CGPM

CCRI President's Report

27th CGPM (2022)

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Report by the President of the CCRI

Dr Martyn Sené, President of the Consultative Committee for Ionizing Radiation (*Comité consultatif des rayonnements ionisants,* CCRI) presented his report on the activities of the CCRI since the 26th meeting of the CGPM (2018).

CCRI Executive summary

In the period 2018 to 2022 since the 26th meeting of the CGPM, the CCRI has continued to focus on enabling all users of ionizing radiation to make measurements with confidence at an accuracy that is fit for purpose so that the many benefits of ionizing radiation (IR) can be realized and the risks minimized. At a CCRI level, and in the 3 "Sections" that focus on metrology for different aspects of ionizing radiation, the CCRI has continued to work across the metrology community and with a wide range of end-users and other stakeholders to ensure that the CCRI understands their needs and collaborates with them to achieve its mission.

In the last 4 years the CCRI has welcomed five new members, one observer and two liaison organizations. There are now a total of 48 institutes and organizations currently involved at the CCRI plenary or Section level.

At the heart of this has been an enormous amount of work maintaining the integrity, validity and utility of ionizing radiation CMCs (calibration and measurement capabilities) and improving some of the fundamental data that underpin them. The BIPM contribution to this is particularly noteworthy; of the 110 comparisons in the period of this report, 80 % have been bilateral BIPM comparisons.

Particular developments in the last four years include:

- A new WG bringing together metrologists and stakeholders from the medical community to address measurement issues in the rapidly developing fields of radionuclide therapy and quantitative nuclear imaging.
- A new Task Group, collaborating with the Consultative Committee for Electricity and Magnetism (CCEM), to guide the introduction of new technologies for the measurement of low electrical current for ionization chambers used in the measurement of radionuclide standards and used widely in medical and radiation protection applications.
- Working with Consultative Committee for Amount of Substance: Metrology in Chemistry and Biology (CCQM) to understand how developments in metrology using mass spectrometry can be applied to its increasing potential use in measuring low-level (for example environmental) and long-lived (for example nuclear waste and forensics) radionuclides.

The constraints on working due to the Covid-19 pandemic during this period catalyzed the development of new virtual mechanisms for communication and involvement of the community. These included a series of webinars that have brought together stakeholders and metrologists from across the globe with a total of 1 277 individuals from 89 states and economies participating across 17 webinars. The CCRI has now convened a CCRI Communication Working Group (CCRI-COMWG) to ensure it can continue to use these and other (in person and virtual) mechanisms to support the CCRI and its mission.

Looking ahead, the CCRI will continue to respond to challenges such as those above, but will also need to respond to the digital revolution including the integration of the SI Digital Framework into ionizing radiation metrology. New requirements from technological developments are anticipated, such as innovative nuclear reactor designs and the transition of fusion power from R&D to commercial application.

The success and impact of the CCRI is the result of the work of a large number of individuals from across the global IR community. As president of CCRI, I would like to recognize and express my gratitude for their commitment and contribution.

Scope of the CCRI

Ionizing radiation continues to be used around the world for many beneficial applications in healthcare, research, material production and characterization, and in support of a secure (low-carbon) energy supply. However, ionizing radiation is also known to cause material and physical damage, including the risk of carcinogenesis. The Vision and Mission of CCRI and the Mission of the BIPM Ionizing Radiation Department recognize and reflect our valuable role in this context:

CCRI Vision:
A world in which the many benefits of ionizing radiation for healthcare, industry and technology can be realized by accurate and scientifically-rigorous measurement, confident that the associated risks are minimized.

CCRI Mission:
to discuss, foster, enable and coordinate the development, comparison and promulgation of national measurement standards for ionizing radiation. We aim to enable all users of ionizing radiation to make measurements with confidence and at an accuracy that is fit-for-purpose.

BIPM IR Department Mission:
to support the CCRI in its mission, to promote the work of the international metrology community, and to provide services to NMIs and DIs that can be centralized in an efficient way.

