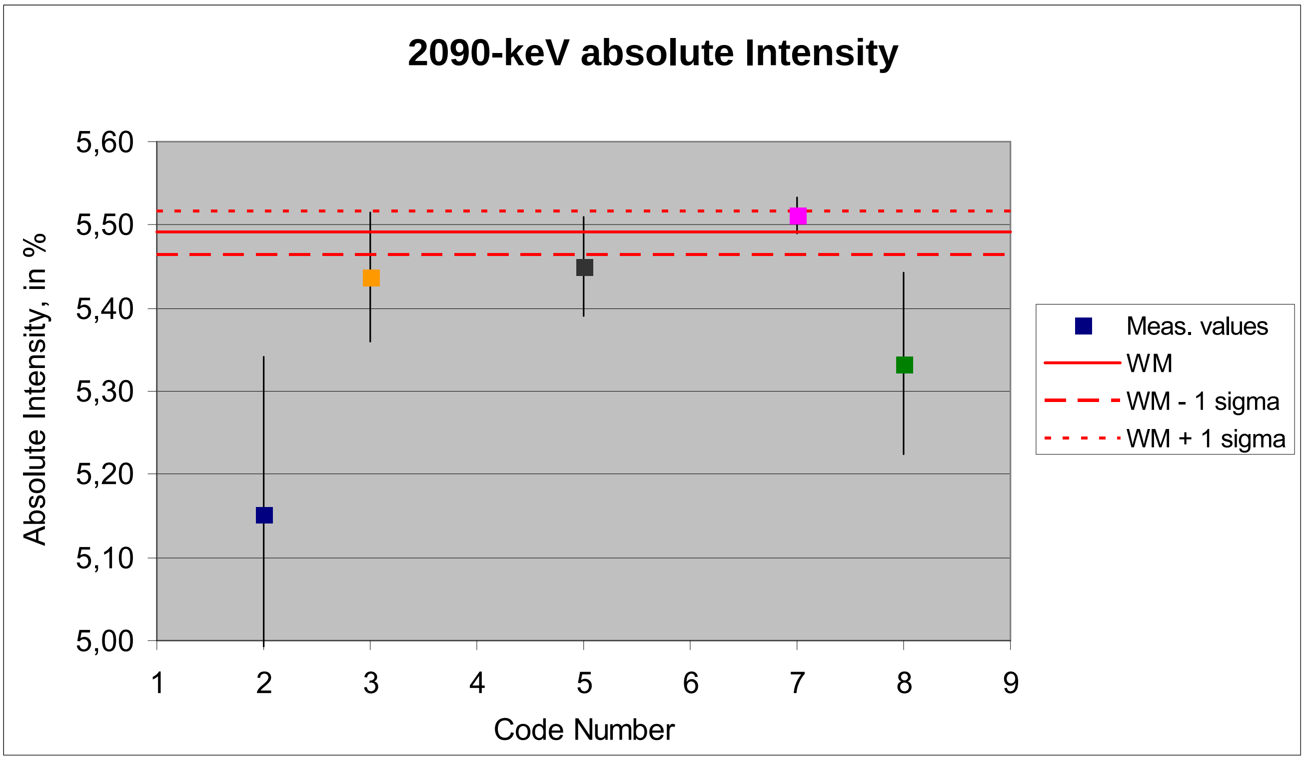

Figure 6.4. Results for the 2090-keV photon-emission absolute intensity

6.6. Comparison with previous published data

As presented in the introduction, a possible explanation for the discrepancy in the activity results obtained by means of various methods could be due to problems in the decay scheme data, this is why a part of this exercise was dedicated to photon emission intensity measurements. There are two ways for working out the Sb-124 decay scheme:

- the first one is to use absolute γ-emission intensity values; this requires the knowledge of the nuclide activity concentration of the solution;
- the second one results from the fact that the sum of all the transitions (including the 602-keV transition) arriving to the ground state level of the daughter nuclide must be equal to 100 % of disintegrations of the parent nuclide.

In the case of Sb-124, the situation is simplified since no β transition populating the ground state level of tellurium 124 is expected; then the sum of the gamma transition probabilities with energies 2807, 2693, 2681, 2455, 2323, 2294, 2182, 2039, 1657, 1325, 602 keV which populate it must be equal to 1. This can be expressed by:

$$\sum_i I_{g_i} \times I_{abs602}\ (1 + a_{Ti}) = 1$$

where I_{gi} is the relative intensity of a gamma emission, α_{Ti} is the total conversion coefficient of the corresponding gamma transition, I_{abs602} the absolute value of the 602-keV gamma line.

I_{abs602}, the absolute value of the 602-keV gamma line, is then deduced from the measured relative I_{gi} values and the total conversion coefficients α_{Ti} ,

$$I_{abs602} = \frac{1}{\sum_i I_{g_i} \left[1 + a_{T\,i}\right]}$$

The same statistical analysis, as previously, was done with larger sets of data, with the relative photon intensity results sent by the participants and including other results published in available journals. The reference line is $I\gamma_{602}$ = 100.

To use the formula above, the total conversion coefficient α_{Ti} of each gamma transition is required. The α_{Ti} coefficients were interpolated from the Band’s tables (2002Ba85) using the program BrIcc with the “frozen orbital approximation” (Kibédi *et al.* 2008Ki07). All transitions with a measured polarity are of E2 type and the energies of the involved transitions are relatively high, then the internal conversion coefficient values derived from theoretical calculations can be considered as very reliable.

As an example, details are given in table 6.7 hereafter for the 1325 keV gamma transition which reaches the ground state level. A relative γ-emission intensity of 1,623 (7) is adopted (see Part B – ^{124}Sb Decay Data Evaluation, for details). All the relative $I_{\gamma i}$ values were calculated in that way.

From the α_{Ti} and the measured relative $I_{\gamma i}$ values, the absolute emission intensity of the 602-keV gamma-ray is then derived to be 97,775 (20) %. This value is in full agreement with the value of 97,77 (26) % obtained from absolute measurements.

Table 6.7. Results for the 1325-keV photon-emission relative intensity

	1325 keV	
	I_g (%)	u_c
E907- 2	1,637	0,033
E907- 3	1,599	0,027
E907- 5	1,603	0,016
E907- 6	1,582	0,137
E907- 7	1,621	0,007
E907- 8	(o) 1,768	0,040
Patil (2006Pa16)	1,707	0,026
Goswamy (1993Go10)	1,61	0,03
Jianming (1988Yo05)	1,645	0,028
Mardirosian (1984Ma13)	1,69	0,29
Iwata (1984Iw03)	1,584	0,023
Johnson (1974Jo03)	1,67	0,04
Meyer (1990Me15)	1,66	0,04
Sharma (1979Sh08)	1,71	0,04
Chi2	2,0	
Chi2 criterion	2,2	
UWM	1,6399	
WM	1,6233	
u_c (int)	0,0051	
u_c (ext)	0,0073	
Adopted	**1,623**	**0,007**

The most intense absolute γ-ray emission intensities obtained from the absolute measurements made by the six participants in Euromet 907 are compared, in the following table, with those obtained from the sets of 14 relative values (same participants + 8 published data) and conversion coefficients (ICC). The agreement is quite good.

Table 6.8. Values of the absolute intensities obtained from absolute measurements and from relative measurements and ICC values

g-**ray energy (keV)**	**Absolute intensity from absolute measurements**	**Absolute intensity from relative measurements and ICC**
602	97,77 (26)	97,775 (20)
645	7,414 (21)	7,422 (15)
709	1,3635 (43)	1,363 (5)
713	2,269 (11)	2,273 (7)
722	10,712 (31)	10,708 (22)
968	1,880 (6)	1,887 (10)
1045	1,835 (6)	1,852 (14)
1325	1,583 (6)	1,587 (7)
1368	2,615 (9)	2,620 (8)
1690	47,39 (22)	47,46 (19)
2090	5,491 (26)	5,493 (24)

From the comparison above, it is concluded that the absolute γ-ray emission intensities can be considered as reliable and the decay scheme consistent. (see also further comments in Part B - ^{124}Sb Decay Data Evaluation). Then the problems in activity measurements should not be due to the decay scheme data.

6.7. Euromet 907, x-ray intensity results

Three laboratories (2, 3, 8) carried out specific measurements of the x-ray emission intensities, using a HPGe planar detector (Table A.1, Appendix A3). Participants 3 and 8 used radioactive sources with low-energy photon radiation emissions, *e.g.* ^{241}Am (Table A.2, Appendix A3), to calibrate their spectrometer in the x-ray energy range.

Table 6.9. X-ray emission intensity results, in % of disintegrations

	E907- 2		***E907- 3***		***E907- 8***		**Calculated**	
Energy (keV)	***I* %**	u_c	***I* %**	u_c	***I* %**	u_c	***I* %**	u_c
27,2 ($K\alpha_2$)			0,128	0,002	0,130	0,003	0,1252	0,0018
27,5 ($K\alpha_1$)			0,264	0,004	0,230	0,006	0,233	0,003
30,9 ($K\beta'_2$)			0,068	0001	0,063	0,002	0,0667	0,0012
31,7 ($K\beta'_1$)			0,017	0,0005	0,0136	0,0006	0,0145	0,0005
Kα	0,35	0,07	0,392	0,0045	0,359	0,007	0,358	0,0035
Kβ	0,087	0,018	0,085	0,0011	0,076	0,0018	0,081	0,0013
K x Total	0,437	0,072	0,476	0,005	0,436	0,007	0,439	0,004

The total K x-ray values obtained by participants 2 and 8 are in agreement, the value given by participant 3 deviates from the others, mainly due to a $K\alpha_1$ higher intensity value.

The calculated x-ray emission intensities were derived from the decay scheme data, *i.e*. from the evaluated γ-ray absolute emission intensities and the internal conversion coefficients, as shown in Part B – ^{124}Sb Decay Data Evaluation, by using the EMISSION program. They are in good agreement with the values of participants 2 and 8.

The agreement found between the measured values and the calculated values derived from all the available measured relative $I_{\gamma i}$ values and the internal conversion coefficients confirm the consistency of that decay scheme.

6.8. Findings for the determination of photon emission intensities

Six participants in eight carried out measurements of the γ- ray emission intensities. All of them used the same kind of apparatus, however significant differences in their reported uncertainty budget were observed, not only due to the activity uncertainty.

The sets of absolute values measured by the participants are generally consistent. Similarly, the set of relative values are consistent and moreover they are in agreement with the other values published elsewhere. So, no major problem was observed.

The dispersion of participants' results obtained for the absolute intensity of the most intense gamma-ray line (602 keV) is significantly smaller (almost three times less) than the one found for activity concentrations. Since those absolute intensities are inversely proportional to activity concentration values, this means that the activity and spectrometry measurement results of a participant are correlated, *i.e.* exposed to a same cause of variation. The volatility of antimony could explain that observation to some extent, even if some participants gave experimental evidence of the resolution of that problem.

Most of the participants made an effort to determine the weak gamma rays in order to improve the overall decay scheme (see Part B – ^{124}Sb Decay Data Evaluation, for details).

The decay scheme evaluation was established on the basis of all the available relative gamma emission intensities, then the activity measurement results had no influence and the weight of the strong 602 keV line reduced to that of its internal conversion coefficient. The resulting gamma intensities were fully consistent with those obtained from absolute gamma emission measurements. From this comparison, it was concluded that the absolute γ-ray emission intensities can be considered as reliable and the decay scheme consistent.

7. Conclusions on the overall exercise

All along this exercise, various problems or questions appeared.

a) Volatility of the antimony solution

When preparing its own solid sources, LNE-LNHB noticed a volatility of antimony. This difficulty was pointed out and a remedy proposed to other participants for their sources. However, only two participants reported the same problem and dealt with. A possible evaporation of the initial solution could explain some low activity results. This assumption is supported by the smaller dispersion of absolute intensity values found by participants for the 602 keV gamma ray compared to their activity concentration values.

b) Activity measurements

Two participants carried out coincidence or anticoincidence measurements with both a proportional counter and a liquid scintillation detector in the beta channel, for which they got very close results. Moreover, the set of results from the coincidence and anticoincidence measurements is consistent. This can confirm the robustness of these results.

The other results (4π-γ, ionisation chambers and LSC) are generally lower but are consistent all together. By now, there is no identified and validated explanation to those lower results.

c) Efficiency curve of HPGe detectors

In this exercise, a participant reported results obtained with an HPGe detector for which the efficiency curve was determined using a Monte Carlo calculation method combined with experimental results. The related uncertainty was significantly lower than for the other participants. The uncertainties claimed by that participant seem optimistic but were accepted for determining the relative photon emission intensities. The assessment of uncertainties resulting from such calculations, associated with measured data, is a question to be addressed since this kind of procedure should become widespread in the future.

In spite of all those questions, the comparison of the absolute photon emission intensities deduced from the measurements carried out in that exercise with the values deduced from the relative photon emission intensities resulting from this exercise and other available measurements, and internal conversion coefficients, demonstrates that inconsistencies in activity measurement results are not due to decay scheme data and then, other causes must be sought.

^{124}Sb – Activity measurement and Determination of photon emission intensities

Characteristics of the radioactive solution

LNE-LNHB

Radionuclide : **Sb-124**

Ampoule number :

Mass of the solution : - g

Chemical composition of the standard solution : $SbCl_3$ in HCl 2M

> **Advice**: During the preparation of solid sources, a problem of volatility with Sb-124 was encountered. To try to solve it we followed the procedure : 1) a weighed deposit of radioactive solution of Sb-124 was made for each solid source, 2) a drop with an equivalent mass of 2,5 mol/L NaOH was added on each deposit. The purpose was to precipitate the element antimony as insoluble oxychlorides (SbOCl, …).

Activity per gram of solution : ~ 1,5 MBq/g (reference date)

Impurity : Gamma and X-ray impurities are under checking and will be checked again in three months. The results of the LNHB tests will be sent to the participants.
All the participants are requested to check for impurities at the receipt of the ampoule and three months later.

Homogeneity of all the ampoules less than 0,1 %

Reference Date : March 1, 2007 – 0H UTC

Saclay, February 2007

^{124}Sb - Activity measurement

EUROMET PROJECT 907

I. GENERALITIES

Participating laboratory :

Name of the contact person :

e-mail address :

Date of receipt of ampoule (DD-MM-YYYY) :

Date of report to LNHB (DD-MM-YYYY) :

Reference date **1 March 2007, 0h UTC** *[*]

Half-life : **:(60.20 ± 0.03) d ****

Ampoule number :

List of all the methods used and the name of the corresponding reporting files

method (acronym)	filename	Name(s) of the person(s) who carried out the measurements

II. PRELIMINARY MEASUREMENTS

II. 1. Method used for preliminary measurements:

Please indicate the method used: calibrated ionization chamber; well crystal, other…

Results obtained	Radioactivity concentration, in kBq.g^{-1} (at reference date)	Date of this measurement
Before opening the original ampoule		
After transfer to another ampoule (if relevant)		

Total mass of solution found in the ampoule (g) :

[*] UTC coordinated universal time
**Nuclear Data Sheet, vol 80 , 4(1997), H.Limura *et al*.

II. 2. Adsorption tests

Please take into account the adsorption tests in the evaluation of the final results.

Please, first rinse the original "empty" ampoule with water or with a solution chemically similar to the radioactive solution. Then chose one of the two methods given below:

- Adsorption tests carried out with liquid scintillation counting by using water-immiscible cocktail to measure the residual activity
- Adsorption tests carried out with proportional counting or g spectrometry by using an aggressive solution to remove most of the activity and prepare solid source(s) to measure the residual activity

Please explain the measuring procedure used:

Activity remaining in the “empty” original ampoule (Bq).:
Date of this test
Correction factor deduced from these adsorption tests and its standard incertainty:

II. 3. Impurity checks :

Method of measurement :

Nuclide	Radioactivity concentration, in $kBq.g^{-1}$ (at reference date)	Impurity to ^{124}Sb ratio and its uncertainty

III. PRIMARY MEASUREMENT METHODS

III. 1. Coincidences measurement

a Preparation sources

- Dilution

Dilution carried out? (Y/N):

If yes please indicate the diluent use (chemical, concentration) :

Dilution factor:

- Sources

Solid sources	
Type of film (VYNS,…) and typical thickness	
Metallic coating and typical thickness	
Is the film coated on both sides? (Y/N)	
Metallic ring inner diameter	
Metallic ring outer diameter	
Metallic ring thickness	
Number of sources prepared	
Typical mass	

Liquid sources	
Scintillator	
Chemical used to stabilize the cocktail	
Substance used as quenching agent	
Type of vials	
Volume of cocktail	
Number of sources prepared	
Typical mass	

- Weighing

Balance used:

Date of last calibration:

Traceability to SI:

Weighing conditions: (temperature humidity)

Typical value of buoyancy correction:

b Method and instrumentation

DESCRIPTION OF THE PHOTON COUNTING DETECTOR (channel 1)				
Scintillator detector			*Semiconductor detector*	
Crystal material			Nature	
Number of crystals			Number of detectors	
Crystal diameter			Type	
Well diameter			Diameter	

Window material	
Distance between photon counter and source	
Resolution at	
FWHM	
Solid angle	
Well type(Y/N)	
Crystal height	
Well depth	
Thickness	

Window material	
Distance between photon counter and source	
Resolution at	
FWHM	
Solid angle	
Well type(Y/N)	
Coaxial(Y/N)	
Planar(Y/N)	
Volume	

DESCRIPTION OF THE ELECTRON COUNTING COUNTER (channel 2)			
Proportional counter		*LS Counter*	
Type (pill box, gas flow,…)		Type of counter	
Pressurized ? (Y/N)		Type of phototubes	
Solid angle (2 or 4 π)		Number of phototubes	
Height of each half		Operating temperature	
Anode material		Coincidence resolving time between the phototubes	
Anode diameter		Efficiency variation method	
Anode length			
Anode distance from source			
Gas nature			
Gas pressure			
voltage applied			
Wall material			
Wire length			

ASSOCIATED ELECTRONICS			
Channel 1		*Channel 2*	
Discrimination level or window		Discrimination level or window	
type of dead time		type of dead time	
Minimum dead time		Minimum dead time	
Method used for measurement		Method used for measurement	
Live time clock Y/N			
Pulser technique Y/N			
loss free counting Y/N			
Pile-up rejector Y/N			
COUNTING DATA			
Typical count rate		Typical count rate	
Background rate		Background rate	
Typical time for one measurement		Typical time for one measurement	
Number of sources measured		Number of sources measured	
Maximum ^{124}Sb efficiency achieved		Maximum ^{124}Sb efficiency achieved	

Distance between detector and source			Distance between detector and source	

c Detailed Uncertainty Budget

*Uncertainty components**, in % of the activity concentration, due to

Relative standard uncertainties	u_i x 10^4 evaluated method	
Contributions due to	A	B
counting statistics weighing background dead time resolving time Gandy effect pile-up decay data quenching extrapolation of efficiency curve Accidental coincidences other		
Relative combined standard uncertainty, u_c		

d Final result for a given method

radioactivity concentration of the ^{124}**Sb** solution on the reference date kBq g^{-1},	combined uncertainty kBq g^{-1}	combined uncertainty %

Remarks

III. 2. 4πγ measurement

a Preparation sources

- Dilution

Dilution carried out? (Y/N):

If yes please indicate the diluent use (chemical, concentration) :

* The uncertainty components are to be considered as approximations of the corresponding standard deviations (see also *Metrologia*, 1981, **17**, 73 and *Guide to expression of uncertainty in measurement,* ISO, corrected and reprinted 1995).

Dilution factor:

- Solid sources

Type of film (VYNS,…) and typical thickness:

Number of sources prepared

Typical mass :

- Weighing

Balance used:

Date of last calibration:

Traceability to SI:

Weighing conditions: (temperature humidity)

Typical value of buoyancy correction:

b Method and instrumentation

SCINTILLATION DETECTOR DESCRIPTION	
Crystal material (NaI, CsI,…)	
Number of crystals	
Total solid angle (sr)	
Well type (Y/N):	
If yes Well diameter	
If yes Well depth	
Crystal diameter	
Crystal height	
Window material	
Window thickness	
Resolution at	
FWHM =	
ASSOCIATED ELECTRONICS	
Discrimination level or window	
Dead time and std uncertainty	
Type of dead time (extending or non extending) μs	
Method of measurement of dead time	
Live time clock Y/N	
Pulser technique Y/N	
loss free counting Y/N	
Pile-up rejector Y/N	

COUNTING DATA	
Typical count rate	
Background rate	
Typical time for one measurement	
Number of sources measured	
Maximum ^{124}Sb efficiency achieved	
Distance between detector and source	

c Detailed Uncertainty Budget

Uncertainty components[*], in % of the activity concentration, due to

Relative standard uncertainties	$u_i \times 10^4$ evaluated method	
Contributions due to	A	B
weighing dead time counting statistics background Weighting Impurities Decay corrections		
pile-up		
counting time		
adsorption		
interpolation from calibration curve		
extrapolation due to energy threshold		
Other components		
Relative combined standard uncertainty, u_c		

[*] The uncertainty components are to be considered as approximations of the corresponding standard deviations (see also *Metrologia*, 1981, **17**, 73 and *Guide to expression of uncertainty in measurement,* ISO, corrected and reprinted 1995).

d Final result for a given method

Name(s) of the person(s) who carried out the measurements:

radioactivity concentration of the ^{124}**Sb** solution on the reference date kBq g^{-1},	combined uncertainty kBq g^{-1}	combined uncertainty %

IV. <u>SECONDARY MEASUREMENT METHODS</u>

IV. 1. γ Spectrometry

a Preparation sources

- Dilution

Dilution carried out? (Y/N):

If yes please indicate the diluent use (chemical, concentration) :

Dilution factor:

- Solid sources

Type of film (VYNS,…) and typical thickness:

Number of sources prepared :

Typical mass :

- Weighing

Balance used:

Date of last calibration:

Traceability to SI:

Weighing conditions: (temperature humidity)

Typical value of buoyancy correction:

b Method and instrumentation

SEMI CONDUCTOR DESCRIPTION	
Nature(HPGe, Ge(Li), Si(Li))	
type (p or n)	
Coaxial or planar	
Number of detectors	
Total solid angle	
Well type (Y/N):	
If yes Height Diameter Well	
If yes diameter Well	
depth Window	
material Window	
thickness	
Resolution at X keV	
FWHM =	

ASSOCIATED ELECTRONICS	
Discrimination level or window	
Dead time and std uncertainty	
Type of dead time (extending or non extending) μs	
Method of measurement of dead time	
Live time clock Y/N	
Pulser technique Y/N	
loss free counting Y/N	
Pile-up rejector Y/N	
COUNTING DATA	
Typical count rate	
Background rate	
Typical time for one measurement	
Number of sources measured	
Maximum ^{124}Sb efficiency achieved	
Distance between detector and source	

c Detailed Uncertainty Budget

Uncertainty components[*], in % of the activity concentration, due to

Relative standard uncertainties	u_i x 10^4 evaluated method	
Contributions due to	A	B
Ionization current (111In) including background and geometry uncertainties Reference source Linearity Calibration factor Weighting Impurities Decay corrections		
Quadratic summation		
Other		
Relative combined standard uncertainty, u_c		

d Final result for a given method

Name(s) of the person(s) who carried out the measurements:

radioactivity concentration of the ^{124}**Sb** solution on the reference date kBq g^{-1},	combined uncertainty kBq g^{-1}	combined uncertainty %

IV. 2. Ionisation Chamber

a Preparation sources

- Dilution

Dilution carried out? (Y/N):

If yes please indicate the diluent use (chemical, concentration) :

Dilution factor:

- Liquid sources

Type of ampoule used:

Thickness:

[*] The uncertainty components are to be considered as approximations of the corresponding standard deviations (see also *Metrologia*, 1981, **17**, 73 and *Guide to expression of uncertainty in measurement,* ISO, corrected and reprinted 1995).

