

CCEM.RF-K8.CL, EUROMET.EM.RF-K8.CL and EUROMET.EM.RF-K8.1.CL

MEASURAND : Calibration factor in coaxial 7 mm transmission line

NOMINAL VALUE : 1.00

FREQUENCY : 10 MHz, 50 MHz, 1 GHz, 4 GHz, 8 GHz, 12 GHz, 15 GHz, and 18 GHz

TRAVELLING STANDARDS: thermistor mounts of type-N connector and type-PC7 connector

The actual calibration factors of the devices under test are not relevant for the quality of the measurement results. For each of the devices under test, the results are given as the difference between the laboratory result and the relevant key comparison reference value.

Key comparison CCEM.RF-K8.CL

TRAVELLING STANDARDS : 3 thermistor mounts identified as TM1, TM2, and TM3

TM1 and TM3 have a male type N 50 ohm connector, TM2 has a PC7-connector (For more details see pages 5 and 6 of the Final Report)

For each frequency and for each travelling standard, the key comparison reference value,  $x_R$ , is obtained as the unweighted average of the results of a number of selected laboratories (see section 7.2 on page 17 of the Final Report). The standard uncertainty,  $u_R$ , of the key comparison reference value is the standard deviation of the mean.  $x_R$  and  $u_R$  are dimensionless quantities. Results are reported here for three values of the frequency, 10 MHz, 4 GHz and 18 GHz.

Travelling standard	10 MHz		4 GHz		18 GHz	
	$x_R$	$u_R$	$x_R$	$u_R$	$x_R$	$u_R$
TM1	0.9681	0.0018	0.9818	0.0010	0.9391	0.0021
TM2	0.9645	0.0023	0.9829	0.0011	0.9434	0.0017
TM3	0.9640	0.0030	0.9790	0.0004	0.9307	0.0016

For each frequency and for each travelling standard of type-N connector (TM1 et TM3), the degree of equivalence of laboratory  $i$  with respect to the reference value is given by a pair of terms, both dimensionless:

$D_{TMn i}$  = the difference between laboratory  $i$  result and  $x_R$ , and  $U_{TMn i}$ , its expanded uncertainty taking into account  $u_R$  ( $n = 1$  or  $3$ ).

These are combined to obtain the degree of equivalence of laboratory  $i$  for type-N connector, using the following expressions:

$$D_i = \text{avg}(D_{TM1 i}, D_{TM3 i}) \text{ and } U_i = \left[ [\text{avg}(U_{TM1 i}, U_{TM3 i})]^2 + [\text{abs}(D_{TM1 i} - D_{TM3 i})/2]^2 \right]^{1/2}.$$

For each frequency and for the travelling standard of type-PC7 connector (TM2) the degree of equivalence of laboratory  $i$  with respect to the reference value is given by a pair of terms, both dimensionless:

$D_i$  = the difference between laboratory  $i$  result and  $x_R$ , and  $U_i$ , its expanded uncertainty taking into account  $u_R$ .

The degree of equivalence between two laboratories  $i$  and  $j$  is given by a pair of terms, both dimensionless:

$$D_{ij} = (D_i - D_j) \text{ and } U_{ij}, \text{ its expanded uncertainty } (k = 2), U_{ij} = (U_i^2 + U_j^2)^{1/2}.$$

The pair-wise degrees of equivalence are not explicitly calculated.

#### **Linking EUROMET.EM.RF-K8.CL key comparison to CCEM.RF-K8.CL**

##### **TRAVELLING STANDARDS FOR EUROMET.EM.RF-K8.CL : 3 thermistor mounts identified as TM4, TM5, and TM6**

TM4 and TM6 have a male type N 50 ohm connector, TM5 has a PC7-connector (For more details see pages 4 and 5 of the EUROMET Final Report)

The laboratories that are participant in both comparisons and which have an independent realisation of the quantity power are used in the process of linking the results obtained in EUROMET.EM.RF-K8.CL to the results obtained in CCEM.RF-K8.CL.

There are four linking laboratories (NPL, INRIM, NRC and NMi-VSL) for the type-N device and two linking laboratories (NMi-VSL and NRC) for the type PC-7 device. The linking process is explained in section 5 of the Linkage Report for the N-type device and in section 6 of the Linkage Report for the PC-7 device.

It follows that the degrees of equivalence and the graphs of equivalence obtained for CCEM.RF-K8.CL are extended with results obtained in EUROMET.EM.RF-K8.CL.