As of November 2022 there are 13 members, four liaison organizations and ten observers of the CCRI. In the four years since the 26th CGPM the CCRI has welcomed five new members, one observer and two liaison organizations. The work of the main CCRI is supported by three "Sections" focused on metrology for particular aspects of ionizing radiation. In addition, eight Working or Task Groups were active during the period of this report, addressing particular issues in IR metrology. The Director of the BIPM Ionizing Radiation Department is the (*ex officio*) Executive Secretary of CCRI. More information on the structure and membership of CCRI can be found at the end of this report.

Strategy

The present CCRI strategy was developed by CCRI members in consultation with the wider ionizing radiation metrology community and by key stakeholders; it was first published in 2018. It was updated in June 2021, following another wide consultation, to reflect new developments in the field of ionizing radiation metrology and use in the stakeholder community. It also responds to the wider strategic review being undertaken by the CIPM that will be reported in detail at the 27th meeting of the CGPM.

The strategy sets out the main scientific, economic, and social challenges along with developments in science, technology and applications of IR that shape the work of CCRI. These lead to five high level strategic aims to:

- improve global comparability of measurements.
- build capabilities at smaller NMIs/DIs.
- progress the "state of the art" for issues identified by stakeholders of benefit to NMIs/DIs and the BIPM.
- expand the coverage of services supported by CMCs.
- coordinate the introduction of the SI Digital Framework in ionizing radiation metrology.

Notable activities and achievements since the last meeting of the CGPM

Comparisons/CMCs

At the heart of CCRI activity is a significant programme of work to maintain the integrity, validity and utility of ionizing radiation CMCs, and to improve the fundamental data that underpin them. The CCRI has sought to remove barriers for NMIs submitting CMCs across all regions and at all stages of development. One important step, by the CCRI RMO Working Group on IR CMCs (CCRI-RMOWG), has been the establishment of an online course on how to enter a CMC claim for ionizing radiation metrology; now part of the e-learning training material provided by the BIPM.

The table below summarizes CCRI comparison activity in the dotation period 2020-2023 (including those scheduled for completion in the final year of the period) and compares this to activity in the previous dotation period (the years 2016-2019).

		Dotation Period 2020-2023				**Dotation Period 2016-2019**		
		Completed	In progress	Scheduled	**Total**	Completed	In progress	**Total**
CCRI	Key	1	2	2	**5**	4		**4**
	Supplementary	1	3		**4**	2	1	**3**
RMO	Key		8		**8**	6		**6**
	Supplementary	2	2	2	**6**	6		**6**
BIPM		24	35	28	**87**	54	10	**64**

These data show that the total number of comparisons for the present dotation period is expected to be significantly higher than 2016-2019. Much (although not all) of this rise reflects the large (and increasing) number of bilateral comparisons undertaken by the BIPM (~80 % of the total number). The importance and value of this, and other work of the BIPM Ionizing Radiation Department, was reflected in the response to the wide consultation undertaken as part of the CCRI strategy development.

There has also been a considerable increase in the level of publications related to comparisons[1].

At the time of this writing, the total number of ionizing radiation CMCs registered in the KCDB is 3 779, reflecting a small (~5 %) reduction compared to the number at the end of the last dotation period. This results from a rebalance among new CMCs in all three Sections and work to reduce/combine CMC categories (notably in Sections II and III).

More detail on this work (including the contributions of the BIPM) is provided below in the reports from the three CCRI Sections More detail on the BIPM programme can be found in the BIPM Annual Review reports and supplements.

CCRI Section I: X- and Gamma-rays, Charged Particles

(Chair: Dr Malcolm McEwen, Vice Chair: Dr Massimo Pinto)

CCRI Section I oversees a robust comparison programme that is centred on the BIPM ionizing radiation laboratories. BIPM.RI(I) Key Comparisons K1-K9 are all carried out as bilateral comparisons between the participating laboratory and the BIPM, and this continues to work very well. During this reporting period, it was agreed to launch a new Key Comparison – K9 – for the determination of absorbed dose to water for medium-energy x-ray beams. This addresses the continued use of such radiation beams in cancer therapy and recognizes that current uncertainties at the point of use can be significantly reduced through this new standard/comparison. Member organizations continue to work on standards for other beam modalities, specifically high-energy electron, proton and light ion beams, and the discussions are ongoing as to when it would be appropriate to launch Key Comparisons for these beams. One supplementary comparison was successfully carried out under the auspices of the CCRI(I) related to dosimetry for industrial processing (for example, sterilization of medical goods). A new feature of this comparison was that the pilot laboratory (NRC, Canada) was not a participant, allowing the section to better understand options for piloting future comparisons.

