INCT – RADIATION METROLOGY IN MEDICINE

PARTIAL REPORT

YEAR 2009

1. Management Committee – meetings and decisions

Minutes and summary of the 1st meeting of the Management Committee: meeting held by electronic means, on May 27, 2009.

Formation of the Management Committee composed by the heads of the Associate Laboratories.

Clarification in which way the project will be implemented for the Participating Institutions:
Duration of the project;
Implementation of grants;
Publications;
Monitoring of the activities;

Allocation of financial resources:
Resources for permanent (national and imported) as well as bibliographical material at FAPESP;
Diaries and transport tickets of the researchers from Sao Paulo State will be paid by FAPESP;
Other costs paid by CNPq;
Fellowships paid by CNPq.

2. Cooperation activities among the groups of INCT participants

INSTITUTO DE PESQUISAS ENERGÉTICAS E NUCLEARES + FACULDADE DE FILOSOFIA CIÊNCIAS E LETRAS DE RIBEIRÃO PRETO

Collaboration in the characterization of X-ray beams.

INSTITUTO DE PESQUISAS ENERGÉTICAS E NUCLEARES AND OTHER PARTICIPANTS

During 2009 participants of the different instituties of this INCT presentd several papers in colaboration in conferences and publications.

Visit of students from the Physics Department of the UFS, Simara Santos Campos and Raquel Aline Pessoa Oliveira, the IPEN / SP and the Institute of Physics to carry out experiments and exchange of information

3. Co-operation activities with other INCTs and Institutions

INSTITUTO DE PESQUISAS ENERGÉTICAS E NUCLEARES - IPEN/CNEN/SP

Departamento of nuclear energy of the Federal University of Pernambuco (DEN / UFPE) – irradiation of samples in Hp(0,07) and H*(10) for the Costa Rica University, with ^{137}Cs.

FEDERAL CENTER FOR TECHNOLOGICAL EDUCATION (CEFET/SP) – irradiation of dosimetric samples in X-ray and ^{60}Co bems, for dose-response curves.

INSTITUTO DE RADIOPROTEÇÃO E DOSIMETRIA - IRD/CNEN/RJ

Brazilian Institute for Cancer (INCA) – research in radiotherapy, with in vivo-dose measurements at patients undergoing treatments, and quality control in radiotherapy.

Studies were also undertaken in the diagnostic radiology area: general radiology and computed tomography.

Municipal Health Secretary of Rio de Janeiro State – quality control in mammography, dose evaluation and image.

University Hospital – UFRJ – measurements taken at the Nuclear Medicine Service, about the application of new pharmaceuticals.

CENTRO DE DESENVOLVIMENTO DA TECNOLOGIA NUCLEAR – CDTN/CNEN/MG

Interactions were undergone with non-INCT Associated Laboratories that have specific experience on metrology or in diagnostic radiology areas.

A scientific visit was done to the Laboratory of Radiological Sciences of UERJ/Rio de Janeiro for calibrating dosimeters in mammographic reference radiations. Data on patient doses in mammography and tomography were sent to the Dosimetry and Nuclear Instrumentation Group (DOIN) of the Nuclear Energy Departament of UFPE/Recife as input for comparison and traceability of standard dosimeters was planned to be established with the National Metrology Laboratory IRD/CNEN/Rio de Janeiro.

Access to the Health Services was achieved due to the formal co-operation between CDTN and the Sanitary Vigilance of Minas Gerais state. This will allow the application of the methodologies of patient dose assessment in order to disseminate the benefits to the society.

4. Main technical-scientific results

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Goal: Development of calibration methodologies applied to diagnostic radiology; Development and characterization of new dosimetric materials; Development of reference systems and methods of measurement of ionizing radiation

1) Development of a monitor ionization chamber for X-radiation beams
Supervisor: Linda V. E. Caldas
Student: Maíra Tiemi Yoshizumi

X-radiation equipment may present variations in the radiation beam intensity due to power supply instabilities. In a calibration laboratory the intensity variation must be known once it can interfere in the measurements. A monitor ionization chamber is used to verify the stability of the radiation beam intensity.

In this work, three ring-shaped ionization chamber prototypes were developed.

The ring-shaped design was thought not to interfere in the X-radiation spectra. During the year of 2009, the last characterization tests of a ring-shaped ionization chamber with an aluminum collecting electrode were performed. The ionization chamber response stability using X-radiation beams did not present results into the recommended limits of ±2%.

A new ring-shaped ionization chamber prototype was developed and tested. This new ionization chamber has a graphite-coated collecting electrode, and it presented very good results in all characterization tests performed: saturation curve, polarity effect, ion collection efficiency, stabilization time, response linearity, leakage current, repeatability and long-term stability response.

The three last tests were performed using a check-source device of $^{90}Sr+^{90}Y$ and X-radiation beams. The graphite-coated ring-shaped ionization chamber was also tested using beta and gamma radiation beams.

2) Establishment of primary standardization for low- and medium- energy X-rays, diagnostic radiology and radiotherapy levels, in the Calibration Laboratory of IPEN
Supervisor: Linda V. E. Caldas
Student: Eric Alexandre B. da Silva

Measurements in procedures involving ionizing radiation usually involves risks and dangers, thus they require high quality control and quality assurance standards.

This work has the objective to establish a primary standardization for low- and medium-energy X-rays at the Calibration Laboratory of IPEN, using an extrapolation ionization chamber as a reference system.

The methodology involved two extrapolation chambers, a commercial chamber PTW and a home-made chamber developed at the laboratory. Several tests, such as: medium- and long-term stability responses, leakage current, response linearity, energy dependence, saturation curve and ion collection efficiency were performed using the PTW extrapolation chamber in radiotherapy, diagnostic radiology and mammography radiation qualities.

A comparison with secondary standards will be performed in each radiation beam quality, as a reference. The obtained results, until the present moment, were considered satisfactory, but for a complete standardization, the correction factors for this standard system, and their uncertainties, have to be carefully determined.

3) Study of the radioprotection monitor response in standard X, gamma and beta radiations
Supervisor: Linda V.E. Caldas
Student: Fernanda B. C. Nonato

It is necessary that the radiation monitors operate according to the specific international recommendations, to ensure the reliability of their measurements. The prior calibration of the instrument constitutes one of the most important quality control procedures.

The main objective of this work was to study the energy and angular dependence of the response of radiation monitors, such as Geiger-Müller detectors and ionization chambers, in X, gamma and beta radiation fields.

The energy dependence, for the ambient dose equivalent operational quantity, was lower than and equal in relation to the case of air kerma quantity, for Geiger-Müller detectors and ionization chambers, respectively, calibrated in gamma radiation fields.
The results of the angular response of the monitors were within the values established by the international standard EN 60846 (2004). The study of the response of radiation monitors to beta radiation fields (^{90}Sr + ^{90}Y and ^{204}Tl) showed how great the variation of correction factors can be, indicating a very high energy dependence.

The correction factors for angular dependence were higher than 40%, this percentage is the maximum limit of the international standard EN 60846 (2004). The results obtained for the ionization chambers calibrated in X-rays fields were satisfactory, according to the recommendations of the IAEA SRS 16 (2000), ISO 4037-2 (1997) and ISO 4037-3 (1999) standards.

4) Comparative study among calibration methods of clinical applicators of beta radiation
Supervisor: Linda V. E. Caldas
Student: Patrícia de Lara Antonio

$^{90}Sr+^{90}Y$ clinical applicators are instruments used in brachytherapy procedures and they have to be periodically calibrated, according to international standards and recommendations.

In this work, four calibration methods of dermatological and ophthalmic applicators were studied, comparing the results with those given by the calibration certificates of the manufacturers. The

methods included the use of the standard applicator of the Calibration Laboratory (LCI), calibrated by the National Institute of Standards and Technology; an Amersham applicator (LCI) as reference; a mini-extrapolation chamber developed at LCI as an absolute standard; and thermoluminescent dosimetry.

The mini-extrapolation chamber and a PTW commercial extrapolation chamber were studied in relation to their performance through quality control tests of their response, as leakage current, repetibility and reproducibility.

The distribution of the depth dose in water, that presents high importance in dosimetry of clinical applicators, was determined using the mini-extrapolation chamber and the thermoluminescent dosimeters.

The results obtained were considered satisfactory for the both cases, and comparable to the data of the IAEA (2002) standard. Furthermore, a dosimetry postal kit was developed for the calibration of clinical applicators using the thermoluminescent technique, to be sent to clinics and hospitals, without the need of the transport of the sources to IPEN for calibration.

5) Establishment of a dosimetry method for the exposure evaluation of ultraviolet radiation
Supervisor: Linda V.E. Caldas
Student: Claudia Carla Gronchi

A dosimetric method for the exposure evaluation to ultraviolet radiation was established with Al_2O_3:C InLight detectors and an OSL microStar reader and software, of Landauer, associated to the techniques of Optically Stimulated Luminescence (OSL) and Phototransferred Optically Stimulated Luminescence (PTOSL).

The main phases of this work were: characterization of the Al_2O_3:C InLight detectors, without pre-conditioning, exposed to ultraviolet radiation (RUV) of solar and artificial sources, using the OSL technique; characterization of the Al_2O_3:C InLight detectors, pre-conditioned, exposed to RUV solar and artificial sources, using the PTOSL technique; practical applications of the Al_2O_3:C InLight detectors to the solar and artificial RUV, originating from TIG (Tungsten Inert Gas) and electric welding.

The Al_2O_3:C InLight detectors presented satisfactory OSL and PTOSL responses in relation to the parameters: wavelength, UV illumination time, irradiance, radiance exposure and angular dependence to the RUV. Those detectors presented maximum OSL and PTOSL stimulation for the wavelength of 330 nm, showing that they are may be useful for UVA radiation detection and dosimetry.

6) Characterization of dosimetric materials for high doses
Supervisor: Linda V.E. Caldas
Student: Gustavo B. Vila

The dosimetric properties, for high doses, of oyster shell samples in powder were studied using mixtures with Teflon in a 1:2 proportion. The samples were sintered at 450ºC during 1.5h into pellets of 20mg with 6mm of diameter and approximately 1mm of thickness. After the irradiation and the thermoluminescent (TL) and thermally stimulated exo-electron (TSEE) measurements, the samples were treated thermally at 300ºC by 1 hour (defined for reutilization of the material).

The irradiations were carried out at a ^{60}Co panoramic irradiator of the Center for Radiation Technology, with a dose rate in the air of 5.97Gy/min and at a ^{60}Co source of the Center for Radiation Metrology. The dose response curves were taken in the range 5 – 10kGy. The TL measurements were taken using a TL reader (Harshaw Chemical Co, model 2000A/B) in the range 100 – 300ºC. A virtual Pico Technology (model ADC-212) instrument was used for the data acquisition. The TSEE measurements were taken using a home made system built at the Calibration Laboratory/IPEN and in the range 100 – 250ºC.

The preliminary results showed the usefulness of the oyster shell samples as high dose detectors. The pellets exposed to radiation showed TL and TSEE emission curves with glow peaks around 110 and 220ºC, and 120 and 180ºC respectively.

The dose response curves of the oyster shell pellets irradiated (^{60}Co) in the range 5-10kGy showed an increase in relation to the dose. TSEE measurements showed a maximum standard deviation of 3.5% and the TL measurements, 4.5%. The reproducibility study showed a maximum standard deviation of 4.2% in the TL response and 2.4% in the TSEE response.

For the study of TL and TSEE response of non irradiated samples thermally treated at 300º C for 1 hour, the lower detection limit for oyster shell samples was determined: 500mGy.

The stability test of the dosimetric peak response using both techniques and the ideal thermal treatment for elimination of the first emission peak of the TL and TSEE curves were determined.
The preliminary results showed usefulness for high dose dosimetry. Moreover, this kind of material is found in abundance in the nature, and it is therefore of very low cost.

TL and TSEE measurements were also taken using natural and synthetic spudomene samples in collaboration with the group of the Physics Department of Federal University of Sergipe (UFS), and Al_2O_3 doped with rare earths in collaboration with the group of the Nuclear Energy Department of Federal University of Pernambuco (UFPE) that provided the samples for the research. In these studies the samples were irradiated in the same irradiation systems. The samples will still be irradiated in X-rays with different qualities to verify their possible use as dosimeters for diagnostic and mammography levels.

7) Characterization of X radiation qualities following the IEC 61267 standard recommendations at the Calibration Laboratory of IPEN
Supervisor: Maria da Penha A. Potiens
Student: Priscila Cerutti Franciscatto

This work presents a methodology for the X radiation qualities characterization following the new recommendations of the standard 61267 of the International Electrotechnical Commission (IEC) to establish a new procedure for calibration of dosimetric systems used in diagnostic radiology measurements.

The IEC 61267 reference radiation qualities RQR 2 to RQR 10, RQA 2 to RQA 10, RQB 2 to RQB 10 and RQN 2 to RQN 10 were established at the calibration laboratory of IPEN (LCI). Their characteristics were analyzed throughout measurements of the beam parameters such as: Practical peak voltage (PPV), specific additional filtrations for each quality (high purity aluminum of about 99.9%), 1st and 2nd Half Value Layers and the homogeneity coefficient. The inherent filtration of the X-rays tube was also determined.

The dosimetric system (ionization chamber coupled to an electrometer), presented a good long term stability, increasing the associated uncertainties assurance. All the measured PPV values for all radiation qualities had been determined not invasively and they were below the uncertainties limits recommended by the standards IEC and TRS 457.

Additionally, in order to analyze all the IEC recommended radiation qualities, special phantoms were developed for the implantation of RQN and RQB radiation qualities. Although it is not possible to determine the air kerma rates, such qualities will allow studies in these specific conditions, using an appropriate ionization chamber, with a larger volume.

With the establishment of these radiation qualities, the LCI will be ready to calibrate the instruments used in diagnostic radiology measurements in the new qualities, allowing an improvement in the calibration services offered by IPEN.

8) Quality control programme implementation in X radiation equipments using a non invasive meter.
Supervisor: Maria da Penha A. Potiens
Student: Rodrigo Ferreira de Lucena

The objective of this work was the development of a quality control programme methodology to be applied to the X-rays system belonging to the Calibration Laboratory of IPEN.

To measure the field uniformity a thimble ionization chamber was used. To the energy, angular, applied current and distance dependence tests, a PTW Diavolt non invasive instrument was used and to do the spectra measurements related to the established radiation qualities and the peak voltage applied it was used a spectrometry system in the range from 25 to 150 kV.

The quality control programme implementation was very useful to a better knowledge of the equipment behaviour during the data acquisition processes, as well as its technical limitations and restrictions of the set up used.

Beside these verifications, it was possible to indicate the better measurements conditions for the three mainly studied quantities (air kerma, peak voltage and practical peak voltage), as well as the necessity of adjustments in the used logistic.

9) Study of calibration routines and procedures of clinical dosimeters in gamma radiation beams at IPEN-CNEN/SP
Supervisor: Vitor Vivolo
Student: Willian B. Damatto

The periodic calibration of clinical dosimeters applied in radiotherapy routines is a very important task. The clinical dosimeters are used to determine the dose received by the patients during radiotherapy procedures, and for that the patient dose should be determined with high accuracy. Then, the clinical dosimeters applied in radiotherapy need to be used carefully and stored in special conditions, such as: low relative air humidity, stable AC power voltage (line voltage) to feed the measurement equipment, the measurement system free of electromagnetic interference (EMI), etc.; these procedures are to avoid current and charge leakage, and system instability that affect the readings accuracy of the measurement system.

The main objective of this paper is to show the importance of periodic calibration of clinical dosimeters, and also the development of a control quality system to assure the reading accuracy of the measurement system. A study of international and national protocols and standards relative to calibration procedures and quality control to be applied to measurement systems was performed. A good quality control system applied to the measurement systems sometimes can help the equipment operator to solve some eventual troubles in the measurement systems, such as incorrect readings.

First, many different kinds of clinical dosimeters applied to radiotherapy were tested (ionization chambers with 0.6 cc). Current leakage tests and reproducibility tests, as recommended by the International Atomic Energy Agency [TRS 398(2000), TRS 374(1994), TRS 277(1987), SRS 16(2000),and other institutions as CNEN-NE-3.06 (2006) and IEC 60731 (1997)], were applied between August 2008 and June 2009. 62 clinical dosimeter systems were tested.

The tests showed that about 25% of the equipment checked during calibration procedures present some fault or trouble. The main problems during the calibration procedures were leakage current in the measurement system, problems in triaxial cables (short-circuit, leakage current, broken cables and connectors, etc.), and also trouble in the batteries. A quality control system applied to the standard measurement system of the Calibration Laboratory (LCI-IPEN/CNEN), and applied to the customer measurement system too, allow a good performance of the measurement systems, such as high stability in their readings, and high accuracy of the measurements. Some international protocols suggest that the radiotherapy treatments should have at least a confidence level of 95% to reach and/or to assure good results in the treatments [IAEA TECDOC 1585 (2008), IAEA TECDOC 1151(2000)].

10) Quality control methodology and implementation of standards X-ray beams used for instruments calibration, mammography level
Supervisor: Maria da Penha A. Potiens
Student: Eduardo de Lima Corrêa

The additional filtrations needed to the implementation of the radiation qualities, mammography level, were defined using the Pantak/Seinfert X-rays system (160 kV), in the Calibration Laboratory of IPEN (LCI), used to calibration of radiation meters. The applied tube voltages were 25kV, 28kV, 30kv and 35kV, and the current was 10 mA, for direct and attenuated beams, according to the standard IEC 61267 (2005).

The spectrometry of the X-rays beams was also made in these same qualities. The air kerma rates will be determined as soon as the LCI mammography standard ionizing chamber returns from the German Primary Standardization Dosimetry Laboratory, Physikalisch-Technische Bundesanstalt (PTB). After that, the new mammography qualities recommended by the standard IEC 61267 implementation will be finalized. The calibration of the standard ionizing chamber has been done using the following target-filtration combination: Mo-Mo, W-Mo and W-Al.

In this period a breast simulator of polymethylmethacrylate (PMMA) was also developed, based on the model given by the Technical Report Series TRS-457 (IAEA 2007), to be used in the mammography tests. This simulator is constituted by 9 plates with 0.5 mm each plus two specials plates with holes to positioning the mammography ionization chamber and the reference source $^{90}Sr+^{90}Y$.

An additional plate containing some small holes to place thermoluminescent (TL) and optical stimulated luminescent (OSL) dosemeters will be developed in order to determine the dose in different depths. Initially scattering tests have already been performed in the mammography equipment recently obtained by the LCI.

11) Research, development, characterization and study of fluoropolymers and polycarbonates commercials dosimetric properties for radiation processes absorbed doses control application
Supervisor: Letícia L. C. Rodrigues
Student: Ana Maria Sisti Galante

Polymeric materials exposed to electron beams, X-rays and gamma rays undergo structural changes due to the crosslinking or chain scission (degradation) reactions, and consequently changes occur in chemical resistance, electrical and surface properties and thermal stability of polymers. These changes can be determined, quantified and related to the radiation dose and dosimetric purposes.

In order to provide new dosimetric materials for quality control of a wide range of services that use ionizing radiation materials such as fluoropolymer and polycarbonate (in the film form) were analyzed.

The main parameters studied were: dosimetric wavelength, response curve as a radiation dose function, lower and upper dose ranges (useful dose range), response stability before and after irradiation, response dependence of the environmental conditions.

As analysis technique, spectrophotometry in the ultraviolet, visible and infrared spectrum region was used. For the characterization of the samples, they were irradiated using a Gammacell source and an electron accelerator JOB 188, both belonging to IPEN.

The radiation changes induced in the absorption spectrum of the studied films can be related to the absorbed dose. The spectra show a linear correlation between the peaks intensity and the radiation dose. The useful dose range is wide. The research is in progress and other characteristics will be determined.

