BUREAU INTERNATIONAL DES POIDS ET MESURES

Comité Consultatif pour les Rayonnements Ionisants

Section I (X- and γ-rays, charged particles)

26th Meeting (1st to 4th June 2021)

Virtual (Cisco Webex): 10:30 UTC to 14:00 UTC

Chair	Dr Malcolm McEwen (NRC)
CCRI President	Dr Martyn Sené (NPL)
CCRI Executive Secretary	Dr Steven Judge (BIPM)

Delegates

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BIPM Staff

Dr David Burns

Dr Cecilia Kessler

Mr Philippe Roger

1. Welcome

Dr Malcolm McEwen (Chair – CCRI Section I) welcomed delegates to the meeting. Due to the ongoing COVID-19 pandemic this will be a virtual meeting but we are optimistic that the next CCRI(I) meeting can be held in person.

2. Report from the CCRI President

Dr Martyn Sené welcomed delegates to the meeting. He gave a brief presentation on the overview of CCRI(I) and discussed the importance of ionizing radiation metrology and the impact of the pandemic. He discussed the CIPM strategy including evolving needs, key scientific challenges (including digital metrology challenges in a virtual world), engagement with other international organisations, the strategy for future membership and modernising CCRI operations. He concluded by thanking Dr Malcolm McEwen for chairing the meeting and Steven Judge of BIPM, the executive secretary, who is retiring.

3. Confirmation of the Agenda and appointment of Rapporteur

Dr Malcolm McEwen discussed how questions and communications can be submitted in the virtual platform (chat) and requested any additions to the Agenda. There were no additions. Dr Bryan Muir (NRC) agreed to act as Rapporteur for the meeting with assistance from Dr Thorsten Sander (NPL) and Mr Russell Thomas (NPL).

4. BIPM-related activities

4.1 Report 2019-2021 of the BIPM Ionizing Radiation Department to CCRI Section I

Dr David Burns presented on the activities of the BIPM IR department over the last two years. The BIPM have been able to continue their comparison and calibration services during the pandemic and have established a new calibration service for high-energy x-rays based at the DOSEO plate-forme de recherche en radiothérapie (located adjacent to the LNE-LNHB facility).

In his presentation, Dr Burns presented upgrades currently taking place at BIPM:

i. Replacement of a failed x-ray generator, which impacted the BIPM absorbed-dose standard. The Seifert Isovolt 320 HS failed in early 2020 and was replaced by a GE Isovolt Titan E 320 generator. Reference instruments were used to verify air-kerma calibrations to within 0.02 %. However, the absorbed dose to water, relative to the air kerma, changed by up to 0.5 % depending on beam quality. This was accounted for by adopting a change in the dose conversion factor $C_{w,air}$.

ii. A new medium-energy x-ray facility is being commissioned. The new system will operate independently and initially in parallel with the current system, which was installed in the 1970s. Dr Burns gave a summary of the components to be changed and those that will remain unchanged. A new free-air-chamber (FAC) is also being built and commissioned. To date, the x-ray tube support has been built with an automated shutter, an automated filter wheel and mechanical and optical options for a precise set up. Future work includes tube alignment and collimator fine-tuning. The measurement bench is close to completion and incorporates vertical translation of the water phantom (to allow for in-air and in-water measurements), lateral translation to alternate between the standard FAC and the ionization chamber under test and a frame for thermal isolation. The electronics and software development are still in progress and the reference fields require characterization. The new FAC is in the design stage. Options are being considered to modify and/or optimize the electric field uniformity, which is the dominant source of uncertainty in the BIPM FAC measurements.

iii. BIPM is looking into options for prolongation of the cobalt-60 facility to 15 years, because of national regulations that do not allow the use of a sealed source for longer than 10 years. *Note – this prolongation has been obtained since the CCRI(I) meeting.*

iv. Due to the same national regulations, the Cs-137 facility, which uses a much older sealed source, has been decommissioned, and the calibration capability will be transferred to the IAEA Seibersdorf laboratory for operation. The BIPM equipment, procedures and personnel will be used while the IAEA provides the Cs-137 beam. Commissioning at the IAEA laboratory has been delayed because of COVID.

Dr Burns highlighted the BIPM's work with primary stakeholders, the IAEA and the ICRU. In progress with the IAEA is the aforementioned transfer of the Cs-137 capability to the IAEA facility as well as work to revise the IAEA TRS-398 Code of Practice. The BIPM is contributing to the ICRU Report Committee 31 on "Dosimetry-Guided Radiopharmaceutical Therapy" and is working with the ICRU on implementation of the ICRU Report 90 by NMIs. The BIPM Capacity Building and Knowledge Transfer Programme (CBKT) was also mentioned.

A question period followed:

Dr Massimo Pinto (ENEA) asked about the primary need to replace the BIPM FAC and Dr Burns responded that it is mainly for duplication since it would be catastrophic if the present standard failed. There is also the opportunity to reduce uncertainties.

Mr Vladimir Sochor (CMI) asked how the warranty period of the HV generator is being handled if installing invasive HV measurements. Dr Burns responded that the voltage divider and measurement apparatus are external so are not invasive to the HV generator.

Dr Ernesto Mainegra-Hing (NRC) asked about the reason for the change in the air kerma to dose conversion factor and if a detailed Monte Carlo simulation of the new x-ray tube could resolve the difference. Dr Burns explained that the effect is measurement-based – the generator technology used is not DC, instead it is a high-frequency AC system with a large ripple. The cables and the voltage divider introduce their own resistance/capacitance/inductance so the DC output might change slightly, which is postulated as the cause of the issue.

Dr Ulrike Ankerhold (PTB) asked if spectrometry measurements were planned to investigate the x-ray spectra. Dr Burns responded that this is not planned given limited staffing resources but would be an interesting project.

