

EURAMET TC-EM Electricity and Magnetism

What's about 2011 ?

François Piquemal

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Lyngby 22 to 23 May 2012

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Outline

- MRA work
 - Comparison & CMC
- Activities of the 4 sub-committees
 - Main highlights in the different fields
- Participation to the EMRP
 - Call 2011 & trends for call 2012
- Preparation for the next phase "EMPIR"
 - 5 roadmaps

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MRA work Comparison - CMC

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MRA work

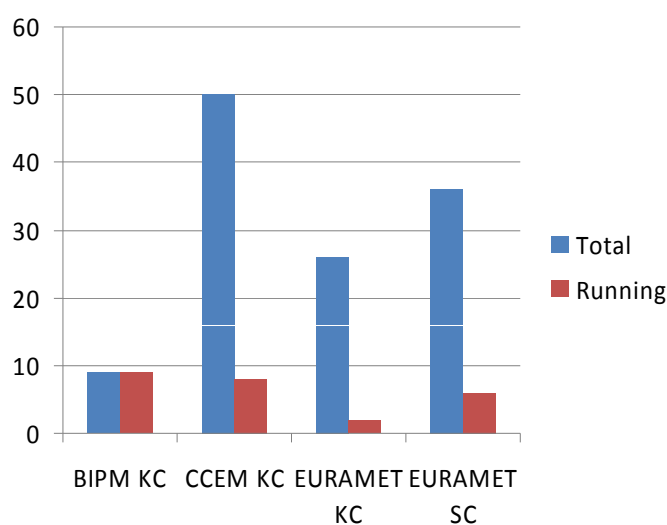


Comparisons (1/3)

Total = 121

Running = 25

**9 comparisons
completed this year !**



These comparisons support

3667 CMC entries in the KCDB (192 service categories)
to be compared with 6874 entries for all the RMOs

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Comparisons (2/3)

How to improve the process for running comparison ?

- shortening the duration (typ. 4 to 5 years but some over 11 years!)
- increasing the number of labs capable to be pilots

Decision

- Role of the support group is extended (sharing of tasks among several NMIs)
- Constitution of a comparison toolbox in progress (*not yet available*)
- a group of experts is composed (with some statisticians)
 - ⇒ data analysis in the hard cases, neutral opinion if disagreement
- Periodic (4 months) reporting of comparison (TC-EM - Pilot)

Comparisons (3/3)

Other action

With CCEM- WGLF:

Organization of the training workshop on the International Comparisons at CPEM'12 - Sunday 1st July 2-4 pm

"design, data analysis and reporting"

Already 22 attendees (incl. speakers) registered

CMCs (1/3)

- **EURAMET.EM.7.2010 published on 1 October 2011 (15 NMIs)**
 - **508** new and modified entries (incl. 95 matrices)
 - **395** entries (23 matrices) : reduced scope, increased uncert., edit.
 - **171** removed entries
- **New set EURAMET.EM.8.2011 in preparation (15 NMIs)**
 - **320** new and modified entries (incl. 90 matrices)
 - **60** entries (10 matrices) : reduced scope, increased uncert., edit.
 - **158** removed entries (incl. 5 matrices)

The Intra EURAMET review process is on-going and should be completed by the end of ~~May~~ **June** 2012

CMCs (2/3)

- **2 Inter-regional reviews of CMCs completed by Dec. 2011**
 - *APMP.EM.7.2011* : 403 new and mod. entries (incl. 30 matrices) from 9 NMIs.
 - *SIM.EM.5.2011*: 9 new entries from 1 NMI

For the first time a sharing of the reviews between RMOs has been decided

CMCs (3/3)

- **Next July:** A new attempt to convince the WG-RMO to adopt improvement measures for the handling of the CMC entries, the form of the entries and the inter-RMO review process !

Re-organisation of service categories,
Consequent use of matrices

Use of Support document „EURAMET reflection on CMC process“

If **no success**, TCEM will proceed with cleaning up the tables !

