Metrology Laboratory of Ionizing Radiation

Carlos Oliveira

The Metrology Laboratory of Ionizing Radiation (LMRI) has been involved in activities related with scientific, technical and legal metrology. A special attention was given to the LMRI Quality System (QS), due to the accreditation process that is involved in. Collaboration with Universities, national and international organizations and other ITN units were established and increased, in the framework of research projects.

Scientific and technical activities:

LMRI continues to participate in the European project in the framework of the EURAMET organization: JRP06 "Increasing cancer treatment efficacy using 3D brachytherapy". A new project elaborated in 2010 has been approved to start in September 2011, JRP13i "Ionizing Radiation Metrology for Metallurgical Industry". These projects arise from the implementation of the "European Metrology Research Programme" (EMRP) and are co-funded by the European Commission.

Two projects for the construction of the two air kerma primary standards are ongoing: a cavity chamber for ^{60}Co gamma rays and a free air chamber for low and medium X-ray energies (20 keV to 150 keV). The collaboration with other metrology laboratories is assured, namely with LNHB and BIPM.

The collaboration with the University has pursued, namely with the FCT – UNL (Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa). The results were, one master thesis has been presented, two master thesis have been realized and a new thesis has been accepted by the University to be performed at the LMRI during the next year.

A collaboration with the ESTeSL – Escola Superior de Tecnologia da Saúde de Lisboa do Instituto Politécnico de Lisboa took place with the realization of a traineeship.

A review of the LMRI 43 Calibration and Measurement Capabilities (CMC's) was started according the recommendations of the EURAMET and this includes a revision of technical procedures, uncertainty assessment and inter-comparison reports.

Legal activities:

The IPQ recognizes since April 2010 the LMRI as OVM (Organismo de Verificação Metrológica), necessary to perform legal metrology. Starting this date the metrological verifications is done according this status.

Concerning the legal metrology 20 medical dosimeters have been calibrated and 140 dosimeters and radiation monitors were metrological controlled. About 1200 TLD's dosimeters were irradiated.

Quality System

A technical audit to some LMRI calibration services was done, by the first time, with a European expert on the field of dosimetry. This visit was done with the support of IAEA. The objective of the mission was to realize a technical assessment of LMRI and its quality management system and also to find evidence of a national quality assurance for dosimetry in medical use of ionising radiation. Recommendations have been done for the LMRI, Government and AIEA. The quality management system with a special emphasis in the accreditation process has also been audited by a second entity, the Instituto de Soldadura e Qualidade (ISQ).

Internal collaborations

The LMRI has collaborated with all the Units of the Campus.

Technical assistance has been assured to the URSN during its annual maintenance of the RPI. The collaboration with the Radiation Dosimetry and Radiobiology Group (GDR) and the technical assistance to the Radioprotection and Radioactive Waste Group at UPSR has pursued. Collaboration with the Group Geochemistry & Luminescence on Cultural Heritage of UCQR in the framework of the *Radiart* project is realized. Some metrological services have been done to the UFA.

International organizations

Due to the activities on ionising radiations of LMRI, the ITN is the Designed Institute on the EURAMET organization.

The LMRI is recognised as a member laboratory of the IAEA/WHO network of the SSDLs and has participated in the TLD audit to the absorbed dose to water for ^{60}Co promoted by the IAEA.

Other activities

One of the members of the team, Luis Santos, is the Quality Manager of the UPSR QS in the Accreditation process and also gives support to management of the Data Base of the Environmental Radioactivity Group.

Members of the Group participate on Computational dosimetry group of EURADOS.

Research Team

Researcher

C. OLIVEIRA, Princ., (Habil.), Group Leader

Technical Personnel

J. CARDOSO

L. SANTOS, (50%)

A. CASTRO

Dosimetric quantities calculated for two brachytherapy sources using Monte Carlo codes.

Milton Rodrigues, Luis Portugal, João Cardoso and C. Oliveira

Objectives

This work is inserted in the jointly European research project T2-J06: "Increasing cancer treatment efficacy using 3D Brachytherapy, co-financed under the project iMERA-Plus according to Grant No. 217257 from the European Commission and EURAMET. The aim of this project is to create a primary standard for measuring absorbed dose in water, D_W, and reduce the uncertainty of dose deposited in a target volume, making it comparable with the current uncertainty in external radiotherapy.

In this work dosimetric quantities were calculated as described in TG-43 (1) of the AAPM using Monte Carlo simulations for two brachytherapy seeds: one used for low rate applications, the Bebig model I25.S06 seed (a ^{125}I source) and another used for high dose rate applications, the Nucletron MicroSelectron V2 source (^{192}Ir). The results have been obtained using two different MC codes, the MCNPX and the PENELOPE code.

