Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

Report on EURAMET Supplementary Comparison
Measurement of Steel Tapes of 10 m and 50 m
EURAMET project 1433
EURAMET.L-S2.3.n01
(previously EURAMET.L-S27)

Final Report

Florian Pollinger (PTB), Martin Wedde (PTB), Sten Bergstrand (RISE), Bojan Ačko (MIRS/UM-FS/LTM), Faisal A. Alqahtani (SASO), Aelio A. Arce (CEM), Muharrem Aşar (UME), Gordana Bajić (MBM), Karina Bastida (INTI), Wen-Jen Chen (CMS/ITRI), Dariusz Czulek (GUM), Unurbileg Darmaa (MASM), Hsu Po Er (CMS/ITRI), Pavel Hánek (VUGTK/RIGTC), Helge Karlsson (JV), Toomas Kübarsepp (Metrosert), Holger Kruusla (Metrosert), Jiří Lechner (VUGTK/RIGTC), Michael Matus (BEV), Hugo Pirée (SMD), Fernanda Saraiva (IPQ), Larisa Svedova (LATMB), Gábor Szikszai (BFKH), Denita Tamakyarska (BIM), Zi Xue (NIM), Daniel Fiala (PTB), Paul Köchert (PTB), Sai Gao (PTB), Tobias Meyer (PTB)

Braunschweig, September 2025

Contents

1 Document control

Version	
Draft A.1	*Issued on October 01, 2022.*
Draft A.2	*Issued on October 04, 2022.*
Draft A.3	*Issued on May 17 2024.*
Draft A.4	*Issued on November 25, 2024*
Draft A.5	*Issued on December 18, 2024*
Draft B	*Issued on March 4, 2025*
Draft B rev 1	*Issued on September 17, 2025*
Final Report	*Issued on September 18, 2025*

2 Introduction

Measurement tapes are a classic and widely used measuring tool in dimensional metrology. High volume commercial tapes play an important role in business transactions and official measurements. For these applications, measuring tapes are subject to legal metrology in many countries around the world. In the European Union, for example, Annex X of the Measuring Instruments Directive MID 2014/32/EU specifies three tolerance classes for measurement tapes for such applications [1]. Verification of compliance with the tolerance classes is part of the conformity assessment of a product. Initial measurements are often carried out by national metrology institutes (NMI). The mutual recognition of such measurements is therefore of great economic importance in this field.

In addition to the more familiar commercially available tape measures for from “everyday use”, there are also extremely high-quality measurement tapes. Many tape manufacturers rely on NMI-calibrated high-quality standard tapes as transfer standards to establish traceability to the SI-definition of the metre for their products. Thus, a single calibration at an NMI can provide SI-traceability to thousands of end user products. High-quality tapes are also used for critical measurements in precision engineering. One example is the use of diameter tapes in aerospace industry. Another example for the high economic relevance of tape calibrations is the application of dip tapes for the calibration of oil tanks [2]. High-precision tapes are also used as transfer standards for the calibration and verification of laboratories, ensuring the traceability of tape-based measurements to the SI definition of the metre in industry and society. The calibration of such transfer standards or measuring instruments with the lowest possible measurement uncertainties is a standard task for NMIs.

Table 1 lists the number of tape calibration services and national laboratories, other than the NMI itself, accredited for tape calibrations in selected countries. In general, local regulations and approaches to legal metrology, industrial quality management and other services vary considerably. Therefore, the figures are not straightforward to compare. For example, in some countries the NMIs perform most of the calibrations themselves, while in others the NMIs ensure SI traceability to accredited laboratories that perform the calibrations. Nevertheless, Table 1 shows that the calibration of measuring tapes is a relevant service in dimensional metrology. As a consequence, there are 39 calibration and measurement capabilities (CMCs) by 23 countries listed in the key comparison database (KCDB) which are related to measurement tapes [3]. But despite their long tradition, the correct calibration of these macroscopic standards remains a major challenge for laboratory equipment, primary standards and metrologists. Ensuring mutual consistency and traceability to the SI definition of the metre remains necessary. The metrological equivalence of national measurement standards and of calibration certificates issued by national metrology institutes is established by a set of key and supplementary comparisons chosen and organized by the Consultative Committees of the CIPM or by the regional metrology organizations in collaboration with the Consultative Committees.

Table 1. Survey on number of tape calibrations and national labs for selected participants. The numbers are given as an orientation for the relevance of tape calibration. Due to differences in regional regulations, e.g., with respect to type approval procedures in legal metrology, their comparability is limited.

Country	DE	AT	CZ	PL	PT	EE	SI	SE	NO	CN	SA	AR	ES	LV	BG	BE	MN
NMI	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM	SASO	INTI	CEM	LATMB	BIM	SMD	MASM
Number of NMI tape calibrations per year	10	176	161	100	10	280	8	50	120	850	25	152	20	1	10	5	50
National labs accredited for tapes[(a)]	16	0	-[(b)]	16	3	1	0	0	0	100	-[(b)]	3	19	3	6	2	-[(b)]

[(a)] Without NMI, [(b)] Information not available

During its meeting in Delft on 17-18 October 2016, the EURAMET Technical Committee for Length (TC-L) decided to carry out a supplementary comparison on steel tapes measurements, named EURAMET.L-S-27, with PTB (Physikalisch-Technische Bundesanstalt) as the pilot laboratory. The fourteen participating national metrology institutes (NMI) from EURAMET were joined by three NMIs from APMP, one from GULFMET and one from SIM. The comparison was registered in December 2017, and artefact circulation started in January 2018. Measurements were completed in August 2022. In 2024, the comparison name was changed from EURAMET.L-S27 to EURAMET.L-S2.3.n01.

3 Organization

3.1 Participants

Table 2. List of participant laboratories and their contacts.

Laboratory code	Contact person, Laboratory	Phone, Fax, email
PTB **Coordinator**	Pollinger, Florian Physikalisch-Technische Bundesanstalt Working group 5.42 Bundesallee 100 D-38116 Braunschweig Germany	Phone: +49 531 592 5420 Fax. +49 531 592 695420 florian.pollinger@ptb.de
BEV	Matus, Michael Bundesamt für Eich- und Vermessungswesen Arltgasse 35 A-1160 Wien Austria	Phone: +43 1 21 110 826540 michael.matus@bev.gv.at
VUGTK/RIGTC	Hánek, Pavel Research Institute of Geodesy, Topography and Cartography Ústecká 98 250 66 Zdiby Czech Republic	Phone: +420 226 802 330 kalibrace@vugtk.cz
GUM	Czulek, Dariusz Central Office of Measures ul. Elektoralna 2 00-950 Warszawa Poland	Phone: +48 22 581 95 43 d.czulek@gum.gov.pl
IPQ	Saraiva, Fernanda Instituto Português da Qualidade Rua António Gião 2 2829-513 Caparica Portugal	Phone: +351 21 294 81 60 Fax: +351 21 264 81 88 fsaraiva@ipq.pt
JV	Karlsson, Helge Justervesenet – Norwegian Metrology Service Fetveien 99 N-2007 Kjeller Norway	Phone: +47 64 84 84 84 Fax: +47 64 84 84 85 hka@justervesenet.no
Metrosert	Jako Siim Eensalu AS Metrosert Teaduspargi 8 12618 Talinn	Phone: +372 5340 7617 toomas.kubarsepp@metrosert.ee

	Estonia	
MIRS/UM-FS/LTM	Acko, Bojan Metrology Institute of the Republic of Slovenia /University of Maribor-Faculty of Mechanical Engineering /Laboratory for Production Measurement Smetanova 17 2000 Maribor Slovenia	Phone: +386 2 220 7581 Fax: +386 2 220 7586 bojan.acko@uni-mb.si
RISE	Bergstrand, Sten RISE Research Institutes of Sweden AB 50115 Borås Sweden	Phone: +46 10 516 57 73 Fax: +46 10 516 56 20 sten.bergstrand@ri.se
SMD	Pirée, Hugo FPS Economy, DG Quality and Safety, Metrology Division Boulevard du Roi Albert II 16 1000 Brussels Belgium	Phone: +32 2 277 7610 Fax: +32-2-277 5405 hugo.piree@economie.fgov.be
BIM	Denita Tamakyarska Bulgarian Institute of Metrology (BIM) 52B, G.M. Dimitrov blvd. 1040 Sofia Bulgaria	Phone : +359 2 970 27 19 Fax: +359 2 970 27 35 d.tamakjarska@bim.government.bg
UME	Aşar, Muharrem Ulusal Metroloji Enstitüsü Barış Mah. Dr. Zeki Acar Cad. No:1 41470 Gebze, Kocaeli Turkey	Phone: +90 262 679 50 00 ext. 5300 Fax: +90 262 679 50 01 muharrem.asar@tubitak.gov.tr
NIM	Dr. Zi Xue National Institute of Metrology (NIM) No.18, Bei San Huan Dong Lu, Chaoyang Dist, 100013 Beijing P. R. China	Phone: +86 10 64524909 Fax: +86 10 64524902 xuez@nim.ac.cn
CMS/ITRI	Dr. Chen, Wen-Jen Center for Measurement Standards(CMS)/ITRI Bldg. 16, No. 321, Sec. 2, Guangfu Rd., East Dist., Hsingchu City 30011, Taiwan (R. O. C.)	Phone: +886 3 573 2176 Fax: +886 3 572 6445 wenjen@itri.org.tw
INTI	Lic. Karina Bastida UT Optica – Coordinadora Unidad Técnica Instituto Nacional De Tecnologia Industrial Física y Metrología Av. General Paz Nº 5445 B1650WAB San Martín Buenos Aires, República Argentina	Phone: +54 11 4724 6200/300/400 Interno 6264 bastida@inti.gob.ar kbastida@inti.gob.ar
SASO-NMCC	Faisal A. Alqahtani Length Measurements Department Saudi Standards, Metrology and Quality Org. Riyadh – Al Muhammadiyah – in front of King Saud University PO. B 3437 Riyadh 11471 Kingdom of Saudi Arabia	Phone: +966 11 2529726 Fax: +966 540455655 f.qahtany@saso.gov.sa
BFKH	Gábor Szikszai Government Office of the Capital City Budapest	Phone: +36-1-4585-995 szikszai.gabor@bfkh.gov.hu

	Metrological and Technical Supervisory Department Section of Mechanical Measurements H-1124 Budapest, Németvölgyi út 37-39 Hungary	
CEM	Mr. Aelio A. Arce Centro Español de Metrologia (CEM) C/del Alfar 2 28760 Tres Cantos (Madrid) Spain	Phone: +34 91 8074 801 aaarce@cem.es
LATMB	Larisa Svedova LNMC, LTD Metrology Bureau LATMB 157 Kr. Valdemara street Riga, LV-1013 Latvia	Phone +371 67517725 Fax +371 67362805 Larisa.Svedova@latmb.lv
MBM	Gordana Bajić Arseija Boljevica bb 81000 Podgorica Montenegro	Phone +382 20 601 360 Fax +382 20 634 651 Gordana.bajic@metrologija.gov.me
MASM	Unurbileg Darmaa Length laboratory Mongolian Agency for Standardization and Metrology Peace Avenue-46 A POB -51 Ulaanbaatar-13343	Phone +976-89086810 unurbileg@masm.gov.mn
VNIIM	Zoya Fomkina D.I. Mendeleyev Institute for Metrology (VNIIM) 190005, Russia, St. Peterburg, Moskovsky pr., 19	Phone +7 812 323-9665 Z.V.Fomkina@vniim.ru

Not all facilities of all participants were able to measure the complete datasets due to limited instrumental lengths. MBM's instrument experienced technical problems in their assigned spot. In agreement with the pilot laboratory, they decided to withdraw participation from this comparison. VNIIM withdrew their participation after their suspension due to the Russian invasion to Ukraine. NIM reported two results from two different facilities. Only those reported for the 80 m comparator (NIM-80) contributed to the supplementary comparison reference value (SCRV), the second one (NIM-26) was analyzed separately.

3.2 Schedule

The comparison was carried out in the form of a circulation. The tape measures were measured at the beginning, five times in between and at the end of the circulation by the pilot laboratory to monitor the stability of the tapes. The schedule had to be adapted several times. In particular, the worldwide measures against the COVID-19 pandemic included shutdowns of laboratories as well as complications in customs affairs. These implied delays in the second half of the comparison. Finally, it took six months to return the standards from the last participant, VNIIM, to the pilot.

Table 3. Schedule of the comparison.

No.	Laboratory	Scheduled
1	PTB0	January 2018
2	BEV	February 2018
3	VUGTK/RIGTC	March 2018
4	GUM	April 2018
5	IPQ	May 2018
6	SMD	June 2018
7	PTB1	July 2018
8	Metrosert	September 2018
9	MIRS/UM-FS/LTM	October 2018
10	RISE	November 2018
11	PTB2	December 2018
12	JV	February 2019
13	NIM	May 2019
14	CMS	July 2019
15	PTB3	September 2019
16	SASO-NMCC	December 2019
17	INTI	March 2020
18	PTB4	July 2020
19	CEM	September 2020
20	LATMB	October 2020
21	(PTB)	November 2020 (only PTB 5060 No. 3)
22	BIM	November 2020
23	BFKH	January 2021
24	SMD	February 2021
25	PTB5	March 2021
26	UME	June 2021
27	MBM	August 2021
28	MASM	November 2021
29	VNIIM	January 2022
30	PTB6	August 2022

4 Artefacts

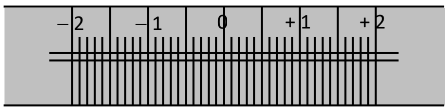
4.1 Description of artefacts

Table 4. List of artefacts.

Length	Width	Nominal load therm. expansion	Identification	Material	Line marks
10 m	13 mm	100 N $(11.5 \pm 1) \cdot 10^{-6}$ K^{-1}	4909 PTB 01	Stainless steel	engraved
50 m	13 mm	100 N $(11.5 \pm 1) \cdot 10^{-6}$ K^{-1}	5060 PTB 06 No. 3	Stainless steel	engraved
50 m	13 mm	50 N $(11.5 \pm 1) \cdot 10^{-6}$ K^{-1}	5.42-0917	Stainless steel	etched

Three tapes were selected as artefacts for the comparison. Two tapes (4909 PTB 01 and 5060 PTB06 No. 3) were of typical reference-grade quality, the third tape 5.42-0917 represented a high-quality commercial tape of MID class I. The physical properties of three tapes are summarized in Table 4 and depicted in Figure 1 to Figure 3.

Figure 1 10 m tape with 5 millimetres graduation (4909 PTB 01)



Drawing of line marks at 0 m and at 1 m

Figure 2 50 m tape with metre graduation (5060 PTB 06 No.3)

Figure 3 50 m tape with millimetre graduation (5.42-0917)

4.2 Stability of artefacts

The pilot laboratory PTB performed five intermediate full control measurements and a final measurement after receiving the standards back from VNIIM. In the following, these measurements are labelled PTB0 to PTB6, the index increasing with the measurement time (see also Table 3).

4.2.1 10 m tape with 5 millimetre graduation (4909 PTB 01)

Figure 4 summarizes all seven PTB measurement campaigns, depicting the deviation from the weighted mean <PTB> of these seven measurements. The maroon dashed lines indicate the expanded uncertainty of the mean value $u_{<\mathrm{PTB}>}$ (coverage factor k = 2). All seven measurements almost perfectly fit within the uncertainty limits of the mean value. The expanded uncertainty of a single PTB measurement is indicated by the blue dotted lines around the mean value. All seven measurements clearly remain within these limits. Nevertheless, there is a small, but visible trend identifiable in Figure 4 for the measurement values to increase with the comparison duration. Part of the elongation of the tape during the measurements is obviously irreversible. With an increasing number of measurements, this leads to the observed systematic elongation of the tape. To account for this small, but systematic change of the artefact, the full span of the pilot monitoring measurements is introduced as position-dependent artefact uncertainty u_{art}:

$$u_{\mathrm{art}}(x_i) = \frac{\max(\mathrm{PTB}n - <\mathrm{PTB}>)_i - \min(\mathrm{PTB}n - <\mathrm{PTB}>)_i}{2\sqrt{3}}. \quad (1)$$

A rectangular probability distribution function is assumed for the artefact uncertainty. The resulting position-dependent artefact uncertainties are summarized in Figure 5 and Table 5. The values remain below 10 µm but systematically increase with length. In Figure 4, the dot-dashed red line indicates the expanded uncertainty combining the uncertainty of the weighted mean with the artefact uncertainty:

$$u_{<\mathrm{PTB}>,\mathrm{art}}(x_i) = \sqrt{u_{<\mathrm{PTB}>}(d_i)^2 + u_{\mathrm{art}}(d_i)^2}. \quad (2)$$

The monitoring data is separately depicted for each marker in Figure 6 to Figure 8. The maroon dashed lines indicate the weighted mean value of all measurements by the pilot laboratory <PTB>. The supplementary comparison reference value (SCRV) calculated according to Section 7.1, considering the artefact uncertainty, is depicted (as deviation from the weighted mean value <PTB>) as dotted lines.

Table 5. Position-dependent artefact uncertainties for tape 4909 PTB 01. The uncertainties u_{art} are given as standard uncertainties (k = 1).

4909 PTB 01							
x_i	u_{art} / mm	x_i	u_{art} / mm	x_i	u_{art} / mm	x_i	u_{art} / mm
0 .. 1 m	0,0030	0 .. 7 m	0,0066	0 .. 1015.0 mm	0,0030	0 .. 5705.0 mm	0,0046
0 .. 2 m	0,0025	0 .. 8 m	0,0054	0 .. 2525.0 mm	0,0039	0 .. 7745.0 mm	0,0035
0 .. 3 m	0,0044	0 .. 9 m	0,0061	0 .. 2530.0 mm	0,0039	0 .. 7750.0 mm	0,0035
0 .. 4 m	0,0023	0 .. 10 m	0,0099	0 .. 2535.0 mm	0,0039	0 .. 7755.0 mm	0,0035
0 .. 5 m	0,0032	0 .. 1005.0 mm	0,0030	0 .. 5695.0 mm	0,0046	0 .. 9990.0 mm	0,0099
0 .. 6 m	0,0033	0 .. 1010.0 mm	0,0030	0 .. 5700.0 mm	0,0046	0 .. 9995.0 mm	0,0099

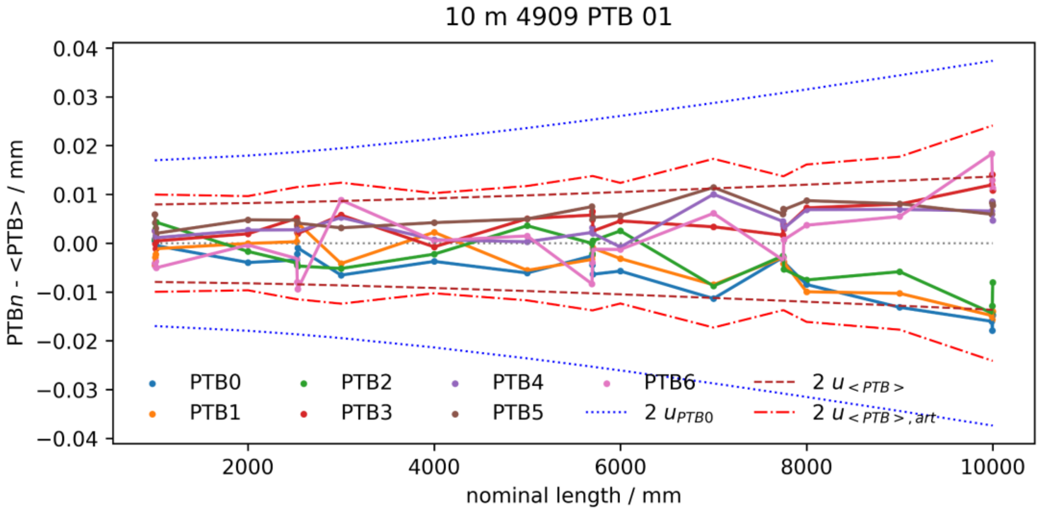


Figure 4 Deviation of the individual control measurements PTBn (with n = 0, 1, … 6) from the weighted mean of all pilot measurement <PTB> for the tape 4909 PTB 01. The blue dotted lines indicate the measurement uncertainty of a single PTB measurement. The dashed maroon lines reflect the uncertainty of the weighted mean of all seven PTB measurements $u_{<PTB>}$, the dotted-dashed red lines indicate the latter combined with the artefact uncertainty. All uncertainties are depicted as expanded uncertainties, using a coverage factor k = 2.

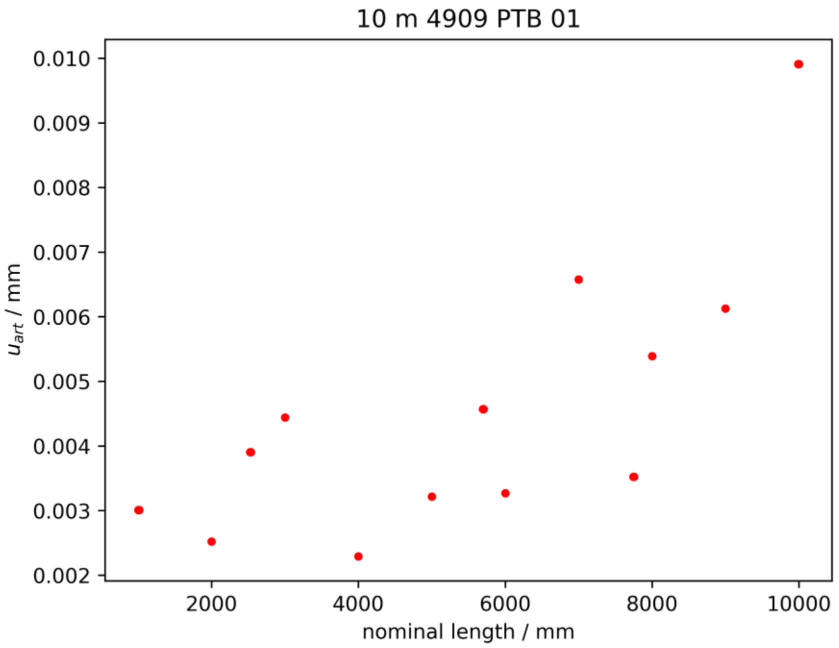


Figure 5 Length-dependency of the artefact uncertainty u_{art} derived from the span of the pilot measurements PTB0 to PTB6 according to Eq. (1).

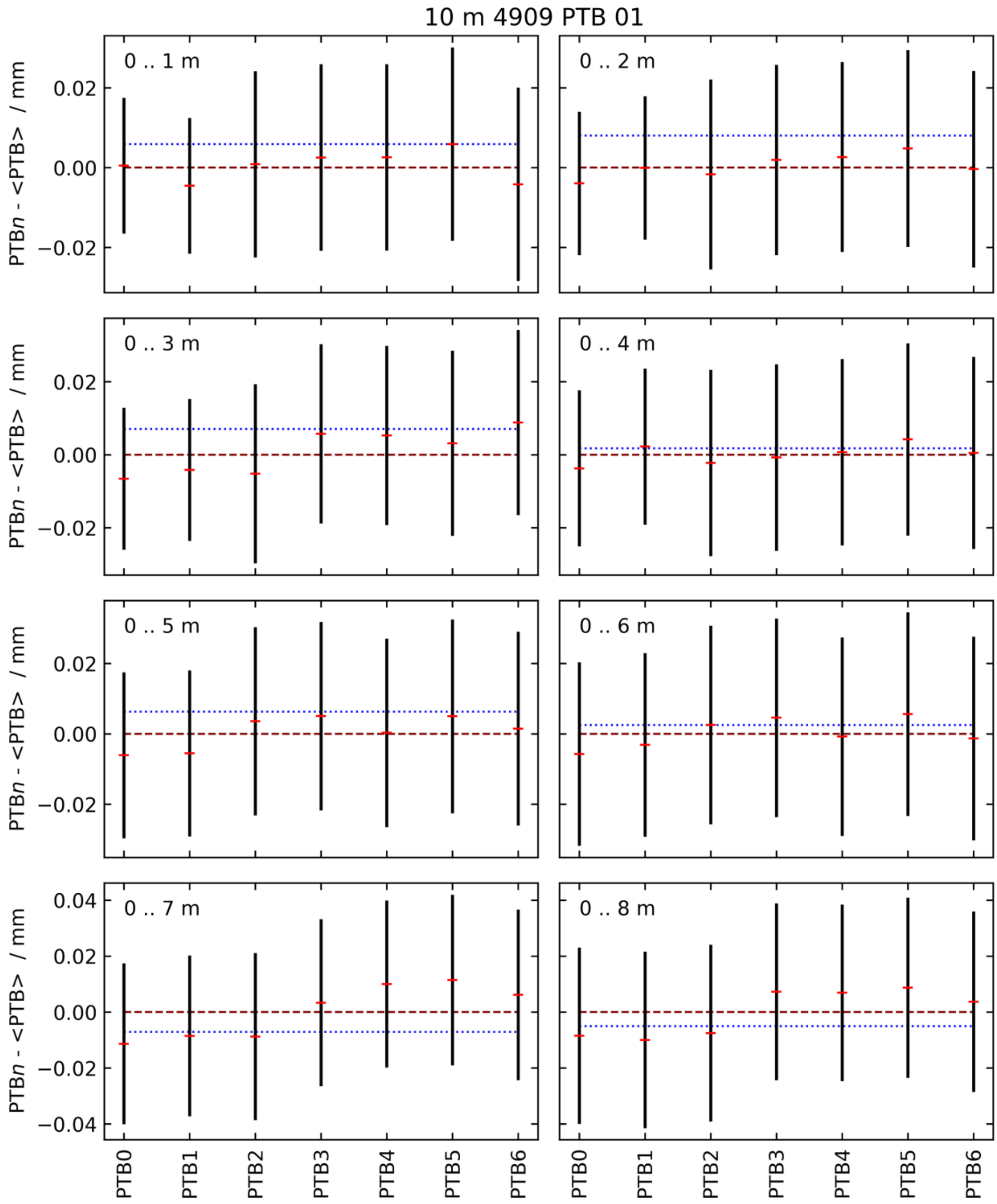


Figure 6 Comparison of the pilot laboratory measurements against their weighted mean (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 4909 PTB 01. The error bars are based on a coverage factor of $k = 2$.

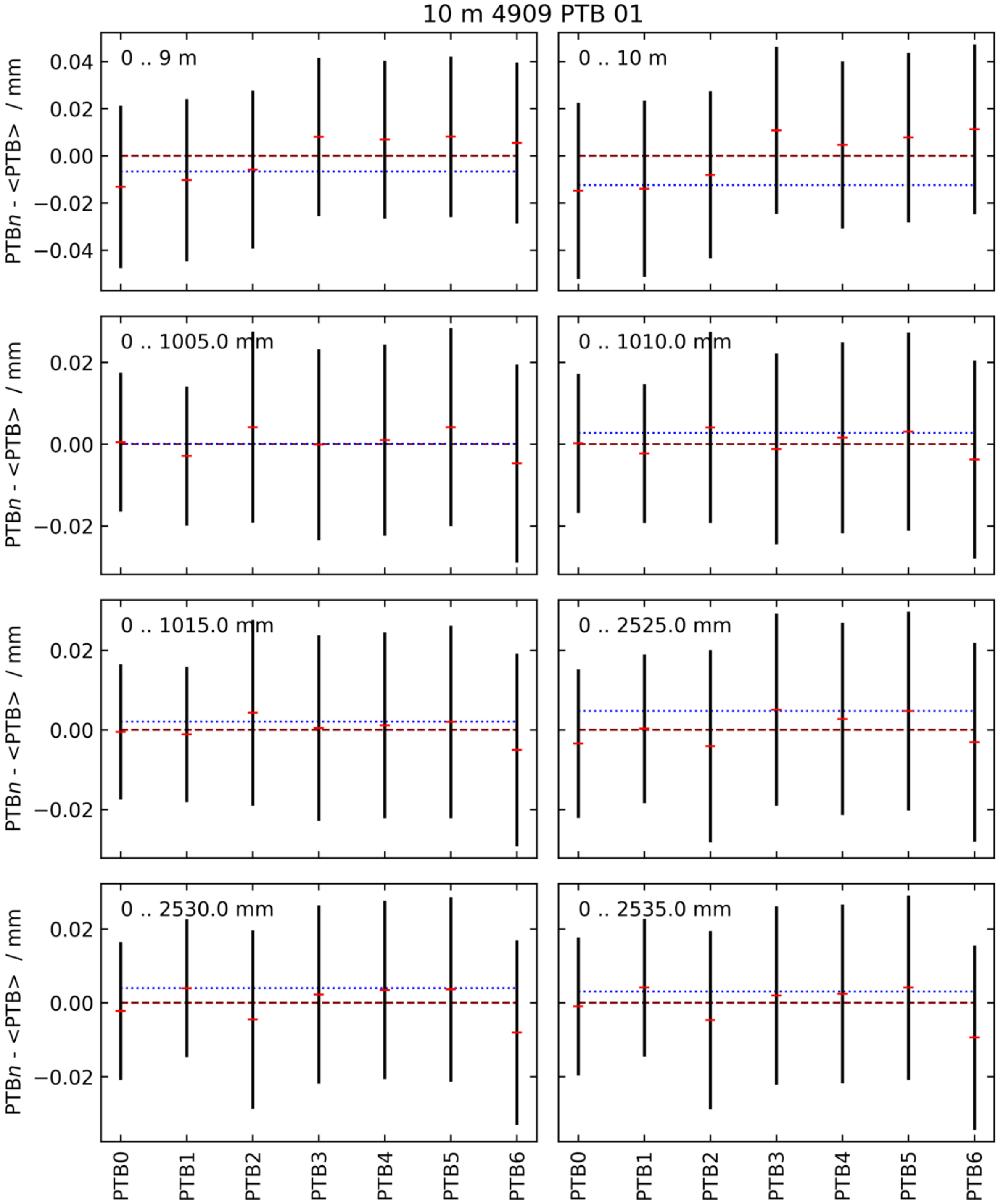


Figure 7 Comparison of the pilot laboratory measurements against their weighted mean (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 4909 PTB 01. The error bars are based on a coverage factor of $k = 2$.

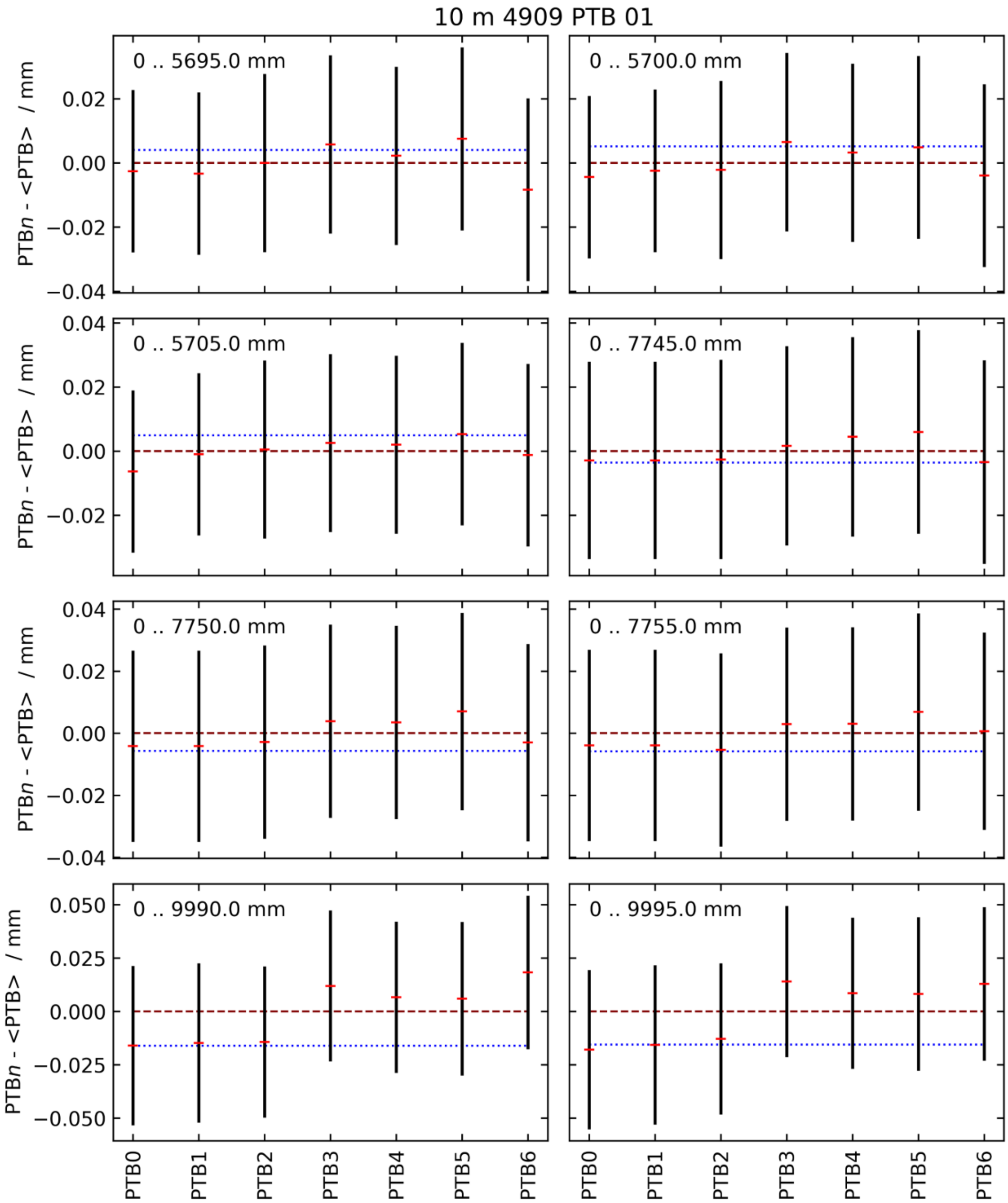


Figure 8 Comparison of the pilot laboratory measurements against their weighted mean (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 4909 PTB 01. The error bars are based on a coverage factor of k = 2.

4.2.2 50 m tape with metre graduation (5060 PTB 06 No.3)

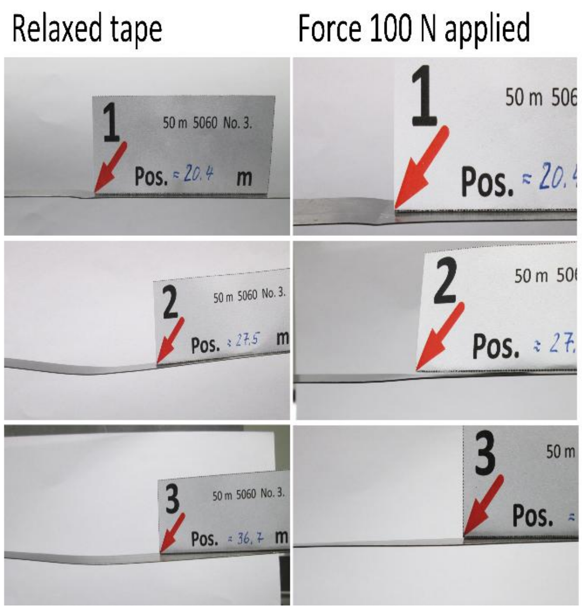


Figure 9 Three locations of major damage to tape 5060 PTB 06 No.3 which occurred during the comparison with and without applied tension force of 100 N.

Tape 5060 PTB 06 No.3 was damaged during the comparison during a measurement at one participant. The participant informed the pilot. The deformations were clearly visible for the relaxed tape (cf. Figure 9). Figure 10 compiles the seven pilot measurements, shown as deviations from the weighted mean of all pilot measurements. The damage occurred between measurements PTB4 and PTB5. At the 20 m mark, one can observe a change in the systematics of the slope of the deviation from the weighted mean. This change, however, is small in comparison to the expanded uncertainty of the mean value (maroon dashed lines), and negligible with respect to the expanded single measurement uncertainty of the pilot (blue dotted lines). There is, however, again a clear trend to larger deviations with

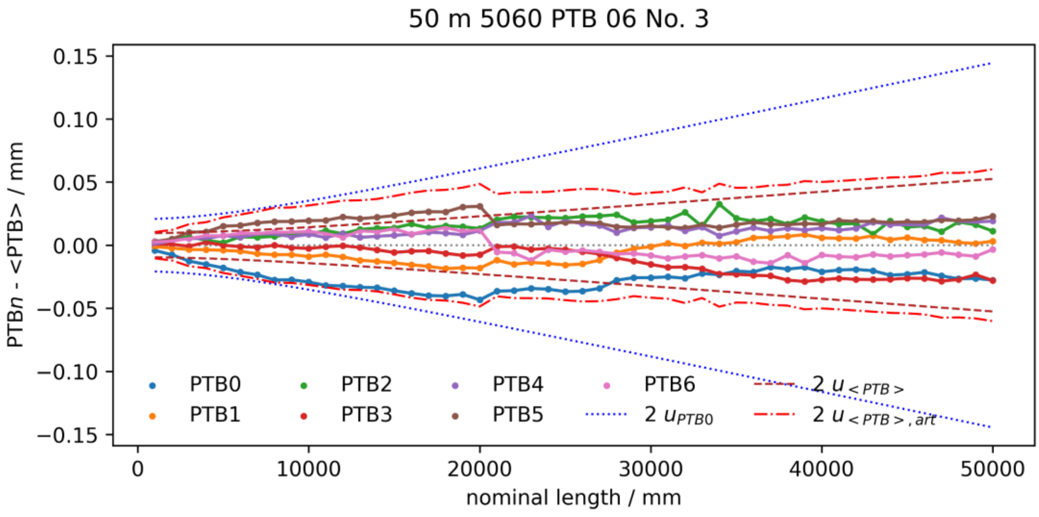


Figure 10 Deviation of the control measurements from the weighted mean of all pilot measurements for tape 5060 PTB 06 No. 3. Dotted lines indicate uncertainty of first measurement for a coverage factor k=2, the dashed maroon lines the uncertainty of the weighted mean, the dotted-dashed red lines the latter combined with the artefact uncertainty.

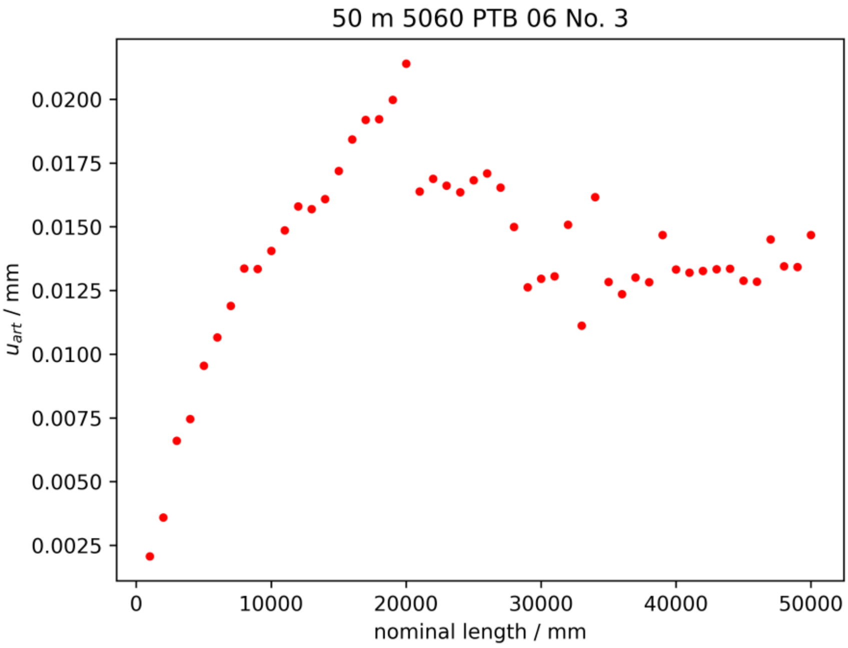


Figure 11 Length-dependency of the artefact uncertainty derived from the span of the pilot measurements for tape 5060 PTB 06 No. 3.

increasing comparison duration. The effect is more pronounced for distances below 20 metres. This can be attributed to the fact that many laboratories only measured up to 20 m. Thus, the wear on the tape is worse for the first 20 m.

To account for the relatively wide spread of the monitoring data, in particular for the short distances, again an artefact uncertainty was introduced according to Eq. (1). The position-dependent values are given in Figure 11 and Table 2. Adding the artefact uncertainty to the uncertainty of the mean value according to Eq. (2) leads to an expanded uncertainty which covers all monitoring observations (red dotted-dashed line in Figure 10). The monitoring data is again separately depicted for each marker in Figure 12 to Figure 18. The weighted mean of the pilot measurements (maroon dashed line) and the SCRV (blue dashed line) are in good agreement with all pilot observations.

Table 6. Position-dependent artefact uncertainties for tape 5060 PTB 06 No. 3. The uncertainties u_{art} are given as standard uncertainties (k = 1).

5060 PTB 06 No. 3									
x_i	u_{art} / mm	x_i	u_{art} / mm	x_i	u_{art} / mm	x_i	u_{art} / mm	x_i	u_{art} / mm
0 .. 1 m	0,0021	0 .. 11 m	0,0149	0 .. 21 m	0,0164	0 .. 31 m	0,0131	0 .. 41 m	0,0132
0 .. 2 m	0,0036	0 .. 12 m	0,0158	0 .. 22 m	0,0169	0 .. 32 m	0,0151	0 .. 42 m	0,0133
0 .. 3 m	0,0066	0 .. 13 m	0,0157	0 .. 23 m	0,0166	0 .. 33 m	0,0111	0 .. 43 m	0,0133
0 .. 4 m	0,0075	0 .. 14 m	0,0161	0 .. 24 m	0,0164	0 .. 34 m	0,0162	0 .. 44 m	0,0134
0 .. 5 m	0,0096	0 .. 15 m	0,0172	0 .. 25 m	0,0168	0 .. 35 m	0,0128	0 .. 45 m	0,0129
0 .. 6 m	0,0107	0 .. 16 m	0,0184	0 .. 26 m	0,0171	0 .. 36 m	0,0124	0 .. 46 m	0,0128
0 .. 7 m	0,0119	0 .. 17 m	0,0192	0 .. 27 m	0,0165	0 .. 37 m	0,0130	0 .. 47 m	0,0145
0 .. 8 m	0,0134	0 .. 18 m	0,0192	0 .. 28 m	0,0150	0 .. 38 m	0,0128	0 .. 48 m	0,0134
0 .. 9 m	0,0133	0 .. 19 m	0,0200	0 .. 29 m	0,0126	0 .. 39 m	0,0147	0 .. 49 m	0,0134
0 .. 10 m	0,0141	0 .. 20 m	0,0214	0 .. 30 m	0,0130	0 .. 40 m	0,0133	0 .. 50 m	0,0147

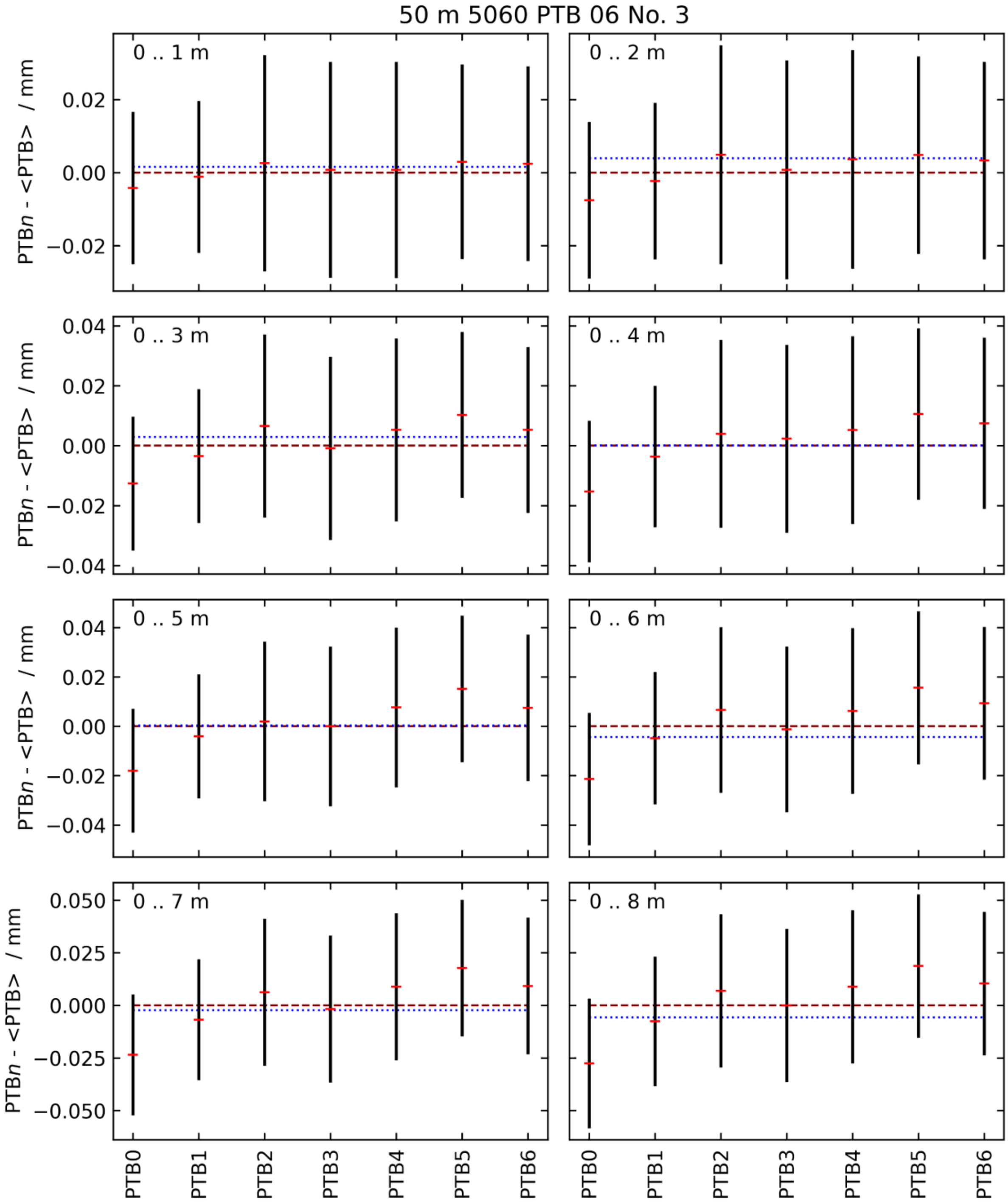


Figure 12 Comparison of the pilot laboratory measurements against their weighted mean (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5060 PTB 06 No. 31. The error bars are based on a coverage factor of k = 2.

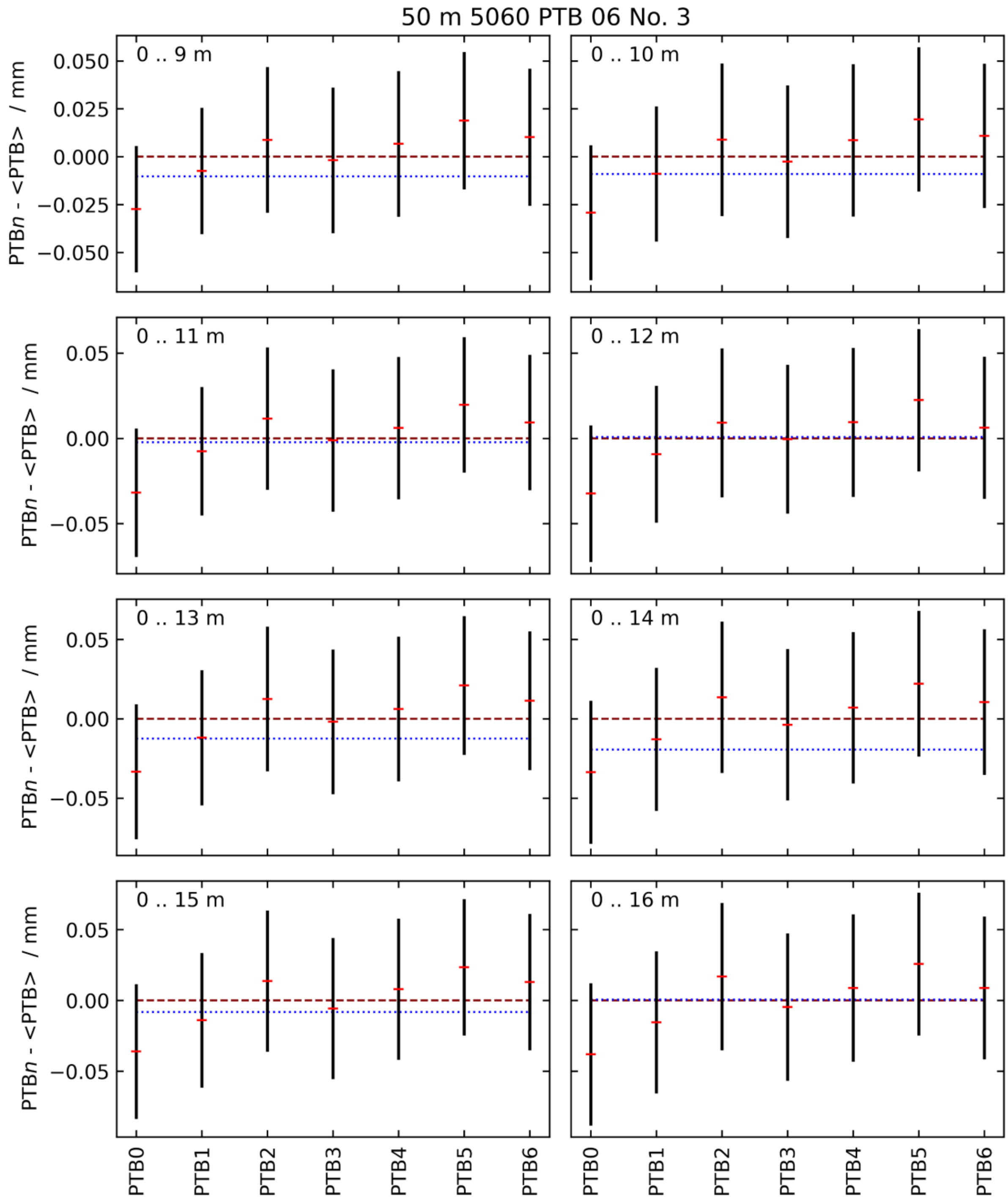


Figure 13 Comparison of the pilot laboratory measurements against their weighted mean (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5060 PTB 06 No. 31. The error bars are based on a coverage factor of k = 2.

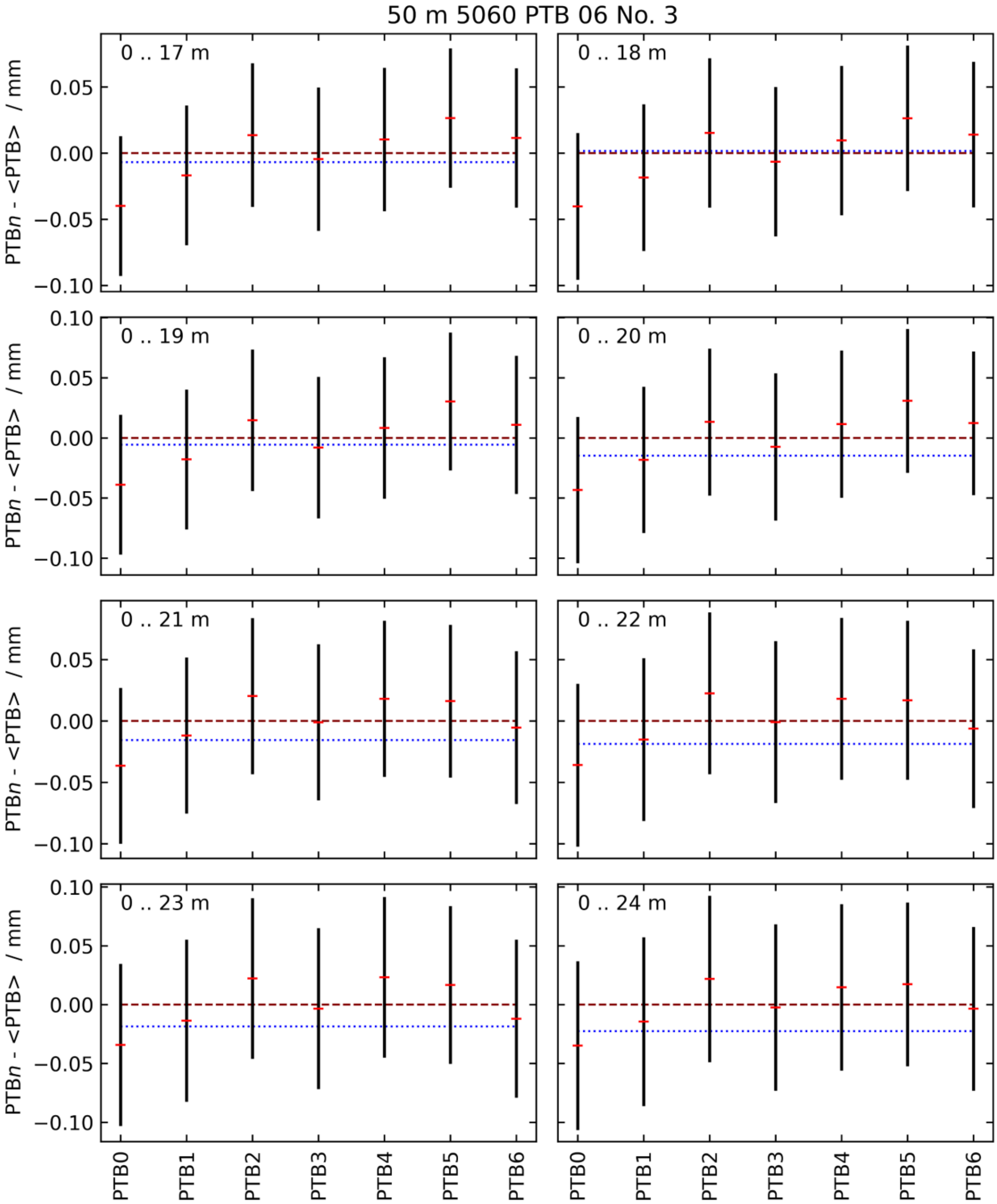


Figure 14 Comparison of the pilot laboratory measurements against their weighted mean (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5060 PTB 06 No. 31. The error bars are based on a coverage factor of k = 2.