12) Standardization of the Fricke gel dosimetry method and tridimensional dose evaluation using the magnetic resonance imaging technique
Supervisor: Letícia L. C. Rodrigues
Student: Christianne C. Cavinato

This study standardized the method for obtaining the Fricke gel solution developed at IPEN. The results for different gel qualities used in the preparation of solutions and the influence of the gelatin concentration in the response of dosimetric solutions were compared. Type tests such as: dose response dependence, minimum and maximum detection limits, response reproducibility, among others, were carried out using different radiation types and the optical absorption (OA) spectrophotometry and magnetic resonance (MR) techniques. The useful dose ranges for ^{60}Co gamma radiation and 6 MeV photons are 0.4 to 30.0 Gy and 0.5 to 100.0 Gy, using OA and MR techniques, respectively.

A study of ferric ions diffusion in solution was performed to determine the optimum time interval between irradiation and samples evaluation; until 2.5 hours after irradiation to obtain sharp MR images. A spherical simulator consisting of Fricke gel solution prepared with 5% by weight 270 Bloom gelatine (national quality) was developed to be used to three-dimensional dose assessment using the magnetic resonance imaging (MRI) technique.

The Fricke gel solution prepared with 270 Bloom gelatin, that, in addition to low cost, can be easily acquired on the national market, presents satisfactory results on the ease of handling, sensitivity, response reproducibility and consistency. The results confirm their applicability in the three-dimensional dosimetry using MRI technique.

13) Development, standardization and characterization of a new thermoluminescent dosimetric material applying the Europium (Eu) as activator material.
Supervisor: Letícia Lucente Campos Rodrigues
Student: Maíra Goes Nunes

The thermoluminescent (TL) dosimetry has been intensively developed during the past three decades due to its successful applications, specially the personal and environmental monitoring, being more recently applied in a raising scale to the radiotherapy.

The application of charged particle beans in medicine adds relevance to the development of new TL materials, traditionally applied to the X, gamma and beta radiation detection, specially for alpha particles and high energy neutrons and electrons high dose dosimetry applications.

Addressing the external dosimetry advances, mainly in the medical area, this study aims to develop a new thermoluminescent material, of high sensitivity and small energetic dependence, based on the calcium sulphate ($CaSO_4$) and using Europium (Eu^{2+}) and/or Cerium (Ce^{3+}) ions as activator materials, to be applied in the clinical dosimetry of the ionizing radiations.

The ideal characteristics of the $CaSO_4$ crystal growth were determined for the activation with different rare earths ions, including Eu^{2+} and Ce^{3+} whose ideal concentrations in the $CaSO_4$ precursor sulfuric acid (H_2SO_4) solution are, respectively, 0.16 ± 0.07 e 0.15 ± 0.04.

The glow curves obtained with the heating rate of 10 ºC.s^{-1} show a single first-order TL peak with temperature of maximum TL emission of 147.62 ± 0.04 ºC for the $CaSO_4$:Eu and of 130.25 ± 0.06 ºC for the $CaSO_4$:Ce, reproducibility smaller than 5% for different samples of the same crystal growth and smaller than 0.5% for samples of different crystal growths.

The dose-response curves present a linear behavior in the dose range that extends from the lower limit of detection to 5.5 Gy, the higher studied dose, and there is no detectable energetic dependence for high energy electrons, although the intrinsic efficiency of $CaSO_4$:Eu and $CaSO_4$:Ce varies with the type and, slightly, with the energy of the radiation.

Goal: Development of new dosimetric methodologies in Radiotherapy

1. Title: Study and validation of dosimetry in terms of non-reference conditions
Supervisor: Laura Natal Rodrigues
Student: Talita Sabino

First a study was conducted to understand the procedures and concepts for the project. The reference paper which was considered is "Small fields: Non-equilibrium radiation dosimetry" (Das et al) presenting the preliminary concepts and essentials to study the topic of this project. For this article was a presentation was held at the HC-SP for the course students of physical therapy in order to show some concepts of dosimetry for small fields. "Determination of the quality index (Q) for photon beams at arbitrary field sizes" (Sauer, Sept. 2009), the study starts by studying a mathematical model that calculates the parameter of beam quality, and measures the TPR, for any field size, especially the small fields, which have a higher concentration of problems in dosimetry due to the size of the field compared to the size of the sensitive detector volume and lack of electronic equilibrium. "Functional representation of tissue phantom ratios for photon fields" (Sauer, dez2009), this is the continuation of the study the article described above, but with a new mathematical formalism.

In both articles the author Otto A. Sauer, we used their mathematical formalisms for calculating the quality factor of the beam "Q", from measurements of the TPR. For this purpose, we collected measured data obtaining during the commissioning at HC-SP in a linear accelerator of 6 MV photons (Varian 6EX linear accelerator). These measurements were given in terms of dose in relation to various depths by means of the dosimetry system with 3D data acquisition Scanditronix / Wellhöfer for each detector, and they are represented by two ionization chambers (CC01 and CC13) and a diode stereotactic. These dose values collected for each detector were processed in TPR and thus calculated the "Q" for various sizes of fields. The data were plotted on a graph of Q x field size. Along this graph, were plotted values presented in the literature (British Journal nº 25) and also by the author Sauer. The results showed a good agreement with literature values, showing that the two formalisms proposed by the author applies to sizes of arbitrary fields, and then applied to small fields, which in turn are the main fields studied in this project because the reference condition given by the protocols are not applicable to them.

We started the study to extrapolate fields zero through the article "Determination of zero-field percent depth doses and tissue-maximum ratios for stereotactic radiosurgery and IMRT dosimetry: Comparasion between experimental measurements and Monte Carlo simulation (Cheng et al).

2. Implementation of Whole-Body Irradiation in patients undergoing radiotherapy
Supervisor: Laura Natal Rodrigues
Student: Angela Beatriz Habitzreuter

The Whole Body Irradiation (TBI) in conjunction with chemotherapy has been widely used as preparation for bone marrow transplantation in patients with hematologic diseases, and the goal is to irradiate the whole body evenly with the prescribed dose, minimizing complications induced to radio lung and other organs normal.
Because it is a treatment where there is wide variation of parameters in relation to conventional treatments should be made both measures to implement the technique and to check in vivo the dose received by patients in various parts of the body.
To this purpose, measurements of Percentage Depth Dose, off axis factor, efficiency, and factor tray were made in terms of TBI, in addition to the calibration of dosimeters, whereby was obtained a factor to convert the values of loading dose.
The next steps to be developed in this work are the creation of data tables, spreadsheet calculations and dose measurements in vivo.

3. Quantitative analysis of test results for quality control in Radiotherapy
Supervisor: Laura Natal Rodrigues
Student: Bruno Martins Pássaro

We performed the studies of bibliographic materials that are bases of the project in question. These works are titled as "Analysis of quality control data of eight modern radiotherapy linear accelerators: the short-and long-term behaviors of the outputs and the reproducibility of quality control

measurements," Review of the energy check of an electron-only linear accelerator over a 6 year period: Sensitivity of the technique to energy shift, and other national and international publications and Task Group as the 40 and 142, which is updated 40.

It was accompanied by preventive maintenance Linear Accelerator 600 C of the Clinical Hospital (Safety Testing and Mechanical Testing) and dosimetry even to understand what tools are used and how it is measured factor income. Then we obtained the data from Linear Accelerators, HC in five years (2004 to 2009). Subsequently we carried out a study on the change in factor income of one linear accelerators (Clinac 600 C), and by the results obtained applied a mathematical model that would fit the data. Therefore, this model was compared with the database literature.

4. Quality assurance in IMRT using portal imaging devices
Supervisor: Laura Natal Rodrigues
Student: Erika Yumi Watanabe

Radiation therapy is a technique widely used in the treatment of malignant tumors and has been developing in recent years due to technological advancement of equipment used. The goal of radiotherapy is to use radiation to destroy tumor cells, sparing the maximum healthy cells.
The modern radiotherapy followed the developments in computer science and as a result of researches in computational inverse planning, using the concept of fragmented fields in 1996 was introduced the technique of Intensity Modulated Radiotherapy (IMRT) by Thomas Bortfeld and Steve Webb. This technique uses intensity-modulated fields that when combined can provide substantial reduction of the dose in healthy tissues adjacent to areas of high doses containing tumor tissues or areas of possible tumor infiltration.

The IMRT technique is a very complex, where each field can be broken up into 300 sub-fields, preventing a manual scan of the calculation of monitor units, as is routinely done in a conventional treatment, so there is a need to develop a control stringent quality dosimetric plan prior to patient treatment. This control is done in two steps: verification of absolute dose off with a phantom, managing a field at a time or all fields, and verification of planar fluence of each individual modulated field, comparing with the calculated dose in the system planning. To verify the fluence can be used movies, or electronic devices developed for this, such as portal imaging devices (EPID) and dosimeters of multiple cameras.

The analysis of the quality controls carried out with these electronic devices can be done qualitatively or quantitatively. The quantitative analysis has been widely explored in order to determine parameters which show the correlation between a specific treatment plan and its administration in the machine for quality control.

Some commercially available EPIDs are accompanied by software that provide these functions for quantitative analysis, but there is a need for studies to ascertain the parameters listed in the software are actually able to identify possible errors in dose delivery.

The work is within the context and aims to evaluate an imaging device shopping portal used in radiotherapy (Portal Dosimetry) quality control of IMRT in both qualitative and quantitative by comparing different methods of quality control.

5. Development of calculation of monitor units for IMRT
Supervisor: Laura Natal Rodrigues
Student: Adriana Aparecida Flosi

Bibliographic databases of commercial software calculation for intensity modulated radiation therapy (IMRT) and the models and mathematical methods developed so far for the calculation of monitor units in intensity modulated plans.

Familiarity with the math software for use in developing the algorithm for calculating independent studies and other tools and similar software to identify the best tool to use.

Development of a pilot algorithm that simulates the flow of the fields planned in commercial planning systems in C language (still in the process of improvement and testing).

6. Evaluation of the tools of quality control for patients treated with IMRT
Supervisor: Laura Natal Rodrigues
Student: Milton Lavor

It is very important to implement a program of quality control before the clinical implementation of IMRT. Generally, the combined procedure of planning and release of IMRT are checked, but without conducting specific tests.

According to the ESTRO Booklet No.9, establishing a program of quality control specific to the patient undergoing IMRT treatments, there are five possible scenarios in which the checks solutions "classes" refer specifically to the patient, the location specific techniques of treatment per patient where only a limited number of degrees of freedom is varied, the limitations of the planning and procedures for the release of the dose are known. Importantly, with the publication of the new document by the International Commission on Radiation Units (ICRU 2008) is introduced a new evaluation of treatment plans with IMRT, because the verification procedures that currently rely on the verification of the dose in point ICRU reference, i.e. the PTV, will be changed now considering the specification of the dose in a volume rather than at one point.

Therefore, the objective of this work, which has already completed the theoretical and practical part will start in March this year the Department of Radiotherapy, Hospital Clinic, is to evaluate and propose a new methodology for quality control at the level of the patient when subjected to treatment with IMRT, establishing levels of action required based on limits set by the control program as proposed, evaluating the most appropriate dosimetric tools for this purpose and finally, disseminating the proposed new methodology for other hospitals.

INSTITUTO DE FÍSICA DA UNIVERSIDADE DE SÃO PAULO – IFUSP

Goal: To equip the laboratory for new dosimetric measurements

Semiconductor detectors were purchased and a new X-ray equipment and ionization chambers are in process of importing.

Goal: OSL Dosimetry - study materials for use in personal and patient dosimetry

1. Development of software for analysis of TL measurements
Supervisor: Elisabeth M. Yoshimura
Student: Bruno Seminaro

The Dosimetry Laboratory (IFUSP) is certificated laboratory with standardized processes for production, evaluation and follow-up of individual monitors, and in this process an analog equipment is still in use. Two thermoluminescent dosimeters are used in this routine process LiF and CaF2, the last one manufactured by Dosimetry Laboratory, based on natural fluorite.

Following market and academic expectations, the implementation of a routine that uses digital equipment is in progress focused on the improvement of these new necessities. My task intends to produce a data analysis software according to contemporary technological environment, to obtain the dose calculations.

Various programming languages appropriate to the problem were studied, and we decide by Java, which produces a user-friendly graphic interface. The effort in this step of the work is concentrated in dose calculation program, which will be first implemented in digital routine, described in the flowchart in Figure 1.

Having the need of calibrating the future program of dose calculation, the study of the process of manufacture of fluorite pellets and methodology of irradiation and measurement were also objects of this study. A group of 101 fluorite pellets was manufactured, and weighted in order to ensure a normal distribution of mass values. The 5 lightest chips were segregated, giving rise to an average value (45.1 (1.2) g, representing a 3% uncertainty.

The 96 pellets, after heat treatment of 400º C for 20 minutes and packaging in bags sealed to light, were irradiated with γ rays (from a 60Co source), to an exposure of 1 R, and then were measured, and the whole process was repeated twice. Through these measurements we select a group of chips with reproducibility near 4%.

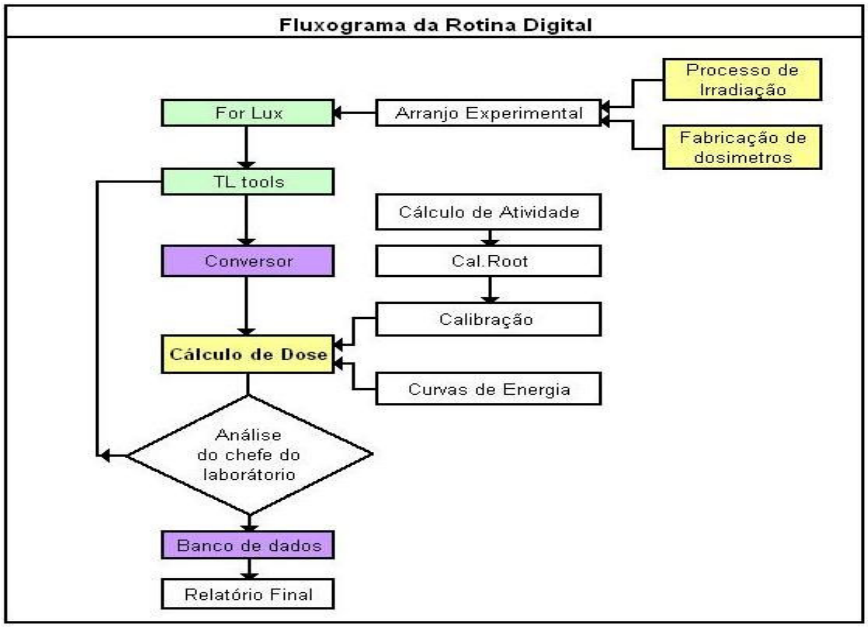

Figure 1: Flowchart of the acquisition system and dose calculation modules for individual monitoring of the Dosimetry Laboratory.

The measurements of thermoluminescence of that group of tablets were made in digital equipment that is in testing phase, and serves to evaluate it. Also they were used for the student training and learning of techniques for data analysis. The results obtained so far showed uncertainties (standard deviation) very high – 11 and 14% in peak height analysis mode – and new measurements shall be made with new reading parameters comparison with a group of standardized dosimeters.

Goal: Implementation of X-ray spectroscopy with silicon PIN and cadmium telluride detectors

2. Development of a methodology for correcting X-ray spectra measured with cadmium telluride detector
Supervisor: Paulo R. Costa
Student: Allan Fattori

In this project a methodology was developed for correcting X-ray spectra measured with one of the spectrometers acquired through the project (INCT in Metrology of Radiation in Medicine). The spectrometer used was the model XR-100T CdTe (Amptek). Measurements were made of primary X-ray spectra (Philips MGC-30) with peak tensions between 60 and 150 kVp, reflecting the range of energies used in diagnostic radiology. The preparation of the code for correction of these spectra was developed in Matlab software. This program performs the correction of spectra considering detector efficiency, the Compton effect and escape of fluorescence photons generated by photoelectric effect.

The primary X-ray spectra were acquired with the detector placed 5.47 m from the source. In addition to the distance a 200 μm tungsten collimator and a spacer brass were used to decrease the fluence of photons in the detector entrance window. The signal that leaves the detector is treated by digital Amptek processor, Beretta PX4, which includes a multichannel analyzer and a source of energy for the detector. The processor output data is sent to the software ADMCA.exe (Amptek) and finally the spectra are saved in the MCA format. The energy calibration of the spectra was performed with radioactive sources of barium (133Ba) and europium (152Eu) that have emission peaks (X-rays and gamma) of known energy. The correction of spectra was done in Matlab software. The algorithm created made a channel by channel correction including the efficiency of the detector, the

fluorescence photon escape fraction and Compton effect. After these steps, the spectra were corrected by mAs (current time product) used to generate the beams. The output of the correction program shows a distribution of counts/mAs by the energy of photons.

Figures 1 and 2 show X-ray spectra (peak voltage 140 kVp and 45 mAs) before and after the correction, respectively.

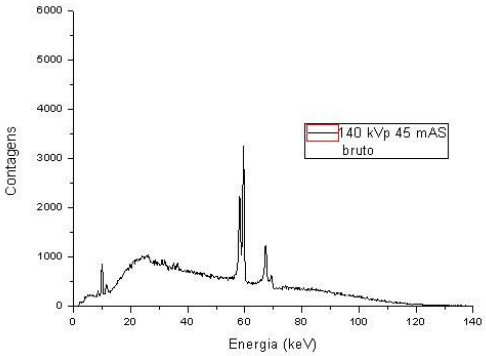

Figure 1 – Gross spectrum at 140 kV

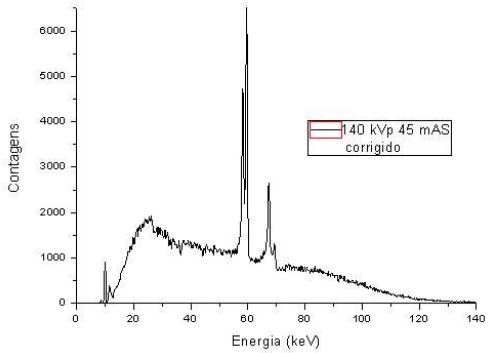

Figure 2 – Corrected spectrum at 140 kV.

Goal: Achievement of conversion coefficients for Air Kerma and Ambient Dose Equivalent in diagnostic radiology

3. Development of a computer program, with an online interface for calculating barrier thicknesses in radiological installations
Supervisor: Paulo R. Costa
Student: Lana Taniguti

According to the radiological protection basis required by the Brazilian legislation, the presentation of the calculation of barriers is essential both for licensing (Portaria SVS/Ms No. 453, 01/06/1998) as for optimizing the architecture of radiological installations. Therefore, this work aims to develop a computer program, whose algorithm performs calculations of thicknesses of conventional barriers in radiological installations, making it into an online interface for easy access. Your differentiator is to provide national parameters scientifically validated, in order to adapt international protocols for the Brazilian reality.

The methodological reference adopted was the American report No. 147, National Council on radiation protection and Measurements (NCRP 147, 2004).

Initially, a study of calculation methodologies outlined in publication was done, including its implications, underscoring the importance of the correct use of the parameters and the development of the stages of calculation. Subsequently, statistical work, together with the Technical Section of Applications in Diagnostic Imaging (IEE/USP), with the purpose of aggregating national averages of workload and of the tube output. Through these, the unshielded air kerma was estimated at 1 m (K1 (0)), for 15 different clinical modalities, such as radiology, dental and veterinary, which do not exist in the publication. Such results will be included in the program under development as an option of national parameters by the user. In the current step, the sitemap (flowchart of the algorithm) was structured and the programming language PHP (Hypertext Preprocessor - Hypertext Markup Language), the Apache Server from the Apache Software Foundation and the MySQL database from Sun Micro system were adopted, as all of them are open source.