#### **Linking EUROMET.EM.RF-K8.1.CL key comparison to CCEM.RF-K8.CL**

##### **TRAVELLING STANDARDS FOR EUROMET.EM.RF-K8.1.CL: 2 thermistor mounts identified as DUT1 and DUT2**

DUT1 and DUT2 have a male type N 50 ohm connector

The NMi-VSL is the pilot laboratory of the bilateral comparison EUROMET.EM.RF-K8.1.CL by which the results of MIKES participant in EUROMET.EM.RF-K8.1.CL are linked to those obtained in EUROMET.EM.RF-K8.CL (see EUROMET.EM.RF-K8.1.CL Final Report).

It follows that the degrees of equivalence and the graphs of equivalence obtained for CCEM.RF-K8.CL are extended with results of MIKES obtained in EUROMET.EM.RF-K8.1.CL.

CCEM.RF-K8.CL, EUROMET.EM.RF-K8.CL and EUROMET.EM.RF-K8.1.CL

MEASURAND : Calibration factor in coaxial 7 mm transmission line

NOMINAL VALUE : 1.00

FREQUENCY : 10 MHz

Lab <i>i</i>	Type-N		PC7	
	$D_i$	$U_i$	$D_i$	$U_i$
INRIM	0.0070	0.0255	N/A	
INTA	0.0027	0.0159	-0.0053	0.0254
SMU	-	-	N/A	
METAS *	-0.0035	0.0106	-0.0008	0.0083
CMI	-0.0021	0.0108	N/A	
OMH	0.0048	0.0110	0.0086	0.0110
PTB *	0.0043	0.0047	0.0077	0.0052
NPL	0.0035	0.0109	0.0045	0.0196
NMi-VSL	-0.0057	0.0091	-0.0064	0.0075
CSIR-NML	-0.0015	0.0173	-0.0005	0.0166
UME	-0.0058	0.0186	-0.0059	0.0184
MIRS/SIQ	0.0050	0.0095	-	-
LNE *	0.0000	0.0083	0.0015	0.0086
NIST	-0.0105	0.0084	-0.0104	0.0081
NMIA	0.0040	0.0069	0.0065	0.0063
KRISS *	0.0083	0.0049	-0.0003	0.0059
NMIJ *	-0.0049	0.0104	-0.0034	0.0105
NRC	-0.0365	0.0104	-	-
NIM	-0.0021	0.0112	N/A	
SPRING Singapore *	0.0029	0.0145	-0.0132	0.0110
NPL	0.0002	0.0206	N/A	
INRIM	0.0236	0.0207	N/A	
METAS	0.0064	0.0236	0.0151	0.0298
NMi-VSL	-0.0019	0.0225	0.0086	0.0292
NRC	-0.0258	0.0208	-0.0206	0.0292
SMU	0.0053	0.0268	N/A	
SP	-	-	N/A	
MIKES	-0.0001	0.0125	N/A	

**TRAVELLING STANDARDS FOR CCEM.RF-K8.CL:**

**3 thermistor mounts identified as TM1, TM2, and TM3**

The results from TM1 and TM3 are combined under the heading Type-N

The result from TM2 is reported under the heading PC7

**TRAVELLING STANDARDS FOR EUROMET.EM.RF-K8.CL:**

**3 thermistor mounts identified as TM4, TM5, and TM6**

The results from TM4 and TM6 are combined under the heading Type-N

The result from TM5 is reported under the heading PC7

**TRAVELLING STANDARDS FOR EUROMET.EM.RF-K8.1.CL:**

**2 thermistor mounts identified as DUT1 and DUT2**

The results from DUT1 and DUT2 are combined under the heading Type-N

- : no measurements on the specified device at this frequency

N/A : not applicable (no measurements at all on the specified device)

\*: TM3 was not measured

In blue: participants in EUROMET.EM.RF-K8.CL

In green: participant in EUROMET.EM.RF-K8.1.CL

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MEASURAND : Calibration factor in coaxial 7 mm transmission line  
 NOMINAL VALUE : 1.00 FREQUENCY : 4 GHz

