Meeting CCRI(I) at the BIPM, Sèvres, June 27-28 2017

Day one, Tuesday 27th June.

3. Confirmation of the Agenda and appointment of the Rapporteur

The agenda as presented was approved without changes. Chair Malcolm McEwen indicated that some items may be addressed out of order to fit within the schedule of the two-day meeting. Massimo Pinto (ENEA) was invited to act as Rapporteur for the meeting and kindly agreed to take on the task. The attendees were reminded that the position of Rapporteur is a shared responsibility, and that a volunteer would be sought for the 2019 meeting.

4. Progress reports

4.1 CCRI Reports. President Wynand Louw, CIPM MRA Facts and Survey

- **4.1.1** Louw presented the current number of CMCs in all CCRI sections, as well as the CCRI organization with the number of (too many) meetings that are involved (the main issue being the total time to complete 3 section meetings, WGs and the full CCRI). A survey was launched to assess how best to carry out the CCRI activities, after which a few statements were made towards efficiency and optimization of the KCs and the CCs. Some of these aspects will be covered in the Thursday CIPM MRA review workshop.
- One of the actions that were recommended as a consequence of the survey is to facilitate communication between the CCRI and the regional metrology organizations (RMOs), also by improving meeting efficiency and duration.
- **Decision CIPM 105/30**.
- Based on a proposal of the CCRI President (Wynand Louw), the CIPM agreed to revise the criteria for CCRI membership, in order to align them with the membership criteria for the other CCs. There are a number of outcomes:
- i) Members: countries who are participating in all three sections of the CCRI.
- ii) Observers: countries who are participating in at least one section of the CCRI. Louw indicated that observers could apply to *full* CCRI Membership (there was further discussion of this process at the CCRI meeting later in the week).
- iii) International organizations (stakeholders) are defined as liaisons. IAEA (Meghzifene) clarifies the status of the signature of the MOU between the IAEA and the BIPM. Challenging, but achieved, and no remarks on any formal changes.
- **4.1.2** Following a hiring process, Steven Judge (from NPL) will replace Jose Maria Los Arcos as the Director of the BIPM ionizing radiation department, from August 2017. Los Arcos is not retiring, but will move back to CIEMAT.
- Concerning the BIPM programs, a contract was signed between the BIPM with DOSEO to use their LINAC facilities. Also a new synergy is envisioned with the institutes with

primary facilities as well as the IAEA, which may require the establishment of a new Working Group.

- **4.1.3** CCRI RMO WG. Had a meeting yesterday on proceeding towards the optimization, development, and (customers') use of the CMCs. EURAMET has issued a document with a proposal of the update of the CMCs (please see here: http://www.bipm.org/cc/CCRI(I)/Restricted/23/03-CMC_Ionising-Radiation_Proposal_EURAMET-TC-IR_062017.pdf), and all RMOs have been invited to follow suit.
- Clarification of the timescale: March 2018 is the meeting of the CIPM when the recommendation on the update of the CMCs is going to be presented by the CCRI. Yesterday's meeting chair (Lisa Karam, NIST) mentions that there may be problems with the new approach for those institutes that have CMCs that are very customer-oriented.
- Wynyard Louw (CCRI) recommends that input to the CIPM on this matter must come soon, noting that the document from EURAMET is in the form of a proposal, and that a lot of discussion is still necessary (time has been allocated for this during the joint workshop on Thursday).
- McEwen reminds attendees that in making the new CMC structure more efficient we are not aiming at it becoming less effective. Discussion is ongoing within Section I to assess whether the current structure of the BIPM.RI(I)-KX structure must stay as it is or whether any key comparisons may be merged with one another, (K1&K5, K2&K7, for example). However, if the number of comparisons is to be reduced, then there must be other ways to demonstrate the full capacity of the NMIs and the DIs to deliver their services.
- Hans Bjerke (NRPA) states that the prospected revision of the CMCs, with the KC 'on top', may serve limited use to those SSDLs who deliver their services in radiation protection-related quantities. He is concerned that the new structure is moving away from their role and the services that they provide.
- Ahmed Meghzifene (IAEA): CMCs have been traditionally aimed at end-users but the metrology community has not done enough to spread the word about their measurement capabilities.
- Ulrike Ankerhold (PTB) asked who are the users of the current CMCs. This discussion is to be continued during the Thursday morning workshop.

4.2 Section I Reports.

- **4.2.1.** Strategic action reports (Chair Malcolm McEwen).
- The main strategic action has been the review the recommendations of the ICRU90 report (key dosimetry data). An ad-hoc committee has been looking at the implications for CCRI(I) and that work will be presented later in the meeting.
- **4.2.2.** Key Comparisons Working Group (KCWG(I), Chair Malcolm McEwen).
- The main focus of the KCWG(I) meeting (held the day before) was the review of comparison reports as they pass from Draft A to Draft B. The main concern is that, upon sending the draft out to the CCRI(I) for review, the number of comments is typically

between zero and two. This calls into question the review procedure, as it is not clear if the CCRI(I) members are actually looking into the reports, or, that they are reviewing the documents, but have no points to raise. McEwen noted that this latter case is still someway short of the journal peer-review process. As a first step, the procedure for requesting comments on comparison drafts will be changed, asking for explicit approval, in addition to specific comments if appropriate.

- Membership of the KCWG: a call was made for *expressions of interest in becoming members*, as there are several current members who are willing to step down.
- Protocols for key (and supplementary) comparisons are also going to be updated, and this is also work going on within the KCWG.
- **4.2.3.** Brachytherapy Standards Working Group (Chair Cecilia Kessler, BIPM). There was no meeting of this working group this year. A report on the brachytherapy activities at the BIPM will be presented later in this meeting.
- McEwen called for any perceived need on the set up of a new working group; no suggestions received.
- **4.3** BIPM Reports will be presented at a later point in the meeting.

5. CIPM MRA

5.1 JCRB Report (JCRB Executive Secretary)

- This will be presented at the CCRI meeting.

