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REPORT ON THE MEASUREMENT RESULTS FOR THE EURAMET 658 EXTENSION: PROJECT TO EXAMINE UNDERLYING PARAMETERS IN RADIANCE TEMPERATURE SCALE REALISATION (CCT WG-KC VERSION FOR PUBLICATION ON BIPM DATABASE)

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EURAMET 658 Extension: Project to Examine Underlying Parameters in Radiance Temperature Scale Realisation from 156 °C to 1000 °C

Main Comparison Measurement Report
(CCT WG-KC Version for Publication on BIPM Database)

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ABSTRACT

This report describes the measurement procedures and participant results for the EURAMET project 658 extension – 'Project to examine underlying parameters in radiance temperature scale realisation from 156 °C to 1000 °C', with particular emphasis on the results of the variable temperature and fixed point blackbody measurements for the justification of radiation thermometry CMCs.

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1 INTRODUCTION

This project is an extension to the EUROMET project 658 – 'The examination of base parameters for ITS-90 scale realisation in radiation thermometry' [1], which was a comparison of measurements of parameters underpinning ITS-90 scale realisation above 962 °C such as spectral response, size-of-source effect, linearity and calculation of the emissivity of a number of different blackbody sources.

The purpose of the extension project was to undertake a comparison of measurements of parameters necessary for radiation thermometers for the medium temperature range (from 156 °C to 1000 °C). The parameters to be measured were the size-of-source effect, gain (range) ratios, calibration using fixed-point blackbody sources, measurements using variable temperature blackbody calibration sources, and an assessment of the effect on the results of changes in the ambient temperature and humidity. Participants were asked to carry out as many of the measurements as possible.

Two InGaAs-based radiation thermometers, operating at a wavelength of nominally 1.6 μm, were used for the comparison. One of the thermometers was supplied by INRiM (Istituto Nazionale di Ricerca Metrologica); the other was an IKE (Institut für Kernenergetik und Energie) LP5 (Linear Pyrometer 5) supplied by IKE, Stuttgart. These were circulated around the participants. A zinc fixed-point blackbody source, also supplied by INRiM, was also circulated. This was used for checking the thermometers before the start (and sometimes also at the end) of the measurements at each institute to confirm the correct performance of the transfer thermometers and to determine any drift in the thermometer output. The technical specifications for the two radiation thermometers are given in the protocol in Appendix 1. The instructions for operating the zinc freezing-point blackbody source are given in Appendix 2.

This report describes the results of the measurements at each laboratory, and compares the results obtained at different laboratories. Further details of the results, as well as the measurement procedures and equipment used by each participant, are given in the measurement reports (see Appendices 7 to 13). For the purpose of CMC verification it should be emphasised that the results are only applicable for radiation thermometers operating at a wavelength near 1.6 microns and do not ensure equivalence at other wavelengths.

1.1 THE PARTICIPANTS

The participant institutes were: NPL (National Physical Laboratory, United Kingdom), PTB (Physikalisch-Technische Bundesanstalt, Germany), TÜBITAK – UME (Türkiye Bilimsel ve Teknolojik Araştirma Kurumu, Turkey), INRiM (Italy), CEM (Centro Español de Metrología, Spain), METAS (Metrology and Accreditation Switzerland, Switzerland) and LNE (Laboratoire National de Métrologie d'Essais, France).

1.2 THE TWO RADIATION THERMOMETERS

A summary of the technical specifications of the INRiM thermometer and the IKE LP5 are given in the Table 1. More information is given in the technical protocol in Appendix 1.

Parameter	Radiation thermometer	
	IKE LP5 serial no. 80-51	INRiM identification TS1
Operating wavelength/ nm	1568 (36 nm bandwidth)	1500 to 1700
Target size at working distance/ mm	2 at 750	5 at 470
Temperature range/ °C	~230 to ~1085	150 to 1000

Table 1: summary of the specification of the thermometers used in the comparison

1.3 THE SCHEDULE FOR THE CIRCULATION

The original timescale for the circulation of the thermometers was as follows:

Institute	Time periods
PTB	1 August 2007 to 30 September 2007
NPL	1 October 2007 to 30 November 2007
CEM	1 December 2007 to 29 February 2008
UME	1 March 2008 to 30 April 2008
METAS	1 May 2008 to 30 June 2008
LNE	1 July 2008 to 30 September 2008
INRiM	1 October 2008 to 30 November 2008

The comparison schedule was delayed, with the final measurements being carried out, and the final participant report being received, during the summer of 2009. Information about the different measurements is given in the sections below and in the Appendices along with the results.

1.4 STABILITY CHECK OF THE RADIATION THERMOMETERS AT THE ZINC POINT

Prior to the start of the measurements at each institute (and also, sometimes, at the end of the measurements) both transfer thermometers were checked using the INRiM-supplied zinc freezing point blackbody source. The instructions for using source were supplied and are given in Appendix 2. The melt was used to ensure that the thermometer was aligned correctly on the source; the freeze was used for the check measurements. The results of all the checks made by the participants are given in the following Tables. (Note that CEM performed measurements twice at the start). The LP5 was not checked again after the end of the comparison since the Zn fixed-point remained at INRiM and the LP5 was returned to IKE (the supplier of the instrument).

Institute	Background/ A	Thermometer output/ A	Output corrected for background / A	Internal temp. /°C	Ambient temp. / °C	Ambient relative humidity / %rh
PTB	1.15 E-14	4.13801 E-10	4.13790 E-10	29.22	22.7	65
NPL	-5 E-15	4.13818 E-10	4.13823 E-10	29.21	22.0	45
CEM (start 1)	6.55 E-14	4.1362 E-10	4.13555 E-10	29.1	22.7	30.4
CEM (start 2)	5.13 E-14	4.1519 E-10	4.15139 E-10	29.23	23.7	20.6
CEM (end)	7.16 E-14	4.1180 E-10	4.11728 E-10	29.22	22.7	53
UME	1.55 E-12	4.13557 E-10	4.12012 E-10	29.21	22.8	38.3
METAS	1.08 E-13	4.1038 E-10	4.1027 E-10	29.21	21.9	44.9
LNE	0.12 E-12	409.57 E-12	409.45 E-12	29.18	22.8	58.2
INRiM	-	-	409.63 E-12	29.2	-	31

Table 2: results of the zinc point checks for the LP5 thermometer

The results of the stability check measurements are plotted below (Figure 1). The differences in signal level compared to the start of the comparison (the PTB measurements) were converted to an equivalent temperature difference for clarity, and these values are plotted too, and are also given in Table 3 for ease of reference. It can be seen that the signal at the Zn point drifted downwards over the course of the comparison by the equivalent of over 0.5 °C.

The results of these measurements were used to help correct the thermometer signal for the variable temperature and fixed-point blackbody measurements in each of the laboratories to try and compensate for the observed drift.

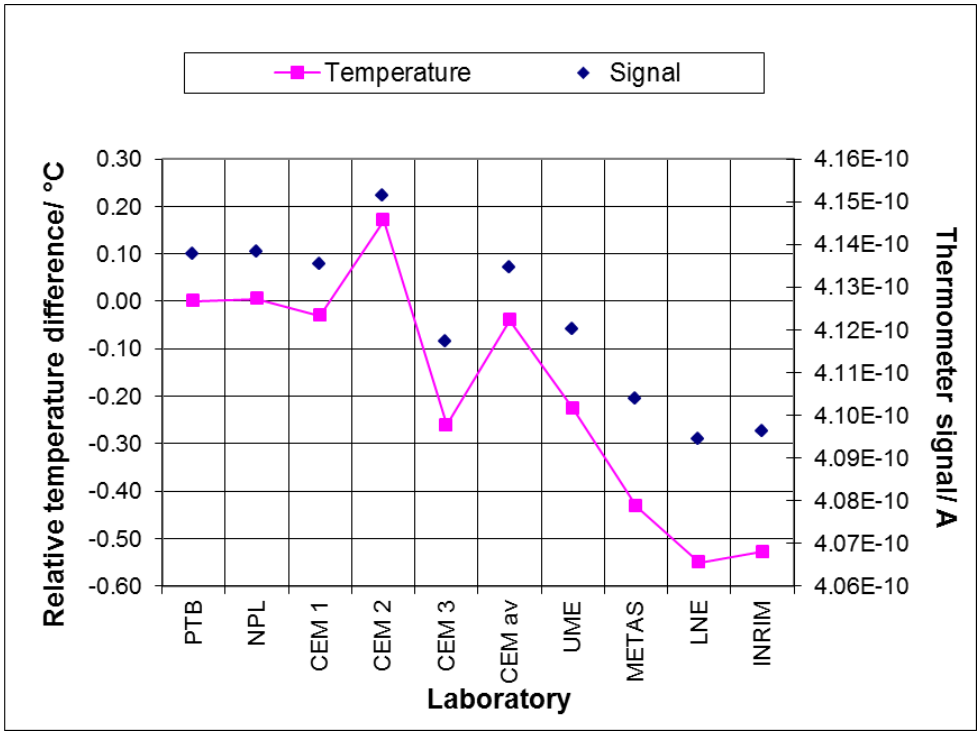


Figure 1: results of the check measurement at the Zn freezing point for the LP5

Laboratory	Difference from PTB/ °C
PTB	0.00
NPL	0.01
CEM 1	-0.03
CEM 2	0.17
CEM 3	-0.26
CEM av	-0.04
UME	-0.22
METAS	-0.43
LNE	-0.55
INRIM	-0.53

Table 3 – the difference, in terms of temperature, of the LP5 Zn point check measurements, compared to the initial (PTB) measurement

Institute	Background / V	Thermometer output/ V	Output corrected for background / V	Internal temp. / °C	Ambient temp. / °C	Ambient relative humidity / %rh
INRiM 1*	-	-	1.98285	-	-	-
PTB	-4.89×10^{-4}	1.98125	1.98174	24.87	22.9	65
NPL	-5.08×10^{-4}	1.98369	1.98420	23.40	21.9	45.5
CEM (start)	-5.14×10^{-4}	1.98058	1.98109	24.64	23.6	19.8
CEM (end)	-5.04×10^{-4}	1.98013	1.98063	24.64	23.6	19.8
UME†	$(-)5.11 \times 10^{-4}$	1.98275	1.98326	23.43	22.8	38.4
METAS	-5.00×10^{-4}	1.98108	1.98158	24.70	21.9	44.3
LNE	-4.83×10^{-4}	1.98142	1.98190	24.09	23.1	47.6
INRiM 2	-	-	1.98204	24.17	-	-

Table 4: results of the zinc point checks for the INRiM thermometer

* Measured before the thermometer was sent to PTB.
† N.B. the background value reported by UME was positive in sign, but it was assumed that this was a typographical error as all the other measured background values were negative.

The results of the stability check measurements are plotted below (Figure 2). The differences in signal level compared to the start of the comparison (the initial measurements made at INRiM before the thermometer was circulated) were converted to an equivalent temperature for clarity, and these values are also plotted in Figure 2 and are also given in Table 5 for ease of reference. It can be seen that there are some small fluctuations but no significant overall drift. Although it would have been adequate to include an uncertainty component for the drift and not apply any corrections to the thermometer signals for the laboratory measurements of the variable temperature and fixed-point blackbody sources, it was decided to apply a correction for completeness and improved uncertainty.

Laboratory	Difference from INRiM 1/ °C	Difference from PTB/ °C
(INRiM 1	0.000)	--
PTB	-0.030	0.000
NPL	0.036	0.066
CEM 1	-0.047	-0.017
CEM 2	-0.060	-0.030
CEM av	-0.053	-0.024
UME	0.011	0.041
METAS	-0.034	-0.004
LNE	-0.026	0.004
INRiM 2	-0.022	0.008

Table 5 – the difference, in terms of temperature, of the INRiM thermometer Zn point check measurements, compared to the initial (INRiM 1) measurement and the PTB measurement (the start of the comparison)

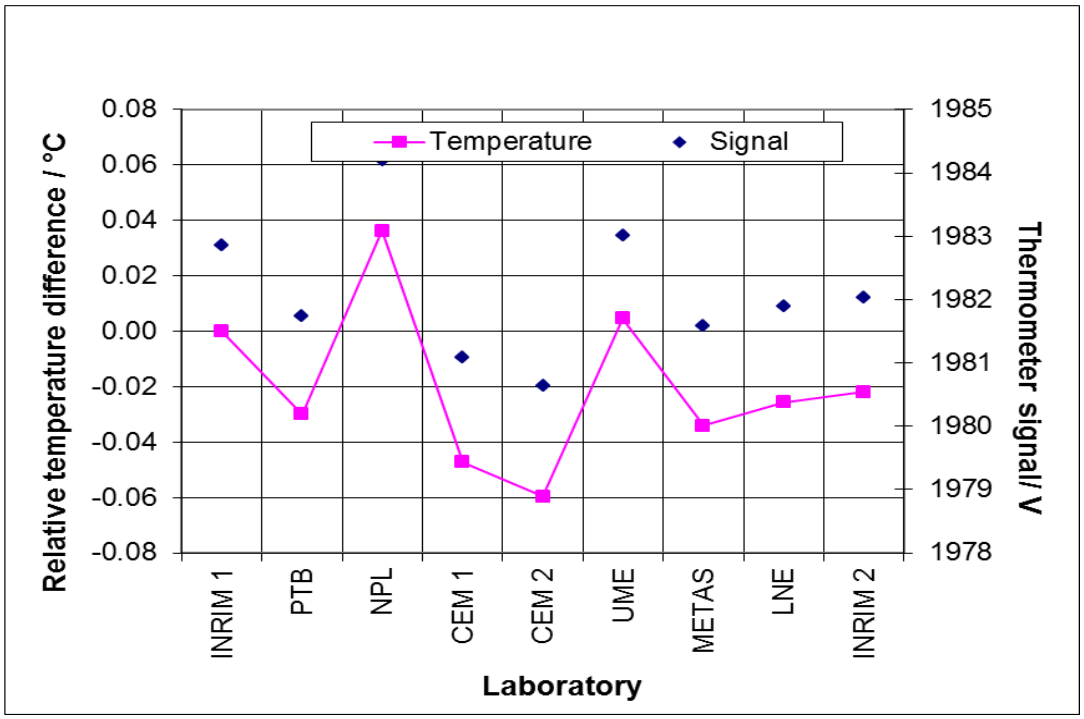


Figure 2: Results of the check measurement at the Zn freezing point for the INRiM thermometer

MEASUREMENT METHODS, RESULTS AND DISCUSSION

2 SIZE-OF-SOURCE EFFECT MEASUREMENTS

A summary of the apparatus used at each institute for the size-of-source effect measurements, the results, analysis and discussion are given in Appendix 3.

3 GAIN AND RANGE RATIO MEASUREMENTS

A summary of the methodology used for the gain ratio measurements, the results, analysis and discussion are given in Appendix 3. (Note that LNE measured the range ratio of the LP5 using the analogue output rather than the photocurrent. The results were not consistent with the rest and have been excluded from the subsequent analysis. This only applies to the LNE measurements of the range ratios; for the all the other measurements LNE used the photocurrent.)

4 EFFECT OF AMBIENT TEMPERATURE AND RELATIVE HUMIDITY

The results of the measurements of the effect of changing ambient temperature and relative humidity, the analysis of the results, the discussion and conclusions are given in Appendix 3.

5 MEASUREMENTS USING THE FIXED POINT AND VARIABLE TEMPERATURE SOURCES

Four laboratories (NPL, UME, CEM and INRiM) carried out measurements using fixed-point (FP) blackbody sources. All the laboratories apart from INRiM carried out measurements

using variable temperature blackbody (VTBB) sources from 156 °C to 1000 °C. For the FP blackbodies the freezing transition of the metal was assumed to occur at the ITS-90 defined temperature; for the VTBB sources the temperature of the source was determined using a calibrated sensor (platinum resistance thermometer or thermocouple) inserted in the source which gave traceability to the ITS-90. Descriptions of the sources are given in the laboratory measurement reports in Appendices 7 to 13, along with full details of the measurement methods and results. Laboratory uncertainty budgets are given in Section 9.

5.1 ANALYSIS OF THE RESULTS

The data was analysed in two ways: (a) a direct comparison of results and (b) a comparison by applying a calibration fit to the results. Both methods are described below.

5.1.1 Direct comparison of measurement results

The direct comparison of the results was carried out using the following steps:

1) For each thermometer the range, or gain, most commonly used by the participants was identified for each temperature. Where this range, or gain, had not been used by a particular laboratory the results were corrected to the common gain/ range setting using the results of the gain or range ratio measured at that laboratory. In the event that the laboratory had not itself measured that particular gain/ range ratio, the average of the values measured by the other laboratories (see Section 2.3.1 and 2.3.2 of Appendix 3) was used.

An uncertainty in the thermometer signal resulting from any gain ratio correction was required. This was calculated using the gain ratio uncertainty ($k = 1$) given by the laboratory (or the standard deviation of the average of all the laboratory values, if the gain ratio had not been measured by that particular laboratory) to determine the maximum uncertainty in the corrected signal value. It was assumed that this uncertainty would have a rectangular probability distribution and so it was divided by √3. The resultant uncertainty in terms of thermometer signal was converted to an equivalent temperature uncertainty and combined with the laboratory measurement uncertainty.

2) The drift of each of the thermometers was calculated for each participant, in terms of equivalent temperature from the start of the comparison (i.e. from PTB), using the results of the zinc point check measurements (see Section 1). For temperatures other than the zinc point, the correction was scaled using the ratio $(t_{source})^2/(t_{zinc})^2$. This temperature correction could be converted to an equivalent signal correction using Equation 1. This correction was applied to the signal values.

$$\Delta S = \Delta T \frac{c_2}{\lambda T^2} S \qquad \textbf{Equation 1}$$

where ΔS is the correction to the thermometer signal S for a temperature correction ΔT, T is the source temperature in K, and λ is the operational wavelength, taken to be 1.57 μm and 1.60 μm respectively for the LP5 and the INRiM thermometer, as given in the technical specifications for the thermometers (Appendix 1 of the comparison protocol).

An additional uncertainty to allow for the drift of the thermometers during the comparison was calculated and combined with the laboratory measurement uncertainty. This additional uncertainty was estimated from the results of the check measurements using the zinc transfer reference source. For the INRiM thermometer, which showed no significant drift, the additional uncertainty was taken to be the maximum observed difference in thermometer output from the start of the comparison (taken to be from INRiM 1 to CEM), treated as a type B uncertainty; i.e. 0.06 °C/√3. For the LP5 thermometer the additional uncertainty was taken

to be half the maximum drift observed between consecutive laboratories, again treated as a type B uncertainty (equivalent to ±0.1 °C/ √3). The uncertainty was scaled using the ratio $(t_{source})^2/(t_{zinc})^2$ to give the uncertainty at all the measurement temperatures.

During the measurements at CEM, it appeared that the LP5 output suddenly shifted mid-way through the measurements, as shown by the results of the zinc point checks carried out at the beginning and end of the measurements, and also observed as an inconsistency in the measurements using the CEM fixed-points. A further additional component was included in the CEM measurement uncertainties to take this shift into account.

3) For the VTBB measurements the thermometer signals were additionally corrected to allow for the difference between the actual temperature of the blackbody, t_{BB} and required comparison temperature, t_{nom}, (500 °C, 961.78 °C etc.). This correction was calculated using Equation 1. (This was not necessary for the FP measurements since the freezing transitions for all the cells were assumed to occur at the ITS-90 defined temperatures).

The results of the direct comparison of all the measurements are given in Sections 6 and 7 Tables 7 to 18 and 22 to 33 for the VTBB results and Section 8 Tables 37 to 41 and 43 to 48 for the FP results. For the purposes of an initial comparison, the results of the fixed-point measurements were kept separate from those of the variable temperature blackbody sources.

For each temperature the average, median and weighted mean thermometer signal was calculated using the results from all the participants. (The weighted mean was weighted with respect to the laboratory measurement uncertainties, which included components for the thermometer drift and gain ratios). The difference between the participant result and the average, median and weighted mean was also calculated. This difference was converted into an equivalent temperature difference, to give clearer information about the performance of each participant with respect to the others. The means and differences from the mean are given in Sections 6 and 7 in Tables 19 to 21 and 34 to 36 for the VTBB results and Section 8 Tables 42 to 43 and 49 to 52 for the FP results. Where a laboratory had used more than one source at a particular temperature, results are given both for the combined data and for each source separately.

The degrees of equivalence (DOE) and quantified demonstrated equivalence (QDE_{95}[1]) values were then calculated for each thermometer at each comparison temperature. The QDE_{95} values for each pair of labs (i,j) were calculated from the equation:

$$QDE_{95(i,j)} \cong |\Delta t|_{(i,j)} + \left\{1.645 + 0.3295 exp\left(\frac{-4.05|\Delta t|_{(i,j)}}{u_{(i,j)}}\right)\right\} u_{(i,j)} \qquad \textbf{Equation 2}$$

where $|\Delta t|_{(i,j)}$ is the absolute difference between the temperature values of the two laboratories and $u_{(i,j)}$ is the combined k = 1 uncertainty.

Since there was quite a large spread of values for the measurements with the VTBBs at some of the temperatures, the differences of each participant from the median values were used for the DOE and QDE_{95} calculations. For the fixed-point blackbody results, where the results were more consistent, the differences of the participants from the mean were used in the calculation of the DOE and QDE_{95}. The DOE and QDE_{95} results for the LP5 are given in Appendix 4; those for the INRiM thermometer [see 5.3] are given in Tables 113 to 134 in Section 10. It should be emphasised that the results are only applicable for a wavelength near 1.6 microns and do not ensure equivalence at other wavelengths. It should also be emphasised that for the purposes of CMC justification the results of the VTBB comparison should be used

1 For example, Wood, B. M., Douglas, R. J., *Metrologia*, 1998, **35**, pp 187-196

to support VTBB CMCs and the results of the FP comparison should be used to support FP CMCs.

Additionally, for the measurements at the fixed-point temperatures, in order to provide additional information, the results using the FP and the VTBB sources were combined and compared in a similar way to that described above. This is of benefit since it highlights any systematic issues with the results from the VTBB measurements. Again, the median, mean and weighted mean values were calculated, along with the difference of the laboratory result from the mean or median. Due to the spread of the results the differences from the median were again used to calculate the DOE and QDE_{95} values. The tables of the results and the DOE and QDE_{95} values are given in Appendix 4.

5.1.2 Comparison of results using the calibration fits

As a different comparison method the results were also compared using a calibration fit. The coefficients of the fit were determined i) using the median of all the laboratory measurements, and ii) using the NPL and the INRiM fixed-point measurements. These approaches are described in more detail in Appendices 5 and 6 respectively, where the results and analysis can also be found.

5.2 DISCUSSION OF THE RESULTS

1) The results of the INRiM and NPL fixed-point calibration fits are in very good agreement for the INRiM thermometer, and also for the LP5 once the results have been corrected to allow for the drift of the thermometer during the comparison. It can be seen that calculating a correction based on the zinc point check is sufficient to adequately compensate for the thermometer drift even up to 1000 °C.

2) For both thermometers the results of the fixed-point measurements made in all the laboratories agree with each other within the laboratories' measurement uncertainties.

2) For the VTBB measurements, the results at lower temperatures agree within the measurement uncertainties. However, as the temperature increases the dispersion of the results increases, for both thermometers, with the results from two of the laboratories (UME and METAS) deviating from the others. The deviation occurs with both thermometers. It should be noted that METAS were aware of some issues with the measurements made using a thermocouple in the blackbody source, but submitted the results anyway out of interest to see how they compared to the results of the other laboratories. UME has suggested that their results above 750 °C could be due to the poorer quality of the blackbody calibration source that was used at these temperatures.

5.3 COMPARISON REFERENCE VALUE FOR THE VTBB AND FP MEASUREMENTS

The results of the VTBB and FP measurements have been analysed in several different ways to provide maximum information. However, one comparison reference value needs to be chosen for each comparison temperature. This value needs to include as many of the measurements as possible from all the different laboratories.

The analysis of the results using the 'direct comparison' approach, looking at the differences of each laboratory from the median value, seems to be the most straightforward method. The laboratory differences using the INRiM thermometer and the LP5 were broadly in agreement. However, the INRiM thermometer did not suffer from drift like the LP5 and, furthermore, covered the full temperature range of the comparison (156.6 °C to 1000 °C). The 'direct

comparison' results for the INRiM thermometer have therefore been used to determine the comparison reference value at each of the different temperatures. These results are as given in Tables 6 to 17 (for the VTBB) results and Tables 37 to 41 (for the FP results). The DOE and QDE_{95} values are given in Tables 113 to 156.

The uncertainty of the comparison reference values at each temperature for the INRIM thermometer VTBB measurements and the FP measurements were calculated.

For the VTBB reference values, which were the median values of the measurement results, the uncertainty, *u* (ref value), was calculated using the 'median of absolute deviations' (or 'MAD') method [2]:

$$u(ref\ value) \cong \frac{1.9}{\sqrt{(n-1)}} MAD$$

Where *n* is the number of results and

$$MAD = median\{|x_i - med|\}$$

With x_i being the result of laboratory *i* and *med* the median value (in this case the comparison reference value).

For the FP reference values, which were the average of the measurement results, the uncertainty was taken to be the semi-range of the maximum deviation between laboratory results (difference between the two results which had maximum dispersion from the mean), and treated as a Type B uncertainty, i.e. divided √3. Table 6 shows the calculated uncertainties in the reference values for the VTBB and FP results respectively.

The uncertainties in the reference values were combined in quadrature with the other uncertainty components for each laboratory. Tables 13 to 18 (for the VTBB measurements) and Tables 37 to 40 (for the FP measurements) give the final calculated uncertainty for each laboratory at each temperature.

VTBB results		FP results	
Nominal Temperature/ °C	Calculated U_{ref} value (k = 2)/ °C	Temperature/ °C	Calculated U_{ref} value (k = 2)/ °C
156.6	0.082	156.599	0.05
200	0.083	231.928	0.01
231.93	0.095	419.527	0.01
250	0.059	660.323	0.01
300	0.180	961.78	0.04
400	0.031		
419.53	0.160		
500	0.064		
600	0.100		
660.32	0.382		
700	0.390		
800	0.609		
900	0.606		
961.78	0.857		
1000	3.432		

Table 6 - calculated uncertainties in the reference values for the INRIM thermometer

Finally the DOE and QDE_{95} values were calculated for each temperature and for each calibration scheme (VTBB and FP) using the final uncertainties (i.e. those also including the uncertainty in the comparison reference values). These are given in Tables 135 to 156 in Section 10.

As stated above the DOE and QDE_{95} values for the LP5 VTBB measurements only and FP measurements only are given in Appendix 4 in Tables 1 to 20. Analysis of the combined VTBB and FP measurements for the LP5 are in Appendix 4 Tables 21 to 38, with the corresponding DOE and QDE_{95} values in Tables 67 to 74. Appendix 4 also gives the results and the DOE and QDE_{95} values for the combined INRiM FP and VTBB results (Tables 39 to 66).

References

1. EUROMET.T-S1, Metrologia 2008, **45**, Tech. Suppl. 03002
2. 'Possible Advantages of a Robust Evaluation of Comparisons' by J. W Muller, J. Res. Natl. Inst. Stand. Technol. **105**, 551, (2000)

6 RESULTS OF THE VTBB MEASUREMENTS FOR THE INRIM THERMOMETER

t_{nom} / °C	Gain used	t_{BB} /°C	Bgrd corrected signal / V	Required gain	Signal at required range/ V	Zn point check drift‡ / °C	Signal corrected for Zn point drift/ V	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom} / V	lab U (k=2) / °C	lab u (k=1) / °C	u (k=1) with gain ratio uncertainty* / °C	u (k=1) plus drift uncertainty† / °C	U (k=2) / °C
156.60	10^10	156.57	0.776219	10^10	0.776219	0.009	0.776568	0.03	0.777703	0.45	0.22	0.22	0.22	0.45
200.00	10^10	200.00	5.135394	10^10	5.135394	0.011	5.137704	0.00	5.137704	0.31	0.15	0.15	0.15	0.31
231.93	10^9	231.88	1.838722	10^9	1.838722	0.013	1.839550	0.05	1.842792	0.30	0.15	0.15	0.15	0.30
250.00	10^9	250.04	3.381156	10^9	3.381156	0.014	3.382676	-0.04	3.378231	0.30	0.15	0.15	0.15	0.30
300.00	10^8	300.02	1.370938	10^8	1.370938	0.016	1.371555	-0.02	1.370804	0.30	0.15	0.15	0.15	0.30
400.00	10^7	399.89	1.362019	10^7	1.362019	0.023	1.362631	0.11	1.365607	0.30	0.15	0.15	0.15	0.31
419.53	10^7	419.49	1.983845	10^7	1.983845	0.024	1.984738	0.04	1.986226	0.30	0.15	0.15	0.16	0.31
500.00	10^7	499.89	7.547499	10^7	7.547499	0.030	7.550894	0.11	7.563392	0.31	0.15	0.15	0.16	0.32
600.00	10^6	600.03	2.837789	10^6	2.837789	0.038	2.839066	-0.03	2.838061	0.27	0.14	0.14	0.15	0.29
660.32	10^6	660.29	5.480883	10^6	5.480883	0.044	5.483348	0.03	5.485046	0.28	0.14	0.14	0.15	0.31
700.00	10^6	700.03	8.093755	10^6	8.093755	0.047	8.097395	-0.03	8.095089	0.29	0.14	0.14	0.16	0.32
800.00	10^5	799.87	1.899449	10^5	1.899449	0.058	1.900303	0.13	1.902232	0.31	0.15	0.15	0.17	0.35
900.00	10^5	899.98	3.858663	10^5	3.858663	0.069	3.860399	0.02	3.860904	0.33	0.17	0.17	0.19	0.39
231.93	10^9	232.02	1.842625	10^9	1.842625	0.013	1.843454	-0.09	1.837608	0.30	0.15	0.15	0.15	0.30
300.00	10^8	300.08	1.375069	10^8	1.375069	0.016	1.375688	-0.08	1.372676	0.30	0.15	0.15	0.15	0.30
500.00	10^7	500.03	7.566450	10^7	7.566450	0.030	7.569853	-0.03	7.566437	0.31	0.15	0.15	0.16	0.32
700.00	10^6	699.99	8.094334	10^6	8.094334	0.047	8.097975	0.01	8.098744	0.29	0.14	0.14	0.16	0.32
900.00	10^5	899.88	3.856424	10^5	3.856424	0.069	3.858159	0.12	3.861185	0.33	0.17	0.17	0.19	0.39

Table 7 - results of the CEM variable temperature blackbody measurements for analysis by direct comparison

‡ Compared to the PTB value at the start of the comparison (see Table 5).

* These uncertainty values include a contribution for the uncertainty of the gain ratio value, as given by the laboratory, where appropriate (i.e. where the signal values have been corrected to a different gain setting).

† These uncertainty values include an additional component to allow for the drift of the thermometer during the comparison, as determined from the measurements using the transfer zinc fixed-point blackbody source (see Section 5.1.1).

t_{nom} / °C	Gain used	t_{BB} / °C	Bgrd corrected Signal / V	Required gain	Signal at required range/ V	Zn point check drift/ °C	Signal corrected for Zn point drift/ V	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ V	lab U (k=2) / °C	lab u (k=1) / °C	u (k=1) with gain ratio uncertainty*/ °C	u (k=1) plus drift uncertainty/ °C	U (k=2) / °C
156.60	10^10	156.566	0.771526	10^10	0.771526	0.00	0.771526	0.034	0.772810	0.064	0.03	0.03	0.03	0.07
200	10^10	200.035	5.165212	10^10	5.165212	0.00	5.165212	-0.035	5.158014	0.064	0.03	0.03	0.04	0.07
231.93	10^9	231.947	1.837326	10^9	1.837326	0.00	1.837326	-0.017	1.836253	0.066	0.03	0.03	0.04	0.08
250	10^9	250.039	3.377719	10^9	3.377719	0.00	3.377719	-0.039	3.373403	0.069	0.03	0.03	0.04	0.08
300	10^8	300.023	1.366982	10^8	1.366982	0.00	1.366982	-0.023	1.366133	0.096	0.05	0.05	0.05	0.11
400	10^7	400.021	1.366276	10^7	1.366276	0.00	1.366276	-0.021	1.365717	0.035	0.02	0.02	0.04	0.07
419.53	10^7	419.519	1.983355	10^7	1.983355	0.00	1.983355	0.011	1.983756	0.036	0.02	0.02	0.04	0.08
500	10^6	500.020	0.757357	10^7	7.569622	0.00	7.569622	-0.020	7.567390	0.039	0.02	0.02	0.05	0.10
600	10^6	600.019	2.835811	10^6	2.835811	0.00	2.835811	-0.019	2.835165	0.044	0.02	0.02	0.06	0.12
660.32	10^6	660.328	5.483683	10^6	5.483683	0.00	5.483683	-0.008	5.483208	0.073	0.04	0.04	0.07	0.15
700	10^6	700.032	8.097138	10^6	8.097138	0.00	8.097138	-0.032	8.094686	0.075	0.04	0.04	0.08	0.16
800	10^5	800.017	1.900651	10^5	1.900651	0.00	1.900651	-0.017	1.900399	0.081	0.04	0.04	0.09	0.19
900	10^5	900.026	3.861526	10^5	3.861526	0.00	3.861526	-0.026	3.860880	0.088	0.04	0.04	0.11	0.22
961.78	10^5	961.728	5.647521	10^5	5.647521	0.00	5.647521	0.052	5.649249	0.094	0.05	0.05	0.12	0.24
156.6	10^10	156.623	0.773692	10^10	0.773692	0.00	0.773692	-0.023	0.772833	0.064	0.03	0.03	0.03	0.07
250	10^9	250.087	3.382039	10^9	3.382039	0.00	3.382039	-0.087	3.372386	0.067	0.03	0.03	0.04	0.08
419.53	10^7	419.516	1.983341	10^7	1.983341	0.00	1.983341	0.014	1.983862	0.036	0.02	0.02	0.04	0.08
500	10^6	500.042	0.757390	10^7	7.569952	0.00	7.569952	-0.042	7.565203	0.039	0.02	0.02	0.05	0.10
700	10^5	700.048	0.809186	10^6	8.098807	0.00	8.098807	-0.048	8.095101	0.075	0.04	0.04	0.08	0.16
961.78	10^5	961.693	5.646728	10^5	5.646728	0.00	5.646728	0.087	5.649622	0.094	0.05	0.05	0.12	0.24

Table 8 - results of the PTB variable temperature blackbody measurements for analysis by direct comparison

t_{nom} / °C	Gain used	t_{BB} / °C	Bgrd corrected Signal/ V	Required gain	Signal at required range/ V	Zn point check drift/ °C	Signal corrected for Zn point drift/ V	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ V	lab U (k=2) / °C	lab u (k=1) / °C	u (k=1) with gain ratio uncertainty*/ V	u (k=1) plus drift uncertainty/ °C	U (k=2) / °C
156.60	10^8	156.53	0.007810	10^10	0.784061	-0.002	0.784002	0.071	0.786711	0.21	0.10	0.10	0.10	0.21
200	10^7	199.90	0.004967	10^10	5.017998	-0.002	5.017622	0.104	5.038499	0.25	0.12	0.12	0.13	0.25
200	10^7	199.89	0.005054	10^10	5.105802	-0.002	5.105420	0.107	5.127274	0.25	0.12	0.12	0.13	0.25
200	10^8	199.90	0.051248	10^10	5.145000	-0.002	5.144614	0.100	5.165303	0.25	0.12	0.12	0.13	0.25
231.93	10^7	231.76	0.016235	10^9	1.779335	-0.002	1.779202	0.174	1.790126	0.28	0.14	0.14	0.14	0.28
231.93	10^8	231.76	0.167536	10^9	1.824540	-0.002	1.824403	0.170	1.835372	0.28	0.14	0.14	0.14	0.28
250	10^7	249.83	0.030599	10^9	3.353591	-0.002	3.353340	0.171	3.372161	0.30	0.15	0.15	0.15	0.30
250	10^8	249.83	0.307849	10^9	3.352601	-0.002	3.352350	0.171	3.371241	0.29	0.15	0.15	0.15	0.30
300	10^7	300.17	0.136254	10^8	1.371208	-0.003	1.371105	-0.175	1.364548	0.32	0.16	0.16	0.16	0.32
300	10^8	300.08	1.366253	10^8	1.366253	-0.003	1.366151	-0.084	1.362999	0.33	0.17	0.17	0.17	0.33
400	10^7	399.91	1.356838	10^7	1.356838	-0.004	1.356736	0.095	1.359292	0.37	0.18	0.18	0.19	0.37
400	10^7	400.12	1.365849	10^7	1.365849	-0.004	1.365746	-0.124	1.362396	0.33	0.17	0.17	0.17	0.34
419.53	10^7	419.68	1.984168	10^7	1.984168	-0.004	1.984019	-0.151	1.978393	0.34	0.17	0.17	0.18	0.35
500	10^7	500.11	7.564966	10^7	7.564966	-0.005	7.564399	-0.108	7.552125	0.36	0.18	0.18	0.18	0.37
600	10^6	600.11	2.833294	10^6	2.833294	-0.006	2.833082	-0.112	2.829329	0.38	0.19	0.19	0.20	0.39
600	10^6	600.02	2.828271	10^6	2.828271	-0.006	2.828059	-0.020	2.827406	0.39	0.19	0.19	0.20	0.40
600	10^6	600.01	2.824760	10^6	2.824760	-0.006	2.824548	-0.014	2.824068	1.09	0.54	0.54	0.55	1.09
660.32	10^6	660.02	5.447661	10^6	5.447661	-0.007	5.447253	0.297	5.463960	1.08	0.54	0.54	0.55	1.09
700	10^6	699.85	8.043894	10^6	8.043894	-0.008	8.043291	0.149	8.054704	1.11	0.55	0.55	0.56	1.12
700	10^6	700.11	8.060855	10^6	8.060855	-0.008	8.060251	-0.112	8.051669	1.11	0.55	0.55	0.56	1.11
800	10^5	800.20	1.893828	10^5	1.893828	-0.010	1.893686	-0.203	1.890692	1.40	0.70	0.70	0.71	1.41
900	10^5	899.89	3.844127	10^5	3.844127	-0.011	3.843839	0.112	3.846649	1.24	0.62	0.62	0.63	1.26
900	10^5	899.92	3.841956	10^5	3.841956	-0.011	3.841668	0.084	3.843779	1.25	0.63	0.63	0.63	1.27
961.78	10^5	961.62	5.618921	10^5	5.618921	-0.013	5.618499	0.160	5.623788	1.54	0.77	0.77	0.78	1.55

Table 9 - results of the LNE variable temperature blackbody measurements for analysis by direct comparison

t_{nom} / °C)	Gain used	t_{BB} / °C	Bgrd corrected signal / mV	Bgrd corrected signal / V	Required gain	Signal at required range/ V	Zn point check drift/ °C	Signal corrected for Zn point drift/ V	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ V	lab u (k=1) / °C	u (k=1) with gain ratio uncertainty* / °C	u (k=1) plus drift uncertainty / °C	U (k=2) / °C
156.60	10^10	156.604	777.185	0.777185	10^10	0.777185	0.00	0.777243	-0.004	0.777100	0.22	0.22	0.22	0.43
231.93	10^9	231.915	1833.114	1.833114	10^9	1.833114	0.00	1.833251	0.015	1.834219	0.22	0.22	0.22	0.45
419.53	10^7	419.485	1980.357	1.980357	10^7	1.980357	0.00	1.980506	0.045	1.982182	0.05	0.05	0.06	0.12
660.32	10^6	660.174	5508.215	5.508215	10^6	5.508215	0.01	5.508628	0.146	5.516949	0.09	0.09	0.11	0.22
961.78	10^5	961.861	5705.270	5.705270	10^5	5.705270	0.01	5.705697	-0.081	5.702984	0.39	0.39	0.40	0.81
200	10^10	199.995	5154.564	5.154564	10^10	5.154564	0.00	5.154950	0.005	5.156070	0.22	0.22	0.22	0.44
250	10^9	249.986	3368.463	3.368463	10^9	3.368463	0.00	3.368716	0.014	3.370250	0.18	0.18	0.18	0.36
300	10^8	300.010	1367.415	1.367415	10^8	1.367415	0.00	1.367518	-0.010	1.367135	0.11	0.11	0.11	0.23
400	10^7	400.063	1366.687	1.366687	10^7	1.366687	0.00	1.366790	-0.063	1.365086	0.05	0.05	0.06	0.12
500[1]	10^7	499.953	7560.209	7.560209	10^7	7.560209	0.00	7.560775	0.047	7.566075	0.06	0.06	0.07	0.14
500[2]	10^7	499.976	7563.477	7.563477	10^7	7.563477	0.00	7.564044	0.024	7.566813	0.07	0.07	0.08	0.16
600[1]	10^6	600.015	2835.845	2.835845	10^6	2.835845	0.01	2.836057	-0.015	2.835560	0.06	0.06	0.08	0.16
600[2]	10^6	599.731	2825.946	2.825946	10^6	2.825946	0.01	2.826157	0.269	2.835120	0.08	0.08	0.10	0.19
300[1]	10^8	300.040	1369.291	1.369291	10^8	1.369291	0.00	1.369394	-0.040	1.367893	0.11	0.11	0.11	0.23
400[1]	10^7	400.058	1366.927	1.366927	10^7	1.366927	0.00	1.367030	-0.058	1.365458	0.05	0.05	0.06	0.12
600[1]	10^6	599.988	2834.872	2.834872	10^6	2.834872	0.01	2.835085	0.012	2.835491	0.06	0.06	0.08	0.16
500[3]	10^7	499.820	7563.477	7.563477	10^7	7.563477	0.00	7.564044	0.180	7.584536	0.24	0.24	0.24	0.48
600[3]	10^6	599.280	2825.946	2.825946	10^6	2.825946	0.01	2.826157	0.720	2.850198	0.25	0.25	0.26	0.52
700[3]	10^6	699.941	8125.120	8.125120	10^6	8.125120	0.01	8.125729	0.059	8.130282	0.27	0.27	0.28	0.55
800[3]	10^5	799.917	1908.946	1.908946	10^5	1.908946	0.01	1.909089	0.083	1.910321	0.31	0.31	0.32	0.64
900[3]	10^5	899.924	3882.634	3.882634	10^5	3.882634	0.01	3.882925	0.076	3.884845	0.36	0.36	0.37	0.75
1000[3]	10^5	1000.048	7070.470	7.070470	10^5	7.070470	0.01	7.071000	-0.048	7.069131	0.42	0.42	0.43	0.87
800[3]	10^5	799.950	1909.781	1.909781	10^5	1.909781	0.01	1.909925	0.050	1.910665	0.31	0.31	0.32	0.64
1000[3]	10^5	1000.095	7071.588	7.071588	10^5	7.071588	0.01	7.072118	-0.095	7.068404	0.42	0.42	0.43	0.87