Lab <i>i</i>	Type-N		PC7	
	$D_i$	$U_i$	$D_i$	$U_i$
INRIM	0.0016	0.0059	N/A	
INTA	0.0010	0.0091	-0.0006	0.0152
SMU	-	-	N/A	
METAS *	-0.0094	0.0122	-0.0008	0.0083
CMI	-0.0028	0.0049	N/A	
OMH	0.0046	0.0112	-0.0012	0.0110
PTB *	-0.0036	0.0037	-0.0003	0.0032
NPL	0.0036	0.0176	0.0051	0.0248
NMi-VSL	0.0003	0.0083	-0.0030	0.0072
CSIR-NML	0.0071	0.0196	0.0071	0.0211
UME	0.0016	0.0081	0.0050	0.0127
MIRS/SIQ	0.0086	0.0107	0.0121	0.0102
LNE *	-0.0021	0.0059	0.0038	0.0042
NIST	-0.0004	0.0031	0.0020	0.0043
NMIA	-0.0004	0.0042	-0.0009	0.0045
KRISS *	0.0013	0.0047	0.0005	0.0036
NMIJ *	-0.0028	0.0101	-0.0023	0.0099
NRC	-0.0062	0.0046	-0.0052	0.0039
NIM	0.0016	0.0064	N/A	
SPRING Singapore *	0.0052	0.0073	0.0023	0.0073
NPL	0.0023	0.0029	N/A	
INRIM	-0.0013	0.0162	N/A	
METAS	0.0045	0.0141	-0.0020	0.0081
NMi-VSL	0.0024	0.0069	-0.0033	0.0015
NRC	0.0013	0.0039	-0.0047	0.0015
SMU	0.0011	0.0151	N/A	
SP	0.0021	0.0067	N/A	
MIKES	0.0021	0.0121	N/A	

**TRAVELLING STANDARDS FOR CCEM.RF-K8.CL:**

**3 thermistor mounts identified as TM1, TM2, and TM3**

The results from TM1 and TM3 are combined under the heading Type-N  
 The result from TM2 is reported under the heading PC7

**TRAVELLING STANDARDS FOR EUROMET.EM.RF-K8.CL:**

**3 thermistor mounts identified as TM4, TM5, and TM6**

The results from TM4 and TM6 are combined under the heading Type-N  
 The result from TM5 is reported under the heading PC7

**TRAVELLING STANDARDS FOR EUROMET.EM.RF-K8.1.CL:**

**2 thermistor mounts identified as DUT1 and DUT2**

The results from DUT1 and DUT2 are combined under the heading Type-N

- : no measurements on the specified device at this frequency

N/A : not applicable (no measurements at all on the specified device)

\*: TM3 was not measured

In blue: participants in EUROMET.EM.RF-K8.CL

In green: participant in EUROMET.EM.RF-K8.1.CL

CCEM.RF-K8.CL, EUROMET.EM.RF-K8.CL and EUROMET.EM.RF-K8.1.CL

MEASURAND : Calibration factor in coaxial 7 mm transmission line

NOMINAL VALUE : 1.00

FREQUENCY : 18 GHz

Lab <i>i</i>	Type-N		PC7	
	$D_i$	$U_i$	$D_i$	$U_i$
INRIM	0.0216	0.0382	N/A	
INTA	-0.0081	0.0222	0.0076	0.0272
SMU	-	-	N/A	
METAS *	-0.0423	0.0244	-0.0241	0.0213
CMI	-0.0098	0.0190	N/A	
OMH	0.0007	0.0292	-	-
PTB *	-0.0078	0.0067	-0.0027	0.0053
NPL	-0.0059	0.0159	0.0036	0.0219
NMi-VSL	0.0003	0.0187	-0.0034	0.0090
CSIR-NML	-0.0004	0.0405	0.0206	0.0461
UME	-0.0010	0.0276	0.0121	0.0424
MIRS/SIQ	-0.0014	0.0230	0.0156	0.0213
LNE *	-0.0024	0.0070	0.0114	0.0054
NIST	0.0027	0.0088	-0.0019	0.0077
NMIA	0.0001	0.0065	-0.0024	0.0091
KRISS *	0.0006	0.0094	0.0002	0.0090
NMIJ *	-0.0047	0.0107	-0.0007	0.0101
NRC	-0.0015	0.0099	-0.0044	0.0071
NIM	0.0039	0.0115	N/A	
SPRING Singapore *	0.0199	0.0108	0.0020	0.0115
NPL	-0.0014	0.0121	N/A	
INRIM	0.0284	0.0414	N/A	
METAS	0.0009	0.0229	-0.0066	0.0176
NMi-VSL	0.0045	0.0159	0.0013	0.0106
NRC	-0.0091	0.0127	-0.0093	0.0106
SMU	-0.0031	0.0264	N/A	
SP	-0.0026	0.0155	N/A	
MIKES	-0.0128	0.0225	N/A	