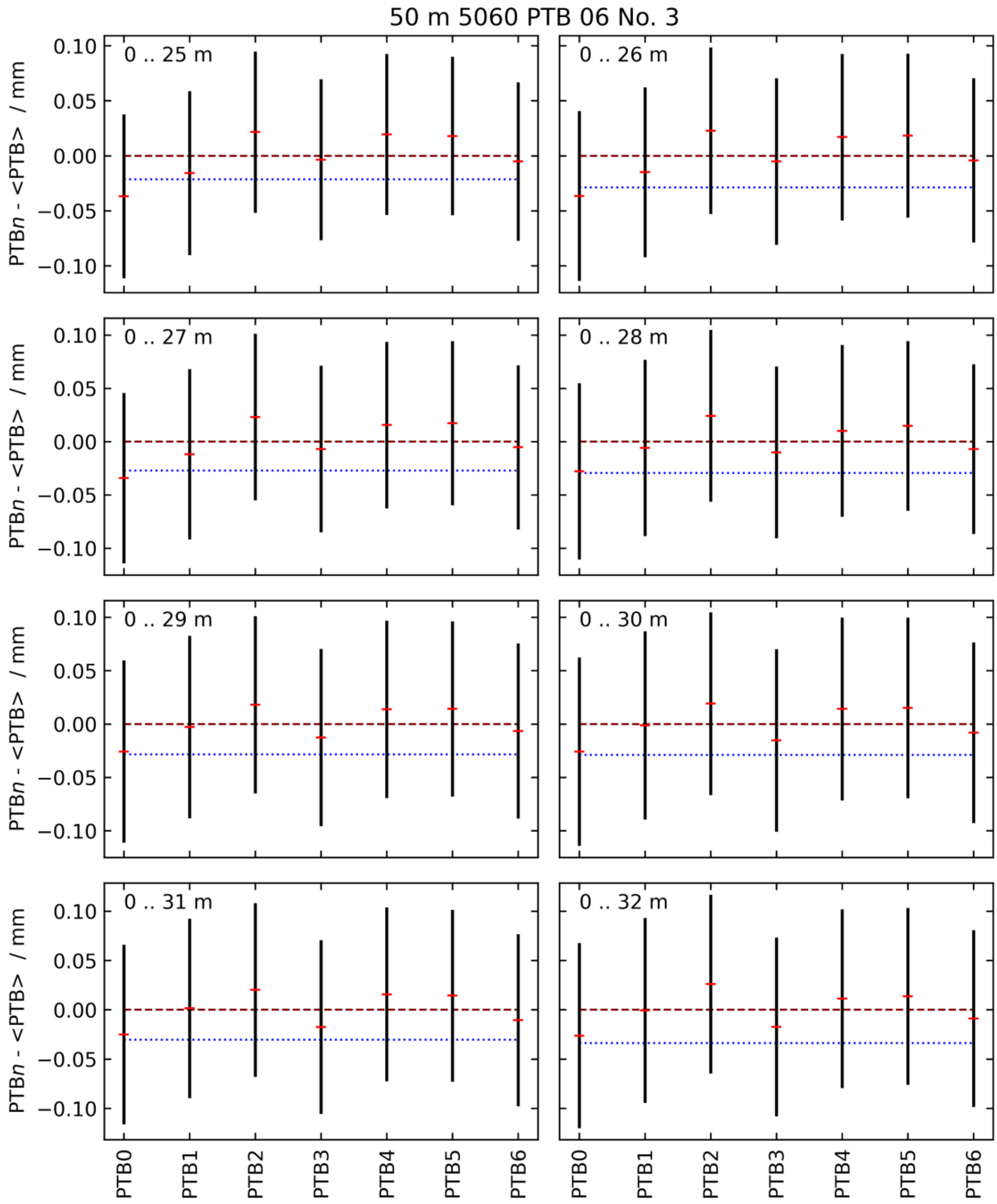


Figure 15 Comparison of the pilot laboratory measurements against their weighted mean (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5060 PTB 06 No. 31. The error bars are based on a coverage factor of *k* = 2..

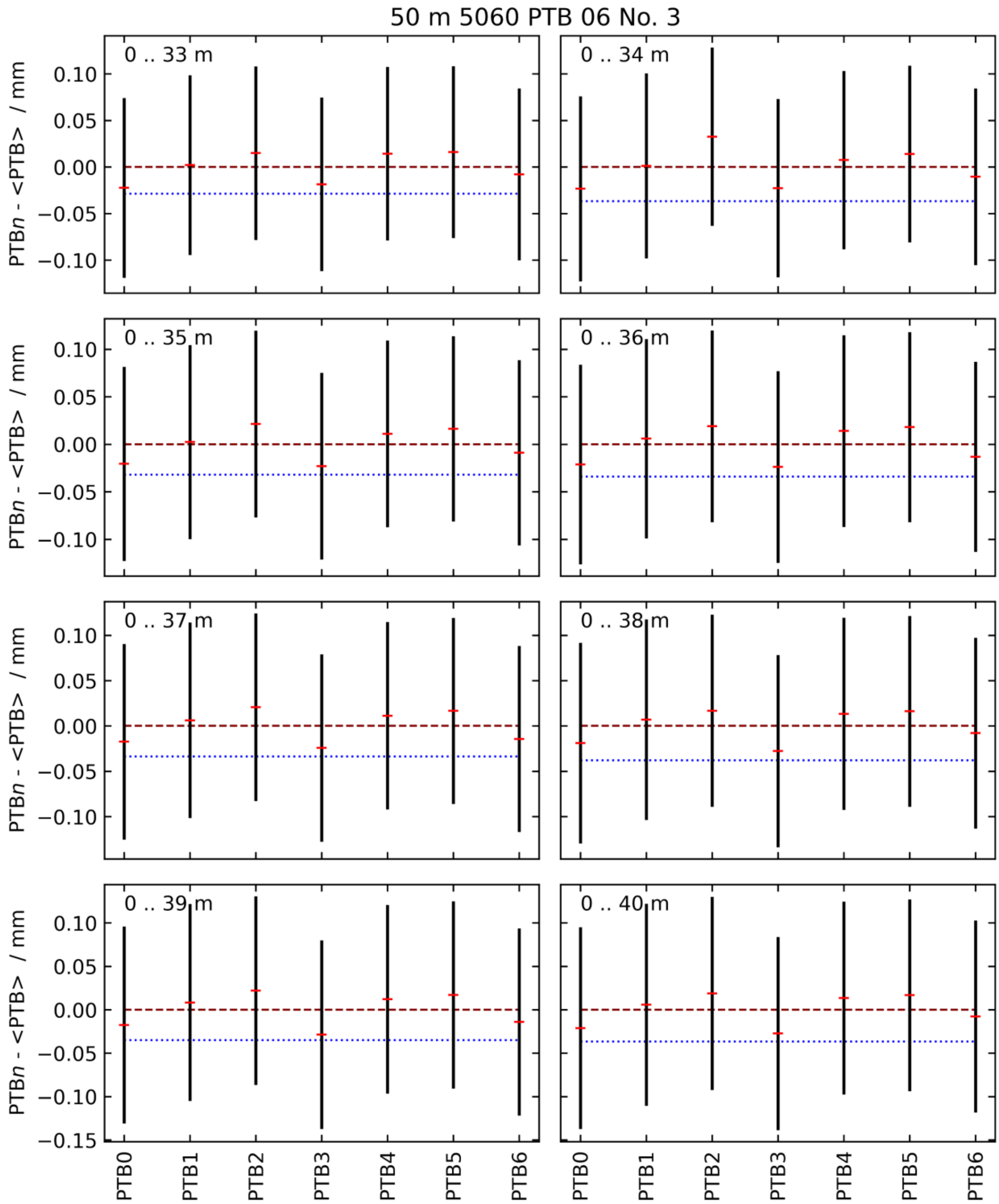


Figure 16 Comparison of the pilot laboratory measurements against their weighted mean (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5060 PTB 06 No. 31. The error bars are based on a coverage factor of *k* = 2.

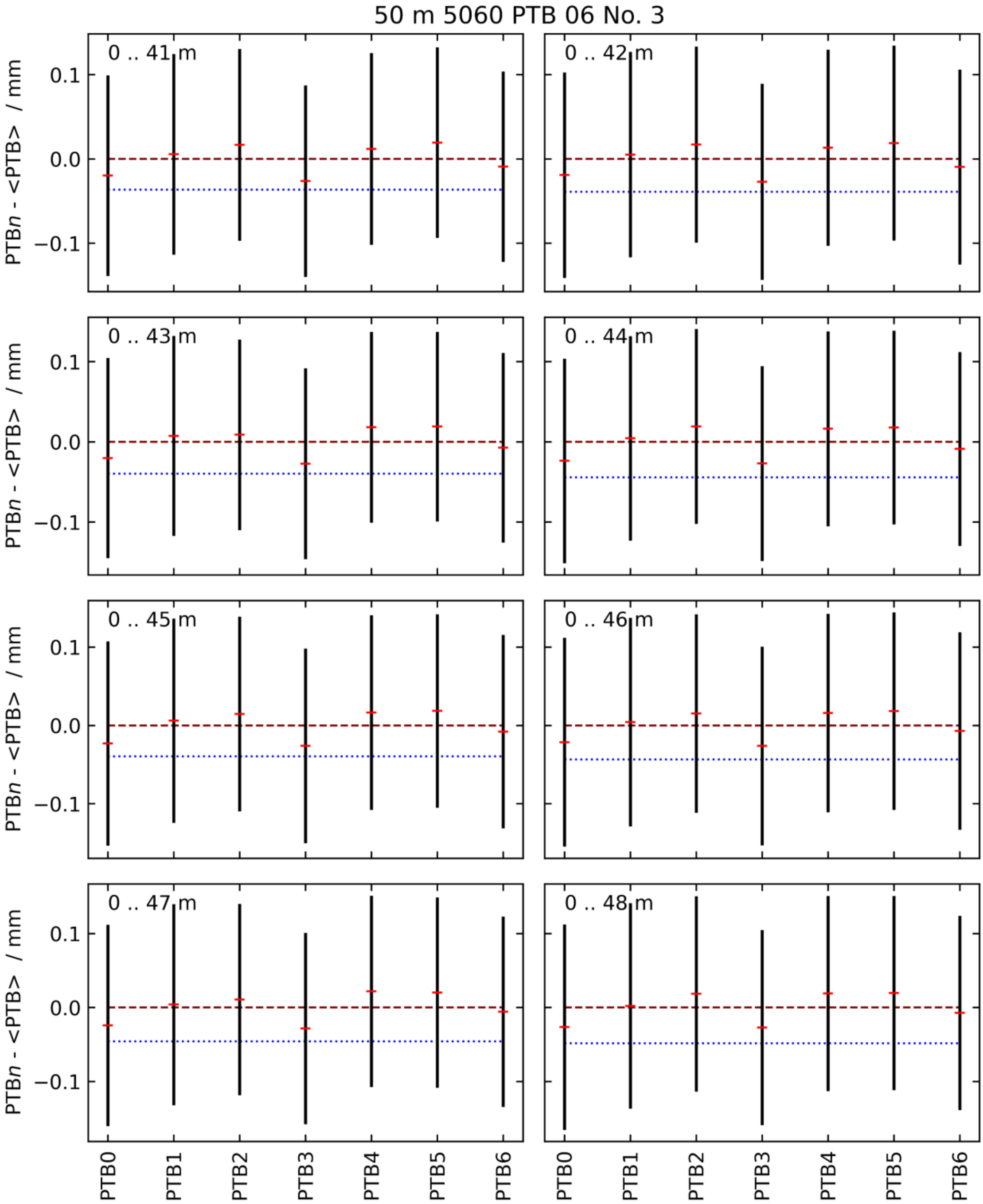


Figure 17 Comparison of the pilot laboratory measurements against their weighted mean (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5060 PTB 06 No. 31. The error bars are based on a coverage factor of k = 2.

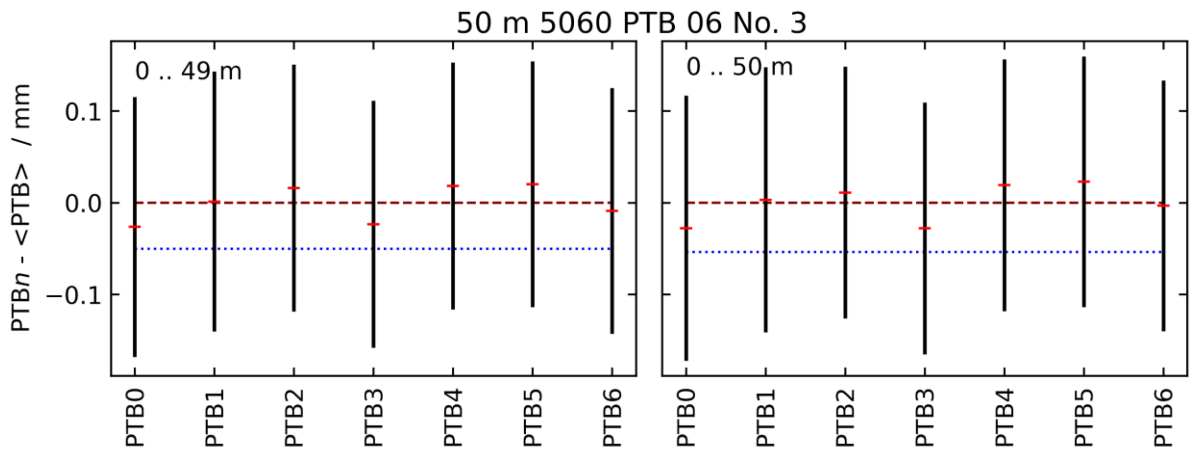


Figure 18 Comparison of the pilot laboratory measurements against their weighted mean (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5060 PTB 06 No. 31. The error bars are based on a coverage factor of k = 2.

4.2.3 50 m tape with millimetre graduation (5.42-0917)

Unlike the previous two standards, tape 5.42-0917 is a commercial-grade tape, not a high-accuracy tape manufactured as standard. It was purchased shortly before the comparison. Figure 19 depicts all pilot measurements as deviations from the weighted average of these seven campaigns. The first six measurements (PTB0 to PTB5) show similar length-dependencies. Nevertheless, the values vary on the scale of the expanded uncertainty of the weighted average (maroon dashed lines). Unlike in the case of the two standard tapes, there is no linear correlation of elongation to comparison duration. In the contrary, the deviations of the control measurement alternate around the mean value. During the last loop, however, the properties of the tape changed drastically. The final pilot measurement PTB6 does not fit at all to the previous six control measurements and can only be explained by substantial damage to the tape. Based on a participant's reports, the time of this incident can be identified. Reported observations after PTB5 are hence to be interpreted with caution.

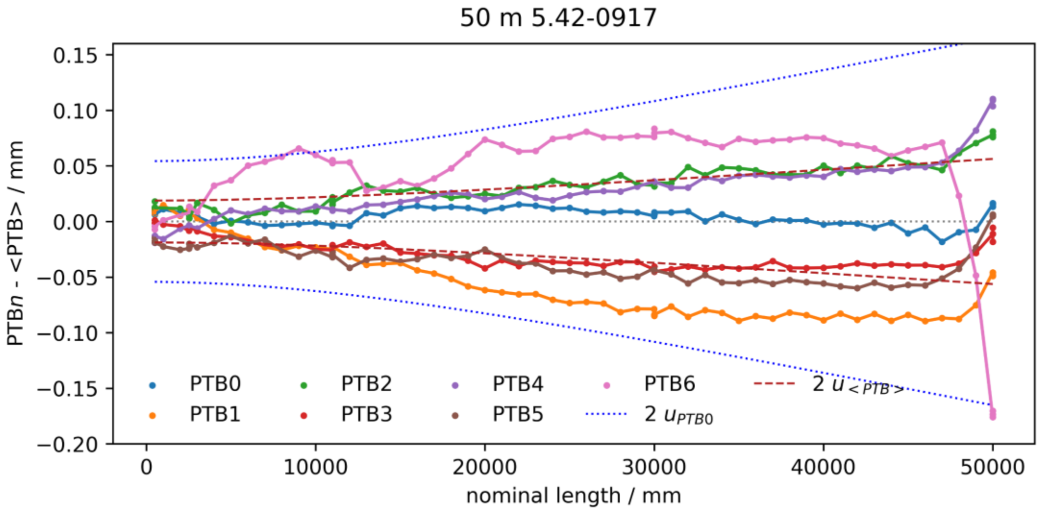


Figure 19 Deviation of the control measurements from the mean of all pilot measurements for tape 5.42-0917. The blue dotted lines indicate the uncertainty of a single measurement for a coverage factor k = 2, the dashed maroon lines the expanded uncertainty of the weighted mean value of all seven pilot measurements.

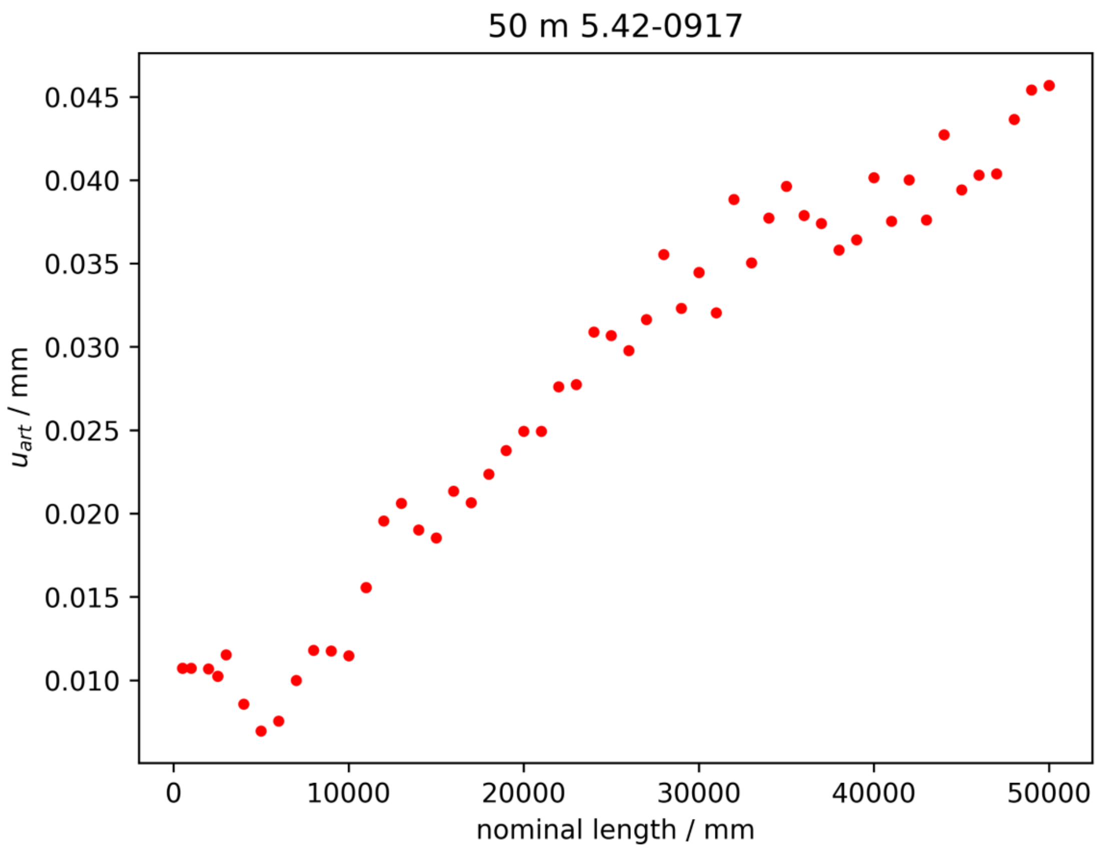


Figure 20 Length-dependency of the artefact uncertainty derived from the span of the pilot measurements PTB0 to PTB5.

Only measurements up to PTB5 are therefore considered for the derivation of the artefact uncertainty according to Eq. (1). Figure 20 shows an almost perfectly monotonous growth of the artefact uncertainty with distance. The magnitude of the artefact uncertainty is more than a factor 2 larger

Table 7. Position-dependent artefact uncertainties for tape 5.42-0917. The uncertainties u_{art} are given as standard uncertainties (k = 1).

5.42-0917									
x_i	u_{art} / mm	x_i	u_{art} / mm	x_i	u_{art} / mm	x_i	u_{art} / mm	x_i	u_{art} / mm
0 .. 1 m	0,011	0 .. 14 m	0,019	0 .. 27 m	0,032	0 .. 40 m	0,040	0 .. 506.0 mm	0,011
0 .. 2 m	0,011	0 .. 15 m	0,019	0 .. 28 m	0,036	0 .. 41 m	0,038	0 .. 507.0 mm	0,011
0 .. 3 m	0,012	0 .. 16 m	0,021	0 .. 29 m	0,032	0 .. 42 m	0,040	0 .. 508.0 mm	0,011
0 .. 4 m	0,009	0 .. 17 m	0,021	0 .. 30 m	0,034	0 .. 43 m	0,038	0 .. 2529.0 mm	0,010
0 .. 5 m	0,007	0 .. 18 m	0,022	0 .. 31 m	0,032	0 .. 44 m	0,043	0 .. 2530.0 mm	0,010
0 .. 6 m	0,008	0 .. 19 m	0,024	0 .. 32 m	0,039	0 .. 45 m	0,039	0 .. 2531.0 mm	0,010
0 .. 7 m	0,010	0 .. 20 m	0,025	0 .. 33 m	0,035	0 .. 46 m	0,040	0 .. 10999.0 mm	0,016
0 .. 8 m	0,012	0 .. 21 m	0,025	0 .. 34 m	0,038	0 .. 47 m	0,040	0 .. 11001.0 mm	0,016
0 .. 9 m	0,012	0 .. 22 m	0,028	0 .. 35 m	0,040	0 .. 48 m	0,044	0 .. 29999.0 mm	0,034
0 .. 10 m	0,011	0 .. 23 m	0,028	0 .. 36 m	0,038	0 .. 49 m	0,045	0 .. 30001.0 mm	0,034
0 .. 11 m	0,016	0 .. 24 m	0,031	0 .. 37 m	0,037	0 .. 50 m	0,046	0 .. 49998.0 mm	0,046
0 .. 12 m	0,020	0 .. 25 m	0,031	0 .. 38 m	0,036			0 .. 49999.0 mm	0,046
0 .. 13 m	0,021	0 .. 26 m	0,030	0 .. 39 m	0,036				

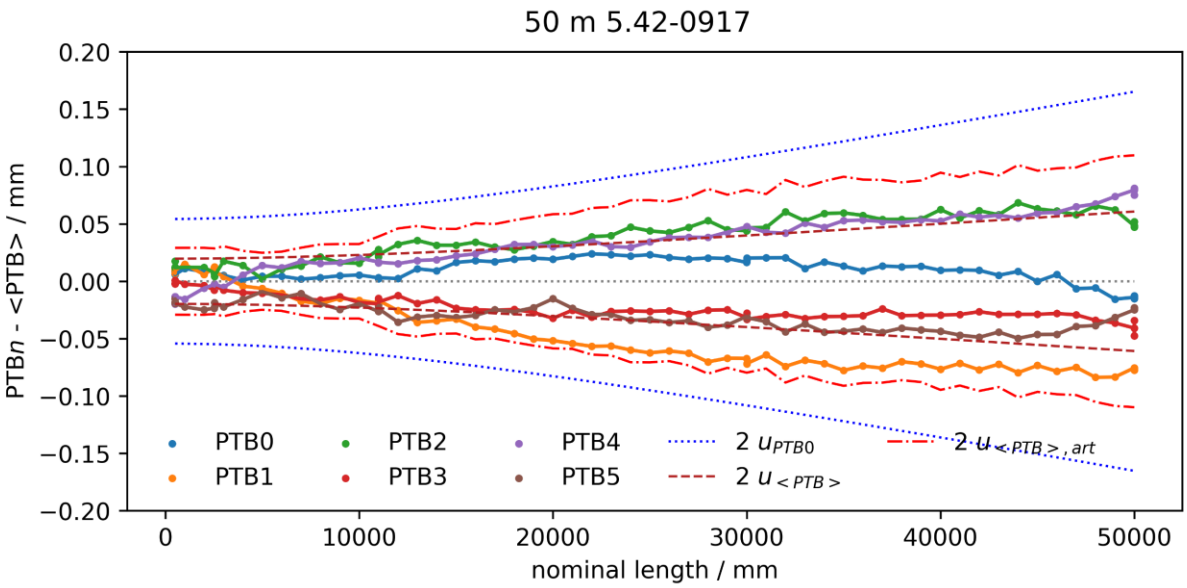


Figure 21 Deviation of the control measurements from the mean of the first six pilot measurements for tape 5.42-0917, omitting the final control measurement PTB6. The blue dotted lines indicate the uncertainty of a single pilot measurement for a coverage factor k = 2, the dashed maroon lines the expanded uncertainty of the weighted mean value of the first six pilot measurements. The red dashed line indicates the expanded uncertainty combining uncertainty of the mean value and the artefact uncertainty according to Eq. (2).

than in the case of the standard tapes (see Table 7). Figure 21 summarizes the treatment for the subset PTB0 to PTB5. Considering the artefact uncertainty, all control measurements agree with the weighted mean value. The detailed graphs in Figure 22 to Figure 29 support the interpretation of a consistent dataset between PTB0 and PTB5, and of PTB6 indicating a fundamental change of the artefact.

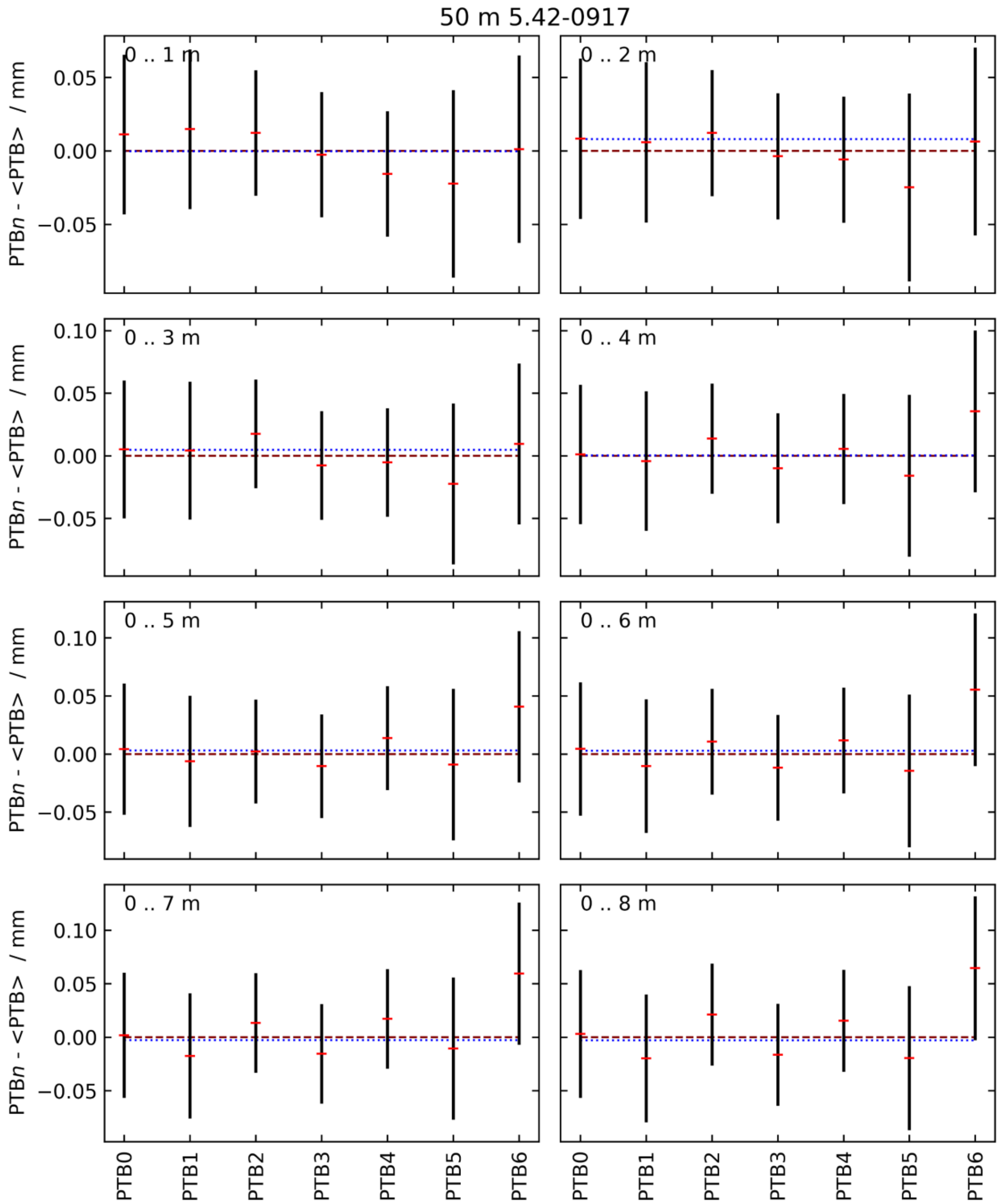


Figure 22 Comparison of the pilot laboratory measurements against the weighted mean of PTB0 through PTB5 (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5.42-0917. The error bars are based on a coverage factor of k =2.

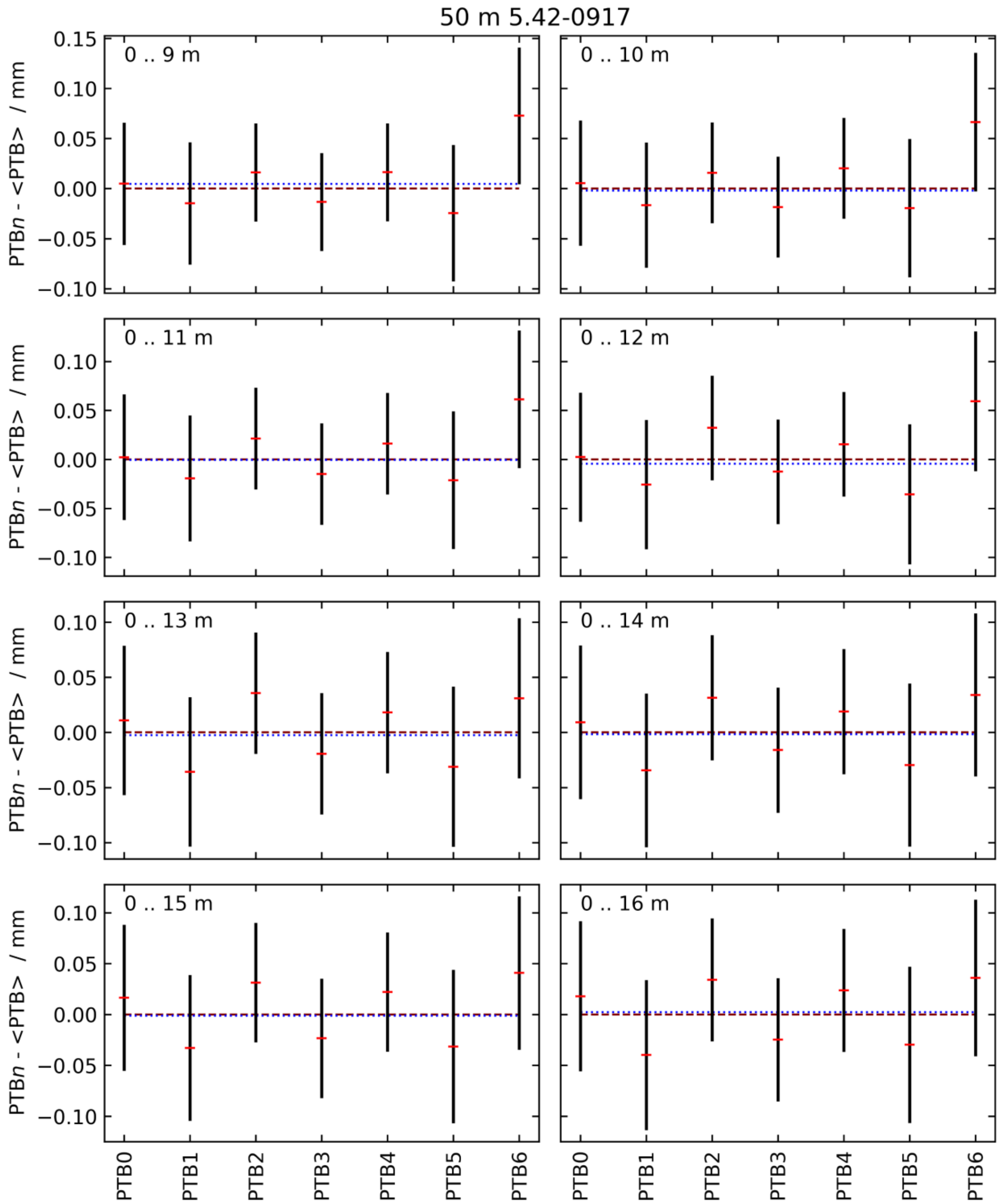


Figure 23 Comparison of the pilot laboratory measurements against the weighted mean of PTB0 through PTB5 (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5.42-0917. The error bars are based on a coverage factor of k =2.

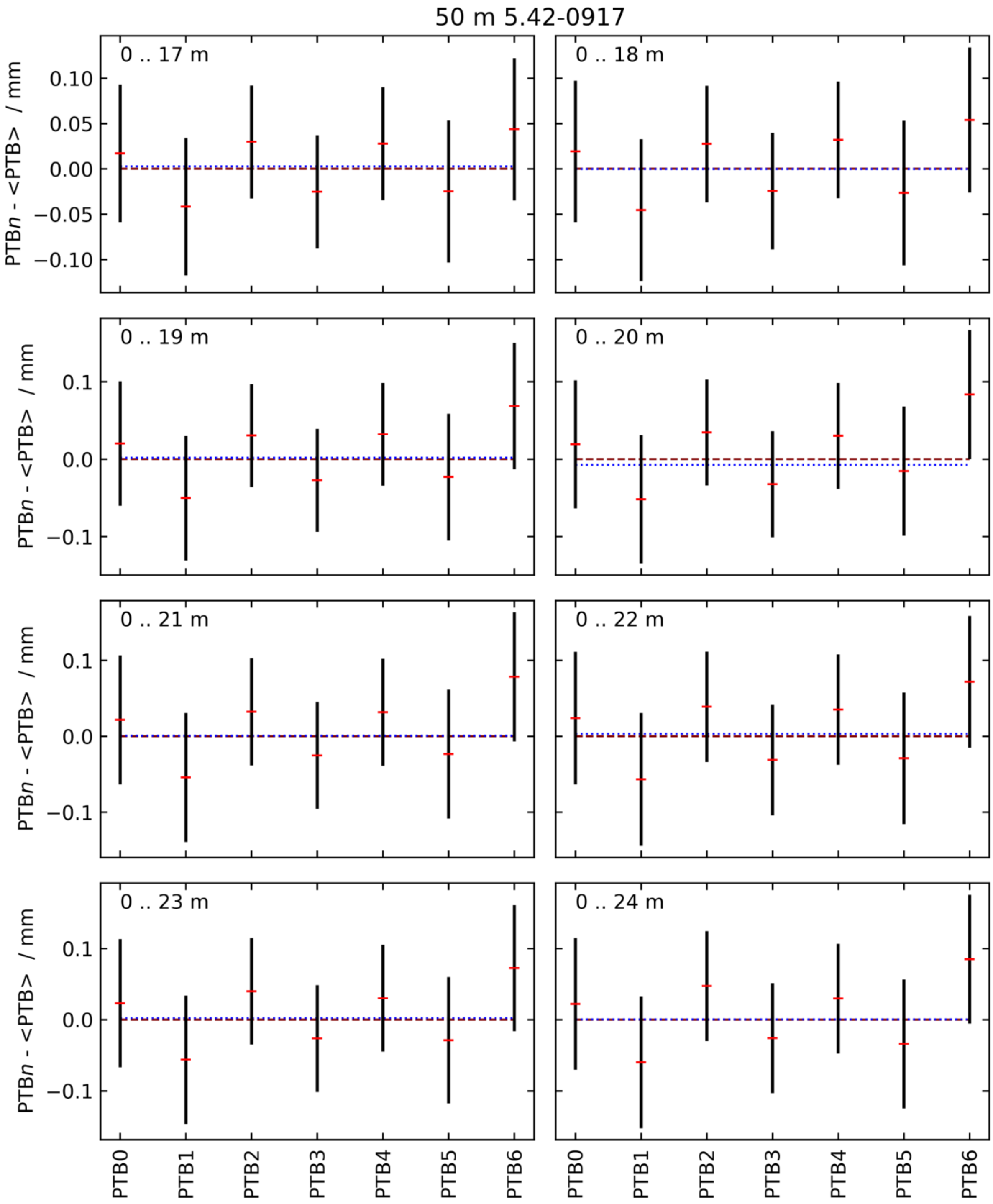


Figure 24 Comparison of the pilot laboratory measurements against the weighted mean of PTB0 through PTB5 (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5.42-0917. The error bars are based on a coverage factor of k =2.

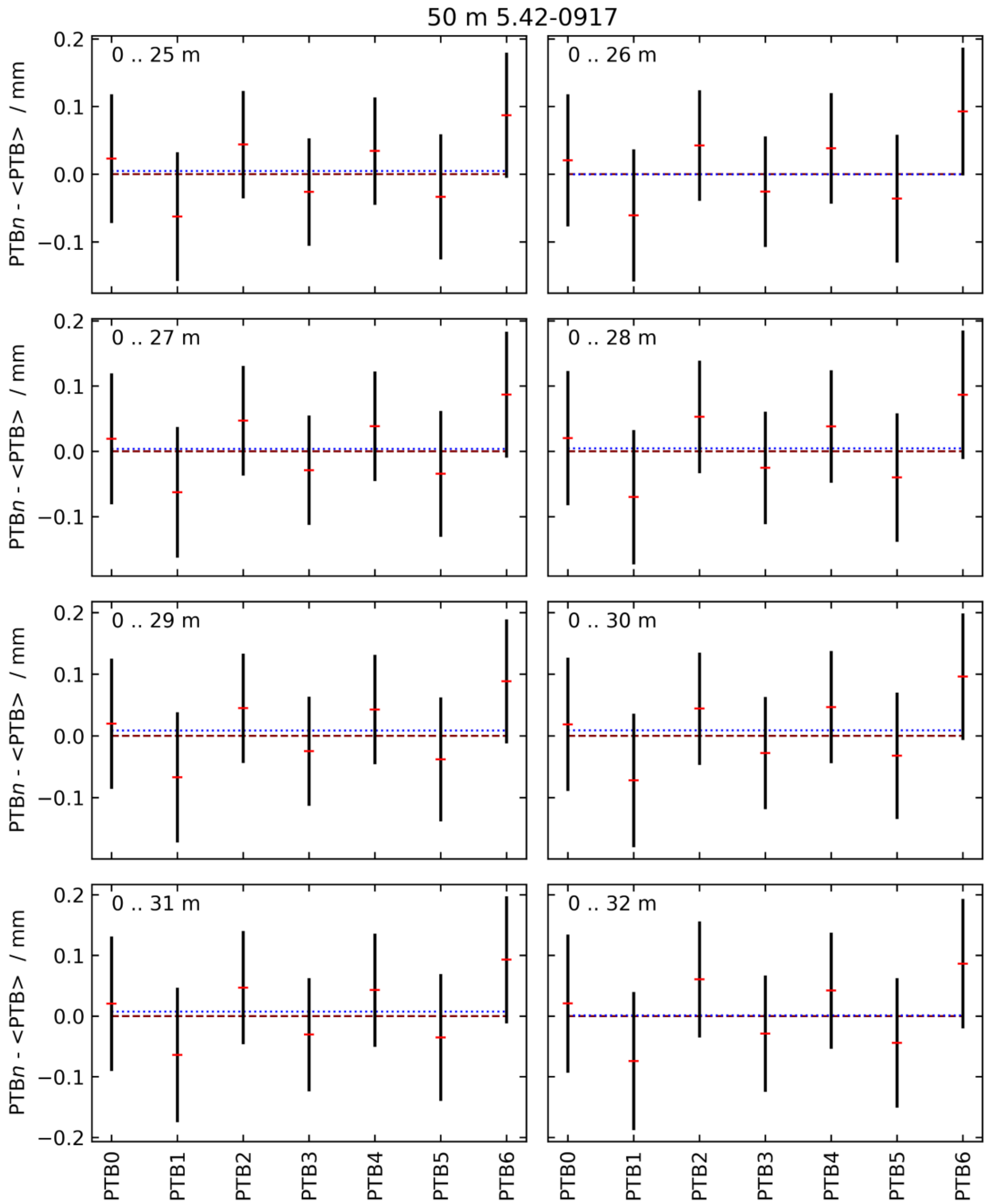


Figure 25 Comparison of the pilot laboratory measurements against the weighted mean of PTB0 through PTB5 (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5.42-0917. The error bars are based on a coverage factor of k =2.

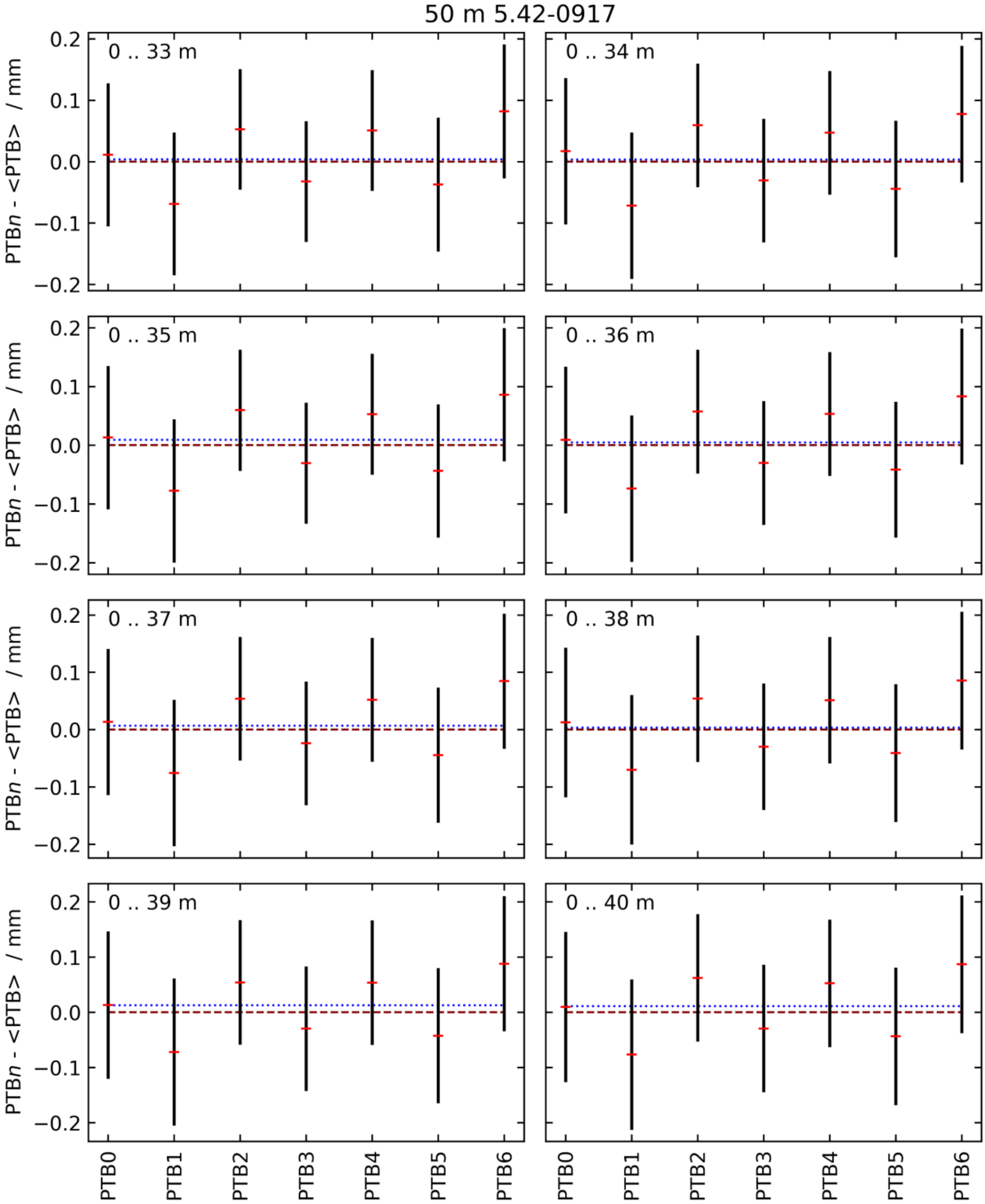


Figure 26 Comparison of the pilot laboratory measurements against the weighted mean of PTB0 through PTB5 (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5.42-0917. The error bars are based on a coverage factor of k =2.

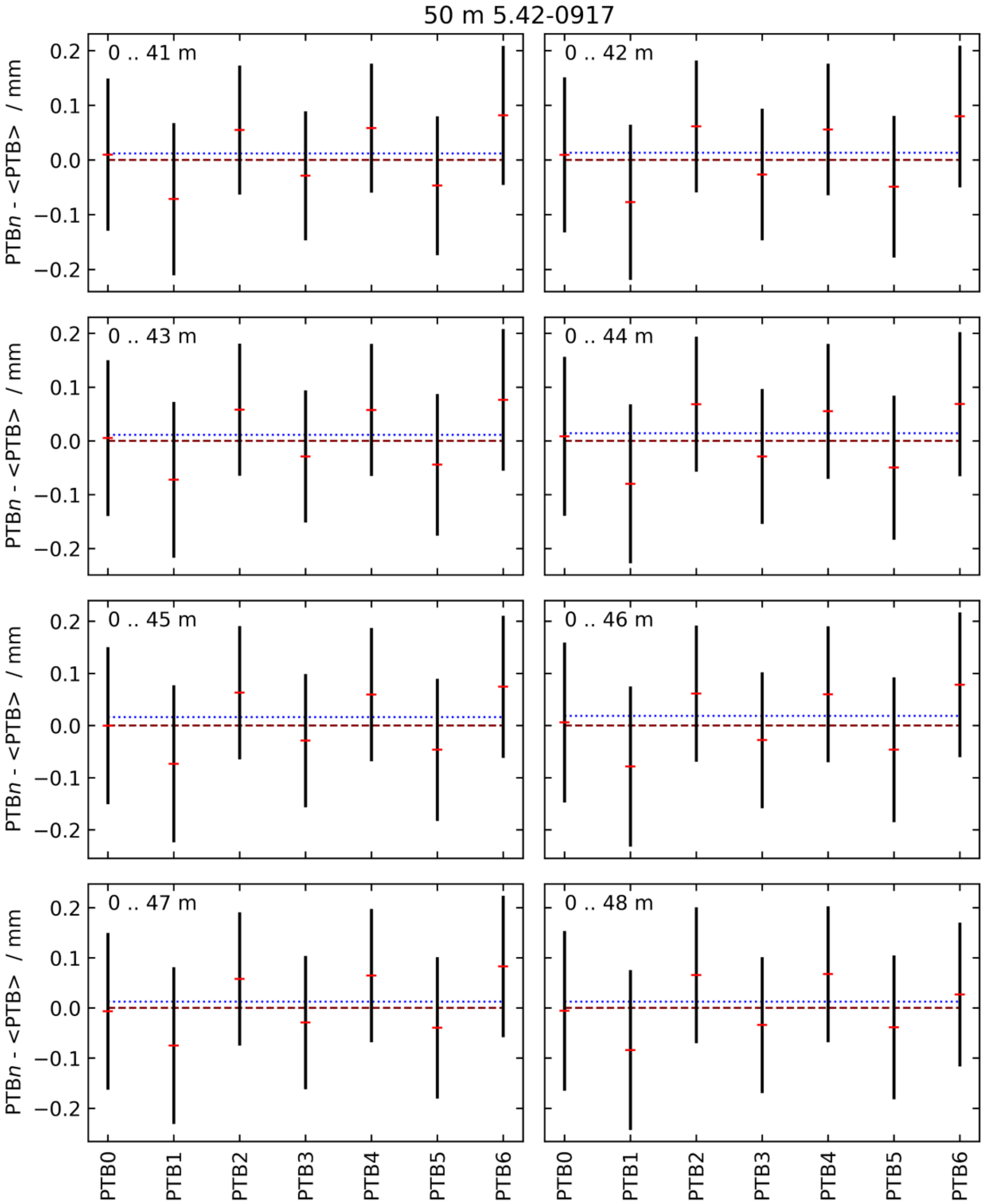


Figure 27 Comparison of the pilot laboratory measurements against the weighted mean of PTB0 through PTB5 (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5.42-0917. The error bars are based on a coverage factor of k =2.

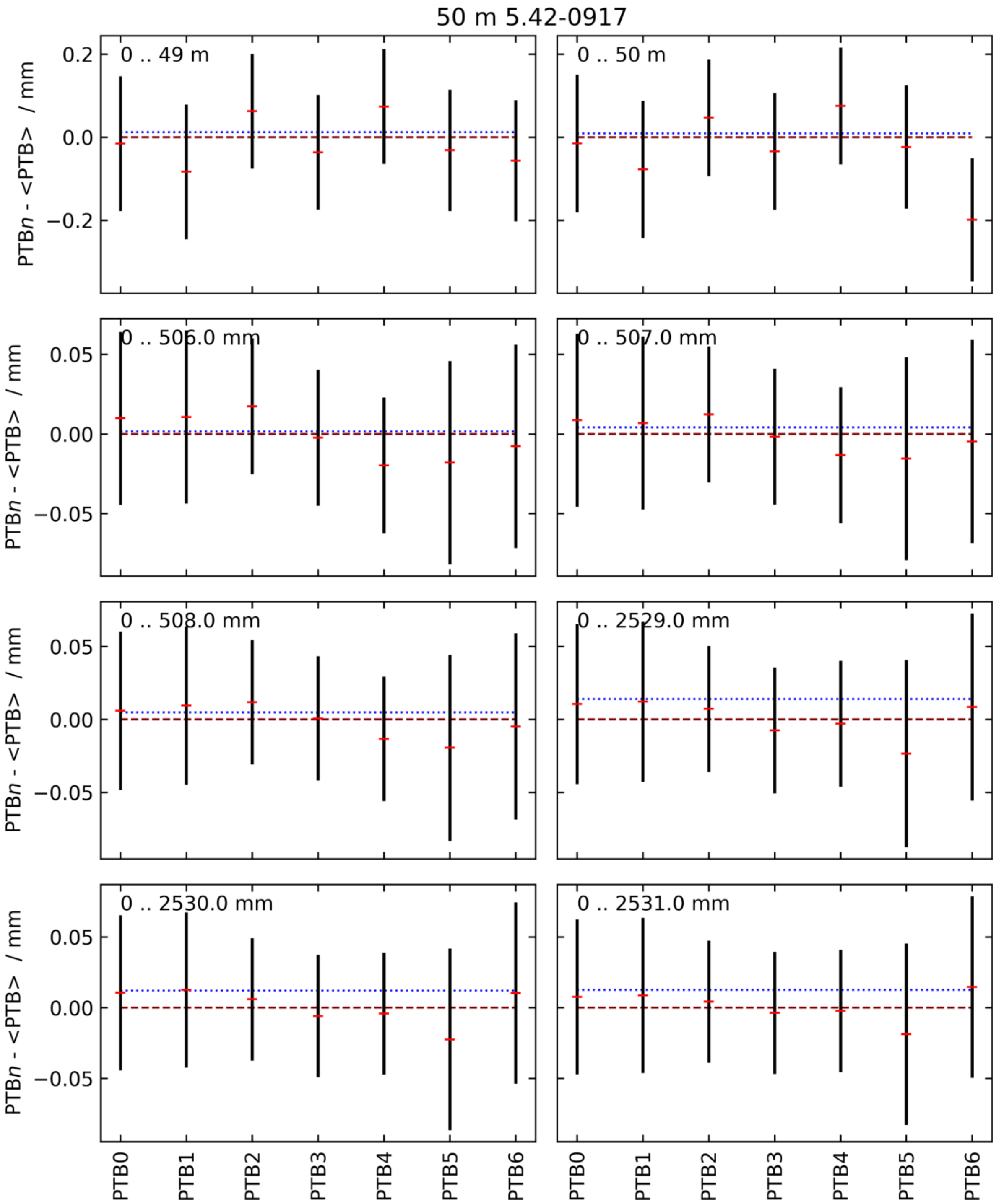


Figure 28 Comparison of the pilot laboratory measurements against the weighted mean of PTB0 through PTB5 (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5.42-0917. The error bars are based on a coverage factor of k =2.

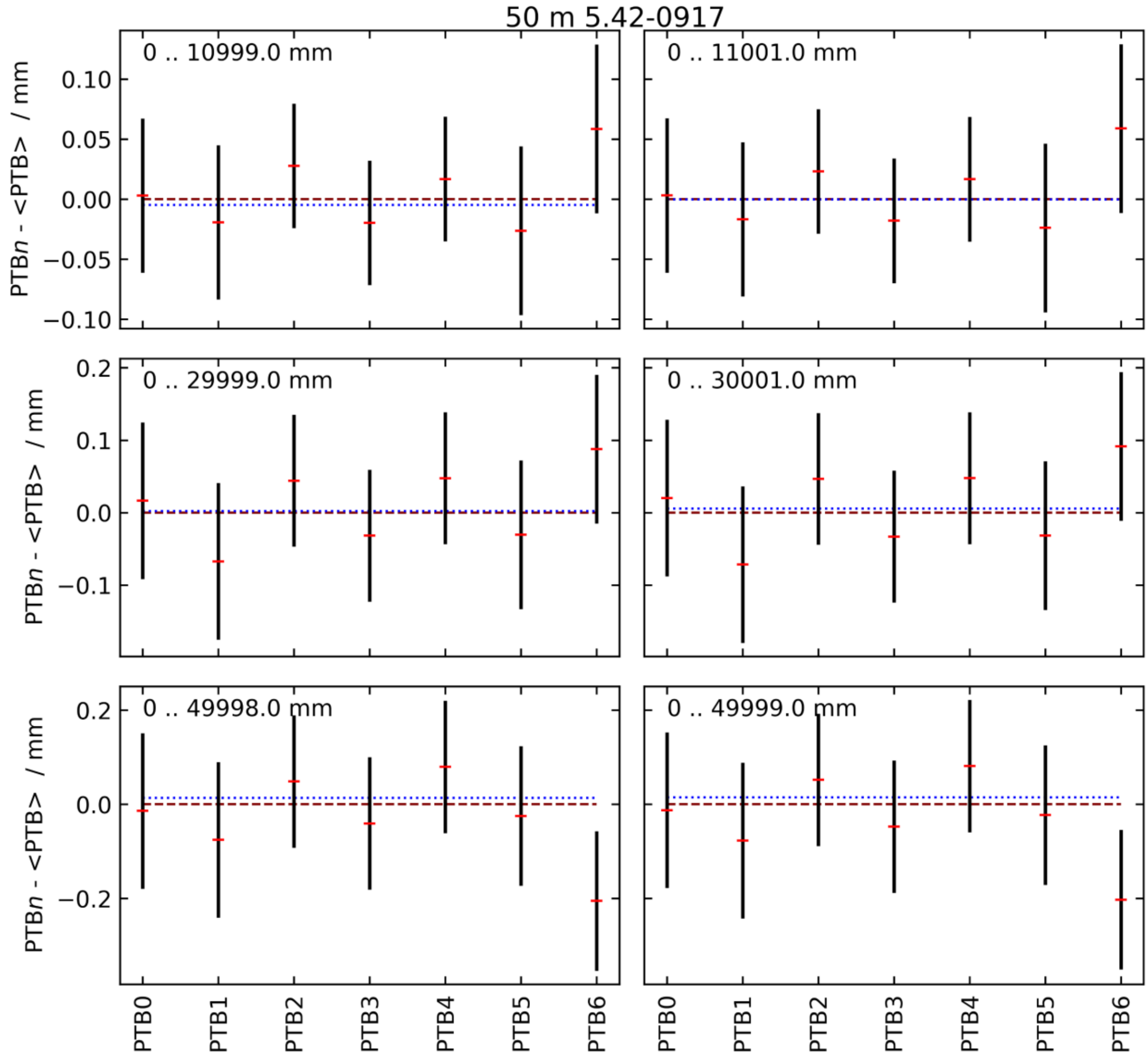


Figure 29 Comparison of the pilot laboratory measurements against the weighted mean of PTB0 through PTB5 (indicated by maroon dashed lines) and the SCRV (indicated by blue dotted lines) for tape 5.42-0917. The error bars are based on a coverage factor of k =2.

5 Measuring instructions

5.1 Handling the artefact

The steel tapes should only be handled by authorized persons wearing appropriate gloves. They should be stored in such a way as to prevent damage. Before making the measurements, the steel tapes had to be checked to verify that the tapes had no kinks and their measuring surfaces were not damaged. Before measurement, the protective oil had to be removed. The condition of the steel tapes before measurement should be reported to the pilot. Laboratories were supposed to measure all steel tapes.

No other measurements were to be attempted by the participants and the steel tapes should not be used for any purpose other than described in this document. The steel tapes were not to be given to any party other than the participants in the comparison.

The steel tapes should be examined before dispatch and any change in condition during the measurement at each laboratory should be communicated to the pilot laboratory. Before shipment, completeness of the package should be checked, and the original packaging was to be used.

5.2 Traceability

Length measurements should be traceable to the latest realisation of the metre as set out in the current "*Mise en Pratique*". Temperature measurements should be made using the International Temperature Scale of 1990 (ITS-90).

5.3 Measurands

The steel tapes were to be measured based on the standard procedure that the laboratory regularly used for this calibration service for its customers. Each tape was to be calibrated in space intervals of 1 m for the tapes of 10 m and 50 m, respectively. All the results were to be given starting from the origin (zero). According to OIML R 35-2 [4], five different places randomly distributed over the measure of length should also be calibrated for the tapes of 10 m with 5-millimetre graduation and 50 m with millimetre graduation.

