IAEA

# SSDL Newsletter

No. 60 June 2012

IAEA/WHO Network of Secondary Standards Dosimetry Laboratories

Prepared by the Joint IAEA/WHO Secretariat of the SSDL Network
http://www-naweb.iaea.org/nahu/dmrp/SSDL/


## Contents



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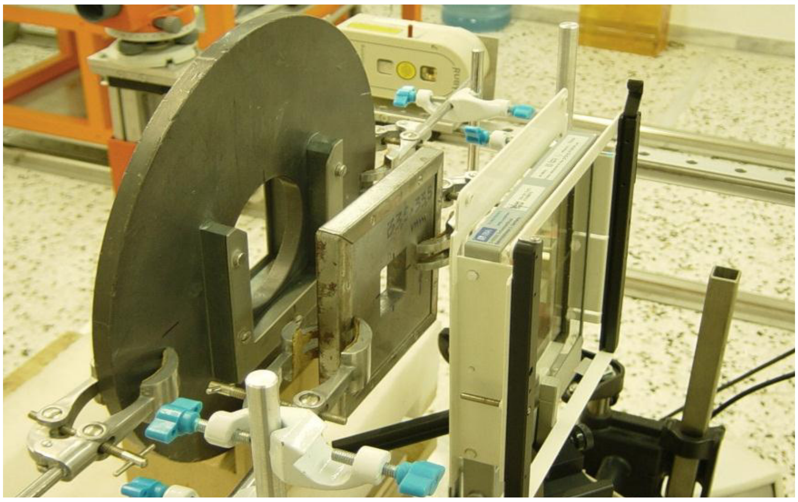

*Set-up for calibration of KAP meters in terms of air kerma area product. EURAMET project 1177 in diagnostic radiology (Courtesy of C. Hourdakis).*

## From the editor

This year, the IAEA will celebrate the 50th anniversary of its Dosimetry Laboratory, which activities are summarized in the first article. The second article is a report of the Regional training course on Uncertainty in Measurements Performed at SSDLs. The third article describes the first comparison programme for calibration of KAP meters used in diagnostic radiology. The fourth article describes steps for the improvements of the dosimetry accuracy in Chilean radiotherapy centres. The last article is a progress report on accuracy requirements and uncertainties in radiation therapy.

The editor would like to welcome a new SSDL that has recently joined our network: the Kenya Bureau of Standards.

The IAEA's Dosimetry and Medical Radiation Physics Section welcomes two new staff members: Mr Harry Delis from Greece, who is a clinical medical physicist in Diagnostic Radiology and Mr Istvan Csete from Hungary, appointed as Senior Laboratory Technician supporting calibration of standards for Member States.

After a short illness, Hans Svensson, a former Section Head of the Dosimetry Section at the IAEA, passed away on 6 December 2011. A tribute to him is given on page 4.

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# SERVICES PROVIDED BY THE IAEA IN DOSIMETRY AND MEDICAL RADIATION PHYSICS

The IAEA's Dosimetry and Medical Radiation Physics Section focuses on services provided to Member States through the IAEA/WHO SSDL Network and on a system of dose quality audits. The measurement standards of Member States are calibrated, free of charge, at the IAEA's Dosimetry Laboratory. The audits are performed through the IAEA/WHO TLD postal dose assurance service for SSDLs and radiotherapy centres.

The Dosimetry Laboratory's Quality Management System has been reviewed and accepted by the Joint Committee of the Regional Metrology Organizations and the BIPM (JCRB). The IAEA Calibration and Measurement Capabilities (CMCs) have been reviewed and published in Appendix C of Comité International des Poids et Mesures (CIPM), Mutual Recognition Arrangement (MRA).

The IAEA CMCs can be found at the following web site: http://kcdb.bipm.org/AppendixC/search.asp?met=RI

The range of services is listed below.

| *Services* | *Radiation quality* |
|---|---|
| Calibration of ionization chambers (radiotherapy, diagnostic radiology including mammography, and radiation protection including environmental dose level) | X rays (10–300kV) and gamma rays from $^{137}$Cs and $^{60}$Co |
| Calibration of well type ionization chambers for low dose rate (LDR) brachytherapy | $\gamma$ rays from $^{137}$Cs |
| Comparison of therapy level ionization chamber calibrations (for SSDLs) | $\gamma$ rays from $^{60}$Co |
| TLD dose quality audits for external radiotherapy beams for SSDLs and hospitals | $\gamma$ rays from $^{60}$Co and high energy X ray beams |
| TLD dose quality audits for radiation protection for SSDLs | $\gamma$ rays from $^{137}$Cs |
| Reference irradiations to dosimeters for radiation protection | X rays (40–300 kV) and $\gamma$ rays from $^{137}$Cs and $^{60}$Co beams |

Member States who are interested in these services should contact the IAEA/WHO SSDL Network Secretariat for further details, at the address provided below. Additional information is also available at the web site: *http://www-naweb.iaea.org/nahu/dmrp/SSDL/default.asp*

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**Note to SSDLs using IAEA calibration and audit services:**

1. To ensure continuous improvement in IAEA calibration and audit services, SSDLs are encouraged to submit suggestions for improvements to the Dosimetry Contact Point.
2. Complaints on IAEA services can be addressed to the Dosimetry Contact Point.

## A tribute to Hans Svensson

I was deeply saddened by the passing away of Hans Svensson. Hans had attended his last meeting at the IAEA in February 2009. Hans had, as usual, favourably responded to the IAEA invitation to attend a preparatory meeting for the International Symposium on Standards, Applications and Quality Assurance in Medical Radiation Dosimetry (IAEA, Vienna, 9 - 12 November 2010).

I first met Hans Svensson in October 1993. He was then the Section Head of the Dosimetry Section at the IAEA and a technical officer for a course on QA in radiotherapy which was organized in Algiers under a regional technical cooperation project. He had come to Algiers with his colleague and friend, Andree Dutreix. He had asked me to lecture at the course and got to know him personally.

Hans was appointed Section Head of the Dosimetry Section in November 1987, succeeding to Horst Eisenlohr. While working at the IAEA, he worked on the International Code of Practice TRS-277. He has also strengthened the IAEA dosimetry services (postal TLD audits and calibrations to Secondary Standards Dosimeter Laboratories- SSDLs). In addition, he has encouraged and supported education and training of medical physicists and SSDL staff through technical cooperation projects. Hans left the IAEA in August 1994 and returned to the University of Umea in Sweden. Hans will be remembered not only for his contribution to the development of dosimetry in radiotherapy, but also as a fervent supporter to education and training of physicists in low and middle income countries.

