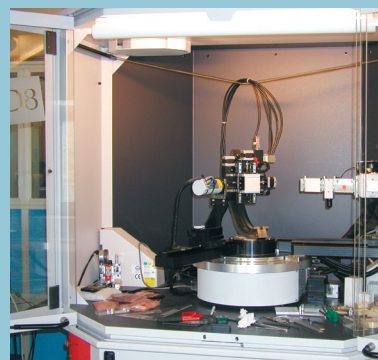
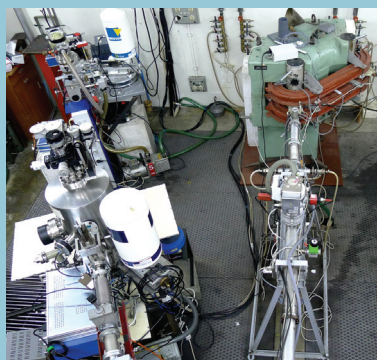




TÉCNICO LISBOA

ANNUAL REPORT 2012

IST/ITN CAMPUS TECNOLÓGICO E NUCLEAR



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Foreword



This document presents the activities carried out in the “Campus Tecnológico e Nuclear” (CTN) in 2012. This year the former “Instituto Tecnológico e Nuclear” (ITN), a state laboratory, was integrated into “Instituto Superior Técnico” (IST), the

engineering school of “Universidade Técnica de Lisboa” (UTL) by the Decree-Law 29/12.

As President of IST, I would like, once again, to welcome all members of the former ITN which are now fully integrated in the IST family. IST is very proud of incorporating such a prestigious institution with a long history and a well deserved international recognition.

IST management has already taken measures to facilitate the integration of ITN into IST. Foremost amongst them are the creation of the Pole of Loures, which will give an important contribution to the consolidation of the multi-pole structure of IST, and the definition of the internal organization of CTN, in terms of research structures, laboratories and administrative support units.

IST will continue to make all efforts to keep CTN as a reference campus for nuclear sciences, technologies and applications. We will also guarantee all the conditions that are required for CTN units to perform the missions that were agreed with the Government, Authorities for Nuclear Safety and Radiological Protection and International Organizations.

Arlindo Oliveira
President of IST



I have had the honor to be the President of the Management Commission (MC) of IST/ITN, a crosscutting structure for teaching, research and advanced services in the areas of Nuclear Sciences and Technologies created by the IST School

Council following the integration of ITN into IST.

The main activities carried out since March 1st 2012 are summarized in pages 5 to 7.

My work has been strongly facilitated by the collaboration that I received from my MC colleagues, the President and other members of the Scientific Commission, the Heads of Research Units and Support Services and, mainly, the staff.

Very special thanks to Profs. Arlindo Oliveira, António Cruz Serra, Leonor Parreira and Miguel Seabra as well as to Ambassador Ana Martinho respectively President of IST, former President of IST and present Dean of the “Universidade Técnica de Lisboa”, Secretary of State for Science, President of “Fundação para a Ciência e a Tecnologia” and Permanent Representative of Portugal to the international organizations sited in Vienna.

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

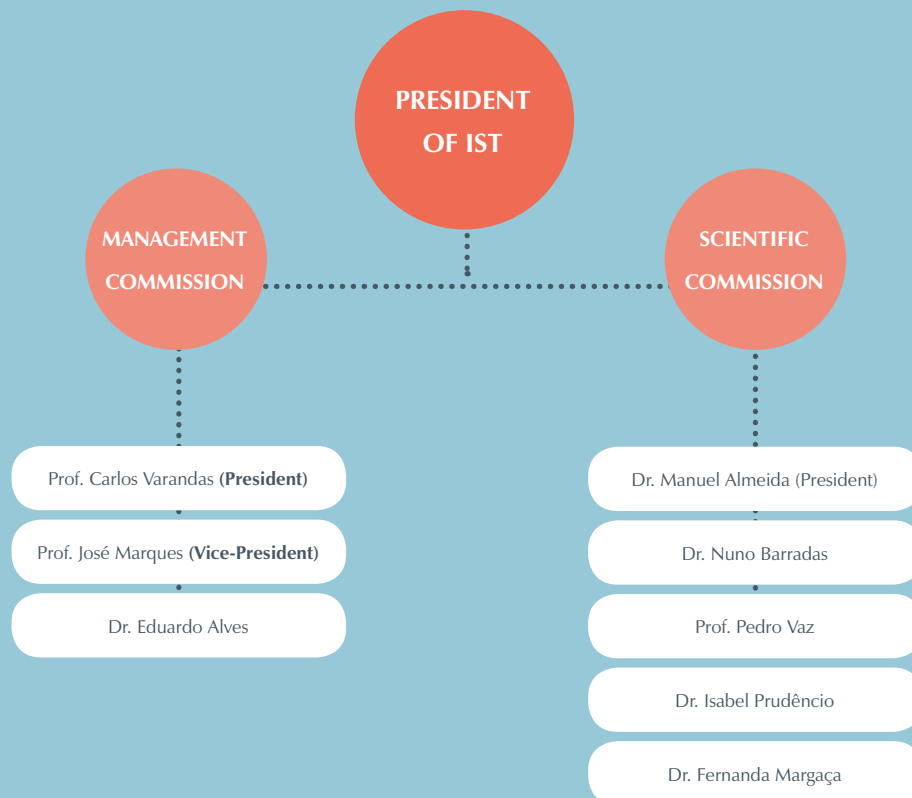
Tecnológico e Nuclear (ITN) after its integration into IST;

- 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.



Air view of the Polo of Loures

A Management Commission, assisted by a Scientific Commission, has been in charge of the management of IST/ITN.

