SOURCES OF INSTABILITIES IN TWO-WAY TIME TRANSFER

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Introduction

- TWSTFT is an important component in the international system for time and frequency transfer
- TWSTFT has shown one day stabilities at the 100 ps level
- Need to identify sources of instabilities at this level in order to make improvements
- Is 10 ps at one day possible?

Environmental Sensitivities

- Almost no information is available from manufacturers on the sensitivity of group delay to environmental parameters.
- Have measured sensitivities on equipment we have had access to.
- This is not intended to be a comprehensive survey.

Environmental Sensitivities

Table 1 Temperature Coefficients of Group Delay
(+5 to +45°C at 40%RH)

Modules

Equipment	Temp. Co. (ps/°C)	Comments
High Power Amplifier	-5 (±2)	Tx path
LNAs and filters	-5 to +2 (±2)	Rx path
Mixer plus two isolators	-18 (±2)	Tx or Rx path
Up-Converters	-4 to +1 (±2)	Tx path
Down-Converters	+2 to +10 (±2)	Rx path
Modem	-20 (±2)	Tx + Rx path

Environmental Sensitivities

Table 2 Temperature Coefficients of Group Delay
(nominally 0 to +50°C)

Systems

Equipment	Temp. Co. (ps/°C)	Comments
All equipment in hub (system A)	+5 (±5)	(Tx-Rx)/2
All equipment in hub (system B) *	+50 (±10)	(Tx-Rx)/2
All equipment in box (system C) *	-180 (±50)	(Tx-Rx)/2
All equipment in box (system D) **	+10 (±5)	(Tx-Rx)/2

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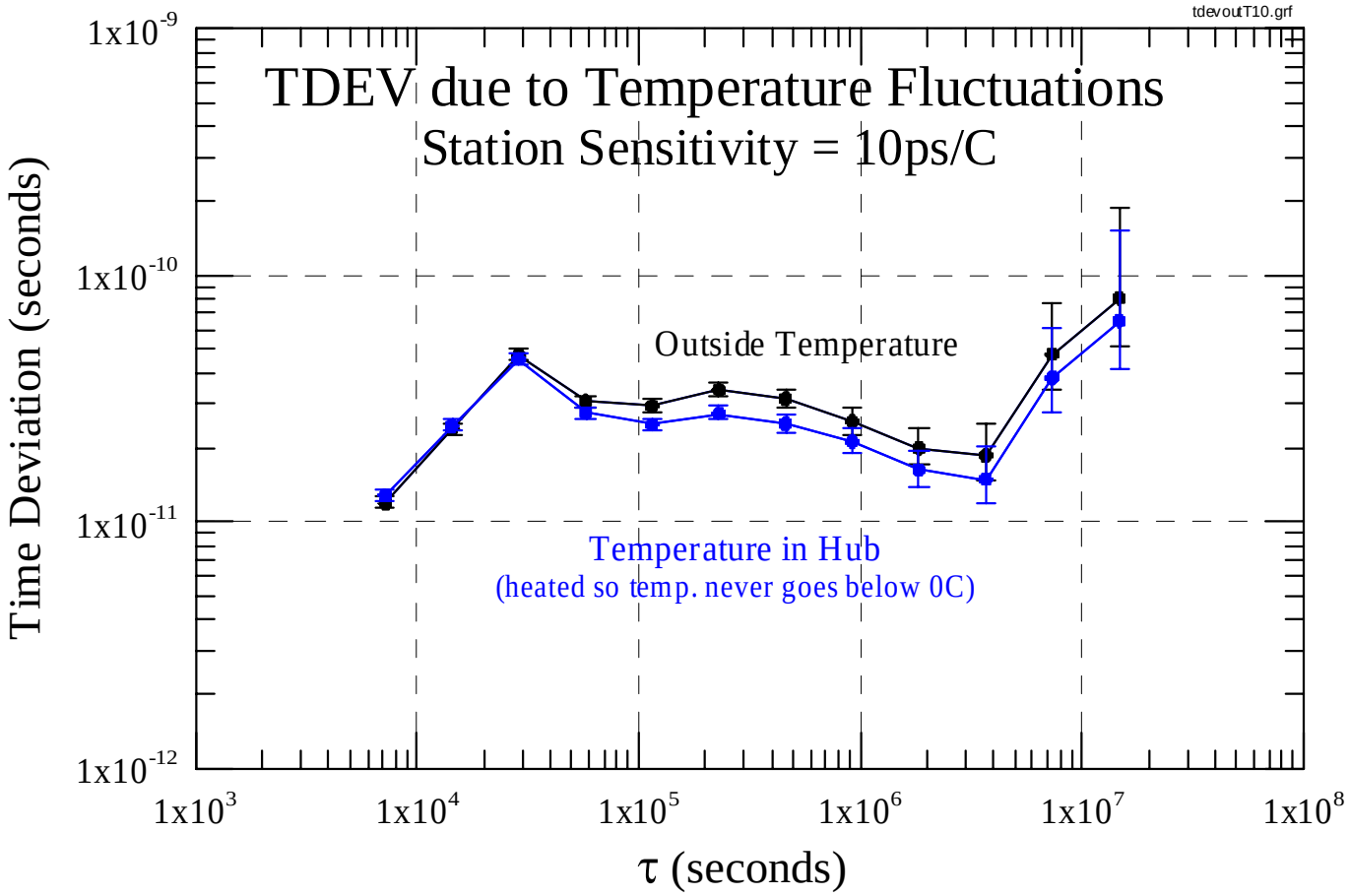
Environmental Sensitivities

Table 3 Sensitivity to Relative Humidity (20% to 60% at 25°C)

