Key comparison CCL-K5

MEASURAND : **Relative positions of the gauge surfaces with respect to the centre of the front surface of the first gauge**
TRAVELLING STANDARD : **A 1020 mm long step gauge with 51 steps**

The participants' reported values and corresponding standard uncertainties are given in Tables 2 and 4 of the Final Report (page 13 and page 15, respectively), for the 51 steps.
For each laboratory *i* , a linear regression was fitted on the data, so the measurement of 51 gauge surfaces is analysed into constant x_{ic} and proportional x_{ip} parts.
The measurement of laboratory *i* is thus expressed as $x_i = x_{ic} + x_{ip} L$, where *L* is the interval length in mm.
In the same way, the standard uncertainty of laboratory *i* is expressed as $u_i = u_{ic} + u_{ip} L$.

Step gauge: S/N 871026/108

Lab *i* ⇩	Constant component		Proportional component		
	x_{ic} / µm	u_{ic} / µm	x_{ip} / (µm/mm)	u_{ip} / (µm/mm)	Date of measurement
PTB	**-4.56**	0.10	**1000.17377**	0.00040	**June 2000**
CEM	**-4.41**	0.03	**1000.17322**	0.00020	**September 2000**
CENAM	**-4.40**	0.63	**1000.17316**	0.00181	**March 2002**
KRISS	**-5.12**	0.11	**1000.17325**	0.00056	**February 2000**
METAS	**-4.58**	0.05	**1000.17375**	0.00021	**October 2000**
NIM	**-4.22**	0.18	**1000.17288**	0.00014	**April 2000**
NMIJ	**4.36**	0.18	**1000.14394**	0.00048	**December 1999**
NIST	**-4.38**	0.11	**1000.17354**	0.00010	**May 1999**
NMIA	**5.55**	0.08	**1000.13503**	0.00051	**November 1999**

VNIIM and INRIM withdrew during the comparison.
NRC and CSIR-NML did not report any data due to technical problems.
CENAM realised a re-measure in 2002.

Key comparison CCL-K5

MEASURAND : Relative positions of the gauge surfaces with respect to the centre of the front surface of the first gauge
TRAVELLING STANDARD : A 1020 mm long step gauge with 51 steps

Step gauge: S/N 871026/108

The key comparison reference value, x_R, is obtained by taking first the mean of the measurement results reported by PTB, METAS, NMIJ and NIST, and then by fitting a linear regression to obtain the constant x_{Rc} and proportional x_{Rp} parts such that $x_R = x_{Rc} + x_{Rp} L$, where L is the interval length in mm.
The combined standard uncertainty of x_R is given by $u_R = u_{Rc} + u_{Rp} L$, as explained in Appendix B on page 32 of the Final Report.

Constant component		Proportional component	
x_{Rc}	u_{Rc}	x_{Rp}	u_{Rp}
/ µm	/ µm	/ (µm/mm)	/ (µm/mm)
-4.490	0.065	1000.17366	0.00014

Degrees of equivalence relative to the key comparison reference value have been analysed into constant D_{ic} and proportional D_{ip} terms with expanded uncertainties (coverage factor k = 2) U_{ic} and U_{ip}, for each laboratory i, as explained in Appendix B on pages 32 and 33 of the Final Report.

The pair-wise degrees of equivalence are not computed for this comparison.

Key comparison CCL-K5

MEASURAND : **Relative positions of the gauge surfaces with respect to the centre of the front surface of the first gauge**
TRAVELLING STANDARD : **A 1020 mm long step gauge with 51 steps**