Dr Paula Toroi (STUK) asked if the BIPM has plans to extend the range of diagnostic radiology calibration services. Dr Burns responded that this is not planned but the BIPM will listen to the community and respond to any request from the CCRI.

Dr Massimo Pinto (ENEA) asked if the K3 and K9 comparisons will be delayed while the x-ray set-up is completed. Dr Burns indicated that delays are not anticipated since the two systems will run in parallel until the BIPM has full confidence in the new system. The two systems are physically next to each other in the same laboratory.

4.2 Comparisons

4.2.1 BIPM and CCRI(I) key comparisons status

Dr Cecilia Kessler gave a presentation on progress on BIPM comparisons and calibrations over the last two years:

Five comparisons were planned for low-energy/mammography x-ray beams. One comparison was performed in 2020 (NMIJ, Japan, BIPM.RI(I)-K7M – Report in Draft A form) while the other four were re-scheduled, two due to the COVID-19 pandemic and two because the NMI service became unavailable for other reasons. Calibrations of national secondary standards were made with 6 calibration certificates issued and 2 calibration certificates ready to issue.

Five comparisons were planned for the medium-energy x-ray beams. Four were completed, with one rescheduled because of the COVID-19 pandemic. Calibrations of national secondary standards were made with 3 calibration certificates issued and 1 calibration certificate ready to issue.

Eight comparisons were performed in the Co-60 γ-ray beam, with two comparisons re-scheduled because of the pandemic. The BEV K1 and K4 reports were published, the GUM and ARPANSA K1 and K4 reports are ready to be published, and the NRC K1 and K4 reports are in draft A form. The KRISS comparison is scheduled for later in 2021.

There are small changes to the K4 comparison due to ICRU-90 recommendations that affect the BIPM standard.

Two comparisons were performed in high-energy x-ray beams (BIPM.RI(I)-K6) and one was rescheduled because of the COVID-19 pandemic. The LNHB report was published (2020), the NRC report is in draft A form (2020) and the PTB comparison is planned for 2021. The NIST will be invited to participate in the K6 comparison next year.

Overall, 52 calibrations were performed for 12 NMIs in 2019/2020.

A question period followed:

Dr Malcolm McEwen (NRC) remarked on his appreciation to the BIPM for carrying out the comparison and calibrations during the pandemic. He also asked about an apparent offset in the K7 comparison, where most NMIs appear to trend in one direction. Dr Kessler responded that it is unclear because of low NMI participation but the BIPM are confident in the their standard because of the results of the K2 comparison.

Dr Nestor Cornejo Diaz (CIEMAT) asked how to participate in the K5 comparison. Dr Kessler responded that the K5 comparison has currently been delayed because of national regulations in France relating to radiation protection. It will proceed once the Cs-137 facility has been established at the IAEA, but this will be deferred until travel restrictions are lifted. For any comparison NMIs are advised to contact Dr Kessler to organize scheduling.

Mr Claus Anderson (DTU) asked if there has been interest in the MV calibration service. Dr Kessler responded that the service was launched last year but has not been widely promoted. There have been two participants, with calibrations performed or underway for the IAEA and DTU.

A question arose about NMIs using obsolete charge measurements systems, which appears to be a potential risk. Dr Burns responded that the BIPM has enough spare equipment to maintain services at least in the near future.

Dr Malcolm McEwen reported on the CCRI.RI(I)-S3 supplementary comparison, which is for high-dose cobalt-60 calibrations. A small number of NMIs are participating with NRC piloting the comparison but not participating. The comparison is completed and the report is in draft A form.

4.2.2 Regional key and supplementary comparisons status

Mr Sibusiso Jozela (NMISA) reported for AFRIMETS that there are no current ongoing comparisons.

Dr Duncan Butler (ARPANSA) reported for APMP that there are a few key comparisons in progress as well as a new supplementary x-ray comparison, piloted by the NIM. The protocol has been developed.

Dr Anna Villevalde (VNIIM) reported for COOMET that there are two comparisons in progress. One is for medium energy x-ray qualities and one is a bilateral comparison with the PTB.

Dr Jacco de Pooter (VSL) reported for EURAMET that a beta dosimetry comparison is in progress, piloted by PTB. There are 19 participants with 7 from EURAMET. There is also a supplementary comparison in progress on the quantity H*(10) for x-rays (qualities N40, N100, N200) and S-Cs and S-Co gamma rays. This comparison is piloted by Vinča/VINS with 13 participants (12 from Euramet).

Ms Samia Mohamed (FANR) reported for GULFMET that there are no current comparisons underway but there are planned comparisons for radiation protection (x-ray beam qualities and Cs-137) and diagnostic imaging.

Dr Malcolm McEwen reported for SIM that the K1/K4 comparison is underway. There is also a supplementary comparison planned for ISO-4037 x-ray beams, piloted by the ININ (Mexico) and a protocol has been developed.

4.2.3 Future comparisons

Proposed Key/Supplementary Comparisons

Over the last several CCRI meetings there has been some interest by a limited number of NMIs (NRC, KRISS, NMIJ) in a key comparison for absorbed dose to water in high-energy (megavoltage) electron beams. During the discussion at this meeting, Dr Frank Delaunay (LNE-LNHB), Dr Peter Peier (METAS) and Dr Duncan Butler (ARPANSA) also indicated their interest in such a comparison. A draft protocol was developed previously but will need to be revisited. The concept of a possible comparison for very high-energy electron beams, in the context of the UHDpulse/EMPIR collaboration was also brought up. This would probably be a supplementary comparison and Dr Malcolm McEwen indicated that he would approach Dr Andreas Schüller (PTB) who is coordinator for the UHDpulse/EMPIR effort.

A comparison for absorbed dose to water for proton and light ion beams is also of interest. Dr Duncan Butler (ARPANSA) asked if there is already a comparison network in countries where these facilities are in use clinically and there are audit networks (IROC-Houston in the US and NPL in the UK). However, dosimetry is based on the IAEA TRS-398 Code of Practice with traceability to absorbed dose in cobalt-60 so uncertainties are at the 4 % level. NPL and other NMIs are developing primary standards for proton beams, which will reduce these uncertainties. It was concluded that more research is required before a comparison can be initiated.

