NMIJ Newsletter

No.22, November 2025

Greetings from the Director of RIEM

Dr. OTA Akihiro
Director of RIEM

The Research Institute for Engineering Measurement (RIEM) promotes the establishment and dissemination of national measurement standards for length, geometric quantities, mass, density, force, torque, pressure, flow rate, acoustics, ultrasonics, and vibration acceleration, and the development of related measurement and evaluation technologies. In particular, RIEM focuses on the development of innovative measurement and evaluation technologies to establish next-generation measurement standards that address social issues and demands, such as carbon neutrality, protection of human health and the environment from exposure to harmful substances, and digital transformation (DX). RIEM also actively contributes to national and international standardization related to these technologies. Furthermore, RIEM conducts legal metrology operations for consumer protection in commercial transactions, such as type approval (testing and review) and inspection of reference standard instruments for the verification of specific measuring instruments. In addition, to ensure the proper enforcement of the Measurement Act in Japan, RIEM supports the creation and revision of technical standards in response to technological innovations in specific measuring instruments and changes in the social environment surrounding measurement systems. Internationally, RIEM ensures the international equivalence of measurement standards and promotes the appropriate operation of the OIML certification system for international legal metrology, thereby supporting the smooth overseas expansion of national calibration service providers and measuring instrument manufacturers.

National Metrology Institute of Japan

- Research Planning Office of NMIJ
- Collaboration Promotion Office of NMIJ
- Research Institute for Engineering Measurement (RIEM)
  - Length Standards Group
  - Dimensional Standards Group
  - Mass Standards Group
  - Force and Torque Standards Group
  - Pressure and Vacuum Standards Group
  - Acoustics, Ultrasound and Vibration Standards Research Group
  - Liquid Flow Standards Group
  - Gas Flow Standards Group
  - Research Group on Data Science for Metrology
  - Type Approval Group
  - Testing and Inspection Group
  - Legal Weighing Metrology Group
  - Legal Flow Metrology Group
  - Dynamic Mechanical Measurement Research Group
- Research Institute for Physical Measurement (RIPM)
- Research Institute for Material and Chemical Measurement (RIMCM)
- Research Institute for Measurement and Analytical Instrumentation (RIMA)
- Center for Quality Management of Metrology

Greetings from the Director of RIPM

Dr. NAKANO Tohru
Director of RIPM

The Research Institute for Physical Measurement (RIPM) develops, maintains, and provides measurement standards for physical quantities such as time and frequency, electromagnetism, temperature, and optical radiation, ensuring reliable measurements across industries and society.

Beyond this core mission, we advance technologies that support industrial innovation, including non-destructive testing using electromagnetic waves, evaluation methods for post-5G/6G communications, and thermoelectric material performance evaluation. Collaborations with private companies have also driven the development of practical tools, such as precision electrical instruments, standard LED sources, and high-accuracy temperature systems.

We are exploring quantum technologies, including single electrons, single photons, and optical frequency combs, to create next-generation standards and measurement technologies. Notably, our work on optical lattice clocks contributes to International Atomic Time and may influence the future redefinition of the second.

As the saying goes, “If you can’t measure it, you can’t make it.” Through continuous innovation, we aim to support future manufacturing and contribute to the advancement of Japanese industry and society.

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  - Time Standards Group
  - Optical Freuquency Measurement Group
  - Quantum Electrical Standards Group
  - Applied Electrical Standards Group
  - Radio-Frequency Standards Group
  - Electromagnetic Measurement Group
  - Electromagnetic Fields Standards Group
  - Thermometry Research Group
  - Optical Thermometry Group
  - Photometry and Radiometry Research Group
  - Applied Optical Measurement Group
  - Quantum Sensor Measurement Research Group
- Research Institute for Material and Chemical Measurement (RIMCM)
- Research Institute for Measurement and Analytical Instrumentation (RIMA)
- Center for Quality Management of Metrology

Introduction of RIEM

The Research Institute for Engineering Measurement (RIEM) celebrated its 11th anniversary in this April, and with the addition of new personnel, it was reorganized from 13 groups into 14 groups. RIEM consists of 10 research groups and four technical groups.

