

# TL TWSTFT Status Report

Huang-Tien Lin and Chia-Shu Liao

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

20th Meeting of the CCTF WG on TWSTFT  
6-7 Sep. 2012, BIPM



# Clocks and Time Scales

➤ **Cesium clocks ensemble:**

**Symmetricom 5071A (high performance tube) × 13**

*-Running: 13 clocks*

*-Under fixing: 1 clock*

**TA(TL) is generated by 12 Cs-Clocks**

➤ **Active H-masers:**

**Kvarz CH1-75 × 2 (without CAT)**

**iMaser-3000 (with CAT)**

➤ **Time Scale:**



iMaser 3000

5 MHz

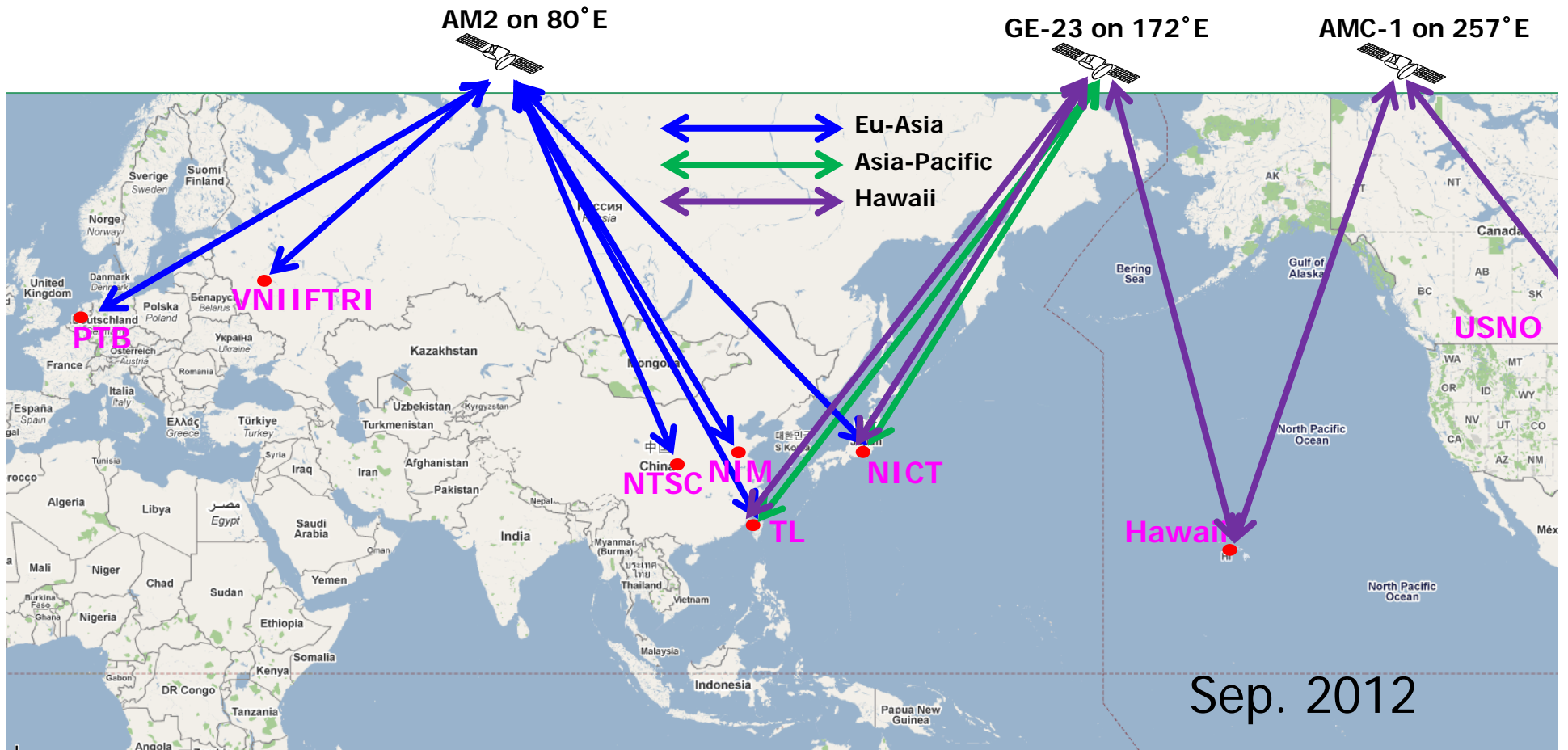
**AOG-110**

Steered base on UTC and TA(TL)

