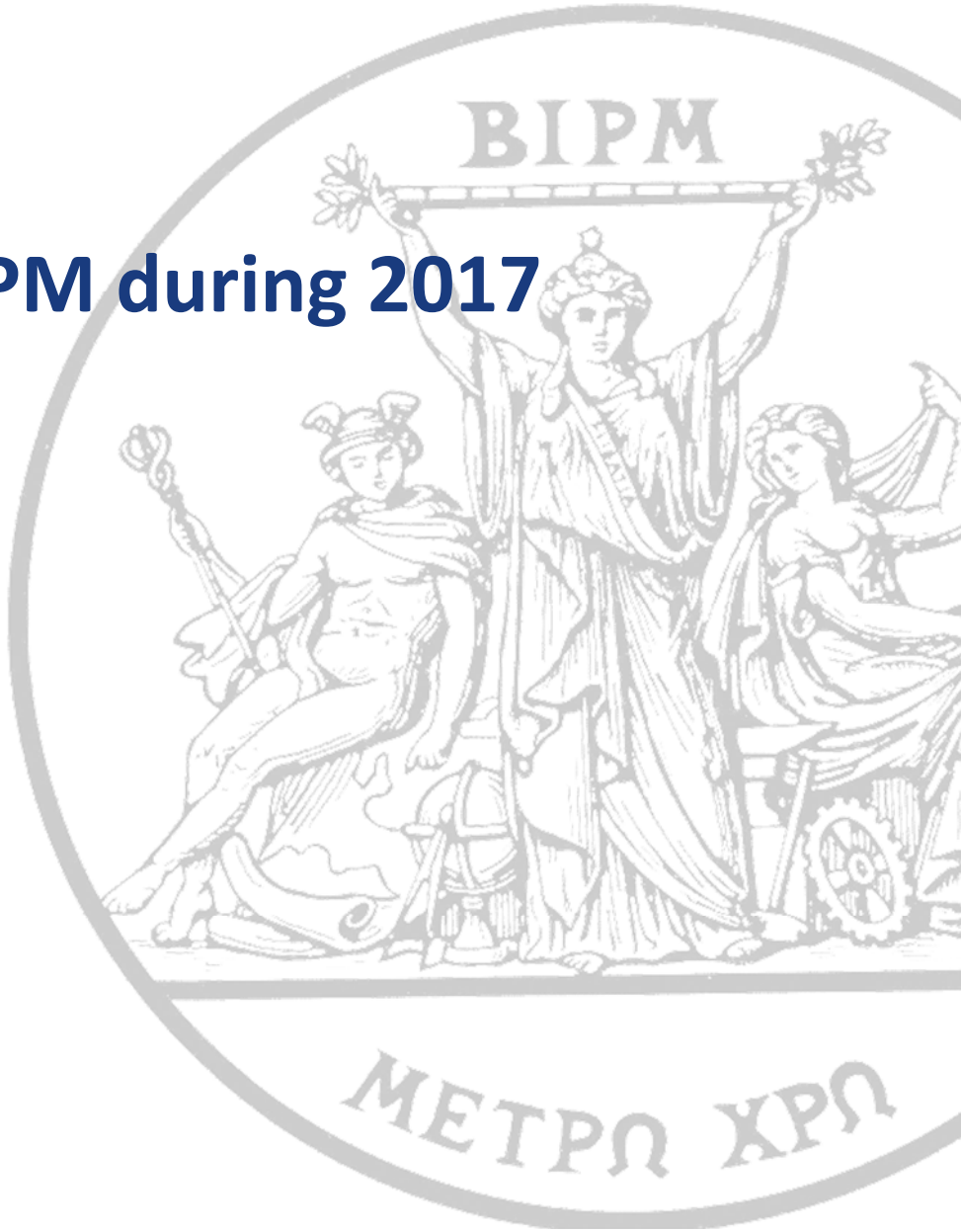
Highlights in the work of the BIPM during 2017

Dr Martin Milton
BIPM Director

18 October 2017

Bureau International des Poids et Mesures



BIPM highlights of 2017

01 – Introduction to the BIPM

02 – Liaison work

03 – Laboratory work

- Physical, Time, Ionising Radiation and Chemistry departments

04 – Finance and Operations

05 – Coordination work

- BIPM Capacity Building & Knowledge Transfer Programme
- Review of the CIPM MRA and the KCDB 2.0

Bureau International des Poids et Mesures

The objectives of the BIPM

To **represent** the worldwide measurement community aiming to maximise its uptake and impact

To be a **centre for scientific and technical** collaboration between Member States providing capabilities for international measurement comparisons on a shared-cost basis.

To be the **coordinator** of the worldwide measurement system ensuring it gives comparable and internationally-accepted measurement results

Fulfilling our mission and objectives is underpinned by our work in:

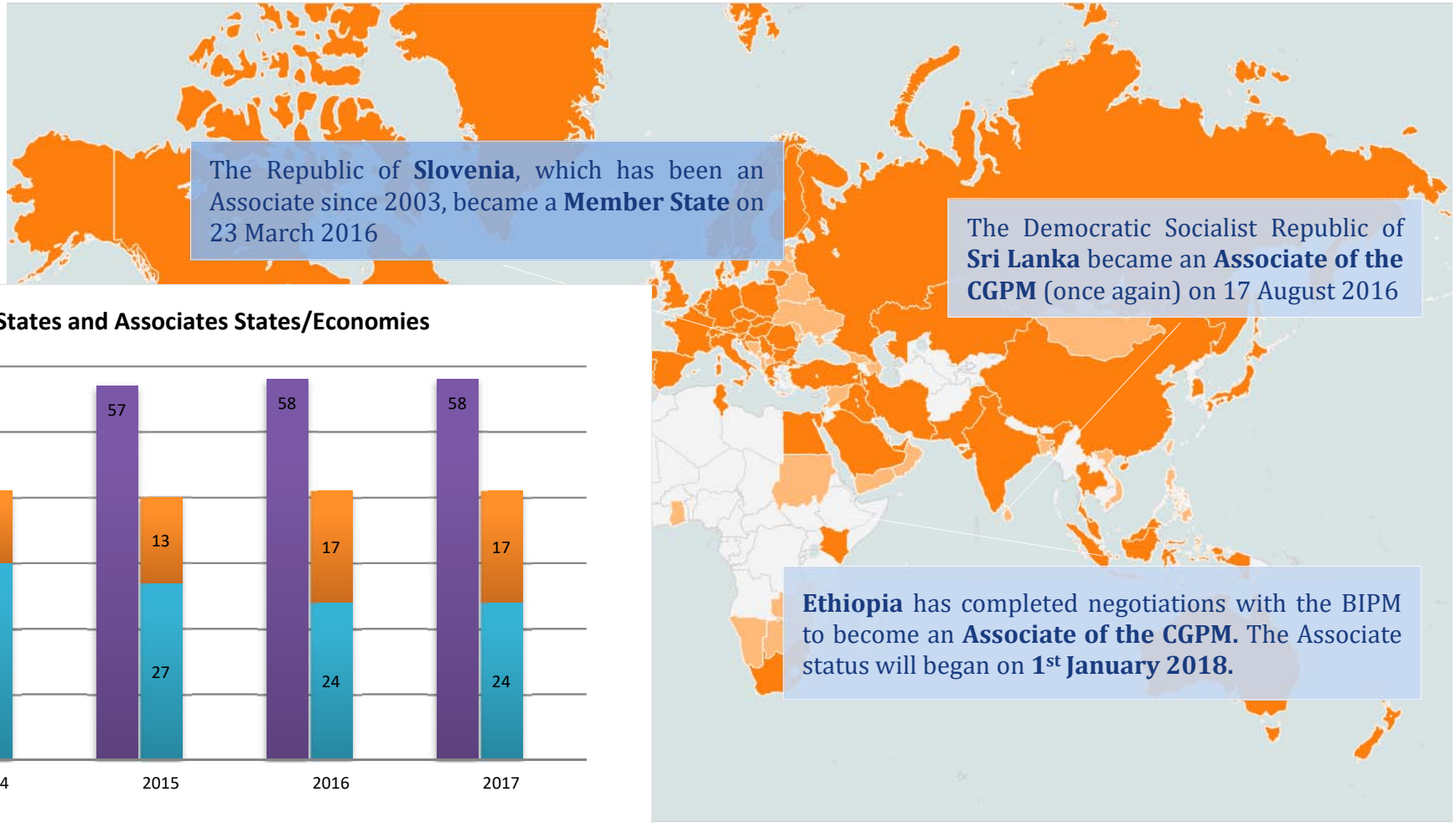
- ***capacity building**, which aims to achieve a global balance between the metrology capabilities in Member States.*
- ***knowledge transfer,** which ensures that our work has the greatest impact.*

Member States and Associates

As of today, there are:

- 58 Member States
- 41 Associates States and Economies

+ Ethiopia on 1st January 2018

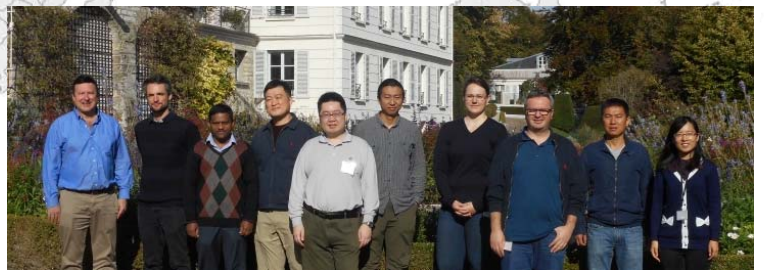


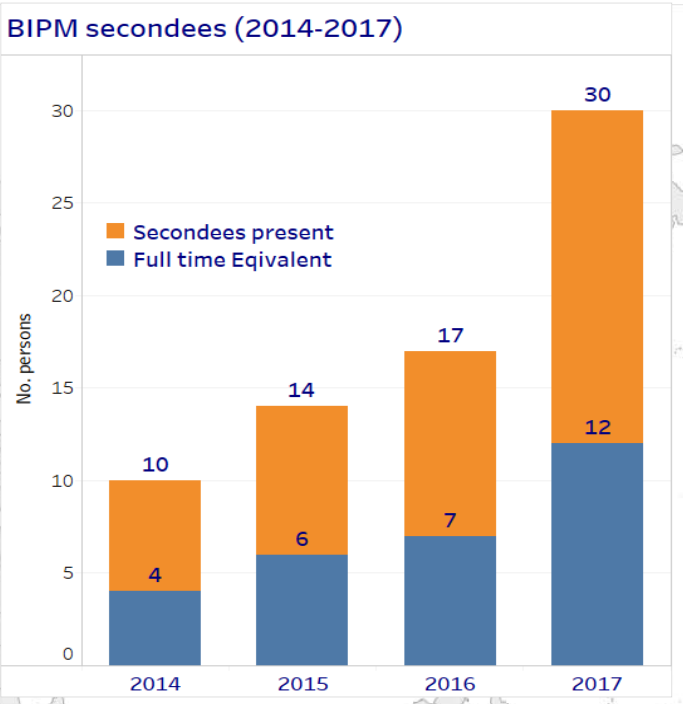
BIPM Staff – changes during 2017

Dr Steven Judge, has been appointed as the Director of the BIPM Ionizing Radiation Department from **15 August 2017.**

We have 71 staff from 21 countries.

Dr Patrizia Tavella, has been appointed as the Director of the BIPM Time Department from **1 November 2017.**





02 – Liaison work

Representation of the worldwide measurement community

Bureau International des Poids et Mesures

Promotion of the world-wide comparability of measurement

Bureau International des Poids et Mesures

BIPM works to foster cooperation with international organizations and promotes the world-wide comparability of measurement.

Food and Agriculture Organization of the United Nations

OIML

ifcc International Federation of Clinical Chemistry and Laboratory Medicine

IUPAC International Union of Pure and Applied Chemistry

JCGM

ISO

IAEA International Atomic Energy Agency

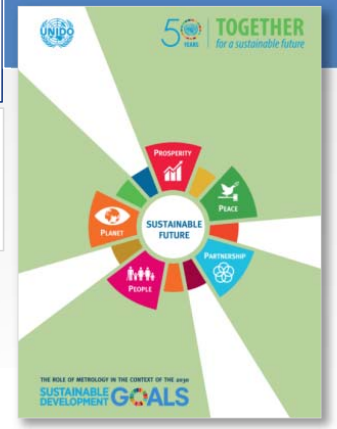
JCTLM

World Trade Organization

ilac

WMO

DCMAS Network



JCRB

World Health Organization

WORLD ANTI-DOPING AGENCY

7 nationalities and
9 languages

Liaison work: working together on QI

Definition adopted in June 2017

by DCMAS Network (BIPM IAF, IEC, ILAC, ISO, ITC, ITU, OIML, UNECE and UNIDO) + the World Bank.

"The system comprising

the organizations (public and private)
together with the policies, relevant legal and regulatory framework, and practices needed
to support and enhance the quality, safety and environmental soundness of goods, services and processes.

The quality infrastructure is required for the effective operation of domestic markets, and its international recognition is important to enable access to foreign markets. It is a critical element in promoting and sustaining economic development, as well as environmental and social wellbeing.

It relies on

- ***metrology***
- ***standardization***
- ***accreditation***
- ***conformity assessment, and***
- ***market surveillance"*** *(in regulated areas)*

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International Regulatory Co-operation and International Organisations

An OECD partnership between 50 International Organizations aims

- **to foster collective action among IOs and their constituency to promote quality, effectiveness and impact of international rules.**
- This builds greater confidence for domestic regulators and legislators in international rules and helps support greater uptake of good quality international instruments in national legislation

Future OECD case studies (2017-2019)

BIPM, WTO, ASTM International.

Case Studies of rule-making practices in IOs (2014-2016)

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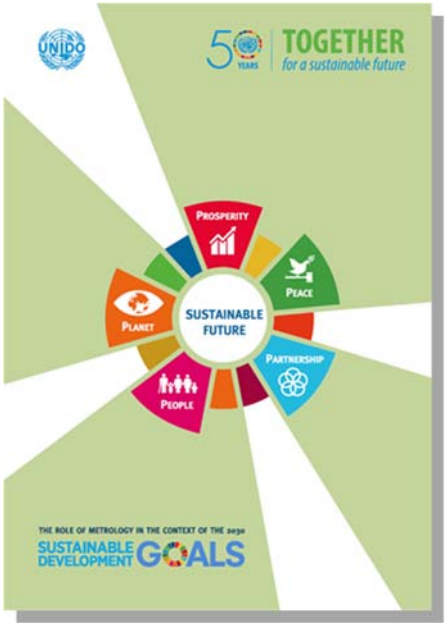
OECD
BETTER POLICIES FOR BETTER LIVES

UNIDO-BIPM-OIML joint publication



THE ROLE OF METROLOGY IN THE CONTEXT OF THE 2030
SUSTAINABLE DEVELOPMENT GOALS

- A new brochure highlights the contribution of metrology to the implementation of the 2030 Agenda for Sustainable Development
- Jointly developed by the UNIDO, the BIPM and the OIML.

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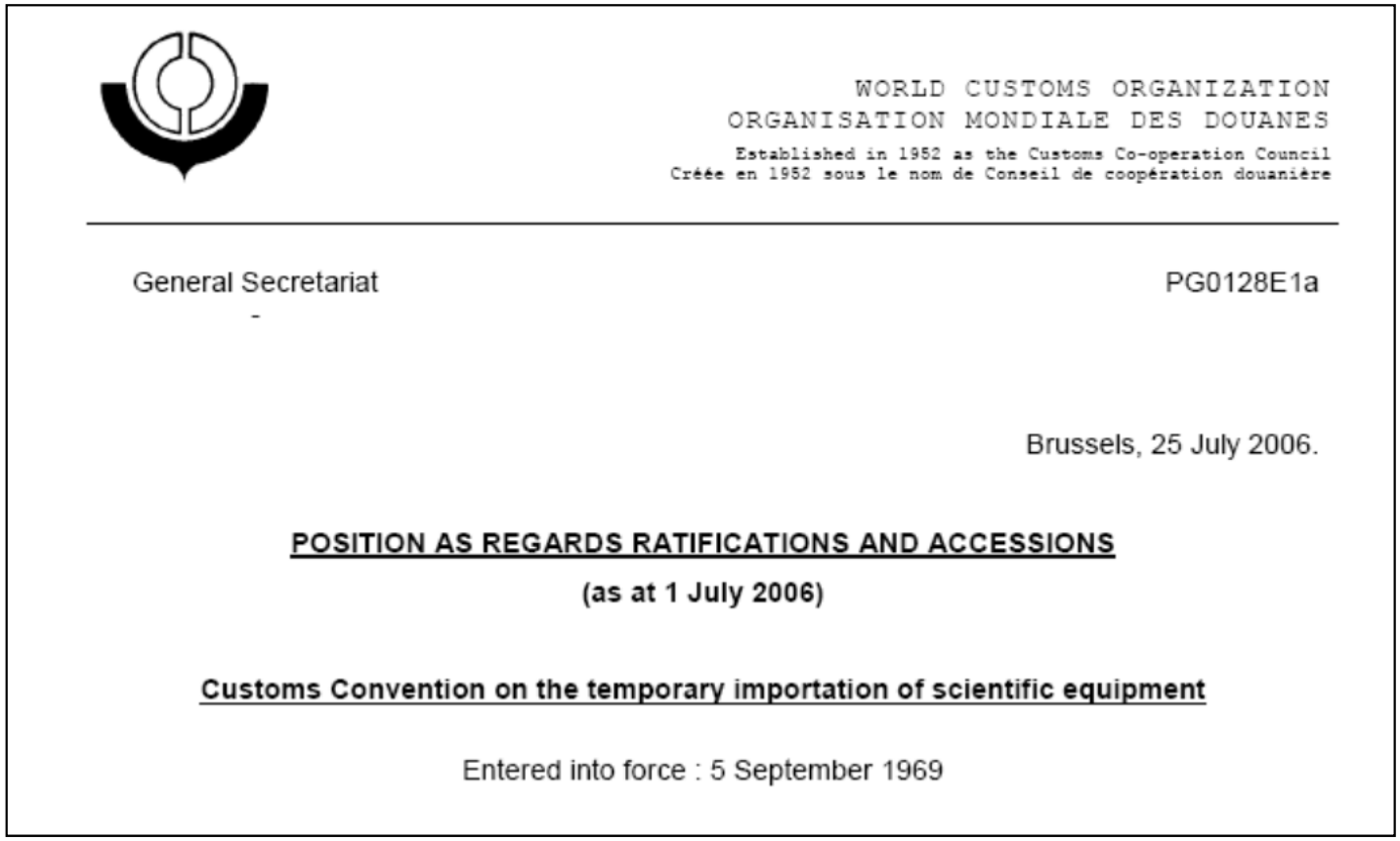
Customs Convention on the temporary importation of scientific equipment



WORLD CUSTOMS ORGANIZATION
ORGANISATION MONDIALE DES DOUANES

Established in 1952 as the Customs Co-operation Council
Créée en 1952 sous le nom de Conseil de coopération douanière

General Secretariat

PG0128E1a

Brussels, 25 July 2006.

