Bureau International des Poids et Mesures

Consultative Committee for Ionizing Radiation (CCRI)

Report of the 22nd meeting
(24 June 2011)
to the International Committee for Weights and Measures

Comité international des poids et mesures

Note:

Following a decision of the International Committee for Weights and Measures at its 92nd meeting (October 2003), reports of meetings of the Consultative Committees are now published only on the BIPM website and in the form presented here.

Full bilingual versions in French and English are no longer published.

M. Kühne
Director BIPM

LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR IONIZING RADIATION

as of 24 June 2011

President

K. Carneiro, member of the International Committee for Weights and Measures.

Executive Secretary

P.J. Allisy-Roberts, International Bureau of Weights and Measures [BIPM], Sèvres.

Members

The Chairman of Section I.

The Chairman of Section II.

The Chairman of Section III.

The Director of the International Bureau of Weights and Measures [BIPM], Sèvres.

Section I: x- and γ-rays, charged particles

Chairman

P. Sharpe, National Physical Laboratory, Teddington.

Members

Australian Radiation Protection and Nuclear Safety Agency [ARPANSA], Yallambie.

Bundesamt für Eich- und Vermessungswesen [BEV], Vienna.

Central Office of Measures/Glówny Urzad Miar [GUM], Warsaw.

Commissariat à l'Énergie Atomique/Laboratoire National Henri Becquerel [LNE-LNHB], Gif-sur-Yvette.

D.I. Mendeleyev Institute for Metrology, Rostekhregulirovaniye of Russia [VNIIM], St Petersburg.

Ente per le Nuove Technologie, l'Energia e l'Ambiente, Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti [ENEA-INMRI], Rome.

Federal Office of Metrology/Office Fédéral de Métrologie [METAS], Bern-Wabern.

Hungarian Trade Licensing Office [MKEH], Budapest.

International Commission on Radiation Units and Measurements [ICRU].

Korea Research Institute of Standards and Science [KRISS], Daejeon.

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg.

National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology [NMIJ/AIST], Tsukuba.

National Physical Laboratory [NPL], Teddington.

National Research Council of Canada - Institute for National Measurement Standards [NRC-INMS], Ottawa, Ontario.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

VSL [VSL], Delft

The Director of the International Bureau of Weights and Measures [BIPM], Sèvres.

Observers

Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas [CIEMAT], Madrid.

Comisión Nacional de Energía Atómica [CNEA], Buenos Aires.

Czech Metrology Institute/Český Metrologický Institut [CMI], Brno.

Instituto Tecnológico e Nuclear [ITN], Sacavém.

International Atomic Energy Agency [IAEA], Vienna.

International Organization for Medical Physics [IOMP].

International Radioprotection Association [IRPA].

National Laboratory for Metrology of Ionizing Radiation, Institute of Radiation Protection and Dosimetry CNEN/Laboratório Nacional de Metrologia das Radiações Ionizantes, Instituto de Radioproteçao e Dosimetria [LNMRI-IRD], Rio de Janeiro.

National Metrology Institute of South Africa [NMISA], Pretoria.

Swedish Radiation Protection Authority [SSI], Stockholm.

Section II: measurement of radionuclides

Chairman

L.R. Karam, National Institute of Standards and Technology [NIST], Gaithersburg.

Members

Australian Nuclear Science and Technology Organisation [ANSTO], Menai.

Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas [CIEMAT], Madrid.

Commissariat à l'Énergie Atomique/Laboratoire National Henri Becquerel [LNE-LNHB], Gif-sur-Yvette.

Czech Metrology Institute/Český Metrologický Institut [CMI], Brno.

D.I. Mendeleyev Institute for Metrology, Rostekhregulirovaniye of Russia [VNIIM], St Petersburg.

Ente per le Nuove Technologie, l'Energia e l'Ambiente, Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti [ENEA-INMRI], Rome.

"Horia Hulubei" National Institute of Physics and Nuclear Engineering [IFIN-HH], Bucharest-Magurele.

Hungarian Trade Licensing Office [MKEH], Budapest.

Institut de Radiophysique Appliquée [IRA], Lausanne.

Institute for Reference Materials and Measurements [IRMM], Geel.

Korea Research Institute of Standards and Science [KRISS], Daejeon.

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg.

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National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology [NMIJ/AIST], Tsukuba.

National Metrology Institute of South Africa [NMISA], Cape Town.

National Physical Laboratory [NPL], Teddington.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

Radioisotope Centre Polatom [RC], Swierk.

The Director of the International Bureau of Weights and Measures [BIPM], Sèvres.

Observers

Bhabha Atomic Research Centre [BARC], Mumbai.

Bundesamt für Eich- und Vermessungswesen [BEV], Vienna.

Comisión Nacional de Energía Atómica [CNEA], Buenos Aires.

International Atomic Energy Agency [IAEA].

International Commission on Radiation Units and Measurements [ICRU].

International Organization for Medical Physics [IOMP].

International Radioprotection Association [IRPA].

National Research Council of Canada - Institute for National Measurement Standards [NRC-INMS], Ottawa, Ontario.

VSL [VSL], Delft.

Section III: neutron measurements

Chairman

D. Thomas, National Physical Laboratory, Teddington.

Members

Commissariat à l'Énergie Atomique/Laboratoire National Henri Becquerel [LNE-LNHB], Gif-sur-Yvette.

Czech Metrology Institute/Český Metrologický Institut [CMI], Brno.

D.I. Mendeleyev Institute for Metrology, Rostekhregulirovaniye of Russia [VNIIM], St Petersburg.

Institute for Reference Materials and Measurements [IRMM], Geel.

Korean Research Institute of Standards and Science [KRISS], Daejon.

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg.

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National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology [NMIJ/AIST], Tsukuba.

National Physical Laboratory [NPL], Teddington.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

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Observers

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Chinese Institute of Atomic Energy [CIAE], Beijing.

International Atomic Energy Agency [IAEA].

International Commission on Radiation Units and Measurements [ICRU].

CONSULTATIVE COMMITTEE FOR IONIZING RADIATION

Report of the 22nd meeting
(24 June 2011)

to the International Committee
for Weights and Measures

1 - 3 OPENING OF THE MEETING: WELCOME / AGENDA / APPOINTMENT OF A RAPPORTEUR

The 22nd meeting of the Consultative Committee for Ionizing Radiation (CCRI) was held at the BIPM headquarters in Sèvres on 24 June 2011.

The following members were present: K. Carneiro (President), M. Kühne (Director of the BIPM), P.J. Allisy-Roberts (Executive Secretary), P. Sharpe (Chairman of CCRI(I)), L. Karam (Chair of CCRI(II)), D. Thomas (Chairman of CCRI(III)).

Guests: C. Borrás (EFOMP), J. Chavaudra (IOMP), A. Wambersie (ICRU).

BIPM participants: O. Altan, D.T. Burns (rapporteur), C. Kessler, C. Michotte, S. Picard, G. Ratel, P. Roger, C. Thomas.

Apologies: R.K. Chhem (IAEA), A.R. Keyser (AAPM).

The numbering below follows that of the agenda.

Prof. Kühne, Director of the BIPM, welcomed the participants and expressed his desire for a productive meeting. Dr Carneiro, President of the CCRI, formally opened the meeting and outlined the agenda. He particularly welcomed the presence of representatives from the medical physics community, as well as Prof. Kühne in his new role as Director of the BIPM, and Dr Karam as the new Chair of CCRI Section II. Dr Allisy-Roberts noted apologies from the representatives of the International Atomic Energy Agency (IAEA) and the absence of the American Association of Physicists in Medicine (AAPM). Dr Burns was appointed rapporteur.

4 REPORT OF THE 2009 CCRI MEETING

Dr Carneiro discussed progress on two recommendations to the International Committee for Weights and Measures (CIPM) as mentioned in the report of the 21st meeting of the CCRI held in 2009. The first recommendation concerned the mechanism for including comparison results for IAEA/World Health Organization (WHO) Secondary Standards Dosimetry Laboratories (SSDLs) that are designated institutes (DIs) in the Key Comparison Database (KCDB). Dr Allisy-Roberts clarified the situation; an appropriate mechanism is now in place and involves the participation of the IAEA, a signatory to the CIPM MRA, in Regional Metrology Organization (RMO) comparisons. An SSDL that is a DI and a signatory can then participate in a bilateral (or other) comparison with the IAEA, and if this comparison is pre-registered in the KCDB the SSDL results can be included in the KCDB. The second recommendation to the CIPM concerned difficulties in the transportation of samples issued for a ^{241}Pu comparison by the NPL; the BIPM had written a statement, signed by the Director, aimed at facilitating the transport of the samples.

5 SUMMARIES OF THE MEETINGS OF THE CCRI SECTIONS

The President of the CCRI invited each CCRI Section Chairman to report on the Section and Working Group meetings.

5.1 CCRI Section I (Chairman P. Sharpe)

In addition to the CCRI(I) meeting held at the beginning of May 2011, meetings of the Accelerator Dosimetry Working Group (ADWG(I)) and the Key Comparison Working Group (KCWG(I)) were held in May 2010 and a further meeting of the KCWG(I) was held immediately prior to the latest CCRI(I) meeting in May 2011.

CCRI(I) discussed the draft CCRI Strategy Document prepared by Dr Carneiro and a number of suggested changes and additions for consideration by the CCRI were made.

Dr Burns presented a review of new and existing data on W_a, the mean energy to produce an ion pair in air, and on the graphite-to-air stopping power ratio $s_{c,a}$. The review indicated a possible change in the stopping power ratio of ~0.5 % or more, which will affect all ^{60}Co air-kerma cavity standards. This analysis forms part of the work being carried out for the International Commission on Radiation Units and Measurements (ICRU) Report Committee on Key Data for Dosimetry, which is expected to report in 2012. The implications of this work will be discussed by CCRI(I) participants at the next meeting in 2013 and a decision will be taken on recommending a change to the accepted value of the product $W_a/e\ s_{c,a}$.

At the suggestion of the KCWG(I), CCRI Section I agreed to propose to the CCRI that pair-wise degrees of equivalence are removed from dosimetry comparisons in the KCDB, with a proviso that comparison reports should contain sufficient information for these to be calculated, if required. This change will significantly reduce the work required to produce reports and maintain entries in the KCDB. Dr C. Thomas noted that this change, which is already approved by the Consultative Committee for Amount of Substance (CCQM) and the Consultative Committee for Photometry and Radiometry (CCPR), did not need to be the subject of a formal recommendation, it is sufficient to report the change to the CIPM.

Further recommendations from the KCWG(I) accepted by CCRI Section I included the publication of the updated BIPM report on measuring conditions and uncertainties (subject to minor changes) and a number of detailed recommendations relating to ^{137}Cs, mammography and absorbed-dose calibrations. The KCWG(I) reviewed the need for comparisons to cover all x-ray qualities used in the NMIs for radiotherapy, diagnostic and protection level applications, and concluded that no additional key comparisons were needed. This recommendation was accepted by CCRI Section I.

The current and future work programme of the BIPM was reviewed, and CCRI(I) praised the considerable progress already made, particularly on mammography, high-energy x-ray absorbed dose and brachytherapy dosimetry comparisons. It was noted that progress in brachytherapy had benefitted from secondees, who developed the methodology and assisted with the comparisons. Further secondments are needed to complete the work. Dr Allisy-Roberts stated that a further contract with J. Alvarez (ININ, Mexico) is under negotiation and a PhD student may be appointed.

CCRI Section I endorsed the Ionizing Radiation Department plans for 2013 to 2016 and reaffirmed its strong support for a linear accelerator to be installed on-site at the BIPM. A proposal for a new EURAMET comparison of absorbed dose to water standards for therapy electron beams was endorsed by the meeting, with ten NMIs expressing an interest to participate.

Several changes in the membership of CCRI(I) are recommended for consideration by the CCRI:

a) The IAEA should become a full member.

b) The NRPA, Norway, should replace the SRPI, Sweden, as observer to represent the Nordic area.

c) RMO TC chairs should be invited as observers to CCRI Section I meetings.

Dr Allisy-Roberts mentioned that the draft report on the validity of comparisons, which aims to assist CMC reviewers is currently being updated to include recommendations by the KCWG(I) on generic groupings of x-ray beam qualities.

5.2 CCRI Section II (Chairman L. Karam)

The CCRI(II) undertook to streamline the process of reporting Key Comparison Reference Values (KCRV) by omitting unnecessary information and refraining from re-publishing existing data for minor changes within the KCRV. The CCRI(II) welcomed the work completed on the method of calculation of the KCRV and the CCRI(II) agreed that it is time to update the procedures by combining scientific judgment and emerging statistical methods as presented at the meeting.

CCRI Section II recommended that the Uncertainties Working Group (UCWG(II)) be incorporated into KCWG(II) to improve the efficiency of its working group structure. CCRI(II) will propose to the CCRI that pair-wise degrees of equivalence be removed from the KCDB, as was the case for CCRI(I). CCRI Section II accepted a recommendation by the KCWG(II) to hold a roundtable during the next KCWG(II) meeting to discuss the lessons learnt from the ^{241}Pu comparison and other comparisons, if appropriate. CCRI Section II recommended to the CCRI that the Radionuclide Measurement Methods Matrix (MMM), formerly the generic groupings table, be made publicly accessible, with a cautionary note on the limits of its use. The importance of the MMM to manage CMCs and to conduct key comparisons was noted. The recommendation was approved by the CCRI.

New KCRVs were accepted for the BIPM.RI(II)-K1 comparisons for the following radionuclides: ^{22}Na, ^{60}Co, ^{75}Se, ^{88}Y, ^{99m}Tc, ^{166m}Ho, ^{111}In, ^{56}Co, ^{57}Co, ^{131}I, ^{137}Cs, ^{152}Eu, ^{241}Am, ^{177}Lu and ^{222}Rn. KCRVs were registered for ^{56}Mn, ^{64}Cu and ^{207}Bi for the first time. For the International Reference System (SIR), seventeen new results for twelve radionuclides, in ampoules from eleven laboratories, were obtained in 2009; thirteen new results for eleven different radionuclides, in ampoules from four laboratories, were obtained in 2010. To date in 2011, five ampoules have been received. The new SIR Transfer Instrument (SIRTI) was used to establish equivalence of ^{99m}Tc standardizations at the LNE-LNHB, NPL, NIST and KRISS. The SIRTI will be used next at the NMIJ.

Since the previous CCRI(II) meeting in 2009, twelve CCRI(II) reports and one RMO key comparison report have been published. Progress on key comparison reports for tritiated water, ^{89}Sr, ^{241}Pu, ^{177}Lu and ^{85}Kr were discussed in detail.

Dr Akira Yunoki (NMIJ) was invited to give a presentation on "The consequences of the earthquake in Japan, and NMIJ measurements regarding the Fukushima nuclear power plant". He presented information on Japan's largest recorded earthquake and the subsequent devastating tsunami. He gave an overview of the evolution of the Fukushima accident; the measurement programme developed by AIST-NMIJ in response to the emergency; and explained the *ad hoc* training courses and seminars mainly on surface contamination measurements given to the personnel of regional authorities. The NMIJ introduced a 16-page procedure for measurements as a first step for quality management. The AIST website provides information to explain the measurement procedures in place in Japan, the traceability of results obtained, and the role of the CIPM MRA in this context.

5.3 CCRI Section III (Chairman D. Thomas)

Although the neutron metrology community is relatively small, eleven NMIs and the IRMM were represented at the CCRI(III) meeting, plus observers from the IAEA and the China Institute of Atomic Energy (CIAE). A guest from Canada, the first for many years, provided evidence of a resurgence of interest by Canada with the NRC-INMS becoming active again in this area.

Four comparisons were discussed. The CCRI(III)-K9.AmBe on neutron source emission rate is completed and awaiting publication in the *Metrologia Technical Supplement*. The results were generally good but included a couple of outliers, and one laboratory was unable to participate in the allotted time. For this reason a small-scale follow-up comparison using a source from the NIM, China is planned, but has been delayed due to closure of research reactors in China following the Japanese earthquake (manganese cannot be activated to calibrate the manganese bath without a reactor).

Progress on the thermal neutron fluence comparison CCRI(III)-K8 was reported. Three scheduled participants were unable to make measurements, resulting in only four results. The results of two laboratories agreed within their uncertainties, a third was consistently about 8 % lower, and the fourth between 5 % and 20 % higher depending on the transfer device. This presented some difficulty in evaluating a reference value for the comparison. Further investigation is under way to understand the discrepancies.

A new comparison for monoenergetic neutron fluence, CCRI(III)-K11, is planned for the autumn of 2011 and will take place at the LNE-IRSN AMANDE facility at Cadarache in the south of France. The protocol was presented for approval. The aim is to compare fluence measurements at four energies 27.4 keV, 565 keV, 2.5 MeV and 17 MeV. The number of energies at which standards are provided presents a problem for comparisons. A solution is to agree that a standard at a particular energy is representative of a range of energies, or of a particular reaction. It is hoped that a final report from the evaluator will be sent to all members of CCRI(III) for discussion and approval around late October 2012.

Arguments for a comparison of calibrations of new electronic personal dosimeters were discussed, but it was considered that the required accuracy was low and no volunteers came forward to organize such a comparison. However, the NIST has registered CMCs for this

type of calibration and its representative agreed to make enquiries to determine what is needed in terms of a protocol for such a comparison and to circulate the findings for comment. Spectrometry comparisons were discussed, although no decisions were taken. Participants were encouraged to formulate ideas for discussion at the next CCRI(III) meeting in 2013.

RMO reports were provided, by the SIM and COOMET. Two EURAMET comparisons in progress are: a long-counter comparison (EURAMET 396), for which preliminary results were presented at the 11th Symposium on Neutron Dosimetry held in Cape Town in 2009 and have been published in a special issue of *Radiation Measurements*; and EURAMET 1104 measurement of the low-energy part of the Am-Be spectrum. An APMP supplementary comparison was proposed for the calibration of ambient dose equivalent survey meters in source-based neutron fields. Discussions are under way regarding the sources to be used and the instruments for calibration.

The NMIs presented the work of their laboratories and it was noted that this is a much appreciated opportunity to share information on research and development in the field. The Japanese presentation, coming soon after the earthquake and tsunami, provided graphic evidence of the damage caused at the NMIJ, recovery from which is expected to take at least 6 months.

Discussion of delays to the special edition of *Metrologia* provoked much subsequent activity within the CCRI(III) and as a result nine papers have been submitted and are currently being refereed. The 2011 deadline for publication is expected to be achieved.

A brief review of the neutron section of the CCRI Strategy Document resulted in a few modifications. A statement about the loss of expertise in the preparation of neutron reaction targets proposed by the PTB representative at the CCRI(III) was strongly supported by the IRMM. Discussion of the statement was postponed until agenda item 10.

Dr Chavaudra (IOMP) enquired about work that was under way on photoneutron reactions around linear accelerators. Dr D. Thomas replied that the neutron whole-body dose to patients is of greater concern during proton therapy, but that the European members of CCRI(III) were unsuccessful in obtaining European Metrology Research Programme (EMRP) funding for work in this area.

6 REPORTS FROM INTERNATIONAL OBSERVERS

Dr Chavaudra outlined the role and organizational structure of the International Organization for Medical Physics (IOMP), an umbrella organization representing over 18 000 medical physicists through four regional organizations (EFOMP in Europe, ALFIM in Latin America, AFOMP in Asia-Oceania and SEAFOMP in South-East Asia) and 76 national member organizations. IOMP functions through two main committees: a Science Committee to advance medical physics practice by disseminating scientific and technical information; and an Education and Training Committee to foster the educational and professional development of medical physicists. A suggestion was made that cooperation between the CCRI and the IOMP could be enhanced through publication of their work in *Medical Physics World*, the journal of the IOMP. Dr Carneiro commented that

traceability could be given a higher profile in the training programmes organized by the IOMP. Dr Chavaudra agreed and stressed that the need for accuracy in radiotherapy was increasing, with a concomitant need for increased accuracy in reference beam calibrations.

Prof. Wambersie commented briefly on the work of the ICRU. The ICRU Report 85 on Fundamental Quantities and Units, replacing ICRU Report 60, has been published and the BIPM was thanked for its contribution. The report series on "Prescribing, Recording and Reporting…" continued with the publication of ICRU Report 83 on intensity-modulated radiotherapy (IMRT), and while the practice of modifying the symbol for radiation units is not permitted, Prof. Wambersie remarked that it remains commonplace in clinical practice to use, for example, GyE (the "gray equivalent" being the physical dose in grays multiplied by the RBE). The ICRU confirmed its strong support for a linear accelerator to be installed at the BIPM and the need for calibrations in beams that are as similar as possible to those used in medical practice. He emphasized that for certain cancers a change in dose of a few percent can be observed in the clinical outcome. Prof. Kühne thanked the international organizations and stressed the importance of their strong support if the BIPM was to be successful in obtaining a linear accelerator.

In the absence of a representative from the IAEA, Dr Allisy-Roberts gave a summary of the document submitted by the Agency. As noted earlier in the meeting, there is now a clear mechanism through which SSDLs designated as DIs could have degrees of equivalence in the KCDB. The IAEA currently has nine CMCs and following an initial review of its Quality System by the JCRB, subsequent reviews will be made by individual RMOs (the next being through EURAMET). In support of the need for accelerator dosimetry, the Directory of Radiotherapy Centres (DIRAC) database has a record of 9920 clinical accelerators in 116 countries. Dr Borrás reported IAEA activities in radiation safety, and Dr Karam stated that the IAEA pilots secondary level comparisons in activity with mixtures of radionuclides often in complex matrices.

Dr Borrás made a short presentation about the EFOMP, a European federation representing 35 national organizations which, like the IOMP, functions through two main committees, a Science Committee and a Committee for Education and Training. Although EFOMP is a separate organization to the IOMP and its members are subject to regulatory requirements, it shares essentially the same goals towards medical physics practice and training within Europe.

Dr Carneiro agreed with the focus on the importance of traceability in the training of medical physicists and thanked the International Observers for their contributions.

7 FUTURE STRATEGY FOR IONIZING RADIATION METROLOGY

7.1 & 7.2 CCRI Strategy

Dr Carneiro stated that the CCRI Strategy Document should be finalized by early September 2011, after which it will serve as a reference for the CCRI and be used to monitor and align progress. The draft document was presented and proposed changes noted, including suggestions from Section Chairmen following discussions within the Section meetings. Minor suggestions on the "Stakeholders" are not noted here. Dr Karam commented that the "Short-term actions" list should distinguish between ongoing and time-limited actions. Dr Carneiro noted progress in reducing the time taken for comparison reports to be published and emphasized the focus on supporting CMCs rather than resolving outstanding scientific issues. Dr Sharpe requested clarification of the statement "Equal opportunities for NMI/DI" and Dr Carneiro explained that this relates specifically to participation in EMRP projects. Dr Allisy-Roberts commented on communication between NMIs and DIs; specifically, stating that in ionizing radiation the national laboratory is often a DI, but only the NMI is represented at BIPM meetings of Directors and at the CGPM.

Dr Carneiro requested that the three Section Chairmen study the action lists (short-, medium- and long-term), to suggest modifications, where necessary, and to produce a single paragraph description for each short-term action (with numbered cross referencing) for inclusion in Chapter 7 of the CCRI Strategy Document. The Chairmen were invited to provide an appropriate paragraph on the "Description of Stakeholders" for each CCRI Section.

A discussion on working groups followed. Chapter 8 of the CCRI Strategy Document provides a table for each working group outlining its membership, remit, time-frame and expected deliverables. Dr Carneiro stated that all working groups should be classified as 'time-limited', with the exception of the KCWGs. The Strategy Working Group should now be closed, while the ADWG(I) could evolve into a linear accelerator fundraising WG (depending on the outcome of the CGPM). Following discussions at the CCRI(II) meeting, the UCWG(II) will be merged with the KCWG(II).

Dr Carneiro will produce a revised document, with the aim of finalizing the document by 1 September 2011.

7.3, 7.4 & 7.5 BIPM present and future work programme (including accelerator project)

Dr Allisy-Roberts summarized the status of the BIPM Ionizing Radiation Department work programme for 2009 to 2012. Progress on the development of standards is steady, while targets for comparisons and calibrations have been surpassed. Dosimetry highlights were noted, including developments in mammography, and accelerator photon beams using a travelling calorimetric standard at the NRC, the PTB and the NIST. Progress on the brachytherapy project was noted and it was commented that a secondee is needed to further this project. A high-dose comparison for industrial applications, piloted by the BIPM, has been successfully completed and published. In radioactivity, new electronics for the SIR have been validated and the SIR transfer instrument for short-lived radionuclides has been

successfully used at the NIST and the KRISS. Developments were outlined for the pressurized proportional counter, solid-source preparation and the extension of the SIR to pure beta emitters. The Ionizing Radiation Department is now responsible for in-house thermometry calibrations. International collaboration and knowledge transfer continues at a high level, for example through visits to the BIPM; around 20 external publications; and participation in committees of the ICRU, the IAEA and the ICRM. Dr Karam joined the others in congratulating the Ionizing Radiation Department on its impressive programme of work.

