LABORATORIJ
ZA METROLOGIJO
IN KAKOVOST

Univerza v Ljubljani
Fakulteta za elektrotehniko
Katedra za merjenja in robotiko

University of Ljubljana
Faculty of Electrical Engineering
Department of Measurements and Robotics

CCT WG-CMC Meeting

Jovan Bojkovski

Sevres, BIPM
16 – 17 May 2024

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Agenda

Final version

1) Review of submitted CMCs – problems and suggestions

    results of K9 and its influence to accepted and future CMCs

2) Review protocol amendments – changes

    Decrease of number of categories (thermocouples only one category) and number of CMCs (use equations, matrices, …)

    Changes as a result of K9

3) Inter-RMO review process harmonization – difficulties and delays in CMC review process in the years

    Which comparisons cover which calibration services

4) Any other business

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New members

Members:

Jovan Bojkovski, Efrem Ejigu (AFRIMET), Hisashi Abe replaced by Inseok Yang (APMP), **Sergey Kondratiev (COOMET), Mohamed Sadli (EURAMET)**, Nasser Dawood (GULFMET) and Ciro Sanchez (SIM)

ToR

to establish and maintain lists of service categories and, where necessary, rules for the preparation of CMC entries;

to agree on detailed technical review criteria;

to coordinate and, where possible, conduct inter-regional reviews of CMCs submitted by RMOs for posting in Appendix C of the CIPM MRA;

to provide guidance on the range of CMCs supported by particular key comparisons;

to examine the sufficiency of existing comparisons for supporting CMC submissions and to recommend new comparisons where deemed necessary; and

to coordinate the review of existing CMCs in the context of new results of key and supplementary comparisons.

The CCT-WG-CMC is tasked to draft and update CMC review protocols, to review fast-track submissions for inclusion in the KCDB Appendix C, and to identify new comparisons needed to support CMC submissions.

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Review of submitted CMCs – problems and suggestions

results of CCT.K9 and its influence to accepted and future CMCs

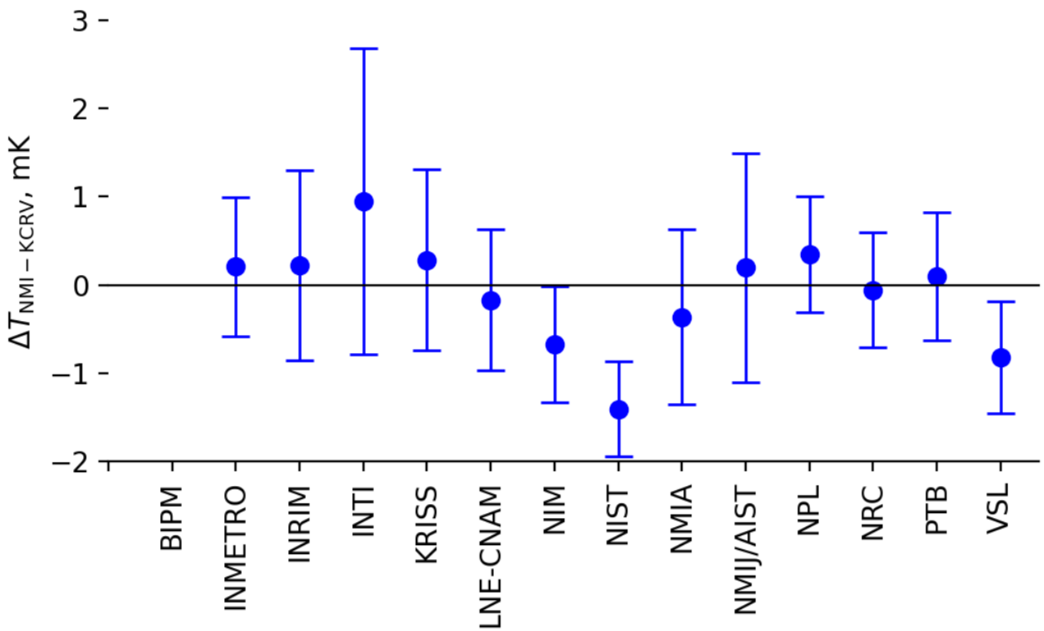

Figure 5.6: Deviationof ΔT_{NMI} from $\overline{\Delta T}$ at the argon point measured by each NMI. Error bars represent uncertainty calculated using the uncertainty budget supplied by the NMI for this key comparison, at the $k = 2$ level.