5.2 Comparisons

5.2.1. BIPM and CCRI(I) key comparisons status (up to June 2017).

- The BIPM QMS is subject to both external (every three years) and internal audits. The last external peer review was carried out in 2015.
- i) *Low energy x-rays including mammography.* Apart from the standard, a new measuring system was installed to comply with the French regulations. New software for the HV generators was written by Philippe Roger in LabView.
- A new system for digital radiography has also been installed, based on a micro-focused x-ray tube, and using a robotic arm to move the object in the beam.
- New comparisons have been run with CMI and KRISS in 2017 and 2015 (new standards). CMI report has been published, KRISS comparison still ongoing (K2 and K7).
- ii) *Medium energy X-rays*. A new ionometric primary standard of D_W in medium-energy x-rays will be presented by D. Burns later. Four new comparisons for the quantity air kerma carried out between 2015 and 2017 under BIPM.RI(I)-K3.
- iii) *Co-60/Cs-137 air kerma*. Both KCs (BIPM.RI(I)-K1 and BIPM.RI(I)-K5) continue to attract participants, with the 10-year schedule for repeating comparisons generally being followed.
- iv) *Co-60 absorbed dose to water* (BIPM.RI(I)-K4). A new participant this year was the Mexican DI, ININ.
- v) *High-energy x-ray absorbed dose to water* (BIPM.RI(I)-K6). NMIs no longer need to provide their phase-space files for their accelerator beams, as an interpolation approach

made by David Burns has been shown to work very well. In the most recent comparisons BIPM went to NMIJ (2015) and NIM (2016), reports either published or in review. For 2017 the comparison with KRISS will be carried out at the DOSEO facility.

. vi) *HDR Ir-192 brachytherapy* (BIPM.RI(I)-K8). Without an Ir-192 HDR source at the BIPM, stability measurements of the travelling transfer instrument are carried out using a Cs-137 source. A new system has been developed that uses a robotic arm to manipulate the source (previously done by hand), moving it from its storage container to a specified position relative to the well-chamber. There has been a hiatus in comparisons, with NMIJ the last NMI in 2015. Future comparisons include Italy in 2018, and possibly France.

. It was noted that the number of comparisons has increased in the past 4 years, putting increased pressure on the BIPM staff. It was also noted that the Co-60 source used for radiation protection is now at a very low activity and the air-kerma primary standard can no longer operate in this beam. The proposal was therefore made to stop this service in the near future due to difficulties with obtaining a new source (it is a very old irradiator, about 50 years old). It is planned that Cs-137 calibrations will still be offered to cover requirements for radiation protection.

. For more detail on calibrations carried out, see CCRI(I)/2017-23.

. Comparisons to be arranged in the period 2018-2019 were presented.

. [*Coffee break*]

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. **Questions/Discussions.**

. i) On the idea of reducing the time for (or number of) key-comparisons, (and also reduce the time pressures on the BIPM staff).

. NMIs are establishing new standards and they (the NMIs) may need new key comparisons to demonstrate their capability of measurement. This may be the case of K9 as well, but other comparisons may emerge. Should the number of key comparison increase, merging some comparisons may be a necessity.

. In regard to K7, McEwen noted that, at least in North America, there is a clinical move away from moly-moly x-ray systems and back to W/Mo systems that can deliver higher doses (and/or have longer lives). Cecilia Kessler noted that BIPM can provide both beam types for the K7 comparison. (David Burns later noted after the meeting that there is little duplication between K2 and K7, so, although they are often done together, there is only a small efficiency gain).

. Susanne Picard (BIPM) outlined that the agreement on the BIPM.RI(I)-K3 comparison is pretty good for all four CCRI qualities (with just one exception with the MKEH where just one point was a little further off from the mean result for the other laboratories). This raised the question as to whether there is still a need to do all four qualities each time in BIPM.RI(I)-K3. David Burns (BIPM) replied that a reduction in the number of qualities would not significantly change the comparison workload but would significantly reduce the information obtained.

. A proposal was made by Simon Duane (NPL) to set up a two-level star-shaped structure for the key comparisons, as a means to compensate for the rising number of participant institutes in each key comparison. In this proposed two-level scheme, the BIPM is at the

centre of a first-level star, with a number of NMIs in that star. From there, stars would be formed around each of the NMI involved in the first comparison (with the BIPM). In this fashion, a degree of equivalence can be determined for each NMI and the workload is shared between the BIPM and a number of the larger NMIs.

. Ronnie Minniti (NIST) suggested that multiple NMIs could visit the BIPM at the same time to complete their participation in a given key comparison and David Burns indicated that this might be worth considering.
. Cecilia Kessler expressed a wish for much faster reporting from the NMIs, making the example of comparison reports being submitted more than one year after the completion of the measurements, which results in a time-consuming review of the entire process at the BIPM end.
. ii) Hans Bjerke (NRPA) asks who is going to ensure traceability if the BIPM is discontinuing the Co-60 calibration service for radiation protection. Cecilia Kessler responds that there may be an interest from the PTB in providing such service, both for air kerma and ambient dose equivalent.
. iii) Hans Bjerke asks why are we not moving to the quantity Dw in Brachytherapy. McEwen responds that there has been little interest from users in this field and that there are no protocols at this time that supports the use of this quantity. Further discussion will take place on this later in section 6.3.
. iv) BIPM.RI(I)-K9 Status: D. Burns reports that a first comparison was made with the PTB (document available in the CCRI(I) members only repository, open for comments: http://www.bipm.org/cc/CCRI(I)/Restricted/23/26-PTB_Med-X_Dw_Rep_Draft_A.3_2017-06-20.doc). There will be a need for a formal approval of this new comparison (note: this was obtained later in the meeting).
. v) Malcolm McEwen presents a proposal for a comparison on D_W for high-energy electron beams. A key technical aspect of this new proposed comparison protocol is that alanine dosimeters will be used as the transfer detectors (supplied by the NPL) but that co-irradiation of dosimeters by the BIPM would provide independence from any single NMI.
. It is anticipated that there won't be a high demand for this comparison but four laboratories expressed their interest. Jian Zhang (NIM) asks when is this comparison going to take place. McEwen: the schedule could start quite soon with one laboratory participating in the comparison every three months. A start as early as 2018 is possible with a projected finish by 2020, but, first, the protocol needs to be completed and reviewed. There was discussion, but no conclusion on whether this should be another KC, or be considered an SC (the latter due to it's ultimate traceability to the BIPM K4 standard).

