Highlights in the work of the BIPM in 2016

Dr Martin Milton
BIPM Director

24 October 2016

Bureau International des Poids et Mesures

BIPM highlights of 2016

- **Introduction to the BIPM**
- **Liaison work**
  - with WADA and JCTLM
- **Laboratory work**
  - Physical, Time, Ionising Radiation and Chemistry departments

International des Poids et Mesures

BIPM highlights of 2016

- **Introduction to the BIPM**
- **Liaison work**
  - with WADA and JCTLM
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  - Physical, Time, Ionising Radiation and Chemistry departments

LATER TODAY

- **Coordination work**
  - Capacity Building and Knowledge Transfer (CBKT) Programme
  - Review of the CIPM-MRA and the KCDB 2.0
- **Finance and operations**

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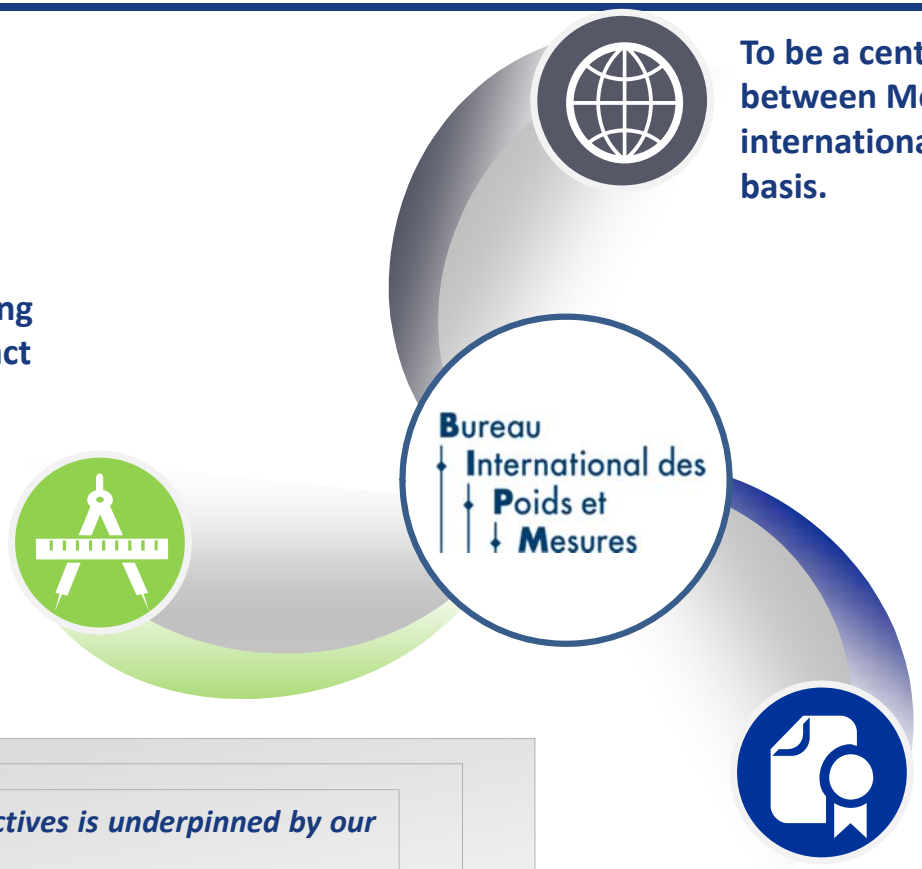
Renewal of the Objectives of the BIPM

- under review by the CIPM

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

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



To be the coordinator of the worldwide measurement system ensuring it gives comparable, internationally-accepted and fit-for-purpose 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.*

Renewal of the Objectives of the BIPM

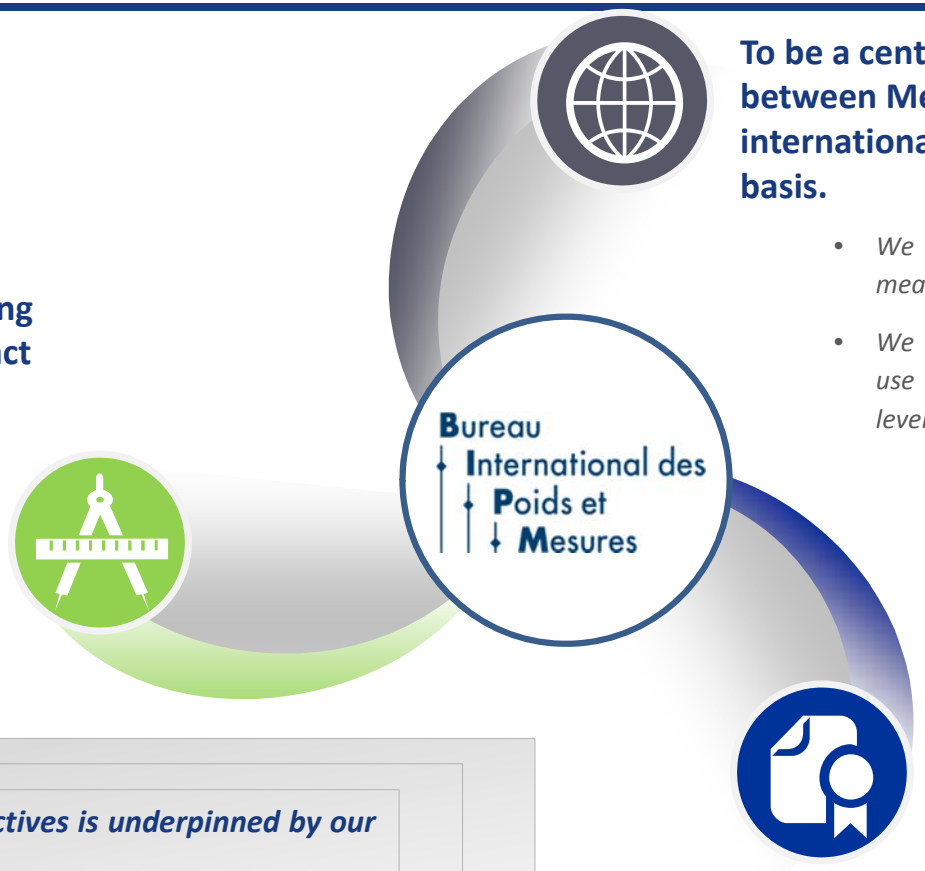
- under review by the CIPM

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

- *We coordinate international comparisons of national measurement standards agreed to be of the highest priority.*
- *We establish and maintain appropriate reference standards for use as the basis of key international comparisons at the highest level and provide selected calibrations from them.*

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

- *We liaise with relevant intergovernmental organizations and other international bodies in order to develop opportunities for the application of metrology to global challenges.*



To be the coordinator of the worldwide measurement system ensuring it gives comparable, internationally-accepted and fit-for-purpose measurement results

- *We coordinate activities between the NMIs of Member States and the RMOs, including the provision of technical services to support the CIPM MRA and the infrastructure for the development and promotion of the SI.*