Highlights in the TC-EM fields

General (SI)

DC quantities and quantum metrology :

Low frequency quantities:

Power and energy:

RF and MW quantities:

JT Janssen

J Melcher/L Callegaro

G Rietveld

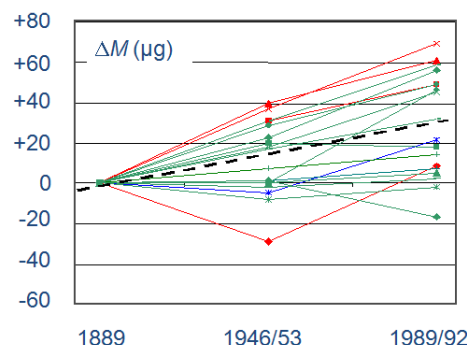
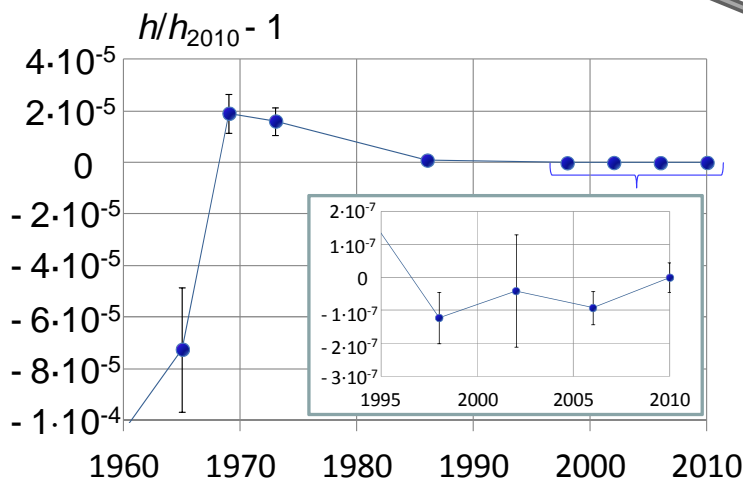
M Zeier

New codata value of h (from IAC2011, METAS 2011, NPL2012)

$$h_{2010} = 6.626\,069\,57\text{ J}\cdot\text{s}, u_r = 4.4 \times 10^{-8}$$

Possible drift of IPK:

3×10^{-8} per century!



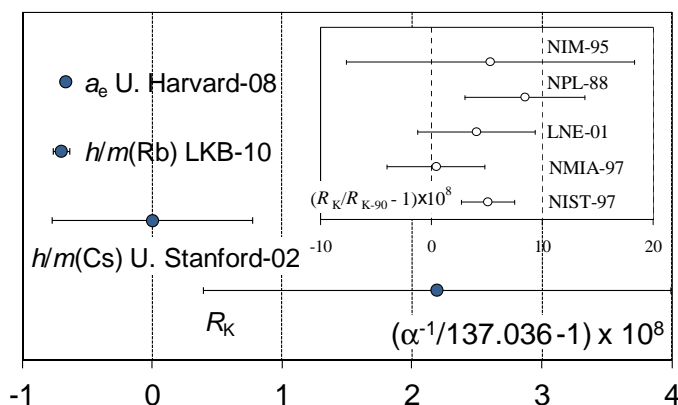
$$K_J = 2e/h(1 + \epsilon_J), \epsilon_J = (5.7 \pm 2.4) \times 10^{-8}$$



New value of α from $h/m(\text{Rb})$ measurements at CNRS-LKB

Agreement with $\alpha(a_e)$ within 6.6 parts in 10^{10}

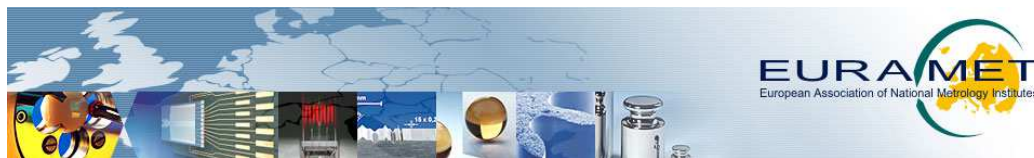
$$R_K = h/e^2(1 + \epsilon_K), \epsilon_K = (2.2 \pm 1.8) \times 10^{-8}$$



