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### Notations

As presented in [Petit et al., 2001] for the Z12-T, the calibration of a geodetic system is divided in (up to) 6 different parts (Figure 1)

- $X_P$  = Delay of the 1PPS-in with respect to the laboratory reference
- $X_O$  = Delay of the “internal reference” with respect to the 1PPS-in

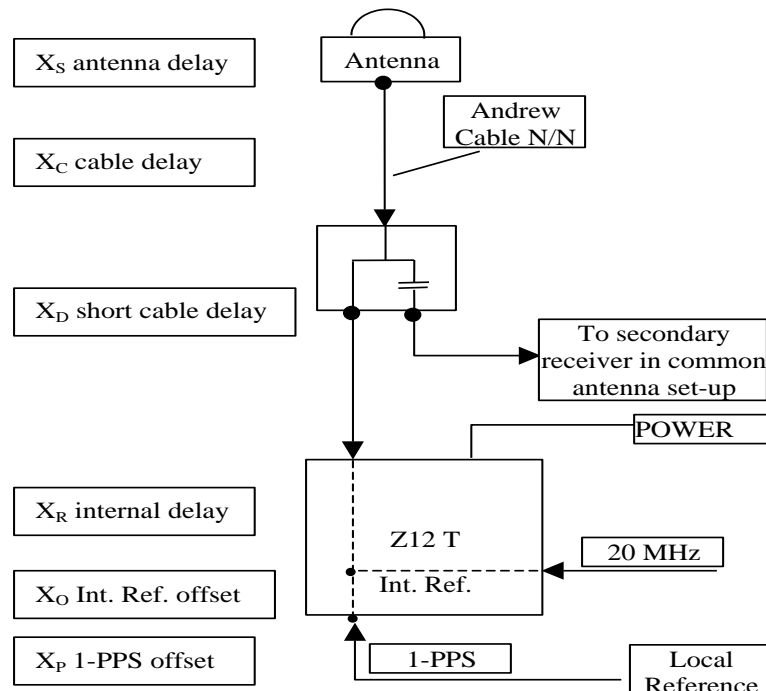
$(X_P + X_O) = \text{REFDLY.}$

- $X_C$  = antenna cable delay
- $[X_D = \text{short cable} + \text{splitter delay}]$

$(X_C + X_D) = \text{CABDLY.}$  In practice,  $X_D$  is generally not used.

- $X_R$  = receiver internal delay, measured from the “internal reference”
- $X_S$  = antenna delay

$(X_R + X_S) = \text{INTDLY.}$



**Figure 1:** Definition of the different delays used in the most general set-up of a geodetic system (here shown for a Z12-T) from [Petit et al, 2001].

**BIPM (16243)**Period

MJD 57630 to 57636

Delays

## BP0R:

$X_O = 226.4$  ns (266.4-48.7+8.7)  
 $X_P = 42.7$  ns (BP1R+C139+BP1S+C72)  
 REFDLY = 269.1 ns  
 CABDLY = 133.4 ns (C113)

## BP1J:

$X_O = 132.5$  ns (186.3-53.8)  
 $X_P = 47.6$  ns (BP1R+C139+BP1S+C172)  
 REFDLY = 180.1 ns  
 CABDLY = 128.7 ns (C138)

## BP1X:

REFDLY = 42.6 ns (BP1R+C139+BP1S+C126)  
 CABDLY = 129.7 ns (C178)  
 INT DLY = -27.5 ns (GPS C1)  
           -33.5 ns (GPS P1)  
           -37.4 ns (GPS P2)

## ZA02:

$X_O = 133.1$  ns (181.8-48.7)  
 $X_P = 42.6$  ns (BP1R+C139+BP1S+C194)  
 REFDLY = 175.7 ns  
 CABDLY = 152.6 ns

Setup at the BIPM**Annex A - Information Sheet**

(to be repeated for each calibrated system)

