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DI PAVIA

RROG annual Meeting

2019

Applied Nuclear Energy Laboratory – L.E.N.A.

University of Pavia

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OUTLINE

- Introduction
- The Nuclear Pole
- Organization and personnel
- Performance Indicators
- Activities
- Gamma Prompt
- Special Topic: Aging management
- Pilot Integrated Research Reactor Utilization Review Mission to LENA (IRRUR)

THE UNIVERSITY OF PAVIA
650 years of excellence

UNIVERSITÀ DI PAVIA

TRADITION

- **One of the oldest** University in Italy – since 1361

- **Three Nobel Prize Laureates:**
  - Camillo Golgi, Giulio Natta, Carlo Rubbia

- **Distinguished scholars:**
  - Gerolamo Cardano, Alessandro Volta,
  - Ugo Foscolo, Albert Einsten

- Unique **College System** established in 16th Century

THE UNIVERSITY TODAY

2 Campuses (Pavia and Cremona)

2nd Best Italian great University in the La Repubblica-CENSIS report

5th Italian University in the "World University rankings" 2013-14

8/10 Student level satisfaction

30 Libraries

18 Departments

17 University Colleges

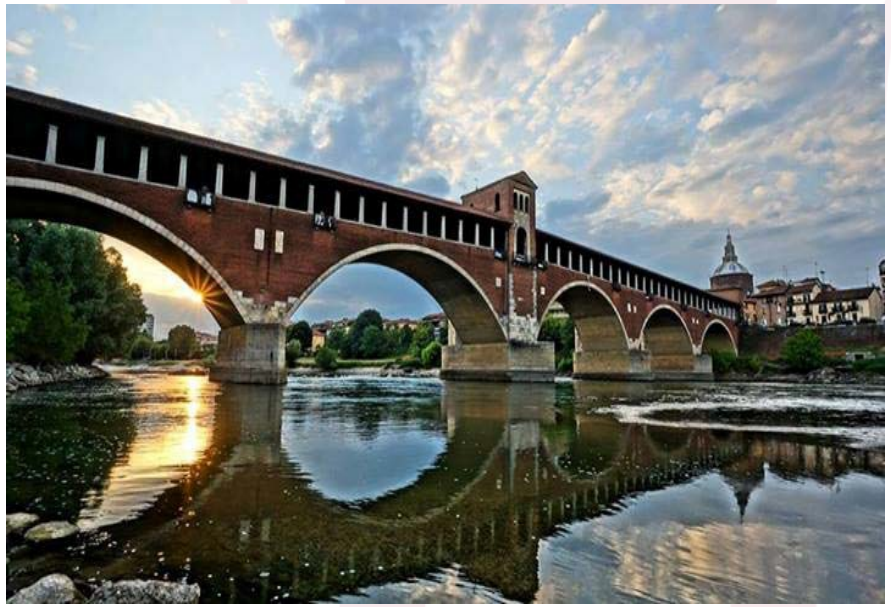
1 Univerisity Language Centre

1 University Sport Centre

23 500 Students

1500 International students

2000 Professors, Lecturers and Staff



A INTERDISCIPLINARY UNIVERSITY

The University of Pavia offers a top level formation from arts to science


Pharmacy

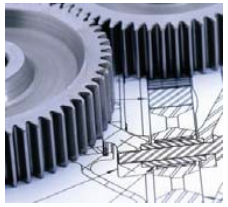

Humanities

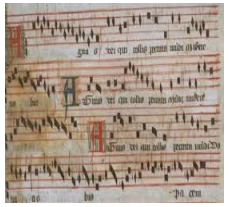

Law


Medicine and Surgery


Maths, Physics, Chemistry, Biology


Political Sciences


Engineering


Musicology


Economics

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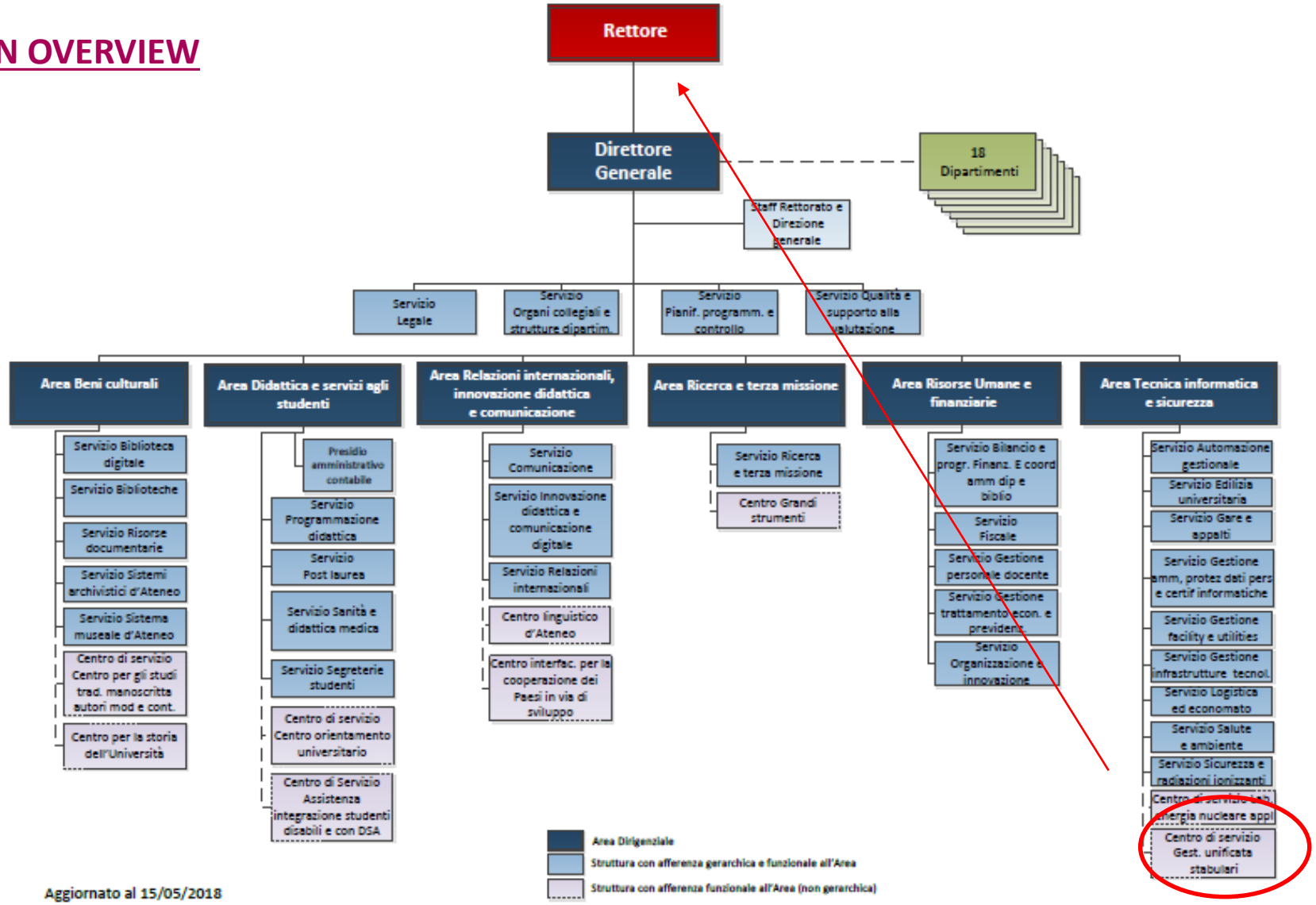
ACADEMIC OFFER