5.2.2. Regional key and supplementary comparison status.

. ***APMP:*** Jinjie Wu (NIM) reports on **APMP** comparisons, noting that there 31 comparisons overall, including the existing, ongoing, and planned comparisons. Examples include a

comparison for HDR Ir-192 brachytherapy (K8), medium-energy x-rays, air-kerma-product and air-kerma-length.

- Beyond these there are plans for absorbed dose to water comparisons in *proton and heavy ion beams*, as well as in small-field photon beams. The increased application of synchrotron x-ray beams will also necessitate a comparison in the future.
- APMP have created a workgroup to analyze uncertainty in regional key-comparison dosimetry (as at a suggestion from Duncan Butler of ARPANSA).
- Malcolm McEwen (NRC) and Ahmed Meghzifene (IAEA) asked whether there is any other laboratory (in the world) who may be interested in expanding this regional APMP comparison for proton and heavy ion dosimetry. NIST responded positively, as well as the PTB who is also interested in bi-lateral comparisons in this field. NPL indicated that their the priority at this time is to introduce a standard for scanned proton beams (Simon Duane). Little demand, apparently, for dosimetry calibrations for heavy ion beams.
- ***EURAMET:*** Ulrike Ankerhold reports on 11 comparison projects, five of which have been completed between May 2016 and May 2017.
- Hans Bjerke (NRPA): What is the status of the *toolbox* to administrate the comparisons? Ulrieke Ankerhold responds that this is a web-based tool to arrange, monitor, and administer the comparisons, developed by EURAMET and not just the TC-IR. She mentions that the *toolbox* is not available yet, but guidelines on EURAMET comparisons are still a good suggested read (available from the EURAMET website).
- ***SIM:*** Lisa Karam (NIST) indicated that bilateral comparisons for Co-60 Dw, involving the CNEN in Argentina and the Chilean DI (CCHEN) are in progress or have been carreid out. A link to the full SIM report can be found here: http://www.bipm.org/cc/CCRI(I)/Restricted/23/11-SIM_MWG_6_report_to_CCRI_2017-.pdf
- Lisa also noted that Brasil, as a large country, has an extensive proficiency testing exercise for the many laboratories distributed around the country.

- ***AFRIMET:*** Zakithi Msimang (NMISA) reports on the ongoing comparisons, including brachytherapy (lad by KEBS, Kenya, but effectively a bi-lateral (due to the small number of laboratories in Africa with the necessary capabilities).
- ***COOMET:*** Anna Villevalde reports on several ongoing comparisons in their region, one of which was piloted by the Belarus institute, and included the IAEA as well.
- McEwen: how do regional organizations persuade laboratories into becoming pilot laboratories for comparisons? EURAMET (Ulrieke Ankerhold) relies on volunteering, as in some countries the number of staff is limited and they cannot force anyone to coordinate comparisons as an additional work. Hans Bjerke (NRPA) adds that one needs a long-term strategy to have a functional set up to carry out a comparison at the level of pilot laboratory, including the *trust* that you need to have from the people who are participating with you in a comparison, concerning the handling of the results and the reporting.
- The above-mentioned EURAMET toolbox is more to support the adminstrative part of the comparison rather than analyzing data and preparing for the report. Susanne Picard adds

that several consultative committees (other than the CCRI) have produced documents that can support the preparation and running of comparisons. They can be taken as an example.

. Also, the BIPM has initiated a knowledge-transfer programme, and is happy to receive requests from participating countries (increasing the number of pilot labs is an aim of this programme). Details of this capacity-building programme can be found at http://www.bipm.org/en/cbkt/

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5.2.3. Future comparisons.

. Simon Duane of NPL requests a CCRI *supplementary* comparison for Co-60 for the quantity absorbed dose, but for high doses (near product sterilization doses). The proposal from the NPL is to repeat the protocol available from 2007.

. Wynand Louw (CCRI) explains that there is indeed some degree of confusion over the difference between key vs supplementary comparisons, and this has also changed a little over the years. Sometimes the word *pilot*, and then *supplement* comparisons have been used. David Burns adds that, as far as the request of NPL, in this specific case the standards are the same

. As for the comparison K4, so there are no new standards constructed. Therefore it's not so much a case of key comparison, but rather a supplementary comparison.

. Wynand Louw: because of the current confusion, there may be a case for going back to the CIPM and re-discuss how comparisons are named. The recommendation of the CCs is that wherever possible, a comparison should be of *key* type. Unless there is a strong and good reason against that.

. Malcolm McEwen asks whether there is any room for further comparisons on high-energy electrons, or for low energy electrons (IORT?).

. Massimo Pinto (ENEA) reports on the future potential comparison of Dw for LDR and HDR brachytherapy. A protocol in 2018 and possibly a comparison in 2019 with those institutes who are still interested in pursuing this activity. He noted that there has been some loss of interest in this activity, relative to the time when the EURAMET-funded project was running (2008-2011).

. Ahmed Meghzifene (IAEA) reports on a meeting held at the IAEA a few years ago on brachytherapy dosimetry to develop an international code of practice, but consensus in this direction was not unanimous.

. McEwen commented that the dosimetric basis for brachytherapy is perhaps not going to greatly benefit from a change in quantity, as there are many other problems in that field of dosimetry.

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lunch break, back at 2.15 p.m.

6. Strategic planning 2015-2025

6.2 Status of the CCRI(I) strategic plan

. The CCRI in this context provides a framework for NMI strategic actions related to the development and dissemination of primary standards.

6.2.1.1. Recommended values for physical constants (ICRU 90). Malcolm McEwen stated that is be the subject of a vote, but this would happen tomorrow to give adequate time for consideration.

. ICRU has always been a committee of technical experts that provide recommendations that the CCRI can decide (or not) to adopt. So CCRI takes the recommendations of the ICRU, evaluates the impact on the primary standards, and provides its own recommendations.

. The CCRI(I) *ad hoc* group produced a document that can be reached here: http://www.bipm.org/cc/CCRI(I)/Restricted/23/07-ICRU90_document_for_CCRI(I)_rev2017_05_30.docx and which summarizes that impact of ICRU 90 on primary dosimetry. This is not to re-view the technical content of the ICRU 90, which is not questioned, but to summarize the impact to our national standards and what should we (i.e. the CCRI.I) do about them. The document prepared by the *ad hoc* group was organized in appendices depending on radiation modality, and implications are discussed in each Appendix. There is no need to repeat the recommendations here.