The critical parameters for barrier calculation were the use actor, the unshielded air kerma at 1 m (K1 (0)) and the attenuation properties of the material, demonstrating the importance of their correct use for the effective fulfilment of the ALARA principle (as low as reasonable achievable). Regarding the values of (K1 (0)) the minimum difference to the values presented in NCRP 147 was found in conventional Radiology (-18%) and the maximum difference in fluoroscopy (86%), making clear the need to update values commonly used in the calculation.

4. Sub-project: Application of nano-materials in Radiological Protection
Supervisor: Emico Okuno
Student: Roseli Kunzel

Recent the application of nano-materials in various sectors of human activity has increased significantly. Typically, nano-materials are lighter and have greater mechanical resistance when compared to conventional materials. These properties are attractive regarding radiological protection, mainly in the manufacture of individual protection device. However, such applications require a comparative study of radiation attenuation of the structures formed by nanoparticles and structures formed by microparticles.

The transmission of radiation through nano-materials and micromaterials was evaluated using samples of copper oxide (CuO) with average particle sizes of 13 nm and 52 □m, respectively. The copper oxide in conventional and nano-materials were separately incorporated in an epoxy resin. The proportions of CuO embedded in resin for both materials were varied between 1% and 30% of the total mass of the compound. From these mixtures plates were produced with thicknesses between 2 and 10 mm and area of approximately 5 cm x 5 cm. Measurements of transmission of radiation through these samples were taken for X-ray beams generated in voltage range between 20 and 150 kV by an industrial X-ray equipment that with tungsten anode. The intensity of radiation transmitted via different thicknesses of material was recorded with the aid of a Farmer type ionizing chamber and an X-ray spectrometer with a CdTe detector (Amptek).

The data collected with the ionizing chamber show that there was no difference in the attenuation of the radiation between conventional and nano-materials for samples obtained with the incorporation of CuO in concentrations lower than 20% of the total mass. On the other hand, for CuO concentration of 30% of the total mass of the compound, there is a greater absorption of radiation by nano-structured compounds.

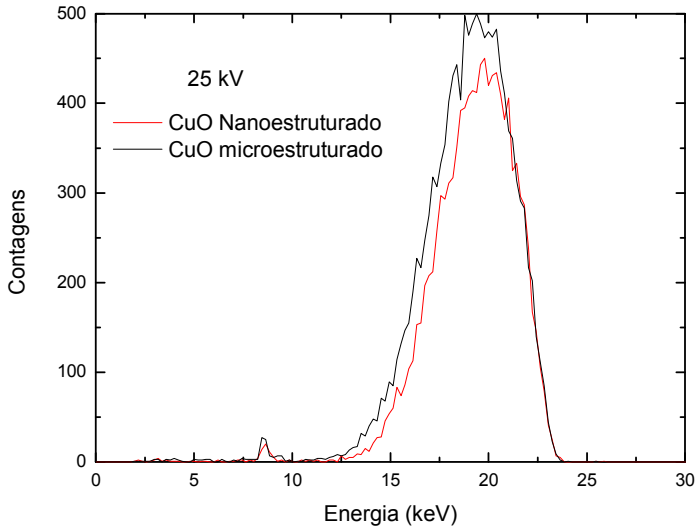

Figure 1 – X-ray transmission spectra through 3,5 mm samples with 30% weight of CuO in the misture.

UNIVERSIDADE FEDERAL DE SÃO PAULO

Instrumentation for evaluation of safety and quality equipment radiology
Team: Regina Bitelli Medeiros, Ana Claudia Patrocínio and Silvio Ricardo Pires

At the current stage of development were designed parts of the hardware that will allow the purchase of the input signals through sensors, signal conditioners and amplifiers; storage of signals (memory with its combinational logic of selection), signal processing, control keys and the instrument (battery 9/-9V volts). Parts of electronic design are in testing.

In the next stage of development will be important to calculate the linear attenuation coefficients for aluminum. The display will be prepared to present the average and peak voltage applied to the case of the waveform from equipment phase. First consideration will be given the independence of the sensors response on the conditions of radiation exposure X. Thus, the use of aluminum as a filter becomes more convenient as it simplifies the algorithm and the calculations to obtain the half-value layer. Extensive measures in the field will be carried out to monitor the logic of the routines implemented using the X-ray equipment.

At this stage it is very important to inter-data using an ionization chamber calibrated to make the necessary compensation in the calculation of the coefficient to achieve a desired precision of $\pm$ 3 %.

Below is a list of tests in development to evaluate the performance of radiological equipment: evaluation of kVp, time, reproducibility of the air kerma, linearity of air kerma and half-value layer.

The performance evaluation of X-ray equipment installed at Coordenadoria de Física e Higiene das Radiações (CFHR) of Departamento de Diagnóstico por Imagem of UNIFESP goal to establish quality parameters and their uncertainties in order to provide reference values in the generation of X-rays, as proposed in the project. This requires assessing the consistency of the physical parameters of the equipment in various techniques by quality control tests. For the first physical measurements will be used a specific instrumentation available in the CFHR, since the instrumentation dedicated to this is in the import process.

The physical parameters of quality of X-ray equipment, Compact Plus 500 VMI / Philips, were collected at different times of the day. The reproducibility of peak voltage, exposure time, linearity of kerma in the air, the out-put of the X-ray and Half value layer were analyzed.

All tests were performed using the detector model Inovision Victoreen 4000M + (with calibration factor 1.0), placed at 100cm from the focal point of the tube X-rays from the sensitive area of measurement of detector.

In the test of half-value layer of X-rays 8 aluminum plates of 0.5 mm thickness were used at a distance of 50 cm from the detector.

The results of all tests were obtained by averaging 10 measurements taken at different times of day and on different days. This method was used to reduce the spread of results related to the operator, the measuring instrument and radiological equipment, which are caused by non-reproducibility in the positioning of equipment, fluctuating electrical current establishment and imprecision of the generation of X-rays. The calculation of the standard error of the measurement considered the percentage of accuracy of the measuring instrument for each measurement, the deviation of the mean and precision equipment X-ray.

The standard error of the measures presented higher due to recalibration of the equipment of X-rays that occurred during the data collection because there was a technical failure of the equipment itself.

The tests reproducibility of peak voltage (kVp) and exposure time, providing confirmation that the equipment complies with the Resolution 453/98 of Anvisa[1], which refers to deviation between the measured and the nominal value for these tests should be in the range of ± 10%.

In the test of reproducibility of kerma in the air the percentage of deviation of the measures should be within the range of ± 10%[1]. For tests with 320 mAs, the value of the deviation exceeds the value desirable. This occurred because during the testing equipment it presented a defect and had to be recalibrated by the team of maintenance service before whole data collection. The recalibration was not appropriate in all the range of mAs. The results are different since two measurements taken after the recalibration of the equipment were taken out. We can conclude that this will require a new calibration in order to maintain the accuracy of the values of kerma in air adjusted to those required by law.

To test the linearity of kerma rate in air, the percentage value should be below 20%[1] for all combinations of time and higher current used in the equipment. The tests show that the values of linearity do not exceed the limits.

The determination of efficiency X-ray production (out-put) serves as a baseline for future testing, and the value obtained was 2,793±0,154mGy/mA.min.

The values of exposure collected with different thicknesses of aluminum filters placed at 50 cm from the detector. From this data a graph was plotted and we calculated the value of the half-value layer (HVL) that was 3.45 mmAl, value in accordance with the minimum acceptable value (2.6 mmAl to 80kV). This value will serve as control of the beam quality and it will alow to identify possible changes in the radiation spectra.

The results allowed the assessing of the performance of radiological equipment after its installation and to verify the consistency of measurements of physical parameters. The results also allowed the identification of a technical problem in the calibration that generated the need of changing a piece and a new calibration.

Due to difficulties in importing the equipment and specific instrumentation within the prescribed period could not perform all field measurements necessary to evaluate the performance of radiological equipment Philips-VMI newly installed. These measures will be validated with the instrumentation in the project and requested that arrive in Brazil in April/2010. We emphasize that the assembly of the prototype will be dependent on the definition of semiconductor sensors used to radiation measure which will be done after the characterization tests.

FACULDADE DE FILOSOFIA CIÊNCIAS E LETRAS DE RIBEIRÃO PRETO – FFCLRP/USP

1. Determination of X-ray spectrum from transmission curve
Supervisor: Alessandro Martins da Costa
Student: Gustavo Santo Pedro Pamplona

The direct measurement of the spectrum of an X-ray beam by some spectroscopic method is relatively expensive, time consuming and require considerable expertise. Spectrum can be alternatively derived by an indirect method from measurement of transmission curve of the X-ray beam and the use of Laplace transforms. The objective of this work was the application of an indirect method that use a spectral model based on a pair of Laplace transforms to derive the X-ray spectrum for a dental radiography equipment.

The spectral model was applied using a measured transmission curve.

The derived spectrum show good agreement with experimental data, showing the value of the analysis of attenuation curves beside spectroscopic methods since the transmission data can be obtained with comparative ease.

2. Establishment of the mammographic radiation qualities in metrological equipment: Spectra determination
Supervisor: Martin Eduardo Poletti
Students: Alessandra Tomal e Mauricio Russo Lopes

The knowledge of spectra produced for an X-ray equipment is important for quality control in mammography, being useful for metrological purposes, as for determination of the image quality and the absorbed dose. The X-ray spectrum is characterized mainly by tube voltage, target material and added filtration, which define the radiation quality. The standards mammographic radiation qualities, in terms of the HVL (High Value Layer) value, are established by the International Electrotechnical Commission (IEC-61267) [1]. However, as the HVL represent only an indirect measure of the spectral proprieties, it is also important to know the energy distribution of a X-ray equipment, which is typically obtained using semiconductor detectors and a proper stripping procedure.

Initially, until the arrival of the equipments imported into this project (detectors and X-ray equipment), an Si(Li) detector was used to measure mammographic X-ray spectrum produces by a industrial tube with Molybdenum (Mo) target, operating at constant tube potentials from 20 to 40 kV. At the tube exit were inserted filters of Mo (0.03mm) and/or Al (with thickness between 1 and 4 mm) with 99,9% of purity, in order to reproduce the radiation qualities produced by X-ray mammographic equipment. These target/filters combinations are recommended in the IEC 61267. The detector response functions used in the stripping procedure were determined using a Monte Carlo method

and validated through comparisons with experimental results obtained for radioactive sources (55Fe, 137Cs, 137Ba and 241Am).

The preliminary results of this work show that an Si(Li) detector exhibits good response function in low energy (particularly in mammographic energies). These results also show that the most important correction is due the detector efficiency, mainly at higher energies (over 25 keV). The measured X-ray spectra for a Mo filtration and corrected using the stripping procedure, showed a good agreement with the reference clinical spectra. Besides, from the HVL values achieved in this work for different tube potentials and filtrations, it can conclude that the radiation qualities implemented in this initial work are consistent with the proposed by the IEC 61267 for mammographic X-ray beams and can be applied to calibration of the diagnostic radiology measurements instruments (e.g. ionization chambers).

3. Spectroscopy of radiotherapy beams using Monte Carlo simulation
Supervisor: Patrícia Nicolucci,
Student: Tatiana Marques Pinto

The determination of the X-ray spectra from radiotherapy beams is important because it allows a quantitative evaluation of dosimetric parameters related to beam quality. In clinical radiotherapy, however, the determination of the beam's spectrum is not a common practice due to the expenses and the difficulties of experimental setups to measure high energy spectra. Monte Carlo simulation is a powerful tool to study radiation beams and its interactions with matter and can be used to accurately and precisely determine high energy spectra without the experimental costs. Moreover, Monte Carlo simulation allows the determination of the primary and secondary beam components separated, helping the understanding of the radiation interaction with matter.

In this work, spectra in depth of water for 6 MV e 10 MV photon beams from a Varian 2100C – Clinac linear accelerator were determined. The simulations were performed with Monte Carlo simulation package PENELOPE. Experimental and simulated percentage depth dose (PDD) curves were compared and used to validate the simulation. The simulated spectra were achieved in seven depths of a homogeneous phantom for each beam: surface, 3 cm, 5 cm, 7 cm, 10 cm, 15 cm e 20cm. Virtual detectors were built with 150 energy channels ranging from 100 keV to 6 MeV and 11 MeV to register the different intensities in the spectra of 6 MV and 10 MV, respectively.

The agreement between experimental and simulated PDD curves was always better than 99.5% to the two beam energies studied, validating the use of PENELOPE in this application. The simulated spectra at phantom's surface allowed the determination of the effective energies (for the high energy component of the spectra) for the 6MV and the 10 MV beams as 1 MeV and 1,5 MeV, respectively. For both beams, however, there is a large spectrum component at around 180 keV. At surface, the normalized intensity of this component is 55% e 62% larger than the normalized intensity of the 1 MeV and 1,5 MeV for the 6MV e 10MV beams, respectively. To the other depths it can be noticed a decrease in the effective energy with depth, mainly due to the enhancement of the secondary component of the beam, that increases the normalized intensities of lower energies in the spectrum, and the attenuation of the beam. The beam intensity also decreases with depth in the phantom as shown by the area under the spectrum.

The simulation parameters used in this work allow the utilization of Monte Carlo simulation package PENELOPE in the determination of depth in water spectra from radiotherapy clinical beams. The spectra obtained in depth permit the study of the different components of the beam and its relations with the dose deposited in matter and helping the determination of dosimetric parameters in radiotherapy.

CENTRO DE DESENVOLVIMENTO DA TECNOLOGIA NUCLEAR – CDTN/CNEN/MG

X-ray reference beams were characterized for the establishment of the metrological base for computed tomography and mammography. The metrological base was established for reliability of patient dosimetry in medical diagnostic radiology (conventional X-rays). A calibration procedure for ionization chambers was made available and experimental methodology for patient dose assessment through in-phantom measurements was validated.

Thermoluminescent dosimeters and Rando anthropomorphic phantoms were characterized for organ dose measurements. A methodology for breast phantom image analysis was developed with the aim of quality control of the mammographic services with conventional film processing.

All mammographic services with conventional film processing in Minas Gerais (344 mammographers) were evaluated as far as dose and image quality. A software for quality data management of mammographic services was developed. A radioprotection and image quality protocol of health services was created and validated to be applied to digital mammography.

INSTITUTO DE RADIOPROTEÇÃO E DOSIMETRIA – IRD/CNEN/RJ

1. Development of an independent system for quality assurance in radiotherapy.
Supervisor: Luiz Antonio Ribeiro da Rosa
Student: Valmiro Santos Almeida da Hora

The aim of this work was to develop, implement and evaluate a system for independent calculation of monitor units (SCMU) as subsidy to the quality assurance program, establishing levels of acceptance. The introduction of the system in clinical routine contributed to ensure the high quality of treatments and to avoid errors that may cause an undesirable treatment clinical result, such as under or over-dosage of important organs.

The system was based on the algorithm of manual calculation. The data of the study were obtained from the linear accelerator PRIMUS, SIEMENS, and the used treatment planning system (TPS) was the Theraplan Plus 3.7. The study used 250 fields to test the system with the procedure for manual calculation, 284 fields for the comparison with the TPS system with the use of a virtual phantom and 1484 fields of treatment over 14 months.

2. Study on the Possibility of Using a Therapy Unit Co-60 in IMRT
Supervisor: Luiz Antonio Ribeiro da Rosa
Student: Samuel Cesar Dantas

With the increasing advances in complex treatment techniques, there is a tendency to obtain more sophisticated equipments to deliver the dose. The use of conformal radiotherapy is now routine in many radiotherapy facilities as well as the utilization of intensity modulated radiotherapy (IMRT). Both are usually implemented using linear accelerators equipped with multileaves collimators, which create the conformity and the fluence distributions required. However, the complexity of increasingly sophisticated equipments, such as linear accelerators, requires a frequent quality control of their operation, as well as a detailed and constant maintenance. Even carrying out these procedures, the accelerators may present technical problems interrupting for a long time a treatment using the IMRT technique.

Despite the clear practical and technological advantages that linear accelerators have on 60Co irradiators, these devices occupy an important place in radiotherapy, mainly due to the low cost of equipment installation and maintenance when compared to those required by accelerators. Many radiotherapy facilities that work with IMRT have teleterapeutic isocentric 60Co units. In principle, such equipment would be able to be used for treatment with IMRT using compensating blocks to modulate the beam. This study investigates this possibility and shows that it is feasible. The comparison of treatment plans of a head and neck cancer and other of a cancer of the central nervous system, based on a Co-60 irradiator and a linac 2300 C / D, presented advantages for the 60Co irradiator. Furthermore, the delivery of dose obtained with the two systems showed themselves equivalent when compared to their plans.

3. Feasibility of Using a Cobalt Therapy Unit for Stereotactic Radiosurgery.
Supervisor: Luiz Antonio Ribeiro da Rosa
Student: Artur Ferreira Menezes

This study explores the possibility of using a telecobalt unit Theratron 780C for radiosurgery. A dosimetric study was performed for narrow beams generated by the Cobalt-60 unit with radiosurgery

collimatros of 7.5, 10, 12.5, 15, 17.5, 20, 25 and 30mm. Percentage depth dose curves were measured with ionization chamber, diodes and radiochromic film. They were also simulated using EGSnrc Monte Carlo Code. The diode presented the best performance PDD curves determination and was used for dose profile curves and relative dose factor (RDF) evaluation.

The TMR curves obtained from PDD curves, dose profiles and RDF date were used for feeding the treatment planning system BrainLab. Radiosurgery treatment plannings for the accelerator Varian 2300C were compared with radiosurgery treatment plannings for cobalt-60 unit. A radiosurgery treatment delivered to an anthropomorphic head phantom filled with radiochromic film was compared to it´s planning in the BrainLab' system. The results indicated the possibility of using the Theratron 780C unit in radiosurgery.

4. The influence of heterogeneities metal present in breast implants in radiotherapy treatments
Supervisor: Luiz Antonio Ribeiro da Rosa
Student: Débora M. Trombetta

In this work, the effects produced in the attenuation of 6 MV radiotherapic beams as consequence of metallic heterogeneities presented in some types of tissue expanders, used in the process of mammary reconstruction, was studied. The study was developed through the quantification of relative transmission making use of computer simulations with Monte Carlo method, using the code MCNPX.

The results show that the presence of this metallic heterogeneity alters the transmission of the beam, causing the reduction up to 20% in the geometry shadowed region. According to dosimetry protocols, the reduction in the dose should be lower than 5%. Therefore the difference found in the study demonstrates that the consideration of the heterogeneity presented in the radiation field can be relevant for the treatment planning.

5. Study of heterogeneities of low density in radiotherapy
Supervisor: Luiz Antonio Ribeiro da Rosa
Student: Marco Antonio Costa Cardoso

The objective of this work is to study the effect of including heterogeneity in the dose calculation of patients by determining the percentage depth dose (PDP) for irradiation field sizes ranging from the conventional field sizes (10x10cm size) to typical fields of new technologies (1x1cm ² and 0.5x0.5cm2). Potential accelerators of 6 and 15 MV were used, which are the most used clinically. This work was carried out experimentally using thermoluminescent dosimeters (TLDs) and through simulations using the Monte Carlo method, EGSnrc code (Electron Gamma Shower National Research Council of Canada) to evaluate the clinical implications of including this heterogeneity in the dose calculations.

The results were compared with different algorithms for correcting the heterogeneity of the Eclipse planning system, which is currently the most widely used in most hospitals for treatment planning of patients undergoing radiotherapy. The results show that the lateral electronic disequilibrium is more pronounced for higher energies and small fields and small fields can cause under or over dosage if the doses are calculated improperly.

6. Evaluation of radioprotection conditions required for the use of new radiopharmaceuticals
Supervisor: Lidia Vasconcellos de Sá
Student: Gustavo Coelho AlvesCosta

The objective of this work was to establish procedures and radioprotection conditions required for the use of new radiopharmaceuticals in therapy with unsealed sources, radionuclides emitting α, β and γ in order to meet the standards in the country. Doses delivered to patients in healthy and diseased tissues, critical organs were evaluated, for the mathematical method.

