

Bureau International des Poids et Mesures

Consultative Committee for Ionizing Radiation (CCRI)

Report of the 25th meeting
(17 May 2015)
to the International Committee for Weights and Measures



Comité international des poids et mesures

LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR IONIZING RADIATION

as of 27 March 2015

President

Dr W. Louw, member of the International Committee for Weights and Measures

Executive Secretary

Dr J. M. Los Arcos, International Bureau of Weights and Measures, Sèvres.

Members

Chairman of CCRI Section I M. McEwen, NRC, Ottawa

Chairman of CCRI Section II L. R. Karam, NIST, Gaithersburg

Chairman of CCRI Section III V. Gressier, LNE-IRSN, Fontenay-aux-Roses

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

1–3 WELCOME / INTRODUCTIONS / RAPPORTEUR

The 25th meeting of the Consultative Committee for Ionizing Radiation (CCRI) was held at the BIPM in Sèvres on 17 May 2015.

The following were present:

W. Louw (President), M. Milton (Director of the BIPM), J.M. Los Arcos (Executive Secretary), M. McEwen (Chairman of CCRI(I)), L. Karam (Chairman of CCRI(II) and representative of SIM), V. Gressier (Chairman of CCRI(III)).

Z. Msimang (AFRIMETS), C.-Y. Yi (APMP).

P J Allisy (EFOMP), A Meghzifene (IAEA), H Menzel (ICRU), J-C Rosenwald (IOMP), A Aalbers (CCRI RMO WG chairman).

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

Apologies: L Johansson, I J Kim.

The numbering of the sections below follows that of the agenda. Presentations are available online and only highlights are presented here along with any relevant discussions.

Dr Milton welcomed the participants and the new President. He briefly presented the highlights of the 2015 meeting of the CGPM and its election of 18 members of the CIPM. He outlined three key elements: (i) Further steps towards the redefinition of the SI, noting the roadmap developed by the CCM and supported by the CCU and the target implementation date of 2018; (ii) A review of the CIPM MRA and its achievements 15 years after its implementation; this will focus on a meeting of the NMI Directors in October 2015 and will require input from the CCs; (iii) A new trend in support for the BIPM in working for the benefit of all members, reflecting on the opportunities for training and specifically the Capacity Building and Knowledge Transfer (CBKT) initiative. He ended by noting the circulation of the draft of the new GUM to the NMIs, with the deadline for comments of 3 April 2015 fast approaching.

Dr Louw presented his background in solid state physics and surface analysis and looked forward to his role in coordinating the work of the CCRI and represented its interests within the CIPM. He stressed the need to find ways of presenting the work of the CCRI to non-experts and that he would endeavour to do this.

The Agenda was formally adopted and, in the absence of volunteers, Dr Burns was appointed rapporteur.

4 REPORT OF THE PRESIDENT

Dr Louw's report first focused on the strong elements of the presentation made by the former President, Dr Carneiro. While maintaining these, he proposed a number of changes, generally aimed at reducing the level of technical detail to better address non-experts. He proposed a change in the mission statement, noting that the BIPM was already the "undisputed hub". While appreciating the 'check box' table on stakeholder involvement in CCRI activities, he proposed work towards strengthening the longer-term (>2020) elements of the strategy.

Regarding deliverables, he noted that there were now 4022 CMCs for ionizing radiation, that the BIPM.RI(I)-K6 comparison was going well and that comparisons for mammography dosimetry were now well established. The SIRTI had been extended to include ^{18}F . Regarding new members, Section I supported the proposal for Egypt (NIS) as an observer, while Section II recommended the Slovak Republic (SMU) as a member and the ICRM as an observer. In Section III, the iThemba laboratory (South Africa) was now designated for medium- and high-energy neutron dosimetry. He made reference to a plan for rationalization of the IR building, now named the Marie Curie Building.

The long-term strategy for accelerator dosimetry must be viewed in the light of what is now seven years with no increase in the BIPM budget; hence the planned workshop was postponed. New areas of interest might include high-resolution magnetic spectrometry (as discussed at Section II).

The President outlined his wish to streamline the organization of the various meetings. He proposed operating the section meetings in a similar way to working group meetings, either back-to-back or in parallel (where appropriate) with a core CCRI meeting – he invited comments and suggestions along these lines. He stressed, however, that the sections would not be renamed as working groups. The administrative burden would be reduced to a single convocation for the CCRI and section meetings. He raised the possibility of combining the three Key Comparison Working Groups.

The report on the 2014 CGPM supported the comments already made by the BIPM Director. The CIPM had been elected, and in turn the CIPM at its meeting in March 2015 had re-elected Dr Inglis as President, with Dr McLaren as Secretary and Dr May and Prof. Ulrich as Vice-Presidents. Dr Louw mentioned the October 2015 workshop on the review of the CIPM MRA and the Workshop on Measurement Uncertainty scheduled for 15-16 June 2015.

During discussions following the presentation, Dr Karam asked for clarification on the suggestion to combine the KCWGs, as their work was very different. Dr Louw suggested that the combined KCWG could have an expanded role and duties, with the work on comparisons carried out within the section meetings. Dr McEwen asked for clarification on the rationalization of the IR facilities and Dr Los Arcos explained that there was to be a re-organization of staff and laboratories, including a new laboratory for brachytherapy reference measurements.

On the postponed workshop on accelerator dosimetry, Dr Louw explained that there were new developments to explore and that the proposal for an accelerator at the BIPM was no longer an option. Thus the goal of the workshop had to be re-defined and it might be more effective (better attended) if it were combined with another international meeting. In collaboration with Dr Los Arcos and Dr McEwen, he would work on the questionnaire on accelerator dosimetry agreed at the Section I meeting.

5 REPORT ON THE WORK OF THE CCRI

5.1 CCRI Section I

Dr McEwen, the new Chairman of CCRI(II), reported on the highlights of the Section I meeting, noting the vote of thanks offered to the outgoing Chairman, Dr Sharpe. The strategy for CCRI(II) was working well and a review resulted in no significant changes, other than explicit inclusion of biological quantities for the 2016-2019 period. On the subject of the BIPM dosimetry programme, he stressed the impressive output from such a small group. Formal agreement had been given for a new ongoing comparison BIPM.RI(I)-K9 for absorbed dose in medium-energy x-rays, which would offer users a significantly reduced uncertainty. A pilot comparison with the PTB was planned for October 2015, which would be followed by the technical protocol before a full comparison to link to the

recently-completed EURAMET.RI(I)-S13 comparison. A EURAMET comparison for absorbed dose to water in high-energy electron beams using alanine was planned for 2016-2017.

On key data, the ICRU Report would be published during 2015 recommending a significant change to charged-particle stopping powers as well as an increased uncertainty for the W -value for air. An *ad hoc* committee of Section I was set up to report on the consequences of adopting these changes and to set a timetable for change. An important element is communication with users and stakeholders early in the process. Other noted developments included calorimetry in synchrotron beams and the use of very narrow photon beams for point scanning. The NIS (Egypt) was recommended for observer status.

In a final comment, Dr McEwen expressed concern that comparison reports were often approved with little comment, and that no comment was taken to mean approval. The BIPM Director agreed that this was not a good mechanism for maintaining the high quality of the *Metrologia Technical Supplement*. Dr Picard mentioned the rolling system of three reviewers used in the CCT, while Dr Karam noted that the KCWG(II) identifies specific reviewers with follow-up. Dr Allisy expressed concern about the changes for ^{60}Co and asked for clear information for end users as soon as possible. Dr McEwen confirmed that the change would not be, for example, January 2016, and that January 2017 was more likely.

5.2 CCRI Section II

Dr Karam noted that the Section II meeting was preceded by a meeting of KCWG(II) and included reports from KCWG(II), the BIPM, the RMOs and stakeholders. A review of the Section II strategy corrected a few omissions in the 'tick box' table, notably related to actions on climate change relevant to Section II but not indicated. The special issue of *Metrologia* on Radionuclide Uncertainties had just been completed, with articles now available online although the printed version was not foreseen before late June. The Fukushima (Japan) accident had generated a number of comparisons of reference materials to support environmental measurements, including wheat flour and marine sediment; a lesson was to be learned from travel difficulties experienced for a circulated sample of brown rice grain, arising because it was labelled as a foodstuff rather than as a scientific sample. The measurement methods matrix (MMM) was operating well, reducing the number of required comparisons, and the power moderated mean (PMM) was used for the evaluation of key comparison reference values (KCRVs); updated KCRVs were agreed for five radionuclides. In the ten-year plan for comparisons, the decision was taken to replace ^{137}Cs by ^{223}Rn . To speed up the reporting process, as well as the new reporting format it was agreed that a single NMI result could appear in the KCDB before publication of the final report. Section II also included an interesting presentation on the search for ^{210}Po in the corpse and personal affairs of Yasser Arafat. There were also discussions on observed annual oscillations in the decay rate of ^{22}Na , with a generally negative view taken of the postulate that these be due to the cycle of solar neutrinos (a temporal correlation does not imply a causal relation).

A short discussion ensued to clarify the very specific decision that an individual NMI result in the SIR, relative to the existing KCRV, could be made available in the KCDB before a re-evaluation of the KCRV and publication of the final report. **The CCRI formally endorsed the SMU as a member of CCRI(I) and the ICRM as an observer.**

5.3 CCRI Section III

Dr Gressier, the new Chairman of CCRI(III), reported on the highlights of its meeting, noting the warm thanks offered to the outgoing Chairman, Dr Thomas. He noted the increasing membership of Section III, from nine delegates in 2013 to thirteen in 2015, plus nine experts, although there was no presence from the IAEA, IRPA or ICRP. The RI(III)-K11 comparison of monoenergetic neutron fluence produced good results, although all measurements were made in the same facility (IRSN) and a new comparison was proposed using different facilities. The RI(III)-K9 comparison using a circulated AmBe source had experienced transport difficulties and was planned to be repeated (using a different source). The RI(III)-K8 comparison of thermal neutron fluence showed significant discrepancies among the four participants, and the PTB had agreed to increase their uncertainties. Before making a new comparison, it was decided to conduct a pilot comparison by circulating activated gold foils. Two new comparisons for the operational quantities were proposed, one for $H^*(10)$ with fourteen participants and the second, for $H_p(10)$, to begin with a pilot study using four personal dosimeters. A representative from ITER invited to Section III described the determination of fusion power from the measurement of neutron emission rate, and there had been several presentations of new or upcoming sources of quasi-monoenergetic neutron (QMN) fields above 20 MeV (including TIARA in Japan and iThemba in South Africa).

During the short discussion that followed, Dr Karam commented that the RI(III)-K8 comparison appeared to have a KCRV uncertainty that was unrealistically low (given the spread of the data), while Dr Menzel mentioned an ICRU Report on Operational Quantities that should be published before the end of 2015.

5.4 CCRI RMO WG

Dr Aalbers gave a short report of the meeting of the CCRI RMO working group the previous afternoon, the main topics being the report from the JCRB and CMC submissions. The JCRB reported that inter-RMO reviews had been reduced from six to three weeks and recommended the use of the BIPM Web Forum and the “fast track” for CMCs. The IR total of 4022 CMCs represents 17 % of all CMCs and no problems were identified. For CMCs in Section II, there was a recommendation regarding column P: “*Column P should include a reference to the publication. The material, its measurement, method and result should be given*”.

5.5 BIPM IR Programme 2013–2015

Dr Los Arcos presented a summary of the BIPM work programme in ionizing radiation for the period 2013–2015, which takes as its terms of reference the BIPM Programme of Work and Budget 2013-2015 and the CCRI Strategic Plan 2013–2023. In dosimetry, maintaining the existing x- and gamma-ray standards for comparisons and calibrations forms a large part of the programme, including the newer facilities for mammography and the travelling calorimeter for accelerator dosimetry (which will travel to the NMIJ, Japan in April). The project to develop an absorbed-dose standard for x-rays is nearing completion, with a pilot comparison with the PTB scheduled for October. The high-dose rate brachytherapy programme was re-launched with a revised protocol, comparison reports published for the previous comparisons, two new comparisons made and another scheduled for April (NMIJ). In radioactivity, besides maintaining the SIR and organizing and participating in CCRI key comparisons, programmes include the extension of the SIR to beta emitters and the extension of the SIRT I to ^{18}F and other short-lived radionuclides. As well as providing

executive secretaries for the CCRI and the CCAUV, the KCDB coordinator and the *rapporteur* and BIPM contact for the JCGM-WG1, the department maintains international coordination through membership of the ICRU, the ICRM and the IAEA Scientific Committee. The department also has responsibility for internal thermometry calibrations for the BIPM.

6 REPORTS FROM INTERNATIONAL STAKEHOLDERS

Dr Meghzifene outlined the main dosimetric concerns of the IAEA as: (i) the implementation of new technologies ahead of the dosimetry, leading to the possibility of accidents; (ii) areas in which traceability is available only through the manufacturer; (iii) educational needs arising from the requirement for certification; (iv) communication with end users. He then listed the activities of the IAEA that relate to specific items of the CCRI Strategic Plan addressing these needs. Of note is a joint IAEA/AAPM code of practice on small-field dosimetry that will be published soon, and a review is planned of the TRS-398 code of practice, which is now 15 years old. Funding for a new bunker has been acquired with the aim to install a clinical accelerator for purposes that will include training for SSDL staff.

Dr Menzel described the ICRU as a small body of fourteen members whose main function was to organize committees of experts and produce reports in specific areas of need related to quantities and units, dosimetric procedures and physical data. Recent reports include low-dose exposures and computed tomography, and reports will be published shortly on key data for dosimetry, stereotactic treatments with small fields, brachytherapy for cervical cancer, and radon exposures. An upcoming report on operational quantities will address shortcomings in the estimation of effective dose for high-energy neutrons, and also for high-energy photons due to the inappropriate use of the kerma approximation. Reports might also be stimulated by the realization post-Fukushima that important lessons had not been learned following Chernobyl. He ended by inviting proposals for new ICRU reports.

J-C Rosenwald, on behalf of the IOMP President Dr Kin Yin Cheung, briefly presented the structure of the IOMP and its many affiliations and joint activities with other national and international organizations, and the scope of its work from medical physics to biomedical engineering. The main activities of the IOMP are in meetings, sponsorship, education, training, web resources and publications – he made note of their affiliation with IUPESM and the World Congress to be held in Toronto (Canada) in June 2015.

Dr Allisy presented the EFOMP with its adopted slogan: “*improving treatments, saving lives*”. EFOMP represents 34 countries in terms of training and education in medical physics. Their main need from the CCRI is to encourage NMIs and DIs to support their professional societies in relation to dosimetry and training. Dr Karam made the point that this is often a case of finding one good contact in an organization.

There followed three brief presentations from RMO representatives. Z Msimang described the increasing activity within AFRIMETS in terms of CMCs and quality systems, noting the designation of the iThemba laboratory for high-energy neutrons and the important role of comparisons with other regional organizations. C-Y Yi presented a table of APMP comparisons in progress or planned as well as information on CMCs. There had been 18 participants at the 2014 TCRI meeting. When asked by Dr Karam about post-Fukushima activities, he mentioned only a comparison for brown rice. Dr Karam for the SIM, spoke of new members (St Kitts & Nevis, Chile) and the review of CMCs – 46 for other RMOs in the past two years. Many comparisons are planned. Regarding quality systems,

the ININ (Mexico) had a personnel problem that resulted in the removal of their neutron CMC. Dr McEwen commented on the wide range of meetings organized by the IRD (Brazil) and Dr Karam confirmed that they were good at communicating with end users. Dr Gressier noted that, although active in neutron dosimetry, the IRD did not send a representative to Section III; Dr Los Arcos confirmed that this was a funding issue, they did not obtain permission. No presentations were made for EURAMET or COOMET.

7 FUTURE IONIZING RADIATION PROGRAMME OF THE CCRI

BIPM IR Programme of Work 2016–2019

Dr Los Arcos presented the proposed programme of work for ionization radiation. The majority of the programme involves maintaining the existing facilities and services, and these were expressed in terms of deliverables. Highlights include the introduction of a new key comparison for absorbed dose to water in medium-energy x-rays, completion of the extension of the SIR to alpha- and beta-emitters, and the development of a backup system for the SIR. This latter requirement arises from the suspension of the project to develop a ‘becquerel chamber’ due to technical difficulties and lack of resources. Two other projects were proposed to the CIPM, but because of budget restrictions these were not maintained in the programme: the development of a primary standard for electron beams and a low dose rate brachytherapy comparison.

Dr McEwen asked about the loss of staff resources resulting from the involvement of Dr Picard in the KCDB. Dr Los Arcos replied that the percentage loss was not yet determined. Dr Allisy expressed surprise that temperature calibrations were not included, and Dr Los Arcos commented that the ongoing needs for internal calibrations at the BIPM were currently being assessed. Dr Louw remarked on the possibility to look for innovative ways of funding additional projects, and Dr Milton provided the example of an NMR system recently obtained by the BIPM through collaboration with the Republic of Korea.

Medium-term programme 2020–2023

In response to a question from Dr Louw on the medium-term programme, Dr Los Arcos suggested that, given the budgetary constraints of recent years, it was too early to make any concrete proposals; nevertheless, he would appreciate input from the CCRI. Dr Louw suggested that the BIPM should continue to explore the possibilities for accelerator dosimetry and Dr Milton spoke of talks with the NMIs about basing some work/research at an NMI. Dr Karam picked up on the earlier comment by Dr Louw on mass spectrometry by noting that Section II has discussed this; mass spectrometry is already in use at the NIST and the NPL is developing the capability. Dr Aalbers raised the subject of proton comparisons on this timescale.

As a more general observation, Dr McEwen noted that the stakeholders present were largely medical, and that for example the radiation processing industry was not represented (as they are at CIRMS). Dr Karam mentioned also the nuclear power industry (for Section III) and environmental analytical laboratories. Dr Los Arcos noted the presence of ITER and iThemba at Section III. Dr Karam strongly suggested making use of the 2011 CIRMS *Report on Needs in Ionizing Radiation* available on the home page www.cirms.org.

8 REPORT TO CIPM / NEXT CCRI MEETING / CONCLUDING REMARKS

Dr Louw said that he would prepare the report to the CIPM to highlight the technical work and would liaise with the section chairs on this.

Regarding a proposed CCRI meeting in 2017, Dr Louw considered that March was not convenient and proposed May or June. The date will be decided.

Dr Los Arcos agreed to communicate by email on whether the various documents presented to the meeting should be open access or restricted.

Dr Louw closed the meeting, thanking all present and the BIPM support staff.

**CONSULTATIVE COMMITTEE
FOR IONIZING RADIATION**

Section I: X- AND γ -RAYS, ELECTRONS
Report of the 22nd meeting
(24-26 March 2015)

Section I (x- and γ -rays, charged particles) of the Consultative Committee for Ionizing Radiation (CCRI) held its 22nd meeting at the Pavillon de Breteuil, Sèvres, on 24-26 March 2015.

The following Members and representatives were present:

U. Ankerhold (PTB), A. Berlyand (VNIIFTRI), V. Berlyand (VNIIFTRI), J.M. Bordy (LNE-LNHB), D. Butler (ARPANSA), M. D'Arienzo (ENEA-INRIM), F. Delaunay (LNE-LNHB), S. Duane (NPL), Z. Jian (NIM), , I.J. Kim (KRISS), A. Knyziak (GUM), C. Kottler (METAS), F.J. Maringer (BEV), G. Machula (MKEH), E. Mainera-Hing (NRC), A. Meghzifene (IAEA), M. Mitch (NIST), M. Pinto (ENEA-INRIM), J. de Pooter (VSL), N. Saito (NMIJ/AIST), P. Sharpe (NPL), A. Steurer (BEV), Anna Y. Villevalde (VNIIM), J. Wu (NIM), C.Y. Yi (KRISS), Y. Zhang (NIM).

Observers:

P. Avilés Lucas (CIEMAT), H. Bjerke (NRPA), J.C. Furnari (CNEA), Z. Msimang (NMISA), V. Sochor (CMI), A. Stefanic (CNEA).

Guests:

T. Aalbers (c/o VSL), G.M Hassan (NIS), M. A. Hassan (NIS), L. Karam (NIST), C. Omondi (KEBS), R. Tosh (NIST).

Excused: J.G. Peixoto (LNMRI/IRD)

BIPM members also present for all or part of the meeting: W. Louw (NMISA) (President of the CCRI), M. McEwen (NRC) (Co-Chair), M. Milton (Director of the BIPM), J.M. Los Arcos (Executive Secretary of the CCRI), D.T. Burns, C. Kessler, C. Michotte, D. Olson (JCRB Secretary), S. Picard, P. Roger, C. Thomas (KCDB coordinator).

Apologies were received from F Delaunay on behalf of J.M. Bordy (LNE-LNHB).

The meeting was called to order at 10:00 a.m. on 24 March, 2015, by the Chair, Dr Peter Sharpe, who circulated a revised meeting agenda (v 20150323) and made special introductions of the new representative from Argentina, Dr Amalia Stefanic and the President of the CCRI, Dr Wynand Louw.

1. WELCOME

Opening remarks by Dr. Louw welcomed the Delegates to the BIPM (also offered on behalf of Dr Milton, who was unable to attend) and to the 22nd meeting of the CCRI(I), and provided a brief overview of the CCRI, emphasizing a need to establish greater visibility of its reports and activities to its stakeholders as well as to the BIPM Ionizing Radiation Department.

Delegates and Guests introduced themselves.

