Report for Calibration of G2 Laboratories KRISS, NMIA and MSL by NIM

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The report is divided by seven parts. The first part introduces the calibration briefly. The second and third parts describe these equipments and operation methods respectively, as well as the experiment setups during the calibration campaign. Part 4 introduces the calibration data processing. Then the fifth part describes the final results after processing. In Section 6, it is shown how to evaluate the calibration uncertainty. Part 7 deals with climatic parameters during calibration.

1. Introduction

Time link calibration is the premise of time transfer. Since 2012, BIPM has started to draw up the new guideline for GNSS link calibration and assigned several NMIs including NIM as the group 1 laboratories to implement the possibility of calibration of group 2 laboratories in the local RMO (Regional Metrology Organization) that might give some assist to BIPM.

NIM Cal-001 has been installed and operated at KRISS since the middle of August of 2021. NIM Cal-001 was sent to NMIA from KRISS and arrived at NMIA in the end of August 2021. NIM Cal-001 was sent to MSL from NMIA and arrived at MSL in the end of October of 2021. Finally, it came back to NIM in early March 2022.

2. Description of the equipments and the operation method

The NIM transportable calibrator NIM Cal-001 is pictured in figure 1 and depicted schematically in figure 2.

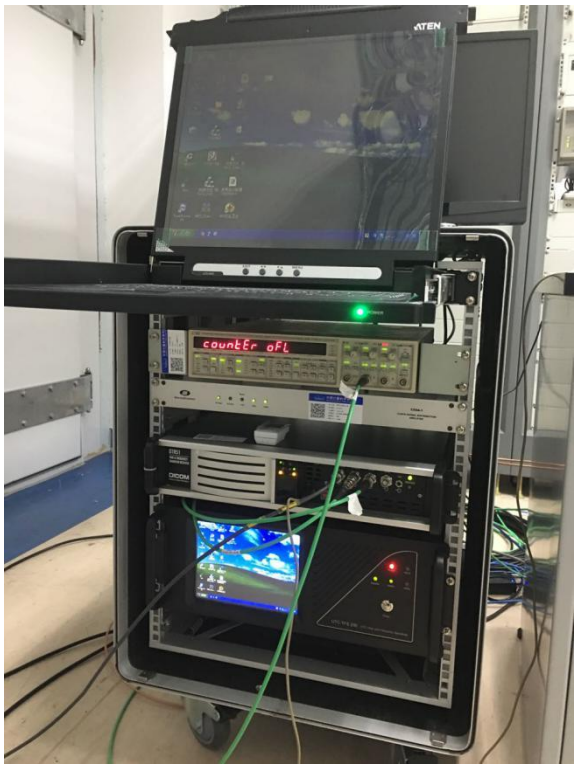


Figure 1. NIM calibrator(NIM Cal-001)

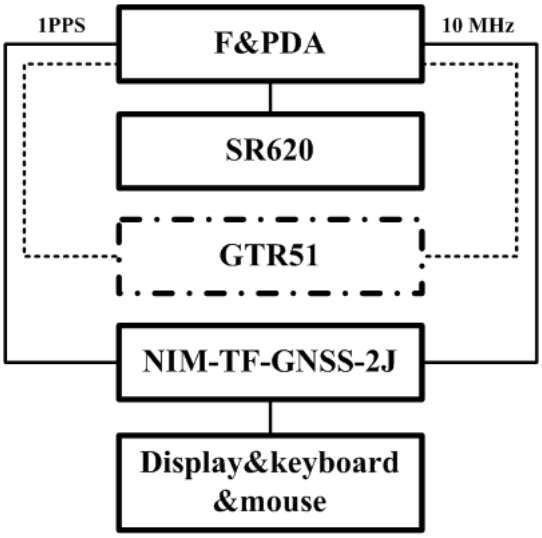


Figure 2. Schematic of NIM Cal-001

Referring to figure 2, the function of each part is as follows.

1. **NIM-TF-GNSS-2J**: GNSS time and frequency transfer travelling receiver
2. SR620:Time interval counter used to measure the reference delay
3. P&FDA: phase and frequency distribution amplifier
4. Display&keyboard&mouse (KVM): Interface between PC and the user, the interface for control of the receiver and logging of GNSS measurement data
5. **GTR51**: Dicom company product
   Physical Size: : 62cm(width)*78cm(height)*89cm(depth) (without the wheels)
   wheel height:12cm
   rough weight: 101 kg

List of supplied items
Receivers:
IM09: NIM-TF-GNSS-2J(with antenna AT1675 AT-200)
IM11: GTR51(with antenna NOV703GGG)
Others:
KVM(ATEN)
PDA and FDA(SDI)
SR620(SRS)
cables
Connectors

All information about the equipments for the calibrator and the receivers to be calibrated are list in table 1.

Table 1. Sites used for the calibration

Timing lab	Site name	BIPM code	Model	Role	Notes
NIM	IM06	IM06	Dicom GTR50	Reference receiver	Master
NIM	IM09	IM09	NIM-TF-GNSS-2	Traveling receiver	Traveling
NIM	IM11	IM11	GTR51	Traveling receiver	Traveling
KRISS	KRP1	KRP1	Septentrio PolaRx5TR	Receiver to be calibrated	
KRISS	KRG2	KRG2	GTR51	Receiver to be calibrated	
NMIA	AU04	AU04	Septentrio PolaRx2eTR	Receiver to be calibrated	
NMIA	AU05	AU05	Septentrio PolaRx4TR PRO	Receiver to be calibrated	
NMIA	AU06	AU06	Septentrio PolaRx5TR	Receiver to be calibrated	
MSL	MS01	MS01	Septentrio PolaRx5TR	Receiver to be calibrated	
MSL	NZ02	NZ02	Septentrio PolaRx4TR	Receiver to be calibrated	
MSL	NZ03	NZ03	Septentrio PolaRx4TR	Receiver to be calibrated	

The whole calibration tour includes start CCD before calibration, calibration on site and closure CCD as shown in table 2.

Table 2. Measurements used for the calibration

Time period	Location	Operation
MJD 59393-MJD 59400	NIM	Start CCD before calibration
MJD 59439-MJD 59448	KRISS	Calibration on site
MJD 59471-MJD 59487	NMIA	Calibration on site
MJD 59519-MJD 59561	MSL	Calibration on site
MJD 59650-MJD 59663	NIM	Closure CCD after calibration

The data from MJD 59439 to MJD 59448, from MJD 59519 to MJD 59561 and from MJD 59471 to MJD 59487 after the signal transmitting was closed which looks

normal are finally used for computation.

The calibration method, the differential calibration with closure of GPS (Global Positioning System) time and frequency transfer receiver, is used. Its principle concept is addressed in [1].

3. Experiment setups

In the campaign, the receivers used were as follows in table 1. IMEJ (site name for CGGTTS is IM06) is the master GPS time and frequency transfer receiver of NIM for TAI contribution and the reference receiver. The calibrator at KRISS, MSL and NMIA was installed and the setups and the sub-delay information for start and closure experiments at NIM and calibration experiments on site at KRISS, MSL and NMIA were depicted in figure 4, 5 and 6.

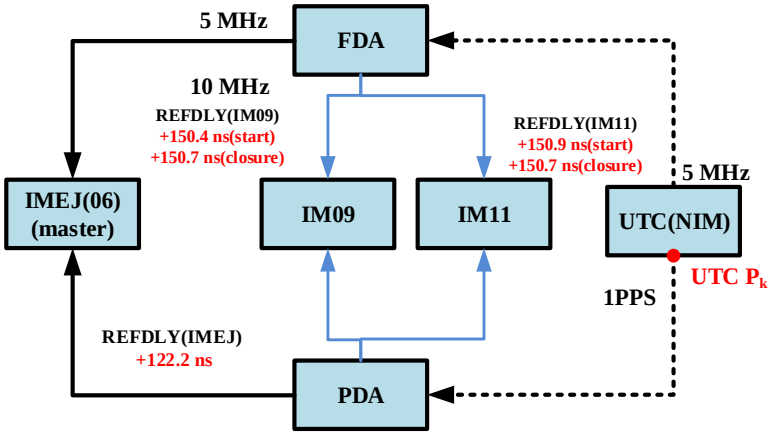


Figure 3. Experiment setup @NIM(for CCD experiments)

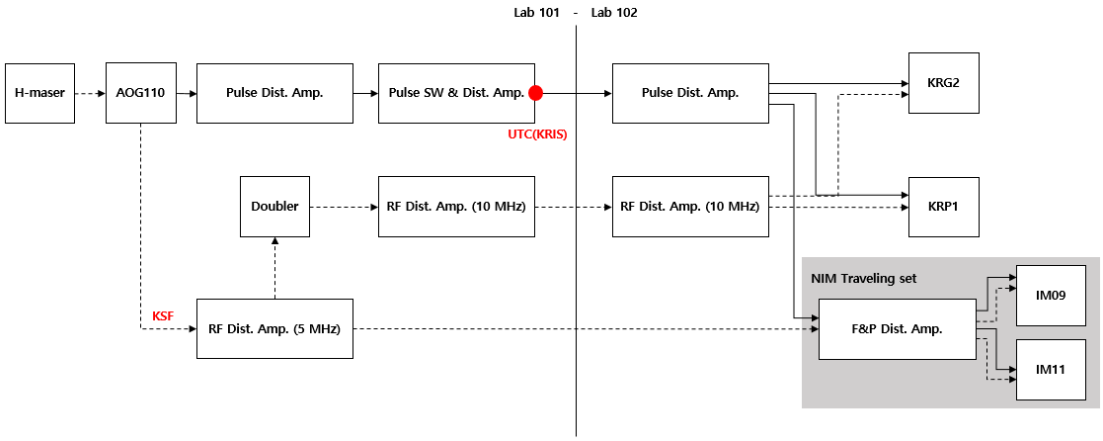


Figure 4. Experiment setup @KRISS(for CCD experiments)

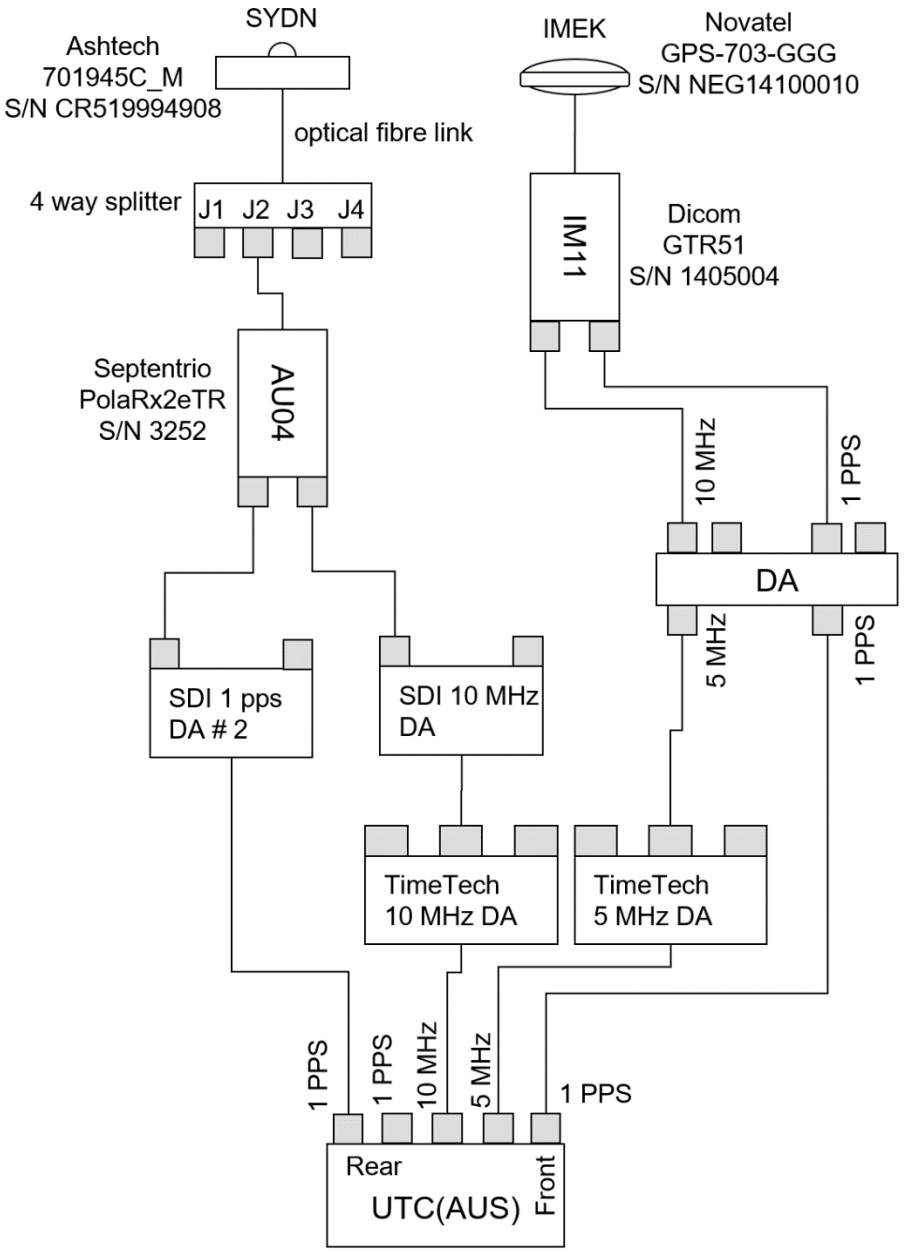


Figure 5. Experiment setup @NMIA(for CCD experiments)

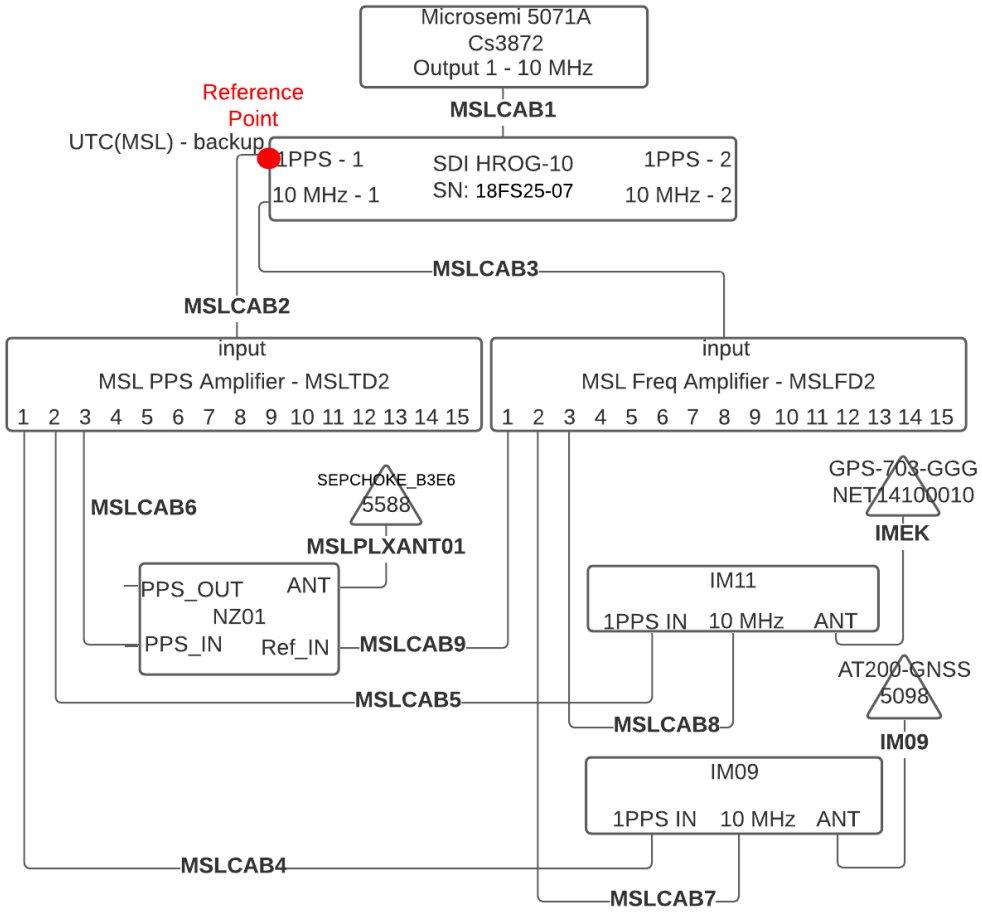


Figure 6. Experiment setup @MSL(for CCD experiments)

4. Data processing

The raw differences $RAWDIF\,(P1/P2)_{A-B}$ between two receivers such as A and B, in the CCD experiments during the calibration, are given by

$$RAWDIF\,(P1/P2)_{A-B} = \Delta CABDLY_{A-B} + \Delta INTDLY\,(P1/P2)_{A-B} - \Delta REFDLY_{A-B} \quad (1)$$

where $RAWDIF\,(P1/P2)_{A-B}$ are the differences of code measurements from Rinex files without compensation of the antenna cable delay(CABDLY), the internal delay(INTDLY), and reference delay(REFDLY) from CGGTTS header. $\Delta CABDLY_{A-B}$, $\Delta REFDLY_{A-B}$ and $\Delta INTDLY_{A-B}$ are the differences of CABDLY, INTDLY, and REFDLY separately, given in table 3. P3 results are calculated by the formula $P3=P1*2.54573-P2*1.54573$.