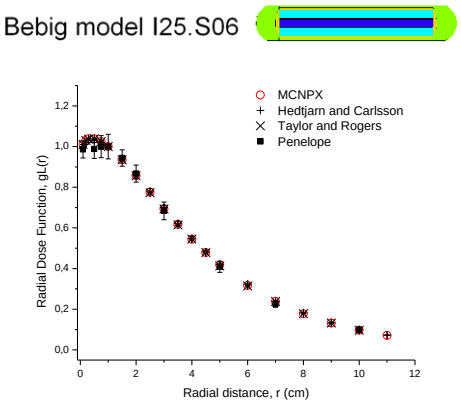


Fig 1 Radial dose function as function of radial distance.

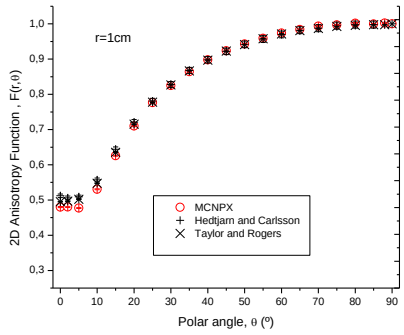


Fig 2. 2D anisotropy function as function of polar angle for a radial distance of 1 cm.

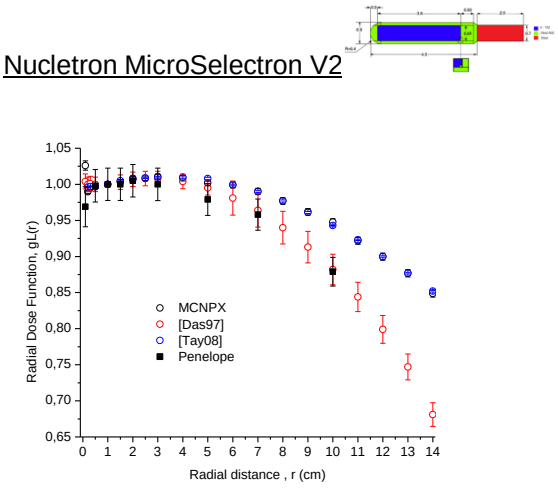


Fig 3 Radial dose function as function of radial distance.

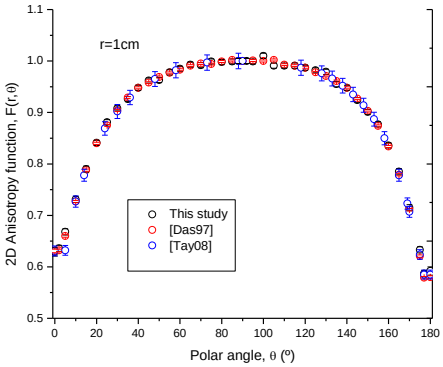


Fig 4 2D anisotropy function as function of polar angle for a radial distance of 1 cm.

The radial dose functions are quite different for the two sources. This is due to the different energy spectra. The higher energy of the ^{192}Ir determine a maximum of the function near the 4.5 cm while for the ^{125}I source the maximum occurs near 1 cm of the source.

The anisotropy function is obviously symmetric for the Bebig seed but for the V2 source its values are lower for the smaller polar angles which correspond to the side of the stain steel cable.

Reference

Rivard, M. J., Coursey, B. M., DeWerd, L. A., Huq, M. S. Ibbott, G. S., Mitch, Nath, R., Williamson, J. F. Update of AAPM Task Group No. 43 Report: A revised AAPM protocol for brachytherapy dose calculations. Medical Physics 2004; 31: 633–674.

