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Definition and Realization of the System Time of COMPASS/BeiDou Navigation Satellite System

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Definition of BDT

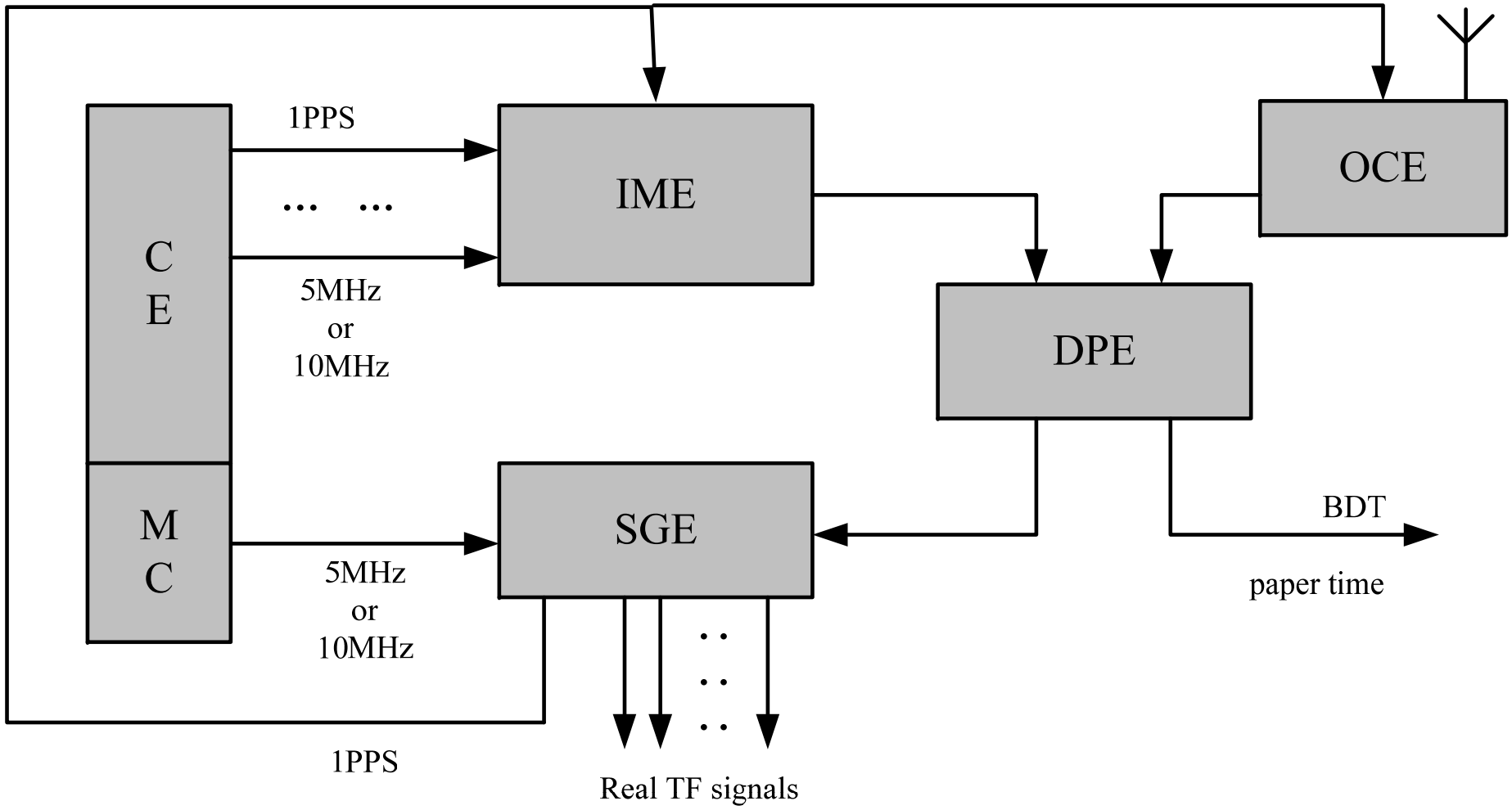
- The system time (BDT) is an internal , continuous navigation time scale, without leap second
- The basic unit is the SI second
- The largest unit used to stating BDT is one week, defined as 604,800 seconds
- BDT is counted with the week number (WN) and the second of week (SoW)
- The zero point is 1 January 2006（Sunday） UTC 00h00m00s

