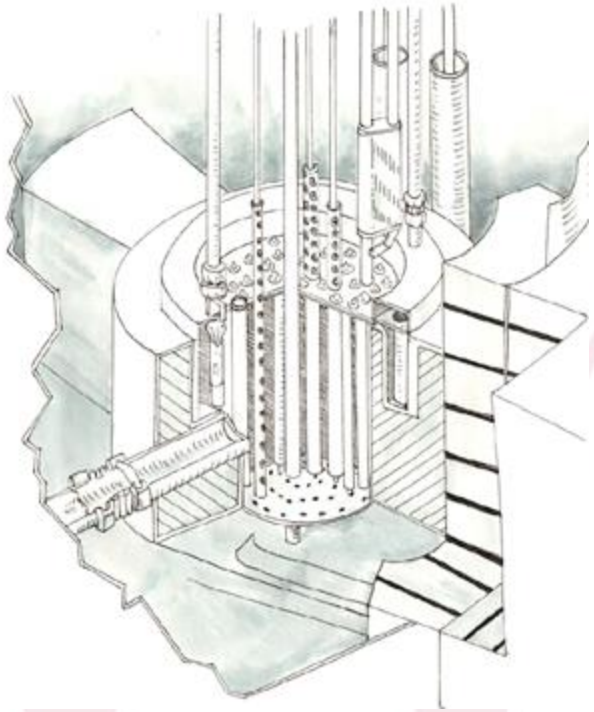

Professional and academic training hosted by LENA applied nuclear energy laboratory of the University of Pavia

A. Salvini, D. Alloni, A. Gandini
LENA – Applied Nuclear Energy Laboratory - University of Pavia
Via Aselli 41, I-27100 Pavia – Italy

IGORR 22nd & IAEA TM

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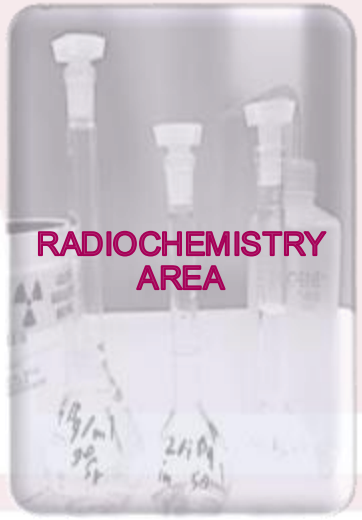
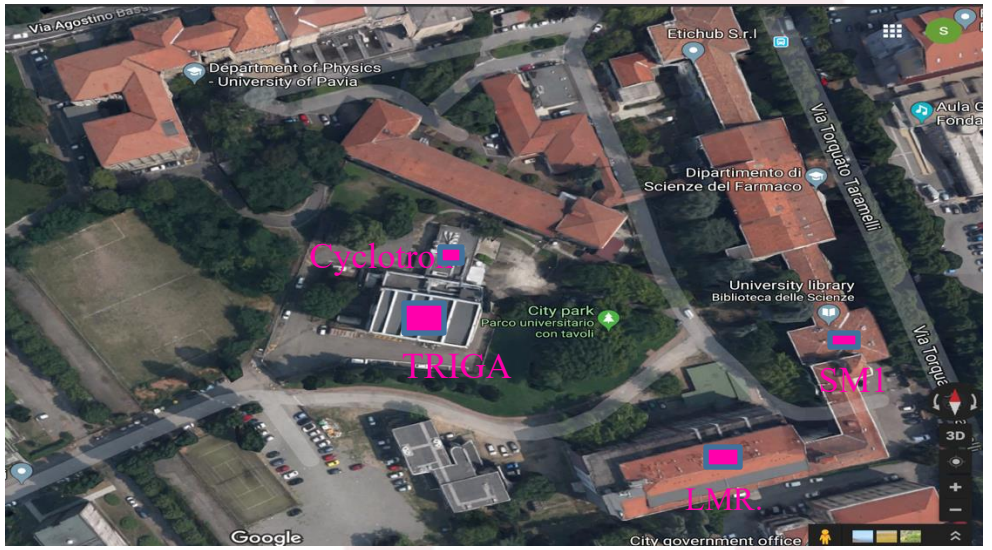
Andrea Salvini – LENA Università di Pavia - Italy