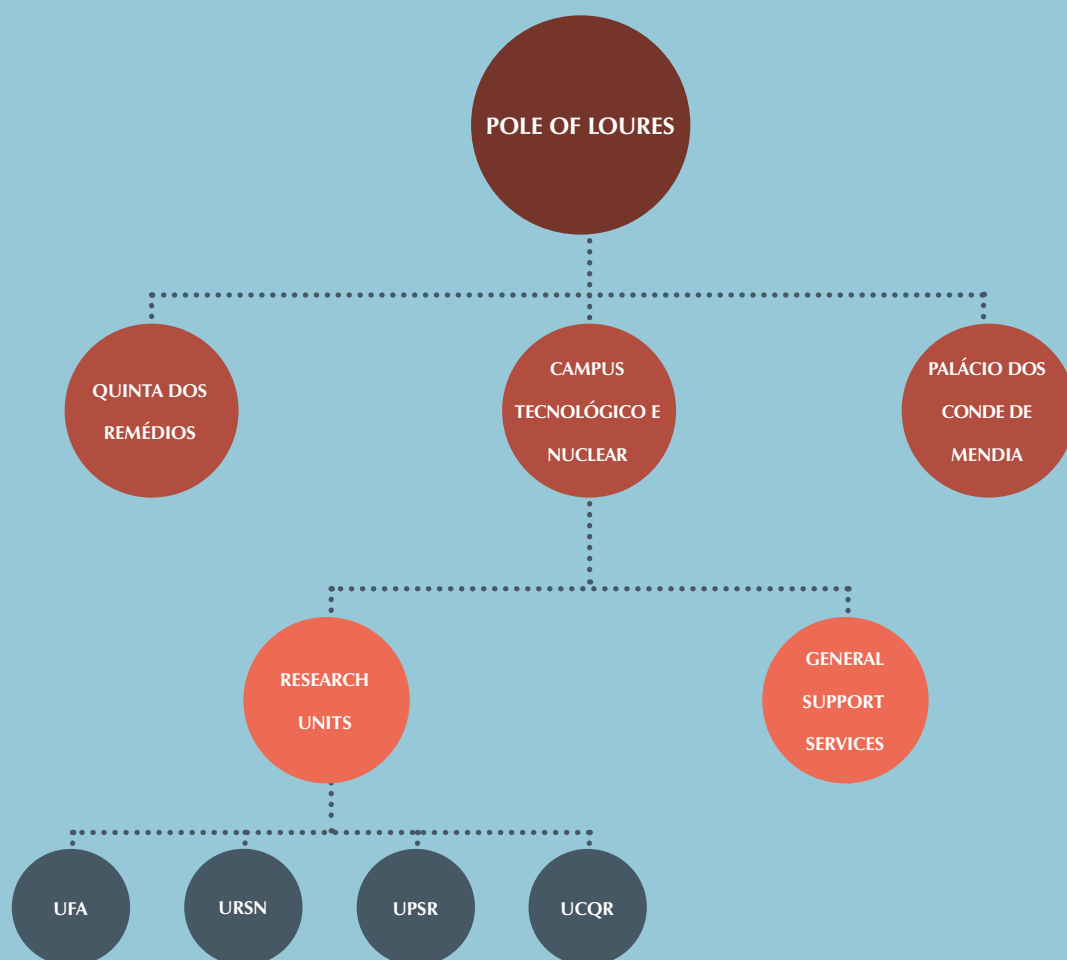


Air view of the CTN

The IST/ITN activities have been mainly performed by the General Support Services and four research units:

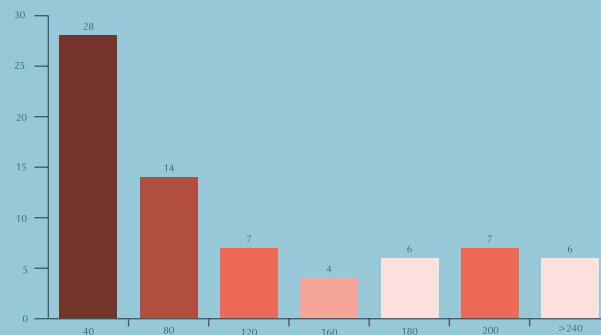
- Unit of Chemical and Radiopharmaceutical Sciences (UCQR);
- Unit of Physics and Accelerators (UFA);
- Unit of Radiological Protection and Safety (UPSR);
- Unit of Reactors and Nuclear Safety (URSN),

using the main experimental facilities that are described in the 2011 ITN Annual Report.

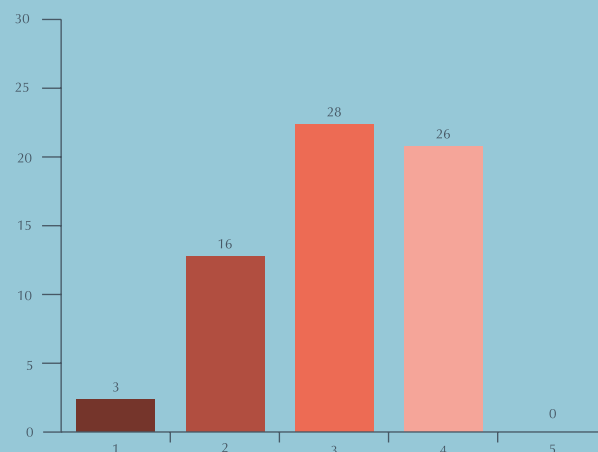


The main activities carried out in 2012 by IST/ITN were:

- Elaboration of the 2012 IST/ITN Budget, 2011 ITN Annual Report and Accounts as well as the ITN accounts until 30 April 2012;
- In depth analysis of the ITN financial situation and adoption of actions for its improvement;
- Implementation of a new policy regarding information in the campus;
- Elaboration of a proposal for the creation of the IST Pole in Loures, composed by the “Campus Tecnológico e Nuclear” (CTN), “Quinta dos Remédios” and “Palácio dos Condes de Mendia”;
- 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 FCT, EU and IAEA;
- Continuation of the activities concerning the ITN national and international missions and commitments that have not been transferred to other entities;
- Increase of the cooperation with IAEA, with strong support from the Portuguese Embassy in Vienna;
- Technical Support to the Portuguese Government on the elaboration of a new Country Programme Framework and the transposition of Euratom Directives;
- Organization at CTN of two international training Workshop of the IAEA Technical Cooperation Programme.