Table 10 - results of the METAS variable temperature blackbody measurements for analysis by direct comparison

[1] values obtained using a Cs heatpipe with PRT;
[2] values obtained using a Na heatpipe with PRT;
[3] values obtained using a Na heatpipe with thermocouple.

t_{nom} / °C)	Gain used	t_{BB} / °C	Bgrd corrected Signal/ V	Required gain	Signal at required range/ V	Zn point check drift/ °C	Signal corrected for Zn point drift/ V	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ V	lab U (k=2) / °C	lab u (k=1) / °C	u (k=1) with gain ratio uncertainty* / °C	u (k=1) plus drift uncertainty / °C	U (k=2) / °C
200	10^9	201.26	0.587914	10^10	5.418297	-0.019	5.414134	-1.261	5.141382	0.955	0.478	0.478	0.480	0.960
250	10^9	250.78	3.470968	10^9	3.470968	-0.023	3.468301	-0.783	3.379299	0.808	0.404	0.404	0.405	0.809
300	10^8	299.80	1.365282	10^8	1.365282	-0.028	1.364233	0.200	1.371707	0.822	0.411	0.411	0.412	0.824
419.53	10^7	417.73	1.923257	10^7	1.923257	-0.041	1.921779	1.796	1.986788	0.860	0.430	0.430	0.431	0.862
500	10^7	497.10	7.285188	10^7	7.285188	-0.051	7.279590	2.896	7.599125	0.810	0.405	0.405	0.407	0.814
600	10^6	596.25	2.739827	10^6	2.739827	-0.065	2.737722	3.750	2.859868	0.850	0.425	0.425	0.429	0.857
660.32	10^6	655.68	5.281204	10^6	5.281204	-0.074	5.277146	4.640	5.532395	0.822	0.411	0.411	0.416	0.832
700	10^6	695.58	7.833208	10^6	7.833208	-0.080	7.827189	4.421	8.158800	0.824	0.412	0.412	0.418	0.835
800	10^5	797.27	1.910186	10^5	1.910186	-0.098	1.908718	2.730	1.949607	1.196	0.598	0.598	0.604	1.208
900	10^5	897.37	3.894053	10^5	3.894053	-0.117	3.891061	2.628	3.958163	1.193	0.596	0.596	0.605	1.209
1000	10^5	1000.09	7.221856	10^5	7.221856	-0.139	7.216306	-0.087	7.212824	1.084	0.542	0.542	0.555	1.110

Table 11 - results of the UME variable temperature blackbody measurements for analysis by direct comparison

t_{nom} / °C	Gain used	t_{BB} / °C	Bgrd corrected Signal/ V	Required Gain	Signal at required range/ V	Zn point check drift/ °C	Signal corrected for Zn point drift/ V	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ V	lab U (k=2) / °C	lab u (k=1) / °C	u (k=1) with gain ratio uncertainty* / °C	u (k=1) plus drift uncertainty/ °C	U (k=2) / °C
156.60	10^10	156.63	0.777632	10^10	0.777632	-0.025	0.776670	-0.032	0.775467	0.20	0.10	0.10	0.10	0.20
200	10^10	200.02	5.186709	10^10	5.186709	-0.031	5.180293	-0.020	5.176180	0.20	0.10	0.10	0.10	0.20
231.93	10^9	232.05	1.841034	10^9	1.841034	-0.035	1.838757	-0.120	1.830977	0.20	0.10	0.10	0.10	0.20
250	10^9	250.01	3.372291	10^9	3.372291	-0.038	3.368120	-0.012	3.366837	0.20	0.10	0.10	0.10	0.20
250	10^9	250.05	3.376714	10^9	3.376714	-0.038	3.372537	-0.054	3.366591	0.20	0.10	0.10	0.10	0.20
300	10^8	300.06	1.365190	10^8	1.365190	-0.045	1.363501	-0.057	1.361375	0.21	0.11	0.11	0.11	0.22
300	10^8	300.02	1.363646	10^8	1.363646	-0.045	1.361959	-0.023	1.361095	0.21	0.11	0.11	0.11	0.22
400	10^7	400.22	1.369248	10^7	1.369248	-0.062	1.367555	-0.223	1.361506	0.20	0.10	0.10	0.11	0.21
400	10^7	400.00	1.363649	10^7	1.363649	-0.062	1.361962	-0.004	1.361856	0.20	0.10	0.10	0.11	0.21
419.53	10^7	419.43	1.976805	10^7	1.976805	-0.066	1.974360	0.100	1.978075	0.20	0.10	0.10	0.11	0.21
500[1]	10^7	499.89	7.546142	10^7	7.546142	-0.082	7.536808	0.112	7.549547	0.20	0.10	0.10	0.11	0.22
500[2]	10^7	500.22	7.612328	10^7	7.612328	-0.082	7.602911	-0.215	7.578334	0.48	0.24	0.24	0.24	0.49
600	10^6	600.05	2.842331	10^6	2.842331	-0.105	2.838815	-0.051	2.837102	0.47	0.24	0.24	0.24	0.48
660.32	10^6	660.03	5.477611	10^6	5.477611	-0.120	5.470836	0.295	5.487479	0.48	0.24	0.24	0.25	0.50
700	10^6	699.95	8.105329	10^6	8.105329	-0.130	8.095303	0.051	8.099225	0.48	0.24	0.24	0.25	0.50
700	10^6	700.00	8.111707	10^6	8.111707	-0.130	8.101673	0.000	8.101673	0.48	0.24	0.24	0.25	0.50
800	10^5	799.81	1.899315	10^5	1.899315	-0.158	1.896965	0.193	1.899818	0.49	0.25	0.25	0.26	0.52
900	10^5	900.19	3.867533	10^5	3.867533	-0.189	3.862749	-0.188	3.858018	0.49	0.25	0.25	0.26	0.53
900	10^5	900.03	3.865023	10^5	3.865023	-0.189	3.860242	-0.028	3.859531	0.49	0.25	0.25	0.26	0.53
961.78	10^5	961.78	5.656693	10^5	5.656693	-0.210	5.649696	0.000	5.649696	0.49	0.25	0.25	0.27	0.54
1000	10^5	1000.00	7.025350	10^5	7.025350	-0.223	7.016660	0.000	7.016660	0.49	0.25	0.25	0.27	0.54
1000	10^5	1000.12	7.034740	10^5	7.034740	-0.223	7.026038	-0.119	7.021394	0.49	0.25	0.25	0.27	0.54

Table 12 - results of the NPL variable temperature blackbody measurements for analysis by direct comparison

[1] values obtained using a Cs heatpipe with PRT;
[2] values obtained using the NPL wide range cavity (WRC);

6.1 AVERAGE LABORATORY RESULTS FOR VTBB MEASUREMENTS WITH THE INRIM THERMOMETER

t_{nom}/ °C	Average signal/ V	U (*k*=2)/ °C	U* (*k*=2)/ °C
156.6	0.777703	0.45	0.46
200	5.137704	0.31	0.32
231.93	1.840200	0.30	0.32
250	3.378231	0.30	0.31
300	1.371740	0.30	0.35
400	1.365607	0.31	0.31
419.53	1.986226	0.31	0.35
500	7.564915	0.32	0.33
600	2.838061	0.29	0.31
660.32	5.485046	0.31	0.49
700	8.096916	0.32	0.50
800	1.902232	0.35	0.70
900	3.861044	0.39	0.72

Table 13 – CEM results

t_{nom}/ °C	Average signal/ V	U (*k*=2)/ °C	U* (*k*=2)/ °C
156.6	0.772821	0.07	0.11
200	5.158014	0.07	0.11
231.93	1.836253	0.08	0.12
250	3.372894	0.08	0.10
300	1.366133	0.11	0.21
400	1.365717	0.07	0.08
419.53	1.983809	0.08	0.18
500	7.566297	0.10	0.11
600	2.835165	0.12	0.16
660.32	5.483208	0.15	0.41
700	8.094893	0.16	0.42
800	1.900399	0.19	0.64
900	3.860880	0.22	0.64
961.78	5.649436	0.24	0.89

Table 14 - PTB results

t_{nom}/ °C	Average signal/ V	U (*k*=2) / °C	U* (*k*=2)/ °C
156.6	0.786711	0.21	0.22
200	5.110359	0.25	0.26
231.93	1.812749	0.28	0.30
250	3.371701	0.30	0.30
300	1.363774	0.33	0.37
400	1.360844	0.36	0.36
419.53	1.978393	0.35	0.39
500	7.552125	0.37	0.37
600	2.826935	0.75	0.75
660.32	5.463960	1.09	1.16
700	8.053186	1.12	1.18
800	1.890692	1.41	1.54
900	3.845214	1.27	1.40
961.78	5.623788	1.55	1.77
600 Cs	2.828368	0.40	0.41
600 Na	2.824068	1.09	1.10

Table 15 - LNE results

t_{nom}/ °C	Average signal/ V	U (*k*=2)/ °C	U* (*k*=2)/ °C
200	5.141382	0.96	0.96
250	3.379299	0.81	0.81
300	1.371707	0.82	0.84
419.53	1.986788	0.86	0.88
500	7.599125	0.81	0.82
600	2.859868	0.86	0.86
660.32	5.532395	0.83	0.92
700	8.158800	0.84	0.92
800	1.949607	1.21	1.35
900	3.958163	1.21	1.35
1000	7.212824	1.11	3.61

Table 16 – UME results

t_{nom}/ °C	Average signal/ V	U (*k*=2)/ °C	U* (*k*=2)/ °C
156.6	0.777100	0.43	0.44
200	5.156070	0.44	0.45
231.93	1.834219	0.45	0.46
250	3.370250	0.36	0.37
300	1.367514	0.23	0.29
400	1.365272	0.12	0.13
419.53	1.982182	0.12	0.20
500	7.572475	0.32	0.33
600	2.839092	0.35	0.37
660.32	5.516949	0.22	0.44
700	8.130282	0.55	0.68
800	1.910493	0.64	0.88
900	3.884845	0.75	0.96
961.78	5.702984	0.81	1.18
1000	7.068768	0.87	3.54
Cs at 500	7.566075	0.14	0.44
Na at 500 1	7.566813	0.16	0.15
Na at 500 2	7.584536	0.48	0.17
Cs at 600	2.835526	0.16	0.49
Na at 600 1	2.835120	0.19	0.19
Na at 600 2	2.850198	0.52	0.22

Table 17 - METAS results

t_{nom}/ °C	Average signal/ V	U (*k*=2)/ °C	U* (k=2)/ °C
156.6	0.775467	0.20	0.22
200	5.176180	0.20	0.22
231.93	1.830977	0.20	0.22
250	3.366714	0.20	0.21
300	1.361235	0.22	0.28
400	1.361681	0.21	0.21
419.53	1.978075	0.21	0.27
500	7.563941	0.36	0.36
600	2.837102	0.48	0.49
660.32	5.487479	0.50	0.63
700	8.100449	0.50	0.63
800	1.899818	0.52	0.80
900	3.858774	0.53	0.80
961.78	5.649696	0.54	1.01
1000	7.019027	0.54	3.48
Cs at 500	7.549547	0.22	0.23
WRC at 500	7.578334	0.49	0.49

Table 18 - NPL results

Note:

U is the total combined uncertainty including the laboratory uncertainty and components for the thermometer drift and gain ratios.

U* is the total combined uncertainty including also the uncertainty in the reference value (uncertainty in the median)

t_{nom}/ °C	Mean signal/ V	Median signal/ V	Weighted signal/ V
156.6	0.777960	0.777100	0.774444
200	5.146618	5.148726	5.155781
231.93	1.830879	1.834219	1.834511
250	3.373182	3.372298	3.372364
300	1.367017	1.366823	1.365928
400	1.363824	1.365272	1.365161
419.53	1.982579	1.982995	1.982871
500	7.569813	7.565606	7.566122
600	2.839371	2.837582	2.836128
660.32	5.494840	5.486262	5.492596
700	8.105754	8.098683	8.098531
800	1.908874	1.901316	1.901897
900	3.878153	3.860962	3.863612
961.78	5.656476	5.649566	5.652625
1000	7.100206	7.068768	7.059511

Table 19 – mean, median and weighted mean values for all the INRiM thermometer measurements with the variable temperature blackbody sources. The weighted mean is calculated using only the laboratory uncertainty, *u*, in the third column of the tables, i.e. not including the uncertainty in the reference value

t_{nom}/ °C	NPL – mean/ V	NPL-median/ V	equiv dT* from median/ °C	NPL-wghted mean/ V	UME – mean/ V	UME-median/ V	equiv dT* from median/ °C	UME-wghted mean/ V	METAS – mean/ V	METAS-median/ V	equiv dT* from median/ °C	METAS – wghted mean/ V
156.6	-0.002493	-0.001632	-0.04	0.001024					-0.000861	0.000000	0.00	0.002656
200	0.029562	0.027454	0.13	0.020399	-0.005236	-0.007344	-0.04	-0.014399	0.009452	0.007344	0.04	0.000289
231.93	0.000097	-0.003242	-0.05	-0.003535	-	-	-	--	0.003339	0.000000	0.00	-0.000292
250	-0.006468	-0.005584	-0.05	-0.005650	0.006118	0.007002	0.06	0.006936	-0.002932	-0.002048	-0.02	-0.002114
300	-0.005782	-0.005588	-0.15	-0.004693	0.004690	0.004883	0.13	0.005779	0.000497	0.000690	0.02	0.001586
400	-0.002143	-0.003591	-0.13	-0.003480	-	-	-	-	0.001448	0.000000	0.00	0.000111
419.53	-0.004504	-0.004921	-0.13	-0.004796	0.004209	0.003792	0.10	0.003917	-0.000397	-0.000814	-0.02	-0.000689
500	-0.005872	-0.001665	-0.01	-0.002182	0.029312	0.033519	0.29	0.033002	0.002662	0.006869	0.06	0.006352
600	-0.002268	-0.000479	-0.01	0.000974	0.020498	0.022287	0.66	0.023740	-0.000278	0.001511	0.05	0.002964
660.32	-0.007361	0.001216	0.02	-0.005117	0.037556	0.046133	0.81	0.039799	0.022110	0.030687	0.54	0.024353
700	-0.005305	0.001766	0.02	0.001918	0.053046	0.060118	0.78	0.060270	0.024527	0.031599	0.41	0.031751
800	-0.009056	-0.001498	-0.10	-0.002079	0.040734	0.048292	3.17	0.047711	0.001620	0.009178	0.62	0.008597
900	-0.019379	-0.002188	-0.09	-0.004838	0.080010	0.097201	3.76	0.094551	0.006692	0.023883	0.94	0.021233
961.78	-0.006780	0.000130	0.00	-0.002929	-	-	-	-	0.046508	0.053418	1.59	0.050358
1000	-0.081179	-0.049740	-1.28	-0.040484	0.112618	0.144057	3.60	0.153313	-0.031439	0.000000	0.00	0.009256
Cs at 500	-0.020266	-0.016059	-0.14	-0.016575	-	-	-	-	-0.003737	0.000470	0.00	-0.000047
Na/WRC‡ at 500 1	0.008521	0.012728	0.11	0.012212	-	-	-	-	-0.003000	0.001207	0.01	0.000690
Na at 500 2	-	-	-	-	-	-	-	-	0.014724	0.018931	0.17	0.018414
Cs at 600	-	-	-	-	-	-	-	-	-0.003845	-0.002056	-0.06	-0.000602
Na at 600 1	-	-	-	-	-	-	-	-	-0.004251	-0.002461	-0.07	-0.001008
Na at 600 2	-	-	-	-	-	-	-	-	0.010828	0.012617	0.38	0.014070

Table 20 – differences of the laboratory results from the mean, median and weighted mean values – table 1 of 2

‡ At 500 °C NPL used a Cs heatpipe blackbody and the wide range cavity (WRC); METAS used a Cs and a Na heatpipe blackbody.

* The equivalent temperature difference, ΔT, from the median value was calculated using the following function, where S is the thermometer signal, ΔS is the difference of the laboratory signal from the median value, T is the source temperature and λ is the thermometer wavelength:

$$\Delta T = \frac{\Delta S}{S} \frac{\lambda T^2}{c_2}$$

t_{nom}/ °C	LNE – mean/ V	LNE-median/ V	equiv dT from median/ °C	LNE-wghted mean/ V	PTB – mean/ V	PTB-median/ V	equiv dT from median/ °C	PTB-wghted mean/ V	CEM – mean/ V	CEM-median/ V	equiv dT from median/ °C	CEM-wghted mean/ V
156.6	0.008751	0.009611	0.25	0.012267	-0.005139	-0.004278	-0.11	-0.001622	-0.000257	0.000603	0.02	0.003259
200	-0.036259	-0.038367	-0.19	-0.045422	0.011396	0.009288	0.04	0.002234	-0.008914	-0.011022	-0.05	-0.018076
231.93	-0.018131	-0.021470	-0.34	-0.021762	0.005373	0.002034	0.03	0.001741	0.009321	0.005982	0.09	0.005689
250	-0.001480	-0.000596	-0.01	-0.000663	-0.000287	0.000596	0.01	0.000530	0.005050	0.005934	0.05	0.005868
300	-0.003243	-0.003050	-0.08	-0.002154	-0.000884	-0.000690	-0.02	0.000205	0.004723	0.004917	0.13	0.005812
400	-0.002980	-0.004428	-0.16	-0.004317	0.001893	0.000445	0.02	0.000556	0.001783	0.000335	0.01	0.000446
419.53	-0.004185	-0.004602	-0.12	-0.004478	0.001230	0.000814	0.02	0.000938	0.003647	0.003230	0.09	0.003355
500	-0.017687	-0.013480	-0.12	-0.013997	-0.003516	0.000691	0.01	0.000174	-0.004898	-0.000691	-0.01	-0.001208
600	-0.012436	-0.010647	-0.32	-0.009193	-0.004206	-0.002417	-0.07	-0.000963	-0.001310	0.000479	0.01	0.001933
660.32	-0.030880	-0.022302	-0.40	-0.028636	-0.011631	-0.003054	-0.05	-0.009388	-0.009793	-0.001216	-0.02	-0.007550
700	-0.052568	-0.045496	-0.59	-0.045344	-0.010861	-0.003789	-0.05	-0.003637	-0.008838	-0.001766	-0.02	-0.001614
800	-0.018182	-0.010624	-0.72	-0.011205	-0.008475	-0.000917	-0.06	-0.001498	-0.006641	0.000917	0.06	0.000336
900	-0.032939	-0.015748	-0.63	-0.018398	-0.017273	-0.000082	0.00	-0.002732	-0.017109	0.000082	0.00	-0.002568
961.78	-0.032688	-0.025777	-0.78	-0.028837	-0.007040	-0.000130	0.00	-0.003190	-	-	-	-
1000	-	-	-	-	-	-	-	-	-	-	-	-
Cs at 600	-0.011003	-0.009214	-0.28	-0.007760	-	-	-	-	-	-	-	-
Na at 600 1	-0.015302	-0.013513	-0.41	-0.012060	-	-	-	-	-	-	-	-

Table 21 - differences of the laboratory results from the mean, median and weighted mean values – table 2 of 2

7 RESULTS OF THE VTBB MEASUREMENTS FOR THE LP5 THERMOMETER

t_{nom} / °C)	Range used	t_{BB} / °C	Bgrd corrected Signal/ A	Required range	Signal at required range/ A	Drift from Zn point check‡/ °C	Signal corrected for Zn point drift/ A	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ A	lab U (k=2) / °C	lab u (k=1) / °C	u (k=1) with range ratio & drift uncertainty* / °C	U (k=2) / °C
231.93	R1	231.91	3.02262E-12	R1	3.02262E-12	0.02	3.02522E-12	0.02	3.02740E-12	0.41	0.21	0.22	0.43
250.00	R1	250.11	5.72417E-12	R1	5.72417E-12	0.03	5.72909E-12	-0.11	5.70800E-12	0.32	0.16	0.18	0.36
300.00	R1	300.09	2.62564E-11	R1	2.62564E-11	0.03	2.62789E-11	-0.09	2.62130E-11	0.31	0.16	0.18	0.36
400.00	R1	399.94	2.81427E-10	R1	2.81427E-10	0.04	2.81669E-10	0.06	2.82010E-10	0.31	0.15	0.20	0.40
419.53	R1	419.55	4.14299E-10	R1	4.14299E-10	0.05	4.14655E-10	-0.02	4.14497E-10	0.31	0.15	0.20	0.41
500.00	R1	499.98	1.63872E-09	R1	1.63872E-09	0.06	1.64013E-09	0.02	1.64063E-09	0.31	0.15	0.23	0.45
600.00	R2	600.09	6.40066E-09	R2	6.40066E-09	0.07	6.40616E-09	-0.09	6.39923E-09	0.26	0.13	0.25	0.50
660.32	R2	660.35	1.25941E-08	R2	1.25941E-08	0.08	1.26049E-08	-0.03	1.26010E-08	0.26	0.13	0.28	0.55
700.00	R2	700.10	1.88022E-08	R2	1.88022E-08	0.09	1.88184E-08	-0.10	1.88002E-08	0.26	0.13	0.30	0.59
800.00	R2	799.91	4.51797E-08	R2	4.51797E-08	0.11	4.52185E-08	0.09	4.52509E-08	0.26	0.13	0.35	0.70
900.00	R2	900.01	9.36263E-08	R2	9.36263E-08	0.13	9.37068E-08	-0.01	9.37006E-08	0.26	0.13	0.41	0.81
231.93	R1	232.07	3.05435E-12	R2	3.05435E-12	0.02	3.05698E-12	-0.14	3.04161E-12	0.39	0.19	0.21	0.41
300.00	R1	300.14	2.63234E-11	R2	2.63234E-11	0.03	2.63460E-11	-0.14	2.62432E-11	0.31	0.15	0.18	0.36
500.00	R1	500.09	1.64322E-09	R2	1.64322E-09	0.06	1.64463E-09	-0.09	1.64236E-09	0.31	0.15	0.23	0.45
700.00	R2	700.04	1.87879E-08	R2	1.87879E-08	0.09	1.88041E-08	-0.04	1.87968E-08	0.26	0.13	0.30	0.59
900.00	R2	899.92	9.36075E-08	R2	9.36075E-08	0.13	9.36880E-08	0.08	9.37379E-08	0.26	0.13	0.41	0.81

Table 22- results of the CEM variable temperature blackbody measurements for analysis by direct comparison

‡ Compared to the PTB value at the start of the comparison (see Table 5).

* These uncertainty values include components for the uncertainty due to the range ratio, as given by the laboratory as appropriate (i.e. where the signal values have been corrected to a different range setting), and a component to allow for the drift in the radiation thermometer during the comparison, as determined from the measurements with the transfer zinc fixed-point blackbody source.

t_{nom} / °C	Range used	t_{BB} / °C	Bgrd corrected Signal/ A	Required range	Signal at required range/ A	Drift from Zn point check / °C	Signal corrected for Zn point drift/ A	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ A	lab U (*k*=2) / °C	lab u (*k*=1) / °C	u (*k*=1) with range ratio & drift uncertainty* / °C	U (*k*=2) / °C
231.93	R1	231.946	3.03946E-12	R1	3.03946E-12	0.00	3.03946E-12	-0.016	3.03774E-12	0.111	0.055	0.064	0.128
250	R1	250.089	5.70504E-12	R1	5.70504E-12	0.00	5.70504E-12	-0.089	5.68802E-12	0.085	0.042	0.055	0.109
300	R1	300.020	2.62226E-11	R1	2.62226E-11	0.00	2.62226E-11	-0.020	2.62081E-11	0.097	0.049	0.064	0.127
400	R1	400.021	2.82049E-10	R1	2.82049E-10	0.00	2.82049E-10	-0.021	2.81932E-10	0.035	0.018	0.059	0.119
419.53	R1	419.530	4.14019E-10	R1	4.14019E-10	0.00	4.14019E-10	0.000	4.14019E-10	0.036	0.018	0.063	0.125
500	R1	500.015	1.64206E-09	R1	1.64206E-09	0.00	1.64206E-09	-0.015	1.64169E-09	0.039	0.020	0.077	0.155
600	R1	600.017	6.38577E-09	R2	6.38515E-09	0.00	6.38515E-09	-0.017	6.38381E-09	0.044	0.022	0.098	0.196
660.32	R2	660.312	1.25796E-08	R2	1.25796E-08	0.00	1.25796E-08	0.008	1.25806E-08	0.073	0.037	0.115	0.230
700	R2	700.031	1.87788E-08	R2	1.87788E-08	0.00	1.87788E-08	-0.031	1.87731E-08	0.075	0.038	0.124	0.248
800	R2	800.012	4.52005E-08	R2	4.52005E-08	0.00	4.52005E-08	-0.011	4.51963E-08	0.081	0.041	0.150	0.299
900	R2	900.011	9.37001E-08	R2	9.37001E-08	0.00	9.37001E-08	-0.011	9.36930E-08	0.088	0.044	0.178	0.355
961.78	R2	961.748	1.38461E-07	R2	1.38461E-07	0.00	1.38461E-07	0.032	1.38488E-07	0.094	0.047	0.196	0.393
231.93	R1	231.947	3.03869E-12	R1	3.03869E-12	0.00	3.03869E-12	-0.017	3.03689E-12	0.132	0.066	0.073	0.147
300	R1	300.027	2.62522E-11	R1	2.62522E-11	0.00	2.62522E-11	-0.027	2.62324E-11	0.184	0.092	0.101	0.201
419.53	R1	419.512	4.13968E-10	R1	4.13968E-10	0.00	4.13968E-10	0.018	4.14109E-10	0.036	0.018	0.063	0.125
500	R1	500.049	1.64205E-09	R1	1.64205E-09	0.00	1.64205E-09	-0.048	1.64083E-09	0.039	0.020	0.077	0.155
700	R2	700.028	1.87822E-08	R2	1.87822E-08	0.00	1.87822E-08	-0.028	1.87770E-08	0.075	0.038	0.124	0.248
961.78	R2	961.696	1.38400E-07	R2	1.38400E-07	0.00	1.38400E-07	0.084	1.38470E-07	0.094	0.047	0.196	0.393

Table 23 - results of the PTB variable temperature blackbody measurements for analysis by direct comparison

t_{nom} / °C	Range used	t_{BB} / °C	Bgrd corrected Signal/ A	Required range	Signal at required range/ A	Drift from Zn point check / °C	Signal corrected for Zn point drift/ A	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ A	lab U (k=2) / °C	lab u (k=1) / °C	u (k=1) with range ratio & drift uncertainty* / °C	U (k=2) / °C
231.93	R1	231.76	2.99090E-12	R1	2.99090E-12	0.293	3.02238E-12	0.17	3.04049E-12	0.60	0.30	0.30	0.60
250	R1	249.83	5.59107E-12	R1	5.59107E-12	0.314	5.64991E-12	0.17	5.68220E-12	0.43	0.22	0.22	0.44
250	R1	249.84	5.30973E-12	R1	5.30973E-12	0.314	5.36561E-12	0.16	5.39469E-12	0.47	0.24	0.24	0.48
250	R1	249.83	5.59853E-12	R1	5.59853E-12	0.314	5.65745E-12	0.17	5.68993E-12	0.44	0.22	0.22	0.44
300	R1	300.19	2.60880E-11	R1	2.60880E-11	0.378	2.63625E-11	-0.19	2.62212E-11	0.35	0.17	0.18	0.36
400	R1	399.93	2.77908E-10	R1	2.77908E-10	0.520	2.80832E-10	0.07	2.81211E-10	0.31	0.16	0.17	0.33
400	R1	400.14	2.79379E-10	R1	2.79379E-10	0.521	2.82319E-10	-0.14	2.81531E-10	0.32	0.16	0.17	0.34
419.53	R1	419.63	4.09805E-10	R1	4.09805E-10	0.551	4.14118E-10	-0.10	4.13359E-10	0.32	0.16	0.17	0.34
500	R1	500.11	1.62441E-09	R1	1.62441E-09	0.687	1.64150E-09	-0.11	1.63862E-09	0.34	0.17	0.18	0.37
600	R2	600.16	6.32775E-09	R2	6.32775E-09	0.876	6.39434E-09	-0.16	6.38240E-09	0.41	0.20	0.22	0.45
600	R2	600.13	6.32566E-09	R2	6.32566E-09	0.876	6.39223E-09	-0.13	6.38234E-09	0.42	0.21	0.23	0.47
660.32	R2	660.06	1.23955E-08	R2	1.23955E-08	1.000	1.25259E-08	0.26	1.25605E-08	1.04	0.52	0.53	1.06
700	R2	699.83	1.84743E-08	R2	1.84743E-08	1.087	1.86687E-08	0.17	1.86988E-08	1.03	0.52	0.53	1.06
700	R2	700.11	1.85300E-08	R2	1.85300E-08	1.088	1.87250E-08	-0.11	1.87048E-08	1.05	0.52	0.54	1.08
800	R2	800.07	4.45481E-08	R2	4.45481E-08	1.323	4.50169E-08	-0.07	4.49915E-08	1.14	0.57	0.59	1.17
900	R2	899.88	9.22973E-08	R2	9.22973E-08	1.580	9.32687E-08	0.12	9.33424E-08	1.17	0.58	0.61	1.22
900	R2	899.94	9.23564E-08	R2	9.23564E-08	1.580	9.33284E-08	0.06	9.33637E-08	1.19	0.60	0.62	1.24
961.78	R2	961.63	1.36561E-07	R2	1.36561E-07	1.751	1.37998E-07	0.15	1.38124E-07	1.24	0.62	0.65	1.30

Table 24- results of the LNE variable temperature blackbody measurements for analysis by direct comparison

t_{nom} / °C	Range used	t_{BB} / °C	Bgrd corrected Signal/ A	Required range	Signal at required range/ A	Drift from Zn point check / °C	Signal corrected for Zn point drift/ A	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ A	lab U (k=2) / °C	lab u (k=1) / °C	u (k=1) with range ratio & drift uncertainty* / °C	U (k=2) / °C
231.93	R1	231.913	3.0206E-12	R1	3.0206E-12	0.237	3.04632E-12	0.02	3.04820E-12	0.445	0.223	0.225	0.450
419.53	R1	419.500	4.1029E-10	R1	4.1029E-10	0.446	4.13790E-10	0.03	4.14031E-10	0.102	0.051	0.079	0.158
660.32	R2	660.335	1.2502E-08	R2	1.2502E-08	0.810	1.26081E-08	-0.02	1.26061E-08	0.174	0.087	0.139	0.278
961.78	R2	961.678	1.3834E-07	R2	1.3834E-07	1.417	1.39516E-07	0.10	1.39601E-07	0.776	0.388	0.432	0.865
250	R1	249.986	5.6051E-12	R1	5.6051E-12	0.254	5.65281E-12	0.01	5.65552E-12	0.358	0.179	0.182	0.365
300	R1	300.011	2.6007E-11	R1	2.6007E-11	0.305	2.62282E-11	-0.01	2.62202E-11	0.224	0.112	0.119	0.239
400	R1	400.063	2.8005E-10	R1	2.8005E-10	0.421	2.82436E-10	-0.06	2.82077E-10	0.102	0.051	0.076	0.153
500[1]	R1	499.955	1.6277E-09	R1	1.6277E-09	0.556	1.64162E-09	0.05	1.64276E-09	0.110	0.055	0.093	0.186
500[2]	R1	499.963	1.6276E-09	R1	1.6276E-09	0.556	1.64151E-09	0.04	1.64244E-09	0.135	0.067	0.101	0.201
600[1]	R1	600.014	6.3365E-09	R2	6.3400E-09	0.709	6.39403E-09	-0.01	6.39292E-09	0.119	0.060	0.113	0.225
600[2]	R1	599.728	6.3123E-09	R2	6.3158E-09	0.708	6.36961E-09	0.27	6.39046E-09	0.158	0.079	0.124	0.247
300	R1	300.040	2.6079E-11	R1	2.6079E-11	0.305	2.63016E-11	-0.04	2.62724E-11	0.224	0.112	0.119	0.239
400	R1	400.060	2.8016E-10	R1	2.8016E-10	0.421	2.82550E-10	-0.06	2.82208E-10	0.102	0.051	0.076	0.153
600[1]	R1	599.988	6.3348E-09	R2	6.3383E-09	0.709	6.39231E-09	0.01	6.39321E-09	0.119	0.060	0.113	0.225
500[3]	R1	499.803	1.6276E-09	R1	1.6276E-09	0.555	1.64151E-09	0.20	1.64646E-09	0.477	0.238	0.250	0.500
600[3]	R1	599.237	6.3123E-09	R2	6.3158E-09	0.707	6.36961E-09	0.76	6.42816E-09	0.507	0.253	0.271	0.541
700[3]	R2	699.935	1.8713E-08	R2	1.8713E-08	0.880	1.88726E-08	0.07	1.88845E-08	0.534	0.267	0.292	0.584
800[3]	R2	799.890	4.5069E-08	R2	4.5069E-08	1.070	4.54527E-08	0.11	4.54926E-08	0.619	0.309	0.341	0.682
900[3]	R2	899.923	9.3482E-08	R2	9.3482E-08	1.279	9.42779E-08	0.08	9.43265E-08	0.719	0.359	0.398	0.797
1000[3]	R2	1000.039	1.7303E-07	R2	1.7303E-07	1.507	1.74506E-07	-0.04	1.74467E-07	0.833	0.416	0.463	0.926
800[3]	R2	799.949	4.5097E-08	R2	4.5097E-08	1.070	4.54812E-08	0.05	4.54995E-08	0.619	0.309	0.341	0.682
1000[3]	R2	1000.080	1.7314E-07	R2	1.7314E-07	1.507	1.74615E-07	-0.08	1.74535E-07	0.833	0.416	0.463	0.926

Table 25- results of the METAS variable temperature blackbody measurements for analysis by direct comparison

[1] values obtained using a Cs heatpipe with PRT;
[2] values obtained using a Na heatpipe with PRT;
[3] values obtained using a Na heatpipe with thermocouple.

t_{nom} / °C	Range used	t_{BB} / °C	Bgrd corrected Signal/ A	Required range	Signal at required range/ A	Drift from Zn point check / °C	Signal corrected for Zn point drift/ A	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ A	lab U (k=2) / °C	lab u (k=1) / °C	u (k=1) with range ratio & drift uncertainty* / °C	U (k=2) / °C
250	R1	250.78	5.76788E-12	R1	5.76788E-12	0.129	5.79267E-12	-0.78	5.64118E-12	0.953	0.477	0.478	0.96
300	R2	299.80	2.60561E-11	R1	2.63989E-11	0.154	2.65124E-11	0.20	2.66604E-11	0.894	0.447	0.634	1.27
419.53	R2	417.73	3.98655E-10	R1	4.03899E-10	0.224	4.05635E-10	1.80	4.19619E-10	0.805	0.402	0.771	1.54
500	R2	497.10	1.56268E-09	R1	1.58323E-09	0.278	1.59004E-09	2.90	1.66117E-09	0.831	0.416	0.917	1.83
600	R2	596.25	6.07226E-09	R2	6.07226E-09	0.354	6.09835E-09	3.75	6.37564E-09	0.830	0.415	0.426	0.85
660.32	R2	655.68	1.19562E-08	R2	1.19562E-08	0.405	1.20076E-08	4.64	1.25996E-08	0.969	0.485	0.497	0.99
700	R2	695.58	1.80514E-08	R2	1.80514E-08	0.440	1.81290E-08	4.42	1.89117E-08	0.921	0.460	0.475	0.95
800	R2	797.27	4.40370E-08	R2	4.40370E-08	0.537	4.42263E-08	2.73	4.51918E-08	1.106	0.553	0.572	1.14
900	R2	897.37	9.18374E-08	R2	9.18374E-08	0.643	9.22321E-08	2.63	9.38530E-08	1.214	0.607	0.631	1.26
1000	R2	1000.09	1.72885E-07	R2	1.72885E-07	0.760	1.73628E-07	-0.09	1.73542E-07	1.179	0.590	0.623	1.25

Table 26- results of the UME variable temperature blackbody measurements for analysis by direct comparison

t_{nom} / °C	Range used	t_{BB} / °C	Bgrd corrected Signal/)	Required range	Signal at required range/ A	Drift from Zn point check / °C	Signal corrected for Zn point drift/ A	dt (t_{nom} - t_{BB}) / °C	Signal corrected to t_{nom}/ A	lab U (*k*=2) / °C	lab u (*k*=1) / °C	u (*k*=1) with range ratio & drift uncertainty* / °C	U (*k*=2) / °C
231.93	R1	232.03	3.06186E-12	R1	3.06186E-12	-0.003	3.06156E-12	-0.10	3.05057E-12	0.26	0.13	0.13	0.27
250	R1	249.99	5.67265E-12	R1	5.67265E-12	-0.003	5.67210E-12	0.01	5.67400E-12	0.25	0.13	0.13	0.26
250	R1	249.99	5.68143E-12	R1	5.68143E-12	-0.003	5.68089E-12	0.01	5.68374E-12	0.25	0.13	0.13	0.26
250	R1	250.06	5.69507E-12	R1	5.69507E-12	-0.003	5.69453E-12	-0.06	5.68404E-12	0.25	0.13	0.13	0.26
300	R1	300.06	2.61833E-11	R1	2.61833E-11	-0.003	2.61808E-11	-0.06	2.61406E-11	0.25	0.13	0.13	0.26
400	R1	400.00	2.81754E-10	R1	2.81754E-10	-0.005	2.81727E-10	0.00	2.81755E-10	0.25	0.13	0.14	0.27
400	R1	400.06	2.82162E-10	R1	2.82162E-10	-0.005	2.82135E-10	-0.06	2.81792E-10	0.25	0.13	0.14	0.27
419.53	R1	419.42	4.12869E-10	R1	4.12869E-10	-0.005	4.12830E-10	0.11	4.13661E-10	0.25	0.13	0.14	0.28
500[1]	R2	499.89	1.63906E-09	R1	1.63849E-09	-0.006	1.63833E-09	0.11	1.64103E-09	0.25	0.13	0.15	0.29
500[1]	R1	499.89	1.63849E-09	R1	1.63849E-09	-0.006	1.63833E-09	0.11	1.64101E-09	0.25	0.13	0.15	0.29
500[2]	R1	500.22	1.65219E-09	R1	1.65219E-09	-0.006	1.65203E-09	-0.22	1.64647E-09	0.50	0.25	0.26	0.52
600	R1	600.04	6.39823E-09	R2	6.40048E-09	-0.008	6.39987E-09	-0.04	6.39660E-09	0.50	0.25	0.27	0.54
660.32	R2	660.04	1.25680E-08	R2	1.25680E-08	-0.009	1.25668E-08	0.28	1.26042E-08	0.51	0.26	0.28	0.55
700	R2	700.00	1.88151E-08	R2	1.88151E-08	-0.010	1.88133E-08	0.00	1.88133E-08	0.51	0.26	0.28	0.56
700	R2	700.00	1.88482E-08	R2	1.88482E-08	-0.010	1.88464E-08	0.00	1.88464E-08	0.51	0.26	0.28	0.56
800	R2	799.80	4.51596E-08	R2	4.51596E-08	-0.012	4.51553E-08	0.20	4.52282E-08	0.51	0.26	0.29	0.58
900	R2	900.19	9.38009E-08	R2	9.38009E-08	-0.014	9.37920E-08	-0.19	9.36745E-08	0.51	0.26	0.31	0.61
900	R2	900.01	9.38529E-08	R2	9.38529E-08	-0.014	9.38439E-08	-0.01	9.38354E-08	0.51	0.26	0.31	0.61
961.78	R2	961.78	1.38637E-07	R2	1.38637E-07	-0.016	1.38624E-07	0.00	1.38624E-07	0.51	0.26	0.32	0.64
1000	R2	1000.00	1.73311E-07	R2	1.73311E-07	-0.017	1.73295E-07	0.00	1.73295E-07	0.52	0.26	0.33	0.66
1000	R2	1000.17	1.73490E-07	R2	1.73490E-07	-0.017	1.73473E-07	-0.17	1.73302E-07	0.52	0.26	0.33	0.66

Table 27- results of the NPL variable temperature blackbody measurements for analysis by direct comparison

[1] values obtained using a Cs heatpipe with PRT;
[2] values obtained using the NPL wide range cavity (WRC).

