Key comparison EUROMET.L-K5.2004

MEASURANDS : **Distances of the centres of the front and back faces of the individual gauges of the step-gauge with respect of the centre of the front face of the first gauge**

TRAVELLING STANDARD : A 420 mm long step-gauge with 11 gauges, designated as Gauge 1 to Gauge 11

Measurement results, as reported by participants, and corresponding measurement uncertainties are given in Sections 6 and 7 on pages 19, 20 and 21 of the Final Report, and also summarized in Section 9.5 on page 43 of the same Report.

Lab *i*	Date of measurement
CEM1	Dec 2004 - Jan 2005
BEV	February 2005
NSAI NML	March 2005
MKEH	May 2005
SP	June 2005
CEM2	July 2005
DTU	September 2005
CMI	October 2005
LNE	November 2005
INM(RO)	December 2005
INRIM	February 2006
CEM3	March - April 2006
NPL	March 2006
NRC	June 2006
NMIA	August 2006
VNIIM	September 2006
MIKES	November 2006
VSL	December 2006
GUM	February 2007
INMETRO	April 2007
CENAM	September 2007
CEM4	December 2007

IPQ and NMISA resigned to measure for technical reasons.

CEM carried out four measurements designated as CEM1, CEM2, CEM3 and CEM4. Only CEM2 and CEM4 are retained in the following, CEM1 and CEM3 having been used to assess the stability of the travelling standard, and for other purposes.

Key comparison EUROMET.L-K5.2004

MEASURANDS : Distances of the centres of the front and back faces of the individual gauges of the step-gauge with respect of the centre of the front face of the first gauge

TRAVELLING STANDARD : A 420 mm long step-gauge with 11 gauges, designated as Gauge 1 to Gauge 11

Looking at the evolution of the measured values along the time, the following actions were taken:

1. To exclude Gauges 5, 7, 8 and 10 from calculation, based on the large variations and anomalous behaviour observed on them by the Pilot Laboratory and the participants.

2. Assume that only Gauges 1, 2, 3, 4, 6, 9 and 11 are reasonably stable along the comparison and use them for the analysis. Although there is a reduction in the number of the gauges, the number of remaining ones is still valid for checking the capability of participants to calibrate step gauges according to their CMCs.

3. To leave out the results of CENAM and CEM4 and analyze them separately, as a secong group, linking later their results to the main group.

Key comparison EUROMET.L-K5.2004

MEASURANDS : **Distances of the centres of the front and back faces of the individual gauges of the step-gauge with respect of the centre of the front face of the first gauge**

TRAVELLING STANDARD : A 420 mm long step-gauge with 11 gauges, designated as Gauge 1 to Gauge 11

For Gauges 1, 2, 3, 4, 6, 9 and 11, the key comparison reference value, x_R, is obtained as the weighted average of the participant results, with exclusion of outliers (see Section 9 of the Final Report for the equations and the list of excluded values). Its standard uncertainty, x_R, is computed as explained in Section 9.2 of the Final Report.

	Gauge 1	Gauge 2		Gauge 3		Gauge 4	
	20 mm	40 mm	60 mm	80 mm	100 mm	120 mm	140 mm
x_R / µm	1.605	16.577	18.014	19.657	20.741	23.490	24.448
u_R / µm	0.024	0.024	0.024	0.025	0.026	0.026	0.027

	Gauge 6		Gauge 9		Gauge 11	
	200 mm	220 mm	320 mm	340 mm	400 mm	420 mm
x_R / µm	43.780	44.720	75.390	76.933	91.908	92.909
u_R / µm	0.031	0.032	0.037	0.038	0.042	0.043

The linkage of the results of CENAM and CEM4 to those of the main group is explained in Section 10 of the Final Report.

In each case, the degree of equivalence of laboratory *i* relative to the key comparison reference value is given by a pair of terms: the deviation D_i of the laboratory measurement to the reference value and the expanded uncertainty (k = 2) U_i of this deviation.

In each case, the degree of equivalence between laboratories *i* and *j* is given by a pair of terms: $D_{ij} = D_i - D_j$ and associated expanded uncertainty (k = 2) U_{ij}, computed as twice the root mean square of the individual standard uncertainties of the two laboratories.
The pair-wise degrees of equivalence are not reported here, but can be found on pages 71 to 83 of the Final Report.

Key comparison EUROMET.L-K5.2004

MEASURANDS : Distances of the centres of the front and back faces of the individual gauges of the step-gauge with respect of the centre of the front face of the first gauge

TRAVELLING STANDARD : A 420 mm long step-gauge with 11 gauges, designated as Gauge 1 to Gauge 11

Degrees of equivalence relative to the key comparison reference values are computed only for Gauges 1, 2, 3, 4, 6, 9 and 11