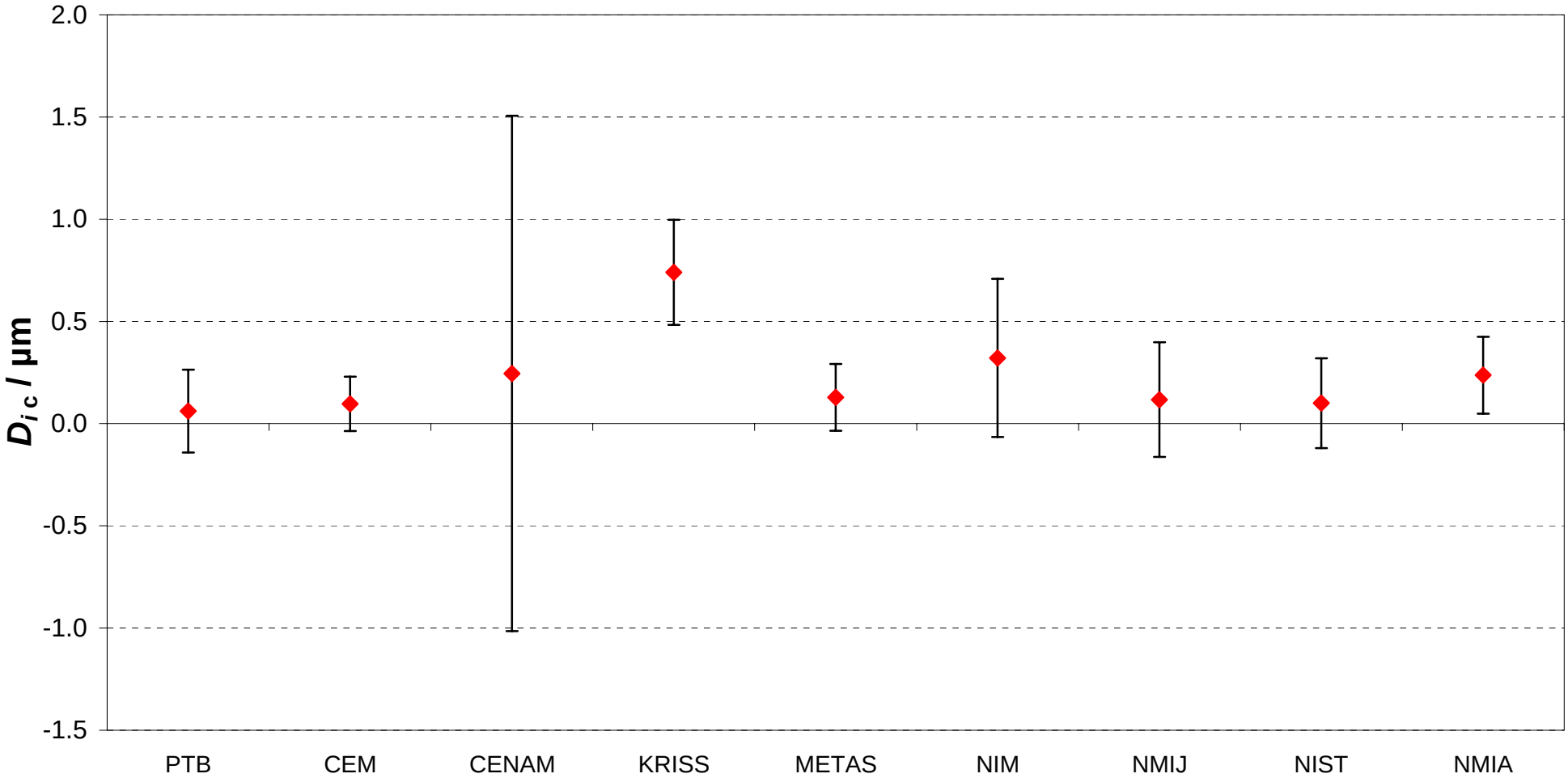
Step gauge: S/N 871026/108

Lab *i* ⇩	Constant component		Proportional component	
	D_{ic} / µm	U_{ic} / µm	D_{ip} / (µm/mm)	U_{ip} / (µm/mm)
PTB	**0.06**	0.20	**0.00011**	0.00058
CEM	**0.10**	0.13	**-0.00043**	0.00048
CENAM	**0.25**	1.26	**-0.00050**	0.00363
KRISS	**0.74**	0.26	**-0.00040**	0.00113
METAS	**0.13**	0.16	**0.00009**	0.00032
NIM	**0.32**	0.39	**-0.00077**	0.00038
NMIJ	**0.12**	0.28	**-0.00021**	0.00075
NIST	**0.10**	0.22	**-0.00011**	0.00022
NMIA	**0.24**	0.19	**-0.00389**	0.00107