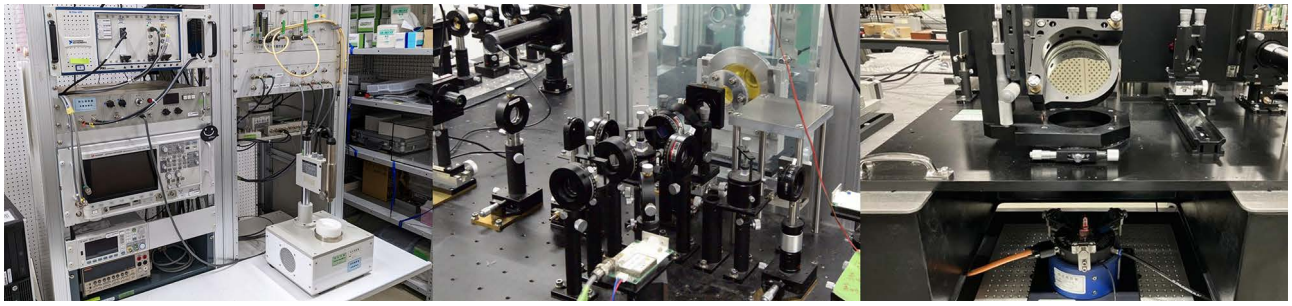
The research groups are responsible for the development, maintenance, and supply of national measurement standards for length-related quantities, mass-related quantities, sound, ultrasound, and vibration, as well as the development of related fundamental and applied measurement and evaluation technologies. They also conduct uncertainty evaluations related to metrology, evaluations of consistency in inter-laboratory comparisons, and conformity assessment technologies for metrological and measurement software.

The technical groups conduct type approval tests and reviews for specified measuring instruments, and inspect legal standard reference instruments in accordance with the Measurement Act. Additionally, they conduct conformity assessments for OIML certificates based on the OIML recommendations. They also support the introduction of technical standards that are harmonized with technological innovation and international recommendations into type approval tests, verifications, and inspections, and investigate rational and cooperative testing and evaluation methods for them.

This year, to strengthen interdisciplinary research, RIEM established two new research groups, which are introduced below.

Acoustics, Ultrasound and Vibration Standards Research Group

The research group develops, maintains, and provides measurement standards in the fields of acoustics, ultrasound, and vibrations. Acoustic standards are essential for accurately measuring sound in air, particularly for evaluating noise levels based on legal regulations. The group provides these standards by calibrating the microphone sensitivity, which determines how sound pressure is converted into electrical signals. Ultrasound standards help measure sound waves in water, mainly for assessing the safety of medical ultrasound. These standards are delivered by calibrating the ultrasonic power, which represents the output of the sound sources, and the sensitivity calibration of hydrophones, which are underwater microphones. Vibration standards are used to measure movements caused by shaking or oscillation and are important for legally assessing environmentally regulated vibrations. The group provides these standards by calibrating accelerometers that convert vibrational acceleration into voltage or electric charge.

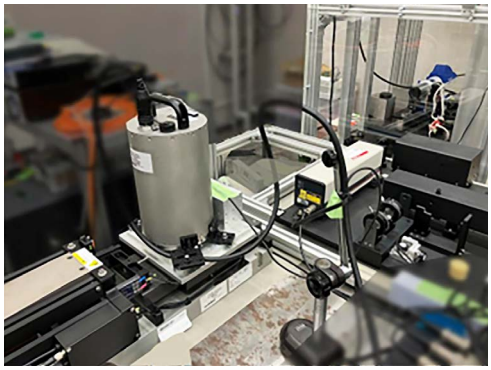


From left: calibration systems for microphones, hydrophones, and accelerometers

Dynamic Mechanical Measurement Research Group

The Dynamic Mechanical Measurement Research Group is engaged in research and development that contributes to the development of precision measurement technologies for dynamic mechanical quantities such as displacement, acceleration, sound pressure in air and underwater, pressure, and material hardness, as well as next-generation national standards. The precision measurement of these physical quantities plays an important role in a wide range of fields, including the health assessment of mechanical structures, environmental monitoring, early detection of large-scale natural disasters, and medical diagnosis.

