

CCT WG NCTh activity report

Graham Machin
Chair of CCT WG NCTh

CCT 17 November 2020

Introduction

- **Terms of reference of CCT WG NCTh (2017)**
- **Members**
- **Meetings held in period May 2017 to May 2020**
- **Workshop on InGaAs detectors Sep 2018**
- **Task Groups of CCT WG NCTh**
 - Task Group for primary radiometric temperature uncertainties*
 - Task Group for Non-Contact Thermometry CMCs*
 - Task Group for Non-Contact Thermometry HTFP Uncertainties*
 - Task Group for Body Temperature Measurement*
- **Progress with Key comparison KC10**

Terms of reference of WG NCTh I: 2017

- To study and advise the CCT on issues related to thermal radiation and other non-contact methods for temperature measurement.
- Working Group NCTh is tasked with:
 - Reviewing and reporting on measurements of $T-T_{90}$ and fixed points by primary non-contact thermometry
 - Reviewing the research and application of non-contact thermometry primary thermometers to realise the kelvin
 - Coordinate activities related to high-temperature fixed points;
 - Provide appropriate input into the *[mise en pratique for the definition of the kelvin](#)*;

Terms of reference of WG NCTh II: 2017

Provide, where required, updates for [a\) the supplementary information](#) and [b\) approximating techniques](#) for the ITS-90;

Provide definitive guidance, when required, on the use of secondary non-contact thermometry methods (e.g. phosphor, gold-cup thermometry);

Support world-wide efforts in standardization of radiation thermometer and thermal imager testing and calibrations;

Develop appropriate uncertainty budgets for radiation thermometry;

Recommend key comparisons relevant to WG-NCTh to the CCT;

Develop, when required, guidance for measurement best practices in novel non-contact thermometry techniques (e.g. plasma and flame thermometry).

PROPOSAL:

Terms of reference be reviewed for approval by CCT 9 Feb 2021

Members - (As agreed at CCT, May 2017)

- A*STAR (Wang Li), CEM (Maria Jose Martin Hernandez), CENAM (Daniel Cardenas-Garcia), INMETRO (Renato Teixeira), INRIM (Ferruccio Girard), KRISS (Yongshim Yoo), LNE-Cnam (Mohamed Sadli), MSL (Peter Saunders), NIM (Zundong Yuan), NIST (Howard Yoon), NMIA (Eric van der Ham), NMIJ (Yoshiro Yamada), NPL (Graham Machin, chair), NRC (Andrew Todd), PTB (Joerg Hollandt), UME (Humbet Nasibli), VNIIM (Mikhail Matveyev)
- Co-opted members: NIM (Pieter Bloembergen), Tiejun Wang (NIM), NPL (Helen McEvoy), PTB (Klaus Anhalt), VNIIOFI (Boris Khlevnoy)
- Observers: Efrem Ejigu (NMISA)

Members - (Changes)

- **Membership changes**

- Nao Sasajima replaces Yoshiro Yamada on his retirement (NMIJ)

- Lenka Kňazovická joined as the first representative of CMI

- Xiaofeng Lu (NIM) was co-opted as leader of BTM KC

Meetings held

- **Four meetings held in period May 2017 to Nov 2020**
 - 31st May 2017 at BIPM, Paris
 - 5th Sep 2018 at IMEKO World Congress, Belfast, UK
 - 14th Jun 2019 at Chengdu, China, Tempmeko 2019
 - 15th Oct 2020 web based
- **In addition, two meetings related to the new TG Body Temperature measurement were held**
 - 7 July 2020 Initiation of TG
 - 25 Sep 2020 sub-TG leaders progress review meeting

WG NCTh Technical workshop: 5 Sep 2018

- **The use of InGaAs detectors in radiation thermometry and radiometry**
- The presentations were:
 - CEM: Testing irradiance and radiance methods for absolute radiation thermometry based on InGaAs detectors in the NIR at CEM/CSIC.
 - PTB: Status of the InGaAs detector based absolute thermometry at PTB.
 - NIST: Thermodynamic measurements of Zn and Al freezing temperatures using an InGaAs based near infrared radiation thermometer 3 (NIRT3).
 - CNAM: Progress thermodynamic assignment to the Zn, Al and Ag points.
- The presentations can be found at:
<https://www.bipm.org/wg/CCT/CCT-WG-NCTh/Restricted/welcome.jsp>

Task Groups of CCT WG NCTh

- There are four task groups of the WG, each have a specific time limited task.

