

Time metrology at the BIPM

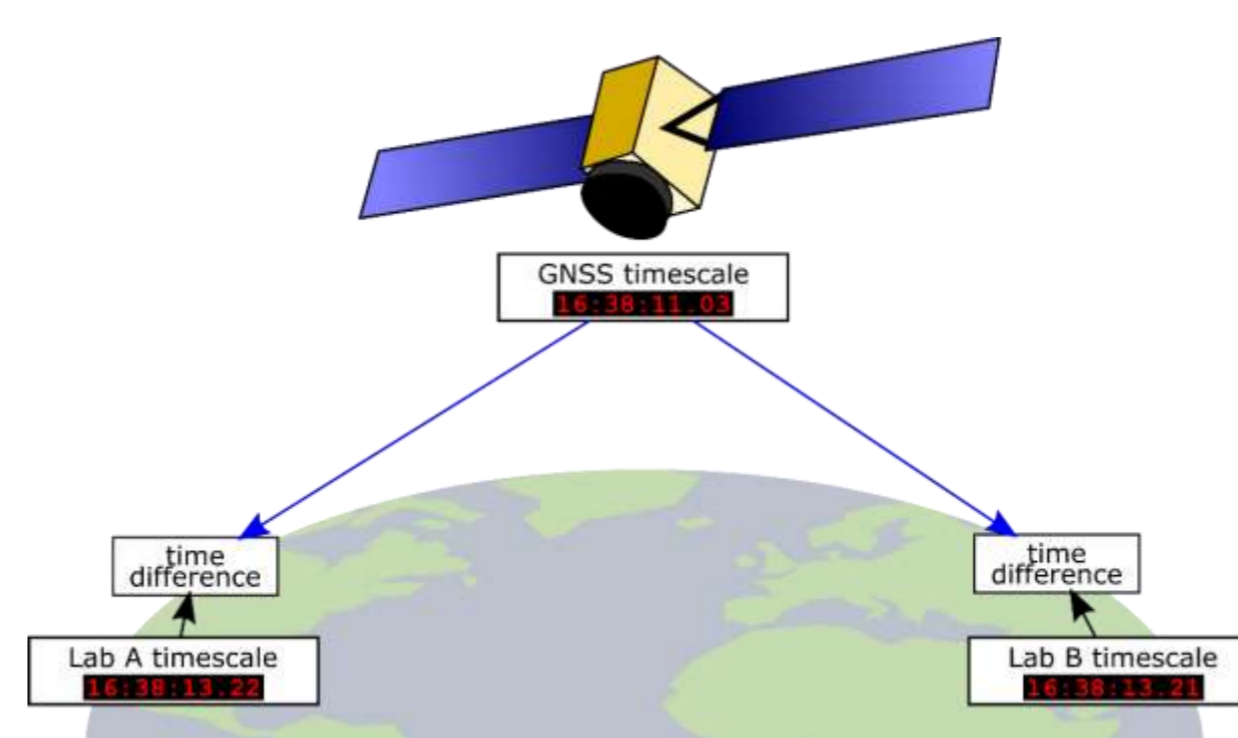
