

Justervesenets arbeid med CMC'er i BIPMs KCDB

<https://www.bipm.org/kcdb/>

The screenshot shows the BIPM KCDB website interface. At the top left is the KCDB logo with the text "All data listed in the KCDB have been reviewed and approved within the CIPM Mutual Recognition Arrangement". The main navigation bar includes "CMCS" and "COMPARISONS", with "CMCS" circled in red. Below this is a breadcrumb "Home > CMC search". The search area features "CMC QUICK SEARCH" and "CMC ADVANCED SEARCH", with the latter circled in red. There are three category filters: "GENERAL PHYSICS" (with "Length" selected and circled in red), "CHEMISTRY AND BIOLOGY", and "IONIZING RADIATION". The "Keywords" section contains five search terms, each in a separate box with a dropdown arrow, all circled in red: "Norway", "Dimensional metrology", "Linear dimensions", "End standards", and "Gauge block". At the bottom right of the search area are "RESET" and "APPLY CRITERIA" buttons, with "APPLY CRITERIA" circled in red. On the right side of the page, there is an inset image of a building with the text "CIPM MRA" below it.

CMC i KCDB MRA database

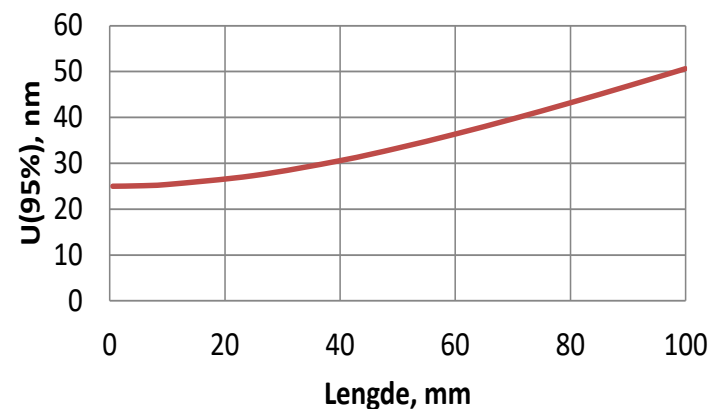
Q[25, 0.44E-06 L]

Results for: Length > Dimensional metrology > Linear dimensions > End standards > G
"Norway"

4 results

In the CMC uncertainty statements, $Q[a,b] = [a^2 + b^2]^{1/2}$

Unless otherwise stated the expanded uncertainties given below correspond to $k=2$ (at a 95 % level of confidence)



<input type="checkbox"/>	GROUP ID	SERVICE PROVIDER	INSTITUTE SERVICE CODE	COMMENTS	BRANCH	SERVICE	QUANTITY	INS ART STU
<input type="checkbox"/>		Norway JV	JV-NL-LEN-020	Display comment	Dimensional metrology	Linear dimensions	End standards	Gau
<input type="checkbox"/>		Norway JV	JV-NL-LEN-030	Display comment	Dimensional metrology	Linear dimensions	End standards	Gau
<input type="checkbox"/>		Norway JV	JV-NL-LEN-021	Display comment	Dimensional metrology	Linear dimensions	End standards	Gau
<input type="checkbox"/>		Norway JV	JV-NL-LEN-022	Display comment	Dimensional metrology	Linear dimensions	End standards	Gau

CMC i KCDB MRA database

Quantity	Instrument or Artifact	Method of Measurement	International standard	Parameters	Measurand	Uncertainty	Uncertainty Equation	Uncertainty Table	Comments	Approval date	NMI Service Identifier
End standards	Gauge block	Interferometry exact fractions		Central length L of gauge block : steel and tungsten	[0.5 , 100.0] mm	[25.0 , 50.0] nm (Absolute)	$Q[25 \text{ nm}, 0.44E-06 L] ()$		Vertical orientation	2016-09-12	JV-NL-LEN-020
End standards	Gauge block	Interferometry exact fractions			[0.0 , 20.0] μm	20.0 nm (Absolute)			Vertical orientation	2017-10-10	JV-NL-LEN-021
End standards	Gauge block	Interferometry exact fractions		Temperature : 15 °C to 25 °C	K^{-1}	$2.0E-7 \text{ K}^{-1}$ (Absolute)			Vertical orientation	2017-10-10	JV-NL-LEN-022
End standards	Gauge block	Mechanical comparison			[0.5 , 100.0] mm	[0.07 , 0.2] μm (Absolute)	$Q[0.07 \mu\text{m}, 1.8E-06 L] ()$		Vertical orientation	2009-01-30	JV-NL-LEN-030

CMC i KCDB MRA database

Quantity	End standards	End standards	End standards	End standards
Instrument or Artifact	Gauge block	Gauge block	Gauge block	Gauge block
Method of Measurement	Interferometry exact fractions	Interferometry exact fractions	Interferometry exact fractions	Mechanical comparison
International standard	ISO 3650	ISO 3650	ISO 3650	ISO 3650
Parameters	Central length L of gauge block : steel and tungsten carbide	Length difference of gauge block pairs	Thermal expansivity Temperature : 15 °C to 25 °C	Central length of gauge block
Measurand	[0.5 , 100.0] mm	[0.0 , 20.0] μm	K ⁻¹	[0.5 , 100.0] mm
Uncertainty	[25.0 , 50.0] nm (Absolute)	20.0 nm (Absolute)	2.0E-7 K ⁻¹ (Absolute)	[0.07 , 0.2] μm (Absolute)
Uncertainty Equation	Q[25 nm, 0.44E-06 L]			Q[0.07 μm, 1.8E-06 L]
Uncertainty Table				
Comments	Vertical orientation	Vertical orientation	Vertical orientation	Vertical orientation
Approval date	2016-09-12	2017-10-10	2017-10-10	2009-01-30
NMI Service Identifier	JV-NL-LEN-020	JV-NL-LEN-021	JV-NL-LEN-022	JV-NL-LEN-030

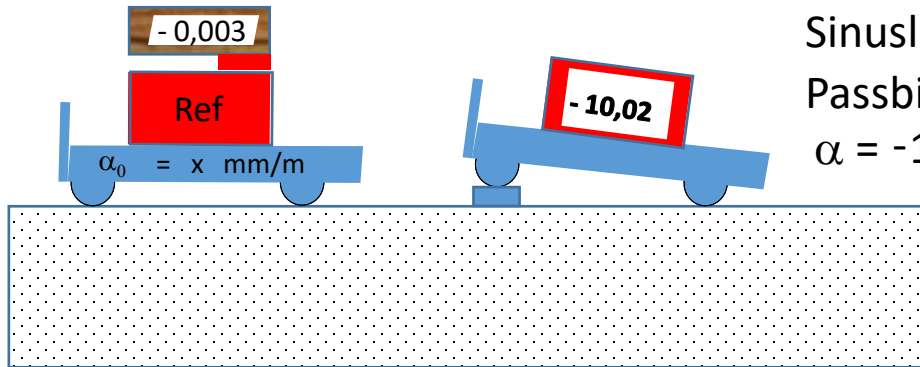
DimVIM:

2.2.1	gauge block	central length; variation in length; thermal expansivity; length difference of gauge block pairs
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<https://www.bipm.org/en/committees/cc/ccl/dimvim>

CMCs 'FAIR' (Findable, Accessible, Interoperable, Reusable)

Ny CMC for kalibrering av vater



Sinuslinjal, $L = 300$ mm

Passbit, $L = 3$ mm

$\alpha = -10$ mm/m

$$\alpha \left(\frac{\text{mm}}{\text{m}} \right) = \frac{PB}{\sqrt{L^2 - PB^2}} = \frac{PB/L}{\sqrt{1 - (PB/L)^2}}$$

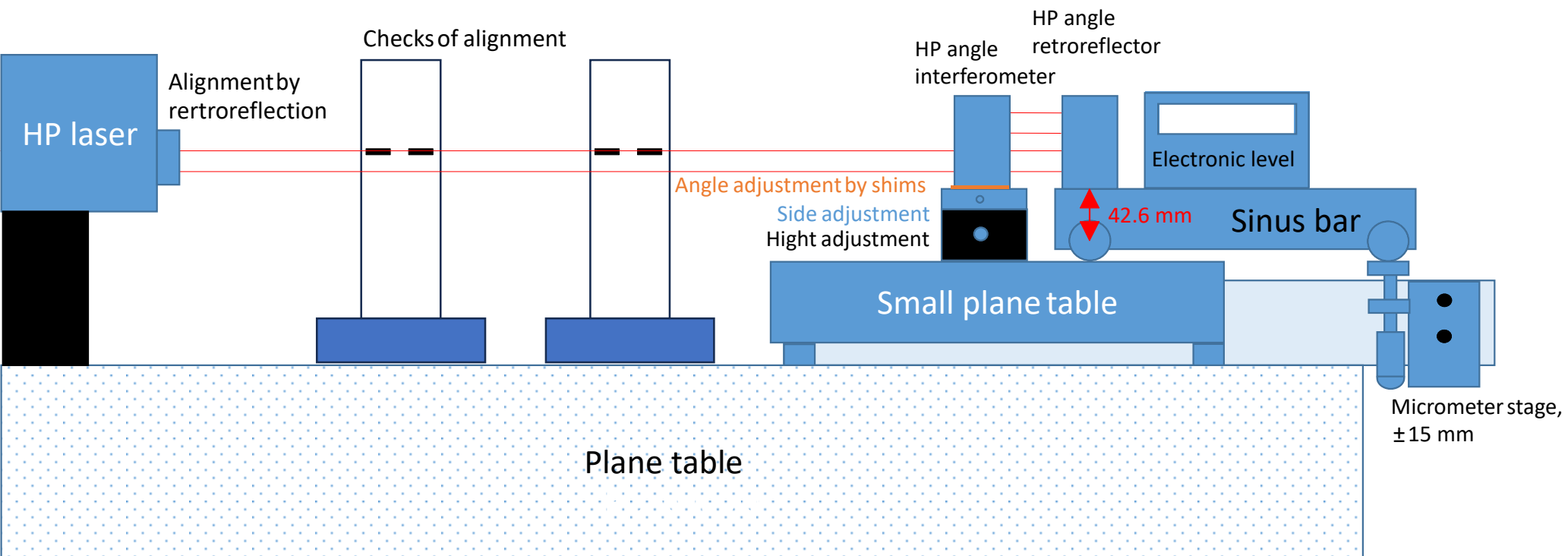
$$\alpha = -10,0005 \text{ mm/m}$$

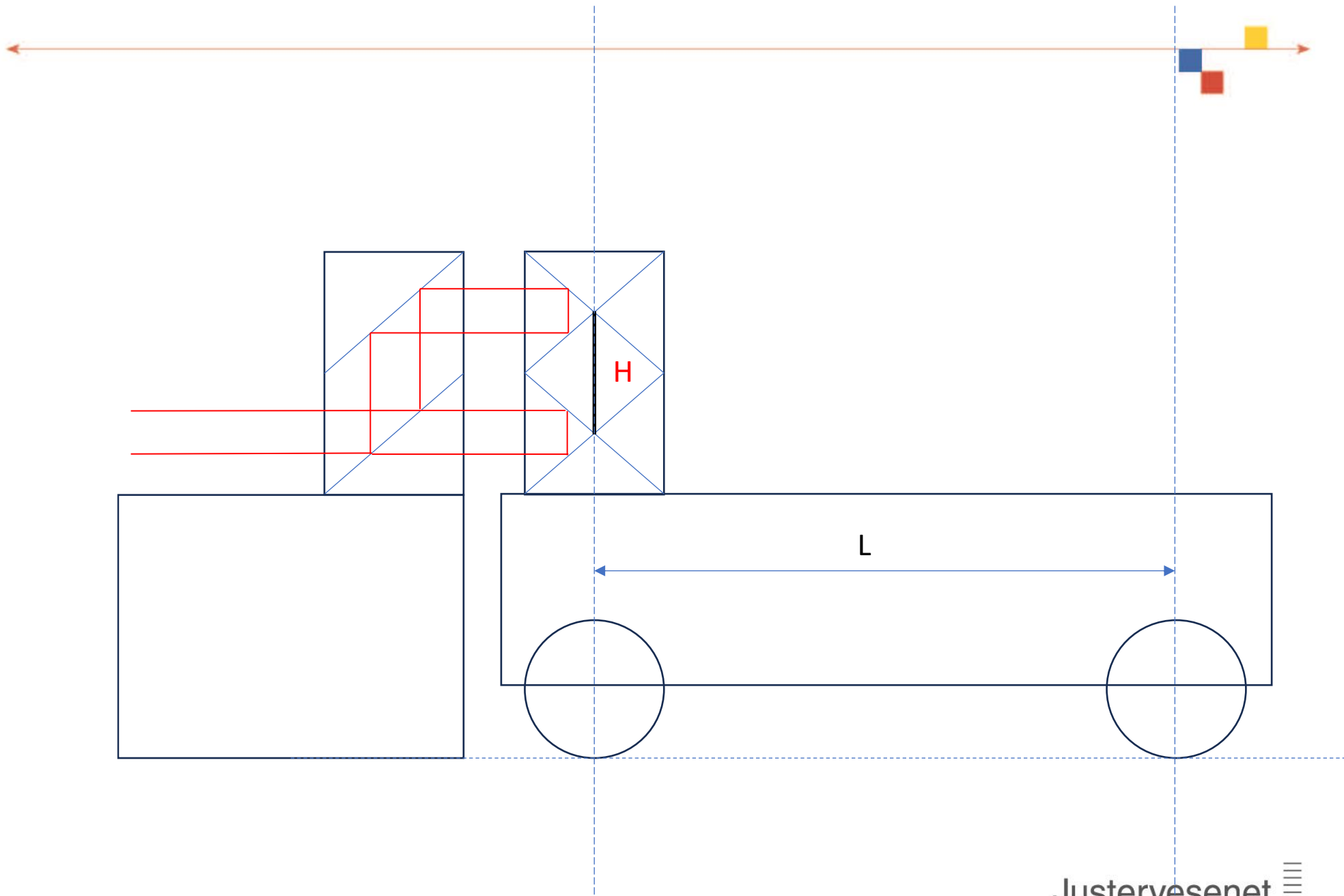
Innvendinger fra teknisk ekspert:

