

Department of Radiological Protection and Nuclear Safety



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Pedro Vaz

The main activities of the Department of Radiological Protection and Nuclear Safety (DPRSN) are four-folded: i) research and development ii) technical services iii) education and training and iv) participation in national and international technical and scientific committees.

The DPRSN staff involved in environmental radioactivity measurements and in nuclear analytical techniques and methods participated in intercomparison exercises organized by the European Commission (EC), by the International Atomic Energy Agency (IAEA) and by Spanish institutions.

The scarcity of human resources (researchers, technicians and research fellows) required to meet the increasingly higher volume of work resulting from the legal obligations and service providing duties as well as from the involvement in research and development projects, is presently seriously limiting and hampering the intervention capacity of the DPRSN.

Research and Development activities:

During 2007, special emphasis has been devoted to i) fostering and establishing partnerships between groups of DPRSN researchers and experts in other sectors of ITN and in other Portuguese and foreign institutions and to ii) the participation of DPRSN researchers in national and international consortia conducting R&D activities and projects funded by the European Union (ongoing in the E.U. 6th Framework Programme or being prepared for submission in the E.U. 7th Framework Programme), and by the Portuguese Foundation for Science and Technology (FCT), among others. Considering the trends in Radiation Protection and Radiation Dosimetry, as well as the DPRSN mission and competences, first steps have been taken to strengthen and boost the involvement of DPRSN and its researchers in areas such as the Medical Applications of Radiations and in Computational Dosimetry. The activities in Radiobiology and associated topics received due attention.

Technical Services:

The DPRSN conducted, through its Environmental Radioactivity and Measurement Units, the National Environmental Radiological Survey (2007), having extended it, compared to the 2006 environmental monitoring programme, to include the monitoring of the areas around the former uranium mining sites and

of the campus of Sacavém.

The Radiological Protection and Radioactive Waste Management Unit performed activities associated to the licensing of radioactive sealed sources, the interim storage of radioactive waste, the detection of radioactive substances in scrap metal, the management of radioactive wastes on medical, and industrial facilities, and the verification of the radiological safety of installations, among others.

The Radiological Risk Assessment Unit pursued its technical activities related to the assessment of the safety of radiological installations, mainly in Nuclear Medicine installations, Radiotherapy vaults and cyclotron units in hospitals and clinics throughout the country.

The Dose Assessment and Dose Registry Unit has strengthened its dosimetry- monitoring- and occupational exposure-related activities through participation in international (European) studies and projects, namely in the framework of the activities of EURADOS (European Radiation Dosimetry Group).

Education and Training:

DPRSN researchers participated in training courses in Radiological Protection for professionals in the medical and industrial sectors and taught several disciplines in post-graduation Courses in Radiological Protection and Safety in several Portuguese universities.

A significant increase was observed during 2007 in the number of final year students undertaking their graduation thesis in the framework of the activities of the different units of the DPRSN. The number of Master thesis and post-graduation works, by DPRSN fellows and/or under the supervision of DPRSN researchers, kept increasing at a consistent pace.

DPRSN participated in the activities of the European platforms and networks in education and training in Radiological Protection, namely in EUTERP and CHERNE.

Participation in national and international technical and scientific committees:

DPRSN researchers act as representatives of Portugal and assisted national delegates to international Committees, Working Groups and Task Forces whose activities are organized under the auspices of the E.U., the IAEA, and the Organization for Economic Cooperation and Development (OECD).

DPRSN Staff

Researchers

P. VAZ, Princ.
F.P. CARVALHO, Princ..
M.J. MADRUGA, Princ.
M.B. MARTINS, Princ.
M.A. NEVES, Princ.
C. OLIVEIRA, Princ.
J. ALVES, Aux.
O. GIL, Aux.
M. GOULART, Aux.
A. D. OLIVEIRA, Aux.

I. PAIVA, Aux.
N. PINHÃO, Aux. (40%)
M. REIS, Aux.
R. TRINDADE, Aux.
J. CORISCO, Assistant

Technical and Admin. Personnel

J. CARDOSO
T. ANTUNES
L. PORTUGAL

G. L. SILVA
D. ALVES
J. OLIVEIRA
J. SEBASTIÃO
J. VENANCIO
L. SANTOS
M. A. LIBÂNIO
M. E. PACHECO
M. MARTINS
M. SARAIVA
V. CORDEIRO
A. MOURATO

Fellows

A. ABRANTES
P. DUARTE
L. MACHADO
M. MALTA
I. LOPES
L. SILVA
S. RANGEL

Dose Assessment and Dose Registry

João Garcia Alves

The activity of the Dose Assessment and Dose Registry unit is directed towards the assessment of doses to the Portuguese population due to several types of exposure to external radiation.

The activity developed in 2007 was mainly directed to the improvement of the performance of the individual monitoring service in the fields of personal and environmental monitoring, the Central Dose Registry, dissemination of results, preparation of research projects, as well as in the participation in international projects. Since January 2007 care was also given to the EURADOS Council membership.

The main activities developed were focused on:

Assessment of the occupational radiation doses: In 2007 the Individual Monitoring Service of ITN provided whole body dosimeters to approx. 3,200 workers on a monthly basis. Two LiF (TLD-100 and TLD-100H) extremity dosimeters were tested and performance tests of the whole body dosimeter were also re-evaluated.

Improvements to the Central Dose Registry and analysis of the occupational exposure data: In 2007 the CDR increased the frequency of occupational data collection to a quarterly basis. Staff doses in cardiology and interventional radiology were analysed into more detail.

Assessment of the cosmic radiation dose received by military aircraft crew: The collaboration with the Centro de Medicina Aeronáutica da Força Aérea Portuguesa, for the estimation of cosmic radiation doses received by military aircraft crew in transport missions was continued. The assessment is based on simulation programs, such as CARI and EPCARD. The latter is used under licence agreement from the Institute of Radiation Protection of GSF-National Research Centre for Environment and Health (presently Helmholtz Zentrum Munchen, German Research Centre for Environmental Health). Collaboration with other groups at DPRSN lead to the preparation of the project *Ionizing radiation and*

malignant melanoma: a clinical and biomolecular approach (PIC/IC/82847/2007). The exposed group concerned are airline pilots and the cosmic dose data will be estimated using the above mentioned software programs. The project was submitted to Fundação para a Ciência e Tecnologia (FCT) for financial support and is presently under evaluation.

Assessment of the environmental gamma radiation dose to the Portuguese population: The ambient dose equivalent integrated in quarterly periods was measured in three sites at ITN *campus* and in a nine other locations in Portugal, as contribution to the National Radiological Monitoring Program.

Partnerships and training: Training on individual monitoring methodologies, dose registry, QA/QC and general routine work was mainly directed to R. Esmail (Mozambique, Ministry of Health).

A partnership in the field of dosimetry and radiological protection was established with Aux. Prof. A. Pascoal, Faculdade de Engenharia (FE) da Universidade Católica Portuguesa (UCP). The project *Mammography: impact of digital imaging technologies and optimization of its use in breast cancer screening and diagnosis* (PIC/IC/83018/2007) was prepared, submitted to FCT for financial support and is presently under evaluation. Three MSc students from FE-UCP collaborated in on-going activities and another student has started PhD work.

International collaboration: On-going collaboration in international working groups was developed in the framework of EURADOS activities, namely the participation in *WG2 Harmonization of Individual Monitoring in Europe* and more recently with the approval of the EC-funded **EU-Trimer** project. In 2007 the Individual Monitoring Service raised approx. € 130.000,00. Three papers were published in scientific journals; four were accepted and are presently in press; an invited lecture was proffered at the SSD-15 Conference in Delft; a MSc thesis and specific contributions for two reports were prepared.

Research Team

Researchers

J.G. ALVES, Aux., Group Leader
M.B. MARTINS, Princ.

Students

M. PEREIRA, ITN grant (since September)
L. NOVAIS, FCT-EURATOM grant (until September)
L. FREIRE, MSc student
A. CALADO, PEPAP grant (until July)

Technical Personnel

M. MARTINS, laboratory technician
M. SARAIVA, administrative (since May)
S. RANGEL, consultancy contract

Collaborators

R. ESMAIL, trainee (Rep. Mozambique, Min. Health)
J. MAIROS, Medical Doctor (Centro de Medicina Aeronáutica)
A. PASCOAL, Aux. Prof. (FE-UCP)

EU-Trimer: European technical recommendations for individual monitoring of external radiation

J.G. Alves, P. Ambrosi², D.T. Bartlett³, L. Currivan⁴, J.W. van Dijk⁵,
E. Fantuzzi⁶, V.Kamenopoulou⁷

Objectives

The aim of this project is to prepare the European technical recommendations for monitoring individuals exposed to external radiation.

It is a two year project funded by the European Commission, Directorate-General Energy and Transport under contract TREN/07/NUCL/S07.70121.

Results

The European Commission Directorate General Transport and Energy (EC-DGTREN) issued in September 2006 a call for a tender entitled "Establishment of European Technical Recommendations for Monitoring Individuals Exposed to External Radiation" (TREN/H4/98-2006).

A proposal was prepared by former subgroup 1 of Eurados WG2 on *Harmonization of Individual Monitoring in Europe* and a Consortium agreement was established between the Greek Atomic Energy Commission (GAEC) and EURADOS.

In February 2007 notice of the success of the proposal was received and the relevant contract between EC DGTREN and GAEC was signed in April 2007.

The project is named EU-Trimer, has a duration of 24 months and the main objective of EU-Trimer is to draft new European Technical Recommendations for Monitoring Individuals Occupationally Exposed to External Radiation, according to the most recent scientific and technical knowledge.

The organizational scheme of EU-Trimer includes the project task group comprised by colleagues from GAEC, HPA, NRG, PTB, RPII, ENEA and ITN for

the preparation and writing of the new document, the previous Eurados WG2 working group members, as well as contact persons from an Extended Group of European Countries (EGEC).

The input from international and European organizations like the IAEA, IEC, ISO, ICRU, ICRP, ESOREX, EUROMET and EAN is ensured.

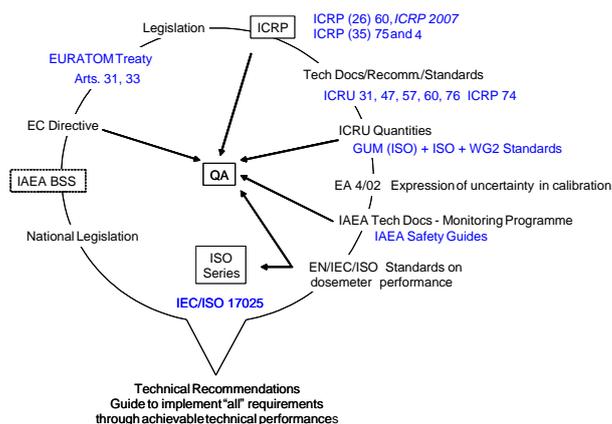
The network of contact persons in the EGEC was also considered crucial to the success of the project to provide inputs from relevant national organizations like radiation protection authorities, individual monitoring services, calibration laboratories from the EU member, candidate and associate States.