Number of sources prepared:

Typical volume :

- Weighing

Balance used:

Date of last calibration:

Traceability to SI:

Weighing conditions: (temperature humidity)

Typical value of buoyancy correction:

b Method and instrumentation

IONISATION CHAMBER DESCRIPTION	
Producer and type	
Shape (U-shape, cylindrical)	
Gas nature	
Gas pressure	
Well diameter	
Thickness of the wall of the well	
IC external diameter	
IC height	
Material of the wall of the well	
Material of the electrodes	
Thickness of lead shielding	
CURRENT MEASUREMENT	
Reference of the electrometer	
Current measurements relative to a long-lived reference source (Y/N)	
If yes, reference source description	
MEASUREMENT DATA	
Typical current pA	
Background current pA	
IC response pA/MBq	
Typical integration time	
Number of measurements	

c Final result for a given method

Name(s) of the person(s) who carried out the measurements:

radioactivity concentration of the ^{124}**Sb** solution on the reference date kBq g^{-1},	combined uncertainty kBq g^{-1}	combined uncertainty %

IV. 3. Other

a Preparation sources

b Method and instrumentation (counter description, associated electronics, counting data)

c Final result for a given method

Name(s) of the person(s) who carried out the measurements:

radioactivity concentration of the ^{124}**Sb** solution on the reference date kBq g^{-1},	combined uncertainty kBq g^{-1}	combined uncertainty %

V. LABORATORY FINAL RESULT

radioactivity concentration of the ^{124}Sb solution on the reference date kBq g^{-1},	**combined uncertainty kBq g^{-1}**	**combined uncertainty %**

If the final result is obtained by a combination of results from several measurement methods, please explain the procedure below (weighted mean, correlations,…)

Appendix - Acronyms used to identify different measurement methods

Geometry	**acronym**	**Detector**	**acronym**
4π	4P	proportional counter	PC
defined solid angle	SA	pressurized proportional counter	PP
2π	2P	liquid scintillation counting	LS
		NaI(Tl)	NA
		Ge(HP)	GH
		Ge-Li	GL
		Si-Li	SL
		CsI	CS
		ionisation chamber	IC
		bolometer	BO
		calorimeter	CA
		PIPS detector	PS
		Grid ionisation chamber	GC

Radiation	**acronym**	**Mode**	**acronym**
positron	PO	efficiency tracing	ET
beta particle	BP	internal gas counting	IG
Auger electron	AE	CIEMAT/NIST	CN
conversion electron	CE	sum counting	SC
bremsstrahlung	BS	coincidence	CO
gamma ray	GR	anti-coincidence	AC
x - rays	XR	coincidence counting with efficiency tracing	CT
alpha - particle	AP	anti-coincidence counting with efficiency tracing	AT
mixture of various radiation e.g. x and gamma	MX	triple-to-double coincidence ratio counting	TD
		selective sampling	SS
		high efficiency	HE

Examples	
method	**acronym**
4π(PC)β–γ-coincidence counting	4P-PC-BP-NA-GR-CO
4π(PPC)β–γ-coincidence counting efficiency. tracing	4P-PP-MX-NA-GR-CT
defined solid angle α-particle counting with a PIPS detector	SA-PS-AP-00-00-00
4π(PPC)AX-γ(GeHP)-anticoincidence counting	4P-PP-MX-GH-GR-AC
4π CsI-β,AX,γ counting	4P-CS-MX-00-00-00
calibrated IC	4P-IC-GR-00-00-00

APPENDIX A3

Table A.1 – Instrumentation - general characteristics, geometry arrangements

Participant	**2**	**2**	**3**	**3**	**5**	**6**	**7**	**8**	**8**
DETECTOR	Coaxial	Planar	Coaxial	Planar	Coaxial	Coaxial Canberra GC 2520	Coaxial Canberra GC4018	Coaxial CANBERRA	Planar CANBERRA
Crystal material	Ge	Ge	Ge	Ge	HP Ge	HP Ge	Ge	HPGe	HPGe
If Ge: material type (P/N)	P	P	N	N	N	P	P	N-type (Extended range)	
Crystal diameter (mm)	64,9	50,5	48	19,5	50,9	53,4	63	77	25,5
Crystal thickness (mm)	79,7	20	52,7	10	62,5	51	59	78	15
Crystal active volume (cm^3)	264		95,36	2,99	127	112,5	cca 180		500 mm^2 active area
Window material	Al	Be	Be	Be	Be	Al	Al	Al	Be
Window thickness (µm)	1000		500	100	500	500	1500	1000	150
SOURCES									
Source-to-detector window distance (cm)	20	20	10,35	8,025	18,5	44,5	25	4, 8, 12	0,325
Nb Sources used *d* (cm) *m* (mg)	10 ~ 0,2 ??		6 ~ 0,2 15,5 to 20,6	1 ~ 0,2 15,5	1 ~ 0,3 8,776	3 - 41,640 38,375 61,870	5 ~ 0,6 29 to 31	4 ~ 0,5 2 to 36	
Nature and thickness of cover foil	0,02 mm Polystyrene		12 µm Mylar	12 µm Mylar	2,2 µg cm^{-2} polyester		25 µg cm^{-2} PE	10 and 0,3 mg cm^{-2}	Polyester
COLLIMATOR (Y/N)	N	N	N	Y	N	N	N	N/A	N/A
If Yes: Material				W					
If Yes: Thickness (mm)				2,23					
If Yes: Collimator diameter (mm)				10					
If Yes: Detector window-to-collimator distance (cm)				7,075					

Table A.1 – Instrumentation - general characteristics, geometry arrangements

Participant	**2**	**2**	**3**	**3**	**5**	**6**	**7**	**8**	**8**
PREAMPLIFIER			Ortec	Canberra	Ortec	Canberra	Canberra	Canberra	Canberra
Model	A257 P	2002 CSL	120-6		EG&ORTEC 137CN2	2002 CSL	2002 CSL	2002 CSL	2008 SL
AMPLIFIER	Ortec	Ortec	Canberra	Canberra	Canberra	Canberra	Canberra	Canberra	Canberra
Model	572	572	2020	2026	2021	2024	DSP 9660	AFT Research Amp 2025	AFT Research Amp 2025
Shaping time constant	6 µs	6 µs	6 µs	6 µs	4 µs	4 µs	Equivalent to 4 µs	4 µs	4 µs
Pile-up rejector (Y/N)	N	N	N	N	N	N	Y	Y	Y
ADC	Ortec	Ortec	Ortec	Ortec	Nucler Data	Canberra	Canberra	Silena	Silena
Model	919E	919E	926	926	ND570	Accuspec/A Board 840632A	DSP 9660	7423 UHS	7423 UHS
Coding type (Wilkinson, „)	SA	SA	Successive-approximation type with sliding-scale linearization.	Successive-approximation type with sliding-scale linearization.		Wilkinson		FDT	FDT
OTHER									
Gate Integrator (Y/N)	N	N	N	N	N	No		LGN, Model DE7732b	LGN, Model DE7732b
Energy resolution (FWHM)									
- at 30 keV (keV)				0,25	1	-			0,25
- at 122 keV (keV)	1,03	0,662	0,77	0,49	1,06	0,875	0,838	1,2	0,35 (@59,5 keV)
- at 1332 keV (keV)	1,86		1,73		2,07	2,37	1,78	2,5	
- at 2500 keV (keV)			2,60		2,71	-	2,6		

Table A.2. Instrumentation – efficiency calibration

EFFICIENCY CALIBRATION			
Nuclide and energy of the corresponding peak(s), in keV, used			
Participant 2		**Participant 7**	
$^{166}Ho^{m}$	48,8 ; 55,9 ; 80,6 ; 184,4 ; 215,4 ; 280,4 ; 300,7 ; 365,8 ; 410,9 ; 450,6 ; 529,8 ; 571,0 ; 670,5 ; 711,7 ; 752,3 ; 810,3 ; 830,6 ; 951		The calibration was done by MC calculation and for the validation the following energies were used:
		^{241}Am	59,5
^{152}Eu	39,9 ; 45,7 ; 121,8 ; 244,7 ; 344,3 ; 411,1 ; 444 ; 779 ; 867,4 ; 964,1 ; 1112,1 ; 1408	^{109}Cd	88
		^{57}Co	122
Participant 3	Next page	^{139}Ce	165
		^{113}Sn	391
		^{85}Sr	514
Participant 5	Next pages	^{137}Cs	662
		^{88}Y	898 ; 1836
Participant 6		^{60}Co	1173 ; 1332
^{60}Co	1173 ; 1332	^{232}Th (^{208}Tl)	2615
^{133}Ba	276 ; 302 ; 356 ; 383		
^{137}Cs	661	**Participant 8**	
^{152}Eu	121 ; 778 ; 1408	Coaxial HPGe	(keV)
^{241}Am	59	^{241}Am	59,5
		^{57}Co	122 ; 136
		^{137}Cs	662
		^{134}Cs	605 ; 796
		^{54}Mn	835
		^{65}Zn	1115,5
		^{60}Co	1173 ; 1332
		Planar HPGe	(keV)
		^{241}Am	26,3 ; 59,5
		^{137}Cs	31,8 ; 32,2 ; 36,4 ; 37,3

Table A.3. Efficiency interpolation

Code Number	Efficiency interpolation	Peak analysis
2	The experimental points of the efficiency curves of germanium spectrometers have been fitted by a polynomial function. The better degree was third degree and evaluated by χ^2 statistical test.	The integral method for liquid peak area evaluation was adopted. This method fits the peak area through an analytical function.
3	Gamma : Polynomial function adjusted with the experimental points, using the software Effigie. Degree of the polynom : 4	The net area of the peaks was determined by using the software MAESTRO. For the multiplets analysis (e.g. 709-713 keV) the computer code COLEGRAM (CEA/LNE-LNHB, Saclay, France) was used, as well as for some weak peaks located over a strongly decreasing slope, e.g. 469 and 481 keV over the Compton front associated to the 602 keV. For the X-ray peaks, the two regions of interest were analyzed with the COLEGRAM computer code.
5	Linear least square fit with cubic spline functions	a) Gaussian fit, background determined between -3 σ to +3 σ and limited by a linear extrapolation from range : between -6 σ to -3 σ (at lower energy) and linear extrapolation from +3 σ to +6 σ (at higher energy), with a step at peak energy. (PROGRAM "GELI") ref /2/ b) Sum of channel contents, reduced by background determined by method a) (PROGRAM "GELI") ref /2/ c) Gaussian fit with complete curve analysis of the peak region of interest including linear or exponential background fit (PROGRAM "Fit9") ref /3/
6	The method of interpolation was based on the use of EFFIGIE software (J. Morel, "Détermination de la réponse en efficacité des détecteurs gamma-X par lissage de points expérimentaux: code EFFIGIE", LPRI, Saclay, France, 1996).	Give a brief description of your peak analysis method: The net area and the associated uncertainty values were determined by using the ACCUSPEC software (Canberra, USA). The analysis of multiple peaks was performed by using the COLEGRAM software (H. Ruellan, M. C. Lépy, J. Plagnard, „Presentation du logiciel "COLEGRAM"", Note Technique LPRI/95/016, Saclay, France, 1995).
7	The efficiency was calculated by Monte Carlo method for each energy and the results were validated by experimental points.	TPA, continuum subtraction with step function, 1 to 5 channels. (???)
8	The experimental values were used to set the parameters for a Monte Carlo simulation of the detector set-ups. The efficiency for each peak energy was then calculated and no interpolation was involved.	The peak analysis was performed by peak fitting using ORTEC's GammaVision-32 (v.6.01). The program was used to obtain the peak area only. The rest of the calculations were done using a spreadsheet.

Table A.4. Main corrections applied for photon intensity measurements

Code Number	Coincidence Summing effect	Absorption by the screens between sample and detector	Pile-up
2	No	No	no
3	Yes (ETNA)	Not necessary	no
5	Yes, described in [1] using nuclide data from the Nucléide 2000 database, version july 2007.	no	Yes, Signal from a 50 Hz pulse generator was fed into pre-amplifier test input positioned at upper region of the spectra.
6	No, (the summing effects were negligible, because the measurements were performed at 44,5 cm from the detector window)	No	No
7	Yes, The coincidence probabilities were calculated by Monte Carlo method by own code. The correction factor for photon with energy E1 in cascade with energy E2, E3… (summing-out effect) is: $C_{out}(E1) = 1/(1 – p_{1,2} * T(E2) – p_{13}*T(E3) - …)$ $p_{1,2}$: is probability of the coincidence E1 and E2 … T : is total efficiency The correction factor for summing-in effect when photon with energy E0 is crossover by cascade Ea → Eb (E0 = Ea+Eb) is: $C_{in}(E0) = 1/(1 + p_{ab}* P(Ea)*P(Eb)/P(E0) + …)$ p_{ab} is the probability of the cascade Ea → Eb related to the emission probability of E0 P : is peak efficiency and $C1 = C_{out} * C_{in}$	No, included in efficiency calibration	Yes, pile-up and dead-time losses were corrected electronically using DSP and AIM Canberra modules
8	Yes, Correction for the coincidence summing effect was applied to peaks with emission probabilities >2%. Cascading gamma photons only were taken into account and the calculations were performed manually as described in (for example) Debertin and Helmer “Gamma- and X-ray spectrometry with semiconductor detectors” (Elsevier, 1988).	Yes, included in efficiency calibration. The absorbers were also included in the Monte Carlo simulation.	Yes, The pile-up rejection of the spectroscopy amplifiers was turned ON and adjusted. For the dead-time, the live time method was used (non-extending dead-time). The inhibit function losses of the pulsed feedback preamplifier of the low-energy planar detector were taken into account

APPENDIX A3

Participant 3: HPGe detectors efficiency calibration

Detector G1, energy range 100 – 2000 keV: ***experimental points***

Nuclide	Energy (keV)	Experimental efficiency	Relative uncertainty (%)	Absolute uncertainty
^{152}Eu	121.78	8.762E-03	0.63	5.520E-05
^{57}Co	122.06	8.775E-03	0.3	2.633E-05
^{57}Co	136.47	8.298E-03	1.4	1.162E-04
^{139}Ce	165.86	7.495E-03	0.35	2.623E-05
^{192}Ir	205.79	6.206E-03	1.31	8.130E-05
^{152}Eu	244.70	5.281E-03	0.63	3.327E-05
^{133}Ba	276.40	4.686E-03	0.61	2.858E-05
^{192}Ir	295.96	4.336E-03	0.6	2.602E-05
^{133}Ba	302.85	4.247E-03	0.6	2.548E-05
^{192}Ir	308.46	4.168E-03	0.62	2.584E-05
^{192}Ir	316.51	4.038E-03	0.42	1.696E-05
^{152}Eu	344.28	3.677E-03	0.51	1.875E-05
^{133}Ba	356.01	3.578E-03	0.5	1.789E-05
^{133}Ba	383.85	3.298E-03	0.6	1.979E-05
^{152}Eu	411.35	3.050E-03	0.86	2.623E-05
^{152}Eu	443.97	2.814E-03	0.66	1.857E-05
^{110}Ag^{m}	446.81	2.815E-03	1.1	3.097E-05
^{192}Ir	468.07	2.656E-03	0.61	1.620E-05
^{134}Cs	475.34	2.599E-03	1.51	3.924E-05
^{192}Ir	484.58	2.563E-03	0.9	2.307E-05
^{134}Cs	563.23	2.195E-03	0.47	1.032E-05
^{134}Cs	569.32	2.184E-03	0.42	9.173E-06
^{192}Ir	588.58	2.096E-03	0.68	1.425E-05
^{192}Ir	604.41	2.045E-03	0.64	1.309E-05
^{134}Cs	604.69	2.053E-03	0.26	5.338E-06
^{192}Ir	612.46	2.022E-03	1.57	3.175E-05
^{110}Ag^{m}	620.36	2.005E-03	1.21	2.426E-05
^{110}Ag^{m}	657.76	1.902E-03	0.31	5.896E-06
^{137}Cs	661.66	1.890E-03	0.42	7.938E-06
^{110}Ag^{m}	677.62	1.869E-03	1.06	1.981E-05
^{110}Ag^{m}	687.01	1.855E-03	0.77	1.428E-05
^{152}Eu	688.62	1.817E-03	2.2	3.997E-05
^{110}Ag^{m}	706.68	1.752E-03	0.75	1.314E-05
^{110}Ag^{m}	744.28	1.710E-03	1.43	2.445E-05
^{110}Ag^{m}	763.94	1.646E-03	0.47	7.736E-06
^{152}Eu	778.90	1.605E-03	0.39	6.260E-06
^{134}Cs	795.84	1.580E-03	0.26	4.108E-06
^{134}Cs	801.93	1.571E-03	0.36	5.656E-06
^{110}Ag^{m}	818.03	1.547E-03	0.72	1.114E-05
^{54}Mn	834.84	1.513E-03	0.43	6.506E-06
^{152}Eu	867.38	1.457E-03	0.73	1.064E-05

$^{110}Ag^m$	884.68	1.442E-03	0.5	7.210E-06
^{88}Y	898.04	1.421E-03	0.5	7.105E-06
$^{110}Ag^m$	937.49	1.368E-03	0.46	6.293E-06
^{152}Eu	964.08	1.323E-03	0.46	6.086E-06
^{134}Cs	1038.56	1.241E-03	0.72	8.935E-06
^{152}Eu	1086.41	1.190E-03	0.53	6.307E-06
^{152}Eu	1112.04	1.166E-03	0.54	6.296E-06
^{65}Zn	1115.55	1.165E-03	0.48	5.592E-06
^{134}Cs	1167.92	1.121E-03	0.77	8.632E-06
^{60}Co	1173.24	1.120E-03	0.3	3.360E-06
^{152}Eu	1212.95	1.082E-03	1.02	1.104E-05
^{60}Co	1332.51	1.001E-03	0.32	3.203E-06
^{134}Cs	1365.16	9.677E-04	0.59	5.709E-06
$^{110}Ag^m$	1384.30	9.747E-04	0.51	4.971E-06
^{152}Eu	1408.01	9.396E-04	0.53	4.980E-06
$^{110}Ag^m$	1475.79	9.125E-04	0.92	8.395E-06
$^{110}Ag^m$	1505.04	8.997E-04	0.58	5.218E-06
$^{110}Ag^m$	1562.29	8.682E-04	1.3	1.129E-05
^{88}Y	1836.05	7.314E-04	0.42	3.072E-06

Detector G1, energy range 500 – 3500 keV: experimental point

Nuclide	**Energy (keV)**	**Experimental efficiency**	**Relative uncertainty (%)**	**Absolute uncertainty**
^{137}Cs	661.66	0.001890	0.41	7.82E-06
^{54}Mn	834.838	0.001477	3.03	4.47E-05
^{56}Co	846.77	0.001500	0.62	9.36E-06
^{56}Co	1037.8427	0.001260	0.79	9.93E-06
^{60}Co	1173.228	0.001122	0.20	2.24E-06
^{56}Co	1238.2883	0.001063	0.67	7.11E-06
^{60}Co	1332.492	0.000996	0.18	1.82E-06
^{56}Co	1771.3567	0.000754	0.69	5.23E-06
^{56}Co	2015.2147	0.000660	0.92	6.04E-06
^{56}Co	2034.7907	0.000664	0.70	4.63E-06
^{56}Co	2598.5	0.000514	0.69	3.55E-06
^{56}Co	3202.029	0.000403	1.08	4.34E-06
^{56}Co	3253.503	0.000394	0.83	3.28E-06
^{56}Co	3273.079	0.000393	1.06	4.17E-06

Detector G2, energy range 10 – 120 keV: experimental points

Nuclide	Energy (keV)	Experimental Efficiency	Relative uncertainty (%)	absolue uncertainty
^{241}Am	13.93	0.0009846	1.008	9.93E-06
^{57}Co	14.41	0.0009830	1.884	1.85E-05
^{241}Am	17.51	0.0010712	0.925	9.91E-06
^{241}Am	21.01	0.0011061	1.349	1.49E-05
^{109}Cd	22.10	0.0010964	3.561	3.90E-05
^{109}Cd	25.07	0.0011078	4.146	4.59E-05
^{241}Am	26.34	0.0011356	1.537	1.75E-05
^{140}Ba	29.96	0.0011444	1.795	2.05E-05
^{133}Ba	30.85	0.0011506	0.916	1.05E-05
^{137}Cs	31.82	0.0011545	1.607	1.85E-05
^{137}Cs	33.19	0.0011464	7.458	8.55E-05
^{139}Ce	33.3	0.0011923	1.048	1.25E-05
^{133}Ba	35.26	0.0011819	0.943	1.11E-05
^{137}Cs	36.63	0.0011839	2.283	2.70E-05
^{139}Ce	38.06	0.0012219	1.511	1.85E-05
^{152}Eu	39.91	0.0011829	1.088	1.29E-05
^{152}Eu	42.75	0.0012032	7.990	9.61E-05
^{152}Eu	45.73	0.0011758	1.493	1.76E-05
^{133}Ba	53.16	0.0012357	1.522	1.88E-05
^{241}Am	59.54	0.0012154	0.462	5.61E-06
^{133}Ba	80.9	0.0012119	0.922	1.12E-05
^{109}Cd	88	0.0011586	1.198	1.39E-05
^{152}Eu	121.8	0.0008789	0.536	4.71E-06
^{57}Co	122.06	0.0008765	0.302	2.64E-06

Enclosure Participant 5 -G-01

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Experimental efficiencies used for the calibration of the spectrometer G8, evaluation method S