- Usikkerhetsbudsjettet ditt ser jo greit ut!
- Men hvordan kalibrerte du lengden til sinuslinjalen?

OBS: Det kan være en forskjell på mekanisk målt lengde og den *effektive lengden* til sinuslinjalen ved ulike vinkler!

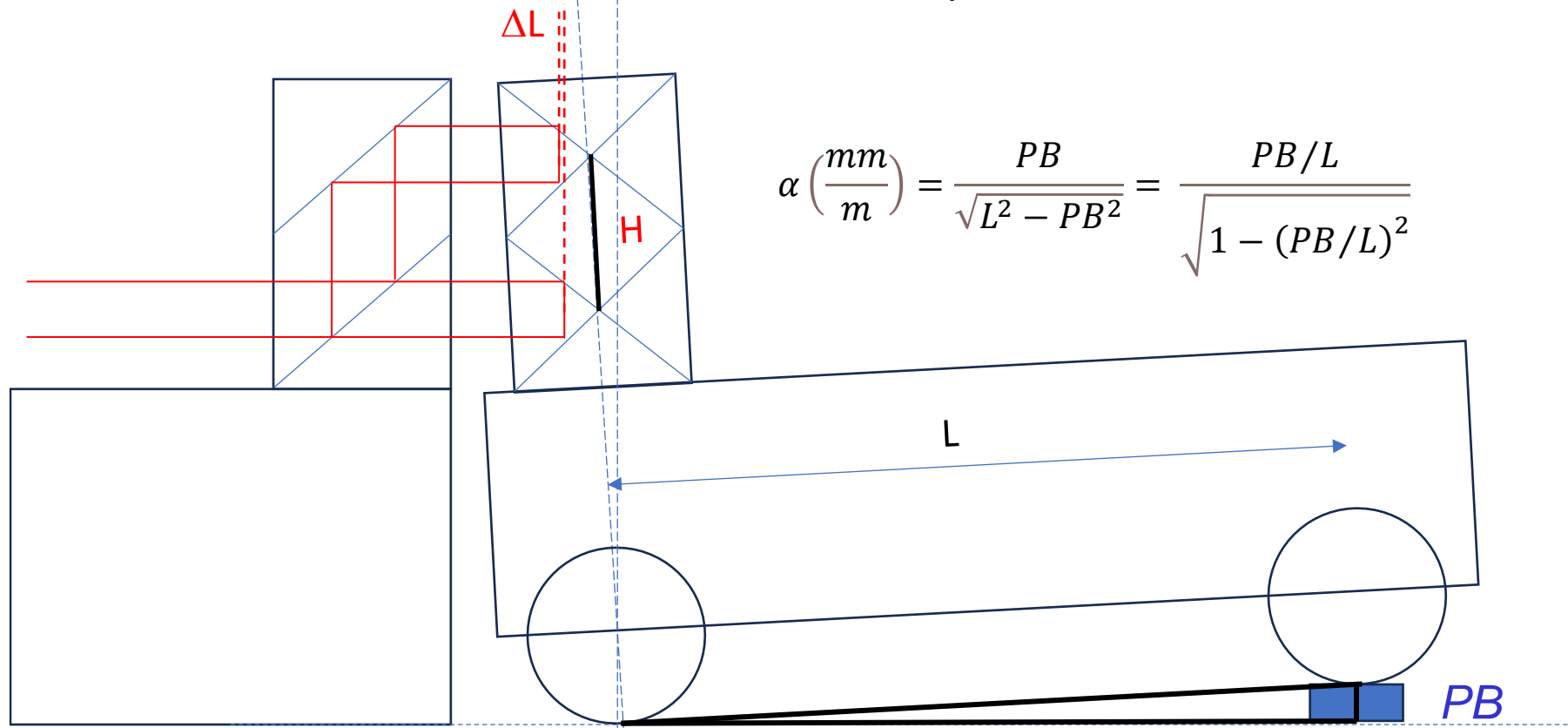
HP 5529A laser interferometer





$$\alpha \left(\frac{mm}{m} \right) = \frac{\Delta L}{\sqrt{H^2 - \Delta L^2}} = \frac{\Delta L/H}{\sqrt{1 - (\Delta L/H)^2}}$$

Størrelsen **H** må kalibreres!
Da er dette en primær målemetode for vinkel.



$$\alpha \left(\frac{mm}{m} \right) = \frac{PB}{\sqrt{L^2 - PB^2}} = \frac{PB/L}{\sqrt{1 - (PB/L)^2}}$$

