Bureau International des Poids et Mesures

Consultative Committee for Ionizing Radiation (CCRI)

Report of the 19th meeting
(27 May 2005)
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.

A.J. Wallard
Director BIPM

LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR IONIZING RADIATION

as of 27 May 2005

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.

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

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

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

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

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

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

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 Authority [SSI], 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.

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

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

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

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

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

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

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

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

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

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

National Institute of Metrology [NIM], Beijing.

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

National Laboratory for Metrology of Ionising Radiation, Institute of Radiation Protection and Dosimetry CNEN/Laborató rio 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 Office of Measures/Országos Mérésügyi Hivatal [OMH], Budapest.

National Physical Laboratory [NPL], Teddington.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

Radioisotope Centre Polatom [RC], Swierk.

Prof. Dr Gerhard Winkler, Institut für Isotopenforschung und Kernphysik "Radiuminstitut" [IIK], Radiuminstitut, Vienna.

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

Observers

Bhabba Atomic Research Center [BARC], Bombay.

International Atomic Energy Agency [IAEA].

International Commission on Radiation Units and Measurements [ICRU].

International Organization for Medical Physics [IOMP].

International Radioprotection Association [IRPA].

National Research Council of Canada [NRC], Ottawa.

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

Section III: neutron measurements

Chairman

H. Klein, Physikalisch-Technische Bundesanstalt, Braunschweig.

Members

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

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

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

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

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.

Prof. Dr J.J. Broerse, Interfaculty Reactor Institute, Department of Radiation Technology [IRI], Delft.

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].

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

CONSULTATIVE COMMITTEE FOR IONIZING RADIATION

Report of the 19th Meeting
(27 May 2005)

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1 OPENING OF THE MEETING

The nineteenth meeting of the Consultative Committee for Ionizing Radiation (CCRI)* was held at the Pavillon de Breteuil, in Sèvres, on 27 May 2005.

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

Also in attendance was: P.J. Allisy-Roberts (Executive Secretary of the CCRI).

The President opened the meeting by thanking the Section Chairmen for their three very productive and useful meetings. He appreciated that it was the last meeting that would be attended by Dr Klein, who would be retiring from the PTB in January 2006 but he hoped that future collaboration would be possible. The President also thanked the Director and his staff for the facilities provided for the meetings and expressed his satisfaction that the administrative procedures had worked well including the advanced organization and the smooth running of the meetings by the Executive Secretary.

Professor Moscati had been most encouraged by the participation in the meetings, especially in Section III where he had noted the presence of new, young faces. He felt that the freedom to comment and pose questions was a strong factor. Although there had sometimes been language problems, all the participation, with the support and encouragement of the Director, had been really helpful. He also commented that the meetings are becoming increasingly focused and professional and that there was good collaboration.

Regarding the content of the meetings, the President expressed the view that the CIPM MRA had changed the way in which participants view their work programmes and he was particularly pleased that Dr C. Thomas, coordinator of the KCDB, had been able to attend during the second week to provide the insight necessary for finding solutions to the problems raised. In general, he felt that many previously open questions had been solved during these two weeks and possible solutions for others had been presented.

Professor Wallard, who had unfortunately only been able to be present during Section I and briefly at Section II owing to prior commitments, was very impressed with the quality of the discussion and pleased to see such profitable outcomes. He expressed the view that the meetings had been very successful.

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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.

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* For the list of acronyms, click here.

** Documents for the meeting which are open access (underlined) 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 on a very good meeting that had some robust discussions with open and honest participation. He then presented the main highlights.

3.1.1 Workshop on dosimetry uncertainties

The Chairman reported that the CCRI(I) had held a very successful workshop on dosimetry uncertainties on the day before their meeting. Fifteen technical recommendations had been presented to the CCRI(I) who modified them slightly and created an open document for the benefit of all national institutes of metrology (NMIs). The only criticism that had been raised was the lack of time to deepen discussions. Professor W. Bich had been invited to make a presentation on using Monte Carlo methods to estimate uncertainties and this had prompted a lively discussion. The participants had asked the CCRI(I) to hold another such workshop and this would be planned in collaboration with a meeting at the LNE-LNHB scheduled for May 2007. The Chairman requested that the CIPM decide the date of the next meeting with the date of this workshop in view.

3.1.2 Fundamental constants and dosimetry quantities

At its previous meetings, the CCRI(I) had invited the ICRU to review the situation regarding the physical constants W/e and stopping power ratios. This was now becoming an urgent matter and the CCRI(I) requested that the ICRU expedite the review of available data, decide whether new data was necessary and present their report as soon as possible.

Some time had also been spent at the meeting discussing the problems associated with biologically weighted doses in radiotherapy. Although the sievert (Sv) is used as the unit for a similar weighted quantity for doses at the radiation protection level, it was not deemed appropriate for radiotherapy dosimetry. The CCRI supported the concerns of the CCRI(I) and recommends that the issue is resolved as soon as possible by the ICRU Quantities and Units Committee, in collaboration with the Consultative Committee for Units.

3.1.3 Corrections for air kerma standards

Dr Burns had presented his work on calculated corrections for air kerma standards and the NIM expressed their concern about the procedure to change national standards and the BIPM standard in particular. This resulted in a recommendation that the BIPM change should not take place before 1 July 2007, once the work had been published and the BIPM had contacted all the NMIs that would be affected.

A major concern was associated with the uncertainty of the change as the value of the change was greater than the expanded uncertainties of the two methods used to arrive at the value for air kerma. Although there is a strong scientific basis for making the change, the President recommended that the change itself should be carefully explained so as to make it totally transparent to the NMI users.

3.1.4 BIPM key comparison database

It was recognized that in the next five years there will be many comparisons that need to be repeated and that this will cause a peak in the workload of the BIPM. The CCRI(I) had agreed that the ten-year period of validity for a comparison would be extended to fifteen years as long as the date of the next due comparison is scheduled within this time.

A recommendation had also been passed by the CCRI(I) on the procedure for NMIs to follow if they make any changes to their own standards. The President suggested that the other Sections, II and III, considered the application of this recommendation to their own domains.

3.1.5 The BIPM work programme

The CCRI(I) fully endorsed the current and future programmes of work for the Ionizing Radiation section of the BIPM. The proposal for an international brachytherapy dosimetry standard had been strongly endorsed. For the long-term programme, the Chairman expressed the view of the CCRI(I) that the megavoltage work would require the installation of a linear accelerator. The Director suggested that various options would be explored to fulfil these needs for the NMIs.

3.1.6 *Metrologia* special issue

The topics and potential authors for the special issue on dosimetry had been agreed with a possible publication date for the end of 2007.

The Chairman concluded his presentation by indicating that the calibration and measurement capabilities (CMCs) for dosimetry were now well represented in the BIPM key comparison database (KCDB), but the participants at the meeting had commented that reviewing CMCs posed a considerable workload on the NMIs.

3.2 **Section II: activity measurements** (Chairman: B.R.S. Simpson)

Dr Simpson reported on the Section II meeting, explaining that the meeting had focused on activity comparisons as these were the most important component in supporting CMC submissions. All aspects relating to activity comparisons such as key comparison reference values (KCRVs), degrees of equivalence, uncertainties, infrastructure at the BIPM and comparison reports had been considered.

3.2.1 Proposals

During the course of the meeting, twelve proposals had been put to the meeting which had provoked good discussion with significant decisions:

a) The generic groupings table was finalized, with the few remaining concerns resolved at the meeting. The table would now be published.

b) Agreement was reached on new, updated KCRVs for a number of radionuclides.

c) To qualify for inclusion in the KCRV from January 2006, only solutions based on absolute measurements should be submitted to the SIR. Other submissions could be made for degrees of equivalence but not as contributors to the KCRV.

d) A workshop on uncertainties would be held perhaps in September 2006.

e) Agreement was reached to display the relative deviation (e.g. kBq/MBq) of results in addition to the absolute deviation on the graph of degrees of equivalence with the KCRV, in the KCDB.

f) Agreement was reached that once the final comments on a Draft A report are received, the first Draft B report is issued and the comparison results are no longer confidential.

g) It was agreed that the CCRI should create a series of guidance notes on the estimation of uncertainty components and that participants in comparisons must describe the mathematical model used in estimating their uncertainty components.

h) It was agreed that D. Reher and M. Woods would be invited to attend the Uncertainties Working Group as personal members.

i) It was agreed that the ^{35}S comparison would be brought forward to 2007, instead of the ^{131}Cs comparison as originally proposed.

j) The three SIM supplementary comparisons for matrix-based standard reference materials of soil, seaweed and shellfish meat required for environmental monitoring and oceanic studies would be open to all the regional metrology organizations (RMOs).

k) Suggestions were made for radionuclide terminology to be submitted to the IUPAC.

l) The proposal for the transfer instrument to be set up for short-lived radionuclides was approved to enable future key comparisons world-wide, initially for ^{99}Tc^{m} with a subsequent extension to include ^{18}F.

3.2.2 The BIPM programme

The Chairman stressed the vital importance of suitable infrastructure at the BIPM to meet the needs of NMIs, particularly in support of CCRI activity comparisons.

The short-term, medium and long-term plans for radionuclide measurement had been reviewed as well as the status of recent CCRI comparisons. In addition to BIPM participation in many of the key comparisons, presentations had been made on the status of equipment maintained at the BIPM. It was noted with pleasure that improvements had been made to the triple-to-double coincidence ratio (TDCR) method, including software enhancements. Tests were being made using both ^{3}H and ^{14}C, and measurements of ^{32}P were undertaken using the comparison solution. A new balance is in place and the SIR will be enhanced by the replacement of the electrometer.

A joint BIPM/NPL project had been described whereby non-linear fits to the SIR photon and beta efficiency curves were obtained, taking into account the impurities and the uncertainties. This has indicated that improvements to the KCRVs of a number of radionuclides are needed

(about 23) and a list was distributed calling for SIR submissions of these gamma-emitting radionuclides. It was also reported that an EXCEL spreadsheet is being prepared to improve the reporting of comparison results by the participating laboratories.

The proposed plans to maintain and extend the services offered were endorsed by the members. Of particular importance are the SIR and the extended SIR (for beta emitters), high resolution gamma detectors for impurity assessment, the K2 type comparison programme, the development and maintenance of a transfer system for short-lived radionuclides and the absolute measurement capability to be maintained. In the longer term, the plans to extend the SIR to alpha emitters and low-energy electron capture radionuclides and to develop new absolute measurement facilities had been fully endorsed.

3.2.3 Activity comparisons

All of the SIR comparisons prior to 2004 had now been published except for three radionuclides; ^{125}I for which the CCRI comparison had provided more coherent data, ^{54}Mn for which only the BIPM had made measurements and ^{228}Th for which the single result was equivocal. There are currently 90 key comparisons in the KCDB with twelve reports in circulation. The various RMO and Consultative Committee comparisons were mentioned, nine were complete and the others were at various stages from planned through to near publication. The ^{32}P comparison was in progress with an extended deadline for reporting the results and the ^{85}Kr comparison had been re-scheduled with a proposed start in October 2006.

A workshop to discuss the results of the previous activity comparisons had been held in December 2004. This had covered the previous two years of comparisons, including seven radionuclides. The Chairman reported the successful outcome of the workshop with collaborations on joint investigations for the few unresolved issues.

To reduce the workload from CCRI comparisons on the NMIs, the CCRI, through its Working Groups on Key Comparisons and on Uncertainties, had produced a table, named the generic grouping table, which groups radionuclides according to perceived measurement difficulty, for each of the various measurement techniques that are used for activity measurements. The successful measurement of a radionuclide in a grouping at the same or a lesser difficulty should reduce the need for K2 type comparisons to support CMCs and so the comparison programme for the next ten years could run at one radionuclide per year. The radionuclide chosen for a comparison starting later in 2005 is ^{55}Fe. Most of the radionuclides selected are non-gamma emitters, as laboratories are able to make extensive use of the SIR to demonstrate equivalence for gamma emitting radionuclides.

Alternatively, the RMOs can organize regional key comparisons for important gamma emitting radionuclides that are already the subject of SIR key comparisons and hence expand the coverage. This will be particularly important as many of the provisional results in the KCDB will be phased out from 2007 onwards to achieve the twenty year target for the acceptability of results.

3.2.4 Working groups

The Key Comparisons Working Group has been the arbiter over proposals for changes to the KCRVs, and has been heavily involved in producing the generic groupings table.

The Uncertainties Working Group has produced the recommended uncertainties for each radionuclide and its measurement method in the generic groupings table. Expected uncertainty budgets for each method are being developed and will eventually be available as EXCEL files. The appropriate way to handle correlations in input data and for the efficiency determination of gamma detectors is being finalized.

The Extension of the SIR Working Group has decided not to use commercial scintillators (partly due to patent protection over their content but mostly due to the non-reproducibility of different batches). A special scintillation cocktail called XAN was developed by the CIEMAT. A version named XAN6535 was distributed to the BIPM, ENEA, LNE-LNHB, NPL and the CIEMAT for testing purposes. Discrepant results to those at the CIEMAT were reported. A new version with slightly modified composition named XAN6040 showed better stability for up to 62 days. Samples of XAN6040 were distributed in April 2005 and preliminary results have been received from the BIPM and the LNE-LNHB. This cocktail looks promising for the 19 radionuclides likely to be sent to the extended SIR.

The Working Group on the Realization of the becquerel initially comprised only the IRMM and the NPL, and aims to design and build a highly reproducible ionization chamber for the SIR system. Accurate reproducibility is the most important criterion. The design and drawing have been checked, the parts have been machined but there is still a problem with the collecting electrode material, and also with the sample containers. Designs for the electrometer are being studied. The first tests of the chamber are expected at the end of 2005. Independent construction of the finalized design will be undertaken by the BIPM and the CIEMAT.

The coordinator of the Working Group on High Efficiency Photon Counting reported that the written text for the Monograph was in progress and that the MC code PENELOPE is being used to study the detection efficiency for x-rays and low-energy gamma rays. A technical presentation explained the need for corrections for ^{67}Ga and for ^{75}Se metastable states. This project is ongoing and may take some years to complete.

The Chairman presented a list of working group Chairmen and members for the approbation of the CIPM.

3.2.5 *Metrologia* special issue

A working group had been established to progress the special issue of *Metrologia* which is aimed at communicating radionuclide activity metrology to a wider metrology community. Suggestions for topics and layout that had been received were presented. Further progress is planned at the ICRM meeting scheduled for September 2005.

A list of working groups and their membership was presented by the Chairman. Details are available in the CCRI(II) report.

3.2.6 Regional metrology organization issues

The CMCs in radionuclide activity measurement have been very successful, with 3200 entries registered at the time of the meeting. Some CMCs cover a range of reference materials, a variety of radionuclides and material matrices. It is proposed to organize generic comparisons using a typical material matrix that would be commonly available. An example of this is the present NIST organized comparisons and these were confirmed as SIM supplementary comparisons.

3.2.7 Technical aspects

Professor K. Ledingham of Strathclyde University (UK) had been invited to present a seminar on the development and perspective for high-power laser production of radionuclides for positron emission tomography (PET). His presentation was welcomed by the CCRI(II).

The members of the CCRI(II) presented their research reports and these included new work on the simulation of the coincidence extrapolation method by the IRMM. This would give a better understanding of the efficiency curves obtained and would be used to investigate the spread of results in CCRI(II) key comparisons. The NPL reported on the development of new systems for internet enabled metrology for nuclear medicine. The CMI had produced a detailed MC model of their HPGe detector that has allowed an improved efficiency calibration.

Other projects were related to the TDCR method, production of large area sources with inkjet printers, use of Bayesian statistics for minimum detection efficiency calculations, and the development of a MC model of a $4\pi\gamma$ counter for the standardization of $^{99}Tc^{m}$.

At the BIPM, a useful general expression had been developed for the decay correction of a radionuclide ^{N}X in the presence of a metastable state $^{N}X^{m}$, without the need to know the time of decay from production. Another report described the measurement of ^{125}I using a secondary method that compared the x-rays from ^{139}Ce. The activity derived was in good agreement with an absolute method.

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

Dr Klein expressed his pleasure in seeing the increased interest in neutron metrology by the NMIs. Both the KRISS and the CIEMAT had been present for the first time. The CIEMAT had been invited as a Guest as they are setting up a neutron metrology facility. Eleven NMIs were represented, which was highly satisfactory.

The Chairman explained that although the CCRI(III) agenda looked as if no progress had been made since the last meeting, in fact this year many satisfactory results and conclusions were reported.

3.3.1 Comparisons

Six comparisons were actually in progress, four of the CCRI(III) and two RMO comparisons. Dr Klein described the status of each one.

The report for the monoenergetic neutron fluence measurements (CCRI(III)-K10) had now been presented, discussed and essentially approved. New information would be included in the report on the primary standards but this would not influence the KCRV. There was only one outlier and this will not be included in the equivalence tables but would be included in the report. Dr Klein hoped to be able to present the Final Report to the participants and then send it for publication.

The 1999 emission rate comparison (CCRI(III)-K9.AmBe) had been subject to various delays. This had been planned to be completed by the end of 2004 but complications in the data analysis for two laboratories that had instabilities with their Mn baths resulted in them repeating their measurement series at the end of the comparison. The KRISS had finished in May and the neutron source was currently in China and the CIAE had agreed to finish their measurements by

the end of June. The last report should then be received by the end of September. Dr Klein is collecting the reports and once he has them all, he will send them to the evaluator (Neil Roberts at the NPL). In this way, the Draft A report should be ready by the end of the year if there are no further difficulties. Dr Klein himself would check for any significant discrepancies in the results and also contact the laboratories to check their uncertainty budgets.

The original proposal to circulate two ^{10}B ionization chambers for the comparison of fluence measurements in thermal neutron beams (CCRI(III)-K8) had been stopped as the chambers had proved to be unstable in use. Instead, the NIST had offered to run the comparison at the NIST but could not do this before 2007. Consequently, the CCRI(III) had decided to perform this exercise in another way using transfer detectors with differing energy dependencies. The participants would then derive information on the neutron spectra as well as the fluence. This would fully check the measurement capability of the laboratories. The draft protocol would be produced in the next three months and the comparison could probably start by the end of the year. This had been an unexpected delay to this important work but Dr Klein had real hopes that it would now be possible.

Regarding the comparison that had been run in 1993 to 1996 (CCRI(III)-K1), Dr Klein reported that the first report had been produced in 1998 but he did not agree with the uncertainty estimates produced by some participants, as at that time there were no full uncertainty budgets. Then the CIPM MRA was signed and, as a consequence, he felt that the uncertainties were more important then ever. The CIAE, China had agreed to try and reconstruct an uncertainty budget but after this lapse of time, this was thought to be difficult.

The CCRI(III) had decided not to perform key comparisons for dosimetric quantities but to devolve these as RMO supplementary comparisons. The EUROMET has a comparison planned for survey meters but this had been delayed due to problems with one of the transfer instruments. There would be five participants from the EUROMET plus others from around the world.

In addition, the CCRI(III) had decided that as there were only three laboratories interested in high energy neutrons, a comparison of high energy fluences should also be a EUROMET supplementary comparison.

Consequently, Dr Klein felt that most of the comparisons were a good way along their path and at least one of the new ones planned would start by the end of the year.

3.3.2 Future needs

Dr Klein explained that there were no plans for additional comparison at the moment but that future needs would stay on the CCRI(III) agenda. Indeed, there were concerns about the measurement of personal dose equivalent and so he would be checking which RMO is willing and able to pilot such a comparison.

Dr Klein also explained that with his forthcoming retirement, he had recommended that his replacement as Chairman of the CCRI(III) should be presented to the CIPM. The CCRI was happy to learn that Dr D. Thomas of the NPL would be willing to take on this role although this would be for a comparatively short period, pending his own retirement within the next few years.