7. Analysis of image uniformity in equipment Positron Emission Tomography (PET)
Supervisor: Lidia Vasconcellos de Sá
Student: Bruna Pereira do Valle

With the recent development of new technologies, including the PET/CT, several studies on the influence of equipment parameters performance to ensure quality clinical images have been performed around the world. Amoung the various parameters to quality control assurance, the uniformity test of the image is designed to ensure that the activities distribution of the same intensity is seen in the same way for all equipment field of view under consideration.

In this paper we addressed a control parameter, named image uniformity in three specific fields of view, axial, transverse and radial en positron emission tomography - PET system, combined with a CT scanner, multi-slice, named called PET / CT. The influence of acquisition time on image quality is also analyzed, where the quality parameter under study was also the uniformity.

For this analysis we used the protocols recommended by the ACR (American College of Radiology). The aim is therefore to establish the time of acquisition more appropriate as it could ensure a satisfactory quality picture for accurate diagnosis and thus contribute to the optimization of the review process as a whole.

The tests were performed in 2D and 3D whole body protocols in four different acquisition times of 4, 6, 8 and 10 minutes, in order to determine which is the most appropriate. The results indicate that the clinical protocol in 2D does not provide adequate uniformity (≤ 5%) and this is now in revision for clinical uses. The 3D measurements taken show proper values, and the best time for acquisition was 5 min / bed.

CENTRO REGIONAL DE CIÊNCIAS NUCLEARES DO NORDESTE – CRCN/CNEN/PE

1. Intercomparation of activitie measurements of radiopharmaceuticals utilized in Nuclear Medicine Services at the Brazilian Northeast
Team: Mércia L Oliveira, Fabiana farias de Lima Guimarães, Maria da Conceição de Farias Fragoso e Antonio Morais de Sá Albuquerque

The development of technology at the nuclear medicine field has enabled early diagnosis of pathological processes, allowing the study of physiological performance in a simple, noninvasive and low risk procedure. Furthermore, therapeutic practices have been implemented successfully. The procedures in nuclear medicine are based on the administration of a radioisotope labeled with a chemical with affinity to a specific organ or the tissue that is being investigated.

The activity administered to the patient must be known with accuracy to not only meet the requirements of radiation protection but also to ensure the success of the medical procedure. The radionuclide calibrators have the advantage of taking the measurements of activity quickly and accurately. These instruments consist essentially of a well type ionization chamber, coupled to an electrometer with digital display, which provides direct measurements in activity units.

Among the programs for quality assurance practices in nuclear medicine, the inter laboratories comparisons represent a tool of particular importance evaluating the all measurement process, including the performance of professionals operate the equipment.

These comparisons consist in sending samples solution containing radionuclides to the participating laboratories. Then, the individual results of the measurements are compared to the true value established by the reference laboratory and further processed by statistical methods being evaluated in this way, the performance of radionuclide calibrators.

The objective of this study was to implement the comparison program of activity of radiopharmaceuticals used in nuclear medicine services (NMS) located in the Northeast of Brazil, using sources of ^{99m}Tc, ^{131}I, ^{67}Ga, ^{201}Tl and ^{57}Co.
This project was developed at Division of Analytical and Nuclear Techniques (DITAN) Regional Center of Nuclear Sciences of the Northeast (CRCN-NE).

The comparison program of activity measurements with radionuclide calibrators used in NMS had the participation of seven northeastern states: Alagoas, Ceara, Paraiba, Pernambuco, Piauí, Sergipe and Rio Grande do Norte (a total of 26 NMS). The traveling standards were measured by professionals who operate the equipment designated by the NMS and their supervisors of radiological protection, without causing any influence on the measurement procedure adopted in each institution.

We asked the technician appointed by the SMN to carry out measurements of background radiation (before and after the introduction of the radioactive sample at the detector well), and measurements of the sample activity. The mean values of the measurements were calculated. Later, this exactly procedure was repeated at the reference laboratory. The performance of radionuclide calibrators of SMN was assessed, according to the activity ratios obtained, with considerable acceptable those who are within the range of ± 10% reference value.

In this comparison program of activity measurements with radionuclide calibrators used in NMS were obtained 129 measures, of which 89% results are acceptable and 11% of unacceptable results. This means that the procedures adopted for measuring the activity of radionuclides in most NMS assessed, and the performance of radionuclide calibrators, are appropriate. The states of Paraiba and Sergipe showed only satisfactory results in the performance of radionuclide calibrators.

The best NMS performances were due to the use of radionuclide calibrators based on ionization chamber, the existence of a quality control program as recommended by the Brazilian standard, and the constant presence of the radiological protection supervisors features observed by Iwahara et al (2001) in the program of comparison of activity in Rio de Janeiro.

The main causes of unacceptable results are the use of radionuclide calibrators based on Geiger-Müller detectors and the ignorance on the part of operators of the instruments about the procedures necessary for the measurement of certain radionuclides.

Radionuclide calibrators type Geiger-Müller have inadequate performance in the activity measurements of radiopharmaceuticals, it is recommended that these equipments be replaced by ionization chambers, since they have more stability in their responses. Regarding the lack of training of operators, it is necessary a new system of training for these professionals, addressing not only theoretical knowledge but also the practical realization of the measurement procedures.

The implementation of the comparison program was very important to review the situation of the quality of measurements of radiopharmaceuticals administered in the NMS in the Northeast, a prerequisite for the success of diagnosis and therapy. Furthermore, it was established a cooperation between the NMS and the reference laboratory (CRCN), which will provide all the necessary support for any problems that arise in the participating institutions.

We suggest the continuity of this program in order to track the performance not only of the NMS that, for some reason, did not obtain acceptable results, but also those who demonstrated excellent results, providing these institutions an objective tool to assess the reliability of measures activity of radiopharmaceuticals that are being carried out.

As continuation of this project, in the second year we will begin the following activities:

- Evaluation of NMS procedures in the Brazilian states, and comparison of the activities administered to patients to those practiced abroad and with the reference levels recommended by IAEA.
- Assessing the quality of radiopharmaceuticals labeled with ^{99m}Tc with respect to radionuclide, chemical and radiochemical purities in SMN after labeling procedure.
- Implementation of the procedure for primary standardization of radionuclides for calibration of radionuclide calibrators in CRCN.

UNIVERSIDADE FEDERAL DE SERGIPE - UFS

1. Construction of head phantoms for dosimetry beam computed tomography
Supervisor: Ana Figueiredo Maia
Students: Laila Galvão Almeida, Cássio Costa, Ferreira

Introduction: The dosimetric protocol currently used has become inadequate since the advancement of multislice computed tomography. Considering this fact and recent studies that show that, the contribution of computed tomography for the collective effective dose is larger than other radiological procedures, it is necessary to define new measuring procedures and to use new detectors and phantoms. This study aimed to test the viability of using an unusual dosimeter since the pencil ion chamber, which has been used since few decades, is considered inappropriate to the new characteristics of the computed tomography beams. Methodology: Tests were performed on a PMMA phantom using a small volume ion chamber with active length of 23 mm and a 100-mm-long pencil chamber. The phantom was constructed locally and it was based on the computed tomography phantom proposed by international recommendations. Results: The comparison of tests results from both types of dosimeters (small volume ion chamber and pencil ion chamber) indicates the viability of using unusual dosimeters to perform measures computed tomography beams.

2. Study of materials for use in simulators head beam tomography CT
Supervisor: Ana Figueiredo Maia
Students: Raimundo Erivan Morais Ximenes Filho, Cássio Costa, Ferreira

Dosimetry of X-rays beams is an important test quality control to ensure the safety of using ionizing radiation in medical applications. The execution of dosimetric procedures is generally related to simulators objects that make possible to estimate the dose received by the patient. Therefore the main objective of this study was to calculate the mass energy-aborption coefficient for ten materials locally available to investigate the viability of using these materials in human brain simulators objects for X-rays beams in computed tomography.

Materials with low cost were chosen to reproduce physical characteristics of human brain. These materials are: bolus, paraffin, PMMA, pitch, modelling clay, Nylon®, articulation wax and bee wax.

Immediately after the obtaining of mass energy-aborption coefficient, they were analyzed and compared ICRU´s (International Commission on Radiation Units and Measurements) brain and ICRP´s (International Commission on Radiological Protection) brain. Graphs and tables used in the comparison showed that the material which had the best results were the modeling clay.

3. UV Radiation protection and dosimetry of workers
Supervisor: Susana O. Souza
Students: Hestia Raissa Ramos Batista Lima, Raquel Aline P. Oliveira, Leonardo Lelis Lima

In recent years, skin cancer has figure as an important cause of retirement work, corresponding to a significant increase in number of disability benefits caused by the acne. This work intended evaluate materials that could be used as dosimeter for ultraviolet radiation that can be used widely by workers who suffer long exposure.

Materials of low cost were chosen for use in radiation detection systems in the form of ceramic or glass. The thermoluminescence and radioluminescência of these materials were tested under the influence of UV radiation.

Aluminum silicate and lithium $LiAlSi_2O_6$, known as spodumene was evaluated in this study. It was found that the main TL peak suffers from the effect of thermal quenching. The short halflife found indicates that there is little chance of it being used for dosimeters production, however, the data must be confirmed with other methods, because it may underestimated parameters due to problems of peak separation by thermal treatments.

4. Luminescence study of spodumene crystals
Supervisor: Susana O. Souz
Students: Raquel Aline Pessoa Oliveira, Hestia Raissa Ramos Batista Lima

In recent years many works have been developed aiming to obtain optical materials with improved luminescent properties for various applications. In search of new materials for these applications due to wide variety of crystals available, one should focus on some desirable features, such as abundance in nature, cost of the crystal, the luminescence intensity, temperature and wavelength of emission. The spodumene is a relatively abundant natural silicate and its thermoluminescence presents peaks in temperature and wavelength suitable for dosimetry and dating, besides the evidence that it produces intense radioluminescence (RL).

Characterization of the spodumene luminescent properties through TL and RL.

The X-rays RL showed there is light emission of approximately 300 nm to 800 nm with the main peak around 600 nm, corresponding to orange region of visible spectrum. The results of thermoluminescence led to the conclusion that the mechanism of charge capture of purple spodumene during irradiation is the same for both types of gamma and beta radiation. The first trap to be filled would be responsible for the peak at ~ 200 – 220 °C, and only after its saturation, the trap responsible for peak at ~ 350 °C would capture charges. The radioluminescence observed under excitation X-ray and beta are assigned to the same recombination center of thermoluminescence, which is due to the aluminum center, i.e. the center due to the exchange of ions of Si^{4+} by Al^{3+} ions, which captures a hole. Preliminary results of RL confirm that the lilac spodumene may be used as scintillator.

5. Study and application of new materials in dosimetry
Supervisor: Susana O. Souza
Student: Simara Santos Campos

Incidents of excessive exposure of the population to ionizing radiation could result from a nuclear explosion, the direct exposure to a stolen/lost source or an accidental exposure to a source without shielding, for example. During these incidents the victims are rarely using individual protection equipment used in the measurement and control of doses that were exposed. One of the ways found to the assessment of the exposure doses due to an accident involving radiation is the retrospective dosimetry, which allows the determination of doses from the excessive exposure to radiation, either chronological or acute, using common materials that are available in the environment.

Retrospective dosimetry using thermoluminescence of buildings materials previously burned, as ceramics, is already well established. In contrast, there is still of a methodology for determining safely the retrospective dose using not annealed materials such as mortar and concrete, which are more commonly found in industrial sites, particularly in nuclear installations. This project aimed to address some of these materials and techniques available for its application in the determination of doses resulting from accidental irradiation by thermoluminescence.

The new method of quartz extraction, called Campos Method, developed here, showed great advantages compared to conventional method, commonly applied. For precise TL dose determination, the kinetic characterization of the luminescent crystal peaks is of fundamental importance and, moreover, the determination of stability and dependence on the radiation dose from a dosimetric peak are also relevant, because they are helpful to identify TL intensity due to the environment radiation and that comes from a radiation accident. In this work, the order of kinetics, the activation energy, the factor of frequency and lifetime of the peak around 225 °C for quartz extracted from common materials of construction, such as mortar and concrete and natural quartz crystals, were determined. Moreover, there was determined its stability after storage for 48 days and its dependence on the radiation dose. By presenting a relatively short lifetime compared to accumulation of the natural radiation signal and long enough for dosimetric applications, besides other favorable characteristics, the natural quartz and, specially, the mortar were considered viable for retrospective dosimetry.

5. National and international events: presentation of papers, organization of courses, seminars, lectures, round tables

1. ARTICLES IN SCIENTIFIC JOURNALS

1. CECATTI, S. G. P; GUIMARÃES, M. I. C. C; CALDAS, L. V. E. Application of a wrist dosimeter prototype for radiation monitoring (^{153}Sm) during a therapeutic procedure simulation. Journal of Radiological Protection, v. 29, p. 519-525, 2009.
2. OKUNO E. Epidemiologia do câncer devido a radiações e a elaboração de recomendações. Revista Brasileira de Física Médica 3(1), 43-55, 2009.
3. RODRIGUES, L. N. Metrologia das radiações ionizantes. Revista Brasileira de Física Médica, v. III, p. 69-75, 2009.
4. IWAHARA, A; TAUHATA, L; OLIVEIRA, A. E; NÍCOLI, I. G; ALABARSE, F. G; XAVIER, A. M; OLIVEIRA, M. L; KOSKINAS, M. F; ALMEIDA, M. C. M. Proficiency test for radioactivity measurements in nuclear medicine. Journal of Radioanalytical and Nuclear Chemistry (Print), v. 281, p. 3-6, 2009.
5. DE LIMA, A.F; SOUZA, S.O; LALIC, M.V. Theoretical analysis of optical characteristics of the alpha spodumene in ultraviolet region. Optical Materials (Amsterdam), v. 31, p. 1478-1482, 2009.
6. SOUZA, S. O; LIMA, A F; LALIC, M. V. Optical properties of alpha spodumene: Orientation of its principal optical axes. Journal of Physics. Conference Series (Online), v. 167, p. 012066, 2009.
7. LIMA, A. F; SOUZA, S. O; LALIC, M. V. Electronic structure and optical absorption of the $Bi_4Ge_3O_{12}$ and the $Bi_4Si_3O_{12}$ scintillators in ultraviolet region: An ab initio study. Journal of Applied Physics, v. 106, p. 013715, 2009.
8. MARQUES, T; FERNANDES, J. P; BARBI, GUSTAVO LAZZARO; NICOLUCCI, P; BAFFA, OSWALDO. MAGIC with formaldehyde applied to dosimetry of HDR Brachytherapy source. Journal of Physics. Conference Series, v. 164, p. 1-6, 2009.
9. FERREIRA, FERNANDA C. S; MAGALHAES, C. M. S; COSTA, N. V; LIMA, LEONARDO LELIS; CARDOSO, LEANDRO XAVIER; CUNHA, C. J; SOUZA, DIVANÍZIA NASCIMENTO; SOUZA, S. O. Avaliação de Rejeitos Radioativos em Serviços de Medicina Nuclear no Estado de Sergipe. Scientia Plena, v. 5, p. 1-5, 2009.
10. ELIAS, S; PIRES, S. R; PATROCINIO, A. C; MEDEIROS, R. B; MEDEIROS, R. B. Uso de software como ferramenta pedagógica no processo de ensino-aprendizagem da mamografia digital. Radiologia Brasileira, v. 42, p. 115-120, 2009.
11. SILVA, MARINA PIACENTI DA; TOMAL, A; PEREZ, C. A; RIBEIRO-SILVA, A; POLETTI, M. E. Determination of Ca, Fe, Cu and Zn and their correlations in breast cancer and normal adjacent tissues. X-ray Spectrometry, v. 38, p. 103-111, 2009.
12. CONCEIÇÃO, A. L. C; ANTONIASSI, M; POLETTI, M. E. Analysis of breast cancer by small angle X-ray scattering (SAXS). Analyst (London. 1877. Print), v. 134, p. 1077-1082, 2009.
13. TIMBO, C; DA ROSA, L. A. R; GONÇALVES, MARCELLO GOMES; DUARTE, S. B. Computational cancer cells identification by fractal dimension analysis. Computer Physics Communications, v. 180, p. 850-853, 2009.
14. OLIVEIRA, J. P. DE; DA ROSA, L. A. R; BATISTA, D. V. S; BARDELLA, L. H; CARVALHO, A. R. Avaliação da dose no reto em pacientes submetidas à braquiterapia de alta taxa de dose para o tratamento do câncer do colo uterino. Radiologia Brasileira, v. 42, p. 83-88, 2009
15. ALVES, C. E. G; AZEVEDO, E. M; SÁ, L. V; DA ROSA, L. A. R; MENDES, L. G; FRANCA, W. F. L; GUTTERRES, R. F; GONÇALVES, MARCELLO GOMES. The effects of the Brazilian regulatory inspection programme on nuclear medicine facilities. Journal of Radiological Protection, v. 29, p. 507-517, 2009
16. OLIVEIRA, L. C. G; DIAS, T. K; LOPES, R. T; DIAS, S. K. Evaluation of the entrance surface air kerma in mammographic examinations in Rio de Janeiro, Brazil. Radiation Protection Dosimetry, v. 133, p. 136-143, 2009.
17. LOPES, REGINA MARIA GODOY; RODRIGUES, L. N; CARVALHO, HELOÍSA DE ANDRADE. Braquiterapia endobrônquica de alta taxa de dose - Estudo dosimétrico. RB. Radiologia Brasileira (Impresso), 2009.

