Education in Metrology: the experience in INRIM and Politecnico of Torino

Summary Paper

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Abstract

The Politecnico of Torino University and the National Metrology Institute, INRIM, in Torino, Italy, have a variety of experience in the education in metrology for graduate and undergraduate students. A joint initiative is the PhD in Metrology, a unique experience in Italy, aiming at offering a broad education from fundamental metrology to the most recent and challenging industrial applications. Other initiatives are courses and laboratories for students, and international summer schools.

1. Introduction

The Politecnico of Torino University, (www.polito.it), and the National Institute for Metrology, INRIM, (www.inrim.it), are located in Torino, Italy, and they have a long tradition of education and training in metrology. A joint initiative dating back to 1984 is a PhD in Metrology, a unique experience in Italy, aiming at offering a broad education from fundamental metrology to the most recent and challenging industrial applications. Other initiatives are courses and laboratories for students, and international summer schools.

2. The PhD in Metrology program

Politecnico of Torino and INRIM are jointly proposing a PhD in Metrology aiming at offering advanced education in all fields of measurements, from cutting-edge frontiers of science to the challenges of a changing society. In 2014 the PhD program was reformed and renewed.

Metrology today goes from the classical physical measurements to the most modern and challenging application as medicine, health, and environment.

All the information on the PhD, including enrollment and application rules, are reported on the website [2].

Professors and researchers from Politecnico of Torino and INRIM, together with a group of experts in metrology emerging fields coming from international institutions and industries are coordinating and managing the school.

The PhD in Metrology offers education in:

- "Classic" Metrology oriented toward cutting-edge applications based on advanced quantum technologies for the development of reference samples of frequency, electrical quantities and for the measurement of the fundamental constants

- "Innovative" Metrology oriented toward the development of new fields, for the verification and certification in industrial processes and environmental impact, energy, life sciences, food, space, nanotechnology.

The programme of study is 3 years long and includes training courses, an annual evaluation, preparation of a doctoral research thesis, and a final exam.
The admission is obtained through a competitive process and the successful candidates can receive a 3 year scholarship. A Master of Science degree is required and a certificate of competence in English is mandatory.

At the end of the PhD in metrology, the students are prepared for a career in the university, in international research centres and industries. The student research activity is often included in EU and international projects such as those belonging to the European Metrology Programme for Innovation and Research (EMPIR). EMPIR is the main programme for European research on metrology. It coordinates research projects to address grand challenges, while supporting and developing the SI system of measurement units.

https://www.euramet.org/research-innovation/empir

Since 2014 the PhD in Metrology has offered about 10 scholarship a year and additional scholarships were made available by external entities as the Institute for Technology in Italy, IIT (www.iit.it), the European Union, through the EMPIR program, and the Italian Ministry of Education.

The educational classes offered by the PhD program are of two types and listed here:
http://dottorato.polito.it/mlg/en/course_catalogue

They include:

1. Soft skills: including entrepreneurship, intellectual property rights, how to write a paper, how to prepare a speech. These classes are common to all the Politecnico PhD programs

2. Hard skills related to the Metrology topics as uncertainty evaluation, fundamentals of metrology, atomic physics, magnetism, spectroscopic methods, nanomaterials, nanoparticles, color metrology, signal and noise, electrical impedance, thermal measurements.

The possibility for Students to carry out stage abroad is encouraged and partnership with other University in Italy and Europe is supported also allowing the Students to get a double PhD diploma in both Universities.

2. The Varenna summer schools

INRIM has a long tradition of collaboration with the BIPM and the Italian Physical Society (SIF) in organizing summer schools in Metrology. Starting from 1976, six schools on Metrology have been so far organized. They are:

Directors: A. Ferro Milone (IEN), P. Giacomo (BIPM);
Scientific Secretary: S. Leschiutta.

Metrology at the Frontiers of Science and Technology
Directors: L. Crovini (IMGC), T.J. Quinn (BIPM);
Scientific Secretary: E. Bava.

