TÉCNICO LISBOA

ANNUAL REPORT 2013

IST/ITN
CAMPUS TECNOLÓGICO E NUCLEAR

Contents

Foreword

The integration of Instituto Tecnológico and Nuclear (ITN) into Instituto Superior Técnico (IST) proceeded, in 2013, in accordance with the general plans established at the time of the integration. A number of different actions were undertaken in order to fully integrate the people and facilities of ITN into IST. These actions, that are significant but too numerous to be addressed here, are described in other parts of this report.

I would like to thank the dedicated work of the commission that was designated to coordinate the integration process, constituted by Prof. Carlos Varandas (chair), Dr. José Marques and Dr. Eduardo Alves. Despite a number of difficulties that originate mainly in the difficult economic conditions of the country and in a lack of a strategy for the nuclear, factors that lead to reduced investment in ITN in the last decades, the work of this commission enabled IST to implement in Campus Tecnológico e Nuclear (CTN, the new designation of the ITN facilities) a number of new procedures and organizational structures. These changes are part of an integration process that will have significant impacts both on CTN and on IST itself, that will have to adapt its mission in accordance with the new requirements that result from the integration of ITN.

As President of IST, I pledge to continue to make all efforts to keep CTN and its units as a reference in the area of nuclear sciences, technologies and applications, in cooperation with the Portuguese government and other organizations, national and international, that are relevant in this area.

Arlindo Oliveira

President of IST

2013 was the first full year where the “Campus Tecnológico e Nuclear” was under responsibility of Instituto Superior Técnico, through the specially created platform IST/ITN. Therefore, the first goal of the management was the solution of several administrative and financial problems still pending from ITN and resulting from the integration of this State Laboratory in an academic environment.

At the same time the IST/ITN management commission has elaborated a “Strategic Development Plan for 2013-2018” which contains the general frame for the development of the main areas of activity (research, services, education and training), not forgetting the support infrastructures and the evolution of the professional careers. Regarding staff, 2013 was a turning year since it was possible to contract new staff and to fill a position of Coordinator Researcher, as a result of a recruitment competition, the first one since more than a decade.

The reorganization of the IST/ITN activities included in 2013 the creation of one Research Unit (C^2TN) and three Technological Development Laboratories, a new concept in the Portuguese academic system, as well as the beginning of the studies for the creation of a Department at CTN, a very important tool for the increase of the education and training components of the IST/ITN activity. The high quality of the work performed by the dedicated staff is well expressed by the figures presented in this report concerning the scientific output and the research and services contracts. Regarding research infrastructures, the IST/ITN management has elaborated preliminary studies on the future of the Portuguese Research Reactor and on the installation of a research and clinical cyclotron in our campus.

Since this preface is, most probably, my last official contribution to IST after a 40 years professional career, I would like to say that it was for me an honor and a privilege to have been the President of IST/ITN from March 1st 2012 to October 31st 2013. I would like to thank the collaboration and support that I received from the President of IST, Prof. Arlindo Oliveira, from my colleagues on the IST/ITN management Drs. José Marques and Eduardo Alves and from the research, technical, administrative and auxiliary staff.

Lisboa, July 2014

Carlos Varandas

President of the Management

Commission of IST/ITN

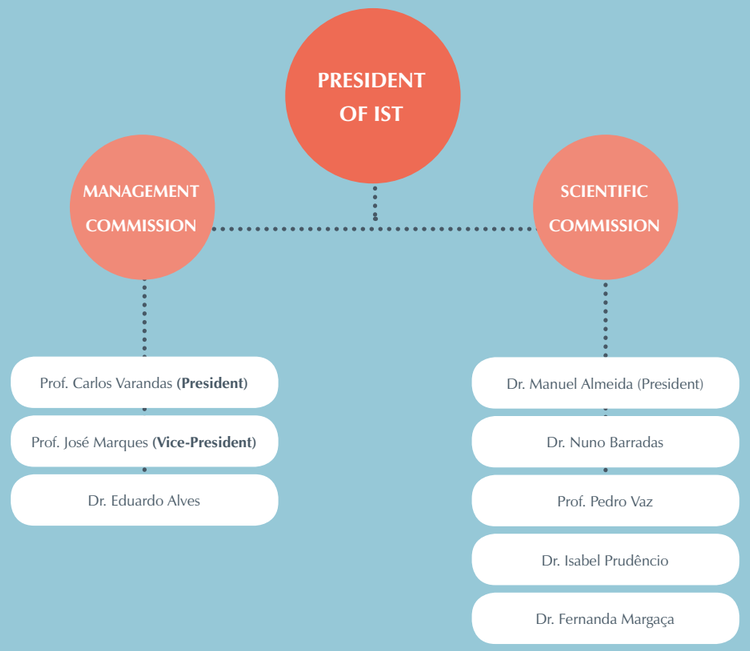
IST/ITN

IST/ITN is a crosscutting structure for teaching, research and advanced services in the areas of Nuclear Science and Technology, created by the IST School Council on 17 February 2012, with the following main objectives:

- To frame the activities of the former Instituto Tecnológico e Nuclear (ITN) after its integration into IST;
- To assure the full integration of ITN in IST;
- To conduct the reorganization of the ITN structure, taking into account the IST Statutes and Rules.

Aerial view of the Polo of Loures and Campus Tecnológico e Nuclear.

A Management Commission, assisted by a Scientific Commission, was in charge of the management of IST/ITN until 31 October 2013. With the retirement of Prof. Carlos Varandas, the President of IST took over the management of this structure, on a temporary basis.

