

24ème Conférence générale des poids et mesures

Rapport du Comité Consultatif du Temps et des Fréquences

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CCTF activities in the period 2007-2011

- Meetings of the CCTF (1)
 - 18th Meeting of the CCTF, 4-5 June 2009
 - Frequency of CCTF meetings is 2-3 years, the next will be in September 2012
- CCTF WG meetings (12) and related events (2)
 - WG on TAI
 - SubWG on Algorithms – V Symposium on Timescale Algorithms, San Fernando (Spain), 28-30 April 2008
 - WG on GNSS Time Transfer Standards
 - WG on TWSTFT – 4 meetings
 - WG on Primary Frequency Standards
 - WG CCL-CCTF Frequency Standards
 - WG on CIPM MRA
 - WG on Coordination of the Development of Advanced Time and Frequency Transfer Techniques
 - BIPM Workshop, 28-29 June 2011
 - WG on Strategic Planning – 2 meetings

CCTF recommendations

- RECOMMENDATION CCTF 1 (2009) – Updates to the list of standard frequencies for applications including the secondary representations of the second

The list of secondary representations of the second includes as today:

One microwave transition: ^{87}Rb

Six optical transitions: neutral atoms of ^{87}Sr , ^{88}Sr , ^{171}Yt
ions of ^{40}Ca , ^{171}Yt , ^{199}Hg

- RECOMMENDATION CCTF 2 (2009) – Characterization of delays of GNSS time transfer equipment in TAI contributing laboratories
Requests RMOs to support BIPM (equipment « calibration »)
- RECOMMENDATION CCTF 3 (2009) – On the weakness of the present definition of UTC

Concerns the need of making a decision on a redefinition of UTC without leap seconds, providing support to the International Telecommunication Union (ITU)

CCTF recommendation and draft resolution to CGPM

- RECOMMENDATION CCTF 4 (2009) – Concerning the adoption of a common terrestrial reference system by the CGPM

Draft Resolution J submitted to the 24th CGPM

Recommends the adoption of the International Terrestrial Reference System (ITRS) as defined by the International Union of Geodesy and Geophysics (IUGG) and realized by the International Earth Rotation and Reference Systems Service (IERS) *

- ❖ *Note that the text of the draft recommendation published in the Convocation has been modified (form only) without any change of its contents*

CCTF recommendations

- RECOMMENDATION 5 (2009) – Alignment of Geodetic References and Synchronization of Time References to international standards