On behalf of my IAEA colleagues working in the Dosimetry and Medical Radiation Physics Section but also from those you strove to support in many countries, I would like to say thank you. You will be sorely missed.

Ahmed Meghzifene
Section Head
Dosimetry and Medical Radiation Physics

# IAEA Dosimetry Laboratory: half-decade of work in radiation dosimetry

Joanna Izewska, Ahmed Meghzifene
DMRP, IAEA

This year, the IAEA commemorates the 50th anniversary of its Dosimetry Laboratory in Seibersdorf near Vienna which has played an integral role in improving the consistency of dosimetry used in radiation medicine and other applications of ionizing radiation worldwide, in particular ensuring the cancer patients treated with radiation beams receive right doses.

Dosimetry Laboratory was set up in 1961 with the aim to design a calorimeter and prepare a dosimetry system suitable for postal dose comparisons for radiotherapy hospitals in order to check whether cancer patients were getting correct doses. At that time there were no dosimetry standards for the beam calibration in radiotherapy and it was a challenge for medical physicists working in hospitals to calibrate their radiotherapy beams. It is worth mentioning that the methodology for $Co^{60}$ and megavoltage beam dosimetry was under development in a few standards laboratories. Therefore the establishing postal dose inter-hospital comparison by the IAEA was a major step in ensuring accurate calibration of clinical radiation beams. First trial postal dose inter-hospital comparisons were conducted by the IAEA in 1965–1966 involving Fricke dosimeters and thermoluminescent dosimeters (TLDs). Eventually, the service was established based on TLDs and it has been operated this way until today. In 1969, the first TLD batch was sent to radiotherapy centres within the project entitled Joint IAEA/WHO Dose Inter-comparison Service for Radiotherapy.

In the next decade, efforts were made to establish national laboratories for dosimetry and standardization of radiation measurements in hospitals. These lead to the establishment of the IAEA/WHO Network of Secondary Standards Dosimetry Laboratories (SSDLs) in 1976 with the IAEA Dosimetry Laboratory acting as the Central Laboratory of the Network. The Network started with 9 laboratories and this number increased to over 30 almost immediately in the following year.

Today, 35 years after its inception, the IAEA/WHO SSDL Network consists of 85 laboratories in 67 countries. Over the years, the IAEA has provided technical support for the establishment of many SSDLs in low and middle income countries, including the supply of calibration equipment, staff training, expert advice on calibration activities and establishment of quality management systems. The IAEA Dosimetry Laboratory calibrates dosimeters for SSDLs; disseminating metrology standards for radiation measurements traceable to the International System of Units (SI) and transferring them to the national level. Currently, the scope of dosimetry calibration services includes external beam radiotherapy, Cs-137 low dose rate brachytherapy, radiation protection and recently developed X ray diagnostic radiology calibrations with a broad range of beam qualities relevant to general radiography, fluoroscopy and dental applications, CT and mammography applications. The Dosimetry Lab organizes inter-laboratory comparisons to verify the quality of dosimetry calibrations of SSDLs. Further, it operates dosimetry audit services for SSDLs in the areas of radiotherapy and radiation protection to ensure that the dose measurements by SSDLs are kept within internationally accepted levels.

By 2011, the IAEA/WHO TLD audit service for radiotherapy hospitals had verified the calibration of more than 8800 radiation beams in about 1800 hospitals in 124 countries. In the early years, the TLD service recorded approximately 50% audited beams having adequate calibration. This percentage of acceptable results has now increased to approximately 95%. This means, of approximately 500 hospital beams Dosimetry Laboratory checks a year, typically about 25 beams are discovered having problems and without an independent audit these problems may have remained undiscovered and patients may have been treated incorrectly.

Subsequent to the IAEA signing the Mutual Recognition Arrangement (MRA), under the auspices of the Comité international des poids et measures (CIPM) in 1999, all IAEA Dosimetry Laboratory services provided to its Member States have been supported by a Quality Management System (QMS). A set of the laboratory calibration and measurement capabilities (CMCs) were prepared by the IAEA and reviewed by Regional Metrology Organizations (RMOs). Further, the QMS of the Dosimetry Laboratory was reviewed and accepted by the Joint Committee of the RMOs and the BIPM (JCRB) in 2006. As the result of these reviews, the IAEA lists its dosimetry calibration services among the first CMCs registered in Appendix C of the BIPM key comparison data base. The formal recognition of the QMS of the IAEA Dosimetry Laboratory by the JCRB resulted in the increased confidence in the quality of IAEA dosimetry calibration and auditing services.

The major role of the IAEA, over the half-decade of the operation of its Dosimetry Laboratory, has been in achieving the worldwide coherence in radiation dosimetry for medical applications traceable to SI. The IAEA/WHO SSDL Network activities have consolidated the international community involved in radiation metrology, assisted individual SSDLs in carrying their functions in radiation measurements, and contributed to the increase of overall expertise in dosimetry worldwide. The IAEA/WHO TLD audits for radiotherapy have brought improvements in dosimetry practices in many hospitals across the globe.

While the IAEA commemorates the Dosimetry Laboratory for its progress, accomplishments and on-going work, it is understood that the laboratory work in the area of dosimetry for radiation medicine is far from over. In particular, the medical physics community is facing new challenges with the calibration of small radiation fields used for novel radiotherapy techniques. The IAEA is addressing this challenge, together with professional societies, and is planning to publish a guidance document on this topic.

International Atomic Energy Agency

Atoms for peace

# 50th Anniversary of the Agency's Nuclear Sciences and Applications Laboratories in Seibersdorf

Believe it or not: the Agency's Nuclear Sciences and Applications (NA) Laboratories in Seibersdorf have just completed half a century of dedicated support to Member States in their efforts to optimally exploit 'atoms for peace'. It seems to be an appropriate time to celebrate the completion of these five decades in a fitting manner.

Throughout these many years, the activities of the NA Laboratories in Seibersdorf have continuously evolved, also through their partnership with FAO, in response to the ever changing landscape of nuclear technologies and applications, and to the multitude of expectations of national and international organizations for cooperation in nuclear research and technology transfer. In this process, the Laboratories have consistently remained at the forefront of assisting Member States in fostering the use of nuclear science and technology wherever these offer unique opportunities or provide added value.