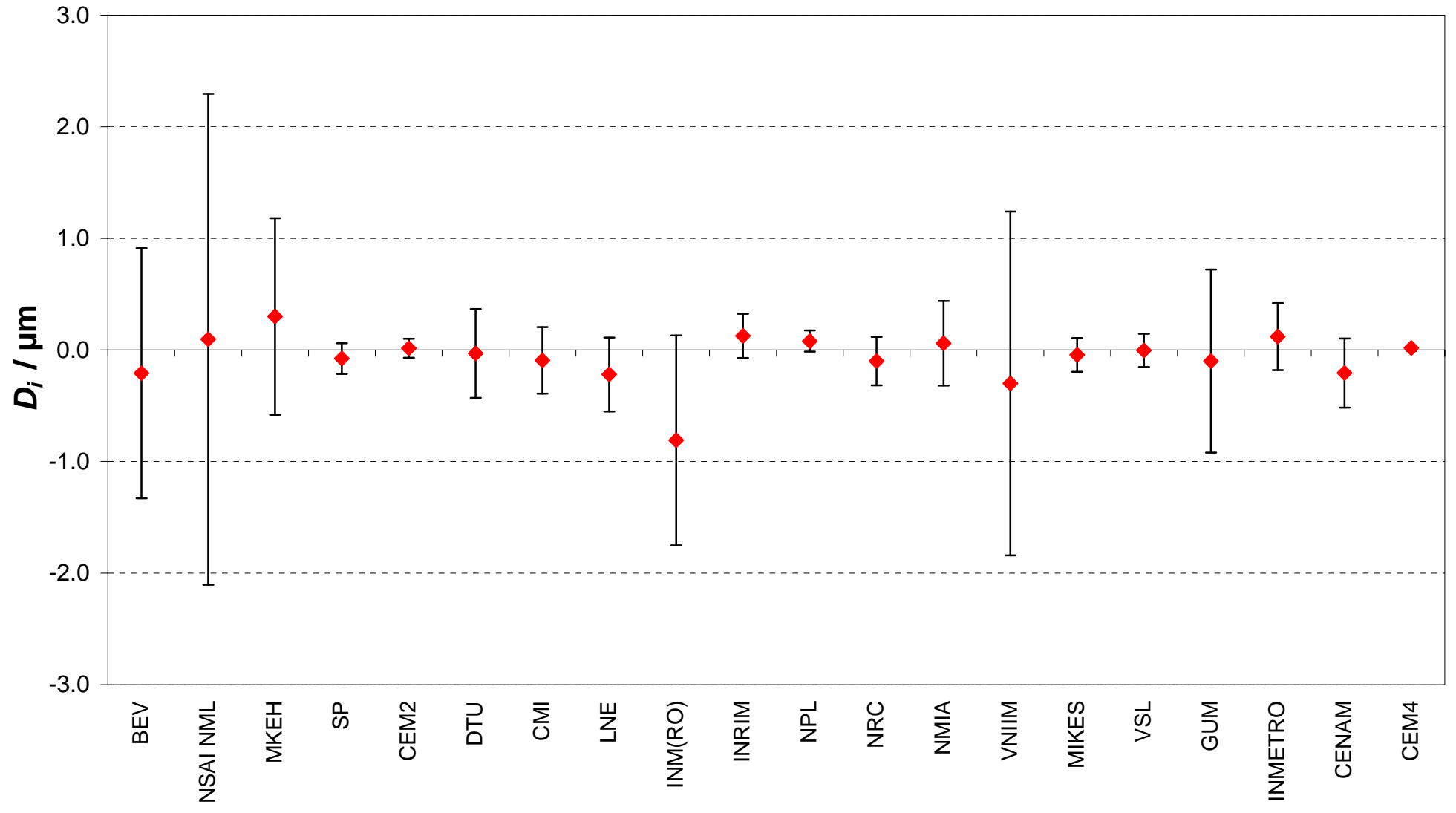| Lab i	Gauge 1 20 mm D_i / µm	U_i / µm	Gauge 2 40 mm D_i / µm	U_i / µm	60 mm D_i / µm	U_i / µm	Gauge 3 80 mm D_i / µm	U_i / µm	100 mm D_i / µm	U_i / µm	Gauge 4 120 mm D_i / µm	U_i / µm	140 mm D_i / µm	U_i / µm
BEV	-0.209	1.120	0.002	1.014	-0.116	1.145	0.139	1.030	-0.287	1.153	0.236	1.066	-0.292	1.196
NSAI NML	0.095	2.200	0.049	2.205	0.368	2.208	-0.104	2.206	0.290	2.205	-0.232	2.214	0.061	2.217
MKEH	0.300	0.881	0.014	0.899	0.081	0.917	0.139	0.923	1.158	0.939	0.620	0.975	0.665	1.001
SP	-0.078	0.138	-0.071	0.205	-0.077	0.246	-0.101	0.227	-0.122	0.222	-0.161	0.301	-0.182	0.320
CEM2	0.015	0.085	-0.150	0.170	-0.107	0.215	-0.046	0.191	-0.015	0.183	0.009	0.271	0.051	0.292
DTU	-0.032	0.399	-0.093	0.426	-0.112	0.447	-0.140	0.437	-0.052	0.435	-0.114	0.481	-0.091	0.495
CMI	-0.093	0.299	-0.043	0.334	-0.127	0.361	-0.052	0.350	-0.135	0.349	-0.074	0.406	-0.178	0.424
LNE	-0.220	0.332	0.154	0.366	-0.029	0.394	0.179	0.388	-0.052	0.393	0.210	0.450	0.085	0.473
INM(RO)	-0.810	0.940	0.394	0.954	-0.269	0.967	0.639	0.968	-0.272	0.973	0.750	1.002	-0.035	1.017
INRIM	0.125	0.198	0.049	0.248	0.111	0.281	-0.037	0.265	0.005	0.261	-0.089	0.331	-0.046	0.350
NPL	0.080	0.095	0.104	0.175	0.131	0.219	0.079	0.195	0.098	0.187	0.010	0.274	0.045	0.294
NRC	-0.100	0.218	0.005	0.263	-0.070	0.294	-0.069	0.277	-0.092	0.272	-0.047	0.338	-0.122	0.355
NMIA	0.060	0.380	-0.056	0.410	0.141	0.435	-0.121	0.430	0.168	0.435	-0.030	0.487	0.105	0.509
VNIIM	-0.300	1.540	-12.474	1.549	-10.708	1.558	-2.358	1.560	-1.141	1.565	12.306	1.585	13.149	1.597
MIKES	-0.044	0.151	0.136	0.211	0.093	0.248	0.091	0.226	0.039	0.218	0.115	0.295	0.071	0.313
VSL	-0.004	0.148	0.116	0.212	0.033	0.254	-0.006	0.240	-0.044	0.241	-0.014	0.321	-0.039	0.347
GUM	-0.100	0.820	-0.186	0.833	0.081	0.845	-0.361	0.841	0.558	0.841	-0.380	0.867	0.265	0.876
INMETRO	0.120	0.300	0.004	0.334	0.031	0.360	0.009	0.349	-0.002	0.347	0.010	0.403	-0.085	0.420
CENAM	-0.207	0.310	0.035	0.310	-0.138	0.309	0.072	0.310	-0.001	0.309	0.114	0.310	0.041	0.311
CEM4	0.016	0.024	-0.003	0.025	0.012	0.026	-0.006	0.028	0.000	0.030	-0.012	0.032	-0.005	0.035

Key comparison EUROMET.L-K5.2004

MEASURANDS : Distances of the centres of the front and back faces of the individual gauges of the step-gauge with respect of the centre of the front face of the first gauge

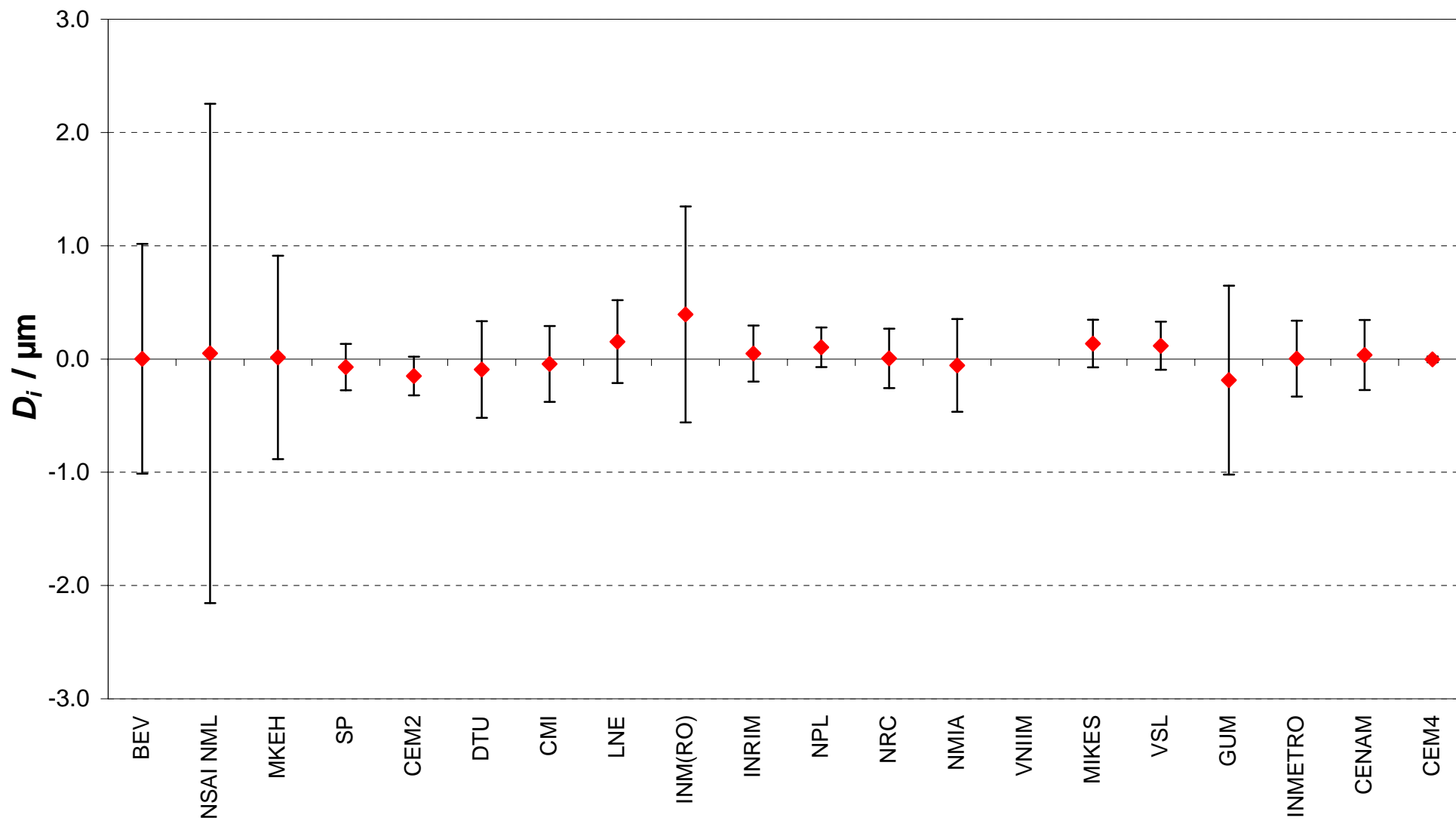**TRAVELLING STANDARD :** A 420 mm long step-gauge with 11 gauges, designated as Gauge 1 to Gauge 11