Discussion:

. Ernesto Mainegra Hing reported on the work carried out at NRC to implement renormalized photoelectric cross sections in EGSnrc (Penelope has them already). They have run attenuation calculations of lightly filtered x-ray beams, because these are beams that are sensitive to the case of the renormalised photo-electric cross-sections. Upon comparing the predictions of EGS to experimental measurements, they have significantly reduced the differences, *when they have adopted the renormalized photo electric cross-sections*. This development of the code will be made available very soon in the GitHub development branch of EGSnrc.

. Hans Bjerke (NRPA) asked about the consistency implcations of the adoption date of the recommendations. Since standards will undergo changes, calibration certificates will accordingly change, particularly to make a comparison with past certificate.

. Reply: *Retrospective correction of calibration certificates is not recommended, nor necessary*. A "standard text" could be included in the calibration certificates in the future.

. Malcolm McEwen noted that, although a common date for adoption was stated, there could be no enforcement of implementation and that it was up to each NMI to act appopriately.

. Susanne Picard (BIPM): Any changes foreseen in the KCDB?

. McEwen: not explored in detail by this *ad hoc* group, because this ultimately depends on the standards used at each NMI (see the case for BIPM.RI(I)-K8 below)

. Ahmed Meghzifene (IAEA): The therapy dosimetry community may benefit, at this point, from a bold step into directly Dw-traceable dosimetry, although this cannot be the same for kV x-rays, where air kerma standard are and still will be a solid base.

- The point was raised that to date, calibrations were provided with uncertainties of about 0.2%, but these are now we shifting in value by 0.7%, but still with a claimed uncertainty of 0.2%, which is potentially embarrassing. A broader scope discussion was initiated on the future way we evaluate uncertainties, *i.e.* potential inclusion of uncertainties for those components of the uncertainty budget that one does not know yet (Meghzifene, McEwen, Duane).
- Ronnie Minniti (NIST) asks whether the degree of equivalence will not change.
- Response: in general, all standards are 100% correlated (e.g. via W_{air}) so any change cancels in the comparison of standards. For BIPM.RI(I)-K8 the situation is more complicated because there is not full correlation between standards (depending on methodology and traceability). Individual NMI standards were not investigated by the CCRI(I) *ad hoc* committee.
- Hans Bjerke makes the point again that reference air kerma rate for brachytherapy will accordingly change, which could make things complicated, and he makes it a point for the use of the quantity D_W in brachytherapy. However, Malcolm McEwen responds that although this is correct in principle, it won't make a huge difference to the brachytherapy dosimetry given the other sources of uncertainty that take place there.
- Anna Villevalde of VNIIM asks for a recommendation on how to communicate to the end-users the new values that will be included in the calibration certificates. NIST (Ronaldo Minniti) recalls that they inserted a new page to explain what had changed, relative to the past. In Russia, adopting such changes implies convincing the government that this is absolutely necessary, since the procedure towards the adoption of these values requires multiple steps with as many signatures (Anna Villevalde, VNIIM).
- Response - it's recognized that implementation of the recommendations is not the same in each country and CCRI(I) will assist where it can in providing support to NMIs/DIs.

-Coffee break-

- *Discussion from later in the meeting regarding ICRU90*
- Malcolm McEwen: Regarding the recommendations of the *ad hoc* group that prepared the summary document with the propositions and the uptake date (January 1st, 2018), there will be no formal vote today but this will be made in the next two weeks to let the attendants make sure that they have the formal approval of their institutions.
- David Burns (BIPM): Allow for the possibility that the users cannot used renormalized photoelectric cross sections, and in this case they may resort to the use of an additional uncertainty component. This would have an effect in low-energy photons and not as much in the medium energy x-rays, and even less at higher photon energies.
- David Burns: on the $k_W.k_{ii}$ correction factors: how does one go with the tables? There may be a need for a wider coverage, including the mammography series, not just the CCRI qualities that have already been addressed in the current report.

6.2.1.2. Photon dosimetry.

Air kerma and absorbed dose to water for photon dosimetry.

- i) David Burns reported on the new BIPM absorbed dose to water standard for kV x-rays. It is based on
  a. The existing free-air chamber for air kerma at medium energy x-rays,
  b. A measured charge *ratio* from a given transfer chamber in water, at 2 cm depth, and free-in-air,
  c. A radial non-uniformity factor that reflects both the situation in air and in water,
  d. AMonte Carlo correction factor to convert dose in the cavity to the dose at a point.
- The Monte Carlo part of the D_W measurement/calculation relies on a full simulation of the x-ray tube at the BIPM, including all filtrations, and is based on a suitably large phase-space file.
- Burns showed the results of their new standard procedure with an Exradin A12 and a PTW 30013 and comparisons with the dose to water obtained using protocols - AAPM TG-61 (Exradin A12) and IAEA TRS 277 (generic Thimble chamber). The combined standard uncertainty at the BIPM for D_W is now approximately 0.6%, having also included the new 0.35% uncertainty on W_{air} and also the new 0.05% uncertainty on the application of the $k_W.k_{ii}$ factor, as suggested from a full adoption of the ICRU 90. This is a significantly lower uncertainty than via one of the protcols.
- Previous EURAMET S13 comparison between the PTB, ENEA, LNHB and VSL, used as a link to the bi-lateral comparison between the PTB and the BIPM. Please refer to the working document in the restricted area: http://www.bipm.org/cc/CCRI(I)/Restricted/23/06-New_BIPM_absorbed-dose_standard_for_medium-energy_x-rays_V4_2017-06-16.docx

- Valentin Blideanu (LNHB) : any reason for not going to lower energies? David Burns replies that in principle this may not be a problem, with their ionometric system, but the uncertainty will most probably rise.
- The future BIPM.RI(I)-K9 key comparison will most probably be an indirect comparison, so no major changes with respect to the existing protocols.
- Malcolm McEwen calls for an expression of interest in the upcoming BIPM.RI(I)-K9. Other than those NMIs who have already participated in the EUARMET.RI(I)-S13 comparison (PTBs is done with the bilateral, then there is the VSL, ENEA, and LNHB), there is potentially NIST to participate, and eventually also NRC.
- Hans Bjerke (NRPA) requests for a lower-energy quality to be included in this comparison, down to 50 kV perhaps, since these are of interest in radiotherapy with x-rays. Again, an issue may here be that of the uncertainty involved.
- Any higher energies? The BIPM has established qualities up to the CCRI-250, but might perhaps consider going up to -300.
- McEwen proposes that the key comparison BIPM.RI(I)-K9 is now officially launched. There were no objections from the attendees.
- ii) Ronnie Minniti (NIST) reported that Michelle O'Brien has developed an x-ray beam line for fluoroscopy.