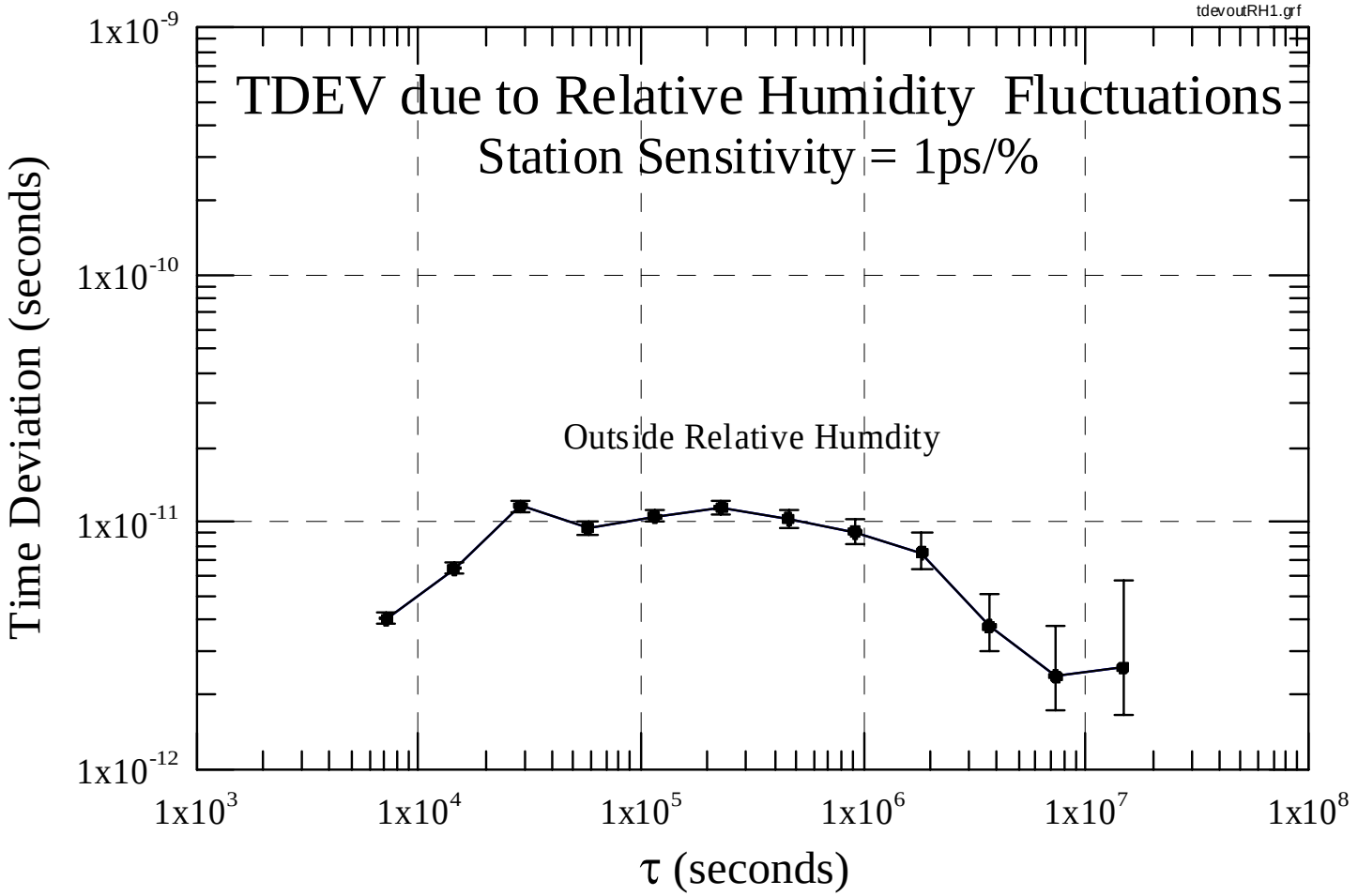
Modules

Equipment	Coefficient (ps/%)	Comments
LNA and filter	-0.3 (±0.1)	Rx path
Up-Converters	0.4 to 1 (±0.1)	Tx path
Down-Converter	0.8 (±0.1)	Rx path

