CCT/2022-40

CCT K9: SPRT calibration from the Ar TP to the Zn FP, 2022 update

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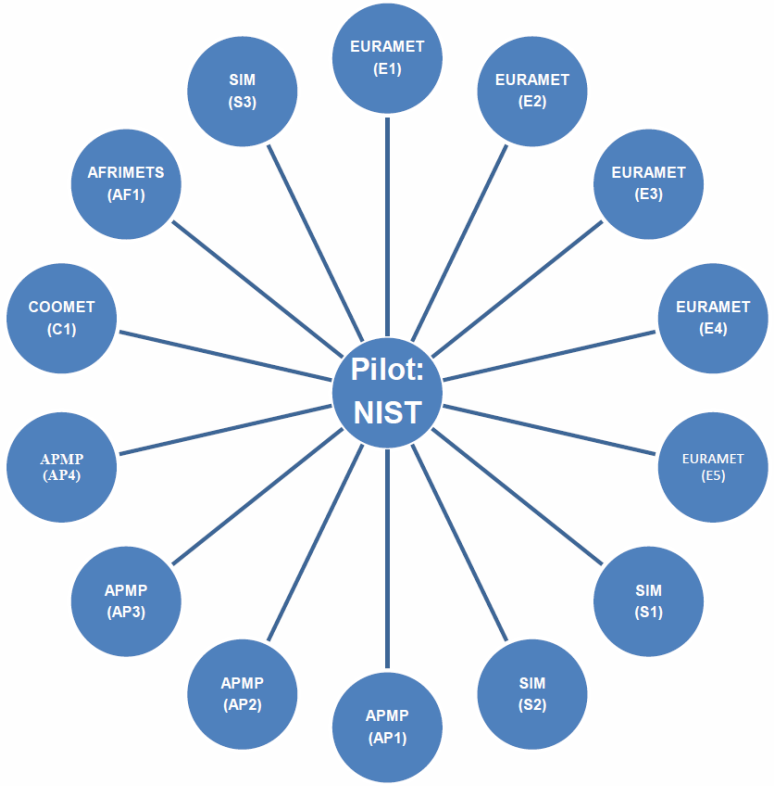
PML

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

Method: Collapsed Star



Key Comparison 9 Protocol

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

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	17-09-2020, Draft A achieved
CCT 30th meeting	**18-01-2022, Draft B achieved!**

Participating NMIs

NMI Participants:

Pilot:	NIST, Gregory Strouse, gstrouse@nist.gov
AFRIMETS:	NMISA, Hans Liedberg, hliedber@nmisa.org
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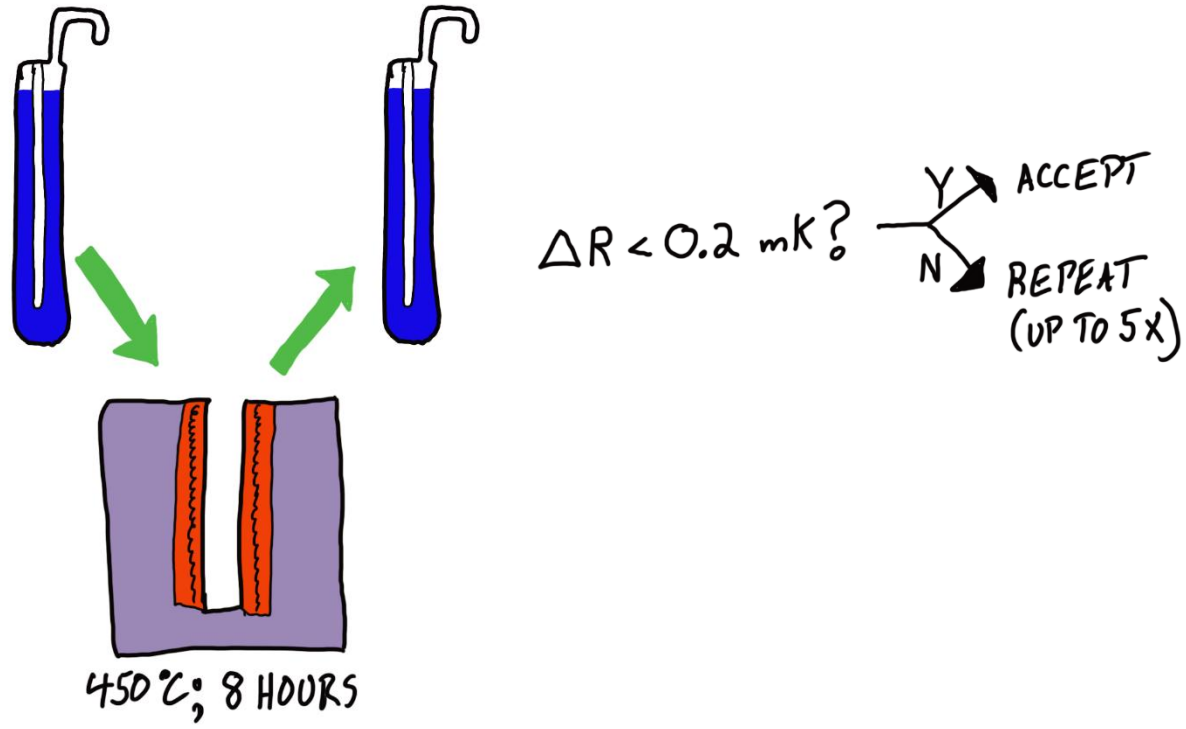
SIM:	INTI, Javier Skabar, jskabar@inti.gob.ar
SIM:	NRC, Ken Hill, ken.hill@nrc-cnrc.gc.ca

