Director's Report on the Activity and Management of the International Bureau of Weights and Measures

Supplement: Ionizing Radiation Department

(1 January 2015 – 31 December 2015)

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Bureau International des Poids et Mesures

BIPM Ionizing Radiation Department

Director: J.M. Los Arcos

(1 January 2015 to 31 December 2015)

1. X- and γ-rays (D.T. Burns, C. Kessler, S. Picard and P. Roger)

1.1 Dosimetry standards and equipment

The project to develop an absorbed-dose standard for medium-energy x-rays is nearing completion. Modifications were made to the water phantom positioning mechanism to allow more accurate depth positioning, a critical parameter in this domain. The chamber depth can now be set to better than 0.02 mm. Repeat measurements were made of the transfer chamber responses in air and water; some observed instabilities remain under investigation and a fourth transfer chamber is currently being characterized. A pilot comparison with the PTB, Germany, was conducted in November 2015. The results were satisfactory, but indicated that more work was necessary on photon attenuation coefficients. This additional work is in progress. A first full comparison is anticipated mid-2016, giving rise to a new series of comparisons and calibrations in this domain.

The Department coordinated the ninth comparison in the series BIPM.RI(I)-K6 for absorbed dose to water in high-energy photon beams, with the NMIJ/AIST, Japan. The measurements were made in the 6 MV, 10 MV and 15 MV beams of the NMIJ/AIST Elekta accelerator from 9 to 23 April 2015 and the corresponding Monte Carlo calculations (for a depth of 10 g cm^{-2}) were made at the BIPM using photon spectra supplied by the NMIJ/AIST. The BIPM equipment was shipped to the NMIJ/AIST in advance, with the exception of the calorimeter core and ionization chambers which were carried by hand. This comparison enabled the NMIJ/AIST to verify robustly the present Japanese primary standard to realize absorbed dose to water in accelerator beams. This comparison presented no particular problems and the draft B report is in progress.

The reports of the previous comparisons with the NPL, UK, were published, and the report of the previous comparison with the VSL, the Netherlands, is currently being reviewed by the CCRI.

The design study to establish a new laboratory for the reference air kerma rate facility for HDR ^{192}Ir brachytherapy sources is complete and is being implemented to allow the continuity of the comparison series BIPM.RI(I)-K8 carried out at the NMIs. This laboratory will also house the x-ray radiograph equipment. The support mechanism for the source transfer and for the radiographic unit has been constructed and the robotic arm installed. A further comparison in the series was carried out with the NMIJ in April 2015. The results and reports of two previous comparisons were published.

Primary measurements and reference chamber calibrations have continued in all of the reference x- and γ-ray beams. Comparisons and calibrations are underpinned by a significant effort in equipment calibration and maintenance, as required by the BIPM Quality System. This system was successfully subject to a peer review external audit in December 2015.

1.2 Dosimetry comparisons

In summary, eight comparisons were carried out in terms of air kerma or absorbed dose to water using the BIPM x- and gamma-radiation beams with the CMI (2), ENEA, ININ, ITN, NIM, NMIJ and the PTB. In addition, one high-energy absorbed-dose-to-water comparison BIPM.RI(I)-K6 was carried out with the NMIJ using their own accelerator facility and another on-site comparison for the reference air kerma rate for HDR ^{192}Ir brachytherapy sources BIPM.RI(I)-K8 was also carried out with the NMIJ using the Japan Radioisotopes Association (JRIA) facility.

Thirteen comparison reports were approved and published in the *Metrologia Technical Supplement* for the BEV (3), ENEA (2), ININ, METAS, NIM, NMIJ, NPL (2), NRC and the PTB, plus one comparison with the LNHB published as a BIPM report (see publication list below).

1.3 Characterization of national standards for dosimetry

Eighteen characterizations of national secondary standards were carried out for the CIEMAT (four in the ^{60}Co radiotherapy beam), CRRD (four in the radioprotection beams), HIRCL (two in the ^{60}Co radiotherapy beam and two in x-rays), IAEA (four in the mammography beams) and the ININ (two in the ^{60}Co radiotherapy beam).

In addition, the IAEA/WHO dosimetry assurance programme continues to be supported by reference irradiations, which involved only one series of irradiations in 2015 for the radiotherapy level in the ^{60}Co beam.

