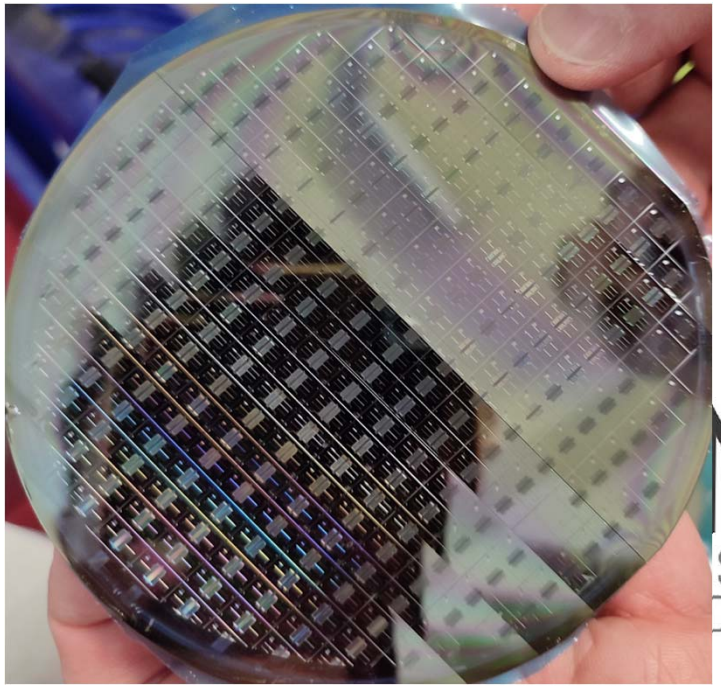
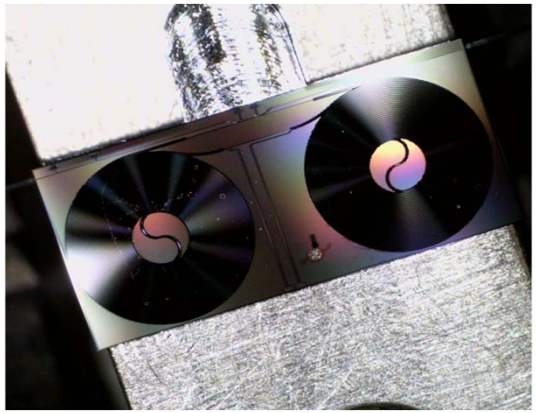




Relazione consuntiva di attività scientifica 2025

Davide Calonico

April 13th, 2026

INRiM's missions and 2025 results

INRiM missions

- Research institute supervised by the MUR (publications, VQR) → **FIRST MISSION**
- Metrological institute under the Metro Convention (standards, services, innovation) → **SECOND MISSION**
- Technology transfer: activities to be expanded and enhanced (important steps in 2025) → **THIRD MISSION**

Organizational growth: 45 new permanent hires, expansion of the Central (Sesto Fiorentino) and Southern (Matera) sites.

Infrastructures and strategic projects: FOREST (ESFRI 2026 Roadmap candidate) with a key role played by **IQB**, **QUAMT-ITA** (Italian quantum metrology), **PiQuET+** project (funded by PPOR-FESR); "Stati Generali del Quantum" event

Organization of scientific conferences and public engagement activities: science outreach to schools and the general public, international conferences "Quantum 2025" (300 participants) and HMM (70 participants).

The 2025 report shows a consolidated institution with excellent performances.

Future challenges: increasing scientific excellence (IF > 8), greater attention to collaboration with industry, and developing value-added services.

INRiM monitors its growth through the following metrics (2025 data):

Scientific output: 1,1 publications/research employee (176 people), with a strong concentration (42%) in high-impact journals (IF > 5).

Funding attractiveness: excellent capacity, equal to approximately €165,000/employee (296 people).

Metrological services: valued at approximately €5,500/employee (296 people).

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

SCIENTIFIC ACTIVITY

In 2025, the **main research lines** were developed, in line with the Vision Document and the 2021-2027 National Research Council (NRC) Plan, within the three INRiM Divisions.