In the physical quantity measurement of time-varying phenomena, in order to accurately capture the correlation between time and that physical quantity, it is necessary to conduct research focusing on the frequency response characteristics and linearity (dynamic range) of the devices (sensors) that detect and convert physical quantities and the measuring instruments used, their traceability, and data processing after acquisition. In particular, this group focuses on the novel development and improvement of sensing technology, and conducts research and development that combines advanced technology with practicality in order to accurately capture dynamic response characteristics such as optoacoustic sensors and multi-axis inertial sensors.



Laser Interferometric Low-frequency Micro-vibration Calibration System

This year 2025 marks the 150th anniversary of the promulgation of the Measurement Control Ordinance (the Measurement Act), marking it as a milestone year for metrology. Internationally, it also marks the 150th anniversary of the signing of the Metre Convention and the 70th anniversary of the signing of the Convention that established an International Organisation of Legal Metrology. We would like to express our deepest gratitude to all those who have dedicated themselves to national and international metrology activities over the years, and we hope that all members of RIEM will continue to work together to build a sustainable future. I look forward to your continued support and cooperation.

Introduction of RIPM

The Research Institute for Physical Measurement has been conducting advanced research and providing measurement standards. The recent research activities of each group are as follows.

■ Time Standards Group

We develop UTC (NMIJ), a 24/7 time standard, and next-generation standards, such as optical lattice clocks, to redefine the SI second. We perform calibration of the International Atomic Time (TAI) using a Yb optical lattice clock capable of long-term continuous operation, as well as remote frequency calibration via GPS. We also conduct basic research such as dark matter exploration.

■ Optical Frequency Measurement Group

We calibrate the optical frequencies of wavelength-stabilized lasers and conduct research and development related to optical frequency measurements. Our research covers a wide range of areas, including the fundamental technologies for comb generation and control to make optical frequency measurements easier and more precise, as well as applied technologies such as high-speed, high-precision gas analysis. We also engage in translational research in these fields.

■ Quantum Electrical Standards Group

We develop and maintain quantum electrical standards based on effects such as the quantum Hall, Josephson, and single-electron tunneling effects. Our work ranges from fundamental research using nanofabrication to industrial applications.

■ Applied Electrical Standards Group

We provide national standards for AC electrical quantities and develop technologies for industrial use, including novel sensors, broadband power measurements, battery impedance evaluations, and thermoelectric material analyses.

■ Electromagnetic Measurement Group

We conduct research on measurement standards and broadband characterization of high-frequency circuits and devices up to the THz range, along with the low-temperature evaluation of materials essential for scalable quantum computers. We also pursue non-contact electromagnetic sensing and its industrial applications.

■ Radio-Frequency Standards Group

We develop advanced measurement technologies for radio frequencies and microwaves, including terahertz wave systems and quantum-based precision microwave measurements, to support growing industrial applications.

■ Electromagnetic Fields Standards Group

We develop and maintain standard antennas for EMI and wireless communication, along with calibration methods for antenna gain, antenna radiation-pattern, and radar cross-section (RCS) for metasurfaces. In addition, we are working on standards and calibration techniques for low-frequency magnetic fields (above 50 Hz) and electric fields (above 20 MHz), contributing to international standardization.

■ Thermometry Research Group

We develop and disseminate temperature standards from -260 °C to nearly 2000 °C. Our work includes research on fixed points, resistance thermometers and thermocouples, to meet industrial demands, as well as fundamental studies on thermodynamic temperature measurements using SI-system-traceable acoustic gas thermometers.

■ Optical Thermometry Group

We develop non-contact, high-speed, and precise temperature measurement technologies utilizing light and terahertz radiation. Our work includes national standards for radiation temperature (−30 °C to 2800 °C) and advanced spectroscopic gas temperature sensing using optical-frequency combs.

■ Photometry and Radiometry Research Group

We develop standards and measurement technologies for evaluating light sources and detector properties, including radiometric and photometric quantities. We also explore industrial applications, such as the absolute measurement of cellular luminescence for drug discovery and toxicity testing.

■ Applied Optical Measurement Group

We research optical measurement technologies using lasers and LEDs, focusing on light-emitting device evaluation, laser control for processing and communication, and optical materials for sensors. We also develop and disseminate related measurement standards.

