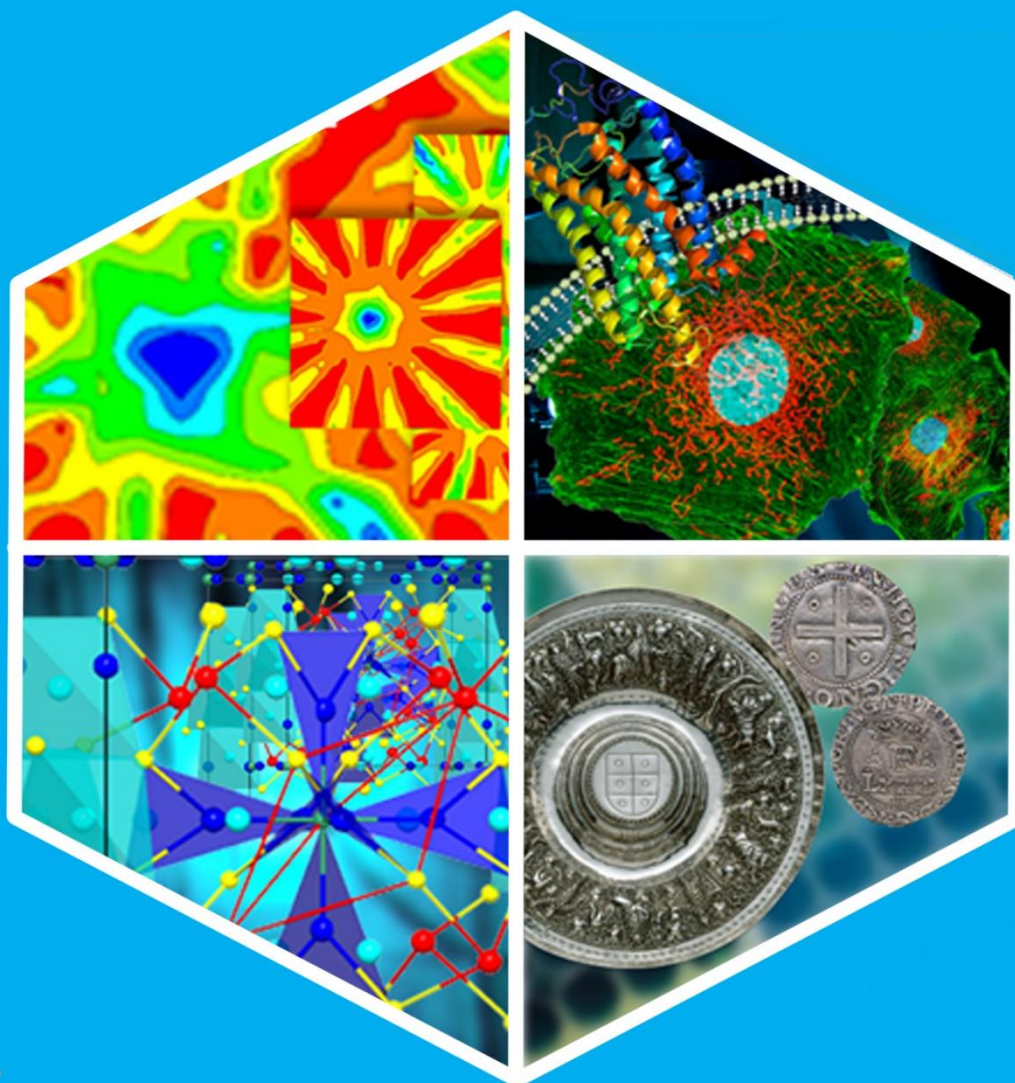


# CENTRO DE CIÊNCIAS E TECNOLOGIAS NUCLEARES



Annual Report 2018



TÉCNICO LISBOA

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# Foreword

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## C<sup>2</sup>TN - Radiation for Science and Society

We are very pleased to walk you through C<sup>2</sup>TN's scientific, technical, education, training and services endeavors and achievements of 2018!

C<sup>2</sup>TN, acronym for “Centro de Ciências e Tecnologias Nucleares” is an interdisciplinary Research Unit of Instituto Superior Técnico (IST), Universidade de Lisboa, established in 2013, located in Campus Tecnológico e Nuclear, the IST science and technology pole. It groups several tens of researchers (physicists, chemists, biologists, geologists, among others) recognized internationally as the Portuguese experts in matters related to Nuclear Sciences and Technologies and applications of Ionizing Radiation. This stems from the unique combination of C<sup>2</sup>TN's knowledge, skills and competence with its experimental facilities.

Indeed, C<sup>2</sup>TN has specialized scientific equipment, laboratories and infrastructures, some unique in Portugal, used as nodes in research networks: Laboratories for Synthesis & Characterization of Materials (licensed to handle radioisotopes), including at Low Temperature and High Magnetic Fields; facilities for Synthesis, Characterization & Preclinical Evaluation of Radioactive Tools for Nuclear Molecular Imaging and Therapy; Clean Rooms; Luminescence, Radiocarbon and Tritium Dating; Spectroscopy facilities - Mössbauer, X-ray fluorescence, Inductively Coupled Plasma Mass Spectrometer; alpha and gamma spectrometry laboratories; liquid scintillation counters; irradiation facilities for metrological verification of radiation detection equipment; linear electron accelerator; and access to Tandem and Van de Graaff accelerators and a Gamma Irradiation Unit, located in the Campus.

During 2018, C<sup>2</sup>TN strengthened its role in the Portuguese Scientific and Technology System and in the international arena. The main axes of activities undertaken aimed at strengthening C<sup>2</sup>TN's excellence in RD&I and to reinforce:

- i) Internationalization, pursuing the collaboration with reference institutions worldwide, in European platforms, international organizations and networks, nurturing new links and consolidating existing ones;
- ii) Engagement of young researchers, students and stakeholders in Portugal and abroad, fostering new collaborations between C<sup>2</sup>TN and RD&I and academic institutions, hospitals, municipalities, environmental, industrial, energy and services companies;
- iii) Outreach, dissemination and communication of Science and its activities.

C<sup>2</sup>TN's motto “Radiation for Science and Society” highlights the outstanding contributions of C<sup>2</sup>TN to several societal challenges, namely:

- a) Better management of cancer and neurodegenerative diseases with more effective and personalized diagnosis and treatments;
- b) Assessment of detrimental effects due to the exposure to ionizing radiation of patients and medical staff, aiming at the Quality and Safety of health care;
- c) Radiological and nuclear emergency response and preparedness;
- d) Prevention of infectious diseases and outbreaks;

- e) Improving the air quality and reducing the carbon footprint;
- f) Environmental protection, management of natural resources and global changes;
- g) Sustainable agro-industry and food safety;
- h) Cultural Heritage leverage and safeguard;
- i) Advanced materials for applications in physics and engineering, electronic sensors and devices, energy conversion, cybersecurity and medical applications.

During 2018, a number of C<sup>2</sup>TN's members, previously holding Post-Doc fellowships, were hired as researchers with a fixed term contract, under the new Government policy on scientific research employment and the corresponding newly approved Decree-Law; although not removing the precarious contractual link of those researchers, the aforementioned policy partially attenuates the uncertainties that affect the sustainability of part of C<sup>2</sup>TN's human resources.

The scientific strength of C<sup>2</sup>TN is highlighted by the number (10) of projects led by its researchers that were approved by the FCT during 2018, for funding with a total amount exceeding 2 M€ over a period of 3 years. Additionally, C<sup>2</sup>TN's researchers also participate in a number of other projects led by other institutions that were also approved for funding by the FCT in a particularly competitive call

During 2018, C<sup>2</sup>TN members pursued their participation in European projects or were members of the consortia that submitted new research projects to the Horizon 2020 programme of the European Union. International collaboration further proceeded through exchange of students and researchers to/from reference international centres.

Outreach activities expanded and consolidated during 2018 with intense participation at national and regional level.

Building on the success of the previous meeting, the wealth and pluridisciplinarity of C<sup>2</sup>TN's activities were exhibited during the 2<sup>nd</sup> C<sup>2</sup>TN Annual Meeting, held in December of 2018, with the participation of external experts.

The highlights of C<sup>2</sup>TN's activities during 2018, detailed in the sequence, follow closely its structure, namely the organization in 6 interdisciplinary Groups:

- i) SS – Solid State: New Materials with Unconventional Electrical and Magnetic properties and characterization using Low Temperature and High Magnetic Field Techniques
- ii) NET – Nuclear Engineering and Techniques, Nuclear Physics, Geo-environments and Cultural Heritage using neutrons, radioactive nuclei and ion beams
- iii) RPS – Radiation Protection and Safety: Dosimetry, Radiobiology, Environmental Radioactivity, Radioecology, Radioactive Waste and Metrology
- iv) RS – Radiopharmaceutical Sciences: Nuclear Tools for Molecular Imaging and Theranostics
- v) REI – Environmental Processes, Archaeological Material Culture & Macromolecular Materials using Nuclear Analytical Techniques and Ionizing Radiation
- vi) QEf – f-Element Chemistry

with the RD&I activities synergistically interwoven into 3 Thematic Strands: i) Advanced Materials ii) Radiopharmaceutical Sciences and Health Physics iii) Earth Systems, Radioactivity & Cultural Heritage.

The most important asset of C<sup>2</sup>TN is its members.

The Executive Commission would like to acknowledge and thank all C<sup>2</sup>TN members for their efforts, contributions and accomplishments that made possible the positive journey throughout 2018!

## **C<sup>2</sup>TN Executive Commission**

Pedro Vaz – President

Fernanda Margaça – Vice-President

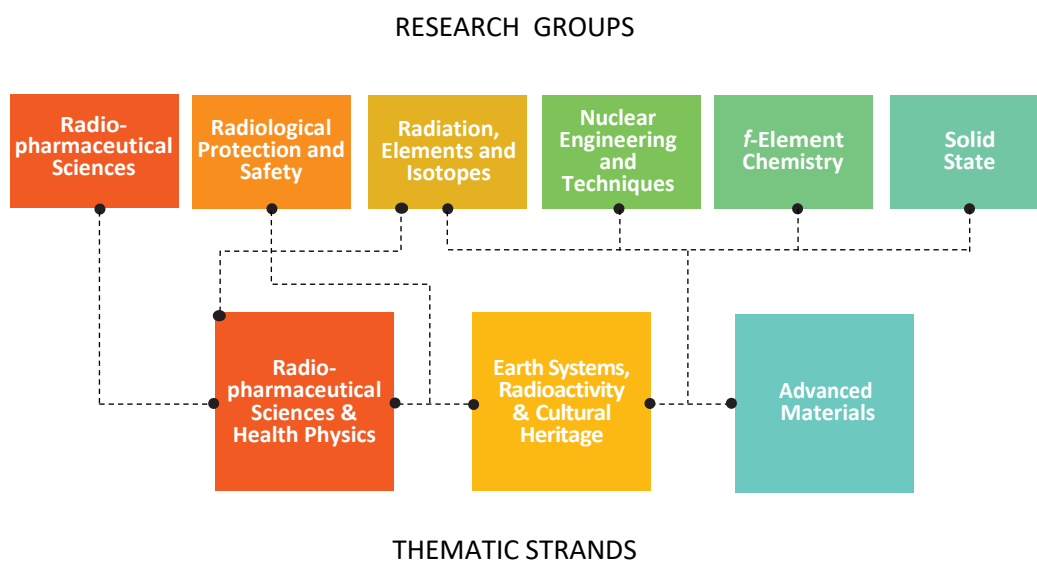
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# C<sup>2</sup>TN Organization and Coordination

Considering the complementary know-how, common interests and facilities, the C<sup>2</sup>TN members are organized in six Research Groups: Radiopharmaceutical Sciences (RS), Radiological Protection and Safety (RPS), Radiation, Elements and Isotopes (REI), Nuclear Engineering and Techniques (NET), *f*-Element Chemistry (QEf) and Solid State (SS). For the period 2015-2020, the 6 groups of scientists will converge and collaborate on 3 main Thematic Strands (TS):



Scheme 1 shows the C<sup>2</sup>TN research groups and their contribution to the three Thematic Strands. Within these TS the role of the groups is well established and the overall research objectives are in line and nicely intersect with the EU Horizon2020 initiative.



## ***The Research Group Coordinators are:***

RS – António Rocha Paulo; RPS – Pedro Vaz; REI – Maria de Fátima Araújo; NET – Maria Isabel Dias; QEf – João Paulo Leal; ES – Manuel Leite de Almeida

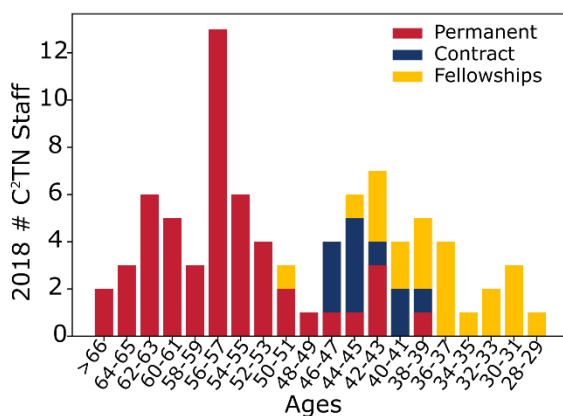
## ***The Thematic Strands Coordinators are:***

RSHP –António Rocha Paulo; ESRCH – Maria Isabel Prudêncio; AM – Manuel Leite de Almeida

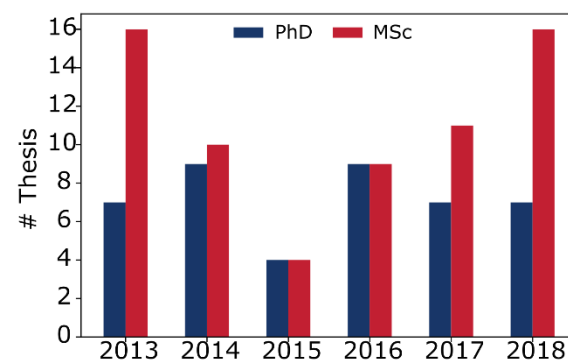
# C<sup>2</sup>TN in Numbers

Information on the number of researchers from C<sup>2</sup>TN and peer – reviewed publications, the correspondent impact factor, Ph.D. and M.Sc. completed theses and values on the budget of C<sup>2</sup>TN is given for 2018 and compared with the corresponding values in previous years.

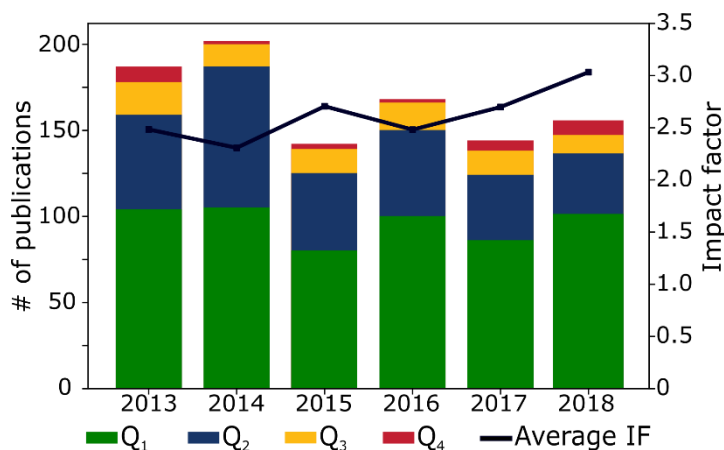
## C<sup>2</sup>TN STAFF



## C<sup>2</sup>TN CONCLUDED THESIS

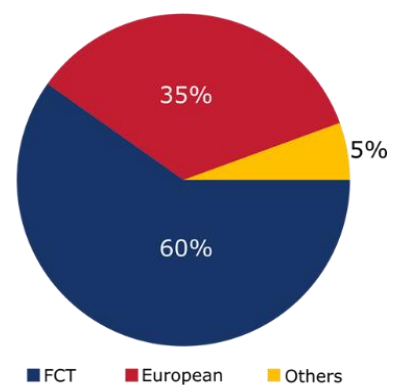


## C<sup>2</sup>TN PUBLICATIONS



## C<sup>2</sup>TN FUNDING

2018 Total funding ~1.1M €



# THEMATIC STRANDS SCIENTIFIC REPORT 2018

Researchers of the RSHP thematic strand applied their know-how, techniques and infrastructures to carry out research on Radiopharmaceutical Sciences, Radiation Protection and Dosimetry, Biological Effects of Ionizing Radiation (IR) and Metrology, aiming to contribute to the following major topics:

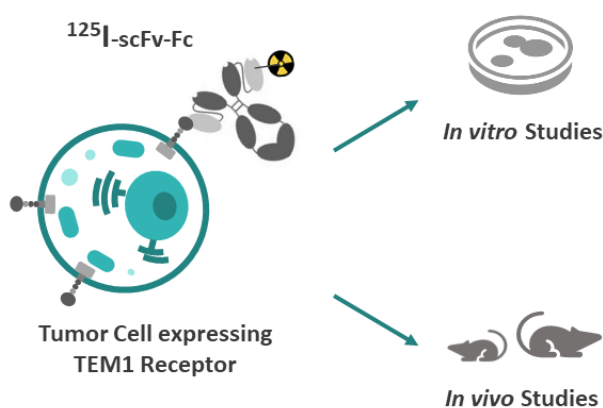
- Design, Synthesis and Pre-Clinical Evaluation of Radioactive Tools for Molecular Imaging and Theranostics;
- Evaluation of Biological Effects of Ionizing Radiation;
- Medical Dosimetry and Metrology of Ionizing Radiation.

The scientific output of the RSHP team was: 36 papers in peer-reviewed journals, 1 book chapter, 5 proceedings, 12 lectures in conferences, 1 Ph.D., 7 M.Sc. and 4 graduation theses. The team has participated in the organization of 2 international conferences and summer schools. The team's research work has been supported by European and FCT competitive funding, with a noteworthy rate of approval of R&D projects (ca. 1 M€) in the 2017-FCT call. There was also a high degree of internationalization with participation in European Union Technology Platforms and Networks, namely MELODI, EURADOS NERIS-TP, IGD-TP and EURAMET, several COST actions and the MCurie ITN MEDICIS-Promed.

Highlights of the R&D activities performed during 2018 are presented below.

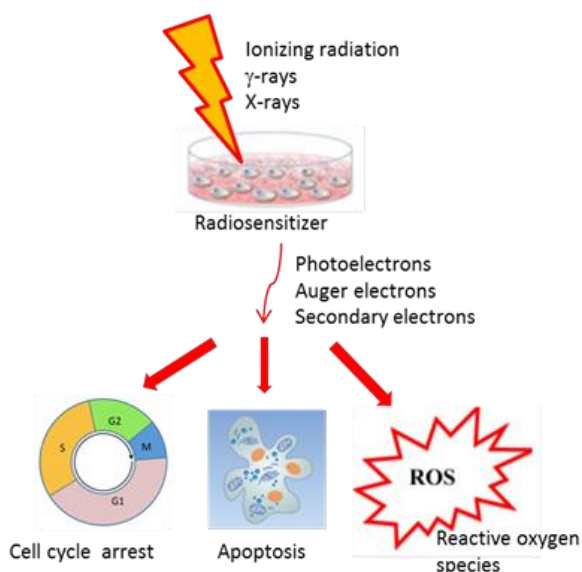
## RADIOLABELED ANTIBODY FRAGMENTS FOR TARGETING OF THE TEM1 RECEPTOR

The endosialin/TEM1 receptor is a suitable target for antibody-mediated therapy due to its minimal expression in normal healthy tissues and its overexpression in several human solid cancers. The preclinical evaluation of a small panel of antibody fragments - scFv-Fc - targeting the TEM1 receptor was undertaken after radiolabeling with  $^{125}\text{I}$ . A preliminary screening to identify the most promising fragments was followed by an extensive *in vitro* characterization in cell lines expressing either the human or the murine receptors, assessing binding affinities and specificity towards the TEM1 receptor. Biodistribution studies in tumor-bearing mice were also performed, paving the way for further investigations on the pre-targeting approach to this receptor, using radiometals and clickable chelators already developed by the Radiopharmaceutical Sciences Group.



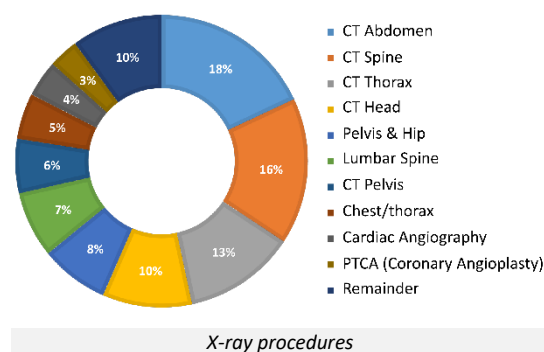
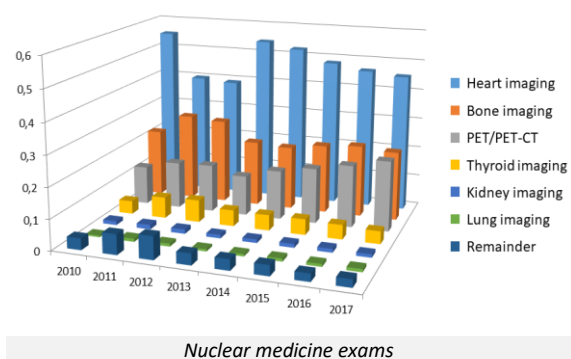
## EVALUATION OF HIGH-Z MATERIALS AS RADIOSENSITIZERS

The main challenges of radiation therapy of cancer are the side effects of ionizing radiation in surrounding healthy tissues and the acquired resistance of tumor cells to radiation. One approach to enhance the efficacy of radiotherapy is the use of radiosensitizers to selectively increase the dose at the tumor site. High-Z (atomic number) materials have emerged as new tools in oncology to improve cancer therapy, based on their radiosensitizing capabilities. Using the CTN irradiation facilities, we have studied the effect of different types of electromagnetic radiation on U87 glioblastoma cells pre-loaded with iodinated molecules or gold nanoparticles, as radiosensitizers. In general, the presence of the radiosensitizers led to an enhanced radiocytotoxicity, most probably due to an increase on ROS production, cell cycle alterations and induction of apoptosis.



## RADIATION EXPOSURE OF THE PORTUGUESE POPULATION IN RADIODIAGNOSTIC PROCEDURES (X-RAY AND NUCLEAR MEDICINE EXAMS)

The use of ionizing radiation (IR) in medical imaging has drastically improved diagnostic outcomes, but has also resulted in an increase of the exposure of the population to man-made IR. This is a cause of concern, both from a radiation protection and Public Health perspectives. To address this issue, this work studied the exposure of the Portuguese population to IR due to radio-diagnostic procedures (x-ray and nuclear medicine exams) in the 2013-2017 period. The estimated total collective dose due to nuclear medicine exams was of 0.088 mSv/person in 2013 and 0.090 mSv/person in 2017.

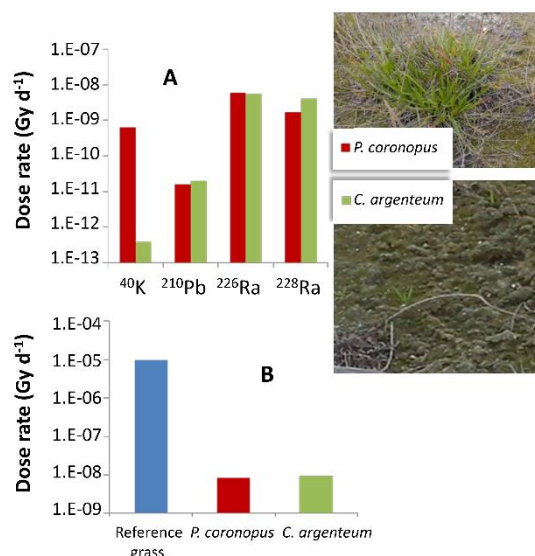


During 2018, the scientific output of the ESRCH team included the publication of 48 papers in peer-reviewed journals, 9 book chapters, 18 international conference proceedings, 8 invited and 32 contributed lectures in international conferences and the completion of 3 PhD and 8 MSc theses. Team members have also given 15 seminars and were responsible for 15 courses given in universities and polytechnical schools, along with the participation in 22 scientific committees of evaluation panels. The team research has been supported by EC (LIFE, ERA-MIN, Interreg Sudoe and Interreg Mediterranean), FCT, IAEA, and bilateral projects. Overall, ESRCH team has participated in 6 European research contracts, 2 bilateral research projects, 5 research contracts with IAEA, 5 research projects funded by FCT and 3 industrial research contracts.

A significant participation in the scientific and technical activities of European Union Technology Platforms and Networks, namely ALLIANCE, IGD-TP and NERIS, and in the COST ACTIONS CA16109 and ES1407 has also taken place. During 2018, the team has also prepared and submitted several common projects under calls from EC, FCT, Interreg Sudoe and Horizon 2020. Two contracts were established with private companies. The ESRCH team has also prepared one patent, along with the development of a new algorithm and one prototype during 2018. In order to promote and disseminate the work developed within this thematic strand, ESRCH members participated in 12 different events, namely performances and exhibitions, that were held in Portugal and abroad.

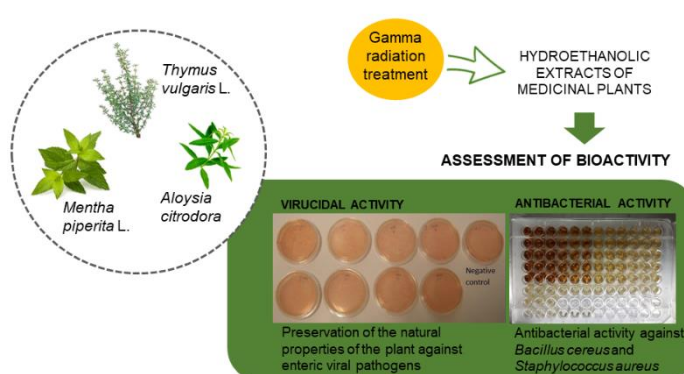
## TRANSFER AND RELATED DOSE ASSESSMENT OF NATURAL RADIONUCLIDES IN PLANTS AND MOSSES GROWING ON A PHOSPHOGYPSUM STOCKPILE IN PORTUGAL

Phosphogypsum (PG) is a phosphate industry sub product with enhanced concentrations of naturally occurring radioactive materials (NORM). A PG stockpile remains as the legacy of a disabled phosphate plant near a suburban area in the south bank of Tejo estuary. Herbaceous plants (*Plantago coronopus*) and moss (*Bryum argenteum*) have been covering the PG surface, so this stockpile can be used as a natural laboratory to quantify the transfer of radionuclides to the vegetal biota and assess the absorbed dose resulting from exposure to ionizing radiation. Dose assessment related to the natural radionuclides uptaken by plants and mosses was performed using the ICRP reference wildgrass coupled with the Monte Carlo code MCNPX. Dosimetric calculations show that internal doses are similar to external doses in herbaceous plants but can exceed 2 orders of magnitude in moss. The estimated doses are in the order of the natural background for ICRP reference wildgrass ( $< 0.01 \text{ mGy d}^{-1}$ ).



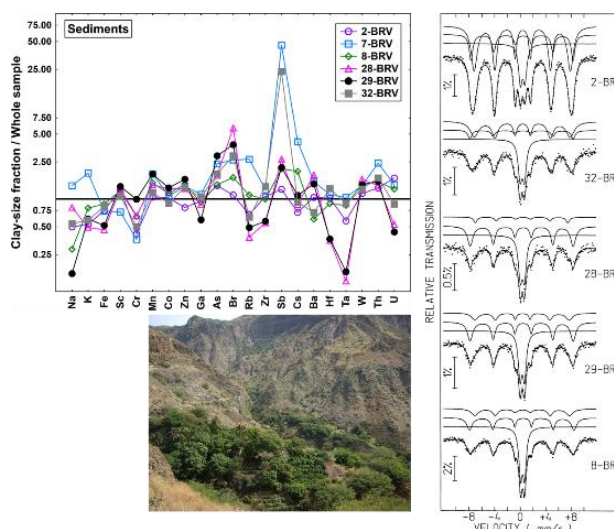
## ANTIMICROBIAL ACTIVITY OF IRRADIATED AROMATIC AND MEDICINAL PLANTS

Irradiation is a safe food processing technology increasingly recognized and supported by several international organizations. The intent of this study was to deepen the knowledge on effects of gamma radiation on the antimicrobial potential of extracts of different plant species used in traditional medicine. It is important to explore the use of green solvents that reduce the impact on the environment and on human health, which also facilitate the incorporation of these extracts in products within different industrial sectors (pharmaceutical, cosmetic and food). This study reveals the antimicrobial potential of hydroalcoholic extracts in both anti-viral and antibacterial assays, and evaluates a new extraction approach as a process to improve value to aromatic plants as bioactive agents. The results highlighted that gamma radiation treatment up to a dose of 10 kGy promotes the antibacterial activity and preserves the virucidal potential on the hydroalcoholic extracts of studied plant species.



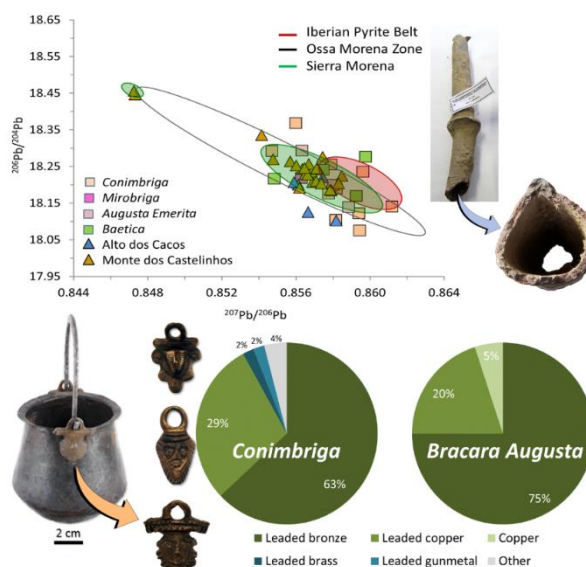
## CHARACTERIZATION OF CLAY-SIZED FRACTION OF VOLCANIC SOILS USED FOR AGRICULTURE – BRAVA ISLAND (CAPE VERDE)

Mössbauer spectroscopy and INAA were used in order to acquire a better knowledge of iron forms and the geochemistry of trace elements in volcanic soils developed on sediments and phonolitic pyroclasts from Brava Island (Cape Verde), used for agriculture. High concentrations of arsenic, bromine, and antimony were found in the clay-size fraction, where only Fe(III) was detected and all the Fe oxides are nano-sized. The existence of significant amounts of these elements and vitreous phases in fine particles of soils contribute to their mobility and accumulation in plants, by absorption and by dust deposition.



## LEAD AND COPPER IN WESTERN PROVINCES OF THE ROMAN EMPIRE: PROVENANCE, PRODUCTION AND USE

Copper-based alloys and lead implements were widely employed by the Roman Civilization having a variety of urban and warfare applications. Archaeometallurgical research was focused in collections from *Conimbriga*, *Augusta Emerita* and *Mirobriga* (Lusitania province) and *Bracara Augusta* (Galaecia). Elemental and isotopic composition of complex hydraulic systems (lead pipes) assigned raw materials to the Iberian Pyrite Belt (argentiferous jarosite ores) and Sierra Morena and Ossa Morena Zone (galena ores). Elemental and microstructural study of anthropomorphic attachments of *situlae* evidenced a conservative metallurgy, mostly composed of leaded copper and leaded bronze. In general, recycling practises became a common activity during the Empire, suggesting a technology strongly influenced by economic factors. The unrefined typology and massive production of those decoration items also agrees with the low incidence of the more expensive brass alloys, thus evidencing a local production quite different from the exquisite Roman artefacts from the core of the Empire.



The research activities under this thematic strand have been focused in different advanced materials, with emphasis on multifunctional and unconventional electrical and magnetic materials, with potential applications in the fields of electronic and optoelectronics, health, catalysis and energy. These activities were possible thanks to a valuable combination of a wide range of complementary techniques existing at C<sup>2</sup>TN for both preparation and characterization of materials, enabling to address current challenges in materials science research and contributing to the establishment of more detailed correlations between the structure and the physical properties.

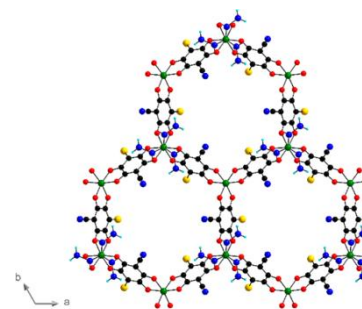
A significant part of the activities in this area has been possible by the operation and development of infrastructures and research tools, rare or even unique at national level, which have been placed open at the benefit of a large external community through an extensive network of scientific collaborations. These facilities include materials modification by ion implantation, neutrons, gamma and electron irradiation, several ion beam techniques for elemental composition analysis and the Low Temperatures and High Magnetic Field Laboratory with facilities for the study of electrical transport, magnetic properties of materials and Mössbauer spectroscopy.

During 2018, the scientific output of the team involved in Advanced Materials studies was: 44 papers in peer-reviewed journals, 3 book chapters, 3 proceedings, 7 invited and 19 contributed lectures in conferences, 1 PhD, 3 MSc and 1 graduated completed theses, and 2 patents. The team research has been supported by European, FCT and bilateral projects, with several new projects being secured this year. The team has participated in the organization of 2 conferences and workshops and 1 international training courses. A significant participation in the scientific and technical activities of European Union Technology Platforms and Networks, namely COST ACTIONS CA15128 CM1105, TD1004 has also taken place. During 2018 the team has also prepared and submitted several common projects under calls from EC, FCT, CERN-FCT, and Horizon 2020.

The activities had contributions from different research groups (ES, ETN, QEf, and REI) as more detailed described in their reports. The following major achievements in 2018 are highlighted.

## MULTIFUNCTIONAL MATERIALS

Moessbuer spectroscopy was used as a key technique to study the role of electron charge transfer and magnetic ordering of the Fe cations on a material combining conducting and magnetic electrons and based on anilate coordination polymer.



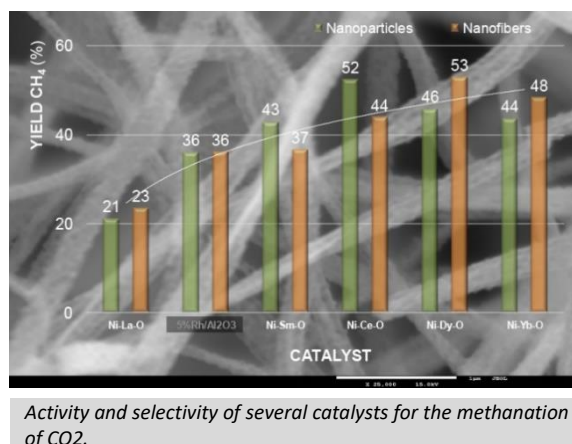
## DEVELOPMENT OF CHITOSAN-BASED MATRICES BY RADIATION TECHNOLOGIES FOR BIOMEDICAL APPLICATIONS

Chitosan-based matrices with poly(vinyl pyrrolidone) (PVP) were obtained by gamma irradiation from a Co-60 source. Radiation dose, copolymer concentration and synthesis procedure were found to tailor matrix porosity and surface roughness, giving materials with enhanced properties to be applied as skin substitute capable of tissue regeneration



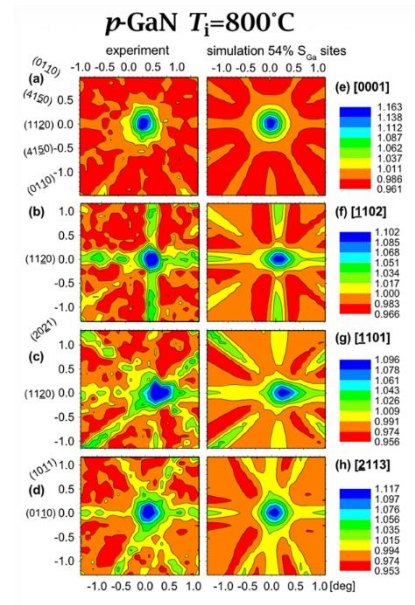
## NANOSTRUCTURED COMPOUNDS CONTAINING f-BLOCK ELEMENTS AND VALORIZATION OF CO<sub>2</sub> AS FEEDSTOCK

Nanostructured bimetallic oxides containing 4f-block elements (La, Ce, Pr, Sm, Dy, and Yb) and nickel supported on silica and alumina obtained by electrospinning, when tested as catalysts for the methanation of CO<sub>2</sub> were found to exhibit enhanced activity and selectivity towards the production of methane and stability on the gaseous stream.



