

Introduction

The Italian NMI structure includes ENEA-INMRI, for ionizing radiation-related quantities, and INRiM for the base SI units and several more. Interlaboratory Comparisons (ILCs) are regularly offered by both institutes and as recognized methods to assess the capabilities of a laboratory to carry out a calibration service according to ISO 17025. These capabilities include the correct use of traceability, the use of adequate methods, and the proficiency of the staff involved in all operations such as handling, measurements, data management, and reporting.

In 2021-2022, ENEA-INMRI carried out the first National Program for the Promotion of Measurement Reliability in the field of measurements related to the use of Ionizing Radiation, funded by the Ministry of Economic Development (MISE, now Ministry of Enterprises and Made in Italy, MIMIT). This first National Program was highly successful, with a large number of both public and private entities and 6 ILCs offered for a total of ~150 participants. The topics covered environment, protection of human health including medical applications of ionizing radiation, and workplace safety.

The first edition of the National Program also offered a platform for the development of new skills, and the improvement of methodologies for delivering ILCs, data management, analysis, and automated technical report generation in line with some of the new challenges of digital transformation. Comparisons were organised in innovative fields never previously offered in Italy, e.g. an ILC on the measurement of the activity/surface emission rate of wide area Sources, and an ILC on radionuclides for medical use in nuclear medicine. Based on this success, a new National Program has been funded by MIMIT for the 2025-2026 biennium.

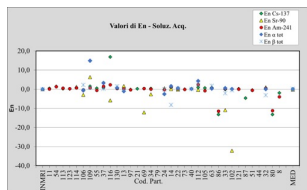
Results

The National Program on the Reliability of Ionizing Radiation Measurements, conducted in 2021-2022, covered six Interlaboratory Comparisons (ILCs), involving numerous organizations and institutes across the national territory. The analysis of the results was based on the comparison of the values of the measurands provided by each Participant with the reference values of the same measurands provided by INMRI. The deviations obtained were analysed with reference to the uncertainties reported by the Participant and those declared by INMRI. The results of the comparison were analysed in terms of indicators commonly used in evaluation tests and interlaboratory comparisons: the percentage deviation and the normalized error

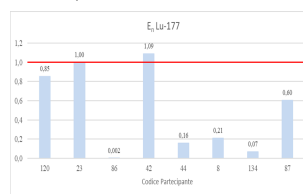
$$R = \frac{M - M_{rif}}{M_{rif}} \times 100$$

$$E_n = \frac{M - M_{rif}}{\sqrt{U^2 + U_{rif}^2 - 2U_{cp}^2}}$$

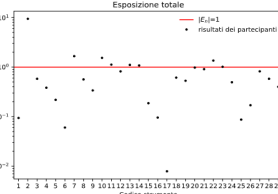
ILC1: Activity of radionuclides in an aqueous liquid solution – normalized error of the participants



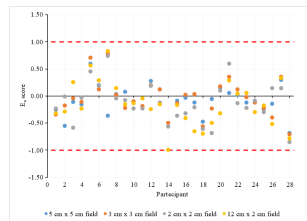
ILC2: Activity of radionuclides used in nuclear medicine



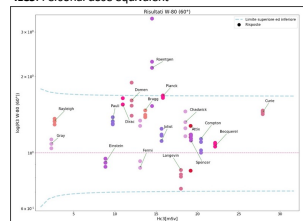
ILC3: Concentration of Rn-222 in air



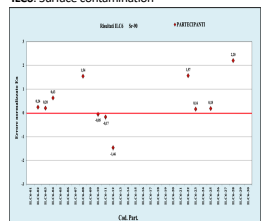
ILC4: Measurement of absorbed dose in water



ILC5: Personal dose equivalent



ILC6: Surface contamination



In radiation dosimetry, ILC4 (in dosimetry for radiotherapy focused on small photon fields) and ILC5 (personal dose equivalent, protection dosimetry) yielded very satisfactory results, and this is in line with expectations with respect to a type of interlaboratory comparison that is very widespread and frequent in our country. In the field of radioactivity, both environmental (ILC 1, 3, 6) and of medical interest (ILC 2), a few cases of failed tests were recorded, and this seems to be attributable to an incorrect estimate of the measurand, an incorrect estimate of the uncertainty, or both. However, cases of failed tests were a minority in all comparisons, and the impression of existing reliability in ionising radiation measurements in Italy remains valid.



