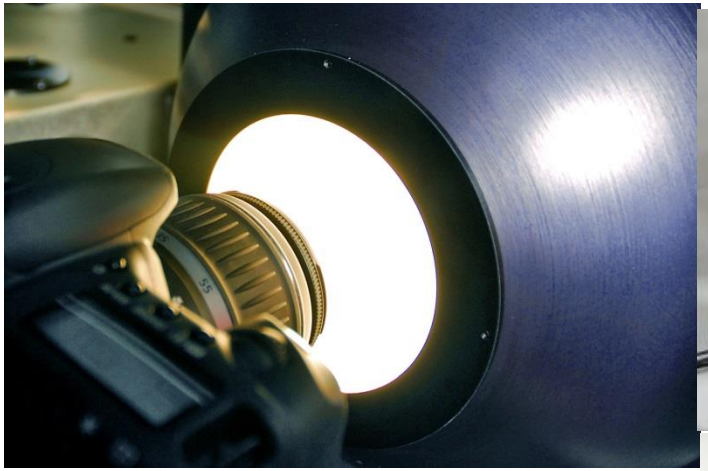
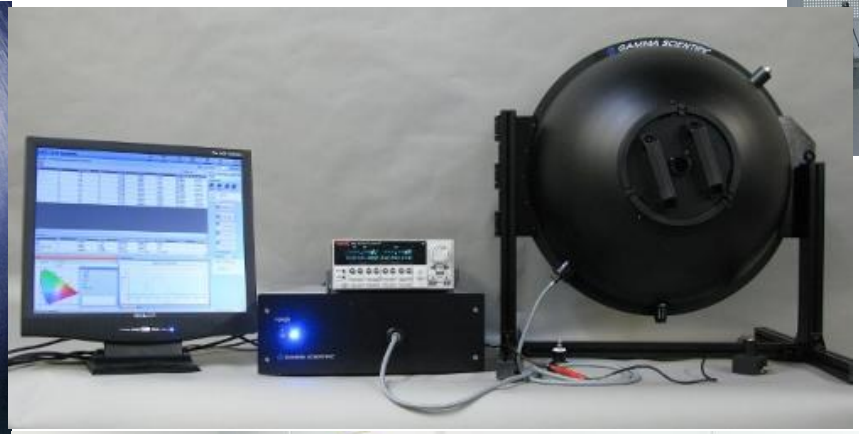
CIPM and *CCPR* – What are these organizations and how do they affect my testing results

Maria Nadal
Photometry, Surface Color and Appearance
NIST

CIE USA Annual Meeting
October 6-7, 2014

Calibration Laboratory





Customer Requirement:

ISO/IEC 17025 Accredited

Laboratory Accreditation Bodies in the US

150+ Accreditation bodies
Operated by government and private not for profits

NVLAP®

PERRY JOHNSON LABORATORY ACCREDITATION, INC. (PJLA)

IAS
International Accreditation Service

LABORATORY ACCREDITATION BUREAU

ANAB ACCREDITED

These bodies accredit testing and calibration labs, reference material producers, PT providers, product certifiers, inspection bodies, forensic institutions and others to a multitude of standards and programs.

ILAC MRA: Operates in accordance to ISA/IEC 17011

International Laboratory Accreditation Cooperation :

- On 2000, 36 laboratory accreditation bodies, full members of ILAC, from 28 economies worldwide signed an "arrangement" to **promote the acceptance of technical test and calibration data for exported goods.**
- Establish methods for mutual accreditation bodies (AB) recognition
- Created **geo-political regions** to manage work needed for such mutual recognition: EA, APLAC, SADCA, and IAAC
- As of 2012, there are **over 35,000 laboratories accredited** under the ILAC arrangement

"The purpose of the ILAC Arrangement is to develop a global network of accredited testing and calibration laboratories that can be relied on to provide accurate results."

Benefits Laboratory Accreditation

- Prove technical expertise
- Prove to stakeholders that measurements are done correctly
- Consistent documented procedures and policies
- Documented methods of verification and validation
- Predetermined decisions are documented
- Secondary staffing – back ups
- System tolerances – environmental, instrument calibration

ISO/IEC 17025

- General requirements for the competence of testing and calibration laboratories
- Assessment by Accreditation Body (AB) to obtain accreditation
- *Continual Improvements*
- Five Elements: Scope, Normative References, Terms and Definitions, Management Requirements, and Technical Requirements.
  - The two main sections are: Chapter 4 and 5
    - **5.6: Measurements Traceability (SI units) - *Candela***
      - National Metrology Institutes (NMIs): NIST, NRC, PTB…

BIPM: International Bureau of Weights and Measures

- To develop the technical and organizational infrastructure of the **International System of Units (SI) as the basis for the world-wide traceability of measurement results**
- Intergovernmental organization through which member s act together on matters related to measurement and standards
- Headquarters: Paris, France

