EURAMET TC-EM SC DC&QM meeting 2021

Wednesday, 2 June (times in UTC)

08:00 – 08:15	Welcome, Confirmation of the agenda	
08:15 – 09:30	EURAMET - Some news from EURAMET TC-EM - EMPIR projects of SC DCQM - EURAMET projects of SC DCQM - Calibration guides etc.	Antti Manninen
09:30 – 10:00	EMN-Q Status Report	Hansjörg Scherer
10:00 – 11:30	***Break***	
11:30 – 11:50	Linking DC voltage scale up to 1000 V to quantum standards	Ilya Budovsky
11:50 – 12:20	Overview on Josephson based applications	Ralf Behr
12.20 – 12:50	Progress on PTB's 4TP impedance bridge within the GIQS project	Stephan Bauer
12:50 – 13:00	***Break***	
13:00 – 13:20	High frequency voltage errors and applications of the Josephson arbitrary waveform synthesizer	Marco Kraus
13:20 – 13:40	EMPIR Parawave project - microwave measurement systems for metrological characterization of Josephson travelling wave parametric amplifiers	Jonathan Williams
13:40 – 14:00	Driving a low critical current Josephson junction array with a mode-locked laser	Jaani Nissilä
14:00 – 14:20	Realizing a Phase Standard Based on Pulse-Driven Josephson Arrays	Stephan Bauer
14:20 – 14:40	Open source quantum traceability for AC power standards	Helge Malmbekk
14:40 –	Possibility for further discussions	All

Thursday, 3 June (times in UTC)

08:00 – 10:00	EURAMET - CCEM and BIPM comparisons - Strategic planning of EURAMET comparisons - EURAMET follow-up of CCEM-K2.2012 - Proposals for other comparisons - Discussion about the next SC DC&QM convener - Next meetings of EURAMET TC-EM SC DCQM - Other topics	Antti Manninen
10:00 – 11:30	***Break***	
11:30 – 11:50	Graphene-based Hall devices for electrical quantum resistance metrology	Mattias Kruskopf
11:50 – 12:20	Investigation of the QHE in low and high-mobility h-BN encapsulated graphene	Wilfrid Poirier
12:20 – 12:40	Improvements of the programmable quantum current generator for better traceability of electrical current measurements	Sophie Djordjevic
12:40 – 13:00	Quantum e-leaps (Toward new era of quantum electrical measurements through phase slips)	Antti Kemppinen
13:00 – 13:20	SEQUOIA - Single-electron quantum optics for metrology	Frank Hohls
13:20 –	Possibility for further discussions	All

DC and Quantum Metrology in EURAMET TC-EM

Antti Manninen

EURAMET Expert Meeting on DC & QM

On-line meeting, 2 – 3 June, 2021

Contents

Wednesday

1. Some news from EURAMET TC-EM
2. EMPIR projects of SC DCQM
3. EURAMET projects of SC DCQM
4. Calibration guidelines etc.

Thursday

5. CCEM and BIPM comparisons
6. Strategic planning of EURAMET comparisons
7. EURAMET follow-up of CCEM-K2.2012
8. Proposals for other comparisons
9. Discussion about the next SC DCQM convenor
10. Next meetings
11. Other topics

Some news from EURAMET TC-EM

EURAMET TC-EM meeting 10/2020

- The meeting was exceptionally held online on 21 – 22 October, 2020
- Markus Zeier (METAS) is available as TC-EM chair for another 2-year term, no other candidates
- KCDB 2.0 taken to use
- EMPIR successor programme: European Partnership on Metrology
  - 2021 call on "Green Deal“, 2022 calls on Integrated European Metrology (earlier SI) and Health, 2023 calls on Fundamental and Industry, etc.
- EMNs vs. TC-EM subcommittees: EMNs are more geared towards stakeholder needs, while SCs cater to NMI needs

Situation with CMCs

- EURAMET.EM.16.2019 (launched on 14 June, 2019)
  - Original submissions were made using the “old” Excel templates
  - Intra-RMO review finished in April 2020
  - Drafts were uploaded to the new KCDB 2.0 in autumn 2020 and submitted for inter-RMO review in December 2020.
  - Most of the new CMCs are accepted by now
- The next deadline for CMC updates: 15 September, 2021
- After that, modified CMCs can be submitted in early spring (March) every year.

EMPIR projects

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

TOPS (2018 – 2021)

- Metrology for topological spin structures
- Partners: **PTB (Mark Bieler)**, INRiM, NPL, Singulus (Germany), TUM (Germany), ULE (UK), UNIPG (Italy)
- Aims:
  - Metrology tools and methods for reliable determination of key material parameters of topologically-protected spin structures (TSS)
  - Measurement techniques capable of unambiguously identifying and manipulating specific nanometre-scale TSS
  - Methods for the investigation and analysis of novel dynamical and quantisation effects in TSS and explore whether TSS might serve as quantum standards
  - Protocols for the reproducible growth of materials for experiments on TSS
  - Reliable micromagnetic simulations and analytical tools for the modelling of TSS

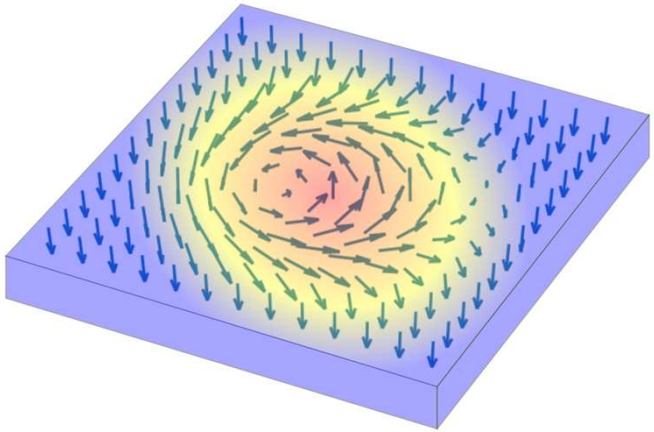
17FUN08 TOPS: Motivation

Metrology for topological spin structures (TOPS):

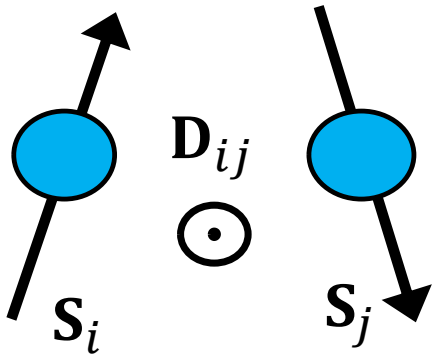
Novel spin-based electronics with materials hosting topologically-protected spin structures (TSS).

- Small size, low threshold for current-induced motion.
  → Smaller, faster, and more-energy efficient data storage devices.
- Characteristic breathing modes.
  → Highly tunable microwave generators & devices.
- Predicted quantized resistance.
  → New quantum standards.