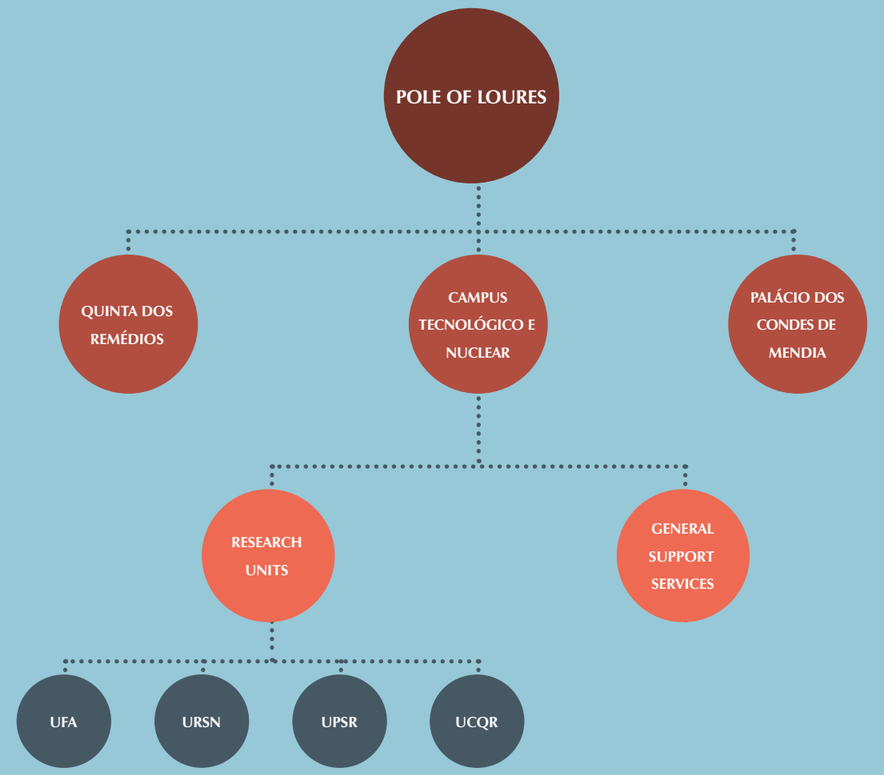


Aerial view of the CTN.

The IST/ITN activities in 2013 were mainly performed by four research units, carried out from the former ITN:

- Unit of Chemical and Radiopharmaceutical Sciences (UCQR);
- Unit of Physics and Accelerators (UFA);
- Unit of Radiological Protection and Safety (UPSR);
- Unit of Reactors and Nuclear Safety (URSN).

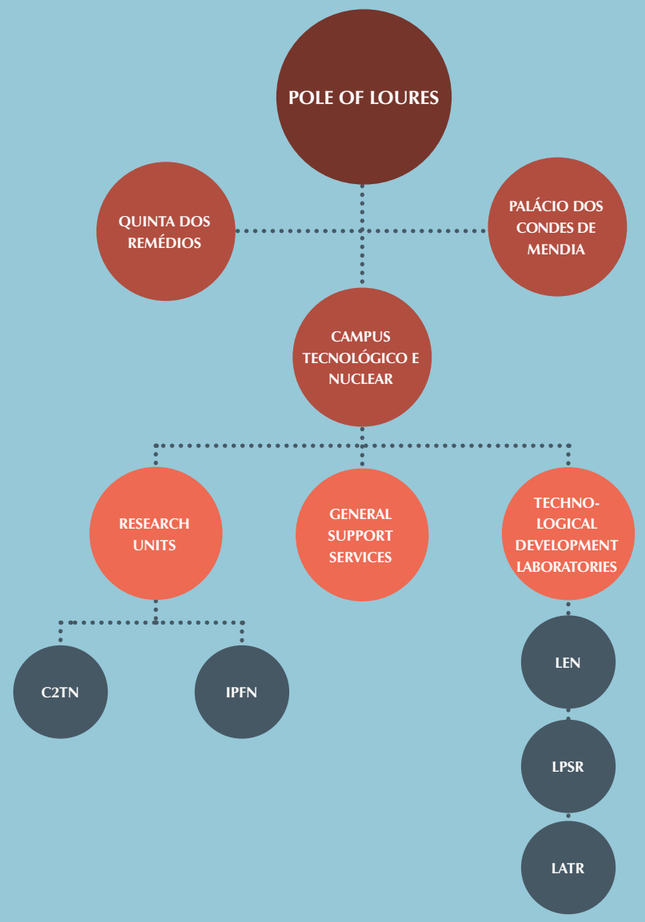
These research units used the main experimental facilities described in the 2011 ITN Annual Report and were assisted by the general support services of the Campus.



The Campus after 1 September 2013 hosted one new research unit and three new laboratories:

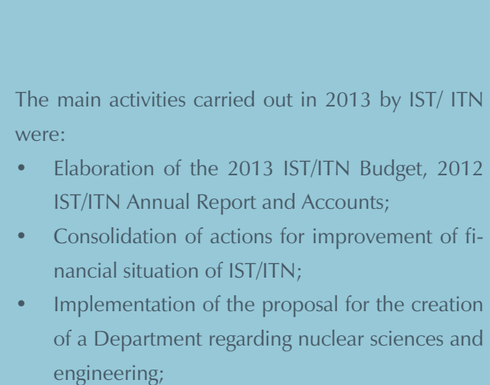
- Center for Nuclear Sciences and Technologies (C^2TN);
- Laboratory for Radiological Protection and Safety (LPSR);
- Laboratory for Accelerators and Radiation Technologies (LATR);
- Laboratory for Nuclear Energy (LEN).

The research unit C^2TN applied for funding by "Fundação para a Ciência e Tecnologia" at the end of 2013 for the cycle 2015-2020. The laboratories perform essential missions, such as radiological monitoring in the country, radioactive waste management as well as the operation of heavy infrastructures used by several research units, such as the Portuguese Research Reactor and the Tandem/ Van de Graaff accelerators. The Campus already hosts the European Shock-Tube for High Enthalpy Research (ESTHER) laboratory of the Institute for Plasmas and Nuclear Fusion (IPFN) research unit.