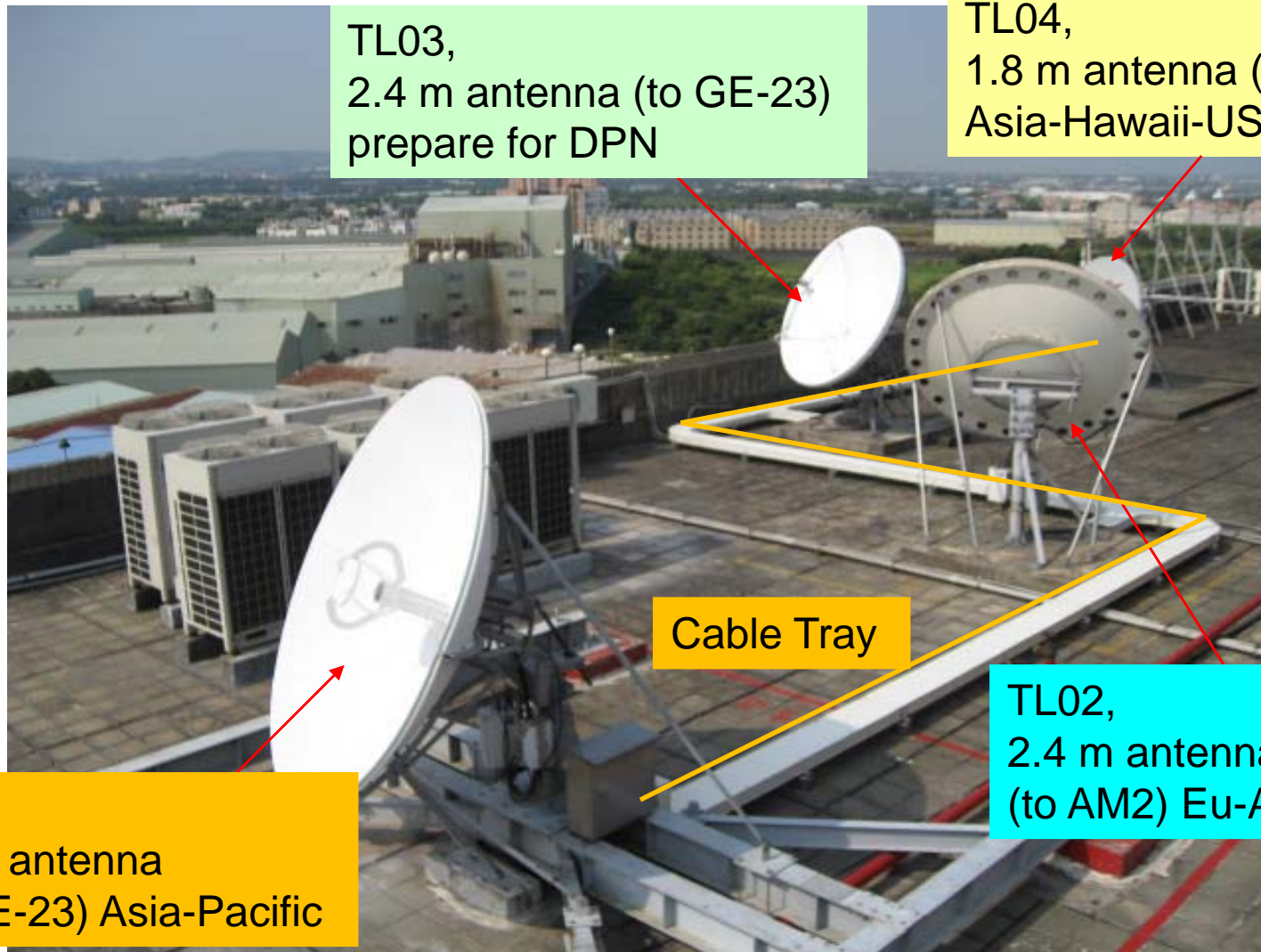
**UTC(TL)**



# TWSTFT Links



# Antennas



TL03,  
2.4 m antenna (to GE-23)  
prepare for DPN

TL04,  
1.8 m antenna (to GE-23)  
Asia-Hawaii-USNO link

Cable Tray

TL01,  
2.4 m antenna  
(to GE-23) Asia-Pacific

TL02,  
2.4 m antenna  
(to AM2) Eu-Asia



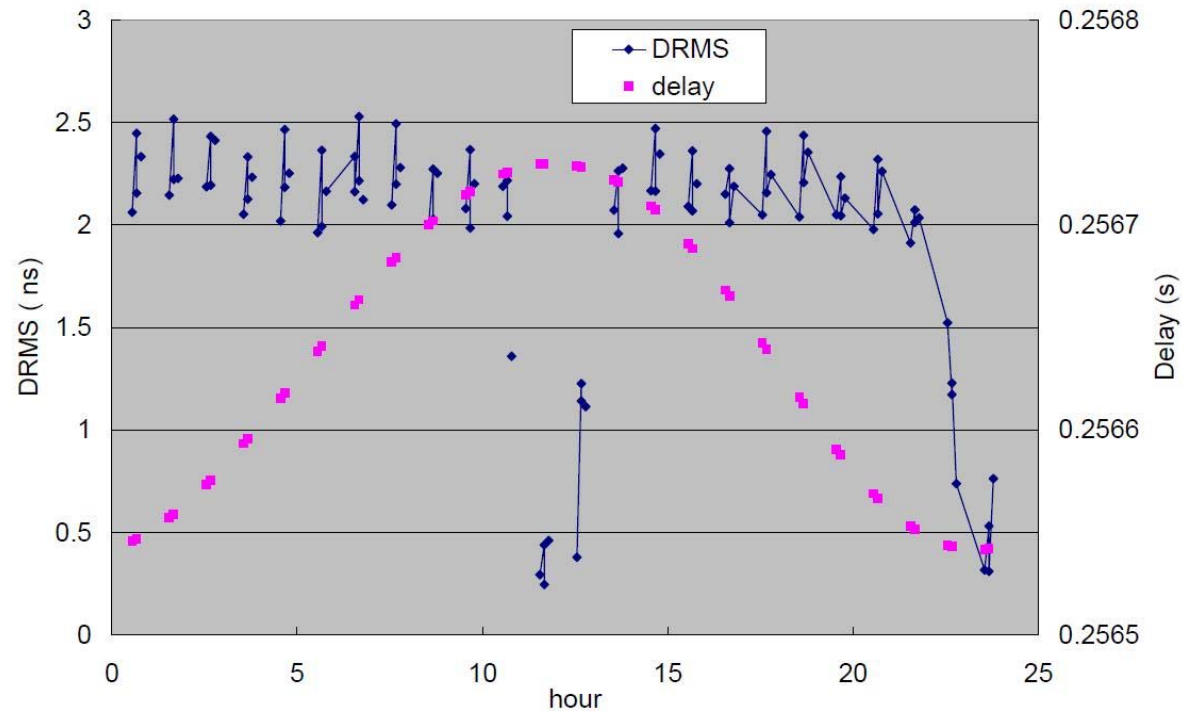
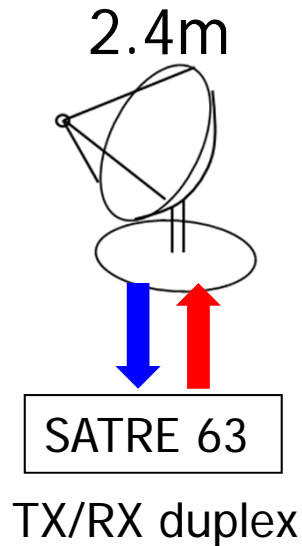
# Earth Stations