Efficency values G80, file 80FES2S.A07
G80S, point soure, position 4, polyester (2005-2007),
energies evaluated by the program

nuclide		E(keV)	p_gamma	summcorr		efficiency	uncert.(%)	
SR85	3x	13.6	.5917	1.005	S	2.937E-03	.95	2
CO57	2x	14.4	.0916	1.006	S	3.065E-03	1.79	2
Y88	3x	14.4	.6160	1.007	S	2.984E-03	1.21	2
NB93M	1x	16.6	.0925	1.000	S	3.300E-03	4.50	2
NB93M	1x	18.7	.0179	1.000	S	3.345E-03	4.27	2
CD109	1x	22.6	1.0137	1.000	S	3.579E-03	1.26	2
I125	1x	28.1	1.3950	1.003	S	3.680E-03	1.67	2
BA133	1x	31.7	1.2100	1.009	S	3.640E-03	1.93	2
CS137	1x	32.1	.0553	1.000	S	3.664E-03	1.99	2
EU152	5x	39.9	.5910	1.012	S	3.695E-03	2.24	2
PB210	1x	46.5	.0424	1.000	S	3.797E-03	1.47	2
BA133	1x	53.2	.0220	1.010	S	3.825E-03	1.15	2
AM241	2x	59.5	.3590	1.000	S	3.890E-03	1.31	2
I131	2x	80.2	.0262	1.005	S	3.848E-03	1.80	2
BA133	1x	80.9	.3668	1.008	S	3.819E-03	.96	2
CD109	1x	88.0	.0366	1.000	S	3.796E-03	1.29	2
SE75	1x	96.7	.0342	1.002	S	3.825E-03	1.75	2
SE75	1x	121.1	.1720	1.007	S	3.505E-03	2.10	2
EU152	3x	121.8	.2858	1.011	S	3.470E-03	.84	2
CO57	2x	122.1	.8560	1.001	S	3.502E-03	.71	2
SE75	1x	136.0	.5820	1.007	S	3.359E-03	1.57	2
CO57	2x	136.5	.1068	.997	S	3.338E-03	.96	2
CE139	1x	165.9	.7990	1.003	S	3.002E-03	.57	2
RA226	2x	186.1	.0351	1.008	S	2.749E-03	2.17	2
EU152	5x	244.7	.0758	1.013	S	2.214E-03	.82	2
SE75	1x	264.7	.5890	1.007	S	2.075E-03	1.18	2
BA133	1x	276.4	.0716	1.009	S	2.007E-03	.66	2
SE75	1x	279.5	.2499	1.005	S	1.978E-03	1.23	2
IR192	1x	296.0	.2872	1.010	S	1.871E-03	.98	2
BA133	1x	302.9	.1833	1.008	S	1.839E-03	.65	2
IR192	1x	308.5	.2968	1.010	S	1.816E-03	.99	2
IR192	1x	316.5	.8279	1.007	S	1.752E-03	.85	2
CR51	1x	320.1	.0987	1.000	S	1.748E-03	.79	2
EU152	5x	344.3	.2650	1.006	S	1.622E-03	2.41	2
BA133	1x	356.0	.6205	1.006	S	1.579E-03	.64	2
I131	2x	364.5	.8170	1.000	S	1.538E-03	1.14	2
BA133	1x	383.9	.0894	1.003	S	1.471E-03	.68	2
SE75	1x	400.7	.1147	.971	S	1.400E-03	1.45	2
EU152	5x	444.0	.0315	1.012	S	1.268E-03	1.03	2
IR192	1x	468.1	.4781	1.005	S	1.196E-03	.94	2
RU106	1x	511.9	.2040	1.003	S	1.120E-03	2.09	2
SR85	3x	514.0	.9850	1.002	S	1.106E-03	.73	2
CS134	1x	567.2	.2375	1.008	S	1.019E-03	.53	2
BI207	1x	569.7	.9774	1.004	S	1.013E-03	.82	2

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CS134	1x	604.7	.9763	1.005	S	9.595E-04	.42	2
RU106	1x	621.5	.1068	1.005	S	9.339E-04	2.49	2
I131	2x	637.2	.0739	1.000	S	9.157E-04	.42	2
CS137	1x	661.7	.8500	1.000	S	8.846E-04	.59	2
EU152	5x	778.9	.1294	1.007	S	7.725E-04	1.40	2
CS134	1x	796.4	.9409	1.005	S	7.620E-04	.59	2
CO58	2x	810.8	.9945	1.002	S	7.438E-04	.67	2
MN54	1x	834.8	.9998	1.000	S	7.270E-04	.42	2
EU152	5x	867.4	.0424	1.014	S	7.029E-04	.91	2
Y88	3x	898.0	.9400	1.005	S	6.865E-04	.65	2
EU152	5x	964.1	.1473	1.009	S	6.392E-04	.77	2
BI207	1x	1063.7	.7450	1.005	S	5.952E-04	.88	2
EU152	5x	1112.0	.1383	1.008	S	5.740E-04	.71	2
ZN65	1x	1115.5	.5022	1.001	S	5.733E-04	.78	2
CO60	2x	1173.2	.9985	1.003	S	5.480E-04	.42	2
NA22	2x	1274.5	.9994	1.009	S	5.066E-04	.45	2
CO60	2x	1332.5	.9998	1.003	S	4.921E-04	.46	2
EU152	5x	1408.0	.2100	1.008	S	4.677E-04	.77	2
RA226	1x	1509.2	.0208	1.005	S	4.397E-04	2.68	2
RA226	2x	1764.5	.1510	1.001	S	3.828E-04	2.30	2
BI207	1x	1770.2	.0687	1.005	S	3.822E-04	1.14	2
Y88	3x	1836.1	.9933	1.006	S	3.699E-04	.54	2
RA226	2x	2204.2	.0498	1.001	S	2.985E-04	2.71	2
RA226	2x	2447.9	.0155	1.001	S	2.716E-04	2.84	2
Y88	3x	2734.0	.0061	.858	S	2.141E-04	3.62	2

Enclosure Participant 5 -G-02

Euromet Project 907

Experimental efficiencies used for the calibration of the spectrometer G8, evaluation method U

Efficency values G80, file 80FES2U.A07
G80U, point soure, position 4, polyester (2005-2007), energies evaluated by the program

nuclide		E(keV)	p_gamma	summcorr		efficiency	uncert.(%)	
SR85	3x	13.6	.5917	1.005	U	2.999E-03	.95	2
CO57	2x	14.4	.0916	1.006	U	3.115E-03	1.79	2
Y88	3x	14.4	.6160	1.007	U	3.073E-03	1.24	2
NB93M	1x	16.9	.1104	1.000	U	3.388E-03	3.09	2
CD109	1x	22.6	1.0137	1.000	U	3.737E-03	1.14	2
I125	1x	28.1	1.3950	1.003	U	3.783E-03	1.48	2
BA133	1x	31.7	1.2100	1.009	U	3.769E-03	1.39	2
CS137	1x	32.1	.0553	1.000	U	3.736E-03	1.98	2
EU152	5x	39.9	.5910	1.012	U	3.680E-03	2.21	2
PB210	1x	46.5	.0424	1.000	U	3.765E-03	1.46	2
BA133	1x	53.2	.0220	1.010	U	3.830E-03	1.13	2
AM241	2x	59.5	.3590	1.000	U	3.864E-03	1.30	2
I131	2x	80.2	.0262	1.005	U	3.827E-03	1.75	2
BA133	1x	80.9	.3668	1.008	U	3.810E-03	.94	2
CD109	1x	88.0	.0366	1.000	U	3.800E-03	1.28	2
SE75	1x	96.7	.0342	1.002	U	3.725E-03	1.78	2
SE75	1x	121.1	.1720	1.007	U	3.495E-03	2.10	2
EU152	3x	121.8	.2858	1.011	U	3.494E-03	.81	2
CO57	2x	122.1	.8560	1.001	U	3.488E-03	.56	2
SE75	1x	136.0	.5820	1.007	U	3.361E-03	1.57	2
CO57	2x	136.5	.1068	.997	U	3.327E-03	.95	2
CE139	1x	165.9	.7990	1.003	U	3.033E-03	.52	2
RA226	2x	186.1	.0351	1.008	U	2.820E-03	2.06	2
EU152	5x	244.7	.0758	1.013	U	2.221E-03	.83	2
SE75	1x	264.7	.5890	1.007	U	2.080E-03	1.18	2
BA133	1x	276.4	.0716	1.009	U	2.012E-03	.65	2
SE75	1x	279.5	.2499	1.005	U	1.978E-03	1.21	2
IR192	1x	296.0	.2872	1.010	U	1.874E-03	.93	2
BA133	1x	302.9	.1833	1.008	U	1.838E-03	.64	2
IR192	1x	308.5	.2968	1.010	U	1.796E-03	.93	2
IR192	1x	316.5	.8279	1.007	U	1.752E-03	.85	2
CR51	1x	320.1	.0987	1.000	U	1.748E-03	.78	2
EU152	5x	344.3	.2650	1.006	U	1.631E-03	2.41	2
BA133	1x	356.0	.6205	1.006	U	1.580E-03	.64	2
I131	2x	364.5	.8170	1.000	U	1.538E-03	1.08	2
BA133	1x	383.9	.0894	1.003	U	1.476E-03	.65	2
SE75	1x	400.7	.1147	.971	U	1.399E-03	1.40	2
EU152	5x	444.0	.0315	1.012	U	1.277E-03	1.00	2
IR192	1x	468.1	.4781	1.005	U	1.198E-03	.99	2
RU106	1x	511.9	.2040	1.003	U	1.116E-03	2.07	2
SR85	3x	514.0	.9850	1.002	U	1.114E-03	.71	2
CS134	1x	567.2	.2375	1.008	U	1.019E-03	.53	2
BI207	1x	569.7	.9774	1.004	U	1.014E-03	.81	2
CS134	1x	604.7	.9763	1.005	U	9.601E-04	.42	2

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RU106	1x	621.5	.1068	1.005	U	9.310E-04	2.58	2
I131	2x	637.2	.0739	1.000	U	9.155E-04	.41	2
CS137	1x	661.7	.8500	1.000	U	8.868E-04	.59	2
EU152	5x	778.9	.1294	1.007	U	7.768E-04	1.39	2
CS134	1x	796.4	.9409	1.005	U	7.600E-04	.58	2
CO58	2x	810.8	.9945	1.002	U	7.457E-04	.66	2
MN54	1x	834.8	.9998	1.000	U	7.300E-04	.42	2
EU152	5x	867.4	.0424	1.014	U	7.064E-04	.92	2
Y88	3x	898.0	.9400	1.005	U	6.903E-04	.67	2
EU152	5x	964.1	.1473	1.009	U	6.418E-04	.77	2
BI207	1x	1063.7	.7450	1.005	U	5.978E-04	.87	2
EU152	5x	1112.0	.1383	1.008	U	5.760E-04	.71	2
ZN65	1x	1115.5	.5022	1.001	U	5.760E-04	.77	2
CO60	2x	1173.2	.9985	1.003	U	5.527E-04	.44	2
NA22	2x	1274.5	.9994	1.009	U	5.099E-04	.43	2
CO60	2x	1332.5	.9998	1.003	U	4.961E-04	.44	2
EU152	5x	1408.0	.2100	1.008	U	4.705E-04	.77	2
RA226	1x	1509.2	.0208	1.005	U	4.462E-04	2.64	2
RA226	2x	1764.5	.1510	1.001	U	3.875E-04	2.28	2
BI207	1x	1770.2	.0687	1.005	U	3.889E-04	1.12	2
Y88	3x	1836.1	.9933	1.006	U	3.737E-04	.53	2
RA226	2x	2204.2	.0498	1.001	U	3.032E-04	2.71	2
RA226	2x	2447.9	.0155	1.001	U	2.769E-04	2.84	2
Y88	3x	2734.0	.0061	.858	U	2.196E-04	3.49	2

Erratum Participant 6

In May 2009, participant 6 sent a revised set of the photon emission intensities. Since the deadline was March, 2008, the values of participant 6 used in the evaluation are the previous ones. These new values are given here as *erratum*.

Since the new values sent by participant 6 remain significantly different of those of the other participants and affected by higher uncertainties in most cases, their introduction in the evaluation would not change most of the adopted values.

As example, a new calculation was done for the most intense gamma line with 602 keV energy, with Iγ = 95,1 ± 1,32 instead of Iγ = 95 ± 1 :

602 keV	Value	Uc	Min Unc. ?	R. WGHT	Chi2/N-1	Unc (if w>0,5)	Outlier ?	New Val.	New Unc.
2	97,52	0,70		0,136892	0,03141			97,5198	0,70
3	97,84	0,85		0,092470	0,00152			97,8354	0,85
5	97,60	0,66		0,153219	0,01615			97,6	0,66
6	95,10	1,32					OUT(CHV)		
7	97,84	0,34	MIN	0,587607	0,01151			97,841	0,33
8	98,14	1,50		0,029810	0,01507			98,138	1,5
			CONSISTENT DATA SET	Chi2 :	0,07568	Chi2 crit.:	3,32	Nb Inp. Val.	5
Chi2	0,1		UWM :	97,78698	uc(UWM) :	0,1084			
Chi2 crit:	3,3		WM :	97,76871	uc(WM)int.	0,2598	uc(WM)ext.	0,07147	
UWM:	97,78698		LWM :	97,76871	uc(LWM) :	0,2598			
WM:	97,76871		LWM :	97,77	uc(LWM) :	0,26			
Uc (int):	0,2598								
Uc (ext) :	0,07147		LWM has used weighted average and internal uncertainty						
LWM :	97,77	0,26							

^{124}Sb exercise, table 3 : result of measurements, absolute values, *erratum participant 6*

(In this table, all the g rays quoted in the literature are listed, fill in the corresponding line or not)

Energy (keV)	Efficiency (%)	Correction Factors **C5**: decay correction (the other corrections C1 ... C4 were considered negligible)	Photon emission intensity per 100 disintegrations	Elementary components of the uncertainty (% -1 σ) **(U1+U2)**, **U3**, **U7** (the other components were considered negligible)	Relative combined standard (1 σ) uncertainty (%)	Comment
Kα : 27,3						
Kβ : 30,9 – 31,8						
148,2						
158,9						
189,6						
210,3						
254,3						
291,4						
335,8						
346,1						
370,4						
385,9						
400,0	0.0285	2.629252	0.160	38, 1.03, 0.55	38	
443,9	0.0258	2.629252	0.195	36, 1.11, 0.55	36	

Energy (keV)	Efficiency (%)	Correction Factors **C5**: decay correction (the other corrections C1 ... C4 were considered negligible)	Photon emission intensity per 100 disintegrations	Elementary components of the uncertainty (% -1 σ) **(U1+U2)**, **U3**, **U7** (the other components were considered negligible)	Relative combined standard (1 σ) uncertainty (%)	Comment
468,6						
476,85						
481,1	0.0239	2.629252	0.151	34, 1.17, 0.55	34	
498,4						
525,4	0.0219	2.629252	0.051	84, 1.21, 0.55	84	
530,3						
553,8						
571,6						
602,7	0.01896	2.629252	95.1	0.22, 1.26, 0.55	1.39	
632,3						
645,8	0.0176	2.629252	7.40	1.11, 1.27, 0.55	1.77	
662,4						
709,3	0.01586	2.629252	1.46	4.64, 1.28, 0.55	4.84	
713,7	0.01575	2.629252	2.29	3.72, 1.29, 0.55	3.98	
722,7	0.01553	2.629252	10.80	1.19, 1.29, 0.55	1.84	
735,7	0.01522	2.629252	0.22	27, 1.29, 0.55	27	
765,8						

Energy (keV)	Efficiency (%)	Correction Factors **C5**: decay correction (the other corrections C1 ... C4 were considered negligible)	Photon emission intensity per 100 disintegrations	Elementary components of the uncertainty (% -1 σ) **(U1+U2)**, **U3**, **U7** (the other components were considered negligible)	Relative combined standard (1 σ) uncertainty (%)	Comment
775,2						
790,7	0.01403	2.629252	0.83	8.73, 1.32, 0.55	8.85	
816,8						
856,9						
899,6						
937,9						
968,1	0.01117	2.629252	3.03	3.88, 1.34, 0.55	4.14	
976,2						
997,7						
1014,5						
1045,1	0.01029	2.629252	2.15	5.4, 1.29, 0.55	5.58	
1053,8						
1086,3						
1097						
1163,2						
1198						
1205,5						

Energy (keV)	Efficiency (%)	Correction Factors **C5**: decay correction (the other corrections C1 ... C4 were considered negligible)	Photon emission intensity per 100 disintegrations	Elementary components of the uncertainty (% -1 σ) **(U1+U2)**, **U3**, **U7** (the other components were considered negligible)	Relative combined standard (1 σ) uncertainty (%)	Comment
1235						
1253,4						
1263,1						
1269						
1301,3						
1325,5	0.00835	2.629252	1.70	8.55, 1.07, 0.55	8.63	
1355,1	0.008234	2.629252	1.09	11.2, 1.16, 0.55	11.3	
1368,1	0.008187	2.629252	2.83	4.55, 1.21, 0.55	4.74	
1376,1	0.00816	2.629252	0.92	19.2, 1.24, 0.55	19.3	
1385,1	0.00813	2.629252	0.32	40, 1.29, 0.55	40	
1428,7						
1436,5	0.007984	2.629252	1.25	8.6, 1.61, 0.55	8.77	
1445,0	0.007963	2.629252	0.41	24, 1.67, 0.55	24.1	
1453,2						
1488,8	0.007873	2.629252	0.73	13.1, 2.03, 0.55	13.3	
1505,6						
1528,1	0.007815	2.629252	0.49	19.2, 2.41, 0.55	19.4	

Energy (keV)	Efficiency (%)	Correction Factors **C5**: decay correction (the other corrections C1 ... C4 were considered negligible)	Photon emission intensity per 100 disintegrations	Elementary components of the uncertainty (% -1 σ) **(U1+U2)**, **U3**, **U7** (the other components were considered negligible)	Relative combined standard (1 σ) uncertainty (%)	Comment
1557						
1565,8						
1579,7						
1622,4	0.007757	2.629252	0.21	23, 3.5, 0.55	23.3	
1657						
1690,9	0.007785	2.629252	45.6	0.5, 4.44, 0.55	4.50	
1720,3	0.007815	2.629252	0.12	32.7, 4.87, 0.55	33.1	
1757,9	0.007869	2.629252	0.0064	291, 5.45, 0.55	291	
1851,5	0.008082	2.629252	0.28	17.7, 7.04, 0.55	19.1	
1918,8	0.008306	2.629252	0.059	49.4, 8.31, 0.55	50.1	
1950,4						
2015,7						
2039,3						
2078,6						
2090,9						
2099,1						

PART B

^{124}Sb – Decay Data Evaluation

^{124}Sb - Comments on evaluation of decay data by M.M. Bé and V. Chisté

This evaluation was completed in December 2008. The literature available by this date was included as well as the results obtained as a part of a specific exercise dedicated to the ^{124}Sb activity and γ-ray emission intensity measurements organized by the Euramet organisation (Project 907, full report to be published).
In the following, the participants in the Euramet 907 project will be referred as E907- *n*, where *n* is a serial number.

1. Decay Scheme

This decay scheme is complete and is based on those proposed by Goswamy (1993Go10), Patil (2006Pa16) and the results obtained in the Euramet-907 project.
A good agreement was found between the effective Q value of 2906 (8) keV computed from the decay scheme data and the adopted Q value of 2904,3 (15) keV from the mass adjustment of Audi *et al.*

2. Nuclear Data

The Q value is from the atomic mass evaluation of Audi *et al.* (2003Au03).

Experimental half-life values (in days) are listed below:

Reference	$T_{1/2}$	**Uc**	**Comments**
Macklin (1957Ma50)	60,4	0,2	
C.H.Johnson (1958Jo01)	59,9	0,5	
J.P.Cali (1959Ca12)	60,1	0,3	
S.A.Reynolds (1968Re04)	60,3	0,2	
D.M.Fleming (1966Fl01)	60,20	0,03	calorimetry
I.A.Kharitonov (2000Kh04)	60,11	0,07	4πβ−γ coincidence method
* E907- 8	60,212	0,011	Ionization chamber
Adopted	**60,208**	**0,011**	Reduced χ^2 =1 ; critical χ^2 =4,6

*Euramet 907 participant number 8

The adopted value is the weighted mean of the three most precise values with the external uncertainty.

2.1 Beta transitions

β^- transition energies have been energies are calculated from the Q value and the level energies.

The β^- transition probabilities were deduced from the γ transition probability balance at each level of the decay scheme. The adopted values are compared with the measured values in the following table:

	(0,1) 2301 keV %	(0,3) 1579 keV %	(0,5) 946 keV %	(0,10) 610 keV %	(0,20) 210 keV %
Langer (1953La35)	21	7	9	49	14
Moreau (1954Mo83)	22	7	9	53	9
Azuma (1955Az29)	22	6	4	56	12
Hsue (1965Hs02)	23	5			
Zolotavin (1956Zo06)	28	10	4	49	9
Adopted	23,44 (28)	4,815 (29)	2,295 (7)	51,21 (19)	8,663 (27)
Nature	1st S(q2+(1p2+16(2) (Hsue) S=k(1-0,25W-0,06/W+0,041W2)(Hsue) S=q2+(1p2+7(2) (Canty) S=0,9q2+p2 (Johnson)				

The weak beta transition probabilities are based on the γ transition probability balance at each level of the decay scheme, especially in the upper part of the decay scheme (from level 2886-keV to level 2483-keV) where there are only gamma transitions depopulating these levels. In this evaluation, only the gamma rays observed in several independent experiments have been retained (see § 4.2) so the corresponding levels can be considered definitely established.

2.2 Gamma transitions and internal conversion coefficients

γ-ray measurements carried out by Doll *et al.* (2000Do11) confirmed the doublet structure of the 2039 level ; one with J^{π} assignment 2^{+} and the second with 3^{+} ; with a spacing of 129 eV.
The γ transitions with energy : 2039,4- ; 790,8- ; 1436,7- ; 713,9-keV start from level with J^{π} = 2^{+} and, those with energy : 790,7- ; 1436,6- ; 713,8-keV from level with J^{π} = 2^{+}. They are shown as doublets in the following table.

Internal conversion coefficients

Multipolarity and multipole mixing ratio (δ) for some transitions were determined using the techniques of directional correlation and nuclear orientation measurements, these are summarized in Table 1 :

Table 1 :

Transition energy (keV)	**multipole mixing ratio (d)**	**Multipolarity**	**Reference**
444	0,57 (17) or 0,06 (8)		Robinson *et al.* 1983
646	0,013 (9) 0,000 (1)	E2, M3	Goswamy *et al.* 1993 Baker *et al.* 1972
709	- 0,8 (+3, -4) - 1 (+6, -8) - 0,18 (5) 0,04 (3, -5)	M1, E2	Goswamy *et al.* 1993 Goswamy *et al.* 1993 Robinson *et al.* 1983 Grabowski *et al.* 1971
714	- 0,65 (+38, - 0,54) 1,15 (16, - 25) 1,5 (7) 1,5 (6)	M1, E2	Goswamy *et al.* 1993 Subrahmanyeswara *et al.* 1990 Robinson *et al.* 1983 Baker *et al.* 1972

Transition energy (keV)	**multipole mixing ratio (d)**	**Multipolarity**	**Reference**
	0,98 (19)		Grabowski *et al.* 1971
723	3,74 (12) - 3,8 (2) - 3,4 (3) - 3,3 (2) - 3,4 (1) - 7,5 (20) - 3,4 (6)	M1, E2	Goswamy *et al.* 1993 Subrahmanyeswara *et al.* 1990 Robinson *et al.* 1983 Baker *et al.* 1972 Grabowski *et al.* 1971 Sites *et al.* 1970 Stelson, 1967
791	- 0,15 (+5, -2) - 0,3 (+52, -14)	E2, M3	Goswamy *et al.* 1993 Goswamy *et al.* 1993
968	0,038 (3) - 0,35 (8) - 0,02 (2) - 0,03 (6, -5) - 0,02 (8)	E1, M2	Goswamy *et al.* 1993 Subrahmanyeswara *et al.* 1990 Robinson *et al.* 1983 Baker *et al.* 1972 Sites *et al.* 1970
1045	- 0,14 (+3, -4) - 0,03 (2) 0,041 (47, -41) - 0,1 (1)	E1, M2	Goswamy *et al.* 1993 Robinson *et al.* 1983 Baker *et al.* 1972 Sites *et al.* 1970
1356	- 0,32 (+25, -18)	E2, M1	Goswamy *et al.* 1993
1368	- 0,28 (6) - 0,02 (1) - 0,045 (90) - 0,01 (8)		Subrahmanyeswara *et al.* 1990 Robinson *et al.* 1983 Baker *et al.* 1972 Sites *et al.* 1970
1376	0,26 (11) < 0,29 - 0,01 (3)	E1, M2	Goswamy *et al.* 1993 Goswamy *et al.* 1993 Robinson *et al.* 1983
1437	0,51 (+13, -11) 1,5 (8) 3,7 (27, -20)	M1, E2	Goswamy *et al.* 1993 Robinson *et al.* 1983 Baker *et al.* 1972
1445	0,015 (80) 0,10 (9)	E1, M2	Goswamy *et al.* 1993 Robinson *et al.* 1983
1489	0,10 (23) - 3,4 (9, -15)		Robinson *et al.* 1983 Baker *et al.* 1972
1691	- 0,009 (22) - 0,06 (3) - 0,02 (1) 0,00 (3)	E1, M2	Goswamy *et al.* 1993 Subrahmanyeswara *et al.* 1990 Baker *et al.* 1972 Sites *et al.* 1970
2091	0,031 (6) 0,032 (32) 0,00 (2, -3) 0,07 (3)	E1, M2	Goswamy *et al.* 1993 Subrahmanyeswara *et al.* 1990 Baker *et al.* 1972 Sites *et al.* 1970

Moreover, there are also available two sets of measured values of the conversion electron intensities (Ice_i): by Grigor'eev *et al.* (1968), and by Johnson (1974Jo03). These values as well as their weighted means are summarized in where α_{K602} is the theoretical K conversion coefficient interpolated from Band's tables using the program BrIcc with the "frozen orbital approximation" (Kibédi *et al.* 2008Ki07) for an E2 transition ; Ice_i are the conversion electron intensities, and $I\gamma_i$, the relative gamma-ray emission probabilities as summarized in Table 3.

