Precise Common-View Time and Frequency Transfer (PCVTFT) based on BDS GEO Satellite

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Content

1 Problem and its solution :PCVTFT

GPS common-view time transfer with code (CV) and Two-Way Satellite Time and Frequency Transfer (TWSTFT) are the main techniques for generating UTC in recent years in BIPM .

Common-view time transfer with carrier phase observation has been studied since serval years ago, however the ambiguity problem is still not well resolved.

BDS have 5 GEO satellites. Based on the character, method of Precise Common-view Time and Frequency Transfer (PCVTFT) based on BDS GEO satellite is presented. PCVTFT improves the traditional GPS CV time transfer, it use BDS GEO satellite and carrier phase observation, and use the iGMAS or IGS orbit products, to get high accuracy.

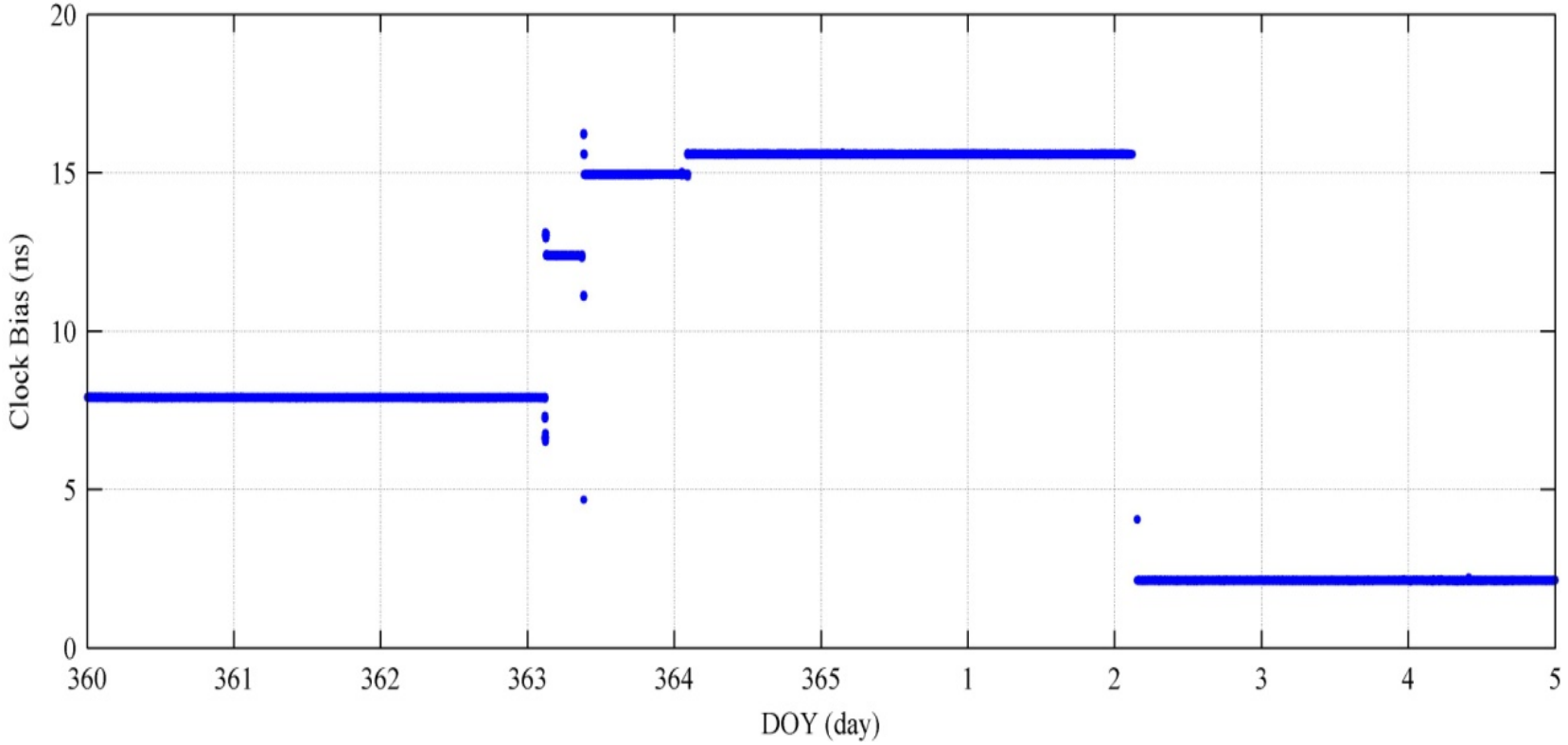
The main advantage of PCVTFT is that two stations can see the GEO satellite all the time, so there is only one ambiguity in very long time (e.g. one year).in the contrast, there are usually two ambiguities each day for MEO satellites.

Frequency transfer is not influenced by ambiguity , but is more convenient with GEO satellite.