Station	TL01	TL02	TL03	TL04
Link	Asia	Eu-Asia	Prepare for DPN	Asia-Hawaii-USNO link (Since April 2012)
Satellite	GE-23	AM2	GE-23	GE-23
Antenna Size	2.4 m	2.4 m	2.4 m	1.8 m
Transceiver	CODAN 5900	CODAN 5900	CODAN 5900	CODAN 5900
Band	Ku, band1	Ku, band1	Ku, band3	Ku, band1
Modem	NICT modem (multi-channel)	SATRE 66 (single channel)	AWG and Sampler	SATRE 63 (multi-channel)
Participants	NICT	PTB, NIM, NTSC, NICT, VNIIFTRI	NICT	NICT, KPGO, USNO
Internal delay measurement	SR620	SR620	N/A	SATRE 63

# Measurement results of TL-Hawaii link

* EARTH-STAT	LI	MJD	STTIME	NTL	TW	DRMS	SMP	ATL	REFDELAY	RSIG	CI	S	CALR	ESDVAR	ESIG	TMP	HUM	PRES	
* LOC	REM		hhmmss	s	s	ns	s	s	s	ns			ns	ns	ns	degC	%	mbar	
TL04	NICT05	15	56144	084000	299	+0.256701798954	1.867	300	299	+0.000000703825	0.007	999	9	999999999	999999999	99999	29	70	981
TL04	KPG001	15	56144	084700	299	+0.382130826720	2.033	289	288	+0.000000703830	0.005	999	9	999999999	999999999	99999	29	69	981
TL04	TL04	15	56144	084700	299	+0.259332878966	1.940	300	299	+0.000000703829	0.005	999	9	999999999	999999999	99999	29	69	981
TL04	KPG001	15	56144	093300	299	+0.059715709738	2.045	300	299	+0.000000703837	0.002	999	9	999999999	999999999	99999	29	70	982
TL04	NICT05	15	56144	093300	299	+0.256714601086	1.842	300	299	+0.000000703837	0.002	999	9	999999999	999999999	99999	29	70	982
TL04	TL04	15	56144	094000	299	+0.259344847979	2.017	299	299	+0.000000703824	0.013	999	9	999999999	999999999	99999	29	70	982
TL04	NICT05	15	56144	094000	299	+0.256715955737	1.737	299	299	+0.000000703824	0.013	999	9	999999999	999999999	99999	29	70	982
TL04	KPG001	15	56144	094700	299	+0.059719033412	1.982	274	274	+0.000000703843	0.002	999	9	999999999	999999999	99999	28	72	982
TL04	TL04	15	56144	094700	299	+0.259346066599	1.857	299	299	+0.000000703843	0.002	999	9	999999999	999999999	99999	28	72	982
TL04	KPG001	15	56144	103300	299	+0.382155839454	1.851	300	299	+0.000000703864	0.011	999	9	999999999	999999999	99999	28	76	982
TL04	NICT05	15	56144	103300	299	+0.256723529091	0.928	300	299	+0.000000703864	0.011	999	9	999999999	999999999	99999	28	76	982
TL04	TL04	15	56144	104000	299	+0.259352616750	1.269	300	299	+0.000000703850	0.008	999	9	999999999	999999999	99999	27	77	982
TL04	NICT05	15	56144	104000	299	+0.256724175723	1.073	300	299	+0.000000703850	0.008	999	9	999999999	999999999	99999	27	77	982
TL04	KPG001	15	56144	104700	299	+0.382157857190	1.964	300	299	+0.000000703866	0.012	999	9	999999999	999999999	99999	27	79	982
TL04	TL04	15	56144	104700	299	+0.259353104062	0.657	300	299	+0.000000703866	0.012	999	9	999999999	999999999	99999	27	79	982
TL04	KPG001	15	56144	113300	299	+0.382162290241	0.555	300	299	+0.000000703864	0.005	999	9	999999999	999999999	99999	27	80	982
TL04	NICT05	15	56144	113300	299	+0.256726382822	0.264	300	299	+0.000000703864	0.005	999	9	999999999	999999999	99999	27	80	982
TL04	TL04	15	56144	114000	299	+0.259354196330	0.403	299	299	+0.000000703879	0.007	999	9	999999999	999999999	99999	27	80	982
TL04	NICT05	15	56144	114000	299	+0.256726330414	0.247	299	299	+0.000000703879	0.007	999	9	999999999	999999999	99999	27	80	982
TL04	KPG001	15	56144	114700	299	+0.382162983242	0.318	294	293	+0.000000703859	0.011	999	9	999999999	999999999	99999	27	79	982
TL04	TL04	15	56144	114700	299	+0.259353980823	0.493	300	299	+0.000000703859	0.011	999	9	999999999	999999999	99999	27	79	982
TL04	KPG001	15	56144	123300	299	+0.382163158837	0.353	300	299	+0.000000703857	0.010	999	9	999999999	999999999	99999	27	79	982
TL04	NICT05	15	56144	123300	299	+0.256723511900	0.762	300	299	+0.000000703857	0.010	999	9	999999999	999999999	99999	27	79	982
TL04	TL04	15	56144	124000	299	+0.259350028850	1.993	300	299	+0.000000703862	0.006	999	9	999999999	999999999	99999	27	80	982
TL04	NICT05	15	56144	124000	299	+0.256722836397	1.674	300	299	+0.000000703862	0.006	999	9	999999999	999999999	99999	27	80	982
TL04	KPG001	15	56144	124700	299	+0.382162608431	0.501	298	297	+0.000000703852	0.016	999	9	999999999	999999999	99999	27	79	982
TL04	TL04	15	56144	124700	299	+0.259349193895	1.709	300	299	+0.000000703852	0.017	999	9	999999999	999999999	99999	27	79	982
TL04	KPG001	15	56144	133300	299	+0.083652941792	1.250	300	299	+0.000000703848	0.007	999	9	999999999	999999999	99999	26	80	982
TL04	NICT05	15	56144	133300	299	+0.256715650229	1.621	300	299	+0.000000703848	0.007	999	9	999999999	999999999	99999	26	80	982
TL04	TL04	15	56144	134000	299	+0.259340923683	1.848	300	299	+0.000000703871	0.010	999	9	999999999	999999999	99999	27	79	982
TL04	NICT05	15	56144	134000	299	+0.256714449441	1.687	300	299	+0.000000703871	0.010	999	9	999999999	999999999	99999	27	79	982
TL04	KPG001	15	56144	134700	299	+0.083651298389	1.644	297	297	+0.000000703865	0.006	999	9	999999999	999999999	99999	27	78	982
TL04	TL04	15	56144	134700	299	+0.259339575560	1.690	299	299	+0.000000703865	0.006	999	9	999999999	999999999	99999	27	78	982
TL04	KPG001	15	56144	143300	299	+0.382150343067	1.748	299	299	+0.000000703863	0.006	999	9	999999999	999999999	99999	26	77	982
TL04	NICT05	15	56144	143300	299	+0.256703713986	1.706	299	299	+0.000000703863	0.006	999	9	999999999	999999999	99999	26	77	982
TL04	TL04	15	56144	144000	299	+0.259327843098	2.024	300	299	+0.000000703866	0.012	999	9	999999999	999999999	99999	26	78	982