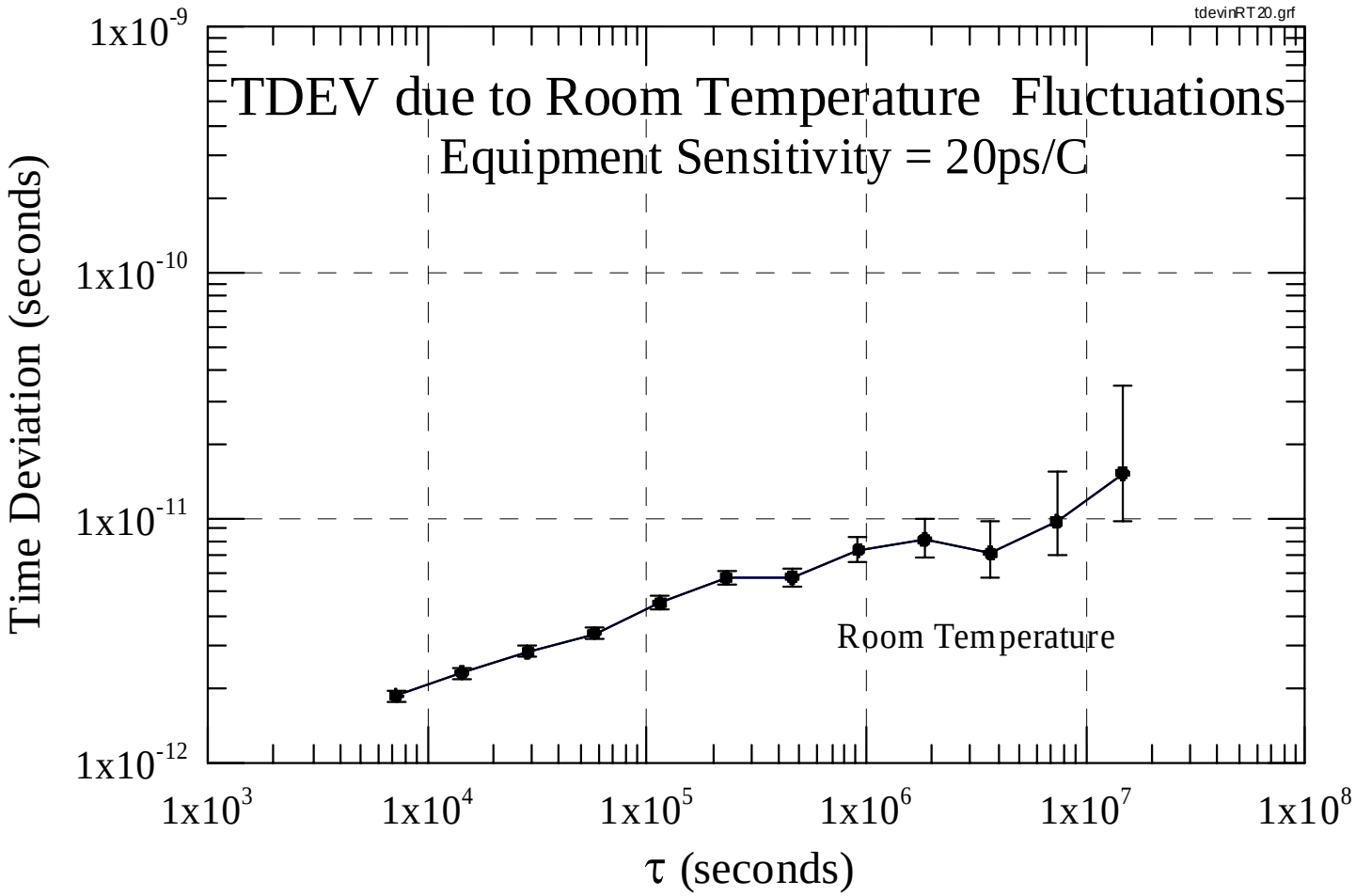
Temperature Sensitivity



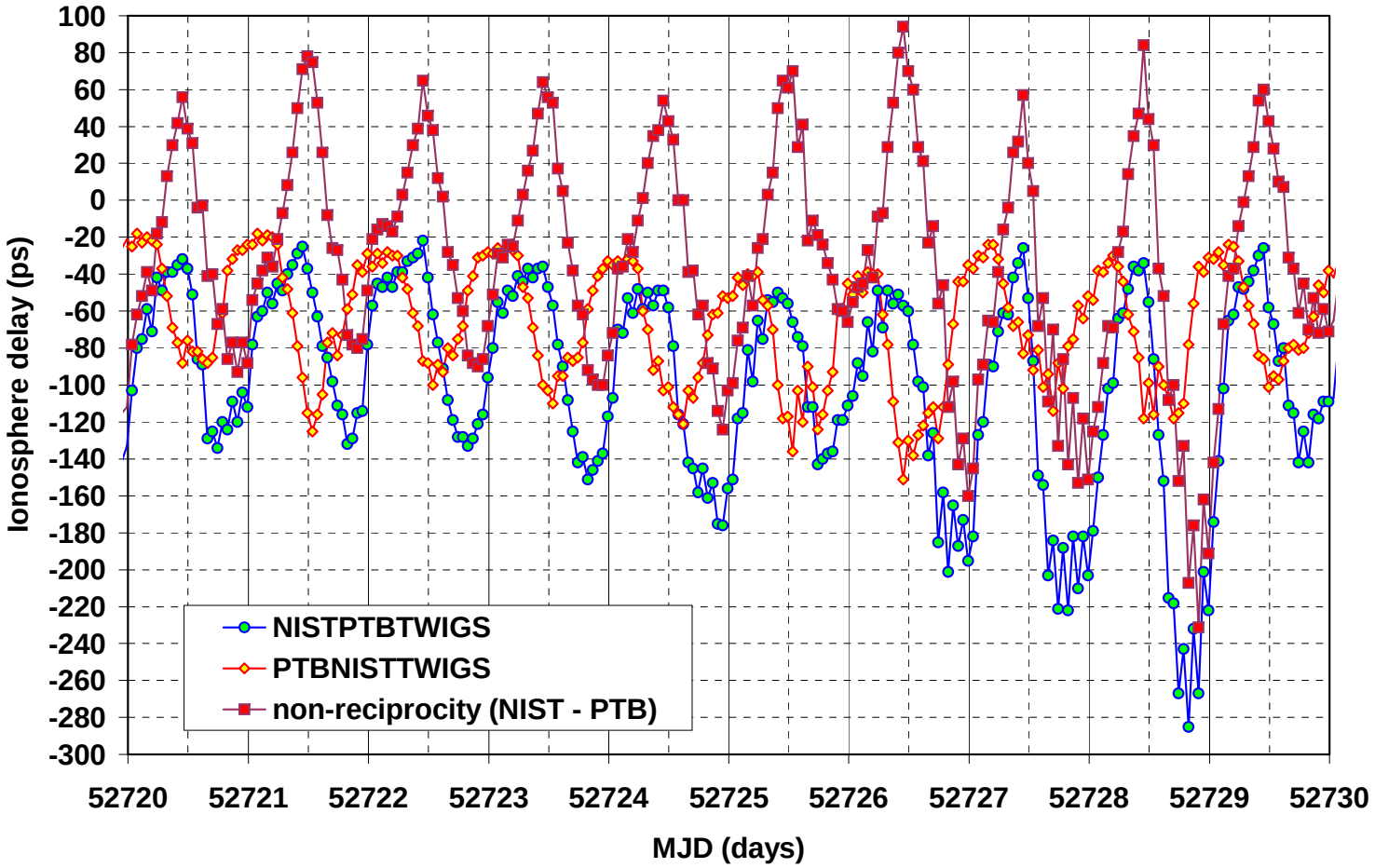
Sensitivity to Relative Humidity



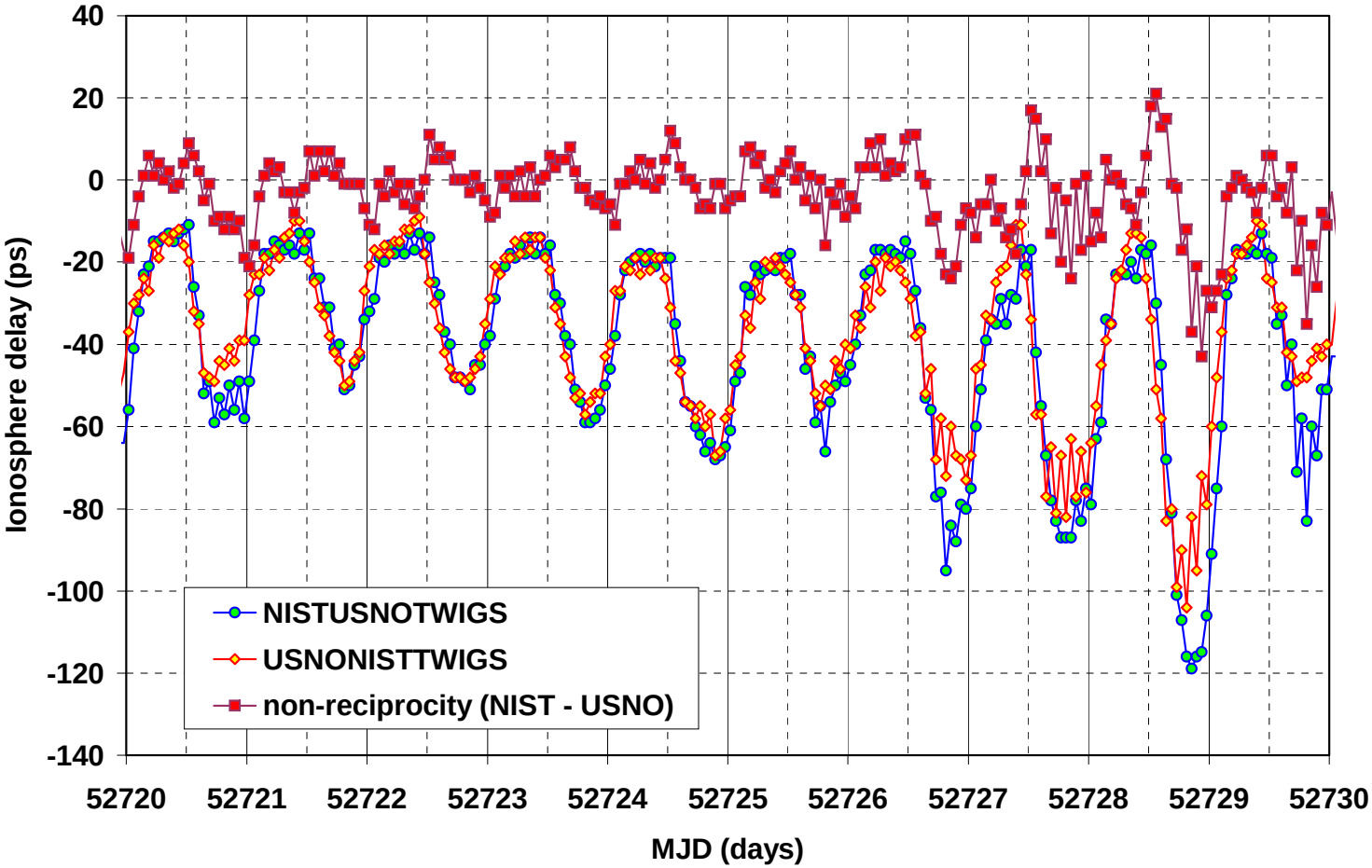
Temperature Sensitivity