Degrees of equivalence relative to the key comparison reference values are computed only for Gauges 1, 2, 3, 4, 6, 9 and 11

Lab i	Gauge 6				Gauge 9				Gauge 11			
	200 mm		220 mm		320 mm		340 mm		400 mm		420 mm	
	D_i / µm	U_i / µm	D_i / µm	U_i / µm	D_i / µm	U_i / µm	D_i / µm	U_i / µm	D_i / µm	U_i / µm	D_i / µm	U_i / µm
BEV	-0.072	1.099	-0.672	1.234	0.005	1.275	-0.457	1.388	-0.363	1.396	-0.718	1.502
NSAI NML	-0.569	2.200	0.088	2.204	-0.340	2.420	0.405	2.415	-0.045	2.424	0.305	2.417
MKEH	0.031	1.043	0.093	1.081	0.202	1.293	0.262	1.324	0.287	1.465	0.090	1.497
SP	-0.143	0.190	-0.166	0.230	0.107	0.377	0.096	0.349	0.088	0.418	0.056	0.379
CEM2	-0.070	0.130	-0.014	0.183	0.096	0.351	0.157	0.321	0.082	0.397	0.143	0.356
DTU	-0.182	0.432	-0.158	0.455	-0.081	0.566	-0.046	0.553	0.095	0.616	-0.041	0.597
CMI	-0.081	0.353	-0.168	0.383	0.119	0.521	0.051	0.509	0.148	0.585	0.149	0.568
LNE	0.211	0.440	0.133	0.476	0.312	0.646	0.112	0.649	0.357	0.748	0.360	0.748
INM(RO)	0.611	1.022	-0.027	1.045	0.202	1.178	-0.478	1.191	0.757	1.281	-0.120	1.293
INRIM	-0.001	0.246	0.032	0.282	-0.179	0.430	-0.116	0.410	-0.260	0.485	-0.119	0.458
NPL	0.101	0.133	0.093	0.184	-0.068	0.349	-0.028	0.318	-0.013	0.393	0.030	0.351
NRC	0.021	0.242	-0.022	0.274	-0.126	0.408	-0.185	0.383	-0.059	0.450	-0.162	0.415
NMIA	0.131	0.480	0.243	0.513	0.132	0.676	0.212	0.680	0.067	0.776	0.210	0.777
VNIIM	7.220	1.610	7.481	1.629	-0.298	1.740	1.262	1.754	3.180	1.834	1.786	1.850
MIKES	0.049	0.164	0.054	0.206	-0.136	0.353	-0.170	0.320	-0.065	0.388	-0.094	0.344
VSL	-0.096	0.271	-0.143	0.315	-0.298	0.495	-0.321	0.489	-0.236	0.583	-0.246	0.572
GUM	0.731	0.847	0.693	0.862	0.902	0.939	0.762	0.935	-0.613	0.984	-0.010	0.977
INMETRO	0.541	0.352	0.483	0.381	0.422	0.501	0.372	0.486	-0.133	0.557	-0.100	0.536
CENAM	0.078	0.314	-0.042	0.316	0.020	0.323	-0.074	0.327	0.222	0.334	0.145	0.337
CEM4	-0.011	0.045	0.007	0.049	-0.005	0.073	0.018	0.078	-0.063	0.095	-0.043	0.100

EUROMET.L-K5.2004 Gauge 1 - 20 mm
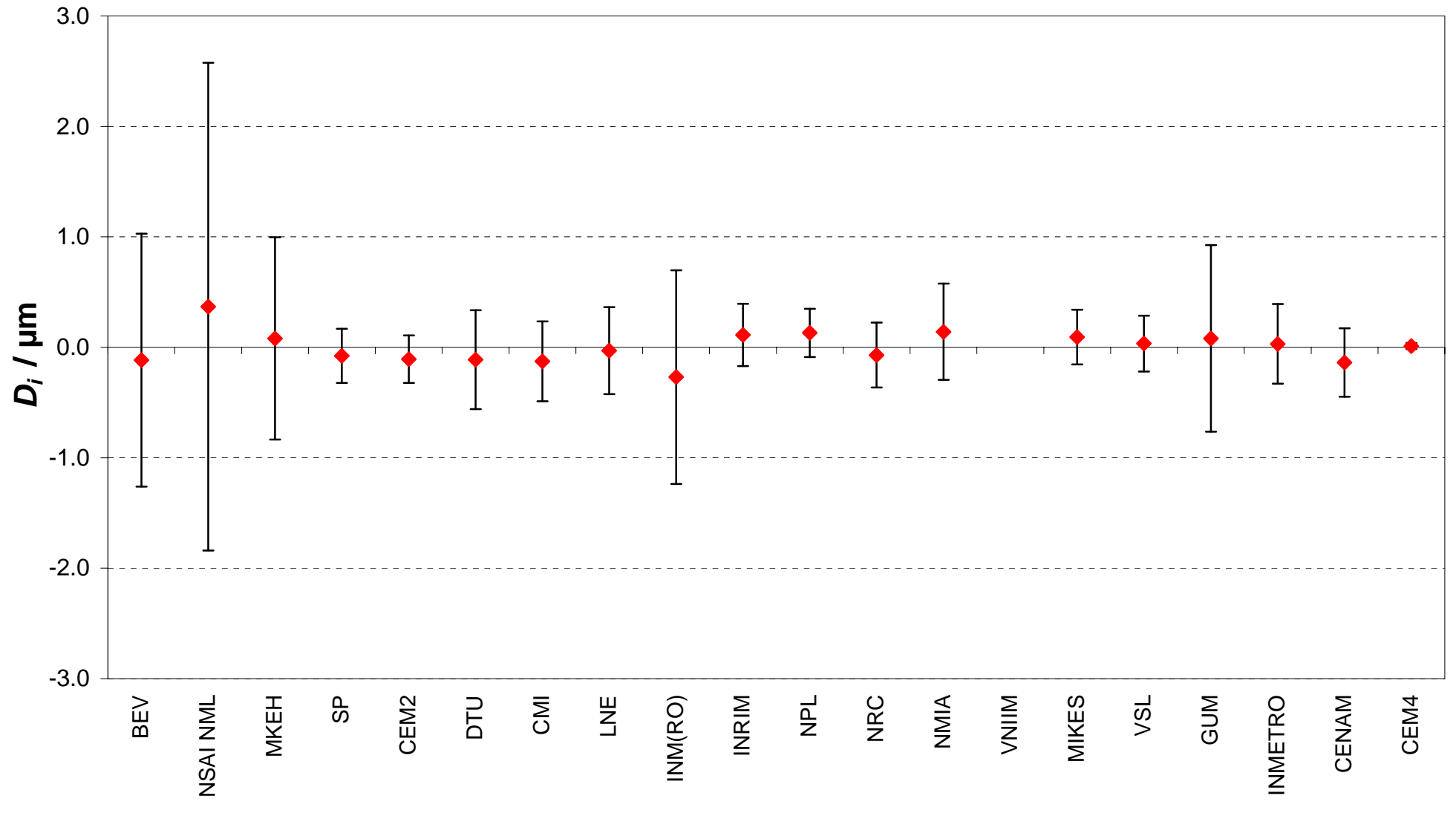Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i