Metrology of Innovative Materials and Life Sciences (ML) develops and maintains national electrical, magnetic, and acoustic standards, ensuring the international traceability of measurements. Its activities include metrology for health, energy, and innovative materials (including quantum and memristive technologies), with a focus on environmental sustainability and magnetic materials.

Applied Metrology and Engineering (AE) ensures traceability for mechanical, thermodynamic, and electrical quantities, offering calibration services and support to industry, particularly in the aerospace sector. It is also a WMO reference center for climate monitoring and develops research on energy efficiency, hydrogen, and applications of artificial intelligence and machine learning.

Quantum Metrology and Nanotechnologies (QN) creates and maintains primary electrical, photometric, and time/frequency standards, including the UTC(IT) scale, also contributing to the Galileo system. It manages strategic infrastructures and conducts research ranging from quantum electronics and optics to atomic clocks, metrology for food safety, and energy and environmental technologies.

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

INFRASTRUCTURES

INRiM is strongly committed to the design, development, and management of excellent research infrastructures, both nationally and internationally.

Infrastructures directly coordinated by the Institute include:

Galileo Timing Research, which supports the Galileo system with time metrology expertise and the development of new timing services;

Italian Quantum Backbone, a fiber-optic network for the distribution of high-accuracy time and frequency signals and for experimentation in quantum technologies;

IMpreSA, dedicated to metrology for food safety and regulatory compliance;

PiQuET, an infrastructure shared with PoliTO and UniTO for micro/nanofabrication and integration of innovative devices and materials;

QuaMT-ITA, focused on certification in quantum technologies and support for industry.

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

RESEARCH LABS

INRiM also participates in important European and national initiatives and networks, including EURAMET for European metrology cooperation, EuroQCI for quantum communications, iENTRANCE for the energy transition, and Metrofood-RI/IT for advanced metrology services in the agri-food sector.

INRiM has a comprehensive network of laboratories:

Metrology of innovative materials and life sciences (ML): 17 laboratory groups, dedicated to micro- and nanofabrication, nanophotonics, neuromorphic and quantum devices, innovative materials, high voltages, EM devices and storage, magnetic resonance tomography, electromagnetic fields, ultrasound, MEMS microphones, biometrology, computational modeling, materials and magnetic fields.

Applied Metrology and Engineering (AE): 18 laboratory groups dedicated to primary standards (length and angle, mass and related quantities, stress and resistance, temperature and humidity), metrological services, stress and high currents, geophysics, space sensors, optical interferometry, mechanical and topographical properties of surfaces, thermometric methods, thermophysical properties and metrology of energy carriers, climate and environment, gas analysis, mathematics and machine learning.

Quantum Metrology and Nanotechnology (QN): 16 laboratory groups dedicated to electrical, radiometric, and time and frequency quantities, physical chemistry, chemical and biological analysis, vibrational spectroscopy, quantum and electrical standards, quantum circuits, quantum optics and communication systems, nanodiamonds, photometry, atomic frequency standards, and satellite systems.

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

Metrologia dei materiali innovativi e scienze della vita (ML)