NCTh Task Group for primary radiometric temperature uncertainties

Task group led by Peter Saunders (MSL)

CCT NCTh Task Group for Non-Contact Thermometry CMCs

Chaired by Yoshiro Yamada (NMIJ) preparing a revision of the Radiation Thermometry CMC Review Protocol for approval by the CCT WG-CMC

CCT NCTh Task Group for Non-Contact Thermometry HTFP Uncertainties

Chaired by Andrew Todd (NRC) objectives are: Construct comprehensive list of uncertainty components for determining T of HTFPs and their use as thermodynamic temperature references (or artefacts); categorize the items as either *well specified* or as *requiring further investigation*

CCT NCTh Task Group for body temperature measurement

Chaired by Graham Machin (NPL)

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CCT NCTh Task Group for body temperature measurement

Currently chaired by Graham Machin (NPL)

NCTh Task Group for primary radiometric temperature uncertainties

- Work began by Emma Woolliams (NPL) subsequently led to successful outcome by Peter Saunders (MSL)
- Monumental 69 page document detailing all aspects of uncertainty estimation in radiometric temperature measurement
- Final version of document released June 2018, incorporated into the *MeP-K-19* and TG disbanded

CCT-WG-NCTh

Uncertainty Estimation in Primary Radiometric Temperature Measurement

Authors: Peter Saunders, Emma Woolliams, Howard Yoon, Andrew Todd, Mohamed Sadli, Eric van der Ham, Klaus Anhalt, Lutz Werner, Dieter R. Taubert, Stephan Briaudeau, Boris Khlevnoy
June 2018

CCT NCTh Task Group for Non-Contact Thermometry CMCs

- Task Group led by Yoshiro Yamada (NMIJ) to revise the Radiation Thermometry CMC Review Protocol
- Members: M. Sadli (CNAM), X. Lu (NIM), K. Anhalt (PTB), A. Todd (NRC), B. Khlevnoy (VNIIOFI), M. Matveyev (VNIIM), J. Bojkovski (UL, WG-CMC Chair)
- “CLASSIFICATION OF SERVICES IN THERMOMETRY” revised to include T and ITS-90 dissemination by HTFPs
- T realization and dissemination through three routes:
 - absolute* primary thermometry, *relative* primary thermometry by HTFPs
 - conversion* from ITS-90 to T apply CCT authorized correction function
- Revised Protocol approved by CCT WG-CMC Oct. 2019
- <https://www.bipm.org/utils/common/pdf/CC/CCT/CMC-RP-03-Radiation-thermometry.pdf> (open)
- TG disbanded end 2019

CCT NCTh Task Group for Non-Contact Thermometry HTFP Uncertainties

- TG led by Andrew Todd (NRC) objectives were: Construct comprehensive list of U components for determining T of HTFPs and their use as T references; categorize items as *well specified* or as *requiring further investigation*
- **Members:** A.Todd (NRC), K. Anhalt (PTB), P. Bloembergen (NIM), B. Khlevnoy (VNIIOFI), D.H. Lowe (NPL), G. Machin (NPL), M. Sadli (LNE-Cnam) and N. Sasajima (NMIJ)
- Work complete Sep '18 and disbanded, paper reporting findings presented at Tempmeko '19 and recently submitted to *Metrologia*

CCT NCTh Task Group for Non-Contact Thermometry HTFP Uncertainties

- Two outstanding issues identified:

Furnace effect, now thought to be due to low angle emissivity in blackbodies (*YY Meas. Sci. Tech.* 2020)

Determine HTFP thermodynamic temperatures; Fe-C, Pd-C, Ru-C, WC-C (In progress EMPIR Real-K '20-'23)

Related to HTFPs: New low uncertainty values for:

Co-C (1597.48 (0.07)) K

Pt-C (2011.50 (0.11)) K

Re-C (2747.91 (0.22)) K

Published in *Metrologia* **54** 390-398 (Lowe *et al* 2017)

background text of MeP-K-19 updated to include these values

CCT NCTh Task Group on Body Temperature Measurement

- *CCT NCTh Task Group for body temperature measurement: Chaired by Graham Machin (NPL)*
- The CCT President, and CCT Strategy WG, established a Task Group for body temperature measurement (TG BTM)
- TG under CCT WG for Non-Contact Thermometry
- The initial focus will be to improve non-contact body temperature measurement (ear, forehead, thermal imaging)

Purpose

- The task groups purpose is to establish reliable clinical thermometry on a global basis

CCT TG Body Temperature Measurement

- Its objectives are:

- Lead a key comparison of calibrators for body temperature thermometers (ear/forehead/thermal imagers) – (Xiaofeng Lu, NIM, China)

- Collect and consolidate current best practice/standards of body temperature scanning in a) health services b) airport and other screening around the world (Igor Pusnik, UL, Slovenia)

- Collect current best practice of body temperature measurement and develop a definitive summary of the main body temperature measurement approaches (Maria-Jose Martin, CEM, Spain)

- Review standards and work with appropriate standardisation bodies (e.g. ISO/IEC) concerned with producing standards for body temperature measurement devices – (Wang Li, NMC A*Star, Singapore)

- The TG, in collaboration with the RMOs, will establish a forum of users and suppliers/manufacturers of body temperature measurement devices to identify the problems and develop practical solutions and establish appropriate links to the World Health Organisation – (Dolores del Campo, Euramet TCT Chair)

CCT TG Body Temperature Measurement

- Actions to date:
- Agree groups initial terms of reference (12 June 2020)
- Hold inaugural meeting (7 July 2020)
- Establish four+one sub-Task Groups
- Progress review meeting with sub-TG chairs (18 Sep 2020)
- Report to CCT on progress (October 2020)

CCT TG Body Temperature Measurement

- External engagement:

Invited keynote to APMP webinar “Challenges of use of IR in public health” July 2020

Publish letter *Thermology International* announcing TG

Machin, G., Lu, X., del Campo, D., Martin, M-J, Pusnik, I., Li, W., “**Letter: Global initiative to improve infra-red based body temperature measurements**”, *Thermology Int.*, **30**, p. 96, (2020)

Gave invited talk about the TG to UK Medicines and Healthcare products Regulatory Agency (MHRA) Sep 20

Wrote guest editorial blog for European Association of Thermology website <http://www.eurothermology.org/news.html>

Questionnaire circulated to all RMO TCTs about current practice re body temperature measurement

CCT TG Body Temperature Measurement

- Next steps to end 2021
- Prepare advanced drafts of GPGs ear, forehead, thermal imaging by end of 2020
- Elicit comments on GPGs from clinical community
- Prepare one-page GPGs for clinical use, with estimates of uncertainty
- Prepare final versions of GPG to encompass all three modalities
- Grow engagement with standards committees – TG members please join (WL)
- Initiate KC of ear thermometer calibrators – Spring '21

- Comparison of ITS-90 realisations from 962 °C to 3000 °C
- Will be used to justify radiation thermometry CMCs: previous key comparison had large uncertainties and did not extend above 1700 °C
- Comparison artefacts are:
 - two transfer radiation thermometers
 - HTFP blackbody cells: Ni-C and Co-C (~1330 °C, both doped to introduce some element of blindness), Ru-C (1953 °C), WC-C (2750 °C)
 - transfer Cu fixed point (for drift checks)