For the 10 m and the 50 m with millimetre graduation tapes, the lines should be localized at nominally the bottom border of the scale (usually considering the first approx. 3 mm of the lines). For the 50 m with metre graduation tape, the lines were to be localized in the middle of the tape, between the two longitudinal lines. The tapes were to be calibrated in horizontal position, loaded by the nominal force (50 N or 100 N, respectively). Any deviation of this position or force should be appropriately corrected. The measurement results should be corrected to the reference temperature of 20°C using the thermal expansion coefficients indicated in Table 4.

5.4 Measurement uncertainty

The uncertainty of measurement should be estimated according to the ISO Guide to the Expression of Uncertainty in Measurement. The participating laboratories were encouraged to use their usual model for the uncertainty calculation. The laboratories were asked to report a detailed uncertainty budget. A summary of these reports is given in Section 6.2, explicit uncertainty values for each point uncertainties are listed in Table 8 till Table 18.

5.5 Reference condition

Measurement results should be reported for the reference temperature of 20 °C. For corrections, the linear thermal expansion coefficient provided in this document (Table 4) should be used.

6 Results

6.1 Results and standard uncertainties as reported by participants

In this section, the reported positions and the corresponding expanded uncertainties of the markers are given. The data are compiled in in Table 8 till Table 18.

Table 8. Reported positions of the markings in mm and their expanded uncertainty *U* (k=2) for tape 4909 PTB 01 of the first 11 participants (Table 9 continues this table).

	PTB		BEV		VUGTK		GUM		IPQ		Metrosert		MIRS		RISE		JV		NIM-80	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 1 m	999,985	0,017	999,994	0,019	999,989	0,047	999,987	0,021	1000,02	0,11	999,990	0,080	999,991	0,023	1000,04	0,11	999,978	0,034	999,9915	0,0069
0 .. 2 m	1999,971	0,018	1999,977	0,020	2000,020	0,053	1999,995	0,023	2000,04	0,12	1999,990	0,090	1999,980	0,035	2000,07	0,11	1999,981	0,036	1999,9863	0,0076
0 .. 3 m	2999,930	0,019	2999,937	0,022	2999,931	0,058	2999,942	0,026	3000,00	0,13	2999,940	0,110	2999,950	0,048	2999,99	0,11	2999,943	0,039	2999,9519	0,0086
0 .. 4 m	3999,877	0,021	3999,871	0,025	3999,824	0,066	3999,879	0,029	4000,01	0,16	3999,860	0,120	3999,898	0,060	3999,88	0,11	3999,878	0,044	3999,8900	0,0098
0 .. 5 m	4999,770	0,024	4999,767	0,028	4999,725	0,077	4999,807	0,033	4999,97	0,19	4999,810	0,140	4999,782	0,073	4999,83	0,12	4999,779	0,049	4999,7881	0,0112
0 .. 6 m	5999,726	0,026	5999,717	0,032	5999,781	0,088	5999,735	0,037	5999,97	0,20	5999,710	0,150	5999,725	0,085	5999,76	0,12	5999,734	0,054	5999,7404	0,0127
0 .. 7 m	6999,702	0,029	6999,690	0,036	6999,607	0,098	6999,711	0,042	7000,00	0,21	6999,700	0,170	6999,719	0,098	6999,74	0,12	6999,723	0,060	6999,7142	0,0143
0 .. 8 m	7999,666	0,032	7999,649	0,040	7999,599	0,109	7999,660	0,046	8000,02	0,23	7999,640	0,180	7999,668	0,110	7999,68	0,13	7999,686	0,066	7999,6785	0,0159
0 .. 9 m	8999,647	0,034	8999,629	0,043	8999,633	0,120	8999,650	0,051	9000,02	0,25	8999,590	0,200	8999,643	0,123	8999,66	0,13	8999,658	0,073	8999,6668	0,0175
0 .. 10 m	9999,597	0,037	9999,579	0,048	9999,503	0,132	9999,562	0,056	10000,03	0,27	9999,540	0,210	9999,594	0,136	9999,6	0,14	9999,615	0,079	9999,6147	0,0192
0 .. 1005.0 mm	1004,985	0,017	1004,990	0,019	1004,984	0,048	1004,978	0,021	1005,02	0,11	1004,990	0,080	1004,986	0,023			1004,982	0,034	1004,9842	0,0069
0 .. 1010.0 mm	1009,991	0,017	1009,997	0,019	1009,984	0,047	1009,984	0,021	1010,02	0,12	1010,000	0,080	1009,989	0,024			1009,986	0,034	1009,9942	0,0069
0 .. 1015.0 mm	1014,986	0,017	1014,994	0,019	1014,981	0,047	1014,981	0,021	1015,02	0,12	1015,000	0,080	1014,988	0,023			1014,982	0,034	1014,9893	0,0069
0 .. 2525.0 mm	2524,923	0,019	2524,928	0,021	2524,920	0,055	2524,947	0,024	2525,01	0,15	2524,930	0,100	2524,938	0,042			2524,936	0,038	2524,9329	0,0081
0 .. 2530.0 mm	2529,938	0,019	2529,940	0,021	2529,932	0,055	2529,959	0,024	2530,04	0,15	2529,940	0,100	2529,947	0,042			2529,949	0,038	2529,9462	0,0081
0 .. 2535.0 mm	2534,935	0,019	2534,935	0,021	2534,927	0,054	2534,951	0,024	2535,03	0,14	2534,940	0,100	2534,943	0,042			2534,939	0,038	2534,9413	0,0081
0 .. 5695.0 mm	5694,738	0,025	5694,727	0,031	5694,723	0,091	5694,737	0,036	5695,02	0,19	5694,720	0,150	5694,748	0,081			5694,743	0,053	5694,7512	0,0122
0 .. 5700.0 mm	5699,727	0,025	5699,720	0,031	5699,709	0,084	5699,728	0,036	5700,02	0,19	5699,720	0,150	5699,740	0,081			5699,741	0,053	5699,7437	0,0123
0 .. 5705.0 mm	5704,734	0,025	5704,729	0,031	5704,722	0,089	5704,735	0,036	5705,03	0,19	5704,720	0,150	5704,751	0,081			5704,745	0,053	5704,7532	0,0123
0 .. 7745.0 mm	7744,676	0,031	7744,651	0,039	7744,568	0,106	7744,650	0,045	7745,02	0,23	7744,640	0,180	7744,676	0,107			7744,683	0,065	7744,6839	0,0155
0 .. 7750.0 mm	7749,671	0,031	7749,647	0,039	7749,562	0,109	7749,645	0,045	7750,03	0,23	7749,630	0,180	7749,665	0,107			7749,683	0,065	7749,6786	0,0155
0 .. 7755.0 mm	7754,681	0,031	7754,656	0,039	7754,573	0,107	7754,652	0,045	7754,99	0,23	7754,640	0,180	7754,676	0,107			7754,686	0,065	7754,6885	0,0155
0 .. 9990.0 mm	9989,602	0,037	9989,586	0,047	9989,506	0,132	9989,551	0,056	9990,02	0,28	9989,550	0,210	9989,591	0,136			9989,616	0,079	9989,6193	0,0192
0 .. 9995.0 mm	9994,589	0,037	9994,574	0,048	9994,495	0,132	9994,538	0,056	9995,00	0,28	9994,530	0,210	9994,581	0,137			9994,617	0,079	9994,6081	0,0192

Table 9. Reported positions of the markings in mm and their expanded uncertainty *U* (k=2) for tape 4909 PTB 01 of the first 11 participants (continuation of Table 8).

	NIM-26		CMS		SASO		INTI		CEM		LATMB		BIM		BFKH		SMD		UME		MASM	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 1 m	999,9904	0,0086	1000,007	0,017	999,9555	0,078	999,68	0,20	1000,001	0,025	1000,08	0,15	999,995	0,058	999,992	0,023	999,979	0,074	999,897	0,090	1000,060	0,046
0 .. 2 m	1999,9778	0,0093	2000,017	0,017	1999,9664	0,078	1999,66	0,20	1999,969	0,026	2000,06	0,15	1999,989	0,060	1999,969	0,042	1999,960	0,073	1999,960	0,090	2000,029	0,046
0 .. 3 m	2999,9439	0,0102	2999,979	0,017	2999,9008	0,078	2999,61	0,21	2999,936	0,028	3000,02	0,15	2999,950	0,061	2999,938	0,059	2999,925	0,073	2999,899	0,091	3000,255	0,046
0 .. 4 m	3999,8833	0,0114	3999,928	0,022	3999,8187	0,078	3999,56	0,22	3999,876	0,030	3999,97	0,16	3999,886	0,064	3999,874	0,077	3999,853	0,073	3999,867	0,091	4000,186	0,047
0 .. 5 m	4999,7781	0,0128	4999,826	0,021	4999,8085	0,078	4999,43	0,23	4999,769	0,032	4999,86	0,16	4999,780	0,067	4999,764	0,096	4999,781	0,073	4999,719	0,092	5000,098	0,047
0 .. 6 m	5999,7312	0,0144	5999,767	0,025			5999,46	0,24	5999,726	0,035	5999,82	0,16	5999,742	0,070	5999,710	0,110	5999,706	0,073	5999,698	0,093	6000,109	0,047
0 .. 7 m	6999,7113	0,0160	6999,748	0,025			6999,36	0,26	6999,695	0,038	6999,80	0,17	6999,717	0,074	6999,690	0,130	6999,692	0,074	6999,655	0,094	7000,038	0,048
0 .. 8 m	7999,6728	0,0176	7999,693	0,027			7999,35	0,28	7999,656	0,041	7999,78	0,17	7999,683	0,078	7999,640	0,150	7999,668	0,074	7999,607	0,096	8000,060	0,048
0 .. 9 m	8999,6578	0,0194	8999,675	0,031			8999,34	0,29	8999,643	0,044	8999,77	0,18	8999,671	0,083	8999,630	0,170	8999,639	0,075	8999,554	0,097	9000,076	0,049
0 .. 10 m	9999,6000	0,0211	9999,619	0,031			9999,25	0,31	9999,583	0,047	9999,75	0,18	9999,635	0,089	9999,550	0,190	9999,576	0,075	9999,557	0,099	10000,040	0,050
0 .. 1005.0 mm	1004,9888	0,0086	1005,006	0,017	1004,9352	0,078	1004,69	0,20	1005,002	0,025	1005,07	0,15	1004,994	0,058	1004,983	0,024	1004,982	0,073	1004,903	0,090	1005,041	0,046
0 .. 1010.0 mm	1009,9943	0,0086	1010,010	0,019	1009,9417	0,078	1009,68	0,20	1010,013	0,025	1010,07	0,15	1009,997	0,058	1009,992	0,023	1010,000	0,073	1009,904	0,090	1010,037	0,046
0 .. 1015.0 mm	1014,9897	0,0086	1015,012	0,018	1014,9361	0,078	1014,69	0,20	1015,007	0,025	1015,07	0,15	1014,995	0,058	1014,983	0,024	1014,985	0,073	1014,898	0,090	1015,049	0,046
0 .. 2525.0 mm	2524,9299	0,0097	2524,931	0,018	2524,8737	0,078	2524,61	0,21	2524,934	0,027	2525,02	0,15	2524,946	0,060	2524,912	0,052	2524,915	0,073	2524,893	0,091	2524,994	0,046
0 .. 2530.0 mm	2529,9442	0,0097	2529,918	0,016	2529,8885	0,078	2529,58	0,21	2529,941	0,027	2530,02	0,15	2529,956	0,060	2529,926	0,051	2529,935	0,073	2529,888	0,091	2529,980	0,046
0 .. 2535.0 mm	2534,9383	0,0097	2534,925	0,017	2534,8802	0,078	2534,59	0,21	2534,941	0,027	2535,02	0,15	2534,955	0,060	2534,918	0,051	2534,930	0,073	2534,890	0,091	2534,989	0,046
0 .. 5695.0 mm	5694,7412	0,0139	5694,778	0,021			5694,46	0,24	5694,745	0,034	5694,83	0,16	5694,755	0,070	5694,720	0,110	5694,744	0,073	5694,697	0,093	5694,916	0,047
0 .. 5700.0 mm	5699,7323	0,0139	5699,775	0,022			5699,39	0,24	5699,736	0,034	5699,83	0,16	5699,748	0,070	5699,710	0,110	5699,737	0,073	5699,694	0,093	5699,881	0,047
0 .. 5705.0 mm	5704,7394	0,0139	5704,779	0,022			5704,42	0,24	5704,742	0,034	5704,83	0,16	5704,755	0,070	5704,720	0,110	5704,739	0,073	5704,700	0,093	5704,916	0,047
0 .. 7745.0 mm	7744,6739	0,0172	7744,709	0,026			7744,28	0,27	7744,676	0,040	7744,79	0,17	7744,693	0,078	7744,640	0,150	7744,669	0,074	7744,618	0,095	7744,902	0,047
0 .. 7750.0 mm	7749,6676	0,0172	7749,697	0,026			7749,32	0,27	7749,666	0,040	7749,79	0,17	7749,687	0,078	7749,630	0,150	7749,662	0,074	7749,616	0,095	7749,906	0,047
0 .. 7755.0 mm	7754,6771	0,0172	7754,706	0,026			7754,30	0,27	7754,679	0,040	7754,79	0,17	7754,696	0,078	7754,640	0,150	7754,672	0,074	7754,625	0,095	7754,925	0,047
0 .. 9990.0 mm	9989,6066	0,0211	9989,626	0,031			9989,20	0,31	9989,593	0,047	9989,75	0,18	9989,636	0,089	9989,570	0,190	9989,584	0,075	9989,572	0,099	9990,070	0,047
0 .. 9995.0 mm	9994,5936	0,0211	9994,619	0,032			9994,19	0,31	9994,583	0,047	9994,75	0,18	9994,626	0,089	9994,550	0,190	9994,572	0,075	9994,551	0,099	9995,064	0,047

Table 10. Reported positions of the markings in mm and their expanded uncertainty *U* (k=2) for tape 5060 PTB 06 No.3 (Table 11 continues this table).

	PTB		BEV		VUGTK		GUM		IPQ		Metrosert		MIRS		RISE		JV		NIM-80	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 1 m	999,997	0,021	1000,004	0,018	1000,004	0,045	1000,009	0,021	999,96	0,11	1000,010	0,080	1000,002	0,023	1000,07	0,11	1000,002	0,034	1000,0036	0,0065
0 .. 2 m	1999,999	0,021	2000,008	0,020	2000,051	0,049	2000,025	0,023	2000,02	0,20	2000,010	0,090	2000,017	0,035	2000,13	0,11	2000,005	0,036	2000,0115	0,0072
0 .. 3 m	3000,005	0,022	3000,019	0,023	3000,005	0,056	3000,037	0,026	3000,00	0,20	3000,020	0,110	3000,034	0,048	3000,10	0,11	3000,020	0,039	3000,0223	0,0082
0 .. 4 m	4000,008	0,024	4000,028	0,027	3999,982	0,065	4000,032	0,029	4000,01	0,23	4000,010	0,120	4000,043	0,060	4000,07	0,11	4000,021	0,044	4000,031	0,010
0 .. 5 m	5000,013	0,025	5000,031	0,032	4999,982	0,074	5000,058	0,033	5000,03	0,26	5000,050	0,140	5000,047	0,073	5000,11	0,12	5000,034	0,049	5000,037	0,011
0 .. 6 m	6000,016	0,027	6000,038	0,037	6000,082	0,085	6000,057	0,037	6000,01	0,26	6000,040	0,150	6000,058	0,085	6000,09	0,12	6000,043	0,054	6000,042	0,012
0 .. 7 m	7000,029	0,029	7000,054	0,041	6999,982	0,095	7000,054	0,042	7000,00	0,30	7000,060	0,170	7000,080	0,098	7000,10	0,12	7000,056	0,060	7000,056	0,014
0 .. 8 m	8000,031	0,031	8000,052	0,046	7999,988	0,106	8000,050	0,046	7999,99	0,33	8000,060	0,180	8000,091	0,110	8000,10	0,13	8000,063	0,066	8000,061	0,016
0 .. 9 m	9000,049	0,033	9000,077	0,051	9000,074	0,118	9000,069	0,051	9000,03	0,35	9000,070	0,200	9000,113	0,123	9000,13	0,13	9000,079	0,073	9000,083	0,017
0 .. 10 m	10000,054	0,035	10000,083	0,057	10000,015	0,128	10000,047	0,056	10000,06	0,41	10000,080	0,210	10000,120	0,135	10000,14	0,14	10000,098	0,079	10000,089	0,019
0 .. 11 m	11000,040	0,038	11000,070	0,062	10999,988	0,140	11000,052	0,061	10999,99	0,43	11000,100	0,230	11000,116	0,148	11000,10	0,14	11000,082	0,086	11000,079	0,021
0 .. 12 m	12000,038	0,040	12000,074	0,067	12000,033	0,151	12000,051	0,066	12000,04	0,46	12000,050	0,240	12000,124	0,160	12000,12	0,15	12000,073	0,092	12000,077	0,022
0 .. 13 m	13000,061	0,043	13000,096	0,072	13000,011	0,163	13000,038	0,071	13000,04	0,50	13000,090	0,260	13000,149	0,173	13000,16	0,15	13000,106	0,099	13000,101	0,024
0 .. 14 m	14000,065	0,045	14000,103	0,077	13999,980	0,175	14000,061	0,076	14000,05	0,54	14000,120	0,270	14000,143	0,185	14000,09	0,16	14000,108	0,106	14000,105	0,026
0 .. 15 m	15000,038	0,048	15000,070	0,083	14999,944	0,187	15000,035	0,081	14999,96	0,57	15000,080	0,290	15000,117	0,198	15000,09	0,17	15000,088	0,113	15000,080	0,028
0 .. 16 m	16000,030	0,050	16000,071	0,088	16000,006	0,198	16000,038	0,086	15999,97	0,60	16000,080	0,300	16000,113	0,210	16000,12	0,17	16000,087	0,120	16000,075	0,029
0 .. 17 m	16999,993	0,053	17000,035	0,093	16999,952	0,210	17000,009	0,091	16999,94	0,65	17000,040	0,320	17000,078	0,223	17000,09	0,18	17000,044	0,127	17000,040	0,031
0 .. 18 m	17999,991	0,055	18000,021	0,099	17999,866	0,222	17999,995	0,096	17999,94	0,69	18000,040	0,330	18000,075	0,235	18000,05	0,19	18000,047	0,134	18000,036	0,033
0 .. 19 m	19000,000	0,058	19000,040	0,104	18999,977	0,233	18999,976	0,101	18999,99	0,71	19000,060	0,350	19000,081	0,248	19000,07	0,19	19000,051	0,141	19000,044	0,035
0 .. 20 m	19999,995	0,061	20000,033	0,109	19999,908	0,245	19999,960	0,106	19999,95	0,76	20000,070	0,360	20000,078	0,260	19999,99	0,20	20000,050	0,148	20000,040	0,037
0 .. 21 m	21000,022	0,064	21000,064	0,115	20999,926	0,258	21000,003	0,111	20999,99	0,79	21000,100	0,380	21000,123	0,273	21000,08	0,21	21000,080	0,155	21000,067	0,038
0 .. 22 m	22000,025	0,066	22000,069	0,120	21999,895	0,270	21999,979	0,116	21999,98	0,83	22000,110	0,390	22000,137	0,286	22000,07	0,22	22000,075	0,162	22000,070	0,040
0 .. 23 m	23000,032	0,069	23000,079	0,125	22999,956	0,281	22999,979	0,122	23000,01	0,86	23000,120	0,410	23000,153	0,298	23000,04	0,22	23000,083	0,169	23000,071	0,042
0 .. 24 m	24000,041	0,072	24000,068	0,131	23999,885	0,293	23999,993	0,127	24000,00	0,90	24000,110	0,420	24000,169	0,310	24000,06	0,23	24000,089	0,176	24000,079	0,044
0 .. 25 m	25000,058	0,074	25000,098	0,136	24999,841	0,305	25000,000	0,132	25000,02	0,93	25000,160	0,440	25000,196	0,323	25000,07	0,24	25000,109	0,183	25000,100	0,045

Table 11. Reported positions of the markings in mm and their expanded uncertainty *U* (k=2) for tape 5060 PTB 06 No.3 (continuation of Table 10).

	PTB		BEV		VUGTK		GUM		IPQ		Metrosert		MIRS		RISE		JV		NIM-80	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 26 m	26000,057	0,077	26000,104	0,141	25999,772	0,315	25999,990	0,137	26000,01	0,97	26000,140	0,450	26000,198	0,335	26000,05	0,25	26000,096	0,190	26000,094	0,047
0 .. 27 m	27000,034	0,080	27000,066	0,147	26999,671	0,327	26999,999	0,142	26999,99	1,01	27000,150	0,470	27000,175	0,348	27000,06	0,25	27000,085	0,197	27000,073	0,049
0 .. 28 m	28000,032	0,083	28000,068	0,152	27999,718	0,339	27999,974	0,147	28000,01	1,04	28000,110	0,480	28000,165	0,360	27999,99	0,26	28000,057	0,204	28000,056	0,051
0 .. 29 m	29000,055	0,085	29000,094	0,158	28999,708	0,351	28999,986	0,152	29000,03	1,08	29000,120	0,500	29000,189	0,373	29000,04	0,27	29000,096	0,211	29000,081	0,053
0 .. 30 m	30000,061	0,088	30000,104	0,163	29999,712	0,365	30000,013	0,158	30000,05	1,12	30000,130	0,510	30000,195	0,385	30000,09	0,28	30000,103	0,219	30000,082	0,054
0 .. 31 m	31000,039	0,091	31000,078	0,168	30999,619	0,375	30999,990	0,163	30999,96	1,15	31000,130	0,530	31000,191	0,398	31000,00	0,28	31000,071	0,226	31000,060	0,056
0 .. 32 m	32000,042	0,094	32000,087	0,174	31999,717	0,387	31999,971	0,168	32000,01	1,19	32000,120	0,540	32000,203	0,410	31999,94	0,29	32000,080	0,233	32000,061	0,058
0 .. 33 m	33000,047	0,097	33000,083	0,179	32999,649	0,400	33000,019	0,173	32999,99	1,23	33000,160	0,560	33000,220	0,423	32999,99	0,30	33000,081	0,240	33000,066	0,060
0 .. 34 m	34000,058	0,099	34000,091	0,184	33999,639	0,411	34000,006	0,178	33999,95	1,26	34000,180	0,570	34000,232	0,435	34000,04	0,31	34000,084	0,247	34000,071	0,062
0 .. 35 m	35000,038	0,102	35000,079	0,190	34999,685	0,423	34999,971	0,183	34999,98	1,30	35000,150	0,590	35000,221	0,448	34999,98	0,32	35000,073	0,254	35000,052	0,063
0 .. 36 m	36000,032	0,105	36000,066	0,195	35999,670	0,436	35999,969	0,189	35999,98	1,34	36000,180	0,600	36000,218	0,460	35999,97	0,32	36000,067	0,261	36000,044	0,065
0 .. 37 m	37000,040	0,108	37000,073	0,201	36999,648	0,447	36999,981	0,194	36999,99	1,38	37000,160	0,620	37000,202	0,473	36999,93	0,33	37000,067	0,268	37000,049	0,067
0 .. 38 m	38000,041	0,111	38000,072	0,206	37999,598	0,460	37999,986	0,199	37999,97	1,41	38000,170	0,630	38000,199	0,485	37999,92	0,34	38000,077	0,276	38000,049	0,069
0 .. 39 m	39000,035	0,113	39000,064	0,211	38999,638	0,472	38999,994	0,204	38999,97	1,45	39000,180	0,650	39000,191	0,498	39000,00	0,35	39000,064	0,283	39000,043	0,070
0 .. 40 m	40000,035	0,116	40000,068	0,217	39999,628	0,484	40000,003	0,209	39999,99	1,49	40000,200	0,660	40000,193	0,510	40000,03	0,36	40000,064	0,290	40000,041	0,072
0 .. 41 m	41000,069	0,119	41000,097	0,222	40999,591	0,496	41000,003	0,215	41000,00	1,52	41000,250	0,680	41000,234	0,523	40999,96	0,36	41000,108	0,297	41000,078	0,074
0 .. 42 m	42000,075	0,122	42000,113	0,227	41999,666	0,509	42000,027	0,220	41999,98	1,56	42000,240	0,690	42000,243	0,535	41999,95	0,37	42000,105	0,304	42000,079	0,076
0 .. 43 m	43000,067	0,125	43000,098	0,233	42999,656	0,521	43000,011	0,225	42999,97	1,59	43000,220	0,710	43000,236	0,548	42999,96	0,38	43000,097	0,311	43000,075	0,078
0 .. 44 m	44000,067	0,128	44000,101	0,238	43999,543	0,533	44000,018	0,230	43999,99	1,63	44000,230	0,720	44000,238	0,560	43999,98	0,39	44000,104	0,319	44000,075	0,079
0 .. 45 m	45000,069	0,130	45000,100	0,244	44999,641	0,545	45000,033	0,235	45000,01	1,67	45000,250	0,740	45000,232	0,573	45000,04	0,40	45000,095	0,326	45000,077	0,081
0 .. 46 m	46000,073	0,133	46000,100	0,249	45999,638	0,558	45999,999	0,241	46000,07	1,71	46000,220	0,750	46000,228	0,585	45999,97	0,40	46000,100	0,333	46000,079	0,083
0 .. 47 m	47000,073	0,136	47000,101	0,254	46999,608	0,569	46999,996	0,246	47000,02	1,74	47000,240	0,770	47000,222	0,598	46999,96	0,41	47000,098	0,340	47000,082	0,085
0 .. 48 m	48000,084	0,139	48000,115	0,260	47999,568	0,582	48000,022	0,251	48000,06	1,78	48000,240	0,780	48000,227	0,610	47999,99	0,42	48000,107	0,347	48000,091	0,087
0 .. 49 m	49000,088	0,142	49000,114	0,265	48999,605	0,594	49000,018	0,256	49000,04	1,82	49000,220	0,800	49000,223	0,623	48999,97	0,43	49000,115	0,354	49000,094	0,088
0 .. 50 m	50000,103	0,144	50000,130	0,271	49999,621	0,605	50000,027	0,261	49999,99	1,86	50000,230	0,810	50000,245	0,635	49999,98	0,44	50000,126	0,362	50000,106	0,090

Table 12. Reported positions of the markings in mm and their expanded uncertainty *U* (k=2) for tape 5060 PTB 06 No.3 (Table 13 continues this table).

	NIM-26		SASO		INTI		CEM		LATMB		BIM		BFKH		SMD		UME		MASM	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 1 m	1000,0040	0,0075	999,937	0,078	1000,00	0,23	999,983	0,025	1000,03	0,15	1000,004	0,058	999,996	0,022	1000,010	0,073	999,944	0,090	1000,076	0,046
0 .. 2 m	2000,0073	0,0082	2000,008	0,078	2000,00	0,23	1999,988	0,026	2000,04	0,15	2000,019	0,060	1999,997	0,038	2000,014	0,073	2000,007	0,090	2000,022	0,046
0 .. 3 m	3000,0188	0,0093	2999,968	0,078	2999,99	0,24	3000,011	0,028	3000,01	0,15	3000,031	0,061	3000,006	0,056	3000,039	0,073	2999,971	0,091	3000,052	0,047
0 .. 4 m	4000,025	0,011	3999,931	0,078	4000,10	0,26	3999,998	0,030	4000,04	0,16	4000,039	0,064	4000,013	0,072	4000,023	0,073	4000,010	0,091	4000,074	0,047
0 .. 5 m	5000,033	0,012	5000,030	0,078	5000,02	0,27	5000,005	0,032	5000,04	0,16	5000,045	0,067	5000,017	0,090	5000,054	0,073	4999,993	0,092	5000,052	0,047
0 .. 6 m	6000,035	0,014			6000,05	0,29	6000,001	0,035	6000,03	0,16	6000,055	0,071	6000,020	0,110	6000,056	0,073	6000,025	0,093	5999,975	0,048
0 .. 7 m	7000,051	0,015			7000,03	0,31	7000,028	0,038	7000,06	0,17	7000,068	0,075	7000,030	0,120	7000,065	0,074	7000,028	0,094	7000,088	0,049
0 .. 8 m	8000,055	0,017			8000,09	0,33	8000,032	0,041	8000,07	0,17	8000,082	0,080	8000,020	0,140	8000,085	0,074	8000,044	0,096	8000,064	0,049
0 .. 9 m	9000,075	0,019			9000,11	0,36	9000,047	0,044	9000,10	0,18	9000,097	0,084	9000,020	0,160	9000,089	0,075	9000,033	0,097	9000,012	0,050
0 .. 10 m	10000,081	0,021			10000,04	0,38	10000,051	0,047	10000,09	0,18	10000,115	0,089	10000,030	0,180	10000,089	0,075	10000,083	0,099	10000,068	0,051
0 .. 11 m	11000,068	0,023			10999,94	0,41	11000,038	0,051	11000,09	0,19	11000,098	0,095	11000,000	0,200	11000,080	0,110	11000,012	0,128	11000,134	0,052
0 .. 12 m	12000,068	0,024			11999,98	0,44	12000,044	0,054	12000,06	0,19	12000,099	0,100	11999,990	0,210	12000,070	0,110	12000,069	0,128	12000,138	0,053
0 .. 13 m	13000,089	0,026			13000,01	0,47	13000,050	0,058	13000,06	0,20	13000,120	0,106	13000,010	0,230	13000,110	0,110	13000,054	0,129	13000,082	0,054
0 .. 14 m	14000,094	0,028			14000,04	0,50	14000,049	0,061	14000,03	0,21	14000,142	0,111	13999,990	0,250	14000,090	0,110	14000,084	0,129	14000,039	0,056
0 .. 15 m	15000,069	0,030			14999,99	0,53	15000,030	0,065	15000,01	0,21	15000,117	0,117	14999,950	0,270	15000,090	0,110	15000,031	0,130	15000,110	0,057
0 .. 16 m	16000,064	0,032			15999,97	0,56	16000,030	0,069	16000,02	0,22	16000,109	0,123	15999,930	0,270	16000,070	0,110	16000,053	0,130	16000,146	0,058
0 .. 17 m	17000,030	0,034			16999,91	0,60	16999,980	0,072	16999,99	0,23	17000,071	0,129	16999,900	0,270	17000,030	0,110	17000,004	0,131	17000,073	0,060
0 .. 18 m	18000,022	0,036			17999,97	0,63	17999,970	0,076	17999,98	0,23	18000,070	0,135	17999,900	0,270	18000,050	0,110	18000,011	0,132	18000,154	0,061
0 .. 19 m	19000,026	0,038			18999,98	0,66	18999,975	0,080	19000,00	0,24	19000,070	0,142	18999,900	0,280	19000,040	0,110	18999,992	0,133	19000,119	0,063
0 .. 20 m	20000,028	0,039			19999,96	0,69	19999,974	0,084	20000,00	0,25	20000,075	0,148	19999,900	0,280	20000,030	0,110	20000,032	0,134	20000,080	0,064
0 .. 21 m	21000,054	0,041			20999,87	0,72	20999,995	0,088			21000,092	0,156	20999,900	0,290	21000,040	0,140				
0 .. 22 m	22000,057	0,043			21999,93	0,75	21999,992	0,091			22000,092	0,163	21999,910	0,290	22000,040	0,140				
0 .. 23 m	23000,052	0,045			22999,90	0,78	23000,001	0,095			23000,094	0,169	22999,900	0,300	23000,060	0,140				
0 .. 24 m	24000,065	0,047			23999,91	0,81	24000,003	0,099			24000,103	0,175	23999,900	0,310	24000,050	0,140				
0 .. 25 m	25000,084	0,049			24999,90	0,84	25000,027	0,103			25000,128	0,182	24999,920	0,320	25000,090	0,140				

Table 13. Reported positions of the markings in mm and their expanded uncertainty *U* (k=2) for tape 5060 PTB 06 No.3 (continuation of Table 12).

	NIM-26		SASO		INTI		CEM		LATMB		BIM		BFKH		SMD		UME		MASM	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 26 m	26000,080	0,056			25999,88	0,87	26000,008	0,103			26000,120	0,188	25999,910	0,330	26000,060	0,140				
0 .. 27 m	27000,052	0,057			26999,90	0,90	26999,968	0,103			27000,101	0,194	26999,890	0,350	27000,030	0,140				
0 .. 28 m	28000,039	0,058			27999,82	0,93	27999,967	0,104			28000,088	0,201	27999,860	0,360	28000,030	0,140				
0 .. 29 m	29000,058	0,060			28999,78	0,96	28999,977	0,104			29000,118	0,207	28999,870	0,370	29000,050	0,140				
0 .. 30 m	30000,062	0,061			29999,71	0,99	29999,984	0,105			30000,115	0,214	29999,870	0,390	30000,050	0,140				
0 .. 31 m	31000,038	0,063			30999,59	1,02	30999,965	0,106			31000,092	0,220	30999,850	0,390	31000,040	0,160				
0 .. 32 m	32000,041	0,064			31999,61	1,05	31999,968	0,107			32000,094	0,227	31999,860	0,390	32000,040	0,160				
0 .. 33 m	33000,039	0,066			32999,69	1,08	32999,959	0,108			33000,116	0,233	32999,870	0,390	33000,050	0,160				
0 .. 34 m	34000,051	0,068			33999,70	1,12	33999,967	0,109			34000,121	0,240	33999,890	0,390	34000,040	0,160				
0 .. 35 m	35000,025	0,070			34999,70	1,15	34999,949	0,110			35000,095	0,246	34999,880	0,400	35000,030	0,160				
0 .. 36 m	36000,021	0,072			35999,63	1,18	35999,943	0,112			36000,090	0,253	35999,890	0,400	36000,020	0,160				
0 .. 37 m	37000,024	0,073			36999,67	1,21	36999,952	0,114			37000,091	0,260	36999,910	0,410	37000,020	0,160				
0 .. 38 m	38000,026	0,075			37999,63	1,24	37999,939	0,115			38000,088	0,266	37999,900	0,410	38000,030	0,160				
0 .. 39 m	39000,019	0,077			38999,63	1,27	38999,930	0,117			39000,084	0,273	38999,900	0,420	39000,020	0,160				
0 .. 40 m	40000,018	0,079			39999,62	1,30	39999,941	0,119			40000,094	0,279	39999,910	0,430	40000,010	0,160				
0 .. 41 m	41000,053	0,081			40999,53	1,33	40999,986	0,121			41000,137	0,287	40999,940	0,430	41000,050	0,180				
0 .. 42 m	42000,058	0,083			41999,58	1,36	41999,978	0,123			42000,144	0,294	41999,960	0,440	42000,050	0,180				
0 .. 43 m	43000,049	0,085			42999,59	1,39	42999,962	0,126			43000,138	0,300	42999,950	0,450	43000,050	0,180				
0 .. 44 m	44000,052	0,087			43999,64	1,42	43999,960	0,128			44000,136	0,307	43999,950	0,460	44000,040	0,180				
0 .. 45 m	45000,054	0,088			44999,66	1,45	44999,965	0,130			45000,162	0,313	44999,950	0,470	45000,050	0,180				
0 .. 46 m	46000,056	0,090			45999,61	1,48	45999,967	0,133			46000,160	0,320	45999,940	0,470	46000,050	0,180				
0 .. 47 m	47000,058	0,092			46999,61	1,51	46999,966	0,135			47000,159	0,327	46999,950	0,470	47000,050	0,180				
0 .. 48 m	48000,067	0,094			47999,60	1,54	47999,978	0,138			48000,170	0,333	47999,950	0,470	48000,060	0,180				
0 .. 49 m	49000,072	0,096			48999,60	1,57	48999,972	0,141			49000,175	0,340	48999,960	0,480	49000,070	0,180				
0 .. 50 m	50000,088	0,098			49999,61	1,60	50000,003	0,144			50000,181	0,347	49999,970	0,480	50000,060	0,180				

Table 14. Reported positions of the complete metre markings in mm and their expanded uncertainty *U* (k=2) for tape 5.42-0917 (Table 15 to Table 18 continue this table).

	PTB		BEV		VUGTK		GUM		IPQ		Metrosert		MIRS		RISE		JV		NIM-80	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 1 m	1000,080	0,054	1000,075	0,048	1000,066	0,089	1000,064	0,021	1000,07	0,12	1000,030	0,080	1000,093	0,029	1000,11	0,11	1000,008	0,047	1000,085	0,014
0 .. 2 m	2000,082	0,055	2000,079	0,049	2000,124	0,103	2000,074	0,023	2000,08	0,15	2000,030	0,090	2000,105	0,048	2000,16	0,11	2000,015	0,054	2000,090	0,015
0 .. 3 m	3000,072	0,055	3000,070	0,051	3000,052	0,103	3000,071	0,026	3000,07	0,17	3000,000	0,110	3000,090	0,073	3000,12	0,11	3000,022	0,062	3000,084	0,016
0 .. 4 m	4000,070	0,056	4000,066	0,053	4000,050	0,116	4000,067	0,029	4000,09	0,19	3999,990	0,120	4000,091	0,096	4000,09	0,11	4000,009	0,069	4000,080	0,017
0 .. 5 m	5000,079	0,056	5000,070	0,055	5000,045	0,126	5000,065	0,033	5000,04	0,18	5000,030	0,140	5000,092	0,112	5000,11	0,12	5000,003	0,076	5000,087	0,018
0 .. 6 m	6000,098	0,057	6000,089	0,058	6000,103	0,139	6000,085	0,037	6000,06	0,19	6000,020	0,150	6000,114	0,135	6000,12	0,12	6000,034	0,083	6000,103	0,019
0 .. 7 m	7000,098	0,059	7000,086	0,062	7000,045	0,160	7000,073	0,042	7000,04	0,21	7000,020	0,170	7000,114	0,150	7000,11	0,12	6999,995	0,090	7000,103	0,020
0 .. 8 m	8000,114	0,060	8000,093	0,065	8000,027	0,173	8000,080	0,046	8000,09	0,22	8000,010	0,180	8000,134	0,160	8000,11	0,13	8000,060	0,098	8000,117	0,022
0 .. 9 m	9000,118	0,061	9000,104	0,069	9000,102	0,189	9000,096	0,051	9000,05	0,23	8999,990	0,200	9000,146	0,175	9000,12	0,13	9000,071	0,105	9000,123	0,025
0 .. 10 m	10000,110	0,063	10000,092	0,073	10000,033	0,205	10000,072	0,056	10000,02	0,26	9999,980	0,210	10000,122	0,180	10000,12	0,14	10000,042	0,112	10000,115	0,027
0 .. 11 m	11000,121	0,064	11000,103	0,077	11000,049	0,227	11000,068	0,061	11000,06	0,29	11000,020	0,230	11000,143	0,189	11000,14	0,14	11000,065	0,119	11000,129	0,029
0 .. 12 m	12000,126	0,066	12000,104	0,082	12000,047	0,241	12000,077	0,066	12000,04	0,29	11999,990	0,240	12000,144	0,197	12000,13	0,15	12000,053	0,126	12000,128	0,031
0 .. 13 m	13000,131	0,068	13000,105	0,086	13000,051	0,260	13000,059	0,071	13000,04	0,32	12999,990	0,260	13000,136	0,206	13000,14	0,15	13000,044	0,134	13000,125	0,033
0 .. 14 m	14000,134	0,070	14000,109	0,091	13999,995	0,277	14000,077	0,076	13999,99	0,34	14000,020	0,270	14000,149	0,213	14000,08	0,16	14000,084	0,141	14000,129	0,035
0 .. 15 m	15000,140	0,072	15000,106	0,095	14999,990	0,296	15000,083	0,081	15000,06	0,37	14999,990	0,290	15000,138	0,222	15000,09	0,17	15000,051	0,148	15000,121	0,038
0 .. 16 m	16000,157	0,074	16000,126	0,100	16000,080	0,314	16000,095	0,086	16000,04	0,39	16000,010	0,300	16000,165	0,235	16000,14	0,17	16000,071	0,155	16000,136	0,040
0 .. 17 m	17000,160	0,076	17000,130	0,105	17000,061	0,349	17000,086	0,091	17000,07	0,40	16999,990	0,320	17000,161	0,249	17000,14	0,18	17000,110	0,162	17000,136	0,042
0 .. 18 m	18000,164	0,078	18000,128	0,110	17999,977	0,348	18000,102	0,096	18000,04	0,44	17999,970	0,330	18000,170	0,260	18000,09	0,19	18000,050	0,170	18000,137	0,045
0 .. 19 m	19000,151	0,080	19000,113	0,115	19000,080	0,368	19000,060	0,101	18999,98	0,45	18999,990	0,350	19000,146	0,272	19000,12	0,19	19000,052	0,177	19000,122	0,047
0 .. 20 m	20000,156	0,083	20000,110	0,120	20000,025	0,384	20000,051	0,106	19999,98	0,47	20000,020	0,360	20000,160	0,278	20000,04	0,20	20000,027	0,184	20000,126	0,049
0 .. 21 m	21000,171	0,085	21000,128	0,125	21000,009	0,407	21000,084	0,111	20999,99	0,49	21000,060	0,380	21000,180	0,293	21000,12	0,21	21000,027	0,191	21000,138	0,052
0 .. 22 m	22000,197	0,088	22000,153	0,130	22000,013	0,421	22000,093	0,116	22000,00	0,51	22000,080	0,390	22000,237	0,305	22000,14	0,22	22000,132	0,198	22000,163	0,054
0 .. 23 m	23000,191	0,090	23000,150	0,135	23000,067	0,437	23000,071	0,122	23000,00	0,54	23000,080	0,410	23000,206	0,317	23000,10	0,22	23000,138	0,206	23000,157	0,056
0 .. 24 m	24000,180	0,092	24000,117	0,140	23999,975	0,456	24000,077	0,127	23999,95	0,56	24000,050	0,420	24000,209	0,329	24000,11	0,23	24000,079	0,213	24000,146	0,059
0 .. 25 m	25000,183	0,095	25000,126	0,146	24999,912	0,473	25000,073	0,132	24999,98	0,58	25000,100	0,440	25000,215	0,340	25000,10	0,24	25000,119	0,220	25000,151	0,061

Table 15. Reported positions of the complete metre markings in mm and their expanded uncertainty *U* (k=2) for tape 5.42-0917 (continuation of Table 14).

	PTB		BEV		VUGTK		GUM		IPQ		Metrosert		MIRS		RISE		JV		NIM-80	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 26 m	26000,185	0,098	26000,138	0,151	25999,914	0,473	26000,058	0,137	25999,97	0,60	26000,060	0,450	26000,213	0,349	26000,10	0,25	26000,079	0,227	26000,153	0,063
0 .. 27 m	27000,205	0,100	27000,139	0,156	26999,980	0,491	27000,097	0,142	26999,99	0,63	27000,090	0,470	27000,230	0,366	27000,12	0,25	27000,123	0,234	27000,178	0,066
0 .. 28 m	28000,202	0,103	28000,135	0,161	27999,924	0,510	28000,086	0,147	28000,00	0,65	28000,060	0,480	28000,229	0,375	28000,11	0,26	28000,108	0,242	28000,176	0,068
0 .. 29 m	29000,201	0,106	29000,137	0,167	28999,915	0,527	29000,067	0,152	28999,98	0,67	29000,040	0,500	29000,223	0,386	29000,14	0,27	29000,116	0,249	29000,179	0,070
0 .. 30 m	30000,206	0,108	30000,144	0,172	29999,899	0,545	30000,086	0,158	30000,00	0,69	30000,050	0,510	30000,235	0,398	30000,18	0,28	30000,119	0,256	30000,180	0,073
0 .. 31 m	31000,205	0,111	31000,130	0,177	30999,972	0,563	31000,073	0,163	30999,99	0,72	31000,070	0,530	31000,236	0,410	31000,12	0,28	31000,137	0,263	31000,180	0,075
0 .. 32 m	32000,217	0,114	32000,146	0,182	31999,893	0,580	32000,063	0,168	32000,03	0,74	32000,060	0,540	32000,255	0,423	32000,06	0,29	32000,117	0,270	32000,189	0,077
0 .. 33 m	33000,225	0,116	33000,153	0,188	32999,896	0,598	33000,087	0,173	33000,01	0,76	33000,080	0,560	33000,279	0,435	33000,12	0,30	33000,165	0,278	33000,207	0,080
0 .. 34 m	34000,233	0,119	34000,149	0,193	33999,961	0,617	34000,071	0,178	34000,05	0,79	34000,110	0,570	34000,287	0,446	34000,15	0,31	34000,157	0,285	34000,210	0,082
0 .. 35 m	35000,213	0,122	35000,145	0,198	34999,884	0,635	35000,056	0,183	35000,06	0,81	35000,060	0,590	35000,285	0,459	35000,12	0,32	35000,116	0,292	35000,201	0,084
0 .. 36 m	36000,231	0,125	36000,149	0,204	35999,899	0,653	36000,076	0,189	36000,04	0,83	36000,100	0,600	36000,301	0,472	36000,11	0,32	36000,182	0,299	36000,218	0,087
0 .. 37 m	37000,247	0,128	37000,165	0,209	36999,942	0,671	37000,097	0,194	37000,05	0,86	37000,100	0,620	37000,317	0,483	37000,10	0,33	37000,169	0,306	37000,233	0,089
0 .. 38 m	38000,263	0,130	38000,179	0,214	37999,929	0,689	38000,090	0,199	38000,07	0,88	38000,110	0,630	38000,329	0,496	38000,09	0,34	38000,178	0,314	38000,250	0,092
0 .. 39 m	39000,251	0,133	39000,166	0,220	38999,880	0,707	39000,082	0,204	39000,06	0,89	39000,110	0,650	39000,313	0,508	39000,18	0,35	39000,207	0,321	39000,242	0,094
0 .. 40 m	40000,257	0,136	40000,166	0,225	39999,868	0,724	40000,100	0,209	40000,08	0,92	40000,120	0,660	40000,327	0,520	40000,22	0,36	40000,161	0,328	40000,246	0,096
0 .. 41 m	41000,276	0,139	41000,185	0,231	40999,960	0,742	41000,091	0,215	41000,07	0,94	41000,150	0,680	41000,353	0,533	41000,15	0,36	41000,194	0,335	41000,271	0,099
0 .. 42 m	42000,281	0,142	42000,198	0,236	41999,951	0,760	42000,100	0,220	42000,05	0,96	42000,150	0,690	42000,423	0,536	42000,13	0,37	42000,240	0,342	42000,274	0,101
0 .. 43 m	43000,282	0,145	43000,194	0,241	42999,866	0,779	43000,096	0,225	43000,03	0,98	43000,150	0,710	43000,377	0,558	43000,15	0,38	43000,198	0,350	43000,283	0,103
0 .. 44 m	44000,296	0,148	44000,200	0,247	43999,984	0,797	44000,097	0,230	44000,05	1,01	44000,180	0,720	44000,379	0,569	44000,17	0,39	44000,223	0,357	44000,291	0,106
0 .. 45 m	45000,283	0,151	45000,190	0,252	44999,912	0,816	45000,085	0,235	45000,08	1,03	45000,180	0,740	45000,378	0,580	45000,22	0,40	45000,235	0,364	45000,287	0,108
0 .. 46 m	46000,299	0,153	46000,197	0,258	45999,908	0,832	46000,090	0,241	46000,03	1,05	46000,180	0,750	46000,386	0,594	46000,18	0,40	46000,215	0,371	46000,304	0,111
0 .. 47 m	47000,298	0,156	47000,205	0,263	46999,892	0,851	47000,086	0,246	47000,09	1,08	47000,180	0,770	47000,385	0,605	47000,16	0,41	47000,239	0,378	47000,310	0,113
0 .. 48 m	48000,306	0,159	48000,207	0,268	47999,941	0,869	48000,092	0,251	48000,03	1,10	48000,170	0,780	48000,391	0,618	48000,19	0,42	48000,254	0,386	48000,309	0,115
0 .. 49 m	49000,310	0,162	49000,211	0,274	48999,875	0,886	49000,105	0,256	49000,06	1,12	49000,180	0,800	49000,394	0,632	49000,18	0,43	49000,241	0,393	49000,326	0,118
0 .. 50 m	50000,321	0,165	50000,219	0,279	49999,822	0,905	50000,109	0,261	50000,05	1,15	50000,200	0,810	50000,384	0,641	50000,19	0,44	50000,325	0,400	50000,325	0,120

Table 16. Reported positions of the complete metre markings in mm and their expanded uncertainty *U* (k=2) for tape 5.42-0917 (continuation of Table 15).

	NIM-26		SASO		INTI		CEM		LATMB		BIM		BFKH		SMD		UME		MASM	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 1 m	1000,097	0,014	999,978	0,078	1000,06	0,24	1000,017	0,025	1000,059	0,150	1000,093	0,076	1000,026	0,021	1000,012	0,074	1000,055	0,090	1000,055	0,046
0 .. 2 m	2000,099	0,015	2000,138	0,078	2000,10	0,25	2000,031	0,026	2000,051	0,151	2000,111	0,077	2000,028	0,038	2000,023	0,074	2000,124	0,090	2000,031	0,046
0 .. 3 m	3000,090	0,016	3000,015	0,078	3000,09	0,26	3000,038	0,028	3000,059	0,153	3000,108	0,079	3000,008	0,058			3000,089	0,091	3000,066	0,046
0 .. 4 m	4000,080	0,017	4000,017	0,078	4000,14	0,27	4000,033	0,030	4000,077	0,155	4000,120	0,081	4000,007	0,073	4000,042	0,074	4000,139	0,091	4000,093	0,046
0 .. 5 m	5000,089	0,019	5000,072	0,078	5000,13	0,29	5000,054	0,032	5000,076	0,158	5000,137	0,083	5000,008	0,091	5000,076	0,075	5000,139	0,092	5000,075	0,046
0 .. 6 m	6000,107	0,019			6000,18	0,31	6000,072	0,035	6000,104	0,162	6000,159	0,086	6000,010	0,110	6000,092	0,075	6000,181	0,093	6000,002	0,047
0 .. 7 m	7000,103	0,021			7000,16	0,33	7000,084	0,038	7000,118	0,166	7000,170	0,090	7000,010	0,130	7000,104	0,075	7000,184	0,094	7000,120	0,047
0 .. 8 m	8000,112	0,023			8000,15	0,35	8000,093	0,041	8000,140	0,170	8000,199	0,093	8000,000	0,140	8000,129	0,075	8000,223	0,096	8000,100	0,047
0 .. 9 m	9000,125	0,025			9000,23	0,38	9000,098	0,044	9000,166	0,175	9000,201	0,098	8999,980	0,160	9000,128	0,076	9000,213	0,097	9000,052	0,047
0 .. 10 m	10000,113	0,028			10000,18	0,40	10000,097	0,047	10000,151	0,180	10000,209	0,102	9999,960	0,180	10000,077	0,076	10000,263	0,099	10000,113	0,047
0 .. 11 m	11000,126	0,030			11000,11	0,44	11000,113	0,051	11000,172	0,186	11000,221	0,107	10999,950	0,200	11000,140	0,110	11000,234	0,128	11000,184	0,048
0 .. 12 m	12000,127	0,032			12000,12	0,47	12000,118	0,054	12000,167	0,192	12000,226	0,112	11999,930	0,220	12000,150	0,110	12000,291	0,128	12000,193	0,048
0 .. 13 m	13000,116	0,035			13000,16	0,50	13000,102	0,058	13000,174	0,199	13000,230	0,117	12999,910	0,230	13000,150	0,110	13000,256	0,129	13000,141	0,048
0 .. 14 m	14000,128	0,037			14000,18	0,53	14000,105	0,061	14000,159	0,205	14000,255	0,122	13999,880	0,250	14000,150	0,110	14000,300	0,129	14000,102	0,049
0 .. 15 m	15000,114	0,039			15000,13	0,57	15000,112	0,065	15000,160	0,212	15000,257	0,127	14999,860	0,270	15000,170	0,110	15000,286	0,130	15000,178	0,049
0 .. 16 m	16000,133	0,042			16000,17	0,60	16000,142	0,069	16000,194	0,219	16000,278	0,133	15999,860	0,270	16000,180	0,110	16000,329	0,130	16000,218	0,050
0 .. 17 m	17000,129	0,044			17000,18	0,63	17000,126	0,072	17000,181	0,227	17000,286	0,138	16999,870	0,270	17000,200	0,110	17000,328	0,131	17000,150	0,050
0 .. 18 m	18000,130	0,047			18000,18	0,66	18000,139	0,076	18000,178	0,234	18000,297	0,144	17999,870	0,280	18000,210	0,110	18000,355	0,132	18000,236	0,050
0 .. 19 m	19000,115	0,049			19000,20	0,70	19000,121	0,080	19000,188	0,242	19000,287	0,150	18999,850	0,280	19000,200	0,110	19000,329	0,133	19000,205	0,051
0 .. 20 m	20000,122	0,051			20000,19	0,73	20000,130	0,084	20000,204	0,250	20000,296	0,156	19999,870	0,290	20000,190	0,110	20000,389	0,134	20000,171	0,051
0 .. 21 m	21000,126	0,054			21000,16	0,76	21000,138	0,088	21000,231	0,258	21000,314	0,167	20999,860	0,290	21000,260	0,140				
0 .. 22 m	22000,157	0,056			22000,25	0,79	22000,156	0,091	22000,253	0,266	22000,341	0,173	21999,880	0,300	22000,260	0,140				
0 .. 23 m	23000,152	0,059			23000,27	0,83	23000,154	0,095	23000,236	0,275	23000,342	0,178	22999,870	0,310	23000,270	0,140				
0 .. 24 m	24000,136	0,061			24000,22	0,86	24000,145	0,099	24000,246	0,282	24000,332	0,184	23999,850	0,320	24000,260	0,140				
0 .. 25 m	25000,143	0,064			25000,21	0,89	25000,146	0,103	25000,231	0,292	25000,347	0,191	24999,850	0,330	25000,270	0,140				

Table 17. Reported positions of the complete metre markings in mm and their expanded uncertainty *U* (k=2) for tape 5.42-0917 (continuation of Table 16).

