# Consultative Committee for Thermometry: CCT K9, SPRT calibration from the Ar TP to the Zn FP


**NIST contributors:**

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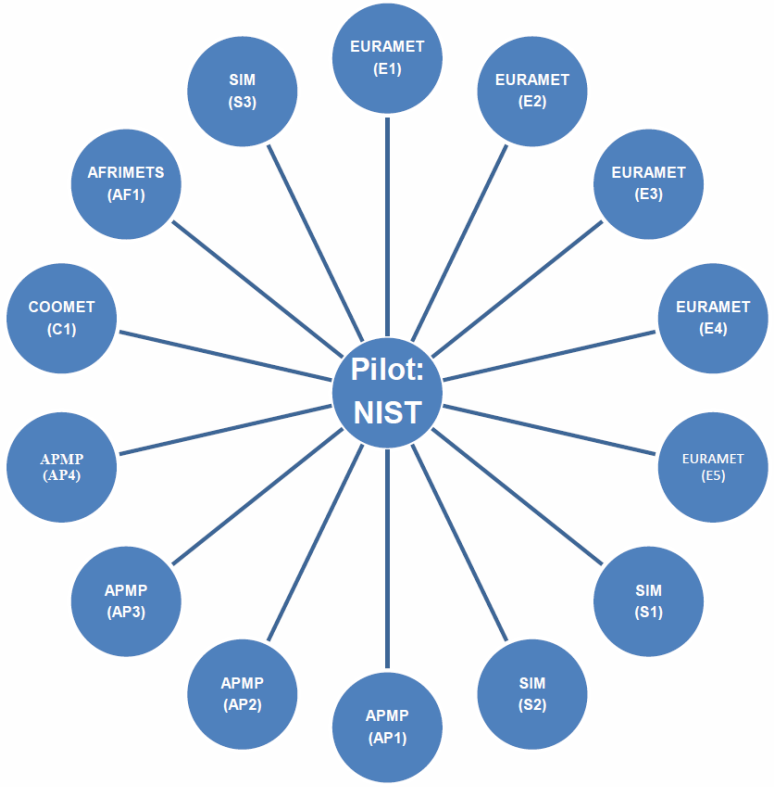
CCT/20-30

# Key Comparison 9:
# SPRT calibration from the Ar TP to the Zn FP

**Key Comparison 9 Protocol**

**ITS-90 SPRT Calibration from the Ar TP to the Zn FP**

**Method:** Collapsed Star




**Objective:** This comparison is designed to compare the realization of the ITS-90 through the calibration of SPRTs. The range of temperature covered in this comparison is from the triple point of Ar (83.8058 K) to the freezing point of Zn (692.677 K). The transfer standards used will be long-stem SPRTs.

## Projected Timeline:

| | | |
|---|---|---|
| Protocol Agreement | January 31, 2011 | 2011-2015 |
| Transfer Standards Sent to NIST | ~~March 31, 2011~~ | |
| Transfer Standards Returned to NMIs | ~~September 30, 2011~~ | 2012-2015 |
| Transfer Standards Re-Measured by NMIs | ~~December 31, 2011~~ | 2012-2015 |
| Draft A Report Completed | ~~March 31, 2012~~ | 2020 |

Toby joined NIST thermometry team

CCT-K9 meeting held on 17-09-2020, Draft A achieved

# Measurement Protocol

- 2 ITS-90 calibrated SPRTs
  - NMI participant will select their own SPRTs based on their own criteria for suitability and will convey the selection criteria to the Pilot Laboratory
  - SPRTs must be calibrated by NMI participant before measurements are made by the pilot and then again on return from the pilot
  - SPRTs are to be measured at every available fixed-point over the range of the comparison including the In FP and Ga MP
  - The calibration of SPRTs by an NMI participant is to be performed by either fixed-point cells or by comparison with an ITS-90 calibrated reference SPRT

