# Report of the CCM Working Group on Gravimetry

Shuqing WU ( NIM, China) and Vojtech Palinkas (VÚGTK, Czechia)

20th CCM meeting, 26-27 June 2025

# WG Meetings

*meetings held since the 19th CCM meeting & future meetings*

**1、26th September 2024, Online - organized by BIPM, 14 Participants (13 CCM-WGG members, 1 invited/observers )**

**This CCM-WGG meeting focused on the discussion on Draft B of CCM.G-K2.2023 Key Comparison. Finally, CCM-WGG recommended the approval of Draft B and CCM approved the Final Report of CCM.G-K2.2023 KC in 2024.**

# WG Meetings

*meetings held since the 19th CCM meeting & future meetings*

**2、23th June 2025, hybrid meeting at BIPM, 21 Participants (16 CCM-WGG members, 5 invited/observers )**

**This CCM-WGG meeting discussed the published CMC, necessity to harmonize the the terminology, needs to prepare guidelines and statements of CCM WGG and to prepare a call for next KC in 2029. Further, reports on instrumentation and application of gravimetry have been discussed.**

**Next CCM-WGG meeting will be held online in 2026. It will decide the pilot lab and host site of the next CCM KC of absolute gravimeter in 2029.**

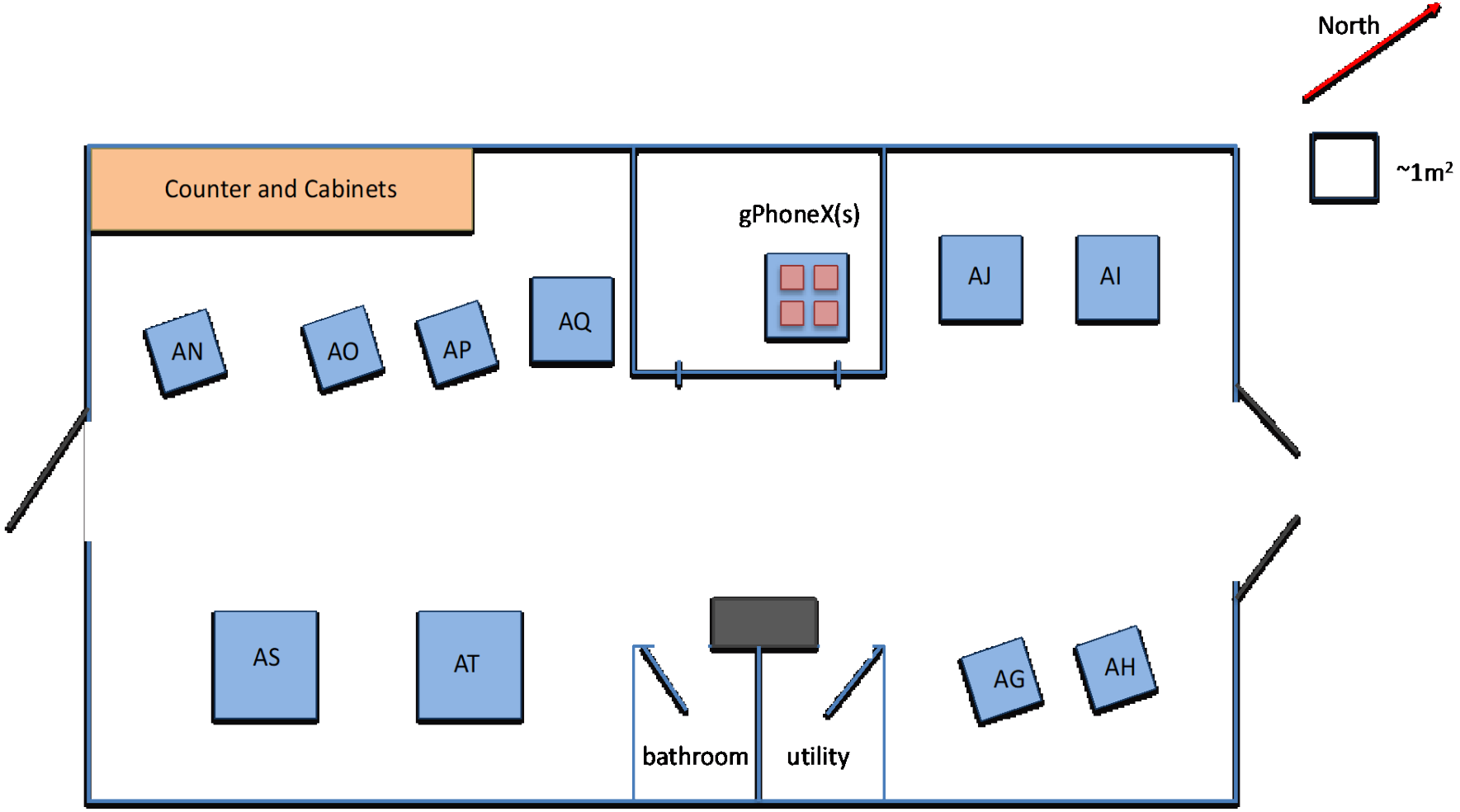
# Main actions and achievements

*main actions and achievements since the 19th CCM meetings*

## CCM.G-K2.2023 Key Comparison and Additional Comparison

**Hosted by NIST (Boulder, Colorado,USA) between August and September, 2023. In total, 30 absolute gravimeters from 27 institutes participated, including 2 atom gravimeters. 15 institutes were NMI or DI.**

# Main actions and achievements




Schematic of the gravity piers. AK have been permanently occupied by three gPhoneXs, and only piers AG, AH, AI, AJ, AO, AQ, AS, and AT were used in the comparison