	NIM-26		SASO		INTI		CEM		LATMB		BIM		BFKH		SMD		UME		MASM	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 26 m	26000,151	0,076			26000,20	0,92	26000,142	0,103	26000,257	0,300	26000,349	0,197	25999,850	0,340	26000,270	0,140				
0 .. 27 m	27000,176	0,076			27000,27	0,96	27000,162	0,103	27000,286	0,309	27000,379	0,203	26999,870	0,350	27000,290	0,140				
0 .. 28 m	28000,173	0,078			28000,22	0,99	28000,172	0,104	28000,278	0,318	28000,381	0,209	27999,860	0,360	28000,300	0,140				
0 .. 29 m	29000,166	0,079			29000,18	1,02	29000,161	0,104	29000,290	0,327	29000,397	0,215	28999,850	0,370	29000,310	0,140				
0 .. 30 m	30000,173	0,081			30000,12	1,05	30000,174	0,105	30000,280	0,335	30000,407	0,221	29999,860	0,380	30000,310	0,140				
0 .. 31 m	31000,170	0,083			31000,08	1,09	31000,173	0,106	31000,285	0,344	31000,407	0,228	30999,840	0,380	31000,320	0,160				
0 .. 32 m	32000,180	0,085			32000,13	1,12	32000,187	0,107	32000,279	0,353	32000,417	0,234	31999,830	0,390	32000,340	0,160				
0 .. 33 m	33000,190	0,087			33000,15	1,15	33000,199	0,108	33000,288	0,363	33000,453	0,240	32999,820	0,390	33000,360	0,160				
0 .. 34 m	34000,201	0,089			34000,18	1,18	34000,204	0,109	34000,272	0,372	34000,462	0,247	33999,800	0,390	34000,350	0,160				
0 .. 35 m	35000,185	0,091			35000,15	1,21	35000,201	0,110	35000,261	0,381	35000,451	0,253	34999,800	0,390	35000,360	0,160				
0 .. 36 m	36000,208	0,094			36000,21	1,25	36000,224	0,112	36000,295	0,390	36000,462	0,259	35999,790	0,400	36000,370	0,160				
0 .. 37 m	37000,218	0,096			37000,23	1,28	37000,242	0,114	37000,293	0,399	37000,485	0,266	36999,780	0,400	37000,380	0,160				
0 .. 38 m	38000,234	0,098			38000,22	1,31	38000,246	0,115	38000,297	0,409	38000,498	0,272	37999,790	0,410	38000,400	0,160				
0 .. 39 m	39000,228	0,101			39000,22	1,34	39000,240	0,117	39000,318	0,418	39000,496	0,279	38999,760	0,420	39000,390	0,160				
0 .. 40 m	40000,232	0,103			40000,25	1,38	40000,250	0,119	40000,342	0,427	40000,515	0,285	39999,750	0,420	40000,400	0,160				
0 .. 41 m	41000,257	0,105			41000,26	1,41	41000,288	0,121	41000,402	0,437	41000,538	0,294	40999,750	0,430	41000,460	0,180				
0 .. 42 m	42000,265	0,108			42000,28	1,44	42000,267	0,123	42000,416	0,446	42000,548	0,301	41999,730	0,440	42000,450	0,180				
0 .. 43 m	43000,266	0,110			43000,30	1,47	43000,284	0,126	43000,396	0,455	43000,555	0,307	42999,700	0,450	43000,470	0,180				
0 .. 44 m	44000,276	0,113			44000,36	1,51	44000,290	0,128	44000,441	0,465	44000,587	0,314	43999,680	0,460	44000,480	0,180				
0 .. 45 m	45000,278	0,115			45000,28	1,54	45000,291	0,130	45000,417	0,474	45000,580	0,320	44999,660	0,470	45000,490	0,180				
0 .. 46 m	46000,284	0,117			46000,31	1,57	46000,305	0,133	46000,453	0,484	46000,594	0,327	45999,650	0,470	46000,510	0,180				
0 .. 47 m	47000,298	0,120			47000,34	1,60	47000,314	0,135	47000,463	0,493	47000,607	0,333	46999,640	0,470	47000,520	0,180				
0 .. 48 m	48000,298	0,122			48000,35	1,63	48000,331	0,138	48000,454	0,503	48000,617	0,340	47999,640	0,470	48000,530	0,180				
0 .. 49 m	49000,307	0,125			49000,42	1,67	49000,347	0,141	49000,483	0,512	49000,624	0,346	48999,640	0,470	49000,560	0,180				
0 .. 50 m	50000,327	0,127			50000,44	1,70	50000,368	0,144	50000,493	0,522	50000,641	0,353	49999,660	0,480	50000,560	0,180				

Table 18. Reported positions of the intermediate millimetre markings in mm and their expanded uncertainty *U* (k=2) for tape 5.42-0917 (continuation of Table 17).

	PTB		BEV		VUGTK		GUM		IPQ		Metrosert		MIRS		RISE		JV		NIM-80	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 506.0 mm	506,242	0,054	506,233	0,048	506,228	0,074	506,232	0,020	506,178	0,15	506,20	0,070	506,263	0,018			506,201	0,044	506,244	0,014
0 .. 507.0 mm	507,236	0,054	507,232	0,048	507,223	0,080	507,227	0,020	507,108	0,17	507,19	0,070	507,252	0,017			507,202	0,044	507,241	0,014
0 .. 508.0 mm	508,235	0,054	508,233	0,048	508,230	0,077	508,234	0,020	508,14	0,20	508,200	0,070	508,258	0,016			508,197	0,044	508,241	0,014
0 .. 2529.0 mm	2529,218	0,055	2529,211	0,050	2529,242	0,087	2529,256	0,024	2529,16	0,15	2529,150	0,100	2529,233	0,063			2529,172	0,058	2529,223	0,015
0 .. 2530.0 mm	2530,215	0,055	2530,205	0,050	2530,234	0,096	2530,248	0,024	2530,14	0,20	2530,150	0,100	2530,231	0,064			2530,162	0,058	2530,220	0,015
0 .. 2531.0 mm	2531,200	0,055	2531,191	0,050	2531,220	0,110	2531,240	0,024	2531,04	0,15	2531,130	0,100	2531,219	0,064			2531,143	0,058	2531,209	0,015
0 .. 10999.0 mm	10999,057	0,064	10999,035	0,077	10998,978	0,222	10999,005	0,061	10998,99	0,28	10998,960	0,230	10999,085	0,188			10998,998	0,119	10999,056	0,029
0 .. 11001.0 mm	11001,106	0,064	11001,083	0,077	11001,025	0,225	11001,052	0,061	11001,37	0,30	11001,000	0,230	11001,132	0,188			11001,050	0,119	11001,111	0,029
0 .. 29999.0 mm	29999,138	0,108	29999,075	0,172	29998,836	0,545	29999,013	0,158	29998,96	0,69	29998,970	0,510	29999,166	0,398			29999,053	0,256	29999,108	0,073
0 .. 30001.0 mm	30001,192	0,108	30001,128	0,172	30000,887	0,545	30001,068	0,158	30001,03	0,69	30001,030	0,520	30001,211	0,399			30001,123	0,256	30001,161	0,073
0 .. 49998.0 mm	49998,273	0,165	49998,168	0,279	49997,765	0,904	49998,051	0,261	49998,07	1,15	49998,150	0,810	49998,345	0,642			49998,280	0,400	49998,276	0,120
0 .. 49999.0 mm	49999,258	0,165	49999,155	0,279	49998,750	0,905	49999,037	0,261	49999,02	1,15	49999,140	0,810	49999,323	0,641			49999,270	0,400	49999,257	0,120

	NIM-26		SASO		INTI		CEM		LATMB		BIM		BFKH		SMD		UME		MASM	
	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm	l/mm	U/mm
0 .. 506.0 mm	506,253	0,014	506,155	0,078	506,18	0,24	506,190	0,025	506,174	0,150	506,250	0,076	506,220	0,017	506,151	0,074	506,247	0,090	506,443	0,046
0 .. 507.0 mm	507,251	0,014	507,158	0,078	507,20	0,24	507,179	0,025	507,174	0,150	507,249	0,076	507,212	0,020	507,174	0,074	507,241	0,090	507,427	0,046
0 .. 508.0 mm	508,250	0,014	508,159	0,078	508,19	0,24	508,198	0,025	508,174	0,150	508,242	0,076	508,218	0,019	508,154	0,074	508,239	0,090	508,413	0,046
0 .. 2529.0 mm	2529,221	0,015	2529,142	0,078	2529,24	0,26	2529,167	0,027	2529,132	0,152	2529,249	0,078	2529,163	0,046	2529,192	0,074	2529,253	0,091		
0 .. 2530.0 mm	2530,220	0,015	2530,136	0,078	2530,25	0,26	2530,168	0,027	2530,132	0,152	2530,245	0,078	2530,150	0,048	2530,201	0,074	2530,250	0,091		
0 .. 2531.0 mm	2531,208	0,015	2531,129	0,078	2531,24	0,26	2531,153	0,027	2531,132	0,152	2531,230	0,078	2531,143	0,046	2531,185	0,074	2531,238	0,091		
0 .. 10999.0 mm	10999,053	0,030			10999,06	0,44	10999,046	0,051	10999,126	0,186	10999,158	0,107	10998,880	0,200	10999,070	0,110	10999,170	0,128		
0 .. 11001.0 mm	11001,108	0,030			11001,10	0,44	11001,095	0,051	11001,129	0,186	11001,204	0,107	11000,920	0,200	11001,130	0,110	11001,217	0,128		
0 .. 29999.0 mm	29999,102	0,081			29999,04	1,05	29999,106	0,105	29999,145	0,335	29999,344	0,221	29998,790	0,380	29999,230	0,140				
0 .. 30001.0 mm	30001,155	0,081			30000,94	1,05	30001,154	0,105	30001,231	0,335	30001,393	0,221	30000,850	0,380	30001,300	0,160				
0 .. 49998.0 mm	49998,276	0,127			49998,39	1,70	49998,317	0,144	49998,455	0,522	49998,592	0,353	49997,590	0,480	49998,500	0,180				
0 .. 49999.0 mm	49999,257	0,127			49999,36	1,70	49999,298	0,144	49999,447	0,522	49999,580	0,353	49998,570	0,480	49999,490	0,180				

6.2 Measurement uncertainty budgets

All participants were asked to submit a detailed measurement uncertainty budget with their data. Naturally, they are not straightforward to compare. The details depend, e.g., on the reference system used (interferometer, master tape comparator, …). Most participants provided detailed descriptions on their measurement equipment as well. They can be reviewed in the Appendix. Following Thalmann [6], it is possible to sort the uncertainty contributions into meaningful categories despite the variety of uncertainty descriptions. Table 19 explains them in detail. The measurement uncertainties adhere in almost all cases to the following model:

$$u_{\mathrm{c}}(l) = \sqrt{a^2 + b^2 l^2}, \quad (3)$$

with *a* representing a constant, and *b* a length (l)-dependent contribution. The 'constant' uncertainty contribution usually contains the repeatability of the individual mark measurement (type A contribution), reflecting both, the repeatability of the reference measurement system, but mainly the marker quality. Given the varying line quality of the three tapes, the latter contribution strongly differs for each tape, or even each measurement. Table 20 shows reported values for the reference-grade 50 m tape 5060 PTB 06 No. 3. The reported uncertainty values for each point which were used for the comparison analysis are listed as expanded measurement uncertainties (k = 2) in detail in Table 8 till Table 18.

Table 19. Measurement uncertainty contributions categories as used in Table 20 after Thalmann [6].

Constant uncertainty contributions:	
Abbe error:	Remnant Abbe error due to an imperfect bench.
Microscope:	Uncertainty of the microscope imaging.
line mark:	Line quality; uncertainty of reading position; zero-point recognition; repeatability (type A contribution) – can therefore be tape- and position-dependent.
Reference (Ref.) fixed part:	Constant calibration uncertainty of the reference instrument (laser interferometer, master tape, …).
Length-dependent uncertainty contributions	
Reference (Ref.) l-dependent part:	Length-dependent uncertainty of the reference calibration (laser interferometer, master tape); uncertainty of the air refractive index.
Alignment:	Cosine error due to imperfect tape alignment.
Tape temperature:	Calibration of temperature sensors; uncertainty of tape temperature measurement; temperature gradients in the tape.
Coefficient of thermal expansion (CTE):	Uncertainty of the CTE value (see Table 5) used for the correction to the reference temperature.
Load:	Uncertainty of load force; remnant influence of friction by the mounts.
Catenary correction:	Uncertainty due to tape catenary/mounting.

Table 20. Measurement uncertainty budgets as reported by the participants. To ease comparison, uncertainty contributions were sorted according to the categories explained in Table 19. Furthermore, the values reported for tape 5060 PTB 06 No. 3, the 50 m tape of reference grade quality, are given in the table. (CMS only measured the 10 m tape 4909 PTB 01. Therefore, their uncertainty refers to this value.) The final two lines indicate the constant and length-dependent part of the combined standard uncertainty u_c (k = 1) as reported by the participants for this tape. They might deviate from the direct quadratic sum of the category contributions as components very specific to individual set ups are missing in this summary.

	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	CMS[(1)]	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
Maximum range / m	50	50	50	50	50	50	50	50	50	50	50	10	5	50	50	20	50	50	50	20	20
Constant uncertainty contributions:																					
Abbe error / µm	1,50	9,2	3,8	0,71		40	0,6		2,4	1,0	1,0	5,0	35,1	80	8,4		14,0	0,225	34,6	44,7	15,4
Microscope / µm								25					11,9			15,2				0,50	
line mark / µm	10,3	9,1	20,0	10,1	5,8	40	4	20	7,1	2,9	3,5	5,0	11,5	80	6,8	35,4	25,4		13,0	8,6	17,1
Ref. fixed part / µm	0,05		0,01	0,029	45	7,2	0,01	40					0,058		0,29	37,4		234		0,029	0,409
Length-dependent uncertainty contributions:																					
Ref. l – dep. part / 10^{-6} l	0,12	1,0	0,69	0,015		0,2	0,3	1,05	0,87	0,036	0,045	0,97		2,240	0,25	2,0	0,50		0,18	0,750	0,128
Alignment / 10^{-6} l	0,00		0,025	0,018	0,122	0,12	0,06							2,215	0,879			0,320		0,046	
Tape temp. / 10^{-6} l	1,3	2,4	2,0	2,5	0,68	6,69	5,8	0,66	2,66	0,679	0,817	0,30	0,664	9,975	1,33	4,4	3,30	0,154	0,80	0,724	0,570
CTE/ 10^{-6} l	0,60		0,10	0,058	14,2		1,15	0,29	0,46	0,29	0,116	0,87	0,289	0,066	0,097		0,40	18,9	0,17	0,058	
Load / 10^{-6} l	0,30	0,28	5,1	0,641		2,70	2		0,46	0,505	0,505			0,014	0,746			0,115	0,01	1,73	
Catenary corr. / 10^{-6} l	0,07			0,007		0,001		4,35													
Reported combined uncertainty for maximum range interval:																					
u_c fixed part / µm	10	8,5	20	10	53	57	4,0	52	7,5	3,1	3,6	7,1	39	113	13	75	29	239	35	64,2	23
u_c prop. part / 10^{-6} l	1,4	2,7	5,5	2,6	15	7,2	6,2	4,2	2,9	0,90	0,97	1,3	0,73	15	2,0	5,0	3,4		1,0	2,0[(2)]	0,58

[(1)]CMS uncertainty for 10 m tape 4909 PTB 01 [(2)]UME combined length dependent uncertainty for 10 m < l < 20 m proportional to (l – 10 m)

6.3 Changes to results after Draft A.1

After receiving the A1 draft of this report, GUM noticed two transmission errors: one in the 2525 mm value of the 10 m steel tape, and one in the 10 m value of the commercial 50 m tape 5.42-0917. The explanation seemed credible and the respective data points were changed accordingly.

7 Analysis

7.1 Calculation of the SCRV

The supplementary comparison reference value was derived as weighted mean for each marking position. The procedure is briefly discussed in the following, based on the treatment by Lewis et al in their guidance document [7].

In the following discussion, the reported measured value of each laboratory participant is denoted by x_i and its associated combined standard uncertainty $u_c(x_i)$. As shown in Section 4.2, the imperfect artefact stability requires the introduction of a position-dependent artefact uncertainty $u_{\text{art}}(x)$ according to Eq. (1). In analogy to Eq. (2), the reported standard uncertainty $u_c(x_i)$ is amended for the respective artefact uncertainty for the analysis by:

$$u_{\text{c,art}}(x_i) = \sqrt{u_{\text{c}}(x_i)^2 + u_{\text{art}}(x)^2}. \tag{4}$$

The normalised weight, w_i, for the result d_i is given by:

$$w_i = C \cdot \frac{1}{\left[u_{\text{c,art}}(x_i)\right]^2} \tag{5}$$

where the normalising factor, C, is given by:

$$C = \frac{1}{\sum_{i=1}^{n}\left(\frac{1}{u_{\text{c,art}}(x_i)}\right)^2} \tag{6}$$

with n denoting the total number of values contributing. The weighted mean, $\bar{x}_w$, is then derived by:

$$\bar{x}_w = \sum_{i=1}^{I} w_i \cdot x_i \tag{7}$$

The uncertainty of the weighted mean is calculated by:

$$u(\bar{x}_w) = \sqrt{\frac{1}{\sum_{i=1}^{n}\left(\frac{1}{u_{\text{c,art}}(x_i)}\right)^2}} = \sqrt{C} \tag{8}$$

The supplementary comparison reference values for the three tapes together with their computed expanded uncertainties are compiled in Table 21.

7.2 Deviation from the SCRV value and degrees of equivalence

After deriving the weighted mean and its associated standard uncertainty, the deviation of each laboratory's result from the weighted mean is determined simply as

$$d_i = x_{\text{i}} - \bar{x}_w. \tag{9}$$

Table 21. Supplementary comparison reference values calculated by Eq. (7) together with their expanded uncertainty (k = 2) according to Eq. (8).

4909 PTB 01	SCRV	
	l/mm	U/mm
0 .. 1 m	999,9904	0,0061
0 .. 2 m	1999,9831	0,0065
0 .. 3 m	2999,9432	0,0080
0 .. 4 m	3999,8825	0,0078
0 .. 5 m	4999,7824	0,0090
0 .. 6 m	5999,734	0,010
0 .. 7 m	6999,707	0,012
0 .. 8 m	7999,669	0,013
0 .. 9 m	8999,654	0,014
0 .. 10 m	9999,598	0,016
0 .. 1005.0 mm	1004,9850	0,0061
0 .. 1010.0 mm	1009,9930	0,0061
0 .. 1015.0 mm	1014,9883	0,0061
0 .. 2525.0 mm	2524,9315	0,0075
0 .. 2530.0 mm	2529,9441	0,0075
0 .. 2535.0 mm	2534,9394	0,0075
0 .. 5695.0 mm	5694,744	0,010
0 .. 5700.0 mm	5699,736	0,010
0 .. 5705.0 mm	5704,745	0,010
0 .. 7745.0 mm	7744,675	0,012
0 .. 7750.0 mm	7749,670	0,012
0 .. 7755.0 mm	7754,679	0,012
0 .. 9990.0 mm	9989,602	0,017
0 .. 9995.0 mm	9994,591	0,017

5060 PTB 06	SCRV	
	l/mm	U/mm
0 .. 1 m	1000,0026	0,0055
0 .. 2 m	2000,0107	0,0069
0 .. 3 m	3000,0202	0,0090
0 .. 4 m	4000,0234	0,0101
0 .. 5 m	5000,0317	0,0117
0 .. 6 m	6000,0326	0,0131
0 .. 7 m	7000,050	0,014
0 .. 8 m	8000,053	0,016
0 .. 9 m	9000,066	0,016
0 .. 10 m	10000,074	0,018
0 .. 11 m	11000,069	0,019
0 .. 12 m	12000,071	0,020
0 .. 13 m	13000,081	0,021
0 .. 14 m	14000,079	0,022
0 .. 15 m	15000,065	0,023
0 .. 16 m	16000,069	0,024
0 .. 17 m	17000,026	0,025
0 .. 18 m	18000,033	0,026
0 .. 19 m	19000,034	0,027
0 .. 20 m	20000,024	0,029
0 .. 21 m	21000,043	0,031
0 .. 22 m	22000,042	0,032
0 .. 23 m	23000,048	0,033
0 .. 24 m	24000,053	0,034
0 .. 25 m	25000,074	0,035

5060 PTB 06	SCRV	
	l/mm	U/mm
0 .. 26 m	26000,064	0,036
0 .. 27 m	27000,041	0,037
0 .. 28 m	28000,030	0,037
0 .. 29 m	29000,052	0,037
0 .. 30 m	30000,057	0,038
0 .. 31 m	31000,034	0,039
0 .. 32 m	32000,034	0,041
0 .. 33 m	33000,041	0,041
0 .. 34 m	34000,045	0,043
0 .. 35 m	35000,027	0,043
0 .. 36 m	36000,020	0,044
0 .. 37 m	37000,024	0,045
0 .. 38 m	38000,022	0,046
0 .. 39 m	39000,017	0,047
0 .. 40 m	40000,019	0,048
0 .. 41 m	41000,052	0,049
0 .. 42 m	42000,055	0,050
0 .. 43 m	43000,048	0,051
0 .. 44 m	44000,046	0,052
0 .. 45 m	45000,053	0,053
0 .. 46 m	46000,051	0,054
0 .. 47 m	47000,051	0,055
0 .. 48 m	48000,062	0,056
0 .. 49 m	49000,064	0,057
0 .. 50 m	50000,077	0,058

5.42-0917	SCRV	
	l/mm	U/mm
0 .. 1 m	1000,068	0,014
0 .. 2 m	2000,081	0,015
0 .. 3 m	3000,071	0,016
0 .. 4 m	4000,069	0,015
0 .. 5 m	5000,077	0,015
0 .. 6 m	6000,097	0,017
0 .. 7 m	7000,093	0,019
0 .. 8 m	8000,108	0,021
0 .. 9 m	9000,117	0,022
0 .. 10 m	10000,103	0,022
0 .. 11 m	11000,118	0,026
0 .. 12 m	12000,119	0,029
0 .. 13 m	13000,118	0,030
0 .. 14 m	14000,123	0,031
0 .. 15 m	15000,123	0,031
0 .. 16 m	16000,141	0,034
0 .. 17 m	17000,145	0,034
0 .. 18 m	18000,145	0,036
0 .. 19 m	19000,132	0,038
0 .. 20 m	20000,130	0,039
0 .. 21 m	21000,150	0,041
0 .. 22 m	22000,176	0,043
0 .. 23 m	23000,171	0,045
0 .. 24 m	24000,159	0,047
0 .. 25 m	25000,165	0,048

5.42-0917	SCRV	
	l/mm	U/mm
0 .. 26 m	26000,164	0,049
0 .. 27 m	27000,189	0,050
0 .. 28 m	28000,186	0,053
0 .. 29 m	29000,189	0,053
0 .. 30 m	30000,196	0,055
0 .. 31 m	31000,191	0,055
0 .. 32 m	32000,197	0,059
0 .. 33 m	33000,218	0,059
0 .. 34 m	34000,220	0,061
0 .. 35 m	35000,208	0,063
0 .. 36 m	36000,226	0,063
0 .. 37 m	37000,240	0,064
0 .. 38 m	38000,254	0,064
0 .. 39 m	39000,251	0,066
0 .. 40 m	40000,259	0,068
0 .. 41 m	41000,278	0,069
0 .. 42 m	42000,285	0,071
0 .. 43 m	43000,288	0,071
0 .. 44 m	44000,302	0,074
0 .. 45 m	45000,299	0,074
0 .. 46 m	46000,312	0,076
0 .. 47 m	47000,318	0,077
0 .. 48 m	48000,324	0,079
0 .. 49 m	49000,337	0,081
0 .. 50 m	50000,346	0,082

5.42-0917	SCRV	
	l/mm	U/mm
0 .. 506.0 mm	506,234	0,013
0 .. 507.0 mm	507,230	0,013
0 .. 508.0 mm	508,233	0,013
0 .. 2529.0 mm	2529,221	0,015
0 .. 2530.0 mm	2530,217	0,015
0 .. 2531.0 mm	2531,204	0,015
0 .. 10999.0 mm	10999,049	0,026
0 .. 11001.0 mm	11001,102	0,026
0 .. 29999.0 mm	29999,124	0,056
0 .. 30001.0 mm	30001,178	0,056
0 .. 49998.0 mm	49998,300	0,083
0 .. 49999.0 mm	49999,285	0,083

The uncertainty of this deviation is calculated as a combination of the uncertainties of the result, $u_{\mathrm{c,art}}(x_i)$, and the uncertainty of the weighted mean $u(\bar{x}_w)$. The uncertainty of the deviation from the weighted mean is given by Eq. (10), which includes a minus sign to consider the correlation between the two uncertainties:

$$u(d_i) = \sqrt{\left[u_{\mathrm{c,art}}(x_i)\right]^2 - [u(\bar{x}_w)_{int}]^2}. \quad (10)$$

Uncertainties of data sets that were not included to the SCRV (being identified as outliers) are not correlated with the reference value. Therefore, the contribution below the square root in equation (10) is added to derive the uncertainty $u(d_i)$.

The calculated deviations from the SCRV and the derived expanded uncertainties of these deviations (coverage factor k = 2) are provided in Table 22 through Table 33.

The E_n values which reflect the degree of equivalence are calculated according to

$$E_n = \frac{d_i}{2u(d_i)}. \quad (11)$$

They are summarized in Table 35 through Table 40.

In October 2024, CCL adopted a procedure proposed by Eves and Leroux to analyse the outcomes of a length metrology interlaboratory comparison based on the dispersion of the E_n values [8]. It assesses the consistency of the dispersion of the E_n values with the uncertainty claims of the participants. If there are E_n values exceeding 1 for an ensemble of M individually reported measurements of a single measurement capability under test , then the χ^2-test statistic Q is to be computed by

$$Q = \sum_{i=1}^{M}(k_i E_{ni}) = \sum_{i=1}^{M}\frac{{d_i}^2}{u(d_i)^2}, \quad (12)$$

with k_i representing the coverage factors [8]. The Q value is then to be compared to the 95th percentile of the χ^2-distribution with M degrees of freedom $\chi^2(M)^{0.95}$ [8]. The respective parameters for this round robin are included in Table 43.

7.3 Consistency check and outlier identification

Consistency of the data sets used for the calculation of the SCRV was checked using a χ^2 test, following procedure A of Cox 2002 [5], which was also the approach by Thalmann et al. 2004 [6]. It is required that the χ^2 value observed for the dataset (χ^2_{obs}) shall not exceed the 5% probability value for the theoretical χ^2 value $\chi^2(\nu)^{0.05}$ for a degree of freedom $\nu = n - 1$ and n representing the number of laboratories contributing to the SCRV (Thalmann et al. 2004 [6]). The threshold value $\chi^2(\nu)^{0.05}$ was obtained using the python scipy package function 'scipy.stats.chi2.ppf(0.95, ν)'. If the criterium failed for a significant number of values, iteratively the participants with the largest deviations from the SCRV were removed as outliers. Subsequently, the SCRV were calculated again, together with the new deviations, uncertainties and χ^2_{obs}. Three data sets were excluded as outliers for tape 4909 PTB 01, and four data sets for 5.42-0917 to obtain fully consistent datasets. Removing these outlier datasets, consistent datasets could be derived. Details are given in Table 34.

7.4 Linking of result to other comparions

The results of this comparison are not linked to any other comparison.

Table 22 Deviations from the supplementary comparison reference values according to Eq. (9) for tape 4909 PTB 01.

SCRV deviation in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	CMS	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 1 m	-0,0053	0,0036	-0,0014	-0,0034	0,0317	-0,0004	0,0005	0,0496	-0,0124	0,0011	0,0000	0,0168	-0,0349	-0,3104	0,0106	0,0866	0,0046	0,0016	-0,0114	-0,0938	0,0696
0 .. 2 m	-0,0120	-0,0060	0,0369	0,0119	0,0611	0,0069	-0,0034	0,0869	-0,0021	0,0032	-0,0053	0,0342	-0,0167	-0,3231	-0,0140	0,0789	0,0059	-0,0141	-0,0231	-0,0234	0,0459
0 .. 3 m	-0,0136	-0,0061	-0,0122	-0,0012	0,0532	-0,0032	0,0068	0,0468	-0,0002	0,0087	0,0007	0,0355	-0,0424	-0,3332	-0,0073	0,0738	0,0068	-0,0052	-0,0182	-0,0444	0,3118
0 .. 4 m	-0,0055	-0,0112	-0,0585	-0,0035	0,1260	-0,0225	0,0151	-0,0025	-0,0045	0,0075	0,0008	0,0455	-0,0638	-0,3225	-0,0069	0,0875	0,0035	-0,0085	-0,0295	-0,0151	0,3035
0 .. 5 m	-0,0124	-0,0153	-0,0574	0,0246	0,1882	0,0276	-0,0009	0,0476	-0,0034	0,0057	-0,0043	0,0438	0,0261	-0,3524	-0,0132	0,0726	-0,0024	-0,0184	-0,0014	-0,0630	0,3156
0 .. 6 m	-0,0082	-0,0177	0,0467	0,0007	0,2384	-0,0243	-0,0091	0,0257	-0,0003	0,0061	-0,0031	0,0328		-0,2743	-0,0088	0,0897	0,0077	-0,0243	-0,0283	-0,0363	0,3747
0 .. 7 m	-0,0043	-0,0162	-0,0996	0,0044	0,2983	-0,0066	0,0126	0,0334	0,0164	0,0076	0,0047	0,0413		-0,3466	-0,0115	0,0884	0,0104	-0,0166	-0,0146	-0,0512	0,3314
0 .. 8 m	-0,0034	-0,0198	-0,0703	-0,0093	0,3477	-0,0293	-0,0011	0,0107	0,0167	0,0092	0,0035	0,0236		-0,3193	-0,0136	0,1057	0,0137	-0,0293	-0,0013	-0,0619	0,3907
0 .. 9 m	-0,0065	-0,0251	-0,0208	-0,0038	0,3653	-0,0638	-0,0112	0,0062	0,0042	0,0130	0,0040	0,0208		-0,3138	-0,0104	0,1122	0,0172	-0,0238	-0,0148	-0,1003	0,4222
0 .. 10 m	-0,0012	-0,0188	-0,0951	-0,0361	0,4331	-0,0581	-0,0038	0,0019	0,0169	0,0166	0,0019	0,0210		-0,3481	-0,0153	0,1559	0,0369	-0,0481	-0,0221	-0,0409	0,4419
0 .. 1005.0 mm	0,0003	0,0046	-0,0010	-0,0070	0,0372	0,0050	0,0007		-0,0030	-0,0008	0,0038	0,0210	-0,0498	-0,2950	0,0173	0,0800	0,0090	-0,0020	-0,0030	-0,0825	0,0560
0 .. 1010.0 mm	-0,0024	0,0044	-0,0090	-0,0090	0,0294	0,0070	-0,0040		-0,0070	0,0012	0,0013	0,0172	-0,0513	-0,3130	0,0200	0,0720	0,0040	-0,0010	0,0070	-0,0887	0,0440
0 .. 1015.0 mm	-0,0026	0,0053	-0,0073	-0,0073	0,0341	0,0117	-0,0008		-0,0063	0,0010	0,0014	0,0235	-0,0522	-0,2983	0,0185	0,0767	0,0067	-0,0053	-0,0033	-0,0900	0,0607
0 .. 2525.0 mm	-0,0081	-0,0040	-0,0115	0,0155	0,0743	-0,0015	0,0061		0,0045	0,0014	-0,0016	-0,0002	-0,0578	-0,3215	0,0023	0,0905	0,0145	-0,0195	-0,0165	-0,0388	0,0625
0 .. 2530.0 mm	-0,0061	-0,0041	-0,0121	0,0149	0,0919	-0,0041	0,0030		0,0049	0,0021	0,0001	-0,0262	-0,0556	-0,3641	-0,0029	0,0779	0,0119	-0,0181	-0,0091	-0,0561	0,0359
0 .. 2535.0 mm	-0,0041	-0,0044	-0,0124	0,0116	0,0866	0,0006	0,0033		-0,0004	0,0019	-0,0011	-0,0147	-0,0592	-0,3494	0,0014	0,0826	0,0156	-0,0214	-0,0094	-0,0497	0,0496
0 .. 5695.0 mm	-0,0066	-0,0172	-0,0215	-0,0075	0,2715	-0,0245	0,0030		-0,0015	0,0067	-0,0033	0,0336		-0,2845	0,0009	0,0805	0,0105	-0,0245	-0,0005	-0,0474	0,1715
0 .. 5700.0 mm	-0,0090	-0,0168	-0,0274	-0,0084	0,2797	-0,0164	0,0035		0,0046	0,0073	-0,0041	0,0388		-0,3464	-0,0007	0,0886	0,0116	-0,0264	0,0006	-0,0429	0,1446
0 .. 5705.0 mm	-0,0108	-0,0154	-0,0226	-0,0096	0,2816	-0,0246	0,0067		0,0004	0,0086	-0,0052	0,0348		-0,3246	-0,0028	0,0804	0,0104	-0,0246	-0,0056	-0,0443	0,1714
0 .. 7745.0 mm	0,0010	-0,0239	-0,1072	-0,0252	0,3462	-0,0352	0,0010		0,0078	0,0087	-0,0013	0,0338		-0,3952	0,0006	0,1148	0,0178	-0,0352	-0,0062	-0,0575	0,2268
0 .. 7750.0 mm	0,0016	-0,0226	-0,1079	-0,0249	0,3615	-0,0399	-0,0045		0,0131	0,0087	-0,0023	0,0266		-0,3499	-0,0040	0,1201	0,0171	-0,0399	-0,0079	-0,0540	0,2361
0 .. 7755.0 mm	0,0019	-0,0231	-0,1063	-0,0273	0,3123	-0,0393	-0,0036		0,0067	0,0092	-0,0022	0,0269		-0,3793	-0,0003	0,1107	0,0167	-0,0393	-0,0073	-0,0547	0,2457
0 .. 9990.0 mm	0,0001	-0,0167	-0,0963	-0,0513	0,4187	-0,0523	-0,0114		0,0137	0,0170	0,0043	0,0233		-0,4023	-0,0089	0,1517	0,0337	-0,0323	-0,0183	-0,0299	0,4677
0 .. 9995.0 mm	-0,0020	-0,0165	-0,0960	-0,0530	0,4101	-0,0610	-0,0097		0,0260	0,0171	0,0026	0,0280		-0,4010	-0,0080	0,1630	0,0350	-0,0410	-0,0190	-0,0402	0,4730

Table 23 Deviation uncertainties (k = 1) for the deviations from the supplementary comparison reference values according to Eq. (10) for tape 4909 PTB 01.

Combined uncertainty of the SCRV deviation	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	CMS	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 1 m	0,0085	0,0095	0,0235	0,0105	0,0550	0,0400	0,0115	0,0550	0,0170	0,0034	0,0061	0,0095	0,0390	0,1001	0,0127	0,0750	0,0292	0,0115	0,0370	0,0450	0,0234
0 .. 2 m	0,0087	0,0098	0,0264	0,0113	0,0600	0,0450	0,0174	0,0550	0,0179	0,0032	0,0062	0,0096	0,0389	0,1001	0,0130	0,0755	0,0299	0,0209	0,0364	0,0452	0,0234
0 .. 3 m	0,0099	0,0112	0,0291	0,0131	0,0650	0,0550	0,0241	0,0550	0,0196	0,0047	0,0079	0,0104	0,0390	0,1052	0,0140	0,0765	0,0307	0,0296	0,0366	0,0454	0,0238
0 .. 4 m	0,0102	0,0121	0,0329	0,0142	0,0799	0,0599	0,0298	0,0549	0,0218	0,0038	0,0073	0,0120	0,0389	0,1101	0,0145	0,0774	0,0317	0,0384	0,0364	0,0456	0,0239
0 .. 5 m	0,0114	0,0136	0,0384	0,0162	0,0949	0,0699	0,0364	0,0599	0,0243	0,0047	0,0085	0,0118	0,0389	0,1151	0,0157	0,0789	0,0332	0,0479	0,0364	0,0460	0,0241
0 .. 6 m	0,0125	0,0156	0,0438	0,0181	0,0999	0,0749	0,0423	0,0599	0,0267	0,0051	0,0093	0,0138		0,1201	0,0169	0,0809	0,0349	0,0549	0,0363	0,0464	0,0242
0 .. 7 m	0,0146	0,0182	0,0491	0,0211	0,1050	0,0850	0,0491	0,0600	0,0301	0,0075	0,0120	0,0154		0,1303	0,0189	0,0830	0,0372	0,0650	0,0371	0,0472	0,0256
0 .. 8 m	0,0154	0,0197	0,0544	0,0228	0,1150	0,0899	0,0549	0,0649	0,0328	0,0072	0,0121	0,0158		0,1402	0,0200	0,0849	0,0391	0,0749	0,0369	0,0476	0,0254
0 .. 9 m	0,0169	0,0212	0,0599	0,0253	0,1250	0,0999	0,0614	0,0649	0,0364	0,0081	0,0134	0,0179		0,1453	0,0217	0,0874	0,0414	0,0849	0,0374	0,0483	0,0262
0 .. 10 m	0,0195	0,0246	0,0662	0,0285	0,1351	0,1051	0,0682	0,0702	0,0399	0,0111	0,0167	0,0201		0,1555	0,0242	0,0902	0,0448	0,0952	0,0379	0,0496	0,0281
0 .. 1005.0 mm	0,0085	0,0095	0,0240	0,0105	0,0550	0,0400	0,0115		0,0170	0,0034	0,0061	0,0097	0,0390	0,1001	0,0126	0,0750	0,0290	0,0120	0,0365	0,0450	0,0234
0 .. 1010.0 mm	0,0085	0,0095	0,0235	0,0105	0,0600	0,0400	0,0120		0,0170	0,0034	0,0061	0,0102	0,0390	0,1001	0,0127	0,0750	0,0290	0,0115	0,0365	0,0450	0,0234
0 .. 1015.0 mm	0,0085	0,0095	0,0235	0,0105	0,0600	0,0400	0,0115		0,0170	0,0034	0,0061	0,0097	0,0390	0,1001	0,0127	0,0750	0,0290	0,0120	0,0365	0,0450	0,0234
0 .. 2525.0 mm	0,0094	0,0106	0,0275	0,0121	0,0750	0,0500	0,0210		0,0190	0,0042	0,0073	0,0105	0,0390	0,1051	0,0135	0,0760	0,0300	0,0260	0,0365	0,0453	0,0236
0 .. 2530.0 mm	0,0094	0,0106	0,0275	0,0121	0,0750	0,0500	0,0210		0,0190	0,0042	0,0073	0,0097	0,0390	0,1051	0,0135	0,0760	0,0300	0,0255	0,0365	0,0453	0,0236
0 .. 2535.0 mm	0,0094	0,0106	0,0270	0,0121	0,0700	0,0500	0,0210		0,0190	0,0042	0,0073	0,0102	0,0390	0,1051	0,0135	0,0760	0,0300	0,0255	0,0365	0,0453	0,0236
0 .. 5695.0 mm	0,0124	0,0153	0,0454	0,0178	0,0950	0,0750	0,0404		0,0264	0,0057	0,0098	0,0125		0,1202	0,0167	0,0805	0,0349	0,0549	0,0364	0,0463	0,0245
0 .. 5700.0 mm	0,0124	0,0153	0,0419	0,0178	0,0950	0,0750	0,0404		0,0264	0,0057	0,0098	0,0128		0,1202	0,0168	0,0805	0,0349	0,0550	0,0364	0,0463	0,0245
0 .. 5705.0 mm	0,0124	0,0153	0,0444	0,0178	0,0950	0,0750	0,0404		0,0264	0,0057	0,0098	0,0131		0,1202	0,0168	0,0805	0,0349	0,0549	0,0364	0,0463	0,0245
0 .. 7745.0 mm	0,0147	0,0189	0,0528	0,0220	0,1149	0,0899	0,0533		0,0322	0,0061	0,0110	0,0147		0,1352	0,0193	0,0844	0,0387	0,0749	0,0367	0,0474	0,0245
0 .. 7750.0 mm	0,0147	0,0189	0,0543	0,0220	0,1149	0,0899	0,0533		0,0322	0,0061	0,0110	0,0149		0,1352	0,0193	0,0844	0,0387	0,0749	0,0367	0,0474	0,0245
0 .. 7755.0 mm	0,0147	0,0189	0,0533	0,0220	0,1149	0,0899	0,0533		0,0322	0,0061	0,0110	0,0147		0,1352	0,0193	0,0844	0,0387	0,0749	0,0367	0,0474	0,0245
0 .. 9990.0 mm	0,0195	0,0241	0,0662	0,0285	0,1401	0,1051	0,0682		0,0399	0,0110	0,0167	0,0201		0,1555	0,0242	0,0902	0,0448	0,0952	0,0379	0,0496	0,0268
0 .. 9995.0 mm	0,0194	0,0246	0,0662	0,0285	0,1401	0,1051	0,0687		0,0399	0,0110	0,0167	0,0204		0,1555	0,0242	0,0902	0,0448	0,0952	0,0379	0,0496	0,0268

Table 24 Deviations from the supplementary comparison reference values according to Eq. (9) for tape 5060 PTB No 3. (Table 25 continues this table).

Deviations from the SCRV in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 1 m	-0,0058	0,0011	0,0014	0,0064	-0,0387	0,0074	-0,0002	0,0674	-0,0006	0,0010	0,0014	-0,0654	-0,0026	-0,0198	0,0244	0,0011	-0,0066	0,0074	-0,0583	0,0734
0 .. 2 m	-0,0115	-0,0026	0,0403	0,0143	0,0072	-0,0007	0,0064	0,1193	-0,0057	0,0008	-0,0034	-0,0026	-0,0107	-0,0222	0,0263	0,0079	-0,0137	0,0033	-0,0040	0,0113
0 .. 3 m	-0,0155	-0,0016	-0,0152	0,0168	-0,0184	-0,0002	0,0135	0,0798	-0,0002	0,0021	-0,0014	-0,0519	-0,0302	-0,0091	-0,0102	0,0105	-0,0142	0,0188	-0,0492	0,0318
0 .. 4 m	-0,0153	0,0050	-0,0414	0,0086	-0,0177	-0,0134	0,0193	0,0466	-0,0024	0,0078	0,0017	-0,0924	0,0766	-0,0259	0,0126	0,0156	-0,0104	-0,0004	-0,0134	0,0506
0 .. 5 m	-0,0183	-0,0011	-0,0497	0,0263	-0,0020	0,0183	0,0150	0,0783	0,0023	0,0053	0,0011	-0,0016	-0,0117	-0,0267	0,0053	0,0133	-0,0147	0,0223	-0,0392	0,0203
0 .. 6 m	-0,0170	0,0057	0,0494	0,0244	-0,0190	0,0074	0,0251	0,0574	0,0104	0,0091	0,0022		0,0174	-0,0320	0,0014	0,0223	-0,0126	0,0234	-0,0078	-0,0576
0 .. 7 m	-0,0212	0,0039	-0,0679	0,0041	-0,0523	0,0101	0,0303	0,0501	0,0061	0,0057	0,0012		-0,0199	-0,0216	0,0051	0,0183	-0,0199	0,0151	-0,0215	0,0381
0 .. 8 m	-0,0219	-0,0002	-0,0646	-0,0026	-0,0611	0,0074	0,0382	0,0474	0,0104	0,0088	0,0019		0,0374	-0,0203	0,0204	0,0293	-0,0326	0,0324	-0,0084	0,0114
0 .. 9 m	-0,0170	0,0110	0,0077	0,0027	-0,0408	0,0037	0,0469	0,0637	0,0127	0,0168	0,0089		0,0437	-0,0191	0,0317	0,0307	-0,0463	0,0227	-0,0329	-0,0543
0 .. 10 m	-0,0202	0,0084	-0,0595	-0,0275	-0,0151	0,0055	0,0455	0,0655	0,0235	0,0140	0,0060		-0,0345	-0,0230	0,0175	0,0408	-0,0445	0,0145	0,0082	-0,0065
0 .. 11 m	-0,0295	0,0013	-0,0811	-0,0171	-0,0758	0,0309	0,0469	0,0309	0,0129	0,0097	-0,0008		-0,1291	-0,0314	0,0179	0,0289	-0,0691	0,0109	-0,0569	0,0649
0 .. 12 m	-0,0332	0,0023	-0,0385	-0,0205	-0,0342	-0,0215	0,0520	0,0485	0,0015	0,0059	-0,0031		-0,0915	-0,0274	-0,0125	0,0278	-0,0815	-0,0015	-0,0025	0,0665
0 .. 13 m	-0,0208	0,0144	-0,0704	-0,0434	-0,0402	0,0086	0,0678	0,0786	0,0246	0,0198	0,0076		-0,0714	-0,0318	-0,0214	0,0387	-0,0714	0,0286	-0,0274	0,0006
0 .. 14 m	-0,0143	0,0235	-0,0991	-0,0181	-0,0340	0,0409	0,0642	0,0109	0,0289	0,0255	0,0147		-0,0391	-0,0303	-0,0521	0,0631	-0,0891	0,0109	0,0047	-0,0401
0 .. 15 m	-0,0278	0,0050	-0,1213	-0,0303	-0,1063	0,0147	0,0513	0,0247	0,0227	0,0143	0,0032		-0,0753	-0,0357	-0,0583	0,0518	-0,1153	0,0247	-0,0342	0,0447
0 .. 16 m	-0,0386	0,0025	-0,0630	-0,0310	-0,0960	0,0110	0,0439	0,0510	0,0180	0,0059	-0,0050		-0,0990	-0,0387	-0,0450	0,0397	-0,1390	0,0010	-0,0162	0,0770
0 .. 17 m	-0,0331	0,0086	-0,0744	-0,0174	-0,0895	0,0136	0,0515	0,0636	0,0176	0,0135	0,0031		-0,1164	-0,0465	-0,0364	0,0445	-0,1264	0,0036	-0,0226	0,0466
0 .. 18 m	-0,0419	-0,0112	-0,1665	-0,0375	-0,0917	0,0075	0,0425	0,0175	0,0145	0,0030	-0,0110		-0,0625	-0,0626	-0,0485	0,0372	-0,1325	0,0175	-0,0220	0,1215
0 .. 19 m	-0,0333	0,0068	-0,0565	-0,0575	-0,0387	0,0265	0,0474	0,0365	0,0175	0,0104	-0,0071		-0,0535	-0,0585	-0,0365	0,0363	-0,1335	0,0065	-0,0411	0,0855
0 .. 20 m	-0,0285	0,0096	-0,1158	-0,0638	-0,0751	0,0462	0,0546	-0,0338	0,0262	0,0160	0,0039		-0,0638	-0,0496	-0,0218	0,0509	-0,1238	0,0062	0,0078	0,0562
0 .. 21 m	-0,0210	0,0214	-0,1171	-0,0401	-0,0504	0,0569	0,0801	0,0369	0,0369	0,0240	0,0110		-0,1731	-0,0484		0,0486	-0,1431	-0,0031		
0 .. 22 m	-0,0173	0,0266	-0,1474	-0,0634	-0,0658	0,0676	0,0946	0,0276	0,0326	0,0272	0,0143		-0,1124	-0,0503		0,0497	-0,1324	-0,0024		
0 .. 23 m	-0,0157	0,0312	-0,0918	-0,0688	-0,0373	0,0722	0,1051	-0,0078	0,0352	0,0228	0,0046		-0,1478	-0,0464		0,0460	-0,1478	0,0122		
0 .. 24 m	-0,0122	0,0150	-0,1680	-0,0600	-0,0485	0,0570	0,1156	0,0070	0,0360	0,0263	0,0118		-0,1430	-0,0502		0,0496	-0,1530	-0,0030		
0 .. 25 m	-0,0155	0,0240	-0,2327	-0,0737	-0,0553	0,0863	0,1225	-0,0037	0,0353	0,0266	0,0106		-0,1737	-0,0464		0,0547	-0,1537	0,0163		

Table 25 Deviations from the supplementary comparison reference values according to Eq. (9) for tape 5060 PTB No 3. (Continuation of Table 24.)

Deviations from the SCRV in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 26 m	-0,0076	0,0393	-0,2923	-0,0743	-0,0519	0,0757	0,1339	-0,0143	0,0317	0,0298	0,0156		-0,1843	-0,0560		0,0556	-0,1543	-0,0043		
0 .. 27 m	-0,0070	0,0243	-0,3703	-0,0423	-0,0550	0,1087	0,1340	0,0187	0,0437	0,0313	0,0107		-0,1413	-0,0728		0,0598	-0,1513	-0,0113		
0 .. 28 m	0,0017	0,0383	-0,3120	-0,0560	-0,0198	0,0800	0,1346	-0,0400	0,0270	0,0261	0,0093		-0,2100	-0,0627		0,0575	-0,1700	0,0000		
0 .. 29 m	0,0028	0,0416	-0,3442	-0,0662	-0,0181	0,0678	0,1365	-0,0122	0,0438	0,0285	0,0057		-0,2722	-0,0757		0,0657	-0,1822	-0,0022		
0 .. 30 m	0,0031	0,0463	-0,3454	-0,0444	-0,0093	0,0726	0,1371	0,0326	0,0456	0,0244	0,0047		-0,3474	-0,0738		0,0577	-0,1874	-0,0074		
0 .. 31 m	0,0053	0,0441	-0,4146	-0,0436	-0,0715	0,0964	0,1572	-0,0336	0,0374	0,0262	0,0040		-0,4436	-0,0689		0,0582	-0,1836	0,0064		
0 .. 32 m	0,0076	0,0528	-0,3170	-0,0630	-0,0280	0,0860	0,1694	-0,0940	0,0460	0,0268	0,0070		-0,4240	-0,0659		0,0596	-0,1740	0,0060		
0 .. 33 m	0,0064	0,0422	-0,3920	-0,0220	-0,0511	0,1190	0,1788	-0,0510	0,0400	0,0252	-0,0019		-0,3510	-0,0818		0,0748	-0,1710	0,0090		
0 .. 34 m	0,0132	0,0456	-0,4061	-0,0391	-0,0913	0,1349	0,1870	-0,0051	0,0389	0,0259	0,0062		-0,3451	-0,0778		0,0755	-0,1551	-0,0051		
0 .. 35 m	0,0116	0,0525	-0,3418	-0,0558	-0,0490	0,1232	0,1943	-0,0468	0,0462	0,0256	-0,0019		-0,3268	-0,0777		0,0679	-0,1468	0,0032		
0 .. 36 m	0,0129	0,0463	-0,3495	-0,0505	-0,0378	0,1605	0,1980	-0,0495	0,0475	0,0248	0,0019		-0,3895	-0,0760		0,0701	-0,1295	0,0005		
0 .. 37 m	0,0163	0,0497	-0,3757	-0,0427	-0,0380	0,1363	0,1785	-0,0937	0,0433	0,0254	0,0004		-0,3537	-0,0718		0,0672	-0,1137	-0,0037		
0 .. 38 m	0,0189	0,0499	-0,4238	-0,0358	-0,0522	0,1482	0,1776	-0,1018	0,0552	0,0267	0,0040		-0,3918	-0,0826		0,0665	-0,1218	0,0082		
0 .. 39 m	0,0175	0,0469	-0,3794	-0,0234	-0,0438	0,1626	0,1740	-0,0174	0,0466	0,0251	0,0018		-0,3874	-0,0870		0,0668	-0,1174	0,0026		
0 .. 40 m	0,0155	0,0491	-0,3912	-0,0162	-0,0317	0,1808	0,1734	0,0108	0,0448	0,0220	-0,0016		-0,3992	-0,0783		0,0745	-0,1092	-0,0092		
0 .. 41 m	0,0169	0,0446	-0,4612	-0,0492	-0,0508	0,1978	0,1816	-0,0922	0,0558	0,0256	0,0011		-0,5242	-0,0663		0,0852	-0,1122	-0,0022		
0 .. 42 m	0,0198	0,0576	-0,3895	-0,0285	-0,0802	0,1845	0,1874	-0,1055	0,0495	0,0239	0,0021		-0,4755	-0,0776		0,0881	-0,0955	-0,0055		
0 .. 43 m	0,0195	0,0501	-0,3916	-0,0366	-0,0783	0,1724	0,1880	-0,0876	0,0494	0,0270	0,0009		-0,4576	-0,0852		0,0909	-0,0976	0,0024		
0 .. 44 m	0,0205	0,0547	-0,5034	-0,0284	-0,0532	0,1836	0,1918	-0,0664	0,0576	0,0284	0,0055		-0,4064	-0,0868		0,0901	-0,0964	-0,0064		
0 .. 45 m	0,0165	0,0477	-0,4118	-0,0198	-0,0457	0,1972	0,1796	-0,0128	0,0422	0,0246	0,0007		-0,3928	-0,0874		0,1090	-0,1028	-0,0028		
0 .. 46 m	0,0222	0,0484	-0,4132	-0,0522	0,0199	0,1688	0,1771	-0,0812	0,0488	0,0282	0,0050		-0,4412	-0,0837		0,1084	-0,1112	-0,0012		
0 .. 47 m	0,0218	0,0501	-0,4432	-0,0552	-0,0362	0,1888	0,1708	-0,0912	0,0468	0,0309	0,0071		-0,4412	-0,0852		0,1081	-0,1012	-0,0012		
0 .. 48 m	0,0221	0,0533	-0,4940	-0,0400	-0,0031	0,1780	0,1654	-0,0720	0,0450	0,0291	0,0050		-0,4620	-0,0838		0,1079	-0,1120	-0,0020		
0 .. 49 m	0,0239	0,0496	-0,4590	-0,0460	-0,0211	0,1560	0,1585	-0,0940	0,0510	0,0304	0,0078		-0,4640	-0,0917		0,1114	-0,1040	0,0060		
0 .. 50 m	0,0260	0,0530	-0,4556	-0,0496	-0,0898	0,1534	0,1680	-0,0966	0,0494	0,0292	0,0110		-0,4666	-0,0733		0,1039	-0,1066	-0,0166		

Table 26 Deviation uncertainties (k = 1) for the deviations from the supplementary comparison reference values according to Eq. (10) for tape 5060 PTB No 3.

Expanded uncertainty of the KCRV deviation in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 1 m	0,0102	0,0088	0,0224	0,0103	0,0550	0,0400	0,0114	0,0550	0,0169	0,0027	0,0051	0,0390	0,1150	0,0125	0,0750	0,0291	0,0108	0,0365	0,0450	0,0229
0 .. 2 m	0,0108	0,0101	0,0245	0,0115	0,1000	0,0450	0,0175	0,0550	0,0180	0,0037	0,0064	0,0390	0,1150	0,0132	0,0755	0,0298	0,0190	0,0365	0,0452	0,0230
0 .. 3 m	0,0122	0,0125	0,0284	0,0139	0,1001	0,0552	0,0245	0,0552	0,0201	0,0063	0,0092	0,0393	0,1201	0,0147	0,0767	0,0311	0,0284	0,0368	0,0457	0,0240
0 .. 4 m	0,0130	0,0146	0,0330	0,0155	0,1151	0,0603	0,0305	0,0553	0,0227	0,0073	0,0104	0,0394	0,1301	0,0158	0,0777	0,0325	0,0364	0,0369	0,0460	0,0241
0 .. 5 m	0,0146	0,0177	0,0378	0,0181	0,1302	0,0704	0,0373	0,0605	0,0256	0,0093	0,0127	0,0397	0,1352	0,0177	0,0794	0,0344	0,0456	0,0373	0,0467	0,0247
0 .. 6 m	0,0158	0,0203	0,0433	0,0203	0,1303	0,0755	0,0433	0,0606	0,0283	0,0105	0,0143		0,1452	0,0193	0,0814	0,0364	0,0556	0,0375	0,0473	0,0254
0 .. 7 m	0,0172	0,0226	0,0484	0,0230	0,1503	0,0855	0,0499	0,0607	0,0315	0,0118	0,0159		0,1553	0,0210	0,0835	0,0387	0,0607	0,0382	0,0481	0,0263
0 .. 8 m	0,0188	0,0254	0,0541	0,0254	0,1654	0,0906	0,0561	0,0659	0,0347	0,0133	0,0177		0,1654	0,0230	0,0857	0,0412	0,0708	0,0385	0,0490	0,0268
0 .. 9 m	0,0196	0,0276	0,0599	0,0276	0,1753	0,1005	0,0624	0,0658	0,0380	0,0136	0,0183		0,1803	0,0243	0,0881	0,0434	0,0807	0,0389	0,0496	0,0271
0 .. 10 m	0,0208	0,0305	0,0649	0,0301	0,2053	0,1056	0,0684	0,0709	0,0410	0,0145	0,0195		0,1903	0,0260	0,0907	0,0460	0,0907	0,0391	0,0505	0,0278
0 .. 11 m	0,0220	0,0330	0,0709	0,0326	0,2153	0,1156	0,0749	0,0709	0,0445	0,0154	0,0209		0,2053	0,0278	0,0937	0,0487	0,1007	0,0562	0,0651	0,0284
0 .. 12 m	0,0234	0,0356	0,0765	0,0352	0,2303	0,1206	0,0809	0,0760	0,0476	0,0166	0,0223		0,2203	0,0297	0,0968	0,0515	0,1057	0,0563	0,0652	0,0292
0 .. 13 m	0,0243	0,0379	0,0823	0,0374	0,2503	0,1305	0,0873	0,0759	0,0509	0,0169	0,0230		0,2353	0,0311	0,1002	0,0541	0,1156	0,0562	0,0654	0,0294
0 .. 14 m	0,0254	0,0403	0,0883	0,0398	0,2703	0,1355	0,0933	0,0809	0,0543	0,0176	0,0240		0,2503	0,0329	0,1032	0,0570	0,1256	0,0563	0,0656	0,0304
0 .. 15 m	0,0270	0,0434	0,0944	0,0425	0,2853	0,1456	0,0998	0,0859	0,0579	0,0188	0,0256		0,2653	0,0349	0,1068	0,0600	0,1356	0,0565	0,0660	0,0312
0 .. 16 m	0,0287	0,0461	0,1000	0,0452	0,3003	0,1506	0,1059	0,0861	0,0616	0,0202	0,0272		0,2803	0,0370	0,1104	0,0632	0,1357	0,0567	0,0666	0,0321
0 .. 17 m	0,0301	0,0487	0,1060	0,0477	0,3253	0,1606	0,1124	0,0911	0,0651	0,0212	0,0285		0,3003	0,0390	0,1144	0,0662	0,1358	0,0568	0,0671	0,0333
0 .. 18 m	0,0311	0,0515	0,1119	0,0500	0,3453	0,1656	0,1183	0,0960	0,0685	0,0217	0,0293		0,3153	0,0406	0,1178	0,0692	0,1357	0,0568	0,0674	0,0336
0 .. 19 m	0,0325	0,0540	0,1174	0,0526	0,3553	0,1756	0,1249	0,0961	0,0720	0,0227	0,0306		0,3303	0,0426	0,1219	0,0723	0,1408	0,0569	0,0681	0,0347
0 .. 20 m	0,0343	0,0568	0,1235	0,0554	0,3803	0,1807	0,1310	0,1013	0,0757	0,0243	0,0324		0,3454	0,0448	0,1260	0,0756	0,1409	0,0573	0,0689	0,0358
0 .. 21 m	0,0322	0,0578	0,1291	0,0558	0,3950	0,1901	0,1366	0,1051	0,0777	0,0199	0,0306		0,3600	0,0442		0,0784	0,1451	0,0702		
0 .. 22 m	0,0335	0,0602	0,1351	0,0582	0,4150	0,1951	0,1431	0,1101	0,0812	0,0207	0,0318		0,3750	0,0460		0,0815	0,1451	0,0702		
0 .. 23 m	0,0345	0,0625	0,1405	0,0610	0,4300	0,2050	0,1490	0,1100	0,0845	0,0210	0,0325		0,3900	0,0477		0,0845	0,1500	0,0700		
0 .. 24 m	0,0356	0,0654	0,1464	0,0633	0,4500	0,2100	0,1549	0,1149	0,0879	0,0214	0,0333		0,4050	0,0494		0,0875	0,1549	0,0699		
0 .. 25 m	0,0369	0,0678	0,1524	0,0658	0,4650	0,2199	0,1614	0,1199	0,0914	0,0222	0,0345		0,4200	0,0513		0,0907	0,1599	0,0698		

Table 27 Deviation uncertainties (k = 1) for the deviations from the supplementary comparison reference values according to Eq. (10) for tape 5060 PTB No 3.