7.1 AVERAGE LABORATORY RESULTS FOR VTBB MEASUREMENTS WITH THE LP5

t_{nom}/ °C	Average signal/ A	U (*k*=2)/ °C
231.93	3.03450E-12	0.43
250	5.70800E-12	0.36
300	2.62281E-11	0.36
400	2.82010E-10	0.40
419.53	4.14497E-10	0.41
500	1.64150E-09	0.45
600	6.39923E-09	0.50
660.32	1.26010E-08	0.55
700	1.87985E-08	0.59
800	4.52509E-08	0.70
900	9.37192E-08	0.81

Table 28 – CEM results

t_{nom}/ °C	Average signal/ V	U (*k*=2)/ °C
231.93	3.03731E-12	0.147
250	5.68802E-12	0.109
300	2.62203E-11	0.201
400	2.81932E-10	0.119
419.53	4.14064E-10	0.125
500	1.64126E-09	0.155
600	6.38381E-09	0.196
660.32	1.25806E-08	0.230
700	1.87751E-08	0.248
800	4.51963E-08	0.299
900	9.36930E-08	0.355
961.78	1.38479E-07	0.393

Table 29 - PTB results

t_{nom}/ °C	Average signal/ V	U (*k*=2)/ °C
231.93	3.040492E-12	0.60
250	5.588942E-12	0.48
300	2.622117E-11	0.36
400	2.813707E-10	0.34
419.53	4.133589E-10	0.34
500	1.638618E-09	0.37
600	6.382367E-09	0.47
660.32	1.256055E-08	1.06
700	1.870179E-08	1.08
800	4.499146E-08	1.17
900	9.335301E-08	1.24
961.78	1.381241E-07	1.30

Table 30 - LNE results

t_{nom}/ °C	Average signal/ V	U (*k*=2)/ °C
250	5.64118E-12	0.96
300	2.66604E-11	1.27
419.53	4.19619E-10	1.54
500	1.66117E-09	1.83
600	6.37564E-09	0.85
660.32	1.25996E-08	0.99
700	1.89117E-08	0.95
800	4.51918E-08	1.14
900	9.38530E-08	1.26
1000	1.73542E-07	1.25

Table 31 – UME results

t_{nom}/ °C	Average signal/ V	U (*k*=2)/ °C
231.93	3.04820E-12	0.450
250	5.65552E-12	0.365
300	2.62463E-11	0.239
400	2.82142E-10	0.153
419.53	4.14031E-10	0.158
500	1.64388E-09	0.500
600	6.40119E-09	0.541
660.32	1.26061E-08	0.278
700	1.88845E-08	0.584
800	4.54960E-08	0.682
900	9.43265E-08	0.797
961.78	1.39601E-07	0.865
1000	1.74501E-07	0.926
Cs at 500	1.642757E-09	0.186
Na at 500 1	1.642436E-09	0.201
Na at 500 2	1.646458E-09	0.500
Cs at 600	6.393067E-09	0.225
Na at 600 1	6.390457E-09	0.247
Na at 600 2	6.428157E-09	0.541

Table 32 - METAS results

t_{nom}/ °C	Average signal/ V	U (*k*=2)/ °C

t_{nom}/ °C	Average signal/ A	U (k=2)/ °C
231.93	3.050570E-12	0.27
250	5.680598E-12	0.26
300	2.614062E-11	0.26
400	2.817738E-10	0.27
419.53	4.136607E-10	0.28
500	1.642834E-09	0.41
600	6.396595E-09	0.54
660.32	1.260422E-08	0.55
700	1.882986E-08	0.56
800	4.522818E-08	0.58
900	9.375495E-08	0.61
961.78	1.386242E-07	0.64
1000	1.732983E-07	0.66
Cs at 500	1.641018E-09	0.29
WRC at 500	1.646466E-09	0.52

Table 33 NPL results

t_{nom}/ °C	Mean signal/ A	Median signal/ A	Weighted signal/ A
231.93	3.042216E-12	3.040492E-12	3.040487E-12
250	5.660377E-12	5.668058E-12	5.682344E-12
300	2.628614E-11	2.622463E-11	2.621541E-11
400	2.818459E-10	2.819321E-10	2.819498E-10
419.53	4.148718E-10	4.140475E-10	4.140060E-10
500	1.644876E-09	1.642165E-09	1.641531E-09
600	6.389806E-09	6.390204E-09	6.388230E-09
660.32	1.259201E-08	1.260027E-08	1.259240E-08
700	1.881691E-08	1.881418E-08	1.879902E-08
800	4.522579E-08	4.521226E-08	4.523153E-08
900	9.378328E-08	9.373710E-08	9.376533E-08
961.78	1.387072E-07	1.385516E-07	1.386306E-07
1000	1.737807E-07	1.735425E-07	1.736783E-07

Table 34 – mean, median and weighted mean values for all the LP5 measurements with the variable temperature blackbody sources

t_{nom}/ °C	NPL – mean/ A	NPL-median/ A	equiv dT* from median / °C	NPL-wghted mean/ A	UME – mean/ A	UME-median/ A	equiv dT* from median / °C	UME-wghted mean/ A	METAS – mean/ A	METAS-median/ A	equiv dT* from median / °C	METAS – wghted mean/ A
231.93	8.3539E-15	1.0078E-14	0.09	1.0083E-14	-	-	-	-	5.9858E-15	7.7097E-15	0.07	7.7147E-15
250	2.0221E-14	1.2540E-14	0.07	-1.7458E-15	-1.9197E-14	-2.6878E-14	-0.14	-4.1164E-14	-4.8587E-15	-1.2540E-14	-0.07	-2.6825E-14
300	-1.4551E-13	-8.4006E-14	-0.12	-7.4784E-14	3.7424E-13	4.3575E-13	0.59	4.4497E-13	-3.9859E-14	2.1650E-14	0.03	3.0872E-14
400	-7.2102E-14	-1.5831E-13	-0.03	-1.7606E-13	-	-	-	-	2.9656E-13	2.1036E-13	0.04	1.9260E-13
419.53	-1.2111E-12	-3.8681E-13	-0.05	-3.4534E-13	4.7472E-12	5.5715E-12	0.70	5.6130E-12	-8.4107E-13	-1.6775E-14	0.00	2.4685E-14
500	-2.0422E-12	6.6892E-13	0.03	1.3033E-12	1.6289E-11	1.9000E-11	0.75	1.9634E-11	-9.9218E-13	1.7190E-12	0.07	2.3533E-12
600	6.7896E-12	6.3915E-12	0.08	8.3655E-12	-1.4167E-11	-1.4566E-11	-0.19	-1.2592E-11	1.1381E-11	1.0983E-11	0.14	1.2957E-11
660.32	1.2213E-11	3.9529E-12	0.03	1.1822E-11	7.5569E-12	-7.0342E-13	-0.01	7.1658E-12	1.4089E-11	5.8287E-12	0.04	1.3698E-11
700	1.2947E-11	1.5679E-11	0.09	3.0841E-11	9.4829E-11	9.7561E-11	0.53	1.1272E-10	6.7613E-11	7.0345E-11	0.38	8.5507E-11
800	2.3901E-12	1.5921E-11	0.04	-3.3491E-12	-3.3973E-11	-2.0441E-11	-0.06	-3.9712E-11	2.7024E-10	2.8377E-10	0.78	2.6450E-10
900	-2.8330E-11	1.7853E-11	0.03	-1.0381E-11	6.9736E-11	1.1592E-10	0.19	8.7685E-11	5.4318E-10	5.8937E-10	0.94	5.6113E-10
961.78	-8.3041E-11	7.2561E-11	0.09	-6.4856E-12	-	-	-	-	8.9428E-10	1.0499E-09	1.25	9.7084E-10
1000	-4.8243E-10	-2.4416E-10	-0.25	-3.8006E-10	-2.3828E-10	0.0000E+00	0.00	-1.3590E-10	7.2071E-10	9.5898E-10	0.97	8.2309E-10
Cs at 500	-3.8582E-12	-1.1471E-12	-0.05	-5.1272E-13					-2.1192E-12	5.9199E-13	0.02	1.2263E-12
Na/ WRC‡ at 500 1	2.1693E-12	4.8804E-12	0.25	1.6470E-09					-2.4396E-12	2.7152E-13	0.01	9.0586E-13
Na at 500 2									1.5823E-12	4.2934E-12	0.17	4.9277E-12
Cs at 600									3.2618E-12	2.8637E-12	0.04	4.8377E-12
Na at 600 1									6.5102E-13	2.5290E-13	0.00	2.2269E-12
Na at 600 2									3.8351E-11	3.7953E-11	0.49	3.9927E-11

Table 35 - differences of the laboratory results from the mean, median and weighted mean values for the LP5 thermometer – table 1 of 2

‡ At 500 °C NPL used a Cs heatpipe blackbody and the wide range cavity (WRC); METAS used a Cs and a Na heatpipe blackbody.

t_{nom}/ °C	LNE – mean/ A	LNE-median/ A	equiv dT from median / °C	LNE-wghted mean/ A	PTB – mean/ A	PTB-median/ A	equiv dT from median / °C	PTB-wghted mean/ A	CEM – mean/ A	CEM-median/ A	equiv dT from median / °C	CEM-wghted mean/ A
231.93	-1.7239E-15	0.0000E+00	0.00	4.9979E-18	-4.9026E-15	-3.1787E-15	-0.03	-3.1737E-15	-7.7132E-15	-5.9893E-15	-0.05	-5.9843E-15
250	-7.1435E-14	-7.9116E-14	-0.42	-9.3402E-14	2.7646E-14	1.9965E-14	0.10	5.6800E-15	4.7624E-14	3.9943E-14	0.21	2.5657E-14
300	-6.4964E-14	-3.4553E-15	0.00	5.7668E-15	-6.5850E-14	-4.3414E-15	-0.01	4.8806E-15	-5.8054E-14	3.4553E-15	0.00	1.2677E-14
400	-4.7517E-13	-5.6138E-13	-0.10	-5.7913E-13	8.6208E-14	0.0000E+00	0.00	-1.7751E-14	1.6450E-13	7.8296E-14	0.01	6.0545E-14
419.53	-1.5128E-12	-6.8855E-13	-0.09	-6.4709E-13	-8.0752E-13	1.6775E-14	0.00	5.8235E-14	-3.7468E-13	4.4961E-13	0.06	4.9107E-13
500	-6.2578E-12	-3.5467E-12	-0.14	-2.9123E-12	-3.6166E-12	-9.0549E-13	-0.04	-2.7115E-13	-3.3801E-12	-6.6892E-13	-0.03	-3.4582E-14
600	-7.4383E-12	-7.8364E-12	-0.10	-5.8624E-12	-5.9934E-12	-6.3915E-12	-0.08	-4.4175E-12	9.4281E-12	9.0300E-12	0.12	1.1004E-11
660.32	-3.1463E-11	-3.9723E-11	-0.30	-3.1854E-11	-1.1360E-11	-1.9620E-11	-0.15	-1.1751E-11	8.9637E-12	7.0342E-13	0.01	8.5727E-12
700	-1.1512E-10	-1.1239E-10	-0.62	-9.7229E-11	-4.1853E-11	-3.9121E-11	-0.22	-2.3959E-11	-1.8411E-11	-1.5679E-11	-0.09	-5.1678E-13
800	-2.3433E-10	-2.2080E-10	-0.62	-2.4007E-10	-2.9452E-11	-1.5921E-11	-0.04	-3.5192E-11	2.5122E-11	3.8654E-11	0.11	1.9383E-11
900	-4.3026E-10	-3.8408E-10	-0.62	-4.1232E-10	-9.0288E-11	-4.4105E-11	-0.07	-7.2339E-11	-6.4036E-11	-1.7853E-11	-0.03	-4.6087E-11
961.78	-5.8308E-10	-4.2748E-10	-0.52	-5.0652E-10	-2.2816E-10	-7.2561E-11	-0.09	-1.5161E-10				
1000												

Table 36 - differences of the laboratory results from the mean, median and weighted mean values for the LP5 thermometer – table 2 of 2

8 ANALYSIS OF THE MEASUREMENTS WITH THE FP SOURCES

Fixed point	Gain used	Bgrd corrected Signal/ V	lab U (*k*=2) / °C	Required gain	Signal at required gain / V	dT from NPL result / °C	dT corrected for Zn point drift[1] / °C	dT from INRiM result / °C	dT corrected for Zn point drift[2] / °C	U (*k=2*) with gain ratio & drift uncert / °C	U (*k=2*) also with reference value uncert / °C
In	10^10	0.775825	0.08	10^9	0.084166	0.000	0.000	0.102	0.080	0.09	0.10
Sn	10^9	1.836495	0.06	10^9	1.8364952	0.000	0.000	0.040	0.010	0.07	0.07
Zn	10^7	1.984784	0.02	10^7	1.9847841	0.000	0.000	0.062	0.004	0.07	0.08
Al	10^6	5.488178	0.03	10^6	5.4881776	0.000	0.000	0.123	0.018	0.13	0.13
Ag	10^5	5.653369	0.07	10^5	5.6533689	0.000	0.000	0.248	0.064	0.23	0.24

Table 37 – results of the NPL fixed-point measurements with the INRiM thermometer – direct comparison of results

[1] relative to the NPL measurements, calculated from the drift in the thermometer at the zinc fixed-point – see Table 5
[2] relative to the INRiM measurements, calculated from the drift in the thermometer at the zinc fixed-point – see Table 5

Fixed point	Gain used	Bgrd corrected signal/ V	Bgrd corrected signal ignoring gain/ V	lab U (*k*=2) / °C	Required gain	Signal at required gain/ V	dT from NPL result / °C	dT corrected for Zn point drift/ °C	dT from INRiM result / °C	dT corrected for Zn point drift/ °C	U (*k=2*) with gain ratio & drift uncert / °C	U (*k=2*) also with reference value uncert / °C
Zn	10^7	1.98204E-07	1.982037	0.06	10^7	1.982037	-0.074	0.016	-0.011	0.021	0.09	0.09
Zn	10^6	1.98307E-07	0.198307	0.06	10^7	1.982041	-0.074	0.016	-0.011	0.021	0.09	0.09
Ag 1	10^5	5.64260E-05	5.642604	0.20	10^5	5.642604	-0.324	-0.037	-0.075	0.027	0.30	0.30
Ag 2	10^4	5.70133E-05	0.570133	0.20	10^5	5.643423	-0.299	-0.013	-0.050	0.051	0.30	0.31

Table 38 – results of the CEM fixed-point measurements with the INRiM thermometer – direct comparison of results

Fixed point	Gain used	Bgrd corrected signal / mV	Signal corrected for emissivity / mV	Bgrd corrected Signal / V	lab U (*k*=2) / °C	Required gain	Signal at required gain/ V	dT from NPL result / °C	dT corrected for Zn point drift/ °C	dT from INRiM result / °C	dT corrected for Zn point drift/ °C	U (k=2) with gain ratio & drift uncert / °C	U (k=2) also with ref. value uncert / °C
In	10^9	83.71	83.75	0.08375	0.016	10^9	0.08375	-0.103	-0.081	0.000	0.000	0.03	0.06
Sn	10^9	1833.09	1833.88	1.83388	0.014	10^9	1.83388	-0.040	-0.010	0.000	0.000	0.04	0.04
Zn	10^7	1981.61	1982.46	1.98246	0.018	10^7	1.98246	-0.063	-0.005	0.000	0.000	0.07	0.07
Al	10^6	5478.84	5481.20	5.48120	0.022	10^6	5.48120	-0.123	-0.018	0.000	0.000	0.13	0.13
Ag	10^5	5642.67	5645.10	5.64510	0.026	10^5	5.64510	-0.249	-0.064	0.000	0.000	0.22	0.23

Table 39 – results of the INRiM fixed-point measurements with the INRiM thermometer – direct comparison of results

Fixed point	Gain used	Bgrd corrected Signal/ V	lab U (*k*=2) / °C	Required gain	Signal at required gain / V	dT from NPL result / °C	dT corrected for Zn point drift / °C	dT from INRiM result / °C	dT corrected for Zn point drift / °C	U (*k=2*) with drift uncert / °C	U (k=2) also with reference value uncert / °C
In	10^10	0.772745	0.062	10^9	0.0838469	-0.078	-0.068	0.025	0.012	0.08	0.09
Sn	10^9	1.834863	0.020	10^9	1.834863	-0.025	-0.012	0.015	-0.002	0.04	0.04
Zn	10^7	1.983950	0.026	10^7	1.983950	-0.022	0.003	0.040	0.007	0.07	0.08

Table 40 – results of the UME fixed-point measurements with the INRiM thermometer – direct comparison of results

Fixed point temperature / °C	NPL results		CEM results		INRiM results		UME results	
	dT from reference/ °C	Resultant indicated t/ °C	dT from reference/ °C	Resultant indicated t/ °C	dT from reference/ °C	Resultant indicated t/ °C	dT from reference/ °C	Resultant indicated t/ °C
156.599	0.000	156.599	-	-	-0.081	156.518	-0.068	156.530
231.928	0.000	231.928	-	-	-0.010	231.918	-0.012	231.916
419.527	0.000	419.527	0.016	419.543	-0.005	419.522	0.003	419.530
660.323	0.000	660.323	-	-	-0.018	660.305	-	-
961.780	0.000	961.780	-0.025	961.755	-0.064	961.716	-	-

Table 41 – the thermometer indicated values, in terms of temperature, for the fixed-point measurements, relative to the NPL measurements (the reference)

Fixed point	Mean value/ °C	Median value/ °C	Weighted mean value/ °C
In	156.549	156.530	156.528
Sn	231.921	231.918	231.919
Zn	419.531	419.528	419.528
Al	660.314	660.314	660.322
Ag	961.750	961.755	961.773

Table 42 – the mean, median and weighted mean values for the fixed-point measurements with the INRiM thermometer

Fixed point	NPL – mean / °C	NPL – median / °C	NPL – weighted mean/ °C	CEM – mean* / °C	CEM – median* / °C	CEM – weighted* mean/ °C	INRiM – mean / °C	INRiM – median / °C	INRiM – weighted mean/ °C	UME – mean / °C	UME – median / °C	UME – weighted mean/ °C
In	0.05	0.07	0.07	-	-	-	-0.03	-0.01	-0.01	-0.02	0.00	0.00
Sn	0.01	0.01	0.01	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00
Zn	0.00	0.00	0.00	0.01	0.01	0.02	-0.01	-0.01	-0.01	0.00	0.00	0.00
Al	0.01	0.01	0.00	-	-	-	-0.01	-0.01	-0.02	-	-	-
Ag	0.03	0.03	0.01	0.00	0.00	-0.02	-0.03	-0.04	-0.06	-	-	-

Table 43 – the differences of the laboratory measurements from the mean, median and weighted mean values for the INRiM thermometer measurements with the fixed-points

* calculated from the averages of the CEM Zn point and the CEM Ag point measurements

The results with the LP5 thermometer follow

Fixed point	Range used	Bgrd corrected Signal/ A	lab U (*k*=2) / °C	Required range	Signal at required range / A	dT from NPL result / °C	dT corrected for Zn point drift† / °C	dT from INRiM result / °C	dT corrected for Zn point drift/ °C	U (*k=2*) with range ratio & drift uncert / °C
Sn	R1	3.04800E-12	0.09	R1	3.04800E-12	0.000	0.000	0.325	0.041	0.11
Zn	R1	4.14357E-10	0.04	R1	4.14357E-10	0.000	0.000	0.514	-0.020	0.13
Al	R2	1.25937E-08	0.07	R2	1.25937E-08	0.000	0.000	0.781	-0.189	0.23
Ag	R2	1.38800E-07	0.13	R2	1.38800E-07	0.000	0.000	1.713	0.016	0.40

Table 44 – results of the NPL fixed-point measurements with the LP5 thermometer – direct comparison of results

Fixed point	Range used	Bgrd corrected signal/ A	lab U (*k*=2) / °C	Required range	Signal at required range / A	dT from NPL result / °C	dT corrected for Zn point drift/ °C	dT from INRiM result / °C	dT corrected for Zn point drift/ °C	U (*k=2*) with gain ratio & drift uncert / °C
Zn	R1	4.14927E-10	0.08	R1	4.14927E-10	0.073	0.123	0.587	0.104	0.28
Zn	R1	4.12569E-10	0.07	R1	4.12569E-10	-0.231	-0.181	0.285	-0.198	0.28
Ag 1	R2	1.38577E-07	0.28	R2	1.38577E-07	-0.274	-0.115	1.443	-0.093	0.93
Ag 2	R2	1.38002E-07	0.12	R2	1.38002E-07	-0.981	-0.822	0.742	-0.793	0.89
						dT from CEM average* / °C	dT corrected for Zn point drift/ °C			
Zn	R2	4.15112E-10	0.08	R2	4.15112E-10	0.154	0.154	-	-	0.28
Zn	R2	4.12714E-10	0.07	R2	4.12714E-10	-0.155	-0.155	-	-	0.28

Table 45 – results of the CEM fixed-point measurements with the LP5 thermometer – direct comparison of results

* so that the CEM measurements on range R2 could be directly compared to the UME measurements (Table 46) without adjustment using the range ratio.

Fixed point	Range used	Bgrd corrected signal/ A	Signal corrected for emissivity/ A	lab U (*k*=2) / °C	Required range	Signal at required range/ A	dT from NPL result / °C	dT corrected for Zn point drift/ °C	dT from INRiM result / °C	dT corrected for Zn point drift / °C	U (*k=2*) with gain ratio & drift uncert / °C
Sn	R1	3.01179E-12	3.01309E-12	0.516	R1	3.01309E-12	-0.325	-0.041	0.000	0.000	0.520
Zn	R1	4.10187E-10	4.10363E-10	0.022	R1	4.10363E-10	-0.519	0.014	0.000	0.000	0.122
Al	R2	1.24868E-08	1.24922E-08	0.020	R2	1.24922E-08	-0.788	0.180	0.000	0.000	0.219
Ag	R2	1.37339E-07	1.37398E-07	0.028	R2	1.37398E-07	-1.731	-0.037	0.000	0.000	0.383

Table 46 – results of the INRiM fixed-point measurements with the LP5 thermometer – direct comparison of results

Fixed point	Range used	Bgrd corrected Signal/ A	lab U (*k*=2) / °C	Required range	Signal at required range / A	dT from NPL result / °C	dT corrected for Zn point drift/ °C	dT from INRiM result / °C	dT corrected for Zn point drift/ °C	U (*k=2*) with drift uncert / °C
Sn	R1	3.03065E-12	0.47	R1	3.03065E-12	-0.162	-0.040	0.164	0.003	0.47
Zn	R2	4.11979E-10	0.13	R1	4.17417E-10	0.391	0.621	0.902	0.599	1.29
Al	R2	1.25181E-08	0.05	R2	1.25181E-08	-0.585	-0.168	0.201	-0.350	0.22
						dT from CEM average / °C	dT corrected for Zn point drift/ °C			
Zn	R2	4.11979E-10	0.05	R2	4.11979E-10	-0.250	-0.070	-	-	0.17

Table 47 – results of the UME fixed-point measurements with the LP5 thermometer – direct comparison of results

Fixed point Temperature / °C	NPL results		CEM results		INRiM results		UME results	
	dT from reference/ °C	Resultant indicated t/ °C	dT from reference/ °C	Resultant indicated t/ °C	dT from reference/ °C	Resultant indicated t/ °C	dT from reference/ °C	Resultant indicated t/ °C
231.928	0.000	231.928			-0.041	231.887	-0.040	231.888
419.527	0.000	419.527	-0.029	419.498	0.014	419.541	0.621	420.148
660.323	0.000	660.323			0.180	660.503	-0.168	660.155
961.780?	0.000	961.780	-0.468	961.312	-0.037	961.743		

Table 48 – the thermometer indicated values, in terms of temperature, for the fixed-point measurements, relative to the NPL measurements (the reference)

Fixed point	Mean value/ °C	Median value/ °C	Weighted mean value/ °C
Sn	231.901	231.888	231.924
Zn	419.679	419.534	419.533
Al	660.327	660.323	660.330
Ag	961.612	961.743	961.724

Table 49 – the mean, median and weighted mean values for the fixed-point measurements with the LP5 thermometer

Fixed point	NPL – mean / °C	NPL – median / °C	NPL – weighted mean/ °C	CEM – mean / °C	CEM – median / °C	CEM – weighted mean/ °C	INRiM – mean/ °C	INRiM – median / °C	INRiM – weighted mean/ °C	UME – mean / °C	UME – median / °C	UME – weighted mean/ °C
Sn	0.027	0.040	0.004	-	-	-	-0.014	-0.001	-0.038	-0.013	0.000	-0.036
Zn	-0.152	-0.007	-0.006	-0.180	-0.036	-0.035	-0.138	0.007	0.007	0.470	0.614	0.615
Al	-0.004	0.000	-0.007	-	-	-	0.176	0.180	0.174	-0.172	-0.168	-0.174
Ag	0.168	0.037	0.056	-0.300	-0.432	-0.412	0.132	0.000	0.019	-	-	-

Table 50 – the differences of the laboratory measurements from the mean, median and weighted mean values for the LP5 measurements with the fixed-points

Fixed point	Mean value/ °C	Median value/ °C	Weighted mean value/ °C
Zn	419.492	419.492	419.476

Table 51 – the mean, median and weighted mean values for the CEM and UME Zn point measurements on range R2

Fixed point	CEM – mean/ °C	CEM – median/ °C	CEM – weighted mean/ °C	UME – mean/ °C	UME – median/ °C	UME – weighted mean/ °C
Zn	0.035	0.035	0.051	-0.035	-0.035	-0.020

Table 52 – the differences of the CEM and UME measurements from the mean, median and weighted mean values for the Zn point on range R2

9 DETAILED LABORATORY UNCERTAINTY BUDGETS

9.1 UNCERTAINTY BUDGETS FOR THE NPL FIXED-POINT MEASUREMENTS

INRiM thermometer – In fixed point Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Fixed point impurity	0.001	B	√3	0.00
Fixed point emissivity	0.003	B	√3	0.00
Standard deviation of measurements	0.015	A	√300	0.00
Reproducibility of melts/ freezes	0.110	B	2√3	0.03
Resolution of INRiM thermometer	0.010	B	2√3	0.00
Alignment on aperture	0.010	B	√3	0.01
Size of source effect/ thermal profile	0.004	B	√3	0.00
Gain ratio measurements	0.026	B	1	0.03
Temperature coefficient	0.000	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.04**
Total NPL expanded uncertainty (k = 2)				**0.08**
Thermometer drift				0.013
Total NPL comparison uncertainty				**0.045**
Expanded NPL comparison uncertainty (k =2)				**0.09**

Table 53: uncertainty components for the NPL In FP measurements for the INRIM thermometer

INRiM thermometer – Sn fixed point Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Fixed point impurity	0.001	B	√3	0.00
Fixed point emissivity	0.004	B	√3	0.00
Standard deviation of measurements	0.003	A	√150	0.00
Reproducibility of melts/ freezes	0.010	B	2√3	0.00
Resolution of INRiM thermometer	0.010	B	2√3	0.00
Alignment on aperture	0.010	B	√3	0.01
Size of source effect/ thermal profile	0.006	B	√3	0.00
Gain ratio measurements	0.028	B	1	0.03
Temperature coefficient	0.000	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.03**
Total NPL expanded uncertainty (k = 2)				**0.06**
Thermometer drift				0.019
Total NPL comparison uncertainty				**0.04**
Expanded NPL comparison uncertainty (k =2)				**0.07**

Table 54: uncertainty components for the NPL Sn FP measurements for the INRIM thermometer

INRiM thermometer – Zn fixed point Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Fixed point impurity	0.001	B	√3	0.00
Fixed point emissivity	0.008	B	√3	0.00
Standard deviation of measurements	0.001	A	√200	0.00
Reproducibility of melts/ freezes	0.010	B	2√3	0.00
Resolution of INRiM thermometer	0.010	B	2√3	0.00
Alignment on aperture	0.010	B	√3	0.01
Size of source effect/ thermal profile	0.012	B	√3	0.01
Gain ratio measurements	0.006	B	1	0.01
Temperature coefficient	0.000	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.01**
Total NPL expanded uncertainty (k = 2)				**0.02**
Thermometer drift				0.035
Total NPL comparison uncertainty				**0.04**
Expanded NPL comparison uncertainty (k =2)				**0.07**

Table 55: uncertainty components for the NPL Zn FP measurements for the INRIM thermometer

INRiM thermometer – Al fixed point Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Fixed point impurity	0.001	B	√3	0.00
Fixed point emissivity	0.015	B	√3	0.01
Standard deviation of measurements	0.002	A	√300	0.00
Reproducibility of melts/ freezes	0.010	B	2√3	0.00
Resolution of INRiM thermometer	0.010	B	2√3	0.00
Alignment on aperture	0.010	B	√3	0.01
Size of source effect/ thermal profile	0.021	B	√3	0.01
Gain ratio measurements	0.000	B	1	0.00
Temperature coefficient	0.000	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.02**
Total NPL expanded uncertainty (k = 2)				**0.03**
Thermometer drift				0.064
Total NPL comparison uncertainty				**0.07**
Expanded NPL comparison uncertainty (k =2)				**0.13**

Table 56: uncertainty components for the NPL Al FP measurements for the INRIM thermometer

INRiM thermometer – Ag fixed point Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Fixed point impurity	0.001	B	√3	0.00
Fixed point emissivity	0.025	B	√3	0.01
Standard deviation of measurements	0.011	A	√200	0.00
Reproducibility of melts/ freezes	0.030	B	2√3	0.01
Resolution of INRiM thermometer	0.010	B	2√3	0.00
Alignment on aperture	0.010	B	√3	0.01
Size of source effect/ thermal profile	0.035	B	√3	0.02
Gain ratio measurements	0.009	B	1	0.01
Temperature coefficient	0.040	B	√3	0.02
Total NPL combined uncertainty (k = 1)				**0.04**
Total NPL expanded uncertainty (k = 2)				**0.07**
Thermometer drift				0.111
Total NPL comparison uncertainty				**0.12**
Expanded NPL comparison uncertainty (k =2)				**0.23**

Table 57: uncertainty components for the NPL Ag FP measurements for the INRIM thermometer

LP5 thermometer – Sn fixed point Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Fixed point impurity	0.001	B	√3	0.00
Fixed point emissivity	0.004	B	√3	0.00
Standard deviation of measurements	0.250	A	√150	0.02
Reproducibility of melts/ freezes	0.140	B	2√3	0.04
Resolution of LP5 thermometer	0.010	B	2√3	0.00
Alignment on aperture	0.010	B	√3	0.01
Size of source effect/ thermal profile	0.006	B	√3	0.00
Gain ratio measurements	0.000	B	1	0.00
Temperature coefficient	0.000	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.05**
Total NPL expanded uncertainty (k = 2)				**0.09**
Thermometer drift				0.032
Total NPL comparison uncertainty				**0.06**
Expanded NPL comparison uncertainty (k =2)				**0.11**

Table 58: uncertainty components for the NPL Sn FP measurements for the LP5 thermometer

LP5 thermometer – Zn fixed point Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Fixed point impurity	0.001	B	√3	0.00
Fixed point emissivity	0.008	B	√3	0.00
Standard deviation of measurements	0.010	A	√200	0.00
Reproducibility of melts/ freezes	0.050	B	2√3	0.01
Resolution of LP5 thermometer	0.010	B	2√3	0.00
Alignment on aperture	0.010	B	√3	0.01
Size of source effect/ thermal profile	0.011	B	√3	0.01
Gain ratio measurements	0.000	B	1	0.00
Temperature coefficient	0.000	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.02**
Total NPL expanded uncertainty (k = 2)				**0.03**
Thermometer drift				0.060
Total NPL comparison uncertainty				**0.06**
Expanded NPL comparison uncertainty (k =2)				**0.13**

Table 59: uncertainty components for the NPL Zn FP measurements for the LP5 thermometer

LP5 thermometer – Al fixed point Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Fixed point impurity	0.001	B	√3	0.00
Fixed point emissivity	0.015	B	√3	0.01
Standard deviation of measurements	0.010	A	√300	0.00
Reproducibility of melts/ freezes	0.090	B	2√3	0.03
Resolution of LP5 thermometer	0.010	B	2√3	0.00
Alignment on aperture	0.010	B	√3	0.01
Size of source effect/ thermal profile	0.021	B	√3	0.01
Gain ratio measurements	0.012	B	1	0.01
Temperature coefficient	0.000	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.03**
Total NPL expanded uncertainty (k = 2)				**0.07**
Thermometer drift				0.109
Total NPL comparison uncertainty				**0.11**
Expanded NPL comparison uncertainty (k =2)				**0.23**

Table 60: uncertainty components for the NPL Al FP measurements for the LP5 thermometer

LP5 thermometer – Ag fixed point Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Fixed point impurity	0.001	B	√3	0.00
Fixed point emissivity	0.025	B	√3	0.01
Standard deviation of measurements	0.010	A	√200	0.00
Reproducibility of melts/ freezes	0.200	B	2√3	0.06
Resolution of LP5 thermometer	0.010	B	2√3	0.00
Alignment on aperture	0.010	B	√3	0.01
Size of source effect/ thermal profile	0.035	B	√3	0.02
Gain ratio measurements	0.020	B	1	0.02
Temperature coefficient	0.000	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.07**
Total NPL expanded uncertainty (k = 2)				**0.13**
Thermometer drift				0.191
Total NPL comparison uncertainty				**0.20**
Expanded NPL comparison uncertainty (k =2)				**0.40**

Table 61: uncertainty components for the NPL Ag FP measurements for the LP5 thermometer

9.2 UNCERTAINTY BUDGETS FOR THE NPL VTBB MEASUREMENTS

INRiM - 156 °C with the H_2O heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1)/ / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.01	B	√3	0.00
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.026	B	1	0.03
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.10**
Total NPL expanded uncertainty (k = 2)				**0.20**
Thermometer drift				0.013
Total NPL comparison uncertainty				**0.10**
Expanded NPL comparison uncertainty (k =2)				**0.20**

Table 62 - uncertainty components for the NPL VTBB measurements at 156 °C using the INRiM thermometer

INRiM - 200 °C with the H_2O heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1 / °C)
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.01	B	√3	0.00
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.02	B	1	0.02
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.10**
Total NPL expanded uncertainty (k = 2)				**0.20**
Thermometer drift				0.016
Total NPL comparison uncertainty				**0.10**
Expanded NPL comparison uncertainty (k =2)				**0.20**

Table 63 - uncertainty components for the NPL VTBB measurements at 200 °C using the INRiM thermometer

INRiM - 232 °C with the H_2O heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.01	B	√3	0.00
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.03	B	1	0.03
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.10**
Total NPL expanded uncertainty (k = 2)				**0.20**
Thermometer drift				0.019
Total NPL comparison uncertainty				**0.10**
Expanded NPL comparison uncertainty (k =2)				**0.20**

Table 64 - uncertainty components for the NPL VTBB measurements at 232 °C using the INRiM thermometer

INRiM - 250 °C with the H_2O heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.01	B	√3	0.01
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.03	B	1	0.03
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.10**
Total NPL expanded uncertainty (k = 2)				**0.20**
Thermometer drift				0.020
Total NPL comparison uncertainty				**0.10**
Expanded NPL comparison uncertainty (k =2)				**0.20**

Table 65 - uncertainty components for the NPL VTBB measurements at 250 °C using the INRiM thermometer

INRiM - 300 °C with the Cs heatpipe Source of uncertainty	Value/ / °C	Type A or B	Divisor	u (k = 1)/ / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.01	B	√3	0.01
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.04	B	√3	0.02
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.004	B	1	0.00
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.04	B	√3	0.02
Total NPL combined uncertainty (k = 1)				**0.10**
Total NPL expanded uncertainty (k = 2)				**0.21**
Thermometer drift				0.024
Total NPL comparison uncertainty				**0.11**
Expanded NPL comparison uncertainty (k =2)				**0.22**

Table 66 - uncertainty components for the NPL VTBB measurements at 300 °C using the INRiM thermometer

INRiM - 400 °C with the Cs heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.02	B	√3	0.01
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.00	B	√3	0.00
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.006	B	1	0.01
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.10**
Total NPL expanded uncertainty (k = 2)				**0.20**
Thermometer drift				0.033
Total NPL comparison uncertainty				**0.11**
Expanded NPL comparison uncertainty (k =2)				**0.21**

Table 67 - uncertainty components for the NPL VTBB measurements at 400 °C using the INRiM thermometer

INRiM - 420 °C with the Cs heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.02	B	√3	0.01
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.006	B	1	0.01
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.10**
Total NPL expanded uncertainty (k = 2)				**0.20**
Thermometer drift				0.035
Total NPL comparison uncertainty				**0.11**
Expanded NPL comparison uncertainty (k =2)				**0.21**

Table 68 - uncertainty components for the NPL VTBB measurements at 420 °C using the INRiM thermometer

INRiM - 500 °C with the Cs heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.02	B	√3	0.01
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.008	B	1	0.01
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.10**
Total NPL expanded uncertainty (k = 2)				**0.20**
Thermometer drift				0.044
Total NPL comparison uncertainty				**0.11**
Expanded NPL comparison uncertainty (k =2)				**0.22**

Table 69 - uncertainty components for the NPL Cs VTBB measurements at 500 °C using the INRiM thermometer

INRiM - 500 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.03	B	√3	0.02
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.008	B	1	0.01
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.24**
Total NPL expanded uncertainty (k = 2)				**0.48**
Thermometer drift				0.044
Total NPL comparison uncertainty				**0.24**
Expanded NPL comparison uncertainty (k =2)				**0.49**

Table 70 - uncertainty components for the NPL WRC VTBB measurements at 500 °C using the INRiM thermometer

INRiM - 600 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.04	B	√3	0.02
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.00	B	1	0.00
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.24**
Total NPL expanded uncertainty (k = 2)				**0.47**
Thermometer drift				0.056
Total NPL comparison uncertainty				**0.24**
Expanded NPL comparison uncertainty (k =2)				**0.48**

Table 71 - uncertainty components for the NPL VTBB measurements at 600 °C using the INRiM thermometer

INRiM - 660 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.04	B	√3	0.02
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.00	B	1	0.00
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.015	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.24**
Total NPL expanded uncertainty (k = 2)				**0.48**
Thermometer drift				0.064
Total NPL comparison uncertainty				**0.25**
Expanded NPL comparison uncertainty (k =2)				**0.50**

Table 72 - uncertainty components for the NPL VTBB measurements at 660 °C using the INRiM thermometer

INRiM - 700 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.05	B	√3	0.03
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.00	B	1	0.00
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.015	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.24**
Total NPL expanded uncertainty (k = 2)				**0.48**
Thermometer drift				0.069
Total NPL comparison uncertainty				**0.25**
Expanded NPL comparison uncertainty (k =2)				**0.50**

Table 73 - uncertainty components for the NPL VTBB measurements at 700 °C using the INRiM thermometer

INRiM - 800 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.06	B	√3	0.03
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.006	B	1	0.01
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.02	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.24**
Total NPL expanded uncertainty (k = 2)				**0.49**
Thermometer drift				0.084
Total NPL comparison uncertainty				**0.26**
Expanded NPL comparison uncertainty (k =2)				**0.52**

Table 74 - uncertainty components for the NPL VTBB measurements at 800 °C using the INRiM thermometer

INRiM - 900 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.07	B	√3	0.04
Standard deviation - source temperature	0.06	A	√50	0.01
Standard deviation - INRiM thermometer	0.01	A	√50	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.008	B	1	0.01
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.02	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.24**
Total NPL expanded uncertainty (k = 2)				**0.49**
Thermometer drift				0.100
Total NPL comparison uncertainty				**0.26**
Expanded NPL comparison uncertainty (k =2)				**0.53**

Table 75 - uncertainty components for the NPL VTBB measurements at 900 °C using the INRiM thermometer

INRiM - 960 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.07	B	√3	0.04
Standard deviation - source temperature	0.05	A	√40	0.01
Standard deviation - INRiM thermometer	0.01	A	√40	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.009	B	1	0.01
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.06	B	√3	0.03
Total NPL combined uncertainty (k = 1)				**0.25**
Total NPL expanded uncertainty (k = 2)				**0.49**
Thermometer drift				0.111
Total NPL comparison uncertainty				**0.27**
Expanded NPL comparison uncertainty (k =2)				**0.54**

Table 76 - uncertainty components for the NPL VTBB measurements at 962 °C using the INRiM thermometer

INRiM - 1000 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.08	B	√3	0.05
Standard deviation - source temperature	0.04	A	√30	0.01
Standard deviation - INRiM thermometer	0.01	A	√30	0.00
Calibration of INRiM thermometer	0.15	A	2	0.08
Resolution of INRiM thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.009	B	1	0.01
Repeatability of calibration	0.06	A	1	0.06
Temperature gradients across source	0.06	B	√3	0.03
Total NPL combined uncertainty (k = 1)				**0.25**
Total NPL expanded uncertainty (k = 2)				**0.49**
Thermometer drift				0.118
Total NPL comparison uncertainty				**0.27**
Expanded NPL comparison uncertainty (k =2)				**0.54**

Table 77 - uncertainty components for the NPL VTBB measurements at 1000 °C using the INRiM thermometer

LP5 - 232 °C with the H_2O heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.01	B	√3	0.00
Standard deviation - source temperature	0.00	A	√30	0.00
Standard deviation - LP5 thermometer	0.23	A	√30	0.04
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.00	B	1	0.00
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.13**
Total NPL expanded uncertainty (k = 2)				**0.25**
Thermometer drift				0.032
Total NPL comparison uncertainty				**0.13**
Expanded NPL comparison uncertainty (k =2)				**0.27**

Table 78 - uncertainty components for the NPL VTBB measurements at 232 °C using the LP5

LP5 - 250 °C with the H_2O heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.01	B	√3	0.01
Standard deviation - source temperature	0.00	A	√30	0.00
Standard deviation - LP5 thermometer	0.16	A	√30	0.03
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.00	B	1	0.00
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.13**
Total NPL expanded uncertainty (k = 2)				**0.25**
Thermometer drift				0.034
Total NPL comparison uncertainty				**0.13**
Expanded NPL comparison uncertainty (k =2)				**0.26**

Table 79 - uncertainty components for the NPL VTBB measurements at 250 °C using the LP5

LP5 - 300 °C with the Cs heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.01	B	√3	0.01
Standard deviation - source temperature	0.00	A	√30	0.00
Standard deviation - LP5 thermometer	0.04	A	√30	0.01
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.04	B	√3	0.02
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.00	B	1	0.00
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.04	B	√3	0.02
Total NPL combined uncertainty (k = 1)				**0.13**
Total NPL expanded uncertainty (k = 2)				**0.25**
Thermometer drift				0.041
Total NPL comparison uncertainty				**0.13**
Expanded NPL comparison uncertainty (k =2)				**0.26**

Table 80 - uncertainty components for the NPL VTBB measurements at 300 °C using the LP5

LP5 - 400 °C with the Cs heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.02	B	√3	0.01
Standard deviation - source temperature	0.00	A	√30	0.00
Standard deviation - LP5 thermometer	0.01	A	√30	0.00
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.02	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.01	B	1	0.01
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.12**
Total NPL expanded uncertainty (k = 2)				**0.25**
Thermometer drift				0.057
Total NPL comparison uncertainty				**0.14**
Expanded NPL comparison uncertainty (k =2)				**0.27**

Table 81 - uncertainty components for the NPL VTBB measurements at 400 °C using the LP5

LP5 - 420 °C with the Cs heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.02	B	√3	0.01
Standard deviation - source temperature	0.00	A	√30	0.00
Standard deviation - LP5 thermometer	0.01	A	√30	0.00
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.01	B	1	0.01
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.12**
Total NPL expanded uncertainty (k = 2)				**0.24**
Thermometer drift				0.060
Total NPL comparison uncertainty				**0.14**
Expanded NPL comparison uncertainty (k =2)				**0.28**