CCRI Section II: Measurements of radionuclides

(Chair: Dr Lisa Karam, Vice Chair: Dr Freda van Wyngaardt)

CCRI Section II comparisons have seen an expansion of global measurement support capabilities at the BIPM. This includes a greater variety of sources beyond ^{99m}Tc, ^{18}F, ^{64}Cu and ^{11}C (^{123}I, ^{153}Sm, with ^{13}N, ^{56}Mn, ^{68}Ga, and ^{166}Ho under development) measured by the travelling Système International de Référence (SIRTI), operated in a remote mode since 2021. Plans for regional "versions" of the SIRTI and expansion of BIPM measurement support to beta-particle emitting sources (with future work to alpha emitters) using the extended SIR (ESIR) are anticipated beyond 2022. Strategic planning of other radionuclide (activity) comparisons is done through the use of a sector-based cycling 10-year plan and the Measurement Methods Matrix (MMM).

Administratively, CCRI(II) has revised and reduced the number of service categories for radionuclide CMCs to optimize writing and review, and has prepared several interpretation documents ("*Guidance on Applying the MMM in Using Comparison Results to Support CMCs*", "*The Interpretation of CMCs*" in ionizing radiation, and "*An Interpretation of CIPM MRA-G-11: Implications and Impacts for CCRI*") to help put CIPM MRA guidance in context for ionizing radiation metrology, and is working on a proposal for how CMCs in radionuclide metrology might evolve to a method-based sorting approach from the current radionuclide-based sorting approach (reflected in actions of the RMO WG).

CCRI Section III: Neutron measurements

Chair: Dr. Andreas Zimbal, Vice Chair: Mr. Neil Roberts

CCRI Section III is the forum for neutron metrology and has expanded in recent years to bring together most of the NMI/DIs active in this field. This is reflected in the increase both in the number of participants (notably due to the possibility of participation by videoconference), and also in the number of key or supplementary comparisons piloted by the CCRI(III) (with

[1] In the 3 years (2020-2022), the number of ionizing radiation comparison reports in *Metrologia* is already 25 % higher than for the whole 4 years of the previous period. Including publications in preparation this may rise to ~ 75 % by the end of 2023.

consequently limited activities and number of comparisons running at the RMO level): four comparisons completed or in progress over the period 2019-2022 and two planned to start in 2023-2024.

During the last four years, work has been undertaken to reduce the number of CMCs through focusing on the basic quantities of this field, with additional services (derived quantities) offered by the NMI/DIs being covered by their internal quality management system.

Another important task, arising from revision of the CCRI strategy, has been to develop a response to anticipated future needs for neutron metrology. These will require the development of new measurement methods, as well as new reference neutron fields, which, due to the need for increasingly large facilities, often have to be shared by several institutes. This mainly concerns high-energy (>20 MeV), high-intensity (for example, for BNCT or nuclear fusion) and pulsed neutron fields.

Responding to new challenges and opportunities

Alongside work related to maintaining the integrity, validity and utility of ionizing radiation CMCs; the CCRI community has sought to respond to new challenges from the stakeholder community and new developments in metrology. Once the challenge or opportunity has been identified, a common response is the establishment of Working Groups or (shorter term) Task Groups bringing together the necessary expertise from across the globe. Highlights since the last CGPM include the following.

CCRI Radionuclide Therapy and Quantitative Imaging Working Group (CCRI-RTWG)

The CCRI-RTWG was formed in late 2019 to address measurement issues in the rapidly developing fields of radionuclide therapy and quantitative nuclear imaging. It brings together more than a dozen international experts in the fields of radionuclide metrology and nuclear medicine to develop and promote best practices in radioactivity measurement in the clinical practice of radionuclide-based therapy, including quantitative imaging and dosimetry.