Realization of BDT

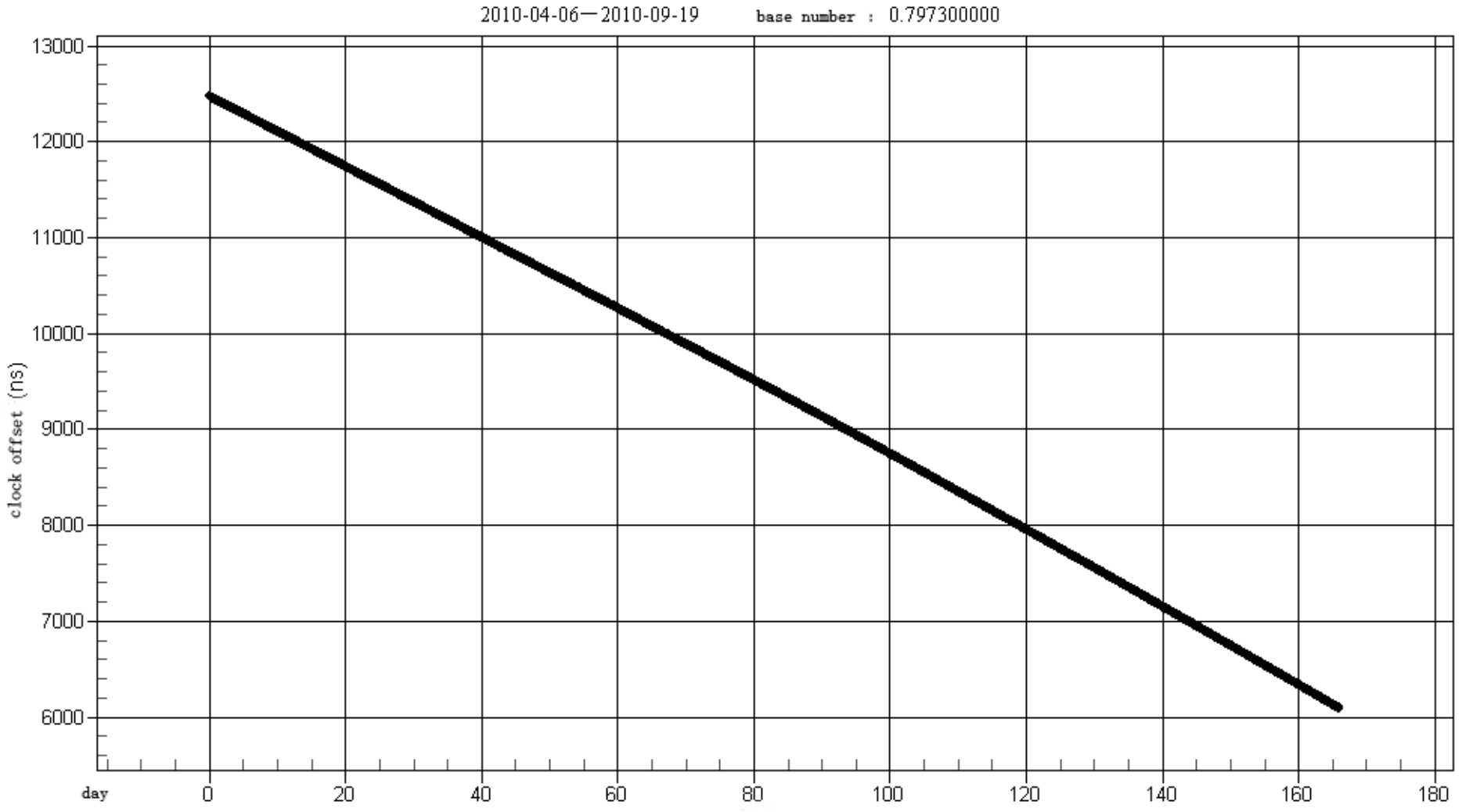
- **BDT is realized in a conception of composite clock**

- **BDT is maintained by a time and frequency system (TFS) located at the master control station (MCS)**