CIPM: International Committee for Weights and Measures

- To promote world-wide uniformity in units of measurement by coordinating international comparisons
- 10 Consultative Committees (Mass, Length, …)

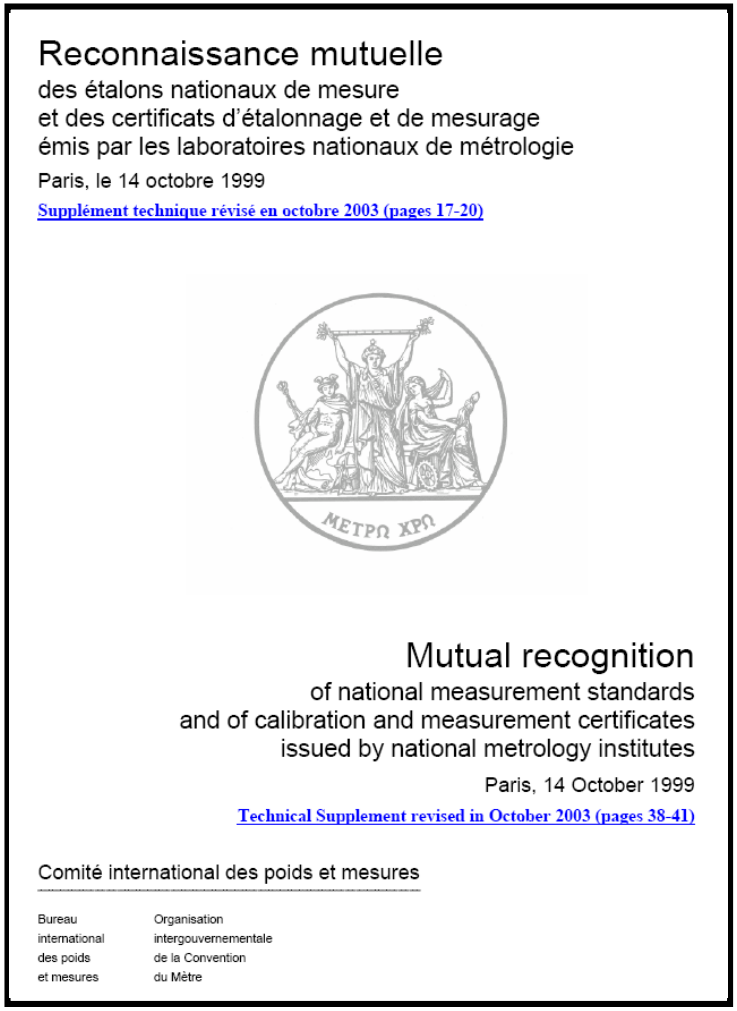
  CCPR: Consultative Committee for Photometry and Radiometry

CIPM Joint Working Groups

- CIPM and ILAC: Joint ILAC-CIPM communication regarding the accreditation of calibration and measurement services of national metrology institutes (7 March 2012) **Review the traceability and dissemination process between NMIs and accredited laboratories**
- BIPM, OIML, ILAC and ISO: Joint declaration on metrological traceability to SI units (9 November 2011)
- BIPM, OIML and ILAC: Common statement and declaration on the relevance of various international agreements on metrology to trade, legislation and standardization (23 January 2006)
- CIPM and ILAC: Joint statement on improving world-wide traceability and acceptance of measurements carried out within the CIPM MRA and the ILAC arrangement – The roles and responsibilities of national metrology institutes and national recognized accreditation bodies (9 November 2005)

http://www.bipm.org/en/committees/cipm/joint-working-groups.html

CIPM Mutual Recognition Arrangement (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

Bureau international des poids et mesures
Organisation intergouvernementale de la Convention du Mètre

In October 1999, the directors of the national metrology institutes (NMIs) of **thirty-eight** Member States of the Metre Convention signed a Mutual Recognition Arrangement (MRA) for national measurement standards and for calibration and measurement certificates issued by national metrology institutes

www.bipm.org/en/convention/mra/

CIPM MRA

- **To establish the *degree of equivalence* of national measurement standards maintained by NMIs;**

- **To provide for the mutual recognition of calibration and measurement certificates issued by NMIs;**

- **Thereby to provide governments and other parties with a** *secure technical foundation for wider agreements related to international trade, commerce and regulatory affairs*.
  - **Assure that measurements traceable to different NMIs can be accepted across borders**

NMIs Demonstrate Competence By:

- Participating in international comparisons of measurements, known as key comparisons
- Participating in supplementary international comparisons of measurements
- Quality systems in accordance with ISO/IEC 17025

Outcome

Statements of the calibration and measurement capabilities (CMCs) of each NMI in a database publicly available on the Web.

http://kcdb.bipm.fr/BIPM-KCDB/

How the quality system of the NMI (as required by ISO/IEC 17025) is examined?

For major NMIs, by self-declaration
For smaller NMIs, by international peer-reviews

How the uncertainties on the CMC list are validated?