Number of projects per funding level



Number of projects per duration

- Continuation of programmes and actions on professional training and advanced education;
- Beginning of the analysis of the CTN experimental facilities;
- 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;
- Restart of the operation of the “Unit of Radiation Technologies” (UTR);
- Beginning of an evaluation of safety and security in the campus;
- Installation of the IST applications for administrative management;
- Adaptation of some IST rules and procedures to the CTN specific reality;
- Beginning of the evaluation of the needs on maintenance and new buildings;
- Logistic support to the construction of a new building for a laboratory of “Instituto de Plasmas e Fusão Nuclear” (IPFN).



View of the Statum RN53, located at Ponta Delgada airport.



Visit to the Portuguese Research Reactor



New IPFN Laboratory in CTN

Opening of the IST Polo of Loures

Official Missions

Almost all the ITN regulatory competences have been transferred to COMRSIN (Decree-Law 30/12). IST is only transitorily in charge with:

- Authorization of sealed radiation sources;
- Removal, management and long-term storage of radioactive materials.

Moreover, IST has been the Portuguese contact point for:

- The Technical Cooperation Programme of the International Atomic Energy Agency;
- The Articles 35 and 36 of the Euratom Treaty;
- The Comprehensive nuclear-Test-Ban Treaty Organization (CTBTO).

New Agreements on Cooperation

IST signed in 2012 Agreements on Cooperation related with IST/ITN with:

- Fundação para a Ciência e a Tecnologia;
- Faculdade de Ciências de Lisboa;
- Câmara Municipal de Loures;
- Direção-Geral de Saúde.

Partnership in International Organizations

Following the integration of ITN, IST belongs to the following international Organizations:

- European Atomic Energy Society;
- Cooperation for Higher Education on Radiological and Nuclear Engineering (CHERNE);
- European Radiation Dosimetry (EURADOS);
- European Association of National Metrology Institutes (EURAMET);
- European Institute of Molecular Magnetism.



Mayor of Loures and the President of IST



Secretary of State for Science

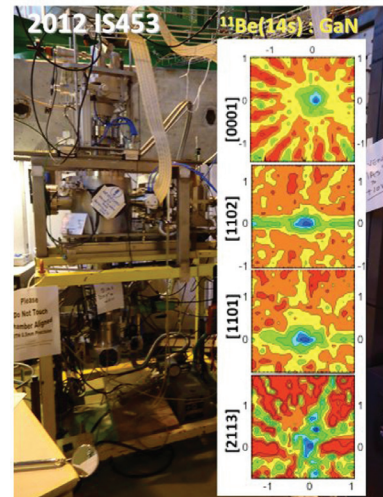


Signature of the protocol between IST and FCT about the archives of Junta de Energia Nuclear

Physics and Accelerators

Mission and Objectives

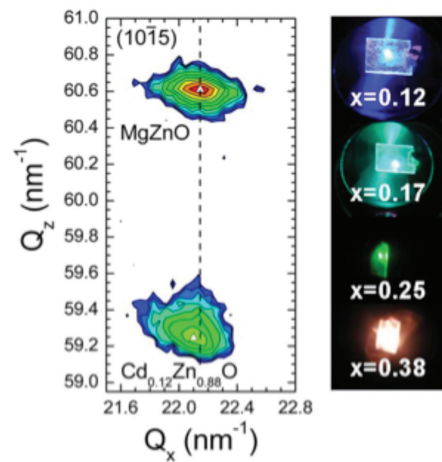
- R&D of advanced materials, processes and technologies for applications to **Industry, Biomedicine, Environment and Cultural Heritage** using ion beams and gamma radiation techniques.
- Maintenance and upgrading of infrastructures and techniques open to the community, through collaborations and services.
- 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.



β - emission channeling patterns obtained from the decay of ^{11}Be implanted into a GaN single crystal. x,y axes represent angular degrees with respect to the principal directions of the crystal.

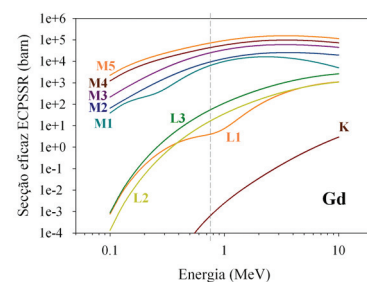
Main Achievements

- A new integrated pin-diode pre-amplifier particle detection system and the upgrade of the external ion beam line.
- Ion beam analysis of new Be marker tiles and reciprocating probes for the Be transport experiment, before and after exposure in JET. Assessment of fuel retention on first wall materials.
- Artefacts from National Treasures and National and World Heritage have been analysed to assess manufacturing processes and provenance of raw materials.
- Research on rare earth doping of wide bandgap ternary compounds.



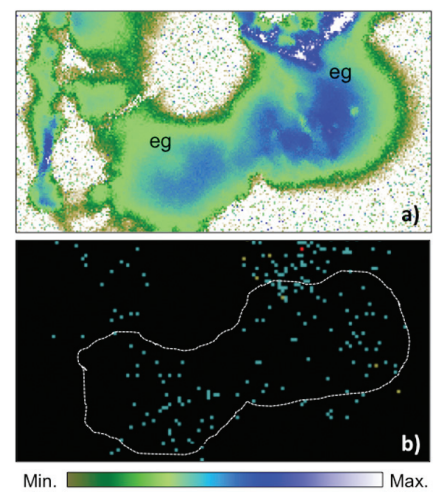
XRD reciprocal space map around the $10\bar{1}5$ reciprocal lattice point of a $\text{Cd}_x\text{Zn}_{1-x}\text{O}$ film ($x=0.12$) grown on MgZnO. Photographs of the visible light emission of $\text{Cd}_x\text{Zn}_{1-x}\text{O}$ films with different CdO molar fractions.