Table 82 - uncertainty components for the NPL VTBB measurements at 420 °C using the LP5

LP5 - 500 °C with the Cs heatpipe Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.03	A	2	0.02
Emissivity of reference source	0.02	B	√3	0.01
Standard deviation - source temperature	0.00	A	√30	0.00
Standard deviation - LP5 thermometer	0.01	A	√30	0.00
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.01	B	1	0.01
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.12**
Total NPL expanded uncertainty (k = 2)				**0.25**
Thermometer drift				0.075
Total NPL comparison uncertainty				**0.15**
Expanded NPL comparison uncertainty (k =2)				**0.29**

Table 83 - uncertainty components for the NPL Cs VTBB measurements at 500 °C using the LP5

LP5 - 500 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.03	B	√3	0.02
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - LP5 thermometer	0.01	A	√30	0.00
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.01	B	√3	0.01
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.01	B	1	0.01
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.01	B	√3	0.01
Total NPL combined uncertainty (k = 1)				**0.25**
Total NPL expanded uncertainty (k = 2)				**0.50**
Thermometer drift				0.075
Total NPL comparison uncertainty				**0.26**
Expanded NPL comparison uncertainty (k =2)				**0.52**

Table 84 - uncertainty components for the NPL WRC VTBB measurements at 500 °C using the LP5

LP5 - 600 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.04	B	√3	0.02
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - LP5 thermometer	0.01	A	√30	0.00
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.00	B	√3	0.00
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.01	B	1	0.01
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.00	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.25**
Total NPL expanded uncertainty (k = 2)				**0.50**
Thermometer drift				0.095
Total NPL comparison uncertainty				**0.27**
Expanded NPL comparison uncertainty (k =2)				**0.54**

Table 85 - uncertainty components for the NPL VTBB measurements at 600 °C using the LP5

LP5 - 660 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.04	B	√3	0.02
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - LP5 thermometer	0.01	A	√30	0.00
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.00	B	√3	0.00
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.024	B	1	0.02
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.00	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.25**
Total NPL expanded uncertainty (k = 2)				**0.51**
Thermometer drift				0.109
Total NPL comparison uncertainty				**0.28**
Expanded NPL comparison uncertainty (k =2)				**0.55**

Table 86 - uncertainty components for the NPL VTBB measurements at 660 °C using the LP5

LP5 - 700 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.05	B	√3	0.03
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - LP5 thermometer	0.01	A	√30	0.00
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.00	B	√3	0.00
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.024	B	1	0.02
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.00	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.25**
Total NPL expanded uncertainty (k = 2)				**0.51**
Thermometer drift				0.118
Total NPL comparison uncertainty				**0.28**
Expanded NPL comparison uncertainty (k =2)				**0.56**

Table 87 - uncertainty components for the NPL VTBB measurements at 700 °C using the LP5

LP5 - 800 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.06	B	√3	0.03
Standard deviation - source temperature	0.01	A	√30	0.00
Standard deviation - LP5 thermometer	0.06	A	√30	0.01
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.00	B	√3	0.00
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.03	B	1	0.03
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.00	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.25**
Total NPL expanded uncertainty (k = 2)				**0.51**
Thermometer drift				0.144
Total NPL comparison uncertainty				**0.29**
Expanded NPL comparison uncertainty (k =2)				**0.58**

Table 88 - uncertainty components for the NPL VTBB measurements at 800 °C using the LP5

LP5 - 900 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.07	B	√3	0.04
Standard deviation - source temperature	0.01	A	√60	0.00
Standard deviation - LP5 thermometer	0.06	A	√60	0.01
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.00	B	√3	0.00
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.034	B	1	0.03
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.00	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.26**
Total NPL expanded uncertainty (k = 2)				**0.51**
Thermometer drift				0.172
Total NPL comparison uncertainty				**0.31**
Expanded NPL comparison uncertainty (k =2)				**0.61**

Table 89 - uncertainty components for the NPL VTBB measurements at 900 °C using the LP5

LP5 - 960 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.07	B	√3	0.04
Standard deviation - source temperature	0.01	A	√35	0.00
Standard deviation - LP5 thermometer	0.06	A	√35	0.01
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.00	B	√3	0.00
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.04	B	1	0.04
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.00	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.25**
Total NPL expanded uncertainty (k = 2)				**0.51**
Thermometer drift				0.191
Total NPL comparison uncertainty				**0.32**
Expanded NPL comparison uncertainty (k =2)				**0.64**

Table 90 - uncertainty components for the NPL VTBB measurements at 962 °C using the LP5

LP5 - 1000 °C with the WRC Source of uncertainty	Value / °C	Type A or B	Divisor	u (k = 1) / °C
Reference blackbody source	0.44	A	2	0.22
Emissivity of reference source	0.08	B	√3	0.05
Standard deviation - source temperature	0.01	A	√40	0.00
Standard deviation - LP5 thermometer	0.06	A	√40	0.01
Calibration of LP5 thermometer	0.18	A	2	0.09
Resolution of LP5 thermometer	0.01	B	2√3	0.00
Resolution of source temperature	0.01	B	2√3	0.00
Alignment on source	0.00	B	√3	0.00
Size of source effect/ thermal profile	0.00	B	√3	0.00
DVM calibration	0.00	B	√3	0.00
Gain ratio measurements	0.04	B	1	0.04
Repeatability of calibration	0.08	A	1	0.08
Temperature gradients across source	0.00	B	√3	0.00
Total NPL combined uncertainty (k = 1)				**0.26**
Total NPL expanded uncertainty (k = 2)				**0.52**
Thermometer drift				0.203
Total NPL comparison uncertainty				**0.33**
Expanded NPL comparison uncertainty (k =2)				**0.66**

Table 91 - uncertainty components for the NPL VTBB measurements at 1000 °C using the LP5

9.3 UNCERTAINTY BUDGETS FOR THE CEM FIXED POINT MEASUREMENTS

INRIM thermometer Source of uncertainty/ °C	Zn	Ag
Standard deviation of thermometer signal	0.000	0.001
Standard deviation of background signal	0.001	0.000
Multimeter calibration (for thermometer signal)	0.003	0.003
Multimeter drift (for thermometer signal)	0.000	0.000
Multimeter (thermometer) resolution	0.000	0.000
Effective radius determination	0.000	0.000
FP temperature uniformity	0.014	0.014
FP emissivity	0.018	0.059
FP impurities	0.001	0.027
Repeatability of measurements	0.011	0.074
Effect of ambient temperature	0.012	0.012
Effect of ambient humidity	0.010	0.010
Total CEM combined uncertainty (k = 1)/ °C	**0.03**	**0.10**
Total CEM expanded uncertainty (k = 2)/ °C	**0.06**	**0.20**
Thermometer drift	0.035	0.111
Gain ratio	0.003	0.028
Total CEM comparison uncertainty (k = 1)/ °C	**0.045**	**0.15**
Expanded CEM comparison uncertainty (k =2)/ °C	**0.09**	**0.30**

Table 92 - uncertainty components for the CEM FP measurements with the INRiM thermometer

LP5 thermometer Source of uncertainty/ °C	Zn set 1	Zn set 2	Ag set 1	Ag set 2
Standard deviation of thermometer signal	0.000	0.000	0.000	0.000
Standard deviation of background signal	0.000	0.000	0.000	0.000
Thermometer resolution	0.000	0.000	0.000	0.000
Effective radius	0.000	0.000	0.000	0.000
FP temperature uniformity	0.014	0.014	0.014	0.014
FP emissivity	0.018	0.018	0.059	0.059
FP impurities	0.000	0.000	0.003	0.003
Repeatability of measurements	0.015	0.002	0.125	0.008
Effect of ambient temperature	0.023	0.023	0.025	0.025
Effect of ambient humidity	0.017	0.017	0.019	0.019
Total CEM combined uncertainty (*k* = 1)/ °C	**0.04**	**0.04**	**0.14**	**0.06**
Total CEM expanded uncertainty (*k* = 2)/ °C	**0.08**	**0.07**	**0.28**	**0.12**
Thermometer drift	0.060	0.060	0.191	0.191
Additional drift – difference in CEM results	0.120	0.120	0.400	0.400
Gain ratio	0.000	0.000	0.000	0.000
Total CEM comparison uncertainty (*k* = 1)/ °C	**0.14**	**0.14**	**0.47**	**0.45**
Expanded CEM comparison uncertainty (*k* =2)/ °C	**0.28**	**0.28**	**0.93**	**0.89**

Table 93 - uncertainty components for the CEM FP measurements with the LP5

9.4 UNCERTAINTY BUDGETS FOR THE UME FIXED POINT MEASUREMENTS

INRiM thermometer Source of uncertainty	In	Sn	Zn
	Standard uncertainty (u_i)/ V		
Fixed point emissivity	0.000154	0.000367	0.000397
Size of source effect	0.000031	0.000073	0.000079
Plateau identification (average)	0.000113	0.000080	0.000038
Repeatability of melts/ freezes (average)	0.000457	0.000472	0.000237
Gain ratio	0.001070	0.000156	0.00000
Total UME combined uncertainty (*k* = 1)/ V	**0.001183**	**0.000649**	**0.000475**
Total UME combined uncertainty (*k* = 1)/ °C	**0.031**	**0.010**	**0.013**
Total UME expanded uncertainty (*k* = 2)/ °C	**0.062**	**0.020**	**0.026**
Thermometer drift	0.013	0.019	0.035
Gain ratio	0.017	0.00	0.00
Total UME comparison uncertainty (*k* = 1)/ °C)	**0.038**	**0.021**	**0.038**
Expanded UME comparison uncertainty (*k* =2)	**0.076**	**0.042**	**0.075**

Table 94: uncertainty components for the UME FP measurements with the INRIM thermometer

LP5 thermometer Source of uncertainty	Sn	Zn (R1)	Zn (R2)	Al
	Standard uncertainty (u_i)/ A			
Fixed point emissivity	6.06E-16	8.24E-14	8.24E-14	2.50E-12
Size of source effect	4.55E-17	6.18E-15	6.18E-15	1.88E-13
Plateau identification (average)	1.54E-14	1.55E-13	1.55E-13	2.58E-13
Repeatability of melts/ freezes (average)	1.99E-14	4.53E-13	4.53E-13	1.61E-12
Gain ratio	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total UME combined uncertainty (*k* = 1)/ V	**2.54E-14**	**4.91E-13**	**4.91E-13**	**3.23E-12**
Total UME combined uncertainty (*k* = 1)/ °C	**0.23**	**0.06**	**0.06**	**0.03**
Total UME expanded uncertainty (*k* = 2)/ °C	**0.47**	**0.13**	**0.13**	**0.05**
Thermometer drift	0.032	0.060	0.060	0.109
Range ratio	0.00	0.64	0.00	0.00
Total UME comparison uncertainty (*k* = 1)/ °C)	**0.24**	**0.65**	**0.09**	**0.11**
Expanded UME comparison uncertainty (*k* =2)/ °C	**0.47**	**1.29**	**0.17**	**0.22**

Table 95: uncertainty components for the UME FP measurements with the LP5 thermometer

9.5 UNCERTAINTY BUDGETS FOR THE CEM VTBB MEASUREMENTS

INRIM thermometer Source of uncertainty/ °C	156	200	232	250	300	400	420	500	600	660	700	800	900
Standard deviation of thermometer signal	0.031	0.001	0.007	0.001	0.002	0.004	0.003	0.002	0.002	0.002	0.002	0.002	0.003
Standard deviation of background signal	0.205	0.037	0.010	0.006	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.002	0.001
Multimeter resolution (for thermometer signal)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Multimeter calibration (for thermometer signal)	0.003	0.001	0.002	0.001	0.003	0.004	0.003	0.001	0.003	0.002	0.001	0.007	0.004
Multimeter drift (for thermometer signal)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Effective radius determination	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
Effect of ambient temperature	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Effect of ambient humidity	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Repeatability of measurements	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Resistance bridge	0.000	-	-	-	-	-	-	-	-	-	-	-	-
Standard deviation of resistance bridge readings	0.001	-	-	-	-	-	-	-	-	-	-	-	-
Calibration and drift of resistance bridge	0.001	-	-	-	-	-	-	-	-	-	-	-	-
Calibration of bridge internal standard resistor	0.001	-	-	-	-	-	-	-	-	-	-	-	-
Drift of bridge internal resistor	0.005	-	-	-	-	-	-	-	-	-	-	-	-
Thermocouple EMF measurement	-	0.024	0.023	0.022	0.020	0.018	0.017	0.016	0.015	0.014	0.014	0.013	0.012
Thermocouple cold junction	-	0.025	0.023	0.022	0.021	0.018	0.018	0.017	0.015	0.014	0.014	0.013	0.012
Thermocouple/ PRT calibration	0.010	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.100	0.100	0.100	0.100	0.100
Thermocouple/ PRT drift	0.006	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
Blackbody furnace stability	0.080	0.004	0.003	0.003	0.003	0.002	0.002	0.006	0.002	0.003	0.002	0.002	0.006
Back wall temperature drop	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.004	0.004	0.004	0.004	0.004
Blackbody emissivity	0.013	0.019	0.021	0.023	0.027	0.038	0.040	0.050	0.064	0.073	0.079	0.096	0.115
Total CEM combined uncertainty (*k* = 1)/ °C	**0.22**	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.14**	**0.14**	**0.14**	**0.15**	**0.17**
Total CEM expanded uncertainty (*k* = 2)/ °C	**0.45**	**0.31**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.31**	**0.27**	**0.28**	**0.29**	**0.31**	**0.33**
Thermometer drift	0.013	0.016	0.019	0.020	0.024	0.033	0.035	0.044	0.056	0.064	0.069	0.084	0.100
Gain ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total CEM comparison uncertainty (*k* = 1)/ °C	**0.22**	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.16**	**0.16**	**0.15**	**0.15**	**0.16**	**0.17**	**0.19**
Expanded CEM comparison uncertainty (*k* =2)/ °C	**0.45**	**0.31**	**0.30**	**0.30**	**0.30**	**0.31**	**0.31**	**0.32**	**0.29**	**0.31**	**0.32**	**0.35**	**0.39**

Table 96 - uncertainty budgets for the CEM VTBB measurements using the INRiM thermometer

LP5 thermometer Source of uncertainty/ °C	232	250	300	400	420	500	600	660	700	800	900
Standard deviation of thermometer signal	0.132	0.043	0.015	0.003	0.002	0.004	0.003	0.002	0.001	0.002	0.003
Standard deviation of background signal	0.023	0.013	0.003	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Thermometer resolution	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Effective radius determination	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Effect of ambient temperature	0.026	0.026	0.025	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.025
Effect of ambient humidity	0.020	0.020	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
Repeatability of measurements	0.042	0.042	0.041	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
Thermocouple EMF measurement	0.023	0.022	0.020	0.018	0.017	0.016	0.015	0.014	0.014	0.013	0.012
Thermocouple cold junction	0.023	0.022	0.021	0.018	0.018	0.017	0.015	0.014	0.014	0.013	0.012
Thermocouple calibration	0.130	0.130	0.130	0.130	0.130	0.130	0.101	0.100	0.100	0.100	0.100
Thermocouple drift	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
Blackbody furnace stability	0.008	0.003	0.003	0.013	0.002	0.003	0.005	0.002	0.001	0.005	0.004
Back wall temperature drop	0.001	0.001	0.001	0.001	0.001	0.001	0.004	0.004	0.004	0.004	0.004
Blackbody emissivity	0.007	0.007	0.008	0.012	0.012	0.015	0.020	0.022	0.024	0.030	0.035
Total CEM combined uncertainty (*k* = 1)/ °C	**0.21**	**0.16**	**0.16**	**0.15**	**0.15**	**0.15**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**
Total CEM expanded uncertainty (*k* = 2)/ °C	**0.41**	**0.32**	**0.31**	**0.31**	**0.31**	**0.31**	**0.26**	**0.26**	**0.26**	**0.26**	**0.27**
Thermometer drift	0.03	0.03	0.04	0.06	0.06	0.07	0.10	0.11	0.12	0.14	0.17
Additional uncertainty due to Zn point drift at CEM	0.06	0.07	0.08	0.11	0.12	0.15	0.19	0.22	0.24	0.29	0.34
Gain ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total CEM comparison uncertainty (*k* = 1)/ °C	**0.22**	**0.18**	**0.18**	**0.20**	**0.20**	**0.23**	**0.25**	**0.28**	**0.30**	**0.35**	**0.41**
Expanded CEM comparison uncertainty (*k* =2)/ °C	**0.43**	**0.36**	**0.36**	**0.40**	**0.41**	**0.46**	**0.50**	**0.55**	**0.59**	**0.70**	**0.81**

Table 97 – uncertainty budgets for the CEM VTBB measurements using the LP5 thermometer

9.6 UNCERTAINTY BUDGETS FOR THE UME VTBB MEASUREMENTS

INRIM thermometer Source of uncertainty/ °C	200	250	300	420	500	600	660	700	800	900	1000
Standard deviation - INRIM thermometer	0.011	0.027	0.035	0.041	0.037	0.052	0.047	0.054	0.270	0.240	0.142
Reference radiation thermometer	0.397	0.393	0.394	0.393	0.393	0.393	0.393	0.393	0.394	0.395	0.394
Emissivity of reference source	0.007	0.008	0.010	0.014	0.017	0.021	0.024	0.027	0.192	0.229	0.270
Size of source effect/ thermal profile	0.001	0.001	0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.006	0.007
Gain ratio measurements	0.002	0.002	0.002	0.000	0.000	0.004	0.005	0.005	0.046	0.055	0.065
Repeatability of calibration	0.266	0.092	0.113	0.170	0.091	0.153	0.110	0.109	0.301	0.294	0.203
Total UME combined uncertainty (*k* = 1)/ °C	**0.478**	**0.404**	**0.411**	**0.430**	**0.405**	**0.425**	**0.411**	**0.412**	**0.598**	**0.596**	**0.542**
Total UME expanded uncertainty (*k* = 2)/ °C	**0.955**	**0.808**	**0.822**	**0.860**	**0.810**	**0.850**	**0.822**	**0.824**	**1.196**	**1.193**	**1.084**
Thermometer drift	0.016	0.020	0.024	0.035	0.044	0.056	0.064	0.069	0.084	0.100	0.118
Gain ratio	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total UME comparison uncertainty (*k* = 1)/ °C	**0.480**	**0.405**	**0.412**	**0.431**	**0.407**	**0.429**	**0.416**	**0.418**	**0.604**	**0.605**	**0.555**
Expanded UME comparison uncertainty (*k* =2)/ °C	**0.960**	**0.809**	**0.824**	**0.862**	**0.814**	**0.857**	**0.832**	**0.835**	**1.208**	**1.209**	**1.110**

Table 98: uncertainty components for the UME VTBB measurements with the INRIM thermometer

LP5 thermometer Source of uncertainty/ °C	250	300	420	500	600	660	700	800	900	1000
Standard deviation – LP5 thermometer	0.077	0.162	0.041	0.055	0.049	0.057	0.072	0.133	0.243	0.172
Reference radiation thermometer	0.393	0.394	0.393	0.393	0.393	0.393	0.393	0.394	0.395	0.394
Emissivity of reference source	0.007	0.009	0.013	0.016	0.021	0.023	0.026	0.188	0.222	0.264
Size of source effect/ thermal profile	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003
Gain ratio measurements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Repeatability of calibration	0.259	0.137	0.078	0.124	0.124	0.278	0.228	0.313	0.323	0.305
Total UME combined uncertainty (*k* = 1)/ °C	**0.477**	**0.447**	**0.402**	**0.416**	**0.415**	**0.485**	**0.460**	**0.553**	**0.607**	**0.590**
Total UME expanded uncertainty (*k* = 2)/ °C	**0.953**	**0.894**	**0.805**	**0.831**	**0.830**	**0.969**	**0.921**	**1.106**	**1.214**	**1.179**
Thermometer drift	0.034	0.041	0.060	0.075	0.095	0.109	0.118	0.144	0.172	0.203
Gain ratio	0.000	0.447	0.654	0.814	0.000	0.000	0.000	0.000	0.000	0.000
Total UME comparison uncertainty (*k* = 1)/ °C	**0.478**	**0.634**	**0.771**	**0.917**	**0.426**	**0.497**	**0.475**	**0.572**	**0.631**	**0.623**
Expanded UME comparison uncertainty (*k* =2)/ °C	**0.956**	**1.268**	**1.541**	**1.834**	**0.852**	**0.993**	**0.951**	**1.143**	**1.262**	**1.247**

Table 99: uncertainty components for the UME VTBB measurements with the LP5 thermometer

9.7 UNCERTAINTY BUDGETS FOR PTB VTBB MEASUREMENTS

INRIM thermometer Source of uncertainty/ °C	156	200	232	250	300	400	420	500	600	660	700	800	900	962
Blackbody source†	0.032	0.032	0.033	0.033	0.048	0.018	0.018	0.020	0.022	0.037	0.038	0.041	0.044	0.047
Standard deviation of blackbody temperature	0.001	0.001	0.002	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
Standard deviation of thermometer signal	0.003	0.001	0.003	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
Standard deviation of background signal	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Size of source effect/ thermal profile	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gain ratio measurements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total PTB combined uncertainty (*k* = 1)/ °C	**0.032**	**0.032**	**0.033**	**0.035**	**0.048**	**0.018**	**0.018**	**0.020**	**0.022**	**0.037**	**0.038**	**0.041**	**0.044**	**0.047**
Total PTB expanded uncertainty (*k* = 2)/ °C	**0.064**	**0.064**	**0.066**	**0.069**	**0.096**	**0.035**	**0.036**	**0.039**	**0.044**	**0.073**	**0.075**	**0.081**	**0.088**	**0.094**
Thermometer drift	0.013	0.016	0.019	0.020	0.024	0.033	0.035	0.044	0.056	0.064	0.069	0.084	0.100	0.111
Gain ratio	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000
Total PTB comparison uncertainty (*k* = 1)/ °C	**0.03**	**0.04**	**0.04**	**0.04**	**0.05**	**0.04**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**	**0.11**	**0.12**
Expanded PTB comparison uncertainty (*k* =2)/ °C	**0.07**	**0.07**	**0.08**	**0.08**	**0.11**	**0.07**	**0.08**	**0.10**	**0.12**	**0.15**	**0.16**	**0.19**	**0.22**	**0.24**

Table 100: uncertainty components for the PTB VTBB measurements with the INRiM thermometer

† This component includes uncertainties in the corrections for the cavity emissivity, the radial temperature and axial non-uniformity of the cavity, the temperature drop across the cavity back wall and the uncertainty in the calibration of the PRT.

LP5 thermometer Source of uncertainty/ °C	232	250	300	400	420	500	600	660	700	800	900	962
Blackbody source	0.033	0.033	0.048	0.018	0.018	0.020	0.022	0.037	0.038	0.041	0.044	0.047
Standard deviation of blackbody temperature	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	0.000	0.000	0.001
Standard deviation of thermometer signal	0.022	0.014	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Standard deviation of background signal	0.039	0.022	0.007	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Size of source effect/ thermal profile	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gain ratio measurements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total PTB combined uncertainty (*k* = 1)/ °C	**0.056**	**0.043**	**0.049**	**0.018**	**0.018**	**0.020**	**0.022**	**0.037**	**0.038**	**0.041**	**0.044**	**0.047**
Total PTB expanded uncertainty (*k* = 2)/ °C	**0.111**	**0.085**	**0.097**	**0.035**	**0.036**	**0.039**	**0.044**	**0.073**	**0.075**	**0.081**	**0.088**	**0.094**
Thermometer drift	0.032	0.034	0.041	0.057	0.060	0.075	0.095	0.109	0.118	0.144	0.172	0.191
Gain ratio	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000
Total PTB comparison uncertainty (*k* = 1)/ °C	**0.064**	**0.055**	**0.064**	**0.059**	**0.063**	**0.077**	**0.098**	**0.115**	**0.124**	**0.150**	**0.178**	**0.196**
Expanded PTB comparison uncertainty (*k* =2)/ °C	**0.128**	**0.109**	**0.127**	**0.119**	**0.125**	**0.155**	**0.196**	**0.230**	**0.248**	**0.299**	**0.355**	**0.393**

Table 101: uncertainty components for the PTB VTBB measurements with the LP5 thermometer

9.8 UNCERTAINTY BUDGETS FOR LNE VTBB MEASUREMENTS

Blackbody reference source for INRIM thermometer measurements Source of uncertainty/ °C	H_2O heatpipe		Cs heatpipe		Na heatpipe	
	150	250	300	600	600	950
Emissivity of the BB cavity	0.004	0.006	0.024	0.055	0.060	0.115
Spectral band	0.006	0.009	0.013	0.037	0.040	0.070
Radiance uniformity of the BB aperture	0.025	0.025	0.063	0.033	0.060	0.080
Short term stability of the BB	0.004	0.004	0.030	0.030	0.153	0.153
Calibration of the contact thermometer within the BB	0.002	0.002	0.003	0.008	0.280	0.400
Implementation of the contact thermometer	0.009	0.009	0.029	0.029	0.060	0.060
Drift of the contact thermometer	0.004	0.004	0.004	0.004	0.060	0.060
Electrical connections	0.002	0.002	0.002	0.002	0.100	0.090
Drift of the multimeter	0.0001	0.0002	0.009	0.010	0.030	0.030
Melting ice	-	-	-	-	0.050	0.050
Total LNE source uncertainty (*k* = 1)/ °C	**0.028**	**0.029**	**0.081**	**0.086**	**0.359**	**0.473**
Position of the contact thermometer's sensitive element / cavity backwall	0.100	0.200	0.100	0.100	0.200	0.200
Correction and uncertainty of the multimeter calibration	0.030	0.030	0.050	0.060	0.100	0.100
LNE expanded source uncertainty (*k* = 2)/ °C	**0.19**	**0.29**	**0.31**	**0.33**	**1.02**	**1.25**

Table 102: uncertainty components for the LNE VTBB measurements with the INRiM thermometer

INRIM thermometer Source of uncertainty/ °C	156	200	232	250	300	400	420	500	600 Cs	600 Na	660	700	800	900	962
Blackbody source*	0.095	0.120	0.135	0.145	0.155	0.160	0.160	0.165	0.165	0.510	0.530	0.540	0.575	0.605	0.625
Standard deviation of signal	0.007	0.006	0.005	0.004	0.010	0.024	0.012	0.016	0.027	0.036	0.014	0.012	0.013	0.018	0.140
Total LNE combined uncertainty (*k* = 1)/ °C	**0.105**	**0.125**	**0.140**	**0.150**	**0.165**	**0.185**	**0.170**	**0.180**	**0.195**	**0.545**	**0.540**	**0.555**	**0.700**	**0.625**	**0.770**
Total LNE expanded uncertainty (*k* = 2)/ °C	**0.210**	**0.250**	**0.280**	**0.300**	**0.330**	**0.370**	**0.340**	**0.360**	**0.390**	**1.090**	**1.080**	**1.110**	**1.400**	**1.250**	**1.540**
Thermometer drift	0.013	0.016	0.019	0.020	0.024	0.033	0.035	0.044	0.056	0.056	0.064	0.069	0.084	0.100	0.111
Gain ratio	0.008	0.012	0.006	0.007	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total LNE uncertainty (*k* = 1)/ °C	**0.10**	**0.13**	**0.14**	**0.15**	**0.17**	**0.19**	**0.18**	**0.18**	**0.20**	**0.55**	**0.55**	**0.56**	**0.71**	**0.63**	**0.78**
Expanded LNE uncertainty (*k* =2)/ °C	**0.21**	**0.25**	**0.28**	**0.30**	**0.33**	**0.37**	**0.35**	**0.37**	**0.40**	**1.09**	**1.09**	**1.12**	**1.41**	**1.27**	**1.55**

Table 103: uncertainty components for the LNE VTBB measurements with the INRiM thermometer – all thermometer components

* Values obtained by interpolation from Table 102

Blackbody reference source for LP5 measurements Source of uncertainty/ °C	H_2O heatpipe		Cs heatpipe		Na heatpipe	
	150	250	300	600	600	950
Emissivity of the BB cavity	0.004	0.006	0.024	0.055	0.060	0.115
Spectral band	0.006	0.009	0.013	0.037	0.040	0.070
Radiance uniformity of the BB aperture	0.025	0.025	0.063	0.033	0.060	0.080
Short term stability of the BB	0.003	0.003	0.005	0.003	0.020	0.014
Calibration of the contact thermometer within the BB	0.002	0.002	0.003	0.008	0.280	0.400
Implementation of the contact thermometer	0.009	0.009	0.029	0.029	0.060	0.060
Drift of the contact thermometer	0.004	0.004	0.004	0.004	0.060	0.060
Electrical connections	0.002	0.002	0.002	0.002	0.100	0.090
Drift of the multimeter	0.0001	0.0002	0.009	0.010	0.030	0.030
Melting ice	-	-	-	-	0.050	0.050
Total LNE source uncertainty (*k* = 1)/ °C	**0.028**	**0.029**	**0.075**	**0.081**	**0.325**	**0.448**
Position of the contact thermometer's sensitive element / cavity backwall	0.100	0.200	0.100	0.100	0.200	0.200
Correction and uncertainty of the multimeter calibration	0.030	0.030	0.050	0.060	0.100	0.100
LNE expanded source uncertainty (*k* = 2)/ °C	**0.19**	**0.29**	**0.30**	**0.32**	**0.95**	**1.20**

Table 104: uncertainty components for the LNE VTBB measurements with the LP5

LP5 thermometer Source of uncertainty/ °C	232	250	300	400	420	500	600 Cs	660 Na	700	800	900	962
Blackbody source*	0.135	0.145	0.150	0.155	0.155	0.155	0.160	0.495	0.510	0.545	0.580	0.600
Standard deviation of signal	0.160	0.093	0.024	0.006	0.004	0.011	0.052	0.022	0.014	0.024	0.014	0.018
Total LNE combined uncertainty (*k* = 1)/ °C	**0.300**	**0.235**	**0.175**	**0.160**	**0.160**	**0.170**	**0.210**	**0.520**	**0.525**	**0.570**	**0.595**	**0.620**
Total LNE expanded uncertainty (*k* = 2)/ °C	**0.600**	**0.470**	**0.035**	**0.320**	**0.320**	**0.340**	**0.420**	**1.040**	**1.050**	**1.14**	**1.19**	**1.240**
Thermometer drift	0.032	0.034	0.041	0.057	0.060	0.075	0.095	0.109	0.118	0.144	0.172	0.191
Gain ratio	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total LNE comparison uncertainty (*k* = 1)/ °C	**0.30**	**0.24**	**0.18**	**0.17**	**0.17**	**0.18**	**0.23**	**0.53**	**0.54**	**0.59**	**0.62**	**0.65**
Expanded LNE comparison uncertainty (*k* =2)/ °C	**0.60**	**0.48**	**0.36**	**0.34**	**0.34**	**0.37**	**0.47**	**1.06**	**1.08**	**1.17**	**1.24**	**1.30**

Table 105: Uncertainty components for the LNE VTBB measurements with the LP5 - all thermometer components

* Values obtained by interpolation from Table 104

9.9 UNCERTAINTY BUDGETS FOR THE METAS VTBB MEASUREMENTS

INRIM thermometer Source of uncertainty/ °C	156.6	200	232	250	300	400
BB calibration at PTB	0.075	0.085	0.090	0.090	0.095	0.025
SPRT accuracy on ITS-90 incl. propagation of WTP-Drift over 1 year	0.003	0.003	0.003	0.003	0.005	0.005
Thermal coupling between BB and SPRT	0.011	0.011	0.012	0.012	0.012	0.013
Electrical measurement of the SPRT	0.003	0.003	0.003	0.003	0.003	0.003
BB radial homogeneity (over aperture of 20 mm)	0.030	0.030	0.030	0.030	0.025	0.020
BB temperature stability during the measurements	0.010	0.010	0.010	0.010	0.010	0.010
Uncertainty of emissivity (incl. correction for e < 1)	0.007	0.009	0.010	0.010	0.026	0.031
Background radiation at 20 °C	0.003	0.003	0.003	0.002	0.010	0.005
Thermal losses by radiation	0.003	0.003	0.003	0.003	0.003	0.004
Thermal losses by convection	0.006	0.009	0.010	0.011	0.012	0.009
Resolution pyrometer	0.010	0.010	0.010	0.010	0.010	0.010
Standard deviation of the pyrometer	0.200	0.200	0.200	0.150	0.040	0.010
Reproducibility of the position of the pyrometer ±0.2 mm on three axes	0.001	0.001	0.001	0.001	0.001	0.001
Total METAS combined uncertainty (*k* = 1)/ °C	**0.217**	**0.221**	**0.223**	**0.179**	**0.112**	**0.051**
Total METAS expanded uncertainty (*k* = 2)/ °C	**0.433**	**0.441**	**0.445**	**0.358**	**0.224**	**0.102**
Thermometer drift	0.013	0.016	0.019	0.020	0.024	0.035
Gain ratio	0.000	0.000	0.000	0.000	0.000	0.000
Total METAS comparison uncertainty (*k* = 1)/ °C	**0.22**	**0.22**	**0.22**	**0.18**	**0.11**	**0.06**
Expanded comparison uncertainty (*k* =2)/ °C	**0.43**	**0.44**	**0.45**	**0.36**	**0.23**	**0.12**

Table 106: uncertainty components for the METAS VTBB measurements with the INRIM thermometer (SPRT sensors)

INRIM thermometer Source of uncertainty/ °C	420	500 (Cs)	500 (Na)	600 (Cs)	600 (Na)	660 (Na)
BB calibration at PTB	0.025	0.025	0.035	0.030	0.045	0.050
SPRT accuracy on ITS-90 incl. propagation of WTP-Drift over 1 year	0.005	0.005	0.005	0.005	0.005	0.005
Thermal coupling between BB and SPRT	0.013	0.014	0.014	0.015	0.015	0.016
Electrical measurement of the SPRT	0.003	0.004	0.004	0.004	0.004	0.004
BB radial homogeneity (over aperture of 20 mm)	0.020	0.020	0.025	0.015	0.030	0.035
BB temperature stability during the measurements	0.010	0.005	0.015	0.005	0.015	0.015
Uncertainty of emissivity (incl. correction for e < 1)	0.031	0.038	0.044	0.042	0.049	0.053
Background radiation at 20 °C	0.005	0.005	0.005	0.005	0.005	0.005
Thermal losses by radiation	0.004	0.005	0.005	0.010	0.010	0.013
Thermal losses by convection	0.009	0.007	0.007	0.008	0.008	0.009
Resolution pyrometer	0.010	0.010	0.010	0.010	0.010	0.010
Standard deviation of the pyrometer	0.010	0.010	0.010	0.010	0.010	0.010
Reproducibility of the position of the pyrometer ±0.2 mm on three axes	0.001	0.001	0.001	0.001	0.001	0.001
Total METAS combined uncertainty (*k* = 1)/ °C	**0.051**	**0.055**	**0.067**	**0.060**	**0.079**	**0.174**
Total METAS expanded uncertainty (*k* = 2)/ °C	**0.102**	**0.110**	**0.135**	**0.119**	**0.158**	**0.087**
Thermometer drift	0.035	0.044	0.044	0.056	0.056	0.064
Gain ratio	0.000	0.000	0.000	0.000	0.000	0.000
Total METAS comparison uncertainty (*k* = 1)/ °C	**0.06**	**0.07**	**0.08**	**0.08**	**0.10**	**0.11**
Expanded comparison uncertainty (*k* =2)/ °C	**0.12**	**0.14**	**0.16**	**0.16**	**0.19**	**0.22**

Table 107: uncertainty components for the METAS VTBB measurements with the INRIM thermometer (SPRT sensors) - continued

INRIM thermometer Source of uncertainty	500	600	700	800	900	962	1000
BB calibration at PTB	0.035	0.045	0.06	0.070	0.080	0.090	0.100
TC type S accuracy on ITS-90	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Thermal coupling between BB and TC	0.087	0.115	0.173	0.230	0.289	0.318	0.346
Electrical measurement of the TC	0.150	0.150	0.100	0.100	0.100	0.100	0.100
Radial homogeneity (over aperture of 20 mm)	0.025	0.030	0.040	0.050	0.060	0.065	0.070
Temperature stability during the measurements	0.015	0.015	0.015	0.020	0.020	0.020	0.020
Uncertainty of emissivity (incl. correction for e < 1)	0.044	0.049	0.055	0.042	0.042	0.055	0.067
Background radiation at 20 °C	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Thermal losses by radiation	0.005	0.010	0.010	0.020	0.025	0.028	0.030
Thermal losses by convection	0.007	0.008	0.009	0.010	0.011	0.012	0.013
Resolution pyrometer	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Standard deviation of the pyrometer	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Reproducibility of the position of the pyrometer ±0.2 mm on three axes	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total METAS combined uncertainty (*k* = 1)/ °C	**0.238**	**0.253**	**0.267**	**0.309**	**0.359**	**0.388**	**0.416**
Total METAS expanded uncertainty (*k* = 2)/ °C	**0.477**	**0.507**	**0.534**	**0.619**	**0.719**	**0.776**	**0.833**
Thermometer drift	0.044	0.056	0.069	0.084	0.100	0.111	0.118
Gain ratio	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total METAS comparison uncertainty (*k* = 1)/ °C	**0.24**	**0.26**	**0.28**	**0.32**	**0.37**	**0.40**	**0.43**
Expanded comparison uncertainty (*k* =2)/ °C	**0.48**	**0.52**	**0.55**	**0.64**	**0.75**	**0.81**	**0.87**

Table 108: uncertainty components for the METAS VTBB measurements with the INRIM thermometer (thermocouple sensors)

LP5 thermometer Source of uncertainty/ °C	232	250	300	400	420	500 (Cs)	500 (Na)	600 (Cs)	600 (Na)	660 (Na)
BB calibration at PTB	0.090	0.090	0.095	0.025	0.025	0.025	0.035	0.030	0.045	0.050
SPRT accuracy on ITS-90 incl. propagation of WTP-Drift over 1 year	0.003	0.003	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Thermal coupling between BB and SPRT	0.012	0.012	0.012	0.013	0.013	0.014	0.014	0.015	0.015	0.016
Electrical measurement of the SPRT	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004
BB radial homogeneity (over aperture of 20 mm)	0.030	0.030	0.025	0.020	0.020	0.020	0.025	0.015	0.030	0.035
BB temperature stability during the measurements	0.010	0.010	0.010	0.010	0.010	0.005	0.015	0.005	0.015	0.015
Uncertainty of emissivity (incl. correction for e < 1)	0.010	0.010	0.026	0.031	0.031	0.038	0.044	0.042	0.049	0.053
Background radiation at 20 °C	0.003	0.002	0.010	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Thermal losses by radiation	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.010	0.010	0.013
Thermal losses by convection	0.010	0.011	0.012	0.009	0.009	0.007	0.007	0.008	0.008	0.009
Resolution pyrometer	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Standard deviation of the pyrometer	0.200	0.150	0.040	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Reproducibility of the position of the pyrometer ±0.2 mm on three axes	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total METAS combined uncertainty (*k* = 1)/ °C	**0.223**	**0.179**	**0.112**	**0.051**	**0.051**	**0.055**	**0.067**	**0.060**	**0.079**	**0.174**
Total METAS expanded uncertainty (*k* = 2)/ °C	**0.445**	**0.358**	**0.224**	**0.102**	**0.102**	**0.110**	**0.135**	**0.119**	**0.158**	**0.087**
Thermometer drift	0.032	0.034	0.041	0.057	0.060	0.075	0.075	0.095	0.095	0.109
Range ratio	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
Total METAS comparison uncertainty (*k* = 1)/ °C	**0.225**	**0.182**	**0.119**	**0.076**	**0.079**	**0.093**	**0.101**	**0.113**	**0.124**	**0.139**
Expanded comparison uncertainty (*k* =2)/ °C	**0.45**	**0.37**	**0.24**	**0.15**	**0.16**	**0.19**	**0.20**	**0.23**	**0.25**	**0.28**

Table 109: uncertainty components for the METAS VTBB measurements with the LP5 thermometer (SPRT sensors)

LP5 thermometer Source of uncertainty	500	600	700	800	900	962	1000
BB calibration at PTB	0.035	0.045	0.06	0.070	0.080	0.090	0.100
TC type S accuracy on ITS-90	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Thermal coupling between BB and TC	0.087	0.115	0.173	0.230	0.289	0.318	0.346
Electrical measurement of the TC	0.150	0.150	0.100	0.100	0.100	0.100	0.100
Radial homogeneity (over aperture of 20 mm)	0.025	0.030	0.040	0.050	0.060	0.065	0.070
Temperature stability during the measurements	0.015	0.015	0.015	0.020	0.020	0.020	0.020
Uncertainty of emissivity (incl. correction for e < 1)	0.044	0.049	0.055	0.042	0.042	0.055	0.067
Background radiation at 20 °C	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Thermal losses by radiation	0.005	0.010	0.010	0.020	0.025	0.028	0.030
Thermal losses by convection	0.007	0.008	0.009	0.010	0.011	0.012	0.013
Resolution pyrometer	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Standard deviation of the pyrometer	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Reproducibility of the position of the pyrometer ±0.2 mm on three axes	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total METAS combined uncertainty (*k* = 1)/ °C	**0.238**	**0.253**	**0.267**	**0.309**	**0.359**	**0.388**	**0.416**
Total METAS expanded uncertainty (*k* = 2)/ °C	**0.477**	**0.507**	**0.534**	**0.619**	**0.719**	**0.776**	**0.833**
Thermometer drift	0.075	0.095	0.118	0.144	0.172	0.191	0.203
Range ratio	0.000	0.001	0.001	0.001	0.001	0.001	0.001
Total METAS comparison uncertainty (*k* = 1)/ °C	**0.250**	**0.271**	**0.292**	**0.341**	**0.398**	**0.432**	**0.463**
Expanded comparison uncertainty (*k* =2)/ °C	**0.50**	**0.54**	**0.58**	**0.68**	**0.80**	**0.87**	**0.93**

Table 110: uncertainty components for the METAS VTBB measurements with the LP5 thermometer (thermocouple sensors)

