Report No. 5

The 2011 UTC Time Links

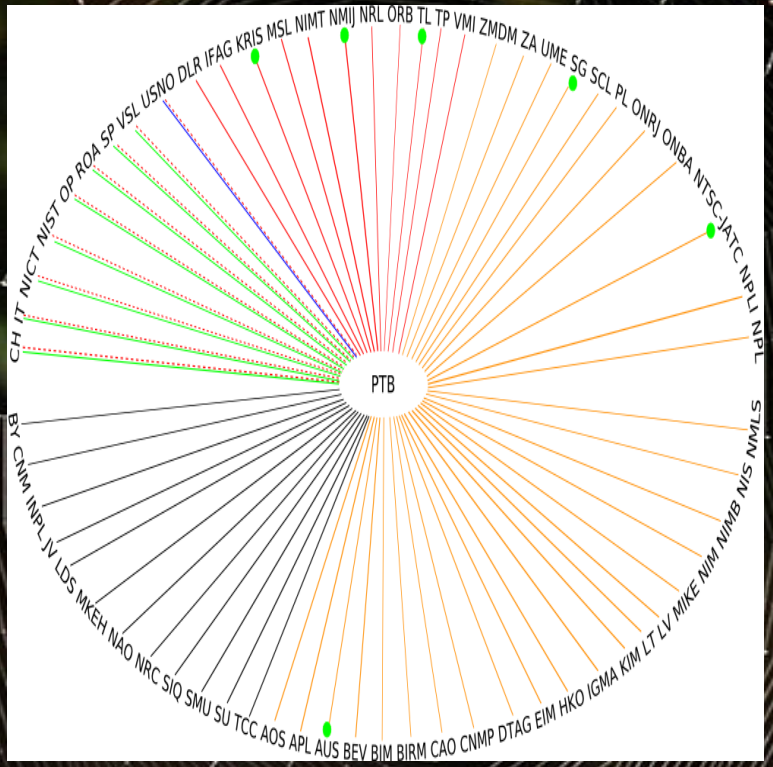
Z. Jiang et W. Lewandowski

Bureau International des Poids et Measures Pavillon de Breteuil
F-92312, SEVRES CEDEX, France
zjiang@bipm.org

Profile

- Status of the TW links
  - Europe-Europe-America
  - Europe-Asia
  - Asia-Asia
- What's new in the 2011 UTC time links
  - Combination TW+GPSPPP (only carrier phase info!)
  - Combination GPS+GLN
- Pilot experience
  - Strengthen the Asia-Europe links

The worldwide UTC time transfer network



- 11 TW links
- More than half GNSS code links
- PTB is the only pivot of the network

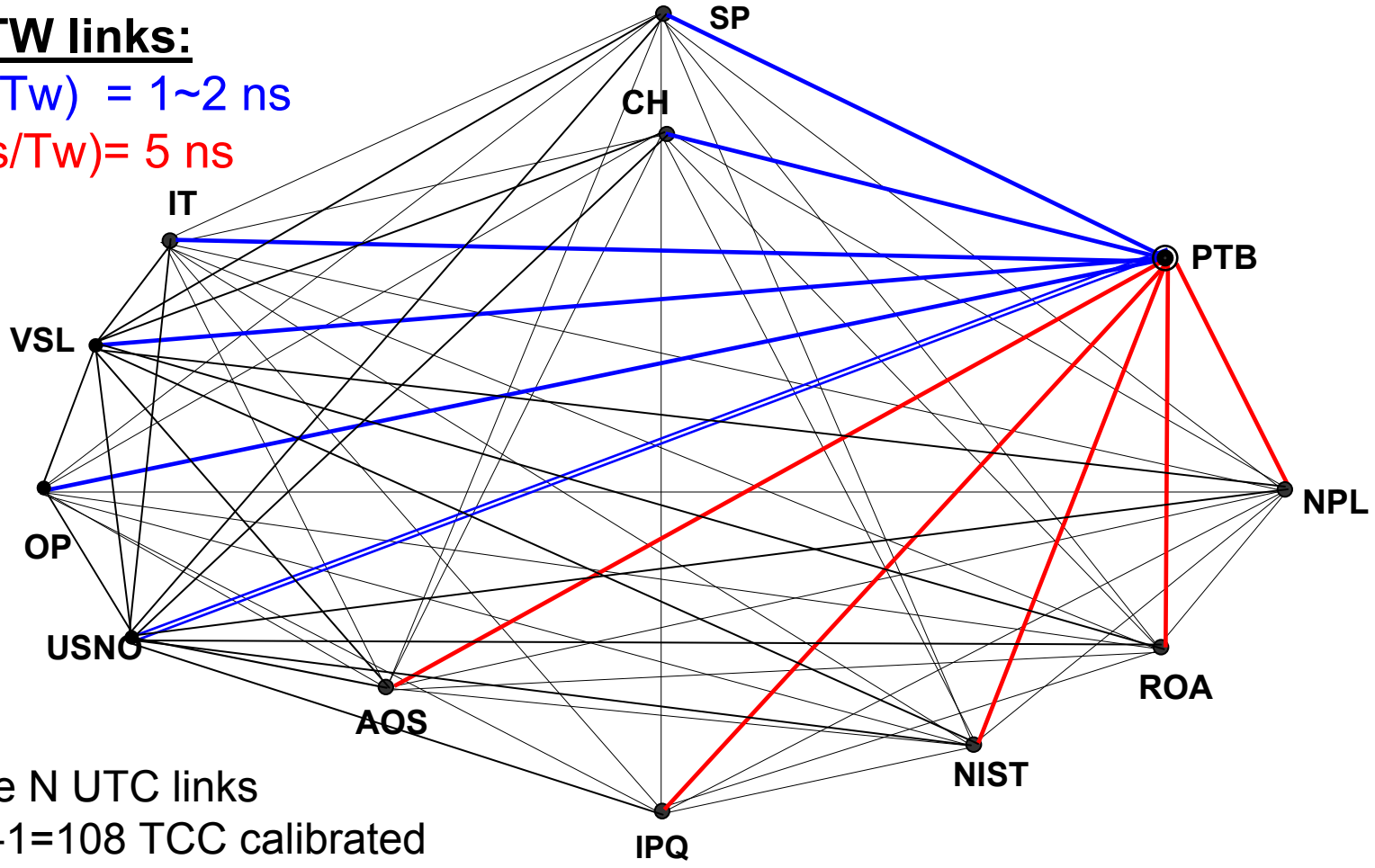
Europe-USA TW network and Calibration

TM198: Restoration on 55769: GPS PPP/TW bridges & TCC (triangle closure calibration)

11 UTC TW links:

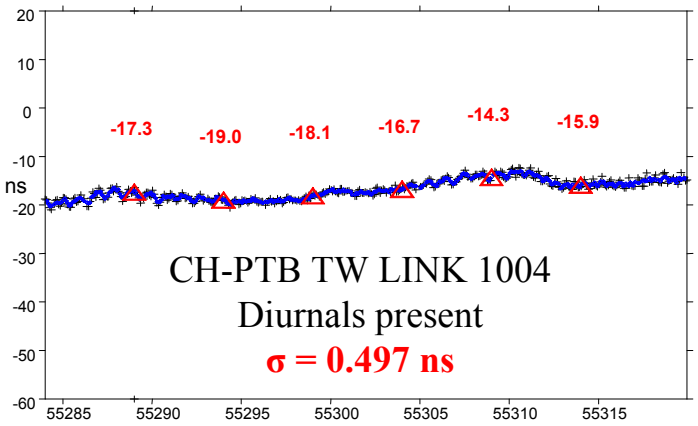
6×uB(Tw/Tw) = 1~2 ns

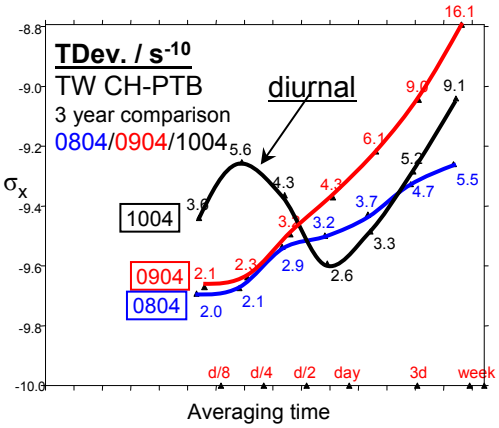
5×uB(Gps/Tw)= 5 ns

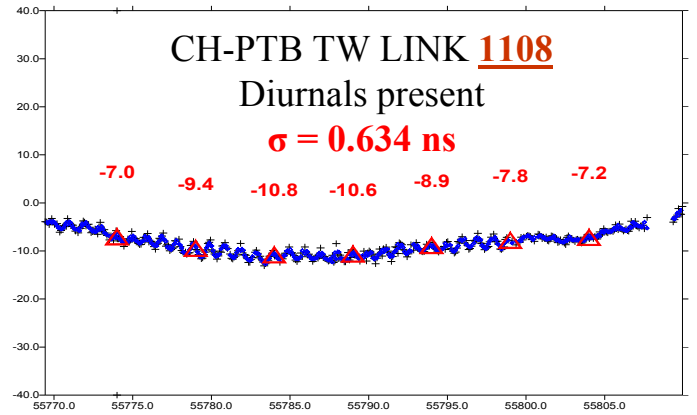


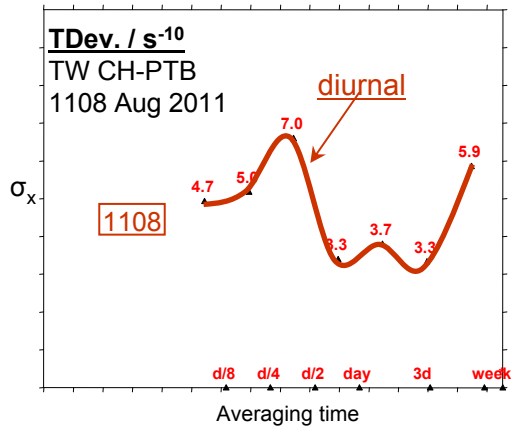
Based on the N UTC links
$(N^2-3N+2)/2-1=108$ TCC calibrated