2. Radionuclides (J.M. Los Arcos, S. Courte, C. Michotte, M. Nonis and G. Ratel)

In parallel to the scientific activities, the department undertook a considerable amount of work with the ampoules containing radioactive solutions received over the last 35 years from radionuclide metrology laboratories around the world and stored in an obsolete facility. All the ampoules were checked before being transferred to a new room that has been specially designed for the storage of radioactive substances. They have been rearranged using a more rigorous and systematic scheme.

2.1 International Reference System (SIR) for γ-ray emitting radionuclides

2.1.1 SIR submissions in 2015

Within the radionuclide measurements programme, the Système International de Référence (SIR) received during 2015 ten ampoules of six different radionuclides from eight NMIs − ^{57}Co (BEV and NMISA), ^{68}Ge (IRA-METAS, LNE-LNHB and NIM), ^{65}Zn (IRD-LNMRI), ^{110m}Ag (PTB), ^{131}I (BEV and POLATOM-RC) and ^{134}Cs (IRD-LNMRI), all oriented to generate equivalence values in the ongoing BIPM.RI(II)-K1 comparison. The three ampoules of ^{68}Ge received from three laboratories will serve to evaluate the key comparison reference value (KCRV) for this radionuclide and to provide a link for the CCRI key comparison CCRI(II)-K2.Ge-68. ^{223}Ra ($T_{1/2}$ = 11.43 d, u = 0.03 d) is a promising radionuclide for the therapy of some cancers, for which two ampoules from two laboratories have been evaluated in 2015, constituting a new SIR entry. An earlier submission of ^{111}Ag has been evaluated and the draft A report issued following receipt of the corresponding reporting form. An ampoule of ^{57}Co arrived at the BIPM slightly deteriorated. The solution will be reconditioned in an undamaged ampoule to allow measurement in the SIR chambers and it will be sent back to the producing laboratory for checking.

2.1.2 SIR reports

Updated final reports of four BIPM.RI(II)-K1 comparisons were published in the *Metrologia Technical Supplement* covering ^{65}Zn, ^{85}Sr, ^{207}Bi and ^{166m}Ho, including linked results from the CCRI(II)-K2.Zn-65 comparison. In addition, a final report for ^{56}Mn was published with the first KCRV for this nuclide. There are 42 SIR results awaiting publication in the KCDB (five in the draft A stage and 37 in the draft B stage) and every effort will be made to ensure that reports are published as quickly as possible, particularly when NMIs make submissions that are to replace outdated results that have already been removed from the KCDB. Finally, reporting forms for ten measurements are still with the NMIs concerned.

Four SIR results for ^{241}Am are pending publication and its KCRV update was proposed and discussed at the KCWG(II) meeting in November 2015. Some potential outliers were identified where the activity in the ampoule

was not sufficiently high in view of the background current of the SIR. However, it was decided that further measurements would be carried out at the BIPM and at the LNE-LNHB in order to confirm whether or not there is a bias.

2.2 Gamma spectrometry

Measurements of potential impurities in SIR ampoules have been suspended since the failure of the Ge(Li) spectrometer in July 2013. Following the contribution of Dr Antohe, who had been on secondment from IFIN-HH, Romania, in 2014, the efficiency curves of the replacement HPGe spectrometer and the uncertainty budget need to be finalized. New procedures will be drafted and the entire process validated before re-offering the gamma-ray spectrometry service to the SIR participants.

2.3 Extension of the SIR to short-lived radionuclides

Monte Carlo simulations of the SIR Transfer Instrument (SIRTI) response for ^{18}F as a function of the ampoule shape and filling height were finalized for the evaluation of the corresponding uncertainty components of the SIRTI measurements. The first three results in the BIPM.RI(II)-K4.F-18 ($T_{1/2}$ = 1.8 h) key comparison (VNIIM, NPL and ENEA-INMRI in 2014) were presented at the ICRM-2015 conference in Vienna, Austria, on 8-11 June 2015 and accepted for publication in *Applied Radiation and Isotopes.* The uncertainty of the SIRTI measurements at the NPL is mainly due to the potential bias related to the presence of a large drop in the ampoule neck. This is evaluated by Monte-Carlo simulation but significant uncertainty arises because the volume of the drop is difficult to estimate. Consequently, it was decided that for future SIRTI comparisons a centrifuge would be sent to the NMI for the comparison, if not already available on-site.

The BIPM.RI(II)-K4.Tc-99m ($T_{1/2}$ = 6.0 h) key comparisons using the SIRTI at VNIIM and ENEA-INMRI in 2014 are in the draft A stage. The ^{99m}Tc and ^{18}F SIRTI comparisons took place at the NMISA, South Africa, in November 2015 and the results are pending.

