CCL Key comparison K8

Surface roughness standards

Ongoing report on linking the comparisons

June 2018

Contents

1 Document history

Date / Version	Content	Author(s) and Institute
June 2018 Version 1.0	First draft taking into account: EURAMET.L-K8, APMP.L-K8, EURAMET.L-K8.2013	R. Thalmann, METAS

2 Introduction

At its meeting in October 2017, the CCL WG-MRA decided to report all linking actions in a separate ongoing document for each KC topic, to be updated constantly when new comparison results are available. The DG moderators are responsible for keeping these documents up to date, supported by their DG, TG-L and by the KC pilots.

3 Linking schemes

The TG-L has developed, proposed and also applied different methods for linking the results of different comparisons. The application of these methods depend on the scheme of the comparisons, which can be categorized as follows:

A. Classical, hierarchical scheme, which requires to choose one comparison as a primary to link the results of other (secondary) comparisons to the first one. This is typically the case for CIPM key comparisons considered to be "primary" and RMO key comparisons considered to be "secondary".

B. The comparisons to be linked are treated equally. This is typically the case for the CCL-RMO scheme, where RMO key comparisons are run in parallel with common participants of other RMOs. Also included in this scheme is the case, where within a comparison two loops are run in parallel and need to be linked.

The linking methods identified so far by CCL and considered to be sufficient for CIPM MRA length comparisons are:

1. Numerical linking: Propagating the key comparison reference value KCRV and its uncertainty from a higher level comparison (e.g. CIPM comparison) to a lower level comparison (e.g. RMO comparison) through the results of laboratories having participated at both levels[1]. This requires a hierarchical comparison scheme A and measurands, which do not too much depend on artefact properties, ideally primary realisations of units and national standards.

2. Visual linking: The results are typically represented on a common graph of both comparisons to be linked, showing deviations from the key comparison reference value KCRV and their uncertainty, where the KCRV is determined in each comparison. The comparisons are considered to be linked, when the results of laboratories having participated in both comparisons are consistent with the respective KCRV. It is commonly accepted to have typically two or three common participants. This method may be applied to both comparison schemes A and B, however, in case of scheme A the CIPM and the RMO comparisons are considered on an equal basis in terms of the KCRV.

3. Distributed linking: The results of two simultaneous comparisons or two parallel loops of one comparison are linked by calculating for each comparison a separate reference value, influenced by the results of common participants in both comparisons, i.e. the KCRV in

[1] Jennifer E Decker, A G Steele and R J Douglas, Measurement science and the linking of CIPM and regional key comparisons, Metrologia 45 (2008) 223–232

comparison (b) depends on the results of a common participant obtained in comparison (a) and vice versa[2]. This method is only applicable for comparisons schemes B.

The special characteristics of length comparisons which are due to unavoidable but detrimental properties of the transfer standards (such as long-term instability, degradation during use, contamination, *etc.*), puts some limitations on a strict numerical linking of length comparisons. The linking process in the field of CCL comparisons is essentially based on NMIs acting as linking laboratories which have shown a good performance in prior comparisons. By this method, linking is based on proven measurement competence of NMIs rather than on propagating of calculated KCRVs of prior comparisons.

4 Overview on K8 key comparisons

4.1 Reports of completed comparisons

The following reports on K8 key comparison reports were published so far:

Identifier	Report
APMP.L-K8	APMP.L-K8 Final Report
EURAMET.L-K8	EURAMET.L-K8 Final Report
EURAMET.L-K8.2013	EURAMET.L-K8.2013 Final Report

4.2 Timeline of the comparisons

Measurements
Final Report

Identifier	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
APMP.L-K8															
EURAMET.L-K8															
EURAMET.L-K8.2013															

4.3 Comparison artefacts and quantities suitable for linking

In each comparison, a number of different roughness standards were circulated. The protocols were designed in such a way, that best possible comparability w.r.t. artefact type and measured parameters may be achieved between the comparisons. Coloured cells in the following table might be suitable for linking.

	Type of standard, parameter (values in µm)							
Identifier	**A1, *d***	**A1, *d***	**C1, *Ra***	**C1, *Ra***	**C1, *RSm***	**C1, *RSm***	**D1, *Ra***	**D1, *Ra***
APMP.L-K8	0.4, 2.7	10	0.95	3.1	80	100	0.2	1.5
EURAMET.L-K8	1.0		0.05	3.0	7.7	100	0.07	
EURAMET.L-K8.2013	0.3, 1.3, 2.7	8.9	1.0	2.4	101	100	0.06	0.13

[2] Michael Krystek, Harald Bosse, A Bayesian approach to the linking of key comparisons, http://arxiv.org/abs/1501.07134