84 Undergraduate and Graduate Programmes
17 Doctoral Programmes
42 Professional Master's Programmes
8 International Graduate (English taught) **Programmes:**

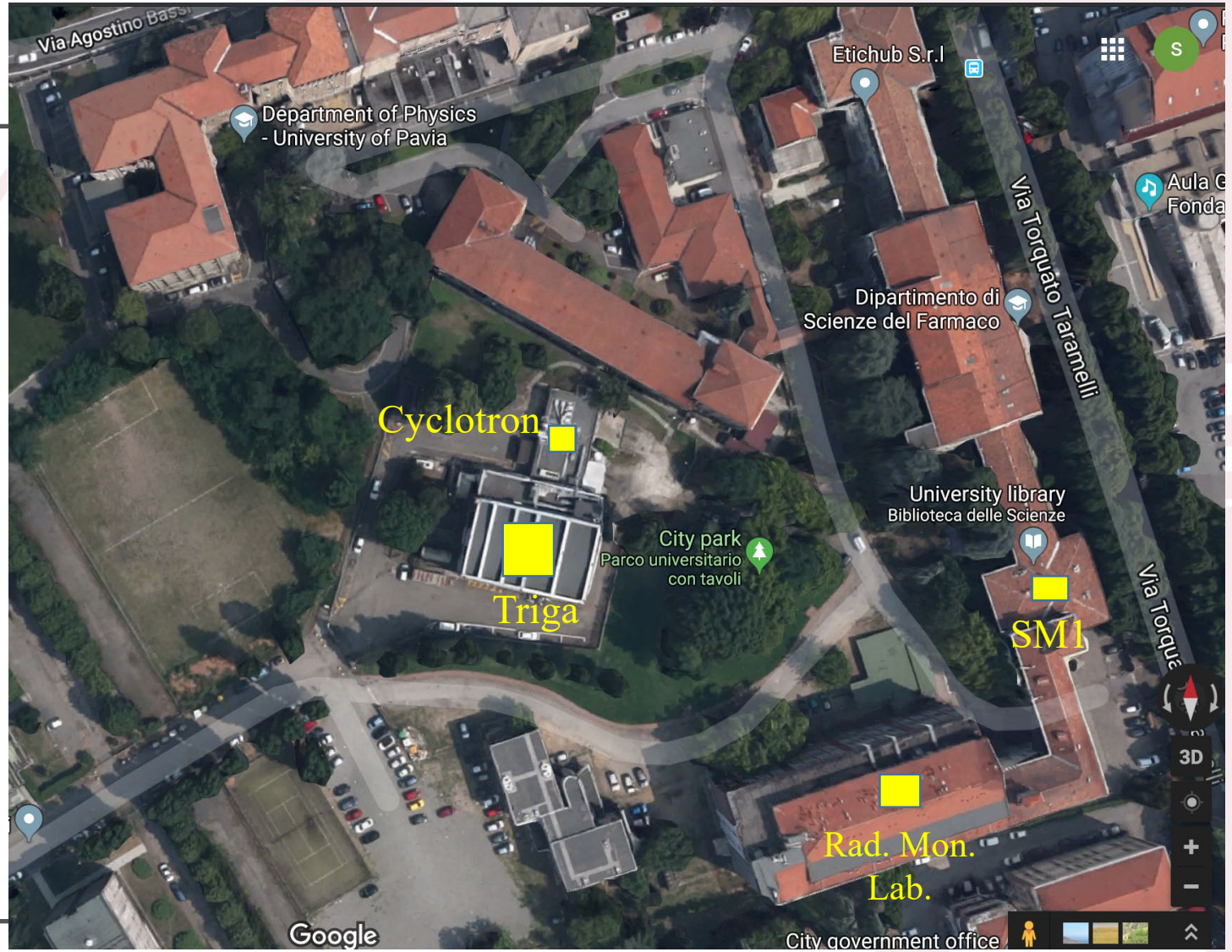
- *Medicine and Surgery*
- *Molecular Biology and Genetics*
- *Electronics Engineering*
- *Computer Engineering*
- *International Business and Entrepreneurship*
- *Economics, Finance and International Integration*
- *World Politics and International Relations*

ORGANIZATION OVERVIEW



Aggiornato al 15/05/2018

The geographical context of the Lena Center



The geographical context of the Lena Center

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The geographical context of the Lena Center

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Description of the structures