The K9 comparison for absorbed dose in medium energy x-rays has not attracted further interest since 2019. This is not unexpected because the four laboratories with standards (PTB, ENEA, VSL, LNHB) already have a comparison result linked through a EURAMET comparison. The BIPM does offer a calibration service. Dr Jacco de Pooter (VSL) remarked that there is little interest from the community and maintaining the standard is a lot of effort so there are no plans to move forward with a calibration service in The Netherlands.

Barriers to Comparisons

When sending artifacts between laboratories there seem to be increasing problems both with delays at customs and the cost of shipping. In GULFMET it was reported that the members do not have a wealth of experience and have a limited budget for artifacts or shipping.

Dr Paula Toroi (STUK) remarked that RMOs can help SSDLs perform comparisons by ensuring that the process is the same as for BIPM comparisons.

4.3 Report 2019-2021 of the BIPM Ionizing Radiation Department on Future Plans

Dr Steven Judge gave a presentation on future plans for the BIPM. This included the relaunch of the Cs-137 facility, improved availability of BIPM services and support for smaller NMIs/DIs. There are also plans to restart secondments, initiate a program for virtual secondments and launch an eLearning platform. The BIPM strategy is available and feedback is requested from delegates from NMIs/DIs.

A question period followed:

The topic of the regulations and needs for sealed sources was discussed. Dr Malcolm McEwen (NRC) remarked that the BIPM needs a cobalt-60 source with sufficient activity to realize absorbed dose standards. Dr Steven Judge remarked that the input from the CCRI(I) to these discussions will be important.

Dr Ulrike Ankerhold (PTB) argued that cobalt-60 sources are becoming more expensive and that it might be appropriate to replace the reference quality with a high-energy (linac) photon beam. There is also the issue of availability in that only two countries can provide cobalt-60 sources while linacs are widely available and are now in many NMIs; the BIPM also provides linac services. The topic requires a thorough review. Dr Malcolm McEwen (NRC) responded that linacs are also expensive and less reliable than cobalt-60 irradiators.

Dr Cecilia Kessler commented that many SSDLs still required cobalt-60 calibrations and Dr Stephen Judge responded that the IAEA still views cobalt-60 calibrations as very valuable.

A definitive report to describe the importance of sealed sources for metrology is needed and an *ad hoc* group is required to draft a review that covers the use of sealed sources in various domains including dosimetry, radiation protection, and radiation processing.

Dr Duncan Butler (ARPANSA) indicated that errors have been made calibrating small volume chambers using the same procedures as for Farmer-type chambers and asked if it is worth adding a supplementary non-standard calibration to BIPM comparisons. The discussion tended toward this not playing a role in BIPM comparisons but that advice should be offered by NMIs to the user. Dr Malcolm McEwen (NRC) suggested that a BIPM webinar on small field dosimetry best practices could be considered.

5. Section I reports

5.1 NMI reports and bibliographies received as presented

Reports from participants were received but are not explicitly reviewed.

Dr Malcolm McEwen (NRC) presented a set of principles for making CCRI(I) reports public. Currently, by default, these reports are private. The proposal put forward would include three options: 1. An NMI/DI can indicate on submission that a report can be made public. 2. An NMI/DI can indicate on submission that a report should not be made public. 3. All other reports will be made public 12 months after the CCRI(I) meeting. As a clarification point, he proposed that option 3 be the default for reports where no preference is indicated.

A discussion period followed:

Dr Massimo Pinto (ENEA) asked if public reports would be assigned a DOI. They can be cited if they are public because they will be assigned a report number. Following up, Dr Pinto indicated that DOIs can be obtained with the DOI generator at https://www.bibguru.com/c/doi-citation-generator/

Dr David Burns (BIPM) remarked that 12 months seems arbitrary and quite long and asked if there is an argument for such a period. There is no basis for this nominal time period and this can be changed upon discussion.

Dr Paula Toroi (STUK) asked if reports contain information about sources and their location as this can be sensitive and restricted information. There should be guidelines about what should

go into the report (technical abilities and new developments, comparisons and a publication list) with explicit instructions not to include restricted or sensitive information. It is not a requirement to send a report (only about 10-15 NMIs do) so it is not clear whether there is an obligation and what is required.

Dr Jean-Marc Bordy (LNHB) suggested that these reports can be partially private with two documents, one that contains information that is released publicly and one that contains information only for CCRI(I). The public version could contain only a table of contents so that the public knows what is in the report and can ask for more details. It was noted that this would be more work for the laboratory, but is a possibility.

Dr Michael Mitch (NIST), Dr Massimo Pinto (ENEA) and Dr Dehong Li (NIM) expressed concern that there might be hesitancy to make the reports public because there could be new items that are intended to for a separate publication. This could make NMIs hesitant about being open and more skeptical to share information. It is possible that these newer items could be omitted from the report and presented in a few slides at the CCRI(I) meeting.

Dr Malcolm McEwen (NRC) proposed an *ad hoc* working group consisting of Dr Malcolm McEwen (NRC), Dr David Burns (BIPM), Dr Paula Toroi (STUK) and Dr Jean-Marc Bordy (LNHB) to discuss further options related to this and report back to CCRI(I). Dr Malcolm McEwen (NRC) will ask Dr Steven Judge (BIPM) to request explicit permission from the NMIs/DIs for their reports to this meeting to be made public.

5.2 Other publications received as presented

Reports from other participants were received but are not explicitly reviewed.