- iii) Ulrike Ankerhold (PTB) shows some slides from her PTB colleague Ludwig Buermann on the EURAMET.RI(I)-S13 comparison, also including the air kerma calibrations that were done at the time, by which the overall chamber correction factor k_{ch} could be computed. The k_{ch} values estimated by the other participating institutes, however, were not in good agreement with one another and this prompts for further investigations.
- Massimo Pinto of ENEA indicates that one of the reasons that may be underpinning the differences between the PTB and the other participating labs in S13 (in terms of k_{ch}) is that fact that in S13 these labs adopted a series of values that were computed by the PTB in their own beams (the ratio of mass attenuation coefficients, averaged over the photon energy spectrum), and which had not been calculated in their corresponding beams. David Burns adds that some of the PTB data (shown in the slides presented by Ulrike Ankerhold) were obtained by interpolation, and therefore may not be independent.
- David Burns (BIPM): K9 is only a Dw comparison, but in principle if institutes carried their transfer chambers calibrated against their kerma standards as well, the chamber correction factor for that specific chamber type could still be deduced from the data.
- iv) Hans Bjerke (NRPA) reports on the supplementary comparisons in x-ray beams in the Nordic European country region. These are the supplementary comparisons EURAMET.RI(I)-S14/S15 on low and medium energy x-rays, using RadCal RC6M and IBA FC65-G chambers, which involved NRPA, STUK, and SSM. Also, a comparison on the ISO narrow series (40, 60, 120 and 300 kV generating voltages), EURAMET.RI(I)-S3.2.
- v) NPL has launched a survey of low-energy photons is in the use of X-ray cabinets, primarily for pre-clinical trials such as for animal irradiators. They are trying to establish dosimetry protocols for these pre-clinical trials as the uncertainties are currently quite large.
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Day one ends.

Day two, Wednesday 28th June.

6.2.1.2. *Brachytherapy dosimetry.*

- i) Plans for participation of ENEA-INMRI in BIPM.RI(I)-K8 by the end of 2018. No other participating countries at the moment.
- ii*) Electronic Brachytherapy*
- Ronnie Minniti presents the NIST electronic brachytherapy measurement service. In one particular case a customer sends both a well chamber and one of their miniaturized electronic brachytherapy sources for combined calibration. Otherwise it's just well chambers.
- Massimo Pinto (ENEA): Any interest from the US community to obtain calibrations in terms of Dw directly? Reply: yes at some point. There is some interest in providing

calibrations in terms of absorbed dose to water, but since there has been a large investment in the TG43 formalism, there is some resistance in making a big jump towards traceability to a standard of absorbed dose to water.

- Valentin Blideanu (CEA-LNHB) mentions a study at LNHB of reproducing the spectra emitted by electronic brachytherapy sources using a conventional x-ray tube, with an appropriate filtration. X-ray spectroscopy is a fundamental step in this study to ensure the spectral match.
- Susanne Picard (BIPM) asks about the cost and lifetime of the Intrabeam sources: they are used for treating patients in hospitals for a couple of years. Ulrieke Ankerhold and Valentin B.: XSoft is a miniaturised x-ray tube, the lifetime can be very short (weeks/months in worst case). The Intrabeam source is a miniaturized accelerator, and it's part of a robotic system, which makes the system relatively expensive.
- iii) In HDR brachytherapy in Russia (Anna Villevalde) there are now emerging local manufacturers and this is becoming an important area of research to them.
- iv) GUM (Poland) is establishing a graphite calorimeter for brachytherapy that is not yet in their submitted annual report.
- v) Malcolm McEwen: In LDR brachytherapy there seems to be a reduction in the types of seeds on the market, with one seed from GE no longer available (6711).
- vi) Mention of an NPL standard for *molecular radiotherapy dosimetry*. An area that overlaps with the scope of CCRI(II). Simon Duane (NPL) shows that the standard is based on an extrapolation chamber in a phantom, and relies on a Monte Carlo conversion of the dose measured on the surface (where the radionuclide solution is) to the dose inside the phantom. It's independent of both activity measurements and nuclear decay data. It's going to be used to measure uptake in the patient in the context of quantitative imaging.
- Marco D'Arienzo reports that ENEA-INMRI is also working on quantitative imaging in the framework of a EU-funded research project
- Mention was also made of Y-90 microspheres and the dosimetric issues that they pose.
- Franz-Jozef Maringer (BEV) and McEwen pose the question of whether CCRI should establish a CCRI(I)-(II) cross-sectional working group to discuss key aspects of standards of absorbed dose for radionuclides. This however receives little enthusiasm.
- vii) Ulrike Ankerhold (PTB) asks about any LDR Brachytherapy reference air kerma rate comparison, and expressions of interest. NIST may be interested in this. Ulrike Ankerhold also asked Massimo Pinto of ENEA-INMRI to provide an account on the PTB workshop on Brachytherapy that was organized at the end of May 2017 by Thorsten Schneider. Massimo Pinto explains that the workshop was organized jointly with a half-day workshop to re-discuss a DIN norm. At the workshop, Franck-André Siebert of ESTRO BRAPYQS group showed that the number of brachytherapy treatments is going down due to a number of possible reasons. Amongthese, the competition from conformal therapy approaches which are now accurate enough to deliver dose profiles that are similar to those that can be obtained in brachytherapy. Also at the workshop (Massimo Pinto reports) there was a presentation of the available standards of reference air kerma rate / air kerma strength) and of absorbed dose to water. Confirming to some extent what was mentioned earlier above by Malcolm McEwen, at the PTB brachytherapy dosimetry

workshop there was a perceived feeling that standards of Dw in brachytherapy were not the most urgent necessity, as problems of tissue inhomogeneity and source positioning, among other factors, were considered priorities. The situation is further complicated by the evidence that in some countries the local legislation is not enforcing calibration procedures with traceability to a standard, and users (of brachytherapy seeds, for example) can get along with the calibration certificate issued by the manufacturer of the source.