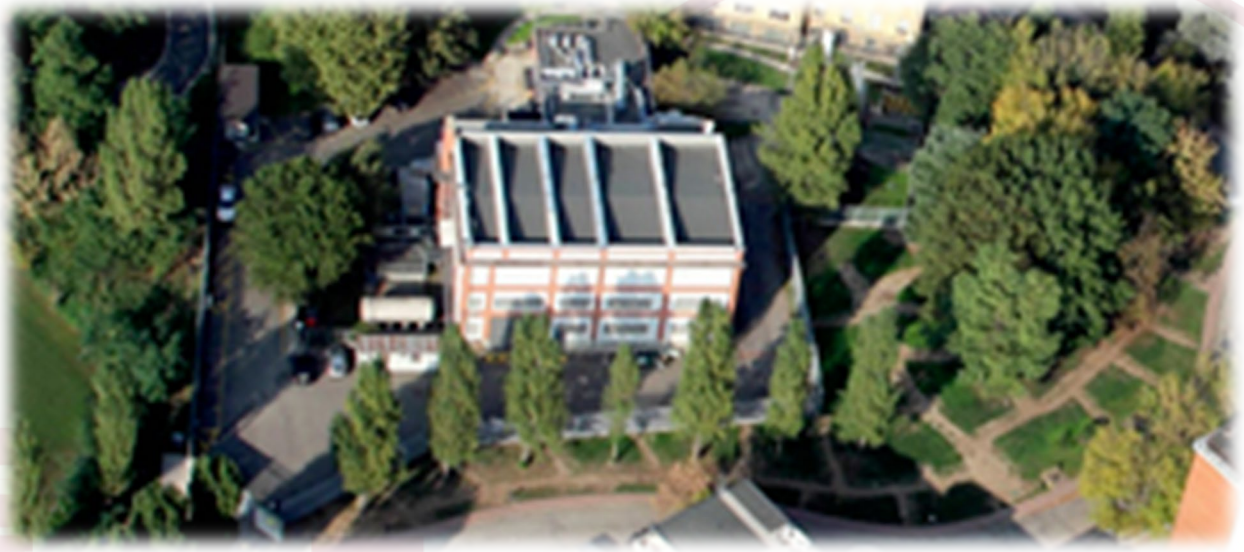
TRIGA MKII

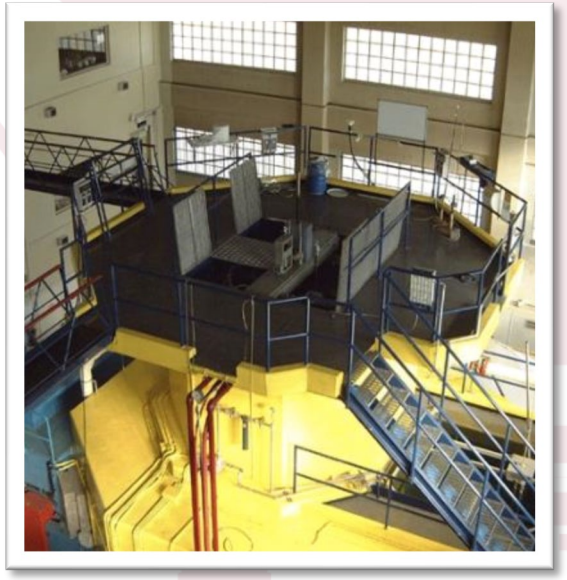
Maximum power (steady state)	250 kW
Maximum flux (central thimble)	$1.72\ 10^{13}\ cm^{-2}\ s^{-1}$
Fissile mass (235-U)	2.2 kg corresponding to 62 fresh fuel elements (first core loading)
Temperature coefficient of fuel-moderator (negatve)	$-1.2x10^{-4}\ \Delta k/k$ C° a 50° C
Moderator	HZr, H_2O
Reflector	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

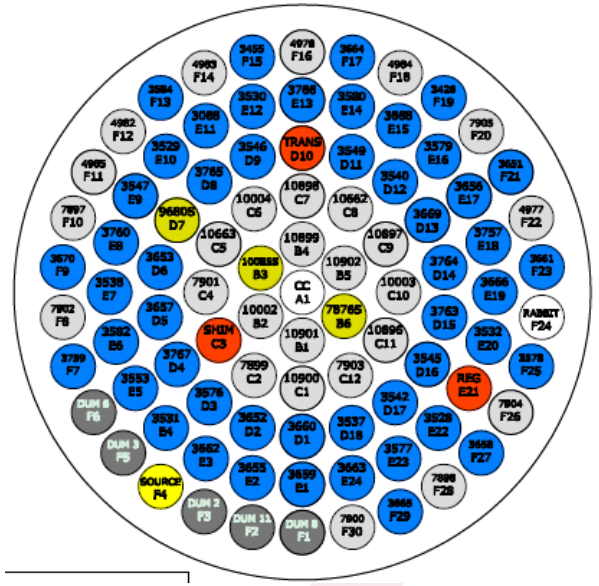
Introduction

- The University of Pavia is the operator of the nuclear plant TRIGA MKII since its **first criticality** occurred on **November 15th, 1965**
- The Authorization and **License of the TRIGA Mark II** facility are **registered in the legal entity of the University of Pavi**a
- To the **Director of the L.E.N.A**. the Rector of the University of Pavia delegates the tasks, responsibilities and **specific obligations** that can be attributed by law by the Employer **regarding the safety and health of workers in the workplace**.
- To the **Director of the L.E.N.A**. the Rector of the University of Pavia also assigns the tasks, responsibilities and **specific obligations** of the Director **responsible for the plant and the plant operation in the field of nuclear safety and health protection**.

REACTOR OVERVIEW







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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 30μA beam current. Actually, it is equipped with three targets: two targets for ^{18}F production, one for ^{13}N production.

GENERATOR Rx Gilardoni MT 350 / 6-12

The Rx generator is an industrial 250 kV 12 mA / 350 kV and 6 mA generator.

SOURCE 2.91 TBq (78 Curie) Cobalt-60

The working range is less than 1kGy/h.

CRAVINO NUCLEAR POLE

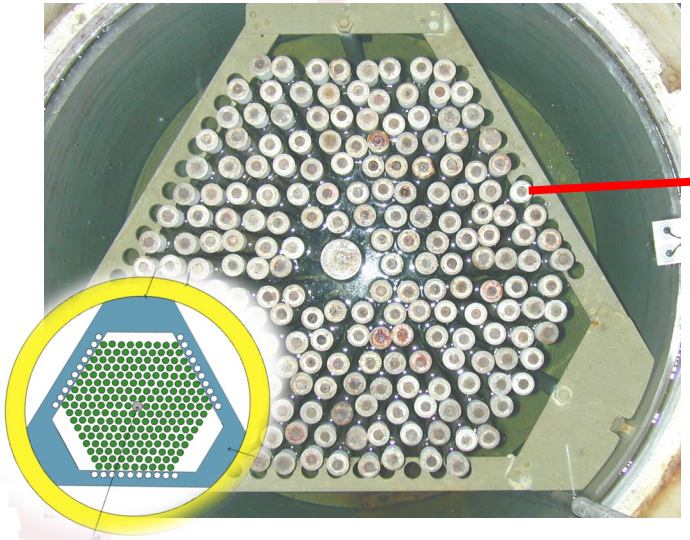
The LENA Center is part of the Cravino Nuclear Pole, which includes the Radiochemistry area and the Environmental Monitoring Laboratory.