# Improvement of TL-Hawaii link (1/5)



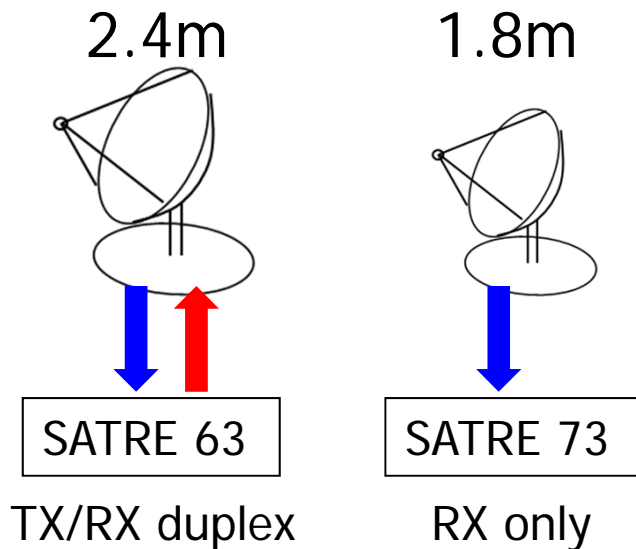
▲ One-way delay measurement vs. DRMS

Check the residual of the quadratic fit

The DRMS is often higher than 1.5ns

It became lower when the variation of delay values were small

# Improvement of TL-Hawaii link (2/5)

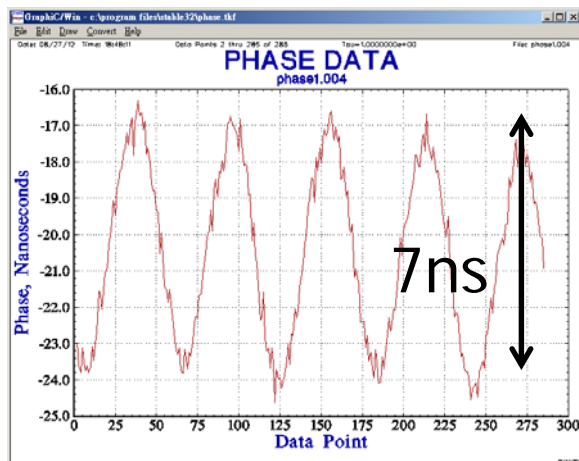


Maybe due to the station ...