■ Quantum Sensor Measurement Research Group

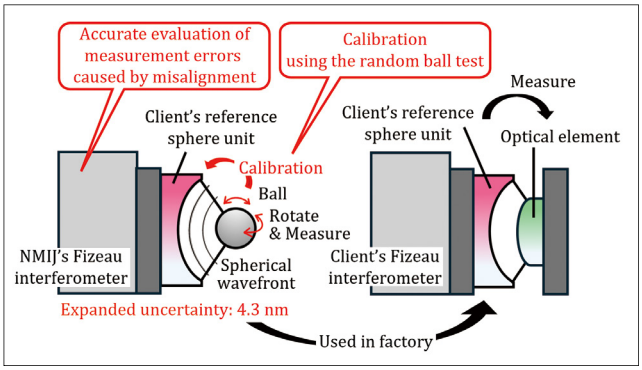
We develop precision measurement technologies based on quantum optics and superconductivity, for applications in medicine and space. In addition, we are working on chip-scale atomic clocks and advanced cooling technologies for quantum computers.

Research Topics

High-precision calibration system for the sphericity of the reference spherical lenses' surface profile

KAWASHIMA Natsumi, KONDO Yohan, HIRAI Akiko, BITOU Youichi

As high-precision optical elements are manufactured in industry and science, high-precision measurement of the deviation from the ideal spherical surface (sphericity) is required. Spherical Fizeau interferometers are widely used for evaluation of sphericity. The measurement result is the sum of the deviations of the test surface and the reference surface from each ideal sphere surface. Therefore, the absolute surface profile of the reference sphere should be calibrated. The sphericity calibration accuracy of the reference spherical lens is the bottleneck of the measurement accuracy of the spherical Fizeau interferometer. The sphericity of the reference spherical lens is about λ/50 (approx. 13 nm) to λ/20 (approx. 32 nm) at commercial lens production sites, and the calibration measurement capability required by the NMIJ is λ/100 (approx. 6 nm). The NMIJ has introduced the random ball method for reference spherical lens calibration, and furthermore, has established an uncertainty evaluation method by analyzing the measurement errors due to misalignment in detail. NMIJ has developed a system that can calibrate the sphericity of the reference spherical lens surface with an expanded uncertainty of 4.3 nm.



Schematic image of sphericity calibration system

Reference:
N. Kawashima et al., *Opt. Lasers Eng,* **184**, 1, 2025
https://doi.org/10.1016/j.optlaseng.2024.108646

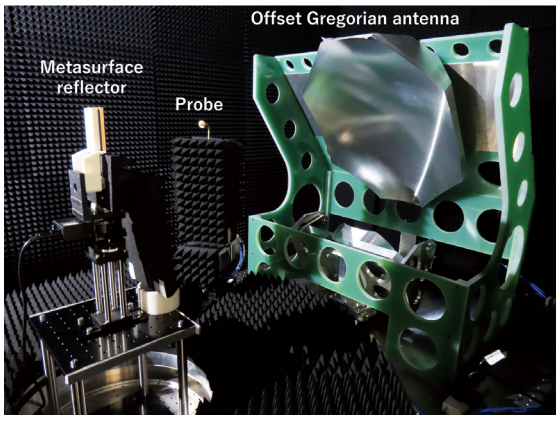
https://www.aist.go.jp/aist_e/list/latest_research/2024/20241227/en20241227-2.html

Characterization and design optimization technologies of metasurface reflectors for terahertz communications

KATO Yuto

In next-generation 6G communications, terahertz waves are expected to enable ultra-high-speed and large-capacity wireless communications. Metasurface reflectors, which efficiently redirect incident waves into specified directions, have attracted significant attention for coverage expansion. However, in the terahertz band, the reflector size becomes extremely large relative to the wavelength, making accurate performance characterization under plane-wave illumination, equivalent to practical use conditions, particularly challenging.

To address this issue, we developed a compact reflector characterization system based on a compact antenna test range (CATR) with an offset Gregorian antenna. This system generates a quasi-plane wave and enables precise far-field characterization of metasurface reflectors within a compact setup. Using this approach, we fabricated and characterized a dual-band metasurface reflector operating at 220 GHz and 293 GHz. The measured results confirmed strong anomalous reflections in the designed direction, demonstrating reflection characteristics consistent with the simulations and validating the effectiveness of the characterization system.