The Laboratories have indeed come a long way. Starting with a mere 1736 $m^2$ of combined laboratory, office and corridor space in 1962, the original U-shaped building housed 14 professional and 24 general service staff. Today, it covers an area of more than 13 000 $m^2$ and is a dynamic hub for nearly one hundred scientists, technicians, fellows, visitors, interns and students from all over the world that are engaged in a wide range of activities dedicated to supporting global development and cooperation. These dedicated and concerted efforts have led to a myriad of success stories in the many areas of work in the Laboratories, which is both satisfying and enthusing.

Many of you have, at some stage in your career, interacted with the NA Laboratories in Seibersdorf and contributed to these successful projects and programmes, which are glowing examples of success stories that fully justify the mandate of these Laboratories. We are very grateful to all of you for seamlessly working with us, as we realize that it is only through the dedication, the enthusiasm and the numerous ideas of our many internal and external stakeholders, that it has been possible for the Laboratories to consistently remain at the forefront in our numerous and very diverse endeavours.

Nonetheless, this is not the time to lay back in satisfaction but a time to look forward to further enhance the performance of the Laboratories and to improve our outreach. While the NA Laboratories in Seibersdorf have served the Member States well over the last half century, they need to be modernized and upgraded to cater to growing demands and to keep pace with increasingly rapid technological developments. The planned 50 year anniversary celebration of the Laboratories is an apt time to look back and feel proud of the numerous achievements, as well as to plan the future road map that will enable the Laboratories to retain the high level and quality of service that Member States have come to expect.

So, when we celebrate the 50th anniversary of the NA Laboratories in Seibersdorf, it is really you we are celebrating. We sincerely hope to see as many of you as possible during this year of celebration or maybe even at the actual event in late November 2012 at the Laboratories.

Daud Mohamad

Deputy Director General
Department of Nuclear Sciences and Applications

# Regional training course on uncertainty in measurements performed at SSDLs and dosimetry service laboratories

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*SSDL, NRC, Algiers, ** MKEH, PSDL Hungary, *** VSL, PSDL , The Netherlands
8 – 12 May 2011

## INTRODUCTION

The need for international traceability for radiation dose measurements has been understood since the early 1960s. The benefits of high dosimetric accuracy were recognized particularly in radiotherapy, where the higher the accuracy on the dose delivered to the tumour, the better the outcome of treatment. In radiation protection, the uncertainty in dosimetric measurements may be greater than for radiation therapy, but proper traceability of measurements is no less important.

In 1976, the IAEA and the WHO created a Network of Secondary Standards Dosimetry Laboratories (SSDLs). At present, it includes 80 laboratories and six (6) SSDL national organizations in 67 Member States, of which over half are developing countries. The SSDLs have a crucial role of providing the necessary link in the traceability chain of radiation dosimetry to the International Measurement System through calibration of end user's radiation measuring instruments.

In the field of radiation protection, among the services provided by the SSDLs, reference irradiations for Dosimetry Service Laboratories (DSLs) constitute an important task. The main task of these services is to assess the occupational exposure due to external radiation sources. In general, measurement techniques are available for whole body and extremity monitoring and a large range of radiation fields encountered in research facilities, medical and industrial applications as well as in emergency situations are covered. Dependent on the country, thousands of dosimeters are evaluated per year by DSLs, and most of these services are based on a Thermoluminescence Dosimetry System even if Film Dosimetry is still used in African countries.

The requirements for traceable and reliable calibrations are becoming more important nowadays where the calibration and testing laboratories should demonstrate their competence through comparisons and the establishment of a quality system complying with the ISO/IEC standard 17025. One of the essential requirements of the quality system of a calibration or testing laboratory is the assessment of the measurement uncertainty.

## PURPOSE OF THE COURSE

The decision to organize a training course on the evaluation of uncertainties at SSDLs reflects - the need of countries having an SSDL or PDSL to train their personnel on the assessment of measurement uncertainty. As an AFRA Regional Designated Centre, the Algerian SSDL was selected to host the training course.

It was organized in the framework of the IAEA Technical Cooperation Regional Project RAF0027 entitled *Consumer Safety And Trade Development Through Competent Nuclear Testing And Metrology Laboratories.*

The course provided delegates with an understanding of the methods used for the assessment of the various uncertainty components and provided guidance on how to report measurement uncertainty related to their calibration services in a way that is consistent with the GUM. The candidates learned, using tutorials adapted to practical examples, how to prepare the uncertainty budget.

In addition to five local participants, 22 participants from Congo, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Morocco, Niger, Nigeria, South Africa, Sudan, United Republic of Tanzania and Zimbabwe attended the course. Furthermore, upon their request, seven medical physics master students were allowed to participate in this course.

## COURSE PROGRAMME

The training course comprised two days of lectures followed by two days practical sessions. The last day was dedicated to the evaluation of the results obtained by the different groups for the practical sessions and to the evaluation of the course. Four local lecturers and two international experts were involved.

The 10 lectures covered the main aspects of radiation dosimetry: from the realization and dissemination of standards at PSDLs and SSDLs to the calibration procedures of DSLs of the different type of dosemeters. These latter procedures included their technical requirements based on the relevant IEC standards, and the corresponding quality assurance programmes and measurement uncertainty calculation as well.

High importance was given to practical aspects; indeed, six practical sessions were organized in four irradiation bunkers, a TLD laboratory and a computer room, on the basis of a rotating cycle. These sessions covered the following topics concerning the evaluation of uncertainty components in:

P1. Therapy level calibrations ($^{60}$Co);
P2. Protection level calibrations ($^{137}$Cs);
P3. X ray calibrations (ISO 4037 narrow spectrum);
P4. External dosimetry laboratory (TLD);
P5. Brachytherapy calibrations ($^{137}$Cs source);
P6. Uncertainty budget calculations using excel worksheet - Case study.

Using detailed guidelines, having been available to all the participants, each group, in number of five, was requested to determine the output of the irradiation units in terms of absorbed dose to water rate for P1 and air kerma rate for P2, P3 and P5. For P3, prior to this, determination of the half value layer of five ISO narrow spectrum series X ray beam qualities, were required.

Using the reference outputs, the participants calibrated a therapy ionization chamber in terms of $N_{D,w}$ in P1, a survey-meter in terms of ambient dose equivalent $H^*$ in P2 and a well type ionization chamber in terms of air kerma in P5. Furthermore, the participants were requested to irradiate batches of TLD dosimeters in terms of $H_p(10)$ in $^{137}$Cs at different doses (for calibration purpose) and in X ray beams at a given dose of 50 mSv for energy dependence determination, using an ISO water phantom. Each group was assigned a batch of dosimeters which was evaluated by them using the Harshaw 6600 TLD reader in P4. Each member of the group was requested to evaluate at least one dosimeter using the guidelines.