5.3 CCRI RMO WG – Mr Sibusiso Jozela (NMISA)

Ms Zakithi Msimang's (previously NMISA, now IAEA) term as chair of the RMO WG ended in October 2020 and Mr Sibusiso Jozela (NMISA) is now serving as the current chair. Mr Jozela gave a brief presentation of the RMO WG with an overview of its membership and activities. A review was conducted of the rules for CMCs and it was agreed that it is important to retain a formal document on the rules. Presentations have been developed on guidelines for entering IR CMCs. EURAMET has proposed grouping radioactivity CMCs – the proposal would change the presentation of the CMCs but not the review process. The RMO WG is requesting a meeting with the IAEA to discuss details on how their calibration/comparison reports can be used to fully support SSDL CMC claims. In addition, it was noted that the RMO WG has been a useful forum for information exchange between CCRI section chairs and the RMO TC chairs.

Dr Malcolm McEwen (NRC) remarked that the CIPM states that CMCs require RMO approval or other means for publishing supplementary comparisons but the CCRI approval/review process is maintained for both key and supplementary comparisons. Dr Ulrike Ankerhold (PTB) asked if that means that supplementary comparisons not approved by CCRI are not published in the technical supplement of KCBD 2.0. Dr Malcolm McEwen (NRC) answered that if the RMO approved the supplementary comparison then it will be published but is not aware of this happening without review by CCRI.

5.4 Key Comparisons Working Group (Coordinator Malcolm McEwen, NRC)

Dr Malcolm McEwen (NRC) reported that this WG is not heavily used and has not met since 2019. The majority of key comparisons are bilateral, which are simple and efficient, so there is

little WG involvement. However, there is a role for the WG in continuing to improve the key comparison review process, reaching out to smaller NMIs/DIs to provide guidance and expertise and through outreach by increasing the number of pilot laboratories and providing resources for piloting comparisons.

Dr Malcolm McEwen (NRC) put forth a proposal to extend the review period of key comparisons from 10 years to 12 years. Currently, the data point representing the NMIs key comparison on the BIPM plots of equivalence is "blacked out" after 10 years and, at least in principle, removed after 15 years, although this has not been rigourously implemented. The current proposal is intended as a move toward ISO 17025:2017 risk-based thinking and to allow better use of BIPM resources.

A discussion followed and, although there were no major objections, there were several clarification points. Dr David Burns (BIPM) suggested that if this is a move toward risk-based management, then the text that accompanies this change should also indicate that a comparison can/should be made sooner than the 12 year period if the NMI/DI has made significant changes to equipment, procedures, staff, etc. Dr Ulrike Ankerhold (PTB) reminded the group that it was decided in 2019 to keep a 10 year period with a possible extension of 5 years. This proposal would still have an ultimate limit of 15 years in effect. Mr Sibusiso Jozela (NMISA) asked if the comparison was made over 10 years ago but within 15 years could it still be used to support a CMC claim.

Dr Malcolm McEwen (NRC) will bring this proposal to the CCRI meeting and, if approved, the text will be changed to incorporate risk-based management.

5.5 Strategy action reports (Chairman Malcolm McEwen, NRC)

Dr Malcolm McEwen (NRC) indicated that there are no new strategy actions to report.

5.6 RPT Working Group (joint 1/II WG) – Dr Brian Zimmerman (NIST)

The radionuclide therapy and quantitative imaging working group was formed after the 2019 CCRI meeting, recognizing the increasing importance of the development of radionuclides for therapy as well as imaging technology becoming more advanced. There are 12 members, most from CCRI(II), but the WG also includes three clinical medical physicists with specialization outside of metrology, two IAEA staff members and one member from CCRI(I).

The WG has held three meetings and the main topic of discussion has been direction for the next 5 years. They have started to develop practice guides by gathering information from the community. To this end, the WG is hosting a series of webinars and virtual meetings sponsored by the BIPM. The first was the week of 24-May-2021 and the second will be in September. The goal is to bring the metrology and clinical communities together. The focus of the guides will be in two main areas: 1. Guidance for NMIs/DIs to establish programs for radionuclide metrology. 2. Uncertainty assessment.

The aim of the WG is to add more participants from CCRI(I) as progress develops. Dr Paula Toroi (STUK) remarked that small countries typically do not have these facilities so it is difficult to provide calibrations. Dr Malcolm McEwen (NRC) and Dr Brian Zimmerman (NIST) indicated that supporting smaller groups is a focus of the group and that the IAEA has been very actively involved.

5.7 Brachytherapy Standards Working Group

Dr Malcolm McEwen (NRC) indicated that there is nothing to report from this working group but proposed that it stays operational since brachytherapy is still an important technique. In addition, there is an increased use of cobalt-60 brachytherapy sources, which should be monitored in case new standards or comparisons are required.

5.8 Call for New Working Groups Required

None of the delegates brought forward suggestions for new working groups.

6. BIPM-related activities

6.1 JCRB Report (*JCRB Executive Secretary*)

To avoid unnecessary duplication, it was decided that this presentation would not occur at this meeting and instead would take place at the general CCRI meeting the following week.

6.2 Calibration and Measurement Capabilities

6.3.1 Impact of KCDB 2.0

Dr Paz Aviles (LMRI) indicated that the strategy to group CMCs can be useful for radioactivity but an attempt to group them for dosimetry is difficult, especially for x-ray dosimetry and radiation protection, and with respect to regulatory issues. Dr Malcolm McEwen (NRC) responded that the NMI/DI can report their CMCs in the way that is most useful for their situation.

Dr Debbie van der Merwe (IAEA) remarked that users should be aware that the search terms may not be the same in that the old categories are not necessarily the same as the new categories.

Dr Paula Toroi (STUK) remarked that the new system is slightly confusing in that it is unclear if a CMC may be used to report operational quantities in radiation protection. Dr Jacco de Pooter (VSL) responded in the affirmative that a fundamental quantity can be used to support derived quantities. Dr Jean-Marc Bordy stated that NMIs/DIs obtaining external accreditation of their QMS must have CMCs directly linked to each calibration service. In the case of radiation protection, he reported that this is problematic as operational quantities need validated spectrometry, and this is not available in the KCDB. He noted that the issue is not present for self-declaration or RMO approval of quality systems.