Laboratory:	BIPM	
Date and hour of the beginning of measurements:	MJD 57630.647	
Date and hour of the end of measurements:	MJD 57636.998	
<b>Information on the system</b>		
	<b>Local:</b>	<b>Travelling:</b>
4-character BIPM code	BP0R	ZA02
• Receiver maker and type: Receiver serial number:	Septentrio PolaRx2e 3113	Septentrio PolaRx4TRpro 3102318
1 PPS trigger level /V:		
• Antenna cable maker and type: Phase stabilised cable (Y/N):		
Length outside the building /m:	~ 15 m	~ 15 m
• Antenna maker and type: Antenna serial number:	Ashtech Chokering 701945-2 CR6200539014	Topcon RegAnt 2-3 RRA00111
Temperature (if stabilised) /°C		
<b>Measured delays /ns</b>		
(if needed fill box "Additional Information" below)		
	<b>Local:</b>	<b>Travelling:</b>
• Delay from local UTC to receiver 1 PPS-in:	42.7 ns	42.6 ns
Delay from 1 PPS-in to internal Reference (if different): <small>(see section 2 for details)</small>	226.4 ns	133.1 ns
• Antenna cable delay:	133.4 ns	152.6 ns
Splitter delay (if any):		(1)
Additional cable delay (if any):		(1)
<b>Data used for the generation of CGGTTS files</b>		
• INT DLY (GPS) /ns:		
• INT DLY (GLONASS) /ns:		
• CAB DLY /ns:		
• REF DLY /ns:		
• Coordinates reference frame:		
Latitude or X /m:		
Longitude or Y /m:		
Height or Z /m:		
<b>General information</b>		
• Rise time of the local UTC pulse:		
• Is the laboratory air conditioned:		
Set temperature value and uncertainty:		21 ± 1°C
Set humidity value and uncertainty:		

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

## Annex A - Information Sheet

(to be repeated for each calibrated system)

Laboratory:	BIPM	
Date and hour of the beginning of measurements:	57634.0	
Date and hour of the end of measurements:	57636.998	
Information on the system		
	Local:	Travelling:
4-character BIPM code	BP1J	
• Receiver maker and type: Receiver serial number:	Septentrio PolaRx4proTR 27	
1 PPS trigger level /V:		
• Antenna cable maker and type: Phase stabilised cable (Y/N):		
Length outside the building /m:	~ 15 m	
• Antenna maker and type: Antenna serial number:	Septentrio Sepchoke_MC 5131	
Temperature (if stabilised) /°C		
Measured delays /ns		
(if needed fill box "Additional Information" below)		
	Local:	Travelling:
• Delay from local UTC to receiver 1 PPS-in:	47.6 ns	
Delay from 1 PPS-in to internal Reference (if different): <small>(see section 2 for details)</small>	132.5 ns	
• Antenna cable delay:	128.7 ns	(1)
Splitter delay (if any):		(1)
Additional cable delay (if any):		(1)
Data used for the generation of CGGTTS files		
• INT DLY (GPS) /ns:		
• INT DLY (GLONASS) /ns:		
• CAB DLY /ns:		
• REF DLY /ns:		
• Coordinates reference frame:		
Latitude or X /m:		
Longitude or Y /m:		
Height or Z /m:		
General information		
• Rise time of the local UTC pulse:		
• Is the laboratory air conditioned:		
Set temperature value and uncertainty:		21 ± 1°C
Set humidity value and uncertainty:		

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.

**Annex A - Information Sheet**

(to be repeated for each calibrated system)

Laboratory:	BIPM	
Date and hour of the beginning of measurements:	MJD 57630.647	
Date and hour of the end of measurements:	MJD 57636.998	
<b>Information on the system</b>		
	<b>Local:</b>	<b>Travelling:</b>
4-character BIPM code	BP1X	
• Receiver maker and type: Receiver serial number:	Dicom GTR51 1306001	
1 PPS trigger level /V:	1 V	
• Antenna cable maker and type: Phase stabilised cable (Y/N):		
Length outside the building /m:	~15 m	
• Antenna maker and type: Antenna serial number:	Novatel 703-GG NEG13160018	
Temperature (if stabilised) /°C		
<b>Measured delays /ns</b>		
(if needed fill box "Additional Information" below)		
	<b>Local:</b>	<b>Travelling:</b>
• Delay from local UTC to receiver 1 PPS-in:	42.6 ns	
Delay from 1 PPS-in to internal Reference (if different): <small>(see section 2 for details)</small>		
• Antenna cable delay:	129.7 ns	(1)
Splitter delay (if any):		(1)
Additional cable delay (if any):		(1)
<b>Data used for the generation of CGGTTS files</b>		
• INT DLY (GPS) /ns:	-27.5 ns (GPS C1), -33.5 ns (GPS P1), -37.4 ns (GPS P2)	
• INT DLY (GLONASS) /ns:		
• CAB DLY /ns:		
• REF DLY /ns:		
• Coordinates reference frame:		
Latitude or X /m:		
Longitude or Y /m:		
Height or Z /m:		
<b>General information</b>		
• Rise time of the local UTC pulse:		
• Is the laboratory air conditioned:		
Set temperature value and uncertainty:	21 ± 1°C	
Set humidity value and uncertainty:		