Natascia De Leo

SSO	**Scienza e tecnologia alla nanoscala** L. Boarino dal 21/10/2025 N. De Leo fino al 20/10/2025	**Campi e sistemi elettromagnetici** M. Zucca	**Acustica e ultrasuoni** G. Durando	**Scienze e tecnologie biomediche** A. Manzin	**Magnetismo, materiali e spintronica** M. Coisson dal 21/10/2025 G. Durin fino al 20/10/2025
Ambiti di ricerca	Digitale, industria, aerospazio / Bioeconomia, risorse naturali, ambiente / Clima, energia, mobilità sostenibile / Salute / Ricerca fondamentale	Salute / Digitale, industria, aerospazio / Clima, energia, mobilità sostenibile / Metrologia primaria	Salute / Metrologia primaria / Digitale, industria, aerospazio	Salute / Digitale, industria, aerospazio / Bioeconomia, risorse naturali, ambiente	Digitale, industria, aerospazio / Clima, energia, mobilità sostenibile / Ricerca fondamentale
Laboratori	Micro-nanofabbricazione e caratterizzazione di materiali innovativi e dispositivi per la nanofotonica, l'energia, la salute e la computazione neuromorfica	Laboratori per taratura e sperimentazione per alte tensioni e forti correnti / Laboratori campi magnetici ed elettrici ac e CEM di riferimento / Laboratori MRI, Phantom e modelli / Laboratorio dispositivi EM e storage / Servizi metrologici	Riferimenti primari di potenza ultrasonora e di pressione sonora / Servizi metrologici / Sistemi d'insonazione ultrasonora utilizzati in ambito BioMed sia *in vitro* che *in vivo*	Tecniche di misura e di microscopia, strumenti computazionali e sistemi di AI per applicazioni in ambito biomedicale e nelle scienze della vita	Preparativa e caratterizzazione materiali magnetici e dispositivi / Servizi metrologici
Infrastrutture INRiM *	QuaMT-ITA / PiQuET		PiQuET	IMPreSA	QuaMT-ITA / PiQuET
Infrastrutture nazionali e internazionali *	Euramet	Euramet / EURONANOLAB iEntrance	Euramet	Euramet / ESFRI Metrofood / IR PNRR Metrofood	Euramet / EURONANOLAB iEntrance
EMN	Advanced Manufacturing / Quantum Technologies / Clean Energy	Smart Electricity Grids / Mathematics and Statistics	Pollution Monitoring	Traceability in Laboratory Medicine	Mathematics and Statistics

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

Metrologia applicata e ingegneria (AE)

Marco Pisani

SSO	**Metrologia della massa e delle grandezze apparentate** D. Mari dal 21/10/2025 A. Germak fino al 20/10/2025	**Metrologia della lunghezza** M. Zucco dal 21/10/2025 M. Pisani fino al 20/10/2025	**Misure elettriche ed elettroniche** P.P. Capra	**Termodinamica fisica** R.M. Gavioso	**Termodinamica applicata** C. Musacchio dal 21/10/2025 A. Merlone fino al 20/10/2025
Ambiti di ricerca	Metrologia primaria / Digitale, industria, aerospazio / Clima, energia, mobilità sostenibile	Digitale, industria, aerospazio / Metrologia primaria / Ricerca fondamentale	Metrologia primaria / Clima, energia, mobilità sostenibile / Digitale, industria, aerospazio	Metrologia primaria /Clima, energia, mobilità sostenibile / Ricerca fondamentale	Clima, energia, mobilità sostenibile, Bioeconomia, risorse naturali, ambiente
Laboratori	Campioni primari / Laboratorio metodi innovativi per la massa e grandezze / Metrologia per la geofisica e fenomeni nano-dinamici / Metrologia delle portate e vettori energetici / Servizi metrologici	Campioni primari / Analisi delle superfici / Metrologia per lo spazio / Interferometria ottica, X e neutroni / Servizi metrologici	Laboratorio alte tensioni e forti correnti / Servizi metrologici	Campioni primari di temperatura e umidità / Metodi termometrici innovativi / Proprietà termofisiche e metrologia dei vettori energetici / Servizi metrologici	Metrologia per il clima e l'ambiente e siti di riferimento / Interazioni radiative / Materiali di Riferimento Certificati gassosi e analisi di gas / Matematica e Machine Learning
Infrastrutture INRiM *		PiQuET		PiQuET	
Infrastrutture nazionali e internazionali*	Euramet	Euramet	EURONANOLAB iEntrance	EURONANOLAB iEntrance / Euramet	Euramet
EMN		Advanced Manufacturing		Climate and Ocean Observation / Energy Gases / Clean Energy	Climate and Ocean Observation / Mathematics and Statistics

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

Metrologia quantistica e nanotecnologie (QN)