## AMPHOTERIC BEHAVIOUR OF Be AS DOPANT IN GaN

The amphoteric nature of Be in p-GaN, n-GaN and as-grown n-d-GaN was revealed using the  $\beta$ -emission channeling technique with implanted radioactive  $^{11}\text{Be}$  (13.8s). Results show a balance of substitutional  $\text{Be}_\text{s}$  vs interstitial  $\text{Be}_\text{i}$  depending on doping type and implantation temperature.



# RESEARCH GROUPS SCIENTIFIC REPORT 2018



## TEAM

Name	Category	R&D (%)
António Manuel Rocha Paulo	Principal Researcher – Group Coordinator	100
João Domingos Galamba Correia	Principal Researcher	100
Célia Maria da Cruz Fernandes	Auxiliary Researcher	100
Fernanda Marujo Marques	Auxiliary Researcher	100
Filipa Fernandes Mendes	Auxiliary Researcher	100
Maria Cristina das Neves Oliveira	Auxiliary Researcher	100
Maria de Lurdes Barreira Patricio Gano	Auxiliary Researcher	100
Maria Paula Cabral Campello	Auxiliary Researcher	100
Paula Dolores Galhofas Raposinho	Auxiliary Researcher	100
Elisabete Correia	Técnica Profissional Principal	100
Elisa Palma	Post-doc Researcher	100
Francisco Silva	Post-doc Researcher	100
Joana F. Guerreiro <sup>1</sup>	Post-doc Researcher	45
Rita Lourenço Paiva de Melo Galvão	Post-doc Researcher	100
Alice d'Onofrio	Ph.D. Student	100
João Miguel Franco Machado	Ph.D. Student	50
Mihaela Cudăbeanu	Ph.D. Student	100
Vera Filipa Cerqueira Ferreira	Ph.D. Student	100
Rúben Diogo Marques da Silva	M.Sc. Student / Research Fellow	100
Adriana Cruz	M.Sc. Student	20
Ana Amendoeira	M.Sc. Student	10
Mafalda Inês Apolinário Pereira	M.Sc. Student	80
Mariana Andersen Moraes David	M.Sc. Student	50
Sofia Batanete	M.Sc. Student	50
Noorani Julficalali	Graduation Student	30
Rita Belo	Graduation Student	30

<sup>1</sup> 45% at the RPS Group and 10% at the GO

## MISSION AND OBJECTIVES

The main research activities of the RSG focus on the development of innovative target-specific radiopharmaceuticals for Positron Emission Tomography (PET) or Single Photon Emission Computed Tomography (SPECT) Imaging and Targeted Radionuclide Therapy (TRT), for the diagnosis and/or treatment of oncological, cardiovascular or neurodegenerative diseases. Owing to its translational potential, this research field can contribute for the rise of molecular and personalized medicine. To this goal, the RSG gathers a multidisciplinary team of scientists with expertise in chemistry, radiochemistry and biological sciences, who run dedicated facilities for: i) chemical synthesis (including solid phase peptide synthesis); ii) radiosynthesis; iii) biochemical, molecular biology and cellular studies; iv) animal housing and biodistribution studies.

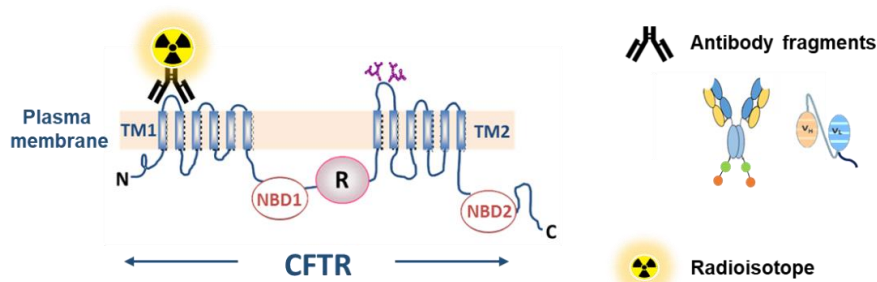
Profiting from a rare combination of radiopharmaceutical chemistry expertise with preclinical evaluation skills, the group is a key partner of renowned national and international institutions involved in radionuclide production, nuclear medicine and biomedical research. There is also an active collaboration with national and international research groups and biotech companies engaged in the discovery and development of novel drugs, namely in the field of antibody-based biopharmaceuticals. The RSG provides advanced training to students and young scientists on Radiopharmaceutical Sciences and Medicinal Chemistry. It is a partner of the Marie-Sklodowska Curie ITN “MEDICIS-Promed” led by CERN and the Ph.D. program “ChemMedTrain” coordinated by the Universities of Coimbra and Lisboa. The RSG also receives undergraduate and graduate students for research and training activities within different graduation, master or Ph.D. programs. The group also organized and coordinated a Summer School on the “Development and Pre-clinical Evaluation of Radiopharmaceuticals”, under the framework of the ITN “MEDICIS-Promed”. This Summer School, which gathered renowned international scientists who addressed hot topics in Radiopharmaceutical Sciences and Nuclear Medicine, was attended by postgraduate students from different European countries.

## MAIN ACHIEVEMENTS

### NOVEL MOLECULAR IMAGING TOOLS FOR CYSTIC FIBROSIS

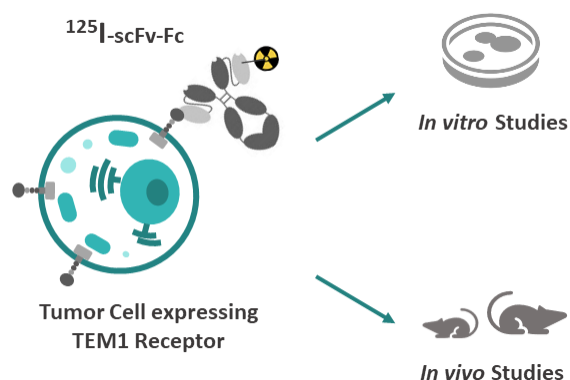
The aim of the research line is to bring forward a novel molecular imaging approach to Cystic Fibrosis (CF). The development of specific nuclear medicine probes for the CF transmembrane conductance regulator

(CFTR) protein, a chloride channel critical for epithelial ion and fluid transport compromised in CF, would be of great value for management of the disease and assessment of therapy response in drug evaluation. In a first step, validation of anti-CFTR antibody fragments (available through collaboration with ProQR Therapeutics) using biochemical techniques revealed detection of CFTR protein. However, cellular uptake studies using the antibodies as radioprobes did not reveal differences between two CFTR-expressing cell lines (normal and mutated). These results paved the way to explore the use of different antibody formats as probes for CFTR imaging. Currently, and using the phage display technology, smaller antibody fragments against CFTR are being selected and expressed for further radiolabelling and evaluation of their ability to recognize the protein in the cellular environment.



### PRE-CLINICAL VALIDATION OF RADIOIODINATED ANTIBODY FRAGMENTS TARGETING THE TEM1 RECEPTOR

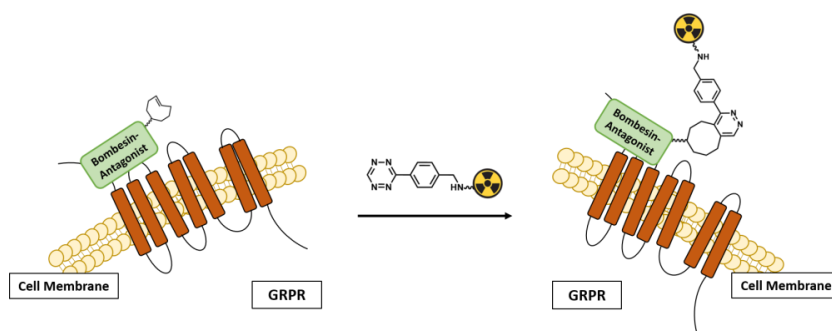
The endosialin/TEM1 receptor is a suitable target for antibody-mediated therapy due to its minimal expression in normal healthy tissues and its overexpression in several human solid cancers. The preclinical evaluation of a small panel of antibody fragments - scFv-Fc - targeting the TEM1 receptor was undertaken after radiolabeling with  $^{125}\text{I}$ . A preliminary screening to identify the most promising fragments was followed by an extensive *in vitro* characterization in cell lines expressing either the human or the murine receptors, assessing binding affinities and specificity towards the TEM1 receptor. Biodistribution studies in tumor-bearing mice were also performed, paving the way for further investigations on the pre-targeting approach to this receptor, using radiometals and clickable chelators already developed in our group.



## CLICKABLE BOMBESIN ANTAGONISTS FOR PROSTATE CANCER THERANOSTICS

The pre-targeting approach based on peptide receptor antagonists might allow a more selective and efficient delivery of radionuclides to tumor sites. Towards this goal, we have studied click reactions of a trans-cyclooctene containing gastrin-releasing peptide receptor (GRPR) antagonist (bombesin derivative, BBN) with a range of clickable  $^{111}\text{In}$ -labelled DOTA derivatives carrying a tetrazine group.

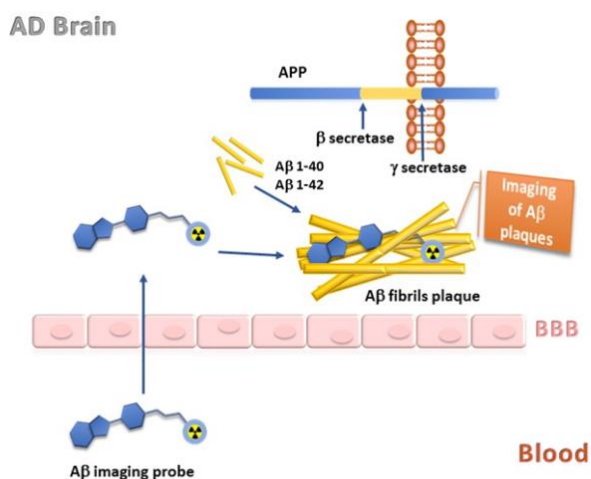
The most promising  $^{111}\text{In}$ -complex showed increased cellular uptake when human prostate PC3 cells were previously incubated with the antagonist, revealing the occurrence of a click reaction with the BBN antagonist interacting with the GRPR on the cell surface. Future studies will confirm whether these results can be translated in vivo using prostate cancer xenografts in mice.



## CONTRIBUTION OF RADIOACTIVE TOOLS TO THE DEVELOPMENT OF CENTRAL NERVOUS SYSTEM (CNS) DRUGS

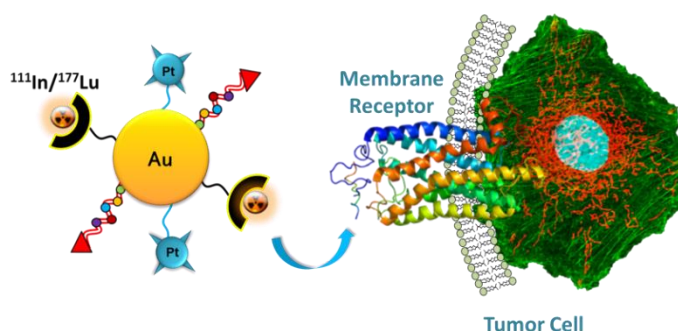
One of the main hurdles to overcome in the design of novel drugs to tackle CNS disorders, such as Alzheimer's disease (AD) or Parkinson's disease, is the blood-brain barrier (BBB). We have been involved in the design and biological evaluation of innovative BBB translocation systems based on short peptides or single domain antibodies (sdAbs) aimed at delivering drugs of different nature (e.g. small molecules or protein-based) into the brain. Additionally, we have also participated in the synthesis and preclinical evaluation of  $^{99\text{m}}\text{Tc}(\text{I})$ -complexes containing a bioactive fragment (stilbene or benzothiazole derivatives) for targeting amyloid- $\beta$  plaques in the brain, in order to image AD.

These collaborative projects combine the RSG expertise with the interests of researchers from the Instituto de Medicina Molecular (Miguel Castanho Lab), Faculdade de Medicina Veterinária/Universidade de Lisboa (Frederico Aires da Silva) and Facultad de Química/Universidad de Vigo (Ezequiel Vázquez-López group).



## MULTIFUNCTIONAL GOLD NANOPARTICLES FOR TARGETED CHEMORADIO THERAPY

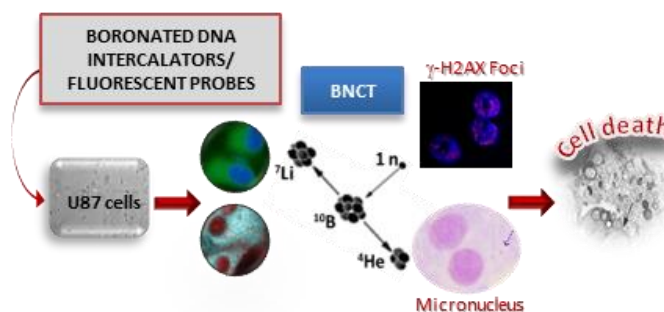
Target-specific AuNPs, carrying a bombesin analog, were evaluated as drug delivery platforms, by conjugation of thiolated Pt(IV) pro-drugs to their surface. The resulting Pt(IV)-AuNPs were successfully radiolabeled with  $^{67}\text{Ga}$  and continued to display significant cell uptake in GRPr-positive cell lines. Cytotoxic assays in human PC3 prostate cancer and U87 glioblastoma cell lines



showed that the Pt(IV)-AuNPs induce significant cell death, when compared with the reference anti-cancer drug cisplatin. These encouraging results prompted further evaluation of these AuNPs for the simultaneous delivery of chemo and radiotherapeutic (Pt(IV) and  $^{111}\text{Lu}$ ) agents, aiming to introduce innovative strategies in cancer theranostics.

## BORONATED DNA INTERCALATORS AS DUAL THERAPEUTIC AGENTS FOR BNCT AND PDT

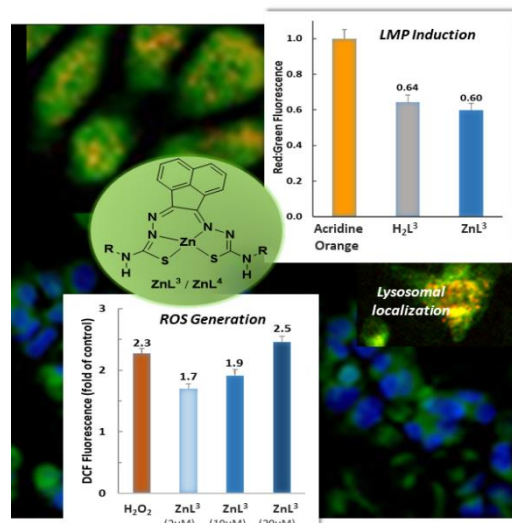
BNCT (Boron Neutron Capture Therapy) and PDT (Photodynamic Therapy) are two therapeutic modalities with potential to destroy tumors that are resistant to current treatments e.g., resection, radiotherapy and chemotherapy. Both modalities rely on the selective accumulation of a sensitizer within tumors, followed by irradiation with thermal neutrons (BNCT) or activation with light (PDT), which can be accomplished using a single compound.



Studies using compounds in which the radiosensitizing ( $^{10}\text{B}$ ) and photosensitizing (acridine derivatives) entities are part of the same molecule were performed in glioblastoma cells. So far, promising results were obtained when the compounds were evaluated as BNCT agents, with significant DNA damage and genotoxic effects as assessed by the  $\gamma\text{-H2AX}$  and the micronucleus assays.

## BIS(THIOSEMICARBAZONE) (BTSC) METAL COMPLEXES AS IMAGING AND/OR THERAPEUTIC AGENTS

Our previous work showed that piperidinyl/morpholinyl derivatives of CuATSM present a significant cytotoxic activity against tumoral cells and high cellular uptake. To shed some light in the mechanisms of action and uptake of these class of M(II) complexes, we have studied fluorescent Zn(II) congeners that are more adequate for preclinical studies by optical imaging modalities. Cell imaging assays showed that an aromatic BTSC Zn(II) complex (ZnL3), carrying a piperidine ring, has the highest cellular uptake, undergoes lysosomal entrapping, produces intracellular ROS, and induces lysosomal membrane permeabilization. Some of these results indicate that the pendant cyclic amines endow M(II)-BTSC complexes with lysomotropic properties.



## METAL-BASED DRUGS FOR THERAPEUTIC APPLICATIONS

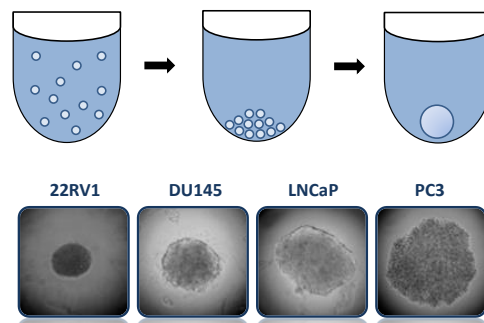
We have investigated the mechanisms of action and cellular targets of complexes with a variety of *d*- and *f*- transition metals (V, Ag, Cu, Zn, Ga, In, Pt and Ln), in collaboration with national and international research groups, as prospective metal-based drugs for therapeutic applications.

As an example, novel osteotropic platinum(II) complexes potentially useful for treating bone metastatic disease were developed and evaluated. The biological properties of the metal-complexes were assessed using microanalytical techniques and the nuclear facilities available at C<sup>2</sup>TN, namely ICP-MS and PIXE (Particle Induced X-ray Emission), as well as via collaborations with other national laboratories with expertise in optical and electron microscopy (confocal, TEM, SEM).



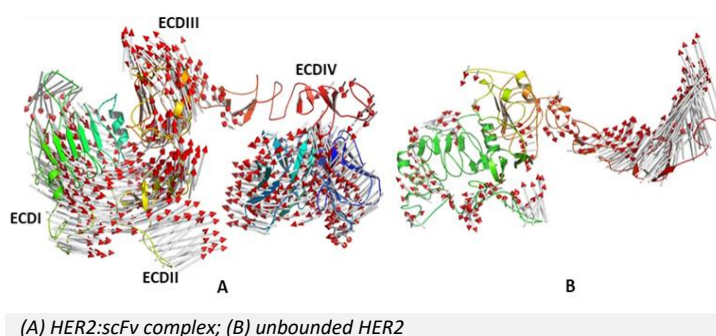
## ADVANCED 3D CULTURES FOR PRECLINICAL EVALUATION OF RADIOPHARMACEUTICAL

One of the main reasons why investigational drugs fail clinical trials is related to the use of preclinical models with limited predictive value, which compromises the ability to translate preclinical findings into the clinical setting. Within this context, we have recently developed more suitable *in vitro* cellular models of prostate cancer (PCa). This includes 3D cellular models (tumor spheres), a model that harbors an enriched population of cancer stem cells, known to be involved in treatment failure and relapse of cancer. These models will be useful to better assess the potential of therapeutic radiopharmaceuticals currently under development at the Radiopharmaceutical Sciences Group.



## AN *IN SILICO* DYNAMIC REARRANGEMENT OF HER2 UPON ANTIBODY BINDING: EFFECTS ON THE DIMERIZATION

The dynamic behavior of the interaction between a HER2-specific single chain variable fragment (scFv) from trastuzumab and HER2 (human epidermal growth factor receptor 2) was studied through molecular dynamics simulations. Interestingly, we observed that not only the interfacial residues in HER2:scFv are relevant, but also residues at ECDII-III, the HER2 dimerization arm, play an important role on protein-protein interactions (PPI). This observation contributed significantly to shed light on the mechanism of action of trastuzumab, namely on the blocking of HER2 dimerization through synergistic inhibition and/or steric hindrance. Overall, these results pave the way toward a new strategy for fine-tuning target activity through allosteric ligands.





## TEAM

Name	Category	R&D (%)
Pedro Vaz	Coordinator Researcher – Group Coordinator	90
Maria José Madruga	Principal Researcher	40
Isabel F. Gonçalves	Auxiliary Researcher	100
Isabel Paiva	Auxiliary Researcher	80
José Alberto Corisco	Auxiliary Researcher	40
Mário Capucho dos Reis	Auxiliary Researcher	50
Octávia Monteiro Gil	Auxiliary Researcher	90
Joana Santos <sup>2</sup>	Researcher / Collaborator	30
Nuno Teixeira <sup>1</sup>	Researcher / Collaborator	30
Carlos Oliveira	Researcher (retiree) / Collaborator	-
Maria dos Anjos Neves	Researcher (retiree) / Collaborator	-
Marta Guimarães Santos	Senior Technician (with Ph.D.)	40
Yuriy Romanets	Senior Technician (with Ph.D.)	40
Eva Andrade	Senior Technician (IST, services)	30
Pedro Teles	Researcher Contract	100
Ana Belchior	Post-Doc Researcher	100
Joana F. Guerreiro <sup>3</sup>	Post-Doc Researcher	45
Salvatore di Maria	Post-Doc Researcher	100
Tomoko Alice Morlat <sup>4</sup>	Post-doc Researcher	50
Margarida Caldeira	Research Fellow (BI) (with Ph.D.)	30
Jorge Borbinha	Research Fellow (BI) – Ph.D. student	100
Mariana Baptista	Research Fellow (BI) – Ph.D. student	100
Ana Catarina Antunes <sup>5</sup>	Research Fellow (BI) (M.Sc.)	100
Ana Cravo Sá	Ph.D. student	50
Luís Cabeça Marques <sup>6</sup>	Ph.D. student	-
Pedro Gomes <sup>7</sup>	Ph.D. student	-
Valerio Santoro	M.Sc. student (Erasmus+, concluded in June)	-
Mariana Trincão	M.Sc. student (concluded in November)	-
Debora António	M.Sc. student (concluded in December)	-
João Canhoto	M.Sc. student (concluded in December)	-
Paula Madeira	Radiographer (CHULC*) / Collaborator	-

<sup>1</sup> Main affiliation: Escola Superior de Tecnologia de Saúde de Lisboa

<sup>2</sup> Main affiliation: Escola Superior de Tecnologia de Saúde de Coimbra

<sup>3</sup> 45% at the RS Group and 10% at the GO

<sup>4</sup> 50% at the NET Group

<sup>5</sup> Until August 2018

<sup>6</sup> Main affiliation: Air Force Academy

<sup>7</sup> Main affiliation: Instituto Soldadura e Qualidade

\* CHULC – Centro Hospitalar Universitário Lisboa Central

## MISSION AND OBJECTIVES

The main objectives of the Group activities consisted on:

- The deployment of unique scientific and technical expertise, skills and competence in radiological protection, radiation safety and radioactive waste 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.
- Education and training of students and professionals in Masters and Doctoral programmes and the supervision of Ph.D. or M.Sc. theses' students.
- The provision of scientific advice and support to the Portuguese competent authorities and stakeholders in the execution of policies in radiological protection and in areas involving application of ionizing radiations and radioisotopes.
- Contribute to raise the awareness of Portuguese and international stakeholders about hot topics, emerging, leading edge and multidisciplinary scientific issues associated to the biological effects arising from the medical, industrial and environmental exposures to ionizing radiation of workers, patients and members of the public.

To achieve such objectives, the GPSR was involved in fundamental and applied research activities addressing multidisciplinary, cross-cutting and leading edge topics in:

- Dosimetry and Radiobiology,
- Environmental Radioactivity and Radioecology,
- Radioactive Waste Management,
- Metrology of ionizing radiation,
- Emergency preparedness and management of radiological & nuclear accidents.

The GPSR researchers have access to laboratory infrastructures and equipment and state-of-the-art radiobiology, radioanalytical, dosimetry and metrology techniques.

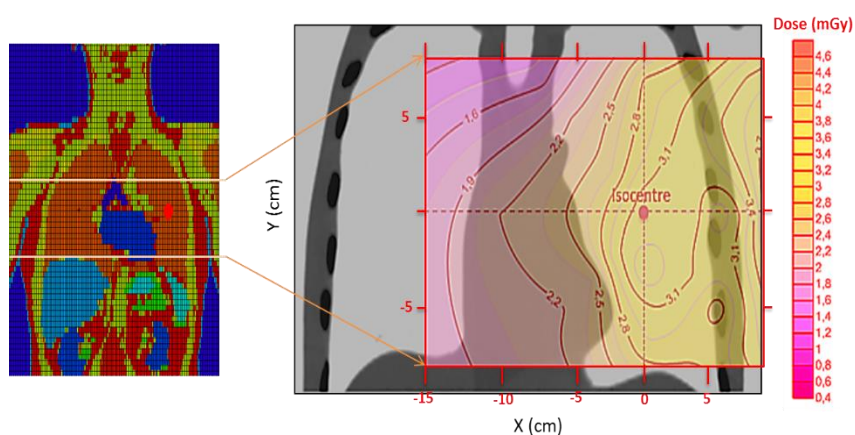
The Group's activities:

- Were sustained by the participation in R&D projects funded by the European Union (EU) Framework Programmes and HORIZON 2020, by the Portuguese Foundation for Science and Technology, by organizations such as EURADOS (European Radiation Dosimetry Group) and EURAMET (European Association of National Metrology Institutes), in collaboration with CERN and other research centers in European countries.
- Included the participation in the EU Technological Platforms MELODI (Multidisciplinary European Low Dose Research), IGD-TP (Implementing Geological Disposal of Radioactive Waste), NERIS-TP (Preparedness for Nuclear and Radiological Emergency Response and Recovery) and Alliance (European Radioecology Alliance).
- Fostered collaborative links with Portuguese research groups, academia, hospitals and other stakeholders in Radiation Protection, in the context of scientific projects and academic, education and training activities.

## MAIN ACHIEVEMENTS

### RADIOTHERAPY - DOSIMETRIC ASSESSMENT OF CONE BEAM COMPUTER TOMOGRAPHY (CBCT)

Cone-beam CT (CBCT) is employed on a daily-basis and several times per patient, to ensure that the patient's position is correct and for targeting the tumor volume localization in Image Guided Radiotherapy (IGRT). This leads to high cumulative imaging doses to the tissues surrounding the exposed target-organs. In this study, we were able to assess the patient's dose distribution during a thorax CBCT scan (see Figure) and which dose metric provides the best evaluation of organ doses. For that, MCNPX simulations to model the CBCT equipment and a male voxel phantom were used. This work indicates that:



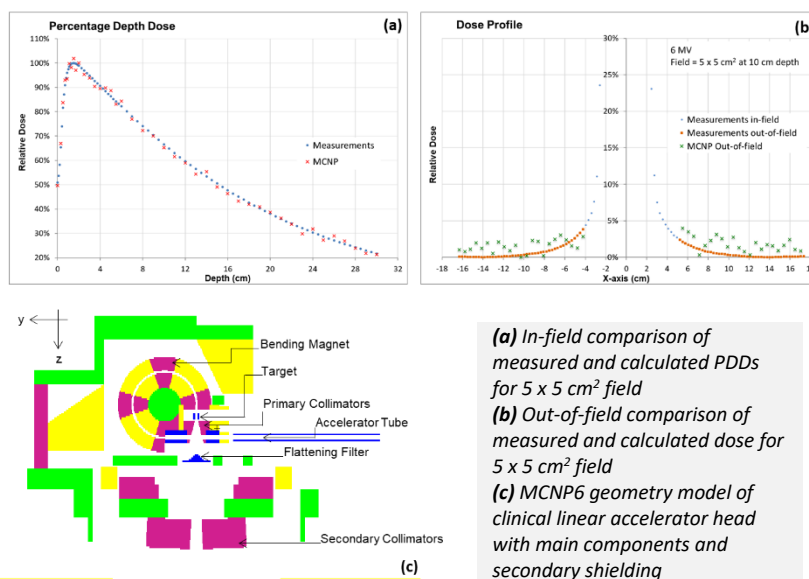
Isodose curves based on MCNPX simulations using the SURFER 13 software with the Kriging gridding method, for a single thorax CBCT scan. The isocentre of the CBCT system was located at the left lung of the patient.

distribution during a thorax CBCT scan (see Figure) and which dose metric provides the best evaluation of organ doses. For that, MCNPX simulations to model the CBCT equipment and a male voxel phantom were used. This work indicates that:

- 1) The CTDI<sub>w</sub> formalism could be used as a quantitative measure for the average dose to all organs exposed to the primary beam, if appropriate air-to-tissues conversion coefficients are applied.
- 2) The  $f_{100}(150)$  formalism permits the definition of more reliable distance limits, starting from the target organ, where this dose metric can explain absorbed organ doses within the scan field.

### RADIOTHERAPY - OUT-OF FIELD AND IN-FIELD VALIDATION OF 6MV LINAC USING MONTE CARLO CALCULATIONS AND CLINICAL MEASUREMENTS

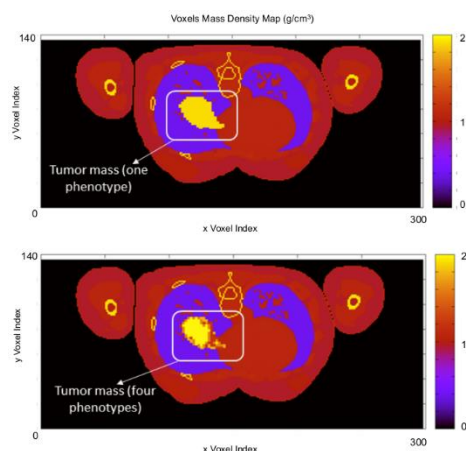
Presently the out-of-field doses are an important topic in radiotherapy treatments, where doses below 3 Gy are ignored in radiotherapy planning. We found good agreements between measured and calculated values for PDD curves and beam profiles, both for in-field and out-of-field doses. Our study provides a model that could be used in clinical research, namely in the dose evaluation outside the treatment fields. This is particularly relevant for studying new radiation therapy treatment techniques, especially in pediatric patients, since it can be used to estimate the development of secondary cancers.



(a) In-field comparison of measured and calculated PDDs for 5 x 5 cm<sup>2</sup> field  
(b) Out-of-field comparison of measured and calculated dose for 5 x 5 cm<sup>2</sup> field  
(c) MCNP6 geometry model of clinical linear accelerator head with main components and secondary shielding

## NANODOSIMETRY AND TARGETED RADIOTHERAPY – DOSIMETRIC ASSESSMENT IN DIFFERENT TUMOR SUB-VOLUMES WITH AUGER ELECTRON-EMITTING RADIONUCLIDES: $^{99m}\text{Tc}$ , $^{125}\text{I}$ , $^{161}\text{Tb}$ , AND $^{177}\text{Lu}$

Internal radiotherapy using Auger-emitting radionuclides presents advantages with respect to external radiotherapy, such as tumor local efficacy. The aim of this study is to assess the dosimetric effectiveness in irradiating a tumor composed by intra tumor heterogeneity with mix radionuclides for each tumor phenotype, such as  $^{161}\text{Tb}$ , and  $^{177}\text{Lu}$ . State of the art Monte Carlo PENELOPE code and ICRP reference voxel phantom are used in order to mimic a lung tumor volume composed by four different sub tumor phenotypes. For each radionuclide, the complete decay mode is considered (i.e. Auger, IC electrons and  $\beta$  radiation). Two main radiation therapy strategies were simulated: i) the entire tumor was irradiated homogenously using once each of the radionuclides; ii) each tumor sub volume was filled with different radionuclides. The optimal dosimetric configuration was studied in terms of the maximum tumor-to-healthy dose ratio. This study shows that the hypothetical use of several electrons beam qualities in different tumor phenotypes, could act as dose radio-sensitizer and minimizing dose in healthy tissues. Two case studies are considered: i) tumor mass composed by only one phenotype (up); tumor mass composed by four phenotypes (down).



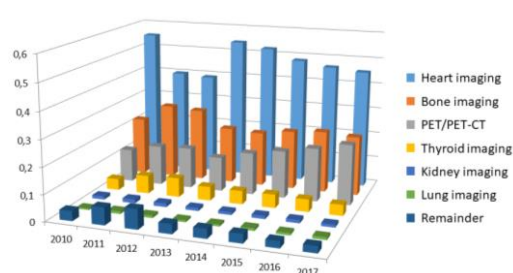
## ESTIMATION OF THE COLLECTIVE DOSE IN THE PORTUGUESE POPULATION DUE TO RADIODIAGNOSTIC AND NUCLEAR MEDICINE EXAMS

The increasing use of ionizing radiation in medicine has led to a rise in the collective dose in the population worldwide. This stresses the importance of periodic evaluations of collective doses and its share relative to the total value.

This work studied the exposure of the Portuguese population to ionizing radiation due to radiodiagnostics (X-ray and nuclear medicine) exams, using a well-established method.

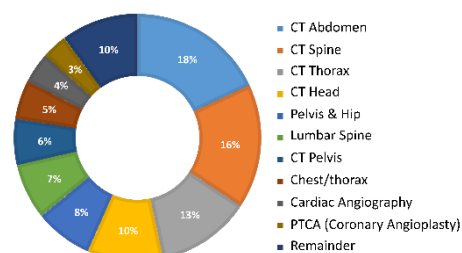
### Nuclear Medicine exams

A survey to 39 nuclear medicine centers was undertaken. The estimated total collective dose due to nuclear medicine exams was of 0.088 mSv per person in 2013 and 0.090 mSv per person in 2017. The results signal the increase in PET/PET-CT examinations, and a diminishing trend of Cardiac exams.



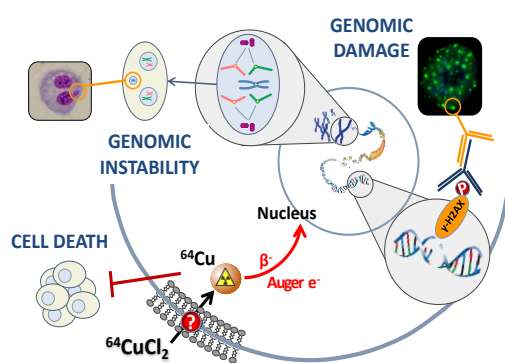
### Radiodiagnostic exams

A survey was undertaken to the 5 Health Regional Administrations concerning the top 20 exams which account for 75-90 % of the total effective dose. The estimated average annual effective dose of the population due to radiodiagnostic exams was 0.79 mSv per person in 2013 and 0.91 mSv per person in 2017. About 2/3 of this dose is due to Computer Tomography (CT) exams, about 20% due to conventional radiology exams, and about 7% due to interventional cardiology exams. The obtained results will provide input to the NRD Portugal project, which will establish National Diagnostic Reference Levels (DRLs) in Portugal for the first time.