(1) For a trip with closure, not needed if the traveling equipment is used in the same set-up throughout.



**Log of Events / Additional Information :**

All measurements at BIPM carried out by L. Tisserand.

Equipment used to measure delays was a time interval counter (TIC), with measurement uncertainty typically less than 0.5 ns (using external reference frequency as timebase).

TIC: model SR620, maker Stanford Research Systems, serial number 4680.

Log of events:

- August 26<sup>th</sup> 2016:

Traveler receiver (PolaRx4TRpro, ZA02) installed in laboratory.

Measurement of CAB DLY of ZA02 receiver.

Synchronization of the 1PPS output to the measurement latching of ZA02 not configured.

- August 30<sup>th</sup> 2016:

General Electric cut planned the morning, shutdown of all equipment at the end of the previous day.

Restart of all equipment and start of observations record (expect BP1J receiver).

Measurement of REF DLY for all receivers (expect BP1J receiver).

- September 02<sup>nd</sup> 2016:

Measurement of REF DLY of BP1J receiver and start of observations record.

- September 09<sup>th</sup> 2016:

Stop of observations record, measurement of REF DLY of all receivers and CAB DLY of ZA02 receiver.



**BP0R - ZA02**

## COMPUTATION OF BASELINE

Number of phase differences to fit baseline = 80250  
 A priori baseline (X,Y,Z)/m = 4.490 -0.450 -3.900  
 Fixed baseline  
 14439 clock jitters computed out of 14483 intervals  
 AVE jitter /ps = -2.2 RMS jitter /ps = 7.1

Iter 1 Large residuals L1= 0  
 Iter 1 Large residuals L2= 4  
 Computed baseline L1 (X,Y,Z)/m = -0.066 0.177 -0.029  
 RMS of residuals L1 /m = 0.004  
 Computed baseline L2 (X,Y,Z)/m = 0.097 -0.231 0.013  
 RMS of residuals L2 /m = 0.005

Use baseline L1 (X,Y,Z)/m = 4.490 -0.450 -3.900  
 Use baseline L2 (X,Y,Z)/m = 4.490 -0.450 -3.900

## COMPUTATION OF CODE DIFFERENCES

Number of code differences = 106343

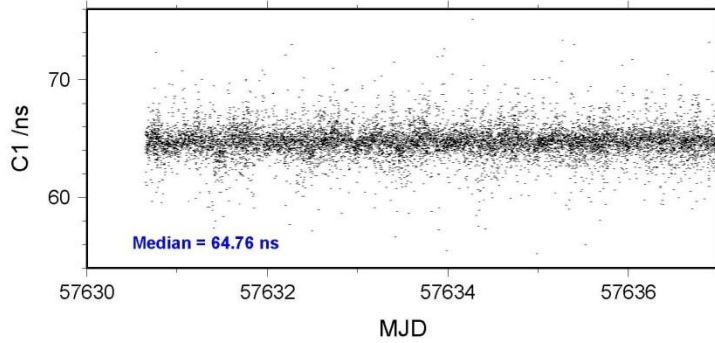
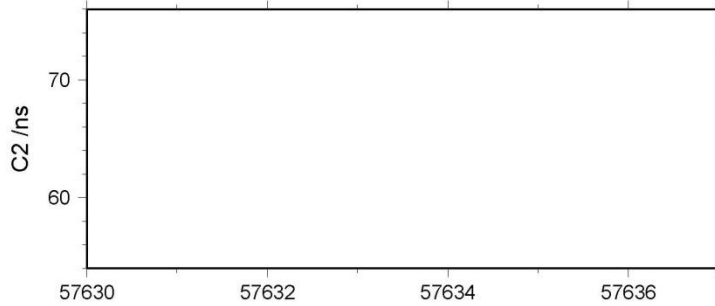
Global average of individual differences

Code #pts, ave/ns, rms/ns  
 C1: 104418 64.768 2.186  
 C2: 0 NaN NaN  
 P1: 100661 62.877 2.424  
 P2: 100622 61.139 2.417

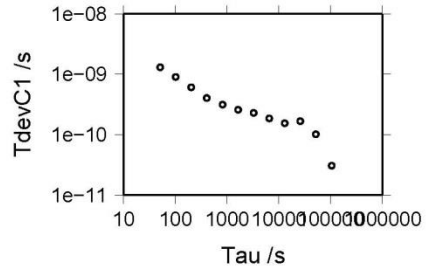
Number of 300s epochs in out file = 1831

Code #pts, median/ns, ave/ns, rms/ns  
 C1: 10797 64.758 64.766 1.291  
 C2: 0 0.000 NaN NaN  
 P1: 10521 62.947 62.908 1.279  
 P2: 10518 61.191 61.157 1.388

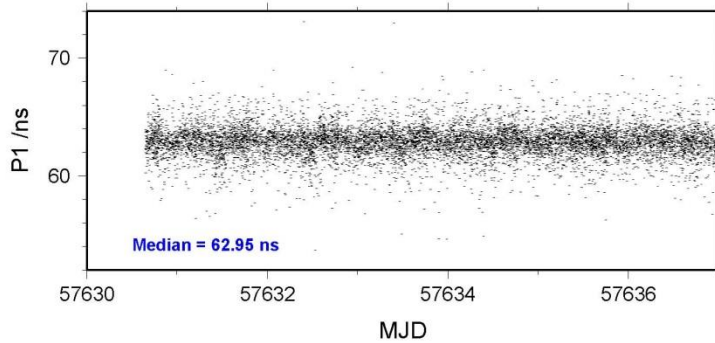
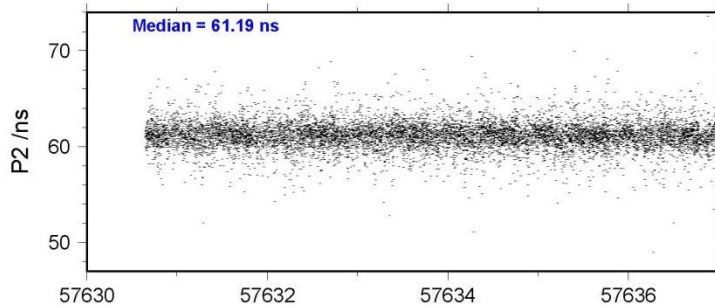
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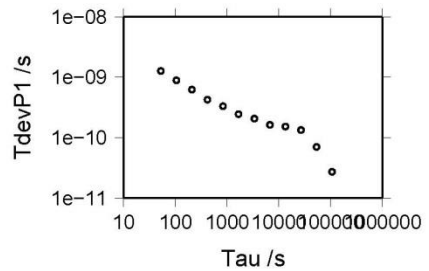
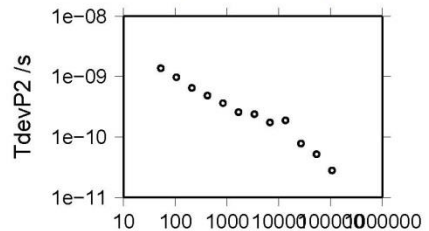
104145 s: C1= 31 ps  
52073 s: C1= 101 ps  
26036 s: C1= 166 ps  
13018 s: C1= 154 ps  
6509 s: C1= 185 ps  
3255 s: C1= 230 ps  
1627 s: C1= 259 ps  
814 s: C1= 314 ps  
407 s: C1= 406 ps  
203 s: C1= 606 ps  
102 s: C1= 902 ps  
51 s: C1= 1294 ps



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106878 s: P1= 27 ps    106908 s: P2= 28 ps  
53439 s: P1= 70 ps    53454 s: P2= 52 ps  
26719 s: P1= 133 ps    26727 s: P2= 78 ps  
13360 s: P1= 153 ps    13364 s: P2= 188 ps  
6680 s: P1= 162 ps    6682 s: P2= 173 ps  
3340 s: P1= 205 ps    3341 s: P2= 238 ps  
1670 s: P1= 245 ps    1670 s: P2= 257 ps  
835 s: P1= 330 ps    835 s: P2= 364 ps  
417 s: P1= 427 ps    418 s: P2= 485 ps  
209 s: P1= 625 ps    209 s: P2= 645 ps  
104 s: P1= 888 ps    104 s: P2= 980 ps  
52 s: P1= 1272 ps    52 s: P2= 1380 ps



**BP1J - ZA02**

## COMPUTATION OF BASELINE

Number of codes to fit baseline and biases = 52598  
 Computed code bias (P1/P2)/m = -6.514 -7.722  
 Computed baseline (X,Y,Z)/m = 1.463 -0.954 -1.505  
 RMS of residuals /m = 0.504

Number of phase differences to fit baseline = 51542  
 A priori baseline (X,Y,Z)/m = 1.463 -0.954 -1.505  
 8636 clock jitters computed out of 8636 intervals  
 AVE jitter /ps = -0.2 RMS jitter /ps = 4.7

Iter 1 Large residuals L1= 0  
 Iter 1 Large residuals L2= 0  
 Computed baseline L1 (X,Y,Z)/m = 0.072 0.000 0.109  
 RMS of residuals L1 /m = 0.003  
 Computed baseline L2 (X,Y,Z)/m = 0.086 -0.003 0.114  
 RMS of residuals L2 /m = 0.004

Final baseline L1 (X,Y,Z)/m = 1.536 -0.954 -1.396  
 Final baseline L2 (X,Y,Z)/m = 1.549 -0.957 -1.392

## COMPUTATION OF CODE DIFFERENCES

Number of code differences = 53749

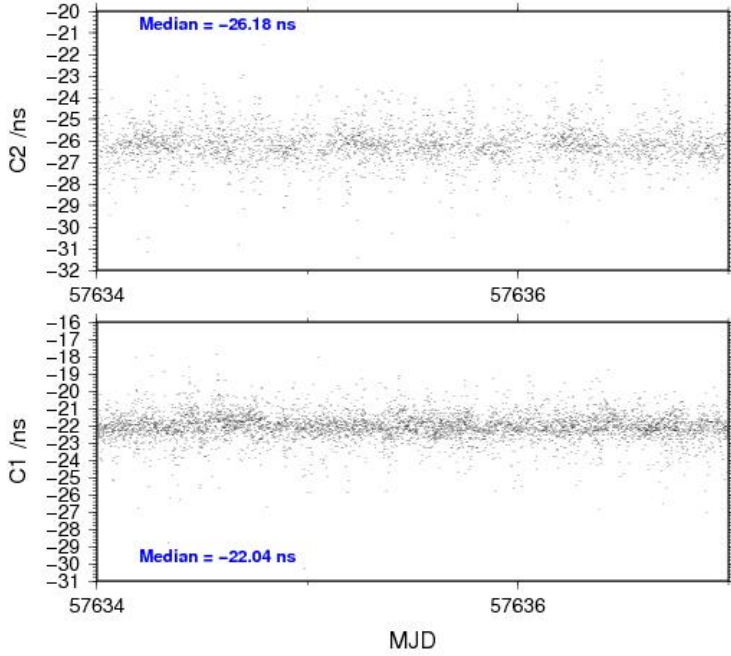
Global average of individual differences

Code #pts, ave/ns, rms/ns  
 C1: 53019 -22.051 1.599  
 C2: 32223 -26.158 1.703  
 P1: 52478 -22.034 1.668  
 P2: 52458 -26.099 2.047

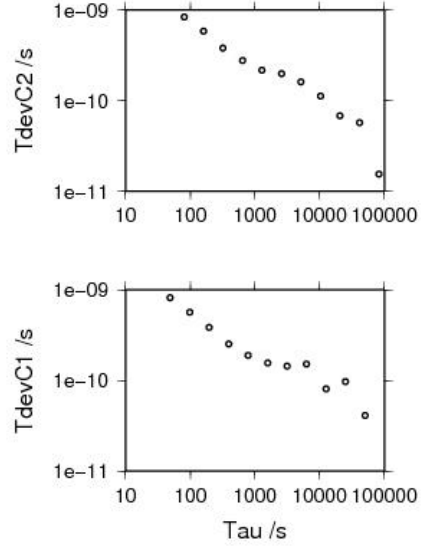
Number of 300s epochs in out file = 864

Code #pts, median/ns, ave/ns, rms/ns  
 C1: 5287 -22.042 -22.046 0.816  
 C2: 3227 -26.185 -26.156 0.841  
 P1: 5233 -22.038 -22.041 0.860  
 P2: 5231 -26.145 -26.097 1.231

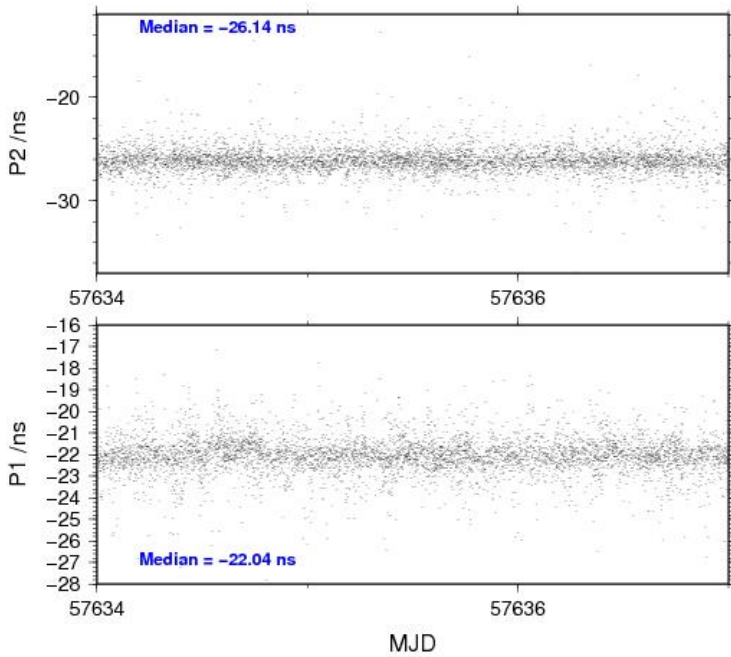
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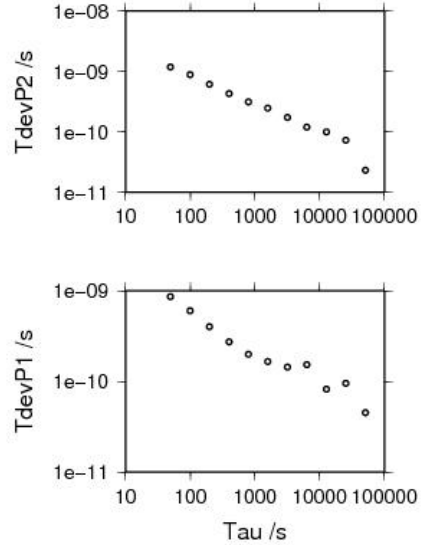
50154 s: C1= 41 ps	82180 s: C2= 16 ps
25077 s: C1= 97 ps	41090 s: C2= 57 ps
12538 s: C1= 81 ps	20545 s: C2= 68 ps
6269 s: C1= 152 ps	10273 s: C2= 113 ps
3135 s: C1= 144 ps	5136 s: C2= 161 ps
1567 s: C1= 156 ps	2568 s: C2= 199 ps
784 s: C1= 189 ps	1284 s: C2= 217 ps
392 s: C1= 253 ps	642 s: C2= 277 ps
196 s: C1= 384 ps	321 s: C2= 381 ps
98 s: C1= 564 ps	161 s: C2= 583 ps
49 s: C1= 819 ps	80 s: C2= 838 ps



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50672 s: P1= 45 ps	50691 s: P2= 23 ps
25336 s: P1= 96 ps	25345 s: P2= 73 ps
12668 s: P1= 82 ps	12673 s: P2= 100 ps
6334 s: P1= 153 ps	6336 s: P2= 121 ps
3167 s: P1= 144 ps	3168 s: P2= 175 ps
1583 s: P1= 166 ps	1584 s: P2= 248 ps
792 s: P1= 199 ps	792 s: P2= 314 ps
396 s: P1= 273 ps	396 s: P2= 433 ps
198 s: P1= 402 ps	198 s: P2= 612 ps
99 s: P1= 601 ps	99 s: P2= 886 ps
49 s: P1= 863 ps	50 s: P2= 1194 ps



**BP1X - ZA02**

## COMPUTATION OF BASELINE

Number of codes to fit baseline and biases = 109594  
 Computed code bias (P1/P2)/m = -8.577 -8.993  
 Computed baseline (X,Y,Z)/m = 2.458 -0.655 -1.804  
 RMS of residuals /m = 0.558

Number of phase differences to fit baseline = 107083  
 A priori baseline (X,Y,Z)/m = 2.458 -0.655 -1.804  
 18297 clock jitters computed out of 18297 intervals  
 AVE jitter /ps = -0.5 RMS jitter /ps = 5.5

Iter 1 Large residuals L1= 1  
 Iter 1 Large residuals L2= 4  
 Computed baseline L1 (X,Y,Z)/m = -0.186 -0.152 -0.209  
 RMS of residuals L1 /m = 0.004  
 Computed baseline L2 (X,Y,Z)/m = -0.169 -0.159 -0.196  
 RMS of residuals L2 /m = 0.005

Iter 2 Large residuals L1= 1  
 Iter 2 Large residuals L2= 4  
 Computed baseline L1 (X,Y,Z)/m = -0.186 -0.152 -0.209  
 RMS of residuals L1 /m = 0.004  
 Computed baseline L2 (X,Y,Z)/m = -0.169 -0.159 -0.196  
 RMS of residuals L2 /m = 0.005

Final baseline L1 (X,Y,Z)/m = 2.271 -0.807 -2.014  
 Final baseline L2 (X,Y,Z)/m = 2.289 -0.814 -2.000

## COMPUTATION OF CODE DIFFERENCES

Number of code differences = 111564

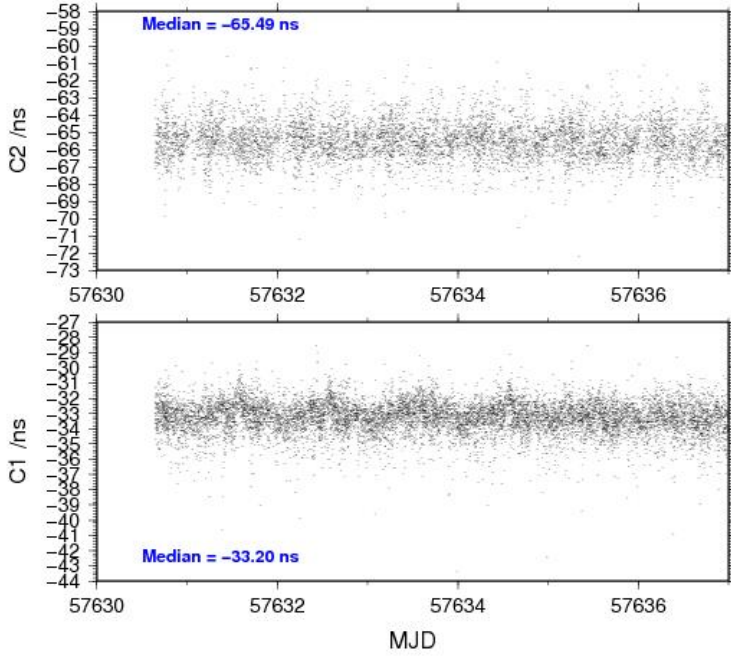
Global average of individual differences

Code #pts, ave/ns, rms/ns  
 C1: 110392 -33.288 1.722  
 C2: 68230 -65.486 1.811  
 P1: 109478 -27.889 2.065  
 P2: 109449 -29.321 2.290

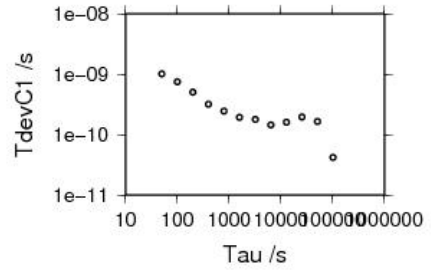
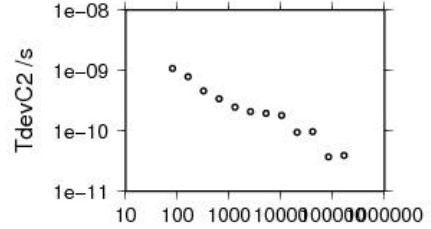
Number of 300s epochs in out file = 1831

Code #pts, median/ns, ave/ns, rms/ns  
 C1: 11003 -33.202 -33.260 1.053  
 C2: 6808 -65.492 -65.469 1.080  
 P1: 10916 -27.772 -27.852 1.155  
 P2: 10916 -29.272 -29.304 1.411

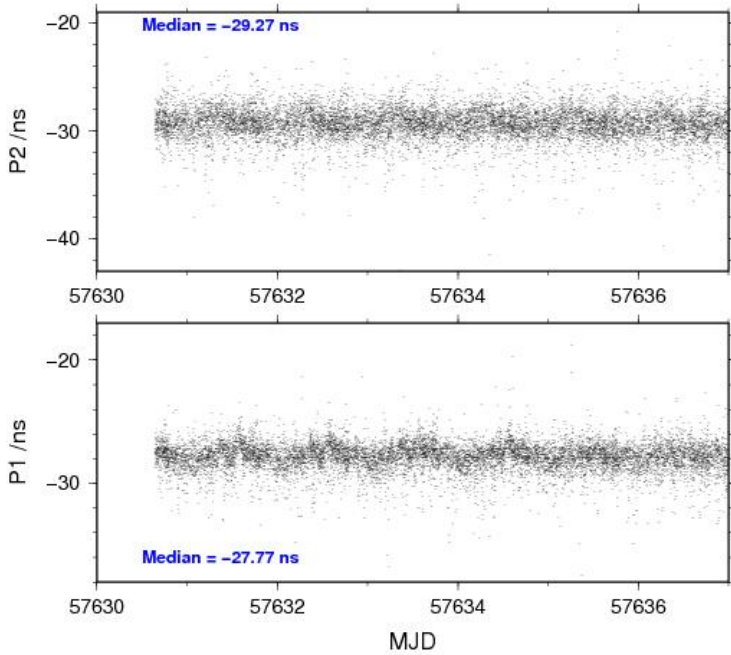
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102195 s: C1= 42 ps	165176 s: C2= 39 ps
51098 s: C1= 165 ps	82588 s: C2= 37 ps
25549 s: C1= 195 ps	41294 s: C2= 97 ps
12774 s: C1= 160 ps	20647 s: C2= 94 ps
6387 s: C1= 144 ps	10323 s: C2= 181 ps
3194 s: C1= 179 ps	5162 s: C2= 195 ps
1597 s: C1= 194 ps	2581 s: C2= 209 ps
798 s: C1= 245 ps	1290 s: C2= 249 ps
399 s: C1= 320 ps	645 s: C2= 339 ps
200 s: C1= 504 ps	323 s: C2= 461 ps
100 s: C1= 745 ps	161 s: C2= 791 ps
50 s: C1= 1007 ps	81 s: C2= 1089 ps



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103010 s: P1= 36 ps	103010 s: P2= 36 ps
51505 s: P1= 208 ps	51505 s: P2= 66 ps
25752 s: P1= 236 ps	25752 s: P2= 120 ps
12876 s: P1= 145 ps	12876 s: P2= 126 ps
6438 s: P1= 156 ps	6438 s: P2= 158 ps
3219 s: P1= 196 ps	3219 s: P2= 207 ps
1610 s: P1= 211 ps	1610 s: P2= 254 ps
805 s: P1= 275 ps	805 s: P2= 303 ps
402 s: P1= 360 ps	402 s: P2= 455 ps
201 s: P1= 530 ps	201 s: P2= 677 ps
101 s: P1= 813 ps	101 s: P2= 1043 ps
50 s: P1= 1126 ps	50 s: P2= 1396 ps