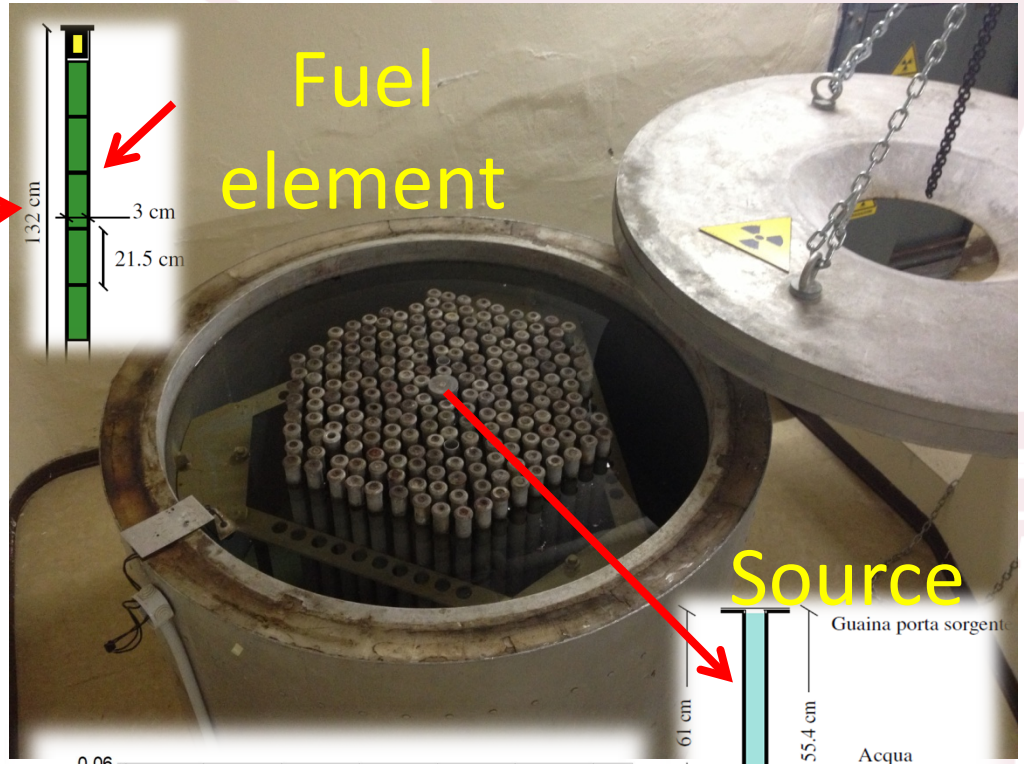
- *Radiochemistry Area and Monitoring Laboratory:*

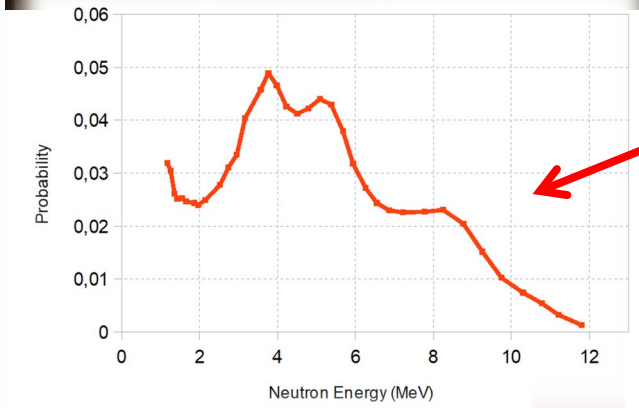
The area is equipped with "low-background" laboratories dedicated to gamma, LSC and alpha measurements, a medium-activity laboratory (NAA), three medium-activity laboratories and a cold laboratory.

- *The sub-critical SM1 complex*

SM1 subcritical assembly







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

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Organization and personnel - Organizational structure and responsibility.

University staff belonging to LENA

Secretariat: 1 unit of administrative staff divided over two centers

Technicians: 2 Part Time units, 7 full time units

Guardians not related to LENA but employees of the University:

4 guardians outside working hours

Staff with assignments paid for a project on behalf of third parties:

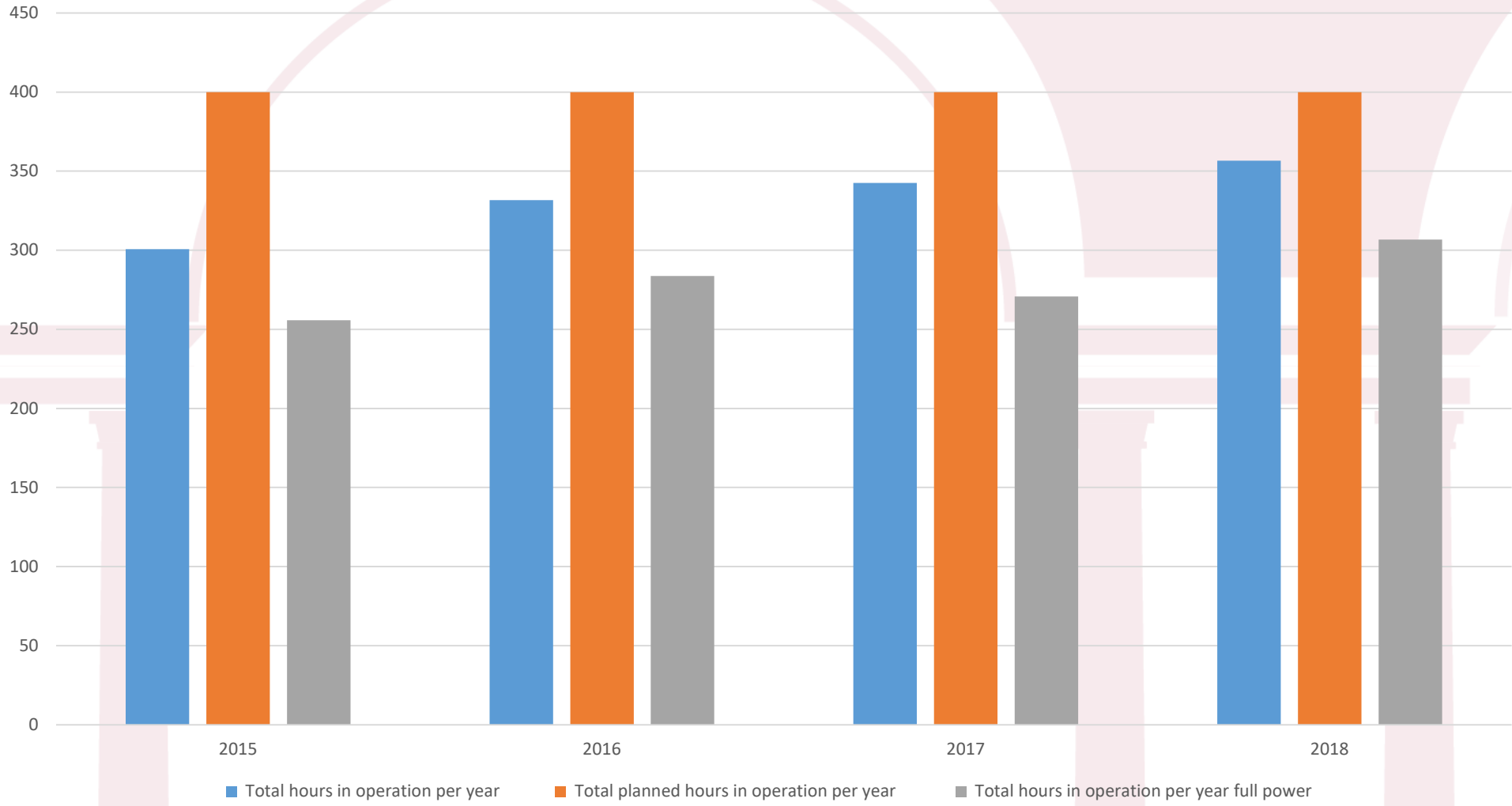
External collaborators for the Cyclotron: 1 technician paid per days, 1 temporary contract