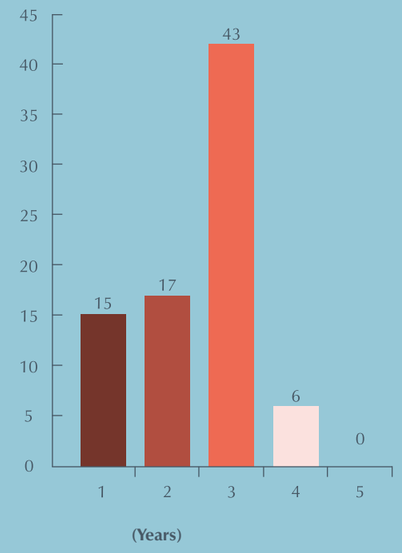


The main activities carried out in 2013 by IST/ ITN were:

- Elaboration of the 2013 IST/ITN Budget, 2012 IST/ITN Annual Report and Accounts;
- Consolidation of actions for improvement of financial situation of IST/ITN;
- Implementation of the proposal for the creation of a Department regarding nuclear sciences and engineering;
- Reorganization of the management of heavy infra-structures and national and international missions with the creation of three laboratories: (i) Laboratory for Radiological Protection and Safety (LPSR), (ii) Laboratory for Accelerators and Radiation Technologies (LATR), (iii) Laboratory for Nuclear Engineering (LEN).
- Promotion of the restructuring of research and development activities in the Campus through a new research unit (C^2TN), that consolidated the existing 19 research groups into 6 new groups;
- Organization of activities in CTN in two research units (C^2TN and IPFN), three laboratories and a general support service.
- Continuation of the research and development (R&D) activities previously performed by ITN in the frame of contracts with funding agencies, like, for instance, "Fundação para a Ciência e a Tecnologia" (FCT), 7th Framework Programme of the European Union (EU) and International Atomic Energy Agency (IAEA);
- Submission of new projects to national and international funding entities;
- Continuation of the activities concerning the ITN national and international missions and commitments that have not been transferred to other entities;



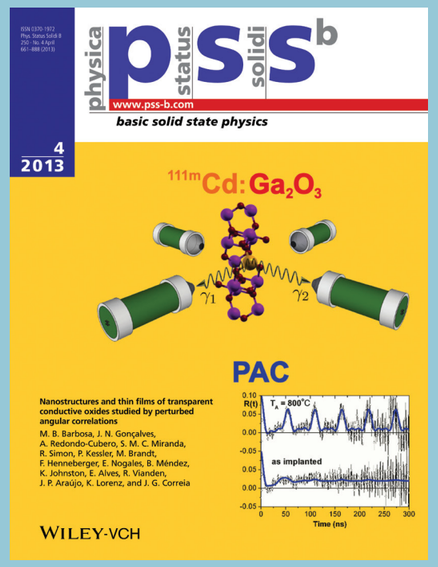
Number of projects per funding level.



Number of projects per duration.

Participants in the IAEA Regional Training Course on Microbiological Aspects of Radiation Sterilization held at CTN.

Monitoring during the CURIEX 2013 exercise.



Back cover of Physica Status Solidi B (published by Wiley-VCH) issue with work done at CTN and ISOLDE/CERN.

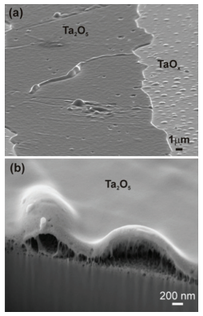
- Increase of the cooperation with IAEA, with strong support from the Portuguese Embassy in Vienna;
- Technical Support to the Portuguese Government on the transposition of Euratom Directives;
- Organization at CTN of one IAEA Regional Training Course within the Technical Cooperation Programme and participation in the organization of other IAEA training actions in other Member States.
- Continuation of programmes and actions on professional training and advanced education;
- Ongoing efforts regarding the elaboration of proposals concerning the research reactor and the installation in Lisbon of a multidisciplinary research and clinical cyclotron facility;
- Participation in the ISOLDE Collaboration at CERN;
- Operation of the Station RN53 of the CTBTO International Monitoring System;
- Participation in the nuclear/radiological emergency exercises CURIEX 2013 in Spain and CONVEX 3 – NRBQ 2013 in Portugal;
- Consolidation of the operation of the "Unit of Radiation Technologies" (UTR) in the frame of the LATR;
- Maintenance intervention in the most affected buildings of the Campus.

Physics and Accelerators

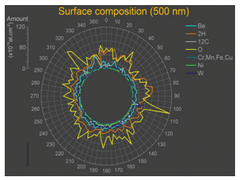
Mission and Objectives

- R&D of advanced materials, processes and technologies for applications to **Industry, Biomedicine, Environment and Cultural Heritage** using Nuclear Techniques and Radiation Technologies.
- Operation and upgrading of infrastructures and techniques open to the community, through collaborations and services.
- Dissemination of knowledge and know-how and promotion of advanced learning in the areas of expertise.
- Specialized services and consultancy and technical assistance to the industry.
- Development of equipment using ionizing radiation for industry and research.

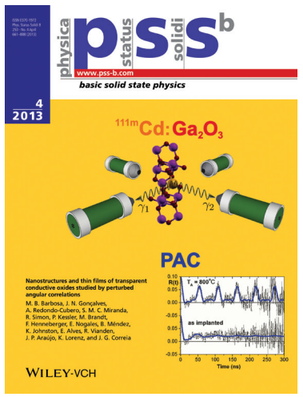
Ion beam studies of hand-written documents with iron gall inks from the XIX century (up) and pigments on XVII century oil paintings on copper support, attributed to the Flemish artist Frans Francken (Down).



Microstructures observed in W-Ta implanted sequentially with He^+ and D^+ ions evidencing (a) blistering in Ta_2O_5 and TaOx regions and (b) blister profile in Ta_2O_5 region.



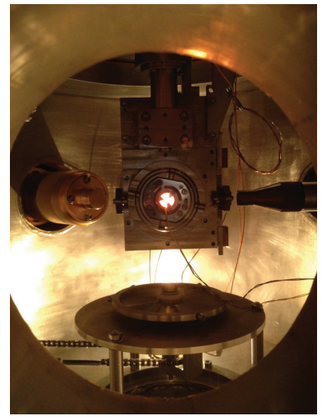
Distribution of deposited elements in a rotating collector from the divertor region of JET.



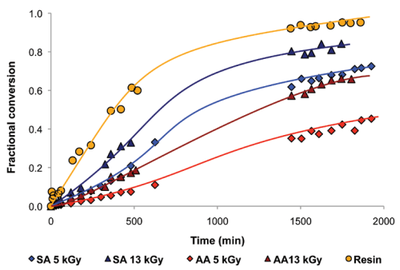
^{111m}Cd/^{111}Cd: Ga_2O_3 PAC studies were chosen to picture the back-cover of Physica Status Solidi B 250, iss 4, 2013, http://dx.doi.org/10.1002/pssb.201200923.