https://web-en.unipv.it/ https://lena.unipv.it/en/homepage/

Nuclear Pole





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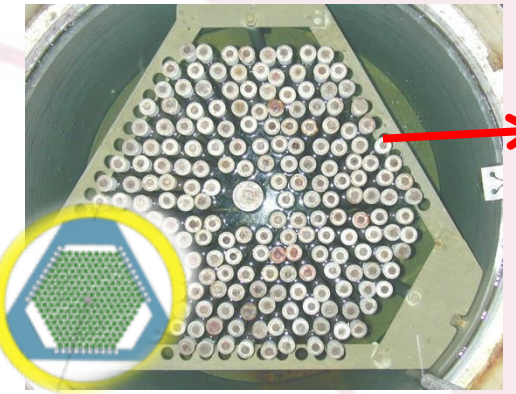
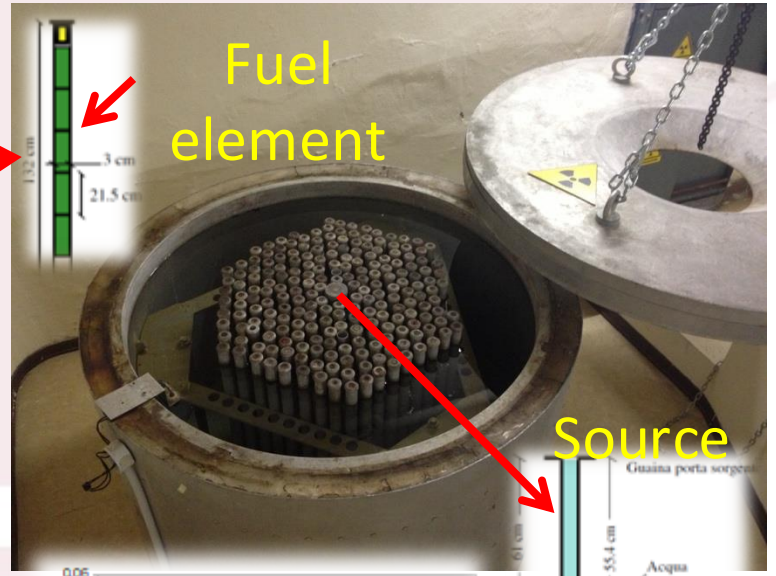
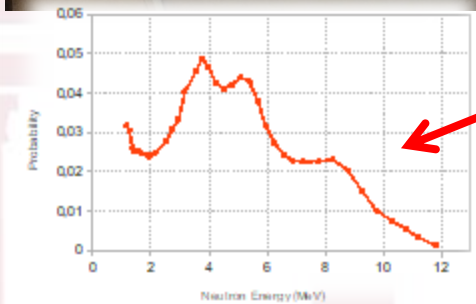
IBA «Cyclone» 18/9

The device is an IBA cyclotron (model Cyclone 18/9) set up for **18 MeV proton** bombardment of a highly ^{18}O-enriched H_2O (^{18}O>98.0 Atom %, provided by Huayi Isotopes Co.) target with a nominal **40 μA beam current**. Actually, it is equipped with three targets: two **targets for ^{18}F production, one for ^{13}N production.**







- ✓ Moderator: Water
- ✓ 206 fuel elements
- ✓~2000 kg of U_{nat}
- ✓ Source: Pu-Be,
- ✓ Source Intensity = 7×10^6 neutrons/s

- ❑weight: 25 t,
- ❑diameter: 2m,
- ❑shielding: 2m concrete (bunker)
- ❑ Proton 18 MeV (40 μA target curre
- ❑Dual-beam mode
- ❑8 beams, 2 target installed (18F LV,