# Participating NMIs

**NMI Participants:**

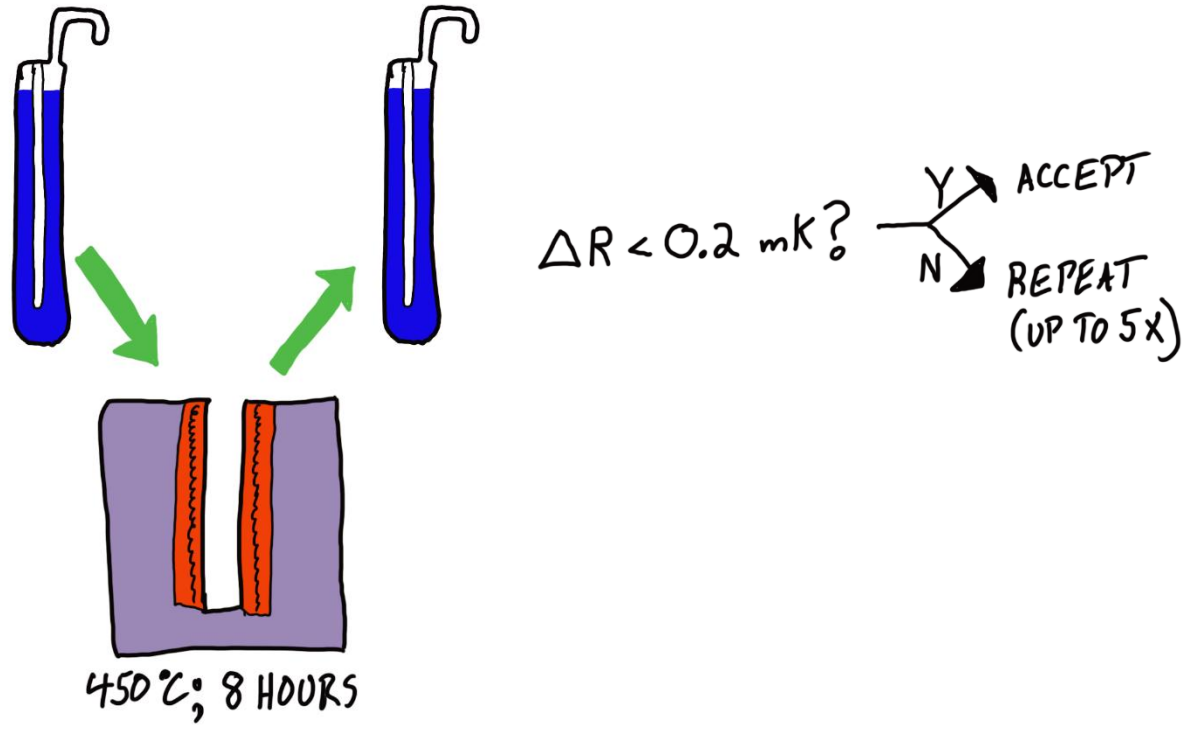
| | |
|---|---|
| Pilot: | NIST, Gregory Strouse, gstrouse@nist.gov |
| AFRIMETS: | NMISA, Hans Liedberg, hliedber@nmisa.org |
| APMP: | KRISS, Inseok Yang, iyang@kriss.re.kr |
| APMP: | NIM, Jianping Sun (孙建平), sunjp@nim.ac.cn |
| APMP: | NMIJ, Jun Tamba, j-tamba@aist.go.jp |
| APMP: | NMIA, Kim Nguyen, kim.nguyen@measurement.gov.au |
| COOMET: | VNIIM, Anatoly Pokhodun, a.i.pokhodun@vniim.ru |
| EURAMET: | NPL, Helen McEvoy, helen.mcevoy@npl.co.uk |
| EURAMET: | VSL, Andrea Peruzzi, aperuzzi@vsl.nl |
| EURAMET: | PTB, Joachim Fischer, joachim.fischer@ptb.de |
| EURAMET: | INRIM, Peter Steur, p.steur@inrim.it |
| EURAMET: | LNE-INM/CNAM, Yves Hermier, hermier@cnam.fr |
| SIM: | INMETRO, Renato Nunes Teixeira, rnteixeira@inmetro.gov.br |
| SIM: | INTI, Javier Skabar, jskabar@inti.gob.ar |
| SIM: | NRC, Ken Hill, ken.hill@nrc-cnrc.gc.ca |