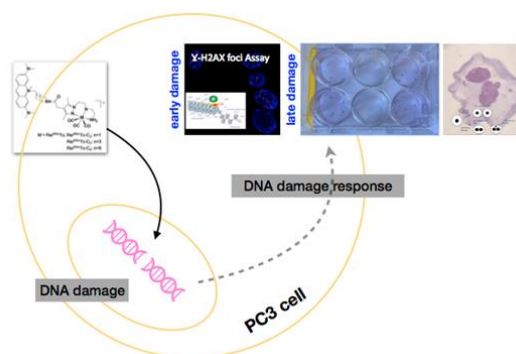
## **$^{64}\text{CuCl}_2$ - A SIMPLE TOOL FOR PROSTATE CANCER THERANOSTICS**

Copper plays a critical role for cancer development and progression, and multiple copper isotopes are explored for cancer imaging and therapy. In collaboration with the RS Group, studies using the simpler ionic form of the medically relevant copper radioisotope,  $^{64}\text{Cu}$ , have been conducted with promising results for prostate cancer (PCa) theranostics. PCa cells were found to exhibit increased  $^{64}\text{CuCl}_2$  uptake, which resulted in higher early DNA damage and genomic instability. In addition, PCa cells were found to have a higher sensitivity to  $^{64}\text{CuCl}_2$  than healthy cells, supporting the idea that this compound deserves to be further evaluated as a targeted theranostic agent in PCa.



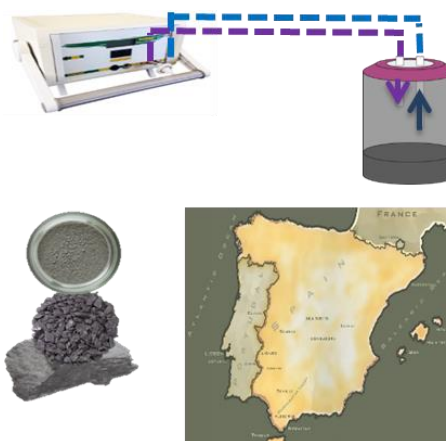
## **RADIOBIOLOGY - ASSESSMENT OF THE BIOLOGICAL EFFECTS INDUCED BY $^{99\text{m}}\text{Tc}$ -LABELLED AO-DERIVATIVES, IN PC3 CELLS**

This on-going work aims at determining the influence of the  $^{99\text{m}}\text{Tc}$ -to-DNA distance on the early and late biological effects induced by Auger-electrons emitted by the  $^{99\text{m}}\text{Tc}$  radionuclide. For this purpose, these effects were quantified using two DNA-intercalating  $^{99\text{m}}\text{Tc}$ -complexes,  $^{99\text{m}}\text{Tc}$ -C3 and  $^{99\text{m}}\text{Tc}$ -C5, which place the  $^{99\text{m}}\text{Tc}$  atom at 10 and 12 Å distances from the central axis of DNA, respectively. The results show a significantly decrease of the early biological effects, quantified by the number of  $\gamma$ -H2AX foci, when human prostate cancer PC3 cells were incubated with  $^{99\text{m}}\text{Tc}$ -C5 instead of  $^{99\text{m}}\text{Tc}$ -C3. Also, the number of micronuclei and survival fractions reveal a decrease on the late biological effects induced by  $^{99\text{m}}\text{Tc}$ -C5 when compared with  $^{99\text{m}}\text{Tc}$ -C3. These results suggest that the Auger-electrons play a crucial role on the radiation-induced biological effects produced by the tested  $^{99\text{m}}\text{Tc}$  complexes.



## **RADON AND THORON EXHALATION RATES FROM BUILDING MATERIALS**

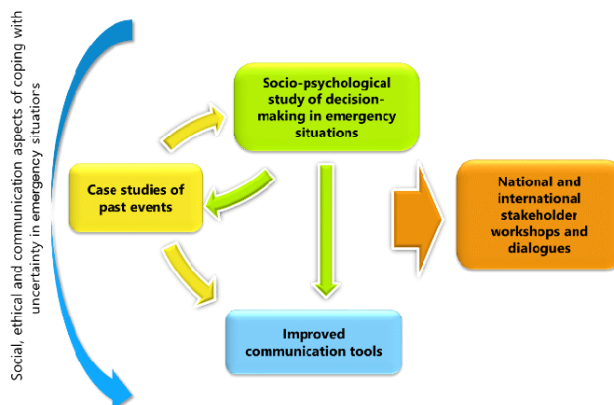
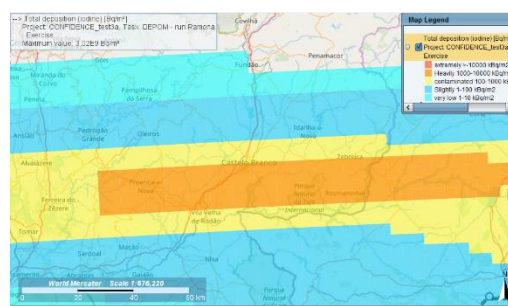
Radon ( $^{222}\text{Rn}$ ) is a major contributor to the ionizing radiation dose received by the general population. Thoron ( $^{220}\text{Rn}$ ) has been growing in importance in the last years. Its health risk is usually ignored owing to its short half-life, but the generated thoron progeny can cause a significant dose contribution. Commonly used earth-based building materials contain uranium and thorium in varying amounts. The radioactive gases produced by these materials are transported to indoor air through diffusion, meaning that building materials are potentially a significant source of the doses received indoors. The studied materials are included in two categories: natural materials (NM) and materials incorporating residues from industries processing naturally occurring radioactive materials (PM).



Radon/Thoron exhalation rates measurement setup to test some natural and processed building materials.

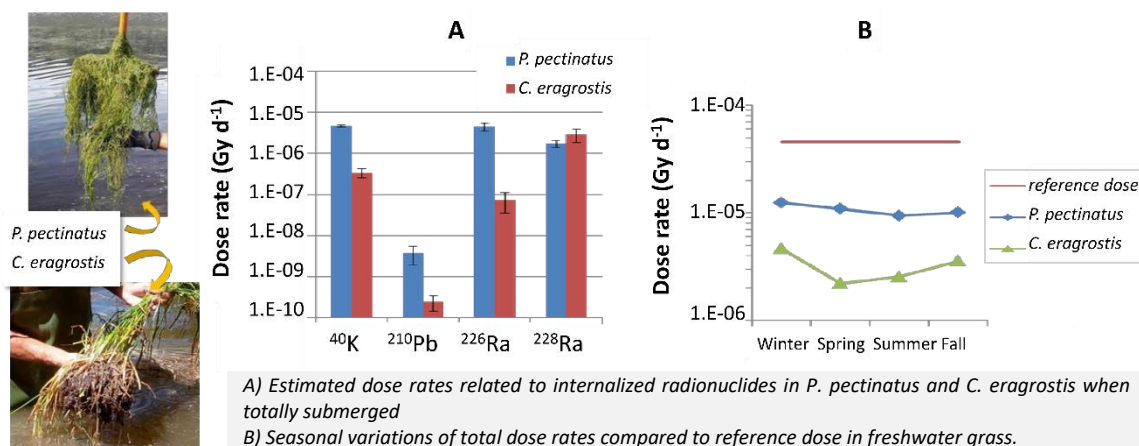
## CONFIDENCE - COPING WITH UNCERTAINTIES FOR IMPROVED MODELLING AND DECISION MAKING IN NUCLEAR EMERGENCIES

The project aims to improve decision making processes in nuclear emergencies. This will be achieved through the reduction of uncertainties and the development of approaches to deal with uncertainty information. It will use a multidisciplinary approach dealing with all aspects regarding the radiological situation following an accidental release, from the prognosis of dispersion and its spatial-temporal evolution, to the off-site consequences and the decision making to select, implement and evaluate remediation strategies, including the viewpoints of stakeholders. IST is involved in WP4: engage national stakeholders to improve the preparedness and response in the transition phase and identify and reduce the uncertainties in the management of the long-term exposure situation; and WP5: identify social and ethical issues related to uncertainty management in emergency and post-accident situations and clarify how stakeholders at the various levels deal with uncertainty in their decision making processes.



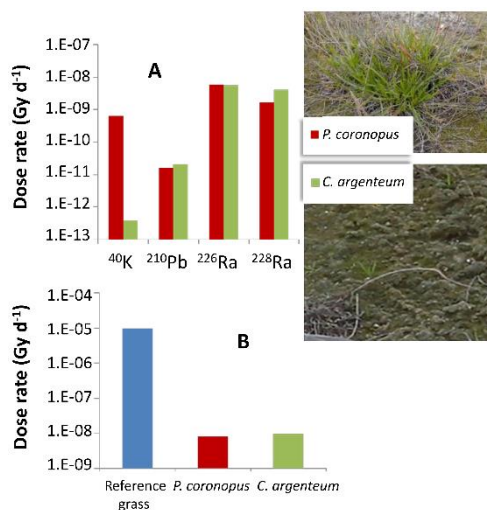
## RADIATION DOSE ASSESSMENT IN AQUATIC AND EMERGENT PLANTS IN TEJO RIVER

From October 2013 to December 2017, aquatic (*Potamogeton pectinatus*) and emergent (*Cyperus eragrostis*) plants in Tejo river have been sampled and used as bioindicators of natural radionuclides. Assessment of internal radiation dose was done using the ICRP reference aquatic plant model coupled with the Monte Carlo code MCNPX. Dose contributors are  $^{40}\text{K}$ ,  $^{210}\text{Pb}$ ,  $^{226}\text{Ra}$  and  $^{228}\text{Ra}$ . Higher absorbed doses were received in winter. Estimated dose rates are below the reference weighted absorbed dose rate in freshwater grass, which, according to Hosseini *et al.* 2010 (*J. Radiol. Prot.* 30) is  $4.56\text{E-}05\text{ Gy d}^{-1}$  (see Figure).



## TRANSFER AND RELATED DOSE ASSESSMENT OF NATURAL RADIONUCLIDES IN PLANTS AND MOSSES GROWING ON A PHOSPHOGYPSUM STOCKPILE IN PORTUGAL

Phosphogypsum (PG) is a phosphate industry sub product with enhanced concentrations of naturally occurring radioactive materials (NORM). A PG stockpile remains as the legacy of a disabled phosphate plant near a suburban area in the south bank of Tejo estuary. Herbaceous plants (*Plantago coronopus*) and moss (*Bryum argenteum*) have been covering the PG surface, so this stockpile can be used as a natural laboratory to quantify the transfer of radionuclides to the vegetal biota and assess the absorbed dose resulting from exposure to ionizing radiation. Dose assessment related to the natural radionuclides uptaken by plants and mosses was performed using the ICRP reference wildgrass coupled with the Monte Carlo code MCNPX. Dosimetric calculations show that internal doses are similar to external doses in herbaceous plants but can exceed 2 orders of magnitude in moss (see Figure). The estimated doses are in the order of the natural background for ICRP reference wildgrass ( $< 0.01 \text{ mGy d}^{-1}$ ).



A) Estimated dose rates related to internalized radionuclides in *P. coronopus* and *B. argenteum*; B) Total dose rates compared to reference dose rate in wildgrass.

## RARE EARTHS FROM SECONDARY SOURCES

Project ENVIREE, addressing exploitation of REEs from secondary sources (Fig. 1) such as historical wastes from former uranium low grade, copper, tungsten, zinc and gold mining sites, has finished April 2018. IST participated as partner, co-coordinator and coordinator in work packages WP1, WP3 and WP5. IST participants in the project also organized 1

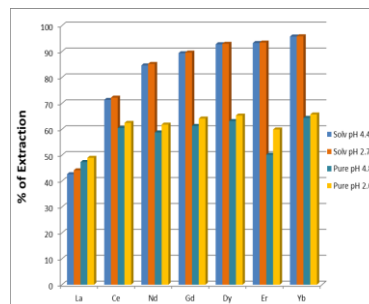
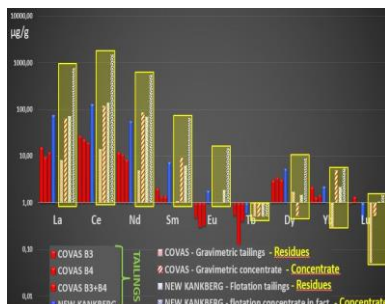


Fig. 1 and 2- REE concentrations discrimination obtained for both original material (tailings) and reprocessed concentrate and residues, by using the diverse chosen approaches for Covas and New Kankberg samples Percentage of extraction in nitric media by using IL1 in toluene and pure at several pH values

international workshop in Lisbon, co-organized 3 courses abroad, participated in 1 Summer Course, 3 technical visits and wrote and participating in writing of more than 10 progress/final reports (WP's and tasks). Papers have been submitted and are also in writing process. Two patents pending.



## TEAM

Name	Category	R&D (%)
Maria de Fátima Araújo	Principal Researcher – Group Coordinator	100
António Manuel Monge Soares	Principal Researcher (collaborator / retiree)	-
António Nazareth Falcão	Principal Researcher	90
Fernanda Maria Amaro Margaça	Principal Researcher	100
Luís Manuel Cerqueira Alves	Auxiliar Researcher	70
Luís Miguel Mota Ferreira	Auxiliar Researcher	100
Paula Maria Carreira Paquete	Auxiliar Researcher	90
Pedro M. F. Valério	Auxiliar Researcher	90
Dina André	Graduated Technician	100
António Amaro	Senior Technician	100
Helena Marcos	Senior Technician	100
Manuela Correia	Senior Technician	100
Rute Pinheiro	Senior Technician	100
Catarina Galinha <sup>1</sup>	Post-Doc Researcher	50
Maria Helena Casimiro	Post-Doc Researcher	100
Pedro Santos	Post-Doc Researcher	100
Sandra Cabo Verde	Post-Doc Researcher	100
Susana Sousa Gomes	Ph.D. student Research Fellow (BI) (with Ph.D.), 26/07/2018	100
Paulo Portela	Research Fellow (BI) (M.Sc.)	100
Ana Monteiro	Ph.D. student (collaborator / teacher at ESTeSL)	-
Filipa Lopes	Ph.D. student	45
Joana Madureira	Ph.D. student	100
Paula Alexandra Rodrigues	Ph.D. student	50
Rui Camara Borges	Ph.D. student	40
Rute Flávia Chaves	Ph.D. student	50
Andreia Severino	M.Sc. student	100
Catarina Palma	M.Sc. student	100
Joana Roque	M.Sc. student	100
Maria Inês Elias	M.Sc. student	100

<sup>1</sup>The remaining 50% at the NET Group of C<sup>2</sup>TN, until September 2018

## MISSION AND OBJECTIVES

GREI is an interdisciplinary group with expertise on nuclear related analytical techniques and ionizing radiation dedicated to the investigation of Environmental Processes, Cultural Materials & Materials Processing. The group operates an Ionizing Radiation Facility with gamma and e-beam sources and a set of laboratory facilities and equipment to perform: elemental, isotopic, trace element and tritium determinations and radiocarbon dating; microbiological and chemical analysis of radiation effects in products; and MeV ion microbeam analytical techniques.

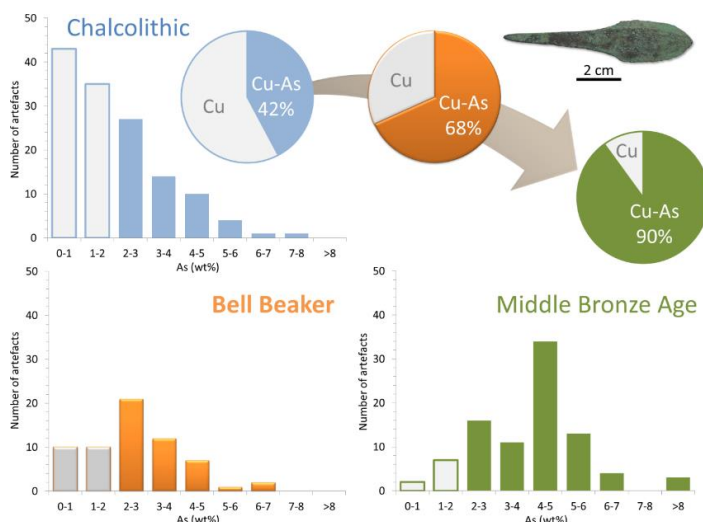
Concerning Environmental Processes research, involves the investigation of ionizing radiation effects on the degradation or extractability of industrial wastes' pollutants, to develop strategies to remediate their environmental impact or valorise its reuse. Also, the study of inactivation mechanisms of water and food-borne virus and bacteria by ionizing radiation will contribute to improve effective disinfection processes. Besides, studies on water resources management are being developed aiming at the evaluation of the impact of groundwater over exploitation in coastal areas in Portugal and semi-arid and arid coastal regions in Africa. Finally, anthropogenic impacts, pollutant sources of materials on diverse environments (aerosols, sediments, soils, plants and waters) and climatic patterns are investigated based on elemental and isotopic compositions and radiocarbon dating.

Research on Cultural Materials is being developed aiming to assess sources, production and circulation of ancient artefacts (metals, glazes and glasses) from prehistoric to Early Modern Period by microanalytical (elemental and Pb isotopes) and microstructural characterization, as well as absolute dating by radiocarbon analysis. Furthermore, research has been performed on macromolecular materials using ionizing radiation for processing or modification, to obtain new properties optimized for biomedical applications (e.g. skin scaffolds) and conservation of cultural artefacts (roman mosaics).

## MAIN ACHIEVEMENTS

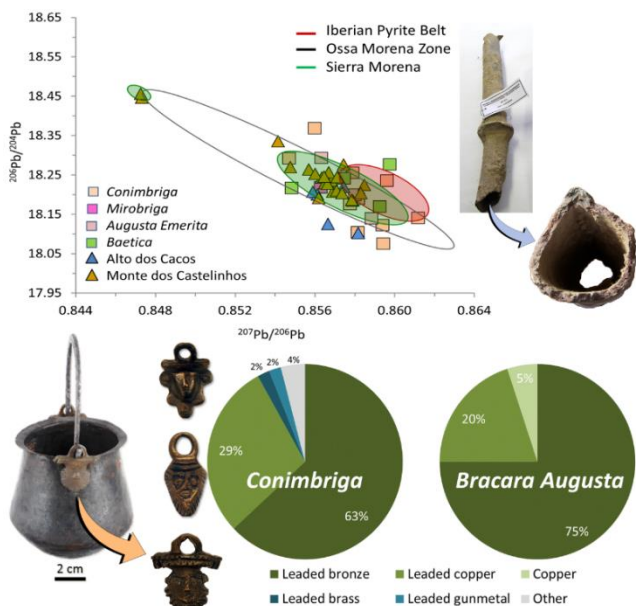
### ARSENICAL COPPER ALLOYS: A LOST CULTURAL MARKER OF BELL BEAKER CULTURE

Research on copper-based metallurgy in SW Iberian Peninsula has been identifying the intensified use of arsenical copper from Chalcolithic to Middle Bronze Age (MBA). More recently, it has shown that the composition of weapons and tools from Bell Beaker sites (c. 2500-1800 BC) fills the gap between early copper and MBA arsenical copper. Prestige items such as daggers were selectively made of high-arsenical copper alloys, most likely for aesthetic rather than functional purposes, due to their seeming inability to fully exploit the hardening potential of arsenic. Therefore, these silvery alloys would indeed have a prestige value among third millennium BC communities, while the shortage of ornaments can be explained by the preference for different prestige goods such as gold. In conclusion, arsenical copper alloys can probably be considered a cultural marker of Bell Beaker communities, similarly to their distinctive pottery, Palmela points, stone wrist guards and bone/ivory V-perforated buttons.



### LEAD AND COPPER IN WESTERN PROVINCES OF THE ROMAN EMPIRE: PROVENANCE, PRODUCTION AND USE

Copper-based alloys and lead implements were widely employed by the Roman Civilization having a variety of urban and warfare applications. Archaeometallurgical research was focused in collections from Conimbriga, Augusta Emerita and Mirobriga (Lusitania province) and Bracara Augusta (Galaecia). Elemental and isotopic composition of complex hydraulic systems (lead pipes) assigned raw materials to the Iberian Pyrite Belt (argentiferous jarosite ores) and Sierra Morena and Ossa Morena Zone (galena ores). Elemental and microstructural study of anthropomorphic attachments of situlae evidenced a conservative metallurgy, mostly composed of leaded copper and leaded bronze. In general, recycling practises became a common activity during the Empire, suggesting a technology strongly influenced by economic factors. The unrefined typology and massive production of those decoration items also agrees with the low incidence of the more expensive brass alloys, thus evidencing a local production quite different from the exquisite Roman artefacts from the core of the Empire.



## CHRONOLOGICAL SILVER ALLOYS COMPOSITION DURING THE 4<sup>TH</sup> DINASTY; COINS VERSUS JEWELLERY

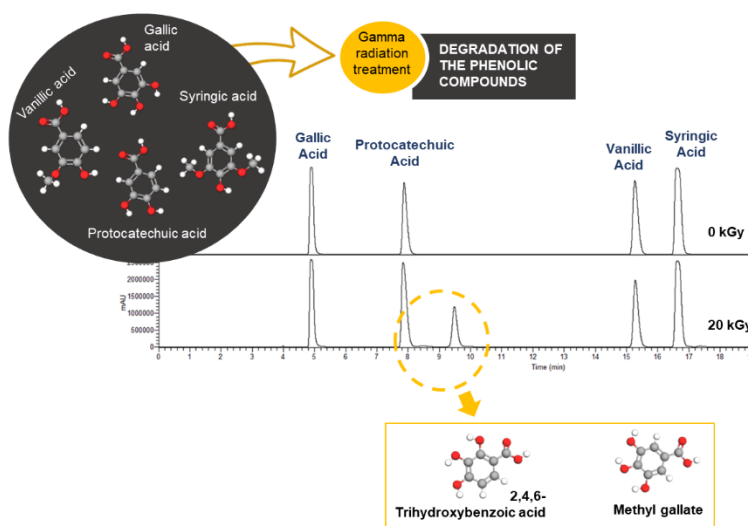
Portuguese silver coins from the 15th-17th centuries were analysed by non-destructive PIXE technique in order to create an elemental data base composition in major, minor and trace elements of the silver alloys which allowed to: 1) determine a chronological framework of the silver alloy used, allowing establishing the silver ore provenance and metallurgical procedures; 2) differentiate production centers (Lisbon and Oporto); 3) allow comparison with coeval Portuguese silver objects, namely Indo-Portuguese silver jewellery from the Ancient Art Nacional Museum (MNAA); 4) help for detecting forgeries.



The work was performed in collaboration and using the silver coin collections from the Portuguese Mint House (ICNM – Imprensa Nacional Casa da Moeda) and from the Bank of Portugal (BdP). The introduction in the Portuguese territory of silver coming from the “New World” Potosí mineral ore is well identified and ascribed to Au contents <100 ppm and very low Bi contents.

## RADIOLYTIC DEGRADATION MECHANISMS OF CORK WASTEWATER POLLUTANTS

The effluent of cork processing is a complex dark liquor with high concentration of phenolic acids, difficult to degrade by conventional treatments. To assess the feasibility of an alternative treatment, the degradation by gamma radiation of four phenolic compounds (gallic acid, protocatechuic acid, vanillic acid and syringic acid) present in cork wastewaters was investigated in isolated and mixture aqueous solutions under different pH's and irradiation atmosphere conditions. Degradation rates of the phenolic

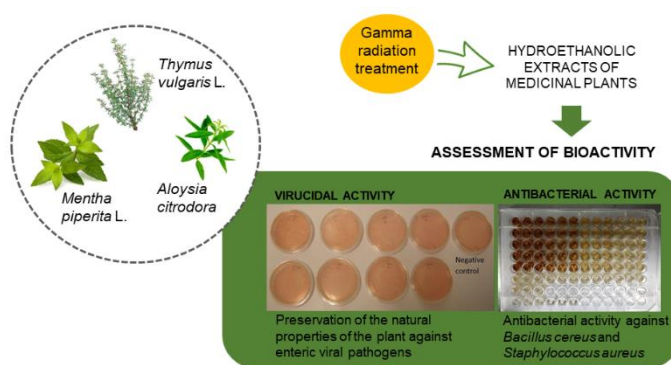


acids were 50% higher for the treated solutions at 20 kGy under aeration and at natural pH. It was verified a partial degradation of the studied phenolics by gamma radiation due to its intra-decomposition and radioprotective effect among each other. Two different compounds were identified as radiolytic products, and their fragmentation pathways were proposed. Results highlighted that ionizing radiation could be used as clean technology, without the addition of chemicals, for pollutants degradation using doses of 20 kGy.

## ANTIMICROBIAL ACTIVITY OF IRRADIATED AROMATIC AND MEDICINAL PLANTS

Irradiation is a safe food processing technology increasingly recognized and supported by several international organizations. The intent of this study was to deepen the knowledge on effects of gamma radiation on the antimicrobial potential of extracts of different plant species used in traditional medicine. It is important to explore the use of green solvents that reduce the impact on the environment and on human health, which

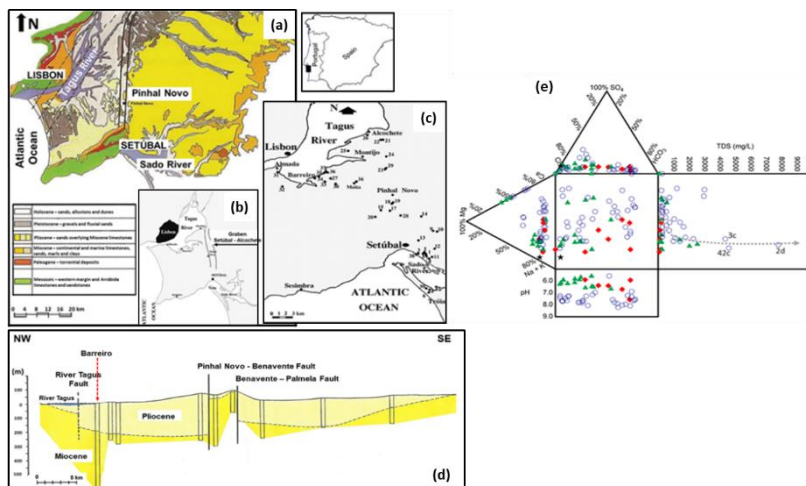
also facilitate the incorporation of these extracts in products within different industrial sectors (pharmaceutical, cosmetic and food). This study reveals the antimicrobial potential of hydroalcoholic extracts in both anti-viral and antibacterial assays, and evaluates a new extraction approach as a process to improve value to aromatic plants as bioactive agents. The results highlighted that gamma radiation treatment up to a dose of 10 kGy promotes the antibacterial activity and preserves the virucidal potential on the hydroalcoholic extracts of studied plant species.



## COASTAL AQUIFERS - DEGRADATION AND CLIMATIC CHANGE FINGERPRINTS

Salinity represents the primary limitation to groundwater Human use. Natural salinity boundaries in aquifers are mainly explained by geological factors, dissolution of minerals and seawater intrusion. The continuous decrease of recharge in semi-arid and arid regions leads to a strong mineralization enhanced by higher evaporation rates. The impact in the groundwater systems due to over exploitation was investigated in coastal aquifers located in: Cape Verde, Tunisia, Morocco and Portugal. Results obtained

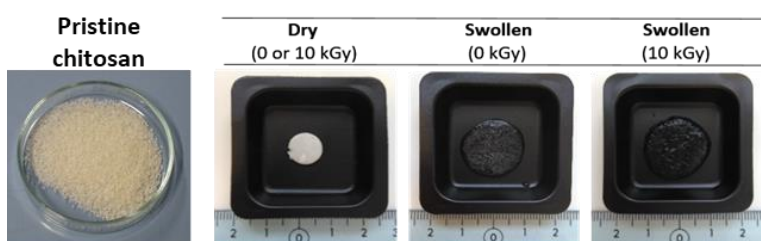
point out to: an increase of land extent by seawater intrusion and a clear influence of marine aerosol; a deficiency of water management together with increase needs for Human supply resulting in serious degradation of water resources; in Santiago Island (using  $^{14}\text{C}$  data) the presence of old groundwater ( $\gg 4000$  years BP) was identified, indicating recharge under different climatic conditions (colder period) and corroborating  $^{18}\text{O}$  obtained data.



(a) Lower Tagus–Lower Sado basin geology and tectonics; (b) Location of the Setúbal – Alcochete graben; (c) Location of the sampling sites; (d) Schematic cross section of the Lower Tagus–Lower Sado basin; (e) Durov diagram: the green triangles represent Pliocene; the red diamond represent the Mio-Pliocene and blue circles represent the Miocene groundwater samples and the stars stands for the mean seawater composition.

## DEVELOPMENT OF CHITOSAN-BASED MATRICES BY RADIATION TECHNOLOGIES FOR BIOMEDICAL APPLICATIONS

Within the framework of a Coordinated Research Project financed by the IAEA, research was performed to engineer chitosan-based matrices using ionising radiation to simultaneously create/sterilise a skin substitute that leads to tissue regeneration. The advantage over more conventional methodologies is the inexistence of initiators or solvents usage and the possibility of preparation and sterilisation in one single step. Several chitosan based matrices with poly(vinyl pyrrolidone) (PVP) were obtained by gamma irradiation from a Co-60 source.

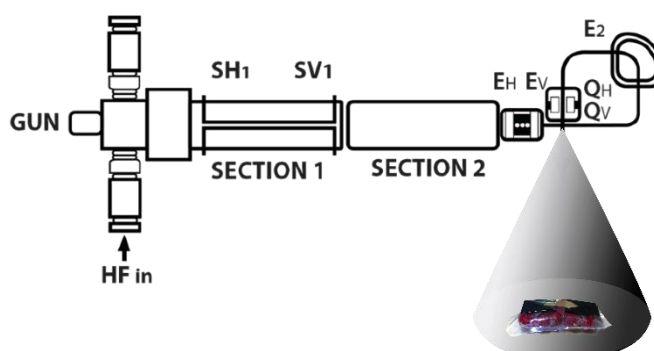


The *in vitro* cellular viability and proliferation of HFFF2 fibroblast cell line was analysed as a measure of matrices' biocompatibility and ability to assist skin regeneration. Results show that gamma-radiation dose, copolymer concentration and synthesis procedure can be used to tailor the matrices' morphology in terms of porosity and surface roughness. Chitosan/PVP (5%) matrices irradiated at 10 kGy presents the higher cellular viability. *In vivo* studies are presently on going.

## MAIN DEVELOPMENTS AT IRIS

The LINAC electron beam needed to reduce its ripple and drifting patterns, and several correction measures were performed to improve the pulse-to-pulse stabilization: additional signal filtration at the gun power supply, corrections in the cathode regulation electronic circuit, magnetic adjustments and optimization of the radiofrequency control feedback loop factor. Ongoing R&D studies made use of the 10 MeV electron beam to address the following subjects: decontamination and shelf life extension of fresh products (mushrooms and raspberries); inactivation mechanistic pattern of waterborne human enteric virus; and improvement of the bioactive compounds extraction efficiency from the olive pomace in order to be used as preservation ingredients in bakery products.

The work developed with the use of the LINAC and the experimental cobalt-60 irradiator facility (PRECISA22) resulted in 7 publications (peer review international journals, books and proceedings), 2 M.Sc. thesis, 4 research contracts and 11 seminars and talks in conferences.



Schematic representation of the electron beam orientation through the linear accelerator to irradiate fresh food products.



## TEAM

Name	Category	R&D (%)
Maria Isabel Dias	Principal Researcher (with Habilitation) – Group Coordinator	70
José Marques	Coordinator Researcher	30
Maria Isabel Prudêncio	Coordinator Researcher	80
Ulrich Wahl	Principal Researcher (with Habilitation)	100
Nuno Barradas	Principal Researcher (with Habilitation)	10
João Guilherme Martins Correia	Principal Researcher	100
José Antunes	Principal Researcher	100
Andreas Kling	Auxiliary Researcher (with Habilitation)	30
Raquel Crespo	Associated Professor (with Habilitation)	60
Ana Cristina Fernandes	Researcher Contract	100
Augusto D. Oliveira	Auxiliary Researcher	30
João Alves	Auxiliary Researcher	30
Marta Almeida	Auxiliary Researcher	70
Miguel A. Reis	Auxiliary Researcher	80
Miguel Felizardo	Auxiliary Researcher (invited)	30
Rosa Marques	Auxiliary Researcher	90
Thomas Girard	Auxiliary Researcher (retired on 31/01/2018)	100
Nuno Canha	Post-doc Researcher Researcher Contract, 15/11/2018	90
P. Cristina Chaves	Researcher Contract	100
Ana Luisa Rodrigues	Post-doc Researcher	100
Catarina Galinha <sup>1</sup>	Post-doc Researcher	50
Joana Coutinho	Post-doc Researcher	100
Joana Lage	Post-doc Researcher	100
José Manuel Benitez	Post-doc Researcher	100
Tomoko Alice Morlat <sup>2</sup>	Post-doc Researcher	50
Vânia Martins	Post-doc Researcher	100
Margarita Evtyugina	Post-doc Researcher (collaborator)	-
Marina Almeida Silva	External Collaborator (with Ph.D.)	-
Vincent Debut	Collaborator (with Ph.D.) (UNL)	40
Guilherme Cardoso	Technician (with M.Sc.)	90
Joana Pereira	Graduate Technician	30
Miguel Pereira	Graduate Technician	30
Filipe Soares	Research fellow (BI) (M.Sc.)	100

Abel Fenta	Ph.D. student	100
Ahmad Baklouti	Ph.D. student (Sfax University, Tunisia)	50
Ângelo Costa	Ph.D. student	100
Carlos Amorim	Ph.D. student	100
Chaima Boussollaa	Ph.D. student (Sfax University, Tunisia)	50
Eric Bosne	Ph.D. student	100
Estela Vicente	Ph.D. student (collaborator)	-
Majdi Yanguì	Ph.D. student (Sfax University, Tunisia)	50
Marcelo Barbosa	Ph.D. student	100
Miguel Carvalho	Ph.D. student (UNL)	25
Tiago Faria	Ph.D. student	100
Vitor Manteigas	Ph.D. student	100
Carolina Correia	M.Sc. student	100
Inês Lopes	M.Sc. student	30
Marta Reis	M.Sc. student	100
Ricardo Teixeira	M.Sc. student	100
Catarina Nunes	B.Sc. student	100

<sup>1</sup> The remaining 50% at the REI Group of C<sup>2</sup>TN, until September 2018

<sup>2</sup> The remaining 50% at the RPS Group of C<sup>2</sup>TN

## MISSION AND OBJECTIVES

The Nuclear Engineering and Techniques research group (NET) explores the uses of nuclear and related techniques within a high range of scientific fields. The group develops advanced materials using unique radioactive beams and nuclear techniques at ISOLDE-CERN, being responsible for the maintenance and development of the experimental Portuguese infrastructure built by CTN teams at that infrastructure. The group is also interested in the study of the violation of the mean field description of exotic nuclei, the development of state-of-the-art software for X-ray analytical methods and establishment/application of quantitative instrumental speciation methods, mainly for PIXE, and the modal identification of dynamical systems under operational conditions as a viable alternative to traditional approaches. NET also probes the interaction of radiation with matter upon emission and detection of the radiation, providing unique information regarding the structural, electronic, magnetic and dynamical local properties. In addition, NET group develops innovative research on earth sciences and cultural heritage (characterization, provenance and luminescence absolute dating) in close relation with museums and other public/ private entities. Regarding health and environmental issues, NET focuses on the study of low activity samples of long-lived isotopes in collaboration with hospitals and other C2TN groups, and research on air pollution assessment and on the transition to a low carbon economy.

