Earth Station Delay Measurement by SATSIM

Wen-Hung Tseng and Calvin Lin

National Standard Time and Frequency Lab.,
Telecommunication Laboratories,
Taiwan

13th Meeting of the CCTF WG on TWSTFT

15-16 November, 2005

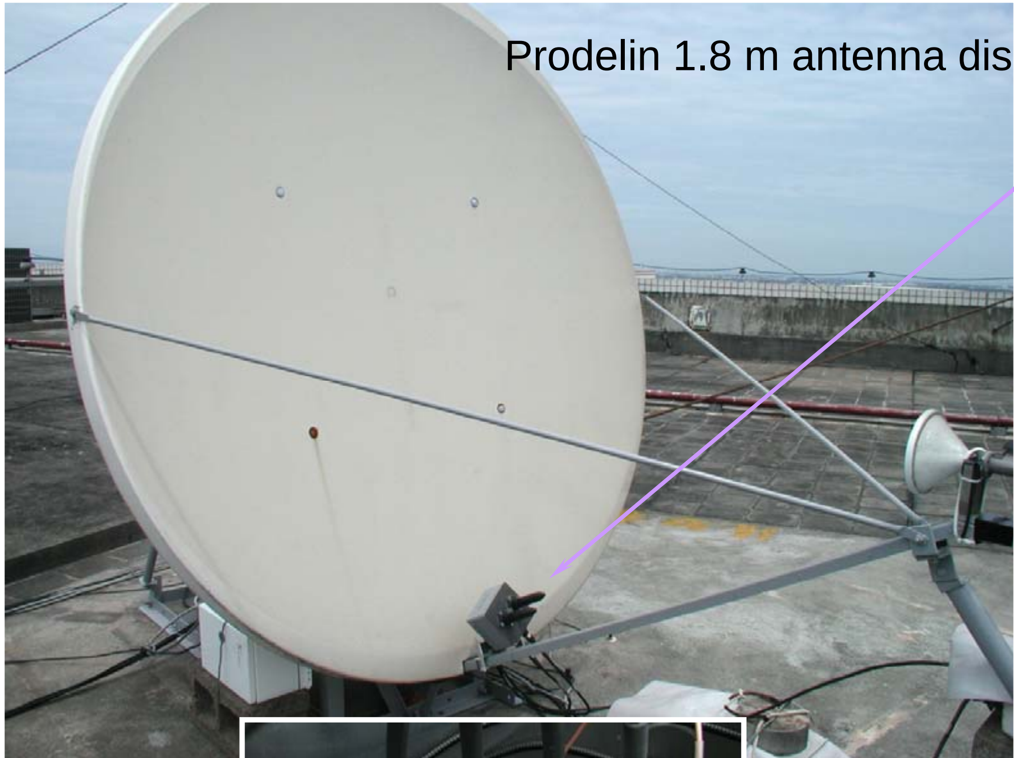
at NMi Van Swinden Laboratorium

Introduction

- *The method to separately measure the transmit and receive delays was first descreibed by Dr. Gerrit de Jong in 1989.*
- *A calibration system based on a satellite simulator and calibrated cable,* TimeTech SATSIM-001, *has been successfully installed on the TL-01 earth station.*
- *The SATSIM has the capability of measuring the transmit and receive delay of the earth station through a series of calibration loops.*
- *The results of delay measurements using 2.5MChip and 20MChip rate coded signal are illustrated.*

Pictures of the SATSIM at TL

Prodelin 1.8 m antenna dish



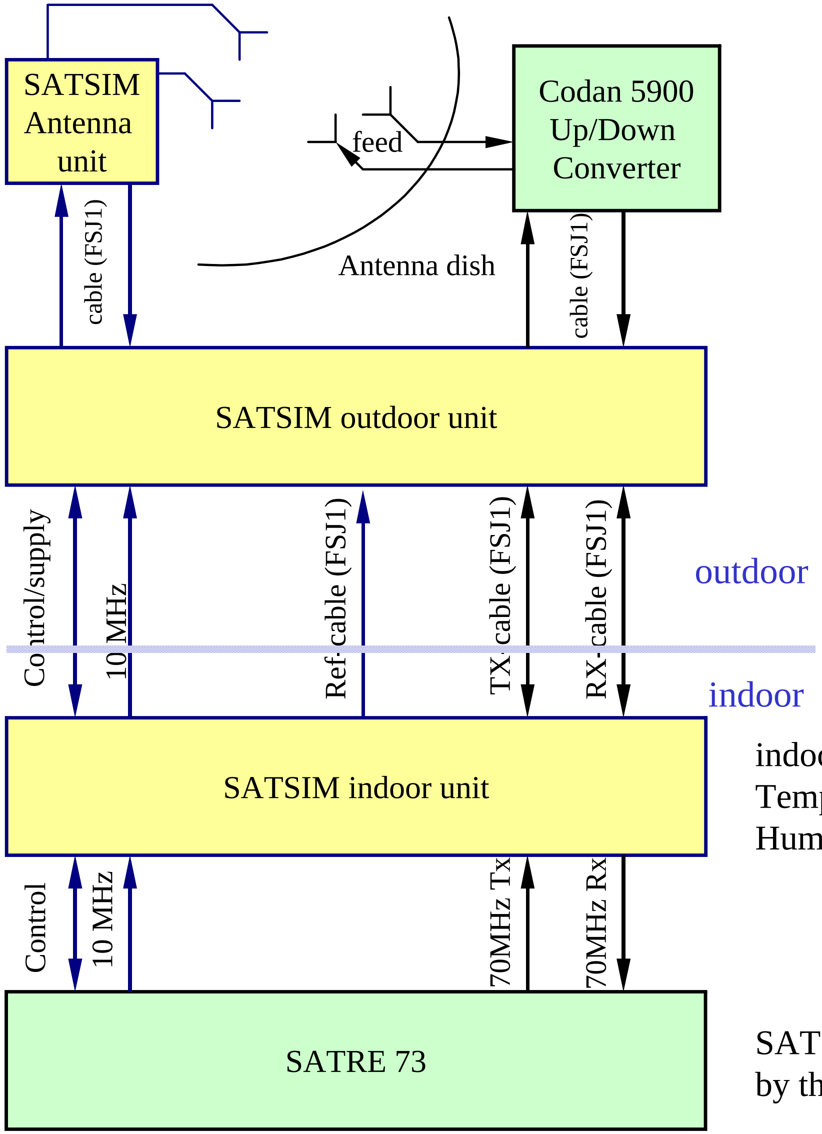
Antenna unit

Outdoor unit

Indoor unit & SATRE modem

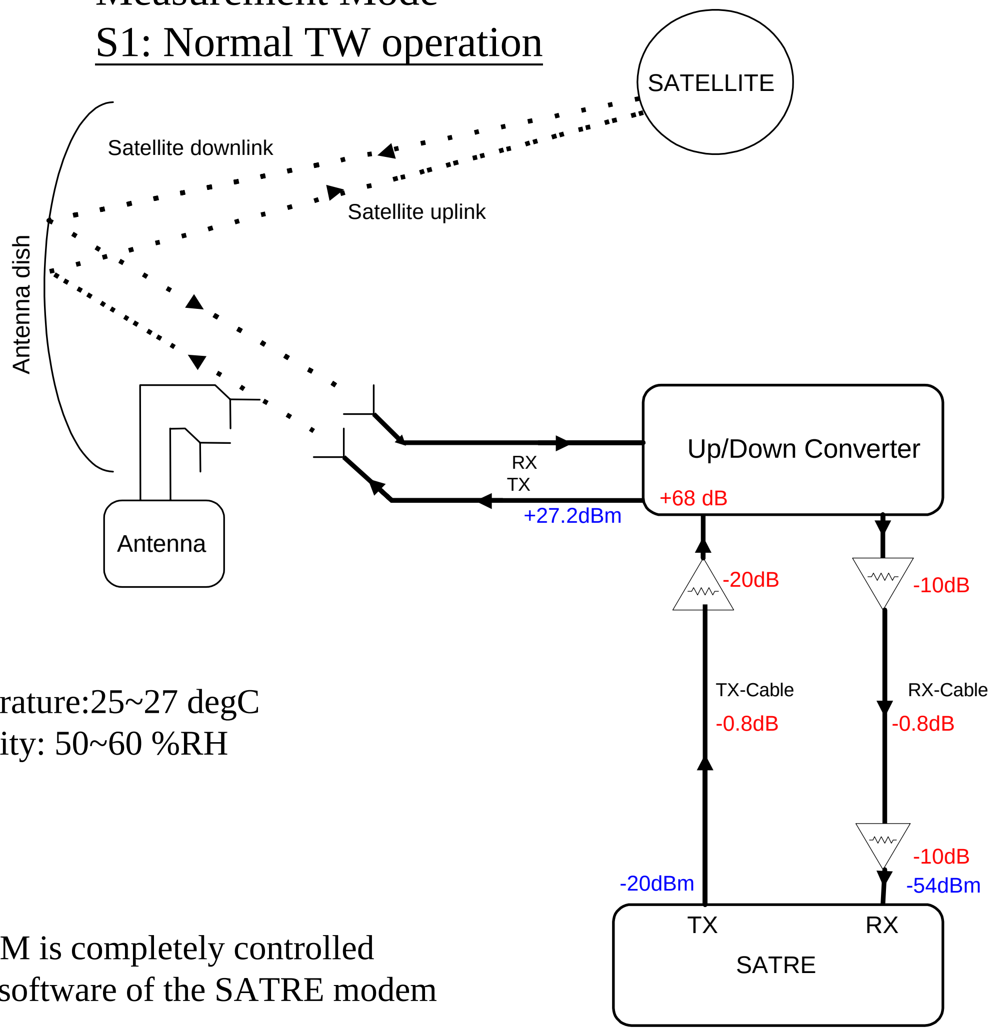
Block diagram of SATSIM

"Satellite-simulator / SATRE calibrator", SA-TIM-MA-1005, TimeTech GmbH 2002



Measurement Mode

S1: Normal TW operation



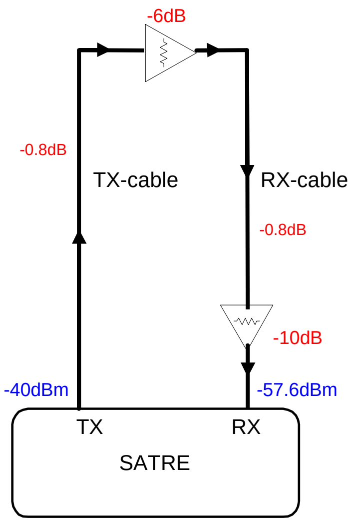
indoor
Temperature:25~27 degC
Humidity: 50~60 %RH