POSITION AS REGARDS RATIFICATIONS AND ACCESSIONS

(as at 1 July 2006)

Customs Convention on the temporary importation of scientific equipment

Entered into force : 5 September 1969

Bureau International des Poids et Mesures

BIPM Workshop: The Quantum Revolution in Metrology

Themes for the workshop

- ***Single photon measurements****, radiometry with entangled sources, superconducting particle detectors*
- ***Quantum standards for*** *mass, pressure, vacuum, temperature, acoustics and vibration.*
- ***Highly entangled systems*** *for metrology, entangled optical clocks*
- ***Advances in quantum electrical standards****, single electron transistors and demonstrations of the quantum metrology triangle*
- ***Beyond quantum metrology***

- 135 participants from 20 countries attended the two-day event
- 23 speakers animated five information packed sessions
- 56 posters were presented in two sessions

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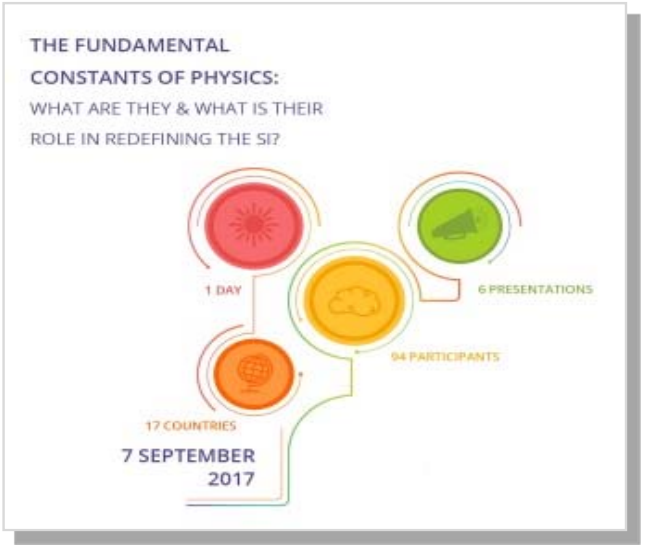

03 – Laboratory work

Providing capabilities for international measurement comparisons

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CCM Pilot Study of future realizations of the kilogram

A pilot comparison of mass calibrations based on methods that will be used to realize the kilogram after its redefinition.

Participants:

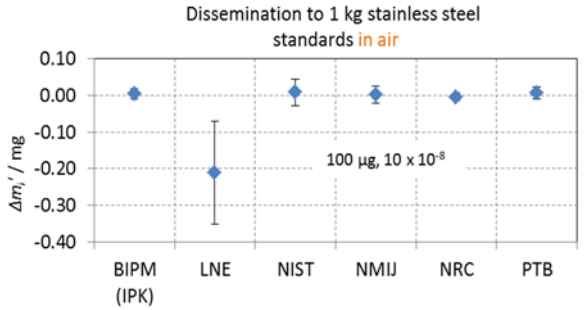
Kibble balances

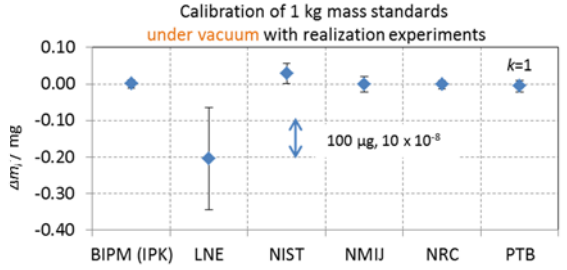
- LNE, France
- NIST , United States America
- NRC, Canada

^{28}Si spheres from the Avogadro coordination project

- PTB, Germany
- NMIJ AIST, Japan

- The results are in good agreement for both sets of standards.
  - Four of the five participants agree within one standard deviation
  - The fifth agrees at the level of k = 2.
- The uncertainty of the weighted mean is 10 µg for both sets.
- The weighted mean agrees with the IPK well within the uncertainty.





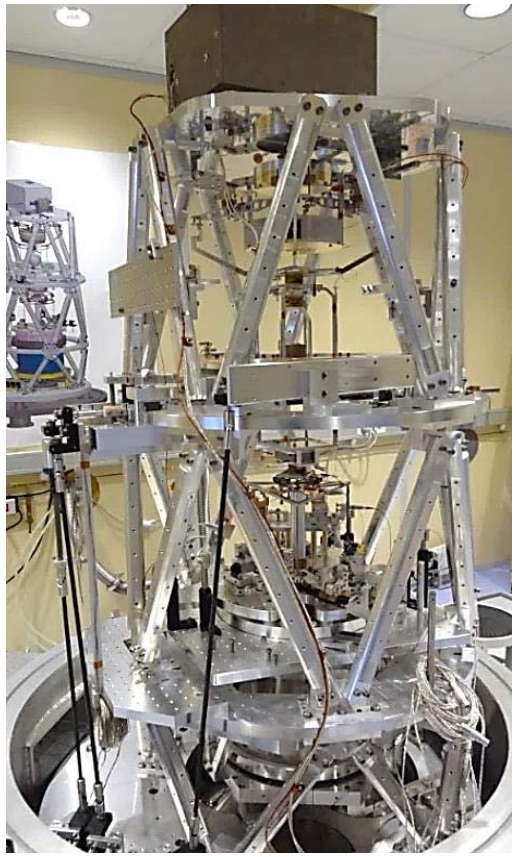
Status of the BIPM Kibble balance (*aka* watt balance)

Progress and achievements

- fully operational in vacuum (and air) with 1 kg mass standard and bifilar coil.
- new suspension & mass loading device
- improved alignment
- noise reduction on force measurement
- completion of 2 PJVS systems
- two papers published, one submitted

Present status and outlook

- day-to-day repeatability of several parts in 10^{7}
- type B uncertainty of a few parts in 10^{7}
- expected uncertainty 1 x 10^{-7} end 2017 and < 3 x 10^{-8} end 2019



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Electricity: Overview of the comparison programme

- CCEM-comparison of capacitance (CCEM-K4), pilot BIPM, **METAS (Switzerland), NIM (China), NIST (USA), NMIA (Australia), NPL (UK), PTB (Germany), VNIIM (Russia)**
- Pilot comparison of ac Josephson voltage standards with PTB, in preparation for a future BIPM comparison
- On-site comparisons of
  - quantum Hall resistance standards (BIPM.EM-K12) with **CMI (Czech Rep.)**
  - Zener voltage calibrations (BIPM.EM-K11) with **NMISA (South Africa)**
  - resistance calibrations (BIPM.EM-K13) with **NMISA (South Africa)**

Calibrations of electrical standards for: Austria, Belgium, Bulgaria, Greece, Hungary, India, Iran, Malaysia, New Zealand, Poland, Portugal, Romania, Saudi Arabia, Serbia, Singapore, Slovenia, Thailand.

Knowledge transfer comparison

Comparison dates:
June 2017 to March 2018

Coordinator:
SCL, Hong Kong

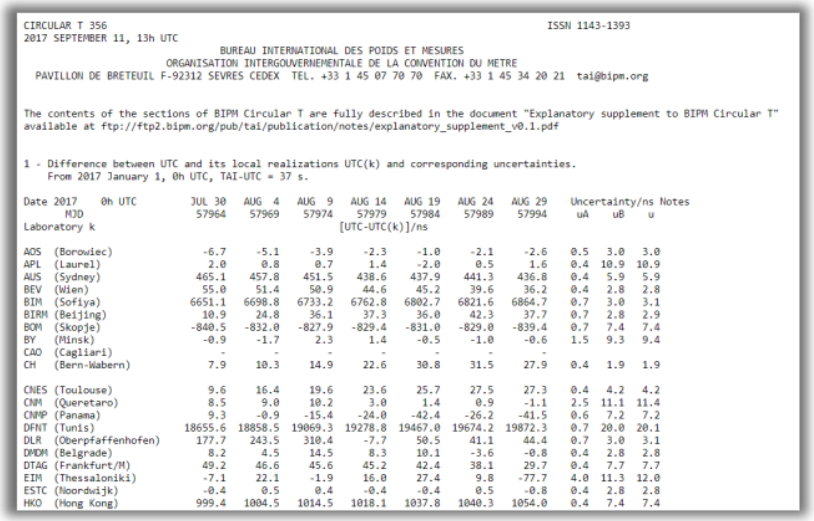
Participants:
- KRISS, Republic of Korea
- IMBIH, Bosnia and Herzegovina
- BIPM

Participants from GULFMET
- EMI, United Arab Emirates
- SASO-NMCC, Saudi Arabia

Time: Improving the uncertainty of [UTC-UTC(k)]

A new algorithm for the calculation of the uncertainties of [UTC-UTC(k)] has been developed.

It correctly takes into account correlations in the uncertainty propagation. Its implementation is planned by November 2017.



CIRCULAR T 356 ISSN 1143-1393
2017 SEPTEMBER 11, 13h UTC

BUREAU INTERNATIONAL DES POIDS ET MESURES
ORGANISATION INTERGOUVERNEMENTALE DE LA CONVENTION DU METRE
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The contents of the sections of BIPM Circular T are fully described in the document "Explanatory supplement to BIPM Circular T" available at ftp://ftp2.bipm.org/pub/tai/publication/notes/explanatory_supplement_v0.1.pdf

1 - Difference between UTC and its local realizations UTC(k) and corresponding uncertainties.
From 2017 January 1, 0h UTC, TAI-UTC = 37 s.