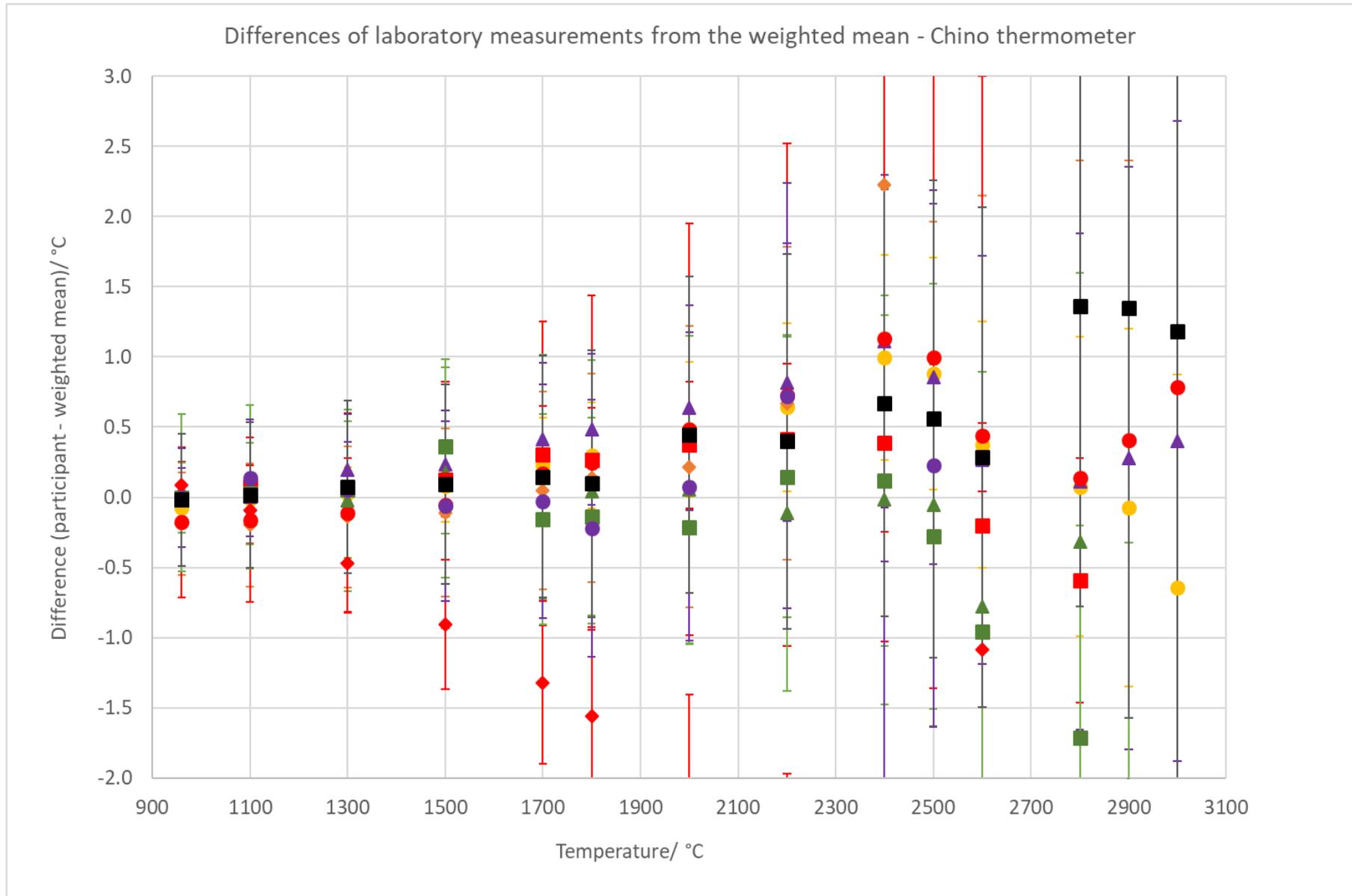
Participants and progress

Region	Laboratories	Status
APMP	NMIJ, NIM, KRISS	✓
SIM	NIST, NRC	✓
COOMET	VNIIM	✓
EURAMET	NPL, CEM, PTB, LNE-Cnam	✓