Description of the structures
TRIGA MKII

Maximum power (steady state)	250 kW
Maximum flux (central thimble)	1.72 10^{13} cm^{-2} s^{-1}
Fissile mass (235-U)	2.2 kg corresponding to 62 fresh fuel elements (first core loading)
Temperature coefficient of fuel-moderator (negatve)	-1.2x10^{-4} Δk/k C° a 50° C
Moderator	HZr, H_2O
Reflector	Grafite
Heat transfer fluid	H_2O
Number of control rods	3
Fuel temperature @ 250 kW	230° C
Heat transfer fluid @ 250 kW	35-40° C

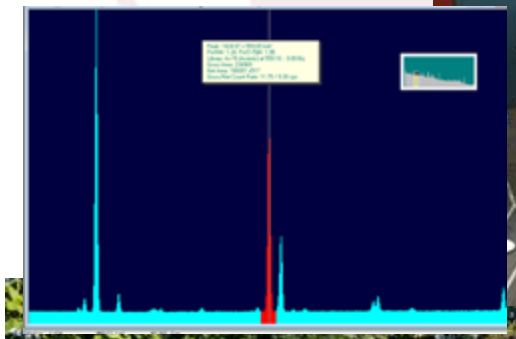
LENA ACTIVITIES

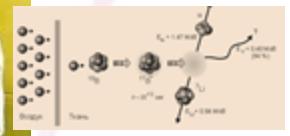
- Research
- Training
- Tests & Analysis
- Industrial services