Main Achievements

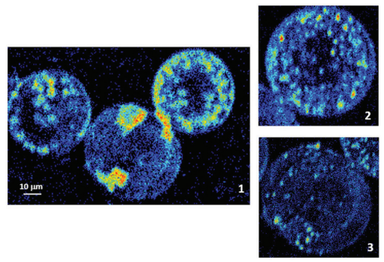
- Rare earth doping of wide bandgap compounds and low dimensional structures with optical active ions was achieved.
- Embedded ferromagnetic nitrides in large bandgap semiconductor oxides for electronics applications.
- Development and Fuel Retention studies on High-Z materials for Plasma Wall applications.
- Ion beam analysis of ITER Like Wall (ILW) tiles exposed to JET plasma in 2012. A significant reduction of erosion and fuel trapping was found.
- Ion beams studies of Cultural Heritage objects, mainly metals, glass and paintings (*Frans Francken: Fleming artist*).
- Study of production processes of decorative paintings with noble metals Au, Ag and Pd in high added value Pb-glasses using ion beams.
- At ISOLDE Perturbed Angular Correlations (PAC) have been used to study Ga_2O_3, a promising material for high power electronics, showing that implanted ^{111m}Cd (p-type dopant) occupies only the octahedral substitutional Ga-sites, in single-crystals, pellets and nanowires.
- Isotopes (EC-SLI) three milestones were achieved when concluding studies on a) Cation versus anion substitution in transition-metal doped GaN and ZnO, b) Lattice sites of implanted Mg in the group-III nitrides and, c) the Lattice sites of transition metals Mn, Fe, Co, and Ni in Si.
- The relationship between iron deposits and ferritin in inflammatory conditions of skin
- Bioaccumulation of metals by diatom cells and plants exposed to metal pollution.
- Functionalization of hybrid materials to promote bioactivity.
- Optimization of PVA supported catalytic crosslinked membranes for biodiesel production.
- Irradiation effects on small fruits to improve the diet of immune-compromised patients.
- Preservation of medicinal plants by gamma radiation.
- Ionizing radiation inactivation patterns of enteric viruses.
- Study of the effects of gamma radiation on cork wastewater: physical-chemical and microbiological aspects.
- Extraction of antioxidants from cork wastewater by activated carbon.
- Evaluation of indoor concentration of airborne bacteria and fungi in several public buildings.
- Microbiological assays of the activity of antibiotics *in vitro*.



The picture shows the EC-SLI goniometer during vacuum annealing of a sample at 900ºC. The beam of radioactive probes enters from the right, through the collimator nozzle.

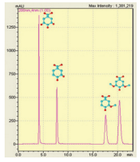


Kinetic curves of esterification reaction of LA over free resin and over resin supported on PVA crosslinked membranes (10% of PVA –OH groups).

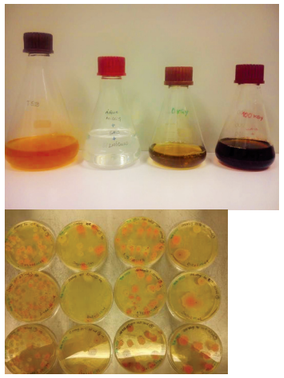


Nuclear microscopy of single diatom cells in valve view. Density image (1) and Ca distribution in 2 cells evidencing the chloroplast distribution and parietal cytoplasmatic arrangement (2 and 3).

Gamma irradiated strawberries at 5 kGy for shelf-life extension.



Extraction of antioxidants from cork wastewater by activated carbon: HPLC chromatogram of phenolic compounds.



(Right) Batch biodegradation experiments of cork wastewater microbiota on irradiated phenolic acids solutions.

Laboratory Equipment for the Determination of Radioactive Element Traces by Electrodeposition.

Nuclear Instruments and Methods:

- Modelling of radiation fields and equipment design;
- Determination of nuclear data - CERN n_TOF Experiment (phase 2);
- Development and application of plasma at atmospheric pressure;
- Development of software for control and data analysis;
- Design of electronic instrumentation for nuclear applications;
- Specialized services (consulting, training and technical assistance);
- Marketing of nuclear instrumentation made in CTN.
- Commissioning of two new EC-SLI electron position sensitive Si pad detectors (30 x 30mm^2, 22x22 pads, 300 μm thick) equipped with new vatagp7 readout chips.

Chemical and Radio-pharmaceutical Sciences

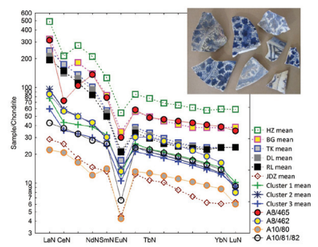
Mission and Objectives

- Promote and provide a focus for networks aiming at the development of research and expertise in the synthesis and characterization of inactive and radioactive compounds, and characterization of cultural, geological and biogenic materials, and hydrological resources.
- Development and application of nuclear methods and luminescence to geoenvironmental and cultural heritage issues; geochemical, mineralogical and absolute dating tools.
- Elemental and Isotopic Analysis and Radiocarbon Dating- applications in the fields of Environmental Geochemistry, Isotope Hydrology, Oceanography and Archaeometry.
- f-Element chemistry studies at fundamental and applied levels in the areas of nuclear science, catalysis and new materials.
- Basic/oriented research and technology transfer on specific halogen- and metal-based nuclear tools for SPECT and PET Molecular Imaging and Targeted Radiotherapy.
- Exploration of ternary intermetallic phase diagrams based on f- and d- elements and studies of exotic ground state properties such as strongly correlated electron behaviour, superconductivity and magnetism.
- Development of multifunctional molecular materials by combination of magnetic and electroactive centres.