Filippo Levi

SSO	**Chimica fisica e nanotecnologie** A.M. Rossi	**Elettronica quantistica** L. Callegaro	**Infrastrutture interdivisionali di ricerca** G. Aprile dal 21/10/2025 D. Calonico fino al 20/10/2025	**Ottica quantistica e fotometria** M. Genovese	**Tempo e frequenza** I. Sesia dal 21/10/2025 F. Levi fino al 20/10/2025
Ambiti di ricerca	Salute / Bioeconomia, industria, risorse naturali, ambiente / Metrologia primaria	Digitale, industria, aerospazio / Clima, energia, mobilità sostenibile / Metrologia primaria / Ricerca fondamentale	Digitale, industria, aerospazio / Bioeconomia, risorse naturali, ambiente / Salute / Metrologia primaria / Clima, energia, mobilità sostenibile	Digitale, industria, aerospazio / Metrologia primaria / Ricerca fondamentale	Digitale, industria, aerospazio / Metrologia primaria / Ricerca fondamentale
Laboratori	Analisi chimiche e biologiche / Spettroscopia vibrazionale per analisi di micro/nanoncontaminanti e caratterizzazione film sottili / Servizi metrologici	Campioni quantistici e campioni nazionali elettrici / Power and energy / Circuiti quantistici / Servizi metrologici	Laboratori micro e nanofabbricazione in camera pulita / Laboratori per la metrologia alimentare / Servizi metrologici	QKD / Ottica quantistica / Nanodiamanti. Radiometria/fotometria / Servizi metrologici	Scala di tempo / Campioni atomici di frequenza / IQB e sensing in fibra / Sistemi GNSS / Servizi metrologici
Infrastrutture INRiM *	IMPreSA	QuaMT-ITA / PiQuET	IMPreSA / PiQuET	IQB / QuaMT-ITA / PiQuET	IQB / Galileo / QuaMT-ITA / PiQuET
Infrastrutture nazionali e internazionali *	ESFRI Metrofood / IR PNRR Metrofood / Euramet	Euramet / EURONANOLAB iEntrance	EURONANOLAB iEntrance / Euramet	EuroQCI / Euramet / EURONANOLAB iEntrance	EuroQCI / Euramet / EURONANOLAB iEntrance
EMN	Safe and Sustainable Food	Quantum Technologies / Smart Electricity Grids	Quantum Technologies / Safe and Sustainable Food / Advanced Manufacturing	Quantum Technologies	Quantum Technologies

INRiM
ISTITUTO NAZIONALE DI RICERCA METROLOGICA

HIGHLIGHTS 2025: Ricerca e Sviluppo (R&S)

TWO active ERC :
MEMBRAIN (neuromorphic computing)
ERC 3DnanoGiant (non linear photonics materials)

MATERIALS

The development of smart materials is of great interest for the energy transition and environmental sustainability**. Magnetostrictive FeGa films have been coupled to a liquid crystal network capable of deforming under exposure to light.**

NEW MEASUREMENT CAPABILITIES

Research in thermodynamics **reduced the uncertainty of the thermodynamic model of the speed of sound in humid air by more than an order of magnitude**. Experimental verification, surpassing current limitations in the environmental, geodetic, and industrial fields.

An NMR relaxometry laboratory has been set up to measure the relaxation times of liquid or gelatinous materials. Using an NMR magnet with a variable magnetic field ranging from 0.5 T to 3 T, the traceability of T1/T2 measurements of qMRI (quantitative Magnetic Resonance Imaging) phantoms is being defined. **An initial interlaboratory comparison has been initiated with over 60 national hospitals as part of the project involving MIMIT, ENEA, and INRIM.**

QUANTUM OPTICS

F. Picariello, et al., Quantum super-resolution microscopy by photon statistics and structured light, Optica 12(4), 490 (2025). **Excellent super-resolution achieved by coupling structured light with both sub- and super-Poissonian emitters,** experimentally demonstrating the advantages (quantum dots).

METROLOGY MINIATURIZATION

M. Gozzelino, et al., Activation and characterization of Rb MEMS cells with an automatic system at wafer level, Sensors & Actuators: A. Physical 391 (2025).
The **publication, supported by Cleanroom PiQuET**, addresses the **miniaturization of optical clocks** through the development of microcells.

Acoustic monitoring is increasingly important for assessing the impact of infrastructure on noise. **Low-cost methods have been developed to improve the reliability and accuracy of MEMS microphones used in environmental networks, including through two projects** (Autostrada del Brennero S.p.A. and the NEXT-GEN project), which have highlighted the potential of piezoelectric MEMS transducers for widespread noise monitoring.