18. COSTA, A. M; BARBI, G. L; BERTUCCI, E. C; FERREIRA, H; SANSAVINO, S; COLENCI, B; CALDAS, L. V. E. In vivo dosimetry with thermoluminescent dosimeters in external photon beam radiotherapy. Applied Radiation and Isotopes, 2009.
19. ANDRADE, P. S. S; POTIENS, M. P. A. Development of an object test to dental image verification. Applied Radiation and Isotopes, 2009.
20. VIVOLO, VITOR; POTIENS, M. P. A. Evaluation of the Planar Sources Surface Homogeneity used to Instruments Calibration. Applied Radiation and Isotopes, 2009.
21. TERINI, RICARDO ANDRADE; POTIENS, M. P. A; HERDADE, S. B; ANDRADE, M. L. G; PIRES, J. S. P; VIDEIRA, H. S. A medição da grandeza practical peak voltage na prática radiológica. RB. Radiologia Brasileira (Online), 2009.
22. GRONCHI, C. C; CECATTI, S. P; FURNARI, LAURA; CAMPOS, L. L. Controle da Exposição Ocupacional às Radiações Ionizantes nos Serviços de Hemodinâmica Segundo Portaria 453 e Americam College of Cardilology. Revista Brasileira de Física Médica, São Paulo, v. 2, n. 2, p. 2-5, 2009.
23. CAVINATO, C C; RODRIGUES, O; CERVANTES, J H; RABBANI, S R; CAMPOS, L L. A dosimetric evaluation of tissue equivalent phantom prepared using 270 Bloom gelatin for absorbed dose imaging in Gamma knife radiosurgery. Journal of Physics. Conference Series (Online), v. 164, p. 012016-5, 2009.
24. DE LIMA, A.F; SOUZA, S.O; LALIC, M.V. Theoretical analysis of optical characteristics of the alpha spodumene in ultraviolet region. Optical Materials (Amsterdam), v. 31, p. 1478-1482, 2009.
25. MARQUES, T; FERNANDES, J. P; BARBI, GUSTAVO LAZZARO; NICOLUCCI, P; BAFFA, OSWALDO. MAGIC with formaldehyde applied to dosimetry of HDR Brachytherapy source. Journal of Physics. Conference Series (Print), v. 164, p. 1-6, 2009.
26. SANTOS, M.M; TAKEDA, F.B; PIANOSCHI, THATIANE ALVES; NICOLUCCI, P. Study of a Well-Type Ionization Chamber by Monte Carlo Simulation. Medical Physics (Lancaster), v. 36, p. 2450-2451, 2009.
27. PIANOSCHI, THATIANE ALVES; SANTOS, M.M; BAFFA, OSWALDO; NICOLUCCI, P. Study of Dosimetric Characteristics of MAGIC Polymer Gel with Formaldehyde for Electrons Beams Using PENELOPE Code. Medical Physics, v. 36, p. 2472-2472, 2009.
28. SCHWARCKE, M; MARQUES, T; NICOLUCCI, P; CARDOSO, D; FERREIRA, N. Evaluation of Dose Rate of Occupational Exposure in Nuclear Medicine Service. Medical Physics, v. 36, p. 2452-2453, 2009.
29. TAKEDA, F.B; SANTOS, M.M; VIEIRA, JOSÉ MAURO; CALVO, WILSON; GHILARDI NETTO, T; NICOLUCCI, P. Development of a Multi Electrode Well Ionization Chamber to Be Used in Nuclear Medicine. Medical Physics, v. 36, p. 2586-2586, 2009.
30. MARQUES, T; SCHWARCKE, M; ALVA, M; BAFFA, OSWALDO; NICOLUCCI, P. Monte Carlo Simulation of Dose Distribution Around 198 Au Nanoparticles: A Preliminary Study for Treatment Quality Criterion. Medical Physics, v. 36, p. 2511-2511, 2009.
31. ALVA, M; MARQUES, T; SCHWARCKE, M; RODRIGUES, L. N; BAFFA, OSWALDO; NICOLUCCI, P. A Water-equivalent calibration of 192Ir HDR Brachytherapy source using MAGIC polymer gel. IFMBE Proceedings, v. 25, p. 248-251, 2009.
32. SCHWARCKE, M; MARQUES, T; NICOLUCCI, P. The dose rate evaluation of occupational exposure in nuclear medicine service. Medical Physics. Medical Physics (Lancaster), v. 36, p. 2452, 2009.
33. SILVA, MARINA PIACENTI DA; ZUCCHI, O. L. A. D.; RIBEIRO-SILVA, A.; POLETTI, M. E. Discriminant analysis of trace elements in normal, benign and malignant breast tissues measured by total reflection X-ray fluorescence. Spectrochimica Acta. Part B, Atomic Spectroscopy, v. 64, p. 587-592, 2009.
34. SOUZA. A. B. B; KODLULOVICH, S; A. MARQUES; F. M. AUGUSTO. Avaliação do kerma no ar na superfície de entrada e da qualidade da imagem me radiografias de tórax. RB. Radiologia Brasileira (Impresso), v. 42, p. 315-319, 2009.

2. ARTICLES ACCEPTED FOR PUBLICATION IN 2010

1. COSTA, A. M; BARBI, G; BERTUCCI, E. C; FERREIRA, H; SANSAVINO, S; COLENCI, B; CALDAS, L. V. E. In vivo dosimetry with thermoluminescent dosimeters in external photon beam radiotherapy. Applied Radiation and Isotopes, v. 68, p. 760-762, 2010.
2. KOSKINAS, M. F; YAMAZAKI, I. M; BESSA, A. C. M; CALDAS, L. V. E; DIAS, M. S. Comparative measurements in dose calibrators and a gamma-ray spectrometer. Applied Radiation and Isotopes, v. 68, p. 589-591, 2010.
3. YOSHIZUMI, M. T; VIVOLO, V; CALDAS, L. V. E. Preliminary studies of a new monitor ionization chamber. Applied Radiation and Isotopes, v. 68, p. 620-622, 2010.
4. TEIXEIRA, M. I; MELO, A. P; FERRAZ, G. M; CALDAS, L. V. E. Application of jade samples for high-dose dosimetry using the EPR technique. Applied Radiation and Isotopes, v. 68, p. 582-585, 2010.
5. MAIA, A. F; CALDAS, L. V. E. Response of TL materials to diagnostic radiology X radiation beams. Applied Radiation and Isotopes, v. 68, p. 780-783, 2010.
6. AFONSO, L. C; VIVOLO, V; CALDAS, L. V. E. Characteristics of a tandem system of ionization chambers in X-ray beams, mammography level. Applied Radiation and Isotopes, v. 68, p. 610-613, 2010.
7. YOSHIZUMI, M. T; YORIYAZ, H; CALDAS, L. V. E. Backscattered radiation into a transmission ionization chamber: Measurement and Monte Carlo simulation. Applied Radiation and Isotopes, v. 68, p. 586-588, 2010.
8. CONCEIÇÃO, A. L. C; ANTONIASSI, M; POLETTI, M. E; CALDAS, L. V. E. Preliminary study of human breast tissue using synchrotron radiation combining WAXS and SAXS techniques. Applied Radiation and Isotopes, v. 68, p. 799-803, 2010.
9. TOMAL, A; POLETTI, M. E; CALDAS, L. V. E. Evaluation of subject contrast and normalized average glandular dose by semi-analytical models. Applied Radiation and Isotopes, v. 68, p. 755-759, 2010.
10. DIAS, ARGLEYDSON LEÃO; KÜNZEL, ROSELI; LEVENHAGEN, RONALDO SAVARINO; OKUNO, E. Application of computed tomography images in the evaluation of magnetic nanoparticles biodistribution. Journal of Magnetism and Magnetic Materials, p. 1-10, 2010.
11. ANDRADE, PAULA S.S; POTIENS, MARIA DA PENHA A. Development of an object test to dental image verification. Applied Radiation and Isotopes, v. 68, p. 600-601, 2010.
12. MANGUEIRA, T.F; SILVA, C.F; COELHO, P.R.P; CAMPOS, L.L. Gamma/neutron dose evaluation using fricke gel and alanine gel dosimeters to be applied in boron neutron capture therapy. Applied Radiation and Isotopes, v. 68, p. 791-794, 2010.
13. OLIVEIRA, MÉRCIA L; MAIA, ANA F. TL tandem systems for the determination of effective energy in X radiation beams. Applied Radiation and Isotopes, v. 68, p. 788-790, 2010.
14. CHEN, FELIPE; RAMIREZ, JOSÉ VEGA; NICOLUCCI, P; BAFFA, OSWALDO. Sensitivity comparison of two l-alanine doped blends to different photon energies. Health Physics (1958), v. 98, p. 383-387, 2010.
15. DA ROSA, L. A. R; CARDOSO, SIMONE COUTINHO; CAMPOS, LUCIANA TOURINHO; ALVES, VICTOR GABRIEL LEANDRO; BATISTA, D. V. S; FACURE, A. Percentage depth dose evaluation in heterogeneous media using thermoluminescent dosimetry. Journal of Applied Clinical Medical Physics, v. 11, p. 117-127, 2010.
16. FACURE, A; CARDOSO, SIMONE COUTINHO; DA ROSA, L. A. R; SILVA, ADEMIR XAVIER DA. Photon doses at the entrance of Co-60 and low-energy medical accelerators rooms under unusual irradiation conditions. Radiation Protection Dosimetry, v. 138, p. 251-256, 2010.
17. DE PAIVA, E; GIANNONI, R. A; VELASCO, A; BRITO, R. R. A.; DOVALES, ANA CRISTINA MURTA; SÁ, L. V; DA ROSA, L. A. R. Radiometric survey of teletherapy treatment rooms in Brazil. Radiation Protection Dosimetry, v. 138, p. 402-406, 2010.
18. PINTO, T. N. O; CALDAS, L. V. E. Determination of transmission factors for beta radiation using Al2O3:C commercial OSL dosimeters. Nuclear Instruments & Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors and Associated Equipment (Print), 2010.
19. YOSHIZUMI, M. T; CALDAS, L. V. E. A new ring-shaped graphite monitor ionization chamber. Nuclear Instruments & Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors and Associated Equipment (Print), 2010.

20. LOPES, REGINA MARIA GODOY; RODRIGUES, L. N; CARVALHO, HELOÍSA DE ANDRADE. Braquiterapia endobrônquica de alta taxa de dose - Estudo dosimétrico. RB. Radiologia Brasileira (Impresso), v. 43, p. 1-6, 2010.
21. RODRIGUES, L. N; SIQUEIRA, PATRÍCIA MARA DE. Comparação das razões CK obtidas por diferentes laboratórios de dosimetria. Revista Brasileira de Física Médica, 2010.
22. OLIVEIRA, M. L; NASCIMENTO, NCES; FRAGOSO, M. C. F.; GALINDO, R. S; MAIA, A. F; HAZIN, C. A. Influência da dependência energética de dosímetros termoluminescentes na medida da dose na entrada da pele em procedimentos radiográficos. RB. Radiologia Brasileira (Impresso), 2010.
23. MARQUES, T; ALVA, M; NICOLUCCI, P. Simulação Monte Carlo do espectro de radiação secundária de feixes de 60Co para o estudo de fatores de correção me medidas de dose profunda com dosímetros termoluminescentes. RB. Radiologia Brasileira (Impresso), 2010.
24. GÓES, EVAMBERTO G; NICOLUCCI, P; NALI, I. C; PELÁ, CARLOS ALBERTO; BRUCO, J. L; BORGES, JOSÉ CARLOS; COVAS, D.T. Study of the spatial distribution of the absorbed dose in blood volumes irradiated using a teletherapy unit. Radiation Physics and Chemistry (1993), 2010.
25. CONCEIÇÃO, A. L. C; ANTONIASSI, M; POLETTI, M. E. Assessment of the differential linear coherent scattering coefficient of biological samples. Nuclear Instruments & Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors and Associated Equipment (Print), 2010.

3. COMPLETE PAPERS PUBLISHED IN PROCEEDINGS OF CONFERENCES

1. RODRIGUES, L. N; MENEGUSSI, GISELA; SILVA, MARCO ANTÔNIO DA; RUBO, RODRIGO A; FURNARI, LAURA; SALES, CAMILA PESSOA DE; GABRIELA REIS DOS SANTOS. Quality assurance program for Radiosurgery at Clinicas Hospital: results of implementation. In: 11th International Congress of IUPESPM, 2009, Munique. IFMBE Proceedings: World Congress on Medical Physics and Biomedical Engineering. Berlim: Springer, 2009. v. 25.
2. ANTONIO, P. L; OLIVEIRA, M. L; CALDAS, L. V. E. Application of the thermoluminescent technique for calibration and dosimetry of 90Sr+90Y applicators. In: 7th International Conference on Luminescent Detectors and Transformers of Ionization Radiation, 2009, Cracóvia - Polônia. Proceedings, 2009. v. 1. p. 1-3.
3. YOSHIZUMI, M. T; AFONSO, L. C; CALDAS, L. V. E. Use of a standard ionization chamber at different distances in diagnostic radiology beams. In: 11th International Congress of the IUPESM, 2009, Munique - Alemanha. Proceedings, 2009.
4. ALCANTARA, M. C; SORDI, G. M. A. A; CALDAS, L. V. E; FURQUIM, T. A. C. Avaliação dos critérios de qualidade de imagem, índice de rejeição e estimativa de doses em um departamento de mamografia. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do evento, 2009.
5. YOSHIZUMI, M. T; CALDAS, L. V. E. Estudo da estabilidade de resposta e da uniformidade do campo elétrico aplicado a uma câmara monitora anelar. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do evento, 2009.
6. NONATO, F. B. C; CARVALHO, Valdir de Souza; DINIZ, R. E; CALDAS, L. V. E. Dependência angular e energética de monitores de radioproteção para medidas de equivalente de dose ambiental para radiação gama. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do evento, 2009.
7. ANTONIO, P. L; OLIVEIRA, M. L; CALDAS, L. V. E. Depth dose curves from 90Sr+90Y clinical applicators using the thermoluminescence technique. In: 2009 International Atlantic Nuclear Conference, 2009, Rio de Janeiro. 2009 INAC, 2009.
8. MORALLES M., GUIMARÃES C.C., BONIFÁCIO D.A.B., OKUNO E., MURATA H.M., BOTTARO M., MENEZES M.O. AND GUIMARÃES V. “Applications of the Monte Carlo method in Nuclear Physics using the GEANT 4 toolkit” Publicado no Proceegings do AIP Conference, Volume 1139, NUCLEAR PHYSICS 2008: XXXI Workshop on Nuclear Physics in Brazil, São Sebastião, São Paulo (Brazil), 8–12 September 2008, ISBN: 978-0-7354-0676-6 (2009). doi:10.1063/1.3157829
9. GUIMARÃES, C. C; MORALLES, M; SENE, F. F; MARTINELLI, J. R; OKUNO, E. Calculation of electron Dose Point Kernel in water with GEANT4 for medical application.

In: XXXI Reunião sobre Física Nuclear no Brasil, 2008, São Sebastião. AIP Conference Proceedings. NUCLEAR PHYSICS 2008: XXXI Workshop on Nuclear Physics in Brazil, 2008. v. 1139. p. 93-96 (2009).

10. PINTO, T. N. O.; CALDAS, L. V. E. Characterization of OSL commercial dosimeters using a hand phantom, in standard beta radiation beams. In: 2009 International Nuclear Atlantic Conference, 2009, Rio de Janeiro. 2009 INAC, 2009.
11. NONATO, F. B. C; CARVALHO, VALDIR DE SOUZA; VIVOLO, V.; CALDAS, L. V. E. Response of radiation protection monitors in terms of H*(10) in X radiation. In: 2009 International Nuclear Atlantic Conference, 2009, Rio de Janeiro. 2009 INAC, 2009.
12. GRONCHI, C. C; CALDAS, L. V. E. OSL response of Al2O3:C inlight dot detectors to ultraviolet radiation. In: 2009 International Nuclear Atlantic Conference, 2009, Rio de Janeiro. 2009 INAC, 2009.
13. YOSHIZUMI, M. T; CALDAS, L. V. E. Testing ring-shaped ionization chamber in standard beta radiation. In: 2009 International Nuclear Atlantic Conference, 2009, Rio de Janeiro. 2009 INAC, 2009.
14. YOSHIZUMI, M. T; CALDAS, L. V. E. A new ring-shaped graphite monitor ionization chamber. In: 11th International Symposium on Radiation Physics, 2009, Melbourne - Austrália. Proceedings, 2009.
15. PINTO, T. N. O.; CALDAS, L. V. E. Transmission factors for beta radiation, using Al2O3:C commercial OSL dosimeters. In: 11th International Symposium on Radiation Physics, 2009, Melbourne - Austrália. Proceedings, 2009.
16. BARROS, G. A. S. J; CALDAS, L. V. E. Cálculo das blindagens do projeto de um laboratório integrado de calibração de instrumentos no IPEN. In: V Congresso Brasileiro de Metrologia, 2009, Salvador - BA. Anais, 2009.
17. YOSHIZUMI, M. T; CALDAS, L. V. E. Dependência da resposta de uma câmara de ionização anelar com o tamanho do campo de radiação X. In: V Congresso Brasileiro de Metrologia, 2009, Salvador - BA. Anais, 2009.
18. ANTONIO, P. L; OLIVEIRA, M. L; CALDAS, L. V. E. Distribuição de dose em profundidade na água para aplicadores clínicos de 90Sr+90Y, com uma mini-câmara de extrapolação. In: V Congresso Brasileiro de Metrologia, 2009, Salvador - BA. Anais, 2009.
19. NONATO, F. B. C; DINIZ, R. E; CARVALHO, V. S; VIVOLO, V.; CALDAS, L. V. E. Estudo da dependência energética de detectores de radiação gama para 137Cs e 60Co. In: V Congresso Brasileiro de Metrologia, 2009, Salvador - BA. Anais, 2009.
20. PAMPLONA, G. S. P; COSTA, A. M; CALDAS, L. V. E. Reconstrução espectral de feixes de raios X padrões nível radioproteção com base nas curvas de transmissão. In: Primeiro Congresso de Proteção contra Radiações de Países e Comunidades de Língua Portuguesa, 2009, Lisboa - Portugal. Anais do evento, 2009.
21. VILA, G. B; CALDAS, L. V. E. Caracterização dosimétrica de casca de ostras para doses altas. In: Primeiro Congresso de Proteção contra Radiações de Países e Comunidades de Língua Portuguesa, 2009, Lisboa - Portugal. Anais do evento, 2009.
22. TEIXEIRA, M. I; CALDAS, L. V. E. Propriedades termoluminescentes do citrino para dosimetria de altas doses. In: Primeiro Congresso de Proteção contra Radiações de Países e Comunidades de Língua Portuguesa, 2009, Lisboa - Portugal. Anais do evento, 2009.
23. YOSHIZUMI, M. T; CALDAS, L. V. E. Estudo comparativo da estabilidade de resposta de câmaras monitoras em feixes de radiação X. In: Primeiro Congresso de Proteção contra Radiações de Países e Comunidades de Língua Portuguesa, 2009, Lisboa - Portugal. Anais do evento, 2009.
24. NONATO, F. B. C; CALDAS, L. V. E. Dependência energética e angular de monitores portáteis para radiação beta. In: Primeiro Congresso de Proteção contra Radiações de Países e Comunidades de Língua Portuguesa, 2009, Lisboa - Portugal. Anais do evento, 2009.
25. ANTONIO, P. L; CALDAS, L. V. E. Desenvolvimento de um sistema postal dosimétrico para a calibração de aplicadores clínicos de 90Sr+90Y. In: Primeiro Congresso de Proteção contra Radiações de Países e Comunidades de Língua Portuguesa, 2009, Lisboa - Portugal. Anais do evento, 2009.
26. ANTONIO, P. L; OLIVEIRA, M. L; CALDAS, L. V. E. Calibração de aplicadores clínicos de 90Sr+90Y utilizando uma mini-câmara de extrapolação como sistema de referência. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do evento, 2009.