Skyrmion



Anisotropic exchange (Dzyaloshinskii-Moriya interaction, DMI)



$$H_{DMI} = \sum_{i,j} \mathbf{D}_{ij} \cdot [\mathbf{S}_i \times \mathbf{S}_j]$$

Current Status

For an overview of previous results, see

- Webpage https://www.ptb.de/empir2018/tops/
- EURAMET News Story from Jan 2021

NEWS

Spintronics EMPIR project publishes papers in prestigious journals

Characterising materials to increase the understanding of spintronics for the next generation of electronics

Project Coordinator Mark Bieler from PTB said

> *'This project is nicely highlighting the importance of metrology in basic science. On example is measurement of the Dzyaloshinskii-Moriya-Interaction (DMI) constant, which is responsible for the formation of TSS. Together with collaborators the project partners are currently performing a comparison of DMI measurements with the aim to publish guidelines on how to accurately measure the DMI'.*

SEQUOIA (2018 – 2021)

- Single-electron quantum optics for quantum-enhanced measurements
- Partners: **PTB (Frank Hohls)**, NPL, LNE, CEA (France), CNRS (France), LatU (Latvia)
- Aims:
  - Semiconductor components for on-demand single-electron quantum optics based sensing and state tomography
  - Metrological tools for the verification of single-electron sources
  - Experimental technique for on-demand single-electron wave packet interferometry
  - Concepts and theoretical tools for a full quantum state tomography
- More info: see https://www.ptb.de/empir2018/sequoia/home/
- Presentation by Frank Hohls on Thursday

ParaWave (2018 – 2021)

- Josephson travelling wave parametric amplifier and its application for metrology
- Partners: **PTB (Ralf Dolata)**, INRiM, NPL, LanU (UK), RHUL (UK)
- Aims:
  - Develop a broadband Josephson traveling wave parametric amplifier (JTWPA) utilizing three-wave mixing
  - Demonstrate thermal noise-squeezing and quantum-limited performance
  - Combine the JTWPA-based preamplifier with nanoSQUID sensors and rf-SET charge detectors
- More info: see https://sites.google.com/inrim.it/parawave/home
- Presentation by Jonathan Williams later today

GIQS (2019 – 2022)

- Graphene impedance quantum standard
- Partners: **PTB (Klaus Pierz)**, CMI, INRiM, LNE, METAS, VTT MIKES, PTB, RISE, CNRS (France), KRISS (South Korea), NIMT (Thailand), Politecnico di Torino (Italy)
- Aims:
  - Graphene material and graphene devices for AC-QHE at temperatures of 4 K or higher in magnetic fields that are as low as possible - at most 6 T
  - Digital bridges for capacitance range 10 pF - 10 nF at frequencies up to 100 kHz, Josephson impedance bridge up to 50 kHz in the entire complex plane
  - Combine graphene devices with a Josephson impedance bridge (< 0.01 μΩ/Ω), and with a full digital bridge for simplified operation (0.1 μΩ/Ω)
  - Develop and investigate a cryo-cooler system hosting the superconducting Josephson device and the graphene device, both operating at AC
- More info: see https://www.ptb.de/empir2019/giqs/home/
- Presentation by Stephan Bauer later today

QuantumPower (2020 – 2023)

- Quantum traceability for AC power standards
- Partners: **JV (Helge Malmbekk)**, CEM, CMI, INRiM, JV, PTB, VTT MIKES, INTI (Argentina), Universidad de Málaga (Spain)
- Aims:
  - To design and realise a practical quantum sampling electrical power standard based on programmable Josephson voltage standards, traceable digitizers and transducers. The quantum sampling standard should be able to measure electrical power, power quality (PQ) parameters and phasor. The target uncertainties are better than 20 μW/VA for power measurements and less than 2 μW/VA for the contribution of the digitizers.
  - To develop software for the operation of the quantum sampling electrical power standard. The software should enable measurement control, data processing and uncertainty estimation. Additionally, it should be open source and easily modifiable to control different AC quantum systems.
  - To develop new methods and algorithms for the measurement of electrical power using quantum systems, validate those methods using a transfer standard and develop a protocol for future comparison of QPSs.
- More info: see http://quantumpower.cmi.cz/
- Presentation by Helge Malmbekk later today

EMPIR Call 2020

- Funded:
  - COMET (Two dimensional lattices of covalent- and metal-organic frameworks for the Quantum Hall resistance standard)
  - MEMQuD (Memristive devices as quantum standard for nanometrology)
  - SuperQuant (Microwave metrology for superconducting quantum circuits)
  - Elena (Electrical nanoscale metrology in industry)
- Is any project with DCQM contribution missing from the list?

European Partnership on Metrology

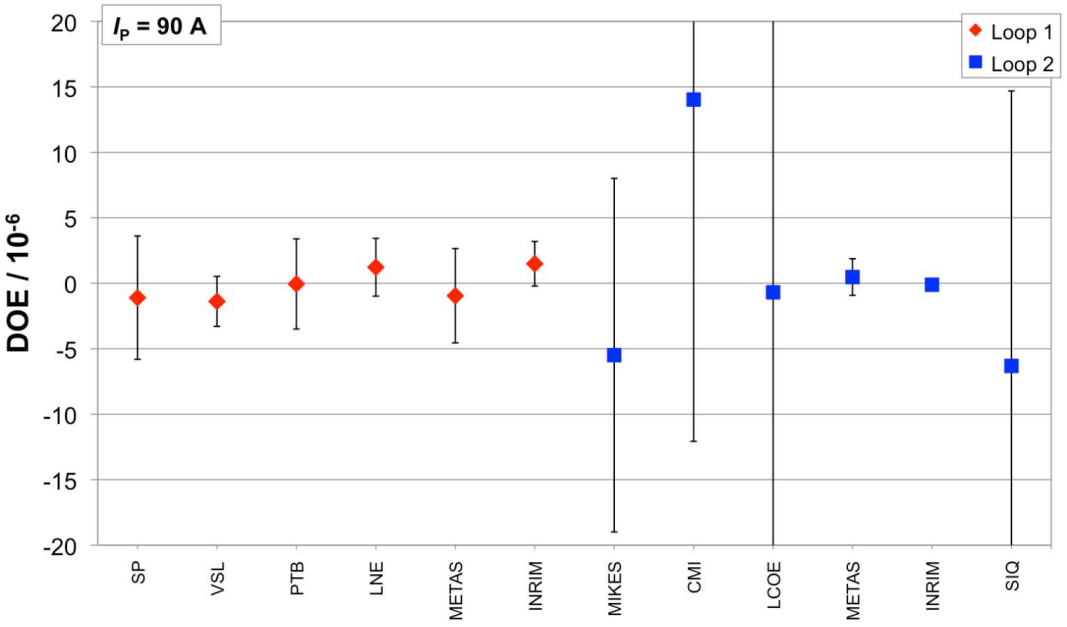
- Negotiations with EU about the new metrology programme are still in progress, but the first PRT call has already been arranged and the preliminary selection of SRTs has been made
- Focus areas of the calls:
  - 2021 Green Deal
  - 2022 Health, Integrated European Metrology
  - 2023 Fundamental, Industry
  - 2024 Green Deal
  - 2025 Health, Integrated European Metrology
  - 2026 Fundamental, Industry
  - 2027 Green Deal
  - In addition, Normative and Research Potential calls every year
- Any ideas related to the next call (especially Integrated European Metrology)?