EUROMET.L-K5.2004   Gauge 2 - 40 mm
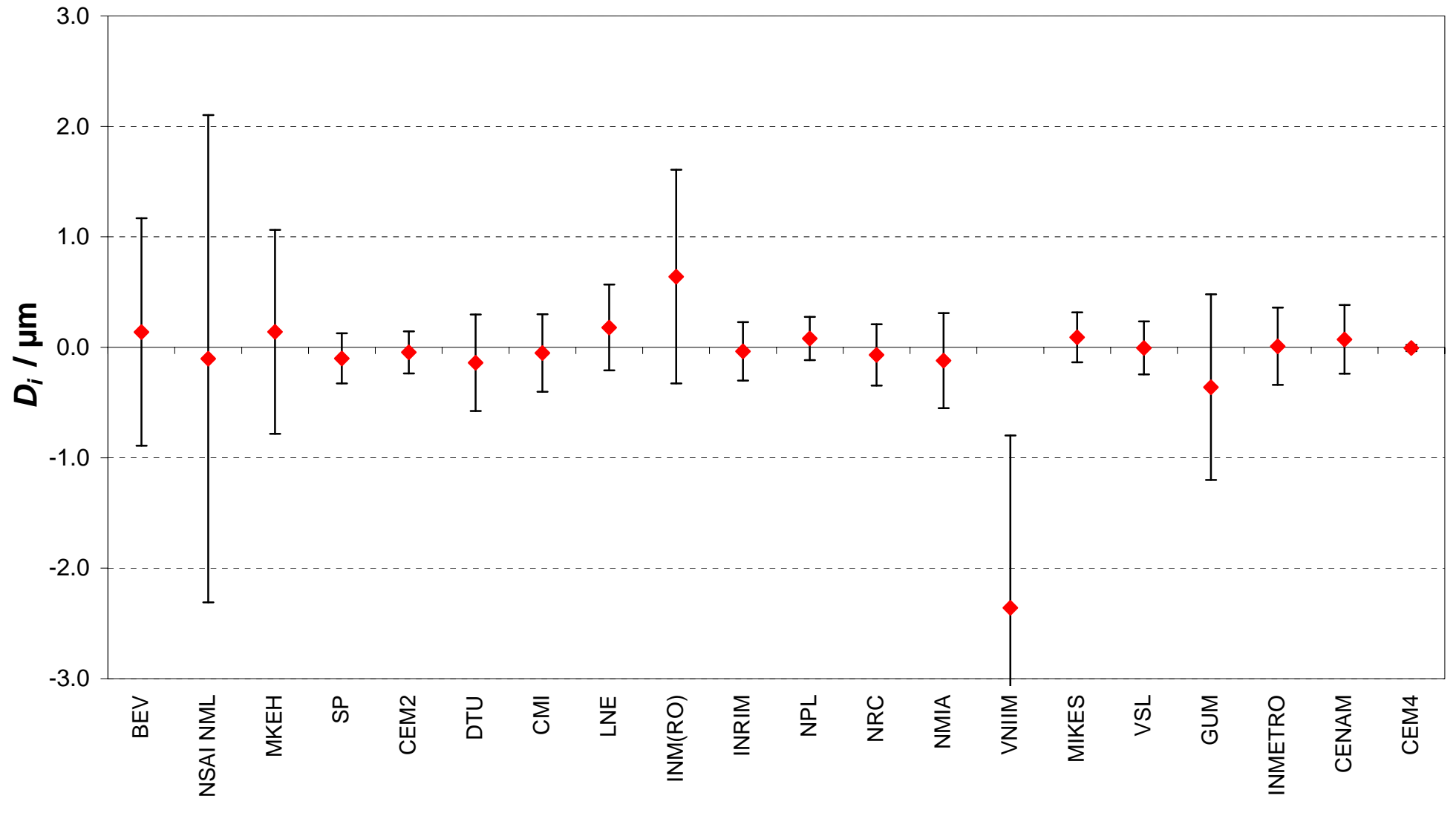## Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i