- Education

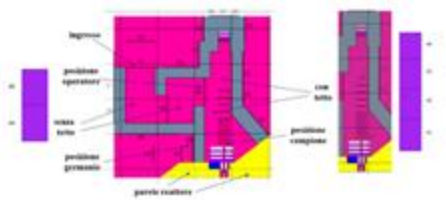
AREAS OF INTEREST

- Decommissioning
- Analysis of waste characterization
- Production of radioisotopes for medical use: Reactor & Cyclotron
- Training: Laboratories (Physics, Chemistry and Engineering), reactor experiments
- Study of materials
- Consultancy (quality and operation of nuclear facilities)
- Research: BNCT, Forensic, Cultural Heritage, Archaeometric, Medicine/ Radiobiology , Materials Science and radiation damage, etc…







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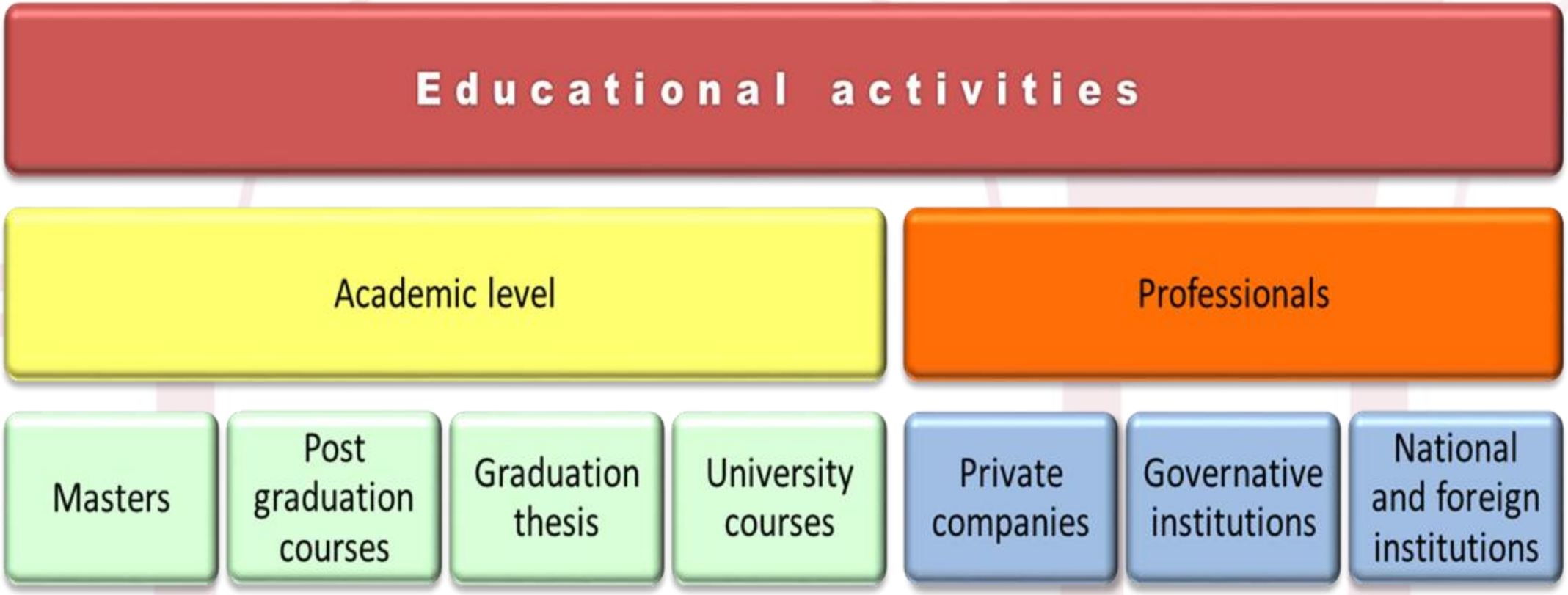
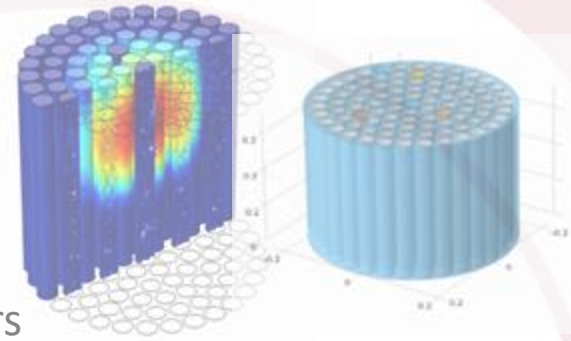