**Attendance at Sept. 17, 2020 Meeting**

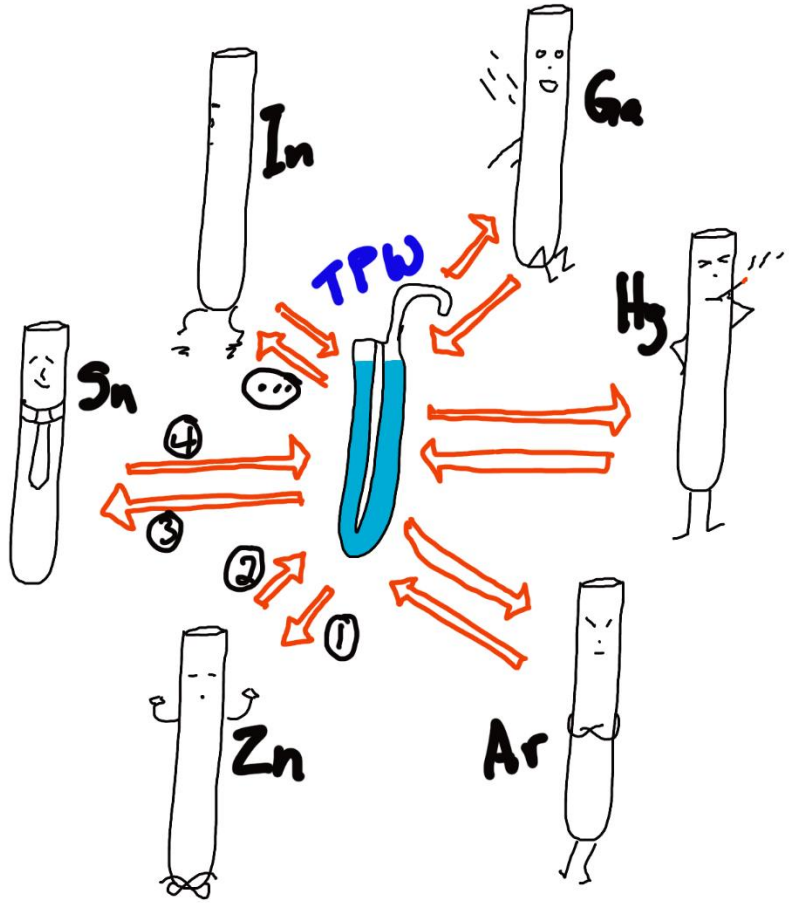
Tobias Herman (NIST),
Giuseppina Lopardo (INRiM),
Javier Garcia Skabar (INTI),
Fernando Sparasci (LNE/CNAM),
Inseok Yang (KRISS),
Jintao Zhang (NIM),
Jianping Sun (NIM),
Eric vd Ham (NMIA),
Mong-Kim Ho (NMIA),
Tohru Nakano (NMIJ),
Jonathan Pearce (NPL),
Sergey Dedyulin (NRC),
Steffen Rudtsch (PTB),
Victor Fuksov (VNIIM),
Conny Barendregt (VSL),
Gijs Snijders (VSL),
Andrea Peruzzi (CCT WG-KC chair).

# Measurement Scheme at NIST

**Stabilize**




**Measure**



# Cutoff criteria and SPRTs rejected

*Which SPRTs will contribute to the KCRV?*

## Criterion 1

$$\left| \frac{W_i^{Post} - W_i^{Ante}}{(dW_r/dT)\sqrt{u_R^2\left(W_i^{Post}\right) + u_R^2\left(W_i^{Ante}\right)}} \right| > t_{0.975,\nu_{eff}}$$