By "*Key Comparisons*" and "*Supplementary Comparisons*"

How the entries to CMC are approved?

Applications to CMC entries (especially the claimed uncertainties) are reviewed

1) within the Regional Metrology Organization (RMO)
2) by other PR RMOs

Supporting evidences (results of participated comparisons, peer-reviews) are examined.

CIPM Appendix C (CMC lists) and CMC entries are approved and maintained by ***JCRB: Joint Committee of the Regional Metrology Organizations and the BIPM.***

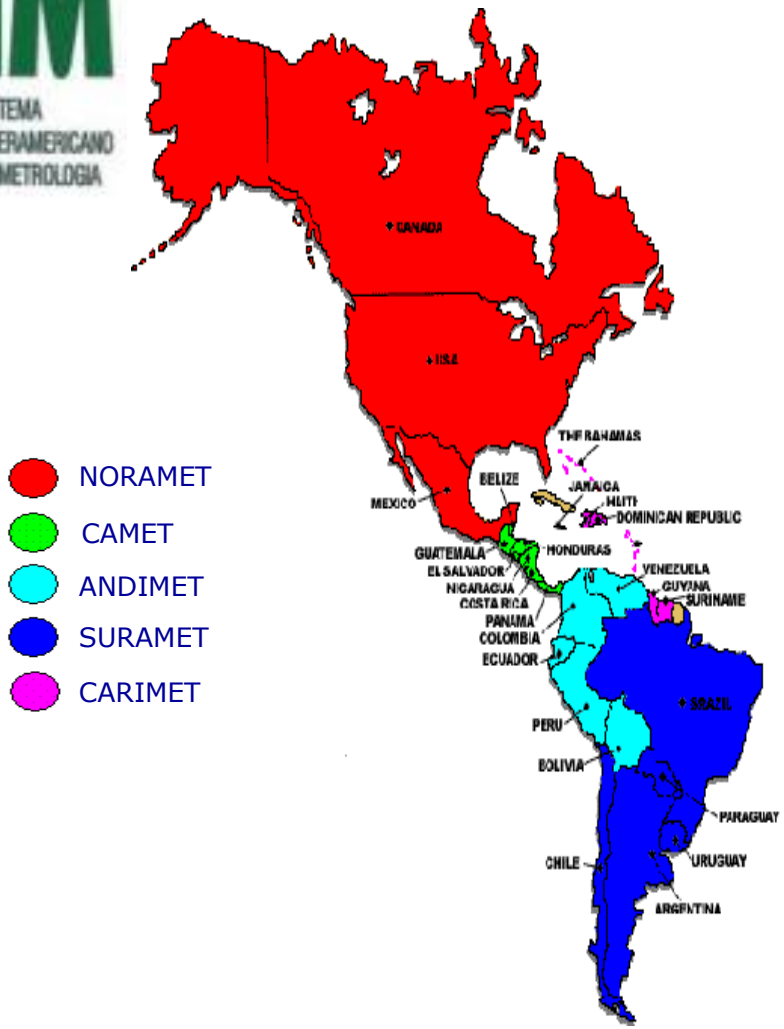
http://www.bipm.org/en/committees/jc/jcrb/

Regional Metrology Organizations (RMOs):

- **AFRIMET** (Intra-Africa Metrology System)
- **APMP** (Asian Pacific Metrology Program)
- **COOMET** (Euro-Asian Cooperation of National Metrological Institutions)
- **EURAMET** (European Association of Metrology Institutes)
- **SIM** (Inter-American Metrology System)

The CIPM MRA has now been signed by the representatives of 95 institutes.