SATSIM is completely controlled by the software of the SATRE modem

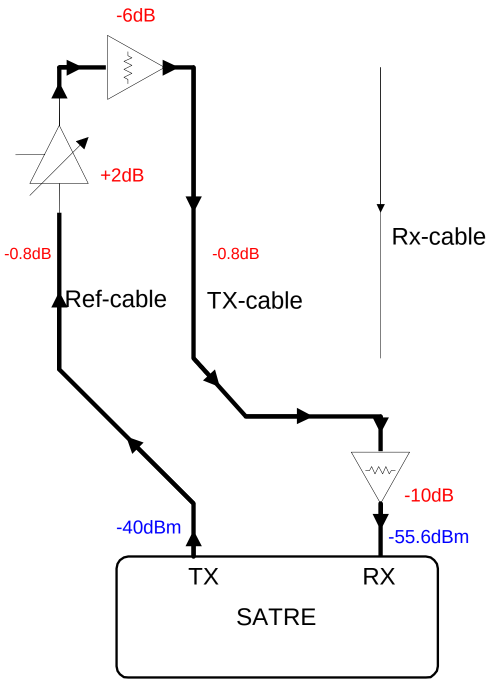
Measurement Modes S2~ S5

"Satellite-simulator / SATRE calibrator", SA-TIM-MA-1005, TimeTech GmbH 2002

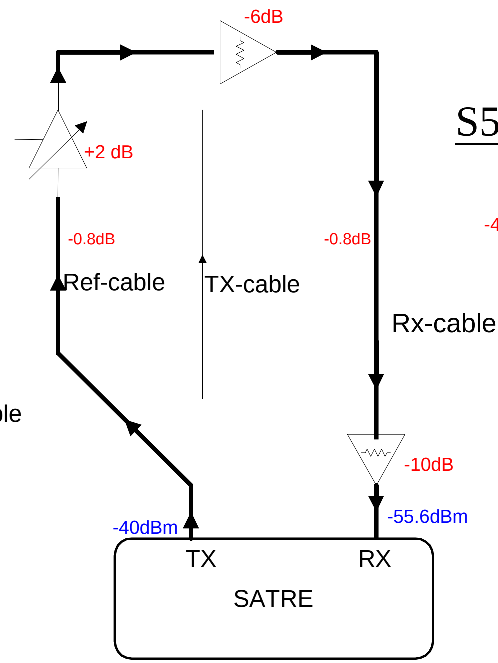
S2: TX&RX cable



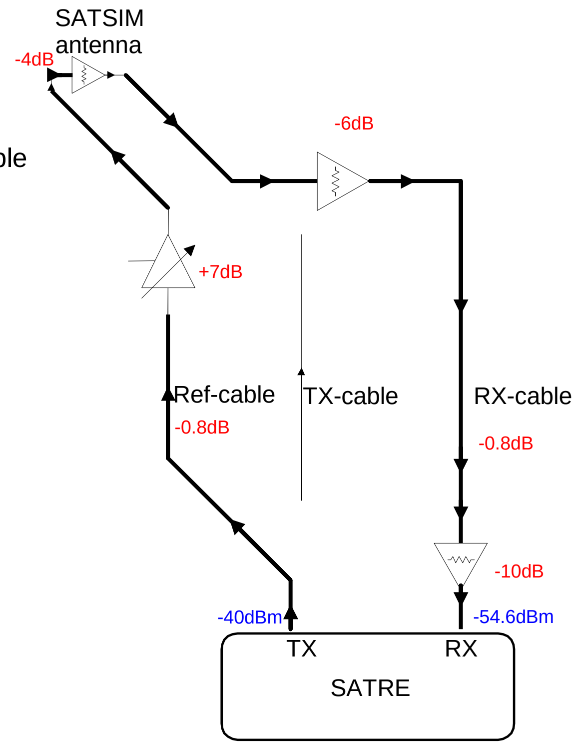
S3:REF&TX cable



S4: REF& RX cable



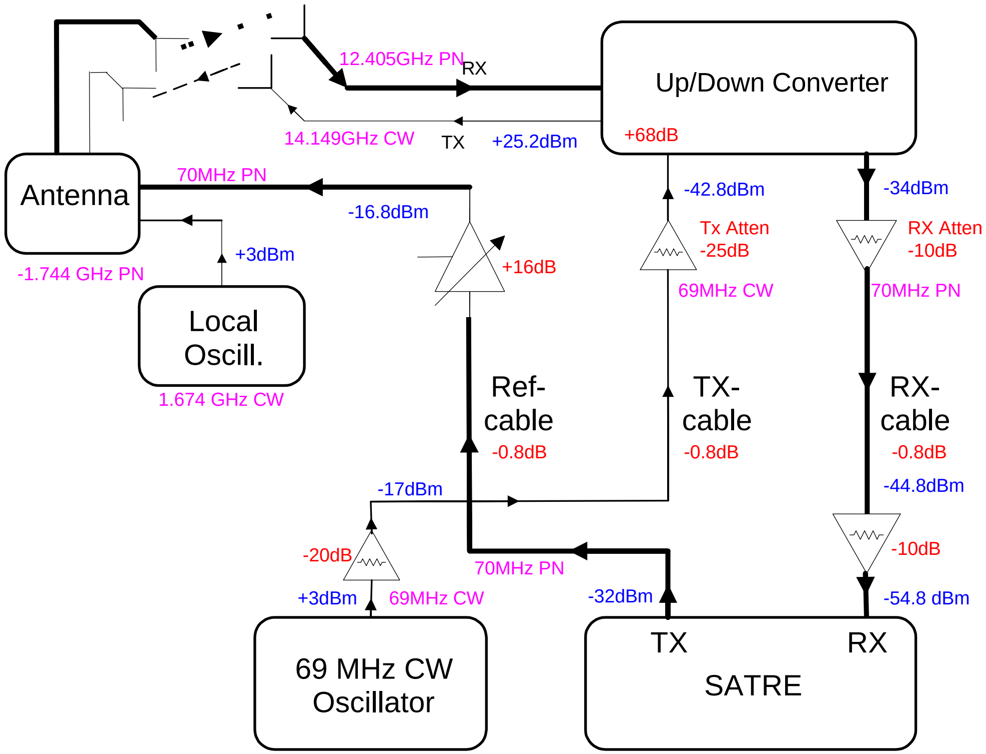
S5: REF& RX&Antenna cable



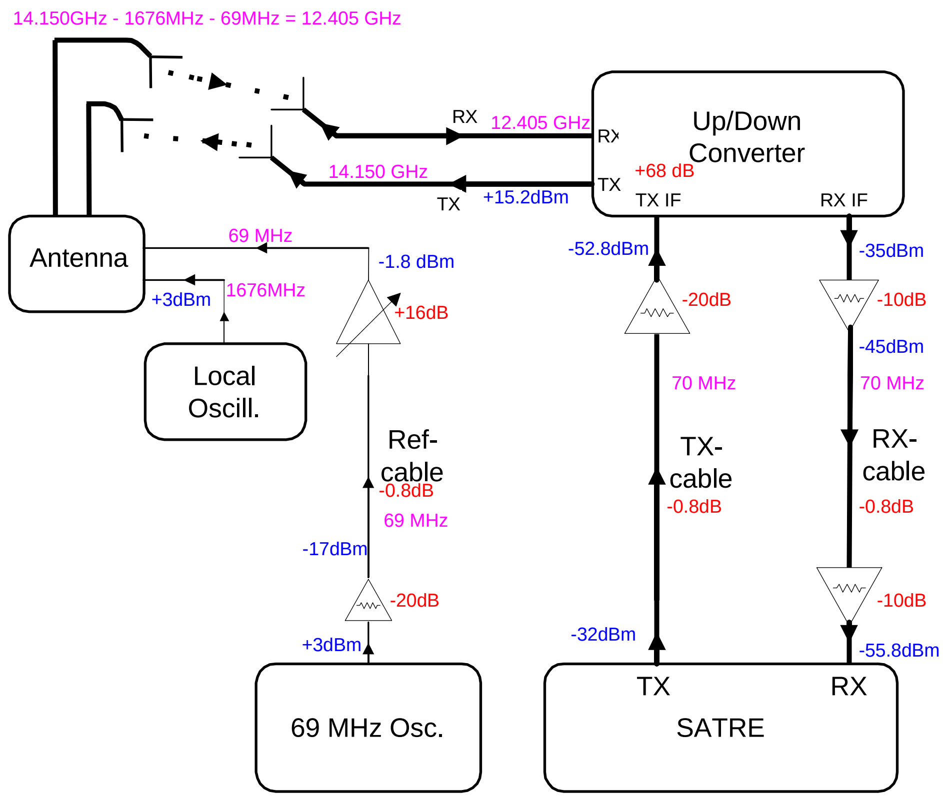
Measurement Modes S6 and S7

"Satellite-simulator / SATRE calibrator", SA-TIM-MA-1005, TimeTech GmbH 2002

S6: REF&RX loop



S7: TX&RX loop (round trip delay)



Components of the measured delays under different modes

Mode	Components of the measured delays
S1	Normal TWSTFT operation
S2	$T_{TX\text{-}cable} + T_{RX\text{-}cable}$
S3	$T_{REF\text{-}cable} + T_{TX\text{-}cable}$
S4	$T_{REF\text{-}cable} + T_{RX\text{-}cable}$
S5	$T_{REF\text{-}cable} + T_{CableToAnt} + T_{CableFromAnt} + T_{RX\text{-}cable}$
S6	$T_{REF\text{-}cable} + T_{CableToAnt} + T_{RadioToRx} + T_{DownConv} + T_{RX\text{-}cable}$
S7(RTDSum)	$T_{TX\text{-}cable} + T_{UpConv} + T_{RadioToAnt} + T_{RadioToRx} + T_{DownConv} + T_{RX\text{-}cable}$

To determine the TX(Uplink)/RX(Downlink) delay by these measurements:

$T_{REF\text{-}cable}$=1/2(S3+S4-S2), $T_{CableToAnt} = T_{CableFromAnt}$ =1/2(S5-S4)

RX=S6-$T_{REF\text{-}cable}$ -$T_{CableToAnt}$ =S6-1/2(S5+S3) +1/2(S2)

TX=S7-**RX**

Finally, the **[TX-RX]/2** is obtained.

Automatic measurements

Two schedules was adopted for the measurements

(1)Hourly schedule

S1 (0:00-0:04)
S2 (0:05-0:09)
S3 (0:10-0:14)
S4 (0:15-0:19)
S5 (0:20-0:24)
S6 (0:25-0:29)
S7 (0:30-0:34)

(2)continuous 15-minute schedule

-Each section lasted 135 seconds including the time of commanding and initial locking

S2 (00:00:15-00:02:30)
S3 (00:02:45-00:05:00)
S4 (00:05:15-00:07:30)
S5 (00:07:45-00:10:00)
S6 (00:10:15-00:12:30)
S7 (00:12:45-00:15:00)

:

S2 (00:15:15-00:17:30)
S3 (00:17:45-00:20:00)
S4 (00:20:15-00:22:30)
S5 (00:22:45-00:25:00)
S6 (00:25:15-00:27:30)
S7 (00:27:45-00:30:00)

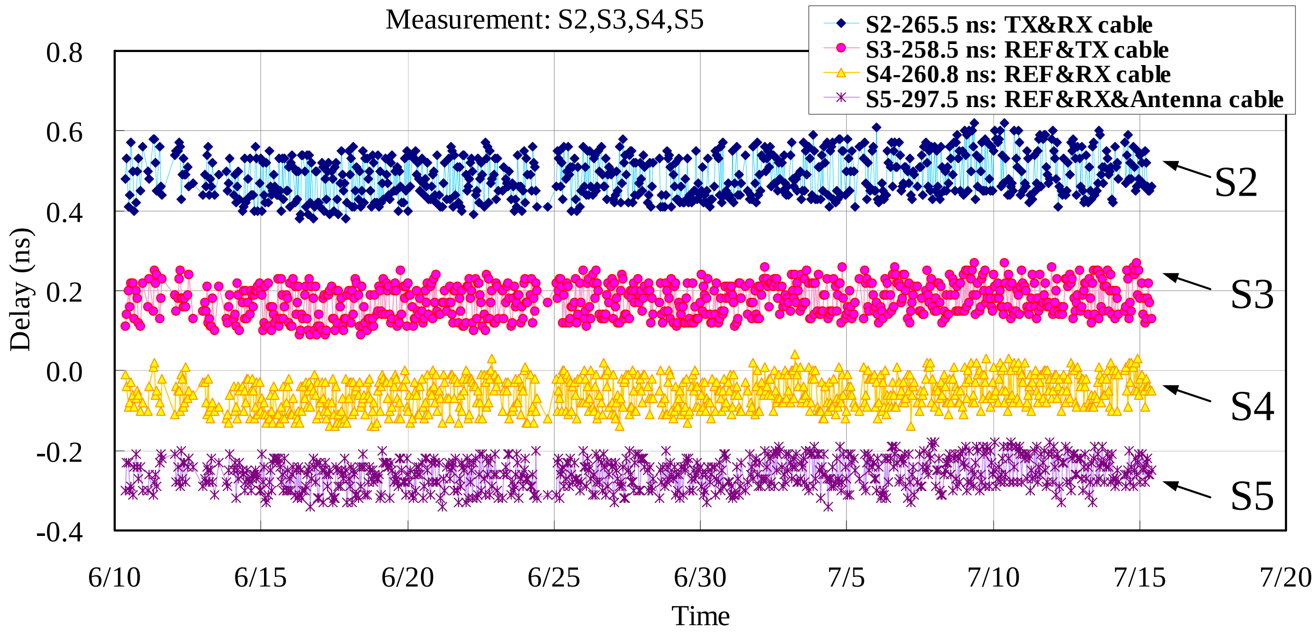
:

S2 (00:30:15-00:32:30)
S3 (00:32:45-00:35:00)
S4 (00:35:15-00:37:30)
S5 (00:37:45-00:40:00)
S6 (00:40:15-00:42:30)
S7 (00:42:45-00:45:00)

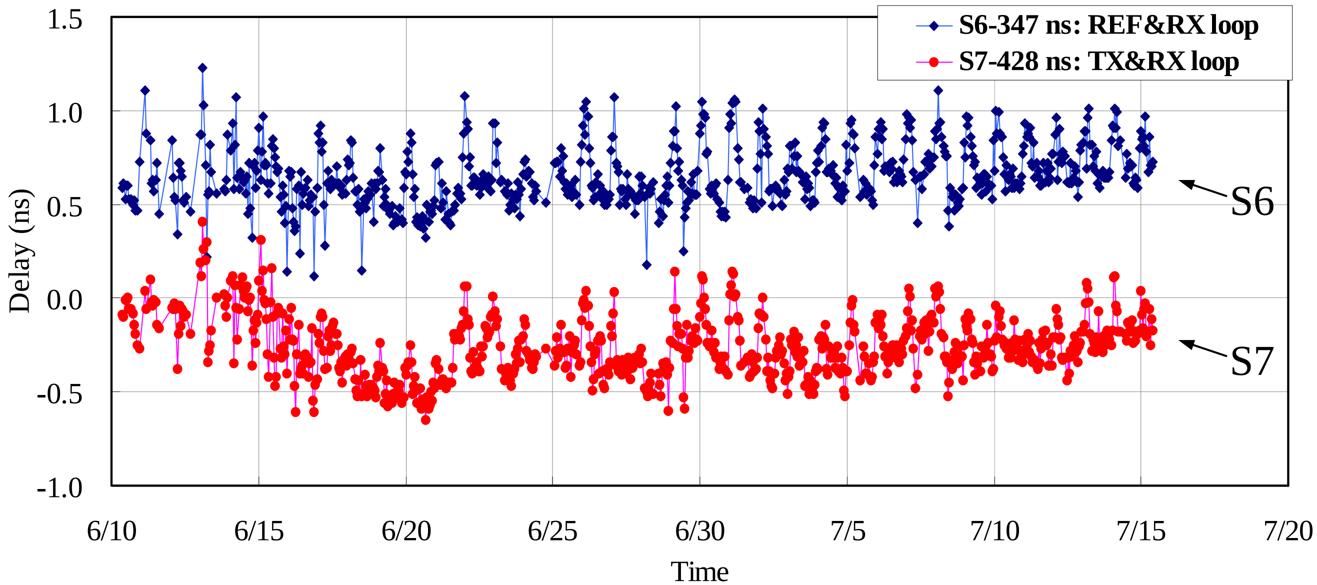
:

S2 (00:45:15-00:47:30)
S3 (00:47:45-00:50:00)
S4 (00:50:15-00:52:30)
S5 (00:52:45-00:55:00)
S6 (00:55:15-00:57:30)
S7 (00:57:45-00:59:59)

2.5MChip measurements with hourly schedule

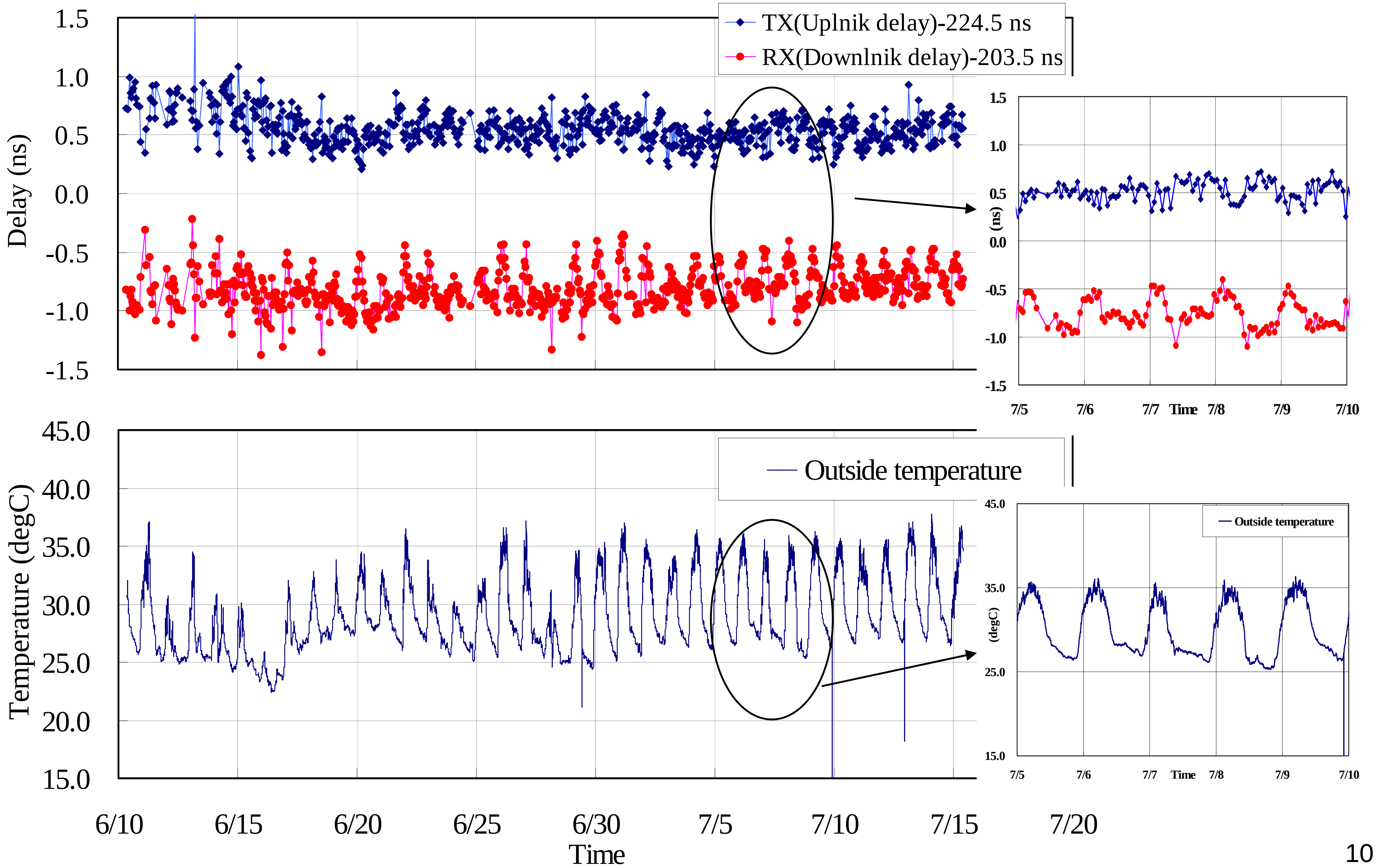


- The measurements of S2~S5 are the cable delays
- All cables are Andrew SFJ1
- No obvious variations