3.3.3 CIPM MRA

The Chairman announced that some CMCs were now published by the COOMET and by the EUROMET. The APMP and SIM CMCs were almost ready and should be approved for publication before too long.

The CMC review group had been working well and once the results of the comparison exercises were available they would be looking at the consistency of the results with the claims in the CMCs.

3.3.4 NMI reports

The Chairman reported that there had been some very interesting developments illustrated by the NMIs in their reports and presentations. The IRSN and the Brazilian NMI had both made good progress and the KRISS has significant plans for the future. Now that there was also an NIM delegate from China, this should increase the activities at the NIM for their Mn bath. However, he hoped there would be good collaboration between the NIM and the CIAE, and that the latter could be designated for their neutron beam fluence measurements.

3.3.5 *Metrologia* special issue

The CCRI(III) was also in favour of having a special issue of *Metrologia* devoted to neutron metrology. Dr Klein had presented a table of possible contents and potential authors and hoped to receive comments in due course. There had not been time at the meeting to discuss this issue. Dr Klein recommended that David Thomas co-edit the special issue and once comments had been received, a draft proposal would be ready at the end of 2006 so that this could be presented to the CCRI(III) in May 2007.

4 COMMON INTERESTS

4.1 CIPM MRA

Most matters had been covered during the individual section presentations. All three Chairmen supported the work of the RMO Working Group on CMCs and felt that this was helping to ensure the compatibility of CMC entries.

4.2 Future programme of the BIPM

The Chairmen reported that there had been very positive support from the laboratories for the proposed work programme of the BIPM. Dr Klein reported that the neutron section was not directly involved, and commented that there were economic problems particularly but not exclusively in Germany with reductions in budgets of 1 % to 2 % every year, with no end in sight. He also mentioned the iMERA project that would be coordinated between the different

EUROMET laboratories and provide additional funding. The BIPM Director pointed out that such funds could not be used to support the work of the BIPM directly.

The BIPM Director suggested that if the laboratories wished to support the ionizing radiation programme, then 6 months before the next CGPM in 2007, each NMI should discuss this with their Director to ensure they were properly informed of the needs.

4.3 Membership of Sections

Dr Klein reported that Dr Broerse had retired and that he would write to thank him for his input to the CCRI(III) over the years as a personal member. His name would then be removed from the official list.

Dr Sharpe reported that Dr A. Brosed would be retiring just before the next CCRI(I) meeting. He would write to thank him for his input and then he would cease to be a personal member of the CCRI(I); a relationship that had started after he had worked at the BIPM for about 18 months.

Regarding the membership of international organizations, the WHO would be invited by the BIPM Director as official observers. This was important as the WHO often gives directives to governments and any metrological implications should be addressed.

The RMOs are not members of the Consultative Committees but we would continue to write to RMO Technical Committee Chairmen to encourage them to nominate a Consultative Committee member as a spokesman.

4.4 Recommendations to the CIPM and the CGPM

A number of recommendations had been made during the meetings but the President identified these as being for the CIPM rather than the CGPM. He would present these in his report to the CIPM at their meeting scheduled for October 2005.

4.5 Future programme of the CCRI

The three Chairmen agreed that reporting on their Section's work to a small CCRI seemed satisfactory. There was some discussion on the timing of the Section meetings and whether these really needed to be held at the same period. There was concern that there was no time interval available between Section II and Section III and at least half a day was considered to be a minimum.

Apart from the agreement over organizing regular workshops, having seminars when appropriate during the CCRI meetings and completing the three *Metrologia* special issues, 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.

In response, Dr Sharpe requested a change to the name of the CCRI Section I (x and γ-rays, electrons) to CCRI Section I (x and γ-rays, charged particles). He felt this would better reflect the work that was followed so that it could include protons and heavy ion work that was already being reported by the Section members. Dr Klein said that at the PTB this was covered by

another route but that he would be happy to cooperate and saw no particular problem in changing the name of the CCRI(I).

5 DATE OF NEXT MEETINGS

The CIPM would be asked to reserve two separate weeks in May 2007 for the CCRI and its Sections. These dates were subsequently fixed by the CIPM as :

Week 19

9 to 11 May, Absorbed dose workshop

Week 20

14 to 16 May, CCRI(I)

Week 21

21 May, Activity comparisons workshop

22 May, Activity uncertainties workshop

23 to 25 May, CCRI(II)

Week 22

29 to 31 May, CCRI(III)

31 May, CCRI

6 CONCLUDING REMARKS

The President expressed his satisfaction with the operation of the CCRI. It had been a great pleasure for him personally in terms of following the evolution of change. He thanked all three Chairmen for their effective leadership of the CCRI Sections, especially to Dr Klein who will be retiring, to the Executive Secretary and the staff of the Ionizing Radiation section of the BIPM and to the Director of the BIPM and his staff for hosting the meetings.

April 2007

CONSULTATIVE COMMITTEE FOR IONIZING RADIATION

Section I: X- and γ-rays, electrons
Report of the 17th Meeting
(18-20 May 2005)

Abstract

The highlights of the meeting concerned proposed changes to air kerma standards with recommendations for their implementation, a one day workshop on measurement uncertainties that reported a number of recommendations to the CCRI(I) and the need for new work on the physical constants used in dosimetry. Analysis of key comparisons illustrated the need for an extension of the period of validity of key comparisons to provide support for the large number of dosimetry calibration and measurement capabilities now in the BIPM key comparison database. The current work programme of the BIPM in support of the NMIs was fully endorsed, with strong support for the medium-term proposal for an international brachytherapy standard. The CCRI(I) also supported the long-term proposals, particularly having megavoltage standards at the BIPM. The member laboratories presented highlights of their work with emphasis on developments in their national standards and agreement was reached on the plans for the special issue of *Metrologia* on dosimetry standards.

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 seventeenth meeting at the Pavillon de Breteuil, Sèvres, on 18, 19 and 20 May 2005.

The following members and representatives were present: A.H.L. Aalbers (NMi VSL), F. Bochud (IRA for METAS), A. Brosed (CIEMAT), I. Csete (OMH), P. Damen (NMi VSL), F. Delaunay (LNE-LNHB), S. Duane (NPL), S. Fedina (VNIIM), H.-M. Kramer (PTB), F.-J. Maringer (BEV) G. Moscati (President of the CCRI), M. Pimpinella (ENEA-INMRI), C. Ross (NRC-INMS), N. Saito (NMIJ/AIST), S.M. Seltzer (NIST and ICRU), P. Sharpe (NPL, Chairman of CCRI Section I), M.P. Toni (ENEA-INMRI), A.J. Wallard (Director of the BIPM), D. Webb (ARPANSA), Tian Zhongqing (NIM).

Observers: A. Meghzifene (IAEA), J. Mostert (CSIR-NML), J.G. Peixoto (LNMRI/IRD), V. Sochor (CMI).

Guest: A. Kosunen (STUK).

BIPM members also present for all or part of the meeting: P.J. Allisy-Roberts (Executive Secretary of the CCRI), D.T. Burns, I. Castelazo, C. Kessler, C. Michotte, S. Picard, G. Ratel, C. Thomas (KCDB coordinator).

Apologies were received from: C. Borrás (IOMP), J.-E. Grindborg (SSI), J. Kokocinski (GUM), P.H.S. Smith (IOMP), G. Stucki (METAS), A. Wambersie (ICRU).

The meeting was called to order by the Chairman, Dr P. Sharpe. Professor Wallard welcomed the delegates to the BIPM and to the 17th meeting of the CCRI(I), following which he drew attention to the General Conference on Weights and Measures (CGPM) scheduled for October 2007. He urged the participants to forward to the CIPM, through their institutes, topics for the agenda of the CGPM. Furthermore Prof. Wallard reported on the activities of the BIPM aimed at facilitating customs procedures for the international shipping of metrological equipment in general and radionuclide sources in particular during the course of comparisons. However, no substantial progress has yet been made although Prof. Wallard was cautiously optimistic about the eventual outcome. He wished the delegates a successful meeting. Dr Sharpe thanked Professor Wallard for his remarks, noting that several important issues were raised, some of which would be discussed during the meeting.

The delegates introduced themselves.

The agenda was adopted without change.

Dr Kramer was appointed as the *rapporteur*.

2 REPORT OF THE SIXTEENTH MEETING OF THE CCRI(I), 2003

The Chairman called attention to the reports of the 18th meeting of the CCRI including the 16th meeting of the CCRI(I) which are accessible through the web pages of the BIPM. Dr Allisy-Roberts posed the question as to whether the delegates felt that the provision of hyperlinks within the report to working and other documents, and similarly from the agenda, was a useful feature. The delegates confirmed the value of this facility.

3 CURRENT ISSUES IN DOSIMETRY

3.1 Physical constants

Mr Seltzer reported that no progress on physical constants has been made by the ICRU since the previous CCRI(I) meeting. He expected, however, that significant progress would be made before the next CCRI(I) meeting. Due to the urgency of the matter as a whole, and in particular for the stopping powers, the CCRI(I) decided that a letter should be sent to Prof. Wambersie putting emphasis on the need for the publication of a report on physical constants. It was noted that as a first step, the ICRU would establish a formal report committee. Mr Seltzer pointed out that the inclusion of data for proton transport would be desirable.

3.2 Corrections to air-kerma standards

Dr Burns, referring to CCRI(I)/05-25, presented the model forming the basis of his calculations and the results obtained for the correction factors for the BIPM air kerma standard for ^{60}Co radiation. The most important changes were identified as an increased correction for axial non-uniformity by 6.3×10^{-3} and a value of k_{wall} decreased by 1.6×10^{-3} while the product $(\mu_{\text{en}}/\rho)_{\text{air}}$, $_{\text{c}}(1-g_{\text{air}})^{-1}$ remains essentially unaltered. A first analysis of the ratio of the graphite to air stopping powers seems to indicate that a new value, about 2.5×10^{-3} lower, should be used (closer to the Bragg-Gray estimate than the Spencer-Attix value presently in use). However, such a change cannot be made without evaluating the impact of this change on the value for W. This is because the recommended value for W is derived largely, although not entirely, from evaluations of the product $(W/e)\cdot s_{\text{c,air}}$ that arise from comparisons of calorimetric and ionometric measurements. The net effect on air kerma standards, which are sensitive to the product $(W/e)\cdot s_{\text{c,air}}$, might be small. However a change in the W-value would have a larger impact on the realization of the unit gray using free air chambers, which are sensitive to W but not to $s_{\text{c,air}}$. On the basis of the evidence presented by Dr Burns, the CCRI urged the ICRU, through Mr Seltzer, to address this issue with high priority.

The CCRI(I) agreed that the BIPM should adopt the new values for correction factors for its air kerma standard for ^{60}Co radiation at some time after Dr Burns' results had been published in *Physics and Medicine in Biology*.

Dr Burns raised the question as to why, in the publication ICRU 60, the *bremsstrahlung* loss is not defined as the fraction of the kinetic energy of the electron lost in radiative processes. Apparently the word "kinetic" had disappeared during the transition from ICRU 33 to ICRU 60. Mr Seltzer agreed to address this issue in the ICRU.

Dr Saito referred to CCRI(I)/05-27 and presented results of investigations conducted at the NMIJ on aperture transmission and aperture scatter in free air chambers, aimed at minimizing these effects. The results seemed to indicate that thinner apertures can produce less scatter, which is in accordance with previously observed behaviour. However, more detailed considerations seem advisable, including issues such as the finite focal spot size, the conical shape of apertures and a detailed uncertainty budget.

Dr Saito went on to present his investigations on the response of a free air chamber and of a commercial parallel-plate chamber to radiation scattered on its way from the x-ray tube to the plane of measurement (CCRI(I)/05-29). The effects observed in his studies appeared to be larger than those observed at the BIPM. It was suggested that the source of the scatter should be analyzed either experimentally using different chamber types or by Monte Carlo methods. It was thought that the L-fluorescence radiation produced by the lead shielding that is used in the NMIJ experiment could have an effect.

Referring to CCRI(I)/05-31, Dr Pimpinella presented the results of Monte Carlo calculations on the correction factors k_e, k_{sc} and k_{fl} for the ENEA-INMRI free air chambers. The calculations were performed for a series of mono-energetic photon radiations. Correction factors for the x-ray spectra actually used were obtained by averaging over the measured spectra. With respect to the factors used hitherto, changes within about 10^{-3} were identified. The new values will be used at the ENEA once they have been published.

The changes to its air kerma standards proposed by the ENEA-INMRI lead to a general discussion on the procedures to be adopted for changing entries in the BIPM key comparison database, should this appear to be necessary. Subsequently, recommendations on the procedures to be followed were adopted, under topic 7.2.

Dr Toni referred to CCRI(I)/05-32 and gave an overview of the ENEA-INMRI dosimetric primary standards and of its gamma irradiation facilities. The presentation of new results for k_{wall} factors with values up to about 1.026, depending on the type of chamber, lead into a discussion on the overall uncertainties associated with these values. Doubts were raised whether an uncertainty of 10^{-4} is realistic for a correction factor of this magnitude when the mass-attenuation coefficient of graphite itself has an uncertainty of perhaps 2×10^{-2}. Further investigations into the uncertainties were recommended.

3.3 Uncertainties – feedback from the workshop on uncertainties

After some discussion of the issues raised during the workshop, the following recommendations CCRI(I)/05-45 were adopted by the CCRI(I):

- To encourage more evaluations, both theoretical and experimental, of stopping power data so that a new evaluation of W can be determined.
- To encourage NMIs to have different shapes and sizes of cavity ionization chamber standards to confirm volume estimations and correction factors.
- To adopt the notation $k_{\varnothing}$ for the fluence correction.

- To encourage the ICRU to produce their draft report on the base physical data for ionometry by the time of the next CCRI(I).
- To encourage laboratories to make their recombination corrections using the Niatel voltage ratio method, ideally using a ratio greater than 2 to reduce the uncertainties (Boutillon M., Volume recombination parameter in ionization chambers, *Phys. Med. Biol.*, 1998, **43**, 2061-2072).
- To encourage the NMIs to use [1] when evaluating the effects of pressure and humidity on ion recombination corrections.
- To encourage the BIPM to complete its uncertainty evaluation of ^{60}Co and ^{137}Cs half-lives (and the NIM for ^{60}Co) and publish the results.
- To take into account the effect of field size when making x-ray comparisons.
- To state the field size and calibration distance for x-ray calibrations.
- To encourage the NMIs and the BIPM to continue to study the effect of scatter by the aperture in x-ray beams and apply the necessary corrections.
- To encourage the NMIs and the BIPM to continue their research in both water and graphite calorimetry.
- To encourage the NMIs and the BIPM to undertake research into standards for both high-energy photon and electron beam dosimetry.
- To recommend that members look at the draft GUM Supplement 1 ("Propagation of distributions using a Monte Carlo method") to see how applicable it could be to the evaluation of uncertainties in dosimetry.
- To hold a dosimetry workshop in association with the next CCRI(I) in 2007.

On behalf of the CCRI(I), Dr Sharpe expressed his gratitude to the BIPM and its staff for the organization of the workshop on uncertainties. Feedback from participants had been very positive and highlighted the value of the event.

3.4 Definitions of quantities and terminology (revision of SI Bochure)

The recommendations of the 18th meeting of the CCRI in 2003 have been included in the proposed revision of the SI Brochure. The two important changes are:

- New definition of the quantity dose equivalent $H = Q \cdot D$ (without the symbol N as in the old definition).
- Deletion of the quantity "organ absorbed dose".

The Executive Secretary has published a note of these CCRI recommendations in the *Journal of Radiological Protection* to announce them to the radiation protection community.

Dr Tian reported the confusion associated with the definitions of the quantities dose area product and dose length product used in diagnostic radiology. The CCRI(I) expressed the hope that the ICRU report on dose quantities to be used in diagnostic radiology will clarify these issues.

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

4.1 BIPM and CCRI key comparisons

Referring to CCRI(I)/05-01, Dr Allisy-Roberts presented an overview of the dosimetry comparisons and calibrations conducted at the BIPM since the 2003 CCRI(I) meeting. This presentation was followed by a general discussion on procedures to be followed by an NMI when the ten year period after its last key comparison expires.

As a general rule, an NMI has to conduct key comparisons at intervals no longer than ten years in order to keep its entries in the KCDB. However, given the number of comparisons due under this rule in the next few years, a proposal that the ten-year period after a key comparison may be followed by a five-year extension period was met with enthusiasm. Such a period could be granted if the NMI schedules a key comparison within the time of the extension period. To avoid possible confusion, the definitions of the various types of comparisons were presented:

- BIPM key comparison: conducted in the beams/facilities of the BIPM;
- CCRI key comparison: conducted between primary standards at the NMIs and the BIPM [N.B. a) and b) are both CIPM comparisons];
- RMO key comparison: with at least one participant from a) or b); and
- RMO supplementary comparisons: all other regional comparisons.

The CCRI(I) then endorsed the proposal concerning Recommendation R(I)-1 on the extension of the maximum time interval between key comparisons.

4.2 Appendix B (MRA) comparisons BIPM.RI(I)-K1, BIPM.RI(I)-K2, BIPM.RI(I)-K3, BIPM.RI(I)-K4

Dr Allisy-Roberts opened this topic by reporting that the air kerma comparisons in low- and medium-energy x-rays, and the absorbed dose comparisons in ^{60}Co, were published in the KCDB. However, she continued with an apology that the BIPM had as yet not published the report of the PTB results in the BIPM.RI(I)-K1 key comparison (air kerma in ^{60}Co radiation). In addition, there are four other reports outstanding and hence there is currently no information concerning degrees of equivalence for this key comparison in the KCDB. She planned to have this work completed by the end of the year.

Some laboratories had changed their ^{60}Co air kerma standards by implementing new k_{wall} factors while some had not yet done so. The CCRI(I) then discussed the procedures to be followed by an NMI when changing a national standard and approved Recommendation R(I)-2 on the declaration of a change to a national standard.

In either case, the initial report should be sent to the CCRI Executive Secretary at least six weeks in advance of the proposed implementation date to allow the CCRI(I) to have at least two weeks in which to confirm their approval.

The time scale actually required to agree on some changes may need to be longer depending on the magnitude of the change proposed. There was unanimous agreement that the international community needs to be informed and given a chance to react and prepare for such changes.

The CCRI further recommended that as the key comparison reference value is unity, the basis of the BIPM value for the quantity of concern, should be published with the relevant entries of the KCDB.

Dr Allisy-Roberts gave an overview of those entries in the KCDB for which a new key comparison will become due in the next few years.

In the light of the BIPM workshop on uncertainties a discussion followed on the treatment of correlations in comparisons. Dr Allisy-Roberts posed the question, which ultimately was left to be considered at a future meeting, as to whether correlations in the uncertainties for different NMIs should be taken into account in a generic way or by detailed considerations for each pair of NMIs. Mr Seltzer pointed to the vagueness of the criteria for taking correlations into account. As an example he asked whether correction factors calculated using the same code but for different free air chambers were correlated and if so to what extent. In the absence of firm evidence, he urged the use of only very rough estimates e.g. 0, 0.5 or 1.

Further points raised were that:

- Correlations should not be disregarded with the objective of achieving improved equivalence between different standards.
- Results obtained using one procedure are more likely to be correlated than results obtained with different methods (Dr Duane).

At the end of the discussion a resolution was passed to keep the correlation factor of 0.7 for the heat defect of water until better evidence is available, and to leave the other correlation coefficients as they are published at present.

4.3 Regional key and supplementary comparisons

Referring to CCRI(I)/05-08, Dr Csete presented the EUROMET project 813 on air kerma and absorbed dose to water in ^{60}Co radiation. As there many participants (26), the OMH (as the pilot laboratory) plans to prepare an interim report in October 2006. It is hoped that the project will be finished by the end of 2008.

Dr Aalbers gave an overview of the other EUROMET projects (CCRI(I)/05-39). Two bilateral comparisons between the LNE-LNHB (France) and the VNIIM (Russian Federation) and between the VNIIM and the PTB (Germany) are registered in the KCDB as EUROMET comparisons.