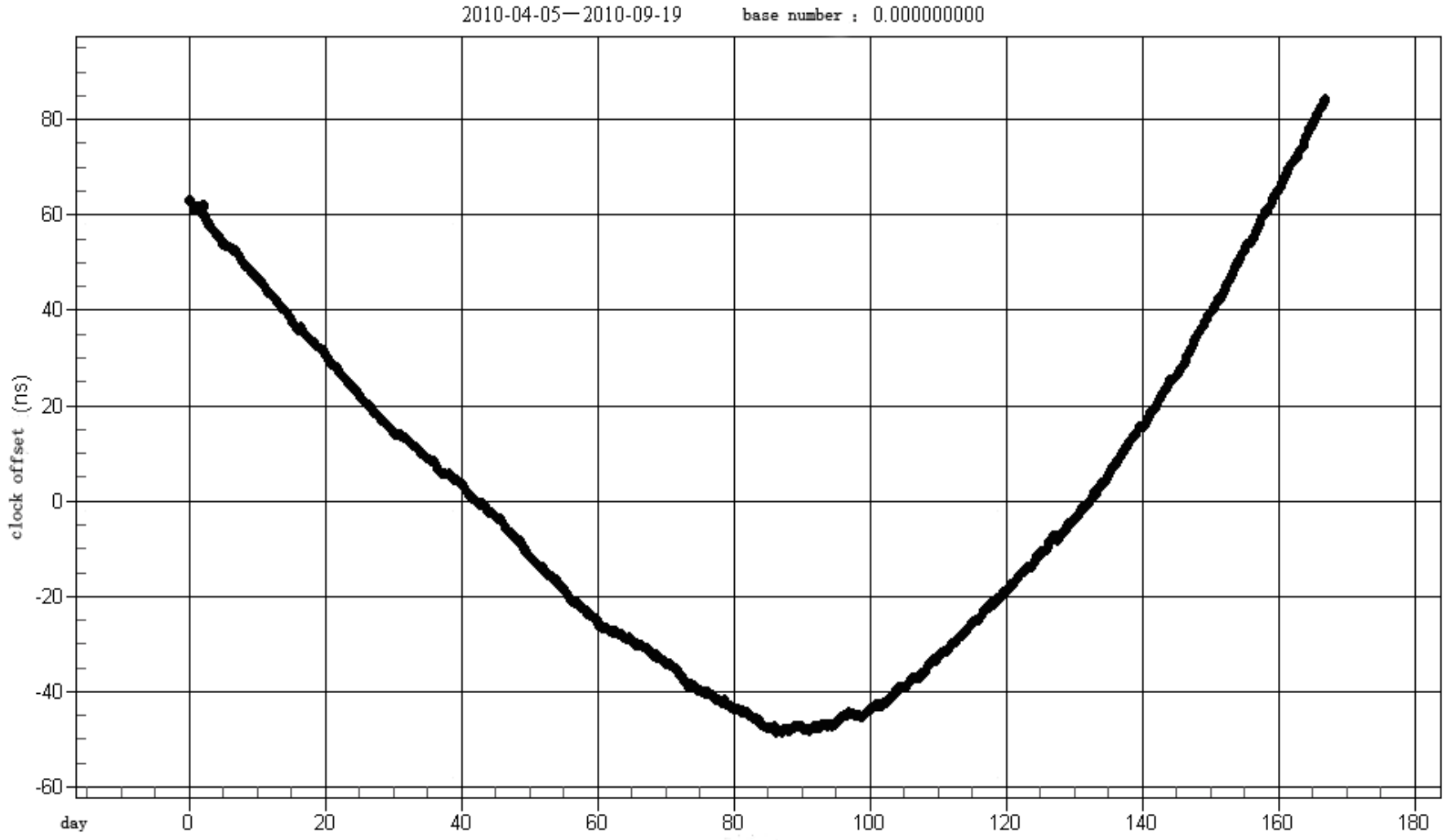
Structure of TFS



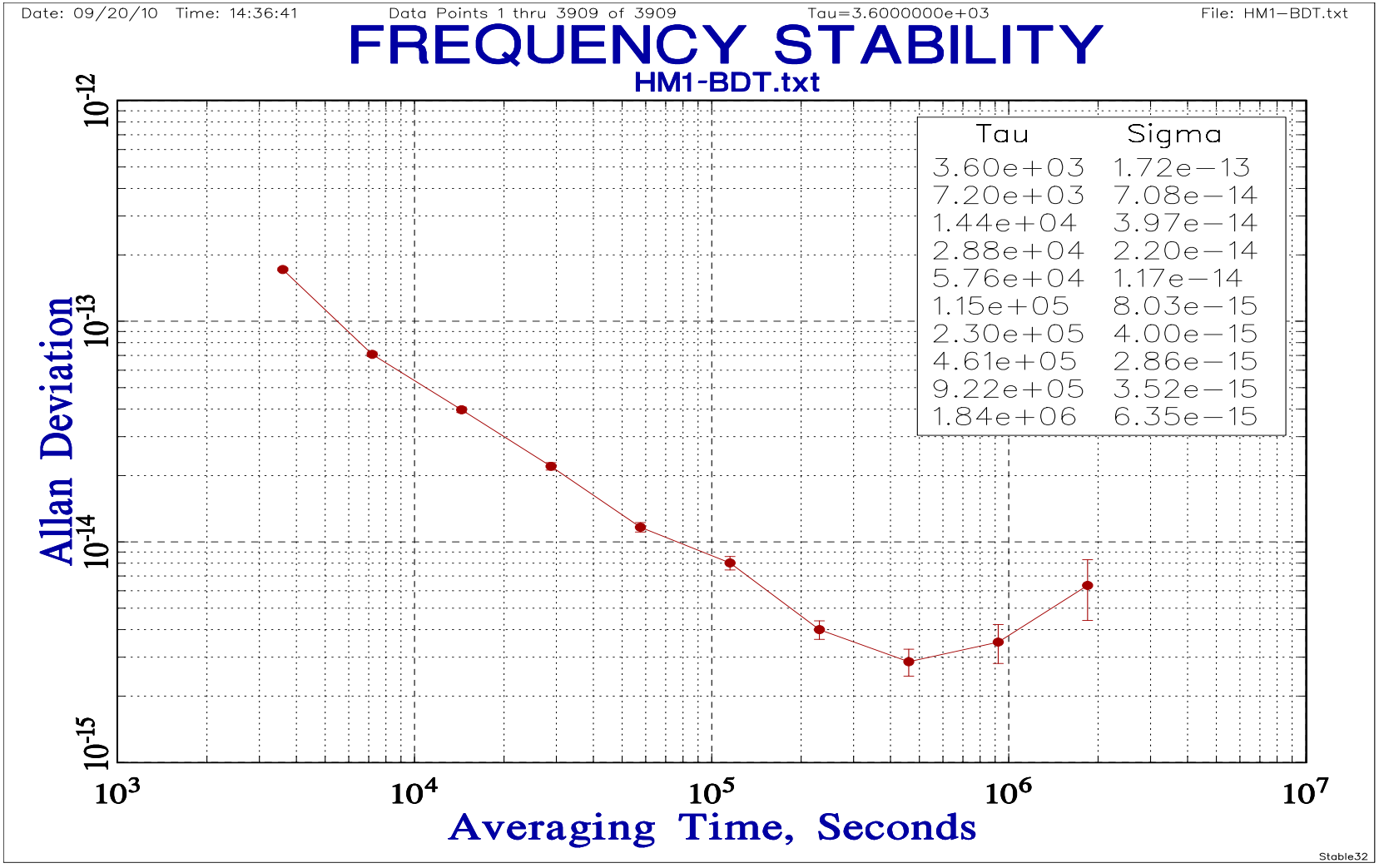
Time deviation of a hydrogen clock referred to BDT



