Dissemination of the kilogram from the consensus value of 2020

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CCU meeting

21-23 September 2021

Bureau International des Poids et Mesures

CCM Recommendation G1 (2017)
“For a new definition of the kilogram in 2018”

Considering

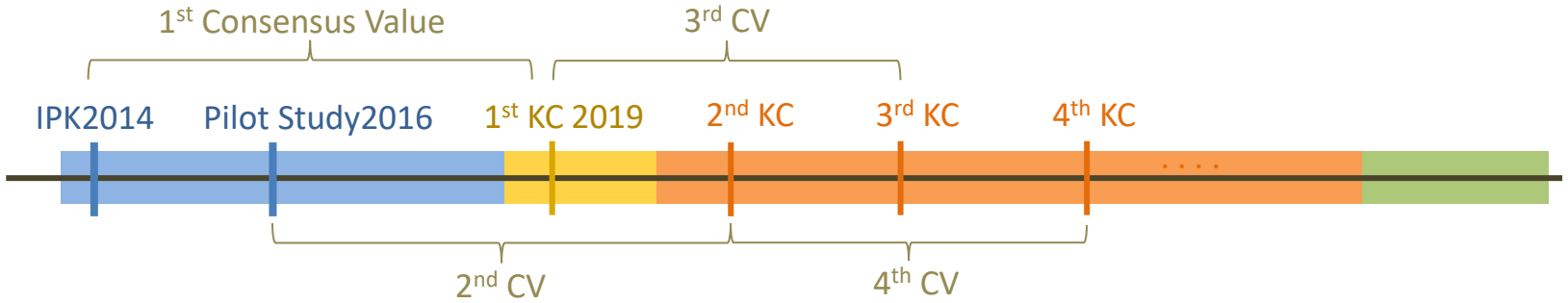
- …that most recent measurement results with relative standard uncertainty below 5×10^{-8} do not pass the standard chi-squared test of consistency, but it is expected that the CODATA value and uncertainty for the Planck constant will be suitable for even the most demanding applications,

requests those National Metrology Institutes having a realization of the kilogram to avail themselves of the consensus value (as determined from the ongoing comparison) when disseminating the unit of mass according to the new definition, until the dispersion in values becomes compatible with the individual realization uncertainties, thus preserving the international equivalence of calibration certificates and in accordance with the principles and agreed protocols of the CIPM Mutual Recognition Arrangement,

Internationally coordinated dissemination of kg, based on consensus value (“international mean kilogram”)