4.4 Common participants suitable for linking

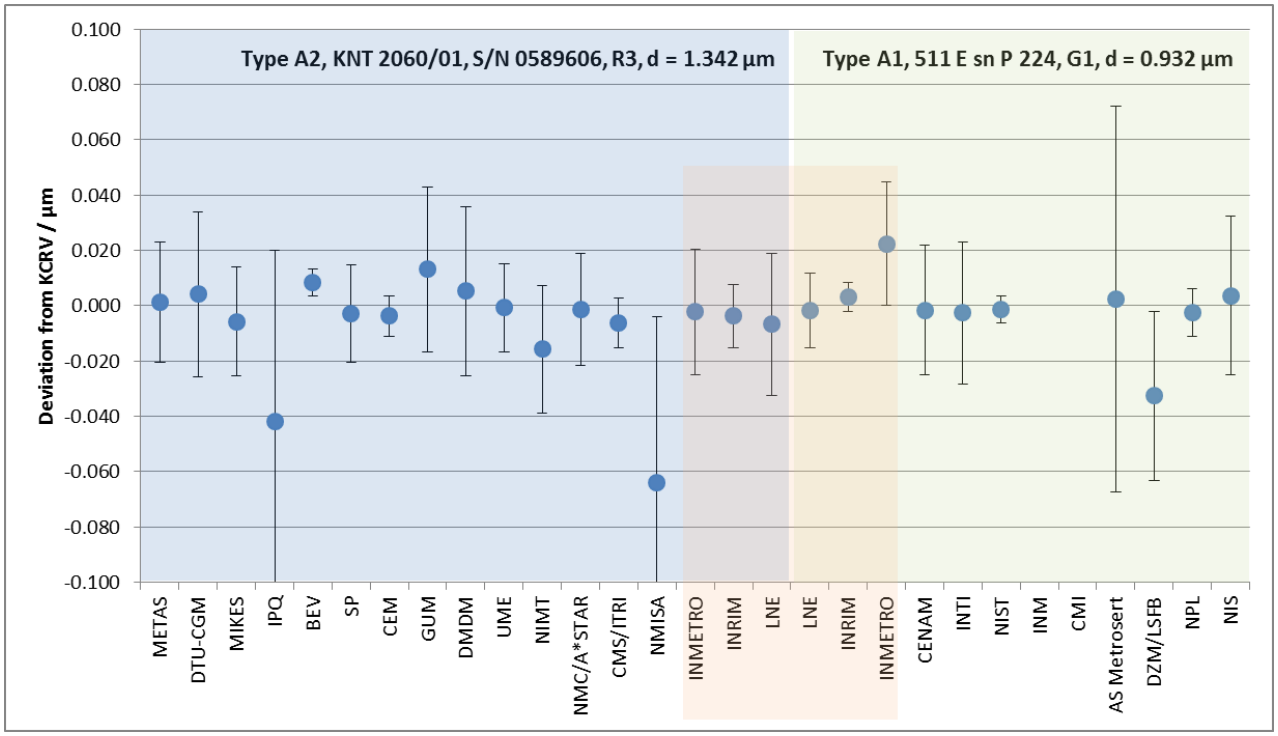
For linking the comparisons participating laboratories common to different comparisons have to be identified.

Identifier	Common participants
EURAMET.L-K8	• LNE, INRIM, INMETRO common participants to EURAMET.L-K8.2013 • NPL, NIST common participants to APMP.L-K8
APMP.L-K8	• A*STAR, CMS/ITRI, NMISA common participant to EURAMET.L-K8.2013 • NPL, NIST common participants to EURAMET.L-K8
EURAMET.L-K8.2013	• LNE, INRIM, INMETRO common participants to EURAMET.L-K8 • A*STAR, CMS/ITRI, NMISA common participant to APMP.L-K8

5 Linking of comparisons

Comparisons shall be linked pairwise by method 2 (common graph) for selected artefact types and parameters, as identified in the table of sect. 4.3. For each laboratory, the difference to the key comparison reference value KCRV and the expanded uncertainty of that difference is plotted, the respective KCRV representing the zero line in each part of the graph. Participating laboratories establishing the link according to the table in sect. 4.4 will be placed in the middle of each graph.

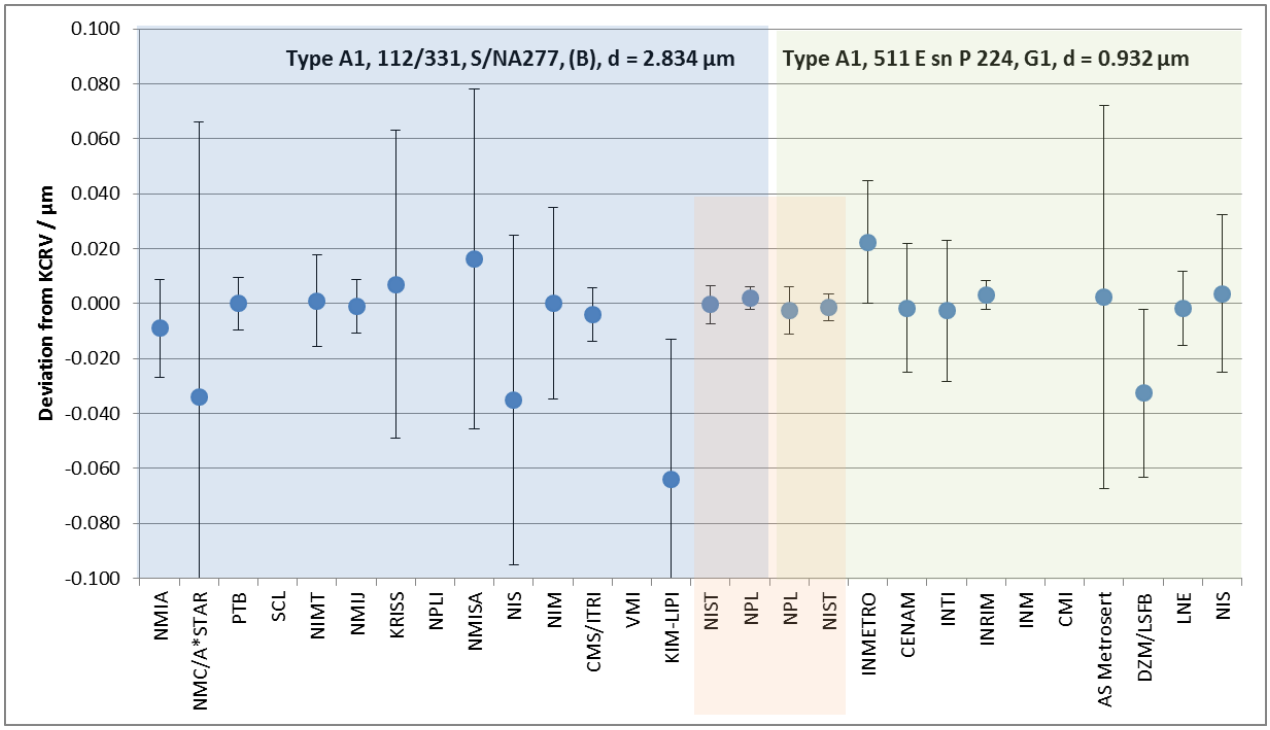
5.1 EURAMET.L-K8 vs. EURAMET.L-K8.2013 for groove depth *d* on type A standard