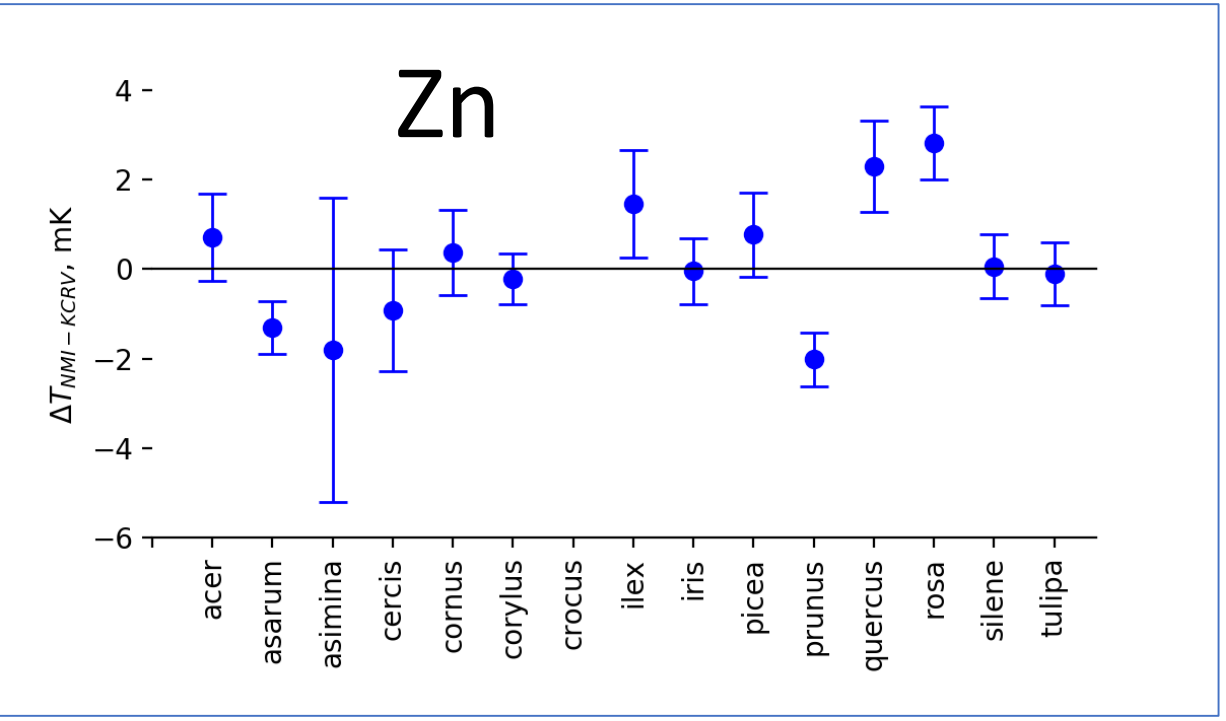
## Criterion 2

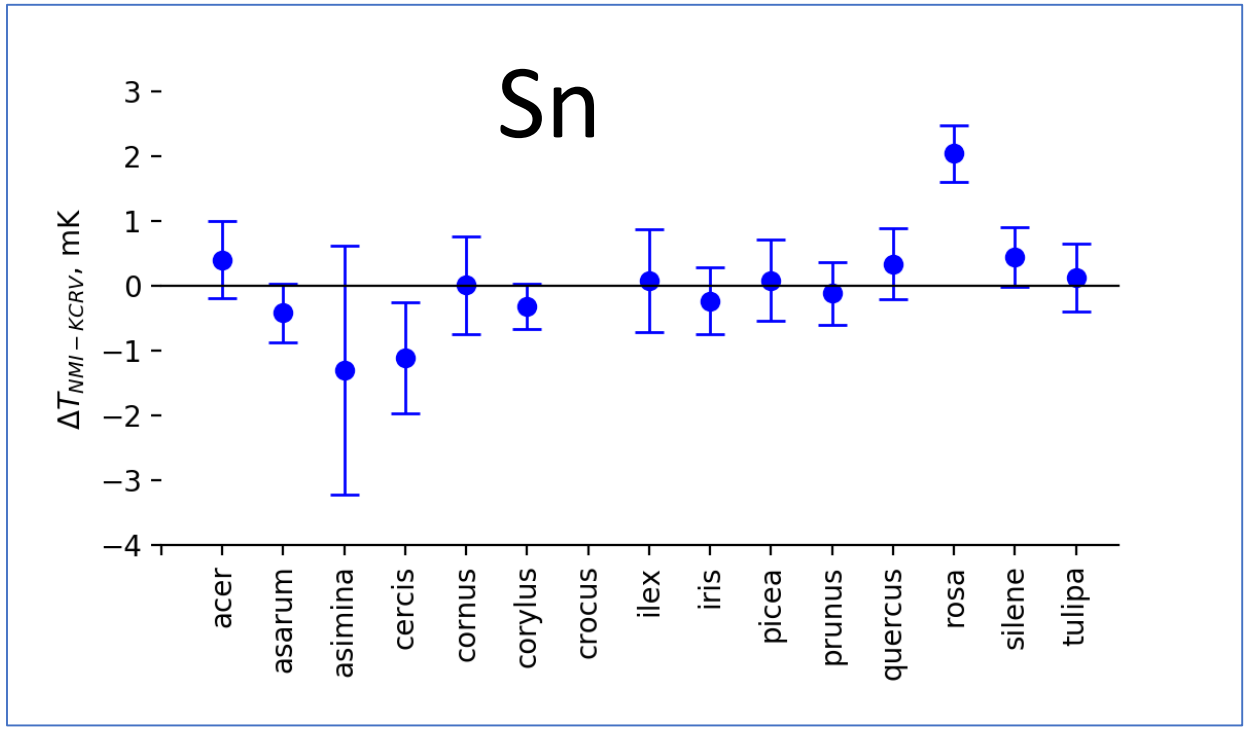
$$u(C_i) = \frac{1}{2\sqrt{3}} \frac{\left|W_i^{Post}(FP) - W_i^{Ante}(FP)\right|}{(dW_r(ITS-90)/dT)}$$