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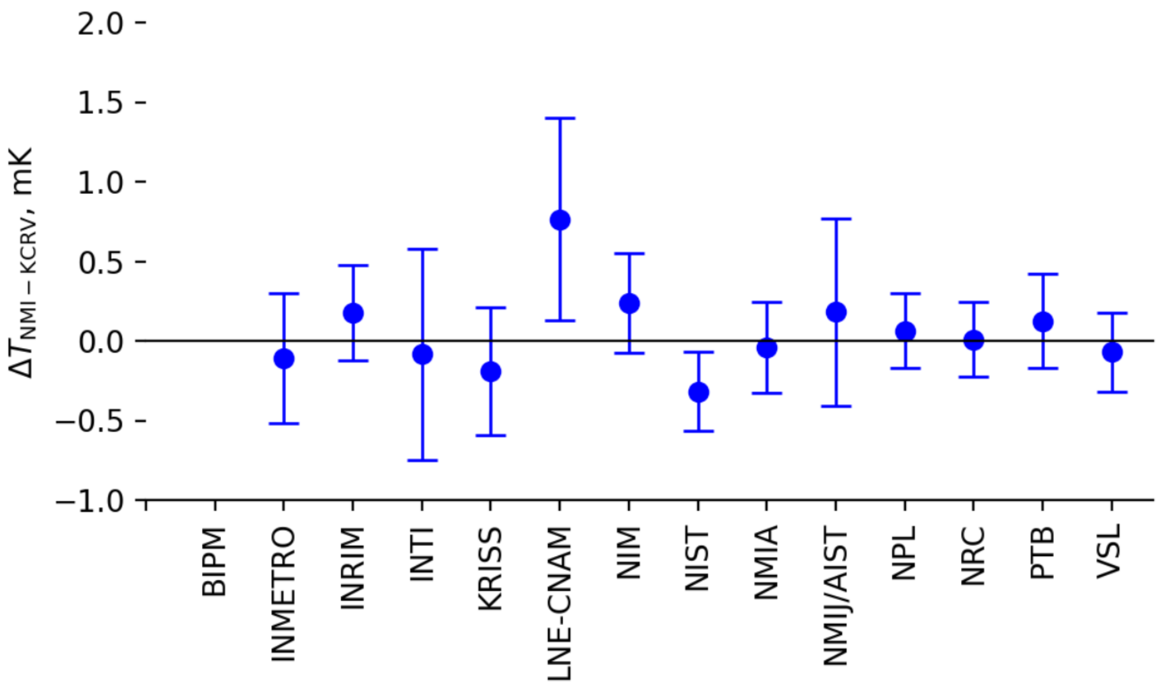

Figure 5.5: Deviationof ΔT_{NMI} from $\overline{\Delta T}$ at the mercury point measured by each NMI. Error bars represent uncertainty calculated using the uncertainty budget supplied by the NMI for this key comparison, at the $k = 2$ level.