2. TRANSFER OF CHAIRMANSHIP OF CCRI(I)

Dr Sharpe announced that he would be stepping down as Chair of CCRI(I) effective immediately, and introduced as new Chair Dr McEwen.

Dr Louw thanked Dr Sharpe for many years of service to CCRI(I) and welcomed Dr McEwen as his successor.

3. CONFIRMATION OF THE AGENDA AND APPOINTMENT OF THE RAPPORTEUR

Dr McEwen requested updates and/or corrections to the Agenda, none was received, and the Agenda (v 20150323) was approved.

Dr McEwen appointed Dr Ronald Tosh as Rapporteur.

4. PROGRESS REPORTS

4.1 CCRI reports (President Wynand Louw; CIPM)

Referring to the CCRI Strategy Report (<http://www.bipm.org/utis/en/pdf/CCRI-strategy-document.pdf>), Dr Louw commented favourably on overall content and the new Measurement Methods Matrix, which emphasizes that the « right » number of comparisons are being done.

CCRI announces change of Chair in Section I, from Dr Sharpe to Dr McEwen, and in Section III, from Dr David Thomas to Dr Vincent Gressier. Applications for observer status in Section III are also being accepted.

4.1.1 Strategy and actions reports (President Wynand Louw; CIPM, CGPM)

The CODATA Task Group on Fundamental Constants announced a deadline (1 July 2017) for acceptance of new data related to the anticipated update of the SI.

The CIPM is to establish a new working group to review the status and operations of the CIPM MRA. Connected with this is a questionnaire (based on the CCQM questionnaire) on MRA matters within the CCRI (e.g. the CMC process). Feedback to be requested from delegates ahead of review of the questionnaire by the CCRI.

The BIPM reports renovations of the Ionizing Radiation Building, new collaborations being undertaken with NMIJ (NMR) and KRISS (gas chromatography), and work toward establishing a traceability chain to the international prototype of the kilogram (IPK) for NMIs employing mass standards based on the Planck constant h , and, in spite of all that, managed a small budget surplus by the end of 2014.

The CGPM voted not to increase the dotation for BIPM over the period 2016-2019; nevertheless, the BIPM has established a new visitor programme for Member States and Associates, the BIPM Capacity Building & Knowledge Transfer (CBKT) Programme, intended to facilitate broader participation in the international metrology community by countries with emerging metrology systems and to encourage infrastructure development projects related to metrology. The new CBKT would require a 2 % increase to the present endowment (to be covered by donations from Member States).

The election process to the CIPM has been revised as of the most recent meeting of the CGPM (November, 2014). The election slate consists of 18 positions, one for each Member State, with letters of support from Member States being required for each candidate. Election results in a fixed, renewable term of 4 years' duration. Guidelines for conducting CIPM elections and succession of CIPM leadership shall be provided by a new Committee for CIPM Election.

The BIPM is to host workshops later in 2015 on Measurement Uncertainty and Global to Urban Scale Carbon Measurements. The anticipated workshop on accelerators is to be delayed.

The floor was opened to questions.

Dr Karam asked about the timeframe for the CCRI/MRA questionnaire. Dr Louw replied that the finalized questionnaire was behind schedule, but was expected to be completed and sent out to recipients before the end of the week. A turnaround time of 3-4 months was expected, in time for the feedback to be reviewed at the upcoming JCRB meeting in Kazakhstan.

Dr Picard requested that questionnaires and delegate feedback be received before the end of the summer, in order to comply with the plan to present feedback at the JCRB meeting. Dr Louw recommended a June (2015) deadline for return of the questionnaires, adding that it should require only 2 hours to complete.

4.1.2 CCRI RMO WG (Dr Aalbers)

Dr Aalbers was not able to attend this session of the meeting, so this item was postponed to the following day (rescheduled to follow item 6.3).

4.2 Section I reports

4.2.1 Strategy action reports (Dr Sharpe)

CCRI(I) strategy for 2013-2015 was reviewed and was acknowledged to have been mostly completed. It was further noted reassuringly that an end-of-year completion date had been mandated (for any remaining items).

CCRI(I) strategy for 2016-2019 was then reviewed. A summary table (Table 4 in the slides) indicated good progress on Actions (alphabetically labelled) *a* through *v*, specifically identifying each Action and the corresponding status of effort, and forthcoming detailed reports were identified. Dr Burns identified a missing item: ICRU participation in small-field dosimetry. Dr Sharpe further suggested that items *k*, *l* and *m* might be more appropriately taken up by Section II, to which Dr Karam replied that Section II had considered this possibility, but had concluded that items *k-m* were more broadly relevant (and thus should not be strictly under the purview of Section II). Dr McEwen suggested that biological dosimetric quantities, currently regarded as part of item n (on nano-dosimetry), deserve consideration as a separate Action. Dr Sharpe acknowledged the feedback and indicated that the timeframe for revision of Table 4 would extend up until the next meeting of the CIPM.

In addition to the Actions reviewed for 2016-2019 were two Initiatives:

1. High-energy MV dosimetry.
2. Review of situations where transition from an air kerma to a dose standard is possible, in order to determine where it is appropriate for CCRI(I) to “push” the transition to dose. Low-energy x-rays were cited as an example where a move to dose standards might be recommended; LDR brachytherapy was cited as a counterexample, because of resistance to such a change (particularly from the US).

A short break for a group photo occurred following this discussion.

4.2.2 Key Comparisons Working Group (Coordinator Dr Sharpe)

It was noted that the KCWG had not yet had a meeting in 2015, but one might be scheduled shortly after the present meeting.

A comparison report expected from Asia Pacific Metrology Programme (APMP) had encountered technical difficulties that have interfered with its timely completion and prompted its authors in January 2015 to request (in a letter to Mr Los Arcos) withdrawal of both the corresponding manuscript submitted earlier to *Metrologia* and the related entry in the KCDB. A two-month window was suggested by Dr Sharpe to allow the authors to resolve the technical issues, but, according to Dr Yi, the matter would likely require six months. Dr McEwen then asked Dr Yi if the six extra months were granted, a status report could be submitted after two months, indicating whether the six months would be sufficient. Dr Yi replied that he would need to confer with his associates at KRISS.

Dr G Hassan asked about the approval timeframe for obtaining Observer Status, which Mr Los Arcos indicated could be as early as the next meeting of the CIPM.

In the final slide, Dr Louw referred to a “large reports” problem, offering as an example the report from EURAMET project 1177, cited in the KCDB as EURAMET RI(I) – S9, which stretches to 103 pages and is being refereed by “anyone who knows anything about” the subject. Raised as a question, no immediate solutions were suggested. Dr McEwen requested comments on difficulties related to either the report or reviewing thereof, adding that Mr Los Arcos would be circulating a Draft B with a 2-week window for review, after which no response would be considered a *de facto* “acceptance” without corrections – problematic when compared to the standard review process for publication in archival literature. Mr Los Arcos commented that only one set of comments had been received for this particular report and that they had not yet been circulated within the CCRI. Dr Sharpe replied that the comments were extensive and worth circulating within the CCRI if no further comments had been received after two more weeks.

4.2.3 Brachytherapy Standards Working Group (Coordinator Dr Kessler)

By way of introduction, a chronology of the BSWG was presented going back to 2007, at which time NMIs had travelling well- and thimble-chamber standards, and response ratios of NMI and BIPM chambers were tabulated separately for NMIs that did or did not have thimble chambers. After a tabulation of recent results involving VSL, NPL, PTB and NRC were displayed, Dr Villevalde expressed interest in future participation and Dr Yi asked about sources KRISS might need to be able to participate.

Dr Mitch asked whether a decision had been reached about including I-125 seeds in the next LDR comparison (the topic having been introduced in the previous CCRI[I] meeting, in 2013), which prompted Dr McEwen to interject that the “dose/kerma quandary” might complicate that discussion. The latter was confirmed by Dr Pinto, who indicated that the forthcoming EURAMET LDR and HDR comparison, scheduled for 2016, would be for dose only, and not kerma. Dr Mitch countered that kerma should be retained, as it is kerma, and not dose, that forms the basis for traceability within the US. This was reinforced later by Dr McEwen, who suggested that including kerma in the comparison would attract wider participation in the comparison, and then asked whether kerma and dose could be obtained/treated similarly within the framework of the comparison. This was affirmed by Dr Pinto. Dr Mainegra-Hing then asked how many European NMIs are basing calibrations on dose; in response, Dr Pinto replied that no brachytherapy dose standards had been commissioned yet by any NMIs, but that lambda factors relating kerma and dose were being compiled.

Discussion about sources to be used in the K8 comparison addressed concerns about non-portable standards, including portable and non-portable sources (the former to accommodate non-portable standards). Variability of sources is of concern – Dr Mitch noted that NIST has much data on such variations – but the intercomparison is being designed so as to minimize the impact (e.g. by excluding particular sources with unacceptably high variation).

4.2.4 Accelerator Dosimetry Working Group (Coordinator Dr Sharpe)

Dr Sharpe said the ADWG(I) was closed in 2013 following the completion of its final report (*The provision of international validation and traceability for high-energy photon dosimetry*), which described four candidate scenarios for carrying out international comparisons of primary standards: i) a reference accelerator at the BIPM to which all NMIs would bring primary standards for comparisons, ii) a network of regional accelerator facilities to be visited periodically by BIPM staff and the BIPM primary standard (calorimeter), to carry out comparisons among primary standards from NMIs within each region, iii) continue with the status quo (BIPM.R[I]-K6 comparison), iv) suspend the K6 programme and revert to comparisons based on Co-60. The final report was not released, but is to be taken up by a subsequent Workshop that would generate a consensus report advocating a preferred path for traceability of accelerator-based dosimetry.

Dr Sharpe noted that this Workshop had convened, but the results had not yet been posted because of difficulties arising from (unspecified) changes underway at the BIPM and the CCRI, adding that the present meeting might afford an opportunity for discussing how to work through these difficulties. Dr McEwen suggested tabling that discussion until later (*viz.* following section 4.3.5), anticipating that technical content in intermediate sections would be helpful to the discussion.

Before closing out this section, Dr McEwen asked for commitments from NMIs to participate in the brachytherapy intercomparison, to which he received affirmative replies from: ENEA, LNHB definitely, NIST definitely, VNIIM interest-only at the present time.

4.3 BIPM reports (Mr Los Arcos)

4.3.1 Report 2013-2015 of the BIPM Ionizing Radiation Department

Mr Los Arcos reviewed personnel, facilities and primary standards of the Dosimetry and Radionuclides Groups within the Ionizing Radiation Department at the BIPM.

The Ionizing Radiation Department (of which Mr Los Arcos is Director) has a staff of eight, distributed between the Dosimetry Group (D Burns, S Picard, C Kessler and P Roger) and the Radionuclides Group (JM Los Arcos, S Courte, C Michotte, M Nonis and G Ratel). Two staff (S Picard and M Nonis) had been shared with the Thermometry Group, primarily to conduct internal calibrations, but those activities were outsourced starting in 2014 (after equipment failure).

The Dosimetry Group continues to maintain standards for low- and intermediate-energy x-rays (including mammography), gamma rays (Co-60 and Cs-137), and brachytherapy; a portable graphite calorimeter for high-energy photon beams has been making the rounds to NMIs as part of the R(I) K6 key comparison.

Dosimetry Group activities in 2013-2015 included three K6 comparisons (NPL, VLS and NMIJ) and the publication of several associated reports (from K6 comparisons with LNHB, NIST, ARPANSA and NPL), contributing to a total of 39 published reports summarizing K6 and numerous other dosimetry comparisons conducted over 2013-2015. Other comparisons with NRC (Canada) and LNE-LNHB (France) were part of a “relaunch” of the K8 key comparison for HDR Ir-192 (for which reports were being prepared). Supplementing these comparison activities were 74 characterization studies of other national standards (pertaining to low-energy and medium-energy x-rays, mammography, Co-60 and Cs-137 radiations) and numerous routine measurements involving internal primary standards and reference chambers in all reference x-ray and gamma beams, as required by the BIPM Quality Manual.

At the same time, the Dosimetry Group undertook several development activities and modelling projects, including work on an absorbed-dose standard for medium-energy x-rays, cavity ionization chambers (to be used as transfer standards in medium-energy x-rays and the Co-60 ranges), a design study for a new laboratory to support BIPM participation in the newly “relaunched” K8 key comparison, Monte Carlo modelling of medium-energy x-ray dosimetry and an investigation of refinements to the theoretical estimate of W_{air} destined for a forthcoming ICRU report.

A summary of work conducted by the Radioactivity Group highlighted preparation of numerous standard sources (PET nuclides, beta and gamma emitters), development of transfer instruments and associated reports. Thermometry activities included calibration of SPRT and other working thermometers and preparation of associated calibration reports. Equipment failure in 2014 of the SPRT instrument led to a discontinuation of internal calibration activities (which were subsequently outsourced in 2015). (Dr Karam noted a mistake on one of the slides, which erroneously indicated a half-life for C-11 of one minute instead of ~20 minutes.)

Work by members of the Ionizing Radiation Department in international coordination activities included participation in Consultative Committees of the CIPM (including CCRI and CCAUV), the KCDB, JCGM/WG1 (GUM), analyses of comparison/calibration needs of RMOs and NMIs, attendance and hosting of numerous workshops and travel to give invited talks.

Dr McEwen opened the floor to questions, but there being none, warmly expressed thanks to the BIPM Ionizing Radiation Department staff for an impressive body of work.

4.3.2 Programme of Work 2016-2019 of Ionizing Radiation Department

Following a short review of the Department’s mission and objectives, it was announced that no growth in the scope of activities (from 2013-2015) was anticipated, owing to zero-growth of funding projected for 2016-2019. In fact, the current forecast suggests reductions in the number of comparisons to be conducted by the Radionuclide Group and possible contraction of coordination activities pertaining to the CCRI and JCGM, while several other alternative activities were explicitly denied funding in the 2016-2019 Programme of Work and were, accordingly, suspended or forfeited. The latter were said to include: internal thermometry calibrations, accelerator dosimetry, comparisons involving LDR I-125 (IR-A1.4.1), development of an ionization chamber for realizing the Bq, and development of a sandwich-type coincidence detector for beta/gamma emitters.

Dr McEwen again opened the floor to questions, and none were asked. He then concluded by referring to the BIPM website repository for individual NMI reports.

5 CIPM MRA

5.1 JCRB report (Douglas Olson, JCRB Executive Secretary)

The JCRB, which usually meets on a semi-annual basis, was represented by Dr Olson, who became Executive Secretary in September 2014.

Dr Olson directed attention to the new JCRB web page on the BIPM website, in particular the JCRB Outcomes tab and online location of guidance documents, indicating that updates to the KCDB and the status of CMC reviews are now available online.

Dr Olson then shared a few of the important Recommendations that emerged from the 30th meeting of the JCRB (March 2013): 1) for CCs and RMOs to use the BIPM Web Forum for exchange of information and to make greater use of “fast track” processing of CMCs, 2) for reducing duplication of reviews of a given CMC by RMOs participating in an interregional review process, and 3) for better timeliness (and stricter deadlines) for CMC review, including the possibility of shutting down overly delayed CMC projects. The latter prompted questions about possible leniency to accommodate busy travel schedules of some reviewers and a suggestion to further streamline the CMC application process by allowing the grouping of similar CMCs, neither of which received favourable responses from Dr Olson or Dr Louw. Reviewers having difficulty meeting review deadlines were urged to consult more closely with the relevant RMO or review manager.

5.2 Comparisons (Claudine Thomas, BIPM)

Dr Thomas observed that the number of Calibration and Measurement Capability listings in the KCDB is approaching 25 000, with many new entries from newcomers and decreases, in the past year approaching 1000, resulting from “rationalization” and reformatting of a subset of CMCs (particularly in the areas of electricity/magnetism and fluid flow). Diverse statistics related to the KCDB were subsequently presented, including the number of CMCs published per country, per metrology area, numbers of “greyed out” CMCs (indicating temporary removal) and the number Associate Members of the CGPM having published CMCs (22 of 41). It was further noted that most of this information is available online, using links on the KCDB web page.

Following this overview, Dr Thomas expressed her thanks to co-workers and colleagues, and announced that she would be retiring from her position at the BIPM, which immediately prompted Dr Karam to ask, “But who will take care of us?” Dr Thomas pointed to Dr Picard, declaring her to be a good pupil: “when anything goes bad, she laughs.” Dr Louw then offered several remarks, noting in particular that CCRI is the biggest user of the KCDB and that Dr Thomas had become “the face of the KCDB” after so many years of service. After extending commendations on a job well done, he expressed best wishes for a happy retirement.

5.2.1 BIPM and CCRI(I) key comparisons status (Cecilia Kessler, BIPM)

BIPM.RI(I)-K1 [Co-60 air kerma], BIPM.RI(I)-K2 [low-energy x-rays], BIPM.RI(I)-K3 [medium-energy x-rays], BIPM.RI(I)-K4 [Co-60 absorbed dose to water], BIPM.RI(I)-K5 [Cs-137 air kerma], BIPM.RI(I)-K6 [high-energy x-rays absorbed dose to water], BIPM.RI(I)-K7 [mammography], BIPM.RI(I)-K8 [Ir-192 brachytherapy].

Dr Kessler reported on status of key comparisons. A total of nine key comparisons involving air kerma in x-rays, corresponding to BIPM.RI(I)-K2 and -K3, were summarized (pending updates were highlighted). This was followed by summaries of four key comparisons involving gamma rays – viz. BIPM.RI(I)-K1, -K4 and -K5 – and two more of HDR Ir-192 (a third had been scheduled). Measurements of dose-to-water in high-energy x-rays, for BIPM.RI(I)-K6, were conducted in 2013 at the NPL, at the NPL again in 2014 for the VSL and in 2015 at the NMIJ.

Plans for the period 2015-2017 include three key comparisons for low- and medium-energy x-rays and altogether eight key comparisons for gamma rays.

Statistics accumulated since 1993 indicate that calibrations and comparisons have averaged 30 +/- 5 per year, approximately two/three of which have been calibrations.

5.2.2 Regional key and supplementary comparisons status

SIM, EURAMET, COOMET, APMP, AFRIMETS

SIM (Dr Karam): K3 comparison report draft B, submitted recently (the previous week), was later than expected due to a misunderstanding by one of the labs.

EURAMET (Mr Bjerke): S11 comparison conducted with 16 partners, measurements were completed and draft A is in preparation (expected in 2015).

COOMET (Ms Villevalde): S1 (PTB pilot) and S2 (VNIIM pilot) comparisons completed; Co-60 dose to water and S3 (BelGIM pilot) are planned.

APMP (Dr Yi): 16 comparisons planned or in various stages of completion, results from three of which had been published in the KCDB, two supplementary comparisons had been proposed, and a technical protocol for a second-round K3 comparison was nearing completion. Dr McEwen prompted Dr Yi to notify delegates that only one week remained for review of the protocol.

AFRIMETS (Ms Msimang): S1 comparison delayed by customs inspections of instruments crossing international borders. Dr McEwen asked whether other Sections had experienced similar delays due to customs, to which Dr Karam and Dr Louw responded in the affirmative for Sections II and III, respectively. Dr Karam added the delays are often unpredictable, thus scheduling for them could be problematic.

5.2.3 Future comparisons

Dr Burns commented on the anticipated BIPM.R(I).I-K9 key comparison for dose to water in low- and medium-energy x-ray beams, suggesting similarities to -K3 regarding use of transfer instruments.

Dr Sharpe provided status on an emerging key comparison for absorbed dose to water for e-beam radiotherapy. As noted in the previous Section I meeting, NRC, METAS and NPL are working up a technical protocol involving an alanine-based detector inserted into a solid-water phantom. With a pilot study conducted by the three labs (which encountered no customs difficulties) in press, and online at *Metrologia*, attention would turn toward establishing a EURAMET comparison. When asked for a show of interest in participating in that development (which would require a primary standard for radiotherapy electron beams) the following responses were received: NRC, PTB and METAS indicated readiness to participate; KRISS was tentatively interested; NIM and NIST indicated interest subject to completion of preliminary work.

5.3 Calibration and Measurement Capabilities (skipped)

6 STRATEGIC PLANNING 2013-2023

6.1 Short term (2013-2015), medium term (2016-2019) (skipped)

6.2 Status of CCRI strategic plan

6.2.1 CCRI(I) strategic actions and working groups 2013-2023, considering the following strategic trends

6.2.1.1 Recommended values for physical constants

W/e and stopping powers (currently short-term strategic action m)

Dr Burns reviewed the status of analysis conducted on data from the BIPM.R(I).I-K6 comparisons that supports a 0.7 % reduction in the graphite-to-air stopping power ratio for Co-60 radiation ($s_{g,air}$), hence a corresponding 0.7 % reduction in air-kerma determinations done with graphite-walled cavity standards. The work has been described in papers published in both *Metrologia* (2012) and, more recently, *Physics in Medicine and Biology* (2014).

Discussion ensued:

Dr McEwen asked about the interpretation of bounding lines in a plot of dose ratio (measured/calculated) vs. $TPR_{20,10}$, which Dr Burns said were indicative of corrections or deflections with relatively greater impact for Co-60.

Mr Bjerke inquired about the larger significance for dosimetry of the 0.7 % shift if ultimately accepted, which prompted consideration of an *ad hoc* group to investigate impacts for other standards.

Dr Yi offered a few critical comments about the adequacy of the Monte Carlo, which Dr Burns attempted to clarify.