Photograph of the developed characterization system for the metasurface reflector

Furthermore, we are addressing the explosive growth of design freedom for large-area metasurfaces by developing efficient optimization frameworks using quantum and quantum-inspired annealing. These foundational technologies are expected to accelerate the advancement and practical deployment of metasurface reflector technologies for terahertz communications.

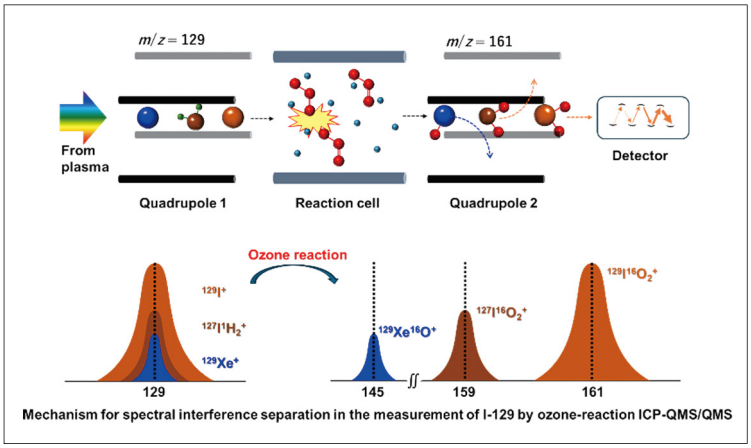
Reference:
[1] Y. Kato, M. Ameya, M. Tezuka, H. Kobuke and A. Sanada, "220/293 GHz Dual-Band Anomalous Reflectors Using Higher-Order Diffraction Modes and Their Precise Characterization Using a Compact Antenna Test Range System," *IEEE Access*, **vol. 11**, pp. 139295-139305, 2023.
https://ieeexplore.ieee.org/document/10348588

[2] Y. Kato, M. Ameya, R. Shimasaki and A. Sanada, "Beam Forming Design of Anomalously Reflective Metasurface Based on Quantum Annealing," 2025 19th European Conference on Antennas and Propagation (EuCAP), Stockholm, Sweden, 2025, pp. 1-4.

Development of ozone reaction technique for determination of ultra-trace radioactive iodine

ZHU Yanbei , ASAKAWA Daiki

Radioactive iodine (I-129, half-life time 15.7 Ma) is one of the radioactive nuclides covered by the World Health Organization's (WHO) Drinking Water Quality Guidelines. As a result, analytical techniques are required to determine I-129 at extremely low concentrations to fulfill the regulation at the guideline level in drinking water, i.e. 1 Bq/L (equivalent to 152 ng/L). Inductively coupled plasma mass spectrometry (ICP-MS) is a candidate technique for determining low-concentration I-129, as well as a versatile analytical technique for analyzing various chemical elements in research fields such as the environment, food, and energy. However, the measurement of I-129 by ICP-MS is affected by spectral interference from the dihydride of non-radioactive iodine (I-127) and a xenon isotope (Xe-129), both of which have the same mass-to-charge ratio as I-129 (m/z = 129). Mathematical-based interference correction is usually required, which results in insufficient precision and accuracy for determining I-129 at the guideline level. Therefore, NMIJ developed a unique ozone reaction technique and applied it to tandem quadrupole ICP-MS (i.e., ICP-QMS/QMS), which helps taking full advantage of molecule-ion reactions to efficiently resolve the spectral interference problem in I-129 measurement. Direct determination of I-129 at extremely low concentration was achieved with a lower limit of detection of 60 pg/L. The blank value was reduced to approximately one hundredth compared with those reported so far. We are currently working to popularize this technology through collaboration with related organizations.