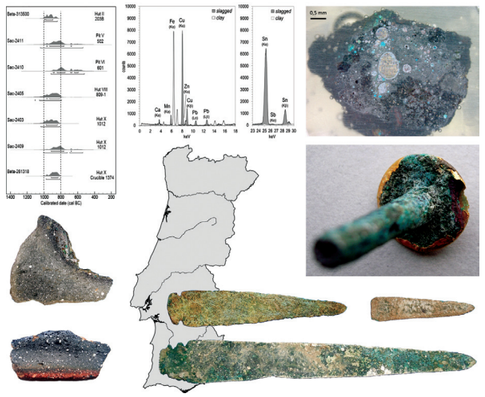
Main Achievements

Nuclear methods applied to Cultural Heritage

The chemical characterization of porcelain fragments from archaeological sites from Lisbon and Coimbra obtained by INAA showed a general provenance from southern China kilns. A few porcelains were attributed to Jingdezhen and Zhangzhou kilns. An increasing improvement of the production procedure from late 15th till the 17th centuries of the Chinese porcelains sent to Portugal was found.



REE patterns of porcelains found in Portugal, and Chinese kilns (Zhangzhou and Jingdezhen).



SW Bronze Age metallurgical remains and metallic artefacts (chemical and microstructural characterization and dating).

Alluvial plain at southern Portuguese coast.

Groundwater sampling at Santiago Island, Cape Verde (sustainable groundwater management).

Archaeometallurgy

Although the production of bronze alloys in the Southwestern Iberia was established to have been initiated during the third quarter of the II Millennium BC, the introduction of these alloys could be pushed backward to the second quarter of the II Millennium BC, probably as imports.

Environmental Geochemistry

Diverse trends of sea level, climatic fluctuations, Bond events, humid episodes and/or Human intervention in the landscape, have been recognized to be recorded in the filling up of alluvial plain estuaries in the Iberian Peninsula over the last 5000 years.

Isotope Hydrology

Salinity sources and renewability of groundwater on coastal aquifers of Algarve, Sado (Portugal), Cap Bon (Tunisia) and Cape Verde were recognised. The conceptual hydrogeological circulation models of Cabeço de Vide mineral waters and in Melgaço-Messagães (N of Portugal) could be established.

Dose rate evaluation from natural radioisotopes

The concentrations of natural radionuclides obtained using two methods for comparison - the field gamma spectrometry (FGS) and instrumental neutron activation analysis (INAA) - as their combination may help detect spatial variations and disequilibrium in the U series.

Molecular thorium and uranium carbide clusters

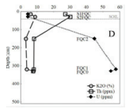
Laser ionization of solid thorium and uranium carbide targets resulted in molecular actinide carbide clusters. Intriguing high abundances for both ThC_{13}^+ and UC_{13}^+ and for $Th_{13}C_n^+$ were observed. A disparity between An = Th and U in the relative abundances of the bimetallic ions $An_2C_3^+$ and $An_2C_4^+$ was apparent and elucidated by computations based on density functional theory.

Targeting of Inducible Nitric Oxide Synthase with M(CO)$^{3+}$-Complexes (M = ^{99m}Tc/Re)

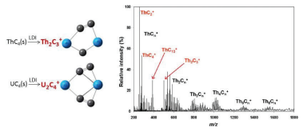
Computational studies, molecular docking, MD simulations and FEP calculations, allowed the identification of the interactions responsible for the iNOS-recognizing ability of the complexes, showing that electrostatic interactions between the $Re(CO)_3$ core and R260/R382 are a key issue. These findings will allow a more rational design of $M(CO)_3$-complexes (M = ^{99m}Tc/Re) for in vivo NOS targeting, offering better opportunities to obtain best performing compounds.

Bisphosphonate-containing ^{99m}Tc(I)/Re(I)-complexes for theranostic of MBD

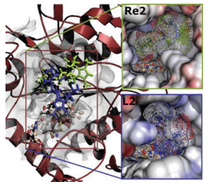
Complexes of the type fac-$[M(CO)_3(k^3\text{-}L)]^+$ (M = ^{99m}Tc, Re) stabilized by azolyl-containing bifunctional chelators with different molecular weight, overall charge, (lipo)hydrophilic nature and different posi-



Radionuclide concentrations through an aplite dyke, which locally exceeded minimum reference levels for gamma radiation despite release of up to 590 Bq. kg^{-1} of ^{220}Rn.



Molecular actinide carbide clusters.



Molecular surfaces of the active site of the complexes L2:iNOS and Re2:iNOS colored according to electrostatic potential.

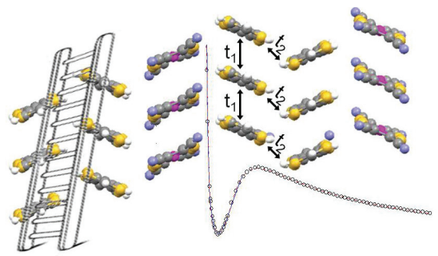
tions of BP attachment were synthesized. Biodistribution studies in mice have shown that complexes bearing the BP unit at position 4 of the azolyl ring (^{99m}Tc1/188Re) present the most favourable pharmacokinetics, and the highest accumulation in the cytosol.

A Weakly Disordered Molecular Spin-Ladder System

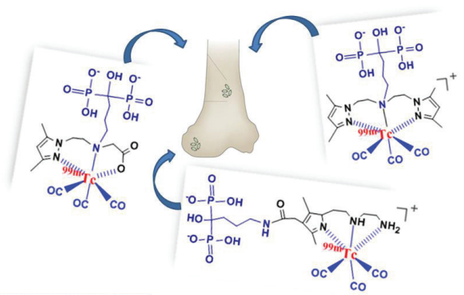
(α-DT-TTF)$_2$[Au(mnt)$_2$] not only enlarges reduced the number of organic spin-ladder systems in a unique series of closely related molecular compounds, but also provides an interesting example of a weakly disordered spin-ladder system.

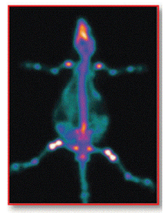
Magnetic properties of f-element materials

$Dy_8(OH)_{20}Cl_4{\cdot}6H_2O$ is the first example of a layered lanthanide compound displaying slow magnetic relaxation below 5 K, even in the absence of an external field, with a blocking temperature of 3 K and an energy barrier of 36.1 K, a behaviour characteristic of single-molecule magnets. The work was highlighted in the cover of issue 29 (October 2013) of the European Journal of Inorganic Chemistry.