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.*

Participation in the CIPM MRA

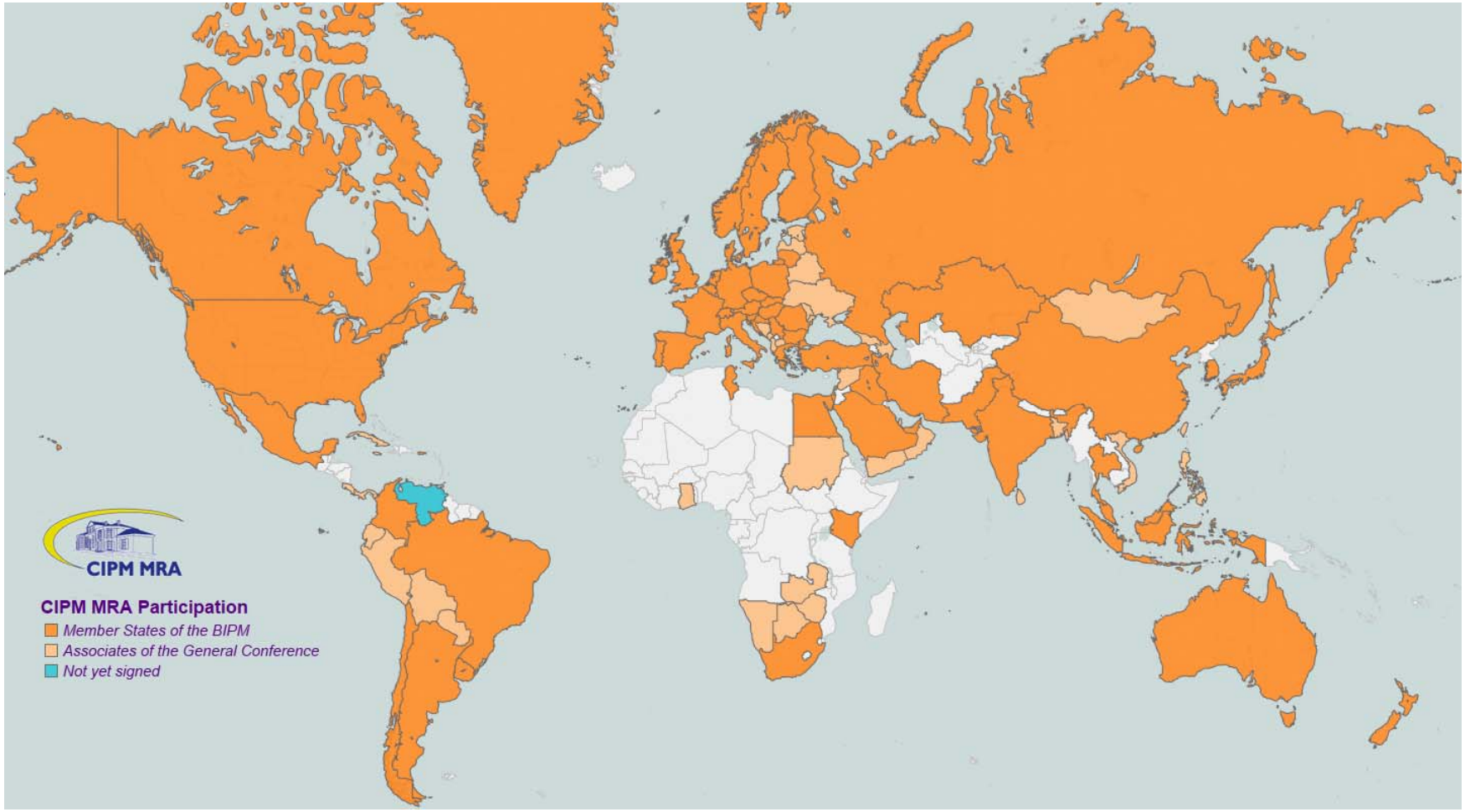
Participation

98 National Metrology Institutes
- *57 Member States*
- *41 Associates*

4 International organizations
(ESA, IAEA, IRMM, WMO)

plus 156 Designated Institutes

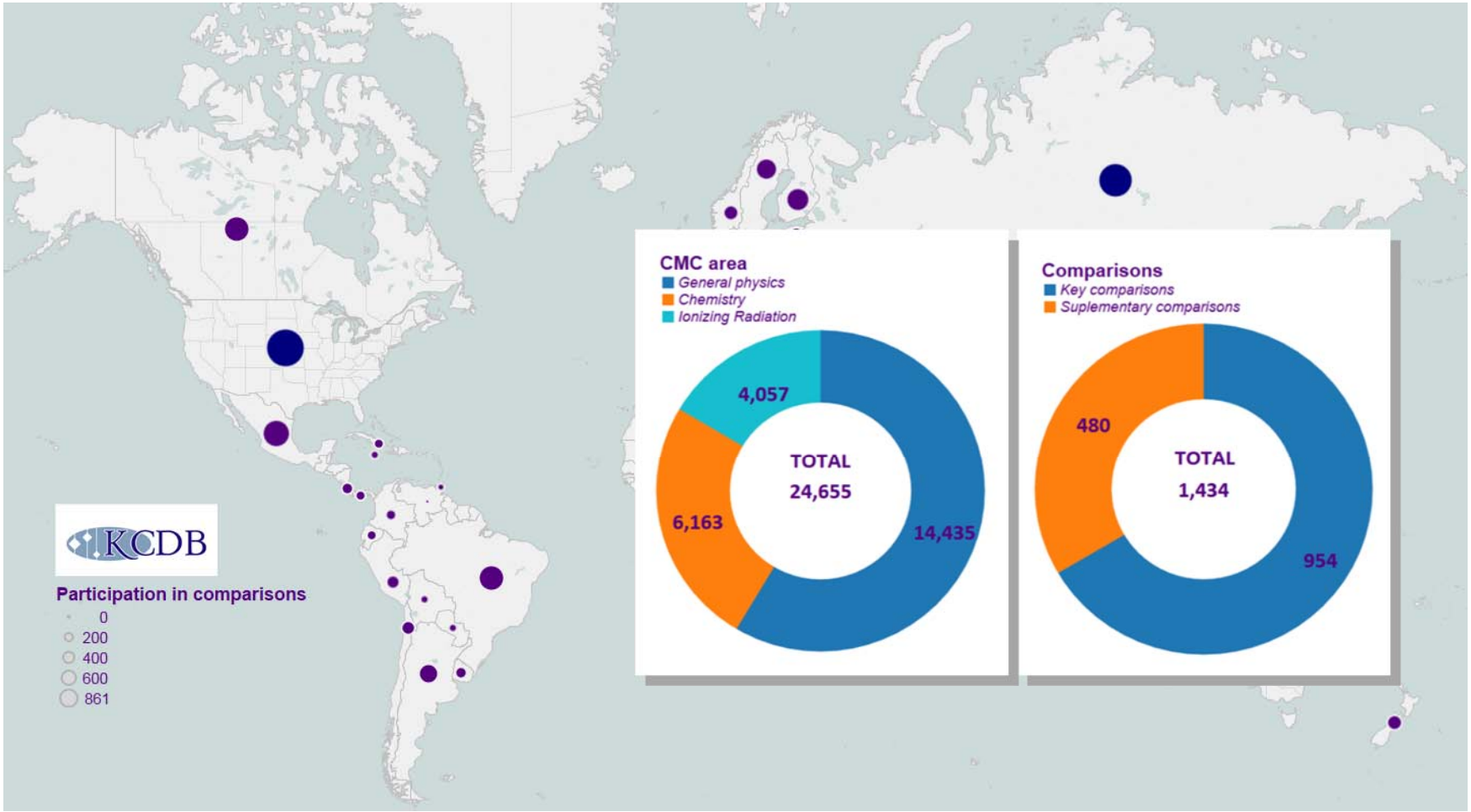
Total: 258 Institutes



Participation in the CIPM MRA


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
Supplément technique révisé en octobre 2003 (pages 17-20)

Mutual recognition
of national measurement standards
and of calibration and measurement certificates
issued by national metrology institutes
Paris, 14 October 1999
Technical Supplement revised in October 2003 (pages 38-41)
Comité international des poids et mesures



BIPM-WADA Workshop

“Standards and Metrology in support of Anti-Doping Analysis” (28-29 Sept 2016)

Secretary of State for Sport,
Thierry BRAILLARD,
Préfet des Hauts-de-Seine,
Pierre SOUBELET
Chair of WADA Technical Commission
Valerie FOURNEYRON,

Workshop Recommendations

- Produce and a prioritized list of CRMs required for anti-doping analysis (WADA)
- Carry out environment scan of opportunity to utilize existing accuracy based EQAS for measurands in blood/serum (WADA)
- Raise awareness in Member States of the need for Measurement Standards (CRMs) in support of Anti-Doping Analysis (BIPM &WADA)
- Seek to make best use of expertise at NMIs, Anti-doping laboratories, Laboratory medicine reference laboratories for developing anti-doping analysis
- Produce documented examples of MU for educational/information purposes (WADA with NMI support)
- Share best practice on processes for optimizing knowledge transfer between laboratories (BIPM/NMIs with WADA)
- Work towards harmonizing LOD and LOQ calculations (WADA with NMI support)

100 participants from NMIs, National Anti-doping and Clinical Chemistry Laboratories

Chemistry: International Liaison 2016

JCTLM

A database of NMI CRMs in support of IVD industry and patient care

ISO REMCO & ISO TC 212
CRMs and Reference Measurement Systems for IVDs

ISO

WORLD ANTI-DOPING AGENCY

BIPM-WADA workshop on "Metrology and Standards for Anti Doping Analysis" (2016)

Joint Workshop on "Peptide and Protein Therapeutics and Diagnostics"

中国计量科学研究院 National Institute of Metrology, China

ifcc International Federation of Clinical Chemistry and Laboratory Medicine

IAEA.org International Atomic Energy Agency

Addressing issues of metrological traceability and CRMs for stable isotope ratio measurements

World Health Organization

IUPAC INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

Input into the Expert Committee for Biological Standardisation: Requirements for Metrological Traceability

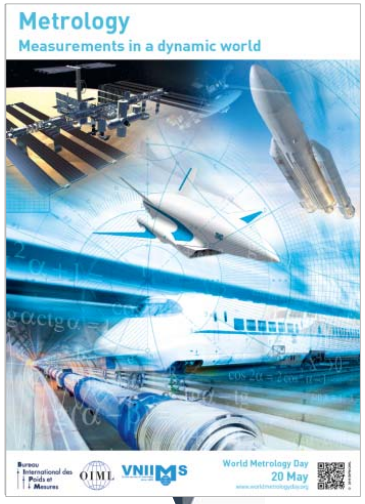
IUPAC Organic Purity Project

- Project chaired by the BIPM with participation by 12 NMIs

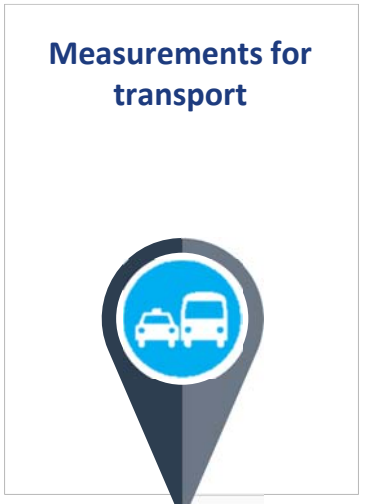
World Metrology Day joint BIPM and OIML initiative