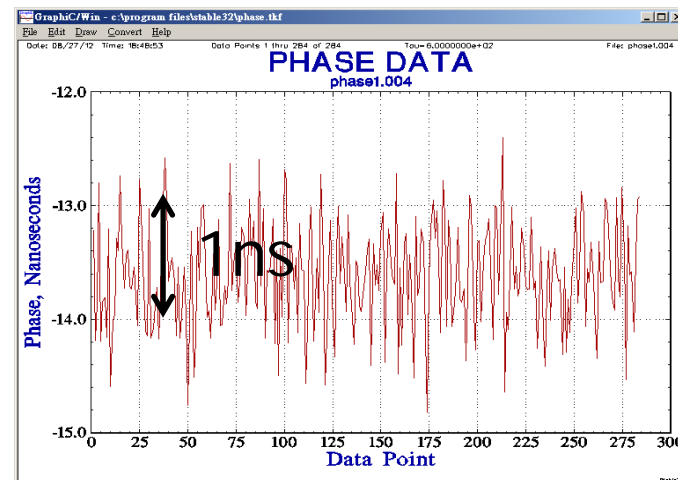
RX by the other 1.8m station

=> 2.4m + SATRE 63 is poor

=> 1.8m + SATRE 73 is normal



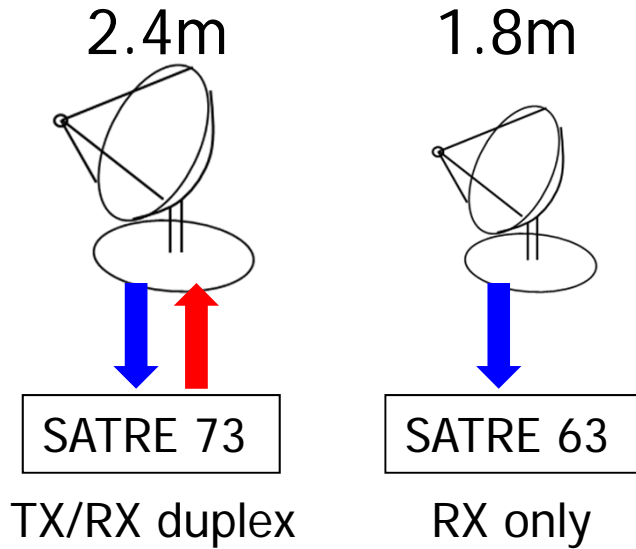
SATRE 63



SATRE 73



# Improvement of TL-Hawaii link (3/5)

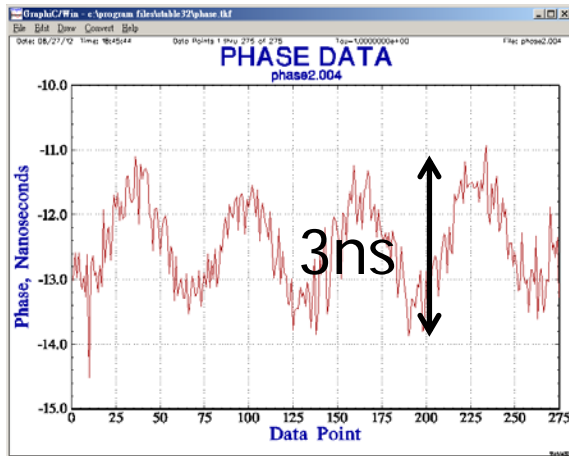


Maybe due to the modem ...

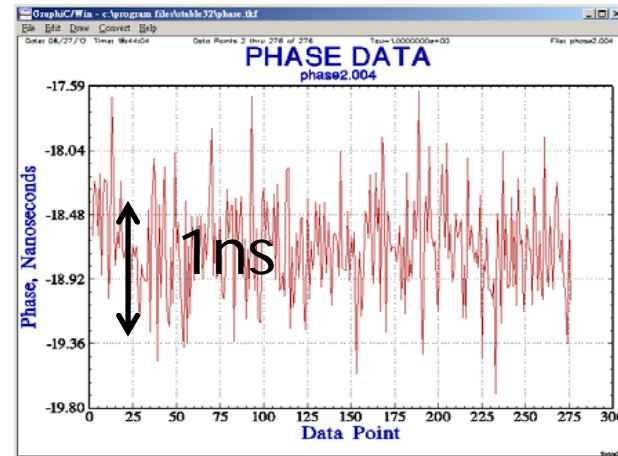
Exchange the modems

=> 2.4m + SATRE 73 is poor

=> 1.8m + SATRE 63 is normal

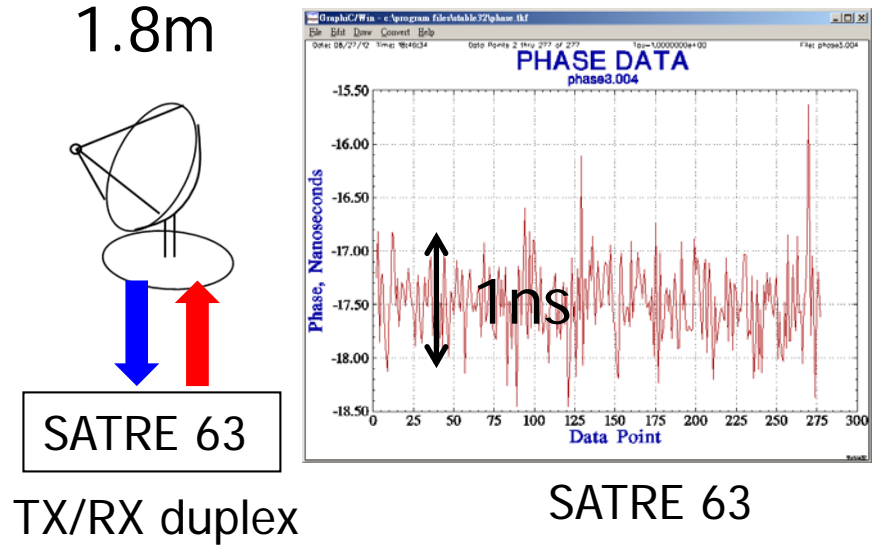
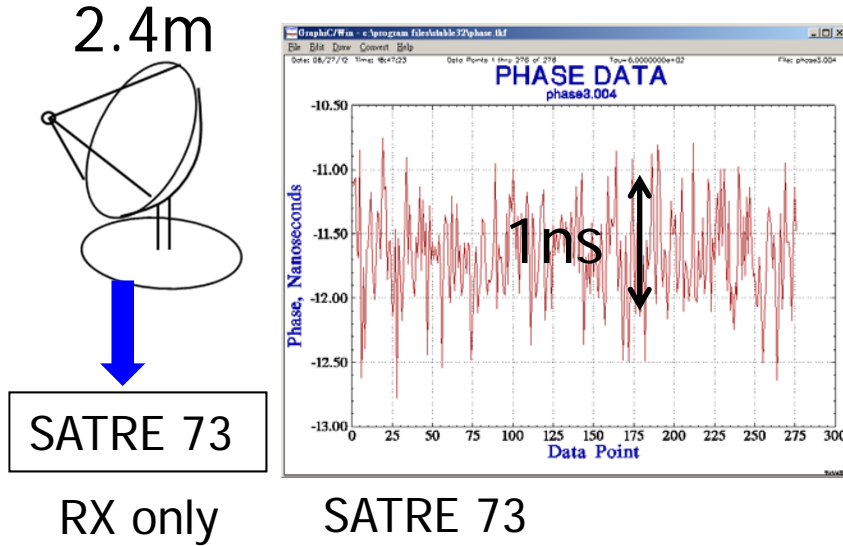