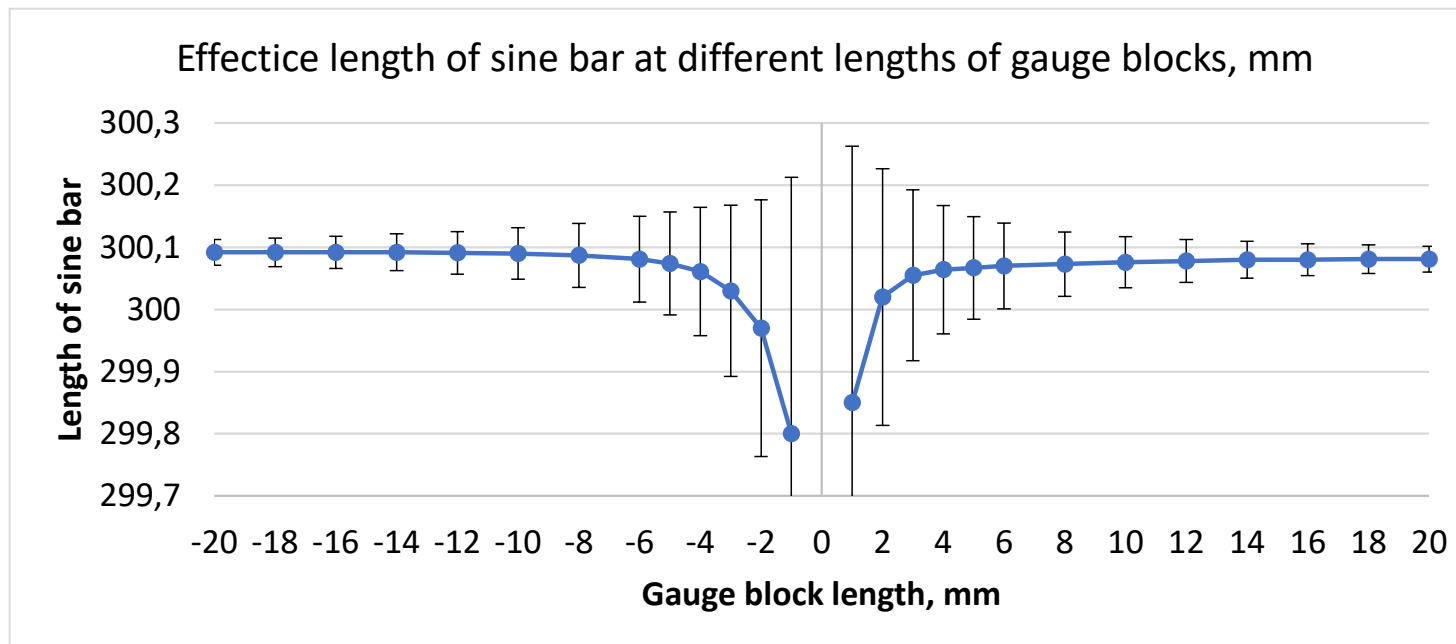
$$\alpha (") = 3600 \cdot \arcsin \left(\frac{\Delta L}{H} \right) \approx 3600 \cdot \frac{\Delta L}{H}$$

$$L = PB \cdot \sqrt{1 + \frac{1}{\alpha^2}}$$

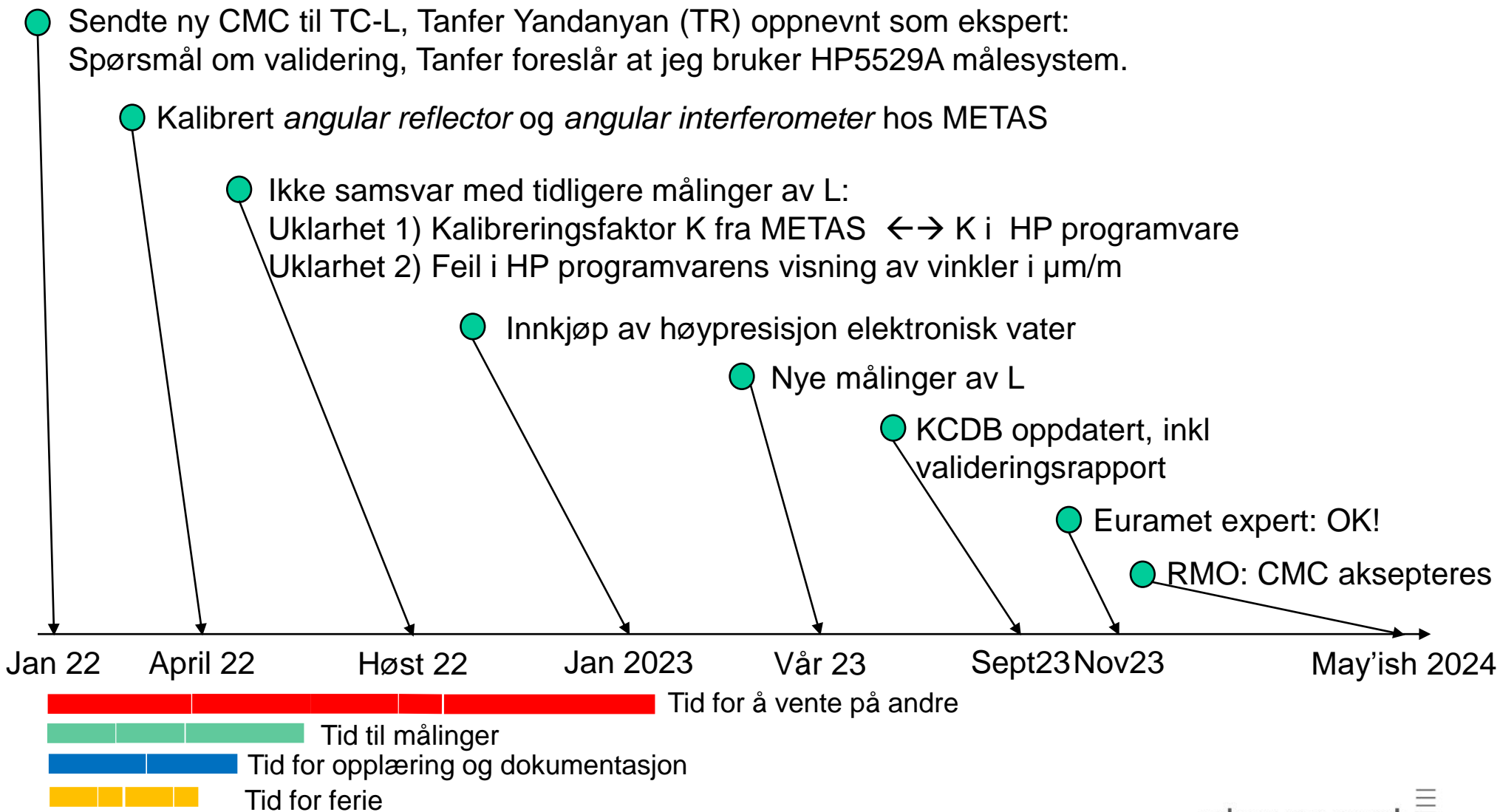
Lengde til sinuslinjal

Før validering: $L = 300,056 \text{ mm} \pm 0,050 \text{ mm}$ (1 sigma) mekanisk måling