The clock deviation deducted with the frequency offset



Frequency stability of the clock



Performance of TFS

Time accuracy : $< 2\times10^{-14}$

Long stability : $< 1\times10^{-14}$ /1 day

$< 6\times10^{-15}$ /5 days

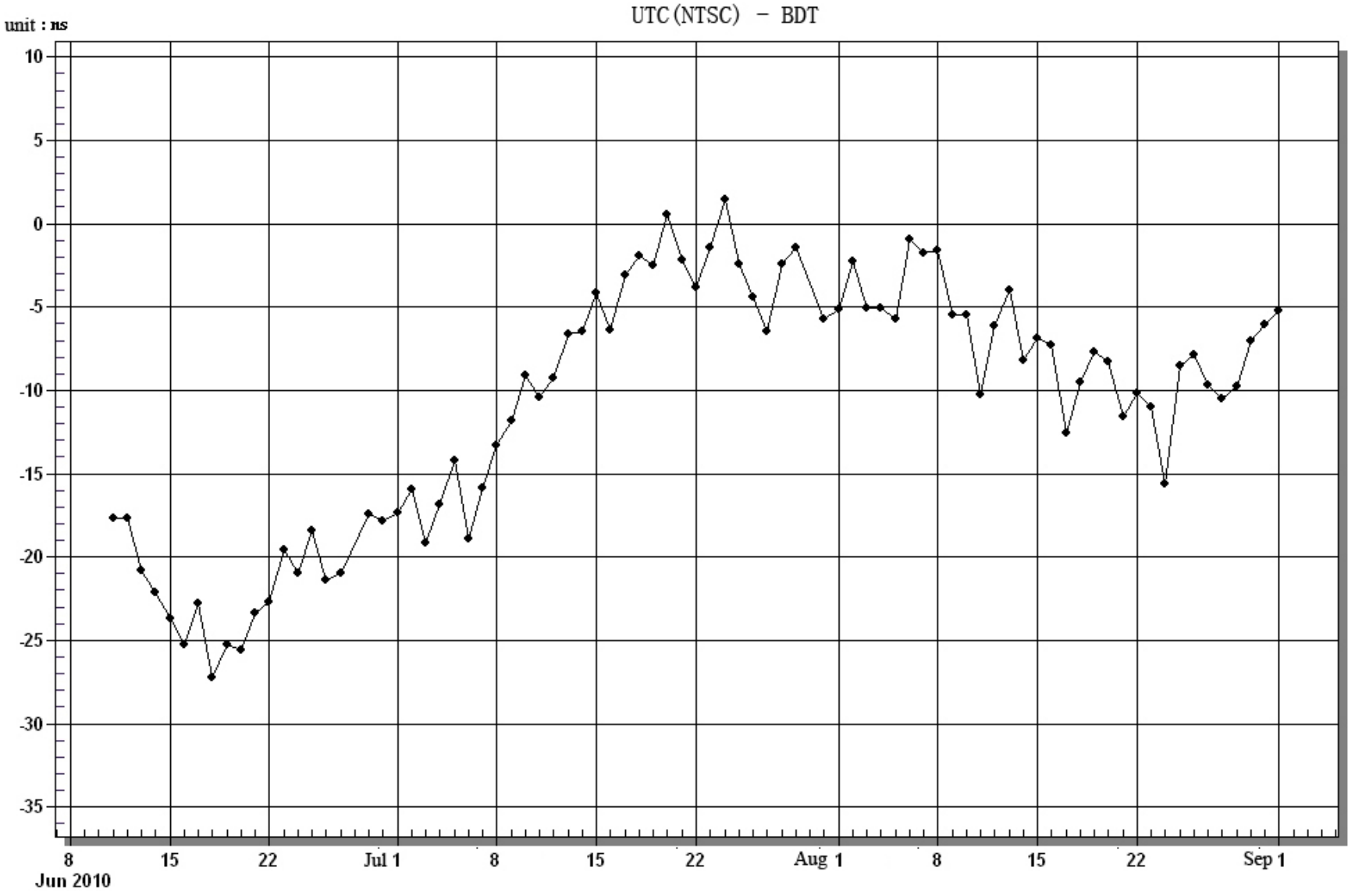