The last part of EU-Trimer will be the presentation of the new document to the Group of Experts established under Article 31 of the EURATOM Treaty and seek for approval.

At its present stage a first draft was prepared in December 2007 and sent to the EU-Trimer group of persons for comments and suggestions. Inputs are expected at the next Eurados Annual meeting to be held in January 2008.

Published work

E. Fantuzzi, J.G. Alves, P.A. Ambrosi, D.T. Bartlett, L. Currivan, J.W.E. Van Dijk and V. Kamenopoulou, Need for a new document to replace EUR 14852 "Technical recommendations for monitoring individuals occupationally exposed to external radiation, Editorial to Radiat. Prot. Dosim. (in press).



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³HPA, Chilton, Didcot, Oxon OX11, United Kingdom,

⁴RPII, 3 Clonskeagh Square, Dublin 14, Ireland,

⁵NRG-REUrechtseweg 310, PO Box 9034, 6800 ES Arnhem, The Netherlands,

⁶ENEA-IRP, Via dei Colli 16, 40136 Bologna, Italy,

⁷GAEC, 15310 Ag. Paraskevi-Attiki, PO Box 60092, Athens, Greece.

Individual Monitoring Service: individual and environmental monitoring

A. Calado¹, L. Freire², L. Novais³, M. Martins, M. Pereira⁴, M. Saraiva, R. Esmail⁵, S. Rangel, J.G. Alves

The Individual Monitoring Service at ITN is based on a TLD system, that consists of two 6600 Harshaw readers and on the Harshaw 8814 TL card and holder containing two LiF:Mg,Ti (TLD-100) detectors for the evaluation of $H_p(10)$ and $H_p(0.07)$. Nearly 3,200 workers are monitored on a monthly basis. Two LiF varieties of extremity dosimeters based on TLD-100 and on LiF:Mg,Cu,P (TLD-100H) were tested according to the ISO 12794:2000 and national requirements (DL 167/02), with the aim of establishing and implementing the extremity monitoring methodology and at the same time selecting an extremity dosimeter for workers in the field of Nuclear Medicine at ITN as well as for outside costumers. Performance tests of the whole body dosimeter were also re-evaluated.



In January 2007 the electronic backup of the dose reports issued every month was introduced. Since then, the individual reports internally issued to ITN workers is performed by e-mail to their personal accounts. Environmental monitoring was also performed at the service based on the same whole body dosimeter calibrated free in air in terms of $H^*(10)$. The aim of this work is to continuously perform quarterly measurements of the ambient dose equivalent due to external radiation at four sites at ITN campus and nine sites at national level, for the National Radiological Environmental Monitoring programme.

Related activities in the field on individual monitoring include the collaboration in working groups (IPAC-Instituto Português para Acreditação), as well as training to outside collaborators, namely, R. Esmail from the Ministry of Health of the Republic of Mozambique and the preparation of a MSc thesis (L. Freire).

1 PEPAP Trainee (left July); 2 MSc student; 3 FCT EURATOM grant (left September); 4 ITN grant; 5 Rep Mozambique, Min. of Health

Central Dose Registry: Collection and Analysis of Occupational Dose data

M.B. Martins, J.G. Alves

ITN is entrusted the task to create and maintain a Central Dose Registry (CDR) for occupational exposure, according to Decree-Laws 165 and 167 of July 2002. Presently the CDR contains the occupational exposure data of the workers monitored in Portugal in the period 1957-2006. The data stored at the CDR consists mainly on the external dose evaluations in terms of the operational quantities $H_p(10)$ and $H_p(0.07)$ and on information concerning the worker's affiliation and type of activity. In 2007 the CDR increased the frequency of data transfer and exchanged information with the six monitoring services operating in Portugal on a quarterly basis. Considering the need for more effective links with the monitoring companies the communication procedure is presently being revised. The database structure of the CDR is also being improved.

The analysis of the occupational dose data stored at the CDR is also an aim of this project, particularly in the case of high dose activities. In 2007 special attention was given to staff doses in cardiology and interventional radiology. The annual whole-body doses evaluated in the period 1999-2003 were analyzed and used to derive the distribution of workers by dose intervals for every profession. The respective annual average doses and annual collective doses, as well as, the total average and total collective doses were also determined.

Harmonization of Individual Monitoring in Europe

J.G. Alves, P. Ambrosi¹, D. Bartlett², L. Curri³, J.W. van Dijk⁴, E. Fantuzzi⁵, V. Kamenopoulou⁶, E. Vartiainen⁷, M. Figel⁸, A.M. Romero⁹, D. Kluszczynski¹⁰, A. McWhan¹¹, H. Stadtmann¹², H. Roed¹³, B. Vekic¹⁴

The previous EURADOS (European Radiation Dosimetry Group) WG2 projects on *Harmonization of Individual Monitoring in Europe* active in the 1996-2000 and 2001-2005 periods and were respectively funded under FP 4 and 5 had reached its end. However the EURADOS Council found necessary the continuation of the project and decided to fund a core group for the period Jun-2005 till Jan-2007 with two main tasks: the review of EUR 14852 – Technical recommendations for monitoring individuals occupationally exposed to external radiation, and the preparation of self-sustained intercomparisons in Europe. WG2 was chaired by V. Kamenopoulou and in order to prepare both tasks Subgroup 1 was coordinated by J.G. Alves and Subgroup 2 by M. Figel. Subgroup 1 was given a further task: should the European Commission publish a call for a tender on this issue, SG1 should be prepared and present a proposal. The work attributed to WG2 including the preparation of a proposal to tender issued by EC-DGTREN was completed and a final report was prepared and presented to the EURADOS Council at the annual meeting held in Madrid in January 2007.

1 PTB, Germany; 2 HPA, United Kingdom; 3 RPII, Ireland; 4 NRG, Netherlands; 5 ENEA, Italy; 6 GAEC, Greece; 7 STUK, Finland; 8 GSF, Germany; 9 CIEMAT, Spain; 10 NIOM, Poland; 11 BNFL, UK; 12 ARCS, Austria; 13 NIRH, Denmark; 14 RBI, Croatia.

Environmental Radioactivity

Maria José Madruga

Under Articles 35 and 36 of the EURATOM Treaty, Portugal has an obligation to conduct yearly a national radiological environmental survey. This survey was established in the Decree-Law 138/2005 of 17th August and its execution legally attributed to ITN. The National Radiological Environmental Monitoring Programme has been performed by the Environmental Radioactivity Unit in collaboration with the Measurement, the Dose Assessment and Dose Registry and the Radiological Protection and Radioactive Waste Management Units. In 2007, the programme has been enlarged with the creation of two specific programmes one for the ITN *campus* and other one for the regions around old uranium mining sites. To carry out this programme a considerable effort of the group has been made in terms of human resources (about 65% of the time consumed). This programme involves a financial cost of about 193 000 €.

In November 2006, in the framework of the EURATOM Treaty Article 35 an EC verification team visited the ITN and in particular, the Environmental Radioactivity Group. The verification team focussed on the degree of implementation of the recommendations of the verification activities performed in 2002. The report of the Commission's Article 35 verification was published in 2007. In this report it is emphasized the appropriate response given by the group to the 2002 recommendations and the noteworthy improvements achieved. The verification team endorses also the initiative to conduct a specific and systematic radiological surveillance programme in the former uranium mining region of Portugal.

In the framework of the EURATOM Treaty Article 35 the group has been participating in the elaboration of the European Atlas of Natural Radiation. Our contribution consisted in the treatment of the Portuguese indoor radon data to be included in a grid defined by the EC.

Current research activities are on going to investigate the levels of radioactive contamination in the atmosphere (aerosols) aquatic and terrestrial environments. Improvements have been introduced on the technique for alpha/beta measurements in drinking

waters using proportional counters. Quality control tests of recovery and accuracy were performed.

The group participated in coordination with the DPRSN/Measurement Unit in an certification exercise of a reference material (spinach) organized by the IAEA and in three international inter-comparison exercises concerning environmental matrices, two organized in the framework of the IAEA/ALMERA and one, in the framework of the OSPAR/IAEA. The results published in 2007 were in good agreement/compatible with the reference values.

The construction of the infrastructure for housing the Radionuclide Particulate Station (RN53) at S. Miguel, Azores, was concluded. The CINDERELA station and all the related equipment (detector, meteo station, VSAT antenna, etc) was installed during this year. The station is now ready to initiate the testing phase, in order to be certified in 2008. This station will be part of the International Monitoring System, established in the framework of the CTBT (Comprehensive Nuclear Test Ban Treaty).

During this year the group begins collaboration with the Medical Physics and Environmental Radioactivity Laboratory (FIMERALL), La Laguna (Tenerife) regarding the **ATRC** (Atmospheric Tracer Research Collaboration) Project. The main goal is the cooperation between participants from Europe, USA and Japan to develop an international data base on atmospheric radioactive tracers.

The technical services developed by the group are carried out under contract with companies or, by request from enterprises or Government organizations. Some of these technical services are: the evaluation of the radioactivity levels in public water supplies (Decree-Law n°306/2007) and mineral waters, the radioactivity analyses of foodstuffs and indoor radon measurements. The group income of these technical services was about 83 000 €.