$$u^2(C_i) \geq \frac{u^2(\Delta T_{NMI_i})}{10}$$

| NMI | | Zn | | Sn | | In | | Ga | | Hg | | Ar | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *I* | II | *I* | II | *I* | II | *I* | II | *I* | II | *I* | II |
| acer | SPRT1 | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ | ✗ | ✗ |
| | SPRT2 | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ |
| asarum | SPRT1 | ✗ | ✓ | ✗ | ✗ | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ |
| | SPRT2 | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ |
| asimina | SPRT1 | – | – | – | – | – | – | – | – | ✓ | ✗ | ✓ | ✓ |
| | SPRT2 | ✗ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | ✓ | ✓ |
| cercis | SPRT1 | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | SPRT2 | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| cornus | SPRT1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | SPRT2 | – | – | – | – | – | – | – | – | – | – | – | – |
| corylus | SPRT1 | – | – | – | – | – | – | – | – | – | – | – | – |
| | SPRT2 | – | – | – | – | – | – | – | – | – | – | – | – |
| | SPRT3 | – | – | – | – | – | – | – | – | – | – | – | – |
| crocus | SPRT1 | – | – | – | – | – | – | ✓ | ✓ | – | – | – | – |
| | SPRT2 | – | – | – | – | – | – | ✓ | ✓ | – | – | – | – |
| ilex | SPRT1 | – | – | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ |
| | SPRT2 | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ |
| iris | SPRT1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | SPRT2 | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| picea | SPRT1 | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ |
| | SPRT2 | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| prunus | SPRT1 | ✓ | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | SPRT2 | ✓ | ✓ | ✓ | – | ✓ | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ |
| quercus | SPRT1 | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ |
| | SPRT2 | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ | ✗ | ✗ |
| rosa | SPRT1 | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ | ✗ | – | – | – | – |
| | SPRT2 | ✗ | ✓ | ✓ | ✓ | ✗ | ✓ | ✗ | ✗ | – | – | – | – |
| silene | SPRT1 | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ |
| | SPRT2 | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| tulipa | SPRT1 | ✗ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ | ✓ |
| | SPRT2 | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ |
| # passes: | | *10* | 18 | *12* | 14 | *10* | 18 | *15* | 15 | *15* | 18 | *13* | 18 |
| # fails: | | *13* | 5 | *12* | 9 | *14* | 6 | *11* | 11 | *8* | 5 | *10* | 5 |

