Bureau International des Poids et Mesures

Consultative Committee for Ionizing Radiation (CCRI)

Report of the 18th Meeting
(30 May 2003)
to the International Committee for Weights and Measures

Comité international des poids et mesures

Bureau international des poids et mesures

Organisation intergouvernementale de la Convention du Mètre

Note:

Following a decision made by the International Committee for Weights and Measures at its 92nd meeting in October 2003, Reports of meetings of Consultative Committees will henceforth be published only on the BIPM website in the form presented here.

Full bilingual printed versions in French and English will no longer appear.

T.J.Quinn,
Director BIPM,
November 2003.

LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR IONIZING RADIATION

as of 30 May 2003

President

G. Moscati, member of the International Committee for Weights and Measures; Instituto de Fisica, Universidade de São Paulo, São Paulo.

Executive Secretary

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

Members

The Chairman of Section I.

The Chairman of Section II.

The Chairman of Section III.

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

Section I: x- and γ-rays, electrons

Chairman

P. Sharpe, National Physical Laboratory, Teddington.

Members

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

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

Bureau National de Métrologie, Laboratoire National Henri Becquerel [BNM-LNHB], Gif-sur-Yvette.

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

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

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

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

International Commission on Radiation Units and Measurements [ICRU].

National Institute of Metrology [NIM], Beijing.

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

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

National Office of Measures/Országos Mérésügyi Hivatal [OMH], Budapest.

National Physical Laboratory [NPL], Teddington.

National Research Council of Canada [NRC], Ottawa.

Nederlands Meetinstituut, Van Swinden Laboratorium [NMi VSL], Delft.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

Swiss Federal Office of Metrology and Accreditation/Office Fédéral de Métrologie et d'Accréditation [METAS], Bern-Wabern.

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

Observers

CSIR National Metrology Laboratory [CSIR-NML], Pretoria.

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

International Atomic Energy Agency [IAEA], Vienna.

International Organization for Medical Physics [IOMP].

International Radioprotection Association [IRPA].

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

Swedish Radiation Protection Institute/Statens Stralskyddsinstitut [SRPI], Stockholm.

Section II: measurement of radionuclides

Chairman

B.R.S. Simpson, CSIR National Metrology Laboratory, Cape Town.

Members

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

Bureau National de Métrologie, Laboratoire National Henri Becquerel [BNM-LNHB], Gif-sur-Yvette.

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

CSIR National Metrology Laboratory [CSIR-NML], Cape Town.

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

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

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

Institut de Radiophysique Appliquée [IRA-METAS], Lausanne.

Institut für Isotopenforschung und Kernphysik “Radiuminstitut” [IIK], Radiuminstitut, Vienna.

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

National Office of Measures/Országos Mérésügyi Hivatal [OMH], Budapest.

National Physical Laboratory [NPL], Teddington.

National Research Council of Canada [NRC], Ottawa.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

Radioisotope Centre Polatom [RC], Swierk.

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

Observers

International Commission on Radiation Units and Measurements [ICRU].

International Organization for Medical Physics [IOMP].

International Radioprotection Association [IRPA].

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

Nederlands Meetinstituut, Van Swinden Laboratorium [NMi VSL], Delft.

Section III: neutron measurements

Chairman

H. Klein, Physikalisch-Technische Bundesanstalt, Braunschweig.

Members

Bureau National de Métrologie, Laboratoire National Henri Becquerel [BNM-LNHB], Gif-sur-Yvette.

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

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

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

Interfaculty Reactor Institute, Department of Radiation Technology [IRI], Delft.

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/Laboratório Nacional de Metrologia das Radiações Ionizantes, Instituto de Radioproteçao e Dosimetria [LNMRI-IRD], Rio de Janeiro.

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

National Physical Laboratory [NPL], Teddington.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

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

Observers

Chinese Institute of Atomic Energy [CIAE], Beijing.

International Atomic Energy Agency [IAEA].

International Commission on Radiation Units and Measurements [ICRU].

CONSULTATIVE COMMITTEE FOR IONIZING RADIATION

Report of the 18th Meeting
(30 May 2003)

to the International Committee
for Weights and Measures

1 OPENING OF THE MEETING

The eighteenth meeting of the Consultative Committee for Ionizing Radiation (CCRI)* was held at the Pavillon de Breteuil, in Sèvres, on 30 May 2003.

The following members were present: H. Klein (Chairman of CCRI Section III), G. Moscati (President of the CCRI), T.J. Quinn (Director of the BIPM), P. Sharpe (Chairman of CCRI Section I) and B.R.S. Simpson (Chairman of CCRI Section II).

Also present: P.J. Allisy-Roberts (Executive Secretary of the CCRI, BIPM).

The President opened the meeting by explaining that it was usual to have the CCRI after the three Section meetings to identify common issues and to co-ordinate the work of the Sections. In welcoming the members, he expressed his thanks for their attendance at the individual Section meetings noting that each Section has a different way of working. He was particularly pleased that the meetings were co-operative and constructive and felt that this was because the members had been meeting for many years.

Dr Quinn apologized for his absence from the Section meetings owing to prior commitments.

2 REPORT OF SEVENTEENTH MEETING OF THE CCRI, 2001**

The President stated that there were no specific items in the report that had not already been discussed during the recent meetings of the Sections. He congratulated the BIPM, especially for its support of the CIPM Mutual Recognition Arrangement (MRA) activities noting the huge efforts that had been made regarding the *modus operandi* of the Consultative Committees to co-ordinate world metrology. He commented that it was a pleasure to work in metrology and particularly appreciated the feedback from the BIPM Director on the content of meetings in the regional metrology organizations (RMOs).

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* For the list of acronyms, click here.

** Documents for the meeting which are open access (underligned) are available on the BIPM website.

3 CONCLUSIONS OF THE MEETINGS OF THE THREE SECTIONS OF THE CCRI

The President invited each Section chairman to present a review of their meeting.

3.1 **Section I: x- and γ-rays, electrons** (Chairman: P. Sharpe)

Dr Sharpe was pleased to report that a number of decisions and recommendations had been made by the Section I of the CCRI (CCRI(I)). He then presented a number of specific issues.

3.1.1 Physical constants

The Chairman reported that the CCRI(I) had discussed stopping powers for graphite, noting that the data had last been reviewed in the 1980s and that more recent data showed differences of up to 1.5 %. However, as there are strong correlations with other factors, the primary standards concerned would not be expected to change by this amount. At its previous meeting, the CCRI(I) had invited the ICRU to review the situation and the ICRU has agreed in principle to set up a Report Committee with terms of reference that were discussed in the meeting. The CCRI(I) urged the ICRU to proceed as fast as possible in the hope of having a draft report within two years.

3.1.2 Wall corrections

Many papers on the calculation of wall correction factors for air kerma cavity standards had been presented. The CCRI(I) agreed a recommendation to acknowledge that electron-photon Monte Carlo calculations are now a robust method of determining k_{wall} correction factors for air kerma cavity-chamber standards in photon fields. The agreed wording is given in the CCRI(I) report. The Chairman felt that this would now enable the CIPM MRA Appendix B equivalence tables to be completed for the air kerma comparisons in ^{60}Co.

3.1.3 The BIPM key comparison database, KCDB

The low-energy and medium-energy x-rays comparisons are close to final publication in the KCDB and it was hoped to have these published before the General Conference. CCRI(I) had supported a change in the BIPM standards and the national metrology institutes (NMIs) would be notified of the magnitude and timing for this change.

The draft B summary reports for absorbed dose and for air kerma in ^{60}Co radiation were also close to completion. It had been agreed that NMIs would send details of any changes in their standards to the BIPM by the end of July 2003.

The declaration of dosimetry calibration and measurement capabilities (CMCs) are behind schedule but this appears to be due to misunderstandings over the administrative procedure rather than any

scientific problem. It was expected that the various issues would be resolved by the meeting of RMO co-ordinators scheduled for September 2003. Dr Quinn had encouraged the submission of CMCs during the EUROMET General Assembly and had recommended that any CMCs that were ready should be submitted rather than waiting for everything to be confirmed.

The CCRI(I) had a long discussion regarding RMO comparisons. Some of these were thought to be incorrectly designated as RMO comparisons because they were worldwide and may therefore be more appropriate as CCRI key comparisons. Comparisons using a transportable primary standard for medium-energy x-rays had produced considerable interest but there were major concerns about a timetable as not more than two laboratories could participate in any given year. As there are 18 such standards worldwide, it would not be feasible for this comparison to replace the existing BIPM comparisons. Section I had asked for more information as no detailed protocol had been submitted.

A number of other comparisons were discussed but the decision was made to keep these as EUROMET supplementary comparisons with cross RMO participation.

3.1.4 Synchrotron radiation

An invited seminar presented by the PTB on synchrotron radiation had been well received and prompted a lively discussion with reports of similar work at other laboratories. It was agreed to have synchrotron radiation standards as an agenda item for the next meeting.

It was also agreed that seminars at future meetings would be useful.

3.1.5 *Metrologia* special issue

This idea had been received with enthusiasm and the CCRI(I) participants had suggested many topics to be covered. Other members of the CCRI felt that finding authors and referees would be more of a problem than identifying the topics.

3.2 **Section II: measurement of radionuclides** (Chairman: B.R.S. Simpson)

Dr Simpson reported that the main thrust of the CCRI Section II (CCRI(II)) meeting had been to consider the feedback from their three working groups, mandated to co-ordinate the implementation of the MRA, each of which had met at least once, with the co-ordinators presenting the outcomes.

3.2.1 The BIPM key comparison database

The CCRI(II) had made various decisions during the meeting, such as not to include outliers in the key comparison reference value (KCRV) evaluation and to use the unweighted mean for the KCRV in each comparison. The treatment of correlations in comparisons was explained and a colour coding system was described to indicate which Appendix B results were more than twenty years old and would eventually be removed from the KCDB.

In view of the twenty year limit for results in the KCDB, the CCRI(II) had also decided that as there were too many radionuclides for each one to be measured in a key comparison within the time frame, a method of grouping radionuclides by their measurement method and difficulty of their measurement within a method should be identified. When a NMI measured a difficult radionuclide within a measurement group, this should ensure their capability for measuring a less difficult radionuclide using the same method. It was noted that this would facilitate the acceptance of CMCs for Appendix C but would not provide degrees of equivalence between NMIs for Appendix B.

The discussions on uncertainties, particularly in CMC claims, had resulted in the agreement over an EXCEL table of uncertainty contributions following the *Guide to the Expression of Uncertainty in Measurement* (GUM). The Uncertainties Working Group had produced some estimates of the minimum uncertainties that would be acceptable for inclusion in the comparisons and thus CMC claims.

A work plan for the extension of the SIR for key comparison of pure beta-emitters was approved with at least 20 radionuclides being measured using two different methods, the CIEMAT/NIST and TDCR, before a final decision on the way forward is reached.

The CIPM MRA had provoked an unprecedented number of BIPM co-ordinated CCRI(II)-K2 comparisons. Those for ^{238}Pu, ^{152}Eu and ^{204}Tl had been completed and as some concerns had been raised over the ^{32}P comparison results, a limited repeat comparison had been agreed. The comparisons of ^{89}Sr, ^{192}Ir and ^{65}Zn were nearing completion and it had been decided that when laboratories were unable to meet the reporting deadline this could be extended if they informed the BIPM.

The BIPM.RI(II)-K1 comparisons are now appearing in the KCDB with 29 already published and a further 18 in draft A or draft B format. The CCRI(II) approves each final report by electronic mail before publication.

A number of future CCRI(II)-K2 comparisons had been agreed, together with the time frames. The comparisons of ^{54}Mn and ^{241}Am are to be completed this year as well as an IAEA initiated comparison of ^{90}Y. For the following year, 2004, there will be a repeat of the ^{32}P comparison with a limited number of participants and also a comparison of ^{125}I.

Reports had been presented giving the status of various regional comparisons, particularly with regard to the current situation regarding the CMC submissions. At present, only the CSIR-NML of SADCMET has radioactivity submissions in Appendix C of the KCDB. A demonstration was given on how to use the BIPM website to obtain information regarding the CMCs.

3.2.2 *Metrologia* special issue

A working group had been assembled to co-ordinate topics for a special issue of *Metrologia* in the field of radioactivity. This review-type of publication is planned for 2006. The working group is comprised of Dr B.R.S. Simpson, the Chairman of CCRI(II), Dr Hino (NMIJ/AIST), Dr Judge (NPL) and Dr Los Arcos (CIEMAT).

3.3 Section III: neutron measurements (Chairman: H. Klein)

Dr Klein reported that the main content of the meeting had been discussions over the scientific aspects of the various key comparisons.

3.3.1 Key comparisons

The four CCRI(III) key comparisons and one EUROMET supplementary comparison are on schedule. The progress and status of each comparison was discussed in detail.

Comparison CCRI(III)-K10 covers the recommended ISO energy range for specific mono-energetic neutron fluences and it was thought possible that after discussion some interpolation of the data may assist in the evaluation of CMCs. The measurements were made in March 2001 and the last of the laboratory reports was provided in April 2002. Two laboratories were asked to review their results and these reviews were received by November 2002. All the results were then sent to the participants and the draft B report was produced by the PTB in April 2003. The CCRI(III) discussed this in detail, agreed the analysis of the results and made some suggestions for changes after discussion of the degrees of equivalence. The EXCEL matrix will now be completed and all but one result will be included in the KCRV evaluation. The report should be complete by the autumn. Some supplementary work by the NPL on their long-counter effective centre and efficiency may be included in the publication or published separately. An explanation for one of the outlier results was deemed to be satisfactory and will also be included in the final report.

The report for comparison CCRI(III)-K1 at 24.5 keV is incomplete and does not include uncertainty budgets. This is partly because this comparison was run before the MRA was signed and so before the guidelines for key comparisons were published. Questions have been raised about some of the uncertainties quoted by the participants and Dr Klein will be following this up with Dr Lewis who wrote the original report to ensure that it complies with the current requirements of the MRA and includes the degrees of equivalence.

The key comparison CCRI(III)-K8.B-10 has now been changed into CCRI(III)-K8 as the B-10 loading of the ionization chambers did not prove to be stable enough for them to be used as transfer chambers under different environmental conditions. This comparison will now be held at the NIST with all participants taking their own equipment to measure the fluence rate in the same thermal neutron fields. A new protocol will be produced for a comparison in the spring of 2005.

Key comparison CCRI(III)-K9.AmBe for emission rates has suffered significant delays including one of one year's duration. Three laboratories are still to participate but it is hoped to finish this comparison by the end of 2003. The BNM/IRSN, the NIST and the NPL will send their reports to Dr Klein who will send all the reports at the end of the comparison to the NIST for evaluation.

It was noted that in CMC services where only one laboratory is capable of making a particular measurement, there could be no comparison or degrees of equivalence; this was the case for example for 20 MeV neutrons.

It had been agreed that the CCRI(III) should not conduct comparisons for radiation protection quantities but they encouraged the EUROMET to do so. Consequently, an EUROMET

supplementary comparison EUROMET.RI(III)-S1 was agreed for ambient dose equivalent meters and this should start in the summer of 2003, running for two years.

No other comparisons were suggested for the forthcoming period nor were any reported from the other RMOs.