Evolution of TW in UTC since 2008 1/2

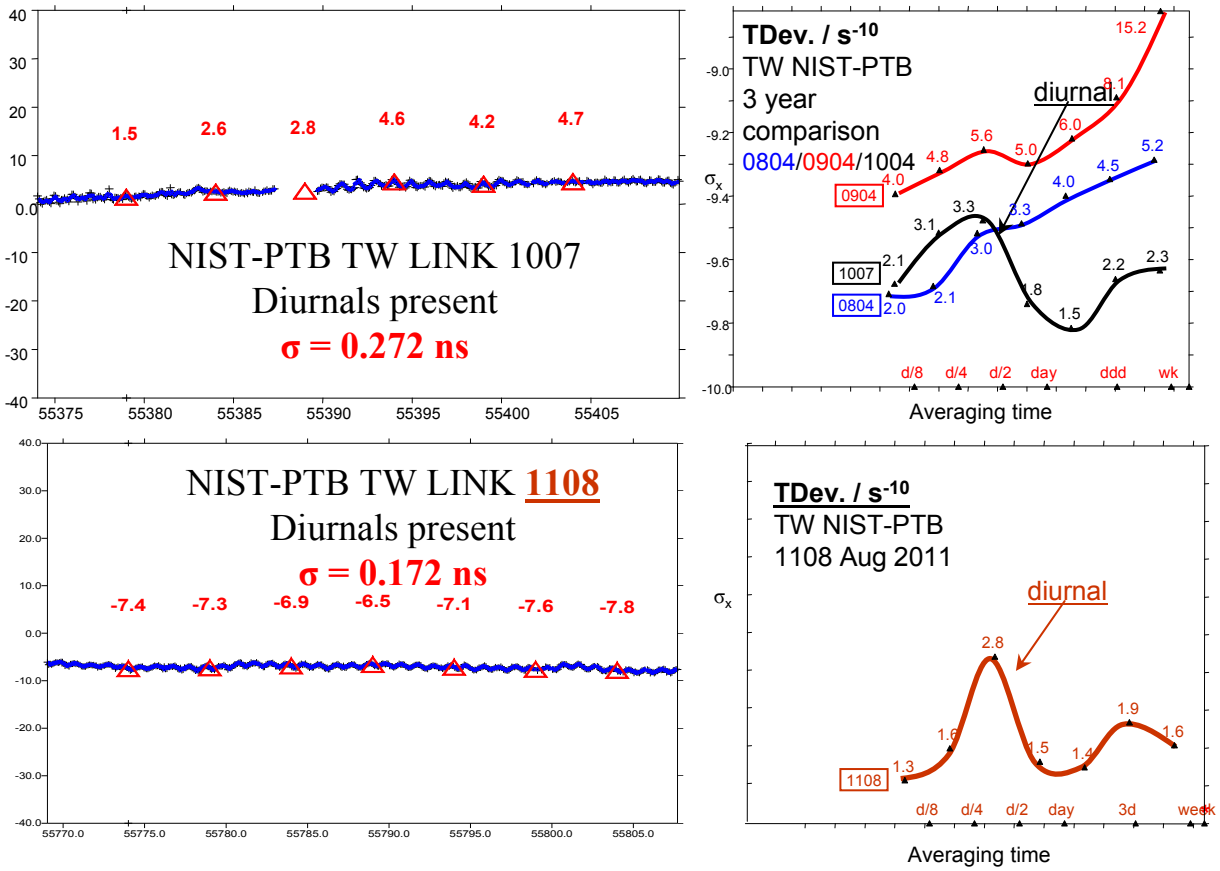








Evolution of TW in UTC since 2008 2/2



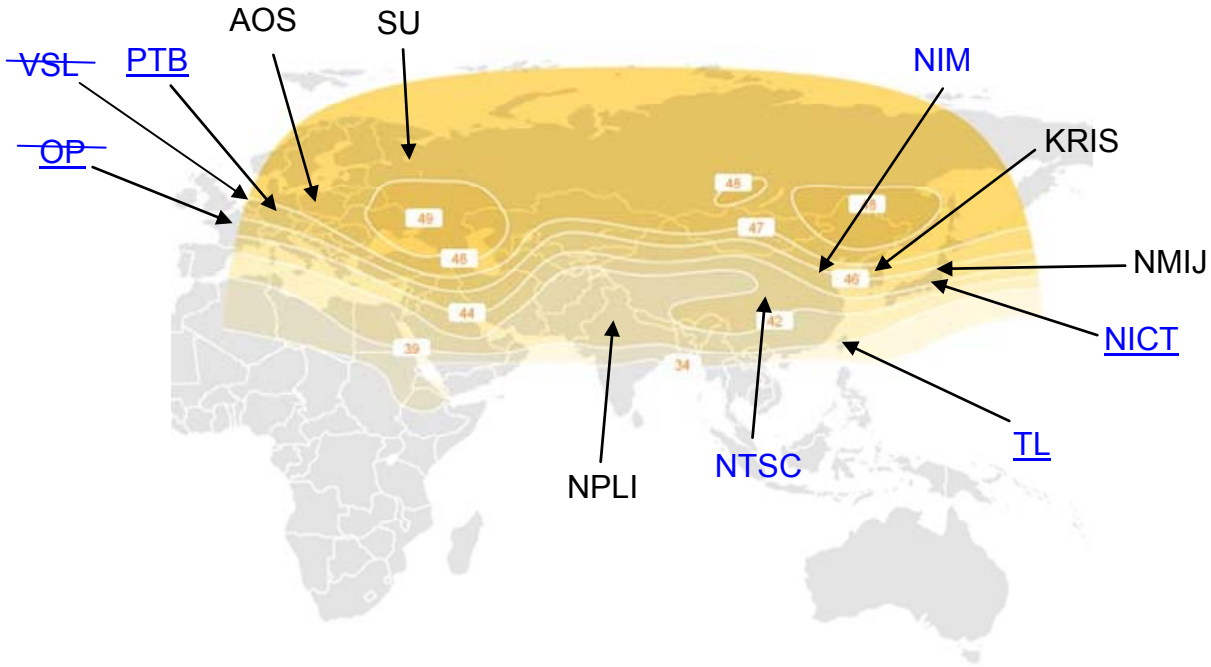
➔ Stronger diurnals

➔ TW satellites problems or the TW stations aged ?

➔ Solution : Combination of TW+PPP

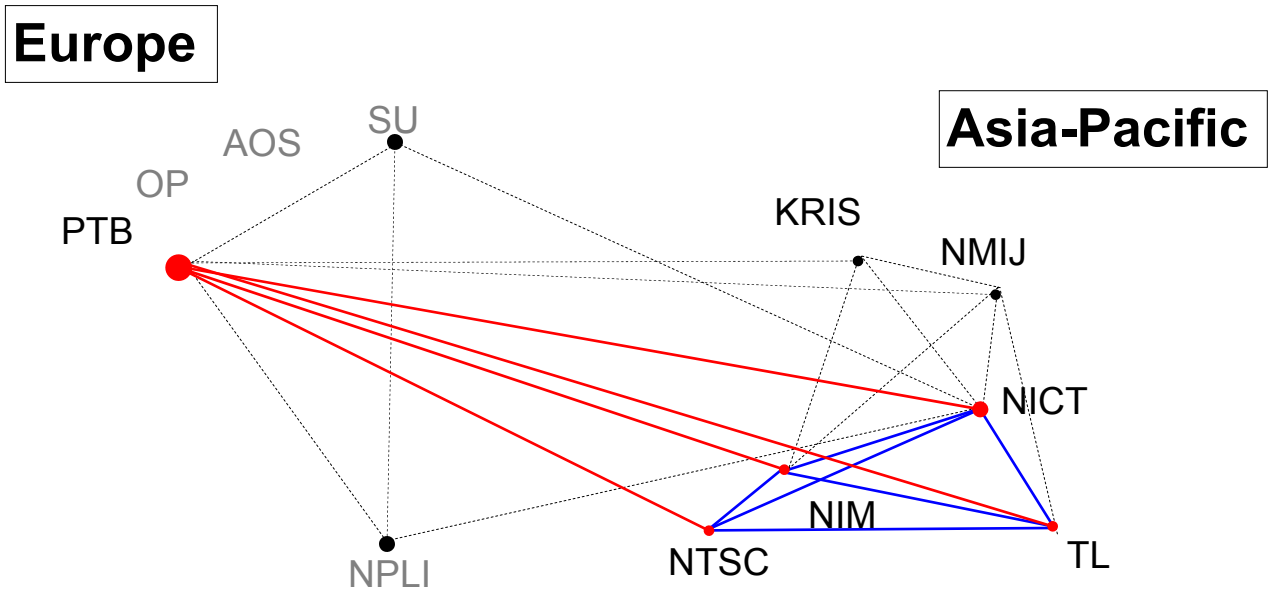
Coverage of the AM2 TW satellite

Visibility and EIRP/dBW



Equivalent isotropically radiated power (EIRP) or, alternatively, Effective isotropically radiated power