6.3.2 Impact of revision of ISO17025

Dr Malcolm McEwen (NRC) requested feedback on the implementation of ISO 17025:2017:

Dr Massimo Pinto (ENEA) indicated that a virtual training series was useful and ENEA incorporated risk-based analysis into their procedures. There has been some resistance. ENEA is rewriting a major portion of their quality management system.

Dr Duncan Butler (ARPANSA) reminded the group of the main changes in the 2017 revision, which include a revised scope, a revised process approach, a stronger focus on information technologies and a chapter on the concept of risk-based thinking.

Dr Michael Mitch (NIST) indicated that the NIST is in the process of updating procedures and identified a major change in adding procedures for proficiency tests.

Ms Samia Mohamed (FANR) reported that operations have been smooth with no interruptions and that an audit of their services occurred virtually during the pandemic.

6.3.3 EURAMET proposal for improved presentation of CMCs

This was not discussed here since it was already covered in 5.3 above.

7. Strategic planning 2020-2030

7.1 Impact of COVID-19 pandemic and implications for future activities

Dr Malcolm McEwen (NRC) requested delegate's comments on their experiences and opened the discussion by remarking that NRC employees have mostly been working from home during the pandemic with a 30 % occupancy limit for on-site activities, and that this is not likely to change before late 2021. He also noted that the BIPM's reports indicated that their focus has been on maintaining and providing services for end users.

Dr Massimo Pinto (ENEA) indicated that ENEA has used the pandemic as an opportunity, while the laboratory was shut down, to carry out collaborative work on Zoom and complete courses on ISO 17025:2017. As a result the staff are better trained in quality systems than if they were still on-site. Currently, around 50 % of staff are working from home and 50 % are on-site, which is tried to increasing vaccination rates in Italy.

Ms Samia Mohamed (FANR) and Dr Mehenna Arib (GULFMET) indicated that the impact on the UAE SSDL was mostly on getting preventative maintenance on equipment performed, getting recalibrations of reference instruments and practical (in-person) training to improve the skills of personnel. These set-backs were due to lockdowns and restrictions on travel and shipping for suppliers. They asked if other laboratories have an internal maintenance team if the supplier is not available for maintenance and the response was that most equipment maintenance is carried out by external engineers.

Dr Michael Mitch (NIST) reported that the NIST laboratory relocation is still underway but there have been delays due to lockdowns. Calibration services have been maintained wherever possible.

Dr Frank Delaunay (LNHB) and Dr Nestor Cornejo Diaz (CIEMAT) reported that less experimental work was performed but progress was made with data analysis of previous reports and report writing. They also reported delays in equipment maintenance due to travel restrictions but that calibration services were maintained.

Dr Chris Oliver (ARPANSA) and Dr Duncan Butler (ARPANSA) indicated that a severe lockdown during mid-2020 impacted the delivery of their calibration services and caused an increased workload toward the end of 2020. The use of digital signatures for calibration reports was implemented.

Mr Russell Thomas (NPL) and Dr Thorsten Sander (NPL) indicated that during the first lockdown in March 2020 only 28 of approximately 1000 staff were on-site. The focus was on delivering critical services. On-site staff numbers have now increased but are still restricted to around 300 with COVID-19 restrictions (PPE) in place. The use of digital signatures for calibration reports was implemented. PhD student research projects have been negatively impacted.

Dr Dehong Li (NIM) reported that were was no significant impact of COVID-19 at the NIM.

Dr Debbie van der Merwe (IAEA) and Ms Samia Mohamed (FANR) indicated that there were impacts from virtual fatigue (virtual meetings, more screen time) and influences on the balance

between work and home life. There is the real possibility of burn-out because of the lack of separation of activities while at home.

Dr Anna Villevalde (VNIIM) reported that the VNIIM continued to work mostly in-person but with a special schedule. There were some problems with travelling and sending instruments. Delays and mistakes were blamed on the pandemic.

Dr Magdalena Szymko (GUM) reported a similar experience to others. Most work such as paper-work, MC calculations and online workshops was done at home. The small number of calibration services requested were delivered. Research activities were affected but are now progressing.

Dr Paz Aviles (LMRI) and several others indicated that there will be changing processes as restrictions are lifted, including more flexibility with working from home. It is also expected that there will be budget cuts due to the suffering global economy.

Mr Sibusiso Jozela (NMISA) reported that at the beginning of the first lockdown NMISA had just received artifacts from PTB for the S16 supplementary comparison and that returning the artifacts was very expensive because of airline lockdowns. Quarantining customer equipment resulted in delays in workflow and turn-around time. NMISA was able to automate about 80 % of their measurement procedures, which is improving efficiency. Due to inefficiencies from most equipment coming from overseas and impacts from the pandemic, NMISA began manufacturing some of their own equipment in-house using their mechanical and electronics workshop as well as a 3-D printer.

7.2 Short term (2021-2023), medium term (2023-2026)

This was not discussed here.

7.3 Status of CCRI strategic plan

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

Nothing specifically discussed here as actions and WGs had been covered elsewhere.

7.3.2 Dosimetry for radiation therapy

Dr Malcolm McEwen (NRC) requested short summaries of new research or activities from the participants.

Dr Ernesto Mainegra-Hing (NRC) presented on type B uncertainties for low-energy brachytherapy calculations. Dr Tadahiro Kurosawa (NMIJ) presented on calorimetry in proton beams. Dr Bryan Muir (NRC) presented on dosimetry for MRgRT and FLASH dosimetry. Dr Jacco de Pooter (VSL) presented on MRgRT-DOS (DOS=dosimetry of small fields) including MR guided x-ray and proton therapies, the impacts of magnetic fields on small field dosimetry, COMSOL simulations for determining the dead volume in ionization chambers (there was a lot of interest in experimental validation of these calculations).