CCL-K5 1020 mm step gauge block, S/N 871026/108

Degrees of equivalence: constant component

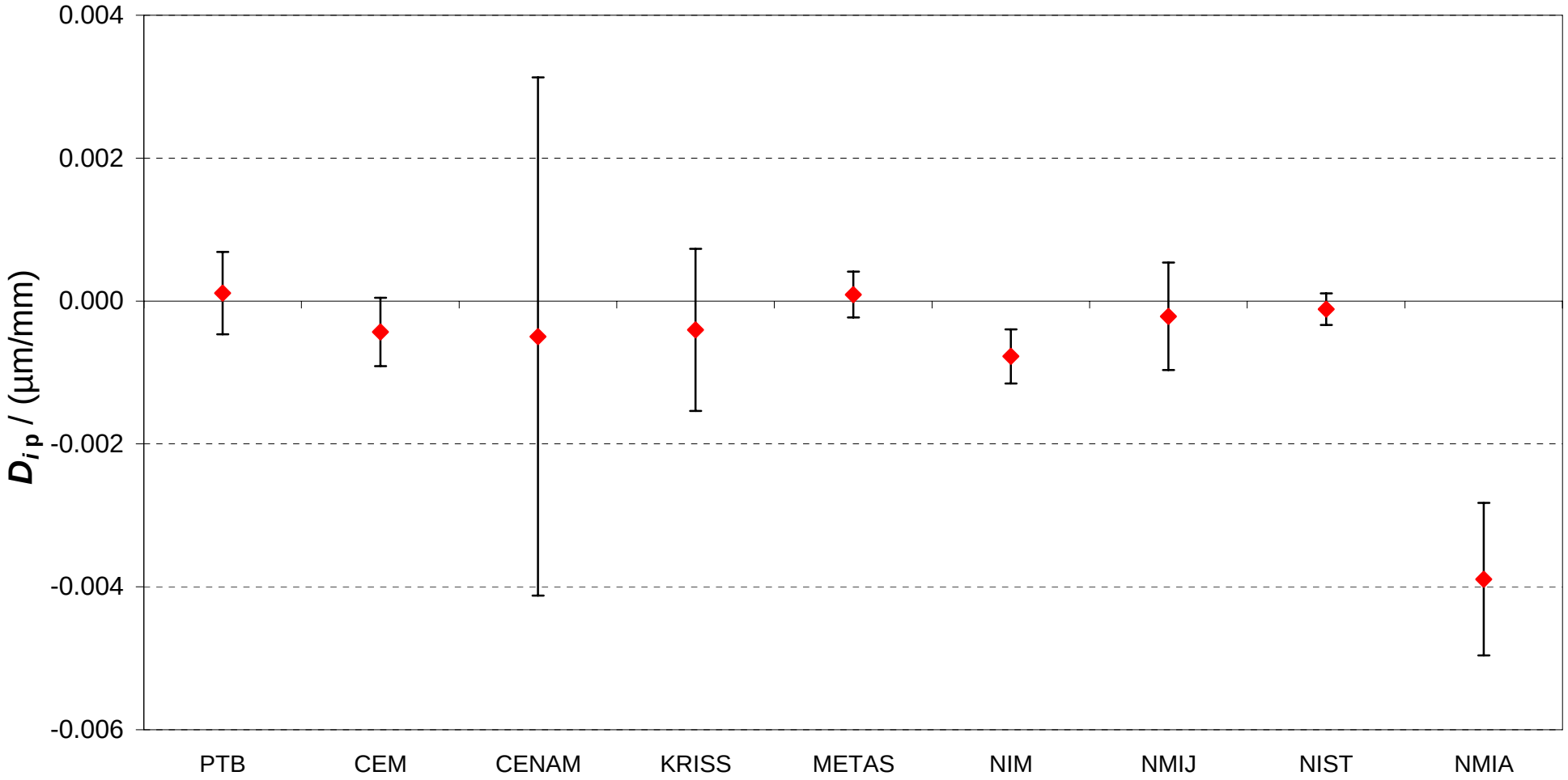
[D_{ic} and its expanded uncertainty (coverage factor: 2) U_{ic}]