Prof. Kühne presented a summary of the proposed work programme for 2013 to 2016 for the BIPM, including the core activities in mass, electricity, time and chemistry. In ionizing radiation, Prof. Kühne presented the technical and financial arguments for a linear accelerator at the BIPM. Although it is unlikely that the CGPM will agree to fund the 3.6 M€ required in the present financial climate, Prof. Kühne was moderately confident that the CGPM will not block the proposal. If the CGPM agrees to cover the estimated cost of inflation over the four-year programme, the BIPM will keep the accelerator project in the programme of work; funded by voluntary contributions and third-parties. Dr Sharpe commented that voluntary contributions could have implications for access. Prof. Kühne stressed that all Member States will have access independently of voluntary contributions. A suggestion was made that introducing charges might be another option. The BIPM already charges in a limited number of areas, including the supply of prototypes of the kilogram.

7.6 Report of the CCRI president to the CGPM

Dr Carneiro presented a draft report describing the activities of the CCRI between 2008 and 2011, which will be presented at the CGPM. Highlights included the plan for a linear accelerator at the BIPM, in the context of which he stressed that the work of the BIPM Ionizing Radiation Department was driven by the uncertainty requirements of the users, and the adoption of a written strategy as discussed above. Dr Carneiro reflected on more than 50 years of CCRI activity; what had been achieved, the present status as documented in three special issues of *Metrologia* dedicated to ionizing radiation, and future prospects as presented at the CCRI Section meetings in 2009 by top-level invited talks on metrological technologies of interest for the medium- and long-term.

The report contains statistics relating to end users world-wide: 7 million radiotherapy patients per year; 33 million nuclear medicine patients per year (diagnosis and treatment); 350 million patients per year for diagnostic x-rays; 11 million ionizing radiation workers per year monitored for personal dose. Further statistics relate to the KCDB (as of 10 March 2011); 3864 CMCs supported by 193 active key and supplementary comparisons (of which 137 are CCRI comparisons). This ratio of 20 CMCs per comparison is typical of the KCDB globally and is optimized via the use of a ‘generic’ approach that minimizes the number of comparisons required to support CMCs in areas such as x-ray dosimetry and radionuclide metrology.

Dr Carneiro concluded with a request for relevant photographs to be supplied by the CCRI Section chairmen for his report to the CGPM, ideally to include images of people to give a sense of scale, as well as performance data, for example the number of comparisons completed per year.

8 CIPM MRA AND MATTERS OF MUTUAL INTEREST

Dr Karam gave a summary of the report, by A Aalbers, of the RMOWG meeting, held at the BIPM on 2 May 2011. The Latvian laboratory, formerly RMTC, was closed and renamed LATMB, operating within a new department. This amounted to a loss of designation and breaks the metrological continuity so the relevant calibration and measurement capabilities (CMCs) were greyed-out in 2010; the JCRB Secretary noted that greyed-out CMCs will be removed after 5 years. The EURAMET TC Chairman will try to ascertain whether the laboratory intends to seek re-designation. The JCRB has requested that CMC files for a given country be separated according to discipline to limit the number of CMCs delayed due to problems within a single discipline. A proposal that authorship of RMO comparison reports is limited to those having made a 'substantial intellectual contribution' is under discussion by the JCRB.

The RMO reports submitted by AFRIMETS, COOMET, EURAMET and the SIM were not presented during the meeting but are available in the working documents.

9 STATUS OF CCRI WORKING GROUPS

As noted in discussions of the Strategy Document and in the working document CCRI-11/14 presented by the CCRI(II), it is proposed that the UCWG(II) is merged with the KCWG(II). The KC working groups are considered to be the only standing working groups of the Sections. It was recommended and accepted that the RMOWG should remain as a standing working group of the CCRI.

10 RECOMMENDATIONS TO THE CIPM

Dr D Thomas presented a recommendation in working document CCRI-11/04 concerning the increasing difficulty in identifying institutions that are able to produce and characterize reference samples needed by the NMIs to carry out their work programmes at an appropriate level of uncertainty. The CCRI requests that the CIPM facilitates knowledge preservation, exchange of expertise and training of specialists in radioactive and non-radioactive sample preparation and, further, that the CIPM actively supports the maintenance of the technical infrastructure needed for sample preparation and characterization, via recommendations to the Member States on the importance of this subject. Dr Karam commented that the same issue was discussed in the CCRI(II) meeting.

Prof. Kühne was not wholly in support of the suggestion that the CIPM should send letters to laboratory Directors on this subject. Dr Allisy-Roberts suggested that the request be clarified by Dr D Thomas and submitted at least one month before the CIPM meeting in October 2011. (**ACTION** Dr D. Thomas)

Dr Allisy-Roberts will summarize and combine the discussions that had taken place in the Section meetings about membership of the CCRI Sections and will formulate a proposal to be presented to the CIPM. (**ACTION** Dr Allisy-Roberts).

The organization of working groups was discussed in the context of the Strategy Document, which includes a table for each working group defining membership, remit, timescale and expected deliverables.

Dr Karam sought advice on an issue that arose in the meeting of CCRI(II) in relation to a recent ^{241}Pu comparison, namely whether a Draft A report could be sent to the TC chair to speed up the review of related CMCs while awaiting the Draft B report. Mr Altan was of the opinion that a comparison report used to support CMCs had to be a published report (i.e. was already approved by the relevant CC). Mr Altan requested the proposal in writing to facilitate his clarification of the issue. Dr Allisy-Roberts commented that such a situation may arise due to the perceived need for a supporting comparison to appear in column 'P' of CMCs, which is a misleading assumption because support by means other than comparisons is permitted.

Both the KCWG(I) and the KCWG(II) supported the proposal to suppress pair-wise degrees of equivalence, with the important proviso that comparison reports continue to contain sufficient data to allow pair-wise degrees of equivalence to be evaluated at a later stage. There was no discussion of this matter at the Section III meeting, however Dr D. Thomas voiced support for the proposal. As noted in Section 5.1, this change does not need to be the subject of a formal recommendation, it is sufficient to report the change to the CIPM. **The CCRI formally decided that pair-wise degrees of equivalence will no longer be evaluated, and will be progressively removed from the KCDB as new results are added, but that comparison reports must contain sufficient information for subsequent evaluation.** Dr Allisy-Roberts commented that the CIPM and the NMIs should be notified of this decision.

11 DATES PROPOSED FOR THE NEXT CCRI MEETINGS

The choice of dates for the next CCRI meetings has been complicated by the rescheduling of the CIPM meeting from October to May of each year, and by the need to optimize the timing for CCRI input to the CGPM in 2015. Dr Allisy-Roberts presented a possible schedule which included meetings of the CCRI and its Sections during September to November 2012 (and subsequently 2014). Prof. Kühne commented that the next meeting of NMI Directors is scheduled to be held in October 2012. Dr Carneiro proposed that a tentative schedule, as prepared, be sent to the CIPM for a decision. Dr Allisy-Roberts stated that the NMIs should be informed that the dates proposed during the Section meetings were no longer valid.

12 CONCLUDING REMARKS

In his concluding remarks, Dr Carneiro suggested that Ionizing Radiation be submitted as a candidate topic for World Metrology Day in 2012, or alternatively to propose Health as a more general topic. Prof. Kühne welcomed the suggestion, stating that the organizers (BIPM and OIML) are still inviting proposals. Dr Carneiro closed the meeting by expressing his

pleasure at the progress which has been made and thanked all participants for their contributions.

D. T. Burns

July 2011

Edited September 2011

APPENDIX R 1.
Working documents submitted to the CCRI for its 22nd meeting

Documents restricted to Committee members can be accessed on the restricted website.

Document CCRI/	
11-00	Draft agenda – updated, P.J. Allisy-Roberts, 2 pp.
11-01	Minutes of the special CCRI meeting on Strategy, D.T. Burns, 3 pp.
11-02	CCRI Strategy paper – updated, K. Carneiro, 13 pp.
11-03	Report from the SIM, L. Karam, 8 pp.
11-04	Statement from the CCRI(III), D.J. Thomas, 1 p.
11-05	Report of the AFRIMETS laboratories to the CCRI, Z. Msimang, 1 p.
11-06	COOMET report on ionizing radiation, V. Yarina, 3 pp.
11-07	EURAMET report on ionizing radiation, H. Bjerke, 12 pp.
11-08	Proposal for the BIPM's programme for 2013 to 2016, M. Kühne, 29 pp.
11-09	BIPM Ionizing Radiation Department work progress, P.J. Allisy-Roberts, 53 pp.
11-10	Activities of the Dosimetry and Medical radiation Physics Section, IAEA, A. Meghzifene, 28 pp.
11-11	Presentation of the IOMP, J. Chavaudra, 13 pp.
11-12	CCRI RMO WG Report, A. Aalbers, 8 pp.
11-13	CCRI Report to the CGPM, 2011, K. Carneiro, 6 pp.
11-14	Recommendation on Working Groups, L. Karam, 1 p.

CONSULTATIVE COMMITTEE
FOR IONIZING RADIATION

Section I: X- and γ-rays, charged particles
Report of the 20th Meeting
(4-6 May 2011)

Abstract

The CCRI(I) meeting was preceded by a meeting of the Key Comparison Working Group (KCWG) on 3 May 2011. Recommendations and feedback from the KCWG provided important input to the CCRI(I) meeting. Of note among the recommendations accepted by the CCRI(I) members was one that eliminates the requirement to report pair-wise degrees of equivalence in comparison reports. An examination by the BIPM staff of the consistency of the recommended values for *W/e* and the graphite stopping power suggested that air kerma standards based on cavity chambers may need to be revised. The BIPM graphite calorimeter, designed to measure the absorbed dose to water in MV x-ray beams, has been successfully used at three NMIs. Visits to several more NMIs that operate clinical accelerators are scheduled over the next two years. The proposal to establish an accelerator laboratory at the BIPM continues to receive strong support from the international community and members acknowledged letters of support received from several international organizations.

1 OPENING OF THE MEETING

Section I (x- and γ-rays, charged particles) of the Consultative Committee for Ionizing Radiation (CCRI) held its 20th meeting at the Pavillon de Breteuil (the BIPM headquarters), Sèvres, from 4-6 May 2011.

The following representatives of member organizations were present:

U. Ankerhold (PTB), J.M. Bordy (LNE-LNHB), D. Butler (ARPANSA), I. Csete (MKEH), F. Delaunay (LNE-LNHB), J. de Pooter (VSL), S. Duane (NPL), A. Knyziak (GUM), H.-M. Kramer (PTB), B. Michael (ICRU), M. Mitch (NIST), M. Pinto (ENEA-INMRI), C. Ross (NRC-INMS), N. Saito (NMIJ), P. Sharpe (NPL, Chairman of CCRI Section I), A. Steurer (BEV), M.P. Toni (ENEA-INMRI), D. Twerenbold (METAS), A.Y. Villevalde (VNIIM), D. Webb (ARPANSA), Z. Yanli (NIM), C.Y. Yi (KRISS).

Observers: J. Chavaudra (IOMP), A. Meghzifene (IAEA), Z. Msimang (NMISA), C. Oliveira (ITN), M. Saravi (CNEA), M.E. Segura (CIEMAT), V. Sochor (CMI).

Guests: H. Bjerke (NRPA, and EURAMET IR TC Chair), J. Alvarez Romero (ININ).

BIPM members also present for all or part of the meeting: M. Kühne (Director of the BIPM), P.J. Allisy-Roberts (Executive Secretary of the CCRI), O. Altan (JCRB Executive Secretary), D.T. Burns, C. Kessler, S. Picard, P. Roger, C. Thomas (KCDB coordinator).

Apologies were received from: K. Carneiro (President of the CCRI) and J.G. Peixoto (LNMRI/IRD).

The meeting was called to order at 10 am on 4 May 2011 by the Chairman, Dr Sharpe.

2 INTRODUCTIONS

Dr Kühne, Director of the BIPM, welcomed the delegates to the BIPM and to the 20th meeting of the CCRI(I). He pointed out that this was his first CCRI(I) meeting since being appointed as Director of the BIPM.

Dr Sharpe also welcomed the delegates and expressed regret that Dr Carneiro, President of the CCRI, would not be able to attend because of recent surgery.

The delegates introduced themselves.

3 APPOINTMENT OF A RAPPORTEUR

Dr Ross was thanked sincerely for his previous reports and was re-appointed as *Rapporteur*.

4 CHANGES OR ADDITIONS TO THE AGENDA

The Chairman recommended that a new subsection, 8.4, be added to the agenda to permit Dr Burns to discuss recent results related to the standard for absorbed dose to water at the BIPM.

As there had been rather few papers on specific research topics submitted for the meeting, the Chairman agreed to call for presentations on the subjects listed under agenda items 12 and 13 that might otherwise be given as part of the laboratory reports under agenda item 15.

Laboratory reports that were received after the agenda was prepared would also be included in item 15. Otherwise, the agenda (CCRI(I)/11-00) was adopted without further change.

The Chairman noted that several papers had been submitted after the deadline. He emphasized the importance of having papers submitted in time for review before the meeting. He also noted that laboratory reports are an important piece of evidence for maintaining delegate status with the CCRI(I).

5 REPORT OF THE CHAIRMAN ON THE CCRI MEETING OF JUNE 2009

Dr Sharpe noted that the 2009 meeting had been the 50th anniversary of the CCRI and a number of guests had been invited to the meeting. Dr Carneiro intends to continue to invite guests as and when appropriate.

All of the recommendations from the CCRI(I) had been approved by the CCRI and the proposal to establish a clinical accelerator at the BIPM continues to have strong support.

Dr Sharpe noted that the CCRI has prepared a strategy document to help guide the work of the three sections.

6 CCRI STRATEGIC PLANNING

The CCRI President, Dr Carneiro had asked each of the three sections to provide input for a CCRI strategy document. A draft is now available, and Dr Sharpe scrolled through this, asking for comments and advice.

With regard to the list of institutional stakeholders, there was some discussion as to whether or not various medical physics organizations should be listed. Prof. Chavaudra felt it was adequate to list the IOMP which is the umbrella organization for the others.

With regard to the list of end-user stakeholders, it was felt that they all made use of the work of the three sections so there would be no need to repeat the lists for each section, it being sufficient simply to list the stakeholders. There was a suggestion that stakeholders working on environmental issues as well as safety and radiation protection should also be listed.

The Chairman went through the various action items in the document. The following comments were noted:

Short term actions:

- The item "equal opportunities for NMI/DI" was not understood and should be explained.
- It was noted that a way has now been identified for SSDL comparisons undertaken by the IAEA to be incorporated into the KCDB as regional bilateral comparisons.
- "Diagnostic imaging needs" might better be replaced with "dosimetry for diagnostic imaging".

Medium term actions:

- The item "air kerma to absorbed dose to water" would be better phrased to indicate that the intent is to promote the use of absorbed dose rather than air kerma.
- The item related to "molecular imaging" needs to be clarified.
- The item "proton therapy" should be replaced with "hadron therapy".

Long term actions:

- Remove hadron therapy because it is now included in medium term actions.

With regard to the SSDL comparisons, Dr Kühne pointed out that only designated institutes can have their results reported in the KCDB.

7 PRESIDENT'S REPORT TO THE CGPM

Dr Sharpe scrolled through the draft of the President's report to the CGPM. Dr Thomas noted that a PowerPoint presentation will be prepared based on this document and will subsequently be available on the BIPM website. Members were invited to provide the President with images for him to use during his presentation.

The Chairman asked that any further comments be submitted before the end of June 2011.

8 CURRENT ISSUES IN DOSIMETRY

8.1 Physical constants – *W/e* and stopping powers

Dr Burns summarized work at the BIPM to obtain a value for *W/e* using ^{60}Co γ-rays and the new BIPM graphite calorimeter. From a measurement of the ratio of the dose-to-graphite to the charge per mass of air in the transfer ionization chamber, one can extract a value for the product of *W/e* and the graphite-to-air electron mass stopping power ratio. The estimated standard uncertainty on the product is 0.18 %. If values of I = 82.5 eV and ρ = 2.265 g/cm^3 are assumed for graphite, then a value of W/e = 34.12 J/C is obtained.

Dr Burns then turned to an analysis of several of the data sets that provide information on either *W/e*, or the graphite stopping power or the product of *W/e* and the graphite-to-air stopping power ratio. From a best fit to the data, he obtained a value for *W/e* that is very close to the accepted value of 33.97 J/C. However, the stopping power ratio is reduced by close to 0.8 % and the combined uncertainty is increased to 0.35 %.

An implication of this analysis is that air kerma standards for ^{60}Co, which depend on graphite cavity chambers, will provide smaller values for the air kerma by about 0.8 %. The air kerma values produced by free-air chambers will not change but the estimated uncertainty will increase.

These data are being considered by an ICRU report committee on key data and will be augmented by separate calculations of the *I*-value for graphite.

Several delegates congratulated Dr Burns on his careful work. Dr Kramer asked if it was time to consider changing air kerma standards. The Chairman felt that the CCRI should wait for recommendations from the ICRU before proposing changes.

8.2 Changes to the BIPM standards

Dr Allisy-Roberts pointed out that the changes to BIPM x-ray and ^{137}Cs standards that were approved at the previous CCRI(I) meeting have been published in *Metrologia* (**46**(5) 2009, L21-23 and L24-L25). These revised standards are now the basis for any comparisons or calibration services carried out by the BIPM.

8.3 BIPM uncertainty budgets

Dr Allisy-Roberts pointed out that the BIPM has prepared a document which describes the measuring conditions and uncertainties associated with each of the services provided by the Ionizing Radiation Department of the BIPM. It was agreed to postpone discussion of the document until agenda item 9.1, which deals with issues arising from the meeting of the key comparison working group on 3 May 2011.

8.4 BIPM determination of D_w

Dr Burns described work at the BIPM to obtain D_w using the new BIPM graphite calorimeter. The conversion coefficient, $C_{w,c}$, is obtained from a Monte Carlo calculation. Results obtained using the PENELOPE code at the BIPM and the EGSnrc code at the NRC agree to 0.15 %. Although this level of agreement is encouraging, a robust evaluation of the uncertainty on $C_{w,c}$ requires an estimate of the effect of the uncertainty of the photon cross-section data. The tentative value of D_w for ^{60}Co is about 0.2 % larger than the present BIPM value, with an uncertainty of 0.25 %.

The Chairman asked when the BIPM would transition to using the graphite calorimeter as the basis of its standard for absorbed dose to water. Dr Burns responded that there is still some work needed to clarify issues related to the water-proofing sleeve used with the transfer chamber.

9 FEEDBACK FROM WORKING GROUPS

The Key Comparison Working Group (KCWG) met on 17 May 2010, the Accelerator Dosimetry Working Group (ADWG) met on 18 May 2010, and the KCWG met again on 3 May 2011. Matters arising from the ADWG meeting are covered elsewhere in the agenda. There were no specific items from the KCWG meeting in 2010 to present to the CCRI(I) as these were raised at the recent KCWG meeting. However, there were nine recommendations arising from this KCWG meeting on 3 May 2011 and the discussions surrounding these are summarized below.

1) Delegates agreed that comparison reports for the KCDB should no longer report pair-wise degrees of equivalence. The burden of work to prepare these tables is considerable, and the information can be obtained from the comparison data with respect to the KCRV. Dr Thomas reported that some other CCs have also stopped reporting the pair-wise values. However, it was emphasized that comparison reports must contain sufficient details regarding the uncertainties so the pair-wise degrees of equivalence could be calculated if required.

2) The second recommendation dealt with document CCRI(I)/11-27 on the general principles that govern comparisons related to ionizing radiation. Dr Allisy-Roberts drew attention to some minor wording changes in the document. She also noted that the JCRB has pointed out that the IAEA itself cannot register a comparison, but it can act as a link laboratory. The comparison must be registered by the RMO of the institute(s) participating in the comparison. Delegates accepted the proposed changes to the document.

3) The third recommendation dealt with document CCRI(I)/11-16 which summarizes measurement conditions and uncertainties for comparisons with the BIPM. Dr Allisy-Roberts summarized some minor changes and indicated that a section on W-Mo beam qualities would be included, if agreed. The document, including the stated uncertainties, was accepted by delegates.

4) The NIST comparison result for ^{137}Cs in BIPM-RI(I)-K5 has formally expired. However, a new comparison is scheduled for September 2011, and delegates accepted that an exemption would be granted in this case, but the exemption would expire at the end of December 2011.

5) For mammography qualities, some laboratories use Mo/Mo systems while others use W/Mo. It was agreed that a laboratory could choose one or the other for a comparison but not both. Separate degrees of equivalence would be maintained for the two set-ups.

6) It was recommended by the KCWG, and accepted by delegates, that for comparisons in accelerator beams (BIPM-RI(I)-K6) the results would be reported as the ratio of the value of D_w obtained by the participating NMI to the value obtained using the BIPM graphite calorimeter.

7) There are a large number of x-ray beam qualities in use for different purposes and holding comparisons for all of them would not be practical. The KCWG recommended, and delegates accepted, that there is no requirement to define new beam qualities for supporting CMCs. The RMOs are free to choose those qualities that best support their CMCs.

8) There has been some confusion as to what uncertainty should be assigned to the product of W/e and $s_{c,a}$ when used for ^{137}Cs. Delegates agreed that the same uncertainty value used for ^{60}Co, namely, 0.11 %, was indeed the appropriate value to use.

9) Dr Allisy-Roberts proposed, and delegates agreed, that there was no justification for holding a key comparison for ambient dose equivalent, $H^*(10)$. It was pointed out that it is really nothing more than a standard of air kerma.

10 COMPARISONS OF DOSIMETRY STANDARDS (X AND γ-RAYS, CHARGED PARTICLES)

10.1 BIPM and CCRI key comparison status

10.1.1 BIPM.RI(I)-K1, BIPM.RI(I)-K2, BIPM.RI(I)-K3, BIPM.RI(I)-K4, BIPM.RI(I)-K5, BIPM.RI(I)-K6, BIPM.RI(I)-K7, BIPM.RI(I)-K8

Dr Allisy-Roberts summarized the status of the key comparisons identified as BIPM.RI(I)-K1 through BIPM.RI(I)-K5. She acknowledged the efforts of Ms Kessler in helping to prepare the comparison reports.

Dr Allisy-Roberts began the discussion of BIPM.RI(I)-K6 (MV x-rays) by pointing out that world-wide there are now 9870 clinical accelerators being used for radiation therapy and twelve nations either already have, or are planning, a clinical accelerator to support their standards work.

Dr Picard provided an overview of the status of the comparisons carried out using the BIPM graphite calorimeter. The first laboratory to be visited was the NRC in June 2009. Since then, the calorimeter has been used successfully at the PTB and at the NIST. Visits have been scheduled to several additional NMIs.

Ms Kessler discussed BIPM.RI(I)-K7 for mammography beam qualities. The BIPM Mo x-ray tube was installed in 2009 and four reference fields have been established. Several comparisons are already complete or under way.

Dr Allisy-Roberts discussed comparison BIPM.RI(I)-K8 for brachytherapy. Measurements had been carried out with the VSL and the results look encouraging. There has been no time to complete the analysis of measurements with the LNE-LNHB or the NPL. The BIPM is hoping that an NMI will be able to volunteer a guest worker to continue the brachytherapy work.

10.1.2 CCRI(I)-S2, ^{60}Co high dose

This comparison is now complete (*Metrologia* **48** (2011) Tech. Suppl. 06009) and Dr Sharpe summarized the results. Eight national laboratories participated, using alanine dosimeters supplied by the NPL and the NIST. There was general agreement among the various standards. An alanine dose rate effect was identified which would be the subject of a separate paper.

10.2 Regional key and supplementary comparisons, AFRIMETS, APMP, COOMET, EURAMET, SIM

The status of regional comparisons was reviewed briefly. The COOMET is planning a ^{137}Cs comparison and the EURAMET has a comparison under way using alanine for therapy dose rates.

The rules for registering a comparison are posted on the JCRB website and Dr Thomas emphasized the importance of completing the form. Regional comparisons can also be registered for inclusion in the KCDB and the JCRB encourages RMOs to register all their comparisons. Registration helps to establish a formal record of the comparison.

10.3 Comparison reports for approval

Dr Allisy-Roberts pointed out that delegates of the CCRI(I) are asked to review and approve all reports. *Metrologia* states that reports have been reviewed by the appropriate committee. All final reports now include the reference to their abstract in *Metrologia*.

11 Current and future programmes at the BIPM

The present four-year programme for the BIPM runs from 2009 to 2012. The CGPM will meet in the autumn of 2011 to fix the budget for the next four-year programme from 2013 to 2016. Dr Allisy-Roberts reviewed the BIPM activities related to the CCRI(I) during the present work term. Significant successes since 2009 include the development of a standard for mammography x-rays and the development of a graphite calorimeter specifically intended for MV x-rays. The work on brachytherapy benefited from having Dr José Alvarez Romero from the ININ as a visiting worker, recipient of an IAEA fellowship, for several months. The staff of the Ionizing Radiation Department work closely with several international organizations, such as the ICRU, IAEA, ICRM, IOMP and the RMO technical committees. In addition to their work on ionizing radiations, the group has taken over responsibility for the BIPM standards for room temperature thermometry.