3.3.2 Laboratory reports

As usual, the participants of the CCRI(III) had reported on recent progress in their laboratories and these are detailed in the CCRI(III) report. Most laboratories also produced a written report and when available these are on open access in the CCRI(III) web pages. A decision was made to publish the PowerPoint presentations in the restricted access web pages.

3.3.3 Special issue of *Metrologia*

Prof. P. Martin, editor of *Metrologia*, had introduced the idea of a special issue concentrating on neutron metrology and this was welcomed by the CCRI(III). Dr Klein will propose a working group for this project with the remit to identify topics, prospective authors and referees. The issue could include a review of future trends in the field of neutron metrology.

3.3.4 Future needs

Dr Klein reported on the wide range of needs for high-quality neutron metrology. This stretched from in-core reactor spectrometry and the determination of precise cross sections for nuclear reactor development (high temperature and breeder reactors) to neutron diagnostics and benchmark experiments in fusion technologies. Radiation protection dosimetry and spectrometry in the workplace were also demanding areas with an extended energy range, up to GeV neutrons. Although Monte Carlo and other mathematical techniques are being used for predictions, these must be verified by appropriate experiments. The stringent propagation of uncertainties is still an unresolved problem and is the real current challenge for neutron metrologists.

4 DISCUSSION OF POINTS OF COMMON INTEREST

The CCRI noted that the CCRI(II) seminar on liquid scintillation counting in 2001 and the CCRI(I) recent seminar on synchrotron radiation, each with invited speakers, had both worked well and proposed that the idea could be repeated in 2005.

The concept of the special issues of *Metrologia* was well received by all three Sections. It was noted that the Section chairmen are the focus for the organization and they would need to designate

themselves or others as “Guest” editors. State of the art scientific papers were needed and the editor of *Metrologia* would write to each Guest editor explaining what was required. Once the authors and referees had been chosen, the editor of *Metrologia* would organize the issue itself.

The President felt that each of the meetings had run well producing decisions, recommendations and real conclusions. He was particularly happy with the closing statement regarding Monte Carlo calculations.

4.1 CIPM MRA and matters of related interest

The CCRI felt that the main issues were the key comparisons for Appendix B and the CMCs for Appendix C. As these had been reported by the Section chairmen in their report and details are available in the following Section reports, no further discussion was held.

4.2 Future programme of the BIPM

The chairmen had mentioned the involvement of the BIPM in their reports and the details are given in the following Section reports. Each chairman reported satisfaction with the work and programme of the BIPM.

4.3 Membership of Sections

The recommendations for change made in each Section report were endorsed and would be taken forward by the President to the CIPM. Specifically, these recommendations were that in CCRI(I), the METAS would become a member and the CMI would become an observer. In the CCRI(II), the CMI would become a member and the NRC an observer and in the CCRI(III) the CMI would become a member and the KRISS an observer.

It was noted that there were also actions on the individual NMIs to apply for membership where appropriate and for current NMI members to ensure that they continued to fulfil the criteria for membership.

4.4 Recommendations to the CIPM and the General Conference

The President reported that the recommendation of the last CCRI on the difficulties of transporting samples for comparisons had resulted in a Resolution to the General Conference. He expressed the hope of a satisfactory outcome for this recommendation as the CCRI was not the only Consultative Committee to have experienced problems.

The CCRI then considered the recommendations for changes to the revised edition of the SI brochure. The proposal to change the definition of the dose equivalent was endorsed and a further recommendation was added:

> "The CCRI, considering the discussions and recommendations of the CCRI(I) and the CCRI(III) on the dosimetric quantities and units specified in the SI brochure (1998), recommends to the CIPM that the derived quantity 'organ equivalent dose' be removed from the list of derived quantities for the sievert in Table 3 (SI derived units with special names and symbols)."

The President also agreed to take forward the recommendations for membership changes to the CIPM. He also stressed the need for input for his presentation to the CGPM and the members agreed to respond with ideas.

4.5 Future programme of the CCRI

Apart from the agreement over having seminars during the CCRI meetings and to pursue the idea of the *Metrologia* special issue, the President felt that there were no other new issues that the CCRI needed to consider for the immediate future. He stressed however, the need to be aware of current developments and to make sure that metrological needs were appropriately addressed.

5 DATE OF NEXT MEETINGS

The CIPM would be asked to reserve two consecutive weeks in May 2005 for the CCRI and its Sections, preferably from 16 May to 27 May.

6 CONCLUDING REMARKS

The President expressed his satisfaction with the operation of the CCRI. He thanked all three chairmen for their effective leadership of the CCRI Sections and the BIPM for hosting the meetings.

Revised March 2004

CONSULTATIVE COMMITTEE FOR IONIZING RADIATION

Section I: X- and γ-rays, electrons
Report of the 16th Meeting
(21-23 May 2003)

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

Section I (X- and γ-rays, electrons) of the Consultative Committee for Ionizing Radiation (CCRI) held its sixteenth meeting at the Pavillon de Breteuil, Sèvres, on 21, 22 and 23 May 2003.

The following were present: A.H.L. Aalbers (NMi VSL), A. Brosed (CIEMAT), I. Csete (OMH), F. Delaunay (BNM-LNHB), S. Duane (NPL), H.-M. Kramer (PTB), R.F. Laitano (ENEA-INMRI), G. Moscati (President of the CCRI), T.J. Quinn (Director of the BIPM), D. Rogers (NRC), S.M. Seltzer (NIST and ICRU), P. Sharpe (NPL, Chairman of CCRI Section I), N. Takata (NMIJ/AIST), G. Ulm (PTB), D. Webb (ARPANSA), J. Witzani (BEV).

Observers: J. Mostert (CSIR-NML), J.G.P. Peixoto (LNMRI/IRD), K.R. Shortt (IAEA).

Guests: M. Deniz (UME), A. Kosunen (STUK), V. Sochor (CMI), G. Stucki (METAS).

Also present for all or part of the meeting: P. Giacomo (Director Emeritus of the BIPM); P. Allisy-Roberts (Executive Secretary of the CCRI), D.T. Burns, C. Kessler, P.W. Martin (editor of *Metrologia*), C. Michotte, S. Picard, G. Ratel, C. Thomas (KCDB coordinator) (BIPM).

Apologies were received from: S.A. Fedina (VNIIM), J.-E. Grindborg (SRPI), C. Grover (NRC), G. Webb (IRPA) and Tian Zhongqing (NIM).

The meeting was called to order by the Chairman, Dr P. Sharpe. Dr T.J. Quinn welcomed the delegates to the BIPM and the 16th meeting of the CCRI(I) following which he outlined a number of issues that were to be addressed in the 22nd meeting of the General Conference in October 2003. These include a budget proposal with a much needed increase in support for the efforts at the BIPM and a proposal to implement special procedures to facilitate the cross-border movement of substances and instruments for comparison measurements, made more difficult with current heightened security. Dr Quinn also called attention to a Memorandum of Understanding with the World Health Organization, agreed to in October 2002, to help in new initiatives for standards in biology and laboratory medicine, and to the upcoming review of regional metrology organizations calibration and measurement capabilities in September 2003. Dr Sharpe thanked Dr Quinn for his remarks, noting that several important issues were raised, some of which would be discussed during the meeting.

Mr Seltzer was appointed as the *rapporteur*.

The work of Dr Rogers on the collection and analysis of $N_{D,w}/N_K$ ratios from the national metrology institutes (NMIs) was added to the agenda. Apart from the current issues related to standards, it was agreed that presentations of laboratory work concerning national standards and other developments would be taken together. No other significant changes to the agenda were suggested.

The participants were thanked for adhering to the 7 May 2003 deadline in submitting their documents, as this greatly facilitated their electronic distribution to the participants and their web-

accessibility with password-restricted access for delegates. All of the documents submitted to the 16th meeting were formally adopted.

2 REPORT OF THE FIFTEENTH MEETING OF THE CCRI(I), 2001

The Chairman called attention to the published report of the 15th meeting previously mailed to all participants. Prof. Moscati reminded the participants that the three Sections of the CCRI meet contiguously, followed by a short meeting of the CCRI, comprised of the President, the Section chairmen and the Director of the BIPM, to agree on common conclusions. The President and the chairmen are thus invited to all Section meetings to improve communication.

3 CURRENT ISSUES IN DOSIMETRY

3.1 Physical constants

Mr Seltzer outlined the terms of reference prepared for a report committee that had been approved by the ICRU, as requested by the Section, to address the issues concerning W/e (for air) and stopping-power ratios. The latter are particularly important for graphite for which there is an issue regarding the appropriate mean excitation energy and density-effect correction. Discussion ensued on particular aspects of this effort. Dr Laitano suggested that possible shell corrections to the electron stopping power be considered, at least in so far as it might affect the uncertainty. Dr Burns emphasized consideration of the product of W/e and the graphite/air stopping-power ratio. Dr Shortt, after some discussion by Dr Rogers and Mr Seltzer, suggested that the ICRU consider also the role and selection of the cut-off energy used in Spencer-Attix cavity theory; and it was recalled that the Section had previously agreed that a larger uncertainty in the stopping-power ratio be assigned in anticipation of a possible change in this factor. Dr Sharpe summarized the importance of these issues, advocating that the ICRU expedite its efforts to address them. Mr Seltzer distributed copies of the terms of reference given to the report committee with the understanding that participants would send any further suggestions directly to him.

3.2 Corrections to air-kerma standards

Dr Duane, referring to CCRI(I)/03-06 and CCRI(I)/03-45, explained that in the interest of minimizing the number of changes to their standards, the NPL has decided to implement in 2004 new corrections, mainly wall corrections, when a new primary-standard for ^{60}Co γ-rays will be introduced. Their approach and progress in Monte Carlo calculations are outlined in CCRI(I)/03-45, along with preliminary results indicating that a 1 % increase in the NPL ^{60}Co air-kerma standard can be expected.

Dr Takata discussed the NMIJ/AIST results, as outlined in CCRI(I)/03-17 and CCRI(I)/03-18, both of measurements and Monte Carlo calculations of the angular response of cylindrical chambers in ^{60}Co and ^{137}Cs γ-ray beams, which supported the validity of the calculated wall corrections. Dr Kramer supported the conclusion that care must be taken in modelling accurately the geometry of the chamber.

Dr Delaunay highlighted the Monte Carlo calculations of the wall correction done for the BNM-LNHB cylindro-spherical graphite cavity chamber in a ^{60}Co beam using EGS4, EGSnrc and various versions of PENELOPE, as indicated in CCRI(I)/03-30. Their test calculations with EGS4 and PENELOPE for two NIST spherical chambers were essentially in agreement with the 1992 results of Bielajew and Rogers. Dr Rogers questioned the validity of the EGS results, as the mixed spherical/ cylindrical geometry of the BNM-LNHB chamber is not handled in EGS.

Dr Laitano referred to CCRI(I)/03-25, CCRI(I)/03-26 and CCRI(I)/03-27 in his description of the re-determination of the air-cavity volume of the ENEA-INMRI ^{60}Co standard cylindrical chambers using geometrical specifications and mechanical tools. New cylindrical chambers were constructed with varying volumes, and it was found that the small volume near the base of the central electrode surrounded by an insulator needed to be included for consistent measurement results. When used with wall corrections calculated with the EGSnrc code, consistent results were obtained among the chambers with different volumes, in contrast to the older linear-extrapolation method. Dr Burns supported the inclusion of the near-insulator volume as consistent with BIPM measurements made at different polarities.

Dr Aalbers indicated in reference to CCRI(I)/03-31 that the NMi has begun a re-evaluation of the wall and other corrections for their ^{60}Co air-kerma standard chambers using the PENELOPE Monte Carlo code.

Mr Seltzer, referring to CCRI(I)/03-21, indicated that the results of their Monte Carlo calculations with the ITS/ACCEPT and MCNP4C Monte Carlo codes of the wall corrections and other factors for the six spherical graphite-walled air-cavity ionization chambers will be implemented in new NIST air-kerma standards for ^{60}Co and ^{137}Cs γ-ray beams, resulting in an increase of about 1 %. For ^{192}Ir γ-rays, no significant change results owing to cancellation of small changes in a number of factors. These results for the wall corrections are in agreement with those from EGS4 and EGSnrc calculations for the NIST chambers published by Rogers and colleagues, supporting the accumulated findings that the choice of Monte Carlo code among the well-known available codes has little effect on the resulting numerical value of the wall correction.

Dr Witzani discussed CCRI(I)/03-11, which outlines Monte Carlo calculations for the cylindrical graphite cavity chambers that serve as the BEV air-kerma standards for ^{60}Co and ^{137}Cs γ-rays. Their wall corrections, obtained with PENELOPE (v.2001) are in agreement with those from other authors using EGS4 and EGSnrc.

Dr Csete pointed out that the OMH pioneered calculations of the wall correction and other factors, and that the OMH air-kerma standards changed by +0.84 % for ^{60}Co and by +1.15 % for ^{137}Cs as presented at the previous meeting of the CCRI(I) in open document CCRI(I)/01-03.

Dr Kramer indicated, with reference to CCRI(I)/03-15, that the PTB presented their new results for the wall correction and axial beam non-uniformity correction at the last meeting of the CCRI(I), and that their new air-kerma standards were implemented on 1 January 2002, with increases of 0.95 % for ^{60}Co and 0.85 % for ^{137}Cs.

Dr Rogers discussed the results of NRC calculations of the corrections and other factors for their graphite cavity chamber using the EGSnrc code, as indicated in CCRI(I)/03-47. He referred to a new publication in *Medical Physics* that describes their Monte Carlo calculations for the correction for the polystyrene insulator, summarizing results of their extensive Monte Carlo investigations that indicate the wall correction and the graphite/air stopping-power ratio are remarkably insensitive to the Monte Carlo model. That the wall correction and the graphite/air stopping-power ratio are rather insensitive to the assumed spectrum as long as it is reasonably realistic, and that the change in the wall correction is small when going from a parallel beam to a point source at 100 cm. However, the uncertainty associated with radiation-interaction data can be significant, particularly with the value for the graphite mean excitation energy that has become a matter of concern.

Dr Burns referred the meeting to CCRI(I)/03-40, which describes the calculation of the wall correction for the parallel-plate chamber that serves as the BIPM air-kerma standard for ^{60}Co, as well as for a cylindrical chamber. The calculations, using PENELOPE (v.2001), included simulation of the spectrum produced by the BIPM ^{60}Co source, with a calculated scatter contribution of 21 % of the total energy fluence. The calculated wall corrections are nearly identical to those reported by others from EGS calculations. Document CCRI(I)/03-41 outlines similar work for the BIPM ^{137}Cs air-kerma standards, using PENELOPE to simulate the source spectrum (scatter contribution of 16 % of the total energy fluence) and the calculation of the wall correction for their standard chamber.

Dr Laitano formally proposed that the conclusion regarding the insensitivity of the wall correction to the Monte Carlo code used and to the spectrum assumed (if realistic) be stated in the record of the CCRI(I). The CCRI(I) prepared the following recommendation that was approved by the members:

The CCRI(I),

considering that present-day Monte Carlo calculations of k_{wall} using, for example, MCNP, EGS4, EGSnrc, PENELOPE or ITS, demonstrate no significant dependence on the particular code used and no significant dependence on the photon spectrum, providing that the spectrum is realistic,

acknowledges that electron-photon Monte Carlo calculations are a robust method of determining k_{wall} correction factors for air-kerma cavity-chamber standards in ^{60}Co, ^{137}Cs and ^{192}Ir photon fields

provided that the chamber is modelled accurately and the source is modelled with reasonable accuracy, and that the codes are used competently.