27. OLIVEIRA, PAULO MÁRCIO CAMPOS DE; SQUAIR, PETERSON; OLIVEIRA, V. L. S. DE; ABRANTES, MARCOS EUGÊNIO SILVA; ALONSO, THESSA CRISTINA; DA SILVA, T. A. Validating methodologies for evaluation of patient doses submitted to chest X-ray examinations. In: World Congress on Medical Physics and Biomedical Engineering, 2009, Munique. IFMBE Proceedings 2503400. Heidelberg: Springer, 2009. v. 25. p. 400-402.
28. LACERDA, MARCO AURÉLIO DE SOUSA; DA SILVA, T. A; KHUORY, HELEN JAMIL. Air kerma-area product in pediatric X-ray examinations of paranasal sinuses: an indirect method of assessment. In: World Congress on Medical Physics and Biomedical Engineering, 2009, Munique. IFMBE proceedings 25030318. Heidelberg: Springer, 2009. v. 25. p. 318-320.
29. MEDEIROS, R. B; H. SCHELIN; DIAS, S; MECCA, F; NOGUEIRA, MARIA DO SOCORRO; DA SILVA, T. A; COSTA, P; FURQUIM, T; VIEIRA, E; BRASILEIRO, I; KHUORY, HELEN JAMIL. Quality and radiation doses in mammograms: Brazil sampling data. In: World Congress on Medical Physics and Biomedical Engineering, 2009, Munique. IFMBE Proceedings 25030648. Heidelberg: Springer, 2009. v. 25. p. 648-651.
30. DA SILVA, T. A; OLIVEIRA, PAULO MÁRCIO CAMPOS DE; BAPTISTA NETO, ANNÍBAL THEOTONIO; SOARES, CARLOS MANOEL DE ASSIS; NOGUEIRA, MARIA DO SOCORRO; PEREIRA, E. G; SQUAIR, PETERSON; ALONSO, THESSA CRISTINA. Implantação da base metrológica para dosimetria de feixes de raios-x usados em radiodiagnóstico em Minas Gerais. In: V Congresso Brasileiro de Metrologia, 2009, Salvador, Bahia. Anais do 5 Congresso Brasileiro Metrologia 2009. Rio de Janeiro: Sociedade Brasileira de Metrologia, 2009. v. 1. p. 1-4.
31. OLIVEIRA, C. M; ABRANTES, MARCOS EUGÊNIO SILVA; OLIVEIRA, PAULO MÁRCIO CAMPOS DE; FERREIRA, F. C. B; LACERDA, MARCO AURÉLIO DE S; ALONSO, THESSA CRISTINA; DA SILVA, T. A. Response of the "Patient Dose Calibrator" chamber for incident positios and sizes of X-ray fields. In: International Nuclear Atlantic Conference - INAC 2009, 2009, Rio de Janeiro. Proceedings INAC 2009'. Rio de Janeiro: Associação Brasileira de Energia Nuclear - ABEN, 2009. v. in CD. p. 1-5.
32. MOURÃO, A. P; ALONSO, THESSA CRISTINA; DA SILVA, T. A. Contribuição da radiação espalhada na composição da dose periférica em varredura por TC de um fantoma de cabeça. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do XIV CBFM. São Paulo: ABFM, 2009. v. 1. p.1-4
33. BAPTISTA NETO, A. T; SOARES, CARLOS MANOEL DE ASSIS; CORRÊA, R.S; DA SILVA, T. A. Characterization of a Cs-137 radiation beam for dosimeter calibration in the CRCN-CO. In: 2009 International Nuclear Atlantic Conference, 2009, Rio de Janeiro. proceedings of the 2009 INAC. Rio de Janeiro: ABEN, 2009. v. 1. p. 1-3.
34. ROCHA, A. M. G; VILELA, E. C; SANTOS, J. A; OLIVEIRA, P. F; DA SILVA, T. A. Neutron spectrometry around the CDTN Triga reactor for radiation protection optimization. In: 2009 International Nuclear Atlantic Conference, 2009, Rio de Janeiro. Proceedings of the 2009 INAC. Rio de Janeiro: ABEN, 2009. v. 1. p. 1-3.
35. CASTRO, W. J; GONZAGA, N. B; SQUAIR, PETERSON; NOGUEIRA, MARIA DO SOCORRO; DA SILVA, T. A. Caracterização de dosímetros termoluminescentes para dosimetria de pacientes em radiodiagnóstico resultados iniciais. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do XIV CBFM. São Paulo: ABFM, 2009. v. 1. p. 1-4.
36. ABRANTES, MARCOS EUGÊNIO SILVA; DA SILVA, T. A. Comparação dos programas computacionais PCXMC e CalDose X na dosimetria de pacientes submetidos a exames de raios-x médico resultados preliminares. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do XIV CBFM. São Paulo: ABFM, 2009. v. 1. p. 1-3.
37. OLIVEIRA, V. L. S. DE; OLIVEIRA, PAULO MÁRCIO CAMPOS DE; ABRANTES, MARCOS EUGÊNIO SILVA; DA SILVA, T. A. Aplicação da metodologia computacional PCXMX para estimativa das doses em pacientes submetidos a exames de abdômen e pelve com raios-x. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do XIV CBFM. São Paulo: ABFM, 2009. v. 1. p. 1-3.
38. BAPTISTA NETO, A. T; OLIVEIRA, PAULO MÁRCIO CAMPOS DE; PEREIRA, J. V; FERREIRA, F. C. B; PINHEIRO, L. DE J. S; DA SILVA, T. A. Implantação das radiações de referência de radiodiagnóstico no CDTN/CNEN para calibração de

dosímetros. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do XIV CBFM. São Paulo: ABFM, 2009. v. 1. p. 1-3.

39. LIMA, F. F; ANDRADE, W. G. Evaluation of the eluate quality of 99Mo-99mTc Generators in the Recife, Brazil. In: 2009 INAC - International Nuclear Atlantic Conference, 2009, Rio de Janeiro. 2009 INAC Proceedings, 2009.
40. SOUZA, P. L. G; BRANDAO, J. O. C; CALIXTO, M. S; Vale, C.H.F.P; SANTOS, N; VILELA, E. C; LIMA, F. F. Analysis of Unstable Chromossome Alterations Frequency Induced by Neutron-Gamma Mixed Field Radiation. In: 2009 INAC - International Nuclear Atlantic Conference, 2009, Rio de janeiro. 2009 INAC Proceedings, 2009.
41. BRANDAO, J. O. C; SOUZA, P. L. G; CALIXTO, M. S; SANTOS, J. A. L; SANTOS, N; VILELA, E. C; LIMA, F. F. Dose-response Curve for Blood Exposed to Gamma-neutron mixed Field by Conventional Cytogenetic Method. In: 2009 INAC - International Nuclear Atlantic Conference, 2009, Rio de Janeiro. 2009 INAC Proceedings, 2009.
42. FRAGOSO, M.C.F; ALBUQUERQUE, A.M.S; OLIVEIRA, M. L; LIMA, R. A; LIMA, F. F. Performance of the Radionuclide Calibrator used at CRCN-NE for Comparison Measurements. In: 2009 INAC - International Nuclear Atlantic Conference, 2009, Rio de Janeiro. 2009 INAC Proceedings, 2009.
43. FRAGOSO, M. C. F; ALBUQUERQUE, A. M. S; OLIVEIRA, M. L; LIMA, R. A; LIMA, F. F. Controle da Qualidade dos Calibradores em Radionuclídeos nos Serviços de Medicina Nuclear de Pernambuco. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais Do XIV Congresso Brasileiro de Física Médica, 2009.
44. SANTOS, J. A. L; BRANDAO, J. O. C; RODRIGUES, G. C. P; SANTANA, M.G; VILELA, E. C; LIMA, F. F. Simulation of absorbed dose in human blood with MCNP4C code. In: 2009 INAC - International Nuclear Atlantic Conference, 2009, Rio de Janeiro. 2009 INAC Proceedings, 2009.
45. COSTA, A. M; POTIENS, MARIA DA PENHA ALBUQUERQUE. Application of a model based on a pair of laplace transforms for standard low-energy X-ray beams spectral reconstruction. In: ENCONTRO NACIONAL DE APLICAÇÕES NUCLEARES, 2009, Rio de Janeiro. Anais do IX Encontro Nacional de Aplicações Nuclerares, 2009.
46. BETTI, FLÁVIO; POTIENS, M. P. A. Automated correction on X-rays calibration using transmission chamber and lab VIEW sup(tm). In: International Nuclear Atlantic Conference; Meeting on Nuclear Applications, 9th; Meeting on Reactor Physics and Thermal Hidraulics, 16th; Meeting on Nuclear Industry, 1st, 2009, Rio de Janeiro. Proceeding of the INAC 2009, 2009.
47. RAPHAEL ELIAS DINIZ; VIVOLO, VITOR; POTIENS, M. P. A. Avaliação de dependência energética de monitores portáteis de radiação utilizados em radioproteção. In: International Nuclear Atlantic Conference; Meeting on Nuclear Applications, 9th; Meeting on Reactor Physics and Thermal Hidraulics, 16th; Meeting on Nuclear Industry, 1st, 2009, Rio de Janeiro. Proceedings of INAC 2009, 2009.
48. DIAS, D. M; SILVA JR., I. A; POTIENS, M. P. A. Caracterização das Qualidades de Radiação (RQT) usadas na determinação das características em aplicações de CT de acordo com a IEC 61267: 2005. In: XIV Congresso Brasileiro de Física Médica - IV Simpósio de Instrumentação e Imagens Médicas, 2009, São Paulo. Anais do CBFM, 2009.
49. CORRÊA, EDUARDO DE LIMA; LUCENA, RODRIGO F; VIVOLO, VITOR; POTIENS, M. P. A. Comparação de espectros de raios-x gerados por um alvo de w e filtração adicional de mo e al para aplicações em metrologia na mamografia. In: XIV Congresso Brasileiro de Física Médica - IV Simpósio de Instrumentação e Imagens Médicas, 2009, São Paulo. Anais do XIV CBFM, 2009.
50. CORRÊA, EDUARDO DE LIMA; VIVOLO, VITOR; POTIENS, M. P. A. Comparison between different kinds of additional filtration in standards X-ray beams, mammography level. In: International Nuclear Atlantic Conference; Meeting on Nuclear Applications, 9th; Meeting on Reactor Physics and Thermal Hidraulics, 16th; Meeting on Nuclear Industry, 1st, 2009, Rio de Janeiro. Proceeding of INAC 2009, 2009.
51. MARTINS, E.W; POTIENS, M. P. A. Controle de Qualidade do Sistema Padrão Secundário NPL-CRC utilizado na Calibração de Ativímetros no IPEN. In: XIV Congresso Brasileiro de Física Médica - IV Simpósio de Instrumentação e Imagens Médicas, 2009, São Paulo. Anais do XIV CBFM, 2009.
52. FRANCISCATTO, P. C; POTIENS, M. P. A. Determination of inherent and additional filtration in order to establish radiation qualities according to IEC 61267. In: International Nuclear Atlantic Conference; Meeting on Nuclear Applications, 9th; Meeting on Reactor

Physics and Thermal Hidraulics, 16th; Meeting on Nuclear Industry, 1st, 2009, Rio de Janeiro. Proceedings of INAC 2009, 2009.

53. DAMATTO, W.B; SANTOS, GELSON PINTO DOS; POTIENS, M. P. A; CALDAS, L. V. E; VIVOLO, VITOR. Estudo da corrente de fuga de dosímetros clínicos para teleterapia. In: V Congresso Brasileiro de Metrologia, 2009, Salvador. Anais do V Congresso Brasileiro de Metrologia, 2009.
54. DAMATTO, W.B; POTIENS, M. P. A; SANTOS, GELSON PINTO DOS; VIVOLO, VITOR. Estudo das rotinas e procedimentos de calibração de dosimetros clínicos e feixes de radiação gama no IPEN-CNEN/SP. In: International Nuclear Atlantic Conference; Meeting on Nuclear Applications, 9th; Meeting on Reactor Physics and Thermal Hidraulics, 16th; Meeting on Nuclear Industry, 1st, 2009, Rio de Janeiro. Proceedings of the INAC 2009, 2009.
55. MIRANDA, J. A; POTIENS, M. P. A. Implantação das qualidades de radiação específicas para fluoroscopia no Laboratório de Calibração do IPEN. In: XIV Congresso Brasileiro de Física Médica - IV Simpósio de Instrumentação e Imagens Médicas, 2009, São Paulo. Anais do XIV CBFM, 2009.
56. LUCENA, RODRIGO F; POTIENS, M. P. A; VIVOLO, VITOR. Measurements of KVp and air kerma values in function of the electric current quantity and the focus-detector distance in one X-ray equipment. In: International Nuclear Atlantic Conference; Meeting on Nuclear Applications, 9th; Meeting on Reactor Physics and Thermal Hidraulics, 16th; Meeting on Nuclear Industry, 1st, 2009, Rio de Janeiro. Proceedings of the INAC 2009, 2009.
57. MARTINS, E.W; POTIENS, M. P. A. Preliminary measurements to the establishment of a quality control programme for the activimeter calibration reference system. In: International Nuclear Atlantic Conference; Meeting on Nuclear Applications, 9th; Meeting on Reactor Physics and Thermal Hidraulics, 16th; Meeting on Nuclear Industry, 1st, 2009, Rio de Janeiro. Proceedings of the INAC 2009, 2009.
58. DAMATTO, W.B; SANTOS, GELSON PINTO DOS; POTIENS, M. P. A; VIVOLO, VITOR. Procedimento de calibração de dosímetros clínicos de radioterapia em feixes de radiação de co-60 no IPEN-CNEN/SP. In: XIV Congresso Brasileiro de Física Médica - IV Simpósio de Instrumentação e Imagens Médicas, 2009, São Paulo. Anais do XIV CBFM, 2009.
59. DIAS, D.M; LUCENA, RODRIGO F; FRANCISCATTO, P. C; CORRÊA, EDUARDO DE LIMA; VIVOLO, VITOR; POTIENS, M. P. A. Testes das grandezas ppv e kvp utilizando um medidor de tensão não invasivo visando um aperfeiçoamento na aquisição de medidas. In: V Congresso Brasileiro de Metrologia, 2009, Salvador. Anais do V Congresso Brasileiro de Metrologia, 2009.
60. SILVA, M. O; LEITE, M. S; COSTA, A. M; GHILARDI NETTO, T. Avaliação de dose para radiografias periapicais na cidade de Limeira. In: Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do XIV Congresso Brasileiro de Física Médica, 2009.
61. DE CHIARA, A. C. M; COSTA, A. M; PARDINI, L. C. Medições De Dose Em Radiodiagnóstico Odontológico Utilizando Dosimetria Termoluminescente. In: Congresso Brasileiro De Física Médica, 2009, São Paulo. Anais do XIV Congresso Brasileiro de Física Médica, 2009.
62. PAMPLONA, G. S. P; COSTA, A. M. Determinação do espectro de raios x a partir da curva de transmissão para um equipamento de radiografia dentária. In: Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do XIV Congresso Brasileiro de Física Médica, 2009.
63. BOIA L. S; SILVA, ADEMIR XAVIER DA; FACURE, A; CARDOSO, SIMONE COUTINHO; DA ROSA, L. A. R; CASTRO C. Methodology for converting CT medical images to MCNP input using the Scan2mcnp system. In: INAC 2009, 2009, Rio de Janeiro. INAC 2009, 2009
64. CAMPOS, L. T; BRAZ, DELSON; DA ROSA, L. A. R. Monte Carlo Simulations of Regular Fields for Electrons Beams from a Medical Accelerator Using EGSnrc. In: INAC 2009, 2009, Rio de Janeiro. INAC 2009, 2009.
65. TROMBETTA, D. M; CARDOSO, SIMONE COUTINHO; FACURE, A; DA ROSA, L. A. R; SILVA, ADEMIR XAVIER DA. Study of dosimetric effects due to metallic heterogeinity of tissue expanders in post-mastectomy radiotherapy. In: INAC 2009, 2009, Rio de Janeiro. INAC 2009, 2009.

66. REIS JUNIOR J. P; FACURE, A; SILVA, ADEMIR XAVIER DA; CARDOSO, SIMONE COUTINHO; DA ROSA, L. A. R. Study of edema impact in permanent prostate implants using the monte carlo method. In: INAC 2009, 2009, Rio de Janeiro. INAC 2009, 2009.
67. TROMBETTA, D. M; CARDOSO, SIMONE COUTINHO; FACURE, A; DA ROSA, L. A. R; SILVA, ADEMIR XAVIER DA. Estudo da atenuação do feixe de 6 MV em tratamentos radioterápicos de mama pós-mastectomia devido à heterogeneidade metálica de expansores de tecido. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. XIV Congresso Brasileiro de Física Médica, 2009.
68. CAMPOS, L. T; DA ROSA, L. A. R; BATISTA, DELANO VALDIVINO SANTOS; BRAZ, DELSON. Características da variação da resposta espacial do escâner Microtek 9800 XL para a dosimetria com filme radiocrômico. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. XIV Congresso Brasileiro de Física Médica, 2009.
69. KHOURY, H.J; MORA, P; DIAS, S. K; YOLANDA DEFAZ. Patient Doses in Latin American Countries. In: World Congress on Medical Physics and Biomedical Engineering, 2009, Munich. Patient Doses in Latin American Countries, 2009. v. 25/III. p. 529-532.
70. CHAGAS, M. A. P; NUNES, MAÍRA GOES; CAMPOS, L. L; SOUZA, D. N. TL. Properties of Anhydrous CaSO4:Tm Improvement. In: LUMDETR-2009 7th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation, 2009, Cracóvia - Polônia. Proc. LUMDETR-2009 7th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation. Cracóvia - Polônia, 2009. v. 1. p. 1-4.
71. VENEZIANI, G. R; MATSUSHIMA, L. C; FERNANDEZ, R.M; CAMPOS, L. L. Thermoluminescence Measurements of Surface Skin Dose in IN Exams of Dog s Chest in Veterinary Radiology. In: LUMDETR-2009 7th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation, 2009, Cracóvia - Polônia. Proc. LUMDETR-2009 7th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation, 2009. v. 1. p. 1-4.
72. VENEZIANI, G. R; MATSUSHIMA, L. C; FERNANDEZ, R.M; CAMPOS, L. L. Study of entrance surface skin dose in veterinary radiology. In: World Congress 2009 on Medical Physics and Biomedical Engineering, 2009, Munich - Alemanha. Proc. World Congress 2009 on Medical Physics and Biomedical Engineering. Muniuch, 2009. v. 1. p. 1-4.
73. VENEZIANI, G. R; MATSUSHIMA, L. C; FERNANDEZ, R.M; CAMPOS, L. L. Avaliação das doses de cães submetidos a exames radiográficos de pulmão e a implicação nas doses individuais dos proprietários e do pessoal clínico. In: Primeiro Congresso de Proteção Contra Radiações da Comunidade de Países de Língua Portuguesa., 2009, Lisboa. Atas do Primeiro Congresso de Proteção Contra Radiações da Comunidade de Países de Língua Portuguesa. Lisboa, 2009. v. 1.
74. CAVINATO, C. C; SAKURABA, R. K; CRUZ, J. C; CAMPOS, L. L. Caracterização da Resposta do Dosímetro Fricke Gel preparado com Gelatina 270 Bloom para Feixes Clínicos de Elétrons. In: Primeiro Congresso de Proteção Contra Radiações da Comunidade de Países de Língua Portuguesa., 2009, Lisboa. Atas do Primeiro Congresso de Proteção Contra Radiações da Comunidade de Países de Língua Portuguesa. Lisboa, 2009. v. 1. p. 1-8.
75. NUNES, MAÍRA GOES; CAMPOS, L. L. Eficiência Intrínseca do CaSO4:Dy para Feixes Clínicos de Elétrons. In: Primeiro Congresso de Proteção Contra Radiações da Comunidade de Países de Língua Portuguesa., 2009, Lisboa. Atas do Primeiro Congresso de Proteção Contra Radiações da Comunidade de Países de Língua Portuguesa. Lisboa, 2009. v. 1. p. 1-8.
76. GALANTE, A. M. S; GALANTE, O. L; CAMPOS, L. L. Study on application of PTFE, FEP and PFA fluoropolymers on radiation dosimetry.. In: 11th International Symposium on Radiation Physics (ISRP-11), 2009, Melbourne. Proceed ofthe 11th International Symposium on Radiation Physics (ISRP-11), 2009. v. 1. p. 1-4.
77. CAVINATO, C. C; CAMPOS, L. L. Energy dependent response of the fricke gel dosimeter prepared with 270 bloom gelatine for photons in the energy range of 13,93 kev to 6 MEV.. In: 11th International Symposium on Radiation Physics (ISRP-11), 2009, Melbourne. Proceed of the 11th International Symposium on Radiation Physics (ISRP-11), 2009. v. 1. p. 1-4.
78. SILVA, C. F; CAMPOS, L. L. Estabilidade da resposta e dependência do sinal óptico em função da taxa de dose do dosimetro alanina gel para feixes de elétrons clínicos. In: 5º Congresso Brasileiro de Metrologia 2009, 2009, Salvador. Proceed. do 5º Congresso Brasileiro de Metrologia 2009, 2009. v. 1. p. 1-4.