Table 3. REFDLY and CABDLY differences between station and traveling receivers

Pair	MJD	△REFDLY(ns)	△CABDLY(ns)
IM09-IM06	59393-59400	28.9	-44.8
IM11-IM06	59393-59400	62.0	-71.6
KRP1-IM09	59439-59448	47.9	-5.1
KRP1-IM11	59439-59448	47.9	3.7
KRG2-IM09	59439-59448	-10.2	-10.3
KRG2-IM11	59439-59448	-10.3	-1.5
AU04-IM09	59471-59485	299.0	2281.4
AU04-IM11	59471-59485	298.6	2308.4
AU05-IM09	59471-59485	178.2	-101.6
AU05-IM11	59471-59485	177.8	-74.6
AU06-IM09	59471-59485	116.9	-29.3
AU06-IM11	59471-59485	116.5	-2.3
MS01-IM09	59519-59531	43.7	-122.5
MS01-IM11	59519-59531	43.6	-95.7
NZ02-IM09	59538-59547	139.7	-122.5
NZ02-IM11	59538-59547	139.7	-95.7
NZ03-IM09	59552-59561	144.4	-122.5
NZ03-IM11	59552-59561	144.2	-95.7
IM09-IM06	59650-59663	66.4	-35.8
IM11-IM06	59650-59663	66.4	-35.2

5. Calibration computation and calibration values

Table 4 shows INTDLY for station IM06. Raw P1, P2, P3 and P1-P2 differences calculated between station and traveling receivers are given in table 5. The values for ΔINTDLY between a given pair of receivers are computed using Eq.(1) and given in table 6. Closure values(the difference between the mean values before calibration and after calibration) are given in table 7. The values of INTDLY for receiver KRP1, KRG2, MS01, NZ02, NZ03, AU04, AU05 and AU06 are computed using ΔINTDLY between receivers to be calibrated and the traveling receivers and ΔINTDLY between the traveling receivers and IM06 (values from 1001-2020). The values of INTDLY are given in table 8.

Table 4. INTDLY for station IM06 from 1001-2020

Rcvr	C1(ns)	P1(ns)	P2(ns)	P3(ns)
IM06	-31.0	-31.8	-18.4	-52.5

5.1. Raw differences

Table 5. Raw differences between station and traveling receivers

Pair	MJD	△C1(ns)	△P1(ns)	△P2(ns)	△P3(ns)
IM09-IM06	59393-59400	-61.3	-60.9	-68.6	-49.0
IM11-IM06	59393-59400	-139.5	-140.6	-153.8	-120.2
KRP1-IM09	59439-59448	-5.3	-6.7	-15.1	6.4
KRP1-IM11	59439-59448	21.9	21.5	18.5	26.2
KRG2-IM09	59439-59448	49.6	50.2	39.4	66.7

KRG2-IM11	59439-59448	76.8	78.3	73.0	86.5
AU04-IM09	59471-59485	2216.8	2213.3	2209.4	2219.5
AU04-IM11	59471-59485	2261.9	2259.8	2261.2	2257.7
AU05-IM09	59471-59485	-206.5	-207.6	-214.2	-197.4
AU05-IM11	59471-59485	-161.4	-161.1	-162.2	-159.2
AU06-IM09	59471-59485	-94.8	-96.9	-103.7	-86.4
AU06-IM11	59471-59485	-49.6	-50.4	-51.8	-48.2
MS01-IM09	59519-59531	-115.3	-116.6	-124.5	--104.4
MS01-IM11	59519-59531	-69.7	-69.5	-71.7	-66.2
NZ02-IM09	59538-59547	-188.6	-189.6	-194.6	-181.8
NZ02-IM11	59538-59547	-143.2	-142.5	-141.8	-143.6
NZ03-IM09	59552-59561	-190.3	-191.4	-198.6	-180.2
NZ03-IM11	59552-59561	-145.0	-144.4	-145.9	-142.1
IM09-IM06	59650-59663	-89.0	-89.1	-97.4	-76.1
IM11-IM06	59650-59663	-108.7	-109.6	-123.0	-88.9

5.2. △INTDLY for receivers

Table 6. INTDLY differences between stations and traveling receivers

Pair	△INTDLY(C1) (ns)	△INTDLY(P1) (ns)	△INTDLY(P2) (ns)	△INTDLY(P3) (ns)
IM09-IM06$\|_{before}$	12.4	12.8	5.1	24.7
IM11-IM06$\|_{before}$	-5.9	-7.0	-20.2	13.4
KRP1-IM09	47.7	46.3	37.9	59.4
KRP1-IM11	66.1	65.7	62.7	70.4
KRG2-IM09	49.7	50.3	39.5	66.8
KRG2-IM11	68.0	69.5	64.2	77.7
AU04-IM09	234.4	230.9	227	237.1
AU04-IM11	252.1	250	251.4	247.9
AU05-IM09	73.3	72.2	65.6	82.4
AU05-IM11	91	91.3	90.2	93.2
AU06-IM09	51.4	49.3	42.5	59.8
AU06-IM11	69.2	68.4	67	70.6
MS01-IM09	50.9	49.6	41.7	61.8
MS01-IM11	69.6	69.8	67.6	73.1
NZ02-IM09	73.6	72.6	67.6	80.4
NZ02-IM11	92.2	92.9	93.6	91.8
NZ03-IM09	76.6	75.5	68.3	86.7
NZ03-IM11	94.9	95.5	94.0	97.8
IM09-IM06$\|_{after}$	13.2	13.1	4.8	26.1
IM11-IM06$\|_{after}$	-7.1	-8.0	-21.4	12.7

5.3. Closure values

Table 7. Closure values

Pair	△C1(ns)	△P1(ns)	△P2(ns)	△P3(ns)
IM09-IM06	-0.8	-0.3	0.3	-1.4
IM11-IM06	1.2	1.0	1.2	0.7

5.4. Calibration values

Table 8. INTDLY for stations KRP1, KRG2, MS01, NZ02, NZ03, AU04, AU05 and AU06

Rcvr	C1(ns)	P1(ns)	P2(ns)	P3(ns)
KRP1	29.2	27.2	24.4	31.5
KRG2	31.1	31.0	26.0	38.9
AU04	215.5	211.7	213.3	209.1
AU05	54.4	53.0	52.0	54.4
AU06	32.6	30.0	29.0	31.5
MS01	32.5	30.8	28.7	34.1
NZ02	55.1	53.9	54.6	52.7
NZ03	58.0	56.6	55.2	58.8

6. Uncertainty Evaluation

Here we evaluated the uncertainty from the sources as follows, for KRISS and MSL we got the combined uncertainty as 1.8 ns conservatively for P codes; for NMIA we got the combined uncertainty as 1.9 ns conservatively for P codes because the REF delay of traveling receivers were combined with two values. All the measurements related to the cable and reference delays were done with SR620 on the trigger level 1.0 V. And the uncertainties from position references and multipaths are just referenced to the description of the guideline. The u_a values are from TDEV of the corresponding CCD results shown in the figures in Annex 6.

Table 9. Uncertainty contributions

Unc.	C1 (ns)	P1 (ns)	P2 (ns)	P3 (ns)	Description
u_a (T-V)	0.2	0.2	0.2	0.3	RAWDIF (traveling-visited)
u_a (T-R)	0.2	0.2	0.2	0.3	RAWDIF (traveling-reference)
u_a	0.3	0.3	0.3	0.4	
	Misclosure				
$u_{b,1}$	1.0	1.0	1.2	1.0	observed mis-closure
	Systematic components related to RAWDIF				
$u_{b,11}$	0.05	0.05	0.05	0.05	Position error at reference
$u_{b,12}$	0.05	0.05	0.05	0.05	Position error at visited
$u_{b,13}$	0.3	0.3	0.3	0.3	Multipaths at reference
$u_{b,14}$	0.3	0.3	0.3	0.3	Multipaths at visited
	Link of the Traveling system to the local UTC(*k*)				
$u_{b,21}$	0.5	0.5	0.5	0.5	$REFDLY_T$ (at ref lab)
$u_{b,22}$	0.5	0.5	0.5	0.5	$REFDLY_T$ (at visited lab)
$u_{b,TOT}$	1.4	1.4	1.5	1.4	
	Link of the Reference system to its local UTC(*k*)				
$u_{b,31}$	0.5	0.5	0.5	0.5	$REFDLY_R$ (at ref lab)
	Link of the Visited system to its local UTC(*k*)				
$u_{b,32}$	0.5	0.5	0.5	0.5	$REFDLY_V$ (at visited lab)
	Antenna cable delays				
$u_{b,41}$	0.5	0.5	0.5	0.5	$CABDLY_R$
$u_{b,42}$	0.5	0.5	0.5	0.5	$CABDLY_V$
u_{CAL}	1.7	1.7	1.8	1.7	Composed of u_a and $u_{b,SYS}$
	Combined Uncertainty: 1.8 ns				

7. Climate parameters

7.1. Temperature and humidity

See Annex 3 in detail.

7.2. Reference signal

Rise time of the local UTC pulse: 2 ns

References:

[1] BIPM. BIPM guidelines for GNSS calibration(V3.2). 05, 02, 2016.

Annex 1. CCD results for KRIS

1. Start CCD before calibration

IM09-IM06

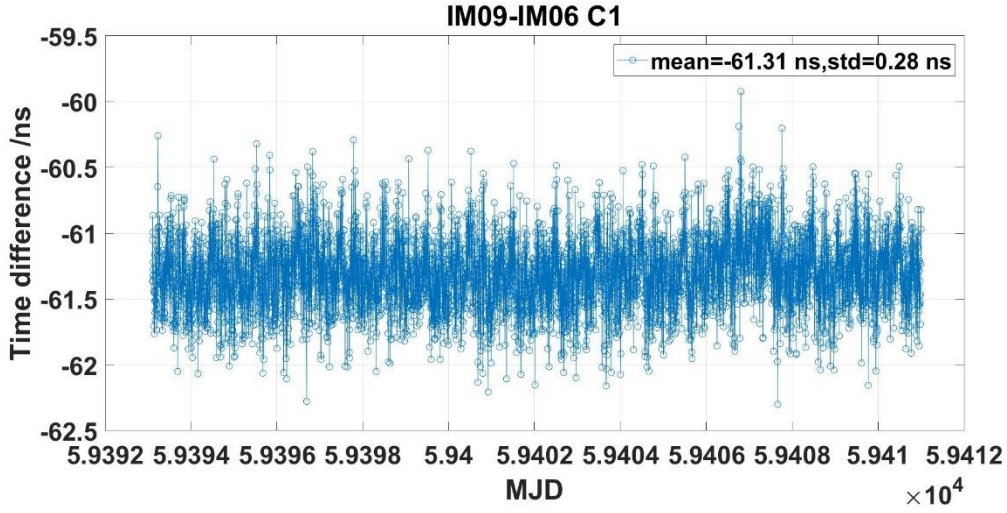


Figure 7. CCD between IM09 and IM06 at NIM(C1)

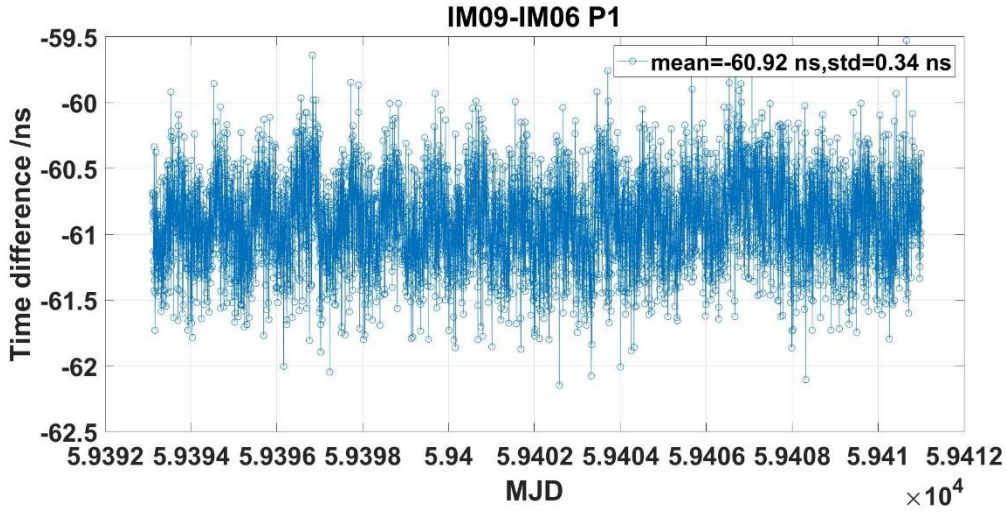


Figure 8. CCD between IM09 and IM06 at NIM(P1)

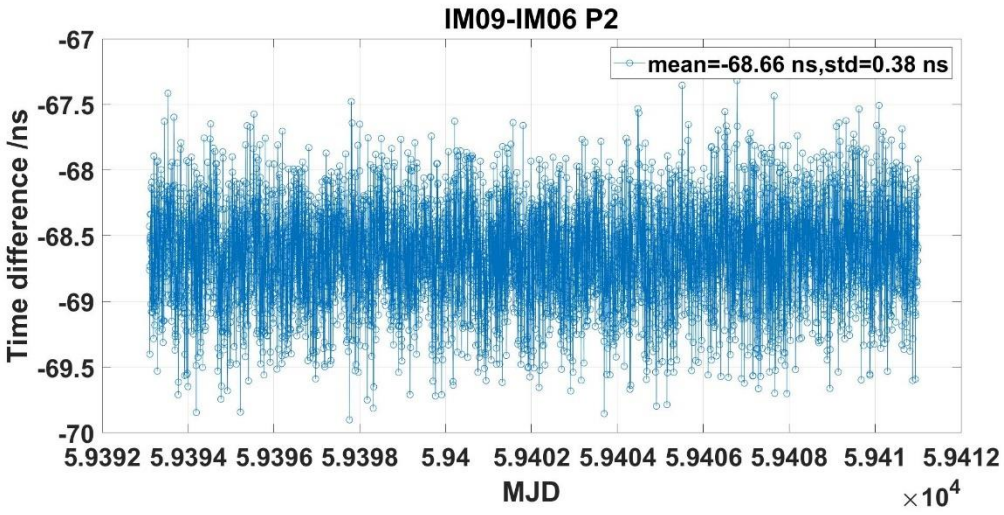


Figure 9. CCD between IM09 and IM06 at NIM(P2)