DEVELOPMENT OF A NEW IONIZATION CHAMBER, FOR HP(10) MEASUREMENT, USING MONTE CARLO SIMULATION AND EXPERIMENTAL METHODS

J. Cardoso, H. Silva[1], C. Oliveira

An ionization chamber that directly measures the quantity personal dose equivalent, Hp(10), is used as a secondary standard in some ionizing radiation metrology laboratories. This ionization chamber was first developed by Ankerhold, at PTB and some years later a similar chamber has been developed and studied in the Metrology Laboratory of Ionizing Radiation (LMRI) of ITN. The work realized recently developed a new ionizing chamber. Some of the basic metrologic characteristics of ionizing radiation detectors were investigated on this chamber, like energy response, angular response, accuracy and a special attention was given to geometrical aspects of the ionization chamber. This was done both by experimental and Monte Carlo simulation work. The objective of this work was to study the influence of all components of the IC on response considering some geometrical modifications. In order to investigate the response of the IC as a function of energy for different dimensions, eleven ionization chambers were designed and simulated. A detailed study of the interaction of X-rays with the several components of the Hp(10) ionization chamber was performed and the results of the simulation studies led to a new ionization chamber, IC_1, that was constructed and its response was compared with the previous LMRI_ chamber, IC_0. From the simulation results there is a geometry which seems to represent a good compromise between a good response and its weight. According to these results a new ionization chamber, IC_1, was constructed and its response was experimentally investigated and compared with the IC_0 chamber. Experimental tests were performed using the X-ray radiation qualities of the narrow spectral series, described in the ISO 4037–1, for angles of incidence α between the photon beam and the normal to the slab phantom's front surface of 0°, 45°, 60° and 75°. The response of the ionizing chamber as a function of photon energy and incidence angle has been studied and the calibration coefficient, N_H was obtained by applying ISO conversion coefficients. Its value is N_H =5.324×106 Sv/C with an expanded uncertainty (k=2) of 6.0 %. The uncertainty was calculated combining all the uncertainty components of the measurement. The main contributions to uncertainties are related to the measurement itself. The new chamber has the advantage to have a weight reduced by a factor of 4 (4 kg *vs* 16 kg) relatively to the previous chamber. This is a great advantage for the portability of the instrument. For the radiation qualities tested, the ionization chamber is fully characterized. The correction factors of the new constructed chamber are lower than for the previous chamber. Some fluctuations were found and are assumed to be linked with electrode construction.

[1]FCT-UNL

Characterization of Mammography Radiation Qualities at LMRI

D. Góis[1], J. Cardoso, C. Oliveira

New radiation beam qualities have been established and characterized at the LMRI using the tungsten-anode low energy x-ray tube with molybdenum filters and molybdenum plus aluminium filters. These radiation qualities simulate the radiation beams used in clinical mammography. The purpose of this study is to have the conditions in order to perform the metrological control of dosimeters used in mammography. The X-ray equipment of LMRI has a W anode and in consequence, the international standard IEC 61267 has been used only for the procedures relatives to the characterization of the radiations qualities.

To characterize the radiation qualities the values of HVL and the homogeneity coefficient *h* have been determined. The applied potential was 23 kV to 31 kV with a step of 1 kV, and 35 kV, 40 kV and 50 kV using 0.06 mm or 0.03 mm of Mo as filtration with and without additional filtration (2 mm Al). The results of the *HVL* (mm of Al) are compared with the values of other laboratories (PTB and BIPM). The dosimetry will be performed using a new ionization chamber, the PTW Mammo Chamber type 34069, purchased recently but requiring a previous calibration scheduled at BIPM in 2011.

[1]FCT-UNL

Project, construction and characterization of a portable irradiator for metrological verification of fixed area monitors.

Ana Carvalho[1], J. Cardoso, C. Oliveira

The purpose of the work is the project and characterization of a portable irradiator equipped with a ^{137}Cs source to be applied to the metrological verification of the fixed area monitors. This equipment measures the ambient dose equivalent, H*(10). The irradiator has a cylindrical shape with two parallel plane bases connected to two small cylinders which fill the respective cylindrical cavities. One of these cavities contains the source. The second cylinder is only removed when the irradiator is operating. The maximum dose at 1m distance is 3 μGy/h. The total weigh is approximately 3 kg. The characterization of the field has been achieved determining the profile, horizontal and vertical, of the radiation field both experimentally and using a Monte Carlo code. The height half width varies between 20 cm and 40 cm for distance to the source from 20 to 40 cm for both profiles. Using an ionising chamber calibrated at H*(10), this quantity has been determined for distance up to 1.5 m. When in operating the irradiator need to have attached a tube to support it and to assure a fixed distance to the area monitor. The influence of this tube has been analysed and its perturbation quantified. The influence of the proximity of a wall near the monitor to be controlled also has been studied.

[1]FCT-UNL

QUALITY SYSTEM

L. Santos, J. Cardoso, C. Oliveira

To meet the requirements of the NP EN ISO/IEC 17025:2005, the quality system deserved, once again, all attention. The LMRI quality system has been audited twice. One of the audits was carried out, during three days, by Hans Bjerke, chair of the Technical Committee for Ionizing Radiation of EURAMET. The objective of the mission was to realize a technical assessment of LMRI and its quality management system and also to find evidence of a national quality assurance for dosimetry in medical use of ionising radiation. The audit has focused with special attention to the CMC's. Recommendations have been done for the LMRI, Government and AIEA. The second audit was realized by ISQ (Instituto de Soldadura e Qualidade) and was focused on accreditation process and the techniques to be accredited.
As has happened in recent years the LMRI participated in the TLD audit to the absorbed dose to water for ^{60}Co promoted by the AIEA.