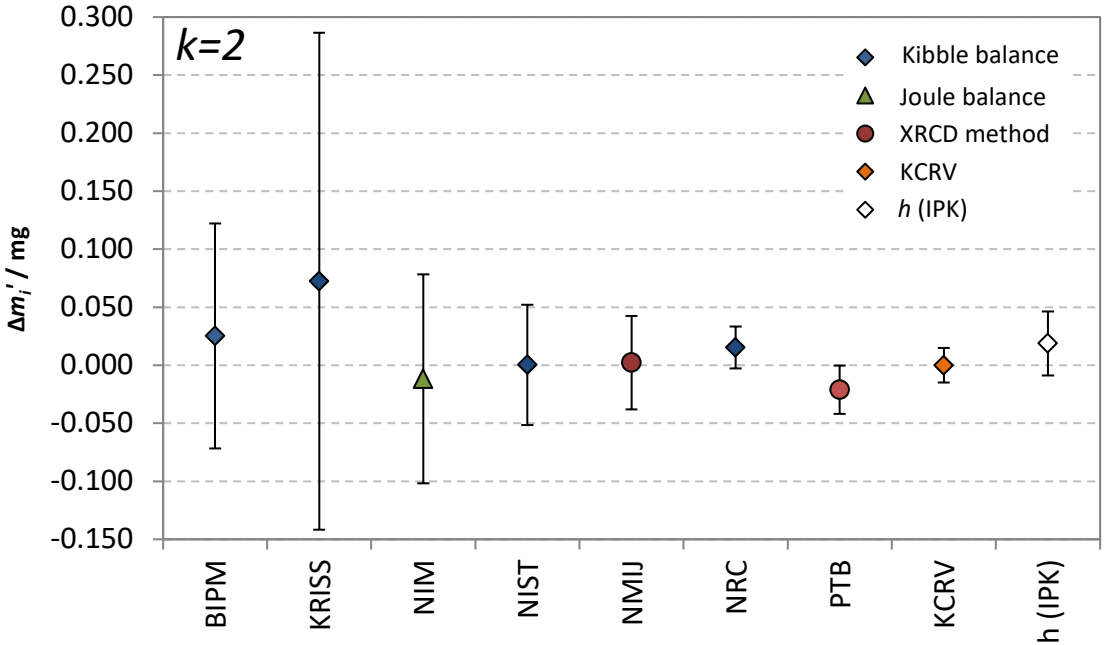
Consensus Value and its uncertainty

- Determination
  - KCs of kg realizations takes place every 2 years (piloted by BIPM)
  - CV is calculated as the average of the last 3 KCRVs (to ensure temporal stability)
  - initial value will be based on IPK, Pilot study result (2016), KCRV of first KC



  - CV is maintained by the BIPM using its Pt-Ir mass standards
  - The uncertainty in the Consensus Value is 20 µg

First KC of realization experiments CCM.M-K8.2019

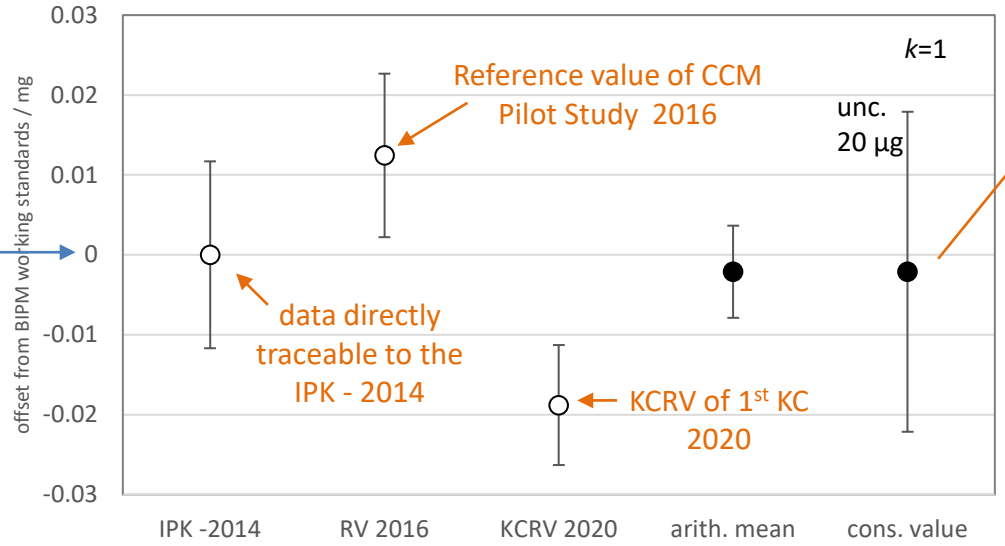


- Pilot: BIPM
- 7 participants: 4 Kibble balances, 1 joule balance, 2 XRCD
- Mass of travelling standards of each participant: measured in vacuum
- KCRV calculated as the weighted mean of the participants' results with u_R (x_R) = 7.5 µg

Calculation of the first CCM Consensus Value for the kilogram

- Consensus Value based on an arithmetic mean of 3 sets of data
- All 3 data sets obtained from work organized by BIPM mass laboratory
- Data sets linked together by BIPM Pt-Ir mass standards

mass unit maintained by BIPM (BIPM working standards)



Mass of the IPK, based on the consensus value is 1 kg - 2 µg with u = 20 µg

Basis for worldwide coordinated mass dissemination for the coming years

2nd KC being started

Dissemination of the Consensus Value

- **no adjustment to the international mass scale needs to be made**, only the uncertainty needs to be increased
- **adjustments to the CMCs** of NMIs are necessary to take into account the increased uncertainty in the CV relative to the current uncertainty in the IPK
- draft adjustments calculated by an ad-hoc TG of the CCM WGM and circulated to the affected NMIs for approval, then updated in KCDB