Date 2017 0h UTC / MJD / Laboratory k	JUL 30 57964	AUG 4 57969	AUG 9 57974	AUG 14 57979	AUG 19 57984	AUG 24 57989	AUG 29 57994	Uncertainty/ns uA	uB	u	Notes
				[UTC-UTC(k)]/ns							
AOS (Borowiec)	-6.7	-5.1	-3.9	-2.3	-1.0	-2.1	-2.6	0.5	3.0	3.0	
APL (Laurel)	2.0	0.8	0.7	1.4	-2.0	0.5	1.6	0.4	10.9	10.9	
AUS (Sydney)	465.1	457.8	451.5	438.6	437.9	441.3	436.8	0.4	5.9	5.9	
BEV (Wien)	55.0	51.4	50.9	44.6	45.2	39.6	36.2	0.4	2.8	2.8	
BIM (Sofiya)	6651.1	6698.8	6733.2	6762.8	6802.7	6821.6	6864.7	0.7	3.0	3.1	
BIRM (Beijing)	10.9	24.8	36.1	37.3	36.0	42.3	37.7	0.7	2.8	2.9	
BOM (Skopje)	-840.5	-832.0	-827.9	-829.4	-831.0	-829.0	-839.4	0.7	7.4	7.4	
BY (Minsk)	-0.9	-1.7	2.3	1.4	-0.5	-1.0	-0.6	1.5	9.3	9.4	
CAO (Cagliari)	-	-	-	-	-	-	-				
CH (Bern-Wabern)	7.9	10.3	14.9	22.6	30.8	31.5	27.9	0.4	1.9	1.9	
CNES (Toulouse)	9.6	16.4	19.6	23.6	25.7	27.5	27.3	0.4	4.2	4.2	
CNM (Queretaro)	8.5	9.0	10.2	3.0	1.4	0.9	-1.1	2.5	11.1	11.4	
CNMP (Panama)	9.3	-0.9	-15.4	-24.0	-42.4	-26.2	-41.5	0.6	7.2	7.2	
DFNT (Tunis)	18655.6	18858.5	19069.3	19278.8	19467.0	19674.2	19872.3	0.7	20.0	20.1	
DLR (Oberpfaffenhofen)	177.7	243.5	310.4	-7.7	50.5	41.1	44.4	0.7	3.0	3.1	
DMDM (Belgrade)	8.2	4.5	14.5	8.3	10.1	-3.6	-0.8	0.4	2.8	2.8	
DTAG (Frankfurt/M)	49.2	46.6	45.6	45.2	42.4	38.1	29.7	0.4	7.7	7.7	
EIM (Thessaloniki)	-7.1	22.1	-1.9	16.0	27.4	9.8	-77.7	4.0	11.3	12.0	
ESTC (Noordwijk)	-0.4	0.5	0.4	-0.4	-0.4	0.5	-0.8	0.4	2.8	2.8	
HKO (Hong Kong)	999.4	1004.5	1014.5	1018.1	1037.8	1040.3	1054.0	0.4	7.4	7.4	

UTC

- Strongly depend on the time link uncertainties
- All the time links connect each contributing laboratory to PTB, which plays a central role. The uncertainty of PTB is underestimated

Two major changes will be introduced in November 2017

- *the pivot for GNSS time links is an "auxiliary time scale" instead of a single NMI (PTB),*
- *correlations are introduced.*

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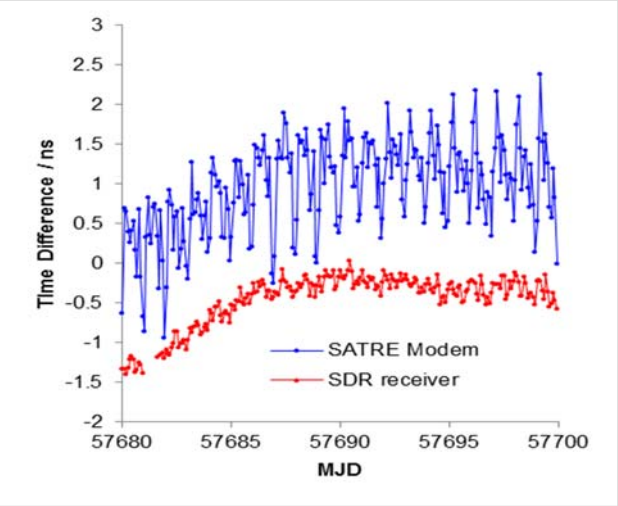
Time: Improvement of TWSTFT uncertainty

Reduction of diurnal noise in UTC time comparisons through software-defined radio receiver modems in TW stations.

Highlights

- *Pilot study launched end 2016 with the participation of TL, NICT, KRISS, NTSC, NIM, PTB, LNE-SYRTE, VNIIFTRI, INRIM, METAS, AOS, RISE and NIST*
- *SDRs proved to significantly reduce the noise of time transfer over short distances, less over long ones*
- *Most TW stations have already implemented the technique;*
- *Next step is the implementation of the SDR in time transfer for UTC computation*



Comparison LNE-PTB
Time Deviation
Gain factor improvement of 3.7

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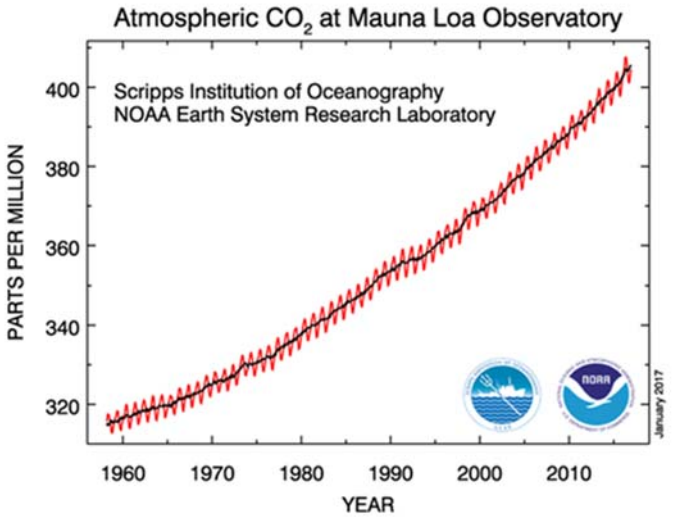
Chemistry: Greenhouse Gas Standard Comparisons

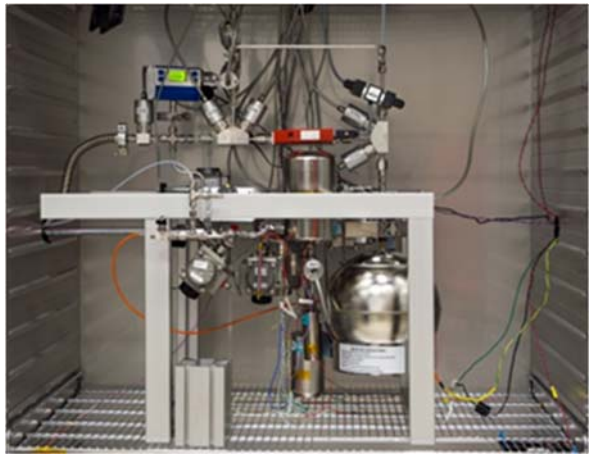
CO_2 in air at atmospheric levels (CCQM-K120)

- Increase confidence in measurements of GHG, ensuring data can be effectively used for decisions on how to tackle climate change
- 46 standards from 16 NMIs/DIs
- Development of unique Primary Reference Standard for CO_2 at BIPM

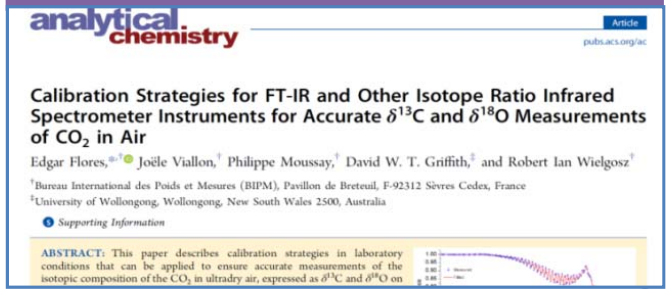


Visiting scientists from:

- NIST, United States America
- NPL, United Kingdom
- NIM, China
- RISE, Sweden
- KRISS, Korea



Calibration methods developed and published for novel CO_2 isotope ratio laser based analysers


analytical chemistry

Article

pubs.acs.org/ac

Calibration Strategies for FT-IR and Other Isotope Ratio Infrared Spectrometer Instruments for Accurate $\delta^{13}C$ and $\delta^{18}O$ Measurements of CO_2 in Air

Edgar Flores, Joële Viallon, Philippe Moussay, David W. T. Griffith, and Robert Ian Wielgosz

Bureau International des Poids et Mesures (BIPM), Pavillon de Breteuil, F-92312 Sèvres Cedex, France

University of Wollongong, Wollongong, New South Wales 2500, Australia

Supporting Information

ABSTRACT: This paper describes calibration strategies in laboratory conditions that can be applied to ensure accurate measurements of the isotopic composition of the CO_2 in ultradry air, expressed as $\delta^{13}C$ and $\delta^{18}O$ on

www.bipm.org

Chemistry: Comparisons of Organic Primary Calibrators

Primary calibrator comparisons supporting SI traceable reference measurement systems