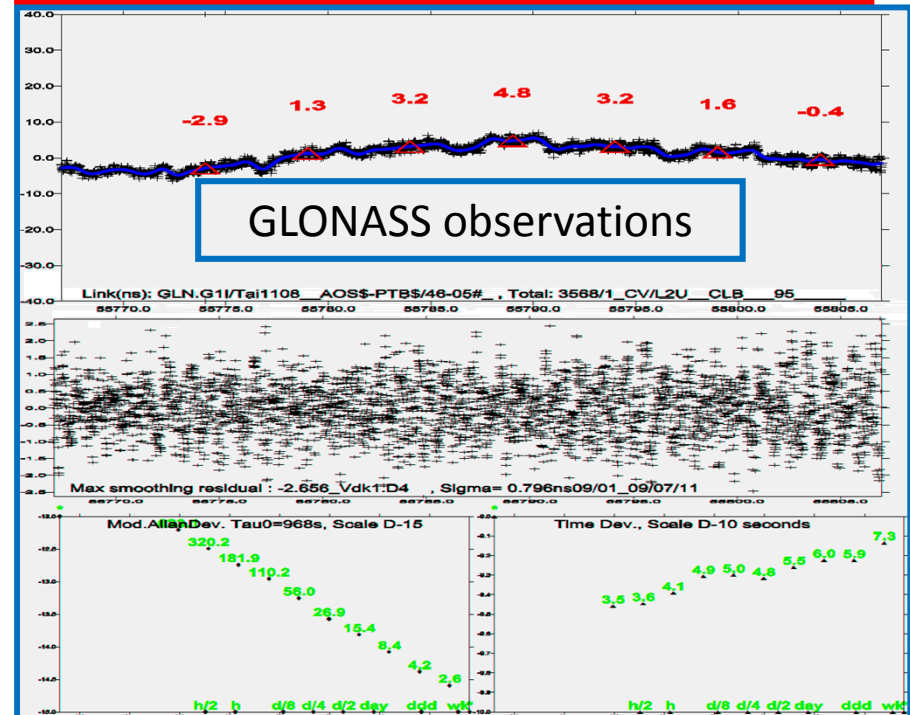
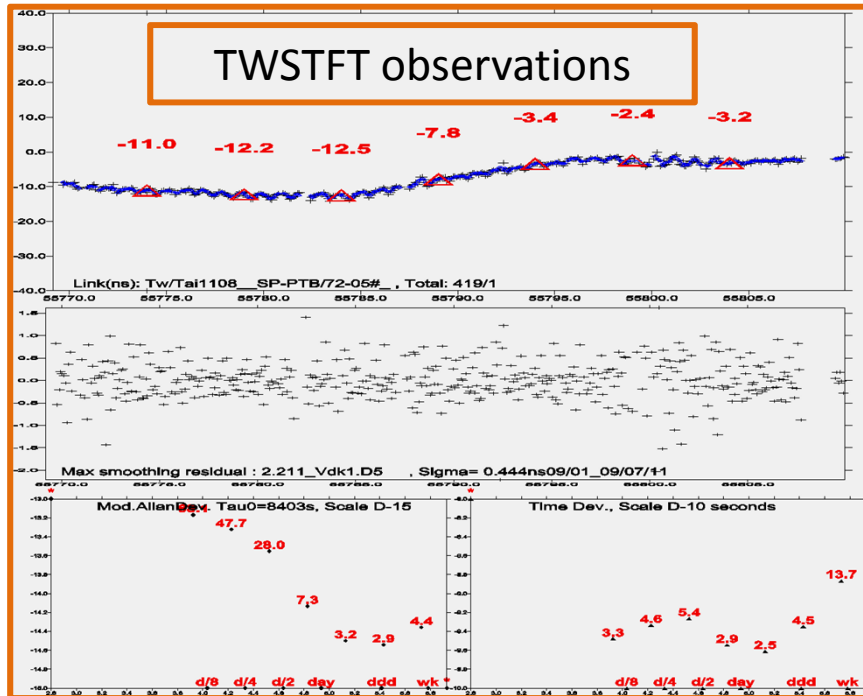
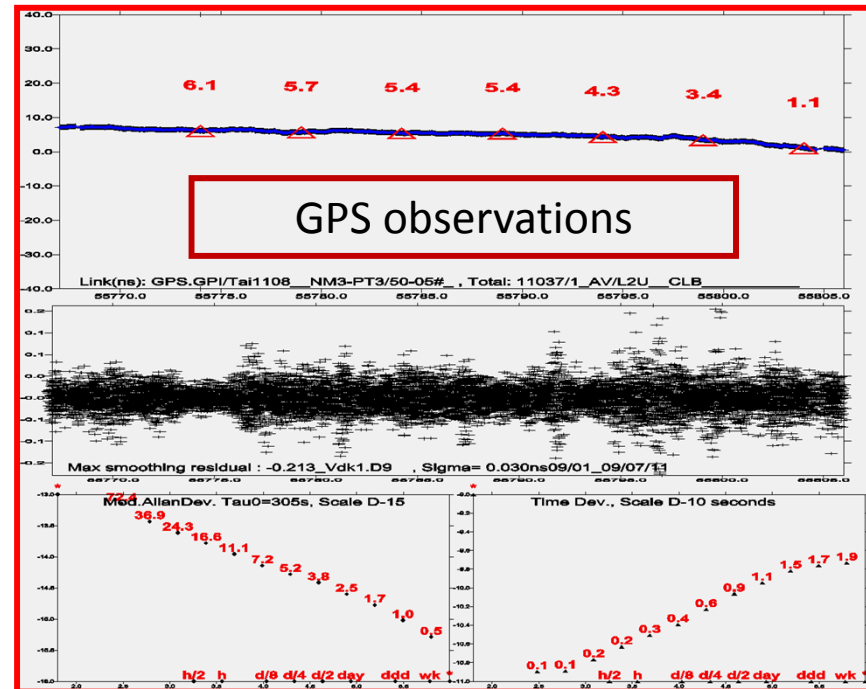
Concerns the adoption for GNSSs of ITRS for geodetic referencing and of UTC for synchronization of GNSS times