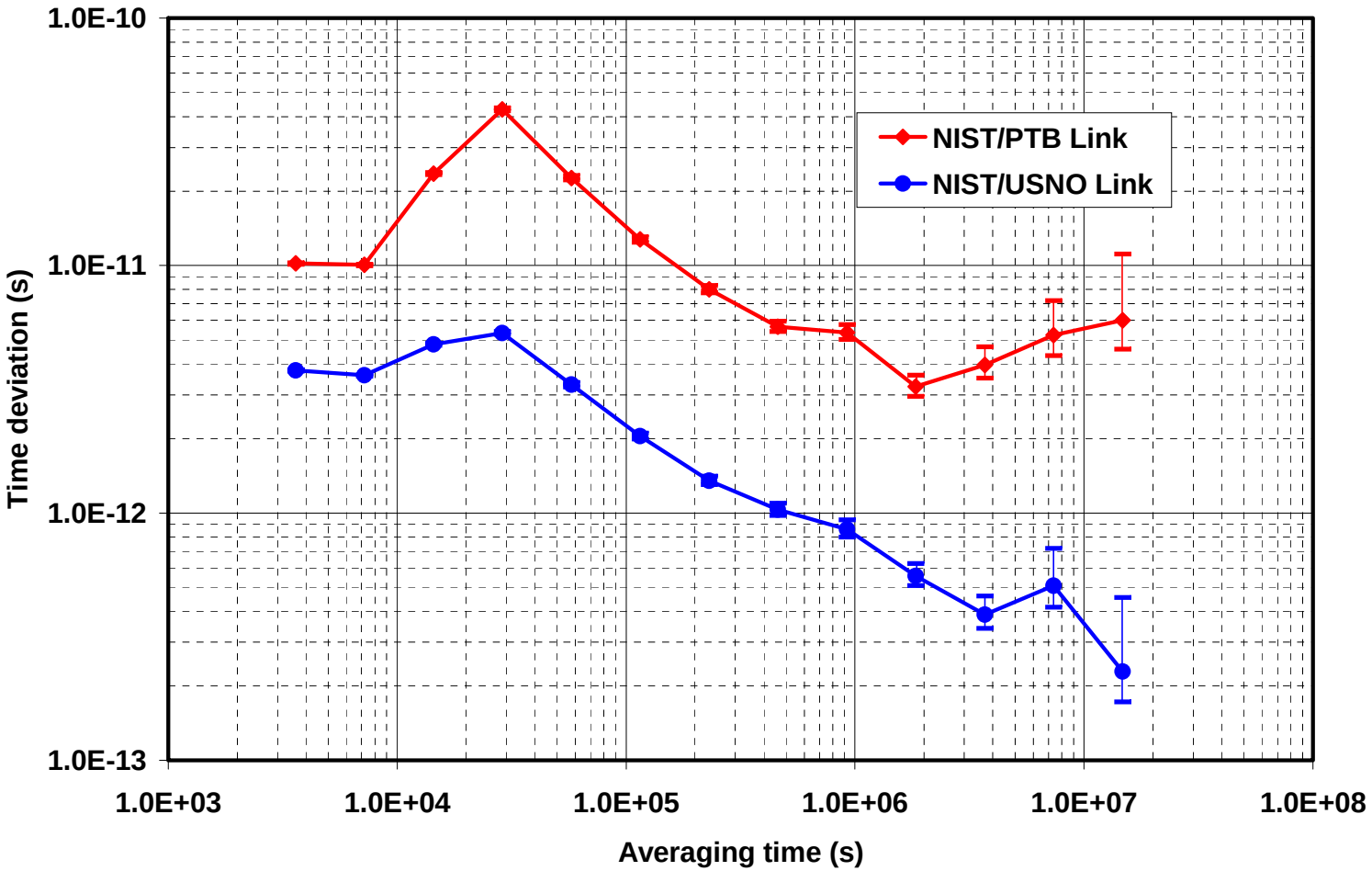
Ionospheric Delay, NIST-PTB



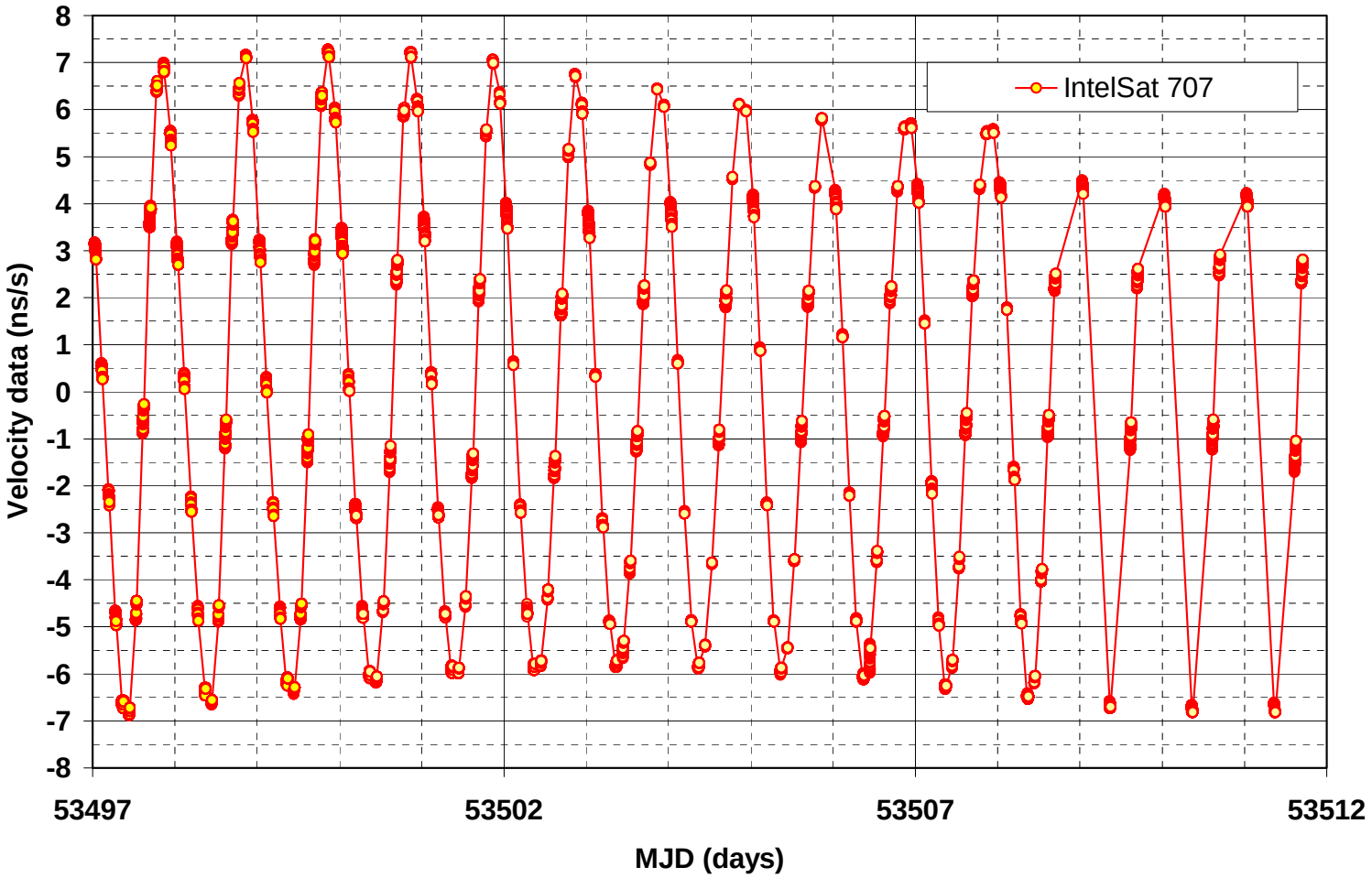
Ionospheric Delay, NIST-USNO



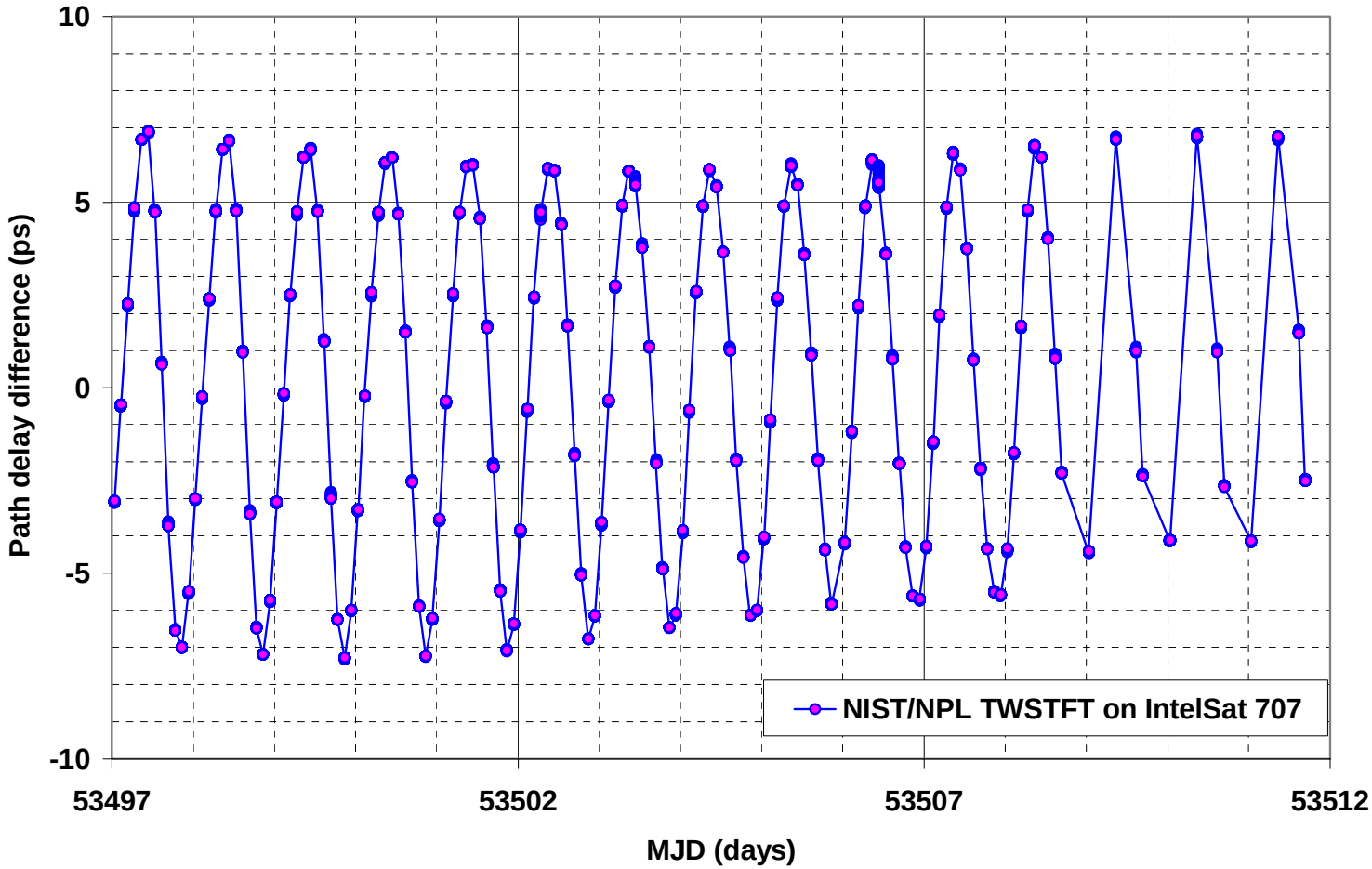
Ionospheric Delay - TDEV