2014

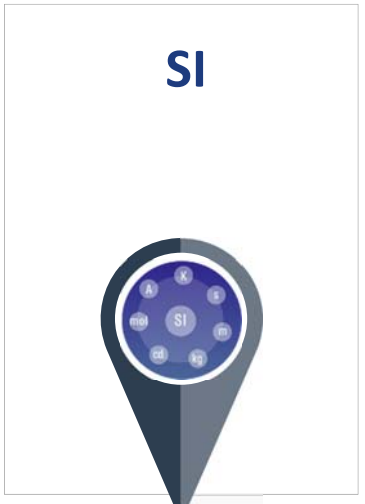
2015



2016



2017

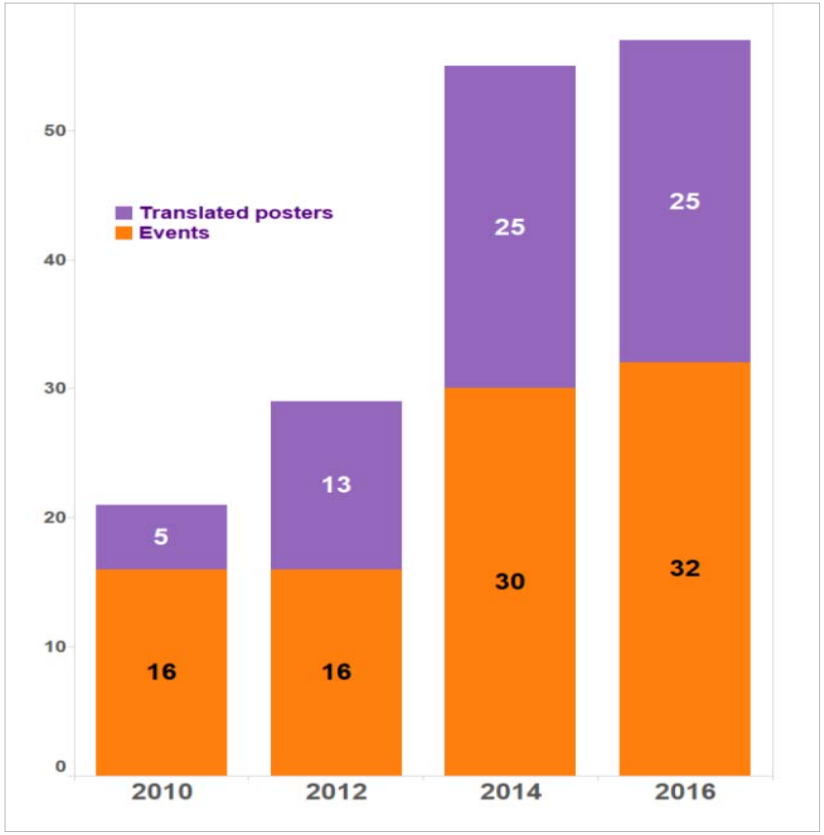


2018

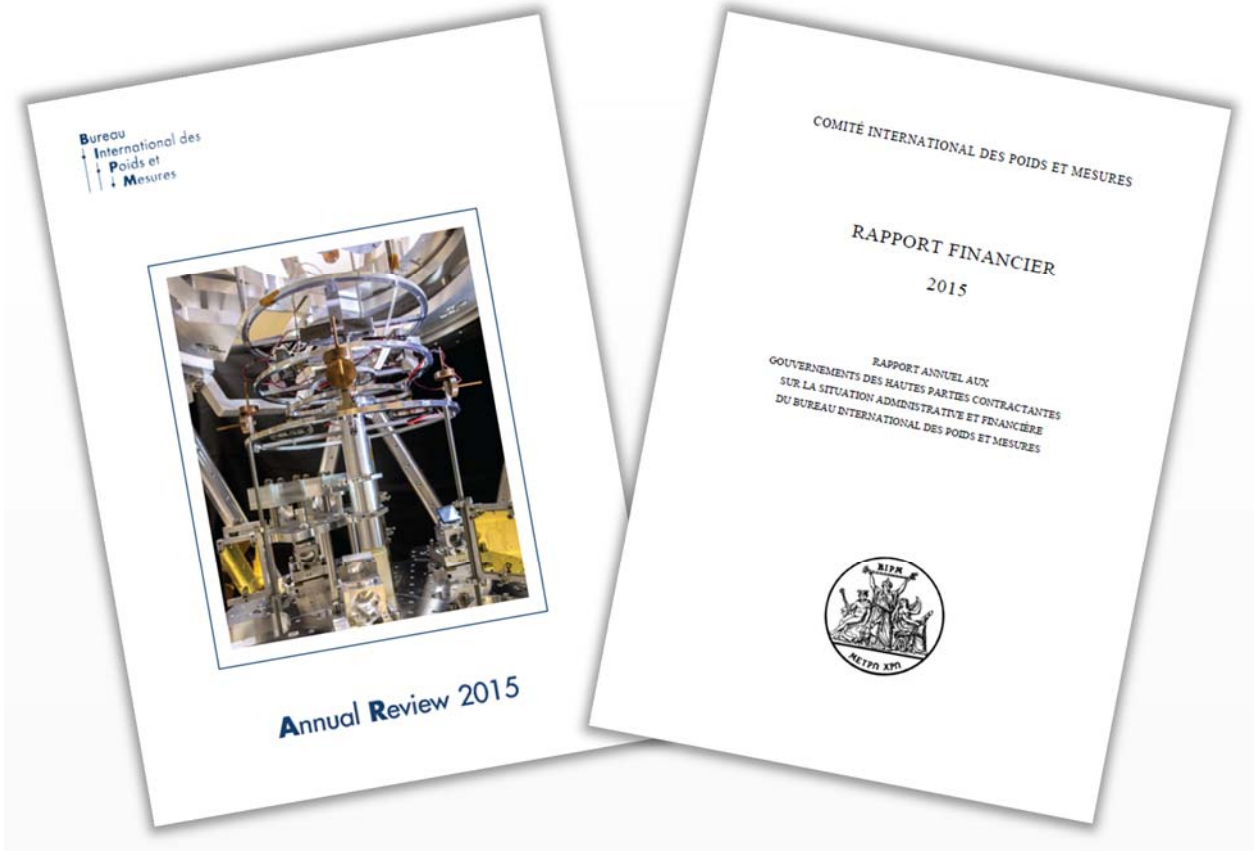
Growing impact of World Metrology Day

www.worldmetrologyday.org

Growth in uptake



New publications



- **Project to digitize all BIPM historic meeting material is very close to completion**
- **Commitment to make CC papers open access where possible.**

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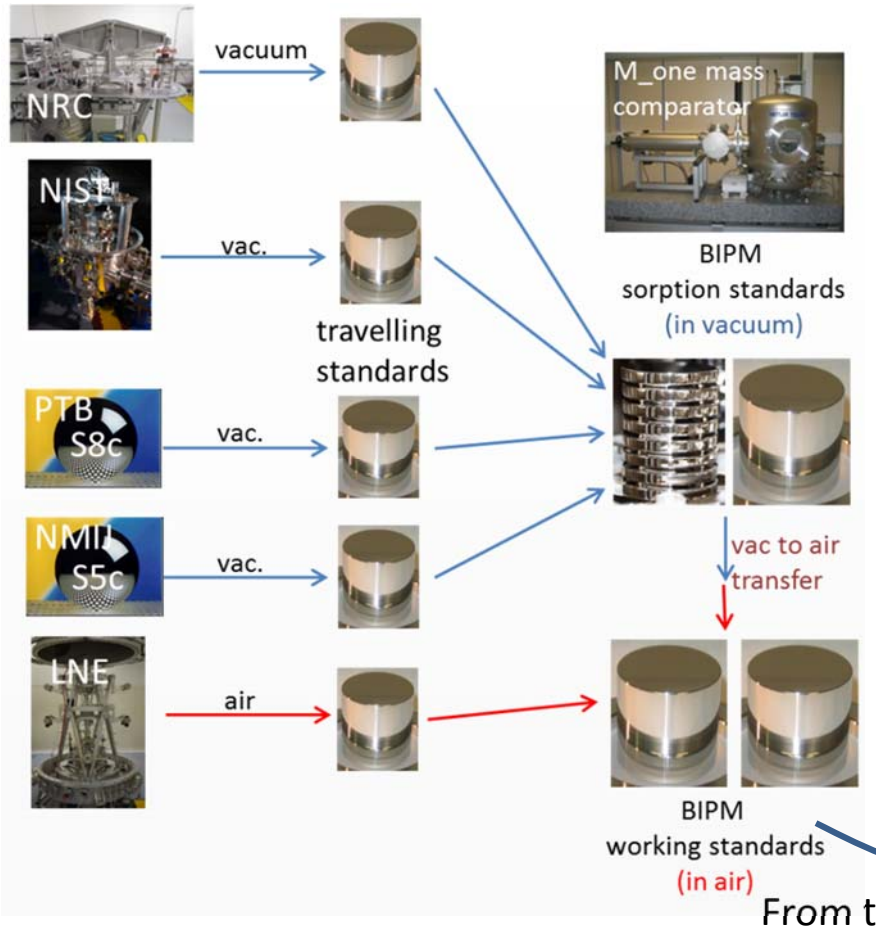
Mass Department - CCM Pilot Study
comparison of future primary realizations of the kilogram

Objectives

- To test the consistency of independent realizations of the kg
- To test for continuity with the present definition

Status to date

- **Measurements close to completion**
- **Report being prepared**
- **Results are satisfactory - consistent with results for *h***
- **No apparent obstacle for redefinition**



From the Extraordinary Calibrations (2014)

