Activities Report To The 19th Session Of The

Consultative Committee For Time And Frequency (CCTF)

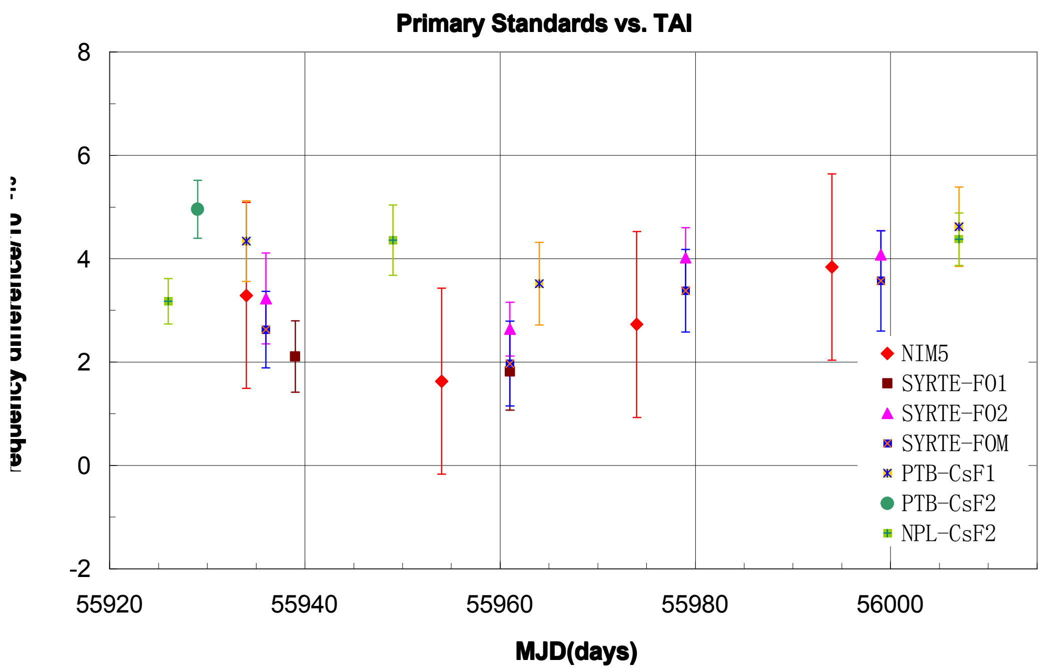
National Institute of Metrology (NIM), China, August 2012

This report covers the activities of NIM in the following research areas:

1. Cesium fountain clock
2. time scales
3. time and frequency comparisons
4. optical clock
5. fiber comb

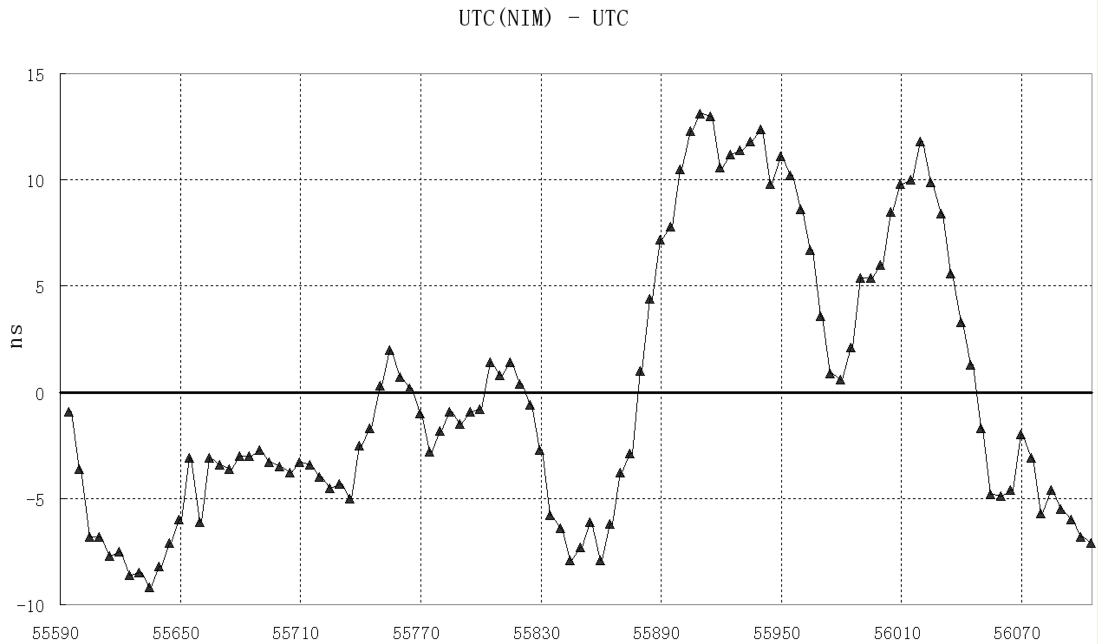
1. Cesium fountain clock

The NIM5 was moved to NIM's new campus (Changping campus) in April, 2011. After readjustment, it has been running semi-continuously since Nov, 2011, with much better stability of trapped atom counts due to a much quieter environment. A series of frequency evaluations show a typical combined uncertainty of 2×10^{-15}. The frequency of NIM5 is compared with TAI and other primary frequency standards through GPS from Jan. to Mar. 2012, and the results are shown in the following figure.

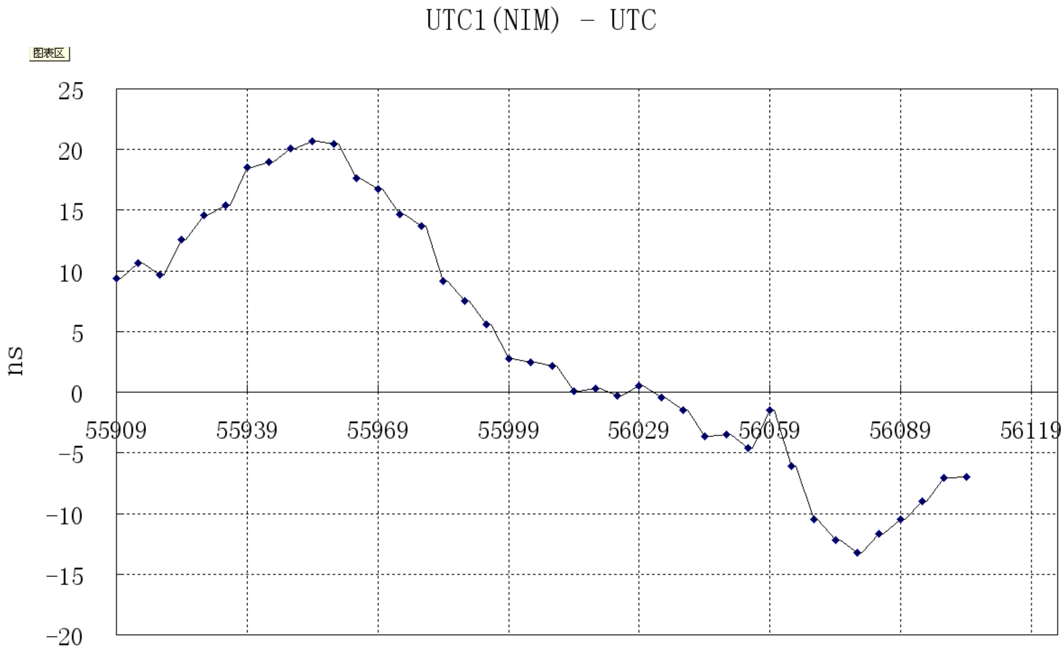


2. time scales

Official UTC(NIM) is now generated from NIM's Hepingli Campus. The master clock is a hydrogen maser and it is steered by UTC. The clock ensemble consists of 1 Hydrogen Maser and 2 Cesium clocks. UTC(NIM) data published by Circular T from February 2011 to June 2012 is shown in the following figure. The time stability is about 0.8ns/5d, and the frequency stability is about 3×10^{-15}/5d.