Metrology in Americas



- NORAMET
- CAMET
- ANDIMET
- SURAMET
- CARIMET

5 Sub-regions
34 Countries
13 Technical Committees
5 PR Members

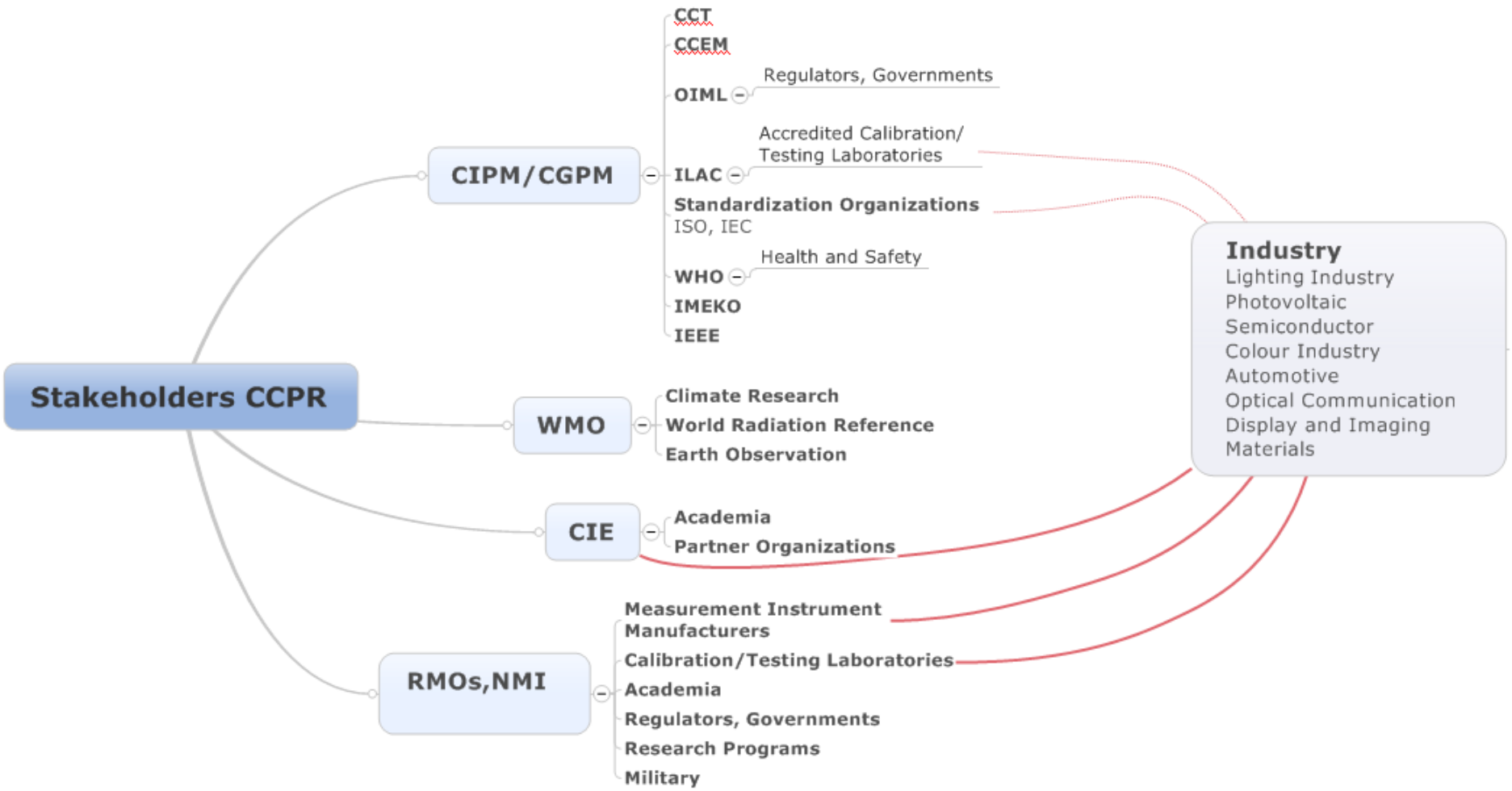
http://www.sim-metrologia.org.br/

SIM TC PR Chair: Maria Nadal

CCPR: Consultative Committee for Photometry and Radiometry

- Founded 1933
- Measurement standards for photometric and radiometric quantities, development of absolute radiometry, and advice to the CIPM on matters concerned with radiometry and photometry
- Working Groups
  - CMCs: Calibration Measurement Capabilities
  - KC: Key Comparison
  - SP: Strategic Planning
- 23 Members
- CCPR meets every two years and WGs meet every year

CCPR Stakeholders



2014 CCPR Meeting
BIPM Headquarters

CCPR WG-CMC

- Members: RMO TC Chairs
- Coordinate and approve the definition of service categories requested by RMOs and to maintain ***lists of service categories***
- Agree on detailed technical review criteria for CMCs
- Coordinate and conduct inter-regional reviews of ***CMCs submitted by RMOs for posting in Appendix C*** of the MRA
- Provide guidance on the range of CMCs supported by particular key and supplementary comparisons
- Coordinate the review of existing CMCs in the context of new results of key and supplementary comparisons
- Issues related to the ***CIPM MRA***

http://kcdb.bipm.org/appendixC/default.asp

CLASSIFICATION OF SERVICES IN PHOTOMETRY AND RADIOMETRY

Version No 11, February 2012

METROLOGY AREA: PHOTOMETRY AND RADIOMETRY

Note 1:
The services numbering given in this text is the one which is used by National Metrology Institutes for drawing up their CMC files in the field of Photometry and Radiometry. To facilitate the selection of services via the database search engine, this metrology area is split up into four different branches: "Photometry", "Properties of detectors and sources", "Properties of materials", and "Fiber optics". It follows that services corresponding to number "5", which are relevant to detectors and sources, are given here before services corresponding to number "4", which are relevant to materials.