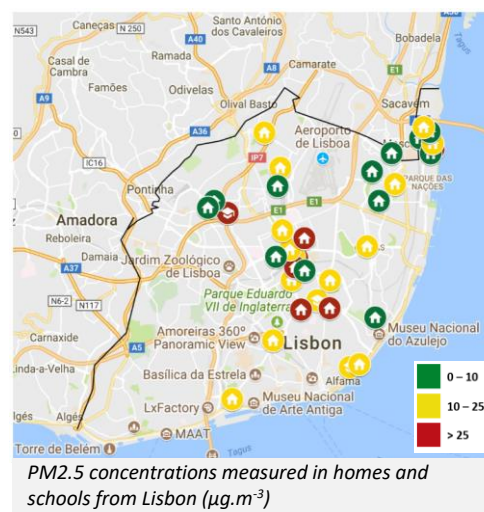
Gamma and alpha Spectroscopy and various ion-beam based techniques (Rutherford Backscattering, Elastic Recoil Detection, Nuclear Reaction Analysis and Resonant Elastic Scattering), Particle Induced X-ray Emission (PIXE), complemented with other techniques like X-ray diffraction are available at C2TN and employed by NET group towards a deep material's characterization, besides collaborations with international laboratories (i.e. GSI, GANIL, RIKEN and BNC).

Education and training is also a major mission of NET group, being encompassed in several Ph.D. and M.Sc. programs. Another challenge of NET group is the development of a policy of linking knowledge with action for effective societal responses to persistent problems of the various level of scientific intervention of NET, aiming to make academic research more relevant to other types of organizations and practitioners. We try that research be problem driven rather than concept centric.

## MAIN ACHIEVEMENTS

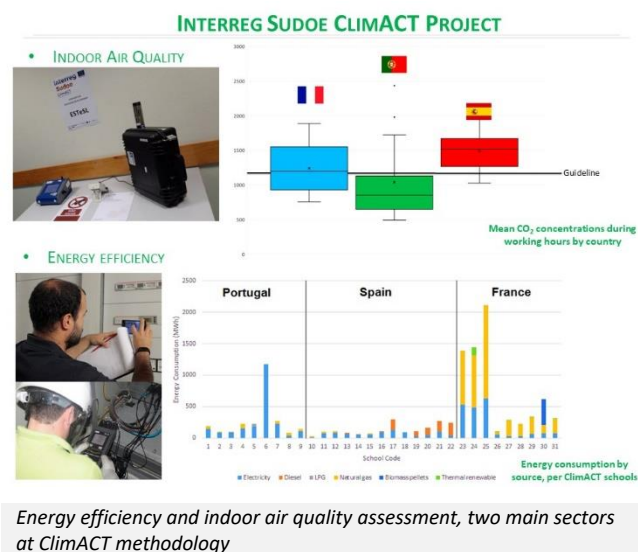
### LIFE INDEX-AIR: ASSESSING CHILDREN EXPOSURE TO AIR POLLUTANTS

The time activity pattern survey for children living in Lisbon, developed within the LIFE Index-Air project ([www.lifeindexair.net](http://www.lifeindexair.net)), showed that during the week they spend 89% of their time indoors - 55% in home, 27% in classrooms and 3.5% in vehicles. Therefore, in this project, PM<sub>2.5-10</sub> and PM<sub>10</sub> samples were collected in parallel in the indoor and outdoor of 40 homes, 5 schools and 4 transport means to calculate the daily children exposure levels to PM components. The elemental analysis of PM samples was performed with a high-resolution energy dispersive X-Ray fluorescence spectrometer; the elemental and organic carbon was analyzed by a thermal-optical method, and Polyaromatic Hydrocarbons were analysed by gas chromatography–mass spectrometry (E. Chalvatzaki, *et al.*, 2018). Results showed that the level of the indoor air pollutants is the principal parameter for the assessment of the exposure, dose and burden of disease, because children spend the majority of their time indoors (see Figure).



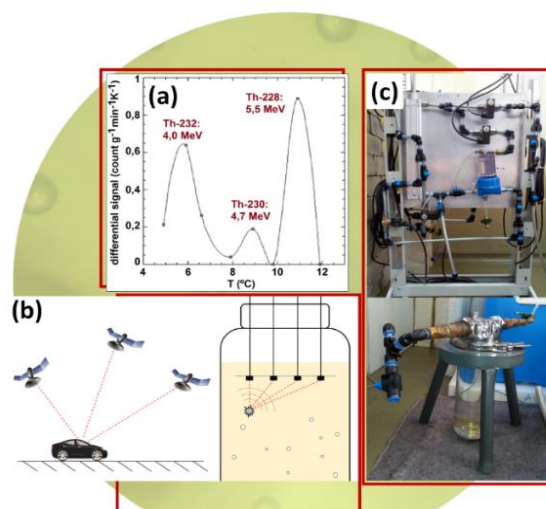
### ClimACT: TRANSITION TO A LOW CARBON ECONOMY IN SCHOOLS

The main objective of the Interreg Sudoe project ClimACT ([www.climact.net](http://www.climact.net)) is to promote the transition to a low carbon economy in schools. ClimACT is developing tools and methodologies to support schools managers and students in the identification of intelligent solutions that consider energy efficiency, respect for the environment, private and external costs, financial support mechanisms and human behaviours. The ClimACT solutions are being validated in real-life conditions in 39 schools from Portugal, Spain, France and Gibraltar. The ClimACT survey revealed the main parameters affecting the overall performance of the investigated buildings: the problematic building envelope, the improper control of heating and lighting systems, and the lack of interest concerning the efficiency of such buildings. Results showed that it is also difficult to achieve the Indoor Air Quality requirements as the operating profile, the high occupation density, the lack of intelligent ventilation systems and the occupants' behaviours complicate its practical application (Blondeau P, *et al.*, 2018) (see Figure).



## ALPHA PARTICLE DETECTION USING SUPERHEATED DROPLETS

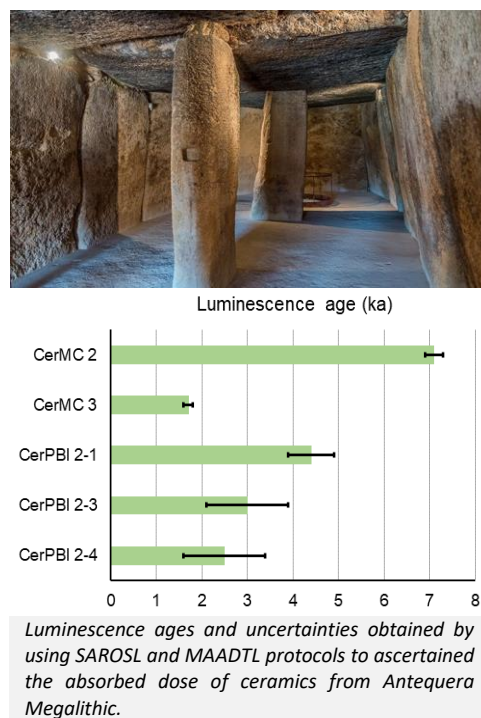
Superheated droplet detector prototypes for detection of alpha particles from solid samples were developed with a novel matrix. Following 2017's activity, alpha spectroscopy of liquid samples was subject of a patent filing request by IST. For further background reduction, spatial localisation of events was implemented using a 4-microphone antenna and applying a triangulation-based method based on time delays of arrival of the processed acoustic signals. A new bubble chamber including a stronger recompression system for astroparticle dark matter searches was designed and tested with respect to the acoustic signal of bubble formation and neutron/alpha responses (T. Morlat *et al.*, 2018) (see Figure).



(a) spectrum of a Th-doped solution measured with a C2CIF5 superheated droplet detector; (b) schematic description of the event spatial localisation; (c) recompression system (up) associated to the newly developed C3F8 bubble chamber (down) prototype.

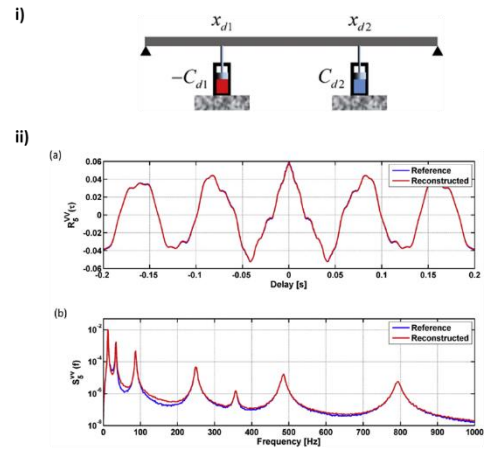
## LUMINESCENCE DATING AND COMPOSITIONAL STUDIES OF CERAMICS FROM ANTEQUERA MEGALITHIC LANDSCAPE (UNESCO WORLD HERITAGE)

Luminescence and compositional studies (geochemistry and mineralogy) were performed on ceramic artefacts from the archaeological sites Matacabras e Piedras Blancas I belonging to the Antequera Megalithic landscape - recently distinguished by UNESCO as World Heritage, in order to contribute to a better establishment of chronologies, provenance and production technologies of ceramics. Ceramics from both sites have been produced with calcite rich raw materials under low firing temperatures, pointing to similar production technologies. Nevertheless, one ceramic sherd from Piedras Blancas I has a different composition, pointing to the resource of non-carbonate and mafic raw materials (Rogerio-Candelera *et al.*, 2018). The luminescence dating has been employed successfully to determine the ages between  $1,7 \pm 0,1$  ka and  $7,1 \pm 0,2$  ka with acceptable uncertainties (see Figure). These results complemented with archaeological data contributed to establish the chronological range of human occupation on Antequera Megalithic landscape.



## BLIND IDENTIFICATION OF COMPLEX MODES USING THE HILBERT TRANSFORM

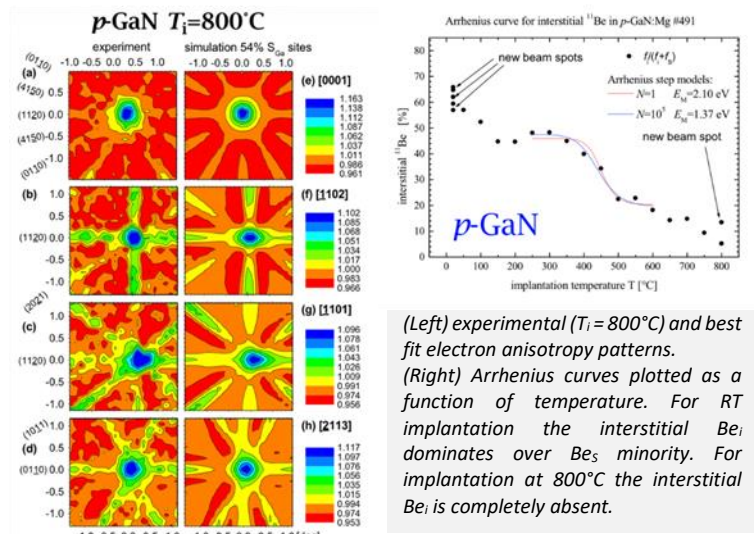
The modal identification of dynamical systems under operational conditions is a viable alternative to traditional approaches based on sets of measured FRFs or impulse responses. Among current techniques, the so-called blind identification methods are the subject of considerable investigation, the SOBI (Second-Order Blind Identification) approach being quite efficient. In this work, we focus on applicability of the SOBI technique for extracting the modal responses from complex analytic signals, built from a set of vibratory responses. The novelty of this work is to propose a straightforward computational procedure for obtaining the complex cross-correlation response matrix used for the modal identification procedure. We demonstrate that the correlation matrix of the analytic responses can be computed through the Hilbert transform of the real correlation matrix, so that the actual time-domain raw responses are no longer required for modal identification purposes. The proposed technique is validated on a conceptual multi-modal system with highly complex modes (see Figures, from Antunes *et al.*, 2018).



(i) Conceptual flexible beam, fitted with a negative and a positive dampers, leading to highly complex modes.  
(ii) Comparison of the response auto-correlations (a) and auto-spectra (b), for the reference data (blue) and the data reconstructed from the identified modal responses (red).

## FIRST STUDIES OF AMPHOTERIC BE-DOPANT IN GaN

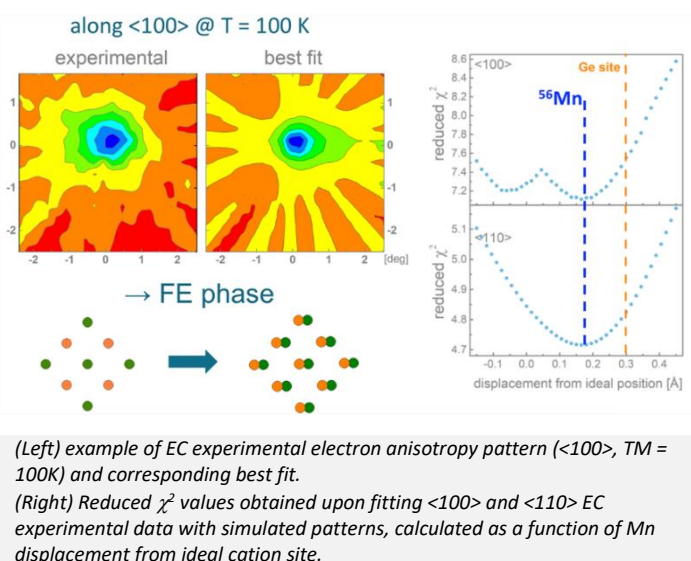
Mg and Be are among the best studied impurities in GaN but, while p-type Mg:GaN is a core component of solid-state optoelectronic devices, Be p-type doping was not yet successful although, theory has predicted an acceptor level shallower than Mg. Using the  $\beta$ -emission channeling technique with radioactive  $^{11}\text{Be}$  (13.8s), we studied the amphoteric nature of Be in p-GaN, n-GaN and as-grown nid-GaN. Preliminary data analysis shows that interstitial  $\text{Be}_i$  fractions are highest in p-GaN (~65%), intermediate in nid-GaN (~55%) and lowest in n-GaN (<26%), hence higher than  $\text{Mg}_i$  (U.Wahl et al. 2017). The balance of substitutional  $\text{Be}_s$  vs interstitial  $\text{Be}_i$  depends on doping type, a clear Fermi-level effect for both Be and Mg amphoteric dopants. Raising the implantation temperature, interstitial  $\text{Be}_i$  is converted to substitutional  $\text{Be}_s$ , but in contrast to Mg, several steps may be involved where  $\text{Be}_i$  is converted to  $\text{Be}_s$ .



(Left) experimental ( $T_i = 800^\circ\text{C}$ ) and best fit electron anisotropy patterns.  
(Right) Arrhenius curves plotted as a function of temperature. For RT implantation the interstitial  $\text{Be}_i$  dominates over  $\text{Be}_s$  minority. For implantation at  $800^\circ\text{C}$  the interstitial  $\text{Be}_i$  is completely absent.

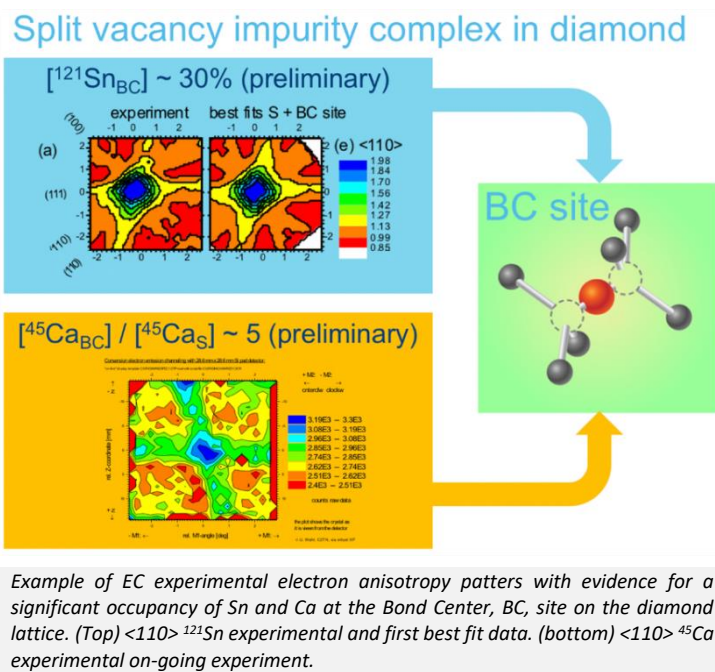
## FIRST STUDIES OF MULTIFERROIC RASHBA SEMICONDUCTORS (Ge<sub>1-x</sub>Mn<sub>x</sub>Te)

Multiferroic Rashba semiconductors (MUFERS) are novel functional materials based on the coupling between ferromagnetism, ferroelectricity and Rashba-Zeeman effects [Krepaský, J., *et al.* PRX 8.2(2018)021067]. Ge<sub>1-x</sub>Mn<sub>x</sub>Te, the model MUFERS, inherits the robust ferroelectricity and giant Rashba splitting of  $\alpha$ -GeTe, undergoing a ferroelectric phase transition at  $T_C^{FE}$ , when the cubic rock-salt symmetry breaks and a rhombohedral phase is formed with elongation along  $\langle 111 \rangle$ . This distortion induces a displacement  $\Delta r$  between the cation, Ge or Mn, and the anion Te sublattices, which is responsible for the spontaneous ferroelectric dipole. Using  $\beta$ -emission channelling with implanted radioactive  $^{56}\text{Mn}$  (2.6h), the direction and magnitude of  $\Delta r$  was measured with sub-Angstrom precision below and above the ferro-electric transition, up to  $[\text{Mn}] = 21\%$ . Still under analysis, the results set the basis of new experiments studying how a magnetic field applied in-situ can affect the direction of the FE polarization through magnetoelectric coupling.



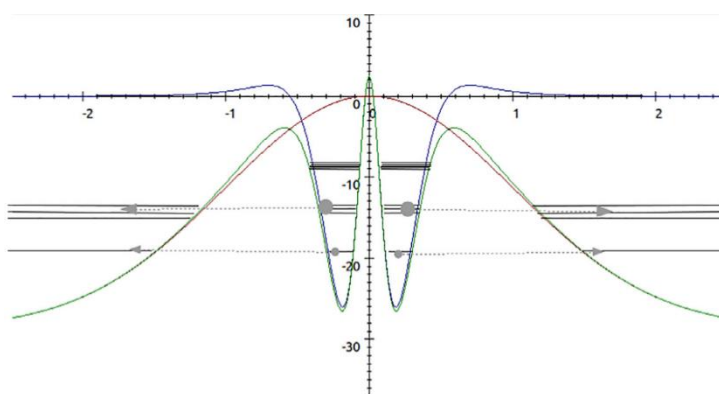
## VACANCY – IMPURITY DEFECTS IN DIAMOND AND QUBITS

A Qubit materialises in diamond as a dopant-vacancy *center* with associated free electrons and multiple “spin” states in superposition. Reliable “write-in” / “read-out” of qubit states require minimal spectral diffusion and dispersion with large Debye-Waller factors and narrow inhomogeneous linewidth. Group IV impurity elements (Si, Ge, Sn, Pb), with larger electronic radius than C, are expected to favour bond center sites in split vacancy configuration where the molecular D3d inversion symmetry makes the optical transition frequency particularly insensitive to electric field noise. Emission channelling, EC, provides direct atomic characterization and quantification of dopants that can be further combined with hyperfine techniques and Density Functional Theory. Our group has already data for  $^{121}\text{Sn:D}$  and foresees new experiments using radioactive  $^{31}\text{Si}$ ,  $^{73}\text{Ge}$ , and  $^{209}\text{Pb}$ . In 2018, not limited to group IV elements, we performed EC experiments in diamond with  $^{56}\text{Mn}$  (2.6h) and are currently performing EC measurements with the long lived  $^{45}\text{Ca}$  (162d). (see Figure)



## TUNNELLING IONIZATION PROCESSES INDUCED IN CHARGED UP ION BEAM IRRADIATED MATERIALS

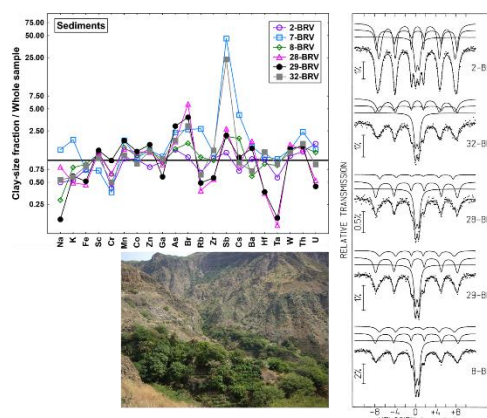
Tunnelling ionization effect model proposed to explain the enhancement emission of X-ray observed in charged materials (normally insulators). In face of an aggregation of ions a potential well represented by the curve in brown may emerge, which is not strong enough to penetrate the electron cloud of the atom, and becomes null at the centre. The action of this potential on the atomic potential, leads to a result presented by the curve in green. Tunnelling transitions are represented by grey arrows (in: Reis & Chaves, 2018) (see Figure).



*Enhancement emission of X-ray by irradiated charged materials is known for more than 50 year now, but never yet fully explained. Experimental results obtained in 2018 lead to the proposal of a new ionization process model as base of the effect, namely, tunnelling ionization. This model, represented here allows explaining all qualitative details of the process. in: Reis & Chaves, 2018.*

## NUCLEAR TECHNIQUES TO STUDY THE COMPOSITION IMBALANCE OF SOILS USED FOR AGRICULTURE IN THE OCEANIC VOLCANIC BRAVA ISLAND (CAPE VERDE)

Volcanic soils developed on sediments and phonolitic pyroclasts from Brava Island (Cape Verde) are used for agriculture. Mössbauer spectroscopy and Instrumental Neutron Activation Analysis (INAA) were used in order to acquire a better knowledge of iron forms and the content and distribution of trace elements in soils. High concentrations of arsenic, bromine, and particularly antimony were found in the clay-size fraction, where only Fe(III) was detected and all the Fe oxides are nano-sized, confirming the predominant adsorption of these elements on the nano-particles surface. The existence of significant amounts of these elements as well as of vitreous phases in fine particles of these soils may contribute to their mobility and accumulation in groundwater and in plants, both by absorption and by dust deposition onto the plant leaves. (Marques *et al.*, 2018). (see Figure)



*Trace element distribution in the clay-size fraction relative to the respective whole sample of topsoils developed on sediments from Brava Island (Cape Verde); Mössbauer spectra taken at 4 K of the clay-size fraction of the same topsoils.*



## TEAM

Name	Category	R&D (%)
João Paulo Leal	Auxiliary Researcher (with Habilitation)	90
Joaquim Marçalo	Principal Researcher	90
Joaquim B. Branco	Auxiliary Researcher	90
José Manuel Carretas	Auxiliary Researcher	90
Bernardo Monteiro	Researcher Contract (IST-ID Contract)	100
Leonor Maria	Researcher Contract (IST-ID Contract)	100
Ana C. Ferreira	Post-doc (C <sup>2</sup> TN grant)	100
Adelaide Cruz	Graduated Technician	100
Beatriz Bento	Research Fellow (BI) (M.Sc.)	100
Pedro de Brito	Graduated Student	100

## MISSION AND OBJECTIVES

The research activities of the QEf Group are centered in the study of the chemistry of lanthanides and actinides at fundamental and applied levels, with focus on topics of relevance in environmental, nuclear and materials sciences.

The activities comprise the synthesis of new f-element compounds and materials (complexes with new coordination environments, metal-organic frameworks, ionic liquids, nanostructured intermetallic compounds and bimetallic oxides), the examination of their properties, searching for unusual or enhanced behaviour, and reactivity and catalytic studies (activation of unsaturated and redox-active substrates, activation/elimination of major gaseous pollutants such as CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O, and production of value-added compounds such as CH<sub>3</sub>OH). Studies on the recovery and separation from secondary sources of Rare Earth Elements (REEs), considered as critical materials by the European Commission, as well as other metal separations, are also carried out by the Group.

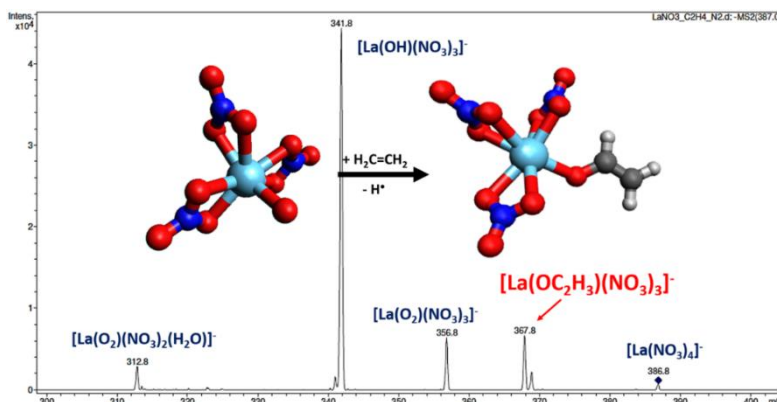
The QEf Group collaborates with other groups within C<sup>2</sup>TN: ES Group - magnetic properties of uranium complexes and layered lanthanide hydroxides; synthesis of nanostructured intermetallics, metal borides, pnictides and chalcogenides, and study of their thermoelectric properties; REI Group - use of gamma radiation for the synthesis of new polymeric materials. REI; RPS and NET Groups - within the recovery/valorization of Rare Earth Elements from secondary sources.

Outside C<sup>2</sup>TN, the QEf Group has collaborations with: IPFN - low temperature plasmas for activation of methane and carbon dioxide; REQUIMTE – luminescent and thermochromic ionic liquids with lanthanides; IPMA/CERENA-IST - FCT project REEuse (Recovery versus environmental impacts of Rare Earth Elements derived from human activities,); INTERECYCLING/CERENA-IST – PT2020 project RecValTR (Recovery and valorization of rare earths from electrical and electronic waste); and other research groups in the framework of the Portuguese Mass Spectrometry Network (RNEM). The QEf Group participates also in the FCT Doctoral Programme CATSUS-Catalysis and Sustainability and in COST ACTION ES1407 (ReCreew).

## MAIN ACHIEVEMENTS

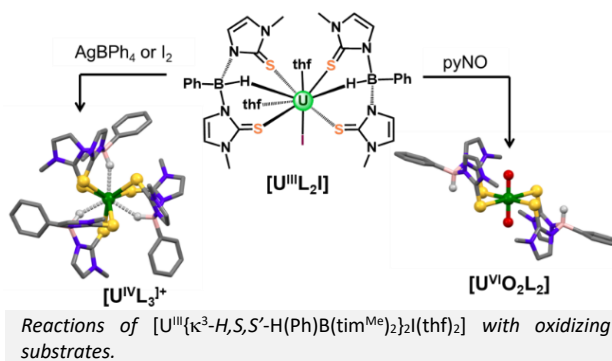
### GAS-PHASE ACTIVATION OF HYDROCARBONS BY RARE EARTH AND ACTINIDE OXIDE NITRATE ANIONS

Trivalent rare earth (RE) tetranitrate anions,  $[M(NO_3)_4]^-$  ( $M = Sc, Y, Ln$ ), are easily produced by electrospray ionization (ESI) and give rise to oxide nitrate anions,  $[MO(NO_3)_3]^-$ , by collision induced dissociation (CID) in a quadrupole ion trap (QIT) that results in  $NO_2$  elimination. For most of the REs, which present a high stability of the +3 oxidation state, these oxide anions contain a radical oxygen and are highly reactive species. They promptly yield, during CID, the stable hydroxide anions,  $[M(OH)(NO_3)_3]^-$ , by reaction with background water in the ion trap. CID of  $[M(NO_3)_4]^-$  in the presence of ethane, ethene and benzene showed the formation of  $[M(OR)(NO_3)_3]^-$ . These C-H activation reactions were also observed for  $[ThO(NO_3)_4]^-$  anions, which, similarly to the case of the REs, are formed by CID of  $[Th(NO_3)_5]^-$  generated by ESI and readily react with background water to give stable  $[Th(OH)(NO_3)_4]^-$ . Other reactive oxide nitrate anions can be obtained by nitrate CID, including for uranyl by starting with the precursor anion  $[UO_2(NO_3)_3]^-$ . These experimental studies bear interest in the long-standing search for systems that are capable of activating methane.



### NON-AQUEOUS URANIUM COORDINATION CHEMISTRY: URANIUM COMPLEXES SUPPORTED BY HYDROBIS(MERCAPTOIMIDAZOLYL)BORATES

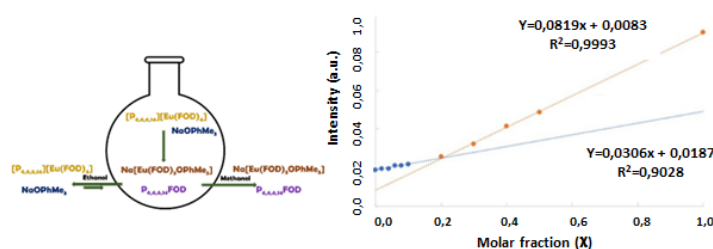
The choice of the ancillary ligand is crucial for the stabilization of highly reactive metal complexes and for controlling their reactivity. Hydrobis(mercaptoimidazolyl)borate ligands are mono-anionic sulphur chelates, analogues to the  $[N_2]$ -donor hydrobis(pyrazolyl)borate ligands, that are able to stabilize neutral and cationic bis(ligand) U(III) complexes. One-electron oxidation of the neutral U(III) complex  $[U\{\kappa^3\text{-}H,S,S'\text{-}H(\text{Ph})B(\text{tim}^{\text{Me}})_2\}_2I(\text{thf})_2]$  (**1**) with  $\text{AgBPh}_4$  or  $\text{I}_2$  resulted in the formation of the uranium tetravalent homoleptic compounds  $[U\{\kappa^3\text{-}H,S,S'\text{-}H(\text{Ph})B(\text{tim}^{\text{Me}})_2\}_3][X]$  ( $X = \text{BPh}_4, \text{I}$ ) (see Figure). Treatment of **1** with pyridine-N oxide (pyNO) led to the formation of the uranyl complex  $[UO_2\{\kappa^2\text{-}S,S'\text{-}H(\text{Ph})B(\text{tim}^{\text{Me}})_2\}_2]$ , while from the reaction of the cationic complex  $[U\{\kappa^3\text{-}H(\text{Ph})B(\text{tim}^{\text{Me}})_2(\text{thf})_3\}][\text{BPh}_4]$  with pyNO, the oxo-bridged U(IV) complex  $[U\{\kappa^3\text{-}H(\text{Ph})B(\text{tim}^{\text{Me}})_2\}_2(\text{pyNO})_2(\mu\text{-O})][\text{BPh}_4]_2$  was also obtained.



The presence of  $U \cdots H-B$  interactions in the solid-state of the U(III) and U(IV) complexes was supported by IR spectroscopy and X-ray diffraction analysis. All these compounds are rare examples of crystallographically characterized U(III), U(IV) and U(VI) complexes supported by hydrobis(mercaptoimidazolyl)borate ligands.

## OPTICAL SENSORS

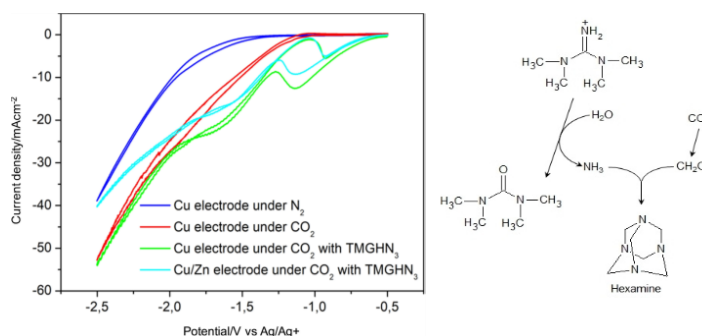
Based on the interaction of trihexyltetradecylphosphonium cation ( $P_{6,6,6,14}^+$ ) with a  $\beta$ -diketonate (1,1,1,2,2,3,3-heptafluoro-7,7-dimethyloctane-4,6-dione - FOD) of an Europium(III) tetrakis- $\beta$ -diketonate complex we found an equilibrium reaction with pronounced solvent effect between ethanol and methanol on Eu(III) luminescence, allowing detection and quantification of methanol in mixtures of both solvents (see Figure). The developed spectrofluorimetric method provides a faster and low-cost quality test to detect and quantify methanol with limit of detection of 15% (w/w).



Calibration curve for methanol estimation in ethanol/methanol mixtures.  $\chi$  is the molar fraction of methanol in ethanol

## CO<sub>2</sub> AS BUILDING BLOCK IN HEXAMINE PRODUCTION

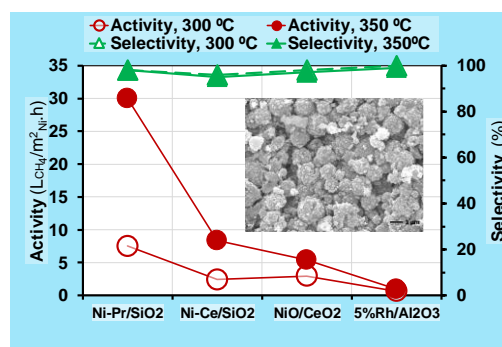
Electrochemical reduction of CO<sub>2</sub> in a EMIMBF<sub>4</sub> saturated solution in the presence of small amounts of the ionic liquid tetramethylguanidinium azide (TMGHN<sub>3</sub>) yield as major product the nonvolatile hexamethylenetetramine (HMTA) also known as hexamine or methenamine. Vestigial concentrations of other reduction products like CO, formic acid and acetic acid were also detected and quantified. Both Cu and Cu/Zn electrodes were tested and presented a similar efficiency towards HMTA production. Electrode modification during CO<sub>2</sub> electro-reduction, including copper nanoparticle (CuNPs) deposition, is the key feature that facilitates HMTA synthesis.



Cyclic voltammograms of catalytic copper and Cu/Zn cathodes at 45 °C and 10 bar, carried out at 20 mVs<sup>-1</sup> in the potential range of -0.5 V to -2.5 V vs. Ag/Ag<sup>+</sup> (left) and schematic representation of the proposed path for hexamine formation (right).

## NANOSTRUCTURED COMPOUNDS CONTAINING F-BLOCK ELEMENTS AND VALORIZATION OF CO<sub>2</sub> AS FEEDSTOCK

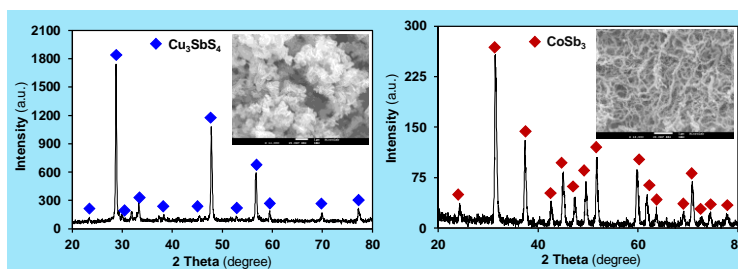
We continued our work on the preparation and characterization of nanostructured bimetallic oxides containing 4f-block elements (La, Ce, Pr, Sm, Dy, and Yb) and nickel this time supported on silica and alumina previously obtained by electrospinning. Electrospinning is a reproducible and low cost route that enables the production of nanostructured materials, whose expected high surface areas and tunable surface properties bring benefits to their properties. They were tested as catalysts for the methanation of CO<sub>2</sub> aiming the production of value added products, such as methane. Enhanced activity and selectivity towards the production of methane and enhanced stability on the gaseous stream are among the good results achieved in this work that are better than those obtained over reference catalysts tested in the same conditions.



## NANOSTRUCTURED METAL PICNITIDES AND CHALCOGENIDES FOR THE THERMOELECTRIC APPLICATIONS

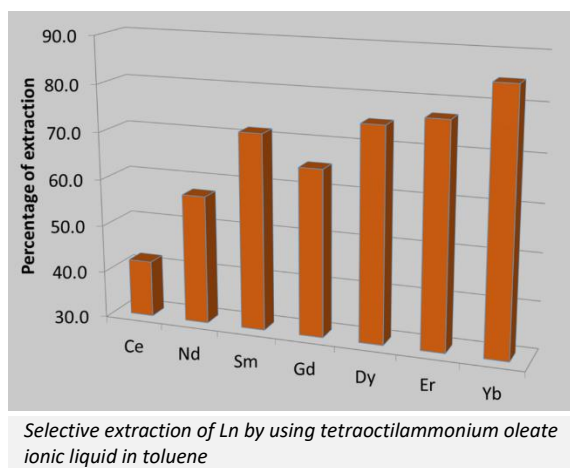
The preparation and characterization of thermoelectric materials such as metal pnictides and chalcogenides was carried out by electrospinning and solvothermal methods, alternatives to the solid-state high temperature techniques.