Dr Paula Toroi (STUK) commented on devices that are able to realize absolute measurements, such as clinical calorimeters. The role of the NMI/DI could then be undermined or compromised. There is also the danger present with new technologies, such as MR-linacs and FLASH beams, where the application of old technologies/detectors can introduce errors if limitations are not well understood. Mr Russell Thomas (NPL) remarked that a clinical

calorimeter would probably be a simplified device that operates as a secondary standard with traceability to the NMI.

Dr Magdalena Szymko (GUM) presented on new graphite chambers for air kerma and absorbed dose standards as well as a graphite chamber. Dr Szymko also presented on a large volume ionization chamber in water for Ir-192 HDR measurements.

Dr Duncan Butler (ARPANSA) reported on synchrotron scans to determine 'dead' regions within the collecting volume of ionization chambers (where charge is not collected) and progress on synchrotron dosimetry with graphite calorimetry and alanine. The Australian synchrotron facility is traceable to the PTB absorbed dose to water kV standard, which has been very useful.

Dr Thorsten Sander (NPL) discussed progress toward establishing dosimetry techniques for electronic brachytherapy sources. There is an EMPIR project that involves six NMIs and three clinical institutions. A focus is on development of primary standards for these sources.

Dr Paula Toroi (STUK) asked about the use of solid state detectors for diagnostic radiology and the challenges for SSDLs to calibrate these devices. The manufacturers have indicated that solid state detectors cannot be calibrated with industrial x-ray tubes (and therefore, could not be calibrated by SSDLs).

Dr Stefan Pojtinger (PTB) presented on a new, larger volume cavity chamber for primary air kerma standards.

7.3.3 Dosimetry for radiation protection

Dr Annette Röttger (PTB) presented on a EMN – European Metrology Network – that is focused on metrological issues for radiation protection. Beyond description of the EMN's mission, the discussion focused around the recently published ICRU/ICRP Report 95, which recommends changes to operational quantities for external radiation exposure. Dr Jean Marc Bordy (LNHB) indicated that the main goal of the report is to improve the reliability of operational quantities in radiation protection following the changes introduced by ICRP on protection quantities. The calibrations do not change but the conversion from air kerma to dose equivalent will and therefore the end-users values will change. Dr Annette Röttger (PTB) indicated that the legal/regulatory aspects will be impacted and the requirement for new equipment and changing regulations will be expensive (an estimate of 1 million GBP was made). Dr Paula Toroi (STUK) indicated that the manufacturers are making large investments to adapt their products but will be able to sell new products. There is a concern that the new devices will be black boxes. Dr Milos Zivanovic (VINS) remarked that there are different problems for developing countries, especially related to costs and the hesitancy to purchase new equipment. The differences that are introduced are large at low energies but not significant for cobalt-60 or cesium-137 sources. Dr Linda Persson (SSM) emphasized that NMIs together have a role to play in education and reassurance and also highlighted that DIs that are part of regulatory organizations (a common situation in CCRI(I)) are ideally placed to bridge the gap between primary standards and end users and regulators.

It was decided to create an ad hoc group on the adoption of the ICRP/ICRU 95 report, a few participants raised hand to take part to this WG (including Dr Röttger and Dr Bordy).

7.3.4 Dosimetry for radiation processing

Dr Michael Mitch (NIST) reported that the NIST is obtaining a new high-dose cobalt-60 irradiator of a new design, and has purchased a low-energy high-dose electron beam accelerator that can produce energies up to 300 keV, which is currently being assembled.

Dr Thorsten Sander (NPL) reported that two of their Gammacell irradiators are being re-sourced in September 2021.

7.3.5 Uncertainty evaluation

Dr Malcolm McEwen (NRC) reported on JCGM uncertainty estimation reports updates with a new report being added. He asked if any laboratories have begun using the new, more detailed reports that discuss modelling. None of the delegates responded and Dr McEwen indicated that NRC has not adopted these approaches. Dr Nestor Cornejo Diaz (CIEMAT) reminded the group about JCGM Report number 101 on the propagation of uncertainty for Monte Carlo simulations. Dr Massimo Pinto (ENEA) recommended a useful document in practice and for teaching: Bentley R E 2005 Uncertainty in Measurement the ISO Guide (National Measurement Institute). Dr Mehenna Arib (GULFMET) indicated that the UAE SSDL follows the IAEA TEC DOC 1585 “Measurement Uncertainty: A Practical Guide for Secondary Standards Dosimetry Laboratories".

Dr Duncan Butler (ARPANSA) asked about the reproducibility of transfer standards for comparisons – the component of uncertainty is reported as the reproducibility at the time of the comparison but does not account for the reproducibility of the calibration coefficient of the device at a given laboratory. Dr David Burns (BIPM) suggested the use of the measurements made at the NMI before and after the comparison and Dr Malcolm McEwen (NRC) responded that this is portrayed as the uncertainty due to the transport of the transfer standard but does have reproducibility effects rolled in. Dr McEwen suggested that the RMO WG or the comparison protocol can give guidance on how to produce uncertainty budgets that are consistent among the participating institutes.

7. Strategic planning 2020-2030 continued

7.4 Presentations by new NMIs/DIs

Dr Pierino De Felice (ENEA) presented on the reasons behind ENEA-INMRI greying out their CMCs and new developments. An internal review of their QMS had resulted in significant non-conformities and ENEA-INMRI requested CMCs be greyed out for all three CCRI sections in 2019. In January 2020, the ENEA president and Italy’s department of industry were approached with support letters from several other organizations. An MoU between ENEA and MiSE was signed in 2020 and an executive plan was signed in April 2021 that includes a new, increased budget (increase from around 400 k€ to around 7 M€). Dr Massimo Pinto (ENEA) reported that the most critical impact was staffing, when they were downsized from six staff to two staff. They are now operating with three staff members and planning to recruit more. However, the loss of expertise was recognized as a remaining challenge.