Challenge

Based on the positive feedback received from participants a second edition of the new program was funded by MIMIT in December 2024. The new ILC National Program will consolidate or start a new path of continuous improvement in the quality of measurements and, consequently, in the services offered to citizens, broadly covering medical, environmental, and food safety applications. These new ILCs will have an impact on the national system in terms of consumers interest, regulations, accreditation, and commercial opportunities. New ILCs, not performed in Italy so far, include dosimetry in brachytherapy and in diagnostic radiology dosimetry (curated by ENEA-INMRI) and an ILC on quantitative Magnetic Resonance Imaging (curated by INRiM). Participants will receive an individual technical report. Additionally, for each ILC, a general technical report will be published with the results of the anonymized participants. Additional focus will be given to further advancing the automation of data management, minimizing the risk of management and reporting errors. The program's definition, as well as the technical protocols, are agreed upon with a Scientific Committee to highlight the country's priorities among the topics proposed by ENEA-INMRI and INRiM. The topics considered innovative and of interest for metrology are listed below.



Food

- Radionuclide activity in solid food matrices (flours, powdered milk, granular broth, feed for sheep and poultry farms).

Environmental/radiation protection

- Radon activity concentration in air/water,
- Measurement of ambient dose equivalent H*(10) in facilities with direct or indirect neutron production (e.g., high-energy radiotherapy accelerators),
- Measurement of surface contamination with extended planar sources (EPS), to be chosen in agreement with the Scientific Committee.



Medical applications (ionizing radiation):

- Nuclear Medicine with radiopharmaceuticals**
Radiopharmaceutical activity measured with well-type ionization chambers and gamma spectrometry.
- Radiodiagnostics**
Patient dosimetry with Dose-Area Product (DAP) meters on X-ray production systems for radiology.
- Radiotherapy**
Brachytherapy dosimetry in terms of the Reference Air Kerma Rate (RAKR) with Ir-192 sources.

Fig.1: Well chamber as transfer instrument in brachytherapy dosimetry



Medical application (Non-Ionizing radiation): Quantitative MRI

The Italian normative in force requires that a control quality is set-up and maintained at the hospital premises on MRI appliances, with the aim of optimizing the diagnostic process. To this aim, protocols for the quantitative evaluation of physical parameters representative of the image quality must be available. This requires periodic ILC, to check the hardware and software quality, led by the NMI and involving the hospital laboratories.

A reference system for providing the traceability to SI units of the relaxation times T1 and T2 of compounds used in MRI phantoms is planned to be built at INRiM. It will be based on a cryogen-free variable field relaxometer working in the range from 20 MHz to 130 MHz (see Fig.2a). The intercomparison will be performed using multi purpose phantoms, properly designed, realized and characterized at INRiM (see Fig.1b).

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Fig.2: Cryogen-free variable field relaxometer to be set-up at INRiM

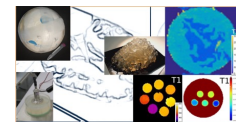


Fig.3: Example of phantoms, designed and realized at INRiM

The ILCs dedicated to medical applications will be carried on in agreement with the Italian association of medical and health physics (Associazione Italiana di Fisica Medica e Sanitaria, AIFM).

Impact

In medical applications, Program participants may include several hundred medical diagnostic laboratories and radiotherapy centres on the national territory, as well as laboratories providing environmental and personal dosimetry services. In the environmental sector, the main operators consist of the Regional Environmental Protection Agencies and the associated laboratories, the Italian Higher Institute for Environmental Protection and Research (ISPRA), nuclear operators, and measurement facilities ranging from Universities to Research Centres. An intensive, continuous, and multi-focus ILC program will positively impact the quality of life of any citizen, patient, or professional living in the monitored environment or consuming products produced in the environment itself.

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