9.10 UNCERTAINTY BUDGETS FOR THE INRIM FIXED POINT MEASUREMENTS

Uncertainty component	**Fixed-Points**				
	In	**Sn**	**Zn**	**Al**	**Ag**
	Standard uncertainty (u_i) (mK)				
Impurities	3	3	5	5	5
Emissivity	2	3	5	6	7
Temperature drop	1	2	3	4	5
Plateau identification	4	1	1	2	2
Size of source effect	5	5	5	5	5
Repeatability	3	1	1	3	7
Total INRIM uncertainty u_{FP} (k = 1)	**8**	**7**	**9**	**11**	**13**
Total INRIM expanded uncertainty U_{FP} (k=2)	**16**	**14**	**18**	**22**	**26**
Gain ratio	0	0	0	0	0
Thermometer drift	13	19	35	64	111
Total INRIM comparison uncertainty u	**15**	**20**	**36**	**65**	**112**
Expanded INRIM comparison uncertainty U (k =2)	**31**	**40**	**72**	**129**	**224**

Table 111: uncertainty components for the INRiM FP measurements for the INRiM thermometer

Uncertainty component	**Fixed-Points**			
	Sn	**Zn**	**Al**	**Ag**
	Standard uncertainty (u_i) (mK)			
Impurities	3	5	5	5
Emissivity	3	5	6	7
Temperature drop	2	3	4	5
Plateau identification	250	5	2	3
Size of source effect	5	5	5	5
Repeatability	64	2	2	8
Total INRIM uncertainty u_{FP} (k = 1)	**258**	**11**	**10**	**14**
Total INRIM expanded uncertainty U_{FP} (k = 2)	**516**	**22**	**20**	**28**
Range ratio	0	0	0	0
Thermometer drift	32	60	109	191
Total INRIM comparison uncertainty u	**260**	**61**	**110**	**192**
Expanded INRIM comparison uncertainty U (k = 2)	**520**	**122**	**219**	**383**

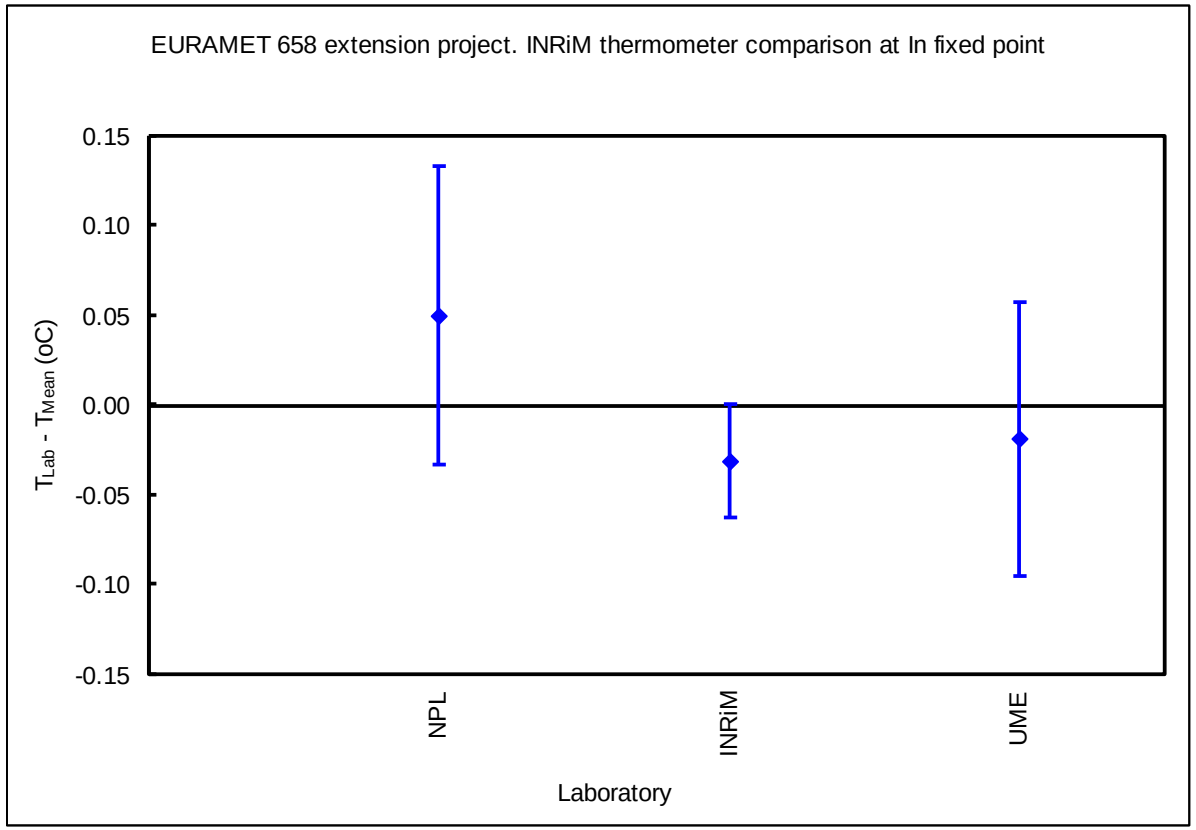
Table 112: uncertainty components for the INRiM FP measurements for the LP5 thermometer

10 THE DOE AND QDE_{95} VALUES FOR THE FIXED-POINT AND VARIABLE TEMPERATURE BLACKBODY COMPARISON FOR THE INRIM THERMOMETER. UNCERTAINTIES INCLUDE THE LABORATORY, THERMOMETER DRIFT AND GAIN RATIO COMPONENTS ONLY

10.1 THE RESULTS OF THE MEASUREMENTS USING THE FIXED-POINTS

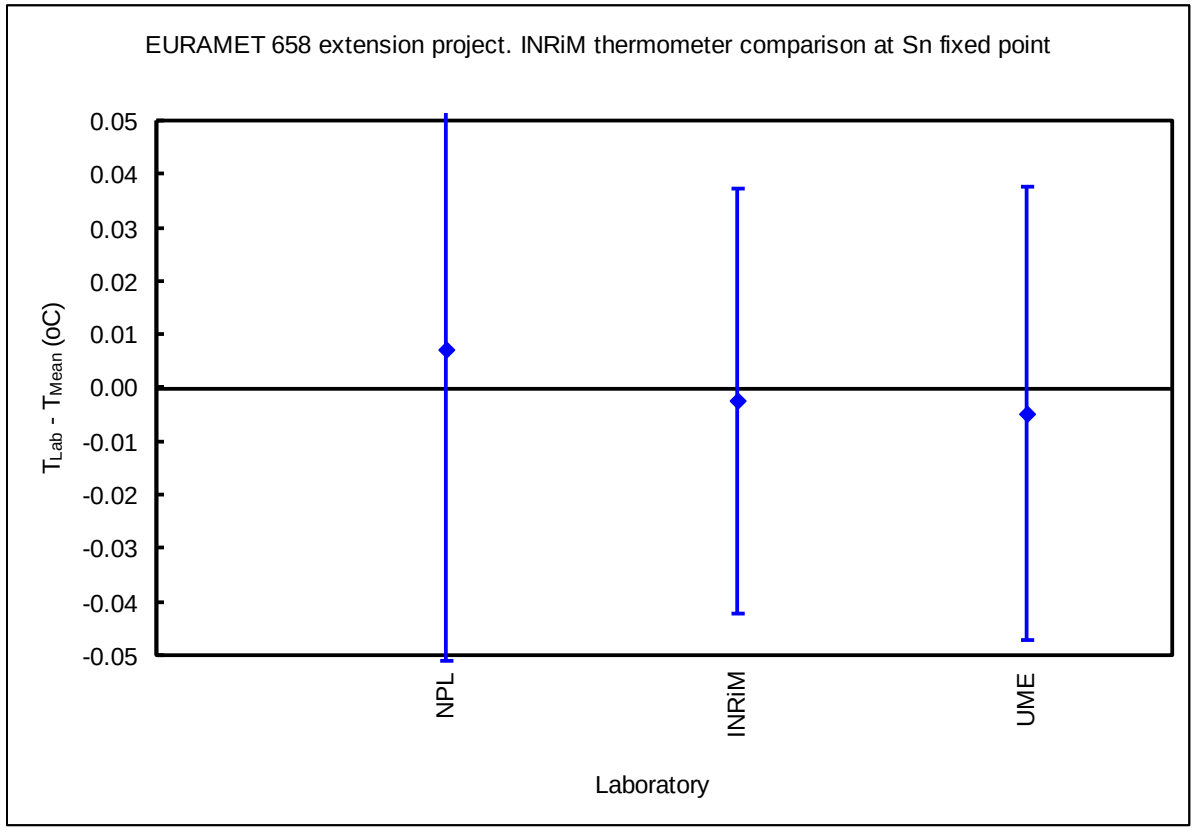
	NPL	INRiM	UME
NPL	-	0.08 ± 0.09	0.07 ± 0.11
INRiM	*0.15*	-	-0.01 ± 0.08
UME	*0.16*	*0.08*	-

Table 113 – direct comparison of the results for the calibration of the INRiM thermometer at the In point



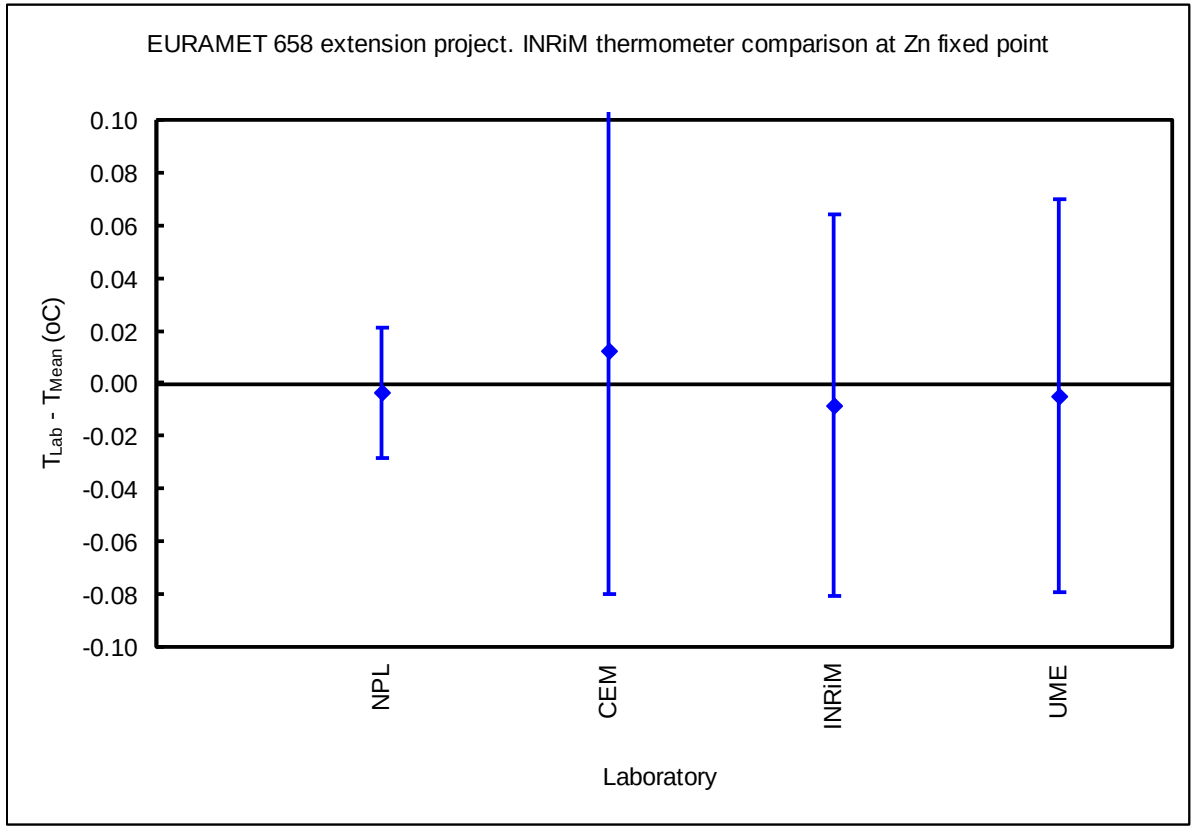
	NPL	INRiM	UME
NPL	-	0.01 ± 0.07	0.01 ± 0.07
INRiM	*0.07*	-	0.00 ± 0.06
UME	*0.07*	*0.06*	-

Table 114 – direct comparison of the results for the calibration of the INRiM thermometer at the Sn point



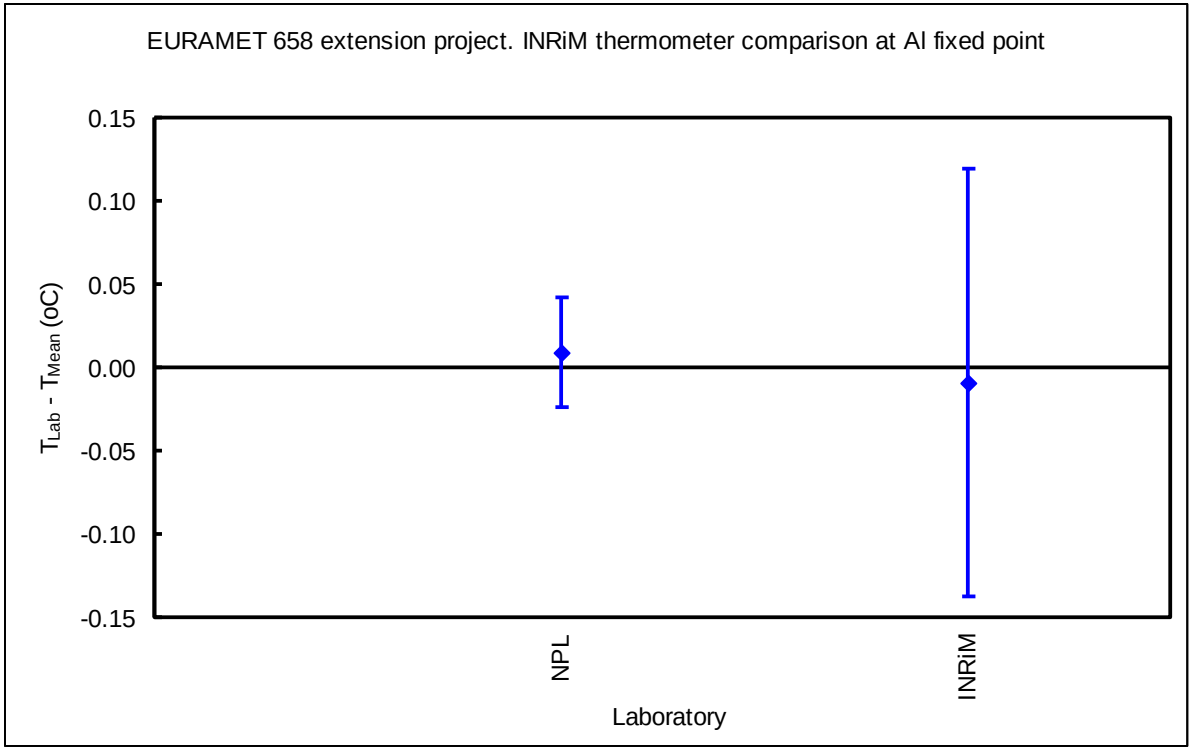
	NPL	CEM	INRiM	UME
NPL	-	-0.02 ± 0.10	0.00 ± 0.08	0.00 ± 0.08
CEM	*0.10*	-	0.02 ± 0.12	0.02 ± 0.12
INRiM	*0.08*	*0.12*	-	0.00 ± 0.10
UME	*0.08*	*0.12*	*0.10*	-

Table 115 – direct comparison of the results for the calibration of the INRiM thermometer at the Zn point



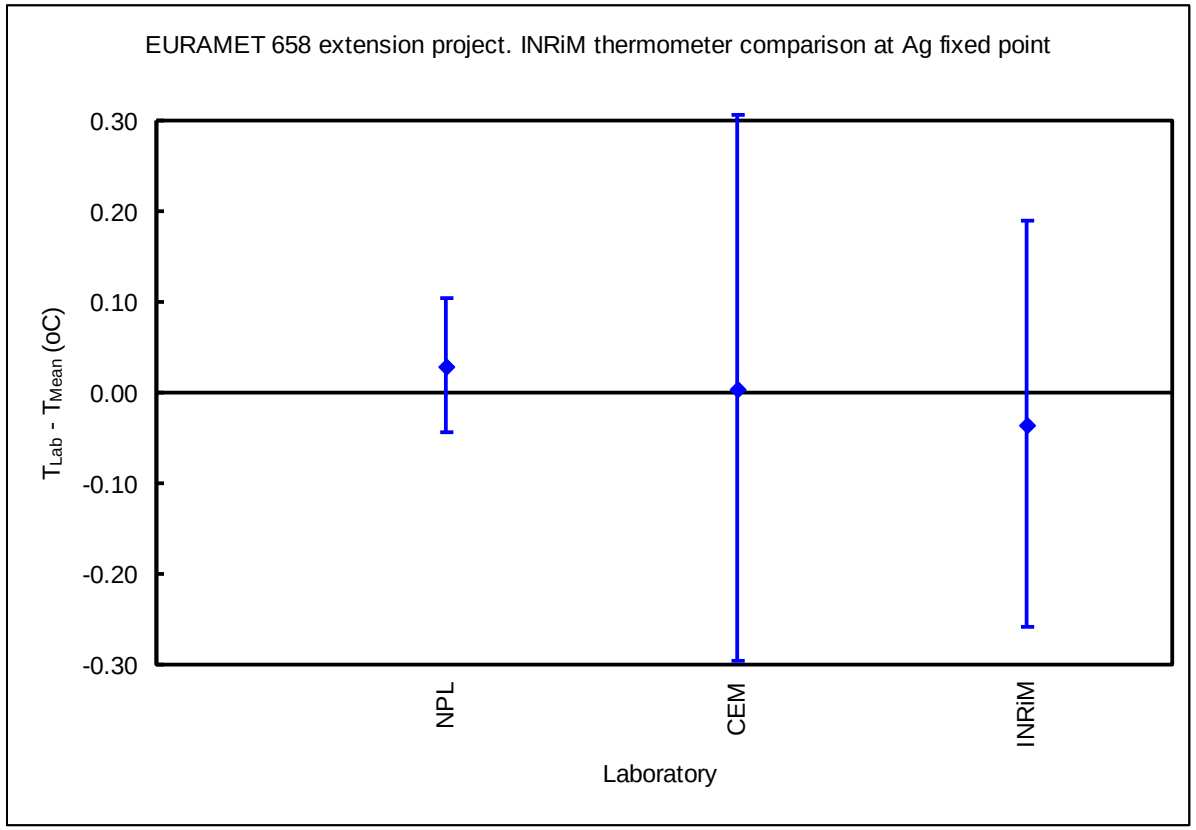
	NPL	INRiM
NPL	-	0.02 ± 0.13
INRiM	*0.13*	-

Table 116 – direct comparison of the results for the calibration of the INRiM thermometer at the Al point



	NPL	CEM	INRiM
NPL	-	0.03 ± 0.31	0.06 ± 0.24
CEM	*0.31*	-	0.04 ± 0.38
INRiM	*0.26*	*0.37*	-

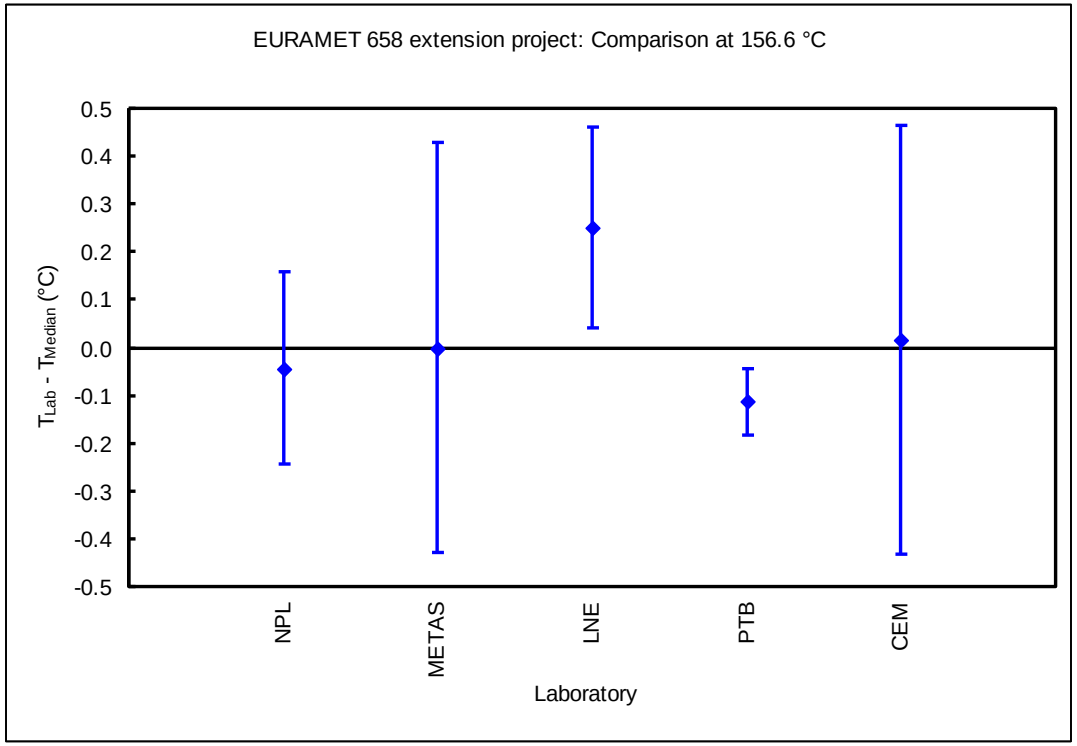
Table 117 – direct comparison of the results for the calibration of the INRiM thermometer at the Ag point



10.2 THE RESULTS OF THE MEASUREMENTS USING THE VARIABLE TEMPERATURE BLACKBODY SOURCES

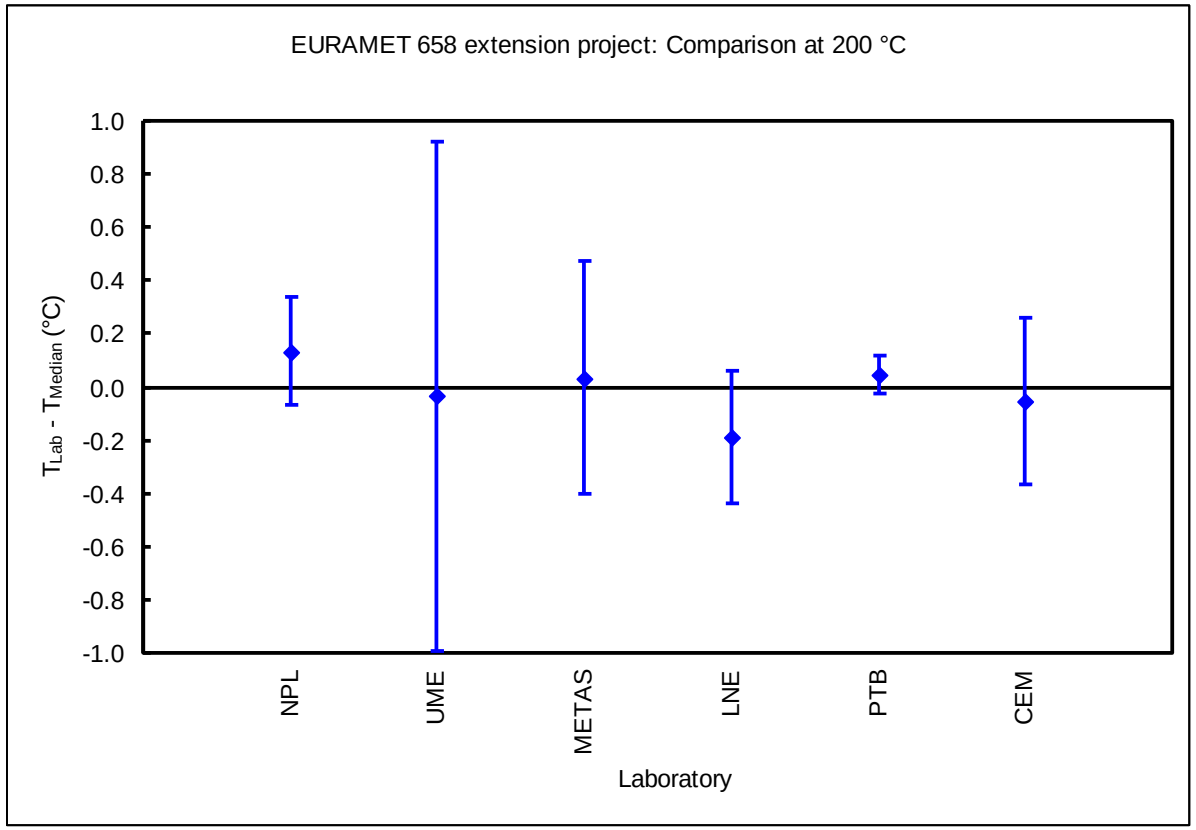
	NPL	METAS	LNE	PTB	CEM
NPL	-	-0.04 ± 0.48	-0.29 ± 0.29	0.07 ± 0.21	-0.06 ± 0.49
METAS	*0.47*	-	-0.25 ± 0.48	0.11 ± 0.44	-0.02 ± 0.62
LNE	*0.53*	*0.65*	-	0.36 ± 0.22	0.23 ± 0.50
PTB	*0.25*	*0.48*	*0.55*	-	-0.13 ± 0.46
CEM	*0.50*	*0.61*	*0.65*	*0.51*	-

Table 118 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 157 °C



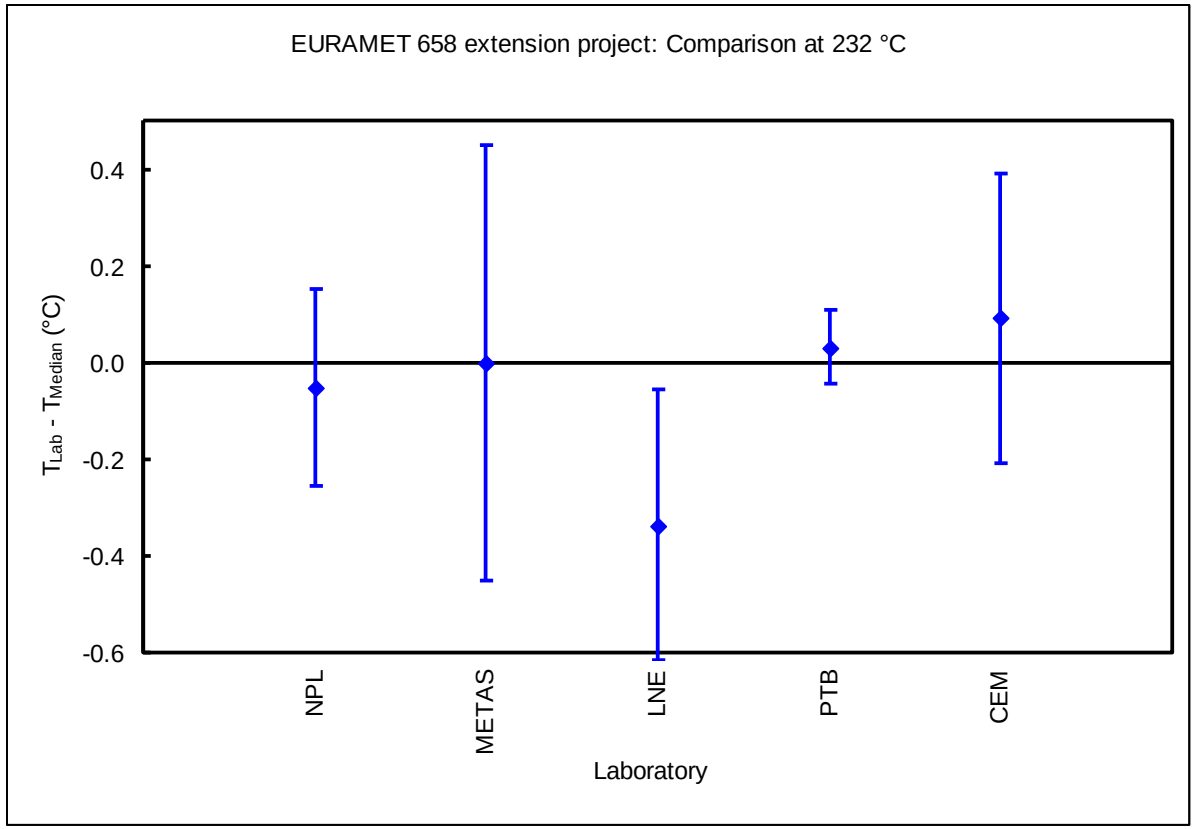
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	0.17 ± 0.98	0.10 ± 0.48	0.32 ± 0.32	0.09 ± 0.22	0.19 ± 0.37
UME	*1.01*	-	-0.07 ± 1.06	0.15 ± 0.99	-0.08 ± 0.96	0.02 ± 1.01
METAS	*0.51*	*1.04*	-	0.22 ± 0.51	-0.01 ± 0.45	0.09 ± 0.54
LNE	*0.58*	*1.01*	*0.64*	-	-0.23 ± 0.26	-0.13 ± 0.40
PTB	*0.27*	*0.95*	*0.44*	*0.45*	-	0.10 ± 0.32
CEM	*0.49*	*0.99*	*0.55*	*0.47*	*0.36*	-

Table 119 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 200 °C



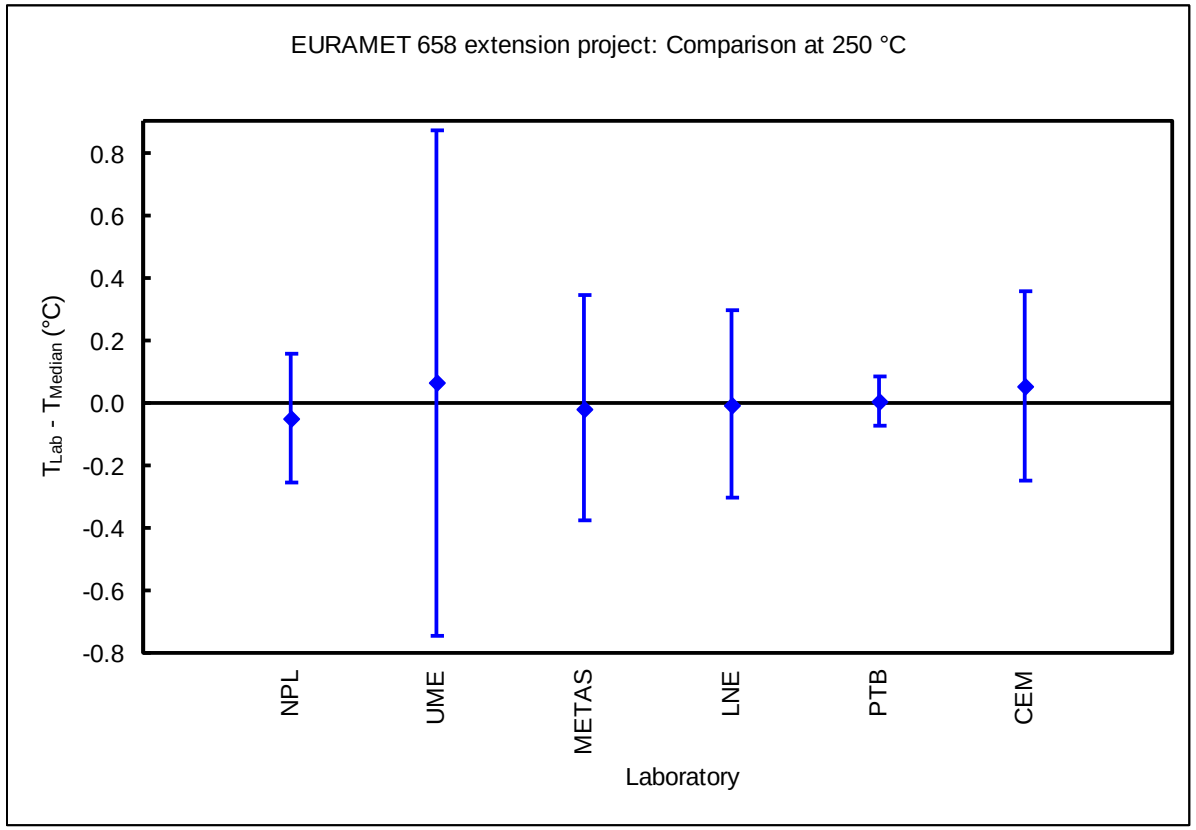
	NPL	METAS	LNE	PTB	CEM
NPL	-	-0.05 ± 0.49	0.29 ± 0.35	-0.08 ± 0.22	-0.14 ± 0.36
METAS	*0.49*	-	0.34 ± 0.53	-0.03 ± 0.46	-0.09 ± 0.54
LNE	*0.57*	*0.77*	-	-0.37 ± 0.29	-0.43 ± 0.41
PTB	*0.26*	*0.45*	*0.61*	-	-0.06 ± 0.31
CEM	*0.44*	*0.56*	*0.77*	*0.33*	-

Table 120 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 232 °C



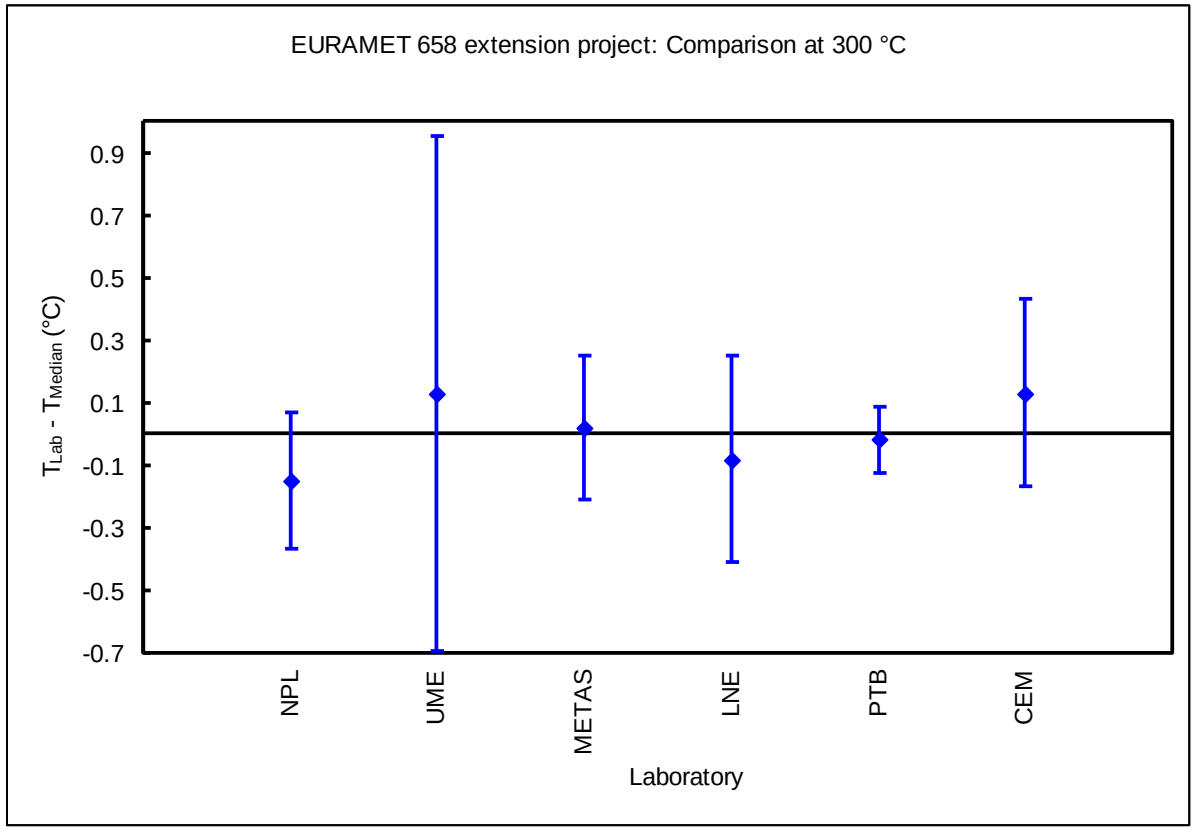
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-0.11 ± 0.84	-0.03 ± 0.41	-0.05 ± 0.36	-0.06 ± 0.22	-0.10 ± 0.36
UME	*0.85*	-	0.08 ± 0.89	0.07 ± 0.86	0.06 ± 0.81	0.01 ± 0.86
METAS	*0.41*	*0.88*	-	-0.01 ± 0.47	-0.02 ± 0.37	-0.07 ± 0.47
LNE	*0.37*	*0.85*	*0.46*	-	-0.01 ± 0.31	-0.06 ± 0.42
PTB	*0.24*	*0.80*	*0.36*	*0.30*	-	-0.05 ± 0.31
CEM	*0.41*	*0.85*	*0.48*	*0.43*	*0.32*	-

Table 121 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 250 °C



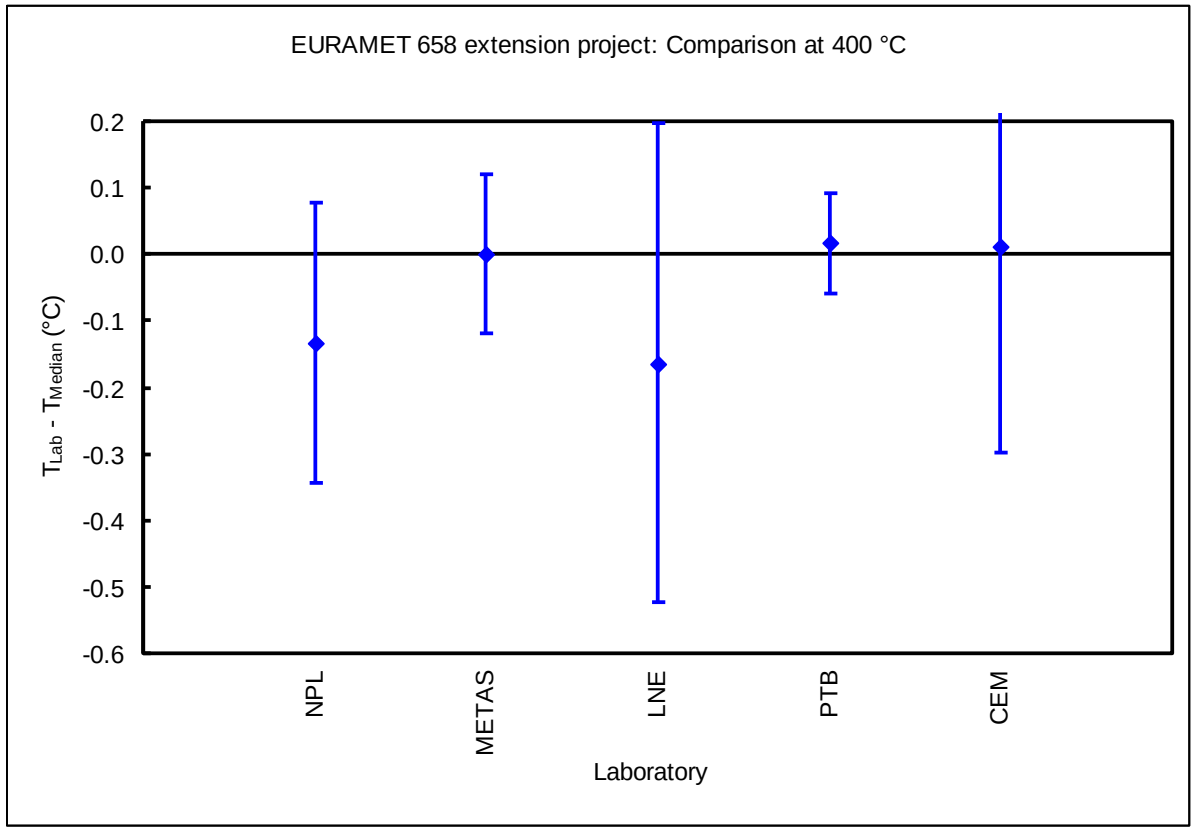
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-0.28 ± 0.85	-0.17 ± 0.32	-0.07 ± 0.39	-0.13 ± 0.24	-0.28 ± 0.37
UME	*0.99*	-	0.11 ± 0.86	0.21 ± 0.89	0.15 ± 0.83	0.00 ± 0.88
METAS	*0.43*	*0.86*	-	0.10 ± 0.40	0.04 ± 0.25	-0.11 ± 0.38
LNE	*0.41*	*0.96*	*0.44*	-	-0.06 ± 0.35	-0.21 ± 0.45
PTB	*0.33*	*0.86*	*0.26*	*0.36*	-	-0.15 ± 0.32
CEM	*0.58*	*0.87*	*0.43*	*0.58*	*0.41*	-