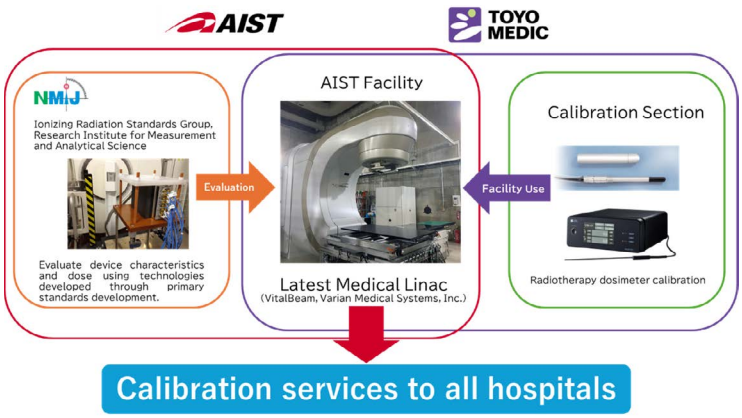
Mechanism for spectral interference separation in the measurement of I-129 by ozone-reaction ICP-QMS/QMS

Reference:
Y. Zhu, D. Asakawa, *iScience*, **27**, 11138, 2024
http://doi.org/10.1016/j.isci.2024.111138

JCSS calibration service for radiotherapy dosimeters utilizing AIST facility

SHIMIZU Morihito

Radiation therapy, which treats cancer by irradiating tumors with high-energy photon and electron beams generated by medical linear accelerators, is performed at more than 800 facilities, treating approximately 250,000 patients annually in Japan. In April 2025, a new JCSS calibration service for radiotherapy dosimeters—used for clinical dose measurements during radiation therapy—was launched. This service is expected to reduce uncertainties in dose measurements at radiation therapy facilities, thereby enhancing the reliability and safety of radiation therapy.



Calibration Service Provided through Collaboration between AIST and Toyo Medic Co., Ltd.

This JCSS calibration service was made possible through the use of medical linear accelerator facility, whose radiation doses and characteristics have been accurately evaluated based on research conducted by NMIJ. Companies can access this facility under AIST's facility utilization program. By leveraging this program, other companies can also utilize AIST's other facilities including NMIJ's research outcomes, to deliver higher-quality products and services.

If you are interested in this opportunity, please feel free to contact NMIJ.

Reference (in Japanese):
https://www.aist.go.jp/aist_j/press_release/pr2025/pr20250214/pr20250214.html

Featured Topics

Report on the Emerging Scientist Workshop (ESW) 2025

The Annual Japan-China-Korea Emerging Scientist Workshop (ESW), attended by young researchers from the national metrology institutes of Japan, China, and South Korea, was held in Matsumoto City, Nagano Prefecture, for three days from June 3–5, 2025. The ESW is an annual workshop held in rotation by NMIJ, the Korea Research Institute of Standards and Science (KRISS), and the National Institute of Metrology of China (NIM). This year's event (ESW2025) was hosted by NMIJ and attended by 54 participants (53 in-person and 1 online), including young researchers, invited speakers, the scientific committee, and staff. Through oral presentations, poster presentations, and group discussions on four different topics, lively exchanges of opinions were achieved. During the workshop period, the participants experienced the history of Japanese measurement and historical measurement instruments through technical tours of the Toyo Measurement-Equipment History Museum, which even deepened the friendship among participants. Invited lectures by internationally recognized senior researchers from each participating institution, held on the final day, were believed to deeply inspire the participants to consider their future career development, which made the workshop meaningful.

Renewal of MOU between National Institute of Metrology Thailand (NIMT) and NMIJ

On August 1, 2025, NMIJ and the National Institute of Metrology Thailand (NIMT) renewed their Memorandum of Understanding (MOU) on research cooperation. This MOU is a renewal of the MOU newly established in 2020 based on the Letter of Intent (LOI) on research cooperation concluded in 2015. The MOU was reconfirmed by both institutions based on discussions held when a delegation led by Pornchai Suteerakune, Director of NIMT, visited NMIJ on April 11, 2025. This MOU is expected to strengthen the ongoing cooperative relationship between the two institutions in the field of metrological standards.