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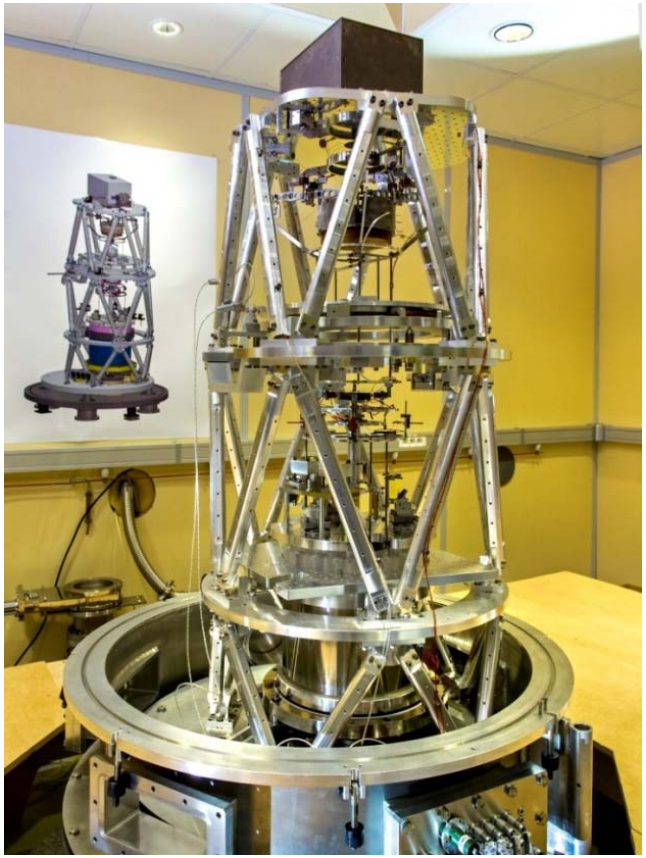
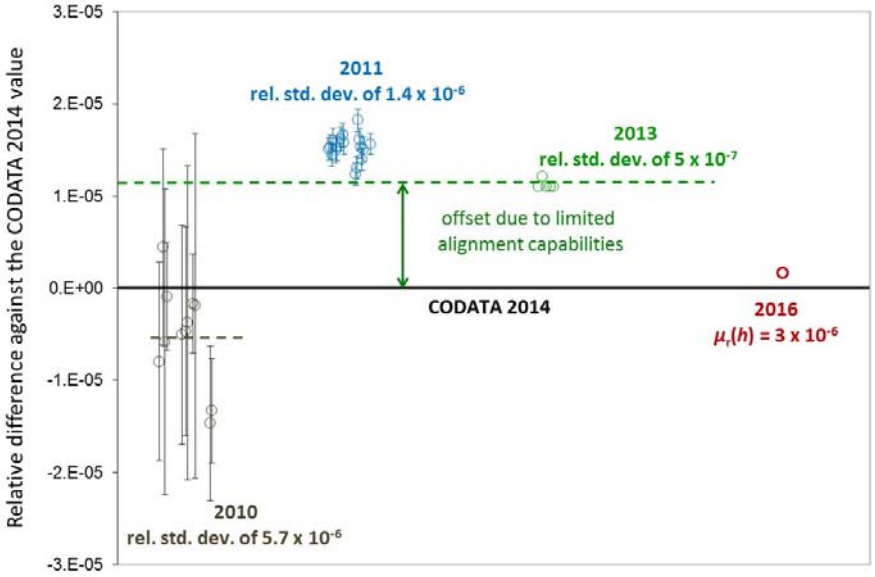
Status of the BIPM Kibble Balance (*aka* watt balance)



- new open support structure
- new interferometer
- accurately aligned magnet (10 µrad)

Evolution of measurement uncertainty

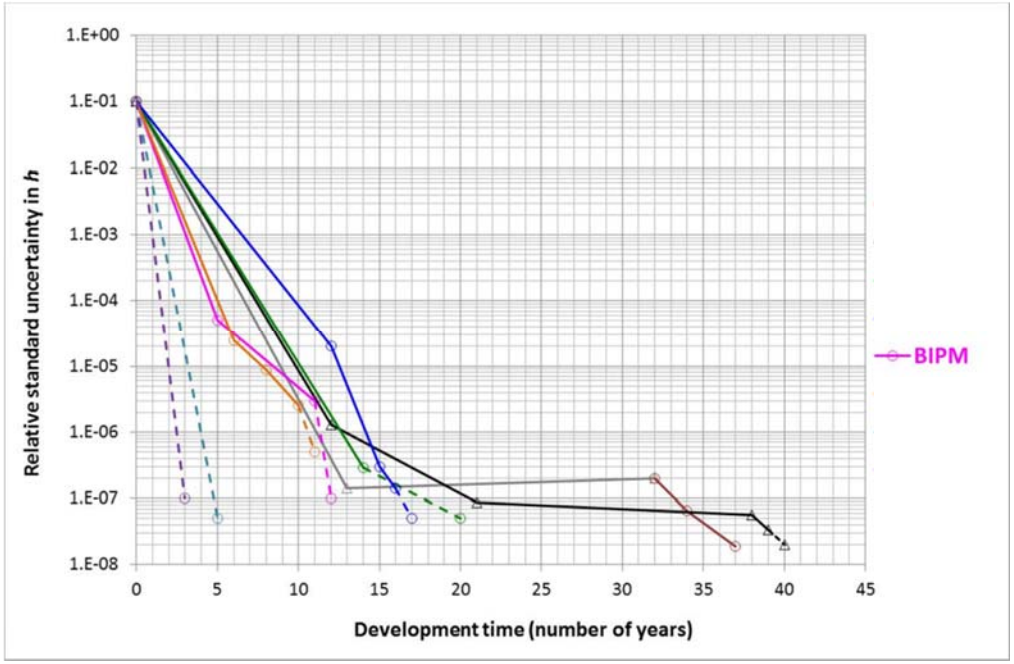


present uncertainty ~ 3 x 10^{-6}

estimated uncertainty by June 2017 ~ 1 x 10^{-7}

- improved alignment
- noise reduction on force measurement
- larger mass
- operation under vacuum

Evolution of uncertainties of watt balance projects



solid lines: published
dashed lines: projected

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BIPM watt balance project

4 full-time staff

Dr Hao FANG

Principal Physicist
>10 years experience
(also CCM Exec. Secr.)

Dr Franck BIELSA

Physicist
8 years experience
at BIPM since 2014

Dr Shisong LI

Research fellow
1 year experience (NIM, NIST)
at BIPM since 09/2016

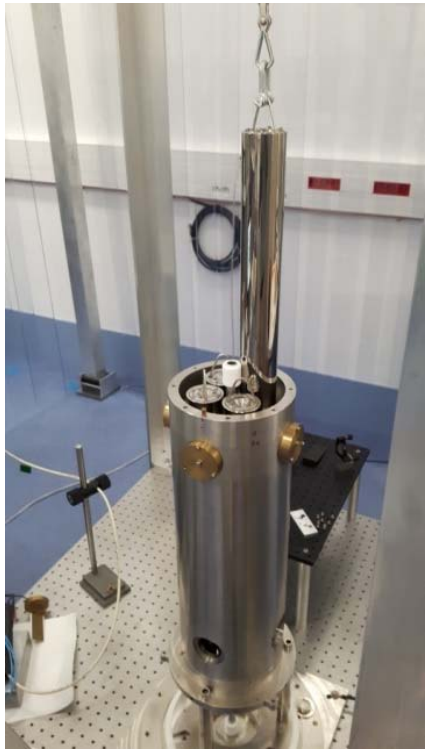
Adrien KISS

Engineer
9 years experience

Supported by 3 staff in the electricity team

The Calculable Capacitor

- for a direct determination of the von Klitzing constant

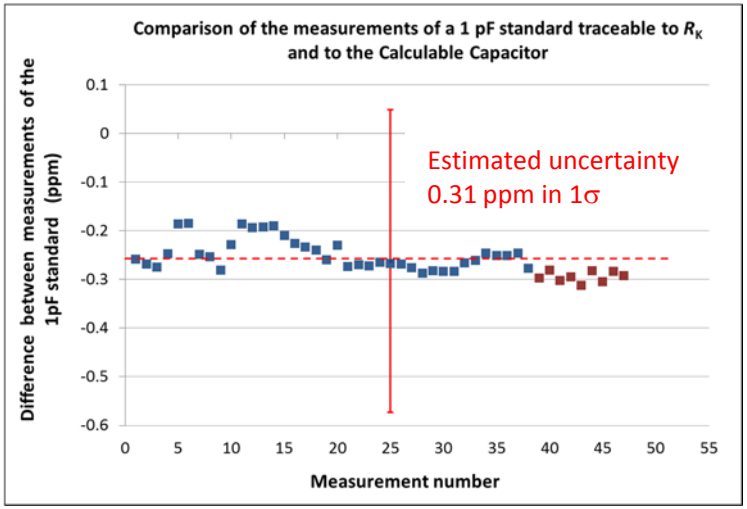


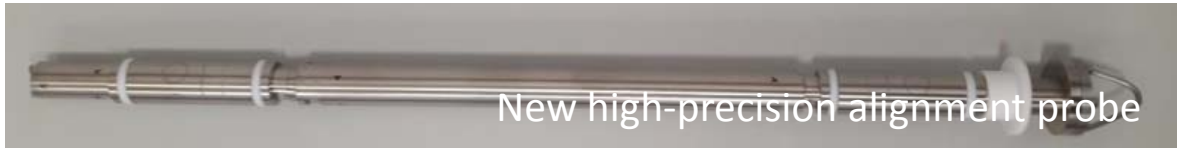
Objective - a direct electrical measurement of R_K (and of α) with smallest uncertainty obtained so far (ie 1 x 10^{-8})

First series of measurements: good repeatability but offset of 2.6 x 10^{-7} due to alignment error of electrode bars

Relocated in a new room offering a floor of much better stability and realigned with geometrical error of the order of 3 x 10^{-9}

At present completion of reassembly, new measurements planned for coming months





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Renovation of the *Observatoire*

- Two-year lab renovation project
  - Two renovated labs
  - New offices for all staff in the Physcial Metrology Dept
  - ➢ Space for visiting scientists

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Active comparison programme in electricity

CCEM-K4 Key Comparison of capacitance

BIPM pilot, protocol finalized, meas. early 2017

On-site comparisons

Josephson voltage standards (BIPM.EM-K10) - JV (Norway)

quantum Hall standards (BIPM.EM-K12) - METAS (Switzerland)

for Sept. 2016 - postponed upon request of METAS

Bilateral comparisons

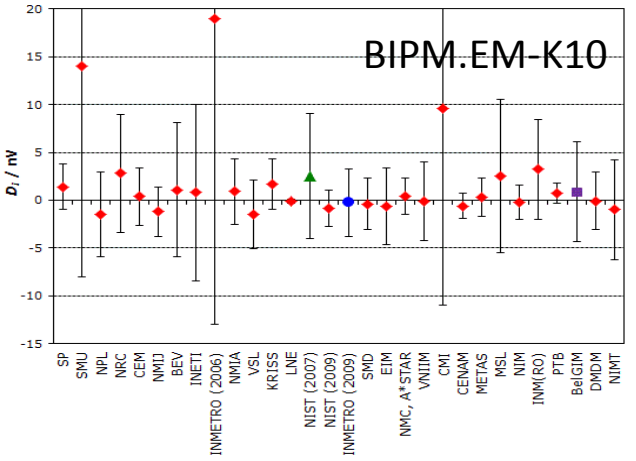
Zener voltage calibrations (BIPM.EM-K11) - DEFNAT (Tunisia)