Table 122 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 300 °C



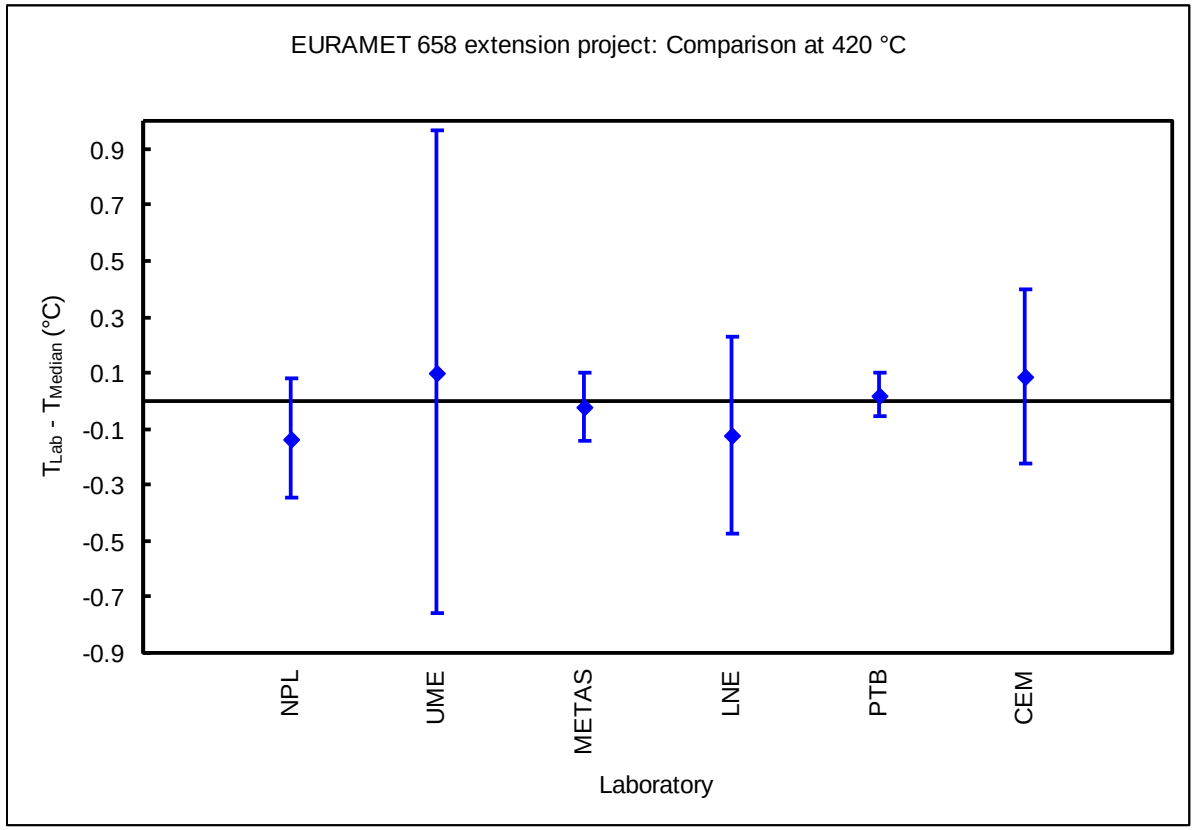
	NPL	METAS	LNE	PTB	CEM
NPL	-	-0.13 ± 0.24	0.03 ± 0.42	-0.15 ± 0.22	-0.15 ± 0.38
METAS	*0.33*	-	0.16 ± 0.38	-0.02 ± 0.14	-0.01 ± 0.33
LNE	*0.41*	*0.48*	-	-0.18 ± 0.37	-0.18 ± 0.48
PTB	*0.33*	*0.14*	*0.48*	-	0.00 ± 0.32
CEM	*0.46*	*0.33*	*0.57*	*0.31*	-

Table 123 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 400 °C



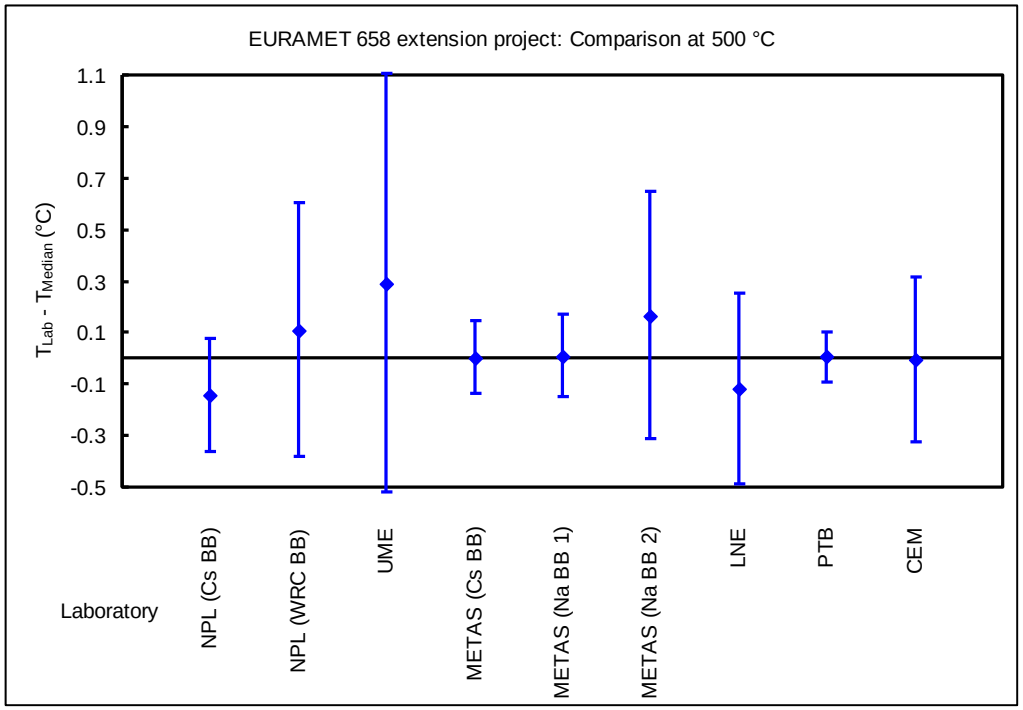
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-0.23 ± 0.89	-0.11 ± 0.24	-0.01 ± 0.41	-0.15 ± 0.23	-0.22 ± 0.38
UME	*0.98*	-	0.12 ± 0.87	0.23 ± 0.93	0.08 ± 0.87	0.02 ± 0.92
METAS	*0.31*	*0.89*	-	0.10 ± 0.37	-0.04 ± 0.14	-0.11 ± 0.33
LNE	*0.40*	*1.01*	*0.41*	-	-0.15 ± 0.36	-0.21 ± 0.47
PTB	*0.34*	*0.86*	*0.16*	*0.44*	-	-0.06 ± 0.32
CEM	*0.53*	*0.90*	*0.39*	*0.60*	*0.34*	-

Table 124 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 420 °C



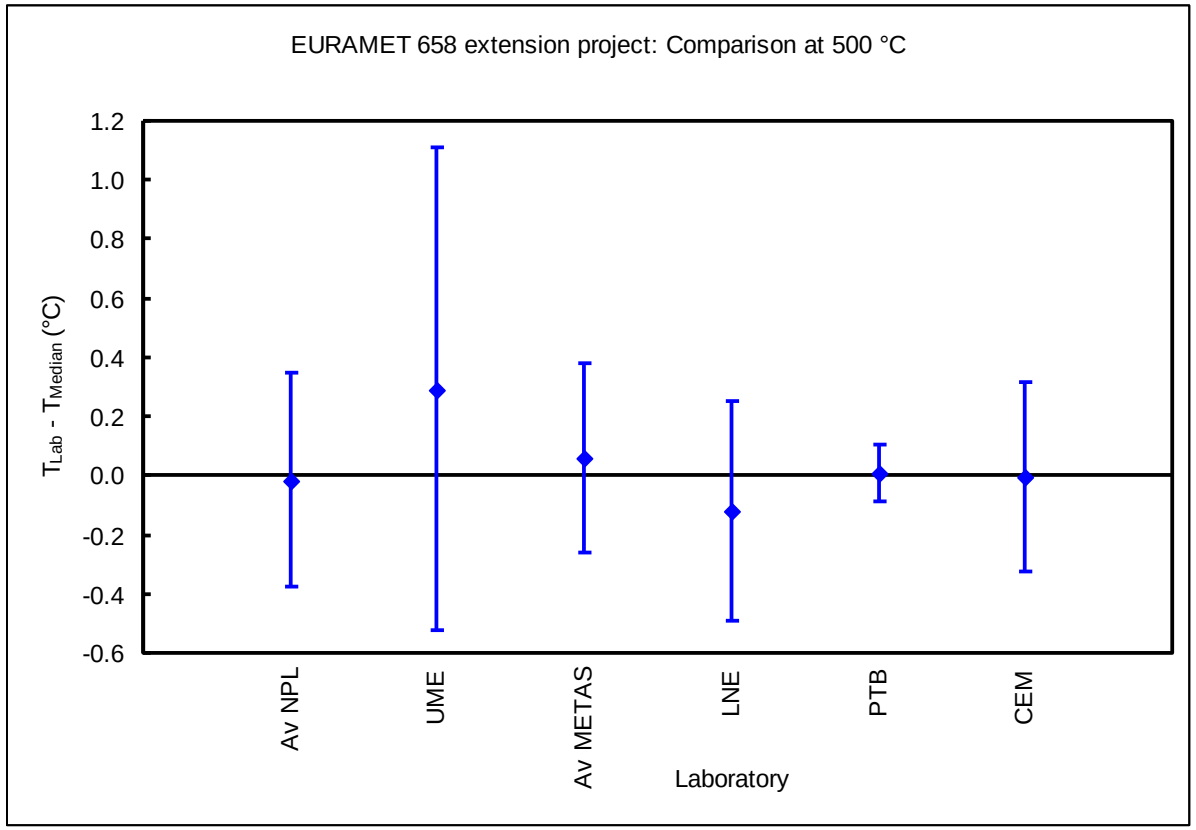
	NPL (Cs BB)	NPL (WRC BB)	UME	METAS (Cs BB)	METAS (Na BB 1)	METAS (Na BB 2)	LNE	PTB	CEM
NPL (Cs BB)	-	-0.25 ± 0.54	-0.43 ± 0.84	-0.15 ± 0.26	-0.15 ± 0.27	-0.31 ± 0.53	-0.02 ± 0.43	-0.15 ± 0.24	-0.14 ± 0.39
NPL (WRC BB)	*0.70*	-	-0.18 ± 0.95	0.11 ± 0.51	0.10 ± 0.52	-0.05 ± 0.69	0.23 ± 0.61	0.11 ± 0.50	0.12 ± 0.59
UME	*1.13*	*1.00*	-	0.29 ± 0.83	0.28 ± 0.83	0.13 ± 0.95	0.41 ± 0.90	0.29 ± 0.82	0.30 ± 0.88
METAS (Cs BB)	*0.36*	*0.54*	*0.98*	-	-0.01 ± 0.21	-0.16 ± 0.50	0.12 ± 0.40	0.00 ± 0.17	0.01 ± 0.35
METAS (Na BB 1)	*0.38*	*0.54*	*0.97*	*0.21*	-	-0.16 ± 0.51	0.13 ± 0.40	0.00 ± 0.19	0.02 ± 0.36
METAS (Na BB 2)	*0.74*	*0.68*	*0.96*	*0.58*	*0.58*	-	0.28 ± 0.61	0.16 ± 0.49	0.17 ± 0.58
LNE	*0.42*	*0.74*	*1.15*	*0.45*	*0.47*	*0.79*	-	-0.12 ± 0.38	-0.11 ± 0.49
PTB	*0.35*	*0.53*	*0.97*	*0.17*	*0.18*	*0.57*	*0.44*	-	0.01 ± 0.33
CEM	*0.46*	*0.62*	*1.03*	*0.34*	*0.35*	*0.65*	*0.53*	*0.33*	-

Table 125 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 500 °C, with data from different sources



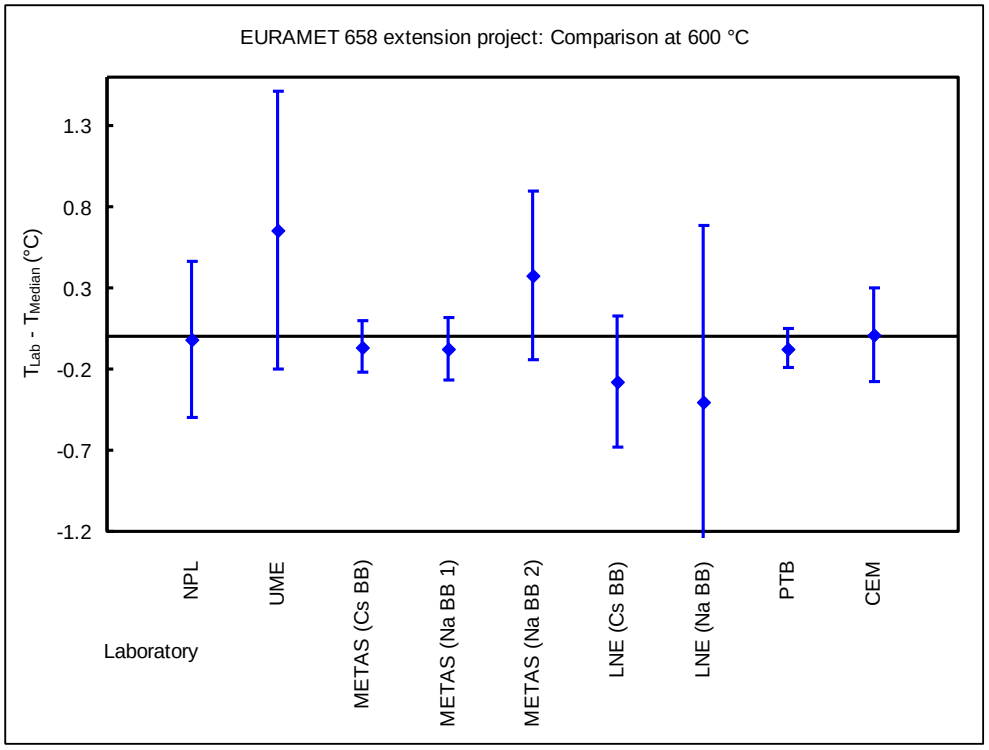
	Average NPL	UME	Average METAS	LNE	PTB	CEM
Av NPL	-	-0.31 ± 0.89	-0.07 ± 0.48	0.10 ± 0.52	-0.02 ± 0.37	-0.01 ± 0.48
UME	*1.05*	-	0.23 ± 0.88	0.41 ± 0.90	0.29 ± 0.82	0.30 ± 0.88
Av METAS	*0.49*	*0.97*	-	0.18 ± 0.49	0.05 ± 0.33	0.07 ± 0.45
LNE	*0.55*	*1.15*	*0.59*	-	-0.12 ± 0.38	-0.11 ± 0.49
PTB	*0.37*	*0.97*	*0.34*	*0.44*	-	0.01 ± 0.33
CEM	*0.47*	*1.03*	*0.46*	*0.53*	*0.33*	-

Table 126 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 500 °C – average data



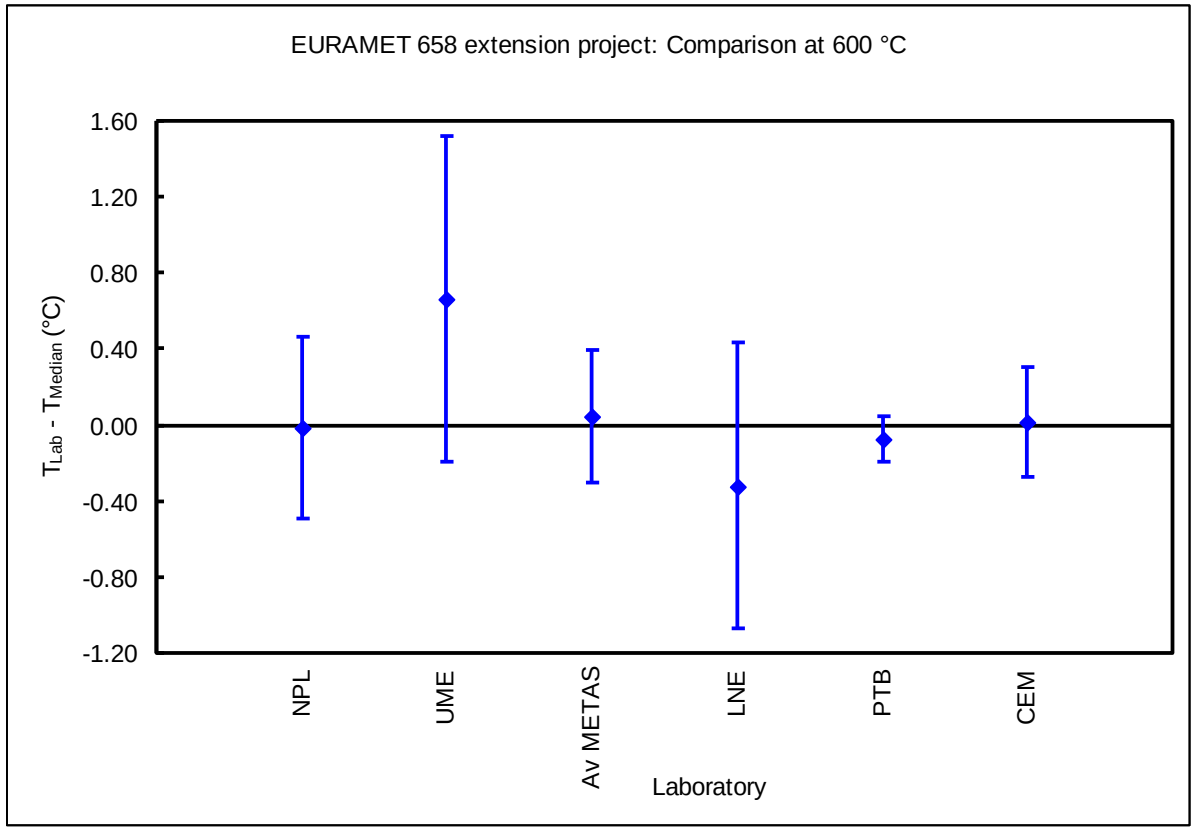
	NPL	UME	METAS (Cs BB)	METAS (Na BB 1)	METAS (Na BB 2)	LNE (Cs BB)	LNE (Na BB)	PTB	CEM
NPL	-	-0.68 ± 0.98	0.05 ± 0.51	0.06 ± 0.52	-0.39 ± 0.71	0.26 ± 0.63	0.39 ± 1.19	0.06 ± 0.50	-0.03 ± 0.56
UME	*1.48*	-	0.72 ± 0.87	0.73 ± 0.88	0.29 ± 1.00	0.94 ± 0.95	1.07 ± 1.39	0.73 ± 0.87	0.65 ± 0.91
METAS (Cs BB)	*0.51*	*1.44*	-	0.01 ± 0.25	-0.44 ± 0.54	0.21 ± 0.43	0.34 ± 1.10	0.01 ± 0.20	-0.08 ± 0.33
METAS (Na BB 1)	*0.52*	*1.46*	*0.24*	-	-0.45 ± 0.55	0.20 ± 0.44	0.33 ± 1.11	0.00 ± 0.23	-0.09 ± 0.35
METAS (Na BB 2)	*0.97*	*1.13*	*0.88*	*0.90*	-	0.65 ± 0.66	0.78 ± 1.21	0.45 ± 0.53	0.36 ± 0.60
LNE (Cs BB)	*0.78*	*1.71*	*0.57*	*0.57*	*1.19*	-	0.13 ± 1.16	-0.20 ± 0.42	-0.29 ± 0.49
LNE (Na BB)	*1.39*	*2.21*	*1.26*	*1.26*	*1.78*	*1.16*	-	-0.33 ± 1.10	-0.42 ± 1.13
PTB	*0.50*	*1.45*	*0.20*	*0.22*	*0.89*	*0.55*	*1.25*	-	-0.09 ± 0.31
CEM	*0.55*	*1.39*	*0.36*	*0.38*	*0.85*	*0.70*	*1.36*	*0.35*	-

Table 127 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 600 °C, with data from different sources



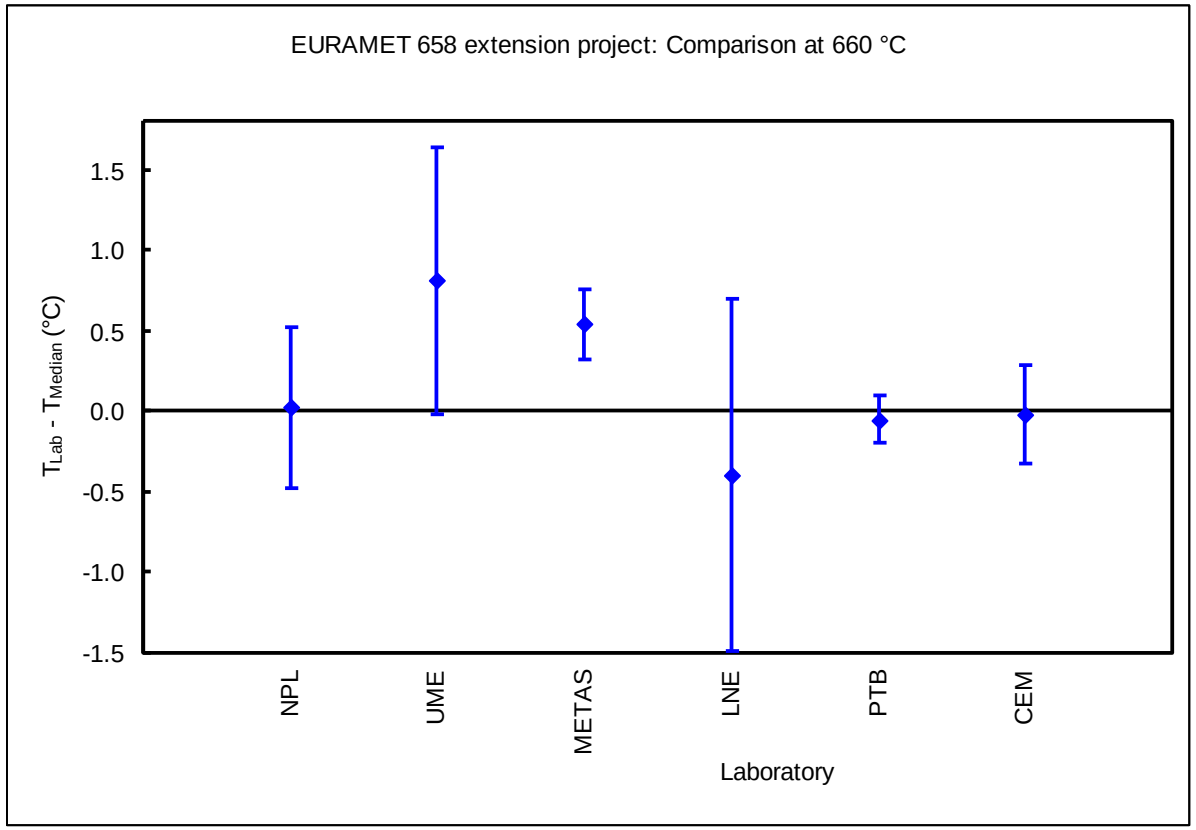
	NPL	UME	Av METAS	LNE	PTB	CEM
NPL	-	-0.68 ± 0.98	-0.06 ± 0.60	0.30 ± 0.89	0.06 ± 0.50	-0.03 ± 0.56
UME	*1.48*	-	0.62 ± 0.93	0.98 ± 1.14	0.73 ± 0.87	0.65 ± 0.91
Av METAS	*0.59*	*1.38*	-	0.36 ± 0.83	0.12 ± 0.37	0.03 ± 0.46
LNE	*1.05*	*1.92*	*1.05*	-	-0.25 ± 0.76	-0.33 ± 0.80
PTB	*0.50*	*1.45*	*0.43*	*0.88*	-	-0.09 ± 0.31
CEM	*0.55*	*1.39*	*0.45*	*1.00*	*0.35*	-

Table 128 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 600 °C – average data



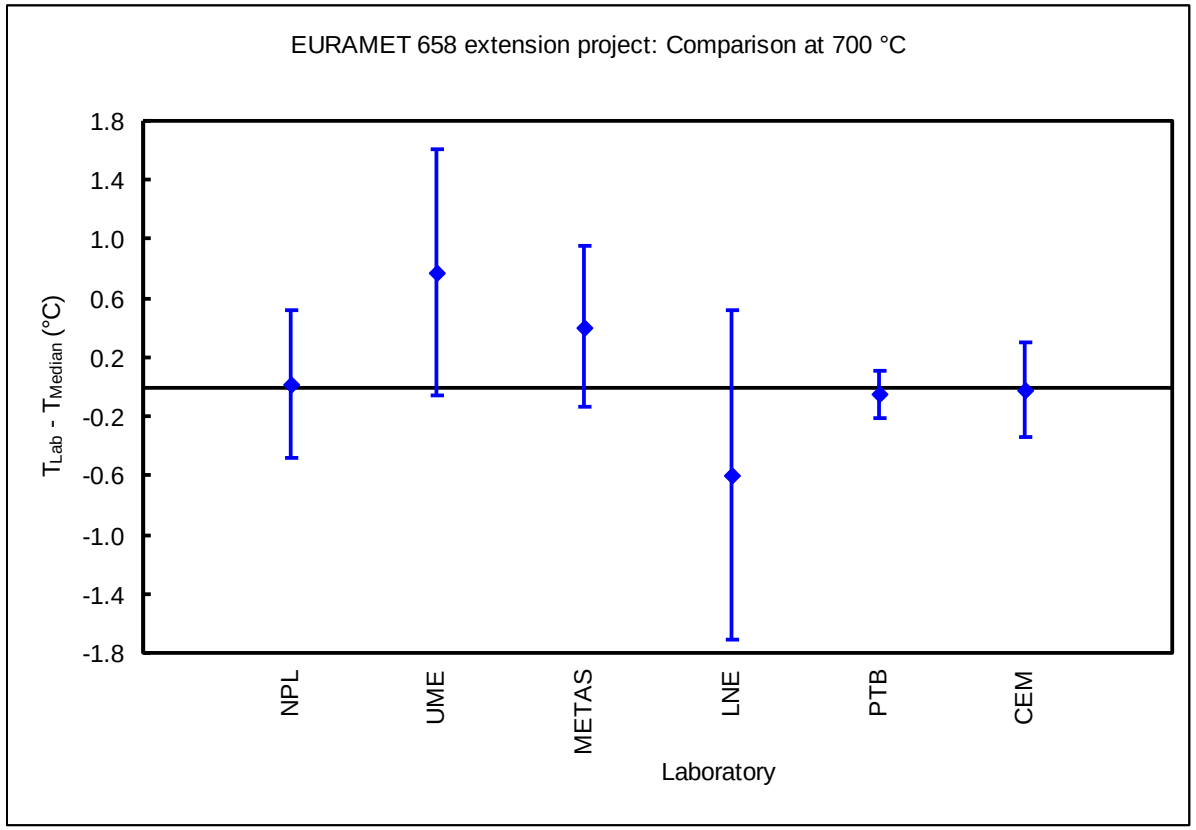
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-0.79 ± 0.97	-0.52 ± 0.55	0.42 ± 1.20	0.08 ± 0.52	0.04 ± 0.59
UME	*1.58*	-	0.27 ± 0.86	1.20 ± 1.37	0.86 ± 0.85	0.83 ± 0.89
METAS	*0.97*	*0.99*	-	0.93 ± 1.11	0.59 ± 0.26	0.56 ± 0.38
LNE	*1.41*	*2.33*	*1.85*	-	-0.34 ± 1.10	-0.37 ± 1.13
PTB	*0.53*	*1.56*	*0.81*	*1.26*	-	-0.03 ± 0.34
CEM	*0.58*	*1.56*	*0.87*	*1.32*	*0.34*	-

Table 129 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 660 °C



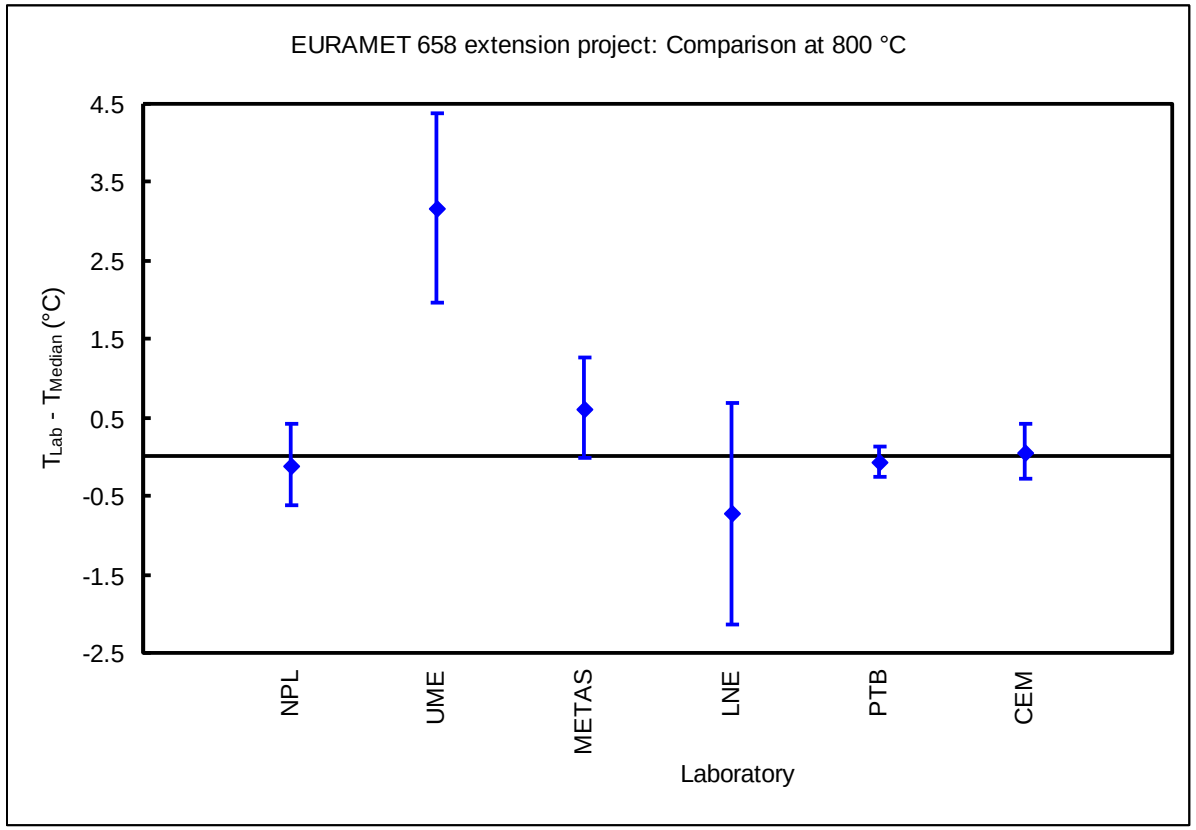
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-0.75 ± 0.97	-0.39 ± 0.74	0.62 ± 1.23	0.07 ± 0.52	0.05 ± 0.59
UME	*1.55*	-	0.37 ± 1.00	1.37 ± 1.40	0.83 ± 0.85	0.80 ± 0.89
METAS	*1.00*	*1.20*	-	1.00 ± 1.25	0.46 ± 0.57	0.43 ± 0.64
LNE	*1.63*	*2.52*	*2.03*	-	-0.55 ± 1.13	-0.57 ± 1.17
PTB	*0.53*	*1.52*	*0.93*	*1.48*	-	-0.03 ± 0.36
CEM	*0.59*	*1.53*	*0.96*	*1.53*	*0.35*	-

Table 130 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 700 °C



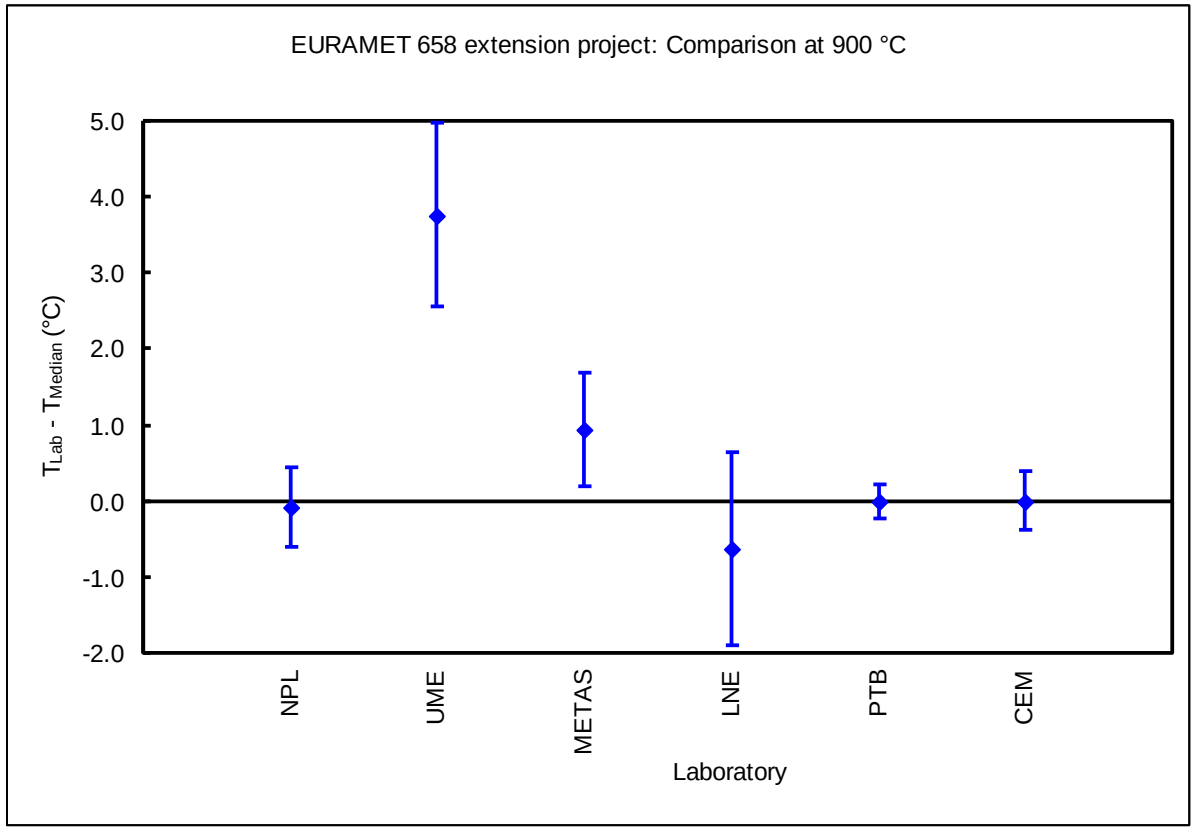
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-3.27 ± 1.31	-0.72 ± 0.82	0.62 ± 1.50	-0.04 ± 0.55	-0.16 ± 0.63
UME	*4.35*	-	2.56 ± 1.37	3.89 ± 1.86	3.23 ± 1.22	3.11 ± 1.26
METAS	*1.39*	*3.68*	-	1.33 ± 1.55	0.68 ± 0.67	0.55 ± 0.73
LNE	*1.86*	*5.42*	*2.61*	-	-0.66 ± 1.42	-0.78 ± 1.45
PTB	*0.54*	*4.24*	*1.23*	*1.83*	-	-0.12 ± 0.40
CEM	*0.69*	*4.14*	*1.15*	*1.98*	*0.45*	-

Table 131 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 800 °C



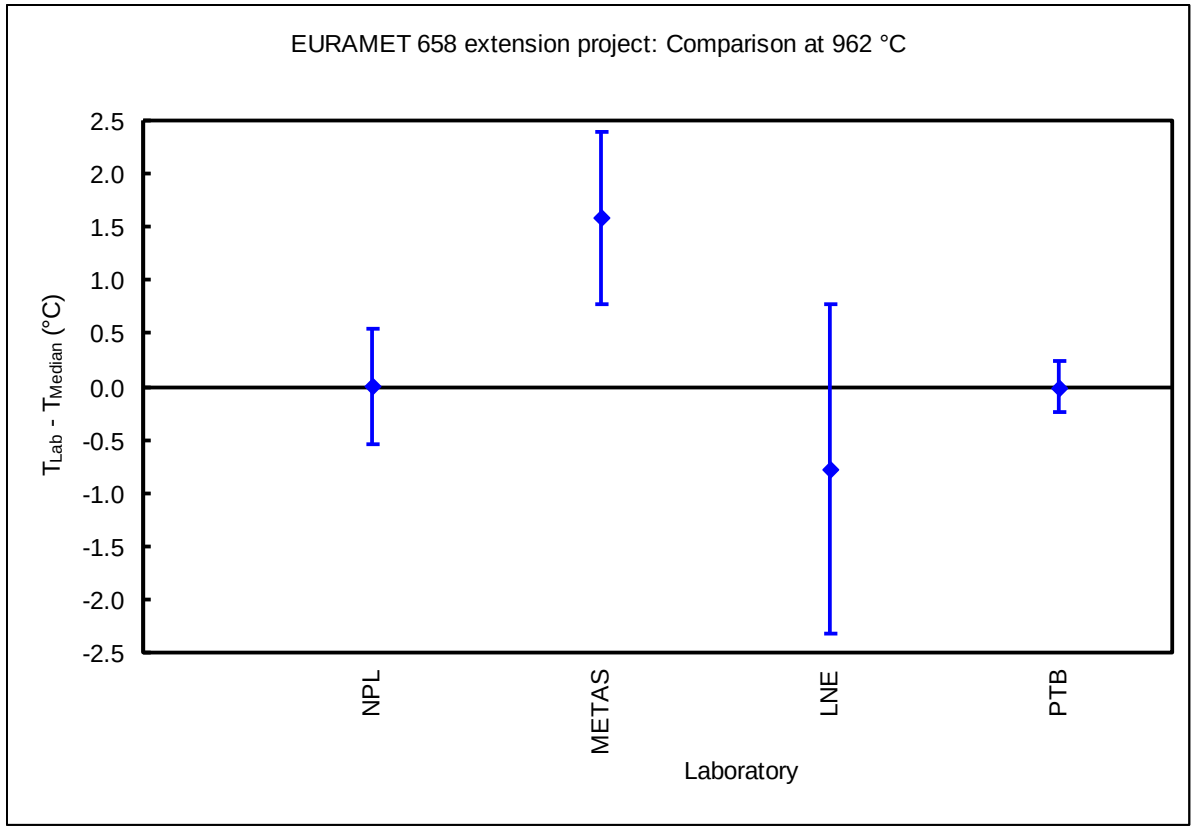
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-3.85 ± 1.32	-1.03 ± 0.92	0.54 ± 1.38	-0.08 ± 0.57	-0.09 ± 0.66
UME	*4.93*	-	2.82 ± 1.42	4.39 ± 1.75	3.76 ± 1.23	3.76 ± 1.27
METAS	*1.78*	*3.99*	-	1.57 ± 1.48	0.94 ± 0.78	0.94 ± 0.85
LNE	*1.68*	*5.83*	*2.78*	-	-0.62 ± 1.29	-0.63 ± 1.33
PTB	*0.58*	*4.77*	*1.59*	*1.69*	-	-0.01 ± 0.45
CEM	*0.67*	*4.80*	*1.63*	*1.73*	*0.44*	-

Table 132 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 900 °C



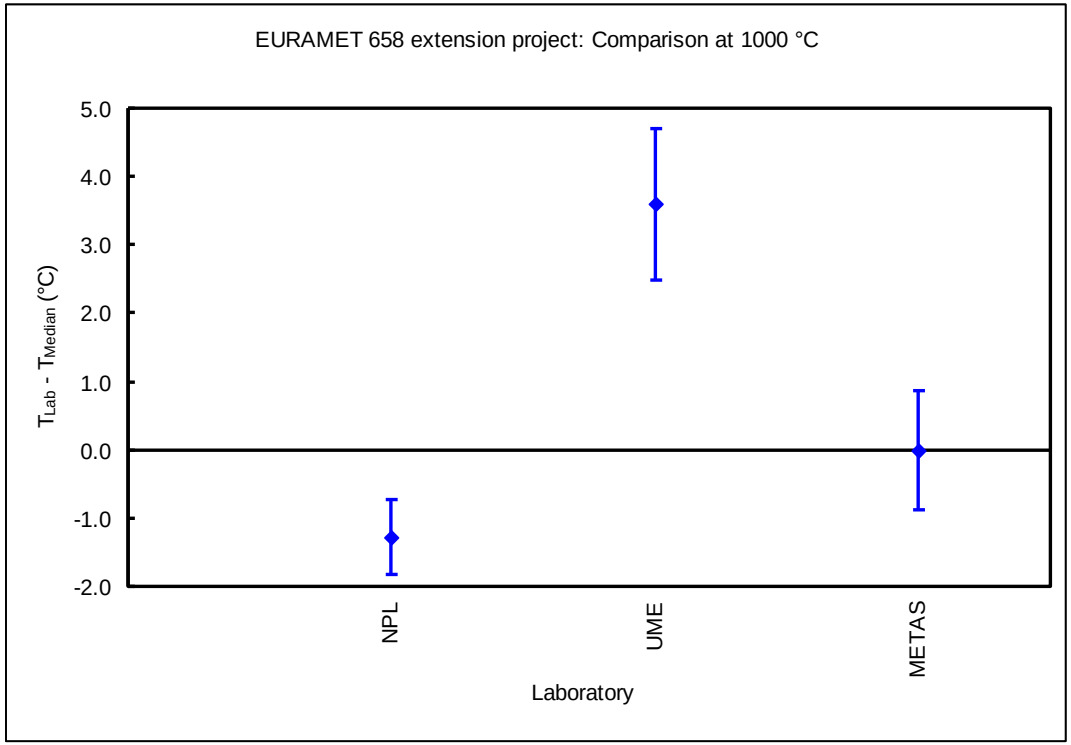
	NPL	METAS	LNE	PTB	CEM
NPL	-	-1.58 ± 0.97	0.78 ± 1.64	0.01 ± 0.59	-0.06 ± 0.48
METAS	*2.38*	-	2.37 ± 1.75	1.59 ± 0.85	-0.02 ± 0.62
LNE	*2.14*	*3.80*	-	-0.77 ± 1.57	0.23 ± 0.50
PTB	*0.58*	*2.29*	*2.07*	-	-0.13 ± 0.46
CEM	*0.48*	*0.61*	*0.65*	*0.51*	-