. Ahmed Meghzifene (IAEA) comments that although there may be no legal obligations in some countries in terms of calibration certificates and traceability, in fact there is an interest in doing them anyway, because in case of a dosimetry mistake the medical physicist is accountable. And there have been recent cases of such accidents, with prison sentences of one year imposed in France.

Co-60 beam dosimetry.

. i) Ronnie Minniti (NIST) presents the new Co-60 facility at NIST, built in collaboration with Hopewell Designs Inc, to be used for both air kerma and absorbed dose to water measurements. One of the novelties of this beam is the used of a chopper that can make irradiation times very controllable. It is equipped with a 14.000 Ci source (518 TBq), which delivers a relatively high dose rate (about 1 Gy / min) in a vertical beam geometry.
. Vladimir Sochor (CMI) asks about the irradiation shortest time: the shutter opens in 0.3 seconds, and overall the shortest irradiation that they can do is 1 second long.
. ii) McEwen reported that at the International Meeting on Radiation Processing (IMRP) in November 2016 there was announcement regarding the long-term supply of Co-60 through an agreement between Nordion and Ontario nuclear power plants.

HV Photon Dosimetry

. i) NRC: McEwen summarized the developments at NRC:
. Installation of a second Elekta LINAC in 2016. Work is progressing on a carbon fibre table that will allow rotational dose deliveries.
. Humidity sensitivity study on 0.6 cc Farmer chambers. The humidity was varied from 8% to 97% without any significant variation in chamber response (published in *Medical Physics*).
. Repeating a previous study where chambers at very low internal air pressure showed an "excess" ionization current that was not proportional to the mass of air in the cavity. This is achieved via putting chambers inside a box that can be evacuated (concerning air pressure). The small effects that are seen are not due to a polarity effect.
. Ronnie Minniti (NIST): magnitude of the current? About 0.2%
. ii) Kun Wang delivers NIM's presentation on dosimetry in radiotherapy involving BIPM.RI(I)-K1, APMP.RI(I)-K4, and BIPM.RI(I)-K6. Photon energies range from 4 to 25 MeV, and the primary standard is a water calorimeter, with an AC Wheatstone bridge, built in collaboration with the NRC. Presented the results of the K6 comparison with the BIPM calorimeter traveling to China last year. After that they moved on to the determination of the kQ factors for a series of chambers including the NE 2571 and the

PTW 30013, as well as comparing the dose that is calculated using the IAEA TRS 277, 398, and AAPM TG 51 dosimetry protocols.

- Also highlighted their close collaboration with the medical physics community in China.
- Ahmed Meghzifene (IAEA): how much is the TRS 398 being adopted in China, versus the 277? Response: customers now choose the protocol that they like, but there is a general shift towards the adoption of the 398 which is expected to take over in the next coming years.
- There was a short discussion on the issue of *activation* at 25 MV in LINACs, sicne NIM had reported a significant problem for their linac. The discussion was not conclusive as to whether this was an issue of allowed personnel dose limits or a real linac effect resulting in elevated dose rates around the head of the accelerator.

- iii) Ronaldo Minniti mentions NIST's effort to measure Dw using optical interferometry instead of classical calorimetry based on thermistors. He also reports on NIST-on-a chip which is a nano-scale photonics dosimeter using interferometry and ultrasound. The reference person at NIST is Ronald Tosh. The temperature change is proportional to the shift of the wavelength of light that is traveling through optical fiber. The magnitude of the wave length shift for 1 Celsius degree is about 50 pm, or 0.05 nm. It may be too ambitious for low dose rates but possibly ok for higher dose rates including the applications of industrial processing. Because they are small, they may be stacked for multiple independent measurements of dose.
- Ultimately the intention is to ship these devices to customers for on-site dose measurements

- iv) Ronaldo Minniti (NIST) also reports on air kerma measurements with a brass chamber (3.2 mm thickness) in MV photon beams, a study supported by the US Department of Homeland Security. This study replicates the idea of the $k_{Q,Q0}$ factors of the TRS 398 CoP but not for the transfer of NDw factors, but rather to convert air kerma Nk values from one quality (60-Co) to a MV photon beam. They called it a $k_{air\text{-}Q,Q0}$rather than a $k_{Q,Q0}$. The corrections involved are larger and so are their uncertainties so in practice they would not advise pursuing this approach.

- v) Jacco De Pooter of VSL reports on Dw for MR-guided radiotherapy, EMPIR's MRgRT project. The scientific problem related to dosimetry that is posed is that the response of a ionization chamber changes in the presence of a magnetic field, dependento both on the field strength and orientation. They introduced a $k_{Q,Q0}$ approach that also incorporates, for the Q quality radiation part, the presence of the magnetic field. These are referred to as $k_{Q,B}$ and k_B factors (depending on whether they incorporate the Q → Q0 approach or only evaluate the role of the magnetic field). The k_B factor alone may be as large as 0.95 for some chambers such as the IBA FC65-G, and 0.96-0.97 for the PTW 30013, or 0.96 for the NE2571 (this one in particular calculated by Monte Carlo).
- The water calorimeter of VSL was designed with the explicit intention to use this calorimeter in strong magnetic fields.

- On a question raised by Massimo Pinto of ENEA-INMRI: the thermistors' response is dependent on the magnetic field, but not their sensitivity. Therefore, the calibration of the thermistors must take place in the presence of the same magnetic field that will be used for the dosimetric measurements.
- Also on the role of the magnetic fields, Simon Duane (NPL) reports on the response of a dosimeter (alanine) in the presence of a magnetic field, in air, and in a water phantom. Their k_B formalism is in principle similar to that already presented by the VSL a moment ago.
- Using alanine as a dosimeter, because the effect seems to be similar for B and -B, they hypothesized that the effect must be due to B^2.
- Ulrike Ankerhold (PTB) presents a similar study (within the project MRgRT) using an ionization chamber and alanine in the presence of a < 1.5 T strong magnetic field. Contact person at the PTB in this field is Ralf-Peter Kapsch. Early results were presented last week in Sydney by one of their PhD students.
- Ernesto Mainegra-Hing (NRC) presents on charged-particle transport in the presence of a magnetic field, in EGSnrc. Using Bielajew's first-order approach to describe the effect of the magnetic field, the code is available on their develop branch of their GitHub repository. Shows the application of this code in the context of a Fano test within the cavity of a PTW 30013 chamber. The key point to pass the Fano Test was to set the appropriate value for the ESTEPE parameter of EGS.
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Radiation Protection

