



International co-operation, basic principles and developments in radiation protection metrology and measurements

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BEV – Federal Office of Metrology and Surveying



Globalization of metrology

International Metre Convention 20 May 1875



„À tous le temps, à tous le peuples“

Reconnaissance mutuelle

des étalons nationaux de mesure
et des certificats d'étalonnage et de mesurage
émis par les laboratoires nationaux de métrologie

Paris, le 14 octobre 1999



Mutual recognition

of national measurement standards
and of calibration and measurement certificates
issued by national metrology institutes

Paris, 14 October 1999

Comité international des poids et mesures

Bureau
international
des poids
et mesures

Organisation
intergouvernementale
de la Convention
du Mètre

International metrological infrastructure

- Convention of the Metre (Convention du Mètre)
 - was signed in Paris in 1875 by seventeen nations
 - to act in common accord on all matters relating to units of measurement
 - remains the basis of international agreement on units of measurement
 - current fifty-four Member States, including all the major industrialized countries
- General Conference on Weights and Measures (CGPM)
- International Committee for Weights and Measures (CIPM)
- International Bureau of Weights and Measures (BIPM)

BIPM acts in matters of world metrology, particularly concerning the demand for measurement standards of ever increasing accuracy, range and diversity, and the need to demonstrate equivalence between national measurement standards.

<http://www.bipm.org>
Bureau International
des Poids et Mesures

- ♦ Version française
- ♦ English version
- ♦ metrologia

↳ ARRANGEMENT DU CIPM

↳ KCDB



↳ BASE DE DONNÉES DU JCTLM



- ♦ La Convention du Mètre
- ♦ Les comités de la Convention du Mètre
- ♦ Le siège du BIPM
- ♦ Le Système international d'unités (SI) – et le « nouvel SI »...
- ♦ Travaux scientifiques du BIPM
- ♦ Publications du BIPM
- ♦ Informations pratiques
- ♦ Réunions | Liens utiles

↳ CIPM MRA

↳ BIPM KEY COMPARISON DATABASE



↳ JCTLM DATABASE



- ♦ The Metre Convention
- ♦ Committee structure of the Metre Convention
- ♦ The BIPM headquarters
- ♦ The International System of Units (SI) – and the "New SI"...
- ♦ Scientific work of the BIPM
- ♦ Publications of the BIPM
- ♦ Practical information
- ♦ Meetings | Useful links

 Bienvenue sur le serveur internet du BIPM
 Welcome to the BIPM internet server


UTC Date: Thursday 17 May

↳ International time

UTC 06:49:38

Your estimated transmission delay: 0.09 second(s)



↳ The International System of Units (SI) – and the "New SI"...

In 1960, the 11th General Conference on Weights and Measures adopted the name *Système International d'Unités* (International System of Units) for the recommended practical system of units of measurement.

- ♦ [More info](#)
- ♦ [Towards the "New SI"...](#)
- ♦ See also: [CODATA TGFC](#)

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New metrology search engine:



New Associate of the CGPM: Oman: As of 8 May 2012, [Oman](#) is an Associate of the CGPM.
 – See also: [How to become an Associate](#)