Table 133 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 962 °C



	NPL	UME	METAS
NPL	-	-4.88 ± 1.24	-1.28 ± 1.03
UME	*5.89*	-	3.60 ± 1.41
METAS	*2.12*	*4.76*	-

Table 134 – direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 1000 °C

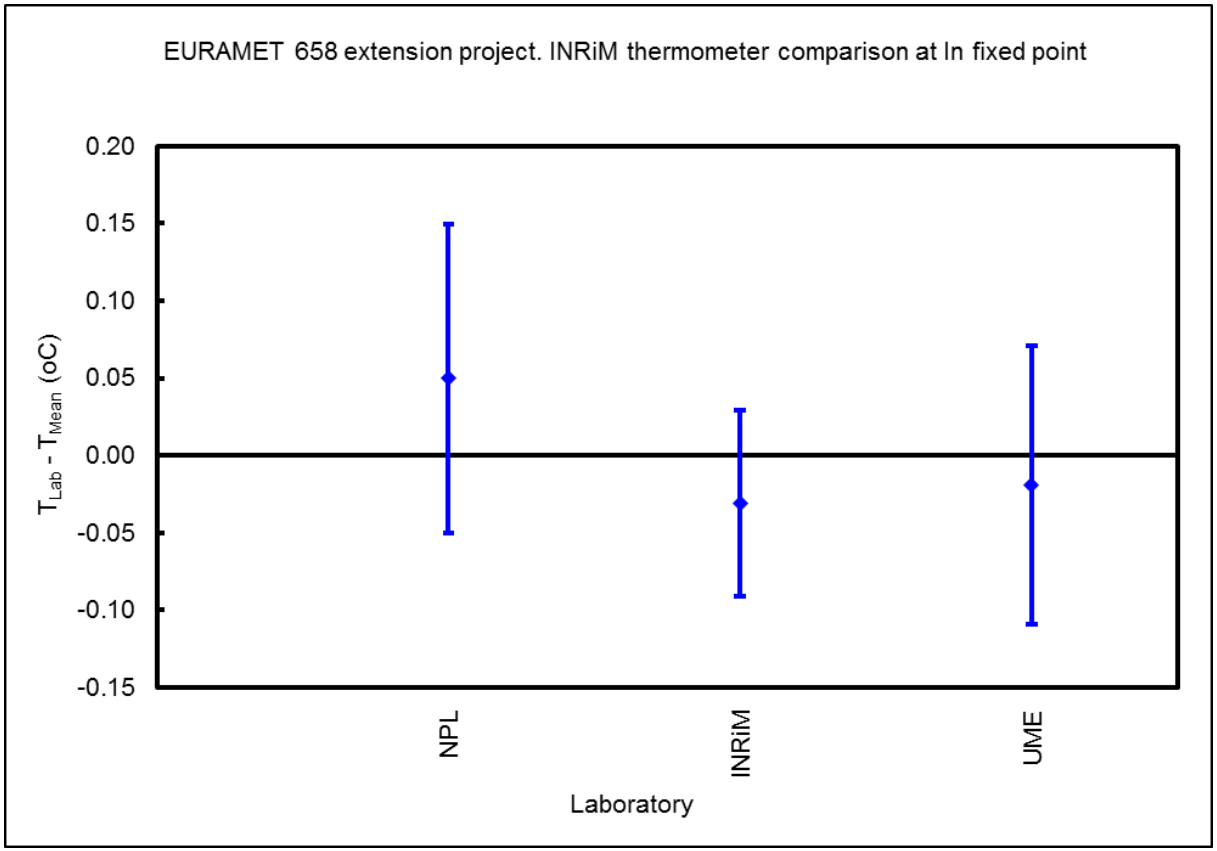


11 THE DOE AND QDE_{95} VALUES FOR THE FIXED-POINT AND VARIABLE TEMPERATURE BLACKBODY COMPARISON FOR THE INRIM THERMOMETER. UNCERTAINTIES ALSO INCLUDE THE REFERENCE VALUE UNCERTAINTY

11.1 THE RESULTS OF THE MEASUREMENTS USING THE FIXED-POINTS

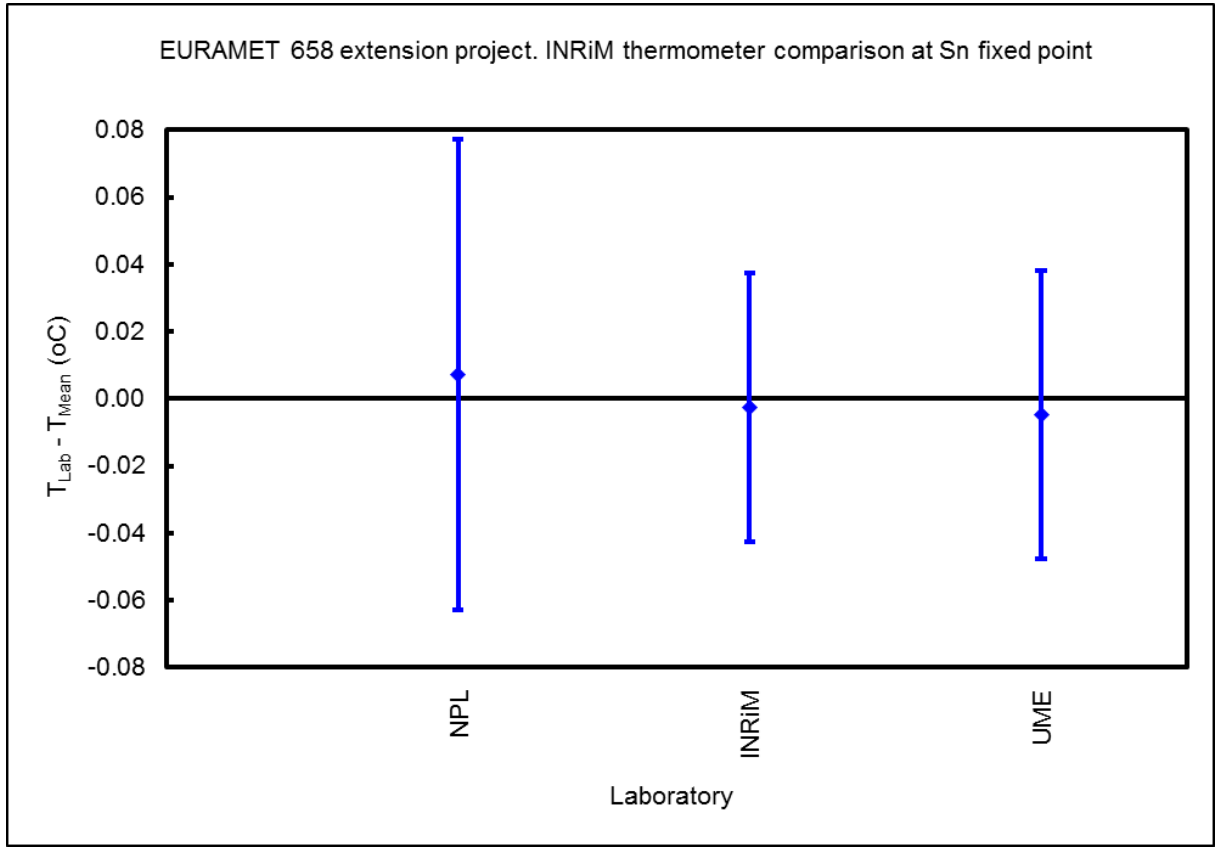
	NPL	INRiM	UME
NPL	-	0.081 ± 0.117	0.068 ± 0.135
INRiM	*0.177*	-	-0.012 ± 0.108
UME	*0.180*	*0.108*	-

Table 135 – direct comparison of the results of the In fixed point measurement with the INRiM thermometer



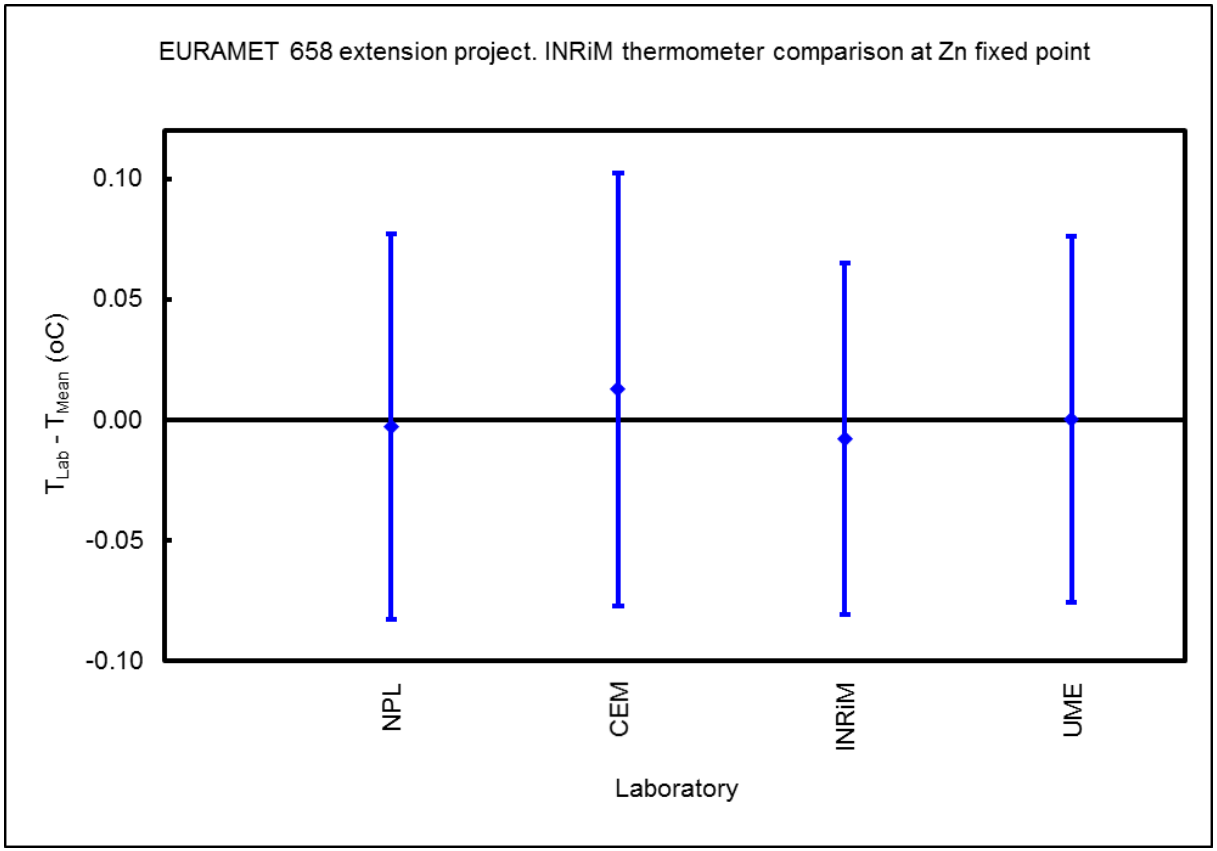
	NPL	INRiM	UME
NPL	-	0.010 ± 0.081	0.012 ± 0.082
INRiM	*0.081*	-	0.002 ± 0.059
UME	*0.084*	*0.058*	-

Table 136 - – direct comparison of the results of the Sn fixed point measurement with the INRiM thermometer



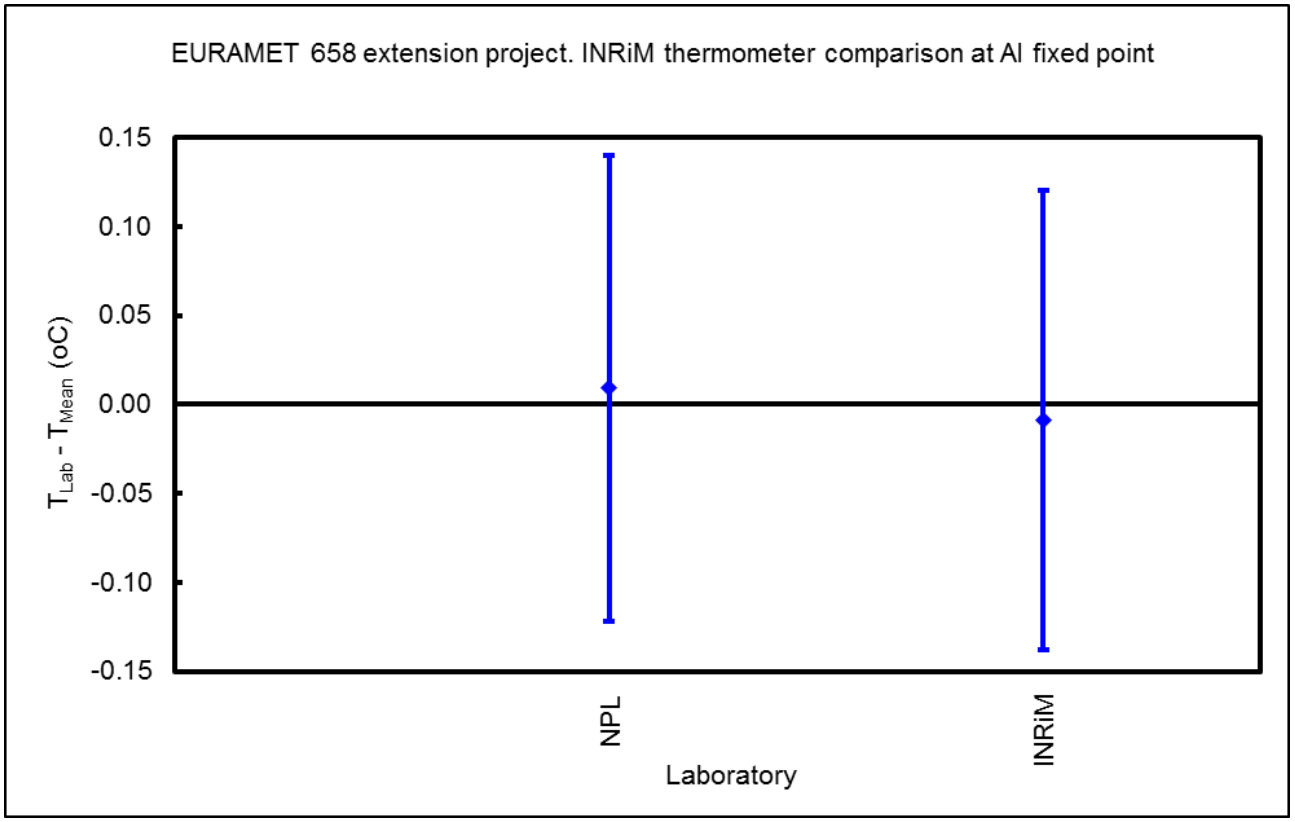
	NPL	CEM	INRiM	UME
NPL	-	-0.016 ± 0.120	0.005 ± 0.108	-0.003 ± 0.110
CEM	*0.122*	-	0.021 ± 0.116	0.013 ± 0.118
INRiM	*0.106*	*0.120*	-	-0.008 ± 0.105
UME	*0.108*	*0.118*	*0.104*	-

Table 137 – direct comparison of the results of the Zn fixed point measurement with the INRiM thermometer



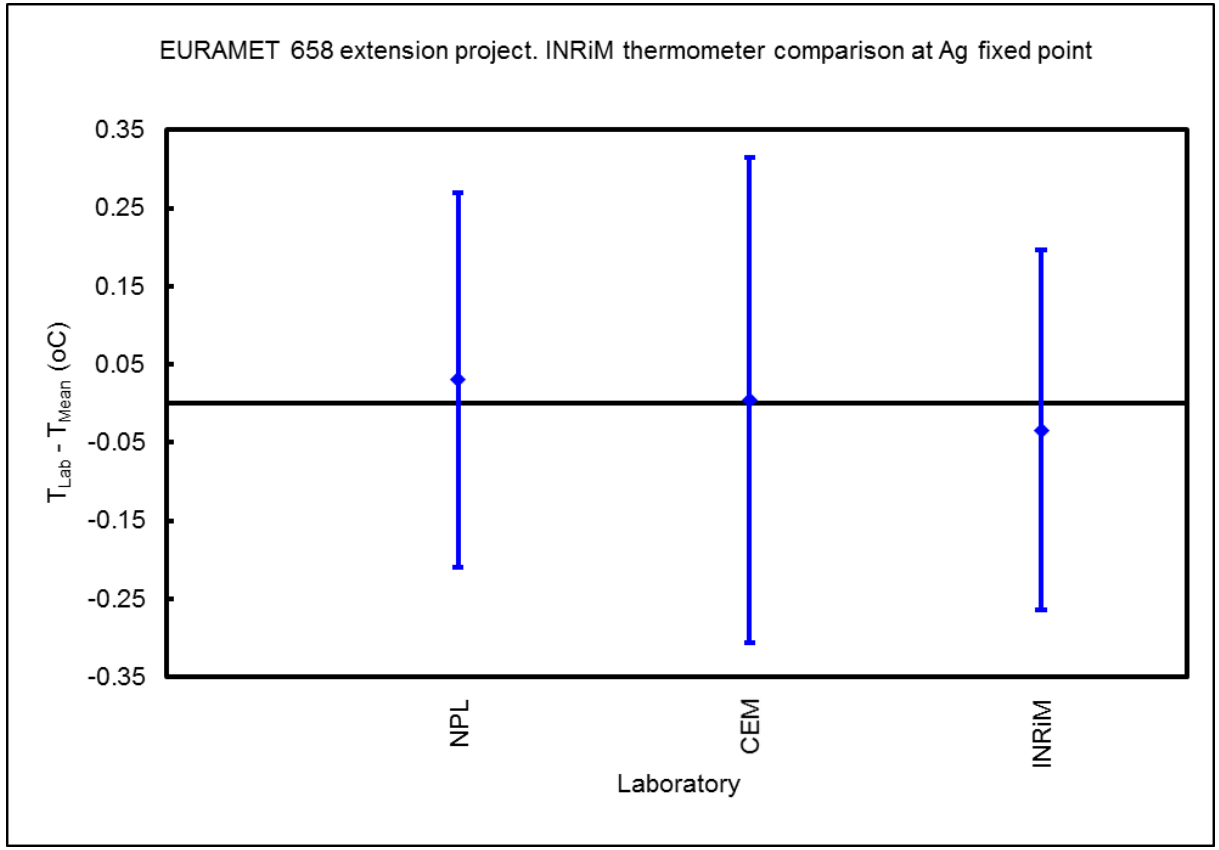
	NPL	INRiM
NPL	-	0.018 ± 0.184
INRiM	*0.183*	-

Table 138 – direct comparison of the results of the Al fixed point measurement with the INRiM thermometer



	NPL	CEM	INRiM
NPL	-	0.025 ± 0.392	0.064 ± 0.332
CEM	*0.386*	-	0.039 ± 0.386
INRiM	*0.349*	*0.384*	-

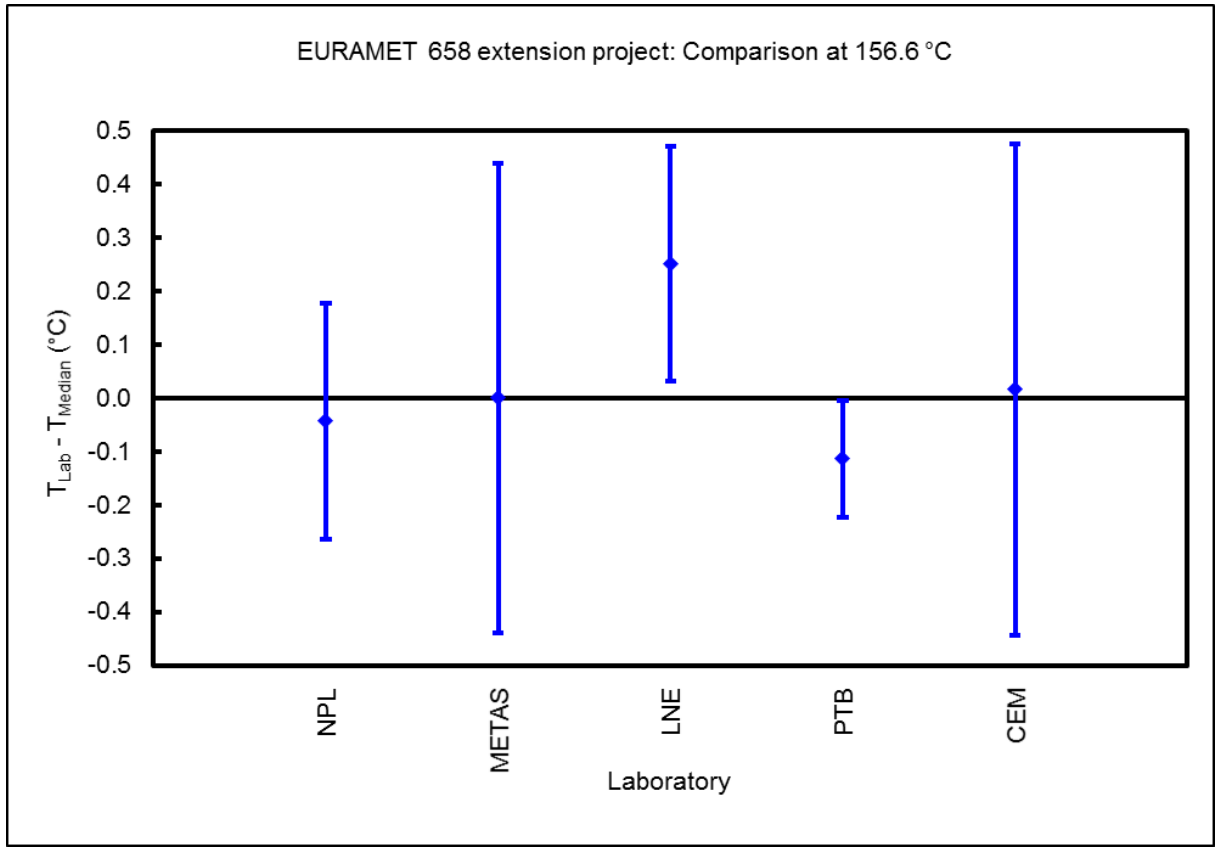
Table 139 – direct comparison of the results of the Ag fixed point measurement with the INRiM thermometer



11.2 THE RESULTS OF THE MEASUREMENTS USING THE VARIABLE TEMPERATURE BLACKBODY SOURCES

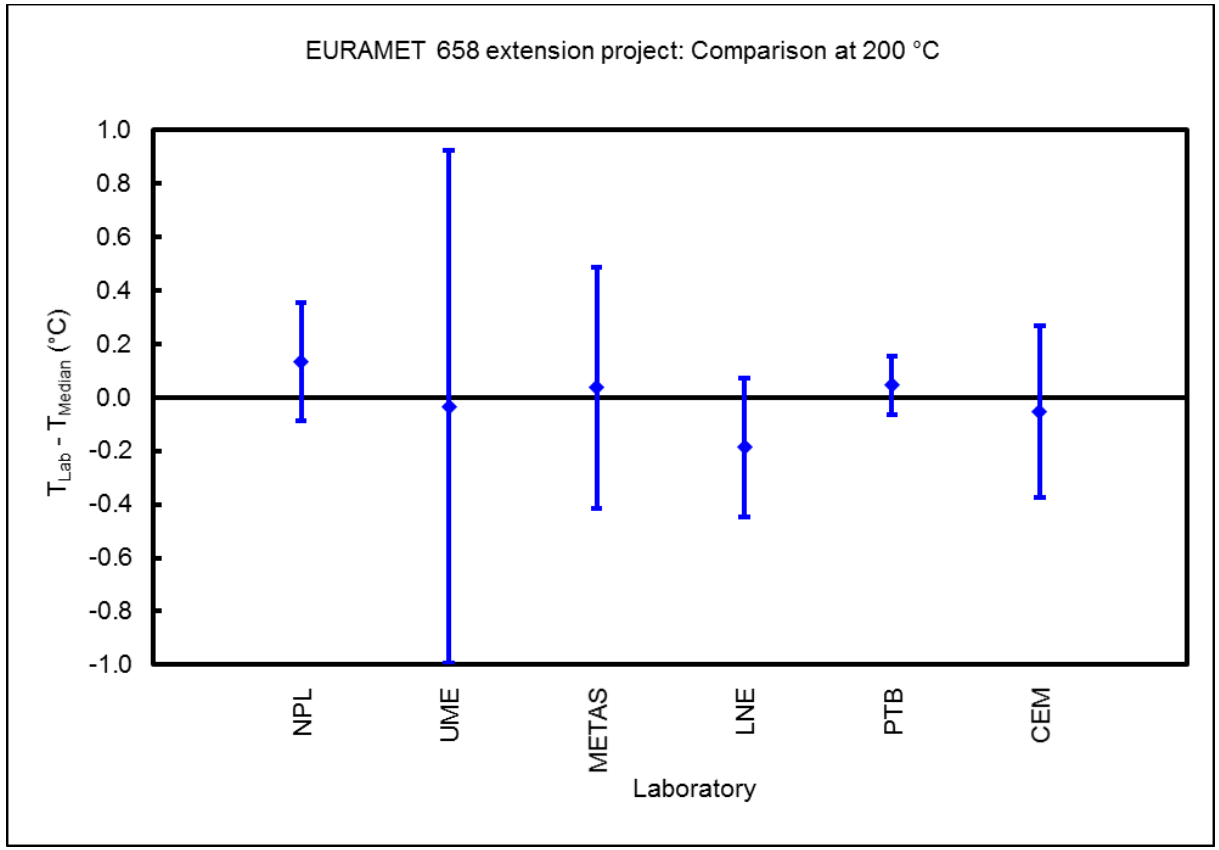
	NPL	METAS	LNE	PTB	CEM
NPL	-	-0.04 ± 0.49	-0.29 ± 0.31	0.07 ± 0.25	-0.06 ± 0.51
METAS	*0.49*	-	-0.25 ± 0.49	0.11 ± 0.45	-0.02 ± 0.64
LNE	*0.55*	*0.66*	-	0.36 ± 0.25	0.23 ± 0.51
PTB	*0.28*	*0.50*	*0.57*	-	-0.13 ± 0.47
CEM	*0.51*	*0.63*	*0.66*	*0.53*	-

Table 140 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 157 °C



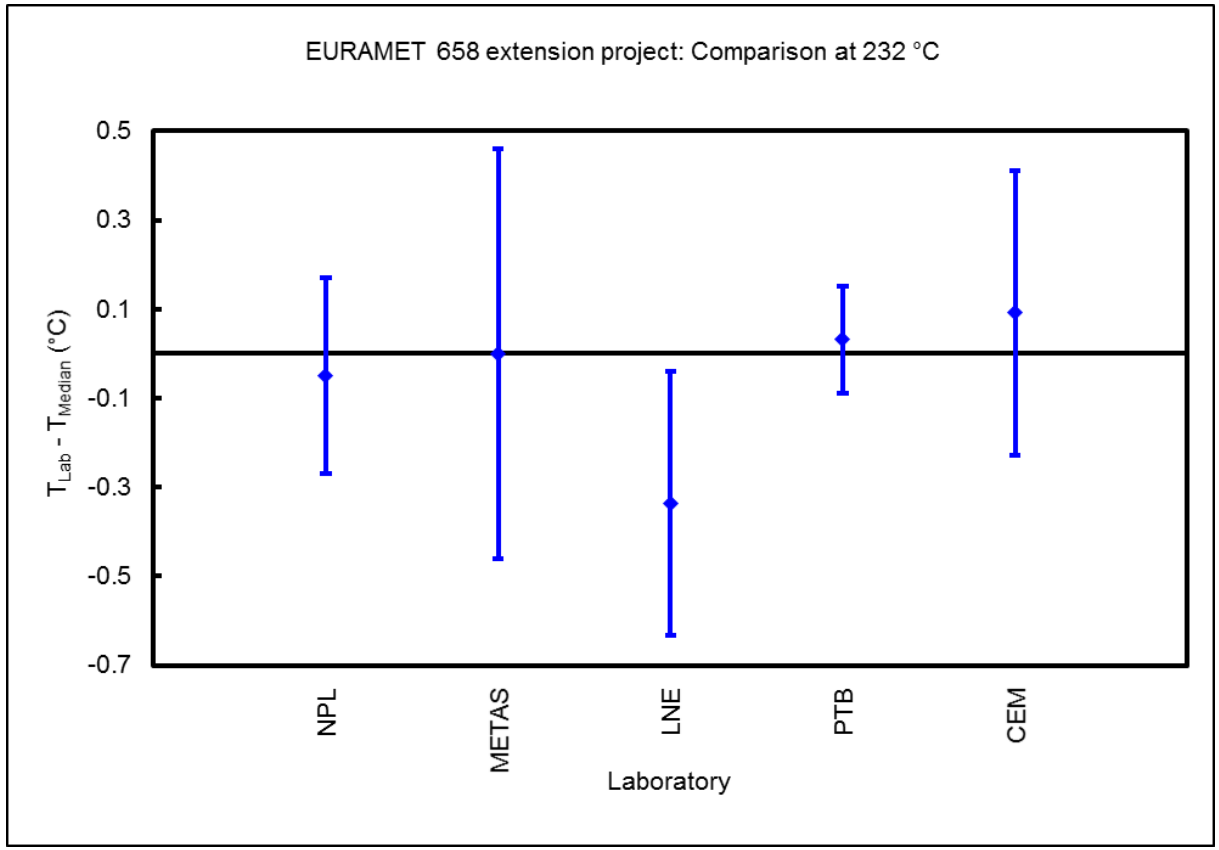
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	0.17 ± 0.98	0.10 ± 0.50	0.32 ± 0.34	0.09 ± 0.25	0.19 ± 0.39
UME	*1.02*	-	-0.07 ± 1.06	0.15 ± 0.99	-0.08 ± 0.97	0.02 ± 1.01
METAS	*0.53*	*1.04*	-	0.22 ± 0.52	-0.01 ± 0.46	0.09 ± 0.55
LNE	*0.60*	*1.02*	*0.65*	-	-0.23 ± 0.28	-0.13 ± 0.41
PTB	*0.29*	*0.96*	*0.46*	*0.46*	-	0.10 ± 0.34
CEM	*0.51*	*0.99*	*0.57*	*0.48*	*0.38*	-

Table 141 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 200 °C



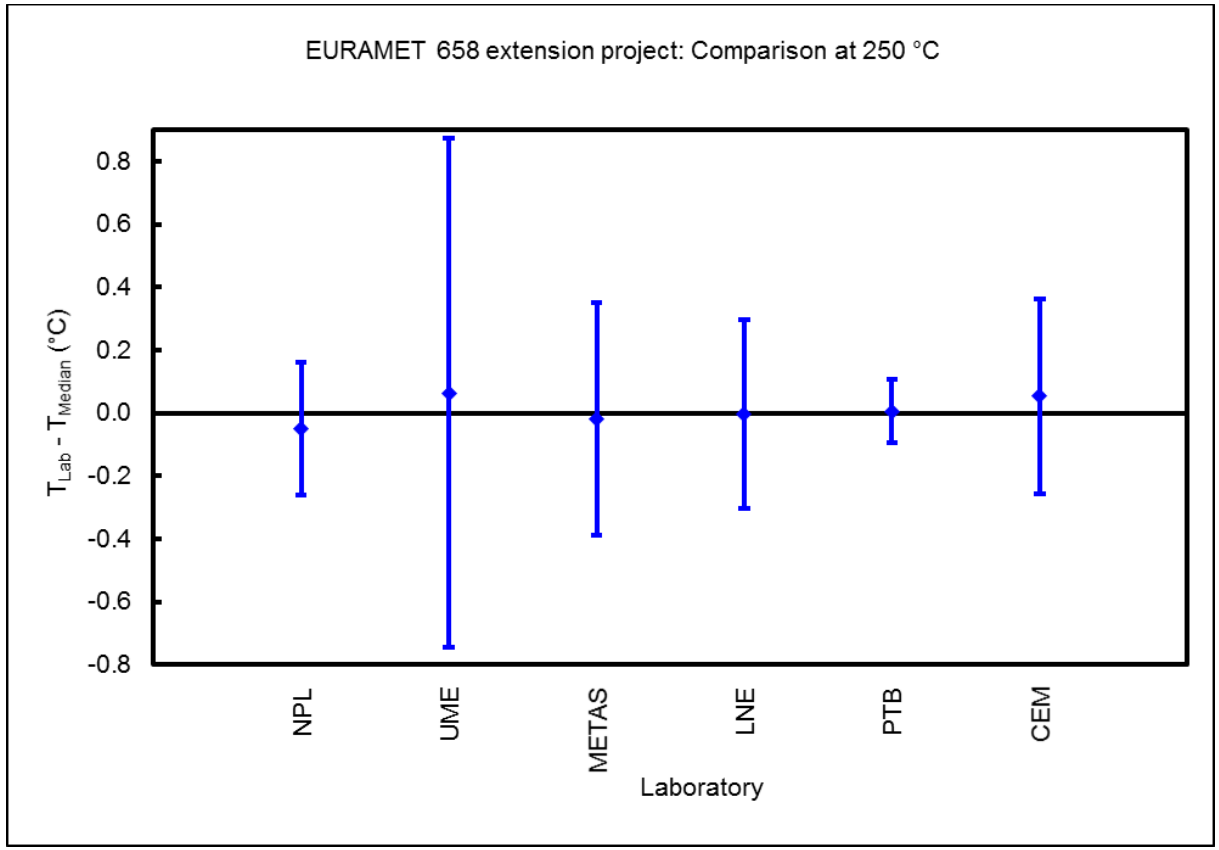
	NPL	METAS	LNE	PTB	CEM
NPL	-	-0.05 ± 0.51	0.29 ± 0.37	-0.08 ± 0.25	-0.14 ± 0.39
METAS	*0.51*	-	0.34 ± 0.55	-0.03 ± 0.48	-0.09 ± 0.56
LNE	*0.59*	*0.79*	-	-0.37 ± 0.32	-0.43 ± 0.44
PTB	*0.29*	*0.47*	*0.63*	-	-0.06 ± 0.34
CEM	*0.47*	*0.58*	*0.79*	*0.36*	-

Table 142 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 232 °C



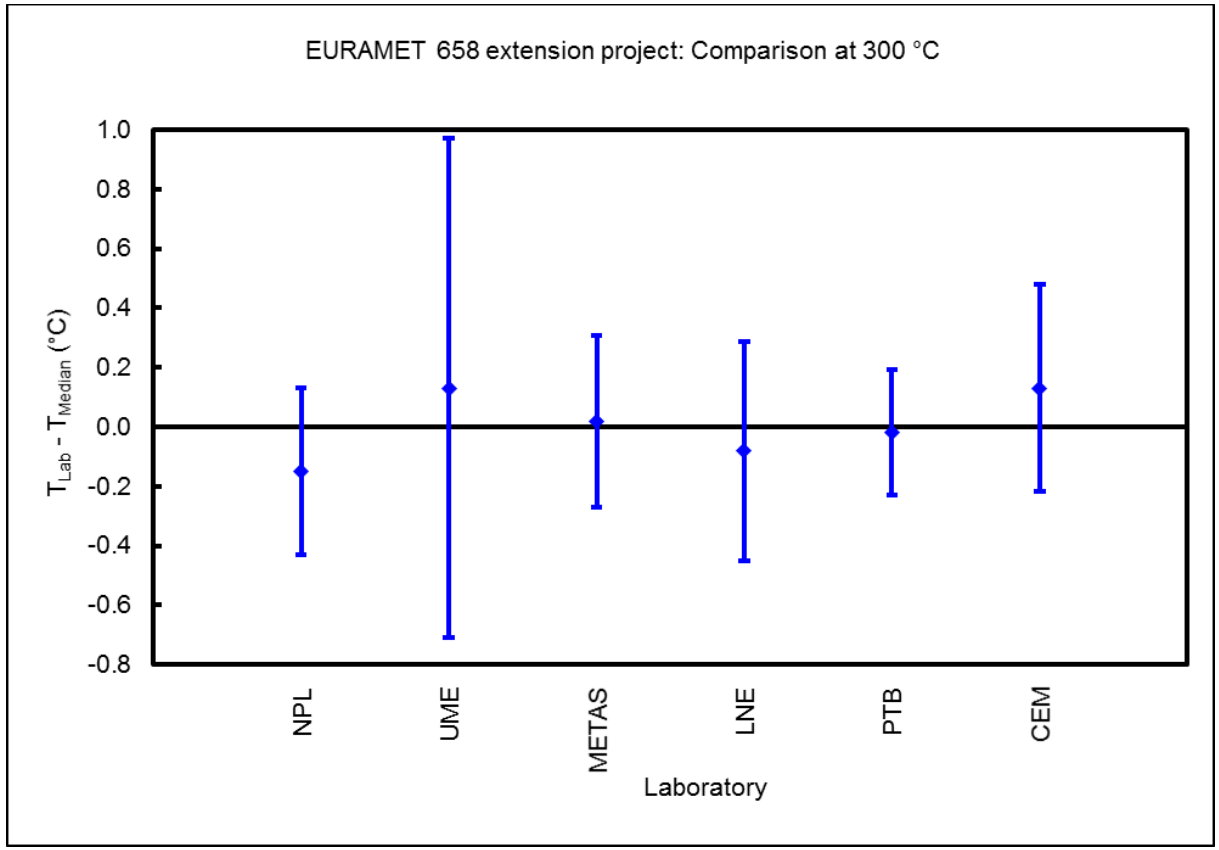
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-0.11 ± 0.84	-0.03 ± 0.43	-0.05 ± 0.37	-0.06 ± 0.23	-0.10 ± 0.37
UME	*0.85*	-	0.08 ± 0.89	0.07 ± 0.86	0.06 ± 0.82	0.01 ± 0.87
METAS	*0.42*	*0.88*	-	-0.01 ± 0.48	-0.02 ± 0.38	-0.07 ± 0.48
LNE	*0.37*	*0.85*	*0.47*	-	-0.01 ± 0.32	-0.06 ± 0.43
PTB	*0.25*	*0.80*	*0.38*	*0.31*	-	-0.05 ± 0.33
CEM	*0.42*	*0.85*	*0.49*	*0.44*	*0.33*	-

Table 143 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 250 °C



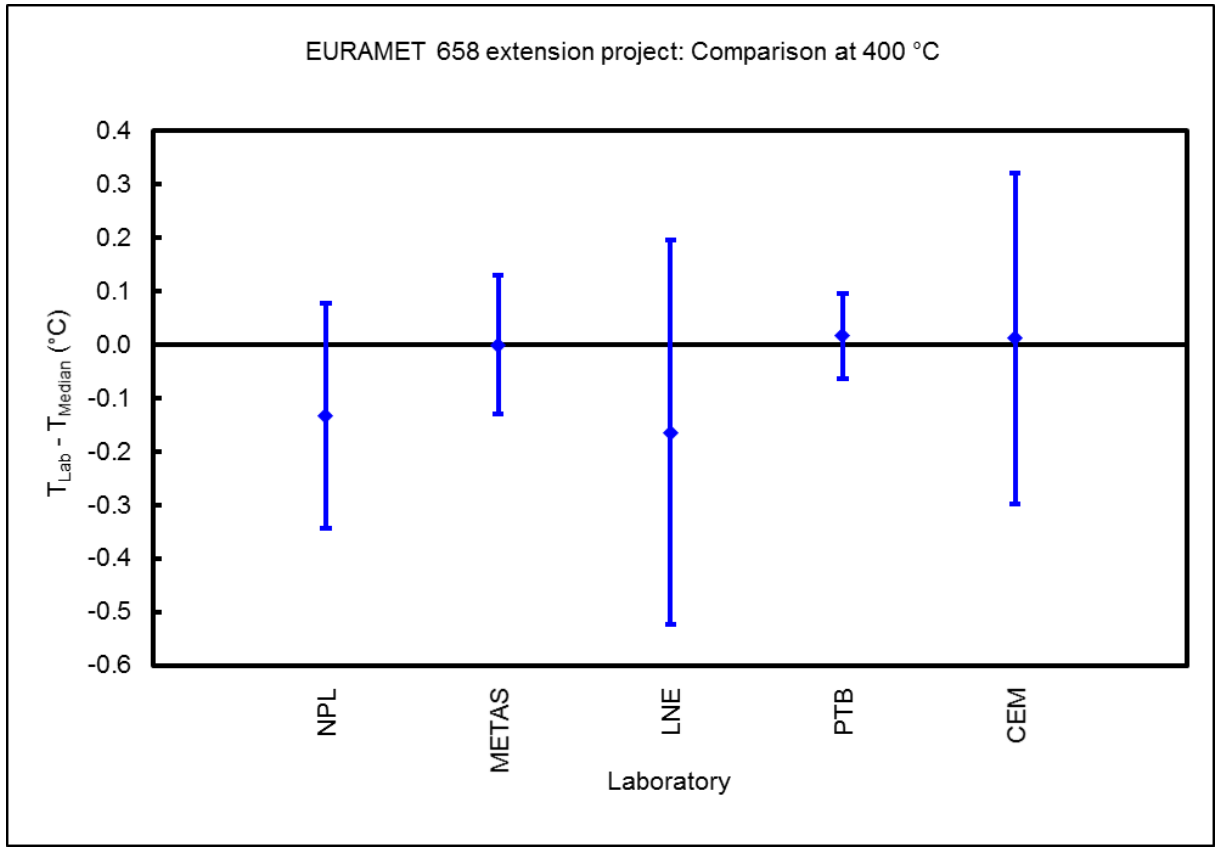
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-0.28 ± 0.89	-0.17 ± 0.40	-0.07 ± 0.46	-0.13 ± 0.35	-0.28 ± 0.45
UME	*1.02*	-	0.11 ± 0.89	0.21 ± 0.92	0.15 ± 0.87	0.00 ± 0.91
METAS	*0.50*	*0.90*	-	0.10 ± 0.47	0.04 ± 0.36	-0.11 ± 0.46
LNE	*0.47*	*0.99*	*0.50*	-	-0.06 ± 0.43	-0.21 ± 0.51
PTB	*0.42*	*0.90*	*0.36*	*0.43*	-	-0.15 ± 0.41
CEM	*0.65*	*0.90*	*0.50*	*0.63*	*0.49*	-