Calibrators for Diabetes diagnostics (CCQM-K115)

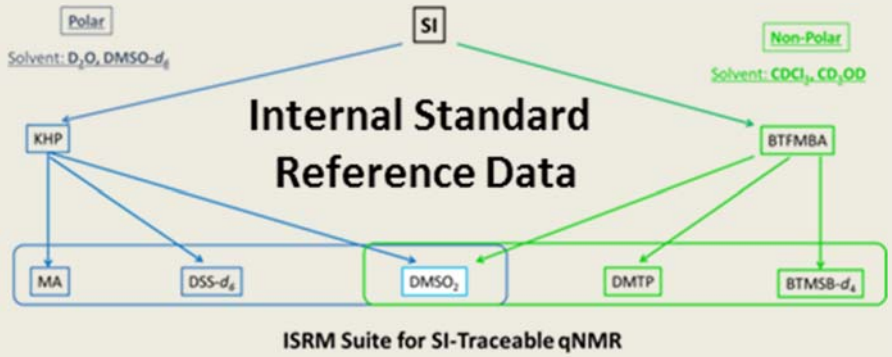
- first peptide purity key comparison on, human C–peptide
- 11 NMIs have participated
- 70 peptide impurities identified and quantified

Visiting scientists support from:

- NIM, China
- INMETRO, Brazil
- NMIJ AIST, Japan
- LGC, United Kingdom
- NIBSC, United Kingdom

Comparisons with qNMR (CCQM-K55 series)

To develop international guidelines developed under an IUPAC project chaired by the BIPM with active participation from eleven NMIs and two international organizations.

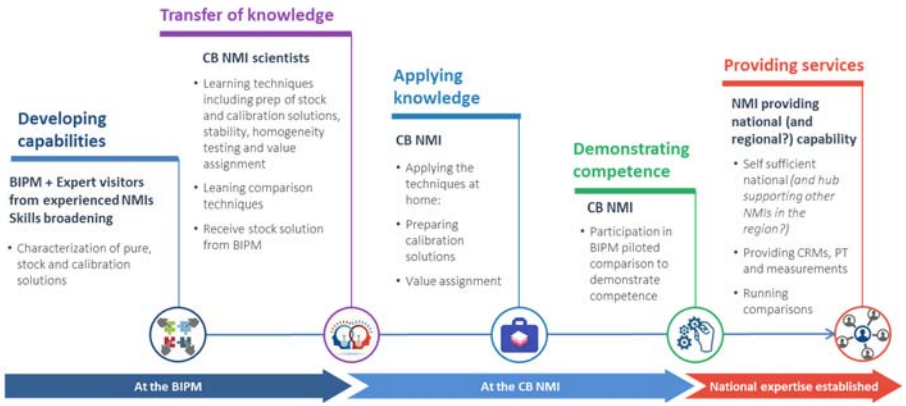


ISRM Suite for SI-Traceable qNMR

Chemistry: Capacity Building projects

Metrology for Safe Food and Feed

✓ *Enables NMIs to provide mycotoxin calibrant and matrix reference materials and proficiency test materials to support mycotoxin testing laboratories within their countries.*



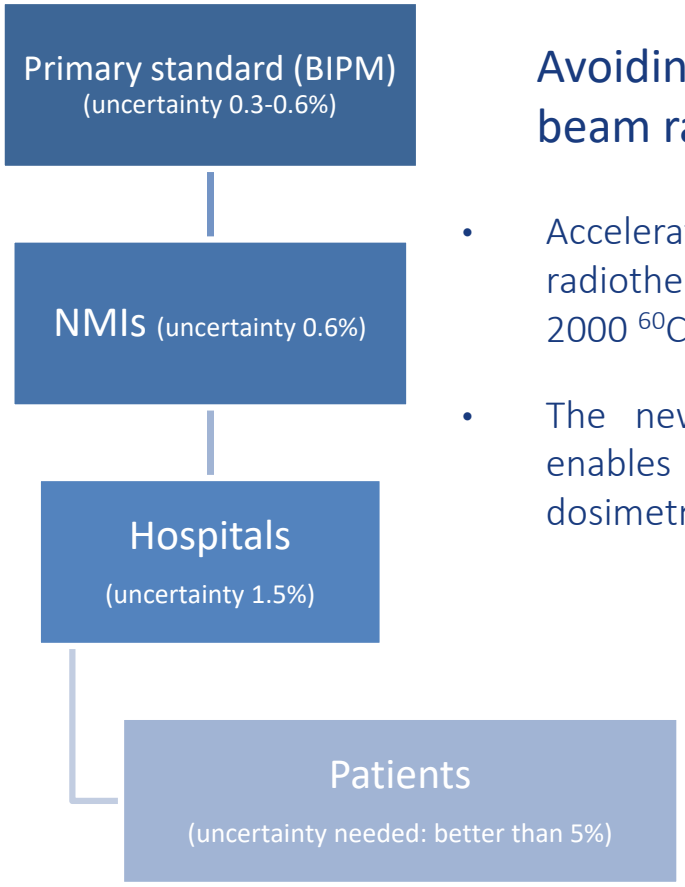
Financial Support from:

- NIM, China
- NPL, United Kingdom
- PTB, Germany
- TÜBİTAK UME, Turkey
- NMISA, South Africa

Metrology for clean air project

✓ *Allows NMIs to strengthen their gas standard capabilities and further develop their national metrology infrastructure in support of their air quality and emissions measurement communities.*

Ionizing Radiation: Effective cancer therapy



Avoiding under- or over-treatment in external beam radiotherapy

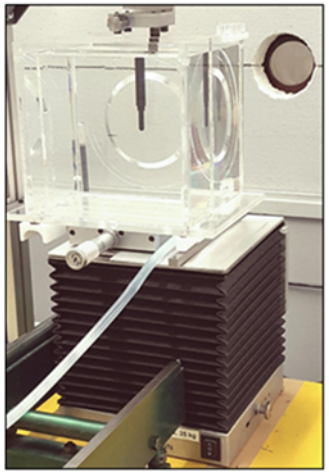
- Accelerators are replacing radioactive sources for radiotherapy (there are 11000 accelerators compared to 2000 ^{60}Co facilities).
- The new partnership with the CEA's DOSEO facility enables BIPM to provide comparisons to underpin dosimetry primary standards at NMIs.

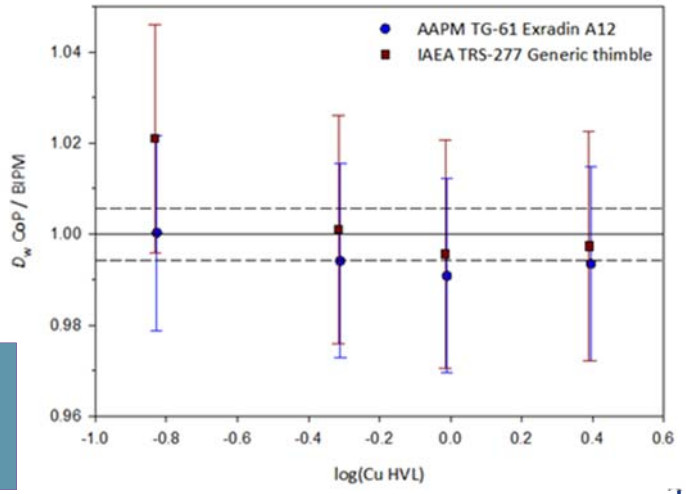
- BIPM staff have characterized the beam (intensity profile, energy, stability) & developed a protocol for comparisons – a comparison with KRISS is starting and a comparison with METAS is next.

Ionizing Radiation: Radiotherapy dosimetry (Gy)

Significant improvement in the traceability chain for patient dosimetry in radiotherapy using medium energy X-rays

- A new absorbed dose to water standard has been developed for medium-energy x-rays.
- An innovative new primary BIPM standard for medium energy X-ray therapy has reduced the measurement uncertainty from 3% to 0.7%.
- The new standard is very stable, easier to implement than calorimetry.
- The first comparison using the standard has been carried out with the PTB.





The KCRV is taken to be the BIPM determination.