One of the tasks of the group is the education and training of staff and young students. During this year one MSc thesis was concluded and two were submitted

Research Team

Researchers

M. J. MADRUGA, Princ., Group Leader
F. P. CARVALHO, Princ.
M. J. REIS, Aux.
J. A. CORISCO, Assistant

Students

A. R. GOMES, FCT grant
H. FONSECA, FCT grant
J. MELO, FCT grant

Technical Personnel

J. M. OLIVEIRA, Technician (1^o) (70%)
A. LIBÂNIO, Professional Technician (1^o)
A. MOURATO, Professional Technician (Principal)

Collaborators

I. LOPES
M. M. MALTA

National Radiological Environmental Monitoring Programme

M.J. Madruga, F.P. Carvalho, M. Reis, N. Pinhão¹, J.G. Alves², J.A. Corisco, J.M. Oliveira, A. Libânio, A. Mourato, G. Silva¹, I. Lopes, J. Abrantes¹, L. Silva¹, L. Torres¹, M. Malta, A.R. Gomes, G. Carvalhal¹, H. Fonseca, J. Melo, L. Novais²

Objectives

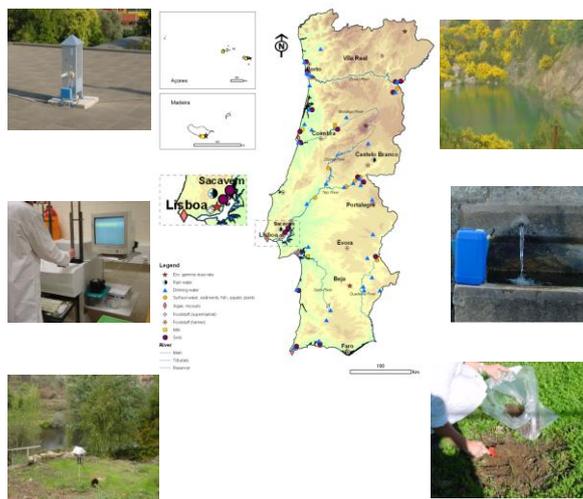
The Article 35 of the EURATOM Treaty stipulates that each Member State shall have the facilities necessary to carry out the continuous monitoring of the levels of radioactivity in the air, water and soil and to ensure the compliance with the basic standards. The Article 36 of the same treaty stipulates that the appropriate authorities shall periodically communicate information on the checks referred to in Article 35 to the Commission so that it is kept informed of the level of radioactivity to which the public is exposed.

The national radiological monitoring programme planned according to the Articles 35 of the EURATOM Treaty requirements has been established by law in 2005 and the competency for its execution legally attributed to ITN (Decree-Law 138/2005, 17th August). The main objectives of the radiological environmental survey were to determine the artificial and natural radionuclide levels in environmental compartments (aquatic, terrestrial and atmospheric environments) considered as direct pathways of contamination to man and to evaluate the external radiation levels in order to provide information for the assessment of the potential exposure of the Portuguese population. This radiological monitoring programme has been enlarged with the introduction of an environmental source related programme for the ITN *campus* and a specific programme for the regions around old uranium mining sites.

The monitoring programme carried out for the ITN *campus* includes measurements of external radiation levels (gamma dose) and measurements of radionuclide activity concentrations in relevant environmental samples (aerosols, rain water and soils). The main objectives of the programme were to verify the compliance with the authorized discharge limits, to check the operation conditions and discharge controls adequacy, to maintain a continuing record on environmental radionuclide levels related to the sources under consideration and to provide information for the public.

The environmental surveillance around old uranium mining sites was implemented to monitor radioactivity levels around the major old uranium mining and milling sites. Three field missions were performed in the regions of Urgeiriça/Canas de Senhorim, Aguiar da Beira-Sabugal, and Urgeiriça/Canas de Senhorim - Mondego River basin. Samples of water, soils and vegetables were collected for radioactivity analysis in the laboratory. Particular attention was paid to the enhancement of concentrations of uranium series radionuclides in water and foodstuffs. Aerosols and atmospheric radon were measured also in Spring and late Summer in the region of Urgeiriça to monitor eventual changes of radioactivity levels during the remediation works of milling waste heaps currently in

progress in this area. Fish from Mondego River basin, receiving surface runoff and discharges from the area of Urgeiriça and from other old mines, were also monitored.



Results

During 2007 about 800 samples (aerosols, rainwater, surface water, drinking water, sediments, fish, mixed diet, complete meals, milk, soils, etc.) were collected accordingly to international sampling procedures and a total of about 2700 analyses were performed for the determination of artificial and natural radionuclides, using gamma and alpha spectrometry, alpha/beta measurements and liquid scintillation technique. Integrated measurements of the ambient dose equivalent with thermoluminescent dosimeters were also performed. The results show that the Portuguese population was not exposed to radioactive contamination levels higher than the radioactive background. Therefore, there is no need to adopt any measures for radiological protection of the population. All the data are published in Internal Reports (1) made available in the ITN website (<http://www.itn.pt>) and included in the European Radioactivity Environmental Monitoring Database (REM) located at the EU Joint Research Centre, ISPRA (Italy).

Published work

M.J. Madruga, F.P. Carvalho, M. Reis, N. Pinhão, J. Alves, J.M. Oliveira, A. Libânio, G. Silva, I. Lopes, L. Silva, J. Abrantes, L. Machado, A.R. Gomes, A.S. Lemos, E. Oliveira, F. Rodrigues, G. Carvalhal, H. Fonseca, J. Melo, L. Novais. *Vigilância Radiológica a Nível Nacional (Ano 2006)*. Internal Report DPRSN, Série A, n°31/2007, ISBN 978-972-8660-32-1, Depósito Legal 194022/03, pp. 89.

¹DPRSN/Measurement Unit;

²DPRSN/Dose Assessment and Dose Registry Unit

Radioactivity in Foodstuffs¹*M.J. Madruga, I. Lopes*

Research on the radioactivity in foodstuffs was performed in order to develop and implement a new technique to the determination of ^{90}Sr in milk matrix. The method is based on the strontium separation from the other interfering elements using ion exchange chromatography (Sr-SPEC Eichrom resin). The $^{90}\text{Sr}/^{90}\text{Y}$ beta activity in the samples is measured by Liquid Scintillation Counting. The chemical yield is determined by adding ^{85}Sr as tracer to the milk samples. The recovery of the method, defined as the ratio of ^{90}Sr activity measured and ^{90}Sr activity added is evaluated and the methodology accuracy is tested in an IAEA 152 reference milk sample. In order to improve the minimum detectable activity (MDA) different amounts of sample and resin were tested. This methodology was applied to milk samples within the radiological environmental monitoring survey.

Marine Radioactivity¹*F.P. Carvalho, J. M. Oliveira, M. Malta, A. F. Sousa*

Research and monitoring of radioactivity levels in the marine environment was performed in order to expand the data base on levels of naturally-occurring radionuclides and to investigate current levels of man made radionuclides from nuclear discharges and nuclear accidents. Research on radionuclides in commercial marine fish species, such as sardines, horse-mackerel, and pouting, including inter-organ variation and monthly fluctuation of concentrations, was part of a Master Thesis (A.F. Sousa) on veterinary control of seafood landings for consumption by the Portuguese population. Research on radionuclides in marine mammals, mainly dolphins, was performed on specimens found on the shoreline. This aimed at investigating the transfer of radionuclides from marine species to mammals by ingestion, allowing for insights into radiation dose levels in tissues resulting from food chain transfer of radioactivity. This research is also part of a Master Thesis (M. Malta) in radiation protection. Monitoring of radionuclide levels and record of temporal trends was performed through the analysis of radionuclides in the tissues of molluscs (mussels) collected along the shoreline at the Portuguese coast in several locations and analyzed for natural and artificial radionuclides.

Completion of the *MinUrar* Project¹*F.P. Carvalho, M. Malta, S. Rábais, J. M. Falcão et. al.*

In February 2007 the Final Report of *MinUrar* project was issued. This report included the results of ^{210}Po and ^{210}Pb measurement in human hair samples collected in the populations of Canas de Senhorim and of other counties for the purpose of identifying enhancement of radionuclide burden in the human body. Results of the research on genotoxic effects in chromosomes from blood cells in a population group living near uranium mining and milling residues showed distinct features when compared with a reference group. Recommendations were presented in order to improve the radiation protection of the population and of the environment in this region.

SERVICES**1. Radioactivity in Drinking and Mineral Waters¹***M.J. Madruga, J. Melo, A.R. Gomes, A. Libânio, I. Lopes, F.P. Carvalho, J.M. Oliveira*

Regarding the evaluation of the radioactivity levels in drinking waters (Decree-Law n°306/2007) the DPRSN was requested by Water Suppliers to carry out the determinations of global alpha, global beta, Tritium, ^{238}U , ^{234}Th , ^{226}Ra and ^{210}Po and the Total Indicative Dose parameter in these waters. The determination of Radon in same water samples was also carried out. To license the mineral waters trade an evaluation of its radioactive levels should be performed (Decree-Law n°84/90). The radiological study included analyses of ^{226}Ra and global beta. Several enterprises often request this radiological study. During 2007, a total of about 1200 analyses were performed.

2. Radioactivity in Groundwaters¹*M.J. Madruga, A.R. Gomes, A. Libânio*

In collaboration with INETI (ex IGM) the tritium levels in groundwater samples were determined within the FCT-IMAGES Project. The main aim of the project is the identification and characterization of strategic groundwater bodies to be used for emergency situations as a result of extreme hydrological events and in case of conflicts or catastrophes. Ten aquifer systems were studied in the littoral centre region of Portugal and 42 water samples analysed.

2. Indoor Radon*M.J. Reis, H. Fonseca*

By request of public and private enterprises indoor radon measurements were performed in buildings. Since November 2003 a collaborative Protocol was established between DPRSN-ITN and DECO to answer the associate's indoor radon requests. A total of 116 measurements were performed during this year.

¹ In collaboration with DPRSN/Measurement Unit

Radiological Protection and Radioactive Waste Management

Romão Trindade

The Radiological Protection and Radioactive Waste Management Group (PRGRR) has not only pursued the main actions mentioned in previous Annual Reports but has also increased its range of activities during the last year.

Concerning R&D activities, the PRGRR Group, in collaboration with Portuguese Universities and Associated Laboratories has two research projects successfully approved by FCT: RADCLAYWASTE and KADCLAY. Lately these projects were combined in one bigger Project, KADRWaste (ADFC/FC/UP, FFC/CREMINER/FC/UL,CG/ADFC/FC/UP,FC/UP, UÉvora, ITN/DPRSN/Química). This Project has been approved in 2007 but is due to start in 2008.

Still in terms of R&D, PRGRR/DPRSN and Química/ITN, are involved in the European IP ACSEPT Project (“*Actinide Recycling by Separation and Transmutation*”) approved under the Euratom FP7-Fission-2007 Framework Program and due to start in 2008. The Group is still involved in another FP7 Project, *EUROTRANS*, when its collaboration is requested.

Included within the framework of the “Projecto de Plano Nacional de Acção Ambiente e Saúde, PNAAS”, supported by Ministério do Ambiente and Ministério da Saúde, the PRGRR Group submitted the project “*Harmonização de Práticas de Gestão de Resíduos Radioactivos em Estabelecimentos Médicos e Industriais*” that has been approved and is waiting for financial contribution.

PRGRR Group has also submitted to Department of Technical Cooperation of IAEA, a Regional Project Concept “*Strengthening and enhancing education and training capabilities in safety and management of Radwaste from medical, industrial and teaching applications*” that has been considered of interest but is still waiting for funding. The Group is involved in a National Project Concept “Strengthening and enhancing the QA/QC system on the nuclear analytical and service providing laboratories of DPRSN/ITN” also submitted to IAEA.