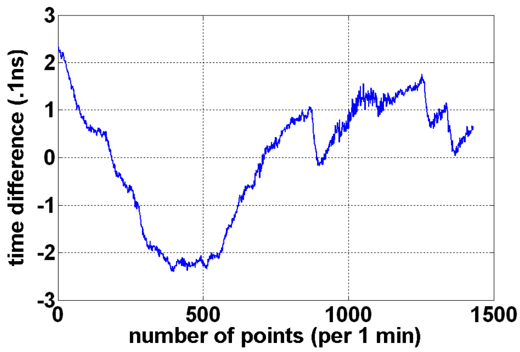
A new timescale is running for test at NIM's Changping campus. The clock ensemble consists of 5 Hydrogen masers and 6 Cesium clocks. The timescale has been synchronized to UTC(NIM) and traceable to UTC(NIM) by GPS, and thus traceable to UTC. The performance of the new timescale between December 2011 and June 2012 is shown in the following figure. The time stability is about 0.9ns/5d, and the frequency stability is about 4×10^{-15}/5d. UTC(NIM) will be switched to the clock ensemble at the Changping campus before the end of this year.

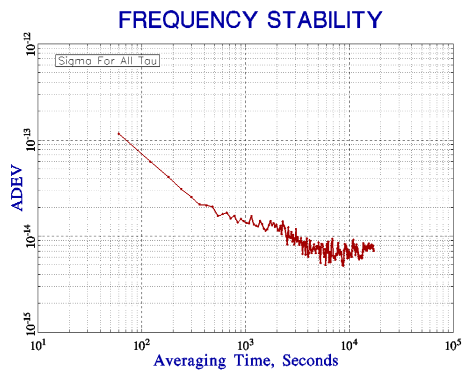


3. time and frequency comparisons

(1) GPS carrier phase time and frequency transfer

One GPS carrier phase processing algorithm is realized at NIM. This algorithm is based on single difference model with the fixed position condition, and the float ambiguity is estimated by Kalman filter. The CCD experiments shows the time stability at one day is within 300 ps. The corresponding stability is shown in the following figure .