Applications of these compounds comprise different fields such as catalysis and for the generation and storage of energy: i) application as thermoelectric materials; ii) hydrogen absorbers (important for the development of fuel cells). The results obtained confirm the preparation of high purity, high ordered pnictides and chalcogenides in less than 48h, which is an advantage to the normal high temperature, high cost, high time consuming techniques used so far.



## RARE EARTH RECOVERY AND VALORISATION / PROTECTION OF ENVIRONMENT

Rare Earth Elements (REEs) are considered as an important raw material in the industry but there exists a significant risk of supply for actual demand. The development of selective, efficient, economical and environmentally friendly separation processes of REEs from different materials is required. Ionic liquids (ILs) with only CHON elements in their composition are being used for separation of REEs from other metals. Some of the ILs studied displayed a significant differentiation between lanthanides and are adequate to selectively extract Ln among them (see Figure), whereas another IL was able to separate Ln from other metals.



The QEf group is involved in several projects: European Project-ENVIREE (ENVironmentally friendly and efficient methods for extraction of Rare Earth Elements from secondary sources); FCT Project-REEuse (Recovery versus environmental impacts of Rare Earth Elements derived from human activities); COST ES1407-ReCreew (European network for innovative recovery strategies of rare earth and other critical metals from electric and electronic waste); Portugal 2020-RecValTR (Recovery and valorization of rare earths from electrical and electronic waste).



## TEAM

Name	Category	R&D (%)
Manuel Leite de Almeida	Coordinator Researcher – Group Coordinator	100
António Pereira Gonçalves	Coordinator Researcher	100
João Carlos Waerenborgh	Principal Researcher	100
Laura C. J. Pereira	Principal Researcher	100
Vasco da Gama	Principal Researcher	100
Elsa Branco Lopes	Auxiliary Researcher	100
Isabel Cordeiro Santos	Auxiliary Researcher	100
Dulce Belo	Invited Researcher (C <sup>2</sup> TN contract) Researcher Contract (IST-ID contract), 01/10/2018	90
Sandra Rabaça	Post-doc (FCT grant) Researcher Contract (IST-ID contract), 15/11/2018	100
Rafaela Silva	Post-doc (C <sup>2</sup> TN grant), since March	100
Bruno José Cardoso Vieira	Post-doc (C <sup>2</sup> TN grant)	100
Andreia Rosatella	Post-doc (C <sup>2</sup> TN grant), since July	100
Ana Cerdeira	Post-doc (C <sup>2</sup> TN grant), since June	100
Duarte Nuno Moço	Ph.D. student (FCT grant), since February	100
Joana Catarina Capinha de Matos	Ph.D. student (FCT grant)	50
José Francisco Malta	Ph.D. student (FCT grant)	50
Maria Antonieta Susano Pinheiro	Ph.D. student (FCT grant)	50
Mariana Velho	Ph.D. student (FCT grant)	50
Patricia Ferreira	Ph.D. student (FCT grant)	50
Sanjib Chowdhury	Ph.D. student	100
Rodrigo Coelho	Research fellow (BI) (M.Sc.), since November	100
Afonso Varatojo	M.Sc. student (concluded in May)	100
Gonçalo Domingues	M.Sc. student (concluded in June)	100
Gonçalo Gonçalves Brás Lopes	M.Sc. student, since February	100
Helena Ferreira	M.Sc. student, since February	100
Tiago Alves	M.Sc. student (Erasmus / concluded in August)	100

## MISSION AND OBJECTIVES

The Solid State Group is a multidisciplinary research group focused on the study of selected new materials with unconventional electrical and magnetic properties. The group combines a wide range of expertise ranging from the synthetic chemistry of either molecular materials with transition metal complexes and electro active organic molecules or intermetallic compounds, to many different specialized solid state characterization techniques. Besides molecular synthesis (organic and inorganic), high temperature synthesis and crystal growth, X-ray diffraction laboratories, the facilities developed maintained and operated by the group include the Low Temperature and High Magnetic Field Laboratory (**LTHMFL**) that has been developed around the only helium liquefier operational in Portugal. The **LTHMFL** hosts different specialized equipment for measurements at low temperatures down to 0.3 K and under high magnetic fields up to 18 T, including several magnetometers (SQUID, extraction and AC susceptibility) electronic transport and magnetotransport equipment, and Mossbauer spectrometers.

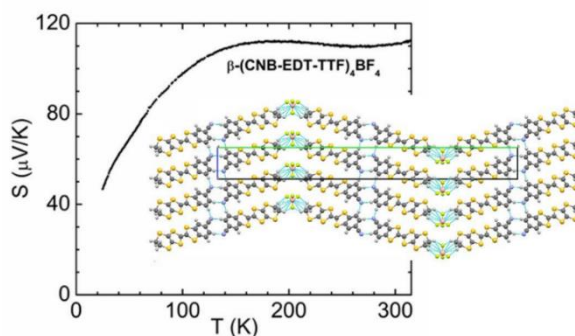
The group pursued basic research activities in **Molecular materials** aiming at further development of multifunctional (electric and magnetic) molecular materials and the study of novel electronic states, including **Neutral transition metal bisdithiolene complexes** for single component molecular metals and their processing by solution techniques, **Bilayer molecular conductors**; based on cyano-substituted TTF donors; **Single-Molecule-Magnet** behaviour in mononuclear U and Ln coordination compounds. Activities in intermetallics were focused on the study of **Strongly correlated electron behaviour** in f-element compounds, development of materials for **spallation targets** and new **Thermoelectric** compounds with enhanced performance.

The group also maintained the **LTHMFL** as an open facility, available to the external scientific community on a scientific collaboration basis, and participated as Director and core team members of the FCT Doctoral Programme **ChemMat- Chemistry of Materials with electronic, magnetic and optical functionalities**.

## MAIN ACHIEVEMENTS

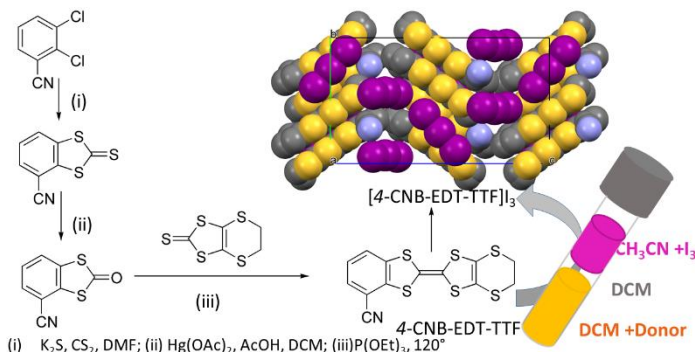
### $\beta''$ -(CNB-EDT-TTF)<sub>4</sub>BF<sub>4</sub>; ANION DISORDER EFFECTS IN BILAYER MOLECULAR METALS

The  $\beta''$ -(CNB-EDT-TTF)<sub>4</sub>BF<sub>4</sub> salt is a new member of the family of 2D metals of the CNB-EDT-TTF donor characterized by a bilayer arrangement of the donors and it was obtained in a monoclinic polymorph with a  $\beta''$ -type donor packing pattern. The small anions are severely disordered. Both electrical conductivity and thermoelectric power measurements denote metallic properties as predicted by electronic band structure calculations. As a consequence of the anion disorder the metallic regime of the electrical conductivity denotes electronic localization effects with a progressive increase of resistivity below ~25 K. Because of the larger lattice parameters the intermolecular interactions and electronic bandwidth are decreased compared to other (CNB-EDT-TTF)<sub>4</sub>X salts. The large and positive thermoelectric power  $S$  of this compound (~110  $\mu$ V/K in the range 100–330 K) and its electrical conductivity  $\sigma$  = 20 S/cm at room temperature lead to a power factor  $S^2\sigma$  = 24  $\mu$ W/K<sup>2</sup>m, quite large among molecular conductors, placing these compounds as potential candidates for thermoelectric materials.



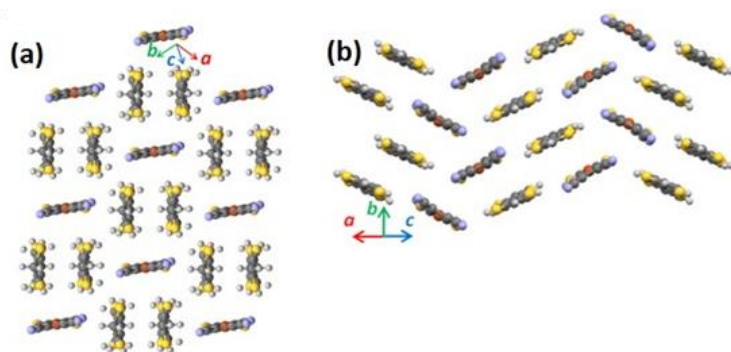
### A 4-CYANO BENZENE-ETHYLENEDITHIO-TTF ELECTRON DONOR AND ITS (1 : 1) TRIIODIDE RADICAL CATION SALT; ISOMER EFFECTS IN C–N···H–C INTERACTIONS

A new electron donor isomer, the 4-CN-EDT-TTF was obtained. It crystallizes into two polymorphs ( $\alpha$  and  $\beta$ ). One of the polymorphs ( $\beta$ ) presents a combination of C–N···H–C interactions associated with a head-to-head arrangement of donor molecules in paired layers (bilayers) described as weaker and stronger  $R^2_3(10)$  synthons. A radical cation salt formulated as (4-CN-EDT-TTF)I<sub>3</sub> was obtained by slow diffusion of solutions of the donor and iodine. In this salt, the (4-CN-EDT-TTF)<sup>•+</sup> radical cations are associated into dyads with a strong pairing of the radical species in a singlet state. The donor dimers are connected to adjacent dimers through C–N···H–C interactions described as an  $R^2_2(10)$  synthon. They present different sources of disorder on the carbon atoms of the dihydrodithiin ring, in the CN group position and on one of the triiodide anions. No relation between the disorders of the triiodide anions and the CN group positions was detected.



## CHARGE TRANSFER SALTS BASED ON $[M(\text{dcdmp})_2]$ WITH TTF TYPE DONORS

Transition metal bisdithiolene complexes continue to be actively explored as building blocks for molecular conducting and magnetic materials due to their interesting and unique structural and electronic properties. Extended dithiolene  $\pi$  ligands containing N atoms have been significantly less explored when compared to sulphur rich ligands, which have been favoured to build intermolecular S...S contacts

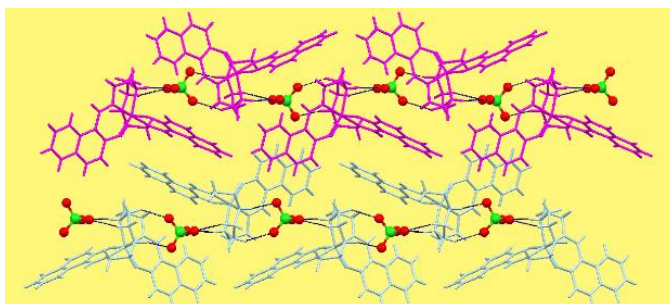


Details of the Crystal structures of (a)  $(\alpha\text{-DT-TTF})[\text{Cu}(\text{dcdmp})_2]$  and (b)  $(\text{BET-TTF})_2[\text{Cu}(\text{dcdmp})_2]$

with improved dimensionality in the solid state. The N atoms in dithiolene ligands are now known to act as an extra coordinating site that can provide an additional degree of freedom in the crystal engineering of these solids.  $[M(\text{dcdmp})_2]$  transition metal complexes based on extended dithiolene  $\pi$  ligand-containing N atoms are, in this context, attractive anions. The diversity of crystal structures and polymorphs found in the  $D_x[M(\text{dcdmp})_2]$  family of compounds ( $D$  = TTF type electronic donors and  $M$  = Au, Cu, and Ni) made them good models for further understanding the correlation between the intermolecular crystal structure patterns and the observed macroscopic electrical transport properties.

## UNVEILING THE ROLE OF CATION–ANION INTERACTIONS IN THE SPIN CROSSOVER PHENOMENON

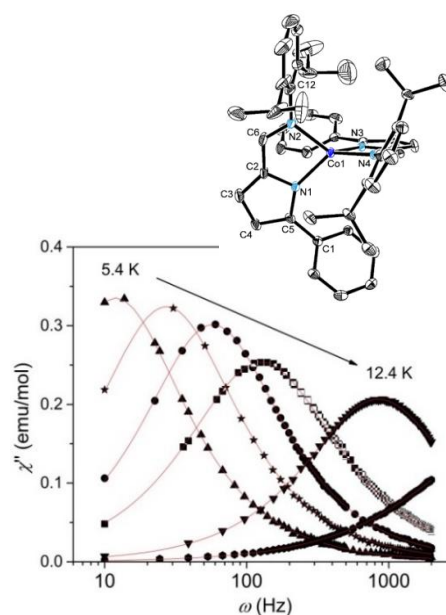
The relevance of cation–anion and cation–solvent–anion interactions to the crystal lattice rigidity and the corresponding effect on the SCO behaviour of six Fe(III) complexes with the hexadentate Schiff base ligand nsal2trien was studied. In the most rigid structures, the SCO behaviour is either not allowed or severely hampered. For lower structural connectivity,



incomplete transitions are observed within the 4–300 K temperature range. The most flexible structure showed a complete transition. The interactions between the cationic units and the anions were found to be more important than the cation–cation interactions for the SCO phenomenon and for the overall cooperativity related to the abrupt/gradual character of the transition. Computational studies were performed in order to determine the crystal field splitting gap  $\Delta_{\text{oct}}$ . The calculated values for the HS and LS  $\Delta_{\text{oct}}$  are very similar for all compounds suggesting that these parameters have very little influence on the SCO behaviour.

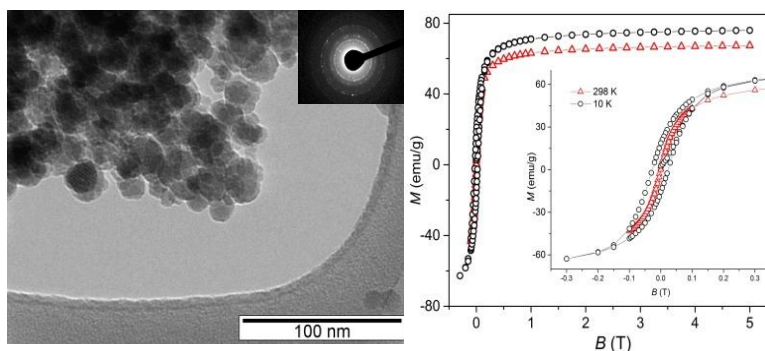
## SLOW RELAXATION OF MAGNETIZATION IN MOLECULAR MATERIALS WITH *d* AND *f* ELECTRONS

Over the past decades, progressive research in the Inorganic Chemistry community has allowed the synthesis of exciting new classes of materials with single molecule magnetic behaviour (SMMs). These compounds behave as traditional magnets, but their slow relaxation of the magnetization is of purely molecular origin with the presence of interplay between classic and quantum effects. This year the impact of our research in this area has continued to grow contributing to elucidate the behaviour of several *d*- and *f*-complexes such as the new series of Co(II) and Fe(II) homoleptic bis(5-aryl-2-iminopyrrolyl) complexes with strong magnetic anisotropy and energy barriers and new multifunctional lanthanides complexes (Gd(III), Ho(III), Pr(III), and Er(III)) with a fluorinated imidodiphosphate ligand, the N-(P,P-dipentafluorophinoyl)-phosphinimidic acid, which has proved to boost the Ln-compounds potentialities as SMM.



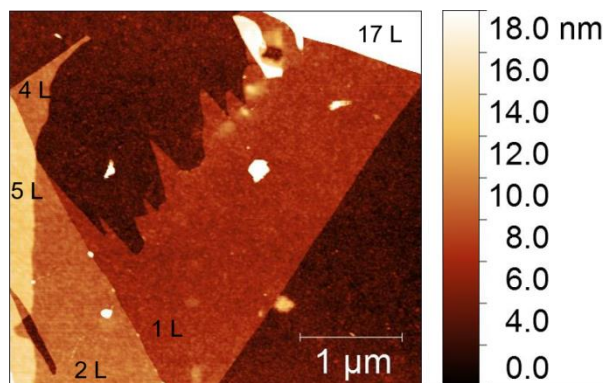
## IRON OXIDE NANOPARTICLES FOR HIPERTHERMIA

Iron oxide nanoparticles (FeNPs) are by far the most commonly employed nanoparticles for biomedical applications, namely in the field of nanomedicine-based diagnostics and therapy. Next-generation multifunctional nanoparticles have been prepared by a facile chemical co-precipitation method, in aqueous medium near room temperature (RT), using neutral atmosphere with pH control. To coat the nanoparticles, an acidic oxidation treatment was used. Variations of pH in the range  $8.3 < \text{pH} < 9.6$  has resulted in FeNPs with different oxidation levels. The highest saturation magnetization was measured for  $\text{pH}=9.3$  and  $9.6$  ( $67.5 \text{ emu/g}$  at RT). It is known that in some cases, an unwanted aggregation may decrease the long-term stability of nanoparticles, leading to large nanoparticle clusters that are undesirable for hyperthermia therapy and cancer theranostics. In order to overcome this question and achieve chemical stability, an acidic oxidation treatment has been developed, originating a quite stable nanoparticle coating.



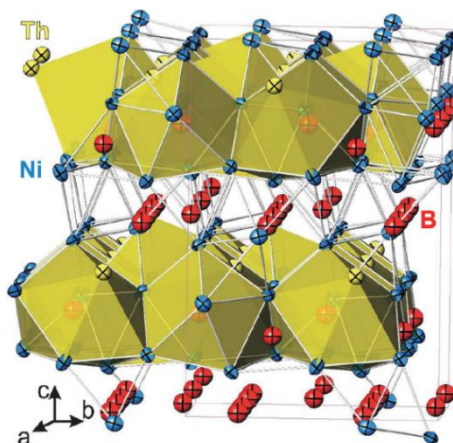
## 2D MAGNETIC MATERIALS

The Fe electronic state (oxidation state 2+, spin state  $S=2$ ) was determined by Mössbauer spectroscopy on a series of five isostructural layered magnetic coordination polymers based on Fe centres and different benzimidazole derivatives (bearing a Cl, H, CH<sub>3</sub>, Br or NH<sub>2</sub> side group). A pre-synthetic approach that allows the isolation of crystalline, robust and magnetic functionalized monolayers of these coordination polymers was used. On mechanical exfoliation 2D materials were obtained that retain their long-range structural order and exhibit good mechanical and magnetic properties. This combination, together with the possibility to functionalize their surface at will, makes them good candidates to explore magnetism in the 2D limit and to fabricate mechanical resonators for selective gas sensing.



## MAGNETISM AND STRONGLY CORRELATED ELECTRON BEHAVIOR IN INTERMETALLICS AND OXIDES

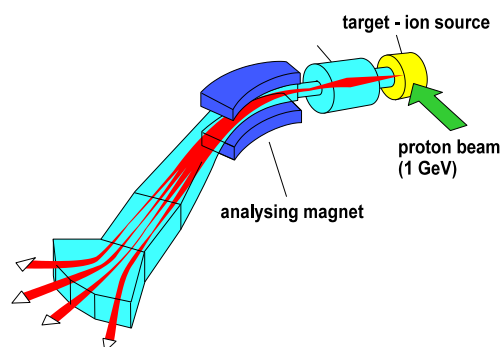
The investigation of magnetism and strongly correlated electron behaviour in intermetallic compounds with  $f$ -elements is a continuing topic of study in the Solid State group. In this framework, a new compound, ThNi<sub>12</sub>B<sub>6</sub>, crystallizing in the CeNi<sub>12</sub>B<sub>6</sub>-type structure, was investigated. Electrical resistivity, magnetic susceptibility and specific heat measurements indicate a Pauli paramagnetic behavior with metallic character for ThNi<sub>12</sub>B<sub>6</sub>, without anomalies, similarly to the isotypic LaNi<sub>12</sub>B<sub>6</sub>. High hardness values (Young's modulus of ~240 GPa), and low coefficients of thermal expansion ( $\alpha \approx 5.5 \times 10^{-6} \text{ K}^{-1}$ ), were observed.



Topological spin textures are extremely interesting ordered phases in condensed matter. A representative example of such textures is the magnetic skyrmion in chiral magnets. Cu<sub>2</sub>OSeO<sub>3</sub> is one of those compounds, being usually prepared by reacting CuO with SeO<sub>2</sub> in a CVD reaction. However, our preliminary studies in this material showed that nanoparticles can be synthesized from CuSeO<sub>3</sub> produced by a simple wet chemical method.

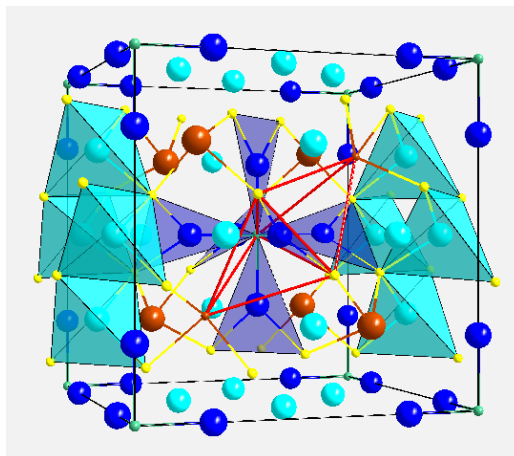
## SPALLATION TARGETS

Radioactive ion beams at ISOLDE, CERN, are produced through nuclear reactions induced by hitting a target with an intense proton beam. Bulk, micrometric, UC<sub>x</sub>-based targets are the current reference at ISOLDE, due to their high melting point, thermal conductivity and stability at high temperatures. However, a significant increase on radioisotopes release is expected from submicron and nanostructured porous materials. In this context, and following the previous production of YC<sub>x</sub> nanofibers, a methodology to successfully produce UC<sub>x</sub> fibers with nanograins was developed based on the electrospinning technique.



## NEW THERMOELECTRIC MATERIALS

Pursuing our studies on tetrahedrites, the effect of composition on thermoelectric properties of as-cast  $\text{Cu}_{12-x}\text{Co}_x\text{Sb}_4\text{S}_{13-y}\text{Se}_y$  was investigated. Almost pure materials were prepared from the melt, and doping with  $x=0.5$  Co leads to high power factors (PF) at  $\sim 25^\circ\text{C}$ , while higher substitutions strongly increase the electrical resistivity, decreasing the PF. Co-doping with Se leads to an increase of PF, pointing to the possibility of the production of good as-cast thermoelectric tetrahedrites. Oxidation studies of tetrahedrites, crucial to understand what happens in devices, were made in air for 1500h, between  $230^\circ\text{C}$  and  $375^\circ\text{C}$ . They show that tetrahedrite starts to oxidize at  $230^\circ\text{C}$ , and that at higher temperatures ( $350^\circ\text{C}$ ,  $375^\circ\text{C}$ ), it is completely decomposed, mainly due to sulfur sublimation.



Previous investigations of glassy Cu–As–Te showed that under specific conditions  $\alpha\text{-As}_2\text{Te}_3$ ,  $\beta\text{-As}_2\text{Te}_3$  and  $\text{AsTe}_3$  can be selectively crystallized from an amorphous matrix. The microstructures and transport properties of the  $\text{Cu}_{20}\text{As}_{30}\text{Te}_{45}$ ,  $\text{Cu}_{15}\text{As}_{30}\text{Te}_{55}$  and  $\text{Cu}_{15}\text{As}_{25}\text{Te}_{65}$  glass ceramics were studied, each of them containing one of these phases with  $\sim 30\%$  vol. The presence of crystallized phases results in a significant decrease in electrical resistivity, while keeping the low thermal conductivity. This work shows that glass crystallization can be used to produce either known or novel compounds, also providing a tuning parameter for improving the transport properties of the parent glass.

## OUTREACH ACTIVITIES REPORT 2018

## OUTREACH GROUP TEAM

Name	Category	R&D (%)
Dulce Belo <sup>1</sup>	Invited Researcher (C <sup>2</sup> TN contract) Auxiliar Researcher (IST-ID contract), 01/10/2018 – Group Coordinator	10
António Nazareth Falcão <sup>2</sup>	Principal Researcher	10
Nuno Canha <sup>3</sup>	Post-doc Researcher Researcher Contract (after 15/11/2018)	10
Joana Guerreiro <sup>4</sup>	Post-doc Researcher	10
Marta F. Dias <sup>5</sup>	Science and Project Manager	100
Ana Catarina Antunes <sup>6</sup>	Science and Technology Manager	100
Margarida Oliveira <sup>7</sup>	Science and Technology Manager	100

<sup>1</sup> The remaining 90% at ES Group

<sup>2</sup> The remaining 90% at REI Group

<sup>3</sup> The remaining 90% at ETN Group

<sup>4</sup> The remaining 90% at RS Group (45%) and RPS Group (45%)

<sup>5</sup> From July 2018

<sup>6</sup> From September 2018

<sup>7</sup> Until May 2018

## MISSION AND OBJECTIVES

The C<sup>2</sup>TN's Outreach Group (GO) was formally created in 2018 with 3 main objectives:

- to promote and disseminate the relevance of the research, development and innovation activities and services provided by C<sup>2</sup>TN for the society and scientific communities, thus promoting the various aspects of scientific culture and knowledge;
- to increase the visibility of C<sup>2</sup>TN in national and international events and in social media;
- to encourage collaborative and cooperative links between C<sup>2</sup>TN and various stakeholders and actors in the academic, scientific, business, industrial and health fields.

GO works towards these objectives through:

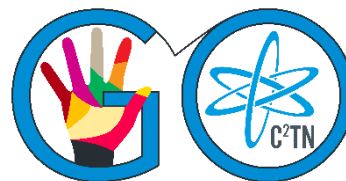
1. the organization and participation in seminars at schools, public libraries, scientific events, targeting different audiences;
2. the coordination of guided visits to the infrastructures operated by C<sup>2</sup>TN members and the organization of "Open Days" dedicated to relevant topics related to C<sup>2</sup>TN activities that have a high social impact;
3. the participation in summer internship programs organized by *Ciência Viva*,
4. the organization of conferences and scientific workshops;
5. the engagement in events of scientific relevance at the national and international levels.

GO's responsibilities also include the design, publication and release of promotional and informative material, such as, Activities Reports, pamphlets and posters. GO is in charge of C<sup>2</sup>TN's official website, social media accounts (such as Facebook, LinkedIn) and Blog, giving focus to all important and pertinent dates and events and also to the achievements of our researchers. Additionally, GO strengthens the bridge between C<sup>2</sup>TN members and other research centres, institutes, municipalities, schools and society in general, both at a national and international level, including IST's Communication Office and students associations. Finally, GO assists C<sup>2</sup>TN scientists in project submissions, contributes to the creation of new scientific networks and disseminates through the C<sup>2</sup>TN community new funding opportunities.

## MAIN ACHIEVEMENTS

### C<sup>2</sup>TN MARKETING PRODUCTS DESIGN

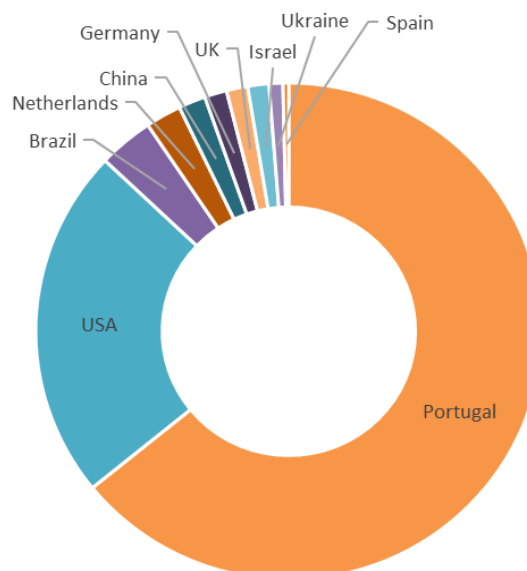
In 2018, GO designed and produced a set of communication and marketing products in order to disseminate C<sup>2</sup>TN and its activities, and to be presented and/or distributed in all events that GO organized and participated. Those include bookmarks, pens, flyers, 1 roll-up, videos and didactic materials (regarding ionizing radiation, e.g.), as well as totems and puzzles focused on showing C<sup>2</sup>TN's role to achieve the Sustainable Development Goals target by the United Nations. Moreover, the image of the Outreach Group was created (see Figure) to highlight the purpose of our activities: reaching the community to disseminate and show the importance and relevance of C<sup>2</sup>TN at the national and international levels.



C<sup>2</sup>TN's Outreach Group logo.

### C<sup>2</sup>TN AT THE SOCIAL MEDIA: SHARING SCIENCE WITH SOCIETY

Living up to the motto "Radiation for Science and Society", GO launched the blog "O Alfabeto das Radiações", directed mainly to the Portuguese speaking non-scientific communities that are curious about science and interested in science supported answers. During 2018, the blog had close to 15000 views, coming from 10 different countries (Figure shows how views per country are distributed). GO was also involved in the promotion of several other C<sup>2</sup>TN's Social Media platforms, such as, the Centre official Website and the Facebook and LinkedIn pages. In 2018, C<sup>2</sup>TN's Facebook page had 3892 page views and 349 likes in a total of 132 posts created. At LinkedIn, C<sup>2</sup>TN's page has until now 83 followers and 493 page views.



Blog visualizations distributed by country

### "CIENTIFICAMENTE PROVÁVEL" PROGRAM

The "Cientificamente Provável" program aims at contributing to bridge the gap between primary and secondary education and higher education (Figure depicts the program logo). In addition, this initiative aims at strengthening the young student's motivation for acquiring knowledge and for pursuing higher education. C<sup>2</sup>TN established partnerships with Agrupamento de Escolas da Bobadela and Escola Secundária Fernão Mendes Pinto (Almada).



"Cientificamente Provável" program's logo.

## C<sup>2</sup>TN AT LOURES InSS

The GO was present on the 3<sup>rd</sup> edition of Loures InSS (a partnership between Câmara Municipal de Loures and Instituto Superior Técnico) that occurred at Parque Urbano de Santa Iria de Azóia last June (see Figure ). The main objectives of this initiative were to convey good environmental and citizenship practices to the general public and to value the environmental potential of the city. The event lasted two days in which different activities occurred:

### Day 1

In the morning, those who passed by C<sup>2</sup>TN's stand had the chance to get to know a little more about the work that is done at C<sup>2</sup>TN in the area of advanced materials. In the afternoon, we had a 3D molecules simulation that especially delighted the kids.

### Day 2

We started the day with the famous strawberries blind tasting. We also showed how ionizing radiation can contribute to the valorisation of toxic waste waters of the textiles industry and how we can measure air quality.



Photographic record of the event "Loures InSS".

## C<sup>2</sup>TN AT ENCONTRO CIÊNCIA 2018

The C<sup>2</sup>TN Outreach Group (GO) was present on the largest science meeting in Portugal in 2018, entitled "Science and Technology Summit in Portugal", that was held at Lisbon, from 2 to 4 of July (see Figure). Those who passed by C<sup>2</sup>TN's stand had the chance to get to know a little more about what is done at C<sup>2</sup>TN. Talks on ongoing research work at C<sup>2</sup>TN were given on behalf of different research groups. The contribution of the Centre was complemented with practical demonstrations about low carbon economy and air quality, based on the work developed under two European projects coordinated by C<sup>2</sup>TN.



Photographic record of the event "Encontro Ciência 2018".

## C<sup>2</sup>TN AT NOITE EUROPEIA DOS INVESTIGADORES 2018

The 2018 edition of the initiative "Noite Europeia dos Investigadores" took place at the Museum of Natural History and Science and at Lisbon's Botanical Garden (Lisbon's University) on the last 28th of September (see Figure). In that context, several activities were developed and promoted by the GO of C<sup>2</sup>TN as part of "C<sup>2</sup>TN's contribution to the cities of tomorrow":

- A blind tasting of delicious strawberries which proved not only that food irradiation is perfectly safe, but also that it does not cause any alterations in food besides increasing its shelf life and safety.



Photographic record of the event "Noite Europeia dos Investigadores 2018".

- A practical demonstration entitled "The air belongs to everyone" performed in the framework of the LifeIndex Air project, which involved the measurement of air quality on site.

- A demonstration related with the ClimACT project that is focused on driving a transition towards a low carbon economy in schools.

- Inspired in the speed dating concept, a very successful "Science Dating powered by C<sup>2</sup>TN" session was organized. It consisted in 5 minutes chats with scientists about relevant scientific topics. In no more than 1h30, this activity attracted close to 100 participants.

## SCIENTIFIC OUTPUT 2018

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Costa, Ângelo Rafael Granadeiro (2018) *Lattice location of impurities in silicon carbide*. Instituto Superior Técnico, Universidade de Lisboa. Supervisors: U. Wahl, J.G. Correia

Gomes, Susana Sousa (2018) *O chumbo no ocidente peninsular em época romana: proveniência e técnicas metalúrgicas*. Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa. Supervisors: Araújo, M.F. (C<sup>2</sup>TN), Co-Supervisors: Soares, A.M.M. (C<sup>2</sup>TN, IST-ULisboa), Correia, V.H. (Museu Monográfico Conimbriga – National Museum)

Lopes, F. (2018) *Roman copper metallurgy: the Conimbriga situlae handle attachments*. Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa. Supervisor: Araújo, M.F. (C<sup>2</sup>TN, IST-ULisboa), Co-Supervisors: Silva, R.J.C. (CENIMAT, FCT-UNL), Correia V.H. (Museu Monográfico Conimbriga – National Museum)

Vultos, Filipe André Jardim (2018) *<sup>111</sup>In-labelled Peptides for Breast Cancer Theranostics*. Doutoramento em Química, Instituto Superior Técnico, Universidade de Lisboa. Supervisors: Lurdes Gano, Célia Fernandes

### M.Sc.

António, Debora (2018) *Dose assessment and reconstruction algorithm optimization in simultaneous breast and lung CT imaging*. Mestrado em Engenharia Biomédica (UNL). Supervisor: Salvatore di Maria

Canhoto, João Figueiredo (2018) *LET- and Radiation Quality-dependence of the complexity of DNA damages*. Mestrado Integrado em Engenharia Física (FCUL). Supervisor: Ana Belchior

Corregidor, Victoria (2018) *Radiotherapy bunker design as a function of technique used: 3D-CTR, IMRT, TBI and SRS. Economic impact evaluation*. Mestrado em Proteção e Segurança Radiológica (IST). Co-supervisor: Mário Reis

Correia, Carolina (2018) *Exposição a partículas atmosféricas e dose inalada em movimentos pendulares em Lisboa*. MSc Environmental Engineering, Instituto Superior Técnico, Universidade de Lisboa. Supervisors: S.M. Almeida e V. Martins

David, Mariana Anderson Moraes (2018) *Cystic Fibrosis: novel molecular imaging tools*. Mestrado em Engenharia Biológica, IST. Supervisor: Filipa Mendes

de Brito, Pedro Daniel Espanhol (2018) *Metanação do CO<sub>2</sub> usando catalisadores de óxidos bimetálicos suportados de níquel-lantanídeo*. MSc in Chemical Engineer, Instituto Superior Técnico. Supervisors: Joaquim B. Branco, Ana Cristina Ferreira

de Oliveira, Tiago Pereira Biscaia (2018) *Electric power generation from hydrocarbon fuels, a detailed study of near wall heat-transfer*. Mestrado em Engenharia Mecânica, Instituto Superior Técnico. Supervisor: Sandra Isabel Godinho Dias, Co-supervisors: António Pereira Gonçalves, Edgar Caetano Fernandes.