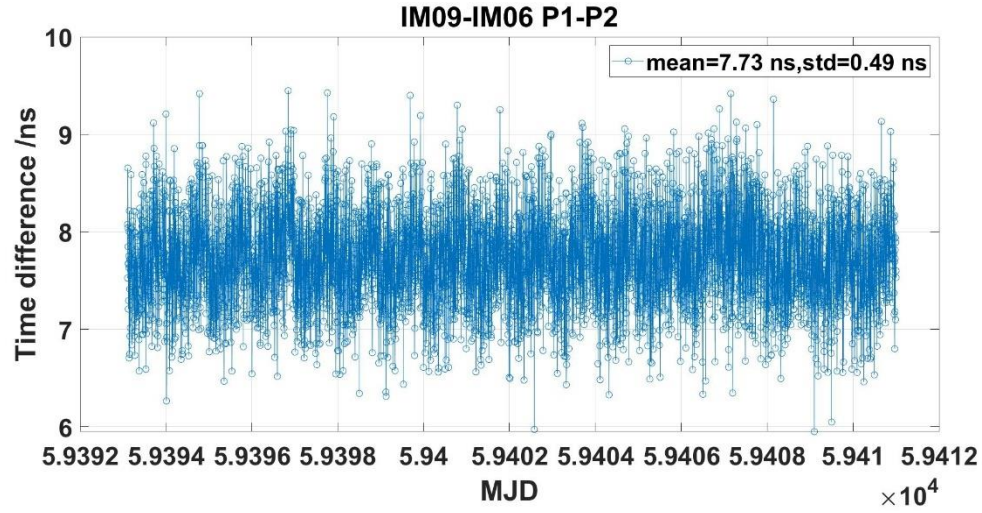


Figure 10. CCD between IM09 and IM06 at NIM(P1-P2)

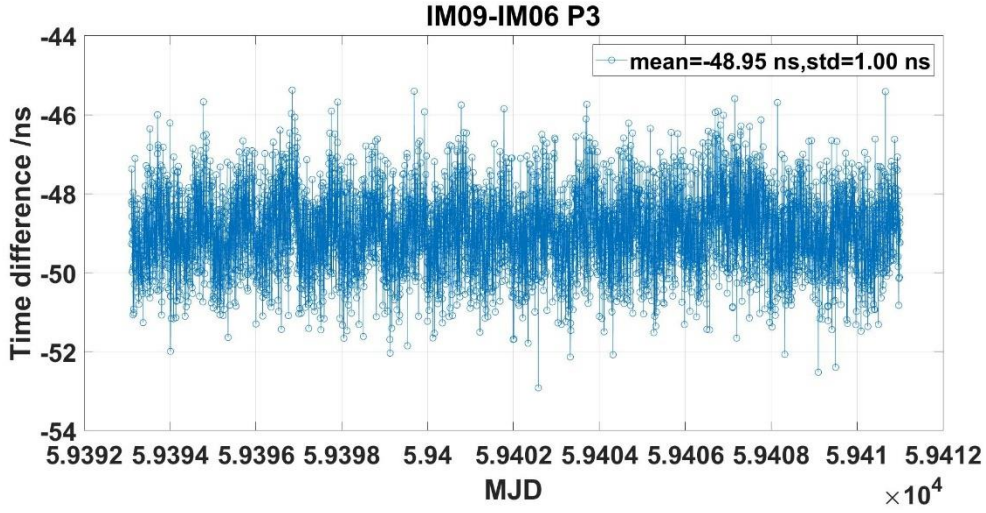


Figure 11. CCD between IM09 and IM06 at NIM(P3)

IM11-IM06

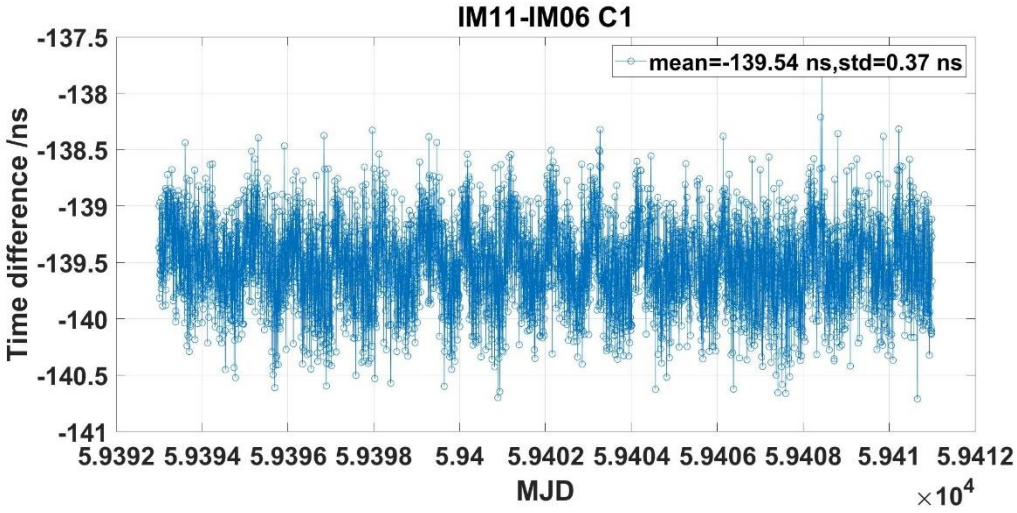


Figure 12. CCD between IM11 and IM06 at NIM(C1)

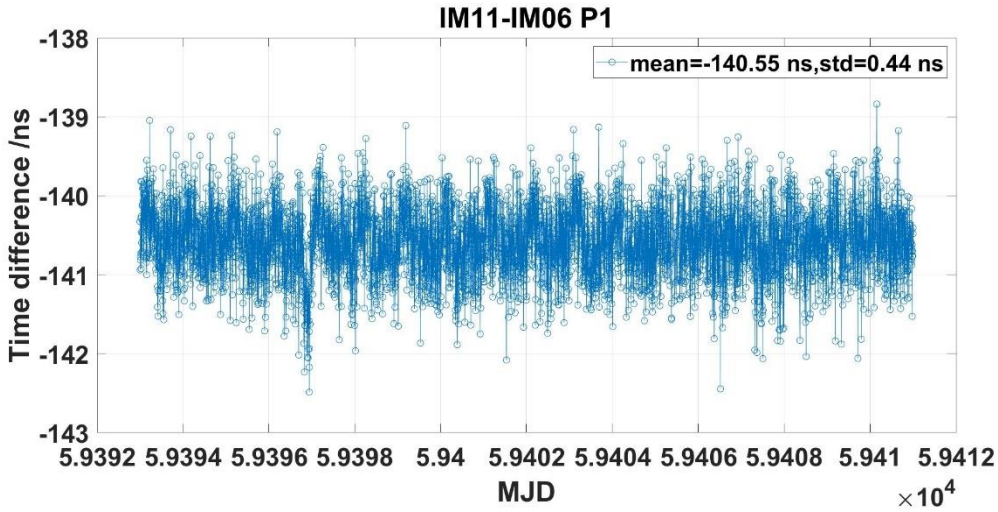


Figure 13. CCD between IM11 and IM06 at NIM(P1)

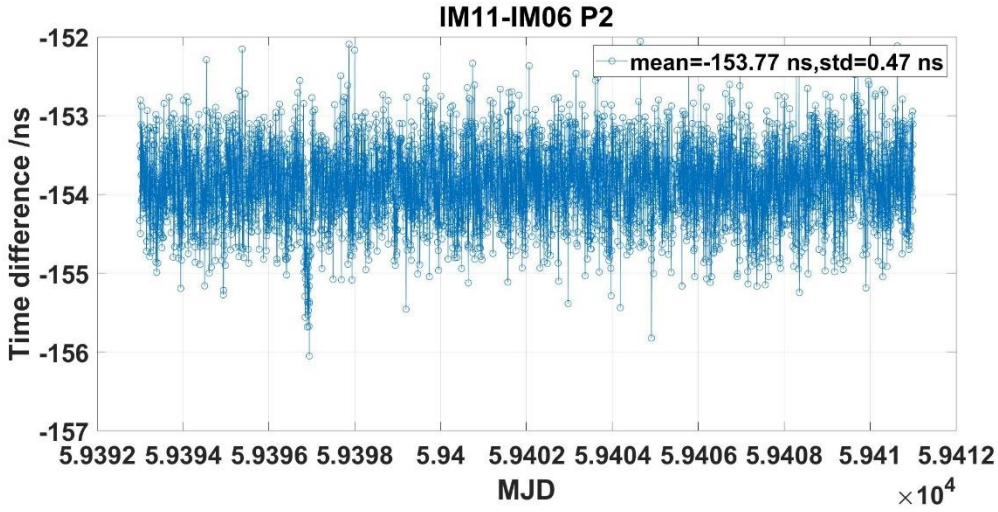


Figure 14. CCD between IM11 and IM06 at NIM(P2)

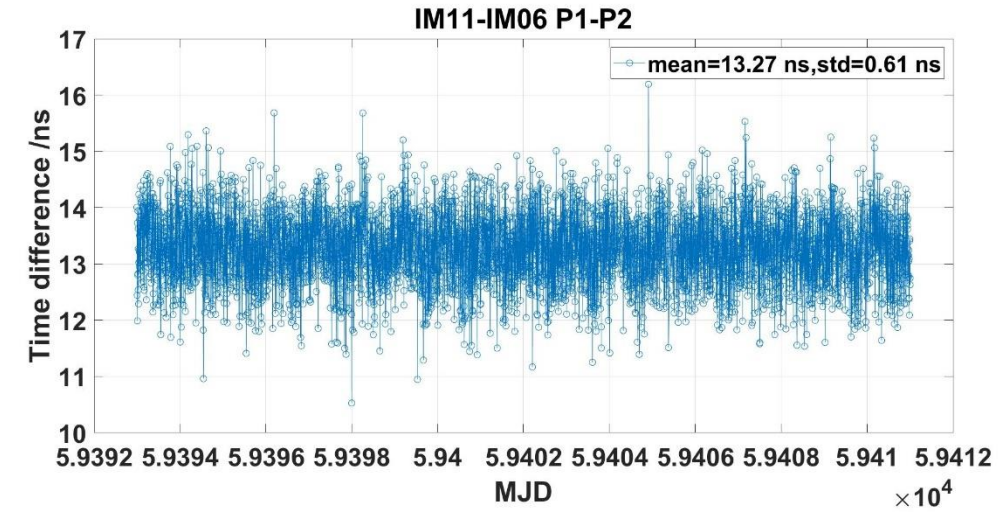


Figure 15. CCD between IM11 and IM06 at NIM(P1-P2)

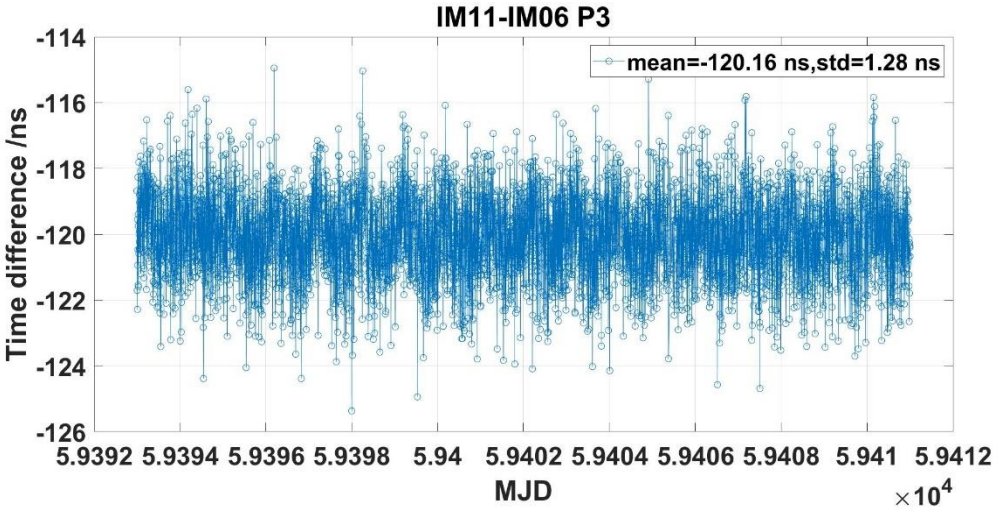


Figure 16. CCD between IM11 and IM06 at NIM(P3)

2. Calibration on site

IM09 – KRP1

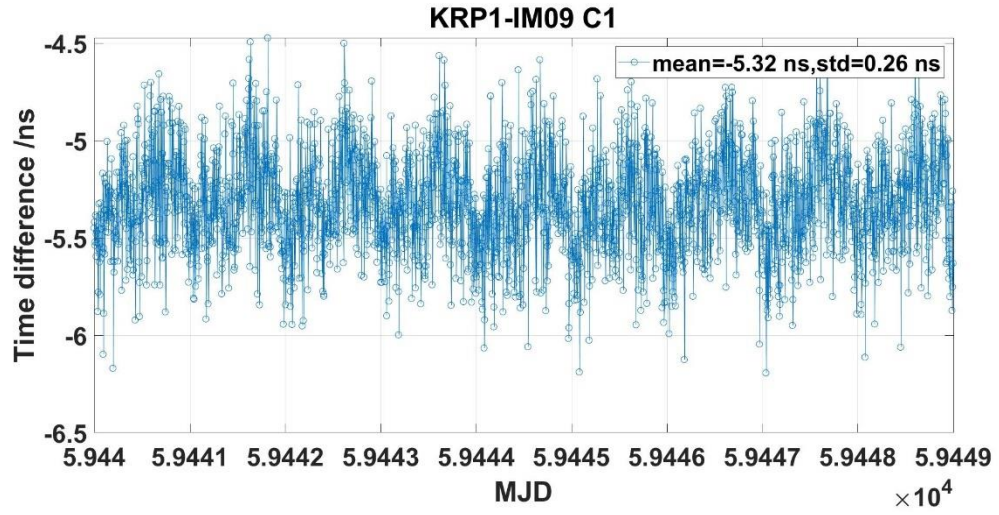


Figure 17. CCD between IM09 and KRP1 at KRIS(C1)

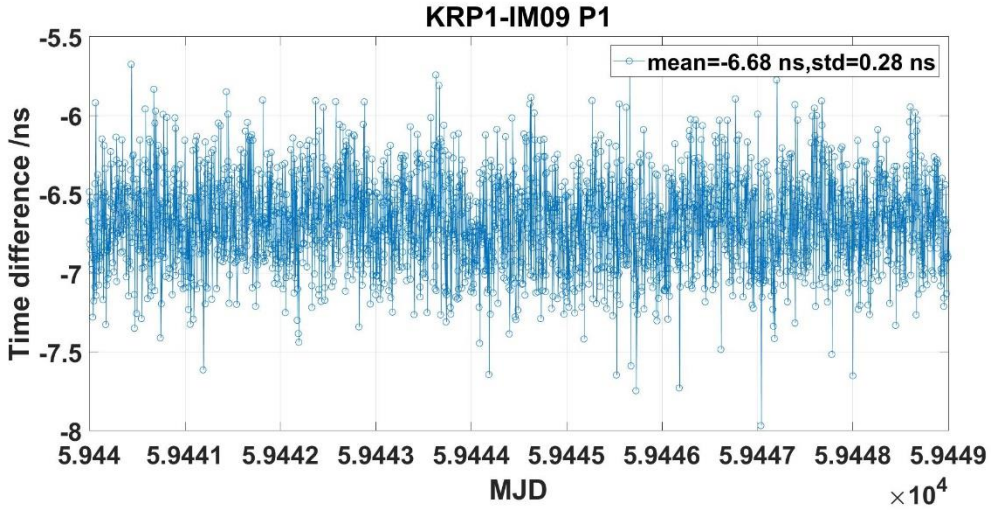


Figure 18. CCD between IM09 and KRP1 at KRIS(P1)

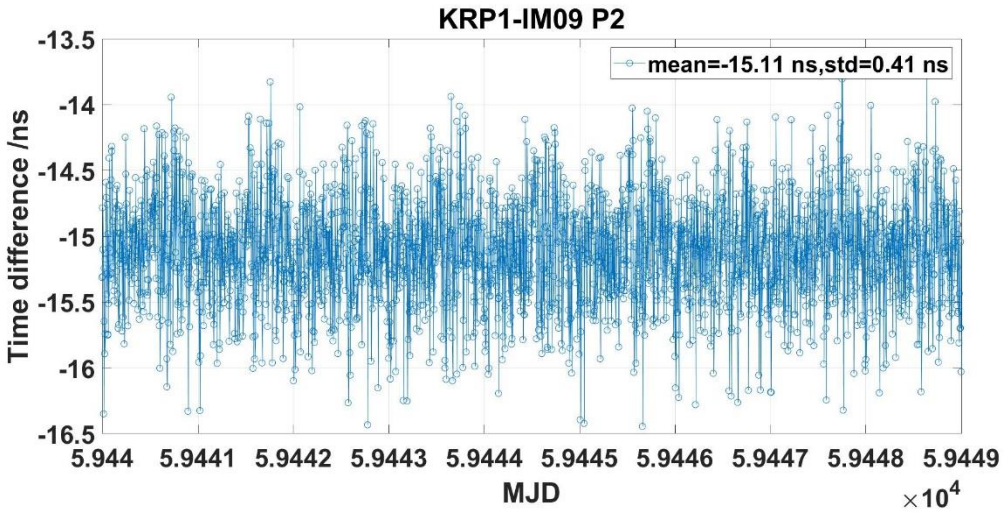


Figure 19. CCD between IM09 and KRP1 at KRIS(P2)