Turning to issues regarding free-air-chamber corrections, Dr Burns detailed results from PENELOPE calculations for the free-air chambers used as the BIPM air-kerma standards for low- and medium-energy x-ray beams, in comparison with earlier calculations made with EGS4 and EGSnrc. Based on an average of the Monte Carlo results for electron loss, photon scatter and fluorescence x-ray re-absorption for the nine BIPM beam qualities, Dr Burns reported (CCRI(I)/03-28) changes in the BIPM standards of between 0.01 % and 0.3 %. The question of implementation of the new BIPM standards was discussed. Dr Burns pointed out that the new standards were already included in his current analyses of the degrees of equivalence among national primary standards for low-energy (CCRI(I)/03-10) and medium-energy (CCRI(I)/03-36) x-ray beams. Mr Seltzer remarked that NIST has adopted earlier calculations by Dr Burns for their free-air chambers, with a change in x-ray air-kerma standards (CCRI(I)/03-19) effective from 1 January 2003. In response to a question by Dr Rogers as to how these modifications are to be implemented, Drs Allisy-Roberts and Sharpe pointed out that such changes must be published for them to be used in key comparisons, and that a CCRI(I) open document would satisfy that requirement. Remarks by Prof. Moscati and Dr Allisy-Roberts returned to the question of implementation for the BIPM standards. It was agreed that the new corrections be implemented in the BIPM standards for x-ray air kerma with effect from 1 October 2003, to allow time for the users of BIPM calibrations to be informed.

3.3 Uncertainties

Vigorous discussion on the reporting of uncertainties was stimulated by considering issues raised in CCRI(I)/03-09. Dr Shortt noted the recommendation presented by the IAEA Dosimetry Symposium, Vienna, November 2002, that uncertainties assigned to absorbed-dose-to-water primary standards should be examined in detail, preferably in a working group of the CCRI, in order to rationalize any apparent discrepancies (CCRI(I)/03-09). Dr Shortt pointed out that the correction for the heat defect in water calorimeters and its uncertainty varies among the NMIs. For example, the PTB assigns unity to the correction with no uncertainty, whereas the NRC assigns an uncertainty of 0.3 % to the correction for the heat defect. Dr Kramer responded that their assignments are based on careful and detailed calculations for the PTB system, and some confounding process, such as O_2 leaking into the system, must be invoked to establish some uncertainty. Dr Rogers suggested that similar considerations pertain to graphite calorimetry. Further discussion included the possible establishment of a working group on uncertainties, but this was rejected. Another suggestion was for the existing working group on uncertainties in stopping-power ratios to take on this broader task.

Acting on the suggestion by Dr Aalbers, Dr Sharpe proposed that the key comparison working group keep an eye on uncertainties, and this action was approved by the CCRI(I). In view of the involvement of the ICRU, Dr Sharpe further proposed that the Working Group on Uncertainties in Stopping-Power Ratios be disbanded, an action that was also approved.

3.4 Definitions of quantities and terminology

In response to a request for updates to a new SI Brochure planned by the CCU, Dr Allisy-Roberts (BIPM) and Mr Seltzer (ICRU) had independently recommended (CCRI(I)/03-12 and -34) that in the definition of dose equivalent *H*, the factor *N* be dropped and the defining equation given as $H = Q \cdot D$, where *Q* is the quality factor and *D* is the absorbed dose. Mr Seltzer's recommendations had included also the additional listing in Table 3 of the SI Brochure of the derived quantities *cema* with the unit gray and *effective dose* with the unit sievert. As the effective dose is not a measurable quantity, the CCU, at its meeting in April 2003, referred the question back to the ICRU and CCRI for further consideration. The CCRI(I) approved a recommendation to the CIPM that *effective dose* and *cema* not be included in the SI Brochure and that *organ equivalent dose* be removed from the list of quantities, as it also is not measurable. This recommendation is to be considered also by the CCRI(III) before presentation to the CIPM (see the CCRI report for the wording of the final recommendation).

4 COMPARISONS OF DOSIMETRY STANDARDS (X- AND γ-RAYS, ELECTRONS)

After a brief review of the current listing of key and supplementary comparisons, the following actions were approved by the CCRI(I):

(a) BIPM.RI(I)-S10, air kerma ^{137}Cs beams, will become a key comparison identified as BIPM.RI(I)-K5;

(b) CCRI(I)-S3, absorbed dose to water in high-energy photon beams, will become a key comparison identified as CCRI(I)-K6;

(c) BIPM.RI(I)-S11, absorbed dose to graphite in ^{60}Co beams will remain a supplementary comparison;

(d) CCRI(I)-S1, absorbed dose to water in ^{60}Co beams at high doses, will remain a supplementary comparison;

(e) EUROMET.RI(I)-S1, personal dose equivalent, will remain a supplementary comparison.

4.1 BIPM and CCRI key comparisons

Dr Allisy-Roberts presented a summary of the current status of dosimetry comparisons and calibrations (CCRI(I)/03-37). In conclusion, the BIPM appears to be on track with the required support to the NMIs in bringing their comparisons up-to-date and keeping up with the recommendations on comparison frequency under the CIPM Mutual Recognition Arrangement.

After considerable discussion on the proposal that a EUROMET direct comparison of primary air-kerma standards for medium-energy x-ray beams should become a CCRI key comparison (CCRI(I)/03-01), it was agreed that owing to the many issues involved the CCRI(I) will look for a more detailed protocol to be submitted for the next meeting.

Dr Webb presented document CCRI(I)/03-42 on the role of bilateral comparisons that form three-way arrangements with the BIPM, providing a check on consistencies in key comparisons, and suggested that they be encouraged. Dr Allisy-Roberts noted that the BIPM key comparisons provide the results that determine the official degrees of equivalence. Dr Rogers and Mr Seltzer remarked that some NMIs might benefit from efforts to close any gaps revealed in bilateral comparisons.

4.2 Appendix B (MRA)

Referring to CCRI(I)/03-10 and 36, Dr Burns reviewed the status of the degrees of equivalence among national primary standards for air kerma from low- and medium-energy x-ray beams, key comparisons BIPM.RI(I)-K2 and BIPM.RI(I)-K3. These analyses bring up-to-date the data that were considered at CCRI(I) in 2001, and sets them in accordance with recommendations made at that meeting. This involved dropping three comparisons for which no reports exist, implementing correction factors for the BIPM free-air chambers derived from Monte Carlo calculations, and adding six new comparisons that have now been published. Dr Burns addressed a number of comparisons that have just been completed, indicating deadlines for the NMIs involved to verify the data by 27 June 2003 and publish any change in standards (in the open literature, *Metrologia*, or as an appendix to the report being prepared) by 1 August 2003, so that the draft could be sent electronically to the CCRI(I) for approval by 15 September 2003. If all goes according to schedule, the results will be entered into the KCDB by 30 September 2003.

Dr Allisy-Roberts reviewed the status of BIPM comparisons of national primary standards for absorbed dose-to-water for ^{60}Co γ-rays, key comparisons BIPM.RI(I)-K4 and CCRI(I)-K4, noting that a few NMIs need to approve draft publications required for entry into Appendix B. In her review of the status of BIPM comparisons of national primary standards for air kerma for ^{60}Co γ-rays, she noted that there will be some inconsistencies due to varying dates of NMI implementations of k_{wall} from Monte Carlo calculations. It was decided that the NMIs will verify the data in light of the status of their primary-standard changes, with a deadline of 31 July 2003, for entry into the KCDB by the end of September. It was suggested that footnotes in Appendix B could serve to explain the differences associated with k_{wall}.

4.3 Regional key and supplementary comparisons

Dr Quinn's explanation of the status and formality of supplementary comparisons, outlined in CCRI(I)/03-05, were largely covered in his introductory remarks so were not elaborated under this agenda item.

Dr Kramer discussed the EUROMET Project 545 outlined in CCRI(I)/03-02 and proposed that it be a CCRI supplementary comparison, noting as a key feature that it involves the ISO narrow-spectrum

x-ray beams and thus probes higher mean energies than other comparisons. It was acknowledged that these beam qualities were important to radiation protection. Drs Allisy-Roberts and Sharpe pointed out that becoming a CCRI comparison was not necessary and may actually hamper the exercise. They stressed that the CCRI endorsed this EUROMET supplementary comparison with the identifier EUROMET.RI(I)-S3, and encouraged the participation of laboratories from outside the EUROMET area.

Referring to CCRI(I)/03-03, Dr Kramer discussed the EUROMET project on the comparison of $H_p(10)$ using ISO narrow-spectrum x-ray beams, probing the strong dependence on energy and angle for low-energy photons. This project will remain a EUROMET supplementary comparison (EUROMET.RI(I)-S5), with a wide participation encouraged. Moving to CCRI(I)/03-04, Dr Kramer briefly outlined the EUROMET project on the comparison of $H'(0.07)$ and $H_p(0.07)$ for beta reference fields, inviting a wider participation.

Dr Witzani presented EUROMET Project 526 (CCRI(I)/03-07), a comprehensive comparison of air-kerma calibrations in mammography x-ray beams generated with Mo, Rh and W anodes at voltages from 20 kV to 50 kV. Dr Allisy-Roberts encouraged the submission of the official registration form to ensure inclusion in the KCDB with the identifier EUROMET.RI(I)-S4.

Dr Webb, referring to CCRI(I)/03-52 and 53, described an RMO key comparison, APMP.RI(I)-K1, organized by the KRISS for the comparison of national air-kerma standards for ^{60}Co γ-rays. Upon the recommendation of Dr Allisy-Roberts, the Section approved the comparison pending the submission of an updated protocol that would be reviewed via e-mail.

Dr Allisy-Roberts mentioned that two SIM key comparisons were in progress, SIM.RI(I)-K1 and SIM.RI(I)-K4, but that there had been no approval of the protocols. Dr Shortt indicated that the protocols had just been submitted. The Section agreed to provisional approval pending review. Dr Allisy-Roberts reminded the Section that key comparison protocols must be approved by the CCRI(I) before a key comparison is started. Similarly, bilateral comparison protocols must have approval beforehand if the results are to be noted in the KCDB.

4.4 Calibration of transfer standards

Dr Rogers briefly discussed findings on the pre-irradiation of ionization chambers used in x- and γ-ray calibrations, given in CCRI(I)/03-48. Dr Rogers, addressing CCRI(I)/03-50 and -54, reviewed a draft prepared of results compiled on values of $N_{D,w}/N_K$ measured at the various NMIs. It was remarked that the results are useful to demonstrate consistency and even to provide data in the absence of measurement, and that publication in *Metrologia* and/or *Physics in Medicine and Biology* would be valuable. Dr Sharpe indicated that, although not a CCRI(I) decision, he would encourage the authors to publish, perhaps in *Physics in Medicine and Biology*.

5 CURRENT AND FUTURE PROGRAMME AT THE BIPM

Dr Quinn presented a brief history of the BIPM under the Metre Convention, indicating that it was decided in 1875 that the BIPM should be a scientific institution rather than merely a repository for the metre and the kilogram. That tradition has continued, with changes in level of effort and new directions dictated by the balance of needs and resources.

Dr Allisy-Roberts reviewed the work of the Ionizing Radiation section in dosimetry. Their staff numbers three scientists, one research fellow and one technician who work to realize primary standards and methods, to reduce uncertainties, and to disseminate the SI quantities through comparisons and calibrations. Some notable progress made since 2001 includes the reinstatement of the medium-energy x-ray facility for comparisons, the acquisition of additional computing capacity, the re-establishment of the ^{60}Co ambient-dose-equivalent facility, and the simulation of mammography x-ray beams. New and future projects include the development of new cavity chamber standards, graphite calorimetry, the verification of low-energy x-ray spectra (including mammography beams), as well as the usual BIPM ongoing comparisons. Dr Sharpe expressed the CCRI(I)'s appreciation to Dr Quinn and the BIPM for their work in establishing the MRA and for improving the resources for the Ionizing Radiation section.

6 NATIONAL STANDARDS FOR PHOTON DOSIMETRY, FOR CHARGED PARTICLE DOSIMETRY, AND OTHER REPORTS FROM MEMBER LABORATORIES

6.1 Radiometry and dosimetry in the energy range from 1 keV to 60 keV

This agenda item included a very interesting seminar presented by Drs Kramer and Ulm from the PTB, and documented in CCRI(I)/03-33. This was the first occasion that a seminar had been held during the CCRI(I). Dr Ulm described the experimental facilities at BESSY II, an electron storage ring capable of producing tunable monochromatized synchrotron radiation with energies up to 60 keV. He pointed out that this source can serve as a standardized source extending from radiometric applications into the dosimetry of low- to medium-energy photons. Dr Kramer highlighted some preliminary studies, including the determination of μ_{en}/ρ, the calibration of a free-air chamber, and scanning of small detectors to determine uniformity of response. He also indicated some future applications of interest to the CCRI(I). The seminar prompted lively discussion indicating that this work might introduce some metrological overlap between the CCRI and the CCPR, and should be watched, perhaps as an ongoing agenda item.

6.2 National standards for absorbed dose-to-water, brachytherapy sources and radiation processing

Dr Duane referred to CCRI(I)/03-14, remarking in particular on their work to establish primary-standard traceability for NPL calibrations of HDR ^{192}Ir sources, their work on their portable graphite calorimeter, and investigations into the 0.6 % difference measured in the response of alanine dosimeters to ^{60}Co γ-rays and megavoltage x-rays.

Dr Webb, in reference to CCRI(I)/03-13, mentioned that the ARPANSA graphite calorimeter was non-functioning, and that they had borrowed the IAEA's calorimeter pending the repair of their own.

Dr Takata recalled that the work at the NMIJ/AIST was covered in previous discussions of CCRI(I)/03-17 and CCRI(I)/03-18.

Work at the NIM was highlighted in an e-mail from Mr Tian Zhongqing, mentioning the comparisons undertaken with the BIPM for ^{60}Co and medium-energy x-ray air-kerma.

Dr Delaunay referred to CCRI(I)/03-29, mentioning work at the BNM-LNHB on a new constant-temperature graphite calorimeter, efforts to set up new facilities for low- and medium-energy and mammography x-rays in conjunction with a recently tested free-air chamber, and the development of standards for HDR ^{192}Ir γ-rays based on calibrated ionization chambers and their comparisons with the University of Wisconsin. Dr Rogers remarked that the necessary interpolation to ^{192}Ir energies should be on the reciprocal of the calibration factors as done by the NPL. Drs Duane and Kramer indicated, respectively, that the NPL and the PTB were developing primary standards for ^{192}Ir based on calculated wall corrections.

Dr Laitano mentioned that, in addition to the work outlined in CCRI(I)/03-25, the ENEA-INMRI has had major laboratory renovations during the last two years, including new alignment systems for their low- and medium-energy x-ray ranges, and will be re-sourcing their ^{60}Co unit.

Dr Aalbers referred to CCRI(I)/03-31, CCRI(I)/03-32 and CCRI(I)/03-35, mentioning in particular a major effort at the NMi in brachytherapy dosimetry including the development of an extrapolation chamber similar to that of the NIST, as well as progress on the testing of their portable water calorimeter.