$D_{VNIIM} = -12.48$ µm $U_{VNIIM} = 1.55$ µm

EUROMET.L-K5.2004   Gauge 2 - 60 mm
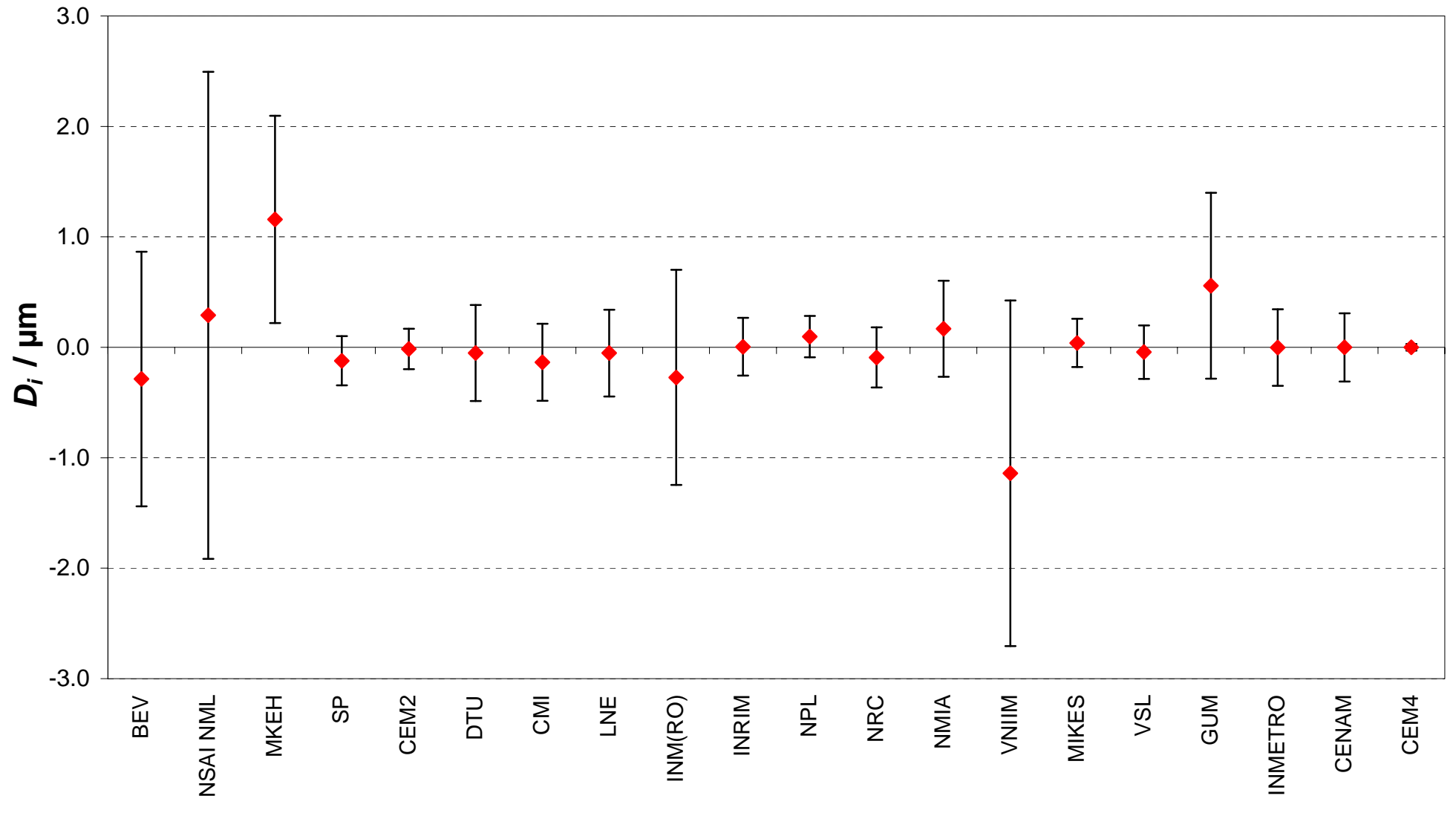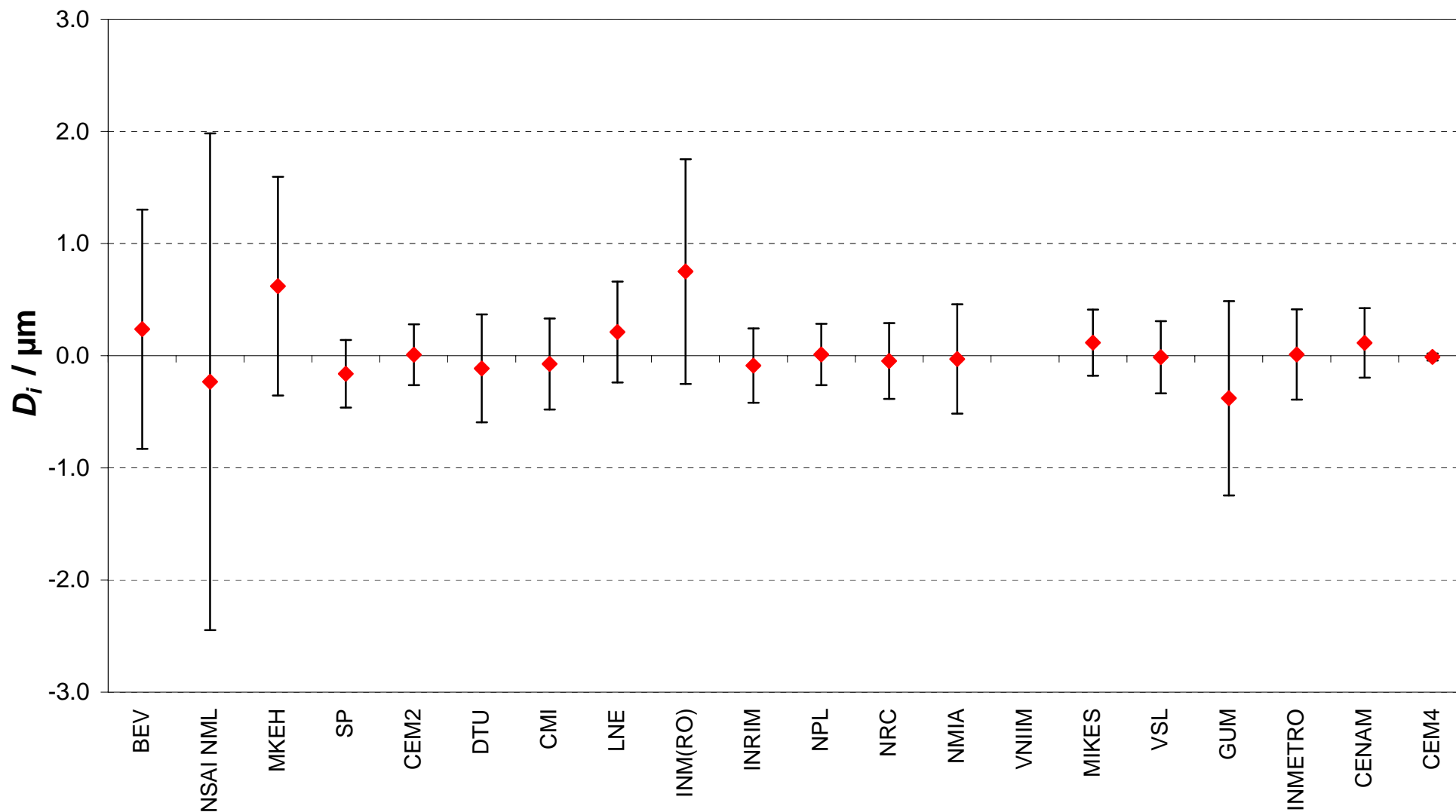