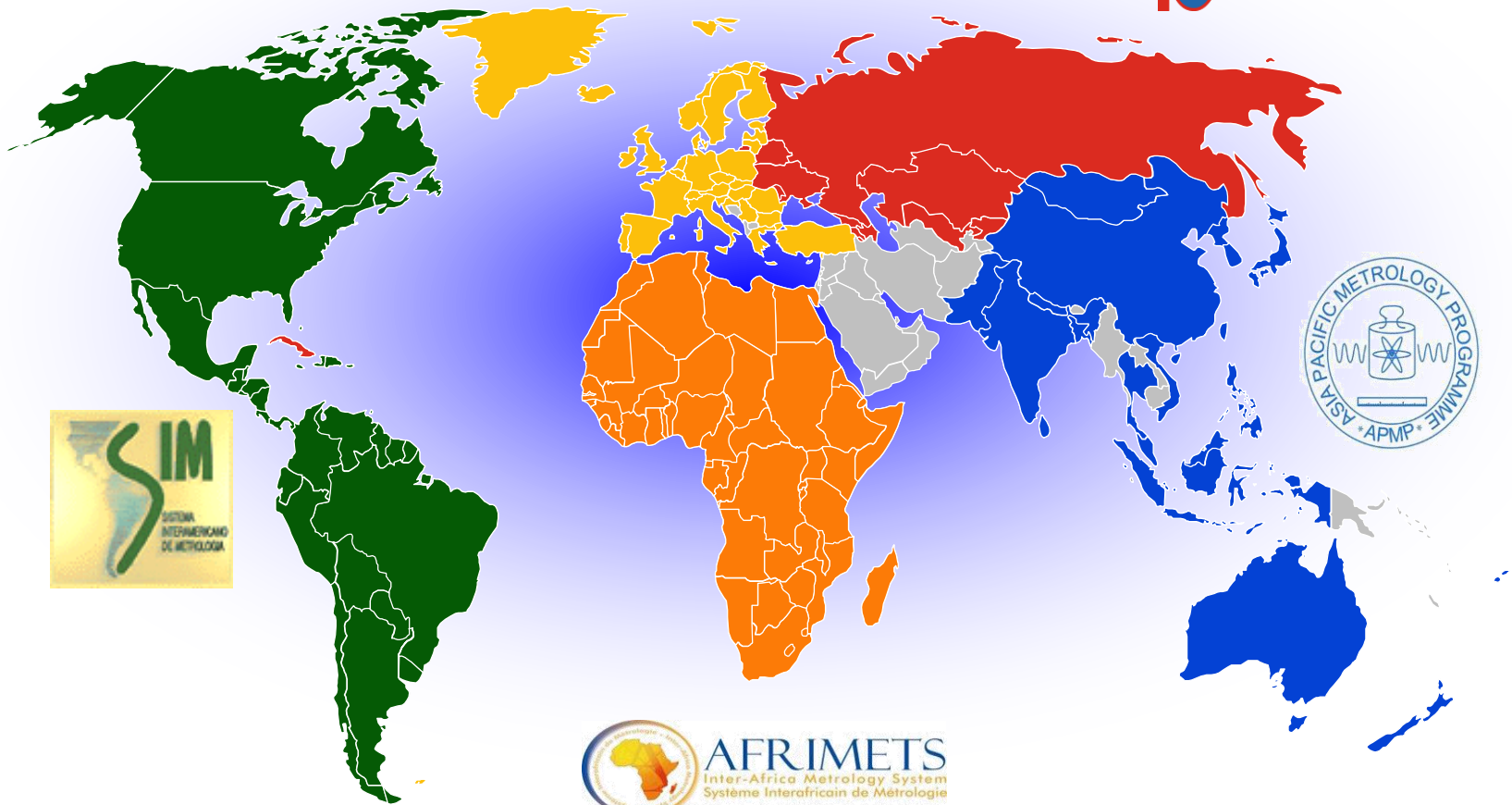
New Member State: Tunisia: The BIPM is pleased to announce that the Republic of Tunisia, which has been an Associate of the CGPM since October 2007, acceded to the BIPM on 1 February 2012, bringing the number of Member States to 56.
 – [How to become a Member of the BIPM](#)

World Metrology Day: 20 May 2012: This year, the theme is "Metrology for Safety" – a wide-ranging topic but one which concerns everyone in a multitude of situations. We invite you to download the promotional poster and other material from the World Metrology Day website, and to register your own event.
 – See www.worldmetrologyday.org

Two-year secondment: Executive Secretary of the JCRB: Note that formal applications should be addressed to the Director of the BIPM through the applicant's NMI Director.
 – Closing date for applications: **15 May 2012**

Publication of JCGM 200:2012: This corrected version of the 3rd edition of the VIM cancels and replaces JCGM 200:2008.