Educational activities
Academic level
Professionals
Masters
Post graduation courses
Graduation thesis
University courses
Private companies
Governative institutions
National and foreign institutions

Educational and Training activities @ LENA

University of Pavia (M.Sc.):

Course of Radiochemistry
Course of Applied Nuclear Chemistry
Course of Cellular Radiobiology
Course of Physics of Inoizing Radiation
Course of Accelerators and nuclear reactors
Lessons on neutron physics
Simulations in Biomedical Physics
Ionizing Radiation laboratory
AVERAGE NR OF STUDENTS/Y ~ 70



Experimental-computational activities for M.Sc. Thesis
AVERAGE NR OF THESIS/Y ~ 8

Polytechnic Milan (M.Sc.):

Experimental Nuclear Reactor Kinetics
Visits to the reactor
AVERAGE NR OF STUDENTS/Y ~ 20

UNIVERSITÀ DI PAVIA

University of Pavia (Ph.D.):

Experimental activity for the thesis
AVERAGE NR OF PhD /Y ~ 2

Bicocca University, Milan (M.Sc. + Ph.D.):

Experimental and computational activities for thesis
AVERAGE NR OF STUDENTS/Y ~ 2

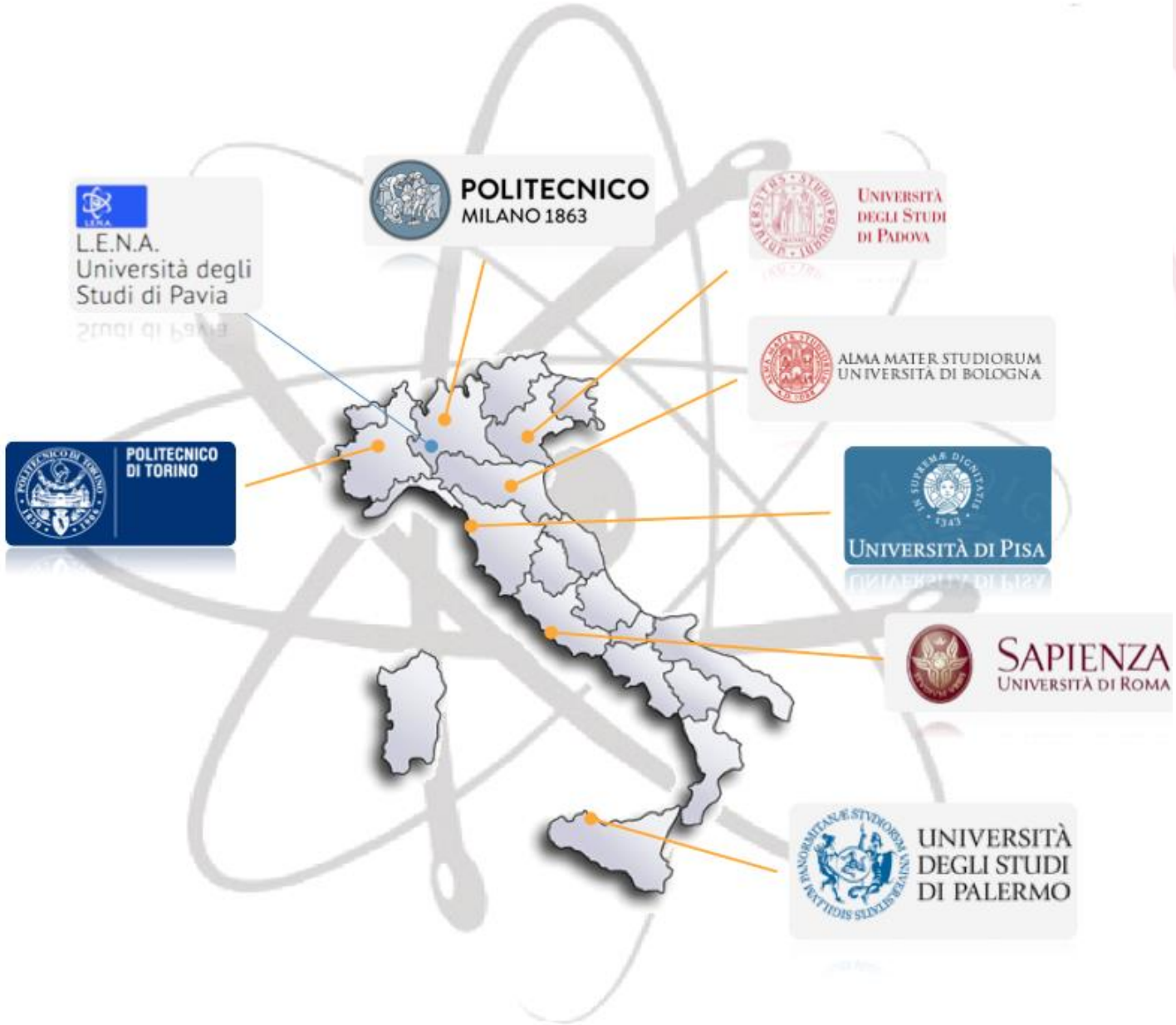
PROFESSIONAL

Radioprotetion training

IAEA FELLOWSHIP

Integrated management system for operation and maintenance
Beam utilization and safety issues
Implementation of an IMS in a research reactor and its update
IAEA safety standards on core management and fuel handling, operational limits and conditions, maintenance periodic testing and inspection, and ageing management for research reactors