In metrology supporting the aerospace and geodesy industries, the **ESA "LIG-on-a-chip" project has been completed. The project, in collaboration with the Bruno Kessler Foundation, involves the design, construction, and characterization of an interferometer built on a chip using integrated photonics technology**. The produced chips have demonstrated the ability to produce a heterodyne interferometer signal with a displacement resolution of 300 pm/√Hz for a Fourier bandwidth greater than 1 Hz.

INRiM
ISTITUTO NAZIONALE
RICERCA METROLOGICA

HIGHLIGHTS 2025: Ruolo Istituto Metrologico Primario (NMI)

T. Lindvall, M. Pizzocaro et al., Coordinated international comparisons between optical clocks connected via fiber and satellite links, Optica 12, 843 (2025).
International collaboration as a jkey-contribution to the **roadmap towards the redefinition of the second**

A.M. Giovannozzi et al, Interlaboratory Comparison Reveals State of the Art in Microplastic Detection and Quantification Methods, Analytical Chemistry (2025).
Global interlaboratory comparison (**84** international laboratories) for state-of-the-art detection and metorlogy of microplastic in environement and food.Use of VAMAS TWA45 platform, INRIM coordination, project Plastic Trace.

The Stupinigi CRS climatological station (Turin) has been included in the WIGOS (**WMO Integrated Global Observing System**) and the ORCAR database. The station is part of the WMO Measurement Lead Center "Traceability and Field Metrology" at INRiM, which in 2025 completed the "EDDIE" tunnel, adding a solar simulator to test the effect of radiation on thermal-environmental measurements.

Velocimetry applied to microsystems for biological applications: realized a system for the determination of micro and nano-dynamic oscillatory phenomena, which allows to measure vibrations up to 24 MHz, and is applied for the determination of the effective flexural and torsional elastic constants of cantilevers used in Atomic Force Microscopy.

M. Marzano, et al, An International Trilateral Comparison Among the Newest Generations of Digital and Josephson Impedance Bridges, IEEE Trans. on Instrumentation and Measurement, 74 (2025).
First international mutual validation of digital impedance bridges (both electronic and Josephson Array Waveform Synthesizer sources), carried out in situ by physically moving the measuring bridges at METAS (Swiss Metrology Institute).

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

HIGHLIGHTS 2025: Knowledge Transfer (KT) / Knowledge Dissemination

The PNRR METROFOOD-IT project developed **a digital platform for the dimensional and morphological analysis of microplastics in food, environmental, and biological samples**. This tool allows for fully automated processing of images acquired with optical microscopy, enabling the segmentation of irregularly shaped particles and particles within aggregates. The service integrates traditional computer vision methods with a trained and validated neural network model.

Two patents have been filed in the field of hardness measurement: 1) an optical-interferometric primary measuring system for the geometric characterization of diamond indenters; 2) a new master microhardness tester. Exploitation is planned through commercial agreements with LTF SpA (Bergamo).

As part of the IMPreSA research infrastructure, a collaboration was initiated with a major food industry company to develop an analytical methodology for protein bars. The work involved the development of the entire protocol, from protein extraction from a complex matrix to the characterization and quantification of individual proteins. The method was validated on samples and subsequently applied to commercial products.

The **international conference "Quantum 2025** – Advances in Foundations of Quantum Mechanics and Quantum Information with Atoms and Photons" (in collaboration with the University of Turin, the University of Bari, and the National Institute for Nuclear Physics), **300 researchers attending in Turin**.
The **14th international symposium on Hysteresis Modeling and Micromagnetics (HMM) organized by INRiM, 70 international researchers** attending in Turin.

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

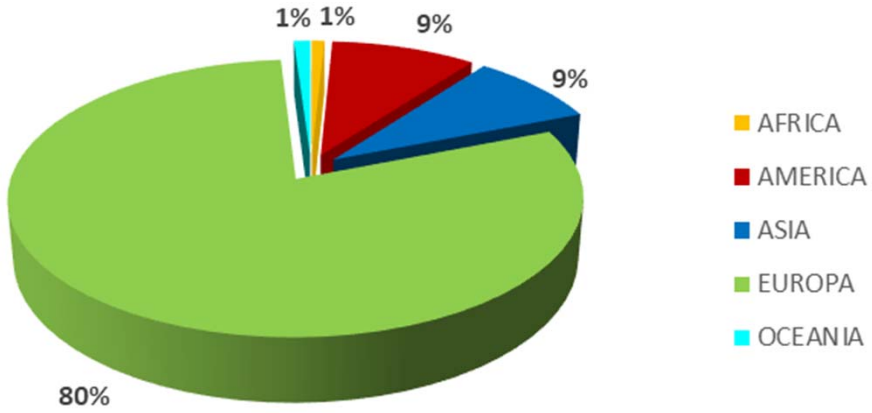
2025 COLLABORATIONS: NATIONAL AND INTERNATIONAL