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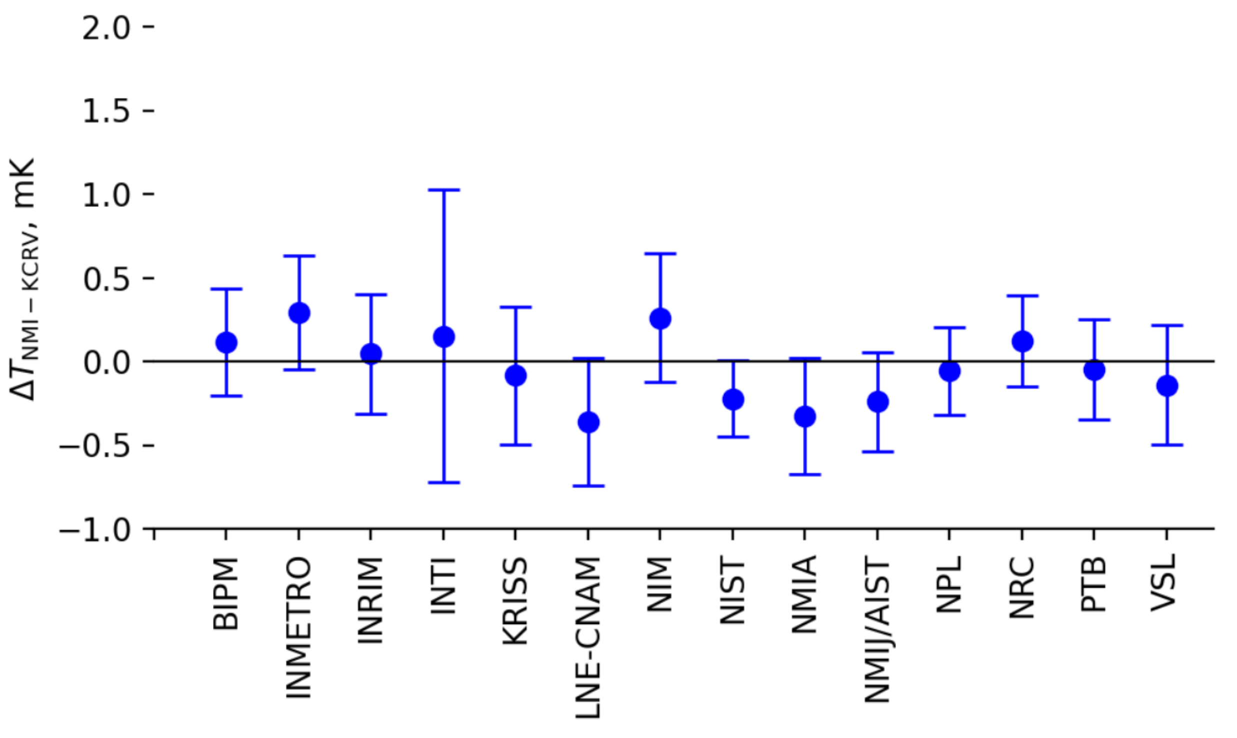

Figure 5.4: Deviationof ΔT_{NMI} from $\overline{\Delta T}$ at the gallium point measured by each NMI. Error bars represent uncertainty calculated using the uncertainty budget supplied by the NMI for this key comparison, at the $k = 2$ level.

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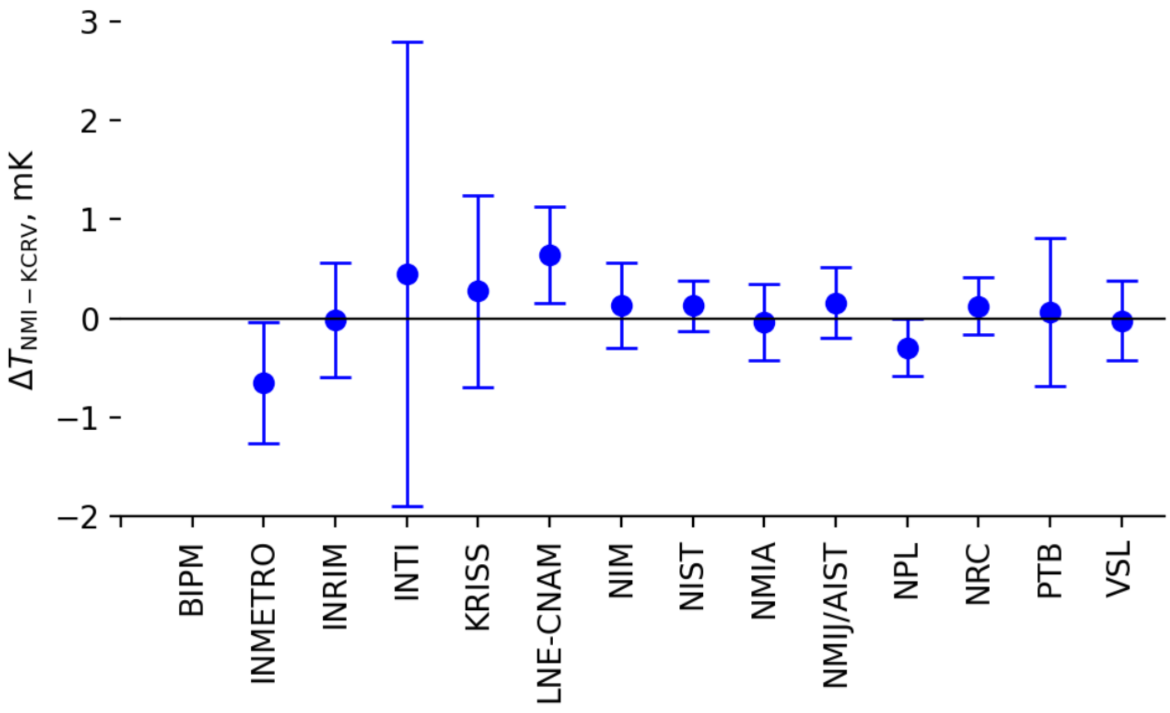