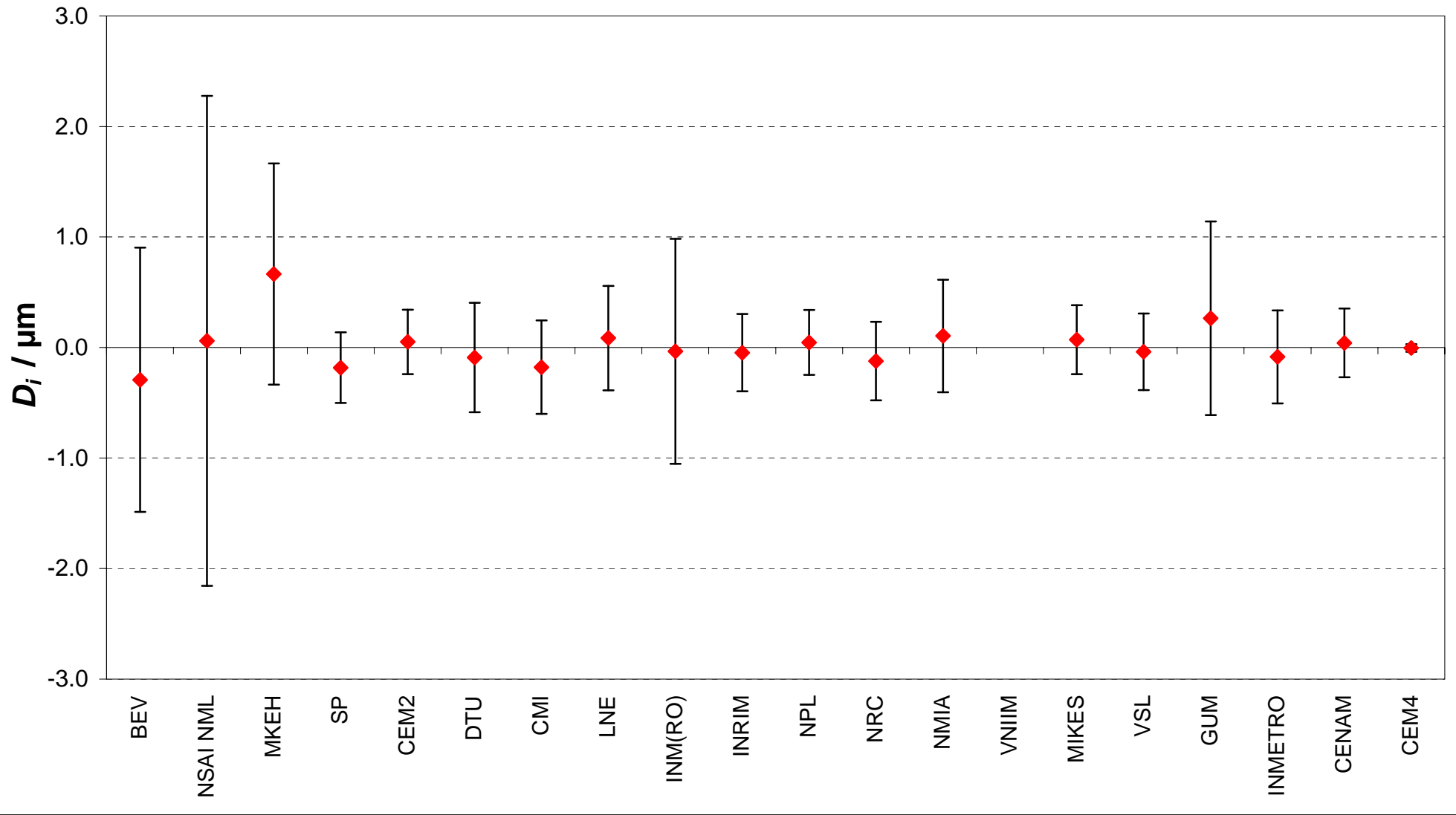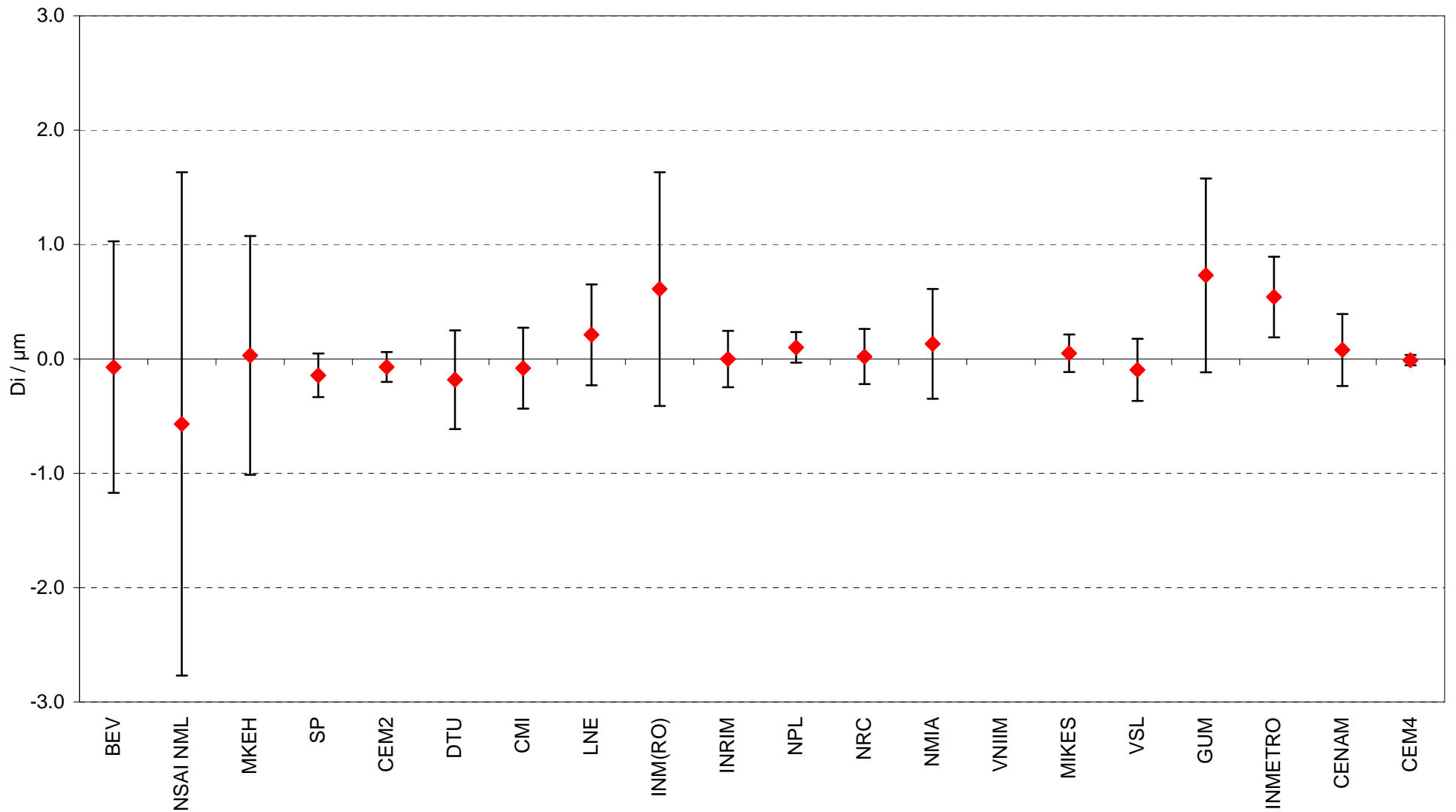## Degrees of equivalence: D_i and its expanded uncertainty (k = 2) U_i

