Report on Rapid UTC (UTCr)

BIPM Time Department

21st CCTF Meeting

8-9 June 2017

Bureau International des Poids et Mesures

UTCr reminder

- The Rapid UTC project (UTCr) was presented at the CCTF(2012)
  - April 2013: Final report to the CCTF WG on TAI
  - July 2013: UTCr an official BIPM product

- UTCr based on daily data reported (daily) by contributing laboratories;
- Weekly solution, generated quasi automatically.
  - Product identified by the week number = YYWW
- Computation interval of 26 to 30 days (sliding solution);
- Weekly access to daily values of [UTCr-UTC(k)]
- Stability of UTCr expected to be about similar to UTC since participating laboratories represent at least 70% of the clocks in UTC.

Four steps of UTCr computation

1. Data checking
   - Daily data, reported daily by laboratories. Automatic detection and sending reminders, checking format

2. Computation of time links
   - TW when available / GPS P3 / GPS MC

3. Algorithm
   - Prediction similar to UTC's ALGOS, with quadratic prediction (since November 2012) for $h_i'(t)$.
   - Weight computed from the clock stability, unlike ALGOS (New weighting procedure implemented January 2014 in UTC)

4. Steering to UTC
   - Each month, after CirT computation, the past UTCr Clock data [UTCr-Clock] are replaced by the newly computed [UTC-Clock]

Publication of UTCr

Every Wednesday before 17:00 UTC on ftp://tai.bipm.org/UTCr/Results/ and on the regular Time Dpt ftp server.

Also ASCII files with UTCr-UTC(k)

Results of the official UTCr product since July 2013;

Back results of the pilot experiment stage in subdirectory Results/pilot_experiment;

UTCr_1344
2013 NOVEMBER 06, 12h UTC

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Computed values of [UTCr-UTC(k)]