Note 2:
In the following, the service numbered as "a.b.c" is described under the form:

- **a. Field**
  - **a.b Measured quantity**
    - a.b.c Instrument or artefact: *parameter(s) in italic*

BRANCH: PHOTOMETRY

- **1. Photometry**
  - **1.1 Luminous intensity**
    - 1.1.1 Tungsten lamp: *correlated colour temperature*
    - 1.1.2 LED: *geometric measurement conditions, peak wavelength (or white)*
  - **1.2 Illuminance responsivity**
    - 1.2.1 Tungsten source, illuminance meter: *illuminance, correlated colour temperature*
  - **1.3 Luminous flux**
    - 1.3.1 Tungsten lamp: *correlated colour temperature*
    - 1.3.2 LED: *geometric measurement conditions (partial, full), , peak wavelength (or white)*
  - **1.4 Illuminance**
    - 1.4.1 Tungsten lamp: *correlated colour temperature*
  - **1.5 Luminance**
    - 1.5.1 Tungsten-based source: *c*
  - **1.6 Luminance responsivity**
    - 1.6.0 Luminance meter: *luminance, type of source used*

http://kcdb.bipm.org/appendixC/PR/PR_services.pdf

Example of NIST CMC list – 20 pages

Calibration and Measurement Capabilities

Photometry and Radiometry, United States, NIST (National Institute of Standards and Technology)

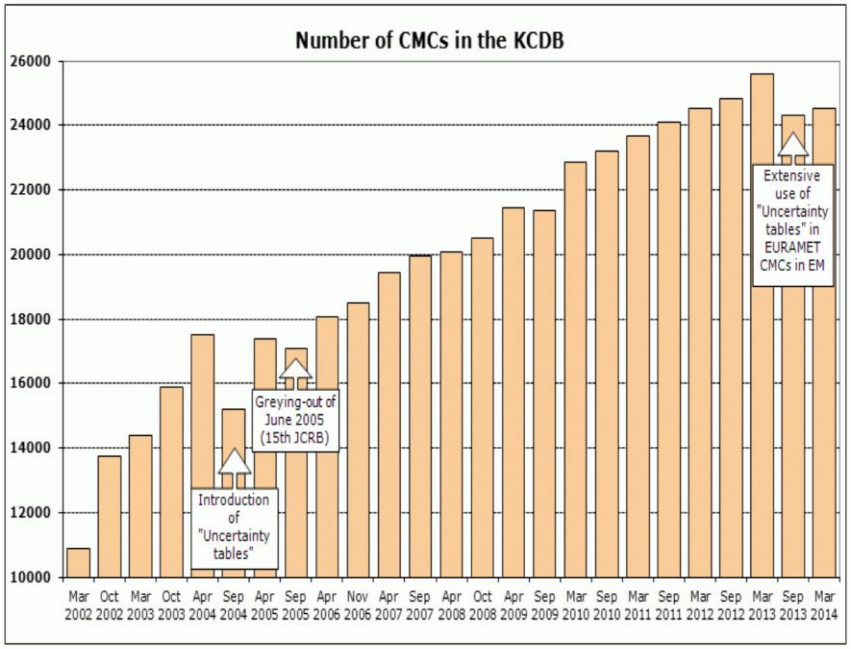
Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					KCDB	
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum value	Maximum value	Units	Parameter	Specifications	Value	Units	Coverage factor	Level of Confidence	Is the expanded uncertainty a relative one?	Comments	NMI Internal Service Identifier
Luminous intensity	Tungsten lamp	Photometric bench	0.001	1	cd	Color temperature	2000 K to 3200 K	1.5 to 0.5, varies with measurand	%	2	95%	Yes	Services also available for sources other than tungsten lamps, with uncertainty evaluated for specific sources.	37010C and 37020S
Luminous intensity	Tungsten lamp	Photometric bench	1	10000	cd	Color temperature	2000 K to 3200 K	0.5	%	2	95%	Yes	Services also available for sources other than tungsten lamps, with uncertainty evaluated for specific sources.	37010C and 37020S
Illuminance responsivity, tungsten source	Illuminance meter	Photometric bench			A/lx or V/lx	Illuminance	0.001 lx to 0.1 lx	1.5 to 0.5 varies with illuminance	%	2	95%	Yes	Services also available for sources other than Illuminant A (e.g., LEDs of various colors), with uncertainty evaluated for specific sources.	37090S
						Color temperature	2856 K							
Illuminance responsivity, tungsten source	Illuminance meter	Photometric bench			A/lx or V/lx	Illuminance	0.1 lx to 1000 lx	0.5	%	2	95%	Yes	Services also available for sources other than Illuminant A (e.g., LEDs of various colors), with uncertainty evaluated for specific sources.	37090S
						Color temperature	2856 K							
Illuminance responsivity, tungsten source	Illuminance meter	Photometric bench			A/lx or V/lx	Illuminance	1000 lx to 70000 lx	0.5 to 1.5, varies with illuminance	%	2	95%	Yes	Services also available for sources other than Illuminant A, with uncertainty evaluated for specific sources.	37090S
						Color temperature	2800 K to 3000 K							
Illuminance	Tungsten lamp	Photometric bench	0.001	1	lx	Color temperature	2000 K to 3200 K	1.5 to 0.5, varies with measurand	%	2	95%	Yes	Services also available for sources other than tungsten lamps, with uncertainty evaluated for specific sources.	37020S
Illuminance	Tungsten lamp	Photometric bench	1	1000	lx	Color temperature	2000 K to 3200 K	0.5	%	2	95%	Yes	Services also available for sources other than tungsten lamps, with uncertainty evaluated for specific sources.	37020S
Illuminance	Tungsten lamp	Photometric bench	1000	70000	lx	Color temperature	2000 K to 3200 K	0.5 to 1.5, varies with measurand	%	2	95%	Yes	Services also available for sources other than tungsten lamps, with uncertainty evaluated for specific sources.	37020S
Lum														