On behalf of the delegates, the Chairman acknowledged the hard work of the BIPM staff. In particular, he noted the extra work load required to develop the case for a clinical accelerator at the BIPM.

Dr Allisy-Roberts then turned to a discussion of programme of work for 2013 to 2016. The group needs a new ^{60}Co unit and have identified a suitable model. Unfortunately, the order has been delayed despite the fact that funding has been committed. On behalf of the delegates, the Chairman expressed concern over the delays and recommended that all necessary measures be taken so that the order can be placed as soon as possible.

The major item for the new work plan concerns standards for MV x-rays. It is generally agreed that the best option is for the BIPM to have its own clinical accelerator, but the CGPM meeting in 2007 asked the BIPM to look at other options. Three options were identified: (A) travelling BIPM calorimeter; (B) use of an accelerator at another NMI; and (C) establishing an accelerator facility at the BIPM. Following the 23rd meeting of the CGPM (2007), Option (A) is already being implemented and works well for NMIs with accelerators but is of no help to those without. Dr Allisy-Roberts reviewed the requirements for Option (B) to be a practical solution. They include: access to at least three x-ray beams with both horizontal and vertical orientations; stable environmental conditions; contiguous access to a ^{60}Co unit; flexibility in scheduling; and on-site access for all fifty-five Member States. Negotiations with the PTB indicated that the costs for the 2013-2016 work period would be about 1.2 million Euros. Cost estimates for option (C) have also been established. The linac vault could be attached to the end of the building housing the ionizing radiation standards group. A one-time investment of about 4 million Euros would be required to build the vault and purchase an accelerator. Operation of the laboratory could be managed using existing allocations. Over a fifteen-year operating period, option (C) would be less expensive than option (B) and would permit a more extensive and robust scientific programme.

Given the world-wide economic problems it seems unlikely that Member States will be able to approve a one-time increase in the budget, even though there is strong scientific support. Dr Twerenbold asked if one option would be for the CGPM to approve the initiative in principle but require that the BIPM find alternative ways of funding the laboratory. It was noted that most CGPM members have an industrial perspective and it may be that more effort should be directed towards representatives from the health care sector. This concept was generally supported. Dr Sharpe pointed out that the worst outcome would be if the CGPM simply rejected the accelerator as part of the BIPM programme of work as this would prevent the BIPM from seeking alternative funding. While completion of the watt balance is the number one priority for the BIPM programme of work for 2013-2016, the linac project is ranked in second place.

12 DEVELOPMENT OF NATIONAL STANDARDS FOR PHOTON DOSIMETRY

There were no specific papers addressing photon dosimetry standards developments. The Chairman asked for any contributions that were included in the laboratory written reports and several presentations were made.

12.1 Air kerma

Dr Yi from the KRISS described the cylindrical graphite chamber that forms the basis of their air kerma standards for ^{137}Cs and ^{60}Co γ-rays. They have carried out a detailed theoretical study of the electric field within the chamber volume. The KRISS operates three ^{137}Cs units and one ^{60}Co unit. Monte Carlo techniques were used to calculate the photon spectra from these irradiators and were found to be in reasonable agreement with spectra obtained by other standards laboratories.

Dr Ankerhold of the PTB described the design of a new free-air chamber for x-rays from 5 keV to 100 keV. The new design will eliminate the presence of guard wires in the beam.

Ms Villevalde of the VNIIM pointed out that an ND1005 graphite cavity chamber manufactured by the MKEH is now the basis of their ^{60}Co air kerma standard. A comparison with the BIPM carried out in 2009 showed satisfactory agreement. Correction factors for their medium-energy free-air chamber have been re-evaluated using Monte Carlo techniques and a comparison with the BIPM was completed in 2010. The low-energy x-ray standards of the VNIIM have been upgraded and a mammography standard has been established.

12.2 Absorbed dose to water

Dr Butler discussed recent work at the ARPANSA using graphite calorimetry. In the past, they used the photon fluence scaling theorem to convert from D_g to D_w, but now use a Monte Carlo calculation. They use measured depth-dose data to test the accuracy of the Monte Carlo code. He said that the ARPANSA is interested in guidance on the best approach for operating their calorimeter and for obtaining D_w. Dr Duane commented that the NPL uses approximate scaling theorem geometry and calculates $N_{D,c}/N_{D,w}$ for their transfer chamber using Monte Carlo techniques. Dr Burns commented that it is important to model the cavity chamber used to measure depth-dose if one wants a robust test of the Monte Carlo code.

Dr Steurer reviewed recent work using the BEV graphite calorimeter. A comparison has been undertaken with the PTB and the METAS for both ^{60}Co γ-rays and MV x-rays and the final results are available on the EURAMET website. The results for the PTB comparison were not completely satisfactory.

Dr Duane reported that the NPL has used their existing graphite calorimeter standard in the MV beams of their new Elekta accelerator. He discussed a re-evaluation of the calorimeter gap effect and showed measured values of k_Q. At this time, the NPL will continue to disseminate calibrations for the absorbed dose to water based on calorimeter measurements of k_Q obtained using their Vickers research accelerator.

Dr Ankerhold pointed out that the PTB operates one water calorimeter for ^{60}Co γ-rays and another for MV x-rays. They have successfully used the calorimeter for field sizes as small as 3 cm by 3 cm. A portable water calorimeter has been developed for use with a beam of ^{12}C ions and measured values of k_Q are in satisfactory agreement with theory. They have also measured k_Q for several parallel-plate chambers in photon beams.

Dr Twerenbold pointed out that the METAS no longer calibrates user chambers directly in high-energy x-ray or electron beams. Instead, they use a ^{60}Co calibration and a set of generic k_Q values, obtained from 10 years of direct chamber calibrations. One consequence of the change is that uncertainties have had to be increased, a move that has led to some client dissatisfaction.

Dr Saito described the graphite calorimeter operated by the NMIJ. It is operated in constant temperature mode for ^{60}Co measurements, and D_g is converted to D_w using a Monte Carlo calculation. The estimated standard uncertainty of D_w is 0.38 %. The laboratory has recently installed an Elekta linac and a new, more compact, graphite calorimeter is under development for use on this machine.

Dr Delaunay described a new water calorimeter developed by the LNE-LNHB. It has been used to measure the absorbed dose to water from ^{60}Co γ-rays. The standard uncertainty of D_w is 0.49 % and the result agrees with that obtained using graphite calorimetry within 0.1 %. They have also developed a graphite calorimeter suitable for measurements in small fields produced by MV x-rays and have used it for fields as small as 2 cm by 2 cm. The dose to water was obtained from the graphite results by using Monte Carlo calculations. They conducted a series of tests to select one ionization chamber, among the eight different types available, to be used as a reference ionization chamber in a 2 cm × 2 cm field.

Values of k_Q for an NE2577 do not show any strong dependence on field size between 10 cm × 10 cm and 4 cm × 4 cm fields. Finally, he reviewed progress on work with a water calorimeter for use in medium-energy x-ray beams.

12.3 Brachytherapy dosimetry

Dr Yi described work at the KRISS to characterize a new design of an ^{192}Ir brachytherapy source. The source parameters were obtained using the AAPM TG-43 formalism, along with the PENELOPE Monte Carlo code. They plan to develop a cavity chamber that will be used to establish a primary standard for the air kerma strength of ^{192}Ir sources.

Dr Pinto summarized work at the ENEA to establish standards for low dose rate (LDR) and high dose rate (HDR) brachytherapy sources. The standard for LDR sources is based on a wide angle, variable volume ionization chamber. Monte Carlo calculations are used to convert the ionization chamber measurements to D_w and the standard uncertainty of the result is expected to be less than 3 %. The HDR standard is under development and is based on a graphite calorimeter with a cylindrical absorber surrounding the source.

Dr Duane summarized work at the NPL to develop a graphite calorimeter for use with HDR sources. The calorimeter is similar in design to that of the ENEA and measures the absorbed dose to graphite at 2.5 cm from the source. The measured dose to graphite is converted to dose to water at 1 cm from the source using Monte Carlo calculations. Although no detailed results are available yet, the expectation is that the overall standard uncertainty will be less than 2 %.

Dr Ankerhold reported that the PTB has developed a water calorimeter that permits the positioning of an HDR source in close proximity to the thermistor probes. The calorimeter has been used to establish the dose rate constant with a standard uncertainty of 1.8 % for two types of ^{192}Ir seeds. In response to a question, Dr Kramer indicated that they have observed four-digit

agreement between source dosimetry established via the conventional air kerma approach and via the recent calorimeter approach, much better than could be expected based on estimated uncertainties.

Dr Delaunay described the LNHB standard for ^{125}I seeds. It is based on a cylindrical free-air chamber with the source mounted on the central axis of the chamber. Ionization is measured in a 2π ring thus eliminating effects due to source anisotropy. The source is mounted at the centre of 1 cm radius water-equivalent sphere. Correction and conversion factors are evaluated using the PENELOPE Monte Carlo code. No final results are available yet, but the standard uncertainty is expected to be about 1 %.

Dr de Pooter described recent work on the development of a water calorimeter for HDR brachytherapy sources. Four thermistors are mounted around the source. In order to reduce the effects of heat conduction from the source to the measuring point, the source is stored at 4 °C when it is not inserted into the calorimeter and a heat sink surrounds the source when a measurement is under way.

Dr Allisy-Roberts expressed satisfaction at the various efforts to establish brachytherapy standards. Most of these efforts receive financial support from the European Commission.

Dr Mitch pointed out that the NIST has now calibrated more than one thousand LDR seeds using their WAFAC chamber. They are also developing a new laboratory that will permit the determination of the air kerma produced by the electronic brachytherapy source manufactured by Xoft. The laboratory is equipped with a free-air chamber that can be rotated about the source.

12.4 Radiation processing

Dr Sharpe noted that the Nordion 220 ^{60}Co irradiator is no longer supported by the company. However, there is another company prepared to re-source the unit but it needs to be sent away for about one month. At the NPL, they have developed a holder for the irradiator that will permit samples to be irradiated at temperatures as low as −80 °C. He noted that blood is typically irradiated with a dose in the range of 25 Gy to 50 Gy using a ^{137}Cs irradiator. Due to security issues associated with using radioactive sources, there is considerable interest in using 150 kV x-rays as an alternative.

12.5 Radiometry and dosimetry in the energy range from 1 keV TO 60 keV

There were no submissions this year on standards for low energy photons.

12.6 Radiation protection

Dr Ankerhold reported on work at the PTB to develop pulsed radiation fields for testing survey meters and personal electronic dosimeters. They have installed an x-ray tube which can be operated with a pulse width that is variable from 0.2 ms to infinity. She also reported that the PTB laboratory that has concentrated on the measurement of very low dose rates has been closed.

Dr Delaunay reported that the LNHB and the ENEA have collaborated on building an ICRU tissue phantom suitable for eye lens dosimetry. Values of $H_p(3)/K_a$ have been calculated using Monte Carlo codes as a function of photon energy and published as an internal report.

Dr Bordy commented that a company in Poland is planning to develop a meter designed to measure $H_p(3)$.

Dr Delaunay also reported on measurements of the effect of the dose per pulse on the response of various dosimeters. He warned that the change in response with dose per pulse depends on the detector design and can vary over a wide range.

13 DEVELOPMENT OF NATIONAL STANDARDS FOR CHARGED PARTICLE DOSIMETRY

13.1 Electron/beta dosimetry

Ms Villevalde reported on comparisons between the VNIIM and the PTB of the absorbed dose rate to tissue for β-ray sources. The comparison was carried out by transporting sources between the two laboratories. Results agreed within the assigned uncertainties. In response to a question, Ms Villevalde reported that the transport of sources presents serious logistical problems.

Members approved a recommendation to request that the CCRI ask the CIPM to consider if there is anything that can be done to expedite the transport of sources that are used for measurement purposes.

Dr Yi described the KRISS standard for absorbed dose to tissue due to β-rays. It is based on a commercially available extrapolation chamber. The effective area of the collecting electrode is determined from capacitance measurements. The KRISS has two β-ray irradiators; one is used to establish the standard and the other for calibration work.

Dr Twerenbold pointed out that the METAS standard for high energy electron beams is based on Fricke dosimetry. Although METAS used to offer direct calibration of client chambers against the standard this is no longer practical. They have determined generic k_Q values based on their 10 years of measurement experience. The user is provided with a ^{60}Co calibration coefficient for their chamber along with generic values of k_Q. This change has required that the estimated uncertainty on the client calibration coefficients for electron beams be increased to 3 %.

He pointed out that the METAS has not registered a CMC for electron beams because no comparison has been completed. This led to some discussion as to when other NMIs might expect to have operational standards for electron beams and the indications were that it might still be a few years. It was agreed that the METAS and the NPL would draft a new protocol for a EURAMET comparison building on the experience of the previous bi-lateral exercise. The comparison would be open to all NMIs when they had developed their electron standards. Dr Chavaudra pointed out that electron beams in the energy range from 6 MeV to 10 MeV are widely used in radiotherapy so there is a need for dosimetry standards.

13.2 Protons

Dr Twerenbold reviewed measurements carried out using a water calorimeter in a proton beam at the Paul Scherrer Institute. A total of 40 hours of beam time was not enough to reduce the uncertainty of D_w below 0.5 %. Additional proton beam measurements were carried out using ionization chambers to compare the relative k_Q values with those reported in TRS-398. The measured and calculated results were in satisfactory agreement for different chamber types.

13.3 Other charged particles

There were no submissions on other charged particle dosimetry.

14 FUTURE TRENDS IN DOSIMETRY

Dr Ankerhold described the PTB ion beam facility that can be used to irradiate living cells with a well defined number of protons or alpha particles. The spatial resolution of the system is 2 µm to 3 µm. She also pointed out that the PTB is hosting a meeting in the autumn of 2011 on metrology for cancer therapy.

15 REPORTS FROM MEMBER LABORATORIES

The Chairman asked members to summarize highlights from their laboratory reports submitted to the meeting.

LNE-LNHB

Dr Delaunay summarized their work using alanine pellets to test the dosimetry of Tomotherapy and Cyberknife systems. When comparing the measured and predicted doses in a PMMA phantom irradiated on a Tomotherapy unit, differences of 4 % were noted. The discrepancy is due largely to an erroneous value for the density of PMMA used by the treatment planning software.

The largest discrepancy observed for the Cyberknife system was also about 4 % and occurred for the smallest field with a diameter of 0.5 cm. In this case, the reason for the discrepancy is not yet identified.

KRISS

Dr Yi focused on their work measuring x- and γ-ray spectra. In general, they find good agreement between measured and calculated spectra, except for low energy x-rays. In this case, the electron impact ionization cross-sections used in the PENELOPE Monte Carlo code may not be adequate to accurately describe the peaks in low energy x-ray spectra. They have also carried out preliminary work measuring spectra with a CdTe detector.

ARPANSA

Dr Butler reported that they are setting up a TLD postal audit system for the radiotherapy centres in Australia.

BEV

Dr Steurer drew attention to the new diagnostic x-ray qualities that have been established at the BEV. Their facilities include two new x-ray tubes designed to deliver mammography beams. He also pointed out that they have successfully used small volume ionization chambers to measure dose distributions near brachytherapy sources.

MKEH

Dr Csete pointed out that they are suffering from a shortage of staff and may have to abandon graphite calorimetry. They have manufactured a new cavity chamber and are using a liquid displacement technique to measure the volume.

VSL

Dr de Pooter pointed out that the name of the Netherlands standards laboratory was changed from the NMi to the VSL in 2009.

NRC

Dr Ross drew attention to recent work using Monte Carlo calculations to determine correction factors for free air chambers. A new correction related to the presence of the aperture has been identified and can be significant for low energy x-ray beams.

NIST

Dr Mitch summarized some organizational changes at the NIST. The Ionizing Radiations Division is now part of the Physical Measurement Laboratory. Dr Soares, who had been responsible for β-ray dosimetry, has retired, as has Mr Seltzer, after 49 years of service. Funding has been received to establish a new ^{137}Cs laboratory and it will be fitted with a 15 TBq source. Progress has been made using ultrasonic thermometry to image dose distributions in water.

NPL

Dr Duane summarized their audit of IMRT facilities in the UK using alanine. Out of sixty-two facilities that offer IMRT therapy, fifty-seven participated in the audit. In most cases there was excellent agreement between the treatment plan predictions and the alanine measurements. However, there were four results that deviated by more than 5 %. It was demonstrated that all of these outliers were due to errors in implementing the comparison protocol, such as simple miscounting of the number of irradiations required to deliver 10 Gy, this being much higher than the normal dose delivered.

PTB

Dr Ankerhold indicated that all of the key points from their laboratory report had already been presented.

NMIJ

Dr Saito described the NMIJ mammography facility, which uses a Mo x-ray tube with either a Mo or Rh filter. A key comparison of their mammography standard with that of the BIPM showed good agreement. They have used their mammography facility to test the performance of a glass dosimeter that is used for quality control in mammography centres. He then described an effect they have observed which is due to charge storage in the build-up cap of an ionization chamber. The effect can be as large as 0.4 %, but is not present if the build-up cap is made of conducting material. He described some of the damage caused by the March 2011 earthquake and results from some of the radiation measurements due to the problems at the Fukushima reactor facility.

NIM

Dr Zhang Yanli summarized a number of recent developments at the NIM: they have developed a graphite calorimeter to establish D_w; they have participated in two high-dose comparisons, one organized by the CCRI and another by the APMP; they are establishing an accelerator for high dose-rate applications; and they hope to have a clinical accelerator operational by the end of 2011.

GUM

Mr Knyziak pointed out that there have been significant efforts over the past few years to modernize their laboratory. New techniques for measuring charge and current have helped improve uncertainties and they expect to implement Monte Carlo techniques to help improve the estimation of correction factors. Their primary air kerma standard for ^{60}Co γ-rays is based on a graphite cavity chamber with the volume measured by the MKEH and they operate free air chambers to establish air kerma standards for low and medium energy x-rays. The GUM has participated in several recent comparisons.

16 CIPM MRA CALIBRATION AND MEASUREMENT CAPABILITIES

16.1 Report from the CCRI RMO WG

Dr Webb reported on the RMO WG meeting that was held on 2 May 2011. Details can be obtained from the full report but highlights include: (a) The Latvian CMCs have had to be removed because of changes at the laboratory. The chair of the EURAMET TC will contact Latvia to discuss the status of the laboratory and the JCRB will discuss options at their autumn meeting; (b) The JCRB has decided that 5 years after being greyed out, CMCs will be removed from the database; (c) The status of the CMCs of the ININ will need to be reviewed because of problems with their quality system; (d) The rules establishing the validity of comparisons were reviewed and updated.

16.2 Traceability through the BIPM

Dr Allisy-Roberts drew attention to the calibration and measurement services of the BIPM now described on their website. These could be thought of as the BIPM CMCs and have been presented in a transparent manner for national laboratories that are traceable to the SI through the BIPM.

16.3 Report from the JCRB

Mr Altan reviewed highlights from the 24th, 25th and 26th meetings of the JCRB. At the 24th meeting, it was decided that CMCs that had been greyed out for more than five years would be deleted and that no private companies could participate in comparisons. At the 25th meeting, procedures were laid out for deleting CMCs and it was proposed that the BIPM should run a workshop on CMCs. The 26th meeting began preparations for the CMC workshop and agreed that information needed to be collected on Designated Institutes. Mr Altan pointed out that the CIPM MRA has six new signatories since the last CCRI(I) meeting.

16.4 Reports from the RMOS: AFRIMETS, APMP, COOMET, EURAMET, SIM

AFRIMETS

Ms Msimang highlighted recent activities, which included a supplementary comparison on radiation protection standards that was piloted by NMISA and a training course on uncertainties. Overall, it was noted by the meeting that AFRIMETS has made excellent progress.

APMP

Dr Webb reported on behalf of the APMP chair (Mr Yang Yuandi) who had encountered problems obtaining a visa. The last TC meeting had 19 participants. He noted that the BARC has had problems with establishing a quality system.

COOMET

In the absence of the IR TC Chair, no report was presented.

EURAMET

Mr Bjerke noted that the EURAMET region has a large number of CMCs. He is concerned that many of them have no entry in column P, which is supposed to provide supporting evidence for the CMC, preferably by citing comparison participation. The EURAMET supports a number of research projects, and one is devoted to developing new techniques for determining D_w for HDR sources as had been described by some of the participants earlier.

SIM

Dr Mitch drew attention to the fact that the next SIM meeting will be in Buenos Aires, Argentina, in November 2011. It will be accompanied by a workshop to help increase awareness of the metrology of ionizing radiation.

17 REPORTS FROM INTERNATIONAL MEMBERS AND OBSERVERS

17.1 ICRU

Dr Michael gave a brief summary of recent ICRU activity. Report 85 on fundamental quantities and units has now been published. Reports on the following subjects are under way: small field dosimetry; radon; and key data for dosimetry.

On behalf of the CCRI(I) members, the Chairman gratefully acknowledged the letter from the ICRU supporting the establishment of a clinical accelerator at the BIPM.

17.2 IAEA

Dr Meghzifene gave a summary of recent IAEA activity, with reference to his report CCRI(I)/09-14. He pointed out that the IAEA quality system had initially been approved by the JCRB and that a new assessment is due in 2012. It has been agreed that EURAMET will review the IAEA quality system on this occasion rather than the JCRB.

About 92 % of the calibrations carried out by the IAEA are for SSDLs, while about 8 % are for hospitals in countries without an SSDL. Recent comparisons carried out with SSDLs show that most of them are within agreed-upon acceptance limits. The IAEA has participated in a number of recent comparisons, including SIM-S1, APMP-K2 and AFRIMETS-S1. Recent results for the IAEA TLD postal service shows that 92 % of the participating hospitals are within the acceptance limits (95 % confidence) of +/- 5 %.

17.3 IOMP

Dr Chavaudra pointed out that the IOMP is an umbrella organization that represents about 18,000 medical physicists in 76 regional organizations. It organizes conferences and workshops and has several publications available. It also offers support for medical physics in developing countries.

Dr Allisy-Roberts thanked both the IAEA and the IOMP for their written support of the BIPM accelerator project.

17.4 IRPA

No representative was present.

18 PUBLICATIONS

Every four years the CIPM reviews membership status in all of its Consultative Committees. An up-to-date bibliography is an important way for an NMI to demonstrate activity relevant to the work of the consultative committee. Dr Allisy-Roberts encouraged the member NMIs to keep their bibliographies up to date, noting that only two had not done so this year.

19 CCRI(I) MEMBERSHIP CHANGES

Dr Allisy-Roberts reviewed four items regarding CCRI(I) membership.

1. The Republic of Korea, represented by its standards laboratory, KRISS, is now a member of CCRI(I).

2. There was unanimous support from members of the CCRI(I) to change the status of the IAEA from observer to member if they so wished.

3. The Swedish NMI has observer status with CCRI(I) but does not attend meetings. Dr Allisy-Roberts proposed, and delegates agreed, to change the Scandinavian observer from Sweden to Norway. The NRPA of Norway will need to send a letter to the CCRI(I) requesting that they become an observer.

4. Not all of the RMO technical chairs (TC) could attend the present meeting. Delegates agreed to propose to the CCRI and the BIPM Director that all RMO TC chairs be invited as regular observers to CCRI(I) meetings.

20 DATE OF NEXT MEETING

Dr Allisy-Roberts noted that the CIPM will now meet in May of every year. It would be helpful, especially for the President if the CCRI sections could coordinate their meetings so that all three either precede or follow the CIPM meeting. The schedule for 2013 will be proposed at a later date.

21 CONCLUDING REMARKS

Dr Sharpe concluded that it had been a very successful meeting and he thanked everyone for their participation. He noted especially the efforts of the BIPM staff and of Dr Allisy-Roberts in hosting the meeting.

Carl Ross, *rapporteur*

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APPENDIX R(I) 1.
Working documents submitted to the CCRI(I) for its 20th meeting

Open working documents of the CCRI(I) can be obtained from the BIPM in their original version, or can be accessed on the BIPM website:

http://www.bipm.org/cc/AllowedDocuments.jsp?cc=CCRI(I)

Documents restricted to Committee members can be accessed on the restricted website.