**TRAVELLING STANDARDS FOR CCEM.RF-K8.CL:**

**3 thermistor mounts identified as TM1, TM2, and TM3**

The results from TM1 and TM3 are combined under the heading Type-N

The result from TM2 is reported under the heading PC7

**TRAVELLING STANDARDS FOR EUROMET.EM.RF-K8.CL:**

**3 thermistor mounts identified as TM4, TM5, and TM6**

The results from TM4 and TM6 are combined under the heading Type-N

The result from TM5 is reported under the heading PC7

**TRAVELLING STANDARDS FOR EUROMET.EM.RF-K8.1.CL:**

**2 thermistor mounts identified as DUT1 and DUT2**

The results from DUT1 and DUT2 are combined under the heading Type-N

- : no measurements on the specified device at this frequency

N/A : not applicable (no measurements at all on the specified device)

\*: TM3 was not measured

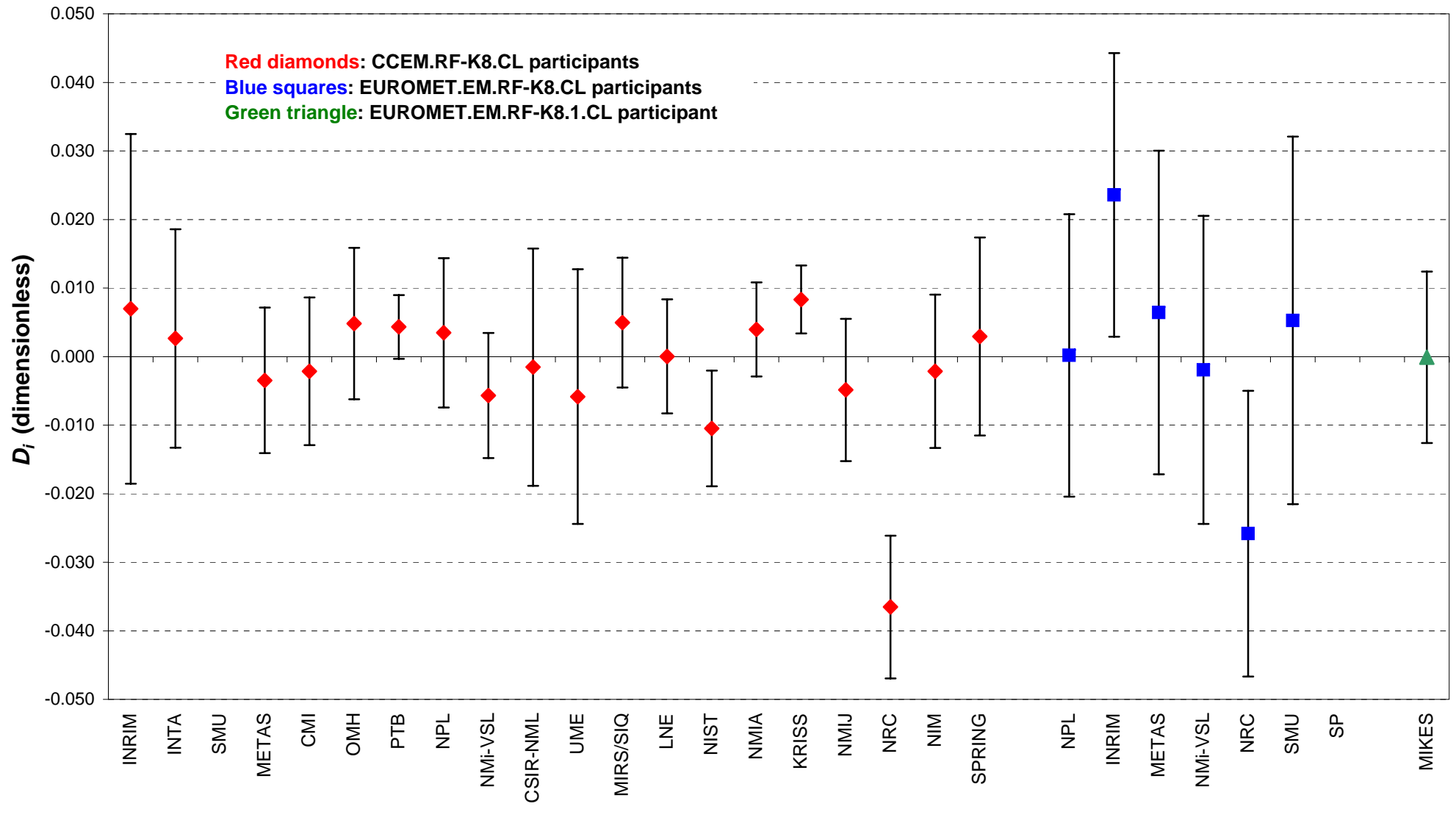
In blue: participants in EUROMET.EM.RF-K8.CL