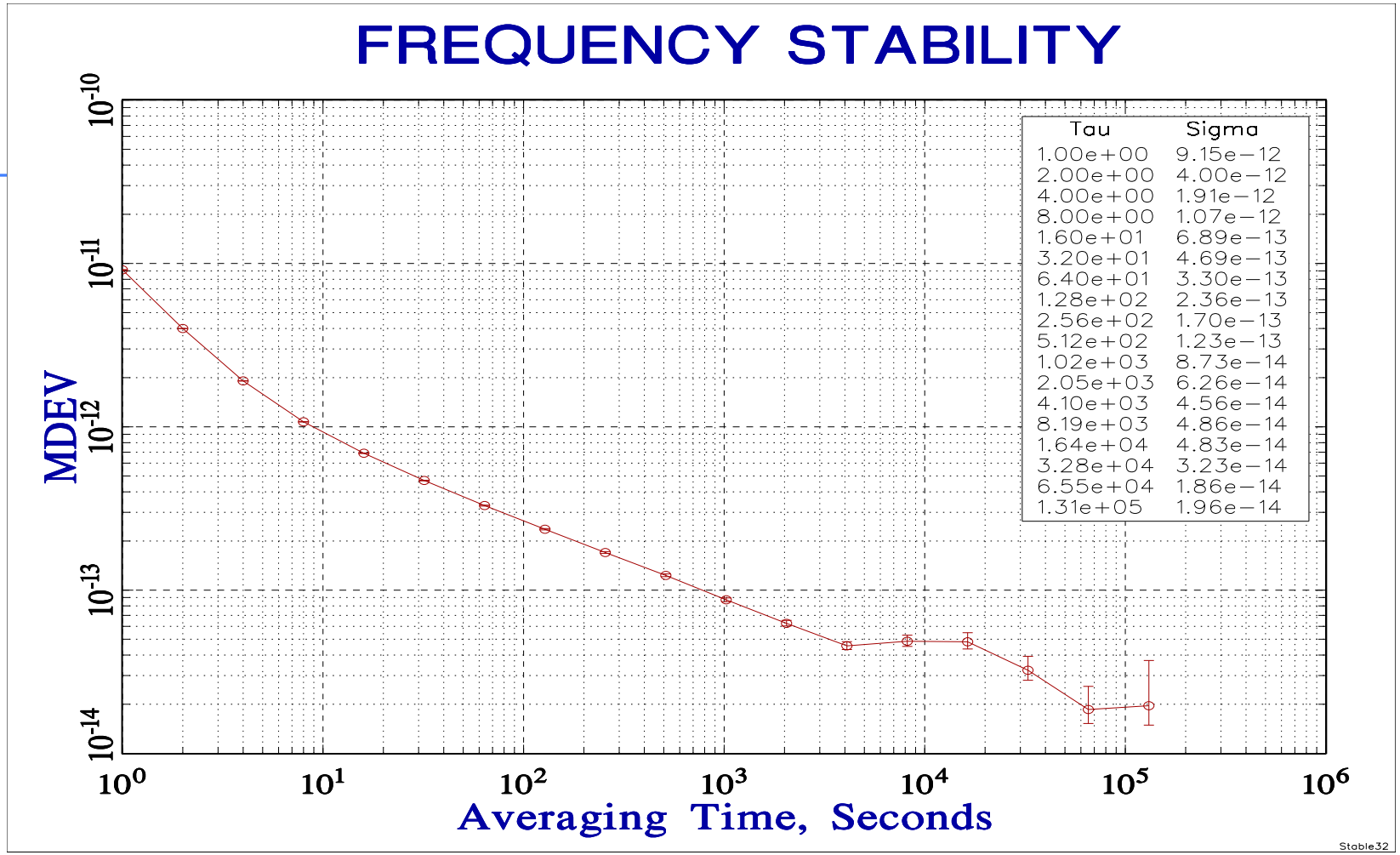
2 Zero-baseline Experiment

- Both receivers are Trimble Net R9, they are connected to signal of UTC(NTSC), the master clock of which is a H maser.
- two receivers with one common antenna, the sampling interval is 1s.
- observation period: Dec 26, 2015. to Jan 4, 2016