- Polynomial models for ionization cross-sections by proton and alpha particle impact.
- Experiments with short-lived radioactive isotopes at ISOLDE GHM beamline.
- Perturbed angular correlations in single crystals and nanowires of Ga_2O_3 .

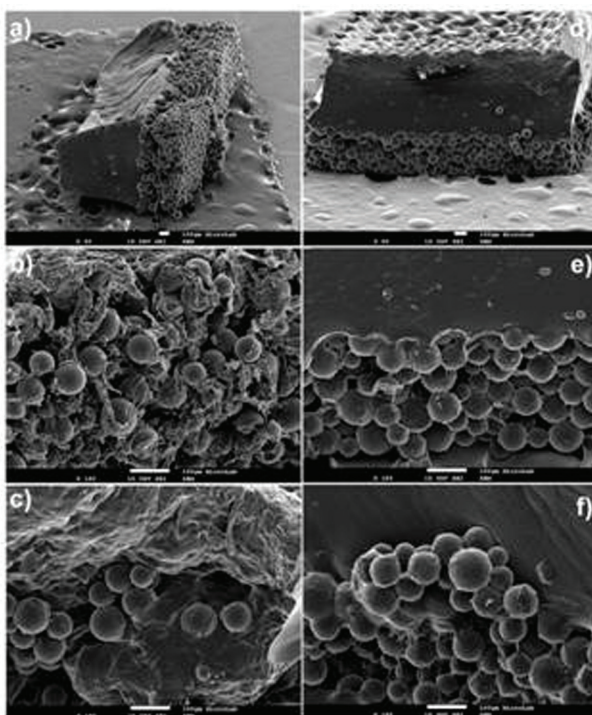


Comparative graph for cross-sections of K, L and M sub-shells by impact of protons in gadolinium.

- Development of hybrid materials with different polymer molecular weight and with addition of Ca.
- Investigation of specific markers of the inflammatory, oxidative and apoptosis processes.
- Study of the iron concentration in skin, in hemochromatosis.
- Toxicity of TiO_2 nanoparticles (TiO_2 -NP) assessment using *Daphnia magna* as a model.
- Development of PVA supported catalytic membranes for biodiesel production.



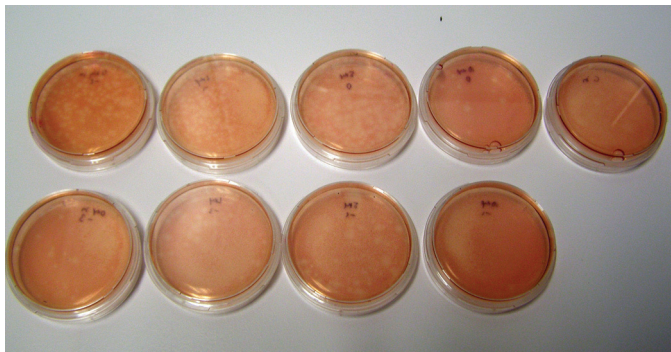
Daphnia magna exposure to TiO_2 nanoparticles: mass density image of the egg pouch delimited by the carapace (ca) and Ti deposits in eggs (eg).



SEM images of PVA supported catalytic membranes prepared with γ -radiation doses: a) and b) SA-5 kGy; c) SA-13 kGy; d) and e) AA-5 kGy; f) AA-13 kGy.



(Left) Gamma irradiated sweet cherries at 5 kGy for conservation.



(Right) Murine norovirus (MNV) before and after irradiation to measure virus infectivity response.

- Irradiation effects on small fruits to improve the diet of immune-compromised patients.
- Ionizing radiation inactivation patterns of the Murine norovirus.
- Study of the effects of gamma radiation on real cork cooking wastewater.
- Evaluation of indoor concentration of airborne bacteria and fungi in several public buildings.
- Microbiological assays of the activity of antibiotics in vitro.
- Developments in Nuclear Instruments and Methods including:
 - Modeling 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.



RADX 100: light weight personal radiation dosimeter.

Chemical and Radio-pharmaceutical Sciences

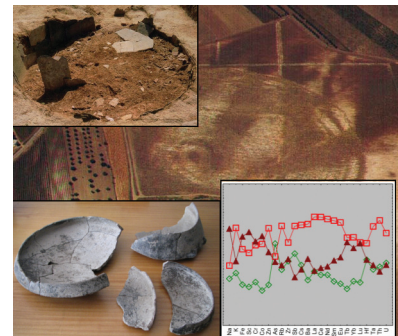
Mission and Objectives

- Promote and provide a focus for networks aiming to develop 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 intermetallics phase diagrams based on f- and d- elements and studies of exotic ground state properties such as strongly correlated electron behavior, superconductivity and magnetism.
- Development of multifunctional molecular materials by combination of magnetic and electroactive centers.

Main Achievements

Nuclear methods applied to Cultural Heritage

Neolithic to Chalcolithic ceramics from Perdigões were mainly produced with regional raw materials. Diverse origins in Chalcolithic funerary pottery occurred - necropolis used by distant communities.



Perdigões archaeological site (Reguengos de Monsaraz, Portugal).

Archaeometallurgy

Grave goods from hypogea and cists produced new evidence on the role of metal (copper, bronze and silver) during the Middle Bronze Age and on the introduction of the first bronzes in southern Portugal.



Middle Bronze Age dagger (Montinhos 6).

Spatial variation of dose rate in superficial environments

Soils and sediments were collected from contrasting lithological settings from locations across north-central Portugal. Detailed in situ measurements and area surveys by gamma spectrometry were done.



Soil sampling and field gamma spectrometry in central Portugal.

Environmental changes along the Portuguese coastal area by organic and inorganic geochemistry and dating

Sources of sedimentary OM in the Guadiana estuary were related to C3 vascular plants and/or fossil carbon. A recent increase in marine OM in the lower estuary was associated to Alqueva dam conditions.