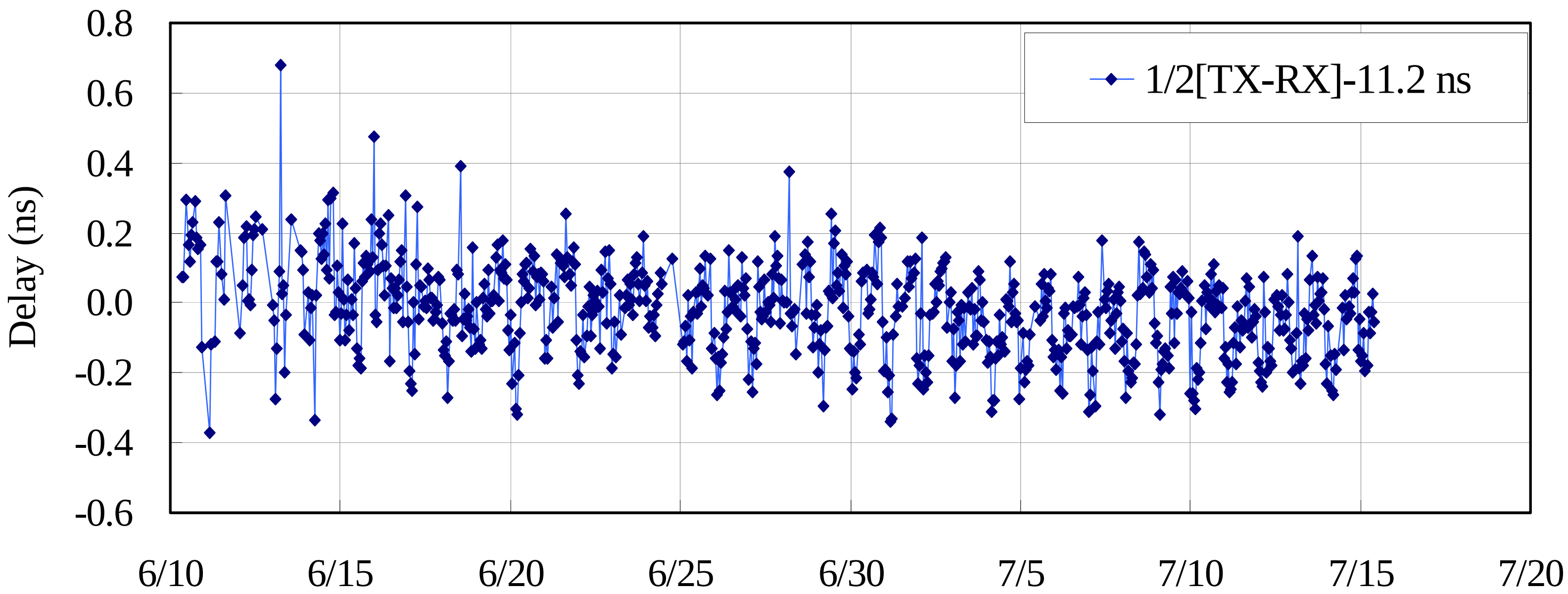


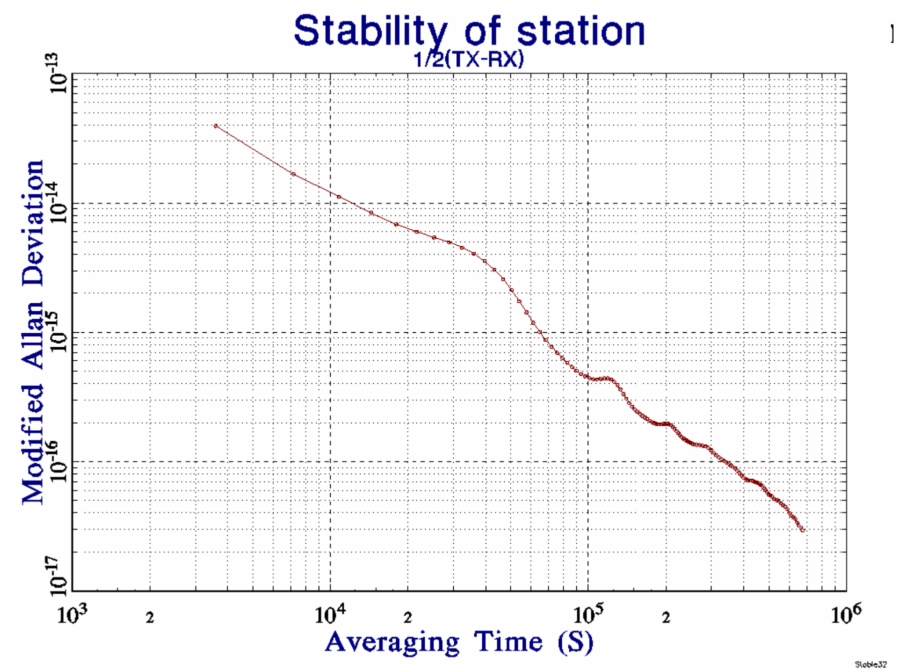
- Visible daily variations

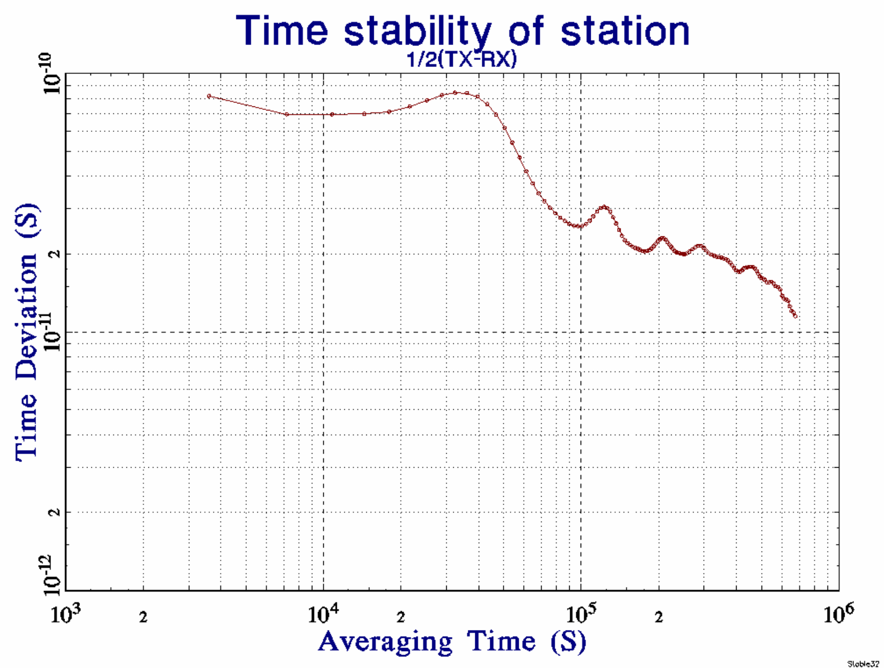
TX and RX delay (2.5MChip & hourly schedule)



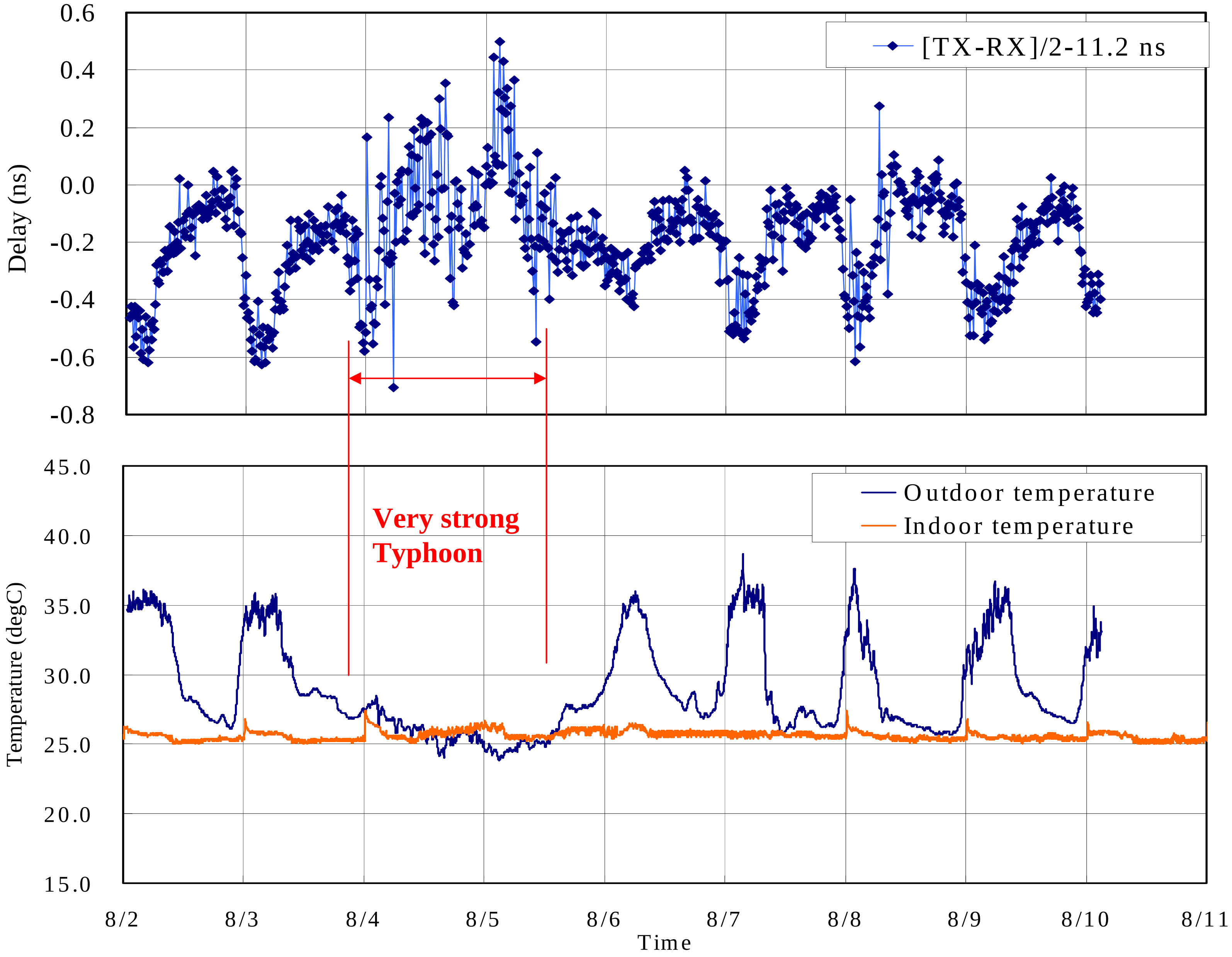
(TX-RX)/2 results (2.5MChip & hourly schedule)







(TX-RX)/2 results vs. Temperature (2.5MChip & 15-min schedule)



Correlation between the delays and temperature

(2.5MChip & 15-min schedule)

correlation coefficient $\rho_{XY} = \frac{\sigma_{XY}}{\sigma_X \sigma_Y}$ *, and* $\sigma_{XY} = \frac{\sum (X_i - \mu_X)(Y_i - \mu_Y)}{N}$

Correlation coefficient	(TX-RX)/2	TX	RX
Outdoor temperature	-0.81	-0.59	0.78
Indoor temperature	-0.43	-0.27	0.45

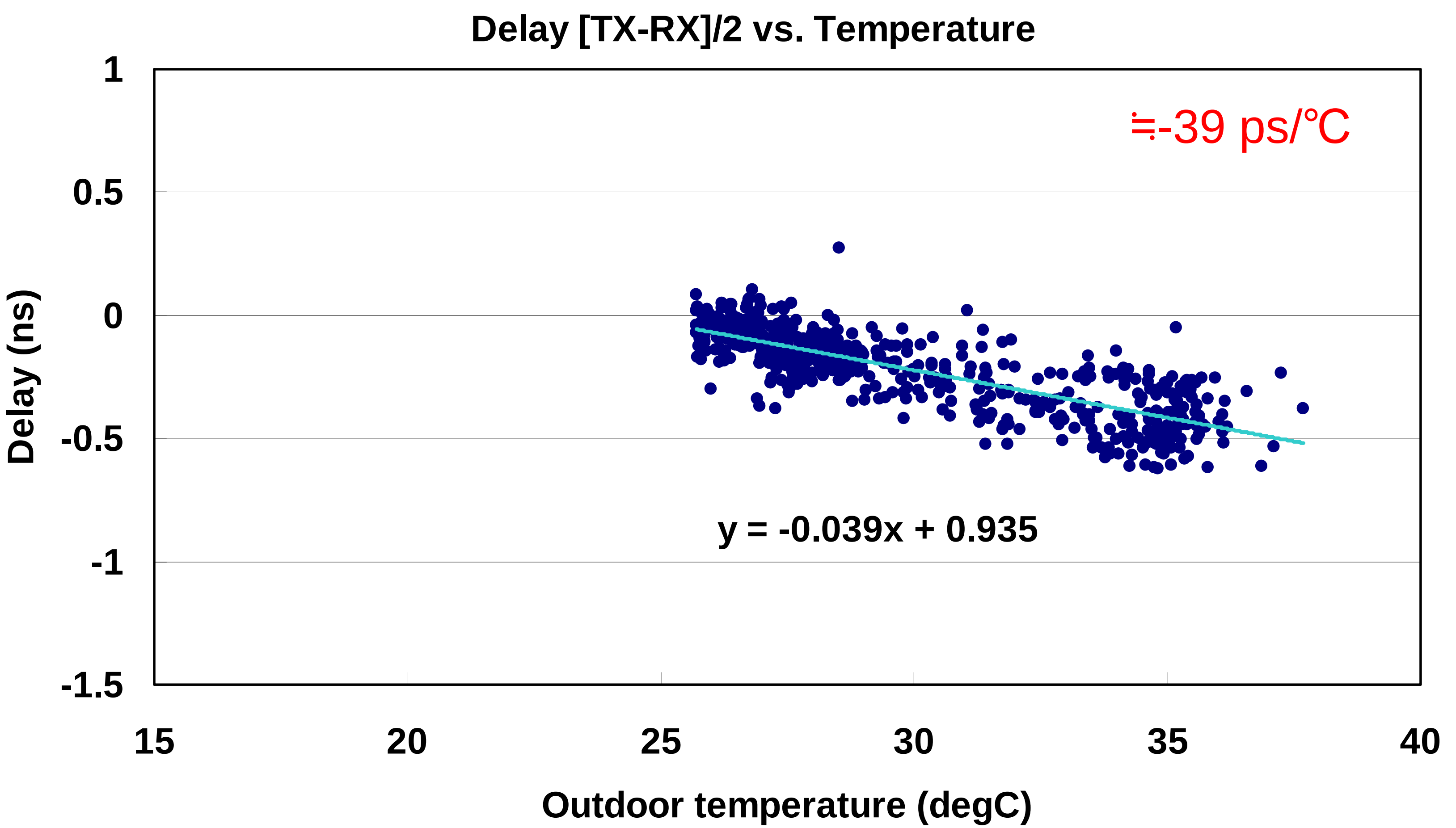
Correlation coefficient	s2	s3	s4	s5	s6	s7(RTD)
Outdoor temperature	-0.33	-0.25	-0.30	-0.31	0.77	0.48
Indoor temperature	-0.01	0.06	0.01	0.01	0.47	0.33

Correlation coefficient	Indoor temperature
Outdoor temperature	0.44

*The analysis didn't include the data during the typhoon.