In green: participant in EUROMET.EM.RF-K8.1.CL

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Travelling standards: Type-N

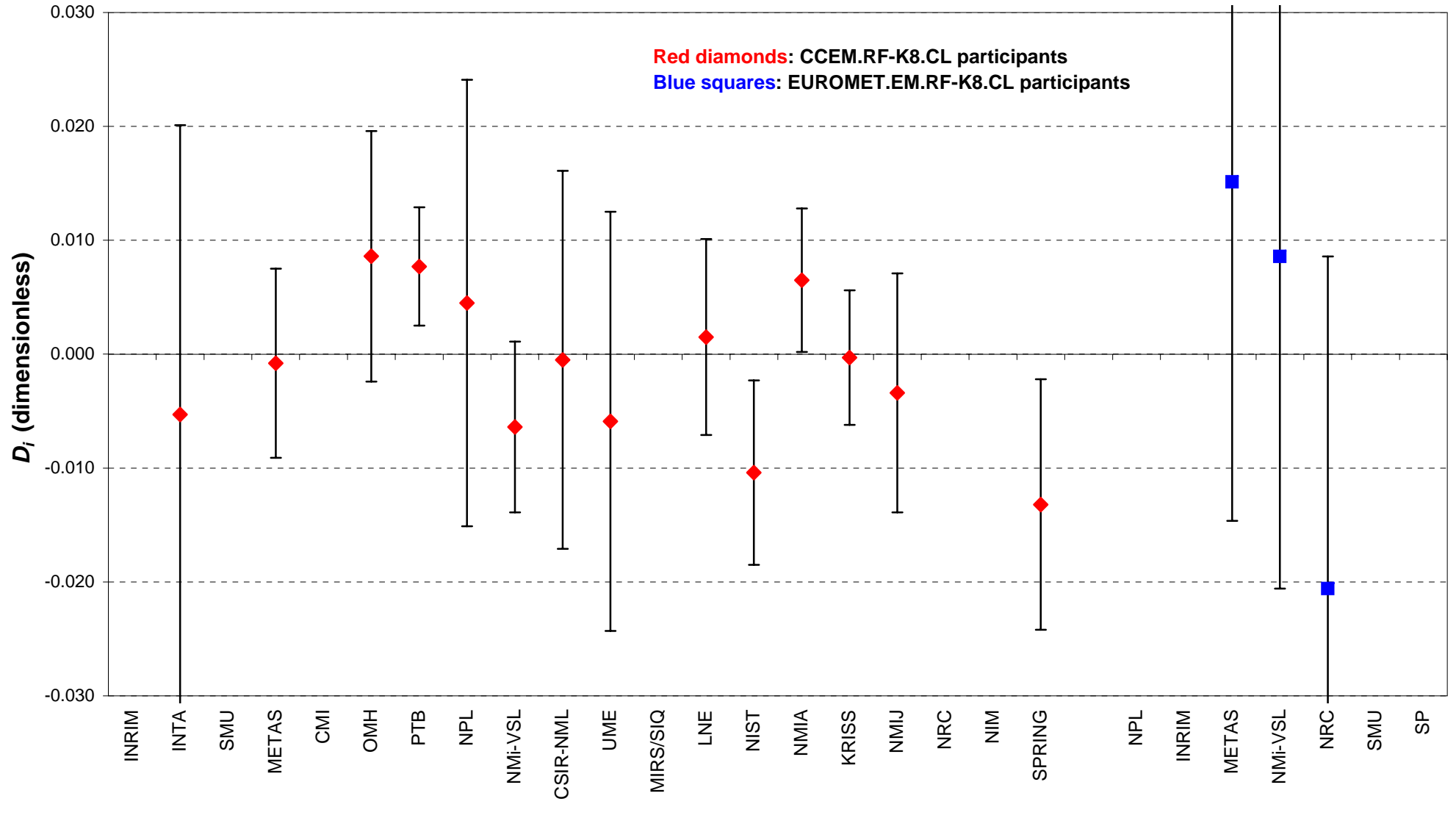
Degrees of equivalence,  $D_i$  and expanded uncertainty  $U_i$  ( $k = 2$ ), for frequency 10 MHz