A member of the Group has submitted to Instituto Superior Técnico (IST/ITN) a thesis for a Master Degree in Radiological Protection and Dosimetry. Another member has been continuing to pursue a PhD degree in the field of radioactive waste management in collaboration with Faculdade de Ciências (FCUL/ITN).

Two Post Graduation students in Geology are carrying out Thesis in the field of radioactive waste and

geological characterization in collaboration with Faculdade de Ciências (Depart. Geologia/FCUL) and Departamento de Química/ITN. A Final Degree Thesis in Environmental Engineering in the area of scrap metal as radioactive waste is also running in collaboration with Universidade Lusófona de Humanidades e Tecnologias.

Members of PRGRR have also participated as teachers and invited professors in high-level education activities: Master Course on “Biomedical Inorganic Chemistry: Diagnostic and Therapeutical Applications” (FCUL/ITN-Química) Advanced Post-Graduation Studies (DFA) on “Radiological Protection and Dosimetry” (IST/ITN-DPRSN). PRGRR had also participated in a variety of professional courses, in-house and at external request.

Members of the Group were also involved in several committees, working groups and task forces from EU, IAEA, OECD, OSPAR, CTBTO and national groups.

Considering activities that are resulting of legal obligations such as licensing of sealed sources for medical, industrial, teaching and research applications, this Group has received 365 licensing requests for analysis and authorization during 2007. Also during 2007 and still considering legal obligations, about 164 requests for collecting and storing radioactive waste were received and solved.

Included in its verification activities, seven (7) operations were carried out in 2007 to verify compliance with the law and radiological protection principles. Fifteen (15) events related to the detection of radioactive substances in scrap metal were carried out by the Group during 2007.

The Monitoring Programme of the radioactive liquid discharges from public and private nuclear medicine services into the public sewage of Lisbon was continued in 2007, in collaboration with Lisbon Borough City Council (CML).

ITN Monitoring Programme in compliance with Articles 35° and 36° of the Euratom Treaty has been pursued with the setup of Estação de Controlo das Descargas dos Efluentes Líquidos Radioactivos, ECoDELiR, to monitoring all radioactive liquid discharges of ITN *Campus*.

Still in the framework of the above mentioned Euratom Articles, the *Campus* environmental gamma radiation dose has been assured through the gamma monitoring network, GAMMANET, with detectors located in three strategic points of the Campus operated and maintained by the Group.

Research Team

Researchers

R. TRINDADE, Aux., Group Leader
M. I. PAIVA, Aux.

Technical Personnel (Graduate)

L.M. PORTUGAL (1st Class grad. Technician)

Technicians

J. SEBASTIÃO (Senior Technician)
J. VENÂNCIO (Senior Technicians)

Collaborators

P. DUARTE (Master in Hydrogeology)
L. BRÁS (Electr. Eng. Stud., until Aug. 2007)
A. BAPTISTA, ITN Grant (since 1 Mar 2005) (Degree in Physical Engineering)

P. SANTOS (Degree in Geology, Post-Graduate Student)

F. MAIA (Degree in Geology, Post-Graduate Student)

C. Betânia (Final Year Environmental Engineering Student)

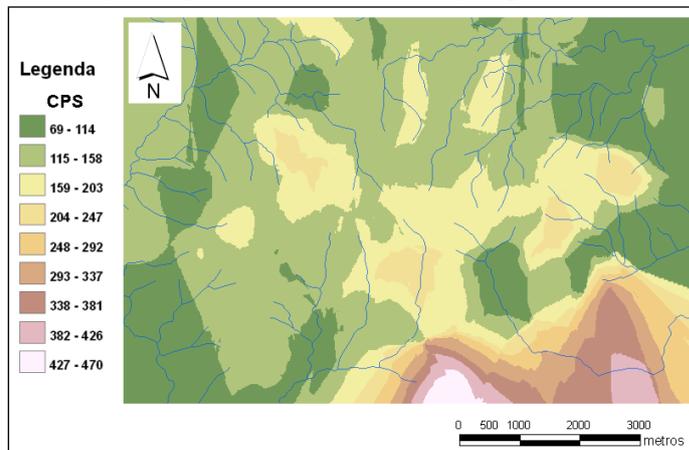
Characterization of Suitable Areas for a Long - Term Radioactive Waste Repository Facility in Portugal

P. Duarte, I. Paiva, A. Mateus¹, R. Trindade

The work in progress is part of a PhD thesis being carried out in collaboration with Department of Geology/FCUL. Following a preliminary study, two specific potential suitable areas to host near-surface repositories (geologically composed by peridotites and schists), have been chosen to be characterized in more detail. Radiological mapping of both areas was performed, using a based Geographic Information System and gamma radiation data from 980 measuring points along several profiles. These data was obtained with portable NaI (TI) gamma detectors. Statistical treatment of the data (interpolation by kriging) obtained from the radiometric profiles pointed out significant and representative sampling locals (Fig.1). In these locals, soils (through vertical profiles in three different depths), rocks, and vegetable covers were collected and were taken to the lab for ongoing analysis by various techniques: Gamma spectrometry for the identification and quantification of natural and artificial gamma emitters (total sample and fraction <63µm); XRD for mineralogical analysis (with emphasis on granulometric fraction <10µm due to the importance of clay minerals in radionuclide retention processes). Organic matter content was also quantified in soil samples and, rock samples mineralogy is in progress.

Studies of the <63µm soil fraction adsorption capacity for radionuclides, mainly ¹³⁷Cs, have started (with the involvement of Group of Environmental Radioactivity of DPRSN). ED-XRF analyses were carried out with the collaboration of the Environmental Analytical Chemistry Group of the ITN's Chemistry Department; Gamma Spectrometry studies were developed in collaboration with the Measurement Unit of ITN's DPRSN; FT-IR measurements were performed in the Department of Geology of FCUP.

Two Graduate students are also working in this research Project: “Técnicas Nucleares na Determinação da Concentração de Radionuclidos em Matrizes Naturais” (P. Santos, Co-supervisors: A. Mateus, P.Duarte, I.Paiva, R. Trindade,) and “Estudo dos Factores que Gerem a Adsorção/Desadsorção de Radiocésio em Matrizes Naturais” (F. Serafim, Co-supervisors: A. Mateus, M.J.Madruga, I.Paiva) in Applied Geology



EUROpean Research Programme for the TRANsmutation of High Level Nuclear Waste in an Accelerator DriveN System (ADS), IP “EUROTRANS”, (7th Programme EURATOM- FP7-Fission2007)
DPRSN/Física/ITN/FEUCP

P. Vaz (Coordinator)¹, I.F. Gonçalves², I. Paiva¹Y.Romanets⁴, R. Pires³, R. Trindade¹

PRGRR collaborates, when it is requested, in the *EUROTRANS Project* (Contract Number FI6W-CT-2004-516520), which is about transmutation of high-level waste from nuclear power plants using an accelerator driven system (ADS). Partitioning and transmutation if achieved at industrial scale will be able to reduce radiotoxicity of high-level wastes and change the safety assessment concept of final disposal.

¹DPRSN/ITN, ²Física/ITN, ³Fac Eng/UCP, ⁴Project fellow

Radioactive Liquid Discharges from Hospitals in Public Sewage of Lisbon Borough Council (CML)

P. Duarte, L.Portugal, L.Brás, J.Venâncio, F.Gomes, I. Paiva, R.Trindade

Radioactive liquid discharges from private and state owned nuclear medicines in Lisbon public sewage as well as residual effluents from Lisbon's four Water Treatment Plant (ETARs), have been continued to be monitored by DPRSN/ITN in 2007. Sampling was carried out in order to identify the radionuclides present and their activities. About 115 samples of liquid effluents were collected and analysed by quantitative and qualitative gamma spectrometry. This monitoring programme, requested by CML, was divided in two different programmes. Programme I involved sequential collection of 4 discrete samples in 5 sampling points from nuclear medicine facilities. In Programme II, 4 discrete samples were taken at one single discharge point of each Lisbon's ETARs.

Published:

R. Trindade, P.Duarte, L. Portugal, L.Brás, J. Trinchreira, F. Gomes, I. Paiva Programa de Vigilância Radiológica da Rede Pública de Saneamento de Lisboa, Report DPRSN - C nº16/2007

1. Radioactive waste management

During 2007 about 164 requests for radioactive waste collection were received, corresponding to 178 sealed sources, 359 ^{99m}Tc generators, 18 lightning rods, 4632 smoke detectors and other heterogeneous radioactive waste. These radioactive wastes were collected, segregated, transported and conditioned in cement matrix for interim storage at the “Pavilhão de Armazenamento Interino de Resíduos Radioactivos”, (PAIRR) located at ITN *Campus*. At this point, the “Pavilhão de Armazenamento Interino de Resíduos Radioactivos”, (PAIRR), has reached almost its full capacity and is in urgent need of being updated to be able to store more radwaste in the future. The only technician that is now working at PAIRR is also insufficient to carry out present duties.

2. Sealed sources licensing

In order to verify the compliance with Decree-Law n° 38/2007 and Decree-Law n° 165/2002, 365 sealed sources licensing requests were analysed and issued: national territory introduction licences (131), transfer (46), transport (53) and ownership (135).

3. Gamma Monitoring Network (GAMMANET) of Instituto Tecnológico e Nuclear (ITN)

The environmental dose gamma radiation at ITN *Campus* is continuously being measured by the gamma network, GAMMANET. The data are collected, analysed and reported to the EU, according to articles 35° and 36° of the Euratom Treaty.

4. Radiological safety verification of medical, industrial and research facilities

The verification of radiological safety conditions and detection of contamination with radioactive substances of public and private medical, industrial and research facilities was pursued in 2007. During the last year seven (7) verifications were requested carried out.

5. Radioactive liquid discharges from Instituto Tecnológico e Nuclear (ITN)

Radioactive liquid wastes originated at ITN are analysed and measured at “Estação de Controlo das Descargas dos Efluentes Líquidos Radioactivos” (ECoDELiR) before being discharged into Estação de Águas Residuais. The data are reported to the EU according Articles 35° and 36° of Euratom Treaty and to the Radioactive Substances Committee of OSPAR Convention.

6. Radioactive liquid discharges from Instituto Português de Oncologia (IPO), Coimbra

In 2007 and as requested by IPO-CROC, EPE, Coimbra, the radiological survey of radioactive liquid waste from the IPO’s Medicine Nuclear Retention Tanks, was carried out by the Group before discharge into the public sewage.