79. MANGUEIRA, T. F; CAMPOS, L. L. Desenvolvimento do sistema de leitura por CCD para aplicação na dosimetria fricke xilenol gel. In: 5º Congresso Brasileiro de Metrologia 2009, 2009, Salvador. Anais do5º Congresso Brasileiro de Metrologia 2009. Salvador, 2009. v. 1. p. 1-4.
80. BRAVIM A; CAMPOS, L. L. Avaliação dosimétrica de micro dosímetros termoluninescentes de LiF:Mg,Ti e CaSO4 para aplicação na dosimetria in vivo de feixes clínicos de elétrons. In: 9th Meeting on Nuclear Applications (IX ENAN), 2009, Rio de Janeiro. Anais do 9th Meeting on Nuclear Applications (IX ENAN). Rio de Janeiro, 2009. v. 1. p. 1-4.
81. SILVA, C. F; CAMPOS, L. L. Study of reproducibility and dose response of alanine gel dosimeter for clinical electron beams. In: 9th Meeting on Nuclear Applications (IX ENAN), 2009, Rio de Janeiro. Anais do 9th Meeting on Nuclear Applications (IX ENAN). Rio de Janeiro, 2009. v. 1. p. 1-4.
82. MULLER, M; ROCHA, FELÍCIA DEL GALLO; CAMPOS, V. P; CAMPOS, L. L. Estudo da reprodutibilidade da resposta TL dos dosimetros de CaSO4:Dy para diferentes condições de resfriamento. In: 9th Meeting on Nuclear Applications (IX ENAN), 2009, Rio de Janeiro. Anais do 9th Meeting on Nuclear Applications (IX ENAN). Rio de Janeiro, 2009. v. 1. p. 1-4.
83. CAVINATO, C. C; CAMPOS, L. L. Influence of gelatine concentration and quality in the spectrophotometric response of fricke gel solution. In: 9th Meeting on Nuclear Applications (IX ENAN), 2009, Rio de Janeiro. Anais do 9th Meeting on Nuclear Applications (IX ENAN). Rio de Janeiro, 2009. v. 1. p. 1-4.
84. CÁRDENAS, J. P. N; MADI FILHO, T; CAMPOS, L. L. Test and evaluation of semiconductor components in mixed field radiation monitoring. In: 9th Meeting on Nuclear Applications (IX ENAN), 2009, Rio de Janeiro. Anais do 9th Meeting on Nuclear Applications (IX ENAN). Rio de Janeiro, 2009. v. 1. p. 1-4.
85. SILVA, C. F; CAMPOS, L. L. Resposta Espectrofotométrica da Solução Gel de Alanina para Feixes Clínicos de Fótons e Elétrons. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do XIV Congresso Brasileiro de Física Médica,. São Paulo, 2009. v. 1. p. 1-4.
86. CAVINATO, C. C; CERVANTES, H. J; RABBANI, S. R; CAMPOS, L. L. Estudo Comparativo entre as Respostas da Solução Fricke Gel Desenvolvida no IPEN Avaliadas pelas Técnicas de Espectrofotometria de Absorção Óptica e Ressonância Magnética. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do XIV Congresso Brasileiro de Física Médica. São Paulo, 2009. v. 1. p. 1-4.
87. BRAVIM A; MATSUSHIMA, L. C; CAMPOS, L. L. Estudo da resposta tl e da sensibilidade de microdosímetros termoluninescentes de LIF:MG,TI e dosímetros de CASO4 e de LIF:MG,TI em feixe de 60CO. In: V CONFIAM Congresso de Física Aplicada à Medicina, 2009, Botucatu. Anais do V CONFIAM Congresso de Física Aplicada à Medicina. Botucatu, 2009. v. 1. p. 1-4.

4. EXPANDED SUMMARIES PUBLISHED IN PROCEEDINGS OF CONFERENCES

1. GUILHERME RIGHETTI ANDRADE RESENDE; SALES, CAMILA PESSOA DE; GABRIELA REIS DOS SANTOS; BRUNO LOOS GIALLUISI; ANGELA BEATRIZ HABTIZREUTER; RODRIGUES, L. N. Avaliação dosimétrica de um detector microMOSFET. In: XIV Congresso Brasileiro de Física Médica, 2009, São Paulo. Anais do XIV Congresso Brasileiro de Física Médica, 2009. p. 1-4.
2. RODRIGUES, L. N; TORETI, D; MENEGUSSI, GISELA; SILVA, MARCO ANTÔNIO DA; RUBO, RODRIGO AUGUSTO; GABRIELA REIS DOS SANTOS. Acceptance and commissioning in Radiosurgery: problems and solutions. In: International Conference on Advances in Radiation Oncology (ICARO), 2009, Vienna. International Conference on Advances in Radiation Oncology (ICARO), 2009.
3. MENEGUSSI, GISELA; SILVA, MARCO ANTONIO DA; RUBO, RODRIGO AUGUSTO; RODRIGUES, L. N. Quality assurance program for Radiosurgery at Clinicas Hospital: results of implementation. In: International Conference on Advances in Radiation Oncology (ICARO), 2008, Vienna. International Conference on Advances in Radiation Oncology (ICARO). Vienna: IAEA, 2009.
4. CORREA MP; FAUSTO AMF; MOL A; OKUNO, E; MOREGULA A; SANTOS JC. Ultraviolet Index measurements in Southern of Bahia. In: International Radiation

Symposium 2008 (IRC/IAMAS), 2009, Foz do Iguaçu. Annals of International Radiation Symposium 2008, 2008. v. 110. p. 463-465.

5. MEDEIROS, R. B; SCHELIN, H; FURQUIM, T. A. C; COSTA, P R. Quality and radiation doses in mammography: Brazilian sample data. In: The 11th Medical Congress of the IUPESM:The World Congress on Medical Physics and Biomedical Engineering, 2009, Munique. Anals of the World Congress on Medical Physics and Biomedical Engineering, 2009.

5. SUMMARIES PUBLISHED IN PROCEEDINGS OF CONFERENCES

1. FEDERICO, C. A; GONCALEZ, O. L; CALDAS, L. V. E; FONSECA, E. S; MARTIN, I. M. Medidas de nêutrons produzidos na atmosfera pela radiação cósmica na região da anomalia magnética do Atlântico Sul. In: IX Workshop Anual do IEAv, 2009, São José dos Campos. Anais, 2009. v. 2. p. 77-77.
2. CORRÊA, M. P; CEBALLOS, J.C; MOREGULA, A; OKUNO, E; FAUSTO, A; MOL, A; SANTOS, J. C. Recent studies on UV radiation in Brazil. In: European Geosciences Union General Assembly 2009, 2009, Viena. Geophysical Research Abstracts, 2009. v. 11.
3. GABRIEL PAIVA FONSECA; SIQUEIRA, PAULO DE TARSO D; FURNARI, LAURA; YORIYAZ, HÉLIO; POLI, MARIA ESMERALDA RAMOS; RUBO, RODRIGO AUGUSTO; ANTUNES, P.C.G; RODRIGUES, L. N. Metodologia para utilização de filmes radiográficos para avaliação dosimétrica em Radioterapia com feixes de elétrons. In: XIII Congresso Brasileiro de Física Médica, 2008, Belo Horizonte. Anais do XIII Congresso Brasileiro de Física Médica, 2008.
4. G. A. SOARES; P. L. SQUAIR; M. T. PEREIRA; MEIRA-BELO, LUIZ CLÁUDIO; GROSSI, P. A. Blood Compounds Irradiation Process: Assessment of Absorbed Dose Using Fricke and Thermoluminescent Dosimetric Systems. In: International Nuclear Atlantic Conference 2009, 2009, Rio de Janeiro. Anais do International Nuclear Atlantic Conference 2009, 2009.
5. G. A. SOARES; P. L. SQUAIR; PINTO, F. C; MEIRA-BELO, LUIZ CLÁUDIO; GROSSI, P. A. Assessment of Dose Rates in Industrial Gamma Irradiation Facilities Using Fricke and Thermoluminescent Dosimetric Systems. In: International Nuclear Atlantic Conference 2009, 2009, Rio de Janeiro. International Nuclear Atlantic Conference 2009 Proceedings, 2009.
6. RODRIGUES, R. R; VERDOLIN, R. S; RIBEIRO, M; GRYNBERG, S. E; FERREIRA, A. V; MEIRA-BELO, LUIZ CLÁUDIO. Gamma Irradiator Dose Mapping: a Monte Carlo Simulation and Experimental Measurements. In: International Nuclear Atlantic Conference 2009, 2009, Rio de Janeiro. International Nuclear Atlantic Conference 2009 Proceedings, 2009.
7. ALMEIDA, L. G; FERREIRA, C.C; MAIA, A. F. Utilização de uma câmara de ionização de pequeno volume em tomógrafos computadorizados. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Anais do XIV ENSEF, 2009.
8. XIMENES FILHO, R. E. M; MAIA, A. F; FERREIRA, C.C. Cálculo dos coeficientes de absorção energética de dez materiais para utilização em tomografia computadorizada. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Anais do XIV ENSEF, 2009.
9. SANTOS, W. S; MAIA, A. F. Riscos ocupacionais e do público durante exames radiológicos em Unidades de Terapia Intensiva (UTIs) de um Hospital Público de Grande Porte. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Anais do XIV ENSEF, 2009.
10. MIYAKAWA, WALTER; OTANI, CHOYU; ARAÚJO, TATIANA SANTOS; SOUZA, S. O; SOUZA, EDÉSIA M. B. Evaluation by atomic force microscopy of HAP:Zn nanoparticles as a function of the calcination temperature. In: XXXII ENCONTRO NACIONAL DE FÍSICA DA MATÉRIA CONDENSADA, 2009, Águas de Lindóia. Livro de resumos do XXXII ENCONTRO NACIONAL DE FÍSICA DA MATÉRIA CONDENSADA, 2009. v. 1. p. 107-108.
11. ARAÚJO, TATIANA SANTOS; SOUZA, S. O; SOUZA, EDÉSIA M. B. Study of the composition and optical absorption of tricalcium phosphate powders prepared by precipitation. In: XXXII ENCONTRO NACIONAL DE FÍSICA DA MATÉRIA

CONDENSADA, 2009, Águas de Lindóia. Livro de Resumos do XXXII ENCONTRO NACIONAL DE FÍSICA DA MATÉRIA CONDENSADA, 2009. v. 1. p. 367-368.

12. CAMPOS, SIMARA SANTOS; ALMEIDA, GEÂNGELA MENEZES; SOUZA, S. O. Avaliação da dose natural remanescente em amostras de quartzo extraído de materiais de construção pela técnica da termoluminescência. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 51-51.
13. SENA, ELAINE LEMOS LEAL; CARDOSO, LEANDRO XAVIER; SANTOS, HAMONA N; SOUZA, S. O. Avaliação da dose acumulada na amazonita através de termoluminescência. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 18-18.
14. OLIVEIRA, R. A. P; LIMA, H. R. B. R; MELO, A. C. S; SOUZA, S. O. Detecção da radiação na indústria utilizando o espodumênio lilás. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 19-19.
15. ALMEIDA, GEÂNGELA MENEZES; CAMPOS, SIMARA SANTOS; SOUZA, S. O. Estudo da estabilidade do sinal termoluminescente induzido por radiação beta em amostras de quartzo extraído de materiais de construção. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 55-55.
16. PEIXOTO, T. C; AQUINO, R. J; CARDOSO, LEANDRO XAVIER; SOUZA, S. O. Estudo dos parâmetros cinéticos da cianita. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 16-16.
17. AQUINO, R. J; PEIXOTO, T. C; CARDOSO, LEANDRO XAVIER; SOUZA, S. O. Determinação da concentração de radionuclídeos naturais e artificiais, no solo do campus da Universidade Federal de Sergipe. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 16.
18. LIMA, H. R. B. R; OLIVEIRA, R. A. P; SOUZA, S. O. Estudo do espodumênio lilás para aplicação como cintilador. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 11-11.
19. ALMEIDA, L. G; FERREIRA, CASSIO COSTA; HENRIQUES, L. M. S; ANDRADE, C. T; SOUZA, S. O. Redução de custos em cálculo de blindagem de salas de raios-x utilizando o novo protocolo NCRP 147. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 12-12.
20. SANTOS, HAMONA N; CAMPOS, SIMARA SANTOS; FERREIRA, CASSIO COSTA; SOUZA, S. O. Caracterização dosimetrica da parafina para a construção de objeto simulador apropriado para a mamografia. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 13-13.
21. ARAÚJO, TATIANA SANTOS; ARAUJO, M. S; SOUZA, S. O; SOUZA, E M B. Análise de hidroxiapatita, fosfato tricálcio e calcita puros e dopados com MN2+ para a produção de filtros solares. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 14-14.
22. ARAGAO, W. W; ALMEIDA, A. C. S; SOUZA, S. O. A casa de ciência e tecnologia da cidade de Aracaju: um grande avanço para a divulgação e ensino de ciências em Sergipe. In: XIV Encontro Sergipano de Física, 2009, São Cristóvão. Livro de resumos do XIV Encontro Sergipano de Física, 2009. v. 1. p. 2-2.
23. OLIVEIRA, RAQUEL ALINE PESSOA; LIMA, LEONARDO LELIS; SOUZA, S. O. Luminescent analysis of lilac alpha spodumene. In: The International Conference on Physics of Optical Materials and Devices ICOM2009, 2009, Herceg Novi. ICOM 2009 Book of abstracts, 2009. v. 1. p. 12-12.
24. GONÇALVES, L. R; ALVA, M; MARQUES, T; PIANOSCHI, THATIANE ALVES; BAFFA, OSWALDO; NICOLUCCI, P. Monte Carlo Simulation of 60Co Tomotherapy dose distributions using MAGIC-f polymer gel. In: World Congress on Medical Physics and Biomedical Engineering, 2009, Munique. Proceedings of the World Congress on Medical Physics and Biomedical Engineering, 2009.

25. GONÇALVES, L. R; NICOLUCCI, P. Estudo da distribuição de dose em tomoterapia utilizando Simulação Monte Carlo com o código PENELOPE. In: XI Congresso da Sociedade Brasileira de Radioterapia, 2009, Florianópolis. Anais do XI Congresso da Sociedade Brasileira de Radioterapia, 2009.
26. MARQUES, T; GONÇALVES, L. R; PIANOSCHI, THATIANE ALVES; ALVA, M; SANTANNA, M; BAFFA, OSWALDO; NICOLUCCI, P. Aplicação do gel MAGIC-f na verificação 3D de dose em radioterapia. In: XI Congresso da Sociedade Brasileira de Radioterapia, 2009, Florianópolis. Anais do XI Congresso da Sociedade Brasileira de Radioterapia, 2009.
27. REIS, CRISTIANO MELO DOS; NICOLUCCI, P. Determinação do espectro de energia de campos de radiação utilizados em Radioterapia a partir de medidas de atenuação e simulação Monte Carlo. In: XI Congresso da Sociedade Brasileira de Radioterapia, 2009, Florianópolis. Anais do XI Congresso da Sociedade Brasileira de Radioterapia, 2009.
28. PIANOSCHI, THATIANE ALVES; MARQUES, T; ALVA, M; SANTANNA, M; BAFFA, OSWALDO; NICOLUCCI, P. Resposta dosimetrica do gel MAGIC-f para feixes de elétrons. In: XI Congresso da Sociedade Brasileira de Radioterapia, 2009, Florianópolis. Anais do XI Congresso da Sociedade Brasileira de Radioterapia, 2009.
29. CORREA M.P; CEBALLOS J.C; MOREGULA A; OKUNO, E; FAUSTO A. M. F; MOL A; SANTOS J. C. Recent studies on UV radiation in Brazil.. In: European Geosciences Union General Assembly 2009, 2009, Viena. Geophysical Research Abstracts, 2009. v. 11.
30. NUNES, MAÍRA GOES; CAMPOS, L. L. Effects of the Doping Agent on the TL CaSO4:RE Crystal Growth. In: LUMDETR--2009 7th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation, 2009, Cracóvia - Polônia. LUMDETR-2009 7th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation. Cracóvia, 2009. v. 1. p. 221-221.
31. GALANTE, A. M. S; CAMPOS, L. L. Dosimetric properties of commercial polycarbonate. In: 11th International Symposium on Radiation Physics (ISRP-11), 2009, Melbourne. Resumos do 11th International Symposium on Radiation Physics (ISRP-11). Melbourne, 2009. v. 1. p. 1-1.
32. GALANTE, A. M. S; RODRIGUES, LAURA N; CAMPOS, L. L. Avaliação tridimensional da dose de radioterapia em expansores de mama estudo preliminar. In: Congresso da Sociedade Brasileira de Radioterapia, 2009, Florianópolis. Anais do Congresso da Sociedade Brasileira de Radioterapia, 2009. v. 1. p. 1-4.

6. Training activities and training of human resources

INSTITUTO DE PESQUISAS ENERGÉTICAS E NUCLEARES - IPEN/CNEN/SP

Participation at the Course: "Joint ICTP-IAEA Advanced School on Dosimetry in Diagnostic Radiology, Trieste, Itália.
Participant: Maria da Penha Albuquerque Potiens
Period: de 11 a 15 de Maio de 2009
Scope: Advanced Course in dosimetry and diagnostic radiology and its clinical implementation, based on the recent published TRS 457 (AIEA) and ICRU 74 recomendations. The Courses had the participation of researches of the world, mainly of the development countries. The teachers were from the diagnostic radiology área.

1. Master Theses – Concluded in 2009

Advisor: Linda V. E. Caldas

1. Student: Gustavo Adolfo San José Barros.
   Title: Project of an integrated Calibration Laboratory of instruments at IPEN.
2. Student: Patrícia de Lara Antonio.
   Title: Comparative study among calibration methods of clinical applicators of beta radiation.

Advisor: Maria da Penha Albuquerque Potiens

1. Student: Priscila Cerutti Franciscatto
   Title: X radiation qualities characterization following the standard IEC 61267 recommendations at the calibration laboratory of IPEN.
2. Student: Jurema Aparecida de Miranda.
   Title: Development of a calibration methodology for instruments used for interventional radiology quality control.

Advisor: Letícia Lucente Rodrigues

1. Student: Cléber Feijó Silva
   Title: Dosimetric Evaluation of Spectrophotometric Response of Alanine Gel Solution for Gamma, Photon, Electron and Thermal Neutron Radiations
2. Student: Thyago Fressati Mangueira
   Title: Dosimetri evaluation of Fricke gel solution using the spectrophotometric technique for the application at electron and neutron dosimetry.
3. Student: Christianne Cobello Cavinato
   Title: Standardization of the Fricke gel dosimetry method and tridimensional dose evaluation using the magnetic resonance imaging technique

Advisor: Laura Natal Rodrigues

1. Student: Student: Dalila Luzia Toreti
   Title: Acceptance, comissioning and quality control in radiosurgery.

2. Ph.D. Thesis – Concluded in 2009

Advisor: Linda V. E. Caldas

1. Student: Cláudia Carla Gronchi.
   Title: Establishment of a dosimetry method for the exposure evaluation to the ultraviolet radiation.

3. Scientific Initiation Programs – Concluded in 2009

Advisor: Letícia Lucente Rodrigues

2. Student: Marcelo Muller Veiga.
   Title: Study of the TL response of dosimetry materials for gamma clinical radiation beams with different simulators.

4. Other Academic Advisory Programs – Concluded in 2009

Advisor: Laura Natal Rodrigues

1. Student: Gabriela Reis dos Santos.
   Title: Use of theMonte Carlo technique for the determnation of a 6 MV electron beam.
2. Student: Marcelo Picioli.
   Title: Determination of the threshold between CTV and PTV in conformal treatments of prostate, lungs, nd skull of the clinics hospital / FMUSP.
3. Student: Geralberto José Santiago Cermeño.
   Title: Transition of 2D to 3D radiotherapy.

Advisor: Vitor Vivolo

1. Student: Iremar Alves da Silva Junior.
   Title: Oimization study of the calibration procedure of gamma radiation detectors, radioprotection level.