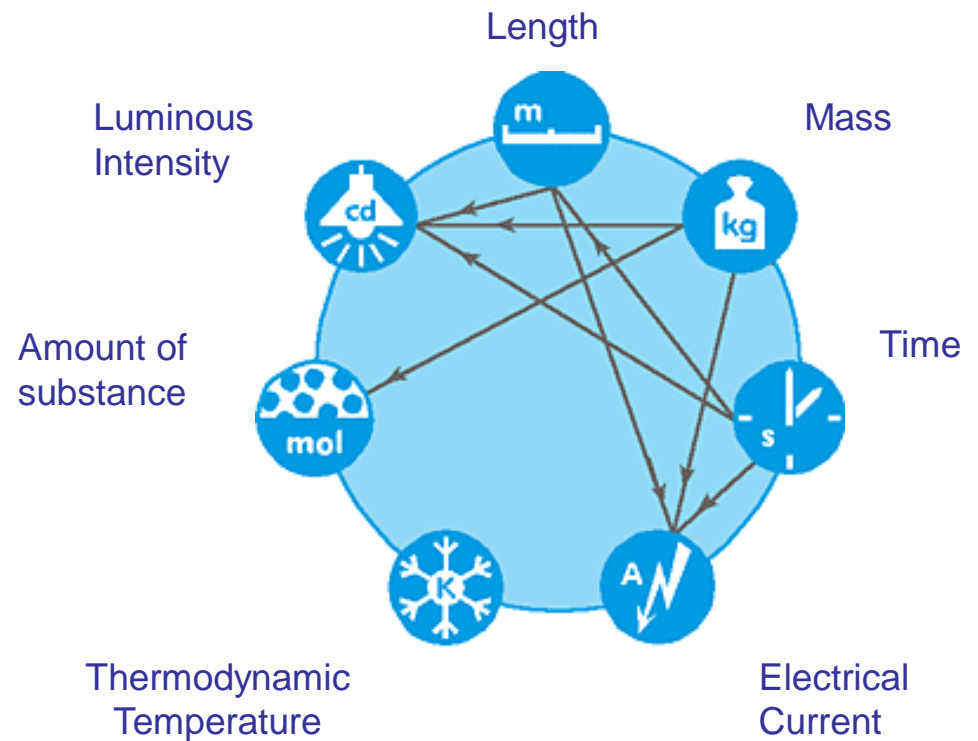
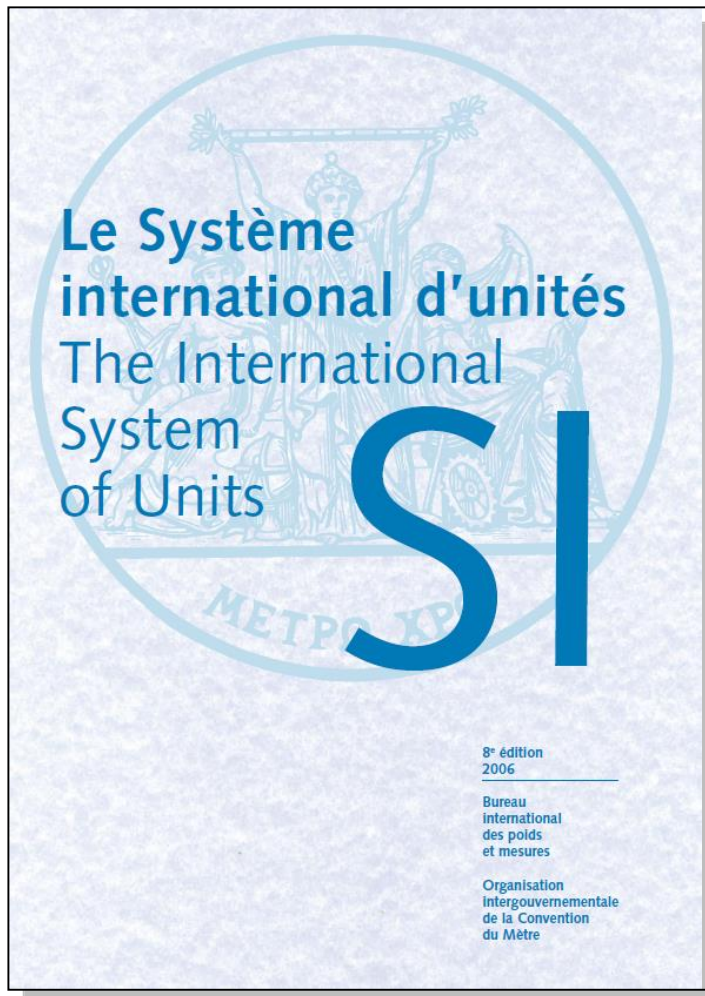
Regional Metrology Organisations



International Co-operation in Metrology

	National	Europe	Worldwide
National Metrology Institutes			
Legal Metrology			
Accreditation			

The International System of Units



Radiation protection measurements ↔ CCRI

Consultative Committee for Ionizing Radiation

(1958/1960) *Comité consultatif des rayonnements ionisants*

- advice to the CIPM on matters related to ionizing radiation standards
- x-ray
- γ -ray
- charged particle
- neutrons
- Radionuclide metrology / radioactivity measurement
- international reference system for radionuclides SIR

ICRM International Committee for Radionuclide Metrology

- **Working groups:**
 - Radionuclide Metrology Techniques
 - Life Sciences
 - Alpha-Particle Spectrometry
 - Gamma-Ray Spectrometry
 - Liquid Scintillation Techniques
 - Low-Level Measurement Techniques
 - Non-Neutron Nuclear Data
- **6th International Conference on Low-Level Radioactivity Measurement Techniques ICRM-LLRMT'12**
September 17 - 21, 2012, Jeju, Korea
Korea Research Institute of Standards and Science (KRISS)