Linking EURAMET.L-K8.2013 and EURAMET.L-K8 for groove depth *d* on type A standard, with linking laboratories INMETRO, INRIM and LNE.

Linking is judged satisfactory: 3 linking labs with reasonably good performance.

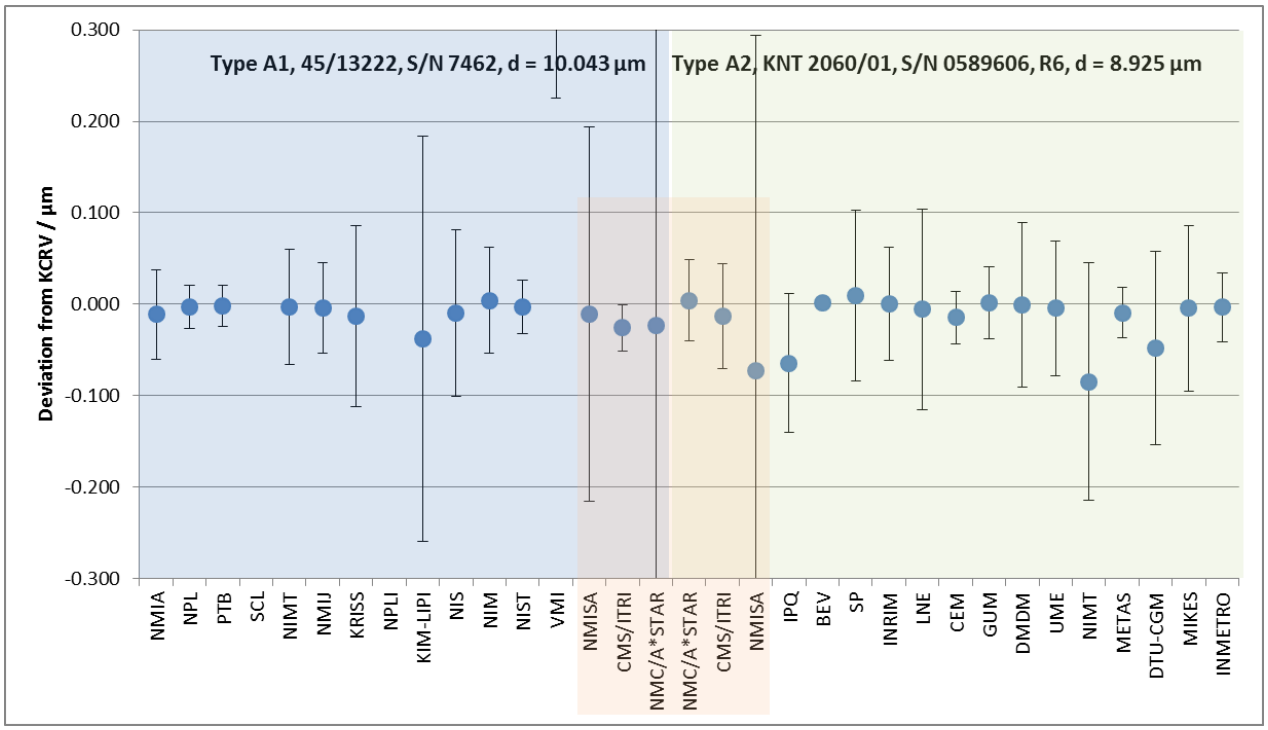
5.2 APMP.L-K8 vs. EURAMET.L-K8 for groove depth *d* on type A standard



Linking APMP.L-K8 and EURAMET.L-K8 for groove depth *d* on type A standard, with linking laboratories NIST and NPL.

Linking is judged satisfactory: 2 linking labs with good performance.