Operational and Coming up Asia-Asia-Europe TW links



Pilot study:

- PPP assisted GNSS-TW link calibrations
- Combination of PPP and TW links

10 operational Asia-Asia-Europe links

This file is the summary of Tw1108.lk file which contains all TW links. Date of computation : 2011 / 9 / 7 at 18 : 46
--- Month 1108 ---

=== LINKS USED (TWO WAYS COMPLETE) ===

LAB1	<==>	LAB2	MJD1	->	MJD2	CALR1	CALR2	ESDVAR1	ESDVAR2
NICT14	<==>	PTB03	55767	->	55809	999999999	999999999	999999999	999999999
NICT14	<==>	TL02	55767	->	55809	999999999	999999999	999999999	999999999
NICT14	<==>	NIM01	55767	->	55809	999999999	999999999	999999999	999999999
NICT14	<==>	NTSC02	55767	->	55809	999999999	999999999	999999999	999999999
NIM01	<==>	NTSC02	55767	->	55809	999999999	999999999	999999999	999999999
NIM01	<==>	PTB03	55767	->	55809	999999999	999999999	999999999	999999999
NIM01	<==>	TL02	55767	->	55809	999999999	999999999	999999999	999999999
NTSC02	<==>	TL02	55767	->	55809	999999999	999999999	999999999	999999999
NTSC02	<==>	PTB03	55767	->	55809	999999999	999999999	999999999	999999999
PTB03	<==>	TL02	55767	->	55809	999999999	999999999	999999999	999999999

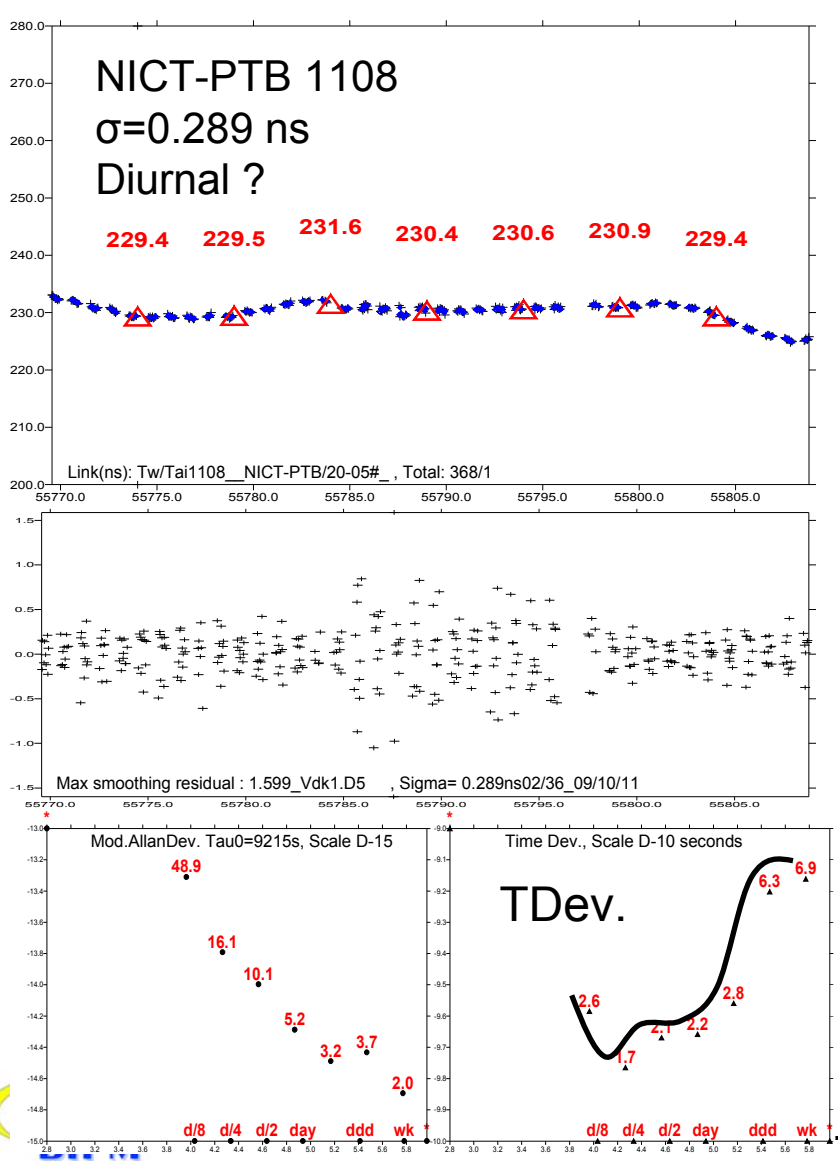
10 points/day: hourly 13h~23h

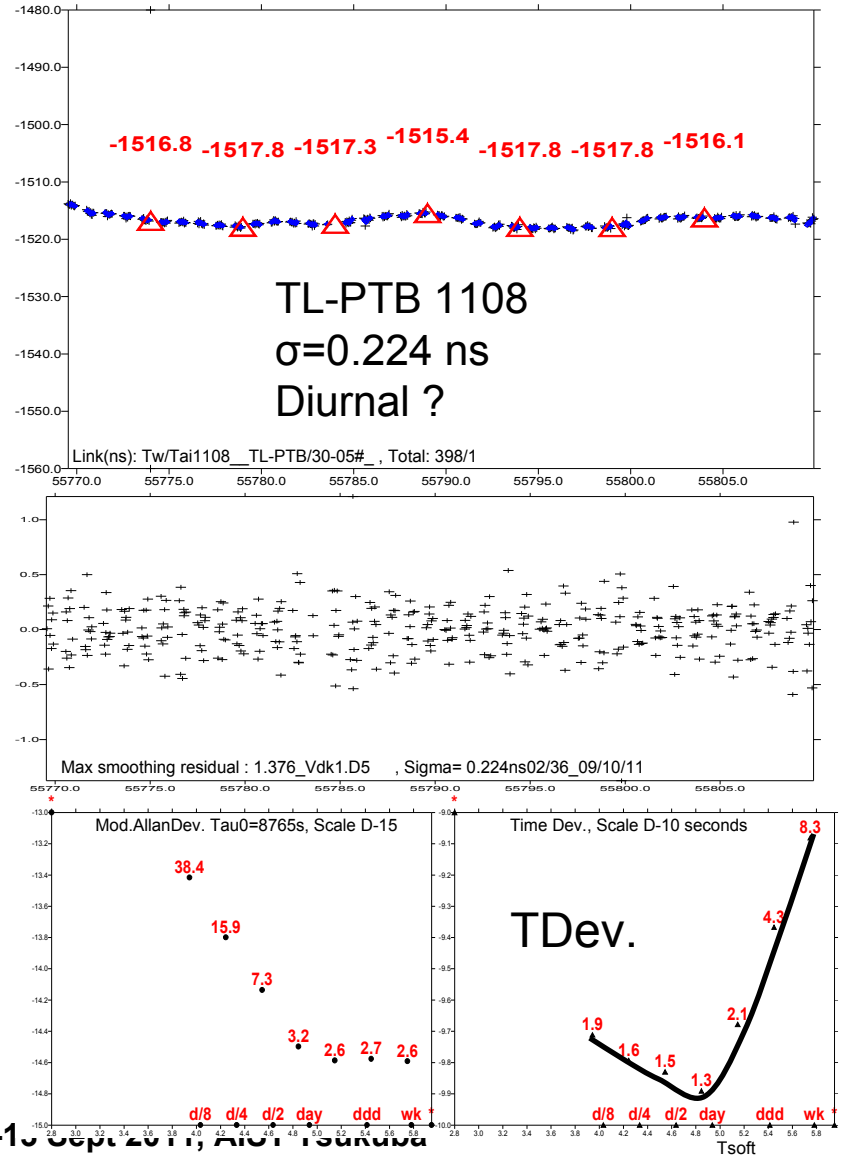
F307: --- Status of Total Existing TW observations, TaN1108, 09/07/11 (S<>1)