For each practical session, the participants were requested to evaluate the uncertainty components using the results of their measurements.

The last practical session, held in a computer room, was dealing with the detailed calculation of ambient dose equivalent rate from a measurement of air kerma rate including the estimation of an uncertainty budget. Each participant was assigned a computer and was requested to perform the calculation using a template prepared by the experts.

The first regional training course on uncertainty in measurements performed at SSDLs and DSLs was successful. The course was a unique opportunity for the participants to get an overview of the calibration facilities and to perform calibration measurements and reference irradiations, to evaluate dosimeters using modern TLD reader and to calculate the associated uncertainties. The participants were provided by a CD including the training materials and further documents related to the calibration and quality assurance procedures performed at SSDLs.

SSDLs from member states can request a copy of this CD from the course director (mehenna.arib@yahoo.fr).

*X-ray calibration* *Opening ceremony* *Theoretical lectures* *Brachytherapy*

*Therapy level calibration* *TLD Laboratory* *Protection Level calibration* *Computer room*

*Participants to the Regional Training Course on Uncertainty in measurements performed at SSDLs and dosimetry service laboratories – Algiers 8 8 - 12 May 2011*

# EURAMET 1177 project in diagnostic radiology: Comparison of calibration of KAP meters in terms of air kerma area product, $P_{KA}$

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## 1. Introduction

Air kerma area product (KAP) meters are usually used for patient dosimetry in interventional radiology, fluoroscopy, general radiography and increasingly in pantomographic dental radiography. This is reflected in the use of KAP meters for the determination of the diagnostic reference levels (DRL) for conventional X ray examinations, as well as for indicating that the patient skin dose thresholds for deterministic effects (trigger levels) are not exceeded in interventional X ray procedures.

KAP meters measure the air kerma area product, $P_{KA}$, which is defined as the integral of the air kerma over the area of the X ray beam in a plane perpendicular to the beam axis, thus

$$P_{KA} = \int K(x,y)dxdy$$

The recommended unit is Gy·cm$^2$ [1], although some other units are often used (Gy mm$^2$ or μGy m$^2$) in practice.

KAP meters are usually mounted on the tube housing after the beam collimation and encompass the entire radiation field. Theoretically, ignoring the scattered and extra focal radiation, $P_{KA}$, is the same along the central X ray beam. Consequently, the $P_{KA}$ measured by the KAP meter on X ray tube exit equals to that pertained on the patient skin. This fact makes the use of KAP meters advantageous for patient dosimetry, since the KAP meter reading measurement can be correlated to the energy imparted to patient, ε, irrespective of the radiation area, the focal spot to skin distance (FSD), the X ray beam direction etc. From ε, the organ doses or effective dose can be deduced [2, 3].

The KAP meter's chambers have a large surface area and are usually transparent to both X ray and light. The requirement for the electrodes of the chamber to be transparent to light results in the use of materials that have a significant energy dependence of response over the diagnostic energy range corresponding to from 50 kV to 120 kV [4, 5, 6, 7]; the difference of the response of a typical KAP meter model at this energy range may be as high as 20% or even more. Since KAP meters measure the integral of the air kerma over the sensitive area of the chamber, they should have a uniform response throughout their entire area [7]. Furthermore, a recent study showed that air humidity affects the KAP meter performance; 14% change in KAP response was detected in the range from 20%RH to 80%RH [8]. In contrast to all other types of ionization chambers, where the influence of the humidity is negligible, humidity should be considered in measurements with KAP chambers. All these indicate that proper calibration is essential to achieve appropriate measurement accuracy and comparable results.

Depending on their use and calibration, the KAP meters measure the incident radiation, i.e. the radiation that falls on the chamber, or the transmitted radiation, i.e. the radiation that emerges from the chamber. The latter includes the attenuation of the radiation by the KAP chamber. The KAP meters installed on the tube housing measure the transmitted radiation, whereas KAP meters used for the X ray beams dosimetry (e.g. pantomographic dental radiography), measure the incident radiation.

KAP meters can be calibrated in calibration laboratories or in situ. The latter is strongly recommended for the KAP meters installed on the tube housing, since the scatter radiation, extra focal radiation and other factors affect the measurements.

Special procedures and radiation qualities are applied for the calibration of KAP meters [3, 4, 9-12]. Two methods are commonly applied.

a. The air kerma area product method, in which the air kerma, K, and the X ray beam cross section area, A, at the same plane of measurement are measured independently and their product refers to the reference $P_{KA}$ value. This method is usually applied in the calibration laboratories.

b. The TANDEM method, in which the reference $P_{KA}$ value is deduced by a properly calibrated reference KAP meter [10]. The reference KAP meter and the field KAP meter being calibrated are placed simultaneously in the X ray beam, being appropriately separated. This method is preferable for in situ calibrations, since extra focal and scattered radiation is taken into account, although the air kerma area product method can be also applied.

As mentioned previously, the response of a typical KAP meter depends significantly on the spectra of the X ray beam. Typical clinically used X ray beam qualities incorporate aluminium (Al) filters 1.5 mm – 4.5 mm thick together with copper (Cu) filters 0.1 mm – 0.9 mm thick at tube voltages from 50 kV to 150 kV. This is addressed in figure 1, which presents the results from a survey on the X ray beam qualities available at interventional and diagnostic radiology departments of several hospitals worldwide. The survey was conducted under an activity of the IAEA CRP E210008 project.

The RQR standard radiation qualities [13], which incorporate Al filters only, are generally used for calibration of diagnostic meters and the proper calibration coefficients are selected based on the HVL, making interpolation, often. For the KAP meters, this approach is not reliable, since the clinical HVL values are extended beyond those of the RQR, and the clinical X ray beams incorporate Al and Cu filters where the beam specifier based only on the HVL is not appropriate [4].

The calibration capabilities should be extended to new radiation qualities based on Al and Cu filter combinations, which will simulate the clinical X ray beams more closely. This could be achieved by using aluminum filtrations 1.5 mm - 4 mm together with copper filtration 0.1 mm - 0.9 mm at tube voltages from 50 kV to 120 kV [4]. Figure 1 presents the results of a preliminary survey conducted under an IAEA CRP, on the availability and use of X ray beams at hospitals worldwide.