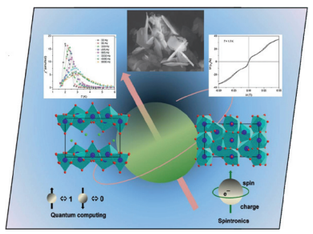


Schematic ladder arrangement of donor molecules in the crystal structure of (a DT-TTF)$_2$[Au(mnt)$_2$] and magnetic susceptibility behaviour





Schematic drawing of selected examples of BP-containing fac-[M(CO)$_3$(k^3-L)]$^+$ complexes and planar whole-body gamma camera image of a rat injected with a radioactive complex.

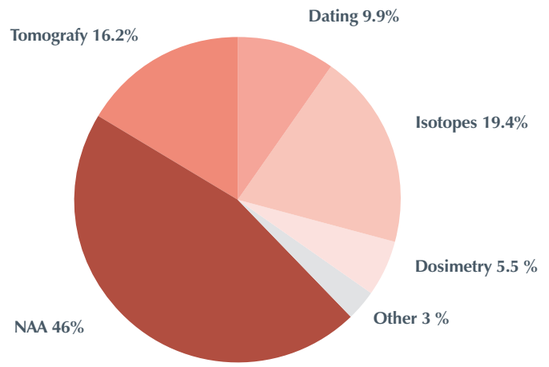


Slow magnetic relaxation in a layered lanthanide hydroxide.

Reactors and Nuclear Safety

Mission and Objectives

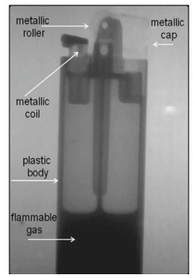
The main mission of this unit is the operation of the Portuguese Research Reactor (RPI), in order to satisfy the user's needs while conducting all tasks with the assurance that the reactor is operated in a safe and reliable manner. The Neutron Activation in Environment, Nutrition and Epidemiology (NANE) group is the main user of the RPI and focus its activities on the development of neutron activation analysis (NAA) methodologies and their application to environment, nutrition and epidemiology studies, while the Applied Dynamics Laboratory (ADL) group does research in the area of vibration and acoustic problems, both of industrial and fundamental nature.



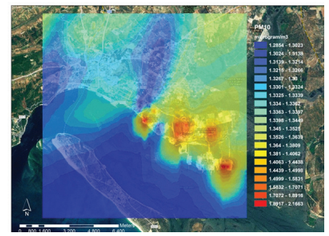
Main uses of the RPI in 2013.

Main Achievements

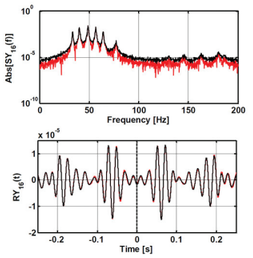
- The RPI was available for its users 192 days in 2013. A total of 497 irradiations were performed, corresponding to 1131 h of reactor time. The main activity supported by the RPI was Neutron Activation Analysis (NAA), which accounted again for about 50% of the use of the reactor. Other significant activities were neutron radiography, isotope production and irradiations for dating with the $^{40}Ar/^{39}Ar$ method.
- Significant improvements were made in neutron imaging using solid state nuclear track detectors. Although these detectors have been used for charged particle detection for several decades, their use in neutron radiography resulted in images with very low contrast. We have used an enriched boron-10 screen as a neutron to charged particle converter and digitised the images using a flatbed scanner with a new procedure resulting in a better contrast. In this way it was possible to obtain a significant reduction on the optimum neutron fluence to obtain a neutron radiography image.
- Within the SIMPLE project, significant progress was made in the understanding of particle discrimination using superheated droplet detectors. Three experiments use the superheated liquid technique: PICASSO, COUPP and SIMPLE, albeit with different molecules, respectively, C_4F_{10} (R-610), CF_3I (R-13I1) and C_2ClF_5 (R-115). Only SIMPLE reported a clear separation between neutron- and α-induced events which was a surprising result. We have shown that this happens because an α particle achieves a LET above the critical level only in a small range of 32-40 μm of liquid penetration, resulting on a size cut-off for bubbles with radius below 16 μm.
- Within the PM-Fugitive project, receptor and dispersion models were used to estimate the environmental impact of fugitive emissions in the industrial area of Mitrena, Setúbal. Results showed fugitive emissions represented an increase in the PM10 concentration which highly depended on the season. It was found that on average fugitive emissions contribute to 20% of PM10, in summer, and to 4%, in the winter;
- A general strategy to identify the turbulence excitation from measurements of nuclear fuel rod response vibrations was further developed in collaboration with CEA-Saclay and applied to multi-supported fuel bundles, a quite delicate inverse problem. We also developed original refined methods for the estimation of unmeasured cross-spectra and cross-correlation functions from a limited set of measured data, in order to reconstruct incomplete measurement matrices. The four data reconstruction techniques developed in 2013 to address difficulties in this project can potentially be also used within a large body of other identification problem fields.



Neutron radiography of a gas lighter. The image was recorded using a CR-39 solid state nuclear track detector and digitized using a HP4370 scanner.



Contribution of fugitive emissions in Summer (Mitrena – Setúbal).



Illustrative results of an original method for the estimation of non-measured data from an incomplete set of measurements: reference (black) and the corresponding estimated (red) cross-spectrum and cross-correlation functions.

Radiological Protection and Safety

Mission and Objectives

- Deployment of unique scientific and technical expertise, skills and competence in radiological protection in Portugal.
- Keeping abreast of the state-of-art in scientific and technical topics and in international regulations and safety standards in modern radiological protection and radiation safety.
- Fulfilment of the Portuguese State duties and obligations in radiological protection and radiation safety.
- Provision of scientific and technical advice and support to the Portuguese Government, to the competent authorities and to other entities and stakeholders in the execution of policies in radiological protection and in areas involving applications of ionizing radiations and radioisotopes.
- To play a leading role in Portugal, through research, services, education and training activities, in the promotion of radiation and nuclear safety culture amongst the staff in radiological installations and in the implementation of radiological protection and safety procedures compliant with the international safety standards and regulations.