Figure 5.3: Deviationof ΔT_{NMI} from $\overline{\Delta T}$ at the indium point measured by each NMI. Error bars represent uncertainty calculated using the uncertainty budget supplied by the NMI for this key comparison, at the $k = 2$ level.

Review of submitted CMCs – problems and suggestions

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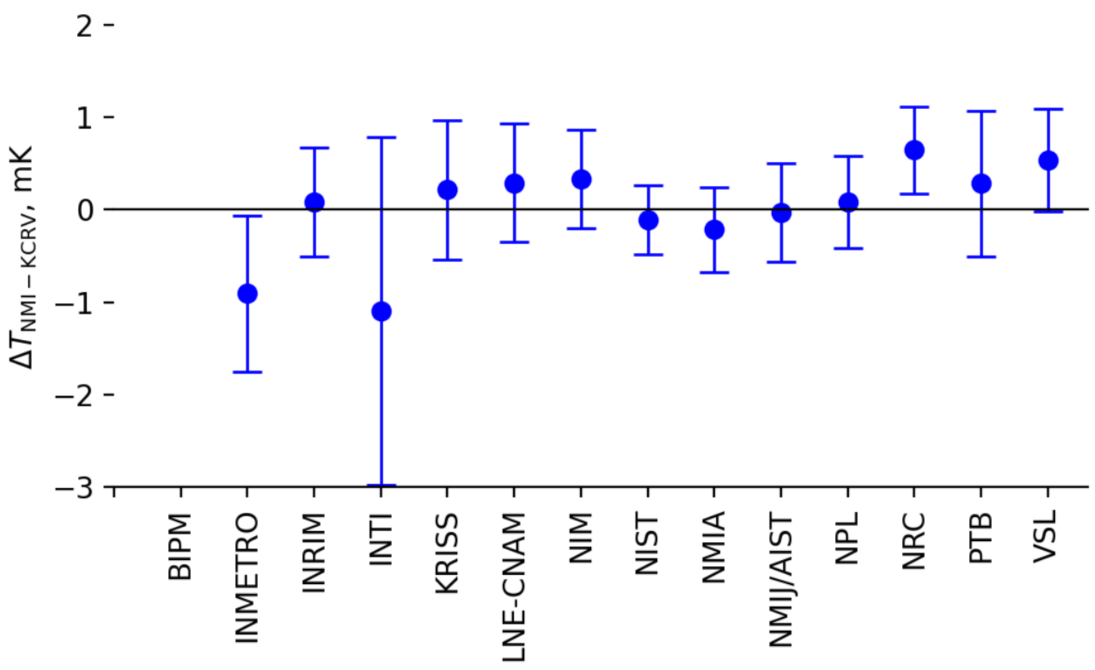

Figure 5.2: Deviationof ΔT_{NMI} from $\overline{\Delta T}$ at the tin point measured by each NMI. Error bars represent uncertainty calculated using the uncertainty budget supplied by the NMI for this key comparison, at the $k = 2$ level.