Dr Mainegra-Hing asked about cavity dimensions; Dr Burns replied that diameter was 5 cm and thickness 5 mm.

Dr Burns turned attention to status of the ICRU report on key dosimetry data, indicating delays owing to communications difficulties among committee members, but added that Stephen Seltzer had recently taken over as chair and completion of the report appeared to be in sight. Among the key dosimetric data discussed in this ICRU report are mean excitation energies I (air, graphite, liquid water), density effect in graphite, heat defect in water, and the mean energy to produce an ion pair in air, W_{air} . The 0.7 % downward shift in the product $W_{air} \cdot s_{g,air}$ for Co-60 was attributed to (or correlated with) a determination of I_c of 81.8 eV +/- 1.8 eV (standard uncertainty).

Discussion ensued:

Dr Tosh asked how the (relatively large) standard uncertainty in I_c would not mask a 0.7 % shift in $W_{air} \cdot s_{g,air}$. Dr Burns suggested it was complicated, but replied that 0.5 % of the shift was attributable to the value of I_c and 0.2 % was attributable to use of the grain density for graphite (rather than the bulk density).

Dr Mainegra-Hing asked about recommendations for electron beams < 50 keV, and was told the report contains no recommendations for those energies.

Dr Butler asked about possible implications for dosimetry of Cs-137 radiation. Dr Burns indicated Monte Carlo corrections would be applicable.

In response to a question from Dr McEwen about possible impacts on dosimetry for -K8 comparisons, Dr Burns affirmed that anything involving cavity chambers would be affected.

Dr Duane asked about changes in the density-effect correction, and Dr Burns offered a few observations but referred him to the forthcoming ICRU report for final details.

Dr Sharpe suggested that earlier ICRU reports (e.g. ICRU 37, published in 1985) be consulted for how to proceed with recommendations for significant changes in key quantities. Dr Burns, unfamiliar with the specific wording of the earlier report, acknowledged the point.

Dr McEwen again raised the possibility of forming an *ad hoc* group to consider implications of the upcoming changes for the various primary standards. When asked for a show of interest in participation, Dr Duane, Dr Butler, Dr Tosh and Dr McEwen all affirmed interest. Dr Karam then asked whether this *ad hoc* group would be a formal working group, but Dr McEwen replied that it would be more of an advisory group, and would not likely begin work until after the ICRU report had been released. Dr Sharpe added that recommendations and findings of such an advisory group would ultimately be presented to the CCRI after consideration first by the CCRI(I). Dr Louw would be an appropriate contact.

Dr Butler asked about the possibility of conducting a crucial experiment to verify the 0.7 % shift, but Dr Burns replied that the 0.7 % is needed to rationalize the results of many experiments. Dr Butler then asked whether new GUM Bayesian analysis impacts the magnitude of the shift or illuminates the causes, to which Dr Burns replied that statistical analysis alone would not erase the effect.

Dr McEwen asked if other labs (besides NRCC) had been looking into W_{air} ; no others indicated any active programmes.

Dr Sharpe suggested that the advisory group include an expert on proton dosimetry.

Dr Picard asked about the anticipated response of NMIs and other stakeholders, to which Dr Sharpe, based on earlier experience with ICRU 37, expressed uncertainty about the latter but urged caution and a deliberate, carefully crafted communication plan. The latter point was reinforced by Dr Meghziene, prompting Dr McEwen to suggest possible tactics for dissemination, to include newsletters through formal bodies (to the effect that “this” is out in the literature, and implications could for dosimetry could be x, y, z).

Dr McEwen concluded the discussion, “We just have to convince people that we are really getting better at air kerma, even though the value keeps changing.” Dr Sharpe added that, in addition to the value, uncertainty changes, too, and recommendations must be justified.

6.2.1.2 Photon dosimetry

Air kerma and absorbed dose to water for photon dosimetry

Presentations delivered in order of photon energy by delegates from the various NMIs.

KRISS: Dr Yi presented specifications and correction factors pertaining to their new FAC. Monte Carlo (PENELOPE) results of correction factors for electron loss, k_e , and photon scattering, k_{sc} , vs. photon energy (0 kV to 340 kV and 100 kV-320 kV, respectively), exhibited modest variation with changes in air density: an 8 % change in air density led to ~1 % variation in k_e and k_{sc} only at the low- and high-energy ends of the spectrum, in each case, and negligible variation at intermediate energies (negligible variation also observed for the other correction factors).

Dr Burns commented on the significance of this variation for spectral-averaged quantities and suggested that 8 % variation in air density is extreme (given that variations rarely exceed 3 %-4 %).

BIPM: Dr Burns described a new absorbed-dose-to-water standard for medium-energy x-rays, for 100 kV to 250 kV, and plans for establishing equivalence with the existing FAC and transferring the standard to two different reference-class chambers: one is a parallel-plate chamber constructed at the BIPM (of graphite or C552 walls – prototypes of each have been constructed and waterproofed), and one

is a thimble chamber (A12). Monte Carlo studies of the various chambers indicate an unexpected variation in performance with beam quality. After finalizing these investigations and establishing the new primary standard, the BIPM would undertake a pilot comparison with the PTB medium-energy dose standard, with eventual plans to link with EURAMET.RI(I)-S13. Thereafter, the instrument would be available for indirect comparisons with primary standards and calibrations of other national standards (waterproof chambers only).

Dr McEwen commented on the similarity of this conversion between K_{air} and D_w to AAPM protocols TG-21 or TG-51.

Dr Mainegra-Hing asked about implications for labs seeking kerma vs. dose calibrations (i.e., would a two-class system develop, where kerma would be viewed negatively?)

Dr Pinto prompted about the need for Monte Carlo for each chamber type, which Dr Burns at first resisted, suggesting that scaling factors would cover some instances, but Dr McEwen pointed out that this would assume that all chamber responses would by necessity fall within the response window of the BIPM test chambers. Mr Bjerke speculated that not only other types of chambers but various measurement depths might be requested. Dr Burns conceded the difficulties, but reiterated that D_w/K_{air} is insensitive to spectrum and that, for the near term, the instrument would be designed for a reference depth of 2 g/cm².

ENEA-INRIM: Dr Pinto described a pilot study related to a supplementary comparison, EURAMET.R(I).I-S13, involving the ENEA graphite calorimeter, MKEH extrapolation chamber, and water calorimeters from PTB, LNE-LNHB and VSL. Dose and kerma measurements were being done at 100 kV, 135 kV, 180 kV and 250 kV and at reference depths of 2 g/cm² and 5 g/cm². Eventual linking of the -S13 comparison to the anticipated BIPM.R(I).I-K9 is expected in 2015-2016, with comparison measurements to involve the new BIPM medium-energy dose standard.

Discussion ensued:

Dr Burns requested that the outcome of the pilot EURAMET comparison not be made available before the -K9 details have been completely worked out. Subsequent discussion between Dr McEwen and Dr Burns touched upon concerns related to the independent development -K9 (from EURAMET-S13), thus initial publication of results would likely involve only normalized results – i.e. no calibration coefficients until after the -K9 key comparison technical protocol is worked out. Dr Pinto added that he would need to confirm with his sponsors whether calibration coefficients could be withheld in published work.

Mr Bjerke asked about 50 kV dose standards, referring to PTB's work at 70 kV, but Dr Burns replied that the BIPM focus would be on intermediate energies, 100 kV – 250 kV.

Dr Pinto continued his presentation, going over particulars related to their graphite calorimeter for medium-energy photons, including several pictures of the calorimeter construction and sample waveforms. The conversion to dose to water, D_w , from dose to graphite, D_g , involves a factor C_{wg_MC} , obtained from Monte Carlo, which contributes a sizable type-B uncertainty of 0.93 %, contributing to an overall relative standard uncertainty of 1.9 %.

Questions followed:

Dr Berlyand asked whether the Monte Carlo studies had included calorimeter-core composition in sufficient detail to model accurately the energy dependence of the mass energy-absorption coefficients. Dr Pinto confirmed that the models did include the graphite, thermistors, cement, Pt wires, and impurities. Dr Berlyand then asked whether future work would attempt to realize the energy spectrum

more precisely. Dr Pinto replied that at present only HVLs were being used to establish beam quality, but that a full spectral determination would be carried out with a newly acquired detector.

Dr Butler asked about the large relative uncertainty of the conversion factor, which Dr Pinto attributed to uncertainty in the energy spectrum, which he anticipated would be greatly reduced when the new detector is put into service.

NIST: Dr Mitch described updates to the NIST medium-energy x-ray system ahead of the planned BIPM.R(I).I-K3 key comparison, which included a new x-ray tube and associated modifications, which have necessitated beam-characterization studies prior to resuming metrology activities. Also described were studies on peak skin dose (PSD), using radiochromic films in the NIST M120 x-ray beam (following the AAPM TG-61 protocol), and CT dose to critical organs, done with a head phantom in the NIST PET/CT diagnostic imaging system. The latter, involving dose to the brain, optic nerve, eye globe, and eye lens were validated with Monte Carlo studies.

Dr Butler requested (and received) further details on the type of film dosimeters used.

NRPA: Mr Bjerke presented work on characterizing uncertainties in CT dose, connected with a plan to establish a new calibration service, in which measurements were carried out with a solid-state detector (diode dose profiler) and a reference-class ionization chamber following the “three scenarios” guidelines in IAEA TRS 457 (which define different levels of control, hence uncertainty, over measurement conditions). Example data exhibited expected characteristics (e.g. ~10 % uncertainty in derived quantities like P_{KL,CT}). Additional comments highlighted problems of cost that arise with annual calibrations.

Dr Ankerhold asked about the possible significance of energy dependence in the sensitivity of the dose profiler, which Mr Bjerke acknowledged.

Dr McEwen commented that annual calibration intervals are typical throughout the world except in the US, where the “value” of annual calibrations seems not to be recognized in the diagnostic community as much as it is in the therapy community. He then polled for comments, receiving responses from PTB, ARPANSA, and LNE-LNHB regarding plans for similar projects and/or problems affecting calibration intervals.

Following a break for coffee, and before resuming with NMI presentations, Dr McEwen prompted a discussion about the strategic importance of developing a key comparison for absorbed dose in medium-energy x-rays (i.e. -K9) independent of the EURAMET-S13 effort. Among other things, it was suggested that development of -K9 may stimulate NMIs to develop associated primary dose standards, possibly to complement kerma standards used in -K3 comparisons. The room was polled for interest in eventual participation in -K9, but response was reserved. Ms Msimang expressed interest in comparisons for lower-energy x-rays, but Dr McEwen pointed out that -K9 would cover 100 kV to 250 kV. Dr Yi then questioned whether an absorbed dose standard for medium-energy x-rays was necessary, but Dr Burns replied that the decision to go ahead with establishing -K9 had been made in previous meetings.

Remaining presentations in this section pertain mostly to studies done in synchrotron x-ray beams.

ARPANSA: Dr Butler presented absolute dosimetry results obtained with a graphite calorimeter at the Imaging and Medical Beamline (IMBL) at the Australian Synchrotron. The 3 GeV electron beam storage ring delivers 4 kGy/s at Hutch 1B (located 22 m away from the ring) – enough to melt a plastic ionization chamber. The graphite calorimeter, built by NPL for ARPANSA, was used in Hutch 3, located 138 metres away. Example beam profiles obtained with radiochromic film were presented, along with sample traces from the calorimeter showing evidence of heat conduction.

Several questions were answered about the collaboration between NPL and ARPANSA, lessons learned about effects on recombination attributable to polarization of the radiation beam, relevance to therapy and aging of components.

Dr Butler continued with results from small-field studies at the same facility, in which a thimble chamber was translated across the path of a sub-mm beam (derived from the synchrotron after passing through a small circular aperture) and its current monitored as a function of position. The resulting curves showed clear features related to chamber walls and central electrode, thereby providing a dose map at sub-millimetre scales over the collecting volume of the chamber.

This generated considerable interest. Dr Ankerhold commented that similar work was being done at PTB with clinical beams (see later). Dr McEwen requested some clarification about how useful the images were as a quantitative dose map, and Dr Duane added that the approach might provide a way to investigate small/micro beam doses (“albeit at smaller energy”).

NPL: Dr Duane presented results obtained at the ESRF, in which a synchrotron beam of 7 kGy/s was obtained through a small aperture (7 mm x 7 mm), and the resulting dose profile was determined with a graphite calorimeter set behind a narrow (50 µm) sampling slit in lead that was moved transversely across the beam in 5 µm steps. The work is relevant to the problem of absolute dosimetry for synchrotron microbeam radiation therapy.

Questions concerned the spectrum of the sampled radiation (breadth ~ 100 kV) and whether evacuation of the space around the calorimeter was believed to be necessary. Dr Duane indicated that evacuation was not believed to be necessary given the high dose rates and the integration times.

NIM: Mr Wu described work to produce monochromatic x-ray beams from the Shanghai Synchrotron Radiation Facility and x-ray tubes used with a Bragg filter. Example data, taken with a tube-collimator-crystal-collimator-HPGe detector configuration constructed over 2012-2014, showed a 50 kV x-ray beam with a field size of 5 mm x 5 mm that was determined to be ~96 % monochromatic. In his introduction, Mr Wu suggested that this work might be more relevant to Section II because of the use of photon counting. The work is intended to advance various astronomical objectives.

Dr Pinto speculated about the use of a monochromator for mass energy-absorption measurements, and Dr Ankerhold asked about the crystal, which Mr Wu said was Si (1 1 1).

LNE-LNHB: Dr Delaunay presented results of measurements done to characterize the spectral response of detectors (HPGe and CdTe) at ESRF (from 20 kV to 250 kV) and at LNHB, using their SOLEX source (from 5 kV to 17 kV), with analysis done using COLEGRAM software (LNHB). Several spectra were presented, some of which displayed anomalous discontinuities that were said to be attributable to Ba used to prevent outgassing in the x-ray tubes. Further questions about possible effects on measured spectra of W content suggested that analysis with a tool like SpekCalc might be recommended.

PTB: Dr Ankerhold presented work done as part of the EMRP joint research project HLT09 on the metrology of complex radiation fields, in which a Kodak ACR 2000i x-ray foil storage system had been characterized in Co-60 radiation, linac x-rays (4 MV, 8 MV and 25 MV) and electrons (10 MeV, 15 MeV and 18 MeV), and low-energy x-rays. Also shown were plots of ionization chamber response obtained in linac x-rays when translated past a narrow slit or edge, demonstrating proof-of-principle spatial resolution of sub-mm features from a clinical microbeam.

Dr Burns asked about the expected dose profile of the microbeam (delta function), Dr Butler commented on similarities to work described above with synchrotron radiation, and Dr Duane had a few questions about effects of secondary electrons from air and from water.

Presentations shifted to absorbed dose in Cs-137 and Co-60 beams

NMIJ/AIST: Dr Saito summarized recent work undertaken after the accident at the Fukushima Daiichi power plant to determine effective dose to the population due to Cs-137 and Cs-134 gammas from dispersed radionuclides. Energy spectra of scattered radiation were measured with a CdTeZn designed to work at very low dose rates: 0.1-3.0 $\mu\text{Sv/h}$ (field surveys were expected as low 0.2 $\mu\text{Sv/h}$). Results yielded dose equivalent H(10) with combined standard uncertainty of 2.02 %, for air kerma 1.92 % (due mostly to non-uniformity of 1.01 %).

NRCC: Dr McEwen provided an update of a report first delivered by CK Ross (NRCC, now retired) at the Paris Dose Workshop in 2007 on the stability of sealed core vessels (adapted triple-point cells) for water calorimetry. At the time of the Paris workshop, 7 years after NRCC had begun using them, no discernible drift had been observed in their performance; and now, another 8 years later, still no discernible change had been observed.

Dr Sharpe asked about the mixture of dissolved gases used (to mitigate heat defects), and was told H_2 dissolved in the water with a He bubble (to accommodate volume changes of the liquid) works best.

Brachytherapy dosimetry

PTB: Dr Ankerhold summarized various projects related to the use of alanine/ESR dosimetry for brachytherapy, including measuring the relative response of alanine pellets at x-ray energies typical of electronic brachytherapy systems (using miniature x-ray tubes) and determining dose distributions within a water phantom around a HDR Ir-192 source outfitted with tungsten applicators (used in intracavity brachytherapy). Also described were investigations of the feasibility of using a radiation quality correction factor k_Q for well-type chambers to derive a calibration coefficient for Co-60 HDR brachytherapy from a calibration coefficient for Ir-192 HDR brachytherapy. The investigations revealed variations with chamber type, but not source strength, and that use of the k_Q factor doubles the combined standard uncertainty (compared to direct calibration with a Co-60 source).

Dr Mitch asked about some of the source variations shown in the k_Q work, and Dr McEwen sought clarification on some of the few-per cent variations presented with the alanine response ratios.

NMIJ: Dr Saito presented air kerma measurements for Ir-192 done with a new graphite cavity chamber, results of which included corrections for scattering and attenuation estimated with the EGS5 code. Results for two different sources were within 0.4 % of values supplied on calibration certificates. Also, participation in the -K8 comparison was expected in April 2015.

NPL: Dr Duane reviewed their recent HDR source upgrade, to a Flexitron system, and status of their source-calibration service (in terms of RAKR), well-chamber calibrations and HDR Ir-192 absorbed dose standard.

NRCC: Dr McEwen described a new Fricke absorbed-dose standard for HDR Ir-192, with photos of the device, details of positioning system and preliminary measurements. G-values for ferric ions, determined by interpolating between G-values for 250 kV x-rays and Co-60 gamma rays, provided the largest component of the 0.8 % combined standard uncertainty obtained following AAPM TG-43.

NIST: Dr Mitch described the new electronic brachytherapy calibration range, including details about operation and performance: 50 kV, 300 μA , and an air-kerma rate of $\sim 1\text{E-}04$ Gy/s, with a combined standard uncertainty of ~ 1 % ($k=2$). Typical lifetime of the miniature x-ray tubes is 6-8 hours, and spectrum varies little from tube to tube.

Dr Sharpe asked whether the tube dies suddenly, which Dr Mitch affirmed. Dr Ankerhold asked about how the well-chamber insert is constructed; Dr Mitch replied that the design is intended to minimize impact on the spectrum. Dr McEwen confirmed that the insert is not in general transferrable between well chambers.

Radiation protection

PTB: Dr Ankerhold reviewed status on radiation-protection initiatives underway, including review of requirements set forth in ISO/TS 18090-1 and their implementation at PTB, PTB coordination of the EMRP research project MetroERM for harmonizing dose rates and airborne activity measurements arising from some 5000 monitoring stations throughout Europe, and participation in a first EURADOS intercomparison of passive H*(10) area dosimeters. Also presented were simulation results pertaining to reference radiation fields from their Beta Secondary Standard and development of associated correction factors for irradiation of various geometries (needed for compliance with ISO standards).

LNE-LNHB: Dr Delaunay described a conical filter + target construction, composed of graphite and copper, for use with their linac e-beam to produce 6 MV – 7 MV photon beams for calibrating radiation protection dosimeters and dose-rate meters. Monte Carlo simulations were carried out to derive conversion coefficients from kerma measurement (spherical ionization chamber) to H*(10) and H_p(10).

Dr McEwen asked about validation of the energy fluence spectra obtained from Monte Carlo, remarking on the peculiar shape shown on plots. Dr Butler asked whether measurements had been compared to survey meters.

Radiation processing

NPL: Dr Sharpe described installation of a cryogenic line to their Gammacell industrial irradiators that now allow operation over the temperature range –60 °C to +60 °C (similar to NIST).

NIST: Dr Mitch described plans for installing the Applied Irradiation Manufacturing Standards facility at NIST, which is to be based on a 10 MeV, 17 kW electron-beam accelerator, and would include a conveyor system to enable metrology under conditions that approximate radiation processing situations used/planned in industry. New graphite calorimeters will be built for use with the setup.

Dr Sharpe asked about the possible incorporation of a target for x-ray generation, which Dr Mitch agreed would make an interesting addition.

International traceability for accelerator dosimetry

BIPM: Dr Picard reviewed the status of the BIPM.R(I).I-K6 key comparison. To date, seven comparisons had been completed, with eight remaining to be done before the end of 2019, which marks 10 years since the cycle began (and thus would begin again). Some detail was provided related to comparisons done since 2013, with NPL and VSL (both done at NPL), and at various reference depths (5 g/cm² and 7 g/cm², to comply with UK codes of practice, and 10 g/cm², to comply with international codes of practice).

A summary slide displaying the ratio R (of NMI dose to BIPM dose) vs. TPR_{20,10} showed very good agreement among the labs represented (*viz.* NRC, PTB, NIST, LNE_LNHB, ARPANSA and NPL). Similarly, a quadratic fit to the Monte Carlo determined dose conversion factors C_{w,c} vs. TPR_{20,10} for the

six labs exhibited such smooth variation, and deviations from the fit were so small, that it was suggested one may be tempted to derive $C_{w,c}$ values for future comparisons from the fit rather than carrying out the more laborious Monte Carlo modelling.

Another plot of the $TPR_{20,10}$ dependence of the calibration coefficient $N_{D,c}$ ($= D_c/Q_c$) for a BIPM transfer chamber (calo-3), evaluated at each of the labs, suggested distinct grouping of points according to accelerator vendor. If found to hold, it was speculated that filtration characteristics for the different manufacturers might be to blame, however follow-up Monte Carlo calculations had shown no such vendor grouping of results – thus, “clearly, something remains to be understood.”

The next stop for the -K6 was said to be NMIJ/AIST, in April 2015, and Mr Roger would henceforth be taking over both technical and administrative activities related to this.