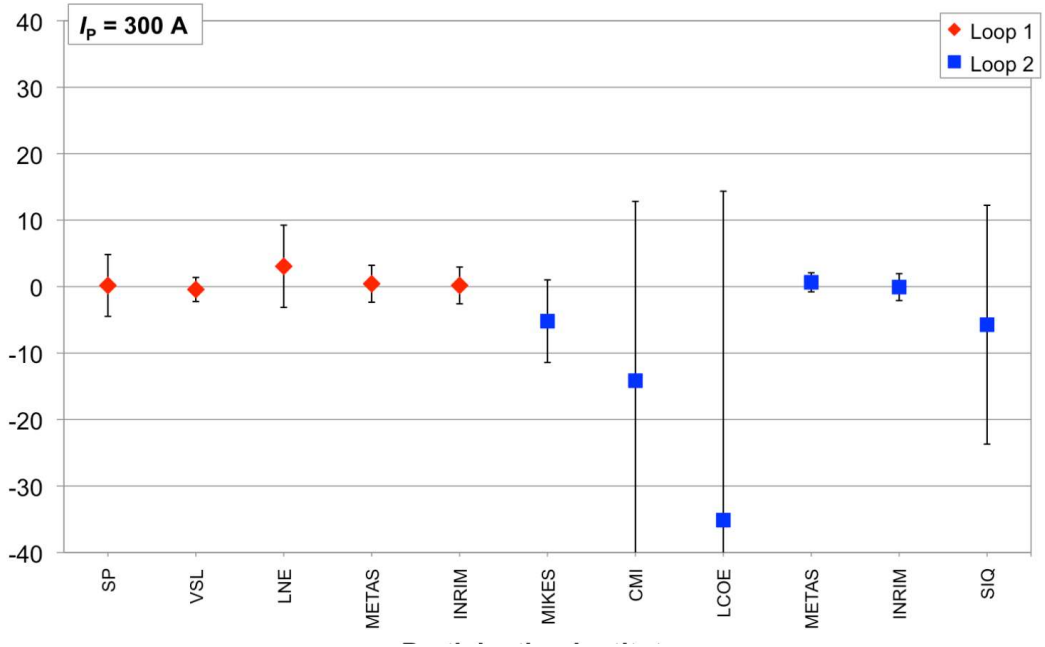
EURAMET projects on SC DC&QM

EURAMET comparisons on DC&QM

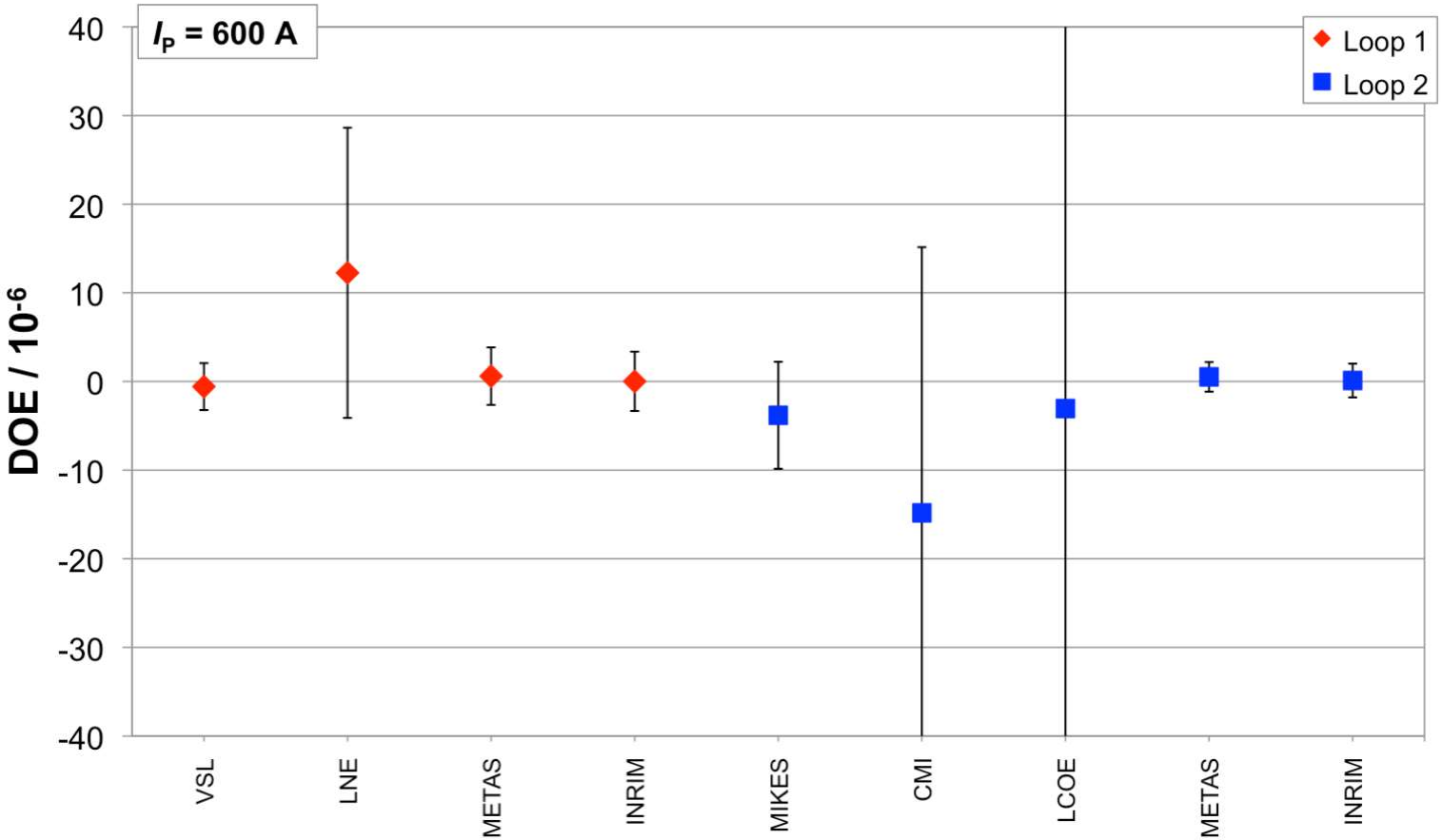
- EURAMET #1217 (EURAMET.EM-S35): Comparison of High-Current Ratio Standard, 2012 – 2020
  - **INRIM**, CMI, LNE, METAS, VTT MIKES, NPL, PTB, RISE, SIQ, VSL
  - Final report published in KCDB early 2020 (C. Cassiago and A. Mortara, Metrologia **57**, 01004 (2020)).
- EURAMET #1324 (EURAMET.EM-S41): Comparison of DC voltage standard at 1V, 1.018V and 10V, 2014 – 2020
  - **LNE**, SNSU-BSN (Indonesia)
  - Final report published in KCDB early 2020 (I. Blanc et al., Metrologia **57**, 01014 (2020)).
- EURAMET #1341 (not registered to KCDB): Comparison on Calibration of Multimeter, 2015 – 2021
  - **UME**, BoM, CMI, DPM, EMI, FER-PEL, FTMC, GUM, IMBiH, INM, IPQ, KMA, MBM, Metrosert, NSAI NML, SASO
  - Final report published in May 2021 (see EURAMET web site)
- EURAMET #1381 (not registered to KCDB): Comparison for Ultra-low DC Current Sources, 2016 -
  - **UME**, BFKH, IPQ, LNE, METAS, NSAI NML, RISE
  - Measurements completed, results not yet available

EURAMET.EM-S35 (90 A, 300 A)