Main quantities and units in radiation protection: dose and activity

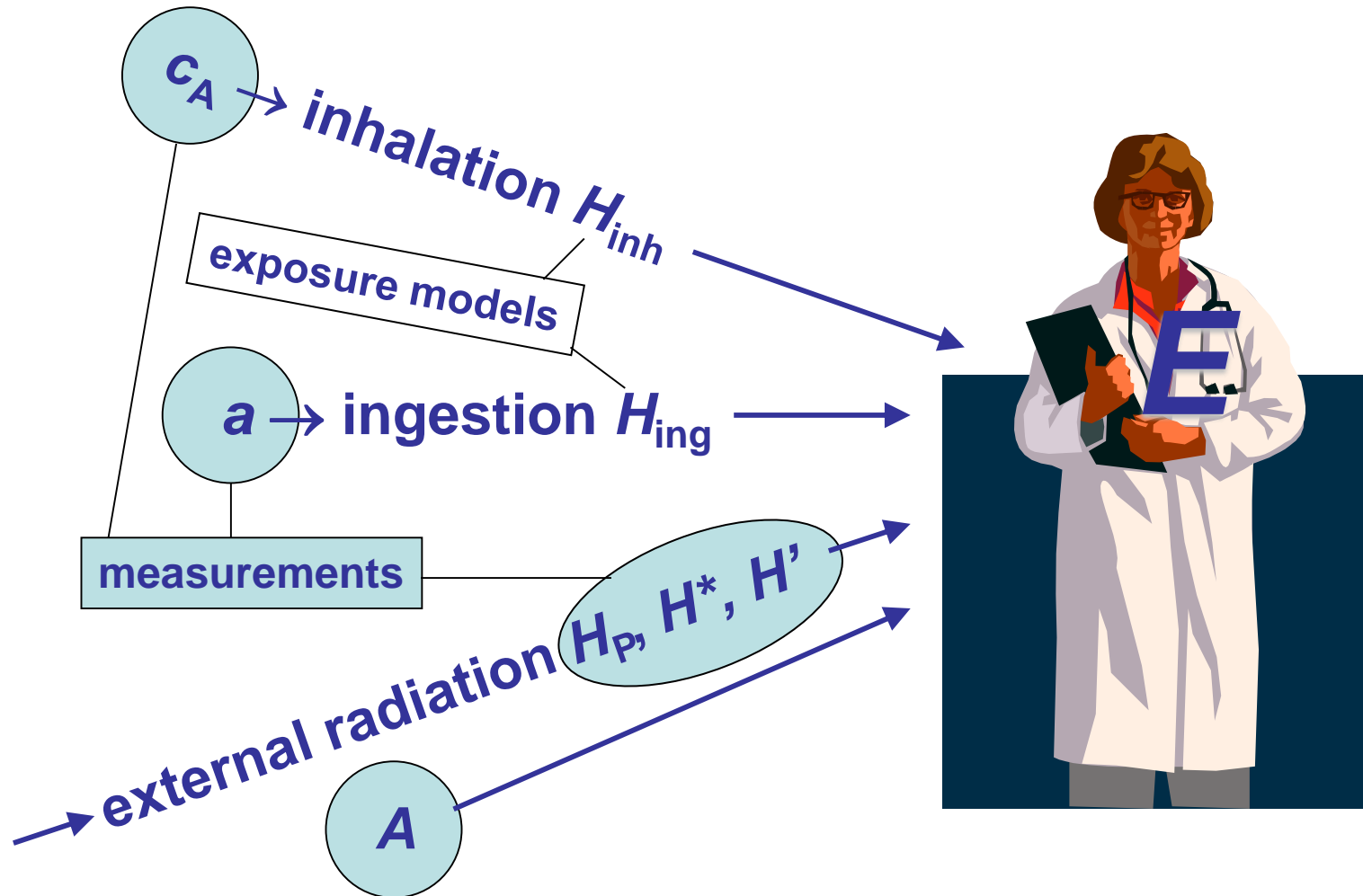
- Dose but which dose quantity?
- Sievert but for which dose quantity?
- Gray ... but for which dose quantity?
- Dosemeter ... but for which dose quantity?

- Effective dose ... E ... not directly measurable ... $\text{Sv} = \text{J kg}^{-1} = \text{m}^2 \text{s}^{-2}$
- Ambient dose equivalent ... $H^*(10)$, $H^*(0,07)$ Sv
- Personal dose equivalent ... $H_p(10)$, $H_p(0,07)$... Sv
- Absorbed dose ... D ... $\text{Gy} = \text{J kg}^{-1} = \text{m}^2 \text{s}^{-2}$ e.g. absorbed dose to water D_W
- Kerma ... K ... Gy e.g. air kerma K_a