$< 5\times10^{-15}$ /10 days

$< 6\times10^{-15}$ /30days

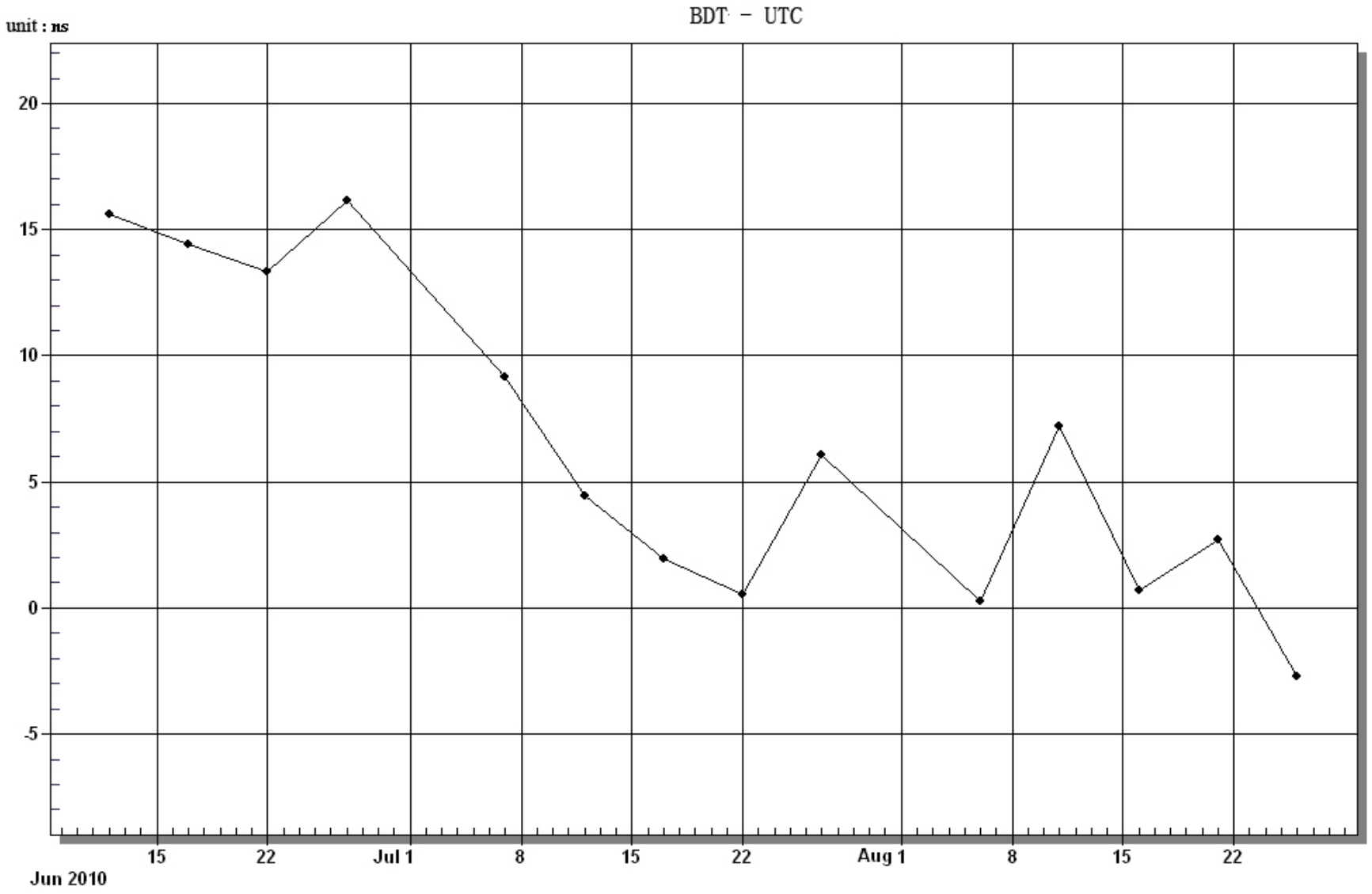
Time deviation: |BDT-UTC| < 100ns

(modulo one second)

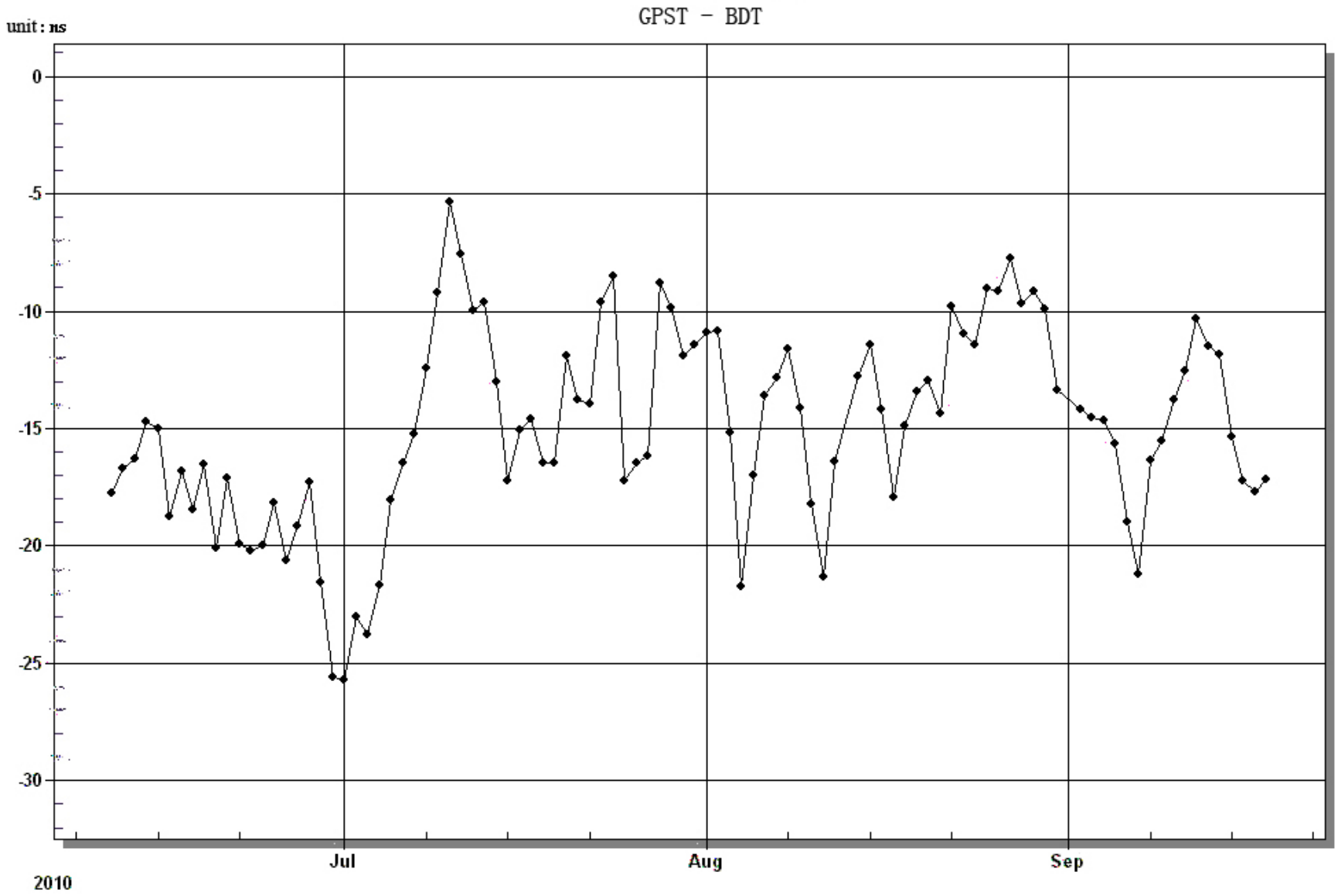
Time difference between BDT and UTC（NTSC）