The first calibration measurements of the SIRTI against the SIR for ^{64}Cu ($T_{1/2}$ = 13 h) were carried out by measuring a solution from the CNRS-Orléans, France, in both systems. A second series of ^{64}Cu calibration measurements will take place in early 2016 prior to the first SIRTI comparison of ^{64}Cu at NIST. As ^{64}Cu is mainly a β^+ emitter like ^{18}F, the uncertainty budget for SIRTI measurements of ^{64}Cu is taken to be identical to that of ^{18}F.

2.4 Extension of the SIR to pure beta emitters

Due to a failure of the micro balance used by the radioactivity group, the pilot study for the extension of the SIR to beta emitters had to be postponed. A new balance has been purchased and installed in a dedicated room that has been refurbished specifically for the purpose. The balance is undergoing tests before it can be used intensively for preparing suitable liquid-scintillation samples to resume the exercise in the second half of 2016.

2.5 Radionuclide comparisons, reports and quality assurance.

In summary, twelve radionuclide activity comparisons were undertaken, ten BIPM.RI(II)-K1 ongoing comparisons for several radionuclides and NMIs (see 2.1) and two BIPM.RI(II)-K4 comparisons for ^{99m}Tc and ^{18}F carried out on-site at the NMISA.

Five updated reports of BIPM.RI(II)-K1 comparisons were published in the *Metrologia Technical Supplement* covering ^{56}Mn, ^{65}Zn, ^{85}Sr, ^{207}Bi and ^{166m}Ho, and the first three results in the BIPM.RI(II)-K4.F-18 comparison were submitted for publication in *Applied Radiation and Isotopes*. In addition, the radioactivity group

contributed to three chapters in the *Metrologia* special issue on 'Uncertainties in Radionuclide Metrology' as well as to the guest editors' team (see references 1, 5, 15 and 24).

Finally, a new simplified scheme for radionuclide K2-comparison reports was proposed and accepted at the meetings of the Key Comparisons Working Group (KCWG(II)) and CCRI(II) in March 2015. Consequently, reports for CCRI.RI(II)-K2.H-3 and CCRI.RI(II)-K2.Sr-89 were circulated through the CCRI(II) for comments. The KCWG(II) finally approved the new scheme in November 2015 and this will be implemented to expedite the delayed reports as well as future reports.

All SIR measurements, including the extension to short-lived radionuclides, are covered by the BIPM Quality Management System which was successfully subjected to a peer review external audit in December 2015.

3. Thermometry (S. Picard, M. Nonis)

From 2010 until 2014 the Ionizing Radiation Department provided internal calibration services for thermometry at the BIPM under the terms of the BIPM Quality Management System. The BIPM high-precision resistance bridge failed during 2014 and needed to be replaced. For economic reasons, it was decided to stop this activity in 2015 and the calibration of SPRTs and work thermometers has been out-sourced.

4. Publications

1. Amiot M.N., Chisté V., Fitzgerald R., Juget F., Michotte C., Pearce A., Ratel G., Zimmerman B.E., Uncertainty evaluation in activity measurements using ionization chambers, *Metrologia*, 2015, **52**(3), S108-S122.
2. Burns D.T., Kessler C., Steurer A., Tiefenboeck W., Bauer M., Key comparison BIPM.RI(I)-K2 of the air-kerma standards of the BEV, Austria and the BIPM in low-energy x-rays, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06001.
3. Burns D.T., Kessler C., Steurer A., Tiefenboeck W., Bauer M., Key comparison BIPM.RI(I)-K3 of the air-kerma standards of the BEV, Austria and the BIPM in medium-energy x-rays, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06004.
4. Burns D.T., Kessler C., Tanaka T., Kurosawa T., Saito N., Key comparison BIPM.RI(I)-K2 of the air-kerma standards of the NMIJ, Japan and the BIPM in low-energy x-rays, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06008.
5. Karam L., Keightley J., Los Arcos J.M., Practical implementation of uncertainty analysis in radionuclide metrology, *Metrologia*, 2015, **52**(3), S1-S2.
6. Karam L. and Ratel G., Consultative committee on ionizing radiation: Impact on radionuclide metrology, *Appl. Radiat. Isotopes* (2015), http://dx.doi.org/10.1016/j.apradiso.2015.11.085 (in press).
7. Kessler C., Allisy-Roberts P.J., Selbach H.J., Comparison BIPM.RI(I)-K8 of high dose-rate Ir-192 brachytherapy standards for reference air kerma rate of the PTB and the BIPM, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06005.
8. Kessler C., Burns D., Roger P., Toni M.P., Pinto M., Bovi M., Cappadozzi G., Silvestri S., Key comparison BIPM.RI(I)-K7 of the air-kerma standards of the ENEA-INMRI, Italy and the BIPM in mammography x-rays, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06025.