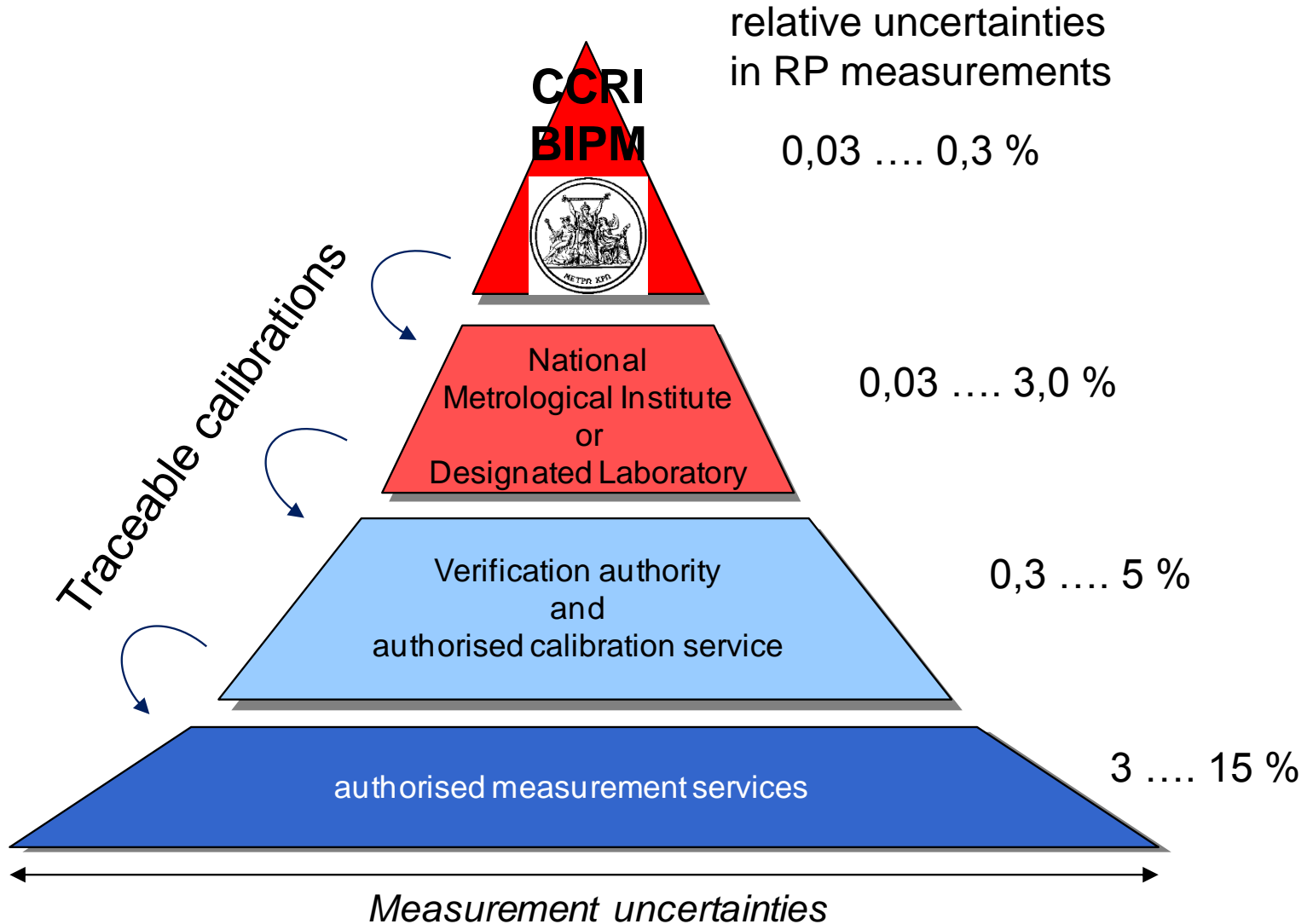
- Activity ... A ... $\text{Bq} = \text{s}^{-1}$
- Activity concentration ... a ... Bq m^{-3} or Bq kg^{-1}
- Specific activity ... a ... Bq kg^{-1}