Document CCRI(I)/

11-00 Draft agenda – revised, P.J. Allisy-Roberts, 2 pp.
11-01 NIST report to the CCRI(I) May 2011, M. Mitch, 32 pp.
11-02 SIM Report 2011 – update, L. Karam, 12 pp.
11-03 New determination of the product (W_a $s_{c,a}$) using the BIPM graphite calorimeter, D.T. Burns, 3 pp.
11-04 An analysis of existing data for W_a, the I-value for graphite and the product (W_a $s_{c,a}$), D.T. Burns, 4 pp.
11-05 Progress report on radiation dosimetry at the VNIIM, A. Villevalde, 6 pp.
11-06 Progress report on photon dosimetry at the CMI, V. Sochor, 2 pp.
11-07 Progress report on radiation dosimetry at the NPL, P. Sharpe, 8 pp.
11-08 NRC Activities and Publications, 2009-2011, C. Ross, 15 pp.
11-09 Progress report on radiation dosimetry standards at the NMIJ-AIST, N. Saito, 9 pp.
11-10 Progress report on radiation dosimetry, facilities and related topics at the NIM, China, Zhang Yanli, 15 pp.
11-11 President's draft report for the CGPM, K. Carneiro, 6 pp.
11-12 Strategy paper for the CCRI, K. Carneiro, 15 pp.
11-13 Dosimetry report from the PTB, U. Ankerhold, 27 pp.
11-14 Activities of the Dosimetry and Medical Radiation Physics Section, IAEA, A. Meghzifene, 28 pp.
11-15 Recent Activities in Measurement Standards and Dosimetry at ARPANSA, D. Webb, 8 pp.
11-16 Measuring conditions and uncertainties for BIPM dosimetry comparisons and calibrations –revised, P.J. Allisy-Roberts, 22 pp.
11-17 Note on the determination of D_w for Co-60 using the BIPM graphite calorimeter, D.T. Burns, 1 p.
11-18 Dosimetry comparisons and calibrations by the BIPM 2009 to 2011 – updated, P.J. Allisy-Roberts, 8 pp.
11-19 Progress report on radiation dosimetry at the MKEH, I. Csete, 2 pp.
11-20 Report of the SSDL, Norwegian Radiation Protection Authority (NRPA), H. Bjerke, 3 pp.
11-21 Recent activities in measurement standards and dosimetry at the GUM, Poland, M. Derlacinski, 3 pp.
11-22 Presentation on progress on radiation dosimetry at the BEV, Austria (revised), A. Steurer, 27 pp.

11-23 LNE-LNHB Highlights 2009-2010, F. Delaunay, 14 pp.
11-24 Report of the AFRIMETS laboratories to the CCRI, Z. Msimang, 1 p.
11-25 Report of the EURAMET TC, H. Bjerke, 12 pp.
11-26 METAS radiation therapy dosimetry laboratory report, D. Twerenbold, 17 pp.
11-27 Validity of Ionizing Radiation Comparisons under the auspices of the CIPM MRA – updated, P.J. Allisy-Roberts, 9 pp.
11-28 Progress report on radiation dosimetry standards, facilities and related activities at the VSL, J.A. de Pooter, 3 pp.
11-29 Dosimetry report from the ENEA, Italy, M. P. Toni, 15 pp.
11-30 Dosimetry report from the KRISS, C-Y Yi, 13 pp.
11-31 Presentation from the JCRB Executive Secretary, O. Altan, 11 pp.

CONSULTATIVE COMMITTEE
FOR IONIZING RADIATION

Section II: MEASUREMENT OF RADIONUCLIDES
Report of the 21st meeting
(21-23 June 2011)

1 OPENING OF THE MEETING WELCOME

Section II (Measurement of radionuclides) of the Consultative Committee for Ionizing Radiation held its twenty-first meeting at the Pavillon de Breteuil (the BIPM headquarters), Sèvres, from 21 to 23 June 2011.

The following representatives of member organizations were present:

D. Arnold (PTB), C. Bobin (LNE-LNHB), F. Bochud (IRA), R. Broda (RC), M. Capogni (ENEA-INMRI), K. Carneiro (President of the CCRI), C.J. da Silva (LNMRI/IRD), C. Fréchou (LNE-LNHB), E. García-Toraño (CIEMAT), L. Johansson (NPL), L. Karam (Chairman of CCRI Section II, NIST), J. Keightley (NPL), J.-M. Los Arcos (CIEMAT), T.S. Park (KRISS), M. Reinhard (ANSTO), M. Sahagia (IFIN-HH), T. Shilnikova (VNIIM), F. van Wyngaardt (NMISA), J. Sochorová (CMI), L. Szücs (MKEH), M. Unterweger (NIST), U. Wätjen (IRMM), Y. Yuandi (NIM), A. Yunoki (NMIJ/AIST).

Observers: J. Chavaudra (IOMP), R. Galea (NRC-INMS), F.A. Iglicki (CNEA), L. Joseph (BARC), F.J. Maringer (BEV).

Guests: C. Borras (EFOMP), S. Pommé (IRMM).

Also attending the meeting from the BIPM for all or part of the time: P.J. Allisy-Roberts (Executive Secretary of the CCRI), D.T. Burns, S. Courte, M. Kühne (Director), C. Michotte, M. Nonis, G. Ratel, C. Thomas (KCDB coordinator).

Apologies for absence were received from: Y. Hino (NMIJ/AIST), G. Winkler (Personal member).

Delegates were greeted by the Director of the BIPM (Prof. Michael Kühne).

Dr Kim Carneiro, President of the CCRI, welcomed the delegates to the biennial meeting of CCRI Section II, to be chaired by the newly appointed chairman Dr Lisa Karam. He reminded the delegates that the previous chairman, Dr Bruce Simpson, had been the longest serving chairman of the CCRI(II). Dr Carneiro extended a special welcome to the guests and observers and expressed his thanks to those present, participants in the three preceding working group meetings, and contributors to the preparation of the meeting. Dr Carneiro further mentioned that during the course of the meeting he would introduce the CCRI strategy, an action he is pursuing on behalf of the CIPM.

2 INTRODUCTION BY THE CHAIRMAN, Dr Lisa Karam

The Chairman, Dr Karam, thanked the Director of the BIPM, Prof. Kühne, for hosting the CCRI Section II meeting, and thanked the President of the CCRI for his introductory words. Dr Karam especially welcomed Dr Akira Yunoki (NMIJ/AIST) and expressed her condolences on behalf of Section II following the recent earthquake and tsunami in Japan. She welcomed the delegates, in particular those new to the CCRI, and asked all present to introduce themselves.

3 APPOINTMENT OF THE RAPPORTEUR

The meeting confirmed the appointment of Dr Uwe Wätjen as *rapporteur*.

4 CONFIRMATION OF THE AGENDA

No changes were made, and the agenda was confirmed although the order of some items changed from the original agenda.

5 REPORT OF THE 21st MEETING OF THE CCRI (2009), INCLUDING THE 20th MEETING OF THE CCRI(II) AND MATTERS ARISING NOT OTHERWISE ON THE AGENDA

Dr Karam gave a short presentation of the highlights from the 21st meeting of the CCRI in 2009. The CCRI celebrated its first 50 years in 2009 with a historical overview of its work. The strategic plan was discussed with the main point being the investment in an accelerator at the BIPM as a matter of priority. A metrologically-proven clinical linear accelerator at BIPM would be advantageous to Member States but costly. It is fully supported by the stakeholder community, having patient safety in mind, as it would serve to achieve world-wide traceability and verification of medical accelerator beam-related dosimetry. A draft brochure emphasizing its benefits is in preparation; a good balance of needs and optimum use of financial resources can be struck. This planned investment was agreed by all three CCRI Section chairmen and the CCRI President. A general strategy document for the CCRI was discussed, which will help formulate the future programme of the CCRI and provide a convincing approach for the CIPM.

Special issues of *Metrologia* were published (an issue on neutron measurements is in progress). The BIPM 2013-2016 programme of work was endorsed. The CCRI gave its formal endorsements to the application for membership of the IAEA to the CCRI(I).

The meeting included summaries of all three Sections. The CCRI(I) has been renamed as “x- and γ-rays, charged particles”. In particular, the chairman of Section II had given an update on the preceding meeting of the Section including: the 50th anniversary lecture by Dr Heinrich Schrader; changes in the now-named Measurement Methods Matrix (MMM); active comparisons including the SIR; and the endorsed 10 year plan of key comparisons. The chairman reported that the BIPM programme of work had been endorsed by CCRI

Section II, including the extension of the SIR Transfer Instrument to other nuclides; new absolute measurement facilities with either large NaI(Tl) well or CsI(Tl) sandwich detectors; one or more ionization chambers to back-up the SIR [BqWG]; extending the SIR to pure alpha-emitters, low-energy gammas and electron capture radionuclides. Updated roadmaps showed the importance of full communication with the user community and of traceability in medical exposure.

In summary, special issues of *Metrologia* have been published, the future BIPM 2013-2016 programme of work was endorsed, a strategy document is under review, there was unanimous support to invite observers from international organizations to future CCRI meetings, and the current CCRI agenda attempts to reflect relevant points. It is proposed that CCRI Section II should add a description of its stakeholders to the strategy, reflecting its wide range of end users in health care, environment, security, industrial, analysis and research. The regulatory requirements in the ionizing radiation community and the wide range of radioactivity to measure, from extremely low (mBq) to very high (TBq), must be kept in mind. CCRI Section II actions also need to be well described in terms of: importance and difficulties of comparisons; implementation of the Measurement Methods Matrix (MMM) as a means of leverage; efforts towards the fields of applications; and evolving needs.

Prof. Kühne, the Director of BIPM, commented on the status of the accelerator project. The CIPM fully supported the project for the 2013-2016 programme of work and has included the project as part of the programme of work. However, the NMI directors had commented that they would find it very difficult to support a budgetary increase for the BIPM in real terms during their meeting in 2010. Thus, the possibility of funding the accelerator from the regular Member State dotation is remote. Prof. Kühne will ask for *voluntary* donations and will also address international organizations as interested stakeholders. A capital investment of 3.6 million Euros to 3.7 million Euros is needed. The accelerator remains a very high priority project, despite the fact that it cannot be financed from the regular dotation of the Member States.

6 REPORT OF THE KEY COMPARISONS WORKING GROUP (WORKING GROUP COORDINATOR: L. KARAM)

Dr John Keightley (NPL) gave a presentation on behalf of the coordinator, updating CCRI Section II on the Key Comparisons Working Group's (KCWG) objectives, membership, the biannual meeting schedule, and progress with work since the last CCRI(II) meeting. Amendments to the Measurement Methods Matrix (MMM) are a regular item on the KCWG agenda, because the MMM is a dynamic document which is regularly updated with the increasing knowledge about measurement methods and uncertainties typically achieved. During the reporting period, changes to the triple-to-double coincidence ratio method (TDCR) column were the focus. Methods to determine the key comparison reference value (KCRV) were widely discussed in several meetings and the proposals will be summarized for this CCRI Section II meeting under a separate agenda item. The VNIIM standardization of ^{137}Cs with the $4\pi\beta$ counting method (and the uncertainty estimation of its results) were critically reviewed and deemed not to meet the criteria of a primary method. Comparisons planned and those in progress were reviewed, including the large area sources comparison

(CCRI(II)-S10); the fate of the ^{90}Y microspheres exercise (CCRI(II)-S9) – which was finally abandoned due to presumed problems in the required dissolution and some legal issues; CCRI(II)-S8 ^{137}Cs, ^{40}K and ^{90}Sr in Bilberry powder matrix; issues with the beta spectral shape in the TDCR measurement of ^{241}Pu (CCRI(II)-K2); the CCRI(II)-K2 comparison on ^{177}Lu; the RMO comparison APMP.RI(II)-K2.I-131; and CCRI(II) supplementary comparisons CCRI(II)-S3 Shellfish, the report of which is now available in Draft B; and CCRI(II)-S7 on the uncertainty evaluation for Co-60 in 4πβ–γ coincidence counting, now a Draft A report.

The rolling 10-year plan of key comparisons was reviewed with some recommendations for change, and a new rule was proposed for final BIPM.RI(II)-K1 (SIR) report production. Furthermore, discussions were devoted to the matrix of "pair wise" equivalences reproduced in all key comparison reports, and also to problems encountered with glassware cleaning.

The KCWG meeting of 20 June 2011 was the first conducted as a *joint* uncertainty and key comparison Working Group meeting. Most of the items mentioned above were reported in more detail and discussed later in this meeting of CCRI Section II under separate agenda items. All delegates were asked to review the MMM (document CCRI(II)/11-10), in particular the column "applications" and the rows of "blue" radionuclides that are currently without uncertainties, and to send their comments to Dr Karam.

6.1 Recommendations of the KCWG(II)

After discussion of the KCWG recommendations, the CCRI(II) took the following decisions or, as appropriate, endorsed the recommendations for decision at the CCRI level:

- To merge UCWG(II) and KCWG(II), which have almost identical membership in order to rationalize membership and the number of meetings; a new remit remains to be made. A consensus decision is needed to recommend this change to CCRI.
- To streamline the KCRV reporting procedure for BIPM.RI(II)-K1 comparisons in order to increase the efficiency and speed of reporting. A full SIR Final Report reflecting the updated KCRV will be made only if the change to the KCRV is significant, the previous report is more than 10 years old, or the KCRV is defined by fewer than 5 values (document CCRI(II)/11-01).
- To adapt the 10-year plan for comparison exercises by postponing ^{131}Cs until its actual need is clarified, and to replace the comparison with ^{99}Tc, because ^{99}Tc has become a more important nuclide for many customers in the community. A potential pilot laboratory has been identified.
- To not consider standardizations of ^{137}Cs by 4πβ-counting as a primary method for inclusion in the KCRV. This decision will affect a new VNIIM result and an old CMI entry based on this method, which as a consequence will be removed as a contributor to the KCRV.
- To hold discussions on ^{241}Pu standardization with all participants of the key comparison, on 17 November 2011, as part of the KCWG(II) meeting at the BIPM on 17-18 November.
- To ask all CCRI(II) members to review the Measurement Methods Matrix (MMM).

- To recommend to the CCRI that the MMM is made available for open access, after a cautionary note on its use and additional explanations (i.e., of the acronyms used) were agreed by Section II (updated document CCRI(II)/11-10).

Later in the course of the Section II meeting, Dr Karam announced that Dr Keightley had agreed to be coordinator of the new combined key comparison and uncertainty WG following acceptance of this change by the CCRI.

6.1.1 Pair-wise degrees of equivalence

CCRI Section II endorsed the recommendation of the KCWG(II) for a decision by the CCRI to drop the matrix of pair-wise degrees of equivalence from key comparison reports. The graph of individual degrees of equivalence with the KCRV, which helps to illustrate the pair-wise relationships, will remain. The method and data needed to calculate the pair-wise degrees of equivalence will continue to be included in the reports, should the need for their determination arise.

6.1.2 Calculation of key comparison reference values (KCRV)

The KCWG(II) believed that time had come to broaden the discussion on how the KCRV is calculated. A working document with draft proposals by Pommé, Cox and Harris had been discussed in the KCWG, but it had not yet phrased a final recommendation. Two detailed presentations were given in this Section II meeting by Dr Pommé (IRMM) and Dr Michotte (BIPM) to explain the different approaches and the resulting options as discussed in the KCWG.

Dr Pommé explained that, so far, the KCRV has been calculated as the arithmetic mean, and its uncertainty from the amount of scatter (standard deviation). This would be acceptable if outliers had been reliably removed and the uncertainties of laboratory results did not contain useful additional information. The arithmetic mean would fail (as would the median) for situations where (some) individual result(s) have large deviation and large uncertainty, leading to a biased mean, and where there is low scatter of data with incidentally close values having large uncertainty, leading to too small an uncertainty in the KCRV.

The weighted mean would be the most efficient for consistent data sets. However, a weighted mean, with an uncertainty derived from claimed measurement uncertainties, is sensitive to uncertainties that are underestimated and would fail if there are discrepant data of low uncertainty leading to a biased mean with too low an uncertainty. The specific method of Cox, based on the weighted mean, uses the largest consistent subset after removal of outliers, more or less implying large data sets are necessary.

A Mandel-Paule-like mean, in which an inter-laboratory variance, s^2, is added to the weighting factors to allow χ to become 1, would be robust for slightly discrepant data, if measurement uncertainties are informative, and also for outliers symmetric in value or uncertainty. A Mandel-Paule-like mean would offer the best solution for both extremes; it approaches the weighted mean for consistent data sets and the arithmetic mean for discrepant data sets; it would be intermediate between arithmetic and weighted mean for somewhat discrepant data sets.

The Pommé-Spasova mean, which uses a power between 0 and 2 for weighting, would give robust results similar to the Mandel-Paule-like mean.

Dr Pommé summarized that not using measurement uncertainty, as in the arithmetic mean approach, would be a waste of available information leading to biased means. The weighted mean of discrepant data would also bias the mean and give an unrealistically small uncertainty. A Mandel-Paule-like mean with outlier rejection would give a more robust mean with a realistic uncertainty for moderately discrepant data. He concluded by saying that an up-to-date method should be used, comprising not only statistics but also input of expert knowledge for outlier rejection.

Dr Michotte had applied the calculation of alternative reference values following the methods presented by Dr Pommé to existing key comparison results. The objective was to investigate whether the expectation of minimized influence of slightly discrepant results on the KCRV would be met. The criterion for an outlier to be rejected would be if the difference between the laboratory value and the Mandel-Paule-like mean is k times larger than the uncertainty of the difference, where k was chosen to be $k = 2$. Dr Michotte's presentation covered the SIR comparisons for ^{137}Cs, ^{131}I, ^{152}Eu, ^{207}Bi, ^{56}Mn, ^{222}Rn, ^{57}Co, ^{64}Cu, ^{241}Am, ^{65}Zn and ^{177}Lu.

In summary, this exercise illustrated that, in 70 % of cases, the Mandel-Paule-like mean would be closer to the SIR efficiency curve than the existing KCRV, and in 35 % of cases it would prove to be less sensitive to slightly discrepant results, whereas in 10 % of the cases it would be more sensitive. In 20 % it would be equal and in another 35 % similar to the KCRV, most of these with smaller uncertainty. The number of outliers that would be rejected from the KCRV would increase in 45 % of cases.

In the discussion it was pointed out that the KCRV should reflect the metrological capabilities of the ensemble of NMIs, and as uncertainty budgets of the laboratories should also reflect their metrological knowledge, a higher number of outliers for the calculation of the best KCRV would be acceptable. This does not greatly affect the degrees of equivalence of the laboratories. Without having arrived at a definite conclusion, the suggested approach to combine modern statistical means with scientific-technical judgment was considered to be the right way to proceed.

6.2 Consideration of new results for inclusion in certain KCRVs

Dr Michotte recalled the present KCWG rules which are that a KCRV is calculated as the arithmetic mean of results from exclusively primary standardization methods (except for gas standards). Outliers, if any, are excluded from the KCRV using the normalized error test with $k = 4$. Following the 2009 CCRI(II) recommendations, updates for ^{22}Na, ^{60}Co, ^{75}Se, ^{88}Y, ^{99m}Tc and ^{166m}Ho were published. Contrary to the 2009 recommendation in the case of ^{111}In, only the PTB result was included in the KCRV, but not the LNE-LNHB result of 2006, as it is based on an ionization chamber measurement. An update for the ^{56}Co KCRV (now comprised of four results) had been agreed by email after the 2009 meeting of Section II.

New entries into the SIR with resulting updates to the KCRV were presented and discussed in detail by Dr Michotte. In particular, KCRVs consisting of only a few entries were influenced significantly by new results (^{177}Lu and ^{222}Rn), and for the nuclides ^{56}Mn, ^{64}Cu

and ^{207}Bi, KCRVs were established for the first time. Dr Karam reminded everyone that laboratories with results not included in the KCRV due to a secondary method used or non-standard mass or volume of solution in the ampoule will still remain in the equivalence tables and graph. The KCRV updates, as summarized in the following table, were accepted by CCRI Section II.

Nuclide	Old Value	New data from	New Value
Co-57	168 770 (350) kBq	IFIN-HH, NIST	168 780 (310) kBq
I-131	40 400 (40) kBq	CMI-IIR, IFIN-HH, NMIJ	40 388 (34) kBq
Cs-137	27 534 (42) kBq	IFIN-HH, NMISA	27 548 (46) kBq
Eu-152	14 942 (26) kBq	VNIIM, LNE-LNHB	14 942 (25) kBq
Am-241	2053.7 (3.3) MBq 2055.8 (2.8) MBq	RC, MKEH	2054.2 (3.1) MBq
Lu-177	555.1 (3.9) MBq	NPL, IRMM	558.9 (3.0) MBq
Rn-222	9961 (53) kBq	LNE-LNHB	9880 (90) kBq
Mn-56	---	BIPM, NPL	10 650 (40) kBq
Cu-64	---	PTB, NPL, CMI-IIR, LNE-LNHB	80 860 (380) kBq
Bi-207	---	PTB, LNE-LNHB	10 861 (28) kBq

7 BIPM.RI(II) KEY COMPARISONS

7.1 Present status of the SIR

Dr Ratel reported that in 2009, 17 new results were obtained by measurement in the SIR, concerning 12 different nuclides sent by 11 laboratories. In 2010, 13 new results for 11 radionuclides in ampoules from 4 laboratories were obtained for the SIR, among them ^{125}Sb was measured for the first time. To date in 2011, five ampoules were received. Since the inauguration of the SIR in 1976 until January 2011, 944 ampoules were measured, contributing to 699 independent results for 65 different radionuclides.

7.1.1 Linearity of the “new” SIR

Dr Michotte gave an update of the new SIR electronics; the electrometer had been replaced by a Keithley type 642, while keeping the principle of the Townsend balance and the set of capacitors unchanged. A LabView interface had been installed, and the system had been validated by measurements of the ^{226}Ra reference sources.

The linearity of the system was assessed using NMI ^{64}Cu and ^{99m}Tc submissions to the SIR and fitting the current ratio measurements (versus the ^{226}Ra reference sources) with time to the decay curves of the nuclides. The results were not entirely conclusive (for example, the expected non-linearities were not seen for all ampoules and may be related to other effects), but the magnitude of non-linearity is, in any case, insignificant for the new system and is smaller than with the original measuring system.

In the discussion, it was suggested to correct for ^{99}Mo as a possible source of non-linearity, and to perform longer measurements without removing ampoules for intermediate ^{226}Ra measurements as is foreseen in the normal SIR procedure.

7.1.2 Update on comparison reports

Dr Allisy-Roberts reported that there are 34 results for which the reports have not yet been finalized although the Draft A results had been issued. Based on the earlier decision to change the rules for key comparison reports, many of these results should be published soon in the agreed condensed format.

7.1.3 BIPM.RI(II)-K4.Tc-99m

This key comparison makes use of the SIR Transfer Instrument (SIRTI) to measure short-lived radionuclides, specifically Tc-99m, on site at a NMI. A new result for the NIST was published in 2010, and a measurement at the KRISS will be published at the ICRM conference. Another measurement is planned for September 2011 at the NMIJ. A call for participation in this key comparison is targeted at NMIs that are distant from the BIPM. In each category of potential participants listed below, priority is given to CCRI(II) members. Laboratories shown in bold have already declared their interest:

1. NMIs with primary standardization for ^{99m}Tc: NIM, **NMISA, VNIIM**.
2. NMIs with CMCs for ^{99m}Tc (even if not primary): **CNEA**, CENTIS, INER.
3. NMIs that cannot rely on another NMI for purchase of ^{99m}Tc calibrated and traceable to the SIR: **LNMRI**, BARC.

So far it has only been possible to perform one comparison per year with the SIR Transfer Instrument; it is planned to increase this to two comparisons per year.

7.1.4 Phasing out of early results (pre-1991) from the KCDB

With the phasing out of earlier results, NMIs have to identify whether using the Measurement Method Matrix (MMM) can provide a more recent key comparison that will support the radionuclide/method in question, or if they should send another ampoule of the same (or another) radionuclide. The ampoule submitted can be measured by the NMI in an ionization chamber, if the ionization chamber calibration is traceable to a primary standardization.

In the discussion, it was clarified that an advance warning will be sent by the CCRI Executive Secretary prior to any result being removed from the KCDB. However, it is the responsibility of each NMI to check the validity of their own results, so that they can plan

their appropriate actions. It was noted that an SIR comparison result for an ampoule calibrated in a NMI's ionization chamber cannot be used to support another radionuclide in the context of the MMM. This is because the MMM represents groupings of radionuclides and primary standardization methods, whereas a calibrated ampoule has no direct association with a primary method.

Dr Thomas requested that only the most up-to-date spreadsheet files be used when sending in changes to CMCs. She demonstrated how to retrieve these files from the BIPM website: *Via Committee structure to the JCRB, and then to the restricted access CMC site. In the Summary "get published CMCs", choose the metrology area and the country to download the valid file.*

It was remarked that EURAMET had recommended to the members of its ionizing radiation section to limit this year's CMC changes to updating what is necessary, in particular column P (supporting evidence), clarifications to uncertainty column L, and other changes not requiring interregional review. This recommendation was intended to reduce the general workload involved in examining CMCs.

8 CCRI(II) AND RMO KEY COMPARISONS

8.1 Results and reports of activity measurements

8.1.1 Reports published since June 2009

Dr Allisy-Roberts showed the comparison reports that had been published on the website in *Metrologia Technical Supplements* since June 2009: the APMP regional key comparison on ^{133}Ba, the re-evaluation of degrees of equivalence for the APMP RMO comparison on ^{166m}Ho together with the inclusion of results from IRA and NPL in the BIPM.RI(II)-K1.Ho-166m on-going SIR comparison, and the other SIR comparison reports on ^{22}Na, ^{60}Co, ^{75}Se, ^{88}Y, ^{99m}Tc and ^{56}Co leading to KCRV updates as mentioned earlier in section 6.2. A first comparison report on ^{64}Cu with a primary standardization result of PTB was published in 2009; consequently, while the PTB results agree with the value deduced from the SIR efficiency curve, no KCRV can yet be produced.