Dr Sharpe underlined the importance of a timely flow of information from the RMOs to the BIPM on the status of projects in order to keep the KCDB up to date.

The PTB's measurement protocols for the EUROMET project 738 (EUROMET.RI(I)-S5) on radiation protection quantities and for the EUROMET project 739 (EUROMET.RI(I)-S2) on absorbed dose for beta radiation have been agreed, and these comparisons are in the KCDB.

Referring to CCRI(I)/05-15, Dr Webb began with an overview of the current projects in APMP. In particular he mentioned problems with customs in the APMP.RI(I)-K1 comparison co-ordinated by the KRISS. In view of the BIPM desire to facilitate customs procedures, Dr Allisy-Roberts asked whether a protocol on customs procedures would be useful. This was confirmed, at least in principle. However, it was suggested that in view of the large case to case variability, the applicability of such a protocol might be rather limited.

Referring to CCRI(I)/05-18, Mr Seltzer addressed the SIM.RI(I)-K1 and SIM.RI(I)-K4 comparisons, the preliminary results of which were presented by Dr K. Shortt at the 2002 AAPM Congress.

In order to finalize the report of these two comparisons, Dr Ross and Dr Meghzifene volunteered to perform the remaining evaluation and prepare the final report.

On behalf of the COOMET, Dr Allisy-Roberts presented COOMET project 318 and explained that, following consultations between the VNIIM and the PTB, the measurement protocol has been altered so that each participating laboratory will be responsible for the measurement of ionization currents. The VNIIM will also take part in EUROMET project 813 (EUROMET.RI(I)-K1 and EUROMET.RI(I)-K4) to strengthen the cross-links to the COOMET comparisons.

4.4 Calibration of transfer standards

Referring to the earlier report CCRI(I)/03-54, it was reported that no progress has been made in publishing the results of a CCRI(I) study on the ratio of absorbed dose and air kerma calibration coefficients. Dr Duane volunteered to edit the draft and to circulate this among the participants so that publication could proceed.

5 CURRENT AND FUTURE PROGRAMME AT THE BIPM

Dr Allisy-Roberts, referring to CCRI(I)/05-36, gave an overview of the BIPM activities for the past two years and presented a series of topics in which the BIPM will be engaged in the years until 2008 with some long-term proposals up to 2012. Notably the BIPM plans to establish a comparison and calibration facility for radiation qualities as used in mammography. Ms Kessler referred to CCRI(I)/05-26 and reported on the establishment of mammographic radiation qualities at the BIPM using Mo and Rh filters with the W-target x-ray tube. A spectrometric investigation of the radiation qualities had been performed and the qualities characterized by the HVLs. Professor Wallard asked the delegates to forward information from their institutes to the BIPM about existing or planned work on dosimetry for mammography so that these needs could be factored into the long-term plans. Another item scheduled for the medium-term programme is the investigation of beam scatter for medium-energy x-rays.

Dr Picard referred to her progress report CCRI(I)/05-30 and described preliminary investigations conducted at the BIPM aimed at developing a graphite calorimeter. A study using several models to analyze temperature-time data provides support for the general practice of determining the temperature rise from extrapolations to mid-irradiation. Further work, to be published, is underway to determine the specific heat capacity of the graphite type to be used in the calorimeter, with an overall uncertainty of less than 0.1 %.

The medium-term programme includes an examination as to what extent the BIPM should engage in the field of dosimetry for brachytherapy. The BIPM plans to convene a working group consisting of experts from some NMIs with experience in brachytherapy dosimetry to give advice on this possibility.

For the long-term programme, the BIPM proposed three new projects. In the discussion following this presentation, the delegates gave support to an engagement of the BIPM in absorbed-dose standards for medium-energy x-rays and in brachytherapy, including both HDR and LDR sources, and proposed representatives from five NMIs as members of the working group. A further discussion concerned new facilities for high energies and noted in particular that a linear accelerator would be better than a betatron because it allows the production of both high-energy photon and electron fields. It was suggested that current developments in radiotherapy seem to indicate that intensity-modulated radiotherapy (IMRT) techniques will eventually replace treatments using high-energy electrons and so it would be more important to have a facility that included megavoltage x-rays.

The new projects were modified following this discussion, and are listed below in priority order:

- to develop an absorbed dose standard in medium-energy x-rays for ongoing BIPM comparisons,
- to provide a megavoltage x-ray facility for ongoing dosimetry comparisons,
- to develop an electron dosimetry standard based on calorimetry and install an appropriate facility for ongoing BIPM electron dosimetry comparisons, and
- to consider an ^{241}Am gamma ray facility and/or ISO x-ray qualities for ongoing ambient dose comparisons.

Professor Wallard welcomed the constructive comments on possible new areas of work for the BIPM. In the light of limited resources every work item requires a clear justification. The BIPM has a limited annual budget which poses severe constraints on introducing new activities unless some activities are dropped. Very strong justifications are required for increased investment. He urged the delegates of the CCRI(I) to inform the Director of their institute about any relevant topics to bring to the CGPM in 2007. It is through this channel that progress can be achieved in matters important to the CCRI(I). In the first instance, the CIPM should be informed so that their plan for the future programme of the BIPM can include the topics of interest to the CCRI(I).

Professor Wallard addressed the possibility of the BIPM welcoming experts from an NMI on secondment for a period of up to one year. Although the NMI would support their secondee, some financial support can be contributed by the BIPM. Dr Aalbers made a plea for cooperation when setting up new fields of metrology as these projects could be well supported by transfer of knowledge between the NMIs and the BIPM.

The delegates of the CCRI(I) endorsed the list of long-term objectives of the BIPM and the sequence of priorities. The Chairman summarized the discussion by emphasising the importance of feed-back from the NMIs to the BIPM and he used the opportunity to express the CCRI(I)'s great appreciation of the excellent work being done by the BIPM.

6 DEVELOPMENT OF NATIONAL STANDARDS FOR PHOTON DOSIMETRY

6.1 Air kerma

Dr Kramer reported that there had been no significant changes at the PTB since the last meeting. He said that a comparison had been made with the NPL medium-energy free air chamber (FAC)

in 2004 under a EUROMET action; that the large volume ionization chamber had been completed and a comparison with the NIST was scheduled.

Mr Seltzer reported that a change had been announced to the NIST air kerma standard on 14 May 2004. A number of developments were taking place, in particular, following suggestions regarding recombination measurements, the NIST is planning a new FAC to replace the Wyckoff chamber although the internal dimensions would remain the same. The new design would enable attenuation corrections to be made more easily.

Dr Ross reported that the NRC air kerma standard was now 0.59 % higher than previously, this had been announced formally in October 2003 with the publication of the report PIRS-876. However, there was still a difference between parallel-plate and spherical design chambers at the 0.3 % level that had been published by McCaffrey *et al* in *Physics Medicine and Biology*..

Dr Webb reported that the ARPANSA had undertaken comparisons with the BIPM in medium-energy and low-energy x-rays using the ARPANSA FACs. While the results of the medium-energy comparison were acceptable, the low-energy results differed by 2 %. Consequently, the low-energy FAC is now used as a secondary standard, traceable to the BIPM. A project is in hand to re-establish the low-energy FAC as a primary standard.

6.2 Absorbed dose to water

Dr Webb referred to CCRI(I)/05-02 and reported on the collaboration between the IAEA and the ARPANSA in which the IAEA loaned a graphite calorimeter to the ARPANSA. He also drew the attention of the delegates to the proceedings of the AbsDos 2003 workshop held at the ARPANSA, which are to be published in the near future.

Referring to CCRI(I)/05-06, Dr Kramer gave a brief description of the PTB's new Co irradiation-facility with a 250 TBq source. The device is characterized by a shutter transit time of about 35 ms. The reproducibility in dose rate for repeated irradiations is better than 0.02 %. The water calorimeter has superseded PTB's old primary standard for absorbed dose to water based on Fricke dosimetry. The water calorimeter has a total relative uncertainty of 0.21 % ($k = 1$). A BIPM key comparison is scheduled for October 2005.

Mr Seltzer reported on the development of a NIST water calorimeter operating at room temperature (CCRI(I)/05-11). The temperature measurement is performed with an AC circuit. Investigations are being performed to analyze heat conduction in frequency space. This is seen as a potential tool in the analysis of possible convection phenomena.

Dr Ross referred to CCRI(I)/05-20 and reported the procurement of a new 220 TBq Co source. By comparing water calorimeter measurements with measurements using transfer chambers, dosimetric consistency between the old and new sources was demonstrated. With the objective of improving the purity specification of the water, the NRC has developed a new all-glass vessel for its calorimeter.

Dr Duane described recent developments of the NPL graphite calorimeter (CCRI(I)/05-35). Detailed thermal modelling had shown that the correction for the heat gain of the core deviated from the hitherto assumed value by 0.1 %, the approximate amount by which the calorimeter overestimated the absorbed dose. For routine calibrations the NPL had decided not to pass on this change. The relative standard uncertainty in the adiabatic mode of operation had been improved by a factor of three.

Dr Damen, referring to CCRI(I)/05-38, reported on explorative measurements with the transportable NMi water calorimeter in fields of medium-energy x-rays. The standard deviation of the mean of 70 runs was about 0.8 %. A preliminary comparison with ionometric measurements showed an agreement within about 0.6 %. However, this figure needs to be substantiated in further investigations.

6.3 Brachytherapy dosimetry

Referring to CCRI(I)/05-06, Dr Kramer gave a brief account of a new type of a large volume free air chamber called *Großvolumige Extrapolationskammer* (GROVEX). A PhD student from the University of Wisconsin had substantially contributed to the development of the GROVEX and it has been designed to measure the reference air kerma rate of ^{125}I and ^{103}Pd seeds. A bilateral comparison with the NIST is planned in 2005.

Mr Seltzer, referring to CCRI(I)/05-13, reported on seed-to-seed variation for certain types of seed. These variations result in differences in the angular distribution of the emitted radiation.

Dr Duane reported on the development of a new air kerma primary standard for ^{192}Ir HDR brachytherapy sources and mentioned a bilateral comparison with the LNE-LNHB involving such sources. Provisional results indicate agreement within about 0.5 % (CCRI(I)/05-34).

6.4 Radiation processing

Dr Kramer reported that the PTB had abandoned the use of Fricke dosimetry in the year 2000 and was now using alanine as it secondary standard for absorbed dose to water. They were achieving a reproducibility of 0.5 %. In response to a question from Dr Ross, he explained that three pellets were measured at a time, each being measured once to achieve this uncertainty value.

Mr Seltzer reported that the NIST were close to beta-testing an internet-based remote certification of high-dose radiation sources, CCRI(I)/05-14. Their high-dose quality system includes an annual comparison with the NPL and the disagreement has remained constant at between 1.5 % and 1.9 % (about one standard uncertainty) over the past seven years.

Dr Ross reported that the NRC uses alanine at radiotherapy levels but not at radiation processing levels. They have measured the energy dependence in both electron and photon beams. The response is consistent with the expectation of mass-energy transfer coefficients. There do not appear to be any LET effects nor anomalies with the alanine to water stopping power ratios. Monte Carlo calculations have been used to predict the 1.6 % measured difference between ^{60}Co and high-energy x-ray beams.

Dr Sharpe reported on a collaboration between the NPL and the RISØ (Denmark) on primary standards for low-energy electron beams from 80 keV to 120 keV in which the electron range in air is about 10 cm. He commented that the beams are so intense that the air temperature rises at a rate of 100 °C per second. The project is to develop a calorimeter for surface dose which they believe to be just feasible. Currently at the design stage for the vacuum enclosures and thermal modelling of both direct heating and conduction from the hot air, the estimate of the achievable uncertainty is between 5 % and 10 %.

Dr Tian Zhongqing from the NIM reported that China has over 200 processing plants and that alanine dosimeters are posted to them every six months. However, there are no particular developments currently under study.

Dr Toni reported that the ENEA-INMRI has a ^{60}Co gamma cell and uses Fricke dosimetry for the standardizations.

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

Dr Kramer reported on measurements of the mass-energy absorption coefficient of air using monochromatized synchrotron radiation from the BESSY storage ring (CCRI(I)/05-06). The experiments covered the energy range from 3 keV to 10 keV and the overall relative uncertainty is about 1 % ($k = 1$). Publication of this work is in progress.

Dr Saito, referring to CCRI(I)/05-23, reported on ionometric measurements of the photon flux in monochromatized synchrotron radiation in the energy range from 0.1 keV to 1 keV. The measurements show differences of about 5 % compared to results obtained with a cryogenic radiometer and this is subject to further investigations.

Referring to CCRI(I)/05-32, Dr Toni reported on efforts by the ENEA-INMRI to measure the air kerma in the ELETTRA synchrotron facilities at Trieste. The beam is to be used for mammography. The investigations are continuing.

7 DEVELOPMENT OF NATIONAL STANDARDS FOR CHARGED PARTICULE DOSIMETRY

7.1 Electron/beta dosimetry

Dr Kramer, referring to CCRI(I)/05-06, gave a brief description of the multi-extrapolation chamber developed at the PTB. This device allows the determination of the absorbed dose to water in close vicinity to beta-brachytherapy sources. Through the parallel use of twenty-eight electrode/ electrometer channels, two-dimensional information on the dose distribution is obtained in a single measurement. A bilateral comparison with the NIST is planned in 2005.

Dr Duane reported that the NPL has developed a facility for measuring the absorbed dose to water for ophthalmic applicators. Two methods were used: a) thin alanine tablets and b) an extrapolation chamber. The results obtained with the two approaches are in good agreement (CCRI(I)/05-21).

7.2 Other charged particles/protons

Referring to CCRI(I)/05-22, Dr Duane reported on dose measurement in the 60 MeV proton beam at Clatterbridge Centre of Oncology. To this end a dedicated small-body portable graphite calorimeter was developed at the NPL. In combination with ionometric measurements this instrument was used to determine the W/e for low-energy protons. Values between 33.6 J/C and 34.9 J/C with uncertainties between 1.9 % and 2.5 % were obtained. Attempts were also made to

measure dose distributions using alanine, including the region of the Bragg-peak. Dr Ross added that the NRC had collaborated with Joakim Medin at Malmo with his construction of a copy of the NRC water calorimeter which he was now using in a proton beam having an energy of 150 MeV.

The concerns of the medical community over the possible confusion that could arise in prescriptions for radiotherapy using heavy particle beams were discussed in some detail. In response to these concerns, the CCRI(I) strongly supported the proposal that the ICRU Standing Committee on Fundamental Quantities and Units considers defining a new quantity for use when treatments involve the use of one or more multiplying factors to describe the corresponding biological effects of the absorbed dose. The ICRU representative was encouraged to recommend that the ICRU identify a solution.

It was noted that the quantities air kerma and absorbed dose each has the unit J/kg with the special name of gray and that it is always necessary to specify the quantity. It was assumed that any newly defined quantity relating to the biological effects of a particular radiation and given dose rate used in radiotherapy would also be described using the gray. It was also noted that for radiation protection quantities the unit J/kg with the special name of sievert had been adopted specifically to avoid any confusion with medical doses

8 OTHER REPORTS FROM MEMBERS LABORATORIES

Referring to the contents of CCRI(I)/05-32, not addressed so far, Dr Toni gave a brief description of the ENEA-INMRI activities in the measurement of absorbed dose to tissue for beta radiation. She provided an overview on the range of radiation qualities, including mammography, for which the ENEA-INMRI provides calibration services.

Dr Webb reported on the re-assessment of the ARPANSA low energy free air chamber for the tube voltage range from 10 kV to 70 kV. This is a collaboration with the University of Wollongong to calculate the correction factors with the PENELOPE MC code. The central electrode of the ARPANSA cavity chamber has been repaired successfully; and the results obtained with the repaired chamber are consistent with the previous results. In a pilot study the ARPANSA has conducted voluntary, TLD-based absorbed dose to water audits among the Australian radiation therapy centres. About half the centres responded. The results for photon radiations were correct to within 3 %. A new round is planned for 2005.

Dr Tian Zhongqing (CCRI(I)/05-42) reported that the efforts to construct a new graphite cavity chamber at the NIM are continuing and a 500 TBq ^{60}Co source will be installed for this purpose. Their existing 50 TBq ^{60}Co source, purchased by the NIM from a hospital, has a beam flatness not better than 4×10^{-4} over a 60 mm diameter. The NIM plans to purchase a new diagnostic x-ray machine for tube voltages up to 150 kV.

Dr Saito (CCRI(I)/05-23) reported on the development of a graphite calorimeter for D_w measurements at the NMIJ. They are working on absorbed dose standards for beta radiation and plan to be ready for calibrations in 2006.

Dr Ross (NRC) referred to the NRC investigations with radiochromic films in the course of which the useful dose range was extended down to about 1 Gy. The film exhibits an humidity dependence and is sensitive to polarization effects.

Dr Duane reported on efforts at the NPL to purchase a new clinical Linac and to replace the NPL's research Linac. A new calibration facility for mammography radiation qualities is being established. The development of the new graphite cavity chamber standards is nearing completion. Eight different chambers of four types with volumes up to 100 cm^3 will be available.

Mr Seltzer reported on the installation at the NIST of a new Varian 2100 Clinac and said that preliminary characterization of the radiation fields had taken place. He also reported on a proficiency test of the Accredited Dosimetry Calibration Laboratories (ADCLs) in which they documented their capability to perform D_w calibrations relative to the NIST standard with an uncertainty of 0.2 %. By using a small angle aperture, the NIST is capable of performing dose measurements for ophthalmic applicators with a reduced uncertainty that is now 6 %. Investigations have been carried out to use alanine dosimetry at a temperature of –77 °C. Below about 10 °C the temperature coefficient of alanine becomes non-linear.

Dr Aalbers reported on the new NMi facilities at Delft. He continued by describing the ongoing measurements of k_Q in Dutch and Belgian clinics. He emphasized the good co-operation between the Dutch and Belgian medical physics societies.

Dr Kramer referred to CCRI(I)/05-06 and gave a brief description of the electron accelerator project that is currently underway at the PTB. Three accelerators will be installed in a new building. There will be two Elekta Precise accelerators, one predominantly for the realization of the unit gray and the other predominantly for dosimetric investigations of clinical techniques, such as IMRT. The third accelerator will be a research machine providing an electron pencil beam covering the energy range from 0.5 MeV to 50 MeV. The beam energy and current will be specified to within an uncertainty of 0.1 %. The total cost is 14 M€. The facility is planned to be in operation by the end of 2007.

Dr Kramer also reported on progress in nano-dosimetry with calculations carried out by Dr Großwendt at the PTB on ionization clusters in volumes of the dimension of a DNA molecule. In these studies it could be shown that the number of single strand breaks in a DNA molecule correlates well with the number of ionizations in a nanometric volume element of liquid water. The PTB also has a new reference facility for environmental dosimetry with continuous recording of muon, neutron and photon events. In response to a question from Dr Ross about the use of alanine for clinical audits, Dr Kramer explained that the SSDLs provided calibrations for the clinics using measured k_Q values (or calculated from TRS 398) and a private company, traceable to the PTB, runs a clinical audit using TLD.

Dr Fedina (CCRI(I)/05-40) reported on the procurement of a new Isovolt x-ray machine for the VNIIM. The ISO radiation qualities of the low air kerma rate, the narrow series, and the high air kerma rate series as well as the BIPM radiation qualities have been established. She gave an overview of the calibration and verification services for photon and beta radiation provided by the VNIIM, which also has a 50 MeV betatron.

Dr Csete (CCRI(I)/05-08) reported on the reconstruction of x- and γ-ray irradiation facilities underway at the OMH. A new facility for diagnostic radiation qualities according to IEC 61267 is being set up, including mammography qualities. The OMH ^{60}Co source needs replacement; a

100 TBq source is planned. The OMH is currently engaged in three EUROMET comparisons, one of which is piloted by them.

Representing the METAS on behalf of Dr Stucki, Dr Bochud from the IRA reported that the electronics of the racetrack accelerator are being upgraded. The METAS has brought into operation a PC cluster with a total of 22 CPUs for MC calculations and a new water calorimeter based on the NRC type will be built next year.

