Rapport BIPM-76/8

International comparison of a solution of ^{139}Ce (March 1976)

Preliminary report

by A. Rytz

July 1976

BUREAU INTERNATIONAL DES POIDS ET MESURES

F-92310 SEVRES

List of the laboratories having submitted their results by 1976-07-05

1. AAEC Australian Atomic Energy Commission, Lucas Heights, Australia
2. AECL Atomic Energy of Canada Limited, Chalk River, Canada
3. AIEA Agence Internationale de l'Energie Atomique, Vienna, Austria
4. ASMW Amt für Standardisierung, Messwesen und Warenprüfung, Berlin, Democratic Republic of Germany
5. BARC Bhabha Atomic Research Centre, Trombay, India
6. BCMN Bureau Central de Mesures Nucléaires d'Euratom, Geel, Belgium
7. BIPM Bureau International des Poids et Mesures, Sèvres, France
8. ETL Electrotechnical Laboratory, Tokyo, Japan
9. IEA Instituto de Energia Atômica, Pinheiros-São Paulo, Brazil
10. IER Institut d'Electrochimie et de Radiochimie de l'Ecole Polytechnique Fédérale, Lausanne, Switzerland
11. IMM Institut de Métrologie D.I. Mendéléev, Leningrad, USSR
12. IRK Institut für Radiumforschung und Kernphysik, Vienna, Austria
13. LMRI Laboratoire de Métrologie des Rayonnements Ionisants, Saclay, France
14. NBS National Bureau of Standards, Washington, D.C., USA
15. NPL National Physical Laboratory, Teddington, United Kingdom
16. NPRL National Physical Research Laboratory, Pretoria, South Africa
17. NRCC National Research Council of Canada, Ottawa, Canada
18. PTB Physikalisch-Technische Bundesanstalt, Braunschweig, Federal Republic of Germany
19. SCK Studiecentrum voor Kernenergie, Mol, Belgium
20. UVVVR Ústav pro výzkum, výrobu a využití radioisotopů, Prague, ČSSR

Summary of the forms filled in by the participants

Laboratory	Method used 1)	Sources: Range of mass (mg)	Sources: Total backing mass ($\mu g/cm^2$)	Proportional counter: Gas 2)	Proportional counter: Pressure (kPa)	Proportional counter: Discr. level (keV)	Gamma ray counter NaI(Tl) crystals: Number	Diam. (mm)	Height (mm)	Dead times (μs): τ_β 3)	Dead times (μs): τ_γ 3)	Resolving time τ_r (μs) 3)
AAEC	4πPC-γ	22-55	30-2050	CH_4 Ar/CH_4	atm.	0.3	1	75	25	9.00 (5)	20.0 (2)	1.175 (1)
AECL	4πPC-γ 4)	16-53 14-45	$\approx$16 $\approx$16	CH_4 Ar/CH_4	atm. "	$\approx$0.1 "	2 "	76 "	76 "	2.049 (6) 2.020 (6)	2.043 (6) 2.016 (6)	0.6430 (3) 0.6645 (3)
AIEA	4πPC-γ	9-20	40	CH_4	atm.	0.17 or 0.7	1	76	76	4.087 (12)	4.085 (12)	0.9507 (42)
ASMW	4πPC-γ	11-33	30	C_3H_8	atm.	0.25	2 (1)	102	76	4.008 (18)	4.000 (18)	1.046 (6)
BARC	4πPC-γ	10-60	$\approx$ 35	Ar/CH_4	atm.	0.2	1	76	76	10 (1)	10 (1)	1.8 (2)
BCMN	4πPC-γ	15	50	Ar/CH_4	atm.	-	2	75	50	$\approx$7	$\approx$7	0.99
BIPM	4πPC-γ 5)	13-184 54-123	20 20	Ar/CH_4 "	atm. "	$\approx$0.075 "	1 "	75 "	50 "	4.43 (1) "	4.48 (1) "	1.05 (1) "
ETL	4πPC-γ	8-20	30	P-10 CH_4	atm.	0.2	2	76	76	4.35 (5)	2.11 (5)	0.6887 (28)
IEA	4πPC-γ	30-40	35	Ar/CH_4	atm.	0.05	2	76	76	3.01 (2)	3.01 (2)	1.04 (1)
IER	4πPC-γ	13-86	50	CH_4	atm.	1.0	1	76	76	2.201 (1)	2.196 (1)	0.775 (2)
IMM	4πPC-γ	40-80	30-40	Ar/CH_4	atm.	0.2	1	40	30	1.36 (2)	1.36 (2)	1.475 2.080 (10)
	KX(NaI)-γ	120-300	-	-	-	-	1	30	20	2.34 (5)	2.34 (5)	0.915 (7) 1.475 (10)
	2πPCLX-γ	"	-	Ar/CH_4	atm.	0.1	1	40	30	2.34 (5)	2.34 (5)	1.475 2.08 (10)