Lopes, Inês (2018) *Avaliação da exposição de crianças a matéria particulada em ambiente urbano*, MSc Environmental Engineering, Instituto Superior Técnico, Universidade de Lisboa. Supervisors: S.M. Almeida e V. Martins

Palma, C. (2018) *Adenovirus' inactivation mechanisms by gamma radiation*. Faculdade de Farmácia, Universidade de Lisboa. Supervisor: Cabo Verde, S. Co-supervisor: Gonçalves, J. (FF-ULisboa).

Pereira, Mafalda Inês Apolinário (2018) *Design of Peptides to Interfere with the RANK-TRAF6 Pathway: an Integrated Approach*. Mestrado em Engenharia Química e Bioquímica, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa. Supervisors: Rita Melo, João Correia

Reis, Marta (2018) *Deployment of a Bubble Chamber for Dark Matter Searches*. Mestrado Integrado em Engenharia Física Tecnológica, Instituto Superior Técnico, Universidade de Lisboa. Supervisor: Miguel Felizardo

Santiago, M. (2018) *Estudo de minérios recolhidos do povoado calcolítico de São Pedro (Redondo)*. Departamento de Conservação e Restauro, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa. Supervisor: Cardoso, I.P. (DCR-FCT-UNL), Co-Supervisors: Araújo, M.F., Valério, P.

Santoro Valerio (2018) *Dosimetry and biological effectiveness of protons and light ions for hadrontherapy – a computational study*. (U. Bologna). Supervisor: Pedro Vaz

Severino, A. (2018) *Avaliação da extensão do tempo de prateleira de tomates cereja irradiados por feixe de eletrões*. Faculdade de Ciências, Universidade de Lisboa. Supervisor: Cabo Verde, S., Co-supervisor: Carolino, M. (DBV, FC-ULisboa)

Tavares, Álvaro (2018) *Gestão de Fontes Radioativas Seladas na indústria – Um Estudo Introductório*, Mestrado em Engenharia do Ambiente (IPBeja)/IST. Supervisor: I. Paiva

Trincão, Mariana (2018) *Avaliação da exposição da população portuguesa a radiações ionizantes devido a exames médicos de radiodiagnóstico e medicina nuclear*. Mestrado em Proteção e Segurança Radiológica (IST). Supervisor: Pedro Teles

Varatojo, Afonso Jorge (2018) *Síntese de novos Condutores Moleculares em Bicamada; em busca de novos Supercondutores*. Mestrado em Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa. Supervisor: Sandra Rabaça

## CONCLUDED GRADUATIONS

Catarina Nunes (2018) *Avaliação do desempenho ambiental de escolas ClimACT*. Internship in Environmental Health II, BSc Environmental Health, Escola Superior de Tecnologia da Saúde de Lisboa. Supervisors: Joana Lage, Nuno Canha, Marta Almeida

Melissa Orlanda Pereira da Costa (2018) *Síntese de complexos de  $^{99m}\text{Tc(I)}$  com afinidade para as placas  $\beta$  amiloide*. Estágio em Medicina Nuclear II, 4º ano – 1º Semestre, Licenciatura em Medicina Nuclear da ESTeSL. Supervisor: Célia Fernandes

Naureo João Balanca (2018) *Estudo da dissolução de Cobre e Zinco em líquidos iónicos*. Graduation in Chemical Engineering, Instituto Politécnico de Setúbal, Escola Superior de Tecnologia do Barreiro. Supervisors: João Paulo Leal, António Pereira Gonçalves, Rui Antunes.

Noorani Julficarali (2018) *Terapia com Eletrões Auger - Alaranjado de Acridina como molécula intercaladora do DNA e influência do espaçador nos danos causados*. Estágio em Medicina Nuclear III, 4º ano – 2º Semestre, Licenciatura em Medicina Nuclear, ESTeSL. Supervisor: Célia Fernandes

Rita Belo (2018) *Complexos de Cobre-64 para aplicações teranósticas*. Estágio em Medicina Nuclear III, 4º ano – 2º Semestre, Licenciatura em Medicina Nuclear da ESTeSL. Supervisor: Paula Raposinho

Salomé Galaio (2018) *Terapia com electrões Auger*. Estágio em Medicina Nuclear II, 4º ano – 1º Semestre, Licenciatura em Medicina Nuclear, ESTeSL. Supervisor: Paula Raposinho

## INTERNSHIPS

Ana Alves (2018) *O ar que respiramos enquanto dormimos – avaliação da exposição humana a poluentes*. IST Summer Internship of short duration. July to September 2018. Supervisor: Nuno Canha

Catarina Marta (2018) *O ar que respiramos enquanto dormimos – avaliação da exposição humana a poluentes*. IST Summer Internship of short duration. July to September 2018. Supervisor: Nuno Canha

Justino A.R. (2018) *Determinação de elementos traço incluindo elementos tóxicos em amostras ambientais*. IST Summer Internship of short duration – 8 weeks. Supervisor: Catarina Galinha

Catarina Pinto and Marta Avelar (2018) *Development of 3D spheroid cultures of prostate cancer cells for future preclinical evaluation of novel (radio)pharmaceuticals*. IST Summer Internship of short duration – 8 weeks. Supervisor: Joana Guerreiro

## Patents and performing patents

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Leal, J.P., Carretas, J.M., Cruz, A., Maria, L., Monteiro, B. *Processo para a síntese de um líquido iónico puro contendo apenas CHON na sua composição e útil para a separação selectiva de lantanídeos* – Patent pending

Leal, J.P., Carretas, J.M., Cruz, A., Maria, L., Monteiro, B. *Processo para a síntese de um líquido iónico puro contendo apenas CHON na sua composição e sua aplicação num processo para a remediação ambiental de lantanídeos e actinídeos* – Patent pending

Morlat, T., Fernandes, A.C., Felizardo, M., Kling, A., Marques, J.G., *Alpha spectroscopy of liquids using superheated droplets* – Patent filing

## New Materials, devices, products and processes, software, computer codes and algorithms

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Automated analysis algorithms of superheated droplet detector signals.

Bubble chamber prototypes for astroparticle dark matter search: 30 liter and 1.7 liter with recompression system up to 16 bar.

Development and computer implementation of techniques for the robust identification of constraining forces between dynamical subsystems.

Development and computer implementation of techniques for the time-domain numerical simulation of dynamical systems fitted with impact dampers.

## Edited special issues of journals

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Fourth International Conference on Precision Image-Guided Small Animal Radiotherapy Research, Lisbon (Portugal) 12-14 March. Proceedings (selected papers) to appear as a special issue of the Journal of Radiological Protection (in press). Editors: F. Verhaegen, P. Vaz

Materials Today: Proceedings, special issue on the “14th European Conference on Thermoelectrics”, 5 (2018) 10185–10412, A.P. Gonçalves, Francisco P. Brito, Luis M. Gonçalves, Florinda M. Costa, Isabel Ferreira, Elsa Lopes (Editors).

PRS2017 - Conference session summaries - special issue of "Radioproteção", Vol. IV, ISSN-0874-7016, 2018. Editors: W. Weiss, E. Vaño, M. Perez, L. Neves, P. Vaz.

## Performances and Exhibitions

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Almeida, S. M., Lage, J. (2018) ClimACT project exhibition at the final Ceremony of the RegioStars Awards contest organized by the European Commission, as finalist project, 9<sup>th</sup> October, Brussels, Belgium.

Almeida, S.M., Canha, N., Lage, J., Martins, V., Coutinho, J., Faria, T., Galinha, C., Lopes, I., Correia, C., Dionísio, I. (2018) Exhibition in Loures Inss – Inovação, Sustentabilidade e Sociedade, awareness campaigns conducted within LIFE Index-Air and ClimACT projects with environment education games designed for children, Loures (Portugal). Target audience: 240 students and 6 teachers.

Almeida, S.M., Lage, J. (2018) ClimACT presentation in the Interact Programme session at the EU Regions Week 2018, as finalist project of the contest “Interreg Talks: 6 projects, 1 slam”, 10<sup>th</sup> October, Brussels, Belgium

Alves, J.G. (2018) Monitorização Radiológica na Ilha Terceira, Praia da Vitória, 30 May

Cabo Verde, S. (2018) *C2TN and ONU Sustainable Development Goals*, Exhibition in Loures Inss – Inovação, Sustentabilidade e Sociedade Feira do ambiente Loures, Parque Urbano de Santa Iria de Azóia, 3 - 5 June

Cabo Verde, S. (2018) *O contributo do C2TN para as cidades do amanhã*, European Researchers' Night, 28<sup>th</sup> September, Lisbon (Portugal)

Correia, C., Lopes, I., Coutinho, J., Lage, J., Dionísio, I., Faria, T., Canha, N., Martins, V., Almeida, S.M. (2018) Awareness campaign conducted within LIFE Index-Air and ClimACT projects with environment education games designed for children at Escola EB1 n.º 4 da Póvoa de Santa Iria (Loures, Portugal) for , Loures (Portugal). Target audience: 258 students and 11 teachers.

Correia, C., Lopes, I., Faria, T., Martins, V., Canha, N. (2018) Participation in the Ciência2018 – the national science event at Portugal – in the stand of C2TN – Centro de Ciências e Tecnologias Nucleares of Instituto Superior Técnico, with a demonstration entitled “The air that we breath – know to act”, 2 July, Lisbon (Portugal)

Nunes, C., Faria, T., Canha, N. (2018) *The air belongs to everyone*, demonstration at European Researchers' Night, 28<sup>th</sup> September, Lisbon (Portugal)

Reis, M., Soares, F. (2018) *Science Dating powered by C2TN*, European Researchers' Night, 28<sup>th</sup> September, Lisbon (Portugal)

Soares, A.M.M. & Valério, P. (2018). A metalurgia do cobre no sul de Portugal entre 3000 e 800 a.C. *Sob a Terra e as Águas – Arqueologia no Núcleo Museológico da Rua do Sembrano*. Câmara Municipal de Beja.

### EUROPEAN RESEARCH CONTRACTS

*ClimACT – Acting for the transition to a low carbon economy in schools – development of support tools* - SOE1/P3/P0429, Interreg Sudoe, 2016-2019. (Total budget 1,374,128€; C2TN Budget: 255,058€; FEDER Contribution to C2TN: 191,293€) Project Coordinator: Marta Almeida

*COLOSSAL – Chemical On-Line cOmpoSition and Source Apportionment of fine aerosol*, COST/CA16109–COLOSSAL (2017-2020) Marta Almeida

*CONFIDENCE – Coping with uncertainties for improved modelling and decision making in nuclear emergencies*. HORIZON 2020. Funding scheme: CONCERT. Leading institution: KIT (Germany). C2TN participants: Mário Reis (IST coordinator), Pedro Vaz, Maria José Madruga, Isabel Paiva, Octávia Monteiro Gil. EU funding (IST): 69,788.00€

*ENVIREE – Environmentally friendly and efficient methods for extraction of rare earth elements from secondary sources*. ERACall. Funding scheme: FCT/ERAMIN. (2015-2018). EU funding (IST): 100,000.00€. Leading institution: Chalmers University (Sweden). IST responsible – Isabel Paiva. Participants – M.I. Dias, M.I. Prudêncio, M.F. Araújo, R. Marques, J.P. Leal, J.C. Waerenborgh, J. Marçalo, L. Maria, J.M. Carretas, D. Russo, G. Cardoso, C. Galinha.

*LIFE Index-Air – Development of an Integrated Exposure – Dose Management Tool for Reduction of Particulate Matter in Air* – LIFE15 ENV/PT/000674 (2016-2019) (Total budget 1,369,071€; C2TN Budget: 487,159€; EU Contribution to C2TN: 282,321€) Project Coordinator: Marta Almeida

*MEDICIS – produced radioisotope beams for medicine* (MEDICIS-PROMED), ITN (H2020-MSCA-ITN-2014) Total Funding: 2,829,269.88€, C<sup>2</sup>TN Funding: 476,712.72€. Responsible: Thierry Stora - CERN. C<sup>2</sup>TN responsible: António Paulo. Research Team (C<sup>2</sup>TN): António Paulo, António Gonçalves, Alice D’Onofrio, Sanjib Chowdhury

*MYRTE – MYRRHA Research and Transmutation Endeavour* (HORIZON 2020 EURATOM). Funding scheme: Research and Innovation Action (RIA). EU funding (IST-ID): 18,750.00 €. Starting date Apr-2015. Leading institution: SCK/CEN (Belgium). Portuguese participants: Pedro Vaz (Coordinator), Yuriy Romanets.

*ReCreew – European network for innovative recovery strategies of rare earth and other critical metals from electric and electronic waste*. COST Action ES1407 (Earth System Science and Environmental Management) (2015-2019) M.I. Dias.

*REMEDIIO – Regenerating Mixed-Use Med Urban Communities Congested by Traffic through Innovative Low Carbon Mobility Solutions*, European Regional Development Fund (ERDF) - Interreg Med project REMEDIIO (Ref. 862). Total budget 2.215.512,50€, IST Budget: 240.000,00€. C2TN responsible: Marta Almeida

*RTNORM – Calculation of kQ factors in modern external beam radiotherapy applications to update IAEA TRS – 398*. EMPIR/EURAMET/16RNM03. Joint Research Project. EU funding (IST-ID): 40,000.00€. Leading Institution ENEA (Italy). C2TN participants: Pedro Teles (coordinator), Salvatore di Maria, Margarida Caldeira, Jorge Borbinha

*THERMOSS – Sustainable Thermoelectric Modules based on Non-toxic Silicides and Sulphides for Recovery of Waste Heat to Power Generation*, M-ERA.NET 2016, “Functional Materials” (Jun 2017 to May 2020) C<sup>2</sup>TN Funding 87204€. A.P. Gonçalves

*UPCAST – Unified Platform for CBRN Attack/Accident Scenario management*. Funding PT 2020 (IST: approx. 140.000€). Start date: Jan 2016. Leading institution: TEKEVER. IST participants: Pedro Vaz (IST Coordinator), Octávia Monteiro Gil, Mário Reis, Ana Catarina Antunes.

*Visual – Santa Vitória – Utensils and Ornaments of an Enclosure Site*, IPERION CH Project H2020: BNC proposal BRR\_ 563 (2018) Coordinator: A. L. Rodrigues. Participant: M.I. Dias

## INDUSTRIAL RESEARCH CONTRACTS

Microbiological analysis for Indoor Air Quality in clean rooms, Contract IST-Tradelabor (Jan – Dec 2018) 7.5 k€. Responsible: S. Cabo Verde

Microbiological analysis for Indoor Air Quality in the scope of the Energy Certification for Buildings, Contract IST-ATM (Jan to Dec 2018) 1.7 k€. Responsible: S. Cabo Verde

RecValTR (Portugal 2020) (Recovery and valorization of rare earths from electrical and electronic waste) - INTERECYCLING - SOCIEDADE DE RECICLAGEM S.A Projeto: 33576 (2018-2020), Team Members: J. Marçalo, J.P. Leal, J.M. Carretas

Study of the resistance/degradation of API compounds to gamma radiation for validation of a sterilization process, Hovione. 2.7 k€. Responsible: S. Cabo Verde

## FCT PROJECTS

BILMET - *2D Molecular Metals and Superconductors; Coherence and Anisotropy in Bilayer Systems*, FCT Research contract 02/SAICT/2017, ref. LISBOA-01-0145-FEDER-029666 (Funding total 229.391,12€, IST 186.841,12€). M. Almeida

CERN-FIS-PAR-0005-2017, *PORTUGAL AT ISOLDE: Materials and Nuclear Physics Research with Radioactive Isotopes and Techniques*. Jul-2018 to Jun-2020, Budget: 170 k€

CExhaust 2 Energy - *Recuperação de calor dos gases de escape de automóveis com controlo térmico*. PTDC/EMS-ENE/3009/2014. A.P. Gonçalves

CO2CRASH – *Catalytic reduction of carbon dioxide and selective production of hidrocarbons*. PTDC/EAM-PEC/28374/2017 (Oct-2018 to Sep-2021). PI: Ana Ferreira; co-PI: J. B. Branco

*Development of a novel class of antibody-drug conjugates molecules for cancer treatment - ADC1.1*, PTDC/BTM-SAL/32085/2017 (Total Funding: 239.638,46€; C<sup>2</sup>TN Funding: 7,500€) Principal Investigator: Frederico Aires da Silva – FMV-UL, C<sup>2</sup>TN responsible: J.D.G. Correia

*Drug Delivery Nanosystem for HPV infection therapy*, UTAP-EXPL/NTec/0015/2017 (Total Funding: 99.994,00€; C<sup>2</sup>TN Funding: 34.948,00€) Principal Investigator: Carla Cruz-UBI, C<sup>2</sup>TN responsible: A. Paulo

*Engineering of Smart Exosomes for Amyloid-beta Clearance in Alzheimer disease*, PTDC/BTM-SAL/31057/2017 (Total Funding: 237.853,85€; C<sup>2</sup>TN Funding: 20,000€) Principal Investigator: Fábio Monteiro Fernandes – CQFM (IST/ID), C<sup>2</sup>TN responsible: J.D.G. Correia

*ExpoLIS: Assessment of human exposure to air pollution to change the way people move in cities*, LISBOA-01-0145-FEDER-032088 (2018-2021) Total budget: 240k€; C2TN budget: 168k€. Project Coordinator: Marta Almeida

*f-Element Clusters in the Gas Phase – Prototypes of Catalytic Processes*, PTDC/QEQ-QFI/6430/2014 (Jul-2016 to Jun-2018). PI: J. Marçalo. Team Members: J. P. Leal, J. B. Branco, B. Monteiro

*Innovative measurement of alfa particle contamination in integrated circuits – a contribution to the assessment of soft error rates*, FCT Project PTDC/EEI-ELC/2468/2014 (since 1/Jul/2016) 171 577€

*Instabilidades de rede funcionais em perovskites naturalmente estruturadas*, FCT Research contract from 02/SAICT/2017-029454-CL1148. Jan-2018 to Dec-2020. Budget: 33 k€

*ISOLTOP-SUP – Novos materiais isoladores topológicos e supercondutores*. PTDC/FISNAN/6099/2014. C<sup>2</sup>TN responsible: António Gonçalves

*Local Resources for Multifunctional Tetrahedrite-based Energy-Harvesting Applications, Local Energy*, FCT project PTDC/EAM-PEC/29905/2017 (Oct 2018 to Sep 2021) C<sup>2</sup>TN Funding 41000€. A.P. Gonçalves

*Low level alpha measurements using superheated droplet detectors*, IF/00628/2012/CP0171/CT0008, FCT Project, 50 000€ (Dec 2013 to Nov 2018). A. Fernandes

*LTHMFL-NECL; Low Temperature and High Magnetic Field Laboratory – Network of Extreme conditions* FCT ROTEIRO/0068/2013 -LISBOA-01-0145-FEDER-022096 – FCT Project 022096 from 01/SAICT/2016 (Set 2017 to Set 2020) IST Funding 501 000€. M. Almeida.

*Membrane proteins – development of new computational approaches and its application to G-Protein Coupled Receptors*, FCT-PTDC/QUI-OUT/32243/2017. Total Funding: 237.267,54€, C<sup>2</sup>TN Funding: 158.419,43€. Principal Investigator: R. Melo

*Multifunctional Nanoseeds for Chemoradiotherapy of Glioblastoma*, FCT-PTDC/MED-QUI/29649/2017. Total Funding: 237.211,87€, C<sup>2</sup>TN Funding: 220.211,87€. Principal Investigator: A. Paulo

*Neutrability: Materiais Neutros Solúveis para a Electrónica Molecular*, FCT Research contract from 02/SAICT/2017, PTDC/QUI-QIN/29834/2017. D. Belo

*Novel Molecular Imaging tools for Cystic Fibrosis*, PTDC/BTM-TEC/29256/2017. Total Funding: 233.315,10€, C<sup>2</sup>TN Funding: 188.315,10€. Principal Investigator: F. Mendes

*Overcoming the Brain Drug Delivery Bottleneck: Development of single domain antibodies for brain targeting and drug delivery across the Blood Brain Barrier*, FCT-PTDC/BBB-BIO/0508/2014. Total Funding: 192 320,00 €; C<sup>2</sup>TN Funding: 15 600,00 €. Principal Investigator: Frederico Aires da Silva – FMV-UL. C<sup>2</sup>TN responsible: J.D.G. Correia

*Peptides for blood brain barrier transmigration and drug delivery novel therapies for the central nervous system*, FCT-PTDC/BBB-NAN/1578/2014. Total Funding: 190 090€, C<sup>2</sup>TN Funding: 12 500€. Principal Investigator: Vera Neves – IMM. C<sup>2</sup>TN responsible: J.D.G. Correia

*Radon – A Gas-Phase Ion Chemistry Perspective*, PTDC/QUI-QFI/31896/2017 (Oct-2018 to Sep-2021). PI: J. Marçalo; Team Members QEf: J. P. Leal, J. M. Carretas, B. Monteiro, L. Maria

Recovery versus environmental impacts of Rare Earth Elements derived from human activities-REEuse, (PTDC/QEQ-EPR/1249/2014). PI: Miguel Caetano (IPMA), Team Members: J. Marçalo, J.P. Leal

*RNEM – Portuguese Mass Spectrometry Network*, Research Infrastructure n. 22125 (Jan 2017 to Dec 2019). IST-Node Co-Coordinator: J. Marçalo; Team Members QEf: J.P. Leal, J.M. Carretas, L. Maria, B. Monteiro; Team Members REI: M.F. Araújo, P.M. Carreira, C. Galinha

*SHELLS – Temperatura da água do mar superficial, afloramento costeiro, produtividade de águas costeiras e sazonalidade da colheita de moluscos pelas populações Neandertais do Centro de Portugal no Último Interglacial*, PTDC/EPH-ARQ/6485/2014 (2016-2019) Budget: 188 k€

*Targeting the transporters of cationic amino acids for cancer radiotheranostics: experimental and computational chemistry approach*, FCT-PTDC/QUI-NUC/30147/2017. Total Funding: 231.078,67€ (C<sup>2</sup>TN Funding: 224.579,32€). Principal Investigator: J.D.G. Correia

*XPOSURE - Integrated human exposure to particles: characterization, identification of sources and health effects*, IF/01078/2013, FCT (2016-2019). Total budget 50,000€, C2TN Budget: 50,000€. Project Coordinator: Marta Almeida

## BILATERAL RESEARCH PROJECTS

*Mining-metallic resources, trade and commerce in the Prehistory and Protohistory of the Iberian Peninsula (Catalonia and the northern Valencian Country)*. Ministry of the Economy and Competitiveness (HAR2014-54012-P) (2018) Team – M. I. Dias, M. I. Prudêncio, A. L. Rodrigues

*Nature, Society and Monumentality: High-Resolution Archaeological Research of the Antequera Megalithic Landscape* (HAR2013-45149-P). Plan Nacional I+D. Dirección General de Investigación. Ministerio de Economía y Competitividad, Secretaría General de Investigación. Coordinator: Leonardo Sanjuan. Univ. Sevilla, Espanha. (2015-2018). PI - IST: M. Isabel Dias. Team – M.I. Dias, M.I. Prudêncio, A.L. Rodrigues.

*Radiolabeled and Clickable Antagonists for Targeted Radionuclide*, Bilateral Action Cooperação Científica e Tecnológica FCT/Polonia – 2017/2018. C<sup>2</sup>TN Funding: 4,000 €. Responsible: António Paulo; Partners: Polatom, Poland

## RESEARCH CONTRACTS WITH IAEA

*Biodegradable polymer matrices obtained by ionizing radiation for skin scaffolds*, IAEA Research Contract No. 18202 (2014-2019). IAEA Coordinate Research Project CRP F23030-E31007 - Instructive Surfaces and Scaffolds for Tissue Engineering Using Radiation Technology. Funding: 22.5 k€. Coordinator (C<sup>2</sup>TN): L.M. Ferreira

*Enhancing Nuclear Analytical Techniques to Meet the Needs of Forensic Sciences*, IAEA - CRP F11021 Research Contract No. 22195 Funding: 5 k€. Coordinator: L.C. Alves

*Enhancing Radioactive Waste Management Capabilities*, IAEA technical cooperation project RER9143, (applications to attend meetings, workshops and courses are funded)

*Enhancing the inventory of aerosol source profiles characterized by nuclear analytic techniques in support of air quality* - TC project RER7011, IAEA, 2018-2019. Marta Almeida

*Fostering e-beam food irradiation: Modelling and Validation*, IAEA – CRP D61024 Project no. 19220 (2015-2019) Funding: 6 k€. Coordinator: S. Cabo Verde

*Hybrid Materials Prepared by Ionizing Radiation for Consolidation and Preservation of Roman Mosaics*, IAEA Research Contract No: 18982 (2016-2018). IAEA Coordinated Research Project CRP F23032 - Developing Radiation Treatment Methodologies and New Resin Formulations for Consolidation and Preservation of Archived Materials and Cultural Heritage Artefacts. Funding: 12 k€. Coordinator (C<sup>2</sup>TN): L.M. Ferreira

*Simultaneous Heavy Ions PIXE and SIMS Analysis of Georesources and Environmental Samples (SHIPS-AGES)*, included in the IAEA Coordinated Research Project “Development of Molecular Concentration Mapping Techniques Using MeV Focussed Ion Beams” IAEA Research Contract No: 18357/R1 (4<sup>th</sup> year)

*Tracking Enteric Virus Inactivation by E-beam Irradiation*, IAEA - CRP F23033 Research Contract No. 22668 (2018-2022) Funding: 5 k€. Coordinator: S. Cabo Verde

## OTHER RESEARCH PROJECTS

*Analyse des forces de couplage appliquée à des systèmes académiques*, IFS-2018, ADIST, Commissariat à l'Energie Atomique et aux Energies Alternatives CEA/4000815374 P5B61, Oct-2018 to Mar-2019 (Funding 9800 €)

EURADOS WG6 *Intercomparison study on the usage of the ICRP/ICRU voxel reference computational phantoms* (ICRP Publication 110, 2009) together with radiation transport codes. (not funded)

IVECO-2017 – *Identification of flow turbulence excitation from the CALVI experiments*, ADIST, Commissariat à l'Energie Atomique et aux Energies Alternatives CEA/4000765990 P5B61, Oct-2017 to Mar-2018 (Funding 9800 €)

## Invited Talks in Conferences

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Almeida, M., Oliveira, S., Gonçalves, A.C., Gama, V., Santos, I.C., Oliveira, G., Lopes, E.B., Rabaça, S., Paixão, J.A., Canadell, E., (2018) 2D Molecular Conductors by Bilayer Self-Assembly, 43<sup>rd</sup> International Conference on Coordination Chemistry (ICCC2018), Sendai (Japan) July 30 to August 4

Almeida, S.M. (2018) Interreg Sudoe en la práctica: proyectos para la cohesión – Cambio climático. 15 years of the Interreg Sudoe programme, Brussels (Belgium) 6 June

Almeida, S.M. (2018) LIFE Index-Air project for improving the air quality. Fifth Life Training on Conservation and Environment, Budapest (Hungary) 28 November

Alves, J.G. (2018) Encontro Radão em Portugal: Presente e Futuro. Mesa Redonda Riscos do Radão, Consequências da BSS, LIP Cidade Universitária, 16 July

Alves, J.G. (2018) Req.11: Protection of emergency workers and helpers, IAEA material. Regional Workshop on the use of EPRIMS and completing maritime EPR self-assessment for the Mediterranean Member states, IAEA, Vienna (Austria) 7 to 11 May

Alves, J.G. (2018) Req.13: Communicating with the public, IAEA material. Regional Workshop on the use of EPRIMS and completing maritime EPR self-assessment for the Mediterranean Member states, IAEA, Vienna (Austria) 7 to 11 May

Alves, J.G. (2018) Req.2: Roles and responsibilities in EPR, IAEA material. Regional Workshop on the use of EPRIMS and completing maritime EPR self-assessment for the Mediterranean Member states, IAEA, Vienna (Austria) 7 to 11 May

Alves, J.G. (2018) Req.20-26: Infrastructural elements, IAEA material. Protection of emergency workers and helpers, IAEA material. Regional Workshop on the use of EPRIMS and completing maritime EPR self-assessment for the Mediterranean Member states, IAEA, Vienna (Austria) 7 to 11 May

Alves, J.G. (2018) Req.7: Identifying, Notifying and Activating, IAEA material. Regional Workshop on the use of EPRIMS and completing maritime EPR self-assessment for the Mediterranean Member states, IAEA, Vienna (Austria) 7 to 11 May

Antunes, J. (2018) Dynamical modelling of flexible constrained systems using the Udwadia-Kalaba formulation. Keynote conference at the 2<sup>nd</sup> International Conference on Advanced Materials, Mechanics and Manufacturing, Hammamet (Tunisia) 17 to 19 December

Cabo Verde, S. (2018) Fostering e-beam food irradiation: Modelling and Validation. IAEA 3<sup>rd</sup> Research Coordinated Meeting on New applications of Machine Generated Food Irradiation Technologies, Bangkok (Thailand) 11 to 15 June

Cabo Verde, S. (2018) LETAL: a Laboratory for Ionizing Radiation *et al.*, Workshop ICNAS/LIP/CTN: Future directions in nuclear sciences applied to health, Universidade de Coimbra, Coimbra (Portugal) 23 March

Cabo Verde, S. (2018) Tracking Enteric Virus Inactivation by e-beam Irradiation. IAEA 1<sup>st</sup> Research Coordination Meeting of the Coordinate Research Project Radiation Inactivation of Bio-Hazards using High Powered Electron Beam Accelerators, Vienna (Austria) 25-29 June

Canha, N., Lage, J., Candeias, S., Alves, C., Almeida, M. (2018) Indoor air quality during sleep under different ventilation patterns. Indoor Air 2018 – 15<sup>th</sup> Conference of the International Society of Indoor Air Quality & Climate, Philadelphia, PA (USA) 22-27 July

Crespo, R. (2018) N-knockout, reactions and structure, Workshop "ENSAR2 - NUSPRASEN Workshop on Nuclear Reactions (Theory and Experiment)" Warsaw, 22 to 24 January

Crespo, R. (2018) Theory on Nuclear reactions with exotic beams, Euroschool on Exotic Beams 25-years Symposium, 30 August

Dias, M.I., Prudêncio, M.I., Amaro, C., Gonçalves, C. (2018) The roman figlina in Garrocheira (Benavente), a production centre Amphorae supplier to Olisipo and to the Tagus estuary. Secção de Arqueologia da Sociedade de Geografia de Lisboa e Centro de Arqueologia de Lisboa (Câmara Municipal de Lisboa) November

Ferreira A.C., Branco J.B. (2018) Nanofibras bimetálicas de lantanídeo-níquel para a metanação do dióxido de carbono, XXVI Congresso Ibero-Americano de Catalise (CICATXXVI), Coimbra (Portugal) 9 to 14 September

Ferreira, L.M., Casimiro, M.H., Rodrigues, A.P., Leal, J.P., Margaça, F.M.A., Radiation Processing for Advanced Polymeric Materials at Center for Nuclear Sciences and Technologies (C<sup>2</sup>TN). IAEA Regional workshop on Radiation Processing for advanced polymeric materials, in the frame of the Technical Cooperation Project RER1019, Enhancing Standardized Radiation Technologies and Quality Control Procedures for Human Health, Safety, Cleaner Environment and Advanced Materials, Warsaw (Poland) 15 to 19 October

Ferreira, L.M., Rodrigues, A.P., Margaça, F.M.A., Casimiro, M.H., Hybrid materials (gel/solid) by ionizing radiation for conservation of non-metallic inorganic historical materials. Technical Meeting on Strategies for Preservation and Consolidation of Cultural Heritage Artefacts through Radiation Processing, Zagreb (Croatia) 4 to 8 June

Gonçalves A.P., Lopes E.B. (2018) Towards the use of Cu-S based synthetic minerals for thermoelectric applications", XVI Interstate Conference "Thermoelectrics and their Applications-2018", Saint Petersburg (Russia) 8 to 11 October

Oliveira, S., Gonçalves, A.C., Gama, V., Santos, I.C., Oliveira, G., Lopes, E.B., Rabaça, S., Paixão, J.A., Canadell, E., Almeida, M. (2018) Molecular Bilayer Conductors (CNB-EDT-TTF)<sub>4</sub>X; Progresses in New Prototype of 2D Metals", 24<sup>th</sup> International Conference on Science and Technology of Synthetic Metals (ICSM 2018), Busan (Korea) 1 to 6 July

Paiva, I. (2018), DSRS Management in Portugal, IAEA Meeting to Review Waste Acceptance Criteria for the Management of Radioactive Source (RS) and Disused Radioactive Sealed Source (DSRS)", Rabat, Morocco, 7 to 11 May

Paiva, I. (2018), Actual and Future Panorama of Radioactive Waste post-RPI, IAEA Meeting on International Harmonization and Safety Demonstration Project for Predisposal of Radioactive Waste Management - IAEA Project ECLIPSE – Enhancing Confidence over the Lifetime of Predisposal Safety Management", Vienna, Austria, 24 to 28 September

Paiva, I. (2018) Solutions and Trends in Radioactive Waste Management, invited presentation during the "12<sup>th</sup> School on the Physics and Chemistry of the Actinides (SPCA)", CTN-IST, Bobadela (Portugal) 19 to 21 March

Pereira, L.M.C., Wahl, U., Correia, J.G. (2018) Unraveling the atomic structure of quantum materials using radioactive ions". 2018 ISOLDE Workshop and Users Meeting, CERN, Geneva (Switzerland) 5 to 7 December

Silva, F., Campello, M.P.C., Gano, L., Marques, F., Santos, P., Guerreiro, J., Cardoso, J., Belchior, A., Matos, A.P., Fernandes, A., Baptista, P., Kannan, R., Paulo, A. (2018) Multifunctional Bioconjugated Gold Nanoparticles for Cancer Theranostics. Fourth International Conference on Precision Image-Guided Small Animal Radiotherapy Research, Lisbon (Portugal) 12-14 March

Vaz, P. (2018) Computational Dosimetry and Modelling in support of Radiation Protection, invited "Refresher Course" during the "5<sup>th</sup> European IRPA Congress", The Hague (Netherlands) 4 to 8 June

Vaz, P. (2018) Radiation Protection and Dosimetry in Medicine - selected topics, invited talk during the "14th Symposium on Radiation Physics (ISRP-14)", Cordoba (Argentina) 7 to 11 October

Vaz, P. (2018) Radiological Protection, Safety and Security Issues Associated to the Applications of Radiation Sources (and Production of Actinides), invited presentation during the 12<sup>th</sup> School on the Physics and Chemistry of the Actinides (SPCA)", CTN-IST, Bobadela (Portugal) 19 to 21 March

Vultos, F., Silva, F., Fernandes, C., Mendes, F., Correia, J.D.G., Viertl, D., Gano, L. (2018) Multifunctional agent for breast cancer radiotheranostics. Fourth International Conference on Precision Image-Guided Small Animal Radiotherapy Research, Lisbon (Portugal) 12-14 March

Wahl, U., Correia, J.G., Costa, A., David-Bosne, E., Lima, T.A.L., Lippertz, G., da Silva, M.R., Kappers, M.J., Temst, K., Vantomme, A., Pereira, L.M.C. (2018) Emission channeling lattice location of Mg in GaN. 15<sup>th</sup> Congreso Nacional de Materiales and 1<sup>st</sup> Iberian Meeting on Materials Science, Salamanca (Spain), 4 to 7 July