To date CCRI-RTWG has led three BIPM webinars; most notably one entitled “Engagement Between NMIs/DIs and End-Users”. This brought together representatives from an NMI and the end-user community (physicians, physicists, regulators) from each of three different countries. The result was an increased insight into the needs of each side and a better understanding of how engagement between the communities can improve patient care. Feedback from all of the webinars has been used to develop the workplan for the Working Group for the coming years. This includes developing two guidance documents, on establishing and maintaining measurement traceability for quantitative imaging that contains specific guidance on phantom preparation and uncertainty assessment (expected mid-2023), and on measurement issues associated with the new class of alpha-emitter-based therapies.

CCEM-CCRI Task Group – Low Current Measurement (CCEM-CCRI-TG-LCM)

This Task Group was established in 2019, in collaboration with CCEM, to guide the introduction of new technologies for the measurement of low electrical current for ionization chambers, which are widely used in medical and radiation protection applications and are at the heart of NMI reference systems and the BIPM Système International de Référence (SIR).

In the electrical metrology community, the development of electron pumps in recent years has focused attention on small current metrology. The need to measure these currents for research purposes has driven a better understanding of existing low current systems as well as development of new systems. This new technology offers a number of benefits, including the potential for replacing most of the long-lived radionuclide sources (for example, ^{226}Ra) with stable current systems to monitor the stability of ionization chambers.

The Task Group brings together 18 experts in electrical measurement and radionuclide metrology, with the aim of developing and publishing a “best practice” guide for the use of the low current measurements for ionization chambers.

CCRI-CCQM collaboration on Mass Spectrometry in Radionuclide Metrology

Mass spectrometry (MS) methods have been used in various laboratories as a tool for the measurement of long-lived radionuclides, particularly in complex matrices for about 25 years. However, its use in radionuclide metrology (particularly at the NMI level) has to date been limited. The CCRI (led by Section II) has initiated a collaboration with the CCQM to investigate

how MS might play a role in meeting some of the metrological needs in applications such as decommissioning and decontamination of nuclear/radiological sites, pollution monitoring and control, nuclear safeguards and forensics, impurity and interferences evaluation (especially in environmental and therapeutic nuclear medicine applications), and critical nuclear decay data for extremely long-lived radioisotopes.

Initial work has included meetings to present and understand the needs and expertise of the two communities, a survey of the current status of mass spectrometry in the CCRI community and a webinar to understand work currently under way at some of the NMIs/DIs and future plans (including research proposals). A workshop is planned for February 2023 to bring together the CCRI and the CCQM communities to discuss possible uses, potential benefits, and challenges in extending the use of MS to the radionuclide community.

CCRI Task Group on radioactive sources and alternative technologies (CCRI-TG-RS)

A Task Group was set up by CCRI(I) in 2021 in response to the increasing regulatory burden on large radionuclide sources, which are a critical component of the ionizing radiation metrology infrastructure. There are increasing regulatory pressures that may mean certain key isotopes will be more difficult to obtain and/or operate within metrology laboratories, highlighted in a report from the US National Academies of Science on this topic[2]. At the BIPM the plans to access the IAEA Cs-137 source rather than install a facility at Sèvres, and moves to minimize other source holdings, are a response to this long-term trend. This TG aims to produce a report for consideration by the CCRI, on the implications and options for ionizing radiation metrology, in 2023.

Communications

The constraints on in-person activities due to the Covid-19 pandemic from 2020 into 2022 impacted the work of the CCRI, with events cancelled and meetings moving online. However, it also catalyzed the development of new virtual mechanisms for communication and involvement of the ionizing radiation community and provided the stimulus to explore new communication tools to support its mission and to review its approach to communications. This included a series of webinars that brought together stakeholders and metrologists from across the globe. These webinars have enabled knowledge transfer, reviews of state-of-the-art in specific fields and have also provided a forum for stakeholders to share their measurement challenges and metrologists to share their response. A total of 1 277 individuals from 89 states and economies have participated in 17 webinars to date.