Fellowship of Chemistry and Physics: 2 Fellowship

Felloship funded by the LENA Center (2 in 2018)

PERFORMANCE INDICATORS

Hours in operation



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PERFORMANCE INDICATORS

Shutdown and maintenance data

Number of unscheduled shutdowns	9	18	7	1
Unscheduled shutdown hours	0	0	0	0
Number of work permits issued	5	5	9	7
Number of preventive maintenance events	214	216	215	215
Number of failures detected during preventive maintenance	1	2	3	2
Number of corrective maintenance events	2	2	3	3
Operation hours lost due to corrective maintenance	0	0	0	0

PERFORMANCE INDICATORS

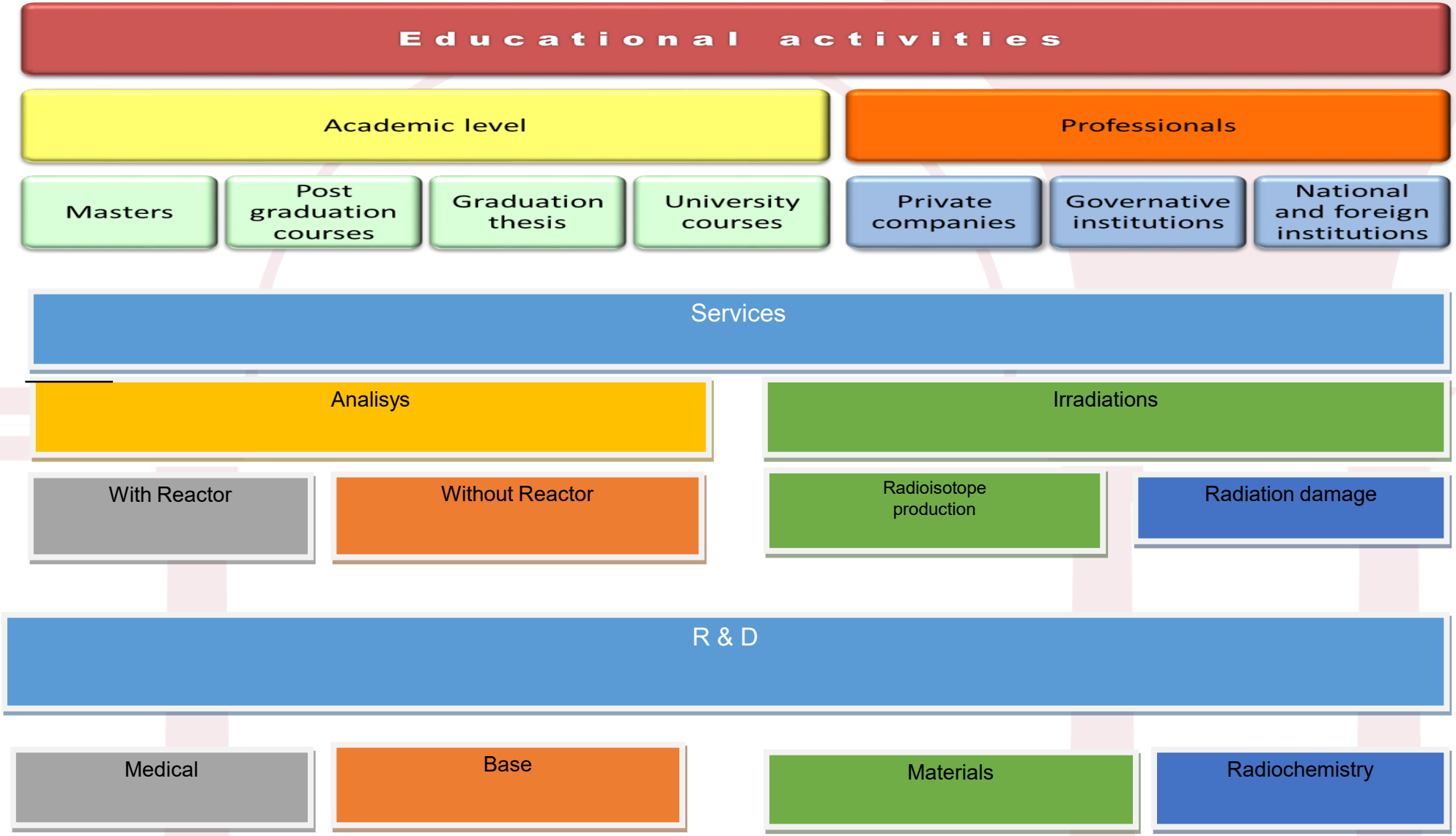
RADIATION DOSE EXPOSURE

D1(a)	Collective radiation dose to Reactor Operations staff (mSv)	0
D1(b)	Number of Reactor Operations staff	8
D1(c)	D1(a)/D1(b) (mSv/man)	0
D2(a)	Collective radiation dose to all staff from reactor related work (mSv)	0
D2(b)	Total number of staff involved	12
D2(c)	D2(a)/D2(b))mSv/man)	0

RADIOACTIVITY RELEASED

E1	Rare gas released to atmosphere (TBq) - Ar41	0,027
E2	Tritium released to atmosphere (TBq)	--
E3	Tritiated water discharged (GBq)	--
E4	Iodine released to atmosphere (MBq)	--

Activities


Educational activities
Academic level
Professionals
Masters
Post graduation courses
Graduation thesis
University courses
Private companies
Governative institutions
National and foreign institutions
Services
Analisys
Irradiations
With Reactor
Without Reactor
Radioisotope production
Radiation damage
R & D
Medical
Base
Materials
Radiochemistry

Activities

Although all the areas are present in the activities of the Center some aspects are considered priority and others are integrated with new objectives .