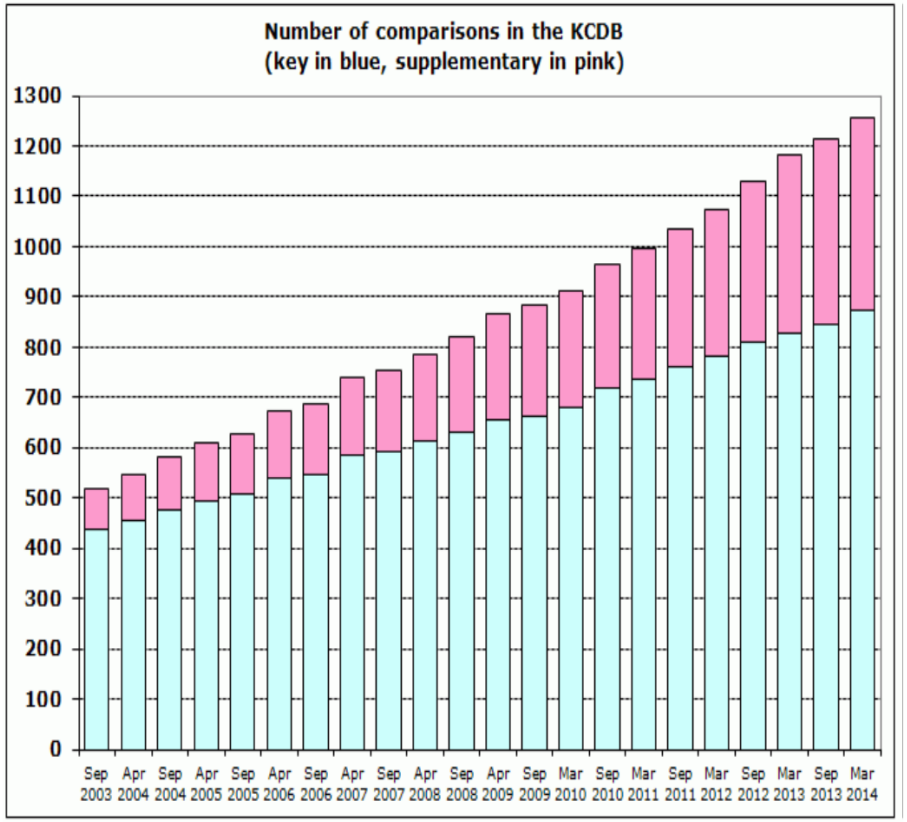
http://kcdb.bipm.org/appendixC/search.asp?reset=1&met=PR

Towards a sustainable CIPM MRA

Maintenance Cost: Threat to the MRA!

NIST maintains over 2000 CMCs





The given procedures were established for a much smaller number of CMCs and comparisons.

What kind of procedures do we need?

MRA Phase II

- We can look back on **15 years of mutual trust building** within the MRA formalism
- Transition from a system of 100% checking that is building upon the trust generated in Phase I of the MRA.

Proposed solution

- New CMC entries will only be discussed and quality-checked **within** the Regional Metrology Organization (RMO) of origin
- Once an RMO has approved a new CMC it is entered into the database without additional quality control steps
- Strong “appeals mechanism”
- Reduce the number of key comparisons (KC) and **participants**
- ….

Action Item: for RMO TC Chairs during the RMO General Assemblies (SIM GA NOV 2014) and for the 2015 NMIs Directors Meeting

CCPR WG-KC

- Chair: Yoshi Ohno, NIST
- Manages all CCPR Key Comparisons, and also provide advices to RMO Key and Supplementary Comparisons
- Reviews and approves the technical protocols and Draft B (final) reports of all CCPR and RMO Key Comparisons
- Investigates specific technical issues related to comparisons
  - A new Task Group is formed in 2014 to investigate white LED sources as transfer standards for photometry comparisons
- http://kcdb.bipm.org/