## Contributed Talks in Conferences

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Almeida, S.M., Blondeau, P., Manteigas, V., Lage, J., D'Espiney, A., Almeida-Silva, M. et al (2018) Managing Indoor Air Quality in ClimACT Schools. 10<sup>th</sup> International Aerosol Conference, St. Louis, Missouri, (USA) 2-7 September

Almeida, S.M., Faria, T., Martins, V., Canha, N., Diapouli, E., Manousakas, M., Eleftheriadis, K. (2018) Indoor-to-outdoor particle concentration assessment for human exposure analysis. Indoor Air 2018 – 15<sup>th</sup> Conference of the International Society of Indoor Air Quality & Climate, Philadelphia, PA (USA) 22-27 July

Alves, J., Cherestes, C., Fantuzzi, E., Figel, M., Gilvin, P., Grimbergen, T., Hajek, M., Hupe, O., et al (2018) EURADOS Action on Harmonisation of Individual Monitoring for External Radiation: Intercomparisons, Surveys, and Training and Networking Activities. 5<sup>th</sup> European IRPA Congress, Encouraging Sustainability in Radiation Protection, The Hague (Netherlands), June. Oral

Baptista M. et al. (2018) Dosimetric and risk assessment of Digital Breast Tomosynthesis (DBT) and Cone-Beam Computed Tomography (CBCT) examination. Encontro Ciência 2018, Centro de Congressos de Lisboa, Lisbon (Portugal) 2-4 July. Poster

Baptista M. et al. (2018) Risk-based dosimetric assessment of Cone-Beam Computed Tomography (CBCT) examinations. PhD Open Days 2018, IST, Lisbon (Portugal) 21-22 March. Poster

Baptista, M. (2018) Quality and Safety of Patient Healthcare and Personalized Medicine Using Ionizing Radiation. Encontro Ciência 2018, Centro de Congressos de Lisboa, Lisbon (Portugal) 2-4 July. Oral

Barrulas, R.V., Paiva, T.G., Casimiro, M.H., Sequeira, S.O., Macedo, M.F., Corvo, M.C. (2018) Development of gels for cleaning fungal stains on paper. IBBS 2018 – New Trends in Cultural Heritage Biodeterioration, Coimbra (Portugal) 5 -7 September

Belo, D. (2018) Outreach Group of C<sup>2</sup>TN: Sharing Science with Society. 2<sup>nd</sup> Workshop C<sup>2</sup>TN - Radiation for Science and Society, CTN-IST, Bobadela (Portugal) 11 December

Cabo Verde, S., Carreira, P., Madureira, J., Palma, C., Marcos, H., Nunes, D., Santos, P. et al (2018). Recursos Hídricos – Impacto antropogénico: Avaliação, Tratamento e Reciclagem. Encontro Ciência 2018, Centro de Congressos de Lisboa, Lisbon (Portugal) 2-4 July

Canha, N., Lage, J., Belo, J., Picado, M., Faria, T., Cruz, M.M., Macedo, P., Cabo Verde, S. et al (2018) Será que o ar que respiramos enquanto dormimos condiciona a qualidade do nosso sono? Conferência Internacional de Ambiente em Língua Portuguesa | XX Encontro REALP | XI CNA. Aveiro (Portugal) 8-10 May

Canha, N., Lage, J., Belo, J., Picado, M., Macedo, P., Faria, T., Meira Cruz, M., Cabo Verde, S., et al (2018) Indoor air quality during sleep. Indoor Air 2018 – 15<sup>th</sup> Conference of the International Society of Indoor Air Quality & Climate, Philadelphia, PA (USA) 22-27 July

Canha, N., Lage, J., Belo, J., Picado, M., Macedo, P., Faria, T., Meira e Cruz, M., Cabo Verde, S., et al (2018) Is the air that we breathe during sleep affecting our sleep quality? 2<sup>nd</sup> Workshop C<sup>2</sup>TN - Radiation for Science and Society, CTN-IST, Bobadela (Portugal) 11 December

- Canha, N., Lage, J., Galinha, C., Stieghorst, C., Revay, Z., Araújo, M.F., Alves, C., Almeida, S.M. (2018) Avaliação do impacto da produção tradicional de carvão na qualidade do ar através de biomonitorização. Conferência Internacional de Ambiente em Língua Portuguesa | XX Encontro REALP | XI CNA. Aveiro (Portugal) 8-10 May
- Casimiro, M.H., Ferreira, L.M., Paiva, T.G., Barrulas, R.V., Corvo, M.C., Sequeira, S.O. et al (2018). Gels for cleaning artworks. Technical Meeting on Strategies for Preservation and Consolidation of Cultural Heritage Artefacts through Radiation Processing, Zagreb (Croatia) 4-8 June
- Casimiro, M.H., Rodrigues, A.P., Margaça, M.F.A., Falcão, A.N., Alves, L.C., Ferreira, L.M. (2018) Radiation Processing for Advanced Macromolecular Materials at C<sup>2</sup>TN. 2<sup>nd</sup> Workshop C<sup>2</sup>TN - Radiation for Science and Society, CTN-IST, Bobadela (Portugal) 11 December
- Casimiro, M.H., Vital, J., Ramos, A.M., Rodrigues, G., Leal, J.P., Ferreira, L.M. (2018) Ionizing radiation induced functionalization of polymeric materials. 9<sup>th</sup> Global Chemistry Congress, Lisbon (Portugal) 23-24 July
- Chaves, P.C., Conceição, P., Madureira, P., Reis, M.A. (2018) Qualitative study of Fe-Mn crust samples by High Resolution and High Energy PIXE. EXRS2018. European Conference on X-Ray Spectrometry, Ljubljana (Slovenia) 24-29 June. Oral
- Chowdhury, S., Henriques, M.S., Maria, L., Cruz, A., Stora, T., Gonçalves, A.P. (2018) Recent developments in UC<sub>x</sub> targets at C<sup>2</sup>TN. 48<sup>èmes</sup> Journées des Actinides, Hotel Golf Mar, Praia de Porto Novo (Portugal) 21-24 March
- Corisco, J. (2018) Ionizing radiation dose assessment in aquatic plants of Tejo river and in the wild vegetation covering a phosphogypsum tailing. Workshop C2TN - Thematic strands: Earth Sciences, Radioactivity and Cultural Heritage, CTN-IST, Bobadela (Portugal) 23 October
- Corisco, J. (2018) Radiation dose assessment in aquatic and emergent plants in Tejo river. The 7<sup>th</sup> International Conference on Radioactivity in the Arctic & Other Vulnerable Environments, 18-20 June, Oslo (Norway). Oral
- Corisco, J. (2018) Transfer and related dose assessment of natural radionuclides in plants and mosses growing on a phosphogypsum stockpile in Portugal. 3<sup>rd</sup> European Radiological Protection Research Week, Rovinj-Rovigno (Croatia) 1-5 October. Oral
- Cruz, A., Monteiro, B., Galinha, C., Paiva, I., Leal, J.P., Marçalo, J., Carretas, J.M., Maria, L. et al (2018) Recovery of Rare Earth Elements from Secondary Sources: A Purpose for the Future. 27<sup>th</sup> EuCheMS Conference on Molten Salts and Ionic Liquids | EuCheMSIL 2018, Lisbon (Portugal) October
- Cruz, T.F.C., Lopes, P.S., Pereira, L.C.J., Veiros, L.F., Gomes, P.T. (2018) Electronic structure of a trinuclear cobalt complex bearing 2-iminopyrrolyl ligands. SPINON Workshop 2018 Multifunctional Magnetic Materials, Academia das Ciências, Lisbon (Portugal) 1-2 October
- D'Espiney, A., Almeida, S.M., Manteigas, V., Lage, J., Almeida-Silva, M., Canha, N. et al. (2018) A mobilidade enquanto veículo de transição para uma Economia de Baixo Carbono nas escolas. CIALP - Conferência Internacional de Ambiente em Língua Portuguesa, Aveiro (Portugal) 8-10 May
- Dias, M.F. (2018) Earth Systems, Radioactivity and Cultural Heritage: funding opportunities. Workshop C2TN - Thematic strands: Earth Sciences, Radioactivity and Cultural Heritage, CTN-IST, Bobadela (Portugal) 24 October

D'Onofrio, A. (2018) Clickable Radioimmunoconjugates as Theranostic Agents for TEM1 Pre-Targeting. Workshop 'Imaging and therapeutic targeting in cancerology: New advances and trends in preclinical and clinical studies', Le Bono (France) 26-29 September

Debut V., Soeiro de Carvalho J. (2018) Técnicas experimentais e numéricas para investigar e valorizar um património sineiro. Simpósio Musical de Guimarães, 13 May

Dias, M.F., Belchior, A., Fernandes, A., Paulo, A., Margaça, M.F.A, Mendes, F., Guerreiro, J.F. et al (2018) Protons and ion therapy. 2<sup>nd</sup> Workshop C<sup>2</sup>TN - Radiation for Science and Society, CTN-IST, Bobadela (Portugal) 11 December

Dias, M.I., Prudêncio, M.I., Kasztovszky, Zs., Harsányi, I., Kovács, I., Szőkefalvi-Nagy, Z. et al (2018) Investigating artefacts from Chalcolithic funerary cremation contexts (Portugal) by using non-invasive nuclear techniques. 42<sup>nd</sup> International Symposium on Archaeometry (ISA 2018), Mérida, Yucatán (Mexico). 20-26 May. Oral

Domingos, G., Kalil, T., Alves, C., Lopes, E.B., Gonçalves, A.P. (2018) Study of novel coatings as diffusion barriers for thermoelectric modules. E-MRS Fall Meeting, Warsaw (Poland) 17-20 September

Domingues, G., Alves, T., Lopes, E.B., Gonçalves, A.P. (2018) Effect of composition on thermoelectric properties of as-cast materials: the  $\text{Cu}_{12-x}\text{Co}_x\text{Sb}_4\text{S}_{13-y}\text{Se}_y$  case. ICT2018, Caen (France) 1-5 July

Eixea, A., Martínez-Alfaro, A., Angel Bel, M., Roldan, C., Murcia, S., Dias, M.I., Prudêncio, M.I et al (2018) First data on the characterization of siliceous raw materials and the catchment areas from Cova de les Malladetes (Barx, Valencia). 18<sup>th</sup> UISPP WORLD CONGRESS, Paris (France) 4-9 June. Oral

Faria, T., Martins, V., Diapouli, E., Manousakas, M., Eleftheriadis, K., Alves, C., Almeida, S.M. (2018) Avaliação da exposição de crianças a matéria particulada em ambiente urbano. CIALP - Conferência Internacional de Ambiente em Língua Portuguesa, Aveiro (Portugal) 8-10 May

Gonçalves, A.P., Lopes, E.B. (2018) Thermoelectric Materials for Sustainable Development. 2<sup>nd</sup> Workshop C<sup>2</sup>TN - Radiation for Science and Society, CTN-IST, Bobadela (Portugal) 11 December

Guerreiro JF et al. (2018)  $^{64}\text{CuCl}_2$ , a simple tool for prostate cancer theranostics. EACR Conference 'Radiation Break-through: from DNA damage responses to precision cancer therapy', Oxford (United Kingdom) 12-14 March. Poster

Guerreiro, J.F. (2018) Radiobiological characterization of  $^{64}\text{CuCl}_2$  for prostate cancer theranostics. Workshop 'Imaging and therapeutic targeting in cancerology: New advances and trends in preclinical and clinical studies', Le Bono (France) 26-29 September. Oral

Lage, J., Almeida, S.M., Manteigas, V., d'Espiney, A., Almeida-Silva, M., Canha, N. (2018) Os espaços verdes no desempenho ambiental das escolas ClimACT. CIALP - Conferência Internacional de Ambiente em Língua Portuguesa, Aveiro (Portugal) 8-10 May

Lima, T.A.L., Moens, J., Villareal, R., Bosne, E., Costa, A., Correia, J.G., da Silva, M.R., Springholz, G. et al (2018) Sub-lattice displacement in multiferroic Rashba semiconductor (Ge,Mn)Te (IS648). 2018 ISOLDE Workshop and Users Meeting, CERN, Geneva (Switzerland) 5-7 December. Oral

Marques R., Prudêncio M.I., Rocha F., Ferreira da Silva E., Sousa A.J. (2018) Trace and major elements distribution in topsoils from Fogo and Brava islands (Cape Verde). 27<sup>th</sup> Colloquium of

African Geology (27 CAG) and 17<sup>th</sup> Conference of the Geological Society of Africa (GSAf17), Aveiro (Portugal) 21-28 July. Oral

Marques R., Prudêncio M.I., Waerenborgh J.C., Vieira B., Dias M.I., Russo D., Cardoso G. (2018) Geochemistry Of Surficial Environments Of Oceanic Volcanic Islands In Arid And Semi-Arid Climates – A Contribution To Regional Development Planning. 2<sup>nd</sup> Workshop C<sup>2</sup>TN - Radiation for Science and Society, CTN-IST, Bobadela (Portugal) 11 December. Poster

Marques, F., Guerreiro, J.F., Rodrigues, C., Belchior, A., Waerenborgh, J.C., Vieira, B.J.C. et al (2018) Metallacarboranes with dual application in boron neutron capture therapy and radiation therapy: biological studies in human glioblastoma cells. PBSI2018 – Int. Conf. on Phosphorus, Boron and Silicon, Barcelona (Spain) 10-12 December

Martins, V., Almeida, S. M., Faria, T., Canha, N., Diapouli, E., Manousakas, M., Eleftheriadis, K. (2018) Child Exposure to Indoor and Outdoor PM at Schools and Homes in the Lisbon Metropolitan Area, Portugal. 10<sup>th</sup> International Aerosol Conference, St. Louis, Missouri, (USA) 2-7 September

Martins, V., Faria, T., Canha, N., Almeida-Silva, M., Diapouli, E., Manousakas, M., et al (2018) Distribuição Granulométrica da Massa de Partículas Amostradas no Interior e Exterior de Casas e Escolas de Lisboa. CIALP - Conferência Internacional de Ambiente em Língua Portuguesa, Aveiro (Portugal) 8-10 May

Matos, J.C., Gonçalves, M.C., Pereira, L.C.J., Waerenborgh, J.C. (2018) Synthesis and characterization of SPIONs for smart theranostics. NanoMedicine International Conference 2018, NanoMed 2018, Venice (Italy) 23-25 October

Outis, M., Leal, J.P., Cruz, H., Casimiro, M.H., Ferreira, L.M., Fernandes, F., Monteiro, B., et al (2018) Photoluminescence and thermochemical properties of highly emissive Eu(III) ionic liquids. 12<sup>th</sup> Inorganic and Bioinorganic Chemistry Conference, Porto (Portugal), July

Paiva I. et al. (2018) Portuguese Involvement in Radioactive Waste RD&ET Activities. TP' Eight Exchange Forum, BMW, Berlin (Germany) 3-4 December. Poster

Paiva, I., Dias, M.I., Prudêncio, M.I., R. Marques, J.P. Leal, J.C. Waerenborgh, J. Marçalo, M. Reis et al (2018) Rare Earths in Secondary Resources - Project ENVIREE (ERA-MIN), 3rd Workshop "Cultural Heritage & GeoProcesses, Strategic Resources and Global Change, C2TN Thematic Strand - Earth Systems, Radioactivity and Cultural Heritage, CTN-IST, 24 October

Paiva, I., Reis, M., Madruga, M.J., Andrade, E., Araújo, M.F., Dias, M.I., Prudêncio, M.I. et al (2018) Radioactive Waste: Research, Education And Training, Public Perception And Societal Acceptance. 2<sup>nd</sup> Workshop C<sup>2</sup>TN - Radiation for Science and Society, CTN-IST, Bobadela (Portugal) 11 December. Poster

Palma, E. (2018) Bis(thiosemicarbazonato)<sup>64</sup>Cu(II) complexes: Structure-Activity Relationships and Mechanistic studies. 3<sup>rd</sup> Meeting of the College of Chemistry (3ECQUL), Lisbon (Portugal) June 27-28

Pasturel, M., Brisset, N., Gonçalves, A.P., Chowdury, S., Fryars, S., Gouttefangeas, F., Joanny, L., Tougait, O. (2018) Spark Plasma Sintering of uranium carbides and silicides. 48<sup>èmes</sup> Journées des Actinides, Hotel Golf Mar, Praia de Porto Novo (Portugal) 21-24 March

Pereira, C.C.L., Gomes da Silva, M.R., Leal, J.P., Monteiro, B. (2018) Carbon Dioxide as building block in the synthesis of the anti-infective agent hexamine. 12<sup>th</sup> Inorganic and Bioinorganic Chemistry Conference, Porto (Portugal), July

Pereira, D.R., Díaz-Guerra, C., Peres, M., Magalhães, S., Correia, J.G., Marques, J.G., Silva, A.G. et al (2018) Strain and defect engineering of molybdenum oxide lamellar crystals by ion implantation. 21<sup>st</sup> International Conference on Ion Beam Modification of Materials (IBMM 2018), San Antonio (USA) 24-29 June. Poster

Pereira, D.R., Díaz-Guerra, C., Peres, M., Magalhães, S., Correia, J.G., Marques, J.G., et al (2018) Strain and electrical conductivity induced by ion implantation in  $\alpha$ -MoO<sub>3</sub> lamellar crystals. 1<sup>st</sup> Iberian meeting of materials science (CNMAT 2018), Salamanca (Spain) 4-6 July. Oral

Pereira, L.C.J., Coutinho, J.T., Antunes, M.A., Almeida, M. (2018) Single-Ion Magnets based on Uranium Compounds. 48<sup>èmes</sup> Journées des Actinides, Hotel Golf Mar, Praia de Porto Novo (Portugal) 21-24 March

Pereira, L.C.J., Coutinho, J.T., Perfetti, M., Baldoví, J.J., Antunes, M.A., Hallmen, P.P., et al (2018) First steps towards the rational development of uranium single molecule magnets, SPINON Workshop 2018 Multifunctional Magnetic Materials, Academia das Ciências, Lisbon (Portugal) 1-2 October

Pereira, L.M.C., Wahl, U., Correia, J.G. (2018) Nuclear probes with non-conventional isotopes. 2018 ISOLDE Workshop and Users Meeting, CERN, Geneva (Switzerland) 5-7 December. Oral

Prudêncio M. I., Marques R., Waerenborgh J.C., Rocha F., Vieira B. J. C., Dias M. I., Silva T.P. (2018) REE and Fe crystalchemistry in topsoils of Fogo Island (Cape Verde). 27<sup>th</sup> Colloquium of African Geology (27 CAG) and 17<sup>th</sup> Conference of the Geological Society of Africa (GSAf17), Aveiro (Portugal) 21-28 July. Oral

Redondo-Cubero, A., David-Bosne, E., Wahl, U., Miranda, P., da Silva, M.R., Correia, J.G., Lorenz, K. (2018) Ion channeling patterns as a tool for strain measurement in lattice-matched AlInN/GaN bilayers. 1<sup>st</sup> Iberian meeting of materials science (CNMAT 2018), Salamanca (Spain) 4-6 July. Oral

Reis, M. (2018) Improving Decision Making in Nuclear Emergencies – The CONFIDENCE Project. Workshop C2TN - Thematic strands: cultural heritage & geoprocesses, strategic resources and global change, CTN-IST, Bobadela (Portugal) 23-24 October

Relvas, H., Ferreira, J., Lopes, D., Rafael, S., Almeida, S.M., Miranda, A.I. (2018) Improving air quality and human health: an approach based on artificial neural networks. Air Pollution 2018 - 26<sup>th</sup> International Conference on Modelling, Monitoring and Management of Air Pollution, Naples (Italy) 19-21 June

Rocha-Rodrigues, P., Leal, T., Oliveira, G.N.P., Moreira, R., Teixeira, R.C.C., Miranda, I.P. et al (2018) Perturbed Angular Correlation  $\gamma$ - $\gamma$  measurements on Naturally Layered Perovskites Ca<sub>n+1</sub>Mn<sub>n</sub>O<sub>3n+1</sub>. ISOLDE Workshop and Users Meeting, CERN, Geneva (Switzerland) 5-7 December. Oral

Rodrigues, A.L. (2018) Estudos de luminescência para a identificação de tecnologias de exploração mineira na pré-história. Workshop C2TN - Thematic strands: cultural heritage & geoprocesses, strategic resources and global change, CTN-IST, Bobadela (Portugal) 23-24 October. Oral

Rodrigues, A.L., Dias, M.I., Cardoso, G., Prudêncio, M.I., Marques, R., Russo, D., et al (2018) Identifying archaeological “firesetting” evidence by luminescence protocols at the La Turquesa mine in Catalonia, Spain. UK Luminescence and ESR dating meeting, Sheffield (United Kingdom) 11-12 September. Poster

Rodrigues, A.L., Dias, M.I., Prudêncio, M.I., Flor, P. (2018) Cronologia e tecnologias de produção de esculturas de Della Robia em Portugal. A Universidade de Lisboa e o património - 1º ENCONTRO – Instituto Superior Técnico, Lisbon (Portugal) 19-20 November. Poster

Rodrigues, A.L., Dias, M.I., Prudêncio, M.I., Marques, R., Cardoso, G., Russo, D. (2018) Nuclear and radiation-based methods as tools to cultural heritage safeguard. 2<sup>nd</sup> Workshop C<sup>2</sup>TN - Radiation for Science and Society, CTN-IST, Bobadela (Portugal) 11 December. Poster

Rodrigues, A.L., Dias, M.I., Valera, A.C., Prudêncio, M.I., Marques, R., Cardoso, G., Franco, D. (2018) Luminescence and compositional studies to the establishment of fill dynamics in Neolithic/Chalcolithic ditch enclosures from south of Portugal. 42<sup>nd</sup> International Symposium on Archaeometry (ISA 2018), Mérida, Yucatán (Mexico). 20-26 May. Poster

Rodrigues, A.L., Valério, P., Dias, M.I., Prudêncio, M.I., Araújo, M.F., Soares, A.M., et al (2018) Entre a ciência e o património cultural. Sessão sobre o Objetivo de Desenvolvimento Sustentável 11 - Cidades e Comunidades Sustentáveis - ODS.11, Salvar o Património Cultural e Natural. Encontro Ciência 2018, Centro de Congressos de Lisboa, Lisbon (Portugal) 2-4 July. Oral

Rodrigues, A.P., Cabo Verde, S., Casimiro, M.H., Correia, V.H., Coroado, J., Ferreira, L.M. (2018) Hybrid materials for the conservation of Roman mosaics: preventing biodeterioration. IBBS 2018 – New Trends in Cultural Heritage Biodeterioration, Coimbra (Portugal) 5-7 September

Rodrigues, A.P., Cabo Verde, S., Casimiro, M.H., Correia, V.H., Coroado, J., Ferreira, L.M. (2018) O cubículo da Casa do Tridente e da Espada – Um caso de consolidação em Conímbriga. Workshop C<sup>2</sup>TN - Thematic strands: cultural heritage & geoprocesses, strategic resources and global change, CTN-IST, Bobadela (Portugal) 23-24 October

Rodrigues, A.P., Cabo Verde, S., Casimiro, M.H., Correia, V.H., Coroado, J., Ferreira, L.M. (2018) A case study of consolidation in Conímbriga: the House of Trident and Sword. Technical Meeting on Strategies for Preservation and Consolidation of Cultural Heritage Artefacts through Radiation Processing, Zagreb (Croatia) 4-8 June

Rogl, G., Rogl, P., Michor, H., Giester, G., Gonçalves, A.P. (2018) Structure and properties of a novel boride ThNi<sub>12</sub>B<sub>6</sub>. 48<sup>èmes</sup> Journées des Actinides, Hotel Golf Mar, Praia de Porto Novo (Portugal) 21-24 March

Sanjurjo Sánchez, J., Blanco-Rotea, R., Prudêncio, M.I., Dias, M.I. (2018) OSL dating of lime mortars in a singular building of NW Spain: Sta. Eulalia de Boveda (Lugo). MoDIM 2018: Mortar Dating International Meeting, Bordeaux (France) 25-27 October. Oral

Silva, R.A.L., Andrade, M.M., Santos, R., Lopes, E.B., Pereira, L.C.J., Coutinho, J.T., Santos, I.C. et al (2018) Thiophenic bisdithiolenes Complexes as Single Component Molecular Conductors. 43<sup>rd</sup> International Conference on Coordination Chemistry (ICCC2018), Sendai (Japan) July 30-August 4. Oral

Soares, J., Valério, P., Soares, A.M.M. & Araújo, M.F. (2018). Depósito metálico de Agro Velho - Montalegre. A insólita biografia de um artefacto cruzada com o incêndio dos museus da Faculdade de Ciências em 1978. 3<sup>o</sup> Encontro de Museus com Coleções de Arqueologia. Museu Nacional de Arqueologia, Lisboa, 19 October.

Teles, P. (2018) Fano theory validation of the MCNP6.0 Monte Carlo code for medical applications. 2<sup>nd</sup> European Congress in Medical Physics, Copenhagen (Denmark) 23-25 September. Oral

Vultos, F., Belo, M., Scheepstra, M., Silva, F., Fernandes, C., Oliveira, M. C., Mendes, F., et al (2018) Biological Assessment of a Radiolabelled LXXLL-Peptide for Breast Cancer Theranostics. 19<sup>th</sup> European Symposium on Radiopharmacy and Radiopharmaceuticals, Groningen, (Netherlands) April

Waerenborgh, J.C., Vieira, B.J.C., Capinha de Matos, J. (2018) Mössbauer spectroscopy an invaluable technique in materials science. 2<sup>nd</sup> Workshop C<sup>2</sup>TN - Radiation for Science and Society, CTN-IST, Bobadela (Portugal) 11 December

Wahl, U., Correia, J.G., Costa, A., David-Bosne, E., Lima, T.A.L., Lippertz, G., da Silva, M.R. et al (2018) Lattice sites of implanted Mg in different doping types of GaN. 21<sup>st</sup> International Conference on Ion Beam Modification of Materials (IBMM 2018), San Antonio (USA) 24-29 June. Poster

Wahl, U., Correia, J.G., Pereira, L.M.C. (2018) Portuguese and Belgian experiments with radioactive probes in solids at ISOLDE/CERN. 2018 IAEA Technical Meeting on Novel Multidisciplinary Applications with Unstable Ion Beams and Complementary Techniques, Vienna (Austria) 10-14 December. Oral

Wahl, U., Costa, A., Lima, T.A.L., Moens, J., Correia, J.G., da Silva, M.R., Temst, K., et al (2018) IS634: First results on the temperature dependence of the <sup>11</sup>Be lattice location in GaN. 2018 ISOLDE Workshop and Users Meeting, CERN, Geneva (Switzerland) 5-7 December. Poster

## Seminars Given

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Almeida, S.M (2018) ClimACT – Acting for the transition to a low carbon economy in schools. Conference CTC promoted by Escola Superior de Tecnologia da Saúde de Lisboa, Lisbon (Portugal) 23 March.

Almeida, S.M (2018) Indoor air quality: measures to reduce exposure to pollutants. Commemorative Session “Safety and Health at Work”, Instituto Superior Técnico, Lisbon, (Portugal) 9 May.

Almeida, S.M (2018) LIFE Index-Air: Development of a decision support tool to reduce exposure to atmospheric particles. 34<sup>th</sup> Meeting of the Air Working Group, event promoted by Agência Portuguesa do Ambiente, Alfragide (Portugal) 2 March

Almeida, S.M. (2018) Low carbon schools. ClimACT Project. National Seminar of the Eco-Schools 2018, Guimarães (Portugal) 27 January

Almeida, S.M. (2018) Transição para a Faculty Life, Basic training for teachers and auxiliary researchers in experimental period, Lisbon (Portugal) 5-7 September

Antunes, J. (2018) "The Udwadia-Kalaba formulation and its application for the physical modelling of string instruments". General seminary at the Institut d'Alembert, Université Pierre et Marie Curie, Sorbonne Université, Paris (France) 31 May

Cabo Verde, S. (2018) Aplicações de Radiação Ionizante. Mestrado em Proteção e Segurança Radiológica, Instituto Superior Técnico, Universidade de Lisboa, 3 October

Cabo Verde, S. (2018) Ionizing radiation applications. Unidade curricular Efeitos da Radiação, Mestrado em Bioquímica, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 14 May

Cabo Verde, S. (2018) Irradiação de Alimentos: uma tecnologia para a segurança alimentar. Unidade curricular Higiene e Segurança Alimentar, Curso Curso Saúde ambiental, Escola Superior de Tecnologia de Saúde de Lisboa, 6 April

Carreira, P.M. (2018) Aplicações de isótopos estáveis no Ciclo da Água. Casos de estudo - Seminários em Ciências da Engenharia da Terra, do 3º ano, Curso de Engenharia Geológica e de Minas. Instituto Superior Técnico, Universidade de Lisboa. 28 November

Carreira, P.M. (2018) Datação de sistemas aquíferos minerais e geotérmicos. Mestrado em Engenharia Geológica e de Minas - Disciplina Recursos Hidrominerais e Geotérmicos. IST – U. Lisboa, 21 April

Correia, J.G. (2018) Friendly Hyperfine Interactions between matter and (radioactive) nuclei - Can we p-type dope the transparent semiconductor  $\beta$ -Ga<sub>2</sub>O<sub>3</sub>? ISOLDE group seminar: ISOLDE, CERN, Geneva (Switzerland) 7 March

Cravo Sá, A. (2018) Monte Carlo Validation of 6MV Varian 2100 CD Linear Accelerator. Jornadas de Doutoramento, Physics Department, Faculdade de Ciências, Universidade de Lisboa, February

Galinha C. (2018) Níveis de selénio em solo agrícola e na alimentação. Seminário sobre a deficiência de selénio em Portugal, PharmaNord. 18 January, Leiria. 8 February, Coimbra. 22 February, Braga. 15 March, Torres Vedras. 22 March, Porto. 19 April, Lisboa. 17 May, Funchal

Lage, J., Almeida, S.M., Manteigas, V., Almeida-Silva, M., Canha, N., Alexandre, J.L., Gonçalves, K. et al (2018) O papel das escolas no combate às alterações climáticas: o projecto ClimACT. Ciclo da Cultura e do Conhecimento (C3), Ponte de Sôr (Portugal) 3 November

Lage, J., Almeida, S.M., Manteigas, V., Almeida-Silva, M., Canha, N., Alexandre, J.L., Gonçalves, K. et al (2018) The ClimACT project - to promote the transition to a low carbon economy in schools. Loures InSS 2018, Loures (Portugal) 5 June

Leal, J.P. (2018) Todos temos energia, Externato da Luz, Lisbon (Portugal) May

Mário Reis, (2018) CONFIDENCE - Coping with uncertainties for improved modelling and decision making in nuclear emergencies. Infoday, INSA, 22 February

Mário Reis. (2018) Radiation Protection of the Environment, Programme for Education, Training and Research on Underground Storage. European Master Science on the framework of the PETRUS III project, IST, 22 June (by videoconference)

Marques, R. (2018) “Atlas Geoquímico de Cabo Verde” no âmbito da disciplina de Seminários em Ciências da Engenharia da Terra do 3º ano do Curso de Engenharia Geológica e de Minas, 29 November

Marques, R. (2018) Análise por Activação com neutrões (AAN) no âmbito do Mestrado em Protecção e Segurança Radiológica (2017-2019) do IST, Unidade Curricular Resíduos Radioactivos (66h/2º semestre), 22 May

Monteiro Gil, O. (2018) Protecção e Segurança Radiológica - Efeitos biológicos da exposição a radiação ionizante. Faculdade de Ciências e Tecnologia UNL, Campus da Caparica (Portugal) 28 May

Reis, M. (2018) Protecção Radiológica – A Radioactividade no Ambiente. Seminários em Ciências da Engenharia da Terra do 3º ano do curso de Eng. Geológica e de Minas, IST, 15 November

Teles, P. (2018) A Física e a Radiação na Fronteira com a Medicina. TEDxYouth@EstorilSchool, Colégio Salesianos, Estoril, 30 May

Teles, P. (2018) Níveis de Referência de Dose em Medicina Nuclear 2013-2018 – resultados preliminares. Workshop NRD – Portugal, ESTeSC, Coimbra, 7 December

Valério, P. (2018) Metalurgia na Antiguidade. Metodologias analíticas e casos de estudo. Licenciatura em Arqueologia – Disciplina de Mineração e Metalurgia na Antiguidade, Faculdade de Letras, Universidade de Lisboa. 28 October

Vaz, P. (2018) Computational Dosimetry and Modelling in support of Radiation Protection. Faculdade de Ciências e Tecnologia UNL, Campus da Caparica (Portugal) 28 May

Wahl, U. (2018) Influence of Fermi-level on the lattice location of <sup>27</sup>Mg in GaN. Work group seminar, Instituut voor Kern- en Stralingsfysica, KU Leuven, Leuven (Belgium) 9 February

## Seminars and Workshops at C<sup>2</sup>TN

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During 2018, C<sup>2</sup>TN organized and hosted several scientific meetings, as well as a regular series of seminars by internal and external researchers.