8.1.2 Results and progress of reports for ^{3}H, ^{85}Kr, ^{177}Lu, ^{241}Pu, ~~^{241}Am,~~ ~~^{55}Fe~~, ^{89}Sr, ~~^{32}P,~~ ~~^{125}I,~~ ~~^{65}Zn,~~ ~~^{54}Mn,~~ ~~^{192}Ir,~~ ~~^{90}Sr~~

Dr Ratel presented the results of the **CCRI(II)-K2.H-3 tritiated water comparison**. The LNE-LNHB was the pilot laboratory providing the sources for this comparison which had 19 participants. The deadline was postponed from 31 May to 30 June 2009. Six different methods were used: TDCR, LSC (CIEMAT/NIST) with in-house ^{3}H or commercial ^{3}H standards, the LSC CIEMAT/NIST method using ^{54}Mn as efficiency tracer, internal gas counting, efficiency tracing with a Compton electron source, and digital TDCR with a resolving time of 240 ns. A total of 22 results were received from 15 laboratories. The stated uncertainties varied by more than a factor of 4. With one result evaluated as an outlier, 14 laboratory results contributed to the mean of 37.15 (19) kBq·g^{-1}.

Dr Ratel also presented the results of the **CCRI(II)-K2.Sr-89 comparison**. The PTB was the pilot laboratory providing the sources for the 19 participants, having identified impurities of ^{85}Sr, ^{90}Sr, ^{84}Rb and ^{86}Rb in the solution. The dispatched solution had an activity too low to be measured directly in the SIR so the PTB kindly sent six ampoules of undiluted solution to the BIPM. The mass of the solutions were different and had to be corrected for the normal 3.6 g (which amounted to slightly more than 1 % correction) to determine the equivalent activity in the SIR. Four different liquid scintillation methods had been used by the participants: CIEMAT/NIST, TDCR, 4πβ LSC, and LSC with ^{14}C as internal tracer. And in addition, 4πβ–γ efficiency tracing with ^{24}Na, ^{60}Co or ^{134}Cs as a tracer, 4πβ CsI(Tl), 4π PPC with a large counter and 4π PC were used. Dr Ratel discussed the results method-wise in some detail; most of the techniques gave results which agree to better than 1 %. Three results obtained with 4πβ–γ efficiency tracing with ^{60}Co, however, deviate rather more from the mean value. The detection efficiency of the ^{89}Sr γ-ray, deduced from the individual equivalent values, was close to the value deduced from the SIR efficiency curve. With these results, the SIR can also be used to evaluate degrees of equivalence for the ^{89}Sr determination. In the discussion it was pointed out that the ^{60}Co discrepancy for 3 of the 5 results when using this as a tracer is not surprising in view of the large difference in emitted energy. It was requested that ampoules of ^{24}Na, used in this comparison for efficiency tracing by two laboratories, be sent to the BIPM for measurement in the SIR, if these solutions had been standardized using primary methods.

Dr Johansson presented the status of the **CCRI(II)-K2.Pu-241 comparison**. The NPL was the pilot laboratory and there were 7 participants. The solutions were distributed in November 2009, and the deadline for reporting was postponed from 31 May to 30 September 2010. The importance of this nuclide is underlined by the fact that its activity in reactors is about 500 times that of ^{239}Pu. Impurities in the solution were determined by mass spectrometry (at IRMM on behalf of NPL as pilot) and by alpha- and gamma-spectrometry by all the participants. Four laboratories used the CIEMAT/NIST method, five laboratories TDCR, and three laboratories used the in-growth of ^{241}Am measured with α-spectrometry, γ-spectrometry or 4πα–γ anticoincidence counting. The ^{241}Pu beta spectrum has a very large impact on the results. As a complement to theoretical considerations, the LNE-LNHB determined the beta spectrum by cryogenic methods. In view of the difficulties observed in this comparison, all the scientists who performed the measurements at the participating laboratories are recommended to attend the ^{241}Pu standardization discussion meeting in November 2011 as decided earlier in section 6.1.

Dr Karam reported on the **CCRI(II)-K2.Lu-177 comparison**, piloted by the NIST with 12 participants. The Draft A report was accepted by all participants and will now be converted into a Draft B report, and will be reported at the forthcoming ICRM conference. Eleven laboratory results are being used for the KCRV. Two ampoules (IRMM, NPL) were sent to the SIR but the NIST ampoule gave a different result in the SIR than was expected from its equivalence with the NPL ampoule in the key comparison.

Dr Ratel reported on the status of the **CCRI(II)-K2.Kr-85 comparison**, piloted by the LNE-LNHB together with BIPM for the SIR measurements. Prior to distribution, all 10 ampoules had been measured in the SIR. The methods used by the 7 participants were γ-spectrometry, 4π (PC) internal gas counting, and measurement in a calibrated ionization chamber. However, conclusions cannot yet be drawn and the report is in preparation.

8.1.3 RMO key comparison reports

Although a number of reports are in progress there were no reports to present to the CCRI(II). Some RMO comparisons are discussed further in section 9.

8.2 Present CCRI activity key comparisons

The following CCRI(II)-K2 comparisons have the status of a report being in progress as Draft B: ^{55}Fe, ^{32}P, ^{238}Pu, ^{204}Tl, and recently also ^{3}H, ^{85}Kr, ^{177}Lu, ^{89}Sr, and ^{65}Zn. The reports for ^{125}I, ^{54}Mn, ^{90}Sr, ^{32}P, and recently also ^{241}Pu have Draft A status. The reports for CCRI(II)-K2 key comparisons on ^{241}Am and ^{192}Ir have been published.

8.3 Present RMO activity comparisons

The APMP key comparison on ^{131}I now has a comparison report at the Draft B stage, whereas the status of the COOMET key comparison on ^{152}Eu is presently unknown.

The Tuesday session was concluded with an invited seminar given by Dr Akira Yunoki (NMIJ/AIST) entitled “The consequences of the earthquake in Japan and NMIJ measurements regarding the Fukushima nuclear power plant”.

The earthquake of 11 March 2011 was felt in the NMIJ/AIST building with a gradually increasing amplitude. Whereas earthquakes usually last up to a maximum of 1 minute, this quake had a duration of 5 minutes. Most of the equipment at the NMIJ, including safes for sources, remained intact. With a magnitude of 9.0, this earthquake was the largest ever recorded in Japan. Its epicentre was at a depth of 24 km off the coast. The immediate impact did not destroy many buildings even closer to the epicentre on the coast line. The large magnitude of the earthquake resulted in repeated aftershocks, even after 3 months. However, the aftershocks have not disturbed the calibration measurements continuing at the NMIJ/AIST.

The tsunami induced by the earthquake caused devastating damage in the Tohoku region. It has not been possible to estimate the actual height of the tsunami wave yet due to the damage caused.

As background to the Fukushima accident, Dr Yunoki said that 54 nuclear power plants in Japan produce one third of the country’s electricity consumption. Five of the six units of Fukushima I (Daiichi), which were operating at the time of the earthquake, were correctly shut down by the emergency systems (injection of control rods) at 14:46 local time. At 15:27, the tsunami hit the NPP site, resulting in a breakdown of the electricity supply at 15:42 and a loss of the emergency core cooling one hour later. Starting the next day and repeatedly during several following days, reactor vessels had to be vented and massive hydrogen gas explosions occurred, which caused serious damage. The precise evolution of the events that followed, such as lack of cooling water, cracking and melting of fuel rods, and (partial) meltdown of fuel cores is not known yet.

Emergency management plans by the operator TEPCO anticipate the construction of containments around the reactors during the next 6 to 8 months to seal them off as a source of contamination. Testing of decontamination of the huge volumes of cooling water has started.

The NMIJ engaged early in dose-rate and activity measurements at two points on the AIST campus: a balcony on the third floor and 1 m above ground at several metres from the building. The wind direction turned towards Tsukuba (site of the AIST) on 15 March and rain fell on 21 and 22 March, resulting in fallout of radioactivity being registered. The gamma dose-rate increased on 15 March from 0.1 to 1.5 μSv/h registered as a peak maximum. On 15 June, dose-rate values had fallen to 0.1 μSv/h again. Activity monitoring of swipes taken from vinyl sheets spread on the ground was used to inform the public on radionuclides present in the fallout: ^{132}Te, ^{131}I, ^{132}I, ^{133}I, ^{134}Cs, and ^{137}Cs were identified.

As support to neighbouring prefectures, surface contamination measurements were performed, and seminars were held at the NMIJ to train regional government employees in contamination measurements and the estimation of surface contamination. The NMIJ/AIST pinpointed two underlying problems: there were no accepted criteria for surface contamination of industrial products in existence, but some governments wanted such measurements due to fears of potential trade problems. A second concern is with the written standards themselves that prescribe several mm distance from the surface for measurements, which is difficult to realize. As a first step towards quality management, the NMIJ introduced a procedure for surface contamination measurements. Messages on the AIST website explain the measurement procedures that are in place in Japan, and the concept of traceability and the CIPM MRA.

9 PROGRESS WITH CCRI(II) AND RMO SUPPLEMENTARY COMPARISONS

Dr Karam informed the CCRI(II) that the comparison CCRI(II)-S3 “shellfish” now has a Draft B report, which was sent to BIPM on 23 May 2011. Dr Yunoki added that the RMO comparison APMP.RI(II)-S1 on the surface emission rate of charged particles from a ^{36}Cl source is now at the Draft A report stage. The status of other supplementary comparisons not discussed in detail below is as follows: CCRI(II)-S6.Co-57 and CCRI(II)-S6.I-131 are in Draft B report stage, the report of COOMET.RI(II)-S2 on Sr/Y-90 is available as a Draft A report, and the measurements for APMP.RI(II)-S2.Ho-166m were complete.

9.1 Supplementary comparison on uncertainty estimation CCRI(II)-S7

Dr Bochud reported on the progress of this comparison on uncertainty estimations for the standardization of a ^{60}Co solution using the data from $4\pi\beta-\gamma$ coincidence counting measured at NPL. Activity concentration and uncertainty had to be calculated for the comparison data with special emphasis on extrapolation and weighing (source preparation). All calculated activity concentrations were consistent within 0.03 %, but the estimated uncertainties spanned a range of 2.6. For some uncertainty components, very large differences between participants’ estimates were observed. Also the estimation of weighing uncertainties varied significantly, possibly due to different approaches in substitution weighing (for example the DKD method with fixed uncertainty for weights versus NPL certificate of weights). Some uncertainties proposed also differed in attribution of Type A or B evaluation. Although most participants used the least-squares method for extrapolation, all extrapolation lines were different; no participant obtained overlapping intercepts for both gates with the y-axis. In spite of the surprisingly different extrapolations, the final values for activity concentration

were compatible, which supports the robustness of coincidence counting. The Draft A report will be sent to the participants after this present meeting of CCRI Section II.

9.2 Supplementary comparison on activity measurements in a rice matrix CCRI(II)-S9

Dr Park explained the protocol of this CCRI(II) comparison piloted by the KRISS and gave some background information. For Asian countries, rice is a predominant food component; for example, each Korean eats about 80 kg of rice per year. The rice for the comparison was grown in a paddy field in a greenhouse, with ^{137}Cs added to the water. The harvested rice was air dried in the greenhouse and irradiated with ^{60}Co to prevent degradation. Its moisture content at the time of bottling (in units of 150 g) was 8 % to 10 %. The participants are requested to determine the activity concentration of ^{137}Cs and ^{40}K.

Samples will be issued until the end of 2011; results are expected within 2 months after receipt of the samples. The Draft A report will be issued early in 2012. So far, the Copernicus University – Bratislava, **NIST**, US FDA, IAEA Seibersdorf, IAEA Monaco, UK NOC, Radiation Protection Bureau – Health Canada, **LNE-LNHB**, KAERI, **PTB, IRMM**, Nuclear Research Institute – VAEC Vietnam, and **Nuclear Malaysia** are participating (NMIs, which can contribute to the KCRV are shown in bold). Nine of these 13 laboratories have already sent their results to the KRISS.

Since this CCRI(II) comparison is still open for participation, several more laboratories represented at the Section II meeting declared an interest to participate: LNMRI/IRD, NMIJ, NIM, NPL, IFIN-HH, BARC, ENEA-INMRI, BEV, MKEH. CNEA, CIEMAT and the VNIIM (through a partner institute) are considering participation. In addition it was proposed that the CENTIS-DMR and other laboratories from COOMET and possibly AFRIMETS should also be approached.

9.3 Large area sources comparison (LASCE) CCRI(II)-S10

Dr Unterweger presented an update of the status of the large area sources supplementary comparison on behalf of Dr de Felice from the pilot laboratory ENEA-INMRI. Calibration of surface contamination monitors is generally undertaken using anodized reference sources. The NMIJ is also providing reference sources prepared with an ink jet printer. The technical requirements for such sources are given in ISO and IEC standards, among them ISO-7503 and ISO-8769. The only comparison conducted to date has been the RMO comparison of the APMP on the beta-particle emission rate from large area sources of ^{36}Cl.

The present comparison was proposed in 2007 at an ICRM Working Group meeting and endorsed as the CCRI(II)-S10 at the last meeting of CCRI(II) in 2009. Participants will be mainly NMIs and designated institutes (DIs) for activity measurements, but other laboratories involved in calibration of large area reference sources can participate, if their country's NMI agrees. To date, 24 laboratories from 18 countries have been enlisted. The measurand is the emission rate of beta/alpha particles into 2π sr solid angle. For beta particles, a threshold of 0.590 keV according to ISO-8769 will be set. The nuclides ^{14}C, ^{147}Pm, ^{90}Sr/^{90}Y and ^{241}Am will be used, prepared as flat 100 mm x 100 mm anodized Al sources. The same sources, distributed according to a schedule planned by the pilot laboratory, will be measured by all the participants.

During a discussion of the source distribution schedule, Dr Wätjen suggested planning for more intermediate check measurements beyond the anticipated single re-measurement by the PTB at the end of the comparison. It emerged that such checks could be made, for example, before and after the sources enter or leave a different continent or Russia. Dr Keightley added that, since the UK has 6 participants, NPL could measure at the beginning and the end of the UK round. CCRI Section II recommended revising the time schedule taking these concerns into account. Furthermore, Dr Arnold mentioned that a proposal to review problems that arise with the ISO standards will be discussed at the ICRM conference.

9.4 Supplementary comparison on activity measurements in bilberry CCRI(II)-S8

Dr Wätjen from the pilot laboratory IRMM reported the status of this comparison of activity measurements of a bilberry matrix reference material, which was also endorsed at the CCRI(II) meeting of 2009. The material was a dried powder of bilberries harvested in the region of Chernobyl. The bilberries had metabolized increased levels of ^{137}Cs and ^{90}Sr due to fallout from the nuclear power plant accident of 1986. In collaboration with the Reference Materials (RM) unit of IRMM, the material had been well homogenized and bottled in approximately 1200 units of ~100 g. Since the results of the supplementary comparison will be used to establish the property values for this reference material, the participants received six samples each to provide six individual analyses in accordance with RM certification requirements. In addition to the activity concentrations of the anthropogenic radionuclides ^{137}Cs and ^{90}Sr, the participants were also requested to determine the activity concentration of natural ^{40}K.

In late summer of 2010, samples were distributed to the 10 participating laboratories. An incorrect drying procedure was originally issued with the samples, resulting in a delay until the end of November 2010 so that the corrected drying instructions could be supplied. To compensate for this delay, the original deadline of the end of January 2011 was extended until 24 February 2011 to report results for the gamma-ray emitters, and to 22 April 2011 for the ^{90}Sr results. The status of the comparison at the time of the Section II meeting was that all measurements were complete. One laboratory still needed to reply to the invitation of the pilot laboratory to check its results of ^{90}Sr for possible numerical errors. Dr Wätjen mentioned that the standard deviation of the results for ^{137}Cs and ^{40}K was of the order of 5 %. Responding to the question as to when the Draft A report would be prepared, Dr Wätjen replied that this would be towards end of 2011 after the ICRM conference.

10 FUTURE CCRI(II) AND BIPM (SIR) KEY COMPARISONS

10.1 Recommendations for SIR (BIPM) comparisons (call for submissions)

Dr Michotte repeated the call to NMIs to submit ampoules to the SIR when they make primary standardizations in order to improve the KCRVs. She presented lists of radionuclides for which primary results are particularly needed, either because no KCRV is defined yet (^{47}Sc, ^{113}Sn, ^{140}Ba, ^{155}Eu, ^{195}Au, ^{243}Am), or the KCRV is based on very few results (^{24}Na, ^{56}Co, ^{56}Mn, ^{64}Cu, ^{99}Mo, ^{103}Ru, ^{106}Ru, ^{109}Cd, ^{123}I, ^{124}Sb, ^{133}Xe, ^{153}Gd, ^{153}Sm, ^{154}Eu, ^{166m}Ho, ^{177}Lu, ^{207}Bi, ^{222}Rn), or the KCRV is defined with inconsistent primary results:

^{57}Co, ^{58}Co, ^{67}Ga, ^{75}Se, ^{111}In, ^{144}Ce, ^{169}Yb, ^{201}Tl, and ^{203}Hg. Dr Keightley mentioned that the BIPM will soon receive an ampoule of ^{153}Gd from the NPL.

10.2 Recommendations for CCRI(II) comparisons

10.2.1 Rolling ten-year plan

As decided earlier in this Section II meeting, the ^{131}Cs comparison will be postponed until it is clarified whether this nuclide is important for the wider community; instead, a ^{99}Tc comparison will be started soon with the NPL as the pilot laboratory supported by NIST. Laboratories interested in this new key comparison were: LNMRI/IRD, IFIN-HH, CNEA, NMISA, BARC, KRISS, NMIJ, NIM, NIST, CIEMAT, PTB, IRMM, NPL, VNIIM, CMI, RC, IRA, LNE-LNHB, ENEA-INMRI, BIPM, and possibly BEV.

In view of key comparison results being phased out from the KCDB, everyone was reminded that ^{109}Cd, ^{228}Th, ^{222}Rn, ^{123m}Te, ^{137}Cs, ^{133}Xe are radionuclides which can be measured in the SIR and thus can be used – after primary standardization – to prevent CMCs from becoming invalid. Dr Karam further remarked that the scheduled years in the present 10-year plan should not be taken too strictly as a new rolling 10-year plan will be prepared by the KCWG shortly.

10.3 Registration of new RMO key comparisons

Representatives from the APMP announced that it is planning a key comparison of ^{59}Fe activity measurements. APMP was invited to submit a comparison proposal form.

11 WORKING GROUP REPORTS

11.1 Uncertainties (Working Group Coordinator: M. Unterweger)

Dr Unterweger reported on the meetings of the Uncertainties WG that took place in April 2010, November 2010 and June 2011. The meeting just prior to this Section II meeting had been held as a first joint meeting with the Key Comparison WG. A *BIPM Monographie* (or a special issue of *Metrologia*) dealing with uncertainty analysis for various radionuclide measurement techniques is in preparation. A draft should be available by the next CCRI(II) meeting. The WG had prepared a recommendation for CCRI(II) to encourage the radionuclide metrology community to detail exactly how a reported measurement uncertainty was derived in order to correctly follow the GUM. Following a discussion it was decided to accept the recommendation that the GUM requirement to provide detailed information on how the uncertainties are derived should be followed.

11.2 Realization of the becquerel at the basic level (Working Group Coordinator: U. Wätjen)

The coordinator presented the progress that had been achieved since a bilateral stocktaking meeting between the IRMM and the BIPM in Sèvres, shortly after a new post-doc researcher had been recruited by the IRMM in 2010 to undertake this project. The previous

WG meeting in June 2009 had concluded that a new design of a reproducible ionization chamber (with better definition of the measurement volume, consideration of the impact of an additional wall on efficiency variation/reproducibility, geometric efficiency losses, etc.) was needed. In two WG meetings held in November 2010 and April 2011, the results of the work achieved had been discussed and further research to be undertaken, mostly at the IRMM, was agreed.

Key elements of this progress were software developments (e.g., Geant4 MC simulation package incorporated into a ROOT environment), making the analysis of simulation results much more flexible; examples were presented that demonstrated the possibility of considering a segmented inner well (short central part), which would be easier to machine to the required tolerances, and mesh-structured materials or rolled metal sheets as alternatives for the electrode. Dimensional and radio-purity specifications of the lead shield, the need for a new source holder (designed for reproducible source positioning), and the need to understand and control stray capacitance and leakage current (for low current measurements) were also discussed. Since the wall thickness and inner diameter were shown to be the critical parameters of ampoules in the low-energy region, the working group decided it was worthwhile to distinguish between general use or low-energy applications and reproducibility testing of the chambers. Several options were considered (non-destructive methods, select sub-batches of ampoules and plastic ampoules for chamber testing).

It has become clear that a Be alloy as the inner well material would be a viable, but expensive solution. A company was identified that could produce the well tube in Be S200F alloy within the fine tolerances required. The costs, however, would be between 44 000 US $ and 59 000 US $ per tube depending on the number of units ordered. Simulations had shown that with this Be alloy all the challenging requirements for a reproducible signal response at low-energy (down to 20 keV) gamma-radiation would be fulfilled. In view of the high costs, however, two alternatives – the machining of the tube in Mg alloy or in three sections of Al – would still be evaluated, and Be will be considered only if the other options fail to produce the required results. Micro x-ray computed tomography was identified as a method to select a sub-batch of ampoules with small dimensional tolerances in wall thickness and inner diameter for testing purposes. Further progress will largely depend on experimental work with the existing ("old design") prototype chamber at the IRMM, which will be used to test new components such as the inner well machined from Mg alloy, and to validate MC simulations. At the time of this Section II meeting, a new source holder was already available, and work on a stable low-current source to allow testing of the electrometer system was being pursued.

The costs for constructing a "new design" prototype were discussed; depending on the material to be used (e.g., Be alloy), costs may be between 60 k€ and 100 k€. Even if a suitable electrometer system were available and Be alloy were not needed for the inner well, the machining costs of the ionization chamber itself, following the new design, were estimated at 20 k€ to 30 k€. The coordinator considered it feasible that a definite design can be achieved, and one or more prototype chambers built, within the next BIPM programme of work for 2013-2016. The next BqWG meeting was announced for 16 November 2011.

11.3 Extension of the SIR to pure beta emitters (Working Group Coordinator: J.-M. Los Arcos)

The coordinator gave an extensive presentation on the recent progress made by the WG in developing and implementing a self-consistent scheme for including the alpha- and beta-emitters within the SIR. From previous WG meetings (three since the last CCRI(II) in 2009), the specifications for the operation of the ESIR at the BIPM can be summarized as: NMIs should be able to standardize a pure beta-emitting radionuclide and to send a solution to the BIPM for contribution to the ESIR and the BIPM should have a measurement method to establish degrees of equivalence. The reference scintillation cocktail needs to have a well-defined and highly reproducible composition, for example XAN6040 has been shown to function well with about 20 radionuclides; it can be prepared in the laboratories with high reproducibility and has an efficiency comparable to commercial products. Two operational comparison approaches have been proposed: the "apparent activities" method based on TDCR or CIEMAT/NIST models, and the "apparent efficiencies" method. The latter method does not require a standardized tracer nuclide, any decay model, nuclear data, or even standard nuclides. It does not depend on instrument, scintillator or volume. It is based on the definition of a universal cross-efficiency curve for each radionuclide, which will continuously be improved by the cumulative contributions of the NMIs. It does however require a tracer nuclide, e.g. ^{3}H or ^{14}C that does not need to be standardized. Preliminary tests of this method were made in 2010 at CIEMAT, and Dr Los Arcos presented a number of results of cross-efficiency curves for 7 nuclides using ^{3}H, and for 3 nuclides using ^{14}C as the tracer. The best sensitivity is obtained with a tracer nuclide with a short half-life and low energy (^{3}H), and the method is also applicable to ^{3}H as the radionuclide for activity comparison.

A trial comparison of ^{63}Ni and ^{3}H was initiated during the WG meeting of November 2010 with 7 participating laboratories and 2 pilot laboratories; CIEMAT and BIPM. This was still in progress at the time of the Section II meeting. Both ESIR comparison approaches were being tested, the "apparent activities" method in the TDCR systems of the BIPM and the LNE-LNHB, and the "apparent efficiencies" method using commercial LSC counters at both the BIPM and the CIEMAT. The participating NMIs prepared and standardized ^{63}Ni solutions and sent aliquots of the solution to the BIPM and the CIEMAT for the comparison measurements. At the time of the CCRI(II) meeting, CIEMAT had measured ^{63}Ni ampoules from the PTB, IRMM, NMISA and the LNE-LNHB using two LSC counters with 2 different volumes and the results had been evaluated. Some ^{63}Ni and ^{3}H measurements at the CIEMAT were still in progress. The measurements at the BIPM are reported in section 11.3.1 by Dr Ratel.