The experimental α_{Ki} conversion coefficients have been compared with the theoretical ICC, the deduced mixing ratios δ are in good agreement with those determined by directional correlation and nuclear orientation measurements summarized in Table 1.

Table 2. Then, the experimental K conversion coefficients α_{Ki} were deduced from the relation :

$\alpha_{Ki} = \alpha_{K602} \times Ice_i / I\gamma i$

where α_{K602} is the theoretical K conversion coefficient interpolated from Band's tables using the program BrIcc with the "frozen orbital approximation" (Kibédi *et al.* 2008Ki07) for an E2 transition ; Ice_i are the conversion electron intensities, and $I\gamma_i$, the relative gamma-ray emission probabilities as summarized in Table 3.

The experimental α_{Ki} conversion coefficients have been compared with the theoretical ICC, the deduced mixing ratios δ are in good agreement with those determined by directional correlation and nuclear orientation measurements summarized in Table 1.

Table 2 :

							α_k (602)=	0,00420	0,00006						
	Johnson		Grigor'eev						α_k =						
Energy	Iec	Uc	Ice	Uc	Ice WM	Uc dopt.	Ig rel.	Uc Ig	Ice/Ig * ak602	uc α_k	Multipolarity	delta	%	α_k theo	α_T theo.
159	2,3	0,2			2,3	0,2	0,0050	0,0006	1,93	0,29					
254	0,10	0,08			0,1	0,08	0,0145	0,0009	0,0290	0,0232	E1 ?			0,01269 (18)	0,01465 (21)
336	0,12	0,08			0,12	0,08	0,0741	0,0009	0,0068	0,0045	E1			0,00611 (9)	0,00704 (10)
371	0,1	0,08			0,1	0,08	0,0292	0,0011	0,0144	0,0115					
400	0,45	0,08			0,45	0,08	0,128	0,0027	0,0148	0,0027	E2			0,01323 (2)	0,01566 (2)
444	0,35	0,15			0,35	0,15	0,192	0,009	0,0077	0,0033	M1+E2	0,06	26,5	0,01092 (16)	0,01261 (18)
469	< 0,14				< 0,14		0,0469	0,0027			E1			0,00268 (4)	0,00309 (5)
481	< 0,07				< 0,07		0,0237	0,0032							
525	0,14	0,08			0,14	0,08	0,1484	0,0036	0,0040	0,0023	M1+E2	1	50	0,0066 (3)	0,0077 (3)
602	100		100		100		100		0,00420	0,00006	E2			0,00420 (6)	0,00490 (7)
646	5,4	0,5	6,6	0,3	6,28	0,53	7,591	0,015	0,0035	0,0003	E2+M3	0,006	0,0036	0,00351 (5)	0,00409 (6)
709	1,4	0,5	1,2	0,1	1,21	0,10	1,3941	0,0046	0,0036	0,0003	M1+E2	-0,18	3,1	0,00349 (5)	0,00402 (6)
713	1,6	0,5	1,6	0,2	1,60	0,19	2,325	0,007	0,0029	0,0003	M1+E2	1	50	0,0031 (4)	0,0036 (4)
722	5,7	0,5	7,5	0,3	7,02	0,79	10,952	0,022	0,0027	0,0003	M1+E2	-3,4	92	0,00271 (4)	0,00314 (5)
735	0,04	0,02			0,04	0,02	0,1342	0,0016	0,0013	0,0006					
766	0,035	0,02	0,06	0,02	0,048	0,014	0,0105	0,0009	0,0190	0,0059	E0, M1			0,019 (6)	0,021 (7)
790	0,44	0,08	0,44	0,03	0,440	0,028	0,7584	0,0025	0,0024	0,0002	E2			0,00214 (6)	0,00248 (8)
968	0,24	0,08	0,33	0,03	0,319	0,030	1,93	0,01	0,0007	0,0001	E1(+M2)	-0,2	3,8	0,000569 (9)	0,000653 (11)
1045	0,18	0,08	0,25	0,03	0,241	0,028	1,894	0,014	0,0005	0,0001	E1(+M2)	-0,03	0,09	0,000494 (9)	0,000567 (10)
1325	0,35	0,1	0,30	0,03	0,304	0,029	1,623	0,007	0,0008	0,0001	E2			0,000693 (10)	0,000827 (12)
1355	0,17	0,1	0,20	0,02	0,199	0,020	1,0649	0,0039	0,0008	0,0001	E2(+M3)	-0,32	9,3	0,0009 (5)	0,0011 (5)
1368	0,14	0,05	0,22	0,03	0,199	0,035	2,680	0,008	0,0003	0,0001	E1(+M2)	-0,02	0,04	0,000303 (5)	0,000478 (7)
1376	0,035	0,03			0,035	0,03	0,5113	0,0044	0,0003	0,0002	E1(+M2)	-0,01	0,01	0,000300 (5)	0,000479 (7)
1418	0,25	0,1			0,25	0,1	0	0							
1436	0,28	0,1	0,17	0,03	0,18	0,03	1,262	0,008	0,0006	0,0001	M1+E2	1,5	69,23	0,00063 (5)	0,00078 (5)
1489	0,14	0,1	0,13	0,02	0,13	0,02	0,6924	0,0038	0,0008	0,0001	M1+E2	0,1	0,9901	0,000659 (14)	0,000829 (16)
1526	0,035	0,03	< 0,04		0,035	0,03	0,4232	0,0048	0,0003	0,0003	E1			0,000252 (6)	0,000535 (8)
1657	0,2	0,1			0,2	0,1	0,00	0,00							
1691	2,7	0,4	2,5	0,2	2,54	0,18	48,54	0,19	0,00022	0,00002	E1+M2	0,01	0,01	0,000213 (4)	0,000615 (9)
2090,9	0,24	0,06	0,20	0,04	0,212	0,033	5,618	0,025	0,00016	0,00002	E1(+M2)	0,03	0,1	0,0001522 (23)	0,000838 (12)

3. Atomic Data

The fluorescence yield data are from 1996Sc06 (Schönfeld and Janssen).

3.1 X Radiations

The relative K x-ray emission probabilities are from 1996Sc06.

3.2 Auger Electrons

The ratios P(KLX)/P(KLL) and P(KXY)/P(KLL) are from 1996Sc06.

4. Radiation Emissions

4.1 Electron Emissions

The β- emission energies and intensities were deduced from γ transition probabilities (§ 2.1).
The conversion electron emission intensities have been calculated from the γ-ray emission intensities in sects. 4.2, and the internal-conversion coefficients in sect. 2.2.
The Auger electron emission intensities were calculated by the EMISSION program from PTB using the γ-ray emission probabilities, the atomic data of sect. 3, and the internal-conversion coefficients of sect. 2.2.

4.2 Photon Emissions

The X-ray absolute emission intensities were calculated using the EMISSION program and the γ-ray emission intensities, the atomic data given in sect. 3, and the internal-conversion coefficients in sect. 2.2. They are compared with the three sets of absolute values measured by participants in the Euramet exercise. They are, in general, in good agreement.

	E907- 2		E907- 3		E907- 8		Calculated	
Energy (keV)	**I %**	**Uc**	**I %**	**Uc**	**I %**	**Uc**	**I %**	**Uc**
27,2 (Kα2)			0,128	0,002	0,130	0,003	0,1252	0,0018
27,5 (Kα1)			0,264	0,004	0,230	0,006	0,233	0,003
30,9 (Kβ'2)			0,068	0001	0,063	0,002	0,0667	0,0012
31,7 (Kβ'1)			0,0170	0,0005	0,0136	0,0006	0,0145	0,0005
Kα	0,35	0,07	0,392	0,0045	0,359	0,007	0,358	0,0035
Kβ	0,087	0,018	0,085	0,0011	0,076	0,0018	0,081	0,0013
K X Total	0,437	0,072	0,476	0,005	0,436	0,007	0,439	0,004

The X-ray relative emission intensities given by Euramet participants 2 and 8 are compared, in the following table, with the published values of Patil (2006) and Goswamy (1993).

	E907- 2		E907- 3		Patil (2006)		Goswamy (1993)	
Energy (keV)	Rel. Int.	Uc	Rel. Int.	Uc	Rel. Int.	Uc	Rel. Int.	Uc
Kα : 27,3	0,361	0,076	0,4000	0,0046	0,3681	0,0066	0,366	0,017
Kβ : 30,9 – 31,8	0,089	0,018	0,0864	0,0014	0,0852	0,0017	0,084	0,050

γ-ray energies

The γ-ray energies in the following table, are from Helmer (2000He14). The other energies were deduced from the level energy differences.

E (keV)	Uc (keV)	E (keV)	Uc (keV)
602,7260	0,0023	1045,125	0,004
645,8520	0,0019	1325,504	0,004
713,776	0,004	1368,157	0,005
722,782	0,003	1436,554	0,007
790,706	0,007	1690,971	0,004
968,195	0,004	2090,930	0,007

γ-ray emission intensities

The 6 participants in the Euramet project sent their γ-ray emission intensities in both relative and absolute scales, since they also carried out activity measurements of the solution.
Moreover, eight sets of measured values published in the literature are available. All of them are relative to the most intense 602-keV γ-ray line (Table 3).
Among the 111 γ rays mentioned before or in this exercise, some weak lines were observed once and not confirmed by other measurements, these are summarized below:

- Weak gamma rays of weak intensities observed by one Euramet participant often described being "barely visible" and then not adopted in the decay scheme :
2871-keV ; 2274-keV ; 2253-keV ; 2151-keV ; 1970-keV (just detection limits) ; 1950-keV ; 1657-keV ; 1557-keV ; 1428-keV ; 1269-keV ; 1202-keV ; 1198-keV; 1180-keV ; 1163-keV ; 669-keV ;

- Weak gamma rays of weak intensities observed by Patil but by none of the Euramet participant and not adopted in the decay scheme :
2814-keV ; 2746-keV ; 2515-keV ; 2490-keV ; 2386-keV (just detection limits) ; 2373-keV ; 2256-keV ; 2232-keV ; 2145-keV ; 1418-keV ; 795-keV ; 743-keV ; 592-keV ; 186-keV.

A number of weak gamma rays were observed by some Euramet participants or by others :
- 2224-keV, 2204-keV the reported intensities are quite discrepant so they were omitted ;
- 1453-keV could be between levels 2701,6 and 1248,5-keV, but the reported intensities are quite discrepant so this γ-ray was omitted ;
- 476-keV could be between levels 2701,6 and 2224,8-keV, but the reported intensities are quite discrepant so this ray has not been retained ;
- 1757-keV ; 1509-keV ; 1253-keV ; 1097-keV ; 1014-keV ; 937-keV ; 553-keV ; 498,4-keV; 385-keV ; 346-keV ; do not correspond to levels differences, they have not been retained.

- 1235-keV ; 997-keV ; 159,8-keV were accepted but not placed in the decay scheme.

602-keV absolute γ-ray emission intensity

1) A first attempt was made to determine the 602-keV line absolute emission intensity using the results of the absolute measurements carried out in the framework of the Euramet project :

Participant	Ig_{602} in %	Uc
E907- 2	97,5	0,7
E907- 3	97,8	0,9
E907- 5	97,6	0,7
E907- 6	91	1
E907- 7	97,84	0,34
E907- 8	98,1	1,5

Chi2	0,1		χ^2 / (n-1)
Chi2 crit:	3,3		
UWM:	97,787		Unweighted mean
WM:	97,769		Weighted mean
Uc (int):	0,26		Internal uncertainty
Uc (ext) :	0,07		External uncertainty
LWM :	97,77	0,26	Limited WM

The value of participant 6 was found to be an outlier based on Chauvenet's criterion. Value of participant 7 contributes to 58 % to the weighted mean (WM). The set of the five remaining values is consistent, then the evaluated value (LWM) is the weighted mean with the internal uncertainty.

All absolute γ-ray emission intensities measured by the Euramet participants are summarized in Table 4.

2) A second attempt using all the available measurements was done. Since the Euramet participating laboratories sent their results as relative values also, these six sets of results were used as well as the previous measurements published in the literature. So, 14 sets of data were included in the evaluation (Table 3).

In the Euramet project, the participants sent their results as values relative to the reference line $I\gamma_{602} = 100$; with its uncertainty included in the uncertainties of the other γ-ray lines.
In the other publications, when an author gave an uncertainty on this $I\gamma_{602}$ reference line, then this uncertainty was included into each individual value using the relation : Uc = sqrt ($Uc_{rel}*Uc_{rel} + Uc_{I\gamma602}*Uc_{I\gamma602}$). So, all gamma rays have been treated with emission intensities relative to $I\gamma_{602} = 100$ (with no uncertainty).

Since no beta transition populating the ground state level in Tellurium 124 is expected, the sum of the gamma transition probabilities with energy 2807-, 2693-, 2681-, 2455-, 2323-, 2294-, 2182-, 2039-, 1657-, 1325-, 602-keV which populate the ground state must be equal to 100. That is:

$$\sum_i I_{g_i}\left[1+a_{T\,i}\right]=\frac{100}{N}$$

Where: $I_{\gamma i}$ is the relative emission probability of the gamma-ray, α_{Ti} is its total conversion coefficient, and N is a normalisation factor between the relative and absolute scales.

N, the normalization factor, is then deduced from the measured relative $I_{\gamma i}$ values:

$$N=\frac{100}{\sum_i I_{g_i}\left[1+a_{T\,i}\right]} \quad \text{and} \quad dN^2=\sum_i\left(\frac{\partial N}{\partial I_{g_i}}dI_{g_i}\right)^2+\sum_i\left(\frac{\partial N}{\partial a_{T_i}}da_{T_i}\right)^2$$

The α_T coefficients are theoretical values interpolated from Band's tables (2002Ba85) using the program BrIcc with the "frozen orbital approximation" (Kibédi *et al.* 2008Ki07). All transitions with a measured multipolarity are E2.

This leads to N = 0,97775 (20).

The absolute emission intensity of the 602-keV g-ray is then deduced to be: 97,775 (20) %.

This value is in full agreement with the above value of 97,77 (26) %. However, because of the normalization procedure used, its uncertainty is ten times smaller.
Having in mind that the energies of the involved transitions are relatively high and their respective multipolarities are E2, the conversion coefficient values deduced from theoretical calculations can be considered very reliable. Hence, this second absolute intensity value and its associated uncertainty were adopted here.

All the measured relative gamma emission intensities are summarized in Table 3, with the unweighted mean for each set of values given, as well as the weighted mean, the reduced χ^2 and the internal and external uncertainties, the adopted relative emission intensity value and its uncertainty and the deduced and adopted absolute values.

All the absolute gamma-ray emission intensities measured by the participants in the Euramet 907 project are summarized in Table 4. The most intense lines are compared to those obtained from relative values and conversion coefficients (Table 3) in the following table. The agreement is very good.

g-ray energy keV	From absolute measurements (Table 4)	From relative measurements and ICC (Table 3)
602	97,77 (26)	97,775 (20)
645	7,414 (21)	7,422 (15)
709	1,3635 (43)	1,363 (5)
713	2,269 (11)	2,273 (7)
722	10,712 (31)	10,708 (22)
968	1,880 (6)	1,887 (10)
1045	1,835 (6)	1,852 (14)
1325	1,583 (6)	1,587 (7)
1368	2,615 (9)	2,620 (8)
1690	47,39 (22)	47,46 (19)
2090	5,491 (26)	5,493 (24)

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Table 3 : Relative gamma ray intensities and absolute values calculated with (*)Ig602 = 97,775 (20) %.
(i , j) refers to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	(14,12)	148keV	(-1, 1)	159keV	(16,12)	186keV	(14,10)	189 keV	(20,14)	209keV	(10,6)	254keV	(23,14)	291keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2	0,012	0,005	0,005	0,001			0,002	0,001	(o) 0,0088	0,0012	0,009	0,001	0,0046	0,0008
E907- 3	DL=0,0031		DL=0,0032		DL=0,0041		DL=0,0042		DL=0,0043		0,014	0,002	DL=0,0053	
E907- 5														
E907- 6														
E907- 7	0,0053	0,0012	0,0070	0,0014			0,010	0,006	0,0047	0,0024	0,0159	0,0015	0,0092	0,0010
E907- 8	0,0028	0,0008	0,0045	0,0007			0,0049	0,0005	0,0054	0,0010	0,0165	0,0014	0,0059	0,0012
Patil (2006Pa16)					0,0020	0,0036			(o) 0,0147	0,0005	0,0137	0,0006	0,0070	0,0006
Goswamy (1993Go10)	0,0037	0,0007					0,0037	0,0007	0,0055	0,0010	0,0163	0,0008	0,0088	0,0008
Jianming (1988Yo05)	0,006	0,002					0,006	0,002	0,0062	0,0028	0,0214	0,0041	0,012	0,006
Mardirosian (1984Ma13)											(o) 0,030	0,007		
Iwata (1984Iw03)														
Johnson (1974Jo03)														
Meyer (1990Me15)														
Sharma (1979Sh08)														
Chi2	1,4		1,2				1,6		0,1		4,3		4,0	
Chi2 crit:	3,8		4,6				3,3		3,8		2,8		3,0	
UWM:	0,00449		0,00552				0,00530		0,00546		0,01520		0,00795	
WM:	0,00382		0,00504				0,00441		0,00543		0,01447		0,00713	
Uc (int):	0,00047		0,00054				0,00039		0,00066		0,00041		0,00036	
Uc (ext) :	0,00057		0,00060				0,00049		0,00015		0,00086		0,00073	
LWM :	0,0038	0,0006	0,0050	0,0006			0,00441	0,00049	0,0054	0,0007	0,0145	0,0009	0,0071	0,0007
I Abs.*	0,0037	0,0006	0,0049	0,0006	omitted		0,0043	0,0005	0,0053	0,0007	0,0142	0,0009	0,0069	0,0007

(o) Outlier

Table 3 (Con't) : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	(10,5)	336 keV		346,5 keV	(20,11)	371 keV		385 keV	(20,10)	400 keV	(14,6)	444 keV	(20,9)	469 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2	0,079	0,008	0,0034	0,0016	0,034	0,011	0,038	0,026	0,128	0,008	0,190	0,004	0,053	0,009
E907- 3	0,073	0,004	DL=0,0064		0,033	0,006	DL=0,0078		0,120	0,006	0,198	0,006	0,038	0,003
E907- 5	0,072	0,021			>0,0217	<0,0338			0,146	0,011	0,198	0,011	0,045	0,006
E907- 6									0,175	0,066	0,211	0,076		
E907- 7	0,0733	0,0016	0,0018	0,0018	0,0295	0,0027	DL=0,0024		0,130	0,007	0,1981	0,0024	0,0518	0,0028
E907- 8	0,0708	0,0026	0,0036	0,0025	0,0333	0,0022			0,1246	0,0037	0,1901	0,0047	0,0449	0,0021
Patil (2006Pa16)	0,076	0,002			0,0257	0,0015			0,125	0,007	0,1830	0,0021	0,0364	0,0023
Goswamy (1993Go10)	0,0750	0,0021	0,0060	0,0013	0,034	0,008			0,124	0,013	0,1920	0,0028	0,047	0,003
Jianming (1988Yo05)	(o) 0,086	0,006	0,013	0,005	0,036	0,006			0,155	0,013	0,204	0,010	0,053	0,003
Mardirosian (1984Ma13)	0,078	0,007			0,024	0,006			0,168	0,012	0,226	0,015	(o) 0,079	0,005
Iwata (1984Iw03)					(o) 0,051	0,009			0,129	0,016	0,205	0,010	0,058	0,008
Johnson (1974Jo03)					0,03	0,01			0,132	0,015	0,173	0,015	0,031	0,010
Meyer (1990Me15)									0,15	0,01	0,20	0,01		
Sharma (1979Sh08)					0,0315	0,0025			(o) 0,215	0,006	0,221	0,006	0,064	0,003
Chi2	0,5		1,3		1,4				2,2		4,7		7,4	
Chi2 crit:	2,6		3,8		2,4				2,2		2,1		2,3	
UWM:	0,07459		0,00369		0,03103				0,13890		0,19929		0,04749	
WM:	0,07407		0,00414		0,02925				0,12934		0,19237		0,04685	
Uc (int):	0,00094		0,00083		0,00097				0,00219		0,00116		0,00098	
Uc (ext) :	0,00069		0,00096		0,00115				0,00323		0,00252		0,00267	
LWM :	0,0741	0,0009	0,0041	0,0010	0,0292	0,0011			0,1293	0,0032	0,199	(e)0,016	0,0469	0,0027
I Abs.*	0,0725	0,0009	omitted		0,0286	0,0011	omitted		0,1264	0,0031	0,195	0,016	0,0459	0,0026