Attendance at Sept. 17, 2020 Meeting

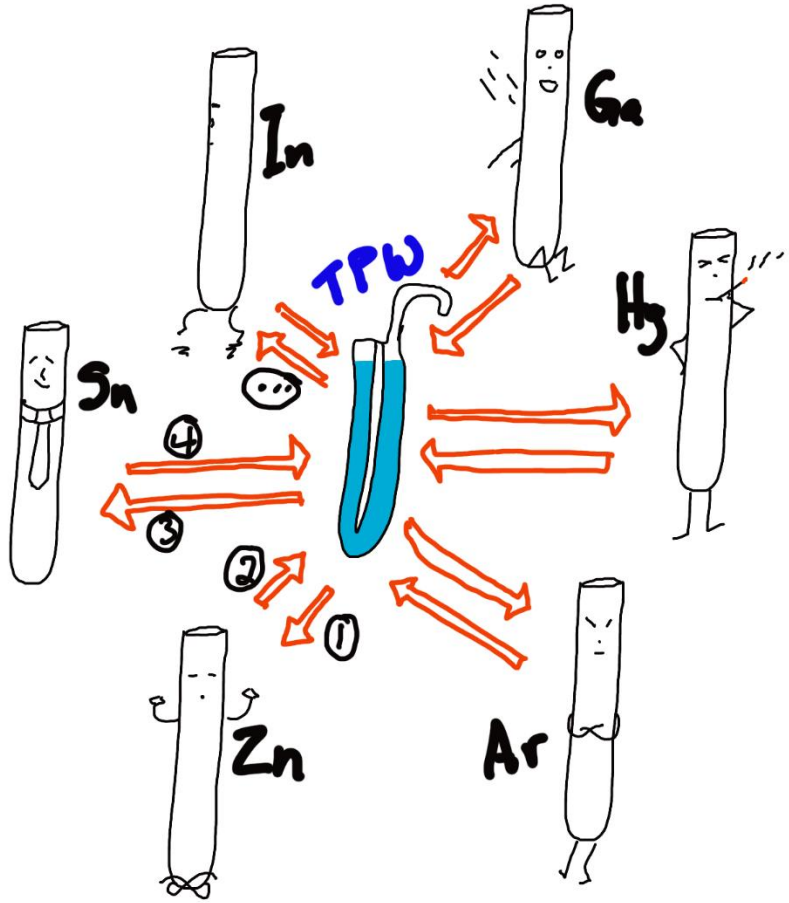
Tobias Herman (NIST),
Giuseppina Lopardo (INRiM),
Javier Garcia Skabar (INTI),
Fernando Sparasci (LNE/CNAM),
Inseok Yang (KRISS),
Jintao Zhang (NIM),
Jianping Sun (NIM),
Eric vd Ham (NMIA),
Mong-Kim Ho (NMIA),
Tohru Nakano (NMIJ),
Jonathan Pearce (NPL),
Sergey Dedyulin (NRC),
Steffen Rudtsch (PTB),
Victor 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