Clock difference of zero-baseline



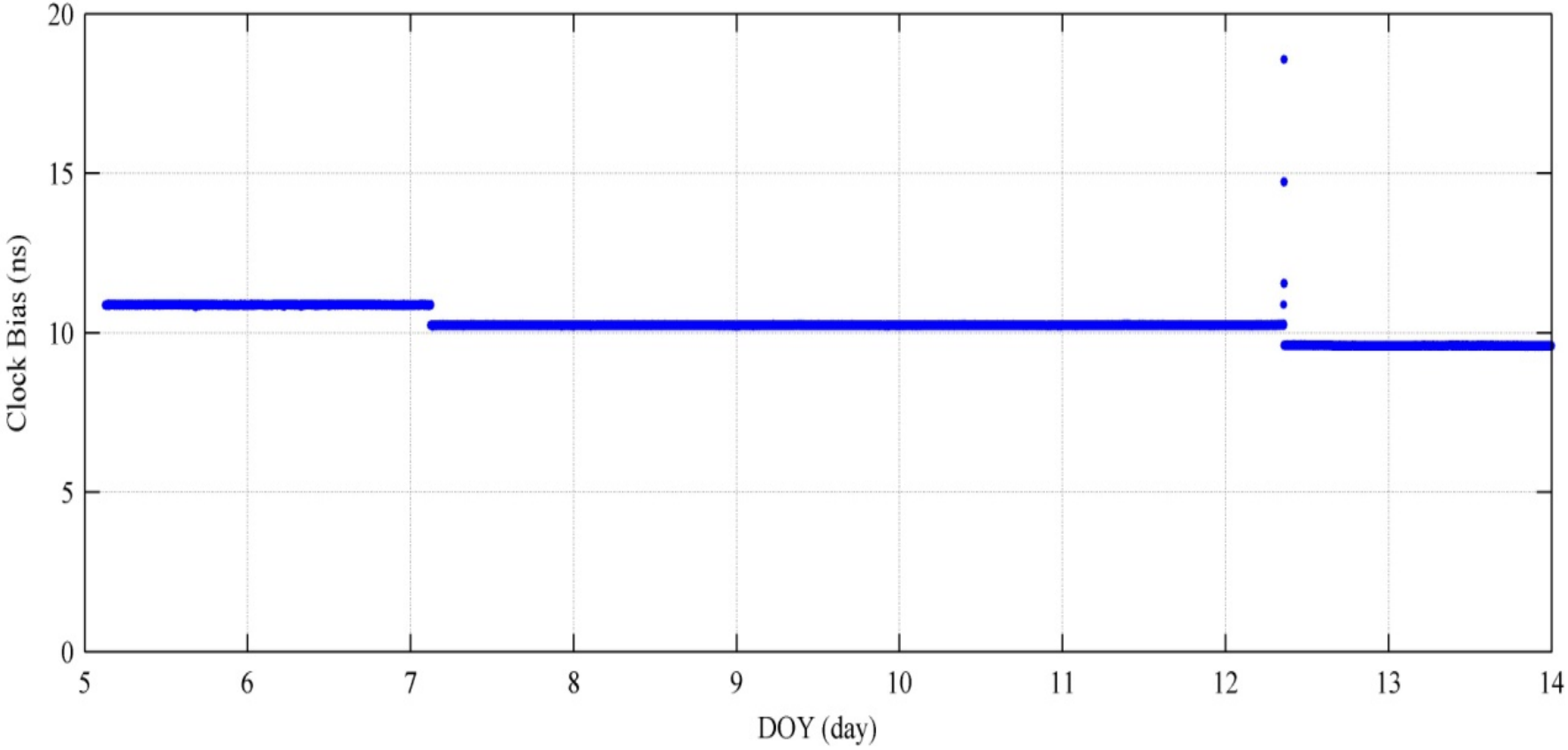
We only process the carrier phase data of frequency B1 of BDS G3 satellite(110°E) . The clock difference is calculated by PCVTFT.



The Allan variance of PCVTFT is obtained, it is $1.96*10^{-14}$, ($\tau=1.3*10^{+5}$s), it reflect the stability of two clocks and the link