Discussion ensued:

Dr McEwen asked about possible difficulties fitting in the remaining eight comparisons over only three years, but as most of the remaining visits were “local” (to European NMIs), no difficulties were anticipated. He then asked about the better agreement NPL points and the best-fit curve in the plot of $N_{D,c}$ vs. $TPR_{20,10}$, which was speculated to be attributable to better monitoring of variations in the beam output.

The vendor-grouping problem stimulated a lively discussion, some of it involving analysis au podium of possible groupings by other factors, none of which appeared to exhibit the bias evident with grouping by accelerator vendor. Dr Tosh asked whether the Monte Carlo results suggested the vendor grouping was fictitious, but Dr Burns believed the results suggest the problem, if there is one, lies in hardware (e.g. filters) whose details may not have been adequately characterized in the models. Dr Butler pointed out that the effect “goes away” if a couple of points in the plot are ignored. Dr Sharpe expressed concern about the wisdom of disseminating data that suggests a manufacturer bias, but Dr Picard assured him that the data groupings had been anonymized in published reports. Dr Duane then asked whether the effect would seem less evident in a plot of $N_{D,w}$, instead of $N_{D,c}$, vs. $TPR_{20,10}$, but Dr Burns replied that the effect, being “carried along” with the measurements, would not be any less evident there.

NPL: Dr Duane reviewed status on their linac and their graphite calorimeter primary standard for linac photons and electrons, both of which had been replaced since the previous meeting of the CCRI(I). (Replacement of the linac became necessary due to instabilities and down time; replacement of the calorimeter became necessary because of large uncertainties to heat-transfer corrections due to insufficiently characterized materials used in its construction.)

Work with alanine dosimeters over a wide span of $TPR_{20,10}$, from 0.56 to 0.80 (Co-60 to 20 MV), showed a ~1 % correlated variation, thus a possible beam-quality dependence. (Dr Sharpe commented that the “old 0.994” relative response of alanine to D_w may need to be replaced by something that captures the variation with $TPR_{20,10}$.) Variations in alanine response in strong B fields were studied as well, and the effect – a possible ~0.5 % linear increase with B over 0 T to 2.5 T – was said to be much smaller than effects observed under similar conditions with a NE2571 ionization chamber.

Concluding comments were given on the dosimetry challenges posed by non-uniformities in FFF beams, whose adoption in the clinic is becoming widespread owing to therapeutic outcomes and higher patient throughput.

VSL: Dr Pooter introduced a new, portable water calorimeter intended (and, in many cases, already tested) for use in Co-60, MV photons (w/w FFF), proton beams, and MR-linacs. Electrical and mechanical specifications were shown – e.g. active cooling circuit, insulation around entrance window, rugged, portable mechanical design intended for operation with vertical or horizontal beams, thermal

stability of 0.4 $\mu\text{K/s}$ attainable after 8 hours (demonstrated experimentally, but also in agreement with finite-element modelling). Measurements in Co-60 agreed with decay-corrected measurements of D_w from their previous water calorimetry standard, and measurements in MV photon beams were used to verify k_Q factors to within 0.3 %. Some exploration of effects in the MR-linac (8 MeV linac with 1.5 T field) included discussion of hysteresis and chamber orientation dependence of a NE2571 (c.f. earlier discussion presented by Dr Duane), effects on thermistor resistances due to the B field ($\sim 0.45 \Omega$ per 10 k Ω), and effects on excess heat due to curling of electron trajectories near material boundaries (shown in Monte Carlo calculations). Commissioning of the new calorimeter for use in MR-linacs was expected later in the year.

Dr Picard asked about typical field sizes in MR-integrated photon beams, which were said to be variable, although, as Dr Duane indicated, in some cases quite smaller than the usual MV reference conditions (e.g. TomoTherapy field sizes ≤ 5 cm), which led to discussion about reference dosimetry in non-standard fields and small fields.

NMIJ/AIST: Dr Saito presented details and results of measurements from their new primary standard graphite calorimeter. Comparison measurements conducted with ARPANSA at four beam qualities at/above TPR_{20,10} showed very good agreement. Noting similarity to the BIPM design, Dr Burns suggested that his Monte Carlo modelling of the BIPM calorimeter might be applicable to the NMIJ/AIST instrument, which Dr Saito agreed should be pursued in advance of the upcoming -K6 comparison.

As the (second) day of the meeting was nearing an end, Dr McEwen called a temporary halt to the NMI reports until the next morning, and proposed the idea of a 1-day workshop to develop and review options (for -K6) if the BIPM is to procure a medical linac, with possible recommendations to be passed to the CIPM. As the present -K6 cycle is set to close in 2019, the impact of such a workshop was expected to be greater the sooner it is held. Dr Louw suggested circulating a questionnaire within CCRI(I) to poll for issues to prime the discussion.

Upon resuming the meeting on the morning of March 26, Dr McEwen proposed to postpone resuming the technical presentations (under agenda item 6.2.1.2) and to proceed immediately with agenda item 6.2.1.4, on uncertainty evaluation.

6.2.1.4 Uncertainty evaluation (n.b. earlier than originally scheduled)

Summary on GUM2 workshop (C. Michotte, Scientific Secretary of JCGM-WG1)

Dr Michotte reviewed major updates to the GUM (whose revision had been heralded in *Metrologia* articles by Bich *et al.* in 2012 and Bich in 2014), including uncertainties in modelling, handling estimates of uncertainty, increasing the default coverage factor for standard uncertainty, simplifying uncertainty propagation, Bayesian approaches for Type A and B uncertainties and worked examples. Examples include application of a new factor for standard deviation $\sqrt{[(n-2)/(n-3)]}$ (implying that, for $n < 4$, other information, e.g. historical performance, would be needed to estimate standard deviation), iterative refinement in uncertainty estimation and propagation, and guidelines on the use of Monte Carlo when a model is “sufficiently” nonlinear). An upcoming workshop in early June (1-2 or 15-16 June 2015) was announced and its agenda reviewed.

Dr Karam commented that CCRI attendance to the workshop should, in principle, be high, but as the timing would nearly coincide with the ICRM meeting, travel back to both may prove difficult, thus would online attendance be an option. Dr Michotte replied that she would have to look into that possibility. Dr Picard asked about how some of the new guidelines would work in intercomparisons

involving four or fewer labs (as occurs, for example, with neutron standards). Dr Michotte was unsure about recommendations GUM2 might have for such circumstances.

NMIs feedback on GUM2 applicability to dosimetry measurement methods

The floor was opened for comments on the revisions to the GUM.

Dr McEwen acknowledged that there are deep concerns about the GUM at NRCC, with challenges asserted against each of the supposed improvements, although he also acknowledged that part of this was likely a consequence of people not having internalized the original GUM. Accordingly, he expressed a preference for delaying the workshop or opening the agenda to discussing the many misgivings.

Dr Mitch requested clarification on the increase in default coverage factor.

Dr Aalbers proposed that implications of the revised GUM for KCs and CMCs etc. be investigated, suggesting that such an effort, far from constituting an endorsement of the revision itself, may reveal difficulties that require attention.

Dr Burns emphasized that because the GUM offers guidelines, not requirements, the judgment of the scientist is always paramount. Dr Sharpe challenged this by pointing out that the GUM, not any given scientist's implementation of it, would form the basis for judgments in lab assessments and accreditations (in accordance with ISO 17025, among other things).

Dr Picard asked about supporting reference materials for use with the revised GUM, and Dr Michotte mentioned software tools, example data and worked exercises.

Ms Aviles Lucas had a few questions about software related to Supplement 1 and whether revisions to the software will cover specific (unspecified) cases of interest. Dr Michotte indicated that the working group is attempting to address this concern.

Dr McEwen redirected attention back to remaining NMI presentations under agenda item 6.2.1.2.

6.2.1.2 Photon dosimetry (resumed)

KRISS: Dr Yi presented results of a computational investigation of the thermal response of their graphite calorimeter when subjected to joule heating by embedded thermistors vs. heating from ionizing radiation. The investigation was prompted by work published by Radu *et al.* in *Metrologia* that claimed to demonstrate ~0.11 % differences in temperature rise realized under artificial (thermistor heating) conditions vs. radiation heating. Details regarding his model (COMSOL) applied both to square slab and circular/cylindrical geometry were presented, and the results suggested a much smaller difference, ~0.02 %, in dT between radiation heating and joule heating.

Dr Duane asked whether differences in the two mechanisms might be related to the effectiveness of thermal contact between the thermistor beads and graphite and whether this had been explored in the modelling. Dr Yi indicated that such details may await future work.

6.2.1.3 Charged particle dosimetry

Electron/beta dosimetry

NPL: Dr Duane presented work on electron beam dosimetry, which had been interrupted by the “demise” of their previous primary standard (which has been replaced, as noted earlier). He added that

they were able to “recommission” that standard for measurements at ambient pressure with sufficiently elevated dose rates (10 Gy/min), obtaining k_Q values at $R_{50,D}$ for 10 MeV.

Dr Butler asked Dr Duane to elaborate on details regarding tuning of the Elekta to achieve 10 Gy/min operation, after which Dr McEwen commented that Elekta had previously discouraged the practice. Dr Duane indicated he would be interested to know more about the Elekta recommendations (which he would pursue later).

NIST: Dr Mitch presented preliminary results demonstrating dosimetry of linac electron beams using various remote-sensing strategies based on ultrasonic imaging, laser interferometry and Cherenkov light. Ultrasonic speed-of-sound measurements had been used with a cylindrical array to acquire images of temperature distributions in a water phantom irradiated by 12 MeV electrons and, with send/receive transducer pairs, to obtain points on a depth-dose profile. A laser interferometric technique had also used to obtain heating profiles from a similar beam, and Cherenkov light had been used to obtain dose profiles (depth and lateral).

Dr Picard expressed concerns about correcting temperature distributions for convection evident in example data shown, which was acknowledged to be a difficulty with these approaches (and for which solutions must be found for them to be useful). Dr McEwen commented similar concerns about the remaining difficulties.

Protons

Dr Duane alluded to work going on at NPL, but was uninclined to present anything at this time.

Other charged particles

NMIJ/AIST: Dr Saito described measurements conducted at the Heavy Ion Medical Accelerator in Chiba (HIMAC), including a depth profile in water using a graphite ionization chamber with a 290 MeV/n carbon beam, dose in graphite with 290 MeV/n and 135 MeV/n beams, and measurements of Bragg peaks. A water calorimeter for charged-particle beams is under development.

PTB: Dr Ankerhold presented results obtained in carbon beams at 430 MeV/n, including realizations of D_w and k_Q factors for a PTW 30013 chamber (with a projected standard uncertainty of $< 1\%$), obtained at the Heidelberg Ion-beam Therapy Center (HIT). Plans for a comparison study with NPL were also announced (with a slide showing Achim Krauss and Hugo Palmans shaking hands).

Mr Bjerke asked about Faraday cup measurements.

With the NMI reports now completed, Dr McEwen returned discussion to more general strategic concerns of the CCRI(I), beginning with reviving his earlier proposal to form an advisory group to explore implications the anticipated revision of $W_{air} \cdot s_{g,air}$. Dr Sharpe asked about advanced notice NMIs might need before CCRI would push for an official change, and there seemed to be informal agreement of 1/2016 at the earliest. Dr Ankerhold added that PTB has a postdoc to study the stopping powers of electrons in graphite, and asked whether such input might be of value to the present discussion. Dr McEwen replied that it was unlikely, since the 0.7% shift in $W_{air} \cdot s_{g,air}$ would affect Co-60 calibrations.

6.3 Input from RMOs: AFRIMETS, APMP, COOMET, EURAMET, SIM

Dr Aalbers had a couple of announcements of interest to RMOs, beginning with a WG meeting later that day, in the afternoon, to discuss the CMC review process and associated fast-tracking. Also mentioned were plans to address editorial errors spotted in CMCs and methods for verifying uncertainties in CMCs.

Subsequent discussion led to the suggestion that any change that would decrease uncertainty be made relatively harder – i.e. require relatively more review – than changes that would increase uncertainty.

RMO reports:

AFRIMETS: By way of introduction, Ms Msimang noted that AFRIMETS comprises seven sub-RMOs, with a subset of five having activities in dosimetry. A meeting in 2014 brought four participants (three sub-RMO), where the agenda included membership requirements, plans for an S1 supplementary comparison, and a review of overall strategic vision for the organization. A summary of assessments and comparisons pertaining to Co-60, brachytherapy, radiation protection, diagnostic radiology were provided, along with highlights of activities at NIS and NMISA.

APMP: Dr Yi reported that eight NMIs had attended TC-IR, and summarized status on 30 comparisons. Dr McEwen asked about plans for a -K3 comparison, which Dr Yi expected to occur between July 2015 and December 2016. Dr Picard asked about redundancies in RMO supplementary comparisons, which Dr Karam responded might, in the interest of efficiency, be addressed by encouraging labs to “piggyback” onto other RMO’s supplementary comparisons.

COOMET: no presentation was given, as the representative/s had departed already, so it was noted that their report had been submitted and could be consulted later.

EURAMET: Mr Bjerke, in place of Dr Bordy, briefly reported that a 2014 meeting in Oslo, which included a workshop on bio effects of radiation, had been well attended, with representatives from 27 NMIs and the president of the CCRI.

SIM: Dr Karam drew attention to her written report and a short presentation among working documents submitted ahead of the meeting. She further noted that SIM had welcomed a new lab from Nevis/St. Kitts at a meeting at NRCC in 2013; also since then, Chile was about to bring its own NMI online. She concluded by noting that certain, recently submitted CMCs had run into difficulties during review, but had been resubmitted.

6.4 Input from institutional stakeholders

IAEA: Dr Meghzifene presented a summary of activities pertaining to calibrations, comparisons, and TLD audits, and noted future plans: for conducting HDR Co-60 and Ir-192 dosimetry and installing a medical linac (funding for a bunker awarded; funding for a machine pending); replacing TLDs in hospital audits with glass dosimeters; and developing codes of practice for small (external) field dosimetry, brachytherapy, and a revision of TRS-398 (to be started in August of 2015). Dr McEwen asked about the move away from TLDs, and Dr Aalbers asked whether the planned CoP for brachytherapy would be restricted to HDR only, but was told that it was to include LDR and, possibly, electronic brachytherapy as well.

Mr Los Arcos noted that Brazil would be taking part in the -K3 comparison.

AAPM: Dr Tosh noted that the AAPM would like to see NIST participation in the -K8 key comparison ASAP and that air kerma should be retained for dissemination of LDR brachytherapy.

IRML/NIS: Dr Gamal Hassan reviewed organizational structure of NIS and the IRML, and summarized activities related to maintaining traceability of measurements with respect to diagnostic radiation dosimetry, HDR brachytherapy, personnel dosimetry, implementation of 17025 and activity audits of SSDLs. NIS had three bilateral comparisons with IAEA; participated in the APMP.R(I).I-K4, -K1.1 and S1; and had three comparisons underway (including one with AFRIMETS). Additional activities in EPR

dosimetry and nanocrystalline BaSO₄ were summarized with slides displaying data and analysis to determine detection limits, reproducibility and stability/decay (nano- form proving to be much more stable over time than microcrystalline forms).

Dr Burns asked about details regarding some of the comparisons, but agreed to pursue with Dr Hassan later. Dr Karam asked a few questions about some of the measurements presented.

A motion to grant Observer status to NIS by the CCRI(I) was approved.

7 PUBLICATIONS

7.1 NMIs bibliographies

The NMIs were asked to extract their lists of publications from their annual reports (over the past two years) and to send them to Mr Los Arcos.

7.2 Other publications

None

8 CCRI(I) MEMBERSHIP CHANGES

None

9 DATE OF NEXT MEETING

2017 but no other details provided.

10 ANY OTHER BUSINESS

Dr McEwen asked for remaining business items, and received a response from Dr Duane, who asked about comparisons for small-field dosimetry. Dr McEwen replied that EURAMET was already aware of this, and encouraged sharing of findings among NMIs/RMOs, anticipating that small fields would occupy more attention at future meetings. Dr Louw made three requests: 1) CCRI MRA review: delegates were to look for emails requesting input for CCRI for the Oct 2015 meeting, 2) to provide input for a possible workshop on linac dosimetry, 3) to fill out the CCRI(I) review questionnaire from Mr Los Arcos.

Dr Sharpe expressed thanks to all and especially to Dr McEwen for a job well done conducting this meeting, which brought a round of applause. Mr Los Arcos thanked Dr Sharpe for his stewardship chairing CCRI(I) since 2001, which brought another round of applause.

There being no other business to discuss, Dr McEwen adjourned the meeting.

**CONSULTATIVE COMMITTEE
FOR IONIZING RADIATION**

Section II: MEASUREMENTS OF RADIONUCLIDES
Report of the 23rd meeting
(17-19 March 2015)

LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR IONIZING RADIATION (SECTION II)

as of 17-19 March 2015

Section II - Chair

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

Executive Secretary

Mr José María Los Arcos, International Bureau of Weights and Measures [BIPM], Sèvres.

Members

“Horia Hulubei” National Institute of Research and Development for Physics and Nuclear Engineering [IFIN-HH], Bucharest - Magurele

Australian Nuclear Science & 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 cedex

Czech Metrology Institute [CMI], Brno

D.I. Mendeleev Institute for Metrology, (Rosstandart of Russia) Federal Agency on Technical Regulating & Metrology [VNIIM], St Petersburg

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

Hungarian Trade Licensing Office [MKEH], Budapest

Institute for Reference Materials and Measurements [IRMM], Geel

Institut de Radiophysique Appliquée [IRA], Lausanne

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

National Institute of Metrology [NIM], Beijing

National Institute of Standards and Technology [NIST], Gaithersburg

National Laboratory for Metrology of Ionising Radiation/Institute of Radiation Protection and Dosimetry CNEN [LNMRI/IRD], Rio de Janeiro

National Metrology Institute of Japan, AIST [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

Observers

Bhabha Atomic Research Centre [BARC], Mumbai

Bundesamt für Eich- und Vermessungswesen [BEV], Vienna

Comision Nacional de Energia Atomica [CNEA], Buenos Aires

International Atomic Energy Agency [IAEA], Vienna

International Commission on Radiation Units and Measurements [ICRU], Bethesda

International Organization for Medical Physics [IOMP]

International Radiation Protection Association [IRPA], Fontenay aux Roses Cedex

National Research Council of Canada - Measurement Science and Standards Portfolio [NRC],
Ottawa, Ontario

VSL [VSL], Delft

Personal Member

Prof. Dr G. Winkler

1-4 OPENING OF THE MEETING:

WELCOME; INTRODUCTION BY THE CHAIR; APPROVAL OF THE AGENDA; APPOINTMENT OF RAPPORTEURS

Section II (Measurement of radionuclides) of the Consultative Committee for Ionizing Radiation held its twenty third meeting at the Pavillon de Breteuil (the BIPM headquarters), Sèvres, from 17 to 19 March 2015.

The following representatives of member organizations were present:

I. Alexeev (VNIIM), D. Arnold (PTB), C. Bobin (LNE-LNHB), F. Bochud (IRA), R. Broda (RC), M. Capogni (ENEA-INMRI), C. Fréchet (LNE-LNHB), L. Karam (Chairman of Section II CCRI, NIST), J. Keightley (NPL), K. Kossert (PTB), M. Krivosik (SMU), K.B Lee (KRISS), Z. Ming (NIM), S. Pommé (IRMM), M. Reinhard (ANSTO), M. Roteta (CIEMAT), M. Sahagia (IFIN-HH), M. van Rooy (NMISA), J. Sochorová (CMI), L. Szücs (MKEH), A. Yunoki (NMIJ/AIST).

Observers: J.C. Furnari (CNEA), R. Galea (NRC-MSS), A. Harms (IAEA), F.A. Iglicki (CNEA), F.J. Maringer (BEV).

Also attending the meeting for all or part of the time: D.T. Burns (BIPM), S. Courte (BIPM), J.M. Los Arcos (Executive Secretary of the CCRI), W. Louw (CIPM, President of the CCRI), C. Michotte (BIPM), M. Nonis (BIPM), G. Ratel (BIPM), C. Thomas (BIPM, KCDB coordinator).

Apologies for absence were received from: Dr Ryan P. Fitzgerald (NIST), Ms Leena Joseph (BARC), Dr Chul-Young Yi (KRISS), Dr Lena Johansson (NPL), Dr Jacco de Pooter (VSL), Dr Martin J.T. Milton (BIPM).

The Chair, L. R. Karam, welcomed the Members, Observers and Guests.

The Executive Secretary J.M. Los Arcos also welcomed Members, Observers and Guests on behalf of the BIPM in the absence of the BIPM Director M. J. T. Milton.

The meeting confirmed the appointment of Dr Mark Reinhard (ANSTO) as *rappporteur*.

No changes were made to the agenda (rev. 20141219) excluding a change to the order of items presented.

The CCRI(II) Chair asked those present to introduce themselves.

Agenda Item 6.3 was brought forward following a request to the CCRI(II) Chair from Dr Claudine Thomas on account of limited availability.

6.3 **KDCB Report and Calibration and Measurement Capabilities (C. Thomas, BIPM)**

Dr Claudine Thomas (KCDB Coordinator, BIPM) gave her report entitled *The BIPM Key Comparison Database: Numbers and Comments* (not loaded on CCRI(II) Working Documents as of 23 March 2015).