Mr Seltzer, referring to CCRI(I)/03-20, CCRI(I)/03-22, CCRI(I)/03-23 and CCRI(I)/03-24, briefly indicated new divergence corrections being developed through Monte Carlo calculations for the NIST extrapolation chamber, the ongoing work on prostate-seed air-kerma standards and calibrations to support 25 seed designs from 17 manufacturers, and the re-calibration of the NIST high-dose-rate ^{60}Co sources, including a new high dose-rate irradiation cell for radiation-processing level dosimetry.

Dr Witzani indicated that the pertinent work at the BEV had been covered in the discussions of previous agenda items.

Dr Csete took the opportunity to highlight two efforts at the OMH outlined in CCRI(I)/03-51, their new facility for radiation-protection dosimetry, including two ^{137}Cs sources and one ^{60}Co source, and their planned development of a graphite extrapolation chamber for the determination of absorbed dose-to-water from medium-energy x-rays.

Dr Kramer highlighted a few items contained in CCRI(I)/03-15, including the delayed acquisition of a new ^{60}Co source that will facilitate progress on the PTB water calorimeter, the initiation of alanine dosimetry that will be used down to therapy levels, the planned implementation of their multi-electrode extrapolation chamber as the PTB primary standard for clinical beta sources, and the development of a large-volume extrapolation free-air chamber (FAC) which is similar to that of the NIST) for ^{125}I and ^{103}Pd seed sources.

Dr Rogers noted, in reference to CCRI(I)/03-47, that the NRC has experienced a significant turnover in staff. He discussed some recent results on the issue of beam-quality specifiers, $TPR^{20/10}$ and $\%dd(10)_x$, indicating that $TPR^{20/10}$ is good for clinical beams, while $\%dd(10)_x$ is good for both clinical beams and the few lightly filtered calibrating beams at standards laboratories. Also mentioned were preliminary results for electron-beam dosimetry using water calorimetry, a study of TLD response to photons with energies down to 20 keV, the extension of alanine dosimetry down to 10 Gy at a precision of about 0.5 %, and the revival of the NRC beta standards based on an extrapolation chamber (see also CCRI(I)/03-49).

The summary of activities at the VNIIM (CCRI(I)/03-38) was noted.

7 REPORTS FROM RMOS

Dr Webb spoke as the new chairman of the APMP/TCRI, as indicated in CCRI(I)/03-46, stating that CMCs from eight participants had been submitted to the JCRB and two had been withheld pending appropriate formal designation of the laboratories concerned. He also reviewed key comparisons that had been published, were in progress or scheduled.

Dr Shortt reported some SIM activity, pointing out that no document had been submitted to the CCRI(I) and further noting some weakness at the RMO level in driving activities in the framework of the MRA.

Participants were referred to CCRI(I)/03-39 submitted by Dr Kharitonov, which summarized the activities relating to the COOMET.

8 APPENDIX C (MRA) CALIBRATION AND MEASUREMENT CAPABILITIES

The JCRB review process was described and it was pointed out that many details were available on the BIPM website. Document CCRI(I)/03-43 was introduced, giving the draft agenda for the upcoming RMO meeting for Ionizing Radiation CMCs at the BIPM on 25-26 September 2003 that includes the Technical Committee or working group chairmen from the APMP, COOMET, EUROMET, SADCMET and the SIM. It was emphasized that the RMO members should be fully briefed on CMC issues within their RMO prior to the meeting and should bring colleagues who are expert in the pertinent fields as appropriate. It was stressed that is not necessary for a laboratory to have a complete set of CMCs; it can submit those CMCs that are prepared in areas where the issues are clear and submit others later.

9 REPORTS FROM INTERNATIONAL MEMBERS AND OBSERVERS

Dr Shortt commented on CCRI(I)/03-8 and CCRI(I)/03-9, indicating that the IAEA CMCs have been approved and published and are being used as a model for the SIM laboratories. He reported on a strong dosimetry programme at the IAEA, indicating that they were well advanced with preparations for the new dissemination of radioactivity measurements, were involved in a study of diagnostic radiology, and had developed a training manual for medical physicists. He pointed to the recommendations in CCRI(I)/03-09 from the recent IAEA International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry, many of which involve concerns of the CCRI.

Mr Seltzer indicated new ICRU activities, including, in addition to approval of the establishment of a report committee on critical data for radiation dosimetry mentioned in 6.1, the formation of a joint ICRU/IAEA report committee on prescribing, recording and reporting proton-beam therapy. Expected for Commission review this fall are reports on stopping power for heavy ions, statistical aspects of radioecological sampling and, possibly, measurement quality assurance for ionizing radiation dosimetry.

10 PUBLICATIONS: *METROLOGIA* SPECIAL ISSUE ON IONIZING RADIATION

Prof. Martin, the editor of *Metrologia*, outlined plans for a special issue on ionizing radiation for each of the three sections of the CCRI to be published in 2005-2006. He indicated that each issue (published by the IOPP), with the Section Chairman as organizer, should be about 150 pages, with all contributions peer reviewed. Prof. Moscati identified this as a great opportunity and highlighted *Metrologi*a as an important channel for work in ionizing radiation. He suggested the articles could include reviews, historical and future trends, applications and methods. Dr Allisy-Roberts suggested seven to ten review articles would be appropriate, and she and Dr Sharpe asked for ideas on topics. Dr Rogers suggested that the issues covered by the meeting would be appropriate. He listed absorbed dose standards (including high-energy photons), air-kerma cavity standards, review of free-air chambers, review of Monte Carlo methods, clinical dosimetry protocols, brachytherapy standards and dosimetry protocols, β-ray standards and dosimetry, the international framework of comparisons, radiation protection standards, high-dose standards, electron dosimetry and environmental standards. The Section accepted Dr Aalbers' suggestion of a one-month deadline for other suggestions.

On other matters, Dr Allisy-Roberts asked for and noted the decisions on whether the working documents presented at the 16th meeting of the CCRI(I) are to be open or kept restricted.

11 FUTURE MEMBERSHIP

Dr Allisy-Roberts referred to CCRI(I)/03-16, which lists the current membership of the CCRI(I) with some proposed changes. It was agreed that CMI-IIR and the STUK would be recommended to the CIPM as observers and that METAS would become a member.

12 TRENDS AND FUTURE NEEDS IN IONIZING RADIATION METROLOGY – CCRI/CGPM REPORT

Prof. Moscati explained that the CCRI needs to advise the CGPM on such matters. Dr Aalbers suggested the possible consideration of non-ionizing radiation. Prof. Moscati commented that microwave, radiofrequency and ultraviolet radiations are covered by other Consultative Committees.

13 DATE OF NEXT MEETING; CONCLUDING REMARKS

Dr Allisy-Roberts asked whether the CCRI wished to change its schedule to avoid conflicts with other important meetings, perhaps to meet biennially on even years. The Section agreed that it wished to remain on the odd-year schedule, with the meetings held in May if possible.

Dr Sharpe concluded the meeting as he thanked the participants, congratulated them on addressing the rather full agenda in the time allotted, and indicated that a number of important decisions had been made.

S. Seltzer, *Rapporteur*

June 2003

Revised February 2004

CONSULTATIVE COMMITTEE
FOR IONIZING RADIATION

Section II: Measurement of radionuclides
Report of the 17th Meeting
(28-30 May 2003)

Abstract

Section II (Measurement of radionuclides) of the Consultative Committee for Ionizing Radiation (CCRI) held its seventeenth meeting at the Pavillon de Breteuil, Sèvres, on 28, 29 and 30 May 2003. The principal discussions related to issues which impinged on the completion of Appendices B and C in the BIPM databases. Significant progress had been made in populating these databases despite the very large volume of data that had to be reviewed, validated and entered. The Key Comparison Working Group (KCWG) had played a significant role in defining and clarifying procedures to enable these processes. This included the rules for selecting and analyzing comparison data, and identifying potential outliers, in the production of the key comparison reference values (KCRVs). Guidelines were developed and agreed, for the conduct of key comparisons that address the specific issues relating to radioactivity standardizations. The ten-year cut-off rule for other disciplines would have produced unacceptable comparison workloads for many national metrology institutes. A generic grouping system is being developed which addresses this issue and, together with a twenty-year cut-off period, this should reduce the workload to a more acceptable level. A rolling programme to bring forward the cut-off date progressively has been agreed which will ensure that, after 2011, only data that is no older than twenty years will remain in the equivalence database. At the previous meeting of the CCRI(II) in 2001, it was agreed to increase significantly the number of key comparisons to be conducted each year. Despite some teething problems, this has succeeded and a new set of comparisons for the next two years was agreed, using the same increased frequency. The Measurement Uncertainties Working Group has identified a number of issues that need to be addressed to enable progress on the reduction of the current level of uncertainties and initiatives are being developed to take these forward. The extension of the SIR to beta and alpha emitting radionuclides has taken a significant step forward and validation comparisons are planned during 2004. Monte Carlo simulations and empirical fitting routines based on experimental data have been initiated for the determination of new efficiency curves for the ionization chamber that is the foundation of the SIR. A special issue of *Metrologia* is planned for 2005/6 that will address the area of radioactivity standardizations.

1 OPENING OF THE MEETING; APPROVAL OF THE AGENDA; APPOINTMENT OF RAPPORTEURS

Section II (Measurement of radionuclides) of the Consultative Committee for Ionizing Radiation (CCRI) held its seventeenth meeting at the Pavillon de Breteuil, Sèvres, on 28, 29 and 30 May 2003.

The following members were present: D. Alexiev (ANSTO), R. Broda (RC), N. Coursol (BNM-LNHB), Y. Hino (NMIJ/AIST), H. Janβen (PTB), S. Judge (NPL), J.M. Los Arcos (CIEMAT), F. Morris (CSIR-NML), G. Moscati (President of the CCRI), T.S. Park (KRISS), D.F.G. Reher (IRMM), C. Ross (NRC), S. Sepman (VNIIM), B.R.S. Simpson (Chairman of CCRI Section II, CSIR-NML), L. Szücs (OMH), M.P. Unterweger (NIST), U. Wätjen (IRMM), G. Winkler (IIK), M.J. Woods (NPL).

Observers: P. Dryák (CMI), B. Michael (ICRU), W. Pereira (LNMRI/IRD), P. Sharpe (Chairman of CCRI Section I), W. de Vries (NMi).

Guest: B. Zimmerman (IAEA).

Also attending the meeting, for all or part of the time: A.J. Wallard (Director designate of the BIPM), P.J. Allisy-Roberts (Executive Secretary of the CCRI), D.T. Burns, C. Michotte, S. Picard, G. Ratel and C. Thomas (KCDB coordinator) (BIPM).

Apologies were received from: P. De Felice (ENEA-INMRI), C. Grover (NRC), H. Klein (Chairman of CCRI Section III), G. Webb (IRPA), Yang Yuandi (NIM).

Dr Allisy-Roberts presented apologies for the absence of the Director of the BIPM, Dr T.J. Quinn, and opened the meeting on his behalf.

Dr Simpson, the Chairman, welcomed the participants and noted that, since the last meeting, Mr J.-J. Gostely (IRA, Switzerland) had retired. He expressed the appreciation of CCRI(II) for the input that Mr Gostely had made in Section II activities and his many contributions in the field of radionuclide metrology. He continued by reiterating that the traditional role of the Consultative Committees has been to offer advice and guidance to the BIPM in fulfilling the requirements of the international metrology community regarding the need for traceability. Since the signing of the CIPM Mutual Recognition Arrangement (the MRA), the mandate of the Consultative Committees has been rather more formalized in that its role now includes the definition and coordination of the CIPM key comparisons and then, together with the BIPM, the analysis of the results. The key comparisons play a vital function in determining equivalence between national metrology institutes (NMIs) and providing support for claims made in calibration and measurement capability (CMC) submissions.

During the transitional period, much of this work related to implementing the MRA in Section II (Measurement of radionuclides) has been undertaken by essentially three working groups, namely the Key Comparisons Working Group (KCWG), the Measurement Uncertainties Working Group and the Extended SIR Working Group (ESWG) and their predecessors, e.g. Analysis of SIR

Working Group. These Working Groups have met on a number of occasions since the last Section II meeting in 2001, to ensure progress on various issues and to be able to put forward proposals at this meeting, particularly because the transitional period of the MRA ends on 31 December 2003. Decisions need to be taken to resolve remaining difficulties.

Much has happened in the past two years in fulfilling the 2001 actions. This has, amongst other things, entailed the organization of key comparisons and documenting past comparisons into reports for publication, and the placing of the results into the BIPM key comparison database (the KCDB). This effort will be reviewed and discussed at this meeting.

The meeting confirmed the appointment of Mr Woods and Dr Judge as the joint *rapporteurs*.

The agenda was approved.

2 REPORT OF THE SEVENTEENTH MEETING OF THE CCRI

Prof. Moscati pointed out that the full details of the meeting are contained in the relevant BIPM publication. As well as stating that he would meet with the three CCRI chairmen after their respective meetings and report back to CIPM, he informed the meeting that the General Conference would be meeting later during the year.

Dr Allisy-Roberts reminded the meeting that the problems relating to the transport of radioactive materials had been raised at the previous CCRI(II) meeting. Subsequently, Prof. Moscati had raised this at the CIPM which had in turn produced a resolution on this topic that will be discussed at the next General Conference.

3 PUBLICATION OF APPENDIX B COMPARISON REPORTS

3.1 **Acronyms for standardization methods** (CCRI(II)/03-03)

Mr Reher outlined the table of acronyms that had been proposed to describe the various standardization methods used by the NMIs and that is currently being used in the draft A and draft B comparison reports. The purpose of these acronyms was to introduce a degree of harmonization that would minimize the potential for confusion when comparing the results of standardizations by different methods. Additions and amendments would arise from time to time and it was suggested

that the table should be a live document with changes being left to the discretion of the Key Comparisons Working Group and that the acronym system should be formally adopted. It was noted that the tables in Appendix C still use the original format and that consideration might need to be given to a possible change in the future. It was agreed by the CCRI(II) to adopt these proposals.

3.2 **Progress of activity comparison reports** (CCRI(II)/03-21)

Dr Allisy-Roberts summarized progress on publication of the key comparison reports in the KCDB. By 28 May 2003, there were a total of 29 entries, comprising 24 BIPM comparisons, three CCRI comparisons and two RMO comparisons. The aim was to complete the analysis of half the available data by the time of the CGPM. It was emphasized that individual NMIs need to respond to requests for information and approval as quickly as possible to enable Appendix B entries to be completed in a reasonable period of time.

CCRI(II) members expressed their thanks to the staff at BIPM for the excellent progress that had already been made in analyzing the results and producing the subsequent reports.

3.3 **Proposals regarding provisional equivalence and old data** (CCRI(II)/03-25)

Dr Allisy-Roberts explained that the original intention had been to include in the KCDB only those results that are less than ten years old. However, the long term stability of measurements had been demonstrated in the NMIs as well as at the BIPM and it was proposed to extend this time-frame to 20 years. Proposals for a gradual phasing to achieve the 20 year target were presented to the CCRI(II) as:

- at the end of 2003, when the transitional period of the MRA will end, the notation “approved for provisional equivalence” no longer applies. All the SIR results in the KCDB that are more than 20 years old (pre-1983) and currently indicated in red, will be re-coloured black but will remain in the KCDB. Similarly for CCRI(II), RMO and bilateral comparisons that are currently coloured in blue;
- at the end of 2005, pre-1985 results will be re-coloured in black;
- at the end of 2007, pre-1987 results will be re-coloured in black and pre-1977 results (i.e. more than 30 years old) will no longer be visible in the degrees of equivalence;
- at the end of 2009, pre-1989 results will be re-coloured in black and pre-1984 results (i.e. more than 25 years old) will no longer be visible in the degrees of equivalence;
- at the end of 2011, pre-1991 results will no longer be visible in the degrees of equivalence;
- all the earlier results will remain in the original published reports and may still be used in the KCRV if relevant.