On-going development of calculable capacitors
BIPM, NIM, NMIA, NRC and LNE

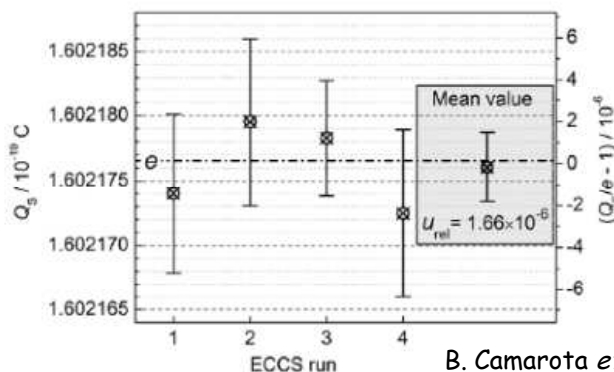


Highlights DC & QM

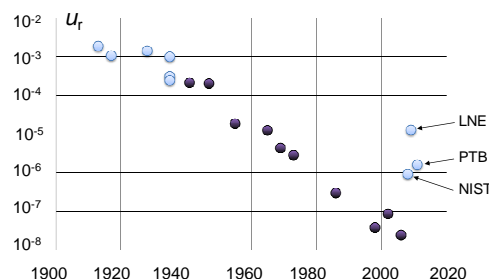


- The quantum metrological triangle has been closed at the uncertainty level of 1.66 parts in 10^6 at PTB by implementing an electron counting capacitance standard.

$$Q_X/e - 1 = (-0.31 \pm 1.66) \times 10^{-6}$$



B. Camarota *et al.* Metrologia 2012



- The JRP "quantum ampere" from EMRP call 2011 has just started on 1st May 2012.

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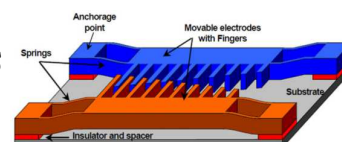


Highlights LF



Significant progress have been made in digital sampling and synthesis techniques for the impedance metrology :

- Digital current comparator ratio bridge at INRIM
L. Callegaro *et al.* CPEM'2012
- Impedance simulator for LCR bridge calibrations at METAS.
F. Overney *et al.* CPEM'2012
- MEMS electrostatic devices as ac voltage standards have been developed at LNE.
A. Bounouh *et al.* Metrologia 2011
- Measurement of phase angle of current shunts with sampling methods has been carried out at INRIM.
U. Pogliano *et al.*, Metrologia 2012



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Highlights P & E



Sub committee: "only" 4 years young !



Activities in 2011 - 2012

- High voltage experts meeting with worldwide attendance (Aug 2011)
- 4th SC meeting held on 7 March 2012 at METAS, Bern
- Roadmapping for EMPIR "Energy":
 - Brainstorm with stakeholders from industry at SmartGrid JRP meeting (60 persons)
 - Triggers and targets with complete SC (30 persons)
 - Details on targets with special task group (10 persons)



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Highlights P & E



Cooperation projects

- "Sampling power cookbook" (SIQ)
- "Wideband power" & "power quality" both starting

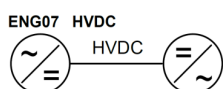


Comparisons

- 3 finished, 1 running, 3 in preparation
- Primary power: *Euramet needs new comparison due to strong developments in the area; however CCEM comparison must be started first*

EMRP projects

- SmartGrid metrology, HVDC, Energy harvesting, SSL, Power plants
- Brainstorm for 2013 projects \Rightarrow collection of ideas running



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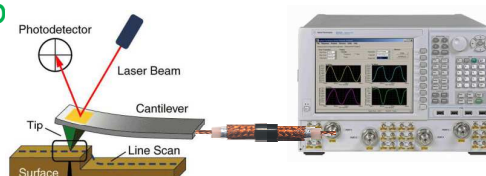
Highlights RF & MW



EMINDA (IND02)

Electromagnetic Characterization of Materials for Industrial Applications up to Microwave Frequencies

Started June 1, 2011



WP1: AFM based scanning microwave microscope (SMM)

WP2: Resonator based SMM

WP3: Substrates and laminar materials

WP4: Advanced and functional materials

WP5: Macroscale measurements on bulk materials



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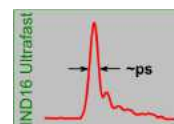
Highlights RF & MW



Ultrafast (IND16)

Metrology for ultrafast electronics and high-speed communications

Started July 1, 2011



WP1: traceability for high frequency measurement instrumentation

WP2: uncertainty propagation between time and frequency domains

WP3: characterisation of antenna and channel properties

WP4: characterisation of vector signal generators and analyzers



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From EURAMET TC-EM: **one third of contributions !**