# Main actions and achievements

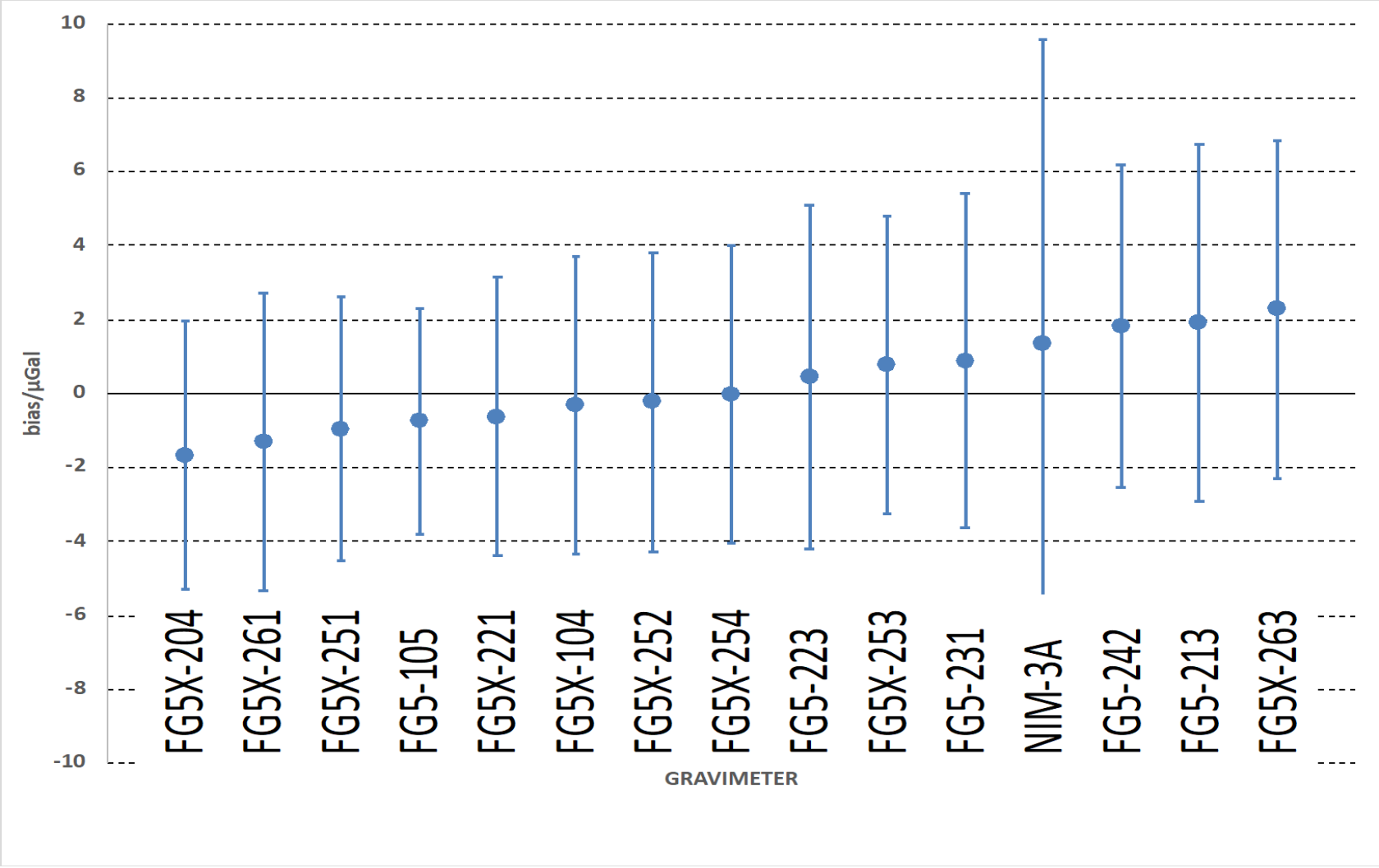
**30 instruments**

- **27 FG5/FG5X**
- **1 NIM-3A**
- **2 atom**

# Main actions and achievements

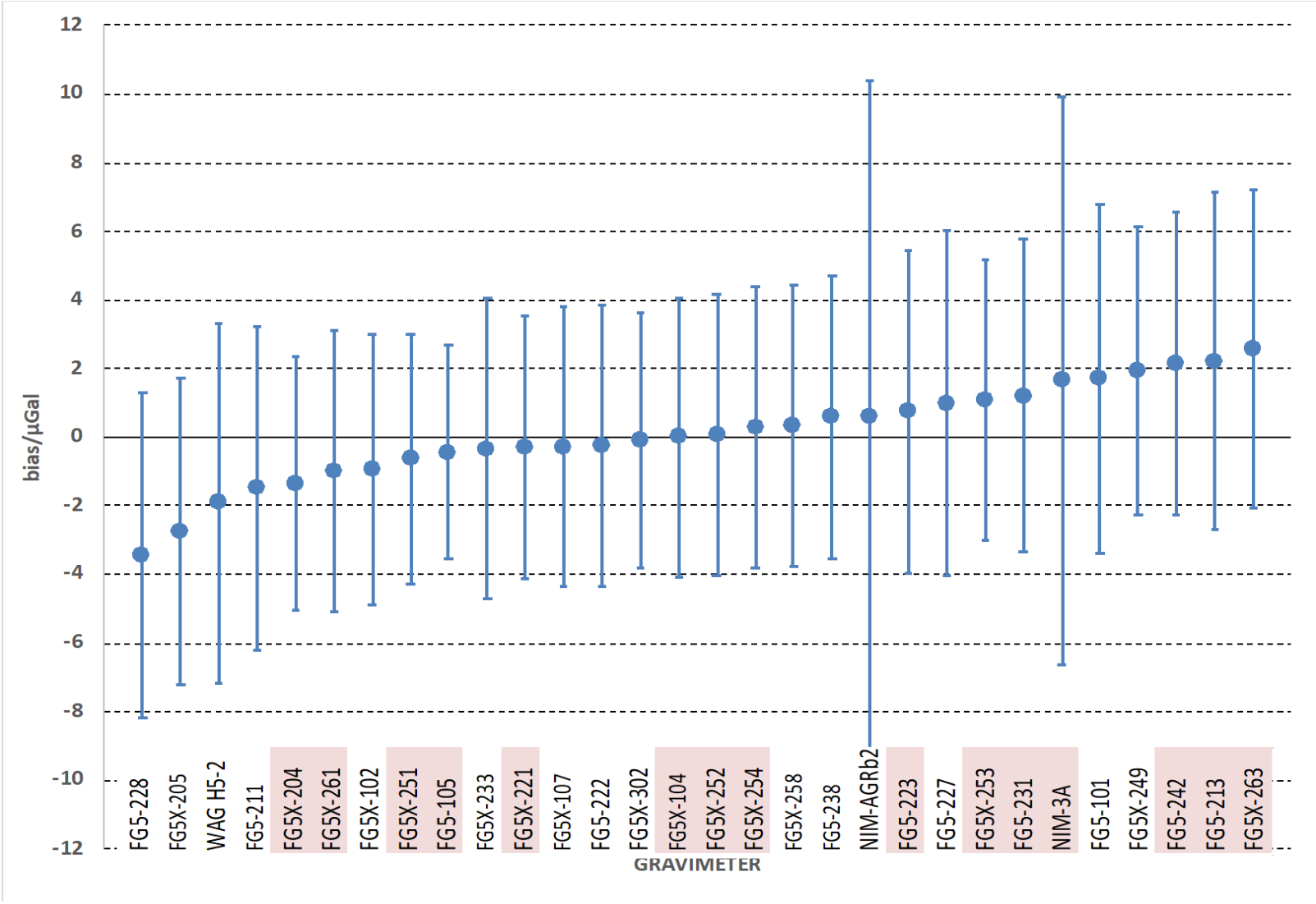

**2 atom gravimeters were both from China, one was from NIM China the other was from Chinese Academy of Sciences.