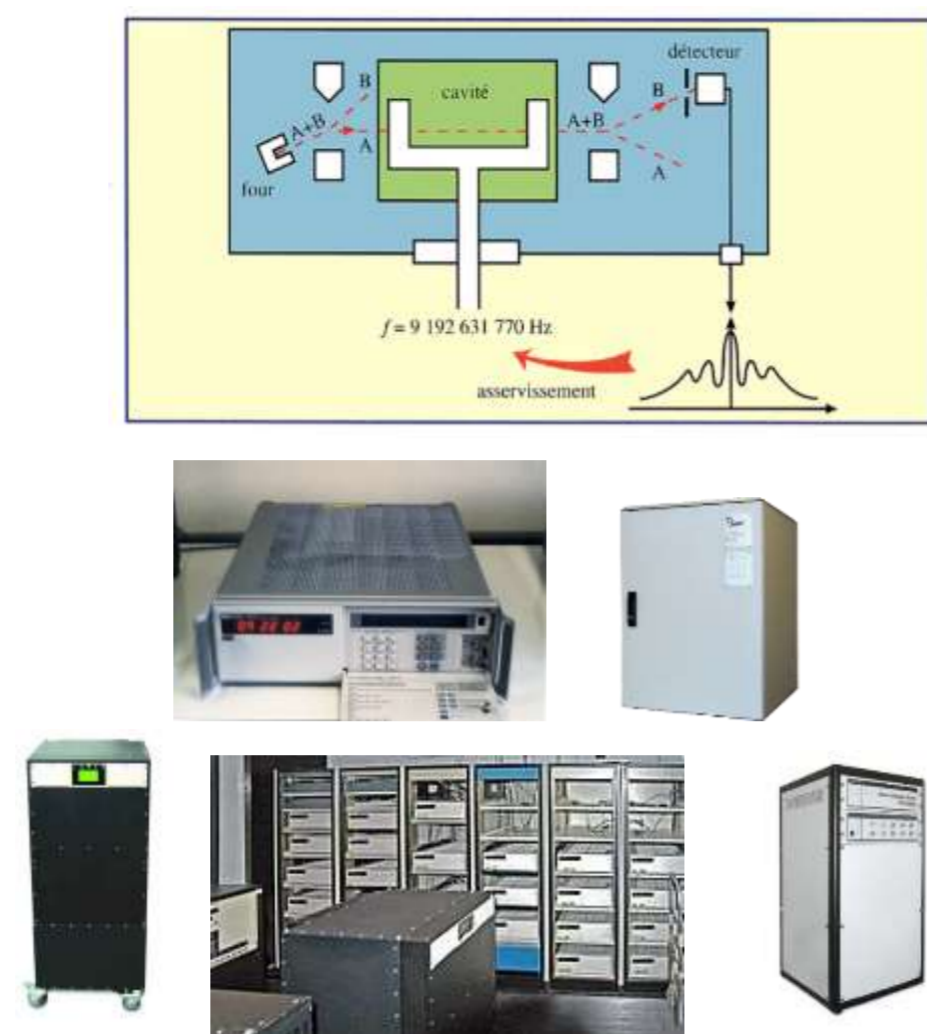
The reference time scale UTC - Coordinated Universal Time