Date 2013 0h UTC	OCT 28	OCT 29	OCT 30	OCT 31	NOV 1	NOV 2	NOV 3
MJD	56593	56594	56595	56596	56597	56598	56599
Laboratory k	[UTCr-UTC(k)]/ns						
AOS (Borowiec)	0.3	0.6	0.1	-0.3	-0.4	-1.2	-1.0
BEV (Wien)	-36.1	-37.0	-31.8	-25.5	-26.1	-20.5	-20.9
CH (Bern-Wabern)	-3.7	-6.4	-7.6	-8.3	-8.2	-9.1	-9.5
CNM (Queretaro)	-5.4	-6.4	-5.0	-5.8	-5.3	-5.9	-6.6
CNMP (Panama)	0.0	-1.6	-8.5	-13.2	-23.9	-17.1	-25.4
DMDM (Belgrade)	-13.1	-16.6	-17.5	-22.3	-30.5	-31.0	-29.4
DTAG (Frankfurt/M)	240.8	240.5	239.0	239.9	238.4	235.1	233.7
IFAG (Wettzell)	-863.1	-863.1	-865.7	-871.3	-875.1	-876.9	-875.4
IGNA (Buenos Aires)	4621.9	4637.8	4654.7	4669.3	4686.0	4705.1	4724.0
INTI (Buenos Aires)	62.2	61.0	61.3	60.7	67.8	75.9	73.1
IT (Torino)	-8.8	-9.2	-8.9	-9.0	-9.2	-10.3	-10.0
KRIS (Daejeon)	-16.0	-16.3	-15.8	-15.7	-15.3	-15.7	-15.0
LT (Vilnius)	410.7	402.9	393.9	396.9	391.9	389.0	382.2
MSL (Lower Hutt)	782.4	781.8	791.7	802.6	813.9	828.0	842.6
NAO (Mizusawa)	-20.3	-23.1	-23.2	-20.5	-23.4	-23.8	-25.4
NICT (Tokyo)	10.9	10.6	10.4	10.2	10.0	8.9	8.3
NIM (Beijing)	-7.8	-7.7	-7.8	-9.1	-8.5	-9.7	-9.9
NIMT (Pathumthani)	0.1	1.8	2.5	-2.1	-2.3	-1.0	0.0
NIST (Boulder)	-1.4	-1.9	-2.7	-3.5	-3.5	-4.3	-3.9
NMIJ (Tsukuba)	0.6	0.3	0.0	-0.4	-0.3	-1.1	-1.2
NMLS (Sepang)	1119.1	1104.1	1084.3	1072.6	1053.4	1037.7	1018.2
NPLI (New-Delhi)	-3.7	-3.4	-3.7	-4.2	-4.0	-3.6	-3.3
NRC (Ottawa)	-22.6	-19.6	-22.1	-20.6	-26.5	-26.6	-22.8
NRL (Washington DC)	-4.6	-4.4	-4.2	-4.1	-3.4	-2.1	-1.1
NTSC (Lintong)	-0.1	-0.2	-1.3	0.7	-2.6	-1.9	-3.6
ONRJ (Rio de Janeiro)	-11.8	-12.1	-13.0	-13.5	-14.8	-14.3	-15.0
OP (Paris)	-3.1	-2.8	-3.1	-3.3	-3.2	-3.6	-3.4
ORB (Bruxelles)	-11.4	-10.6	-10.7	-12.9	-12.4	-15.2	-17.3
PL (Warszawa)	38.2	38.8	35.7	32.6	29.9	32.5	29.1
PTB (Braunschweig)	-6.9	-6.6	-7.1	-7.7	-8.1	-8.7	-8.5
ROA (San Fernando)	0.4	0.6	0.2	-1.1	-1.8	-3.2	-4.0
SCL (Hong Kong)	33.7	35.6	27.5	34.7	29.3	32.4	28.1
SG (Singapore)	-17.2	-17.9	-19.2	-20.6	-19.2	-20.2	-19.4
SP (Boras)	-6.4	-5.7	-6.3	-6.9	-7.2	-7.6	-7.5
SU (Moskva)	-2.0	-1.7	-2.1	-2.4	-2.2	-2.6	-1.9
TL (Chung-Li)	-5.6	-6.2	-6.9	-7.4	-7.8	-8.9	-8.1
UME (Gebze-Kocaeli)	1363.3	1367.5	1369.9	1370.5	1376.8	1380.7	1379.1
USNO (Washington DC)	-3.4	-3.8	-4.2	-5.0	-5.1	-5.3	-5.5
VSL (Delft)	-23.0	-22.2	-22.0	-20.5	-18.3	-18.8	-12.9

UTC remains available from the monthly Circular T at
(http://www.bipm.org/jsp/en/TimeFtp.jsp?TypePub=publication).