No	Lab1	Lab2	55771	72	73	74/	75	76	77	78	79/	80	…	99/100	101	102	103	104/105	106
1	NICT	PTB	322	9	10	10	10	10	7	10	10	10	…	10	9	10	10	10	10	10
2	NICT	TL	333	9	10	10	10	10	7	10	10	9	…	10	10	10	10	10	9	10	10
3	NICT	NIM	337	10	10	10	10	10	7	10	10	10	…	10	10	10	10	10	10	10	10
4	NICT	NTSC	291	8	10	10	10	9	7	10	___	10	…	10	10	10	10	4	10	10	10
5	NIM	NTSC	304	10	10	10	10	10	10	10	___	10	…	10	7	10	10	4	10	10	10
6	NIM	PTB	343	10	10	10	10	10	10	10	10	10	…	10	7	10	10	10	10	10	10
7	NIM	TL	345	10	10	10	10	10	10	9	10	10	…	10	7	10	10	10	10	10	10
8	NIM	NICT	333	10	10	10	10	10	7	10	9	10	…	10	7	10	10	10	10	10	10
9	NTSC	NIM	226	10	10	10	10	10	3	9	___	3	…	10	5	10	7	4	4	4	2
10	NTSC	TL	234	10	10	10	10	10	3	9	___	10	…	10	5	10	7	4	4	4	2
11	NTSC	PTB	231	10	10	10	10	9	3	9	___	9	…	9	5	10	7	4	4	4	2
12	NTSC	NICT	146	7	10	10	10	8	2	10	___	10	…	10	4	10	6	3	3	2	1
13	PTB	TL	349	10	10	10	10	10	10	10	10	10	…	10	10	10	10	10	10	10	10
14	PTB	NIM	344	10	10	10	10	10	10	9	10	10	…	10	10	10	10	10	10	10	10
15	PTB	NTSC	307	10	10	10	10	10	10	10	___	10	…	10	10	10	10	4	10	10	10
16	PTB	NICT	335	10	10	10	10	10	7	10	10	10	…	10	10	10	10	10	10	10	10
17	TL	PTB	348	10	10	10	10	10	10	10	10	10	…	10	10	10	10	10	10	10	10
18	TL	NTSC	310	10	10	10	10	10	10	10	1	10	…	10	10	10	10	4	10	10	10
19	TL	NIM	350	10	10	10	10	10	10	10	10	10	…	10	10	10	10	10	10	10	10
20	TL	NICT	336	10	10	10	10	10	7	10	10	10	…	10	10	10	10	10	9	10	10

