

Bureau International des Poids et Mesures

Consultative Committee for Electricity and Magnetism  
Report to CGPM meeting 2011

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# ***Consultative Committee for Electricity and Magnetism***

## **Status**

**Meetings:** 12-13 March 2009; 17-18 March 2011

### **Working Groups:**

- ac Quantum Hall Resistance (WGacQHR) - closed
- Strategic Planning (WGSP) - closed
- Quantities at Low Frequency (WGLF) - active
- Quantities at Radio Frequencies (GT-RF) - active
- Monitoring progress on experiments for kg redefinition (WGkg) - active
- Redefinition of electrical SI units (WGSI) - active
- Regional Metrology Organisation coordination (WGRMO) - active

## ***Consultative Committee for Electricity and Magnetism***

### **Redefinition of Units**

- The primary task of the WGS1 was to examine and advise the CCEM on the preferred redefinition of units and in particular the electrical units.
- Recommendations of WGS1 were discussed in the CCEM and its resulting position has been incorporated in the final Draft Resolution A, proposed by the CCU.
- A *mise en pratique* for the ampere and other electrical units have been proposed and approved in principle.

# *Consultative Committee for Electricity and Magnetism*

## **Strategic Planning**

### **Brief for WGSP:**

To identify long-term challenges for metrology involving electricity and magnetism - mindful that many of the challenges were likely to be multi-disciplinary and may well involve other CCs.

### **Outcome:**

Production of a report entitled "Big Problems in Electromagnetics"

<http://www.bipm.org/utils/common/pdf/CCEM-WGSP-2011.pdf>.

## ***Consultative Committee for Electricity and Magnetism***

### **Mutual Recognition Arrangement**

- **Monitoring and coordinating key comparisons for the MRA is a core activity of the CCEM and its WGs.**
- **During the past four years some 90 key and supplementary comparisons have been conducted in Electricity and Magnetism.**
- **In collaboration with the KCDB Coordinator the CCEM has sought ways and means of increasing the efficiency of entering and maintaining data in the database.**
- **Some changes in format and procedure for the E&M entries for increased efficiency.**

# ***Consultative Committee for Electricity and Magnetism***

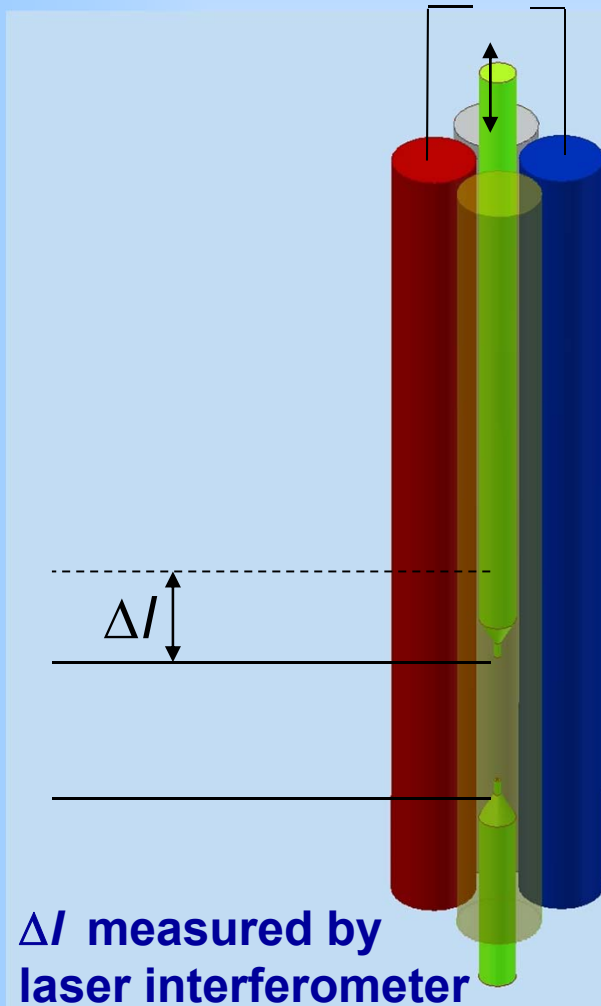
## **Work of the Electricity Department**

An important activity of the CCEM is to oversee and advise on the activities of the Electricity Department.

Main Activities of the Department:

- Development of the Watt Balance (in collaboration with the Mass Dept.)
- Development of a Calculable Capacitor
- On-site comparisons and the development of improved traveling standards
- On-going provision of a limited range of calibrations for Member States

## Calculable capacitor collaboration NMIA-BIPM



2 new systems developed by **NMIA** and **BIPM**, target uncertainty  $1 \times 10^{-8}$

### Purposes

- determination of  $R_K$  in SI-units with reduced uncertainty (fundamental for *m.e.p.* of el. units)
- absolute realization of the **farad** and the **ohm** for BIPM measurement services