Satellite Motion



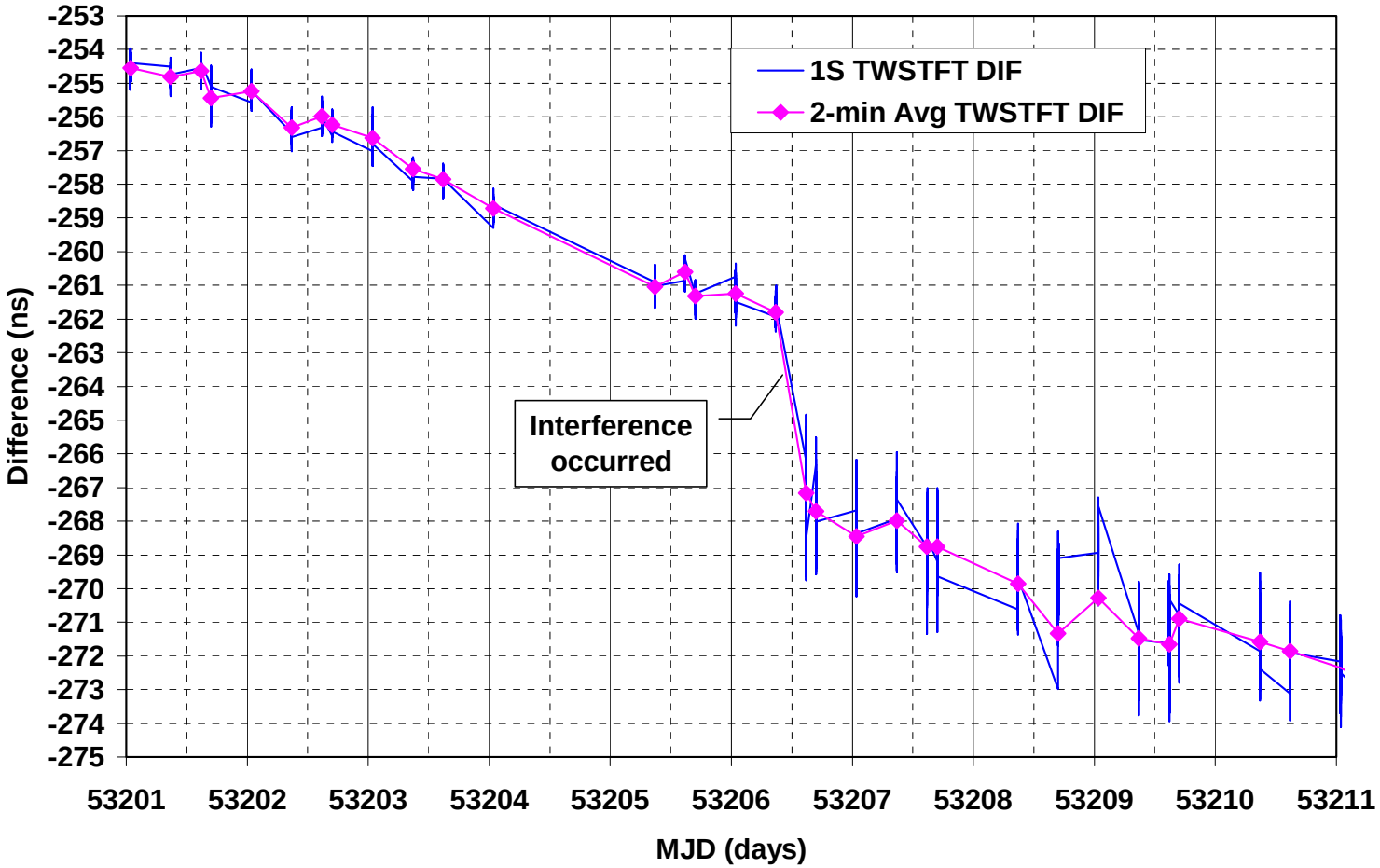
Satellite Motion



Transponder Instabilities

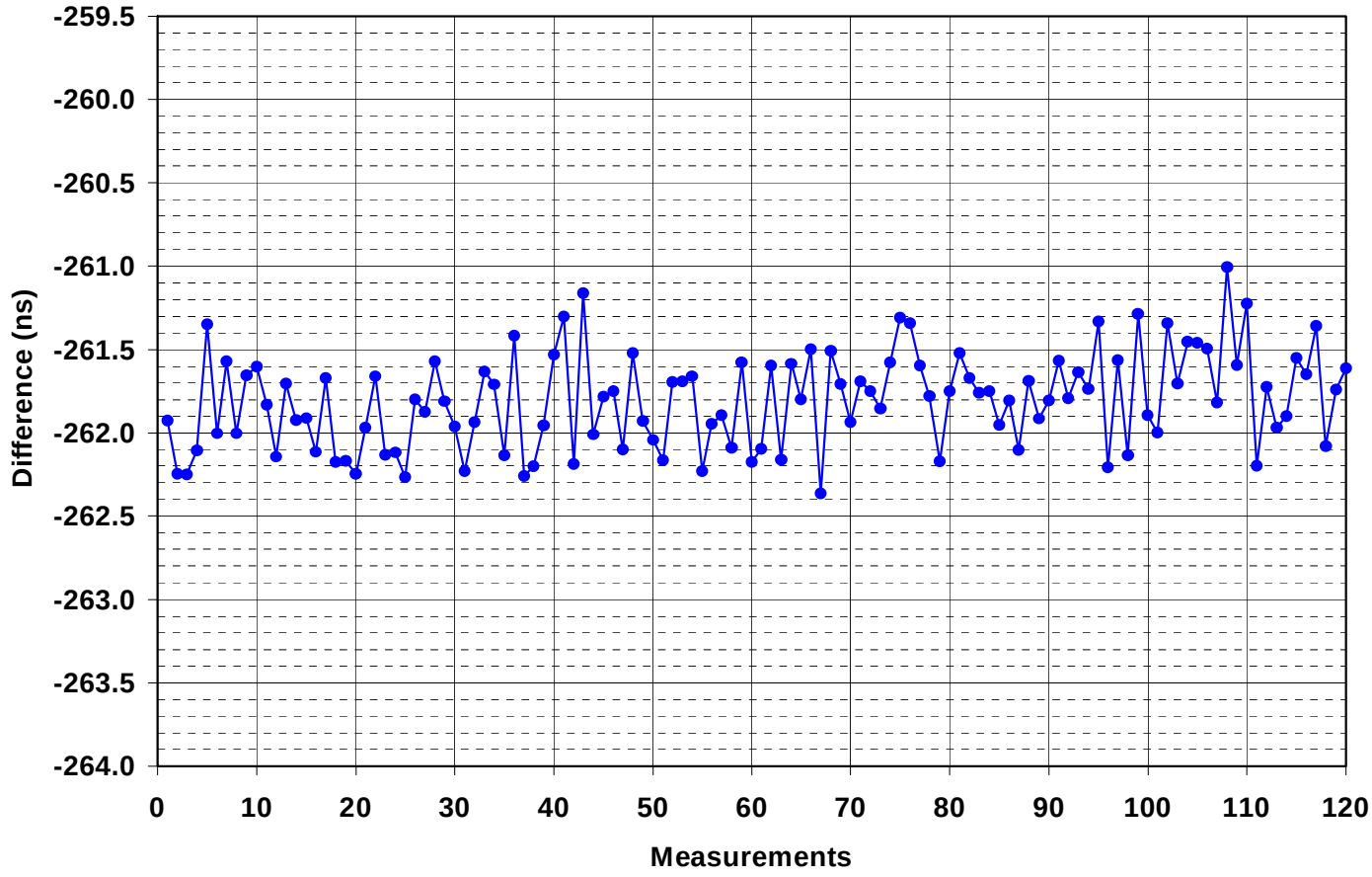
step caused by interference

(NIST – PTB)