**

# Main actions and achievements




**For the KC part, all the 15 NMI or DI instruments showed excellent agreement.**

# Main actions and achievements




**For the KC+Additional Comparison, all the 30 instruments showed excellent agreement.**

# Main actions and achievements


# Main actions and achievements

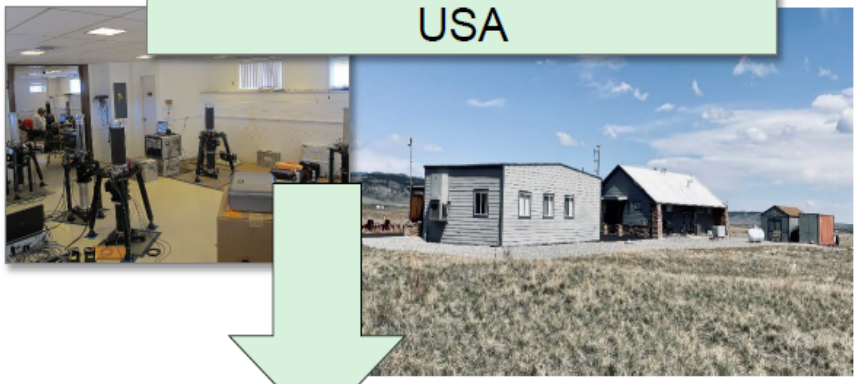
**RMO Comparison link to CCM.G-K2.2023**