Temperature dependence of the differential delay (TX-RX)/2

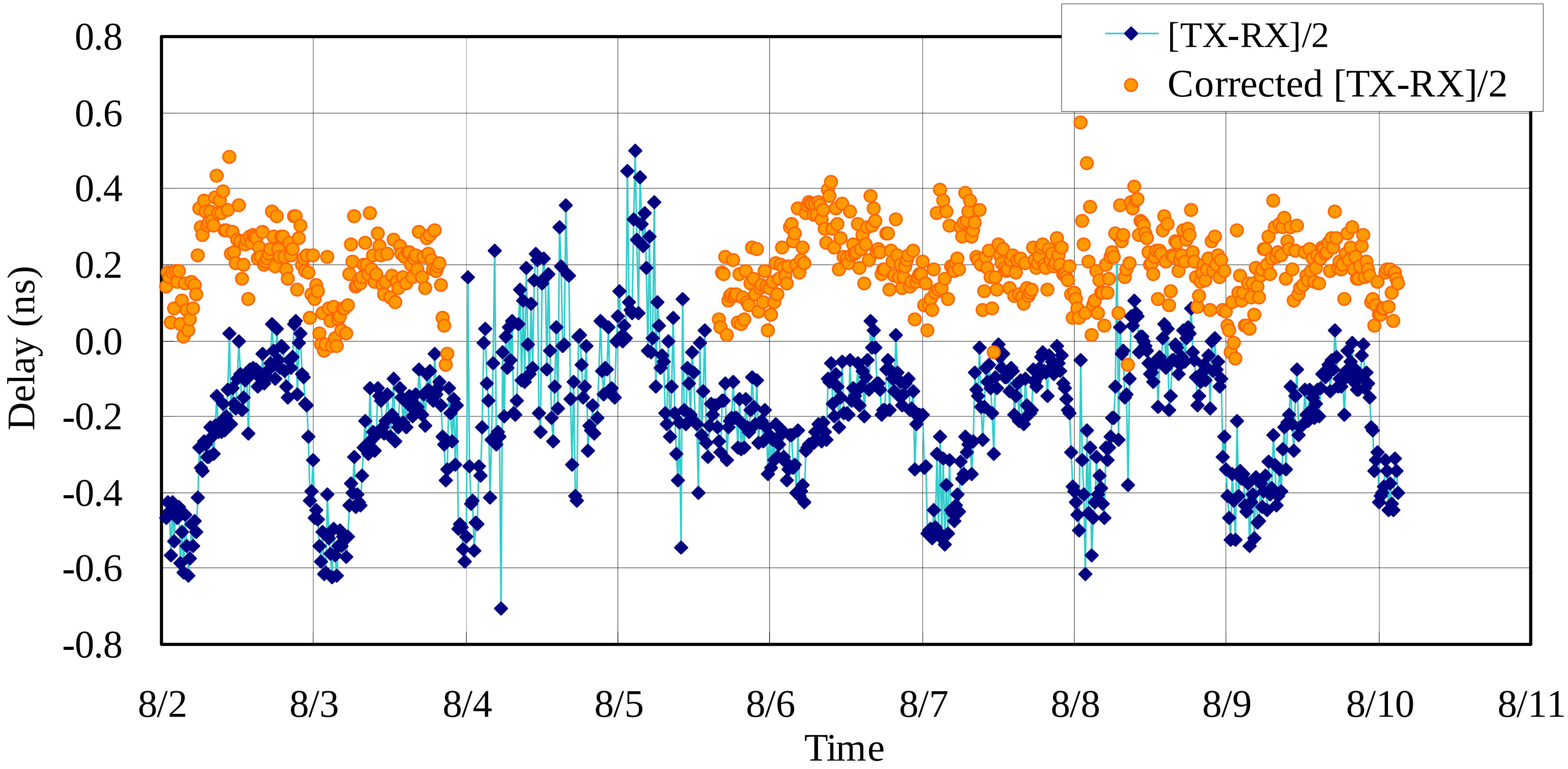
(2.5MChip & 15-min schedule)



*The analysis didn't include the data during the typhoon.

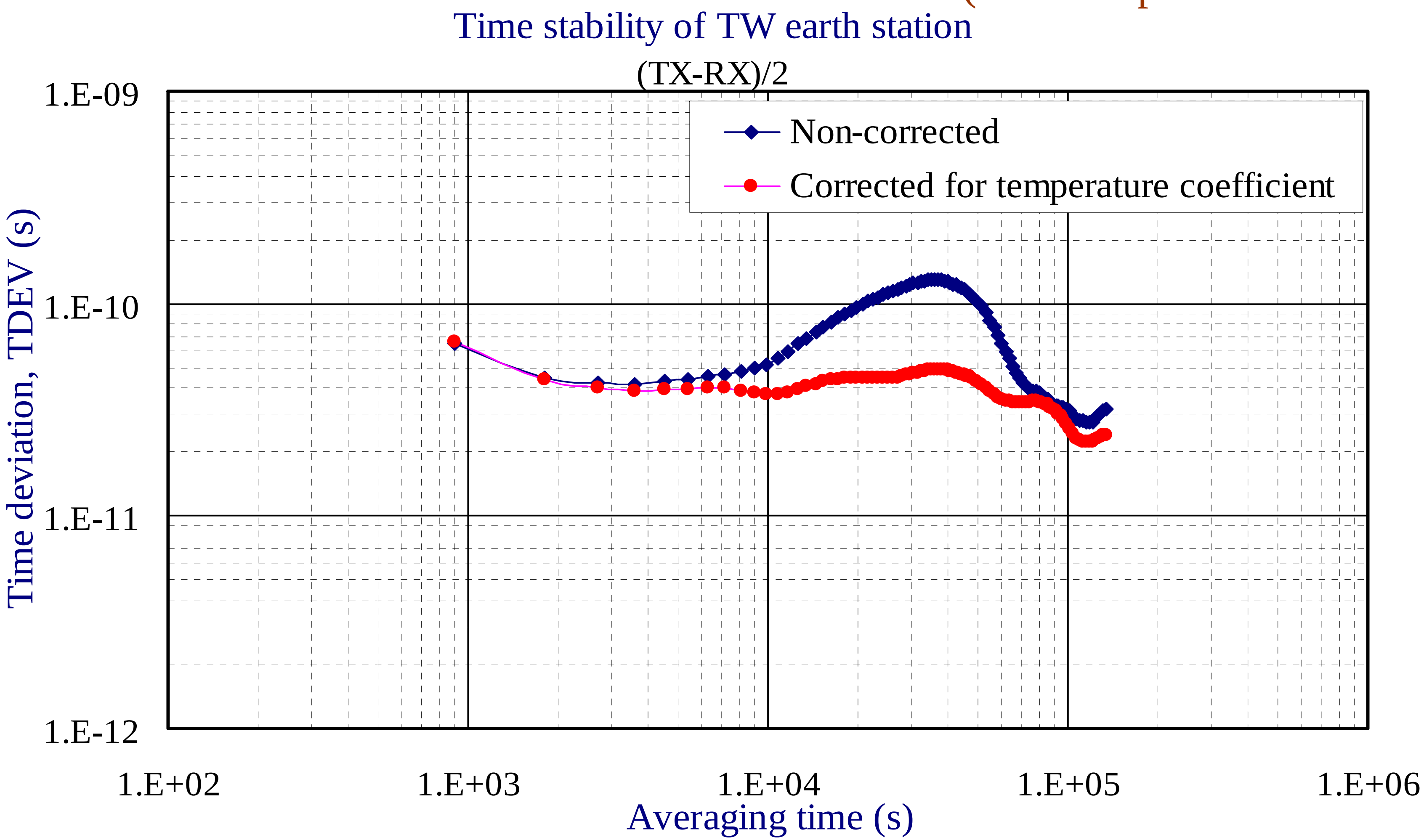
Differential delay corrected for the temperature coefficient

(2.5MChip & 15-min schedule)

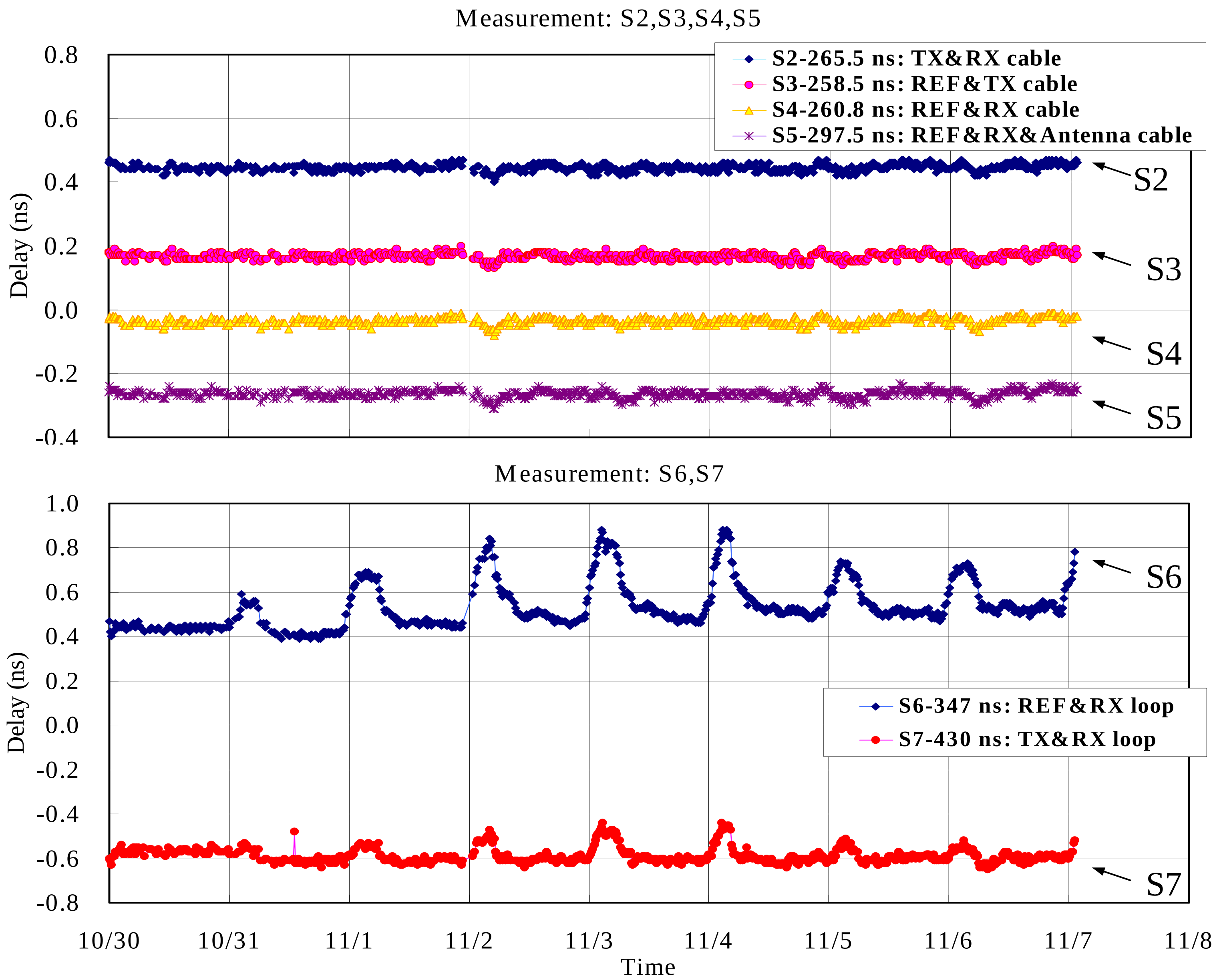


Comparison between of corrected and non-corrected differential delay

(2.5MChip & 15-min schedule)