USUDA Takashi
Director General, NMIJ

Pornchai Suteerakune
Director, NIMT

Hosting the CCRI Section I Meeting and Joint Workshops among NMIJ, CCRI and F-REI

The Consultative Committee for Ionizing Radiation (CCRI) is one of the consultative committees established under the International Committee for Weights and Measures (CIPM) and works to enhance international reliability in radiation standards and measurements. The biennial meeting of CCRI Section I (CCRI(I)), responsible for quantities related to X-ray, gamma-ray, and charged particles, was held on September 17 and 18, 2025, at Maruya Grande in Minamisoma City, Fukushima Prefecture. Thirty-six participants attended in person from overseas, along with four Japanese participants and twenty participants joined the meeting online. To coincide with the meeting, CCRI workshops were held on September 15 and in the morning of the16th, followed by an international workshop titled “Medical Applications of Radiation and Metrology Standards” on the afternoon of the 16th, jointly organized by NMIJ, CCRI, and the Fukushima International Research and Education Institute (F-REI). Presentations were given by Dr. Koetsu Yamazaki, President of F-REI; Dr. Seigo Kinutani from F-REI; Dr. Hideyuki Mizuno from the National Institute for Quantum Science and Technology (QST); Dr. Duncan Butler and Dr. Malcolm Macween, Chair of CCRI(I), from CCRI; and Dr. Masahiro Kato, Group Leader of the National Institute of Advanced Industrial Science and Technology (AIST). There was a lively exchange of views on the recent applications of radiation in medicine and the contributions of measurement standards. Approximately 80 participants attended on-site, with about 120 joining online. The workshop program is available at the following website: https://www.f-rei.go.jp/activity/9_16_f-rei_ccri.html

Following the conclusion of the meeting on September 19, participants visited the Great East Japan Earthquake and Nuclear Disaster Memorial Museum and the Fukushima Daiichi Nuclear Power Station. This tour deepened their understanding of the details of the accident and the current state of recovery efforts.

20th KRISS-NMIJ Summit

NMIJ and Korea Research Institute of Standards and Science (KRISS) participated in the 20th KRISS-NMIJ Summit, held on June 12–13, 2025, at the Daejeon Convention Center (DCC), Daejeon, Korea.

This annual meeting between the national metrology institutes of Korea (KRISS) and Japan (NMIJ) aims to share research updates on measurement standards and explore ways to expand bilateral and multilateral cooperation.

Delegations from KRISS, including the President and Directors, and from NMIJ, including the Director General and Directors, discussed a range of topics, such as updates on the cooperation package.

During the summit, both parties agreed to collaborate in specific areas. These initiatives are expected to further strengthen technical exchanges between the two institutes.

Group photo of the 20th KRISS-NMIJ Summit

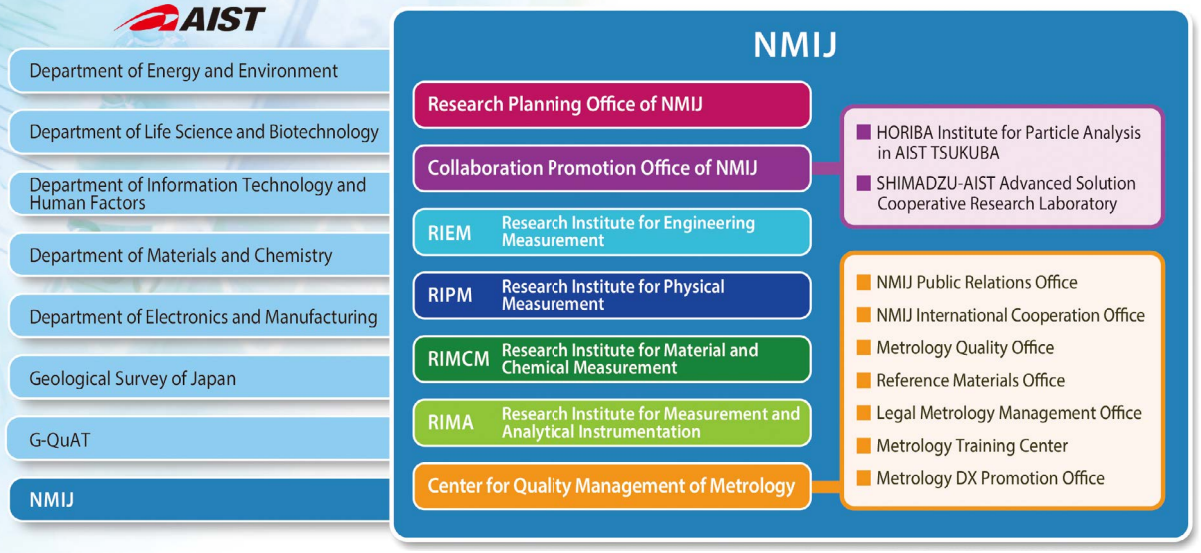
KRISS Holds the 20th KRISS-NMIJ Summit

- Expanding Joint Research for Emerging Needs in Global Measurement Standards **-**