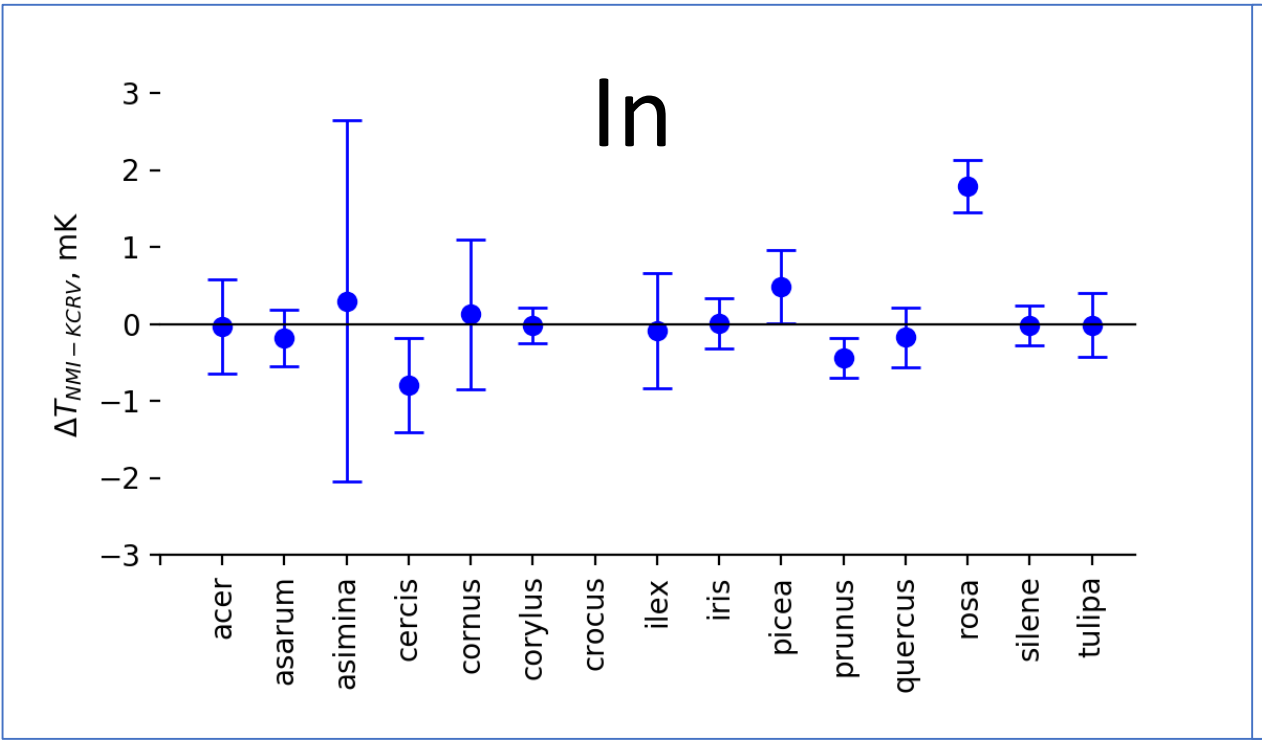
# Zn and Sn

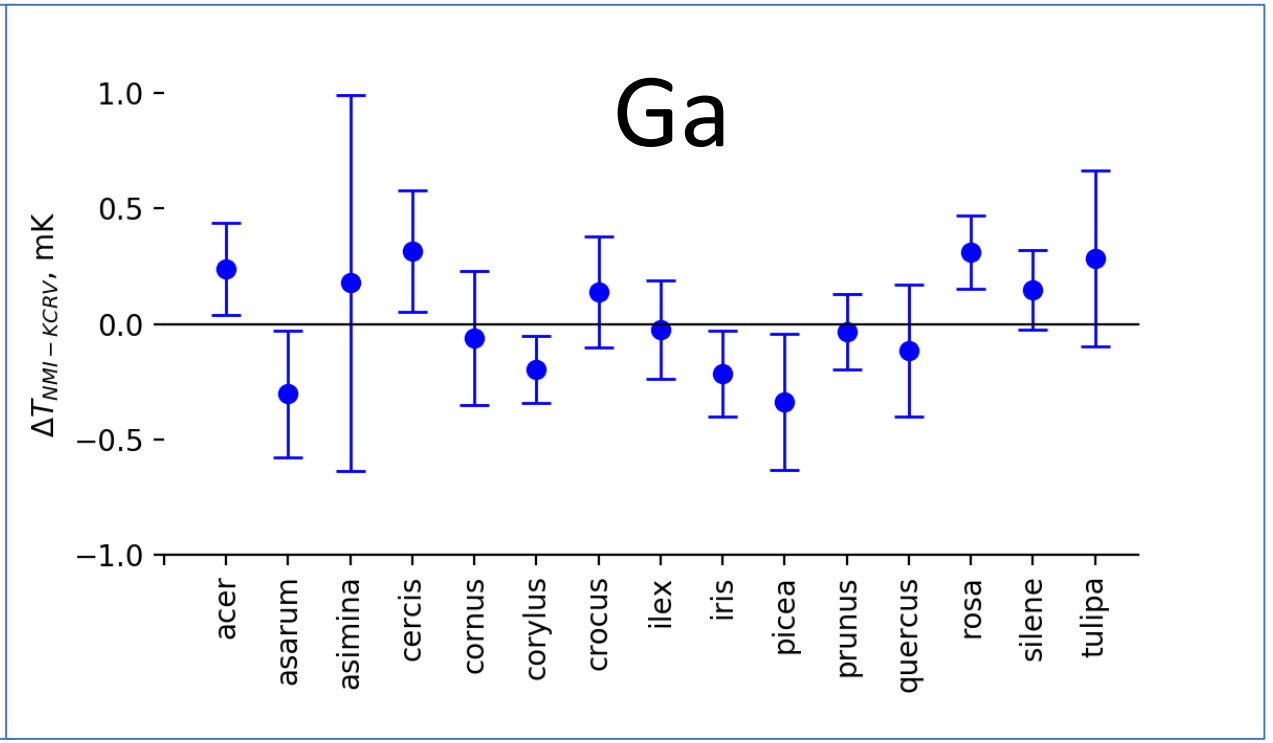


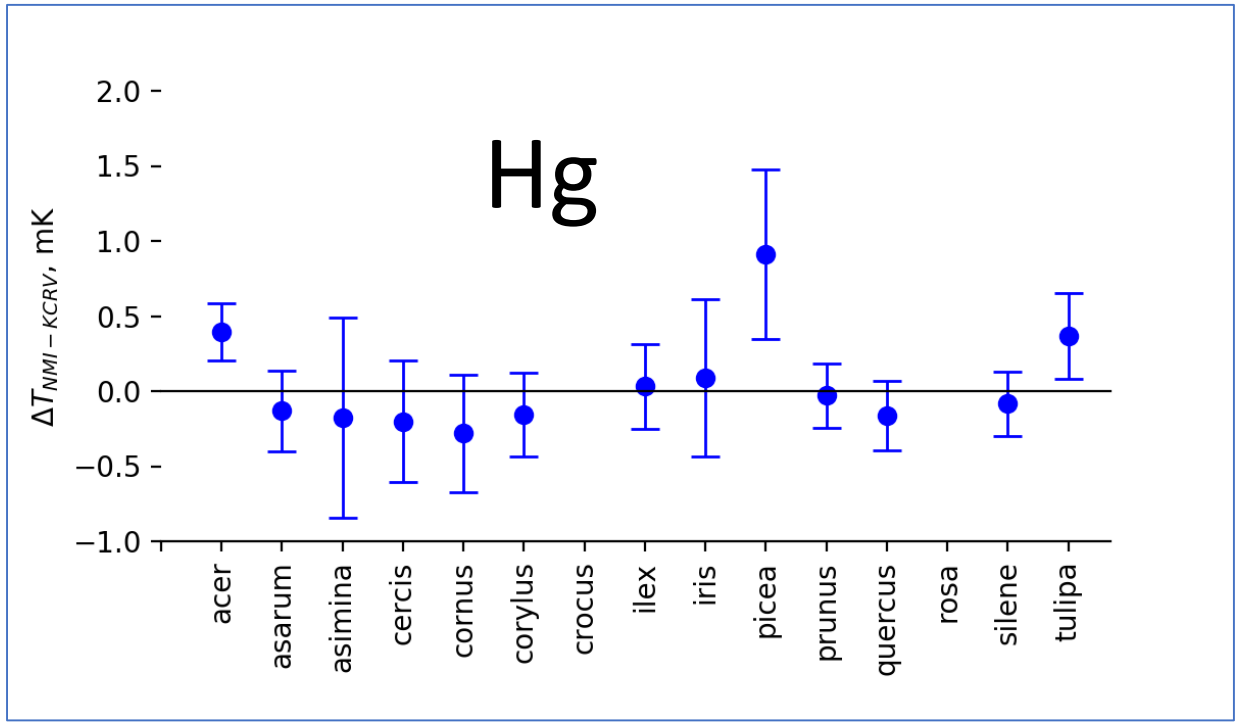

***k***=2 uncertainties of each NMI

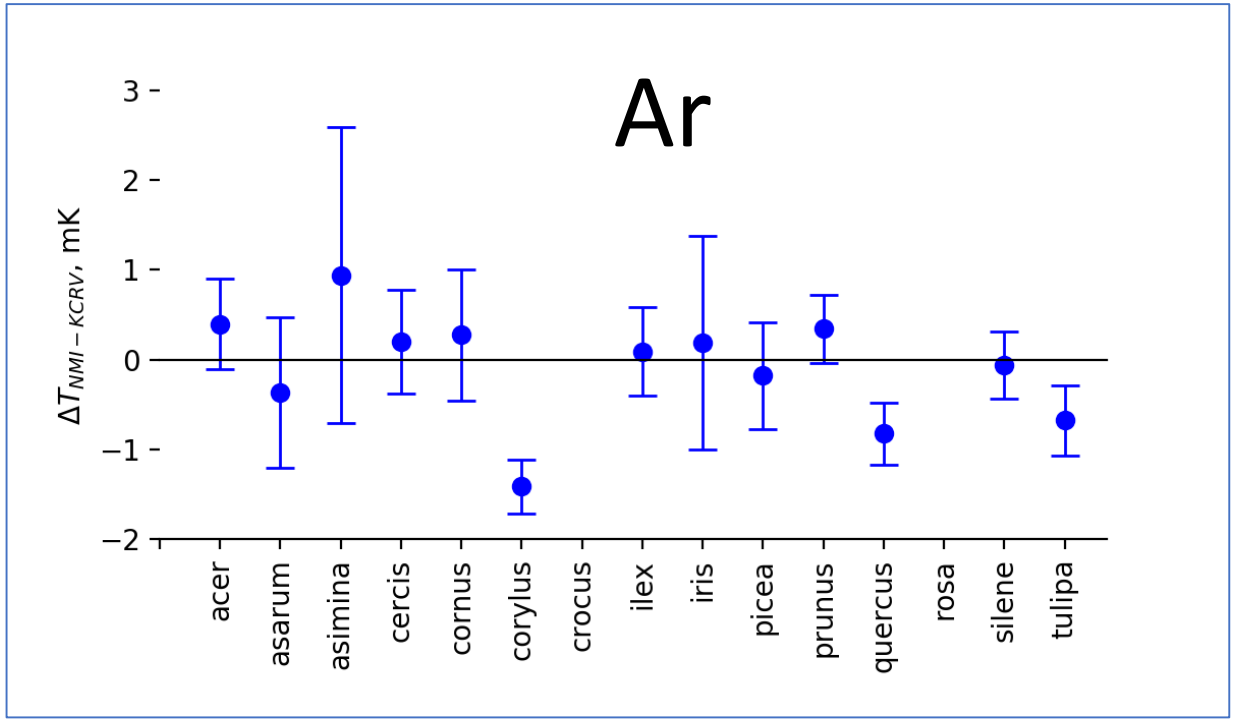
# In and Ga


In
$\Delta T_{NMI-KCRV}$, mK
3
2
1
0
−1
−2
−3
acer
asarum
asimina
cercis
cornus
corylus
crocus
ilex
iris
picea
prunus
quercus
rosa
silene
tulipa


Ga
$\Delta T_{NMI-KCRV}$, mK
1.0
0.5
0.0
−0.5
−1.0
acer
asarum
asimina
cercis
cornus
corylus
crocus
ilex
iris
picea
prunus
quercus
rosa
silene