Dr Karam inquired about the time frame needed to decide whether the presented approaches to the extension of the SIR to beta emitters can be considered to be established. After completion of the present comparison, the coordinator sees the need to clarify several practical implementations and to write a *Monographie* documenting the whole procedure and operation of the ESIR. Dr Johansson stated that the NPL would like to participate in the trial comparison. This proposal was welcomed in particular as it could serve to demonstrate that there are no adverse effects of the methods over a longer time scale. The next ESIR WG meeting will take place on 16 November 2011.

11.3.1 Pilot comparison with ^{63}Ni

Dr Ratel reported the status of the ^{63}Ni pilot comparison at the BIPM for the ESIR WG. Both methods to extend the SIR to β emitters were to be tested. Whereas the measurements for the TDCR approach proposed by NMISA were not yet complete, Dr Ratel presented the results of the measurements for the "apparent efficiencies" method with standardizations and ampoules of ^{63}Ni from all 7 participants. Three commercial scintillators (Ultima Gold, Hionic Fluor and BioFluor+) were used to prepare samples gravimetrically. Measurements were performed in three LSC counters at the BIPM and LNE-LNHB. Quench curves were recorded using the ^{3}H solution of the CCRI(II)-K2 comparison with the addition of nitromethane. The results presented in detail showed linear universal curves of $\varepsilon(^{63}\text{Ni})$ versus $\varepsilon(^{3}\text{H})$ for Ultima Gold and also for Hionic Fluor, albeit at lower values. For BioFluor+, two groups of results were obtained that differed by 7 %, which may be due to an instability of the scintillator and this needs to be studied.

11.4 High-efficiency photon detection systems (Working Group Coordinator: G. Winkler)

Dr Allisy-Roberts reported that despite some unavoidable delays, Prof. Winkler has recently completed the initial 25 pages of the anticipated *Monographie*, and is keen to finish the whole manuscript. Dr Maringer, who is in contact with him, added that Prof. Winkler is planning to finish the manuscript in 2012. At that time, a WG meeting could be held in Vienna, Austria.

11.5 SIR Transfer Instrument (Working Group Coordinator: C. Michotte)

Dr Michotte reported that the BIPM.RI(II)-K4 comparison for ^{99m}Tc was running smoothly, explaining that she hand-carried the NaI detector part of the SIR Transfer Instrument (SIRTI) to keep the temperature of the crystal at acceptable in-cabin levels. Hence, there had been no need to hold a WG meeting since the last CCRI(II) meeting in 2009. Dr Michotte reported that the main achievements since 2009 included the close agreement of MC simulations with experimental efficiencies based on the three available results of the LNE-LNHB, NPL and the NIST. The effect of solution drops on the inner ampoule walls observed at the NIST (of the order of $2 \cdot 10^{-3}$ for 11 drops) was reproduced well by MC simulation. Due to the comparatively shallow well of the NaI crystal, the SIRTI response was found to be more sensitive to solution volume than to mass. Accordingly, the SIRTI protocol has been changed, requiring now 3.6 (1) cm^3 instead of 3.6 (2) g that is the case for the SIR. Other points mentioned were: the base thickness of SIR ampoules has a much smaller influence than the walls because of the small solid angle subtended; there are negligible effects from the shape of the ampoule head, the solution chemistry or the glass composition (as long as glass data from BIPM *Monographie* 6 are used). The two largest components in the uncertainty budget for SIRTI measurements are ampoule dimensions and filling height with $7 \cdot 10^{-4}$ and $6 \cdot 10^{-4}$, respectively (relative standard uncertainty). For full traceability to SIR, the uncertainty components of the SIRTI link to SIR of $1.6 \cdot 10^{-3}$ and the NMI standardization both need to be added to the budget that was presented.

The results of the KRISS comparison held in 2010 will be reported at the ICRM conference in September 2011 and the NMIJ measurements will also be made in September 2011,

having been postponed because of the earthquake in Japan in March 2011. A BIPM report on the SIRTI development is in preparation. The extension of the SIRTI to ^{18}F is in progress and the first tests with a PVC liner to suppress electron contributions have been successful. A TI WG meeting is planned for May 2012.

12 TRENDS AND FUTURE METROLOGICAL NEEDS (PREVIOUSLY AGENDA ITEM 14)

12.1 President's report for the CGPM

All CC Presidents had been asked in March 2011 to submit a very brief report (of only 6 pages) for the CGPM. Dr Carneiro presented his report (document CCRI(II)/11-28), opening with CCRI at a glance, introducing the Section structure, traceability issues in ionizing radiation, the quantities covered and their units and ranges. Typical levels of uncertainties are 1 % at standard laboratories, and 5 % at the applied level (in nuclear medicine and radiotherapy). Indeed, CMCs in the ionizing radiation field are under pressure from the low uncertainty requirements in cancer treatment.

The CCRI is the third largest CC in terms of CMCs, with the majority coming from the SIR, the common scale of activity measurements for about 65 radionuclides. The SIR is a unique BIPM facility. The CCRI directly benefits the network of SSDLs operated by the WHO and the IAEA that includes many States whose institutes are not signatories to the CIPM MRA. Dr Carneiro believes that the CCRI profits greatly from the BIPM Ionizing Radiation Department, particularly CCRI Sections I and II.

Of the many achievements of the CCRI, the President highlighted the proposal for a medical-type linear accelerator at the BIPM, the adoption of a strategic plan for the CCRI, and reflected on the first 50 years of the CCRI. The plans for the linear accelerator are based on very solid arguments, the most important being the ability to assure the equivalence in dosimetry for radiotherapy, particularly for countries which do not have their own standards facilities. The strategic plan structures the future actions of the CCRI into short-, medium- and long-term actions, and sets priorities, which will be continuously updated to take account of the progress achieved and to ensure their validity. The President appreciated very much the special sessions two years ago that celebrated the achievements of the CCRI over 50 years.

End users of radiation metrology include the 7 million patients treated by radiotherapy, the 33 million people diagnosed or treated using nuclear medicine and the 360 million people diagnosed using x-rays each year. In addition, about 11 million workers are monitored because of potential exposure in their profession. Dr Carneiro commented that the global need for emergency monitoring became prominent in the aftermath of the Fukushima accident, when the level of awareness of the need for radiation metrology associated with nuclear energy increased dramatically, especially in Japan.

One of the peculiarities of the CCRI is that a large part of ionizing radiation metrology is undertaken by designated institutes rather than NMIs, and the CCRI is working towards a means of integrating them more closely. The 3864 CMCs of the CCRI are supported by 193 active key and supplementary comparisons, 137 of these are executed as BIPM comparisons demonstrating the strong engagement of the BIPM in the work of the CCRI.

The measurement methods matrix (MMM) has proved its usefulness by cross-linking comparisons of one radionuclide to nuclides requiring similar measurement approaches.

Future challenges include the transfer of traceability from primary standards to patient treatment to ensure optimized treatment in radiotherapy and nuclear medicine. In spite of the nuclear power accident in Japan following the devastating earthquake and tsunami of 11 March 2011, the world will need nuclear power to bridge the energy gap until a viable sustainable energy supply can be established. Increased efforts in ionizing radiation metrology will be required, namely to improve neutron cross-section data for modern generations of power plants, to provide metrology for environmental monitoring of radioactivity as well as for security needs in protecting the public against ever-present terrorist threats, by monitoring radioactive and nuclear material. With the priority actions planned for the period 2013 to 2018, the CCRI is well prepared and forward-looking to take up these challenges.

Discussing the President's report, Dr Arnold suggested that natural radiation sources be mentioned because radon, for example, produces about half of the natural radiation dose to which populations are exposed. Prof. Chavaudra inquired about work on low-energy beta emission spectra as these are important to assess the dose from medical procedures. He was reminded that the BIPM *Monographie* 5 contains emission spectra. Dr Carneiro asked for pictures of metrology equipment being used with reference to its size, as such material would be very useful for his presentation to the CGPM.

12.2 Strategy for the CCRI (draft paper)

All the CC chairs had been charged with producing a strategy document for the CIPM. The boundary conditions are such that the CIPM, as the management body of the BIPM, cannot decide the BIPM budget; that is the prerogative of the CGPM, and certainly not the budgets of the participating NMIs. Therefore, a CC strategy paper should contain the agreed BIPM programme of work and the NMIs with time estimates, which would provide a reference for stakeholders.

The draft paper presents the mission and tasks of the CCRI, and includes the internal structure of CCRI Sections and Working Groups. A full list of stakeholders is given, listing end-user stakeholders such as laboratories requiring calibrations separately. The vision and strategy of the CCRI are phrased to respond to present, emerging and long-term needs in timescales of 8 to 12 years, and to provide for the engagement and distribution of work among the stakeholders.

All actions are listed, structured into short-term actions with a time scale of 1-4 years, i.e. within the present programme of work, but also including ongoing actions, such as ongoing BIPM comparisons. Medium-term actions cover a timescale of 4-8 years, i.e. the BIPM programme of work for 2013 to 2016. The 5 long-term actions cover 12 years or more. The supervision of WGs is explicitly mentioned as a task of the CCRI and its Sections. The further description of stakeholders and actions needs to be refined and the Section chairmen will assist with this task. The draft paper closes with a detailed description of the WGs based on their individual remits and objectives.

Dr Karam reminded participants that the purpose of the strategy paper is to aid the CCRI and the BIPM. Since the MMM is of such importance in structuring the Section's future

comparison work, it should be more prominent and have a separate action line. All WG coordinators are asked to review the description of the work and to add timing information. Dr Borrás raised the question whether this document will be openly accessible. In that case, the stakeholders should be informed of its existence. Moreover, if CCRI Section III covers neutron dosimetry (not only fluence), this fact and its stakeholders should be added to the document. With respect to open access, the President raised the concern that if the document should contain a SWOT analysis at a later stage (describing CCRI in terms of strengths, weaknesses, opportunities, threats), that part of the document should not be made public.

12.3 Roadmaps update

The members present at the CCRI(II) meeting were unaware if EURAMET has produced a roadmap update specifically for ionizing radiation metrology.

12.4 ICRM 2011 progress report

Dr Yunoki gave an update on the preparations for the ICRM conference to be held in Tsukuba, Japan, from 19 to 23 September 2011. There will be a special session on the Fukushima accident. Gilbert Le Petit of the CEA, France, will give a presentation entitled "Analysis of the Fukushima accident by the French national data centre". Dr Sasaki Yasuhito of NIRS/Japan will give a presentation, although the title is not yet known. A third presentation by a Japanese speaker is awaiting confirmation.

13 CURRENT AND FUTURE BIPM PROGRAMME: REPORT FROM THE RI DEPARTMENT; BIPM FUTURE PROGRAMME (PREVIOUSLY AGENDA ITEM 12)

Dr Allisy-Roberts presented a report from the BIPM Ionizing Radiation Department. The radionuclide metrology team consists of four members working on seven metrological activities. Central to the work of the team, and also to CCRI Section II, are the SIR and the SIR Transfer Instrument (SIRTI) as an extension of the SIR to short-lived radionuclides. A strengthening of the BIPM's own potential in primary standardization by purchasing a NaI well detector for the gamma sum counting method, earlier recommended by the CCRI(II), had not been accepted due to budgetary constraints. Similarly, the extension of the SIR to alpha-emitters had not been approved. The evaporator for thin film coatings, crucial for the preparation of solid sources used in primary standardization, will need to be replaced.

The electronics upgrade of the SIR was fully validated. Fifteen laboratories had participated in the ongoing SIR comparison submitting 60 ampoules with solutions of 31 different radionuclides, including for the first time ^{64}Cu and ^{125}Sb. Twenty comparison reports had been published. The uncertainty budget for measurements with the SIRTI was supported by the MC simulations, and the gamma-ray spectrometry laboratory for impurity measurements of submitted SIR ampoules had been refurbished. During the past four years the BIPM has collaborated with NMIs or DIs from 31 countries and with two international organizations, and had contact in writing with standards laboratories from seven more countries. The Ionizing Radiation Department published 73 external papers and 6 BIPM reports, and it had supported the publication of two special issues of *Metrologia*, on radiation dosimetry in

2009 and neutron metrology in 2011 (a special issue on radionuclide metrology had been published in 2007), two further volumes (no. 4 and 5) of *BIPM Monographie 5* on radionuclide decay data, and updates of the *Measurement Methods Matrix*. Furthermore, the Department has supported all CCRI meetings, the 3 Sections and 12 working groups as well as meetings of the CCAUV and its working groups, and has acted as *rapporteur* in 8 meetings of JCGM/WG1. Finally, the department liaised internationally with the ICRU, IAEA Scientific Committee and the ICRM.

Dr Ratel presented the improvements made to the TDCR system of the BIPM; the new design of the optical chamber to allow more accurate location of the photomultiplier tubes was constructed from Al painted with TiO_2. To implement the Compton efficiency tracer method, an external ^{241}Am tracer, a HPGe detector and modifications to the electronics were foreseen as requirements. The optical efficiency of the new chamber is about 50 %.

Dr Allisy-Roberts reported that one of the most important future projects for the BIPM is the proposal for a clinical-type linear accelerator at the BIPM. There are currently about 9000 clinical accelerators world-wide, and more than 7 million patients are treated for cancer with these facilities each year. For successful treatments, without medical complications, each treatment needs to be accurate to within 5 %. According to an IAEA/WHO audit of 681 clinical accelerator centres, 11 % of all doses delivered are outside acceptable limits. The advantages of an accelerator at the BIPM, as a primary reference facility, would be to provide international equivalence for those countries that have accelerator standards at their NMI as well as providing direct calibrations in accelerator beams to reduce uncertainties and treatment errors for those countries that do not have accelerator standards at their NMI. Consequently, a BIPM accelerator would serve all Member States.

Dr Karam underlined that the members of CCRI Section II should be encouraged to provide the necessary technical input to the appropriate policy makers in their country in support of an accelerator at the BIPM, which would be used to serve the global community. Such input could aid their governments' decisions.

14 NMI RESEARCH PROJECTS (PREVIOUSLY AGENDA ITEM 13)

14.1 IRA

Prof. Bochud presented a summary of the IRA and its standards dissemination work for Switzerland via inter-laboratory comparisons for gamma-ray spectrometry. In evaluation of these comparisons, the IRA has been applying ISO standards since the comparisons of 2009 and 2010. The IRA is planning to improve its reference ionization chamber and as a result it is considering using ^{166m}Ho as a reference solution because of its long half-life of 1200 a. The uncertainty, though, was prohibitively large at 180 a. Its project to determine the half-life of ^{166m}Ho, which was mentioned two years ago when the results were equivocal, now gave a result of (1132.6 ± 3.9) a. Prof. Bochud reported that the IRA has developed a mechanical system to determine wall and base thicknesses of ampoules with 10 μm precision.

14.2 NRC-INMS

Dr Galea presented the work of the NRC-INMS to re-establish radionuclide metrology in Canada. The $4\pi\beta-\gamma$ equipment is operating again as it was in 2000; hardware and software upgrades are planned for data acquisition. Ionization chambers are operational again, and a nation-wide radionuclide calibrator service will be re-launched soon. Research activities support nuclear forensics and protection from chemical-biological-radiological-nuclear-explosives (CBRNE) terrorist threats; a new radiochronometer for nuclear forensics is one of the goals. In the field of producing radionuclides for nuclear medicine, the ^{100}Mo photoneutron reaction ^{100}Mo$(\gamma,n)^{99}$Mo will meet Canada's demands for ^{99m}Tc.

The CCRI(II) chairman, Dr Karam, who is also SIM TC chairman for ionizing radiation, explicitly stated how pleased she was that Canada was re-establishing a radionuclide metrology laboratory.

14.3 LNMRI/IRD

Dr da Silva presented an overview of the standardizations performed at the LNMRI/IRD during the past few years: coincidence and anti-coincidence counting for standardization of ^{177}Lu, ^{123}I, ^{111}In, and ^{18}F; sum peak counting for ^{123}I, ^{111}In, ^{18}F, ^{65}Zn, and ^{22}Na; anti-coincidence counting for ^{243}Am/^{239}Np and ^{166m}Ho; the CIEMAT/NIST method applied to ^{14}C, ^{32}P, ^{3}H, and ^{242}Pu. The half-lives of ^{177}Lu, ^{57}Co, ^{111}In, ^{123}I and $P_\gamma(^{177}\text{Lu})$ were also determined. At the international level, the LNMRI/IRD participated in the ^{177}Lu key comparison. With location distances of more than 2000 km in the Brazilian network of nuclear medicine laboratories, it is difficult to establish traceability for short half-life radionuclides. Dr da Silva showed results of comparisons among 42 nuclear medicine departments with deviations of up to 30 % for some. In response to a question about what LNMIR/IRD does when it finds such non-conformities, Dr da Silva replied that they discuss the results with the laboratories and give advice on procedures. LNMIR/IRD also provides support to producers of ^{123}I and ^{99m}Tc in Brazil.

14.4 NMIJ/AIST

Dr Yunoki presented the results of the APMP.RI(II)-K2.I-131 comparison. Improvements to the method of inkjet printing of large area sources using primer, undercoating, ink, and topcoat layers have been made. Excellent uniformity can be obtained, any shape can be produced, and a range of three to four orders of magnitude in activity can be achieved. These large area sources fulfil the criteria of Class 1 reference sources of ISO-8769. ^{123}I brachytherapy seeds were standardized. There are plans to restart calibration services for radioactive gas, to improve the TDCR system, and to provide environmental radioactivity reference standards.

14.5 ANSTO

Dr Reinhard reported that the ANSTO had initiated major capital works to refit the activity standards laboratories. The upgrade will provide a modern laboratory infrastructure designed to meet safety and regulatory compliance requirements. Recommissioning of the

laboratories and the resumption of metrology functions is expected in the fourth quarter of 2011.

14.6 BARC

Dr Joseph reported that the BARC 4πβ–γ (PC) coincidence system was recently complemented by a liquid-scintillation based 4πβ(LSC)-γ coincidence system. The CIEMAT/NIST method at the BARC was validated with a ^{131}I sample received under the framework of the APMP ^{131}I comparison. The national audit for ^{131}I is ongoing. In November-December 2010, BARC undertook an audit in which 90 % of the results obtained from nuclear medicine laboratories were within ± 10 %.

14.7 BEV

Dr Maringer reported that the BEV's main work is verification and type approval, i.e., activities of legal metrology. The BEV recently built a large area standard, and plans to build a 4πγ NaI well high-efficiency sum counting system making use of an existing NaI crystal of about 50 cm diameter and 50 cm height with a 5 cm well.

14.8 LNE-LNHB

Dr Frechou reported that the management of the LNE-LNHB had decided to stop the work with the ^{222}Rn gas standardization. Consequently, this system will no longer be available. The Section II chair Dr Karam commented that since a CCRI(II) comparison on ^{222}Rn activity is likely to be held in 2013, this it might be an incentive for the management of the LNE-LNHB to reconsider their decision on the ^{222}Rn system. It was noted that the laboratories interested in a ^{222}Rn comparison in 2013 are NIST, IFIN-HH, NMIJ, PTB, LNE-LNHB, IRA, ENEA-INMRI, KRISS, and possibly NPL and CMI.

15 REGIONAL REPORTS

15.1 RMO activities: AFRIMETS, APMP, COOMET, EURAMET, SIM

The following documents are available on the website: AFRIMETS CCRI(II)/11-16, COOMET CCRI(II)/11-26, EURAMET CCRI(II)/11-27, SIM CCRI(II)/11-04.

15.1.1 SIM

Dr Karam presented the activities of SIM consisting of: Canada, USA, Mexico, Argentina, and Brazil. All have CMCs in radionuclide metrology except for Canada, the activities of which are under development. The CMCs of Mexico have been greyed out because a quality system is not yet in place. The member NMIs and DIs are participating in BIPM and CCRI(II) key and supplementary comparisons, in SIM regional and IAEA comparisons, and in proficiency tests organized in Latin America. A SIM workshop on radiation metrology will be held during November 2011 in Buenos Aires, Argentina. The agenda includes

regulatory compliance issues, quality systems, and applications in health and industry, safety and security.

Highlights from SIM members included the fact that NRC is now providing ^{192}Ir brachytherapy calibrations with a graphite calorimeter. Recently a bilateral comparison between NIST and the BIPM was conducted of absorbed dose to water for high-energy accelerator photon beams. The LNMRI/IRD improved its $4\pi\beta-\gamma$ counting system and performed several standardizations reported by Dr da Silva. The ININ measured the neutron spectrum in the TRIGA Mark-III reactor for the calibration of neutron detectors in the neutron beam reference field. The CNEA has a new building for its radioactivity group.

15.1.2 EURAMET

Dr Maringer presented the EURAMET activities on behalf of the TC IR chairman Hans Bjerke. Some of the highlights were the determination of alpha-emission probabilities of ^{240}Pu in the frame of a EURAMET project, presented at the ICRM conference 2009 in Bratislava, Slovakia. The project "Metrology for New Generation Nuclear Power Plants" in the frame of the European Metrology Research Programme (EMRP) was started, and the new EMRP projects for metrology in radioactive waste management and for the metallurgical industry are accepted and at present in the negotiation phase. The members of the EURAMET have 1165 CMCs in radioactivity. There were changes in the membership, DIs for Belgium and Lithuania have nominated their contact persons, the previous Latvian standards laboratory for ionizing radiation was split in two and is not linked to metrology at this time. Finally, the EURAMET TC IR had discussed the challenges with piloting and the delayed reporting of comparisons. The solution suggested was quite similar to the decisions taken by CCRI(II) to report comparisons in specific short notes of about 2 to 3 pages of text to the corresponding CCRI KC WG. Dr Allisy-Roberts welcomed the idea of a short report and suggested that Section II should take it up. At the request of the Section chairman it was clarified that, at the time of this meeting, it was not known which institute in Latvia is undertaking IR metrology; meanwhile, all the Latvian CMCs have been greyed out until the situation becomes clear.

15.1.3 APMP

Dr Yunoki presented the APMP activities on behalf of its previous IR section chairman Ming-Chen Yuan. The APMP is organized similarly to the CCRI sections in 3 working groups; CMCs are reviewed by the WGs with 3 reviewers each. Recently, the APMP performed the RMO APMP.RI(II)-K2 comparison for ^{131}I and two supplementary comparisons, one on the surface emission rate of beta-particles from ^{36}Cl, the other one on IC calibration factors relative to ^{166m}Ho. An APMP.RI(II)-K2 comparison on ^{59}Fe is planned. The APMP members have about 1100 CMCs in radioactivity. The new chairman since October 2010 (after their IR section meeting) has been Prof. Yang Yuandi from China.

15.2 CCRI RMO WG on CMCs

In May 2011 the CCRI RMO WG met at the BIPM headquarters. The metrology part of RMTC, Latvia, has been renamed as LATMB as a new Metrology Bureau of the

Standardisation, Accreditation and Metrology Centre (SAMC). The Latvian CMCs were greyed out because the metrological link had been broken. Hans Bjerke (TC chair of EURAMET) will ask the LATMB management if and how it intends to resume metrology in ionizing radiation.

The JCRB requests that separate CMC files be submitted per country and (sub)discipline, in order not to delay the whole list for a comment in one discipline. The CMCs that have been greyed out for 5 years will be removed, unless action is taken in the following year; laboratories will be informed one year prior to removal. In order to constrain the number of authors in comparison reports, an author must have made a substantial intellectual contribution. Since a comparison result demonstrates the institutional capability, in principle one author can represent the institution. It was observed that the KRISS rice comparison was still awaiting registration as a CCRI(II) supplementary comparison.

With respect to the comparison process it was noted that, for activity, the accepted Draft A is the point at which a SIR comparison result can support a CMC (column P), since it can no longer be changed. For other comparisons, approval by all participants of the Draft A gives a basis for the Draft B that can then be used to support CMCs. The RMO WG should not review CMCs in detail, now that the review process has stabilized. A mechanism needs to be established, though, to report if difficulties arise in the inter-RMO review process. The next meeting was proposed for May 2012.

16 INTERNATIONAL REPORTS (IAEA, ICRU, IOMP, IRPA, EFOMP)

The IAEA report is available on the website. The ICRU apologized that it could not send a representative this time.

16.1 International Organization for Medical Physics (IOMP)

Prof. Chavaudra presented the International Organization for Medical Physics (IOMP) report. The IOMP represents 18 000 medical physicists who work in clinical, academic and research institutions. It should be noted, however, that medical physics covers more than just clinical radiation medical physics. The IOMP has delegates from 75 member countries and 4 regional organizations; 2 new ones are currently being formed. It cooperates with 10 international organizations. The IOMP is heavily involved in training; it has regional medical physics training centres, typically at the reference site of a company in a hospital. It organizes conferences, workshops etc., and it contributes to standardization work. IOMP publishes its own journal and supports several member organizations' official journals. Support for developing countries consists of an equipment donation programme, library support programme, travel assistance and support in forming national organizations.