Ionizing Radiation: Radioactivity (Bq)

Long lived gamma emitters	Short lived gamma emitters	Beta emitters	Alpha emitters	Low activity samples
• High precision ionization chambers (SIR) • Established 1973	• High precision scintillation detector • Established 2009	• Demand for medical applications • Scoping studies completed	• Demand for medical applications, environmental, decommissioning, nuclear forensics • Work to start 2018	• Demand for environmental and decommissioning applications • Work to start in 2018+

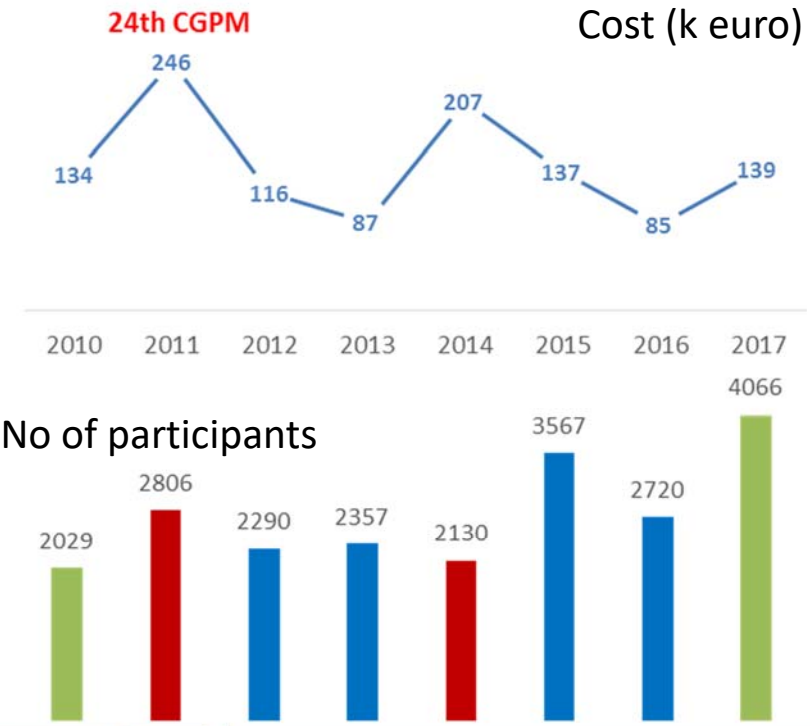
SIRTI was taken to **NRC (Canada)** for a comparison exercise for ^{11}C (used for medical imaging) and is currently en route to **ANSTO (Australia)**

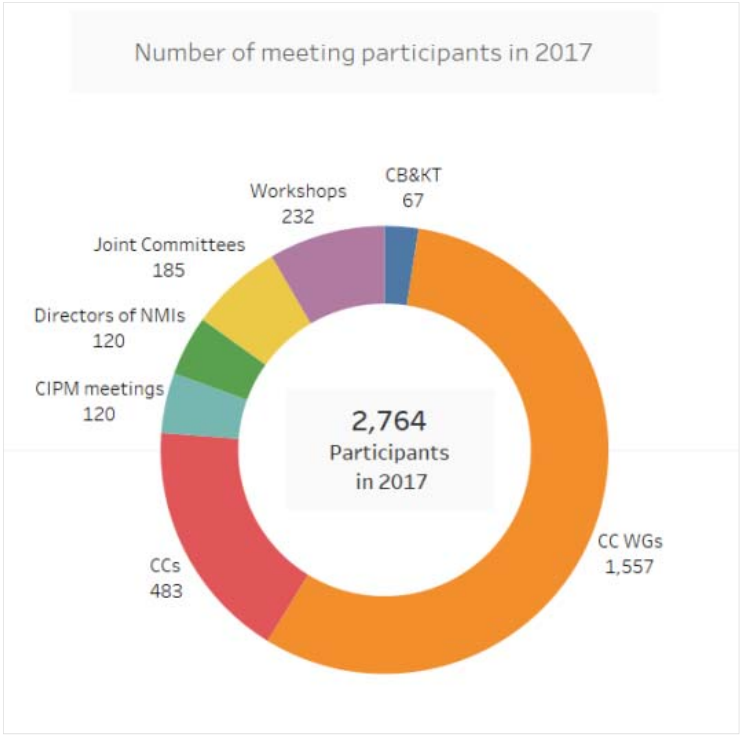
Bureau International des Poids et Mesures

04 – Finance and operations

Bureau International des Poids et Mesures

The BIPM's work involves hosting international meetings





New partnership with the

Centre international d'études pédagogiques (CIEP)

in Sèvres

- fully equipped meeting rooms, and
- overnight accommodation for 90 students.

05 – Coordination work

Ensuring that measurement results are comparable and internationally-accepted

Bureau International des Poids et Mesures

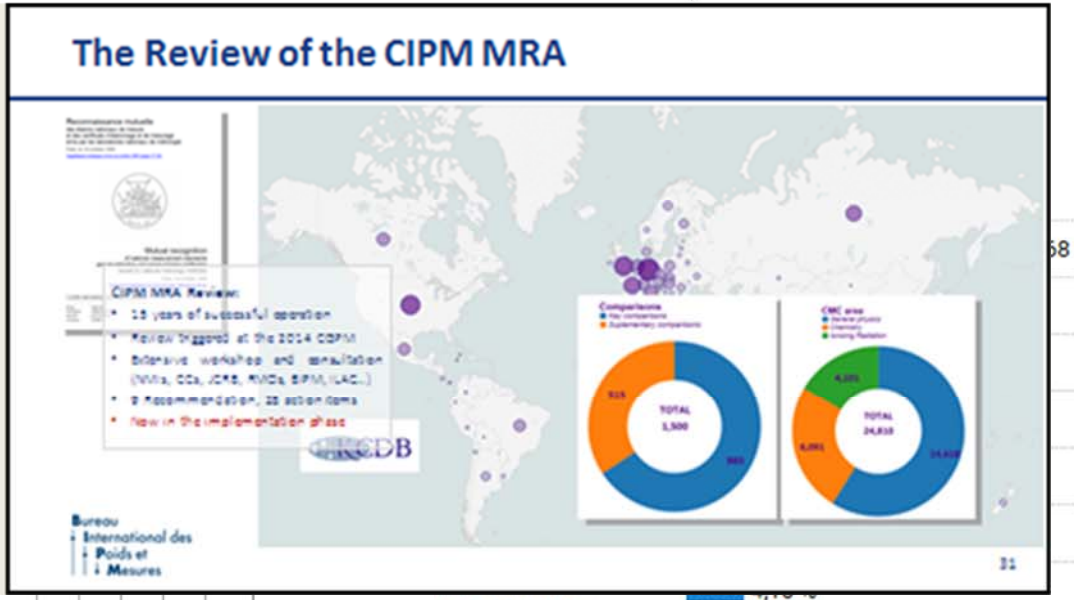
Joint Committee for Traceability in Laboratory Medicine

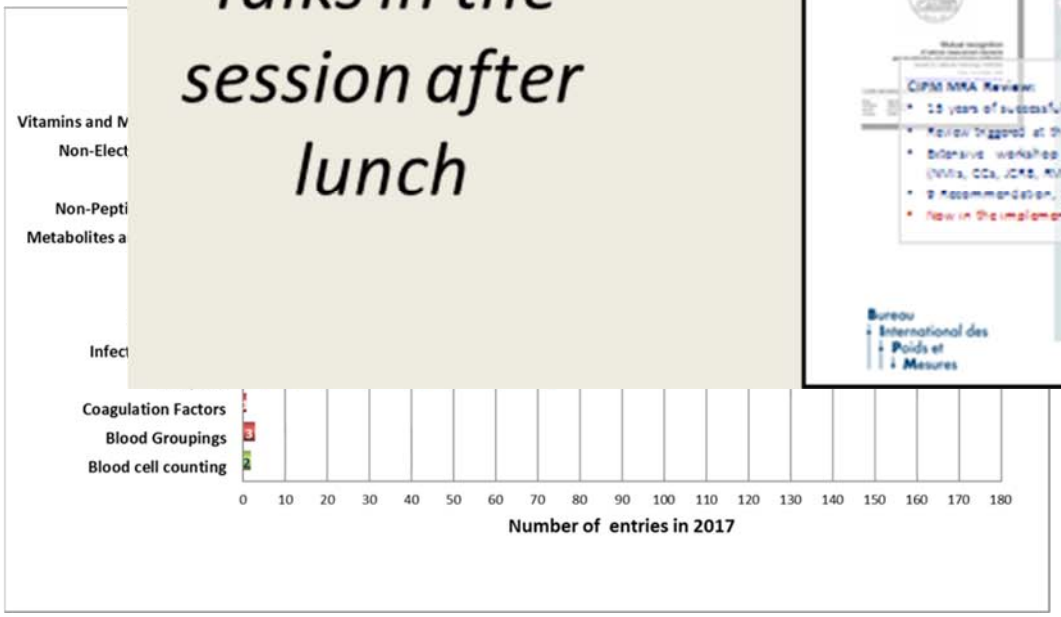
Database of higher-order reference materials, measurement methods/procedures and services