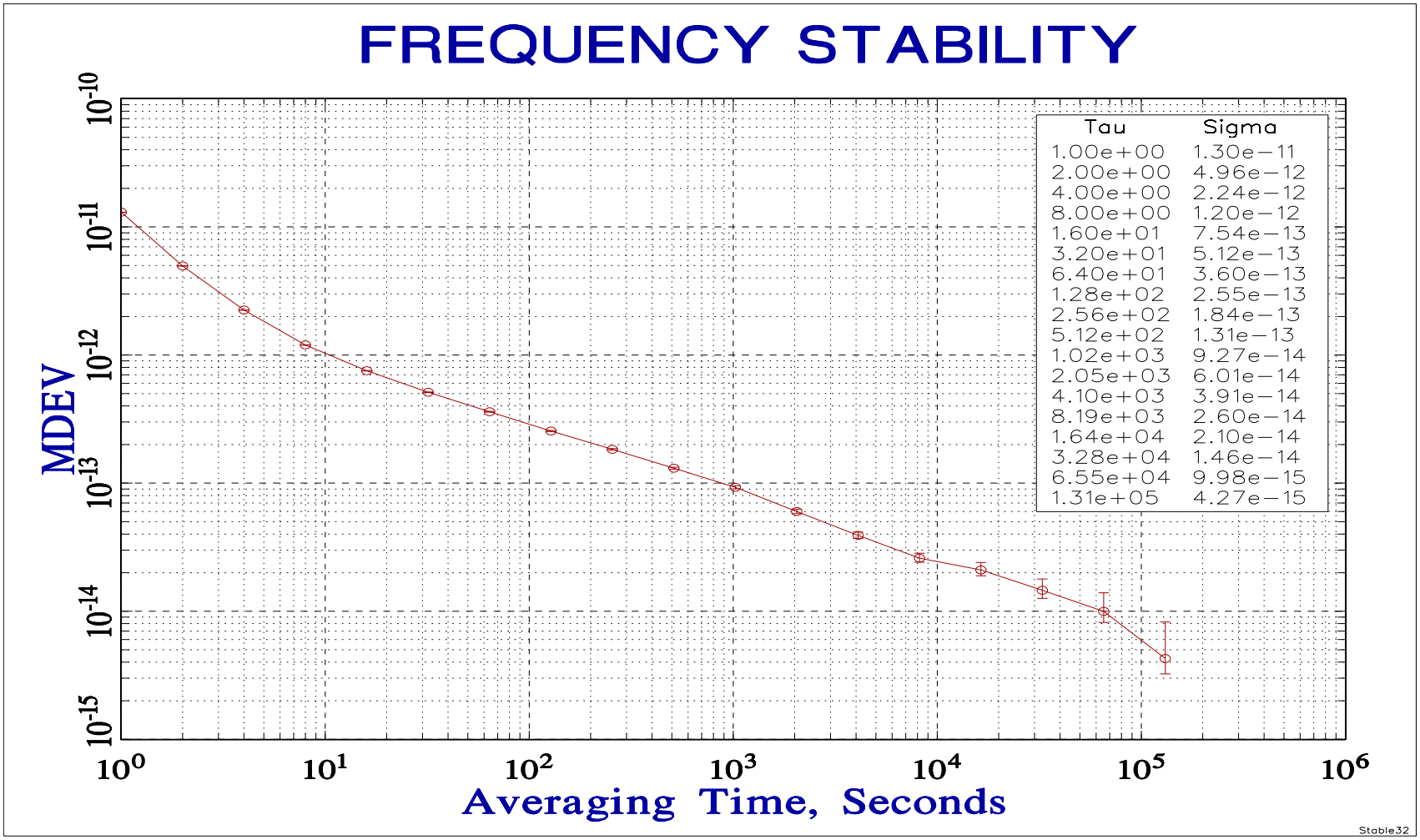
3 Ultra-short baseline Experiment

- **Baseline is shorter than 5m**
- Both the receivers are Trimble Net R9, they are connected to signal of UTC(NTSC), the master clock of which is a H maser.
- **Each receiver with its own antenna, the sampling interval is 1s.**
- **Observation period： DOY 005/2016 to DOY 013/2016**



We only process the carrier phase data of frequency B1 of BDS G3 satellite(110°E) . The clock difference is calculated by PCVTFT.

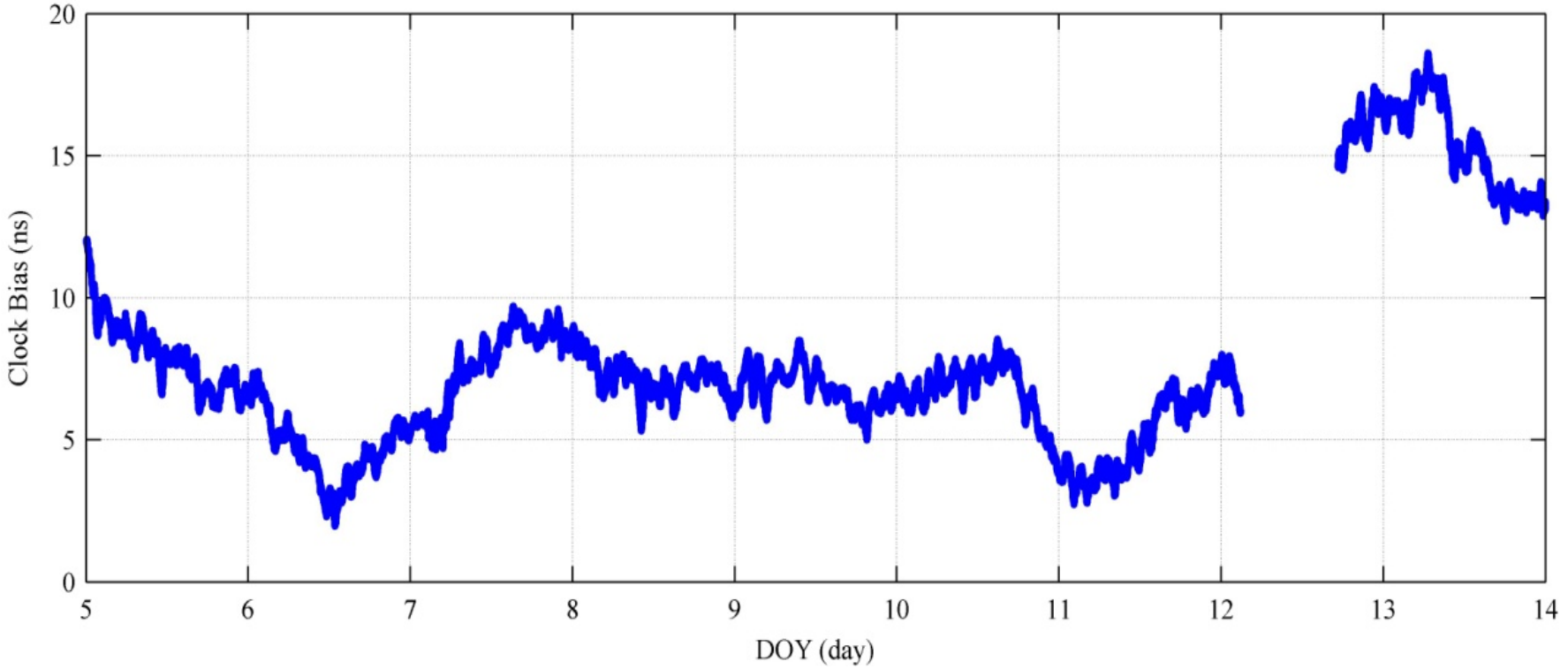
Experiment time: 2016.1.5(DOY 5) to 2016.1.13(DOY 13)



The Allan variance of PCVTFT is obtained, it is $4.27*10^{-15}$, ($\tau=1.3*10^{+5}$), it reflect the stability of two clocks and the link