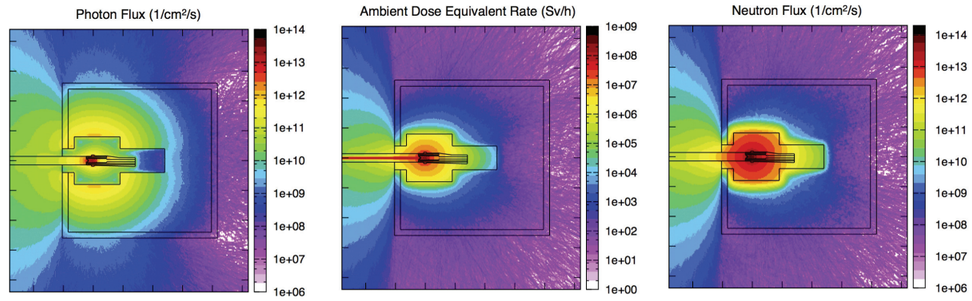
Main Achievements

R&D activities

- Research activities in radiological protection, dosimetry, radiobiology, metrology, environmental radioactivity and radioactive waste management were undertaken in the framework of:
- The participation in several R&D projects funded by EU FP7 programmes and by FCT in collaboration with Portuguese academia, research centres and hospitals.
- The cooperation with CERN, EURADOS (European Radiation Dosimetry Group) and EURAMET (European Association of National Metrology Institutes) in the fields of radiological protection and safety, dosimetry and metrology of ionizing radiation.
- The membership of European Union Technology Platforms such as MELODI (Multidisciplinary European Low Dose Initiative) and IGD-TP (Implementing Geological Disposal Technology Platform).

High added value Services, Quality Management System and accreditation of techniques

- The assessment of the safe use of ionizing radiation in 7 medical (radiotherapy and nuclear medicine) and industrial facilities.
- Radiological safety assessment, implementation of safety culture and training in facilities and activities with LINACs cargo-scanners of three harbours in Cape-Verde.
- The individual monitoring of the exposure of workers to ionizing radiation (approximately 3800 workers from 700 facilities were monitored on a monthly or quarterly basis).
- The assessment of indoor radon concentrations (about 490 measurements of radon concentration were performed during the year).
- Analyses of the radioactivity contents of environmental (waters, foodstuffs, building materials, soils, aerosols, etc.) and biological samples. Several hundreds of samples were measured throughout the year using techniques such as gamma and alpha spectrometry, liquid scintillation and proportional counters.
- The collection, segregation and interim disposal of radioactive waste from the medical, industrial and research uses of ionizing radiation (154 interventions were performed during the year).
- The licensing of radioactive sealed sources (545 licenses were issued).
- The calibration and metrological verification of radiation monitors and detectors (approximately 125 monitors and detectors were calibrated).
- Detection of radioactive materials in scrap metal at smelting factories (23 events were reported).
- Radiological protection and safety verifications (6 verifications and monitoring actions were undertaken concerning radiological protection and safety of medical and industrial facilities).
- The environmental radiological monitoring during the visit of 3 nuclear propulsion vessels at Portinho da Costa harbour in the estuary of Rio Tejo.
- The implementation and consolidation of the Quality Management System of the UPSR was pursued, aiming at receiving the accreditation from the IPAC (Portuguese Institute for Accreditation) for ten radioanalytical, dosimetric and metrology techniques.



Cooperation with CERN in radiological protection and safety studies, dosimetry and shielding assessment of nuclear technology facilities, using Monte Carlo simulations.

Fulfilment of legal obligations

- Perform under Article 35 of the EURATOM Treaty, the environmental radiological monitoring of the Portuguese territory. Sampling of aerosols, rainwater, surface water, sediments, fish, drinking water, mixed diet, complete meals, milk and soils were performed during the year. The results are published yearly and made available to the European Commission.
- Maintaining the national standards for ionizing radiation at the Laboratory of Metrology of Ionizing Radiation.
- Statistical survey of the most frequently performed medical examinations in radiodiagnostic and nuclear medicine in Portugal (continuation of the DoseDataMed 2 project).
- Maintain and update databases on the exposure of workers to ionizing radiation and the corresponding doses received, on radon concentration and on environmental radioactivity measurements.

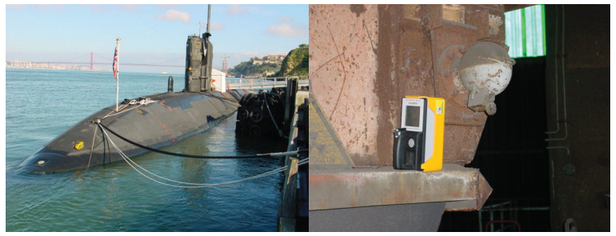
Preparedness of response to radiological and nuclear accidents/emergencies

- The scientific and technical expertise, competences and skills in the existing biodosimetry and radiobiology techniques were further consolidated and new techniques were implemented, in the framework of the UPSR participation in European networks and projects, aiming at increasing the preparedness of response to radiological and nuclear emergencies.
- The operation of the Whole Body Counter, unique equipment in Portugal, to assess the internal contamination of individuals due to the incorporation of radionuclides, was pursued.

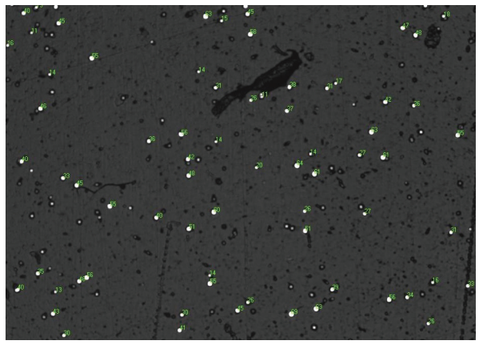
Organization of Conferences and Workshops, education and training activities

The undertaken activities included, *inter alia*:

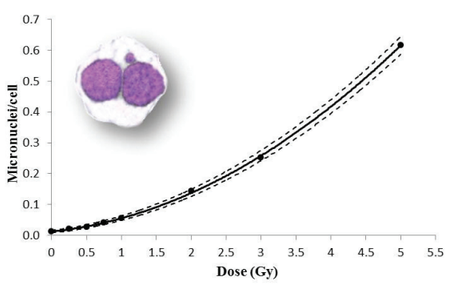
- The organization of the Conference “Protecção Radiológica na Saúde 2013 (PRS2013)” promoted by IST and DGS (General Directorate for Health), which gathered medical doctors, medical physicists, radiation technologists, representatives from research organizations, academia, international organizations and foreign institutions, competent and regulatory authorities, medical equipment manufacturers and companies. PRS2013 addressed a wide spectrum of state-of-the-art and leading edge scientific and technical topics in modern radiological protection of the patient and staff in the medical applications of ionizing radiation.
- The organization of three Workshops and Training Courses in the framework of international research projects addressing scientific and legal metrology issues and radiological and nuclear emergencies.
- The organization of training courses for staff in the industrial sector and companies.
- The supervision of 7 PhD and several Master´s thesis students.
- Lecturing of radiological protection related disciplines in Portuguese Universities and Higher Education establishments.