7. Nuclear vessels radiological monitoring

In 2007, four nuclear vessels (3 submarines and 1 sea-plane carrier) stayed at Portinho da Costa harbour and estuary of Rio Tejo. Environmental radioactivity survey programmes consisting on continuous monitoring of radioactive aerosols and airborne radioiodine, sampling of water, sediments and biological species for gamma spectrometry analysis were carried out. Sampling was done before, during and after the stay of the vessel. Reports were sent to Ministry of Defence.

8. Radioactivity in scrap metal

In 2007, and as result of radiological surveys requested by the smelting industry, fifteen (15) events related to the detection of radioactive materials in scrap metal at smelting factories have been reported. The material collected has been stored at Pavilhão de Armazenamento Interino de Resíduos Radioactivos, (PAIRR) as radioactive waste. Reports were sent to the smelting company.

9. Dismantling of “Sala dos Cofres e dos Moldes” at Instituto Português de Oncologia (IPO FG), Lisboa

Dismantling of “*Sala dos Cofres e Sala dos Moldes*” of IPOFG/Lisbon was carried out in 2007. These rooms were the core of a very old laboratory where radioactive substances were manipulated in the past, namely ²²⁶Ra solutions and needles. The laboratory was decontaminated and the resulting radwaste was packed and transported to “*Pavilhão de Armazenamento Interino de Resíduos Radioactivos*”, (PAIRR)

Radiological Risk and Safety Assessment

A. D. Oliveira

Radiological risk is concerned with biological effects of radiation. The importance of the biological effects of ionizing radiation has gathered recently a lot of attention from researchers due to possible new implications in radiation protection. One of the main aspects to consider is related with the recognition of the existence of non targeted effects such as, for example, the bystander effect. This means that well established paradigms of radiobiology are nowadays challenged, leading to a growing development of biophysical and biochemical research activities related with such radiobiological studies. Recognizing this new trend in research a new member integrates the group with expertise in molecular biology. In that field the conference Lowrad 2008, 7th International Meeting on the Effects of Low Doses on Radiation in Biological Systems is in preparation. Also a world-wide radiobiological consortium is under development aiming to study the “mechanisms developed by mammals exposed to low doses of ionizing radiation”.

Traditional radiobiology applications such as dosimetry by cytogenetics methods, specifically related with uranium mining are an activity that ends in this year. However, new plans are in development for an increase of this methodology with new applications.

Design and production of radiopharmaceuticals involves a reasonable time of activity of this group with collaboration with Poland researchers, concerning mainly with application of bisphosphonates and Auger electron studies in a potential therapeutic application and special concerns with radiation protection aspects.

In safety assessment of radiological facilities, it was decided that routine safety assessment are not an objective of ITN. Radiation safety assessments of radiological facilities it was restricted to services provided to owners of complex facilities such as radiotherapy and nuclear medicine which had been carried out together with the group RPRWM (Radiological Protection and Radioactive Waste Management). Concerning radiation protection regulations some activity was accomplished from the point of view of qualified expert advisory.

It was increased the activity in risk assessment and radiation protection from the scientific point of view concerned with interventional radiology. A master thesis is under development and a new one is programmed to start in 2008. More developments are expected in near future.

Research Team

Researchers

A. D. OLIVEIRA, Aux., Group Leader
P. VAZ, Princ.
M. A. NEVES, Princ.
O. GIL, Aux.
M. GOULART, Aux., since Dec 1

Students

P. CARDOSO, FCT grant, until Aug 31
L. FERNANDES, PEPAP grant until May 31

Technical Personnel

T. ANTUNES, superior technician

Collaborators

D. ALVES, since May
M. SARAIVA, until May

Radiological Safety Assessment in interventional cardiology

P. Vaz, I.F. Gonçalves¹, C. Carrapiço², A.D. Oliveira and L Terramoto³

Objectives

Concerning Interventional Radiology, two separate lines of activities were developed during 2008. One of the lines of activity was mainly in computational simulation while the other was mainly in experimental measures in real hospital cardiologic intervention. Future works will cross the results of these different approaches.

Results

Simulations were accomplished within a Coordinated Network for Radiation Dosimetry – Computational Dosimetry, within the CONRAD – COordinated Network for RADIation Dosimetry (CONRAD) the Project CONRAD was a collaborative effort led by the Technical University of Delft and involving several European institutions under the umbrella of EURADOS (the European Radiation Dosimetry group). Its activities are funded by the European Union in the 6th Framework Programme for Research and Development. In this context, it participates in the computation of two exercises entitled “Medical Staff Dosimetry in Interventional Cardiology” and in the measurement of staff doses, aiming at estimating the effective dose to the cardiologist due to the X-ray machine and to compare it with the personal dosimeter readings. The ITN team together with experts of SCK/CEN (Belgium), CEA and IRSN (France) and TU-Delft has performed Monte Carlo simulations in the framework of an intercomparison exercise.

Experimental measures were made considering that, the procedures involved in IC are complex, and not easy to describe. There are many variables to consider

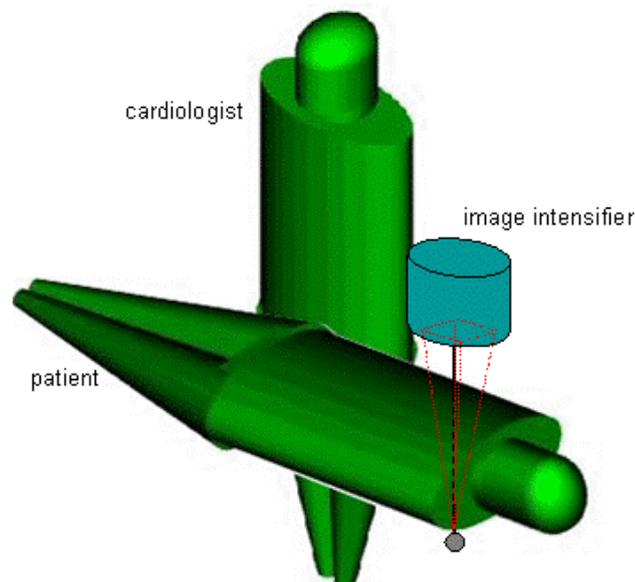
for a complete description of the procedures. Some of them are: the procedures are geometrically dynamic; the radiation field is uneven; the filtration is not the same during the intervention (depends of the operational mode); patients have different sizes from each other (influences the scattered radiation field). Studying and collecting data for all the different procedures would be time consuming, so we used well defined rotation and angulation’s geometries of the fluoroscopic device to make doses assessment. The ITN team participates in the determination of patient and staff doses in interventional radiology in collaboration with a national Hospital. The scope was to assess incident dose rates in several conditions, in order to create a procedure that can be used in medical facilities.

Published work

“Intercomparison of Active Personal Dosimeters in Interventional Radiology”, I. Clairand et. al., Proceedings of Workshop on "Safety and Efficacy for New Techniques and Imaging using New equipment to support European Legislation" (SENTINEL), Delft (Holanda) de 18 a 20 de Abril de 2007, accepted for publication in Radiation Protection Dosimetry (2008)

“Staff Doses in Interventional Cardiology: Use of C-Arm standard positions to assess incident dose rate”, L. Terramoto, A.D. Oliveira, E. Leite, T. Matoso, 13^a Jornadas da Sociedade Portuguesa de Protecção Contra Radiações, Nov. 2007.

“Radiologia de Intervenção”, AD Oliveira, Workshop: Aplicações médicas das radiações ionizantes em Portugal – investigação científica e prestação de serviços, ITN, Nov. 2007.



Safety Assessment

A.D. Oliveira, P. Vaz, T. Antunes, D. Alves, M. Saraiva

It was increased the activity in risk assessment and radiation protection from the scientific point of view concerning interventional radiology. Some new insights in interventional cardiology were achieved, working in collaboration with a reference hospital. The dynamics in space, time and technical parameters is shortly the scope of the work. A master thesis is under development and a new one is programmed to start in 2008. Radiation safety assessments of complex radiological facilities such as radiotherapy and nuclear medicine had been carried out together with the group RPRWM (Radiological Protection and Radioactive Waste Management). These services are provided according to international recommendations NCRP, IAEA, DIN, etc. Concerning radiation protection regulations some activity was accomplished from the point of view of qualified expert advisory in order to help the national authorities to fulfil the recommendations of IAEA and the European Community. Participation in IAEA committee RASSC it was a major goal of the activity mainly concerned with the implementation of the IAEA safety standards.

Radiobiology and dosimetry by cytogenetic methods applied to populations living near old uranium mining areas and compared with population living in areas without uranium mines

O. Monteiro Gil, P.A. Cardoso Painço

We finished the work regarding the evaluation of the biological effects of low-level ionizing radiation and genotoxic damage as a result of chronic exposure to ionizing radiation in populations living near old uranium mines and tailings (Canas de Senhorim) started in partnership with INSA. The report has been already published. Evaluation of the reference populational group belonging to a region from Alentejo (without uranium mines) is also finished. Equally in this study, chromosomes 1, 2, 4 were analysed for chromosomal translocations, by the FISH technique (Fluorescent *In Situ* Hybridization) for irradiated (blood irradiated *in vitro* with 2 Gy gamma radiation for the challenge assay, 700 metaphases studied for each donor) and unirradiated samples (2000 metaphases studied for each donor). A total of 62645 metaphases were studied for unirradiated samples and 24181 metaphases were studied for the irradiated ones.

We also initiated the elaboration of an *in vitro* dose response curve using the FISH technique (at this moment this work is stopped because I have to finish writing my PhD thesis).

Auger and low energy electrons therapy

M. Neves

Participation in projects related to the development of new targeted radiotherapy agents with Auger and low electrons emitters, in collaboration with INETI and the Institute of Nuclear Chemistry and Technology (IcHTJ) of Warsaw, Poland under a EU Marie Curie Transfer of Knowledge project and Portugal/Poland scientific agreement. Indazolebisphosphonates and carboxylbiguanides derivatives were synthesized and complexed with the radiometals (Sc-46, Rh-105 and Lu-177). Radiochemical and biologic activities were tested.

CANDIDE – Coordination Action on Nuclear Data for Industrial Developments in Europe

P. Vaz, I.F. Gonçalves¹

CANDIDE is a European Union co-financed Coordination Action (ref. FP6-036397) in the 6th Framework Program EURATOM. It addresses the following two objectives:

1. Establishment of better links between academia, research centres and industry end users of nuclear data.
2. Assessment of nuclear data needs for advanced nuclear reactors. The emphasis is on the radioactive waste issue, i.e., either waste transmutation in critical or sub-critical devices or minimizing the production of nuclear waste in future nuclear reactors, as envisaged in, e.g., the GEN-IV systems.