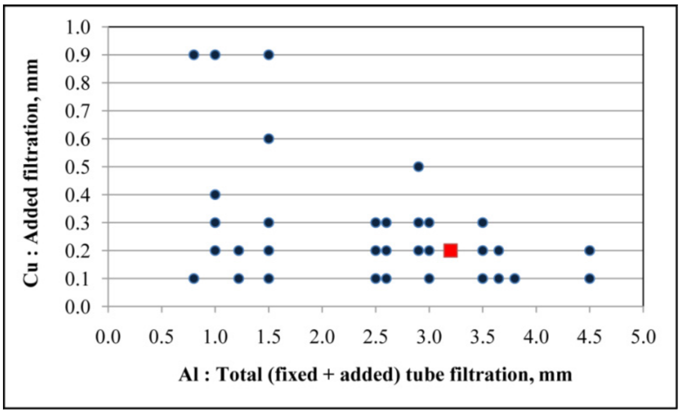


*FIG 1 : Results from a IAEA CRP survey: Al and Cu filter combinations used in hospitals. The RQT8 quality (3.2 mm Al + 0.2 mm Cu) is marked in red square.*

Figure 2 presents typical half-value-layer (HVL) values versus the tube voltage for the three filter combinations (3 mm Al + 0.1 mm Cu, 4 mm Al + 0.2 mm Cu and 1.5 mm Al + 0.9 mm Cu), as well as for the standard RQR (3, 6, 8 and 9) and RQT (8 and 9) beam qualities. It is clearly shown that the RQR and RQT standard beam qualities differ, in terms of HVL, from the clinical ones.

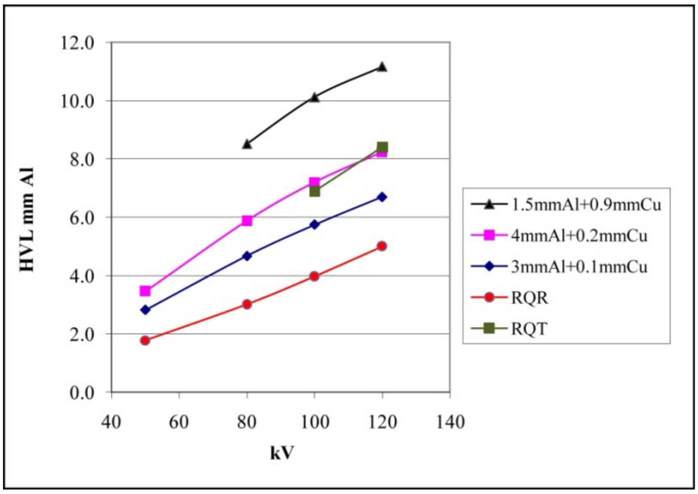


*FIG 2 : The HVL of the three Al and Cu filter combinations versus the tube voltage. Data for the RQR3, 5, 8 and 9 and RQT 8 and 9 are also presented.*

## 2. Comparison studies in diagnostic radiology

Comparisons of calibrations and dosimetry standards in diagnostic radiology at European and international level are rare.

A comprehensive comparison of diagnostic radiology dosemeters including mammography was conducted in 1990. This exercise was performed in 162 participants (most of them users in hospitals/clinics) from 19 European countries. One reference dosemeter for conventional radiology and one for mammography were calibrated by the participants and the calibration coefficients were compared to that deduced by the Physikalisch-Technische Bundesanstalt (PTB) PSDL. [14-16]. The results indicated that about one-third of all cases, the calibration coefficients obtained by the users deviated from the reference value (PTB value) by more than 10%.

In the EUROMET project #364, a number of European standard laboratories have compared their national air kerma standards for a selected set of 17 X ray qualities used for calibration in the field of diagnostic radiology, including mammography. The results indicated reasonable agreement in the calibration coefficients for the two transfer ionization chambers used in this project [17].

During 2001-2003, the EURAMET project #526 was conducted, where two ionization chambers (IC) and two semiconductor detectors were calibrated by 13 dosimetry calibration laboratories for radiation qualities used in mammography. It was concluded that dosimeters with IC designed for mammography measurements have a flat energy response in a broad energy range so that, any radiation quality with an HVL in the mammographic range can be used for calibration. However, dosimeters with marked energy dependence, like ST, have to be calibrated in radiation quality with a spectrum as close as possible to the clinical beam [18].

Few international projects regarding the KAP meters calibration have been conducted in clinical environment, where KAP meters fitted to clinical X ray tubes were calibrated in situ [19, 20].

Under the European SANTINEL project, twelve countries participated and 25 KAP meters fitted to undercouch clinical X ray tubes were calibrated using simplified air kerma area calibration methods [20]. The obtained values of calibration factors range from 0.4 to 0.9.

Few other studies concerning the calibration of different types/models of KAP meters in calibration laboratories have been reported [5, 9].

Recently, the IAEA coordinated research programme (CRP E2.10.08), Activity 3, focuses on the KAP meter calibration comparison which will be carried out by the participating calibration laboratories in four countries (CZ, FI, GR, RS).

Simultaneously, a similar comparison will be performed between the partner laboratories of EURADOS WG 12, SG 3: Technical aspects on DAP calibration and CT calibration to include three other countries (ES, IT, FI, GR, PL).

Finally, during the annual EURAMET IR-CP meeting in Bratislava, 2010 some secondary standard dosimetry laboratories (SSDL) expressed their interest to participate in such a comparison in at least five other countries.

All above suggest that there is a clear need for a broad scale comparison study between metrology laboratories at an European level in the field of diagnostic radiology and especially for the calibration of KAP meters. Therefore, the EURAMET 1177 project has been proposed and is being conducted.

The project enables participating calibration laboratories to test and verify their calibration methods and capabilities and to support the relevant calibration and measurement capabilities (CMCs).

## 3. The EURAMET 1177 project

Two KAP meters are circulated between participating laboratories and the calibration coefficients in terms of PKA and the associate uncertainties will be compared.

Since the KAP meter calibration depends on the air kerma (rate) and the area of the radiation field, diagnostic radiology chambers suitable to measure the air kerma (rate) will be circulated as well and they should be calibrated in terms of air kerma. Thus, the differences in the air kerma calibration coefficients and those of the air kerma area product can be compared separately.

The two KAP meters, (a) IBA KermaX-plus DDP TinO, Model 120-205, with KAP Ionization chamber IBA Model 120-131 TinO, and (b) Radcal Patient Dose Calibrator PDC, Radcal Corp, will be calibrated in terms of KAP (in Gy cm$^2$ / digit) for incident and/or transmitted radiation as indicated below, so the $N_{KAP,inc}$ and/or $N_{KAP,trans}$ can be deduced for each X ray beam quality.