BIPM

Note on the impact of the beginning of Phase 2 of the kilogram dissemination process on BIPM mass calibrations

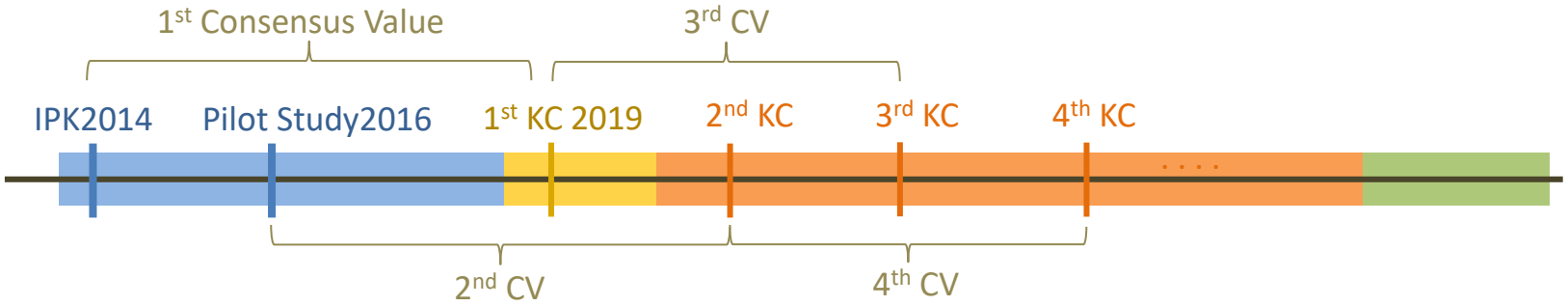
Dissemination phases

Phase	Time scale	Description	Source of traceability	Uncertainty of BIPM mass calibrations	Role of realization experiments	Dissemination of mass from NMIs with realization experiments
0	Until 20 May 19[1]	Traceability to the IPK	$m_{\mathrm{IPK}} \equiv 1$ kg $u_{m_{\mathrm{IPK}}} \equiv 0$	$u_{\mathrm{stab}}(t)$	Measurement of h	Dissemination from national prototype traceable to IPK
1	20 May 19 - date 1[2]	Traceability to the Planck constant via the IPK, with additional uncertainty from the (new) definition	$m_{\mathrm{IPK}} = 1$ kg $u_{m_{\mathrm{IPK}}} = 10\ \mu$g	$\approx \sqrt{u^2_{m_{\mathrm{IPK}}} + u^2_{\mathrm{stab}}(t)}$	Contribute to Key Comparison (KC), improve and resolve discrepancies	Dissemination from national prototype traceable to IPK, with 10 µg added uncertainty
2	date 1 – date 2[3]	Traceability to the Planck constant, dissemination from a consensus value[4] (CV)	Consensus value (CV)	$\approx \sqrt{u^2_{\mathrm{CV}} + u^2_{\mathrm{stab}}(t)}$	contribute to CV (via KC), improve experiments and resolve discrepancies	Dissemination from consensus value with uncertainty $\approx \sqrt{u^2_{\mathrm{CV}} + u^2_{\mathrm{stab,NMI}}(t)}$
3	from date 2	Traceability to the Planck constant, dissemination by individual realizations	Fixed value of h $u(h) \equiv 0$	(Uncertainty of BIPM realization experiment)	Realization of the unit of mass, Participation in KCs to demonstrate equivalence	Dissemination from validated realization experiments with the uncertainty of the experiment. The terms of the CIPM MRA are applicable.

Table 1: The four phases necessary for the reliable transition from the IPK to independent NMI realizations of the unit of mass

Next steps

- Repeat the CCM.M-K8 (scheduled to take place every 2 years): next 2021-2022
- Determination of the 2nd Consensus Value
  - based on results of CCM Pilot Study, KCRVs of the 1st KC and of the 2nd KC
  - check of the temporal stability of the CV
- Dissemination of the 2nd Consensus Value



- Iteration until the decision of the CCM to go into Phase 3