Mr Woods and Dr Coursol spoke in support of the proposal. In response to a question as to why a cut-off date was required, Dr Allisy-Roberts said that it must be possible to demonstrate that data used in the KCDB were current. A cut-off date was essential to maintain credibility of the KCDB as a requirement of the MRA is that the data are current; for example, results would also be excluded if

a laboratory ceased work in ionizing radiation and re-started sometime later. Mr Woods and Mr Reher commented that this topic was linked to the issue of generic grouping of radionuclides. Dr Allisy-Roberts said that the generic grouping proposal was designed to support CMC tables in Appendix C and, as such, was independent of Appendix B. Dr Simpson expressed concern that some laboratories might not have had sufficient time to consider the proposal. Mr Reher said that, because of the imminent end of the transitional period, the decision should be taken at the meeting. Dr Simpson concurred and CCRI(II) agreed to adopt the schedule as proposed.

3.4 Key comparison results and the determination of the KCRV (CCRI(II)/03-28)

It was noted that the current policy of the CCRI(II) is that the most recent key comparison result is the value that is always used in the KCDB to demonstrate degrees of equivalence. Whilst implementing this policy, a number of issues had arisen and some interim policies had been applied. It was necessary for CCRI(II) to confirm these. In particular, some earlier results had been submitted in the frame of what would now be called a pilot study. It was noted that some NMIs might wish even now to withdraw their earlier results from the KCDB. In addition, when an NMI had used several methods in the earlier CCRI(II) comparisons, a weighted mean may have been used to represent the NMI's result but it might not represent the NMI's standard as currently disseminated. Some discussion would be needed with the NMI to determine the appropriate result to be used.

Regarding the value to be used in the determination of the KCRV, where an NMI had submitted primary standardized solutions originally to the SIR and subsequently solutions measured in an ionization chamber (IC), the following is applied:

- when the IC measurement is traceable to a primary measurement previously submitted to the SIR, then the primary measurement is the candidate for the KCRV;
- when the IC measurement is traceable to a primary measurement but not one previously submitted to the SIR, then the IC measurement is the candidate for the KCRV;
- when several IC measurements are submitted to the SIR consecutively and these are all traceable to the same primary standardization that has not itself been submitted, then the earliest IC measurement submitted is normally the candidate for the KCRV.

CCRI(II) agreed to these proposals and indicated that the flow chart in the working document was helpful.

3.5 Correlations in the KCDB (CCRI(II)/03-29)

It was noted that correlations are not presently taken into account except when one laboratory's result is traceable to another laboratory. However, in the case of linked comparisons, the correlations associated with the measurement in the SIR of a single ampoule used as this link, is taken into account.

3.6 Update on the International Reference System (SIR) for gamma-ray emitting radionuclides (CCRI(II)/03-38)

Dr Ratel reported that, in 2001, 17 new ampoules had been submitted to the SIR covering eight nuclides. In 2002, the corresponding numbers had been 15 ampoules covering 12 nuclides and, to date in 2003, five ampoules of five different nuclides had been submitted. In addition, a solid source of $^{166}Ho^{m}$ had been received.

4 CURRENT CCRI(II) KEY COMPARISONS OF ACTIVITY MEASUREMENTS

4.1 Guidelines for CCRI(II) key comparisons (CCRI(II)/03-06)

Dr Michotte explained that the proposed CCRI(II) guidelines were based on the CIPM guidelines and that the status of each comparison was available on the KCDB website. She added that participants who submit more than one result for a comparison exercise should select a single value to use for the KCDB otherwise a weighted mean of the results will be used. The value selected by the NMI may be one of the results or some combination. Dr Ratel commented that every result is shown in the report but only one numerical value can be used for the degree of equivalence.

Dr Coursol then asked, if the value used was a combination of results, how the method could be identified. In response, Dr Allisy-Roberts said that the BIPM contacts the laboratory to ask which result or combined value represents the value disseminated by the laboratory and is to be used in the KCDB. This decision is taken in advance of announcing the results from the other laboratories.

As the results from the SIR system can be used to identify the most appropriate method to standardize radionuclides, Mr Reher questioned the usefulness of using a combined value. Dr Allisy-Roberts replied that all the results were shown in the full report to allow comparison of methods. Mr Reher pointed out that, as results were correlated, the NMI rather than the BIPM should calculate their weighted mean value. Dr Ratel confirmed that the BIPM uses the value put forward by the NMI.

Mr Woods sought clarification of the timing of scientific publications using the measurements from a comparison exercise. Dr Allisy-Roberts said that information on the current status of comparisons is on the KCDB website and that, if the database has a comparison where the draft A report is marked as “in progress”, the measurements must not be published. Measurements may be published only when the draft B report is marked “in progress”. Dr Allisy-Roberts also emphasized the need for the CCRI(II) Chairman and Executive Secretary to be kept regularly informed of the current status of comparisons so that the KCDB is kept up to date.

CCRI(II) approved the guidelines as proposed.

4.2 Proposal to convert an ICRM comparison into a CCRI(II) key comparison of ^{18}F (CCRI(II)/03-08)

This paper was presented by Mr Woods who explained that the measurements were completed in April 2003 and linked to the SIR through BNM-LNHB and NPL. The aim of the work was to establish a method to compare short lived radionuclides. The scheme used a ^{68}Ge source for normalization purposes.

Dr Alexiev supported the scheme as it gave a working comparison value for short-lived radionuclides. Dr Michotte agreed that it was important to link measurements of ^{18}F to the SIR but was concerned that the guidelines should be followed. Dr Allisy-Roberts re-iterated that if the comparison was to be accepted as a key comparison, any publication of results before the draft B report must be anonymous and a scaling factor used, for example. Mr Woods stated that the results to be published the following week at the ICRM conference were calibration factors for the NPL secondary standard chamber and were unrelated to the SIR system. However, he would change the presentation, using a scaling factor, and hence ensure that linkages could not be established at this stage. In response to a question from Mr Reher, Mr Woods replied that it was for the BIPM to decide the best approach for establishing the linkage to the SIR.

The proposal to include this comparison exercise as a key comparison was adopted on condition that the rules for such a comparison were followed. Dr Michotte said that this was a new type of comparison and it would be identified as CCRI(II)-K3.F-18.

4.3 Progress report on the current CCRI(II) key comparisons (CCRI(II)/03-37)

Dr Ratel reported on the various key comparisons that are in progress.

The comparison of ^{152}Eu measurements (CCRI(II)-K2.Eu-152) raised two issues. First, a discrepancy was noted between measurements of the ^{152}Eu activity at two NMIs. This had been traced to the calculation of the correction factor in 4π gamma counting. The results had been revised and the discrepancy resolved. Second, it was noted that corrections had to be applied to measurements on the SIR system in order to take into account the effects of gamma-ray emitting impurities in the samples. For this radionuclide, there was a distinct difference in the fitting to the SIR efficiency curve between those measurements with and without impurity corrections. Dr Allisy-Roberts summarized the proposal: (a) the KCRV will use only those results with impurity corrections applied; (b) for the KCDB results, the BIPM will apply a correction for impurities using a common impurity value. This was accepted.

No issues were raised concerning the ^{238}Pu comparison (CCRI(II)-K2.Pu-238).

The ^{32}P comparison (CCRI(II)-K2.P-32) had shown two groups of results and a wide variation in estimates of the impurity content (^{33}P, ^{35}S). In reply to questions from Dr Janβen, Dr Ratel said that no correlation with ampoule number could be observed and participants had used the same reference date. Dr Hino pointed out that there could be a problem with the detection efficiency of different radionuclides in different liquid scintillation counting systems. Mr Woods said that, as estimating the impurities was difficult, the uncertainty estimates looked unrealistic and suggested that it would be

possible to apply a correction factor based on an average figure for impurities. In reply, Dr Los Arcos said the correction for impurities was small at CIEMAT, and Mr Reher said the IRMM uncertainties had been calculated by least squares fitting and were realistic. Dr Allisy-Roberts proposed that the results should stand and all the comments be incorporated in the report. Mr Woods proposed a small scale comparison to resolve the discrepancy. Dr Janβen agreed that the PTB will repeat the dispensing of ^{32}P for an additional comparison to be coordinated by Dr Ratel. The proposal for the additional comparison was agreed by CCRI(II) and would be registered in the KCDB as (CCRI(II)-K2.P-32(2)).

The results from the ^{204}Tl comparison (CCRI(II)-K2.Tl-204) were then reviewed. The measurements were in reasonable agreement except for the value obtained by one NMI. The discrepancy had been discussed with BIPM who had recommended that ^{60}Co was not a suitable tracer for this radionuclide. Mr Reher added that the tracer technique with solid sources is prone to problems if the tracer does not co-precipitate with the radionuclide being assayed. Mr Woods reported that NPL had used several techniques and found discrepancies between using additional carrier and adding foils to vary the detection efficiency. These results seemed to confirm that the carrier material was not co-precipitating with the thallium. Dr Allisy-Roberts concluded that the BIPM would contact the NMI concerned.

The ^{192}Ir comparison (CCRI(II)-K2.Ir-192) was then discussed. Dr Hino raised the issue of a type B uncertainty due to the setting of the gate on the gamma-ray spectrum as a discontinuity had been observed in the extrapolation curve. Mr Woods confirmed that this had also been observed by NPL and said that it was important that this was reported to the radionuclide community. Mr Reher suggested that the accuracy of measurements of ^{192}Ir can be improved using a high pressure proportional counter to increase detection efficiency, particularly for the electron capture emissions. An alternative method was to change the gas mixture in an atmospheric pressure counter but this was not as effective.

Dr Ratel stated that the draft A report for the ^{89}Sr comparison (CCRI(II)-K2.Sr-89) was in preparation. Mr Woods said that the KCWG had recommended that results obtained using ^{60}Co as a tracer should be excluded as beta spectra characteristics and chemical effects mean that the fundamental conditions of the tracer technique are not met. It was noted that although this advice had not been published specifically for ^{89}Sr, the general conditions were in the literature. Dr Allisy-Roberts pointed out that two measurements obtained using this method were in good agreement with the KCRV and a review paper on the topic might be useful.

The issue of deadlines for submitting results from comparison exercises was discussed. Dr Simpson said that NMIs should explain why a deadline had been missed and give a firm commitment date. Mr Woods replied that the frequency of comparisons has increased and pressure of other work means that NMIs may have to miss deadlines. External factors, such as delays in obtaining export licenses, have also affected timescales. Nonetheless, the introduction of deadlines has reduced the delays in completing comparison exercises.

The ^{65}Zn comparison (CCRI(II)-K2.Zn-65) was still ongoing although most of the results had been received. Dr Ratel requested that the deadline for the submission of the BIPM measurements for this nuclide be postponed to the first week in July 2003. This was accepted by CCRI(II).

The ^{241}Am comparison (CCRI(II)-K2.Am-241) was still underway with a deadline of December 2003. OMH and NIST were still awaiting the delivery of the comparison samples whilst CIEMAT was also awaiting the delivery of a sample containing a smaller aliquot in order to comply with their internal restrictions on activity of holdings. Dr Judge agreed to pursue these samples from the NPL.

5 WORKING GROUP PROGRESS

5.1 **Key comparisons** (coordinator: M.J. Woods) (CCRI(II)/03-02 to -05 CCRI(II)/03-06 and -07)

Mr Woods reported the progress made by the KCWG since the previous CCRI(II) meeting in 2001. The KCWG had addressed a large number of issues and the principal activities had included:

- development of data selection rules and a protocol for the analysis of comparison data to be used in the calculation of the KCRV;
- development of a procedure for identifying potential outliers to exclude from the KCRV data;
- review of other comparison data and recommendations to CCRI(II) on their acceptability for inclusion into the KCRV and into the equivalence database;
- development of acronyms for standardization methods;
- production of guidelines for the conduct of CCRI(II) key comparisons;
- definition of a reporting schedule for key comparisons aimed at minimizing the times for producing both draft A and draft B reports;
- definition of generic groupings of radionuclides with the objective of reducing the number of key comparisons that NMIs need to complete in order to maintain their CMCs for all nuclides in the KCDB.

A discussion followed on the proposal to group radionuclides by type. The objective was to reduce the number of key comparisons that would be needed each year in order to support the requirements of Appendix C. The intention was to group radionuclides together on the combined basis of decay characteristics and measurement technique. Successful comparisons with one radionuclide within a group would validate other radionuclides in the same group, although there was the intention to split each group into easy, medium and hard sub-groups. Dr Michotte asked why beta- and alpha-emitting radionuclides had been grouped together although source preparation for alpha-emitting radionuclides was more difficult. Mr Reher replied that the measurement technique was the same and that the groupings were based on both radionuclide and technique – some radionuclides were in more than one table. It would be necessary to put these proposals to the relevant working group of RMO coordinators for acceptance as a means of providing supporting comparisons in Appendix C. Dr Allisy-Roberts commented that this multi-dimensional aspect was very useful.

The CCRI(II) agreed to support this approach and comments on the working document should be sent to Mr Reher by the end of July 2003.

Working document CCRI(II)/03-02 on the use of the median to estimate the KCRV for discrepant data was noted but it was agreed to retain the present system.

For the record, it was noted that the proposals for the identification of potential outliers in key comparison data had been circulated to the CCRI(II) in July 2002 and had been approved by correspondence.

5.2 **Measurement uncertainties** (coordinator: H. Janβen)

Dr Janβen reported on the deliberation of the Uncertainties Working Group (UCWG) over the past two years which had been directed towards resolving the questions of uncertainties raised during the analysis of key comparisons. The UCWG has met three times since its creation, on 19 March 2002, 24–25 April 2003 and 27 May 2003.

The uncertainty budgets for the recent CCRI(II) comparisons of activity measurements on ^{152}Eu and ^{238}Pu were considered as examples to outline the problems in the analysis of comparisons. It was noted that, in general, the underlying mathematical model is not described and only the uncertainties assigned to the input quantities of the analysis are given. The contributions of input quantities to the relative standard uncertainty of the output quantity are stated but the sensitivity coefficients are not known. The UCWG proposes to establish a set of uncertainty budgets for several standardization methods, which could serve as a practical guide for participants in comparisons of activity measurements. The methods considered include coincidence and anti-coincidence counting, internal gas counting, 4π-counting, defined solid angle counting and liquid scintillation counting (CIEMAT/NIST, TDCR).

For new comparisons, the UCWG proposes to change the existing format of the BIPM reporting form so that the participants can submit results in electronic form as EXCEL files with one table for each method. Participants would be encouraged to describe in detail the mathematical model underlying their analysis. Correlation matrices for input quantities could be included in the tables. This proposal was agreed.