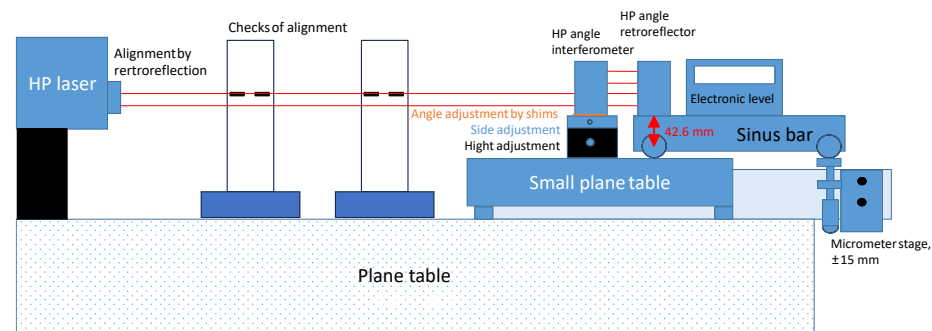
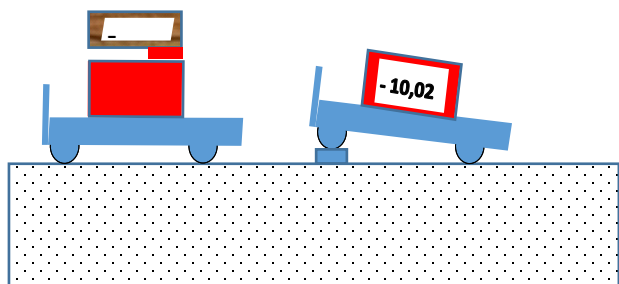
Etter validering: Ved 16 mm passbit: $L = 300,086 \text{ mm} \pm 0,026 \text{ mm}$
Ved 12 mm passbit: $L = 300,085 \text{ mm} \pm 0,034 \text{ mm}$
Ved 6 mm passbit: $L = 300,076 \text{ mm} \pm 0,069 \text{ mm}$
Ved 3 mm passbit: $L = 300,043 \text{ mm} \pm 0,138 \text{ mm}$



