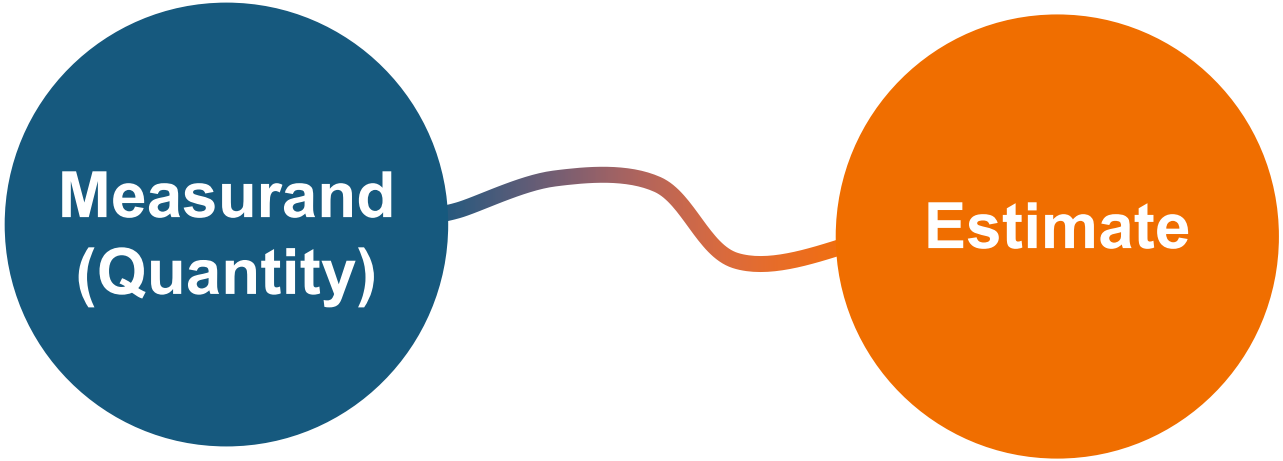
National Metrology Institute VTT MIKES

Metrologia tänään ja tulevaisuudessa

Martti Heinonen



Metrology: Science of measurement studying the relationship between measurands and their estimates

Controlling this relationship is a key factor in manufacturing, trade, safety & security, health care and sciences

RELIABILITY

VTT

INDEPENDENT

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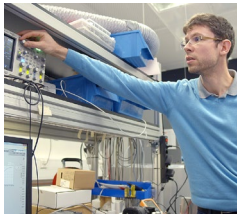
TRUST

National Metrology Institute VTT MIKES

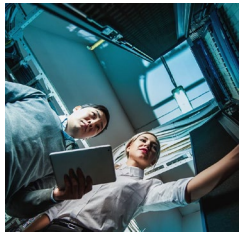
VTT MIKES provides the most accurate measurements and calibrations, metrological research and measuring solutions in partnerships with industry

VTT MIKES Technologies



Measurement technologies for demanding applications

- Active hyperspectral sensing
- Isotope spectroscopy
- Optical instrumentation for quality control in advanced manufacturing



Calibration technologies and methods

- High voltage and transient measurements for smart electric grids
- Time synchronization
- Dynamic pressure
- Laser interferometric length measurements

National measurement system (SI unit system in Finland)

- Length, geometry
- Electricity, acoustics, quantum metrology
- Time, frequency
- Mass, pressure, force, torque, flow
- Temperature, humidity

R&D Customers

Industry

- Manufacturing, Mining
- Electricity grid, Nuclear and thermal energy
- Sensor and measurement instrument manufacturing

Service providers

- Calibration and testing
- Teleoperators

Research

- Research institutes
- ESA

Laser spectroscopy – an innovative way to measure stack emissions

VTT partnered with **Fortum** to develop a groundbreaking method for monitoring of carbon-14 stack emissions at nuclear power plants. The method uses laser spectroscopy to detect airborne molecules. This direct measurement has key advantages over current processes: greatly boosted speed, with reduced costs and complexity.

1-hour measure-ments
rather than days

Much less manual work
needed for measurements

Currently the only solution
based on laser spectroscopy and demonstrated on-site, outside laboratory conditions

The method has been tested during successful field measurements

In the future, the measurement method can be applied across many fields and industries: biomedical studies, environ-mental monitoring, and nuclear waste repositories.