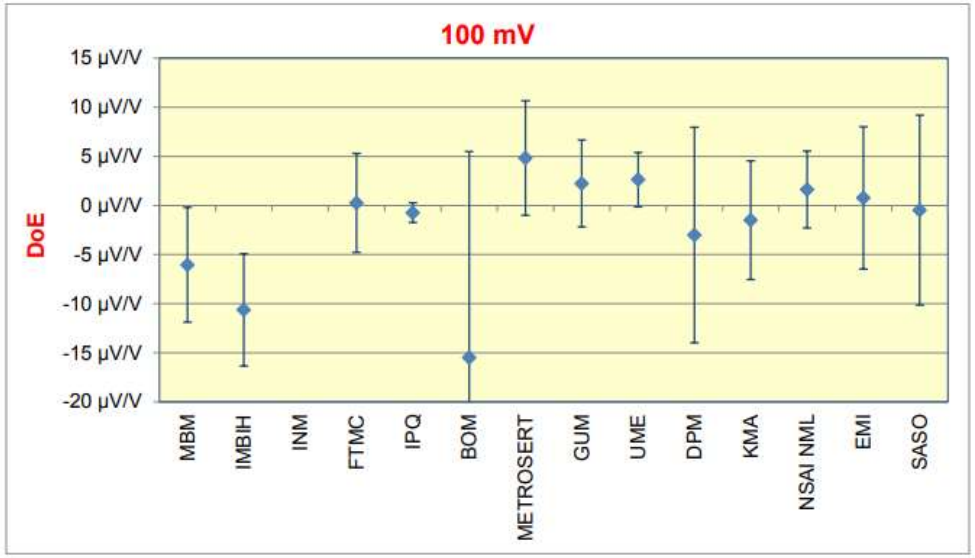


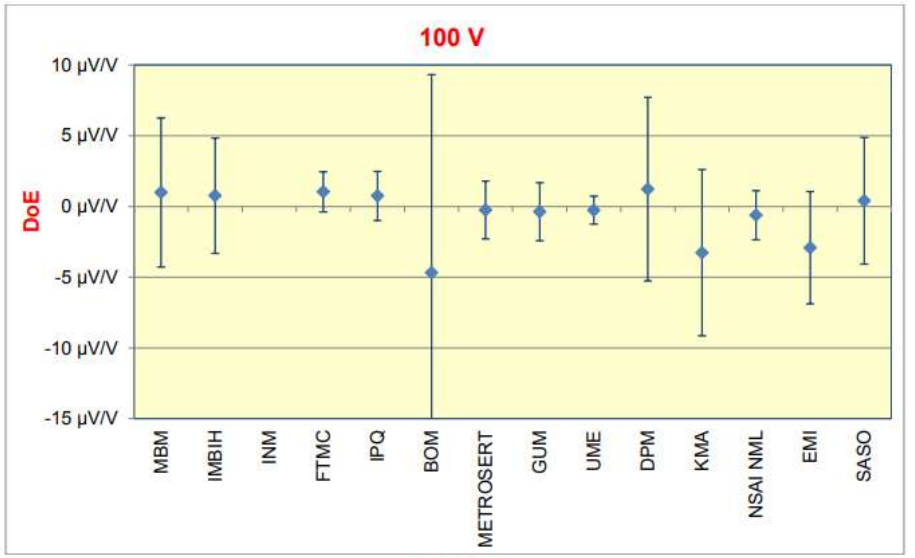


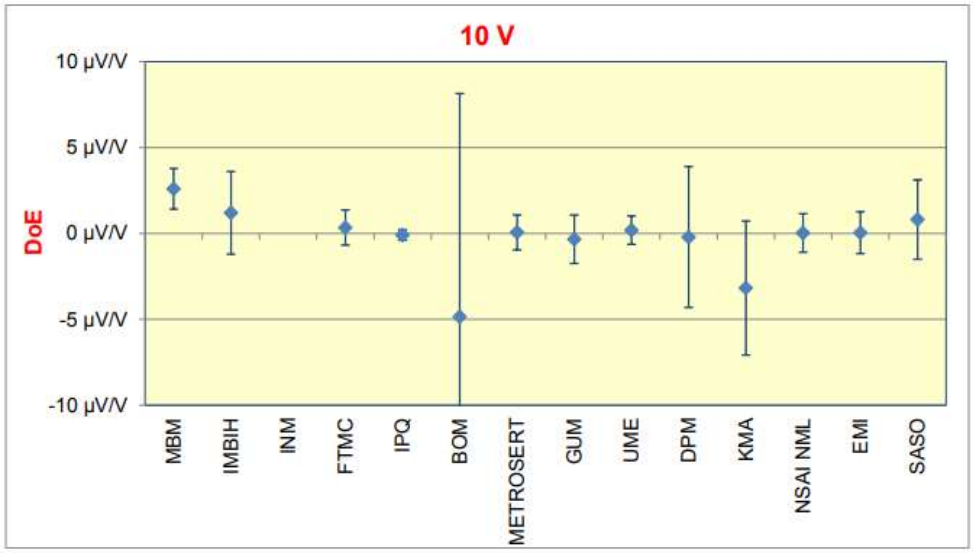
EURAMET.EM-S35 (600 A)

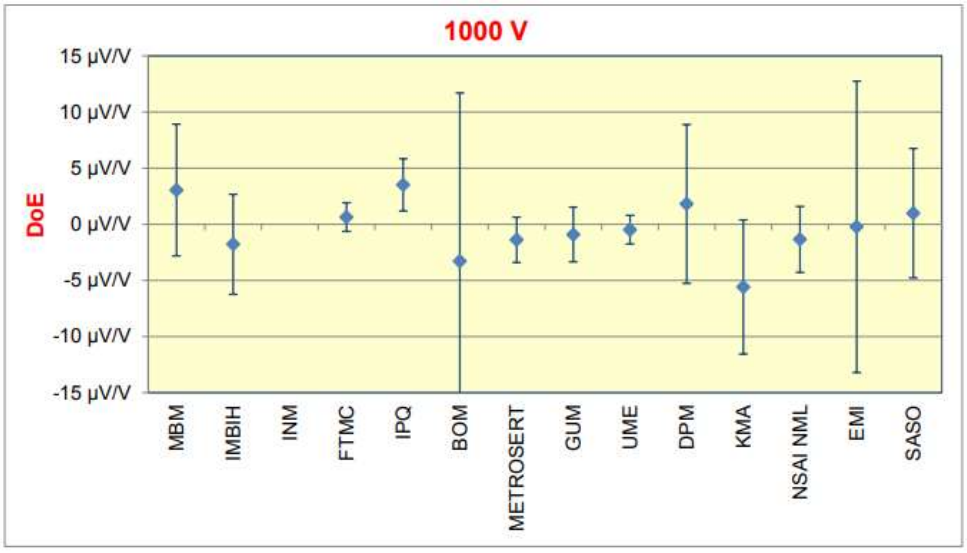


EURAMET #1341 (DCV)