Dr Allisy-Roberts and Dr Karam emphasized the importance of CCRI relationships with international organizations, because these are the links to the wider user community, through these relationships timely information on the future needs of end users can be received.

16.2 European Federation of Organisations for Medical Physics (EFOMP)

Dr Borrás presented the European Federation of Organisations for Medical Physics (EFOMP) report. Thirty-seven national organizations are members of EFOMP, including South Africa, Algeria and Israel. The EFOMP gives policy advice, devises procedures for acceptance testing e.g. of radionuclide calibrators, and provides guidelines for QS. Its main committees are the science committee and the education and training committee. The education and training committee encourages national member organizations to support competence and excellence through courses, seminars, workshops and conferences. A six-week European School of Medical Physics is organized, where the sixth week is devoted to dosimetry and radiological protection. The EFOMP networks with numerous organizations, and is involved in the revision of the international basic safety standards (BSS). One of the provisions of the international BSS reads "The medical physicist shall ensure that (amongst others) calibration of all dosimeters used for dosimetry of patients and for the calibration of sources is traceable to a standards dosimetry laboratory."

17 PUBLICATIONS

17.1 BIPM Monographs and future projects – *Monographie 5 volume 6*

Volume 5 of *Monographie 5* has been published and a contents table of all 5 volumes is available on the BIPM website. For radionuclides that are not yet included, a link for online access to the LNE-LNHB database is given. The comments on the evaluations that detail how these evaluations were made are also available on the BIPM website and in the LNE-LNHB database. It is also included on the CD that is supplied with the printed volume. Volume 6 will be published in the near future. Dr Allisy-Roberts demonstrated examples of the search facility and the structured results page.

17.2 CCRI(II) bibliographies

The bibliographies are available on the open access part of the CCRI(II) website. CCRI(II) members were reminded to send a separate list of publications, together with the laboratory report, at least biennially or more frequently, if they so wish.

18 NMI LABORATORY REPORTS (TO BE NOTED FOR THE RECORD)

The NMI laboratory reports are available on the open access section the BIPM website. This allows all NMIs to follow the work of their colleagues in other countries, with a view to supporting knowledge transfer and research collaboration. Three laboratories presented highlights of their work during the CCRI(II) meeting.

18.1 VNIIM report

Dr Shilnikova presented the work in secondary standardization to support nine medical institutions in St. Petersburg, Russian Federation. She mentioned international cooperation in the framework of the CCRI(II)-S7 uncertainty comparison, the construction of a TDCR

system in collaboration with LNE-LNHB and PTB, and participation in the ICRM and LSC conferences. Metrology support is given to proficiency testing for 50 Russian laboratories. Future plans envisage participation in the ^{99m}Tc comparison, completion of the TDCR in 2011, and modernization of the VNIIM measurement standards after 2012. Dr Karam commented that this report demonstrated the excellent interaction between the primary laboratory and the secondary laboratories within the Russian Federation.

18.2 IFIN-HH report

Dr Sahagia gave a presentation on the new Romanian ^{222}Rn primary standard; the generation system is based on a Pylon ^{226}Ra source. In the future, IFIN-HH will participate in the K2 comparison on ^{222}Rn, and it will construct a Rn chamber to calibrate Rn measurement equipment.

18.3 ENEA-INMRI report

Dr Capogni presented the extensive list of national standards maintained by the INMRI, Italy, among them a Rn-in-water generator, a Rn chamber of 1 m^3 volume, and a 2π windowless gas flow proportional counter for surface emission rate measurements of alpha- and beta-particles. The development of a primary standardization of ^{64}Cu was published, and traceability was established for a production centre close to Rome. The INMRI is receiving a growing number of requests from nuclear medicine departments to establish traceability for ^{131}I and has three measurement methods available.

19 CCRI(II) MEMBERSHIP ISSUES

19.1 CCRI Membership

Dr Allisy-Roberts reminded CCRI Section II that the laboratories are members and that the laboratories' directors nominate persons as delegates. She presented briefly the status of current membership. On her recommendation, CCRI(II) decided to add EFOMP as observer to CCRI Section II. It was further decided to invite SMU as observer; the invitation letter will be written by the BIPM.

19.1.1 VSL - cessation of radionuclide metrology

Section II accepted VSL's self-recommendation to be removed as an observer from CCRI(II). The laboratory no longer pursues radionuclide activity metrology.

19.2 Working Group Membership

Convenors of WGs should consider reducing their membership lists in line with their objectives and anticipated outcomes. Official members will be included in the strategy document annex. Additional guests can be invited.

20 DATE OF THE NEXT MEETING

As the CIPM has changed its calendar of meetings to biannual, the schedule for the next meeting of CCRI(II) in 2013 is completely open. It may be held in April, June or in the autumn (of 2012). It will be announced as soon as a decision is made by the CIPM.

The chairman conveyed her thanks to the BIPM, the Executive Secretary and the BIPM ionizing radiation team, to the rapporteur, and to all delegates for their contributions and participation. The President of CCRI, Dr Carneiro closed the meeting by thanking all those present for their contributions, and commenting how impressed he was with the progress made during the last two years.

APPENDIX R(II) 1.
Working documents submitted to the CCRI(II) for its 21st meeting

Open working documents of the CCRI(II) can be obtained from the BIPM in their original version, or can be accessed on the BIPM website:

http://www.bipm.org/cc/AllowedDocuments.jsp?cc=CCRI(II)

Documents restricted to Committee members can be accessed on the restricted website.

Document CCRI(II)/	
11-00	Draft agenda – updated, P.J. Allisy-Roberts, 4 pp.
11-01	Proposed new rule for the production of SIR reports when the KCRV changes, C. Michotte, 1 p.
11-02	IFIN-HH Laboratory report 2011, M. Sahagia, 7 pp.
11-03	NIST report to the CCRI(II) June 2011, M. Unterweger, 35 pp.
11-04	SIM report to the CCRI(II) June 2011, L. Karam, 9 pp.
11-05	Call for participation in the BIPM.RI(II)-K4.Tc-99m, C. Michotte, 1 p.
11-06	IRA-METAS report for 2011, F. Bochud, 2 pp.
11-07	April 2010 meeting report of the KCWG, L. Karam, 4 pp.
11-08	Report and recommendations of the KCWG(II), November 2010, L. Karam, 6 pp.
11-09	Presentation of the IOMP, J. Chavaudra, 13 pp.
11-10	Radionuclide Measurement Methods Matrix, L. Karam, 8 pp.
11-11	NRC Radionuclide metrology update for 2011, R. Galea, 3 pp.
11-12	Radionuclide report from the IRD-LNMRI, Brazil – revised, C. de Silva, 5 pp.
11-13	NMIJ progress report in radionuclide metrology, A. Yunoki, 2 pp.
11-14	Proposals for KCRV updates, C. Michotte, 8 pp.
11-15	Review of the activities at the NMISA, F. van Wyngaardt, 3 pp.
11-16	Report of the AFRIMETS laboratories to the CCRI, Z. Msimang, 2 pp.
11-17	Recommendations for SIR comparisons, C. Michotte, 1 p.
11-18	Recent activities in activity measurement at the CMI, J. Sochorova, 2 pp.
11-19	CIEMAT report, E. García-Toraño, 3 pp.
11-20	Summary of comparison status (KCDB), L. Karam, 3 pp.
11-21	Progress report of the BARC in radionuclide metrology, A.K. Mahant, 1 p.
11-22	Report of the Transfer Instrument Working Group, C. Michotte, 7 pp.
11-23	KCRVs obtained with different rules, C. Michotte, 11 pp.
11-24	Simulation tests for the KCRV, S. Pommé, 6 pp.
11-25	KRISS Progress Report on Radionuclide Metrology (2009-2011), Tae Soon Park, 2 pp.
11-26	COOMET report for ionizing radiation, V. Yarina, 3 pp.
11-27	EURAMET report on ionizing radiation, H. Bjerke, 12 pp.
11-28	President's report for the CGPM, K. Carneiro, 6 pp.
11-29	Strategy paper for the CCRI – updated, K. Carneiro, 15 pp.
11-30	CCRI RMO WG Report, A. Aalbers, 8 pp.
11-31	Linearity of the new SIR, C. Michotte, 10 pp.
11-32	Draft protocol for a comparison of activity in a rice matrix, Sang-Han Lee, 3 pp.

11-33 Activity Standards at ANSTO, M. Reinhard, 3 pp.
11-34 Report from the VNIIM, T.I. Shilnikova, 2 pp.
11-35 ENEA-INMRI report on radionuclide measurements, M. Capogni, 10 pp.
11-36 Radionuclide Metrology progress at the MKEH, L. Szücs, 2 pp.
11-37 Review of POLATOM radionuclide metrology, R. Broda, 3 pp.
11-38 Report of the BIPM RI Department, P.J. Allisy-Roberts, 11 pp.
11-39 Report of the Uncertainties Working Group, M. Unterweger, 3 pp.
11-40 BIPM Proposed Work Programme 2013 to 2016, M. Kühne, 29 pp.
11-41 IRMM Radionuclide Metrology Report, U. Wätjen, 4 pp.
11-42 Draft A Report for the Lu-177 comparison, B. Zimmerman, 27 pp.
11-43 Radionuclide metrology report from the NPL, L. Johansson, 7 pp.
11-44 Protocol for CCRI(II)-S9 comparison – LASCE, P. De Felice, 4 pp.
11-45 Participants in CCRI(II)-S9, P. De Felice, 1 p.
11-46 Report of the Bq WG, U. Wätjen, 11 pp.
11-47 Progress report from the LNE-LNHB, C. Bobin, 3 pp

CONSULTATIVE COMMITTEE
FOR IONIZING RADIATION

Section III: NEUTRON MEASUREMENTS
Report of the 19th meeting
(30 March to 1 April 2011)

Abstract

Eleven NMIs and the IRMM were represented together with observers from the IAEA and the China Institute of Atomic Energy (CIAE) and a guest from the NRC-INMS, Canada.

Four comparisons were discussed. The CCRI(III)-K9.AmBe on neutron source emission rate is complete and scheduled for publication. The results were generally good but a small-scale follow-up comparison is planned. Only four out of seven possible participations in the thermal neutron fluence comparison CCRI(III)-K8 have been completed. However, two sets of results are somewhat discrepant and further investigation is under way to understand the causes.

A new comparison for monoenergetic neutron fluence, CCRI(III)-K11 will take place at the LNE-IRSN AMANDE facility at Cadarache in the south of France in the autumn of 2011. The protocol was approved to compare fluence measurements at four energies. The number of energies at which standards are provided presents a problem for comparisons.

Arguments for a comparison of calibrations of new electronic personal dosimeters were discussed, but it was considered that the required accuracy was low and no volunteers came forward to organize such a comparison at present. Spectrometry comparisons were discussed, although no decisions were taken. Participants were encouraged to formulate ideas for discussion at the next CCRI(III) meeting in 2013.

RMO reports were provided, by the SIM and the COOMET. Two EURAMET comparisons were presented: a long-counter comparison (EURAMET 396), for which preliminary results have been published in a special issue of *Radiation Measurements*; and EURAMET 1104 on the measurement of the low-energy part of the ^{241}Am-Be spectrum. An APMP supplementary comparison was proposed for the calibration of ambient dose equivalent survey meters in source-based neutron fields.

The NMIs presented the work of their laboratories and it was noted that this is a much appreciated opportunity to share information on research and development in the field. The Japanese presentation, coming soon after the earthquake and tsunami, provided graphic evidence of the damage caused at the NMIJ, recovery from which is expected to take at least 6 months.

It is hoped that discussion of delays to the special edition of *Metrologia* will provoke sufficient reaction so that the 2011 deadline for publication can be achieved.

A brief review of the neutron section of the CCRI Strategy Document resulted in a few modifications. A statement about the loss of expertise in the preparation of neutron reaction targets proposed by the PTB representative at the CCRI(III) was strongly supported by the IRMM.

1 OPENING OF THE MEETING

Section III (Neutron measurements) of the Consultative Committee for Ionizing Radiation (CCRI) held its 19th meeting at the Pavillon de Breteuil, Sèvres, from 30 March to 1 April 2011.

The following representatives of member organizations were present:

P. Cassette (LNE-LNHB), M.S. Dewey (NIST), V. Gressier (LNE-IRSN), H. Harano, (NMIJ), M. Kralik (CMI), T. Matsumoto (NMIJ), N.N. Moiseev (VNIIM), R. Nolte (PTB), S. Oberstedt (IRMM), H. Park (KRISS), N. Roberts (NPL), D. Thomas (Chairman, NPL), W. Walsan (LNMRI/IRD), H. Zhang (NIM).

Observers: M. Kellett (IAEA), J. Chen (CIAE), H. Ye (CIAE).

Guest: J.-P. Archambault (NRC-INMS).

BIPM members also present for all or part of the meeting: P.J. Allisy-Roberts (Executive Secretary of the CCRI), O. Altan (JCRB Executive Secretary), M. Kühne (Director), S. Picard, C. Thomas (KCDB coordinator).

Apologies were received from: K. Carneiro (President of the CCRI), J. Leena (BARC), J.M. Los Arcos (CIEMAT), H.-G. Menzel (ICRU), S. Röttger (PTB), V. Sathian (BARC).

2 WELCOME

Prof. Kühne, Director of the BIPM, welcomed the delegates to the BIPM. He apologized for not being able to attend the entire meeting because he was chairing another meeting during the week. The statement by Prof. Kühne that, 'ionizing radiation is important to us' was appreciated. The President of the CCRI, Dr Carneiro, was unable to attend because of recent surgery. The delegates expressed their sympathy and warm wishes for his full recovery.

Dr D. Thomas, Chairman, invited the delegates to introduce themselves. The representatives from Japan described the situation at their damaged laboratory following the earthquake on 11 March 2011. In addition to the general disruption, the lack of electrical power was perceived as the main problem. The Japanese delegation thanked the National Metrology Institutes (NMIs) and their Governments for the aid and support that Japan has received.

3 APPOINTMENT OF THE RAPPORTEUR

Dr Dewey, NIST, was appointed as the Rapporteur of the meeting. He was thanked for undertaking this task at this and previous meetings.

4 CHANGES OR ADDITIONS TO THE AGENDA

Mr Roberts, NPL, requested the addition of some EURAMET comparisons for discussion. There were a few other minor modifications.

5 REPORT OF THE PRESIDENT ON THE 21st MEETING OF THE CCRI (2009), AND MATTERS ARISING FROM THE 18th MEETING OF THE CCRI(III) 2009

In the absence of the President of the CCRI, it was agreed to raise any issues for discussion during the appropriate agenda items.

6 SPECIAL ISSUE OF *METROLOGIA*: PROGRESS REPORT BY THE BIPM EDITOR AND THE CCRI(III) CHAIRMAN

No one was present to represent *Metrologia* but Dr D. Thomas gave an update of the situation. All three guest editors were present (Dr D. Thomas, Dr Nolte and Dr Gressier). There is still a need for reviewers, including some who are not neutron experts. Dr D. Thomas reviewed the status of the nine papers that will be included. All nine papers are expected to meet the target publication date, with the last due to be received at the *Metrologia* office by 1 September 2011. Dr D. Thomas noted that colour is expensive to reproduce and the preference is for the papers to include high-quality black and white images unless the authors pay the additional costs. Colour is a free option in the electronic version. Individual contributions can vary in length, but the sum of the entire special issue must not exceed the agreed page limit.

7 CCRI STRATEGY PLAN CCRI(III)/11-03 DR CARNEIRO

Dr D. Thomas reviewed Dr Carneiro's document "Strategy paper for the CCRI" with the CCRI(III) participants. Dr D. Thomas invited each member of the CCRI(III) to suggest how NMIs can assist people who make or use neutron measurements. In particular, users of radionuclide neutron sources, who need to know emission rates accurately, and users of accelerator-based neutron standards. Contributions should be

sent to the Chairman of the CCRI(III) and to the President of the CCRI for inclusion in the version of the document to be presented to the CIPM in October 2011.

8 CCRI(III) COMPARISONS

8.1 Present comparisons

8.1.1 CCRI(III)-K11 neutron fluence: Protocol for approval CCRI(III)/11-01; V. Gressier (LNE-IRSN)

This exercise, as stated in the protocol, aims to compare measurements of the fluence of monoenergetic neutrons with energies of 27.4 keV, 565 keV, 2.5 MeV and 17 MeV. The protocol is similar to that for the CCRI(III)-K10 comparison; and fulfils the need to repeat these measurements every 10 years. All measurements will be performed at the LNE-IRSN AMANDE facility in France. The neutron fields will be produced in the low-scatter experimental hall of the facility using a 2 MV Tandetron accelerator. The measurements are planned to be performed between 5 September 2011 and 21 October 2011. It is envisioned that two groups will carry out measurements during a five-day period. The CIAE, LNMRI/IRD, IRMM, NIST, NPL, PTB, VNIIM and the NMIJ have requested to participate. Two empty standard Nuclear Instrument Modules (NIM) racks (12 slots each) will be made available for the NMIs' electronics. Concern was expressed that there would not be enough safe high voltage (SHV) connectors available. A remote-controlled multi-parameter scalar (including all monitors), cables, connectors and shadow cones will be available. Preparations for shipping equipment internationally will commence shortly to avoid any problems. Dr Gressier invited participants to supply their preferred dates within the six weeks. The final schedule will be communicated to Dr Allisy-Roberts. A final report from the evaluator will be sent to all members of CCRI(III) for discussion and approval by 31 October 2012.

8.1.2 CCRI(III)-K8 thermal neutron fluence: Progress report; R. Nolte (PTB)

Dr Nolte informed delegates of the status of this comparison. Only four laboratories have obtained results, the NMIJ, NPL, CIAE and the PTB. The VNIIM was unable to participate due to customs issues with the transfer instrument. The NIST did not have the resources to complete the measurements prior to a 10 month reactor shutdown. The LNE-IRSN could not obtain the ^{252}Cf source necessary for its thermal pile facility. The four participants used activation of gold as a standard. Outlying results made it desirable to use the largest consistent subset (LCS) to calculate the weighted mean; however the validity with only four results is questionable. Dr Nolte recommended that: the comparison is stopped immediately; the 200 kPa SP9 detector results are used to determine the KCRV of the results; and the results for the other detectors are stated in the report. To understand the discrepancies, Dr Nolte requested each participant to evaluate directly $(R_{SP9\text{-}200}/M)/(R_{Au}/m_{Au}/M)$ for the sub-Cd spectrum

(thereby checking the normalization). Dr Nolte requested that this ratio be sent to him by the end of May 2011. A critical review of all reports submitted by the participants is required. Dr Allisy-Roberts commented that the comparison could be converted into a pilot study if no conclusion could be reached on the results; concern was expressed that this would not support CMCs. However, for a key comparison, laboratories with results that are outliers should be informed of this fact to enable them to ensure that no arithmetic or transposition errors have occurred. It was agreed that the measurements have been completed and that Dr Nolte will produce a Draft A report once all the required information has been collected.

8.1.3 CCRI(III)-K9.AmBe emission rate – publication

It was stated that this work will be published as soon as possible and the results entered in the KCDB at the same time.

8.1.4 CCRI(III)-K9.AmBe.1 emission rate – source provision

Two laboratories, the CIAE and the LNE-LNHB, requested that repeat measurements be undertaken, and the NIM asked to join this comparison via a bilateral comparison. Measurements are planned with the NPL as the link laboratory. The NIM is unable to commence work before 2012 and the comparison will require a new ^{241}Am-Be source. The NIM proposed to obtain a source approximately three times more intense than that used previously. The source will be shipped in a type B container via the BIPM.

8.2 Future needs for comparisons

8.2.1 Comparison of personal dosimeter calibrations

A comparison of personal dosimeter calibrations had been raised at the previous meeting and again engendered considerable discussion. It was agreed that this item could be deferred due to the lack of volunteers to pilot the comparison. Before such a comparison can be undertaken, it is necessary to clarify the procedure to satisfy questions concerning room return, phantom positioning, and the specifications of the ^{241}Am-Be source that might be used. The NPL offered to provide two dosimeters for calibration by each participant. The NIST has registered CMCs for this purpose, and could provide guidance for the protocol. Dr Dewey will ask his colleagues at the NIST and report back to CCRI(III). A protocol will be written and supplied to everyone for comment. It was noted that personal dosimeter calibration would be a supplementary comparison because it would involve a secondary quantity; personal dose equivalent.

9 RMO NEUTRON COMPARISONS

9.1 Present comparisons

9.1.1 EUROMET.RI(III)-S2 - EUROMET 822 – Comparison of neutron fluence measurements for neutron energies of 15.5 MeV, 16 MeV, 17 MeV and 19 MeV

This is complete. Preparation of the Draft B report is under way.

9.1.2 EUROMET.RI(III)-S1 comparison of neutron survey meter calibrations

A number of problems were experienced during operation; instruments failed and although repaired proved not to be robust enough to continue. A completed report on the partial comparison is available and could be published. It was agreed that the comparison should be extended with new instruments as EURAMET.RI(III)-S1.1, but there were no volunteers to pilot the study. No decisions were reached.

9.1.3 EURAMET 936

Mr Roberts discussed neutron field measurements made by the NPL, PTB and the LNE-IRSN. The following neutron fields were measured: radionuclide sources ^{252}Cf, ^{241}Am-Be, ^{241}Am-Li, ^{241}Am-B, and ^{241}Am-F; and mono-energetic energies 144 keV, 565 keV, 1.2 MeV, 5 MeV and 17 MeV. The comparison included four long counters of three different types described in the report. There was good agreement with the radionuclide source measurements, although the NPL standard long-counter result was just outside one standard uncertainty from the mean, and good agreement with the measurements of the mono-energetic energies. The results were presented at the NEUDOS11 conference and published in a special issue of *Radiation Measurements,* 2010, **45** (10). The comparison has not been registered in the KCDB.

9.1.4 EURAMET 1104

Mr Roberts discussed this ongoing comparison of neutron source spectra, which aims to improve the content of the ISO-8529 standard and consequently is not registered in the KCDB. The comparison fulfils the need for accurate measurements of ^{241}Am-Be spectra with different size sources, encapsulation, and constituting materials. Bonner spheres were used to measure spectra from three different activity ^{241}Am-Be sources at the NPL, namely 37 GBq, 370 GBq and 555 GBq (1, 10, and 15 Ci). The INFN-LNF, PTB, LNE-IRSN, NPL and the UAB are participants in the exercise although to date measurements have only been performed by the INFN-LNF, NPL, and the UAB. Preliminary analysis indicates that there are more low energy neutrons than expected in the 370 GBq and 555 GBq sources. The INFN and the UAB will finalize the

unfolding, and a decision will be taken on whether there is value in the PTB and the LNE-IRSN making further measurements.

9.2 Planned RMO comparisons

9.2.1 APMP.RI(IIII) supplementary comparison for neutron survey meters – proposed

A comparison of the calibration of ambient dose equivalent meters in neutron radiation fields is proposed using one of the following neutron fields: ^{252}Cf, ^{252}Cf (D_2O moderated) or ^{241}Am-Be. Candidate ambient dose equivalent meters include the LB6411 (Berthold) and the Studsvik 2222A (or 2202D). Possible calibration procedures are: shadow-cone method, generalized-fit method, semi-empirical method and reduced-fitting method. Dr Allisy-Roberts recommended that the proposal be registered in the KCDB if the intention is to go ahead, and that a protocol is established.

9.3 Future needs (RMO key or supplementary comparisons)

Dr Gressier discussed the possibility of spectral evaluation and comparison for realistic (or "true") fields. Further discussion followed on whether or not there are CMCs for spectra, and if spectral measurements could be incorporated into the KCDB. Dr Allisy-Roberts commented that spectra could be incorporated into the KCDB if measurement uncertainties can be characterized. Each member was invited to think about these ideas for discussion at the next CCRI(III) meeting.

Dr Kralik suggested a comparison involving spectral fluence measurement around casks containing spent fuel in the Czech Republic (a real working field environment). The fluence is typically around 1000 neutrons cm^{-2}. It is predicted that measurements could be carried out in 2015. This is related to work that the CMI will undertake and other laboratories may participate using their Bonner spheres. This would make such a comparison a real possibility.

10 EXCHANGE OF INFORMATION ON NEUTRON METROLOGY IN PROGRESS AT PARTICIPANTS' LABORATORIES, PART 1

10.1 CIAE (C. Jun) – CCRI(III)/11-02

Dr Jun described recent activities at the CIAE. The 5SDH-2 tandem accelerator has been pulsed to undertake neutron time-of-flight (TOF) spectroscopy of mono-energetic beams to improve their characteristics. A Bonner sphere system has been developed to measure neutron fields for radiation protection purposes. A tissue-equivalent proportional counter has been developed for microdosimetry. Mono-

energetic neutron beams at 8 keV and 24 keV are being developed. Work on simulated workplace neutron fields will continue.