Atomic clocks realize the SI second

The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom (CGPM 1967).

Any device able to generate the caesium reference signal is a frequency standard.

Devices can fail, the use of an ensemble of clocks and frequency standards helps to ensure reliability, robustness, accuracy, and continuity of a time scale.



Clocks in different laboratories are compared by suitable time and frequency transfer techniques

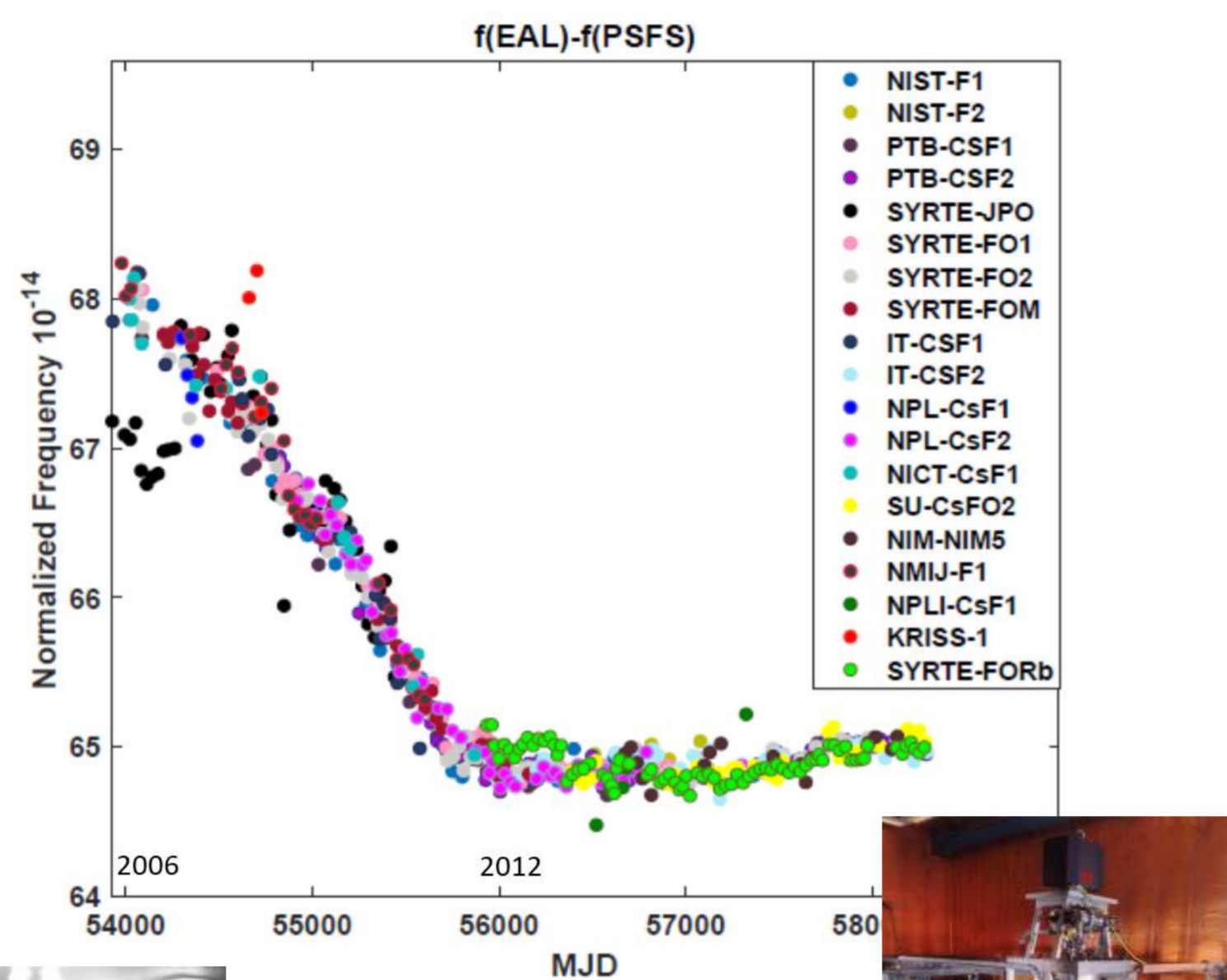
The uncertainty of a caesium commercial clock is about 10^{-14}