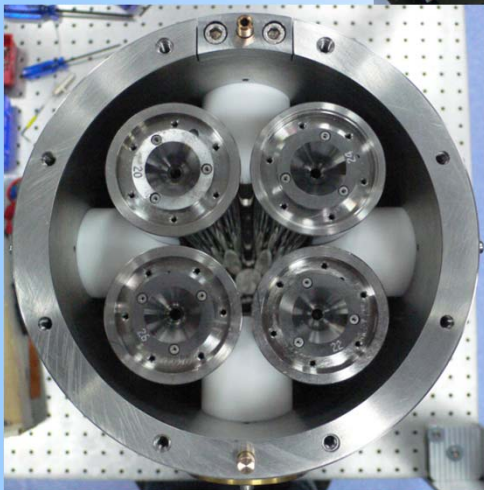
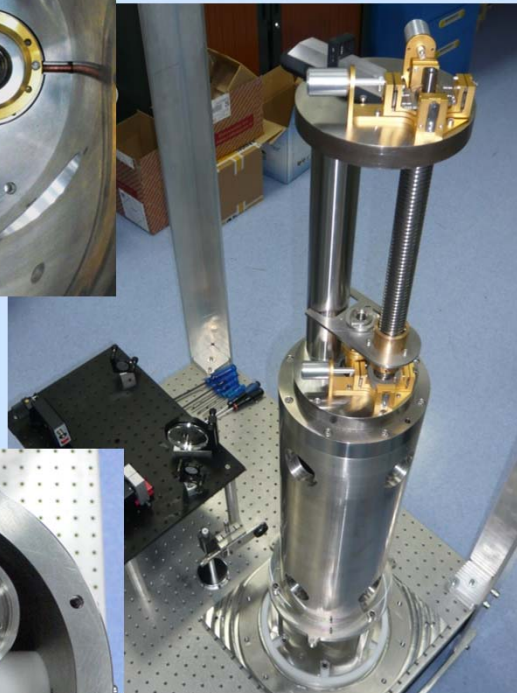
### Principle

Capacitance change is given by

$$\Delta C = \varepsilon_0 (\ln 2 / \pi) \Delta l$$

0.4 pF equivalent to  $\Delta l = 20$  cm

## Calculable capacitor collaboration NMIA-BIPM



- **general design** of the apparatus by NMIA
- **optical interferometry** by NMIA and BIPM
- **fabrication** of most of the parts at BIPM
- fabrication of the **precision electrodes** at NMIA



- at present both instruments being **assembled**
- first **measurements** at BIPM end 2011



# BIPM ongoing key comparisons in electricity

## Key comparisons of the basic electrical standards

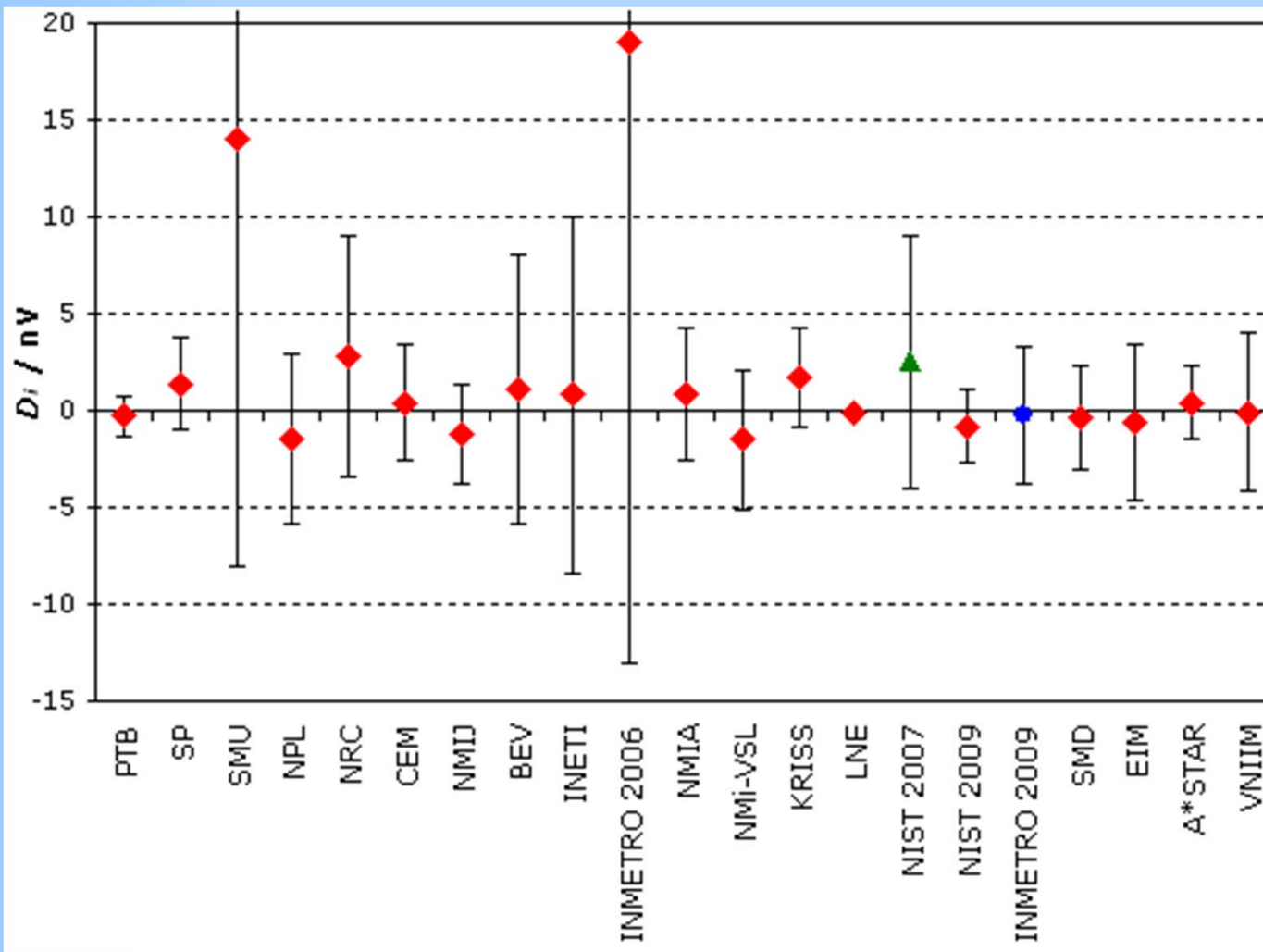
- **Josephson voltage** standards at 1.018 V and 10 V, **on-site** BIPM.EM-K10
- **Zener voltage** standards at 1.018 V and 10 V BIPM.EM-K11
- **QHR resistance** standards, **on-site** BIPM.EM-K12
- 1  $\Omega$  and 10 k $\Omega$  **resistance** standards BIPM.EM-K13
- 10 pF and 100 pF **capacitance** standards BIPM.EM-K14