(o) Outlier
(e) expanded uncertainty so range to include the most precise Value

Table 3 (Cont'd) : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	?(21,9)	476 keV	(23,10)	481 keV		498 keV	(14, 5)	525 keV	(26, 12)	530 keV		553 keV	(26, 10)	572 keV
	Value	**Uc**	**Value**	**Uc**	**Value**	**Uc**	**Value**	**Uc**	**Value**	**Uc**	**Value**	**Uc**	**Value**	**Uc**
E907- 2	0,046	0,017	0,024	0,007	0,038	0,014	0,1428	0,005	0,043	0,006	0,019	0,005	0,020	0,004
E907- 3	DL=0,0069		(o) 0,015	0,006			0,140	0,005	0,022	0,003			0,013	0,004
E907- 5			>0,0197	<0,0298			0,182	0,009						
E907- 6			(o) 0,163	0,055			(o) 0,055	0,046						
E907- 7	DL=0,0018		0,0253	0,0014	DL=0,0018		0,140	0,005	0,0281	0,0012	0,0019	0,0008	0,0153	0,0017
E907- 8	0,0020	0,0009	0,0269	0,0014	0,0007	0,0005	0,1451	0,0034	0,0431	0,0015				
Patil (2006Pa16)			0,0205	0,0010			0,1429	0,0076	0,0421	0,0013			0,0184	0,0010
Goswamy (1993Go10)			0,024	0,0020			0,14	0,02	0,043	0,002			0,0193	0,0013
Jianming (1988Yo05)			0,029	0,0080			0,165	0,010	0,047	0,011			0,025	0,010
Mardirosian (1984Ma13)			0,030	0,005			0,178	0,012						
Iwata (1984Iw03)							0,117	0,012						
Johnson (1974Jo03)							0,132	0,010						
Meyer (1990Me15)							0,16	0,01						
Sharma (1979Sh08)							0,162	0,004						
Chi2	3,5		3,1				4,5		20,6				1,3	
Chi2 crit:	6,6		2,8				2,2		2,8				3,0	
UWM:	0,02402		0,02567				0,14975		0,03828				0,01843	
WM:	0,02402		0,02367				0,14837		0,03675				0,01799	
Uc (int):	0,01171		0,00065				0,00168		0,00068				0,00070	
Uc (ext) :	0,02198		0,00115				0,00357		0,00310				0,00080	
LWM :	0,024	0,022	0,0237	0,0032			0,1484	0,0036	0,037	(e) 0,009			0,018	0,0008
I Abs.*	omitted		0,0232	0,0031	omitted		0,1451	0,0035	0,036	0,009	omitted		0,0176	0,0008

(o) Outlier
(e) expanded uncertainty so range to include the most precise Value

Table 3 (Cont'd) : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

		592 keV	(1, 0)	602 keV	(5, 3)	632 keV	(2, 1)	646 keV	(21, 6)	662 keV		669 keV	(5, 2)	709 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2			100		0,100	0,008	7,57	0,07	0,041	0,004			1,358	0,019
E907- 3			100		0,098	0,004	7,59	0,10	DL=0,0063				1,388	0,016
E907- 5			100		0,109	0,007	7,603	0,027	<0,0157				1,396	0,007
E907- 6			100				7,69	0,14					1,484	0,072
E907- 7			100		0,1073	0,0010	7,58	0,03	0,0139	0,0009			1,397	0,006
E907- 8			100		0,1053	0,0028	(o) 7,35	0,16	0,0227	0,0012	0,180	0,004	1,36	0,03
Patil (2006Pa16)	0,014	0,002	100		0,0990	0,0013	7,69	0,09	0,0148	0,0010			1,39	0,02
Goswamy (1993Go10)			100		0,1070	0,0015	7,55	0,11	0,032	0,002			1,34	0,02
Jianming (1988Yo05)			100		0,101	0,006	7,55	0,13	0,035	0,011			1,38	0,04
Mardirosian (1984Ma13)			100		0,118	0,007	(o) 7,82	0,22	0,043	0,005			1,49	0,07
Iwata (1984Iw03)			100		0,114	0,006	7,61	0,04	0,016	0,005			1,399	0,012
Johnson (1974Jo03)			100		0,12	0,03	7,53	0,16	0,015	0,003			1,38	0,09
Meyer (1990Me15)			100		0,10	0,01	7,55	0,05					1,38	0,02
Sharma (1979Sh08)			100		0,111	0,003	7,52	0,15	0,0148	0,0015			1,465	0,029
Chi2					3,4		0,3		18,7				1,6	
Chi2 crit:					2,2		2,2		2,4				2,1	
UWM:					0,10692		7,5861		0,02480				1,4008	
WM:					0,10524		7,5911		0,01790				1,3941	
Uc (int):					0,00064		0,0152		0,00050				0,0036	
Uc (ext) :					0,00118		0,0084		0,00217				0,0046	
LWM :					0,1052	(e) 0,0021	7,591	0,015	(u) 0,025	(e) 0,011			1,394	0,005
I Abs.*	Omitted		97,775	0,020	0,1029	0,0021	7,422	0,015	0,024	0,011	omitted		1,363	0,005

(o) Outlier
(e) expanded uncertainty so range to include the most precise Value
(u) unweighted mean

Table 3 (Cont'd) : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	(6, 3)	713 keV	(3, 1)	722 keV	(23, 6)	735 keV		743 keV	(7, 3)	766 keV	(25, 6)	775 keV	(6, 2)	790 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2	2,26	0,03	10,81	0,10	0,137	0,005			0,012	0,003	0,0104	0,0017	0,756	0,008
E907- 3	2,324	0,026	10,95	0,13	0,132	0,006			DL=0,0072		0,000		0,753	0,012
E907- 5	2,327	0,012	10,950	0,037	0,125	0,013			>0,0177	<0,0268			0,756	0,008
E907- 6	2,33	0,09	10,95	0,20	(o) 0,22	0,06							(o) 0,824	0,073
E907- 7	2,33	0,01	10,96	0,04	0,1338	0,0016			0,0080	0,0012	0,0097	0,0005	0,758	0,004
E907- 8	2,26	0,05	10,73	0,24	0,1245	0,0030			0,0089	0,0014	0,0100	0,0014	(o) 0,733	0,016
Patil (2006Pa16)	2,29	0,03	10,88	0,16	0,1399	0,0024	0,0058	0,0011	(o) 0,0039	0,0003	0,0119	0,0012	0,766	0,012
Goswamy (1993Go10)	2,27	0,04	10,77	0,18	0,129	0,002			0,0124	(i) 0,0002	0,0093	0,0018	0,752	0,012
Jianming (1988Yo05)	2,29	0,05	10,99	0,19	0,145	0,021			0,0092	0,0041	0,0112	0,0041	0,753	0,013
Mardirosian (1984Ma13)	2,46	0,09	(o) 11,46	0,16	0,142	0,005			0,009	0,005	0,0112	0,0041	0,766	0,008
Iwata (1984Iw03)	2,338	0,015	11,02	0,06	0,133	0,009							0,758	0,009
Johnson (1974Jo03)	2,43	0,10	11,16	0,20	0,14	0,03							0,763	0,015
Meyer (1990Me15)	2,32	0,03	11,0	0,2	0,14	0,01							0,76	0,01
Sharma (1979Sh08)	2,42	0,05	(o) 11,31	0,22	0,146	0,004							0,734	0,016
Chi2	1,4		0,6		2,8				2,2		0,5		0,2	
Chi2 crit:	2,1		2,2		2,2				3,0		2,8		2,3	
UWM:	2,3317		10,9300		0,1359				0,00986		0,01052		0,75832	
WM:	2,3250		10,9525		0,1342				0,01053		0,01002		0,75842	
Uc (int):	0,0061		0,0224		0,0010				0,00059		0,00041		0,00247	
Uc (ext) :	0,0072		0,0176		0,0016				0,00089		0,00030		0,00120	
LWM :	2,325	0,007	10,952	0,022	0,1342	0,0016			0,0105	0,0009	0,01002	0,00041	0,7584	0,0025
I Abs.*	2,273	0,007	10,708	0,022	0,1312	0,0016	omitted		0,0103	0,0009	0,0098	0,0004	0,7415	0,0024

(o) Outlier
(i) This original uncertainty was increased in order to limit the relative weight to 50%

Table 3 : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

		795 keV	(23, 5)	817 keV	(8, 3)	856 keV	(9, 3)	899 keV		937 keV	(10, 3)	968 keV	(9, 2)	976 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2			0,081	0,007	0,0203	0,006	0,023	0,009	0,0206	0,005	1,907	0,055	0,084	0,005
E907- 3			0,074	0,007	0,017	0,006	0,026	0,016	DL=0,0085		1,921	0,024	(o) 0,095	0,011
E907- 5			0,076	0,013	>0,0187	<0,0288	<0,0187				1,909	0,013	0,088	0,013
E907- 6											(o) 2,857	0,118		
E907- 7			0,0735	0,0037	0,0228	0,0007	0,0175	0,0010	DL=0,0012		1,926	0,008	0,0862	0,0011
E907- 8			0,0745	0,0021	0,0243	0,0017	0,0176	0,0015	0,0032	0,0012	1,873	0,042	0,0833	0,0023
Patil (2006Pa16)	0,0368	0,0012			0,0216	0,0011	0,020	0,001			(o) 2,105	0,031	0,0841	0,0013
Goswamy (1993Go10)			0,074	0,002	0,024	0,001	0,0175	0,0014			1,92	0,028	0,0845	0,0019
Jianming (1988Yo05)			0,074	0,007	0,032	0,006	0,020	0,006			1,945	0,030	0,088	0,005
Mardirosian (1984Ma13)			0,086	0,008	0,027	0,006					2,038	0,024	0,088	0,012
Iwata (1984Iw03)			0,079	0,006	0,029	0,007	0,016	0,009			1,919	0,015	0,088	0,008
Johnson (1974Jo03)			(o) 0,065	0,006	0,022	0,006	0,011	0,004			2,03	0,04	(o) 0,102	0,020
Meyer (1990Me15)											1,93	0,03	0,09	0,01
Sharma (1979Sh08)			0,083	0,003	0,029	0,003	0,028	0,004			2,03	0,04	(o) 0,097	0,004
Chi2			1,1		1,2		1,4		5,3		3,5		0,4	
Chi2 crit:			2,4		2,3		2,4		6,6		2,2		2,4	
UWM:			0,0775		0,02447		0,01962		0,0119		1,9457		0,08639	
WM:			0,0761		0,02315		0,01825		0,0119		1,9304		0,08512	
Uc (int):			0,0012		0,00048		0,00059		0,0038		0,0053		0,00070	
Uc (ext) :			0,0012		0,00052		0,00071		0,0087		0,0099		0,00042	
LWM :			0,0761	0,0012	0,0232	0,0005	0,0183	0,0007	0,012	0,009	1,93	0,01	0,0851	0,0007
I Abs.*	omitted		0,0744	0,0012	0,0227	0,0005	0,0179	0,0007	omitted		1,887	0,010	0,0832	0,0007

(o) Outlier

Table 3 (Cont'd) : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	(-1,2)	997 keV		1014 keV	(10, 2)	1045 keV	(4, 1)	1053 keV	(12, 2)	1086 keV	1097 keV			1163 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2	0,025	0,007			1,884	0,036			0,041	0,004	0,034	0,008		
E907- 3	DL=0,0091		DL=0,0093		1,867	0,024	DL=0,0097		0,042	0,009			DL=0,0108	
E907- 5					1,861	0,017			0,050	0,008				
E907- 6					2,00	0,11								
E907- 7	0,0014	0,0014 (i)	0,0025	0,0025	1,880	0,008	0,0026	0,0026	0,0369	0,0012	DL=0,0019		DL=0,0019	
E907- 8	0,0046	0,0009	0,0046	0,0014	1,841	0,041	0,0036	0,0012	0,0368	0,0018	0,0026	0,0012	0,0033	
Patil (2006Pa16)					2,026	0,022			0,0358	0,0016				
Goswamy (1993Go10)					1,87	0,03	0,005	0,002	0,038	0,002				
Jianming (1988Yo05)					1,90	0,03			0,043	0,005				
Mardirosian (1984Ma13)					2,01	0,02	0,007	0,001	(o) 0,058	0,005				
Iwata (1984Iw03)					1,86	0,02			0,038	0,009				
Johnson (1974Jo03)					1,92	0,04			0,031	0,005				
Meyer (1990Me15)					1,88	0,04								
Sharma (1979Sh08)					1,97	0,04			0,046	0,004				
Chi2	5,8		0,5		6,2		1,9		1,2					
Chi2 crit:	4,6		6,6		2,1		3,8		2,3					
UWM:	0,01033		0,00354		1,9123		0,00457		0,03985					
WM:	0,00343		0,00408		1,8936		0,00538		0,03739					
Uc (int):	0,00099		0,00124		0,0053		0,00070		0,00074					
Uc (ext) :	0,00238		0,00088		0,0133		0,00097		0,00081					
LWM :	0,0034	0,0024	0,0041	0,0012	1,894	0,014	0,0054	0,0010	0,0374	0,0008				
I Abs.*	0,0033	0,0023	Omitted		1,852	0,014	0,0053	0,0010	0,0366	0,0008	omitted		omitted	

(o) Outlier
(i) This original uncertainty was increased in order to limit the relative weight to 50%

Table 3 : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

		1180 keV		1198 keV		1205 keV	(-1,3)	1235 keV		1253 keV	(15, 2)	1263 keV		1269 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2							0,028	0,006	0,042	0,009	0,043	0,004		
E907- 3			DL=0,0112		DL=0,012				DL=0,0117		0,030	0,010	DL=0,0118	
E907- 5											0,031	0,008		
E907- 6														
E907- 7			DL=0,002		DL=0,016		0,0047	[i] 0,0010	DL=0,0019		0,0413	0,0015	DL=0,0019	
E907- 8	0,630	0,014	0,0031	0,0009	0,0314	0,0012	0,0094	0,0012			0,0382	0,0018	0,0037	0,0013
Patil (2006Pa16)											0,0482	0,0015		
Goswamy (1993Go10)											0,042	0,002		
Jianming (1988Yo05)											0,043	0,005		
Mardirosian (1984Ma13)											0,054	0,010		
Iwata (1984Iw03)											0,046	0,015		
Johnson (1974Jo03)											0,045	0,010		
Meyer (1990Me15)														
Sharma (1979Sh08)											0,057	0,005		
Chi2							9,8				3,1			
Chi2 crit:							4,6				2,2			
UWM:							0,0141				0,0432			
WM:							0,0075				0,0432			
Uc (int):							0,00086				0,0008			
Uc (ext) :							0,00269				0,0014			
LWM :							0,0075	0,0027			0,0432	[e] 0,0019		
I Abs.*	Omitted		omitted		omitted		0,0073	0,0026	omitted		0,0422	0,0019	omitted	

[e] expanded uncertainty so range to include the most precise Value
[i] This original uncertainty was increased in order to limit the relative weight to 50%

Table 3 : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	(17, 2)	1301 keV	(3, 0)	1325 keV	(5, 1)	1355 keV	(20, 3)	1368 keV	(21, 3)	1376 keV	(22, 3)	1385 keV		1418 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2	0,032	0,004	1,637	0,033	1,066	0,031	2,650	0,045	0,521	0,021	0,072	0,006		
E907- 3	0,047	0,010	1,599	0,027	1,059	0,022	2,628	0,034	0,481	0,016	0,051	0,012		
E907- 5	0,037	0,009	1,603	0,016	1,055	0,022	2,686	0,017	0,505	0,009	0,064	0,008		
E907- 6			1,582	0,137	1,011	0,114	2,65	0,13	0,516	0,099	(o) 0,20	0,08		
E907- 7	0,0339	0,0021	1,621	0,007	1,062	0,004	2,682	0,011	0,5130	(i) 0,0034	0,070	0,002		
E907- 8	0,037	0,003	(o) 1,768	0,040	1,070	0,024	2,633	0,061	0,493	0,011	0,060	0,002		
Patil (2006Pa16)	0,0256	0,0013	1,707	0,026	1,093	0,017	2,7	0,034	0,543	0,007	0,064	0,002	0,005	0,002
Goswamy (1993Go10)	0,035	0,001	1,61	0,03	1,05	0,015	2,64	0,04	0,493	0,008	0,062	0,003		
Jianming (1988Yo05)	0,039	0,005	1,645	0,028	1,103	0,021	2,696	0,041	0,496	0,011	0,071	0,006		
Mardirosian (1984Ma13)	(o) 0,061	0,008	1,69	0,29	1,108	0,022	2,758	0,069	0,531	0,046	0,079	0,025		
Iwata (1984Iw03)	0,041	0,015	1,584	0,023	1,042	0,027	2,67	0,03	0,50	0,02	0,061	0,026		
Johnson (1974Jo03)			1,67	0,04	(o) 1,14	0,04	2,76	0,06	0,54	0,03	(o) 0,03	0,01		
Meyer (1990Me15)			1,66	0,04	1,06	0,04	2,68	0,05	0,51	0,04				
Sharma (1979Sh08)	0,045	0,004	1,71	0,04	1,17	0,02	(o) 2,82	0,06	(o) 0,572	0,012	0,053	0,003		
Chi2	5,5		2,0		1,1		0,7		2,9		3,5			
Chi2 crit:	2,4		2,2		2,2		2,2		2,2		2,3			
UWM:	0,0372		1,6399		1,06493		2,6794		0,51101		0,06434			
WM:	0,0327		1,6233		1,06491		2,6796		0,51128		0,06337			
Uc (int):	0,0007		0,0051		0,00363		0,0076		0,00258		0,00096			
Uc (ext) :	0,0017		0,0073		0,00387		0,0063		0,00438		0,00180			
LWM :	(u) 0,0372	(e) 0,0022	1,623	0,007	1,0649	0,0039	2,680	0,008	0,5113	0,0044	0,063	(e) 0,006		
I Abs.*	0,0364	0,0022	1,587	0,007	1,0412	0,0038	2,620	0,008	0,4999	0,0043	0,062	0,006	omitted	

(o) Outlier
(e) expanded uncertainty so range to include the most precise Value
(u) unweighted mean

Table 3 (Cont'd) : Relative gamma ray intensities and absolute Values calculated with [*]Ig602 = 97,775 (20) %.
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	1428 keV		(6, 1)	1436 keV	(20, 2)	1445 keV	(21, 2) ?	1453 keV	(7, 1)	1489 keV		1509 keV	(23, 2)	1526 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2	0,049	0,007	1,253	0,026	0,336	0,008	0,032	0,007	0,686	0,018	0,052	0,016	0,421	0,019
E907- 3			1,266	0,022	0,309	0,014	DL=0,0163		0,684	0,016			0,404	0,012
E907- 5			1,244	0,031	0,350	0,012			0,693	0,015			0,443	0,016
E907- 6			1,19	0,10	0,38	0,09			0,71	0,09			0,43	0,08
E907- 7	DL=0,0026		1,257	[i] 0,005	0,336	[i] 0,002	DL=0,0027		0,700	0,007			0,4184	[i] 0,0026
E907- 8	0,0276	[i] 0,0017	1,313	0,030	0,384	0,009	0,080	0,002	0,667	0,015	0,0074	0,0025	0,398	0,010
Patil (2006Pa16)			1,27	0,017	0,335	0,032			0,692	0,009	0,008	0,001	0,451	0,006
Goswamy (1993Go10)			1,25	0,016	0,334	0,005			0,687	0,009			0,414	0,006
Jianming (1988Yo05)			1,236	0,021	0,346	0,011			0,71	0,05			0,434	0,010
Mardirosian (1984Ma13)			1,34	0,27	0,329	0,014			0,72	0,02			0,433	0,008
Iwata (1984Iw03)			1,225	0,024	0,358	0,017			0,68	0,02			0,41	0,02
Johnson (1974Jo03)			1,38	0,04	0,30	0,03			0,70	0,03			0,45	0,02
Meyer (1990Me15)			1,26	0,05	0,34	0,04			0,71	0,03			0,41	0,03
Sharma (1979Sh08)			1,37	0,03	0,41	0,01			[o] 0,80	0,02			[o] 0,49	0,01
Chi2	4,9		2,5		7,2		21,4		0,7		3,7		3,4	
Chi2 crit:	6,6		2,1		2,1		6,6		2,2		4,6		2,2	
UWM:	0,0383		1,2748		0,3460		0,0561		0,6959		0,0225		0,4241	
WM:	0,0383		1,2619		0,3423		0,0561		0,6924		0,0081		0,4232	
Uc (int):	0,0049		0,0051		0,0021		0,0052		0,0038		0,0009		0,0022	
Uc (ext) :	0,0107		0,0080		0,0057		0,0241		0,0031		0,0018		0,0040	
LWM :	0,038	0,011	1,262	0,008	0,342	[e] 0,007	0,056	0,024	0,6924	0,0038	0,0081	0,0018	0,423	0,005
I Abs.*	omitted		1,234	0,008	0,334	0,007	omitted		0,677	0,0037	omitted		0,414	0,005

[o] Outlier
[e] expanded uncertainty so range to include the most precise Value
[i] This original uncertainty was increased in order to limit the relative weight to 50%

Table 3 : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	1557 keV		(25, 2)	1565 keV	(8, 1)	1580 keV	(9, 1)	1622 keV	(4, 0)	1657 keV	(10, 1)	1691 keV	(11, 1)	1720 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2					0,441	0,018	0,041	0,003			46,72	1,16	0,098	0,005
E907- 3			DL=0,0105		0,422	0,015	0,043	0,008	DL=0,0089		48,08	0,57	(o) 0,090	0,004
E907- 5			>0,0197	<0,0298	0,414	0,008					48,28	0,21	0,100	0,007
E907- 6							(o) 0,22	0,05			49,12	0,94	(o) 0,135	0,044
E907- 7	DL=0,0017		0,012	0,001	(r) 0,145	0,001	0,041	0,001	DL=0,0012		48,70	0,18	0,0967	0,0007
E907- 8	0,014	0,007	0,006	(i) 0,001	0,354	0,009	0,042	0,001	0,0086	0,0034	46,35	1,13	0,0963	0,0025
Patil (2006Pa16)					0,460	0,006	0,0477	0,0013			46,63	0,65	0,097	0,0180
Goswamy (1993Go10)			0,015	0,004	0,427	0,007	0,042	0,001			49,32	0,74	0,096	0,0022
Jianming (1988Yo05)			0,013	0,004	0,42	0,04	0,040	0,004			48,73	0,78	0,102	0,0041
Mardirosian (1984Ma13)					(r) 0,238	0,007	0,047	0,004			50,88	0,88	0,101	0,005
Iwata (1984Iw03)					(r) 0,155	0,012	0,035	0,012			48,58	0,25	0,097	0,0070
Johnson (1974Jo03)					(r) 0,15	0,05	(o) 0,03	0,01			51,3	1,0	0,096	0,007
Meyer (1990Me15)					0,42	0,03					48,4	0,8		
Sharma (1979Sh08)					0,49	0,01	0,047	0,003			50,6	1,0	(o) 0,104	0,003
Chi2			2,9		0,4		3,0				3,0		0,3	
Chi2 crit:			3,8		3,3		2,4				2,1		2,4	
UWM:			0,0114		0,4203		0,0425				48,692		0,09794	
WM:			0,0111		0,4217		0,0425				48,545		0,09684	
Uc (int):			0,0007		0,0047		0,0005				0,108		0,00063	
Uc (ext) :			0,0012		0,030		0,0009				0,186		0,00035	
LWM :			0,0111	0,0012	0,422	0,005	0,0425	(e) 0,0019			48,54	0,19	0,0968	0,0006
I Abs.*	omitted		0,0109	0,0012	0,412	0,005	0,0416	0,0019			47,46	0,19	0,0946	0,0006

(i) This original uncertainty was increased in order to limit the relative weight to 50%
(r) Removed from analysis
(o) Outlier
(e) expanded uncertainty so range to include the most precise Value

Table 3 (Cont'd) : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.