Collaboration with 221 national bodies:

- 94 public research /academia
- 15 public bodies
- 57 others e.g. foundations, consortia
- 55 national companies

Collaboration with >800 international bodies:

- 72 other NMIs and DIs
- 513 public research /academia;
- 74 others e.g. foundations, consortia
- 180 international companies

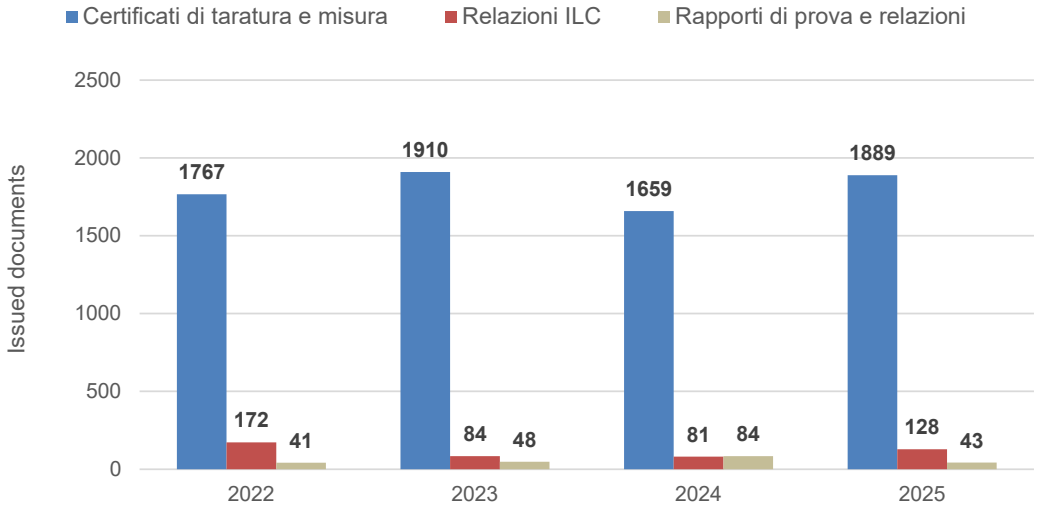


INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

CMC AND METROLOGICAL SERVICES

Aree metrologiche	2022	2023	2024	2025
Acustica, Ultrasuoni e Vibrazioni	42	41	41	41
Chimica	10	10	12	13
Elettricità e Magnetismo	140	135	135	137
Lunghezza	51	51	51	51
Massa e grandezze apparentate	63	64	71	84
Fotometria e radiometria	17	17	17	15
Termometria	111	111	111	111
Tempo e frequenza	10	10	10	10
Totali	**444**	**439**	**448**	**462**

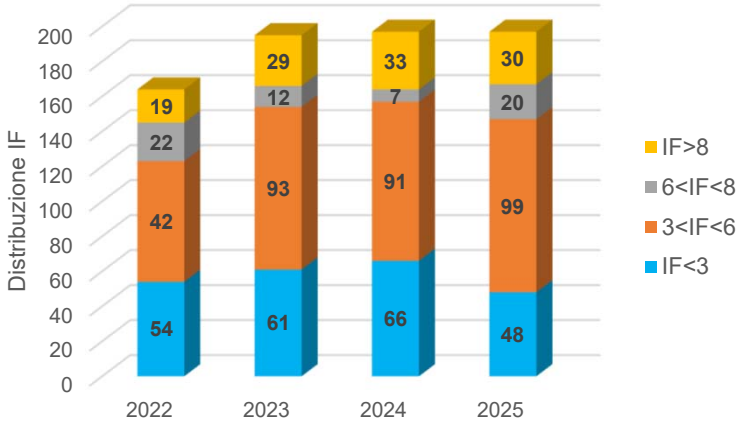
Calibration and Measurement Capabilities (CMC) dell'INRiM

