National Metrology Institute VTT MIKES

Ajankohtaista VTT MIKESin toiminnasta

13/03/2023 VTT – beyond the obvious

Sisältö

- Yleiskuva
- Ajankohtaista tutkimus- ja kalibrointitoiminnasta
- CGPM 2022
- Kohti tulevaisuutta

Yleiskuva

National Metrology Institute VTT MIKES

National Metrology Institute VTT MIKES

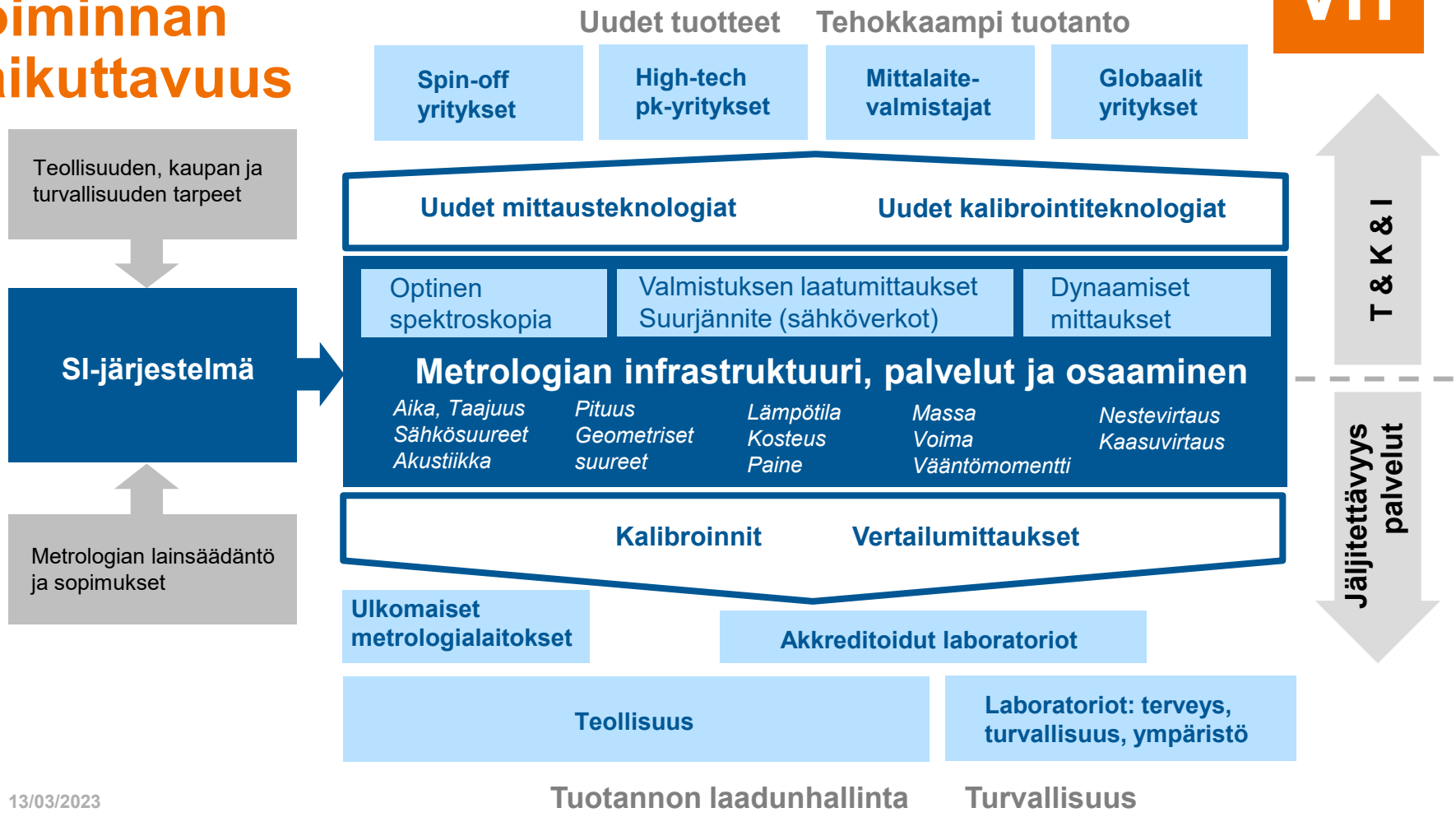
VTT MIKES provides the most accurate measurements and calibrations, metrological research and measuring solutions in partnerships with industry.