### MEETINGS

**EURADOS Annual Meeting 2018 (AM2018) & Winter School on “Application of physical and computational phantoms in dose assessment”**

5 to 8 February 2018

IST, Congress Centre, Lisbon (Portugal)

**4th Conference on Small Animal Precision Image-Guided Radiotherapy**

12 to 14 March 2018

CTN-IST, Bobadela (Portugal)

**48<sup>èmes</sup> Journées des Actinides (JdA2018) & 12th School on the Physics and Chemistry of the Actinides (12<sup>th</sup> SPCA)**

19 to 22 March 2018

CTN-IST, Bobadela (Portugal) & Hotel Golf Mar, Praia de Porto Novo (Portugal)

**ChemMat Doctoral Programme Workshop**

19 November 2018

CTN-IST, Bobadela (Portugal)

**Defense and Security Workshop**

21 November 2018

CTN-IST, Bobadela (Portugal)

**Workshop NRD Portugal**

7 December 2018

Escola Superior de Tecnologia da Saúde de Coimbra, Coimbra (Portugal)

**2<sup>nd</sup> C<sup>2</sup>TN Workshop**

11 December 2018

CTN-IST, Bobadela (Portugal)

### SEMINARS

Conflict, Risk, and Resilience: A two-step process to overcome NIMBY and coordination failures  
**Prof. José Palma-Oliveira** - University of Lisbon, Lisbon (Portugal) 18 January

Modeling and simulations for nuclear science and engineering applications  
**Bojan Petrovic** - Georgia Institute of Technology, Atlanta, GA (USA) 19 March

Materials analysis by high energy heavy ions, focused protons, and low energy positrons  
**Günther Dollinger** - Universität der Bundeswehr München (Germany) 22 March

First-row transition-metal-based molecular sensors and molecular switches  
**Paulo N. Martinho** - CQB, Faculdade de Ciências, Universidade de Lisboa (Portugal) 12 April

What's next? ERC and Interreg Sudo  
**Marta Ferraz Dias** - C<sup>2</sup>TN-IST, Universidade de Lisboa (Portugal) 4 October

Current Status of Radiation Processing in Syria: Cultural Heritage Consolidation  
**Zaki Ajji** - Atomic Energy Commission, Department of Chemistry, Division of Analytical Chemistry, Damascus (Syria) 29 November

### COURSES GIVEN IN UNIVERSITIES AND POLYTECHNICAL SCHOOLS

Almeida, M. – Course on “Electrical and Magnetic Properties of Materials”, doctoral programme in Chemistry (ChemMat), Instituto Superior Técnico (2<sup>nd</sup> semester 2017-2018)

Almeida, S.M. (2018) Responsible for the Course “Air Quality Management”, MSc Environmental Engineering, Instituto Superior Técnico, Universidade de Lisboa

Almeida, S.M. (2018) Responsible for the Course “Air Quality Management”, BSc Saúde Ambiental, Escola Superior de Tecnologia da Saúde de Lisboa, Instituto Politécnico de Lisboa

Araújo, M.F. – Invited Lecturer, in “Energy Dispersive X-ray Fluorescence Spectrometry” in the framework of one semester course on “Examination and Analysis Methods I” for the MSc’s in “Conservation and Restoration”, Departamento de Conservação e Restauro, FCT, UNL, January – February 2018

Belchior, A. – Collaboration as lecturer in the Curricular Unit “Radiation Dosimetry and Shielding”, Master’s degree in Radiation Protection and Safety, IST (1<sup>st</sup> semester 2017/2018 and 2018/2019)

Belo, D. – Course of Química Geral Mestrado Integrado em Engenharia Electrotécnica e de Computadores (1<sup>st</sup> semester 2018-2019)

Cabo Verde, S. – Microbial inactivation by ionizing radiation for the Microbial Biotechnology curricular unit of the Degree in Biology, FCUL, November-December 2018

Cabo Verde, S. – Sistemas de Gestão de Qualidade – HACCP: Hazard Analysis and Critical Control Point for Biotechnology, curricular unit of the Master degree in Applied Microbiology, FCUL, April 2018

Caldeira, M. – Collaboration as lecturer in the Curricular Unity “Metrologia das Radiações Ionizantes na Saúde e na Indústria”, Master’s degree in Radiation Protection and Safety, IST (1<sup>st</sup> semester 2017/2018 and 2018/2019)

Corisco, J. – Collaboration as lecturer in the Curricular Unit “Environmental Radioactivity”, Master’s degree in Radiation Protection and Safety, IST (1<sup>st</sup> semester 2017/2018 and 2018/2019)

Cravo Sá, A. – Invited lecturer of medical imaging and radiotherapy department, Escola Superior Tecnologia da Saúde de Lisboa, Instituto Politécnico de Lisboa. Curricular units: technologies in medical imaging and radiotherapy I and II, Image processing in medical imaging and radiotherapy, fundamental of medical imaging and radiotherapy, clinical dosimetry I and II

Cravo Sá, A. – Invited lecturer of medical imaging and radiotherapy department, Escola Superior de Saúde Dr<sup>o</sup> Lopes Dias, Instituto Politécnico de Castelo Branco. Curricular units: oncology, methods and techniques in medical imaging and radiotherapy III and IV, bioethics applied to medical imaging and radiotherapy, case studies in radiotherapy, care for the cancer patient, research applied to medical imaging and radiotherapy

Crespo R. – Laboratório de Eletromagnetismo e Termodinâmica (LET) (2<sup>nd</sup> semester), IST

Crespo R. – Electromagnetismo e Óptica (EO221795) (1<sup>st</sup> semester), IST

Dias M.I. – Curricular unit “Radioactive wastes” Master “Protecção e Segurança Radiológica”, IST

Dias M.I. – Opcional curricular unit “Environmental Reconstruction and Geochronology” Integrated Master in Engenharia do Ambiente, IST

Kling A., Fernandes A.C. – subject “Risks and Safety in the Application of Ionising Radiations”, Master in Radiation Protection and Safety, IST (1<sup>st</sup> semester of 2<sup>nd</sup> year: Sep-Dec 2018)

Lage J. – Responsible for the Course “Air Pollution”, BSc Environmental Engineering, Faculty of Engineering of Universidade Lusófona de Humanidades e Tecnologias de Lisboa

Lage J. – Responsible for the Course “Occupational Health”, BSc Saúde Ambiental, Escola Superior de Tecnologia da Saúde de Lisboa, Instituto Politécnico de Lisboa

Leal J.P. – Invited Teacher, Department of Chemical Engineering, Instituto Superior Técnico, Universidade de Lisboa, Physical Chemistry discipline, in IST integrated Master course of Chemical Engineering (2<sup>nd</sup> semester 2017/2018)

Leal J.P. – Invited Teacher, Department of Chemical Engineering, Instituto Superior Técnico, Universidade de Lisboa, General Chemistry discipline, in IST integrated Master course of Electrical and Computer Engineering (1<sup>st</sup> semester 2018/2019)

Lopes, E.B. – Experimental class of Advanced Experimental Physics (MEFT), Instituto Superior Técnico (3<sup>rd</sup> year, 2<sup>nd</sup> semester 2017-2018)

Madruga, M.J. – Collaboration as lecturer in the Curricular Unit “Environmental Radioactivity”, Master’s degree in Radiation Protection and Safety, IST (1<sup>st</sup> semester 2017/2018 and 2018/2019)

Marçalo, J. – Lecturer on Actinide Chemistry in the Radioactive Waste Course of the Bologna Master Degree in Radiation Protection and Safety – IST (2<sup>nd</sup> semester 2017/2018)

Marques, R. – Lecture on Neutron Activation Analysis, Radioactive wastes subject, MSc Radiation Protection and Safety, Instituto Superior Técnico, 2017-2018

Marques, R. – Lecture on “Geochemical atlas of Cape Verde”, Ciências da Engenharia da Terra (3<sup>o</sup> ano do Curso de Engenharia Geológica e de Minas), Instituto Superior Técnico, 2018

Mendes, F. – Genetic Engineering, Integrated Masters in Biological Eng and Biomedical Eng, ECTS 4,5 (average 3h/week – lectures and laboratory classes), Department of Bioengineering, Instituto Superior Técnico, Universidade de Lisboa

Mendes, F. – Molecular Biotechnology - Masters in Biotechnology, Microbiology and Radiation Protection and Safety, ECTS 4,5 (average 3h/week – lectures and laboratory classes), Department of Bioengineering, Instituto Superior Técnico, Universidade de Lisboa

Monteiro Gil, O. – Responsible for the Curricular Unit “Efeitos Biológicos das Radiações”, Master’s degree in Radiation Protection and Safety, IST (2<sup>nd</sup> semester 2017/2018)

Paiva, I. – Responsible for the Curricular Unit “Radioactive Waste”, Master’s degree in Radiation Protection and Safety, IST (2<sup>nd</sup> semester 2017/2018)

Paulo, A. – Invited Coordinator Professor at ESTeSL, Disciplines: Radiopharmacy I (2<sup>nd</sup> year, 1<sup>st</sup> Semester), Radiopharmacy II (2<sup>nd</sup> year, 2<sup>nd</sup> Semester)

Pereira, L.C.J. – Course on “Electrical and Magnetic Properties of Materials”, doctoral programme in Chemistry (ChemMat), Instituto Superior Técnico (2<sup>nd</sup> semester 2017-2018)

Pinhão, N., Alves, L.C. – Systems and Techniques of Radiation Detection, Bologna Master Degree in Radiation Protection and Safety, Dept. de Ciências e Engenharias Nucleares, Instituto Superior Técnico (1<sup>st</sup> Semester 2017/2018)

Reis, M. – Responsible for the Curricular Unity “Metrologia das Radiações Ionizantes na Saúde e na Indústria”, Master’s degree in Radiation Protection and Safety, IST (1<sup>st</sup> semester 2017/2018 and 2018/2019)

Reis, M. – Responsible for the Curricular Unity “Radioactividade Ambiente”, Master’s degree in Radiation Protection and Safety, IST (1<sup>st</sup> semester 2017/2018 and 2018/2019)

Soares, A.M.M. – Invited Lecturer in “Isotope Analysis”, “Radiocarbon Dating” and “Luminescence Dating” in the framework of one semester course on “Examination and Analysis Methods II” for the Master degrees in “Conservation and Restoration”, FCT/UNL, February 2018

Teles, P. – Collaboration as lecturer in the Curricular Unit “Radiation Dosimetry and Shielding”, Master’s degree in Radiation Protection and Safety, IST (1<sup>st</sup> semester 2017/2018 and 2018/2019)

Teles, P. – Collaborator at the Nuclear Engineering and Sciences Department of IST (‘Dosimetry and Shielding of Radiation’, Masters, 1st semester 2017/2018)

Vaz, P. – Responsible for the Curricular Unit “Física e Engenharia Nuclear”, Master’s degree in Radiation Protection and Safety, IST (2<sup>nd</sup> semester 2017/2018)

Vaz, P. – Responsible for the Curricular Unit “Radiation Dosimetry and Shielding”, Master’s degree in Radiation Protection and Safety, IST (1<sup>st</sup> semester 2017/2018 and 2018/2019)

Waerenborgh, J.C. – Lectures on Mössbauer Spectroscopy, Radioactive wastes subject, MSc Radiation Protection and Safety, Instituto Superior Técnico, 2017-2018

## SHORT COURSES GIVEN IN INTERNATIONAL ORGANIZATIONS

Almeida, S.M., Canha, N. – Workshop "Teaching STEM Students - Transformation Guide for Teaching Assistants 1st Ed." (6h), Academic Development Office of Instituto Superior Técnico de Universidade de Lisboa (NDA), 10 and 12 September

Almeida, S.M., Galinha, C. – Training School on Black and Brown Carbon, Jožef Stefan Institute, Ljubljana, Slovenia, 15-17 January

Alves, J.G. – Lectures given at the DOSEtrace Training Course on Metrology and Calibration in Radiation Protection, held at IST-Campus Tecnológico e Nuclear, 24-27 September

Carreira, P.M. – Improving Knowledge of Groundwater Resources to Contribute to their Protection, Integrated Management and Governance (ARCAL CXXXV). IAEA – Isotope Hydrology Section Expert on the introduction of isotope techniques in solving hydrological problems. Training course organized by the IAEA and ANA (Agência Nacional de Águas –National Water Agency) Brasília (Brazil) 6-10 March

Correia, J.D.G. – Invited lecturer, Lecture on “Radiometallated Peptides and Proteins”, Summer School “Development and Pre-clinical Evaluation of Radiopharmaceuticals”, organized by the MCurie Innovative Training Network "MEDICIS-Promed"

Coutinho, J. – Regional Training Course with the purpose of setting harmonized procedures for air particulate matter characterization using nuclear and complimentary techniques - The International Atomic Energy Agency Headquarters, Seibersdorf (Austria) 3-14 December

Coutinho, J. – Short Term Scientific Mission on aerosol source apportionment in a traffic site combining on-line and off-line measurements - COST Action CA16109 COLOSSAL (Chemical On-Line cOmpoSition and Source Apportionment of fine aerosol), Jožef Stefan Institute and AEROSOL d.o.o., Ljubljana – Slovenia, 20 October-16 November

Fernandes, C. – Invited lecturer, Lecture on “Analytical control and purification of radiopharmaceuticals”, Summer School “Development and Pre-clinical Evaluation of Radiopharmaceuticals”, organized by the MCurie Innovative Training Network "MEDICIS-Promed"

Gano, L. – Invited Lecturer, Lecture on “*In vivo* evaluation - Animal Models, Biodistribution and Metabolism Studies”, Summer School “Development and Pre-clinical Evaluation of Radiopharmaceuticals”, organized by the MCurie Innovative Training Network "MEDICIS-Promed"

Lage, J. – Advocacy Bootcamp camp training on promotion and lobbying, to support approved projects in their marketing and capitalisation actions, organized by the Interreg Sudoe Programme addressed to the project’s communication responsible, Faro (Portugal) 28-29 June

Lage, J. – Training course in Communication focused on Digital Communications and Social Media, Video and Photography Skills, Public and Media Relations, promoted by the RegioStars organization, European Commission, to the projects finalists’ communication responsables. 18-20 September, Brussels (Belgium)

Lage, J., Canha, N. – Training School on source apportionment of organic aerosol - COST Action CA16109 COLOSSAL (Chemical On-Line cOmpoSition and Source Apportionment of fine aerosol), Institute of Chemical Process Fundamentals of the CAS, Prague (Czech Republic) 15-17 February

Lage, J., Canha, N. – Training School on ToF-ACSM - COST Action CA16109 COLOSSAL (Chemical On-Line cOmpoSition and Source Apportionment of fine aerosol), Institute of Chemical Process Fundamentals of the CAS, Prague (Czech Republic) 15-17 February

Mendes, F. – Invited lecturer, Lecture on “Molecular and Cell Biology methods for validation of (imaging) biomarkers”, Summer School “Development and Pre-clinical Evaluation of Radiopharmaceuticals”, organized by the MCurie Innovative Training Network "MEDICIS-Promed"

Paulo, A. – Invited lecturer, Lecture on “Matching Chelators and Radiometals”, Summer School “Development and Pre-clinical Evaluation of Radiopharmaceuticals”, organized by the MCurie Innovative Training Network "MEDICIS-Promed"

Raposo, P. – Invited Lecturer, Lecture on “*In vitro* evaluation- Cell-Based Assays”, Summer School “Development and Pre-clinical Evaluation of Radiopharmaceuticals”, organized by the MCurie Innovative Training Network "MEDICIS-Promed"

## SHORT COURSES GIVEN IN NATIONAL INSTITUTIONS

Almeida, S.M. – Seminar “Indoor Air Quality in Buildings’ Maintenance”, Post-Graduation in Maintenance Management, Instituto de Soldadura e Qualidade.

Alves, J.G. – Session Conceitos de Proteção Radiológica. 4º Curso de Resposta a Emergências Radiológicas organized by Autoridade Nacional de Proteção Civil (ANPC), Castelo Branco, 16-18 January

Correia, J.D.G – Invited teacher, Lecture on “Research with Radionuclides”. Preceptorship Program in Bone metastases and bone-targeting agents” organized by Professor Luís Costa from Faculdade de Medicina da Universidade de Lisboa, IMM and Divisão de Oncologia e Radiologia do HSM

Correia, J.D.G. – Invited teacher, Lecture on “Nano-radioteranóstica”. Course “Bionanotecnologia” from several Master programs, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa

Correia, J.D.G. – Invited teacher, Lecture on “Nuclear Techniques /SPECT and PET in Drug Discovery”. Course “Analytical and Imaging Tools in Drug Discovery” from the PhD Program ChemMedTrain, Universidade de Lisboa and Universidade de Coimbra

Correia, J.D.G. – Invited teacher, Lecture on “Radiopharmaceutical Science and Cancer Therapy”. Course “Drug Discovery and Development in Oncology”, Master in Oncobiology, Faculdade de Medicina, Universidade de Lisboa

Gano, L. – Use of radionuclides for in vitro assays, Course “Analytical Methodologies”, Master Course on Clinical Analysis, Faculdade de Farmácia, Universidade de Lisboa

Marçalo, J. – Lecturer on MS in the Course Modern Methods of Structure Elucidation–2018, CQE-IST, Lisbon, 15-19 October

Maria, L. – Lecturer on NMR techniques - Course “Modern Methods of Structure Elucidation–2018”, CQE-IST/C2TN, UL, Lisbon, 15-19 October

Melo, R. – Tutor at the 2018 Summer School in Computational Biology, Faculdade de Ciências, Coimbra, Portugal.

Paulo, A. – Invited teacher, Lecture on “Biodistribution of Nanoparticulate Drug Delivery Systems” COURSE i3DU, PhD Program Advanced Drug Delivery, Faculdade de Farmácia, Universidade de Lisboa

Paulo, A. – Invited teacher, Lecture on “Development of Radioactive Probes for Imaging and Therapy”. Course “Biological Chemistry” from the PhD Program ChemMedTrain, Universidade de Lisboa e Universidade de Coimbra

Paulo, A. – Invited teacher, Lecture on “Radiopharmaceutical Chemistry and Radiopharmaceuticals”. Course “Inorganic Medicinal Chemistry”, Master in Pharmaceutical Sciences, Universidade Lusófona, Lisboa

## Scientific Committees

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Almeida, M. – Chairman of the Organizing Committee of the "13<sup>th</sup> International Symposium on Crystalline Organic Metals, Superconductors and Ferromagnets, ISCOM 2019", Tomar (Portugal) 22-27 September 2019

Almeida, M. – Director of the PhD programme "ChemMat - Materials Chemistry of Nanostructured Materials with Optic Electric and Magnetic Functionalities", FCT (PD/0045/2013) (IST) 2014-2019

Almeida, M. – Executive Committee for Research of Colégio da Química of the University of Lisbon

Almeida, M. – Management Committee of the COST Action CA15128 – MOLECULAR SPINTRONICS (MOLSPIN)

Almeida, M., Branco, J.B., Leal, J.P., Pereira, L.C.J. – Organizing Committee of the 48<sup>èmes</sup> Journées des Actinides, Hotel Golf Mar, Praia de Porto Novo (Portugal) 21-24 March

Almeida, S.M. – Member of the Evaluation Panel of Academy of Finland - Research Council for Natural Sciences and Engineering. Panel for research proposals in the field of Atmospheric sciences. December 2018.

Almeida, S.M. – Member of the Evaluation Panel of EU COST. COST Open Call OC-2018-1. August 2018. Researcher: Member of the Evaluation Panel of Universiteit Antwerpen, University Research Fund. Call GOA BOF 2019-2022. August

Almeida, S.M. – Member of the Evaluation Panel of Lund University - Physics Department at LTH, External expert in reviewing a senior lecture application. May

Almeida, S.M. – Member of the Evaluation Panel of MIUR - Italian Ministry for Education, University and Research. Call for proposal "PRIN 2017". December 2018. Researcher: Member of the Evaluation Panel of Fundação para a Ciência e Tecnologia. Environmental Engineering review panel for PhD fellows. October

Almeida, S.M. – MSc jury – Inês Lopes (2018) Avaliação da exposição de crianças a matéria particulada em ambiente urbano, MSc in Environmental Engineering, Instituto Superior Técnico, 19 November

Almeida, S.M. – PhD External Expert Commission - Marta Becerril Valle (2018) Physico-chemical properties of the atmospheric aerosols in urban and rural areas in Southern Europe, Universidad Complutense de Madrid, Facultad de Ciencias Fisicas

Almeida, S.M. – PhD jury - Carla Gama (2018) Contribuição das poeiras do deserto para o aerossol atmosférico em Cabo Verde e em Portugal, PhD in Environmental Sciences, Universidade de Aveiro, 27 February

Almeida, S.M. – PhD jury - Helder Relvas (2018) Modelos de avaliação integrada para melhorar a qualidade do ar urbano, PhD in Environmental Sciences, Universidade de Aveiro, 10 July

Almeida, S.M. – Scientific Committee "6<sup>th</sup> Iberian Meeting on Aerosol Science and Technology (RICTA 2018)", Bilbao (Spain) 20-22 June

Alves, J. – Moderator of WG1 to WG4 on EPR in two emergency scenarios, IAEA material prepared at the consultancy meeting held in March

Alves, J.G. – Committee of the 4<sup>o</sup> Curso de Resposta a Emergências Radiológicas organized by Autoridade Nacional de Proteção Civil (ANPC), Castelo Branco, 16-18 January

Alves, J.G. – EURADOS Council member. Attended the winter meeting at IST-Lisboa (Portugal) in February and the summer meeting at ENEA, Bologna (Italy) in July

Antunes, A.C., Belchior A., Belo, D., Dias, M.F., Marques, R., Melo, R., Valério, P. - Members of Organizing Committee of 2<sup>nd</sup> Workshop C<sup>2</sup>TN - Radiation for Science and Society, CTN-IST, Bobadela (Portugal) 11 December

Antunes, A.C., Baptista, M., Belchior A., Cravo Sá, A., di Maria, S., Monteiro Gil O., Romanets, Y., Teles, P. – Organizing Committee of the ICDA-3 – International Conference on Dosimetry and Its Applications”, Lisbon, 27-31 May 2019

Antunes, J. – Member of the "Haut Conseil de l'Évaluation de la recherche et de l'Enseignement Supérieur" (HCERES) scientific Committee for the 2018 evaluation of the Institut Jean le Rond d'Alembert, Sorbonne Université, Paris (France)

Antunes, J. – Member of the Cientific Council of the "Institut des Sciences de la Mécanique et Applications Industrielles" (IMSIA), partenariat EDF/CNRS/CEA (France)

Antunes, J. – Member of the scientific Committee of the 2<sup>nd</sup> International Conference on Acoustics and Vibration ICAV'2018, Hammamet (Tunisia) 19-21 March

Antunes, J. – Member of the scientific Committee of the 9<sup>th</sup> International Symposium on Fluid-Structure Interactions, Flow-Sound Interactions, Flow-Induced Vibration & Noise, Toronto (Canada) 8 -11 July

Antunes, J. – Member of the scientific Committee of the International Conference on Condition Monitoring of Machinery in Non-Stationary Operations, Santander (Spain) 20-22 June

Araújo, M.F. – Member of the Scientific Comission IX Symposium on the Iberian Atlantic Margin, Coimbra (Portugal) 4-7 September

Belchior A., Vaz, P. Fourth International Conference on Precision Image-Guided Small Animal Radiotherapy Research, Lisbon (Portugal) 12-14 March

Belchior, A., Romanets, Y. – Organizing and Scientific Committees of EURADOS 2018 Annual Meeting and Workshop

Branco, J.B. – Member of the Directive Board of the FCT Doctoral Programme CATSUS - Catalysis and Sustainability (PD/00248/2012)

Canha, N. – Member of the international scientific committee of the international conference Indoor Air 2018 – 15<sup>th</sup> Conference of the International Society of Indoor Air Quality & Climate, Philadelphia, PA (USA) 22-27 July

Canha, N. – Objective manager of sub-area of “Environment and new energy sources - anthropogenic impact, evaluation, treatment and recycling” of thematic strand “Earth systems, radioactivity and cultural heritage” of C<sup>2</sup>TN-IST. Responsibilities: organization of workshops and promotion of dialogue between peers.

Casimiro, M.H. – Member of the Scientific Commission of the International Conference on Pharmaceutical Sciences and Drug Development (IPSD), Prague (Czech Republic) 5-6 November

Correia, J.G. – Member of: The international advisory committee of the Joint International Conference on Hyperfine Interactions and Nuclear Quadrupole Interactions, since 2007

Correia, J.G. – Member of: The international advisory committee of the international conference on Application of Radiotracers and Energetic Beams in Sciences, ARCEBS 2018

Crespo, R. – Member of the International Advisory Committee Nucleus-Nucleus 2018 Conference

Crespo, R. – Member R3B /FAIR Science Board

Dias, M.I. – Directive board of the Iberian "Sociedade de Arqueometria Aplicada ao Património Cultural" (SAPaC)

Dias, M.I. – Member of Projects evaluation panel - FET-Open RIA. European Project H2020 – work programme 2018-2020

Dias, M.I. – Member of the Management Committee da COST ACTION ES1407 “European network for innovative recovery strategies of rare earth and other critical metals from electric and electronic waste (ReCreew)” 2015 – 2018

Dias, M.I. – Member of the Organizing and Scientific Committee of “A Universidade de Lisboa e o património - 1º ENCONTRO” – Instituto Superior Técnico, Lisbon (Portugal) 19-20 November

Dias, M.I. – Participation in academic jury PhD – Javier García Rivas, “Cristaloquímica y génesis de arcillas magnéticas”. Supervisors: Mercedes Suarez Barrios (Univ. Salamanca) and Emilia Garcia Romero (Univ. Compl. Madrid)

Gonçalves, A.P. – Chairman of the Organizing Committee of the 12<sup>th</sup> School on the Physics and Chemistry of the Actinides (SPCA)”, CTN-IST, Bobadela (Portugal) 19 to 21 March

Gonçalves, A.P. – Chairman of the Organizing Committee of the 48<sup>èmes</sup> Journées des Actinides, Hotel Golf Mar, Praia de Porto Novo (Portugal) 21-24 March

Gonçalves, A.P. – Executive Committee of the European Thermoelectric Society

Gonçalves, A.P. – International Advisory Board of the “International Conference on Solid Compounds of Transition Elements” biannual conference series

Gonçalves, A.P. – International Advisory Board of the “Magnetism and Low Temperatures Laboratories”, Faculty of Mathematics and Physics, Charles University, Prague (Czech Republic)

Gonçalves, A.P. – International Advisory Board of the annual conference series “Journées des Actinides”

Dias, M.F., Gonçalves, A.P. – Organizing Committee of the Workshop “Defense and Security”, CTN-IST, Bobadela (Portugal) 21 November

Leal, J.P. – Management Committee Substitute Member of the COST ACTION ES1407 “European network for innovative recovery strategies of rare earth and other critical metals from electric and electronic waste (ReCreew)” 2015 – 2018

Madrugá, M.J. – Alliance (European Radioecology Alliance) General Assembly

Madrugá, M.J. – Group of Experts under Article 35 of the EURATOM Treaty – Portuguese expert

Marçalo, J. – Member of the International Advisory Committee of the 10<sup>th</sup> International Conference on f-Elements (ICFE-10), Lausanne (EPFL), 3-6 September

Marçalo, J., Maria, L. – Member of the Scientific Committee of the Course Modern Methods of Structure Elucidation–2018, CQE-IST, Lisbon, 15-19 October

Marques, R. – Chair of the Workshop C2TN - Thematic strands: cultural heritage & geoprocesses, strategic resources and global change, CTN-IST, Bobadela (Portugal) 23-24 October (Thematic Strand Objective Driver)

Martins, V. – Chair in Session entitled “Indoor Aerosols III: Air Purification & Case Studies” in 10<sup>th</sup> International Aerosol Conference, St. Louis, Missouri, (USA) 2-7 September

Martins, V. – MSc jury – Ana Isabel Neto (2018) Estudo comparativo das emissões de pellets não comerciais numa caldeira doméstica, MSc in Environmental Engineering, Universidade de Aveiro, 14 December

Martins, V. – MSc jury – Carolina Correia (2018) Exposição a partículas atmosféricas e dose inalada em movimentos pendulares em Lisboa, MSc in Environmental Engineering, Instituto Superior Técnico, 19 November

Melo, R. – Member of the scientific committee of MOL2NET, International Conference of Multidisciplinary Sciences

Mendes, F. – Member of the Life Science and Medicine Panel of Reviewers of the European Science Foundation

Monteiro Gil, O. – EPR Biodose 2018 - Joint International Symposium on EPR dosimetry and dating and International Conference on Biological Dosimetry, Munich (Germany) 11-15 June

Paiva, I. – Group of Experts under Article 37 of the EURATOM Treaty – Portuguese expert

Paiva, I. – IGD-TP Implementing Geological Disposal – Technology Platform

Paiva, I. – OSPAR Convention

Paulo, A. – Coordinator of the Summer School “Development and Pre-clinical Evaluation of Radiopharmaceuticals”, organized by the MCurie Innovative Training Network "MEDICIS-Promed".

Paulo, A. – Member of the Chemistry Panel of Reviewers in the FCT-call 2018 for PhD grants

Pereira, L.C.J. – Management Committee substitute member of the COST Action CA15128 – MOLECULAR SPINTRONICS (MOLSPIN)

Pereira, L.C.J. – Short Term Scientific Mission (STSM) Coordinator of the COST Action CA15128 – MOLECULAR SPINTRONICS (MOLSPIN)

Prudêncio, M.I. – Member of the Organizing Committee of “A Universidade de Lisboa e o património - 1º ENCONTRO” – Instituto Superior Técnico, Lisbon (Portugal) 19-20 November

Reis M.A. – Chairman of the International Advisory Committee of the International Conference on Particle Induced X-ray Emission since 2010

Reis, M. – NERIS-TP (European platform on preparedness for nuclear and radiological emergency response and recovery) General Assembly

Rodrigues, A.L. – Member of the International standing committee of Luminescence in Archaeology International Symposium, since January of 2018

Teles, P. – Chair of the Organizing and Scientific Committees EURADOS 2018 Annual Meeting and Workshop

Valério, P. – Workshop C2TN - Thematic strands: cultural heritage & geoprocesses, strategic resources and global change, CTN-IST, Bobadela (Portugal) 23-24 October

Vaz, P. – Chairman of the Organizing Committee of the ICDA-3 – International Conference on Dosimetry and Its Applications”, Lisbon, 27-31 May 2019

Vaz, P. – Computational Medical Physics Working Group (CMPWG) of the American Nuclear Society (ANS)

Vaz, P. – EURADOS (“European Radiation Dosimetry Group) General Assembly

Vaz, P. – Group of Experts under Article 31 of the EURATOM Treaty – Portuguese expert (2015-2019)

Vaz, P. – IRPA 2018 - 5<sup>th</sup> European IRPA Congress, Encouraging Sustainability in Radiation Protection, The Hague (Netherlands), June

Vaz, P. – MELODI (“Multidisciplinary European Low Dose Initiative”) General Assembly

Vaz, P. – MELODI E&T Working Group

Vaz, P. – RPSD-2018 - 20<sup>th</sup> Annual Topical Meeting of the Radiation Protection & Shielding Division of the American Nuclear Society, Santa Fé, New Mexico, USA, 26-31 August

Vaz, P. – SATIF-14 “Fourteenth Specialists’ meeting on Shielding Aspects of Accelerators, Targets and Irradiation Facilities”, Bomun, Gyeongju, Coreia do Sul, 30 October - 2 November

Waerenborgh, J.C. – Member of IBAME (The International Board on the Applications of the Mössbauer Effect)

Wahl, U. – Member of: The advisory committee on the “Use of large-scale facilities for condensed matter research” of the German Federal Ministry for Education and Research, since Jan. 2013

Low Temperatures and High Magnetic Fields Laboratory. Research Team; Manuel Almeida, E.B. Lopes, L.C. Pereira, J.C. Waerenborgh; Partners: C<sup>2</sup>TN - IST-UL, CFMC/FC/UL. ; Funding Total 879 000,00 €; C<sup>2</sup>TN -IST-UL 701 000,00 €

Portuguese Mass Spectrometry Network (RNEM) ROTEIRO/0028/2013, 2014 - 2019. Research Team: Maria Helena Florêncio (PI, FCUL), Joaquim Marçalo (C<sup>2</sup>TN -IST, Management Team member), M. Conceição Oliveira (CQE-IST, Implementation Team member); Partners/Nodes: Centro de Neurociências e Biologia Celular (CNBC/UC), Faculdade de Ciências da Universidade de Lisboa (FC/UL), Faculdade de Farmácia da Universidade de Lisboa (FF/UL), Instituto de Patologia e Imunologia Molecular (IPATIMUP/UP), Instituto de Tecnologia Química e Biológica (ITQB/UNL), Instituto Nacional de Saúde Dr. Ricardo Jorge (INSARJ), Instituto Superior Técnico (IST/UTL), Universidade da Madeira (UMA), Universidade de Aveiro (UA), Universidade de Coimbra (UC); International Partners: INSTRUMENT - European Research Infrastructure for Integrated Structural Biology, HUPO - Human Proteome Organization, EuPA - European Proteomics Association; Funding Total 5 820 300.00 €; IST/UL 979 000.00 €

Portuguese Platform for BioImaging (PPBI). Research Team: IST: Mario Berberan (CQFM), João Galamba Correia (C<sup>2</sup>TN); Partners: U. Porto, U. Minho, INEB, U. Coimbra, U. Aveiro, U. Beira Interior, Champalimaud Foundation, Gulbenkian Institute, U. Nova Lisboa, U. Lisboa, U. Algarve; Funding Total: 7.5 M€; IST (CQFM+ C<sup>2</sup>TN) – 350 000,00 €

### EUROPEAN PLATFORMS

Alliance (<http://www.er-alliance.eu/>). European Radioecology Alliance is a Research Platform, in accordance with relevant European Union policies. For this purpose, it will contribute to the following: definition of priority objectives in the Research Area, identification of research programmes and resources to be implemented in order to achieve these objectives, assessment of results obtained, and promotion of communication on these issues between the various actors and parties involved.

EIMM (<http://www.eimm.eu/>). European Institute of Molecular Magnetism is a joint initiative stemming from the European Network of Excellence MAGMANet. The institute aims to become a centre of excellence in Europe for research and training as well as a world leading reference in the area of Molecular Magnetism.

EURADOS (<http://www.eurados.org/>). EUROpean Radiation Dosimetry Group gathers 60 institutions in European countries, Russia and USA and is a non-profit association for promoting research and development and European cooperation in the field of the dosimetry of ionizing radiation. EURADOS maintains a network, which includes experts (more than 250), reference and research laboratories, and dosimetry services.

EURAMET (<https://www.euramet.org/>). The European Association of National Metrology Institutes (EURAMET) is a Regional Metrology Organisation (RMO) of Europe. It coordinates the cooperation of National Metrology Institutes (NMI) of Europe in fields like research in metrology, traceability of measurements to the SI units, international recognition of national measurement standards and related Calibration and Measurement Capabilities (CMC) of its members. Through Knowledge Transfer and cooperation among its members, EURAMET facilitates the development of the national metrology infrastructures. EURAMET is responsible for the elaboration and execution of the European Metrology Research Programme (EMRP), which is designed to encourage collaboration between European National Metrology Institutes (NMIs) and partners in industry or academia. The programme funds joint research projects in specific fields of metrology with over 50 projects selected for funding so far and many more expected over the coming years.

IGD-TP (<https://igdtp.eu/>). The Implementing Geological Disposal of radioactive waste Technology Platform (IGD-TP) is dedicated to initiating and carrying out European strategic initiatives to facilitate the stepwise implementation of safe, deep geological disposal of spent fuel, high-level waste and other long-lived radioactive waste. It aims to address the remaining scientific, technological and social challenges, and support European waste management programmes.

MELODI (<http://www.melodi-online.eu/>). Multidisciplinary European LOW Dose Initiative is an European Platform dedicated to low dose radiation risk research. In 2010, MELODI was founded as a registered association with 15 members. The purpose of MELODI is: 1) MELODI will propose R&T priorities for Europe in its field of competence; EUROPE 2020 Strategy. 2) MELODI will seek

the views of stakeholders on the priorities for research, keep them informed on progress made, and contribute to the dissemination of knowledge. 3) MELODI will interface with international partners like WHO and IAEA.

NERIS (<https://www.eu-neris.net/>). European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery The mission of the NERIS Platform is to establish a forum for dialogue and methodological development between all European organisations and associations taking part in decision making of protective actions in nuclear and radiological emergencies and recovery in Europe.

RENEB (<http://www.reneb.net/>). Running the European Network of Biological and retrospective Physical dosimetry is a network founded within the 7th EU framework EURATOM Fission Programme. Beginning 2016 a total of 26 organisations from 16 European countries have signed a Memorandum of Understanding (MoU) for mutual assistance in individual dose estimation in large scale radiological and nuclear emergencies. In 2017, the RENEB association was founded with the capability to act as a legal partner for organisations and platforms, active in emergency preparedness, radiation protection and research. The network provides rapid, comprehensive and standardised methodology for individualised dose estimation in case of large- scale radiological events in Europe and beyond.

## INTERNATIONAL COLLABORATIONS

CONCERT-EJP (<http://www.concert-h2020.eu/>). Integrating radiation research in the European Union. EU provide 70% of funding total (40M euros) the FCT and equivalent research institutions cover the remaining value.

MEDICIS (<https://medicis-promed.web.cern.ch/>). Production of alpha and beta emitters for medical applications (One MARIE Curie approved). Collaboration with CERN.

n-TOF (<https://home.cern/science/experiments/ntof>). The n-TOF collaboration is a consortium of 40 institutions in European countries, USA, Russia and Japan. It undertakes a experimental programme using the Time of Flight (TOF) spectrometer at CERN, to perform the measurement of the neutron capture and fission cross-sections in actinides, structural materials and radionuclides of relevance for nNuclear Technology and Astrophysics.

ISOLDE (<http://isolde.web.cern.ch/>). ISOLDE-CERN is a facility for the production of radioactive ion beams for experiments in the fields of nuclear and atomic physics, materials science and life sciences. Since 1986 Portugal maintains an experimental infra-structure dedicated to materials science at ISOLDE, which is being developed and permanently maintained under the responsibility and coordination of C<sup>2</sup>TN.