D_{VNIIM} = -10.71 µm U_{VNIIM} = 1.56 µm

EUROMET.L-K5.2004   Gauge 3 - 80 mm

Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i

EUROMET.L-K5.2004   Gauge 3 - 100 mm

Degrees of equivalence: D_i and its expanded uncertainty (k = 2) U_i
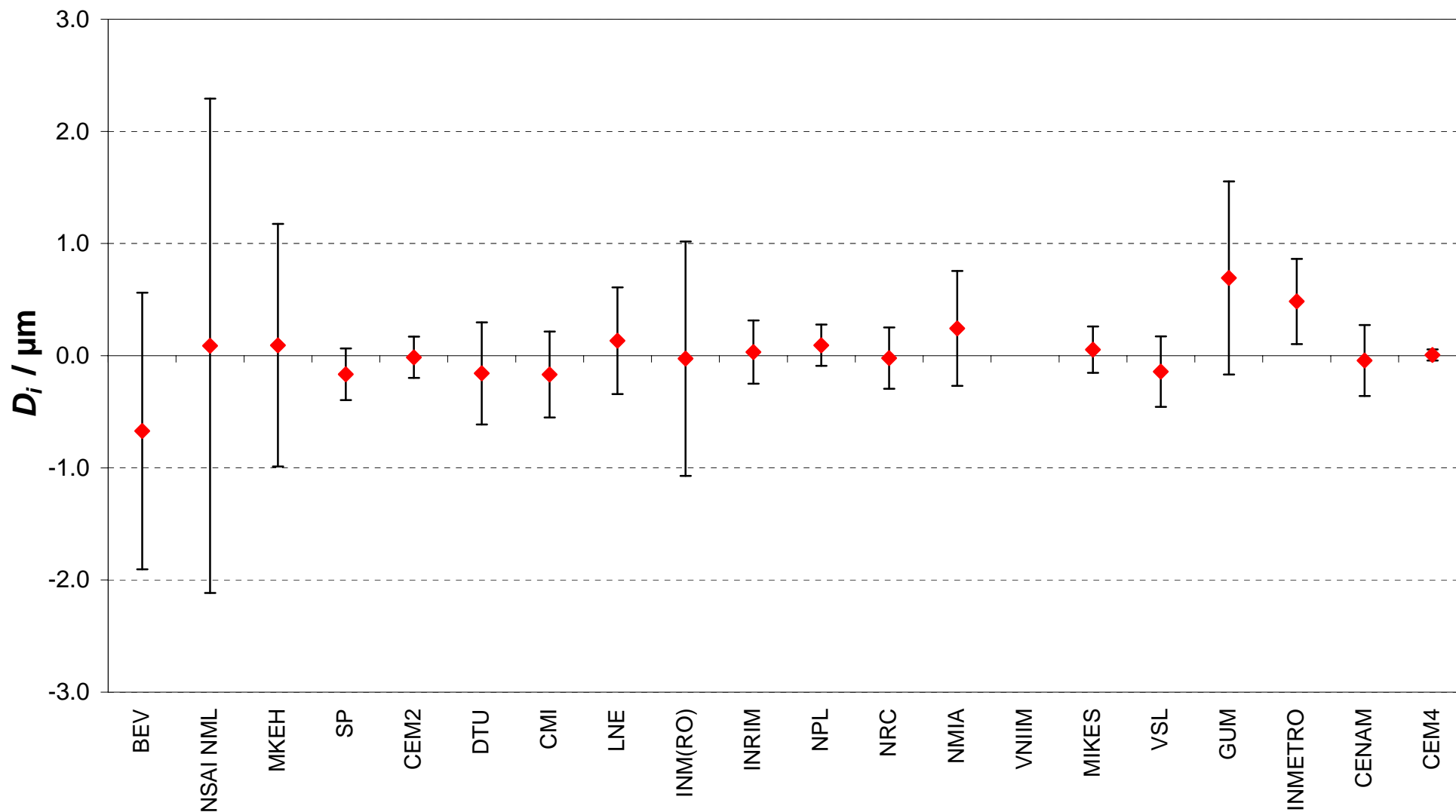
EUROMET.L-K5.2004   Gauge 4 - 120 mm

Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i
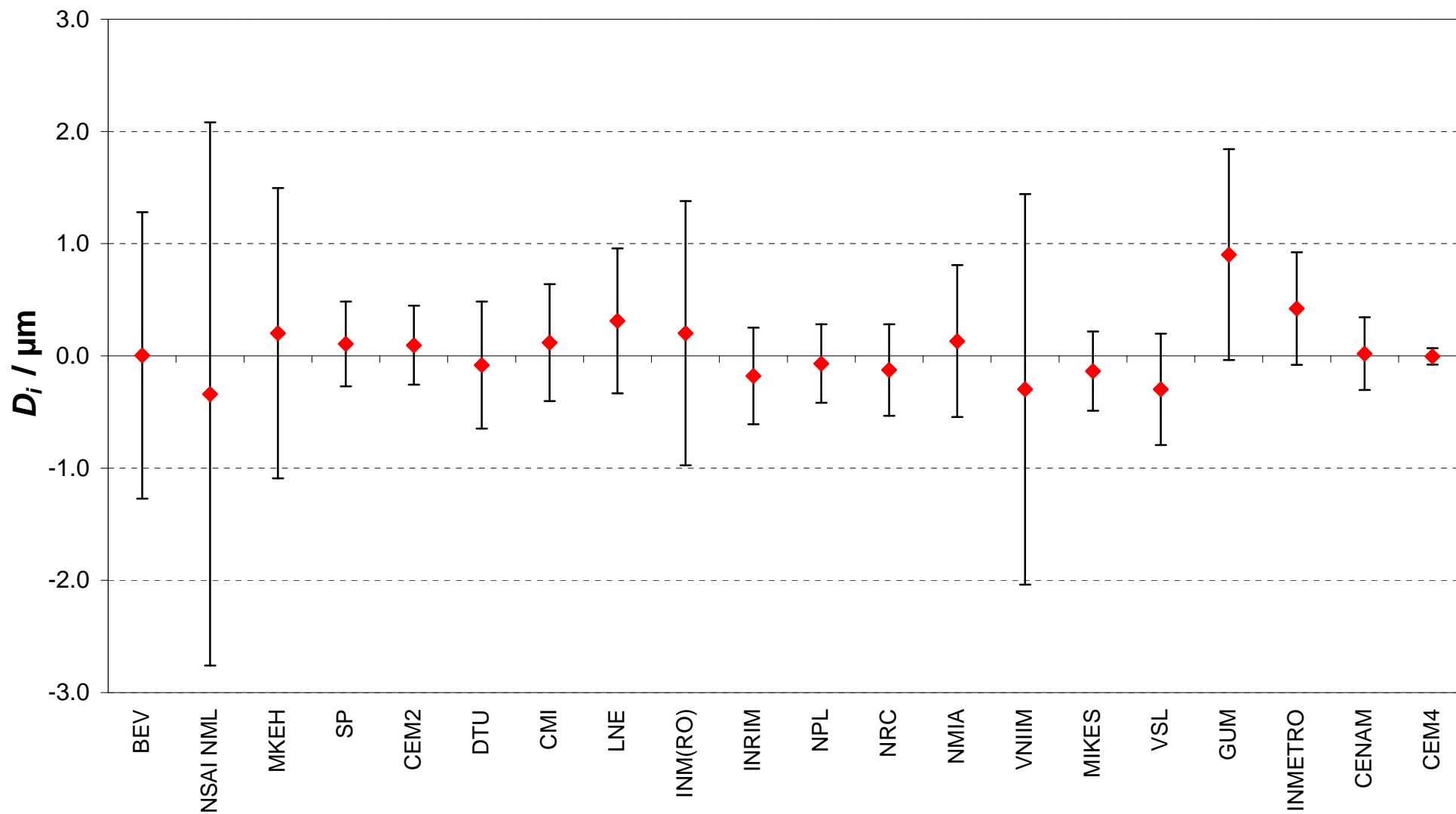
$D_{\text{VNIIM}} = 12.31\ \mu m$ $U_{\text{VNIIM}} = 1.58\ \mu m$

EUROMET.L-K5.2004   Gauge 4 - 140 mm
Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i

D_{VNIIM} = 13.15 µm U_{VNIIM} = 1.60 µm

EUROMET.L-K5.2004   Gauge 6 - 200 mm
Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i