- RECOMMENDATION CCTF 6 (2009) – Relationship of predictions of UTC(k) disseminated by GNSS to UTC and TAI
Concerns information provided by the BIPM in complement to the key comparison in time CCTF-K001.UTC

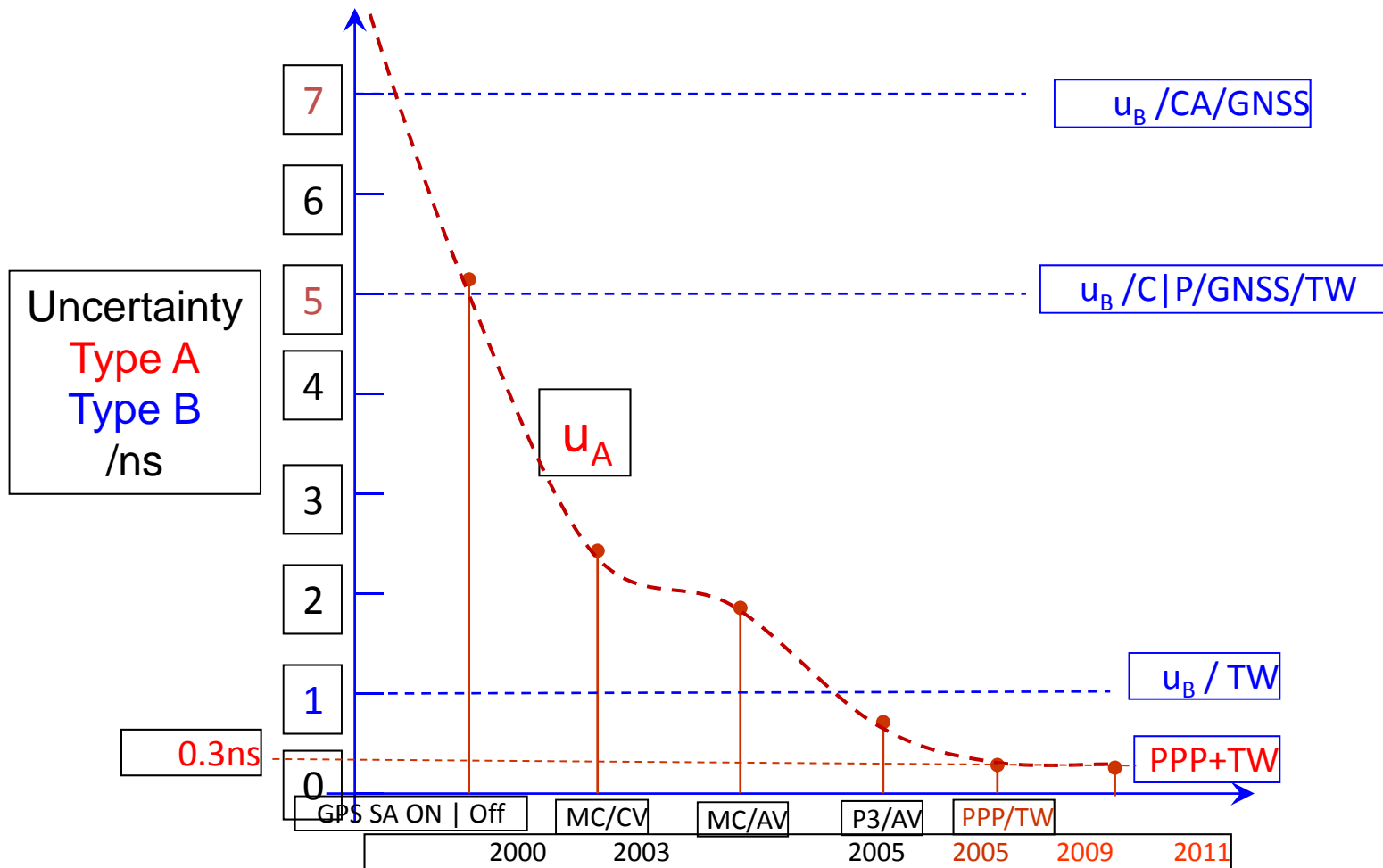
Progress at the BIPM and in National Metrology Institutes