In particular, a balance is struck between the three-macro types, considering the **mission of Educational and Training and Research and Development, while the provision of services is to be considered as support and self-financing.**

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: Forensic, Cultural Heritage, Archaeometric, Medicine/ Radiobiology , Materials Science and radiation damage

Research activities

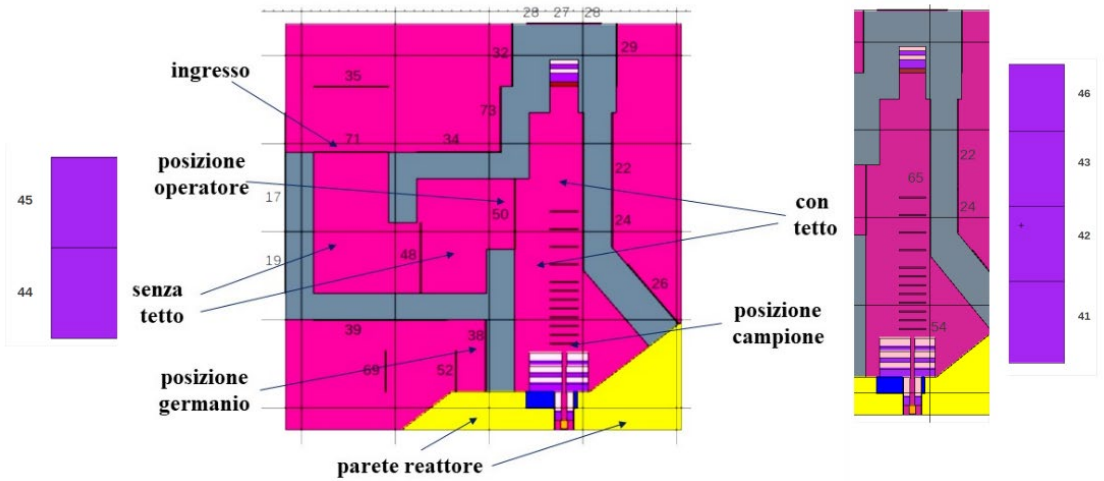
The Laboratory hosts and directly promotes research activities co-funded by national research institutions such as INFN, CNR, INRIM, etc. in the various fields listed below:

- *Boron Neutron Capture Therapy (BNCT)*
- *Electronic devices response to radiation*
- *Neutron Activation Analysis*
  - New separation methods for the determination of trace elements in the geological, cosmological and environmental matrices
  - Application of neutron activation analysis to archaeological investigations as for provenance studies
  - Dating methods in archeology and geology
  - Forensic Science
  - Quality control of ion exchange resins
  - Characterization of silicon crystals for the redetermination of the Avogadro constant
- *Prompt Gamma Neutron Activation Analysis*
- *Reactor Physics and Nuclear Engineering*
  - INFN-Energy
- *Environmental analysis*
- *Radioisotope production:* ^{99}Mo / ^{99m}Tc, ^{124}I, ^{166}Ho, ^{111}Ag, ^{64}Cu, Process Tracers
- *Studies on radiation damage on materials:* Partner of the RDS_SPES project

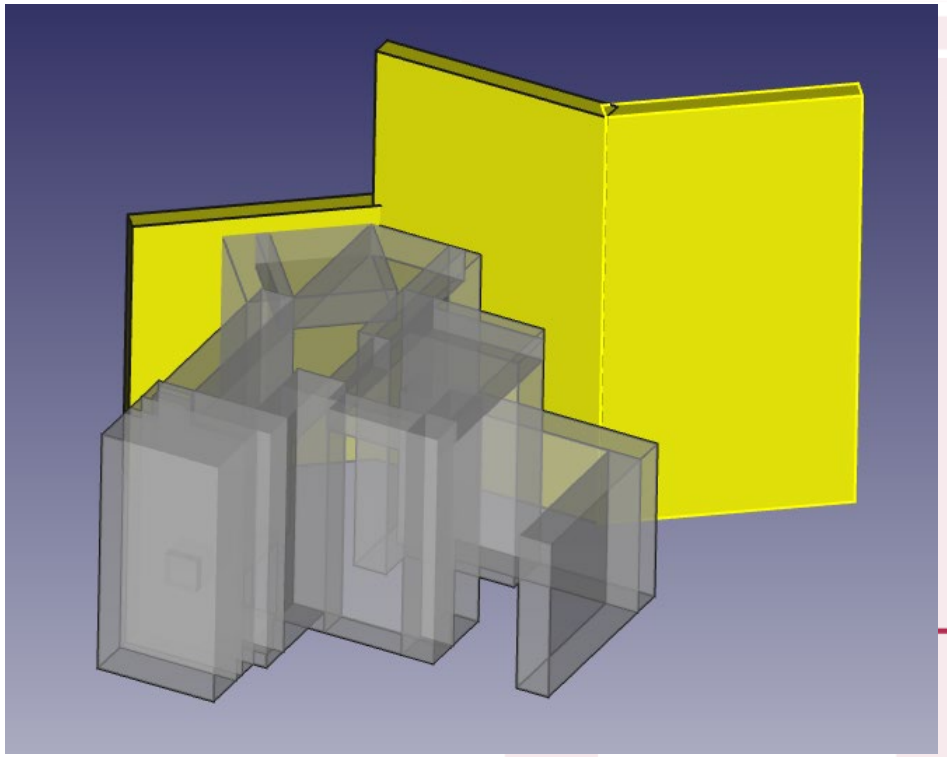
Studies on cyclotron:

- Characterization of the neutron field generated by medical cyclotron
- Characterization of the radioisotopic impurities generated during proton bombardment of enriched water in medical cyclotron

Gamma Prompt



- Thermal beam filtering with Bi and single crystal sapphire
- Beam flux : ≈ 1.3 ·10^7 n/(cm^2s)
- Beam size: ≈ 3 cm Ø
- Detection system : HPGe N type coaxial configuration
- Sensitivity for natural boron 1000 cps/mg
- Sensitivity for other elements to be assessed




baribloc
PROMPT GAMMA NEUTRON ACTIVATION ANALISYS (PGNAA)
FACILITY BY L.E.N.A. LABORATORY
UNIVERSITY OF PAVIA


baribloc

ENSREG
European Nuclear Safety Regulators Group

ITALY

1st Topical Peer Review Workshop

Ageing management

May 14th – 18th, 2018

National Presentation of ITALY

National Centre for Nuclear Safety and Radiation Protection
ISPRA – Italian Institute for Environmental Protection and Research