Expanded uncertainty of the KCRV deviation in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 26 m	0,0382	0,0703	0,1574	0,0683	0,4850	0,2249	0,1674	0,1249	0,0948	0,0229	0,0376		0,4350	0,0512		0,0938	0,1649	0,0698		
0 .. 27 m	0,0392	0,0731	0,1633	0,0706	0,5049	0,2349	0,1738	0,1247	0,0982	0,0232	0,0378		0,4499	0,0510		0,0969	0,1748	0,0695		
0 .. 28 m	0,0399	0,0752	0,1692	0,0727	0,5199	0,2398	0,1797	0,1295	0,1014	0,0230	0,0376		0,4649	0,0507		0,0998	0,1797	0,0692		
0 .. 29 m	0,0405	0,0778	0,1750	0,0748	0,5398	0,2496	0,1860	0,1343	0,1046	0,0225	0,0373		0,4798	0,0503		0,1028	0,1845	0,0687		
0 .. 30 m	0,0418	0,0803	0,1820	0,0777	0,5598	0,2546	0,1920	0,1393	0,1086	0,0233	0,0383		0,4948	0,0506		0,1060	0,1945	0,0686		
0 .. 31 m	0,0431	0,0827	0,1869	0,0802	0,5748	0,2646	0,1985	0,1392	0,1120	0,0239	0,0393		0,5098	0,0508		0,1092	0,1944	0,0786		
0 .. 32 m	0,0448	0,0859	0,1930	0,0828	0,5948	0,2696	0,2045	0,1443	0,1157	0,0254	0,0410		0,5248	0,0515		0,1126	0,1945	0,0788		
0 .. 33 m	0,0452	0,0879	0,1993	0,0848	0,6148	0,2795	0,2108	0,1490	0,1188	0,0245	0,0404		0,5397	0,0512		0,1154	0,1943	0,0782		
0 .. 34 m	0,0476	0,0909	0,2050	0,0879	0,6298	0,2846	0,2170	0,1543	0,1227	0,0273	0,0433		0,5598	0,0527		0,1191	0,1945	0,0787		
0 .. 35 m	0,0481	0,0934	0,2108	0,0899	0,6498	0,2945	0,2233	0,1591	0,1258	0,0265	0,0429		0,5747	0,0525		0,1220	0,1993	0,0781		
0 .. 36 m	0,0493	0,0958	0,2172	0,0927	0,6698	0,2995	0,2293	0,1590	0,1292	0,0270	0,0437		0,5897	0,0530		0,1252	0,1992	0,0779		
0 .. 37 m	0,0507	0,0988	0,2227	0,0952	0,6898	0,3095	0,2358	0,1640	0,1327	0,0280	0,0450		0,6047	0,0538		0,1285	0,2042	0,0779		
0 .. 38 m	0,0519	0,1012	0,2292	0,0977	0,7047	0,3144	0,2418	0,1689	0,1367	0,0286	0,0459		0,6197	0,0545		0,1317	0,2041	0,0777		
0 .. 39 m	0,0536	0,1039	0,2353	0,1003	0,7248	0,3245	0,2483	0,1740	0,1403	0,0300	0,0476		0,6347	0,0556		0,1351	0,2092	0,0778		
0 .. 40 m	0,0546	0,1067	0,2412	0,1026	0,7447	0,3294	0,2542	0,1789	0,1436	0,0302	0,0481		0,6497	0,0562		0,1383	0,2141	0,0775		
0 .. 41 m	0,0558	0,1090	0,2471	0,1055	0,7597	0,3394	0,2607	0,1788	0,1470	0,0307	0,0492		0,6647	0,0570		0,1420	0,2140	0,0876		
0 .. 42 m	0,0571	0,1115	0,2536	0,1079	0,7797	0,3443	0,2666	0,1838	0,1505	0,0314	0,0502		0,6797	0,0579		0,1452	0,2190	0,0874		
0 .. 43 m	0,0584	0,1144	0,2596	0,1104	0,7947	0,3543	0,2731	0,1887	0,1540	0,0321	0,0512		0,6947	0,0589		0,1485	0,2239	0,0873		
0 .. 44 m	0,0597	0,1169	0,2656	0,1128	0,8147	0,3593	0,2791	0,1937	0,1579	0,0328	0,0523		0,7096	0,0599		0,1518	0,2289	0,0872		
0 .. 45 m	0,0609	0,1198	0,2715	0,1152	0,8347	0,3693	0,2856	0,1986	0,1613	0,0333	0,0532		0,7246	0,0609		0,1550	0,2339	0,0870		
0 .. 46 m	0,0622	0,1222	0,2780	0,1181	0,8547	0,3742	0,2915	0,1986	0,1648	0,0340	0,0542		0,7396	0,0621		0,1583	0,2338	0,0868		
0 .. 47 m	0,0638	0,1248	0,2835	0,1207	0,8697	0,3843	0,2981	0,2036	0,1684	0,0353	0,0557		0,7546	0,0635		0,1617	0,2338	0,0869		
0 .. 48 m	0,0649	0,1277	0,2900	0,1231	0,8897	0,3892	0,3040	0,2086	0,1717	0,0356	0,0565		0,7696	0,0645		0,1649	0,2337	0,0866		
0 .. 49 m	0,0662	0,1301	0,2959	0,1255	0,9097	0,3992	0,3105	0,2135	0,1752	0,0363	0,0575		0,7846	0,0657		0,1682	0,2387	0,0864		
0 .. 50 m	0,0677	0,1331	0,3015	0,1280	0,9297	0,4042	0,3165	0,2186	0,1792	0,0374	0,0589		0,7996	0,0672		0,1715	0,2387	0,0864		

Table 28 Deviations from the supplementary comparison reference values according to Eq. (9) for tape 5.42-0917.

Deviations from the SCRV in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 1 m	0,0115	0,0071	-0,0021	-0,0041	-0,0017	-0,0381	0,0245	0,0419	-0,0601	0,0165	0,0291	-0,0905	-0,0081	-0,0507	-0,0091	0,0244	-0,0421	-0,0561	-0,0128	-0,0131
0 .. 2 m	0,0003	-0,0019	0,0428	-0,0072	0,0015	-0,0512	0,0237	0,0788	-0,0662	0,0083	0,0176	0,0570	0,0188	-0,0503	-0,0302	0,0298	-0,0532	-0,0582	0,0424	-0,0502
0 .. 3 m	0,0005	-0,0018	-0,0195	-0,0005	-0,0023	-0,0715	0,0181	0,0485	-0,0495	0,0124	0,0187	-0,0564	0,0185	-0,0338	-0,0125	0,0369	-0,0635		0,0174	-0,0055
0 .. 4 m	0,0008	-0,0022	-0,0187	-0,0017	0,0169	-0,0787	0,0219	0,0213	-0,0597	0,0115	0,0116	-0,0516	0,0713	-0,0354	0,0083	0,0510	-0,0617	-0,0267	0,0706	0,0243
0 .. 5 m	0,0012	-0,0073	-0,0325	-0,0125	-0,0355	-0,0475	0,0146	0,0325	-0,0745	0,0098	0,0111	-0,0060	0,0525	-0,0235	-0,0015	0,0600	-0,0695	-0,0015	0,0615	-0,0025
0 .. 6 m	0,0016	-0,0079	0,0062	-0,0118	-0,0385	-0,0768	0,0169	0,0232	-0,0628	0,0064	0,0097		0,0832	-0,0250	0,0072	0,0619	-0,0868	-0,0048	0,0846	-0,0948
0 .. 7 m	0,0047	-0,0073	-0,0479	-0,0199	-0,0482	-0,0729	0,0213	0,0171	-0,0979	0,0100	0,0098		0,0671	-0,0094	0,0251	0,0767	-0,0829	0,0111	0,0912	0,0271
0 .. 8 m	0,0060	-0,0151	-0,0814	-0,0284	-0,0173	-0,0984	0,0256	0,0016	-0,0484	0,0081	0,0035		0,0416	-0,0155	0,0316	0,0905	-0,1084	0,0206	0,1149	-0,0084
0 .. 9 m	0,0002	-0,0129	-0,0154	-0,0214	-0,0699	-0,1274	0,0287	0,0026	-0,0464	0,0053	0,0073		0,1126	-0,0197	0,0486	0,0836	-0,1374	0,0106	0,0954	-0,0654
0 .. 10 m	0,0074	-0,0110	-0,0699	-0,0309	-0,0790	-0,1229	0,0188	0,0171	-0,0609	0,0122	0,0104		0,0771	-0,0059	0,0481	0,1059	-0,1429	-0,0259	0,1598	0,0101
0 .. 11 m	0,0033	-0,0146	-0,0687	-0,0497	-0,0574	-0,0977	0,0248	0,0223	-0,0527	0,0108	0,0085		-0,0077	-0,0047	0,0543	0,1033	-0,1677	0,0223	0,1159	0,0663
0 .. 12 m	0,0067	-0,0149	-0,0719	-0,0419	-0,0822	-0,1289	0,0249	0,0111	-0,0659	0,0090	0,0077		0,0011	-0,0004	0,0481	0,1068	-0,1889	0,0311	0,1725	0,0741
0 .. 13 m	0,0133	-0,0125	-0,0665	-0,0585	-0,0744	-0,1275	0,0186	0,0225	-0,0735	0,0072	-0,0011		0,0425	-0,0153	0,0565	0,1129	-0,2075	0,0325	0,1384	0,0235
0 .. 14 m	0,0109	-0,0139	-0,1281	-0,0461	-0,1337	-0,1031	0,0262	-0,0431	-0,0391	0,0054	0,0044		0,0569	-0,0179	0,0359	0,1322	-0,2431	0,0269	0,1765	-0,0211
0 .. 15 m	0,0175	-0,0163	-0,1327	-0,0397	-0,0669	-0,1327	0,0150	-0,0327	-0,0717	-0,0019	-0,0085		0,0073	-0,0104	0,0373	0,1339	-0,2627	0,0473	0,1628	0,0553
0 .. 16 m	0,0155	-0,0158	-0,0613	-0,0463	-0,0991	-0,1313	0,0237	-0,0013	-0,0703	-0,0057	-0,0088		0,0287	0,0004	0,0527	0,1365	-0,2813	0,0387	0,1879	0,0767
0 .. 17 m	0,0145	-0,0147	-0,0841	-0,0591	-0,0765	-0,1551	0,0158	-0,0051	-0,0351	-0,0089	-0,0159		0,0349	-0,0187	0,0359	0,1408	-0,2751	0,0549	0,1828	0,0049
0 .. 18 m	0,0194	-0,0169	-0,1676	-0,0426	-0,1095	-0,1746	0,0253	-0,0546	-0,0946	-0,0072	-0,0146		0,0354	-0,0060	0,0334	0,1525	-0,2746	0,0654	0,2099	0,0914
0 .. 19 m	0,0183	-0,0190	-0,0523	-0,0723	-0,1509	-0,1423	0,0139	-0,0123	-0,0803	-0,0104	-0,0172		0,0677	-0,0115	0,0557	0,1547	-0,2823	0,0677	0,1971	0,0727
0 .. 20 m	0,0266	-0,0194	-0,1047	-0,0787	-0,1519	-0,1097	0,0302	-0,0897	-0,1027	-0,0041	-0,0073		0,0603	0,0002	0,0743	0,1668	-0,2597	0,0603	0,2588	0,0413
0 .. 21 m	0,0210	-0,0227	-0,1412	-0,0662	-0,1560	-0,0902	0,0295	-0,0302	-0,1232	-0,0125	-0,0242		0,0098	-0,0123	0,0808	0,1639	-0,2902	0,1098		
0 .. 22 m	0,0210	-0,0235	-0,1635	-0,0835	-0,1759	-0,0965	0,0602	-0,0365	-0,0445	-0,0135	-0,0198		0,0735	-0,0204	0,0765	0,1649	-0,2965	0,0835		
0 .. 23 m	0,0208	-0,0202	-0,1036	-0,0996	-0,1737	-0,0906	0,0357	-0,0706	-0,0326	-0,0139	-0,0185		0,0994	-0,0161	0,0654	0,1712	-0,3006	0,0994		
0 .. 24 m	0,0217	-0,0420	-0,1837	-0,0817	-0,2053	-0,1087	0,0498	-0,0487	-0,0797	-0,0127	-0,0224		0,0613	-0,0135	0,0873	0,1733	-0,3087	0,1013		
0 .. 25 m	0,0185	-0,0385	-0,2530	-0,0920	-0,1852	-0,0650	0,0496	-0,0650	-0,0460	-0,0142	-0,0219		0,0450	-0,0187	0,0660	0,1820	-0,3150	0,1050		

Table 29 Deviations from the supplementary comparison reference values according to Eq. (9) for tape 5.42-0917.

Deviations from the SCRV in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 26 m	0,0208	-0,0261	-0,2503	-0,1063	-0,1982	-0,1043	0,0484	-0,0643	-0,0853	-0,0115	-0,0136		0,0357	-0,0226	0,0927	0,1848	-0,3143	0,1057		
0 .. 27 m	0,0154	-0,0501	-0,2092	-0,0922	-0,1967	-0,0992	0,0406	-0,0692	-0,0662	-0,0115	-0,0137		0,0808	-0,0274	0,0968	0,1898	-0,3192	0,1008		
0 .. 28 m	0,0158	-0,0520	-0,2625	-0,1005	-0,1876	-0,1265	0,0420	-0,0765	-0,0785	-0,0105	-0,0135		0,0335	-0,0144	0,0915	0,1943	-0,3265	0,1135		
0 .. 29 m	0,0114	-0,0524	-0,2744	-0,1224	-0,2141	-0,1494	0,0332	-0,0494	-0,0734	-0,0105	-0,0237		-0,0094	-0,0280	0,1006	0,2078	-0,3394	0,1206		
0 .. 30 m	0,0097	-0,0522	-0,2971	-0,1101	-0,1944	-0,1461	0,0393	-0,0161	-0,0771	-0,0163	-0,0235		-0,0761	-0,0222	0,0839	0,2104	-0,3361	0,1139		
0 .. 31 m	0,0132	-0,0617	-0,2194	-0,1184	-0,2033	-0,1214	0,0443	-0,0714	-0,0544	-0,0118	-0,0212		-0,1114	-0,0187	0,0936	0,2153	-0,3514	0,1286		
0 .. 32 m	0,0196	-0,0508	-0,3040	-0,1340	-0,1625	-0,1370	0,0575	-0,1370	-0,0800	-0,0081	-0,0170		-0,0670	-0,0102	0,0820	0,2195	-0,3670	0,1430		
0 .. 33 m	0,0076	-0,0645	-0,3217	-0,1307	-0,2068	-0,1377	0,0615	-0,0977	-0,0527	-0,0104	-0,0274		-0,0677	-0,0186	0,0703	0,2355	-0,3977	0,1423		
0 .. 34 m	0,0137	-0,0707	-0,2588	-0,1488	-0,1726	-0,1098	0,0669	-0,0698	-0,0628	-0,0103	-0,0189		-0,0398	-0,0163	0,0522	0,2419	-0,4198	0,1302		
0 .. 35 m	0,0042	-0,0634	-0,3245	-0,1525	-0,1449	-0,1485	0,0760	-0,0885	-0,0925	-0,0076	-0,0233		-0,0585	-0,0079	0,0525	0,2421	-0,4085	0,1515		
0 .. 36 m	0,0045	-0,0768	-0,3272	-0,1502	-0,1862	-0,1262	0,0745	-0,1162	-0,0442	-0,0084	-0,0183		-0,0162	-0,0021	0,0688	0,2359	-0,4362	0,1438		
0 .. 37 m	0,0064	-0,0755	-0,2984	-0,1434	-0,1940	-0,1404	0,0770	-0,1404	-0,0714	-0,0073	-0,0229		-0,0104	0,0013	0,0526	0,2445	-0,4604	0,1396		
0 .. 38 m	0,0091	-0,0749	-0,3247	-0,1637	-0,1809	-0,1437	0,0748	-0,1637	-0,0757	-0,0041	-0,0202		-0,0337	-0,0073	0,0433	0,2440	-0,4637	0,1463		
0 .. 39 m	0,0005	-0,0850	-0,3708	-0,1688	-0,1916	-0,1408	0,0619	-0,0708	-0,0438	-0,0089	-0,0226		-0,0308	-0,0109	0,0672	0,2453	-0,4908	0,1392		
0 .. 40 m	-0,0013	-0,0922	-0,3906	-0,1586	-0,1830	-0,1386	0,0688	-0,0386	-0,0976	-0,0124	-0,0263		-0,0086	-0,0083	0,0834	0,2569	-0,5086	0,1414		
0 .. 41 m	-0,0021	-0,0929	-0,3182	-0,1872	-0,2062	-0,1282	0,0750	-0,1282	-0,0842	-0,0073	-0,0210		-0,0182	0,0095	0,1238	0,2600	-0,5282	0,1818		
0 .. 42 m	-0,0036	-0,0866	-0,3337	-0,1847	-0,2363	-0,1347	0,1384	-0,1547	-0,0447	-0,0107	-0,0201		-0,0047	-0,0180	0,1313	0,2633	-0,5547	0,1653		
0 .. 43 m	-0,0058	-0,0941	-0,4217	-0,1917	-0,2530	-0,1377	0,0896	-0,1377	-0,0897	-0,0052	-0,0213		0,0123	-0,0040	0,1083	0,2670	-0,5877	0,1823		
0 .. 44 m	-0,0058	-0,1017	-0,3178	-0,2048	-0,2507	-0,1218	0,0768	-0,1318	-0,0788	-0,0109	-0,0260		0,0582	-0,0120	0,1392	0,2847	-0,6218	0,1782		
0 .. 45 m	-0,0163	-0,1092	-0,3874	-0,2144	-0,2219	-0,1194	0,0784	-0,0794	-0,0644	-0,0122	-0,0213		-0,0194	-0,0083	0,1176	0,2808	-0,6394	0,1906		
0 .. 46 m	-0,0126	-0,1145	-0,4039	-0,2219	-0,2780	-0,1319	0,0738	-0,1319	-0,0969	-0,0079	-0,0275		-0,0019	-0,0071	0,1411	0,2817	-0,6619	0,1981		
0 .. 47 m	-0,0193	-0,1131	-0,4257	-0,2317	-0,2274	-0,1377	0,0674	-0,1577	-0,0787	-0,0082	-0,0194		0,0223	-0,0040	0,1453	0,2892	-0,6777	0,2023		
0 .. 48 m	-0,0184	-0,1170	-0,3830	-0,2320	-0,2973	-0,1540	0,0669	-0,1340	-0,0700	-0,0152	-0,0256		0,0260	0,0065	0,1300	0,2932	-0,6840	0,2060		
0 .. 49 m	-0,0274	-0,1262	-0,4623	-0,2323	-0,2743	-0,1573	0,0570	-0,1573	-0,0963	-0,0114	-0,0304		0,0827	0,0099	0,1457	0,2864	-0,6973	0,2227		
0 .. 50 m	-0,0243	-0,1264	-0,5237	-0,2367	-0,2962	-0,1457	0,0379	-0,1557	-0,0207	-0,0209	-0,0191		0,0943	0,0228	0,1473	0,2953	-0,6857	0,2143		

Table 30 Deviations from the supplementary comparison reference values according to Eq. (9) for tape 5.42-0917.

Deviations from the SCRV in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 506.0 mm	0,0082	-0,0014	-0,0062	-0,0022	-0,0562	-0,0342	0,0290		-0,0332	0,0095	0,0184	-0,0791	-0,0542	-0,0442	-0,0602	0,0162	-0,0142	-0,0832	0,0128	0,2088
0 .. 507.0 mm	0,0064	0,0023	-0,0070	-0,0030	-0,1219	-0,0400	0,0219		-0,0280	0,0105	0,0208	-0,0719	-0,0300	-0,0513	-0,0560	0,0194	-0,0180	-0,0560	0,0110	0,1970
0 .. 508.0 mm	0,0026	0,0003	-0,0026	0,0014	-0,0946	-0,0326	0,0250		-0,0356	0,0083	0,0173	-0,0739	-0,0426	-0,0346	-0,0586	0,0092	-0,0146	-0,0786	0,0066	0,1804
0 .. 2529.0 mm	-0,0034	-0,0103	0,0209	0,0349	-0,0608	-0,0711	0,0114		-0,0491	0,0020	-0,0004	-0,0787	0,0189	-0,0543	-0,0891	0,0275	-0,0581	-0,0291	0,0322	
0 .. 2530.0 mm	-0,0014	-0,0116	0,0171	0,0311	-0,0767	-0,0669	0,0141		-0,0549	0,0033	0,0032	-0,0810	0,0331	-0,0493	-0,0849	0,0285	-0,0669	-0,0159	0,0327	
0 .. 2531.0 mm	-0,0032	-0,0123	0,0163	0,0363	-0,1635	-0,0737	0,0150		-0,0607	0,0049	0,0047	-0,0750	0,0363	-0,0511	-0,0717	0,0265	-0,0607	-0,0187	0,0338	
0 .. 10999.0 mm	0,0078	-0,0148	-0,0715	-0,0445	-0,0592	-0,0895	0,0355		-0,0515	0,0069	0,0039		0,0105	-0,0033	0,0765	0,1080	-0,1695	0,0205	0,1203	
0 .. 11001.0 mm	0,0036	-0,0188	-0,0772	-0,0502	0,2681	-0,1022	0,0294		-0,0522	0,0085	0,0056		-0,0022	-0,0068	0,0268	0,1020	-0,1822	0,0278	0,1146	
0 .. 29999.0 mm	0,0144	-0,0493	-0,2880	-0,1110	-0,1623	-0,1540	0,0424		-0,0710	-0,0163	-0,0219		-0,0840	-0,0180	0,0210	0,2197	-0,3340	0,1060		
0 .. 30001.0 mm	0,0145	-0,0501	-0,2906	-0,1096	-0,1460	-0,1476	0,0330		-0,0546	-0,0164	-0,0229		-0,2376	-0,0232	0,0534	0,2150	-0,3276	0,1224		
0 .. 49998.0 mm	-0,0273	-0,1322	-0,5350	-0,2490	-0,2305	-0,1500	0,0452		-0,0200	-0,0244	-0,0241		0,0900	0,0166	0,1550	0,2918	-0,7100	0,2000		
0 .. 49999.0 mm	-0,0274	-0,1306	-0,5352	-0,2482	-0,2657	-0,1452	0,0376		-0,0152	-0,0285	-0,0286		0,0748	0,0127	0,1618	0,2950	-0,7152	0,2048		

Table 31 Deviation uncertainties (k = 1) for the deviations from the supplementary comparison reference values according to Eq. (10) for tape 5.42-0917.

Combined uncer-tainty of the SCRV deviation in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 1 m	0,0284	0,0254	0,0453	0,0134	0,0606	0,0408	0,0167	0,0556	0,0249	0,0109	0,0146	0,0399	0,1203	0,0179	0,0755	0,0390	0,0165	0,0379	0,0468	0,0263
0 .. 2 m	0,0284	0,0257	0,0521	0,0139	0,0754	0,0457	0,0252	0,0555	0,0281	0,0107	0,0149	0,0398	0,1252	0,0184	0,0759	0,0394	0,0230	0,0378	0,0470	0,0264
0 .. 3 m	0,0287	0,0268	0,0521	0,0153	0,0854	0,0556	0,0374	0,0556	0,0321	0,0113	0,0162	0,0398	0,1303	0,0198	0,0769	0,0402	0,0323		0,0475	0,0270
0 .. 4 m	0,0281	0,0268	0,0581	0,0150	0,0951	0,0601	0,0482	0,0551	0,0347	0,0093	0,0143	0,0392	0,1351	0,0188	0,0776	0,0405	0,0383	0,0372	0,0471	0,0257
0 .. 5 m	0,0281	0,0273	0,0629	0,0162	0,0899	0,0699	0,0559	0,0599	0,0379	0,0086	0,0140	0,0389	0,1450	0,0191	0,0789	0,0415	0,0467	0,0374	0,0473	0,0252
0 .. 6 m	0,0285	0,0288	0,0694	0,0182	0,0949	0,0749	0,0674	0,0599	0,0414	0,0087	0,0147		0,1550	0,0206	0,0809	0,0430	0,0561	0,0374	0,0479	0,0260
0 .. 7 m	0,0294	0,0312	0,0801	0,0213	0,1051	0,0851	0,0751	0,0601	0,0451	0,0108	0,0173		0,1650	0,0232	0,0831	0,0450	0,0664	0,0377	0,0491	0,0272
0 .. 8 m	0,0304	0,0330	0,0867	0,0237	0,1102	0,0902	0,0802	0,0653	0,0493	0,0126	0,0195		0,1751	0,0256	0,0852	0,0471	0,0717	0,0379	0,0503	0,0282
0 .. 9 m	0,0309	0,0348	0,0946	0,0259	0,1151	0,1001	0,0876	0,0652	0,0527	0,0131	0,0204		0,1901	0,0271	0,0876	0,0490	0,0816	0,0383	0,0509	0,0284
0 .. 10 m	0,0314	0,0366	0,1025	0,0281	0,1300	0,1050	0,0900	0,0700	0,0560	0,0135	0,0212		0,2000	0,0285	0,0900	0,0510	0,0914	0,0381	0,0518	0,0285
0 .. 11 m	0,0332	0,0395	0,1138	0,0317	0,1453	0,1153	0,0949	0,0705	0,0601	0,0168	0,0252		0,2202	0,0324	0,0934	0,0540	0,1020	0,0557	0,0672	0,0314
0 .. 12 m	0,0355	0,0431	0,1212	0,0356	0,1456	0,1207	0,0994	0,0762	0,0644	0,0204	0,0291		0,2354	0,0364	0,0969	0,0573	0,1126	0,0566	0,0685	0,0341
0 .. 13 m	0,0367	0,0452	0,1308	0,0382	0,1606	0,1308	0,1040	0,0763	0,0685	0,0217	0,0309		0,2504	0,0386	0,1005	0,0600	0,1178	0,0568	0,0692	0,0351
0 .. 14 m	0,0366	0,0469	0,1390	0,0397	0,1704	0,1355	0,1071	0,0808	0,0714	0,0211	0,0306		0,2652	0,0392	0,1031	0,0620	0,1274	0,0562	0,0690	0,0346
0 .. 15 m	0,0372	0,0485	0,1483	0,0417	0,1853	0,1453	0,1114	0,0856	0,0747	0,0213	0,0313		0,2852	0,0406	0,1065	0,0644	0,1372	0,0559	0,0692	0,0345
0 .. 16 m	0,0392	0,0517	0,1576	0,0450	0,1954	0,1506	0,1182	0,0860	0,0786	0,0239	0,0342		0,3003	0,0438	0,1103	0,0677	0,1377	0,0566	0,0705	0,0369
0 .. 17 m	0,0396	0,0537	0,1749	0,0469	0,2003	0,1604	0,1250	0,0907	0,0818	0,0240	0,0348		0,3152	0,0451	0,1141	0,0701	0,1376	0,0562	0,0708	0,0367
0 .. 18 m	0,0412	0,0565	0,1745	0,0498	0,2204	0,1655	0,1307	0,0959	0,0860	0,0259	0,0370		0,3303	0,0477	0,1177	0,0732	0,1429	0,0565	0,0719	0,0381
0 .. 19 m	0,0427	0,0593	0,1846	0,0525	0,2255	0,1756	0,1368	0,0961	0,0897	0,0276	0,0390		0,3503	0,0502	0,1219	0,0763	0,1433	0,0569	0,0731	0,0397
0 .. 20 m	0,0441	0,0619	0,1926	0,0552	0,2355	0,1807	0,1398	0,1012	0,0933	0,0290	0,0408		0,3653	0,0526	0,1259	0,0794	0,1484	0,0571	0,0742	0,0407
0 .. 21 m	0,0448	0,0641	0,2040	0,0573	0,2454	0,1905	0,1472	0,1059	0,0965	0,0294	0,0421		0,3803	0,0545	0,1298	0,0845	0,1486	0,0714		
0 .. 22 m	0,0470	0,0672	0,2112	0,0605	0,2556	0,1957	0,1535	0,1113	0,1005	0,0319	0,0450		0,3954	0,0577	0,1341	0,0880	0,1541	0,0721		
0 .. 23 m	0,0479	0,0695	0,2191	0,0632	0,2705	0,2057	0,1594	0,1112	0,1043	0,0326	0,0461		0,4153	0,0595	0,1385	0,0908	0,1590	0,0719		
0 .. 24 m	0,0504	0,0728	0,2289	0,0666	0,2807	0,2110	0,1657	0,1167	0,1084	0,0355	0,0494		0,4305	0,0630	0,1424	0,0944	0,1646	0,0728		
0 .. 25 m	0,0512	0,0755	0,2373	0,0687	0,2906	0,2208	0,1711	0,1215	0,1117	0,0360	0,0503		0,4454	0,0646	0,1473	0,0972	0,1695	0,0726		

Table 32 Deviation uncertainties (k = 1) for the deviations from the supplementary comparison reference values according to Eq. (10) for tape 5.42-0917.

Combined uncer-tainty of the SCRV deviation in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 26 m	0,0518	0,0774	0,2371	0,0706	0,3005	0,2257	0,1753	0,1262	0,1148	0,0360	0,0539		0,4603	0,0643	0,1510	0,0998	0,1743	0,0721		
0 .. 27 m	0,0536	0,0803	0,2462	0,0735	0,3156	0,2358	0,1840	0,1265	0,1186	0,0380	0,0556		0,4804	0,0656	0,1557	0,1032	0,1796	0,0726		
0 .. 28 m	0,0566	0,0839	0,2561	0,0772	0,3259	0,2412	0,1890	0,1321	0,1233	0,0414	0,0589		0,4956	0,0682	0,1608	0,1071	0,1854	0,0739		
0 .. 29 m	0,0560	0,0856	0,2642	0,0783	0,3355	0,2507	0,1939	0,1363	0,1259	0,0398	0,0575		0,5103	0,0668	0,1646	0,1092	0,1896	0,0724		
0 .. 30 m	0,0580	0,0885	0,2733	0,0817	0,3456	0,2559	0,2001	0,1416	0,1297	0,0419	0,0597		0,5254	0,0685	0,1688	0,1127	0,1950	0,0731		
0 .. 31 m	0,0577	0,0899	0,2820	0,0831	0,3604	0,2655	0,2056	0,1409	0,1325	0,0408	0,0592		0,5452	0,0678	0,1727	0,1150	0,1947	0,0816		
0 .. 32 m	0,0621	0,0944	0,2911	0,0877	0,3709	0,2712	0,2130	0,1472	0,1373	0,0461	0,0647		0,5606	0,0724	0,1783	0,1197	0,2010	0,0838		
0 .. 33 m	0,0612	0,0959	0,2996	0,0886	0,3805	0,2806	0,2183	0,1512	0,1403	0,0442	0,0631		0,5753	0,0707	0,1825	0,1217	0,2003	0,0822		
0 .. 34 m	0,0636	0,0990	0,3093	0,0917	0,3956	0,2859	0,2241	0,1566	0,1442	0,0467	0,0658		0,5904	0,0730	0,1873	0,1253	0,2009	0,0830		
0 .. 35 m	0,0656	0,1019	0,3184	0,0946	0,4057	0,2960	0,2308	0,1618	0,1480	0,0487	0,0681		0,6055	0,0749	0,1920	0,1288	0,2015	0,0836		
0 .. 36 m	0,0658	0,1041	0,3272	0,0968	0,4155	0,3007	0,2369	0,1614	0,1510	0,0482	0,0680		0,6254	0,0746	0,1961	0,1314	0,2060	0,0827		
0 .. 37 m	0,0667	0,1063	0,3361	0,0989	0,4304	0,3106	0,2423	0,1661	0,1542	0,0486	0,0687		0,6403	0,0752	0,2004	0,1343	0,2060	0,0823		
0 .. 38 m	0,0670	0,1081	0,3449	0,1007	0,4403	0,3154	0,2485	0,1707	0,1578	0,0484	0,0688		0,6552	0,0752	0,2051	0,1371	0,2106	0,0815		
0 .. 39 m	0,0684	0,1111	0,3538	0,1032	0,4453	0,3254	0,2545	0,1757	0,1613	0,0495	0,0703		0,6702	0,0765	0,2096	0,1403	0,2157	0,0815		
0 .. 40 m	0,0713	0,1145	0,3626	0,1066	0,4605	0,3307	0,2609	0,1812	0,1654	0,0526	0,0737		0,6903	0,0796	0,2145	0,1442	0,2165	0,0827		
0 .. 41 m	0,0710	0,1164	0,3713	0,1085	0,4702	0,3403	0,2669	0,1806	0,1681	0,0514	0,0734		0,7051	0,0793	0,2190	0,1478	0,2210	0,0912		
0 .. 42 m	0,0732	0,1194	0,3804	0,1115	0,4803	0,3455	0,2686	0,1859	0,1720	0,0537	0,0760		0,7202	0,0817	0,2237	0,1514	0,2264	0,0918		
0 .. 43 m	0,0733	0,1211	0,3897	0,1131	0,4901	0,3552	0,2792	0,1904	0,1754	0,0530	0,0757		0,7351	0,0815	0,2278	0,1540	0,2309	0,0908		
0 .. 44 m	0,0767	0,1253	0,3991	0,1169	0,5054	0,3606	0,2853	0,1961	0,1797	0,0569	0,0799		0,7553	0,0855	0,2334	0,1582	0,2369	0,0924		
0 .. 45 m	0,0764	0,1267	0,4082	0,1182	0,5152	0,3702	0,2903	0,2004	0,1825	0,0557	0,0790		0,7701	0,0848	0,2374	0,1606	0,2412	0,0910		
0 .. 46 m	0,0780	0,1298	0,4162	0,1213	0,5252	0,3753	0,2973	0,2005	0,1860	0,0570	0,0806		0,7851	0,0864	0,2424	0,1639	0,2414	0,0911		
0 .. 47 m	0,0792	0,1321	0,4257	0,1236	0,5401	0,3852	0,3028	0,2054	0,1894	0,0579	0,0818		0,8001	0,0877	0,2468	0,1670	0,2415	0,0909		
0 .. 48 m	0,0818	0,1353	0,4349	0,1269	0,5503	0,3904	0,3096	0,2108	0,1939	0,0606	0,0849		0,8152	0,0907	0,2522	0,1708	0,2423	0,0919		
0 .. 49 m	0,0838	0,1386	0,4435	0,1297	0,5604	0,4005	0,3167	0,2160	0,1976	0,0624	0,0871		0,8353	0,0930	0,2568	0,1744	0,2427	0,0924		
0 .. 50 m	0,0851	0,1410	0,4530	0,1321	0,5754	0,4055	0,3211	0,2209	0,2010	0,0634	0,0884		0,8502	0,0944	0,2618	0,1775	0,2477	0,0923		

Table 33 Deviation uncertainties (k = 1) for the deviations from the supplementary comparison reference values according to Eq. (10) for tape 5.42-0917.

Combined uncertainty of the SCRV deviation in mm	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 506.0 mm	0,0285	0,0255	0,0380	0,0132	0,0755	0,0360	0,0124		0,0236	0,0111	0,0144	0,0399	0,1203	0,0177	0,0755	0,0390	0,0151	0,0380	0,0467	0,0262
0 .. 507.0 mm	0,0285	0,0255	0,0409	0,0132	0,0854	0,0360	0,0121		0,0236	0,0111	0,0144	0,0399	0,1203	0,0177	0,0755	0,0390	0,0160	0,0380	0,0467	0,0262
0 .. 508.0 mm	0,0285	0,0255	0,0394	0,0132	0,1004	0,0360	0,0117		0,0236	0,0111	0,0143	0,0399	0,1203	0,0177	0,0755	0,0390	0,0157	0,0380	0,0467	0,0262
0 .. 2529.0 mm	0,0283	0,0260	0,0441	0,0139	0,0753	0,0505	0,0323		0,0298	0,0103	0,0148	0,0396	0,1302	0,0185	0,0763	0,0396	0,0263	0,0377	0,0470	
0 .. 2530.0 mm	0,0283	0,0259	0,0485	0,0139	0,1002	0,0505	0,0327		0,0298	0,0103	0,0149	0,0396	0,1302	0,0185	0,0763	0,0396	0,0272	0,0376	0,0471	
0 .. 2531.0 mm	0,0283	0,0259	0,0554	0,0139	0,0753	0,0505	0,0327		0,0298	0,0103	0,0149	0,0396	0,1302	0,0185	0,0763	0,0396	0,0263	0,0376	0,0471	
0 .. 10999.0 mm	0,0332	0,0394	0,1113	0,0316	0,1402	0,1153	0,0944		0,0601	0,0166	0,0253		0,2202	0,0325	0,0934	0,0541	0,1021	0,0556	0,0672	
0 .. 11001.0 mm	0,0332	0,0394	0,1128	0,0316	0,1502	0,1153	0,0944		0,0601	0,0166	0,0253		0,2202	0,0325	0,0934	0,0541	0,1021	0,0556	0,0672	
0 .. 29999.0 mm	0,0578	0,0884	0,2733	0,0816	0,3456	0,2558	0,2000		0,1296	0,0416	0,0600		0,5254	0,0687	0,1687	0,1123	0,1951	0,0729		
0 .. 30001.0 mm	0,0576	0,0882	0,2732	0,0814	0,3456	0,2608	0,2005		0,1295	0,0414	0,0601		0,5254	0,0688	0,1687	0,1123	0,1952	0,0824		
0 .. 49998.0 mm	0,0847	0,1408	0,4524	0,1319	0,5753	0,4054	0,3216		0,2009	0,0629	0,0887		0,8502	0,0947	0,2617	0,1775	0,2478	0,0920		
0 .. 49999.0 mm	0,0847	0,1408	0,4529	0,1319	0,5753	0,4054	0,3211		0,2009	0,0629	0,0887		0,8502	0,0947	0,2617	0,1775	0,2478	0,0920		

Table 34 Result of the consistency checks for the final data sets according to Section 7.3 used for the calculation of the SCRVs given in Table 21. Three data sets were excluded as outliers for tape 4909 PTB 01, and four data sets for 5.42-0917 to obtain fully consistent datasets.

4909 PTB 01	ν	$\chi^2(\nu)^{0.05}$	χ^2_{obs}
0 .. 1 m	16	26,3	9,5
0 .. 2 m	16	26,3	12,5
0 .. 3 m	16	26,3	9,1
0 .. 4 m	16	26,3	14,0
0 .. 5 m	16	26,3	16,0
0 .. 6 m	15	25,0	12,3
0 .. 7 m	15	25,0	17,1
0 .. 8 m	15	25,0	17,1
0 .. 9 m	15	25,0	18,4
0 .. 10 m	15	25,0	21,4
0 .. 1005.0 mm	15	25,0	9,2
0 .. 1010.0 mm	15	25,0	10,6
0 .. 1015.0 mm	15	25,0	10,6
0 .. 2525.0 mm	15	25,0	8,9
0 .. 2530.0 mm	15	25,0	9,1
0 .. 2535.0 mm	15	25,0	8,7
0 .. 5695.0 mm	14	23,7	13,1
0 .. 5700.0 mm	14	23,7	14,2
0 .. 5705.0 mm	14	23,7	14,5
0 .. 7745.0 mm	14	23,7	20,8
0 .. 7750.0 mm	14	23,7	21,6
0 .. 7755.0 mm	14	23,7	19,0
0 .. 9990.0 mm	14	23,7	20,5
0 .. 9995.0 mm	14	23,7	21,5

5060 PTB No 3	ν	$\chi^2(\nu)^{0.05}$	χ^2_{obs}
0 .. 1 m	18	28,9	20,2
0 .. 2 m	18	28,9	13,7
0 .. 3 m	18	28,9	11,1
0 .. 4 m	18	28,9	17,9
0 .. 5 m	18	28,9	11,1
0 .. 6 m	17	27,6	13,7
0 .. 7 m	17	27,6	8,2
0 .. 8 m	17	27,6	6,4
0 .. 9 m	17	27,6	9,5
0 .. 10 m	17	27,6	6,7
0 .. 11 m	17	27,6	12,1
0 .. 12 m	17	27,6	9,7
0 .. 13 m	17	27,6	8,0
0 .. 14 m	17	27,6	8,7
0 .. 15 m	17	27,6	9,1
0 .. 16 m	17	27,6	10,9
0 .. 17 m	17	27,6	7,5
0 .. 18 m	17	27,6	19,7
0 .. 19 m	17	27,6	11,4
0 .. 20 m	17	27,6	8,1
0 .. 21 m	14	23,7	6,1
0 .. 22 m	14	23,7	6,9
0 .. 23 m	14	23,7	5,8
0 .. 24 m	14	23,7	6,3
0 .. 25 m	14	23,7	7,7

5060 PTB No 3	ν	$\chi^2(\nu)^{0.05}$	χ^2_{obs}
0 .. 26 m	14	23,7	9,2
0 .. 27 m	14	23,7	10,7
0 .. 28 m	14	23,7	8,5
0 .. 29 m	14	23,7	10,3
0 .. 30 m	14	23,7	9,2
0 .. 31 m	14	23,7	10,6
0 .. 32 m	14	23,7	8,8
0 .. 33 m	14	23,7	9,7
0 .. 34 m	14	23,7	9,3
0 .. 35 m	14	23,7	8,1
0 .. 36 m	14	23,7	7,8
0 .. 37 m	14	23,7	7,5
0 .. 38 m	14	23,7	8,6
0 .. 39 m	14	23,7	7,2
0 .. 40 m	14	23,7	6,7
0 .. 41 m	14	23,7	7,9
0 .. 42 m	14	23,7	6,9
0 .. 43 m	14	23,7	6,8
0 .. 44 m	14	23,7	8,0
0 .. 45 m	14	23,7	6,3
0 .. 46 m	14	23,7	6,4
0 .. 47 m	14	23,7	6,7
0 .. 48 m	14	23,7	6,8
0 .. 49 m	14	23,7	6,5
0 .. 50 m	14	23,7	5,7

5.42-0917	ν	$\chi^2(\nu)^{0.05}$	χ^2_{obs}
0 .. 1 m	14	23,7	18,1
0 .. 2 m	14	23,7	15,5
0 .. 3 m	13	22,4	8,5
0 .. 4 m	14	23,7	9,9
0 .. 5 m	14	23,7	8,4
0 .. 6 m	13	22,4	6,6
0 .. 7 m	13	22,4	10,4
0 .. 8 m	13	22,4	8,8
0 .. 9 m	13	22,4	7,1
0 .. 10 m	13	22,4	10,0
0 .. 11 m	13	22,4	8,6
0 .. 12 m	13	22,4	8,1
0 .. 13 m	13	22,4	8,9
0 .. 14 m	13	22,4	8,7
0 .. 15 m	13	22,4	8,8
0 .. 16 m	13	22,4	7,6
0 .. 17 m	13	22,4	7,9
0 .. 18 m	13	22,4	10,1
0 .. 19 m	13	22,4	9,4
0 .. 20 m	13	22,4	10,8
0 .. 21 m	13	22,4	10,5
0 .. 22 m	13	22,4	8,7
0 .. 23 m	13	22,4	9,3
0 .. 24 m	13	22,4	9,4
0 .. 25 m	13	22,4	9,6

5.42-0917	ν	$\chi^2(\nu)^{0.05}$	χ^2_{obs}
0 .. 26 m	13	22,4	10,5
0 .. 27 m	13	22,4	9,1
0 .. 28 m	13	22,4	9,9
0 .. 29 m	13	22,4	11,2
0 .. 30 m	13	22,4	10,0
0 .. 31 m	13	22,4	9,8
0 .. 32 m	13	22,4	11,2
0 .. 33 m	13	22,4	11,1
0 .. 34 m	13	22,4	10,2
0 .. 35 m	13	22,4	11,2
0 .. 36 m	13	22,4	10,5
0 .. 37 m	13	22,4	10,3
0 .. 38 m	13	22,4	11,1
0 .. 39 m	13	22,4	10,2
0 .. 40 m	13	22,4	10,2
0 .. 41 m	13	22,4	11,9
0 .. 42 m	13	22,4	11,2
0 .. 43 m	13	22,4	12,2
0 .. 44 m	13	22,4	11,7
0 .. 45 m	13	22,4	12,2
0 .. 46 m	13	22,4	13,0
0 .. 47 m	13	22,4	13,4
0 .. 48 m	13	22,4	12,9
0 .. 49 m	13	22,4	13,8
0 .. 50 m	13	22,4	13,5

5.42-0917	ν	$\chi^2(\nu)^{0.05}$	χ^2_{obs}
0 .. 506.0 mm	13	22,4	17,7
0 .. 507.0 mm	13	22,4	14,0
0 .. 508.0 mm	13	22,4	16,0
0 .. 2529.0 mm	13	22,4	16,8
0 .. 2530.0 mm	13	22,4	15,9
0 .. 2531.0 mm	13	22,4	21,7
0 .. 10999.0 mm	12	21,0	8,5
0 .. 11001.0 mm	12	21,0	11,4
0 .. 29999.0 mm	12	21,0	9,6
0 .. 30001.0 mm	12	21,0	9,6
0 .. 49998.0 mm	12	21,0	12,8
0 .. 49999.0 mm	12	21,0	13,1

Table 35 E_n values for tape 4909 PTB 01. Values exceeding an absolute value of 1 are marked in red.

E_n	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	CMS	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 1 m	-0,31	0,19	-0,03	-0,16	0,29	0,00	0,02	0,45	-0,36	0,16	0,00	0,89	-0,45	-1,55	0,42	0,58	0,08	0,07	-0,15	-1,04	1,49
0 .. 2 m	-0,69	-0,31	0,70	0,53	0,51	0,08	-0,10	0,79	-0,06	0,50	-0,43	1,78	-0,21	-1,61	-0,54	0,52	0,10	-0,34	-0,32	-0,26	0,98
0 .. 3 m	-0,68	-0,27	-0,21	-0,05	0,41	-0,03	0,14	0,43	0,00	0,92	0,04	1,71	-0,54	-1,58	-0,26	0,48	0,11	-0,09	-0,25	-0,49	6,56
0 .. 4 m	-0,27	-0,46	-0,89	-0,12	0,79	-0,19	0,25	-0,02	-0,10	0,99	0,05	1,90	-0,82	-1,46	-0,24	0,56	0,05	-0,11	-0,41	-0,17	6,34
0 .. 5 m	-0,55	-0,56	-0,75	0,76	0,99	0,20	-0,01	0,40	-0,07	0,61	-0,25	1,86	0,34	-1,53	-0,42	0,46	-0,04	-0,19	-0,02	-0,68	6,54
0 .. 6 m	-0,33	-0,57	0,53	0,02	1,19	-0,16	-0,11	0,21	-0,01	0,59	-0,17	1,19		-1,14	-0,26	0,55	0,11	-0,22	-0,39	-0,39	7,73
0 .. 7 m	-0,15	-0,45	-1,02	0,10	1,42	-0,04	0,13	0,28	0,27	0,51	0,20	1,34		-1,33	-0,30	0,53	0,14	-0,13	-0,20	-0,54	6,47
0 .. 8 m	-0,11	-0,50	-0,65	-0,20	1,51	-0,16	-0,01	0,08	0,25	0,64	0,14	0,74		-1,14	-0,34	0,62	0,18	-0,20	-0,02	-0,65	7,69
0 .. 9 m	-0,19	-0,59	-0,17	-0,08	1,46	-0,32	-0,09	0,05	0,06	0,80	0,15	0,58		-1,08	-0,24	0,64	0,21	-0,14	-0,20	-1,04	8,06
0 .. 10 m	-0,03	-0,38	-0,72	-0,63	1,60	-0,28	-0,03	0,01	0,21	0,75	0,06	0,52		-1,12	-0,32	0,86	0,41	-0,25	-0,29	-0,41	7,86
0 .. 1005.0 mm	0,02	0,24	-0,02	-0,33	0,34	0,06	0,03		-0,09	-0,12	0,31	1,08	-0,64	-1,47	0,69	0,53	0,15	-0,08	-0,04	-0,92	1,20
0 .. 1010.0 mm	-0,14	0,23	-0,19	-0,43	0,24	0,09	-0,17		-0,21	0,18	0,11	0,84	-0,66	-1,56	0,79	0,48	0,07	-0,04	0,10	-0,98	0,94
0 .. 1015.0 mm	-0,15	0,28	-0,16	-0,35	0,28	0,15	-0,04		-0,19	0,14	0,11	1,21	-0,67	-1,49	0,73	0,51	0,12	-0,22	-0,05	-1,00	1,30
0 .. 2525.0 mm	-0,43	-0,19	-0,21	0,64	0,50	-0,02	0,14		0,12	0,16	-0,11	-0,01	-0,74	-1,53	0,09	0,60	0,24	-0,37	-0,23	-0,43	1,32
0 .. 2530.0 mm	-0,33	-0,19	-0,22	0,62	0,61	-0,04	0,07		0,13	0,25	0,01	-1,35	-0,71	-1,73	-0,11	0,51	0,20	-0,35	-0,12	-0,62	0,76
0 .. 2535.0 mm	-0,22	-0,21	-0,23	0,48	0,62	0,01	0,08		-0,01	0,22	-0,08	-0,72	-0,76	-1,66	0,05	0,54	0,26	-0,42	-0,13	-0,55	1,05
0 .. 5695.0 mm	-0,27	-0,56	-0,24	-0,21	1,43	-0,16	0,04		-0,03	0,60	-0,17	1,35		-1,18	0,03	0,50	0,15	-0,22	-0,01	-0,51	3,50
0 .. 5700.0 mm	-0,36	-0,55	-0,33	-0,24	1,47	-0,11	0,04		0,09	0,64	-0,21	1,52		-1,44	-0,02	0,55	0,17	-0,24	0,01	-0,46	2,95
0 .. 5705.0 mm	-0,43	-0,50	-0,25	-0,27	1,48	-0,16	0,08		0,01	0,76	-0,27	1,33		-1,35	-0,08	0,50	0,15	-0,22	-0,08	-0,48	3,50
0 .. 7745.0 mm	0,03	-0,63	-1,02	-0,57	1,51	-0,20	0,01		0,12	0,71	-0,06	1,15		-1,46	0,01	0,68	0,23	-0,23	-0,08	-0,61	4,63
0 .. 7750.0 mm	0,05	-0,60	-0,99	-0,57	1,57	-0,22	-0,04		0,20	0,71	-0,10	0,89		-1,29	-0,10	0,71	0,22	-0,27	-0,11	-0,57	4,82
0 .. 7755.0 mm	0,07	-0,61	-1,00	-0,62	1,36	-0,22	-0,03		0,10	0,75	-0,10	0,92		-1,40	-0,01	0,66	0,22	-0,26	-0,10	-0,58	5,02
0 .. 9990.0 mm	0,00	-0,35	-0,73	-0,90	1,49	-0,25	-0,08		0,17	0,77	0,13	0,58		-1,29	-0,18	0,84	0,38	-0,17	-0,24	-0,30	8,72
0 .. 9995.0 mm	-0,05	-0,34	-0,72	-0,93	1,46	-0,29	-0,07		0,33	0,78	0,08	0,69		-1,29	-0,16	0,90	0,39	-0,22	-0,25	-0,41	8,82

Table 36 E_n values for tape 5060 PTB 06 No. 3. Values exceeding an absolute value of 1 are marked in red.

E_n	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 1 m	-0,28	0,06	0,03	0,31	-0,35	0,09	-0,01	0,61	-0,02	0,18	0,13	-0,84	-0,01	-0,79	0,16	0,02	-0,31	0,10	-0,65	1,60
0 .. 2 m	-0,53	-0,13	0,82	0,62	0,04	-0,01	0,18	1,08	-0,16	0,11	-0,27	-0,03	-0,05	-0,84	0,17	0,13	-0,36	0,04	-0,04	0,25
0 .. 3 m	-0,64	-0,07	-0,27	0,60	-0,09	0,00	0,27	0,72	-0,01	0,16	-0,08	-0,66	-0,13	-0,31	-0,07	0,17	-0,25	0,25	-0,54	0,66
0 .. 4 m	-0,59	0,17	-0,63	0,28	-0,08	-0,11	0,32	0,42	-0,05	0,54	0,08	-1,17	0,29	-0,82	0,08	0,24	-0,14	-0,01	-0,15	1,05
0 .. 5 m	-0,63	-0,03	-0,66	0,73	-0,01	0,13	0,20	0,65	0,05	0,29	0,04	-0,02	-0,04	-0,75	0,03	0,19	-0,16	0,30	-0,42	0,41
0 .. 6 m	-0,54	0,14	0,57	0,60	-0,07	0,05	0,29	0,47	0,18	0,43	0,08		0,06	-0,83	0,01	0,31	-0,11	0,31	-0,08	-1,13
0 .. 7 m	-0,62	0,09	-0,70	0,09	-0,17	0,06	0,30	0,41	0,10	0,24	0,04		-0,06	-0,51	0,03	0,24	-0,16	0,20	-0,22	0,73
0 .. 8 m	-0,58	0,00	-0,60	-0,05	-0,18	0,04	0,34	0,36	0,15	0,33	0,05		0,11	-0,44	0,12	0,36	-0,23	0,42	-0,09	0,21
0 .. 9 m	-0,43	0,20	0,06	0,05	-0,12	0,02	0,38	0,48	0,17	0,62	0,24		0,12	-0,39	0,18	0,35	-0,29	0,29	-0,33	-1,00
0 .. 10 m	-0,49	0,14	-0,46	-0,46	-0,04	0,03	0,33	0,46	0,29	0,48	0,15		-0,09	-0,44	0,10	0,44	-0,25	0,19	0,08	-0,12
0 .. 11 m	-0,67	0,02	-0,57	-0,26	-0,18	0,13	0,31	0,22	0,15	0,31	-0,02		-0,31	-0,57	0,10	0,30	-0,34	0,10	-0,44	1,14
0 .. 12 m	-0,71	0,03	-0,25	-0,29	-0,07	-0,09	0,32	0,32	0,02	0,18	-0,07		-0,21	-0,46	-0,06	0,27	-0,39	-0,01	-0,02	1,14
0 .. 13 m	-0,43	0,19	-0,43	-0,58	-0,08	0,03	0,39	0,52	0,24	0,59	0,17		-0,15	-0,51	-0,11	0,36	-0,31	0,25	-0,21	0,01
0 .. 14 m	-0,28	0,29	-0,56	-0,23	-0,06	0,15	0,34	0,07	0,27	0,73	0,31		-0,08	-0,46	-0,25	0,55	-0,35	0,10	0,04	-0,66
0 .. 15 m	-0,51	0,06	-0,64	-0,36	-0,19	0,05	0,26	0,14	0,20	0,38	0,06		-0,14	-0,51	-0,27	0,43	-0,43	0,22	-0,26	0,72
0 .. 16 m	-0,67	0,03	-0,31	-0,34	-0,16	0,04	0,21	0,30	0,15	0,15	-0,09		-0,18	-0,52	-0,20	0,31	-0,51	0,01	-0,12	1,20
0 .. 17 m	-0,55	0,09	-0,35	-0,18	-0,14	0,04	0,23	0,35	0,13	0,32	0,05		-0,19	-0,60	-0,16	0,34	-0,47	0,03	-0,17	0,70
0 .. 18 m	-0,67	-0,11	-0,74	-0,37	-0,13	0,02	0,18	0,09	0,11	0,07	-0,19		-0,10	-0,77	-0,21	0,27	-0,49	0,15	-0,16	1,81
0 .. 19 m	-0,51	0,06	-0,24	-0,55	-0,05	0,08	0,19	0,19	0,12	0,23	-0,12		-0,08	-0,69	-0,15	0,25	-0,47	0,06	-0,30	1,23
0 .. 20 m	-0,41	0,08	-0,47	-0,58	-0,10	0,13	0,21	-0,17	0,17	0,33	0,06		-0,09	-0,55	-0,09	0,34	-0,44	0,05	0,06	0,79
0 .. 21 m	-0,33	0,19	-0,45	-0,36	-0,06	0,15	0,29	0,18	0,24	0,60	0,18		-0,24	-0,55		0,31	-0,49	-0,02		
0 .. 22 m	-0,26	0,22	-0,55	-0,54	-0,08	0,17	0,33	0,13	0,20	0,66	0,22		-0,15	-0,55		0,31	-0,46	-0,02		
0 .. 23 m	-0,23	0,25	-0,33	-0,56	-0,04	0,18	0,35	-0,04	0,21	0,54	0,07		-0,19	-0,49		0,27	-0,49	0,09		
0 .. 24 m	-0,17	0,11	-0,57	-0,47	-0,05	0,14	0,37	0,03	0,20	0,62	0,18		-0,18	-0,51		0,28	-0,49	-0,02		
0 .. 25 m	-0,21	0,18	-0,76	-0,56	-0,06	0,20	0,38	-0,02	0,19	0,60	0,15		-0,21	-0,45		0,30	-0,48	0,12		

Table 37 E_n values for tape 5060 PTB 06 No. 3. Values exceeding an absolute value of 1 are marked in red.