Dr C. Thomas reported:

- As of March 2015 the KCDB contained more than 24,000 published entries and continues to increase at a rate of ~ 900 per year. There is an ongoing need to reduce the number of CMCs.
- The KCDB has implemented the process of 'greying out' KCDB entries where the full set of requirements for maintaining valid CMC entries is lacking (for example an approved Quality System is not in place).
- The status of key and supplementary comparisons concerning the KCDB in relation to CCRI.
- That the utility and efficiency of the CIPM MRA is currently being reviewed.

A discussion ensued in relation to the role of Quality Management Systems (QMS) within radionuclide metrology laboratories. Specifically, their usefulness in light of the additional burdens they present to a laboratory.

Dr Thomas informed the CCRI(II) of her pending retirement at the end of June 2015. Dr Lisa Karam (CCRI(II) Chair) thanked Dr Thomas for her many years of valuable service to the CCRI(II) and the metrology community more widely. The CCRI Executive Secretary advised that BIPM's succession plan will see Dr Suzanne Picard assuming responsibility for much of the future KCDB effort.

At this point, observers to the CCRI(II) were invited to join the meeting to facilitate interaction among all participants.

5. PROGRESS REPORTS

5.1 CCRI reports (President Wynand Louw, CIPM)

5.1.1 Strategy and actions report

Agenda Item 5.1.1 relating to strategy and action reports of the CCRI was rescheduled to later in the morning of Tuesday 17 March 2015. To correctly follow the flow of discussions within this meeting, this Agenda items will be reported just prior to agenda item 6.

5.1.2 CCRI RMO WG

Dr Lisa Karam (CCRI(II) Chair) indicated that the CCRI RMO WG had not provided a report for this meeting. Additionally, she reported that the Becquerel WG action had been put on hold until the next meeting of the Key Comparisons Working Group (KCWG(II)), scheduled for November 2015.

5.2 Section II WG reports

5.2.1 Key Comparisons WG (Coordinator: John Keightley, NPL)

Mr John Keightley (CCRI(II) KCWG Coordinator) provided an update from the CCRI(II) Key Comparisons Working Group.

Mr Keightley reported on:

- Changes to the KCWG membership including new members and the overall role/functions of the KCWG on behalf of CCRI(II).
- KCWG recommended changes to Key Comparison Reference Values (KCRVs).
- Progress towards the inclusion of SIRTI results in the relevant KCRV.
- Recommendations to the CCRI(II) concerning changes to the 10-year plan.
- The shortened reporting form for comparison results.
- The need for addition laboratories to take on the responsibility of pilot for international comparisons.
- A new group email address for the SIR (sir@bipm.org)

ACTION: CCRI(II) to take note of the new SIR group email address (sir@bipm.org). [Owner: CCRI(II)]

5.2.2 Extension of the SIR WG (Coordinator José Maria Los Arcos, BIPM)

Dr José Maria Los Arcos (CCRI(II) ESIR WG Coordinator) gave the report *ESWG(II) Report 2015* (CCRI(II)/15-29).

J.M. Los Arcos reported on:

- The basis and need to extend the SIR to beta and alpha emitting radionuclides.
- Progress in the ESWG(II) trial exercise on ^3H and ^{63}Ni at CIEMAT (2013) using the cross-efficiency method, and plans to repeat a similar programme of work at the BIPM. The need to further investigate and resolve discrepancies in the LNHB results was noted.
- Preliminary work for the large scale trials of ^3H , ^{14}C , ^{55}Fe and ^{63}Ni adopted by CCRI-2013 was started in October 2014 but had to be delayed and subsequently put on hold until a balance used in this programme of work has been satisfactorily repaired. The balance was taken for investigation by Mettler in February 2015 after erratic behaviour observed during that period.

Dr Karsten Kossert (PTB) sought clarification as to the appropriate chemical form for sample submission given the noted technical complexities in carbon chemistry and in particular any potential precipitation concerns or the formation of gaseous CO_2 and potential impacts on the ^{14}C measurements. Dr Los Arcos indicated that this question is the subject of ongoing experimentally-based stability tests at the BIPM.

Dr Kossert also raised concerns regarding the impact on measurement uncertainty in the measurement of ^{63}Ni attributable to the lack of precise knowledge of the ^{63}Ni beta spectrum. Dr Los Arcos acknowledged this concern.

The BIPM is also looking to investigate TDCR measurements (M. Sahagia indicated that the IFIN will submit samples).

Mr Milton van Rooy (NMISA) queried the use of a Tricarb 2910TR by the ESWG, and the measurement uncertainties that will be attributable. Dr Los Arcos described the sources of error and role of the measurements laboratories' contributable errors.

I Alexeev (VNIIM) queried whether alternate scintillation cocktails would be investigated to which Dr Los Arcos indicated that this had already been considered culminating in a decision to select a particular home-made cocktail, although it was additionally noted that the cross-efficiency method obviates the need for a specific cocktail.

Dr Louw took this opportunity to introduce himself as the CCRI President, and welcomed the group.

5.3 Report of the BIPM Program of Work 2013-2014 (J. M. Los Arcos, BIPM)

Dr Los Arcos (CCRI Executive Secretary, BIPM) gave a report entitled *BIPM-Ionizing Radiation Report 2013-2015* (CCRI(II)/15-28).

He reported on the progress and outputs of the BIPM Ionizing Radiation Department, specifically referring to resources, terms of reference, main achievements, comparison activities and international coordination / cooperation efforts in dosimetry, radionuclides and thermometry metrology.

With regard to the measurement of radionuclides, Dr Los Arcos reported on an extensive programme by the BIPM, including:

- Hardware upgrades to the SIR and a successful 2014 campaign in the SIRT extension to ^{18}F involving three participating NIMs (VNIIM, NPL and ENEA).
- The application of the power moderated mean (PMM) to the KCRVs in accordance with the CCRI(II) policy position adopted at the 2013 CCRI(II) meeting.
- Contributions to the special issue of *Metrologia* on measurement uncertainties in radionuclide metrology.
- Implementation of new practices to facilitate accelerated report production and publication.
- Considerable international engagement efforts contributing to activities of the JCGM/WG1, KCDB, ICRU, ICRM, IAEA and CCRI RMOs.

Dr Los Arcos gave a brief overview of the other activities in the Department in radiation dosimetry and thermometry, as well as its role as a coordinator for international activities. Dr Akira Yunoki (NMIJ/AIST) queried the current activities of the BIPM Ionizing Radiation Department in low dose-rate brachytherapy and its future plans; Dr Los Arcos indicated that efforts were ongoing under the auspices of the CCRI(I).

5.4 Written reports from NMIs (for the record)

The Agenda Item 5.2 relating to written reports from NMIs was rescheduled to later in the programme to align with Agenda item 7.

5.1.1 Strategy and actions reports (President Wynand Louw, CIMP) Rescheduled from Section 5

CCRI President Dr Louw began his presentation by reminding the group of his background in the CCQM and his role in the establishment of AFRIMETS in 2007; based on this history, he will be looking to see how to better organize and optimize the structure of CCRI and its three Sections. He expressed his appreciation for the CCRI Strategy, and its role in demonstrating to the NMI Directors how the CCRI strategizes its efforts. Dr Louw then presented the CCRI President's Report, which included the following points:

- The CCRI President is to meet with the CCRI Section Chairs in the week commencing 23 March 2015 to discuss organizational and structural changes to all sections of the CCRI in the interests of optimization and improved operating efficiency.
- The CCRI President spoke in support of the CCRI(II) Strategy indicating the need for minor amendments only in order to facilitate improved accessibility of the strategy to non-CCRI(II) technical experts.
- The CCRI President spoke of the ongoing requirement to improve the efficiency of all CCRI sections with a particular interest in reducing the number of key comparisons undertaken.

Dr Louw reported on matters arising at the CIPM meeting held 13-14 November 2014. In his report the following points were noted:

- CODATA deadline of 1 July 2017.
- Phase II of the BIPM mass unit.
- Big G Consortium.
- A planned proposal on evaluation mycotoxins in food (although no funding is planned for this effort at the BIPM).
- Introduction of new Associates.
- Upcoming refurbishment to BIPM infrastructure.
- Prudent financial management, which delivered a financial surplus in the last reporting period.
- Successful outcome in funding negotiations resulting in a fixed dotation at the 2015 level for the years 2016 to 2019.
- Announced the BIPM Visitor Programme (unfunded at present and seeking ~ 2 % of overall CIPM operating budget in additional contributions from Members).
- CIPM succession planning initiatives.
- Pending review of the CIPM MRA, which will include a dedicated workshop in October 2015.

The CCRI President issued a special request for CCRI members to consider participating in the upcoming GUM Review Workshop to be held 15-16 June 2015 (registration will close towards

the end of April 2015). A webcast of the workshop is under consideration subject to excess expressions of interests for offsite attendees.

A workshop on accelerator dosimetry was postponed until 2016/2017.

6. CIPM MRA

6.1 Present Comparisons

6.1.1 BIPM and CCRI(II) key and supplementary comparisons status (John Keightley and BIPM staff)

Dr Keightley presented a list concerning the status of key comparisons together with other members of the KCWG.

- APMP.RI(II)-K2.Fe-59

Dr Akira Yunoki (NMIJ/AIST) reported that the Draft A report on the NMIJ piloted APMP ^{59}Fe comparison is currently undergoing preparation with an expectation that the document will be ready for comment/revisions by the end of March 2015.

- CCRI(II)-K2.H-3

Dr Guy Ratel (BIPM) reported that the Draft B report on the tritium comparison has been circulated to the CCRI(II) with comments/revisions due by 3 April 2015. The report has been prepared using the new simplified format. Dr Ratel requested that CCRI(II) review the new format and provide feedback to BIPM within the consideration period.

ACTION: CCRI(II) to review the new report format used in the CCRI(II)-K2.H-3 comparison and provide feedback to BIPM by 3 April 2015. [Owner: members of CCRI(II)]

- CCRI(II)-K2.Sr-89

Dr Ratel indicated the report is to be issued shortly to CCRI(II) for comment/revision. It was additionally noted by Dr Ratel that the pending report makes use of the new reporting format referred to above in the tritium comparison reporting point.

Given the considerable amount of time that has passed since the experimental component of the comparison took place and the yet to be finalized publication of the key comparison a question was raised by Dr Dick Arnold (PTB) as to the appropriate record date to be used for a comparison with respect to terms of the CMC entry. Dr Lisa Karam (NIST, CCRI(II) Chair) indicated the appropriate date is that date when the actual measurements took place.

- BIPM.R(II)-K1.Bi-207: Comparison currently in Draft B status with the inclusion of the LNHB result.

Following ensuing discussions concerning ^{207}Bi , the CCRI(II) Chair confirmed the longevity in KCRV data points in contrast to the more limited 20 year rule which applies to CMC entries.

- $^{68}\text{Ge}/^{68}\text{Ga}$: To be completed as soon as possible with additional input to be provided by NIST.
- ^{99}Tc : Dr Keightley indicated the report is due for completion.
- ^{177}Lu : Report published.

- S9 Cs-137 K-40 in rice flour: Dr Kyong Beom Lee (KRISS) indicated that KRISS is currently working on the Draft A report with an expectation the report will be circulated in April 2015.
- S10 Surface Monitors: Draft B under final stages of preparation. Limited opportunity exists for additional participants to enter a result.
- ^{99}mTc ; (to be discussed later in this meeting; next agenda item)
- ^{222}Rn : Carole Fréchet reported that the questionnaire has been distributed with four laboratories having subsequently responded as interested in participating. A final call for participants was issued (to be followed up with an email reminder), with an expectation the comparison will take place in April/May 2015.
- APMP.RI(II).S3.Cs-134.Cs-137 in brown rice: NMIJ is currently working on a draft A report with an expectation for distribution in April 2015.
- ^{137}Cs : Dr Lisa Karam (NIST) reported sources could be distributed by NIST later in 2015. (It is noted by the rapporteur that a subsequent recommendation adopted by the CCRI(II) later in the meeting, and taking immediate effect, has removed the ^{137}Cs key comparison from the 10-year plan.
- $^{166\text{m}}\text{Ho}$: Results published. A (minor) change of the KCRV was recorded.
- Tritium: It was reported on behalf of Dr Phillippe Cassette that ten participants have responded to date to this key comparison call with a final call issued to the CCRI(II) at the 23rd CCRI(II) meeting. A follow up reminder to be sent.

ACTION: A final call to the CCRI(II) for participants in the tritium data set comparison to be sent to the CCRI(II). [Owner: J. Keightley, KCWG Coordinator]

- BIPM.R1(II)-K1 [diverse; SIR]: Dr Ratel reported that the ^{226}Ra check source stability data has greatly improved over recent years following laboratory refurbishment upgrades which have delivered greater stability in the laboratory operating conditions.

In the preceding calendar years of 2013 and 2014, a total of 7 and 11 submissions respectively were received by the SIR. Multiple issues have arisen in the import of radioactive sources from the ININ to the BIPM. The BIPM will provide further assistance to the ININ to rectify these issues.

The 43rd SIR circular letter to be distributed to CCRI(II) by end March 2015.

ACTION: Distribution of the 43rd SIR circular to CCRI(II) by end March 2015. [Owner: BIPM]

- SIRT (K4): Dr Carine Michotte gave a presentation, making special mention of:
 - Technical upgrades to the SIRT hardware including the replacement of scalers and subsequent work on instrument revalidation.
 - Publication of results from the LNMRI and the IFIN.
 - Measurements with the instrument at the VNIIM and ENEA in 2014, and a new value from the LNHB.
 - The forward deployment schedule of SIRT to CCRI(II) members.
 - Preliminary planning efforts to link SIRT with SIR through measurement.

- Efforts directed to the extension of SIRTI to ^{18}F were described which included a discussion on unresolved discrepancies between Monte Carlo simulation and experimental results associated with the formation of droplets on the ampoule wall (although Monte Carlo simulation shows an effect of drops, while actual measurements do not). Dr Stefaan Pommé (IRMM) queried the likely magnitude of measurement uncertainties attributable to material compositions of the ^{18}F source solution. Mrs Carole Fréchet (LNE-LNHB) commented on and further questioned the possibility of differences in instrument response introduced as a result of material composition variations between commercially obtained and NMI sourced materials in the context of the SIRTI instrument response. Dr Kyong Beom Lee suggested a possible explanation associated with the differences in the Bremsstrahlung spectra brought about by material composition variations. Further work is planned by Dr Michotte to address the remaining unresolved discrepancies.

ACTION: Carine to obtain a beta spectrum for ^{18}F to assist with Monte Carlo simulations. [Owner: Dr Carine Michotte, NPL]

- SIRTI comparisons of ^{18}F completed in 2014 included VNIM, NPL and ENEA.
- SIRTI comparison of ^{18}F is next planned at the NMISA, and then (in 2016) at the NIST.
- The results of a successful pilot in 2014 with NPL on the extension of SIRTI to C-11 was described (BIPM.R1(II).K4.C-11).
- The first measurements of the SIRTI against the SIR for ^{64}Cu are scheduled to take place in April 2015 at BIPM. Dr Michotte sought volunteers to send a ^{64}Cu source to the BIPM and launched an informal call for future CCRI(II) participants in the comparison.
- A second detector has been acquired, which will be calibrated.

BIPM.R1(II)-K1

Dr Carine Michotte (BIPM) gave a presentation entitled *Proposal for KSRV updates of the SIR (BIPM.R1(II)-K1) comparisons* (CCRI(II)/15-07).

She reported on the revised and published KCRV for ^{64}Cu , ^{131}I , ^{133}Ba , ^{152}Eu , ^{177}Lu and ^{207}Bi following application to the relevant data sets of the power moderated mean (PMM) in accordance with the resolutions adopted at the 22nd CCRI(II) meeting in 2013.

^{56}Mn

Dr Michotte reported on a new result has been received by BIPM from the NPL.

^{65}Zn

Dr Michotte reported that results for the K2 comparison are to be included in the K1(SIR) KCRV.

^{85}Sr and ^{241}Am

Dr Michotte reported that given the relatively recent receipt by the BIPM of new results for ^{85}Sr (from the POLATOM) and ^{241}Am (several more recent results), the respective KCRVs are yet to be updated and published.

^{18}F

DECISION: A revision to the KCRV for ^{18}F accounting for a new result from LNE-LNHB that supersedes a previous result and application of PMM to the data was adopted by the CCRI(II).

 ^{60}Co

DECISION: A revision to the KCRV for ^{60}Co accounting for new results from CNEA and NIM (China) that supersedes the previous results, a new result from NRC, and application of the PMM to the data was adopted by the CCRI(II).

In the context of the new NRC (Canada) result added to the KCRV, the presence of preexisting results for Canada from the AECL and from the ASMW (Germany) as currently listed within the KCRV led to a discussion to the appropriateness of a country having two entries within the KCRV concurrently.

An uncontested position on the matter of multiple entries from a single country (although from different institutions) within the KCRV was put forward by the CCRI(II) Chair that will see the possibility of more than one entry from a single country remain in the KCRV unless a request is received from the current NMI/DI of the submitting country to remove an entry.

 ^{113}Sn

DECISION: The first KCRV for ^{113}Sn following the submission of results from PTB, CIEMAT and CMI, which includes the application of PMM to the data, was adopted by the CCRI(II).

 ^{134}Cs

DECISION: A revision to the KCRV for ^{134}Cs , which included application of PMM to the data and now entries from the IFIN, NMISA, POLATOM and NRC, was adopted by the CCRI(II).

 ^{201}Tl

DECISION: A revision to the KCRV for ^{201}Tl accounting for a new result from NIST that supersedes a previous result, and application of the PMM to the data, was adopted by the CCRI(II).

A question was raised concerning application by NMIs of the Funck 1983 correction factor for ^{201}Tl measurement by coincidence (Funck IJARI p. 565, **34** (1983)) as was applied by LNE-LNHB.

ACTION: A proposal that CCRI(II) NMI's review their primary standardizations of ^{201}Tl in the context of the Funck 1983 correction factor was accepted by CCRI(II). [Owner: CCRI(II)]

 ^{228}Th

DECISION: The first KCRV for ^{228}Th following the submission of results from PTB (2010) and NIST (1986), including the application of PMM to the data, was adopted by the CCRI(II).

The BIPM will now be able to proceed with publication.

 $^{99\text{m}}\text{Tc}$

DECISION: A proposal to include SIRTI results based on primary measurements and SIRTI results based on ionization chamber factors where the ionization chamber factor was derived from a primary measurement within one year prior to the comparison date by the respective NMI was adopted.

Publication process for SIR results

Dr Michotte made a proposal concerning the fast tracking of KCRV published updates associated with SIR results. Discussions ensued culminating in a recommendation that the Chair of CCRI(II) raise a proposal to CCRI that will facilitate the rapid consolidation of a table of tables of results for posting with Draft B status on the KCDB.

ACTION: Dr Lisa Karam (CCRI(II) Chair) to raise with CCRI RMO CMC WG a proposal to facilitate the rapid consolidation of a table of tables of results arising from SIR submissions for posting with Draft B status on the KCDB. [Owner Dr Lisa Karam CCRI(II) Chair]

ACTION: BIPM to post Drafts B on the KCDB. [Owner Dr Los Arcos CCRI Executive Secretary]

6.1.2 Regional key and supplementary comparisons status (RMO delegates)

Dr Lisa Karam (Chair CCRI(II)) sought a response from RMO delegates as to the status of key and supplementary comparisons within their respective RMOs. The responses from the RMO delegates are collated below.

AFRIMETS	No
COOMET	No
EURAMET	No
SIM	No (with the exception of Mexico that will make a submission to SIR)

6.2 Future Comparisons (10-year plan) (J. Keightley, RMO delegates)

6.2.1 Future needs for BIPM, CCRI(II) comparisons

J. Keightley (KCWG Chair) gave a report entitled “KCWG 10-year plan”. J. Keightley reported that the following comparisons were to be appended to the current 10-year plan (with the proposed time frame for the comparison indicated):

- ^{152}Eu (2021)
- ^{90}Y (2022)
- ^{241}Am (2023)

It was noted by J. Keightley that some of the key comparison timeframes require updating and some further consideration required as to the correctness of the ^{137}Cs entry in the MMM.

ACTION: Review and update the timeframes for key comparisons within the CCRI(II) Strategy 10-year plan. [Owner: J. Keightley, KCWG Chair]

ACTION: Review the correctness of the ^{137}Cs entry in the MMM and report findings back to the CCRI(II) Chair. [Owner: J. Keightley, KCWG Chair]

^{222}Rn

The upcoming key comparison of ^{222}Rn requires further deliberation by the KCWG on an appropriate measurement protocol. Mrs Carole Fréchet, LNE-LNHB, reported on the substantial progress made in resolving concerns over source containment and the readiness to implement

technical findings into the measurement protocol. An issue yet to be resolved is the manner in which ^{222}Rn results will be linked to the SIR. The vessel encapsulation requirements of ^{222}Rn are not met by the ampoule geometry of SIR. Discussions between BIPM and LNE-LNHB are ongoing. The sources are planned to be distributed in May after the protocol is revised.

A final reminder call for participants to the ^{222}Rn comparison needs to be distributed to CCRI(II).