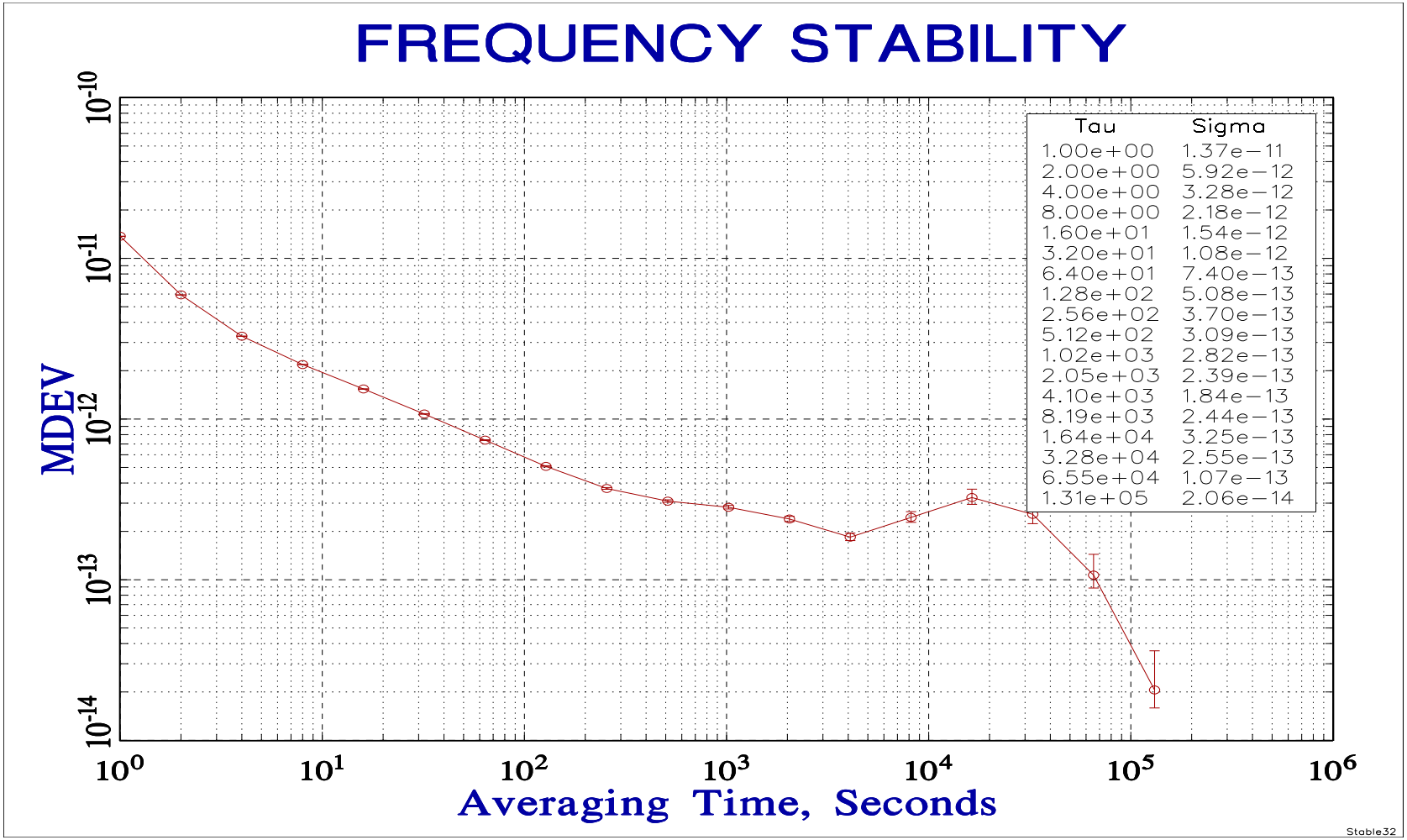
4 Short baseline (30km) experiment between Xi’an and Lintong

- 30km baseline between Xi’an and Lintong
- Both the receivers are Trimble Net R9 BDS/GPS receiver, **Lintong receiver is connected to the signal of the master clock of UTC(NTSC), and Xi’an receiver is connected to Cs atomic clock.**
- the sampling interval is 1s.
- **experiment time：2016.1.5(DOY 5) to 2016.1.13(DOY 13)**



We only process the carrier phase data of frequency B1 of BDS G3 satellite(110°E) . **Based on the iGMAS orbit product, the clock difference (Xi'an – Lintong) is calculated by PCVTFT. The big data of system error is only deducted simply.**

Experiment time: 2016.1.5(DOY 5) to 2016.1.13(DOY 13)