Marine radiocarbon reservoir effect (ΔR) in southern Iberian Atlantic coast which depends upon oceanographic conditions allowed to identify a Bond event at 0.8 ka cal BP and a drastic change of these during the V Millennium cal BP off Barlavento and Andalusian coastal areas.

Isotope hydrology

Relationships between mineral water and local infiltration of rainwater in the Melgaço-Messagães and Caldas da Rainha systems. At Melgaço system the $\delta^{13}\text{C}$ on CO_2 in the groundwater indicates methane origin from the upper mantle.

Salinization in coastal aquifers of Algarve, lower Tagus-Sado basins and Cape Verde. $\delta^2\text{H}$ and $\delta^{18}\text{O}$ contents point to recent (Algarve, and Cape Verde) and ancient seawater (Sado) trapped in sediments.

Organometallic chemistry and catalysis of the f-elements

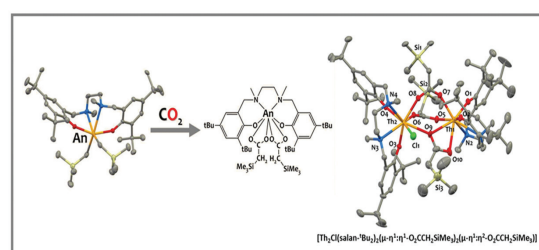
Rare examples of CO_2 activation by molecular thorium(IV) and uranium(IV) alkyl compounds were obtained, and new bimetallic copper or nickel and thorium or uranium oxides were shown to be active in the oxidation or conversion of methane to C2 hydrocarbons, using nitrous oxide as oxidant.

Radiopharmaceutical sciences research

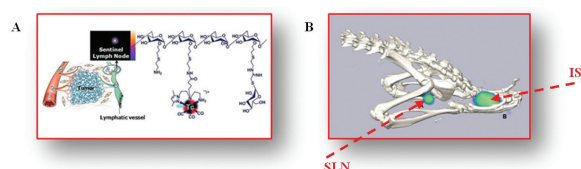
Development of a nanoplatform bearing bifunctional chelators and mannose units labeled with $^{99\text{m}}\text{Tc}$. Pre-clinical evaluation of this compound has shown its suitability for sentinel lymph node detection (SLND).



Groundwater - a natural resource at Santiago island (sustainability and management).

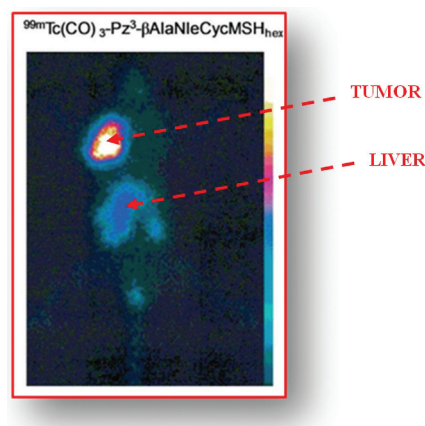


Activation of CO_2 by thorium and uranium alkyl complexes.



A) Structure of the $^{99\text{m}}\text{Tc}$ -nanocompound; B) SPECT/CT Imaging after injection of the radioprobe (IS, injection site; SLN, sentinel lymph node).

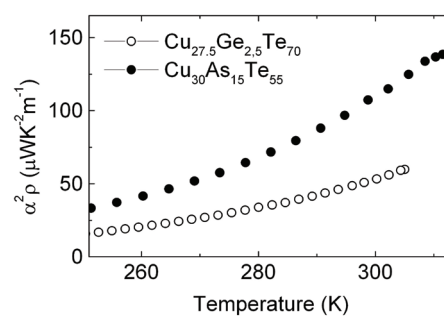
Radiopeptides for melanoma detection (MD) showed, at the pre-clinical level, how the substitution pattern of a bifunctional chelator affects the pharmacokinetic profile of the peptide, without compromising in vitro and in vivo targeting properties.



MD: Planar scintigraphic images of B16F1 murine melanoma-bearing mice after injection of the radiotracer.

New thermoelectric materials

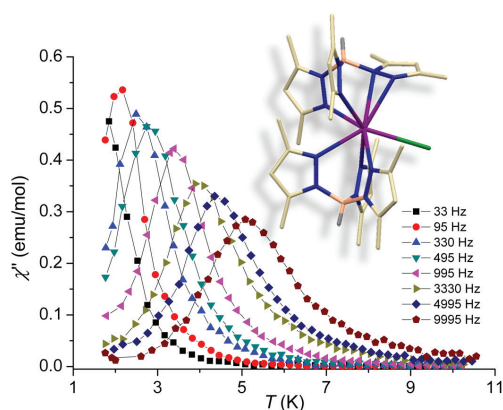
Synthesis and characterization of new thermoelectric semiconducting chalcogenide glasses with high ZT, namely $\text{Cu}_x\text{As}_y\text{Te}_z$ ones showing power factors as high as $110 \mu\text{WK}^{-2}\text{m}^{-1}$ at room temperature.



Temperature dependent power factor of glasses.

f-Element centers for single molecule magnetic behavior; from lanthanides to uranium

Identification of a new series of lanthanide one-dimensional coordination polymers with single molecule magnetic (SMM) behavior of the still rare family of mononuclear U(III) compounds.

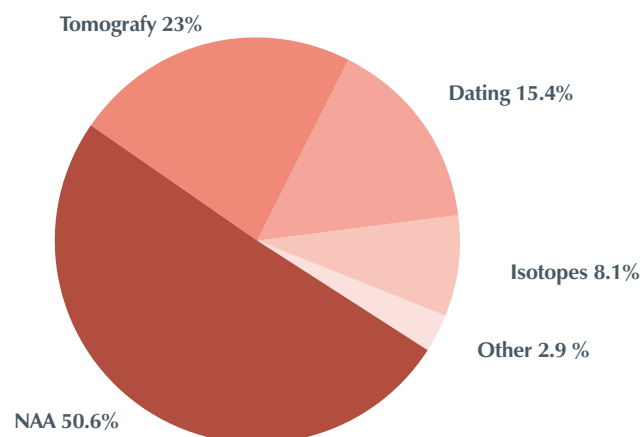


Slow relaxation of magnetisation in a U compound (structure shown in inset) as denoted by the temperature dependence of the imaginary component of the AC susceptibility at different frequencies.