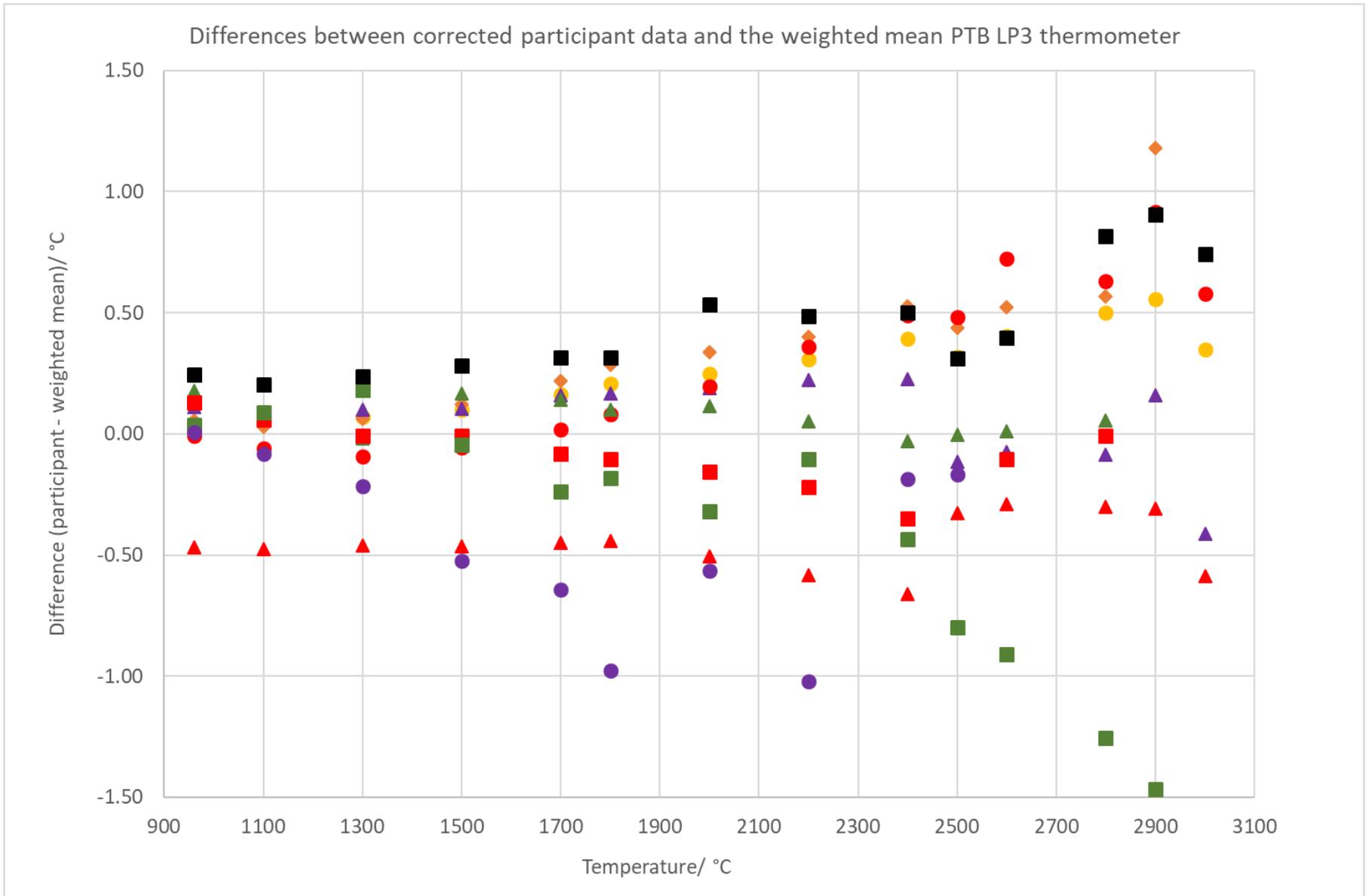
All measurements complete

Draft A in advanced state of WG discussion

Participant results – Chino

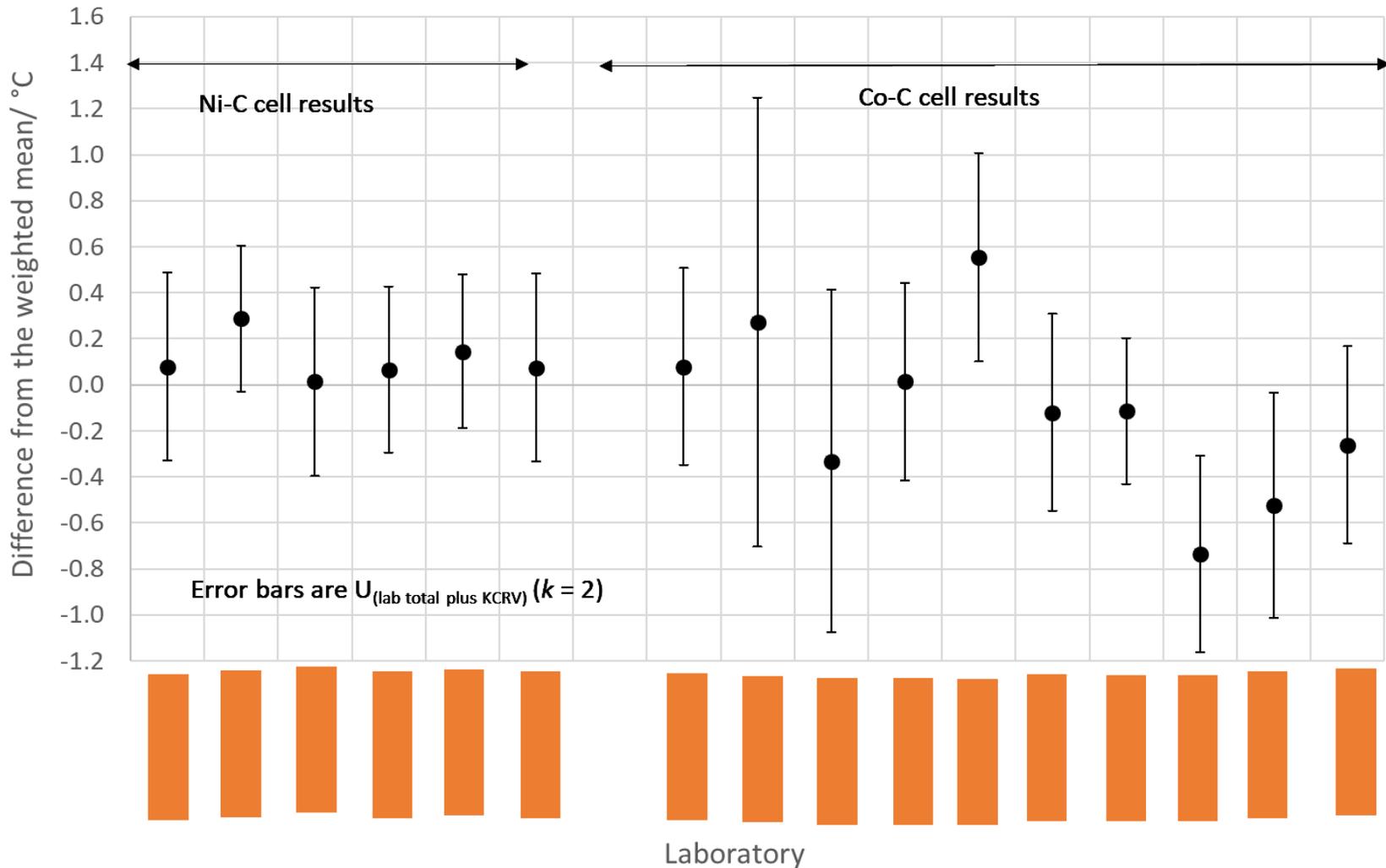


Participant results – LP3



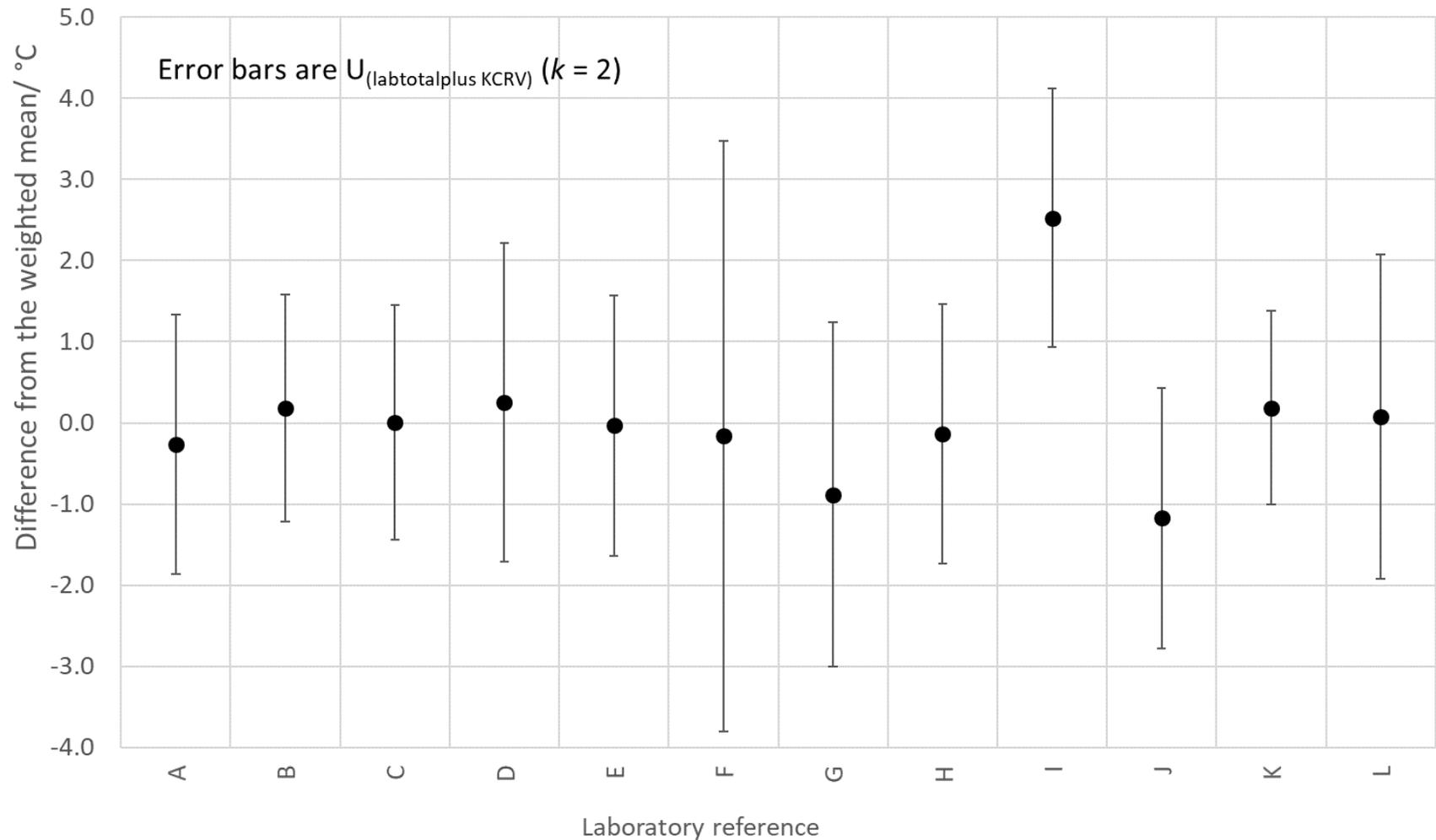
Results – Ni-C-X and Co-C-X cells (melting transition ~1325 °C/ 1328 °C)

The comparison of the measurements of the Ni-C and Co-C cells



Results – WC-C cells (melting transition 2747 °C)

Comparison measurements of WC-C cells - outlier not in weighted mean



Conclusions and Next steps

- Drift in the transfer thermometers required significant corrections to be applied to the results but still good agreement up to 3000 °C, within uncertainties
- Agreement with the HTFPs was better, within $\pm 1^\circ\text{C}$ at $\sim 2750^\circ\text{C}$
- Comments on the Draft A report have been received from the participants
- Analysis and report will be modified in the light of the comments
- Draft B report will be prepared, planned completion is December 2020

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