Ny CMC for kalibrering av vater, tidslinje



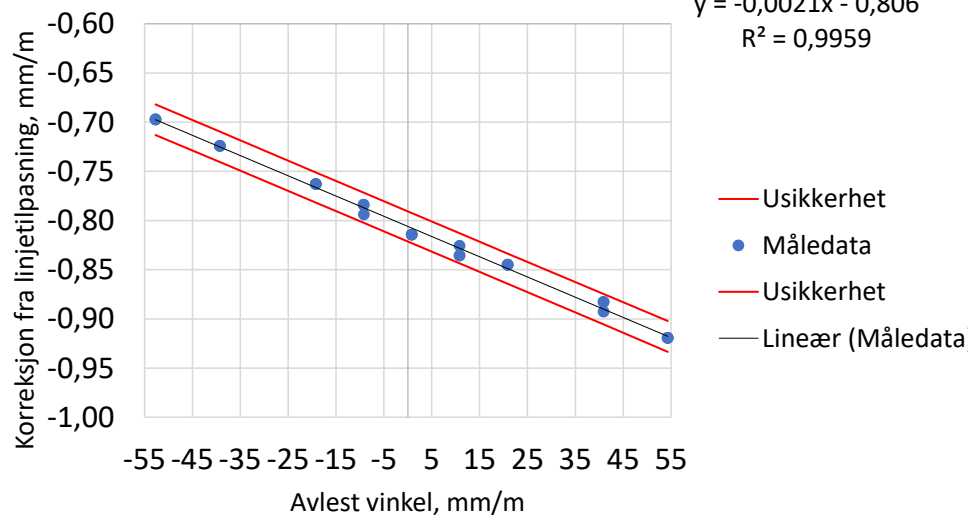
Vater nr 1: Oppløsning 0,01 mm/m



Rettlinje-tilpasset modell

$$y = -0,0021x - 0,806$$

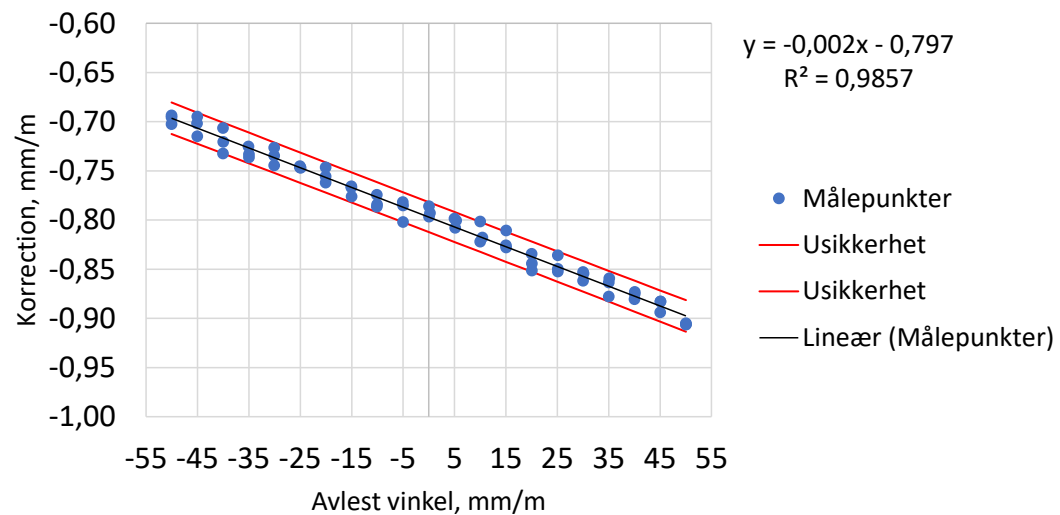
$$R^2 = 0,9959$$



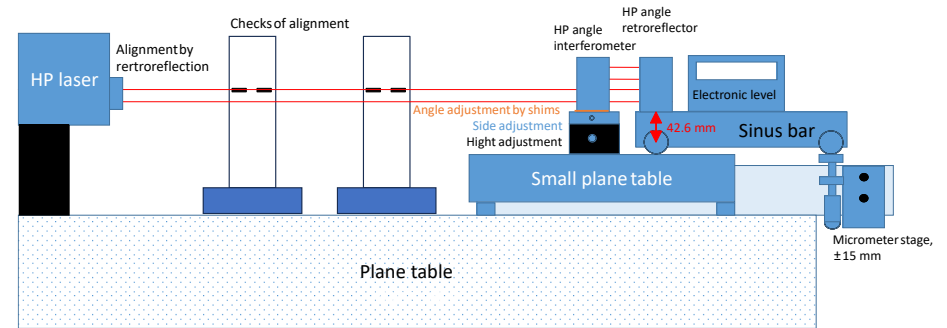
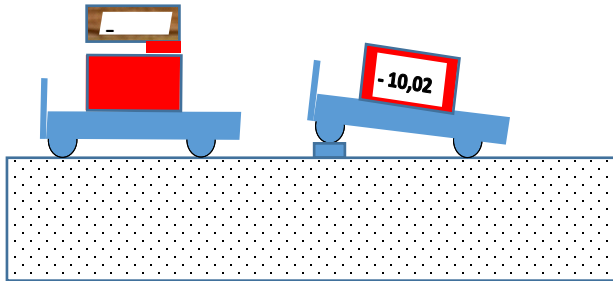
Rettlinje-tilpasset modell

$$y = -0,002x - 0,797$$

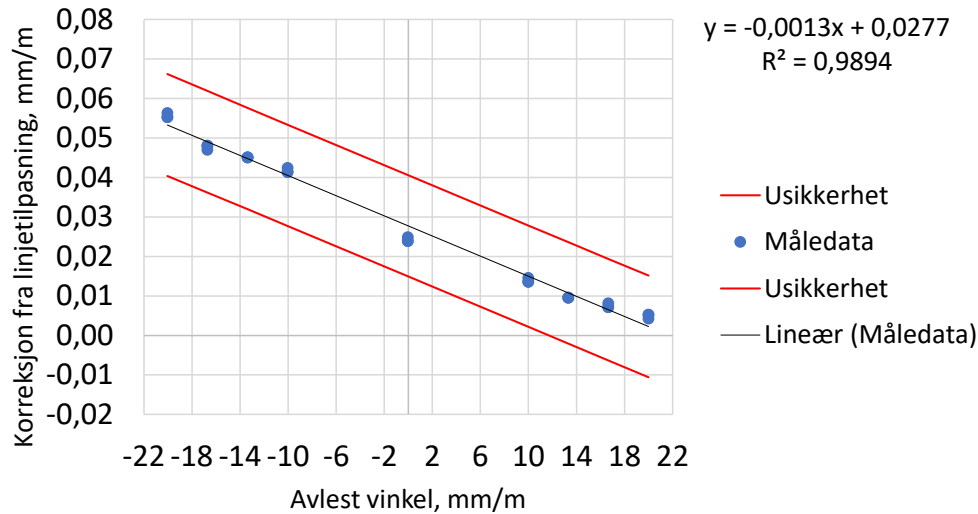
$$R^2 = 0,9857$$



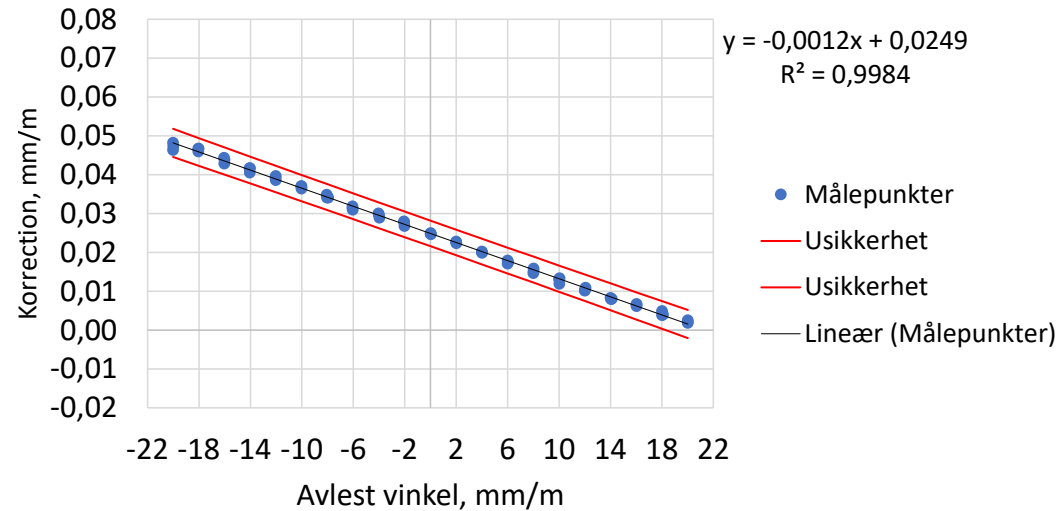
Vater nr 2: Oppløsning 0,001 mm/m



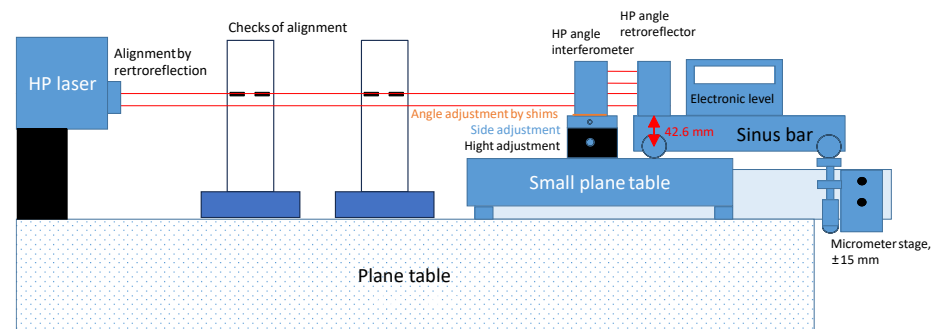
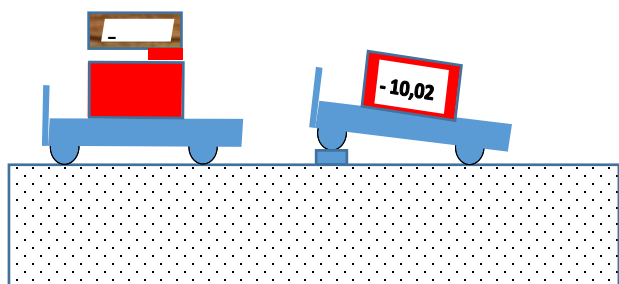
Rettlinje-tilpasset modell