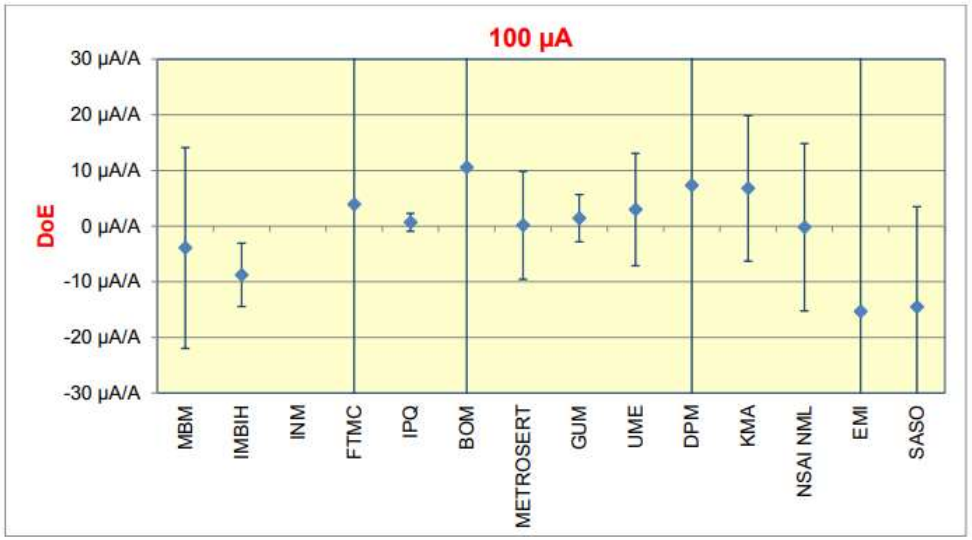


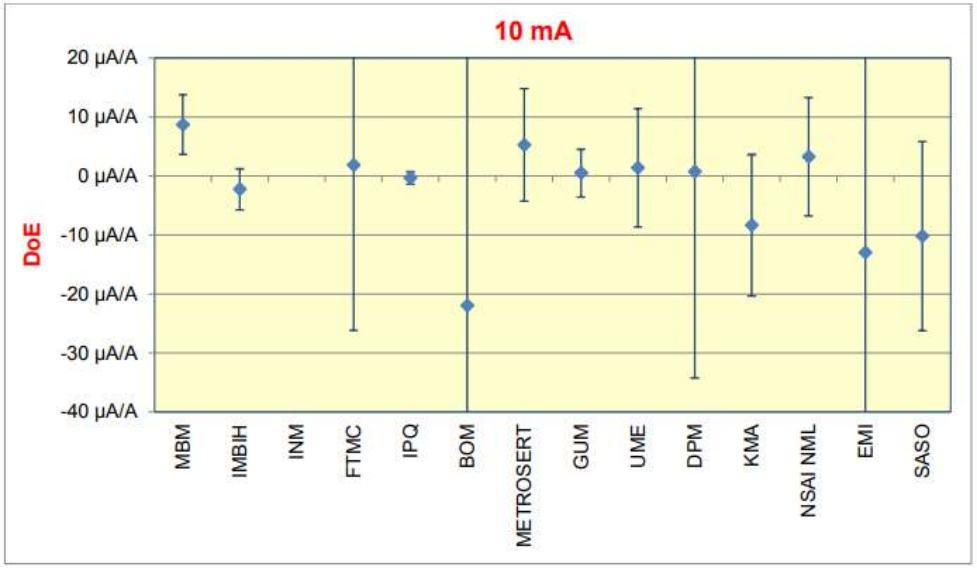


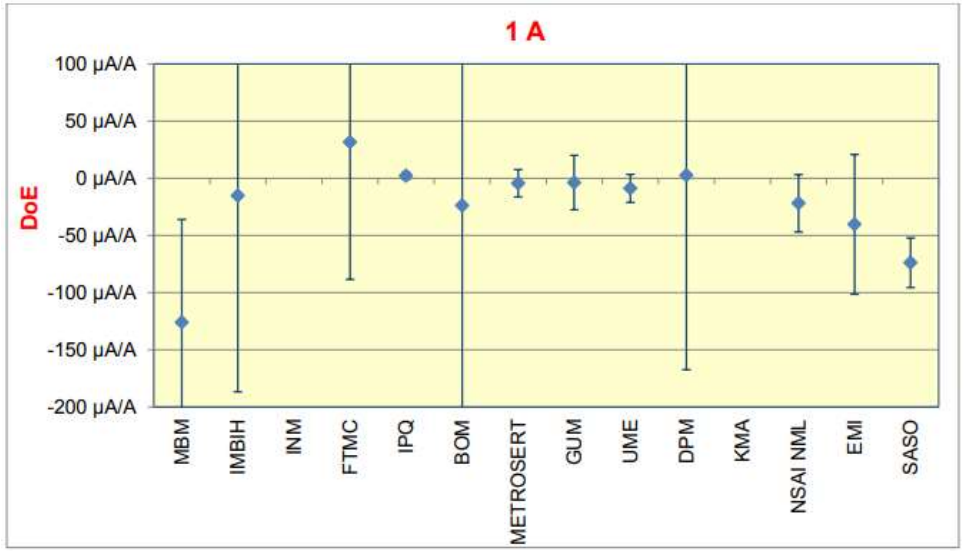




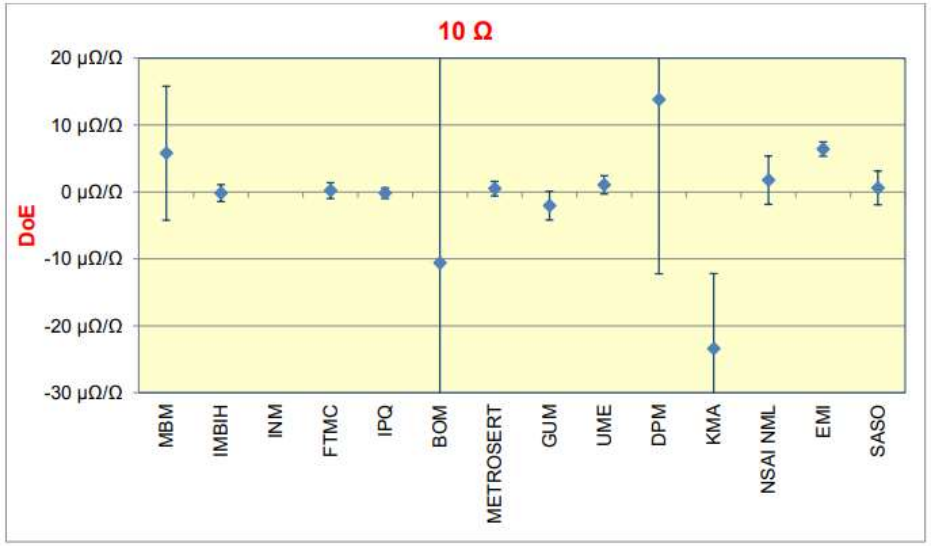
EURAMET #1341 (DCI)