(2) GNSS time and frequency transfer receiver

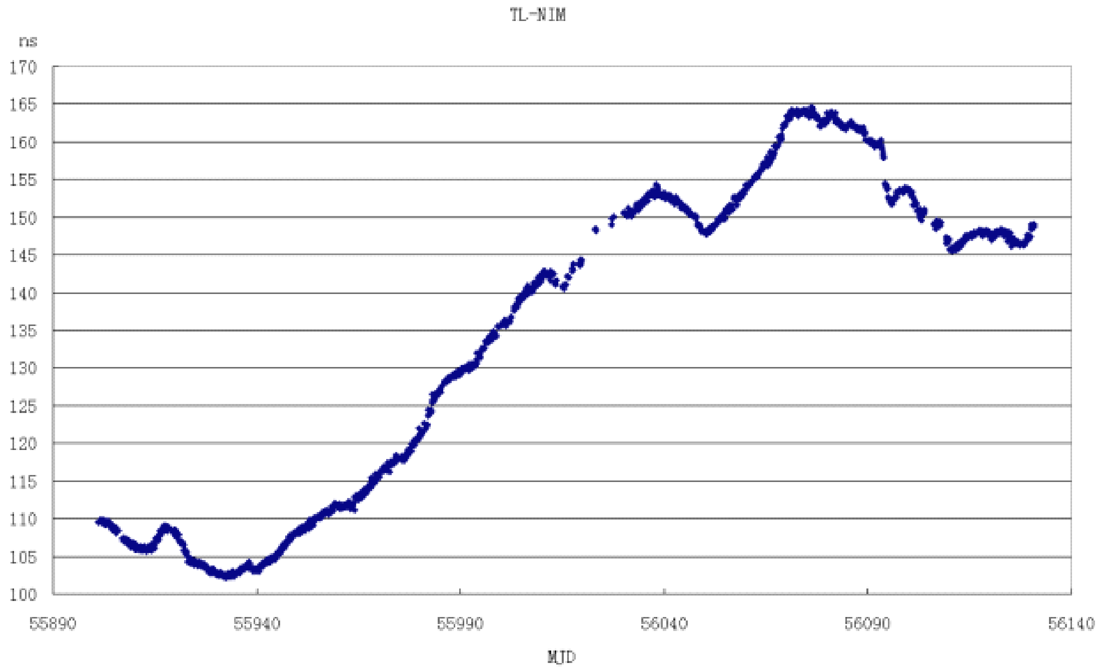
A new type of GNSS(GPS and GLONASS) receiver is developed for time and frequency transfer, with the operation mode where the receiver is directly synchronized to the external time and frequency reference. The receiver can generate and log original binary measurement data, GPS and GLONASS RINEX data and CGGTTS data that could be uploaded to some FTP server automatically.

(3) Time link calibration

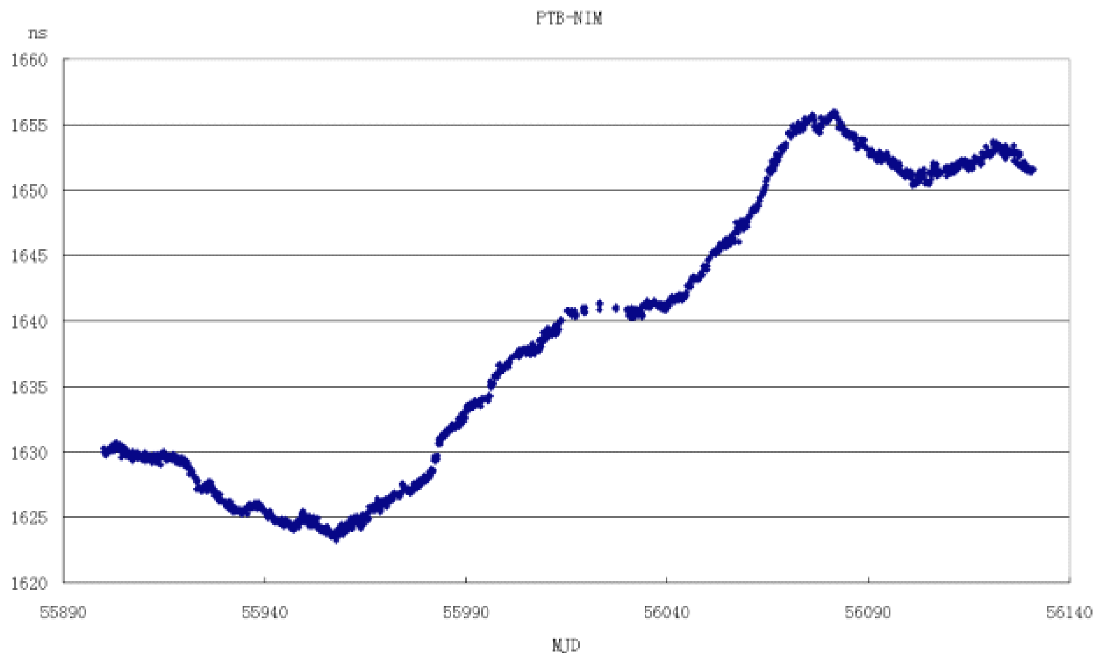
The first calibration experiment of GPS links between NIM and PTB was conducted with the homemade GNSS receiver,The calibration uncertainty was about 2 ns. After that, four officially used P3 time links between NIM and PTB were calibrated. One link result and the differential calibration result provided by BIPM agree within 1ns.