The ITN team has participated during 2007 in the Work Package 3 entitled “Nuclear Data Assessment”, performing activities related to the assessment of the state-of-the-art nuclear data libraries.

¹ ITN / Physics Sector

EUROpean Research Programme for the TRANsmutation of High Level Nuclear Waste in an Accelerator Driven System (IP-EUROTRANS)

P. Vaz¹, I.F. Gonçalves², I. Paiva¹, R. Pires³, Y. Romanets⁴, P. Teles⁴, R. Trindade¹

IP EUROTRANS is a European Union co-financed project (ref. FI6W-CT-2004-516520) in the 6th Framework Program EURATOM. The objective of IP EUROTRANS is the design and the feasibility assessment of an industrial ADS (Accelerator Driven System) prototype dedicated to the transmutation of high-radiotoxicity and long-lived radioactive waste. The Portuguese team, led by ITN, actively participated in:

- Dosimetry (dose and neutron flux distributions) and radiation shielding calculations,
- Assessment of the radiation damage of the structural components,
- Reliability of the accelerator system,

in the following Domains:

- DM1-DESIGN – “*Development of a detailed design of XT-ADS and a conceptual design of the European Facility for Industrial Transmutation EFIT with heavy liquid metal cooling*” – participating in WP 1.2 (“Development and Assessment of XT-ADS and EFIT Designs”) and WP 1.3 (“High Power Proton Accelerator Development”).
- DM2 – ECATS – “*Experiment on the Coupling of an Accelerator, a spallation Target and a Sub-critical blanket*”, participating in WP 2.1 (Experiments at YALINA – current to flux reactivity on-line monitoring techniques, interim calibration techniques used at beam trips and full calibration techniques for kinetic parameters) and WP2.3 (The GUINEVERE project – Study of the reactivity monitoring methodology for an ADS in a modified lead VENUS reactor coupled to a modified continuous-beam GENEPI accelerator).

1 – ITN / DPRSN; 2 - ITN / Physics Sector; 3 – Fac. de Engenharia / Univ. Católica Portuguesa; 4- ITN fellow

Participation of ITN in the n-TOF-Ph2 experiment (PS213) at CERN

P. Vaz¹, I.F. Gonçalves², C. Cruz², J. Neves², C. Carrapiço³, C. Santos³, L. Ferreira⁴, L. Távora⁵

An experimental programme is being carried out since 2001 by the n-TOF Collaboration (a consortium of 40 laboratories in Europe, U.S.A. and Japan) at the neutron time of flight (TOF) facility at CERN, using the CERN/PS accelerator complex. A single proton pulse of $7 \cdot 10^{12}$ protons of 20 GeV impinges on a lead target every 2.4 seconds. After collimation, a neutron flux of the order of 10^5 neutrons/cm²/pulse is available for cross section measurements in the detectors station located 185 m downstream the target area.

These cross-sections measurements are required in many applications such as the design of innovative Accelerator Driven Systems (ADS) for incineration of nuclear waste and energy production, radioisotope production for medical and industrial applications and many other subjects in Astrophysics, Nuclear Physics and Nuclear Technology. New or improved measurements of neutron cross-sections will also be very valuable for Radiation Shielding, Dosimetry and Monte Carlo Radiation Transport calculations. During 2007, ITN researchers in cooperation with researchers from CIEMAT/Madrid and CEA/Saclay:

- Participated in the design studies of the new shielding system for the TAC calorimeter, performing simulations using the state-of-the-art Monte Carlo program GEANT4
- Performed Monte Carlo simulation studies of the neutron and gamma fluxes for alternative targets at n-TOF, for different materials (e.g. Tungsten) and geometries, using the Monte Carlo program MCNPX
- Participated in the analysis of the ²³³U data

The ITN participation was undertaken in the framework of two projects funded by the Portuguese Foundation for the Science and Technology (FCT).

1- ITN / DPRSN; 2 – IST / Physics Department; 3 – project fellow; 4- DF/ IST; 5 –C. de Instrumentação / U. Coimbra

PATEROS - Partitioning and Transmutation European Roadmap for Sustainable Nuclear Energy

P. Vaz¹

PATEROS is a European Union co-financed Coordinated Action (ref. FP6-036418) in the 6th Framework Program EURATOM, under the specific programme for Research and Training in Nuclear Energy.

A closed fuel cycle is a prerequisite for making nuclear energy a sustainable one. This can be reached by deploying advanced partitioning and efficient transmutation systems to reduce the burden on the geological storage. This objective is of relevance both for countries committed to nuclear energy in the future and for countries not committed to a further deployment of nuclear energy. The objectives of this Coordinated Action is to deliver a European vision for the deployment of the partitioning and transmutation technology up to the scale level of pilot plants for all its components. ITN contributes to the activities of:

- Work Package 1: Rational and added value of P&T for waste management policies
- Work Package 2: Review & selection of Relevant Fuel Cycle Strategies in Europe supplemented by Regional Context for Development and Deployment.
- Work Package 6: Integration and Evaluation of Resources and Time Planning.

During 2007, ITN has contributed to the preparation of reports in the framework of the WP1 and WP2

1 – ITN / DPRSN

CONRAD – COordinated Network for RAdiation Dosimetry (CONRAD)

P. Vaz¹, I.F. Gonçalves², C. Carrapiço³ – SG4/WP4/WP7

The Project CONRAD was a collaborative effort led by the Technical University of Delft and involving several European institutions under the umbrella of EURADOS (the European Radiation Dosimetry group). Its activities are funded by the European Union in the 6th Framework Programme for Research and Development.

The ITN team participates in the determination of patient and staff doses in interventional radiology in collaboration with the “Hospital de Santa Maria” concerned with the following Work Packages of CONRAD:

- WP4 - Assessment of Uncertainties in Computational Dosimetry
- WP7 – Dosimetry for Radiation Protection of Medical Staff

In this context, it participates in the computation of two exercises entitled “Medical Staff Dosimetry in Interventional Cardiology” and in the measurement of staff doses, aiming at estimating the effective dose to the cardiologist due to the X-ray machine and to compare it with the personal dosimeter readings. The importance of wearing protective clothes (lead equivalent apron, thyroid collar, etc.) are used, as well as the influence of parameters such as the beam geometry and quality, the position of the dosimeter (above or below the apron) and the relevance of the usage of double dosimetry (one dosimeter above and another below the apron) will be performed. The ultimate goal is the determination of the effective dose to the professionals exposed.

The ITN team together with experts of SCK/CEN (Belgium), CEA and IRSN (France) and TU-Delft has performed Monte Carlo simulations in the framework of an intercomparison exercise.

1 – ITN / DPRSN; 2 - ITN / Physics Sector; 3 – ITN Fellow

EURISOL DS - Design Study of an European Isotope Separation On-Line Radioactive Ion Beam Facility

P. Vaz¹, J.G.Correia², I.F. Gonçalves², Y. Romanets³

The Project EURISOL-DS is a Collaboration of twenty institutions and laboratories in European countries and CERN. Its activities are funded by the European Union in the 6th Framework Programme for Research and Development (“Research Infrastructures Action”).

EURISOL DS aims at performing the detailed design studies for the deployment in Europe of a world class Radioactive Ion Beam Facility, able to produce radioactive beams with much higher intensities than the ones currently available in other facilities worldwide. Very selective extraction methods combined to the high intensity of the beams will allow the discovery and study of new isotopes as well as the production of isotopes for a wide range of applications ranging from Fundamental Nuclear Physics and Astrophysics studies to Life Sciences, in particular Medicine. The innovative characteristics of such a facility are also associated to its multi-MegaWatt target unit where a high-intensity beam of protons of energy in the 1-2 GeV range will impinge on a high-Z material, mercury, tungsten or tantalum being currently considered as potential candidates. ITN is participating in the computational activities of the following sub-groups:

- WP2 (“Target Design Studies”)
- WP5 (“Radiation Protection Issues”)

During 2007, the ITN team has performed, together with the CERN team, Monte Carlo simulation studies to assess the feasibility of an alternative, so-called MAFF-like, design of the target system.

1 – ITN / DPRSN; 2 - ITN / Physics Sector; 3 – ITN Fellow

CANDIDE – Coordination Action on Nuclear Data for Industrial Developments in Europe

P. Vaz¹, I.F. Gonçalves²

CANDIDE is a European Union co-financed Coordination Action (ref. FP6-036397) in the 6th Framework Program EURATOM. It addresses the following two objectives:

1. Establishment of better links between academia, research centres and industry end users of nuclear data.
2. Assessment of nuclear data needs for advanced nuclear reactors. The emphasis is on the radioactive waste issue, i.e., either waste transmutation in critical or sub-critical devices or minimizing the production of nuclear waste in future nuclear reactors, as envisaged in, e.g., the GEN-IV systems.

The ITN team has participated during 2007 in the Work Package 3 entitled “Nuclear Data Assessment”, performing activities related to the assessment of the state-of-the-art nuclear data libraries.

1 – ITN / DPRSN; 2 - ITN / Physics Sector

Metrology Laboratory of Ionizing Radiation

João Cardoso and C. Oliveira

The Metrology Laboratory of Ionising Radiation (LMRI) of Nuclear and Technological Institute (ITN) had actively been involved in activities concerning the legal, applied and scientific metrology as well as other related research topics and services.

The primary standard for air kerma for the gamma radiation of Cs-137 is an ionisation chamber of the type CC01. For the first time this instrument was used to characterize the radiation field, in terms of air kerma, originated by the Shepherd irradiator, model 81, with a Cs-137 source used mainly for radiation protection calibration purposes. Monte Carlo simulation studies in order to characterize this radiation field and to obtain correction factors were also performed. This work was presented, in the Workshop on “Absorbed Dose and Air Kerma Primary Standards”, organised by LNHB and BIPM.

In order to know the air kerma value at 50 cm distance from a ¹³⁷Cs source positioned inside an irradiator for the reference configuration and to investigate the influence of some parameters on air kerma value and consequently to have an uncertainty budget, calculations were performed considering different values for several parameters. This type of exercises was promoted by Conrad WP4 of EURADOS. This work was presented in the *Workshop on Uncertainty Assessment in Computational Dosimetry: A Comparison of Approaches*, in Bolonha.

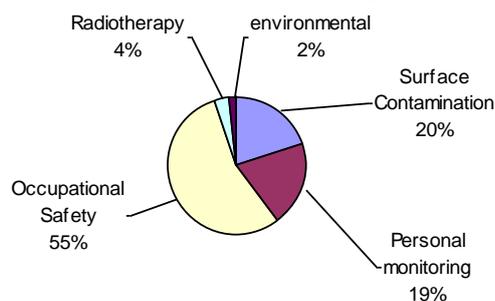
The LMRI has also developed efforts to be involved in the Targeted Program 2 (TP2 (Health)) of EURAMET. These efforts result in the inclusion of LMRI in two Joint Research Projects, the JRP6, Brachytherapy Dosimetry and the JRP7, External Beam Cancer Therapy.