→ 300 nanoseconds accumulated in one year

Primary frequency standard

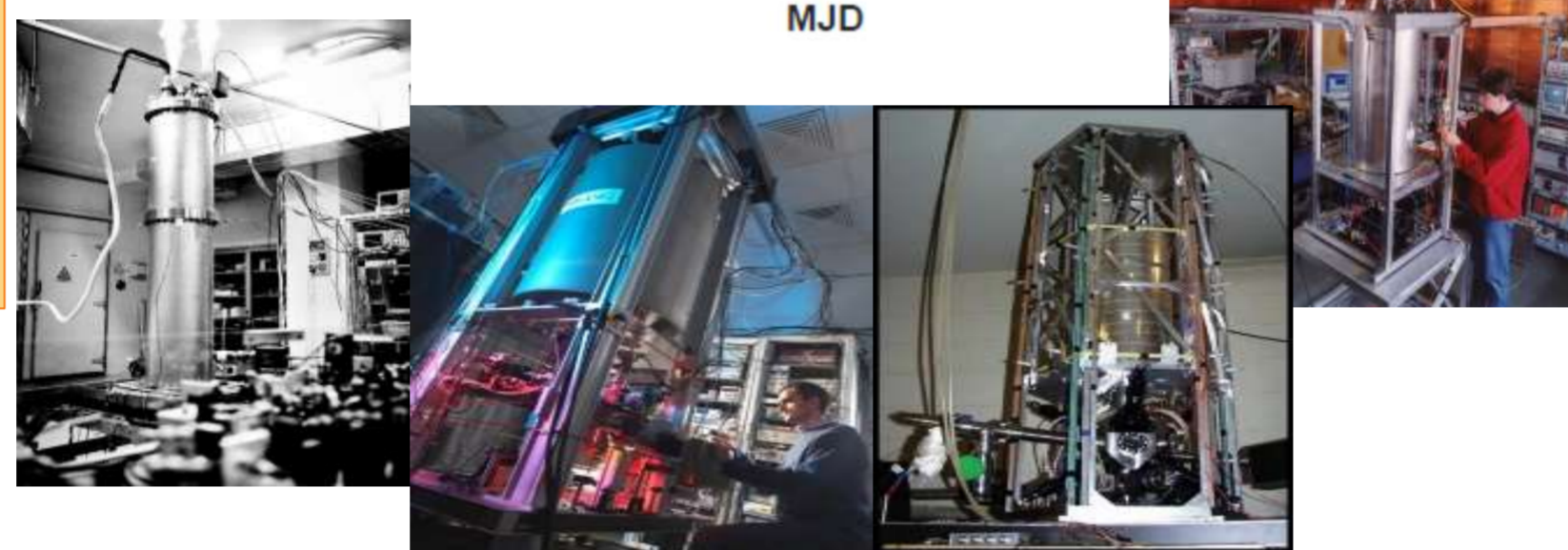
Some laboratories operate primary frequency standards. Their uncertainty can be evaluated by examining the different effects

Primary standards calibrate the frequency of the Echelle Atomique Libre (EAL)