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Scope, Objectives and Organisation of the first Topical Peer Review

According to the Terms of Reference and Technical Specification, **the peer review focused on the Ageing Management Programmes (AMPs) at Nuclear Power Plants (NPPs) and Research Reactors (RRs) above 1 MWth**. **On a voluntary basis, participating countries extended the scope of their national assessment to encompass other Research Reactors**. Several countries reported on specific aspects of ageing management related to long-term operation (LTO) of NPPs although LTO was not specifically required by technical specifications. In addition to reviewing the programmatic part of ageing management, the peer review process examined the application of the AMPs to the selected systems, structures and components (SSCs) in four thematic areas, namely; electrical cables, concealed piping, reactor pressure vessels, or equivalent structures, and concrete containment structures.

The objective of the first Topical Peer Review was to examine how well Ageing Management Programmes in participating countries meet international requirements on ageing management (in particular WENRA Safety Reference Levels – (SRLs) and the IAEA Safety Standards). Moreover, the objectives of the Topical Peer Review were to:

- Enable participating countries to review their provisions for ageing management, to identify good practices and to identify areas for improvement.
- Undertake a European peer review to share operating experience and identify common issues faced by Member States.
- Provide an open and transparent framework for participating countries to develop appropriate follow-up measures to address areas for improvement.

AGEING MANAGEMENT REPORT – TRIGA PAVIA

2017

Abstract

Over all facility information with list of the major activities, relate reactor ageing. A description of the Ageing Management system implemented at the Pavia TRIGA Nuclear Research Reactor.

Data 18 10 2017

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1 Sommario

SSC	Replacement complexity	Ageing mechanism	Periodic checks, preventative or mitigating actions	Frequency	Recording
Liner and inner Reactor structures					
Tank structure, liner	A	1,5	Video inspection, ordinary cleaning	Each 3 years	MPEG files on USB storage
Core structure	A	1,5	Video inspection, ordinary cleaning	Each 3 years	MPEG files on USB storage
Riflector	A	1,5	Video inspection, ordinary cleaning	Each 3 years	MPEG files on USB storage
Control rods	A	1,5	Video inspection, ordinary cleaning	Each 3 years	MPEG files on USB storage
Handling of control rods					
Cabling	B	2,4	Visual Inspection, Regular Cleaning, Greasing, Screw Clamping and Connections	Six moth	MD SMESICS
Electrical components	B	2,4		Six moth	MD SMESICS
Mechanical components, leak inspections, wear, tightening connections and joints	B	2		Six moth	MD SMESICS
Rods guide	B	2		Monthly	Reg EC Module SDM (Fall Time / Extraction Time)
Experimental Channels (A, B, C, D, CT, thermalisation column)	A	1,5,7	Video inspection, ordinary cleaning	Each 3 years	MPEG files on USB storage

Aging Mechanisms (coding according to IAEA SSG10)
1. Change of properties (physical, chemical, mechanical) due to neutron irradiation
2. Change of properties (physical, chemical, mechanical) of materials due to operating temperatures
3. Mechanical stresses or cracks due to temperature / or operating pressure
4. Fatigue phenomena, material consumption due to thermal cycles, mechanical load, flow, induced vibrations
5. Corrosion
6. Chemical processes
7. Erosion
8. Technology change
9. Regulatory changes, regulations, prescriptions, etc.
10. Documentation obsolescence
Replacement difficulty
A = high
B= medium C= low

Topical Peer Review 2017

Ageing Management

National Assessment Report

2017

This National Report has been prepared by the National Center for Nuclear Safety and Radiation Protection of ISPRA (Institute for Environmental Protection and Research), which carries out the functions of national competent regulatory Authority for nuclear safety and radiation protection

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Table of Content

Ageing management

2006 – Area Radiation Monitoring system

2007 – Reactor I&C refurbishment

2008 – Reactor cooling system

2010 – Ion and fission chambers positioning system

2011 – Water demineralization system

2011 – DAQ for I&C

2012 – DAQ Cooling system

2014 – Periodic Reactor Safety Review

2016 – Building Seismic evaluation

2016 – New particulate monitor

2016 – New UNIT 300

2018 –SC rewiring

2018/2019 New log installed waiting for substitution

Topical peer review on the ageing of nuclear installations in Europe promoted by ENSREG in implementation of the directive on nuclear safety n. 21014/87 / EURATOM

In October 2018, at the end of the review of the activity mentioned, the results were published in the following link:
http://www.ensreg.eu/eu-topical-peer-review

As established by ENSREG, each member state must prepare a national action plan.

For Italy, the recommendation is the systematic development of a general program for managing the aging of research reactors

By 31 May the LENA must officially send, to the regulatory body, the management plan for the reactor aging

Pilot Integrated Research Reactor Utilization Review Mission to LENA TRIGA Mk II

Counterpart: Laboratory of Applied Nuclear Energy (LENA) of the University of Pavia

Pavia, Italy

1-5 April 2019

EVT1901473

DEPARTMENT OF NUCLEAR SCIENCES & APPLICATIONS

Division of Physics and Chemical Sciences

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Scope of the mission

The **IRRUR mission**, that is being developed by the IAEA, **aims to perform an independent and objective review**, it is not intended to be an external audit nor an inspection of the research reactor utilization against established requirements or pre-defined utilization levels nor a direct endorsement of the Member State self-assessment.

The mission is a comprehensive review of the overall situation in the requesting research reactor regarding its current and potential utilization.

Prerequisite mission

For the Pavia mission as a prerequisite the following reports were submitted to the IAEA prior to implementation of the pilot mission:

- An updated strategic plan;
- A set of research reactor key performance indicators for utilization;
- Self-assessment Report based on Utilization Assessment criteria provided in the mission Terms of Reference.

In preparation for the onsite mission LENA management confirmed that:

- Key management, operations, and utilization staff (users) are available during the review period;
- The access to research reactor and its experimental and production facilities is granted;
- The meeting with the key research reactor stakeholders and facility users is arranged.