Dr Delaunay, referring to CCRI(I)/05-17, described a new set up established at the LNE-LNHB for the determination of the air kerma strength of ^{192}Ir HDR sources. An ionization chamber is rotated around the sources axis in such a way that the same side of the chamber always faces the source. A successful comparison has been carried out with an ADCL. He also gave a brief description of the design and operation of the graphite calorimeter.

Dr Maringer (CCRI(I)/05-28) drew the attention of the CCRI to changes in the BEV air kerma standards for ^{60}Co (+ 0.8 %) and ^{137}Cs (+ 1.0 %) with respect to the previous values, having used PENELOPE for the k_{wall} calculations. He reported further that the BEV has acquired a new 72 TBq ^{60}Co source. The use of the BEV's medium energy free air chamber has been extended so as to cover the radiation qualities RQR and RQA of IEC 61267.

Referring to CCRI(I)/05-07, Dr Meghzifene gave a presentation on the IAEA dosimetry activities. The SSDL network comprises 76 laboratories in 61 Member States. Most of these laboratories obtain traceabilty to the SI through the IAEA. In TLD and ionization chamber dose audits organized by the IAEA, the SSDLs have repeatedly demonstrated the quality of their work in radiation therapy and radiation protection. In the years 2003 and 2004, the IAEA carried out 884 TLD dose audits directly in clinics of their member states. In the dosimetry laboratory at Seibersdorf, the IAEA has started calibrations for mammographic radiation qualities. The IAEA Quality System has successfully undergone a peer review and the IAEA CMCs have been approved and entered into the KCDB. New international Codes of Practice on dosimetry in diagnostic radiology and on nuclear medicine are currently in the final stages of preparation.

Mr Peixoto gave an overview on the activities of the LNMRI which is the designated laboratory in the field of dosimetric standards for Brazil, for which the INMETRO is the NMI. He described the instrumentation available at LNMRI and the way in which traceability is secured in a country as large as Brazil.

On behalf of the ICRU and referring to CCRI(I)/05-41, Mr Seltzer informed the CCRI(I) of a change in the path of publication of ICRU reports that used to be published through Nuclear Technology Publishing but are now with Oxford University Press. About two publications are planned per year, with one on radiation processing and one on dosimetry measurement assurance scheduled for 2006. In cooperation with the IAEA, a report on RBE and dose reporting for ion therapy is in progress, in which the issue of appropriate quantities and units will also be addressed. Mr Seltzer confirmed that he would be addressing the question at the ICRU.

Dr Sochor (CCRI(I)/05-34) reported on the construction of new irradiation facilities at the CMI incorporating the ISO standardized x-ray narrow spectral series, including a computerized 3D-positioning system. The characteristics of their ^{60}Co field have been determined by means of the MC code 'Sabrina'. The CMI is currently planning to build a set of new graphite cavity standards consisting of three different chamber sizes. Three-dimensional measurement systems will be used to quantify the volumes.

Dr Kosunen described the role of the STUK in Finland. Belonging to the department of regulatory issues, it is the STUK's task to visit and advise hospitals. The STUK is Finland's national standards laboratory as well as being an IAEA/WHO SSDL, and is traceable to the BIPM at the therapy level and the PTB for protection level dosimetry. It is currently participating in EUROMET projects 545, 738 and 739 as well as in the IAEA TLD annual dose audit, in which it complies within the acceptance levels. Developments are under way for the calibration of kerma-area-product and kerma-length-product chambers. Finland has adopted the TRS 398 methodology through a national protocol.

Dr Mostert gave a short overview of the CSIR-NML. Four permanent staff are engaged, two of whom are physicists and two are technicians. The CSIR-NML provides calibrations for radiation therapy and radiation protection. The CSIR standards are directly traceable to the BIPM, with the exception of the beta-ray standards, which are traceable to the PTB. It is an SSDL of the IAEA and it has been accredited by the National Accreditation Board of South Africa.

9 APPENDIX C (MRA) CALIBRATION AND MEASUREMENT CAPABILITIES – REPORT FROM THE CCRI RMO WORKING GROUP

The chairman of the CCRI RMO working group, Dr Aalbers, referred to CCRI(I)/05-05 and explained that, following the advice of the JCRB, the RMO Working Group has acquired the status of a CCRI working group. At its last meeting in September 2004, the working group reached agreement on more specific rules for completing the CMC entries and the revised document is available on the KCDB website. All current entries in the KCDB comply with these new rules. Dr Castelazo, the Executive Secretary of the JCRB, emphasized in the discussion that CMC entries that are not backed by a Quality System have to be deleted. So far this has not been needed for the ionizing radiation entries. Dr Webb was thanked for his excellent written report of the working group meeting.

10 REPORTS FROM THE REGIONAL METROLOGY ORGANIZATIONS

Speaking on behalf of the APMP, Dr Webb informed the CCRI(I) that three countries are in negotiations to join the APMP. In this context, efforts are being made to harmonize the procedures for establishing quality systems and for preparing CMCs. He reminded the CCRI(I) of the high workload caused by the inter-RMO review process of the CMCs, mentioning in particular the extensive CMCs of the EUROMET. He expressed his gratitude to his colleagues who had worked through the review process.

Referring to CCRI(I)/05-39, Dr Aalbers reported on two bilateral comparisons between the VNIIM and the OMH. He gave an overview on the situation regarding Quality Systems among the EUROMET members. The thirteen institutes currently in the KCDB are in full compliance with all requirements. Ten further institutes have submitted their CMCs to the EUROMET.

Dr Webb asked the EUROMET to separate CMC entries into those for activity and those for dosimetry to facilitate their review. A comment was made by Dr Ross that the inter-regional review is not an easy task.

Dr Mostert, referring to CCRI(I)/05-03, reported from the SADCMET that, so far, CMCs have been submitted only by the CSIR-NML and consequently that they work with the APMP for the intra-regional review.

Mr Seltzer referred to CCRI(I)/05-18 for the SIM and explained that the CMCs from the NIST have been entered into the KCDB, while those for Mexico, Brazil and Argentina were still circulating for inter-regional review. Quality Systems seemed to be in place with the NIST making a self declaration of compliance with ISO 17025. The NRC has opted for full third-party accreditation and the external review for this is due soon.

Dr Meghzifene inquired whether all the RMOs have a co-ordinated way of reviewing quality systems such as the quality forum of the EUROMET. This was confirmed by Dr Castelazo.

11 REPORTS FROM INTERNATIONAL MEMBERS AND OBSERVERS

The reports of the IAEA and the ICRU were presented under item 11. There was no formal report from the IOMP.

12 PUBLICATIONS

12.1 Publications of changes to national standards

At this point in the agenda, Dr Tian (NIM) expressed a formal view on the publication of changes to national standards. Referring to the change in air kerma at ^{60}Co made by several institutes, he questioned whether the metrology institutes introducing a change significantly greater than the stated uncertainty risked losing their credibility. He informed the CCRI(I) that Chinese legislation on metrology does not allow the NIM to change its standards. This led to a discussion on the importance of transparency when changes are made and also of the consequences of such changes in their dissemination through calibrations. Dr Duane underlined that the KCRV of the quantity in question is not changed if individual NMIs change their standard but that the relationship in terms of degrees of equivalence between the NMIs can change. Mr Seltzer considered such changes to be a natural consequence of progress in metrology and as an example cited the changes in values of the physical constants made in 1983. However, as changes are often a balance of scientific and administrative issues they can be complicated. He emphasized that every effort needs to be made to make any change transparent.

Referring to the particular case of the BIPM air kerma standard as this also defines the KCRV, Dr Allisy-Roberts suggested that the standard should remain unchanged until the beginning of the year 2007, or possibly 2008. A discussion followed on whether it might be appropriate in the

interim to increase the stated uncertainty, particularly that for the axial non-uniformity correction factor. This view did not find general support and the CCRI recommended the continued use of the present uncertainties and asked the BIPM to prepare a paper for peer review and publication in *Physics in Medicine and Biology*. Once this paper had been published, the CCRI would be given the opportunity of confirming the date at which any change should be announced in *Metrologia*, with letters of explanation to the Members of the Metre Convention, as had been done for the changes to the x-ray standards. On the question by Dr Csete as to when the BIPM.RI(I)-K1 comparison results will be published in the KCDB, Dr Allisy-Roberts reiterated that this was planned to be before the end of 2005.

Professor Wallard concluded the discussion by expressing his gratitude to Dr Tian for having raised this important issue. Referring to historical examples, e.g. in the early nineties when Josephson junctions revolutionized metrology in electricity, he underlined that changes in standards have to be permissible when there is good scientific reason and that even the definition of the kilogram is likely to change in the future. He also emphasized that the implementation of a new standard requires a far-sighted approach. Professor Wallard suggested that the new BIPM air kerma standard in ^{60}Co radiation be implemented with effect from 1 July 2007 which would be after the next CCRI(I) meeting. He asked the president of the CCRI to inform the CIPM about the changes to be made. A draft note for *Metrologia* would be circulated to the CCRI(I) and a period of at least one month would be given for comments on the change to be made prior to submission, with the proposed implementation date of 1 July 2007. This should give all the NMIs traceable to the BIPM adequate time to implement the consequent changes in the dissemination of their own standards.

12.2 Special Issue of *Metrologia*

The Chairman of the CCRI(I) presented the results of the inquiry circulated amongst the NMIs on possible contributions to the planned special volume of *Metrologia*. From this list, he had extracted eight priority topics each with one or possibly two authors. A discussion arose on the contents of the proposed chapter on Monte Carlo calculations. As this method is applied within each of the subject areas covered in the special issue, it was decided that this chapter should cover the physics and the modelling of radiation transport. The specific methods used to address a particular question, such as wall correction factors for cavity chambers, should be covered in the relevant chapter. Dr Ross asked whether the dosimetry of protons and heavy ions should be included. The chairman explained that the special issue was aimed at covering the mainstream and he felt that these topics should not be added.

The topics to be covered were: photon absorbed dose standards (including high-energy photons); electron absorbed dose standards; air kerma cavity standards; free air chambers; brachytherapy standards and dosimetry protocols (including ophthalmic applicators); physical models for Monte Carlo; radiation protection and environmental standards; international framework of radiation dosimetry comparisons. The special issue would be about 150 pages although all chapters would not necessarily be of the same length. Dr Allisy-Roberts agreed to pass the information to the Editor of *Metrologia*. It was noted that the special issue editors would identify and contact the authors and referees while the *Metrologia* office would co-ordinate the project.

12.3 Publication of NMI bibliographies

Dr Allisy-Roberts asked the delegates to provide the BIPM with the list of publications of their institute in dosimetry over the last few years. These lists are published in the CCRI web page and provide evidence of the research activities of the members of the CCRI. This was noted to be of particular importance when the CIPM reviews membership of the CCs and it also helps to promote the work of the CCRI.

In addition, as the working documents provided for each meeting are full of valuable information, she asked each participant whether these documents could be made publicly accessible. This request was with the *proviso* that any material that would otherwise be published would not be open and that any material that had been given to the CCRI(I) in confidence would likewise remain restricted. Approval was then given by the NMIs for the appropriate working documents to be made openly available and these are available at CCRI(I) Working Documents.

13 CURRENT AND FUTURE MEMBERSHIP

Dr Allisy-Roberts informed the CCRI that the Czech Metrology Institute has now the status of an official Observer. Dr Aalbers proposed that Belgium should become a member of the CCRI(I), the appropriate Belgian institute being the University of Ghent. The President of the CCRI agreed to consider this proposal for the next CIPM. The current membership appears in the CCRI(I) web page.

14 DATE OF THE NEXT MEETING

The next meeting of the CCRI and its Sections was proposed for May 2007. It will be in the same year as the CGPM. The date will be decided by the CIPM at their meeting in October 2005. The President was asked to synchronize if possible the CCRI(I) meeting in 2007 with the Absorbed Dose Workshop 2007 to be hosted by the LNE-LNHB in Paris.

15 CONCLUDING REMARKS

Professor Wallard thanked the delegates for their participation in the meeting. In view of the great amount of work that has gone into the preparation of data for both Appendix B and Appendix C of the KCDB, he urged the delegates to promote its existence and propagate its contents, and particularly to inform him about any non-conformities.

Dr Sharpe closed the meeting. On behalf of the CCRI(I), he expressed his gratitude to the BIPM, to the Executive Secretary and to the staff of the Ionizing Radiation section of the BIPM for the excellent organization of this highly successful seventeenth meeting.

H.-M. Kramer, *Rapporteur*

July 2005,
revised October 2005

RECOMMANDATIONS DE LA SECTION I (RAYONS X ET γ, ÉLECTRONS) DU COMITÉ CONSULTATIF DES RAYONNEMENTS IONISANTS PRÉSENTÉES AU COMITÉ INTERNATIONAL DES POIDS ET MESURES

Recommandation R(I)-1 (2005) : Sur l'extension de l'intervalle maximal de temps entre les comparaisons clés

La Section I du Comité consultatif des rayonnements ionisants (CCRI),

considérant

- la charge de travail considérable concernant les comparaisons clés qui risque d'incomber au Bureau international des poids et mesures (BIPM) pendant les années 2005 à 2010,
- la nécessité actuelle de répéter chaque comparaison clé au moins une fois tous les dix ans,
- le besoin de transparence dans la base de données du BIPM sur les comparaisons clés (KCDB),

recommande d'accorder cinq ans de plus pour la répétition d'une comparaison, à la condition que

- la prochaine comparaison soit clairement programmée et qu'elle ait lieu pendant cet intervalle supplémentaire de temps,
- les résultats datant de plus de dix ans soient identifiés comme tels dans la KCDB.

Recommandation R(I)-2 (2005) : Déclaration d'une modification concernant un étalon national

La Section I du Comité consultatif des rayonnements ionisants (CCRI),

considérant

- que les laboratoires nationaux de métrologie ont la responsabilité de déclarer toute modification concernant leurs étalons,
- la nécessité que la base de données du BIPM sur les comparaisons clés (KCDB) reflète l'état actuel des étalons nationaux disséminés par les laboratoires nationaux de métrologie,
- le besoin de mettre à jour les résultats présentés dans la KCDB,
- la nécessité pour le CCRI d'avoir l'opportunité de noter l'effet de telles modifications dans la matrice des degrés d'équivalence,
- la nécessité de présenter un rapport au CCRI pour approbation et publication avant la publication des résultats dans la KCDB,
- le besoin de synchroniser la publication du nouveau résultat dans la KCDB avec la date de mise en vigueur du nouvel étalon,

recommande que

- lorsqu'un laboratoire national de métrologie souhaite déclarer une modification concernant un étalon national qui implique un changement de la méthode, d'un instrument ou d'une source de rayonnement, et afin de confirmer son nouveau résultat dans la KCDB, il effectue une comparaison bilatérale avec le BIPM ou, après notification au CCRI, avec un autre laboratoire national de métrologie qui détient déjà un résultat de comparaison avec le BIPM, ou
- lorsqu'un laboratoire national de métrologie souhaite déclarer une modification d'un étalon national qui implique seulement un changement des facteurs de correction, il fournisse un rapport écrit comprenant une réévaluation du bilan d'incertitude afin que le BIPM publie un rapport supplémentaire.

Dans tous les cas, le rapport initial doit être envoyé au secrétaire exécutif du CCRI au moins six semaines avant la date de mise en vigueur proposée afin de laisser au CCRI au moins deux semaines pour donner son accord.

L'intervalle de temps requis pour accepter certaines modifications pourrait être étendu en fonction de leur importance. Tous sont d'accord pour reconnaître que la communauté internationale a besoin d'en être informée, afin d'avoir une chance de réagir et de se préparer à de telles modifications.

Le CCRI **recommande aussi** que la valeur de référence de la comparaison clé, c'est-à-dire la valeur du BIPM pour la grandeur concernée, soit approuvée par le CCRI et fasse l'objet d'une publication référencée dans la KCDB, à l'endroit où la comparaison correspondante est enregistrée.

RECOMMENDATIONS OF SECTION I (X- AND γ-RAYS, ELECTRONS) OF THE CONSULTATIVE COMMITTEE FOR IONIZATION RADIATION SUBMITTED TO THE INTERNATIONAL COMMITTEE FOR WEIGHTS AND MEASURES

Recommendation R(I)-1 (2005): Extension of the maximum time interval between key comparisons

Section I of the Consultative Committee for Ionizing Radiation (CCRI),

considering that there is

- likely to be a considerable work load of key comparisons that will fall on the International Bureau of Weights and Measures (BIPM) in the years from 2005 to 2010,
- a current requirement to repeat a key comparison at least every ten years,
- a need for transparency in the BIPM key comparison database (KCDB),

recommends that an extension of five years is allowed in which to repeat a comparison on condition that

- the next comparison is clearly scheduled, to occur within the extension period,
- the results that are more than ten years old are identified as such in the KCDB.

RECOMMENDATION R(I)-2 (2005): Declaration of a change to a national standard

Section I of the Consultative Committee for Ionizing Radiation (CCRI),

considering

- the responsibility of national metrology institutes (NMIs) in declaring any changes to their standards,
- the need for the BIPM key comparison database (KCDB) to reflect the current state of national standards that are being disseminated by the NMIs,
- the requirement for an update to the results presented in the KCDB,
- the need for the CCRI to have the opportunity to note the effect of such a change on the matrix of degrees of equivalence,
- the need for a report to be issued to the CCRI for approval and publication before the results are published in the KCDB,
- the need to synchronize the publication of the new result in the KCDB with the implementation date for the new standard,

recommends that

- when an NMI wishes to declare a change to a national standard that involves a change in method, instrumentation or radiation source, to confirm its new result for the KCDB, it conducts a bilateral comparison with the International Bureau of Weights and Measures (BIPM) or with prior notification to the CCRI, with another NMI that already has a BIPM comparison result, or
- when an NMI wishes to declare a change to a national standard that involves a change in correction factors only, it provides a written report including the re-evaluated uncertainty budget to the BIPM to produce a supplementary report.

In either case, the initial report should be sent to the CCRI Executive Secretary at least six weeks in advance of the proposed implementation date to allow the CCRI to have at least two weeks in which to confirm their approval.

The time scale actually required to agree some changes may need to be longer depending on the magnitude of the change proposed. There was unanimous agreement that the international community needs to be informed and given a chance to react and prepare for such changes.

The CCRI **further recommended** that the key comparison reference value, that is the BIPM value for the quantity of concern, should be approved by the CCRI with a publication linked to the relevant comparison in the KCDB.