SATRE 73



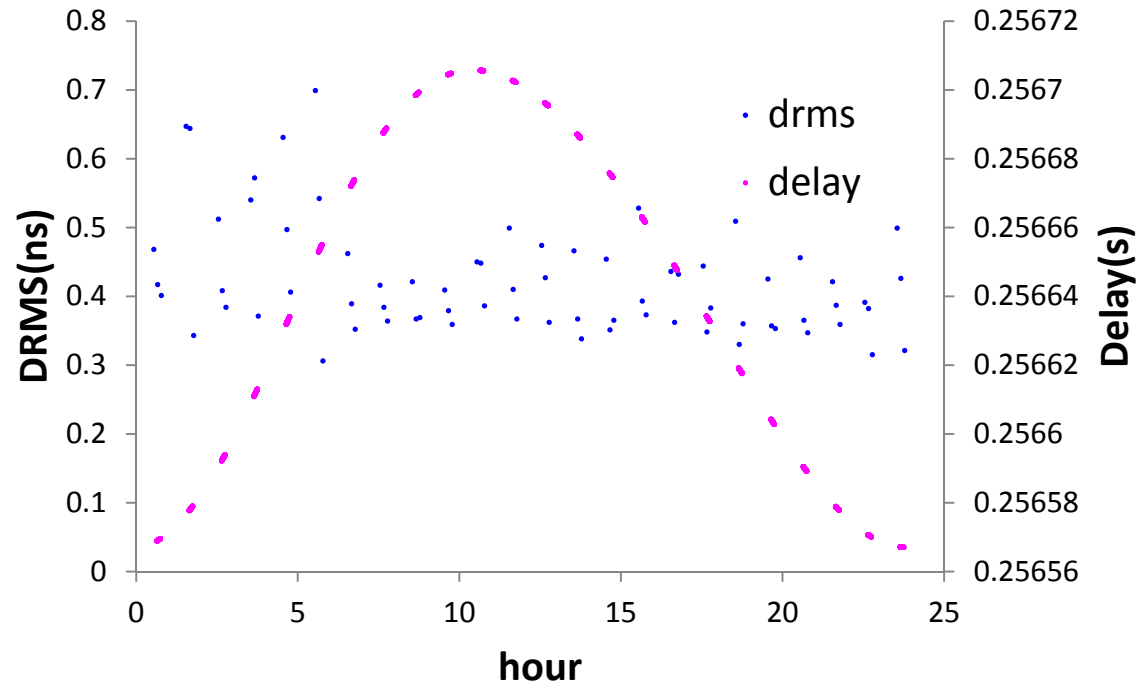
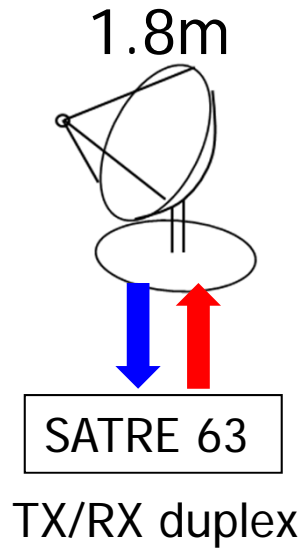
SATRE 63

# Improvement of TL-Hawaii link (4/5)



Maybe due to TX ... => Change TX to 1.8m station  
 => 2.4m + SATRE 73 is normal & 1.8m + SATRE 63 is normal  
 => TRF (Transmit Reject Filter)