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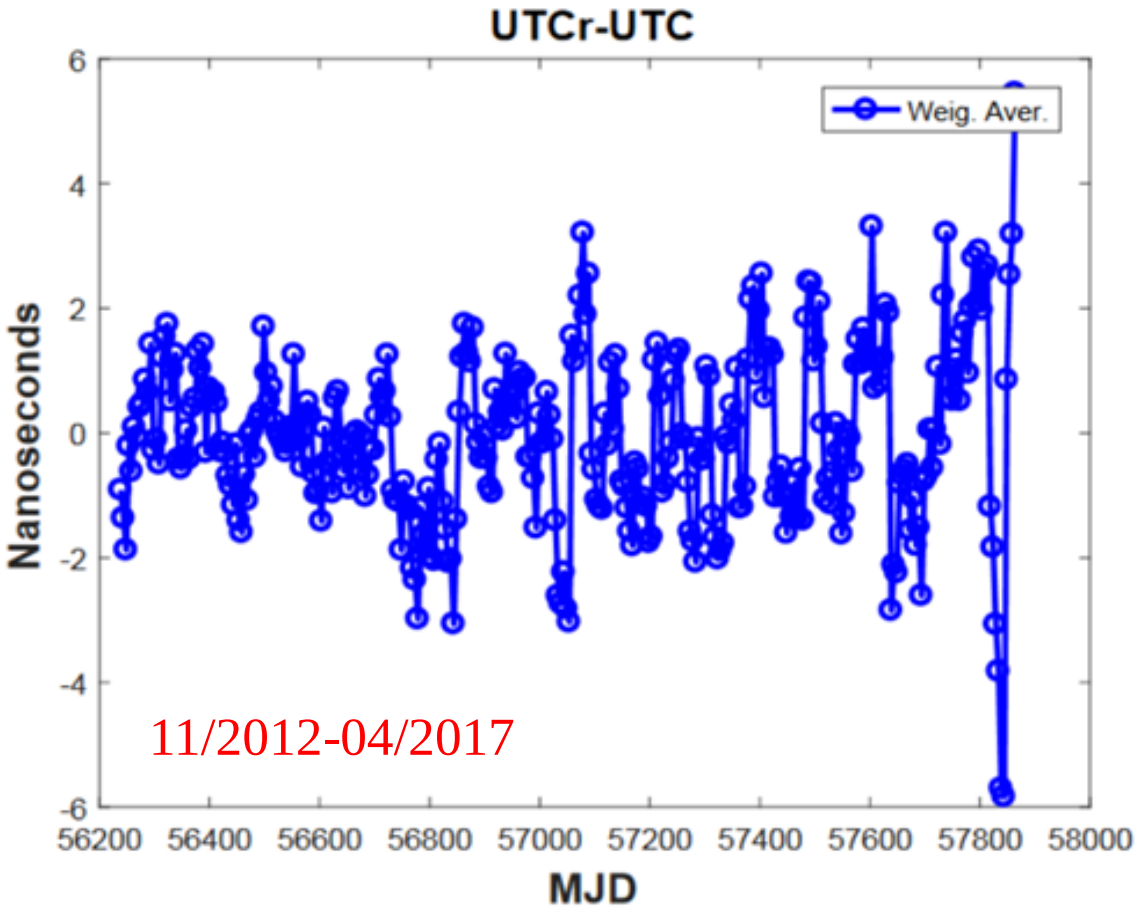
Comparisons between UTCr and UTC

Not a single way to estimate UTCr-UTC.

We use a weighted average over the laboratories participating to UTCr:

$$D(t_j) = \sum^{N_k} W_k\left([UTCr - UTC(k)](t_j) - [UTC - UTC(k)](t_j)\right)$$