tulipa

# Hg and Ar


Hg
$\Delta T_{NMI-KCRV}$, mK
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
acer
asarum
asimina
cercis
cornus
corylus
crocus
ilex
iris
picea
prunus
quercus
rosa
silene
tulipa


Ar
$\Delta T_{NMI-KCRV}$, mK
3
2
1
0
−1
−2
acer
asarum
asimina
cercis
cornus
corylus
crocus
ilex
iris
picea
prunus
quercus
rosa
silene
tulipa

# KCRV and results

| | KCRV (mK) | *u*(KCRV) (mK) | $E_n$>1 (# labs) |
|---|---|---|---|
| **Zn** | 0.04 | 0.20 | 5 |
| **Sn** | 0.26 | 0.14 | 2 |
| **In** | 0.07 | 0.08 | 3 |
| **Ga** | 0.21 | 0.06 | 7 |
| **Hg** | 0.37 | 0.07 | 3 |
| **Ar** | 0.81 | 0.14 | 3 |

# Changes underway to Draft A

1. Two NMIs: unstable SPRT data will be excluded

2. Stabilization procedure at NIST will be documented in Section 3.2 (“Data collection at NIST”)

3. $R_0$(TPW) values will be included for final measurement at NIST

4. Some errors of transcription, and some adjustments to uncertainties (determined before draft was unblinded), will be made

5. **Final Draft A to be distributed by pilot by 01 Dec. 2020**