(4) NIM TWSTFT system

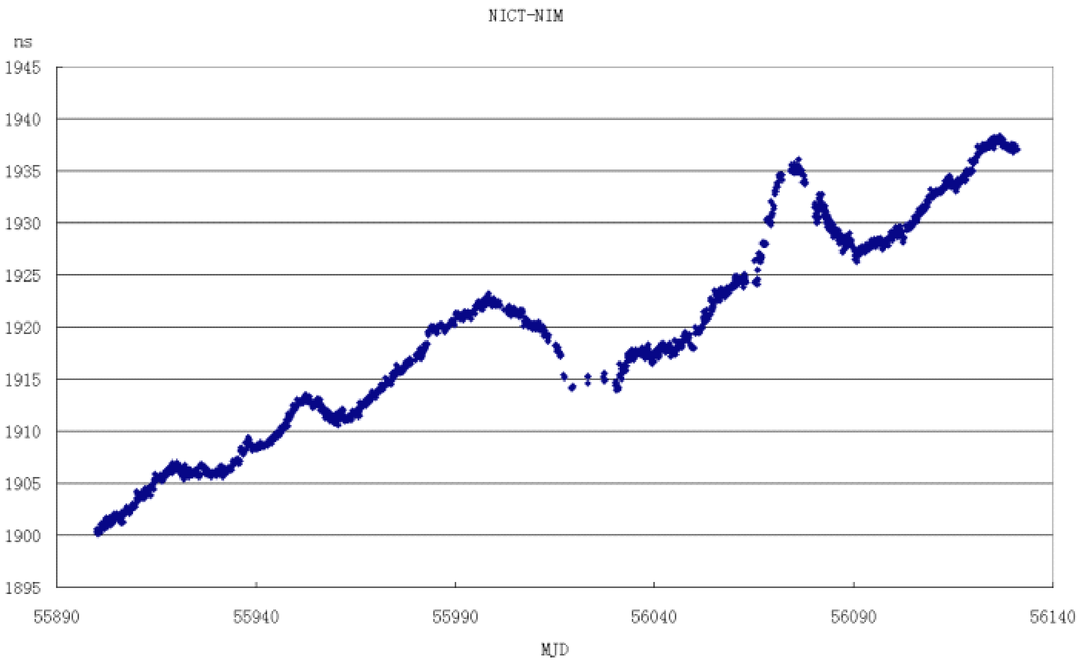
NIM established TWSTFT system at the Changping campus in the year 2008 and participated the Europe-Asia TWSTFT link. The test running UTC(NIM) is the reference of the NIM TWSTFT system. The following figures show the TWSTFT experimental results and frequency stability between NIM and PTB, NIM and TL, NIM and NICT, respectively. That data shows that the relative frequency stability at one day is better than 5×10^{-15}.