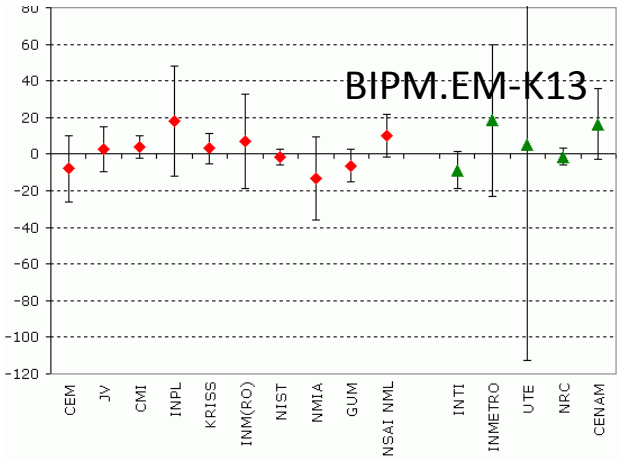
resistance calibrations (BIPM.EM-K13) - SMD (Belgium)

capacitance calibrations (BIPM.EM-K14)

- NMISA (South Africa)
- NIS (Egypt)
- NSAI (Ireland)

…… and, a large number of calibrations (typ. 50-60 per year)





Time Department

Regular provision of the highest quality time scales

Weekly « Real-time » UTC through Rapid UTC solution

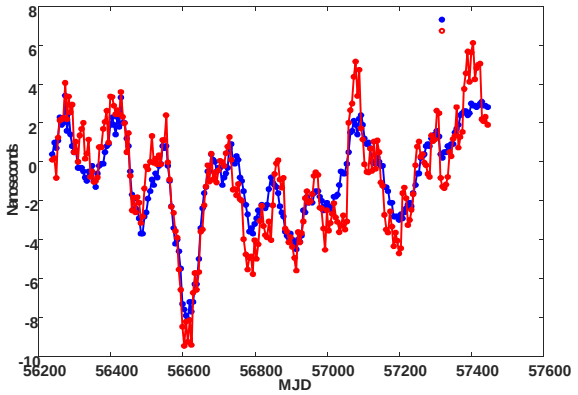
Monthly UTC through BIPM *Circular T* and CCTF K-001.UTC

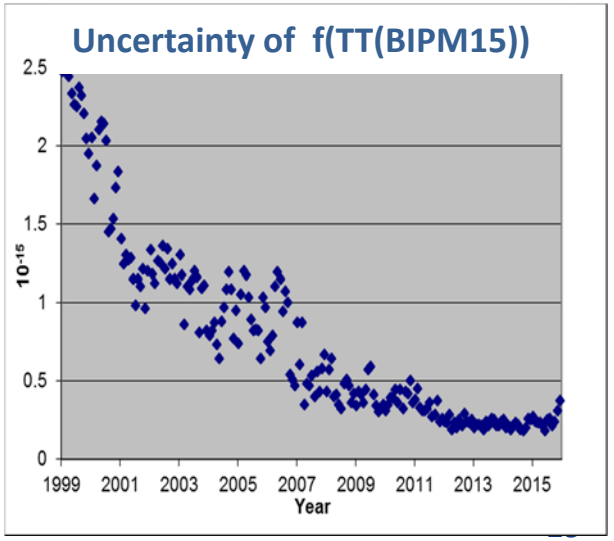
Yearly long-term stable TT(BIPM)

Rapid reference for better synchronization to UTC of local UTC(k)
Stability 5×10^{-16} @ 30 d
Offset wrt UTC < |3 ns|

Ultimate traceability to the SI second to NMIs
Stability 2×10^{-16} @ 30 d
Accuracy 4×10^{-16}

UTC-UTC(PTB) / UTCr-UTC(PTB)





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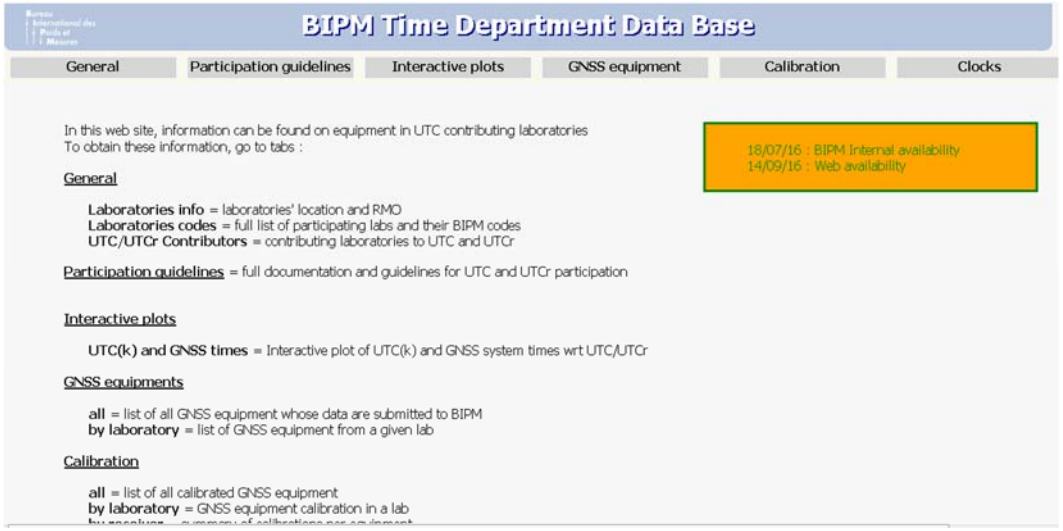
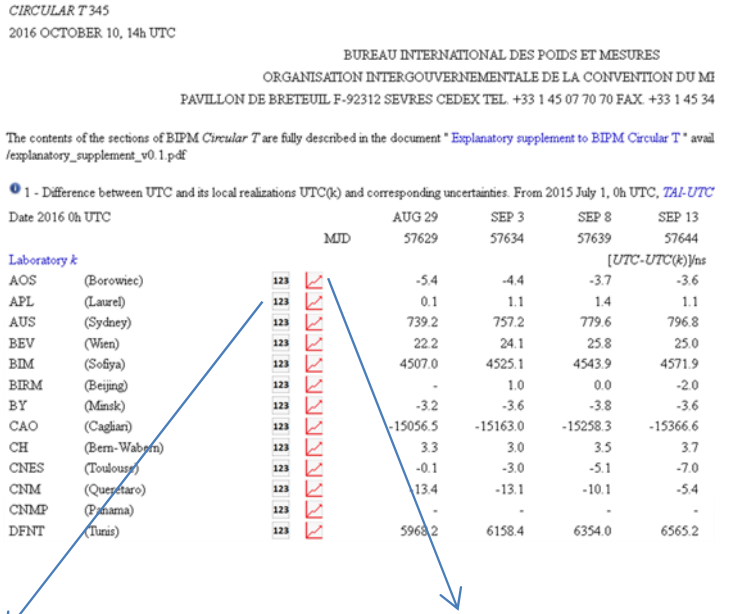
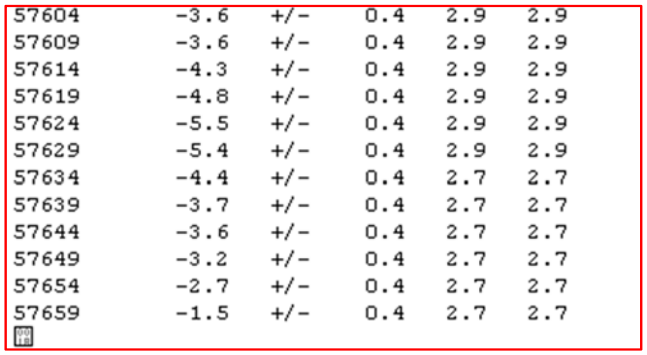
Enhanced distribution of data and results through interactive Circular-T and Time Department Data Base

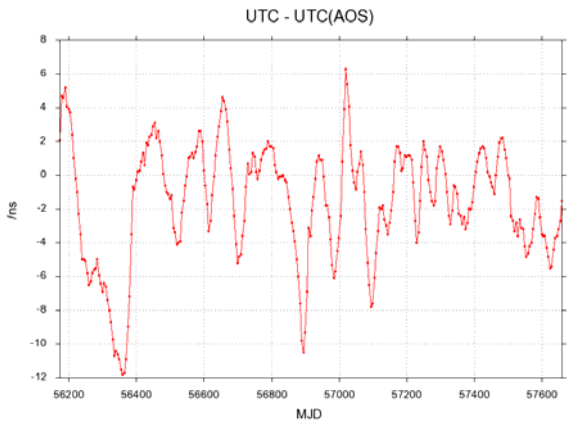


www.bipm.org/en/bipm/tai/





57604	-3.6	+/-	0.4	2.9	2.9
57609	-3.6	+/-	0.4	2.9	2.9
57614	-4.3	+/-	0.4	2.9	2.9
57619	-4.8	+/-	0.4	2.9	2.9
57624	-5.5	+/-	0.4	2.9	2.9
57629	-5.4	+/-	0.4	2.9	2.9
57634	-4.4	+/-	0.4	2.7	2.7
57639	-3.7	+/-	0.4	2.7	2.7
57644	-3.6	+/-	0.4	2.7	2.7
57649	-3.2	+/-	0.4	2.7	2.7
57654	-2.7	+/-	0.4	2.7	2.7
57659	-1.5	+/-	0.4	2.7	2.7