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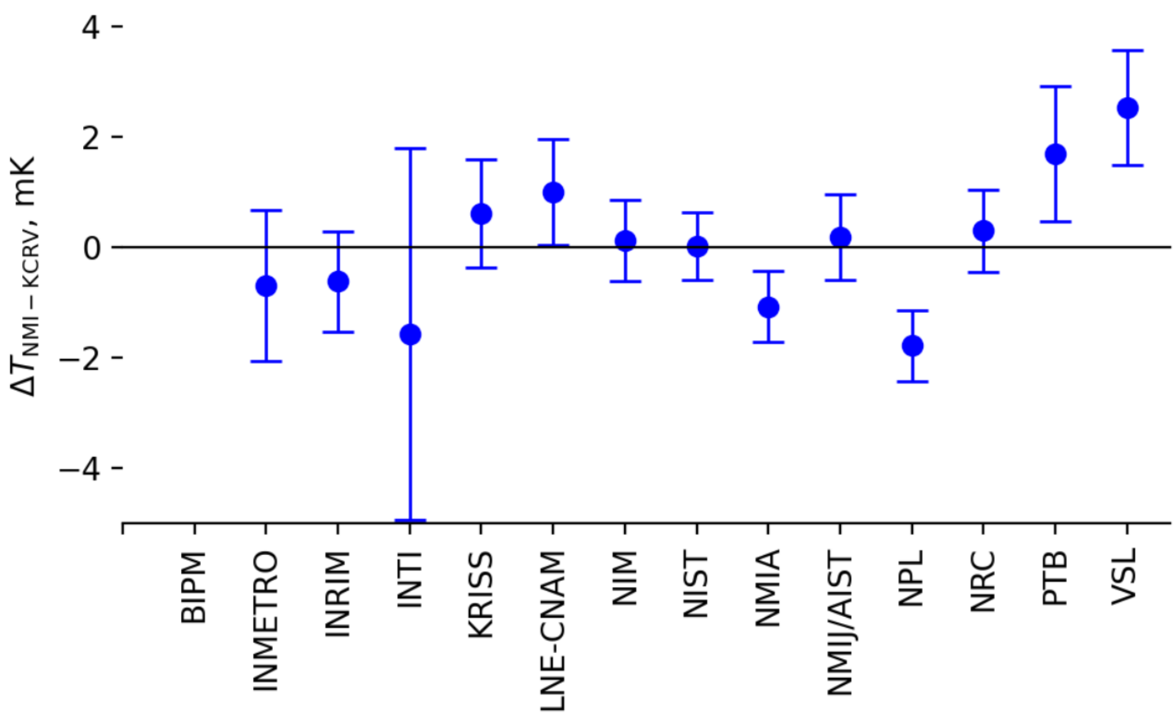

Figure 5.1: Deviationof ΔT_{NMI} from $\overline{\Delta T}$ at the zinc point measured by each NMI. Error bars represent uncertainty calculated using the uncertainty budget supplied by the NMI for this key comparison, at the $k = 2$ level.

CCT K9 – Zn point

NMI	CCT K9 result ΔT_{NMI}–KCRV mK	Unc k=2 mK	KCDB CMC mK
INMETRO	-0.69	1.37	
INRIM	-0.61	0.91	0.84
INTI	-1.56	3.37	
KRISS	0.61	0.99	1.3
LNE-CNAM	1.01	0.96	1.1
NIM	0.13	0.74	1.4
NIST	0.02	0.61	0.37
NMIA	-1.07	0.64	0.5
NMIJ/AIST	0.19	0.78	2.00
NPL	-1.78	0.64	0.90
NRC	0.30	0.75	0.6
PTB	1.69	1.23	1.3
VSL	2.53	1.04	0.9

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Review protocol amendments – changes

ITS-90 Subrange Review Protocol – revised by Jovan Bojkovski

TPW CMC Review protocol potential error – identified by Inseok Yang

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Which comparisons cover which calibration services

The BIPM key comparison database

KCDB

CLASSIFICATION OF SERVICES IN THERMOMETRY

Version 1.3, January 2022

METROLOGY AREA: THERMOMETRY

BRANCH: TEMPERATURE

7. Temperature – Items used for disseminating thermodynamic temperature

7.1 Radiation thermometry

7.1.1 Fixed-point blackbody cells and apparatus
7.1.2 Radiation thermometers
7.1.3 Variable temperature blackbody radiation sources

1. Temperature – Items used for defining ITS-90

1.1 Primary fixed-point cells

1.1.1 Cells for contact thermometry
1.1.2 Cells for radiation thermometry

Introduction

- The NMI submitting a CMC must take part in a comparison
- The comparison protocol and report are reviewed by experts in the field and may require several iterations before approval
- The NMI drafts its CMC and submits it to its RMO
- The CMC is reviewed by the RMO experts and this may require several iterations before approval
- When required, the CMC is reviewed also by the other RMOs (Inter-RMO review) and this may also require several iterations before approval
- The comparison is published in the BIPM database

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Revison of the CIPM MRA implementation