Table 144 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 300 °C



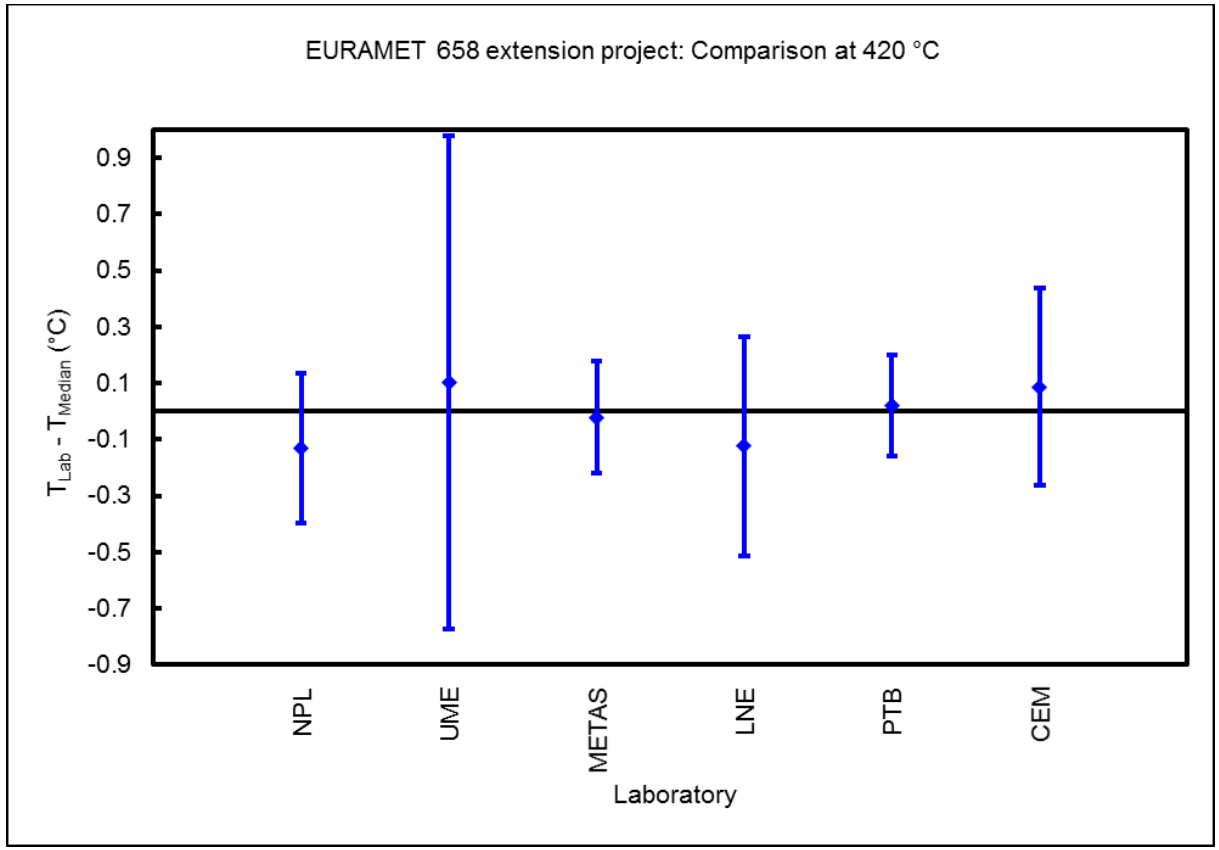
	NPL	METAS	LNE	PTB	CEM
NPL	-	-0.13 ± 0.25	0.03 ± 0.42	-0.15 ± 0.23	-0.15 ± 0.38
METAS	*0.34*	-	0.16 ± 0.38	-0.02 ± 0.15	-0.01 ± 0.34
LNE	*0.41*	*0.48*	-	-0.18 ± 0.37	-0.18 ± 0.48
PTB	*0.33*	*0.15*	*0.48*	-	0.00 ± 0.32
CEM	*0.46*	*0.33*	*0.57*	*0.31*	-

Table 145 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 400 °C



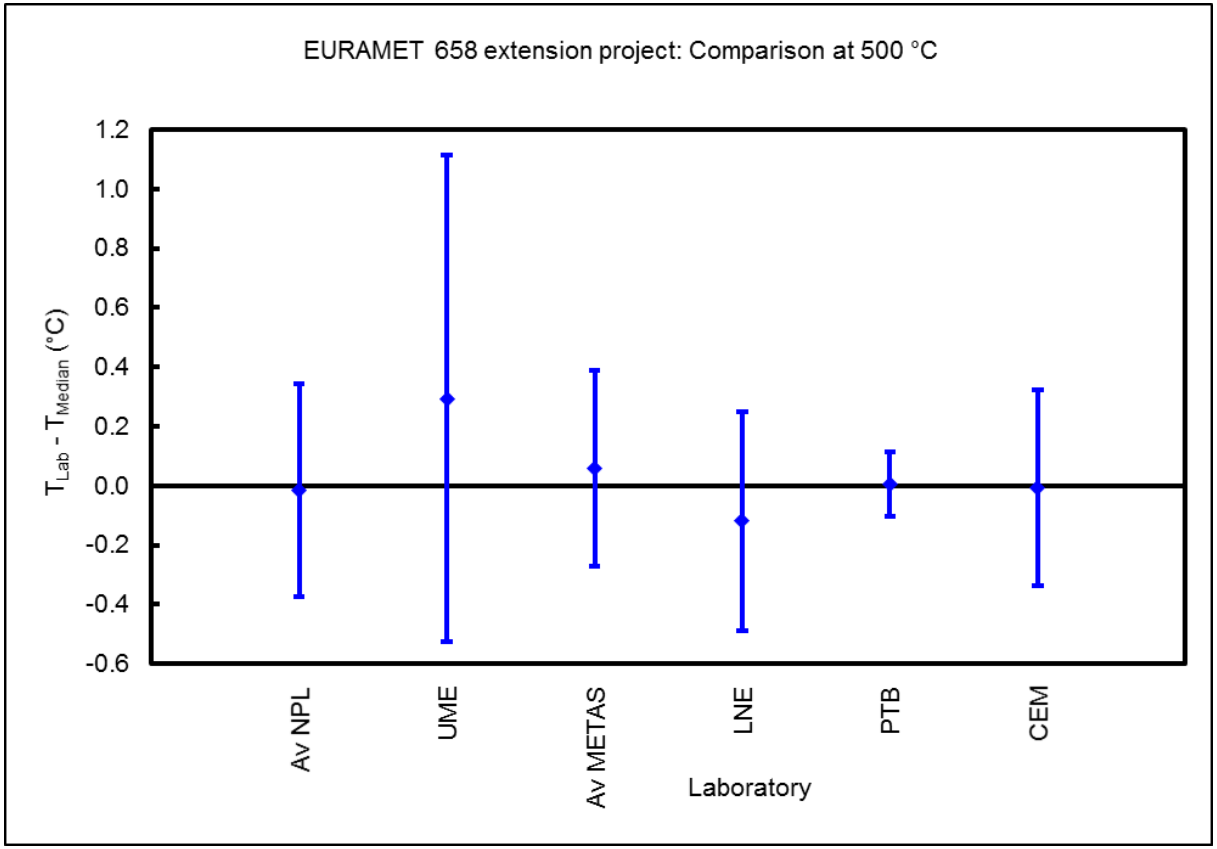
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-0.23 ± 0.92	-0.11 ± 0.33	-0.01 ± 0.47	-0.15 ± 0.32	-0.22 ± 0.44
UME	*1.01*	-	0.12 ± 0.90	0.23 ± 0.96	0.08 ± 0.90	0.02 ± 0.94
METAS	*0.39*	*0.91*	-	0.10 ± 0.44	-0.04 ± 0.27	-0.11 ± 0.40
LNE	*0.46*	*1.04*	*0.47*	-	-0.15 ± 0.43	-0.21 ± 0.52
PTB	*0.42*	*0.89*	*0.28*	*0.50*	-	-0.06 ± 0.39
CEM	*0.58*	*0.93*	*0.45*	*0.65*	*0.41*	-

Table 146 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 420 °C



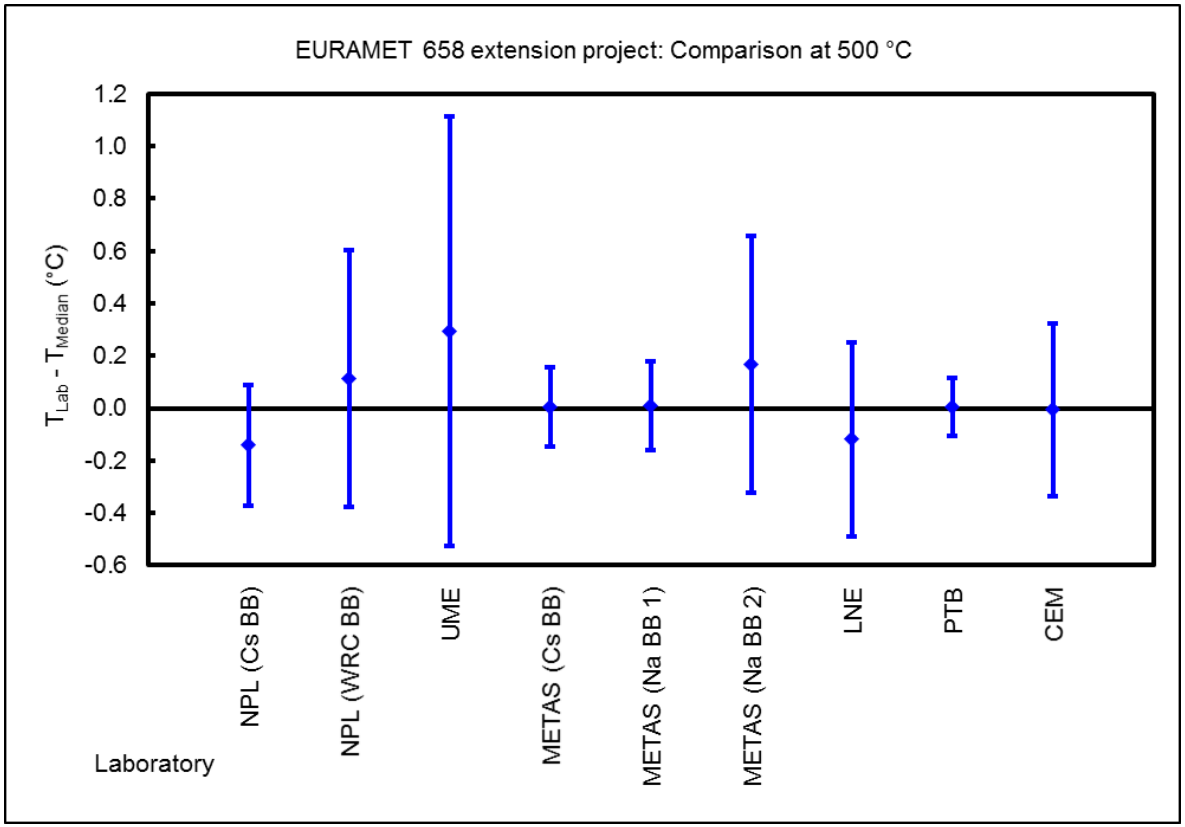
	Av NPL	UME	Av METAS	LNE	PTB	CEM
Av NPL	-	-0.31 ± 0.90	-0.07 ± 0.49	0.10 ± 0.52	-0.02 ± 0.38	-0.01 ± 0.49
UME	*1.05*	-	0.23 ± 0.88	0.41 ± 0.90	0.29 ± 0.83	0.30 ± 0.88
Av METAS	*0.50*	*0.98*	-	0.18 ± 0.50	0.05 ± 0.35	0.07 ± 0.47
LNE	*0.55*	*1.16*	*0.59*	-	-0.12 ± 0.39	-0.11 ± 0.50
PTB	*0.37*	*0.98*	*0.36*	*0.45*	-	0.01 ± 0.35
CEM	*0.48*	*1.04*	*0.47*	*0.53*	*0.34*	-

Table 147 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 500 °C – average data



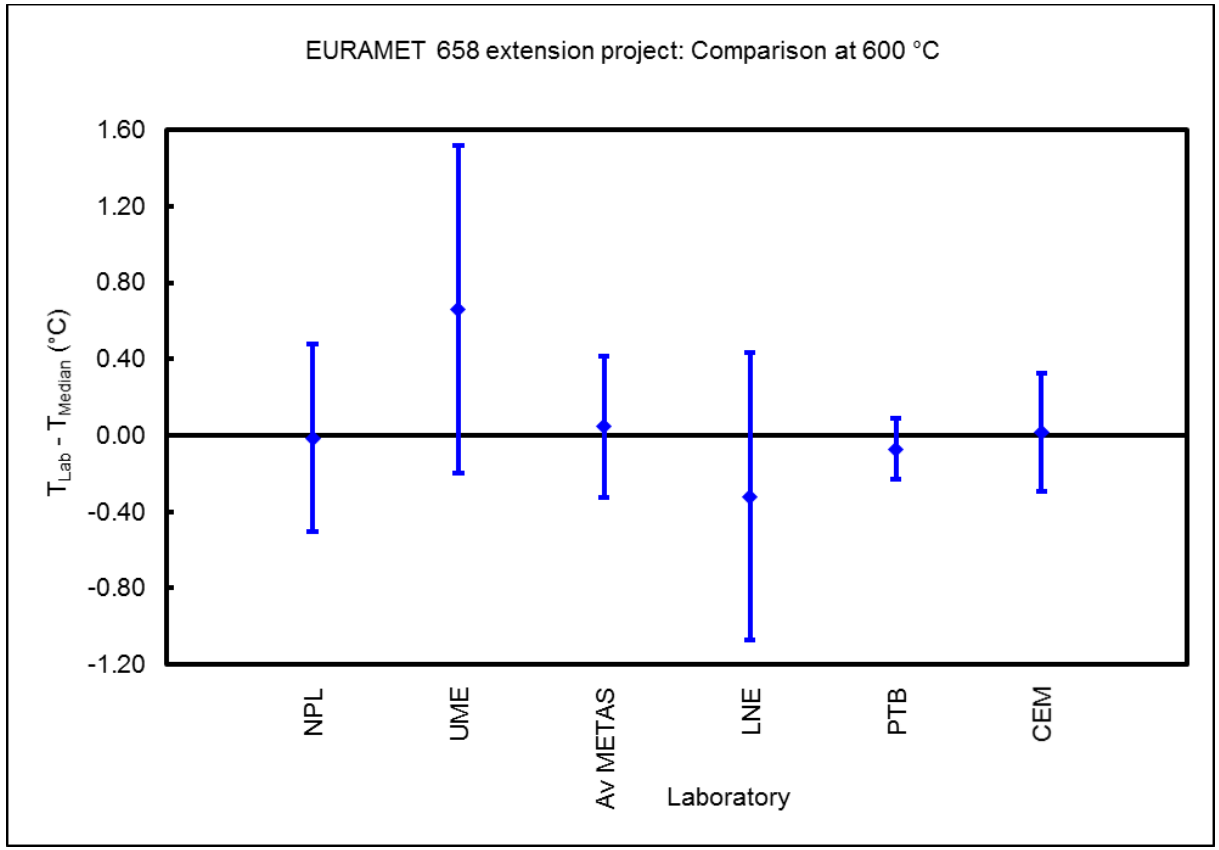
	NPL (Cs BB)	NPL (WRC BB)	UME	METAS (Cs BB)	METAS (Na BB 1)	METAS (Na BB 2)	LNE	PTB	CEM
NPL (Cs BB)	-	-0.25 ± 0.54	-0.43 ± 0.85	-0.15 ± 0.28	-0.15 ± 0.29	-0.31 ± 0.54	-0.02 ± 0.44	-0.15 ± 0.26	-0.14 ± 0.40
NPL (WRC BB)	*0.70*	-	-0.18 ± 0.96	0.11 ± 0.51	0.10 ± 0.52	-0.05 ± 0.69	0.23 ± 0.61	0.11 ± 0.50	0.12 ± 0.59
UME	*1.14*	*1.00*	-	0.29 ± 0.83	0.28 ± 0.84	0.13 ± 0.96	0.41 ± 0.90	0.29 ± 0.83	0.30 ± 0.88
METAS (Cs BB)	*0.37*	*0.54*	*0.98*	-	-0.01 ± 0.23	-0.16 ± 0.51	0.12 ± 0.40	0.00 ± 0.19	0.01 ± 0.36
METAS (Na BB 1)	*0.39*	*0.55*	*0.98*	*0.22*	-	-0.16 ± 0.52	0.13 ± 0.41	0.00 ± 0.20	0.02 ± 0.37
METAS (Na BB 2)	*0.75*	*0.68*	*0.97*	*0.59*	*0.59*	-	0.28 ± 0.61	0.16 ± 0.50	0.17 ± 0.59
LNE	*0.43*	*0.74*	*1.16*	*0.46*	*0.47*	*0.79*	-	-0.12 ± 0.39	-0.11 ± 0.50
PTB	*0.36*	*0.53*	*0.98*	*0.18*	*0.20*	*0.58*	*0.45*	-	0.01 ± 0.35
CEM	*0.47*	*0.62*	*1.04*	*0.36*	*0.36*	*0.67*	*0.53*	*0.34*	-

Table 148 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 500 °C, with data from different sources



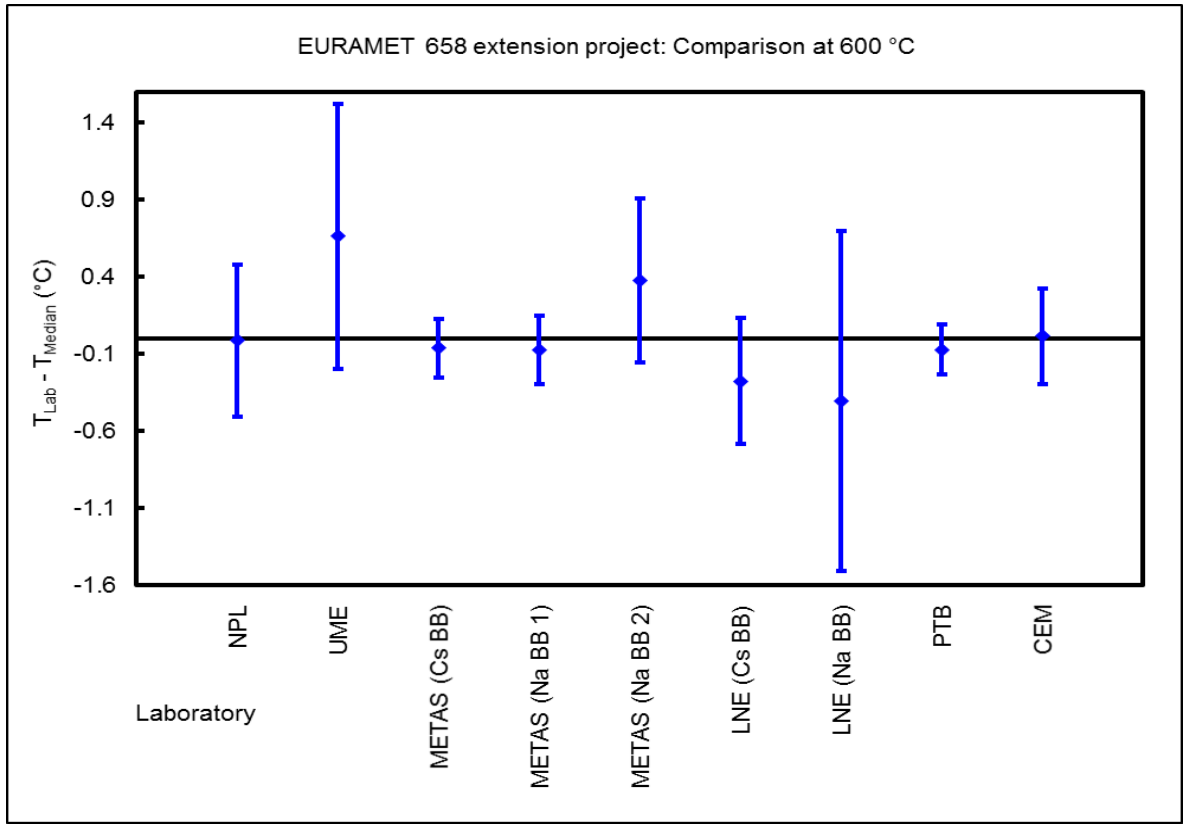
	NPL	UME	Av METAS	LNE	PTB	CEM
NPL	-	-0.68 ± 0.99	-0.06 ± 0.61	0.30 ± 0.90	0.06 ± 0.52	-0.03 ± 0.58
UME	*1.49*	-	0.62 ± 0.93	0.98 ± 1.14	0.73 ± 0.87	0.65 ± 0.91
Av METAS	*0.61*	*1.38*	-	0.36 ± 0.84	0.12 ± 0.40	0.03 ± 0.48
LNE	*1.05*	*1.92*	*1.06*	-	-0.25 ± 0.77	-0.33 ± 0.81
PTB	*0.52*	*1.45*	*0.46*	*0.89*	-	-0.09 ± 0.35
CEM	*0.57*	*1.40*	*0.48*	*1.01*	*0.38*	-

Table 149 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 600 °C – average data



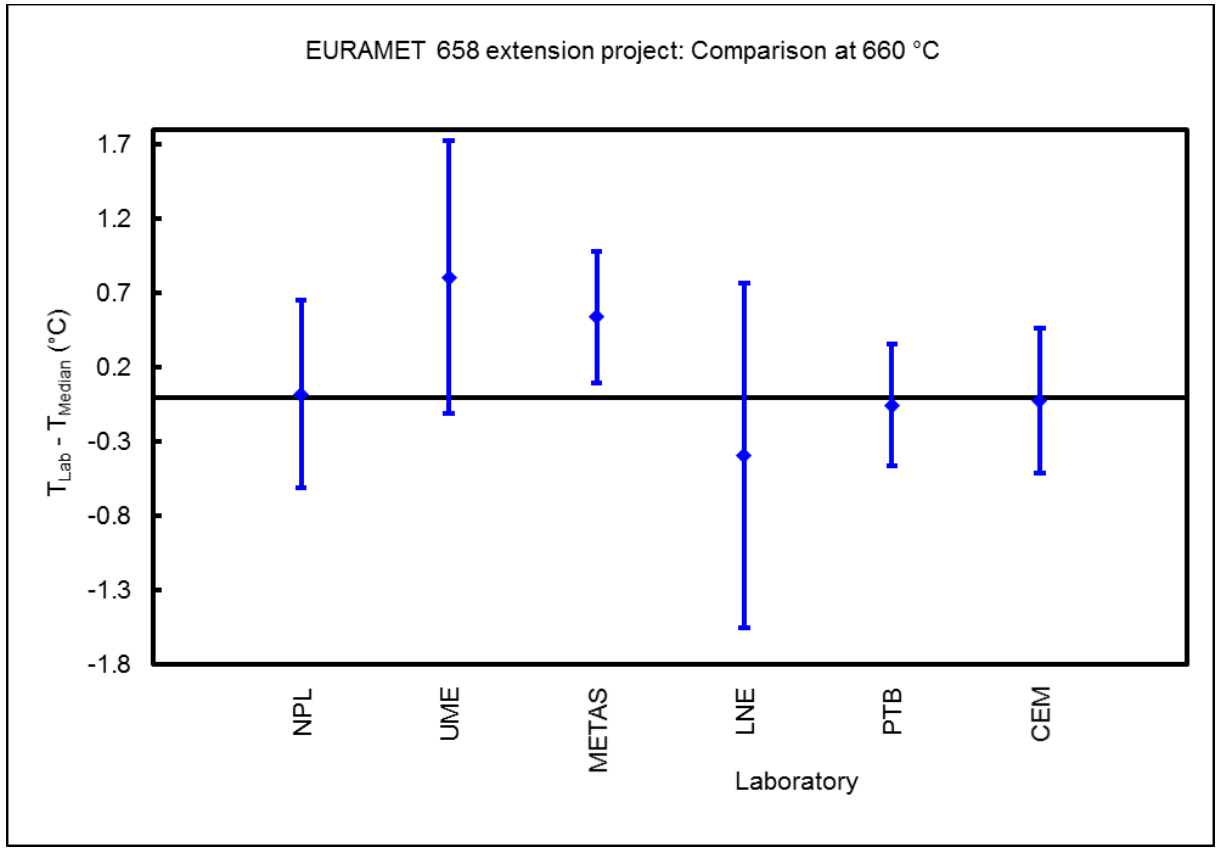
	NPL	UME	METAS (Cs BB)	METAS (Na BB 1)	METAS (Na BB 2)	LNE (Cs BB)	LNE (Na BB)	PTB	CEM
NPL	-	-0.68 ± 0.99	0.05 ± 0.53	0.06 ± 0.54	-0.39 ± 0.72	0.26 ± 0.64	0.39 ± 1.20	0.06 ± 0.52	-0.03 ± 0.58
UME	*1.49*	-	0.72 ± 0.88	0.73 ± 0.89	0.29 ± 1.01	0.94 ± 0.95	1.07 ± 1.40	0.73 ± 0.87	0.65 ± 0.91
METAS (Cs BB)	*0.52*	*1.44*	-	0.01 ± 0.29	-0.44 ± 0.56	0.21 ± 0.45	0.34 ± 1.12	0.01 ± 0.25	-0.08 ± 0.36
METAS (Na BB 1)	*0.54*	*1.46*	*0.29*	-	-0.45 ± 0.57	0.20 ± 0.47	0.33 ± 1.12	0.00 ± 0.27	-0.09 ± 0.38
METAS (Na BB 2)	*0.98*	*1.13*	*0.90*	*0.92*	-	0.65 ± 0.67	0.78 ± 1.22	0.45 ± 0.55	0.36 ± 0.61
LNE (Cs BB)	*0.79*	*1.72*	*0.59*	*0.59*	*1.20*	-	0.13 ± 1.17	-0.20 ± 0.44	-0.29 ± 0.51
LNE (Na BB)	*1.40*	*2.21*	*1.28*	*1.27*	*1.79*	*1.17*	-	-0.33 ± 1.11	-0.42 ± 1.14
PTB	*0.52*	*1.45*	*0.24*	*0.27*	*0.90*	*0.57*	*1.26*	-	-0.09 ± 0.35
CEM	*0.57*	*1.40*	*0.39*	*0.41*	*0.87*	*0.71*	*1.37*	*0.38*	-

Table 150 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 600 °C, with data from different sources



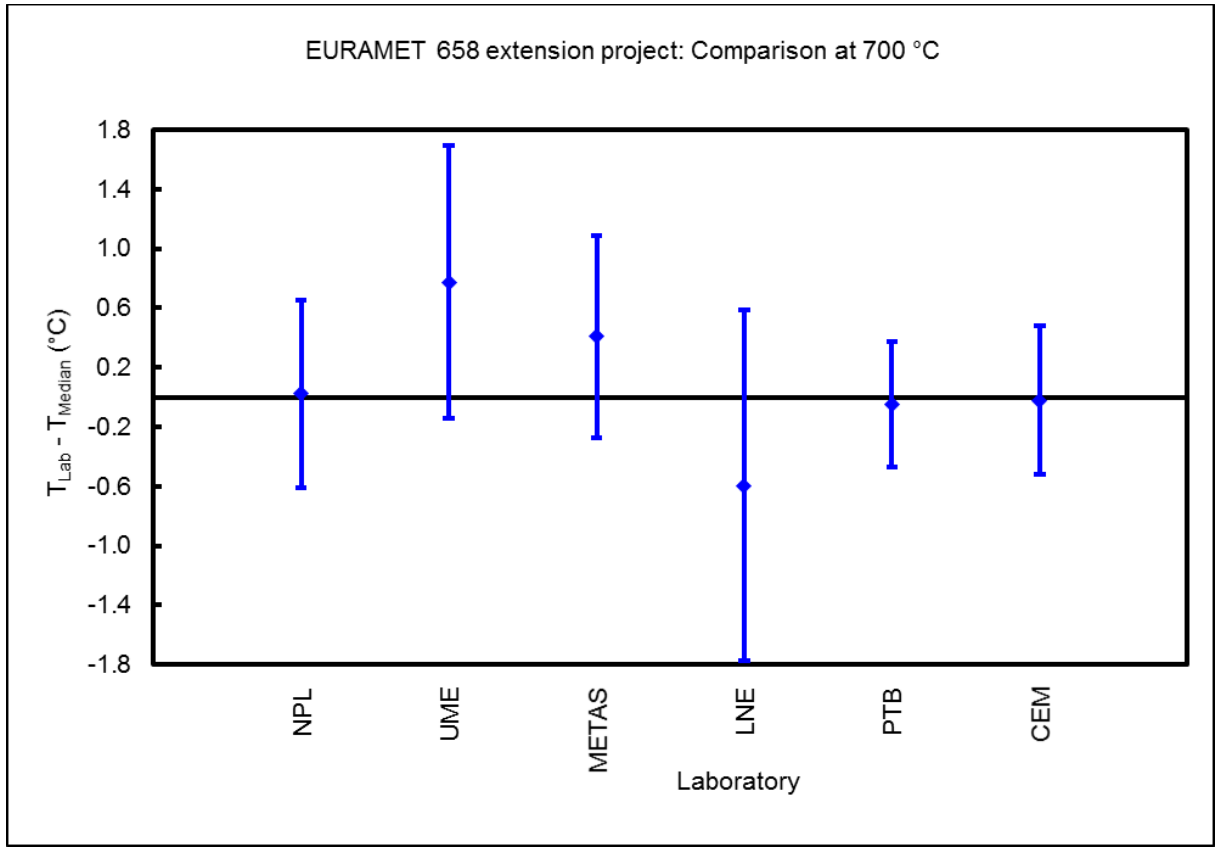
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-0.79 ± 1.12	-0.52 ± 0.77	0.42 ± 1.32	0.08 ± 0.75	0.04 ± 0.80
UME	*1.70*	-	0.27 ± 1.02	1.20 ± 1.48	0.86 ± 1.01	0.83 ± 1.04
METAS	*1.15*	*1.13*	-	0.93 ± 1.24	0.59 ± 0.60	0.56 ± 0.66
LNE	*1.52*	*2.42*	*1.96*	-	-0.34 ± 1.23	-0.37 ± 1.26
PTB	*0.75*	*1.69*	*1.09*	*1.37*	-	-0.03 ± 0.64
CEM	*0.78*	*1.69*	*1.10*	*1.43*	*0.63*	-

Table 151 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 660 °C



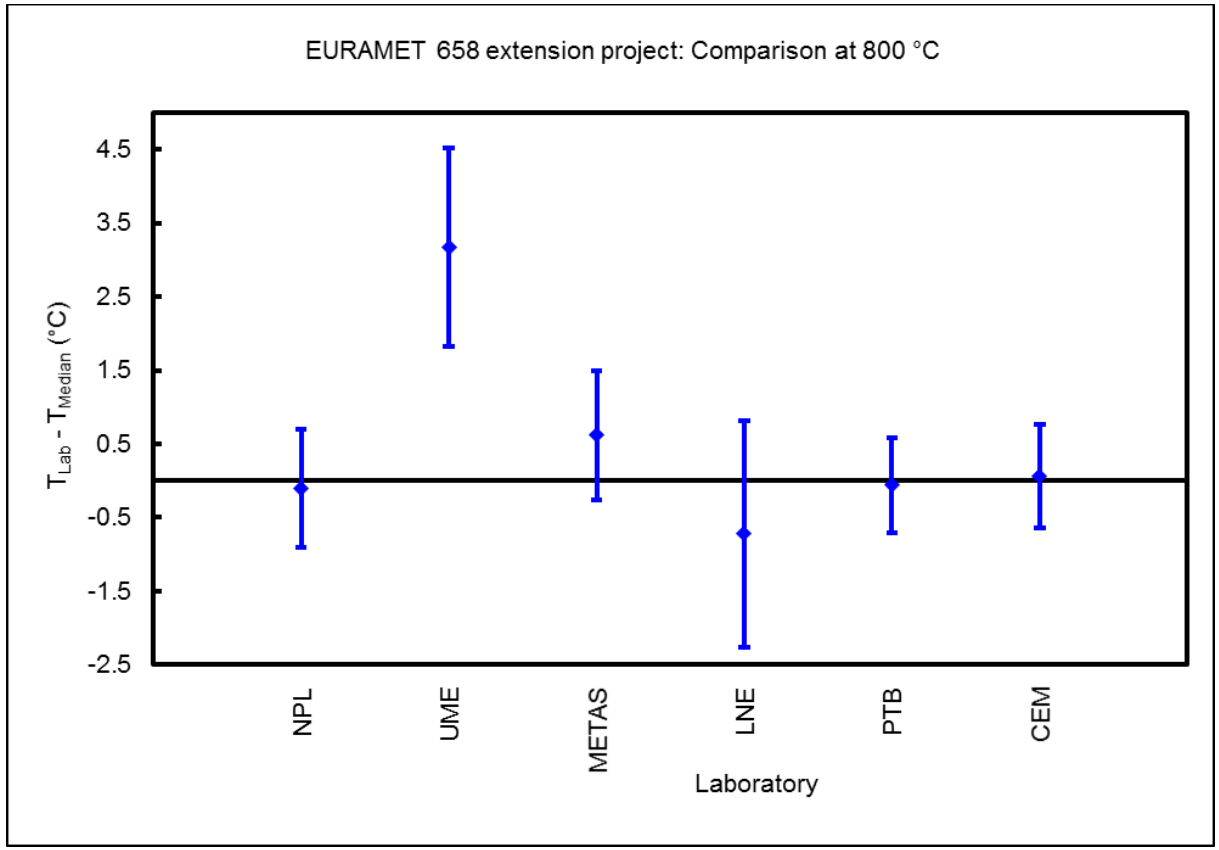
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-0.75 ± 1.12	-0.39 ± 0.93	0.62 ± 1.34	0.07 ± 0.76	0.05 ± 0.80
UME	*1.67*	-	0.37 ± 1.14	1.37 ± 1.50	0.83 ± 1.01	0.80 ± 1.05
METAS	*1.15*	*1.32*	-	1.00 ± 1.36	0.46 ± 0.80	0.43 ± 0.84
LNE	*1.72*	*2.60*	*2.13*	-	-0.55 ± 1.25	-0.57 ± 1.28
PTB	*0.75*	*1.66*	*1.12*	*1.58*	-	-0.03 ± 0.65
CEM	*0.79*	*1.66*	*1.13*	*1.63*	*0.64*	-

Table 152 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 700 °C



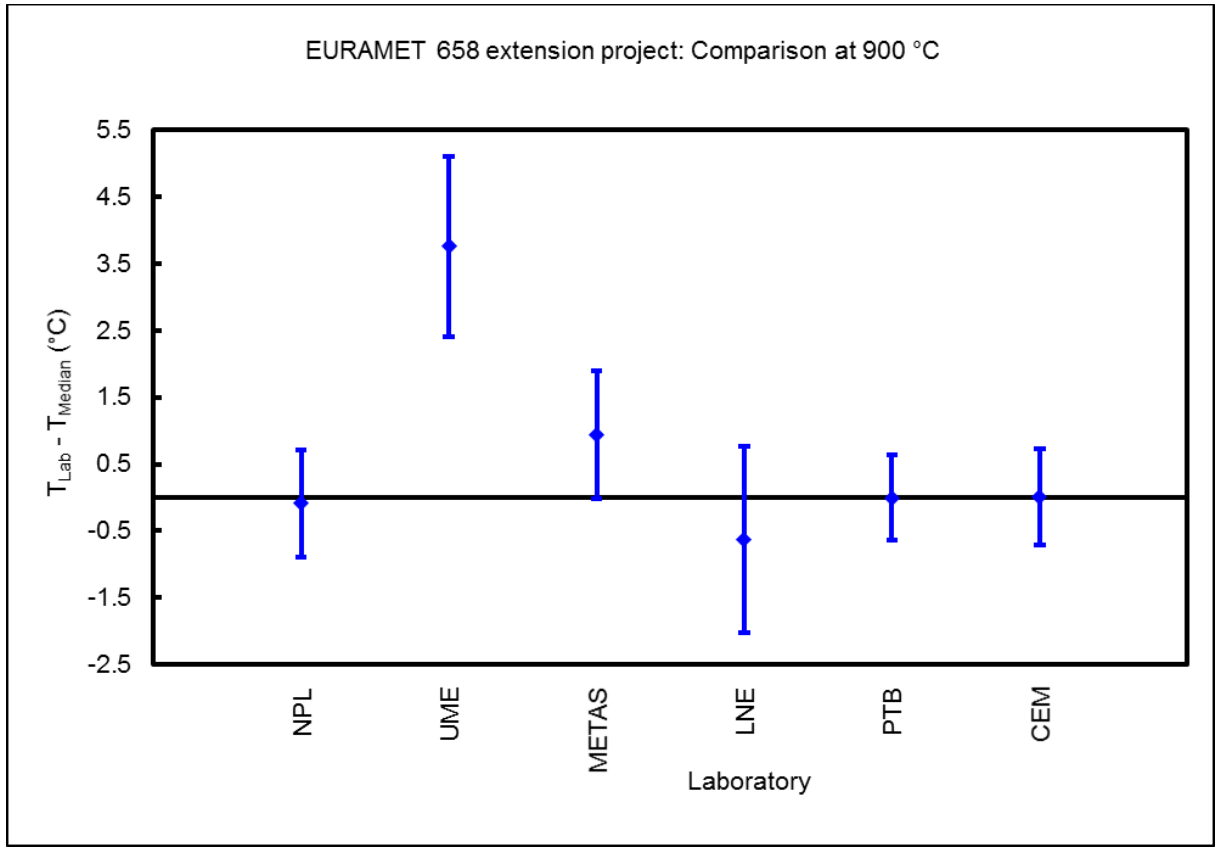
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-3.27 ± 1.57	-0.72 ± 1.19	0.62 ± 1.74	-0.04 ± 1.02	-0.16 ± 1.06
UME	*4.56*	-	2.56 ± 1.61	3.89 ± 2.05	3.23 ± 1.49	3.11 ± 1.52
METAS	*1.70*	*3.88*	-	1.33 ± 1.77	0.68 ± 1.09	0.55 ± 1.12
LNE	*2.06*	*5.58*	*2.79*	-	-0.66 ± 1.67	-0.78 ± 1.69
PTB	*1.01*	*4.46*	*1.57*	*2.04*	-	-0.12 ± 0.95
CEM	*1.09*	*4.36*	*1.48*	*2.18*	*0.96*	-

Table 153 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 800 °C



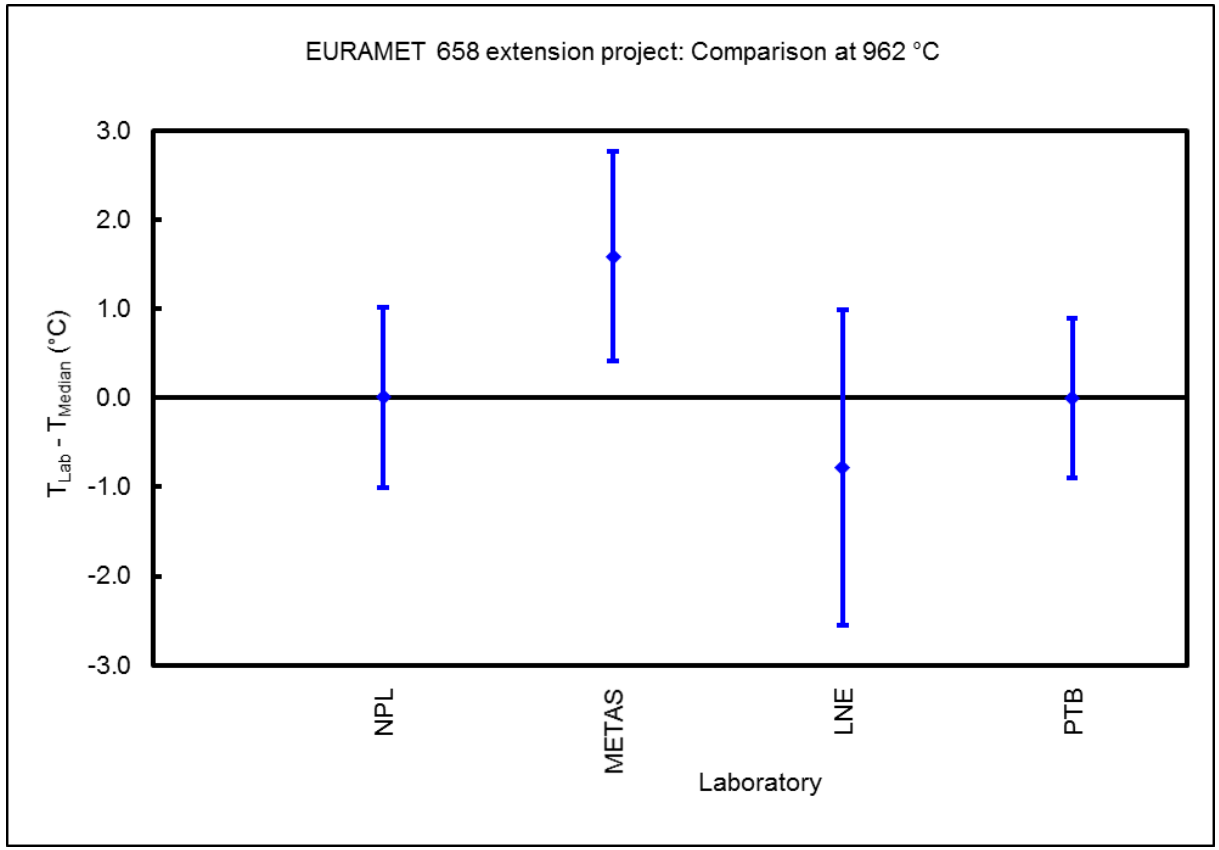
	NPL	UME	METAS	LNE	PTB	CEM
NPL	-	-3.85 ± 1.57	-1.03 ± 1.25	0.54 ± 1.61	-0.08 ± 1.02	-0.09 ± 1.08
UME	*5.14*	-	2.82 ± 1.66	4.39 ± 1.95	3.76 ± 1.49	3.76 ± 1.53
METAS	*2.06*	*4.18*	-	1.57 ± 1.70	0.94 ± 1.15	0.94 ± 1.20
LNE	*1.88*	*5.98*	*2.96*	-	-0.62 ± 1.54	-0.63 ± 1.57
PTB	*1.01*	*4.99*	*1.89*	*1.90*	-	-0.01 ± 0.96
CEM	*1.07*	*5.01*	*1.92*	*1.94*	*0.95*	-

Table 154 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 900 °C



	NPL	METAS	LNE	PTB	CEM
NPL	-	-1.58 ± 1.56	0.78 ± 2.04	0.01 ± 1.35	-0.06 ± 0.48
METAS	*2.86*	-	2.37 ± 2.13	1.59 ± 1.48	-0.02 ± 0.62
LNE	*2.47*	*4.12*	-	-0.77 ± 1.98	0.23 ± 0.50
PTB	*1.33*	*2.81*	*2.42*	-	-0.13 ± 0.46
CEM	*0.48*	*0.61*	*0.65*	*0.51*	-

Table 155 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 962 °C



	NPL	UME	METAS
NPL	-	-4.88 ± 5.01	-1.28 ± 4.96
UME	*9.00*	-	3.60 ± 5.05
METAS	*5.46*	*7.76*	-

Table 156 - direct comparison of the results for the INRiM thermometer variable temperature blackbody measurements at 1000 °C