The Metrology Laboratory of Ionizing Radiation (LMRI) submitted for accreditation three techniques in metrological control of radiation protection monitors in terms of the operational quantities, personal dose equivalent, Hp(10), and ambient dose equivalent, H*(10), according to the standards IEC 61344, IEC 61526 and IEC 60846, respectively.

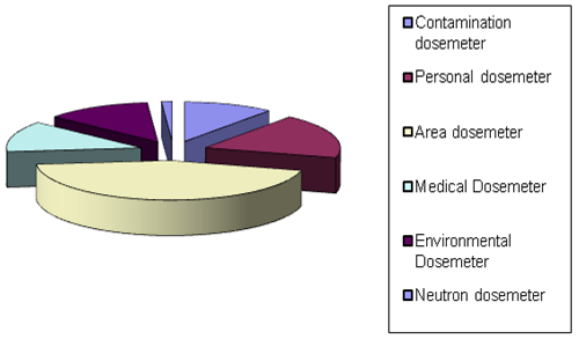
Calibration and Measurement Capabilities (CMC's)

According to the recommendations of the EURAMET a revision of the CMC's, namely the revision of procedures, uncertainties assessment, update of inter-laboratorial comparison, have been initiated.

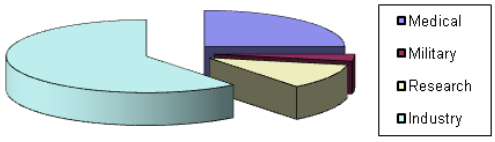
SERVICES

L. Santos, J. Cardoso, A. Castro, C. Oliveira

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 nº. 1106/2009 dated of 24 of September. During 2010 were calibrated 160 dosimeters. The following figures can quantify the work done in this particular area.
In 2010, the LMRI, have irradiated personal dosimeters for the reader system calibration of two private companies.



Instruments calibrated by users activity.



Instruments calibrated by type of use.

INTERNAL SERVICES

LMRI collaboration with ITN Groups

L. Santos, J. Cardoso, C. Oliveira

Unit of Reactors and Nuclear Safety (URSN)

The LMRI performs, every year, in the RPI maintenance period, the metrological control of installed detectors and associated instrumentation of the RPI radiological protection system. This includes the hand-foot contamination monitor, MAB HFM 2102; five area monitors measuring system MGP C/EIP 51 equipped with ionisation chambers; four area monitors measuring system Automess 632.1 equipped with Geiger-Muller detectors; the fission products detection system, Tracerlab, Inc. MWP-1A; the noble gas monitor system Mirion NGM 204L the Iodine detection system, AIEA AIRMON; two, alpha and beta radiation detection systems in aerosols, ABPM201L; detection system for beta radiation on samples or filters, ECM21+BCF31; iodine detection system, IM201S; and, also, metrological control of three personal electronic monitors, two area monitors and one contamination monitor.

Unit of Physics and Accelerators (UFA)

In 2010 the LMRI has carried out the control metrological of two radiation monitors.

Unit of Chemical and Radiopharmaceutical Sciences (UCQR)
Geochemistry & Luminescence on Cultural Heritage Group

In the framework of the *Radiart* project a few TLD's have been irradiated.

Unit of Radiological Protection and Safety (UPSR)
Dosimetry and Radiobiology Group

In 2010 about 1200 TLD dosimeters have been irradiated for UPSR individual dosimetry group. About 700 for *H*p(10) and about 300 for Hp(0.07). In collaboration with other groups, the cells and blood irradiation for the UPSR Radiobiology Group has been one of the most important collaboration. The purpose of the work was the establishment of a dose response curve for biological dosimetry, using lymphocytes from human peripheral blood from healthy donors for both gender and different age group. The dose range studied is from 0.25 Gy to 3.0 Gy using a source of ^{60}Co. About 50 irradiations have been carried out.
In the scope of a master degree, one ionizing chamber was calibrated in X-ray N-120 radiation quality.

Environmental Radioactivity Group

The technical support to UPSR - Environmental Radioactivity group database (SIAC) and the data submission for the Radioactivity European Measurement Database (REM) has been made by a LMRI technician (LS). For data submission to REM, first it's necessary the treatment of the SIAC values in an access database, export this files to "tab delimited file" format and after this submit them to REM.