ACTION: A final call to the CCRI(II) for participants in the ^{222}Rn comparison to be sent to CCRI(II). [Owner: C. Fréchet, pilot]

^{223}Ra

Dr Keightley presented a proposal outlining the need for activity standards in ^{223}Ra to support the emerging clinical use of Xofigo (a ^{223}Ra -containing palliative treatment of bone metastatic prostate cancer). The existing clinical protocols for Xofigo developed out of the ALSY MPCA trials were based on a ^{223}Ra result that differs from more recently obtained results of two NMIs by approximately 10 %. Harmonization of the clinical protocols with any ^{223}Ra result accepted in the future is essential on a clinical basis. It was recognized that this issue, and CCRI(II) assistance to its clients/customers in its resolution, is of potential strategic relevance to CCRI(II).

Dr Keightley reported that large uncertainties in the photon emission intensities of ^{223}Ra and its progeny provide further metrological basis for developing an improved ^{223}Ra result. Dr Keightley indicated that the vendor of Xofigo was willing to make sufficient product available to facilitate a key comparison of CCRI(II) involving all willing participants of the CCRI(II). A comparison using liquid scintillation counting (TDCR and CIEMAT/NIST methods) was proposed, with corresponding entries in the Measurement Methods Matrix anticipated to be “yellow” at 1 % expected uncertainty ($k = 1$).

Discussions concerning the implications of the insertion of a ^{223}Ra comparison into the CCRI(II) 10-year plan by way of a change to the CCRI(II) strategy ensued.

Dr Lisa Karam (Chair CCRI(II)) prepared and made a proposal, which included a supportive rationale relating to internal and external drivers, to modify the CCRI(II) 10-year strategy by way of undertaking a key comparison of ^{223}Ra in 2015 as a substitution to ^{137}Cs .

DECISION: A proposal to revise the CCRI(II) 10-year strategy by way of replacing the upcoming ^{137}Cs key comparison with a ^{223}Ra key comparison was adopted by the CCRI(II).

ACTION: The CCRI(II) 10-year plan to be updated to reflect a Decision of CCRI(II) concerning the inclusion of ^{223}Ra into the MMM (yellow, 1 %) to be made with final documentation to be sent to the CCRI(II) Chair. [Owner: K. Keightley, NPL]

In deliberations of this proposal it was noted that ^{223}Ra does not replicate the same MMM outcomes of ^{137}Cs .

ACTION: The adoption of a CCRI(II) Decision concerning the change to the CCRI 10-year plan necessitates a number of laboratories to submit ^{137}Cs results to SIR in order to maintain recognition within a period of up to five years. [Owner: ANSTO, BARC, CMI, CNEA, LNHB, NIM China, NPL, MKEH, Indonesia and PTB; others?]

Pilot laboratories for future comparisons

It was noted by the CCRI(II) that a laboratory to pilot future comparisons of ^{229}Th , $^{123\text{m}}\text{Te}$, ^{152}Eu , ^{90}Y and ^{241}Am has not been identified.

A workshop is under consideration to allow the sharing of experience in how to run or pilot a comparison exercise.

ACTION: KCWG to hold a session or workshop on how to run or pilot a comparison exercise, lessons learned etc. [Owner: J. Keightley, KCWG Coordinator]

ACTION: All CCRI(II) delegates of NMIs that have in place the necessary capabilities to pilot a key comparison, excluding LNE-LNHB, PTB, NIST, and NPL, to consider volunteering to pilot the unassigned key comparisons in the 10-year plan namely ^{229}Th , $^{123\text{m}}\text{Te}$, ^{152}Eu , ^{90}Y and ^{241}Am . [Owner: CCRI(II) delegates]

Future needs for supplementary comparison

Marine sediment supplementary comparison piloted by IAEA-Monaco

Dr Arend Victor Harms (IAEA) made a proposal concerning a possible CCRI(II) supplementary comparison on marine sediments. The marine sediment artefact (“Ibaraki”) was collected ~ 75 km south of the Fukushima Dai-ichi NPP and consists of marine sediments containing approximately 40 Bq/kg of ^{134}Cs , 120 Bq/kg of ^{137}Cs and 0.5 Bq/kg of ^{90}Sr (a low level of ambient Pu isotopes may be present). The proposed supplementary comparison to be piloted by the IAEA-Monaco, and involving ~ 150 g samples of the artefact, would start in November 2015.

DECISION: A proposal that CCRI(II) accepts as taken a future decision by the KCWG in June 2015 concerning the suitability of a CCRI(II) supplementary comparison of marine sediments piloted by the IAEA-Monaco was adopted by the CCRI(II).

^{134}Cs and ^{137}Cs in wheat flour

Dr Akira Yunoki (NMIJ/AIST) reported a revision to the timetable for the CCRI(II) supplementary comparison of ^{137}Cs and ^{134}Cs in wheat flour. The comparison involves wheat flour samples of 150 g containing approximately 100 Bq/kg ^{137}Cs and a few tens of Bq/kg of ^{134}Cs . The revised schedule is as follows.

Distribution of Questionnaire:	April 2015
Sample distribution to participants:	September 2015
Result submission deadline:	March 2016
Issue of Draft A:	December 2016

Supplementary comparison on ^{234}Th , $^{234\text{m}}\text{Pa}$ and ^{234}Pa

Dr Keightley (NPL) presented an NPL proposal concerning a supplementary comparison on ^{234}Th , $^{234\text{m}}\text{Pa}$ and ^{234}Pa . The series ($^{234}\text{Th} \rightarrow ^{234\text{m}}\text{Pa} \rightarrow ^{234}\text{Pa}$) is useful in the determination of

activity of ^{238}U . The NPL will be “milking” the ^{234}Th (~ 5 MBq each time) and could make 500 kBq -1000 kBq available (with a Ce tracer) for a comparison.

The proposed supplementary comparison, to be piloted by NPL, can start preparation work in 2015 with a pilot commencing in December 2016. An expression of interest from CCRI(II) was canvassed.

DECISION: Delegates from the following laboratories expressed interest in participating in the NPL proposed supplementary comparison on ^{234}Th , $^{234\text{m}}\text{Pr}$ and ^{234}Pr (ANSTO, ENEA-INRIM, LNE-LNH, NRC, INMM, KRIS, NMISA, PTB, NIST)

6.2.2 Future needs for RMO comparisons

EURAMET

^{11}C

Dr Carine Michotte (BIPM) gave a report entitled *Proposal of grouped SIRTI comparison for ^{11}C activity measurements at the CIEMAT (CCRI(II)/15-06)*. The comparison exercise will take place at CIEMAT, which is the process of constructing a cyclotron onsite with commissioning expected in 2017. Considerable efforts are ongoing to ascertain the sensitivity of SIRTI to the chemistry of carbon. A general consensus was reached that the proposed way forward was sound.

A remaining issue yet to be resolved is the method that may constitute a primary measurement in the context of a ^{11}C SIRTI. As it is currently proposed, an ionization chamber calibrated by the respective NMI through a primary standardization would be transported to a ^{11}C -producing location for comparison with the SIRTI. Unanswered questions remain concerning the stability of the ionization chamber in the context of transferring a measurement of ^{11}C with the status of a primary measurement. Previous experiences (e.g., at the IFIN during the K4) do not seem supportive and further investigation is required.

ACTION: A plan to address the remaining issues concerning the primary measurement status of a transported ionisation chamber-based used for a comparisons of ^{11}C SIRTI to be provided to the CCRI(II) Chair. [Owner: Carine Michotte BIPM]

APMP

No future comparison to report.

COOMET

No future comparison to report.

AFRIMETS

To be discussed in RMO Report (agenda item 8.3)

SIM

To be discussed in RMO Report (agenda item 8.3)

6.3 (Reported proceeding Agenda Item 4)

7. RECENT PROGRESS ON RADIONUCLIDE METROLOGY AT THE NMIs [NMI DELEGATES]

The Chair noted the NMI reports tabled to the meeting by members and observers to CCRI(II). The reports are available on the restricted access area of the CCRI(II) Working Documents directory of the BIPM internet site. The CCRI Executive Secretary circulated a request to CCRI(II) members and observers seeking approval to transfer reports to the publicly accessible area of the BIPM CCRI(II) internet site. The list of NMIs with reports uploaded on the restricted area is: ANSTO, BEV, CIEMAT, ENEA, IFIN, IRMM, LNE-LNHB, LNMRI/IRD, MKEH, NIM, NISTNMIJ, NMISA, NRC, POLATOM, PTB.

IFIN-HH (Romania)

Dr Maria Sahagia presented the IFIN-HH progress report. IFIN-HH was attested as the owner of the National Standard of the physical quantity activity (of a radionuclide), order of the General Director of the Romanian Bureau of Legal Metrology no. 103/08.04.2013. Dr Sahagia highlighted and described progress on a new national project in radon measurement.

ENEA-INRIM (Italy)

Dr Marco Capogni presented the ENEA-INRIM progress report and highlighted the participation by ENEA-INRIM in key and supplementary comparisons and made reference to a recently implemented national capability in alpha particle measurement.

NIM (China)

Dr Zhang Ming gave the NIM progress report and highlighted becquerel dissemination activities of the NIM across China and recent progress in the construction of internal gas proportional counters for radioactive gas measurements.

MKEH (Hungary)

Dr László Szűcs gave the MKEH progress report and highlighted participation by MKEH in EUROMET EMRP projects (ENV09 MetroRWM, IND04 MetroMetal and IND57 MetroNORM).

8 STRATEGIC PLANNING 2013-2023

8.1 Short Term (2013-2015), medium term (2016-2019), long-term (2020-2023) (L. Karam / J.M. Los Arcos)

Dr Keightley referred to recent announcements concerning the supplementary comparison on ^3H using the TDCR method in LSC. The comparison will involve the distribution of data only to the exclusion of an artefact. The comparison is being piloted by LNE-LNHB.

ACTION: John Keightley to resend the email from Philippe Cassette (LNE-LNHB) regarding the protocol. [Owner: John Keightley, NPL]

8.2 Status of the CCRI strategic plan

8.2.1 CCRI(II) strategic actions and working groups 2013-2023, considering the following specific strategic trends

8.2.1.1 Responding to urgent needs

Harmonize stringency in uncertainties: special issue of *Metrologia* (currently short-term strategic action *a*) (Guest Editors L. Karam, J. Keightley, J.M. Los Arcos)

Dr Lisa Karam provided an extensive update as to the status of the special issue of *Metrologia* on “Practical implementation of uncertainty analysis in radionuclide metrology”. It was noted that:

- Prior to the CIPM MRA, fewer constraints were applied to the robustness of data control when contrasted to the situation post CIPM MRA.
- CCRI(II) was tasked with assessing and reporting on how measurement uncertainties are evaluated in radionuclide metrology, with the possibility such reporting may feature as a special issue of *Metrologia*.
- Final versions of all chapters are due by 20 March 2015 with final publication expected in the second half of June 2015.

Dr Karam thanked all those members within the radionuclide metrology community who have contributed so extensively to the fulfilment of this considerable task.

Standards for contaminated environment or foodstuffs post-Fukushima (currently “new” short-term strategic action *t*) (A. Yunoki (NMIJ))

Dr Akira Yunoki gave a presentation concerning the need for new standards for contaminated environments and foodstuffs post-Fukushima.

Dr Yunoki noted the substantive issues arising as a result of personnel performing measurements of radionuclides post-Fukushima who may be best described as non-experts with limited to no training. Dr Yunoki described the progress made by NMIJ in bringing to the community a new reference material in the form of brown rice containing relatively low concentrations of radionuclides (NMIJ CRM 7541-n). The approximate concentrations of specific radionuclides of interest within the CRM are:

^{134}Cs	33.6 Bq/kg
^{137}Cs	51.8 Bq/kg
^{40}K	40.3 Bq/kg

Standards for nuclear forensics (currently “new” short-term strategic action *u*) (NPL/NIST/IRMM/CTBTO)

Dr Keightley gave a presentation espousing the needs and requirements of the international nuclear forensics community for radionuclide metrology in order to address the threats of radiological and nuclear terrorism. He referred to the relevance of the Daubert standard, which stems from the Daubert vs. Merrell Dow Pharmaceuticals (1993) decision, and the importance in

establishing a test for the admissibility of scientific expert testimony and thus the relevance to nuclear forensics investigations of metrology bodies like NMIs and CCRI(II). The publication, “Uncertainty Propagation in Nuclear Forensics” (S. Pommé, S.M. Jerome, and C. Venchiarutti, 2014, *Appl. Radiat. Isot.* **89**, 58-64), was indicated as a useful reference.

8.2.1.2 Support for environmental stewardship

Climate change needs for low-level measurement standards and tracers (currently related to medium-term strategic action *k*)

This agenda item was rescheduled to later in the meeting following an offer from Prof. Dr Franz Josef Maringer (BEV) to prepare a presentation at short notice. In order to correctly follow the flow of discussions within this meeting, this agenda item will be reported just prior to agenda item 8.3.

Anthropogenic (waste) and naturally occurring radioactive material (NORM) standards (currently relating to medium-term strategic action *l*) (IRMM/IAEA/NPL,...)

This agenda item was not reported at this meeting.

Single atom counting techniques for activity-mass connection (currently medium-term strategic action *m*) (NIST/NPL)

Dr Lisa Karam (NIST) gave a presentation, which outlined a programme of work underway at NIST, concerned with establishing the mass-spectrometry capabilities within the radionuclide metrology department for applications in radionuclide metrology. Following a request from the Chair, a relatively small number of NMIs, through a show of hands, indicated related programmes of work on mass spectrometry underway within their respective radionuclide metrology departments. Almost everyone agreed that such a technology requires a detected individual, which is not always possible in smaller laboratories.

8.2.1.3 Radionuclides in new and emerging applications

Standardization of Zr-93 (currently related to long-term strategic action *a*).

This agenda item was not reported at this meeting.

Decay rate of ^{22}Na under the action of elevated flux of antineutrinos. New agenda item

Mr Milton van Rooy (NMISA) gave a report entitled *An investigation of a possible effect of reactor antineutrinos on the decay rate of ^{22}Na* . Mr van Rooy introduced the Jenkins hypothesis before presenting and detailing an experimental programme carried out at Koeberg nuclear power station (Cape Town, South Africa) to investigate any association between reactor-generated antineutrino fluence rates on the decay rate of ^{22}Na (specifically, on the impact on β^+ decay). Mr van Rooy reported that the data collected and analyzed at this point in time does not support the Jenkins hypothesis. The work is continuing.

Following an ensuing discussion, a request for assistance from NMIs was put forward by Dr Stefaan Pommé (IRMM) to make available decay rate and stability data of ionization chambers.

ACTION: A draft request to be prepared and supplied to the CCRI(II) Chair seeking NMIs to provide decay rate data and stability data of ionization chambers to assist in work associated with the Jenkins hypothesis. [Owner: Stefaan Pommé (IRMM)]

Y-90 in medicine (currently related to long-term strategic action *a*)

Dr Christophe Bobin (LNE-LNHB) gave a report entitled *Standardisation of SIR-Spheres at LNHB* concerning the programme of work under Metromet (metrology for molecular radiation therapy, <http://projects.npl.co.uk/metromrt>) to standardize ^{90}Y in Sirtex Microspheres (SIR-Spheres). Dr Bobin described a new dissolution technique (based on the Fenton reaction) for dissolving the SIR-Spheres within vial geometries, and reported on the subsequent results of LNE-LNHB ^{90}Y solution standardization using TDCR, Čerenkov, and ionization chamber measurements. Dr Bobin indicated there are still a substantial number of issues associated with calibration factors for this ^{90}Y preparation which are yet to be resolved.

Update and status of APMP.RI(II)-K2.Fe-59 (currently related to long-term strategic action *a*) (Y. Yunoki (NMIJ))

This Agenda Item was addressed by Dr Akira Yunoki as part of Agenda Item 6.1.1 reported earlier in the proceedings.

8.2.1.4 (Rescheduled from earlier in the meeting)

Climate change needs for low-level measurement standards and tracers (currently related to medium-term strategic action *k*) Rescheduled from Section 5

Prof. Dr Franz Josef Maringer (BEV) spoke to a report entitled *Climate change needs for low level measurement standards and tracers – CCRI strategic action k 2016-2019*. Prof. Dr Maringer reported on stable and radioactive isotopes in measuring flow, and the associated relevance of radionuclides in assisting in climate change research. Prof. Dr Maringer made particular mention of ^3H , ^{14}C , ^{90}Sr , ^{137}Cs , Pu isotopes, $^{137}\text{Cs}/^{90}\text{Sr}$, $^{41}\text{Ca}/^{45}\text{Ca}$ and others and the relevance to ocean and atmosphere systems, age dating, ice core measurements and tools for monitoring the environment. Prof. Dr Maringer indicated a considerable amount of work is required and made the CCRI(II) aware of a call from EMRP to European laboratories for assistance in isotope methodologies (including trace analysis at the single atom level). Dr Karsten Kossert (PTB) cautioned about the potential difficulty in getting the relevant isotopes, which was also discussed by Dr Mark Reinhard (ANSTO).

8.3 Input from RMOs (RMO delegates) APMP, COOMET, AFRIMETS, EURAMET, SIM EURAMET

EURAMET delegates presented the following items:

- Prof. Dr Franz Josef Maringer (BEV) gave a report entitled *The EMRP IND57 JRP* which concerned a European funded activity known as *Metrology for processing materials with high natural radioactivity* or *MetroNORM* for short. This project focuses on industrial and NORM-relevant isotopes (U, Pu, etc.) and the need for traceability for *in-situ* measurements.
- Mr John Keightley (NPL) spoke about the EURAMET internet site (euramet.org). He discussed the operation and management of the Technical Committee for Ionising Radiation (TCIR), the various roadmaps agreed and in place, and the primary drivers for future efforts.

APMP

Dr Kyong Beom Lee (APMP RMO delegate) referred the CCRI(II) to the APMP report entitled *2014-APMP Meeting-TCRI Report* (CCRI/15-30) and the contents contained therein.

AFRIMETS

Mr Milton van Rooy gave a report on behalf of Zakithi Msmang (AFRIMETS RMO delegate) entitled *Report from the TCRI WG of AFRIMETS* (CCRI(II)/15-17). He reported on training workshops, planned comparisons including a comparison with the involvement of Egypt in 2015 for therapy dosimetry, and work on a low-level radioactivity laboratory in support of national regulatory needs.

SIM

Dr Lisa Karam (SIM delegate) gave a report entitled *SIM Report to CCRI* (CCRI(II)/15-03). She reported on SIM's progress on CMC evaluations, recent and future comparisons, Quality Systems, workshops and training, and a selection of SIM highlights among the RMO's NMIs and DIs.

COOMET

Dr Ilya Alexeev (COOMET RMO delegate) referred CCRI(II) to the COOMET report prepared by S. Korostin and N. Moiseev entitled *TC-1.9 COOMET Annual Report* (CCRI/15-14) and the contents contained therein.

8.4 Input from institutional stakeholders (stakeholder representatives)

ICRU

Dr David Burns (ICRU, BIPM) reported that the ICRU has released two reports during the past year entitled:

- “Measurement and reporting of radon exposures” (approved for distribution)
- “Key data for dosimetry” (not yet approved)

He noted that the second report (not yet approved) contains revisions to the value of ω_{air} as well as the mean excitation energies and stopping powers for graphite and water.

Dr Burns also noted that the ICRU was open to suggestions for new reports from ICRU as well as for requests concerning ICRU reports that require revision.

BIPM

Dr Carine Michotte (BIPM) reminded the CCRI(II) of the BIPM Workshop on Measurement Uncertainty to take place 15-16 June 2015 as part of the GUM review.

CIRMS

Dr Lisa Karam (NIST) informed the meeting of the upcoming conference of the Council of Ionizing Radiation Measurements and Standards (CIRMS) entitled *Fundamentals of Ionizing Radiation* to take place at Gaithersburg, (USA) on 22-29 April 2015.

ICRM

Dr Lisa Karam (NIST) in conjunction with Dr Dirk Arnold (PTB and ICRM President) informed the CCRI(II) of the upcoming meeting of the International Committee on Radionuclide Metrology conference entitled *Radionuclide Metrology and its Applications* to take place in Vienna (Austria) on 8-11 June 2015.

Prof. Dr Franz Josef Maringer (BEV) gave a presentation entitled “ICRM 2015 Vienna 8-11 June 2015” in which draft programme details of the meeting were described. He noted that there were already about 100 people registered to participate in the conference.

Dr Dirk Arnold (PTB) requested consideration for the ICRM to have observer status in the CCRI(II).

IRA (Lausanne)

Prof. François Bochud (IRA) presented a report entitled *Metrology aspects of the Swiss expertise about President Arafat's death*. François provided details on how the Swiss laboratory proceeded in an analysis of forensic exhibits associated with the death of President Arafat in context of allegations of poisoning with ^{210}Po .