APPENDIX R(I) 1.
WORKING DOCUMENTS SUBMITTED TO THE CCRI(I) AT ITS 17TH MEETING

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

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

Document CCRI(I)/	
05-00	Draft agenda, 2 pp. (restricted access)
05-01	BIPM. — Dosimetry comparisons and calibrations at the BIPM 2003 to 2005, April 2005, P.J. Allisy-Roberts, D.T. Burns, C. Kessler, P. Roger, 8 pp.
05-02	ARPANSA (Australia). — Recent activities in measurement standards and dosimetry at ARPANSA, 2003-2005, D. Webb, D. Butler, C. Oliver, 6 pp.
05-03	SADCMET. — Recent SADCMET events in ionizing radiation, J. Mostert, 1 p.
05-04	BIPM. — Sensitivity of x-ray comparisons and calibrations to radiation field size, D.T. Burns, 2 pp.
05-05	CCRI RMO WG for Ionizing Radiation, CMCs. — Notes of the RMO WG meeting of September 2004, 8 pp. (restricted access)
05-06	PTB (Germany). — Progress in Radiation Dosimetry at PTB, May 2005, U. Ankerhold, M. Anton, L. Büermann, K. Derikum, B. Grosswendt, K. Helmstäder, R.-P. Kapsch, H.-M. Kramer, A. Krauss, H.-J. Selbach, F. Wissmann, 9 pp.
05-07	I.A.E.A. — I.A.E.A. subprogramme on dosimetry and medical radiation physics 2003 to 2004, K. Shortt, A. Meghzifene, J. Isewska, F. Pernicka, B. Zimmerman, S. Vatnisky, P. Bera, L. Czap, R. Girzikowsky, 19 pp.
05-08	OMH (Hungary). — Progress Report on the Radiation Dosimetry at the OMH, April 2005, I. Csete, 2 pp.
05-09	NIST (United-States). — Recent Dosimetry Activities at the NIST, April 2005, S.M. Seltzer, 21 pp.
05-10	NIST (United-States). — Update on NIST X-Ray Air-Kerma Standards and Calibrations, March 2005, M. O'Brien, S.M. Seltzer, 4 pp.
05-11	NIST (United-States). — Update on the NIST Second-Generation Room-Temperature Water-Calorimeter, April 2005, H. Chen-Mayer, R. Tosh, 3 pp. (restricted access)
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CONSULTATIVE COMMITTEE
FOR IONIZING RADIATION

SECTION II: MEASUREMENT OF RADIONUCLIDES
REPORT OF THE 18TH MEETING
(23-25 MAY 2005)

Abstract

Section II (Measurement of radionuclides) of the Consultative Committee for Ionizing Radiation held its eighteenth meeting at the Pavillon de Breteuil, Sèvres, on 23, 24 and 25 May 2005. The main discussions of the meeting were concerned with issues relating to Appendices B and C of the CIPM Mutual Recognition Arrangement (MRA). The results from key comparisons were reviewed. Significant progress had been made since the previous meeting of the Committee on a system to categorize radionuclides to enable national measurement institutes to demonstrate their measurement capability while avoiding a heavy workload of participation in key comparisons. This categorization, known as generic groupings, was used as a basis for agreeing a long-term programme of key comparisons at a reduced frequency in comparison with previous years. Significant progress was also reported on the development of a method, using liquid-scintillation counting, to extend the BIPM International Reference System (SIR) to cover alpha- and beta-emitting radionuclides. New procedures were agreed for submission of samples to the existing SIR and for their inclusion in the key comparison reference values. Agreement was also reached on extending the CMC entries to cover measurements of radionuclides in reference materials. The proposals for the long-term programme of work at the BIPM were strongly supported.

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

Section II (Measurement of radionuclides) of the Consultative Committee for Ionizing Radiation held its eighteenth meeting at the Pavillon de Breteuil, Sevres, on 23, 24 and 25 May 2005.

The following representatives of member organizations were present: D. Alexiev (ANSTO), F. Bochud (IRA), R. Broda (RC), M. Capogni (ENEA-INMRI), N. Coursol (LNE-LNHB), P. Dryák (CMI), Y. Hino (NMIJ/AIST), H. Janβen (PTB), L. Johansson (NPL), S.M. Judge (NPL), L. Karam (NIST), J.-M. Los Arcos (CIEMAT), N. Moisseev (VNIIM), G. Moscati (President of the CCRI), T.S. Park (KRISS), M. Sahagia (IFIN), C. da Silva (LNMRI/IRD), B.R.S. Simpson (Chairman of Section II CCRI, CSIR-NML), L. Szücs (OMH), M. Unterweger (NIST), A.J. Wallard (Director of the BIPM), U. Wätjen (IRMM), F. van Wyngaardt (CSIR-NML), Yang Yuandi (NIM).

Observers: B.D. Michael (ICRU), U. Sansone (IAEA), W. de Vries (NMi VSL).

Personal member: G. Winkler (IIK).

Guest: B. Zimmerman (IAEA).

Also attending the meeting for all or part of the time: P.J. Allisy-Roberts (Executive Secretary of the CCRI), D.T. Burns, C. Michotte and G. Ratel (BIPM).

Apologies for absence were received from: C. Borrás (IOMP), J. McLaren (NRC-INMS), J. Mintcheva (SAMTS), S. Shaha (BARC), P. Smith (IOMP).

Dr Simpson, the Chairman, welcomed the participants.

The Director of the BIPM, Prof. Wallard, then opened the meeting. Professor Wallard emphasized the value of radionuclide metrology given the impact on user communities. He went on to underline the importance of the Consultative Committees in advising the CIPM on the direction of work at BIPM. As the BIPM is expanding its work in standards for chemistry and laboratory medicine, the CIPM will be proposing a larger programme of work for approval at the General Conference to be held in October 2007. Professor Wallard concluded by thanking the committee and the Chairman for their support.

Dr Simpson outlined the purpose of the meeting and gave an overview of the work of the committee. The Consultative Committee for Ionizing Radiation was established in 1958. It currently meets every two years and its membership is open to national measurement institutes with active research programmes in radionuclide metrology, as demonstrated by publications in scientific journals and participation in international comparison exercises. Since the last meeting (held in 2003), two organizations have joined as members (CMI, IFIN), and two organizations (BARC, CNEA) have become observers. The committee now has nineteen members plus seven observers and one personal member. The committee oversees five working groups: Key Comparison Working Group; Uncertainties Working Group; Extension of the SIR to beta emitters; Realization of the becquerel at the basic level; and High-efficiency photon detection systems. Dr Simpson explained that the main work of the committee in recent years has been to support the CIPM Mutual Recognition Arrangement (MRA), and this work would be discussed further during the meeting.

The meeting then confirmed the appointment of Dr Judge as *Rapporteur*.

The agenda was approved. It was noted that Professor Ken Ledingham had been invited to address the CCRI(II) on the second day with a seminar entitled "The development of and the perspective for high-power laser production of radionuclides for PET".

2 REPORT OF THE EIGHTEENTH MEETING OF THE CCRI

Professor Moscati welcomed the delegates to the meeting and wished them a pleasant and profitable meeting. He explained that the CCRI meeting is attended by the President, the Chairmen of the three Sections, the Executive Secretary, and the Director of the BIPM. The CCRI meeting reviews the items arising from the section meetings that should be taken to the CIPM meeting. The proceedings of the meeting are available on the BIPM website.

Professor Moscati informed the participants that the next meeting of the General Conference would be held in 2007. Any issues to be considered would be needed formally by the beginning of 2007. The previous General Conference had approved Resolution 9 raised by the CIPM in 2003 expressing concern at the difficulties delegates had experienced in shipping radioactive materials for international comparisons.

Professor Moscati also explained the progress in guidance on the estimation of uncertainties in measurement. The JCGM Working Group on the Guide to the Expression of Uncertainty in Measurement (GUM) had decided that the Guide itself would not be updated in the short term but supplements will be published to cover developments in the field. The first supplement will cover the estimation of uncertainties by using a Monte Carlo method for propagating distributions, including guidance on handling non-symmetrical uncertainties and non-linear models. The 2nd version of the supplement has been distributed for comment and will be made available to members on the restricted area of the CCRI(II) website.

3 APPENDIX B COMPARISON REPORTS

3.1 Update on Appendix B comparison reports (CCRI(II)/05-14, CCRI(II)/05-15)

Dr Allisy-Roberts summarized progress on the MRA Appendix B comparison reports. There are now ninety key comparisons recorded in the database and a further twelve reports in draft (fifty-nine reports were published in the last two years). All results for the SIR pre-2004 are now published and results from ten more recent comparisons are in preparation (CCRI(II)/05-14). Participants were encouraged to submit samples of ^{56}Mn and ^{228}Th to the SIR to establish an improved KCRV for these radionuclides which would also contribute to the response function for the SIR ionization chamber. Dr Allisy-Roberts also drew the attention of the committee to approaching deadlines for the display of results in Appendix B: at the end of 2005, any results that were submitted before 1985 will remain in Appendix B but will be coloured in black to

indicate that they are more than 20 years old; at the end of 2007, any results submitted before 1977 will be removed from Appendix B (CCRI(II)/05-15).

CCRI(II) members expressed their thanks to the staff at the BIPM for their hard work in processing the comparison reports.

3.2 Report from the Key Comparisons Working Group (CCRI(II)/05-09, 05-03, 05-04)

The Executive Secretary summarized the work carried out by the Key Comparisons Working Group on behalf of the Working Group Chairman, Mr M. Woods. The working group had met about every six months since the previous CCRI(II) meeting and had prepared or contributed to reports on recommended KCRVs (CCRI(II)/05-28), acronyms (CCRI(II)/05-03), guidelines for key comparisons (CCRI(II)/05-01), generic groupings (CCRI(II)/05-04), future comparisons (CCRI(II)/05-12), comparison of short-lived radionuclides (CCRI(II)/05-08) and reference materials (CCRI(II)/05-36). These reports would be considered in more detail later in the meeting.

3.3 Measurement acronyms (CCRI(II)/05-03)

Dr Ratel explained the standard nomenclature to use when describing measurement methods. Each method is described using a set of six 2-character acronyms describing the geometry, the radiations detected, the types of detector used and the counting mode (CCRI(II)/05-03). In discussion, Dr Ratel and Dr Simpson outlined the main reasons for introducing a standard nomenclature – to avoid possible confusion over the measurement techniques used, to make it easier to distinguish between techniques and to avoid the use of Greek characters (which are difficult to manipulate in databases).

3.4 Generic groups (CCRI(II)/05-04)

The Executive Secretary introduced this paper on generic groupings of radionuclides. The intention of the paper is to address the need under the MRA for key comparisons to support CMCs for a large number of different radionuclides. The Key Comparisons Working Group recommended grouping radionuclides together by measurement technique; evidence of participation in a comparison for one radionuclide would then be accepted as evidence that the national measurement institute could standardize other radionuclides in the same group. This approach had been refined to reflect that some radionuclides are more difficult to standardize than others within the group; standardization of an 'easy to measure' radionuclide would be evidence that the national measurement institute could standardize only the other 'easy' radionuclides in the same measurement group.

The on-going reviews of the generic groupings had highlighted six issues for the CCRI(II) to decide:

1. Uncertainty allocation for ^{68}Ge/^{68}Ga standardization by techniques of the form (??-XR/AE/PO-??-00-00-??), where the ?? indicate not yet identified.

Dr Karam explained that the working group would like to ask CCRI(II) if any of these measurement techniques had been used. The participants confirmed that methods of this type

had not been used, so it was agreed to delete this entry for ^{68}Ge/^{68}Ga from the generic groupings table.

2. Measurement of ^{103}Pd by 4P-??-PP-00-00-HE(DS)

Similarly, no participants had used this method and no CMCs were recorded in the database, so it was agreed to delete this entry.

3. Measurement difficulty level for ^{125}Sb and ^{132}Te using the method 4P-??-LS-00-00-CN/TD

Dr Karam recommended ^{125}Sb should be colour-coded yellow to indicate the measurement difficulty, Dr Dryák recommended that ^{132}Te should also be colour-coded yellow. These recommendations were accepted by the committee.

4. Measurement uncertainty and difficulty level for ^{148}Ge by the method 4P-BP/AP-PP-00-00-HE

Inspection of the CMC database showed one entry for ^{148}Ge (NIST, using the CIEMAT-NIST method). It was therefore agreed to delete the entry in the generic groupings table by 4P-BP/AP-PP-00-00-HE.

5. Measurement uncertainty for ^{233}Pa (4P-BP/AP-LS-PH-00-CN/TD)

Although there were no entries at present in the CMC database, Dr Karam recommended that this radionuclide was retained in the generic groupings table. This was accepted by the committee and an uncertainty of 2 % was estimated based on entries for similar radionuclides.

6. Measurement uncertainty for ^{236}U (4P-BP/AP-PP-00-00-HE)

Entries for other radionuclides were reviewed and it was agreed to allocate an uncertainty of 3 % to measurements of ^{236}U by this method.

Other corrections were identified to document CCRI(II)/05-04. Dr Unterweger pointed out that the entry for ^{37}Ar was in the wrong column. Two columns also had identical headings and needed correction. Dr Judge noted that the wording in the document ‘successful' participation in a key comparison leads one to suppose that the contrary could also occur in which a participant could fail; whereas the result would have implications only for the uncertainty that a measurement institute could claim for a CMC. It was agreed to include explanatory text from Dr Karam in the document and to change ‘Successful participation…’ to ‘Participation in a comparison, with expanded uncertainties where necessary, will support…’.

The committee agreed that the generic groupings table should be published as a live document to replace CCRI(II)/05-04, subject to the above corrections.

3.5 New results for inclusion in key comparison reference values (CCRI(II)/05-27, 05-28)

Dr Ratel put forward a table of changes to key comparison reference values (KCRVs) for CCRI(II) to approve. The following changes were approved by the committee to be included in the next relevant comparison report:

^{18}F: the NPL and CIEMAT results will be included.

^{22}Na: the BARC result and the 1981 ANSTO result will be included to give a KCRV of 7531 (6) kBq, although the KCRV uncertainty increases by 1 kBq.

^{60}Co: the CNEA and RC results and the earlier 1980 NIST result will be included to give a new KCRV of 7062.2 (3.6) kBq.

^{67}Ga: the CIEMAT result will be included.

^{131}I: the PTB result will be included.

^{85}Sr: the effect of the new NMIJ result is to be calculated and published.

^{139}Ce: the NMIJ result will be included.

^{153}Sm: the result from the ANSTO was not recommended for inclusion due to the high level of impurities in the sample at the time of the SIR measurement.

^{137}Cs: the IRMM and NMIJ results will be included.

Dr Michotte then proposed that only results coming directly from primary standardizations would be considered for inclusion in calculations of the KCRVs. The practice of using results assayed by a transfer instrument such as an ionization chamber would no longer be acceptable for inclusion in the KCRV, as this additional step increased measurement uncertainties. Dr Unterweger and Dr Judge raised the problem of submitting samples of short-lived radionuclides but it was pointed out that a delay between submitting the sample and the result was allowed, and that it should be possible to coordinate the standardization and the submission of a sample to BIPM.

It was agreed to adopt the proposal that only results directly from primary standardizations would be accepted for inclusion in KCRVs, with effect from 1 January 2006 (with the exception of radioactive gas standards, for which results from transfer instrument measurements would continue to be included in KCRVs on the recommendation of Dr Unterweger).

3.6 Activity comparisons workshop (CCRI(II)/05-02)

Dr Michotte summarized the feedback from the workshop held at the BIPM in November 2004 to review the results from recent key comparisons (CCRI(II)/05-02). The workshop had proved to be a useful venue to exchange experiences on solving practical problems with measurements for comparisons.

Key findings were that the efficiency tracing method should be avoided where possible, as the method is sensitive to chemical effects in source preparation and to the details of the nuclear decay schemes. Commercial liquid-scintillation counters should be used with care as automatic settings may influence measured values. Different laboratories use different approaches to estimate the extrapolation uncertainty in coincidence counting. The workshop also highlighted that there is a risk of underestimating the uncertainties due to weighing, as there are components to the uncertainty other than the stated accuracy of the balance used.

Following the success of the workshop, the BIPM proposed a workshop on uncertainties with an exercise comparing analysis of the same data by the participants and perhaps one on dilution capability. The proposal for an uncertainties workshop was supported by the committee and Dr Allisy-Roberts agreed to consider including one of the exercises as part of the preparation for the workshop

3.7 Presentation of results from key comparisons (CCRI(II)/05-13)

Dr Karam presented a proposal that graphs of results from the key comparisons should include a scale on the right hand side to show the relative deviation, as a guide for CMC evaluators. Dr Allisy-Roberts showed an example of this proposal but emphasized that the additional scale is an approximation only. It was also noted that correlations in uncertainties between the national metrology institutes (NMIs) may exist in the matrix and the raw data should always be used for any detailed analysis.

The committee voted in favour of including the new form of presentation as the results are updated.

3.8 Status reports on CCRI and RMO key comparisons

A series of short presentations followed on the progress on CCRI and RMO key comparisons. The key comparisons had highlighted difficulties with uncertainty budgets and with detection of low levels of impurities.

^{241}Am CCRI(II)-K2.Am-241 (Presented by Dr Ratel)

All the measurements had been completed, 38 results had been received using 18 different measurement techniques. Analysis of the data had indicated that the measurement uncertainties had been underestimated. Some participants had reported the presence of ^{241}Pu impurity and Dr Simpson stated that the impurity could change the CSIR-NML liquid-scintillation results by approximately 0.1 % since measurements were undertaken about one year after receiving the solution. Each participant was encouraged to re-measure the impurity content and evaluate the effect on their measurement results, to ensure a robust value for the KCRV. Dr Janßen expressed concern about the difficulty of shipping ^{241}Am samples and Dr Alexiev confirmed that movement of ^{241}Am is now subject to stricter controls. The Executive Secretary asked participants to send her specific examples of shipping difficulties as the BIPM is to meet customs regulators in the near future.

^{54}Mn CCRI(II)-K2.Mn-54 (Presented by Dr Ratel)

The results from the 25 measurements reported again showed that uncertainties may have been underestimated. The LNE-LNHB had reported a ^{55}Fe impurity (detected by high resolution x-ray spectrometry). Dr Simpson suggested that there was also some evidence for a high-energy pure beta-emitting radionuclide. Dr Coursol agreed that this was a possibility.

^{90}Y CCRI(II)-K2.Y-90 (Presented by Dr Zimmerman)

The ^{90}Y comparison had been initiated due to the increased use of this radionuclide for radioimmunotherapy. Eight laboratories took part in the key comparison which is reported in more detail in CCRI(II)/05-45 and is published in the KCDB. The ^{90}Y results were in good agreement but a discrepancy of a factor of 100 was observed in measurements of the ^{90}Sr impurity. Dr Michotte pointed out some technical difficulties in the measurements reported at the workshop noting that it is difficult to check the stability of the liquid-scintillation cocktail used for the measurements due to the short half life. Consequently, a fresh cocktail should always be used for the impurity measurements as well as for the standardization. It was agreed that the NPL, PTB and the LNE-LNHB would address the issue of measurement of ^{90}Sr impurity through a EUROMET project.

Dr Alexiev raised the issue that, in clinical use, the radionuclide is bound to monoclonal antibodies or to microspheres and the binding of the radionuclide was not well characterized. Dr Karam suggested that this was a chemistry issue and therefore outside the scope of CCRI(II). Dr Zimmerman added that it could be useful to consider developing a reference material in the future.

Dr Simpson concluded that the comparison had been very valuable and had helped to establish calibration factors for transfer standard ionization chambers.

^{125}I CCRI(II)-K2.I-125(2) (Presented by Dr Ratel)

Twenty-two results had been submitted for participation in this comparison. The results from three laboratories appeared to be inconsistent with other results. These laboratories had been contacted but all had confirmed their values were correct. A report will be available in the summer of 2005.

^{32}P CCRI(II)-K2.P-32(2) (Presented by Dr Ratel)

The solution for this comparison had been supplied by the PTB to follow up an exercise conducted in 2002. The earlier comparison had identified two groups of results separated by 4 %. No clear reason could be identified for this discrepancy as there appeared to be no association with the measurement technique. Wide discrepancies were also noted in the impurity content reported. The second comparison was on-going at the time of the CCRI(II) meeting.

^{192}Ir CCRI(II)-K2.Ir-192 (Presented by Dr Ratel)

The ^{192}Ir comparison had been initiated for two reasons. First, results from ampoules submitted to the SIR had indicated the possibility of two groups of data. Second, a trial comparison organized in 1997 had also shown a wide spread in results. A working group had been set up to investigate and they recommended reducing the concentration of the $Na_2(Ir)Cl_6$ carrier solution from 5 mg/g to 20 μg/g. This reduced carrier concentration solution had been used in this comparison. The results were much improved with good consistency reported by the different national laboratories. Dr Michotte added the workshop comment that the reduced carrier concentration enabled laboratories to prepare thinner (and hence higher detection efficiency) sources, so that the electron capture branch could be better accounted for in the extrapolation curve.