9. Kessler C., Burns D.T., Alvarez Romero J.T., De la Cruz Hernández D., Cabrera Vertti M.R., Tovar-Muñoz V.M., Key comparison BIPM.RI(I)-K5 of the air kerma standards of the ININ, Mexico and the BIPM in ^{137}Cs gamma radiation, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06020.

10. Kessler C., Burns D.T., Li D., Wang P., Key comparison BIPM.RI(I)-K5 of the air kerma standards of the NIM, China, and the BIPM in ^{137}Cs gamma radiation, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06009.

11. Kessler C., Burns D.T., Steurer A., Tiefenboeck W., Bauer M., Key comparison BIPM.RI(I)-K7 of the air-kerma standards of the BEV, Austria and the BIPM in mammography x-rays, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06003.

12. Kessler C., Burns D.T., Vörös S., Hofstetter-Boillat B., Key comparison BIPM.RI(I)-K4 of the absorbed dose to water standards of the METAS, Switzerland and the BIPM in ^{60}Co gamma radiation, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06002.

13. Kessler C., Downton B., Mainegra-Hing E., Comparison BIPM.RI(I)-K8 of high dose-rate Ir-192 brachytherapy standards for reference air kerma rate of the NRC and the BIPM, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06013.

14. Kessler C., Pinto M., Cappadozzi G., Silvestri C., Bovi M., Toni M.P., Key comparison BIPM.RI(I)-K1 of the air-kerma standards of the ENEA-INMRI, Italy and the BIPM in ^{60}Co gamma, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06023.

15. Kossert K., Broda R., Cassette P., Ratel G. and Zimmerman B., Uncertainty determination for activity measurements by means of the TDCR method and the CIEMAT/NIST efficiency tracing technique, *Metrologia*, 2015, **52**(3), S172-S190.

16. Los Arcos J.M., Stock M., Wielgosz R., Arias F. and Milton M., News from the BIPM laboratories: 2014, *Metrologia*, 2015, **52**(1), 155-162.

17. Michotte C., Ratel G., Courte S., Bobin C., Moune M., Update of the BIPM comparison BIPM.RI(II)-K1.Bi-207 of activity measurements of the radionuclide ^{207}Bi to include the 2010 result of the LNE-LNHB (France), *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06012.

18. Michotte C., Ratel G., Courte S., Dziel T., Listkowska A., Update of the BIPM comparison BIPM.RI(II)-K1.Sr-85 of activity measurements of the radionuclide ^{85}Sr to include the 2009 result of the POLATOM (Poland), *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06022.

19. Michotte C., Ratel G., Courte S., Joseph L., BIPM comparison BIPM.RI(II)-K1.Zn-65 of activity measurements of the radionuclide ^{65}Zn for the BARC (India) with linked results for the CCRI(II)-K2.Zn-65 comparison, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06007.

20. Michotte C., Ratel G., Courte S., Keightley J., Participation of the NPL in 2008 in the BIPM.RI(II)-K1.Mn-56 comparison of activity measurements of the radionuclide ^{56}Mn, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06018.

21. Picard S., Burns D.T., Roger P., Duane S., Bass G.A., Manning J.W. Shipley D.R., Key comparison BIPM.RI(I)-K6 of the standards for absorbed dose to water at 5 g cm^{-2} and 7 g cm^{-2} of the NPL, United Kingdom, and the BIPM in accelerator photon beams, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06010.

22. Picard S., Burns D.T., Roger P., Duane S., Bass G.A., Manning J.W. Shipley D.R., Key comparison BIPM.RI(I)-K6 of the standards for absorbed dose to water at 10 g cm^{-2} of the NPL, United Kingdom, and the BIPM in accelerator photon beams, *Metrologia*, 2015, **52**, *Tech. Suppl.*, 06021.

23. Picard S., Burns D.T., C. Kessler, Roger P., Delaunay F., Daures J., Donois, M., Ostrowsky A., Report of a Comparison between the LNE-LNHB and the BIPM of Absorbed Dose to Graphite in a Co-60 Reference beam, *BIPM Report*-15/03.

24. Ratel G., Michotte C., Bochud F.O., Uncertainty of combined activity estimations, *Metrologia,* 2015, **52**(3), S30-S41.