8.5 Summary of actions (rapporteur)

ACTION: CCRI(II) to take note of the new SIR group email address (sir@bipm.org). [Owner: CCRI(II)]

ACTION: CCRI(II) to review the new report format used in the CCRI(II)-K2.H-3 comparison and provide feedback to BIPM by 3 April 2015. [Owner: CCRI(II)]

ACTION: A final call to the CCRI(II) for participants in the tritium data set comparison to be sent to CCRI(II). [Owner: J. Keightley, KCWG Coordinator]

ACTION: Distribution of the 43rd SIR circular to CCRI(II) by end March 2015. [Owner: BIPM]

ACTION: Carine to obtain a beta spectrum for ^{18}F to assist with Monte Carlo simulations. [Owner: Dr Carine Michotte, NPL]

ACTION: A proposal that CCRI(II) NMI's review their primary standardizations of ^{201}Tl in the context of the Funck 1983 correction factor was accepted by CCRI(II). [Owner: CCRI(II)]

ACTION: Dr Lisa Karam (CCRI(II) Chair) to raise with CCRI RMO CMC WG a proposal to facilitate the rapid consolidation of a table of tables of results arising from SIR submissions for posting with Draft B status on the KCDB. [Owner Dr Lisa Karam CCRI(II) Chair]

ACTION: Review and update the timeframes for key comparisons within the CCRI(II) Strategy 10-year plan. [Owner: J. Keightley, KCWG Chair]

ACTION: Review the correctness of the ^{137}Cs entry in the MMM and report findings back to the CCRI(II) Chair. [Owner: J. Keightley, KCWG Chair]

ACTION: A final call to the CCRI(II) for participants in the ^{222}Rn comparison to be sent to CCRI(II). [Owner: J. Keightley, KCWG Coordinator]

ACTION: The CCRI(II) 10-year plan to be updated to reflect a decision of CCRI(II) concerning the inclusion of ^{223}Ra into the MMM to be made with final documentation to be sent to the CCRI(II) Chair. [Owner: K. Keightley, NPL]

ACTION: The adoption of a CCRI(II) Decision concerning the change to the CCRI 10-year plan necessitates a number of laboratories to submit ^{137}Cs results to SIR in order to maintain recognition within a period of up to five years. [Owner: ANSTO, BARC, CMI, CNEA, LNHB, NIM China, NPL, MKEH, Indonesia and PTB; others?]

ACTION: KCWG to hold a session or workshop on how to run or pilot a comparison exercise, lessons learned etc. [Owner: J. Keightley, KCWG Coordinator]

ACTION: All CCRI(II) delegates of NMI's that have in place the necessary capabilities to pilot a key comparison, excluding LNE-LNHB, PTB, NIST, and NPL, to consider volunteering to pilot the unassigned key comparisons in the 10 year plan namely ^{229}Th , $^{123\text{m}}\text{Te}$, ^{152}Eu , ^{90}Y and ^{241}Am . [Owner: CCRI(II) delegates]

ACTION: A plan to address the remaining issues concerning primary measurement status of transported ionization chamber based comparisons on ^{11}C SIRTI to be provided to the CCRI(II) Chair. [Owner: Dr Carine Michotte BIPM]

ACTION: John Keightley to resend the email from Philippe Cassette (LNE-LNHB) regarding the protocol. [Owner: John Keightley, NPL]

ACTION: A draft request to be prepared and supplied to the CCRI(II) Chair seeking NMIs to provide decay rate data and stability data of ionization chambers to assist in work associated with the Jenkins hypothesis. [Owner: Stefaan Pommé (IRMM)]

ACTION: The CCRI(II) Chair to take a proposal to CCRI recommending that ICRM be appointed observer status to the CCRI(II). [Owner: Dr Lisa Karam CCRI(II) Chair]

ACTION: Establish a Doodle Poll for members of the KCWG(II) as to their availability for a meeting to be held in November. [Owner: John Keightley (NPL)]

ACTION: All CCRI(II) delegates to review the implications of the proposed changes to the CIPM MRA. [Owner: CCRI(II)]

8.6 Summary of Decisions

DECISION: A revision to the KCRV for ^{18}F accounting for a new result from LNE-LNHB that supersedes a previous result and application of PMM to the data was adopted by the CCRI(II).

DECISION: A revision to the KCRV for ^{60}Co accounting for new results from CNEA and NIM (Beijing) that supersedes the previous results, a new result from NRC, and application of the PMM to the data was adopted by the CCRI(II).

DECISION: The first KCRV for ^{113}Sn following the submission of results from PTB, CIEMAT and CMI, which includes the application of PMM to the data, was adopted by the CCRI(II).

DECISION: A revision to the KCRV for ^{134}Cs , which included application of PMM to the data, was adopted by the CCRI(II).

DECISION: A revision to the KCRV for ^{201}Tl accounting for a new result from NIST that supersedes a previous result, and application of the PMM to the data, was adopted by the CCRI(II).

DECISION: The first KCRV for ^{228}Th following the submission of results from PTB (2010) and NIST (1986), including the application of PMM to the data, was adopted by the CCRI(II).

DECISION: A proposal to include SIRTI results based on primary measurements and SIRTI results based on ionization chamber factors where the ionization chamber factor was derived from a primary measurement within one year prior to the comparison date by the respective NMI was adopted.

DECISION: A proposal to revise the CCRI(II) 10-year strategy by way of replacing the upcoming ^{137}Cs key comparison with a ^{223}Ra key comparison was adopted by the CCRI(II).

DECISION: A proposal that CCRI(II) accepts as taken a future decision taken by the KCWG in June 2015 concerning the suitability of a CCRI(II) supplementary comparison of marine sediments piloted by the IAEA-Monaco was adopted by the CCRI(II).

DECISION: Delegates from the following laboratories expressed interest in participating in the NPL proposed supplementary comparison on ^{234}Th , $^{234\text{m}}\text{Pr}$ and ^{234}Pr (ANSTO, ENEA-INRIM, LNE-LNH, NRC, INMM, KRIS, NMISA, PTB, NIST)

9 PUBLICATIONS FOR THE RECORD

9.1 NMI bibliographies

The bibliographies of CCRI(II) members have been updated recently and appear in the CCRI(II) restricted area.

9.2 Other publications

10 CCRI(II) MEMBERSHIP UPDATE

A request was made by Dr Dirk Arnold (ICRM President) to the CCRI(II) Chair take a proposal forward to the BIPM requesting that the ICRM be appointed observer status to the CCRI(II).

ACTION: The CCRI(II) Chair to take a proposal to CCRI recommending that ICRM be appointed observer status to the CCRI(II). [Owner: Dr Lisa Karam CCRI(II) Chair]

11. Any other business

Dr John Keightley (NPL) presented on a report entitled *Initiative to develop an international standard for list-mode data acquisition related to radioactivity measurements*. He reported on the needs that exist to develop standardized data formats for list-mode data sets in support of national security. Dr Akira Yunoki (NMIJ) issued an informal invitation open to all CCRI(II) to participate and contribute to the working group.

Dr John Keightley (CCRI(II) KCWG Coordinator) advised that the meeting of the CCRI(II) key comparison working group is proposed to occur during the second week of November 2015.

ACTION: Establish a Doodle Poll for members of the KCWG(II) as to their availability for a meeting to be held in November. [Owner: John Keightley (NPL)]

The Chair requested that all CCRI(II) delegates review the implications of the proposed changes to the CIPM MRA.

ACTION: All CCRI(II) delegates to review the implications of the proposed changes to the CIPM MRA. [Owner: CCRI(II)]

The Chair encouraged CCRI(II) to make use of the new SIR email SIR.bipm.org.

12. Date of next meeting

The Chair requested CCRI(II) to send either the CCRI(II) Chair or the CCRI Executive Secretary any thoughts on the future meeting and membership of CCRI(II).

Date of the next meeting to be advised.

**CONSULTATIVE COMMITTEE
FOR IONIZING RADIATION**

Section III: NEUTRON MEASUREMENTS
Report of the 21st meeting
(4-6 March 2015)

**LIST OF MEMBERS OF THE
CONSULTATIVE COMMITTEE FOR
IONIZING RADIATION (SECTION III)**

as of 4-6 March 2015

Section III - Chairman

D. Thomas, National Physical Laboratory, Teddington

Members

Commissariat à l'énergie atomique/Laboratoire National Henri Becquerel [LNE-LNHB], Gif-sur-Yvette cedex

Czech Metrology Institute [CMI], Brno

D.I. Mendeleev Institute for Metrology, Rosstandart [VNIIM], St Petersburg

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

National Laboratory for Metrology of Ionising Radiation/Institute of Radiation Protection and Dosimetry CNEN [LNMRI/IRD], Rio de Janeiro

National Metrology Institute of Japan, AIST [NMIJ/AIST], Tsukuba

National Physical Laboratory [NPL], Teddington

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig

Official observers

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

China Institute of Atomic Energy [CIAE], Beijing

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

International Atomic Energy Agency [IAEA], Vienna

International Commission on Radiation Units and Measurements [ICRU]

**OPENING OF THE MEETING;
APPROVAL OF THE AGENDA;
APPOINTMENT OF A RAPPORTEUR**

Section III (Neutron measurements) of the Consultative Committee for Ionizing Radiation held its 21st meeting at the Pavillon de Breteuil (the BIPM headquarters), Sèvres, from 4 to 6 March 2015.

The following were present:

J.P. Archambault (NRC-INMS), M. Arif (NIST), L. Bertalot (ITER), T. Cheick (LNE-LNHB), M.S. Dewey (NIST), V. Gressier (LNE-IRSN), Zhang Hui (NIM), J. Kim (KRISS), M. Kralík (CMI), W. Louw (President of the CCRI), P. Maleka (Ithemba Labs), L.C. Mihailescu (SCK-CEN), M.J.T. Milton (Director of the BIPM), T. Matsumoto (NMIJ/AIST), N.N. Moiseev (VNIIM), Z. Msimang (NMISA), R. Nolte (PTB), S. Oberstedt (IRMM), H. Park (KRISS), L. Quinteri (ENEA-INRIM), N. Roberts (NPL), F.D. Smit (Ithemba Labs), D.J. Thomas (Chairman of Section III, NPL), R.M. Villafane (CIEMAT), Z. Vykydal (CMI), A. Zimbal (PTB).

Members of the BIPM who attended all or part of the meeting: D. Burns (BIPM), J.M Los Arcos (Executive Secretary of the CCRI), D. Olson (Executive Secretary JCRB), G. Ratel (BIPM), C. Thomas (KCDB coordinator).

Apologies: C.Y. Yi (KRISS), L. Johansson (NPL).

1. WELCOME BY THE DIRECTOR OF THE BIPM, DR MARTIN MILTON, AND THE PRESIDENT OF THE CCRI, DR WYNAND LOUW, TO THE PARTICIPANTS (MEMBERS, OBSERVERS AND GUESTS)

The meeting started at 10 am. Dr Louw, who is new to this post, introduced himself.

2. INTRODUCTION BY THE CHAIRMAN, DR DAVID THOMAS, NPL

Dr Thomas introduced himself. Each attendee then introduced themselves and their laboratories. There were several new participants attending the CCRI(III) meeting for the first time – SCK/CEN, NMISA, i-Themba Labs and ITER.

3. APPOINTMENT OF THE RAPPORTEUR

Scott Dewey agreed to be rapporteur.

4. CHANGES OR ADDITIONS TO THE AGENDA

No changes to the agenda.

5. PROGRESS REPORTS:

5.1 CCRI reports (President Wynand Louw, CIPM)

Strategy and actions reports CCRI President's Report – Session II of the 103rd meeting of the CIPM

Dr Louw summarized this report. There is an issue with discrepancies among copies of the kilogram. A Big *G* consortium will try to resolve problems with measurements of *G*. Rationalization of the Ionizing Radiation Building will start in 2015. There have been changes to the way donations can be made to the BIPM and finances are more tightly managed. The CGPM voted for no increase to the dotation of the BIPM for 2016-2019. Mandates for the CCRI head and section heads are four years. It is the International Year of Light.

5.2 Section III reports

Key Comparisons Working Group

A short report was presented by the Chair.

New Chair of CCRI(III)

At this point, the Chair, Dr Thomas, announced that he will step down at this meeting and the CCRI President Dr Louw introduced the new Chair, Dr Vincent Grassier, from the IRSN, who took the floor.

Report of BIPM Programme of Work 2013-2014

Dr Los Arcos presented the report “2013-2015 Report of the BIPM Ionizing Radiation (IR) Department”. This touched on IR resources (facilities and standards), terms of reference, and progress. They are constrained to follow the “Programme of work and budget of the BIPM for the 3 years 2013-2015” (CIPM, 2012), and the “CCRI strategic plan for the period 2013-2023”. He described work on dosimetry, radionuclides, international coordination activities and thermometry. For dosimetry: six ongoing and on-demand comparisons of national primary standards at the BIPM; two ongoing and on-demand comparisons of national primary standards onsite at National Metrology Institutes (NMIs) or Designated Institutes (DIs); calibrations of national secondary standards. For radionuclides, one ongoing and on-demand comparison for activity of gamma emitters at the BIPM; and one ongoing and on demand comparison for activity of short-lived radionuclides, onsite at NMIs or DIs (^{99m}Tc , ^{18}F ,...).

5.3 Written reports from NMIs (for the record)

NMI/DI's activity reports had been uploaded into the working documents' restricted area, for the record.

6. CIPM MRA PART 1:

Dr Los Arcos introduced this topic with a general discussion that included the status: K11 has been published while K8 is due out this week; a K9.AmBe.1 report is in progress (draft A); APMP.RI(III)-S1: Draft B (deadline 18 March); Euromet.RI(III)-S1: report in progress (draft B). It was noted that some simplification of the process “draft report” → CMC is being worked on.

6.1 Present comparisons

CCRI(III)-K11 neutron fluence – progress report Vincent Gressier

This has been published in *Metrologia*. A summary of results from K-11 were presented. There were nine participants and many different techniques were employed. Seven of the nine participants provided results. The measured neutron fields were described. There did not appear to be any outliers. At 17 MeV, there is perhaps an inconsistency between the long counter and other techniques. This needs to be investigated. Key comparison reference values are available at all fields and there is good agreement across the board. Perhaps a future version of this comparison should circulate one instrument while each participant makes his/her own monoenergetic fields. It was asked if this should be in 2021 or before.

CCRI(III)-K8 thermal neutron fluence – progress report Ralf Nolte

This comparison is finished. Andreas Zimbal, Ralf Nolte's colleague, talked about some consistency checks that he had examined. There were only four participants in this comparison, which involved the response of SP9 type ^3He counters to thermal neutrons. There were various discrepancies to deal with. The PTB has a new thermal facility. Sixteen Am-Be neutron sources provide a yield of 6×10^7 neutrons/s. There were consequential inconsistencies in the encapsulation of the SP9 detector. The PTB calculated a new response function taking into account a more accurate description of the encapsulation. The ^3He pressure in the SP9 counters was then adjusted by calibration of the whole BSS system in front of their calibrated ^{252}Cf source. As a result, the response of the detector in a thermal field can be obtained. This method, applied to the two SP9 detectors used in the K8 comparison, gives a response that is similar to those determined by PTB in K8.

David Thomas spoke about this comparison and the work that the NPL has been doing to understand their results. The NMIJ/AIST and PTB results were in agreement, however the NPL results were discrepant. The comparison included measurements with SP9 (20 mbar) + moderator as well as SP9 (200 mbar) + moderator. The NPL thermal pile facility is Van de Graaf driven, making it a unique facility. It produces an accurately known fluence. Neutrons are produced by the Be(d,n) reaction in two thick beryllium targets. There is a feedback system. They found that the detector dead-time was not stable. There is an effective thermal neutron temperature which is obtained from an empirical formula. Two corrections for temperature almost cancel. They obtain the thermal fluence from gold foil activation. Whichever parameter they checked, they could not find any reason to modify their result from K8. This leaves the difference between PTB and NPL an unresolved problem. There were some problems with K8: too few participants; the added complexity of four detectors did not illuminate anything; and the excessive time taken for transfer instruments to reach all participants. There are some possibilities going forward: do nothing; a new review of K8 by others; repeat K8; or try a simpler exercise such as a gold foil activation comparison.

CCRI(III)-K9.AmBe.1 emission rate – progress report Neil Roberts

Supplementary comparison: CIAE, NIM, LNHB, ENEA with the NPL as a link to original K9. The NIM and LNHB were outliers from K9; ENEA was a newcomer. The NIM provided an Am-Be source. Only two NMIs (the NIM and NPL) were able to make measurements. The LNHB could not acquire the source because the source container was not permitted for transportation in France. The CIAE could not participate because only one participant from each country is allowed (it was the NIM from China). They

could not get the source to the ENEA. It therefore became a bilateral comparison between the NPL and NIM. A Draft A report is in progress. The source was manufactured in China and the 'special form certificate' was unusual.

Future needs for CCRI(III) comparisons

Neil Roberts (NPL) stated the need for a new source emission rate measurement. The source must be available for 5 years; it needs an acceptable special form certificate; it can be Am-Be or Cf; and it needs a high enough emission rate to be measured in all Mn baths for the next 5 years. The shipping container that is required must be: available for up to 5 years; Type A certified; and re-usable with maintenance instructions. A pilot institute is needed and this will probably be the NPL again. It should be noted that the special forms certification usually expires after ~15 years. The ^{250}Cf content should be low; therefore the source should be less than two years old. The NPL has a cask that can be used (originally Type B, it is now Type A). Its Transport Index (TI) with 5 micrograms Cf is between 2 and 3. The NPL has a 5 microgram ^{252}Cf source that could be used. Its neutron emission rate is: $1.2 \times 10^7 \text{ s}^{-1}$. Many institutes expressed an interest in participating. It was considered whether or not this comparison should be advertised outside of this group. It is noted that the previous protocol exists. There seemed to be a preference for ^{252}Cf rather than Am-Be. It costs about 1000 euros to ship a source around the world.

Later, Vincent Gressier (LNE-IRSN) returned to the topic of a new CCRI(III)-K9 or emission rate comparison. After discussion, it was agreed that the source will be ^{252}Cf ; the pilot institute will be NPL (Neil Roberts); and participants will be ENEA, NRC, KRISS, NIST, LNHB, CMI, NPL, NIM, VNIIM, NMIJ, (+LNMRI?). A protocol should be written and submitted to the BIPM. The NPL noted that being the pilot institute depends upon whether or not they receive the ^{252}Cf source. The protocol is written by the pilot institute, validated by participants, and then submitted to the BIPM. Could this start as early as 2015?

Andreas Zimbal presented a proposal for an $\text{H}^*(10)$ key comparison (an area survey instrument). There has been no CCRI key comparison of this quantity. The PTB has a spherical transfer instrument (SmartRem) with a diameter of 208 mm. It contains an SP9 counter with ^3He and a 2K MCA with display. This would be sent around and measure reference fields of Cf, Cf(D₂O), and Am-Be from ISO 8529. One would determine $\text{H}^*(10)$ and the fluence response. The PTB would be the pilot laboratory. Each laboratory would use the same method that is used in routine calibrations (at PTB this involves a shadow cone). The instrument would be sent back to the PTB for a stability check between measurements. This would start in 2016. There was a comprehensive discussion on the topic, with opposing views expressed. It is a choice of restricting oneself to carrying out primary calibrations versus including that which interests customers the most. For this comparison, the output is really fluence times a conversion factor. Many groups expressed interest in participating in this. It was suggested that there could be two instruments.

A series of decisions were taken. For the $\text{H}^*(10)$ measurements, the circulation of two "SmartRem" survey meters, one from the PTB and one from the IRSN are envisaged. Would this comparison of $\text{H}^*(10)/\text{count}$ or of the calibration factor be a key comparison? The pilot institute will be the PTB (Andreas Zimbal), and one or several of the following fields will be used: Am-Be, Cf, Cf+D₂O (30 cm). Measurements will start in 2016 at the PTB. Fourteen participants are already interested.

David Thomas (NPL) discussed a possible future key comparison involving personal dosimeters or calibrations to personal dose equivalent ($\text{H}_p(10)$ calibrations). This could utilize active, electronic personal dosimeters (e.g. EPD-N2, Fuji NRF31, and MGP devices). If undertaken using neutron sources, many more labs than usual could participate. The interest in this comparison is always somewhat weak. One might need to carry it out in a 10 mSv field in order to get enough statistics for a relative uncertainty

lower than 2 % - 3 %. Since this is a relatively high value there should be a pilot study between two or more laboratories to establish the feasibility of such a comparison. The Fuji NRF 31 might be better in terms of statistics but one would need to know the algorithm. The suggestion was made to use at least two types of dosimeter. There seems to be less interest in this than in a $H^*(10)$ comparison.

A series of decisions were made. For the $H_p(10)$ comparison, the circulation of four electronic personal dosimeters (two Fuji by NPL and two MGP by KRISS) are envisaged. There will be a pilot study with the NPL, KRISS, PTB, SCK/CEN and CMI before deciding on the key comparison at the next meeting. A protocol for the pilot study will be organized by the KRISS. This must then be validated by participants and submitted to the BIPM. This can start in 2015.

David Thomas returned the discussion to K8. Should we do nothing; have others review it; repeat it; try a “simpler” exercise, e.g. use of gold foils? Ralf Nolte believes the discrepancy could be a problem of “normalization”. What are the advantages and disadvantages of using Au foils? There was a previous measurement of this in 1970 (E.J. Axton). How many irradiation laboratories do we have? Do we need a pilot study?

How can K8 be “continued”? Possibilities include a new key comparison, a supplementary comparison, and a pilot study. Concerning a new thermal comparison, there are lots of facilities under development, but it is still too early to organize a new K8 comparison. A comparison of gold foil activation, i.e. of the thermal neutron fluence calculated from activated gold foil could be considered. The position of the majority of the group seemed to be that there should be a new K8. David Thomas argued that the Au foil counting has to be resolved first and this was agreed. David Thomas will organize and circulate a questionnaire.

Comparison CCRI(III)-K8: thermal is being published. There were four participants and only two in agreement. It was asked what should be decided concerning CMCs. One possibility is modification of CMCs by increasing uncertainties while awaiting resolution of discrepancies. This would be the responsibility of each NMI. An NMI can access the CMC database and increase its uncertainty. This is done on the website.

Note that pilot studies are a third category of comparison normally undertaken to establish measurement parameters for a “new” field or instrument, or as a training exercise. The results of pilot studies alone are not normally considered to be sufficient support for a CMC.