- i) Ulrike Ankerhold (PTB) reports on their radiation protection activities. Contact person for this area is Oliver Hupe at the PTB. Involvement in an EMPIR project SRT-r07 "Reseach capabilities for radiation-protection dosimeters", a EURAMET comparison project 1132 on H*(10) and EURADOS comparisons.
- ii) Ulrike A. Reports on the EMRP project MetroERM which completed recently, on the radiological early warning system across Europe, and on the first EURADOS passive area dosimeters comparison in H*(10), which lasted for 3 or 6 months in 2014 at the PTB, measuring dose from terrestrial as well as cosmic radiation. Contact person for this activity is Stefan Neumeier.
- iii) Dosimetry for beta radiation using extrapolation chambers (Bohm's) and re-evalaution of a series of correction factors is in progress. Reports on the EURAMET.RI(I)-S16 comparison on Hp(0.07) and Hp(3), which involves European countries as well as other countries outside of the EU, still ongoing.
- In the discussion, Ahmed Meghzifene (IAEA) hypothesizes reaching the stakeholders in the international radiation protection community in the same fashion as how we currently do with the medical physics community.

Radiation Processing

- i) Malcolm McEwen indicated the intention of NRC to re-establish a high-dose capability based on alanine dosimetry and offer a calibration service for industrial level radiation processing.
- ii) Simon Duane (NPL) reported on the graphite calorimeter that they are building in conjunction with DTU to measure absorbed dose from extremely intense sources of low-energy electrons (<100 keV), doses up to 200 kGy, and their preliminary results obtained at 20 kGy to 34.6 kGy. These calorimeters are based on thermistors, and Susan Picard wonders whether there is any damage to the thermistors, or the glue. Response by Malcom McEwen: thermistors typically resist up to a MGy, and typically other parts fail first. However, Sebastian Galer of NPL mentions that the thermistors are in fact not reached by radiation because they are further away then the electron's range in graphite.
- The commercial application is sterilization of syringes for 'isolators', i.e. sterile environments.
- iii) John Logar of ASTM International gave a presentation on their standard practice for the calibration of routine dosimetry systems in radiation processing applications, and the necessity to provide traceability in their measurements, as regulated by both ISO and US norms.
- Their calibration function is a non-linear, third order polynomial curve that relates response 'x' to the dose. Their projected uncertainty on the delivered dose is about 6-7%.
- ASTM was present at the CCRI as an industrial stakeholder.

- -lunch break-

- *HV Photon Dosimetry continued*
- iv) Susanne Picard (BIPM) reports on the recent activities in BIPM.RI(I)-K6 at the BIPM. Over the last two years, they have completed comparisons with NIM (draft A, submitted for review), NMIJ, VSL (published 2017) and NPL. LabView based software re-written by Philippe Roger for this calorimeter. Susanne also reports on the historical measurements on the BIPM.RI(I)-K6. Since the $C_{w,c}$ conversion factors can be fitted very well with a curve vs $TPR_{20,10}$ (see the
- BIPM.RI(I)-K6 document here), the opportunity exists now for the host lab that his undergoing the comparison *not to provide the phase-space files* (option 1 of the K6 comparison version 2.0).
- The DOSEO agreements granst access to an Elekta Versa HD at the facility for about 40 days per year (can be modified as necessary). Three energies are available on this accelerator: 6 MV, 10 MV, and 18 MV, with access to the FFF modality as well.
- José Maria Los Arcos: the user calendar is pretty much set at the beginning of each year but there is some slight flexibility if necessary.

- BIPM will characterize the beams to which they will travel, in terms of PDD, $TPR_{20,10}$, beam profile stability… to ensure that each NMI has conditions that are as close as possible to the conditions defined at the BIPM on their accelerator (the DOSEO Elekat Versa HD).
- There is the possibility to provide $k_{Q,Q0}$ factors using the reference Co-60 beam at the BIPM as well.
- In the past, the key comparison reference value (KCRV) was set by the result of the BIPM measurements. Future bilateral comparisons will be using the same format, unless decided otherwise, i.e. that the KCRV is set in a different way, such as by the average. If the KCRV changed, the entire KCDB would change for this key comparison (question raised by FJ Maringer of BEV). Keeping the same KCRV as it is now (the BIPM value) will probably provide stability of the results, given that the BIPM has now being given access to a stable facility.
- Concerning development, the BIPM has now purchased the PTW water phantom and purchased software to pilot its position, and moved to set up the irradiations at the DOSEO facility using their calorimeter.
- Future K6 comparisons will include KRISS a the DOSEO facility, and that is the first time (November 2017), follow up with METAS, NRC, DTU, and GUM, the countries so far to have expressed an interest in K6.
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- **6.2.1.3** Charged Particle Dosimetry

Electron/beta dosimetry

- i) Malcolm McEwen presents for NRC their electron beam calorimeter, an updated uncertainty budget and a series of k_Q factors for a series of chamber types, in the 22 and the 18 MeV beams, and some extra work related to the 2014 addendum to the TG51 on photon dosimetry.
- Ulrike Ankerhold (PTB) reports on the work by her colleague Achim Krauss on water calorimetry for high-energy electrons, at energies 6 - 20 MeV corresponding to R50 of 19 mm - 75 mm. Their calorimeter supports different geometries for the detectors, which are ensured by multiple positions of the thermistors's probe inside the calorimeter.
- Relative standard uncertainties achieved on the k_Q values are 0.5% at 20 MeV and 0.75% at 6 MeV.

Protons, heavy ion and other charged particle dosimetry

- i) Simon Duane: NPL is working towards providing services for proton beam dosimetry. Some of the difficulties at this time are in agreeing on the reference conditions.
- ii) Ulrike Ankerhold presents for PTB the work of Achim Krauss on proton and heavy ion beam water calorimetry, in conjunction with the Heidelberg heavy ion beam therapy center (HIT), Including a 430 MV 12-C beam, and measurement of the k_Q factor for the FC65G and the PTW 30013, now with a k_Q factor with a projected uncertainty of just below 1%. Part of this work was published in PMB in 2017.