Transfer standards are provided by BIPM: well known and well characterized.

These comparisons allow NMIs to demonstrate their measurement capabilities.

For NMIs which do not possess primary standards, calibrations are provided for the same quantities.

## Example: BIPM.EM-K10.b, Josephson on-site comp. at 10 V

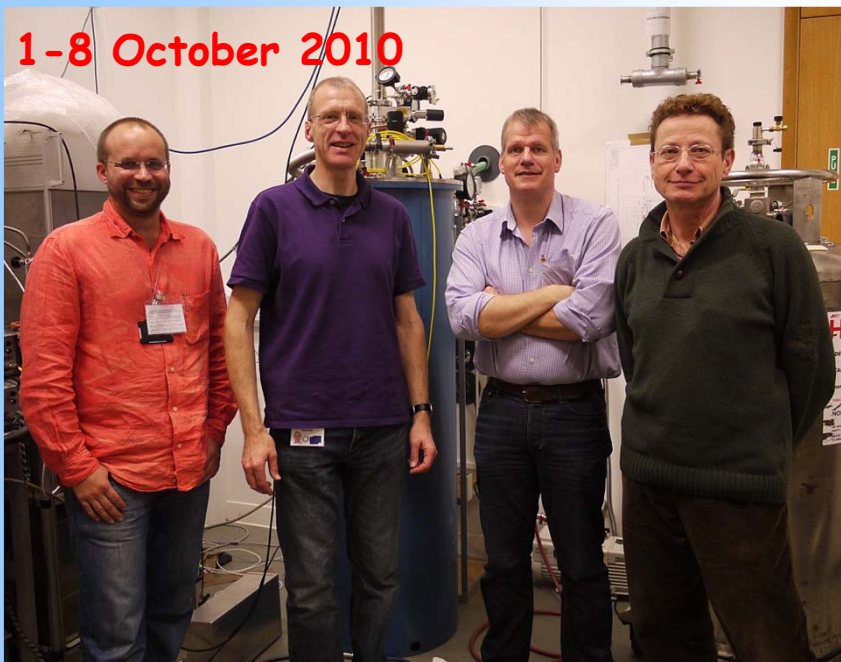
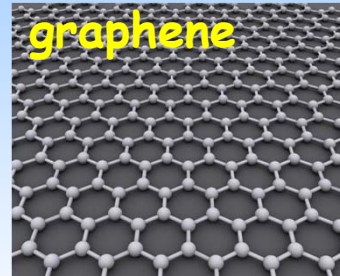


In 2009, 15 NMIs expressed interest to carry out a **Josephson voltage** comparison with the BIPM.

14 NMIs want to participate in an on-site **quantum Hall resistance** comparison with the BIPM (starting 2012).

# NPL / BIPM collaboration: Direct GaAs - Graphene comparison

Using the BIPM transportable QHR cryostat to set up a direct measurement to detect any difference between  $R_K$  in graphene and  $R_K$  in GaAs.



$$R_K \stackrel{?}{=} \frac{h}{e^2}$$

**Final Result:**

$$\begin{aligned} & (R_K[\text{GaAs}] - R_K[\text{graphene}]) / R_K \\ & = (5 \pm 9) \times 10^{-11} \end{aligned}$$

- most accurate measurement of the QHR on graphene so far
- published in *New Journal of Physics*
- cited as “research highlight” in *Nature*