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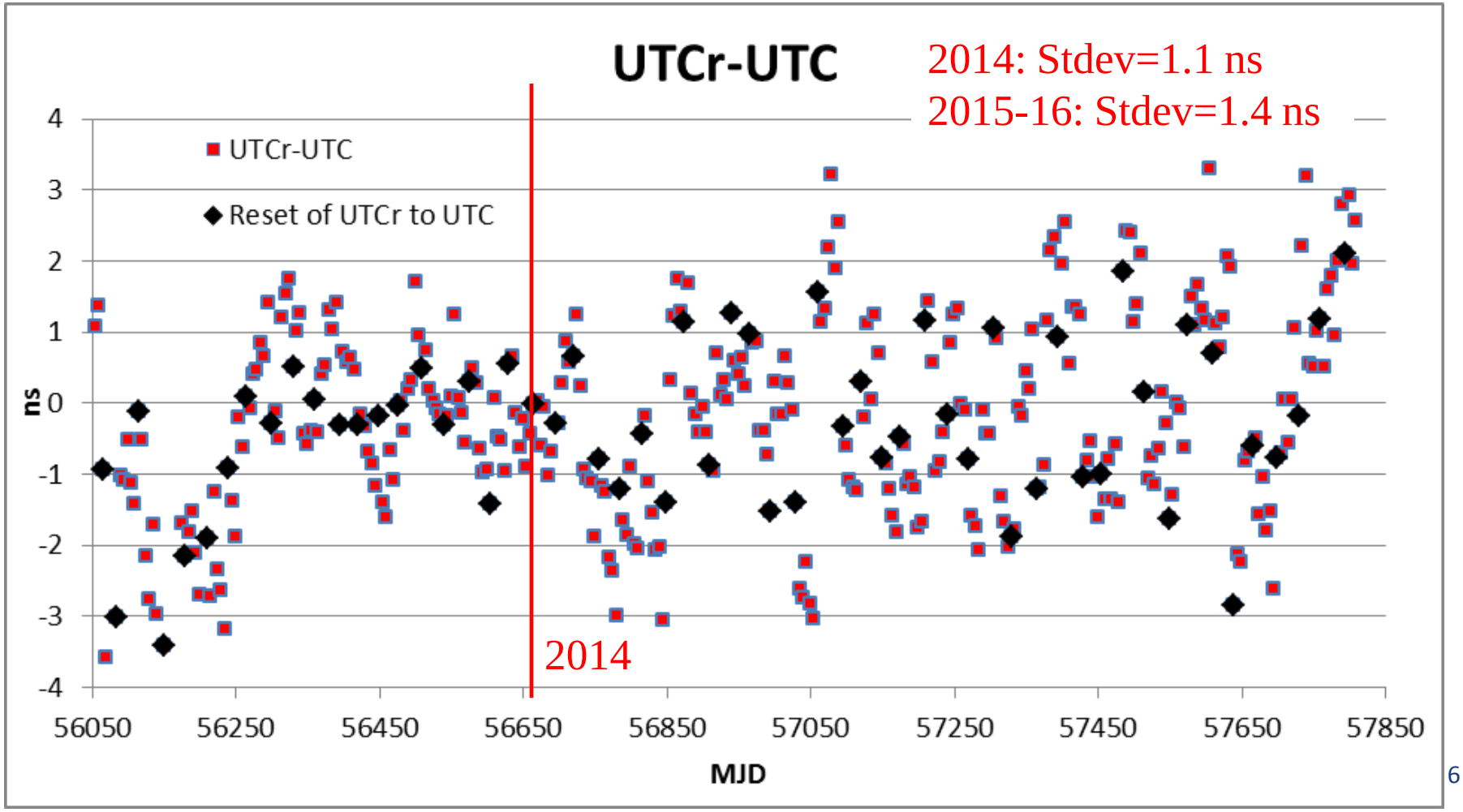
Comparisons between UTCr and UTC

Significant degradation of [UTCr-UTC] starting ~2014

Also visible when UTCr has just been reset to UTC.



A test study on 64 weeks (1601 to 1712) 1/2

- Several possible causes identified, to be tested
  1. Different data in UTCr and UTC
  2. UTCr sliding computation interval / “date charnière”
  3. Weighting algorithm

- Findings
  1. Different data can produce significant effect, mostly due to errors in UTCr reports; but the global effect cannot be estimated
  2. UTCr sliding computation interval better be replaced by an interval starting from the latest available UTC date.

     => Interval ranging from 10-15 days to 40-45 days
  3. Exact same weighting algorithm not tested. Rather test of weighting clocks based on their variance from the most recent UTC computation found to bring significant improvement.