The diagnostic radiology chambers (a) Ionization chamber EXRADIN - Standard Imaging MAGNA A650, and (b) Radcal Patient Dose Calibrator PDC, Radcal Corp, are calibrated in terms of air kerma, K (in mGy / nC for the MAGNA A650 and in mGy / digit for the PDC), so the $N_K$ values can be deduced for each X ray beam quality.

The project started on 28 of March 2011 and will last for about one and half years.

### 3.1 Participants and pilot laboratory

Several PSDL, SSDL and other calibration laboratories, being or not being EURAMET members, have been assigned to participate.

EURAMET members are: CMI (CZ), PTB (DE), SIS (DK), STUK (FI), LNE-LNHB (FR), IRCL/GAEC-EIM (GR), MKEH (HU), IAEA, GR (IS), VSL (NL), NRPA (NO), ITN (PT), IFIN-HH (RO), SSM (SE)[1].

Not EURAMET members are: SCK-CEN Belgian Nuclear Research Centre (BE), SURO National Radiation Protection Institute (CZ), UPC Universitat Politècnica de Catalunya (ES), IRP-DOS Istituto di Radioprotezione (IT), NIOM Nofer Institute of Occupational Medicine (PL), VINCA Institute of Nuclear Science, Radiation and Environmental Protection Laboratory (RS).

The ICRL/GAEC-EIM, Greece is the pilot laboratory, being responsible for the overall coordination of the comparison. It follows the rules of the CIPM MRA in establishing the reference values, compiling and analyzing the results of the calibrations including their uncertainty budgets. The Draft A report will include the degrees of equivalence of participants. The pilot laboratory will publish the final report in the Techn. Suppl. of Metrologia.

### 3.2 Comparison procedure

The first calibration was carried out by the pilot laboratory (GAEC), including constancy checks of the KAP meters and the DR chambers, before mailing to the second laboratory in accordance with the agreed order and time schedule. After the calibration at the second laboratory, the instruments are shipped to the third laboratory. After every three laboratories, the instruments will be returned to the pilot laboratory for an interim re-calibration, hereafter the circulation is continued to the remaining labora-

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tories. Each laboratory will send to the pilot laboratory: the calibration report with the calibration coefficients and the associate uncertainties as well as a short description of the calibration procedure; the pilot laboratory having first submitted its own first set of results to the CCRI Executive Secretary. The calibration coefficients and the associated uncertainties will be strictly confidential during the comparison process.

### 3.3 Radiation qualities for KAP meters and DR chambers calibration

The KAP meters and the DR chambers should be calibrated at the following radiation qualities:

- Reference beam qualities according to IEC 61267 [2] RQR 3 (50 kV) - RQR 5 (70 kV) - RQR 6 (80 kV) - RQR 8 (100 kV) - RQR 9 (120 kV)

For transmitted radiation measurements, the KAP meter contributes to the beam quality, so the above reference radiation qualities are altered. The laboratory should use the above mentioned reference beam qualities for the X ray system emerging radiation beams that are incident on the KAP meter. The use of appropriate corrections, the traceability of measurement and the additional contribution to the uncertainties for the transmitted radiation cases should be provided by the participating laboratory.

- Non-reference beam qualities :
  Non-reference beam qualities are selected to simulate the clinical X ray beams that are often applied in practice. On a voluntary basis the laboratories may perform the KAP meter and DR chamber calibrations at the non-reference beam qualities presented in Table 1. At such copper filtrations, the thickness of aluminum filtration is not so important. So, the laboratories may use aluminum thickness close to the values (Table 1) - the Cu thickness should be precise.

*Table 1 : Non standard radiation qualities*

| # series | Tube voltage | Total tube filtration |
|---|---|---|
| A | 50, 80, 100, 120 | 3.0 mm Al + 0.1 mm Cu |
| B | 50, 80, 100, 120 | 4.0 mm Al + 0.2 mm Cu |
| C | 80, 100, 120 | 1.5 mm Al + 0.9 mm Cu |

Details on the traceability of the standards, measurements and calibration results at these qualities including the detailed uncertainty budget should be provided by the participating laboratory.

## References


[1] INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Patient dosimetry for x-rays used in medical imaging, ICRU Report 74 J. ICRU **5(2)** (2005) 1–113.

[2] CARLSSON, C.A., ALM CARLSSON, G., “Dosimetry in diagnostic radiology and computerised tomography”, The Dosimetry of Ionizing Radiation (KASE, K.R., BJÄRNGARD, B.E., ATTIX, F.H., Eds), Academic Press, Orlando (1990) 163–257.

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Dosimetry in Diagnostic Radiology: An International Code of Practice, Technical Reports Series No. 457, IAEA, Vienna (2007).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Implementation of the International Code of Practice on Dosimetry in Diagnostic Radiology (TRS 457): Review of Test Results, IAEA Human Health Report No. 4, IAEA, Vienna (2011).

[5] TOROI, P., KOSUNEN, A., The energy dependence of the response of a patient dose calibrator, Phys. Med. Biol. 54 (2009) N151-N156.

[6] TOROI, P., KOMPPA, T., KOSUNEN, A., TAPIOVAARA, M., Effects of radiation quality on the calibration of kerma-area product meters in X ray beams, Phys. Med. Biol. 53 (2008) 5207–5221.

[7] LARSSON J.P., PERSLIDEN J, SANDBORG M. and CARLSSON G.A., Transmission ionization chambers for measurements of air collision kerma integrated over beam area. Factors limiting the accuracy of calibration, Phys. Med. Biol. 41 (1996): 2381–2398.

[8] HETLAND P.O., Humidity dependence in Kerma Area Product meter used in diagnostic x-ray examination, Poster presentation, International Symposium on Standards, Applications and Quality Assurance on Medical Radiation Dosimetry, IDOS, IAEA, Vienna, 8-12 Nov 2010.

[9] HETLAND PO, FRIBERG EG, OVREBØ KM, BJERKE HH., Calibration of reference KAP-meters at SSDL and cross calibration of clinical KAP-meters., Acta Oncol. 2009;48(2):289-94.