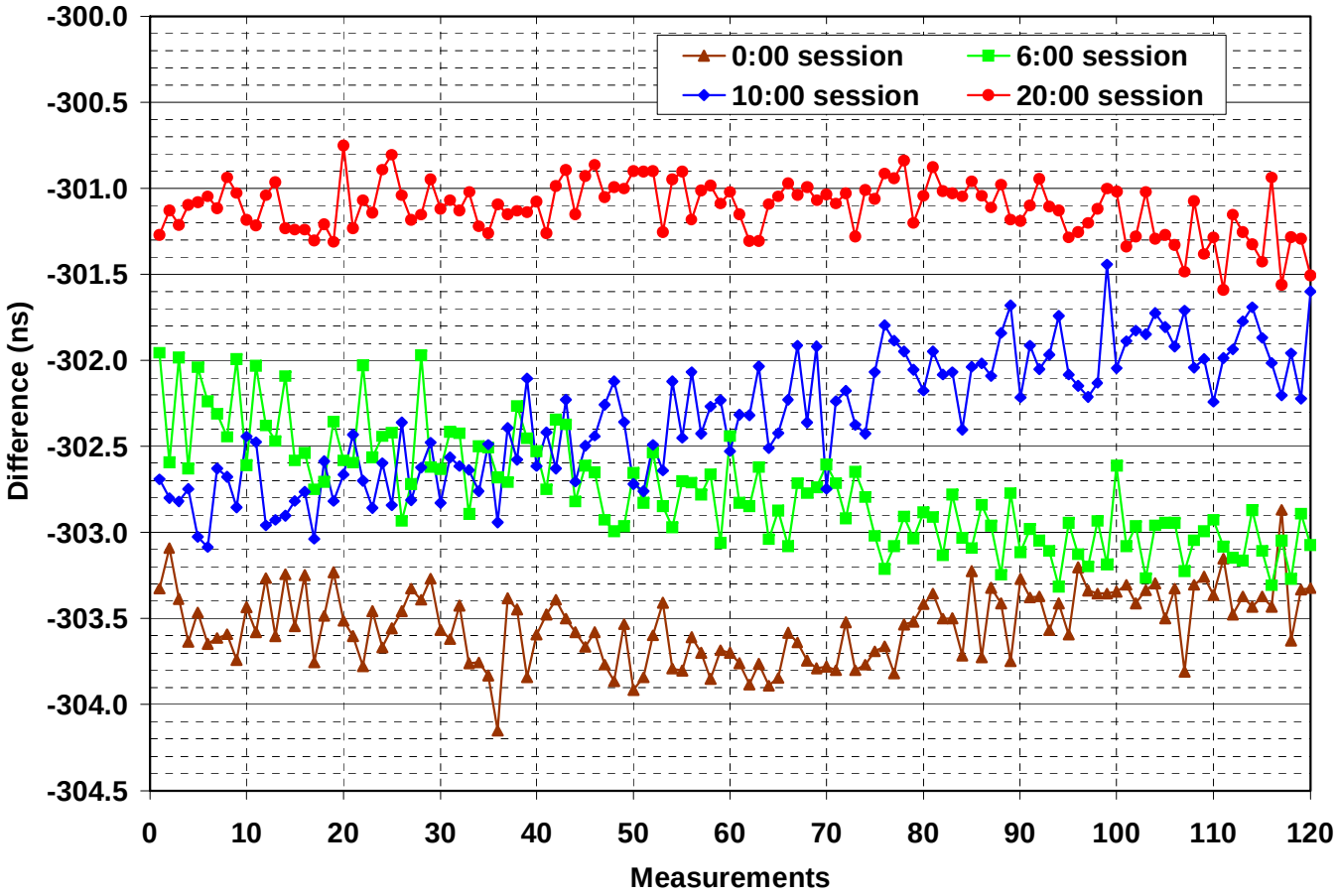
Transponder Instabilities

before interference

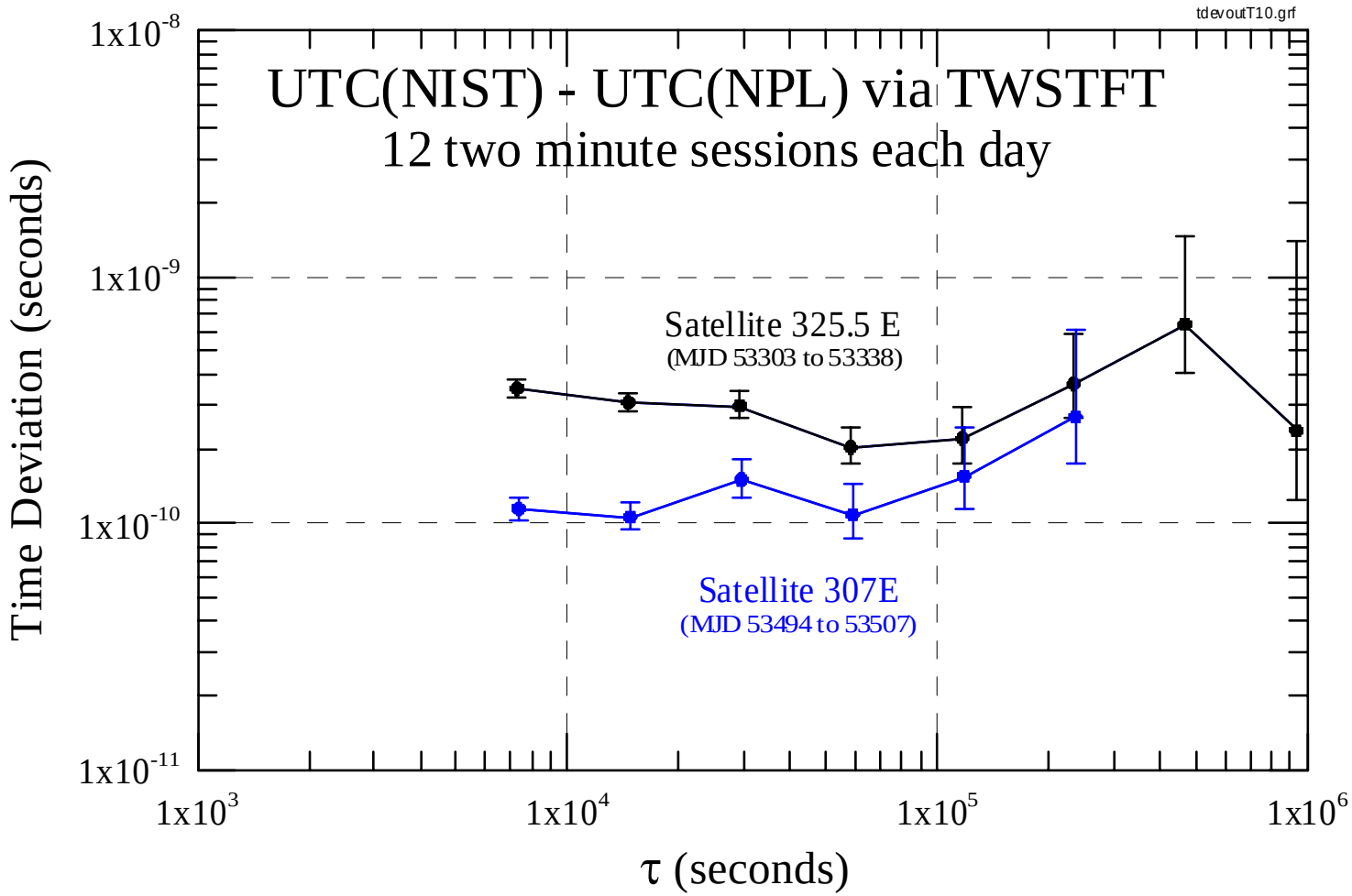


Transponder Instabilities