- Why ?
  - The increased demand of resources and the time required for bringing comparisons to conclusion
  - Many signatories continuously expand the number of declared capabilities
  - Staff changes and new techniques appear, the validity of a comparison is limited in time and its ability to underpin CMC expires

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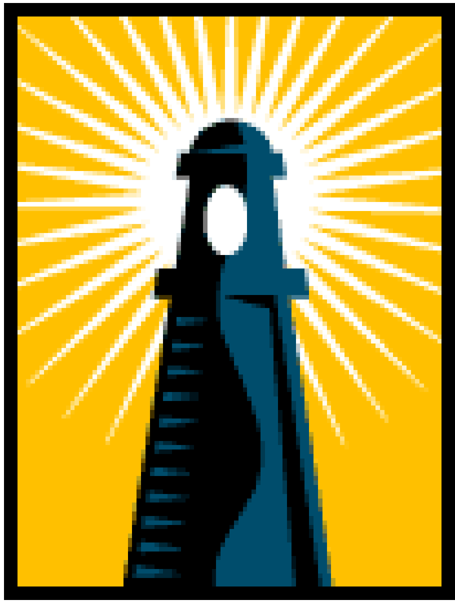
CCT KC in contact thermometry

KC	Measurements	Year of publication of report
CCT-K1	1997 to 2001	2006
CCT-K2	1997 to 2001	2001
CCT-K3	1997 to 2001	2003
CCT-K4	1998 to 2000	2002
CCT-K7	2002 to 2004	2006
CCT-K9	2011 to 2015	2023
CCT-K7.2021	2021 to 2022	2023

Important questions

- "How far the light shines ?"
  - It is impossible to perfom comparisons for every CMC entry
  - Does the comparison in range of SPRT at fixed points also covers CMC for PRT by comparison ?
- When do we have to repeat comparison ?



Revison of the CIPM MRA implementation

- How – the CCT new suggestion how to further reduce workload
  - taking a broader view of the impact of the comparisons, while preserving the scientific objectiveness of the process
  - an example of in the fields of contact thermometry and hygrometry

KC	Range	Device calibrated in the KC	Calibration services tested by the KC in the range
CCT-K1	0.65 K to 24.5561 K	Rhodium-Iron resistance thermometers (**2.2.1**)	Calibration of e-H and Ne fixed point cells (**1.1.1**) Calibration of complete apparatus realizing fixed points for CSPRTs (**1.2.1**) Calibration of Rhodium-Iron resistance thermometers at fixed points (**2.2.1**)
CCT-K2	13.8 K to 273.16 K	Capsule-type SPRTs (**1.3.1**)-	Calibration of fixed point cells for CSPRTs (**1.1.1**) Calibration of CSPRTs at fixed points (**1.3.1**) Calibration of complete apparatus realizing fixed points for CSPRTs (**1.2.1**)
CCT-K3	83.8058 K to 660.323 ^{o}C	Long-stem SPRTs (**1.3.2**)	Calibration of fixed point cells for LSPRTs (**1.1.1**) Calibration of fixed point cells for LSPRTs (**1.1.1**) Calibration of complete apparatus realizing fixed points for LSPRTs (**1.2.1**)
CCT-K4	660.323 ^{o}C to 961.78 ^{o}C	Long-stem SPRTs (**1.3.2**)	Calibration of fixed point cells for LSPRTs (**1.1.1**) Calibration of LSPRTs at fixed points (**1.3.1**) Calibration of complete apparatus realizing fixed points for LSPRTs (**1.2.1**)
CCT-K7	273.16 K	Triple point of water cell (**1.1.1**)	Calibration of fixed point cells for LSPRTs (**1.1.1**) Calibration of LSPRTs at fixed points (**1.3.1**)