47 talks

59 posters

106/319 summaries in EM (374 in total)

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Participation to the EMRP

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Participation to the EMRP - Call 2011

Four of nine proposals selected for funding

TP	Rank	SRT n°	Title
SI Broader Scope	3	S06	Realization of the awaited definition of the kilogram - resolving the discrepancies
	7	S02	Quantum ampere: Realization of the new SI ampere
	11	S03	Automated impedance metrology extending the quantum toolbox for electricity
	12	S01	A quantum standard for sampled electrical measurements
New Technologies	7	N15	Microwave and terahertz metrology for homeland security
	8	N07	Metrology with/for NEMS
	12	N08	Metrology for spintronic circuits and devices
	13	N04	Graphene metrology
Health	14	H16	Diagnostic and therapy using magnetic nanoparticles

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Preparation for the EMRP Call 2012

- **EMRP workshop**, 17-18 January 2012, attended by 35 delegates from 13 NMIs
- 12 potential topics were defined and drafted
 - 4 in "metrology for Industry - II",
 - 5 in "SI broader scope - II"
 - 3 in "Open excellence call"

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Preparation for the next phase "EMPIR"

5 proposed roadmaps !

Pillar	Topic	Responsible SC
Great Challenges	Power and Energy in an era of emerging smart grids	P&E
Innovation + Capacity Building	Innovative calibration means in electricity/magnetism	DCQM and LF
Innovation	Metrology for future applications of complex RF to THz systems	RF&MW
Science	Foundations of the SI, fundamental tests and quantum measurements	DCQM
	Nanoelectronics and nanomagnetism	DCQM

"interdisciplinary" topics pointed out in these roadmaps!
 nanometrology, THz metrology and material properties.

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Present status on the roadmap process

- All the 5 roadmaps have been drawn up for the period 2012-2024.
- They all are completed.
- Explanatory notes have been drafted for three of them.

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Thanks a lot for your attention!

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Power and Energy in an era of emerging smart grids

- **3 triggers**
 - Make our energy supply and use sustainable - economically, environmentally and socially;
 - Ensure continuity and quality of electricity supply in an era where electrical grids, the backbone of our society, are evolving into Smart Grids;
 - Scarcity of resources demand energy saving and efficient supply, transport, and utilisation.
- **4 targets**
 - Network Power Quality tools;
 - In-situ and complex power measurement;
 - Energy saving and efficiency;
 - Improved tools for grid monitoring and control.

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Innovative calibration means in electricity/magnetism

- **1 trigger**
 - Need for improved production and support to emerging technologies through intrinsically referenced, "best practice" electrical measurements.
- **3 targets**
 - Improved and extended scales of electrical units;
 - Simplified "fit-for-purpose" calibration tools and procedures;
 - Quantum calibration systems for industrial use.

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Metrology for future applications of complex RF to THz systems

- **4 triggers**
 - New and improved technologies for health care, security, traffic management, environmental monitoring, advanced industrial production and quality testing;
 - Demand for unlimited information at any time and at any place;
 - Improving the quality of life;
 - Enhancing the competitiveness of the European industry.
- **3 targets**
 - Improved and extended scales of units for RF quantities;
 - Multi-parameter characterisation of RF systems;
 - Metrology for large-scale fully-automated complex RF systems.

Foundations of the SI, fundamental tests and quantum measurements

- **2 triggers**
 - Development of future quantum technologies and exploitation of fundamental science requires new (quantum based) metrology;
 - New science will create new opportunities for metrology.
- **Four targets**
 - Practical realization of the new definition of the SI units according to the CIPM recommendations;
 - Fundamental consistency tests in electrical quantum metrology and determination of fundamental constants;
 - Metrology for solid-state quantum engineering;
 - Quantum enhanced electrical SI standards.