Some lectures activities to universities and in professional courses were made during this year, namely lectures on radiation detection techniques. It is also usual to have visits from university students to have a close contact with the dosimetry reality in order to complement their knowledge and training. A staff member from Health Ministry of Mozambique was trained in dosimetry and calibration of instruments during three months.

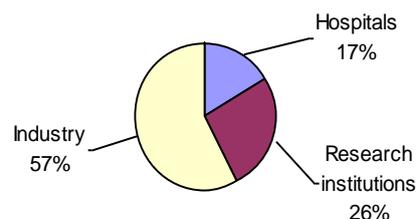
The irradiation facilities of LMRI are often sought for research teams from ITN or outside ITN. However the

calibration services are our more visible activity, providing to the community, mainly for industry, universities, hospitals, armed forces and departments of ITN, services of metrological control. This metrological control of instruments for measurement of ionising radiation is being carried out under a contract with Portuguese Institute of Quality and is the enforcement of *Portaria* n.º. 423/98 from 21 of July. Technical support was given to the Portuguese Institute for Quality (IPQ) to write a new *Portaria* for the metrological control of ionising radiation measuring instruments in Portugal. This new law will be published in 2008 and will include new domains of metrological control namely in instruments dedicated to nuclear medicine and diagnostic radiology. During 2007 were calibrated 135 dosimeters and about 1000 TLD dosimeters were irradiated. The following figures can quantify the work done in this particular area.

Instruments calibrated by type of use



Instruments calibrated by users activity



Research Team

Researchers

C. OLIVEIRA, Princ. (50%) (since July 2007)

Technical Personnel

J. CARDOSO, graduated technician

L. SANTOS, technician

A. CASTRO, technician ITN consultancy contract

Air Kerma Primary Standard: Experimental and Simulation Studies on Cs-137

J. Cardoso, L. Santos, C. Oliveira

Objectives

Determination of the air kerma rate of the gamma radiation of ^{137}Cs using a graphite-cavity ionization chamber as an air kerma primary standard.

Results

The gamma radiation from ^{137}Cs sources is used in the LMRI mainly for calibration and verification of radiation protection dosimeters. Until now the air kerma rate was obtained using a secondary standard, an ionization chamber OFZ LS-01/113 calibrated by PTB. For the first time a graphite-cavity ionization chamber of the type CC01, with serial number 134, schematically presented in figure 1, was used at LMRI as an air kerma primary standard for the gamma radiation of ^{137}Cs . The CC01 ionization chamber is made of graphite with a density of 1.80 g/cm^3 . The chamber wall has a thickness of 4 mm and the electrode has a diameter of 2 mm and 9 mm height. The sensitive volume of the ionization chamber is 1.0161 cm^3 obtained with an uncertainty of 0.1 % (1σ). The polarising potential is +250 V and is applied in the wall.

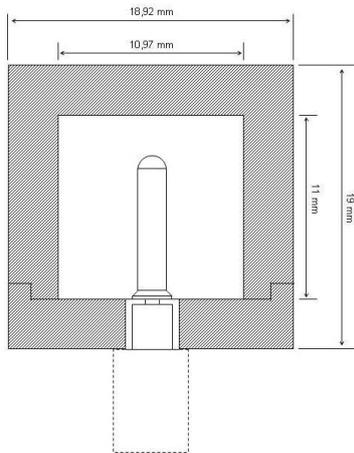


Fig. 1. CC01 ionisation chamber scheme.

The air kerma rate, \dot{K} , is obtained from,

$$\dot{K} = \frac{I W}{m e} \frac{1}{1 - \bar{g}} \left(\frac{\mu_{en}}{\rho} \right)_{a,c} \bar{s}_{c,a} \prod k_i$$

where I is the ionization current measured; m is the mass of air in the sensitive volume of the ionization chamber, W is the average energy spent by an electron of charge e to produce an ion pair in dry air, \bar{g} is average fraction of electron energy lost to radiative processes, $(\bar{\mu}_{en}/\rho)_{a,c}$ is the ratio of the mean mass energy absorption coefficients of air and graphite,

$\bar{s}_{c,a}$ is the ratio of the mean stopping powers of graphite and air, $\prod k_i$ is the product of correction factors to be applied to the standard. Correction factors as polarization, recombination losses, stem scattering and wall effects were experimentally determined; axial non-uniformity, radial non-uniformity and humidity are obtained from the published data.

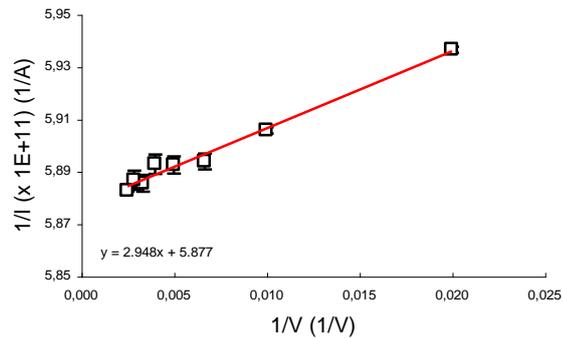


Fig. 2. Results on the calculation of recombination losses.

Additionally, a Monte Carlo simulation study was performed in order to calculate some experimental correction factors used in the determination of air kerma for ^{137}Cs . In the computational simulation the transport of photons and electrons has been considered (mode p e).

: The value obtained for the air kerma rate at 1m is $6.212 \text{ mGy min}^{-1}$ (at 7th Dec. 2006). This value is in agreement with the previous reference air kerma rate, however decreasing the uncertainty from 0.9 % to 0.4% (1σ). In conclusion, the LMRI air kerma primary standard was used, successfully, to obtain the air kerma rate of a ^{137}Cs source. The simulations studies allowed a better knowledge of the irradiation conditions and of the ionization chamber itself. Further work is needed, namely in the characterization of the LMRI irradiator in order to obtain the LMRI radiation beam fluence and more accurate correction factors.

Published work

This work was presented on the Workshop on "Absorbed Dose and Air Kerma Primary Standards, Paris, May 2007 as invited talk and can be seen on site http://www.nucleide.org/ADAKPS_WS/Session%20F%20-%20IC%20Kerma/F3_Or-Cardoso.pdf

Photon Irradiation Facility

J. Cardoso, C. Oliveira

The aim of the problem concerning the Photon Irradiation Facility is to calculate the air kerma value at 50 cm distance from a ¹³⁷Cs source positioned inside an irradiator for the reference configuration. Besides that, and in order to investigate the influence of some parameters on air kerma value and consequently to have an uncertainty budget, calculations were performed considering different values for several parameters.

The shape and dimensions of the irradiator are described in the problem protocol, as well the shape, dimensions and material composition of the source. The variables studied in this problem with potential influence on air kerma value were the positioning of source, the source chamber depth, the dimension of the rings collimator, the tungsten density, the CsCl density and the source diameter. The problem was simulated by Monte Carlo method using the MCNP code, version 5.

All the results presented arise from the averaging of four independent runs which use different control numbers in the card DBCN. The simulations were done in mode P. With this mode on photons were transported and the electrons were not transported. However in this mode electrons can originate bremsstrahlung photons. This simplification saves computer time and the physics of the problem support this decision.

The photon fluence is obtained with a F4 tally, which averages the photon fluence over a cell, in a cylinder of 0.5 cm radius and height. The air kerma at 50 cm from radioactive source is obtained by applying the conversion coefficients, suggested in the protocol, to the photon fluence. However a new calculation was done with different conversion coefficients. These conversion coefficients are described in table A.21 of ICRP publication 74, which are slightly different from the ones that the problem suggests. All the other calculations were obtained with the conversion coefficients suggested. The photon energy considered in the ¹³⁷Cs emission is 0.66166 MeV. The number of particles simulated in each run was 1E+8 and each run spent approximately 150 min of computer time. Each run has a standard uncertainty of 4%. For the reference conditions and for each different condition, 4 independent runs were performed. The uncertainties were calculated according to GUM.

Ionising Radiation Metrological Control Law

J. Cardoso, C. Oliveira, L. Santos

The ITN-LMRI belongs, as associated laboratory, to the National Metrology Subsystem which is included in the Portuguese Quality System managed by IPQ. The Subsystem of Metrology is organized according to figure 1.

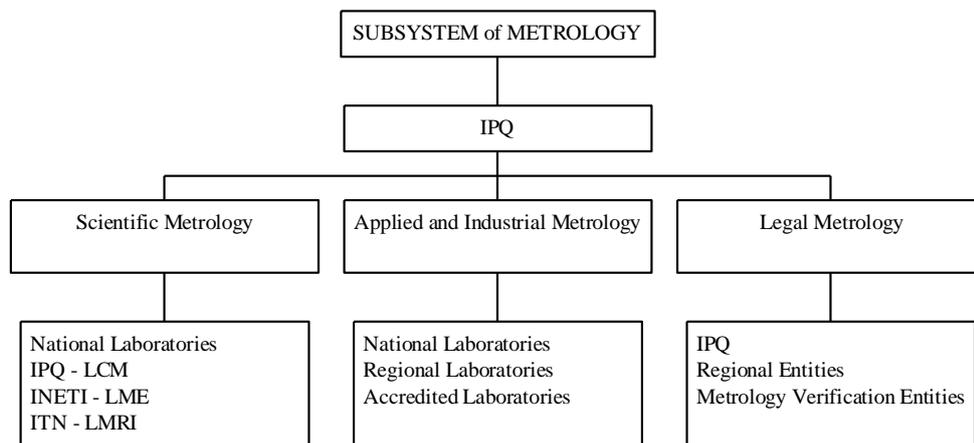


Fig.1. Structure of the National Metrology Subsystem

According to this figure, the National Laboratories for Scientific Metrology are IPQ-LCM, INETI-LME and ITN-LMRI. This link to IPQ is clearly defined by a Protocol between the two institutions and according to this the ITN-LMRI gives scientific and technical support to IPQ in the ionizing radiation field. Recently, technical support was given to the Portuguese Institute for Quality (IPQ) to write a new law for the metrological control of ionising radiation measuring instruments in Portugal. This new law will be published in 2008 and will substitute the old one from 1998, Portaria n° 423/98 and will include new domains of metrological control namely in instruments for measurements in nuclear medicine and diagnostic radiology. For Radiation Protection, new type of instruments, concerning their use, were added.