E_n	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 26 m	-0,10	0,28	-0,93	-0,54	-0,05	0,17	0,40	-0,06	0,17	0,65	0,21		-0,21	-0,55		0,30	-0,47	-0,03		
0 .. 27 m	-0,09	0,17	-1,13	-0,30	-0,05	0,23	0,39	0,07	0,22	0,68	0,14		-0,16	-0,71		0,31	-0,43	-0,08		
0 .. 28 m	0,02	0,25	-0,92	-0,39	-0,02	0,17	0,37	-0,15	0,13	0,57	0,12		-0,23	-0,62		0,29	-0,47	0,00		
0 .. 29 m	0,03	0,27	-0,98	-0,44	-0,02	0,14	0,37	-0,05	0,21	0,63	0,08		-0,28	-0,75		0,32	-0,49	-0,02		
0 .. 30 m	0,04	0,29	-0,95	-0,29	-0,01	0,14	0,36	0,12	0,21	0,52	0,06		-0,35	-0,73		0,27	-0,48	-0,05		
0 .. 31 m	0,06	0,27	-1,11	-0,27	-0,06	0,18	0,40	-0,12	0,17	0,55	0,05		-0,44	-0,68		0,27	-0,47	0,04		
0 .. 32 m	0,09	0,31	-0,82	-0,38	-0,02	0,16	0,41	-0,33	0,20	0,53	0,09		-0,40	-0,64		0,26	-0,45	0,04		
0 .. 33 m	0,07	0,24	-0,98	-0,13	-0,04	0,21	0,42	-0,17	0,17	0,51	-0,02		-0,33	-0,80		0,32	-0,44	0,06		
0 .. 34 m	0,14	0,25	-0,99	-0,22	-0,07	0,24	0,43	-0,02	0,16	0,47	0,07		-0,31	-0,74		0,32	-0,40	-0,03		
0 .. 35 m	0,12	0,28	-0,81	-0,31	-0,04	0,21	0,44	-0,15	0,18	0,48	-0,02		-0,28	-0,74		0,28	-0,37	0,02		
0 .. 36 m	0,13	0,24	-0,80	-0,27	-0,03	0,27	0,43	-0,16	0,18	0,46	0,02		-0,33	-0,72		0,28	-0,33	0,00		
0 .. 37 m	0,16	0,25	-0,84	-0,22	-0,03	0,22	0,38	-0,29	0,16	0,45	0,00		-0,29	-0,67		0,26	-0,28	-0,02		
0 .. 38 m	0,18	0,25	-0,92	-0,18	-0,04	0,24	0,37	-0,30	0,20	0,47	0,04		-0,32	-0,76		0,25	-0,30	0,05		
0 .. 39 m	0,16	0,23	-0,81	-0,12	-0,03	0,25	0,35	-0,05	0,17	0,42	0,02		-0,31	-0,78		0,25	-0,28	0,02		
0 .. 40 m	0,14	0,23	-0,81	-0,08	-0,02	0,27	0,34	0,03	0,16	0,37	-0,02		-0,31	-0,70		0,27	-0,25	-0,06		
0 .. 41 m	0,15	0,20	-0,93	-0,23	-0,03	0,29	0,35	-0,26	0,19	0,42	0,01		-0,39	-0,58		0,30	-0,26	-0,01		
0 .. 42 m	0,17	0,26	-0,77	-0,13	-0,05	0,27	0,35	-0,29	0,16	0,38	0,02		-0,35	-0,67		0,30	-0,22	-0,03		
0 .. 43 m	0,17	0,22	-0,75	-0,17	-0,05	0,24	0,34	-0,23	0,16	0,42	0,01		-0,33	-0,72		0,31	-0,22	0,01		
0 .. 44 m	0,17	0,23	-0,95	-0,13	-0,03	0,26	0,34	-0,17	0,18	0,43	0,05		-0,29	-0,72		0,30	-0,21	-0,04		
0 .. 45 m	0,14	0,20	-0,76	-0,09	-0,03	0,27	0,31	-0,03	0,13	0,37	0,01		-0,27	-0,72		0,35	-0,22	-0,02		
0 .. 46 m	0,18	0,20	-0,74	-0,22	0,01	0,23	0,30	-0,20	0,15	0,41	0,05		-0,30	-0,67		0,34	-0,24	-0,01		
0 .. 47 m	0,17	0,20	-0,78	-0,23	-0,02	0,25	0,29	-0,22	0,14	0,44	0,06		-0,29	-0,67		0,33	-0,22	-0,01		
0 .. 48 m	0,17	0,21	-0,85	-0,16	0,00	0,23	0,27	-0,17	0,13	0,41	0,04		-0,30	-0,65		0,33	-0,24	-0,01		
0 .. 49 m	0,18	0,19	-0,78	-0,18	-0,01	0,20	0,26	-0,22	0,15	0,42	0,07		-0,30	-0,70		0,33	-0,22	0,03		
0 .. 50 m	0,19	0,20	-0,76	-0,19	-0,05	0,19	0,27	-0,22	0,14	0,39	0,09		-0,29	-0,55		0,30	-0,22	-0,10		

Table 38 E_n values for tape 5.42-0917. Values exceeding an absolute value of 1 are marked in red.

E_n	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 1 m	0,20	0,14	-0,02	-0,15	-0,01	-0,47	0,73	0,38	-1,21	0,76	1,00	-1,14	-0,03	-1,41	-0,06	0,31	-1,28	-0,74	-0,14	-0,25
0 .. 2 m	0,01	-0,04	0,41	-0,26	0,01	-0,56	0,47	0,71	-1,18	0,38	0,59	0,72	0,07	-1,36	-0,20	0,38	-1,16	-0,77	0,45	-0,95
0 .. 3 m	0,01	-0,03	-0,19	-0,01	-0,01	-0,64	0,24	0,44	-0,77	0,55	0,58	-0,71	0,07	-0,85	-0,08	0,46	-0,98		0,18	-0,10
0 .. 4 m	0,01	-0,04	-0,16	-0,06	0,09	-0,65	0,23	0,19	-0,86	0,62	0,41	-0,66	0,26	-0,94	0,05	0,63	-0,81	-0,36	0,75	0,47
0 .. 5 m	0,02	-0,13	-0,26	-0,39	-0,20	-0,34	0,13	0,27	-0,98	0,57	0,40	-0,08	0,18	-0,62	-0,01	0,72	-0,74	-0,02	0,65	-0,05
0 .. 6 m	0,03	-0,14	0,04	-0,32	-0,20	-0,51	0,13	0,19	-0,76	0,37	0,33		0,27	-0,60	0,04	0,72	-0,77	-0,06	0,88	-1,82
0 .. 7 m	0,08	-0,12	-0,30	-0,47	-0,23	-0,43	0,14	0,14	-1,09	0,46	0,28		0,20	-0,20	0,15	0,85	-0,62	0,15	0,93	0,50
0 .. 8 m	0,10	-0,23	-0,47	-0,60	-0,08	-0,55	0,16	0,01	-0,49	0,32	0,09		0,12	-0,30	0,19	0,96	-0,76	0,27	1,14	-0,15
0 .. 9 m	0,00	-0,18	-0,08	-0,41	-0,30	-0,64	0,16	0,02	-0,44	0,20	0,18		0,30	-0,36	0,28	0,85	-0,84	0,14	0,94	-1,15
0 .. 10 m	0,12	-0,15	-0,34	-0,55	-0,30	-0,58	0,10	0,12	-0,54	0,45	0,25		0,19	-0,10	0,27	1,04	-0,78	-0,34	1,54	0,18
0 .. 11 m	0,05	-0,19	-0,30	-0,78	-0,20	-0,42	0,13	0,16	-0,44	0,32	0,17		-0,02	-0,07	0,29	0,96	-0,82	0,20	0,86	1,06
0 .. 12 m	0,09	-0,17	-0,30	-0,59	-0,28	-0,53	0,13	0,07	-0,51	0,22	0,13		0,00	-0,01	0,25	0,93	-0,84	0,28	1,26	1,09
0 .. 13 m	0,18	-0,14	-0,25	-0,77	-0,23	-0,49	0,09	0,15	-0,54	0,17	-0,02		0,08	-0,20	0,28	0,94	-0,88	0,29	1,00	0,33
0 .. 14 m	0,15	-0,15	-0,46	-0,58	-0,39	-0,38	0,12	-0,27	-0,27	0,13	0,07		0,11	-0,23	0,17	1,07	-0,95	0,24	1,28	-0,31
0 .. 15 m	0,24	-0,17	-0,45	-0,48	-0,18	-0,46	0,07	-0,19	-0,48	-0,05	-0,14		0,01	-0,13	0,18	1,04	-0,96	0,42	1,18	0,80
0 .. 16 m	0,20	-0,15	-0,19	-0,52	-0,25	-0,44	0,10	-0,01	-0,45	-0,12	-0,13		0,05	0,01	0,24	1,01	-1,02	0,34	1,33	1,04
0 .. 17 m	0,18	-0,14	-0,24	-0,63	-0,19	-0,48	0,06	-0,03	-0,21	-0,19	-0,23		0,06	-0,21	0,16	1,00	-1,00	0,49	1,29	0,07
0 .. 18 m	0,24	-0,15	-0,48	-0,43	-0,25	-0,53	0,10	-0,28	-0,55	-0,14	-0,20		0,05	-0,06	0,14	1,04	-0,96	0,58	1,46	1,20
0 .. 19 m	0,21	-0,16	-0,14	-0,69	-0,33	-0,41	0,05	-0,06	-0,45	-0,19	-0,22		0,10	-0,11	0,23	1,01	-0,99	0,60	1,35	0,92
0 .. 20 m	0,30	-0,16	-0,27	-0,71	-0,32	-0,30	0,11	-0,44	-0,55	-0,07	-0,09		0,08	0,00	0,30	1,05	-0,87	0,53	1,74	0,51
0 .. 21 m	0,23	-0,18	-0,35	-0,58	-0,32	-0,24	0,10	-0,14	-0,64	-0,21	-0,29		0,01	-0,11	0,31	0,97	-0,98	0,77		
0 .. 22 m	0,22	-0,17	-0,39	-0,69	-0,34	-0,25	0,20	-0,16	-0,22	-0,21	-0,22		0,09	-0,18	0,29	0,94	-0,96	0,58		
0 .. 23 m	0,22	-0,15	-0,24	-0,79	-0,32	-0,22	0,11	-0,32	-0,16	-0,21	-0,20		0,12	-0,14	0,24	0,94	-0,95	0,69		
0 .. 24 m	0,22	-0,29	-0,40	-0,61	-0,37	-0,26	0,15	-0,21	-0,37	-0,18	-0,23		0,07	-0,11	0,31	0,92	-0,94	0,70		
0 .. 25 m	0,18	-0,25	-0,53	-0,67	-0,32	-0,15	0,15	-0,27	-0,21	-0,20	-0,22		0,05	-0,14	0,22	0,94	-0,93	0,72		

Table 39 E_n values for tape 5.42-0917. Values exceeding an absolute value of 1 are marked in red.

E_n	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 26 m	0,20	-0,17	-0,53	-0,75	-0,33	-0,23	0,14	-0,25	-0,37	-0,16	-0,13		0,04	-0,18	0,31	0,93	-0,90	0,73		
0 .. 27 m	0,14	-0,31	-0,42	-0,63	-0,31	-0,21	0,11	-0,27	-0,28	-0,15	-0,12		0,08	-0,21	0,31	0,92	-0,89	0,69		
0 .. 28 m	0,14	-0,31	-0,51	-0,65	-0,29	-0,26	0,11	-0,29	-0,32	-0,13	-0,11		0,03	-0,11	0,28	0,91	-0,88	0,77		
0 .. 29 m	0,10	-0,31	-0,52	-0,78	-0,32	-0,30	0,09	-0,18	-0,29	-0,13	-0,21		-0,01	-0,21	0,31	0,95	-0,89	0,83		
0 .. 30 m	0,08	-0,30	-0,54	-0,67	-0,28	-0,29	0,10	-0,06	-0,30	-0,19	-0,20		-0,07	-0,16	0,25	0,93	-0,86	0,78		
0 .. 31 m	0,11	-0,34	-0,39	-0,71	-0,28	-0,23	0,11	-0,25	-0,21	-0,14	-0,18		-0,10	-0,14	0,27	0,94	-0,90	0,79		
0 .. 32 m	0,16	-0,27	-0,52	-0,76	-0,22	-0,25	0,14	-0,47	-0,29	-0,09	-0,13		-0,06	-0,07	0,23	0,92	-0,91	0,85		
0 .. 33 m	0,06	-0,34	-0,54	-0,74	-0,27	-0,25	0,14	-0,32	-0,19	-0,12	-0,22		-0,06	-0,13	0,19	0,97	-0,99	0,87		
0 .. 34 m	0,11	-0,36	-0,42	-0,81	-0,22	-0,19	0,15	-0,22	-0,22	-0,11	-0,14		-0,03	-0,11	0,14	0,97	-1,04	0,78		
0 .. 35 m	0,03	-0,31	-0,51	-0,81	-0,18	-0,25	0,16	-0,27	-0,31	-0,08	-0,17		-0,05	-0,05	0,14	0,94	-1,01	0,91		
0 .. 36 m	0,03	-0,37	-0,50	-0,78	-0,22	-0,21	0,16	-0,36	-0,15	-0,09	-0,13		-0,01	-0,01	0,18	0,90	-1,06	0,87		
0 .. 37 m	0,05	-0,36	-0,44	-0,72	-0,23	-0,23	0,16	-0,42	-0,23	-0,08	-0,17		-0,01	0,01	0,13	0,91	-1,12	0,85		
0 .. 38 m	0,07	-0,35	-0,47	-0,81	-0,21	-0,23	0,15	-0,48	-0,24	-0,04	-0,15		-0,03	-0,05	0,11	0,89	-1,10	0,90		
0 .. 39 m	0,00	-0,38	-0,52	-0,82	-0,22	-0,22	0,12	-0,20	-0,14	-0,09	-0,16		-0,02	-0,07	0,16	0,87	-1,14	0,85		
0 .. 40 m	-0,01	-0,40	-0,54	-0,74	-0,20	-0,21	0,13	-0,11	-0,30	-0,12	-0,18		-0,01	-0,05	0,19	0,89	-1,17	0,85		
0 .. 41 m	-0,01	-0,40	-0,43	-0,86	-0,22	-0,19	0,14	-0,35	-0,25	-0,07	-0,14		-0,01	0,06	0,28	0,88	-1,20	1,00		
0 .. 42 m	-0,02	-0,36	-0,44	-0,83	-0,25	-0,19	0,26	-0,42	-0,13	-0,10	-0,13		0,00	-0,11	0,29	0,87	-1,22	0,90		
0 .. 43 m	-0,04	-0,39	-0,54	-0,85	-0,26	-0,19	0,16	-0,36	-0,26	-0,05	-0,14		0,01	-0,02	0,24	0,87	-1,27	1,00		
0 .. 44 m	-0,04	-0,41	-0,40	-0,88	-0,25	-0,17	0,13	-0,34	-0,22	-0,10	-0,16		0,04	-0,07	0,30	0,90	-1,31	0,96		
0 .. 45 m	-0,11	-0,43	-0,47	-0,91	-0,22	-0,16	0,13	-0,20	-0,18	-0,11	-0,14		-0,01	-0,05	0,25	0,87	-1,33	1,05		
0 .. 46 m	-0,08	-0,44	-0,49	-0,91	-0,26	-0,18	0,12	-0,33	-0,26	-0,07	-0,17		0,00	-0,04	0,29	0,86	-1,37	1,09		
0 .. 47 m	-0,12	-0,43	-0,50	-0,94	-0,21	-0,18	0,11	-0,38	-0,21	-0,07	-0,12		0,01	-0,02	0,29	0,87	-1,40	1,11		
0 .. 48 m	-0,11	-0,43	-0,44	-0,91	-0,27	-0,20	0,11	-0,32	-0,18	-0,13	-0,15		0,02	0,04	0,26	0,86	-1,41	1,12		
0 .. 49 m	-0,16	-0,46	-0,52	-0,90	-0,24	-0,20	0,09	-0,36	-0,24	-0,09	-0,17		0,05	0,05	0,28	0,82	-1,44	1,21		
0 .. 50 m	-0,14	-0,45	-0,58	-0,90	-0,26	-0,18	0,06	-0,35	-0,05	-0,16	-0,11		0,06	0,12	0,28	0,83	-1,38	1,16		

Table 40 E_n values for tape 5.42-0917. Values exceeding an absolute value of 1.0 are marked in red.

E_n	PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80	NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
0 .. 506.0 mm	0,14	-0,03	-0,08	-0,08	-0,37	-0,47	1,17		-0,70	0,43	0,64	-0,99	-0,23	-1,25	-0,40	0,21	-0,47	-1,10	0,14	3,99
0 .. 507.0 mm	0,11	0,05	-0,09	-0,11	-0,71	-0,55	0,91		-0,59	0,48	0,73	-0,90	-0,12	-1,45	-0,37	0,25	-0,56	-0,74	0,12	3,76
0 .. 508.0 mm	0,05	0,01	-0,03	0,05	-0,47	-0,45	1,07		-0,75	0,37	0,60	-0,93	-0,18	-0,98	-0,39	0,12	-0,47	-1,03	0,07	3,45
0 .. 2529.0 mm	-0,06	-0,20	0,24	1,26	-0,40	-0,70	0,18		-0,82	0,10	-0,01	-0,99	0,07	-1,47	-0,58	0,35	-1,11	-0,39	0,34	
0 .. 2530.0 mm	-0,03	-0,22	0,18	1,12	-0,38	-0,66	0,22		-0,92	0,16	0,11	-1,02	0,13	-1,33	-0,56	0,36	-1,23	-0,21	0,35	
0 .. 2531.0 mm	-0,06	-0,24	0,15	1,31	-1,09	-0,73	0,23		-1,02	0,24	0,16	-0,95	0,14	-1,38	-0,47	0,33	-1,16	-0,25	0,36	
0 .. 10999.0 mm	0,12	-0,19	-0,32	-0,70	-0,21	-0,39	0,19		-0,43	0,21	0,08		0,02	-0,05	0,41	1,00	-0,83	0,18	0,90	
0 .. 11001.0 mm	0,05	-0,24	-0,34	-0,79	0,89	-0,44	0,16		-0,43	0,26	0,11		0,00	-0,10	0,14	0,94	-0,89	0,25	0,85	
0 .. 29999.0 mm	0,12	-0,28	-0,53	-0,68	-0,23	-0,30	0,11		-0,27	-0,20	-0,18		-0,08	-0,13	0,06	0,98	-0,86	0,73		
0 .. 30001.0 mm	0,13	-0,28	-0,53	-0,67	-0,21	-0,28	0,08		-0,21	-0,20	-0,19		-0,23	-0,17	0,16	0,96	-0,84	0,74		
0 .. 49998.0 mm	-0,16	-0,47	-0,59	-0,94	-0,20	-0,18	0,07		-0,05	-0,19	-0,14		0,05	0,09	0,30	0,82	-1,43	1,09		
0 .. 49999.0 mm	-0,16	-0,46	-0,59	-0,94	-0,23	-0,18	0,06		-0,04	-0,23	-0,16		0,04	0,07	0,31	0,83	-1,44	1,11		

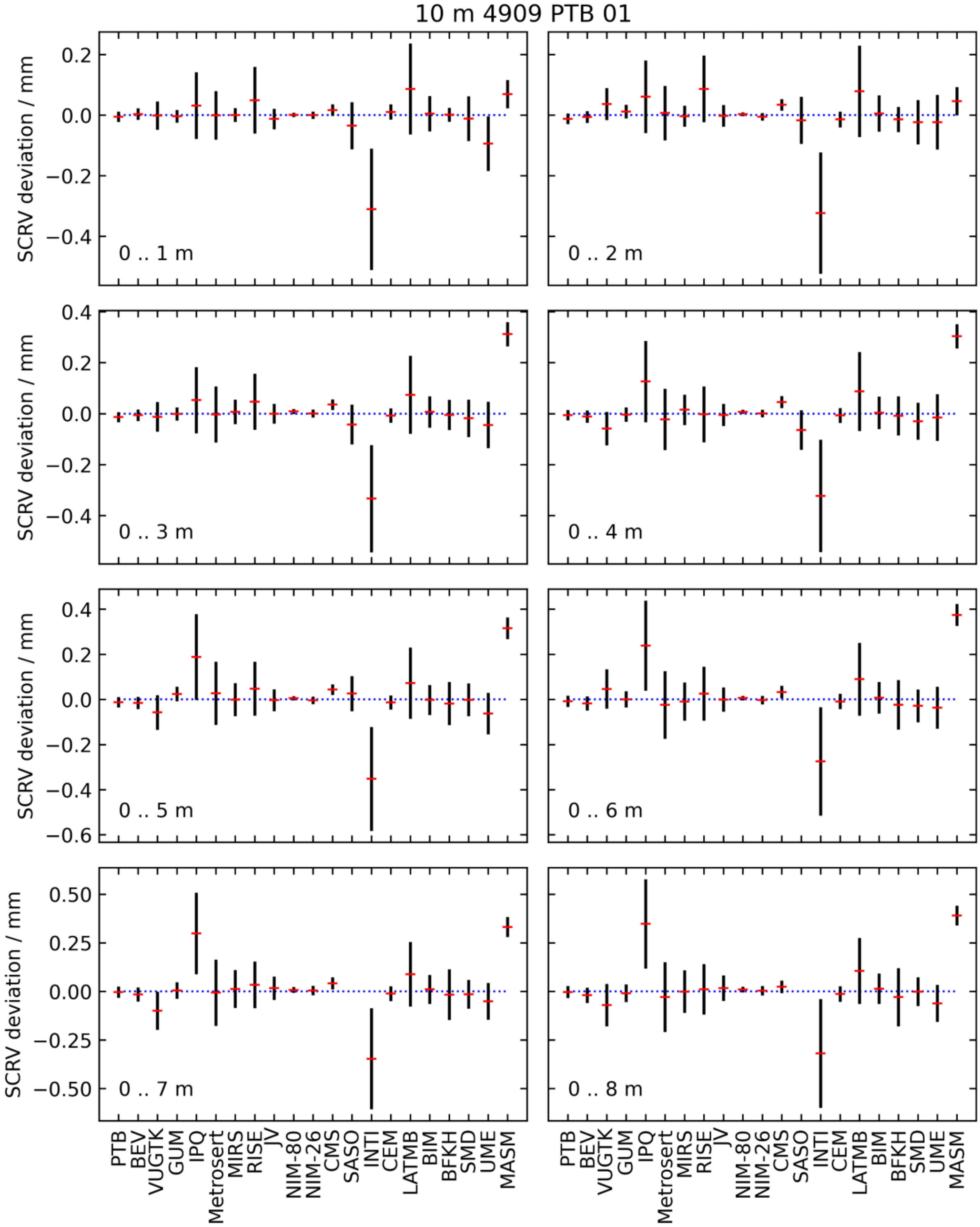


Figure 30 Deviation of the reported values from the SCRV for tape 4909 PTB 01. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

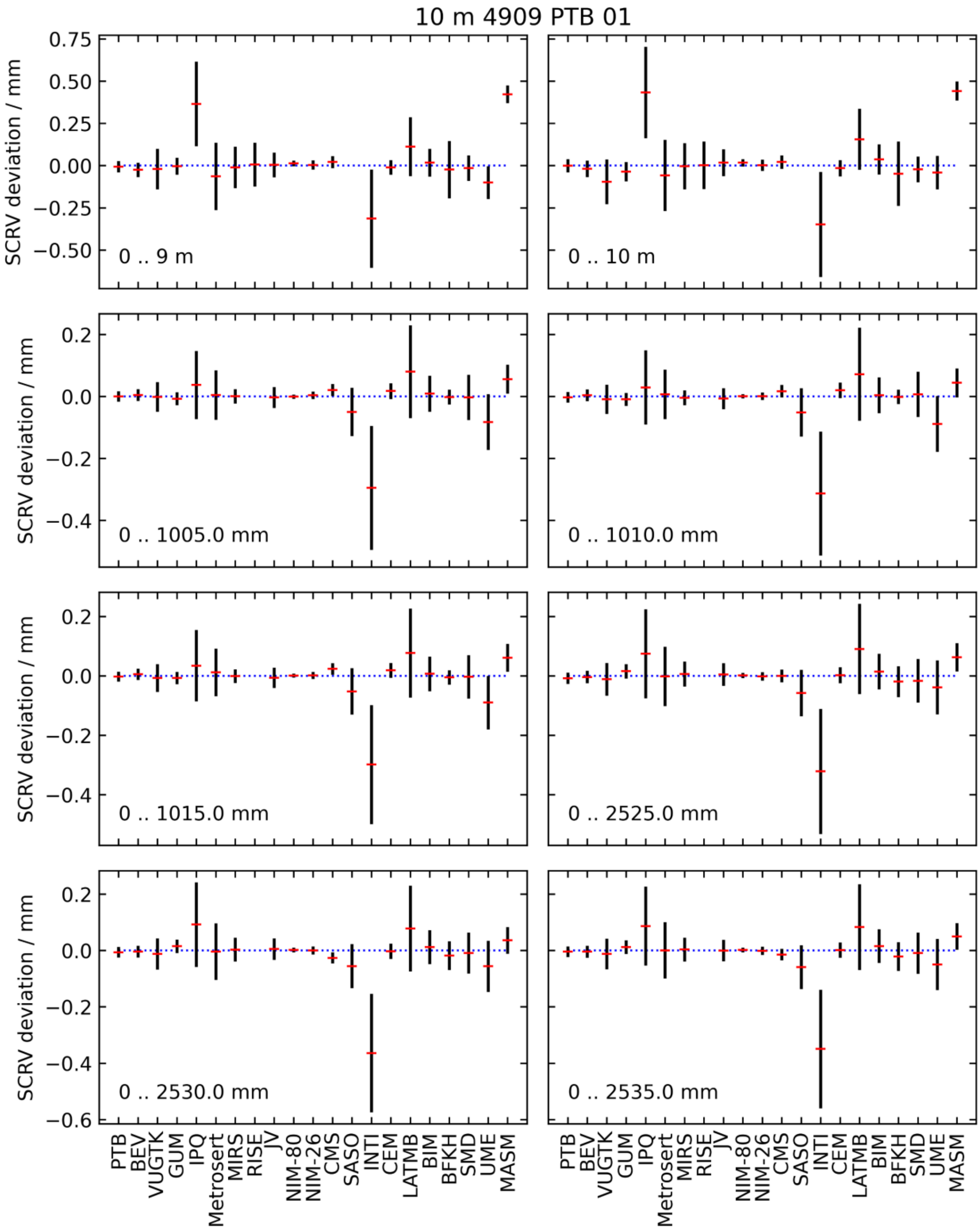


Figure 31 Deviation of the reported values from the SCRV for tape 4909 PTB 01. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

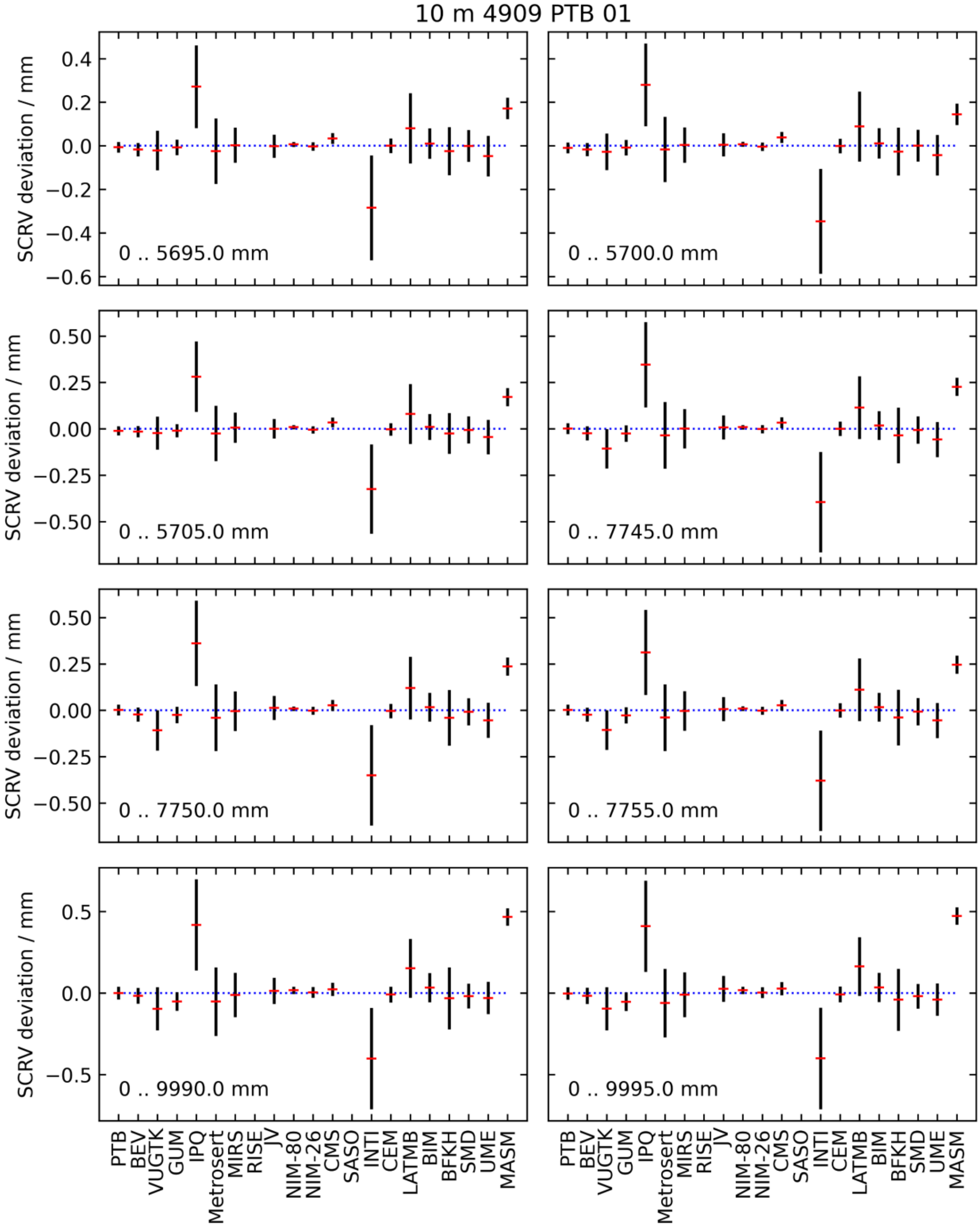


Figure 32 Deviation of the reported values from the SCRV for tape 4909 PTB 01. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

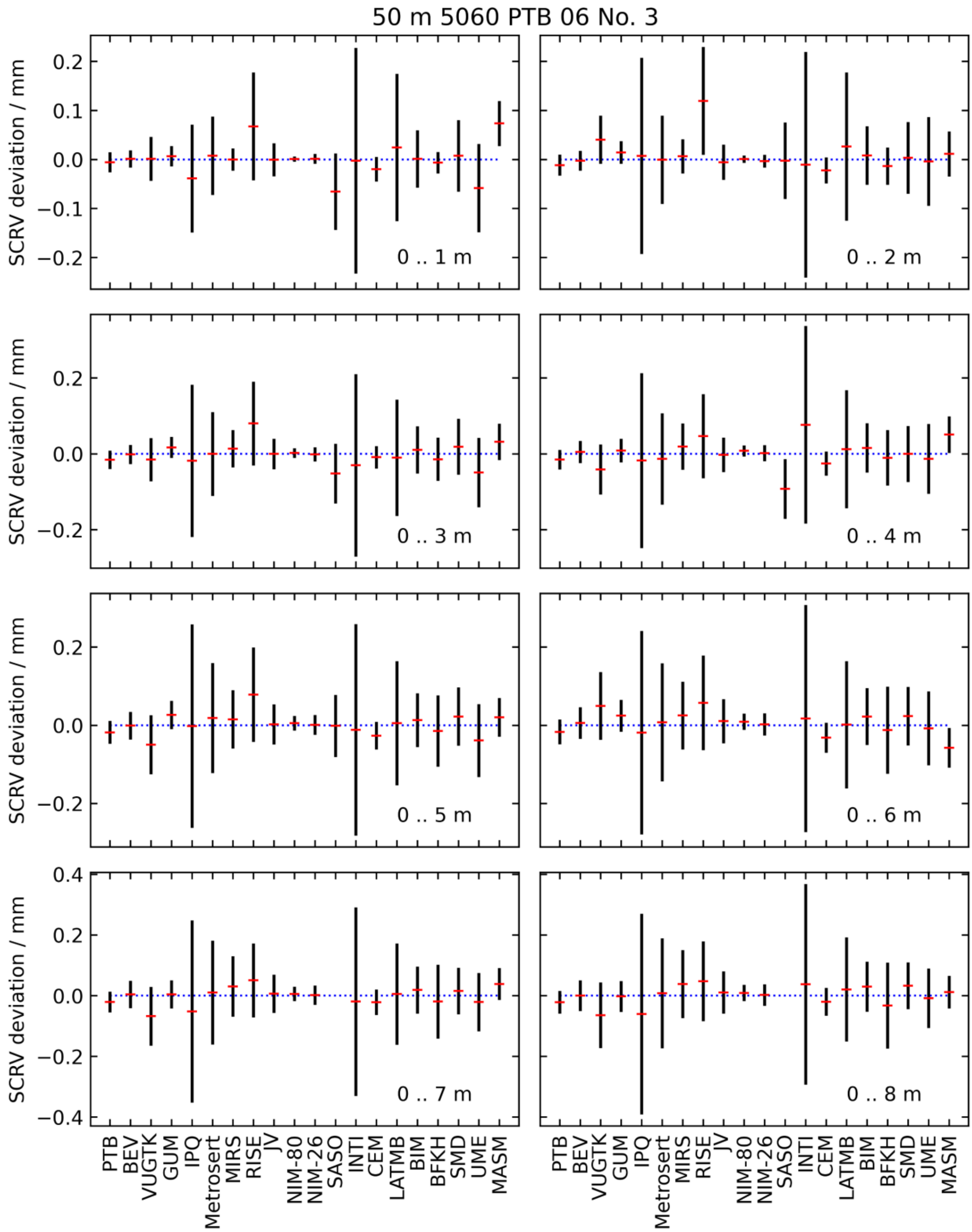


Figure 33 Deviation of the reported values from the SCRV for tape 5060 PTB 06 No. 3. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

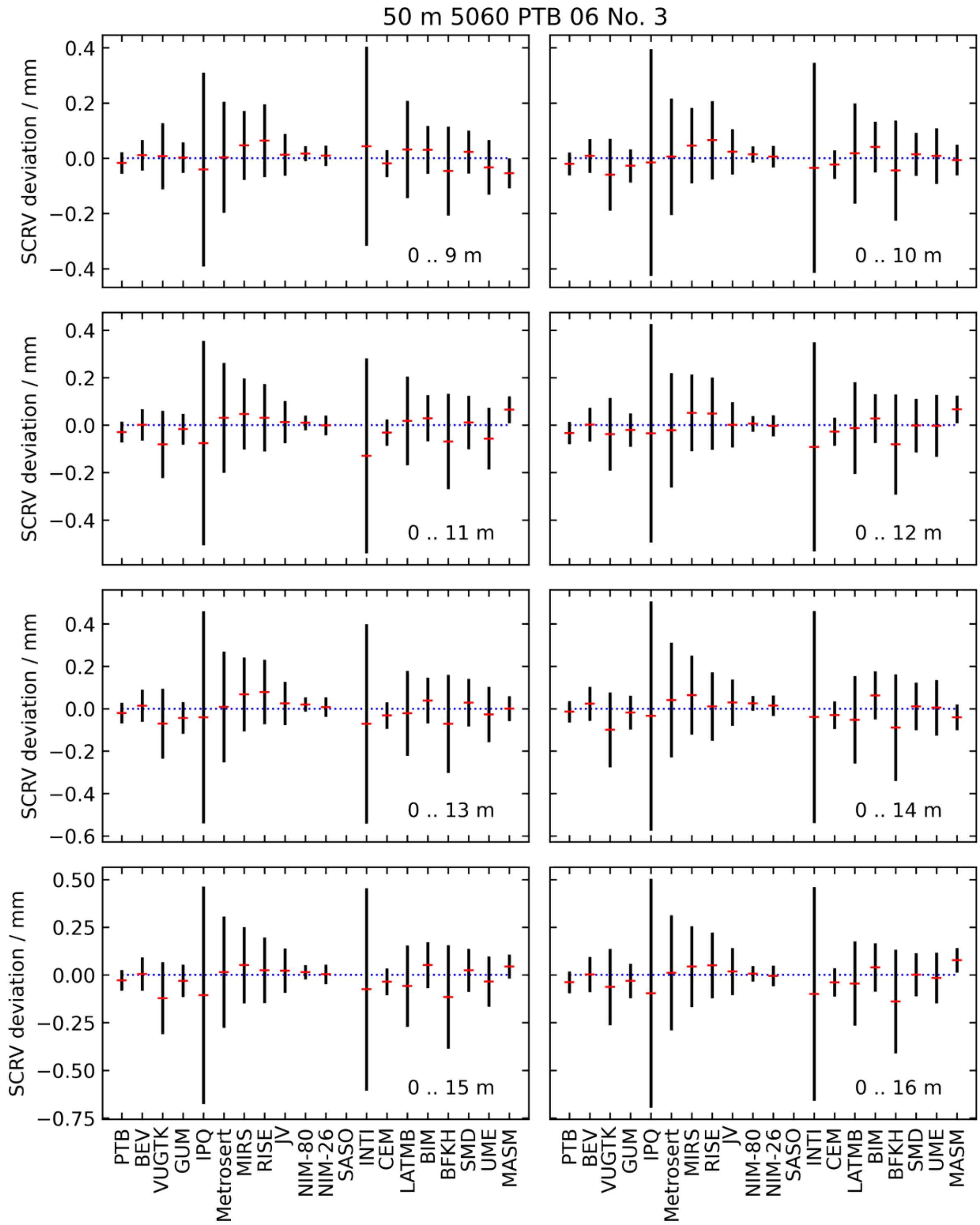


Figure 34 Deviation of the reported values from the SCRV for tape 5060 PTB 06 No. 3. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

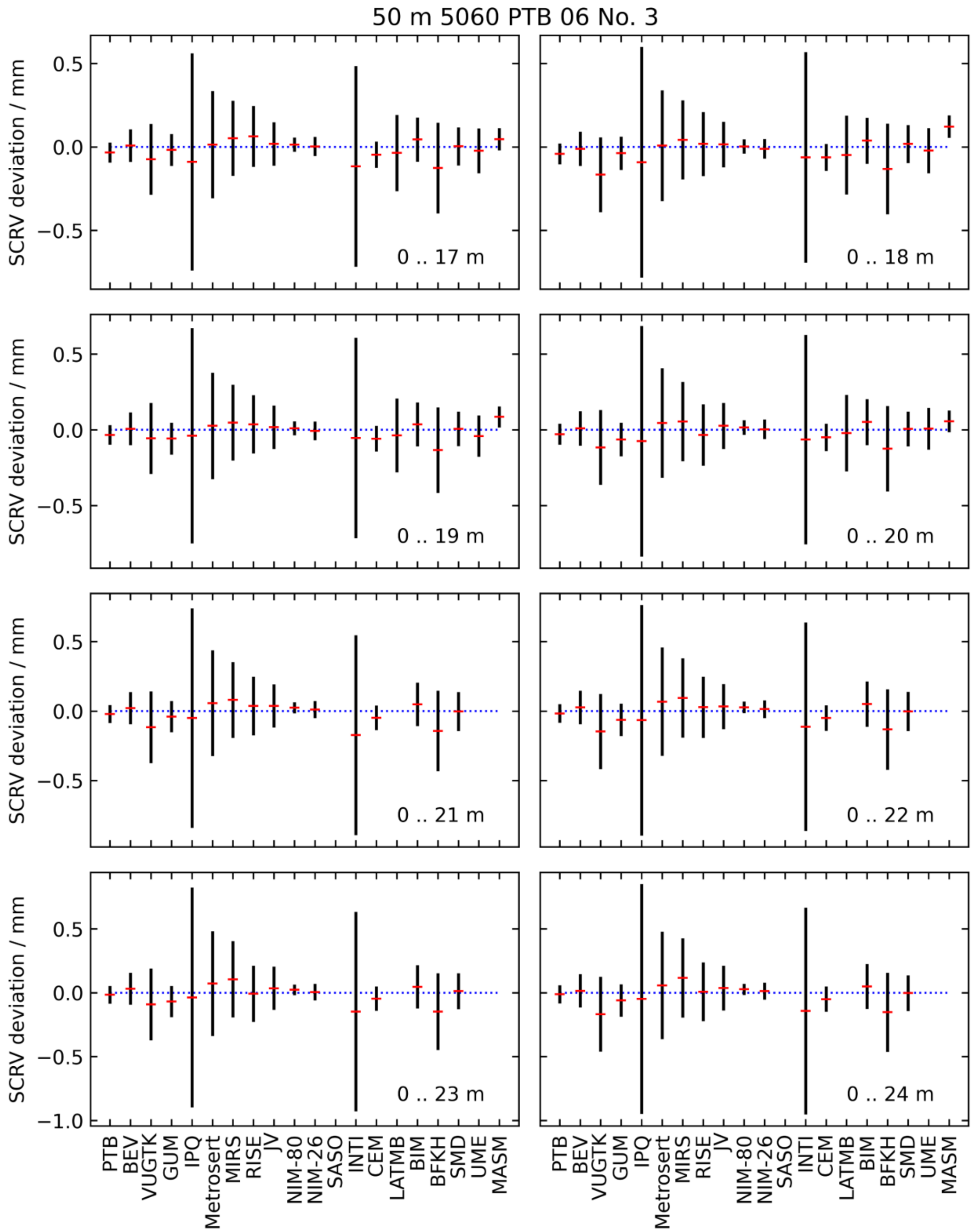


Figure 35 Deviation of the reported values from the SCRV for tape 5060 PTB 06 No. 3. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

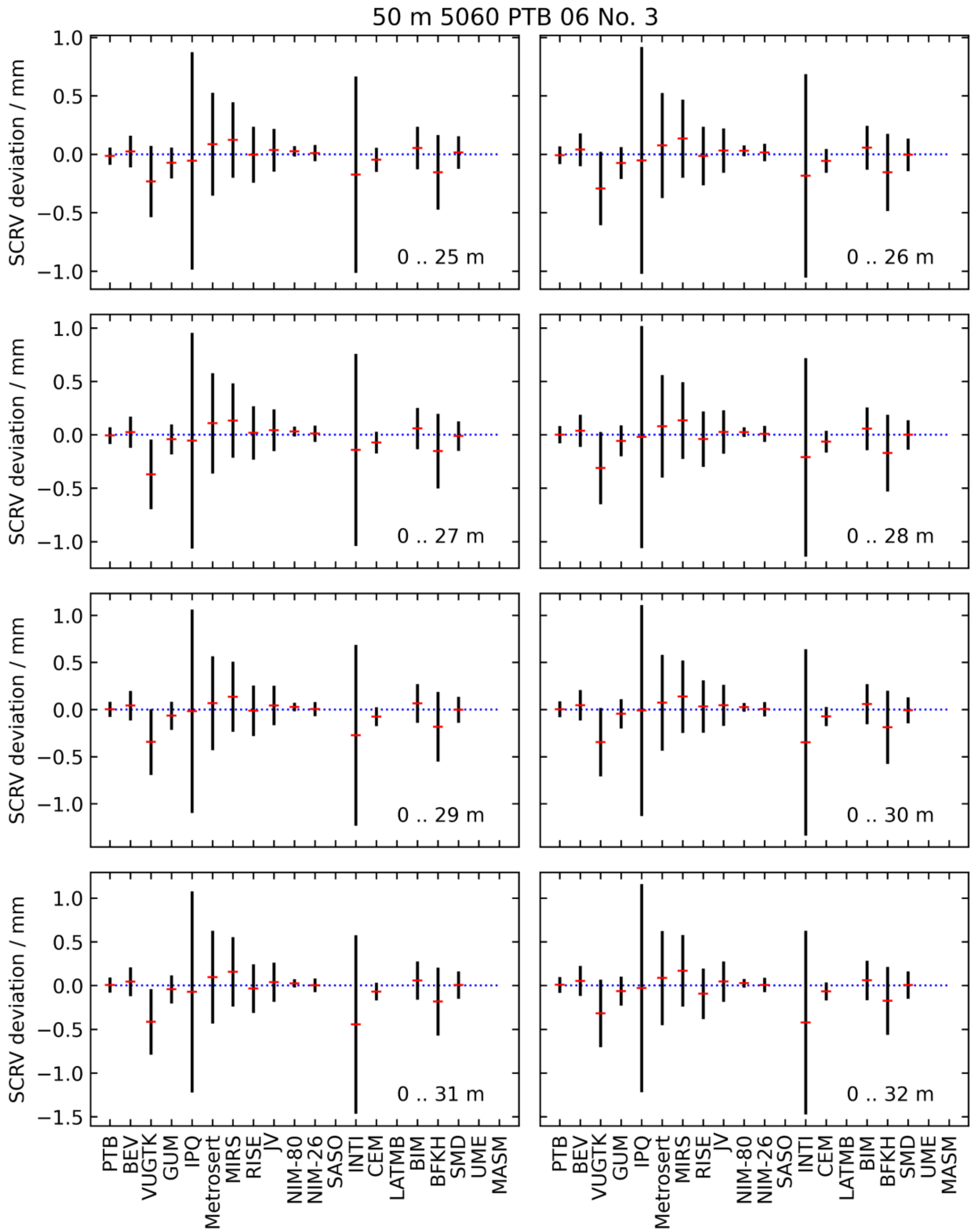


Figure 36 Deviation of the reported values from the SCRV for tape 5060 PTB 06 No. 3. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

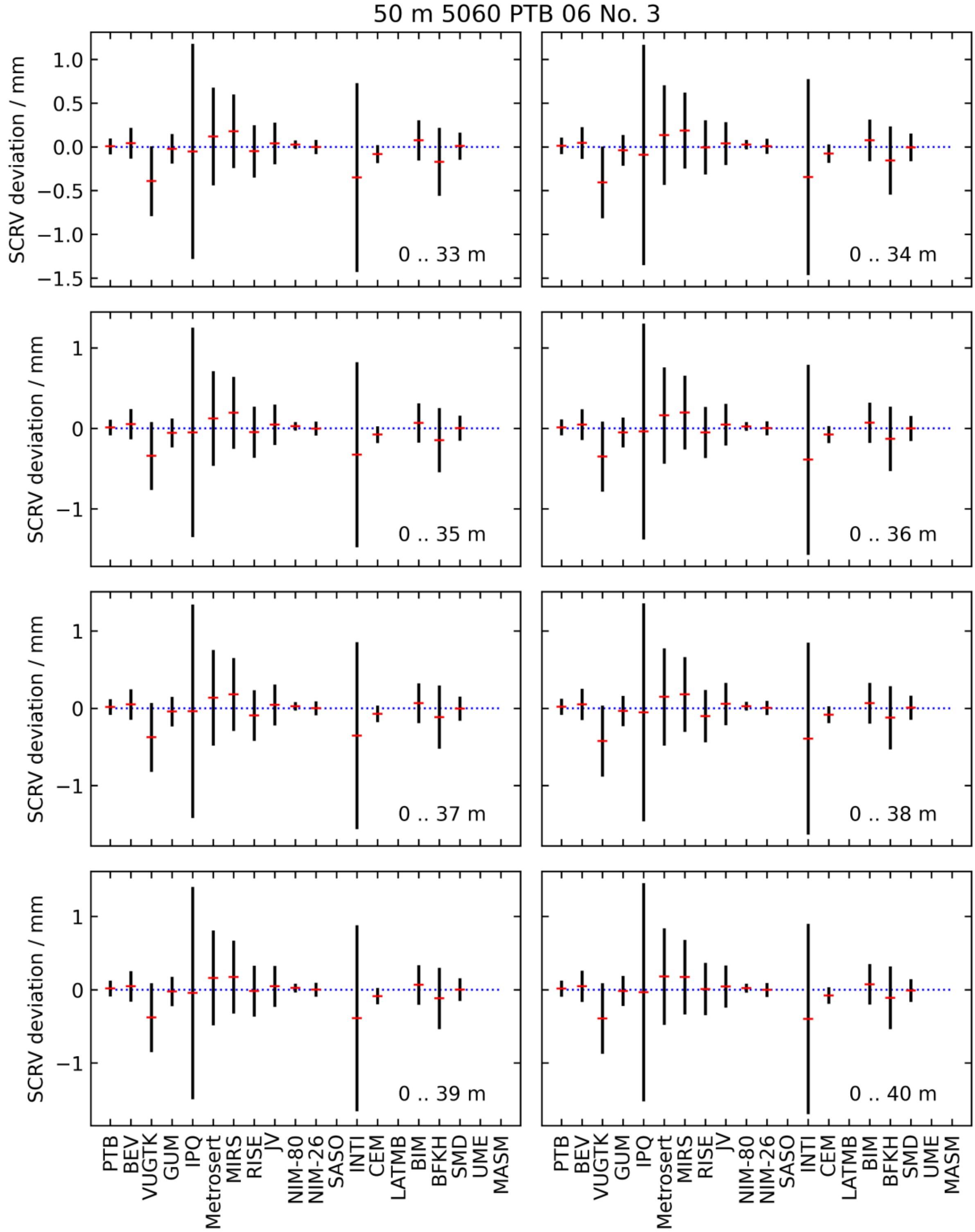


Figure 37 Deviation of the reported values from the SCRV for tape 5060 PTB 06 No. 3. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

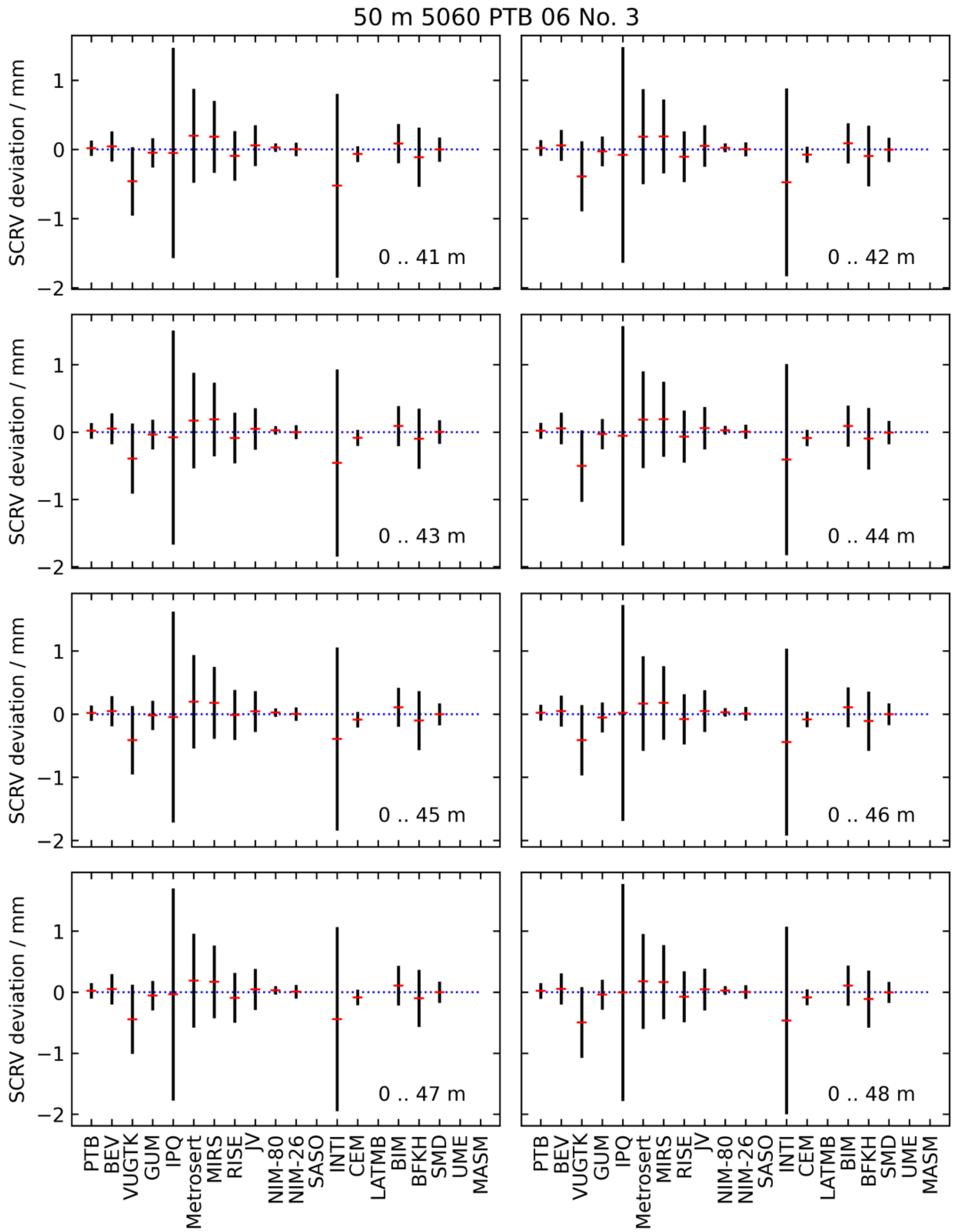


Figure 38 Deviation of the reported values from the SCRV for tape 5060 PTB 06 No. 3. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