**APMP and SIM has no need,because all the instruments from NMI or DI participated in CCM.G-K2.2023 directly.**

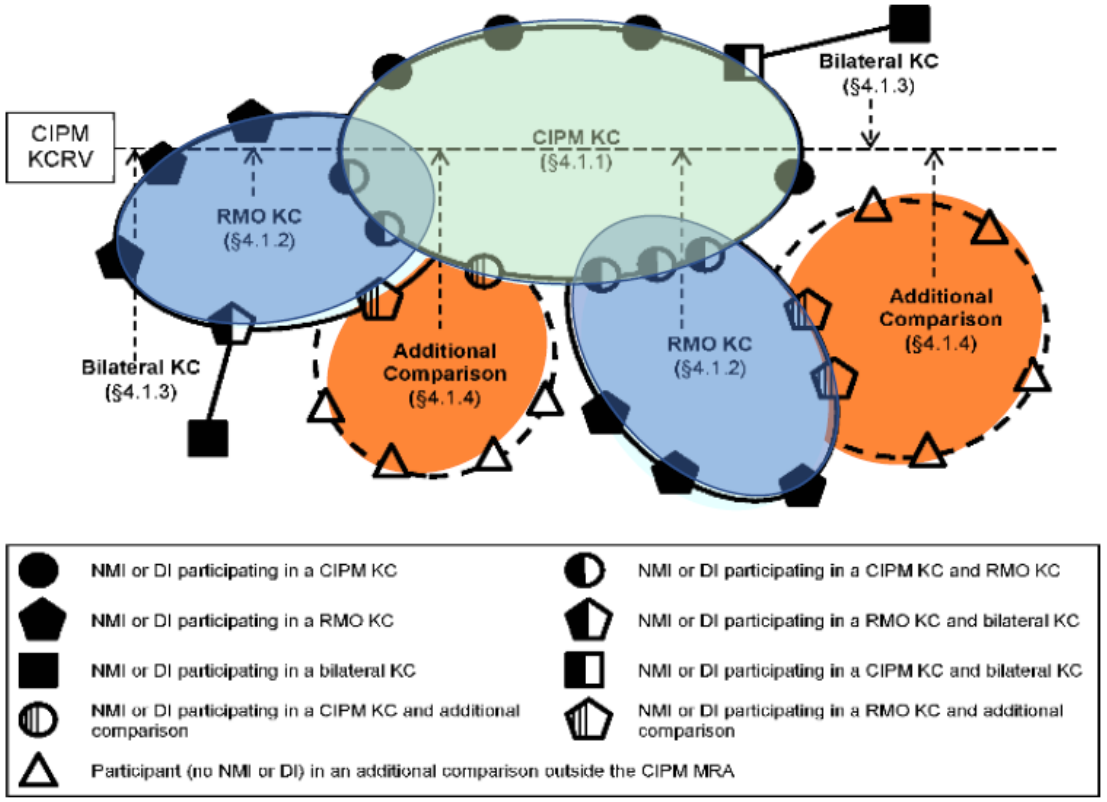
**EURAMET comparison of absolute gravimeters registered as EURAMET.M.G-K2.2023 – pilot institute VÚGTK (Czechia) and host site at Geodetic observatory Wettzell (BKG, Germany). All measurements realized in 2024, Draft B presented in June 2025.**