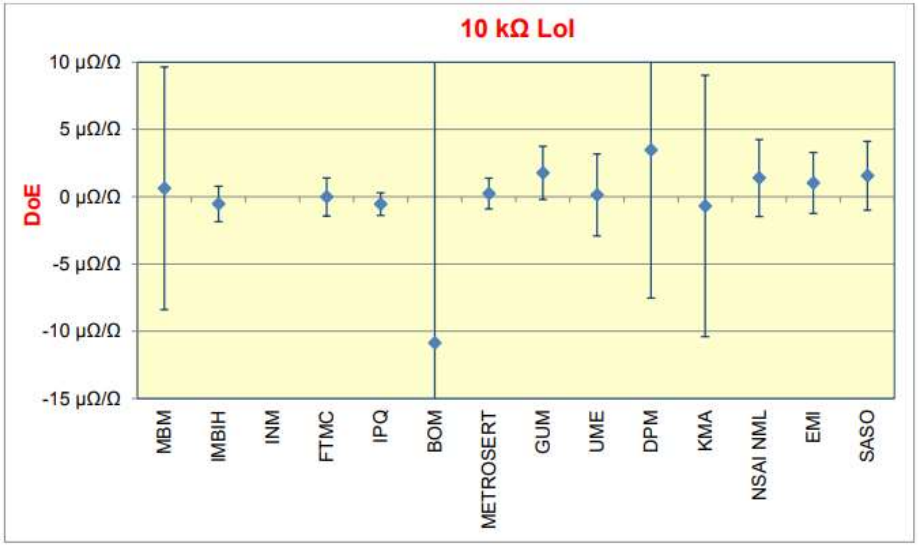


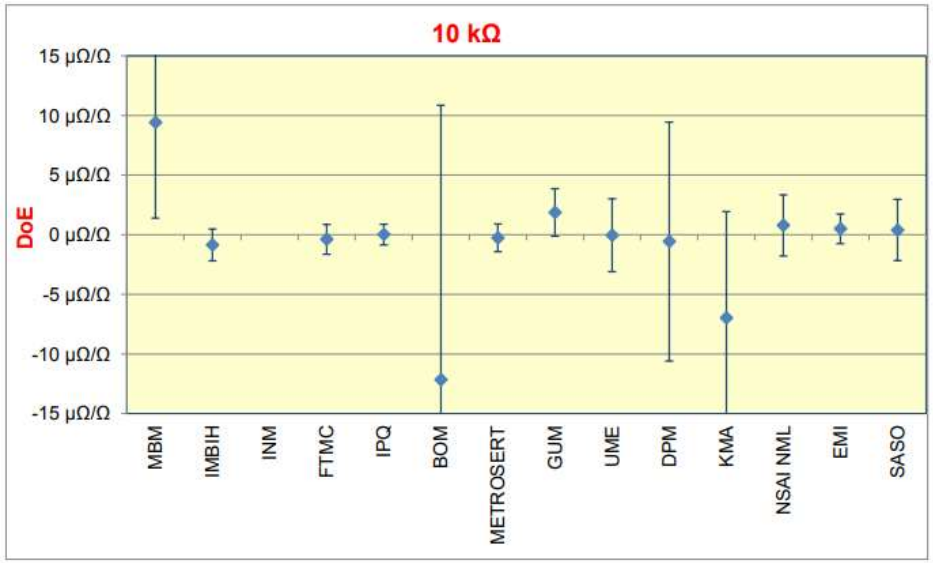


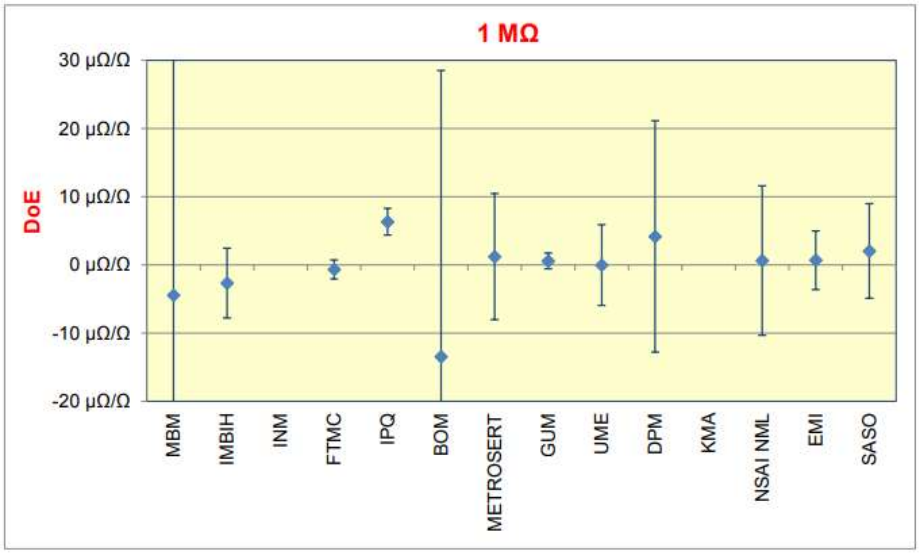


EURAMET #1341 (Resistance)









Other EURAMET projects

- No ongoing Consultation or Research Projects
- New ideas for EURAMET projects?

Technical guides on DC&QM

EURAMET Calibration Guidelines

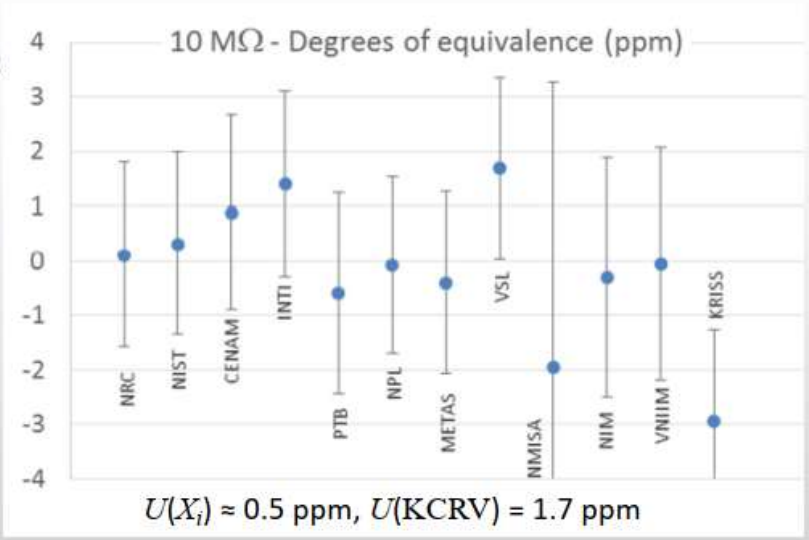
- No. 15, Guidelines on the Calibration of Digital Multimeters
  - https://www.euramet.org/publications-media-centre/calibration-guidelines/
  - Version 3.0, 02/2015
  - SC LF is mainly responsible for updates
  - DC current: need for more test points for nonlinearities (Peter Schiebenreiter)
- Low-DC-current measurement guide in progress at CCEM (mainly related to current measurements in ionization chambers)
- Should there be other Calibration Guidelines related to DC&QM?
- Guidelines would be especially for accredited labs etc.
- Need for technical guidelines of using QHE in graphene?
  - CCEM level documentation was proposed in the previous meeting
  - Is the field still a little too premature?

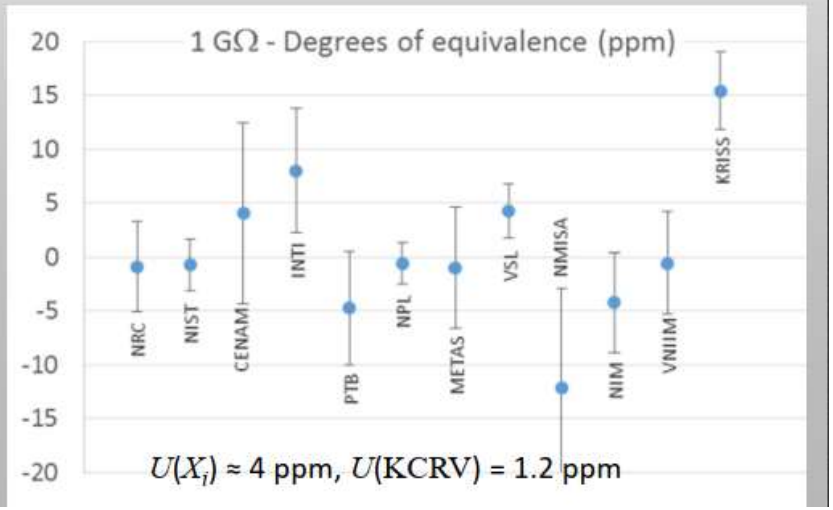
CCEM and BIPM comparisons

CCEM
2021

Completed Key Comparison: CCEM-K2.2012

- Measurand: DC resistance at 10 MΩ and 1 GΩ
- Pilot laboratory: **NRC**
- Other participants: **NIST, CENAM, INTI, PTB, NLP, METAS, VSL, NMISA, NIM, VNIIM, KRISS**
- Started September 2012, Final Report April 2020
- Improved uncertainties from 2002 comparison (10 MΩ dominated by resistor stability)
- Delays: usual (carnet/customs, timing, participants) but also technical (pressure coefficients required) and workload

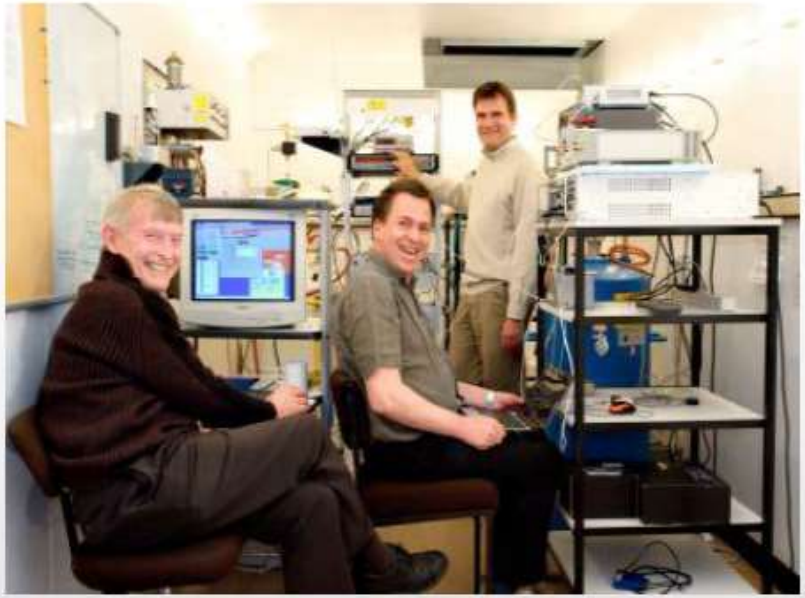




Murray Early,
CCEM meeting,
04/2021

CCEM
2021

BIPM Comparisons



Onsite Comparisons

- BIPM.EM-K10.a/b JVS on-site comparison
- BIPM.EM-K12 QHR on-site comparison
- Developing on-site PJVS comparison of ac voltages