CCL-K5 1020 mm step gauge block, S/N 871026/108

Degrees of equivalence: proportional component

[$D_{i\,p}$ and its expanded uncertainty (coverage factor: 2) $U_{i\,p}$]



Key comparison CCL-K5

MEASURAND : Length between the ball centres of each ball bar
Ball bar material: 2 steel ball bars and one Super Invar ball bar

NOMINAL VALUES : 400 mm and 800 mm for steel ball bars and 800 mm for Super Invar ball bar

x_{ik} : result of measurement carried out by laboratory i for ball bar k with nominal length L_k, expressed as the deviation from nominal length in µm

u_{ik} : combined standard uncertainty of x_{ik} reported by laboratory i

Nominal length L_k (k = 1 to 3) ⇨

Lab i ⇩	400 mm		800 mm		800 mm		Date of measurement
	S/N UHP-455-SS-04		S/N UHP-455-09		S/N UHP-SI-NIST-01		
	x_{i1} / µm	u_{i1} / µm	x_{i2} / µm	u_{i2} / µm	x_{i3} / µm	u_{i3} / µm	
PTB	5.10	0.60	-10.30	0.80	-2105.70	0.80	June 2000
KRISS	4.71	0.61	-9.83	0.77	-2107.08	0.72	February 2000
NMIJ	5.00	0.54					December 1999
NIM	5.22	0.20	-10.32	0.30	-2105.99	0.19	April 2000
NIST	4.99	0.16	-10.69	0.20	-2108.10	0.20	May 1999
NMIA	3.87	0.50					November 1999

VNIIM and INRIM withdrew during the comparison.
NRC and CSIR-NML did not report any data due to technical problems.
CEM, CENAM, and METAS did not participate in the ball bars comparison.
NMIJ and NMIA reported results only for steel ball bar with nominal length 400 mm.

Key comparison CCL-K5

MEASURAND : Length between the ball centres of each ball bar
Ball bar material: 2 steel ball bars and one Super Invar ball bar

NOMINAL VALUES : 400 mm and 800 mm for steel ball bars and 800 mm for Super Invar ball bar

For each ball bar k, the key comparison reference value, x_{Rk}, is obtained as the mean of all participants' values x_{ik}. The standard uncertainty, u_{Rk}, of key comparison reference value x_{Rk}, is obtained from the reported standard uncertainties u_{ik}, as given in equation 6 on page 25 of the Final Report.

nominal length L_k (k = 1 to 3) ⇨

400 mm		800 mm		800 mm	
S/N UHP-455-SS-04		S/N UHP-455-09		S/N UHP-SI-NIST-01	
x_{R1} / µm	u_{R1} / µm	x_{R2} / µm	u_{R2} / µm	x_{R3} / µm	u_{R3} / µm
4.82	0.19	-10.29	0.29	-2106.72	0.28

The degree of equivalence of each laboratory i with respect to the key comparison reference value for each ball bar k is given by a pair of terms expressed in µm: $D_{ik} = x_{ik} - x_{Rk}$ and its expanded uncertainty U_{ik} (coverage factor 2) calculated from the equation 4 on page 16 of the Final Report.