Ionising radiation exposure

Radiation sources → radiation exposure



Traceability



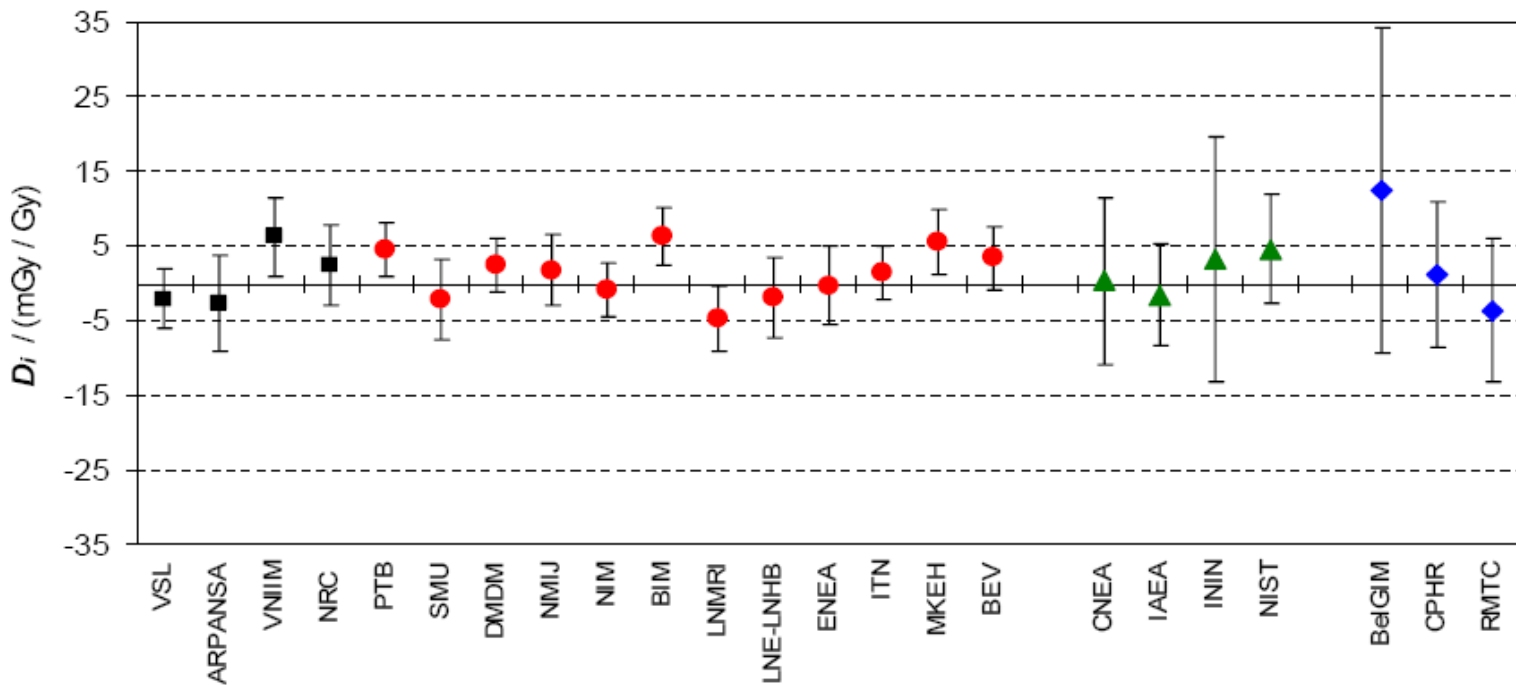
CCRI at BIPM

- **Key comparisons dosimetry**

- BIPM.RI(I)-K1: Measurement of Air Kerma for Cobalt 60
- BIPM.RI(I)-K2: Measurement of air kerma for low energy X-rays
- BIPM.RI(I)-K3: Measurement of air kerma for medium energy X-rays
- BIPM.RI(I)-K4: Measurement of Absorbed Dose to Water for Cobalt 60
- BIPM.RI(I)-K5: Measurement of Air Kerma for Cesium 137

Key comparison - air kerma in ^{60}Co radiation

BIPM.RI(I)-K1, SIM.RI(I)-K1 (2002) and COOMET.RI(I)-K1 (2006)
Degrees of equivalence with the KCRV for air kerma in ^{60}Co




N.B. Black squares indicate results that are more than 10 years old.

- BIPM.RI(I)-K1
- ▲ SIM.RI(I)-K1
- ◆ COOMET.RI(I)-K1

SIR at BIPM: International Reference System for γ -ray emitting radionuclides

- Ionisation chamber / ^{226}Ra / established at BIPM 1976
- ~ 900 measurements, > 60 radionuclides

	<u>F-18</u>	<u>Na-22</u>	<u>Na-24</u>	<u>Sc-46</u>	<u>Sc-47</u>	<u>Cr-51</u>	<u>Mn-54</u>	<u>Mn-56</u>	<u>Co-56</u>
	<u>Co-57</u>	<u>Co-58</u>	<u>Fe-59</u>	<u>Co-60</u>	<u>Cu-64</u>	<u>Zn-65</u>	<u>Ga-67</u>	<u>Se-75</u>	<u>Kr-85</u>
	<u>Sr-85</u>	<u>Y-88</u>	<u>Nb-95</u>	<u>Mo-99</u>	<u>Tc-99m</u>	<u>Ru-103</u>	<u>Ru-106</u>	<u>Cd-109</u>	
	<u>Aq-110m</u>	<u>In-111</u>	<u>Sn-113</u>	<u>I-123</u>	<u>Sb-124</u>	<u>I-125</u>	<u>I-131</u>	<u>Ba-133</u>	
	<u>Xe-133</u>	<u>Cs-134</u>	<u>Cs-137</u>	<u>Ce-139</u>	<u>Ba-140</u>	<u>Ce-141</u>	<u>Ce-144</u>	<u>Eu-152</u>	
	<u>Gd-153</u>	<u>Sm-153</u>	<u>Eu-154</u>	<u>Eu-155</u>	<u>Ho-166m</u>	<u>Yb-169</u>	<u>Lu-177</u>		
	<u>Ta-182</u>	<u>Re-186</u>	<u>Ir-192</u>	<u>Au-195</u>	<u>Tl-201</u>	<u>Hg-203</u>	<u>Pb-203</u>	<u>Bi-207</u>	
	<u>Rn-222</u>	<u>Th-228</u>	<u>Am-241</u>	<u>Am-243</u>					

- results: published in the key comparison database KCDB
- efficiency curve of the ionization chamber (IC) as a function of γ -ray energy.

e.g. BEV SIR key comparisons

- 1998: Co-57, Co-60, Ba-133, Cs-137
- 2000: Eu-152
- 2001: Na-22, Mn-54, Y-88
- 2002: F-18, Zn-65, Tc-99m
- 2003: Mn-54, Ir-192, Am-241
- 2004: I-125
- 2007: I-131

- 2008: Cs-134
- 2008: Ce-139
- 2009: Co-60
- 2010/11: Cs-137
- 2011/12: Ba-133

SIR 2008 - Key comparison BIPM.RI(II)-K1.Ce-139

Draft B Update Report for Ce-139 2011/09/06

Update of the BIPM comparison BIPM.RI(II)-K1.Ce-139 of activity measurements of the radionuclide ^{139}Ce to include the 2008 results of the PTB, Germany and the BEV, Austria

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³BEV - Bundesamt für Eich- und Vermessungswesen, Schiffamtsgasse 1-3, 1020 Wien, Austria