5. Academic Advisory – In Development

Advisor	Master Theses	Ph.D. Theses	Scientific Initiation	Other	Postdoctorate
Linda V. E. Caldas	1	9	0	0	1
Laura Natal	6	0	0	1	0
Letícia L. Rodrigues	2	7	1	0	2
Maria da P. A. Potiens	7	0	0	0	0
Vitor Vivolo	0	0	1	0	0
TOTAL	16	16	2	1	3

6. Graduation Courses

1. Therapeutic Radiological Physics - Responsible Docent: Laura Natal Rodrigues
2. Applied Metrology in High Enegy Radiotherapy - Responsible Docent: Laura Natal Rodrigues
3. Secial Topics in Radiaion Dosimetry - Responsible Docents: Linda V. E. Caldas e Letícia Lucente Campos Rodrigues
4. Fundamnts in Nuclear Tecnology - Radioprotection - Responsible Docents: Alberto Saburo Todo e Orlando Rodrigues Junior

7. Specialization

1. Phisycs of radiotherapy - Responsible Docent: Laura Natal Rodrigues

INSTITUTO DE FÍSICA DA UNIVERSIDADE DE SÃO PAULO – IFUSP

During the period the wok of 3 graduate students, with ITI scholarships, and a postdoctoral student was supervisioned.

1. Postdoctorate – Concluded in 2009

Advisor: Emico Okuno

1. Student: Roseli Kunzel.
   Title: Application of nanoestrctured materials in Radioprotection

2. Scientific Initiation Programs – concluded in 2009

Advisor: Elisabeth Mateus Yoshimura

1. Student: Marcia Tiemi Saito.
   Title: Light diffusion in biological tissues

Advisor: Paulo Roberto Costa

1. Student: Allan Felipe Fattori Alves.
   Title: Development of a correction methodology for x-ray spectre, measured by CdTe detectors.

3. Academic Advisory – In Development

Advisor	Master Theses	Ph.D. Theses	Scientific Initiation	Other	Postdoctorate
Emico Okuno	0	0	0	0	1
Elisabeth M. Yoshimura	5	0	2	0	0
Paulo Roberto Costa	1	0	1	1	0
TOTAL	6	0	3	1	1

4. Courses, Lectures and Seminars

1. **Short course "Physics of ionizing radiation"**, during the XIV Brazilian Congress of medical physics. São Paulo, 8 and 9/10/2009, duration: 8 hours. Speakers: Emico Okuno e Elisabeth Mateus Yoshimura.

2. **Course: Understanding the human body with physics/part on Biomechanics at the 4th Meeting IFUSP-School** from 19 to 23 January 2009. Course given with Dr. Cecil C. Robilotta. Speaker: Emico Okuno
3. **Short course: "Biological effects of ionizing and non ionizing radiation" for students of physics and engineering environmental UNESP of Presidente Prudente** 01 and 2 July 2009 - 8 hours. Speaker: Emico Okuno
4. **Specialization** – organization of module "Environment and technology in Radiology I specialization course in nursing in Diagnostic and therapeutic Radiology. 03/08/15/07 2009/2010 Nursing School USP. Theme: biological effects of radiation. Speaker: Emico Okuno
5. **Lecture: "Non-ionizing Radiation: State of the art" in JPR Radiology** (2009) held from 30/04 03/05/2009 Transamérica Expo Center in São Paulo. Speaker: Emico Okuno
6. **Lecture: "Dosimetry and Radiological Protection in Pediatric Radiology" in JPR Radiology** (2009) held from 30/04 03/05/2009 Transamérica Expo Center in São Paulo.
7. **Lecture: "Myths and facts about dose enhancement in patients undergoing PET/CT examinations"** Conference on integrated technology PET/CT - Meetings on PET – Physics, clinic, Radiofarmácia-29 May 2009.
8. **Seminar: "Introduction to Biomechanics" at the School of Physical Education of the Federal University of Porto Alegre** on 25 May 2009. Speaker: Emico Okuno
9. **Seminar: "From epidemiology to the establishment of radiation exposure limits" in the Department of Nuclear Physics - Institute of Physics USP** on 09/04/2009. Speaker: Emico Okuno
10. **Lecture: "Radiation in medicine: Physics applied to health"** – Week of Biological Physics IBILCE/UNESP – June 2009.
11. **Lecture: "Applications and biological effects of ionizing radiation"** Academic week of physics at the UNOCHAPECÓ in Chapecó on 14/09/2009. Speaker: Emico Okuno
12. **Lecture: Biological effects of non-ionizing radiation Academic week of physics at the UNOCHAPECÓ** in Chapecó on 14/09/2009. Speaker: Emico Okuno
13. **Freeman Hospital, Newcastle upon Tyne** – England, 22/9/2009.
14. **Lecture: "Radiation from mobile phones"** - CIENTEC/USP S. Paulo on 24/10/2009. Speaker: Emico Okuno
15. **Lecture: Characterization of plaster with barium for use in f PET/CT shielding** 2009. Speaker: Paulo Roberto Costa
16. **Lecture: Training of medical physicists and labour market**. 2009. Speaker: Paulo Roberto Costa
17. **Lecture: Shielding Methods in Brazil**. 2009. Speaker: Paulo Roberto Costa
18. **Lecture: Medical Physicists education**. 2009. (Congress). Speaker: Paulo Roberto Costa
19. **Lecture: Medical physics: applications & prospects**. 2009. (Symposium). Speaker: Paulo Roberto Costa

5. Undergraduation Courses:

1. Radiation Physics I - Teacher: Elisabeth Mateus Yoshimura
2. Modern Physics Laboratory - Teacher: Elisabeth Mateus Yoshimura
3. Biological Effects of Ionizing and Non—Ionizing Radiation - Teacher: Emico Okuno
4. Human Body Physics - Teacher: Emico Okuno
5. Modern Physics Laboratory - Teacher: Paulo Roberto Costa
6. Electromagnetism Laboratory - Teacher: Paulo Roberto Costa

UNIVERSIDADE FEDERAL DE SÃO PAULO – UNIFESP

1. Scientific Initiation Programs – concluded in 2009

Advisor: Regina Bitelli Medeiros

1. Student: Cristiano Munerati.
   Title: Auxiliarly system for quality control tests.

2. Other Academic Advisory Programs– Concluded in 2009

Advisor: Ana Claudia Patrocinio

1. Student: Cristiano Munerati.
   Title: Sistema de auxilio a testes de controle de qualidade

3. Academic Advisory – In Development

Advisor	Master Theses	Ph.D. Theses	Scientific Initiation	Other	Postdoctorate
Regina Bitelli Medeiros	0	2	0	2	1
Ana Claudia Patrocinio	1	0	0	0	0
Silvio Ricardo Pires	0	0	0	0	0
TOTAL	1	2	0	2	1

4. Undergraduation Courses

1. Practice in Physics I (Health Tecnology Course) - Responsible Docent: Silvio Ricardo Pires
2. Physics (Medicine Course) - Colaborator Docent: Silvio Ricardo Pires
3. Diagnostics by Image - Responsible Docent: Regina Bitelli Medeiros

5. Graduation Courses

1. Physics for Residents in Radiology/Mastology - Colaborator Docent: Silvio Ricardo Pires
2. Physics and Radioprotection for Residents of Cardiology and Radiology - Responsible Docent: Regina Bitelli Medeiros
3. Radiolgical Physics Applied to Mammography for Radiologists and Gynecologists - Responsible Docent: Regina Bitelli Medeiros

6. Specialization

1. Specialization in Medical Physics (1920 hours) - Responsible Docent: Regina Bitelli Medeiros

FACULDADE DE FILOSOFIA CIÊNCIAS E LETRAS DE RIBEIRÃO PRETO - FFCLRP/USP

1. Scientific Initiation Programs Concluded in 2009

Advisor: Alessandro Martins da Costa

1. Student: Gustavo Santo Pedro Pamplona.
   Title: Determination of X-ray spectre using transmission curves.
2. Student: Fernanda Ferretti de Oliveira.
   Title: Avaliation of radiation doses in computed tomography examination.

Advisor: Martin Eduardo Poletti

1. Student: Wender Geraldelli.
   Title: Study and evaluation of equivalent materials used in diagnostic radiological: attenuation properties and scattering.

Advisor: Patrícia Nicolucci

1. Student: Tatiana Marques Pinto.
   Title: Application of polymeric gel dosimetry for radiotherapy clinical procedures.

2. Other Academic Advisory - Concluded in 2009

Advisor: Alessandro Martins da Costa

1. Student: André Luiz Coelho Conceição.
   Title: Program of teaching improvement in the course experiments in ionizing radiation dosimetry.

Advisor: Martin Eduardo Poletti

1. Student: Marcelo Antoniassi.
   Title: Program of teaching improvement in the course atomic physics and ionizing radiation
2. Student: Rodrigo Massakatsu Nishiharu Tanaka.
   Title: Study of the interaction of x-ray photons with the matter: theory and experimentation
3. Student: Marina Piacenti da Silva.
   Title: Program of teaching improvement in the course experiments in radiation physics.
4. Student: Raúl Ernesto Camargo Mendoza.
   Title: Program of Teaching Improvement in the Course Experimental Physics – Eletricity and Magnetism

3. Academic Advisory – In Development

Advisor	Master Theses	Ph.D. Theses	Scientific Initiation	Other	Postdoctorate
Alessandro M. da Costa	1	0	1	0	0
Martin Eduardo Poletti	0	5	1	0	0
Patrícia Nicolucci	3	3	1	0	0
TOTAL	4	8	3	0	0

4. Undergraduation Courses

1. Experiments in Ionizing Radiation Dosimetry - Responsible Docent: Alessandro Martins da Costa
2. Theoretical Mechanics - Responsible Docent: Alessandro Martins da Costa
3. Diagnostic Radiology - Responsible Docent: Alessandro Martins da Costa
4. Quality Control in Nuclear Medicine - Responsible Docent: Alessandro Martins da Costa
5. Clinical Radiotherapy - Responsible Docent: Patrícia Nicolucci
6. Electromagnetism and Optics - Responsible Docent: Patrícia Nicolucci
7. Physics II for Teachers Degree - Responsible Docent: Patrícia Nicolucci
8. Exprimental Physics - Responsible Docent: Patrícia Nicolucci

5. Graduation Courses

1. Laboratory for Physics Applied to Radiotherapy - Responsible Docents: Alessandro Martins da Costa, Patrícia Nicolucci e Adelaide de Almeida
2. Laboratory for Physics Applied to Diagnostic Radiology - Responsible Docent: Alessandro Martins da Costa, Thomaz Ghilardi Netto e Martin Eduardo Poletti

INSTITUTO DE RADIOPROTEÇÃO E DOSIMETRIA - IRD/CNEN/RJ

1. Master Theses – Concluded in 2009

Advisor: Luiz Antonio Ribeiro da Rosa

1. Student: Artur Ferreira Menezes.
   Title: Usefulness of a therapeutic cobalt unity for stereotatic radiosurgery.
2. Student: Samuel Cesar Dantas.
   Title: Study about the Possibility of Use of a Co-60 Unit for IMRT.
3. Student: Valmiro Santos Almeida da Hora.
   Title: Development of a Independent System for Quality Assurance in Radiotherapy.

Advisor: Simone Kodlulovich Dias

1. Student: Fernando Mecca Augusto.
   Title: Study about image quality and dose index in computed tomography.

2. Scientific Initiation Programs – Concluded in 2009

Advisor: Luiz Antonio Ribeiro da Rosa

1. Student: Débora Montano Trombetta.
   Title: Study of the influence of metalic heterogeneities in mamo protheses in the radiotherapy treatments.
2. Student: Marco Antônio Costa Cardoso.
   Title: Study of low density heterogeneities in radiotherapy.

3. Academic Advisory – In Development

Advisor	Master Theses	Ph.D. Theses	Scientific Initiation	Other	Postdoctorate
Luís Antônio R. da Rosa	2	1	2	0	0
Simone Kodlulovich Dias	1	2	2	1	0
Lidia Vasconcellos de Sa	0	0	2	2	0
TOTAL	3	3	6	3	0

4. Undergraduation Courses

1. Physics in Radiotherapy (Universidade Federal do Rio de Janeiro) - Responsible Docent: Luiz Antonio Ribeiro da Rosa
2. Nuclear Medicine (Universidade Federal do Rio de Janeiro) - Responsible Docent: Lidia Vasconcellos de Sá
3. Diagnostic Radiology (Universidade Federal do Rio de Janeiro) - Responsible Docent: Simone Kodlulovich Dias

5. Graduation Courses

1. Physics in Radiotherapy - Responsible Docent: Luiz Antonio Ribeiro da Rosa
2. Radioprotection in Nuclear Medicine - Responsible Docent: Lidia Vasconcellos de Sá

CENTRO DE DESENVOLVIMENTO TECNOLÓGICO E NUCLEAR – CDTN/CNEN/MG

1. Master Theses – Concluded in 2009

Advisor: Teogenes Augusto da Silva

1. Student: Vania Lucia Soares de Oliveira.
   Title: Validation and application of computed methodology for dose measurements in patients in conventional x-ray medical examinations

Co-Advisor: Luiz Cláudio Meira Belo

1. Student: Elizabeth Juruminha Tavares Rodrigues
   Title: Methodology for dosimetric characterization and isodose curves of gamma emiters brachitherapy sources

2. Scientific Initiation Programs – Concluded in 2009

Advisor: Teogenes Augusto da Silva

1. Student: Natália Barbosa Gonzaga.
   Title: Validation and establishement of methodologies for dosimetry of patients during X-ray examinations

2. Student: Luciana de Jesus Souza.
   Title: Establishment of Reference X-Rays for Dosimetry in Diagnostic Radiology.

3. Other Academic Advisory Programs – Concluded in 2009

Advisor: Teogenes Augusto da Silva

1. Student: Marcos Eugênio Silva Abrantes.
   Title: Dosimetry of patients during X-rays examinations – Establishment of Metrology in Minas Gerais.
2. Student: Cassio Miri Oliveira.
   Title: Dosimetry of patients during X-rays examinations - Establishment of Capacity in Minas Gerais.
   Student: Sibele Reis Reynaldo.
   Title: Dosimetry of patients during X-rays examinations - Establishment of Capacity in Minas Gerais.
3. Student: Flávia Cristina Bastos Ferreira.
   Title: Application of the Metrological Capacity of CDTN.

4. Academic Advisory - In Development

Advisor	Master Theses	Ph.D. Theses	Scientific Initiation	Other	Postdoctorate
Teogenes A. da Silva	6	4	0	0	0
Maria do S. Nogueira	3	1	0	0	0
Luiz Cláudio Meira Belo	1	0	2	0	0
Thêssa Cristina Alonso	0	0	0	0	0
TOTAL	10	5	2	0	0

5. Graduation Courses

1. Radioprotection - Responsible Docent: Teógenes Augusto da Silva
2. Radiation Metrology - Responsible Docent: Teógenes Augusto da Silva
3. Nuclear Instrumentation and Radiation Detection - Responsible Docent: Maria do Socorro Nogueira

CENTRO REGIONAL DE CIÊNCIAS NUCLEARES DO NORDESTE - CRCN/CNEN/PE

1. Master Theses – Concluded in 2009

Co-Advisor: Fabiana Farias de Lima Guimarães

1. Student: José Odinilson de Caldas Brandão.
   Title: Biological Dosimetry of mixed neutron-gamma field by the conventional citogenic method: calibration curve.

1. Scientific Initiation Programs – Concluded in 2009

Advisor: Fabiana Farias de Lima Guimarães

1. Student: Priscilla Luna Góis de Souza.
   Title: Establishment of the cromossomic alteration rate in human blood irradiated in a mixed neutron-gamma field.

2. Other Academic Advisory Programs – Concluded in 2009

Advisor: Mércia Liane de Oliveira

1. Student: Maria da Conceição de Farias Fragoso.
   Title: Quality assurance in measurements of radiopharmaceuticals.
2. Student: Ricardo Braz Ferreira da Silva.
   Title: Effect of pre-irradiation thermal treatments on the TL reprodutibility of CaSO4: Dy pellets.

Advisor: Fabiana Farias de Lima Guimarães

1. Student: Wellington Gomes de Andrade.
   Title: Quality evaluation of eluation of MO-99/Tc-99m.

3. Academic Advisory - In Development

Advisor	Master Theses	Ph.D. Theses	Scientific Initiation	Other	Postdoctorate
Mércia Liane de Oliveira	1	0	4	1	0
Fabiana F. L. Guimarães	2	0	1	0	0
TOTAL	3	0	5	1	0

UNIVERSIDADE FEDERAL DE SERGIPE - UFS

1. Master Theses – Concluded in 2009

Advisor: Susana Oliveira de Souza

1. Student: Raquel Aline Pessoa Oliveira.
   Title: Study of the luminescence of spodemenium crystals
2. Student: Simara Santos Campos.
   Title: Study of the application of new materials in retrospective dosimetry

2. Scientific Initiation Programs - Concluded in 2009

Advisor: Ana Figueiredo Maia

1. Student: Raimundo Erivan Morais Ximenes Filho.
   Title: Performance study of a fluoroscopy equipment and evaluation of its use risk.
2. Student: Laila Galvão Almeida.
   Title: Utilization of an ionizing chamber of small volume for dosimetry in computed tomography.

3. Academic Advisory – In Development

Advisor	Master Theses	Ph.D. Theses	Scientific Initiation	Other	Postdoctorate
Ana Figueiredo Maia	5	5	0	0	0
Susana O. de Souza	2	6	3	0	0
TOTAL	7	11	3	0	0

4. Undergraduation Courses

1. Laboratory of Structure of Matter D - Responsible Docent: Ana Figueiredo Maia
2. Radiation Physics - Responsible Docent: Ana Figueiredo Maia
3. Radioprotection - Responsible Docent: Ana Figueiredo Maia
4. Curricular Stage - Supervision - Responsible Docent: Ana Figueiredo Maia
5. Laboratory of Physics A - Responsible Docent: Ana Figueiredo Maia
6. Radioprotection - Responsible Docent: Suzana Oliveira de Souza
7. Methods in Experimental Physics - Responsible Docent: Suzana Oliveira de Souza
8. Introduction to Physics - Responsible Docent: Suzana Oliveira de Souza
9. Introduction to Nuclear Physics and Elementary Particles - Responsible Docent: Suzana Oliveira de Souza

5. Graduation Courses

1. Topics of Radiprotection - Responsible Docent: Ana Figueiredo Maia
2. Topics of Ionizing Radiation Physics - Responsible Docent: Suzana Oliveira de Souza
3. Topics in Physics Research I, II, III e IV - Responsible Docent: Suzana Oliveira de Souza

7. Perspectives and future developments

Through the competent professionals and the divulgation of the developed research results, we hope to contribute for the improvement of the quality control procedures in radiotherapy, nuclear medicine and diagnostic radiology, and also for a higher radioprotection to the patients, professionals and public involved in medical practices that use ionizing radiations.

Next year (2010) we plan a great cooperation among the participant institutions. Several intercomparison programs will be necessary to demonstrate the conformity and the metrological coherence of the established methodologies in the different laboratories.

We await the conclusion of the importation procedures of the necessary equipment, essential for the continuity of the project activities.

8. Additional Information

A web site of the INCT project Radiation Metrology in Medicine was elaborated for the divulgation of this INCT: objectives, staff (researchers, collaborators, students), technical and scientific results, participation in national and international events and publications in periodicals.

The web site was elaborated by the students:

- Ana Paula Perini
- Lucio Pereira Neves
- Talita Sabino

The web site is: www.ipen.be/inct

An institutional e-mail was also created: inct.mrm@ipen.br

The e-mail and the web site will be administered by the students Ana Paula Perini and Lucio Pereira Neves, with the coordination of Linda V. E. Caldas.

Moreover, an institutional video about a theme linked to this INCT project was elaborated, called “Days of Fight”. The theme of this first video was about the importance of the mammographic examinations for cancer prevention and the role of the radiation metrology to assure the correct elaboration of the medical reports.