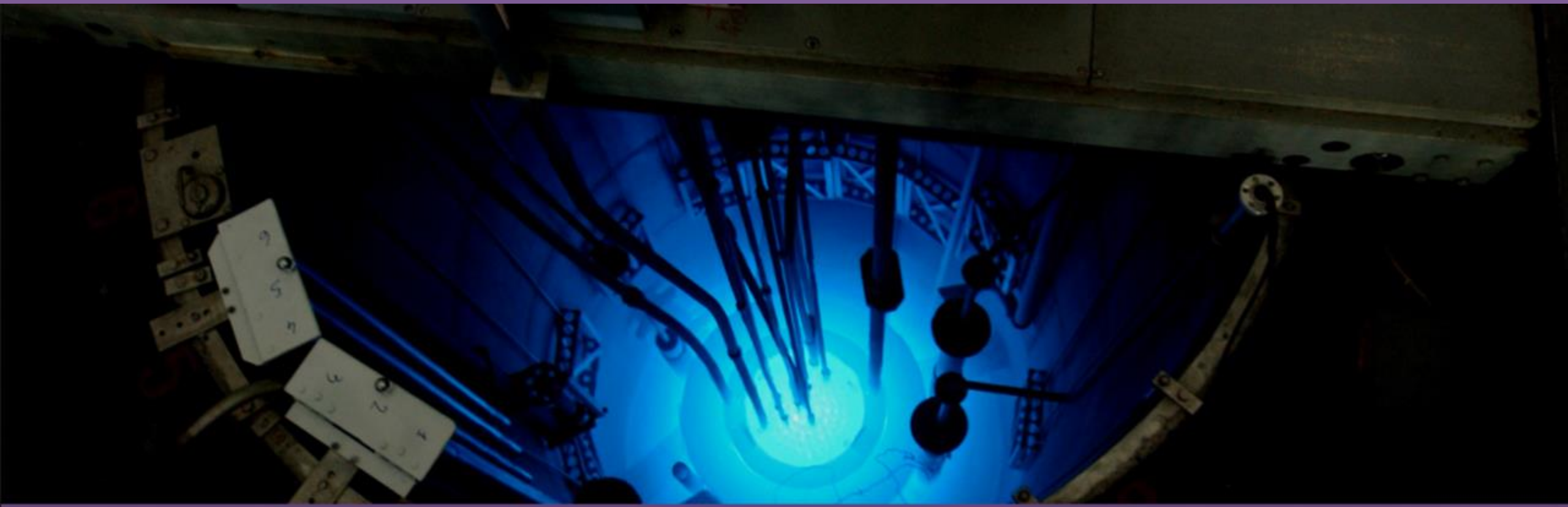
- **2000+ Average visitors per year**
- **More then 100+ academic students per year**
  - **Reactor and laboratories experiences**
  - **Thesis**
  - **PhDs**
  - **exchange student programs**
  - **Master's degrees**



- **The CIRTEN consortium**
- **CIRTEN**
*(***C**onsorzio **I**nteruniversitario per la **R**icerca **TE**cnologica **N**ucleare*, alias "Intra-University Consortium for Nuclear Technology Research")*
- *is the Consortium of the Italian Universities involved in nuclear science and technology research activities, and where educational programmes (MSc, PhD) on nuclear engineering are offered to the young generations.*

Moreover, CIRTEN is collaborating with **Università di Pavia** and its **LENA lab** (Laboratorio Energia Nucleare Applicata), which operates a **TRIGA Mark II research reactor**. Both R&D and education & training activities are carried out at the facility.

Radiation Protection
2nd level Master's degree



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IDCD INNOVAZIONE DIDATTICA COMUNICAZIONE DIGITALE

Cester & Co.

CAMPOVERDE WAYS TO BE SAFE

CNAO Centro Nazionale di Adroterapia Oncologica

40 ANNI MiT AMBIENTE

JRC EUROPEAN COMMISSION

DIPARTIMENTO di Fisica

L.E.N.A.

Program of study

The total number of hours of classes amounts to 240 hours. The final examination involves the writing and discussion of a thesis on a topic agreed upon with the Master's Coordinator. Sessions for said discussion will begin in November 2024 and end by April 2025

The Course is divided into 11 modules:

– Nuclear and Atomic Physics;
– Basic Radiobiology;
– Quality Assurance;
– Radiogenic apparatus and sources;
– Dosimetry;
– Risk assessment, occupational safety and prevention/protection;
– Regulatory framework and guidelines;
– Emergencies;
– Waste and transportation;
– Operation of radiogenic and accelerator facilities;
– Nuclear facilities.

List of new ENEEP courses for 2024

Summer School in Environmental Monitoring (UNIPV)

Summer School in Environmental Monitoring (UNIPV) Date: 29.07.2024 – 02.08.2024 (5 working days) Venue: Pavia, Italy Organizer ...