^{65}Zn CCRI(II)-K2.Zn-65 (Presented by Dr Ratel)

Nineteen laboratories had participated in the ^{65}Zn comparison, submitting a total of twenty-seven results. Most results were in good agreement. Dr Michotte reported from the workshop that the main problem with the standardization was the low count rate in the gamma channel, and pointed out that linearity conditions for the coincidence extrapolation can be reached by using a lead absorber to attenuate the γ-rays.

^{85}Kr CCRI(II)-K2.Kr-85 (Presented by Dr Michotte)

Dr Michotte reported the results from experiments to investigate the reason for discrepancies between measurements by the LNE-LNHB and the NIST of ^{85}Kr equivalent activity in the SIR. The BIPM thought that the discrepancy could be due to the different gas pressures used, and a series of measurements at the LNE-LNHB and the BIPM had been carried out varying the pressure of stable Kr gas in the ampoule. The results had demonstrated that the ionization chamber results were indeed pressure dependent but further discrepancies remain.

Tests are continuing at the LNE-LNHB and the NIST to investigate this problem and identify appropriate ampoule filling procedures. In the meantime, the proposed international comparison has been postponed. Three laboratories, the CIEMAT, IRMM and the NMi, stated that they would withdraw from the comparison and the Executive Secretary will contact the BEV to confirm their participation.

Two options were identified for future measurements of ^{85}Kr in the SIR: either to apply a correction factor of about – 46 kBq per hPa of stable Kr or to request that samples are submitted at a given, fixed, pressure. The consensus at the meeting was that it was preferable to apply a correction factor. This would be defined after the publication of the final results of the investigation.

^{18}F CCRI(II)-K3.F-18 (Presented by Dr Michotte)

This comparison had been organized due to the increased use of ^{18}F for positron emission tomography, in particular to support the need for traceability for materials used in international clinical trials. Dr Michotte explained that due to the short half life, the NPL secondary standard ionization chambers at several national measurement institutes had been used as transfer instruments. The NPL had prepared and despatched ^{68}Ge samples to be used to normalize the results. The LNE-LNHB and the NPL also submitted samples directly to the SIR, enabling a link of the K3 results to the SIR K1 results.

The linking factors based on the results from the LNE-LNHB and the NPL were discrepant by 1.5 % which is outside the stated uncertainties. The mean of the two factors and a relative standard uncertainty estimated as 6×10^{-3} was used for the link to the SIR.

Dr Karam confirmed that the NIST was happy with the draft report and this could now be processed for publication.

^{139}Ce APMP.RI(II)-K2.Ce-139 (Presented by Dr Hino)

Nine laboratories had taken part in this APMP/TCRI comparison. Good agreement between the results was observed. Three of the laboratories had participated in order to update calibration factors for their ionization chambers so only six of the results were included in the analysis (CCRI(II)/05-33).

^{237}Np EUROMET.RI(II)-K2.Np-237 (Presented by Dr Michotte)

Dr Michotte reported that although the EUROMET ^{237}Np comparison had been organised in 2001 (and reported in NPL Report CIRM 43 with a Draft B BIPM report in circulation), there still remained an opportunity to link the results to the SIR. The BIPM planned to use the material supplied as part of the comparison exercise but would have to open the ampoules to transfer 3.6 g for measurement. The new ampoules would then be stored for at least 2 months so that equilibrium could be established. Dr Janßen said that the PTB would contribute a further ^{237}Np ampoule that would contain the appropriate 3.6 g mass to avoid the manipulation proposed by the BIPM. This suggestion was readily accepted by the BIPM.

4 FUTURE BIPM INTERNATIONAL REFERENCE SYSTEM (SIR) AND CCRI(II) KEY COMPARISONS

4.1 Status of the BIPM SIR (CCRI(II)/05-29)

Dr Ratel presented a report on the status on the BIPM SIR. The report CCRI(II)/05-29 summarizes the new entries submitted to the SIR and the planned entries.

The Executive Secretary explained that there had been changes in despatch regulations, so the form included in the above report had to be completed by the NMI concerned before the BIPM could take delivery of samples. Dr Ratel requested that samples are despatched to arrive in Paris early in the week (Wednesday at the latest) to avoid the heavy traffic congestion at the airport. This is especially important for short-lived radionuclides.

4.2 Future CCRI(II) key comparisons

The Executive Secretary presented the ten-year plan for key comparisons, developed by the Key Comparisons Working Group. The proposal is for one key comparison per year, covering all the groups defined in the generic groupings proposal within ten years, with the aim of facilitating compliance with the CIPM MRA.

Dr Wätjen asked for clarification of the timescale of the proposed $^{99}Tc^{m}$ comparison project. Dr Allisy-Roberts replied that the BIPM had scheduled resources to develop the transfer instrument needed for this exercise and was anticipating that this could be an ongoing comparison as the transfer instrument would be delivered to each participating laboratory in turn. Dr Judge asked why ^{131}Cs had been selected for a key comparison; Dr Karam explained that it had been chosen as its decay scheme meant that participation in a ^{131}Cs exercise would demonstrate the capability to measure several other radionuclides under the generic groupings proposal. It was decided to accept the first three proposed key comparisons listed (^{55}Fe, $^{99}Tc^{m}$ and ^{3}H) and to review the proposal for ^{131}Cs at the following CCRI(II) meeting, so that availability of the raw material could be checked. It was also agreed that the ^{35}S comparison would be brought forward to give further time to consider ^{131}Cs.

The first comparison in the new series, ^{55}Fe, will be organized by the NPL. The following laboratories expressed interest in participating: the CIEMAT, CMI, CSIR-NML, ENEA, IFIN, IRMM, KRISS, LNE-LNHB, LNMRI, NIST, NMi, NMIJ, OMH, PTB, RC and the VNIIM.

4.3 Proposal for a system for comparison of short-lived radionuclides (CCRI(II)/05-08)

Dr Allisy-Roberts outlined BIPM's proposal to develop a transportable NaI(Tl) instrument, to be used for comparison exercises for short-lived radionuclides.

In response to a question from Dr Judge, Dr Allisy-Roberts explained that a NaI(Tl) detector had been chosen in preference to an ionization chamber due to the more complex shipping regulations for ionization chambers which contain gas at high pressure.

A working group will be set up to advise on the design of the new transfer instrument. The IRMM, LNE-LNHB, NIST, NMIJ and the NPL agreed to participate with the BIPM in the working group.

4.4 Changes to the guidelines for participation in key comparisons

Dr Michotte explained proposed changes to the guidelines for participation in key comparisons based on feedback from the CCRI(II) meeting held in 2003 and from the Key Comparisons Working Group. The main changes proposed were:

- Measurement of the impurity content is considered part of the comparison and must not be revealed to other participants until the comparison is complete.
- Impurities identified by the pilot laboratory should be stated by name on the accompanying documentation but the activity should not be given.
- The isotope production method should be stated so that participants may identify other possible impurities.

Several changes in wording were suggested:

- Replace 'non-expected' by 'unexpected'.
- Paragraph 5: replace 'in consequence' by 'consequently'.
- Paragraph 8: replace 'entitled to revise their value up to deadline' by 'allowed to re-submit their reporting form up to the deadline'.
- Replace the first two sentences in the last bullet point on page 5 by 'On receipt of final comments from participants on Draft A, the Draft B is distributed to participants and the Key Comparisons Working Group, and is no longer confidential. Subsequently, the status of the comparison is indicated as 'Draft B in progress' on the relevant KCDB web page on the BIPM site'.

These proposed changes to the guidelines were approved by the committee (CCRI(II)/05-01). Dr Simpson requested that the report on the 2001 ^{89}Sr comparison be at the Draft B stage well before the ICRM meeting scheduled for September.

4.5 Proposed RMO key comparisons

The Executive Secretary requested that BIPM is kept informed of any RMO key comparisons and supplementary comparisons so that they can be recorded in Appendix B on the BIPM website. It was reported that an APMP C-14 supplementary comparison is scheduled, with the KRISS as the pilot laboratory.

5 WORKING GROUP REPORTS

5.1 Uncertainties Working Group (Coordinator: H. Janßen)

Dr Janßen reported on the work of the Uncertainties Working Group. The Group had been set up in 2001 to resolve questions of uncertainty estimation arising from key comparison measurements. Since the previous CCRI(II) meeting, the group had covered the following topics:

- Guide uncertainties for standardizations

For each radionuclide included in the generic groupings table, the working group had estimated a typical uncertainty that could be achieved using each measurement technique recorded. The results from these deliberations had been incorporated in the generic groupings table. The values stated were intended to be used as a benchmark, and laboratories are recommended to compare estimated uncertainties against these values and to justify any large discrepancies.

- Uncertainty budgets

The working group is developing detailed uncertainty budgets for typical standardizations. These will be made available as spreadsheets but can be amended by laboratories to include other components of uncertainty or to change suggested values to those actually estimated by the laboratory.

- Correlations in gamma spectrometry

Commercial software for calibrating gamma spectrometers does not take into account correlations in input data due to, for example, nuclear decay data. This issue had been identified as some laboratories reported measurements by gamma spectrometry as having lower uncertainties than primary measurement methods. Calculations by the working group had demonstrated an increase in uncertainties in the efficiency versus energy calibration when correlations are taken into account.

The working group proposed that the mathematical model equation for standardizations should be stated on the report form when submitting results for key comparisons. This proposal was supported by the committee.

The group proposed to include guidance on uncertainty components for source weighing and dead time corrections in future work. Dr Allisy-Roberts proposed that the work would feed into the planned BIPM Workshop on Uncertainties.

It was agreed that Dr Pommé (IRMM) and Dr Johansson (NPL) would be invited to join the working group.

5.2 Extension of the SIR to beta-emitters (coordinator: J.-M. Los Arcos)

Dr Los Arcos reported on the activities of the Working Group on the Extension of the SIR to beta-emitters. The aim of the working group is to develop and validate a reproducible system that can be used to compare measurements of radionuclides which cannot be compared using the SIR ionization chamber.

The working group had decided to develop a reproducible liquid-scintillation cocktail. Proprietary cocktails cannot be used as they may not be available long term and their chemical content can be modified without a name change. The working group cocktail would be validated for ^{63}Ni, ^{204}Tl, ^{89}Sr, ^{90}Sr, ^{55}Fe and ^{241}Am, and a monograph written including operational details.

Two meetings of the working group had been held. During the first meeting in October 2003, it was decided not to use diisopropyl naphthalene isomers (DIN) scintillators as they are protected by patents and, results from different batches are not reproducible to the precision required for the international system. The CIEMAT proposed using an extractive cocktail based on xylene, acetonitrile and naphthalene (XAN) which has obtained patent protection. It was agreed that laboratories participating in the working group would test XAN6535 (65 % xylene, 35 % acetonitrile) for stability.

Some laboratories had experienced difficulties with the cocktail – a coloured solution had been obtained, efficiency varied over 20 days, detection efficiency for ^{3}H was low with a discontinuity, and detection efficiency for ^{90}Sr apparently exceeded 100 %. The group agreed to carry out further tests using a revised cocktail (XAN6040). Initial results at the CIEMAT for some 19 radionuclides (including ^{241}Am, ^{55}Fe, ^{3}H, ^{63}Ni, ^{90}Sr) were promising, with good efficiency, quench stability over 60 days and apparently transparent samples. The results for ^{55}Fe showed a reduction in detection efficiency over time, but the CIEMAT found that adding a small quantity of dibutylphthalate (DBP) improved stability (0.5 ml DBP to 14.5 ml XAN6040).

Following the second meeting held in March 2005, the CIEMAT prepared a batch of the new scintillation cocktail and distributed it to the participating laboratories (the BIPM, ENEA, IRMM, LNE-LNHB and NPL) in April 2005. Tests were underway some of the initial problems with colouration have been solved, although sensitivity to ultraviolet may be an issue.

A full report will be available when the results from the participating laboratories are available. Ms Freda van Wyngaardt is to replace Dr Bruce Simpson on this working group.

5.3 **Realization of the becquerel at the basic level** (coordinator: D.F.G. Reher)

Dr Wätjen on behalf of the coordinator Dr Reher outlined the reason for the development of a new ionization chamber to replace the BIPM SIR chamber (CCRI(II)/05-19). The measurements recorded on the chamber represent considerable effort at national laboratories over many years; all these data would be lost if the SIR chamber or the reference radium sources were to be damaged.

There is no commercial ionization chamber available on the market with sufficiently tight manufacturing tolerances to meet the reproducibility needed to provide a long-term replacement for the BIPM SIR chamber. The outline specifications for the chamber are:

- Range of gamma energies covered, 50 keV to 2000 keV, with reproducibility of 0.1 % to 0.2 %.
- All the properties of the chamber must be traceable to the SI.
- Direct measurement of current to replace measurements relative to a radium source.
- Gas filling system would use a pressure balance to ensure traceability.

- Simple components (Monte Carlo simulation has shown that a tolerance of 10 μm is needed on some critical components).

The NPL secondary ionization chamber design was taken into account in developing the new chamber. Some components of the chamber have been constructed but problems remain with conduction of the inner wall and the collector electrode (it may be necessary to replace the initial plastic design with aluminium), and the design of the container for the radionuclide is still to be decided.

Other features of the proposed chamber were discussed by the committee. The operating gas pressure suggested was 1 MPa (10 bar) as the aim of the chamber is reproducibility rather than high detection efficiency. Nitrogen had been chosen as the shape of the efficiency curve was less problematic. Dr Coursol said that the LNE-LNHB had also studied factors that affect ionization chamber response and had found that the electrode thickness was less important than the influence of the gas.

A new container was needed for the radionuclides as batches of commercial ampoules are not identical; trace elements added to the glass may affect the response of the chamber to low-energy photon emitting radionuclides. The general discussion highlighted the issue of the availability of ampoules for comparison exercises. Dr Ratel said that the BIPM has a limited stock available, about 600 ampoules are left and approximately 30 ampoules are used every year. Dr Janßen said that the PTB had recently ordered a stock of 150 000 ampoules and will be comparing samples to their previous batch. Dr Coursol added that the LNHB are currently testing a new 5 ml ampoule and will report on the findings.

It was agreed to revise the membership of the working group following staff changes at several organizations involved, and the membership will be expanded to include further interested laboratories. The new membership was agreed as follows:

- Dr U. Wätjen (Coordinator) (IRMM)
- Dr A. Švec (IRMM)
- Dr J. Sephton (NPL)
- Dr M.-N. Amiot (LNE-LNHB)
- Dr G. Ratel (BIPM)
- The PTB, NIST and the CIEMAT will also provide representatives.

5.4 **High efficiency photon detection systems working group** (coordinator: G. Winkler)

Professor Winkler summarized progress on his report on high efficiency photon detection systems (CCRI(II)/05-17). A review paper had been written based on presentations given at a training workshop organized by the VERMI (Virtual European Radionuclide Metrology Institute). The paper outlines the principles of the method and explains how high accuracy standardizations are possible. One important issue to consider when applying the method is the random coincidence correction necessary if there are any metastable levels in the decay of the radionuclide.

Dr Michotte asked if it was possible to use an extending dead time to correct for any metastable states. Professor Winkler explained that this technique would not work as the emissions feeding the state may not be detected, so a correction is still needed.

It was pointed out that the technique had unfortunately been omitted from the generic groupings table (the acronym for the method is 4P-NA-PH-00-00-HE), although it had been included in an earlier version (dated 24 September 2003). It was agreed that this omission would be corrected before the table is published

6 CURRENT AND FUTURE BIPM PROGRAMMES (CCRI(II)/05-40)

Dr Allisy-Roberts summarized the work being carried out and planned at BIPM in support of radionuclide metrology. The radionuclide activities are supported by four full time members of staff led by Dr Allisy-Roberts who is also responsible for the dosimetry activities. A guest worker from the ANSTO had joined the team for three months.

There have been 14 key comparisons since 2001, three of which have been published and the remaining 11 are in progress. Seven reports have been published on previous key comparisons.

The experimental programme at the BIPM has seen significant progress. A new TDCR system has been set up and work carried out to improve the low energy detection efficiency. A study has been carried out on the effect of Kr gas pressure on ^{85}Kr SIR measurements. The balance room and a radiochemistry laboratory are being updated.

Dr Ratel gave further information on the developments of TDCR. The equipment has been modified to improve light transmission and the electronics have been changed to optimise the phototube response. The effects of asymmetry of the phototube response have also been investigated using a mathematical model.

Dr Michotte then gave a presentation on a project to develop a complete parametric mathematical model of the response function of the BIPM SIR ionization chamber (collaboration with Prof. M. Cox and Mr A Pearce, NPL). The model uses a non-linear least squares fitting algorithm, taking account of beta spectrum shapes, correlations and impurity corrections; one difficulty being that the input data depends on the model itself. Correlations in nuclear decay data may be included in the model where they are known. Response functions for photons and for electrons have been calculated using the model and compared to experimental data. There are few data at high photon energies (greater than 2.5 MeV), so the response function has large uncertainties in this energy region. The accuracy of the response function has been used to identify discrepancies in published nuclear decay data.

Dr Michotte went on to describe other projects at BIPM. A report had been issued on applying decay corrections for the case of a metastable state (*Rapport BIPM*-04/15). The current measurement system for the BIPM SIR ionization chamber is being rebuilt using a similar Townsend balance and a Keithley electrometer. Validation of the NPL/ANSTO digital coincidence counting (DCC) system is also underway; results from the ^{241}Am comparison exercise showed agreement to better than 5×10^{-4}.

Results from studies in the dosimetry programme had also been used to estimate the half lives of ^{60}Co and ^{137}Cs. The BIPM results were 1924.5(5) days and 10 955(30) days, respectively, compared with 1925.19(37) days and 10 964(9) days from the evaluations made by the Decay Data Evaluation Project (DDEP). Dr Allisy-Roberts confirmed that the BIPM results would be published so they could be included in future evaluations.

In the medium term (2006-2008), Dr Allisy-Roberts reported that the BIPM would be continuing work to support and improve the SIR including using the second ionization chamber regularly, investigating measurement uncertainties due to the density of solutions and determining the mass correction. Further work would also be carried out to establish the calibration of the HPGe gamma spectrometer for impurity assays.

The BIPM will also be involved in running an uncertainties workshop in 2006, developing the NaI(Tl) transfer instrument and will work with the PTB on the replacement of the SIR ampoules. In addition, the BIPM is planning to standardize one or more of the radionuclides ^{155}Eu, ^{243}Am, ^{207}Bi, ^{113}Sn, ^{177}Lu, ^{195}Au, ^{140}Ba, ^{203}Pb or ^{47}Sc to supplement the existing SIR data.

In the long term, BIPM aims to support the CCRI(II) comparison programme, develop the SIR system and introduce the extended SIR system for beta emitting radionuclides, extend the SIR system to alpha emitters and low energy photon emitters, study and publish guidance on uncertainties, cover further short-lived radionuclides such as ^{18}F with the transfer instrument and develop at least one additional primary measurement method.

The effects of export regulations on this programme of work were discussed. Dr Sahagia and Dr Alexiev both confirmed that customs officials may not recognise the customs tariff codes for temporary importation of instruments, and that laboratories may face high import duties. BIPM had contacted the IAEA for advice but had been informed that these issues were not under the IAEA's jurisdiction. Dr Allisy-Roberts re-iterated the need for specific examples so that a case could be made to the appropriate authorities and requested all present to send details of any difficulties with import/export of radioactivity or instrumentation.

Members of CCRI(II) expressed their strong support for the proposals for the future work at BIPM

7 NMI PROJECTS AND LABORATORY REPORTS

Representatives gave a brief summary of highlights from their laboratories:

LNE-LNHB (Dr Coursol) CCRI(II)/05-41

- The national measurement system in France has been re-organized; the BNM has been dissolved and replaced by the Laboratoire National de Métrologie et d'Essais (LNE).
- The LNE-LNHB has been confirmed as the national laboratory for ionizing radiation.
- Highlights of the research programme included characterization of a low energy x-ray source for attenuation measurements, development of freeze drying methods for source preparation and development of bolometry for radionuclide activity measurements.