Recent Advances in Metrology and Fundamental Constants
Directors: T.J. Quinn (BIPM), S. Leschiutta (INRIM);
Scientific Secretary: P. Tavella (INRIM)

Metrology and Fundamental Constants
Directors: T.W. Hänsch (MPG), S. Leschiutta (INRIM), A.J.Wallard (BIPM);
Scientific Secretary: M. L. Rastello (INRIM)

Metrology and Physical constants,
Directors: E. Bava (INRIM), M. Kühne (BIPM)
Scientific Secretary: A. M. Rossi (INRIM)

Metrology: from physics fundamentals to quality of life
June 26 – July 6, 2016
Directors: M.Inguscio (CNR), M.Milton (BIPM), P.Tavella (INRIM)
Scientific Secretary: N. Deleo (INRIM)

The Varenna school is considered an important step in the education of the young scientists working in Metrology and it will now follow a more frequent rhythm with a
school every 2 or 3 years jointly organized by the BIPM and the INRIM.

![Image](66x613 to 260x736)

**Fig 1: The Varenna summer school of the Italian Society of Physics, on the Come Lake, Italy**

### 3. Other educational activities

In addition to the above initiative, it is worth mentioning that the Politecnico of Torino offers metrology classes at all the level of the University career, in particular:

- **For the Bachelor degree:** Specific Electronic Measurement Courses in the BSC of Electronics and Electrical Engineering. Integrated courses in the BSC Physics Engineering, Electronic and Communication Engineering, Computer science.

- **For the Master of Science degree:** Specific Sensor & Industrial Measurement Course in the MS of Electronic, Optional course in Electrical Engineering.

The courses are always supported by laboratories, where the student can test their capacity in measurement. For example under the responsibility of the Department of Electronic and Telecommunication there are:

- **Experimental Laboratories for all levels Students.**
  - Eight laboratories
  - About 100 benches
  - Room for about 380 students at the same time
  - Opening hours from 8.30 am to 7 pm
  - Days for free practice (of registered students)

- **Remote accessible laboratory for selected students of the other courses,** sponsored by POLITO under the enhanced didactic project.

Recently, laboratories remotely accessible have been created as for example the **iHomeCorr**, devoted to increase the knowledge of MS students in Material Science, [http://iHomeCorr.led.polito.it](http://iHomeCorr.led.polito.it)

**iHomeCorr** stands for intelligent Home accessible Corrosion laboratory and is designed to:

- allow students to carry out long corrosion experiments without having to get to the laboratory at regular interval

- follow the corrosion reaction as a function of exposure time to the electrolyte

- act (remotely) on the experimental parameters to alter the corrosion reaction and see the effects

The figure below represents the scheme of the iHomeCorr lab.

![Diagram](315x523 to 550x678)

**Fig 2: Scheme of the remotely accessible iHomeCorr laboratory.**

Moreover, the Politecnico and the INRIM take part to the activity of the Italian University Group on Electrical and Electronic Measurements, which is organizing several activities, as a national congress, a summer school for PhD students, providing scholarships and awards to Students in metrology and also organizing the well-known “Day of the Measurements” annually devoted to the different fields of research in metrology [3].

In particular, the GMEE organizes the PhD Summer School "Italo Gorini", which is a school offered to all PhD students interested in Measurements and which is organized by the GMEE in different places around Italy. The school is organized on a three year basis: each year the school offers different topics, which returns after the three years. In this way PhD students have the possibility of attending different seminars during their PhD course. As an example, 2016 edition was in Cagliari [4]; in all editions special rates are granted to the students both for the attendance and for the accommodation to increase the possibility of participation.

### 4. References

1. Varenna Summer schools in Metrology: [https://www.sif.it/attivita/scuola_fermi](https://www.sif.it/attivita/scuola_fermi)
4. [http://sites.unica.it/gorini2016/italo-gorini/](http://sites.unica.it/gorini2016/italo-gorini/)