Objectives of the mission

The main objective of the mission was to provide advice and assistance to LENA on, but not limited to:

- **Review of research reactor strategic plan** and corresponding action plans;
- **Review of the utilization level through key performance indicators (KPIs),** utilization assessment criteria and against available capabilities of a research reactor facility.
- **Review of the potential capabilities** identified already in the strategic plan document given the needs for products and services in the country and the constraints and threats that may limit the further development of research reactor services and products;
- **Identification of the gaps and areas of improvement** towards effective, efficient, and sustainable utilization of the facility;
- **Identify the opportunity to strengthen the LENA research reactor user community** and enlarge the stakeholder base.

The Terms of Reference of the IRRUR mission were developed in the Consultancy Meetings on development of the IRRUR mission (13-17 November 2017 and 25-29 June 2018, IAEA Headquarters, Vienna).

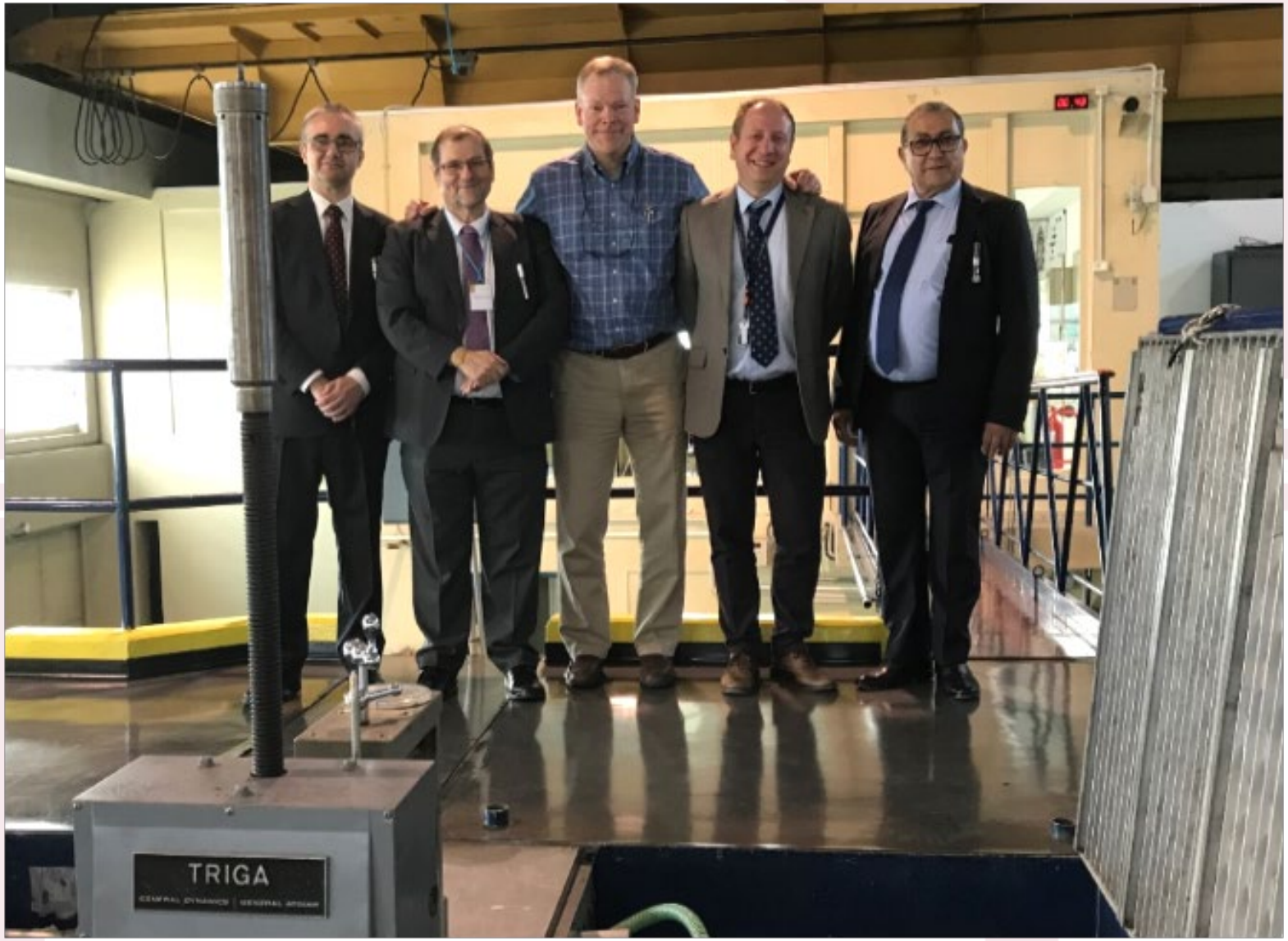
The draft of the strategic plan was developed in accordance with IAEA No. NG-T-3.16 and will be submitted for approval to the Scientific Committee.

	Name	Institution
1	Mr Saverio Altieri	LENA (University of Pavia)
2	Mr Andrea Salvini	LENA (University of Pavia)
3	Mr Daniele Alloni	LENA (University of Pavia)
4	Mr Michele Prata	LENA (University of Pavia)
5	Mr Sergio Manera	LENA (University of Pavia)
6	Mr Michelangelo Giordano	LENA (University of Pavia)
7	Mr Gabriele Vinciguerra	LENA (University of Pavia)
8	Mr Fausto Marchetti	LENA (University of Pavia)
9	Ms Carmela Piccitto	LENA (University of Pavia)
10	Mr Massimo Oddone	Chemistry department (University of Pavia)
11	Mr Simone Lazzaroni	Chemistry department (University of Pavia)
12	Ms Barbara Smilgys	Physics department (University of Pavia)
13	Ms Anna Condino	Monitoring Laboratory (University of Pavia)
14	Ms Emiliana Saletta	University of Pavia Radioprotection office
15	Mr Giancarlo D'Agostino	INRIM National Institute for Meteorological Research
16	Mr Marco Di Luzio	INRIM National Institute for Meteorological Research
17	Mr Paolo Pedroni	INFN National Institute of Nuclear Physics
18	Mr Massimiliano Clemenza	INFN National Institute of Nuclear Physics
IAEA team		
1	Mr Nuno Pessoa Barradas	IAEA
2	Mr Lubomir Sklenka	Czech Technical University, Czech Republic
3	Mr Ahmed Boufraqech	National Center for Energy and Nuclear Science and Technology (CNESTEN), Morocco
4	Mr Ronald A. Crone	Idaho National Laboratory, United States of America

The mission was a positive experience that directly involved the political component of the management, which increased the awareness of developed capacities and development opportunities.

The mission helped the plant to develop a systematic approach in the valuation of assets and planning for the development of the center

LENA staff is now more involved and aware of the Laboratory's strategic development planning and team spirit has increased.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