The UCWG also proposes to provide representative state-of-the-art values for uncertainty components of input quantities in the EXCEL tables. The participant should defend his result if it is less than this value. The CCRI(II) agreed to this course of action.

Decay data had also been discussed at the UCWG and it was proposed that decay scheme data should be provided with the information for comparison exercises. Prof. Moscati welcomed this proposal as many different nuclear data sets are available. Dr Zimmerman added that the IAEA was very active in the field of nuclear data, and that only evaluated data should be used; he went on to say that such a recommendation from the CCRI would encourage good practice. Dr Winkler suggested that previous comparisons should be looked at to identify any discrepancies due to the nuclear decay scheme data used. Dr Coursol felt that the data should be recommended but not obligatory. Prof. Moscati said that the reports should show any dependence on decay data so that

results could be updated if improved data becomes available. It was proposed, and agreed by the CCRI(II) that, for future comparisons, comprehensive sets of decay data are provided and recommended for use by the participants. If a laboratory decides to use data other than those recommended, the laboratory should deliver two results and uncertainty budgets, one result gained with the data set recommended and a second result for the data set preferred by the laboratory.

For the purpose of evaluation of the MRA-CMC tables, the UCWG considered that it would be useful to have a table that provides information on the acceptability of measurement uncertainties for a specified radionuclide and standardization method. The CCRI(II) approved this proposal and agreed that a draft table be prepared by the UCWG and circulated for comment before the inter-RMO meeting planned for September 2003. Comments should be sent to Mr Reher.

The UCWG also considered the *Proposal on the choice of the procedure for processing the key comparison data to establish the equivalence of national measurement standards*, dated 4 January 2003, prepared by I.A. Kharitonov of the VNIIM. In this context, indicators for unacceptable small uncertainties reported in the CMC tables of NMIs were discussed. It was agreed that the value of $u(x_i)$ should be adjusted to ensure that the condition

$$\left| (x_i - x_{ref})/(u^2(x_i) + u^2(x_{ref}))0.5 \right| \leq 2$$

is met for any CMC entry. The CCRI(II) supported this proposal.

In some cases, uncertainties assigned to secondary standards that are smaller than those of primary standards for the same radionuclide are reported in the CMC tables. The UCWG is concerned that correlation of input data is generally ignored when calibration curves (e.g. for the efficiency of photon spectrometers) are established. The CCRI(II) agreed two courses of action. First, Dr Los Arcos, with the support of the ICRM Gamma Spectrometry Working Group was asked to examine this problem urgently and to present recommendations for presentation at the inter-RMO meeting in September 2003. Second, Dr Michael (ICRU) was invited to establish an ICRU report committee which would examine and make recommendations in more depth, based on a proposal from the UCWG which would be forwarded via the CCRI(II).

It was agreed that Dr Unterweger would join the UCWG.

5.3 **Extension of the SIR to beta-emitters** (coordinator: J.-M. Los Arcos) (CCRI(II)/03-43)

Dr Los Arcos summarized the progress towards extending the SIR system to cover pure beta-emitters. A summary of the current position includes:

- the extension of the SIR can cover beta-emitters from 20 keV to 1700 keV and also alpha-emitters without adding special difficulties;
- samples should be prepared by NMIs using reference scintillators and vials provided by the BIPM;
- non-commercial, stable reference scintillators should be prepared at the BIPM;

- the extended SIR procedure will be based on comparison of apparent efficiency (from NMI activity and BIPM counting) with efficiency predicted by the BIPM for the particular sample quench;
- both CIEMAT-NIST and TDCR will be operated in parallel at the BIPM for at least 20 samples for evaluation purposes;
- the Extended SIR Working Group (ESWG) members will exchange experiences and information about scintillants etc., by September 2003, for ^{3}H, ^{63}Ni, ^{204}Tl, ^{89}Sr, ^{90}Sr/^{90}Y, ^{55}Fe and ^{241}Am;
- the next meeting of the ESWG scheduled for October 2003 will select the first reference scintillator and radionuclide;
- the other radionuclides will be compared in 2004;
- a monograph will be produced starting at the October 2003 meeting.

Dr Michotte asked whether a beta-gamma-emitting radionuclide could be used to test the long-term stability of the system as this could also be compared in the SIR. Dr Los Arcos said this was a good suggestion.

It was agreed that Dr Zimmerman and Dr Timos Altzizoglou (IRMM) will be invited to join the ESWG.

5.4 **Realization of the becquerel at the basic level** (coordinator: D.F.G. Reher) (CCRI(II)/03-13)

Mr Reher gave a presentation on the design of the proposed BIPM SIR ionization chamber. The aim was to have working prototypes at IRMM and NPL by the time of the next meeting of the CCRI in 2005, although it could be seven years before the chamber is fully validated. One issue to address is the container, as different batches of glass have different composition which may affect chamber response. Mr Reher said that it may be possible to design an aluminium container with a plastic layer on the interior surface. Dr Los Arcos said he would send details of a possible suitable electrochemical process to Mr Reher.

Dr Dryák commented on the use of plastic in the chamber design. There is a risk that the material can evaporate in the long term and contaminate the counting gas. Mr Reher said that the plastic material had been chosen to reduce attenuation and it could be replaced with stainless steel.

Dr Alexiev asked if the chamber would replace the commercial NPL secondary standard chamber; Mr Reher replied that this was not the intention. Two chambers would be constructed initially, that would later be supplied to the BIPM for the SIR system. Dr Coursol asked for further details of the gas system. Mr Reher explained that the chamber will use a gas pressure balance system, traceable to national standards. The pressure will be constant at a value between 1 MPa and 2 MPa, the exact value to be decided. Dr Dryák said that below 0.7 MPa, the chamber could be more sensitive to small fluctuations in gas pressure as most of the ionization is then due to interaction with the chamber walls.

6 REGIONAL REPORTS

6.1 RMO activities

Dr Sepman presented a report on COOMET activities (CCRI(II)/03-24).

Dr Coursol presented a report of EUROMET activities (CCRI(II)/03-46). At the latest EUROMET general assembly, 22 NMIs were represented, 14 of which were involved in ionizing radiation. The next meeting will take place in November 2003.

Dr Park presented a report on APMP/TCRI activities (CCRI(II)/03-27).

Dr Simpson presented an oral report from SADCMET (CCRI(II)/03-65).

Dr Wallard emphasized the importance of NMIs establishing a quality system for compliance with the MRA. The JCRB will remove entries to Appendix C from NMIs that do not intend to put a quality system in place in due course.

Dr Allisy-Roberts presented the RMO Working Group for Ionizing Radiation CMCs. The previous meeting had been held in September 2000, principally to establish the criteria for CMC entries. The next such RMO coordinators' meeting will be held in September 2003. Each regional organization had been invited to attend.

6.2 Proposals for supplementary comparisons

Dr Allisy-Roberts presented a note prepared by Dr Quinn on supplementary comparisons (CCRI(II)/03-05) which had the objective of seeking to clarify whether a comparison was a key or a supplementary comparison. Supplementary comparisons are generally the prerogative of the RMOs and are designed to address specific issues that are not covered by key comparisons. Results of supplementary comparisons do not have a KCRV but reports on them may be published in *Metrologia Technical Supplement*.

With reference to CCRI(II)/03-09 (Discussion paper on key comparisons for reference materials), Mr Reher reported that some organizations had submitted entries to the CMC for reference materials and asked whether supplementary comparisons were needed to support the entries. Mr Woods pointed out that the manufacture of reference sources should be covered by the quality system (e.g. ISO 17025) but exploratory comparisons could be useful. Dr Wätjen added that in the field of chemical measurements, any measurement is specific to the analyte and the matrix, so supplementary comparisons are recommended. Dr Allisy-Roberts reminded the meeting that any comparison must be run in accordance with an agreed protocol. She indicated that there was no need to wait for the next CCRI meeting for approval as email messages would suffice. Dr Wallard confirmed that a supplementary comparison may be used to support a CMC in the absence of a key comparison. Dr Allisy-Roberts added that RMOs may invite participation from any laboratory but only participants in the MRA may have their results published in the KCDB.

Dr Janβen noted that a comparison proposed by his colleagues at the PTB had the objective of comparing secondary standards of radon. This comparison had been approved by EUROMET as a supplementary comparison (EUROMET.RI(II)-S1.Rn-222).

Dr Coursol presented working document CCRI(II)/03-40, proposing a ^{85}Kr comparison which would be designated as CCRI(II)-K2.Kr-85. The CCRI(II) approved this in principle. The BNM-LNHB would need to develop a detailed protocol in accordance with the key comparison guidelines and submit it to the CCRI(II) for approval. The IRD, NMi, OMH and the PTB all expressed interest in participating in the comparison. It was noted that there was also parallel work going on at BNM-LNHB on the calculation of ionization chamber responses to ^{85}Kr. This work had been initiated by the ICRM Radionuclide Metrology Techniques Working Group.

Mr Woods said that the Key Comparison Working Group had proposed that previous EUROMET comparisons for ^{85}Kr (EUROMET.RI(II)-S2.Kr-85) and ^{3}H (EUROMET.RI(II)-S3.H-3) be used in the interim as comparisons in support of Appendix C submissions. Dr Allisy-Roberts agreed that this was possible. The proposal was approved by CCRI(II) and Dr Coursol agreed to submit the necessary information.

For information, Dr Coursol presented working document CCRI(II)/03-41 which detailed EUROMET project 721. This project was designed to improve the quality of decay scheme data, in particular, gamma-ray emission probabilities for ^{65}Zn. It was hoped that measurements could be linked to the solutions being used for the CCRI(II) key comparison of ^{65}Zn which was in progress, CCRI(II)-K2.Zn-65.

For the record, Dr Allisy-Roberts reported that two supplementary comparisons were being organized by APMP, one for ^{36}Cl (APMP.RI(II)-S1.Cl-36) and the other for ^{166}Ho^{m} (APMP.RI(II)-S2.Ho-166m). Dr Hino explained that one aim of the comparisons was to check the response function of ionization chambers.

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

New key comparisons proposed over the next two years were discussed. The following programme of comparisons was agreed, with the participants to be confirmed:

Radionuclide	Source provider	Pilot laboratory	Participants	Start date	End date
Mn-54 (CCRI(II)-K2.Mn-54)	PTB	BIPM	ANSTO, BARC, BEV, BIPM, BNM-LNHB, CIEMAT, CMI, CNEA, CSIR-NML, ENEA, IFIN, ININ, IRA, IRMM, KRISS, LNMRI, NIST, NMIJ/AIST, NPL, PTB, RC, SMU, VNIIM.	June 2003	November 2003
P-32 (CCRI(II)-K2.P-32(2))	PTB	BIPM	BARC, BIPM, BNM-LNHB, CIEMAT, CSIR-NML, IFIN, IRD, IRMM, NIST, NMIJ/AIST, PTB, RC.	January 2004	March 2004
I-125 (CCRI(II)-K2.I-125(2))	NPL	BIPM	BIPM, BNM-LNHB, CIEMAT, CMI, CSIR-NML, IRMM, NIST, NMIJ/AIST, NPL, OMH, PTB, RC, VNIIM.	October 2004	March 2005
Kr-85 (CCRI(II)-K2.Kr-85)	BNM-LNHB	BIPM	BEV, BNM-LNHB, CIEMAT, CMI, IRD, IRMM, KRISS, NIST, NMi, NMIJ/AIST, NPL, OMH, PTB.	January 2004	February 2005
Y-90	NIST	IAEA	To be decided	November 2004	November 2004
H-3	BNM-LNHB or NIST		To be decided	2005	2006

Mr Woods (as Chairman of the Key Comparison Working Group) said that there was a need to finalize the system of generic groupings of radionuclides (CCRI(II)/03-17). When this work is complete, the KCWG will put together a recommended list of radionuclides for comparisons in the long term.

Dr Allisy-Roberts reported progress at BIPM on the SIR comparison reports for the KCDB. Twenty-four BIPM.RI(II)-K1 reports had been published, reports for ^{109}Cd and ^{99}Mo would be published at the end of May 2003 and ^{85}Kr is in progress. The linked CCRI(II) and RMO comparisons were being included as appropriate.

8 NMI PROJECTS AND LABORATORY REPORTS

Representatives gave a brief summary of highlights.

NPL (Dr Judge) (CCRI(II)/03-10):

- a Monte Carlo model of coincidence counting systems is being developed (in collaboration with Liverpool University);
- the response of ionization chambers to common radiopharmaceuticals in syringes has been investigated and a report is in preparation;
- a solution standard of organically bound tritium is in preparation.

NMIJ/AIST (Dr Hino) (CCRI(II)/03-26):

- new staff have been recruited;
- a system has been developed using an ink jet printer to dispense large area reference sources;
- a remote calibration system is being set up for ionization chambers.

KRISS (Dr Park) (CCRI(II)/03-23):

- the laboratory has been accredited to ISO 17025.

CIEMAT (Dr Los Arcos) (CCRI(II)/03-44):

- a new laboratory has been set up;
- a quality system is in place for compliance with the MRA;
- the scope of the work is extending to cover neutron measurements.

ANSTO (Dr Alexiev) (CCRI(II)/03-12):

- there has been an organizational restructuring at ANSTO;
- it is the intention to implement liquid scintillation metrology.

BNM-LNHB (Dr Coursol) (CCRI(II)/03-31):

- an x-ray system (SOLEX) has been set up to characterize gamma-ray spectrometers for the measurement of nuclear decay data;
- the laboratory has been accredited to ISO 17025.

IRMM (Mr Reher) (CCRI(II)/03-14):

- the IRMM has been re-organized following changes to the EC programme under which the laboratory operates (FP6);
- a system for defined solid angle alpha counting has been set up;
- phosphor imaging is being used to determine activity distribution over surfaces;
- a source drier system is in use for producing ultra-thin sources;
- a system has been set up for 4π sum counting using a high pressure proportional counter and a well NaI detector.

PTB (Dr Janβen):

- the German Government has evaluated the work of PTB with the assistance of an international commission and it is hoped that the overall situation of PTB will be determined for the long term;
- the work has expanded to include metrology for chemistry.

NIST (Dr Unterweger):

- some staff changes have occurred: Dr Zimmerman has transferred to the IAEA, Dr Colle has retired and Dr Lucas will retire in September;
- a strong programme of support for environmental measurements is underway.

NRC (Dr Ross):

- the radioactivity programme at the NRC has been suspended and a future programme is not yet clear.

IIK (Dr Winkler) (CCRI(II)/03-15):

- the monograph on high efficiency gamma-detectors will be submitted soon to CCRI(II);
- a project is in hand to simulate stochastic pulse trains to test dead-time corrections;
- new techniques based on mass spectrometry are also being developed to replace some nuclear counting techniques.

OMH (Dr Szücs) (CCRI(II)/03-42):

- five radionuclides were standardized in 2002;
- participation in SIR programme is continuing – ^{59}Fe and ^{99}Tcm have been submitted.

RC (Dr Broda):

- the metrology laboratory has been re-organized into two sections (Quality Control and Research and Development);
- work is continuing on TDCR;
- a new liquid scintillation cocktail is in development.

VNIIM (Dr Sepman) (CCRI(II)/03-22):

- an active research programme is underway, including the investigation of cascade summing corrections, the simulation of gamma-ray detectors, standardization of ^{134}Cs by 4π-γ counting;
- the laboratory has participated in CCRI(II) comparisons of ^{238}Pu, ^{204}Tl, ^{65}Zn and COOMET reference material comparisons of ^{90}Sr, ^{137}Cs and ^{40}K.