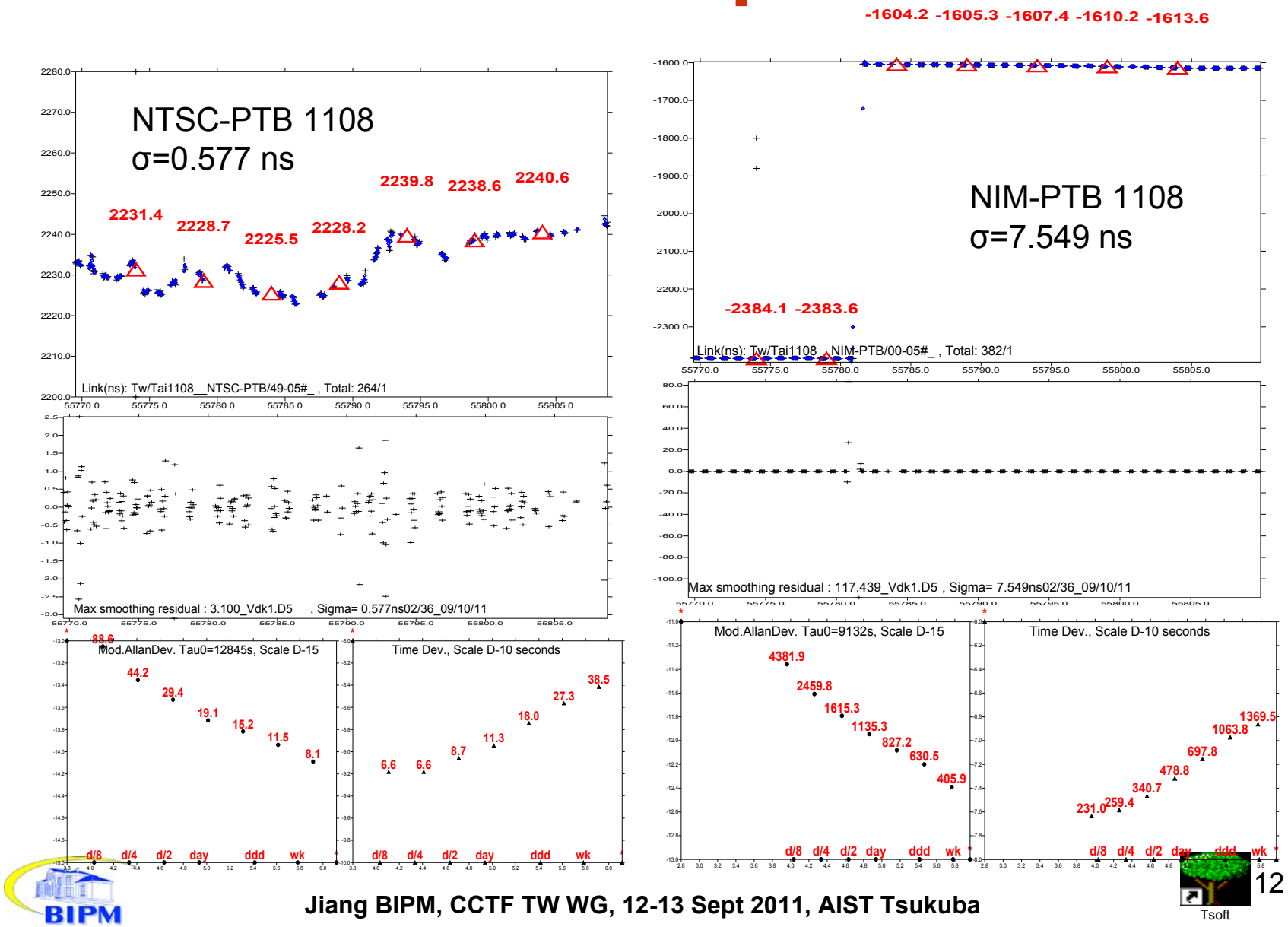
--- Total TW links: 20

TW Asia-Asia-Europe Links 1/3



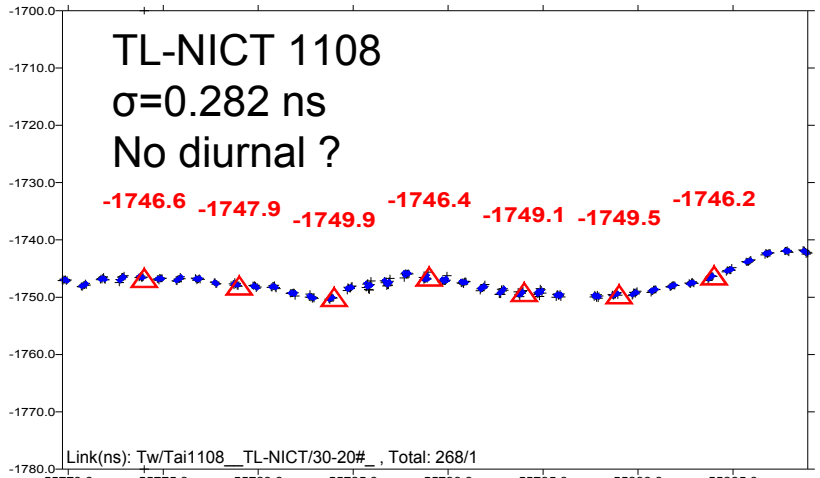


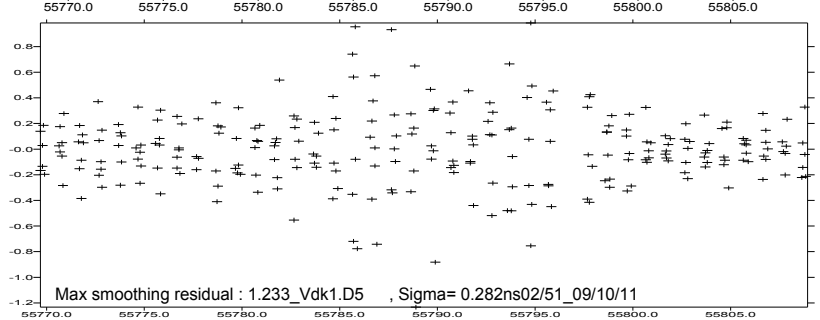
TW Asia-Asia-Europe Links 2/3

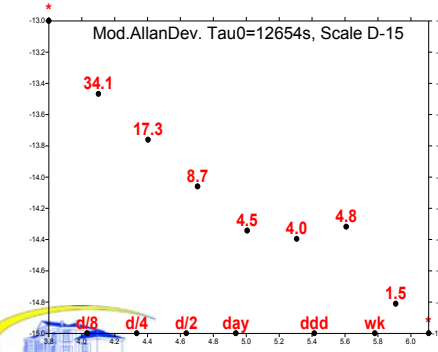


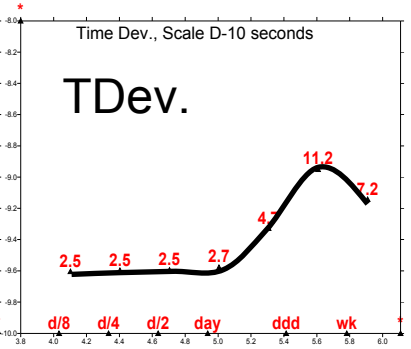
Tsoft

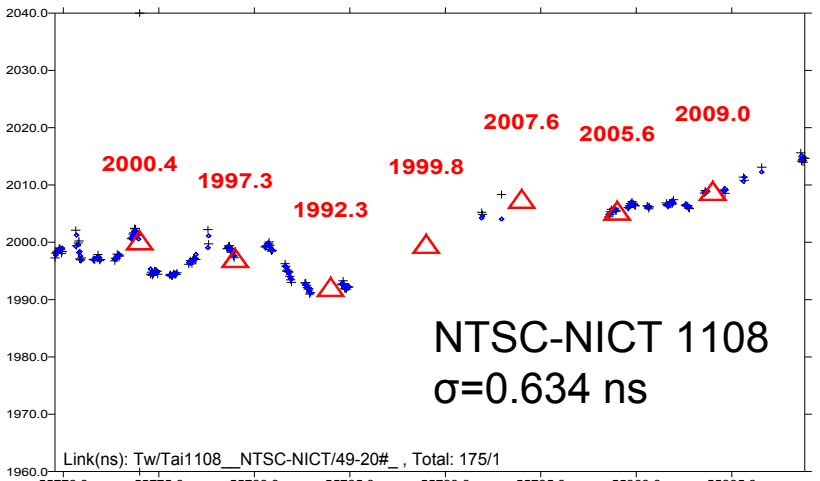
TW Asia-Asia-Europe Links 3/3

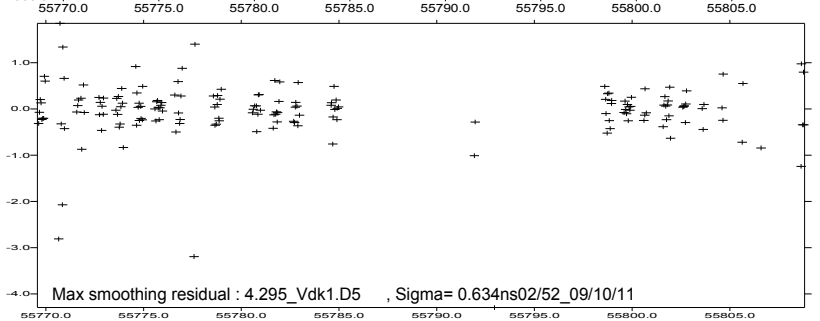


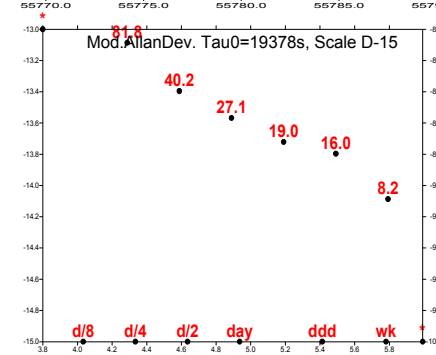


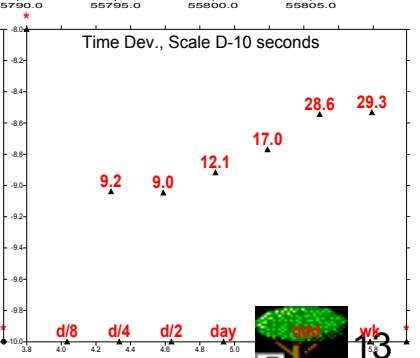




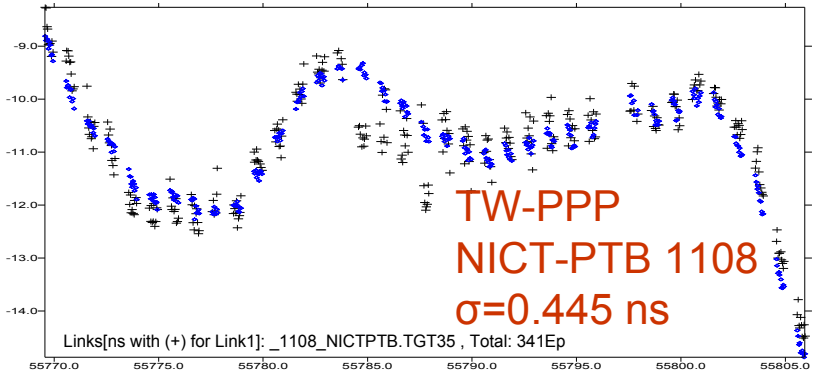


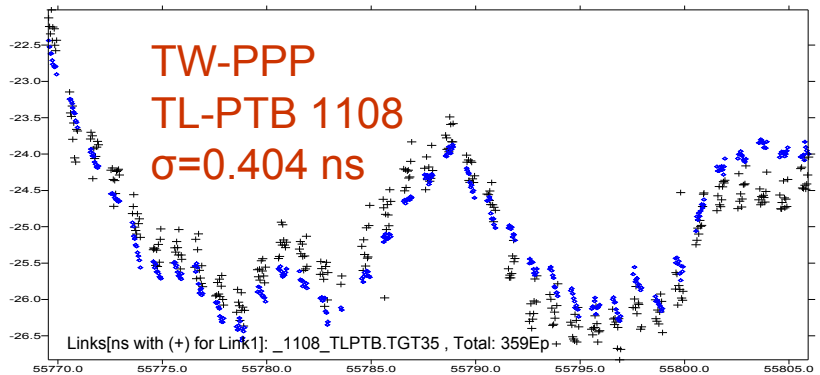


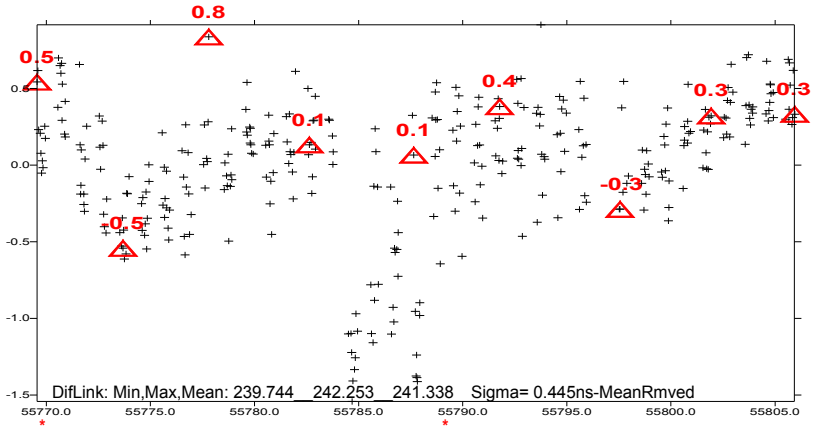


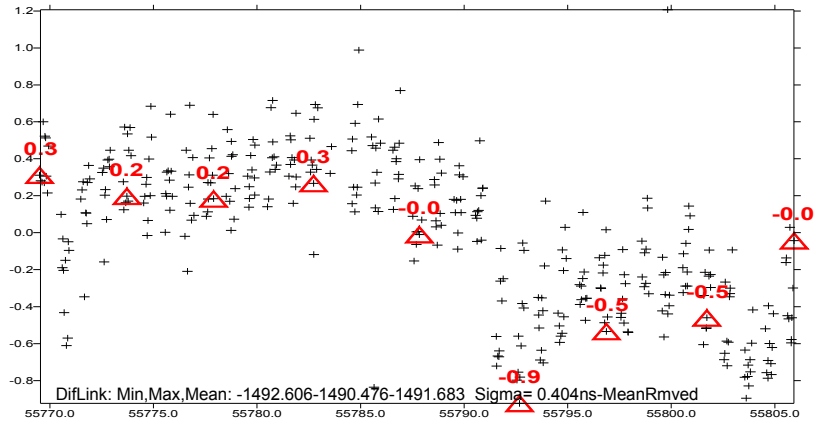