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. The Applied Dynamics Laboratory (ADL) group does research in the area of vibration and acoustic problems, both of industrial and fundamental nature.

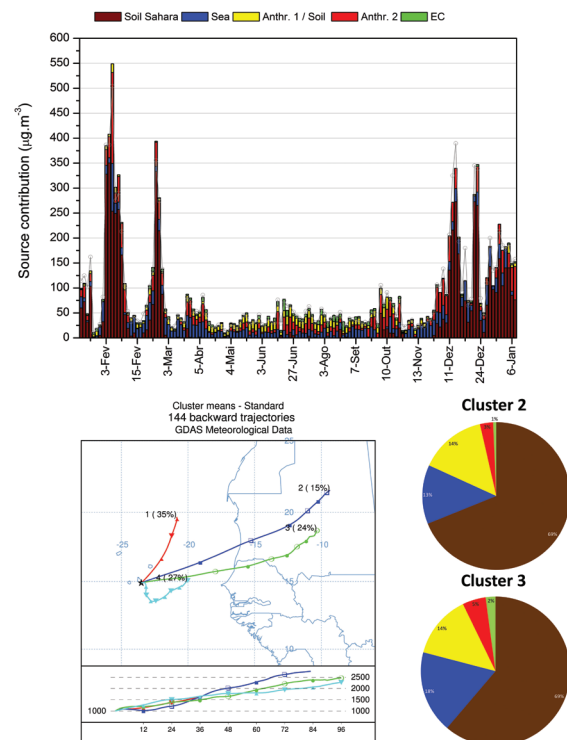


Main uses of the RPI in 2012.

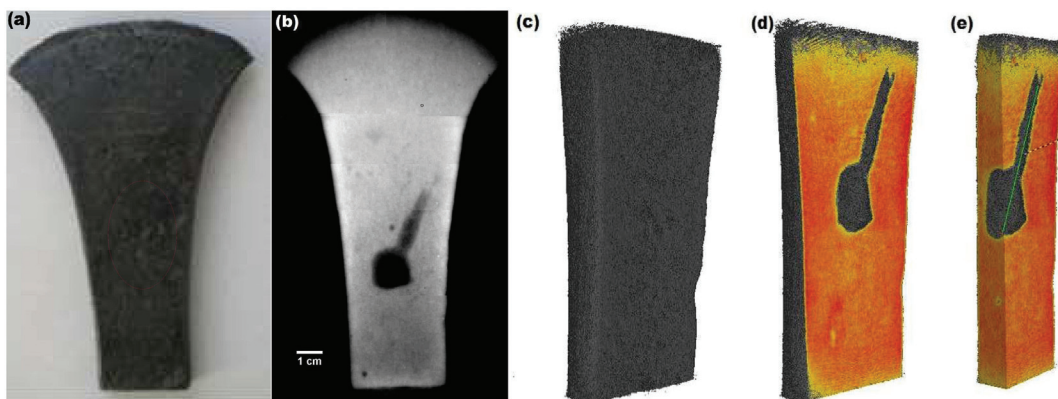
Main Achievements

- The RPI was available for its users 213 days in 2012. A total of 561 irradiations were performed, corresponding to 1503 h of reactor time. This value is 21% higher than the average value during the period 2007-2011. The largest activity is NAA, which accounts for approximately 50% of the use of the RPI.
- Particulate matter (PM10) sampled in Cape Verde within the CV-Dust project was chemically characterized and the identification of the main sources and origins of the particles were carried out by integrating complementary tools. Figure shows the source contribution for the measured PM10 concentrations. The main identified sources are natural: dust from the Sahara desert (48%) and sea salt spray (20%).

Source contribution for PM10 concentrations measured in Cape Verde.

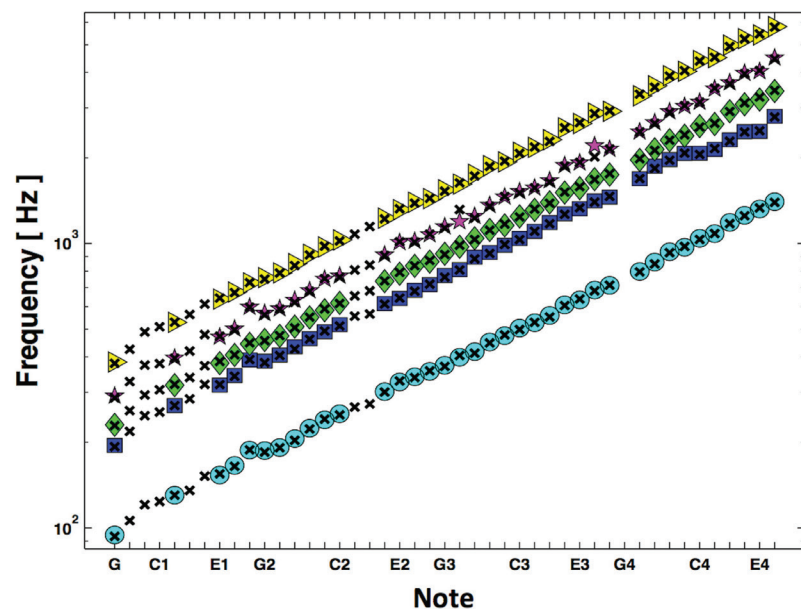
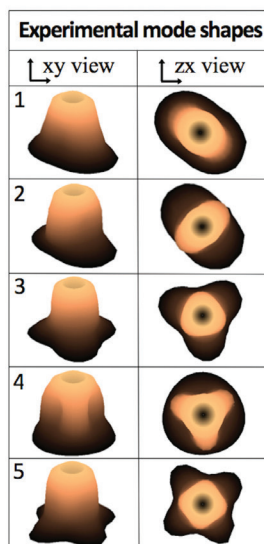


- Determination of contributions to the background of the SIMPLE Dark Matter search project, in its Stage II, using Monte Carlo simulations and analytical techniques. The major contribution (98%) to the background was found to come from the borosilicate glass used as detector container, due to the simultaneous occurrence of high alpha emitter levels and boron content. A substantial background reduction for the subsequent Phase III is being planned based on low-activity containers and improved water radio-purity.
- A Bronze Age ax from the Portuguese territory (Minho) was studied using neutron tomography. This technique has easily shown the existence of a void in the structure, with the shape of the comet, which would not be visible using conventional radiography due to the thickness of the material.