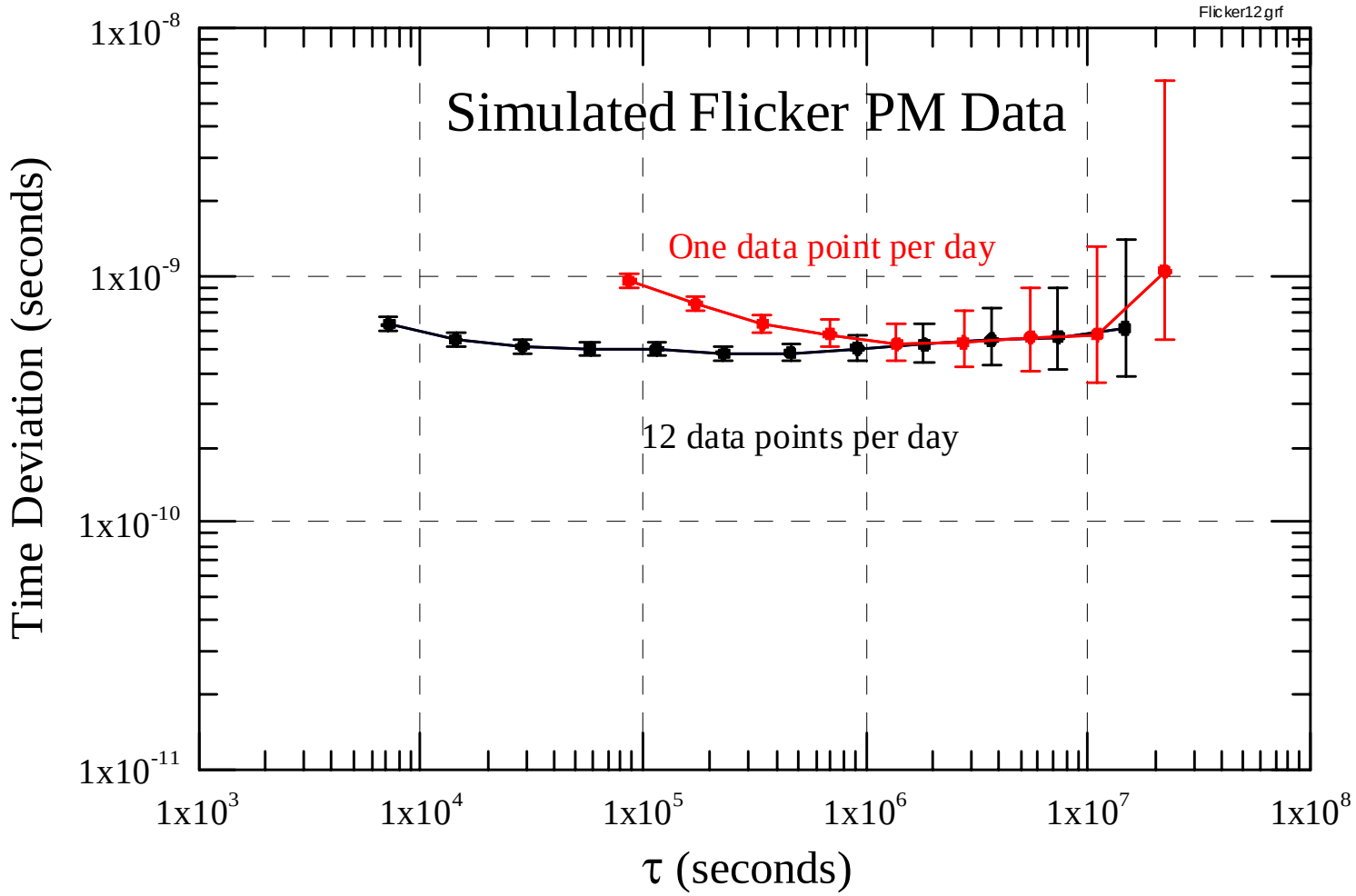
after interference started



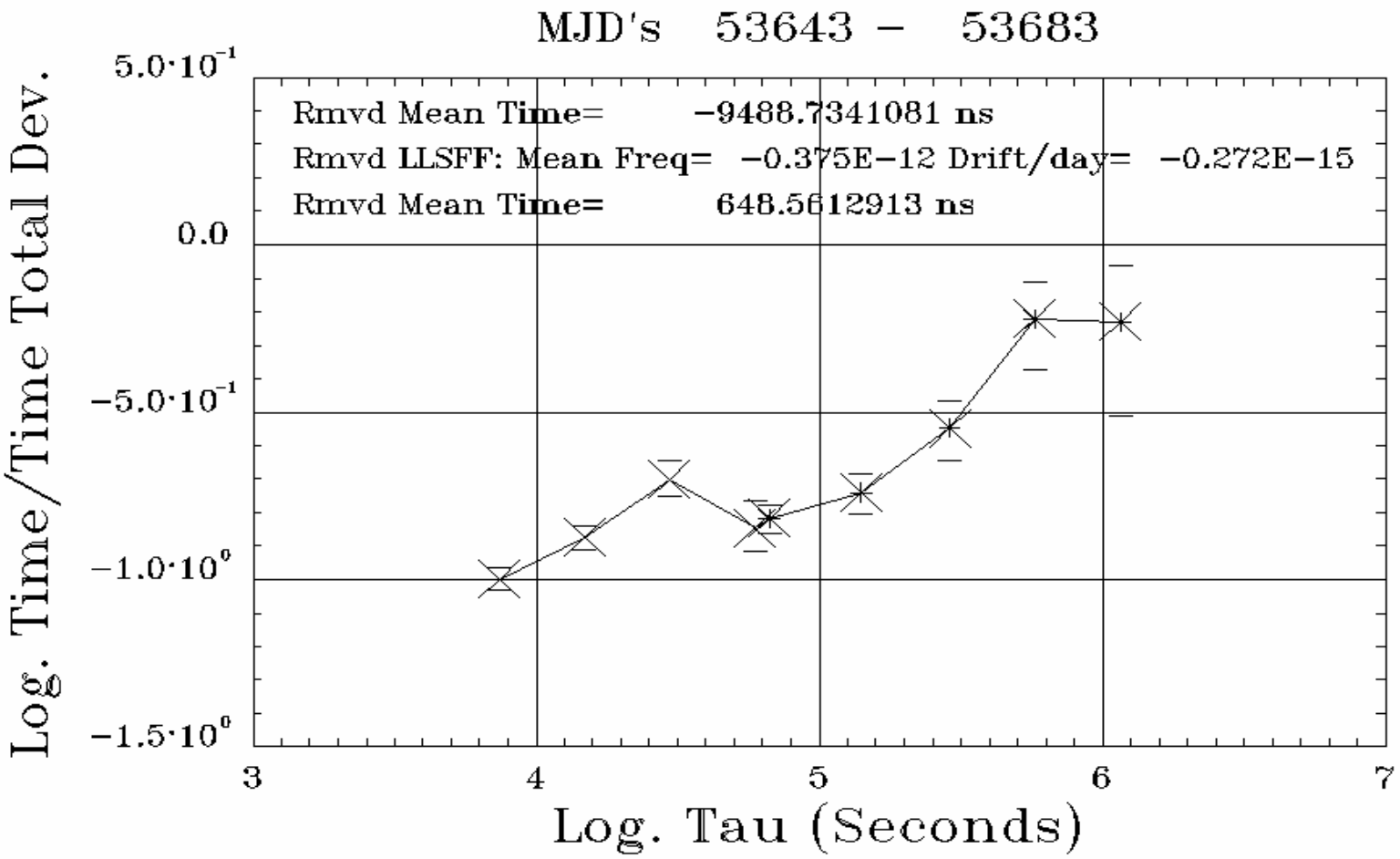
Transponder Instabilities
before and after satellite change