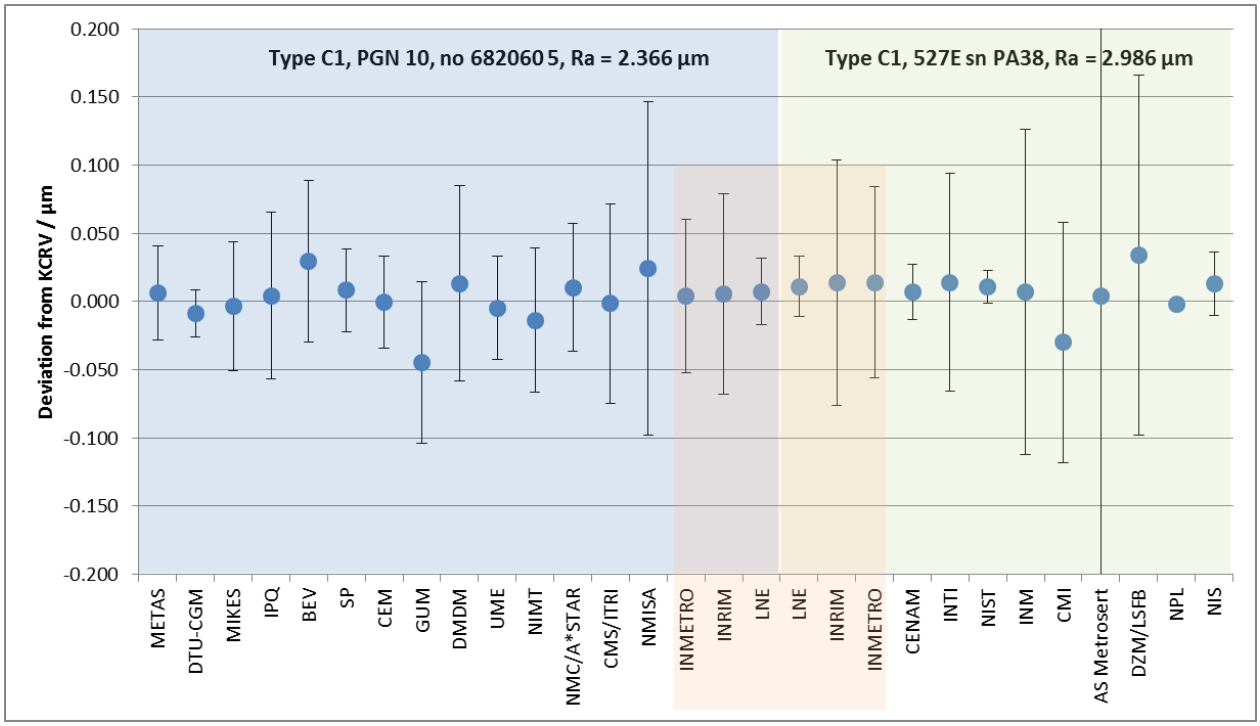
5.3 APMP.L-K8 vs. EURAMET.L-K8.2013 for groove depth *d* on type A standard



Linking APMP.L-K8 and EURAMET.L-K8.2013 for groove depth *d* on type A standard, with linking laboratory NMC/A*STAR, CMS/ITRI and NMISA.

Linking is judged satisfactory: 3 linking lab with good performance but partly large uncertainty.

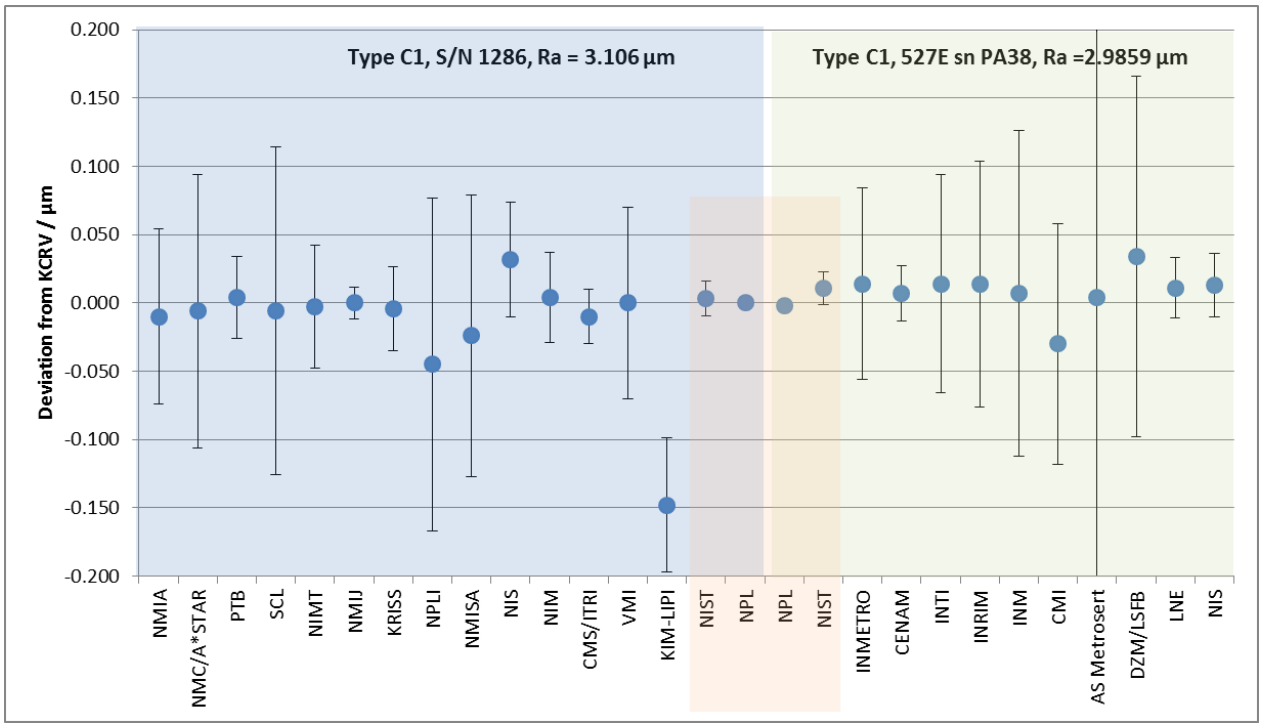
5.4 EURAMET.L-K8 vs. EURAMET.L-K8.2013 for *Ra* on type C1 standard



Linking EURAMET.L-K8.2013 and EURAMET.L-K8 for *Ra* on type C1 standard, with linking laboratories INMETRO, INRIM and LNE.

Linking is judged good: 3 linking labs with good performance.