(a) Photography, (b) neutron radiography, and neutron tomography images, (c) reconstructed neutron tomography of interest ax area, (d) front cut with the surface (about 4mm), (e) frontal and transversal cuts with internal measurements, (f) Void shown with grey color, while the red/yellow represent the core material (colors added).

- The Mafra carillons bells form the largest surviving 18th century carillons in Europe. The ADL developed suitable multi-reference identification techniques to extract the bell vibration modes from experiments, and devised strategies to infer their tuning status and tuning errors with respect to historical tempered scales. The original modes of several large bells were identified, with the bells provisionally supported by scaffolds, leading to very different constrained modes. To infer the original bell resonances from the constrained bell modes is a difficult inverse problem, which we solved using suitable structural modification formulations coupled with an optimization scheme.



Experimentally identified bell modal frequencies of the North tower Mafra carillon:
First bell modal shapes (left); Identified tuning of the first bell modes (right).

Radiological Protection and Safety

Mission and Objectives

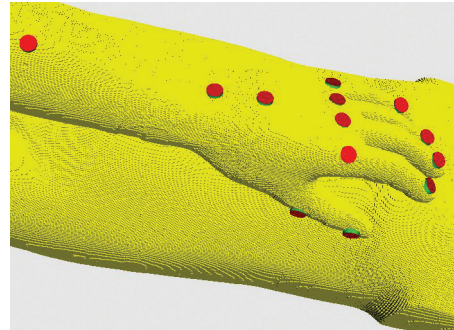
- Deployment of unique scientific and technical expertise, skills and competence in radiological protection in Portugal.
- Keeping abreast of the state-of-art in scientific and technical topics and in international regulations and safety standards in modern radiological protection and radiation safety.
- Fulfillment 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.

Main Achievements

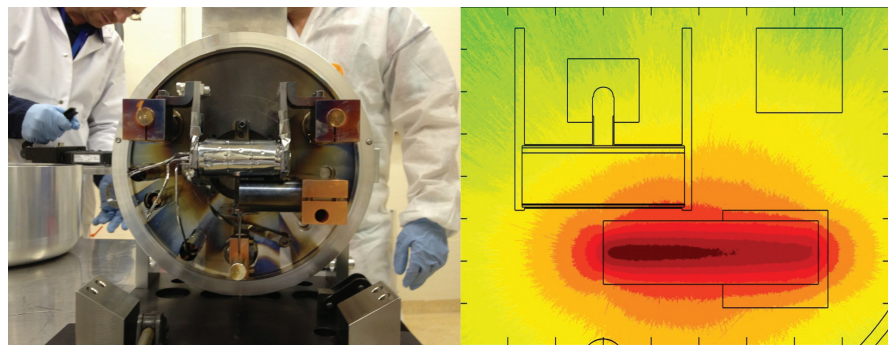
R&D activities

Research activities in radiological protection, dosimetry, metrology, environmental radioactivity were undertaken in the framework of:

- The participation in several R&D projects funded by EU FP7 programmes and FCT in collaboration with Portuguese academia, research centers 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.



Dosimetry of the medical applications of ionizing radiation. Exposure of the extremities of the medical doctors in CT-fluoroscopy: physical hand phantom with dosemeters (left) and implemented computational model (right, voxel phantom with the red dots corresponding to dosemeters).



Cooperation with CERN in the development and simulation of target prototypes for ISOLDE.

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

- The assessment of the safe use of ionizing radiation in 14 medical (radiotherapy and nuclear medicine) and industrial facilities.
- The individual monitoring of the exposure of workers to ionizing radiation (approximately 3000 workers were monitored on a monthly or quarterly basis).
- The assessment of indoor radon concentrations (about 400 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 (165 interventions were performed during the year to collect and segregate radioactive sources).
- The authorization and licensing of radioactive sealed sources (495 authorizations were issued).



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

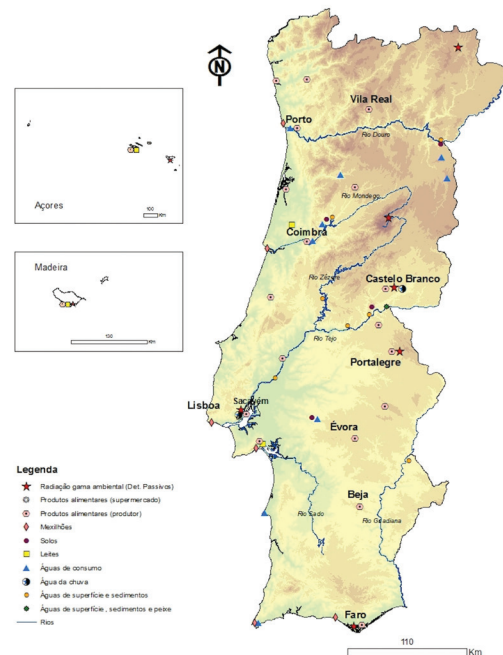
Radiological monitoring during the visit of nuclear propulsion vessels (left) and radiation surveys of facilities (right)



- The calibration and metrological verification of radiation monitors and detectors (approximately 130 monitors and detectors were calibrated).
- The radiological protection and safety monitoring actions of 21 medical and industrial facilities, including 14 detections of radioactive materials in scrap metal at smelting factories.
- The environmental radiological monitoring during the visit of 4 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. Eight radioanalytical and dosimetric techniques received the accreditation from the IPAC (Portuguese Institute for Accreditation) and other 2 techniques should be accredited soon.