CCPR Key Comparisons: 2nd round

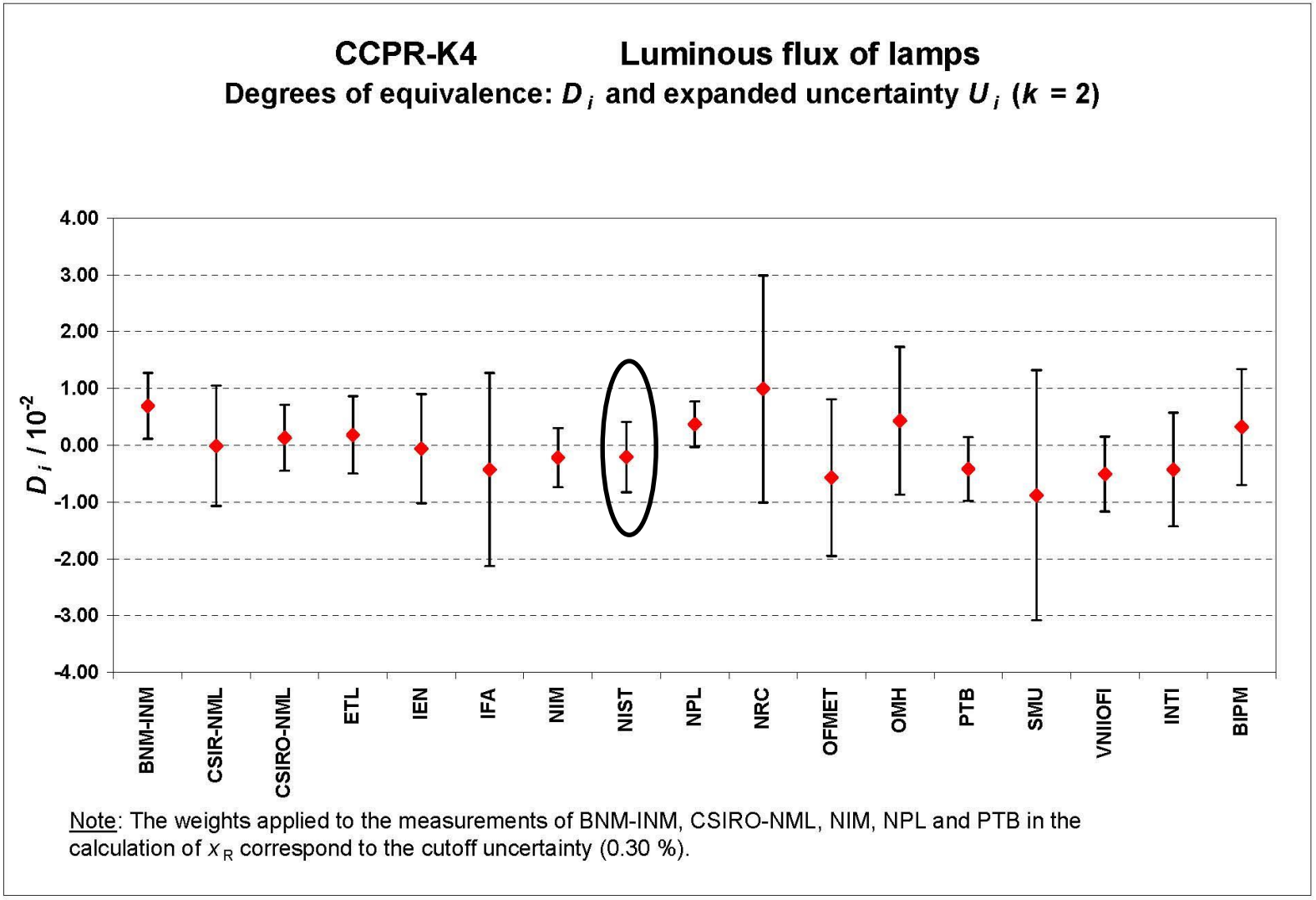
6 quantities, 10 comparisons

Meas. Start	Id	Quantity	Pilot	Status
2013	K6-2010	Regular spectral transmittance	MSL	Registered. Filters being stabilized.
2014	K3	Luminous intensity	NRC	Measurement started
2015	K4	Luminous flux	NMIJ	Protocol being developed
2015	K2.b	Spectral responsivity 300 nm to 1000 nm	KRISS	Protocol being developed
2015	K2.a	Spectral responsivity 900 nm to 1600 nm	NPL	Protocol being developed
2016	K1.a	Spectral irradiance 250 nm to 2500 nm	VNIIOFI	
2016	K5	Diffuse spectral reflectance	MIKES	
2017	K1.b	Spectral irradiance 200 nm to 350 nm	NIST	
2018	K2.c	Spectral responsivity 200 nm to 400 nm	PTB	
2019	K2.d	Spectral responsivity 10 nm to 200 nm	PTB	

NIST Participation in PR Comparisons

- Participation in CCPR K3:2014
- Participation in CCPR K6:2010
- Participation in CCPR K4:2014
- Pilot of SIM PR.S3.1, Pre Draft A
- Pilot and Link of SIM K6:2014
- Pilot and Link of SIM K3:2015
- Planned participation in 2nd round of CCPR K1.a Spectral irradiance
- Planned participation in 2nd round of CCPR K2.a Spectral responsivity
- Planned participation in 2nd round of CCPR K2.b Spectral responsivity

Example of Photometry Key Comparison



Note: The weights applied to the measurements of BNM-INM, CSIRO-NML, NIM, NPL and PTB in the calculation of x_R correspond to the cutoff uncertainty (0.30 %).