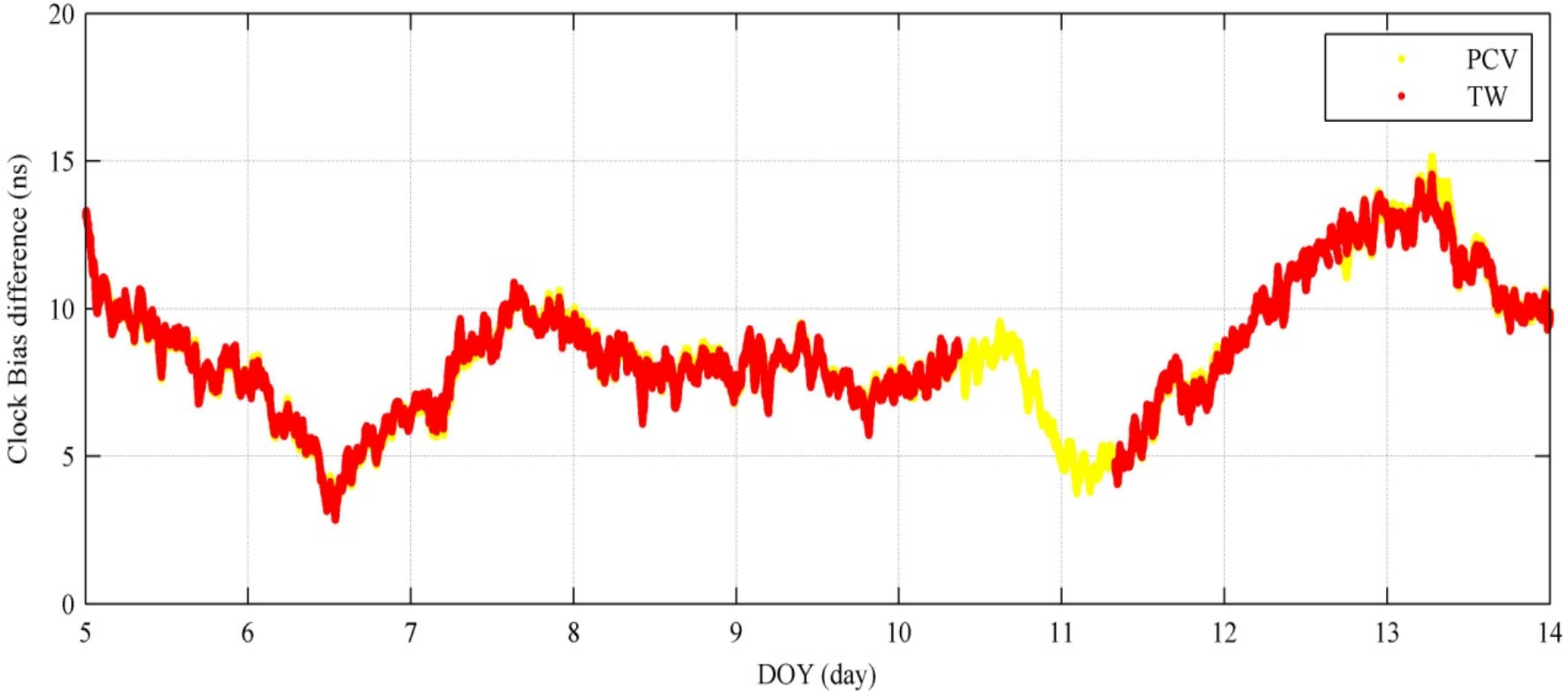


The Allan variance of PCVTFT is obtained, it is $2.06*10^{-14}$, ($\tau=1.3*10^{+5}$s) it reflect the stability of two clocks and the link

Two way fiber time transfer(TWFTT) is also carried on at the same time, for comparing and verifying PCVTFT：

- 30km baseline between Xi'an and Lintong
- fiber is directly connected from Lintong to Xi'an, and there is no router.
- experiment time：2016.1.5(DOY 5) to 2016.1.13(DOY 13)

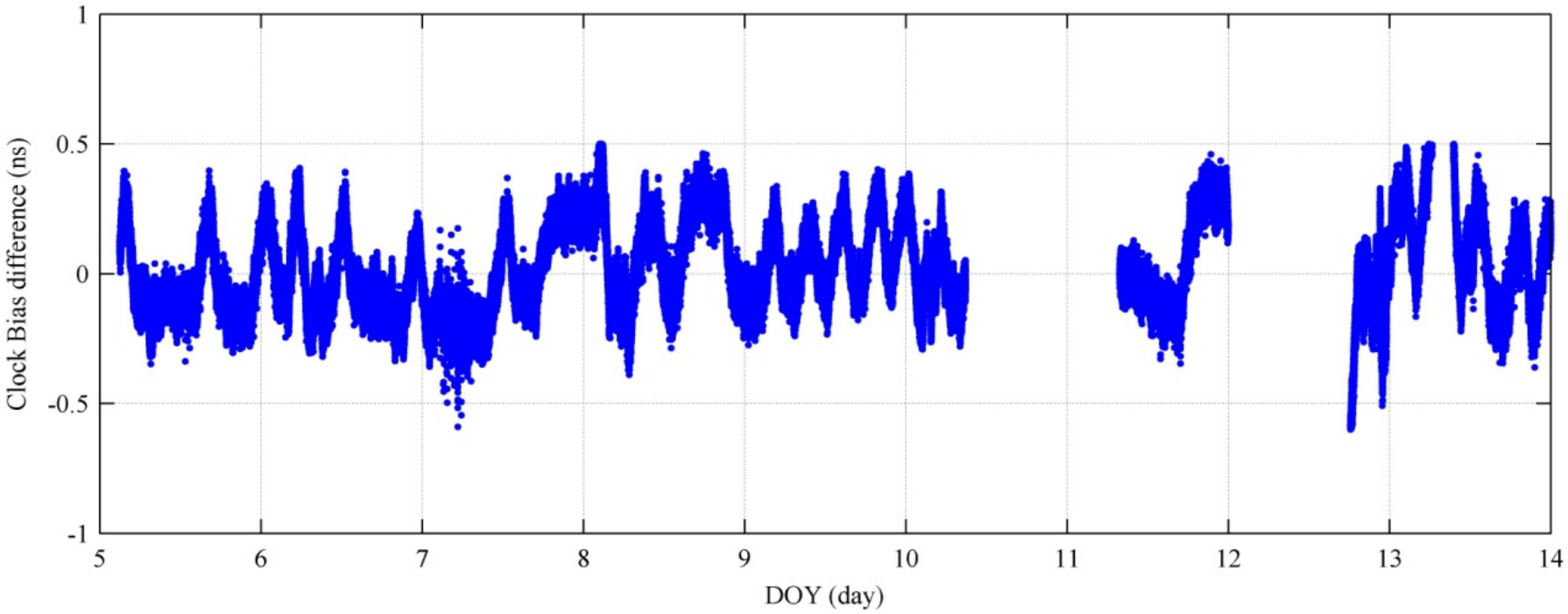
Two way fiber time transfer has better accuracy and stability for the symmetry link and avoiding many influence in space when the baseline is short. (of course, the router problem is not solved, so can't transfer time in remote distance)



The clock difference (Xi'an – Lintong) from PCVTFT, and that from TWFTT (fiber), are in one figure.