. Using their water calorimeter, the measured depth in water is 67 mm (entrance channel).
. iii) Tadahiro Kurosawa of NMIJ reports on their absorbed dose to water standard in Japan. This is based on a water calorimeter, and they demonstrate the use in a 290 MeV / n Carbon ion beam. They make their measurements in the SOBP. At the time of their participation in the K6 comparison, Japan was using a graphite calorimeter, but now both are available.
. Hans Bjerke (NRPA) asks about the recommended reference chamber for protons. McEwen: depending on what one measures, Famer chambers appears ok. Simon Duane: NPL has committed to measure not only Farmer chambers in EMPIR 16NRM03 RTNORM, contributing towards the update of the TRS 398, but also Roos-type chambers.

-coffee break-

6.2.1.4 Uncertainty evaluation, status of the GUM 2.
Carine Michotte (BIPM) on the revision of the GUM that was initiated in 2014. One of the key aspects is that there would no longer be type A and type B uncertainties, and Bayesian inference for input quantities. Feedback received was largely negative with about 1000 comments and 17 letters. In the end, the advancement of the GUM was suspended because of such negative criticism. Since then, the JCGM-WG1 is discussing the next steps of the GUM revision. The GUM would become the *whole suite of the documents* published by the WG1 of the JCGM, as at a decision taken in May 2017 (including a guide on inter-comparisons, JCGM-107) .

. Ulrike Ankerhold (PTB): what is the time scale for the revision? Several years apparently.
. Franz Joseph Marigner (BEV): what did people not like in the revision proposal? Generally the Bayesian approach, and the cost that would derive from the adoption of the new framework.
. Ronaldo Minniti (NIST): What was the feedback on the suppression of type A and type B uncertainty? That was well accepted, relatively speaking.

6.3 Input from the RMOs

AFRIMETS TCRI
Zakithi Msimang (NMISA) reports on the TC-IR (which she chairs, and which includes only Burkina Faso, Egypt, Kenya, Ethiopia, Namibia, and South Africa) meeting in 2016, the next one to be held in South Africa on August 2-8, 2017. They gave the TCRI a structure to assign coordination activities in radiation protection (Markos, NMIE), neutron dosimetry (El-Sersy, NIS) […] (Noha Khaled, NIS) … etc.

APMP TCRI
Jinjie Wu (NIM) reports on the TC-IR structure and meetings. The APMP TCRI now counts 14 members. Annual meetings distributed across Asia, this year to be organised in India, in

November. Also organized a workshop at the IAEA in 2016. The 2016 TCRI meeting saw 15 participants and discussed comparisons, CMCs, and the CIMP MRA review.
A mid-year meeting was held in May 2017 in Malacca, Malaysia. Provided an update of the CMCs maintained in the KCDB in TCRI.
They are planning to establish a working group on uncertainties in regional comparisons.

6.4 Input from the Stakeholders

IAEA

Ahmed Meghzifene reports for IAEA on the IAEA/WHO network of secondary standard dosimetry laboratories. The 2nd edition of the SSDL *Charter* is just about to be published in the next couple of months (the first version was published around the year 2000).
On dosimetry services: over the last two years they calibrated around half of the customers dosimeters for radiation protection. Also reported on inter-comparisons and audits. The proportion of LINACS that are requesting audits is taking over the Co-60 units. The results of the audits in the last few years is demonstrated better than in the past, with over 96% of the audited cases accurate within 5% (was 86% before 2016).
Establishing a Dosimetry Audit Network (DAN) database. See https://dosimetry-audit-networks.iaea.org/
They are hoping to construct a new bunker and acquire a LINAC with a calibration bench, as well as a Co-60/Ir-192 brachytherapy HDR source, and replace out-of-date equipment. For this, they are seeking for extra funding from the IAEA member states, with some having already pledged.
Announces an international conference on standards, applications and QA in Medical Dosimetry in 2019, June, which will be called IDOS-2.
Announces retirement and the replacement of the Medical Physics Unit Chair at the IAEA (from December 2017).

. On a question by Susanne Picard (BIPM), Meghzifene responds that the IAEA is not planning on heading towards their own primary standard given the geographical vicinity to the BEV.

On the update of the TRS 398, presented by Karen Christaki and Ahmed Meghzifene.
The TRS 398 CoP is being updated because there is now a comprehsensive set of new data, because there has been a substantial change in primary standards, for several other reasons, and the first publication was in 2000 which is sometime ago.
To summarise, new technologies, new standards, new detectors (and new decade).
There new several expected major changes on the CoP, including FFF beams, kQ,Q0 factors that will incorporate ICRU 90 data, and for the case of kV x-rays a more detailed description on how the Dw will be determined starting from the air kerma.
A survey of the end-users on the TRS 398 revealed the following:

- more chambers to be included in to CoP,

- a clarification of the cross calibration procedures,
- to include other techniques, including VMAT and IMRT,
- a guidance on new technologies included Cyberknife, gamma knife, tomotherapy,
- simplified dosimetry for electron beams

Malcolm McEwen on the TRS 398 update. The CCRI would like to send a survey on the TRS 398 update. This is a four pages-long survey, focused on the types of calibrations offered. The survey will be sent out to the CCRI members.

6.5 Concluding remarks

Malcolm McEwen highlights the CCRI strategic plan for 2013-2013.
The institutes' reports will be kept in the private area until the next meeting in 2019 and institutes will be contacted to confirm that they are willing to make those documents public.

8. CCRI Membership changes

DTU is seeking to become an observer member of the CCRI and no longer a guest. Claus Andersen (DTU) presents a summary of their activities at DTU in the field of Dosimetry. They have an accelerator and a Cobalt Theratron source. The lab now counts 6 permanent staff persons, two technicians, and currently 5 PhD students. DTU is currently a DI institute and they have 5 registered CMCs at present.
There was unanimous approval of the proposal to recommend this change of status for DTU. CCRI rules need to be clarified (there was discussion at the CCRI meeting later in the week) but it is believed that only CCRI needs to approve this recommendation.

9. Date of the next meeting

Date of the next meeting is 2019, and it would be desirable (Wynand Louw) to align the next meeting to the other meetings, especially for this who are traveling from far.
The IAEA IDOS2 conference is due to be held in the spring of 2019. This would be an obvious meeting to link with.

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