Summary of the forms filled in by the participants (cont'd)

Laboratory	Method used 1)	Sources: Range of mass (mg)	Sources: Total backing mass ($\mu g/cm^2$)	Proportional counter: Gas 2)	Proportional counter: Pressure (kPa)	Proportional counter: Discr. level (keV)	Gamma ray counter NaI(Tl) crystals: Number	Gamma ray counter NaI(Tl) crystals: Diam. (mm)	Gamma ray counter NaI(Tl) crystals: Height (mm)	Dead times (μs): τ_β 3)	Dead times (μs): τ_γ 3)	Resolving time τ_r (μs) 3)
IRK	4π(NaI)γ	6) 14-35	-	-	-	-	1	127	7) 127	-	10.3 (2)	-
LMRI	4πPC-γ	15-25	100-160	Ar/CH_4	atm.	$\approx$0.1	1 8)	44	3	5.200 (25)	5.200 (25)	0.973 (2)
NBS	4πPPC-γ	9) 16-48	20-30	Ar/CH_4	1 430	1-20	2	76	76	20.0 (12)	20.0 (12)	0.60 (5)
	4πPC-γ	16-48	20-30	Ar/CH_4	atm.	0.75	2	76	76	5.12 (49)	5.24 (20)	0.47 (2)
NPL	4πPC-γ	29-49	50	Ar/CH_4	atm.	0.3	2	100	75	1.527 (5)	3.0 (5)	0.716 (5)
	4πPC-γ	28-35	5) 50	Ar/CH_4	"	0.3	2	100	75	"	"	"
	4πLS-γ	15-30	-	-	-	-	1	100	100	24.6 (1)	1.96 (5)	0.25 (1)
	4πSi(Li)-γ	16-21	200	-	-	-	2 1	76 100	76 10) 150	8.00 (1)	6.01 (2)	2.95 (5) 0.502 11)
NPRL	4πLS-γ	32-59	-	-	-	-	1	76	76	1.25 (2)	3.23 (10)	0.510 (3) 0.513
NRCC	4πPPC-γ	20-25	$\approx$ 40	Ar/CH_4	1 584	0.6-6.0	2	76	76	2.03 (2)	2.04 (2)	0.982 (10)
	" 12)	20-25	"	"	"	"	"	"	"	2.03 (2)	2.04 (2)	0.982 (10)
	" 13)	20-25	"	"	"	"	"	"	"	2.12 (2)	2.10 (2)	0.976 (10)
	AC 14)	20-25	"	"	"	"	"	"	"	5.4 (1)	2.07 (2)	-
PTB	4πPC-γ	17-19	45	CH_4	atm.	0.5	1	75	75	2.98 (3)	3.00 (3)	2.87 (3)
SCK	4πPC-γ	4-20 15)	10	Ar/CH_4	atm. 17)	0.04	1	76	76	15.0 (5)	2.2 (1)	2.0 (1)
	4πPPC-γ				540	not det.	1	76	76	15.0 (5)	2.2 (1)	2.0 (1)
	4π(CsI)γ			-	-	-	2 16)	25	13	-	-	-
UVVVR	4πPPC-γ	19-25	$\approx$ 40	Ar/CH_4	$\approx$500	$\approx$1	2	75	50	6.57 (5)	4.12 (5)	1.98 (8)

Summary of the forms filled in by the participants (cont'd)

Laboratory	γ channel setting (keV)	Number of sources measured with var. of N_c/N_γ	Number of sources measured without var. of N_c/N_γ	Range of N_c/N_γ (%)	Slope to intercept ratio 1)	Radioactive concentration 1976-03-15 0 h UT (Bq/mg)	Standard error of the mean (Bq/mg)	Number of degrees of freedom	Total syst. uncertainty of the final result (Bq/mg)
AAEC	161 - 171	4	6	16 - 59	0.199 18 (18)	710.24	0.82	13	1.78
AECL	125 - 200	16	0	8 - 57	0.200 32 (4)	710.55	0.09	208	0.34
	120 - 200	15	0	9 - 54	0.200 39 (7)	710.46	0.12	178	0.61
AIEA	60 - 240	10	20	9 - 79	0.198 72 (25)	711.59	0.33	-	0.71
ASMW	100 - 200	9	0	8 - 55	0.201 64 (7)	711.1	0.7	9	1.9
BARC	-	4	29	7 - 29	0.197 0 (4)	712.2	1.1	640 (?)	3.8
BCMN	-	8	0	10 - 40	0.210 4 (6)	709.98	0.21	> 10	4.62
BIPM	140 - 190	6	4	15 - 47	0.203 6 (8)	710.56	2.02	25	8.24
	"	10	2	15 - 37	0.202 9 (3)	711.68	0.81	31	3.27
ETL	130 - 200	10	10	14 - 48	0.201 4 (6)	710.37	0.96	37	3.48
IEA	148 - 200	3	50	14 - 44	0.206 7 (7)	708.5	0.3	44	1.5
IER	-	8	46	14 - 45	0.200 36 (16)	709.86	0.08	45	2.13
IMM	-	5	0	18 - 40	-	710.47	0.71	3	+ 0.78 - 1.07
	-	0	13	-	-	709.01	0.35	12	4.96
	-	0	13	-	-	708.05	0.35	12	5.67