Time offset of BDT with respect to UTC calculated Through UTC（NTSC）



The observed time difference between BDT and GPST



System Synchronizations

Satellite time synchronization

- ✓ Two-way time and frequency transfer is used between satellites and ground stations
- ✓ Time prediction :

$$\Delta T \equiv T - t = a_0 + a_1(t - t_0) + a_2(t - t_0)^2$$

a_0, a_1 , a_2 and t_0 are given in the NAV data

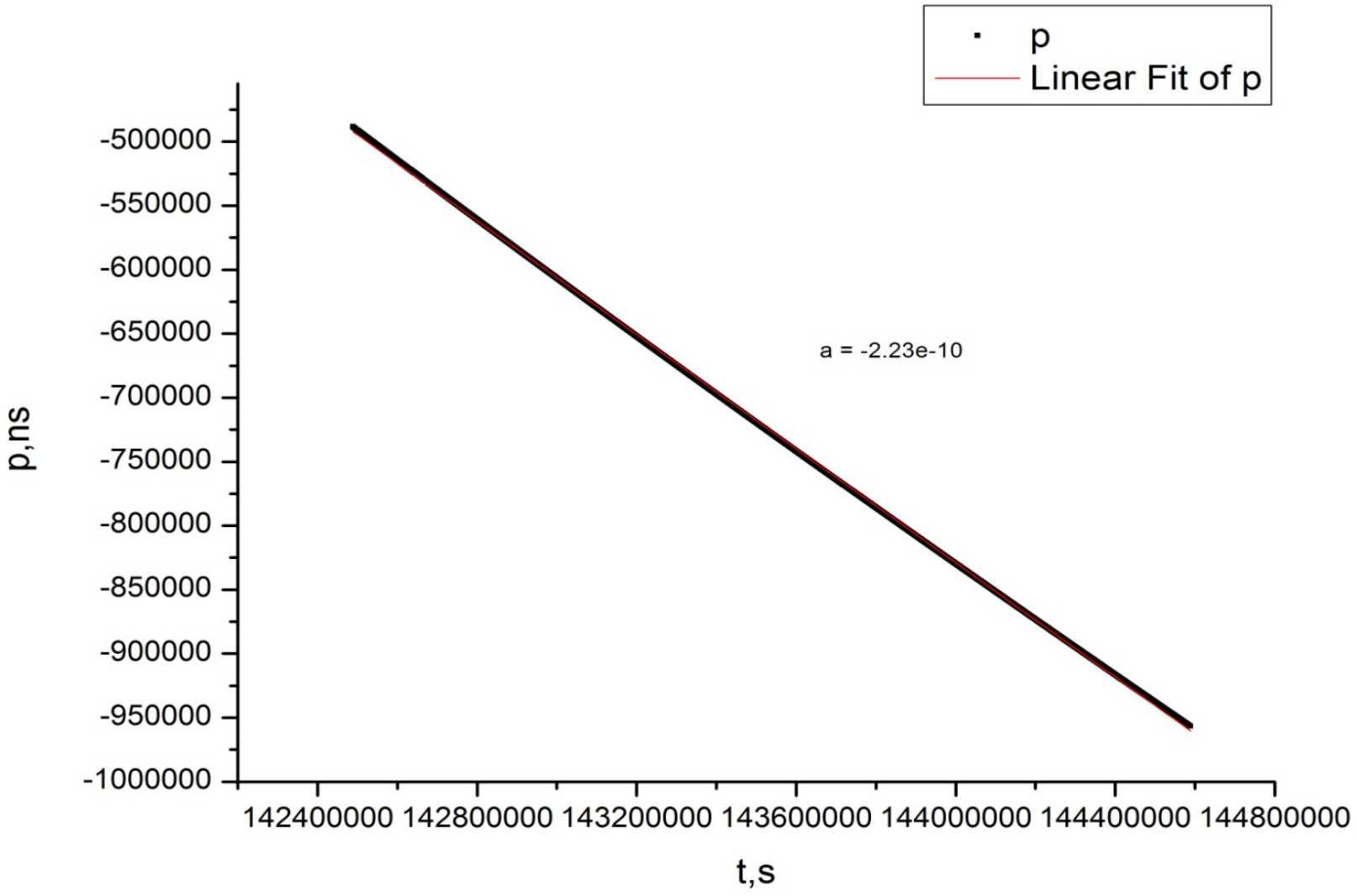