Artefact Comparisons

- BIPM.EM-K11.a/b Zener voltage: 1.018 V and 10 V
- BIPM.EM-K13.a/b resistance: 1 Ω and 10 kΩ
- BIPM.EM-K14.a/b capacitance: 10 pF and 100 pF

BIPM participation

- GULFMET.EM.BIPM-K11 and APMP.EM.BIPM-K11.3 (Zener)

Calibration Services

- Zeners, resistors, capacitors

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CCEM meeting,
04/2021

CCEM
2021

Murray Early,
CCEM meeting,
04/2021

WGLF Future Comparisons: Survey Results

Cat	Sub-Cat	Quantity	Key Comparison
1		**DC Voltage**	
	1.1	Sources	
	1.2	Meters	Yes: 8
	1.3	Ratios	Yes: 8
		Measurand	
		Artefact	
2		**DC Resistance**	
	2.1.3	> 1 MΩ	Yes: 10
		Measurand	
		Artefact	
8		**High Voltage and Current**	
	8.1	High DC voltage	Yes: 11
	8.3	High AC voltage and voltage transformers	Yes: 10
		Measurand	
		Artefact	
6		**AC Current**	
		AC/DC Current	
		Measurand	
		Artefact	

Tentative Conclusions

1. K8: DCV ratio should repeat – start 2023?
2. Strong interest in 1000 V dc – could try DVM collapsing star using 3458A or similar (supplementary?)
3. Strong interest in 1 TΩ or higher – optional point(s) in next K2? (could start 2025?)
4. Strong interest in both dc and ac voltage at 100 kV (or higher) – aim to start 2023?
5. AC-DC Current – call for pilot/support group and participants to get underway 2023

Notes

- Consider low current (ULCA) rather than 1 T Ω or higher

CCEM 2021

Proposed Future Key Comparisons

To be presented at the CCEM- WGLF meeting 2023:

- New KC to support high voltage (DC/AC)
  - Task group of VTT, NMIA, RISE, INTI, VNIIMS to make a proposal (measurand and artefact)
- K12 AC-DC Current (10 mA and 5A to 100 kHz)
  - Task group of INTI, PTB, CENAM, ?

Will also discuss in 2023:

- Develop Process for implementing BIPM Onsite PJVS ac voltage comparison
  - Presentation by Stephane Solve – ready to start discussing protocol matters
  - Task group of BIPM, MIKES, KRISS, NRC, NMIA, PTB, NPL, METAS, CENAM, NMIJ
- Develop ideas to initiate K8: DC voltage ratio
  - Traditional artefacts (e.g. Datron 4902S) no longer produced
  - New artefacts available but yet to be proven
  - Task group: NMIA, PTB, NMC, VSL
- Extend K2 to include 1 TΩ or more (optional), proposal due by 2025
  - Consider NMIJ development of new artefacts

Murray Early, CCEM meeting, 04/2021

CCEM 2021

Proposed Future Key Comparisons

To be considered at future CCEM- WGLF meetings

- Possible needs to support new linearity measurands
- SI redefinition suggests measurement of very low current could become more important – future KC?
  - Interest in findings of CCEM-CCRI task group on small currents
- Agreed DMM for DCV up to 1 kV in collapsing star pattern – interesting but premature for now
- AC and DC ratio are longer term KCs – do RMOs want these?
- Rationalise the four ac-dc voltage comparisons in light of future on-site PJVS for ac voltages

Murray Early, CCEM meeting, 04/2021

CCEM
2021

Future Comparison Schedule

CCEM Key Comparisons	Repeat	Next	RMO
K14: high ac voltage	15	2023	?
K12: ac-dc current, 10mA/5A	15	2023	Y
K8: dc voltage ratio?	20	2025	?
K11: low ac-dc voltage, 10mV/100mV	15	2025	Y
K2: high dc resistance, 10MΩ, 1GΩ and 1TΩ?	15	2025	Y
K7: ac voltage ratio, 1kHz	20	2027	?
K5: single phase ac power, 50/60Hz	15	2029	Y
K6.a: mid ac-dc voltage, 3V to 1MHz	15	2031	Y
K6.c: RF-dc voltage, 3V to 100MHz	15	2031	Y
K4: capacitance, 10pF/100pF	20	2035	Y
K9: high ac-dc voltage, 500V/1000V (was K6.b)	15	2031	Y
K3: inductance, 10mH	20	2041	Y
K1: dc resistance, 1Ω and 10kΩ	-	-	-
K10: dc resistance, 100Ω	-	-	-
K13: power harmonics	-	-	-

Murray Early,
CCEM meeting,
04/2021

CCEM 2021

Murray Early, CCEM meeting, 04/2021

Future Priority (proposed start)	Branch	Key Comparisons		Cat	Sub-Cat	Quantity	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012
	DC VOLTAGE, CURRENT, AND RESISTANCE			1		DC Voltage											
BIPM					1.1	Sources											
Not yet					1.2	Meters											
#3 - 2025 (K8)		1	K8		1.3	Ratios											
				2		DC Resistance											
BIPM					2.1.2	1 Ω to 1 MΩ											BIPM.EM-K13a/b: 1Ω
#5 - 2025 (K2)		2	K2		2.1.3	> 1 MΩ			K2.2012: 10MΩ and 1GΩ								
				3		DC Current to 100 A											
NB: not a key quantity																	
	IMPEDANCE UP TO THE MEGAHERTZ RANGE			4		Impedance											
NB: not a key quantity					4.1	Resistance											
2035? (K4) BIPM		3	K4		4.2	Capacitance		BIPM.EM-K14a/b: 10pF/100pF			K4: 10pF / 100pF						
starting 2021		4	K3		4.3	Inductance		K3X: 10 mH (to start)									
	AC VOLTAGE, CURRENT, AND POWER			5		AC Voltage											
#4 - 2025 (K11)		5	K11		5.1.1	AC/DC <0.5 V											
active BIPM (PJVS?)		6	K6.a		5.1.2	AC/DC 0.5 V to 5 V		K6.aX: 3V to 1 MHz									
active		7	K9		5.1.3	AC/DC >5 V		K9X: 500V/1000V									
#6 - 2027 (K7)		8	K7		5.3.1	AC Ratio											
				6		AC Current											
#2 - 2023 (K12)		9	K12			AC/DC Current											
				7		AC Power											
active		10	K5		7.1.1	Power		K5.2017: 50/60 Hz									
	HIGH VOLTAGE AND CURRENT			8		High Voltage and Current											
#1b - 2023 (K14?)					8.1	High DC voltage											
#1a - 2023 (K14?)					8.3	High AC voltage and voltage transformers											
	OTHER DC AND LOW FREQUENCY MEASUREMENTS			9		Other DC and low frequency measurements											
not repeated		11	K13		9.3.1	Harmonics		K13: power harmonic									
	ELECTRIC AND MAGNETIC FIELDS			10		Electric and magnetic fields											
NB: not a key quantity																	
	RADIO FREQUENCY MEASUREMENTS			11		Radio frequency measurements											
active		12	K6.c		11.7.1	RF-DC voltage difference		K6.cX: 3V to 100 MHz									
	MATERIALS			12		Measurements on materials											
NB: not a key quantity																	

EURAMET DCQM strategic plan for comparisons

EURAMET strategic plan for comparisons

- The first draft of EURAMET TC-EM strategic plan for comparisons was made in spring 2018
- The updated draft of DC&QM plan based on input from SC DC&QM contact persons and discussions during the meeting is in a separate Excel file on the meeting web site (EURAMET_TCEM_ComparisonPlan_DCQM_2021_06_03).
  - Note: SC-DC&QM deals with the following CMC branches:
    1. DC voltage;
    2. DC resistance;
    3. DC current;
    4. Impedance - if based on quantum standards, together with SC-LF
    5. AC voltage (up to the MHz range) - if based on quantum standards, together with SC-LF