National measurement system

Calibration technologies and methods

Measurement technologies for demanding applications

Toiminnan vaikuttavuus



VTT MIKES Technologies

Optical spectroscopy

- Isotope spectroscopy
- Active hyperspectral sensing
- Trace gas sensing

Dynamic pressure

- Calibrators

Quantum metrology

- Quantum electrical reference instruments
- Cryogenic photo-electric signal adaptation
- Optical atom clocks

SI unit realisations

- Time, frequency
- Electricity, acoustics
- Length, geometry
- Mass, temperature, pressure, humidity
- Force, torque, flow

Metrology for advanced manufacturing

- Laser interferometry
- Nanometrology
- Optical measurement of quality
- X-ray computer tomography
- Scatterometry

Metrological solutions for smart electric grids

- Reference instruments and techniques
- Time synchronisation

Ajankohtaista tutkimus- ja kalibrointitoiminnasta

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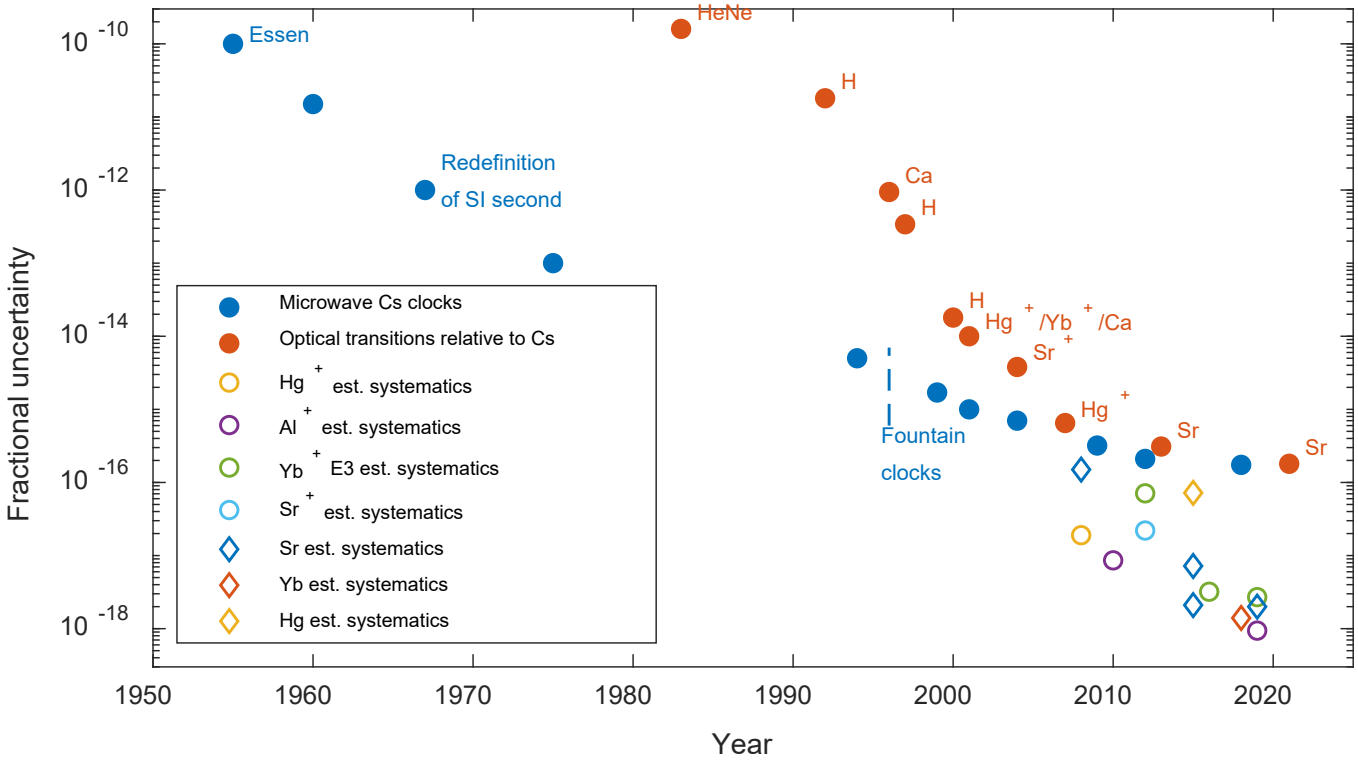
Ajan realisoinnin historiallinen kehitys

