Electrical metrology at the BIPM

Objectives

The electricity laboratories of the BIPM provide the following services to the NMIs of Member States:

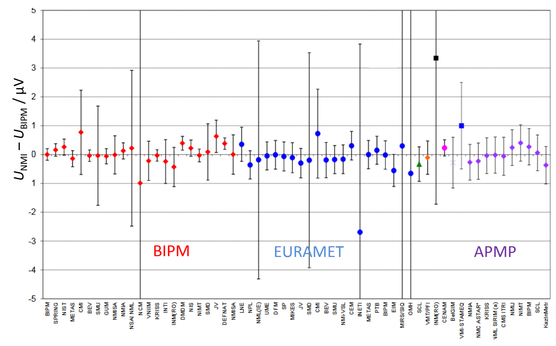
- Organization of comparisons of primary standards to support the CIPM MRA
- Calibrations of secondary standards to support NMIs without quantum standards

In addition, the electricity laboratories are involved in development activities related to the realization of units and the determination of fundamental constants.

Organization of comparisons to support the CIPM MRA

In the field of electricity, the BIPM carries out five ongoing key comparisons on a continuous basis. They allow NMIs to demonstrate their capabilities and to evaluate their equivalence:

- dc voltage: - Josephson quantum voltage standards, on-site
  - Zener voltage standards, 1.018 V and 10 V
- resistance: - quantum Hall resistance standards, on-site
  - resistance transfer standards, 1 Ω and 10 kΩ
- capacitance: - capacitance transfer standards, 10 pF and 100 pF



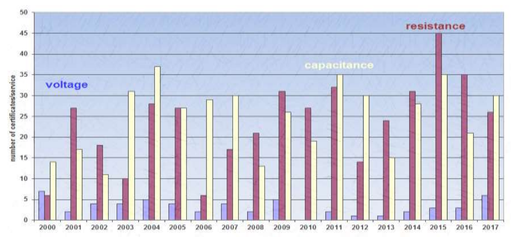
BIPM.EM-K11.b: Comparison of calibrations of Zener voltage standards at 10 V

Occasionally the BIPM organizes CCEM comparisons (CCEM-K4, capacitance) and participates in RMO comparisons (GULFMET.EM.BIPM-K11 , APMP.EM.BIPM-K11.3, voltage)

Calibrations, supporting NMIs without quantum standards

The electricity laboratories provide the following calibration services to Member States:

- voltage: 1.018 V and 10 V
- resistance: 1 Ω, 100 Ω and 10 kΩ
- capacitance: 1 pF, 10 pF and 100 pF



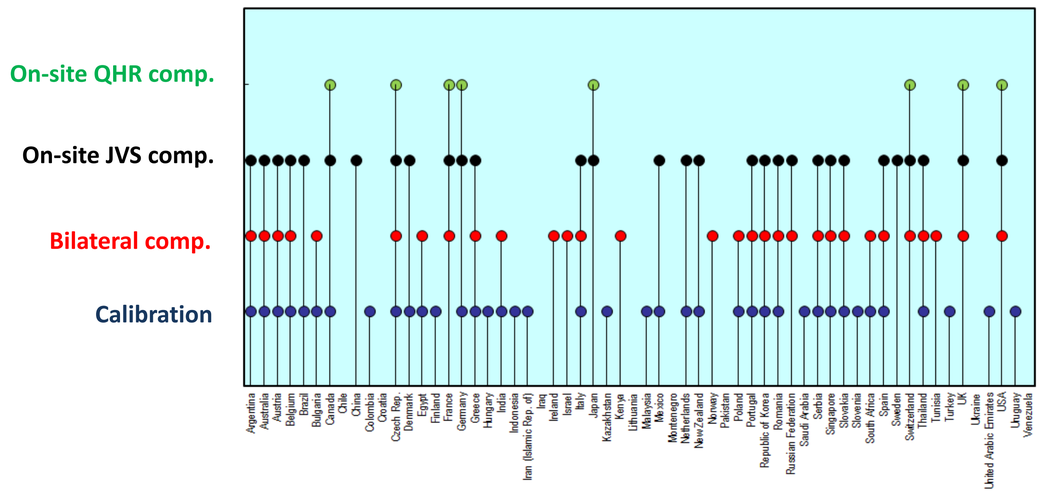
On average, the department provides about 60 calibration certificates per year.

Zener voltage standard

Standard resistor

Standard capacitor

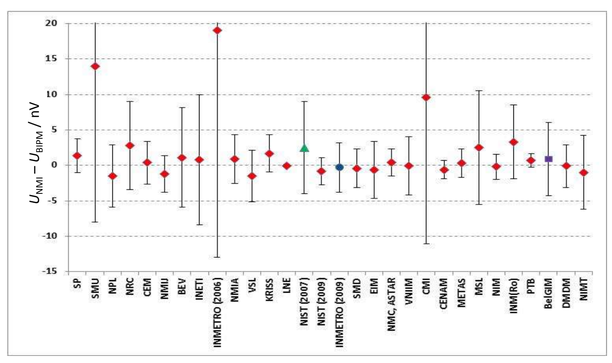
Users of the BIPM technical services in Electricity



85 % of the Member States have been served

On-site Josephson voltage standard comparisons (BIPM.EM-K10)

To verify international coherence of primary dc (direct current) voltage standards by comparing Josephson-effect-based standards of the NMIs with that of the BIPM.