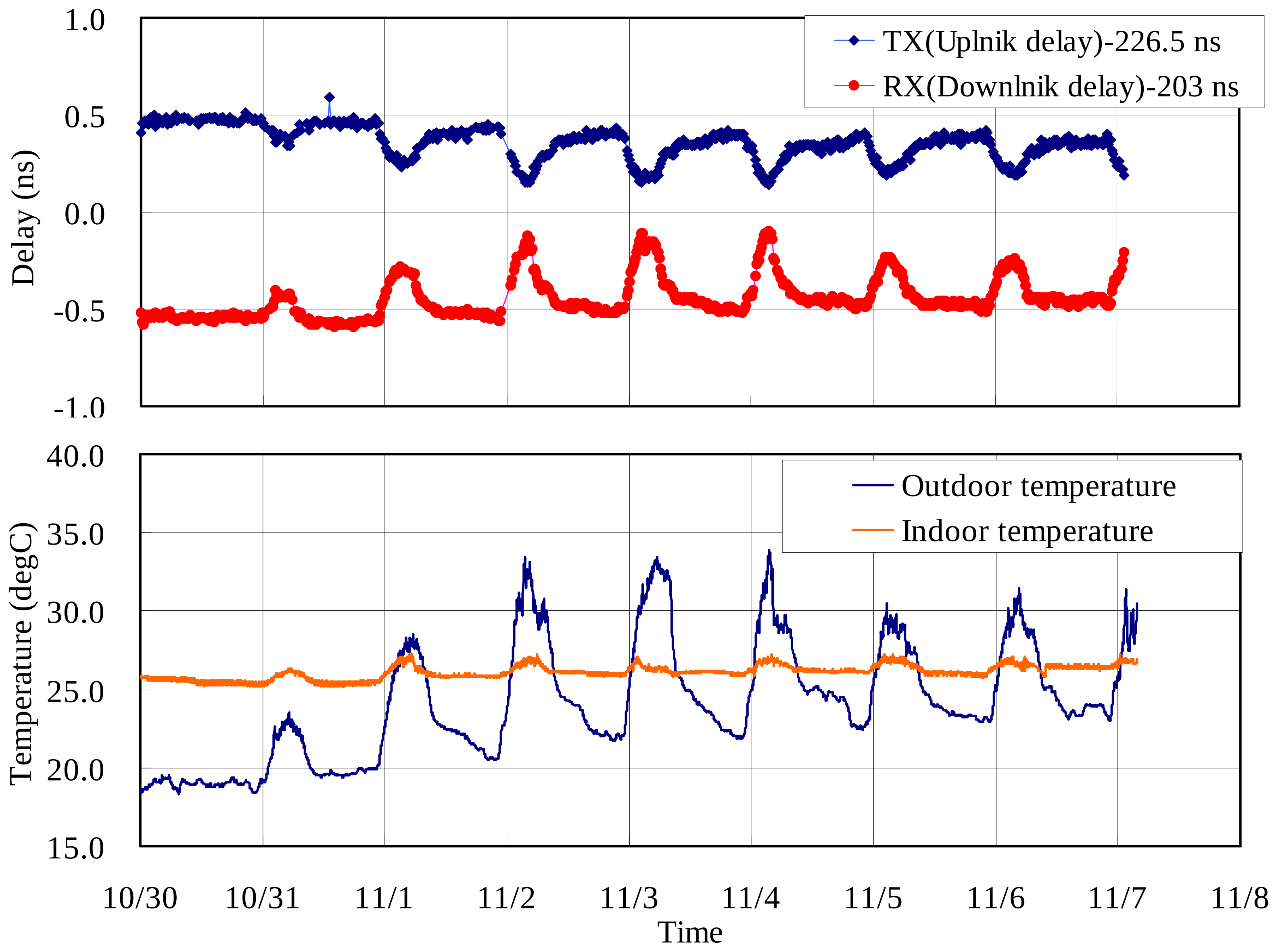


20MChip measurements with 15-minute schedule

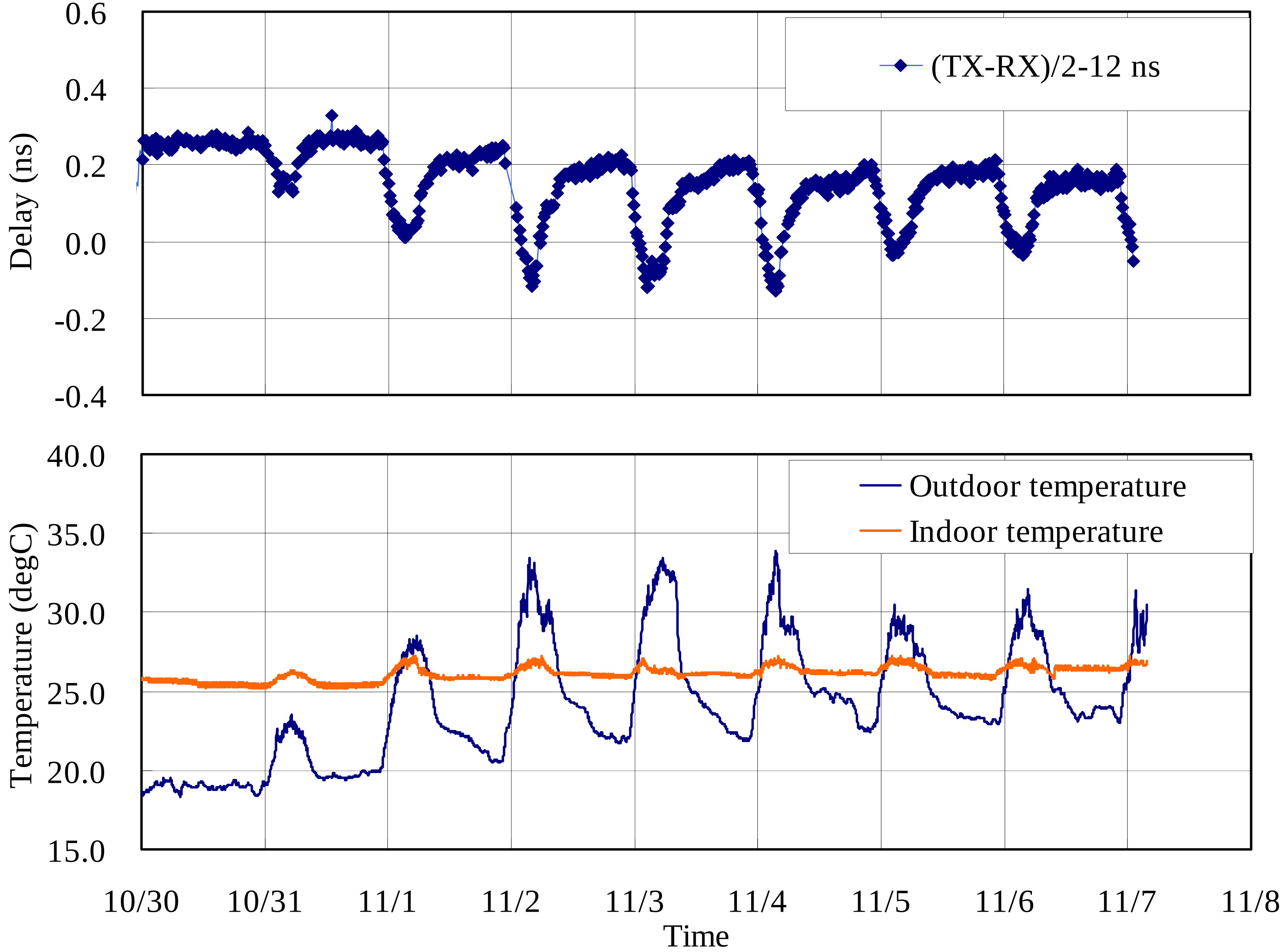


TX and RX delay

(20MChip & 15-min schedule)



(TX-RX)/2 results vs. Temperature (20MChip & 15-min schedule)



Correlation between the delays and temperature

(20MChip & 15-min schedule)

correlation coefficient $\rho_{XY} = \frac{\sigma_{XY}}{\sigma_X \sigma_Y}$ *, and* $\sigma_{XY} = \frac{\sum (X_i - \mu_X)(Y_i - \mu_Y)}{N}$

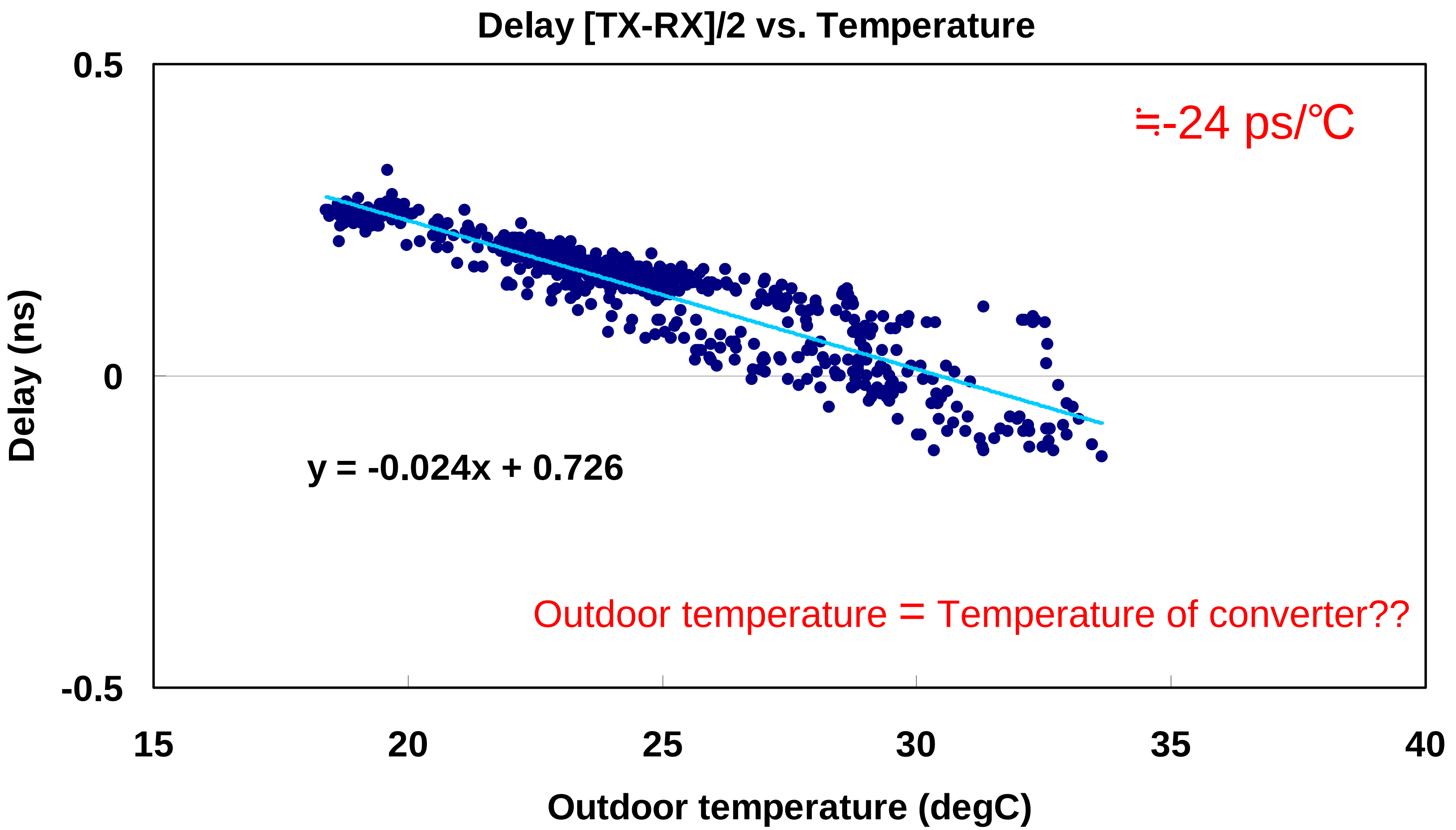
Correlation coefficient	(TX-RX)/2	TX	RX
Outdoor temperature	-0.92	-0.93	0.89
Indoor temperature	-0.85	-0.88	0.81