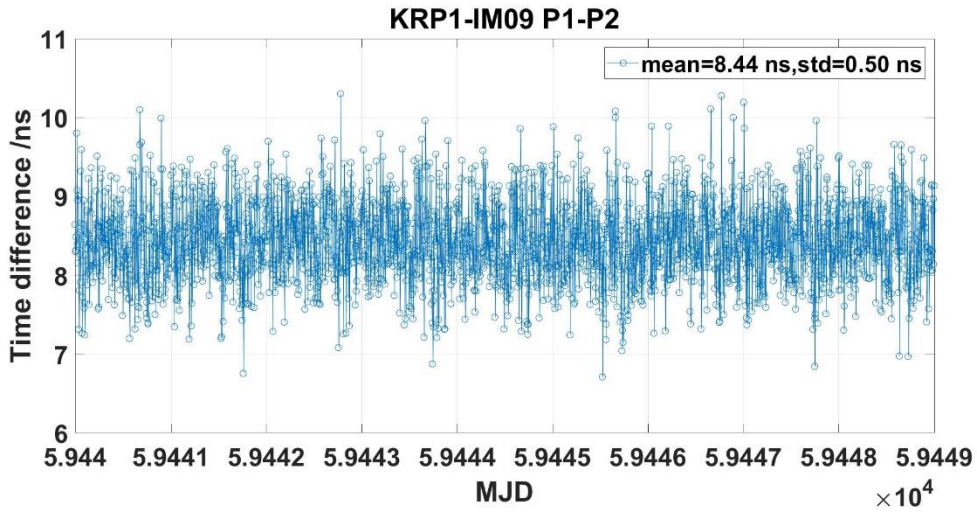


Figure 20. CCD between IM09 and KRP1 at KRIS(P1-P2)

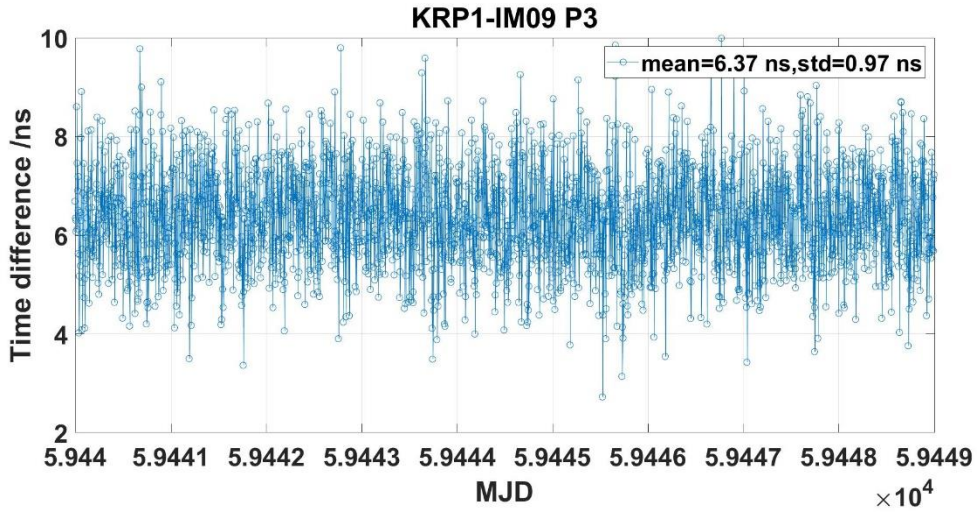


Figure 21. CCD between IM09 and KRP1 at KRIS(P3)

IM11 – KRP1

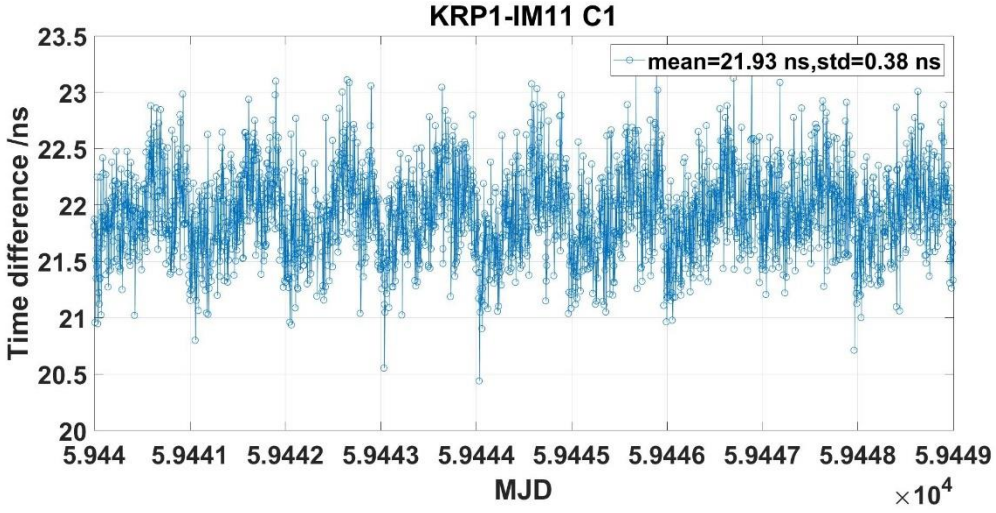


Figure 22. CCD between IM11 and KRP1 at KRIS(C1)

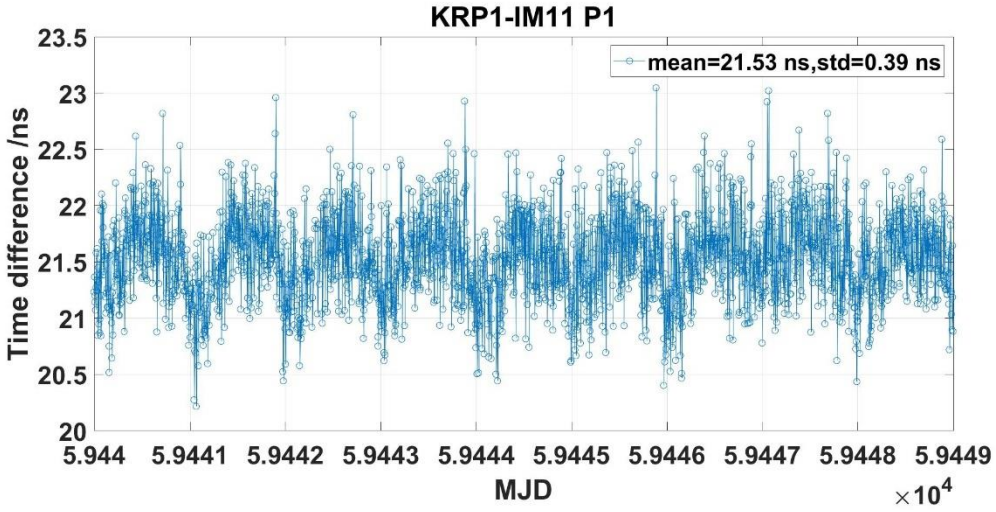


Figure 23. CCD between IM11 and KRP1 at KRIS(P1)

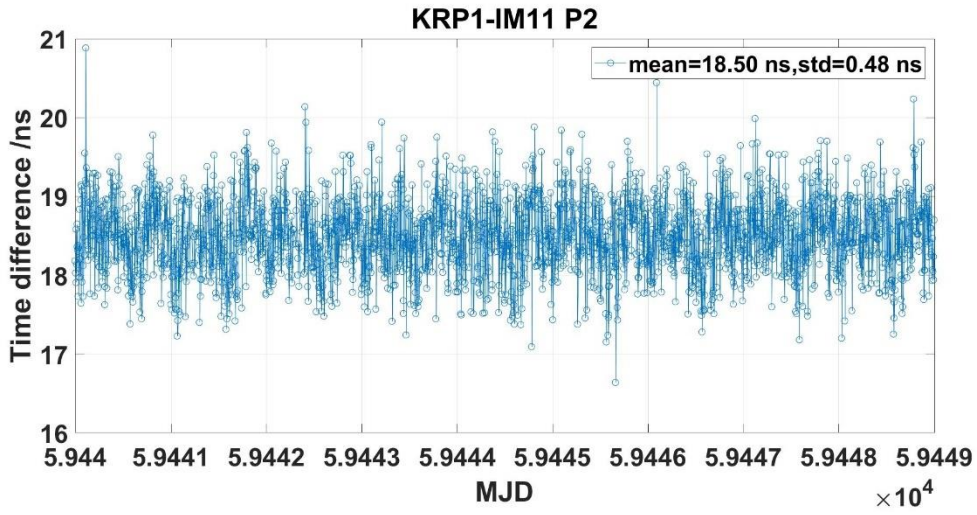


Figure 24. CCD between IM11 and KRP1 at KRIS(P2)

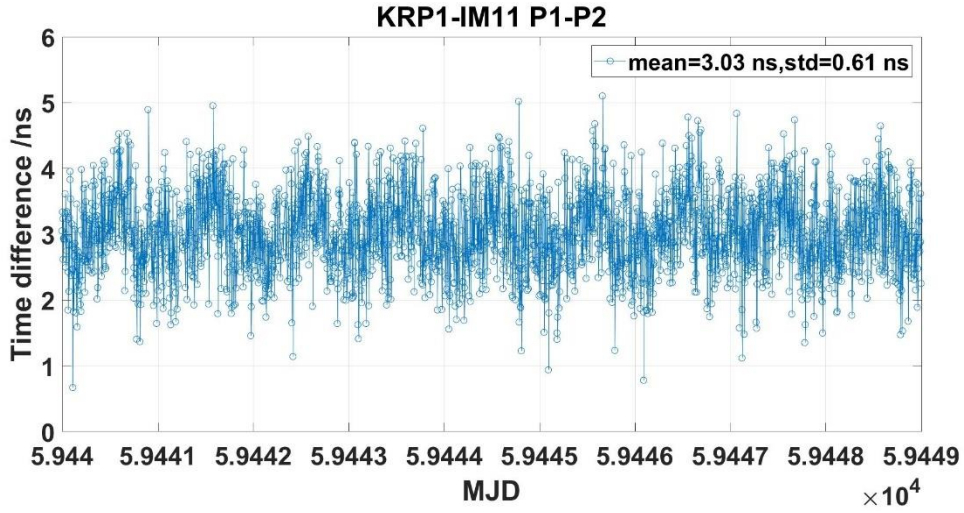


Figure 25. CCD between IM11 and KRP1 at KRIS(P1-P2)

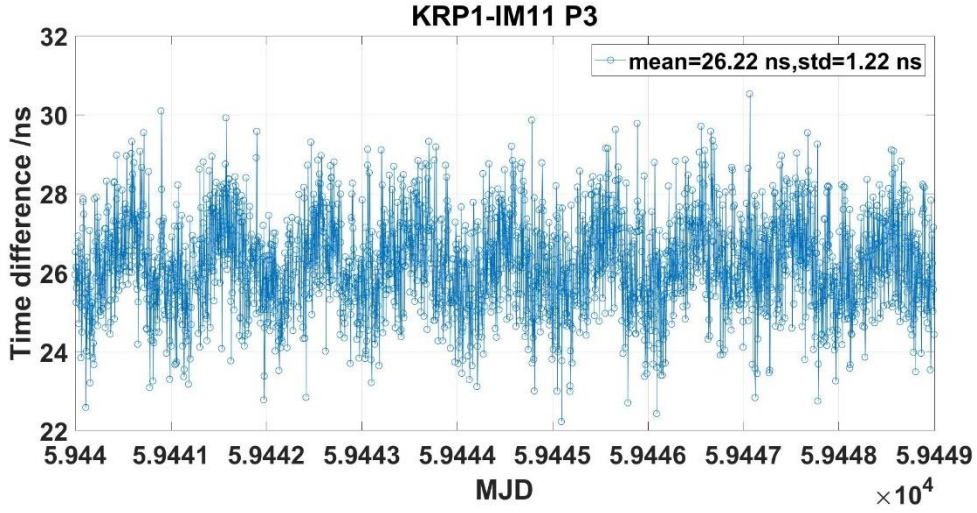


Figure 26. CCD between IM11 and KRP1 at KRIS(P3)

IM09 – KRG2

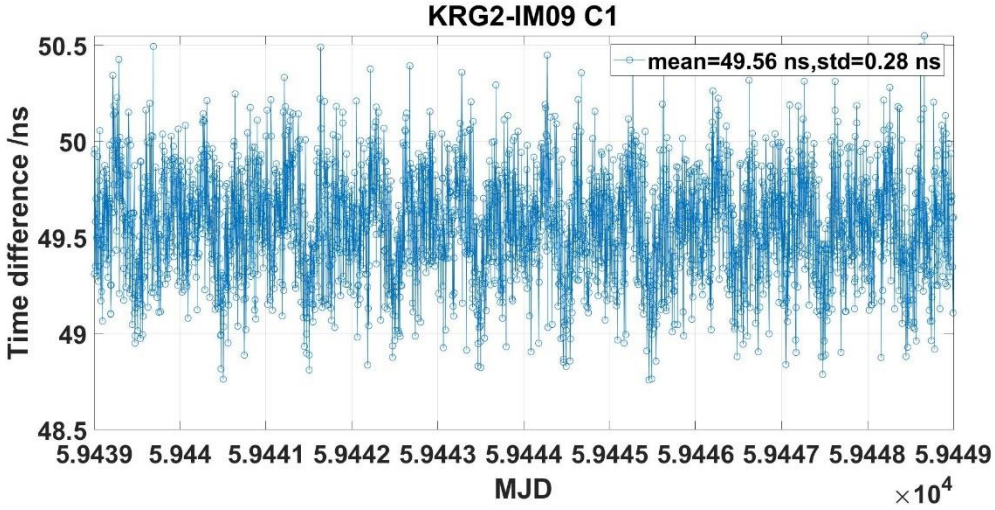


Figure 27. CCD between IM09 and KRG2 at KRIS(C1)

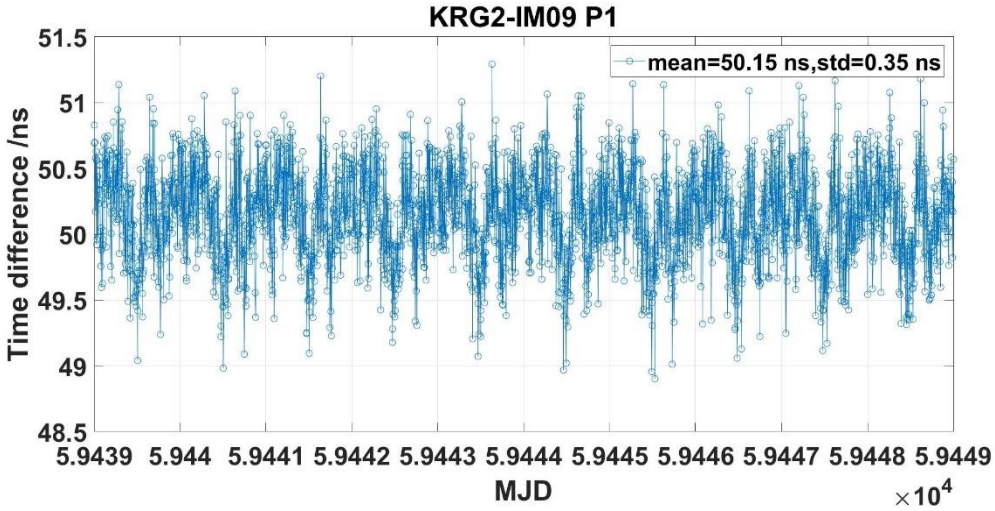


Figure 28. CCD between IM09 and KRG2 at KRIS(P1)