Supplementary comparisons are comparisons, usually carried out by an RMO to meet specific needs that are not covered by key comparisons (e.g. regional needs), for instance measurements of specific artefacts, or measurements of parameters not within the “normal” scope of the Consultative Committees. Consultative Committees may however decide to run a supplementary comparison when there are only a few participants capable of measuring the required quantity (none sharing the same RMO) or when no link can be made to an RMO.

RMO neutron comparisons

This had been covered in the previous discussion.

7. EXCHANGE OF INFORMATION ON NEUTRON METROLOGY IN PROGRESS NMIS PART 1:

CMI

M. Kralik and Z. Vykydal gave a presentation on the CMI. A new researcher, Zdenek Vykydal, started in 2014. They have a Mn bath (1 m diameter) whose range is $10^4 - 10^8 \text{ s}^{-1}$. They work with radionuclide sources and fluence standards. The Extended Bonner Spheres Spectrometer (EBS) allows measurements of neutron spectra with energies above 20 MeV. A new graphite pile with a 40 cm diameter internal cavity is a source of thermal neutrons. Their work includes investigation of new detector technologies. Their Bonner spheres include 10 pure PE spheres supplemented with three spheres with Pb and W layers. They are devoting considerable efforts to characterizing their Bonner spheres in high-energy neutron fields. They would like to find a partner for a bilateral or wider comparison of thermal neutron fluence. They are studying fast pixelated detectors that work with low and high intensities. They are participating in the European metrology programmes EMRP and EMPiR. Their metrology of high energy neutron fields includes calculations for 20 MeV - 250 MeV neutrons.

ENEA

L. Quinteri gave a presentation on the ENEA Neutron Metrology Laboratory which is located in Rome. They have a source storage room, a thermal standard room, a control room, and an irradiation room. For reference fields they have Am-Li, Am-F, Am-B, Am-Be, Po-Li, and ^{252}Cf . Only Am-Be is used for calibration services. Six Am-Be sources are used in their thermal neutron density standard. Their main focus is on maintaining and improving the survey meter calibration service. They have questions about their calibration reports. They are getting a neutron generator. The ENEA has requested more details on the De Pangher long counter. They have a Mn bath and have carried out Au foil counting. Monte Carlo studies are carried out using FLUKA, Geant4, and MCNP. They seek both collaboration and EU projects. It was noted that the NPL has a good MCNP model of its long counter. They also intend to develop a thermal reference field at a TRIGA reactor.

KRISS

H. Park and J. Kim gave a presentation on KRISS. One engineer and two students are working on setting up a DD neutron generator (Adelphi DD-109). They have constructed a thermal neutron field using a graphite pile and Am-Be source ($1.2\text{m} \times 1.4\text{m} \times 1.2\text{m}$; $10\text{cm} \times 10\text{cm}$ cavity for detectors in the graphite pile). The Am-Be source emission rate is $1.2 \times 10^7 \text{ n/s}$ and the number of graphite blocks is 239. The neutron spectrum was calculated with MCNPX, and the fluence measured with Au foil activation and $4\pi\beta\text{-}\gamma$ coincidence counting methods. They carry out neutron spectrometry with 10 Bonner spheres. They are building a mini-Mn bath (similar to the NIST apparatus). A thermal neutron field calibration service will begin in 2015. They used BSS to measure secondary neutron spectra at the Samsung Medical Center in 2015. The neutron generator will be used for a quenching factor measurement of a NaI detector (used for dark matter search). They note that commercial graphite contains ~ 100 ppm boron. This can be removed. Dr Park's colleague Dr Kim further discussed neutron spectrometry with BSS, activation foil-based BSS, BSS measurements at the Korea Institute of Radiological & Medical Science where their ^{197}Au and Dy foil results agree within uncertainties, and measurements at Samsung Medical Center. They have made measurements at the following facilities: KIRAM, proton cyclotron; KRISS, Electron LINAC; Samsung Medical Center, proton cyclotron.

LNE-IRSN

Vincent Gressier gave a presentation on the LNE-IRSN. The replacement of its ^{245}Am -Be source is expected in 2015. The new source will be 592 GBq (emission rate of $4 \times 10^7 \text{ s}^{-1}$) and is from QSA Global, based on the X.14 design. Calibration will take place using the NPL and LNE-LNHB Mn baths.

Replacement of its ^{252}Cf source will occur in 2016-2017 ($3 \times 10^8 \text{ s}^{-1}$). They continue research and development on new recoil proton telescopes with increased efficiency. Their work, supported by LNE, concerning measurements of absolute neutron energy distributions of AMANDE monoenergetic neutron fields was presented. For the μ -TPC telescope there is a problem with the ionization quenching factor that has to be experimentally determined. LNE-IRSN has a small 50 kV accelerator dedicated to that measurement. The CMOS-RPT detector covering the range 5 MeV - 20 MeV, uses 3D track reconstruction with three pixelated CMOS sensors that are 50 μm thick, and a Si(Li) detector for energy determination. A new design is currently being developed. They continue their work characterizing the HERMEIS low pressure system which is dedicated to neutron spectrometry at medical facilities. In the low pressure central ^3He counter there is a large amount of ^4He leading to an n- ^4He resonance in the BSS response functions. The MIRCOM project involves the irradiation of cells with an ion micro-beam for IRSN radiobiology programmes. There is an accelerator upgrade underway as well as new building construction at AMANDE. This facility has therefore been shut down since March 2014 and is expected to reopen in early 2016. Future facility developments include: high energy neutron fields at iThemba Labs, thermal neutron fields (2018-2019), and realistic neutron fields (in connection with ITER).

8. STRATEGIC PLANNING 2013-2023:

Dr Wynand Louw began this broad discussion. There are 35 CCRI members, 20 observers, and 3903 CMCs. The vision of the CCRI for 2009-2015 is to become the undisputed hub for ionizing radiation global metrology. This will be achieved in close collaboration with its institutional stakeholders and in close dialogue with its end-users. There will be a process: research \rightarrow services vision \rightarrow initiatives. The CCRI has operated according to a strategic plan since 2009. Directors and stakeholders have questioned why the BIPM has technical capability/laboratories in one area and not in another. The BIPM is flat-funded for ~6-7 years. He articulated why the BIPM has particular technical capabilities/activities or not in the supported technical areas. He discussed the BIPM 2016-2019 work programme document. Dr Louw advocates for the CCRI at the CGPM and CIPM meetings. Dr Gressier led a discussion on how to get resources from BIPM towards neutron projects. It will be very difficult, despite the fact that the directors of the BIPM are in favour of our activities.

David Thomas asked everyone why we do what we do. There is radiation protection, nuclear energy generation/technology, and cross sections at ever higher energies. Is there anything else?

- a. **Short term (2013-2015), medium term (2013-2019), long term (2013-2023)**
- b. **Status of CCRI strategic plan**
- c. **CCRI(III) strategic actions and working groups 2013-2023, considering the following specific strategic trends:**
 - i. **Short-term:**
 1. **Comparison of personal dose equivalent**
 2. **New neutron cross-section data – identify needs and potential funding**
 3. **Standards for fusion – identify needs and possible actions**

Here, a significant driver is ITER's neutron diagnostics and calibration. A brief description of the ITER was given. It is a tokamak-based plasma device operating with a toroidal field of around 5.3 Tesla and a plasma current of 15 MA. The collaboration includes six countries plus the EU and is situated in Cadarache, France. The project is in its construction phase. The measured neutron emission rate allows a determination of the fusion power. For these purposes, 10 % accuracy is required with a temporal resolution of 10^{-3} seconds. Consequently, neutron measurements are extremely important. Some of the technologies under development include a neutron activation system from the Republic of Korea; neutron flux monitors from China, microfission blankets from Japan, and divertor neutron flux monitors from Russia. There was an ITER Neutron Workshop in 2013 sorting out the calibration strategy of ITER neutron diagnostics: calibration of neutron diagnostics is done by domestic agencies (DA); only functional tests to be performed at the ITER site with some specific tests/calibration to be performed at a metrological laboratory; priorities on neutron transport calculations to support in-vessel calibration; two in-situ neutron calibrations with a ^{252}Cf source and a 14 MeV sealed tube neutron generator both moved inside the vacuum vessel (one area where neutron metrology expertise from NMIs would clearly be invaluable); and cross-calibrations of the less sensitive neutron diagnostics using standard reference plasma discharges. One of the present concerns is the calibration performed by the DA, as ITER does not know the type of calibration they intend to do. ITER will therefore organize a dedicated workshop in October/November 2015 with a panel of neutron calibration experts from NMIs. The Republic of Korea and China are making major contributions concerning neutronics.

ii. Medium term:

1. **Operational quantities for radiation protection (nano-dosimetry) - needs in the neutron area**
2. **Radiobiological data for neutrons – is this a Section (III) activity?**
3. **High-energy (>20 MeV) neutron standards – is there a way forward?**

Tetsuro Matsumoto presented work on high energy neutron fields in Japan. At TIARA-JAEA they are characterizing neutrons of 45 MeV and 60 MeV. At the Research Center of Nuclear Physics, Osaka University, quasi-monoenergetic neutron fields up to 390 MeV are available. Their work includes characterization of neutron energy spectra, calibration tests of BSS as well as several kinds of neutron dosimeters, and evaluating shielding data for concrete and iron. The main problem is the very limited beam time availability for neutron metrology.

F.D. Smit presented an introduction to South Africa's iThemba LABS. They have been designated by NMISA for neutron metrology in the 30 MeV - 200 MeV energy range. They intend to develop their neutron beam line to propose a quasi-monoenergetic neutron field for calibration services and metrology in that range. The PTB and LNE-IRSN could also be involved in that work. There are still uncertainties about the beam time availability.

A comparison between these two facilities could be a topic for the next CCRI(III) meeting.

4. **New needs in public security, health and industry – what are the needs?**
5. **New therapy modalities (hadron, BNCT) – neutron metrology needs**

The NMIJ is interested in BNCT as it is currently in development in Japan through accelerator driven medical facilities. This is however still limited to Japan for the moment.

iii. Long term:

1. Any long term needs identified since last edition of strategy?

M. Arif from NIST brought up neutron imaging. Comparing it to the “Wild West”, he stated that there are no standards. This field is taking off.

d. Input from RMOs: AFRIMETS, APMP, COOMET, EURAMET, SIM

AFRIMETS reports that the National Institute of Standards, Egypt and the National Metrology Institute of South Africa have neutron capabilities. In particular, the iThemba LABS (South Africa) has been designated for medium- to high-energy neutron capabilities.

e. Input from institutional stakeholders

f. Concluding remarks

9. CIPM MRA PART 2:

RMO activities: AFRIMETS; APMP; COOMET; EURAMET; SIM

SIM: M. Dewey presenting. The recent CIPM key comparison, CCRI(III)-K11 (neutron fluence for neutron energies 27.4 keV, 565 keV, 2.5 MeV and 17 MeV) had participation from the LNMRI and NIST; results were published in 2015. The LNMRI/IRD also coordinated the second National Comparison of neutron $H_p(10)$ (12/2013), for worker protection. An internal audit was done at the LNMRI/IRD in 2013 while the technical and quality systems for dosimetry, neutrons and radioactivity were peer reviewed in 2014. It was noticed that LNMRI did not come to the last two CCRI(III) meetings even though they are active in neutron metrology.

APMP: Hyeonso Park presenting. Highlights were an APMP Technical Committee on Ionizing Radiation meeting at Daejeon, Republic of Korea and a report on CMCs.

EURAMET: Neil Roberts spoke about comparison: #1104: Comparison of neutron source spectra for improvement of ISO8529. There is a need for accurate measurements of Am-Be spectra with sources having different sizes, encapsulations, and constituent materials. Below 1 MeV spectra are only estimated by interpolation or calculation. The comparison involved the use of BSs to measure spectra from different sized Am-Be sources at NPL (1, 10, 15 Ci). The goal was to study Am-Be spectra. Different intensities lead to different spectra. The results were published in 2014.

EURAMET: Neil Roberts spoke about comparison #936: Long Counter Comparison. Measurements were made at the NPL in 2008. Preliminary results appeared in NEUDOS11 (2009). The PTB De Pangher counter is 1.6 % higher than the NPL De Pangher but they have the same response function shape. Since then, there have been revisions of source data and of NPL and IRSN long counter responses. New results were presented showing slight differences with no evident improvement but there is still a good agreement

between all participants. Neutron fields included Am-Li, Am-F, ^{252}Cf , Am-B, and Am-Be plus monoenergetic neutron fields at 144 keV, 565 keV, 1.2 MeV, 5 MeV and 17 MeV.

APMP: Hyeonseo Park spoke about a comparison of the calibration of ambient dose equivalent meters. Both the shadow cone and distance method were used. Neutron fields included Cf, Am-Be Cf(D₂O). Draft B is in circulation. The due date is 18 March 2015. There was a discussion on considering outliers. KRISS did not consider obvious outliers and chose to use the median. R. Nolte and V. Gressier said that outliers should be eliminated and the weighted mean calculated with the selected participants. H. Park did not do this as it would have reduced the number of participants to too small a value.

BIPM-KCDB: Appendix C submissions for discussion and approval

There is nothing new in neutrons. The last addition was Brazil in 2013. Mexico has an expired/expiring CMC that is being dealt with. Ralf Nolte asked about changing a result (CMC) in the database. There is a 43 page document on the BIPM website that explains how to do this. It was suggested that we should write a short summary paper of CMC operations and put it on the CCRI(III) webpage. An increase of scope or decrease of uncertainty must go through a new review.

JCRB Report

Douglas Olson, from NIST and currently Executive Secretary of the JCRB gave a presentation. The JCRB holds two meetings per year. Some streamlining of the CMC process has been going on. He introduced the website and gave a description of the review process which includes submission, review by other RMOs, voting, and publishing. The total turnaround time is about 131 days. CCRI(I) has a fast track on some CMCs.

10. EXCHANGE OF INFORMATION ON NEUTRON METROLOGY IN PROGRESS, NMIs PART 2:

NIM

Zhang Hui presented a report on the Division of Metrology in Ionizing Radiation, NIM (China). A ^{137}Cs gamma irradiator (1.85×10^{11} Bq) was used to verify the photon response of various neutron instruments/detectors. They are continuing to characterize their long counters. They have calibrated their direct reading neutron personnel dosimeters EPD-N2 and DMC2000GN. In the future, their long counter will be calibrated at CIAE and other relevant tests from 2015 will be carried out. They have acquired a new set of 12 Bonner spheres. This spectrometer will be used to measure the neutron spectrum in actual workplaces.

NIST

M. Dewey gave a presentation on the NIST Neutron Physics Group's work over the last two years. Highlights include: research and development of post-Cf neutron sources, technical updates to the neutron meter calibration service, a successful high precision measurement of the $^6\text{Li}(n,t)^4\text{He}$ cross section at sub-thermal energy, work on a novel fast neutron spectrometer, and the commencement of operations on NG-C, the NIST's new beam line for fundamental physics with cold neutrons.

NMIJ/AIST

T. Matsumoto gave this presentation. He discussed high-energy neutron field work at 45 MeV at TIARA. Details include: ${}^7\text{Li}(p,n)$ reaction, proton energy: 50 MeV, 10 cm diameter collimator made of concrete and iron. The neutron fluence was measured with a proton recoil detector. They will start a calibration service in 2015. They work with high-energy neutron fields (100 MeV–400 MeV) at the RCNP. These are also produced by the ${}^7\text{Li}(p,n)$ reaction. They tried to calibrate Bonner spheres at high energies (100 MeV - 390 MeV). There are other experiments at the RCNP as well. They have developed a D_2O moderated ${}^{252}\text{Cf}$ neutron field. The NMIJ will establish a Mn bath with solution again by 2022. In the meantime they are developing a new type of Mn bath utilizing manganese alloy plates. The alloy is Mn 70.3 %, Cu 22.4 %, Ni 5.1 %, Fe 2.0 %. The bath has a multi-layered structure with the 12 mm thick Mn plates and 8 mm thick PE plates. At present, it is calibrated by calculations with MCNP. A D_2O moderated Cf neutron fluence service commenced in 2014. A calibration service of the 45 MeV neutron fluence rate will commence in 2015. Their future plans include neutron fluence calibration services at 19 MeV, 1.2 MeV, and 2.5 MeV to commence by 2020. A Mn bath for emission rate will be established again by 2022.

NPL

Neil Roberts gave this presentation. The observed decrease in Ra-Be source intensity appears to have been due to an unscrewing of the outer Be shell. There is now borderline agreement with the historic mean, suggesting it may have recovered. Concerning the absolute measurement of Mn activity, the housing for an inline Cerenkov-gamma counting cell is under construction. The system includes a UV reflecting sphere, a synthetic quartz cell of 5 cm diameter, two PMTs, quartz windows, two NaI detectors (2" × 2"), and lead shielding. They have observed that the photon to neutron dose ratio of Cf changes with the age of the source. Concerning photon spectra from neutron sources, they have unfolded HPGe measurements using Gravel, MCNP. They have carried out new fast spectrometer tests using Li-loaded Zaitseva plastic scintillators. Other work that was mentioned included modelling TEPC response with GEANT4, a directionally sensitive dosimeter (PhD project), measurements in pulsed fields, improving the knowledge of neutron spectra from targets, neutron dosimetry based on radiobiology, and improved tissue equivalence of personal dosimeters.

PTB

Ralf Nolte made this presentation of the neutron metrology, neutron dosimetry, and related areas at the PTB. There was an evaluation of PTB division 6 by an international panel. Some consequences for the PTB neutron departments are: re-unification of departments 6.4 and 6.5, working groups are unchanged, and the new department 6.4 should form a "Center of Competence in Neutron Metrology". There were three staff retirements, and now there are insufficient accelerator staff members. One legacy of the K11 comparison is a comparison of recoil proportional counter P2 and the long counter LC1. Progress on the 14.7 MeV TCAP standard has been good. They have investigated elastic scattering of neutrons on deuterium. The recent cross-section evaluation ENDF/B-VII is consistent with their measurements while those of ENDF/B-VI.3 are not. This could have implications for the ${}^{252}\text{Cf}/\text{D}_2\text{O}$ spectral shape. They are replacing their Van de Graaff Accelerator. Procurement was in May 2014 and delivery will be September 2016. The dismantling of the VdG is scheduled for February 2016. It will be equipped with two ion sources for p, d, and α .

VNIIM

Nikolay Moisseev gave this presentation. There was a complex modernization of equipment. The Mn bath solution was exchanged and its parameters reinvestigated. The Mn-56 activity was determined by

$4\pi\gamma$ -counting and by Cerenkov-gamma coincidence. The two methods agreed well. Efficiencies of the associated particle method were reinvestigated. A standard field of thermal neutrons was created. Gold foil activation is used. The neutron temperature was measured carefully using the “cadmium ratios” method.

11. EXCHANGE OF INFORMATION ON NEUTRON METROLOGY IN PROGRESS, INSTITUTIONAL STAKEHOLDERS

There were no contributions to this section.

12. PRESENT AND FUTURE MEMBERSHIP OF THE CCRI(III)

The full members and official observers are listed on the website. New members since 2003 include: NMISA (South Africa), i-TLABS (South Africa), SCK/CEN (Belgium), and ITER.

CCRI(III) is missing potential new participants with neutron CMCs: LNMRI (they used to attend), ARPANSA, and SMU. CERN is an interesting possibility. It has a new radiation protection dosimetry laboratory with Pu-Be, Am-Be and Cf, and it has the CERN-EU high-energy Reference Field Facility (CERF). However, CERN is seen as more of a secondary laboratory that is already strongly involved in EURADOS and not really in neutron metrology.

The invitation of experts closely allied to strategic actions is encouraged. The goals would be to better drive strategic actions, define new ones, and give more visibility to neutron metrology with potential new stakeholders. As an example, the ITER, present at this meeting, can be assisted by the CCRI(III). It is important to have a presence at the ITER meeting which will take place at the end of 2015. The ITER delegate in turn should return to future CCRI(III) meetings. What are some possibilities for future meetings: an expert from the ESS; the laser ignition facility; BNCT; neutron imaging?

There is a reluctance to expand our scope. The consensus seems to be to invite persons with specific needs, that have contacted NMIs in the last two years, and these persons or the contacted NMI will then discuss those needs at the CCRI. It was suggested that meetings should have more time for special presentations. More participants would mean more presentations. Perhaps the length of progress reports could be limited to 15 minutes. Everyone should be encouraged to give a presentation.

A proposal was made to create a “Facilities document”. This would be a simple document/table listing present and future neutron reference facilities with their main characteristics, to be updated at each CCRI(III) meeting. R. Nolte said that it would not be very useful and hard to keep updated. After some discussions, this proposal was not adopted.

13. WORK PROGRAMME 2016-2019 OF THE BIPM IONIZING RADIATION DEPARTMENT (FOR INFORMATION)

Dr Los Arcos discussed the programme looking towards the future, including the objectives of the BIPM. An increased scope is desired, but there is no additional funding.

14. CCRI(III) WORKING DOCUMENT STATUS

Delegates were asked to make their documents available. These will be added to website. PDF and PPT formats are OK.

a. Bibliography

b. Other publications

The bibliographies were revised and published on the BIPM webpage for the CCRI(III).

15. ANY OTHER BUSINESS

None.

16. DATE OF NEXT MEETING

There should be no delays between different CCRI section meetings and the next CCRI(III) meeting will be in 2017.