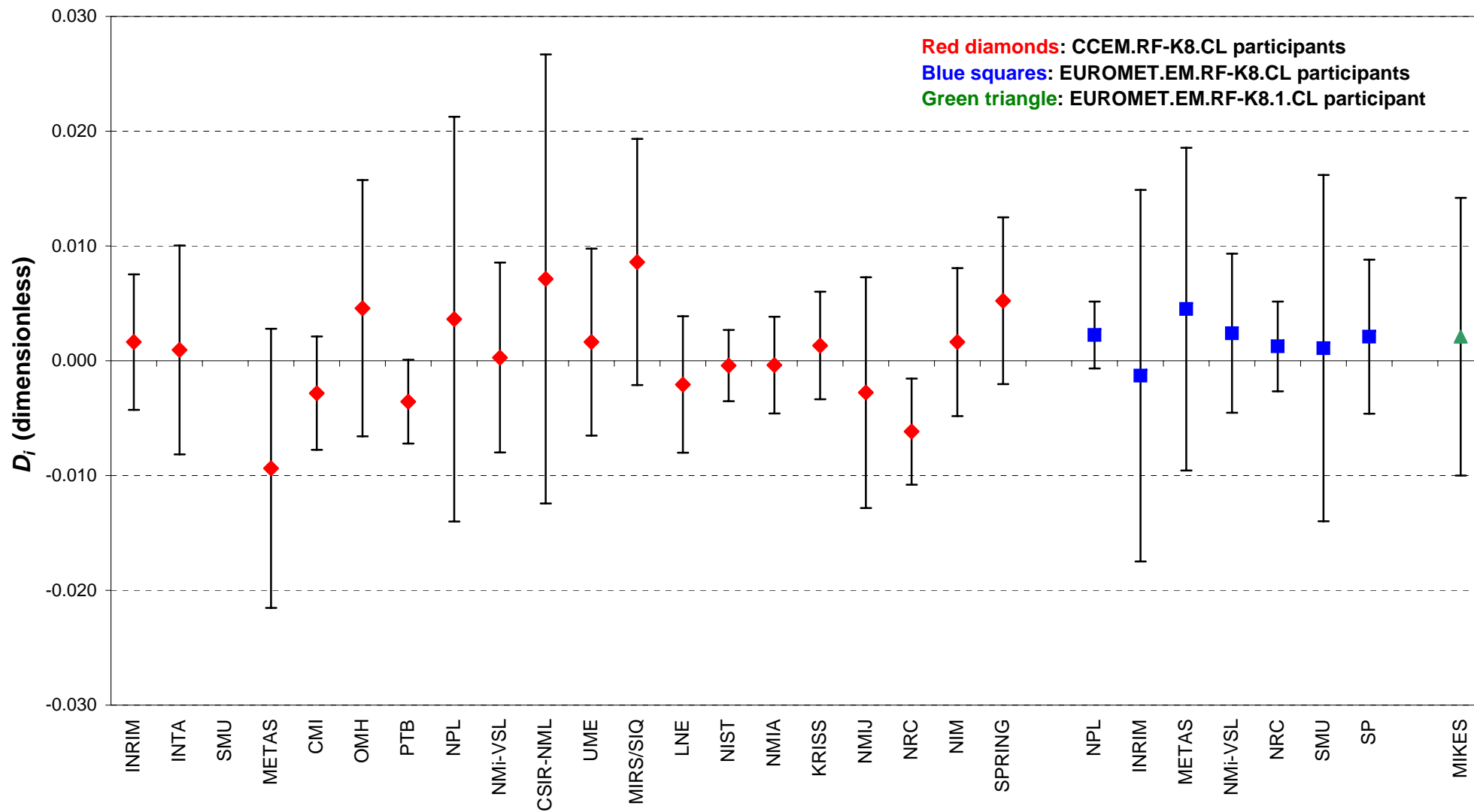
CCEM.RF-K8.CL and EUROMET.EM.RF-K8.CL

Travelling standards: PC7

Degrees of equivalence,  $D_i$  and expanded uncertainty  $U_i$  ( $k = 2$ ), for frequency 10 MHz