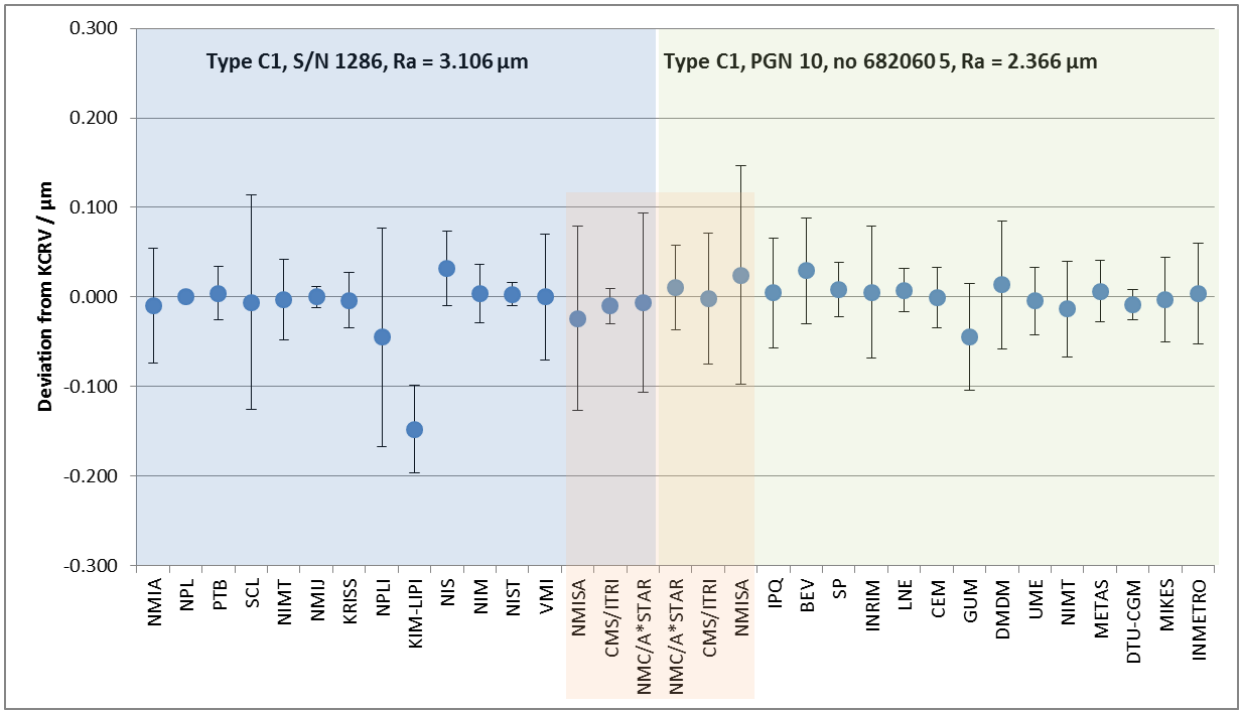
5.5 APMP.L-K8 vs. EURAMET.L-K8 for *Ra* on type C1 standard



Linking APMP.L-K8 and EURAMET.L-K8 for *Ra* on type C1 standard, with linking laboratories NIST and NPL.

Linking is judged satisfactory: 2 linking labs with reasonably good performance.

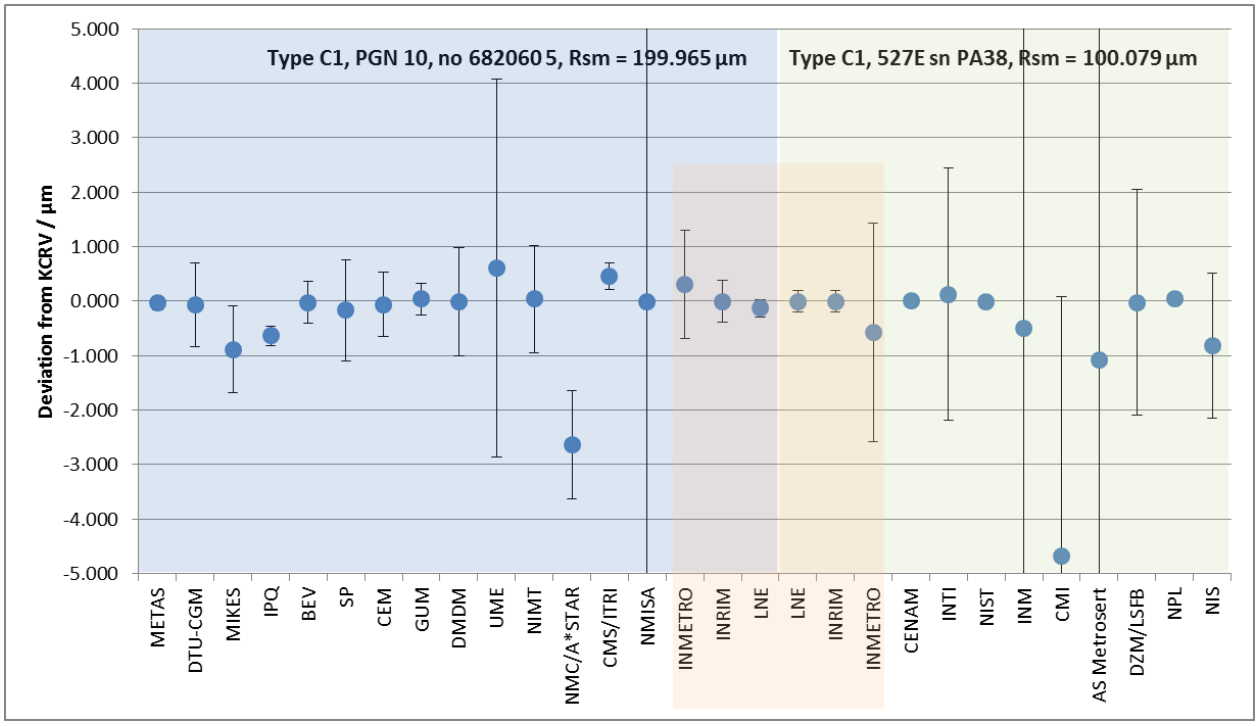
5.6 APMP.L-K8 vs. EURAMET.L-K8.2013 for *Ra* on type C1 standard



Linking APMP.L-K8 and EURAMET.L-K8.2013 for *Ra* on type C1 standard, with linking laboratory NMC/A*STAR, CMS/ITRI and NMISA..