The CCRI has convened the CCRI Communication Working Group (CCRI-COMWG) to ensure it can continue to use these and other (in person and virtual) mechanisms to support the CCRI mission. In particular, as the world emerges from the pandemic restrictions, it will be necessary to understand the benefits/drawbacks of different modes of communication, training and meeting formats. For example, how to best balance the inclusivity of virtual meetings with the depth of face-to-face communications.

Outlook in the short and long term

The CCRI continues, through direct liaison and through the wider network of its Members, to understand the evolving needs of its stakeholders and end-users. The CCRI will continue to respond to these challenges, to embrace new metrological science and technology and to support NMIs who are seeking to enhance their capabilities in IR metrology.

The following activities, which are examples of this response since 2018, are expected to continue in the short/medium term:

- The work of the CCRI-RMOWG on CMCs optimizing the scope of ionizing radiation CMCs to maximize their value without placing an unreasonable burden on the community to maintain them.
- The work of the CCEM-CCRI-TG-LCM and of the CCRI-RTWG.
- The work of the CCRI-TG-RS.
- Further development of work with CCQM on the application of mass spectrometry in ionizing radiation metrology, including a workshop planned for February 2023.

[2] "Radioactive Sources: Applications and Alternative Technologies;" 2021 report from the US National Academies of Sciences, Engineering and Medicine.

– The work of the CCRI-COMWG to harness established and new communication tools to support the CCRI's mission.

Other challenges which it is anticipated will need to be addressed in the coming years include:

– Understanding the implications of the Digital Revolution for ionizing radiation metrology and coordinating the introduction of the SI Digital Framework in ionizing radiation metrology. Technical challenges include determination of how the SI Digitalization Framework can be integrated into the established use of digital technologies in ionizing radiation metrology and in applications of ionizing radiation, and how CCRI members can expand the use of digitalization technologies (for example, comparison reports including digital data, electronic calibration certificates) in serving the stakeholder communities. The CCRI is establishing a Digital TG to address this challenge, and to provide a link to the overall Digital-SI programme of the CIPM. Its first meeting is planned for 2023.
– In the longer term, the CCRI is anticipating a resurgence of interest in some countries in nuclear power, with innovative (for example, Small Modular Reactor) designs. There are also a number of national and international programmes seeking to accelerate the transition of fusion power from R&D to commercial application. Both of these will require metrological support.

Strategies are living documents that need to reflect the changing global context that the above examples illustrate. Hence, the CCRI Strategy will be reviewed again over the next few years, in parallel with the development of the wider strategy and vision work of the CIPM, before the 150th anniversary of the Metre Convention in 2025.

CCRI Data

CCRI set up in 1958 (From 1958 to 1999 the committee was under the name CCEMRI.)

President: M. Sené	Executive secretary: V. Gressier (Dr S. Judge prior to June 2021)
Membership:	13 members, five liaison organizations and ten observers
List of CCRI members and observers:	https://www.bipm.org/en/committees/cc/ccri/members
Meetings since the 26th CGPM meeting:	7 June 2019, 8-10 June 2021
Full reports of the CCRI meetings:	https://www.bipm.org/en/committees/cc/ccri/publications

The work of the main CC is supported by three "Sections" focused on metrology for the particular aspects of ionizing radiation:

– CCRI Section I X- and gamma rays, charged particles
– CCRI Section II Measurement of radionuclides
– CCRI Section III Neutron Measurements

Eight Working Groups: https://www.bipm.org/en/committees/cc/ccri

– CCEM-CCRI Task Group - Low Current Measurement (CCEM-CCRI-TG-LCM)
– Section I: Brachytherapy Standards Working Group (CCRI-BSWG(I))
– Communication Working Group (CCRI-COMWG)
– Section I: Key Comparisons Working Group (CCRI-KCWG(I))
– Section II: Key Comparisons Working Group (CCRI-KCWG(II))
– RMO Working Group on IR CMCs (CCRI-RMOWG)
– Radionuclide Therapy and Quantitative Imaging Working Group (CCRI-RTWG)
– *ad hoc* Working Group on Strategy (CCRI-SWG)