The CCRI(II) encouraged Dr Sepman to register the COOMET reference material comparisons as supplementary comparisons in the KCDB.

CMI (Dr Dryák) (CCRI(II)/03-36):

- the laboratory continues to maintain a wide range of systems for standardizations;
- the use of digital signal processing is being investigated;
- accreditation to ISO 9001 and ISO 17025 is maintained;

- ^{85}Kr, ^{41}Ar and ^{133}Xe have been standardized for use by a nuclear power plant;
- a windowless NaI detector has been developed;
- Monte Carlo simulation of ionization chambers is underway;
- standards produced include ^{226}Ra Marinelli beakers and a BOMAB phantom (bottle mannequin) for calibrating whole body monitors;
- CMI had led a EUROMET project No. 634 on the calibration of ionization chambers for nuclear medicine.

LNMRI/IRD (Dr Pereira) (CCRI(II)/03-19):

- the laboratory is working towards accreditation to ISO 17025;
- nuclear decay data for ^{241}Am, ^{65}Zn and ^{192}Ir are being measured.

NMi (Dr de Vries) (CCRI(II)/03-20):

- the laboratory will be moved from Utrecht to a new building in Delft;
- a coincidence counting system is being set up using a liquid scintillation/NaI combination;
- accreditation to ISO 9001 has been achieved.

IAEA (Dr Zimmerman) (CCRI(II)/03-11):

- a new programme is being set up to disseminate standards for nuclear medicine for the calibration of ionization chambers;
- the aim is for the IAEA to act as a secondary laboratory to provide standards and technical advice to Member States.

CSIR-NML (Dr Simpson) (CCRI(II)/03-16):

- an additional member of staff has been recruited;
- solid water equivalent reference sources are being produced;
- a non-extrapolation method has been developed and is being tested for ^{54}Mn and ^{65}Zn.

The report of the ENEA from Dr De Felice was noted (CCRI(II)/03-35).

9 CURRENT AND FUTURE BIPM PROGRAMMES (CCRI(II)/03-38 AND CCRI(II)/03-39)

Dr Michotte summarized other projects taking place at BIPM. A novel system has been developed for accurate dead-time correction of gamma-ray spectrometers using a fast analogue switch. TDCR is being tested and the NPL-ANSTO digital signal processing system is being investigated. The energy response function of the SIR ionization chamber is being developed using Monte Carlo

simulations (using GEANT in collaboration with the IRA) and by experimental data (the latter project is a collaboration with NPL).

Future projects for the BIPM involve investigating the influence of gas pressure on ^{85}Kr measurements and the effects of the density of solutions in the SIR, upgrading the hardware and software for the coincidence counting systems and Monte Carlo simulation studies using a different code (PENELOPE).

Dr Michotte added that submissions to the SIR of the following radionuclides were needed to improve the key comparison reference values: ^{24}Na, ^{67}Ga, ^{99}Mo, ^{103}Ru, ^{111}In, ^{124}Sb, ^{140}Ba, ^{153}Gd, ^{153}Sm, ^{154}Eu, ^{155}Eu, ^{166}Ho^{m}, ^{169}Yb, ^{177}Lu, ^{195}Au, ^{201}Tl, ^{207}Bi and ^{243}Am.

10 *METROLOGIA* SPECIAL ISSUE

Prof. P. Martin (editor of *Metrologia*) announced that a special issue on the subject of radioactivity metrology was planned for 2005 or 2006. Submissions were needed six months ahead of publication. The issue was expected to have 150 pages. Organizers were needed to recruit authors, appoint referees and identify topics for the issue.

Prof. Moscati welcomed the opportunity to highlight work in the field of radioactivity and to enhance the status of *Metrologia* in the community. He added that it would be a valuable reference material. Dr Simpson said that a committee should be set up to coordinate actions.

A discussion took place on whether material to be covered at the VERMI training courses on radioactivity metrology would be suitable for publication. Dr Simpson expressed the view that the issue should be a reflection of “state-of-the-art” rather than training material. Prof. Moscati said that the special issue of *Metrologia* should be aimed at a wider audience and VERMI should concentrate on the basic science.

The NPL (Dr Judge), CIEMAT (Dr Los Arcos) and the NMIJ/AIST (Dr Hino) offered to send representatives to participate in the coordinating committee.

11 TRENDS AND FUTURE METROLOGICAL NEEDS

Prof. Moscati explained that a report had to be prepared for the forthcoming General Conference. He expressed concern that the public knowledge of the field of ionizing radiation is poor and that, in

general, only bad news is publicized. He felt that the benefits for the general public needed to be emphasized. Ideas for the report would be welcome and CCRI(II) members should send these to Dr Allisy-Roberts.

Dr Alexiev recommended using case studies to illustrate the beneficial uses of ionizing radiation.

A general discussion followed on possible approaches to show the need for standards of radioactivity. Mr Woods said that nuclear medicine was widely used and there was increasing use of radionuclides for targeted radiotherapy. Dr Allisy-Roberts reported from IAEA and WHO data published in 1999 that 18 million doses of radiopharmaceuticals were dispensed per year and there were four million radiation workers worldwide. For doses of radiopharmaceuticals to be assayed with an accuracy of better than 5 %, instruments should be calibrated to better than 2 % and national standards were needed to 1 % accuracy. Dr Coursol said that there were no specific regulations in France to enforce these limits but that hospitals aim for an accuracy of 5 %. Dr Dryák thought that 5 % was difficult to achieve in practice and 10 % was more realistic. Dr Judge added that radiopharmaceutical manufacturers dispense doses in compliance with tolerances set in the drug license or in the relevant Pharmacopoiea and these were typically 10 %. Dr Allisy-Roberts understood that a hospital in the United Kingdom could be prosecuted if the delivered therapy dose is more than 10 % from the prescribed dose.

Dr Los Arcos said it might be useful to indicate to the CIPM the number of organizations that are supported by activity standards, for example, in Spain, the national standards are used by 120 companies, 25 universities and 80 hospitals. Dr Simpson agreed that these figures do show the impact of radioactivity standards.

Dr Allisy-Roberts underlined the need to gain support for radioactivity measurements during the CGPM noting that the BIPM budget was set at the General Conference.

Dr Zimmerman concluded the discussion with a further example of the need to maintain an international infrastructure for radioactivity measurements. The IAEA provides reference standards for some member organizations but had been challenged to demonstrate that the standards were correct.

12 CCRI(II) MEMBERSHIP (CCRI(II)03-18)

Dr Allisy-Roberts set out the criteria for membership of the CCRI(II). Key points were:

- the member is the organization, not the individual;
- the organization must be a national metrology institute or a designated laboratory of the country;
- it must have an active research programme, shown by publications;
- it must participate in comparison exercises.

The following organizations were asked to update their records on the CCRI web site to demonstrate that these criteria are being met: the ANSTO, CIEMAT, NIM, NIST, NRC, OMH, PTB, RC and the VNIIM.

Two NMIs with observer status, CMI and LNMRI/IRD, were encouraged to apply for full member status. NMi would remain an observer. Dr Ross confirmed that the NRC was no longer active in the field and could not object to the NRC becoming an observer.

Other organizations that are active in the field (the BARC, BEV, CNEA and IFIN-HH) may be invited to attend as guests. It was noted that the BARC and the CNEA were not designated laboratories at the time of the meeting. Dr Allisy-Roberts would check whether the IFIN-HH is a designated laboratory; if so, they will be invited to apply to be an observer. It was commented that the BEV has no primary standardization systems. Each of these laboratories would be contacted to check their publications before being invited to attend future meetings as guests. The IAEA and the IRA were also encouraged to apply formally for observer status.

13 ANY OTHER BUSINESS

Dr Allisy-Roberts will write to Mr Gostely (IRA) to thank him for his input over the many years that he had participated as a personal member of the CCRI(II) and its predecessor, the CCEMRI.

Regarding the working documents of the meeting, it was agreed that documents will be restricted if they are provisional or intended for publication elsewhere. All other documents will be open. Any PowerPoint presentations will be placed on the password protected area of the BIPM website.

Dr Coursol requested that the terms of reference for membership of a Consultative Committee should be added as a working document (CCRI(II)/03-34).

14 DATES OF NEXT MEETINGS

It was proposed to hold the next CCRI(II) meeting at BIPM in May 2005.

The next meeting of the Extended SIR Working Group was scheduled for 2 and 3 October 2003.

The Key Comparison Working Group would meet later in 2003.

A joint meeting of the Measurement Uncertainties Working Group and the Key Comparison Working Group would be scheduled in 2004.

It was noted that the next ICRM conference would be held in Oxford, United Kingdom, in September 2005.

The Chairman, Dr Simpson thanked Dr Allisy-Roberts and the staff at BIPM for organizing the meeting and also all of the delegates for their input. To conclude, the committee thanked Mr Reher for his hard work and his contribution to the field of radionuclide metrology and wished him a very happy retirement.

S.M. Judge and M.J. Woods, *Rapporteurs*

September 2003

Revised February 2004

CONSULTATIVE COMMITTEE
FOR IONIZING RADIATION

Section III: Neutron measurements
Report of the 15th Meeting
(26-27 May 2003)

Abstract

Section III (Neutron measurements) of the Consultative Committee for Ionizing Radiation (CCRI) held its fifteenth meeting at the Pavillon de Breteuil, Sèvres, on 26 and 27 May 2003. The more rapid pace of key comparisons initiated at the thirteenth meeting is continuing. The final draft report on the fast neutron fluence rate comparison CCRI(III)-K10 (Pilot PTB) is expected within the next few months. All measurements for the neutron source emission rate comparison CCRI(III)-K9.AmBe (Pilot NPL) are scheduled for completion by the end of 2003. Agreement has been reached for the thermal neutron fluence rate comparison CCRI(III)-K8 (Pilot NIST) to proceed under a revised protocol following the successful example of the CCRI(III)-K10 comparison at a single laboratory, rather than by the slower procedure of circulation of a transfer instrument to many laboratories around the world. Agreement was also reached on a procedure for resolving problems in the uncertainty analyses of two participants in the 24.5 keV comparison CCRI(III)-K1 so that the publication of the results of this comparison can proceed. Section III received a report on the status of the RMO comparison of neutron survey meter calibrations, EUROMET project 608, EUROMET.RI(III)-S1 (Pilot BNM/IRSN), and plans were made by two participants to conduct a bilateral comparison of neutron fluence rate measurements at 19 MeV as a EUROMET supplementary comparison. Section III was advised of stricter deadlines adopted by the Joint Committee of Regional Metrology Organizations and the BIPM (JCRB) for reviews of lists of calibration and measurement capabilities. Finally, there was an exchange of information on the status of neutron metrology at the participants' laboratories, emphasizing current applications and future needs.

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

Section III (Neutron measurements) of the Consultative Committee for Ionizing Radiation (CCRI) held its fifteenth meeting at the Pavillon de Breteuil, Sèvres, on 26-27 May 2003.

The following were present: T. Bolognese (BNM/ISRN), D.M. Gilliam (NIST), H. Klein (Chairman of Section III, PTB), N.N. Moisseev (VNIIM), G. Moscati (President of the CCRI), W.W. Pereira (LNMRI/IRD), A.J.M. Plompen (IRMM), D.J. Thomas (NPL), A. Uritani (NMIJ/AIST).

Observer: A. Wambersie (ICRU).

Guests: B.R.S. Simpson (Chairman of Section II), M. Kralik (CMI).

Also present to all or part of the meeting: P.J. Allisy-Roberts (Executive Secretary of the CCRI, BIPM), P.W. Martin (Editor of *Metrologia*), A. Samuel (Executive Secretary of the JCRB), C. Thomas (KCDB Coordinator), A.J. Wallard (Director designate of the BIPM).

Apologies: K. Kudo (NMIJ/AIST), J.J. Broerse (IRI/TNO), T.J. Quinn (Director of the BIPM), P.P. De Regge (IAEA), C. Rong (CIAE), Yang Yuandi (NIM).

The Director designate of the BIPM welcomed the participants of Section III, noting that Dr Quinn was attending a meeting of EUROMET.

Dr H. Klein, Chairman of Section III, welcomed participants and invited everyone to introduce themselves briefly for the benefit of the new participants. He commended Dr P.J. Allisy-Roberts on the preparations for the meeting and welcomed Dr B.R.S. Simpson, Chairman of Section II.

Dr D.M. Gilliam was proposed and accepted the task of rapporteur.

The agenda proposed by Dr Klein was accepted with the addition of two topics for discussion under the heading “Other business”. These were the designation of open or closed status for each working document presented at the meeting with regard to public access on the BIPM website and, a special issue of *Metrologia* reviewing the metrology of ionizing radiation.

2 MINUTES OF PRECEDING MEETINGS OF CCRI AND SECTION III

Prof. Moscati, President of the CCRI, welcomed the attendees and referred them to the published report of the seventeenth meeting of the CCRI, of which printed copies were available.

No changes were suggested to the report of the fourteenth meeting of Section III that is included in the CCRI report.

3 MEASUREMENT COMPARISONS UNDER SECTION III

3.1 Neutron fluence rate CCRI(III)-K10 (Pilot PTB)

The CCRI key comparison on neutron fluence rate measurements was performed in March 2001 by participants from the CIAE, IRMM, NIST, NMIJ, NPL, PTB and the VNIIM at the accelerator facility of the PTB. The fluence of monoenergetic neutrons with the ISO-recommended energies 144 keV, 1.2 MeV, 5.0 MeV and 14.8 MeV was to be determined at a distance of 1 m from the target (in vacuum) normalized to one count of a selected neutron monitor. The pilot laboratory provided in June 2001 a detailed description of the neutron field properties, including the relative spectral neutron fluence of uncollided and target scattered neutrons, the observed mean energy for each nominal neutron energy, and the neutron monitor rate with proper correction factors accounting for the particular set-up of the fluence measurement systems including shadow cones. As the evaluator, Dr H. Klein from the PTB, received the last report from the participants in April 2002. Two laboratories, the NIST and the VNIIM, had been asked to re-investigate their data analysis and they provided revised data in November 2002. In addition, the CIAE submitted a supplement with the requested description of details of their primary standard instruments employed at the PTB. Copies of all reports were distributed to the participants in December 2002, which is therefore regarded as the completion date of the comparison exercise. In May 2003, the evaluator distributed the first draft of a type B report to all participants for discussion at the 15th meeting of Section III.

Dr Klein presented the report in great detail. First he discussed the calculation of the spectral fluence of the desired uncollided, almost-monoenergetic neutrons and of the unavoidable background of neutrons scattered from the target assembly into the point of measurement. The participants confirmed that they had corrected their fluence measurements in an adequate way for the fraction of scattered neutrons which amounted to up to 3.5 % of the total fluence rate. Dr Klein also showed that the calculated mean energy of the desired neutrons was well confirmed by spectrometry. He then demonstrated how the monitor rates were inspected and corrected for instabilities of the fields and for the influence of the instruments installed for the fluence measurements, including the shadow cones used to determine the response to air-scattered and room return neutrons. The groups agreed with the statement that the uncertainty of the properly corrected neutron monitor rate did not exceed 0.5 %. Reproducibility of the neutron fields investigated on different days was confirmed to better than 0.5 % by repeated fluence measurements of the pilot laboratory for all neutron energies except for the 5.0 MeV field for which a scatter of about 2 % in the fluence per monitor count was observed.