Linking is judged good: 3 linking lab with good performance.

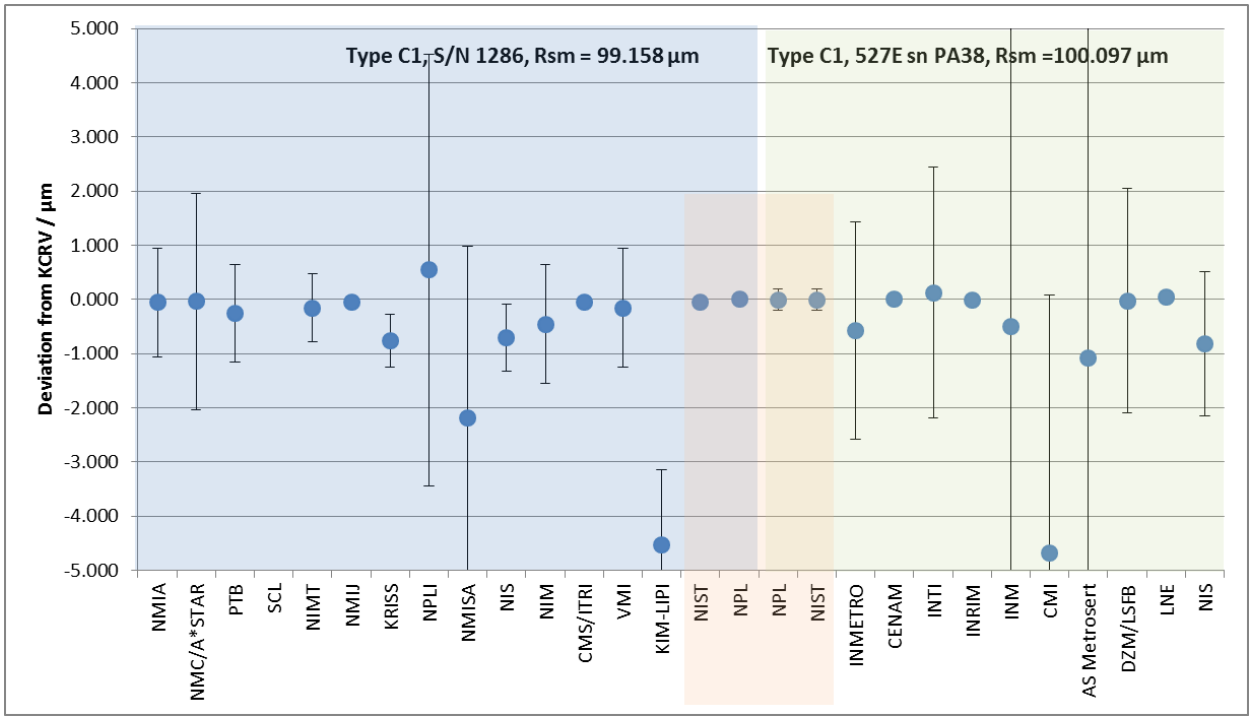
5.7 EURAMET.L-K8 vs. EURAMET.L-K8.2013 for *Rsm* on type C1 standard



Linking EURAMET.L-K8.2013 and EURAMET.L-K8 for *Rsm* on type C1 standard, with linking laboratories INMETRO, INRIM and LNE.

Linking is judged good: 3 linking labs with good performance.

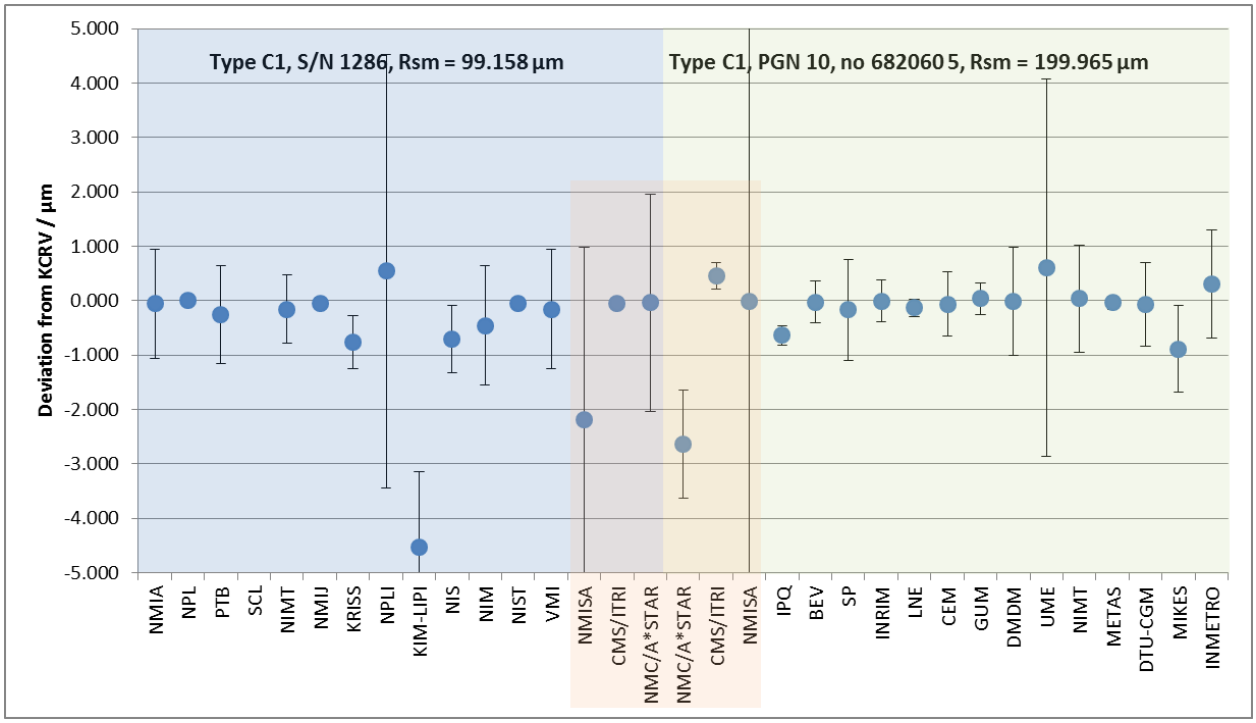
5.8 APMP.L-K8 vs. EURAMET.L-K8 for *Rsm* on type C1 standard