    9.1 Electric charge - not including partial discharge measurements.
- In the meeting:
  - Discussion about pros and cons of DCV comparison at kV level either via voltage ratio or by direct voltage measurements
  - Importance of resistance comparison at mΩ range, and discussion about availability of suitable travelling standards (development ongoing at PTB, simulated shunt development at INRIM), reasonably good results on VSL-METAS-NIST comparison about 10 years ago at 0.1 mΩ - 100 mΩ [Rietveld et al., IEEE TIM 62, 1723 (2013)]
  - No big needs for 100 Ω comparisons
  - PTB proposes a comparison at about 100 fA – 1 μA DCI using ULCA (perhaps starting in 2023)
  - A possible travelling standard for 10 mA DCI comparison would be available

Proposals for new EURAMET comparisons

EURAMET follow-up of CCEM-K2.2012

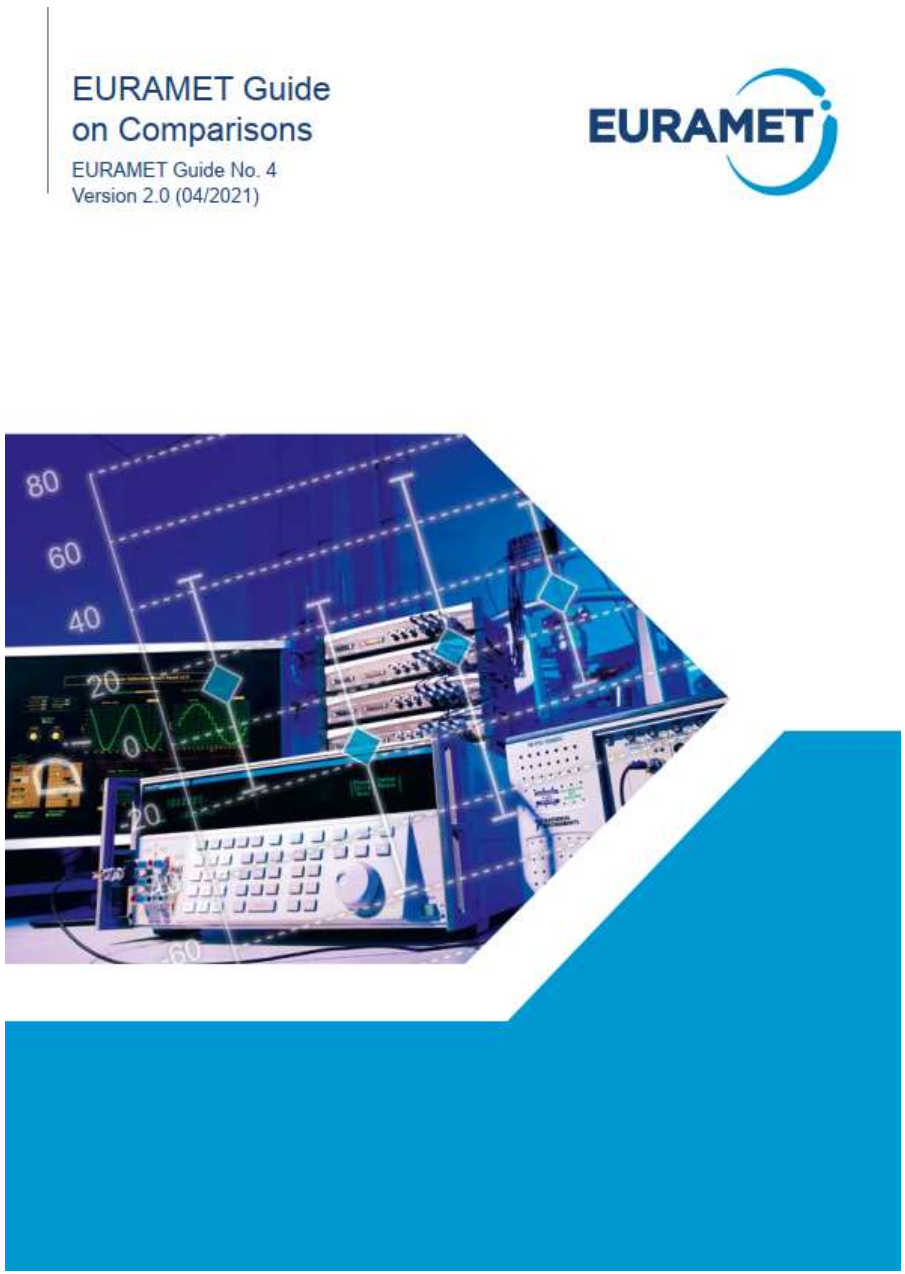
- CCEM-K2.2012 key comparison of resistance standards at 10 MΩ and 1 GΩ
  - Final report published in 2020
  - EURAMET participants: METAS, NPL, PTB, VSL
- Planning of EURAMET follow-up in TC-EM meeting (October 2020)
  - Preliminary expression of interest to participate: BEV, BIM, CMI, FTMC, GUM, IMBIH, INM, INRiM, JV, LNE, METAS, Metrosert, NPL, NSAI, PTB, RISE, SIQ, SMD, TÜBİTAK UME, VSL, VTT MIKES
  - Ready to participate/support piloting: NPL, PTB, TÜBİTAK UME
    - NPL: measurements (star) using CCC up to 1 GΩ
    - TÜBITAK UME: protocol and timetable
    - PTB: final report
  - Combine star approach with a conventional loop (there are interested labs for both types), but from where to get the travelling standard? Possibly from PTB (at least 1 GΩ). What about the standards of NMIJ (10 MΩ)?
  - NPL will take the responsibility to get the comparison running (with help from supporting laboratories)
  - What about 1 TΩ as an option? Not suitable for measurements at NPL.

Proposals for other comparisons

- Low currents using ULCA
  - Two ULCAs available from PTB
  - From 100 fA up to 5 μA (possibly up to 100 μA)
  - ULCA could be used either as a meter or as a source
  - Interested labs: NPL, LNE, VTT MIKES, INRIM, VSL

EURAMET Guide on Comparisons

- A new version (2.0) was approved by the Board of Director on 27 April 2021
  - The current version of the Guide (2.0) refers to the requirements described in the new CIPM MRA-G-11 document
  - In addition, the concept of hybrid comparisons has been introduced in the Guide in line with the JCRB resolution 40/1



Other topics

The next SC DC&QM convenor

- Antti's 5-year term as the convenor of SC DC&QM will end in the end of this year, and Antti will not continue as the convenor after that
- Rules of procedures for EURAMET SC Convenors are:
  - The work within each SC is coordinated by a Convenor who is a nominated Contact Person to the SC. The Convenors support the TC Chairs and keep them informed about the progress in their Sub-Fields.
  - A Convenor is proposed by the TC Chair after consultation of the SC Contact Persons and shall be appointed by the EURAMET Chairperson.
  - Each Convenor will be appointed for a period of five years and may be reappointed. His/her term of office is linked to the term of the SC.
- So far, one potential candidate has been proposed: Ralf Behr
- How to continue?
  - Antti will wait for new proposals from SC DCQM contact persons until 15 June
  - If there will be more than one candidate, TC-EM chair Markus Zeier will do an election by email among the TC-EM contact persons

Next meeting(s)

- CPEM 2022 conference will take place in Wellington, New Zealand, on 12 – 16 December, 2022 (please express your interest at https://www.cpem2022.nz/ for possible updates etc.)
- Shall we arrange an (informal) DC&QM satellite meeting during the CPEM?
- Or should we arrange an “extra” DC&QM meeting in Europe e.g. in June 2022 (possibly combined with an EMN-Q or EMPIR project meeting)?
  - Yes, there is interest for an “extra” DC&QM meeting in Europe in summer 2022

- What about the next regular meeting in 2023?
- Is May/June a good time?
- Should the meeting be synchronized with some EMPIR project meetings (and/or with EMN-Q)?
- Are there interested hosts?

Anything else?