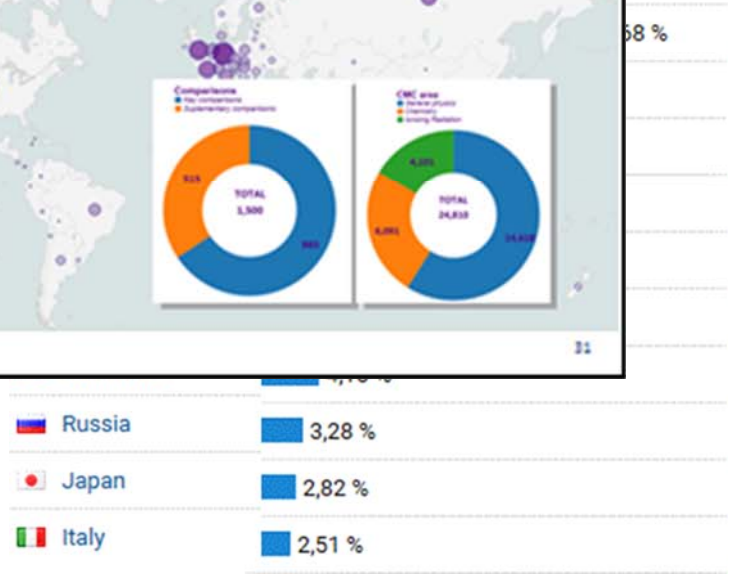
JCTLM

-
-

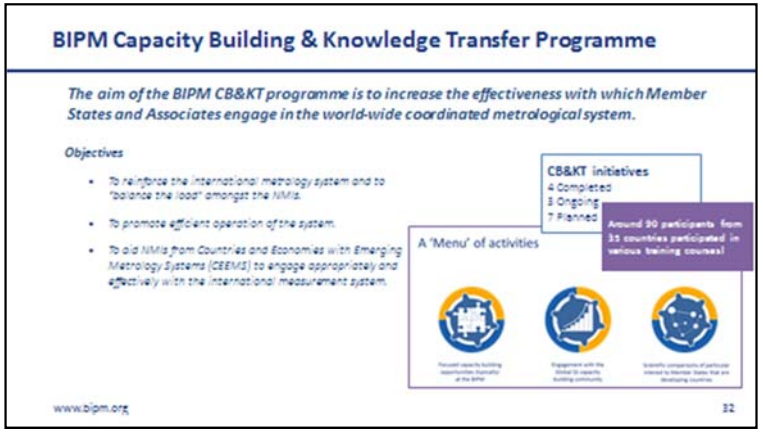
Talks in the session after lunch

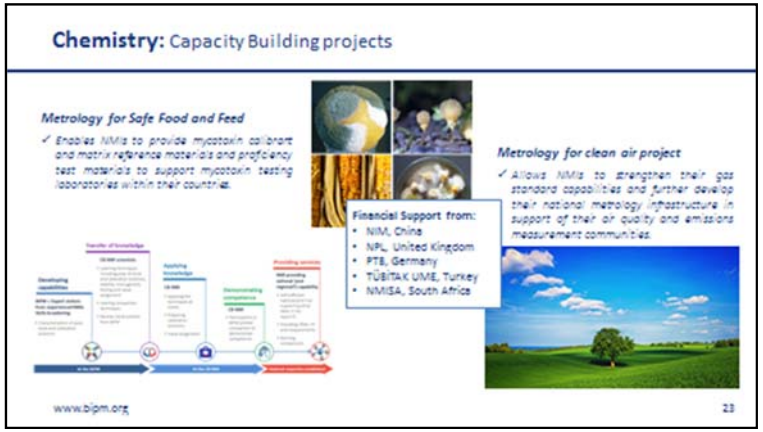


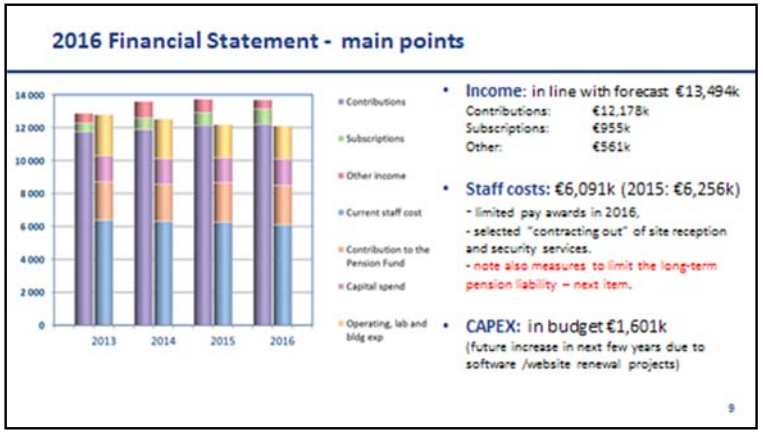


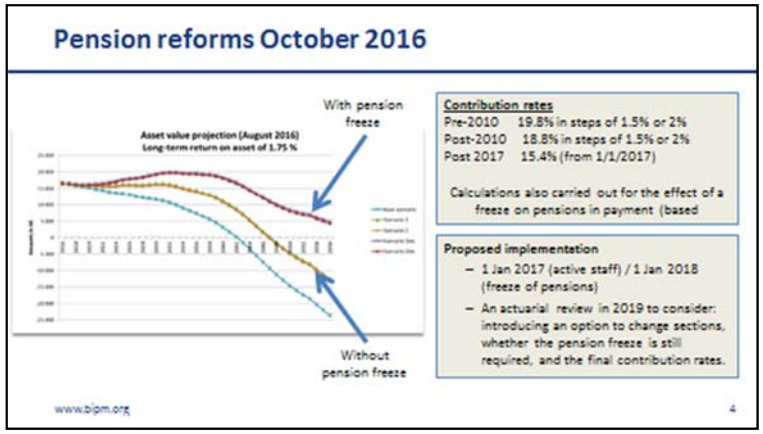


Highlights – **in more detail in the following talks**



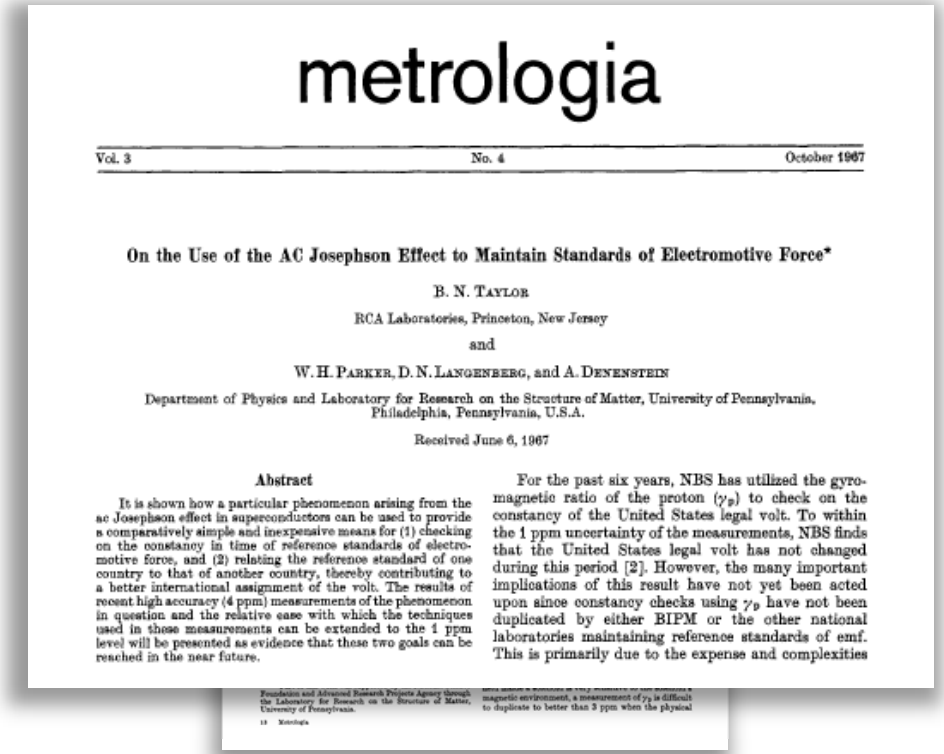






50th Anniversaries

50 years of quantum metrology



metrologia

Vol. 3 No. 4 October 1967

On the Use of the AC Josephson Effect to Maintain Standards of Electromotive Force*

B. N. Taylor

RCA Laboratories, Princeton, New Jersey

and

W. H. Parker, D. N. Langenberg, and A. Denenstein

Department of Physics and Laboratory for Research on the Structure of Matter, University of Pennsylvania, Philadelphia, Pennsylvania, U.S.A.

Received June 6, 1967

Abstract

It is shown how a particular phenomenon arising from the ac Josephson effect in superconductors can be used to provide a comparatively simple and inexpensive means for (1) checking on the constancy in time of reference standards of electromotive force, and (2) relating the reference standard of one country to that of another country, thereby contributing to a better international assignment of the volt. The results of recent high accuracy (4 ppm) measurements of the phenomenon in question and the relative ease with which the techniques used in these measurements can be extended to the 1 ppm level will be presented as evidence that these two goals can be reached in the near future.

For the past six years, NBS has utilized the gyromagnetic ratio of the proton (γ_p) to check on the constancy of the United States legal volt. To within the 1 ppm uncertainty of the measurements, NBS finds that the United States legal volt has not changed during this period [2]. However, the many important implications of this result have not yet been acted upon since constancy checks using γ_p have not been duplicated by either BIPM or the other national laboratories maintaining reference standards of emf. This is primarily due to the expense and complexities

Bureau International des Poids et Mesures

50th Anniversaries

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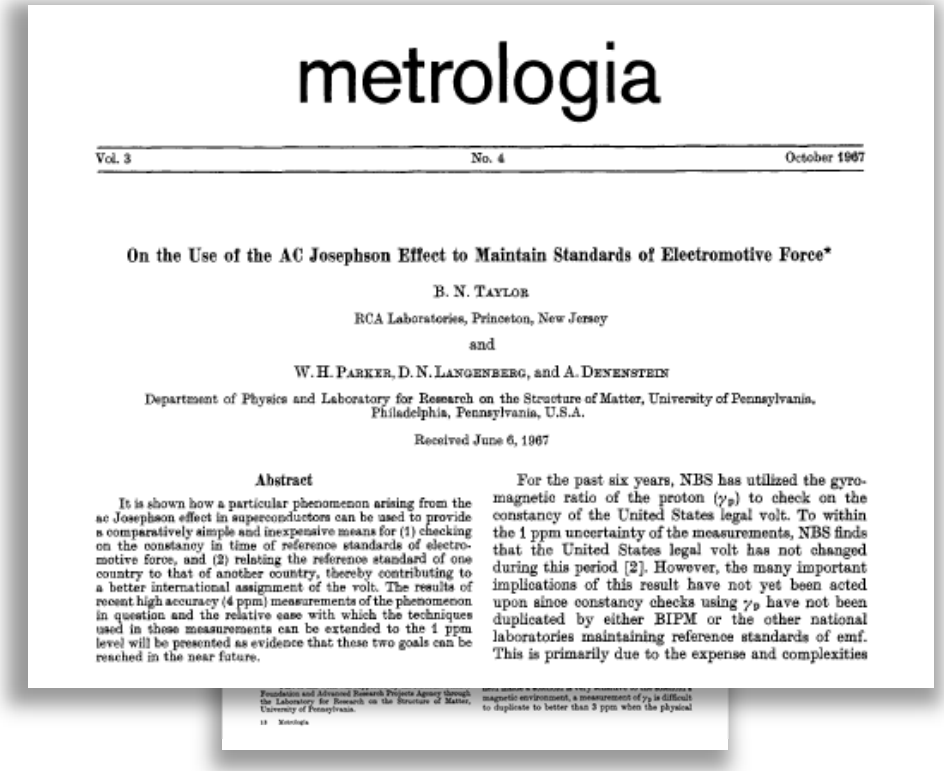

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Bureau International des Poids et Mesures

50 years since the definition of the second

The SI unit of time which had been based on the ephemeris second since 1960 was re-defined.