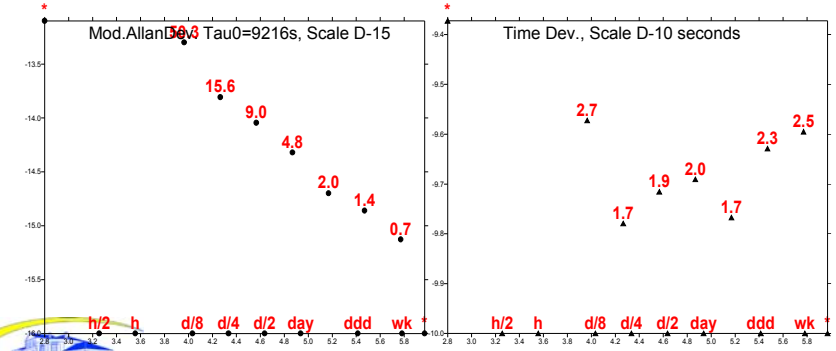
Comparison TW-PPP Asia-Europe Links

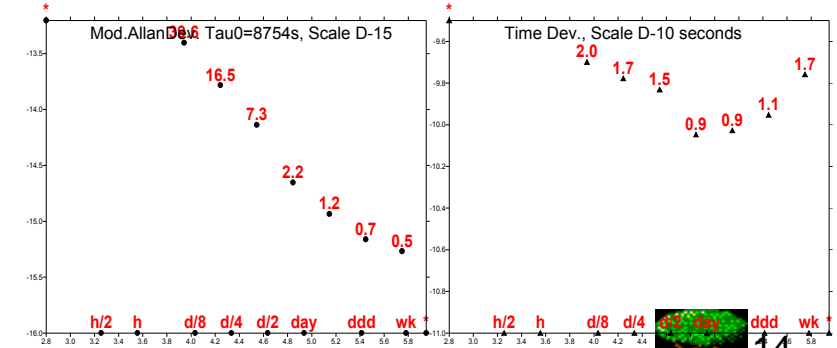








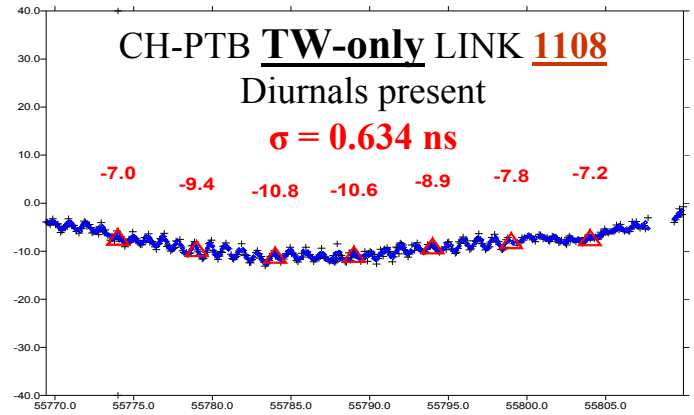


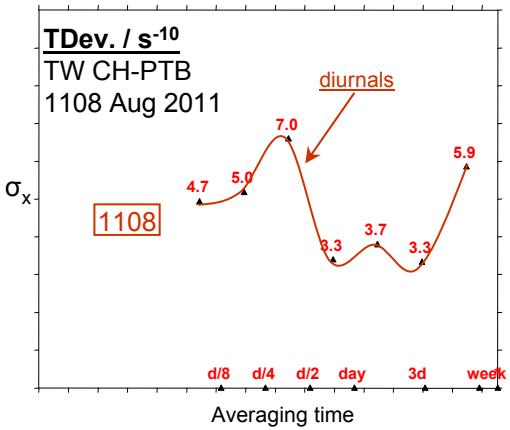


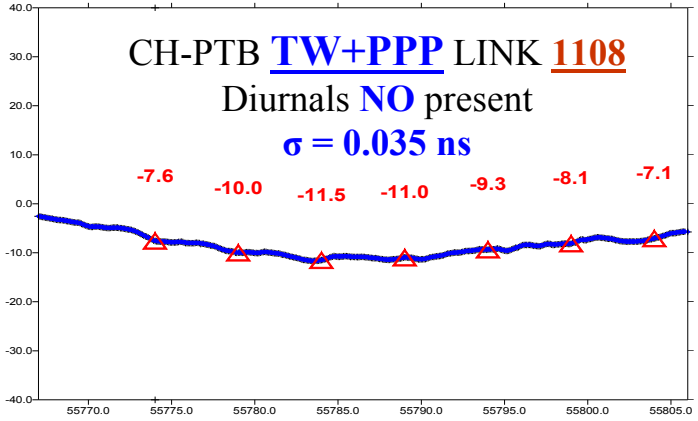
What's new in the 2011 UTC time links

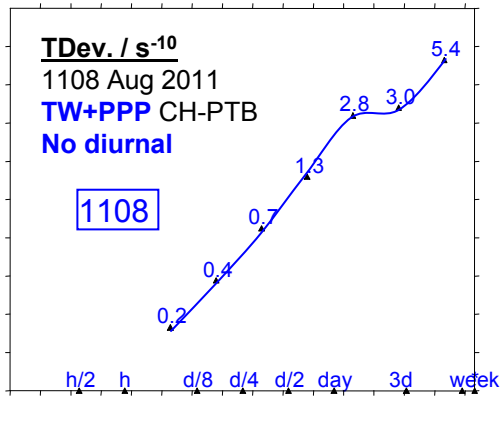
- Combination TW+GPSPPP ← TW+CP Jiang,Petit Metrologia 2009
- Combination GPS+GLN
- Pilot Studies to Strengthen the Asia-Europe links
  - Announced June 2011: PTB, OP, NICT, TL, BIPM
  - Combination TW+GPSPPP
  - Calibration (Asia-Asia-PTB), 2 steps:
    1. Compute CALR of TW with GPS then TCC uB=5ns ← asap
    2. Bipm calibration station → uB=2 ns