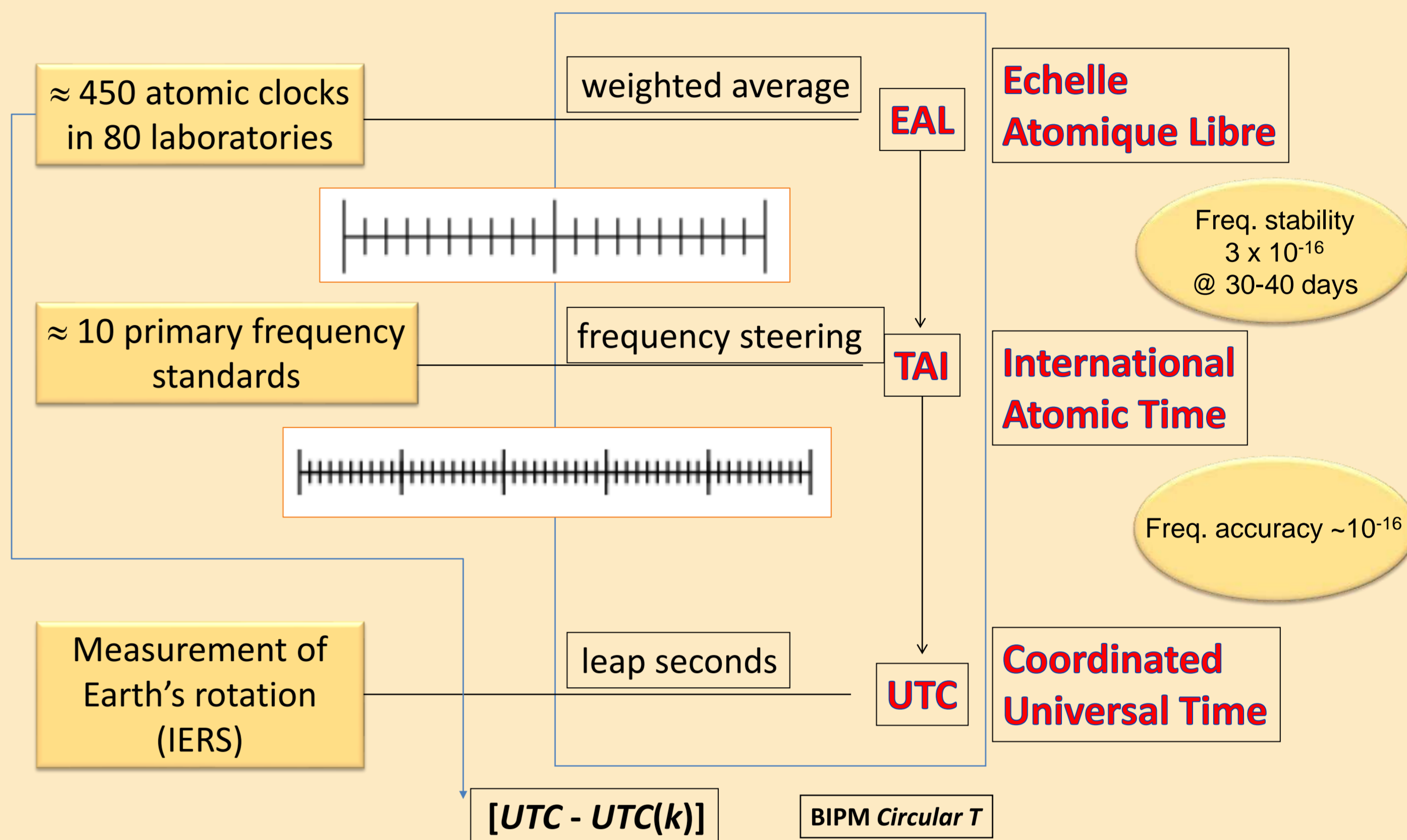


The uncertainty of caesium primary fountains can reach 10^{-16}

→ 3 nanoseconds accumulated in one year



Computation of UTC (monthly) at the BIPM

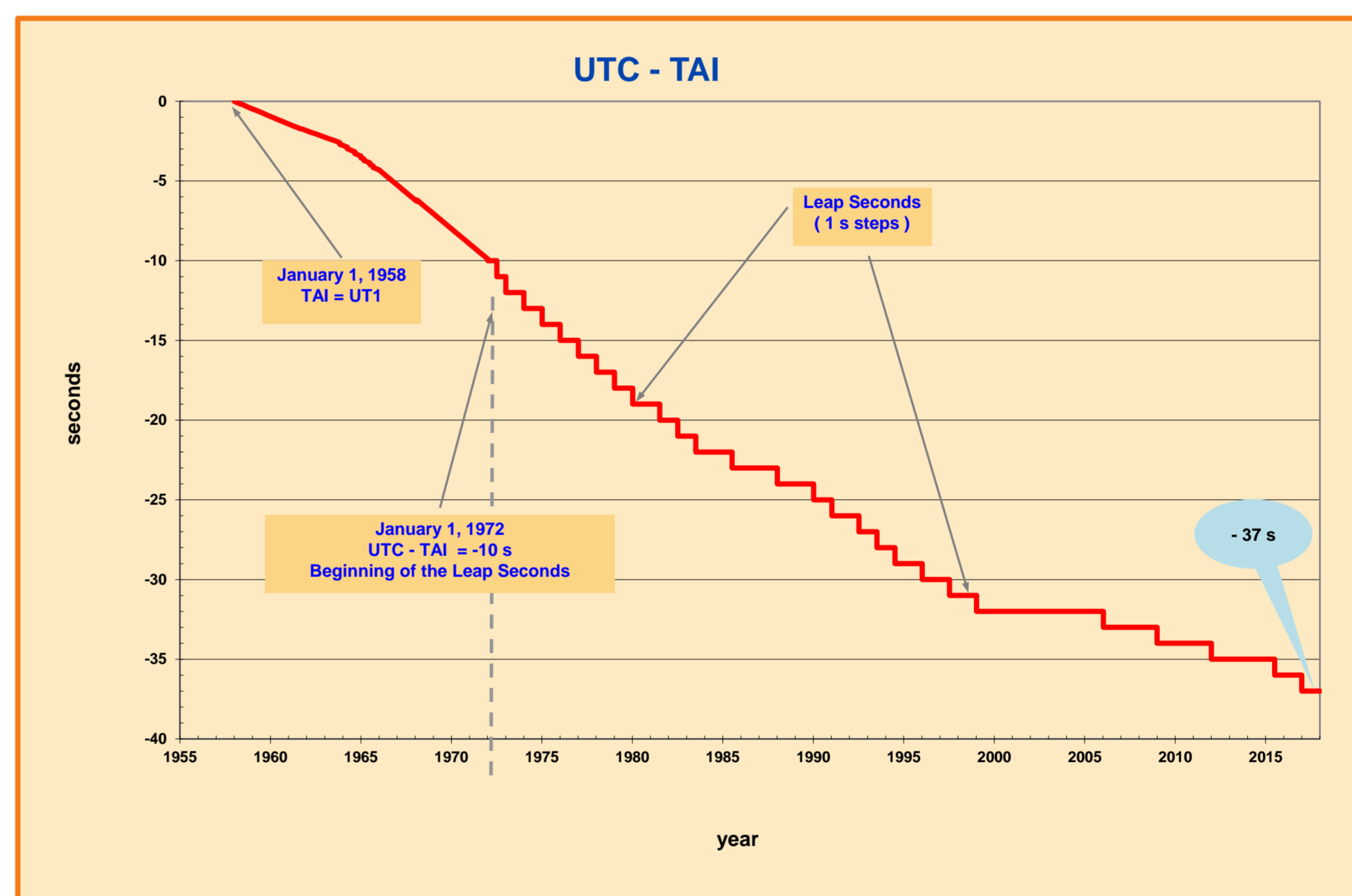


Agreement with the (irregular) rotation of the Earth

When the rotation of the Earth (UT1 time scale) reaches a one second difference with respect to atomic time TAI, one second is added to maintain the reference time scale UTC in agreement with the Earth's rotation