Special measurements for verifying safety and reliability of aircraft electrical components

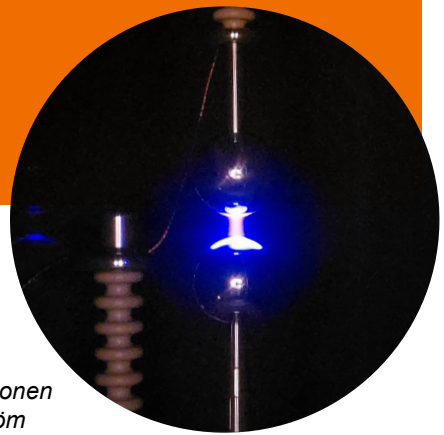
Saab AB turned to VTT MIKES for investigating the voltage withstand of aircraft electrical components to verify safety and reliability of equipment under varying atmospheric conditions. VTT designed and constructed a novel measurement setup for this demanding application to carry out measurements at the appropriate low pressures and temperatures.

In addition to standard calibration services, VTT MIKES provides custom measurement solutions to solve challenging problems.

Reliable measurement results traceable to international system of units, SI

Boost R&D through precise measurements in controlled test environment

Verify safety and reliability and maximize lifetime of equipment



Contact: Tuomas Poikonen & Jari Hällström

Dynamic pressure calibrator

Primary dynamic pressure standard

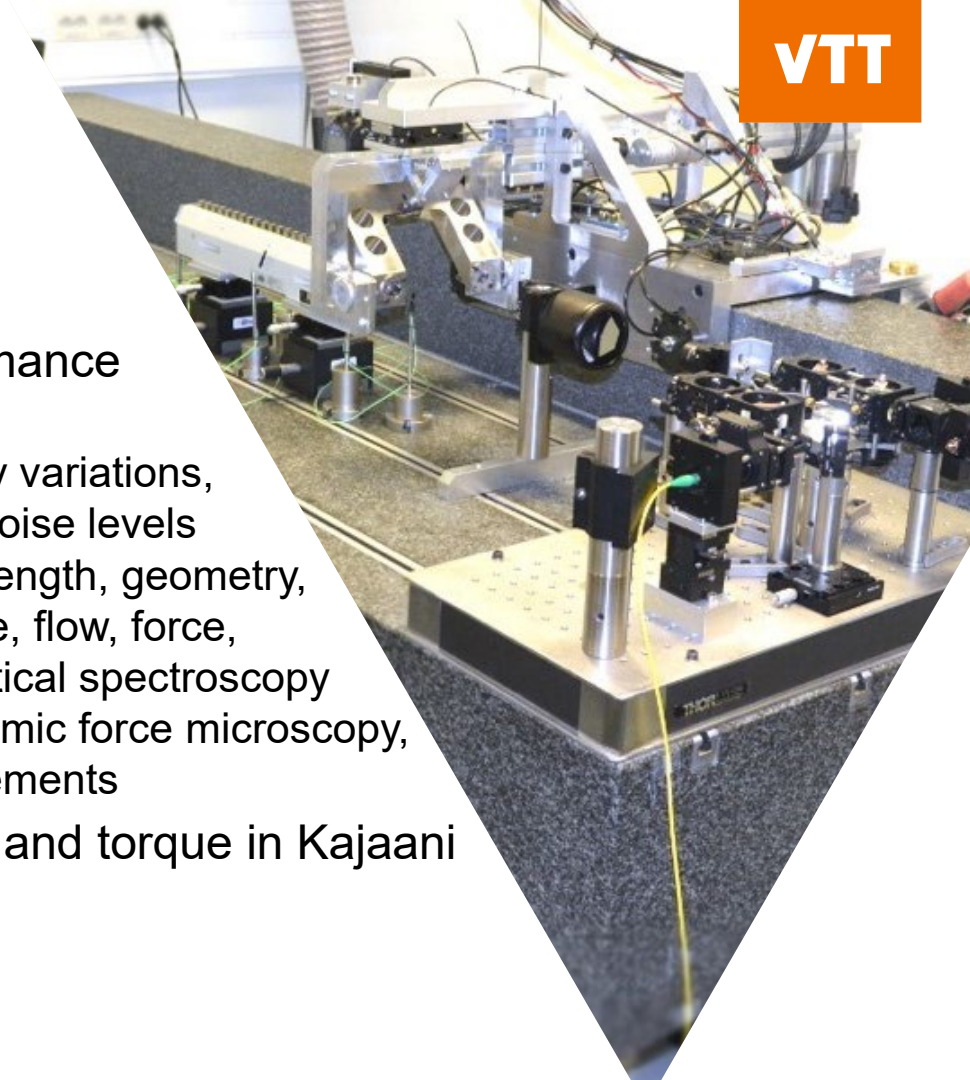
Dynamic pressure calibrator

VTT dynamic pressure calibrator enables cost-effective calibration and testing of dynamic pressure sensors. The calibrator generates pressure pulses in the millisecond range up to 350 bar and includes a heating option to enable calibrations at temperatures up to 200 °C — a unique feature not available in commercial calibrators. This makes the calibrator an ideal solution for calibrating dynamic pressure sensors used in harsh conditions, e.g. inside combustion engines. SI traceability of the calibration results is established through a reference sensor calibrated against VTT MIKES dynamic pressure standard.