Radiological monitoring during the visit of nuclear propulsion vessels (left) and radiation surveys of facilities (right).



Microscopic image of alpha particles tracks from radon in a LR115 solid state nuclear track detector. Each dot corresponds to the interaction of an alpha particle with the film.

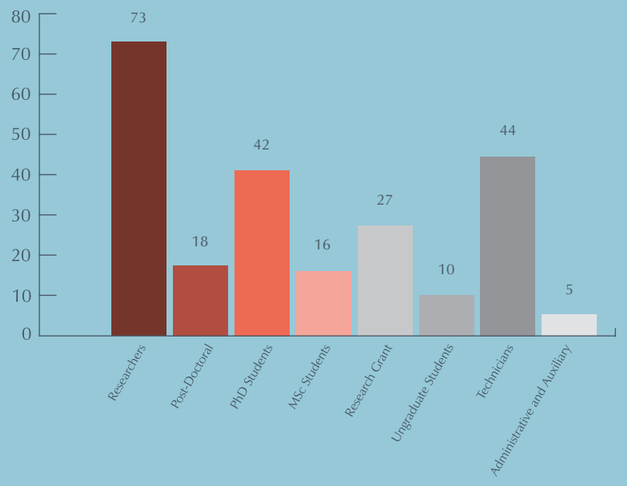


Dose response curve for Portuguese population using the micronucleus assay. Results are from 16 donors and a total of 128000 binucleated cells were scored.

UPSR Infrastructures: Cobalt-60 irradiator (left) and HPGe detectors for gamma spectrometry (right).

Staff, Budget and Scientific Output

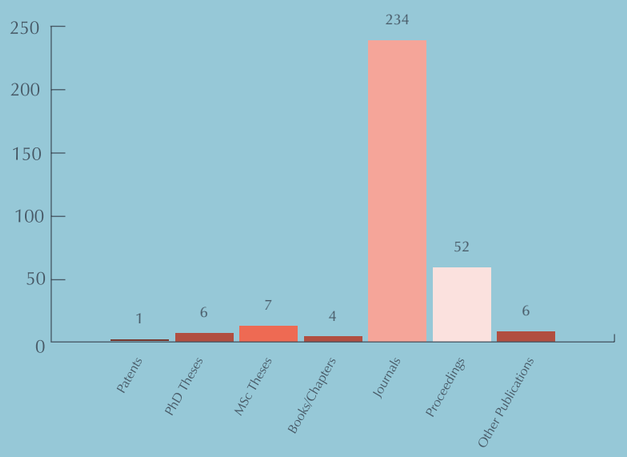
STAFF



Technicians - Graduated: 20; Undergraduated: 24.

Undergraduated Students: BSc Students; ERASMUS and AIEA Fellowship Students.

Scientific Output

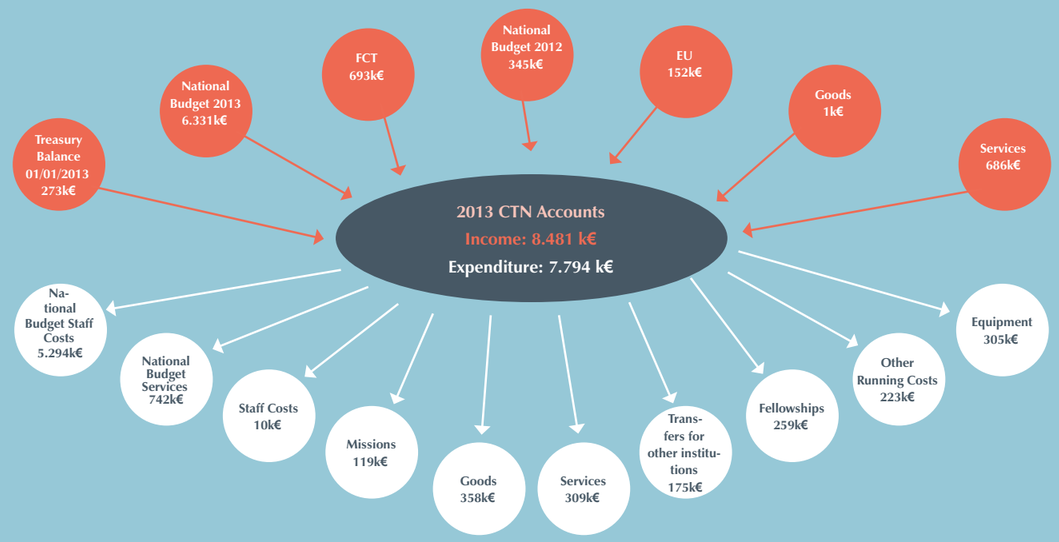


Journals - International: 224 (ISI/WOS: 208; com DOI: 11; sem indicação de DOI: 5); National: 10.

Proceedings - International: 38 ; National: 14.

Patents – 1: "Selective electrochemical conversion of CO_2 into C_2 hydrocarbons"; Proponent: OMNIDEA; Inventores: T. Pardal, R. Fernandes, M. Gonçalves, J. Condeço, A. Boavida, J. Branco; international ambit (INPI, Pt 105566 de 2011). International-European Patent (classification C25B 3/04 (2006.01); Patent nº: 12715237.9-1360 PCT/PT2012000008) (21.10.2013).

2013 CTN Cash Flows (in K€)



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