Combination TW+PPP since 1101 1/2

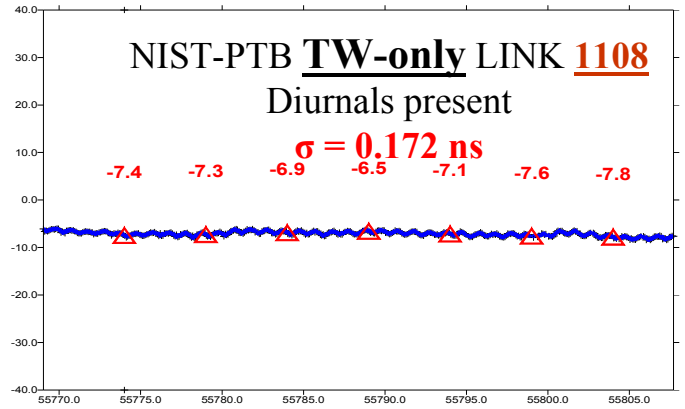


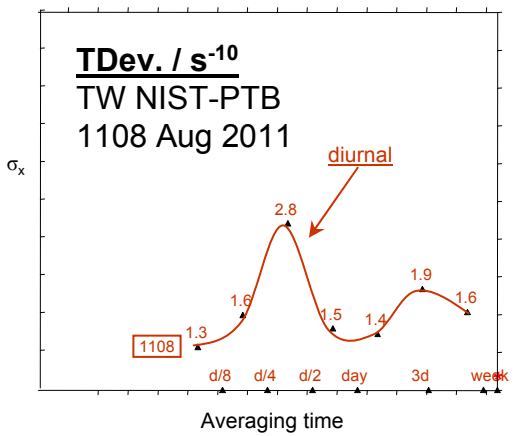


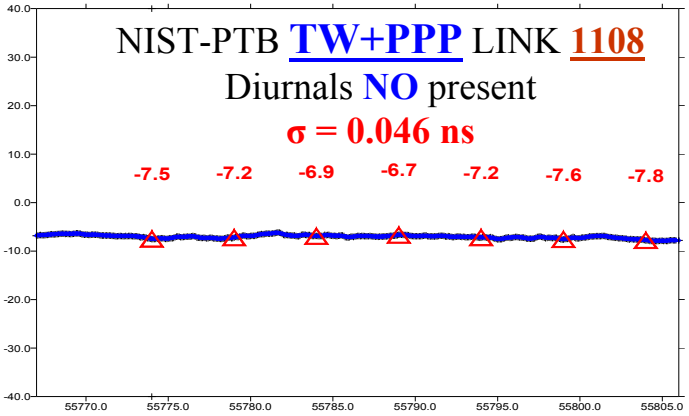


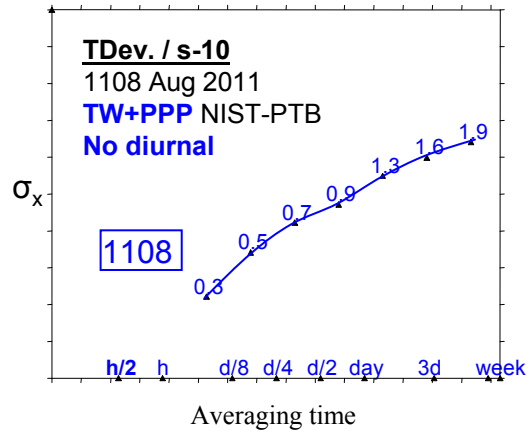


Combination TW+PPP since 1101 2/2





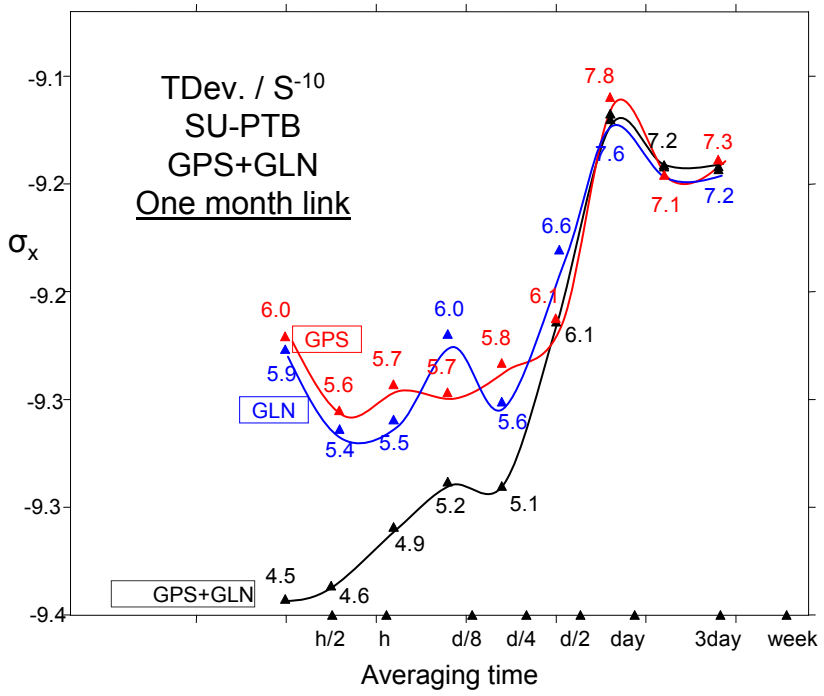


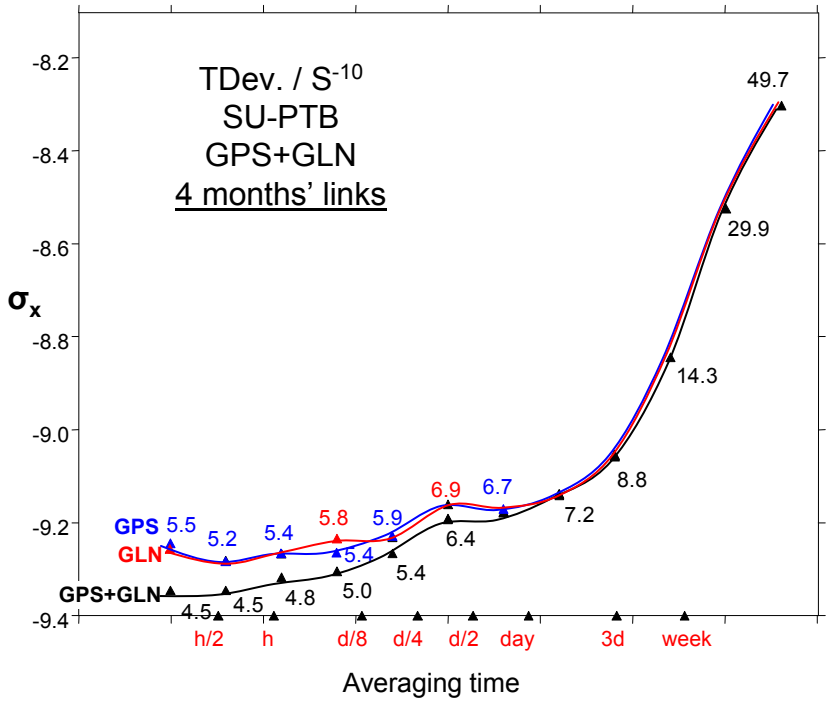


uA=uA(PPP)=0.3 ns
uB=uB(TW)=1~5 ns

Combination GPS+GLN since 1011

Weighted mean C-codes: (2×GPS+1×GLN)/3

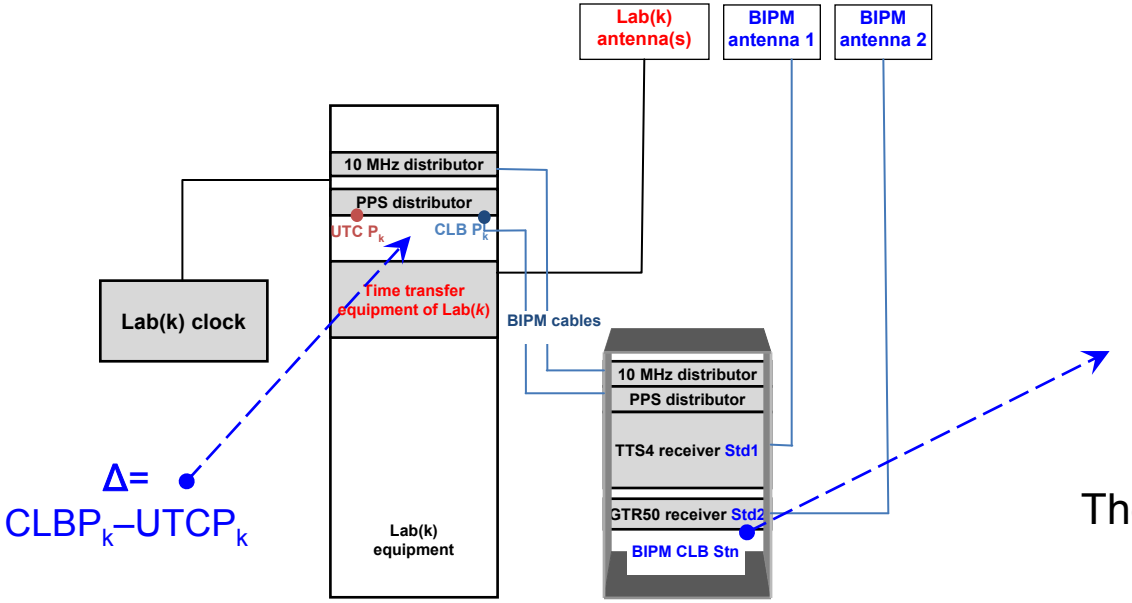


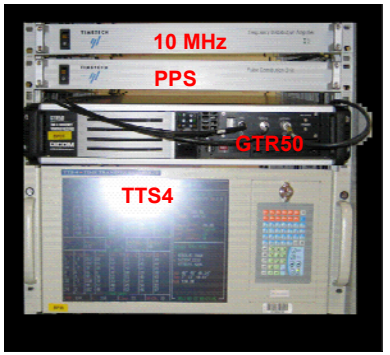


'Link' Calibration so far practices and studies

- **BIPM** link alignment (*always in CirT, e.g. TW Calib. Rest.*) ➔ $u_B \geq u^{\circ}_B$
- **TW** scheme *(Piester et al. Metrologia* 2008) ➔ $u_B \approx 1$ ns
- **BEV/PTB** scheme *(Niessner,Jiang et al.* PTTI 2008) ➔ $u_B = 3$ ns (GPS)
- **ROA** scheme (*Esteban et al*. EFTF 2009) ➔ $u_B \leq 2$ ns (GPS)
- **PTB** scheme (*Feldmann et al*. EFTF 2010) ➔ $u_B \leq 2$ ns (GPS)
- **BIPM** scheme (*Jiang et al.* PTTI 2008, EFTF 2010) ➔ $u_B < 2$ ns (TW/GNSS)
  ➔ ➔ we try to establish a standard procedure with TWO traveling receivers