IFIN (Dr Sahagia) CCRI(II)/05-06

- The laboratory has a wide range of instrumentation including coincidence counters, TDCR, large area reference source counters, Compton-suppressed gamma spectrometers and ionization chambers.
- The IFIN produces reference sources including standardized solutions, large area sources and soil samples.
- Recent activities included organizing national comparisons in nuclear medicine and environmental monitoring.

CSIR-NML (Ms van Wyngaardt) CCRI(II)/05-23

- A national comparison has been organized on measurements of ^{131}I capsules; results will be published in *Physica Medica*. The results reported by hospitals ranged from – 15 % to + 10 % of the known activity.

IIK (Prof. Winkler) CCRI(II)/05-16

- Measurements are underway of the half lives of long-lived radionuclides needed for astrophysics (for example, ^{182}Hf).
- The Hönigschmid standards have been transferred to the Technical University of Munich where the high purity ^{226}Ra material will be used to manufacture ^{225}Ac for cancer treatment.

LNMRI (Dr da Silva) CCRI(II)/05-21

- Measurements have been completed of nuclear decay data for ^{54}Mn, ^{201}Tl and ^{203}Hg.
- A network of regional laboratories is being established to support measurements in nuclear medicine.

IRMM (Dr Wätjen) CCRI(II)/05-31

- The IRMM has run a comparison within the European Community on monitoring airborne radioactivity, with 42 laboratories participating.
- Work is continuing on simulation of digital coincidence counting (DCC) with the aim of improving the extrapolation of coincidence curves.
- Training workshops for researchers in radionuclide metrology have been run in collaboration with the PTB, LNHB and the NPL.

RC Polatom (Dr Broda) CCRI(II)/05-43

- In 2005, Polatom was split into Polatom Co. Ltd (which manufactures and distributes radio-pharmaceuticals worldwide) and the RC Polatom (which covers research and metrology).
- The RC Polatom has a wide range of facilities including TDCR, liquid-scintillation counters and spectrometers.
- Recent activities included organizing a technical comparison of ^{63}Ni measurements by four laboratories using TDCR. The results were in good agreement, except for one participant. An investigation is underway to establish the reasons for the difference.

NMIJ (Dr Hino) CCRI(II)/05-32

- The NMIJ had organized an international comparison of the β-emission rate from a ^{36}Cl large area reference source involving the CSIR-NML, INER, KRISS, NIST, PTB, and the VNIIM. The VNIIM had observed small structures in the shape of the spectrum at low energy, due to x-rays from the substrate and x-ray emission from ^{36}Cl.
- The NMIJ had also organized the RMO key comparison of ^{139}Ce and participated in bilateral comparisons of ^{51}Cr and ^{134}Cs.
- A project is underway to investigate the portability of the calibration factors of ionization chambers.
- Other developments include the use of ink-jet printers to manufacture large area reference sources for calibration of instruments for the measurement of radioactive waste.

CMI (Dr Dryák) CCRI(II)/05-25

- Since 2003, the CMI has standardized more than 20 radionuclides for the production of reference standards.
- Work on a novel measurement method for coincidence counting will be presented at the ICRM conference in Oxford, 2005. The method optimises the gamma energy window in order to improve the accuracy of the extrapolation which has been made possible through advances in digital pulse processing.
- A detailed Monte Carlo code has been developed to model the response of a high resolution gamma spectrometer to better than 0.8 %. It had proved necessary to radiograph the spectrometer to obtain accurate data on the construction of the instrument. The surface dead layer on the detector element had been measured using a narrow beam from an ^{241}Am source.

IRA (Dr Bochud)

- Recent work at the IRA included the verification of radionuclide calibrators, the standardization of ^{222}Rn by solid angle α-counting, and the Monte Carlo simulation of an ionization chamber.
- The laboratory had also tackled the issue of expressing the results from measurements where the background count rate exceeded the observed count rate from the source (leading to a meaningless negative source activity). The use of Bayesian statistics resolved this problem and also allowed uncertainties to be calculated in a way that was consistent with the GUM.

ENEA (Dr Capogni) CCRI(II)/05-30

- A new measurement system using the 4πγ method had been developed and applied to the standardization of ^{99}Tc^{m} using a Monte Carlo model of detector response.
- To meet a growing requirement for traceability of ^{18}F measurements for positron emission tomography, the CIEMAT-NIST technique had been used in-situ at the manufacturers (at the Ispra facility) to provide a link to the national standard. A ^{48}V impurity was observed in the material standardized. A portable ionization chamber had also been developed as a transfer instrument.

- A new quality assurance programme had been conducted to support the national network for environmental radioactivity surveillance. Discrepancies in the results had been observed, most had been traced to corrections for true coincidence summing in gamma spectrometry.

NPL (Dr Judge) CCRI(II)/05-22

- The NPL had been heavily involved in supporting the international measurement system through leading and participating in key comparisons and through work with the BIPM to develop a complete mathematical model of the BIPM SIR ionization chamber.
- A new reference material (organically bound tritium) had been developed.
- A system had been developed to standardize the short-lived radionuclide $^{81}Kr^{m}$ used in lung scintigraphy.
- Work in progress included the use of internet-enabled metrology for radionuclide calibrators, the development of a positron-in-gas standard, the standardization of radionuclides for use in nuclear medicine, and support for metrology in nuclear site clearance and decommissioning.

IAEA CCRI(II)/05-34, CCRI(II)/05-38, CCRI(II)/05-45

- The IAEA had been developing guidance on quality assurance procedures for radioactivity measurements in nuclear medicine; the document was undergoing external review and was expected to be published as an IAEA TECDOC by the end of 2005.
- A cooperative research programme was underway to harmonise quality assurance procedures in their Member States.
- The Analytical Quality Control Services had organized comparison exercises, proficiency tests and the certification of reference materials. Recent exercises had included Irish and North Sea fish, Irish Sea sediment and Mediterranean seawater.
- The IAEA Chemistry Unit had coordinated the preparation of reference materials such as mushroom, sediment and mussel. Other work had included a proficiency testing exercise for the measurement of radionuclides in soil and milk reference materials.

8 CURRENT MEASUREMENT CAPABILITIES

This section of the meeting covered issues related to entries from national measurement institutes to Appendix C of the CIPM MRA on calibration and measurement capabilities (CMCs).

Freda van Wyngaardt is to replace Dr Bruce Simpson on this working group.

8.1 Progress reports

Representatives from the regional metrology organizations reported on the highlights and issues from their regions.

APMP

Dr Hino referring to CCRI(II)/05-18 reported that CMCs from the ANSTO, ENEA, KRISS and the NMIJ had been accepted.

EUROMET

In a written submission CCRI(II)/05-44, Dr Coursol reported that EUROMET had met twice since the previous CCRI(II) meeting. Some 765 radioactivity CMCs had been published in 2003 and a further 196 were being processed. Initial assessments have been carried out of CMC submissions from Latvia, Poland and Romania. The EUROMET CMC group had also reviewed CMCs from the APMP, COOMET and the SIM.

A EUROMET project on the gamma emission probabilities in the decay of ^{65}Zn had also been completed (CCRI(II)/05-42). Dr Michotte commented that the revised nuclear decay data was in good agreement with the new response function of the SIR ionization chamber.

COOMET

Dr Moisseev indicated that several supplementary comparisons are planned but there was no formal written report.

SADCMET

Ms van Wyngaardt explained (CCRI(II)/05-11) that SADCMET had one member for radioactivity metrology (CSIR-NML) so the organization was also an associate member of the APMP. The CSIR-NML currently had 36 CMC entries in radioactivity.

SIM

Dr Karam presented CCRI(II)/05-20 and highlighted recent SIM comparisons of ^{85}Kr and ^{54}Mn standardizations both of which were linked to the KCRVs through submissions by the NIST. Proposals for future comparisons included reference materials (seaweed, soils and shellfish); the NIST will pilot all three comparisons.

8.2 Meeting of the CCRI RMO Working Group (CCRI(II)/05-05)

Dr Karam reported on the meeting of the RMO Working Group for Ionizing Radiation CMCs, held in September 2004. The meeting covered the international rules for completing IR CMC tables, progress on CMCs, Quality Systems, compatibility of existing CMCs with key comparison uncertainties and guidelines for CMC reviews. Dr Thomas reported that there are more than 3200 entries for radioactivity in the KCDB Appendix C CMC database.

8.3 Proposal for CMC's on reference materials

Dr Karam explained the rationale behind the proposal in CCRI(II)/05-36 to establish CMCs for measurements of radionuclides in three reference materials. There was a need in radioactivity metrology to reflect user demand for reference materials (for example, soils, organic materials,

natural waters) but existing CMCs on the database had niche applications and a more general approach was needed. As the development of a new reference material can take several years, the proposal was to build on existing international work to characterize three particular materials (SRM 4353A (Rocky Flats II), Seaweed SRM, Shellfish SRM). It was also proposed that demonstrating the capability to measure a radionuclide in, for example, a high calcium content soil, should also support claims for measurements in other high calcium content soils or sediments.

Dr Wätjen welcomed the approach, and said it was a significant move forward in devising a process to cover reference materials under the CIPM MRA. In response to the proposal for an international comparison, the Executive Secretary suggested that the SIM should organize a supplementary comparison exercise and that laboratories from other RMOs should be allowed to participate. This suggestion was accepted by CCRI(II).

Dr Wätjen raised the issue of specialist CMCs - for example, the measurement of radioactivity in semiconductor chips – and questioned how comparison exercises could be set up for such measurements. The Executive Secretary replied that this issue had been discussed in other fields of measurement, and it had been decided that CMCs were permitted if they were supported by publications in peer-reviewed journals or other supporting data were available.

9 PUBLICATIONS

9.1 *Metrologia* special issue

Professor Moscati explained that a special issue of *Metrologia* was being planned on Radionuclide Metrology, and this was an opportunity to raise the profile of the discipline in the wider metrological community. Dr Simpson summarized progress so far: it was proposed that the issue should be aimed at a wide audience and should summarize the ‘state-of-the-art’. An outline list of topics had been agreed but there was still much work to do. Dr Judge agreed to organize a meeting at the ICRM Conference in September, 2005 to take the project forward, and would invite Dr Simpson, Dr Hino, Dr Los Arcos and Dr Unterweger to attend.

9.2 BIPM Monographs

The Executive Secretary reported that *Monographie BIPM-5* had been published and indicated that *Monographie BIPM-6* was in preparation. The proposal was that this new *Monographie* on source preparation would be published on the BIPM website.

9.3 Bibliographies

The Executive Secretary explained that the bibliographies submitted by national laboratories are included on the CCRI(II) website and need to be kept up-to-date to support continued membership of the CC.

9.4 Terminology in activity measurement

The Executive Secretary reported that the CCRI(II) had an opportunity to influence international deliberations at the IUPAC on terminology in activity measurements (document CCRI(II)/05-39). Following a general discussion, the recommendations from CCRI(II) were:

- To combine the definition of 'activity concentration' on page 2 of the paper into one definition covering solids, liquids and gases.
- To delete the word 'unit' from 'per unit mass' throughout.
- To retain the terms 'specific activity', 'molar activity' and 'surface activity concentration' as defined in the paper.

Dr Allisy-Roberts agreed to collate the recommendations and forward them to the IUPAC.

10 MEMBERSHIP OF THE CCRI(II)

The IFIN was welcomed as a new member of the committee, and the BARC as a new observer. The NRC retains observer status but was not represented at the meeting as no radioactivity measurements are carried out at the NRC at present. No further recommendations were made as to new members. Current membership is available on the CCRI(II) webpage.

11 ANY OTHER BUSINESS

The committee recorded their sincere thanks to Dr Reher (IRMM) and Mr Woods (NPL), who had made significant contributions to the work of CCRI(II) over many years and who had both retired recently.

12 DATES OF NEXT MEETINGS

It was proposed to hold the next CCRI(II) meeting at BIPM in May 2007.

The next meeting of the Uncertainties Working Group and the Key Comparisons Working Group were scheduled for September 2006 while the Extended SIR Working Group was scheduled for November 2005.

The *Metrologia* Special Issue Working Group would hold a meeting at the ICRM Conference in Oxford, 5 to 9 September 2005.

Dr Simpson (Chair) and Professor Moscati closed the meeting by thanking Dr Allisy-Roberts and the staff at BIPM for organizing the meeting, and the delegates for their participation in the meeting.

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

June 2005

APPENDIX R(II) 1.
WORKING DOCUMENTS SUBMITTED TO THE CCRI(II) AT ITS 18TH MEETING

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

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

Document CCRI(II)/	
05-00	Draft agenda, 2 pp. (restricted access)
05-01	BIPM. — Guidelines for CCRI(II) key comparisons, May 2005, C. Michotte, 9 pp.
05-02	BIPM. — Conclusions of CCRI(II) Activity Comparisons Workshop BIPM, December 2004, C. Michotte, G. Ratel, 5 pp.
05-03	BIPM. — Appendix 3. Acronyms used to identify different measurement methods, G. Ratel, 1 p.
05-04	KCWG and UCWG of CCRI(II). – Grouping criteria for radionuclides to support CMCs, March 2005, D. Reher, M.J. Woods, H. Janssen, 5 pp. (restricted access)
05-05	CCRI RMO. — Draft version 5 – 19/11/04 — Meeting of CCRI RMO Working Group for Ionizing Radiation CMCs, November 2004, D. Webb, 8 pp. (restricted access)
05-06	IFIN-HH (Romania). — "Horia Hulubei" National Institute of Research and Development for Physics and Nuclear Engineering, IFIN-HH, Bucharest, Romania, Radionuclide Metrology Laboratory, M. Sahagia, 3 pp.
05-07	ANSTO (Australia). — ANSTO report to the CCRI(II) meeting 2005, D. Alexiev, L. Mo, M. Reinhard, J. Davies, 3 pp.
05-08	EC JCR - IRMM (Italy) and BIPM, on behalf of the KCWG(II). — Proposal for a travelling well detector (TWD) for CCRI(II) key comparisons of short lived radionuclides, March 2005, D. Reher, P. Allisy, 5 pp. (restricted access)
05-09	NPL (United Kingdom). — Report of the CCRI(II) Key Comparisons Working Group 2003-2005, March 2005, M. Woods, 4 pp. (restricted access)
05-10	CSIR-NML (South Africa). — Review of the activities at the CSIR-National Metrology Laboratory, June 2003 to April 2005, B.R.S. Simpson, W.M. van Wyngaardt 2 pp.
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05-15 BIPM. — Update report on the phasing out of old data from KCDB, April 2005, P.J. Allisy-Roberts, G. Ratel, 1 p.

05-16 IIK University of Vienna (Austria). — Summary of research programme related to radionuclide metrology at the "Institut für Isotopenforschung und Kernphysik" (IIK) of the University of Vienna (Austria), April 2005, G. Winkler, 3 pp.

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05-18 APMP. — APMP/TCRI Activity Summary 2005, D.V. Webb, 4 pp.

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05-21 IRD, LNMRI (Brazil). — Radionuclide report 2003/2004, C.J. Da Silva, 2 pp.

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05-28 BIPM. — SIR updates to KCRVs and recommended procedures, G. Ratel, C. Michotte, P.J. Allisy-Roberts, 2 pp. (restricted access)

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05-30 ENEA-INMRI (Italy). — Report to the CCRI Section II on the activity carried out at the ENEA-INMRI on radionuclide measurements in the period 2003-2005, M. Capogni, P. De Felice, 7 pp.

05-31 EC–DG JRC – IRMM (Belgium). — Laboratory Report 2003-2005 of IRMM, April 2005, U. Wätjen, 2 pp.

05-32 NMIJ/AIST (Japan). — Progress report of NMIJ/AIST (May 2003 to April 2005), Y. Hino, 4 pp.

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05-34 IAEA. — Review of the activities related to metrology at the IAEA's Seibersdorf Laboratories (2004-2005), U. Sansone, A. Sakhashiro, A. Trinkl, 7 pp.

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05-38 IAEA. — IAEA Marine Environment Laboratory Monaco, AQCS activity in Radiometrics laboratory, 2 pp.

05-39 BIPM. — Radionuclide terminology, P.J. Allisy-Roberts, 3 pp (restricted access)

05-40 BIPM. — BIPM Programme in Ionizing Radiation Metrology, P.J. Allisy-Roberts, 16 pp. (restricted access)

05-41 LNE-LNHB (France). — LNE-LNHB progress report related to radionuclide metrology, April 2003 to March 2005, N. Coursol, 5 pp.

05-42 LNE-LNHB (France). — Short report on EUROMET IR project number 721: Activity measurements and gamma emission intensities determination in the decay of ^{65}Zn, M.-M. Bé, 1 p.

05-43 POLATOM (Poland). — Review of Activity (2003-2005), R. Broda, 2 pp.

05-44 EUROMET. — EUROMET IR-TCC short report to the CCRI(II), 2005 meeting at Sèvres, N. Coursol, 2 pp.

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05-45 IAEA. — IAEA Subprogramme on Dosimetry and Medical Radiation Physics (DMRP), Report on Activities 2003-2005, B.E. Zimmerman, K.R. Shortt, A. Meghzifene, J. Izewska, 4 pp.

05-46 CIEMAT (Spain). — Extension of SIR (ESIR) Working Group, J.M. Los Arcos, 7 pp. (restricted access)

CONSULTATIVE COMMITTEE
FOR IONIZING RADIATION

Section III: Neutron measurements
Report of the 16th Meeting
(25-26 May 2005)

Abstract

Section III (Neutron measurements) of the Consultative Committee for Ionizing Radiation (CCRI) held its sixteenth meeting at the Pavillon de Breteuil, Sèvres, on 25 and 26 May 2005.

The responsibilities of the CCRI, the regional metrology organizations (RMOs) and the BIPM in implementation of the CIPM mutual recognition arrangement (MRA) were reviewed. Progress on developing and reviewing the MRA database of certified measurement capabilities (Appendix C) was reported.

Preparation of final reports for two completed key comparisons on fast neutron fluence rate measurements and the derivations of degrees of equivalence from these data were discussed. The status of the on-going key comparison on neutron source emission rate was reviewed, and a new key comparison was proposed for thermal neutron measurements in place of a previous proposal that would have entailed unacceptable delays. Two supplementary comparisons led by the EUROMET, but also involving other RMOs as participants, were discussed; these involve survey meter calibrations and neutron fluence rate measurements in the range 15.5 MeV to 19 MeV.

Brief reports were heard from participants, highlighting their written reports that had been submitted as working documents for the meeting. Discussions of future needs, future membership of the CCRI and a planned special issue of *Metrologia* were brief due to time constraints.

Dr D. Thomas will succeed Dr H. Klein as the Chairman of Section III.

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

Section III (Neutron measurements) of the Consultative Committee for Ionizing Radiation held its sixteenth meeting at the Pavillon de Breteuil, Sèvres, on 25-26 May 2005.

The following were present: T. Bolognese (LNE-ISRN), J.-M. Bordy (LNE-LNHB), M.S. Dewey (NIST), D.M. Gilliam (NIST), V. Gressier (LNE-IRSN), H. Harano (NMIJ), H. Klein (Chairman of Section III, PTB), M. Kralík (CMI), G. Lövestam (IRMM), N.N. Moisseev (VNIIM), G. Moscati (President of the CCRI), R. Nolte (PTB), W.W. Pereira (LNMRI/IRD), C.J. da Silva (LNMRI/IRD), D.J. Thomas (NPL), Y. Zhang (NIM).

Observers: H. Park (KRISS), C. Rong (CIAE), A. Trkov (IAEA), A. Wambersie (ICRU), Z. Wang (CIAE).