Yellow one is PCVTFT result, red one is TWFTT result, and They are very consistent.

Experiment time: 2016.1.5(DOY 5) to 2016.1.13(DOY 13)



The difference between PCVTFT result and TWFTT result, it is better than 0.2ns

5 Long baseline (2000km) experiment between Xi’an and Changchun

Observation：

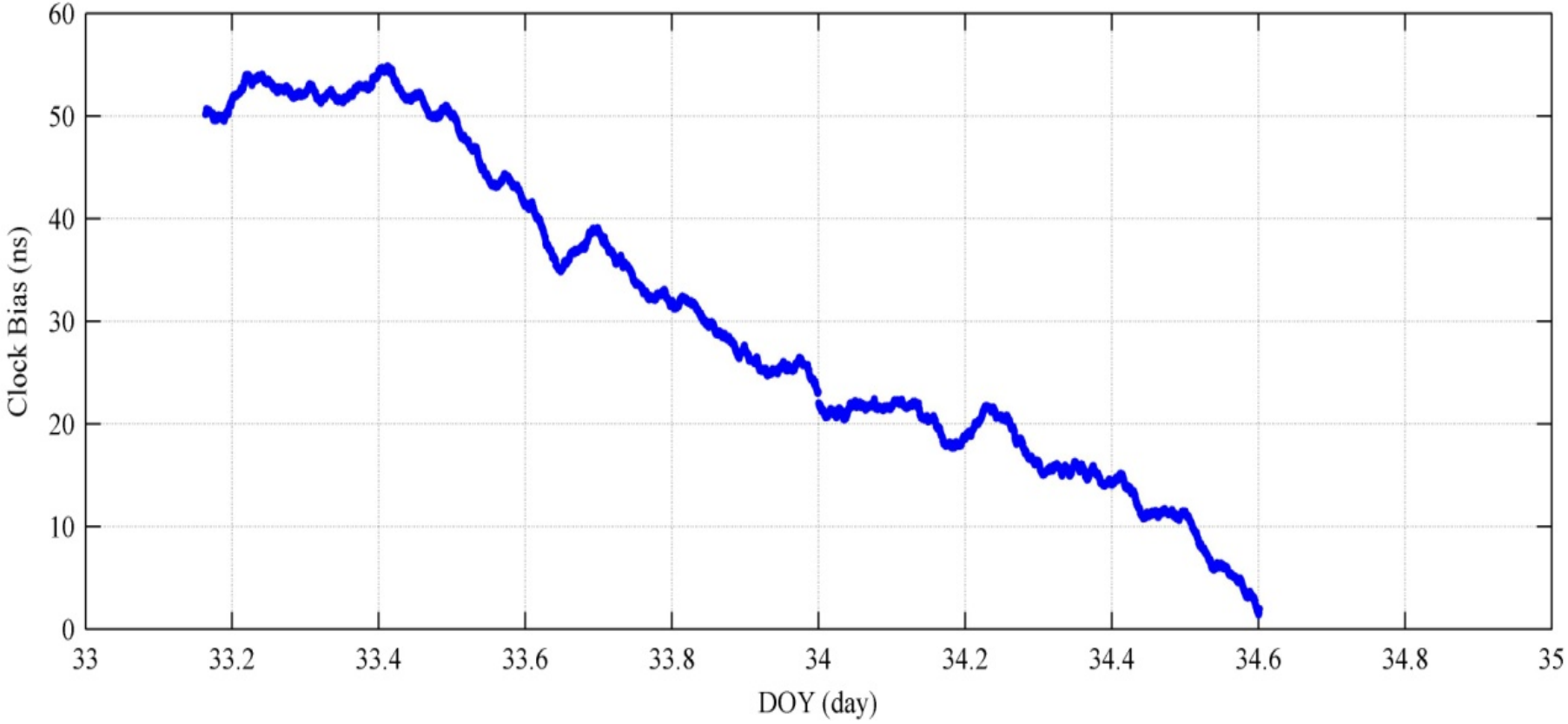
0）Baseline between Xi’an and Changchun is about 2000km

1）Both the receivers are Trimble Net R9 BDS/GPS receiver, Changchun receiver is connected to Cs atomic clock, and Xi’an receiver is also connected to another Cs atomic clock.