25. Ratel G., Michotte C., Courte S., Kossert K., Update of the BIPM comparison BIPM.RI(II)-K1.Ho-166m activity measurements of the radionuclide ^{166m}Ho for the PTB (Germany), with linked results for the EURAMET.RI(II)-K2.Ho-166m comparison, *Metrologia,* 2015, **52**, *Tech. Suppl.,* 06006.

5. Activities related to the work of Consultative Committees and RMOs.

J.M. Los Arcos is the Executive Secretary of the CCRI, an *ex-officio* member of all CCRI working groups, Coordinator of the CCRI(II) Working Group on the Extension of the SIR to beta-emitters (ESWG(II)) and Rapporteur of the CCRI RMO Working Group (RMOWG). During 2015, a complete series of meetings of the CCRI(I), CCRI(II), CCRI(III), CCRI and CCRI RMOWG was held in March and the Key Comparisons Working Group (KCWG(II)) met in March and November.

D.T. Burns is a member of the CCRI(I) Key Comparisons Working Group (KCWG(I)) and the Brachytherapy Standards Working Group (BSWG(I)). He is also a member of an *ad hoc* group evaluating the effect of excess charge on the value for W_{air} (work that will be reported this year in the ICRU Report on Key Data). Since 2009 he has been *rapporteur* at annual meetings of the CCRI.

C. Kessler is the Coordinator of the CCRI(I) Brachytherapy Standards Working Group (BSWG(I)).

C. Michotte is a member of the Key Comparisons Working Group (KCWG(II)) which met in March and November 2015.

S. Picard is the Executive Secretary of the Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV) which held its 10th meeting on 25-27 November 2015. She is the Executive Secretary of the Consultative Committee for Thermometry (CCT). Susanne Picard became KCDB Coordinator on 1 July 2015. She was invited to participate in the APMP-TC-AUV, APMP-TC-T, and APMP-TC-IR meetings in November.

G. Ratel is a member of the CCRI(II) Working Group on the Extension of the SIR to beta-emitters using liquid scintillation (ESWG(II)) and of the KCWG(II), the latter of which met in March and November 2015.

For ionizing radiations, seven comparison reports from the CCRI(III), APMP.RI(II), EURAMET.RI(I) (2), EURAMET.RI(II) (2) and SIM.RI(I) were reviewed technically and editorially prior to its circulation through the respective CCRI section for approval and were eventually published in the *Metrologia Tech. Suppl*. In the CCAUV area, two comparison reports from CCOMET.AUV.W and EURAMET.AUV.V and a pilot study report from APMP.AUV.V were processed for approval and published in the *Metrologia Tech. Suppl.* In the CCT field, eight comparison reports from the CCT (2), COOMET.T (2) and SIM.T (4) were processed for approval and published in the *Metrologia Tech. Suppl.*

6. Activities related to external organizations

J.M. Los Arcos had been proposed and was elected in June 2015 as an Associate Member of the International Committee for Radionuclide Metrology (ICRM). He also evaluates scientific projects for the Spanish National Evaluation and Foresight Agency (ANEP) and is a technical auditor for the Spanish accreditation body.

D.T. Burns is a Fellow of the Institute of Physics (FInstP) in the UK, an elected Commissioner of the ICRU and Chairman of the ICRU Committee on Fundamental Quantities and Units. He is a member of the ICRU Report Committee on Key Data for Dosimetry and is Commission Sponsor for three ICRU reports (Key Data for Dosimetry, Operational Quantities for Radiation Protection, and Small and Non-Standard Fields). He is a

member of the Scientific Committee of the IAEA/WHO Network of Secondary Standards Dosimetry Laboratories.

C. Michotte is the Scientific Secretary and *rapporteur* for the JCGM-WG1 meetings, which were held in June and October 2015. She was the Scientific Secretary of the Organizing Committee for the BIPM Workshop on Measurement Uncertainty which took place the 15-16 June 2015 and was attended by over 100 scientists from more than 40 countries. In addition a number of other registered participants were able to see and hear the presentations live over the internet as part of the first ever webcast transmitted by the BIPM. She also gave an invited talk at the workshop, entitled "Feedback from NMIs and JCGM MOs to the circulated JCGM 100 and 110 Committee Drafts".

G. Ratel is the BIPM representative at the ICRM and is the President of the ICRM Nominating Committee. He is a member of the Scientific Committee for the 20th International Conference on Radionuclide Metrology and its Applications (ICRM 2015), held in Vienna (Austria) on 8-11 June 2015.