$D_{VNIIM} = 7.22\ \mu m$ $U_{VNIIM} = 1.61\ \mu m$

EUROMET.L-K5.2004　　Gauge 6 - 220 mm

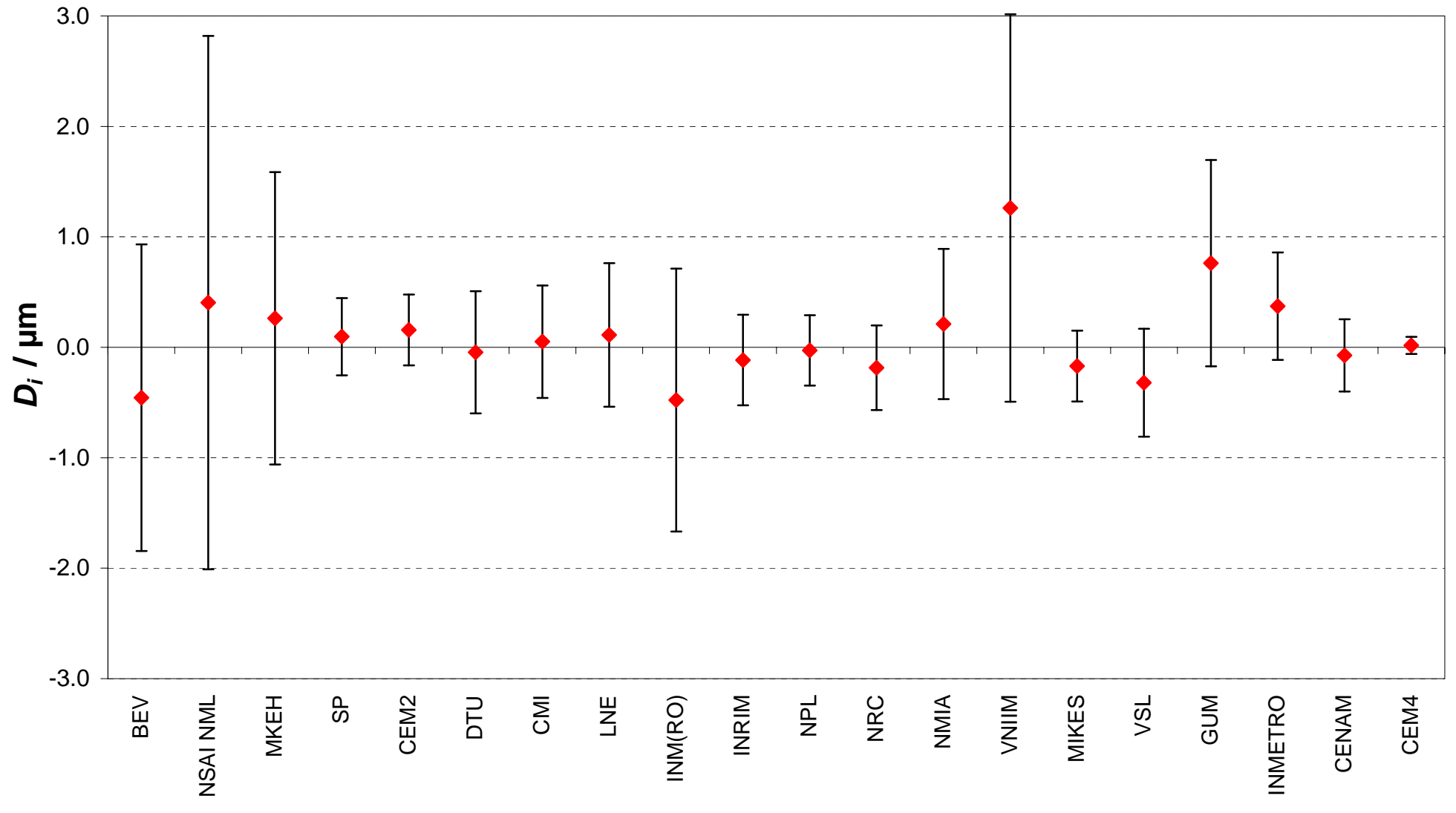## Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i

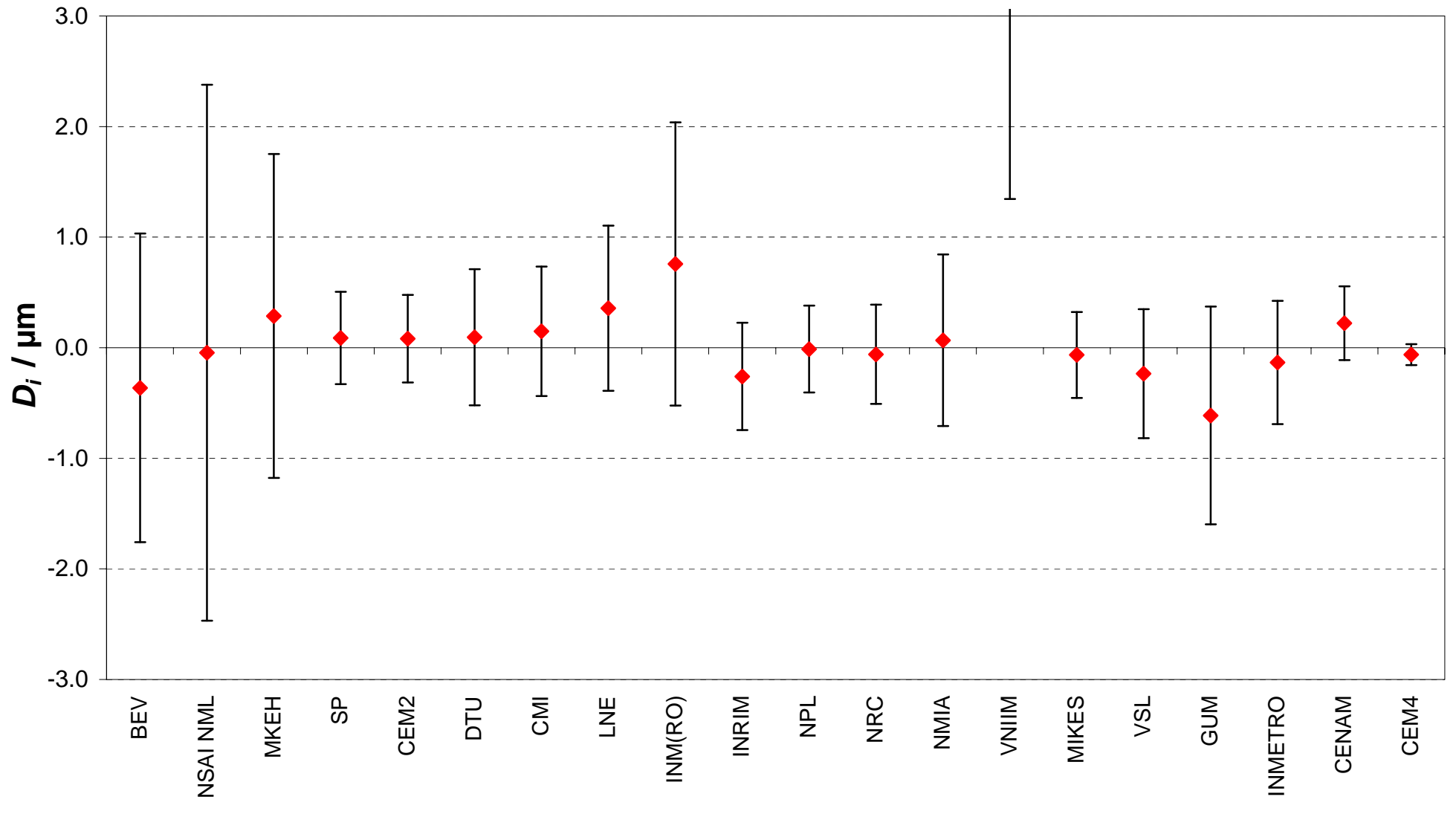$D_{VNIIM} = 7.48\ \mu m$　　　　$U_{VNIIM} = 1.63\ \mu m$

EUROMET.L-K5.2004   Gauge 9 - 320 mm

Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i

EUROMET.L-K5.2004   Gauge 9 - 340 mm

Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i

EUROMET.L-K5.2004   Gauge 11 - 400 mm

Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i

D_{VNIIM} = 3.18 µm U_{VNIIM} = 1.83 µm

EUROMET.L-K5.2004   Gauge 11 - 420 mm
Degrees of equivalence: D_i and its expanded uncertainty ($k = 2$) U_i