TWSTFT result between NIM and TL



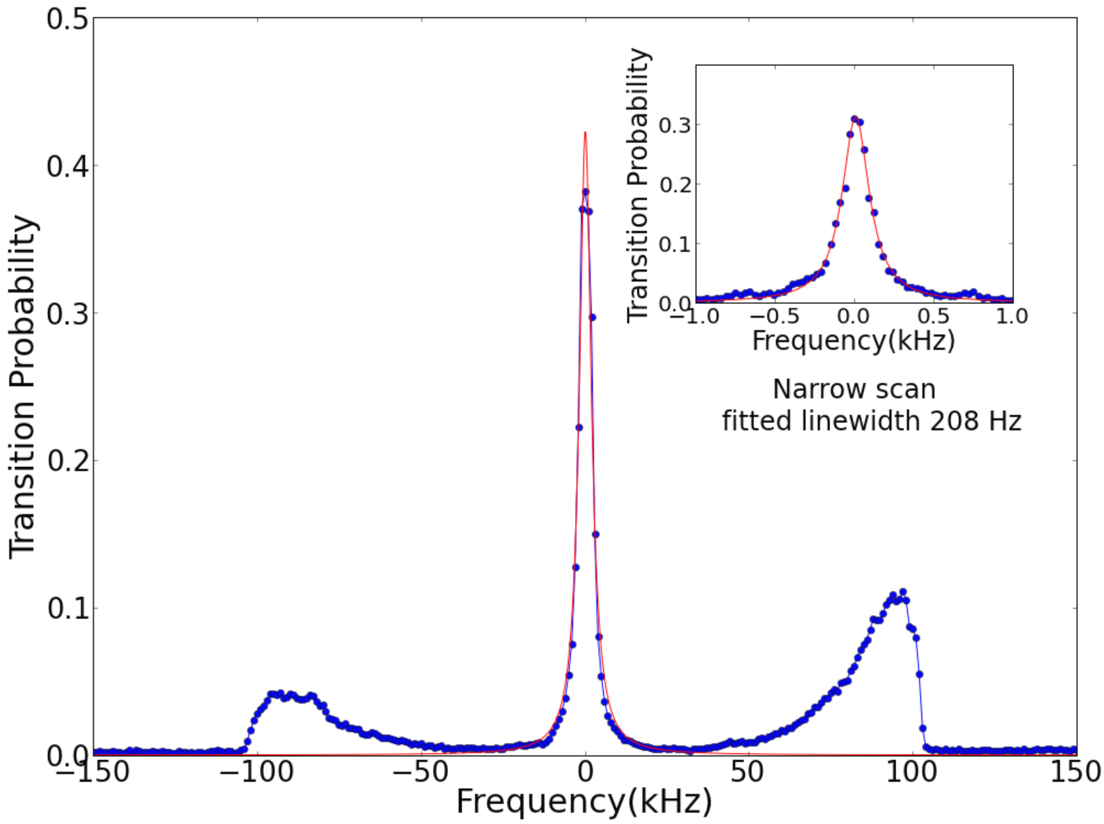
TWSTFT result between NIM and PTB



TWSTFT result between NIM and NICT

4. optical clock

A strontium lattice clock is being built in NIM. After two stages of laser cooling, more than 10^5 ^{88}Sr atoms are cooled down to ~3μK and loaded into a horizontal oriented optical lattice. The linewidth of the 698 nm clock laser has been narrowed down to ~5 Hz. A static magnetic field is applied to induce the forbidden $^1S_0$-$^3P_0$ transition in ^{88}Sr. In the following figure, the sideband-resolved spectrum shows the trapping frequency is about 100 kHz. With optimized clock laser intensity and magnetic field, the Rabi excitation linewidth could be narrowed down to ~ 100 Hz. We are now switching our experiments from ^{88}Sr to ^{87}Sr to build the lattice clock.



5. fiber comb

We demonstrate a home-made Er-doped fiber comb, consisting of an Er-doped fs fiber laser, a two-stage fiber amplifier, a highly nonlinear fiber and a single-beam f-2f interferometer. With optimized parameters, a carrier-envelope-offset frequency (f_0) with an S/N ratio of 40 dB at 300 kHz RBW is obtained in the Er-doped fiber comb. Moreover, the repetition rate (f_r) and the f_0 of the Er-doper fiber comb are precisely stabilized for more than six days. The residual fluctuation of the stabilized repetition frequency and carrier-envelop offset frequency are shown in the following figure, which have 1σ fluctuation of 0.63 mHz for f_r and 0.59 mHz for f_0. The home-made fiber combs in NIM are going to be used for the absolute frequency measurement of the optical clock, microwave generation, and the link between the Sr lattice clock and the Cs fountain clock.