Set-up of the traveling Std_{Bipm}





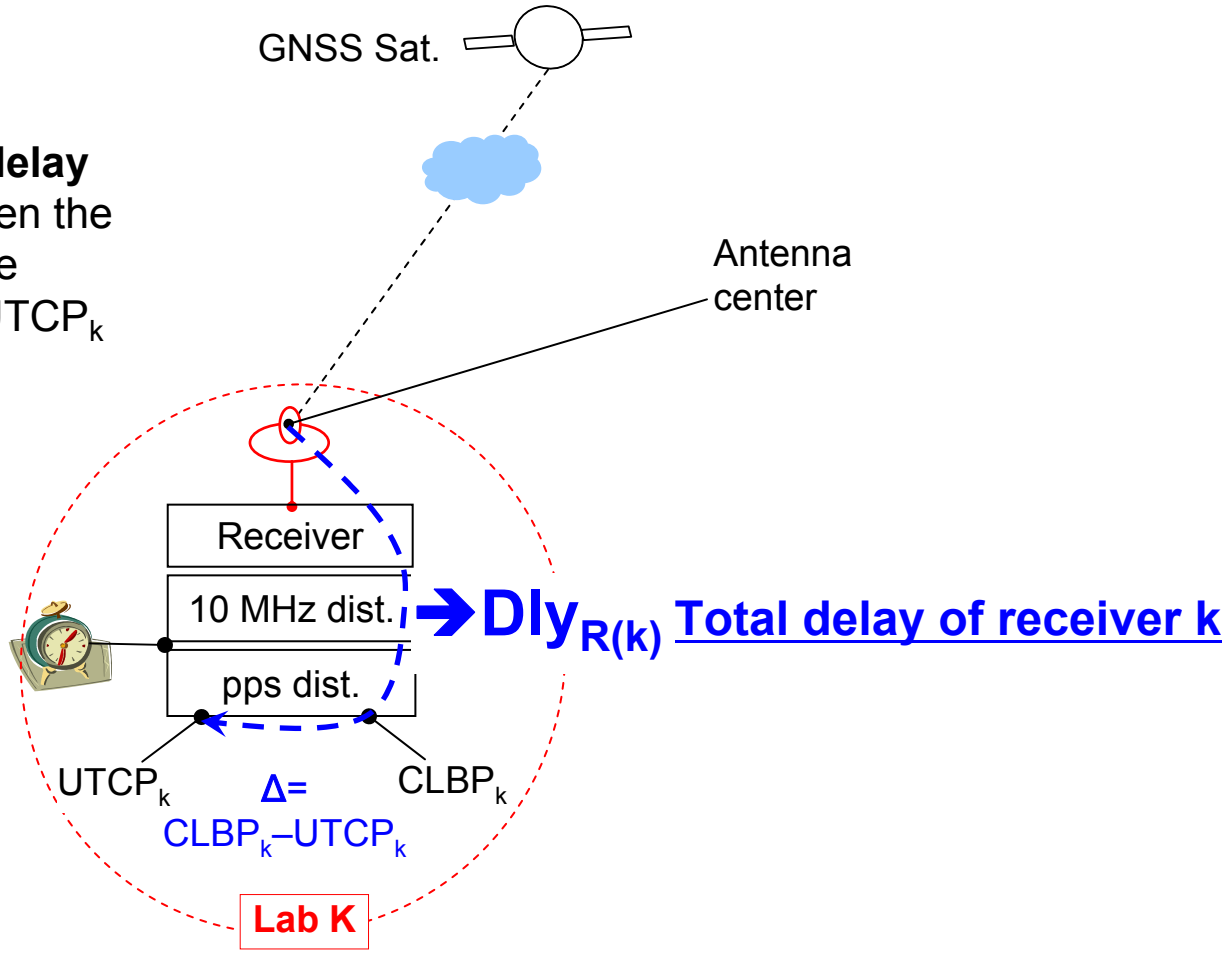
The BIPM calibration station
Std_{Bipm}
2 geodesic receivers

Easy operation:

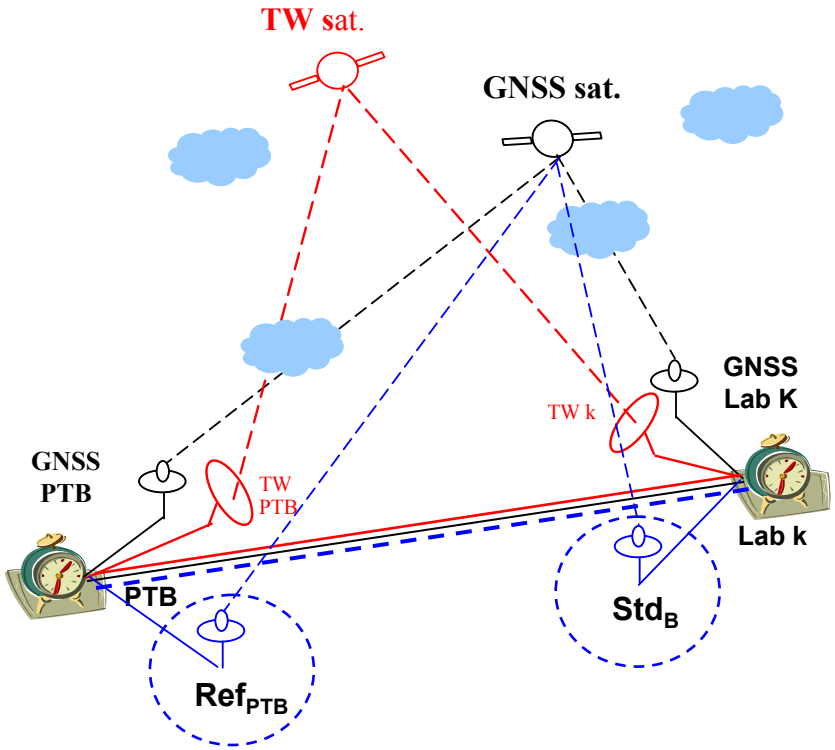
- Antenna positioning by PPP
- Intergraded station: open-connect-work
- Automatic data collection

‘Total Delay’ of a ‘Receiver’ at Lab_k

Total electronic delay is the delay between the phase center of the antenna and the $UTCP_k$



An 'one for all' *link* calibration



Std$_B$ - Ref$_{PTB}$

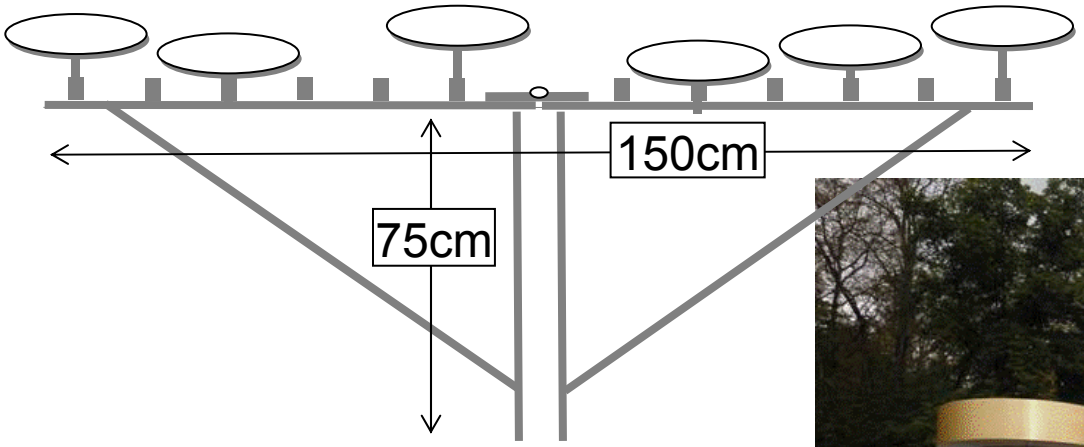
TW: Lab$_K$-PTB

GNSS Lab$_K$-PTB: Ref$_k$ - Ref$_{PTB}$

The side-by-side common-clock short-baseline set-up and the total delay Std$_B$-Ref$_k$: Dly$_L$(Std$_B$-Ref$_k$)=Dly$_R$(StdB)-Dly$_R$(Refk)

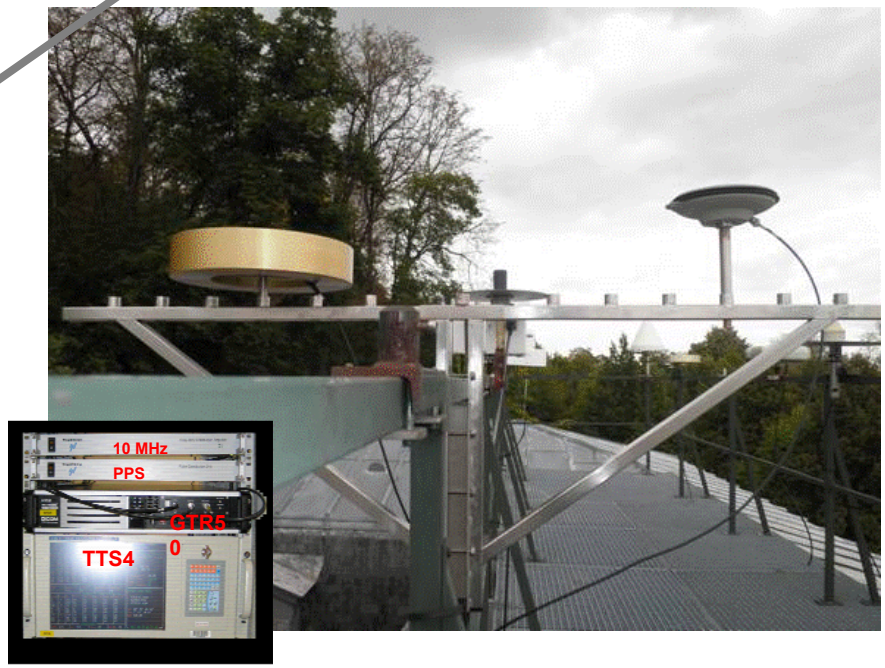
Antennas' Set-up: *adjustable location*

Montage des antennes du BIPM Calibration Station



➔ Vertically & horizontally adjustable location
➔ Minimum inter-affections
➔ Minimum multi-paths

Tests at BIPM/CNES
Process the data …



Evolution of u_B: *aging*

u_B of a link degrading with time as, for example, a random walk function:

$$u_B^2(T - T_0)_{k\text{-PTB}} = u_B^2(T_0)_{k\text{-PTB}} + (T - T_0) \times u_A^2{}_{k\text{-PTB}}$$

$u_B(T - T_0)$ degrades with its age for a GPS P3 link

Age /year	u_B /ns
0	2.0
1	2.1
3	2.3
5	2.5
10	3.0
>10	**10**

Thank for your attention
Special thanks to
our NMIJ Colleagues

Evolution of TW in UTC 5/6: 10 year tendency