Guests: J.M. Los Arcos (CIEMAT), T. Park (KRISS).

Members of the BIPM who attended all or part of the meeting: P.J. Allisy-Roberts (Executive Secretary of the CCRI), I. Castelazo (Executive Secretary of the JCRB), C. Thomas (KCDB coordinator).

Apologies: K. Kudo (NMIJ), A.L. Nichols (IAEA), V.V. Shaha (BARC), B.R.S. Simpson (CSIR-NML, Chairman of the CCRI(II), A.J. Wallard (Director of the BIPM), J. Zoetelief (IRI).

Dr P.J. Allisy-Roberts of the BIPM greeted the attendees and introduced the President of the CCRI, Professor G. Moscati, who welcomed the participants of Section III, noting that the Director of the BIPM, Professor A.J. Wallard, was attending a meeting of the EUROMET.

Dr H. Klein, Chairman of Section III, welcomed the participants whom he invited to introduce themselves briefly for the benefit of the many new participants. Dr Klein commended Dr P.J. Allisy-Roberts on the preparations for the meeting.

The participants were pleased that Dr D.M. Gilliam accepted to be re-appointed as the *Rapporteur*.

The agenda proposed by Dr Klein was accepted.

2 MINUTES OF PRECEDING MEETINGS OF CCRI AND SECTION III

Professor Moscati, President of CCRI, referred the attendees to the published report of the eighteenth meeting of the CCRI and the fifteenth meeting of the CCRI Section III, which are available on the CCRI-web page. He noted in particular that this last meeting of the CCRI had approved recommendations on the transport of chemicals and radioactive samples for CIPM comparisons, resulting in a Resolution to the General Conference that had been approved in October 2003.

3 IMPACT OF THE CIPM MRA ON THE CCRI, RMOS, AND THE BIPM

Dr I. Castelazo reported on the most recent meeting of the JCRB (Joint Committee of RMOs and BIPM) in Minsk and their decisions. For example, the inclusion of the CMCs of a particular NMI in Appendix C now depends on the NMI having implemented a documented Quality System.

The RMO representatives may post CMC information directly into the JCRB website for CMC review and this information will be approved by a fast track process if there are no objections raised during the time limit for comments.

The three Sections of the CCRI will continue to conduct, evaluate, and publish the results of key comparisons, as well as approving the protocols for RMO key comparisons.

The CCRI-RMO Working Group on CMCs, the report of which was submitted as a working document to the meeting (CCRI(III)/05-05), had discussed and slightly revised the rules for filling in CMCs, and confirmed the definition of the service categories for ionizing radiation measurements. Members of this working group are appointed by the RMO Technical Committees.

The CCRI Section III, as it has representatives from each of the RMOs active in this field, proposes to examine the consistency of the CMCs for neutron measurements against the degrees of equivalence with the key comparison reference value (KCRV) in the comparisons that are to be published.

4 MEASUREMENT COMPARISONS UNDER SECTION III

4.1 Neutron fluence rate measurement (CCRI(III)-K10) (Pilot PTB)

Dr Klein reported on the status of this key comparison. For various reasons the preparation of the final type B report was delayed. He summarized briefly the results of the evaluation which had been presented and thoroughly discussed at the last meeting. The degrees of equivalence, however, had to be recalculated and will be reported as is generally requested for key comparisons; being both tabulated in Appendix A of the report and, with figures, discussed in the text (chapter 6). Section III agreed to a request of the VNIIM not to include their 14 MeV result, which was already excluded from the calculation of the KCRV in the degrees of equivalence.

Since May 2003, the evaluator received revised results from some participants which were chiefly based on re-investigations of the response of their fluence measurement instruments employed in the framework of this comparison exercise (CIAE, VNIIM) or on the final specifications of the primary standard instrument used (NPL). Since the revised results were obtained after the discussion of the evaluation based on the data submitted by November 2002, these data cannot be included for the evaluation of the KCRV or the degrees of equivalence. Not surprisingly, the revised results considerably improve the data and Section III decided to present

the new results both as an extension of the tabulated results in Appendix A of the report, and in additional figures discussed in the conclusions (chapter 7). The draft B report that was distributed in advance of this meeting will be revised according to these suggestions, and then circulated for final approval by all the participating laboratories.

The plan accepted by Section III for publication of the results is that the final report, once approved by the CCRI(III) would be published in the Technical Supplement of *Metrologia* with a link to the results published in Appendix B of the key comparison database of the CIPM MRA (KCDB).

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

This comparison was started in 1999 but has been considerably delayed for various reasons. Dr D. Thomas reported on the status and the final actions still planned in 2005 for completion of the comparison. The measurements with the circulating Am/Be source were recently completed at the LNE-LNHB. In 2004, the KRISS and the CIAE each requested an opportunity to repeat the emission rate measurements because their first measurements could not be analyzed, and all the participants finally agreed to extend the comparison by these additional two measurements. In Spring 2005, the source emission rate had already been measured at the KRISS, and the source then passed to the CIAE. The measurements at the CIAE were scheduled to be completed in July 2005. Measurements made at the NPL in October 1999 and July 2004 indicate that there has been no change in the emission rate of the Am/Be source between these dates.

The participants were reminded 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 collect all reports, which should be submitted not later than two months after completion of the measurements. The complete set of reports will then be sent to Dr N. Roberts at the NPL, who will be asked by Section III to evaluate this key comparison.

4.3 Fluence rate determination of thermal neutrons (CCRI(III)-K8) (Pilot PTB)

At the last meeting of Section III, Dr Gilliam suggested conducting this comparison with well-specified thermal neutron beams available at the NIST research reactor and agreed to present a protocol for approval. For various reasons, this comparison cannot be started at the NIST before 2007. Section III therefore discussed two alternatives proposed by the PTB. Firstly, the PTB has regular access to a thermal neutron beam at the research reactor of the GKSS research centre in Geesthacht which is appropriate for this purpose and could be used to conduct the comparison within the next 12 months. Secondly, for comparison of measurements at each participant's local thermal neutron fields, the PTB could provide a set of transfer instruments consisting of two spherical proportional counters filled with ^{3}He gas at different pressure which also fit into a PE-sphere (3 inch diameter). When calibrating the response of the two ^{3}He counters, both bare and encapsulated with the moderator, in their local thermal neutron fields, the participants will need to determine both the integral fluence (rate) and the spectral distribution. The latter is needed for corrections of the measured response for an agreed reference spectrum. Section III preferred the second alternative. Consequently, the PTB was asked to prepare the transfer instruments and to draft the protocol for this comparison, which could start as soon as November 2005 with the

measurements of the PTB. In order to check the stability of the ^{3}He-detectors regularly at the PTB, the comparison will be carried out in a star-shape. In addition to the PTB (pilot laboratory), the CIAE, KRISS, LNE-IRSN, NIST, NMIJ and the NPL were interested in participating. The PTB agreed to contact all potential participants in the near future.

4.4 Fast neutron fluence measurements at 24.5 keV (CCRI(III)-K1) (Pilot NPL)

The measurements for this comparison had been carried out in 1993-1996 prior to the CIPM MRA requirements for key comparisons. The coordinator, Dr V. Lewis (NPL) presented the evaluation to the CCRI(III) in 1998 in an NPL report. However, Section III did not approve this type of report for publication in *Metrologia* as there were some inconsistencies in the data analysis by the participants using Sb/Be sources, and also because of some incomplete uncertainty budgets.

In the meantime, the VNIIM had calculated the spectral fluence of the CIAE Sb/Be source and the CIAE agreed to consider this result in their re-analysis and to re-evaluate their uncertainty budget. Unfortunately, the calculation of the VNIIM sources by the CIAE is not possible because the code used at CIAE is no longer available. Section III decided to conclude the investigations at this point. All participants were requested to submit uncertainty budgets (as full as possible) by the end of July 2005. To the extent that satisfactory input data are available, Drs Klein and Thomas will prepare a revised report for approval by the participants and for publication.

4.5 Future needs

There seems to be no urgent need for other comparisons to be run before the current and planned comparisons are finalized. Having completed these, Section III should first discuss whether these key comparisons are sufficient to support all the CMCs published in Appendix C of the KCDB concerning neutron emission rate and fluence measurements.

As is the case for neutron survey meters that have to be calibrated in terms of ambient dose equivalent, Section III decided not to propose a CCRI(III) key comparison for the calibration of neutron personal dosimeters in terms of personal dose equivalent. However, for such cases Section III suggested that RMO supplementary comparisons were more appropriate.

Once again, the question was raised as to whether neutron spectrometers used for measurements in the laboratories as well as in the field should be compared – but without any well defined proposal at this stage.

5 RMO COMPARISONS

5.1 Neutron survey meter calibrations EUROMET project 608 (EUROMET.RI(III)-S1) (Pilot LNE/IRSN)

Dr V. Gressier (LNE-IRSN) spoke on behalf of the co-ordinator, Dr L. Van Ryckeghem (LNE-IRSN) on the status of this EUROMET supplementary comparison, which was considerably delayed due to serious problems with one of the two transfer instruments. The instability of the STUDSVIK survey meter now seems to have been resolved by repairs and the comparison can be restarted in June 2005. The first measurements will be at LNE-IRSN and a new schedule planned for up to 11 participants from four different RMOs (the APMP, COOMET, EUROMET and the SIM). Provided that both transfer instruments are working reliably and all participants comply with the schedule as agreed, the exercise may be completed within a two-year period.

5.2 Neutron fluence rate measurements at 15.5 MeV to 19 MeV (Pilot PTB)

The coordinator Dr R. Nolte (PTB) reported on the status of this supplementary RMO comparison with the IRMM and the NPL. Similarly to the procedure applied for the key comparison CCRI(III)-K10, the measurements were performed at the PTB accelerator facility in December 2004. The analysis of the measured data is in progress. The PTB has to provide corrected monitor rates for the calibration of one selected neutron monitor as well as the relative spectral fluences needed for corrections to the readings of the fluence measurement devices used by the participants. The final reports of the participants are to be submitted by the end of 2005. The results will be evaluated by Dr Nolte at the PTB.

5.3 Comparisons of other RMOs

No other RMO supplementary comparisons were reported as planned or in progress.

5.4 Future needs for RMO comparisons

Section III suggested that an RMO, possibly the EUROMET, should propose a supplementary comparison for the calibration of neutron personal dosimeters in terms of personal dose equivalent. This comparison could be made by circulating electronic personal dosimeters mounted on a standardized phantom and using radionuclide neutron sources according to the procedures described in the standard ISO 8529.

5.5 Evaluation of RMO and key comparison data

Dr Klein referred to a paper submitted by the VNIIM (CCRI(III)/05-12). However, the paper was not discussed in detail due to lack of time and the Chairman suggested that the draft proposal be reviewed by in-house experts. His colleagues at the PTB had already commented

directly to the authors. Meanwhile the paper had also been presented at a workshop held in May at the NMIJ, Tsukuba, and was discussed in detail on this occasion.

6 THE MUTUAL RECOGNITION ARRANGEMENT

Reports from the RMOs concerning CMC reviews have been received (CCRI(III)/05-02, CCRI(III)/05-03 and CCRI(III)/05-15).

With regard to the determination of the key comparison reference values, there is no single approach currently employed by all the Consultative Committees or all the Sections of the CCRI, and no such recommendation is expected. Section III is in favour of calculating weighted means as long as the uncertainty budgets of all the participants are acceptable.

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

7.1 CIAE (CCRI(III)/05-01)

Dr Z. Wang presented recent developments and the status of neutron measurements at CIAE.

7.2 CMI (CCRI(III)/05-04)

Dr M. Kralik presented recent progress in neutron metrology at the Czech Metrology Institute.

7.3 NMIJ/AIST and JAERI (CCRI(III)/05-06) and (CCRI(III)/05-07)

Dr H. Harano reported on recent developments in neutron standardization and calibration fields in Japan.

7.4 NPL (CCRI(III)/05-08)

Dr D. Thomas reported on recent developments in neutron metrology at the NPL.

7.5 LNMRI/IRD (CCRI(III)/05-09)

Dr W. Wagner Pereira described recent work in neutron metrology at LNMRI.

7.6 PTB (CCRI(III)/05-10)

Dr R. Nolte described the reorganization of the PTB and in particular, of activities in the field of neutron metrology and dosimetry.

7.7 NIST (CCRI(III)/05-11)

Dr D. Gilliam made some brief comments on neutron standards work at the NIST and referred participants to the detailed report in the working document.

7.8 KRISS (CCRI(III)/05-13)

Dr H. Park reviewed the activities of the KRISS in the field of neutron metrology.

7.9 LNE-IRSN (CCRI(III)/05-18)

Dr V. Gressier discussed recent developments in neutron metrology at the LNE-IRSN.

7.10 IRMM (CCRI(III)/05-16)

Dr G. Lövestam reported on recent activities of the IRMM Neutron Physics Unit.

7.11 VNIIM (CCRI(III)/05-17)

Dr N. Moisseev reported on the recent activities of the VNIIM Neutron Group.

7.12 IAEA

Dr A. Trkov reported the activities of the Nuclear Data Section with emphasis on the evaluated data files supported by the IAEA.

7.13 CIEMAT

Dr J.M. Los Arcos presented the activities of the CIEMAT dosimetry laboratory including the plans for setting up a neutron calibration service, in particular the installation of a Mn-bath for the determination of the emission rate of radionuclide neutron sources used in Spain.

7.14 NIM

Dr Y. Zhang spoke briefly about future activities of the NIM in the field of neutron metrology. He supported the CIAE participation in key comparisons and agreed to propose a formal link to enable them to be designated for appropriate neutron measurements in China. This would enable results for China to appear in the KCDB Appendix B.

8 TRENDS AND FUTURE NEEDS IN NEUTRON METROLOGY

This topic could not be discussed in detail due to a lack of time.

9 FUTURE MEMBERSHIP OF CCRI(III)

The KRISS had applied for regular cooperation in the framework of Section III of CCRI as an observer and had nominated Dr H. Park as their representative in the field of neutron metrology. Consequently, Dr Park was able to participate in the present meeting.

The BARC had informed the CCRI of in their activities in the field of neutron metrology and dosimetry and announced their interest in participation in Section III activities. Unfortunately, although invited as a guest, they were not able to send a participant to this meeting.

The participants were reminded to keep their CCRI(III) bibliographies up to date as this fulfilled an important part of the criteria for CCRI(III) membership.

10 FUTURE CHAIRMAN OF CCRI(III)

Since the present Chairman will retire from the PTB in January 2006, he proposed that a new chairman of Section III be appointed. Dr Thomas (NPL) was asked to chair this section of CCRI, at least for the next meeting. He agreed to this and to continue with the present tasks. Section III commended Dr Klein for his effective and congenial leadership of Section III, and his many years of service to the CCRI(III) and the field of neutron metrology.

11 WORK PROGRAMME OF THE BIPM IONIZING RADIATION SECTION

Due to the lack of time, Dr Allisy-Roberts waived her presentation. The participants were referred to the working document CCRI(III)/05-14. Dr Klein noted that his protestations at the last CCRI meeting against the loss of some BIPM support for the in-house ionizing radiation programme appeared to have had a positive effect. Dr Allisy-Roberts concurred that the Director had indeed taken action and thanked Dr Klein for his timely intervention.

12 OTHER BUSINESS

12.1 Public access to Section III working documents

Most of the working documents submitted by the laboratories and institutions were accepted by the delegates for transfer to the open-access area of the CCRI web page. However, the draft paper of the VNIIM cannot be included because the authors of the paper intend to submit a revised version for publication in *Metrologia*.

12.2 Special Issue of *Metrologia*

Professor P.W. Martin, past editor of *Metrologia*, had offered to publish reviews of the metrology of ionizing radiation in special issues of *Metrologia* which may appear in 2007/2008. The idea, initiated by the President of the CCRI, Professor Moscati, is to review the state of the art, current applications and future needs of metrology in the field of ionizing radiation. Each section of the 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. The subject areas, potential contributing authors and the assignment of referees (two per article) are the responsibility of the CCRI Guest Editors while the organization of the project will be in the hands of the present Editor of *Metrologia*, Dr J. Williams. However, no progress had been achieved since the last meeting.

Shortly in advance of the present meeting, Dr Klein had distributed a preliminary table of contents for discussion. Although there was no time to discuss this proposal in detail, Section III participants agreed to review the quantities to be measured, the status achieved for the various techniques and the future needs of neutron metrology. Drs Thomas and Klein, the new and retiring Chairmen of Section III, were asked to act as the Guest Editors and to prepare an updated version of the table of contents with potential authors identified for each chapter and suggestions for a time schedule. This will be circulated for comment before submitting it to the Editor of *Metrologia* as the final project plan for the special issue.

13 DATE OF THE NEXT MEETING

Subject to the approval of the CIPM, the next meeting of Section III will be scheduled in May 2007, close the meeting of the CCRI. Section III requested the allocation of two full days to ensure adequate discussion of neutron metrology.

D. Gilliam, *Rapporteur*

September 2005

APPENDIX R(III) 1.
WORKING DOCUMENTS SUBMITTED TO THE CCRI(III) AT ITS 16TH MEETING

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

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

Document CCRI(III)/	
05-00	Draft agenda, 2 pp. (restricted access)
05-01	CIAE (China)— The status and development of Neutron metrology in CIAE, C. Rong, Z. Wang, J. Chen, Y. Liu, H. Luo, 4 pp.
05-02	APMP. — APMP/TCRI Activity Summary 2005, D. V. Webb, 4 pp.
05-03	SIM. — Report of SIM Laboratories to the CCRI (section III, neutron measurements), April 2005, L. Karam, 1 p.
05-04	CMI (Czech Republic). — Recent Activities in Neutron Metrology at the Czech Metrology Institute, April 2005, M. Kralik, V. Olsovcova, 3 pp.
05-05	RMO. — Meeting of CCRI RMO Working Group for Ionizing Radiation CMCs, November 2004, D.V. Webb, 8 pp. (restricted access)
05-06	NMIJ/AIST (Japan). — Recent activities in neutron standardization at NMIJ/AIST, H. Harano, T. Matsumoto, T. Shimoyama, A. Uritani, K. Kudo, 9 pp.
05-07	JAERI (Japan). — Recent Activities on Neutron Calibration Fields at FRS of JAERI, Y. Tanimura, Y. Uchita, J. Saegusa, M. Yoshizawa, 7 pp.
05-08	NPL (United-Kingdom). — Recent Developments in Neutron Metrology at the National Physical Laboratory, April 2005, D. Thomas, A. Bennett, S. Cheema, N. Hawkes, N. Horwood, L. Jones, P. Kolkowski, N. Roberts, G. Taylor, April 2005, 8 pp.
05-09	LNMRI/IRD (Brazil). — Progress Report 2003-2005, 2 pp.
05-10	PTB (Germany). — Neutron Metrology and Dosimetry at the PTB – Changes and Progress since May 2003, H. Klein, R. Nolte, 2 pp.
05-11	NIST (United-States). — CCRI Activities of the NIST Neutron Interactions and Dosimetry Group, D. Gilliam, 20 pp.
05-12	COOMET. — Evaluation of Regional Key Comparison Data, I.A. Kharitonov, A.G. Chunovkina, 13 pp. (restricted access)
05-13	KRISS (Republic of Korea). — Activities of the neutron standardization at the Korean Research Institute of Standard and Science, H. Park, 7 pp.
05-14	BIPM. — BIPM Programme on Ionizing Radiation Metrology, P.J. Allisy-Roberts, 16 pp. (restricted access)

Document
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05-15 EUROMET. — Euromet activities in the field of neutron measurements, reporting period: May 2003 – May 2005, H. Klein, M. Kralik, 5 pp.

05-16 EC–JRC–IRMM (Belgium). — Report on th IRMM Neutron Physics Unit with regard to recent neutron fluence intercomparisons and measurements, G. Lövestam, 3 pp.

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