Customers:
Metrology services

- Calibration laboratories
- Testing laboratories
- Research laboratories
- Manufacturers of measurement instruments
- Maintenance and quality control in manufacturing, energy generation and distribution, process industry
- Metrology institutes in other countries
- Institutes designated for providing specific national standards
- FINAS – Finnish Accreditation Service

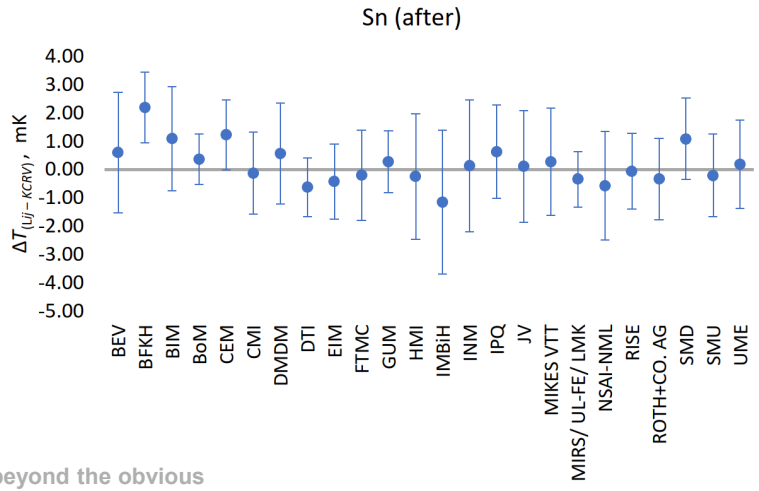
MIKES infrastructure

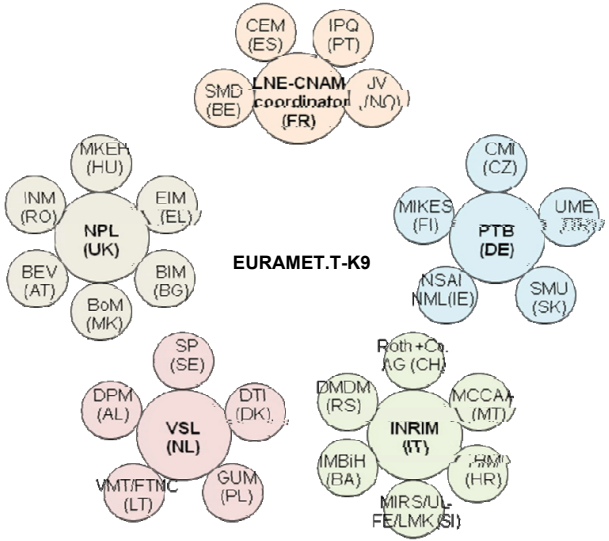


- Metrology building with high performance laboratory rooms
  - Ultra-low air temperature and humidity variations, vibration levels and electromagnetic noise levels
  - Laboratories for electrical quantities, length, geometry, temperature, humidity, mass, pressure, flow, force, torque, time, frequency, acoustics, optical spectroscopy
  - Special facilities for atomic clocks, atomic force microscopy, interferometry and cryogenic measurements
- Premises for large liquid flow, force and torque in Kajaani
  - Maximum flow pipe size DN500
  - Test rig for pulp flow

International equivalence

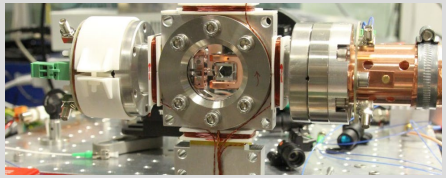
- To achieve the goal of trust, it is vital to provide scientific evidence on the equivalence of national measurement standards
  ⇒ International comparisons





VTT MIKES Time & Frequency Infrastructure

$^{88}Sr^{+}$ 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

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

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
- ~$2x10^{-18}$ total uncertainty will be received with minor technical improvements leading to top 5-10 results
- Contributing to International Atomic Time (TAI)

Teknologisia haasteita ratkaistavaksi:

Hiilineutraaliuden todentaminen mittaamalla

Materiaalien tunnistus koskettamatta jatkuva-toimisesti

Energiaratkaisut Biokaasu, vety, varastointi, älykkäät verkot

Älykkäiden mittausjärjestelmien kalibrointi

Kvanttiteknologian tarvitsemat mittaukset

Aikasynkronointi yhä tarkemmin ja häirittynä

Digitaalinen kalibrointi-datan välitys ja saatavuus

VTT

beyond

the obvious

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