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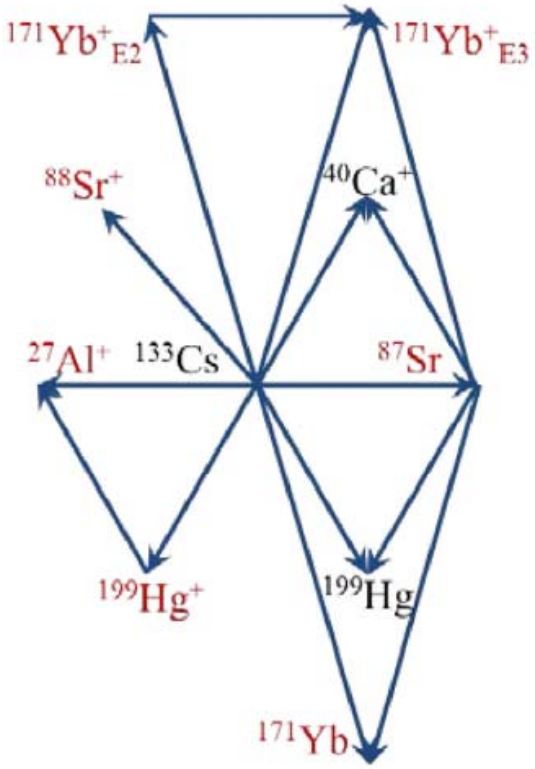
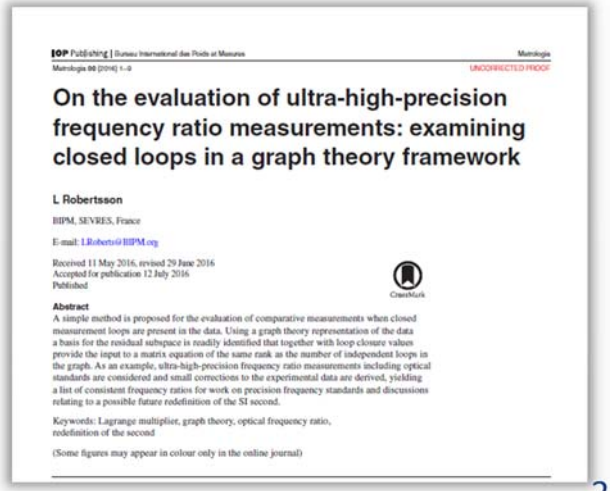
New uncertainty evaluation of optical frequencies for secondary definitions of the second

- ✓ Optical transitions recommended by the CIPM as SRS are potential candidates to redefine the SI second; they are selected by the CCTF from measurements of frequencies and frequency rations reported by NMIs;
- ✓ The number of reported transitions and rations is increasing, as well as the number of NMIs developing the same atomic species, making the system more complex.



Based on the graph theory a second method* for solving measurement and ratio loops with deviations to zero closure due to noise or systematic errors has been implemented and validated by comparison to Margolis and Gill (*Metrologia* 52 628-634, 2015)



IOP Publishing | Bureau International des Poids et Mesures — Metrologia
Metrologia 00 (2016) 1–9 — UNCORRECTED PROOF

On the evaluation of ultra-high-precision frequency ratio measurements: examining closed loops in a graph theory framework

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Received 11 May 2016, revised 29 June 2016
Accepted for publication 12 July 2016
Published

Abstract
A simple method is proposed for the evaluation of comparative measurements when closed measurement loops are present in the data. Using a graph theory representation of the data a basis for the residual subspace is readily identified that together with loop closure values provide the input to a matrix equation of the same rank as the number of independent loops in the graph. As an example, ultra-high-precision frequency ratio measurements including optical standards are considered and small corrections to the experimental data are derived, yielding a list of consistent frequency ratios for work on precision frequency standards and discussions relating to a possible future redefinition of the SI second.

Keywords: Lagrange multiplier, graph theory, optical frequency ratio, redefinition of the second

(Some figures may appear in colour only in the online journal)

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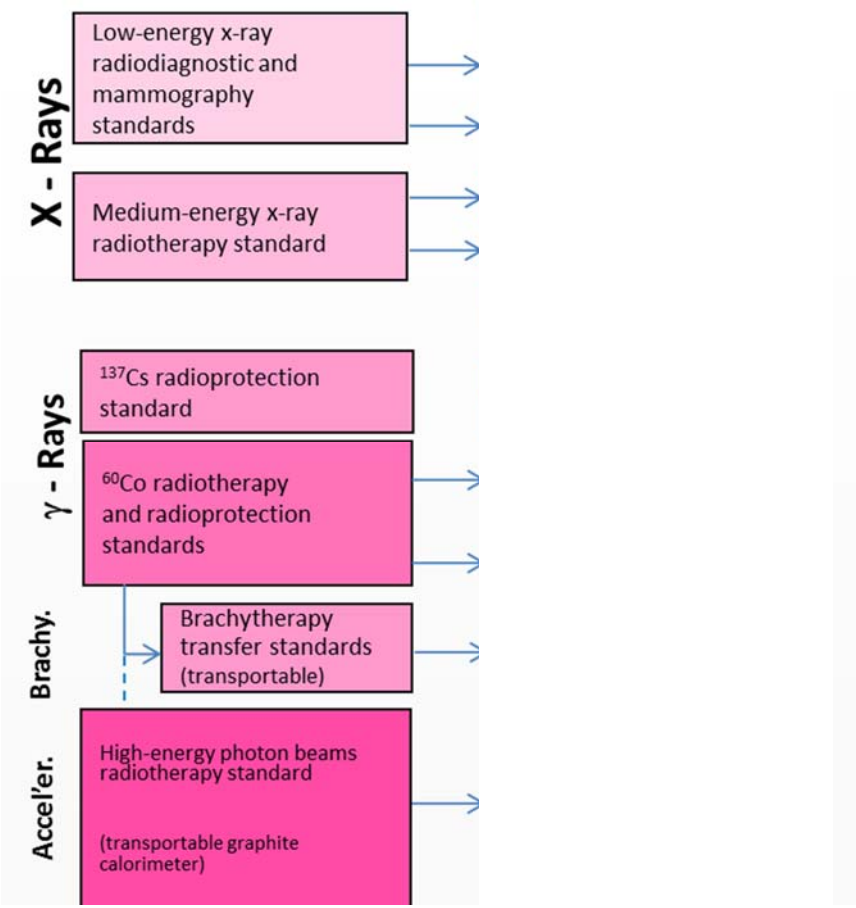
Dosimetry – facilities and services



Summary

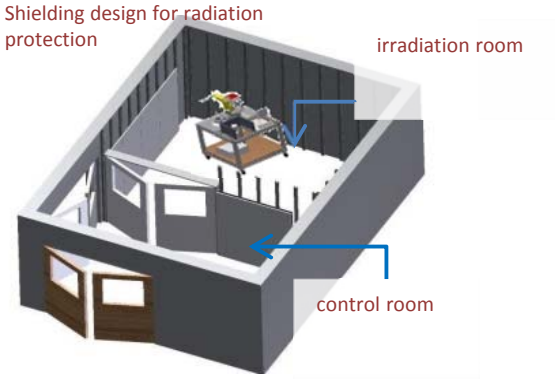
6 on-going comparisons of national primary standards, on demand, at the BIPM

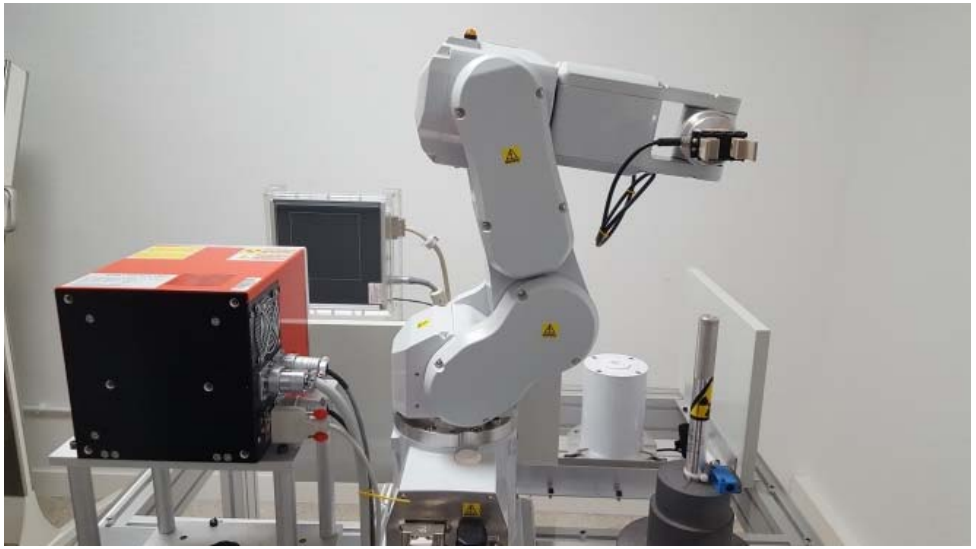
2 on-going comparisons of national primary standards, on demand, on-site at the NMI/DI

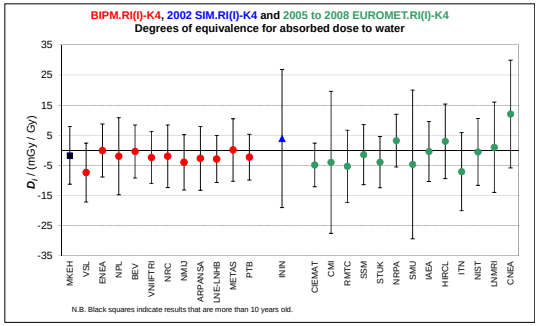
Calibrations of national secondary standards