(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

		1757 keV	(13, 1)	1852 keV	(16, 1)	1918 keV		1950 keV		1970 keV	(18, 1)	2016 keV	(6, 0)	2039 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2					0,056	0,005					0,013	0,002	0,0633	0,004
E907- 3			DL=0,0077		0,051	0,003			DL=0,016		0,008	0,002	0,064	0,003
E907- 5					0,054	0,008							0,064	0,006
E907- 6	0,007	0,021	(o) 0,341	0,061	(o) 0,077	0,038								
E907- 7	DL=0,0009		0,0054	0,0006	0,0537	0,0005	DL=0,0006				0,0092	(i) 0,0003	0,0636	0,0006
E907- 8			0,0008	(i) 0,0001	0,0529	0,0019	0,053	0,011			0,0098	0,0011	(o) 0,0753	0,0020
Patil (2006Pa16)			0,0026	0,0001	0,058	0,016					0,0090	0,0009	0,0661	0,0020
Goswamy (1993Go10)	0,0049	0,0023	0,0062	0,0009	0,055	0,002					0,0112	0,0010	0,066	0,0021
Jianming (1988Yo05)			(o) 0,0112	0,0031	0,06	0,03					0,0124	0,0007	0,068	0,0021
Mardirosian (1984Ma13)	0,0188	0,0035	0,0025	0,0025	0,055	0,003					0,0112	0,0025	0,068	0,003
Iwata (1984Iw03)					0,052	0,004					0,0093	0,0026	(o) 0,0589	0,0029
Johnson (1974Jo03)					0,058	0,004					0,007	0,002	0,067	0,004
Meyer (1990Me15)					0,05	0,01							0,07	0,01
Sharma (1979Sh08)					0,059	0,002					0,012	0,001	0,067	0,003
Chi2	4,0		10,5		0,8						2,9		0,9	
Chi2 crit:	4,6		3,3		2,2						2,3		2,3	
UWM:	0,01032		0,00350		0,05494						0,01017		0,06611	
WM:	0,01170		0,00314		0,05405						0,00999		0,06446	
Uc (int):	0,0024		0,0003		0,00046						0,00026		0,00051	
Uc (ext) :	0,0049		0,0009		0,00042						0,00044		0,00049	
LWM :	0,0117	0,0049	0,0031	0,0009	0,0541	0,0005					0,0100	(e) 0,0008	0,0645	0,0005
I Abs.*	omitted		0,0030	0,0009	0,0529	0,0005	omitted		omitted		0,0098	0,0008	0,0631	0,0005

(o) Outlier
(e) expanded uncertainty so range to include the most precise Value
(i) This original uncertainty was increased in order to limit the relative weight to 50%

Table 3 (Cont'd) : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	(19, 1)	2079 keV	(20, 1)	2090,9 keV	(21, 1)	2099 keV	(22, 1)	2108 keV		2145 keV		2151 keV	(23, 1)	2172 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2	0,0289	0,003	5,28	0,20	0,046	0,003	0,052	0,003						
E907- 3	0,024	0,001	5,56	0,08	0,058	0,001	0,048	0,001					0,0030	0,0003
E907- 5	0,018	0,002	5,59	0,05	0,054	0,003	0,057	0,004						
E907- 6														
E907- 7	0,0206	0,0006	5,63	0,02	0,0448	(i) 0,0004	0,0430	(i) 0,0003			DL=0,0002		0,0014	(i) 0,0001
E907- 8	0,0213	0,0008	5,34	0,14	0,0532	0,0016	0,0457	0,0013			0,0010	0,0005	0,0057	0,0002
Patil (2006Pa16)	(o) 0,0741	0,0019	5,40	0,07	0,0572	0,0013	0,0501	0,0009	0,00068	0,0000				
Goswamy (1993Go10)	0,0268	0,0014	5,74	0,09	0,047	0,001	0,045	0,002					0,0021	0,0005
Jianming (1988Yo05)	0,0163	0,0025	5,69	0,11	0,046	0,002	0,044	0,002						
Mardirosian (1984Ma13)	0,037	0,009	5,92	0,1	0,037	0,005	0,035	0,005					0,0046	0,0010
Iwata (1984Iw03)	0,0163	0,0025	5,59	0,03	0,045	0,006	0,0438	0,0027						
Johnson (1974Jo03)	(r) 0,081		5,86	0,14	0,051	0,020	0,056	0,010						
Meyer (1990Me15)			5,7	0,1	0,04	0,01	0,04	0,01						
Sharma (1979Sh08)	0,0305	0,0010	5,75	0,12	0,04	0,01	0,047	0,002						
Chi2	12,2		2,8		12,0		6,1						74,3	
Chi2 crit:	2,4		2,2		2,2		2,2						3,3	
UWM:	0,02393		5,6195		0,04762		0,04667						0,00337	
WM:	0,02286		5,6176		0,04824		0,04540						0,00301	
Uc (int):	0,00036		0,0150		0,00042		0,00037						0,00011	
Uc (ext) :	0,0012		0,025		0,00146		0,00092						0,00094	
LWM :	0,0229	(e) 0,0023	5,618	0,025	0,0482	(e) 0,0034	0,0454	(e) 0,0024					0,0030	(e) 0,0016
I Abs.*	0,0224	0,0022	5,493	0,024	0,0471	0,0033	0,0444	0,0023	omitted		omitted		0,0029	0,0016

(i) This original uncertainty was increased in order to limit the relative weight to 50%
(o) Outlier
(e) expanded uncertainty so range to include the most precise Value

Table 3 (Cont'd) : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.

(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	(8, 0)	2182 keV	? (24, 1)	2204 keV	? (9, 0)	2224 keV		2232 keV		2253 keV		2256 keV		2274 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2	0,043	0,003	0,030	0,002	0,021	0,013								
E907- 3	0,041	0,001												
E907- 5	0,042	0,008												
E907- 6														
E907- 7	0,0422	0,0004	0,0004	0,0002	0,0002	0,0001			DL=0,00014		DL=0,00015			
E907- 8	0,0424	0,0011	0,0051	0,0002	0,0020	0,0003			0,0006	0,0001			0,0008	0,0003
Patil (2006Pa16)	(o) 0,036	0,007	0,0310	0,0007			0,001	0,003			0,0006	0,0002		
Goswamy (1993Go10)	0,044	0,001												
Jianming (1988Yo05)	0,045	0,002												
Mardirosian (1984Ma13)	(o) 0,048	0,002												
Iwata (1984Iw03)	0,0398	0,0019												
Johnson (1974Jo03)	0,041	0,003												
Meyer (1990Me15)	0,04	0,01												
Sharma (1979Sh08)	0,044	0,001												
Chi2	1,0		706,4		11,9									
Chi2 crit:	2,3		3,8		4,6									
UWM:	0,04217		0,01671		0,00773									
WM:	0,04241		0,00415		0,00109									
Uc (int):	0,00032		0,00015		0,00020									
Uc (ext) :	0,00031		0,00392		0,00068									
LWM :	0,04241	0,00032	0,017	0,016	0,0011	0,0009								
I Abs.*	0,04147	0,00031	Omitted		omitted		omitted		omitted		omitted		omitted	

(o) Outlier

Table 3 (Cont'd) : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

	(27, 1)	2283 keV	(10, 0)	2294 keV	(11, 0)	2323 keV		2373 keV		2386 keV	(13, 0)	2455 keV		2490 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2	(o) 0,024	0,015	(r) 0,082	0,007	(o) 0,0098	0,0044					0,0093	0,0034		
E907- 3	0,0051	0,0004	0,029	(i) 0,001	DL=0,005		DL=0,0049		DL=0,004					
E907- 5			0,032	0,002										
E907- 6														
E907- 7	0,0046	0,0006	0,0342	0,0010	0,0020	(i) 0,0001					0,0015	0,0002		
E907- 8	0,0064	0,0004	(o) 0,413	0,011	0,0037	0,0003					0,0019	0,0003		
Patil (2006Pa16)	(o) 0,0422	0,0010	0,056	0,023	(o) 0,0060	0,0003	0,0009	0,0003	0,00024	0,00002	(r) 0,0092	0,0001	0,0020	0,0010
Goswamy (1993Go10)	0,0101	0,0008	(r) 0,076	0,005	0,0027	0,0003					0,0018	0,0002		
Jianming (1988Yo05)	0,0076	0,0014	0,031	0,005	0,0025	0,0007					0,0016	0,0006		
Mardirosian (1984Ma13)	0,010	0,002	0,045	0,002	0,004	0,001					0,0010	0,0005		
Iwata (1984Iw03)	0,0041	0,0013	0,031	0,010										
Johnson (1974Jo03)	0,007	0,002	0,025	0,005										
Meyer (1990Me15)	0,008	0,001	0,031	0,001										
Sharma (1979Sh08)	0,0051	0,0006	0,059	0,002										
Chi2	5,8		43,2		5,7						0,8			
Chi2 crit:	2,4		2,4		3,3						3,3			
UWM:	0,00677		0,0374		0,00298						0,00156			
WM:	0,00596		0,03335		0,00260						0,00164			
Uc (int):	0,00020		0,00042		0,00014						0,00012			
Uc (ext) :	0,00048		0,0027		0,00034						0,00011			
LWM :	0,0060	0,0005	0,0334	(e) 0,0042	0,0026	(e) 0,0006					0,00164	0,00012		
I Abs.*	0,0059	0,0005	0,0327	0,0041	0,0025	0,0006	omitted		omitted		0,00160	0,00012	omitted	

(o) Outlier
(e) expanded uncertainty so range to include the most precise Value
(r) removed from analysis
(i) This original uncertainty was increased in order to limit the relative weight to 50%

Table 3 (Cont'd) : Relative gamma ray intensities and absolute Values calculated with (*)Ig602 = 97,775 (20) %.
(i , j) refer to initial and final levels, (-1, n) transition not placed in the decay scheme. DL = Detection Limit

		2515 keV	(19, 0)	2682 keV	(20, 0)	2693 keV		2746 keV	(24, 0)	2807 keV		2814 keV		2871 keV
	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc	Value	Uc
E907- 2			(o) 0,007	0,003	0,0048	0,0021			(o) 0,0069	0,003				
E907- 3					0,0019	0,0001								
E907- 5					0,0025	0,0003								
E907- 6														
E907- 7			0,0017	0,0001	0,0033	0,0001			0,0007	0,0002			0,0002	0,0001
E907- 8			0,0019	0,0001	(o) 0,0433	0,0012			0,0016	0,0002				
Patil (2006Pa16)	0,00049	0,00001			0,0003	0,0001	0,0010	0,0001			0,0035	0,0002		
Goswamy (1993Go10)			0,0020	0,0004	0,0047	0,0005			0,0015	0,0002				
Jianming (1988Yo05)			0,0018	0,0006	0,0026	0,0016			0,0020	0,0008				
Mardirosian (1984Ma13)			(o) 0,0025	0,0010	0,0056	0,0010								
Iwata (1984Iw03)					0,0027	0,0019								
Johnson (1974Jo03)					0,0024	0,0005								
Meyer (1990Me15)					0,0026	0,0003								
Sharma (1979Sh08)					0,0066	0,0005								
Chi2			0,7		48,2				4,5					
Chi2 crit:			3,8		2,2				3,8					
UWM:			0,00187		0,00334				0,00145					
WM:			0,00180		0,00186				0,00121					
Uc (int):			0,00006		0,00005				0,00011					
Uc (ext) :			0,00005		0,00038				0,00024					
LWM :			0,00180	0,00006	(u) 0,0033	(e) 0,0014			0,0012	(e) 0,0005				
I Abs.*	omitted		0,00176	0,00006	0,0032	0,0014	omitted		0,0012	0,0005	omitted		omitted	

(o) Outlier
(e) expanded uncertainty so range to include the most precise Value
(u) unweighted mean

Table 4 : Absolute gamma ray intensity Value measured by the participants in the Euramet project 907; in %.

	148 keV		158 keV		185 keV		189 keV		210 keV		254 keV		291 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2	0,012	0,005	0,005	0,001			0,002	0,001	0,0086	0,0012	0,0089	0,0014	0,0045	0,0008
E907- 3	DL=0,0031		DL=0,0032		DL=0,0041		DL=0,0042		DL=0,0043		0,013	0,002	DL=0,0053	
E907- 5														
E907- 6														
E907- 7	0,0052	0,0011	0,0069	0,0014			0,0096	0,0058	0,0046	0,0023	0,0155	0,0015	0,0090	0,0009
E907- 8	0,0029	0,00084	0,0046	0,0007			0,0053	0,0005	0,0054	0,0010	0,0159	0,0014	0,0054	0,0011
Chi2	3,0		1,1				2,5		2,5		5,2		6,9	
Chi2 crit:	4,6		4,6				4,6		4,6		3,8		4,6	
UWM:	0,00669		0,00549				0,0056		0,00621		0,01340		0,00631	
WM:	0,00385		0,00506				0,0050		0,00649		0,01345		0,00618	
Uc (int):	0,00067		0,00055				0,0005		0,00073		0,00076		0,00053	
Uc (ext) :	0,00115		0,00056				0,0008		0,00114		0,00172		0,00140	
LWM :	0,0038	0,0012	0,0051	0,0006			0,005	0,0008	0,0065	0,0011	0,0135	(e) 0,0025	0,0062	(e) 0,0017

	335 keV		346 keV		370 keV		385 keV		400 keV		443 keV		468 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2	0,077	0,007	0,0033	0,0016	0,033	0,011	0,037	0,025	0,124	0,008	(o) 0,186	0,004	0,052	0,009
E907- 3	0,071	0,004	DL=0,0064		0,032	0,006	DL=0,0078		0,117	0,006	0,194	0,005	0,037	0,003
E907- 5	0,071	0,020			>0,0217	<0,0328			0,143	0,011	0,193	0,011	0,044	0,006
E907- 6									0,16	0,06	0,192	0,069		
E907- 7	0,0717	0,0015	0,0018	0,0018	0,0289	0,0026	DL=0,0023		0,13	0,01	0,1938	0,0023	0,0507	0,0027
E907- 8	0,0710	0,0024	0,0034	0,0023	0,0334	0,0021			0,125	0,003	0,1899	0,0037	0,0467	0,0021
Chi2	0,0		0,3		0,6				1,0		0,2		3,0	
Chi2 crit:	3,8		4,6		3,8				3,0		3,3		3,3	
UWM:	0,07116		0,00280		0,03186				0,13252		0,19259		0,04617	
WM:	0,07144		0,00276		0,03167				0,12446		0,19289		0,04577	
Uc (int):	0,00123		0,00105		0,00155				0,00236		0,00183		0,00139	
Uc (ext) :	0,00020		0,00053		0,00122				0,00232		0,00086		0,00239	
LWM :	0,0714	0,0012	0,0028	0,001	0,0317	0,0016			0,1245	0,0024	0,1929	0,0018	0,0458	0,0024

	476 keV		481 keV		498 keV		525 keV		530 keV		553 keV		571 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2	0,045	0,016	0,023	0,007	0,037	0,014	0,1393	0,0045	0,042	0,005	0,019	0,005	0,020	0,004
E907- 3	DL=0,0069		0,014	0,006			0,1367	0,0044	0,022	0,003			0,012	0,004
E907- 5			>0,0187	<0,0288			(o) 0,178	0,009						
E907- 6			0,148	0,050			(o) 0,050	0,042						
E907- 7	DL=0,0018		0,0248	0,0013	DL=0,0018		0,1372	0,0050	0,0275	(i) 0,0012	0,0019	0,0008	0,0149	0,0017
E907- 8	0,0019	0,0008	0,0250	0,0012	0,0007	(i) 0,0005	0,1449	0,0026	0,0433	0,0014				
Chi2	3,5		1,0		3,5		1,3		31,2				0,9	
Chi2 crit:	6,6		3,8		6,6		3,8		3,8				4,6	
UWM:	0,02344		0,02175		0,01884		0,13952		0,03348				0,01575	
WM:	0,02344		0,02465		0,01884		0,14138		0,03338				0,01508	
Uc (int):	0,01146		0,00088		0,00968		0,00187		0,00086				0,00143	
Uc (ext) :	0,02156		0,00087		0,01816		0,00211		0,00480				0,00136	
LWM :	0,023	0,022	0,0247	0,0009	0,019	0,018	0,1414	0,0021	0,033	(e) 0,006			0,0151	0,0014

	602 keV		632 keV		645 keV		662 keV		669 keV		709 keV		713 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2	97,5	0,7	0,098	0,007	7,386	0,058	0,040	0,004			(o) 1,325	0,019	2,205	0,029
E907- 3	97,8	0,9	0,096	0,004	7,42	0,07	DL=0,0063				1,358	0,009	2,273	0,015
E907- 5	97,6	0,7	0,106	0,007	7,420	0,053	<0,0157				1,362	0,011	2,270	0,018
E907- 6	(o) 91	1			(o) 7,00	0,11					1,350	0,065	(o) 2,12	0,08
E907- 7	97,84	0,34	0,1050	0,0012	7,417	0,028	0,0136	0,0009			1,3671	0,0056	2,28	0,01
E907- 8	98,1	1,5	0,1052	0,0023	(o)7,33	0,11	0,0229	0,0011	0,1793	0,0029	1,350	0,021	2,21	0,04
Chi2	0,1		1,4		0,1		36,6				0,3		2,1	
Chi2 crit:	3,3		3,3		3,8		4,6				3,3		3,3	
UWM:	97,787		0,10209		7,4117		0,0254				1,35734		2,2475	
WM:	97,769		0,10440		7,4137		0,0190				1,36347		2,2694	
Uc (int):	0,260		0,00098		0,0214		0,0007				0,00426		0,0074	
Uc (ext) :	0,071		0,00115		0,0065		0,0045				0,00246		0,0107	
LWM :	97,77	0,26	0,1044	0,0011	7,414	0,021	0,019	0,005			1,3635	0,0043	2,269	0,011

	722 keV		735 keV		765 keV		775 keV		790 keV		816 keV		856 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2	(o) 10,538	0,084	0,134	0,005	0,0114	0,003	0,0101	0,002	0,737	0,007	(o) 0,079	0,006	0,020	0,001
E907- 3	10,713	0,072	0,129	0,005	DL=0,0072		DL=0,0073		0,737	0,010	0,072	0,007	0,017	0,005
E907- 5	10,680	0,075	0,122	0,012	>0,0167	<0,0258			0,737	0,009	0,074	0,013	>0,0177	<0,0278
E907- 6	(o) 9,96	0,16	(o) 0,200	0,054					0,750	0,066				
E907- 7	10,72	0,04	0,1309	(i) 0,0016	0,0078	0,0012	0,0095	0,0005	0,742	0,004	0,0719	0,0036	0,0223	0,0007
E907- 8	10,71	0,17	0,1173	0,0022	0,0085	0,0013	0,0093	0,0013	0,727	0,012	0,0745	0,0017	0,0230	0,0015
Chi2	0,1		6,4		0,6		0,1		0,3		0,2		3,1	
Chi2 crit:	3,8		3,3		4,6		4,6		3,0		3,8		3,8	
UWM:	10,7067		0,1266		0,00925		0,00962		0,73830		0,07313		0,02049	
WM:	10,7122		0,1260		0,00836		0,00951		0,73906		0,07398		0,02108	
Uc (int):	0,0310		0,0013		0,00084		0,00044		0,00293		0,00150		0,00044	
Uc (ext) :	0,0087		0,0033		0,00063		0,00013		0,00173		0,00060		0,00078	
LWM :	10,712	0,031	0,126	(e) 0,005	0,0084	0,0008	0,00951	0,00044	0,7391	0,0029	0,0740	0,0015	0,0211	0,0008

	899 keV		937 keV		968 keV		976 keV		997 keV		1014 keV		1045 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2	0,022	0,009	0,020	0,005	1,86	0,05	0,082	0,005	0,024	0,007	0		1,837	0,033
E907- 3	0,026	0,016	DL=0,0085		1,880	0,018	(o) 0,093	0,011	DL=0,0091		DL=0,0093		1,826	0,019
E907- 5	<0,0187				1,863	0,017	0,086	0,013					1,816	0,020
E907- 6					(i) 2,60	0,11							1,82	0,10
E907- 7	0,0171	0,0010	DL=0,0012		1,88	0,01	0,0843	0,0010	0,0014	0,0014	0,0025	0,0025	1,839	0,008
E907- 8	0,0171	0,0014	0,0030	(i) 0,0012	1,87	0,03	0,0824	0,0019	0,0037	(i) 0,0007	0,0068	0,0021	1,836	0,029
Chi2	0,2		5,3		0,4		0,4		5,4		1,8		0,3	
Chi2 crit:	3,8		6,6		3,3		3,8		4,6		6,6		3,0	
UWM:	0,02041		0,0116		1,8711		0,08360		0,00971		0,00463		1,8292	
WM:	0,01717		0,0116		1,8797		0,08379		0,00300		0,00497		1,8350	
Uc (int):	0,00079		0,0037		0,0064		0,00090		0,00097		0,00161		0,0063	
Uc (ext) :	0,00035		0,0085		0,0040		0,00054		0,00224		0,00215		0,0034	
LWM :	0,0172	0,0008	0,012	0,009	1,880	0,006	0,0838	0,0009	0,0030	0,0022	0,0050	0,0021	1,835	0,006

	1053 keV		1086 keV		1097 keV		1163 keV		1180 keV		1198 keV		1205 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2			0,040	0,004	0,0335	0,008								
E907- 3	DL=0,0097		0,041	0,009			DL=0,0108				DL=0,0112		DL=0,0115	
E907- 5			(o) 0,049	0,008										
E907- 6														
E907- 7	0,0026	0,0026	0,0361	0,0012	DL=0,0019		DL=0,0019				DL=0,002		DL=0,016	
E907- 8	0,0038	0,0013	0,0369	0,0017	0,0028	(i) 0,0013	0,0016	0,0010	0,606	0,010	0,0030	0,0009	0,0142	0,0005
Chi2	0,2		0,4		7,3									
Chi2 crit:	6,6		3,8		6,6									
UWM:	0,00319		0,03850		0,01815									
WM:	0,00357		0,03660		0,01815									
Uc (int):	0,00116		0,00095		0,00569									
Uc (ext) :	0,00051		0,00057		0,01535									
LWM :	0,0036	0,0012	0,0366	0,0009	0,018	0,015								

	1235 keV		1253 keV		1263 keV		1269 keV		1301 keV		1325 keV		1355 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2	0,027	0,006	0,041	0,009	0,042	0,004			0,031	0,004	1,597	0,030	1,039	0,029
E907- 3			DL=0,0117		0,029	0,010	DL=0,0118		0,046	0,010	1,565	0,024	1,036	0,020
E907- 5					0,030	0,008			0,036	0,009	1,564	0,018	1,029	0,022
E907- 6											(o) 1,440	0,124	(o) 0,92	0,10
E907- 7	0,0046	(i) 0,0009	DL=0,0018		0,0404	0,0014	DL=0,0019		0,0332	0,0021	1,586	0,006	1,0394	0,0043
E907- 8	0,0116	0,0015	0,0005			0,0016	0,0028	0,0010	0,0376	0,0030	(o) 1,76	0,03	(o) 1,06	0,02
Chi2	10,8		11,0						0,9		0,7		0,1	
Chi2 crit:	4,6		6,6						3,3		3,8		3,8	
UWM:	0,01456		0,0208						0,03669		1,57771		1,03606	
WM:	0,00867		0,0208						0,03442		1,58251		1,03894	
Uc (int):	0,00105		0,0061						0,00154		0,00581		0,00405	
Uc (ext) :	0,00346		0,0202						0,00144		0,00480		0,00112	
LWM :	0,0087	0,004	0,021			0,0014			0,0344	0,0015	1,583	0,006	1,0389	0,0040