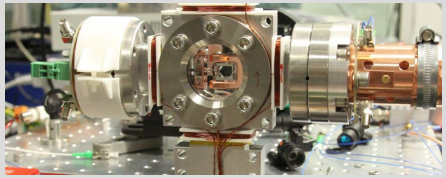


CGPM 2022 sopi jatkoaskelista kohti sekunnin uuden määritelmän hyväksymistä CGPM 2030:ssa

1973 Optical single-ion frequency standards proposed by Dehmelt
1980s Experimental single-ion work (NBS/NIST, NRC, NPL,PTB)
2000 Optical frequency comb
2006- Optical transitions chosen as secondary representations of the second
2011- VTT MIKES ion-clock work

VTT MIKES Ajan ja taajuuden infrastruktuuri

$^{88}Sr^{+}$ single-ion clock



- Stationary clock laser
- Transportable under construction

Frequency combs

- Menlo 250 MHz
- Menlo 100 MHz

UTC(MIKE)

- 3 Active Hydrogen Masers
- 2 Cs 5071A
- 1 PHM
- HROG steering

Time and frequency transfer

- NTP
- PTP
- White Rabbit
- GNSS

VTT Espoo Grand Master

VTT Kajaani

Metsähovi Observatory

50 km dark fiber

1000 km

VTT MIKESin $^{88}Sr^{+}$ ionikello

Key features

- $^{88}Sr^{+}$ benefits from 'easy' laser wavelengts
- Endcap Paul ion trap optimized for low rf heating
- Single ion implementation enables very low and well controlled systematic uncertainity

Performance

- Ion storage time
  - With laser cooling: weeks
  - Without cooling: a few days
- <4 Hz Fourier-limited linewidth shown against ion spectral linewidth
- International comparison (2022) VTT in good agreement with PTB and NRC

Future work

- Transportable optical clock by new cavity and housing
- ~2 x 10^{-18} total uncertainty will be received with minor technical improvements leading to top 5-10 results
- Contributing to International Atomic Time (TAI)

VTT

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Upgrade your interfero-meter to the modern Phase Stepping Gauge Block Interferometer

beyond the obvious

Figure 2. Optics for SM fibre coupling for lasers of an upgraded GBI.

VTT

State-of-the-art dynamic pressure calibration solutions

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Dynamic pressure calibrator

Primary dynamic pressure standard

VTT

Palvelumme · Tutkimusympäristöt · Uutiset ja tarinat · Tietoa meistä · FI

Etusivu > Uutiset ja tarinat > Marsin säätä tutkittaessa tarvitaan luotettavaa dataa – VTT:n analyysi paransi mittausdatan tarkkuutta merkittävästi

Marsin säätä tutkittaessa tarvitaan luotettavaa dataa – VTT:n analyysi paransi mittausdatan tarkkuutta merkittävästi

Uutiset, Lehdistötiedote 09.08.2022 09:05

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VTT:n tutkijat ovat onnistuneet parantamaan Marsissa kerätyn mittausdatan tarkkuutta hyödyntämällä matematiikkaa. Suhteellisen kosteuden mittaustarkkuus ylitti merkittävästi Mars-mission vaatimukset. Parempaan mittaustarkkuuteen päästiin käyttämällä VTT:n virhekompensaatiomallia. Mittaustarkkuuteen liittyvän epävarmuuden merkittävä pienentyminen tarkoittaa, että planeettatieteilijät ja muut tutkijat ympäri maailman voivat nyt hyödyntää tätä mittausdataa tutkiessaan Marsin ilmakehää, veden kiertokulkua tai planeetan historiallista asuinkelpoisuutta.