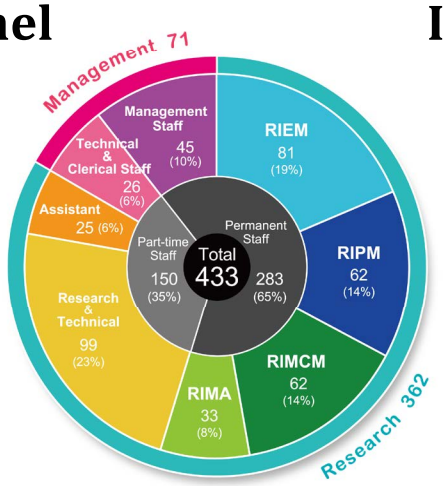
https://www.kriss.re.kr/gallery.es?mid=a20302000000&bid=0017&list_no=4922&act=view

Fact sheet

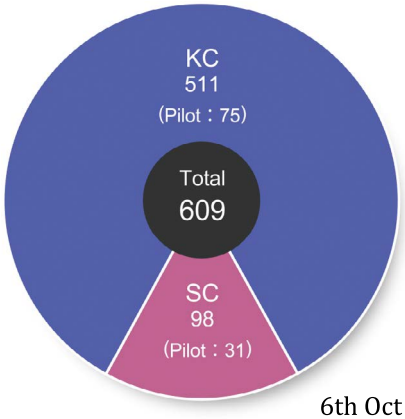
NMIJ: A Metrology Center within AIST



Personnel



International Comparison



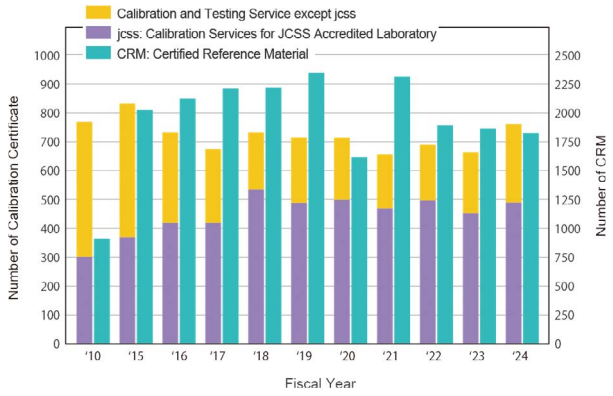
6th Oct 2025

Public Service

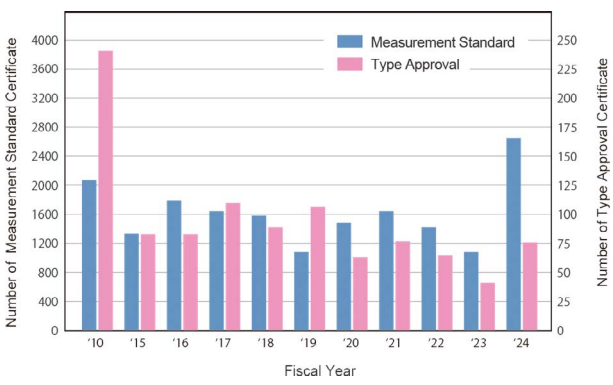
jcss: Calibration service for JCSS accredited laboratory

JCSS: Japan Calibration Service System consists of the measurement standards provision system and the calibration laboratory accreditation system introduced by the amended Measurement Act enforced in November, 1993.

Calibration, Testing Service and Reference Material Production



Metrological Service for Legal Metrology



**Edited and issued by NMIJ International Cooperation Office (NMIJ ICO),
National Metrology Institute of Japan (NMIJ),
National Institute of Advanced Industrial Science and Technology (AIST)**

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