The key comparison reference value, x_R, is calculated as the weighted average of the individual results x_i, weighted by the in
square of the individual standard uncertainties, u_i, with the application of a minimum uncertainty cutoff of 0.30 %.
The INTI and the BIPM are excluded from the calculation of x_R.
The standard uncertainty of x_R is u_R = 0.1 %. It is negligible compared to the u_i values.

The degree of equivalence of each laboratory with respect to the reference value is given by a pair of terms:
$D_i = (x_i - x_R) / x_R$ and U_i, its expanded uncertainty (k = 2), both expressed in relative units. $U_i = 2u_i$.

The degree of equivalence between two laboratories is given by a pair of terms:
$D_{ij} = (x_i - x_j) / x_R$ and U_{ij}, its expanded uncertainty (k = 2), both expressed in relative units. $U_{ij}^2 = 2^2(u_i^2 + u_j^2)$.

Lab j ⟹

Lab i ⇩

	D_i / 10^{-2}	U_i / 10^{-2}	NPL		NRC		OFMET		OMH		PTB		SMU	
			D_{ij} / 10^{-2}	U_{ij} / 10^{-2}	D_{ij} / 10^{-2}	U_{ij} / 10^{-2}	D_{ij} / 10^{-2}	U_{ij} / 10^{-2}	D_{ij} / 10^{-2}	U_{ij} / 10^{-2}	D_{ij} / 10^{-2}	U_{ij} / 10^{-2}	D_{ij} / 10^{-2}	U_{ij} / 10^{-2}
BNM-INM	0.69	0.58	0.32	0.70	-0.30	2.08	1.26	1.50	0.26	1.42	1.11	0.81	1.57	2.28
CSIR-NML	-0.01	1.06	-0.38	1.13	-1.00	2.26	0.56	1.74	-0.44	1.68	0.41	1.20	0.87	2.44
CSIRO-NML	0.13	0.58	-0.24	0.70	-0.86	2.08	0.70	1.50	-0.30	1.42	0.55	0.81	1.01	2.28
ETL	0.18	0.68	-0.19	0.79	-0.81	2.11	0.75	1.54	-0.25	1.47	0.60	0.88	1.06	2.30
IEN	-0.06	0.96	-0.43	1.04	-1.05	2.22	0.51	1.68	-0.49	1.62	0.36	1.11	0.82	2.40
IFA	-0.43	1.70	-0.80	1.75	-1.42	2.62	0.14	2.19	-0.86	2.14	-0.01	1.79	0.45	2.78
NIM	-0.22	0.52	-0.59	0.66	-1.21	2.07	0.35	1.47	-0.65	1.40	0.20	0.76	0.66	2.26
NIST	-0.21	0.62	-0.58	0.74	-1.20	2.09	0.36	1.51	-0.64	1.44	0.21	0.84	0.67	2.29
NPL	0.37	0.40			-0.62	2.04	0.94	1.44	-0.06	1.36	0.79	0.69	1.25	2.24
NRC	0.99	2.00	0.62	2.04			1.56	2.43	0.56	2.39	1.41	2.08	1.87	2.97
OFMET	-0.57	1.38	-0.94	1.44	-1.56	2.43			-1.00	1.90	-0.15	1.49	0.31	2.60
OMH	0.43	1.30	0.06	1.36	-0.56	2.39	1.00	1.90			0.85	1.42	1.31	2.56
PTB	-0.42	0.56	-0.79	0.69	-1.41	2.08	0.15	1.49	-0.85	1.42			0.46	2.27
SMU	-0.88	2.20	-1.25	2.24	-1.87	2.97	-0.31	2.60	-1.31	2.56	-0.46	2.27		
VNIIOFI	-0.51	0.66	-0.88	0.77	-1.50	2.11	0.06	1.53	-0.94	1.46	-0.09	0.87	0.37	2.30
INTI	-0.43	1.00	-0.80	1.08	-1.42	2.24	0.14	1.70	-0.86	1.64	-0.01	1.15	0.45	2.42
BIPM	0.32	1.02	-0.05	1.10	-0.67	2.25	0.89	1.72	-0.11	1.65	0.74	1.16	1.20	2.42

Cutoff uncertainty (0.30 %) applied to the laboratory measurement in the calculation of x_R

Summary

- ISO/IEC 17025 accredited
  - Accreditation Bodies
  - ILAC
  - Traceable to SI units - Candela
- CIPM
  - CIPM MRA
    - RMOs
  - CCPR
  - Key Comparisons
  - CMCs