Nanoelectronics and nanomagnetics

• 1 trigger

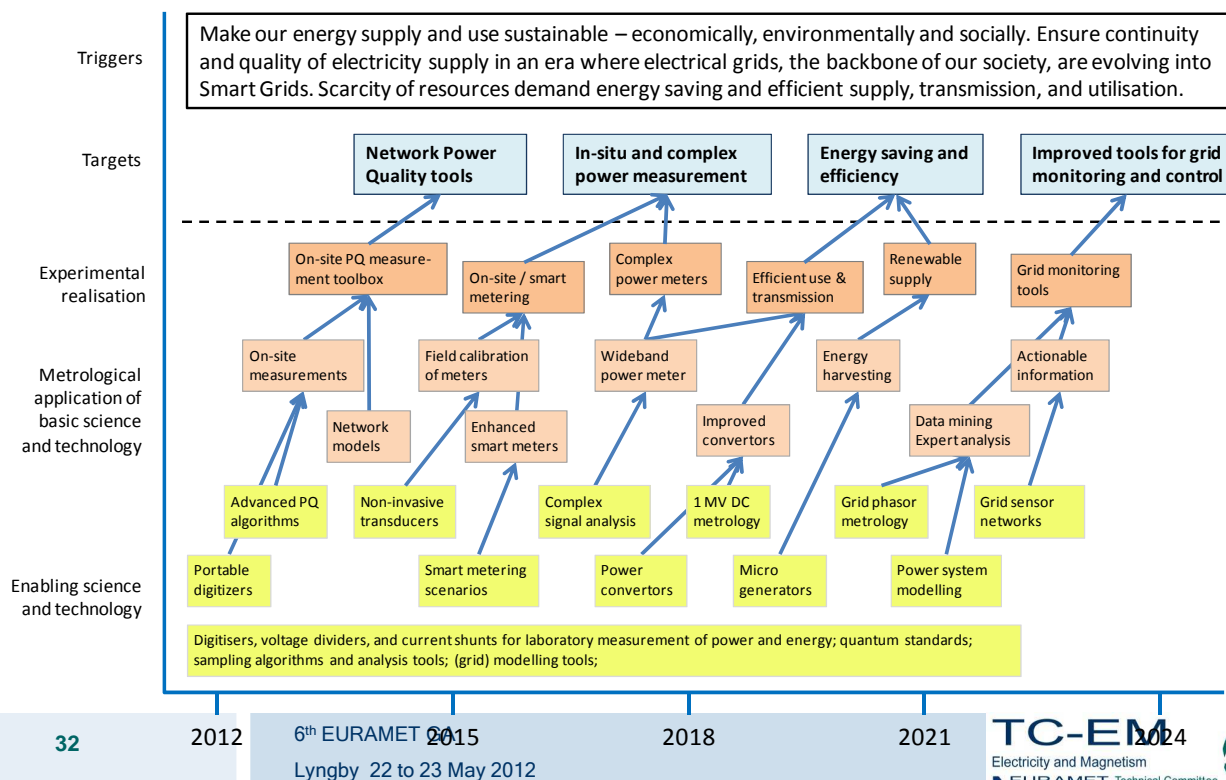
- Metrology at the nanoscale is required by industry and society to enable down scaling of electronics for advanced ICT and nano bio applications for health and environment.