# Main actions and achievements

**CIPM comparison 2023**
CCM.G-K2.2023
Table Mountain, Boulder, CO, USA

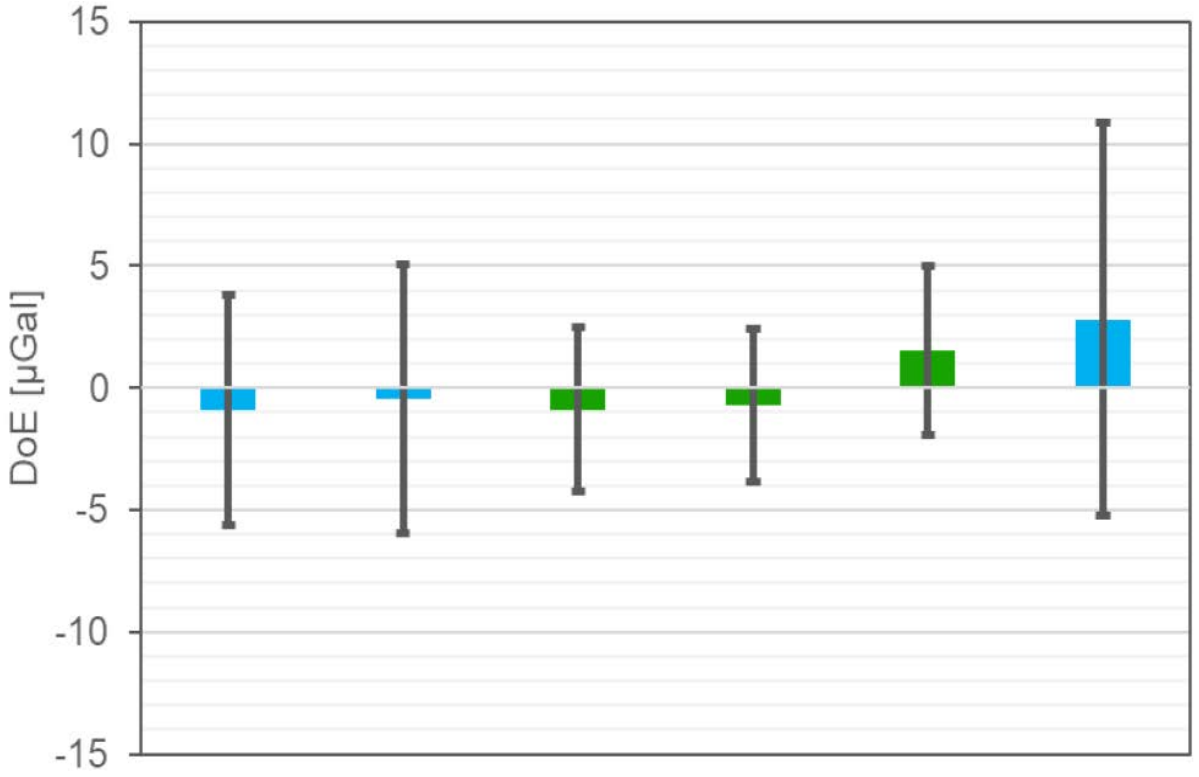


**RMO Europe 2024**
EURAMET.M.G-K2.2023
Wettzell, Germany




Scheme for Key Comparisons and other comparisons

# Main actions and achievements




| Country | Institution | Gravimeter | NMI or DI | CCM.G-K2.2023 |
|---|---|---|---|---|
| EURAMET.M.G-K2.2023 | | | | |
| Czech Republic | Research Institute of Geodesy, Topography and Cartography (VÚGTK/RIGTC), Zdiby | FG5X-251/HS5 | YES | YES |
| Finland | Finnish Geospatial Research Institute (FGI), National Land Survey of Finland (NLS), Helsinki | FG5X-221 | YES | YES |
| France | LNE-OP / LTE, Paris (EOST, Strasbourg) | FG5X-206 | YES | NO |
| Germany | PTB, Braunschweig | FG5X-263 | YES | YES |
| Italy | Istituto Nazionale di Ricerca Metrologica (INRIM), Torino | IMGC-02 | YES | NO |
| Switzerland | METAS, Wabern | FG5X-209 | YES | NO |

**3 gravimeters established the link. All the gravimeters participating in EURAMET.M.G-K2.2023 Key Comparison are in equivalence.**

# Main actions and achievements

## Two Guidance documents

1、The CCM-WGG Guidance document of “Note for comparisons of absolute gravimeters” has been accepted in CCM-WGG meeting and published on the website of BIPM.

2、 The document of “Guidelines for Submission and Review of gravity acceleration CMCs” has been discussed in CCM-WGG meeting and is under preparation.

# Progressing the state of the art

Absolute gravimeters based on laser interferometry, particularly FG5/FG5X gravimeters are the most accurate: A set of newly determined corrections (signal distortion and dispersion, Coriolis, verticality) might be associated with measurements, which improve the uncertainty slightly below 2 µGal.