BIPM.EM-K10.b: comparison of Josephson voltage standards at 10 V

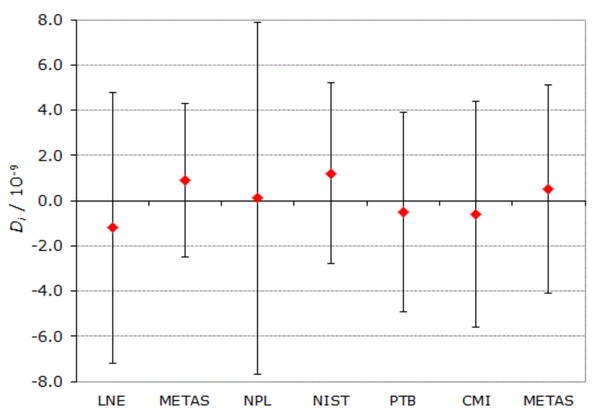
A future comparison of ac (alternating current) Josephson voltage standards is being prepared with active support from

- **NIST** (USA): programmable Josephson voltage standard
- **KRISS** (Rep. of Korea): guest scientist for 12 months
- **CENAM** (Mexico), **PTB** (Germany), **NPL** (UK): trial comparisons

On-site quantum Hall resistance standard comparisons (BIPM.EM-K12)

To verify international coherence of primary resistance standards by comparing quantum-Hall-effect-based standards of the NMIs with that of the BIPM.

Comparison of calibrations of a 100 Ohm resistor against the quantum Hall standard



D_i ≡ Relative difference between the result of measurement of laboratory *i* and that of the BIPM

Calculable cross capacitor: Primary capacitance standard, to verify the theoretical basis of the "quantum ohm"

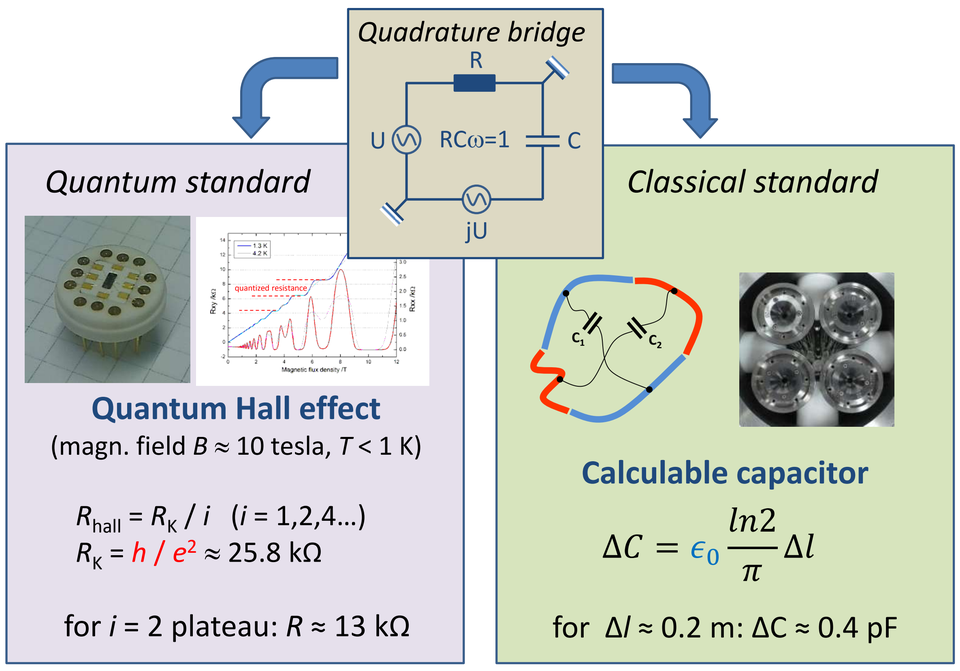
- Test of the relationship

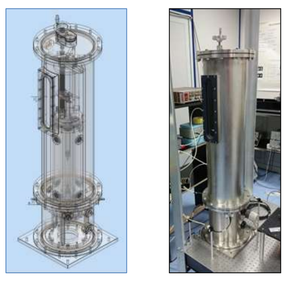
$$R_K = h / e^2$$

basis for the realization of the ohm in the revised SI:

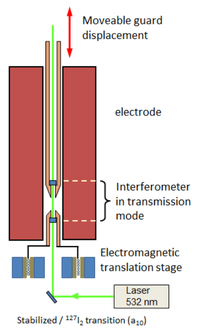
comparison of the SI "quantum" ohm with the ohm realized from the farad

- Primary capacitance standard





BIPM calculable capacitor



Validation of the relationship $R_K = \frac{h}{e^2}$

Determination of the fine structure constant α independent from QED calculations

$\alpha = \frac{1}{2\,c\,\epsilon_0}\left(\frac{e^2}{h}\right)$ ⟹ Comparison with α values from electron magnetic moment anomaly (QED) and photon recoil spectroscopy