KC	Range	Other calibration services underpinned by the KC
CCT-K1	0.65 K to 24.5561 K	Calibration of Rhodium-Iron resistance thermometers by comparison (**2.2.1**)
CCT-K2	13.8 K to 273.16 K	Calibration of CSPRTs in the ITS-90 sub-ranges (**1.3.1**) Calibration of industrial platinum resistance thermometers (**2.2.2**) Calibration of thermistors and other resistive thermometers (**2.2.3**) Calibration of noble-, base- and pure-metal thermocouples (**2.3.1, 2.3.2, 2.3.3**) Calibration of liquid-in-glass thermometers (**2.4.1**) Calibration of temperature sensors with display unit (**2.7.1**) Calibration of dry-well block calibrators (**2.8.6**)
CCT-K3	83.8058 K to 660.323 °C	Calibration of LSPRTs in the ITS-90 sub-ranges (**1.3.1**) Calibration of industrial platinum resistance thermometers (**2.2.2**) Calibration of thermistors and other resistive thermometers (**2.2.3**) Calibration of noble-, base- and pure-metal thermocouples (**2.3.1, 2.3.2, 2.3.3**) Calibration of liquid-in-glass thermometers (**2.4.1**) Calibration of temperature sensors with display unit (**2.7.1**) Calibration of dry-well block calibrators (**2.8.6**)
CCT-K4	660.323 °C to 961.78 °C	Calibration of LSPRTs in the ITS-90 sub-ranges (**1.3.1**) Calibration of industrial platinum resistance thermometers (**2.2.2**) Calibration of thermistors and other resistive thermometers (**2.2.3**) Calibration of noble-, base- and pure-metal thermocouples (**2.3.1, 2.3.2, 2.3.3**) Calibration of temperature sensors with display unit (**2.7.1**) Calibration of dry-well block calibrators (**2.8.6**)
CCT-K7	273.16 K	

KC	Range	Device calibrated in the KC	Calibration services tested by the KC in the range	Other calibration services underpinned by the KC	Other services requiring traceability to other quantities
K6/K8	-50 °C to 95 °C	Dew-point Hygrometer (**3.1.1**)	Dew-point hygrometers (**3.1.1**) Dew-point generators (**4.1.1**)	Psychrometers (**3.2.1**) Other hygrometers (**3.4.1**) Reference gases (**5.2.1**)	Relative humidity sensors (**3.3.1**) → T Relative humidity generators (**4.2.1**) → T Flow mixing (**4.3.1**) → Q Salt solutions (**5.2.1**) → T

Other possibilities

- By reducing the number of service categories
  - For example, instead of having CMCs for noble metal, base metal and pure metal thermocouples, only a single service category for thermocouples could be defined, leaving as a remark which type of thermocouples the uncertainty refers to
- This will reduce the workload at a price of a moderate loss in the level of detail with which the BIPM database presents the calibration and measurement capabilities of the NMIs

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Discussion

- Currently the KCs are testing only the ITS-90 realization, however, with the redefinition of the kelvin in 2019, we should start reflecting on how the kelvin redefinition will affect the way KCs are performed and the way CMCs are classified
- Will separate KCs need to be performed to test primary realizations?
- Will there need to be different CMCs for two different quantities (thermodynamic temperature, T, and international temperature of 1990, T_{90})?

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Any other business ?

- Taking into account time frame of the comparisons, CMCs should have additional information:
  - Is the equipment still the same ?
    - If not additional support with report – paper, to provide evidence and linkage with original comparison
  - Is the location of the laboratory still the same ?
  - Is the staff still the same ?
- New key comparisons to support CMCs
  - New K4 (Al and Ag), new K9 with fixed point cells, not SPRTs
- How to speed up data processing after the measurements ?
  - Good example CCTK7.2021 (TPW)
  - Not too good example CCTK8 (high temperature dew-point)