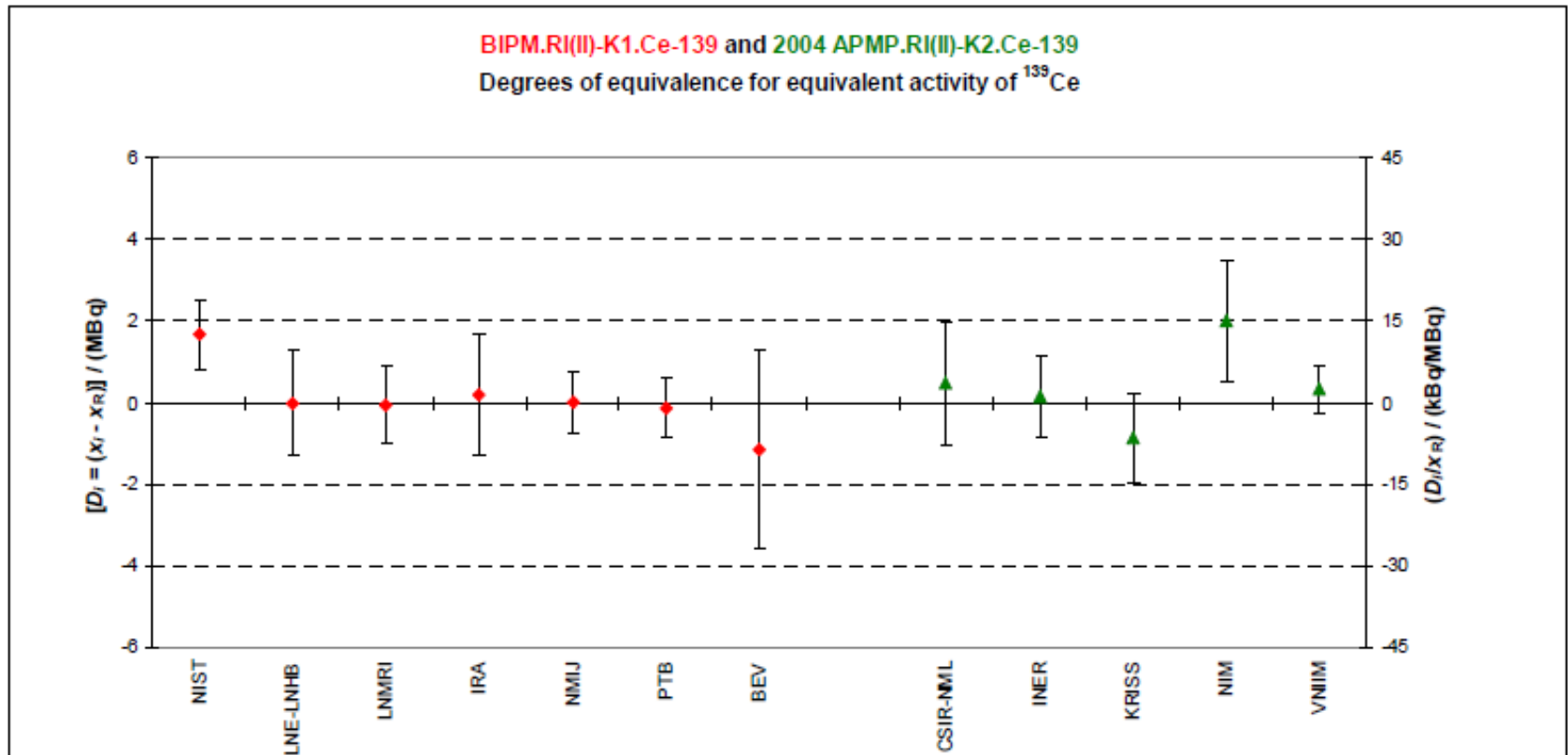
Draft B Update Report for Ce-139 2011/09/06

Table 2. Standardization methods of the recent participants for ^{139}Ce

NMI	Method used and acronym (see Appendix 2)	Half-life /d	Activity / kBq	Reference date YY-MM-DD	Relative standard uncertainty $\times 100$ by method of evaluation	
					A	B
PTB 1999	4 π (PC and PPC)EC- γ coincidence 4P-PC-MX-NA-GR-CO 4P-PP-MX-NA-GR-CO	137.66 (6)	5 400	1999-11-01 0 h UT	0.06	0.14
	coincidence methods 4P-PC-MX-NA-GR-CO 4P-PP-MX-NA-GR-CO	137.66 (6)	4 145*	2008-02-01 0 h UT	0.06	0.23
BEV 2008	Pressurized ionization chamber 4P-IC-GR-00-00-00	137.6410	484	2008-12-01 0 h UT	0.31	0.84

* weighted mean result taking correlation into account for the uncertainties

Figure 1. Graph of degrees of equivalence with the KCRV for ^{139}Ce



N.B. Right –hand axis gives approximate values only

SIR 2011/12 - Key comparison BIPM.RI(II)-K1.Ba-133

Detailed Uncertainty Budget

Laboratory: BEV;

Radionuclide: Ba-133 ;