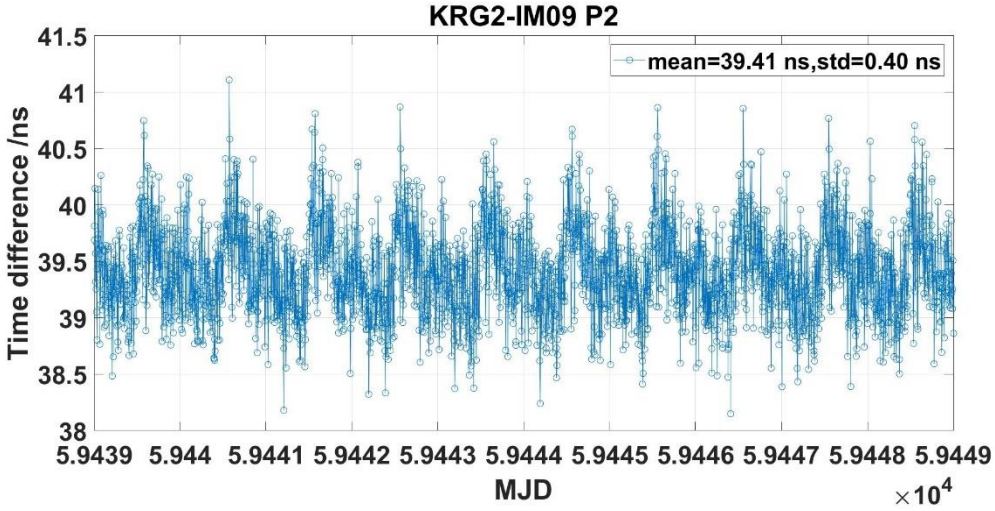


Figure 29. CCD between IM09 and KRG2 at KRIS(P2)

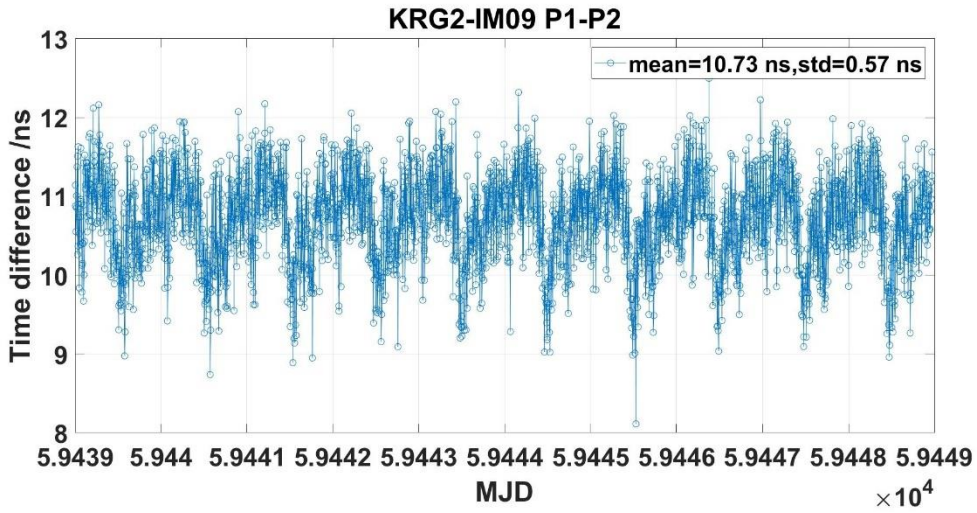


Figure 30. CCD between IM09 and KRG2 at KRIS(P1-P2)

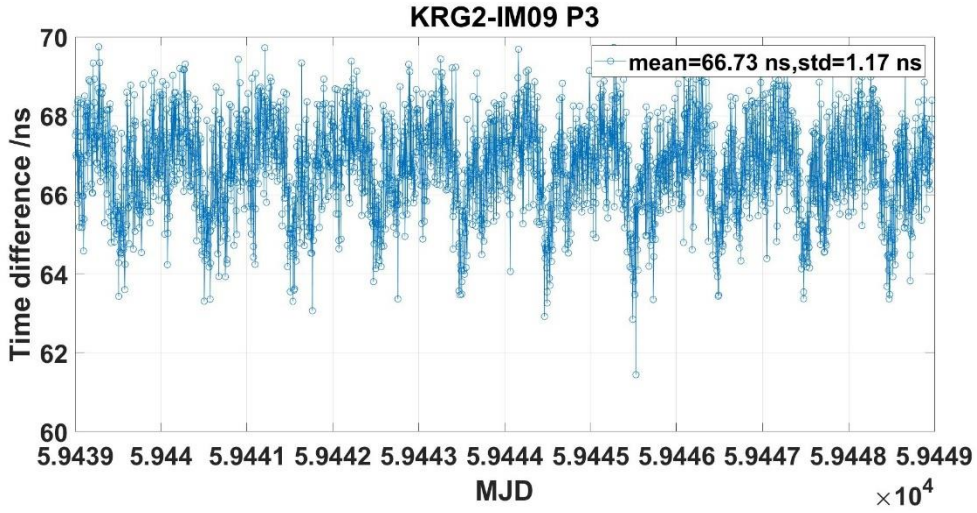


Figure 31. CCD between IM09 and KRG2 at KRIS(P3)

IM11 – KRG2

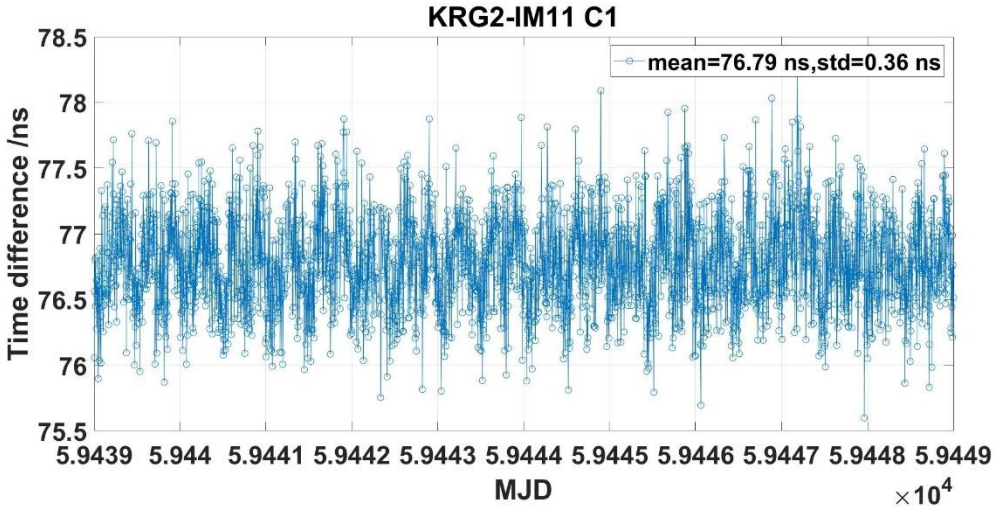


Figure 32. CCD between IM11 and KRG2 at KRIS(C1)

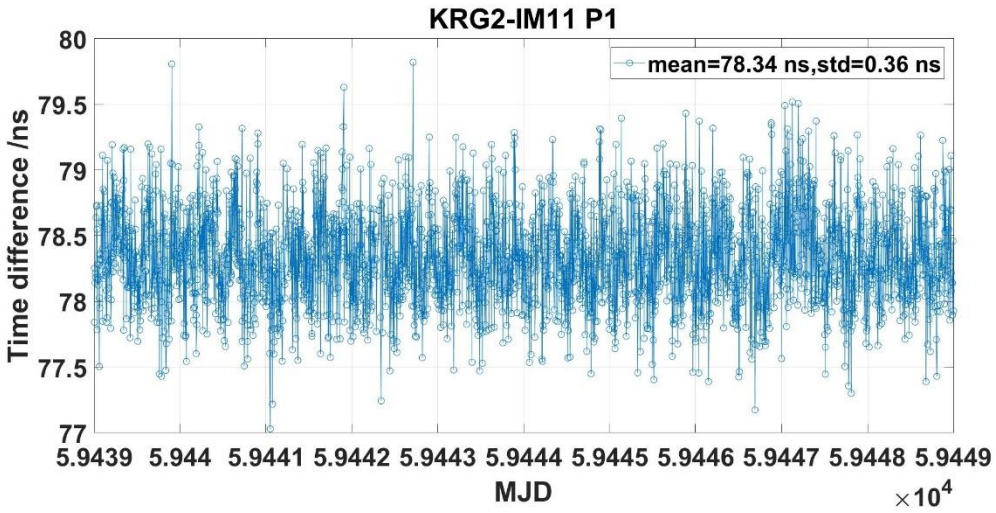


Figure 33. CCD between IM11 and KRG2 at KRIS(P1)

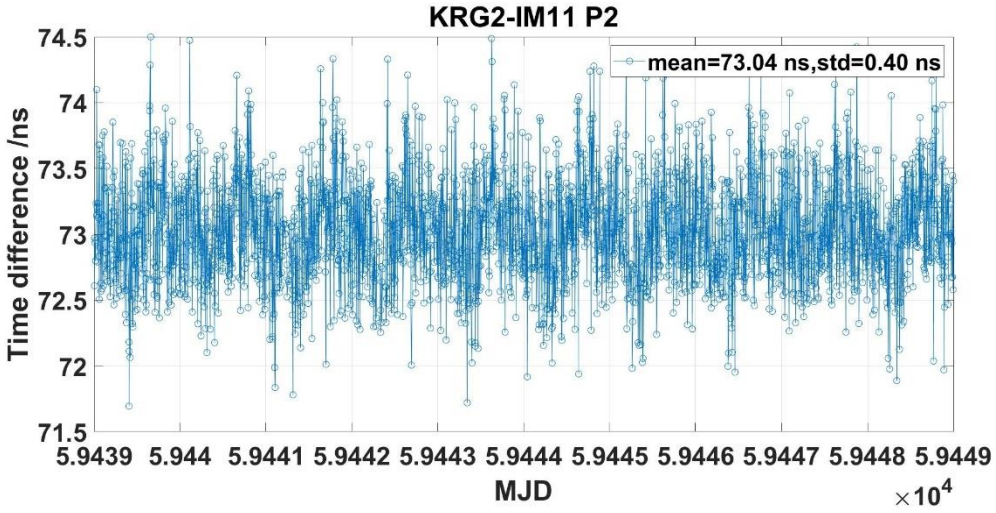


Figure 34. CCD between IM11 and KRG2 at KRIS(P2)

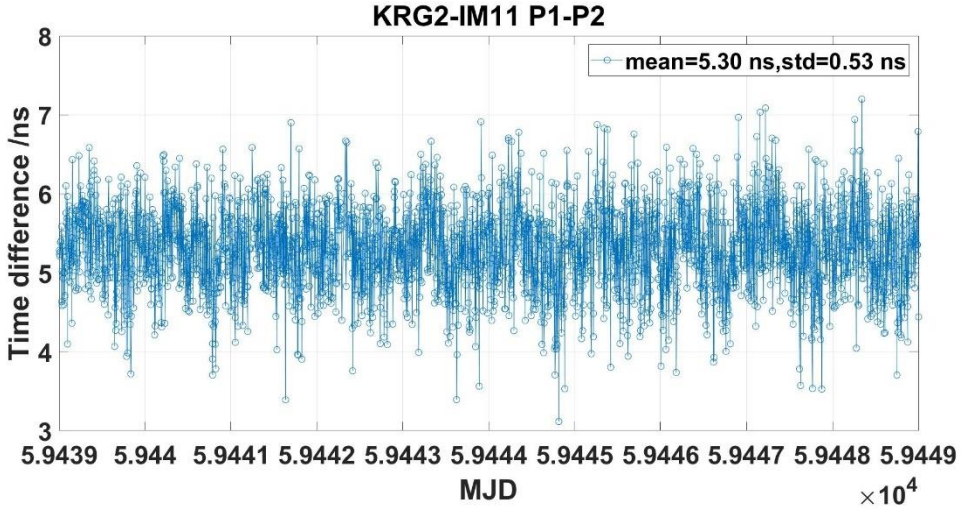


Figure 35. CCD between IM11 and KRG2 at KRIS(P1-P2)

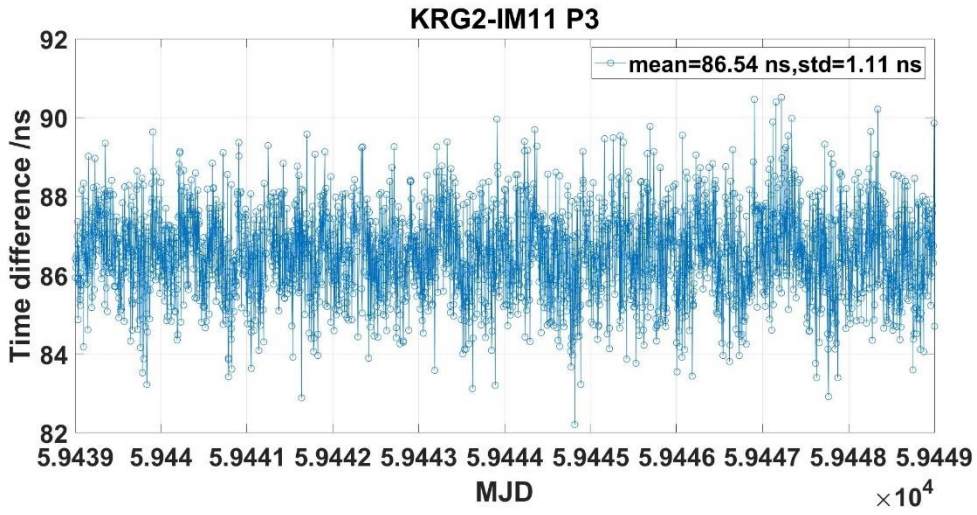


Figure 36. CCD between IM11 and KRG2 at KRIS(P3)

3. Closure CCD after calibration

IM06-IM09

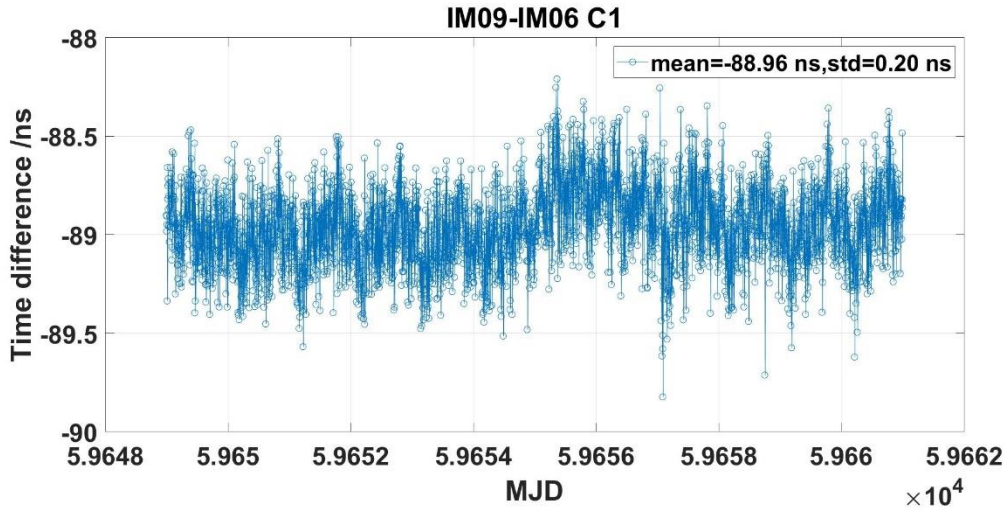


Figure 37. CCD between IM06 and IM09 at NIM(C1)