nominal length L_k (k = 1 to 3) ⇨

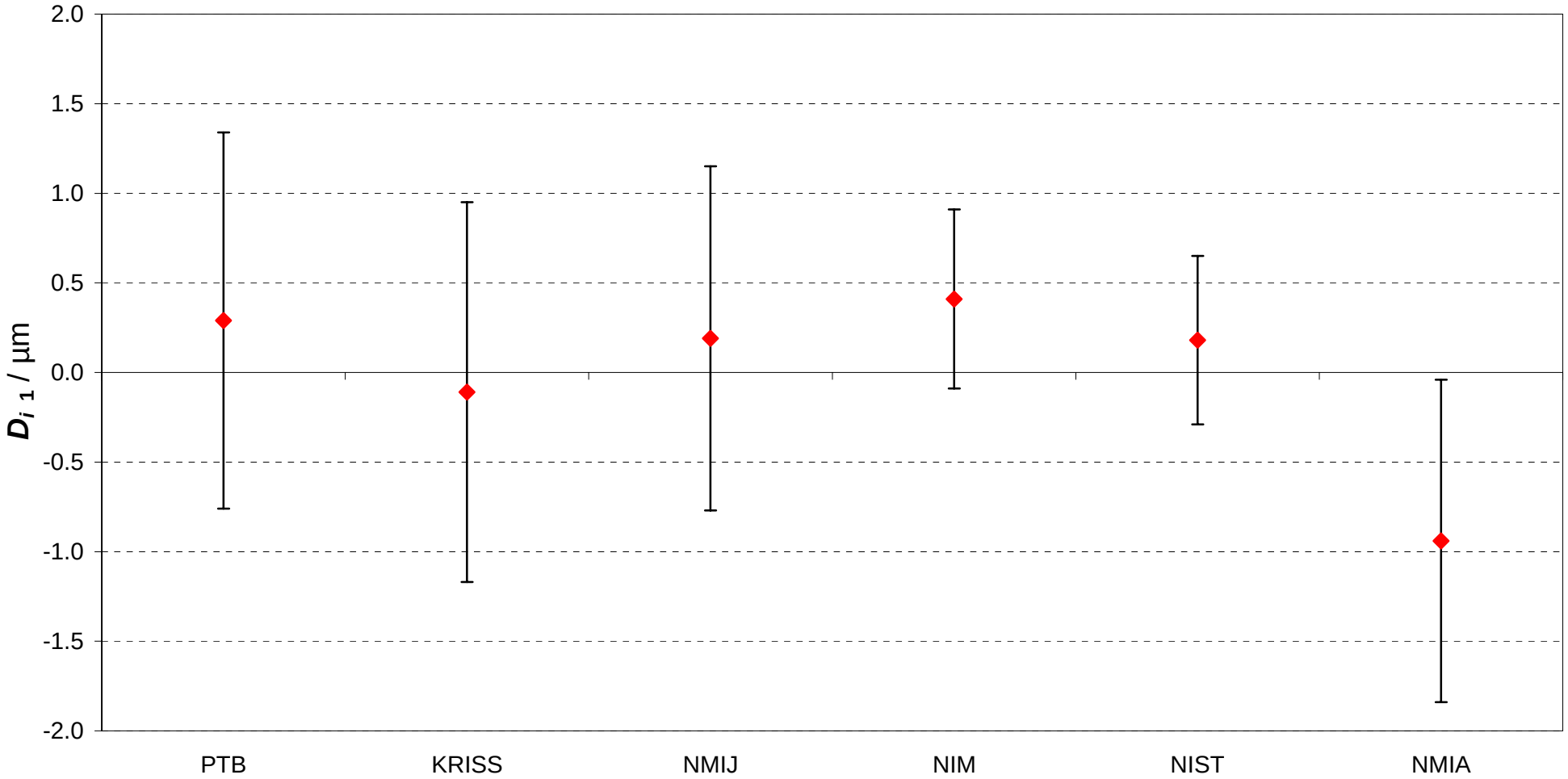
Lab i ⇩

	400 mm		800 mm		800 mm	
	S/N UHP-455-SS-04		S/N UHP-455-09		S/N UHP-SI-NIST-01	
	D_{i1} / µm	U_{i1} / µm	D_{i2} / µm	U_{i2} / µm	D_{i3} / µm	U_{i3} / µm
PTB	**0.29**	1.05	**-0.02**	1.27	**1.02**	1.26
KRISS	**-0.11**	1.06	**0.46**	1.24	**-0.36**	1.16
NMIJ	**0.19**	0.96				
NIM	**0.41**	0.50	**-0.03**	0.72	**0.73**	0.62
NIST	**0.18**	0.47	**-0.40**	0.65	**-1.38**	0.62
NMIA	**-0.94**	0.90				

The pair-wise degrees of equivalence are not computed for this comparison.