Kuva:NASA/JPL-Caltech

Nasan Perseverance-mönkijä on kerännyt dataa jo yli vuoden, lähes siitä asti, kun se laskeutui Marsiin helmikuussa 2021. Mönkijän keräämä data voi tulevaisuudessa auttaa vastaamaan keskeisiin kysymyksiin koskien Marsia sekä auttaa meitä ymmärtämään paremmin myös kotiplaneettaamme ja sen ilmakehää. Mönkijään on kiinnitetty edistyksellistä teknologiaa sisältävä sääasema, johon kuuluvat myös Ilmatieteen laitoksensuunnittelemat ja valmistamat kaasukehän suhteellisen kosteuden ja paineen mittalaitteet jotka perustuvat Vaisalan anturiteknologiaan. Sääaseman laitteet toimittavat ympäri vuorokauden dataa myös Marsin lämpötilasta, tuulen nopeudesta ja suunnasta, sekä pölyhiukkasten koosta ja määrästä.

Comparison on v-groove measurement: EURAMET.L-S26 comparison

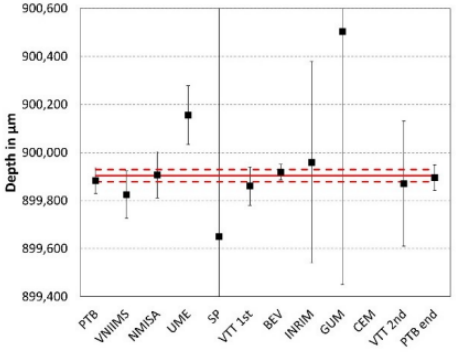


Figure 34 Measured depth values of the participants for the 900 µm groove (red line: KCRV, dotted red lines: expanded uncertainty of KCRV).

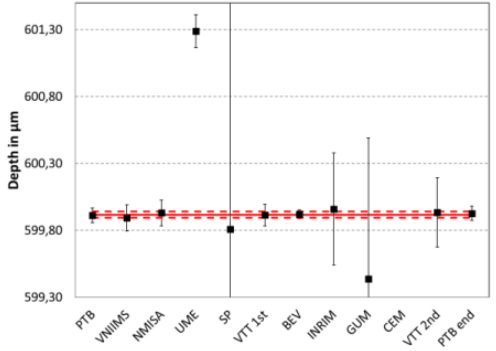
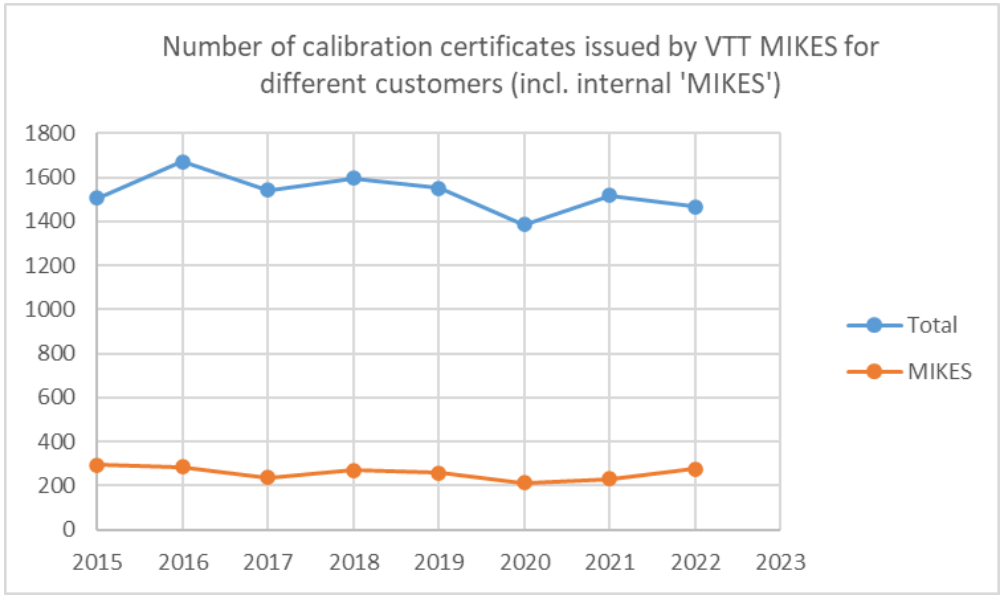


Figure 35 Measured depth values of the participants for the 600 µm groove (red line: KCRV, dotted red lines: expanded uncertainty of KCRV).