Linking APMP.L-K8 and EURAMET.L-K8 for *Rsm* on type C1 standard, with linking laboratories NIST and NPL.

Linking is judged good: 2 linking labs with good performance.

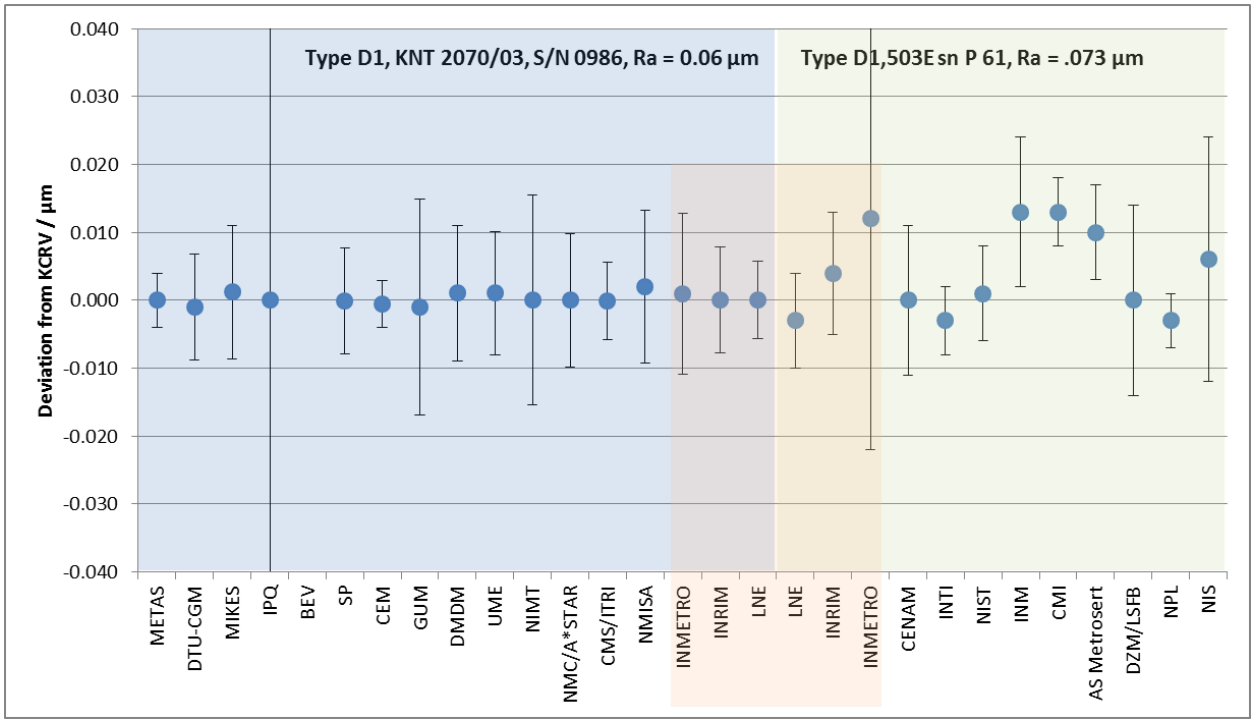
5.9 APMP.L-K8 vs. EURAMET.L-K8.2013 for *Rsm* on type C1 standard



Linking APMP.L-K8 and EURAMET.L-K8.2013 for *Rsm* on type C1 standard, with linking laboratory NMC/A*STAR, CMS/ITRI and NMISA..

Linking is judged satisfactory: 3 linking lab with unequal performance.