7. Travel in 2015 (conferences, lectures and presentations, visits)

D.T. Burns to:

- Tsukuba (Japan), 16-24 April, to participate in the BIPM.RI(I)-K6 comparison of absorbed dose to water in accelerator beams of the NMIJ/AIST.

C. Kessler to:

- Tsukuba (Japan), 15-22 April, to participate in the BIPM.RI(I)-K6 comparison of absorbed dose to water in accelerator beams of the NMIJ/AIST.

C. Kessler and P. Roger to:

- Lyon (France), 3 July, to visit the Inno-Robot exhibition on developments in robotics, for a demonstration of the robotic arm necessary for the new brachytherapy installation.

S. Picard to:

- Lisbon (Portugal), 26 February, to participate at the EURAMET TC-T meeting and to present recent news from the BIPM and the CCT.
- Tsukuba (Japan), 7-17 April, to carry out the BIPM.RI(I)-K6 comparison of absorbed dose to water in accelerator beams with the NMIJ/AIST at their medical accelerator facility.
- Toronto (Canada), 7-12 June, to participate at the World Congress on Medical Physics and Biomedical Engineering, where she gave a presentation entitled "Results from the on-going key comparison BIPM.RI(I)-K6 : What have we learned ?" (co-author D. T. Burns, BIPM).
- Beijing (China), invited by the NIM (China), 1-6 November, to visit the NIM and participate at the APMP-TC meeting in Acoustics, Ultrasound and Vibration where she gave a presentation "The BIPM and recent activities of the CCAUV", the APMP-TC meeting in Thermometry where she gave a presentation "The BIPM and recent activities of the CCT", and the APMP-TC meeting in Ionizing Radiation where she gave the presentation "The BIPM and recent activities of the Ionizing Radiation Department". She also gave a presentation at the NIM entitled "BIPM KCDB: today and tomorrow".

C. Michotte to:

- Vienna (Austria), 8-11 June, to attend the 20th ICRM conference and make a presentation entitled "Comparison of ^{18}F activity measurements at the VNIIM, NPL and ENEA-INMRI using the SIRTI of the BIPM".

C. Michotte and M. Nonis to:

- Cape Town (South Africa), 16-28 November, to carry out activity comparisons of ^{99m}Tc (BIPM.RI(II)-K4.Tc-99m) and ^{18}F (BIPM.RI(II)-K4.F-18) at the NMISA using the SIR Transfer Instrument.

G. Ratel to:

- Vienna (Austria), 8-12 June, to attend the 20th ICRM conference, chair two sessions of the ICRM conference and to attend the ICRM General Meeting.

P. Roger to:

- Tsukuba (Japan), 7-24 April, to participate in the BIPM.RI(I)-K6 comparison of absorbed dose to water in accelerator beams with the NMIJ/AIST.
- Paris, 23 September, to visit the Enova exhibition for new developments in metrology and electronics.

8. Visitors in 2015

A number of delegations from different countries or organizations visited the Ionizing Radiation Department in 2015:

- Mr F. Ferrer, Director and Dr J.A. Robles, Director of the Scientific and International Relations Division, Centro Español de Metrología (CEM), Spain, 23 April.
- Dr P. Oropesa, Head, Radionuclide Metrology Department, Centro de Isótopos (CENTIS), Cuba, 18 June.
- Dr U.W. Lee, President, Dr Y.K. Park, Dean of Academic Affairs, Mr K.T. Park (Academic Affairs) and J.I. Park (Global Cooperation), Korean University of Science and Technology, Republic of Korea, 17 July.
- Dr K. Madanipour, President, Dr A.M. Livari, Deputy and Dr O. Masoudi, President's Advisor, National Metrology Center of Iran (NMCI) , Iran, 23 October.
- Dr T. Yamada, Planning Section Manager, Japan Radioisotope Association (JRIA), Japan, 9 December.

9. Guest workers in 2015

- Dr L. Rodríguez (ex-CIEMAT, Spain), 1 January to 7 March.
- Dr J.T. Alvarez (ININ, Mexico), 27 February to 5 March.
- Dr M. Pinto (ENEA-INMRI, Italy), 22-26 June.
- Dr T. Tanaka (NMIJ/AIST, Japan), 7-11 September.
- Dr P. Avilés and C. García (CIEMAT, Spain), 14-18 September.
- Dr V. Sochor (CMI, Czech Republic) 1-3 December.
- Dr J. Cardoso (ITN, Portugal), 14-17 December.