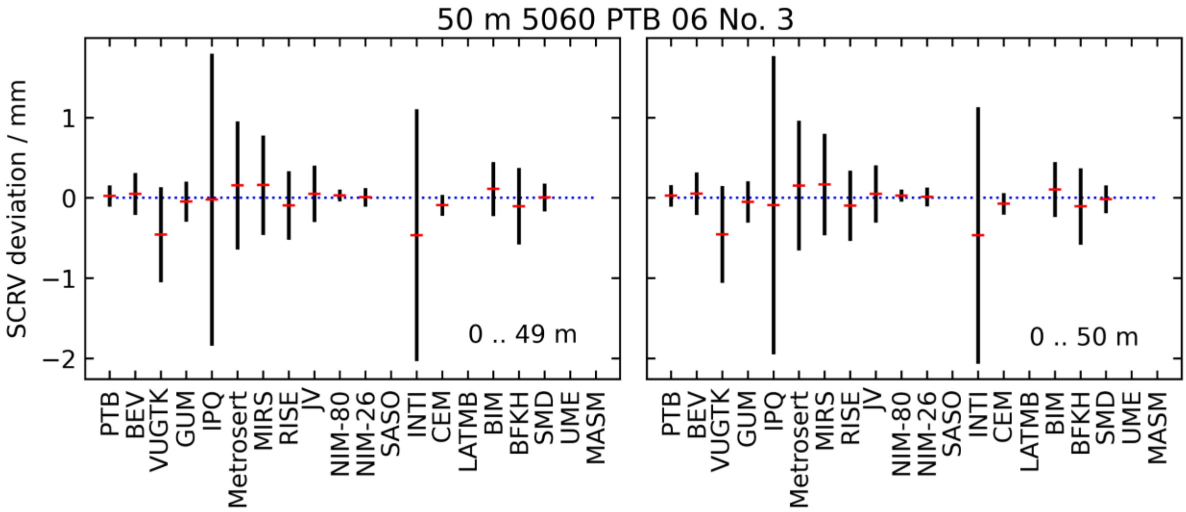


Figure 39 Deviation of the reported values from the SCRV for tape 5060 PTB 06 No. 3. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

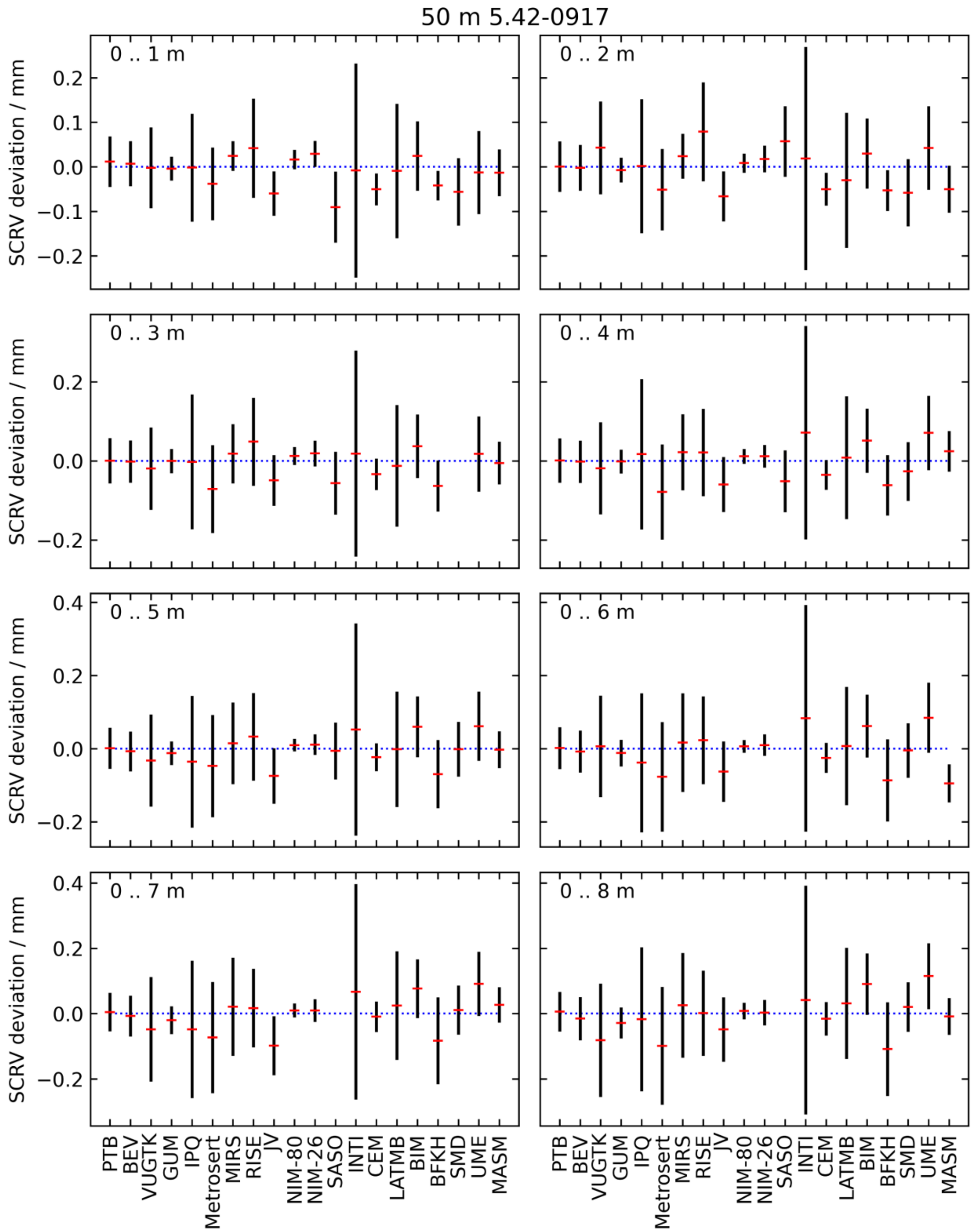


Figure 40 Deviation of the reported values from the SCRV for tape 5.42-0917. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

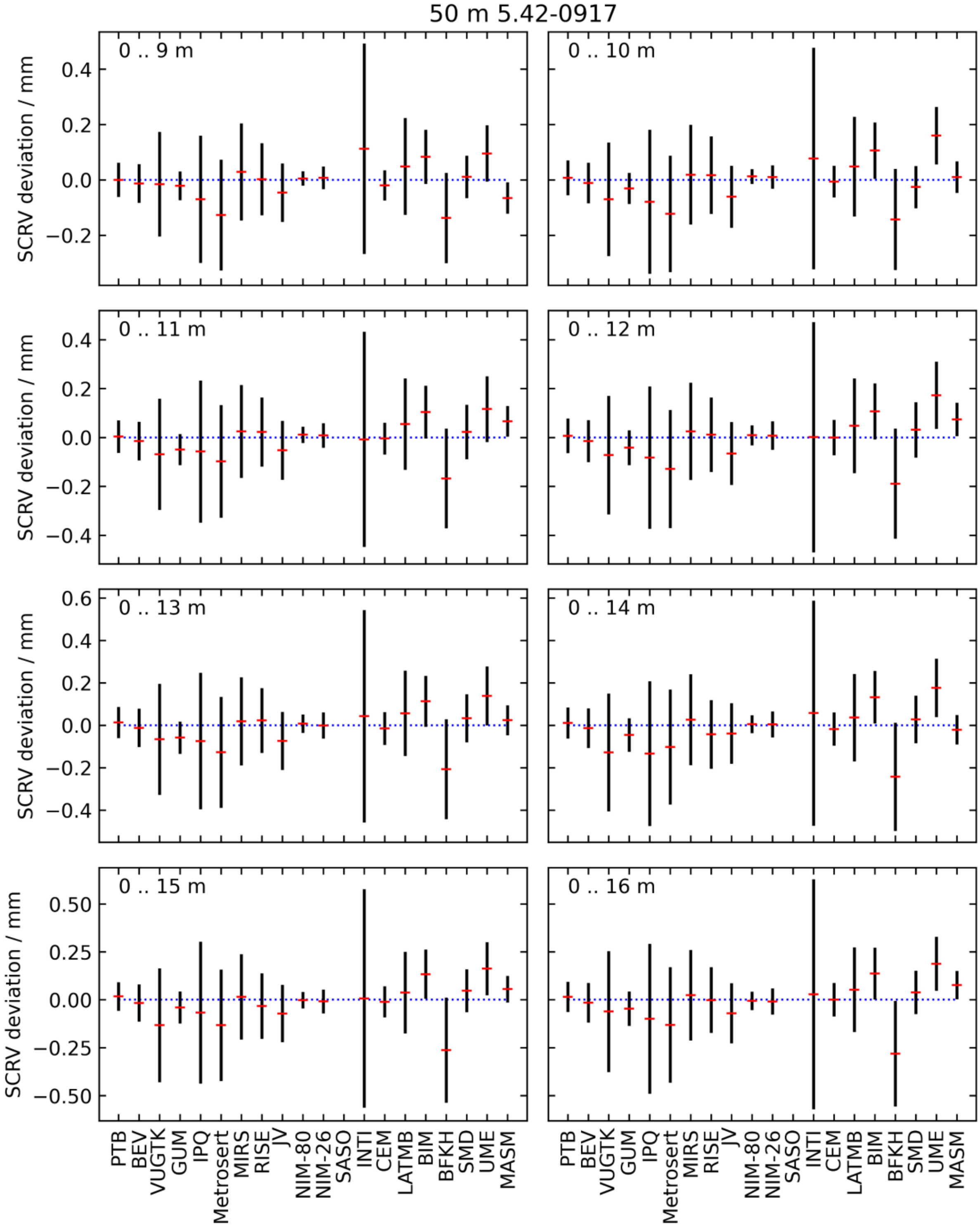


Figure 41 Deviation of the reported values from the SCRV for tape 5.42-0917. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

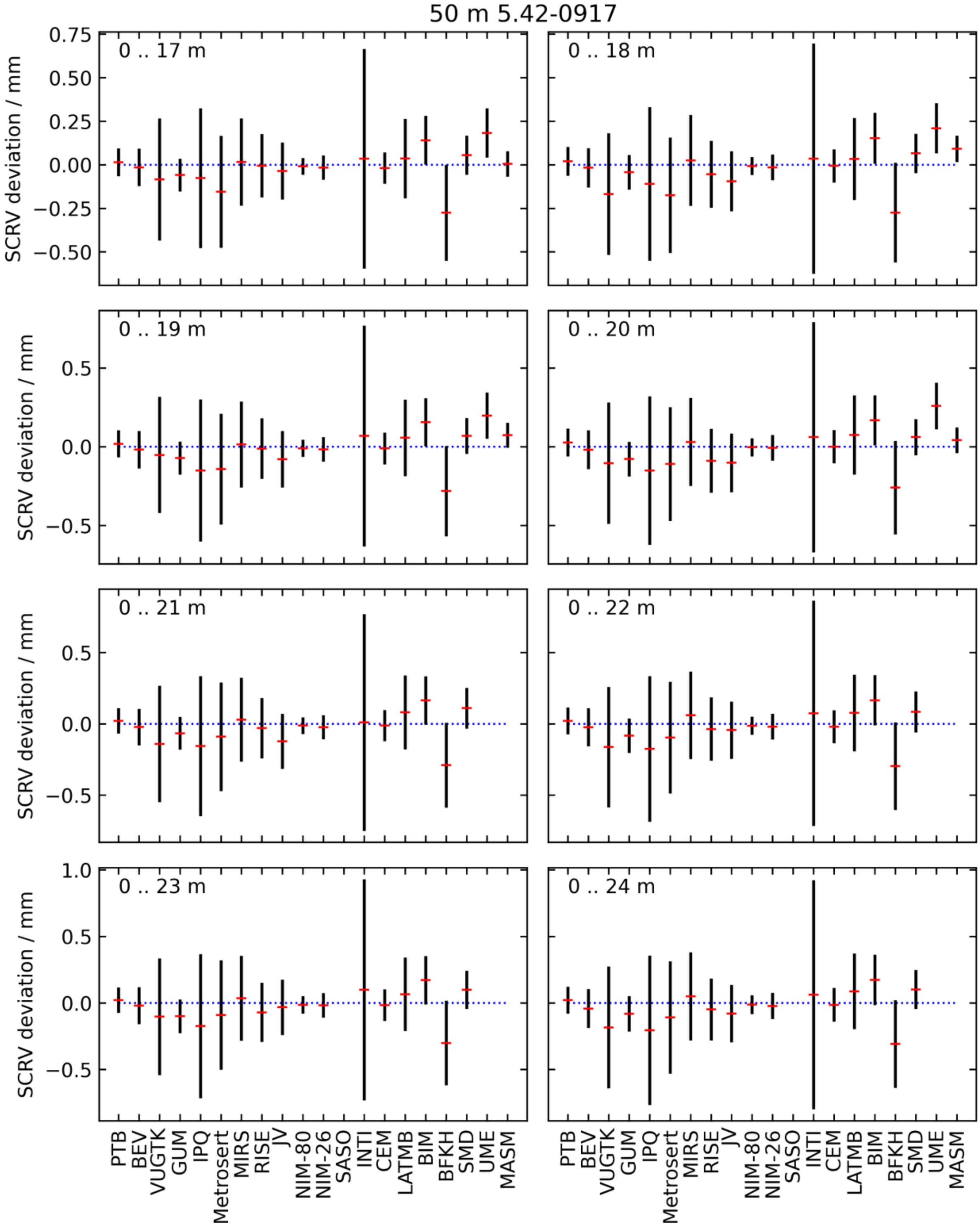


Figure 42 Deviation of the reported values from the SCRV for tape 5.42-0917. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

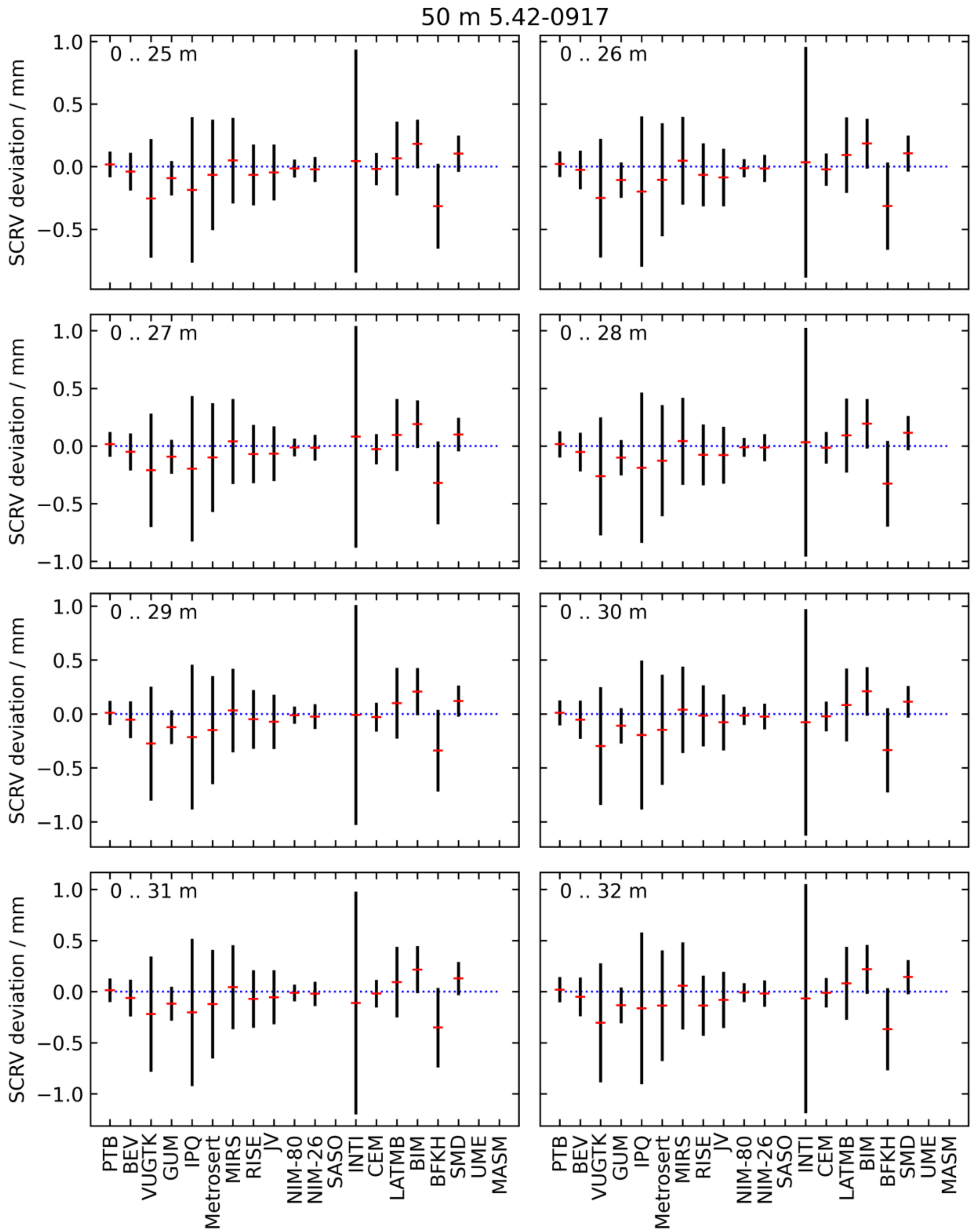


Figure 43 Deviation of the reported values from the SCRV for tape 5.42-0917. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

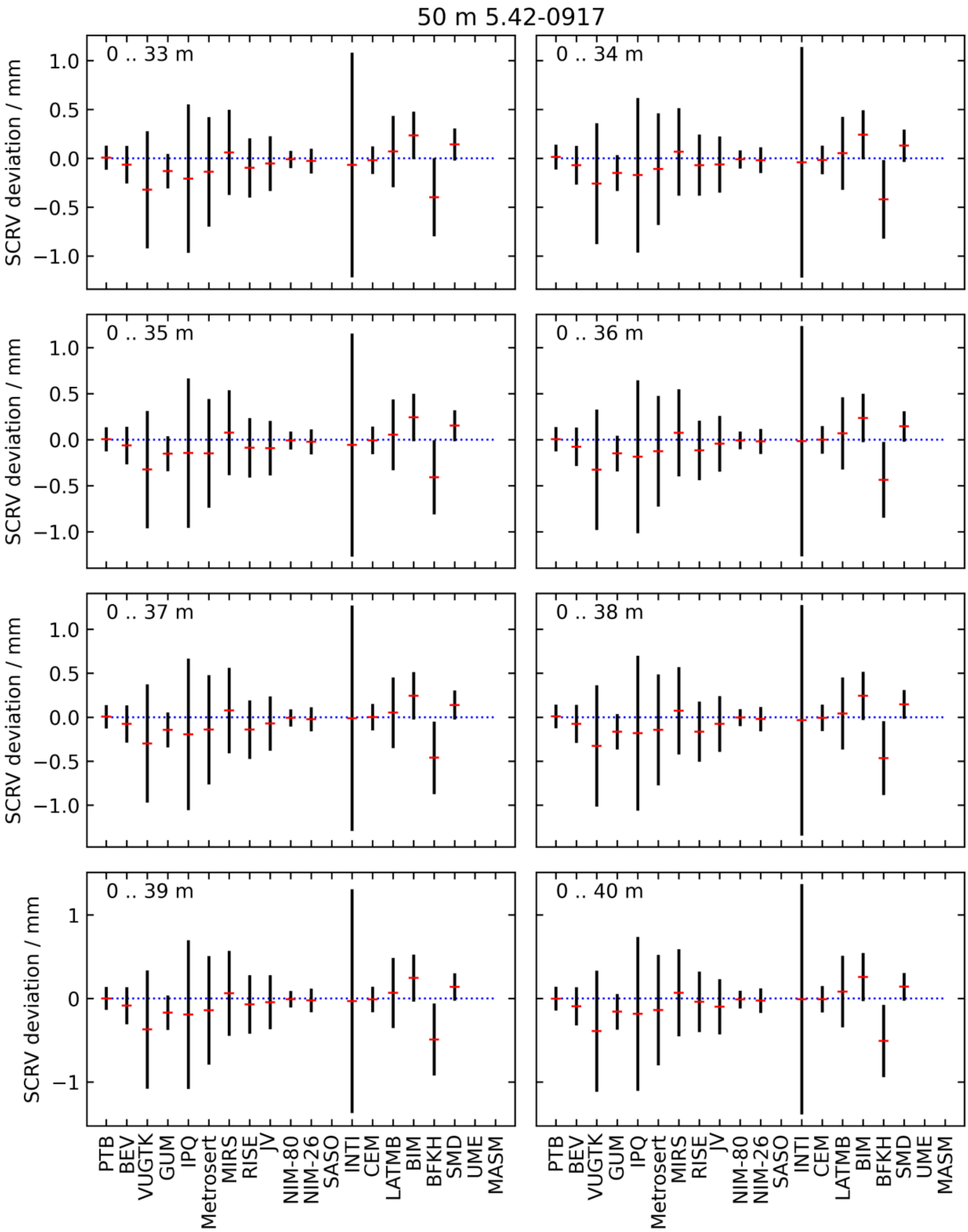


Figure 44 Deviation of the reported values from the SCRV for tape 5.42-0917. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

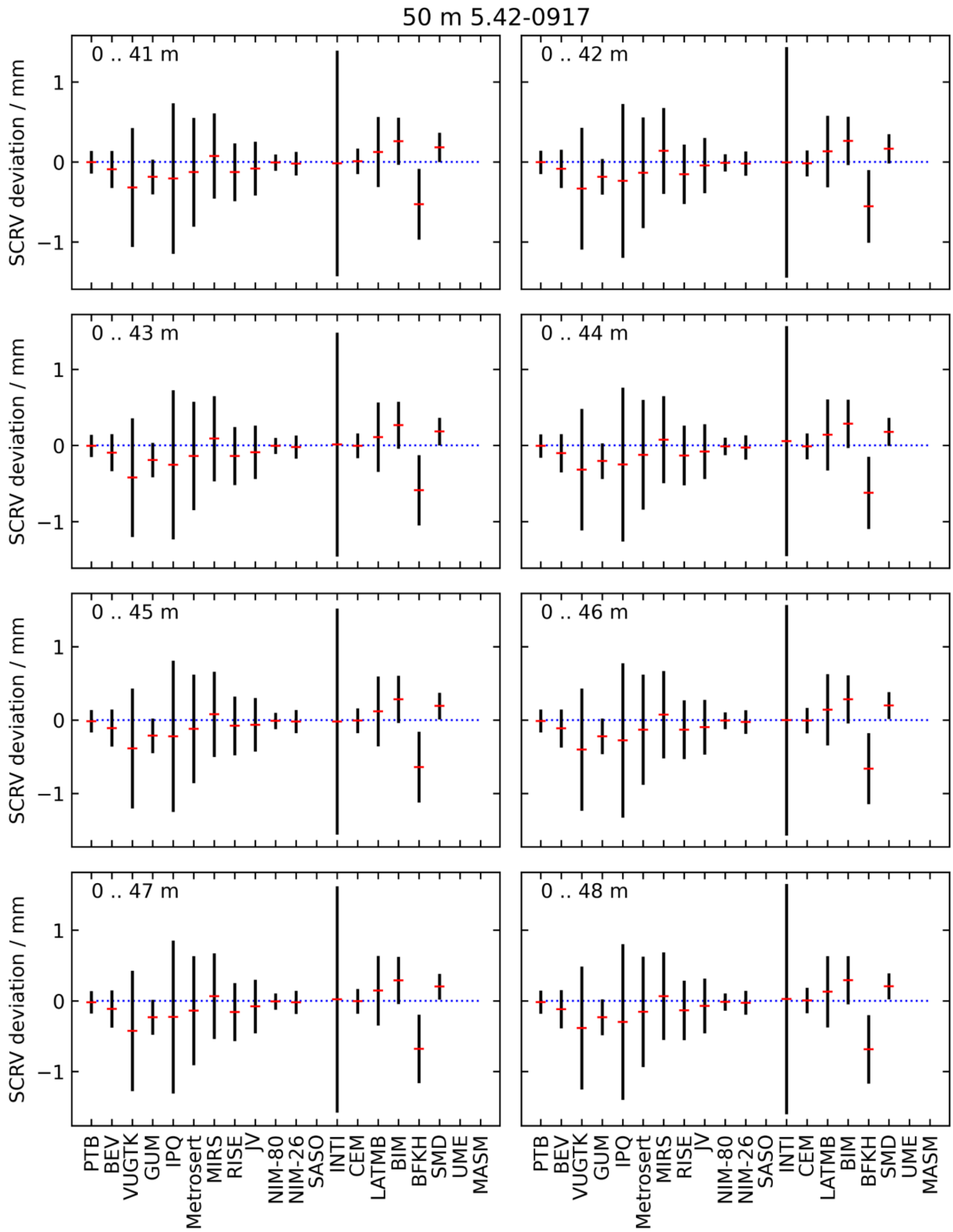


Figure 45 Deviation of the reported values from the SCRV for tape 5.42-0917. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

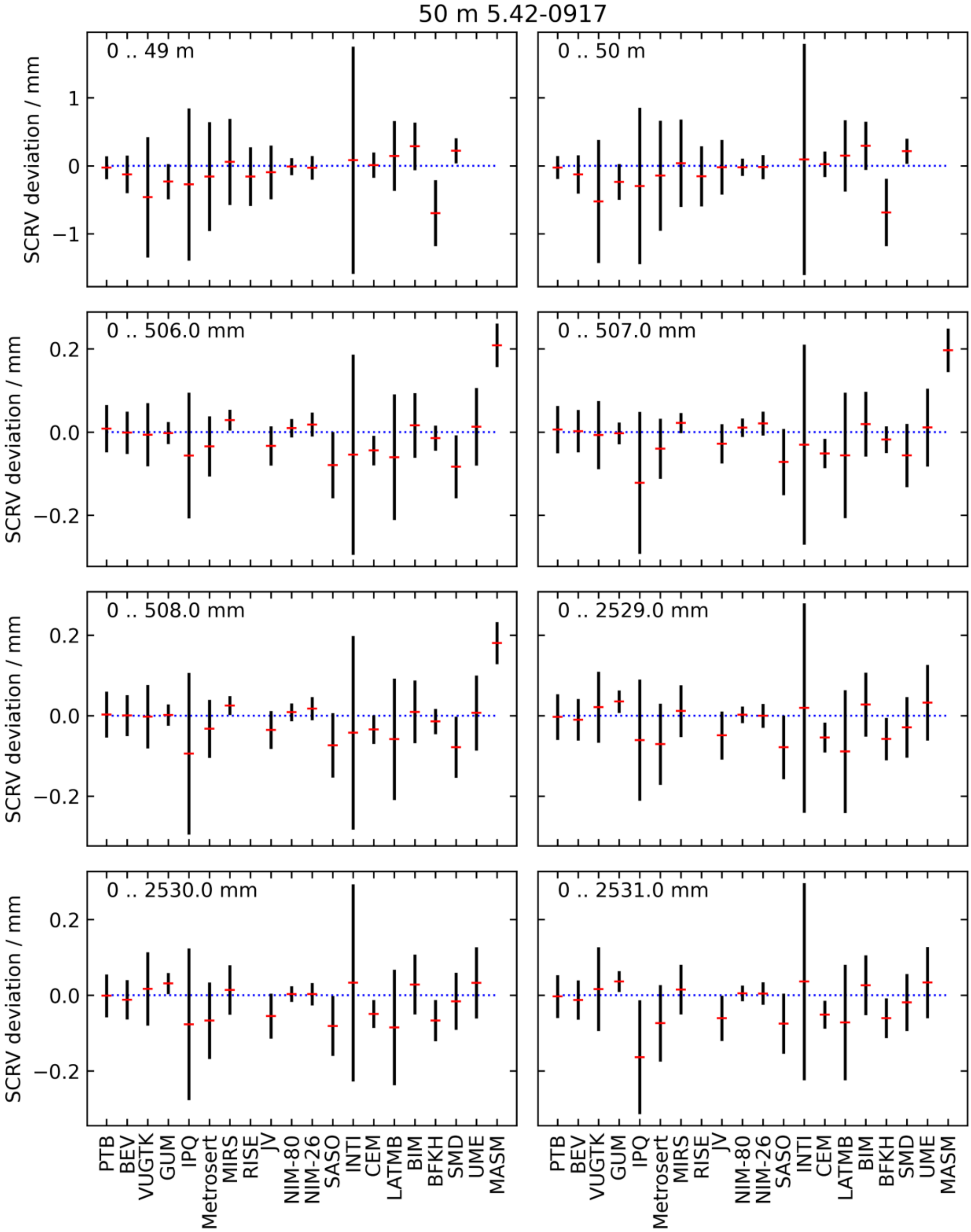


Figure 46 Deviation of the reported values from the SCRV for tape 5.42-0917. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

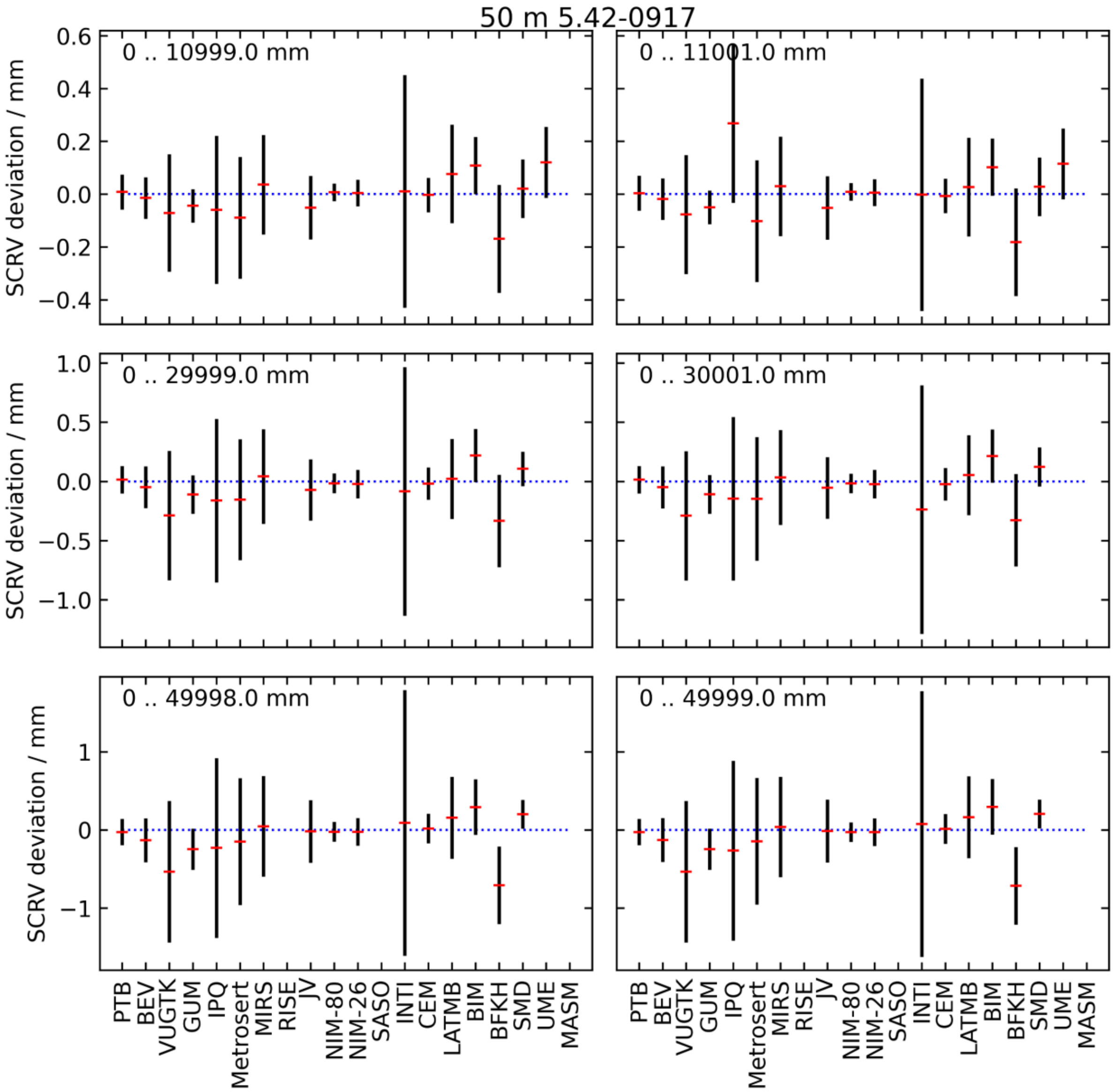


Figure 47 Deviation of the reported values from the SCRV for tape 5.42-0917. The error bars indicate the expanded measurement uncertainty (k = 2) of the deviation from the SCRV according to Eq. (10).

7.5 Alternative analysis for the last loop of tape 5.42-0917

As reported in Section 4.2.3, tape 5.42-0917 was seriously damaged during the final loop of the comparison. The final control measurement PTB6 does not fit to the previous six control measurements by the pilot. It is therefore unreasonable to compare measurements in this loop against an SCRV derived for the complete comparison. Of all participants from the final loop, only UME and MASM reported data from the 5.42-0917 tape measurement, which can be used for the final evaluation. As can be seen from Table 38 to Table 40, their results indeed show unsatisfactory agreement with the respective SCRV.

As an alternative approach, the final loop is separately analyzed from the rest of the comparison. The results of the two participants are compared to the PTB5 and PTB6 measurements only. Based on the other comparison results, the measurements and uncertainty statements by the pilot can be interpreted as reliable, and thus, as reference values for a bilateral comparison.

Table 41. Bilateral analysis of tape 5.42-0917 between the results reported from UME and the pilot measurements before (PTB5) and after (PTB6) the final comparison loop. E_n values with an absolute values exceeding 1 are marked in red.

		UME vs PTB5				UME vs PTB6		
		d_i / mm	$u_{bi}(d_i)$ / mm	E_n		d_i / mm	$u_{bi}(d_i)$ / mm	E_n
0 .. 1 m		0,009	0,055	0,08		-0,014	0,055	-0,13
0 .. 2 m		0,075	0,055	0,68		0,044	0,055	0,40
0 .. 3 m		0,045	0,056	0,40		0,013	0,056	0,11
0 .. 4 m		0,087	0,056	0,78		0,035	0,056	0,32
0 .. 5 m		0,074	0,056	0,65		0,024	0,056	0,21
0 .. 6 m		0,102	0,057	0,89		0,032	0,057	0,28
0 .. 7 m		0,099	0,058	0,86		0,029	0,058	0,25
0 .. 8 m		0,131	0,058	1,13		0,047	0,058	0,41
0 .. 9 m		0,125	0,059	1,05		0,027	0,059	0,23
0 .. 10 m		0,177	0,060	1,47		0,091	0,060	0,76
0 .. 11 m		0,136	0,073	0,93		0,053	0,073	0,37
0 .. 12 m		0,204	0,073	1,39		0,109	0,073	0,74
0 .. 13 m		0,167	0,074	1,13		0,105	0,074	0,71
0 .. 14 m		0,204	0,074	1,37		0,141	0,074	0,95
0 .. 15 m		0,193	0,075	1,29		0,121	0,075	0,81
0 .. 16 m		0,220	0,076	1,46		0,154	0,076	1,02
0 .. 17 m		0,210	0,076	1,38		0,142	0,076	0,93
0 .. 18 m		0,236	0,077	1,53		0,156	0,077	1,01
0 .. 19 m		0,222	0,078	1,42		0,130	0,078	0,84
0 .. 20 m		0,267	0,079	1,69		0,168	0,079	1,06
0 .. 506.0 mm		0,032	0,055	0,29		0,022	0,055	0,20
0 .. 507.0 mm		0,029	0,055	0,26		0,018	0,055	0,16
0 .. 508.0 mm		0,029	0,055	0,27		0,015	0,055	0,13
0 .. 2529.0 mm		0,070	0,055	0,63		0,038	0,055	0,34
0 .. 2530.0 mm		0,067	0,055	0,60		0,034	0,055	0,31
0 .. 2531.0 mm		0,063	0,055	0,57		0,030	0,055	0,27
0 .. 10999.0 mm		0,142	0,073	0,97		0,057	0,073	0,39
0 .. 11001.0 mm		0,138	0,073	0,94		0,055	0,073	0,38

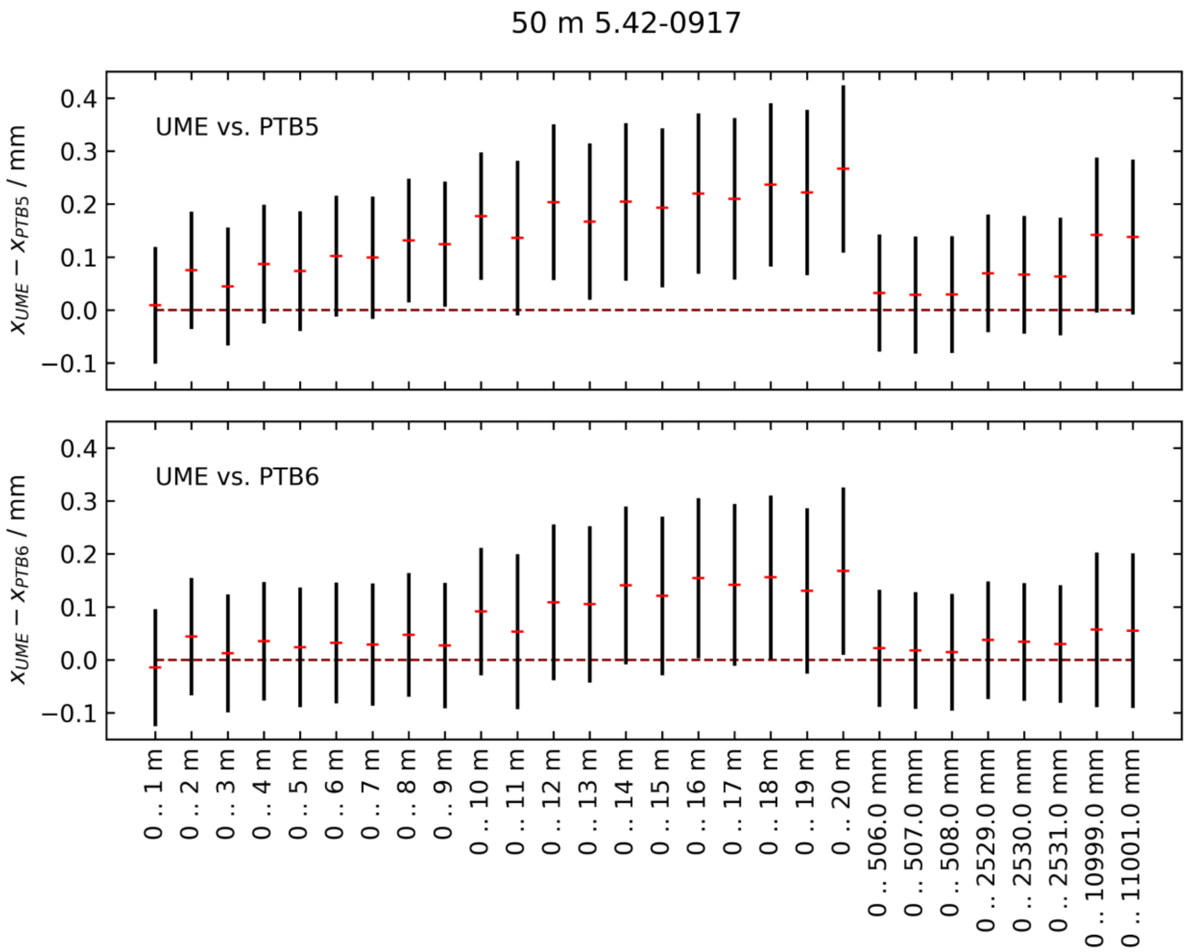


Figure 48 Deviation of the reported values by UME from the PTB5 (upper graph) and PTB6 (lower graph) measurement values for tape 5.42-0917. The error bars indicate the expanded measurement uncertainty $2u_{\mathrm{bi}}$ (k = 2) of these deviations according to Equation (15).

The deviation d_i of the participant value from the pilot reference value is hence be given in complete analogy to Eq. (9) by

$$d_i = x_{i,\,\mathrm{participant}} - x_{i,\,\mathrm{pilot}}. \tag{13}$$

The uncertainty of this deviation is calculated as quadratic sum of the combined measurement uncertainties of pilot and participant:

$$u_{\mathrm{bi}}(d_i) = \sqrt{\left[u_{\mathrm{c,\,pilot}}(x_i)\right]^2 + \left[u_{\mathrm{c,\,participant}}(x_i)\right]^2}. \tag{14}$$

Since the time span between the measurements is relatively short and the major cause of changes is an incident with the tape, there is no argument to introduce an additional artefact uncertainty for this analysis. The E_n values are calculated according to

$$E_n = \frac{d_i}{2u_{\mathrm{bi}}(d_i)}. \tag{15}$$

The bilateral analysis was performed both for the PTB5 and PTB6 datasets. The results compiled in Table 41 and Figure 48 show a much better agreement of the UME data with the PTB6 measurement. The MASM data (Table 42 and Figure 49) shows a similar tendency. The comparison against PTB6 is hence used for the overall interpretation of UME's and MASM's comparison results in Section 8.

Table 42. Bilateral analysis of tape 5.42-0917 between the results reported from MASM and the pilot measurements before (PTB5) and after (PTB6) the final comparison loop. E_n values with an absolute values exceeding 1 are marked in red.

		MASM vs PTB5				MASM vs PTB6		
		d_i / mm	$u_{bi}(d_i)$ / mm	E_n		d_i / mm	$u_{bi}(d_i)$ / mm	E_n
0 .. 1 m		0,009	0,039	0,11		-0,015	0,039	-0,19
0 .. 2 m		-0,017	0,039	-0,22		-0,049	0,039	-0,62
0 .. 3 m		0,022	0,040	0,27		-0,010	0,040	-0,13
0 .. 4 m		0,041	0,040	0,51		-0,011	0,040	-0,14
0 .. 5 m		0,010	0,040	0,12		-0,040	0,040	-0,50
0 .. 6 m		-0,078	0,040	-0,96		-0,147	0,040	-1,82
0 .. 7 m		0,035	0,041	0,43		-0,035	0,041	-0,43
0 .. 8 m		0,008	0,041	0,10		-0,076	0,041	-0,92
0 .. 9 m		-0,036	0,041	-0,44		-0,133	0,041	-1,61
0 .. 10 m		0,028	0,042	0,33		-0,058	0,042	-0,70
0 .. 11 m		0,087	0,043	1,02		0,004	0,043	0,05
0 .. 12 m		0,105	0,043	1,22		0,010	0,043	0,12
0 .. 13 m		0,052	0,044	0,60		-0,010	0,044	-0,11
0 .. 14 m		0,007	0,044	0,08		-0,057	0,044	-0,64
0 .. 15 m		0,086	0,045	0,95		0,013	0,045	0,15
0 .. 16 m		0,109	0,046	1,19		0,043	0,046	0,47
0 .. 17 m		0,032	0,046	0,35		-0,036	0,046	-0,39
0 .. 18 m		0,118	0,047	1,25		0,037	0,047	0,40
0 .. 19 m		0,098	0,048	1,01		0,006	0,048	0,06
0 .. 20 m		0,049	0,049	0,50		-0,050	0,049	-0,51
0 .. 506.0 mm		0,228	0,039	2,90		0,218	0,039	2,77
0 .. 507.0 mm		0,215	0,039	2,73		0,204	0,039	2,59
0 .. 508.0 mm		0,203	0,039	2,58		0,188	0,039	2,40

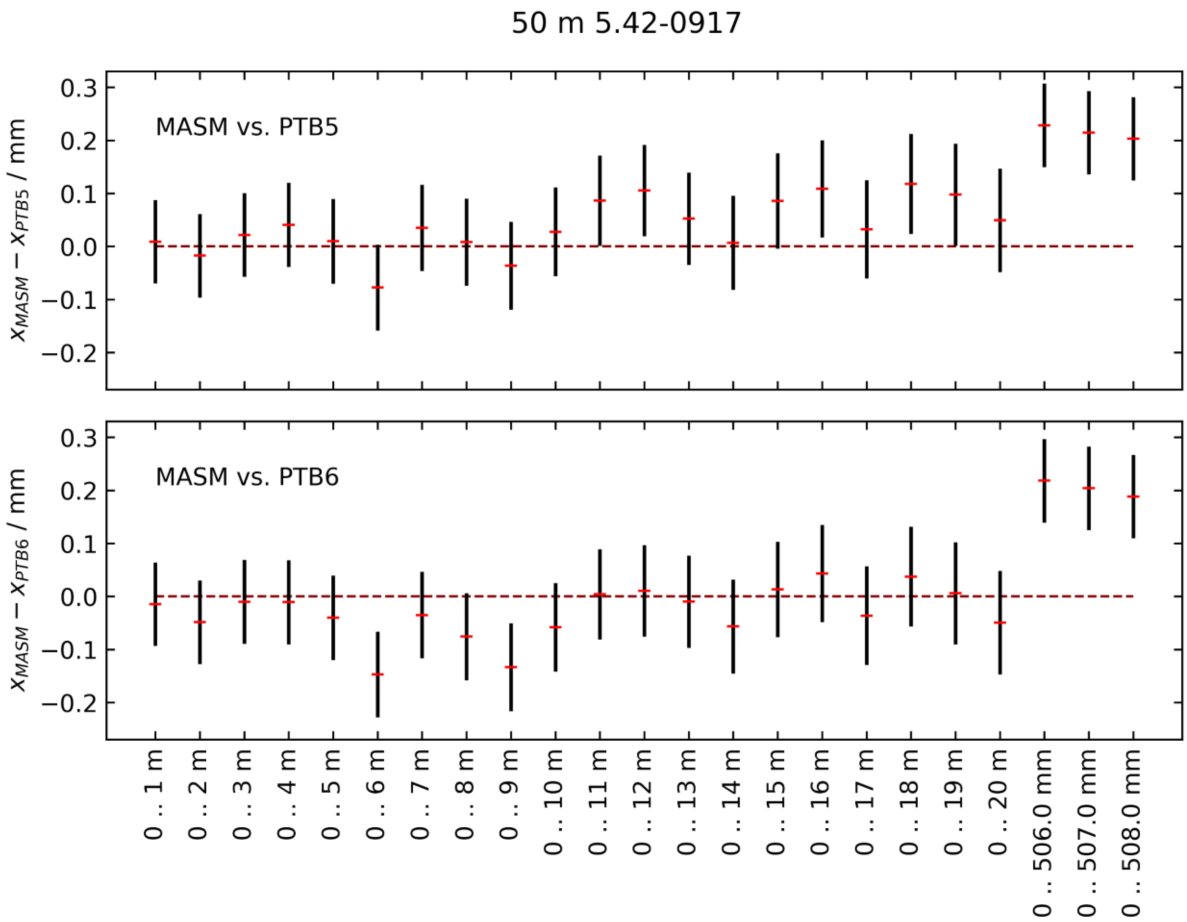


Figure 49 Deviation of the reported values by MASM from the PTB5 (upper graph) and PTB6 (lower graph) measurement values for tape 5.42-0917. The error bars indicate the expanded measurement uncertainty $2u_{bi}$ a(k = 2) of these deviations according to Equation (15).

8 Discussion

Table 43. Summary of E_n values exceeding 1 for all three tapes for all participants and compilation of the parameters characterising the statistic dispersion of the comparison results according to Eves and Leroux (see Section 7.2 and Reference [8]).

	10 m 4909 PTB 01		50 m 5060 PTB 06 No. 3		50 m 5.42-0917		Eves and Leroux parameters [8]		
	$\Sigma\|E_n\| > 1$	measurements performed	$\Sigma\|E_n\| > 1$	measurements performed	$\Sigma\|E_n\| > 1$	measurements performed	Q	M	$\chi^2(M)^{0.95}$
PTB	0	24	0	50	0	62	41,2	136	164,2
BEV	0	24	0	50	0	62	45,4	136	164,2
VUGTK	2	24	2	50	0	62	180,6	136	164,2
GUM	0	24	0	50	3	62	178,1	136	164,2
IPQ	13	24	0	50	1	62	152,8	136	164,2
Metrosert	0	24	0	50	0	62	45,8	136	164,2
MIRS	0	24	0	50	2	62	43,2	136	164,2
RISE	0	10	1	50	0	50	43,5	110	135,5
JV	0	24	0	50	4	62	73,7	136	164,2
NIM-80	0	24	0	50	0	62	94,7	136	164,2
NIM-26	0	24	0	50	0	62	24,9	136	164,2
CMS	13	24					134,8	24	36,4
SASO	0	11	1	5	2	11	60,3	27	40,1
INTI	24	24	0	50	0	62	207,5	136	164,2
CEM	0	24	0	50	7	62	164,6	136	164,2
LATMB	0	24	0	20	0	62	55,0	106	131,0
BIM	0	24	0	50	8	62	205,5	136	164,2
BFKH	0	24	0	50	25	62	294,6	136	164,2
SMD	0	24	0	50	11	61	142,4	135	163,1
UME	2	24	0	20	3(1)	28	82,6	72	92,8
MASM	21	24	9	20	5(1)	23	2914,4	67	87,1

(1)For UME and MASM, the values from the bilateral comparison are used for tape 5.42-0917 (cf. Section 7.4)

Table 43 summarizes the results of the EURAMET.L-S2.3.n01 tape comparison. The 50 m standard tape 5060 PTB 06 No.3 with a well-defined position of the readings is correctly measured by almost all participating laboratories, only 1.5 % of all E_n values being larger than 1. This gives confidence in the capability of the international length metrology community to calibrate high-quality reference tapes.

For the high-quality 10 m tape 4909 PTB 01, however, the number of 15.7 % E_n values exceeding 1 might appear surprising. But 71 of the 75 E_n values larger 1 for this tape are attributed to four laboratories (IPQ, CMS, INTI, MASM) only, which are relatively equally distributed over the course of the comparison. The monitoring measurements by the pilot laboratory do not corroborate a problem with this standard. CMS measured only the 10 m tape. The results of the other three laboratories, however, do not stand out in case of the other two tapes. The systematics of the deviations from the

Table 44. Correlation between E_n values exceeding 1 and the measurement uncertainty adaption to the tape under test. The first box lists the percentage of E_n values exceeding 1 observed for the commercial tape 5.42-0917. A percentage larger than 3 is marked in grey. The second box compares the reported expanded measurement uncertainties for the first marker for the high-quality standard tape 5060 PTB No. 3 with those reported for the commercial 50 m tape 5.42-0917 in mm. A deviation below 5 µm between those values is marked in grey.

		PTB	BEV	VUGTK	GUM	IPQ	Metrosert	MIRS	RISE	JV	NIM-80
%|En| > 1 for 5.42-0917		0,0	0,0	0,0	4,8	1,6	0,0	3,2	0,0	6,5	0,0
5.42-0917	0 .. 1 m	0,054	0,048	0,089	0,021	0,12	0,080	0,029	0,11	0,047	0,014
5060 PTB 06 No. 3		0,021	0,018	0,045	0,021	0,11	0,080	0,023	0,11	0,034	0,006
Δ		0,034	0,030	0,044	0,000	0,010	0,000	0,006	0,000	0,013	0,008
		NIM-26	SASO	INTI	CEM	LATMB	BIM	BFKH	SMD	UME	MASM
%|En| > 1 for 5.42-0917		0,0	18,2	0,0	11,3	0,0	12,9	40,3	18,0	10,7	21,7
5.42-0917	0 .. 1 m	0,014	0,078	0,24	0,025	0,150	0,076	0,021	0,074	0,090	0,046
5060 PTB 06 No. 3		0,0075	0,078	0,23	0,025	0,15	0,058	0,022	0,073	0,090	0,046
Δ		0,007	0,000	0,01	0,000	0,000	0,018	-0,001	0,001	0,000	0,000

reference value in case of IPQ and INTI suggest an offset problem for the measurements of this tape, which could be explained by a mounting/zero-mark identification problem.

For the commercial tape 50 m 5.42-0917, 71 E_n value outliers are observed. Table 44 suggests a partial explanation for the fact that many participants had problems with this tape. Six out of eight participants with more than 5 % of their E_n values exceeding 1 claim uncertainties for the first interval which are within 5 µm identical to the ones claimed for the high-quality tape 5060 PTB 06 No. 3. **Figure 2** and **Figure 3** in Section 4.1 show the substantial difference in the scale mark quality. Moreover, the measurement position is much better defined for the reference tape 5060 PTB 06 No. 3 than for the commercial tape 5.42-0917. It seems reasonable to assume that the type A contribution to the uncertainty should reflect that and could therefore be underestimated in cases when an ambitious constant value for the marker reading is used. In other cases, the systematics of the E_n value outliers in Table 38 to Table 40 suggest an imperfect assessment of the length-dependent uncertainty contribution (see also Section 6.2).

Finally, a wide variety of calibration methods have been developed over time for measuring tapes. This is also reflected in the methods used by the participants described in the Appendix. One consequence of this can be seen in Table 8 to Table 18. The expanded uncertainties reported by the participants vary considerably. Hence, the individual contributions to the SCRV varies greatly due to the structure of equation (7). This is exemplarily shown for the 20 m SCRV of the reference tape in the blue bars in Figure 50. The consistency of the measured values contributing to the SCRV is verified by the χ^2-criterion. However, it is interesting to note that the broad participation in EURAMET.L-S2.3.n01 reduces this imbalance. If the comparison had been carried out only among the seven participants with the lowest uncertainties, the largest individual contribution to the SCRV would even have increased (orange bars in Figure 50). In addition, the breadth of the methods used also has a conceptual advantage: the risk of systematic effects in the SCRV is significantly reduced. In summary, the wide range of participants of EURAMET.L-S2.3.n01 can be considered more an advantage than a disadvantage.

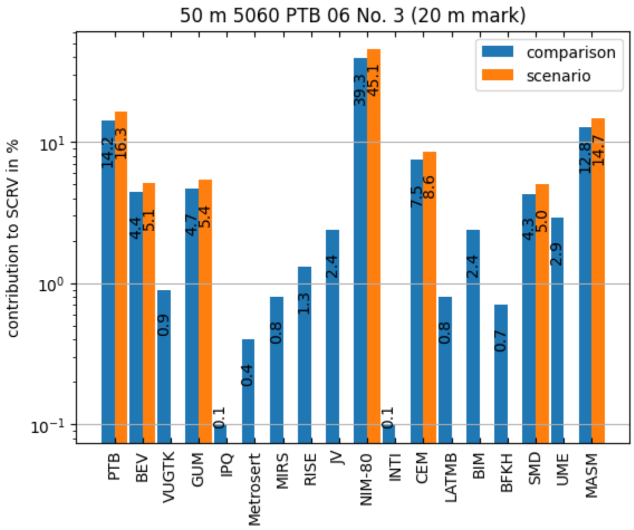


Figure 50 Comparison of the contribution of the participants to the SCRV in the case of all 18 contributors as in the comparison (blue) vs. a scenario containing only the 7 participants with the lowest uncertainties. Example: 20 m mark of the high-quality tape 50 m 5060 PTB 06 No. 3. Mind the logarithmic scale of the y-axis.

9 Conclusions

The EURAMET.L-S2.3.n01 manifests a comparison running over seven years, with twenty participants from four regional metrology organisations (RMOs). During its lifetime EURAMET.L-S2.3.n01 also had to face unexpected logistical challenges due to the COVID-19 pandemic or the Russian invasion to Ukraine.

In general, tapes are well-established and widely used measurement instruments, but the comparison results remind that they are still a non-trivial archetype system from which the length metrology community can still learn. The relatively large number of participants which had problems with a single tape only suggested that procedures for zero-point measurement and mounting of the tapes requires a careful review. Furthermore, the analysis of the comparison makes clear that the scale marker quality must be carefully assessed, individually for each tape, e.g. by repeatability (type A) measurements, especially in the case of commercial-grade tapes. Further to this, the results of the six monitoring measurements documented the small, but systematic and persistent change of the artefact properties due to the repeated mechanical elongation– even for standards of decades of age. The pilot control measurements could be successfully used to mitigate this typical challenge for a round robin.

Finally, the good result for the reference-grade tape 5060 PTB 06 No. 3 demonstrates the measurement capabilities of the international dimensional metrology community in the field of tape calibration.