[Metrologia 2020 **57** tech. Suppl. 04001]
[https://www.bipm.org/documents/20126/45452848/EURAMET.L-S26.pdf/0c6a263c-d0bf-fe8b-dd54-39bd2953911d]

A follow-up comparison EURAMET.L-S26.1, showed that our novel interferometric method for v-groove measurement is one of the best in the whole measurement range

Kalibrointien määrä



CGPM 2022

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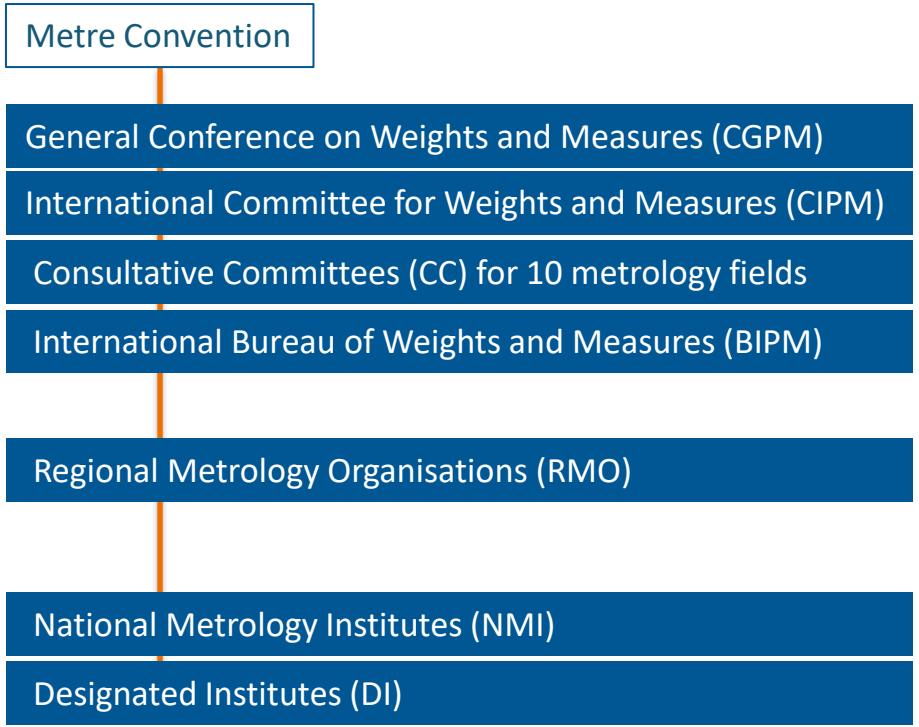
Maailman metrologiainfrastruktuuri



Global

Regional

National

Diplomatic treaty
59 Member States and 42 Associate States and Economies

Delegates of goverments

Members elected by CGPM

Members named by CIPM

Intergovernmental organization

International association of National Metrology Institutes in a region

Institute responsible of national measurement system

Organisation designated to provide national measurement standard in a specific field

CGPM 2022

General Conference on Weights and Measures (CGPM) meets every four years to make most high level and fundamental decisions of the organization

- most important topics were:
  - new prefixes to be included in the SI system
  - increase the maximum difference between the atom clock based coordinated universal time (UTC) and Earth's rotation based time (UT1)
    $\Rightarrow$ abandon the leap second by or before 2035
  - pathway to redefine second
  - work programme and budget of the International Bureau of Weights and Measures (BIPM)
  - members of the International Committee for Weights and Measures (CIPM)