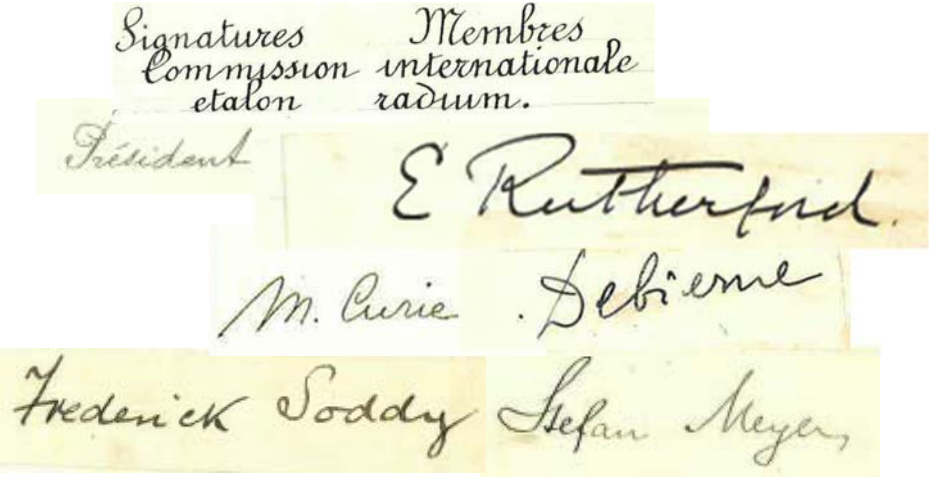
On 13 October 1967, the General Conference on Weights and Measures (CGPM) took the decision

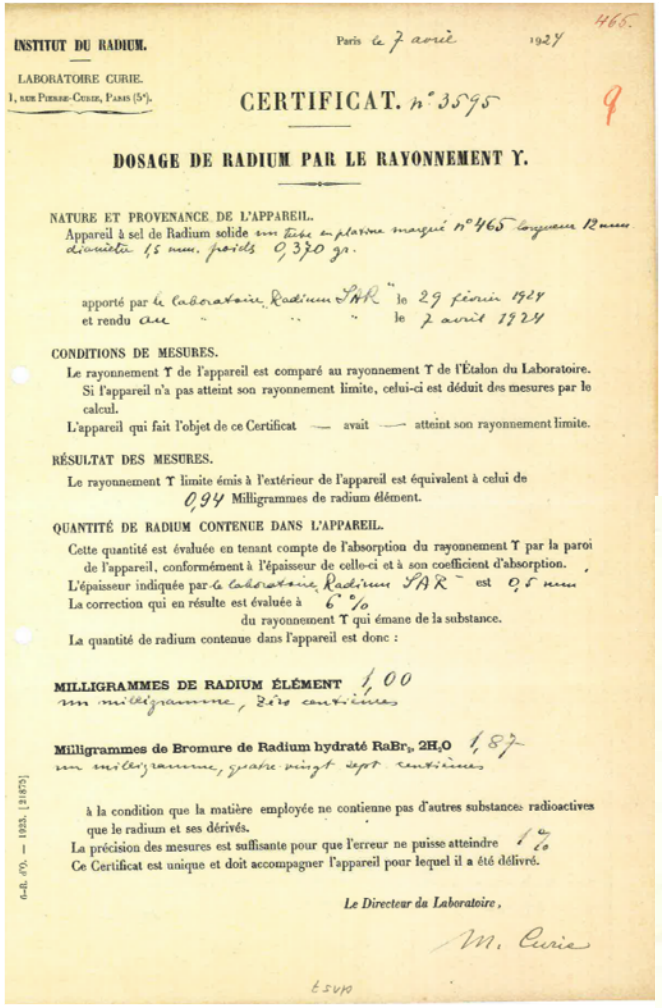
"The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom"

Resolution 1 of the 13th CGPM (1967).

Marie Curie - **150th Anniversary**

- The radium primary standard was kept at the BIPM from 1913 to 1993.
- The strong links between Marie Curie and the BIPM initiated the future of radionuclide measurements at the BIPM.




INSTITUT DU RADIUM.
LABORATOIRE CURIE.
1, RUE PIERRE-CURIE, PARIS (5e).

Paris le 7 avril 1924

465.

CERTIFICAT. n° 3595

9

DOSAGE DE RADIUM PAR LE RAYONNEMENT γ.

NATURE ET PROVENANCE DE L'APPAREIL.
Appareil à sel de Radium solide en tube en platine marqué n°465 longueur 12 mm diamètre 1,5 mm. poids 0,370 gr.

apporté par le Laboratoire Radium SAR le 29 février 1924
et rendu au " " " le 7 avril 1924

CONDITIONS DE MESURES.
Le rayonnement T de l'appareil est comparé au rayonnement T de l'Étalon du Laboratoire.
Si l'appareil n'a pas atteint son rayonnement limite, celui-ci est déduit des mesures par le calcul.
L'appareil qui fait l'objet de ce Certificat — avait — atteint son rayonnement limite.

RÉSULTAT DES MESURES.
Le rayonnement T limite émis à l'extérieur de l'appareil est équivalent à celui de
0,94 Milligrammes de radium élément.

QUANTITÉ DE RADIUM CONTENUE DANS L'APPAREIL.
Cette quantité est évaluée en tenant compte de l'absorption du rayonnement T par la paroi de l'appareil, conformément à l'épaisseur de celle-ci et à son coefficient d'absorption.
L'épaisseur indiquée par le Laboratoire Radium SAR est 0,5 mm
La correction qui en résulte est évaluée à 6 %
du rayonnement T qui émane de la substance.
La quantité de radium contenue dans l'appareil est donc :

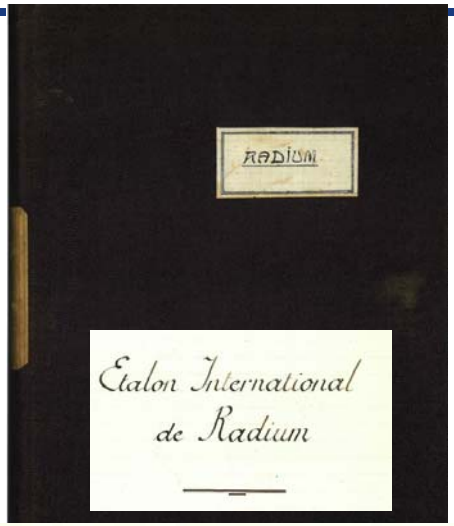
MILLIGRAMMES DE RADIUM ÉLÉMENT 1,00
un milligramme, zéro centièmes

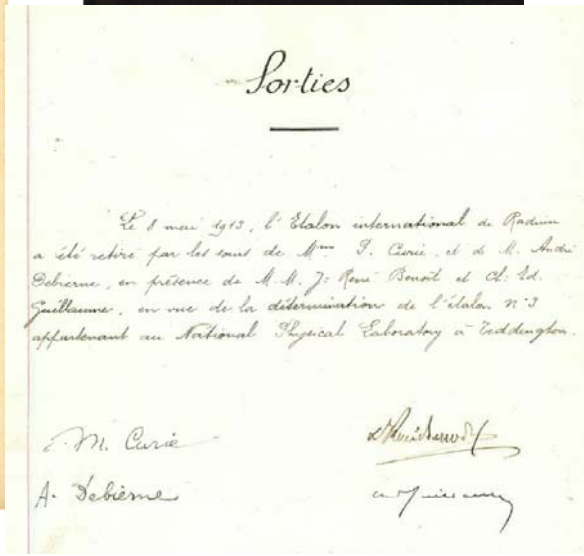
Milligrammes de Bromure de Radium hydraté $RaBr_2.2H_2O$ 1,87
un milligramme, quatre-vingt sept centièmes

à la condition que la matière employée ne contienne pas d'autres substances radioactives que le radium et ses dérivés.
La précision des mesures est suffisante pour que l'erreur ne puisse atteindre 1 %
Ce Certificat est unique et doit accompagner l'appareil pour lequel il a été délivré.

Le Directeur du Laboratoire,
M. Curie

E.S.V.P.




Sorties

Le 8 mai 1913, l'Etalon international de Radium a été retiré par les soins de Mme P. Curie et de M. André Debierne, en présence de MM. J. René Benoit et Ch. Ed. Guillaume, en vue de la détermination de l'étalon n°3 appartenant au National Physical Laboratory à Teddington.

E. M. Curie
A. Debierne

- Thank you

Bureau International des Poids et Mesures