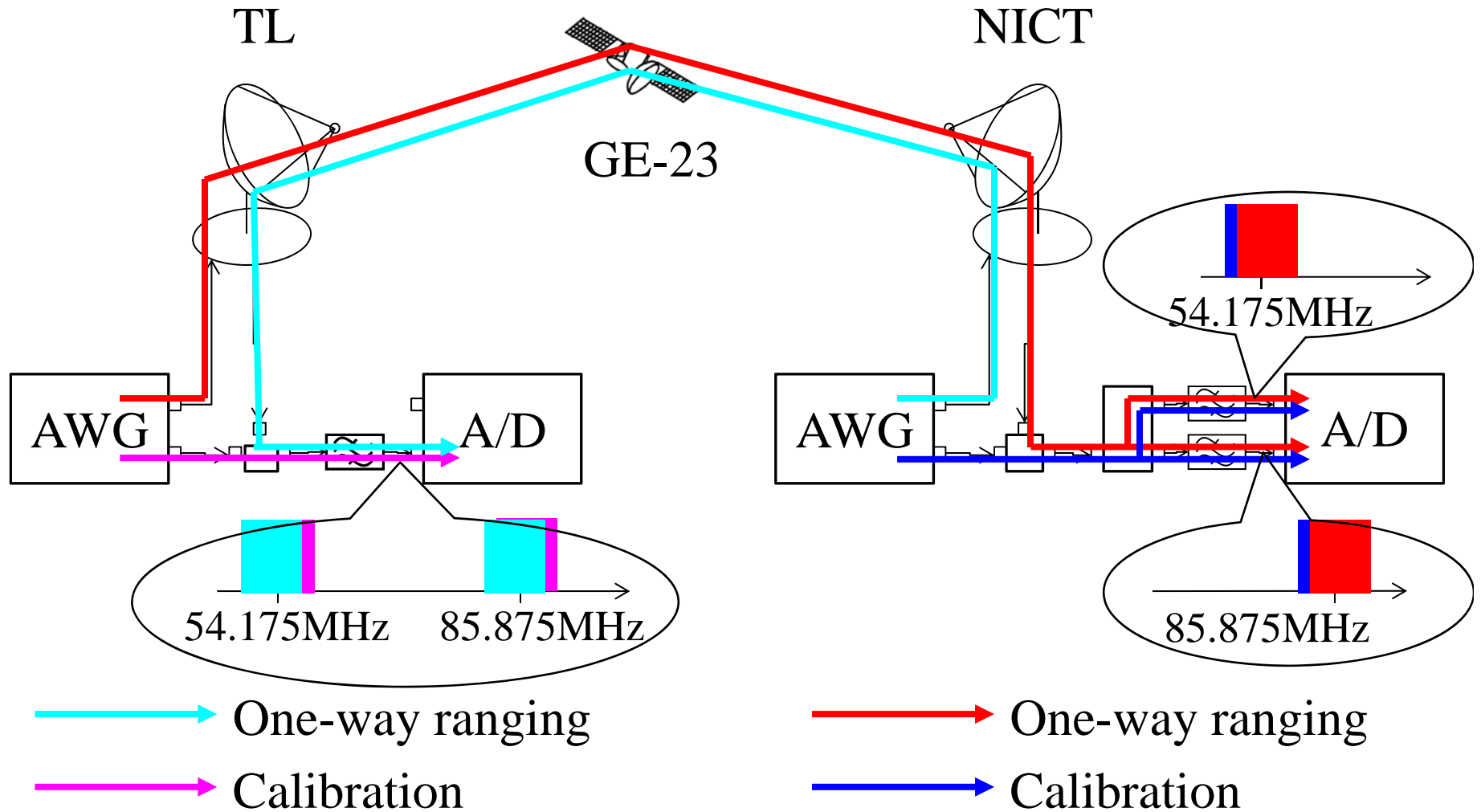
# Improvement of TL-Hawaii link (5/5)



▲ One-way delay measurement and its DRMS

The DRMS values were reduced after changing the station

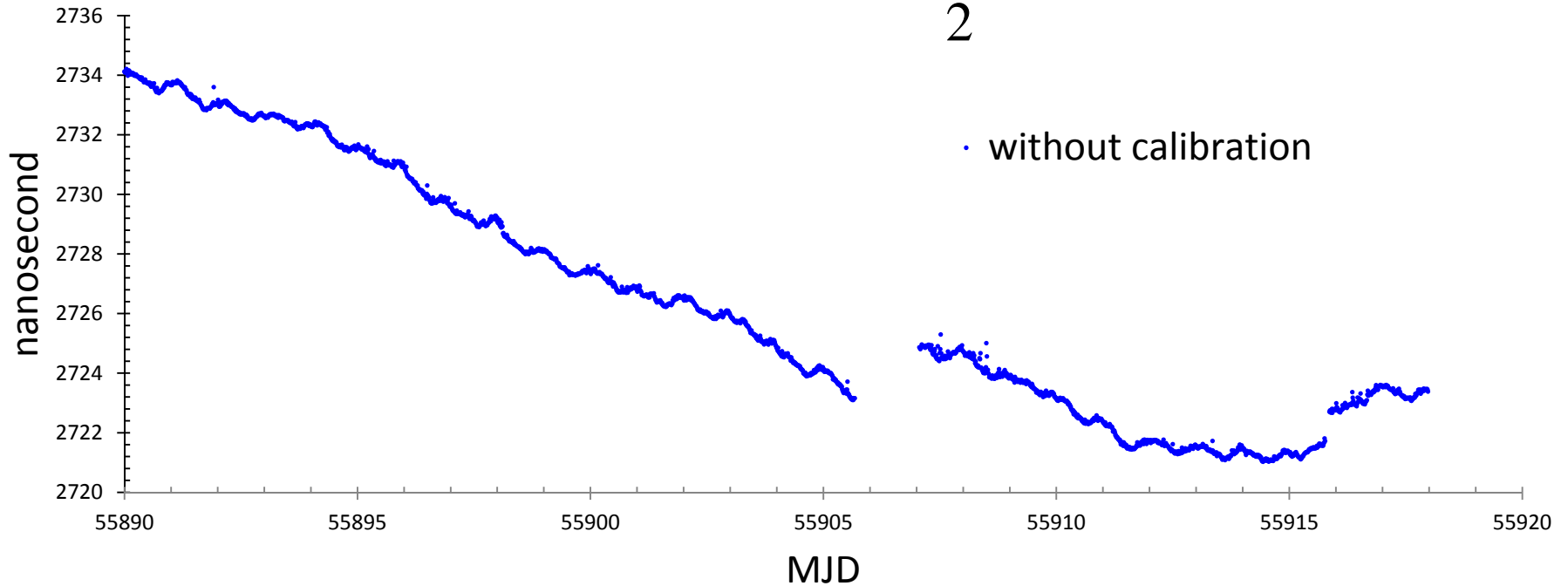
# Dual Pseudo-random Noise TWSTFT (1/3)