- Maintenance of UTC at the BIPM and monthly publication of key comparison CCTF-K001.UTC
- Frequency stability of UTC is **3 parts in 10^{16}** over one month
- Frequency accuracy of UTC is of **order 10^{-16}**
- 69 laboratories have participated to the calculation of UTC at the BIPM, contributing about 400 atomic clocks (industrial Cs and hydrogen-masers)
- Upgraded equipment in contributing laboratories for clock comparison in the calculation of UTC at the BIPM
- Improved time comparisons at the BIPM Time Department by the incorporation of more performing techniques and the improvement of statistical handling and combination of data; to the GPS and TWSTFT observations **GLONASS common-views have been added.**

Time transfer applied to clock comparison in the calculation of TAI/UTC at the BIPM Time Department

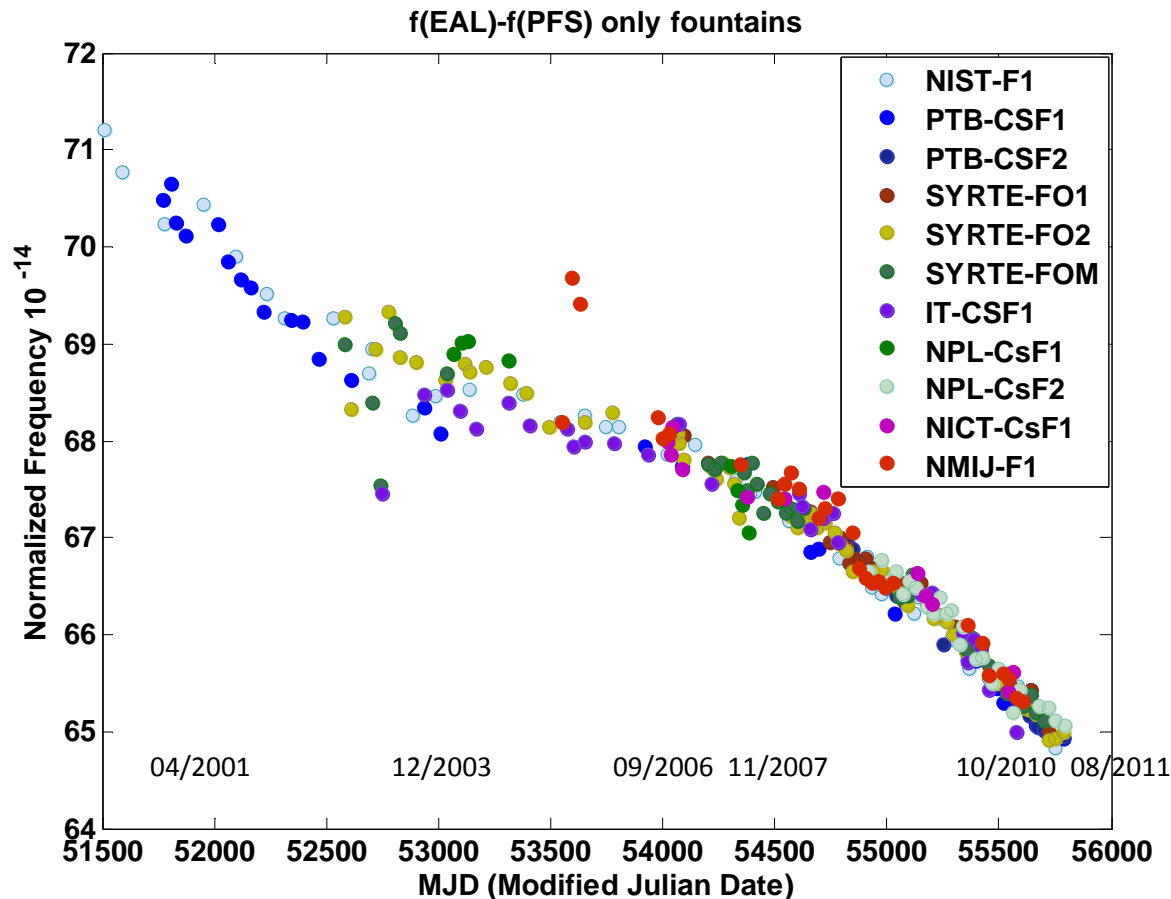


Techniques of time transfer used at the BIPM and evolution of their uncertainties



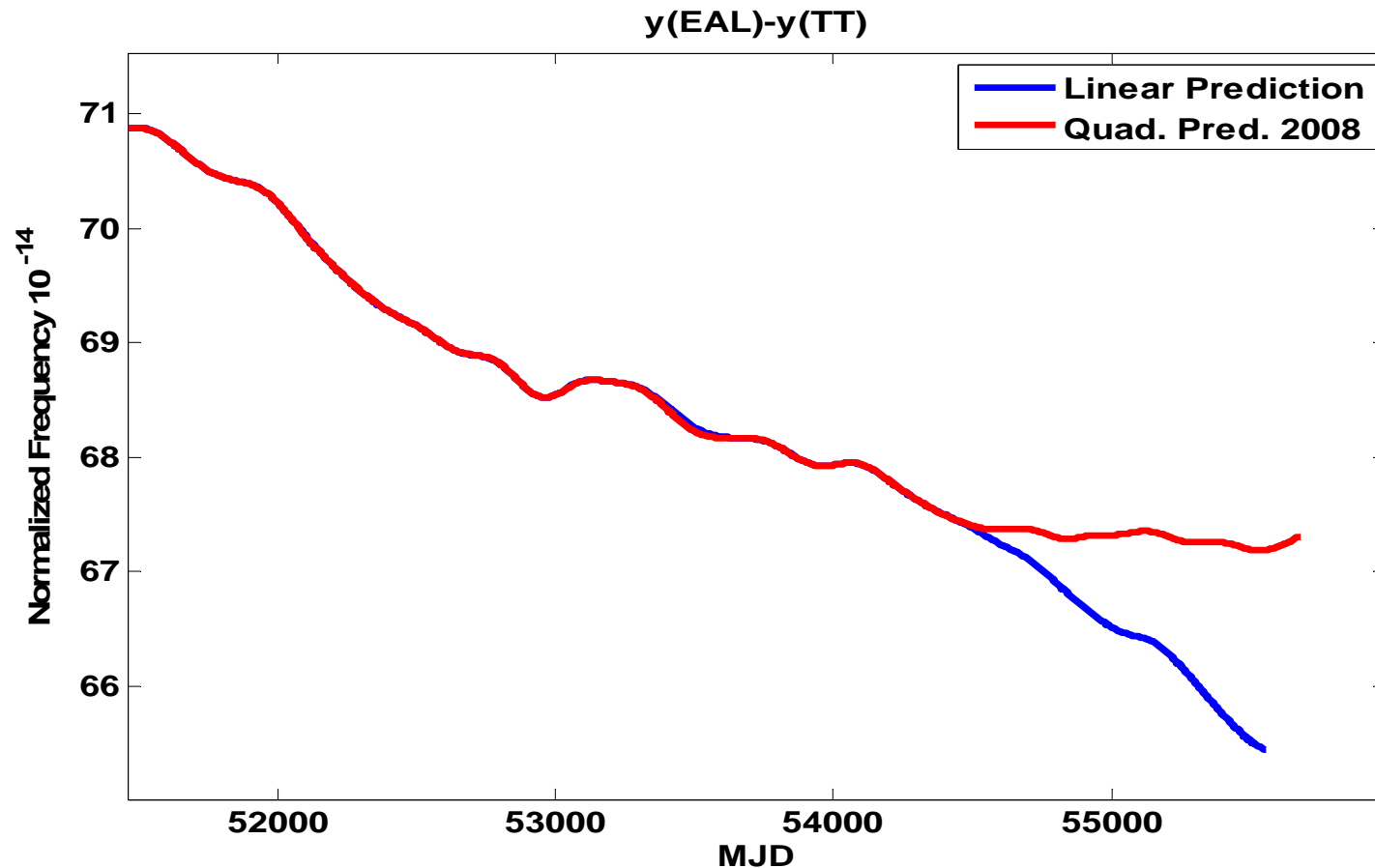
Progress at the BIPM and in National Metrology Institutes