New prefixes

Name	Symbol	Factor	Name	Symbol	Factor
quetta	Q	10^{30}	quecto	q	10^{-30}
ronna	R	10^{27}	ronto	r	10^{-27}
yotta	Y	10^{24}	yocto	y	10^{-24}
zetta	Z	10^{21}	zepto	z	10^{-21}
exa	E	10^{18}	atto	a	10^{-18}
peta	P	10^{15}	femto	f	10^{-15}
tera	T	10^{12}	pico	p	10^{-12}
giga	G	10^{9}	nano	n	10^{-9}
mega	M	10^{6}	micro	μ	10^{-6}
kilo	k	10^{3}	milli	m	10^{-3}
hector	h	10^{2}	centi	c	10^{-2}
dec	da	10^{1}	deci	d	10^{-1}

CIPM

Thirteen current members were re-elected:

- Dr D. Del Campo Maldonado (Spanish)
- Dr N. Dimarcq (French)
- Dr Y. Duan (Chinese)
- Dr H. Laiz (Argentinian)
- Dr W. Louw (South African)
- Prof. P. Neyezhmakov (Ukrainian)
- Dr J. Olthoff (American)
- Dr S.-R. Park (South Korean)
- Dr M.L. Rastello (Italian)
- Dr P. Richard (Swiss)
- Prof. G. Rietveld (Dutch)
- Prof. J. Ullrich (German)
- Dr T. Usuda (Japanese)

[https://www.bipm.org/en/cgpm-2022/cipm-election]

Five new members were elected:

- Dr V.G. Achanta (Indian)
- Dr V. Coleman (Australian)
- Dr J.-T. Janssen (British)
- Ms G. Macdonald (Canadian)
- Dr G.P. Ripper (Brazilian)

Kohti tulevaisuutta

National Metrology Institute VTT MIKES

Our strategy 2021–2025: The path of exponential hope

OUR PEOPLE

Top professional capable of systemic and technological breakthroughs that can bring about fundamental transformation.

The **choices** we make every day

OUR PURPOSE

We bring together people, business, science and technology, to solve the world's biggest challenges, creating sustainable growth, jobs and wellbeing.

1. Always aim for **impact**
2. Always create impact together with a **customer**
3. Always lead for **excellence**
4. Always drive **sustainable** business
5. Always build the world's most **meaningful** place to work

OUR AMBITION

We bring exponential hope to a world that needs to deal with the climate crisis, achieve resource sufficiency, drive industrial renewal, provide safety and security, and enable good life for all.

Future challenges for metrology

Carbon neutrality
monitoring by measurements

Material monitoring
remotely online

Green energy
optimised by measurements

Smart sensor systems
with quality assurance and traceability

Quantum technology
challenges measurement technologies

Time synchronization
for increased data speed and enhanced resilience

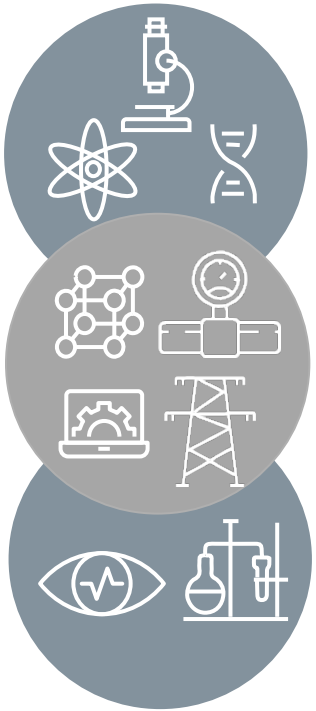
Digital calibration data
delivery, availability and efficient exploitation

MIKES key focus areas

- Our research on **SI unit realisations** is focused in improving our capabilities in **interferometry**, **quantum electrical standards** and **optical atom clocks**. We ensure the international recognition of our calibration services, and we are one of the leading national metrology institutes in selected technology areas. We build competence to deliver globally competitive services in traceable metrology to our stakeholders.

- In developing **improved metrology solutions**, we focus on the fields of **quantum technology**, **advanced manufacturing**, **smart electric grids** and **dynamic measurements**. With our state-of-the art measurement competence we will answer increasing accuracy needs of industry and research as well as contribute to new innovations.

- **Advanced measurement instrument development** is focused on **active hyperspectral imaging** technology and optical **isotope ratio** measurement systems. Continuous on-line monitoring in field applications enable novel measurement solutions across many disciplines.



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