$$u(C_{SPRT_i}) > \frac{\sqrt{u^2(\Delta T_{NMI_i}) - u^2(C_{SPRT_i})}}{3}$$

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

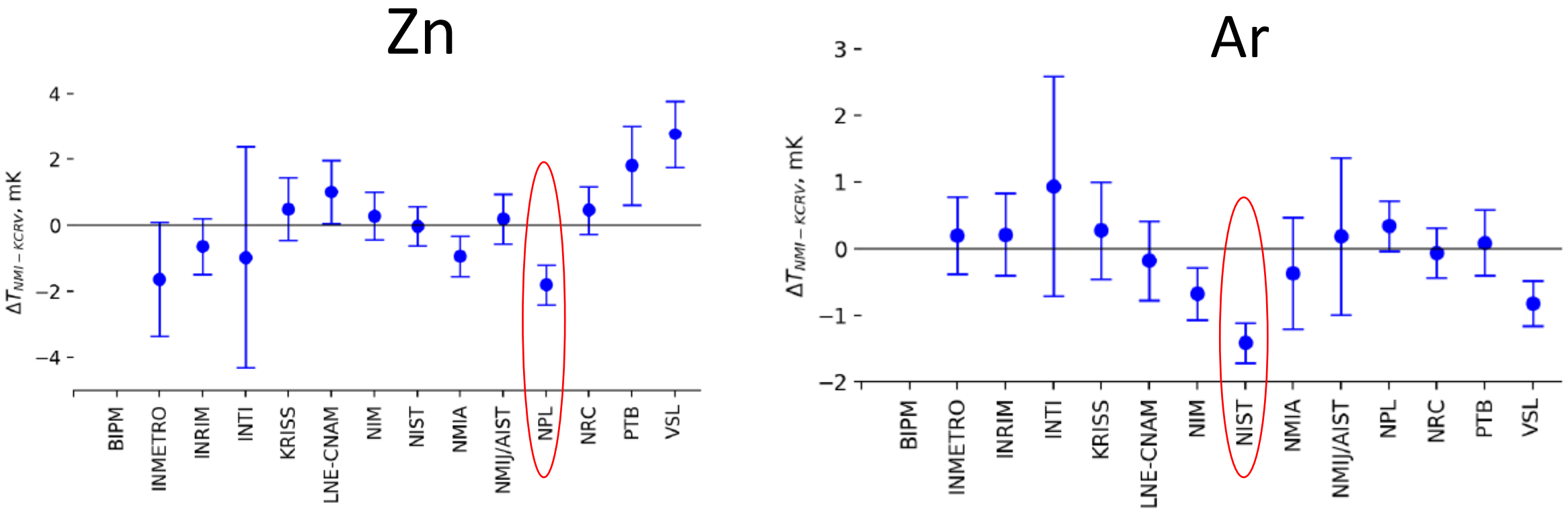
NMI		Zn		Sn		In		Ga		Hg		Ar	
		I	II	*I*	II	*I*	II	*I*	II	*I*	II	*I*	II
BIPM	SPRT1	–	–	–	–	–	–	✓	✓	–	–	–	–
	SPRT2	–	–	–	–	–	–	✓	✓	–	–	–	–
INMETRO	SPRT1	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
	SPRT2	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
INRIM	SPRT1	–	–	–	–	–	–	–	–	–	–	–	–
	SPRT2	✓	✓	✗	✓	✗	✓	✓	✓	✗	✓	✗	✗
INTI	SPRT1	–	–	–	–	–	–	–	–	✓	✓	✓	✓
	SPRT2	✗	✓	✓	✓	✗	✗	✓	✗	✗	✗	✓	✓
KRISS	SPRT1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	SPRT2	–	–	–	–	–	–	–	–	–	–	–	–
LNE-CNAM	SPRT1	✓	✓	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓
	SPRT2	✓	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
NIM	SPRT1	✗	✓	✓	✓	✗	✓	✗	✗	✗	✓	✗	✓
	SPRT2	✗	✓	✗	✓	✗	✓	✗	✓	✓	✓	✓	✓
NIST	SPRT1	–	–	–	–	–	–	–	–	–	–	–	–
	SPRT2	–	–	–	–	–	–	–	–	–	–	–	–
	SPRT3	–	–	–	–	–	–	–	–	–	–	–	–
NMIA	SPRT1	✗	✓	✗	✗	✗	✓	✗	✓	✗	✓	✗	✓
	SPRT2	✗	✓	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓
NMIJ/AIST	SPRT1	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓
	SPRT2	✓	✓	✗	✓	✗	✓	✗	✓	✓	✓	✓	✓
NPL	SPRT1	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓
	SPRT2	✓	✓	✓	–	✓	✓	✗	✓	✓	✓	✓	✓
NRC	SPRT1	✗	✗	✗	✗	✓	✓	✓	✓	✗	✓	✗	✓
	SPRT2	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PTB	SPRT1	–	–	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
	SPRT2	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓
VSL	SPRT1	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓
	SPRT2	✗	✓	✗	✓	✗	✓	✗	✓	✓	✓	✗	✓
# passes:		*10*	16	*9*	12	*9*	18	*13*	19	*14*	21	*13*	21
# fails:		*10*	4	*12*	8	*12*	3	*10*	4	*8*	1	*9*	1