AWG: Arbitrary Waveform Generator

# Dual Pseudo-random Noise TWSTFT (2/3)

$$\text{UTC(TL)} - \text{UTC(NICT)} = \frac{\text{cyan arrow} - \text{red arrow}}{2}$$



cyan arrow → One-way ranging

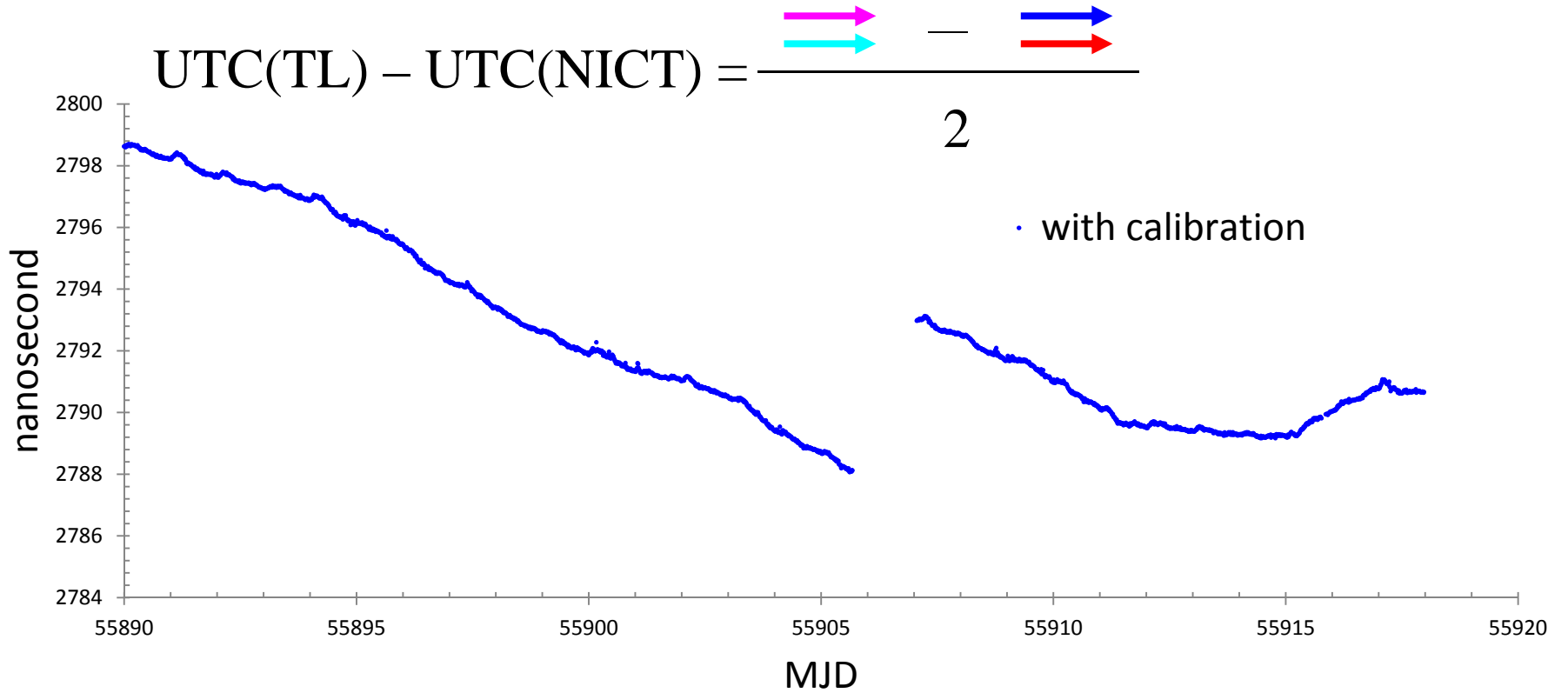
magenta arrow → Calibration

red arrow → One-way ranging

blue arrow → Calibration

By using the one-way ranging data, we got the conventional TWSTFT results.

# Dual Pseudo-random Noise TWSTFT (3/3)



cyan arrow → One-way ranging

red arrow → One-way ranging

magenta arrow → Calibration

blue arrow → Calibration

The DPN results show less diurnal than that of the conventional TWSTFT.

# TWSTFT Events in 2012

## Asia-Hawaii-USNO link:

- Use GE-23, perform experiment at hourly intervals
- **Continuous experiment with USNO and NICT**

## Asia-Pacific network:

- Transponder: Band 3 changed to Band 1
- Use GE-23, perform experiment at hourly intervals
- **Continuous experiment with NICT**

## Europe-Asia network:

- PTB-TL link has been adopted as one of the TAI links
- **Continuous experiments with PTB, NICT, NIM, NTSC and VNIIFTRI**



# Future Works

- TL will keep on cooperating with NICT in the study of DPN TWSTFT
- TL plan to start the study of carrier phase TWSTFT when we get new transceivers

***Thanks for your attention!***





# 2013 - The ATF Workshop

- The **ATF 2013 workshop** will be hosted as the joint sessions of the AP-RASC'13 conference



**AP-RASC' 13**  
2013 Asia-Pacific Radio Science Conference  
September 3-7, 2013, Taipei, Taiwan

**Ruey-Beei Wu, General Co-chair, AP-RASC'13**  
**Hung-Chun Chang, TPC Chair, AP-RASC'13**  
**Tzong-Lin Wu, Secretary, AP-RASC'13**  
Professors  
Department of Electrical Engineering  
National Taiwan University  
Taipei, Taiwan

## Session Topics:

- Calibration and dissemination in electromagnetic metrology
- Microwave frequency standards
- Time and frequency transfer
- Optical frequency standards
- Optical frequency measurement
- Other topics of commission A



# AP-RASC' 13

September 3-7, 2013, Taipei, Taiwan

## Draft Time Table

- Conference Dates : Sept. 3 (Tue) – Sept. 7 (Sat), 2013
- Submission Deadline of One-Page Abstracts : Feb. 28, 2013
- Acceptance Notification : April 30, 2013
- Submission Deadline of Extended Abstracts : July 15, 2013
- **2013 CCTF WG on TWSTFT meeting**  
Sept. 6-7 2013, Taipei, Taiwan