Summary of the forms filled in by the participants (cont'd)

Laboratory	γ channel setting (keV)	Number of sources measured with / without var. of N_c/N_γ		Range of N_c/N_γ (%)	Slope to intercept ratio 1)	Radioactive concentration 1976-03-15 0 h UT (Bq/mg)	Standard error of the mean (Bq/mg)	Number of degrees of freedom	Total syst. uncertainty of the final result (Bq/mg)
IRK	> 13	0	4	-	-	715.0	0.4	7	4.0
LMRI	136 - 216	24	0	24 - 52	0.204 5 (40)	708.4	0.9	117	0.7
NBS	113 - 218	4	0	13 - 60	0.202 8 (1)	713.73	0.16	41	3.07
	128 - 202	11	0	14 - 74	0.198 0 (2)	712.86	0.26	36	3.42
NPL	100 - 300	9	1	14 - 37	0.200 4 (7)	710.1	0.9	62	3.1
	"	8	2	15 - 32	0.200 2 (3)	711.6	0.4	38	3.5
	140 - 190	9	0	15 - 37	-	711.45	0.65	18	11.4
	100 - 230	7	0	2 - 48	-	709.58	2.31	6	9.3
NPRL	photo peak	16	0	14 - 49	0.248 3 (5)	719.8	0.4	15	1.1
NRCC	130 - 200	10	0	9 - 50	0.203 0 (4)	711.9	0.2	9	1.3
	"	10	0	"	0.202 9 (4)	711.7	"	"	1.3
	"	10	0	"	0.203 9 (3)	711.4	"	"	1.3
	"	10	0	-	0.202 9 (3)	711.5	"	"	1.0
PTB	> 130	8	7	4 - 23	0.200 04 (3)	710.51	0.36	51	1.1
SCK	140 - 210	0	25	11 - 32	0.192 9 (13)	729.2	3.4	24	2.6
	140 - 210	0	20	16 - 36	0.201 8 (20)	721.8	4.2	17	2.7
		0	27	-	-	739.3	3.5	26	8.9
UVVVR	90 - 230	2	19	12 - 48	0.200 (2)	715.85	0.24	18	5.37

Footnotes for the table:

"Summary of the forms filled in by the participants"

1) LS Liquid scintillator
PC Proportional counter
PPC Pressurized proportional counter

2) Ar/CH_4 stands for 90% argon + 10% methane

3) in parentheses the uncertainty in units of the last digit is given

4) second ampoule, two electronic systems in parallel

5) second ampoule

6) from a dilution 28.076 5 : 1

7) well-type crystal; well diameter 27.36 mm,
well depth 74.20 "