SPRT changes at TPW (NIST to NMI)

		$R_{TPW}(\Omega)$			
	Serial #	At NIST	Ante-NIST	Post-NIST	$\Delta T(mK)$
BIPM	4240	25.64061374	25.640619	25.64064296	0.23
BIPM	1857442	25.55755298	25.557531	25.55757912	0.47
INMETRO	1251	25.46126337	25.461203	25.46134352	1.38
INMETRO	3713	25.55488045	25.554912	25.55492418	0.12
INRIM	1282	–	–	–	–
INRIM	1283	25.55948027	25.55951355	25.55952085	0.07
INTI	235996	25.23427049	–	–	–
INTI	71089	25.38485260	–	–	–
KRISS	1849612	25.54368993	25.543662	25.543712	0.49
KRISS	1860931	25.55550182	25.555426	–	–
LNE-CNAM	1825320	25.51172691	25.511704	25.511767	0.62
LNE-CNAM	B91280	25.54900936	25.548993	25.549174	1.78
NIM	4101	25.36221253	25.362177	25.36221	0.33
NIM	5128	25.27907422	25.279098	25.279288	1.88
NMIA	1671	25.40693332	25.406873	25.406964	0.90
NMIA	RS104-09	24.92742028	24.927467	24.927852	3.87
NMIJ/AIST	RS994-13	25.30011751	25.30015671	25.30014645	-0.10
NMIJ/AIST	4315	25.52571026	25.52574465	25.52574661	0.02
NPL	4275	25.44133270	25.44142017	25.44142347	0.03
NPL	4276	25.48737558	25.48741357	25.48739757	-0.16
NRC	RS58A-1	25.02200678	25.02201119	25.022002	-0.09
NRC	RS895-2	25.56801650	25.56800657	25.56788925	-1.15
PTB	4807	25.52183426	25.521909	25.521973	0.63
PTB	95185	25.75605948	25.756113	25.756662	5.34
VSL	1761951	25.55174363	25.55186421	25.55228513	4.13
VSL	1867658	25.52491096	25.52496973	25.52522278	2.49

Desire delta T < 0.2 mK

Zn and Ar (larger variations at extremes)



k=2 uncertainties of each NMI

Lessons learned

1. Reached limits of the use of SPRTs as transfer standards: fixed point realization uncertainties are lower than
   A. Variations upon recalibration
   B. Changes from shipping

2. Need protocols to better deal with discrepant data with an *a priori* framework: suggestion of using guidance from this paper:

   Amanda Koepke et al 2017 Metrologia **54** S34 *Consensus building for interlaboratory studies, key comparisons, and meta-analysis*

3. These key comparisons are still useful to check claimed uncertainties.