System Synchronizations

Station time synchronization

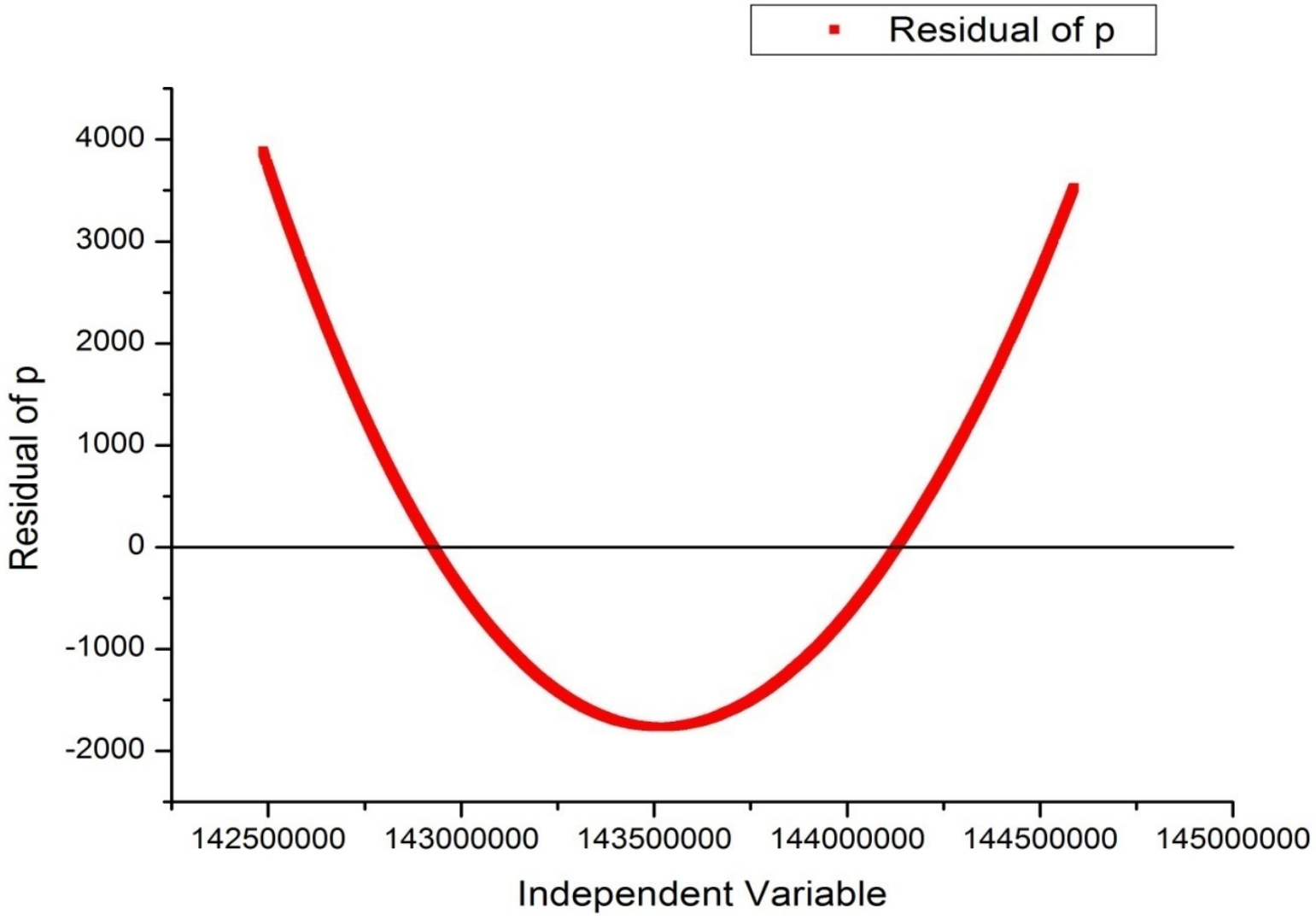
Two-way satellite time and frequency transfer (TWSTFT) are used between the master control station and the up-loading stations.

All the clock offsets are controlled within a limited range with the frequency and phase control.

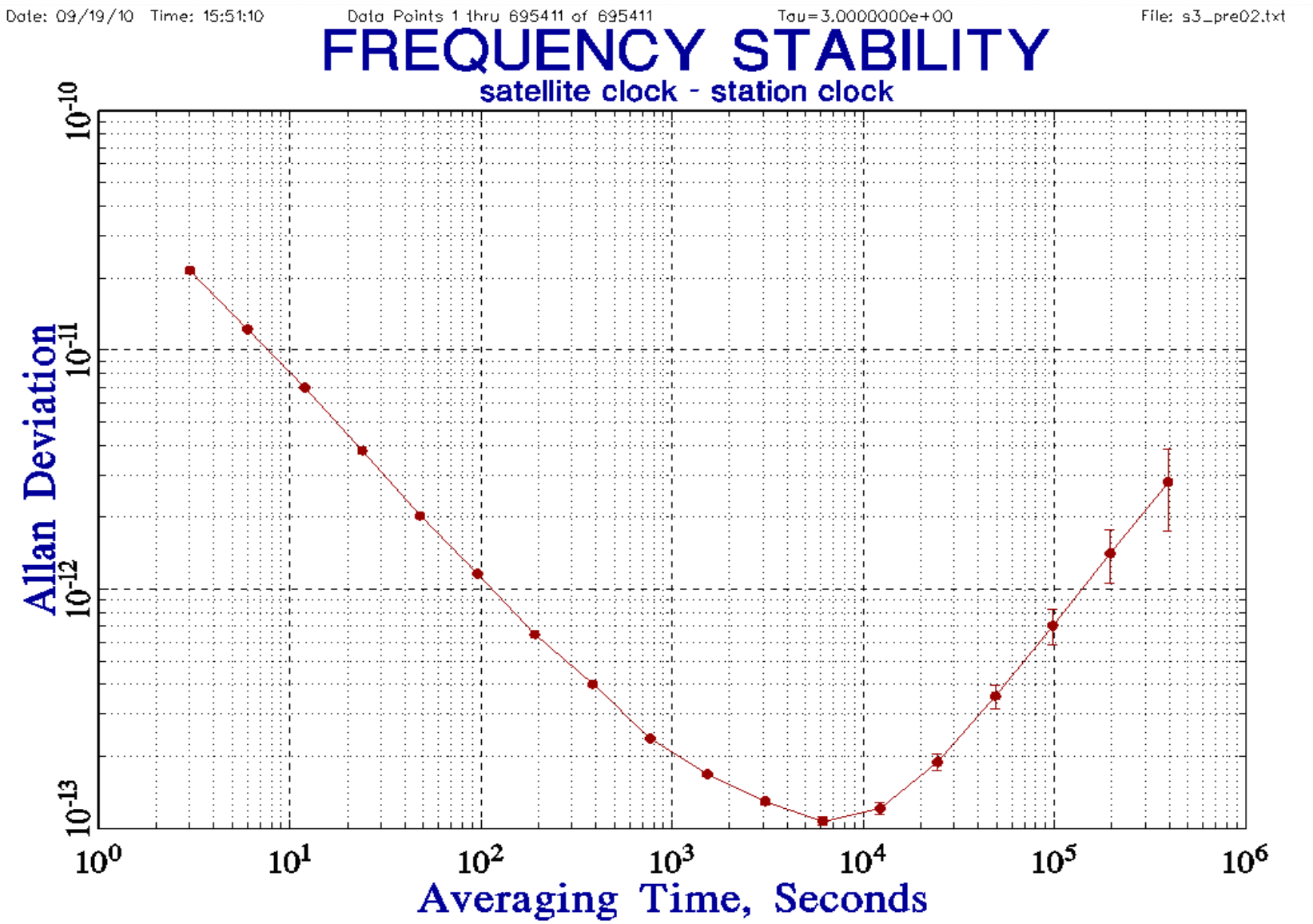
The observed deviation of a satellite clock with respect to BDT