- Primary frequency standards – 13 in the period, 11 are Cs fountains
More than 300 reported measurements from 8 laboratories (KRISS, INRIM, LNE-SYRTE, NICT, NIST, NMIJ, NPL, PTB)

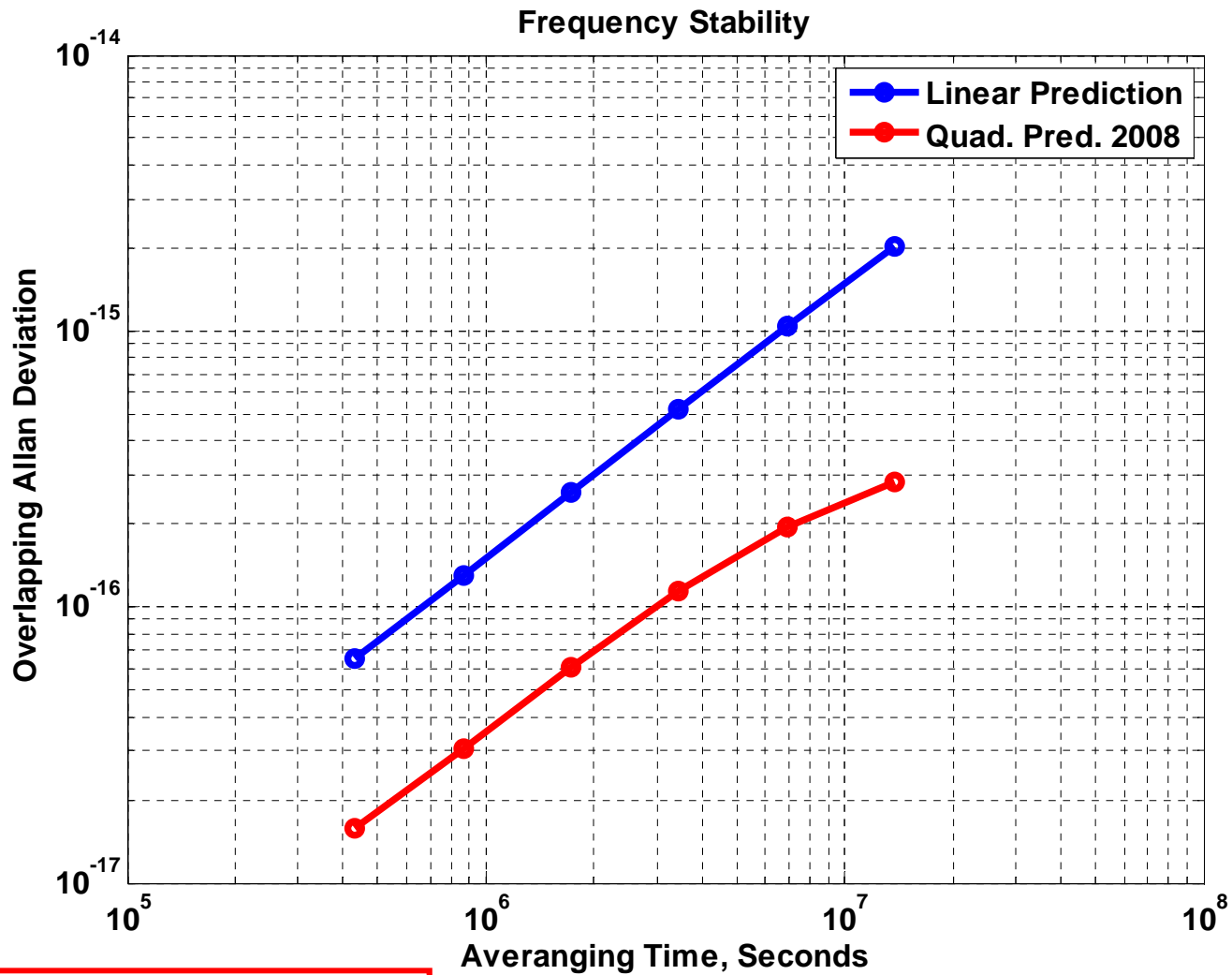


Progress at the BIPM and in National Metrology Institutes

- A drift has been observed in the last years between the « free » time scale EAL and the primary frequency standards. Improvement of the algorithm of calculation of TAI/UTC at the BIPM with a new model for the clock frequency prediction is stopping the drift.



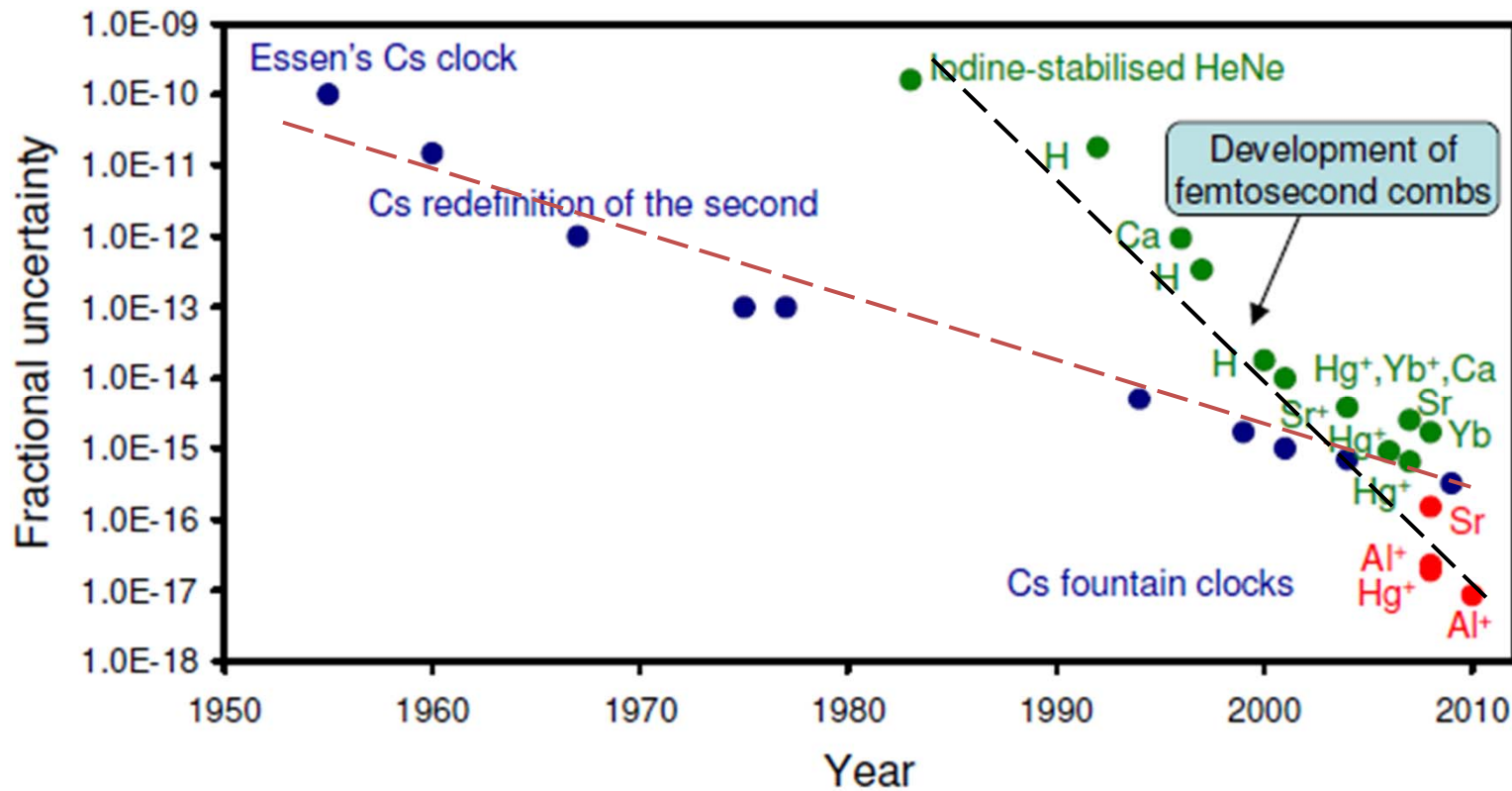
Improvement of the frequency stability of TAI/UTC
with the new clock frequency prediction model