**CCEM.RF-K8.CL, EUROMET.EM.RF-K8.CL and EUROMET.EM.RF-K8.1.CL**  
 Travelling standards: Type-N  
 Degrees of equivalence,  $D_i$ , and expanded uncertainty  $U_i$  ( $k = 2$ ), for frequency 4 GHz

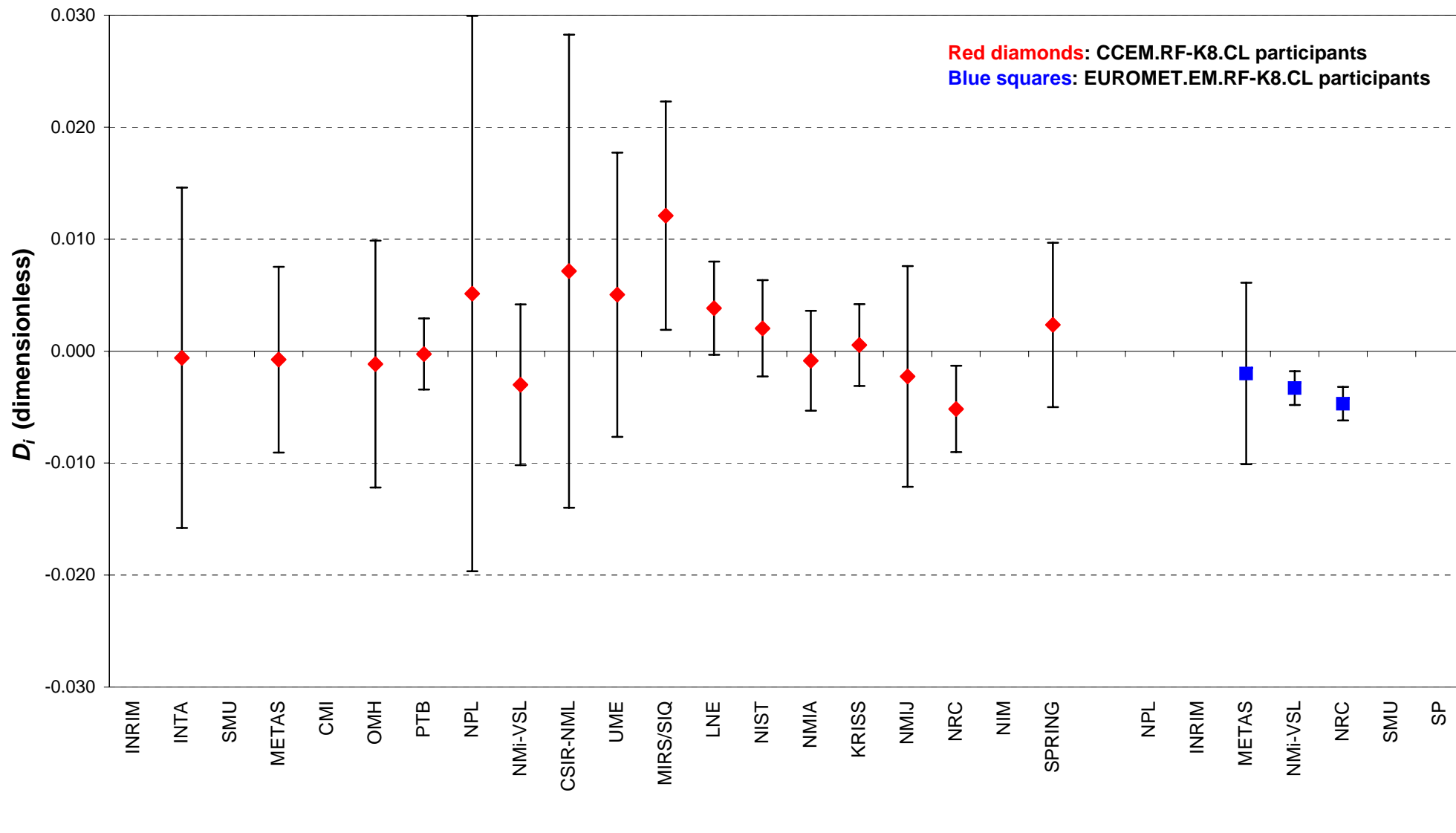




### CCEM.RF-K8.CL and EUROMET.EM.RF-K8.CL

Travelling standards: PC7

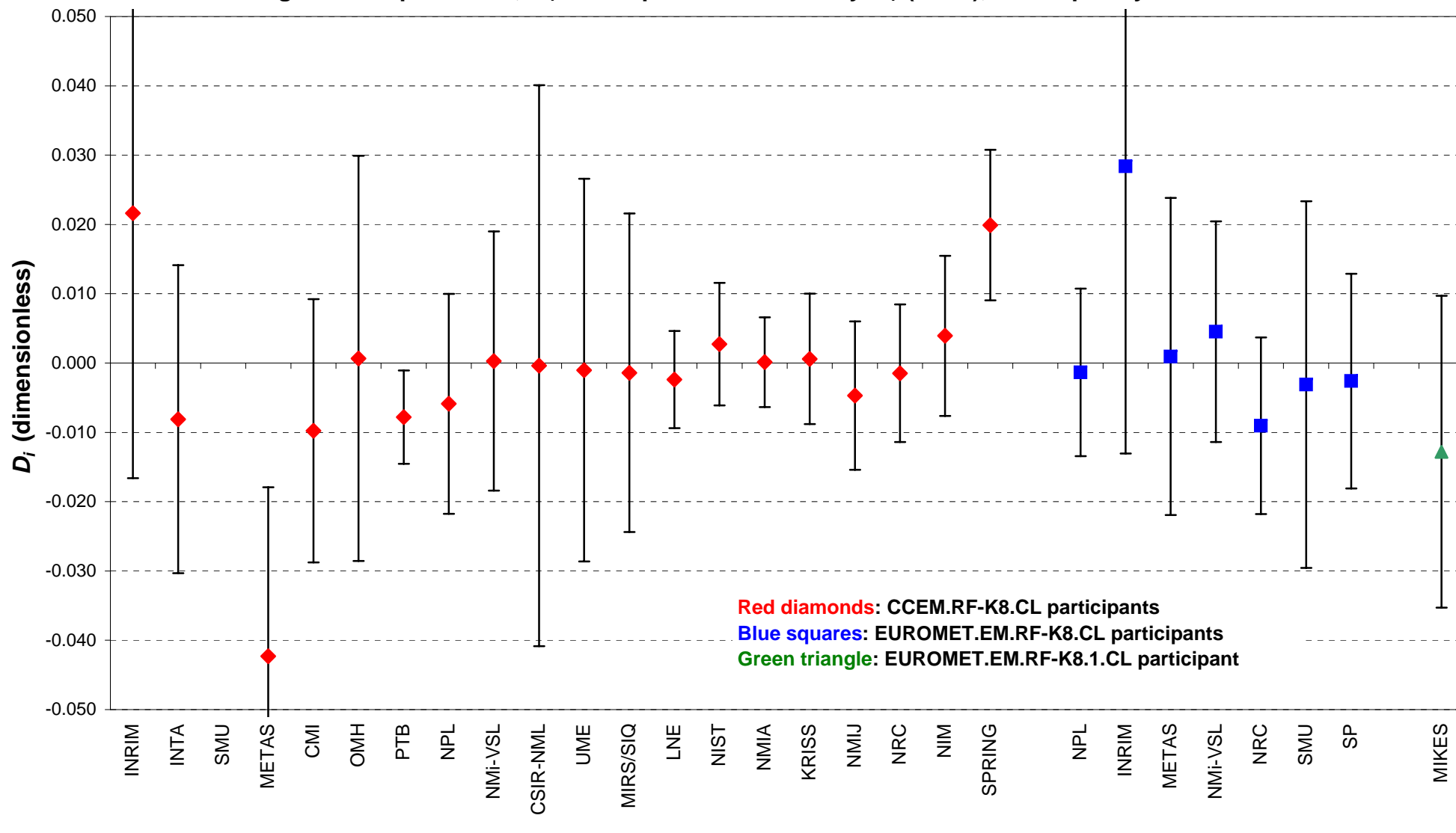
Degrees of equivalence,  $D_i$ , and expanded uncertainty  $U_i$  ( $k = 2$ ), for frequency 4 GHz



**CCEM.RF-K8.CL, EUROMET.EM.RF-K8.CL and EUROMET.EM.RF-K8.1.CL**

Travelling standards: Type-N

Degrees of equivalence,  $D_i$  and expanded uncertainty  $U_i$  ( $k = 2$ ), for frequency 18 GHz



### CCEM.RF-K8.CL and EUROMET.EM.RF-K8.CL

Travelling standards: PC7

Degrees of equivalence,  $D_i$  and expanded uncertainty  $U_i$  ( $k = 2$ ), for frequency 18 GHz