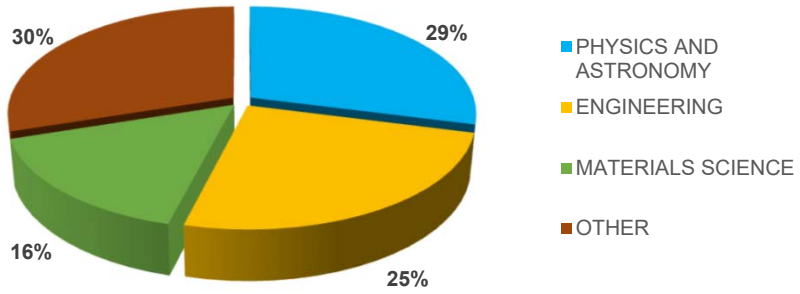


Considering a total income from certification of about 1.7 M€ in 2025, the value corresponds to a value of **about 5,500 euro/employee**.

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

PUBLICATIONS





The number of publications with IF in 2025 (197)* is constant compared to the 2024 value**,** while **the average Impact Factor of publications** in indexed journals **is 5.4**, a slight but significant increase (+4%).

Considering 176 researchers and technologists (both fixed-term and permanent) and 197 publications with IFs, in 2025 INRiM has **1.1 publications/employee.**

The dominant thematic areas are in Physics, Engineering, and Materials**.**

*** Consolidated after the latest update of the databases (Scopus, WoS, Metrica)**

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

PUBLICATIONS

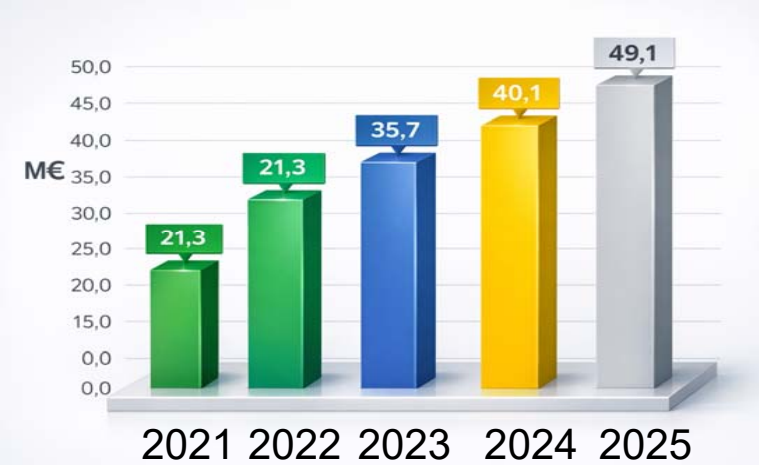
The following table reports the number of INRiM publications in 2025, taking into account the different typologies.