About ENEEP

The Mission of the European Nuclear Experimental Educational Platform (ENEEP) is to fulfill the needs of European users in order to significantly enhance their experimental education and hands-on activities in nuclear curricula, particularly in the field of nuclear safety and radiation protection.

UNIVERSITÀ DI PAVIA

List of new ENEEP courses for 2024

The ENEEP autumn courses are organized in cooperation with the ENEN2plus project. Participants are therefore encouraged to apply for ENEN2plus Mobility Grant. Please, carefully read the ENEN2plus Mobility Manual. The courses are also open for applicants without mobility grants, however, course fees apply.

Fundamentals of Isotope Production (UNIPV)

Fundamentals of Isotope Production (UNIPV) Date: 11.11.2024 – 14.11.2023 (4 working days) Venue: Pavia, Italy Organizer : Univ...

Safety of reactor operation (UNIPV)

Safety of reactor operation (UNIPV) Date: 07.10.2024 – 10.10.2024 (4 working days) Venue: Pavia, Italy Organizer : University ...

Nuclear Based Diagnostic Methods (STU)

Nuclear Based Diagnostic Methods (STU) Date: 25.11.2024 – 28.11.2024 (4 working days) Venue: Bratislava, Slovakia Organizer : ...

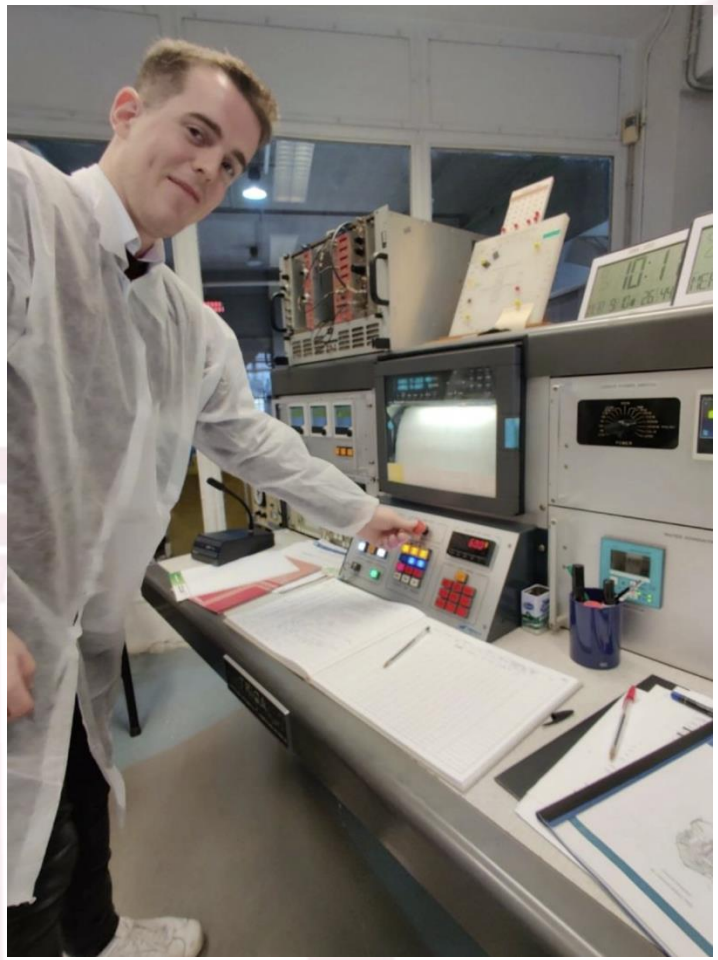
Nuclear Reactor Measurements and Applications (BME)

Nuclear Reactor Measurements and Applications (BME) Date: 24.09.2024 – 27.09.2024 (4 working days) Venue: Training Reactor / Instit...

https://www.eneep.org/courses/new-courses/

Courses for students organized in the framework of ENEEP platform

University of Pavia is member of ENEEP (European Nuclear Experimental Educational Platform), whose mission is to fulfill the needs of European users by significantly enhancing their experimental education and hands-on activities in nuclear curricula, particularly in the fields of nuclear safety and radiation protection. Other members of ENEEP are STU Bratislava, CTU Prague and IJS Ljubljana.