10.2 NIST (S. Dewey) – CCRI(III)/11-04

Dr Dewey advised that the NIST Center for Neutron Research is upgrading the reactor guide hall. Four new guide tubes will be installed in a newly constructed guide hall; one guide will become the new fundamental physics beam line to be operated by the Neutron Interactions and Dosimetry group. The NIST have obtained the first data taken in an electron-antineutrino correlation measurement in neutron beta decay; the status of the ultra-cold neutron lifetime experiment; a measurement of the radiative decay mode of the neutron; and an experiment aiming to measure neutron fluence with sub-0.1% relative accuracy. The NIST is currently operating both a large and a mini Mn bath facility.

10.3 PTB (R. Nolte) – CCRI(III)/11-06

Dr Nolte described the difficulties at the PTB arising as a result of a broken belt on the Van de Graaff generator. This negatively impacted the calibration business for a year. Currently PTB is running with an old belt and new belts have been sourced and ordered. The South African partners of PTB have obtained funding for an upgrade of the TLABS neutron beam line and are working on knowledge transfer to the TLABS/UCT. The PTB has also had problems with the recoil proton telescope radiators. It hopes to collaborate with the IRMM sample production group to solve this problem. A new thermal calibration field has been designed. It will utilize a graphite pile and sixteen ^{241}Am-Be sources. Construction is anticipated in 2011 and characterization in 2012. Dr Nolte summarized PTB's involvement with the EFNUDAT[1] and TRAKULA[2] projects. The EFNUDAT supported TSL and n-TOF efforts and was worth the time invested; the ERINDA project will be its follow-up. The TRAKULA project refers to nuclear-physics investigations of relevance for the transmutation of long-lived actinides. Through this project the PTB will maintain competencies in the fields of nuclear safety and radiation research. The PTB will start construction of a new facility based on a 5 MV Tandetron in 2014. The laboratory is under severe pressure due to redundancies imposed by the German government, consequently, participation in collaborative ventures and prioritization will become increasingly important.

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[1] **E**uropean **F**acilities for **NU**clear **DAT**a measurements

[2] **Tra**nsmutationsrelevante **k**ernphysikalische **U**ntersuchungen **l**anglebiger **A**ktinide

10.4 NIM (Z. Hui) – CCRI(III)/11-07

Dr Hui discussed the main activities of NIM (China) in neutron metrology from 2009 to the present and outlined the plans for the next five years. The NIM has conducted many routine survey meter calibrations in the reference radiation neutron field. The NIM intends to participate in the APMP comparison of the calibration of neutron ambient dose equivalent meters. In 2009 it established a new Mn bath system. The bath, circulation system, and gamma-ray measuring system were changed and an automated system was designed to transport the source into the bath. Future plans are to: improve their neutron reference radiation field; purchase a Bonner sphere system; and rebuild the thermal neutron standard.

10.5 KRISS (H. Park) – CCRI(III)/11-09

Dr Park described the neutron spectroscopy programme at the KRISS which uses an extended Bonner sphere set (extended towards energies as high as 10 GeV). The KRISS has measured the energy spectrum of cosmic neutrons as well as the energy spectrum in an underground laboratory. The KRISS has also carried out activation foil-based spectrometry with its Bonner spheres. The laboratory has constructed a long counter and continues to make measurements with a Mn bath. The KRISS will continue its Bonner sphere programme and will carry out neutron spectroscopy with liquid scintillation counters. The KRISS will also build a thermal neutron field and participate in the APMP comparison for the calibration of ambient dose equivalent meters.

10.6 LNE-IRSN (V. Gressier) – CCRI(III)/11-16

Dr Gressier described recent developments in the LNE-IRSN's neutron metrology programme. The SIGMA thermal neutron facility was shut down and its participation in the CCRI(III)-K8 comparison cancelled. The LNE-IRSN participated in the EURAMET 936 project, which saw its new long counter design being compared favourably with those of the NPL and the PTB. The LNE-IRSN is aiming for COFRAC accreditation in summer 2011 for its calibration work. It is preparing for the CCRI(III)-K11 comparison of neutron fluence measurements in mono-energetic neutron fields which, will take place at the AMANDE facility in autumn 2011. Dr Gressier described problems with the tritium targets; to solve these issues, new tritium targets on gold backings have been ordered. The LNE-IRSN has made many measurements to characterize and improve the quality of its mono-energetic neutron beams, and has improved the performance of the recoil proton telescope technique. Future developments include: a new microbeam for the irradiation of cells at AMANDE (2012 to 2014); investigations into development of high-energy quasi mono-energetic neutron fields at 230 MeV (2013 and later); and a new facility capable of producing neutron fields for the ITER (fusion) project (2015 or later).

11 CIPM MRA

11.1 CCRI RMO CMC Working Group report (2009) and Validity of Comparisons

This session involved a wide-ranging discussion of CMCs. The most important points are summarized below:

a) No CMCs in neutron measurements from Mexico are indicated in the KCDB. A single CMC in neutron measurements was greyed-out on 23 March 2007 while awaiting approval of its quality system (QS). Mexico will be informed that if it is unable to substantiate its CMC, then its CMCs will be removed from the KCDB. This is the only neutron CMC with greyed-out status.

b) The Bhabha Atomic Research Centre (BARC) had been invited to this CCRI(III) 2011 meeting, but was unable to send a representative to attend.

c) When bilateral comparisons are organized, Dr Allisy-Roberts must be informed well in advance so that they can be registered in the KCDB. Registration cannot take place if the comparison has already been held and the report published. It was generally acknowledged that neutron measurements take an unusually long time to complete; therefore the CIPM has already agreed to accept a longer period of validity for neutron comparisons.

d) Dr Allisy-Roberts quoted from a JCRB document, which describes the use of comparisons to support CMCs. This information is repeated in the CCRI RMO WG document that would be discussed at the May 2011 meeting and presented to the CCRI. Supporting comparisons can be BIPM, CCRI, RMO or IAEA comparisons. If there are no comparisons, a supporting scientific publication should be cited. In the CMC Excel files submitted for review, column P, ("Evidence supporting this measurement/calibration service") must now be completed. The CCRI(III) accepted that when a more recent measurement (within 10 years) supports the measurement of other neutron energies, which use the same measurement techniques and equipment, it is not necessary to repeat the older comparison. This will be made clear in the CCRI report on the Validity of Comparisons and circulated for comment prior to publication on the CCRI website. The indication "Approved for provisional equivalence" appears on some old entries and is a problem which needs to be addressed by indicating the replacement comparisons.

e) Two recently submitted CMC files raise issues which will be more easily resolved if during submission for regional review, they are submitted in separate files by subject, i.e. neutron CMCs should be submitted separately from radioactivity and dosimetry CMCs, and submitted by country to prevent any delay of the review. The two laboratories which submitted the recent CMC files were advised to respond to the review comments as soon as possible to complete the process.

f) The restricted access JCRB website enables access to live Excel files, which must be used for all subsequent submissions to avoid unnecessary duplication.

11.1.1 RMO activities: AFRIMETS; APMP; COOMET CCRI(III)/11-15; EURAMET; SIM CCRI(III)/11-05.

A document provided by COOMET is available on the CCRI(III) section of the BIPM website, but no report was given at the meeting because there is no regional activity concerning neutrons.

Dr Dewey reported on recent activities by SIM. In November 2009, the SIM Metrology Working Group 6, MWG 6, (ionizing radiation and radioactivity) met at the LNMRI/IRD. The LNMRI/IRD hopes to participate in $H^*(10)$ and $H_p(10)$ comparisons in the near future. During the SIM RMO meetings in Buenos Aires, Argentina, in early November 2011, there will be a 1.5 to 2 day radiation metrology workshop. It will cover: the basics of radiation physics; the types of techniques used, sources and handling of uncertainties; the role of the CIPM MRA (i.e., international metrology and comparisons, quality systems); and radiation applications (health, safety, security, industry, etc.). Discussions or presentations on regulatory aspects are also being considered, since these are unique to this particular field of metrology. Many of the participants will be new to radiation metrology (even if medical physics or nuclear power is part of their communities), so members of MWG 6 will be prepared to present information on the various laboratories (and how they support radiation use throughout the SIM). In March 2010, the NIST Ionizing Radiation Division was assessed, as is required every five years, to allow continuance of self-declaration of conformity with the NIST Quality System and, on 1 October 2010, a letter from the NIST Assessment Review Board to the NIST Measurement Services Advisory Group stated that the NIST Ionizing Radiation Measurement Services conformed to the NIST Quality System. The LNMRI quality system was peer reviewed in August 2009 (technical and management requirements) for Dosimetry, Radioactivity and Neutrons, and was re-approved (for five years) at the QSTF meeting in Lima, Peru, in October 2009. The LNMRI/IRD may modify its neutron CMCs, once their participation in comparisons of H_p and H^* are completed.

11.2 BIPM-KCDB: Appendix C submissions for discussion and approval

The responsibility for monitoring and reviewing neutron CMCs has been delegated by the CCRI RMO WG to the CCRI(III). Dr Gressier reported that he had a new CMC to submit. Dr Allisy-Roberts suggested that any CMCs that have nothing reported in column P ("Evidence supporting this measurement/calibration service") should be reviewed. Nine neutron CMCs are in this category. The responsibility for each CMC lies with the owner NMI. NMI's should not cite comparisons that are no longer valid in support of their CMCs. It was suggested that a one day CCRI(III) meeting will be held immediately prior to the next CCRI(III) meeting and all neutron CMC

participants will be invited. It was noted that removing a CMC from the KCDB can be politically sensitive unless the request comes from the NMI itself.

12 EXCHANGE OF INFORMATION ON NEUTRON METROLOGY IN PROGRESS AT THE PARTICIPANTS' LABORATORY PART 2

12.1 LNMRI (W.W. Pereira) – CCRI(III)/11-10 and CCRI(III)/11-11

Since the previous meeting in 2009, the LNMRI has modified the source-monitor positioning system in its low-scattering neutron facility. One project is funded and has commenced; current work compares experimental and simulation data to revalidate model parameters. In November 2009, LNMRI hosted a SIM meeting at its institute and also during 2009 the NIST and the LNMRI conducted a neutron metrology course at a neutron workshop in Petropolis. Two annual internal audits of the LNMRI quality system were conducted and validation has been extended. The LNMRI neutron laboratory employs three researchers and expects to hire one new technical staff member. The number of survey meter calibrations continues to increase in its laboratory due to oil exploration off the Brazilian coast. The LNMRI is developing a new system to calibrate its Mn bath and will no longer operate the reactor previously used. LNMRI continues to refine its MCNP model for its Mn bath. Neutron spectra and doses inside radiotherapy rooms are being studied. A national comparison is being prepared to evaluate results from laboratories that offer individual monitoring of personal doses.

12.2 CMI (M. Kralik) – CCRI(III)/11-12

The CMI is continuing to revitalize its 14 MeV generator. Measurements with Bonner sphere spectrometers (BSS) around pulsed sources using passive thermal neutron detectors continue. Work to test and calibrate neutron area and personal dosimeters in ISO 8529-1 neutron fields continues using ^{241}Am-Be and ^{252}Cf sources. Verification and calibration of personal dosimeters that have scales from 10 μSv/h to 10 Sv/h is challenging; the source should be 75 cm from the face of the ISO water phantom. To measure photo-neutron spectra around radiotherapeutic linear accelerators, Bonner spheres with passive thermal neutron detectors are used. A problem was discovered when conventional detectors were unable to measure the neutrons produced by means of high-energy bremsstrahlung photons impinging on a Pb target at a microtron facility. The solution was to use BSS with an activation detector (manganese foils) inside. MCNP5 and MCNPX codes are used routinely in the laboratory.

12.3 NPL (D. Thomas) – CCRI(III)/11-13

The NPL's facilities include a Mn bath (with many radionuclide sources), a thermal pile, a large low-scatter area, and a 3.5 MV Van de Graaff. A software package allows the NPL to convert CAD drawings into MCNP input files. In their Mn bath, the NPL achieves long-term stability with an ^{241}Am-Be source, but its ^{226}Ra-Be(γ,n) source appears to be losing strength (1.3 % since the bath was relocated in 2008). This phenomenon is not yet understood. The NIST observed similar behaviour when its ^{226}Ra-Be(γ,n) source, NBS-2, began to leak. The NPL is using MCNP to calculate the response of its long counter as a function of energy (it should be flat). At energies higher than 6 MeV its long counter responses start to fall off. It is important to know the effective centre of this counter. The NPL has made many effective centre measurements, but the results obtained have inconsistencies which are not yet understood. The NPL is investigating problems with its time-of-flight system with 5 MeV neutrons. Dr D. Thomas described issues with Westcott thermal fluence measurements. The NPL is testing a digital neutron spectroscopy system, to tune processing algorithms to better discriminate neutrons from gamma rays. A charge comparison algorithm gave the best performance. Finally, the NPL has introduced its new CIPM MRA brochure. Many NPL certificates now display the CIPM MRA logo and statement, indicating mutual recognition of national measurement standards and of calibration and measurement certificates issued by National Metrology Institutes.

12.4 VNIIM (N.N. Moiseev) – CCRI(III)/11-14

Dr Moiseev described the VNIIM facilities for radionuclide source emission rate measurements, fast neutron fluence-rate measurements, thermal neutron fluence-rate measurements, and calibrating neutron dosimeters and radiometers in the ISO-8529 recommended fields. During the past year VNIIM has conducted CCRI(III)-K8 key comparison measurements. The VNIIM has also developed a new device for gold foil induced activity measurements using a beta-gamma coincidence technique with geometry close to 4π for both particles. It has also calibrated a hyper-pure (HP)-Ge gamma-spectrometer up to 9 MeV using the (n,2γ) and (n,γ) reactions.

12.5 NMIJ (T. Matsumoto) – CCRI(III)/11-17

The NMIJ is developing high-energy neutron reference fields from 45 MeV to 75 MeV at the TIARA[3] facility. To determine the fluence and spectrum it is developing a proton recoil telescope which incorporates a liquid scintillator detector. Dr Nolte, PTB, requested information on the photomultiplier tubes used in the

[3] Takasaki Ion Accelerators for Advanced Radiation Application at the Japan Atomic Energy Research Institute (JAERI)

scintillator measurements. NMIJ is also: developing high energy reference fields in the range 140 MeV to 400 MeV at the RCNP[4], using Bonner spheres for measurements at 250 MeV and 390 MeV; installing a pulsing system on the 4 MV Pelletron accelerator; and developing a thermal neutron calibration method using a research reactor. It has started calibration services based on the Japan Calibration Service System (JCSS) for thermal neutron fluence-rate and neutron emission-rate for the traceability of neutron measurements in Japan. On 11 March 2011, the NMIJ was struck by a large earthquake and sustained some damage. It is estimated that it will take approximately six months to assess the extent of the damage. The development of a heavy water moderated ^{252}Cf neutron fluence is in progress to simulate realistic spectra and the calibration service will commence in 2011. Development of a 19 MeV mono-energetic neutron fluence standard is in progress and the calibration service will begin in 2012. The NMIJ will start the JCSS for neutron fluence rate and neutron emission rate in 2011.

12.6 NRC (J.P. Archambault) – CCRI(III)/11-08

The NRC is re-establishing a neutron measurement capability. At present it has two staff members. The NRC has ^{241}Am-Be, ^{241}Am-B, ^{238}Pu-Be, and ^{226}Ra-Be sources and it operates a large low-scatter room. It is installing a thermal neutron flux standard, using six ^{241}Am-Be sources and a graphite pile, a Mn bath, and a water-based neutron spectrometer (using BF_3 proportional counters). The NRC is relying heavily upon MCNP5 to validate their designs. It does not have an accelerator.

12.7 LNE-LNHB (P. Cassette) – CCRI(III)/11-18

Dr Cassette described the further development of the LNE-LNHB Mn bath facility for the calibration of neutron source emission rates, including installation of a shielded cell in order to improve radiation protection. Work involved Monte Carlo simulations of neutron-bath interactions, and the design, realization, and validation of a new on-line activity measurement system for ^{56}Mn, based on the 4π-Cerenkov-γ coincidence method. The LNE-LNHB will participate in the CCRI(III)-K9.AmBe.1 comparison, traceable to CCRI(III)-K9.AmBe via the NPL. The Mn bath will measure emission rates between 10^5 s^{-1} and 10^9 s^{-1}; its on-line measurement avoids the necessity of producing a very active source by in-reactor irradiation and consequently deals with short half-life and radiation protection issues. The challenges to this technique are: accounting for cross-talk between the Cerenkov and gamma channels due to Compton scattering of the gamma rays; calculation of the effective measurement volume; and precise determination of the mass of the solution. The LNE-LNHB will check the results with those obtained using the previous method of calibration of the Mn bath. This work is the subject of a PhD thesis.

[4] Research Centre for Nuclear Physics, Osaka University, Japan

13 INTERNATIONAL ORGANIZATIONS

13.1 IRMM (S. Oberstedt)

Dr Oberstedt described the IRMM standard neutron cross-section measurements. The neutron facilities include the GELINA[5] neutron TOF facility and the MONNET[6] mono-energetic neutron source. The programme involves neutron cross-section data relevant for fourth-generation (Gen-IV) reactors and transmutation of nuclear waste, fission fragment characteristics, cross-section standards, and instrument development. They have Bonner spheres, BF_3 (long) counters, Li-glass detectors and a proton recoil telescope. In the near future one new staff member will be employed particularly to: oversee neutron metrology tasks; establish a firm link to standards; refurbish the proton recoil telescope; and refurbish the Van de Graaff generator.

13.2 IAEA (M. Kellett)

Dr Kellett described the International Atomic Energy Agency's nuclear data section, which among other things provides access to data via its website http://www-nds.iaea.org/. Dr Kellett spoke specifically about coordinated research projects, data development projects, publications, training workshops at the International Centre for Theoretical Physics (one or two week courses with lectures and exercises, mainly for scientists from developing countries, but young scientists from developed countries also attend), and specially developed libraries. IAEA makes many documents available free in PDF format at http://www-nds.iaea.org/reports-new/tecdocs/. Dr Kellett disseminates a reference database for neutron activation analysis and updates a decay data library for actinides.

14 PRESENT AND FUTURE MEMBERSHIP OF THE CCRI(III) - UPDATED BIBLIOGRAPHY AND A LABORATORY REPORT

The NRC (Canada) was represented at the CCRI(III) for the first time. Neither the BARC (India) nor the CIEMAT (Spain) was present. It was proposed that the BARC, the CIEMAT and the ENEA (Italy) should be encouraged to participate fully in the work of CCRI(III), since much work with neutrons is conducted by these three laboratories. The criteria for institutional membership is that an institute must be an NMI or be designated as holding national measurement standards in the metrology area, that it be active in research, demonstrated by publications, and that it participates in international comparisons with results in the KCDB. It was noted that experts can always be invited as guests of the President.

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[5] Geel Electron LINear Accelerator.

[6] **mon**oenergetic **neu**tron source, at the IRMM

15 WORK PROGRAMME OF THE BIPM IONIZING RADIATION SECTION (PRESENTATION TO THE CIPM IN OCTOBER 2010, FOR INFORMATION); PROGRAMME PLAN FOR 2013 TO 2016 – M. KÜHNE

A discussion took place about the BIPM proposal to establish a LINAC[7] facility for high-energy photon dosimetry. The high initial investment cost of such a facility will make this a challenge for Members States to fund.

16 CCRI REPORT TO THE CGPM (K. CARNEIRO) – CCRI(III)/11-19

16.1 Discussion on the Strategy Plan

The majority of the discussion dealt with Section 4 of the report concerned with the future outlook for ionizing radiation metrology. It was suggested that neutron metrology be mentioned in the first paragraph of that section; in particular a statement should be included concerning the biological effects of neutrons, perhaps arguing for an effort to reduce uncertainties. The second paragraph discusses neutron cross-sections, and it was suggested that more content is appropriate. Finally, it was suggested that a discussion of neutron metrology should be included in the third paragraph, with something to the effect that security against nuclear attacks requires more measurement strategies. Recommendations for modifications should be sent to Dr Allisy-Roberts or the CCRI President, Dr Carneiro, as soon as possible.

16.2 Statement on neutron reaction targets

The CCRI(III) proposes the inclusion of a statement about the future availability of neutron reaction targets. Recommendations were made during the meeting and a final version of the statement was prepared for approval by the CCRI in June 2011. [N.B. The approved version has been added to the CCRI(III) documents as CCRI(III)/11-41.]

17 CCRI(III) WORKING DOCUMENT STATUS

It was agreed that the laboratory working documents could be open access and PDF versions of presentations will be made available on the restricted access website.

18 OTHER BUSINESS

There was no additional business.

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[7] Linear accelerator of a clinical type for metrology purposes

19 DATE OF THE NEXT MEETING

The CIPM meeting schedule has been changed and it seems likely that April 2013 will not be available, so members were requested to send exclusion dates in 2013 to Dr Allisy-Roberts. It might be possible to hold the meeting in the autumn. A suggestion was made to start the meeting later so that European visitors could arrive in the morning. A starting time of 14:00 was suggested as the CCRI(III) meeting seems to last for about 2.5 days. Finally, the BIPM and the Executive Secretary were warmly thanked for having hosted the meeting.

APPENDIX R(III) 1.
Working documents submitted to the CCRI(III) for its 19th meeting

Open working documents of the CCRI(III) can be obtained from the BIPM in their original version, or can be accessed on the BIPM website:

http://www.bipm.org/cc/AllowedDocuments.jsp?cc=CCRI(III)

Documents restricted to Committee members can be accessed on the restricted website.

Document CCRI(III)/

11-00 Final agenda, P.J. Allisy-Roberts, 2 pp.
11-01 Draft protocol for the key comparison CCRI(III)-K11, V. Gressier, 7 pp.
11-02 Neutron metrology activities at the CIAE, Chen Jun, 9 pp.
11-03 CCRI Strategy Document (draft), K. Carneiro, 14 pp.
11-04 NIST report to the CCRI(III) meeting 2011, M.S. Dewey, 7 pp.
11-05 Report from the SIM, L. Karam, 2 pp.
11-06 Recent developments in neutron metrology at the PTB, R. Nolte, 2 pp.
11-07 NIM recent activities in neutron metrology, Zhang Hui, 5 pp.
11-08 Neutron metrology at the NRC, Canada, J.P. Archambault, 4 pp.
11-09 Recent activities in neutron metrology at the KRISS, H. Park, 13 pp.
11-10 Short report from the LNMRI Neutron Laboratory, W.W. Pereira, 3 pp.
11-11 Radiation Measurements publication - alternative irradiation system, S.P. Leite, 3 pp.
11-12 Progress report on neutron metrology at the CMI, M. Kralik, 2 pp.
11-13 Recent developments in neutron metrology at the NPL, D. Thomas, 12 pp.
11-14 Recent activity of the VNIIM Neutron Group, N. N. Moiseev, 1 p.
11-15 COOMET activity report for ionizing radiation, V. Yarina, 3 pp.
11-16 Developments in neutron metrology at the IRSN, V. Gressier, 8 pp.
11-17 Recent activities in neutron standardization at NMIJ/AIST, T. Matsumoto, 7 pp.
11-18 Neutron cross-section measurements, S. Oberstedt, 31 pp.
11-19 Draft Report to the CGPM on the CCRI activities, K. Carneiro, 9 pp.
11-20 BIPM RI Department presentation to the CIPM in October 2010, P.J. Allisy-Roberts, 53 pp.
11-21 Presentation of the BIPM's programme proposal for 2013 to 2016, M. Kühne, 29 pp.
11-22 PTB presentation on neutron metrology, R. Nolte, 18 pp.
11-23 CCRI(III)-K8 progress presentation, R. Nolte, 17 pp.
11-24 NMIJ presentation on neutron metrology, T. Matsumoto, 52 pp.
11-25 LNMRI presentation on neutron metrology, W. Wagner, 16 pp.
11-26 CIAE presentation on neutron metrology, Chen Jun, 17 pp.
11-27 NIM presentation on neutron metrology, Zhang Hui, 8 pp.
11-28 VNIIM presentation on neutron metrology, N. Moiseev, 10 pp.
11-29 NPL presentation on neutron metrology, N. Roberts, 14 pp.
11-30 NIST presentation on neutron metrology, S. Dewey, 12 pp.
11-31 LNE-LNHB presentation on neutron metrology, P. Cassette, 21 pp.
11-32 LNE-IRSN presentation on neutron metrology, V. Gressier, 12 pp.

11-33 KRISS presentation on neutron metrology, H. Park, 19 pp.
11-34 CMI presentation on neutron metrology, M. Kralik, 22 pp.
11-35 NRC presentation on neutron metrology, J.-P. Archimbault, 9 pp.
11-36 Presentation on the future CCRI(III)-K11 comparison, V. Gressier, 15 pp.
11-37 Proposal for an APMP supplementary comparison, H. Park, 6 pp.
11-38 EURAMET 936 Long Counter Comparison, N. Roberts, 7 pp.
11-39 EURAMET 1104 Source Spectra Comparison, N. Roberts, 11 pp.
11-40 IAEA presentation on nuclear data, M.A. Kellett, 34 pp.
11-41 Statement from the CCRI(III), April 2011 to the CCRI for approval and submission to the CIPM, D.J. Thomas, 1 p.