Fulfillment 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 (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.



Environmental radioactivity monitoring: sampling locations and type of samples

Preparedness of response to radiological and nuclear accidents/emergencies

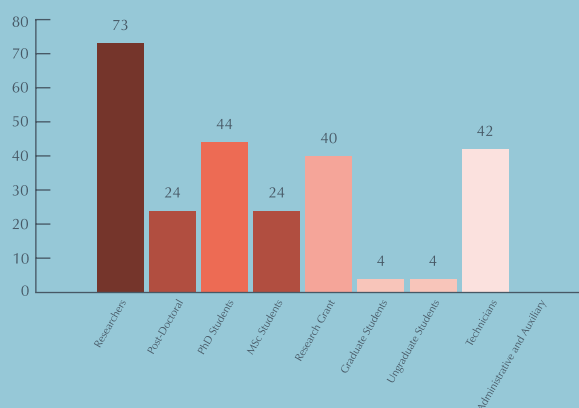
- In the event of a radiological and nuclear accident (such as the one in Fukushima) the UPSR together with the other national competent authorities should play a key role in the response to the resulting emergency situation. In this respect, scientific and technical expertise, techniques and equipment must be available to be deployed.
- The competences in the existing biodosimetry techniques were further consolidated and new techniques started to be 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 maintained.



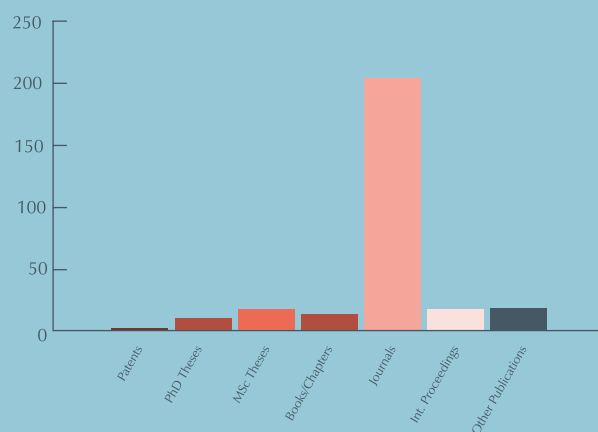
Study of biological damage induced by ionizing radiation using the chromosomal aberration assay. The figure presents a metaphase with a dicentric chromosome (Dic), a tricentric chromosome (Tri) and 3 acentric fragments (Ace).

Staff, Budget and Scientific Output

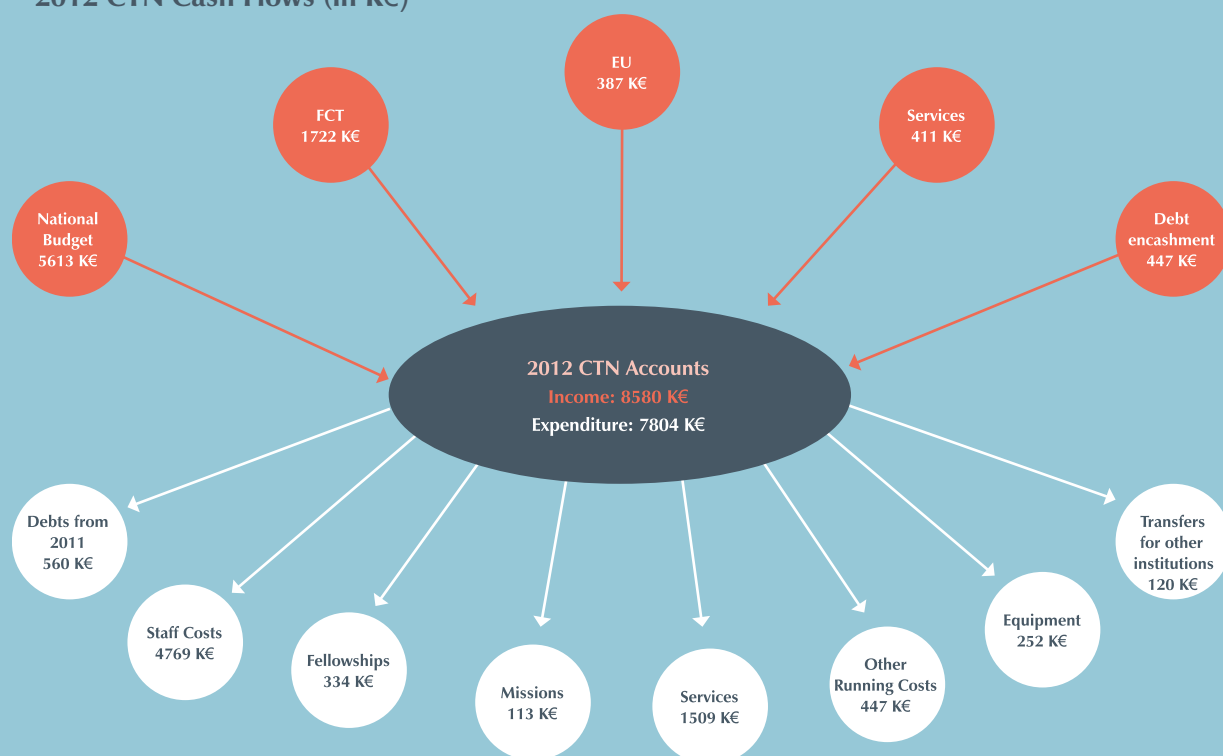
STAFF



Scientific Output



2012 CTN Cash Flows (in K€)



IST/ITN Annual Report 2012

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