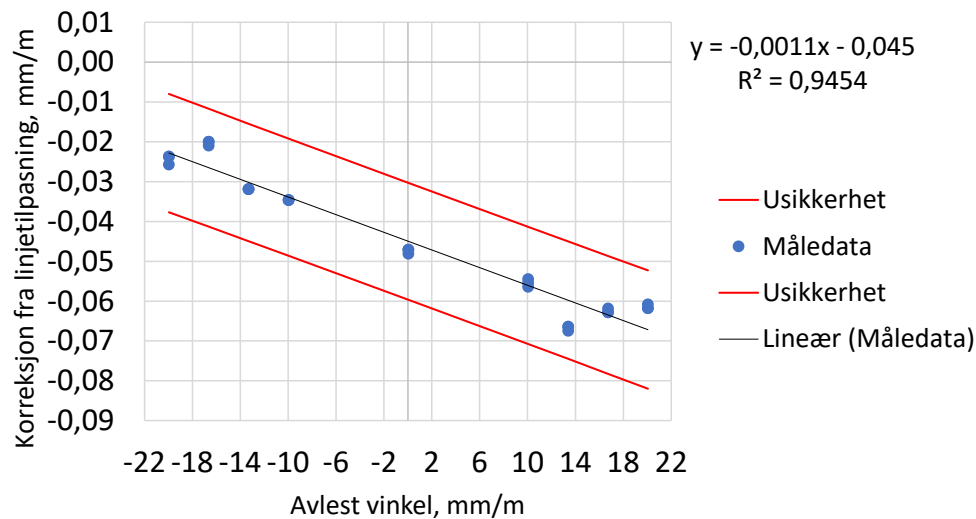
Rettlinje-tilpasset modell



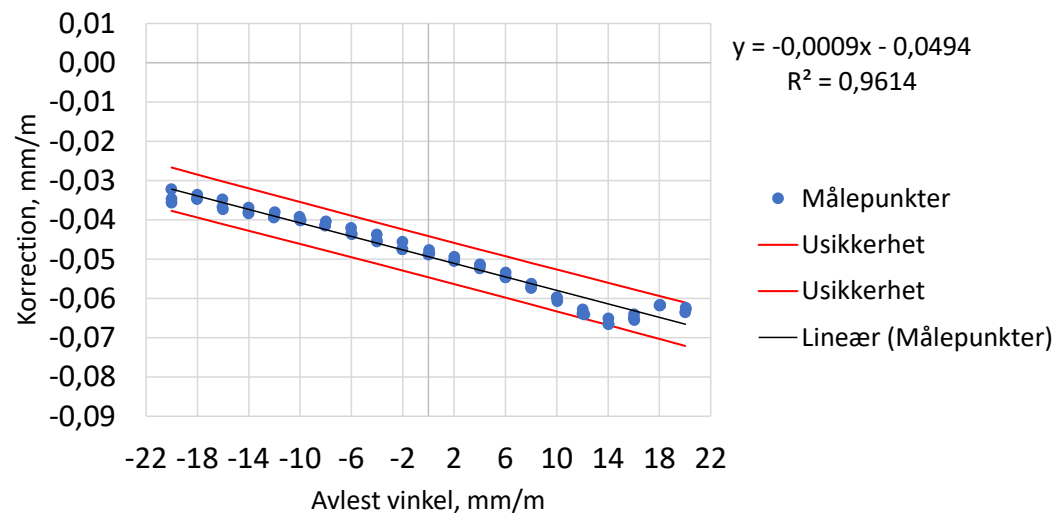
Vater nr 3: Oppløsning 0,001 mm/m



Rettlinje-tilpasset modell

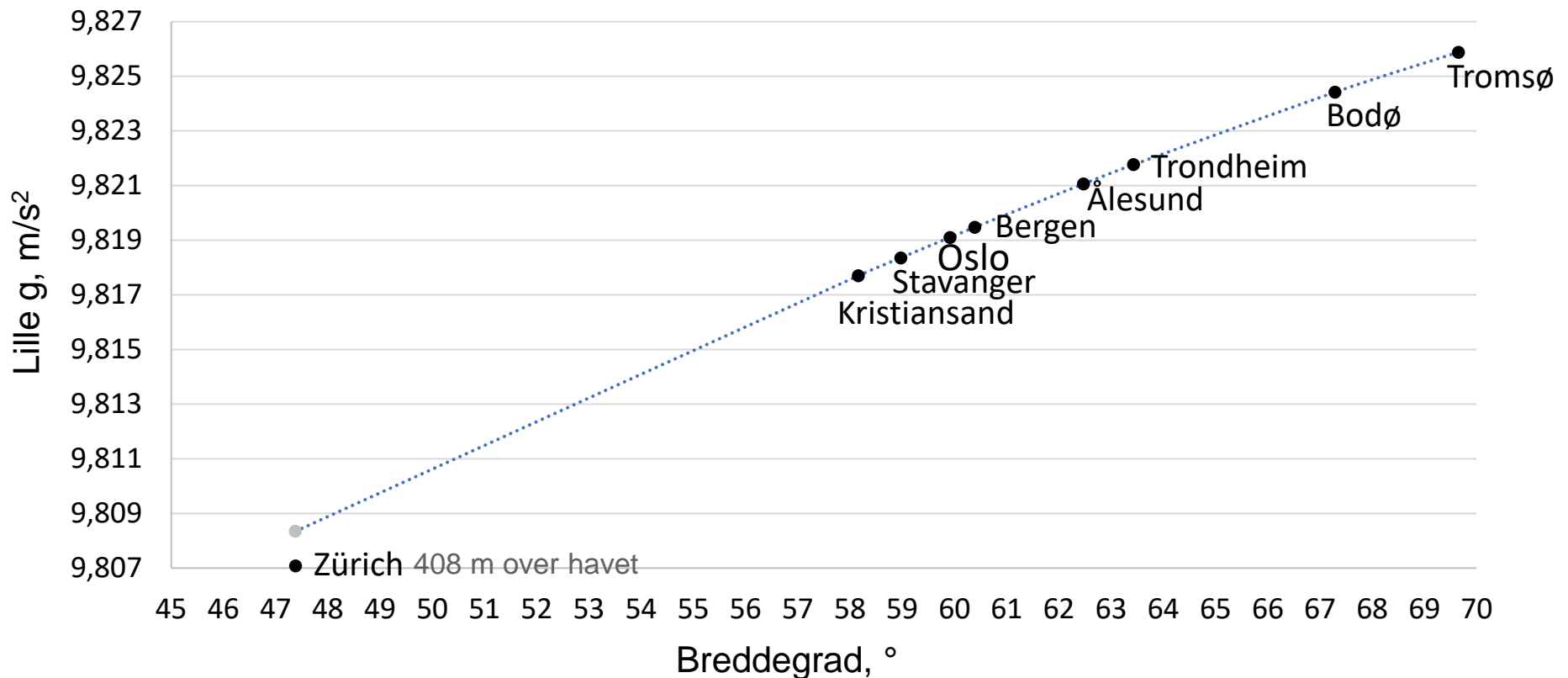


Rettlinje-tilpasset modell



$$g_{\phi} = 9.780318 (1 + 0.0053024 \sin^2 \phi - 0.0000058 \sin^2 2\phi) - 3.086 \times 10^{-6} h$$