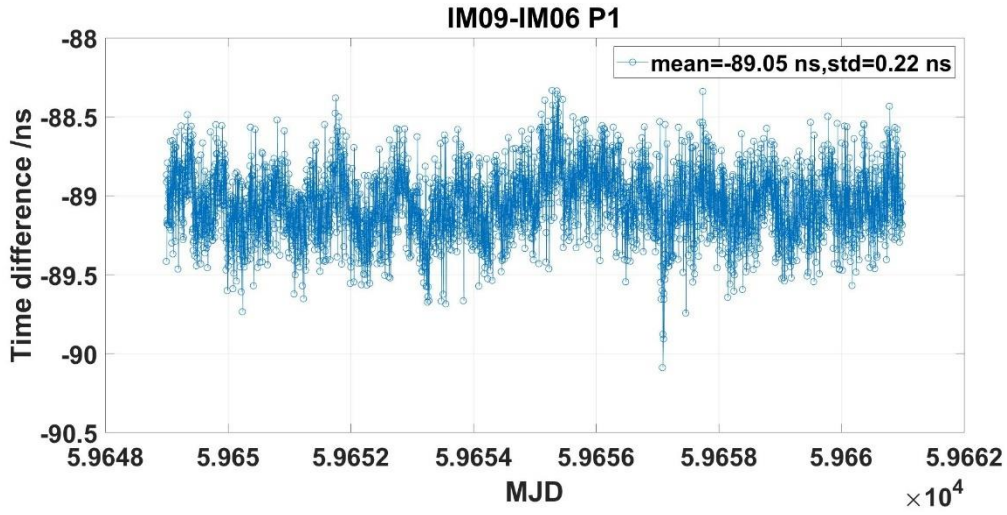


Figure 38. CCD between IM06 and IM09 at NIM(P1)

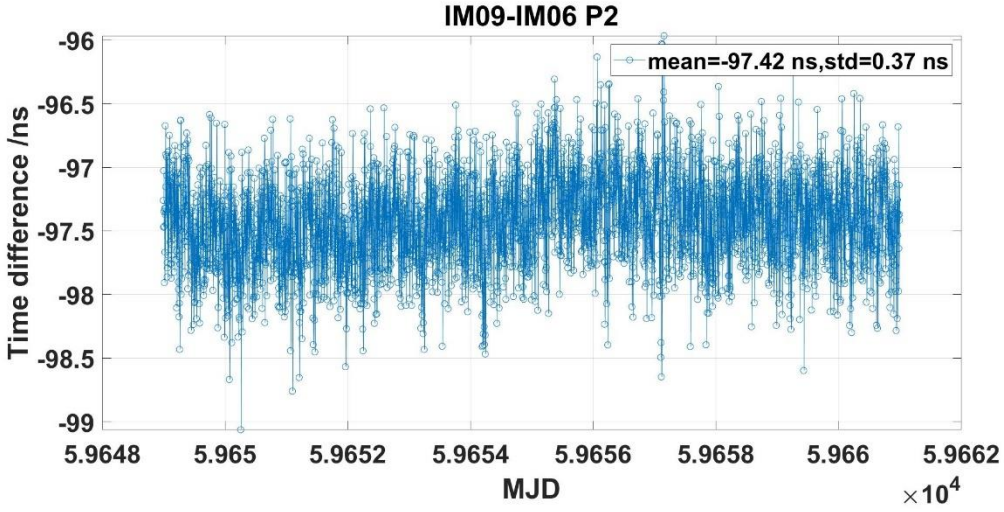


Figure 39. CCD between IM06 and IM09 at NIM(P2)

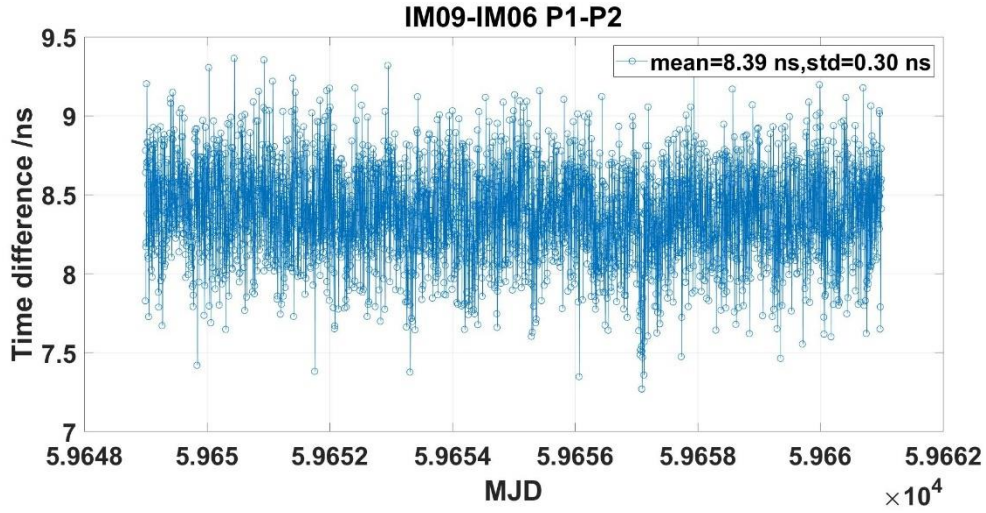


Figure 40. CCD between IM06 and IM09 at NIM(P1-P2)

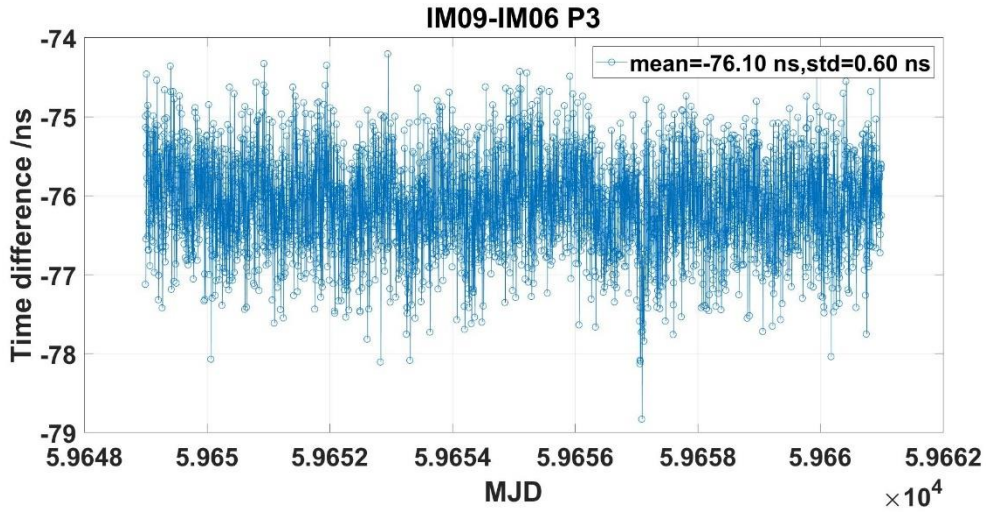


Figure 41. CCD between IM06 and IM09 at NIM(P3)

IM11-IM06

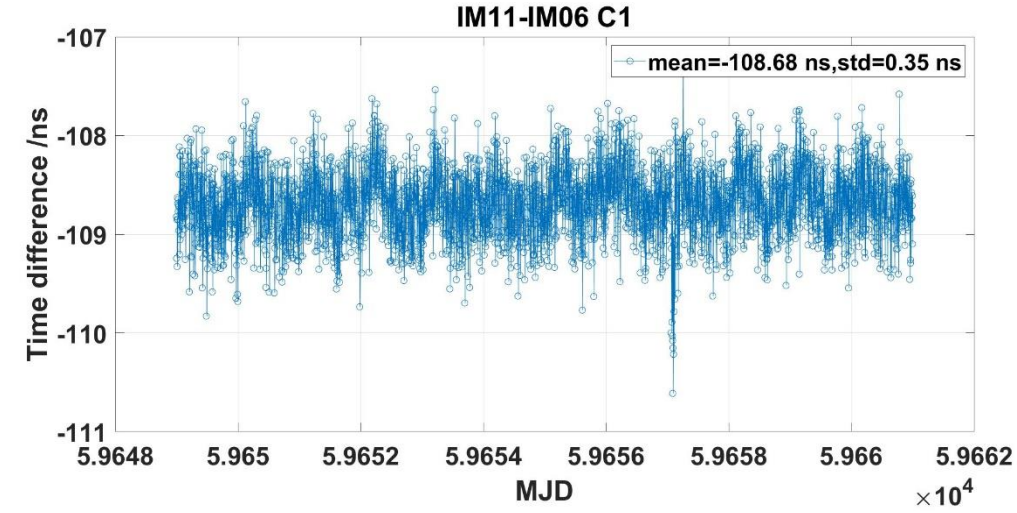


Figure 42. CCD between IM11 and IM06 at NIM(C1)

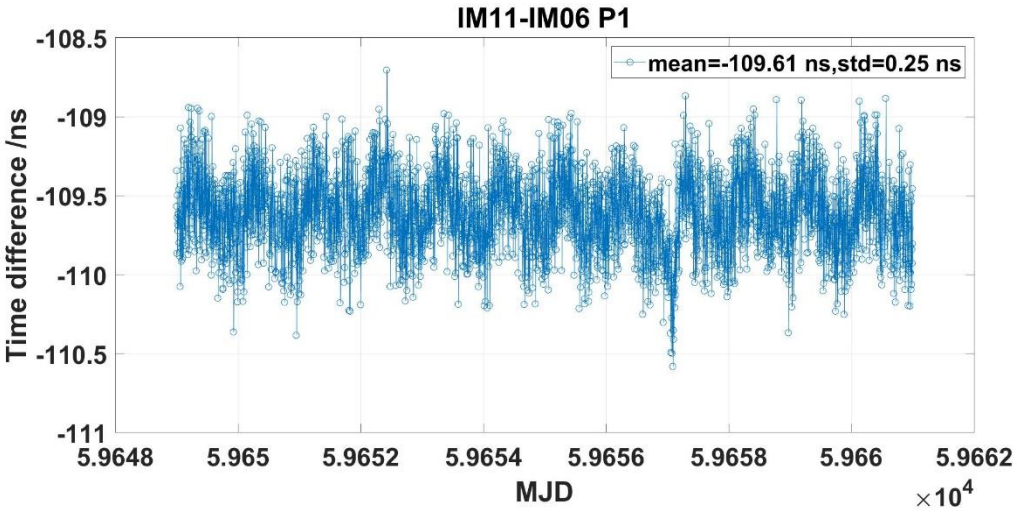


Figure 43. CCD between IM11 and IM06 at NIM(P1)

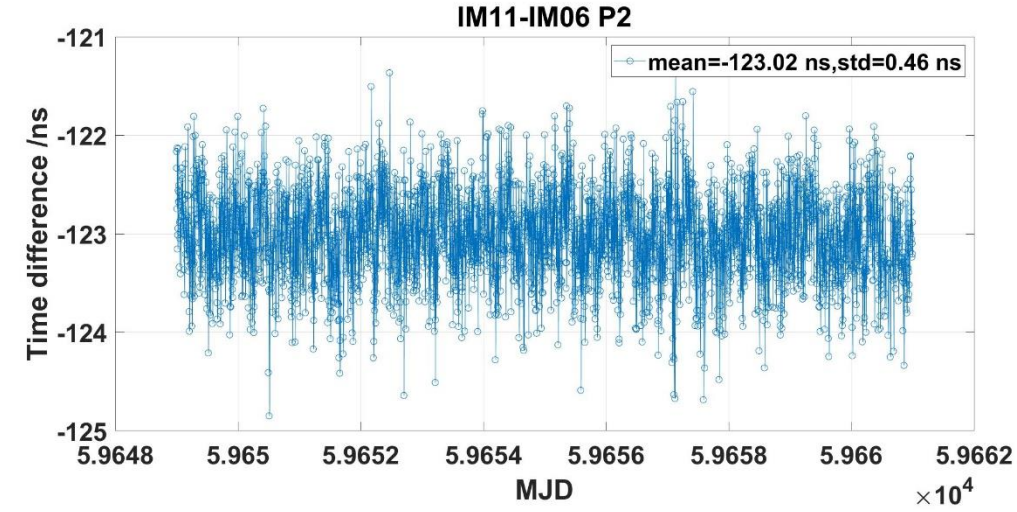


Figure 44. CCD between IM11 and IM06 at NIM(P2)

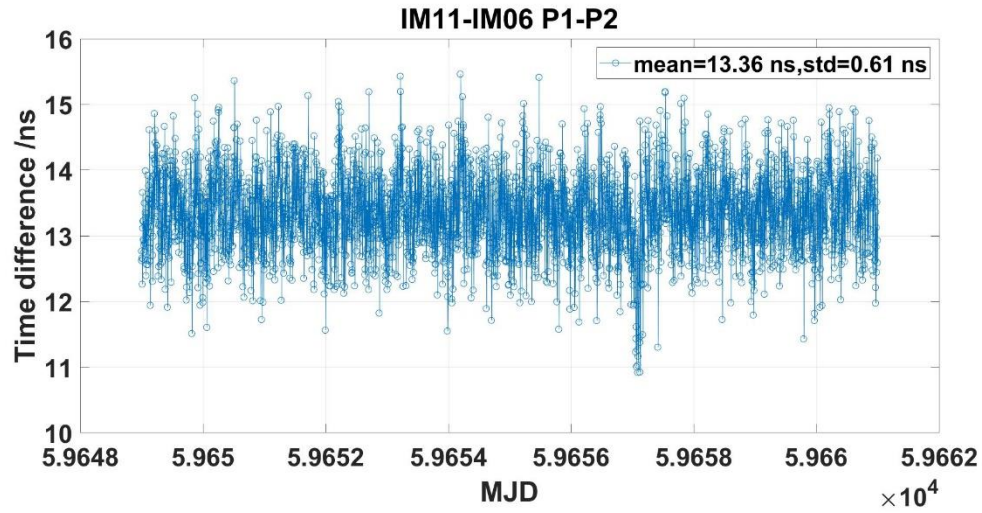


Figure 45. CCD between IM11 and IM06 at NIM(P1-P2)

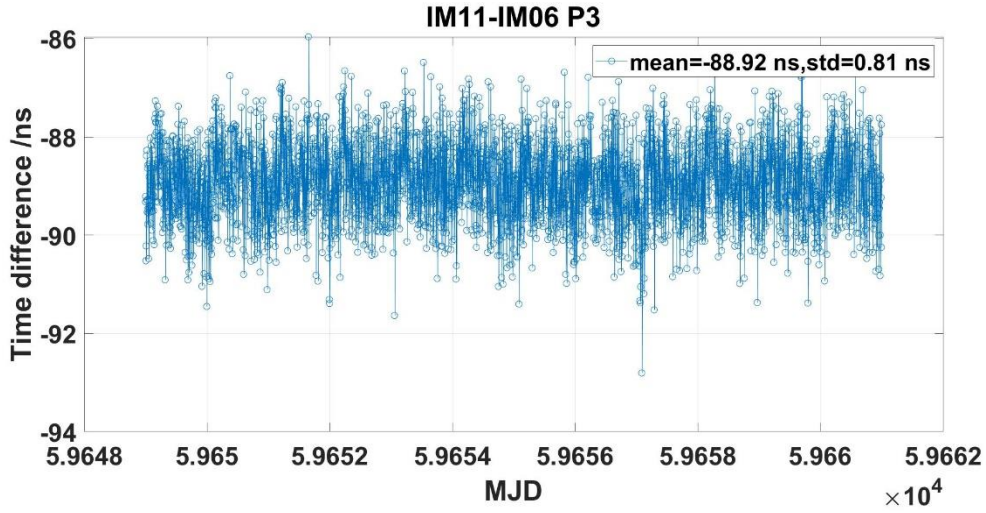


Figure 46. CCD between IM11 and IM06 at NIM(P3)

Annex 2. CCD results for MSL

1. Start CCD before calibration

IM09-IM06

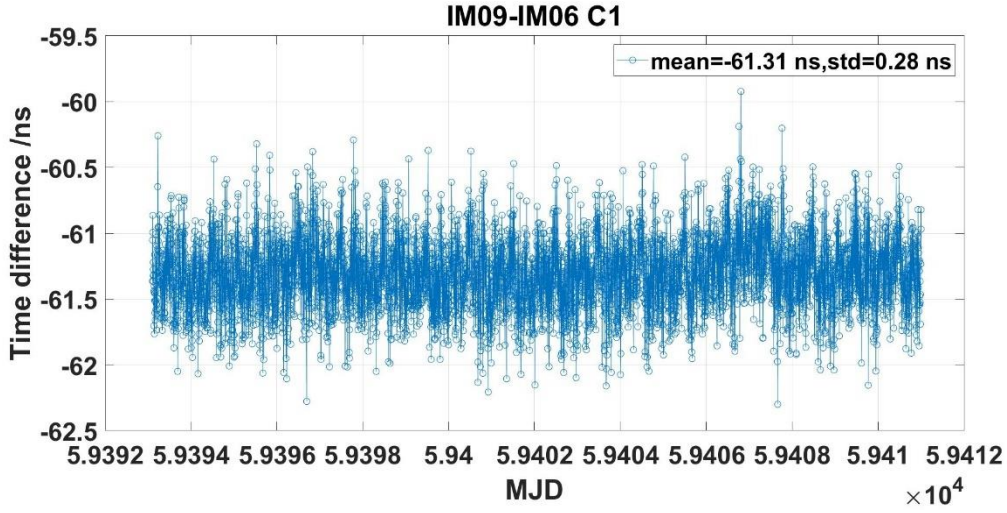


Figure 47. CCD between IM09 and IM06 at NIM(C1)