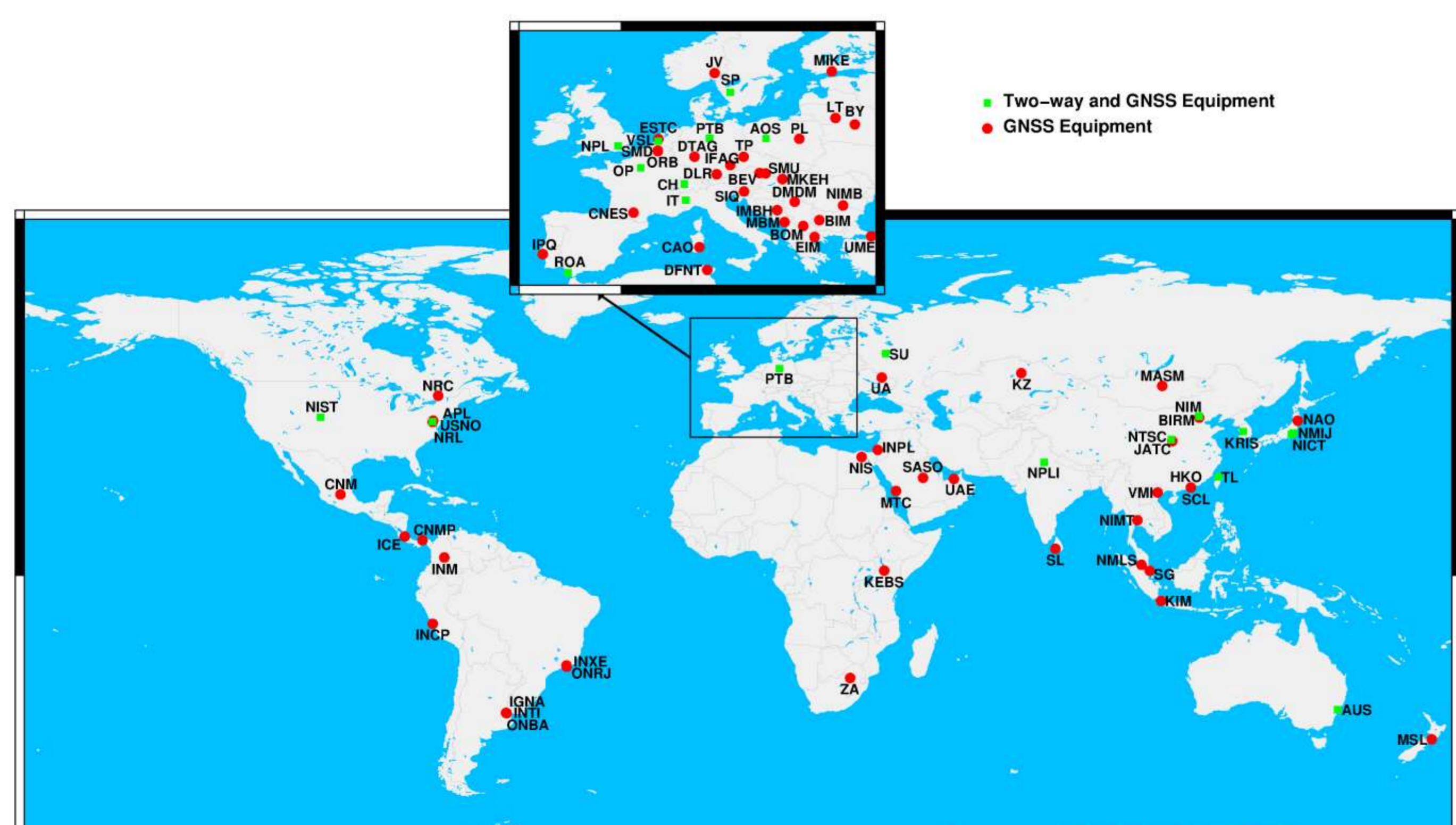
23:59:60

$$UTC = TAI + \text{leap seconds}$$



Laboratories contributing to UTC

Geographical distribution of the laboratories that contribute to UTC and time transfer equipment (2018)



An approximation called Rapid UTC (UTC_r) is calculated weekly and published each Wednesday by the BIPM.

All data and products are available on <http://webtai.bipm.org/database/> and <https://www.bipm.org/en/bipm-services/timescales/time-ftp>

UTC - UTC(k) in BIPM Circular T and the CCTF-K001.UTC

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The contents of the sections of BIPM Circular T are fully described in the document "Explanatory supplement to BIPM Circular T" available at ftp://ftp2.bipm.org/pub/tai/publication/notes/explanatory_supplement_v0.1.pdf

1 - Difference between UTC and its local realizations UTC(k) and corresponding uncertainties. From 2017 January 1, 0h UTC, TAI-UTC = 37 s.

Date 2018 0h UTC	MJD	58299	58304	58309	58314	58319	58324	58329	u _A	u _B	u
Laboratory k											
AOS (Borowiec)	123	✓	-0.3	0.4							
APL (Laurel)	123	✓	-1.4	-1.6							
AUS (Sydney)	123	✓	3.5	2.6							
BEV (Wien)	123	✓	-7.5	-16.5							
BIM (Sofiya)	123	✓									
BIRM (Beijing)	123	✓	6.8	10.4							
BOM (Skopje)	123	✓		-373.5							
BY (Minsk)	123	✓		0.6	0.6						
CAO (Cagliari)	123	✓									
CH (Bern-Wabern)	123	✓	-1.5	-1.4							

The difference UTC - UTC(k) is computed by the BIPM and published in the monthly Circular T

Contributing laboratories realize local real-time timescales named UTC(k)