Dr Malcolm McEwen (NRC) commented that all NMIs/DIs have to recognize the need to continue to make the case to stakeholders and end users that NMIs are essential. He welcomed ENEA back and indicated that the community is available to provide assistance with training.

Dr Vladimir Skliarov (NSC IM) presented on NSC IM. He reported that the institute has 180 CMCs with 15 in ionizing radiation. They also have three SMSs in radioactivity and are

planning one for dosimetry. Dr Anna Villevalde (VNIIM) reported that they hope to have an x-ray comparison in draft B form this year.

Ms Samia Mohamed (FANR) presented on the UAE SSDL FANR and reported that they have four staff and are recognized as a DI in the CIPM MRA . They were accredited to ISO 17025:2017 in 2018 and were granted full membership in the WHO/IAEA network in 2018. They provide calibration services in radiation protection (Cs-137 and x-ray) and air kerma for diagnostic radiology and also provide proficiency testing for dosimetry service providers. They plan to expand their scope to neutron services and contamination meters. GULFMET is working on a 5-year comparison plan for radiation protection, diagnostic radiology and neutron measurements. Dr Mehenna Arib (GULFMET) indicated that members of GULFMET need practical training and not just general or didactic training. Dr Malcolm McEwen (NRC) suggested that the RMO WG can discuss if more practical training (such as showing a calibration procedure) can be provided on the BIPM eLearning platform.

Dr Paula Toroi (STUK) presented on the STUK dosimetry laboratory, which was established in 1958. STUK became an SSDL network member in 1971, a EURAMET member in the 1980s, is involved in a Nordic cooperation network (NORDOS – involves Finland, Sweden, Norway, Denmark and Iceland) and has been recognized as a DI in ionizing radiation since 2002. They operate with 11 staff and have four radiation therapy CMCs, two diagnostic radiology CMCs and 24 CMCs for radiation protection. They calibrate about 500 dosimeters and perform about 2000 reference irradiations per year. Dr Massimo Pinto (ENEA) remarked that the Nordic community seems quite strong and asked if there is a plan to develop primary standards. Dr Paula Toroi (STUK) and Dr Linda Persson (SSM) responded that the situation is already working very well and that the development of primary standards would provide little benefit, other than developing staff as better physicists, especially given the effort required to develop and maintain primary standards. Dr Paula Toroi (STUK) confirmed that STUK is willing to host training fellowships. Dr Nestor Cornejo Diaz (CIEMAT) asked why there are so many more calibrations than calibration certificates and Dr Paula Toroi (STUK) clarified that in some cases one certificate is issued for many instruments.

7.5 Input from RMOs: AFRIMETS, APMP, COOMET, EURAMET, SIM. EMPIR collaborations and EMNs – opportunities for wider collaboration?

AFRIMETS: Mr Sibusiso Jozela (NMISA) reported that no AFRIMETS meetings have taken place since 2019 but one is planned for July 2021. As a relatively new RMO an effort is underway to increase capacity over the next few years and requires support from the key comparison working group on piloting comparisons. Including deputy chairs on TCs from smaller RMOs would be helpful in establishing leadership qualities. Dr Malcolm McEwen (NRC) suggested that leadership training would also be useful and can be discussed in the RMO working group.

EURAMET: Dr Jacco de Pooter (VSL) reported on KCDB 2.0 training and structuring CMCs.

Dr Jacco de Pooter (VSL) reported that EMPIR projects finished in 2020 with a new program beginning that is similar but is more focused on partnerships. EMPIR projects are for a duration of three years but when they end financial support is not available so the additional work which is relevant for the end-user could come to a halt. Three European EMNs related to ionizing radiation have been established; one on the medical use of ionizing radiation, one on radiation

protection, and one on pollution monitoring. The latter EMN is dominated by chemistry but ionizing radiation plays a significant role. Dr Malcolm McEwen (NRC) asked what are the underlying purposes for the EMNs and Dr Jacco de Pooter (VSL) responded that they are to avoid duplication of work, they aim to be more sustainable by forming a strong stakeholder network and include capacity building activities. Technical committees are focused on technological developments and metrology networks are the link between technical committees and stakeholders. Dr Annette Röttger (PTB) indicated that there is a focus on large-scale projects that would not be possible for a single institution and that these projects impact European regulations. Dr Malcolm McEwen (NRC) asked if others have formed these types of networks. Dr Duncan Butler (ARPANSA) indicated that APMP has established focus groups to bring different TCs together to address more general challenges. Dr Massimo Pinto (ENEA) suggested that EURAMET benefits because the countries have opted to put financial support into a common repository, which seems to be the driving force rather than being closer geographically or having tighter financial links.

APMP: Dr Duncan Butler (ARPANSA) indicated that APMP is interested in a diagnostic comparison but needs recommendations for organization and artifacts. Dr Jacco de Pooter (VSL) recommended not making such a comparison too large because there are issues with taking too long and requiring too much effort. Dr Mehenna Arib (GULFMET) asked if it would be acceptable to send a single artifact (ionization chamber) for comparisons and Dr Malcolm McEwen (NRC) indicated that there is a lot of risk in only sending a single chamber because of the lack of redundancy and possible failures.

SIM: Dr Malcolm McEwen (NRC) reported that SIM has been active and have many comparisons planned. There have been some difficulties because of lack of staffing and resources.

7.6 Input from institutional stakeholders.

ICRU: Dr David Burns (BIPM) reported on ICRU Report 31 on dosimetry-guided radiopharmaceutical radiotherapy and reviewed new reports published since ICRU-90 (91, 92, 93, 94, 95), which might be of interest to CCRI(I) delegates. He also reported on the implementation of ICRU-90 at NMIs. He reminded delegates that if there are suggestions or needs for new reports, those requests can be made to the ICRU.