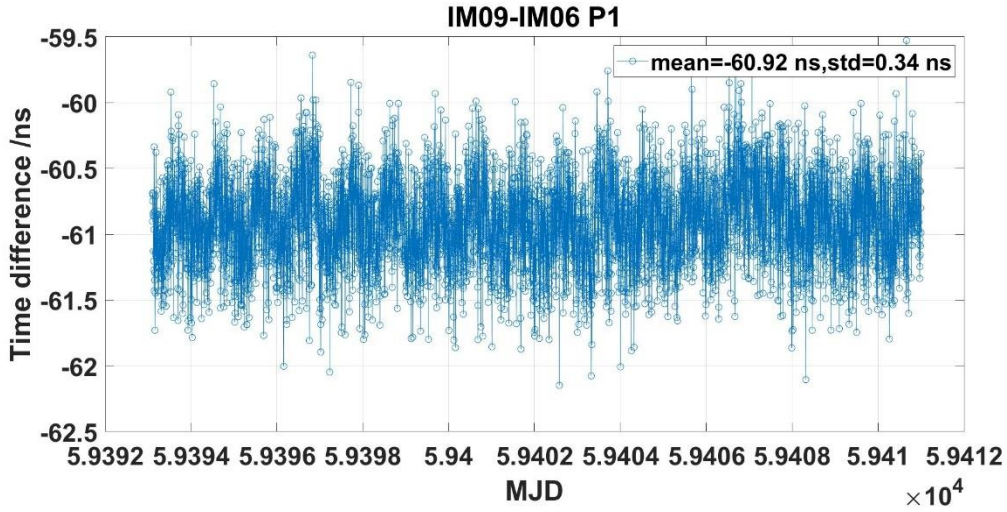


Figure 48. CCD between IM09 and IM06 at NIM(P1)

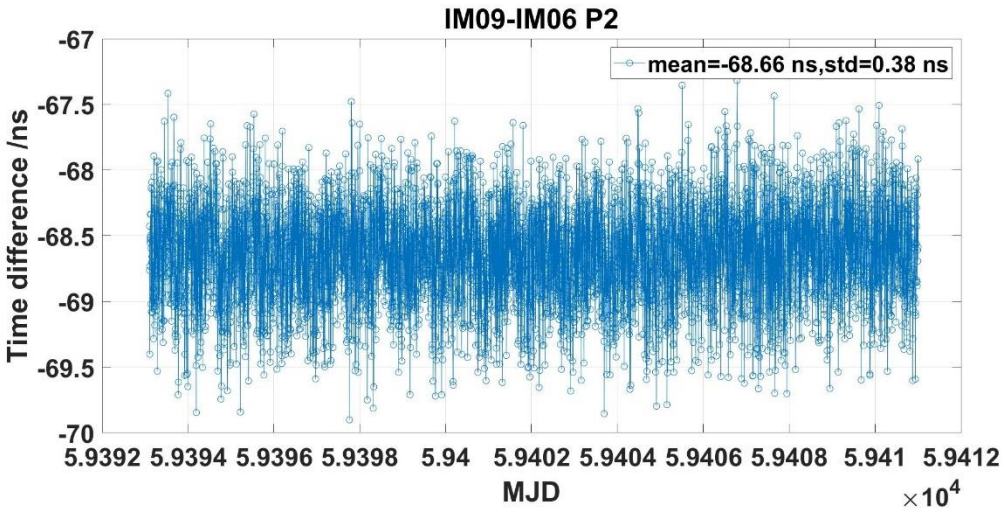


Figure 49. CCD between IM09 and IM06 at NIM(P2)

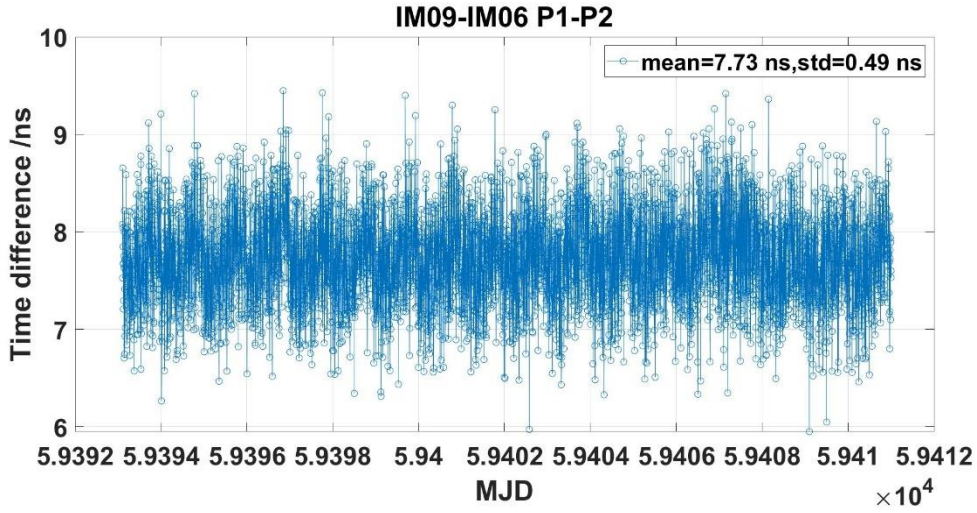


Figure 50. CCD between IM09 and IM06 at NIM(P1-P2)

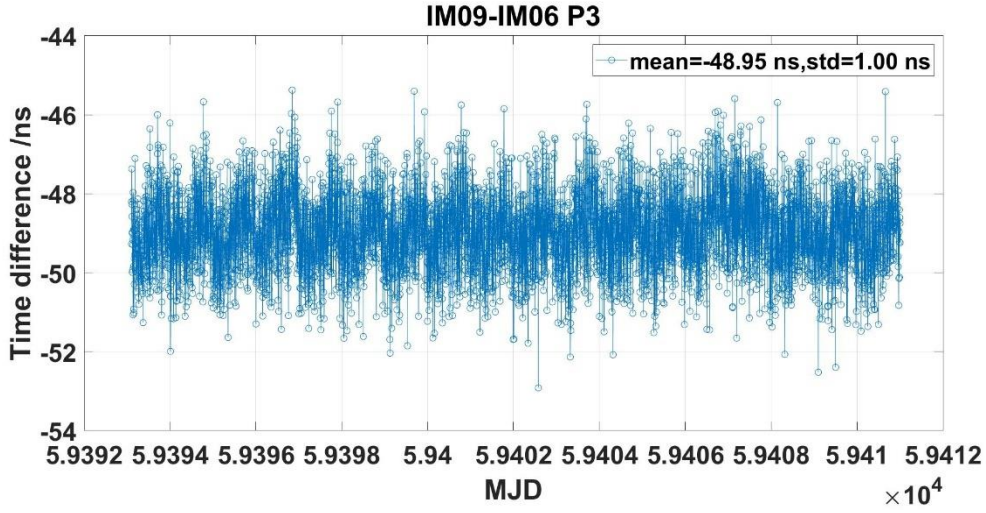


Figure 51. CCD between IM09 and IM06 at NIM(P3)

IM11-IM06

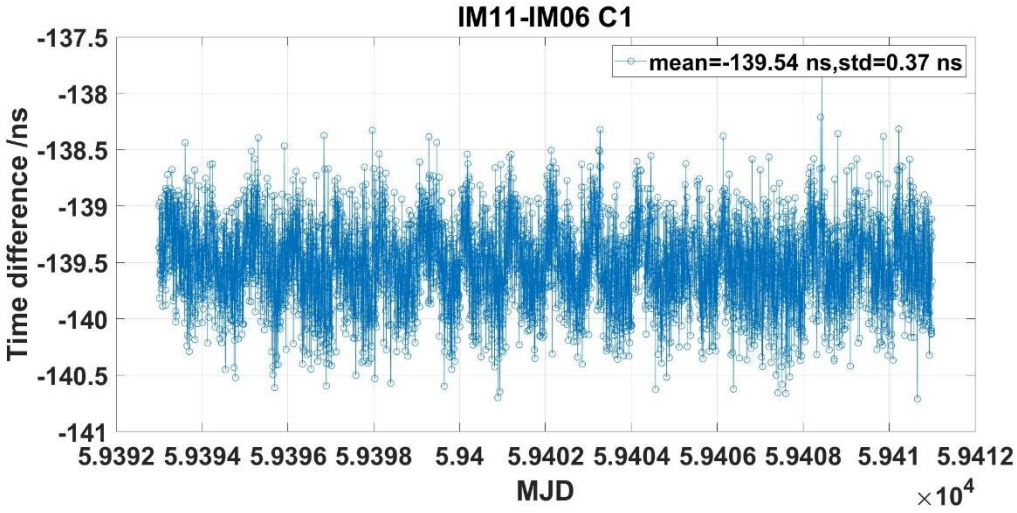


Figure 52. CCD between IM11 and IM06 at NIM(C1)

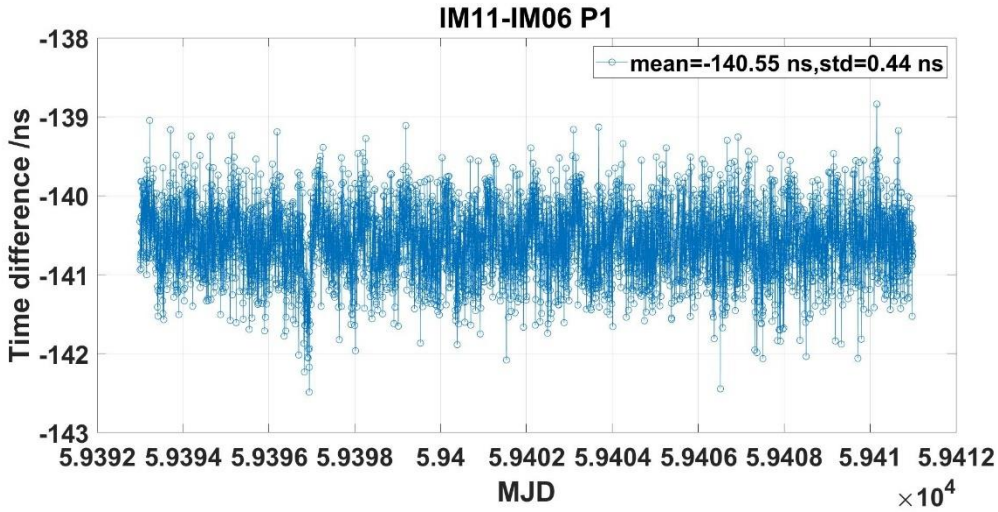


Figure 53. CCD between IM11 and IM06 at NIM(P1)

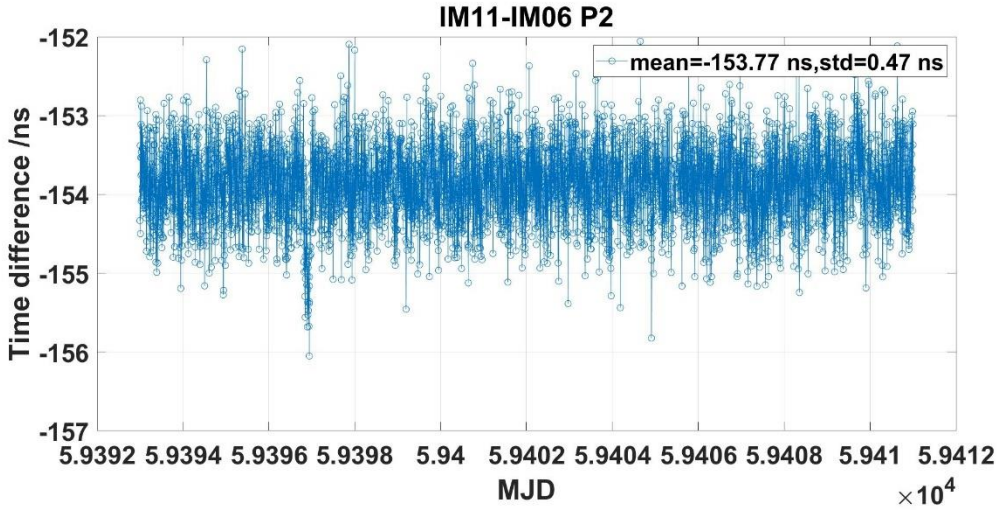


Figure 54. CCD between IM11 and IM06 at NIM(P2)

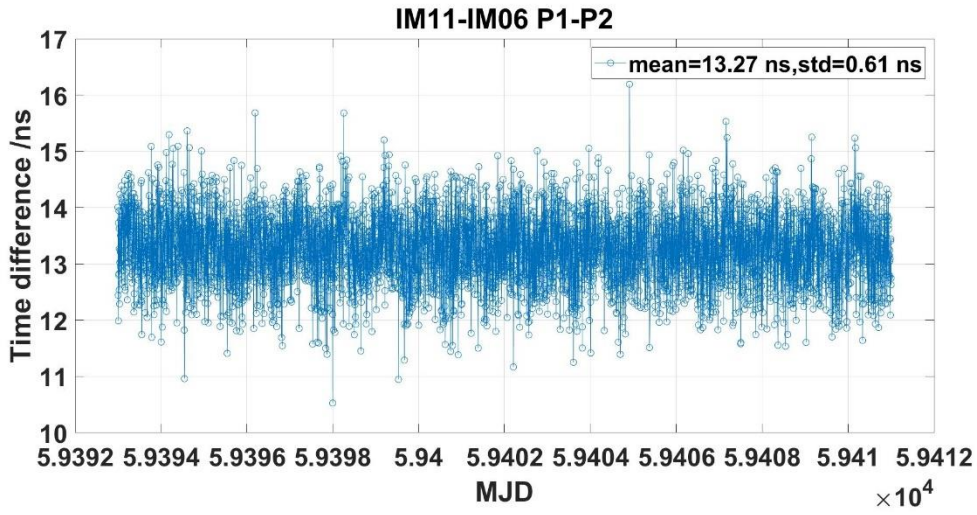


Figure 55. CCD between IM11 and IM06 at NIM(P1-P2)

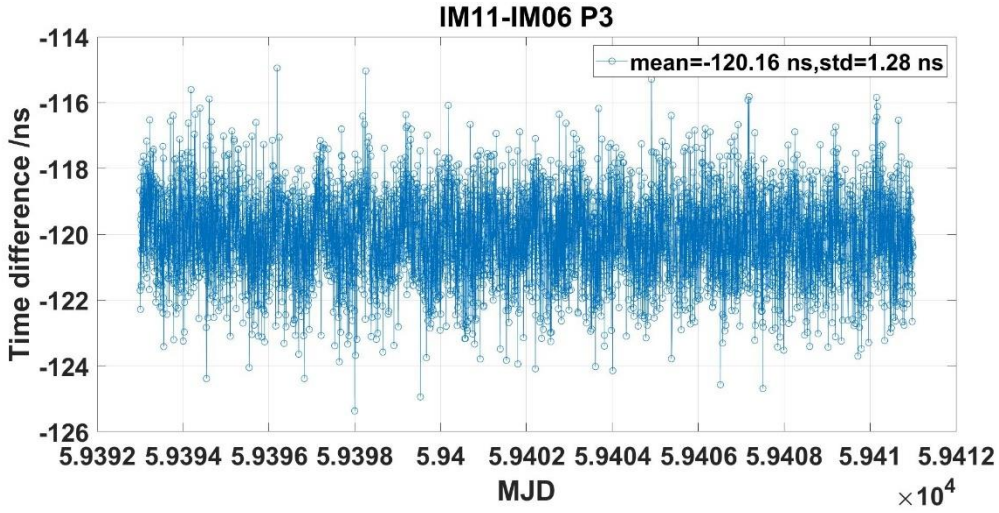


Figure 56. CCD between IM11 and IM06 at NIM(P3)