Measurement Unit

Nuno Rombert Pinhão

The Measurement Unit (MU) provides **analytical services in the area of radioactive control of low and medium activity samples and in measurement of ions in liquid samples.**

Together with the Environment Radioactivity (ER) group (which is responsible for collection, chemical preparation of the samples and data organization), the MU carries out Portugal's obligations under Article 35 of the EURATOM Treaty which requires member states to conduct national environmental radiological survey annually.

The MU is also involved in research work and provides external analytical services to support industrial and commercial activities.

The techniques used are high resolution gamma spectrometry; gross alpha/beta counting and beta counting of specific radionuclide using gas flow proportional counters; liquid scintillation and alpha spectrometry. Ion chromatography is also used to assist in the evaluation of the residual beta activity and in characterization of liquid samples.

In 2007 the range of radioactivity measurement services provided was extended and presently includes:

- Assessment of occupational exposure to I-125 and evaluation of the effective dose of ITN workers;
- analysis of radioisotopes in water to assist in the surveillance of ITN research reactor;
- control of foodstuff, export or import products and building materials;
- analysis of gross alpha/beta and ^3H activities in drinking water (in collaboration with the ER group);
- measurement of ^3H in biological samples by liquid scintillation for cancer research; and
- alpha spectrometry on water and soils samples.

Several techniques were improved or extended:

- The range of ions measured by ion chromatography has been extended to transition metals;
- HpGe spectrometry was extended to measure X-ray and low-energy gamma emission from I-125;
- a new treatment for the detection and quantification limits in gross alpha and beta counting, taking into account interference effects, has been developed; and
- several programs have been developed for the automatic treatment of results.

In 2007 involvement in research projects expanded to include:

- An informal collaboration with Universidade de Aveiro for dating of sediment based on Pb-210 and Cs-137 content; and
- preliminary work on project *KADRWaste* involving gamma spectrometry and ion chromatography.

Finally, the MU continued work for compliance with the ISO/IEC 17025 standard:

- The development of a LIMS (Laboratory Information Management System) adapted to the needs of DPRSN;
- the definition of procedures and organization of equipment records; and
- participation in several intercomparison exercises with good results.

Training and education:

- one group element continued working on a Master thesis;
- one group member concluded his graduation in Physics Engineering;

one FC/UL student finished the final training in Physics in the MU.

Research Team

Researchers

N.R. PINHÃO, Aux. (60%)

Analysis Contractors

L. SILVA, physicist

J. ABRANTES, physics engineer

L. TORRES, chemical engineer

Technical Personnel

J.M. OLIVEIRA, Senior Technician (30%)

G. SILVA, Technician [1*]

Informatics Consultant

J.P. SARAIVA (from August)

Students

G. CARVALHAL, FCT grantee

R. MENDES, FC/UL graduation student

I-125 Measurements for Occupational Exposure Assessment

L. Silva, N. R. Pinhão

Objectives

In ITN, I-125 is used in the production of labeled pharmaceutical compounds for cancer therapy research. Due to the volatility of iodine, there were doubts whether the radiation protection practices followed were effective in preventing exposure at limiting dose levels. The Measurement Unit was asked to perform individual monitoring of the workers handling I-125, in order to assess the level of occupational exposure.

Results

In the present laboratory conditions, the most probable path for iodine intake is inhalation. Since on average, 30% of an iodine uptake is translocated to the thyroid and the remaining 70% directly excreted in urine, *in vitro* measurements were performed in urine samples and an appropriate sampling protocol set.

We used high resolution gamma spectrometry to analyze the X-ray and gamma spectrum of urine samples because a) HPGe detectors are readily available in our laboratory, b) the technique does not require any radiochemical preparation and, c) the minimum detectable concentration is very satisfactory. The complexity of the spectrum, however, requires careful manipulation and analysis.

I-125 decays by electron capture to an excited state of Te-125. This daughter nucleus de-excites by internal

conversion (93%) and by emission of a gamma ray. The resulting spectrum shows a gamma and several X-ray peaks (figure 1) where the effect of coincidence summing and Compton photons on peak shape can be observed. We used the K_{α} and gamma peaks to quantify the activity of the samples.

From the activity found in the urine samples, we estimated the committed effective dose by inhalation of I-125. For a 24-hour excretion period, we found activity values of the order of one Bq and estimated the committed effective doses to be less than 0.3 μ Sv. Although very small, these values led to a re-evaluation and improvement of the laboratory safety conditions.

The low MDA level of the method provides an early detection of potential problems

Published Work

L. Silva and N. Pinhão "I-125 Measurements for Occupational Exposure Assessment" *2nd International Workshop on Application of the Ionizing Radiation & Nuclear Analytical Techniques in Industry, Health and Environment at High Performance*, Bucarest, 6th - 9th October, oral presentation and AIP – Conference Proceedings (in press)

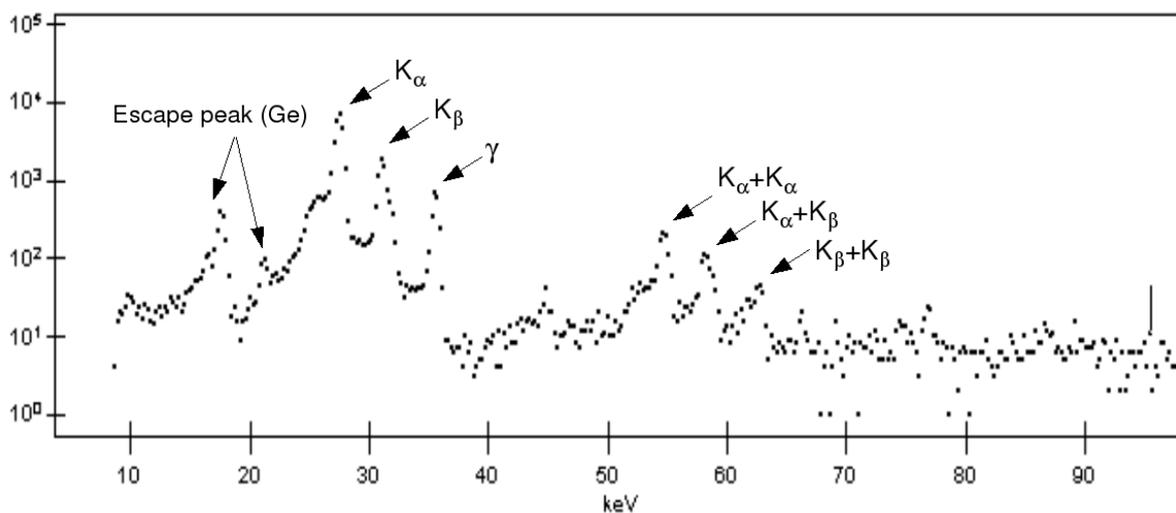


Fig. 1. Spectrum of a I-125 calibration source

Analytical Services on Radioactivity Measurement and Liquid Ion Chromatography

J. Abrantes, G. Carvalhal, J. M. Oliveira, N. R. Pinhão, L. Silva, G. Silva and L. Torres

In 2007, around 3000 measurement reports were emitted. Including analyses for calibration, quality control and intercomparison exercises, a total of 6000 analyses have been performed involving the following techniques: alpha spectrometry (20%), total alpha or beta counting techniques (22%), gamma spectrometry (23%), liquid scintillation (27%), and ion chromatography (8%). About 24% of these analyses were for the national environmental radiological survey, 18% were services for external entities, 28% for research projects, either of DPRSN or other ITN sectors, and the remaining for quality control of the techniques. It is worth mentioning that, excluding the quality control analysis, 20% of the alpha spectrometry, 2% of the gamma spectrometry analysis, 35% of the liquid scintillation and total alpha or beta counting techniques and 81% of the ion chromatography were on samples for research projects of the DPRSN, Chemistry or Physics sectors. The services provided to external entities represent a net income for ITN of over 70 kEuros. Considering the operational costs (including salaries and overheads), we estimate that the results obtained in the MU laboratories represent a net added value of over 50 kEuros.

Measurement of Transition Metals Ions by Liquid Chromatography

L. Torres and N. R. Pinhão

We have extended the analytical capacities available by ion chromatography to include the measurement of transition metal ions – manganese (Mn^{2+}), iron (II) (Fe^{2+}), iron (III) (Fe^{3+}), cobalt (Co^{2+}), nickel, (Ni^{2+}), copper (Cu^{2+}), zinc (Zn^{2+}), cadmium (Cd^{2+}) – and lead (Pb^{2+}) by UV absorption spectroscopy. A UV/visible absorption detector was installed, which complements the existing conductivity detector. For all ions, the value of the minimum detection concentration obtainable is below 1 mg/L. Applications include the evaluation of water contamination, the control of water quality in accordance to the legal limits, and the classification of water resources as adequate for human consumption, agriculture or industrial purposes.

Development and Implementation of a Laboratory Information Management System in DPRSN

J. Saraiva and N. R. Pinhão

A new LIMS application is being developed in DPRSN. This application combines web content management and workflow processing in a single web-based LIMS. It includes in a single application management of clients, services, equipments, procedures, laboratory records, quality control and auditing. Special attention is being given to the requirements for ISO 17025 certification. This application will replace the present databases used by the Environment Radioactivity and MLIR units and will also serve the needs of other units in DPRSN (RRSA and RPRWM). In 2007, the requirement analysis phase was completed and the required infrastructure installed.

The screenshot shows the NuCLIMS web application interface. At the top, there is a search bar and navigation links for 'site map', 'accessibility', and 'contact'. Below the search bar, there is a menu with options: 'entrada', 'clientes', 'pedidos de análise', 'worksheet', 'encomendas', 'consultas', 'importar', and 'relatórios'. The main content area is titled 'NuCLIMS - Versão de Demonstração' and includes the following text:

por admin última modificação 2008-02-11 16:55
Versão: NuCLIMS v0.1, Bika LIMS 1.2.5, Plone 2.5, Zope 2.9
 O NuCLIMS é uma aplicação de gestão de informação de laboratório.

Experimental!
 Este versão de demonstração serve para demonstrar o funcionamento da aplicação e, algumas das ferramentas já implementadas. Nesta versão é possível experimentar todas as funcionalidades sem qualquer risco!

Usar!
 Qualquer utilizador, para usar o NuCLIMS necessita de se autenticar; No futuro cada utilizador vai ter dados individuais de acesso. Contudo, para fins demonstrativos foi criado um utilizador de teste que tem permissões semelhantes ao do Gestor de Unidade. Os dados são os seguintes:
 Nome de Utilizador: **demo**
 Palavra-Chave: **demo**

On the right side of the page, there is a calendar for May 2008, showing the days of the week and the dates from 1 to 31.