Dr Jacco de Pooter (VSL) asked if there will be an evaluation by ICRU on the impact of ICRU-90. Dr Malcolm McEwen (NRC) and Dr David Burns (BIPM) indicated that this is usually not done by ICRU and that it should probably be done by CCRI(I) because the interaction between CCRI and ICRU initiated the ICRU Report 90 effort.

Dr Paula Toroi (STUK) asked if there was a plan for ICRU to move from air kerma to absorbed dose to water for radiation protection and diagnostic radiology (currently a conversion is made from air kerma to equivalent dose). Dr David Burns (BIPM) indicated that this is not planned.

IAEA: Dr Debbie van der Merwe (IAEA) reported on IAEA updates and priorities for 2021 and beyond. These include codes of practice for radiation protection, an update of TRS-398 (will be published in 2022), brachytherapy and radiopharmaceutical dosimetry. Dr van der Merwe reported on IAEA guidance to SSDLs including ESSDOL, training materials and recognition of radiation metrologists and diagnostic radiology dosimetry. The IAEA will launch electron dosimetry audits, are replacing a radiation protection irradiator and will offer linac beam

calibrations. Technical meetings are upcoming for the dosimetry audit network, the SSDL network and IDOS (2026). Research plans include the development of HDR audit methodology, data for an update of TRS-457 for diagnostic radiology (call for proposals) and support for clinical research GRID/LATTICE. They are also developing an audit system for RPT.

Dr Duncan Butler (ARPANSA) asked if the brachytherapy HDR audits will be remote and Dr van der Merwe responded that at this point it is the methodology that is being developed but the practical aspects have yet to be established. Dr Mehenna Arib (GULFMET) asked if there will be SSDL audits for brachytherapy calibrations and Dr van der Merwe said that comparisons are already available.

AAPM: Dr Bryan Muir (NRC) and Dr Ronald Tosh (NIST) indicated that there is nothing to report at this time.

IOMP: There were no IOMP attendees but an IOMP liaison to CCRI(I) has been established (Dr Geoffrey Ibbott, chair of the IOMP Scientific Committee).

ASTM: no formal representative from ASTM was present.

8. **CCRI(I) membership changes.**

Dr. Malcolm McEwen (NRC) will inquire with Dr Steven Judge about the rules for new members and the discussion can be continued via email.

Action items:

Actions to be confirmed by CCRI(I)

1. **Extension from 10 years to 12 years for initial validity period of KCs (limit is still 15 years) with emphasis on a risk-based approach to KC planning**
2. **CCRI(I) chair to liaise with APMP regarding an electron beam comparison and determine best approach**
3. ***Ad hoc* working group to develop a report on the role of radioactive sources in Section I activities**
4. ***Ad hoc* working group to consider options for publication of laboratory reports in the context of open science**
5. ***Ad hoc* working group to assist with implementation/questions regarding ICRU/ICRP Report 95**
6. **Ask RMO WG to look at leadership development/training in addition to technical training.**
7. **Ask CCRI to consider developing relevant KPIs for NMIs/DIs to report**

Reviews of minutes provided by:

Jean-Marc Bordy, David Burns, Frank Delaunay, Annette Röttger, Thorsten Sander,

List of attendees

Name	Organization Name	Country/region
Martyn Sené	CCRI President	United Kingdom
Steven Judge	BIPM	France
Philippe Roger	BIPM	France
Cecilia Kessler	BIPM	France
David Burns	BIPM	France
Chris Oliver	ARPANSA	Australia
Duncan Butler	ARPANSA	Australia
Sachin Mhatre	BARC	India
Sougata Rakshit	BARC	India
Auradha Ravindra	BARC	India
Sunil Singh	BARC	India
Vinatha Panyam	BARC	India
Jian Zhang	NIM	China
Kun Wang	NIM	China
Dehong LI	NIM	China
In Jung Kim	KRISS	Korea, South
Yunho Kim	KRISS	Korea, South
Tadahiro Kurosawa	NMIJ/AIST	Japan
Anna Villevalde	VNIIM	Russia
Vladimir Skliarov	NSC-IM	Ukraine
Samia Mohamed	Federal Authority for Nuclear Regulation	United Arab Emirates
Mehenna Arib	GULFMET	Saudi Arabia
Jacco de Pooter	VSL	Netherlands
Russell Thomas	NPL	United Kingdom
Thorsten Sander	NPL	United Kingdom
Vladimír Sochor	CMI	Czech Republic
Cristina García Mulas	CIEMAT	Spain
Paz Aviles Lucas	CIEMAT	Spain
Néstor Cornejo Díaz	CIEMAT	Spain
Claus Andersen	DTU	Denmark
Alessia Embriaco	ENEA-INMRI	Italy
Massimo Pinto	ENEA-INMRI	Italy
Milos Zivanovic	Vinca Institute of Nuclear Sciences	Serbia
Jean Marc Bordy	CEA LNE LNHB	France
Frank Delaunay	CEA LNE LNHB	France
Viktória Finta	BFKH	Hungary
Ulrike Ankerhold	PTB	Germany
Stefan Pojtinger	PTB	Germany
Annette Röttger	PTB	Germany
Magdalena Szymko	GUM	Poland

Stanislav Sandtner	SMU	Slovakia
Peter Peier	METAS	Switzerland
Paula Toroi	STUK	Finland
Linda Persson	SSM	Sweden
Sibusiso Jozela	NMISA	South Africa
Paulo Henrique Rosado	LNMRI/IRD/BRAZIL	Brazil
Fernando Ortega	CCHEN	Chile
Hernan Loyola	CCHEN	Chile
Michael Mitch	NIST	USA
Ronald Tosh	NIST	USA
Bryan Muir	NRCC	Canada
Ernesto Mainegra-Hing	NRCC	Canada
Malcolm McEwen	NRCC	Canada
Debbie van der Merwe	IAEA	Austria
Zakithi Msimang	IAEA	Austria