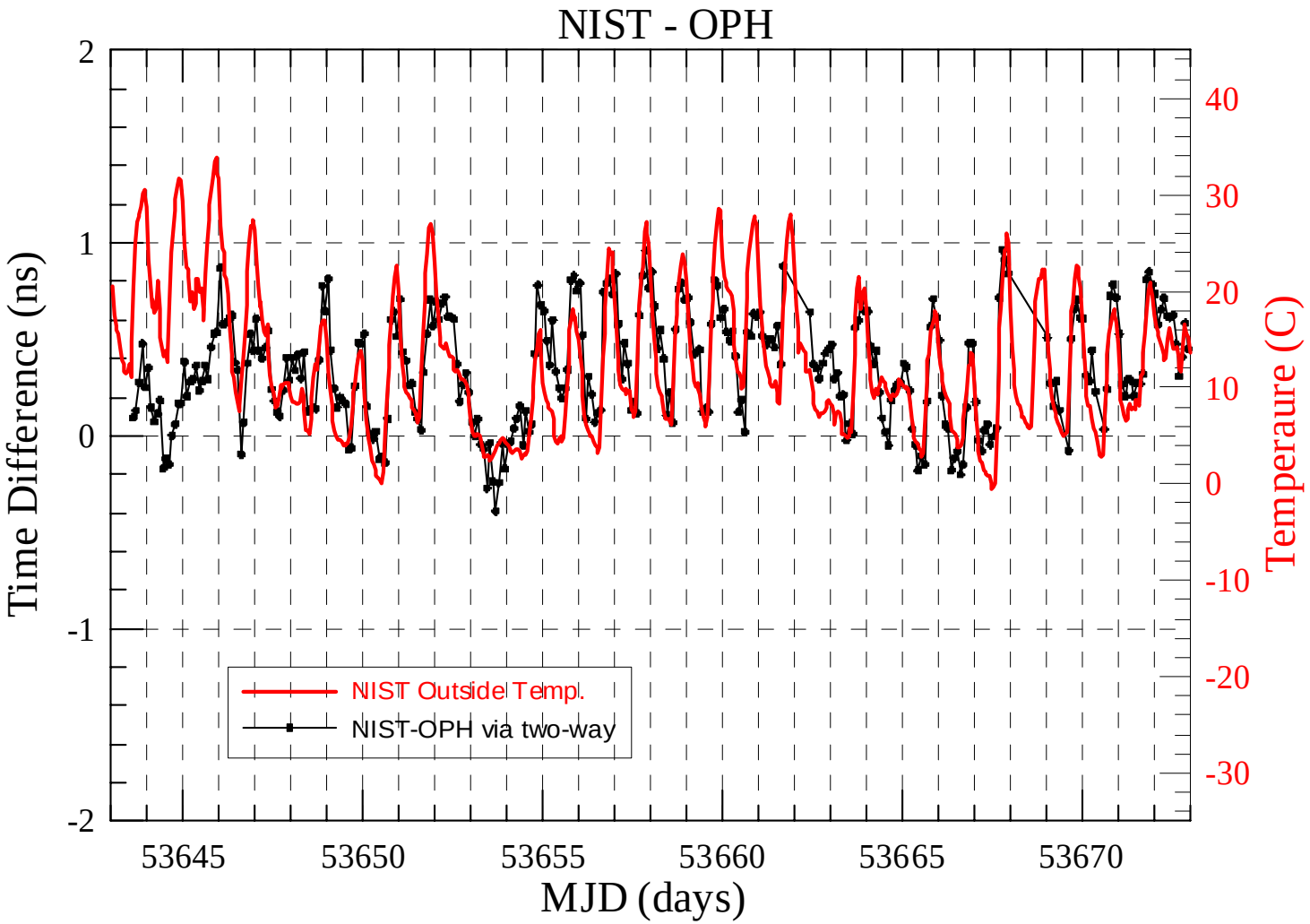
Caution on Using TDEV



Some New Data, NIST-OPH



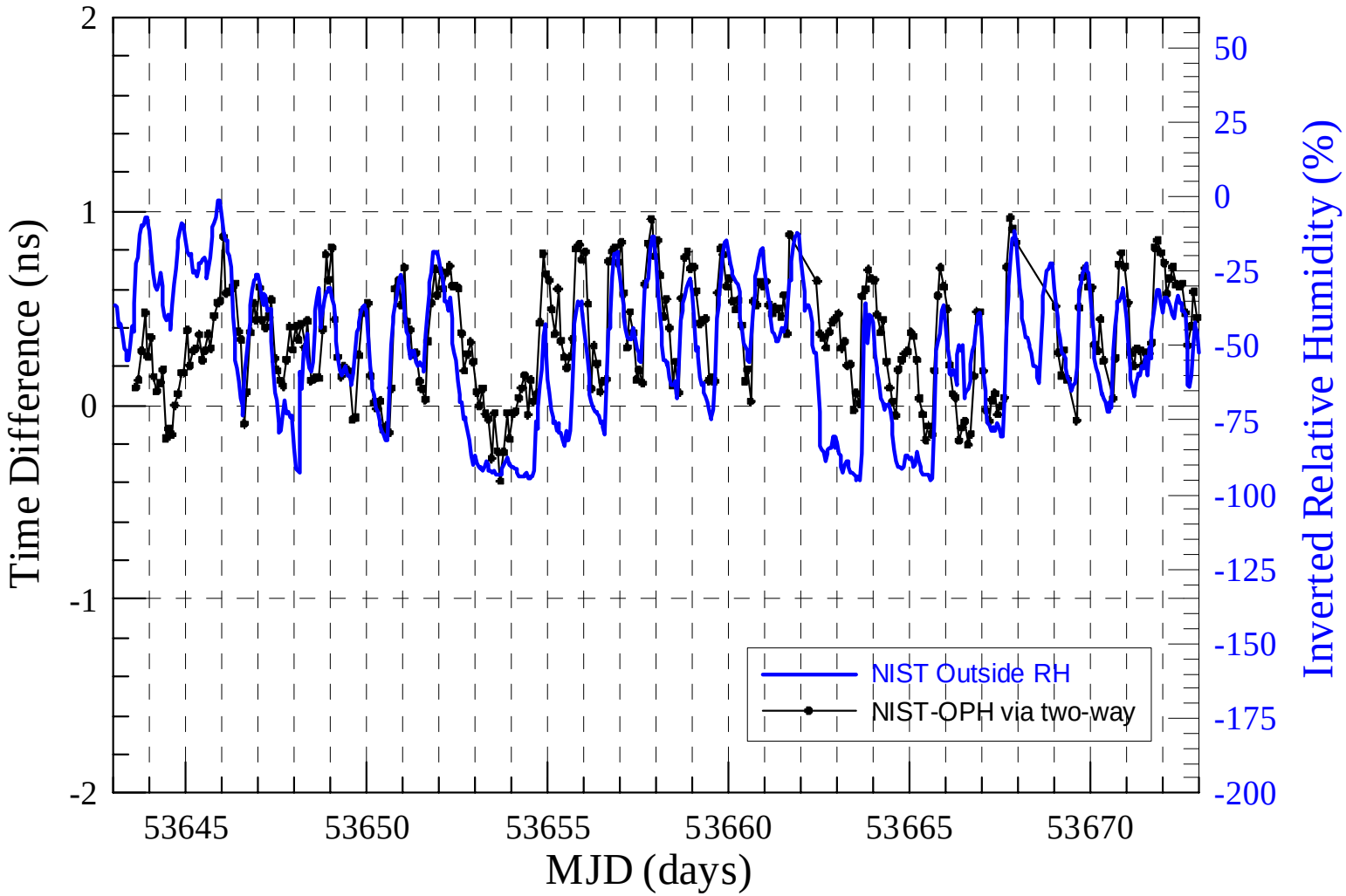
Correlation with Temperature



Summary

- Have not identified all specific sources yet, but environmental factors are a significant source.
- Satellite transponder instabilities are a big concern for certain links (user has no control).
- With corrections for the ionosphere, satellite motion, environmental control, and higher chip rates a stability at one day of 10 ps may be achievable on some links.

Correlation with RH



Sensitivity to Barometric Pressure