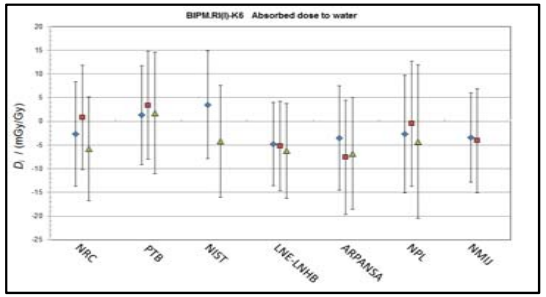
Dosimetry – achievements

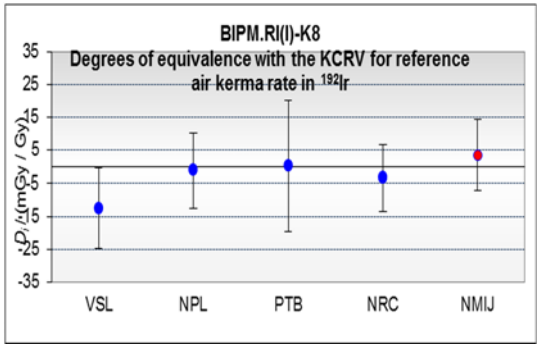
New - robot installed for manipulation brachytherapy sources





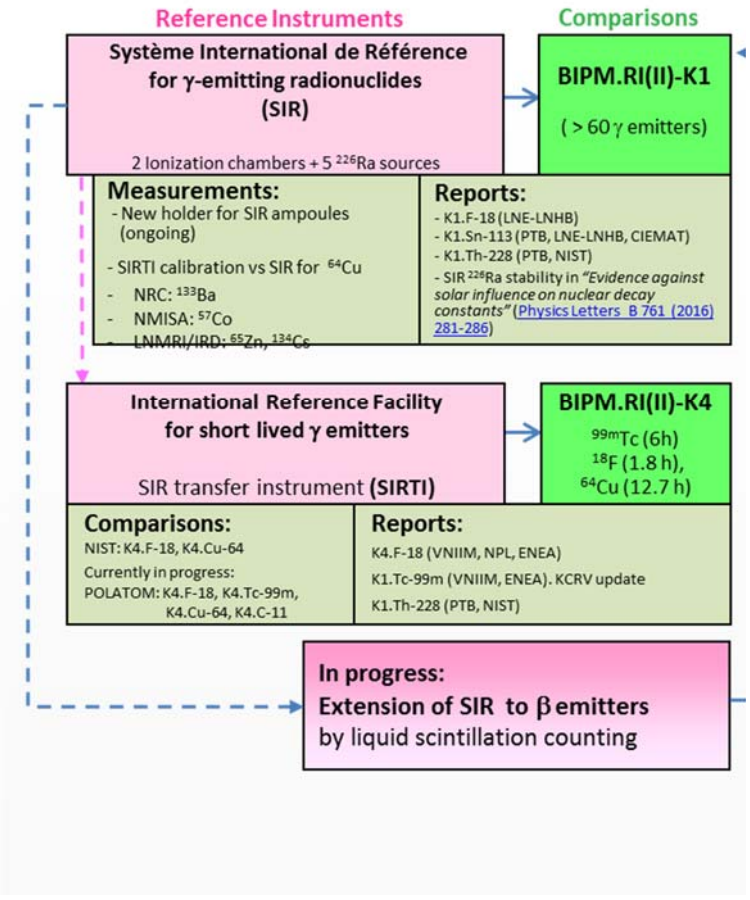






www.bipm.org

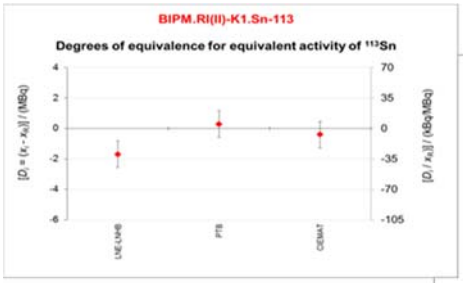
Radionuclide Measurements

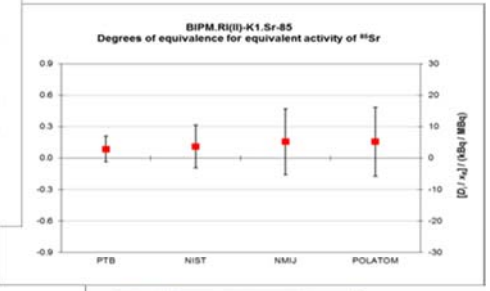


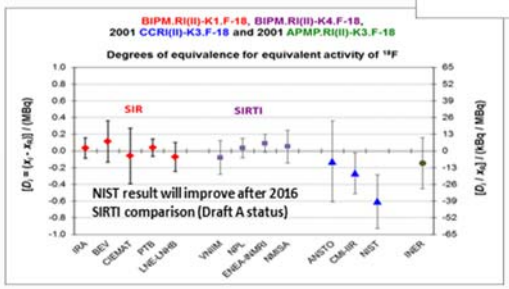
Summary

1 on-going comparison for activity of γ emitters (>60), on demand, at the BIPM (SIR)

1 on-going comparison for activity of short-lived γ - emitting radionuclides, on demand, on-site at the NMI/DI (SIRTI) (99mTc, 18F, 64Cu, 11C…)







Pilot study (September'16 – July'17):
- ^{3}H, ^{14}C, ^{55}Fe, ^{63}Ni
- IFIN, IRMM, NIM, NIST, NMIJ, NRC, POLATOM, PTB (+ ANSTO, BARC, CIEMAT, IRA, MKEH, NPL)
- 1 NIST secondee (September'16 - February'17)
- 1 NIM secondee (February'17 – July'17)

Forthcoming:
- Reports to ESWG(II) (May'17), CCRI(II) (June'17), ICRM (May'17)
- NEW EXTENDED BIPM.RI(II)-K1 including γ and β emitters

Chemistry Department

Air Quality and Greenhouse Gas Standard Comparisons

analytical chemistry

OZONE

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Article

Ozone cross-section measurement by gas phase titration

Joele Viallon, Philippe Moussay, Edgar Flores, and Robert Ian Wielgosz

Anal. Chem., Just Accepted Manuscript
DOI: 10.1021/acs.analchem.6b03299
Publication Date (Web): October 11, 2016
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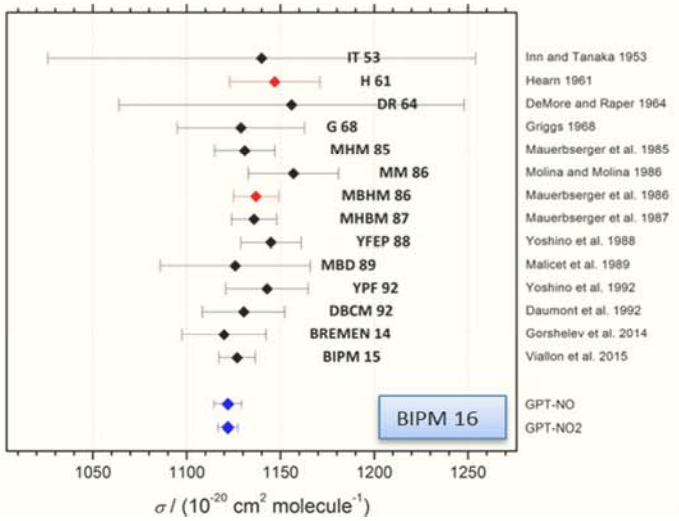

ELSEVIER

Journal of Molecular Spectroscopy
Volume 327, September 2016, Pages 105–121
New Visions of Spectroscopic Databases, Volume II

Absorption cross-sections of ozone in the ultraviolet and visible spectral regions: Status report 2015

Johannes Orphal[a], Johannes Staehelin[b], Johanna Tamminen[c], Geir Braathen[d], Marie-Renée De Backer[e], Alkiviadis Bais[f], Dimitris Balis[f], Alain Barbe[e], Pawan K. Bhartia[g], Manfred Birk[h], James B. Burkholder[aa], Kelly Chance[i], Thomas von Clarmann[a], Anthony Cox[k], Doug Degenstein[l], Robert Evans[i], Jean-Marie Flaud[m], David Flittner[n], Sophie Godin-Beekmann[o], Viktor Gorshelev[p], Aline Gratien[m], Edward Hare[q], Christof Janssen[r], Erkki Kyrölä[c], Thomas McElroy[s], Richard McPeters[g], Maud Pastel[o], Michael Petersen[t, 1], Irina Petropavlovskikh[u, ab], Benedicte Picquet-Varrault[m], Michael Pitts[n], Gordon Labow[g], Maud Rotger-Languereau[e], Thierry Leblanc[u], Christophe Le[illegible], Redondas[w], Michel Van Roozendael[v], Stanley P. San[illegible], Pepijn Veefkind[x], Joële Viallon[t], Camille Viatte[y], Georg Wagner[h], Mark Weber[p], Robert I. Wielgosz[t], Claus

BIPM-QM-K1

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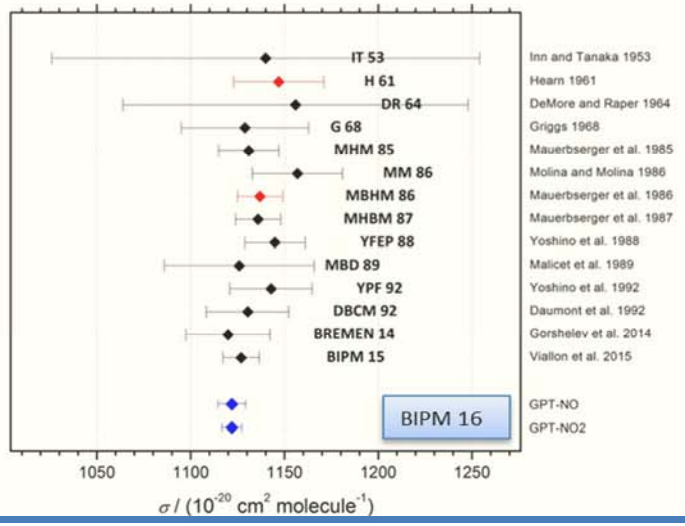