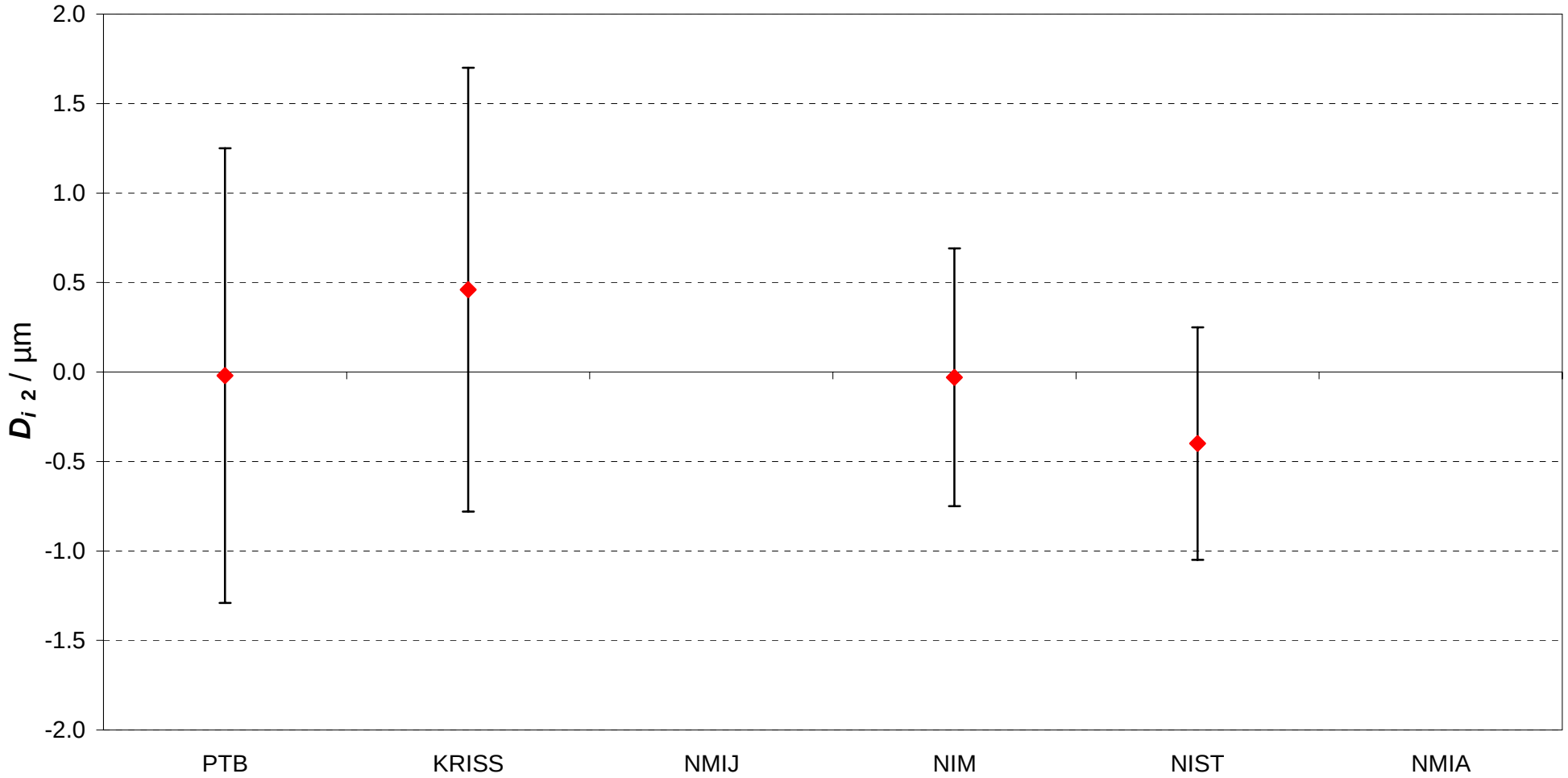
CCL-K5 400 mm steel ball bar, S/N UHP-455-SS-04

Degrees of equivalence [$D_{i\,1}$ and its expanded uncertainty (coverage factor 2) $U_{i\,1}$]



CCL-K5 800 mm steel ball bar, S/N UHP-455-09

Degrees of equivalence [$D_{i\,2}$ and its expanded uncertainty (coverage factor 2) $U_{i\,2}$]



CCL-K5 800 mm Super Invar ball bar, S/N UHP-SI-NIST-01

Degrees of equivalence [$D_{i\,3}$ and its expanded uncertainty (coverage factor 2) $U_{i\,3}$]