	1368 keV		1376 keV		1385 keV		1428 keV		1436 keV		1445 keV		1453 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2	2,585	0,041	0,508	0,020	0,070	0,006	0,048	0,007	1,222	0,024	0,328	0,007	0,031	0,007
E907- 3	2,571	0,025	0,471	0,015	0,050	0,011			1,238	0,019	0,303	0,013	DL=0,0163	
E907- 5	2,621	0,023	0,493	0,009	0,062	0,008			1,210	0,031	0,342	0,012		
E907- 6	(o) 2,41	0,11	0,47	0,09	(o) 0,18	0,07			(o) 1,08	0,09	0,35	0,08		
E907- 7	2,624	0,011	0,5019	(i) 0,0033	0,0682	0,0018	DL=0,0025		1,230	0,005	0,3286	(i) 0,0023	DL=0,0026	
E907- 8	2,63	0,05	0,465	0,008	0,059	0,002	0,0262	0,0016	(o) 1,31	0,02	0,367	0,006	0,077	(i) 0,002
Chi2	1,1		3,4		3,4		5,3		0,2		6,8		20,6	
Chi2 crit:	3,3		3,0		3,3		6,6		3,8		3,0		6,6	
UWM:	2,6058		0,4849		0,06202		0,0371		1,2249		0,3364		0,0539	
WM:	2,6154		0,4904		0,06416		0,0371		1,2296		0,3363		0,0539	
Uc (int):	0,0088		0,0038		0,00125		0,0048		0,0048		0,0030		0,0050	
Uc (ext) :	0,0093		0,0070		0,00232		0,0109		0,0024		0,0078		0,0229	
LWM :	2,615	0,009	0,490	(e) 0,012	0,0642	(e) 0,0041	0,037	0,011	1,2296	0,0048	0,336	0,008	0,054	0,023

	1488 keV		1505 keV		1526 keV		1557 keV		1565 keV		1579 keV		1622 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2	0,669	0,017	0,051	0,016	0,410	0,018					0,430	0,018	0,040	0,003
E907- 3	0,669	0,014			0,395	0,012			DL=0,0105		0,413	0,014	0,042	0,008
E907- 5	0,676	0,015			(o) 0,432	0,016			>0,0187	<0,0298	0,404	0,008		
E907- 6	0,65	0,09			0,39	0,07							(o) 0,200	0,046
E907- 7	0,685	0,007	DL=0,002		0,4094	0,0025	DL=0,0017		0,0114	(i) 0,0007	(o) 0,1420	0,0012	0,0397	0,0008
E907- 8	0,666	0,012	0,0084	0,0028	0,398	0,007	0,013	0,007	0,0053	0,0009	(o) 0,353	0,007	0,0397	0,0012
Chi2	0,5		3,6		0,9				20,9		0,9		0,0	
Chi2 crit:	3,0		6,6		3,3				6,6		4,6		3,8	
UWM:	0,6692		0,02970		0,4005				0,00838		0,4155		0,04028	
WM:	0,6770		0,02970		0,4077				0,00838		0,4091		0,03971	
Uc (int):	0,0051		0,01118		0,0023				0,00066		0,0066		0,00066	
Uc (ext) :	0,0037		0,02130		0,0022				0,00304		0,0064		0,00012	
LWM :	0,677	0,005	0,030	0,021	0,4077	0,0023			0,0084	0,0030	0,409	0,007	0,0397	0,0007

	1657 keV		1690 keV		1720 keV		1757 keV		1851 keV		1918 keV		1950 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2			45,56	1,09	0,095	0,005					0,055	0,004		
E907- 3	DL=0,0089		47,04	0,40	(o) 0,088	0,004			DL=0,0077		0,049	0,003		
E907- 5			47,10	0,35	0,098	0,006					0,052	0,008		
E907- 6			(o) 44,70	0,77	(o) 0,123	0,041	0,007	0,019	(r) 0,31	0,06	(o) 0,070	0,035		
E907- 7	DL=0,0012		47,65	0,18	0,0946	0,0007	DL=0,0009		0,0053	0,0006	0,0526	0,0005	DL=0,0006	
E907- 8	0,009	0,003	46,03	0,87	0,0955	0,0020			0,0008	0,0001	0,0527	0,0017	0,0528	0,0110
Chi2			2,2		0,2				28,9		0,3			
Chi2 crit:			3,3		3,8				6,6		3,3			
UWM:			46,68		0,09581				0,00304		0,05235			
WM:			47,39		0,09475				0,00304		0,05254			
Uc (int):			0,15		0,00065				0,00042		0,00049			
Uc (ext) :			0,22		0,00025				0,00225		0,00028			
LWM :			47,39	0,22	0,0947	0,0006			0,0030	0,0023	0,0525	0,0005		

	1970 keV		2015 keV		2039 keV		2078 keV		2090 keV		2099 keV		2108 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2			0,013	0,002	0,062	0,004	0,028	0,003	5,15	0,19	0,045	0,003	0,051	0,003
E907- 3	DL=0,0016		0,008	0,001	0,063	0,003	0,023	0,001	5,44	0,08	0,056	0,001	0,047	0,001
E907- 5					0,062	0,006	0,017	0,002	5,45	0,06	0,052	0,003	0,056	0,004
E907- 6														
E907- 7			0,0090	0,0003	0,0622	0,0006	0,0201	0,0006	5,511	0,022	0,0439	(i) 0,0004	0,0421	(i) 0,0003
E907- 8			0,0092	0,0010	(o) 0,0751	0,0016	0,0212	0,0007	5,33	0,11	0,0525	0,0013	0,0456	0,0011
Chi2			1,8		0,0		4,5		1,8		17,8		6,2	
Chi2 crit:			3,8		3,8		3,3		3,3		3,3		3,3	
UWM:			0,00968		0,06220		0,02198		5,3766		0,04998		0,0482	
WM:			0,00907		0,06221		0,02120		5,4909		0,04849		0,0444	
Uc (int):			0,00026		0,00058		0,00039		0,0193		0,00062		0,0006	
Uc (ext) :			0,00034		0,00010		0,00082		0,0256		0,00260		0,0014	
LWM :			0,00907	0,00034	0,0622	0,0006	0,0212	(e) 0,0011	5,491	0,026	0,0485	(e) 0,0046	0,048	(e) 0,006

	2151 keV		2172 keV		2182 keV		2203 keV		2224 keV		2253 keV		2274 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2					0,042	0,003	0,030	0,002	0,020	0,013				
E907- 3			0,0029	0,0003	0,040	0,001								
E907- 5					0,040	0,008								
E907- 6														
E907- 7	DL=0,0002		0,0014	0,0001	0,0413	0,0004	0,0004	(i) 0,0002	0,0002	(i) 0,0001	DL=0,0001		DL=0,0002	
E907- 8	0,0016	0,0008	0,0057	0,0002	0,0435	0,0010	0,0063	0,0003	0,0020	0,0003	0,0005	0,0001	0,0008	0,0003
Chi2			172,2		1,6		241,5		12,0					
Chi2 crit:			4,6		3,3		4,6		4,6					
UWM:			0,00335		0,04131		0,01210		0,00738					
WM:			0,00317		0,04145		0,00359		0,00107					
Uc (int):			0,00011		0,00035		0,00018		0,00019					
Uc (ext) :			0,00140		0,00045		0,00280		0,00067					
LWM :			0,0032	(e) 0,0018	0,04145	0,00045	0,0036	(e) 0,0032	0,0011	(e) 0,0009				

	2283 keV		2293 keV		2323 keV		2454 keV		2682 keV		2693 keV		2808 keV	
	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc	I (%)	Uc
E907- 2	0,023	0,014	0,080	0,007	0,0096	0,0043	0,0091	0,0034	0,0071	0,0033	0,0047	0,0020	0,0067	0,0027
E907- 3	0,0049	0,0004	0,028	(i) 0,001	DL=0,005		DL=0,0049		DL=0,004		0,0019	(i) 0,0001	DL=0,0033	
E907- 5			0,032	0,002							0,0024	0,0003		
E907- 6														
E907- 7	0,0045	0,0006	0,0335	0,0010	0,0020	(i) 0,0001	0,0015	0,0002	0,0017	0,0001	0,0032	0,0001	0,0007	0,0002
E907- 8	0,0062	0,0003	(o) 0,414	0,009	0,0042	0,0003	0,0018	0,0003	0,0019	0,0001	(o) 0,0434	0,0010	0,0009	0,0001
Chi2	3,5		20,3		12,0		2,9		2,8		22,6		2,9	
Chi2 crit:	3,8		3,8		4,6		4,6		4,6		3,8		4,6	
UWM:	0,00966		0,04337		0,00526		0,00413		0,00358		0,00305		0,00277	
WM:	0,00545		0,03123		0,00311		0,00159		0,00177		0,00251		0,00084	
Uc (int):	0,00023		0,00065		0,00024		0,00016		0,00006		0,00008		0,00010	
Uc (ext) :	0,00043		0,00295		0,00082		0,00028		0,00010		0,00038		0,00018	
LWM :	0,00545	0,00043	0,0312	0,0029	0,0031	(e) 0,0011	0,00159	0,00028	0,00177	0,00010	0,0025	0,0006	0,00084	0,00018

	2871 keV	
	I (%)	Uc
E907- 2		
E907- 3		
E907- 5		
E907- 6		
E907- 7	0,0002	0,0001
E907- 8		
Chi2		
Chi2 crit:		
UWM:		
WM:		
Uc (int):		
Uc (ext) :		
LWM :		

(i) This original uncertainty was increased in order to limit the relative weight to 50 %
(o) Outlier
(e) expanded uncertainty so range to include the most precise I (%)
(r) removed from analysis

$^{124}_{51}$Sb $_{73}$

1 Decay Scheme

L'antimoine 124 se désintègre par émission bêta moins vers des niveaux excités du tellure 124.
Sb-124 disintegrates by beta minus emissions to excited levels in Te-124.

2 Nuclear Data

$T_{1/2}$(^{124}Sb)	:	60,208	(11)	d
Q^{-}(^{124}Sb)	:	2904,3	(15)	keV

2.1 β^- Transitions

	Energy keV	Probability × 100	Nature	lg ft
$\beta^-_{0,27}$	17,9 (15)	0,0059 (5)	Allowed	6,9
$\beta^-_{0,26}$	38,6 (15)	0,054 (9)	Allowed	6,9
$\beta^-_{0,25}$	89,7 (15)	0,0207 (12)		8,4
$\beta^-_{0,24}$	96,8 (15)	0,0012 (5)	1st Forbidden	9,8
$\beta^-_{0,23}$	129,2 (15)	0,653 (6)		7,5
$\beta^-_{0,22}$	193,3 (15)	0,106 (6)	1st Forbidden	8,8
$\beta^-_{0,21}$	202,7 (15)	0,571 (25)	Allowed	8
$\beta^-_{0,20}$	210,6 (15)	8,663 (27)	Allowed	7
$\beta^-_{0,19}$	221,8 (15)	0,0242 (22)	1st Forbidden	9,6
$\beta^-_{0,18}$	285,2 (15)	0,0098 (8)		10,4
$\beta^-_{0,17}$	354,6 (15)	0,0364 (22)		10
$\beta^-_{0,16}$	382,8 (15)	0,0529 (5)	1st Forbidden	10
$\beta^-_{0,15}$	392,3 (15)	0,0422 (19)	1st Forbidden	10,2
$\beta^-_{0,14}$	421,0 (15)	0,332 (10)	1st Forbidden	9,4
$\beta^-_{0,13}$	449,3 (15)	0,0050 (26)	1st Forbidden	11,3
$\beta^-_{0,11}$	580,9 (15)	0,0686 (14)	1st Forbidden	10,5
$\beta^-_{0,10}$	610,6 (15)	51,21 (19)	Allowed	7,7
$\beta^-_{0,9}$	679,5 (15)	0,0967 (34)	1st Forbidden	10,6

	Energy keV	Probability × 100	Nature	lg ft
$\beta^-_{0,8}$	721,9 (15)	0,47 (30)	1st Forbidden	10
$\beta^-_{0,7}$	812,6 (15)	0,688 (38)	1st Forbidden	10
$\beta^-_{0,6}$	865,0 (15)	4,143 (18)		9,4
$\beta^-_{0,5}$	946,4 (15)	2,295 (7)	1st Forbidden	9,8
$\beta^-_{0,4}$	1247,7 (15)	0,0053 (10)	3rd Forbidden	12,8
$\beta^-_{0,3}$	1578,8 (15)	4,815 (29)	1st Forbidden	10,3
$\beta^-_{0,2}$	1655,7 (15)	2,472 (33)	1st Forbidden	10,7
$\beta^-_{0,1}$	2301,6 (15)	23,44 (28)	1st Forbidden	10,3

2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ × 100	Multipolarity	α_K	α_L	α_M	α_T
$\gamma_{14,12}$(Te)	148,02 (5)	0,0037 (6)	E1+M2				
$\gamma_{(-1,1)}$(Te)	159,867 (35)	0,0049 (6)					
$\gamma_{14,10}$(Te)	189,565 (18)	0,0043 (5)					
$\gamma_{20,14}$(Te)	210,402 (19)	0,0053 (7)					
$\gamma_{10,6}$(Te)	254,424 (6)	0,0144 (9)	(E1)	0,01269 (18)	0,001575 (22)	0,000312 (5)	0,01465 (21)
$\gamma_{23,14}$(Te)	291,793 (25)	0,0069 (7)					
$\gamma_{10,5}$(Te)	335,797 (16)	0,073 (1)	E1	0,00612 (9)	0,000754 (11)	0,0001495 (21)	0,00706 (10)
$\gamma_{20,11}$(Te)	370,269 (30)	0,0286 (11)					
$\gamma_{20,10}$(Te)	399,967 (6)	0,1284 (31)	E2	0,01323 (19)	0,00196 (3)	0,000394 (6)	0,01566 (22)
$\gamma_{14,6}$(Te)	443,989 (18)	0,197 (16)	M1+26%E2	0,01092 (16)	0,001360 (19)	0,000271 (4)	0,01261 (18)
$\gamma_{20,9}$(Te)	468,840 (25)	0,0460 (26)	E1	0,00268 (4)	0,000327 (5)	0,0000648 (9)	0,00309 (5)
$\gamma_{23,10}$(Te)	481,36 (2)	0,0232 (31)					
$\gamma_{14,5}$(Te)	525,362 (24)	0,1462 (35)	M1+50%E2	0,0066 (3)	0,000867 (18)	0,000173 (4)	0,0077 (3)
$\gamma_{26,12}$(Te)	530,46 (7)	0,036 (9)					
$\gamma_{26,10}$(Te)	572,01 (5)	0,0176 (8)					
$\gamma_{1,0}$(Te)	602,7278 (21)	98,254 (21)	E2	0,00420 (6)	0,000566 (8)	0,0001132 (16)	0,00490 (7)
$\gamma_{5,3}$(Te)	632,403 (16)	0,1029 (21)					
$\gamma_{2,1}$(Te)	645,8542 (37)	7,452 (15)	E2+0,004%M3	0,00351 (5)	0,000468 (7)	0,0000935 (14)	0,00409 (6)
$\gamma_{21,6}$(Te)	662,334 (10)	0,024 (11)					
$\gamma_{5,2}$(Te)	709,333 (16)	1,368 (5)	M1+3%E2	0,00349 (5)	0,000429 (7)	0,0000853 (13)	0,00402 (6)
$\gamma_{6,3}$(Te)	713,776 (5)	2,281 (7)	M1+50%E2	0,0031 (4)	0,00039 (4)	0,000078 (7)	0,0036 (4)
$\gamma_{3,1}$(Te)	722,7842 (37)	10,742 (22)	M1+92%E2	0,00271 (4)	0,000352 (5)	0,0000702 (10)	0,00314 (5)
$\gamma_{23,6}$(Te)	735,782 (17)	0,1312 (16)					
$\gamma_{7,3}$(Te)	766,168 (21)	0,0105 (9)	E0,M1	0,019 (6)			0,021 (7)
$\gamma_{25,6}$(Te)	775,27 (7)	0,0098 (4)					
$\gamma_{6,2}$(Te)	790,706 (5)	0,7433 (24)	E2	0,00214 (6)	0,000276 (8)	0,000055 (2)	0,00248 (8)
$\gamma_{23,5}$(Te)	817,155 (23)	0,0744 (12)					
$\gamma_{8,3}$(Te)	856,878 (30)	0,0227 (5)					
$\gamma_{9,3}$(Te)	899,327 (25)	0,0179 (7)					
$\gamma_{10,3}$(Te)	968,200 (5)	1,888 (10)	E1+4%M2	0,000569 (9)	0,0000678 (11)	0,00001343 (22)	0,000653 (11)
$\gamma_{9,2}$(Te)	976,257 (25)	0,0832 (7)					
$\gamma_{(-1,2)}$(Te)	997,80 (3)	0,0033 (23)					
$\gamma_{10,2}$(Te)	1045,130 (5)	1,853 (14)	E1+0,09%M2	0,000494 (9)	0,0000587 (11)	0,00001163 (21)	0,000567 (10)
$\gamma_{4,1}$(Te)	1053,87 (30)	0,0053 (10)	E2	0,001117 (16)	0,0001394 (20)	0,0000277 (4)	0,001290 (18)
$\gamma_{12,2}$(Te)	1086,68 (5)	0,0367 (9)	E1	0,000457 (7)	0,0000543 (8)	0,00001074 (15)	0,000524 (8)
$\gamma_{(-1,3)}$(Te)	1235 (1)	0,0073 (26)					
$\gamma_{15,2}$(Te)	1263,46 (7)	0,0422 (19)					
$\gamma_{17,2}$(Te)	1301,15 (9)	0,0364 (22)					
$\gamma_{3,0}$(Te)	1325,512 (3)	1,588 (7)	E2	0,000693 (10)	0,0000848 (12)	0,00001685 (24)	0,000827 (12)
$\gamma_{5,1}$(Te)	1355,187 (16)	1,0423 (38)	E2+9,3%M3	0,0009 (5)	0,00011 (6)	0,000023 (11)	0,0011 (5)

	Energy keV	$P_{\gamma+ce}$ × 100	Multipolarity	α_K	α_L	α_M	α_T
$\gamma_{20,3}$(Te)	1368,167 (6)	2,621 (8)	E1+0,04%M2	0,000303 (5)	0,0000358 (6)	0,00000709 (10)	0,000478 (7)
$\gamma_{21,3}$(Te)	1376,110 (9)	0,5001 (43)	E1+0,01%M2	0,000300 (5)	0,0000354 (6)	0,00000701 (12)	0,000479 (7)
$\gamma_{22,3}$(Te)	1385,500 (21)	0,062 (6)					
$\gamma_{6,1}$(Te)	1436,5602 (45)	1,235 (8)	M1+69%E2	0,00063 (5)	0,000076 (6)	0,0000151 (11)	0,00078 (5)
$\gamma_{20,2}$(Te)	1445,097 (6)	0,334 (7)	E1+M2	0,00029 (4)	0,000034 (4)	0,0000067 (8)	0,00052 (4)
$\gamma_{7,1}$(Te)	1488,952 (21)	0,6776 (37)	M1+1%E2	0,000659 (14)	0,0000792 (16)	0,0000157 (3)	0,000829 (16)
$\gamma_{23,2}$(Te)	1526,488 (17)	0,414 (5)	E1	0,000252 (4)	0,0000296 (5)	0,00000586 (9)	0,000535 (8)
$\gamma_{25,2}$(Te)	1565,98 (7)	0,0109 (12)					
$\gamma_{8,1}$(Te)	1579,662 (30)	0,412 (5)	M1+E2	0,00054 (5)	0,000065 (6)	0,0000128 (11)	0,00072 (5)
$\gamma_{9,1}$(Te)	1622,111 (25)	0,0416 (19)	E2	0,000467 (7)	0,0000564 (8)	0,00001118 (16)	0,000664 (10)
$\gamma_{4,0}$(Te)	1656,6 (3)		E0				
$\gamma_{10,1}$(Te)	1690,9842 (45)	47,49 (19)	E1+0,01%M2	0,000213 (4)	0,0000250 (4)	0,00000494 (8)	0,000615 (9)
$\gamma_{11,1}$(Te)	1720,682 (30)	0,0947 (6)	M1+E2	0,00045 (4)	0,000054 (4)	0,0000107 (8)	0,00068 (4)
$\gamma_{13,1}$(Te)	1852,23 (7)	0,0030 (9)	M1+E2	0,00039 (3)	0,000047 (4)	0,0000093 (7)	0,00067 (3)
$\gamma_{16,1}$(Te)	1918,75 (6)	0,0529 (5)	M1(+E2)	0,000364 (24)	0,000043 (3)	0,0000086 (6)	0,00067 (3)
$\gamma_{18,1}$(Te)	2016,36 (6)	0,0098 (8)					
$\gamma_{6,0}$(Te)	2039,288 (4)	0,0631 (5)	E2	0,000305 (5)	0,0000364 (5)	0,00000721 (10)	0,000667 (10)
$\gamma_{19,1}$(Te)	2079,77 (13)	0,0224 (22)	M1+E2	0,000311 (18)	0,0000371 (21)	0,0000073 (4)	0,000691 (20)
$\gamma_{20,1}$(Te)	2090,951 (5)	5,498 (24)	E1+0,1%M2	0,0001522 (23)	0,0000178 (3)	0,00000352 (6)	0,000838 (12)
$\gamma_{21,1}$(Te)	2098,894 (9)	0,0471 (33)					
$\gamma_{22,1}$(Te)	2108,284 (21)	0,0444 (23)					
$\gamma_{23,1}$(Te)	2172,342 (17)	0,0029 (16)					
$\gamma_{8,0}$(Te)	2182,39 (3)	0,04147 (31)					
$\gamma_{27,1}$(Te)	2283,64 (6)	0,0059 (5)	E1+M2	0,00033 (21)	0,000040 (25)	0,000008 (5)	0,00091 (5)
$\gamma_{10,0}$(Te)	2293,712 (4)	0,0327 (41)					
$\gamma_{11,0}$(Te)	2323,41 (3)	0,0025 (6)					
$\gamma_{13,0}$(Te)	2454,96 (7)	0,00160 (12)	E2	0,000219 (3)	0,0000259 (4)	0,00000513 (8)	0,000768 (11)
$\gamma_{19,0}$(Te)	2682,50 (15)	0,00176 (6)					
$\gamma_{20,0}$(Te)	2693,679 (10)	0,0032 (14)					
$\gamma_{24,0}$(Te)	2807,55 (24)	0,0012 (5)	E2	0,0001730 (25)	0,0000204 (3)	0,00000404 (6)	0,000878 (13)

3 Atomic Data

3.1 Te

ω_K	:	0,875	(4)
$\bar{\omega}_L$	:	0,0862	(35)
n_{KL}	:	0,917	(4)

3.1.1 X Radiations

		Energy keV		Relative probability
X_K				
	$K\alpha_2$	27,202		53,7
	$K\alpha_1$	27,4726		100
	$K\beta_3$	30,9446	}	
	$K\beta_1$	30,996	}	
	$K\beta_5''$	31,236	}	28,6

		Energy keV		Relative probability
	$K\beta_2$	31,7008	}	
	$K\beta_4$	31,774	}	6,2
	$KO_{2,3}$	31,812	}	
X_L				
	$L\ell$	3,3348		
	$L\alpha$	3,7595 – 3,7697		
	$L\eta$	3,6052		
	$L\beta$	4,0299 – 4,3661		
	$L\gamma$	4,4448 – 4,8228		