Correlation coefficient	s2	s3	s4	s5	s6	s7(RTD)
Outdoor temperature	-0.22	-0.22	-0.20	-0.35	0.88	0.43
Indoor temperature	-0.10	-0.12	-0.08	-0.20	0.81	0.32

Correlation coefficient	Indoor temperature
Outdoor temperature	0.84

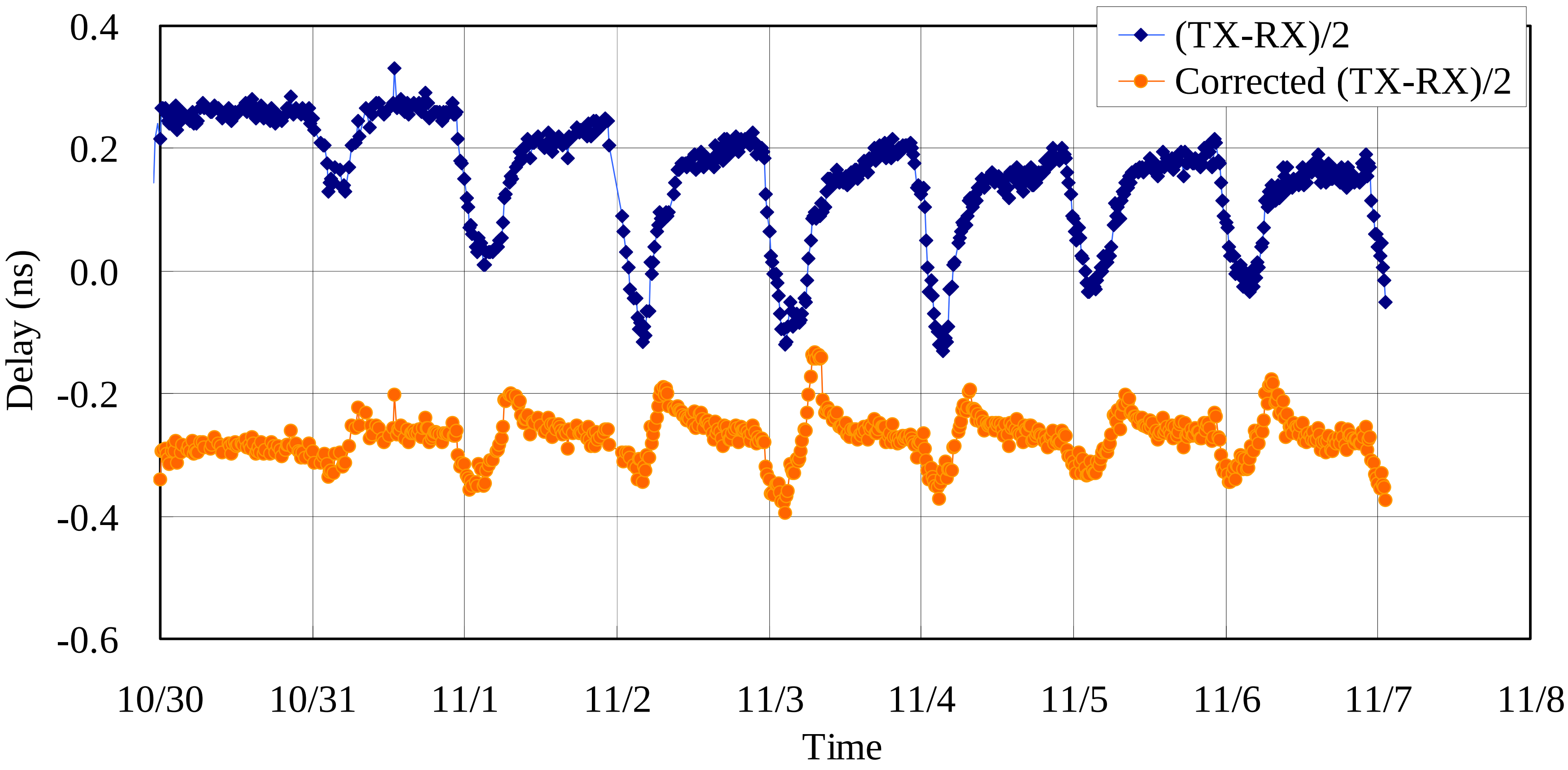
Temperature dependence of the differential delay (TX-RX)/2

(20MChip & 15-min schedule)



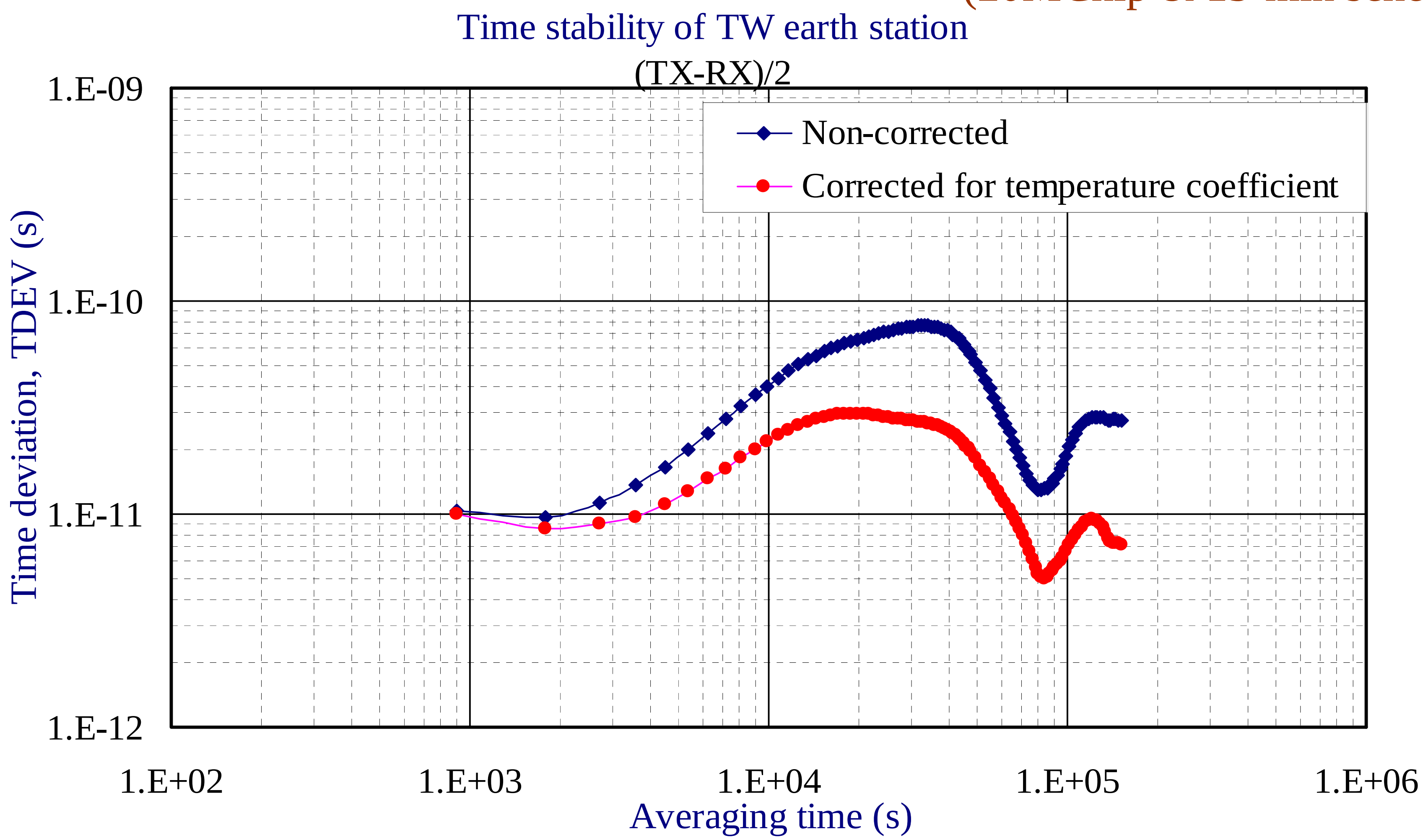
Differential delay corrected for the temperature coefficient

(20MChip & 15-min schedule)



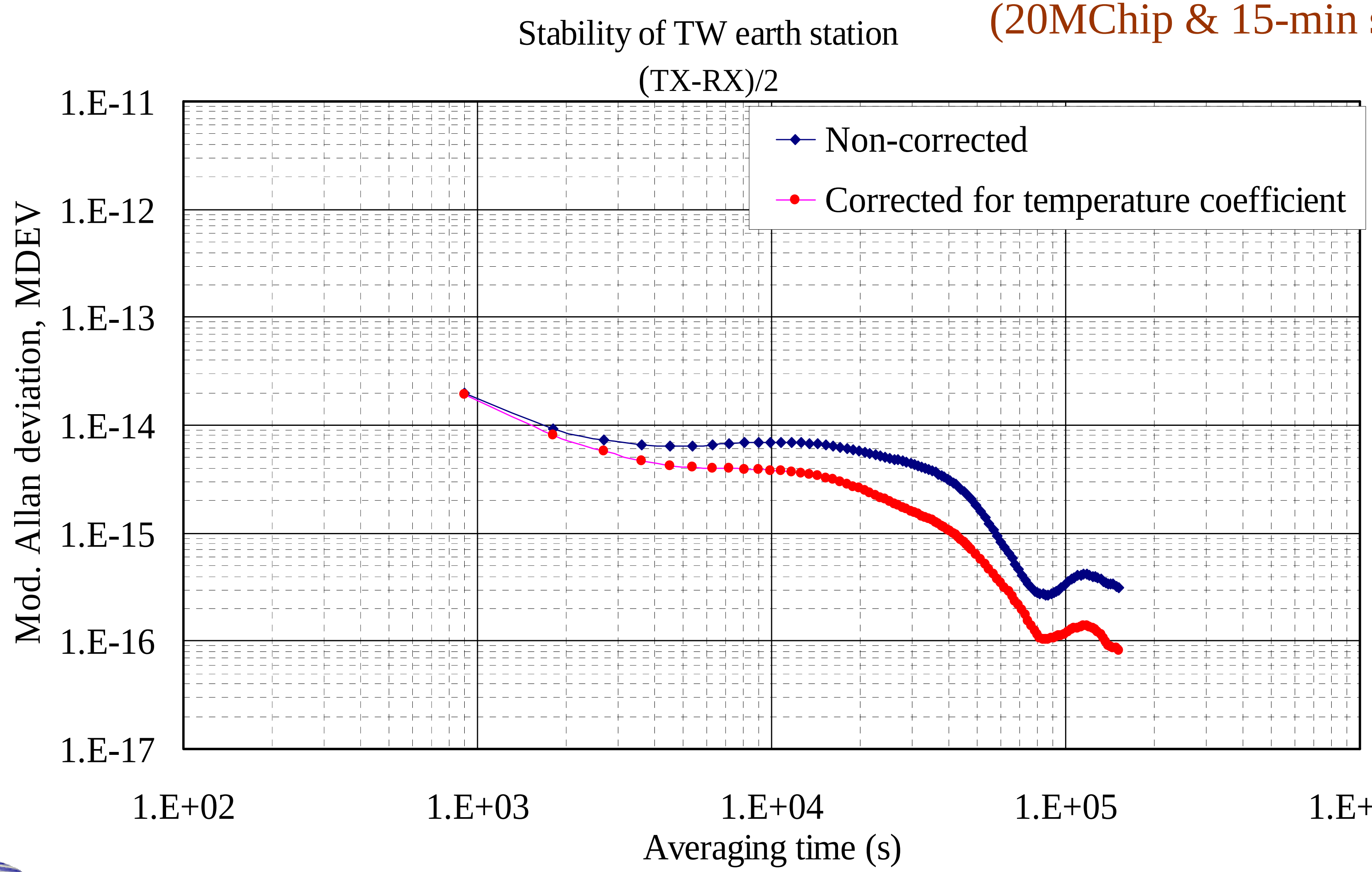
Comparison between of corrected and non-corrected differential delay