Safety of reactor operation

The purpose of the course is to give a theoretical overview of the main topics (notes on then experiences are given before the course) and perform exercise using the TRIGA Mk II reactor to become familiar with the measurement and control procedures of the main reactor parameters with a special focus to safety.

- To get familiar with the reactor console instrumentation for operation and control
- To manage the reactor control procedure before start-up, with the reactor in a critical state, and after shut-down
- The control rod calibration procedure (see Figure 2), as well as the calculation of shutdown margin and core reactivity excess
- The measurement procedure of the void coefficient
- The measurement procedure of the fuel prompt temperature coefficient
- The procedure of reactor power calibration
- The effect of reactivity on reactor period
- Collect physical data from reactor instrumentation

Fundamentals of Isotope Production

The purpose of the course is to give a theoretical and experimental overview of the development of a new process for new interested isotopes.

- the evaluation of the facility characteristics as available irradiation position channels, neutron spectra or flux, and irradiation condition
- the conditions for theoretical estimation of radioisotope activity
- the target sample selection and preparation
- related radiation protection and safety procedures
- related radioisotopes recovery and labeling activities and gamma spectrometry of the irradiated samples (see Figure 5)
- quality assurance introduction of radioisotopes production processes

Summer school

The course aimed to give a theoretical overview of the main topics and perform exercises using the LENA facility and the nearby Radiochemistry Laboratory of the Chemistry Department to become familiar with sampling, measurement, and control procedures applied to the environmental monitoring of a research reactor plant. One day has been also dedicated to visiting an overview of the Environmental Monitoring system of a site in decommissioning.

- the drafting of an environmental monitoring plan based on mandatory and specific requirements
- to get familiar with environmental monitoring procedures and evaluation
- to Identify procedures for sampling various matrices such as air, soil, and water inside
- the direct application of the above-mentioned procedures
- the analysis phase for each different matrices and the evaluation of the results.
- the differences between normal operation conditions and emergency

Special Training for Research Reactor Operator

- Training offered to Turkish candidates from TENMAK for the obtainment of the licensee for Reactor Operator through the ENEEP platform.

- In agreement with their national regulatory body a 3 day training (8 hours per day) has been organized at the Pavia TRIGA reactor

1 st day: Reactor characteristics, instrumentation and technical documentation

- Reactor description & characteristics
- Reference documentation: Reactor Technical prescriptions and Final Safety Report
- Operation in normal and emergency conditions: related systems and role/actions of reactor staff
- Radiation protection, health physics, radiation monitoring and instrumentation

2 nd day: Practical operations at the reactor console

- Console instrumentation: control rods command, neutron source, scram circuits, interlocks. Safety-related SSCs (Safety Classification of Structures, Systems and Components).
- Check-list for reactor startup & Reactor Operational Register
- Reactor start-up & criticality at different power in manual and automatic operational condition, reactor power variation.
- Nuclear tests: generalities and one experience (control rod calibration).
- Calculation of Reactor core excess & shut-down margin
- Reactivity effects. Temperature, void and poisoning effects during operation at different power.

3 rd day: Practical operations at the reactor console

- OLCs: Operative Limits Conditions
- Reactor auxiliary systems (cooling, ventilation, emergency systems).
- Procedures of fuel handling and storage
- Waste management procedure

After the training, with the presence of Turkish regulatory body observers, a judging commission for the final theoretical and practical exam for the Operator Training Course has been formed by experts of the Pavia TRIGA reactor experts in possession of licenses for the management and direction of research nuclear together with the radiation protection expert

The practical exams has been organized from health physics procedures and control, reactor start-up check list compilation before reactor, explanation of reactor parameters read at the control console, reactor start up, power rise and criticality.

Furthermore, reactor safety operation and practical action in reactor normal and emergency conditions have been carried out being a fundamental aspects or reactor operation.