Lille g i ulike byer

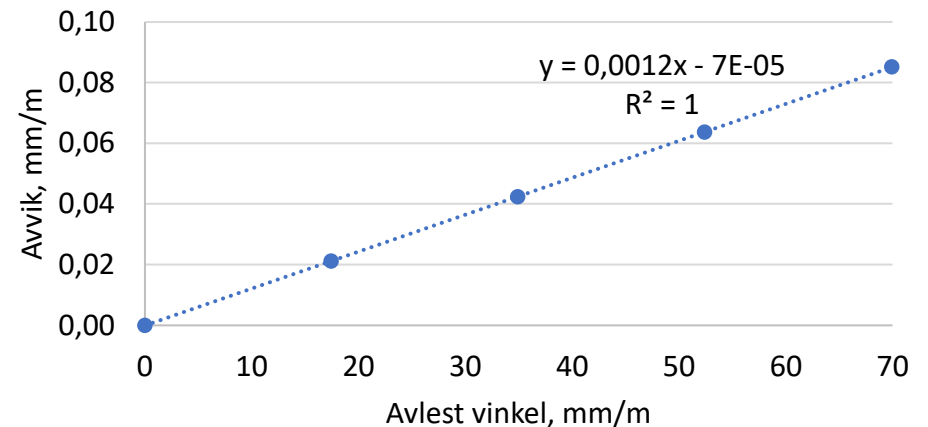
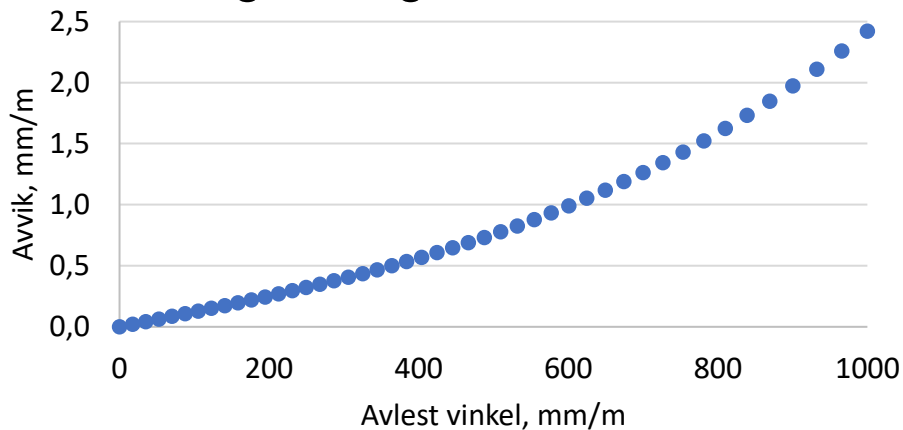


Korreksjon for lokal g

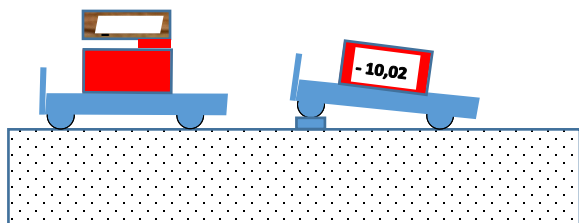
$$\alpha_{corr} = \arcsin\left(\frac{g_{Cal}}{g_{Meas}} \cdot \sin(\alpha_{Displayed})\right)$$



Kalibrert og innregulert i Zürich, måler i Oslo



To nye prosedyrer i kvalitetssystemet



JV-NL-LEN-112 Kalibrering av vater ved sinuslinjal

JV-NL-LEN-112.01 Måleprotokoll og usikkerhetsbudsjett

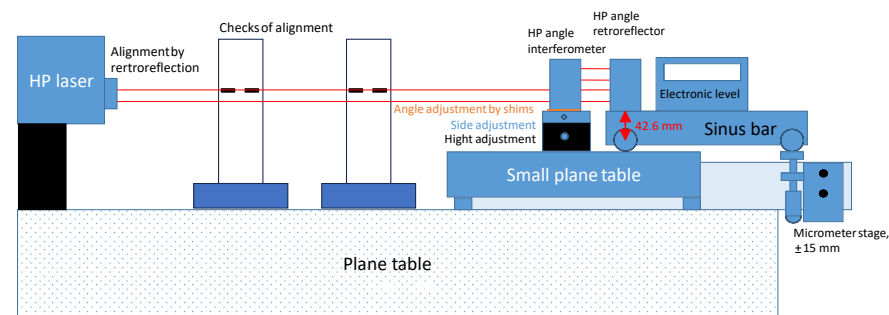
JV-NL-LEN-112.09 Opplærings skjema

CMC claims:

Clinometers, resolution $\geq 10 \mu\text{m/m}$,

Straight line fit to all measurement points on the scale, range $\pm 53 \text{ mm/m}$,

$U(95\%) = 0.020 \text{ mm/m}$ (4.1''), $k = 2$ for a normal distribution.



JV-NL-LEN-017 Kalibrering av elektronisk vater ved laserinterferometri

JV-NL-LEN-017.01 Måleprotokoll og usikkerhetsbudsjett

JV-NL-LEN-017.09 Opplærings skjema

CMC claims:

Electronic levels, resolution $\leq 1 \mu\text{m/m}$,

Straight line fit to all measurement points on the scale, range $\pm 20 \text{ mm/m}$,

$U(95\%) = 5 \mu\text{m/m}$ (1''), $k = 2$ for a normal distribution.

However, poor repeatability and a poor fit of a straight line to the calibration points will increase measurement uncertainty.