(20MChip & 15-min schedule)



Comparison between of corrected and non-corrected differential delay

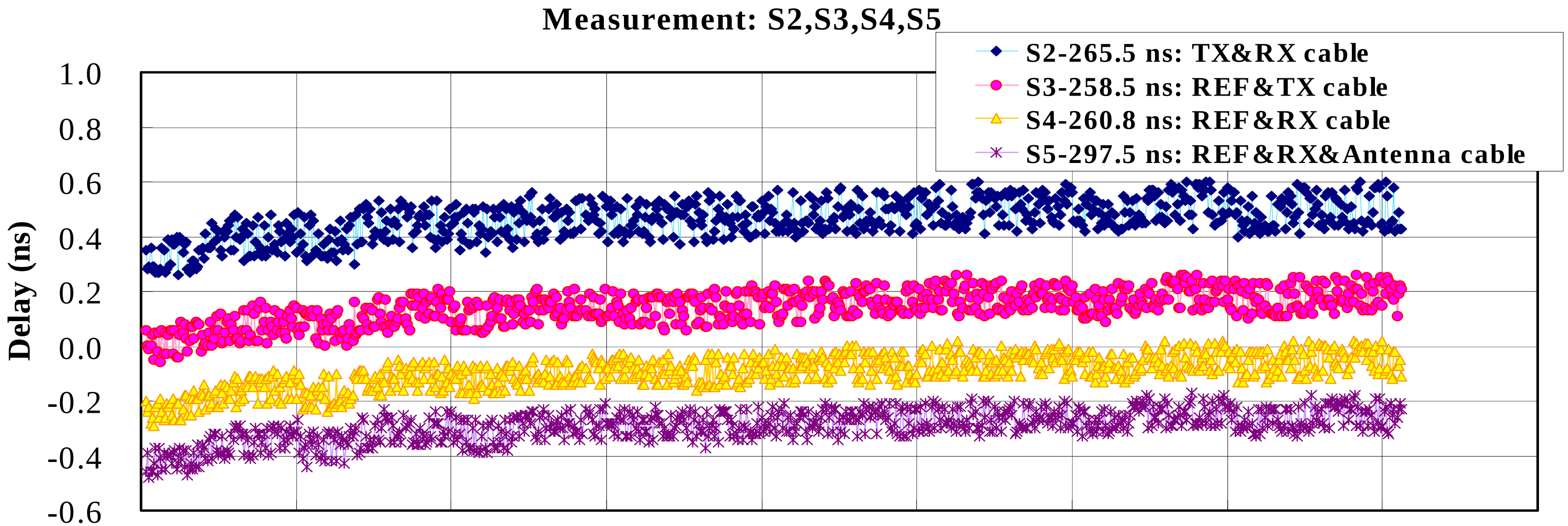
(20MChip & 15-min schedule)

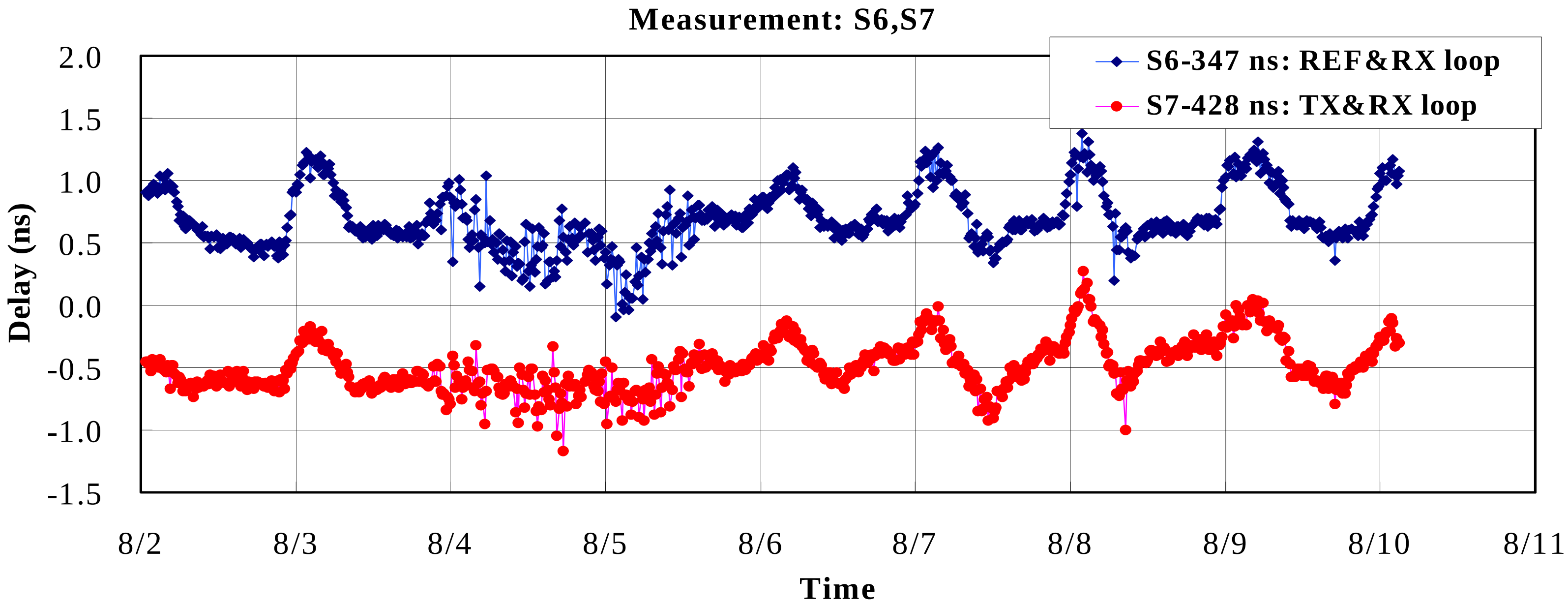


Acknowledgment

Thank Dr. Gerrit de Jong and Dr. Alexander Pawlitzki (TimeTech) for many useful suggestions.

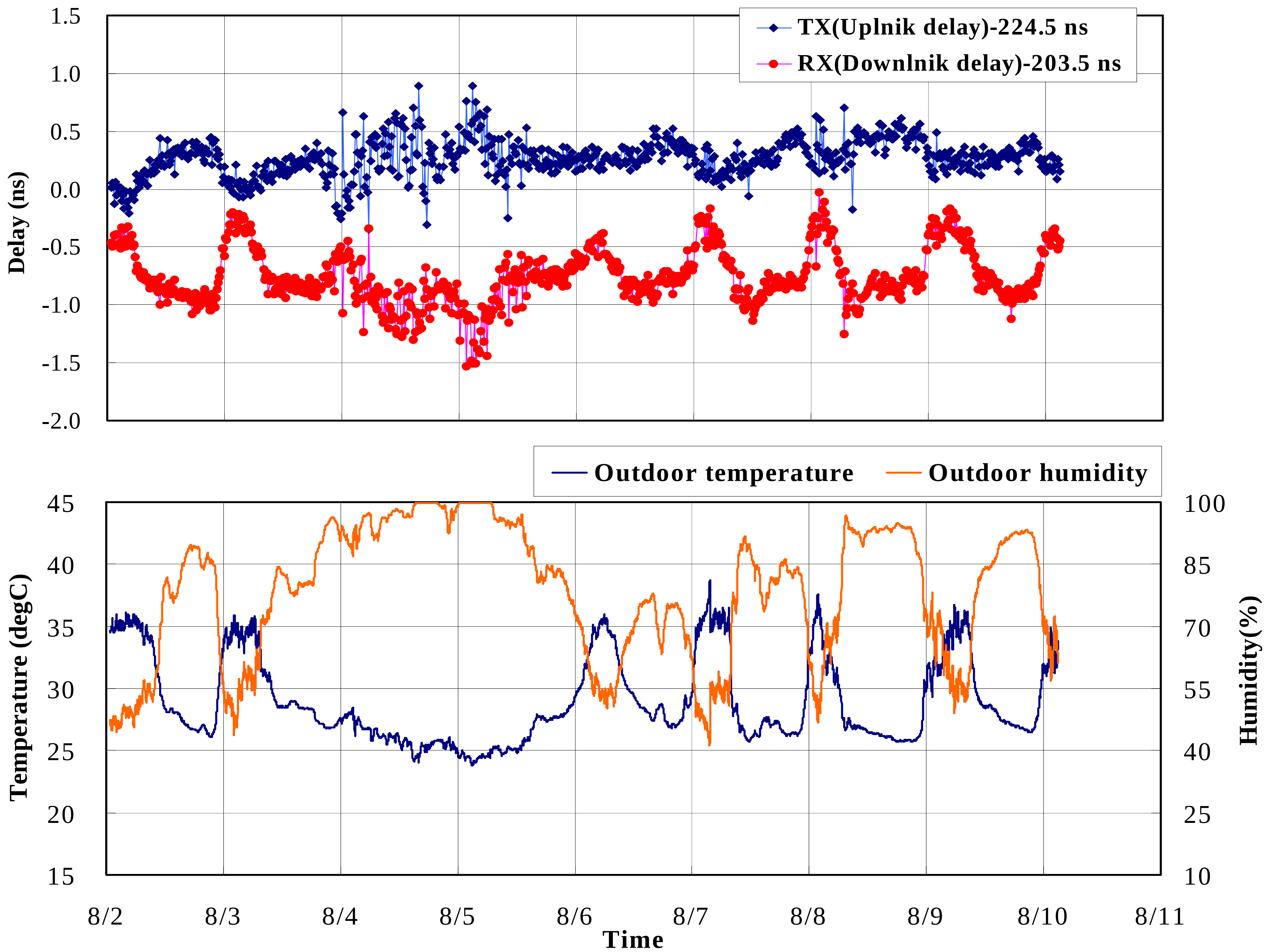
2.5MChip measurements with 15-minute schedule





TX and RX delay

(2.5MChip & 15-min schedule)



Comparison between of corrected and non-corrected differential delay

(2.5MChip & 15-min schedule)