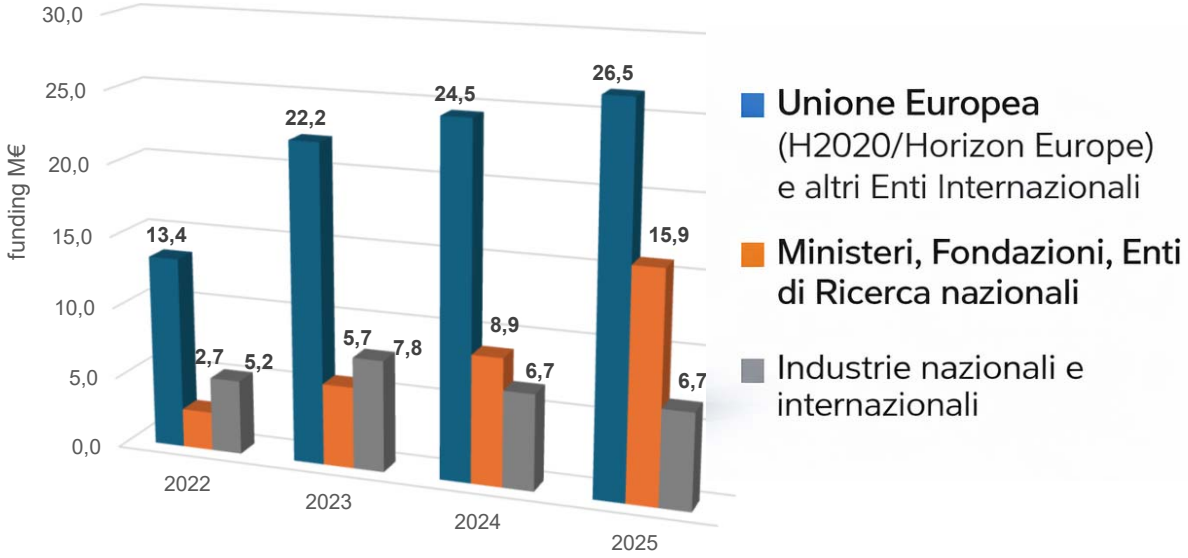
Typologies	2022	2023	2024	2025
Monographs / book chapters	7	4	1	**4**
Articles in indexed journals *(average of IF)*	175*(5.7)*	205*(5.5)*	208*(5.2)*	**202*(5.4)***
Articles in non-indexed journals	7	6	6	**8**
Conference proceedings articles (indexed and non-indexed)	55	77	73	**91**
Technical reports/project reports/guides	54	48	48	**47**
Totals	**298**	**340**	**336**	**352**

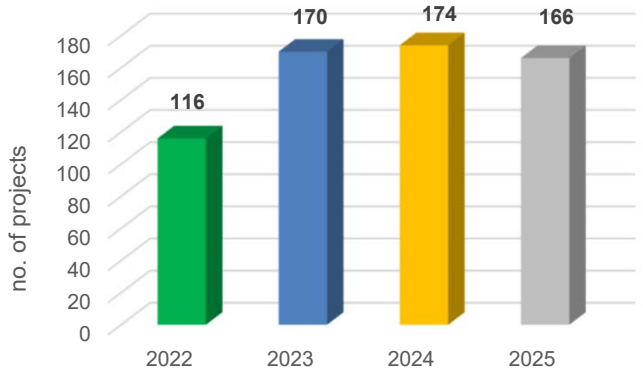
INRiM, through the work of the **Open Science Group**, promotes the culture and practice of Open Science among its community, and supports the openness of scientific publications, data, and software, according to the principle of "As open as possible, as closed as necessary."

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

FUNDING







The number of projects in 2025 remained constant.
The graphs show a **significant increase in funding obtained (€M), rising from €40.1 to €49.1 million** between 2024 and 2025. **The amount of external funding** for research activities per employee in 2025 **will reach approximately €165,000 per employee.**

INRiM
ISTITUTO NAZIONALE DI RICERCA METROLOGICA

THIRD MISSION

Technology Transfer and UTT: the goal is to strengthen the research-industry link.
2025 Results: MIMIT funding (**PoTeMi project**), consolidation of the UTT structure, filing of **5 new patents**, **review of 12 Non-Disclosure Agreements** (NDAs) for project collaborations, front-office consulting services, technology scouting and promotion of collaboration with the industrial sector, **launch of 1 spin-off** (completion expected in 2026).
Public Engagement activities: management and development of the Institute's corporate image, communication of events organized or attended by the Institute, management of media relations, drafting and disseminating press releases, design and implementation of 16 communication campaigns, organization of events and school visits **(Domenica in scienza**), organization of conferences **(Quantum 2025** and **HMM**).
Higher education: doctoral scholarships and curricular internships (collaboration with PoliTO and UniTO), university teaching (12 courses for which INRiM researchers are course lecturers), advanced training schools (**International School "Quantum Timekeepers 2025"**, **Varenna Summer School for Metrology**).
Continuing professional development: courses, seminars, and workshops for the acquisition and development of specific professional skills (**Accredia Academy Summer School**), training of students and young researchers through seminars or lessons outside of institutional university curricula (**School on Nanotechnologies**, **METROFOOD-IT Summer School**)

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

Thank you!

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA