

# UTC time link calibration report

-- MEasurement of T<sub>OTal</sub> DELay for UTC Time Link Calibration  
Phase XIV/2016: Measurements at and between NTSC, NIM and PTB

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## Abstract

*This report includes the calibration results of NTSC, NIM and PTB. During the 19 to 31 July 2016, the BIPM Standard travelling calibration station (Std<sub>B</sub>) visited the NTSC, National Time Service Centre, Lintong, Xian, Chinan to calibrate the TWSTFT links NTSC-PTB (by METODE) and NTSC-NIM (by TCC) as well as the backup time links [1,4].*



The BIPM calibrator setups at NTSC

## Notation

**UTC<sub>p</sub>**: the UTC( $k$ ) point at Lab( $k$ ). Here after the  $k$  stands for NTSC, the laboratory to be calibrated  
**Link**: a time link is a clock comparison result using a particular technique, e.g., a link of GPS C/A, P3, PPP or GLONASS or TWSTFT or TWOTFT. A UTC link at present is the one between Lab( $k$ ) and PTB  
**Std<sub>B</sub>**: the BIPM standard traveling calibration station (calibrator) consisting of  $N$  ( $\geq 2$ ) GNSS receivers+antennas+cables +pps/frequency-distributors. It is a pre-cabled black box calibrator with unknown but constant total delay during a calibration tour  
**Total Delay**: The total electrical delay from the antenna phase center to the UTC<sub>p</sub> including all the devices/cables that the satellite and clock signals pass through. It equals numerically the sum of all the sub-delays. It is the total delay that really affects the UTC time transfer uncertainty  
**METODE**: MEasurement of TOveral DELay, the BIPM calibration scheme composed of related methods and equipment (Std<sub>B</sub>) for the generation of UTC-UTC( $k$ ) in Circular T [1]  
**C<sub>M</sub>**: The METODE total delay correction. It should be *subtracted* from the GPS data, e.g. RefGPS-C<sub>M</sub> in CGGTTS, -C<sub>M</sub> in Clb\_GNSS.Lst file; and the CALR of the ITU TWSTFT data of the Lab( $k$ ) side. Because the PTB is taken as the reference of the calibration, the time link correction is equal to the classic GNSS equipment calibration correction [8]  
**u<sub>A</sub>, u<sub>B</sub>**: type A and type B uncertainties ( $1-\sigma$ )  
**u<sub>M</sub>**: Total uncertainty of the total delay correction C<sub>M</sub>;  
**CCD**: common clock difference  
**DCD**: double clock difference  
**Tour**: a calibration *tour* is a go-back or start-closure calibration travel. It may include several laboratories  
**TCC**: Triangle Closure Calibration [12]

## 1 Summary

### 1.1 General

The last BIPM calibrations at NTSC were made in 2002 and 2004. GPS C/A code time transfer receiver was calibrated. The calibration corrections were respectively -7.0 ns and -12.5 ns, cf. the Annex I [2].

During the 19 to 31 July 2016, the BIPM Standard travelling calibration station (Std<sub>B</sub>) visited the NTSC, National Time Service Center, Lintong, Xian, China. The NTSC time laboratory, together with its TWSTFT and GNSS time/frequency transfer facilities, located in the NTSC Lintong campus, about 40 km in the Est of Xian. The goal is to calibrate the UTC TWSTFT link NTSC-PTB and the link NTSC-NIM and the backup time links [1,4]. For the TWSTFT links, the reference is PTB. The visits to PTB before and after the calibration tour allow the Std<sub>B</sub> transferring the calibration of the PTB master receiver to the Lab( $k$ ) [1,3,4].

This report includes the calibration results (Table 1.2): 1) the main result is the CALR for the TWSTFT (TW for short) links NTSC-PTB by GPSPPP and NTSC-NIM by the triangle closure calibration (TCC), cf. Sect. 4; 2) for a reference, we list also GPS master receiver result (Section 5).

The master receiver is a Septentrio PolaRx4Tr\_Pro, namely NTP1. The backup receivers are the two same type of GNSS receivers NTP2 and NTP3.

The requirements for the setup and computations can be found in the BIPM METODE Notice [6] or the Guideline [3]. Taking into account of the starting and closure measurements at the BIPM, we compute the calibration corrections for the UTC TWSTFT link of NTSC-PTB. For reference, we compute also the total delay calibration correction for the NTSC GPS master receiver, which however according to the TW guidelines, should not be used for the TW link calibration.

It should be pointed out that the TW link and GPS receiver calibrations are independent performed according to two different guidelines for TW time *link* calibration (using TW mobile station or *GPSPPP* link [7]) and the GNSS *receiver* (using *GPS P codes* [8]). The first supplies officially the UTC time link calibration scale through the combination of TW and GPS PPP. The fact that, the local GPS master receiver at Lab( $k$ ) is not at all involved in the TW link calibration, the calibrated TW and GPS links may be slightly different within the  $u_A$ . For the PPP and P3, the  $u_A$  are 0.3 ns and 0.7 ns respectively.

The PPP solutions are used for METODE link calibration of NIM-PTB [1,3,4,7] and TCC [12] for NTSC-NIM.

Hereafter in the expression, we have always  $k=NTSC$  in the term Lab( $k$ ).

## 1.2 The main result

The calibration result is the time link corrections ( $C_M$ ), which should be used for all the GNSS (PPP, C/AL1C, P3) links and the TWSTFT links on the baseline Lab( $k$ )-PTB. The UTC TWSTFT/GPS results are given in Table 1.2a. Cf. the Section 4. Because the PTB is taken as the reference of the calibration and its correction is set zero [1,4], the time link correction  $C_M$  is equal to the GNSS equipment calibration correction and can be converted to the classic equipment calibration result [4], termly INTDLY(P3) in Table 1.2b.

**Table 1.2a** The total delay correction for the UTC GPS and TW time links/Receivers

Labo	Time Rcv/Link	CalR/ $C_M$ /ns	$u_M$	CLBID	ITU CI
NTSC	TWSTFT: NTSC-PTB	<b>-2242.9</b>	1.5 ns	B1 2 PP 49 05 16	<b>418</b>
NTSC	TWSTFT: NTSC-NIM	<b>-80.0</b>	$\leq 2$ ns	B1 2 PP 49 05 16	<b>419</b>
NTSC/NTP1	Sept. PolaRx4/NTP1	<b>-24.3</b>	1.5 ns	B1 1 PP 49 05 16	-
NTSC/NTP2	Sept. PolaRx4/NTP1	<b>-15.2</b>	1.5 ns	B1 1 PP 49 05 16	-
NTSC/NTP3	Sept. PolaRx4/NTP1	<b>-55.1</b>	1.5 ns	B1 1 PP 49 05 16	-

**Table 1.2b** The total delay correction converted to the classic equipment calibration result

Labo	Time Rcv/Link	INTDLY(P3) /ns	$u_M$ /ns	CabD /ns	RefDo/ns	PPS in/out	TotD
NTSC	PolaRx4/NTP1	<b>57,1</b>	$\sim 2$	209,0	224,5	149,3	-107,7
NTSC	PolaRx4/NTP2	<b>58,2</b>	$\sim 2$	221,0	234,4	143,6	-98,8
NTSC	PolaRx4/NTP3	<b>55,1</b>	$\sim 2$	198,0	57,9	134,7	60,5

## 1.3 Uncertainty

The *total uncertainty* ( $U_M$ ) of the  $C_M$  is composed of [3,4,7]:

- Measurement uncertainty ( $u_A$ ): about (0.1~0.3) ns ( $u_A$  of PPP link);
- Calibration uncertainty of the calibrator  $Std_B$ : (0.5~1.0) ns;
- Instability of the reference and traveling receivers: (0.5~0.8) ns;
- Uncertainty relating to the measurements of UTCp-CLBp: (0.2~0.5) ns;
- Others (0.3~0.6) ns (unexpected)

The  $U_M$  is hence (0.8~1.5) ns ( $1\sigma$ ). The conventional uncertainty of 1.5 ns is assigned for this calibration.

The internal delays INTDLY(L1/L2) is obtained by subtracting all the sub-delays from the directly observed 'total delay'. This may produce a few ns uncertainty [4,5]. Ignoring the L1/L2 delay difference going through the antenna cable produces at least 3 ns error [5]. The total uncertainty of INTDLY(P1/P2) is no less than 3 ns. We give only the INTDLY(P3) with  $u_B \sim 2$  ns, as given in the Table 1.2b.

## 2 Setups of the $Std_B$

By the definition of the METHODE UTC time link calibration correction [1,3,4,6], we have the following steps:

- We start from BIPM
- We set the PTB's master GPS receiver (PTBB) as the reference of the calibration and its calibration correction to be zero;
- We align the  $Std_B$  to PTBB, i.e. the BP0U and BP1C in  $Std_B$  are to be corrected -4.7 ns and 2.3 ns, cf. Tab. 6.1.2 of [10];
- The  $Std_B$  goes to the Lab( $k$ ), and makes measurements side by side with the master receiver of Lab( $k$ ), both of the  $Std_B$  and the master receiver use the same reference signals of UTC( $k$ );
- The closure measurement at the starting point. For short tours, the starting-closure point is BIPM;
- We compute the double clock difference:

$$C_M = DCD = [UTC(k)_{rcv(k)} - UTC(PTB)] - [UTC(k)_{StdB} - UTC(PTB)] \quad (2.1)$$

The no-zero DCD is the calibration correction to the master GNSS receiver of Lab( $k$ ).

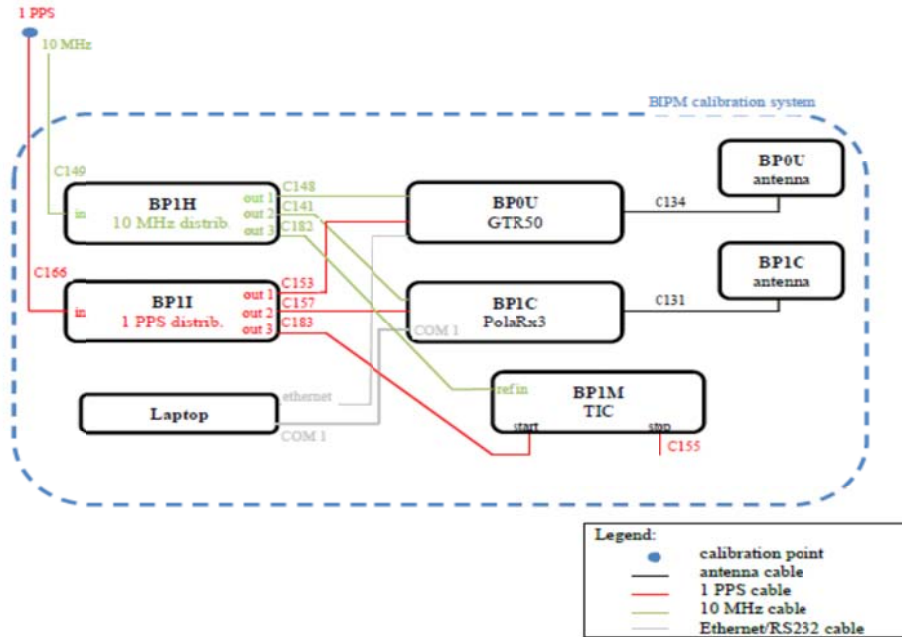
For GPSPPP, the difference between 'link' and 'equipment' solutions is negligible. The (2.1) can be simplified:

$$C_M = DCD \approx CCD = UTC(k)_{rcv(k)} - UTC(k)_{StdB} \quad (2.1a)$$

And the correction of the backup links:

$$C_M = [UTC(k)_{backup} - UTC(PTB)] - [UTC(k)_{calibrated} - UTC(PTB)] \quad (2.2)$$

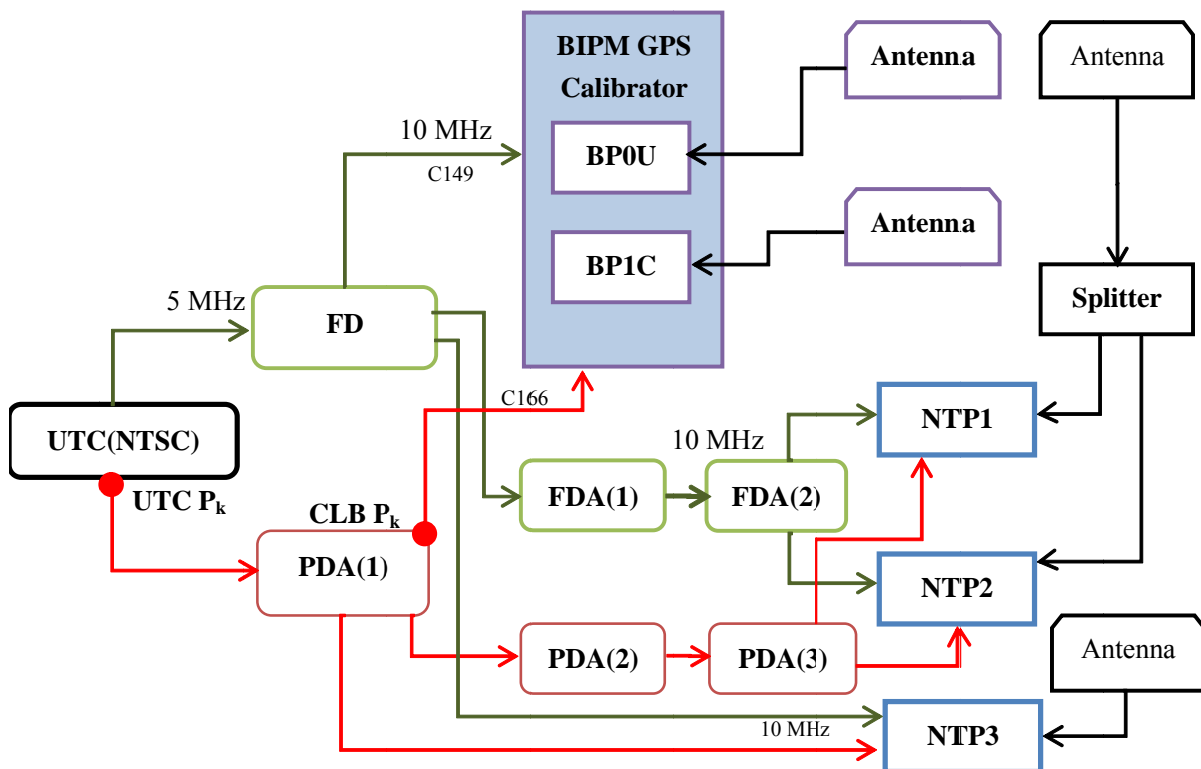
The setup of the  $\text{Std}_B$  is shown in the Figure 2.1. The cable C166 was directly connected to the UTC( $k$ ).



**Figure 2.1** The  $\text{Std}_B$  setups at the BIPM and Lab( $k$ )

### 3 Setups of the Lab( $k$ ) equipment

The experiment setup at NTSC is illustrated in the Figure 3.1. See also the Figures on the cover page.



**Figure 3.1** Setup of the  $\text{Std}_B$  and the UTC devices in the NTSC T/F laboratory

UTC  $P_k$  is the UTC(NTSC) reference point(which is defined in the HROG output point).  
 CLB  $P_k$  is the Calibration point. The delay is 43.9 ns between UTC  $P_k$  and CLB  $P_k$ .

FD is the frequency doubler. PDA is the pulse distribution amplifier; FDA is the frequency distribution amplifier.

The Table 3.1 gives the antenna information used in the PPP data processing.

**Table 3.1.1** The antenna information

No.	Receiver	Receiver type	Antenna	Antenna code	Note
1	BP0U	GRT50	NOV702GG	NAE07190046	
2	BP1C	Sept. Polarx4	ASH701945E_M	2000785	
3	PTBB	AshTech Z127	ASH700936E SNOW	CR15930	
4	NTP1	Sept. Polarx4 3002043	SEPCHOKE_MC	5312	Master
5	NTP2	Sept. Polarx4 3002046			backup
6	NTP3	Sept. Polarx4 3102240	SEPCHOKE_MC	5392	backup

The present(old) delays of the GNSS receiver (in the CGGTTS header)

**Table 3.1.2** The delays of the GNSS receiver *before* calibration:

Receiver code	Int_dly(ns)	Cab_dly(ns)	Ref_dly(ns)	Tot_dly(ns)	Note
NTP1	-132.9	+209.4	+208.5	-132	
NTP2	-123.2	+217	+207.8	-114	Backup
NTP3	-	-	-	-	Backup

Note: NTP3 is a new receiver for the backup, and we plan to use it as the master receiver in the future.

**Table 3.1.3** The delays between 1PPS IN and 1PPS OUT of the Septentrio PolaRx4TR\_PRO - before/after the calibration (measured 20/7/2016/1/8/2016)

Receiver code	Delays between 1PPS IN and 1PPS OUT	average
NTP1	+149.3	
NTP2	+143.6	
NTP3	+134.7	
BP1C	+206.7/206.7	206.7

**Table 3.1.4** The antenna cable delay of the receiver

Receiver code	The delays of the ant. cable (ns)	Note
NTP1	+209	The cable and the Splitter
NTP2	+221	The cable and the Splitter
NTP3	+198	Only the cable (by provider)

**Table 3.1.5** The delays between the receiver 1PPS\_IN and UTC(NTSC)

Receiver code	delay of receiver 1PPS_IN and UTC(NTSC)	Note
NTP1	+224.5	measured 20/7/2016
NTP2	+234.4	measured 20/7/2016
NTP3	+57.9	measured 20/7/2016

The TWSTFT link has never been directly calibrated directly between the PTB and the NTSC.

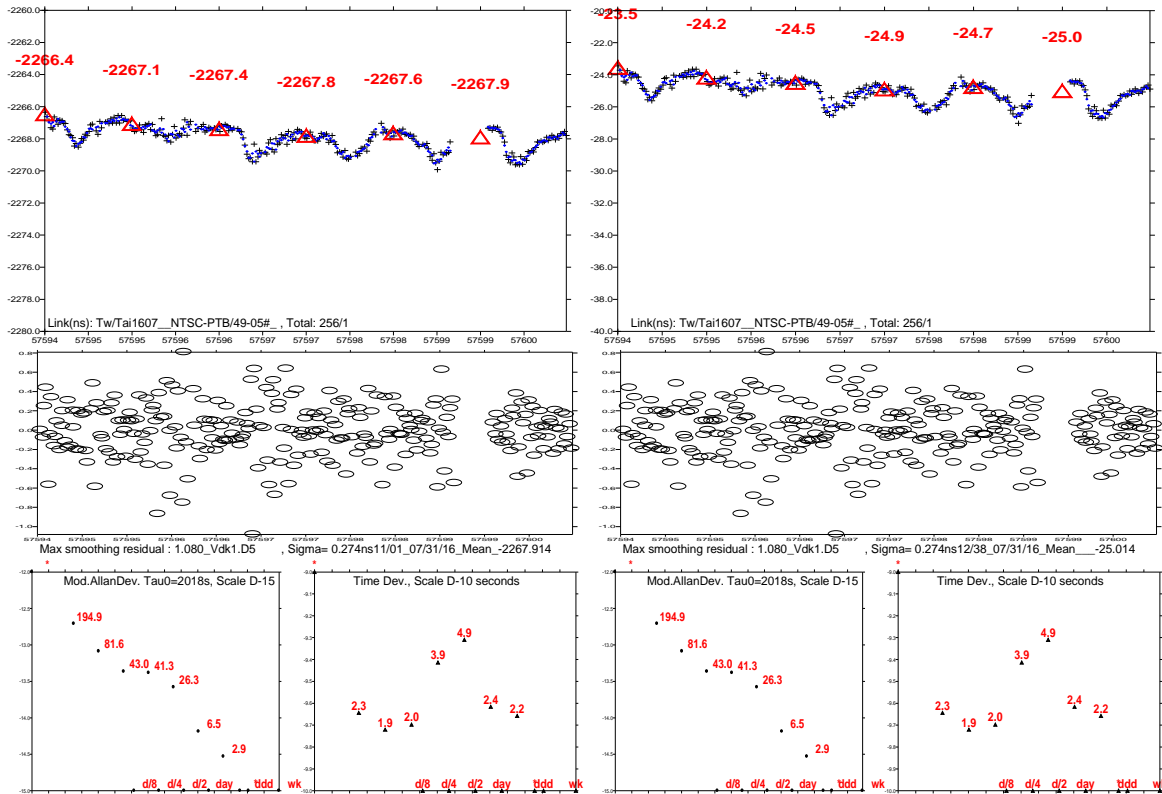
## 4 The calibrations of the UTC TWSTFT links between NTSC-PTB and NTSC-NIM

At present, the official UTC link is that of the combination of TWSTFT and GPSPPP. According to the TW link calibration guideline [7] and by METODE link calibration technique [1,3], we use directly the BIPM calibrator to calibrate the UTC TW link NTSC-PTB.

### 4.1 The calibration of the TWSTFT links

#### 4.1.1 Computation of the CALR by GPSPPP via BIPM calibrator

Figure 4.1.1 is the UTC TW time links of NTSC-PTB before (*left*) and after (*right*) the calibration correction CALR=2242.9 ns to be applied, cf. the Figure 4.1.2 below. As seen, UTC-UTC(NTSC) is about 25 ns.



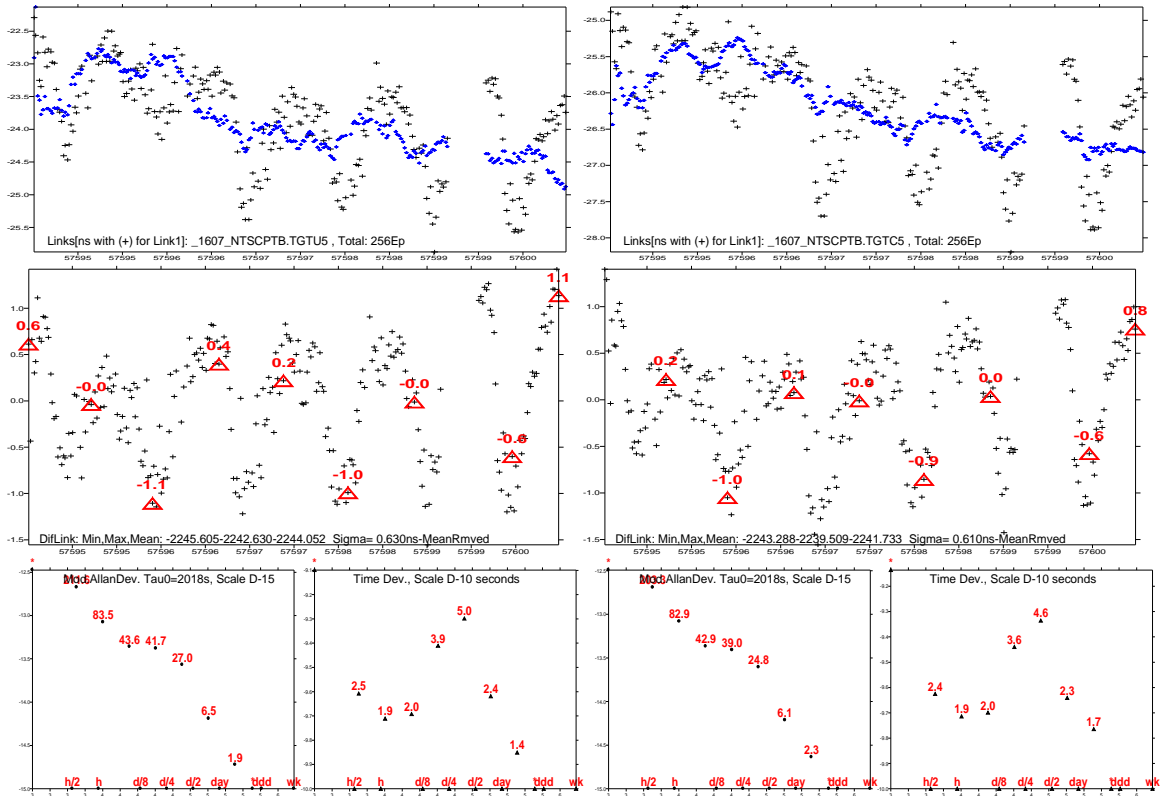
**Figure 4.1.1** The TW links NTSC-PTB before (*left*) and after (*right*) the calibration correction CALR=2242.9 ns

Figure 4.1.2 is the double clock difference DCD of the TW and GPSPPP links respectively for the GPS calibrators BPOU (*left*) and BP1C (*right*):  $-2244.052 \pm 0.630$  ns and  $-2241.733 \pm 0.610$  ns. The mean on average of the two calibrators is  $C_M = -2242.9 \pm 0.4$  ns.

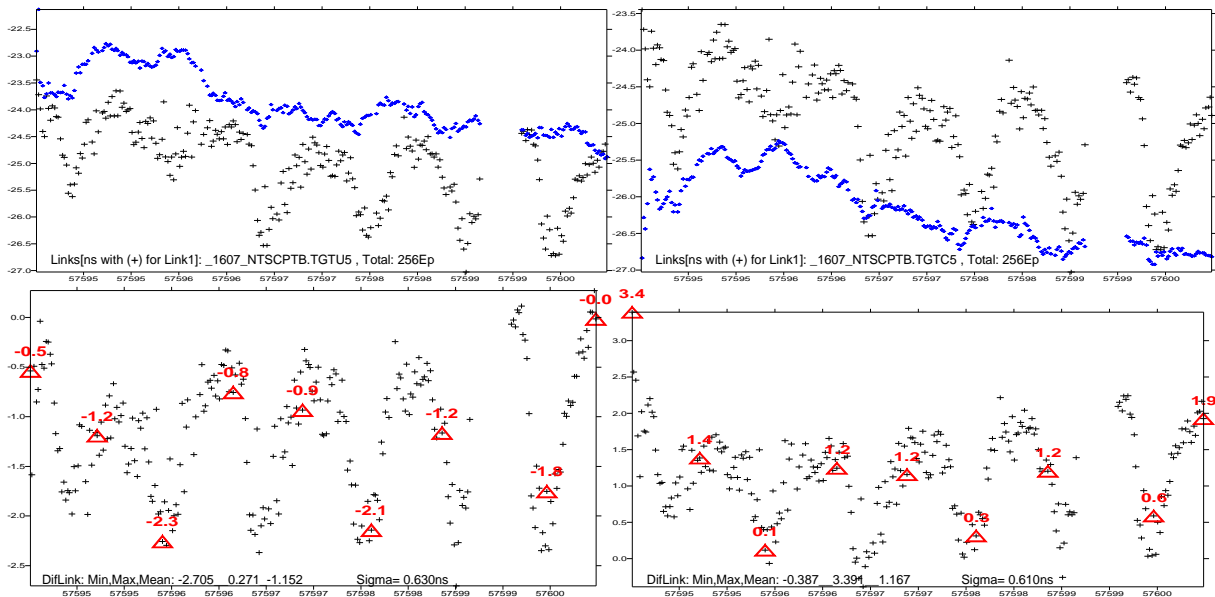
This correction  $C_M$  should be *subtracted* from the old CALR of the ITU TWSTFT data format file of the NTSC side but *added* to that of PTB side, that is,  $\text{new\_CALR(NTSC)} = \text{old\_CLAR} - C_M = 0 - (-2242.9) = 2242.9$  ns for the NTSC side in the ITU data files corresponding to ESDVAR=0. The Job of the Tsoft Menu Y20 to implement this calibration correction (active Calib) is:

```
Calib. _____: S=1 CALR= 00000.000 ESDVAR= 00000.000 ! CLB correction:-2242.9±0.49 ns
Calib. PTB03 NTSC02: S=1 CALR= -2242.9 ESDVAR= 00000.000 ! PTBmj.ddd ITU file
Calib. NTSC02 PTB03: S=1 CALR= +2242.9 ESDVAR= 00000.000 ! NTSCmj.ddd ITU file
```

Note here that, as usual the ESDVAR has to be set zero after the calibration. Figure 4.1.3 shows the DCD of TW-GPSPPP links after the new CALR to be used.



**Figure 4.1.2** DCD of TW and GPSPPP links respectively to the calibrators BP0U (left) and BP1C (right):  $-2244.052 \pm 0.630$  ns and  $-2241.733 \pm 0.610$  ns, and  $-2242.9 \pm 0.4$  ns on average



**Figure 4.1.3** DCD of TW and GPSPPP links respectively to the calibrators BP0U (left) and BP1C (right): after the new CALR =  $2242.9 \pm 0.7$  ns to be applied

#### 4.1.2 Computation of the CALR by the Triangle Closure Calibration (TCC)

According to the TW calibration guidelines [7], TCC is used for the computation of the CALR of the non UTC link NTSC-NIM. Please refer [12] for an example of the TCC calibration in details. The conventional calibration uncertainty of TCC is 2 ns, cf. also [7, 12]. The triangle is PTB-NIM-NTSC. Here we use the calibrated TW links NIM-PTB [10] and NTSC-PTB to calibrate the link NTSC-NIM. The result is below:

The CALR value in ITU data files corresponding to ESDVAR=0 is:

Labi	Labj	S	CALR	StDev	ESDVAR	N	ESIG	CI
Calib.	NIM01	NTSC02: S=1	CALR= 79.979 +/- 0.191,	ESDVAR= 00000.000	88	0.020	419	
Calib.	NTSC02	NIM01: S=1	CALR= -79.979 +/- 0.191,	ESDVAR= 00000.000	88	0.020	419	

#### 4.1.3 Provisional application of the calibration correction

The BIPM monthly computes the DCD of the TW-GPSPPP links which are indispensable to monitor and study of the long-term stability of the UTC links. When the calibration correction is too big, the nanosecond level variation is not observable and the computation is sometimes blocked. Moreover, rigorously speaking, the final CALR should be computed after the closure measurement at PTB, with still several months' delay. And it should be implemented meanwhile on *both* sides with an official CI code issued by BIPM. Therefore a temporary measure may be used to introduce the CALR in the ESDVAR, i.e. by the relation  $ESDVAR(Labk)=2*CALR(Labk)$ . Hens, the  $ESDVAR(NTSC) = 4485.8$  ns.

The Job of the Tsoft Menu Y20 for the implementation(active Calib) are:

##### NTSC-PTB

```
Calib. _____ : S=0 CALR= 00000.000 ESDVAR= 00000.000 ! ESDVAR(NTSC)=CalR*2=2242.9*2
Calib. PTB03 NTSC02: S=0 CALR= 0000.0 ESDVAR= 00000.000 ! subtracted from ITU PTBmj.ddd
Calib. NTSC02 PTB03: S=0 CALR= 0000.0 ESDVAR= 04485.8 ! added to ITU NTSCmj.ddd files
```

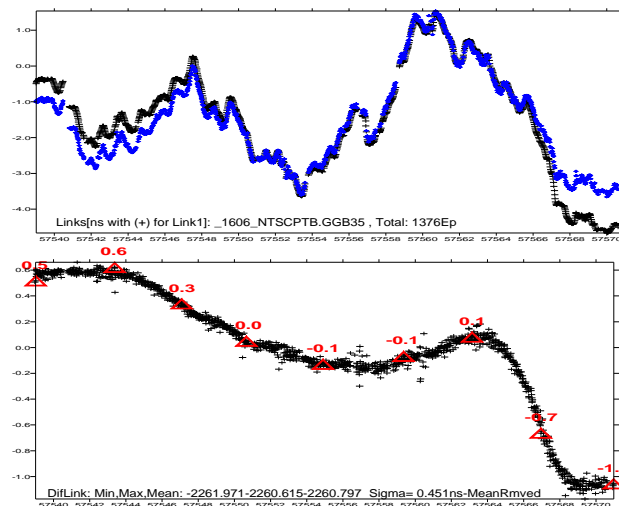
Similar, we have the non UTC link NTSC-NIM

```
Calib. _____ : S=0 CALR= 00000.000 ESDVAR= 00000.000 ! CLB correction: -79.979*2
Calib. NIM01 NTSC02: S=0 CALR= 0.0 ESDVAR= 00000.000 ! NIMmj.ddd files CI=14x
Calib. NTSC02 NIM01: S=0 CALR= 0.0 ESDVAR= -160.0 ! NTSCmj.ddd files CI=14x
```

## 4.2 Discussion

As can be seen in the Figure 4.2.1, there seem slops in the beginning and in the end of the month 1606 comparison between the combined (TW+PPP) and the PPP links. For the first, the TW link calibration dominates. It is abnormal but we do not know the cause for this moment. The calibration used the 1607 data set.

The difference between TW and GPS links of the month 1606 is  $-2260.80 \pm 0.45$  ns. Comparing with that of 1602,  $-2260.2$  ns [9], the difference is only 0.6 ns. The TW/GPS link calibrations are not applied.



**Figure 4.2.1** A monthly (1606) NTSC-PTB comparison between the combined (TW+PPP) vs. the PPP link. A slope about 3 ns/month presents. The difference is  $-2260.80 \pm 0.45$  ns on average.



## 5 GPS Data processing

We first compute the METODE total delay calibration correction  $C_M$  through PPP [3] and then convert it to the classic equipment calibration result, the internal delays: INTDLY(P1/P2), cf. [3] for details.

### 5.1 The GPSPPP solution

Table 5.1.1 gives the *present* calibration values for the master GPS receivers of PTB and Lab(*k*).

6 days data are selected: DOY 207-212 of 2016. The Rinex files are cleaned and composed by using Teqc, then compressed and submitted to CSRS-PPP, cf. Section 9 of [3].

**Table 5.1.1** Computation of the UTC(*k*)-GPST by GPSPPP (6-day NRCan online solution/DOY 207-212)

RevSys	Doy1	Doy2	ClkPh/ns	Drift	ClkPh0/ns	RMS/ns
BP0U	207	213	-80,77	-0,27	-81,58	0,93
BP1C	207	213	-50,88	-0,24	-51,60	0,81
NTP1	207	213	-129,75	-0,22	-130,41	0,82
NTP2	207	213	-120,92	-0,22	-121,58	0,82
NPP3	207	213	38,59	-0,28	37,75	0,84
PTBB	207	213	510,13	0,00	510,13	0,8

### 5.2 The Total delay and the total delay corrections

Tables 5.2.1a/b give the total delay and the total delay correction for the TW link and the GPS receivers of the Lab(*k*). The CCD<sub>u</sub> and CCD<sub>c</sub> are the calibration correction given by BP0U and BP1C of the StdB. When the Internal Delays IntD(L1)= IntD(L2)= IntD(L3)=0, the calibration corrections are the calibrated internal delay of L3. LkGps and LkTw are the mean values of the related links. Note, here the computed  $C_M$  for TW link is approximated value. The final value is given in the DCD computation of Section 4.1, Cf. Figure 4.1.2. However, from the rigorous computation (Fig. 4.1.2) and the approximated value in Table 5.2.1, we have exactly the same result 2242.9 ns. In fact, when there are not data missing in TW/GPS, the two approaches give the same result.

**Table 5.2.1a** Total Delay and Total Delay Correction ( $C_M/L3$ )/DOY207-212, set the old IntDly=0)

Rcv	IntD <sub>L1</sub>	IntD <sub>L2</sub>	L <sub>1</sub> -L <sub>2</sub>	IntD <sub>L3</sub>	CabD	RefD	C <sub>0</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	TotDly	ClkP	m-l	CCD <sub>u</sub>	CCD <sub>c</sub>	C <sub>M</sub> /CalR
	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
a	b	c	d	e	f	g	h	i	j	k	l	m	ns	o	p	q
BP0U				0,0		-43,9	-20,8	4,7			-60,0	-81,6	-21,58			
BP1C				0,0		-43,9	225,2	-2,3	-206,7		-27,7	-51,6	-23,90			
NTP1	0,0	0,0	0,0	0,0	209,0	-224,5			-149,3		-164,8	-130,4	34,4	-56,0	-58,3	-57,1
NTP2	0,0	0,0	0,0	0,0	221,0	-234,4			-143,6		-157,0	-121,6	35,4	-57,0	-59,3	-58,2
NTP3	0,0	0,0	0,0	0,0	198,0	-57,9			-134,7		5,4	37,8	32,4	-53,9	-56,3	-55,1
PTBB	303,9	319,3	-15,4	280,1	301,7	-74,0					507,8	510,1	2,32	-23,90	-26,22	-25,1
LkGps													-25,1			
LkTw												-2268				2242,9

**Table 5.2.1b** The new and old total Delays and Total Delay Correction ( $C_M/L3$ )/DOY207-214)

Rcv	IntD <sub>L1</sub>	IntD <sub>L2</sub>	L <sub>1</sub> -L <sub>2</sub>	IntD <sub>L3</sub>	CabD	RefD0	C <sub>0</sub>	C <sub>1</sub>	PPS/i-o	RefD	TotDly	Old-New
	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
a	b	c	d	e	f	g	h	i	j	k	l	
NTP1	-132,9	-132,9	0,0	-132,9	209,4	-208,5					-132,0	
NTP2	-123,2	-123,2	0,0	-123,2	217,0	-207,8					-114,0	
NTP3	0,0	0,0	0,0	0,0	198,0	-57,9			-134,7		5,4	
NTP1	57,1	57,1	0,0	57,1	209,0	-224,5			-149,3	-373,8	-107,7	-24,3
NTP2	58,2	58,2	0,0	58,2	221,0	-234,4			-143,6	-378,0	-98,8	-15,2
NTP3	55,1	55,1	0,0	55,1	198,0	-57,9			-134,7	-192,6	60,5	-55,1

## 6 The closure measurements before and after the visits to NTSC and NIM

The final calibration should be made after the closure measurement which controls the stability of the StdB. The PPP closures at BIPM before and after the visits to NIM/BSNC vs. the BIPM fixed reference receivers are within 0.5 ns.

Table 6.1 3 months PPP closures at BIPM before and after the visits to NTSC vs. the GTR50 BP0T

Period	BP0U – BP0T/ns	BP1C – BP0T/ns	BP1C – BP0U/ns	Mean/ns
56685-56690	-124.8±0.1	-126.8±0.1	2.0±0.1	-125.8±0.1
56762-56764	-124.7±0.1	-125.7±0.1	1.0±0.1	-125.2±0.1
56864-56865	-124.5±0.1	-125.5±0.1	1.0±0.1	-125.0±0.1
Old-New closure	0.2	0.2	1	0.2

## Acknowledgement

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## Annex I The BIPM calibration history of NTSC

→BIPM calibrations of time transfer equipment

→<http://www.bipm.org/jsp/en/TimeCalibrations.jsp>

→NTSC

### Calibrations between NTSC and OP

$d$  are differential time corrections to be added to  $[UTC(NTSC) - UTC(OP)]$ , and  $u(d)$  are estimated uncertainties for the periods of comparisons.

Date	$d/ns$	$u(d)/ns$	Reference	Note
August 2002	-7.0	4.0	<a href="#">BIPM Report-2003/05</a>	(1)
August 2004	-12.5	3.0	<a href="#">BIPM Report-2008/02</a>	(2)

The uncertainties given in this table are conservative. They are mainly driven by the uncertainty due to the 'round-trip' reproducibility at the OP.

#### Notes

- (1) R100/30T receiver (s/n: 0045) at NTSC  
 (2) NTSCGPS-1 receiver at NTSC

### The traceability of the time transfer facility calibrations since the last BIPM calibration in 2004:

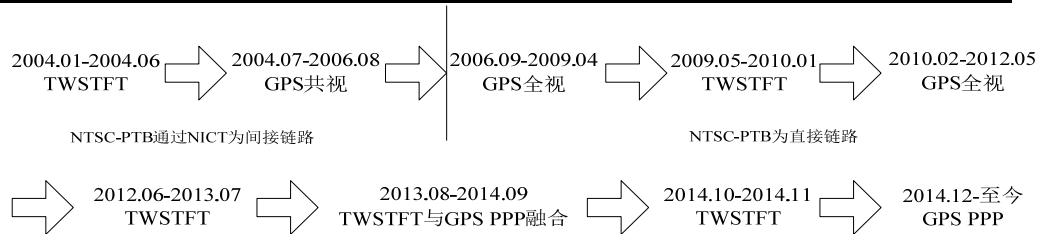


Figure A. The evolution of the time links for UTC(NTSC) between Jan 2004 and May 2016

### A hypothesis of the evolution of the NTSC time equipment calibration corrections since 2002:

One side, as shows by the Figure A, the calibration of 2004 and its transfer to the other time transfer facilities are carefully traceable. On the other side, the calibration corrections are unusually big or huge frankly speaking: -7 ns in 2002, then only two year after in 2004, it was -12.5 ns and became -24.3 ns in 2016. It is unreasonable to have such big corrections taking into account that NTSC is an advance laboratory with experienced staff and about 40 clocks taking a weight of more than 6% of the total UTC clock weight. In fact, it is often the 3<sup>rd</sup> or 4<sup>th</sup> clock weighting laboratory in all the about 70 UTC laboratories in the world. Whatever the causes, we cannot explain the -24.3 ns calibration correction.

A hypothesis is then there is a misunderstanding the BIPM calibration report [2]: the *signs* of the values have been applied in an opposite sense, i.e., instead of applying in 2002 and 2004, the +7 ns and +12.5 ns, -7 ns and -12.5 ns have been implemented. Finally, an offset of near  $12.5 \times 2 = 25$  ns is found finally in the 2016 calibration. If this hypothesis holds, the offset of 25 ns exists since 2006 when it was implemented after the All in View technique to be used for the UTC time transfer.

It is not impossible. The 2002/2004 calibrations were that of the GPS C/A code and the reference laboratory was OP while as the GPS All in View time transfer taking the PTB as reference laboratory. Therefore, the wrong-sign use of the corrections could not be easy to be seen when the implementation of the last calibration correction (-12.5 ns) and the switch the reference from OP to PTB in 2006.

Further investigation is required. However, one of the lessons is that the BIPM should help to check the implementation of the calibration corrections.

## Annex II Computation of GPS PPP

CRNCan 6-day PPP solution. File name suggested: RCV+lab+Doy1-Doy2. E.g. BP0Untsc207-212. Cf. Section 9 of [3].

Results of the \*.Sum file.

### BP0U

#### 3.5 Estime des parametres d'horloge du recepteur

Epoque de reference	:	2016/07/30 00:00:00.00	
Constellation de reference	:	GPS	
Phase horloge (ns)	:	-80,77	0,01
Derive phase (ns/jour)	:	-0,27	0,00
RMS residuelles (ns)	:	0,93	17272

### BPIC

#### 3.5 Estime des parametres d'horloge du recepteur

Epoque de reference	:	2016/07/30 00:00:00.00	
Constellation de reference	:	GPS	
Phase horloge (ns)	:	-50,88	0,01
Derive phase (ns/jour)	:	-0,24	0,00
RMS residuelles (ns)	:	0,81	17273

### NTP1

#### 3.5 Estime des parametres d'horloge du recepteur

Epoque de reference	:	2016/07/30 00:00:00.00	
Constellation de reference	:	GPS	
Phase horloge (ns)	:	-129,75	0,01
Derive phase (ns/jour)	:	-0,22	0,00
RMS residuelles (ns)	:	0,82	17273

### NTP2

#### 3.5 Estime des parametres d'horloge du recepteur

Epoque de reference	:	2016/07/30 00:00:00.00	
Constellation de reference	:	GPS	
Phase horloge (ns)	:	-120,92	0,01
Derive phase (ns/jour)	:	-0,22	0,00
RMS residuelles (ns)	:	0,82	17275

### NTP3

#### 3.5 Estime des parametres d'horloge du recepteur

Epoque de reference	:	2016/07/30 00:00:00.00	
Constellation de reference	:	GPS	
Phase horloge (ns)	:	38,59	0,01
Derive phase (ns/jour)	:	-0,28	0,00
RMS residuelles (ns)	:	0,84	17275

### PTBB

#### 3.5 Estime des parametres d'horloge du recepteur

Epoque de reference	:	2016/07/30 00:00:00.00	
Constellation de reference	:	GPS	
Phase horloge (ns)	:	510,13	0,01
Derive phase (ns/jour)	:	-0,00	0,00
RMS residuelles (ns)	:	0,80	17275

### IMEJ

#### 3.5 Estime des parametres d'horloge du recepteur

Epoque de reference	:	2016/07/30 00:00:00.00	
Constellation de reference	:	GPS	
Phase horloge (ns)	:	4.75	0.01
Derive phase (ns/jour)	:	0.01	0.00
RMS residuelles (ns)	:	0.70	17271

## Annex III Summary of the NIM-NTSC-PTB TW calibrations and implementations

### A3.1 NIM-PTB CI=417 [10]

The ITU data files corresponding to ESDVAR=0:

```
Calib. _____ : S=1 CALR= 00000.000 ESDVAR= 00000.000 ! CLB correction:-2319.7±0.49 ns
Calib. PTB03 NIM01: S=1 CALR= -2319.7 ESDVAR= 00000.000 ! PTBmj.ddd ITU file CI=417
Calib. NIM01 PTB03: S=1 CALR= +2319.7 ESDVAR= 00000.000 ! NIMmj.ddd ITU file CI=417
```

Provisional application of the calibration correction CALR=0:

```
Calib. _____ : S=0 CALR= 00000.000 ESDVAR= 00000.000 ! ESDVAR(NIM)=CalR*2=2319.7*2
Calib. PTB03 NIM01: S=0 CALR= 0000.0 ESDVAR= 00000.000 ! PTBmj.ddd
Calib. NIM01 PTB03: S=0 CALR= 0000.0 ESDVAR= 04639.4 ! NIMmj.ddd files
```

### A3.2 NTSC-PTB CI=418, cf. Sections 4.1.1,4.1.2 and 4.1.3

The ITU data files corresponding to ESDVAR=0:

```
Calib. _____ : S=1 CALR= 00000.000 ESDVAR= 00000.000 ! CLB correction:-2242.9±0.49 ns
Calib. PTB03 NTSC02: S=1 CALR= -2242.9 ESDVAR= 00000.000 ! PTBmj.ddd ITU file CI=418
Calib. NTSC02 PTB03: S=1 CALR= +2242.9 ESDVAR= 00000.000 * ! NTSCmj.ddd ITU file CI=418
* the new CalR produces a jump of near25 ns in UTC(NTSC), which takes 6% of the total weight, i.e., would make a jump of 1.5 ns in
UTC. It is suggested to reduce the jump by monthly adjusting the ESDVAR from 50 to 0, step=10
ns (corresponding CALR 5 ns). See below, there ESDVAR changes as 40, 30, 20, 10, 0.
Calib. PTB03 NTSC02: S=1 CALR= -2242.9 ESDVAR= 00000.000 ! PTBmj.ddd ITU file CI=418
Calib. NTSC02 PTB03: S=1 CALR= +2242.9 ESDVAR= 40.0* ! NTSCmj.ddd ITU file CI=418
```

Provisional application of the calibration correction CALR=0:

```
Calib. _____ : S=0 CALR= 00000.000 ESDVAR= 00000.000 ! ESDVAR(NTSC)=CalR*2=2242.9*2
Calib. PTB03 NTSC02: S=0 CALR= 0000.0 ESDVAR= 00000.000 ! PTBmj.ddd
Calib. NTSC02 PTB03: S=0 CALR= 0000.0 ESDVAR= 04485.8 ! NTSCmj.ddd files
```

### A3.3 NTSC-NIM CI=419

The ITU data files corresponding to ESDVAR=0:

```
Calib. _____ : S=1 CALR= 00000.000 ESDVAR= 00000.000 ! CLB correction: 79.979±0.19 ns
Calib. NIM01 NTSC02: S=1 CALR= 80.0 ESDVAR= 00000.000 ! NIMmj.ddd files CI=419
Calib. NTSC02 NIM01: S=1 CALR= -80.0 ESDVAR= 00000.000 ! NTSCmj.ddd files CI=419
```

Provisional application of the calibration correction CALR=0:

```
Calib. _____ : S=0 CALR= 00000.000 ESDVAR= 00000.000 ! CLB correction: -79.979*2
Calib. NIM01 NTSC02: S=0 CALR= 0.0 ESDVAR= 00000.000 ! NIMmj.ddd files
Calib. NTSC02 NIM01: S=0 CALR= 0.0 ESDVAR= -160.0 ! NTSCmj.ddd files
```

\*\*\* All for Y20 calib.

```
Calib. PTB03 NIM01: S=1 CALR= -2319.7 ESDVAR= 00000.000 ! PTBmj.ddd ITU file CI=417
Calib. NIM01 PTB03: S=1 CALR= +2319.7 ESDVAR= 00000.000 ! NIMmj.ddd ITU file CI=417

Calib. PTB03 NTSC02: S=1 CALR= -2242.9 ESDVAR= 00000.000 ! PTBmj.ddd ITU file CI=418
Calib. NTSC02 PTB03: S=1 CALR= +2242.9 ESDVAR= 00000.000 ! NTSCmj.ddd ITU file CI=418

Calib. NIM01 NTSC02: S=1 CALR= 80.0 ESDVAR= 00000.000 ! NIMmj.ddd files CI=419
Calib. NTSC02 NIM01: S=1 CALR= -80.0 ESDVAR= 00000.000 ! NTSCmj.ddd files CI=419

Calib. PTB03 NIM01: S=0 CALR= 0000.0 ESDVAR= 00000.000 ! PTBmj.ddd
Calib. NIM01 PTB03: S=0 CALR= 0000.0 ESDVAR= 04639.400 ! NIMmj.ddd files

Calib. PTB03 NTSC02: S=0 CALR= 0000.0 ESDVAR= 00000.000 ! PTBmj.ddd
Calib. NTSC02 PTB03: S=0 CALR= 0000.0 ESDVAR= 04485.800 ! NTSCmj.ddd files

Calib. NIM01 NTSC02: S=0 CALR= 0.0 ESDVAR= 00000.000 ! NIMmj.ddd files CI=14x
Calib. NTSC02 NIM01: S=0 CALR= 0.0 ESDVAR= -160.000 ! NTSCmj.ddd files CI=14x
```