References

[1] European Union, “Directive 2014/32/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of measuring instruments (recast) (Text with EEA relevance)” https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0032

[2] ISO 7507-1:2003 “Petroleum and liquid petroleum products – Calibration of vertical cylindrical tanks Part 1: Strapping method”

[3] https://www.bipm.org/kcdb/ (status 2025-08-08)

[4] OIML R 35-2, Edition 2011 (E), Material measures of length for general use. Part 2: Test methods

[5] M G Cox 2002 Metrologia 39 589 The evaluation of key comparison data

[6] R Thalmann 2004 EUROMET 677 Final Report

[7] A Lewis et al 1999 CCL-GC-3.2 KC Report Template

[8] B J Eves 2024 Formal guidance for acceptance criteria on KC supporting CMCs' WGMRA-24-08.01; see also A Lewis and T Coveney 2024 WG-MRA Meeting No 15, Section 8.1 'Formal guidance for acceptance criteria on KC supporting CMCs'; B J Eves and I D Leroux 2024 Proposed Guidance for the Initial Assessment of CCL Comparisons with Several Measurands *(in prep.)*

Appendix: Equipment

The participants provided the following information on their tape calibration facilities.

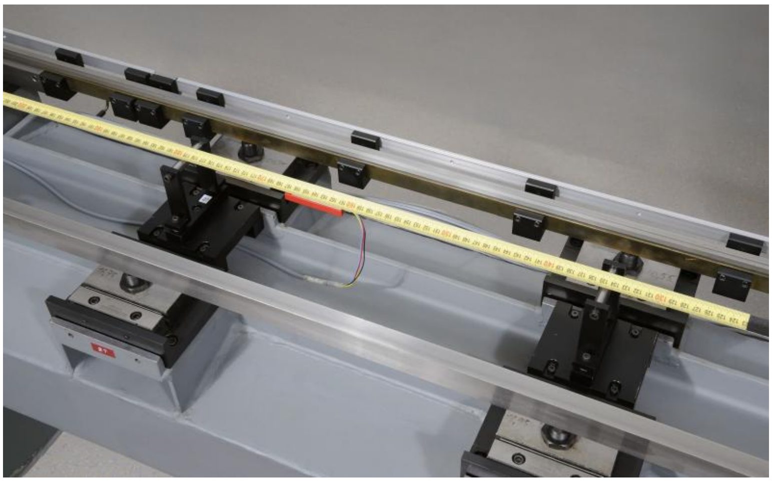
1. PTB

Short description of measurement bench

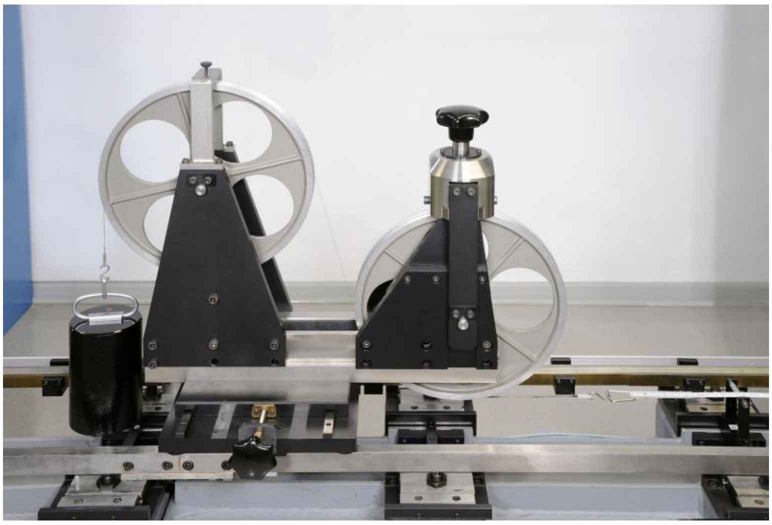
50 m bench with He-Ne laser interferometer in nearly Abbe-free configuration in an air-conditioned laboratory. The tape is mounted on holders with a 40 cm distance. The material temperature is measured every 2.5 m with magnetically attached temperature sensors (up to 21). An operator uses an optical microscope to detect the lines. The laser interferometer measurements are corrected for the index of refraction using a network of 21 distributed air temperature sensors, two humidity sensors and one barometer.

Length measurement instrument
HeNe laser interferometer with custom-built beam expansion and homodyne detection, traceable to the PTB primary standard for laser frequency.

Principle of tape support



The tape is supported by gallow-shaped holders every 40 cm. Weights apply the tension via a deflection pulley.



Microscope for localisation of scale marks

Standard optical microscope with scale

Type of scale mark identification (automated yes/no)? No

Temperature measurement system, number and location of sensors

21 Pt100 sensors for air and material temperatures each, set up every 2.5 m; material sensors magnetically attached to the tape every 2.5 m.

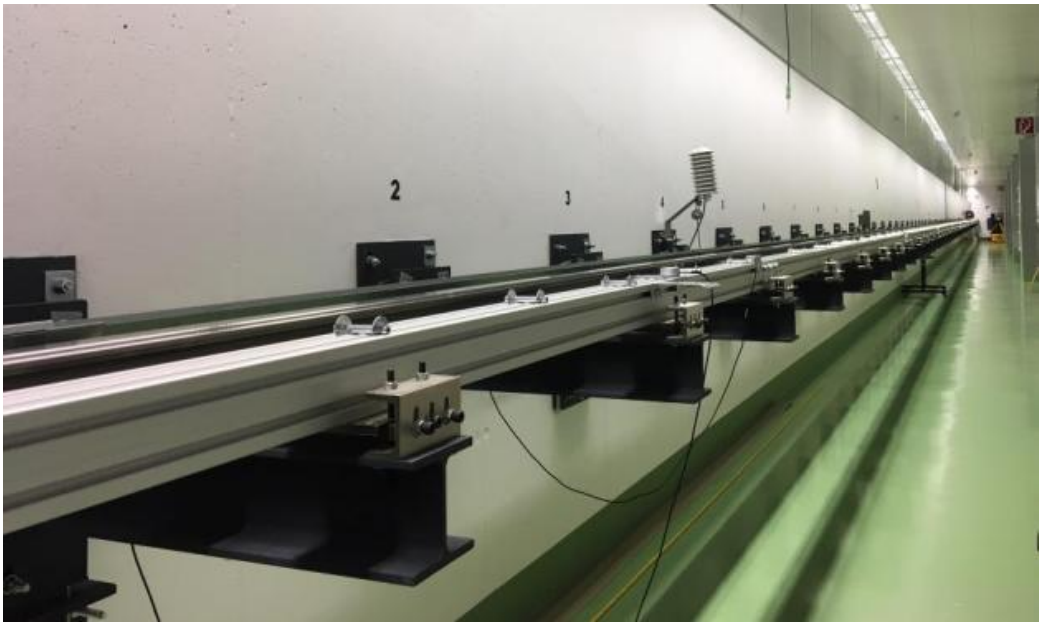
Additional remarks:

None.

2. BEV

Short description of measurement bench

50 m bench, ball bearing straight, tape support 40 mm below the laser beam (Abbe offset). Measurement table is under manual control.



Length measurement instrument
Agilent laser interferometer with long range option.

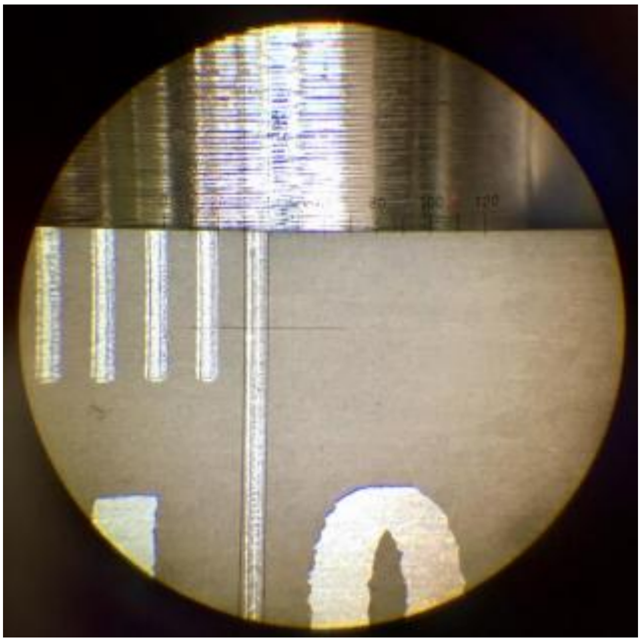
Principle of tape support

Tape is supported on equidistant (50 cm) located rollers to minimize friction. The tape is clamped on one side; the tension is supplied by weights via a deflection pulley.

Microscope for localisation of scale marks

Standard optical microscope for visual observation (no camera used in this project). Eyepiece 15×, object lens 1×/0.05. Illumination by LED ring light or by single LED. Eyepiece with two adjustable cross lines.

Type of scale mark identification (automated yes/no)? no



Temperature measurement system, number and location of sensors

Three material temperature sensors equidistant located in proximity to the tape. Seven air temperature (and humidity) sensors.

Additional remarks:

None

3. VUGTK/RIGTC

No details reported

4. GUM

Short description of measurement bench

The 50 m bench is housed in the corridor laboratory located in the basement and has its own air conditioning system. The base of the bench is made from steel channel bars each 3 m long and 400 mm wide. These are supported by 51 concrete piers. The rails are mounted on the top of channel bars. They are made from 3-metre length stainless steel rods about 40 mm in diameter. They are spaced 250 mm apart and are supported in saddles positioned every 500 mm which are adjustable laterally, in height and for lateral tilt. Between the rails there are a channel bars each 420 mm long and 80 mm wide running the length of the bench. This channel is used for mounting steel rods about 12 mm in diameter and spaced 212 mm apart on which tapes can be supported. Two ends of the tape are connected to a hanging weight by a wire. The wire passes over 300 mm diameter pulley wheels. The measuring carriage is carried microscope with CCD camera and the optics associated with the interferometer. The carriage is driven using belt-transmission and electrical engine with remote – controlled variable speed drive.

Length measurement instrument (comparison with reference tape, laser interferometer...?)

Laser interferometer HP 5529A with long-range option laser head HP 5519A

Principle of tape support

steel rods about 12 mm in diameter and spaced 212 mm apart

Microscope for localisation of scale marks

optical microscopes with CCD camera; magnify of the observed line 110x

Type of scale mark identification (automated yes/no)?

Manual

Temperature measurement system, number and location of sensors

40 temperature sensors type YSI with KEITHLEY multimeter placed along close to the tape,
5 relative humidity sensors made by LAB-EL placed along close to the laser beam,
one atmospheric pressure sensor made by LAB-EL
CO_2 content was measured with analyser IAQ-CALC made by TSI Instruments Ltd.

Additional remarks

None.

5. IPQ

Short description of measurement bench

SIP geodetic base, with a 12 m invar ruler.

Length measurement instrument

It is based on the principle of direct comparison with an invar reference ruler (with a half-centimetre division drawn on one of its edges). The coincidence of the scale lines between the tape and the invar ruler is observed by means of a magnifying glass, on a reticulum adjustable through a micrometre.

Principle of tape support

The fixing of the tape is carried out at one end on a fixed support provided with a set screw for moving the tape relative to the bench, so as to bring their divisions into concordance. The tape is in the horizontal position on the bench and at the other end the tape it is fastening through a pulley and supporting the weight of the tensioner.

Microscope for localisation of scale marks

It is used a magnifying glass, on a reticulum adjustable through a micrometre, which measures the difference between the two line scales (invar ruler and tape).

Type of scale mark identification (automated yes/no)?

Not automated.

Temperature measurement system, number and location of sensors

Two thermometer datalogger were used, located at the ends of the bench.

Additional remarks

None.

6. Metrosert

Short description of measurement bench

Measurements are done on a 20-m tape bench utilising stainless steel rails and a microscope carriage for taking measurements. The bench is situated in a climate-controlled room with temperature setting (20 ± 1) °C.

Length measurement instrument

Tape is compared to laser interferometer Renishaw ML10 readings.

Principle of tape support

Tape is supported on stainless steel rolls every 0.5 m.

Microscope for localisation of scale marks.

Localisation of tape marks is done visually. The tape marks are localised through an eyepiece or with the aid of a camera without automated identification.

Temperature measurement system, number and location of sensors.

Temperature is recorded and compensated with laser interferometer automated climate compensation unit model EC10 from Renishaw. The temperature close to the tape is measured in one position (at 5-m distance from 0) and air temperature is recorded in 3 evenly distributed positions from the beginning to the end of the bench.

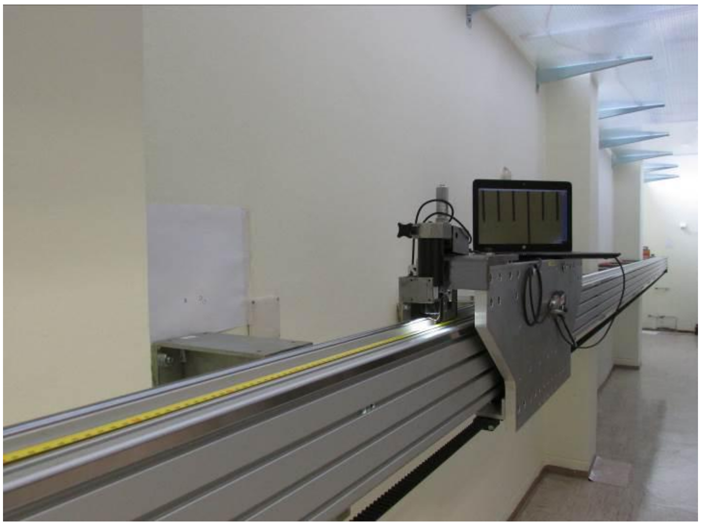
Additional remarks:

None.

7. MIRS/UM-FS/LTM

Short description of the measurement bench

The bench is constructed of aluminium beams (12 m segments can be measured). They are mounted via adjustable consoles to the wall. The trolley carries the microscope and the laser interferometer (LI) retroreflector. The laser axis is 40 mm above the tape (Abbe principle not fulfilled). The whole instrument is located in an air-conditioned room (20 °C ± 1 °C). The tape load is generated via weighing pieces.



Length measurement instrument

HP 5529A Laser interferometer system with standard linear interferometer and Agilent 10751B air sensor.

Principle of tape support

Tape was fixed at one end, at the other end stretched with a weight over a pulley; Tape lies on the aluminium profile.

Microscope for localisation of scale marks

Video probing system with digital microscope. The location of the lines is calculated by in-house developed software (in a pre-selected segment of a line).

Type of scale mark identification (automated yes/no)?

Yes.

Temperature measurement system, number and location of sensors

HP LI material sensors are used; 3 material sensors were attached to the bench at both ends and in the centre of the measured segment of the tape; 1 LI air sensor.

Additional remarks

None.

8. RISE

Short description of measurement bench

The calibration bench is 50 m long and built of a U-shaped aluminium profile with polished steel pins. The pins are at a distance of 0.5 m apart from each other, acting as supports both for the reference tape and the measured tape.

Length measurement instrument

Comparison against a 50 m reference steel tape, graduated in dm the first 5 metres, after that every 0.5 m. The reference tape itself has been calibrated by a laser interferometer.

Principle of tape support

The tapes rest on polished steel pins placed 0.5 m apart.

Microscope for localization of scale marks

Handheld microscope with 10x magnification and 0.1 mm graduation. Localization is done manually by the operating technician.

Temperature measurement system, number and location of sensors

The air temperature of the laboratory is measured in the middle of the room before and after each measuring series. We also logged the room temperature every 5th minute with four temperature sensors. These sensors don't have the same accuracy as the temperature instrument in the middle of the room. They are only used to monitor the overall temperature regulation of the laboratory.

Additional remarks

The coordinator gave us the information that there were some damages on the tapes, reported by the former laboratory. We noticed some indentations and rust stains on the tapes. However, we didn't have any problems measuring the tapes.

9. JV

Short description of measurement bench

Our measurement facility is a 50 m tape bench with a traveling microscope with magnification M = 10x (used for lower quality tapes), 20x or 50x (used for higher quality tapes). The rails for the traveling microscope are delivered from SKF, custom made on a granite table, consisting of 17 big stones resting on neopren cushions for passive vibration damping of underground vibrations. The straightness of the rails on top of the table gives rise to an Abbe error because of axis separation between the laser light and the tape, ca 47 mm. Supports for the rails are every 0.75 m (0 m – 6 m distance) and 1.5 m (6 m – 50 m distance). The stretching force for the tape is realized by using weights of 5 kg (nominal 50 N) or 10 kg (nominal 100 N). We use g = 9.82 m/s^2 , the same value as in our mass laboratory, giving stretching forces of 49.1 N and 98.2 N. The deviation from nominal values 50 N and 100 N is corrected for, using an experimental value of the sensitivity of the force, 0.0010 mm/Nm for the high precision tapes (thickness = 0.40 mm, cross section area = 5.2 mm^2), and 0.0020 mm/Nm for lower precision tape (thickness = 0.20 mm, cross section area = 2.6 mm^2). At 50 m this results in a correction of +0.09 mm for both types.

For high precision measurements, the Abbe error is measured and corrected for. For low precision measurements, the Abbe error is not corrected for, but added linearly to the expanded measurement uncertainty, U(95%) = 2uc + |Abbe error max|. (Quoted like this for sno 5.42-0917.)

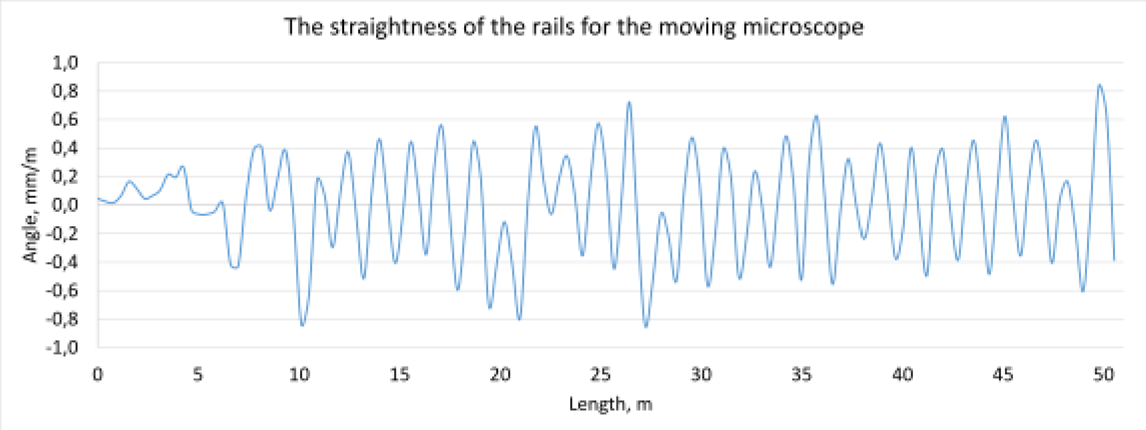


Figure: The straightness of the rails for the moving microscope gives rise to an Abbe error at each reading.

Length measurement instrument (comparison with reference tape. laser interferometer...?)

The reference measurement system is delivered from Agilent, HP 5529A using a laser head HP 5519A with a measurement range of 80 m. The internal signal strength indicator is above 70% along the entire length of the bench.

Principle of tape support

Tape support is a flat aluminium square profile with a thin teflon surface on top. The teflon surface gives low friction between the tape and the table for a dry steel tape. However, a wet, oily or alcohol stained tape surface, can stick quite hard to the teflon surface. So, after cleaning off the oil using a soft paper cloth and alcohol, the tape needs to dry off all moisture. While the alcohol used for cleaning vapours from the tape, the tape is supported by 15 mm cylindrical supports every 3 m while the tape is stretched out by the prescribed nominal force, 50 N or 100 N. During drying, the tape is not in contact with the flat table, only in contact with the top of the cylindrical supports.

After cleaning and drying, the cylinders are removed from the 0 end and upwards, so that the tape lies down flat on the measurement table. Low friction can be checked by adjusting the position of the 0 end of the tape. If the movement is the same at both ends of the tape (0 end and 50 m end), there is no friction between the tape and the table.

Microscope for localisation of scale marks

Magnification of the microscope is M = 10x for ordinary tapes **(50 m steel tape II**, identification: 5.42-0917). For high precision tapes, we use magnification M = 20x (**10 m steel tape**, identification: 4909 PTB 01) and 50x **(50 m steel tape I**, identification: 5060 PTB 06 No.3).

Type of scale mark identification (automated yes/no)?

We use no automation of scale mark identification. The operators own vision is used to define the position of the centre of each scale mark in a manual operation according to the definition in this protocol. A ring light source with white lighting is mounted on the microscope to give similar contrast for all scale marks.

Figure: Image on a TV monitor using M = 10x on **50 m steel tape II**, identification: 5.42-0917

Temperature measurement system, number and location of sensors

We use 3 original HP/Agilent sensors for material temperature measurement. These sensors are mounted on the tape itself at ca 1 m, ca 10 m and ca 21 m from the zero end. There is a weak magnetic force on each sensor, which keeps the sensors attached to the steel tape. Temperature differences between these material sensors are below 0.2 K.

We use external sensors for air temperature, air pressure and air humidity. These are measured in one point only, ca 10 m from the zero end. The temperature difference between the air temperature sensor and the mean value of three material temperature sensors is below 0.2 K.

The entire lab has temperature and humidity air control from a common source with air inlet underneath and along the entire length of the measurement bench, so temperature gradients along the entire length of the laboratory is small compared to our estimation of the measurement uncertainty of the temperature.

Additional remarks

It is standard procedure to test the sensitivity to the stretching force for different types of tapes. Using two different loads, the maximum length is measured at two different loads, and the sensitivity is calculated:

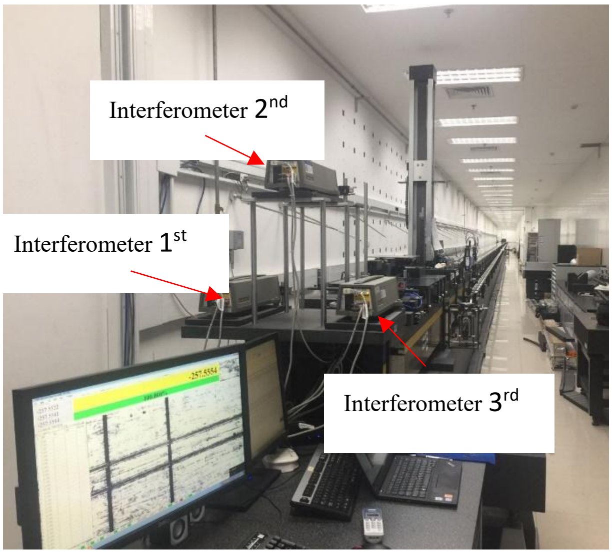
$K = \Delta L / (\Delta m \cdot g \cdot L)$

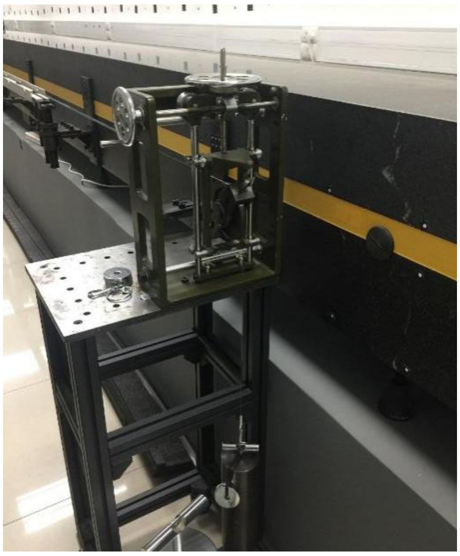
The maximum force to be applied should not enter the plasticity range of the material to avoid that the tape undergoes permanent deformation under the load. In this project, we have measured K for each individual tape using loads of 5 kg and 10 kg. We measured K = 0.0010 mm/(N m) for **10 m steel tape**, identification: 4909 PTB 01 (with 5-mm graduation) and for **50 m steel tape I**, identification: 5060 PTB 06 No.3 (with metre graduation), and K = 0,0020 mm/(N m) for **50 m steel tape II**, identification: 5.42- 0917 (with millimetre graduation). We quote a conservative estimate of the uncertainty of K to be u = 20% of the measured value.

10. NIM1 (80 m)

Short description of measurement bench

This measurement bench is 80m Laser Comparator (No. NIM1), consists of one 81 m granite guide rail, one air floating platform, three laser interferometers and one set of environmental parameters measuring system.





Length measurement instrument

Consists of three laser interferometers (Keysight 5519B), which placed in equilateral triangle, the side length of the triangle is 500 mm. The coordinate of interferometer 1^{st} is at (x=0, z=0), interferometer 2^{nd} at (x=500 mm, z=0), interferometer 3^{rd} at (x=250 mm, z=433 mm) and the measurement line of steel tape is (x=673 mm, z=-278 mm). Abbe error is corrected in real-time.

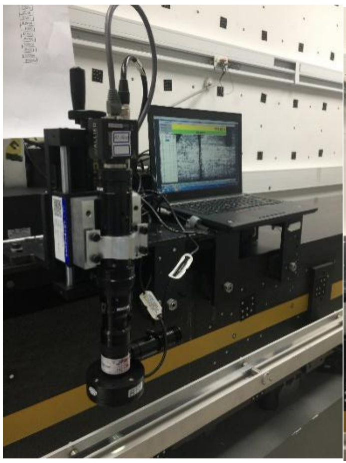
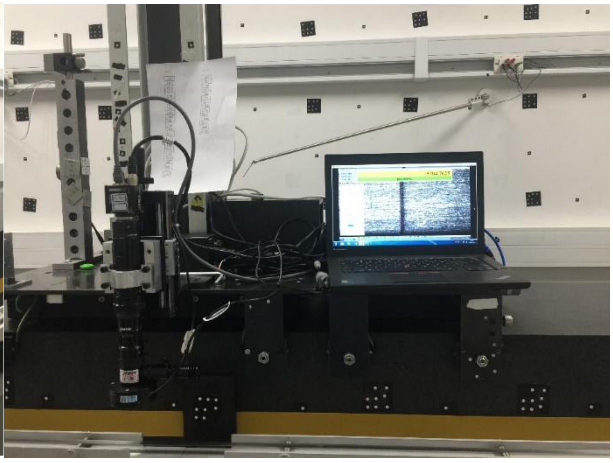
Principle of tape support

The steel tape is support on multiple catenary support. Each catenary support point is the rolling bearing shaft (13 mm diameter) for reducing the friction of the tape, and the distance between two adjacent catenary support points is 0.33m.

When measuring, the steel tape is stretched on the multiple catenary supports by the specified tension (100 N or 50 N) through pulley, and the pulley is suspended in the two-dimensional adjustable frame.

Microscope for localization of scale marks

For three steel tapes, Objective lens with CCD camera, monitor and coaxial light illumination are used. Operator's eye identifies and locates scale marks.

Temperature measurement system, number and location of sensors

Consists of 26 temperature sensors (13 PT100 and 13 PT25 sensors within 50m measuring range), one F18 Electric bridge and scan switchs (40 channels), All sensors are installed in a line and located near the first laser beam.

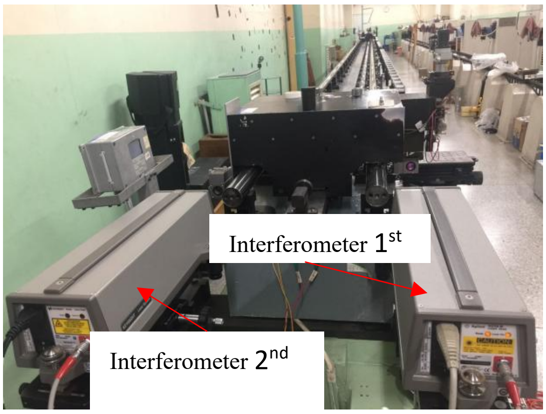
Additional remarks

The measurement bench is in the basement which doesn‘t use air conditioning to control the temperature.

11. NIM2 (26 m)

Short description of measurement bench

This measurement bench is 26 m Laser Comparator (No. NIM2), consists of two laser interferometers, one 27 m round steel guide and one steel bed. The round steel guide of 40 mm diameter is supported on the steel bed which is placed on a concrete base.



Length measurement instrument

Consists of two laser interferometers (Keysight 5519B). The spacing between the two interferometers is about 489 mm, the interferometers are at the same height as the steel tape.

Principle of tape support

The steel tape is supported by multiple catenary supports. Each catenary support point is the rolling bearing shaft (13mm diameter) in order to reducing the friction of the tape, and the distance between two adjacent catenary support points is 0.25m.

When measuring, the steel tape is stretched on the multiple catenary supports by the specified tension (100 N or 50 N) through pulley, and the pulley is suspended in the two-dimensional adjustable frame.

Microscope for localization of scale marks

For 50 m tape (SN: 5060 PTB 06) and 10 m tape (SN: 4909 PTB 01), 20X magnification microscope and coaxial light illumination are used. Operator's eye identifies and locates scale marks.

For 50 m tape (SN: 5.42-0917), Objective lens with CCD camera, monitor and ring light illumination are used. Operator's eye identifies and locates scale marks.

Temperature measurement system, number and location of sensors

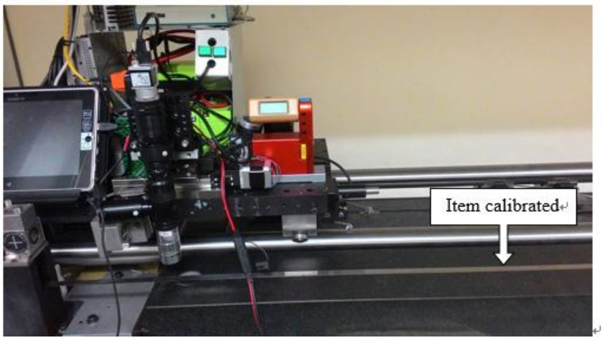
Consists of 8 PT100 sensors and one F200 thermometer (8 channels). All sensors are installed in a line and located near the first laser beam, the distance is about 80 mm from the first laser beam, and about 150 mm from the steel tape.

Additional remarks

The measurement bench is on the 1st floor which using air conditioning to control the temperature.

12. CMS

Short description of measurement bench



Length measurement instrument

Calibration system consists of a laser interferometer, a precise rail, a carriage, wireless transmission modules, and a positioned microscope with a CCD.

Principle of tape support

Tape calibrated is placed on the granite basement, one end is pressed by jig and the other end is suspended by 100 N.

Microscope for localization of scale marks

During measurement, CCD center is focus on the left side of scale mark

Type of scale mark identification (automated yes/no)?

no

Temperature measurement system, number and location

Temperature measurement system: HART/1575, three temperature SPRT sensors are fixed on granite basement at location 0 m, 5 m, and 10 m.

Additional remarks

None.

13. SASO-NMCC

Short description of measurement bench

The SASO-NMCC bench measurement system is approximately 7.25 m in length and 0.3 m in width and about 1 m in height. The system consists of a 7.25 m long steel profile body, a 6 steel profile stand, 2 line linear rails and various apparatus. It is operating at 20 ± 0.5°C. The angular errors (pitch and yaw) of the rails was minimized by measurement with laser interferometer angle optics. The carrier is connected to 4 sliding bearings on the main body and it move manually on the rails. The carrier has a 3-axis micrometre moving table carrying the laser interferometer distance optics attached on the CCD camera body. With this mechanism, it is easy to adjust the distance optics or the view on the software screen.

SASO-NMCC bench measurement system

Length measurement instrument

He-Ne Keysight 5519A Laser interferometer.

Principle of tape support

The tapes are placed carefully on top of the table (on steel body). One end of the tape is attached to the holder unit carefully using steel wires. The other end of the tape is attached to the mounting clip and using steel wires placed over-stretching unit. The other end of the steel wire is attached to the weight which is determined in the technical protocol. The tape is adjusted by moving left or right using a stretching unit until it is parallel on the video display on the software.

Microscope for localisation of scale marks

Dino-Lite Digital Microscope, Type Pro HR AM 7000.

Type of scale mark identification (automated yes/no)?

No.

Temperature measurement system, number and location of sensors

3 Material temperature sensors were used and located at different locations of the bench system.

Additional remarks

None.

14. INTI

Short description of measurement bench

INTI has a 10 m bench with a central flat rail to position de tape and two lateral cylindrical rails that support a carriage (Figure 1). In the carriage there is mounted a retroreflector on one side and a camera in the other side (Figura 2). The carriage can be moved manually along the whole bench.

Figure 1: INTI´s 10 metres bench.

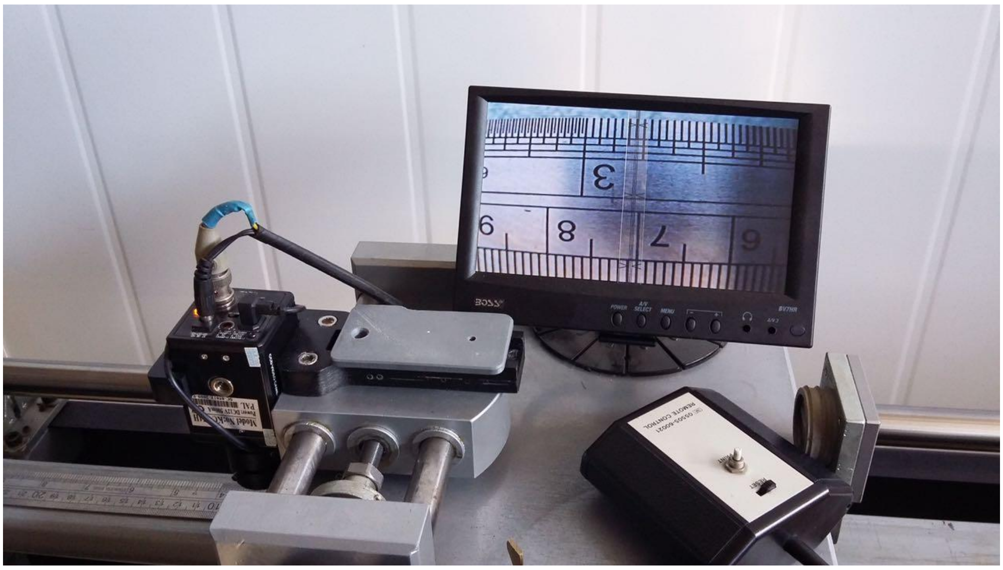


Figure 2: movable carriage with a camera (on the left), the retroreflector (on the right) and a screen mounted in its middle.

Length measurement instrument
(comparison with reference tape, laser interferometer...?)

The tape is measured with a reference interferometer laser system Hewlett Packard, model HP 5528A. The laser is mounted in a tripod outside the bench. The beam splitter of the interferometer with one of the retroreflectors of the system are mounted on a platform on the bench (see Figure 3). The second retroreflector is mounted on the movable carriage, as shown in Figure 2.

Figure 3: Reference interferometric laser system.

Principle of tape support

The tape is placed on a flat rail in the middle of the bench (see Figure 4). The part of the tape being measured rests on the flat track, in perfect contact with it. The bench has a system that allows to tense the tape with the appropriate weight.

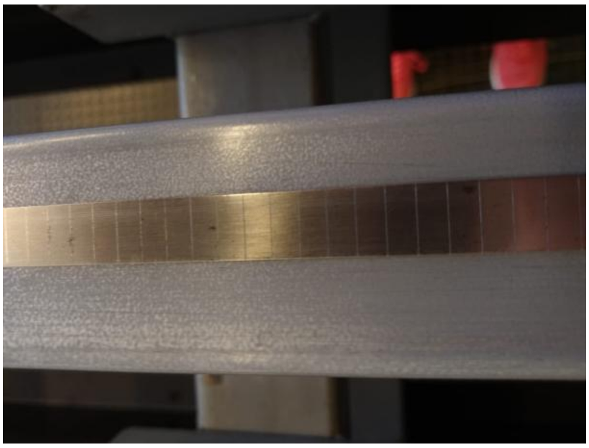


Figure 4: The tape rest in a flat rail in the middle of the bench.

Microscope for localisation of scale marks

The system has a camera with a 2,5X magnification mounted on the carriage. The position of the carriage is determined by looking the camera image in a little screen mounted on it. It is possible to take off the camera and mount a microscope of 20X to position the carriage. In this case the scale mark is viewed by eye through the microscope (no camera is used).In all the three calibrations made in this comparison we used the camera.

Type of scale mark identification (automated yes/no)?

No.

Temperature measurement system, number and location of sensors

The laser measurement system has a meteorological station and three thermometers included.

The meteorological station is mounted with a magnet in the metallic inner wall of the bench, in thermal contact with the bench in a position near 3 m (Figure 5).

Figure 5: Meteorological station, in thermal contact with the bench.

The three thermometers are although mounted with a magnet, in thermal contact with the bench, positioned approximately at 0 m; 1,5 m and 10 m respectively (Figure 6).

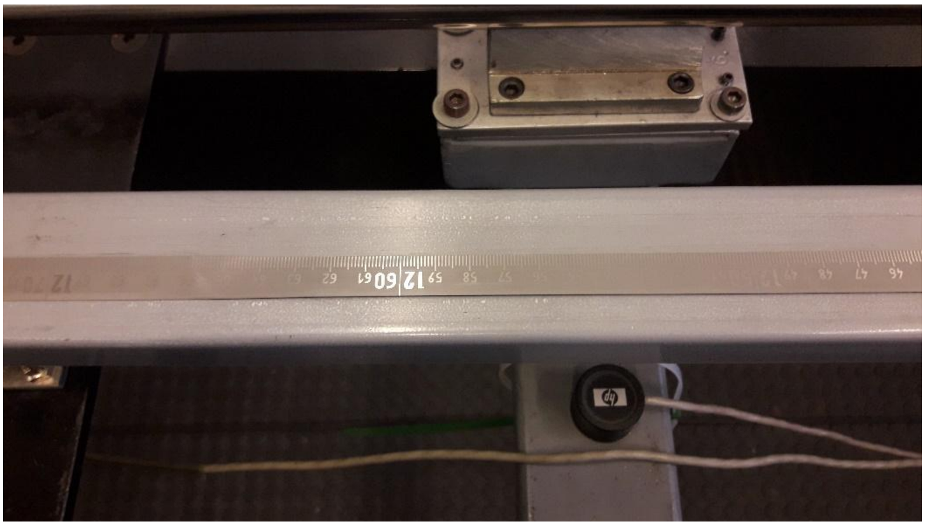


Figure 6: The tape rest in a flat rail in the middle of the bench.

Additional remarks

None.

15. CEM

Short description of measurement bench / Length measurement instrument

The measurements performed at CEM were made by using a 25 m granite bench, with a camera and a light source mounted on a moving carriage supported by air. The displacements of the carriage were measured by a laser interferometer. Environmental conditions were also monitored to compensate for refractive index of air.

Principle of tape support

The tapes were supported by small cylinders separated 1 m each to reduce friction, and different masses were attached to apply the nominal force.

Type of scale mark identification (automated yes/no)?

Whenever possible, an automatic edge detection algorithm was used to analyse the images coming from the camera. Once the optical centre was positioned on top of the scale mark, the readings of the laser interferometer and the environmental sensors were stored.

Temperature measurement system, number and location of sensors

Four temperature sensors were used: 1 for air temperature and 3 more evenly distributed along the tape.

Additional remarks

None.

16. LATMB

No details reported.

17. BIM

Short description of measurement bench

24 m bench with He-Ne laser interferometer, XL-80 by Renishaw. The lines are detected by a digital microscope. The corner retroreflector and microscope are mounted on a moving carriage. The carriage is moved by specialized software. The whole system is located in an air-conditioned room.

Length measurement instrument

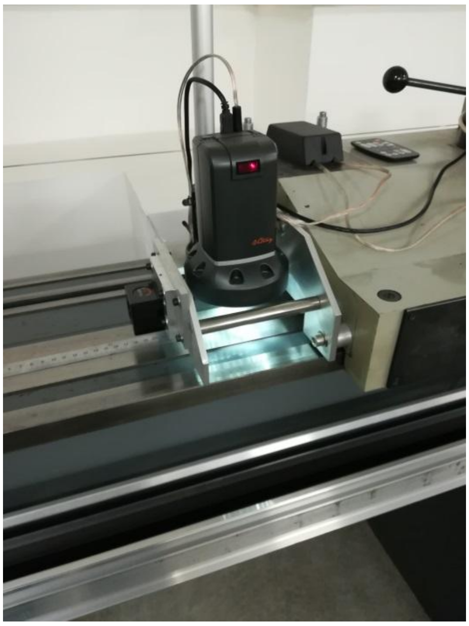
He-Ne laser interferometer XL-80 by Renishaw is used.

Principle of tape support

The tape is supported horizontally on rollers with a distance between rollers about 0.5 m.

Microscope for localisation of scale marks

The lines are detected by a digital microscope.
Magnification: 13X – 300X



Type of scale mark identification (automated yes/no)?

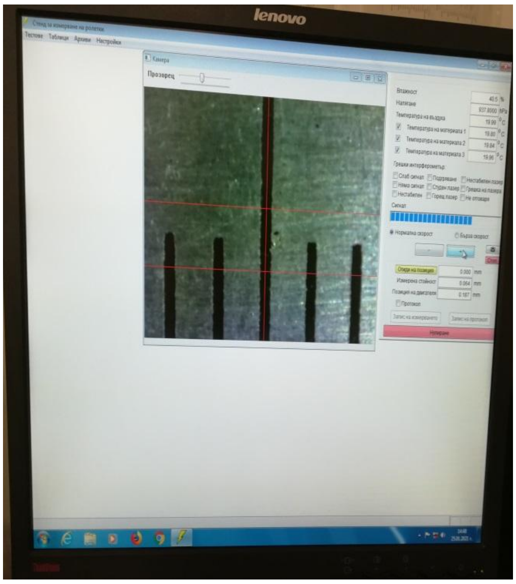
Yes.

Temperature measurement system, number and location of sensors

A XC-80 environmental compensation unit is used. Three material sensors are positioned along the bench, the air temperature, air pressure and humidity are measured in one position.

Additional remarks

Specialized software is used for tapes calibration.



18. BFKH

Short description of measurement bench

The measurements were made in the dedicated air-conditioned laboratory, on the 15.5 m capacity tape measuring bench, equipped with flat plastic tape supports and dead weight tape loader mechanism (Manufacturer: K.G. Technika Bt.; Type: LHG-1501; Serial number: 99001501). The determination of scale mark positions was performed by a laser interferometer, based on the monitor displayed, electronically processed picture of the built-in video microscope. The raw results were compensated according to the guide way errors of the bench.

Length measurement instrument (comparison with reference tape, laser interferometer...?)

Interferometer (Renishaw; XL8O; 355H12) with automatic environmental compensation

Principle of tape support

Flat, 80 mm width, 100 mm spaced plastic supporting plates distributed on the whole length of the measuring range, adjustable clamp fixtures at the ends and side bumpers in between. Tape loading with switchable dead weight tape loader mechanism.

Microscope for localisation of scale marks

CCD microscope with electronic image processing unit and display monitor.

Type of scale mark identification (automated yes/no)?

The position of each scale division, selected by an aiming laser spot is observed relative to adjustable distance vertical lines on the video microscope display - not automated.

Temperature measurement system, number and location of sensors

Automatic environmental compensation unit (Renisaw; XC; 473U72 pressure and humidity at 5 m; t: 497F29 at 5 m; tml: 361R27 at 2 m; tm2: 466H17 at 8 m; tm3: 472E39 at 14 m.

Additional remarks

The rough results obtained through measurements were compensated according to the tape measuring bench guide way errors, related to the relative positions of the optics and the measured tape.

19. SMD

Short description of measurement bench

The measuring system is based on a horizontal " ⊓ " shaped steel profile with a height of 70 mm, a width of 180 mm and a length of 14 m. This steel profile is aligned for straightness on adjustable supports every metre. The maximum measurable length is 10 m. Tapes with longer lengths are measured in steps of 10 m. At the left end, the laser interferometer is mounted on this profile. At about 2.5 m from the left end, the necessary accessories are mounted on the steel profile for attaching or clamping the tape and for winding up the measured parts of tapes longer than 10 m. At the right end the necessary accessories are mounted on the steel profile for attaching or clamping the tape, for (un)winding parts of tape to be measured and for applying the measuring force. The measured part of the tape rests on an aluminium profile that is mounted and aligned on the steel profile. This profile includes the material temperature sensors, 1 sensor per metre. The bench is equipped with a laser interferometer. The lines of the tapes are probed with a camera, mounted on a carriage that moves over the tape. The bench is installed in a laboratory that is specially dedicated to and climatized (temperature and relative humidity) for this application.

Length measurement instrument

Measurements are made with a Hewlett Packard laser interferometer. The retroreflector is mounted on the part of the moving carriage that supports the camera. This carriage has a course and a fine adjustment. The measuring laser beam is as close as possible to the tape and protected against air turbulence. The refractive index of air is taken into account. Air temperature and air pressure are measured. Air humidity can be selected with a switch (25 %, 50 % and 75 %) in function of the measured relative humidity in the laboratory. The environmental sensor of the laser interferometer is mounted halfway the bench as close as possible to the laser beam and at about the same height as the laser beam. Material temperature sensors are mounted each metre in the aluminium profile supporting the tape, starting at the 0.5 m tape position.

Principle of tape support

The tape is supported over its whole measured length on a L shaped aluminium profile that is mounted and aligned on the steel profile. The side of the tape is aligned with micrometre screws. When moving the tape over the aluminium support, free turning rollers, mounted every metre, can be pneumatically put just above the aluminium profile in order to support the tape and minimise friction.

Microscope for localisation of scale marks

A camera with macro vision is mounted on the upper part of the motorized carriage. The upper part of the carriage can be fine adjusted to the lower part with a joystick on the command console. The carriage itself is moving over the measuring bench with special cylindrical rollers on long bars. These bars are aligned with the aluminium profile that supports the tape.

The image of the camera is displayed on a monitor. On this monitor are supplementary reference lines for exact positioning of the camera on the measured line. The image on the monitor can be inverted (positive - negative image) to get the optimal image contrast. Once the type of image is selected, this has to be used for all the measurements on a tape.

Type of scale mark identification (automated yes/no)?

No

Temperature measurement system, number and location of sensors

Every metre (starting at 0.5 m) PT100 sensors are mounted in the aluminium profile, on which rests the tape, to measure the tape temperature. At every measurement, the temperature of the measured part of tape is taken into account for the correction for the measured part of the tape. The PT100 sensors are connected to a Keithley system and temperatures are read from this system by the software.

Additional remarks

None.

20. UME

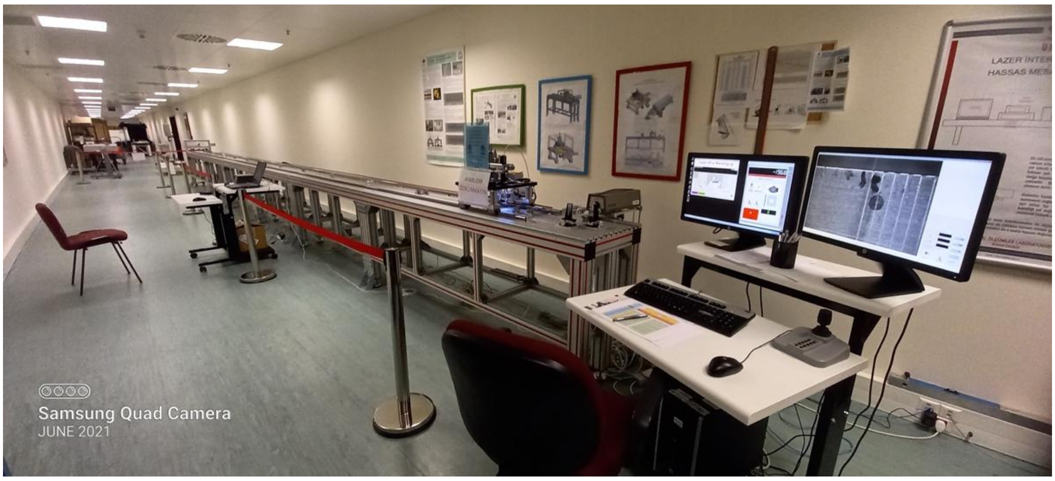
Short description of measurement bench

The bench system is constructed out of aluminium sigma profiles. The total construction length of the system is 13 metres at which maximum of 11.5 metres of this length used for measurement. In this comparison 10 metres of the bench is used for measurement and with using stitching method, total of 20 metres of comparison artefact tapes are measured.

The system consists of laser interferometer as reference measuring instrument, a camera equipped with objective lens for detection of scale marks which is mounted on a motorized carriage on which the laser interferometer retroreflector is also mounted. An XYZ translational stage with micrometre adjustments on the carriage can be used for fine adjustments of localizations of scale line marks when needed.

A home-built software is used to move carriage unit as well as acquiring the camera image to localize scale marks.

The measurement results are given with the temperature correction made for 20 °C.

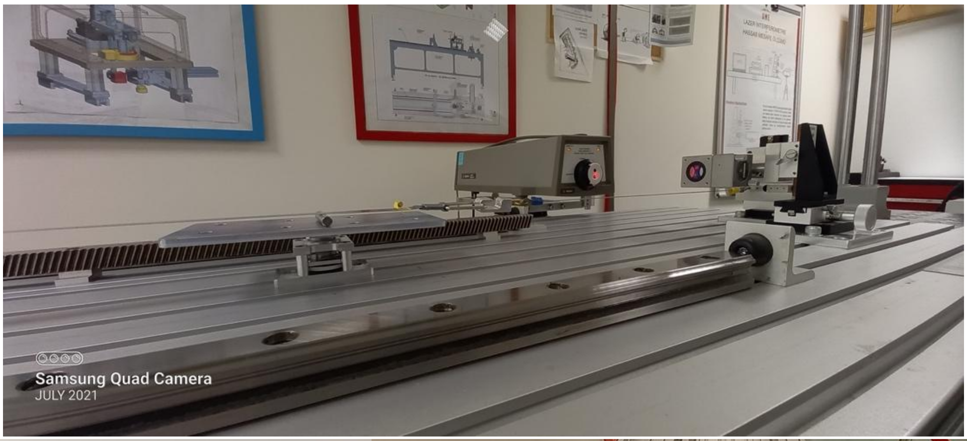


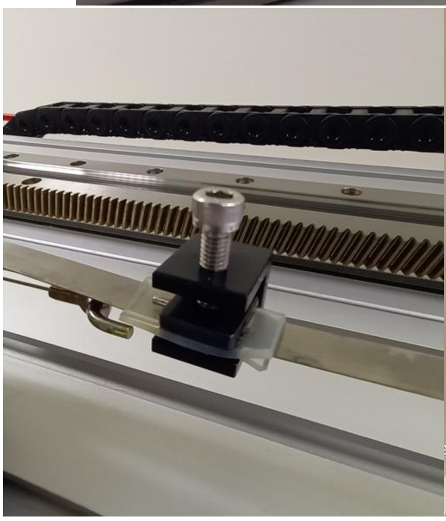
Length measurement instrument
(comparison with reference tape, laser interferometer...?)

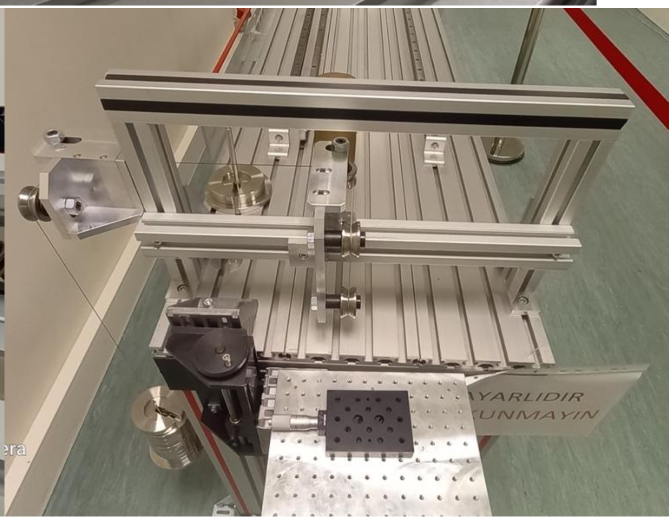
A laser interferometer is used as reference measurement device. The device is Agilent (HP) 5529A Laser Interferometer (633 nm) with its environmental sensors and electronic unit. 0.1 μm resolution is used during measurement.

Principle of tape support

Tapes are mounted on the bench using the clamping (see picture below). Also, tapes are supported underneath with cylindrical supports to minimize the distance between reference laser line as to minimize Abbe error. Dead weights are used to apply nominal force.

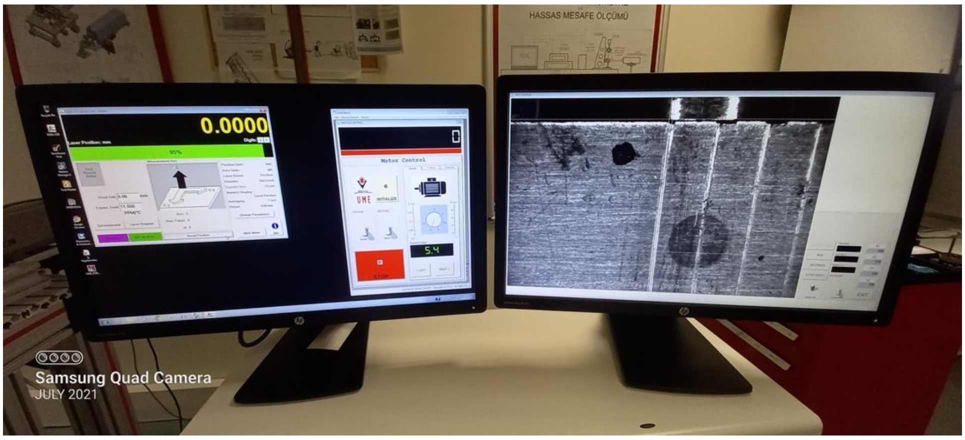






Microscope for localisation of scale marks

For localisation of scale marks, a CCD camera with objective lens and attached illumination is used. Localisation of the scale marks is done using the CCD camera image and laser interferometer reading. Scale mark identification/decision is done manually (not automated)



Temperature measurement system, number and location of sensors

The three temperature sensors of Agilent laser interferometer evenly distributed along the bench (near but not touching the tape) is used to measure temperature. Additionally, four PT100 sensors attached to a Fluke 1529 reference thermometer is used. Deviation of determining the temperatures are added in the uncertainty budget.

Additional remarks

During the measurements (from start to end) different temperatures were observed, thus for different set of measurements (e.g., from 0-10 m and 10-20 m) temperature corrections to 20 °C were applied according to observed temperatures.

21. MASM

Short description of measurement bench

The measurements were performed on the 20 m interferometric bench of MASM which is situated at underground laboratory. The linear guide comprises of two parallel rails made of rectangular rods lay on the metal supports which are mounted on concrete flooring. The rails are adjustable fixtures at every 0.5 m. A carriage with ball bush bearings carries the retroreflector and operator moves it along the rail. The lab is equipped with air conditioning system. Typically, air temperature is around. Due to length of the bench only measurements up to 20 m could be made.

Length measurement instrument

For the determination of tape length, the LIMTEK LMS laser interferometer system was used. Wavelength of 633 nm is traceable to national primary standard of length. The reference interferometer is set up in Michelson geometry. The air Index of refraction is calculated using environmental parameters recorded by TR73U logger SN:8063967 and we employed P.E. Ciddor's equation (Applied Optics, Vol.35, No.9, 1566-1573,1996).

Principle of tape support

Tape meter was supported on airy metal ball rolling which were fixed at every 50 cm.

Microscope for localization of scale marks

For the line detection of tape meter, we used microscope ZM1 from Walter Uhl GmbH with 5X magnification.

Temperature measurement system, number and location of sensors

There are three temperature and humidity sensors (one of which is Vaisala PTU-300 and another two ones are TR73U logger) located for recording of environmental parameters (T, RH, P) at every 30 second or 1 minute time interval. TR73U (SN:8063967) logger attached to carriage and moves along the 20 m long stage.

Additional remarks

Due to length of the bench only measurements up to 20 m could be made.

Acknowledgments

The authors would like to thank Tim Rietschel for his editorial support compiling the Appendix, and Dagmar Burgo Gonzales for her support in the logistics organisation of this comparison.