2）the sampling period in Xi’an is 1s, and that in Changchun is 30s

3）experiment time：2016.2.2(DOY 33) to 2016.2.3(DOY 34)

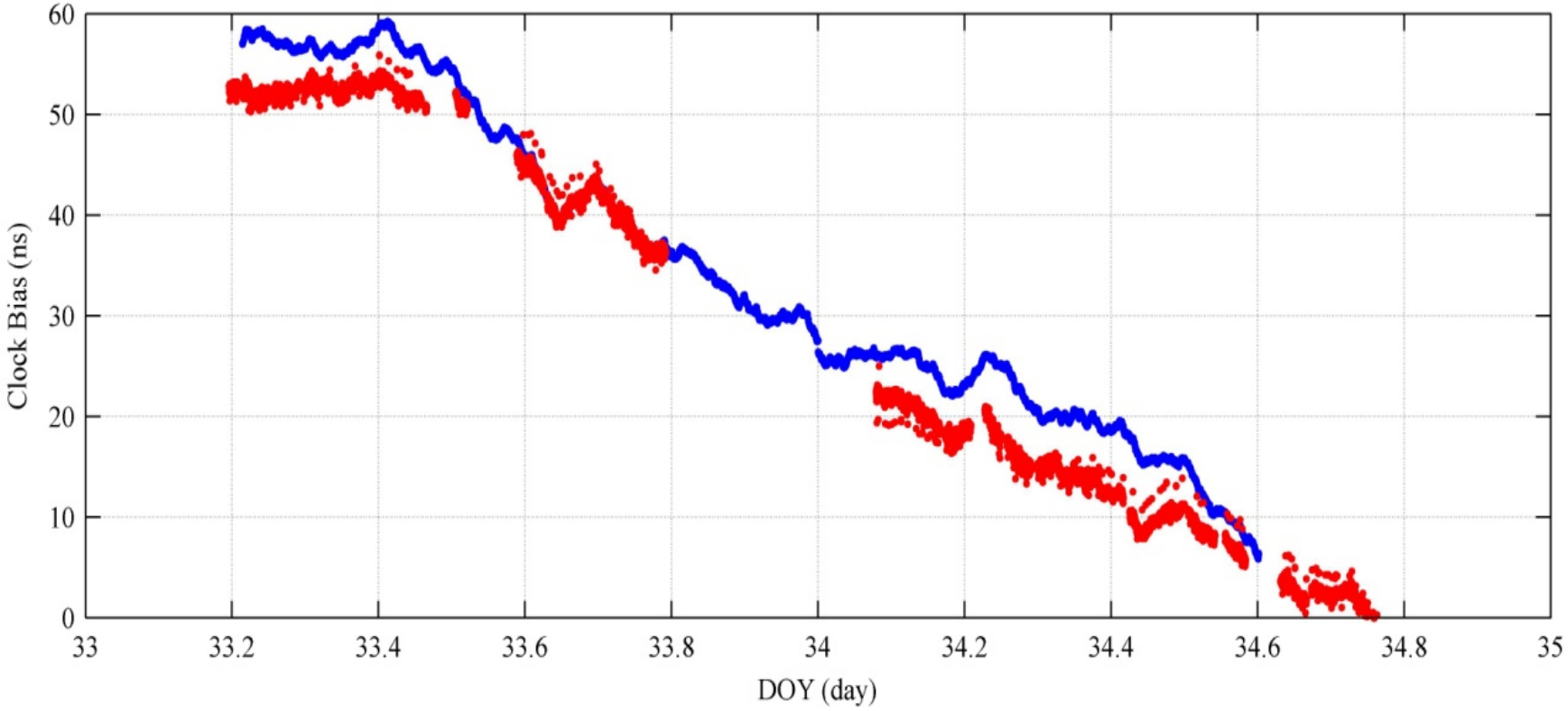
Two way satellite time and frequency transfer(TWSTFT) is also carried on at the same time, for comparing and verifying PCVTFT， and it use the GEO communication satellite. PCVFTF and TWSTFT connected to the common Cs atomic clock in Xi’an, and it’s similar in Changchun.



We only process the carrier phase data of frequency B1 of BDS G3 satellite(110°E) .

Based on the iGMAS orbit product, the clock difference (Changchun - Xi'an) is calculated by PCVTFT. The big data of system error is only deducted simply.

Experiment time: 2016.2.2(DOY 33) to 2016.2.3(DOY 34)



The clock difference (Changchun - Xi'an) from PCVTFT, and that from TWSTFT, are in one figure.

Blue one is PCVTFT result, red one is TWSTFT result, and there is small difference between them, about several ns.

Experiment time: 2016.2.2(DOY 33) to 2016.2.3(DOY 34)

Analysis：

1）the experiment was just ended last week.

2）the troposphere is not modified;

3）the solid tide is also not modified;

4）the variation with one day period in TWSTFT maybe is also in the result.

6 Summary

1）In zero-baseline and Ultra-short baseline case, the Allan variance of PCVTFT is better than $1.96*10^{-14}$, (τ=$1.3*10^{+5}$s, about 1 day).

2）In short-baseline (30km), the Allan variance of PCVTFT is $2.06*10^{-14}$, (τ=$1.3*10^{+5}$, about 1 day),) . And the difference between PCVTFT and TWFTT (fiber) is better than 0.2ns.

3）In long-baseline (2000km), PCVTFT and TWSTFT are identical basically , and there is small difference between them, about several ns. The experiment was ended last week, the troposphere and solid tide are not modified. So, it's only a preliminary result.

In general, PCVTFT use the BDS character--- GEO satellite, two stations can see the GEO all the time, so there is only one ambiguity in very long time (e.g. 1 year).

PCVTFT can get high precision and accuracy.

In addition, it's a independent technique for only using the iGMAS or IGS product, so it is easy to be applied in time science field.

7 Future work

1）modify troposphere delay and solid tide, modify ionosphere delay with two frequency, PCVTFT experiment in long baseline should be carried on for more time;

2）the first ambiguity should be solved with other technique.

3）how to combine several frequency and several GEO satellites?
（at least , the influence of maneuver should be solved)

4）the relative receiver delay should be measured in order to get high accuracy in time transfer.

Thank you !

Happy Spring Festival!