3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	21,804 – 22,989	100
KLX	25,814 – 27,470	45,3
KXY	29,80 – 31,81	5,13
Auger L	2,3 – 4,9	

4 Electron Emissions

		Energy keV			Electrons per 100 disint.
e_{AL}	(Te)	2,3	- 4,9		0,4829 (26)
e_{AK}	(Te)				0,0628 (22)
	KLL	21,804	- 22,989	}	
	KLX	25,814	- 27,470	}	
	KXY	29,80	- 31,81	}	
$ec_{1,0\ K}$	(Te)	570,9140	(21)		0,411 (6)
$ec_{1,0\ L}$	(Te)	597,7886	- 598,3864		0,0553 (8)
$ec_{1,0\ M}$	(Te)	601,7220	- 602,1557		0,01107 (16)
$ec_{2,1\ K}$	(Te)	614,0404	(37)		0,02605 (37)
$ec_{3,1\ K}$	(Te)	690,9704	(37)		0,02902 (43)
$ec_{10,1\ K}$	(Te)	1659,1704	(45)		0,01011 (19)

		Energy keV		Electrons per 100 disint.
$\beta^-_{0,27}$	max:	17,9	(15)	0,0059 (5)
$\beta^-_{0,27}$	avg:	4,5	(4)	
$\beta^-_{0,26}$	max:	38,6	(15)	0,054 (9)
$\beta^-_{0,26}$	avg:	9,8	(4)	
$\beta^-_{0,25}$	max:	89,7	(15)	0,0207 (12)
$\beta^-_{0,25}$	avg:	23,4	(4)	
$\beta^-_{0,24}$	max:	96,8	(15)	0,0012 (5)
$\beta^-_{0,24}$	avg:	25,3	(4)	
$\beta^-_{0,23}$	max:	129,2	(15)	0,653 (6)
$\beta^-_{0,23}$	avg:	34,4	(4)	
$\beta^-_{0,22}$	max:	193,3	(15)	0,106 (6)
$\beta^-_{0,22}$	avg:	52,9	(5)	
$\beta^-_{0,21}$	max:	202,7	(15)	0,571 (25)
$\beta^-_{0,21}$	avg:	55,7	(5)	
$\beta^-_{0,20}$	max:	210,6	(15)	8,663 (27)
$\beta^-_{0,20}$	avg:	58,0	(5)	
$\beta^-_{0,19}$	max:	221,8	(15)	0,0242 (22)
$\beta^-_{0,19}$	avg:	61,5	(5)	
$\beta^-_{0,18}$	max:	285,2	(15)	0,0098 (8)
$\beta^-_{0,18}$	avg:	81,0	(5)	
$\beta^-_{0,17}$	max:	354,6	(15)	0,0364 (22)
$\beta^-_{0,17}$	avg:	103,6	(5)	
$\beta^-_{0,16}$	max:	382,8	(15)	0,0529 (5)
$\beta^-_{0,16}$	avg:	113,0	(5)	
$\beta^-_{0,15}$	max:	392,3	(15)	0,0422 (19)
$\beta^-_{0,15}$	avg:	116,0	(5)	
$\beta^-_{0,14}$	max:	421,0	(15)	0,332 (10)
$\beta^-_{0,14}$	avg:	126,0	(5)	
$\beta^-_{0,13}$	max:	449,3	(15)	0,0050 (26)
$\beta^-_{0,13}$	avg:	135,8	(6)	
$\beta^-_{0,11}$	max:	580,9	(15)	0,0686 (14)
$\beta^-_{0,11}$	avg:	182,8	(6)	
$\beta^-_{0,10}$	max:	610,6	(15)	51,21 (19)
$\beta^-_{0,10}$	avg:	193,8	(6)	
$\beta^-_{0,9}$	max:	679,5	(15)	0,0967 (34)
$\beta^-_{0,9}$	avg:	219,5	(6)	
$\beta^-_{0,8}$	max:	721,9	(15)	0,47 (30)
$\beta^-_{0,8}$	avg:	236,0	(6)	
$\beta^-_{0,7}$	max:	812,6	(15)	0,688 (38)
$\beta^-_{0,7}$	avg:	271,0	(6)	
$\beta^-_{0,6}$	max:	865,0	(15)	4,143 (18)
$\beta^-_{0,6}$	avg:	292	(1)	

		Energy keV		Electrons per 100 disint.
$\beta^-_{0,5}$	max:	946,4	(15)	2,295 (7)
$\beta^-_{0,5}$	avg:	324	(1)	
$\beta^-_{0,4}$	max:	1247,7	(15)	0,0053 (10)
$\beta^-_{0,4}$	avg:	450	(1)	
$\beta^-_{0,3}$	max:	1578,8	(15)	4,815 (29)
$\beta^-_{0,3}$	avg:	593	(1)	
$\beta^-_{0,2}$	max:	1655,7	(15)	2,472 (33)
$\beta^-_{0,2}$	avg:	627	(1)	
$\beta^-_{0,1}$	max:	2301,6	(15)	23,44 (28)
$\beta^-_{0,1}$	avg:	918	(1)	

5 Photon Emissions

5.1 X-Ray Emissions

		Energy keV		Photons per 100 disint.	
XL	(Te)	3,3348 — 4,8228		0,0449 (9)	
XKα_2	(Te)	27,202		0,1252 (18)	} Kα
XKα_1	(Te)	27,4726		0,233 (3)	}
XKβ_3	(Te)	30,9446	}		
XKβ_1	(Te)	30,996	}	0,0667 (12)	K$'\beta_1$
XKβ_5''	(Te)	31,236	}		
XKβ_2	(Te)	31,7008	}		
XKβ_4	(Te)	31,774	}	0,0145 (5)	K$'\beta_2$
XKO$_{2,3}$	(Te)	31,812	}		

5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{14,12}$(Te)	148,02 (5)	0,0037 (6)
$\gamma_{(-1,1)}$(Te)	159,867 (35)	0,0049 (6)
$\gamma_{14,10}$(Te)	189,57 (2)	0,0043 (5)
$\gamma_{20,14}$(Te)	210,40 (2)	0,0053 (7)
$\gamma_{10,6}$(Te)	254,42 (1)	0,0142 (9)
$\gamma_{23,14}$(Te)	291,79 (3)	0,0069 (7)

	Energy keV	Photons per 100 disint.
$\gamma_{10,5}$(Te)	335,80 (2)	0,0725 (9)
$\gamma_{20,11}$(Te)	370,27 (3)	0,0286 (11)
$\gamma_{20,10}$(Te)	399,97 (1)	0,1264 (31)
$\gamma_{14,6}$(Te)	444,00 (2)	0,195 (16)
$\gamma_{20,9}$(Te)	468,84 (3)	0,0459 (26)
$\gamma_{23,10}$(Te)	481,36 (2)	0,0232 (31)
$\gamma_{14,5}$(Te)	525,36 (3)	0,1451 (35)
$\gamma_{26,12}$(Te)	530,46 (7)	0,036 (9)
$\gamma_{26,10}$(Te)	572,01 (5)	0,0176 (8)
$\gamma_{1,0}$(Te)	602,7260 (23)	97,775 (20)
$\gamma_{5,3}$(Te)	632,40 (2)	0,1029 (21)
$\gamma_{2,1}$(Te)	645,8520 (19)	7,422 (15)
$\gamma_{21,6}$(Te)	662,33 (1)	0,024 (11)
$\gamma_{5,2}$(Te)	709,33 (2)	1,363 (5)
$\gamma_{6,3}$(Te)	713,776 (4)	2,273 (7)
$\gamma_{3,1}$(Te)	722,782 (3)	10,708 (22)
$\gamma_{23,6}$(Te)	735,78 (2)	0,1312 (16)
$\gamma_{7,3}$(Te)	766,17 (2)	0,0103 (9)
$\gamma_{25,6}$(Te)	775,27 (7)	0,0098 (4)
$\gamma_{6,2}$(Te)	790,706 (7)	0,7415 (24)
$\gamma_{23,5}$(Te)	817,15 (3)	0,0744 (12)
$\gamma_{8,3}$(Te)	856,87 (3)	0,0227 (5)
$\gamma_{9,3}$(Te)	899,32 (3)	0,0179 (7)
$\gamma_{10,3}$(Te)	968,195 (4)	1,887 (10)
$\gamma_{9,2}$(Te)	976,25 (3)	0,0832 (7)
$\gamma_{(-1,2)}$(Te)	997,8 (3)	0,0033 (23)
$\gamma_{10,2}$(Te)	1045,125 (4)	1,852 (14)
$\gamma_{4,1}$(Te)	1053,9 (3)	0,0053 (10)
$\gamma_{12,2}$(Te)	1086,67 (5)	0,0367 (9)
$\gamma_{(-1,3)}$(Te)	1235 (1)	0,0073 (26)
$\gamma_{15,2}$(Te)	1263,45 (7)	0,0422 (19)
$\gamma_{17,2}$(Te)	1301,14 (9)	0,0364 (22)
$\gamma_{3,0}$(Te)	1325,504 (4)	1,587 (7)
$\gamma_{5,1}$(Te)	1355,20 (2)	1,0412 (38)
$\gamma_{20,3}$(Te)	1368,157 (5)	2,620 (8)
$\gamma_{21,3}$(Te)	1376,10 (1)	0,4999 (43)
$\gamma_{22,3}$(Te)	1385,49 (2)	0,062 (6)
$\gamma_{6,1}$(Te)	1436,554 (7)	1,234 (8)
$\gamma_{20,2}$(Te)	1445,09 (1)	0,334 (7)
$\gamma_{7,1}$(Te)	1488,94 (2)	0,6770 (37)
$\gamma_{23,2}$(Te)	1526,48 (2)	0,414 (5)
$\gamma_{25,2}$(Te)	1565,97 (7)	0,0109 (12)
$\gamma_{8,1}$(Te)	1579,65 (3)	0,412 (5)
$\gamma_{9,1}$(Te)	1622,10 (3)	0,0416 (19)
$\gamma_{10,1}$(Te)	1690,971 (4)	47,46 (19)
$\gamma_{11,1}$(Te)	1720,67 (3)	0,0946 (6)
$\gamma_{13,1}$(Te)	1852,22 (7)	0,0030 (9)

	Energy keV	Photons per 100 disint.
$\gamma_{16,1}$(Te)	1918,74 (6)	0,0529 (5)
$\gamma_{18,1}$(Te)	2016,34 (6)	0,0098 (8)
$\gamma_{6,0}$(Te)	2039,27 (1)	0,0631 (5)
$\gamma_{19,1}$(Te)	2079,75 (13)	0,0224 (22)
$\gamma_{20,1}$(Te)	2090,930 (7)	5,493 (24)
$\gamma_{21,1}$(Te)	2098,88 (1)	0,0471 (33)
$\gamma_{22,1}$(Te)	2108,27 (2)	0,0444 (23)
$\gamma_{23,1}$(Te)	2172,32 (2)	0,0029 (16)
$\gamma_{8,0}$(Te)	2182,37 (3)	0,04147 (31)
$\gamma_{27,1}$(Te)	2283,62 (6)	0,0059 (5)
$\gamma_{10,0}$(Te)	2293,69 (1)	0,0327 (41)
$\gamma_{11,0}$(Te)	2323,39 (3)	0,0025 (6)
$\gamma_{13,0}$(Te)	2454,93 (7)	0,00160 (12)
$\gamma_{19,0}$(Te)	2682,47 (13)	0,00176 (6)
$\gamma_{20,0}$(Te)	2693,65 (1)	0,0032 (14)
$\gamma_{24,0}$(Te)	2807,52 (24)	0,0012 (5)

6 Main Production Modes

Sb − 123(n,γ)Sb − 124 σ : 3,88 (12) barns
Possible impurities : Sb − 122

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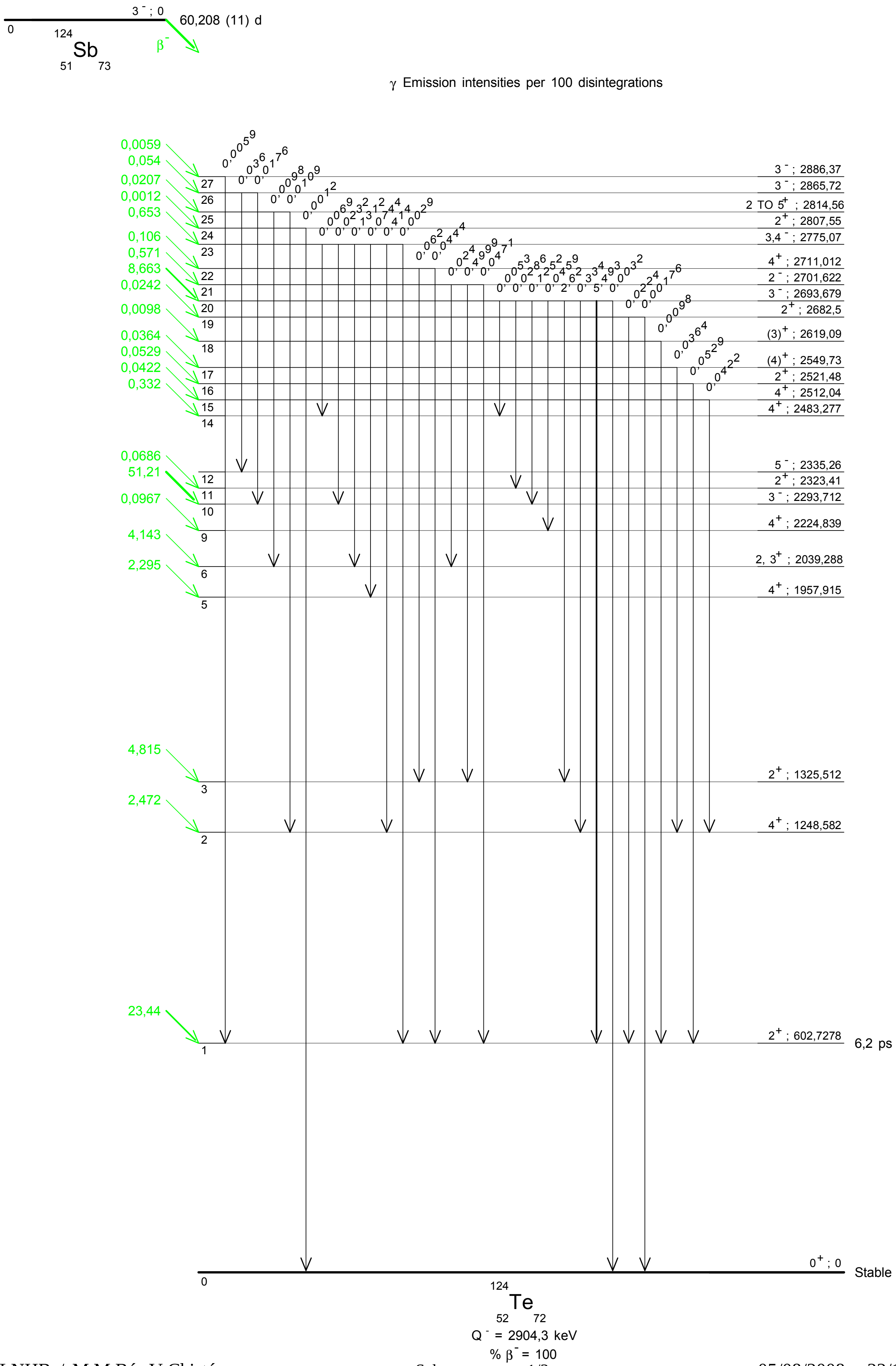
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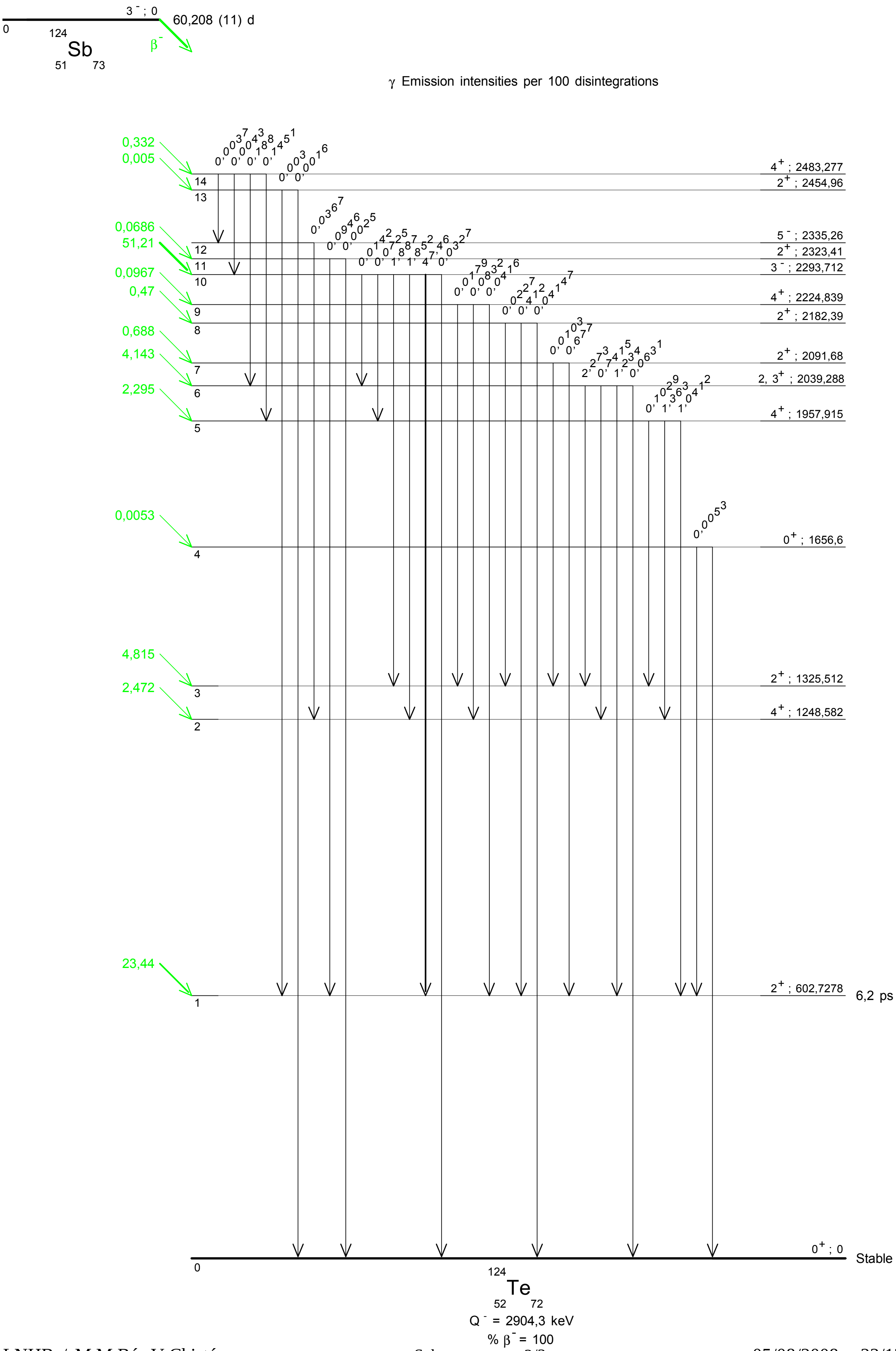
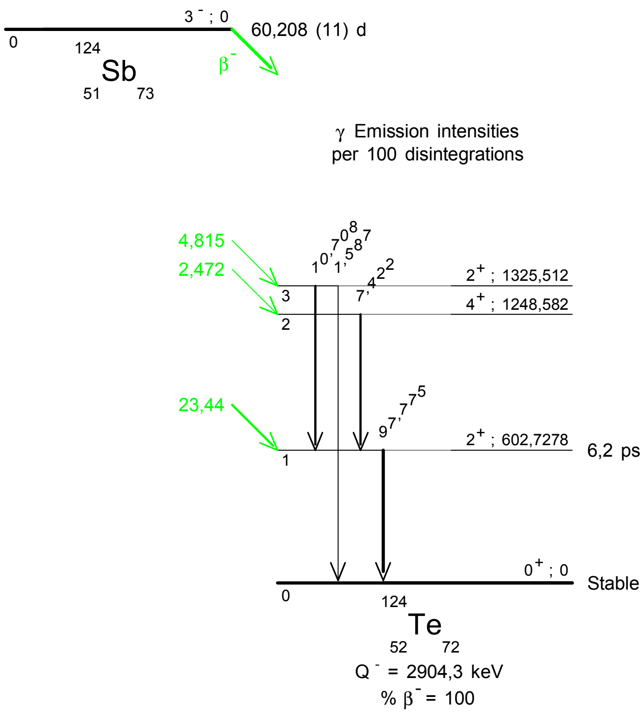
60,208 (11) d
124 Sb 51 73
β-
γ Emission intensities per 100 disintegrations
3 - ; 2886,37
3 - ; 2865,72
2 TO 5+ ; 2814,56
2+ ; 2807,55
3,4 - ; 2775,07
4+ ; 2711,012
2 - ; 2701,622
3 - ; 2693,679
2+ ; 2682,5
(3)+ ; 2619,09
(4)+ ; 2549,73
2+ ; 2521,48
4+ ; 2512,04
4+ ; 2483,277
5 - ; 2335,26
2+ ; 2323,41
3 - ; 2293,712
4+ ; 2224,839
2, 3+ ; 2039,288
4+ ; 1957,915
2+ ; 1325,512
4+ ; 1248,582
2+ ; 602,7278
6,2 ps
0+ ; 0
Stable
0,0059
0,054
0,0207
0,0012
0,653
0,106
0,571
8,663
0,0242
0,0098
0,0364
0,0529
0,0422
0,332
0,0686
51,21
0,0967
4,143
2,295
4,815
2,472
23,44
124 Te 52 72
Q - = 2904,3 keV
% β- = 100


3 - ; 0
60,208 (11) d
124 Sb 51 73
β-
γ Emission intensities per 100 disintegrations
4+ ; 2483,277
2+ ; 2454,96
5 - ; 2335,26
2+ ; 2323,41
3 - ; 2293,712
4+ ; 2224,839
2+ ; 2182,39
2+ ; 2091,68
2, 3+ ; 2039,288
4+ ; 1957,915
0+ ; 1656,6
2+ ; 1325,512
4+ ; 1248,582
2+ ; 602,7278
6,2 ps
0+ ; 0
Stable
0,332
0,005
0,0686
51,21
0,0967
0,47
0,688
4,143
2,295
0,0053
4,815
2,472
23,44
124 Te 52 72
Q - = 2904,3 keV
% β- = 100


3⁻ ; 0
60,208 (11) d
0
124
Sb
51 73
β⁻
γ Emission intensities
per 100 disintegrations
4,815
2,472
23,44
3
2
1
2⁺ ; 1325,512
4⁺ ; 1248,582
2⁺ ; 602,7278
6,2 ps
0⁺ ; 0
Stable
0
124
Te
52 72
Q⁻ = 2904,3 keV
% β⁻ = 100

ÉDITÉ PAR
LA DIRECTION DES SYSTÈMES
D'INFORMATION

CEA / SACLAY 91191 GIF-SUR-YVETTE CEDEX FRANCE