Ampoule number: SIR-2011 Ba-133

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

		Remarks	Evaluation type (A or B)	Relative Sensitivity Factors
counting statistics	0,021	-----	A	1,00E+00
weighing	0,0056	-----	B	-1,00E+00
background	-----	included into current measurement		-----
impurities	0,00037	-----	B	-4,35E-05
half life ($T_{1/2} = 3849,65$ d; $u = 2,20$ d)	0,00019	-----	B	3,28E-03
other effects (if relevant) (explain)	0,67	calibration factor	B	-1,00E+00
	0,029	current measurement	B	1,00E+00
	0,029	ionisation chamber	B	1,00E+00
	0,029	filling height	B	1,00E+00
combined uncertainty (as quadratic sum of all uncertainty components	0,68	k=1	-----	-----

European Metrology Research Programme (EMRP)

- 2010 - 2016
- Collaboration of European metrology institutes, designated laboratories, industrial and academical partners in joint research projects
- To accelerate innovation in areas where shared resources and decision-making processes are desirable due to economic factors and the distribution of expertise across different countries and sectors
- Implemented by EURAMET, organised by 22 National Metrology Institutes (NMIs), supported by the European Union and has a value of 400 M€

EMRP 2010 Call Industry / 2011-2014

JRP IND 04 MetroMETAL

“Ionizing Radiation Metrology for Metallurgical Industry”

- Design of traceable measurement methods, optimized for the control of scrap loads, metal products, slag and fumes dust, according to EC, national regulations and IAEA recommendations.
- Development of standard reference sources for cast steel and slags with:
 - most frequent potential contaminant radionuclides (^{60}Co , ^{137}Cs , ^{192}Ir , ^{226}Ra , ...)
 - different steel compositions, black and grey slags and fumes filters
 - different geometries, matching the cast steel probes currently used for on-line measurements

JRP IND 04 MetroMETAL

“Ionizing Radiation Metrology for Metallurgical Industry”

JRP start date and duration: 1 September 2011

JRP-Coordinator: José M. Los Arcos 1 Dezember 2011

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JRP-Partners:

1) BEV/PTP, Austria

8) ITN, Portugal

2) CEA-LNHB, France

9) JRC-IRMM, EC

3) CIEMAT-LMRI

10) MKEH, Hungary

4) CMI, Czech Republic

11) POLATOM, Poland

5) ENEA, Italy

12) PTB, Germany

6) IFIN-HH, Romania

13) SMU, Slovakia

7) IJS, Slovenia

14) STUK, Finland

EMRP 2010 Call Environment / 2011-2014

JRP ENV09 MetroRWM

Metrology for Radioactive Waste Management

- Development of standardised traceable measurement methods for solid radioactive waste - clearance levels verification and acceptance criteria verification
- Design of measurement facilities, software, calibration and testing methods.
- Development of novel instruments and methods for in-situ measurements: improved on-site radiochemical analysis, rapid in-situ screening techniques for alpha, beta and gamma emitters
- Development of a gaseous effluent monitor/sampler for stored wastes.
- key radionuclides (e.g. ^3H , ^{14}C , ^{222}Rn).
- Standards and 'spiked' or characterized 'real' reference materials (concrete, steel, aluminium, cables, wood, insulator and others).
- Improvements to decay data for selected radionuclides present in nuclear wastes

MetroRWM “Metrology for Radioactive Waste Management”

		Short name	Organisation legal full name	Country
1	JRP-Coordinator	CMI	Cesky Metrologicky Institut Brno	Czech Republic
2	Funded JRP-Partner	BEV/PTP	Bundesamt fuer Eich- und Vermessungswesen, Physikalisch-Technischer Pruefdienst	Austria
3	Funded JRP-Partner	CEA	Commissariat a l' Energie Atomique et aux énergies alternatives	France
4	Funded JRP-Partner	CIEMAT	Centro de investigaciones energeticas, medioambientales y tecnologicas	Spain
5	Funded JRP-Partner	ENEA	Agenzia Nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile	Italy
6	Funded JRP-Partner	IJS	Institut Jozef Stefan	Slovenia
7	Funded JRP-Partner	JRC	JRC - Joint Research Centre -European Commission	EC
8	Funded JRP-Partner	MIKES	Mittatekniikan Keskus	Finland
9	Funded JRP-Partner	MKEH	Magyar Kereskedelmi Engedelyezesi Hivatal	Hungary
10	Funded JRP-Partner	NPL	NPL Management Limited	UK
11	Funded JRP-Partner	POLATOM	Institute of Atomic Energy POLATOM	Poland
12	Funded JRP-Partner	PTB	Physikalisch-Technische Bundesanstalt	Germany
13	Funded JRP-Partner	SMU	Slovenský Metrologický Ustav	Slovakia

Conclusions

Danke schön!

- RP \Leftrightarrow reliable measurement methods
- RP \Leftrightarrow appropriate quantities and units
- RP \Leftrightarrow evaluation of measurement uncertainties
- RP \Leftrightarrow metrological traceability of instruments
- RP \Leftrightarrow quality management system

- Service of the international / regional (e.g. European) / national metrological infrastructure to RP:
 - RP measurement methods development and verification
 - Traceability
 - Calibration and/or legal verification