[10] TOROI P., KOMPPA T. AND KOSUNEN A., A tandem calibration method for kerma–area product meters, Phys. Med. Biol. 53 (2008): 4941–4958

[11] LARSSON JP, PERSLIDEN J, CARLSSON GA., Ionization chambers for measuring air kerma integrated over beam area. Deviations in calibration values using simplified calibration methods, Phys Med Biol. 1998 Mar;43(3):599-607.

[12] LARSSON J. P., PERSLIDEN J. AND CARLSSON G. A., Ionization chambers for measuring air kerma integrated over beam area. Deviations in calibration values using simplified calibration methods, Phys. Med. Biol. 43 (1998) 599–607.

[13] INTERNATIONAL ELECTROTECHNICAL COMMISSION, Medical diagnostic X-ray equipment - Radiation Conditions for use in the determination of characteristics, IEC 61267, IEC, Geneva (2005).

[14] KRAMER H.M., European Intercomparison of Diagnostic Dosemeters: Calibration of the Reference Dosemeters, Radiat Prot Dosimetry (1992) 43(1-4): 75-79

[15] JURAN R., NOEL A., AND OLERUD H.M., European Intercomparison of Diagnostic Dosemeters: Performance of the Programme, Radiat Prot Dosimetry (1992) 43(1-4): 81-86

[16] CLARK M.J., DELGADO A ., HJARDEMAAL O., KRAMER H.M., AND ZOETELIEF J. European Intercomparison of Diagnostic Dosemeters: Results, Radiat Prot Dosimetry (1992) 43(1-4): 87-91

[17] VAN DIJK, E. AND DE VRIES, W. Results of the comparison of primary air kerma standards for x-ray qualities used in diagnostic radiology. (NMi Van Swinden Laboratorium) EUROMET 364. Report nr. S-TS-2000-10.

[18] WITZANI J, BJERKE H, BOCHUD F, CSETE I, DENOZIERE M, DEVRIES W, ENNOW K, GRINBORG J E, HOURDAKIS C J, KOSUNEN A, KRAMMER H M, PERNICK F AND SANDER T., Calibration of dosemeters used in mammography with different X ray qualities: EUROMET project no. 526, Radiat. Prot. Dosimetry, (2004) 108(1), 33-45

[19] FAULKNER K., BUSCH H.P.,. COONEY P, MALONE J.F, MARSHALL N.W., AND RAWLINGS D.J., An International Intercomparison of Dose-Area Product Meters, Radiat Prot Dosimetry (1992) 43(1-4): 131-134.

[20] JANKOWSKI J., DOMIENIK J., PAPIERZ S.,. PADOVANI R, VANO E.AND FAULKNER K., An international calibration of kerma–area product meters for patient dose optimisation study, Radiat. Prot. Dosimetry (2008): 1–5.

[21] International Organization for Standardization (ISO). Guide to the Expression of Uncertainty of Measurement. ISO, Geneva; 1995.

# Improving dosimetry in Chilean radiotherapy services

Rodolfo Alfonso, consultant, DMRP, IAEA

Chile has a population of 17 million inhabitants, 40.3% concentrated in the capital, Santiago, and its surroundings. The estimated annual incidence of cancer is 40 000, so there are approximately 20 000 new patients that would require radiotherapy every year.

As of 2005, the Chilean Ministry of Health (MINSAL), in conjunction with the Institute for Public Health (ISP) reorganized the national programme for upgrading and expanding the radiotherapy services in the public sector. This programme included the acquisition of new radiotherapy machines, including imaging and dosimetry equipment. In only 5 years, from 2006 to 2010, the number of teletherapy units increased 67%. Currently, there are 21 radiotherapy services in Chile, 6 public and 15 in the private sector, with a total of 46 teletherapy units, 15 public and 35 private. The number of medical physicists working in radiotherapy services has also increased significantly.

This expansion in the public sector meant a challenge to the National Program for Quality Assurance in Radiotherapy, sponsored by the ISP, with support of the IAEA and the Ionizing Radiation Metrology Lab of the Chilean Nuclear Energy Commission, as this programme had implemented a system of external quality audit visits, which performs an annual review of the most relevant medical physics aspects at the visited institution.

The ISP has also promoted the recognition of the medical physics profession in the institutions with radiotherapy facilities. This is reflected in the fact that currently, all public radiotherapy departments have contracted at least one medical physicist.

Last September, the ISP organized a National Dosimetry Workshop, addressed to medical physicists and technologists in charge of the dosimetry and quality assurance of their radiotherapy equipment. Representatives from all public and 7 private radiotherapy services attended the workshop. During the workshop, practical sessions were implemented at the Radiotherapy facilities of the National Cancer Institute (INC), where the participants, supported by an IAEA expert, exchanged experiences on dosimetry procedures for the calibration of megavoltage photon beam, and the irradiation of TLD capsules used in the IAEA's dosimetry audits.

As a collateral result of the workshop, an exercise for inter-comparison of ionization chambers exercise was sponsored by ISP, and most of the participants in the meeting subscribed to take part in it.

This kind of activities is expected to be very useful for the improvement of the dosimetry accuracy in Radiotherapy, since they can function as a continuous education tool for medical physicists and technologist, promoting cooperation among staff with different level of training, exchange of experiences, with potential impact in the overall quality and safety of the radiotherapy treatments.

Acknowledgments: To Ms. Niurka Pérez, Head, National Program for Quality Assurance in Radiotherapy, ISP, for the organization of the workshop and the provision of information and data on equipment and staffing; to INC for offering their facilities for the practical sessions.

*Participants in the National Dosimetry Workshop, ISP/INC, Santiago de Chile, Chile, September 28th – October 2nd, 2011*

# Update on activities related to consultants' report on *Accuracy Requirements and Uncertainties in Radiation Therapy*

Jacob Van Dyk, consultant, DMRP, IAEA

There have been major advances in radiation oncology-related technologies in recent years. These technological developments have allowed for a transition from conventional 2-D radiation therapy to the implementation of 3-D conformal radiation therapy (CRT), intensity- modulated radiation therapy (IMRT), image-guided radiation therapy (IGRT), adaptive radiation therapy (ART), and 4-D imaging and patient motion management in radiation therapy. Brachytherapy procedures have also evolved both for high dose rate (HDR) techniques as well as permanent implants, especially for prostate cancer treatments. Multiple imaging modalities are now available for target volume and normal tissue delineation for radiation treatment planning both for external beam radiation therapy and brachytherapy. These new technologies are often combined with an integrated computerized radiation information system allowing cancer centres to evolve into a fully networked, paperless and filmless environment. The principal goal of these multiple advancements is to achieve improved tumour control while maintaining normal tissue complications at acceptable levels for patients undergoing treatments with curative intent, or to improve the quality of life for those patients being treated for palliation. With these new advanced technologies and improved outcome considerations for both external beam and brachytherapy, there is also a recognized need for greater accuracy in the radiation treatment process.