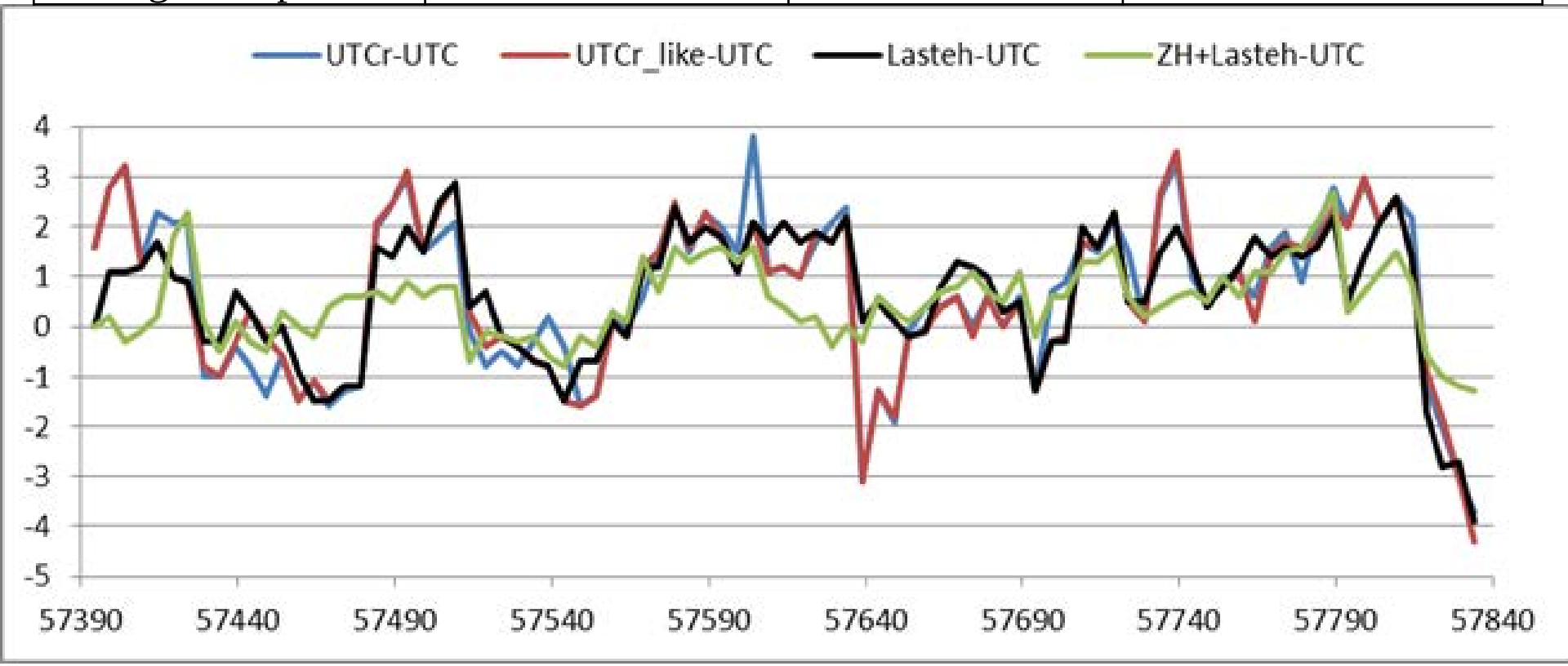
Tests 2 and 3 significantly reduce the standard deviation of [UTCr-UTC]

A test study on 64 weeks (1601 to 1712) 2/2

« Lasteh » : Use adapted computation interval

« ZH+Lasteh »: In addition use weights « à la UTC »

	UTCrlike-UTC	Lasteh - UTC	ZH+Lasteh - UTC
Stdev / ns	1.57	1.31	0.78
Largest step / ns	5.3	3.1	2.4



Conclusions

- UTCr started as a pilot experiment in January 2012, declared an official product in July 2013 (week 1336)
- **Published *Metrologia* 51 33, 2014**

- Degradation since ~ 2014 will be addressed by implementing two simple changes in the short term
  - Adapt computation interval
  - Adopt weight based on latest UTC computation

- UTC laboratories wishing to participate, see the information in ftp://tai.bipm.org/UTCr/Documents/

THANK YOU

Thank you to all participating laboratories

Please make sure that the data that you report for UTCr and for UTC agree!