• Four targets

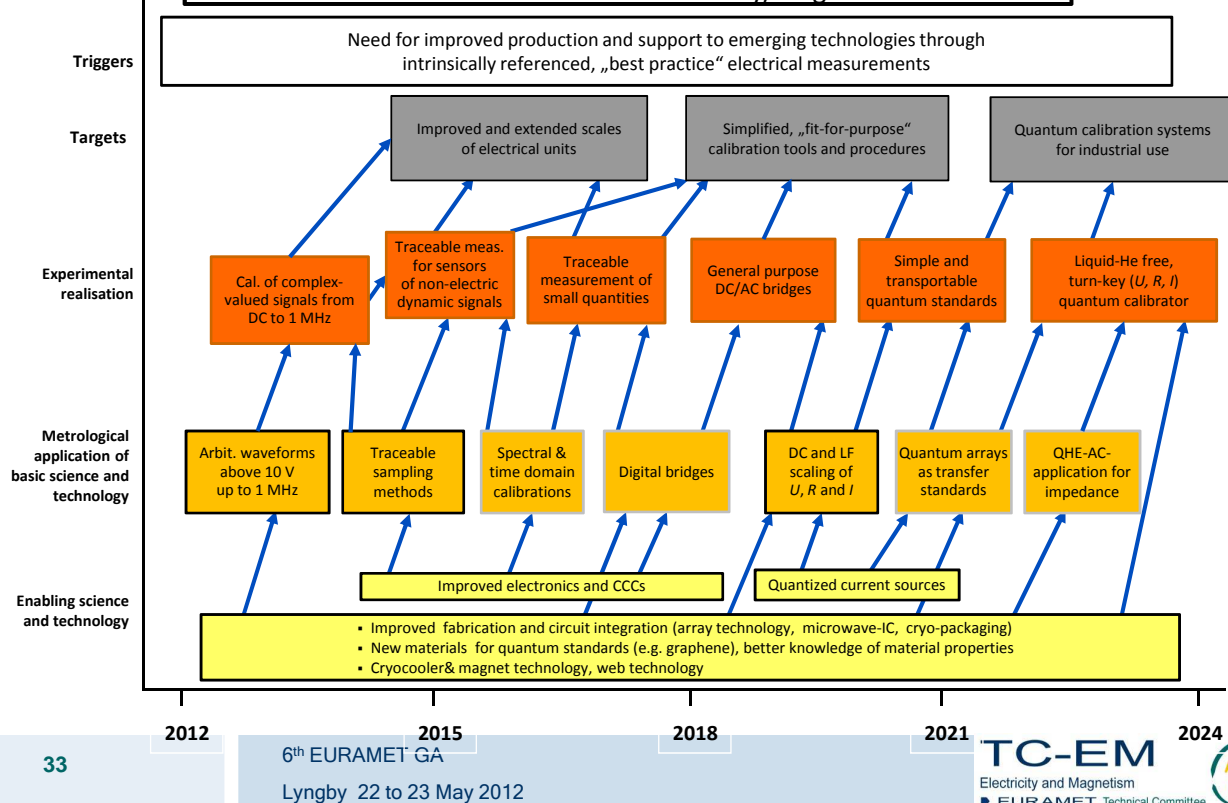
- Characterization tools for today's electronics and sensors;
- Characterization tools for beyond CMOS technology;
- Characterization tools on single molecule / single atom level..



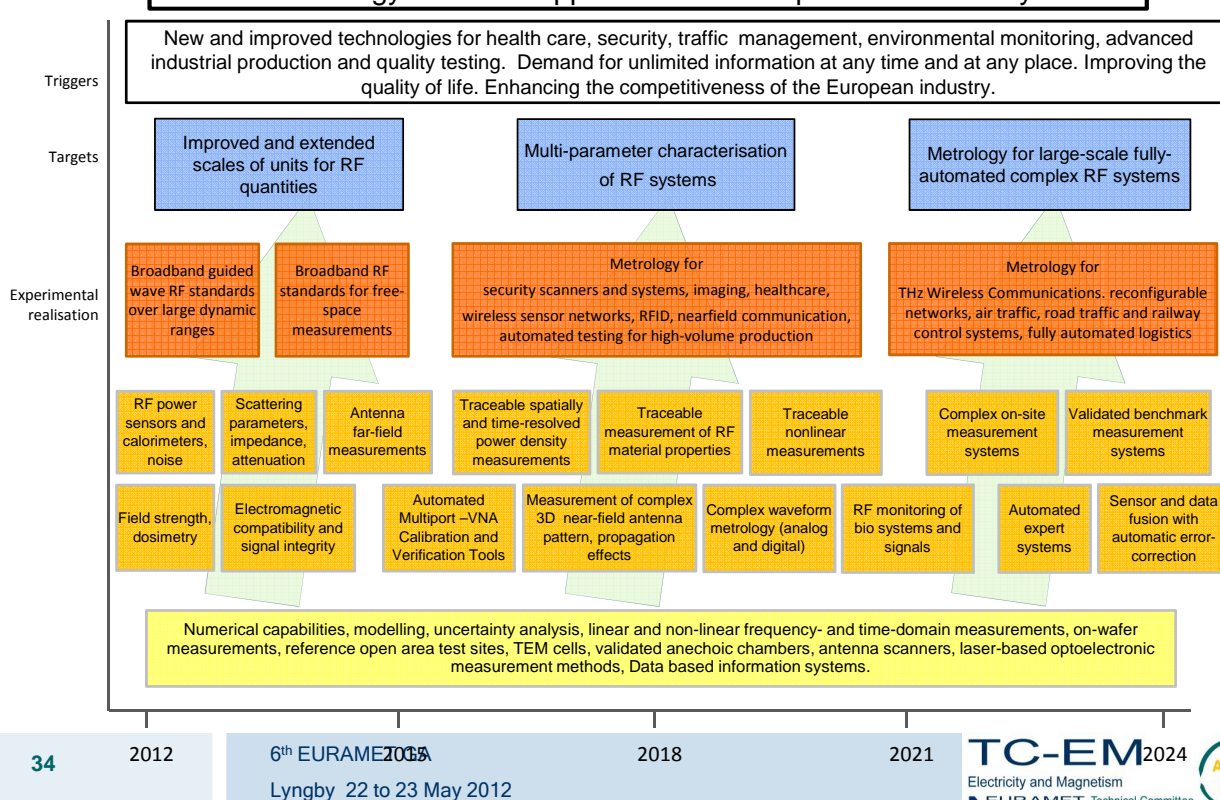
TC-EM: Power and Energy in an era of emerging Smart Grids