8) with a Be window 48.5 diam. x 0.24 mm

9) from a dilution 5.145 035 : 1

10) well type

11) three units in parallel

12) using the second ampoule and coincidence system 1

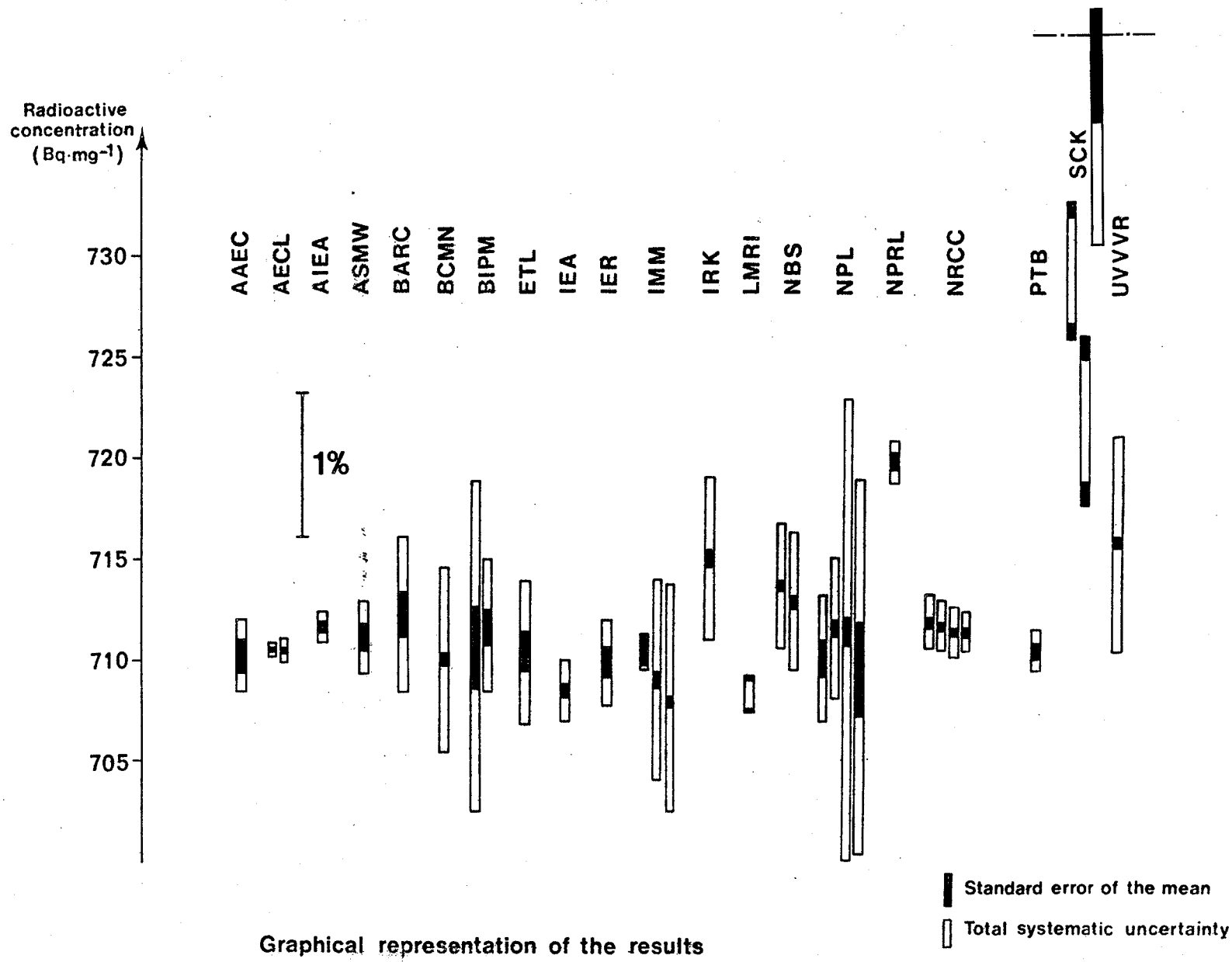
13) " " first " " " " 2

14) 4πPPC-γ anti coincidence

15) from dilutions

16) CsI (Tl)

17) each anode consisting of 5 wires



Graphical representation of the results

BUREAU INTERNATIONAL
DES
POIDS & MESURES

PAVILLON DE BRETEUIL
F 92310 SÈVRES FRANCE
TÉLÉGRAMME : POIDMESURE, SÈVRES
TÉLÉPHONE 027 00-51

July 15, 1976

To the participants in the international comparison
of a solution of ^{139}Ce (March 1976)

Dear Colleague,

Twenty participants have submitted their results to date. The numerous forms, drawings, diagrams, reprints and remarks contain a wealth of information which must be carefully studied before the results can be adequately interpreted. As this analysis may take several months, we decided to present in the meantime the enclosed preliminary report containing only the most important details of the measurements. Any interpretation or discussion has been omitted and is postponed until later.

Much information is now available on the various extrapolations carried out. However, we feel that the discussion would gain considerably if second order fitting were applied as well. Some participants have already done so, but all except one have omitted to indicate the coefficients of higher order polynomials as asked for in the forms. We should like now to make up for this. It would be sufficient to state the values for a_o (see form) for linear and for second order fit. If this problem does not seem clear enough or if computational facilities or time are lacking, the BIPM would be happy to carry out the calculations. In this case, the participants should send us the values of $x = \dfrac{1 - N_c/N_\gamma}{N_c/N_\gamma}$, $y = \dfrac{N_\beta N_\gamma}{mN_c}$ and σ_y (st. error), for the reference date and for all data points to be used in the extrapolations.

We hope we shall receive this additional information before the end of September 1976. Any remarks and suggestions will be welcome.

Yours sincerely,

for the Director,

encls.

A. Ryt