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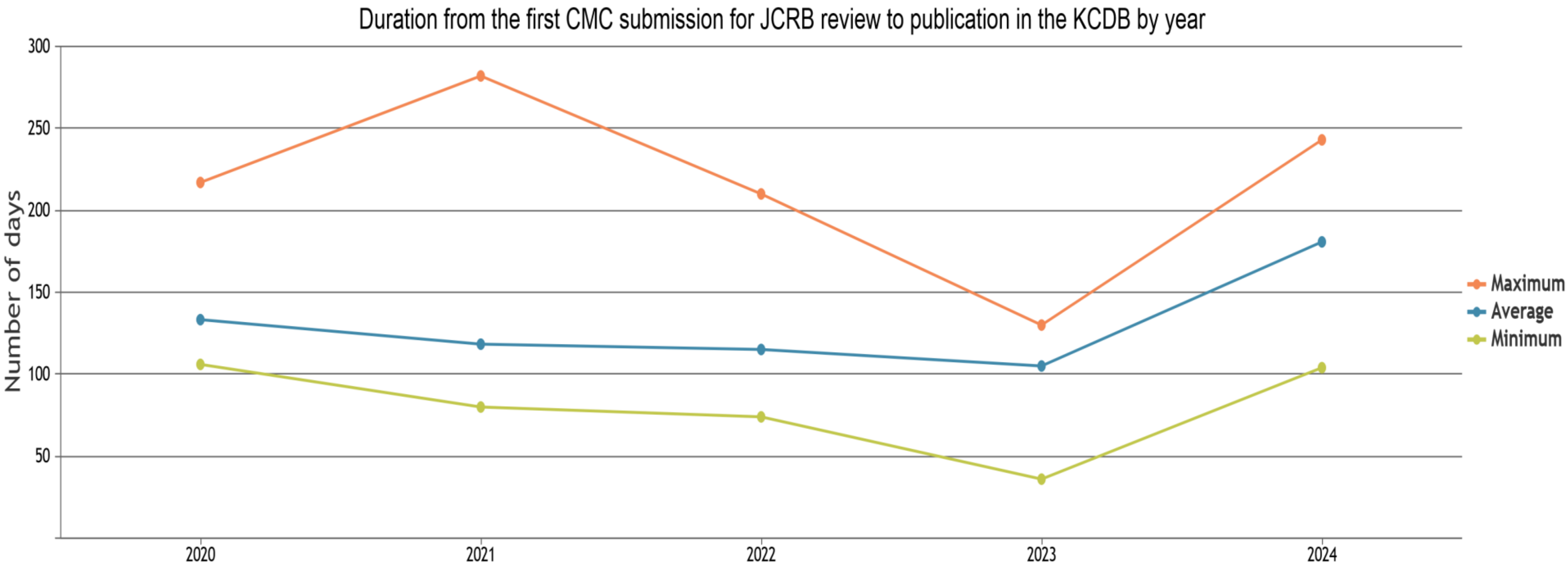
Statistics



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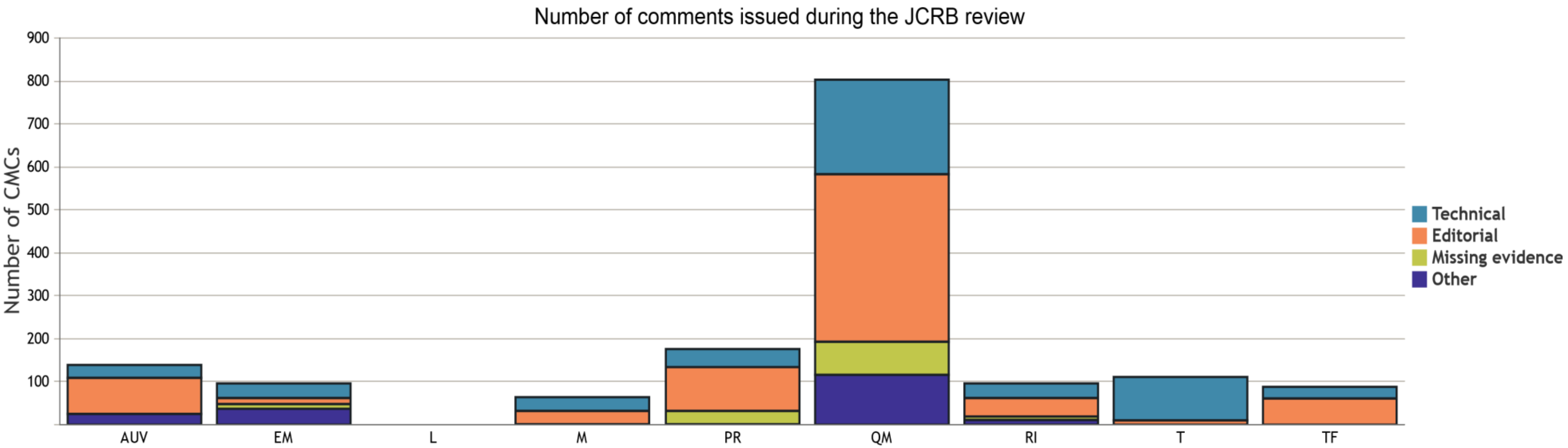
Statistics



Next meeting October 2025, TEMPMEKO 2025, France
Thank you very much