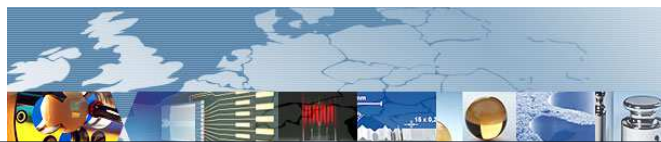


TC-EM: Innovative calibration means in electricity/magnetism

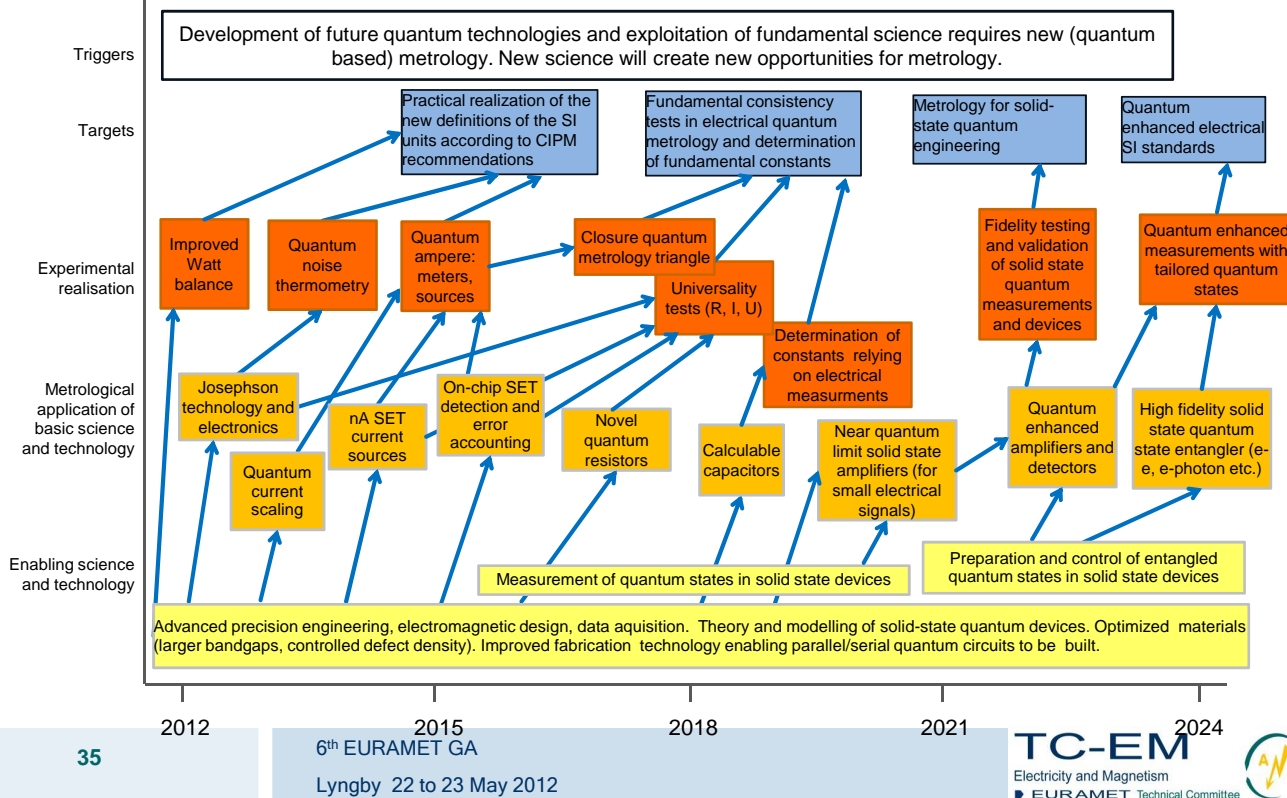


TC-EM: Metrology for future applications of Complex RF to THz Systems

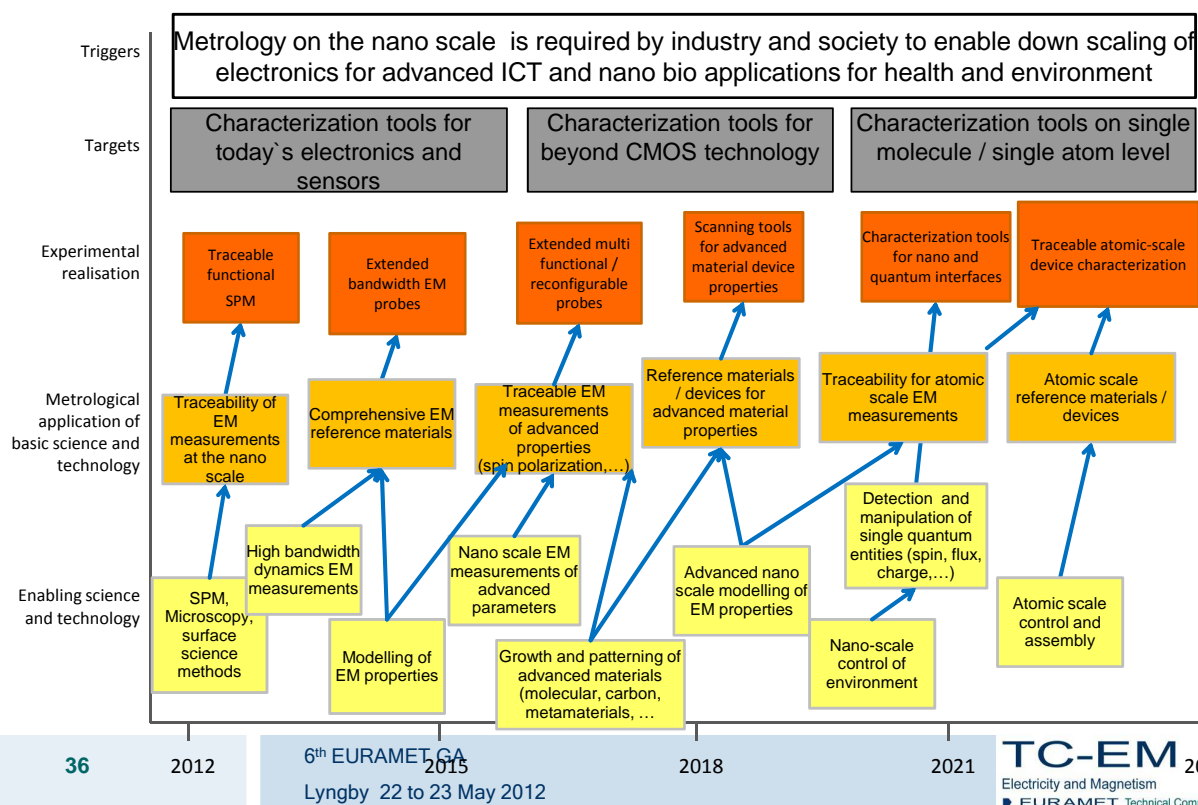




TC-EM: Foundations of the SI, fundamental tests and quantum measurements



TC-EM: Nanoelectronics and nanomagnetism



EURAMET projects

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EURAMET projects



- Slight increase (2%)
- No more consultation project
- Very small number (3) of coop. & research projects
- Small number of traceability projects

It does not reflect the real situation in the EM field !

⇒ The present form needs to be rethought, allowing a NMI to document especially the cases where it establishes traceability through the calibration of its equipment in another NMI

⇒ An improved template will be proposed soon !

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