The final data sets were then evaluated for unweighted means, weighted means and median values. The results were discussed in detail for the four neutron energies. The uncertainty budgets reported by the participants were regarded as adequate and complete and will be added to the report in an appendix. The group finally decided to propose the weighted mean values for the key comparison reference values (KCRVs). All data reported by participants will be considered for the KCRVs except for the 14.8 MeV result of the VNIIM that will be excluded from the analysis as an obvious outlier. The degree of equivalence will then be derived from these data sets. Dr D.J. Thomas (NPL) then reported on recent results obtained for the effective centres of the De Pangher long counter employed at the PTB which resulted in slightly revised data of the fluence of 144 keV, 1.2 MeV and 5.0 MeV neutrons. Although these new data are regarded as more reliable and would even improve the database, these results cannot be considered in the final analysis of this key comparison because they were obtained after the completion date. For the same reason, the revised response functions which the VNIIM recently obtained for their transfer instrument cannot be considered although the outlier at 14.8 MeV is now explained and the revised 1.2 MeV result would also improve the database considerably. This information will, however, be included in the final report. Section III agreed that the final report should be based on the draft B report considering all the decisions taken at the meeting and the suggestions of some participants for editorial changes. Dr Klein promised to prepare the draft of the final report for distribution within a period of two months. The plan accepted by Section III for publication of the results is that the final report would be posted on the BIPM key comparison database (the KCDB), as a *Metrologia Technical Supplement* with a link to the appropriate web page. No other possibilities for publication of the results were suggested.

3.2 Fast neutron fluence measurement: Bonner sphere comparison at 24.5 keV CCRI(III)-K1 (Pilot NPL)

The report of the evaluator Dr V. Lewis (NPL) (CCRI(III)/01-07) had already been discussed in great detail at the 14th meeting of Section III. The report has to be expanded considerably because the descriptions of the primary standard instruments used by some of the participating laboratories are missing, as are their uncertainty budgets. In addition, the calculations of the CIAE and the VNIIM for the spectral fluence for their Sb-Be sources were questioned. Since the considerable corrections for the fraction of high-energy neutrons seem to be quite uncertain, the rather small uncertainties claimed by these laboratories may not be justified. The laboratories were asked to calculate the source spectra for both sources using their normal procedures in order to check for consistency. Section III is still waiting for these new results. Provided that consistent results are obtained, the claimed uncertainties will be accepted for the final analysis of the data sets submitted. Section III already agreed to propose the weighted mean as the key comparison reference value from which the degree of equivalence will be derived. Complete uncertainty budgets are still required for the report and for publication in the KCDB. Section III will ask Dr V. Lewis, who very recently retired, to update his report according to the CIPM guidelines, with support from Dr D.J. Thomas and Dr H. Klein who will urgently ask the CIAE and the VNIIM for appropriate actions.

3.3 Neutron fluence rate: thermal neutrons CCRI(III)-K8.B-10 (Pilot NIST)

The comparison exercise had been started according to the agreed protocol (CCRI(III)/01-11). The initial measurements at the NPL, however, exhibited serious problems with the transfer instruments, in particular the sensitivity of the B-10 ionization chambers to environmental disturbances (noise, electromagnetic interference) and long-term instabilities. Dr D. Gilliam therefore suggested discontinuing the exercise as originally planned. He proposed instead to use different well-characterized thermal neutron fields available at the NIST research reactor for the comparison exercise. Neutron fluence rates from $10^4\,cm^{-2}\,s^{-1}$ to $10^9\,cm^{-2}\,s^{-1}$ can be realized to meet the requirements of the different instruments and methods, which may be used by different participants for the measurement comparisons. Section III agreed with the proposals and six laboratories, the IRMM, IRSN, NMIJ, NPL, PTB and the VNIIM, expressed an interest to participate in this comparison which, however, can only be carried out in the spring of 2005 at the earliest. Dr Gilliam will distribute a revised protocol including the main properties of the available fields, the monitoring procedures and the irradiation conditions within the next few months for comments. The project will then be continued as CCRI key comparison CCRI(III)-K8.

3.4 Neutron emission rate CCRI(III)-K9.AmBe (Pilot NPL)

The comparison exercise was started in 1999 and is still on schedule, in spite of one considerable delay of more than one year. Dr D.J. Thomas reported on the status and the final actions still planned in 2003. The measurements with the travelling AmBe source were recently completed at the LNMRI/IRD. Next, the source emission will be measured at the NIST, then at the NPL for a second time, and finally at the BNM/IRSN. The end of the year 2003 should see the completion of all the measurements. The participants were asked to send their reports to Dr H. Klein with a detailed description of the measurement method, the corrections applied and a complete uncertainty budget for their results, according to the GUM recommendations. Dr Klein will act as the repository for all reports until the report of the NIST is available. Reports should be sent to him within two months after completion of measurements. The complete set of reports will then be sent to Dr J. Adams at the NIST, who will be asked by Section III to evaluate this key comparison.

3.5 Future comparisons

At the preceding (14th) meeting of Section III, the IRMM proposed a comparison exercise with 19 MeV neutrons. As the PTB was the only other laboratory to express an interest, Section III suggested that this comparison should be run as a EUROMET supplementary comparison. The IRMM and the PTB agreed and will immediately propose this exercise to EUROMET for approval.

There seems to be no urgent need for other comparison exercises before the current and planned exercises are finalized.

4 RMO COMPARISON: COMPARISON OF NEUTRON SURVEY METER CALIBRATIONS EUROMET PROJECT 608 EUROMET.RI(III)-S1 (PILOT BNM/IRSN)

Dr T. Bolognese, BNM/IRSN, reported on the status of the EUROMET project 608, initiated by the EUROMET and approved by the CCRI as an RMO supplementary comparison. Seven partners from the EUROMET, the CMI, IEA, IRSN, NPL, SCK, SMU and the PTB together with four laboratories from other RMOs, the CIAE, IRD, NIST and the VNIIM, will participate in this comparison. Due to technical problems with one of the transfer instruments, the start was delayed until summer 2003. The coordinator, Dr L Van-Ryckeghem from the BNM/IRSN, will prepare a schedule taking into account the time windows offered by the partners within the next two years. Provided that the transfer instruments are not kept for more than one month in each laboratory, this comparison exercise could be completed by the summer of 2005. The participants were requested to keep within the proposed schedule as a matter of urgency.

5 THE MUTUAL RECOGNITION ARRANGEMENT

Dr Angela Samuel, the Executive Secretary of the JCRB, presented to Section III the status of the MRA database Appendix C entries as shown on the JCRB web page. She emphasized that the JCRB had defined rules with some stricter deadlines for the review of the CMC lists. The status of the CMC lists submitted by the RMOs to the JCRB may be taken from this JCRB web page.

6 EXCHANGE OF INFORMATION ON WORK IN PROGRESS AT THE PARTICIPANTS' LABORATORIES

6.1 IRMM (CCRI(III)/03-25)

Dr A. Plompen discussed recent activities at the IRMM related to data needs for characterization and transmutation of nuclear waste, as well as data needs for basic nuclear physics and standards. Some topics of research included yields of fission fragments and tritium (from ternary fission), production of ^{14}C in nitride fuels for accelerator-driven thorium-fuelled sub-critical reactor systems, and refinement of the ^{10}B cross-section standard.

of ^{14}C in nitride fuels for accelerator-driven thorium-fuelled sub-critical reactor systems, and refinement of the ^{10}B cross-section standard.

6.2 BNM/IRSN (CCRI(III)/03-18)

Dr T. Bolognese-Milstajn discussed recent progress at the BNM/IRSN in the set-up and characterization of a "realistic" radiation field called CANEL at the T400 accelerator. The 3.3 MeV neutrons from the (d, d) reaction are moderated by layers of iron and water. The neutron spectrum as measured by the Bonner sphere method was compared with MCNP4C simulation as part of the EUROMET 670 project.

6.3 LNMRI/IRD (CCRI(III)/03-09)

Dr W. Pereira listed a wide range of activities in calibrations, irradiations, preparation of ISO reference fields based on radionuclide neutron sources and a new 14 MeV neutron generator. He described both the experimental and computational capabilities at the LNMRI/IRD. The Laboratório de Neutrons has completed its measurements in the neutron emission rates comparison, using the manganese sulfate bath method and new MCNP calculations of correction factors.

6.4 NIST (CCRI(III)/03-01)

Dr D. Gilliam described the thermal neutron and cold neutron beam facilities at the NIST that will be available for the revised protocol of the thermal neutron fluence rate comparison. New work in neutron spectrometry in collaboration with the Russian Institute for Nuclear Research was described. This work is motivated by needs for neutron detection and radiation protection related to United States homeland security projects.

6.5 NMIJ/AIST (CCRI(III)/03-03 and CCRI(III)/03-04)

Dr A. Uritani described recent work in spectrum adjustment for shallow or deep tumours in boron neutron capture therapy and depth-dose measurements in water phantoms at the NMIJ/AIST. Both an optical fibre neutron detector and gold wire activation were used to make measurements in the phantom. Preparations of the ISO monoenergetic fast neutron standard fields between 8 keV and 19 MeV at a new Pelletron-type accelerator at the JAERI were described. At the facility for radiation standards of the JAERI, the graphite pile for both internal neutron fields and external neutron beams has been enlarged and refurbished (CCRI(III)/03-07).

6.6 NPL (CCRI(III)/03-08)

Dr D.J. Thomas summarized recent developments in neutron metrology at the NPL. The MCNP code was employed to investigate corrections for parasitic neutron reactions in manganese bath measurements and to investigate calculations of the effective centre of long counters as a function of incident neutron energy. Significant revisions (~1 %) in the bath corrections were attributed mostly to a factor-of-two change in the (n, α) cross section of oxygen. It was noted that spurious trends and correlations in the effective centre calculations could occur if the MCNP code was permitted to start successive calculations with the same random number seed. Considerable improvements were achieved in calculating the effective centre of the long counter in dependence of the neutron energy.

6.7 PTB

Dr H. Klein made a presentation on recent work at the PTB, including calibration field developments, lithium target phenomena, neutron spectroscopy developments, dosimetry developments, and micro beam research. The organization of PTB neutron work was revised to include the designations: Ion accelerators and reference radiation fields (new Department 6.4), and Neutron radiation (new Department 6.5). Experiments with neutrons on lymphocytes have given an RBE value for fast neutrons of the order of 28 ± 13 relative to 200 keV x-rays. Experiments with a portable water calorimeter have shown that a single curve for caloric defect as a function of LET applies to all of the following ions: ^{4}He, ^{2}H, ^{1}H, and ^{12}C. The new micro ion beam facility allows the irradiation of biological samples with a pre-selected number of ions and a wide LET range. The beam and sample position can be aligned with an uncertainty of 2 μm. (No document available.)

6.8 VNIIM (CCRI(III)/03-10)

Dr N. Moisseev reviewed the recent research and comparison activities of the VNIIM. Research efforts included study of fast neutron interactions with carbon and thermal neutron measurements in a large, spherical, accelerator-driven graphite pile. Applied work included calibration of secondary standards, tests of a scintillation spectrometer for mixed neutron/gamma-ray fields, and tests of bubble detectors. A ^{248}Cm neutron source of 10^{6} neutrons per second has been produced, but regulatory problems prevent its circulation.

6.9 CMI (CCRI(III)/03-17)

Dr M. Kralik discussed recent activities of the CMI. Calibrations of ^{252}Cf sources were made for use in brachytherapy and intracavity therapy for cervical carcinomas. Personal dosimeters were calibrated using AmBe and bare or moderated ^{252}Cf sources. Bonner sphere measurements were used for neutron spectroscopy in workplaces at nuclear power plants and around clinical linacs. The creation of photoneutrons in the polyethylene of the Bonner spheres by high-energy photons had caused some measurement problems. Solutions were derived for six of the eight numerical

comparisons in the EU concerted action for the quality assurance in dosimetry workshop (QUADOS) to be held in July 2003.

The title of the workshop is "Intercomparison on the usage of computational codes in radiation dosimetry" (http://www.nea.fr/download/quados/quados.html)

6.10 CIAE (CCRI(III)/03-02)

The developments and plans at the CIAE were noted in the unavoidable absence of Dr C. Rong.

7 QUANTITIES AND UNITS (CCRI(III)/03-13 AND -14)

Various resolutions to change the explanation of dose equivalent in the SI brochure were presented to Section III for comments and suggestions. After a short discussion Section III followed the suggestions of Dr Wambersie, member of the main commission of ICRU. This was to agree to delete the free parameter N in the current definition of dose equivalent quantities, so that it becomes $H = Q \cdot D$, and to delete organ equivalent dose from the list of quantities pertaining to the sievert.

8 TRENDS AND FUTURE NEEDS IN NEUTRON METROLOGY

This topic was not discussed in great detail. The contribution, which Prof. Moscati has to present on behalf of CCRI at the next CGPM in October 2003, will be prepared on the basis of the minutes of recent meetings.

9 FUTURE MEMBERSHIP OF CCRI(III)

There was some confusion about the membership of CCRI(III). Dr Kralik (and Dr Dryák in Section II) are currently invited as guests to the meetings. In order for the CMI to become members

of the CCRI sections, the president of the CMI, Dr Klenovsky, needs to propose this to the next CIPM meeting (CCRI(III)/03-16).

Dr Klein is in contact with Dr Park from the KRISS. The ionizing radiation division is going to extend the activities in the field of neutron metrology with applications in nuclear technology (e.g. in core spectrometry) and radiation protection (dosimetry and workplace spectrometry). Since the KRISS had already participated in the key comparison on neutron emission rate measurements, the Chairman agreed to invite them as a guest to the next meeting.

As part of the commitment for CCRI(III) membership, all participants were asked to provide an updated list of publications which are related to neutron metrology and dosimetry and appeared or were submitted in recent years.

10 OTHER BUSINESS

10.1 Public access to Section III working documents

The status of the CCRI(III) documents was discussed. Most of the working documents on the BIPM web page, which previously were only accessible by CCRI(III) members, will be opened for public access. The participants were also asked to provide the files of their laboratory presentations for inclusion in the working documents although these would be accessible only by CCRI(III) participants.

10.2 Special Issue of *Metrologia*

Prof. P.W. Martin, editor of *Metrologia*, offered to publish a review of the metrology of ionizing radiation in special issues of *Metrologia* that may appear in 2005/2006. The idea, supported by the president of CCRI Prof. Moscati as an opportunity to promote the work of the CCRI, is to review the state of the art, current applications and future needs of metrology in the field of ionizing radiation. Each section of CCRI may publish a review with up to 150 printed pages.

Section III was asked to propose a list of topics for this special issue. Invitations to contributing authors, the assignment of referees (two per article) and the organization of the project will be the responsibility of the organizers from CCRI. A proposal could not be prepared immediately due to the short notice, but Section III regards this project as an excellent opportunity to describe the state of the art in this field and the Chairman will provide a proposal as soon as possible.

11 DATE OF THE NEXT MEETING

Subject to the approval of the CIPM, it was proposed that the next meeting of Section III be held in May 2005, during the same week as the meeting of the CCRI.

D. Gilliam, *Rapporteur*

June 2003

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