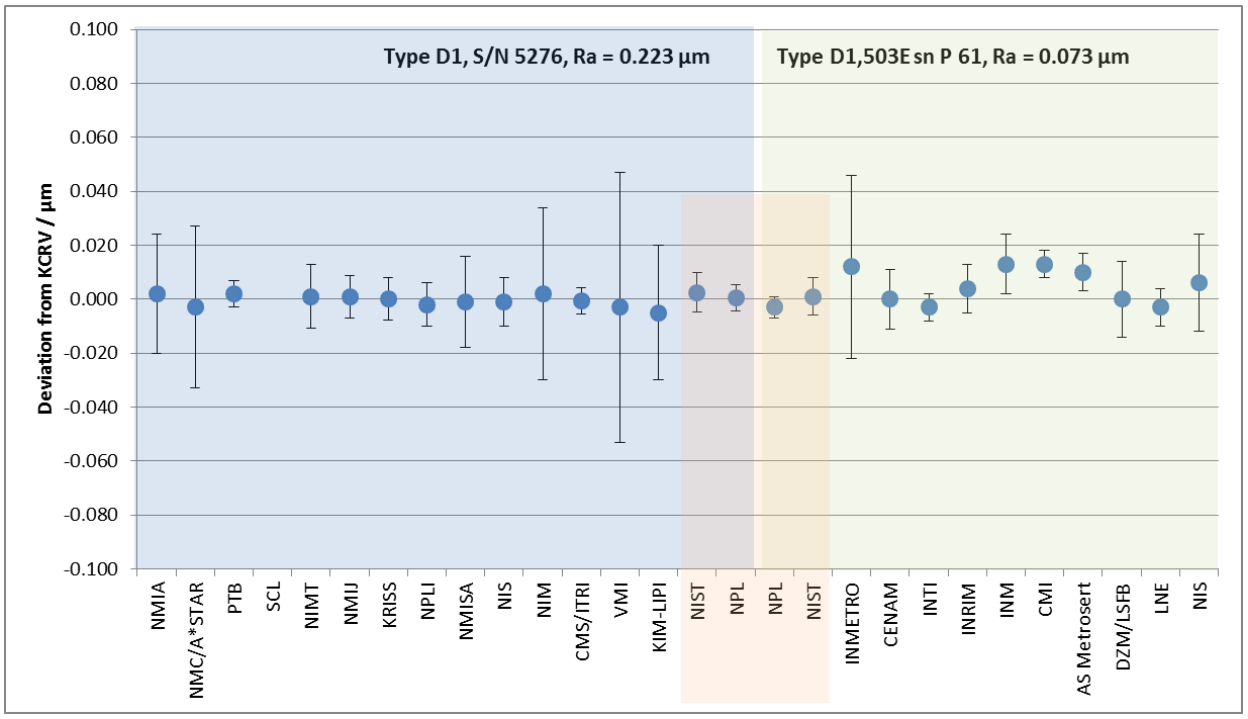
5.10 EURAMET.L-K8 vs. EURAMET.L-K8.2013 for *Ra* on type D1 standard



Linking EURAMET.L-K8.2013 and EURAMET.L-K8 for *Ra* on type D1 standard, with linking laboratories INMETRO, INRIM and LNE.

Linking is judged good: 3 linking labs with good performance.

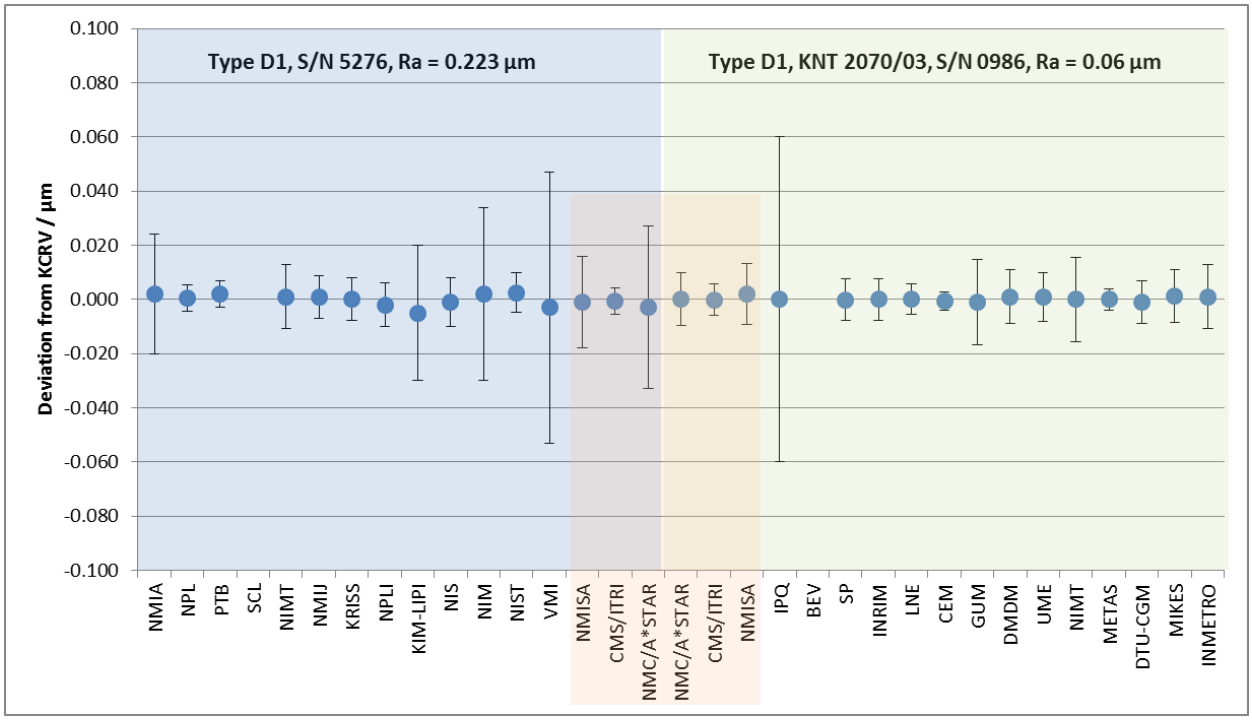
5.11 APMP.L-K8 vs. EURAMET.L-K8 for *Ra* on type D1 standard



Linking APMP.L-K8 and EURAMET.L-K8 for *Ra* on type D1 standard, with linking laboratories NIST and NPL.

Linking is judged good: 2 linking labs with good performance.

5.12 APMP.L-K8 vs. EURAMET.L-K8.2013 for *Ra* on type D1 standard



Linking APMP.L-K8 and EURAMET.L-K8.2013 for *Ra* on type D1 standard, with linking laboratory NMC/A*STAR, CMS/ITRI and NMISA..

Linking is judged good: 3 linking lab with good performance.