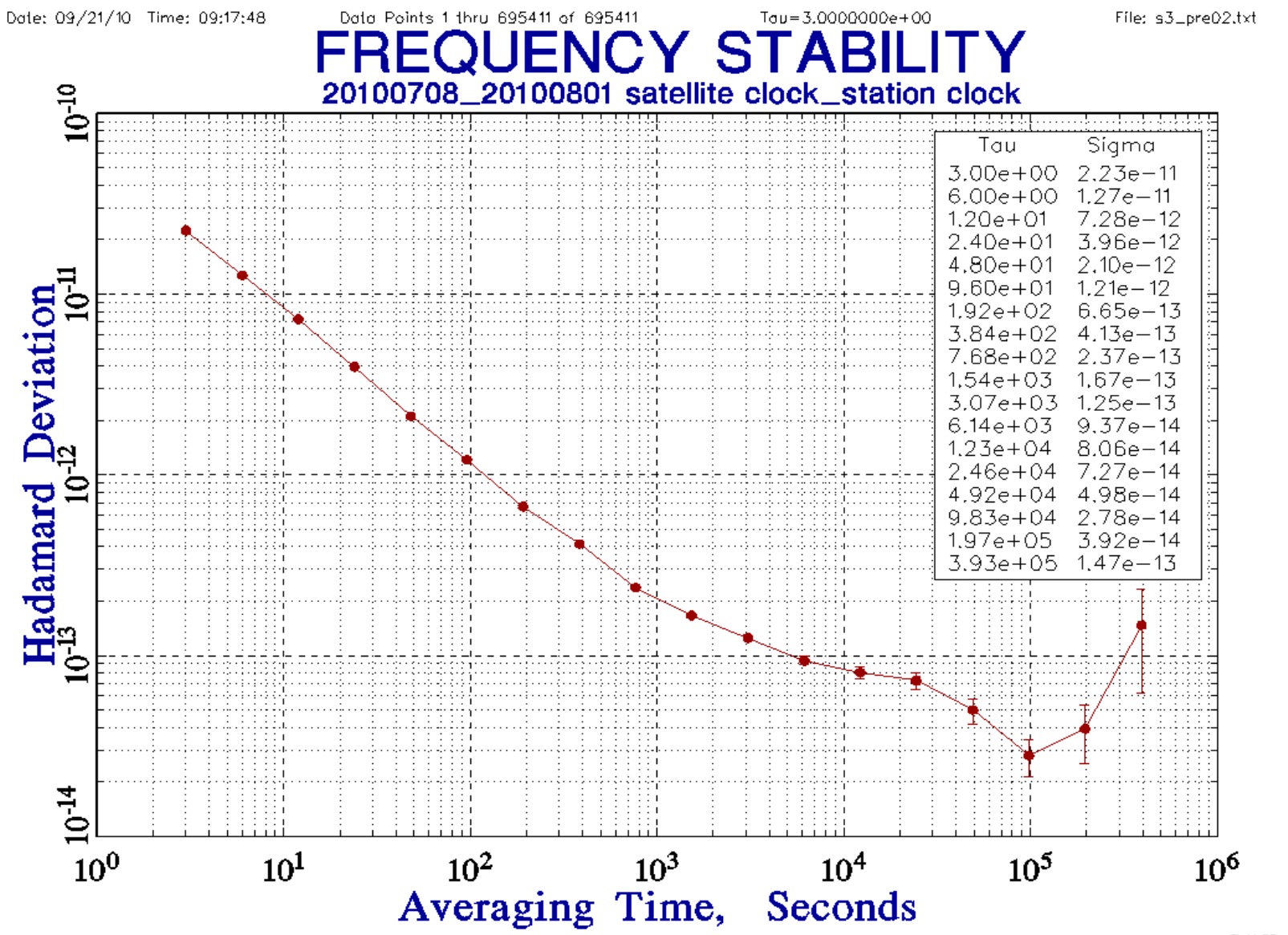
The deviation of the satellite clock taken off the mean clock rate



The observed Allan variance of the satellite clock



The Hadamard variance of the clock



BD Time services

- **RDSS one-way time service:**

  uncertainty :100ns → 50ns

  (referred to BDT)

- **RDSS two-way time service**

  uncertainty :20ns → 10ns

- **RNSS one-way time service**

  uncertainty : 50ns

Improvements and developments

- ✓ **Accurate relation of BDT to UTC**
  - TWSTFT
  - Fiber time and frequency transfer
- ✓ **Long stability of BDT**
  - the time keeping clocks
  - the hardware and software of TFS

Improvements and developments

- **GNSS time monitor system**

  observe the time differences

  calculate the system time offset

  broadcast the parameters in BD NAV data.


Thanks
谢谢!