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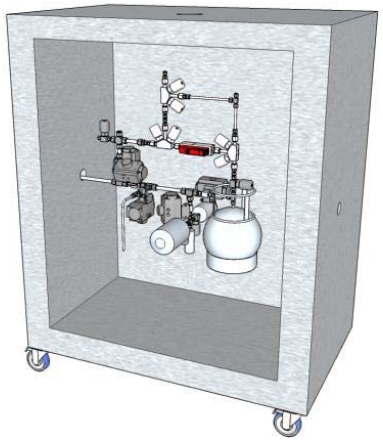
BIPM-QM-K1

CARBON DIOXIDE

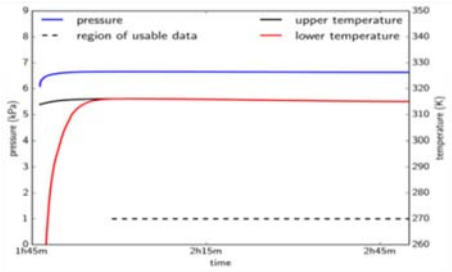
CCQM-K120 (2016)

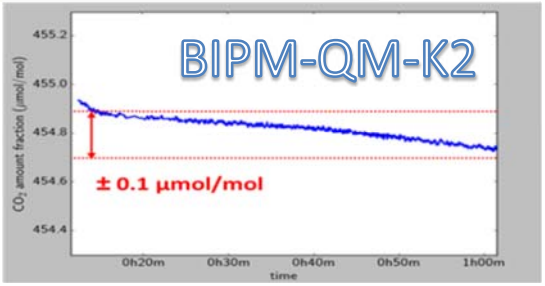
(380 – 800) µmol/mol

43 NMI Participations



Scientist (NMI)	Period
S. Maxwell (NIST)	1 Sept 2015 – 29 Feb 2016
F. Arrhén (SP)	15 Jan 2016 – 15 July 2016
C. Meyer (NIST)	15 Jan 2017- 15 July 2017





www.bipm.org

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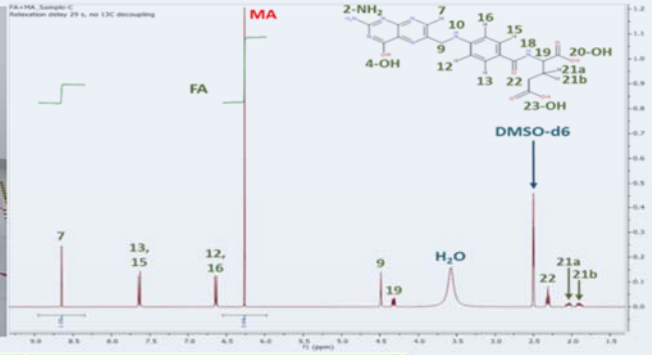
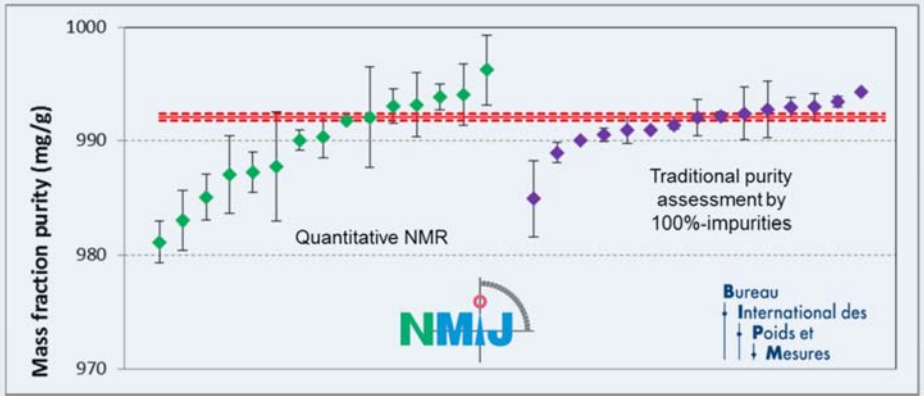
Primary Organic Calibrator Comparisons

CCQM-K55.c,d: Supporting qNMR development for Primary Reference Materials at NMIs



Scientist (NMI)	Period
W. Zhang (NIM)	15 Feb 2016 – 15 Aug 2016
B. Garrido (INMETRO)	1 Sept 2016 – 28 Feb 2017



Chemistry Department

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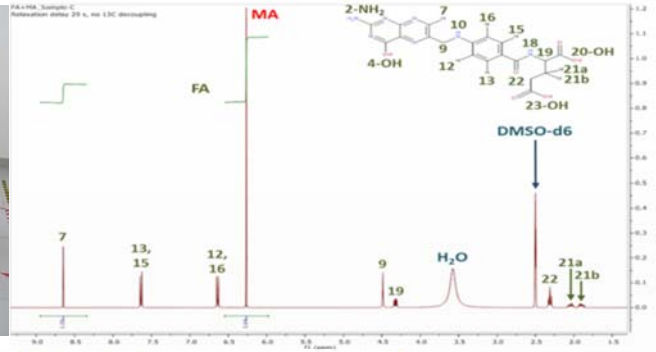

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W. Zhang (NIM)	15 Feb 2016 – 15 Aug 2016
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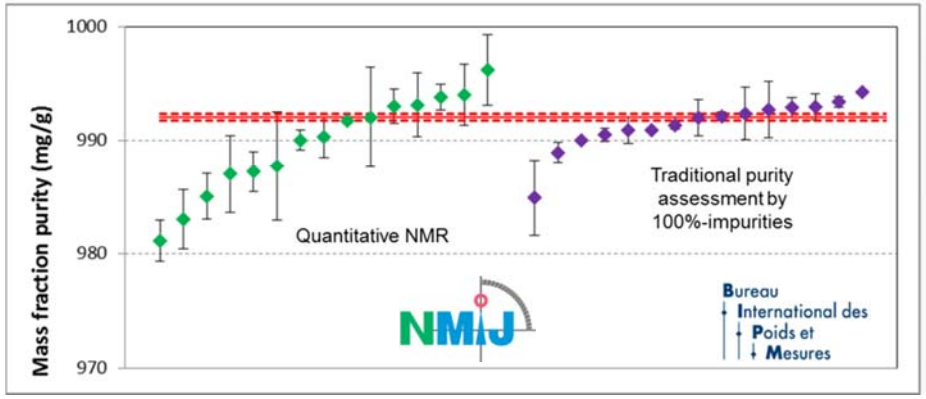
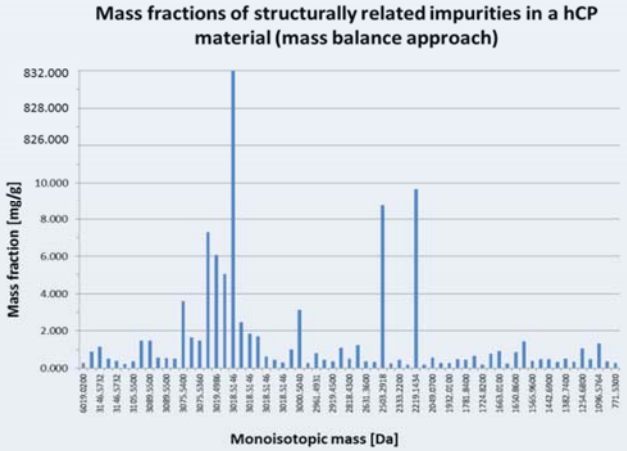
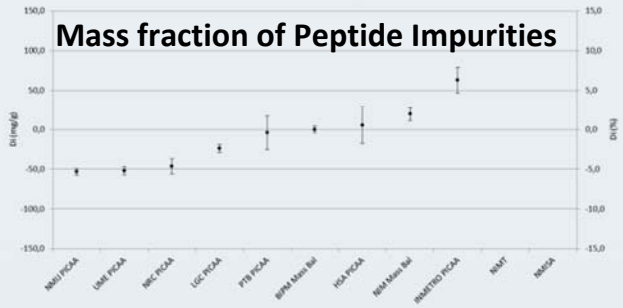
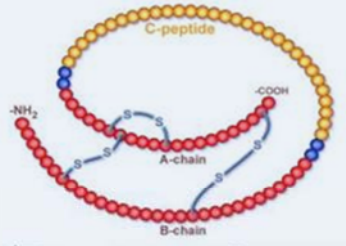


CCQM-K115: Reference Systems to Differentiate between Type I and Type II Diabetes







Bureau International des Poids et Mesures

Most abundant [mg/g]:

hCP: 831.32

acetyl-hCP(9-31): 9.67

acetyl-hCP(6-31): 8.76

dea9hCP: 7.30

dea6hCP: 6.08

dea22hCP: 5.04

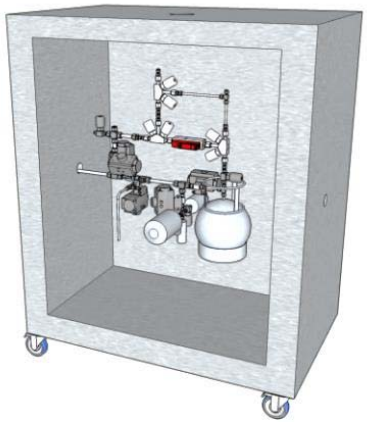
Scientist (NMI)	Period
P. Bros (LNE)	1 July 2015 – 31 Jan 2016
L. Wong (HSA)	1 Feb 2016 – 30 Apr 2016

Lab visits at 13:00 today

Quantum electrical standards and the calculable capacitor

&

Primary carbon dioxide measurement facility



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