The degree of application of the various technologies within the radiation therapy community varies dramatically worldwide. These variations not only occur from one nation to another, but there are also very large variations within individual nations. Independent of the level of technological sophistication, accuracy in radiation therapy and the means by which it is achieved and maintained remain central to the process. In order to attain the required accuracy in dose delivery, all steps of the radiation therapy process should be covered by comprehensive quality assurance (QA) programmes. It is well recognized that there is a need to evaluate the influence of different factors affecting the accuracy of radiation dose delivery and to define the actions necessary to maintain treatment uncertainties at acceptable levels.

While a number of reports and publications have defined accuracy needs in radiation oncology, most of these reports were developed in an era with different radiation technologies. In the meantime, there have also been improvements in dosimetry standards. Furthermore, the published accuracy requirements were partially based on clinical information and clinical procedures available at that time, prior to the days of image-based 3-D CRT or IMRT. In addition to technological changes and advances in dosimetry, significant data have been published on clinical studies using these new technologies. In view of the new technologies and techniques, improvements in dosimetry methodologies and new clinical dose-volume data, a consultant group of experts met in December 2008 and recommended that the IAEA should develop international guidelines on accuracy requirements and uncertainties in radiation therapy in order to reduce these uncertainties to provide safer and more effective patient treatments. As a follow-up to this, consultants meetings were held in July 2009 and 2010. At the present time, a comprehensive report is in draft form (~270 pages of text, in addition to ~650 references). The document reviews the steps in the entire radiation therapy process, looks at accuracy considerations from radiobiological and clinic perspectives, and then reviews each step in the process to see what levels of accuracy are actually achievable. This is followed by a discussion on managing uncertainties in radiation therapy and then suggests a number of specific recommendations.

The first recommendation makes it clear that a single number accuracy requirement in radiation therapy would be an oversimplification for the many technological circumstances and the many different types of patients that are treated. Indeed, it is suggested that all forms of radiation therapy should be applied as accurately as reasonable achievable, technological and biological factors being taken into account. Another recommendation summarizes the data presented earlier in the report to provide a guide for estimating levels of accuracy that are practically achievable.

After further review by the consultants, the report will be submitted to various professional organizations for their comments and endorsements. The goal is to have the final report published by the end of 2012.

In association with the contents of this report, a regional training course was held in February 2012 in Rabat, Morocco to address the topic of accuracy requirements and uncertainties in radiation therapy.

The ultimate goal is that this report, along with training courses and other educational venues, will help to provide more effective radiation treatments for cancer patients throughout the world.

# Courses, Meetings and Consultancies in 2012

## Courses and workshops

RAS6031/6044: Regional Training Course on Accuracy requirements and uncertainty in radiation therapy, Rabat, Morocco, 6 - 10 February 2012

ESTRO/IAEA Training Course on Modern Brachytherapy Techniques (under RER/6/023), London, United Kingdom, 1 - 4 April 2012

RAS6031/6044: Regional Training Course on Frontline Servicing of an Equinox cobalt teletherapy unit, Tunis, Tunisia, 19 - 23 April 2012

RAF6031/6044: Task Force Meeting on Medical Physics Education and Training, Vienna, Austria, 21 - 25 May 2012

National Workshop on Radiotherapy and Nuclear Medicine, Kuala Lumpur, Malaysia, 20 - 22 June 2012

ESTRO/IAEA Training Course on Advanced Treatment Planning (under RER/6/023), Prague, Czech Republic, 24 - 28 June 2012

RAS6038/012: IAEA/RCA Regional Training Course on Radiotherapy Techniques with Emphasis on Imaging and Treatment Planning, Beijing, China, 3 - 7 September 2012

RER/6/023: Regional Training Course on TPS Commissioning and Quality Assurance, Novi Sad, Serbia, 14 - 18 November 2012

RAS6031/6044: Regional Training course on Accidents and Audits in Radiotherapy Medical Physics, Argonne, United States of America, 26 - 30 November 2012

Joint ICTP-IAEA School on Transitioning from 2D to 3D Conformal Radiotherapy and Intensity Modulated Radiation Therapy (SMR-2378), Trieste, Italy, 10 - 14 December 2012

## Meetings and consultancies

15th Meeting of the SSDL Scientific Committee (SSC-15), IAEA HQ, Vienna, Austria, 12 - 16 March 2012

Consultants Meeting on the Development of an International Database on Activities of National Dosimetry Audit Networks for Radiotherapy, IAEA HQ, Vienna, Austria, 23 - 27 April 2012

Consultants Meeting on Quantitation and Evaluation of Treatment-related Uncertainties in Image-based Radiotherapy, IAEA HQ, Vienna, Austria, 14 - 16 May 2012

Consultants Meeting on the Worldwide radiotherapy infrastructure data analysis and further development of the DIRAC Database (jointly with ARBR Section), IAEA HQ, Vienna, Austria, 16 - 18 July 2012

Consultants meeting on Academic Syllabus on Medical Physics, IAEA, Vienna, Austria, 22 - 24 August 2012

Consultants Meeting on the Development of Quality Audits for Advanced Technology in Radiotherapy Dose Delivery, IAEA HQ, Vienna, Austria, 10 - 14 September 2012

2nd RCM on the Development of Advanced Dosimetry Techniques for Diagnostic and Interventional Radiology, IAEA HQ, Vienna, Austria, 9 - 12 October 2012

3rd RCM on Doctoral CRP on Quality Assurance of the Physical Aspects of Advanced Technology in Radiotherapy, IAEA HQ, Vienna, Austria, 12 - 16 November 2012

Technical Meeting on Dosimetry and Comparisons in Diagnostic Radiology at the SSDL level, IAEA Seibersdorf, 5 - 9 November 2012

3rd RCM on Development of Quantitative Nuclear Medicine Imaging for Patient Specific Dosimetry, IAEA HQ, Vienna, Austria, 3 - 7 December 2012

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# Impressum

**SSDL Newsletter No. 60, June 2012**

The SSDL Newsletter is prepared by the Dosimetry and Medical Radiation Physics Section,
Division of Human Health, Department of Nuclear Sciences and Applications.

International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Printed by the IAEA in Austria, June 2012.

12-20371