New model used in the
calculation since July 2011

Progress at the BIPM and in National Metrology Institutes

- Secondary representations of the second – new microwave and optical clocks developed in laboratories, with uncertainties around parts in 10^{17} , 10^{18}



Future needs, projects

- The techniques of time transfer routinely used for comparing primary standards (TWSTFT, phase of the GPS) are not accurate enough for comparing optical standards without degrading their performances.
- Potential methods are
 - Optical fibres, good results over some hundred kilometers in some countries, projects under preparation for continental links.
 - The problem of long distances, intercontinental comparisons still exists; TWSTFT should improve; Very Long Baseline Interferometry (VLBI) could be a good candidate, provided that laboratories are equipped.
- The progress in the development of optical clocks has already opened the discussion on a future redefinition of the second. More accurate frequency transfer at the level of 10^{-18} is necessary for comparing optical clocks.

Future needs, projects

NEW DEFINITION OF THE SECOND

- In view of the progress in the development of optical clocks a redefinition of the SI second could be possible;
- Frequency combs allow on-site comparison of optical clocks;

BUT

- The state of the art in t&f transfer is impeding today the comparison of remote optical clocks, necessary for redefining the SI second;
- Accurate frequency transfer at the level of 10^{-18} is necessary for these comparisons;
- Foreseen progress indicates that a redefinition would not be possible before 2019;

ADDITIONAL DISCUSSION ON

- Form of the new definition and its realization (s)?

Future needs, projects

UTC issues

- UTC is a post-processed timescale disseminated by values of [UTC-UTC(k)];
- Contributing laboratories « k » predict UTC-UTC(k) values over up to 45 days;
- Some UTC(k) are used for GNSS times synchronization (USA, Russian Federation, Europe, China, India)

BUT

- The delayed UTC is not suitable to all applications;
- More frequent access to the UTC reference is necessary for better UTC(k) and GNSS times synchronization

CONSEQUENTLY

- The BIPM is putting in place a pilot experiment for testing the production of a weekly, rapid UTC. Contributing laboratories and GNSS providers welcome this proposal.



Merci de votre attention