Absolute gravimeters with cold-atom sensors（ Quantum Technology ）

Quantum gravity gradiometer ( can simultaneously determine g and its vertical gradient) was developed in LNE France and NIM China.

# Liaison & stakeholders

Continuous cooperation with International Association of Geodesy (IAG).

IAG SC 2.1: Land, Marine and Airborne Gravimetry
IAG JWG 2.1.1: Establishment of International Gravity Reference System and Frame
IAG WG Q.1: Quantum gravimetry in space and on ground

Continuous cooperation with IMEKO TC3 (Force,Mass,Torque and gravity)

Ensure traceability to the International System of Units (SI) for gravimetry

# CIPM MRA: KCs & CMCs

*Please provide an update of status and identification of any issues/highlights/lessons learned*

**CMCs on gravity acceleration should be increased and covered all the RMOs. Up to now, we only have two kinds of CMCs related to absolute gravimeters and all the number of CMCs is only fourteen...( Cover five RMOs, which are APMP, EURAMET, SIM, ULFMET, COOMET )**

# CIPM MRA: KCs & CMCs

| NO. | Country | Measurement method | Uncertainty (*k*=2) | Approved date |
|---|---|---|---|---|
| 1 | Austria | Free-fall experiment | 10 µGal | 2001-10-21 |
| 2 | Finland | Free-fall experiment | 8 µGal | 2007-01-03 |
| 3 | Italy | Free-fall experiment | 15 µGal | 2007-01-03 |
| 4 | Switzerland | Free-fall experiment | 8 µGal | 2008-07-02 |
| 5 | Ukraine | Free-fall experiment | 20 µGal | 2017-06-21 |
| 6 | Mexico | Free-fall experiment | 4.8 µGal | 2020-04-01 |
| 7 | Czech Rep. | Free-fall experiment | 4.4 µGal | 2020-09-15 |
| 8 | Czech Rep. | Comparison against a gravity value of a reference station | 6.0 µGal | 2020-09-15 |

# CIPM MRA: KCs & CMCs

| NO. | Country | Measurement method | Uncertainty (*k*=2) | Approved date |
|---|---|---|---|---|
| 9 | Korea | Free-fall experiment | 5.0 μGal | 2023-08-29 |
| 10 | Italy | Free-fall experiment | 11.0 μGal | 2023-09-28 |
| 11 | Thailand | Free-fall experiment | 10.0μGal | 2024-06-28 |
| 12 | Thailand | Comparison against a gravity value of a reference station | 180.0 μGal | 2024-06-28 |
| 13 | China | Comparison against a gravity value of a reference station | 4.0μGal | 2024-06-28 |
| 14 | China | Free-fall experiment | 10.0 μGal | 2024-07-30 |

# Program of work for the next 2 years

1、Improvement of CMCs ( increase number of CMCs and update technical specifications)

2、Publishing Guidelines on CMCs, statements on the evalutaion of key comparisons

3、Digital calibration certificates of gravimeters

# Program of work for the next 2 years

4、Resolving the possible systematic difference between classical and atomic absolute gravimeters at comparisons (pilot studies)

5、Validation and calibration of gravimeters based on different technologies at reference stations of the International Gravity Reference System/Frame

# Proposals (KCs, chairmanship, membership..)

No change in CCM-WGG chairmanship

Chair: Shuqing WU, NIM, China

Vice-chair: Vojtech Palinkas, VÚGTK – Czechia

CCM-WGG has two kinds of membership (institute and personal experts)

Institute: LGUL (Luxembourg), discard (no further activity in gravimetry)

PTB (Germany), as new member

Personal experts : Dr. Reinhard Falk (BKG, Germany) - retirement

Dr. Hartmut Wziontek (BKG, Germany), as new member

# Thank you.

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