2. Calibration on site

MS01-IM09

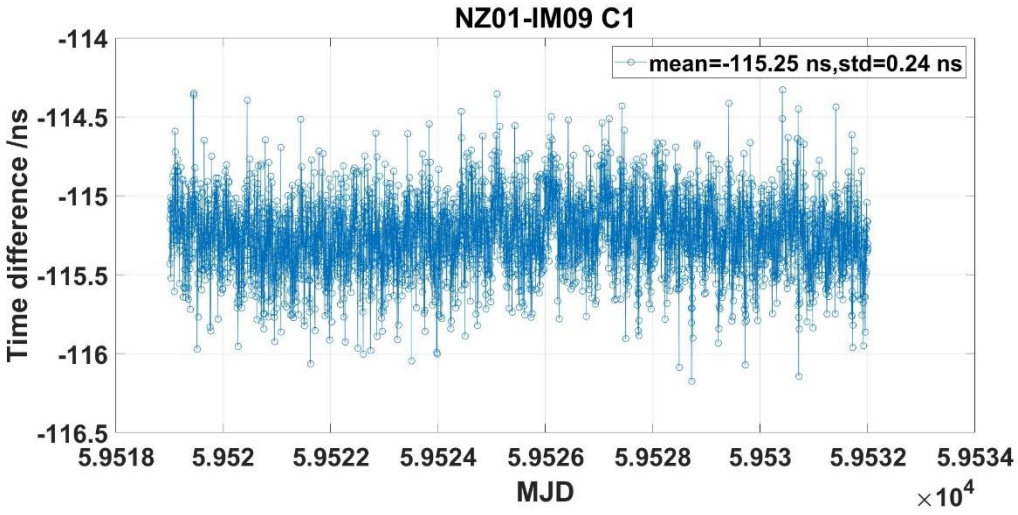


Figure 57. CCD between IM09 and MS01 at MSL(C1)

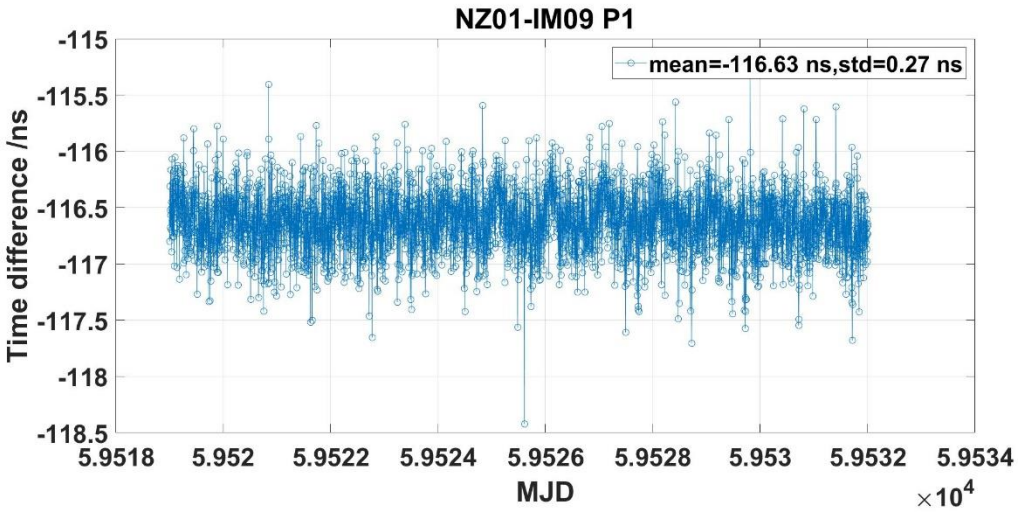


Figure 58. CCD between IM09 and MS01 at MSL(P1)

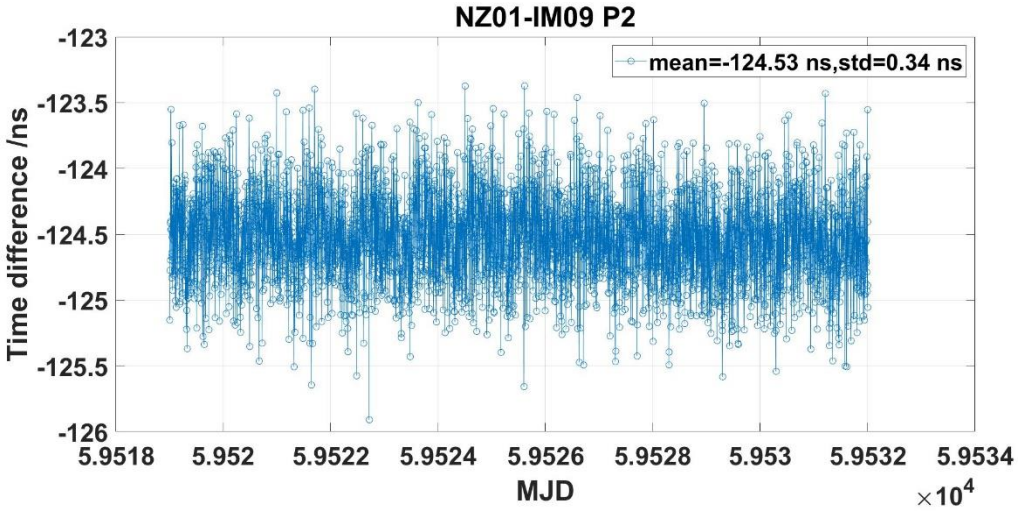


Figure 59. CCD between IM09 and MS01 at MSL(P2)

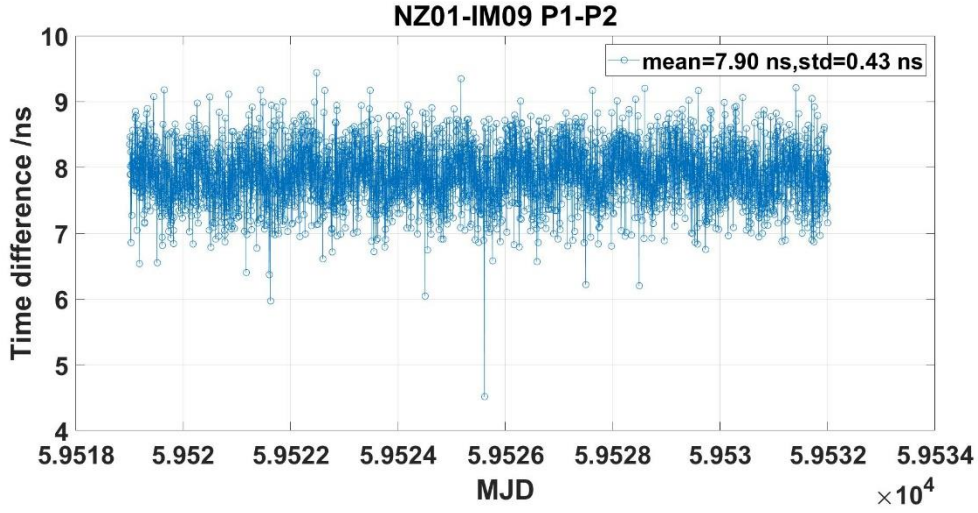


Figure 60. CCD between IM09 and MS01 at MSL(P1-P2)

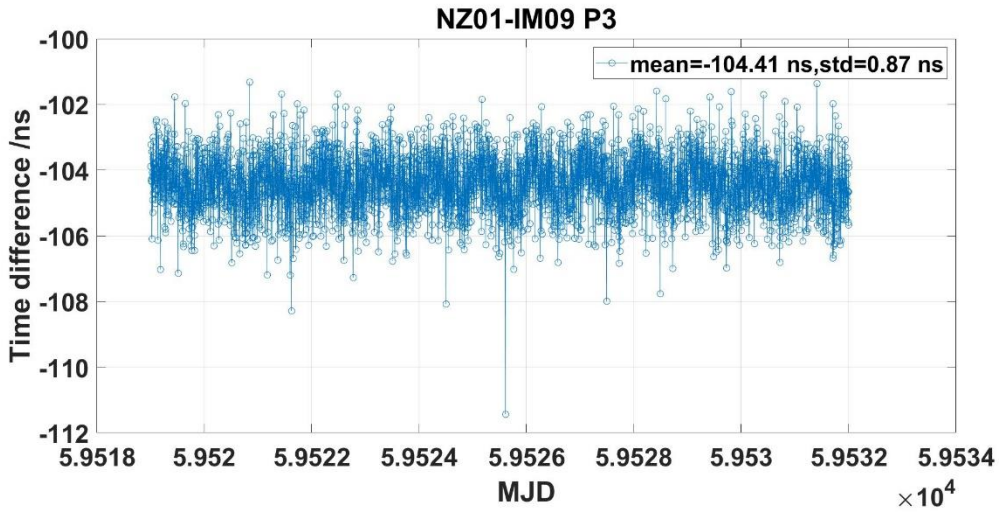


Figure 61. CCD between IM09 and MS01 at MSL(P3)

MS01-IM11

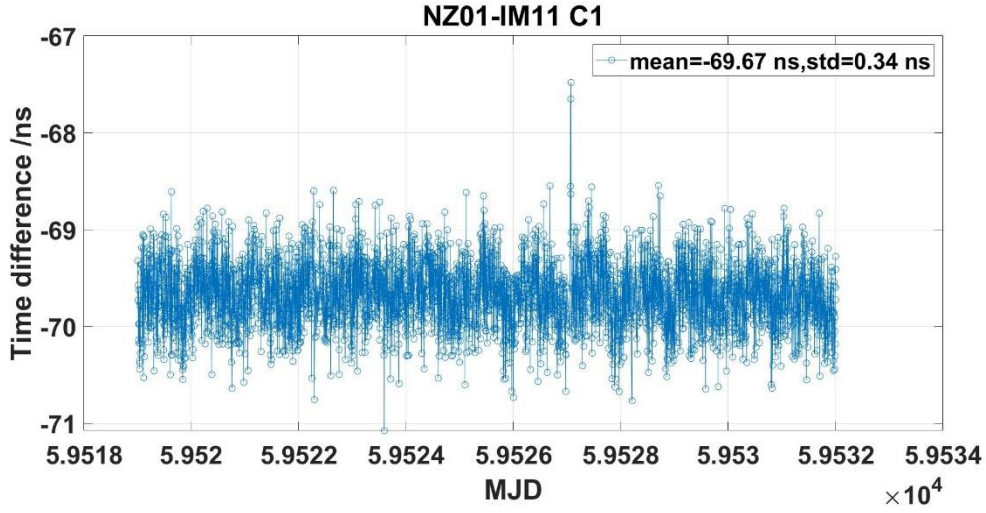


Figure 62. CCD between IM11 and MS01 at MSL(C1)

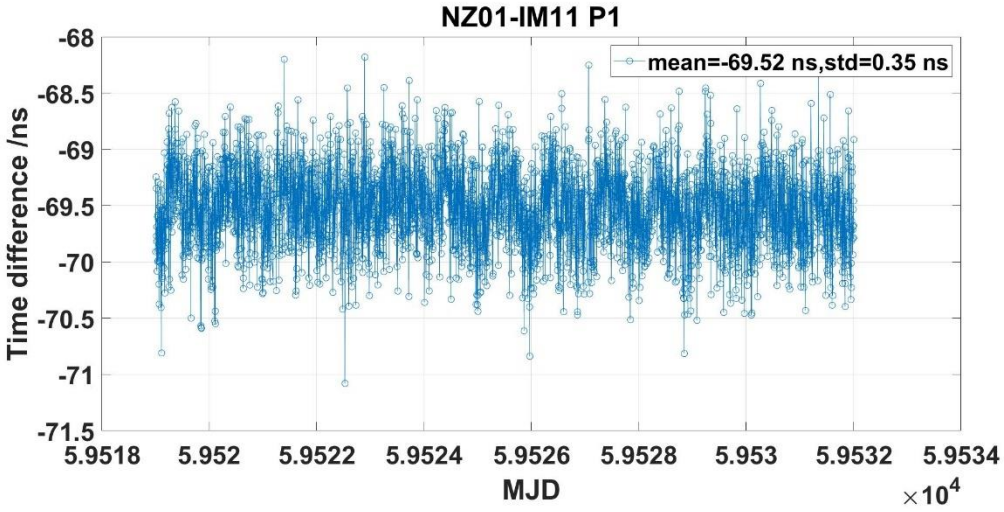


Figure 63. CCD between IM11 and MS01 at MSL(P1)

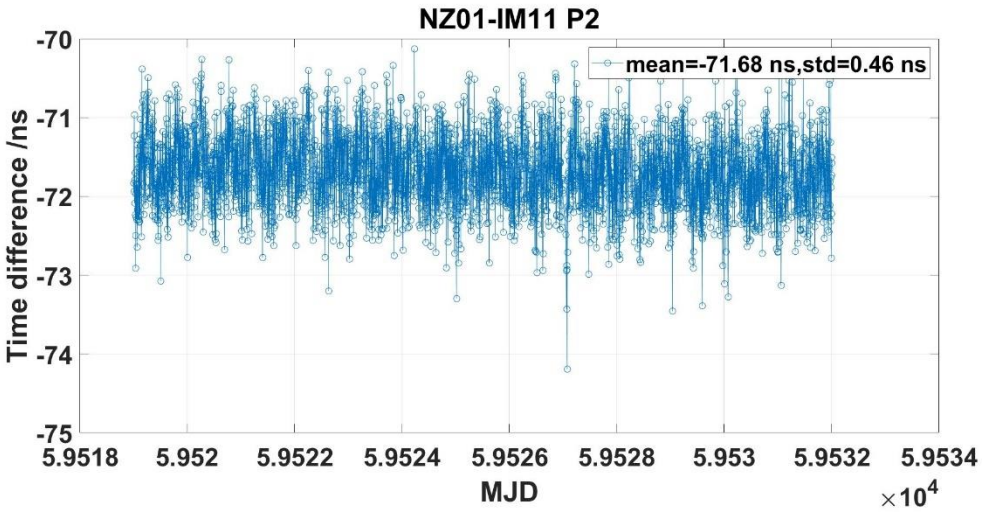


Figure 64. CCD between IM11 and MS01 at MSL(P2)

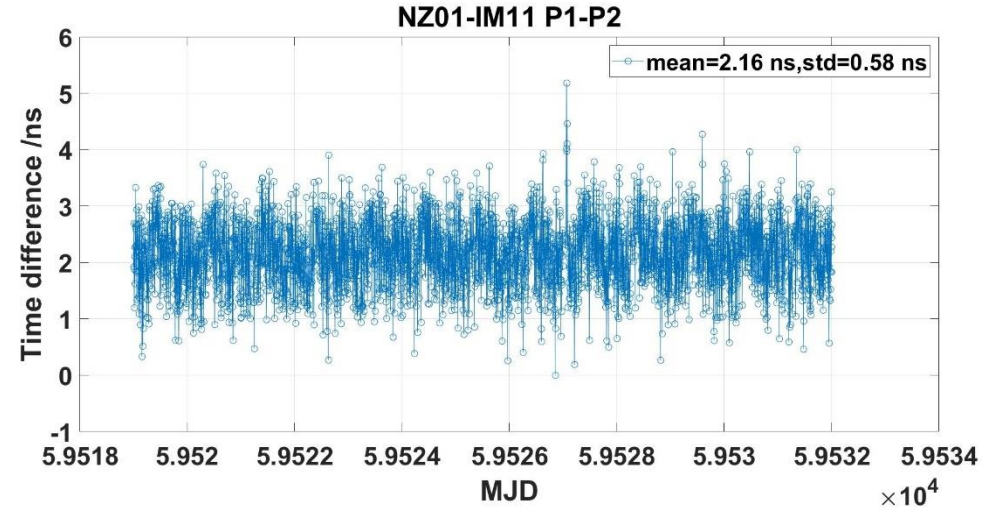


Figure 65. CCD between IM11 and MS01 at MSL(P1-P2)

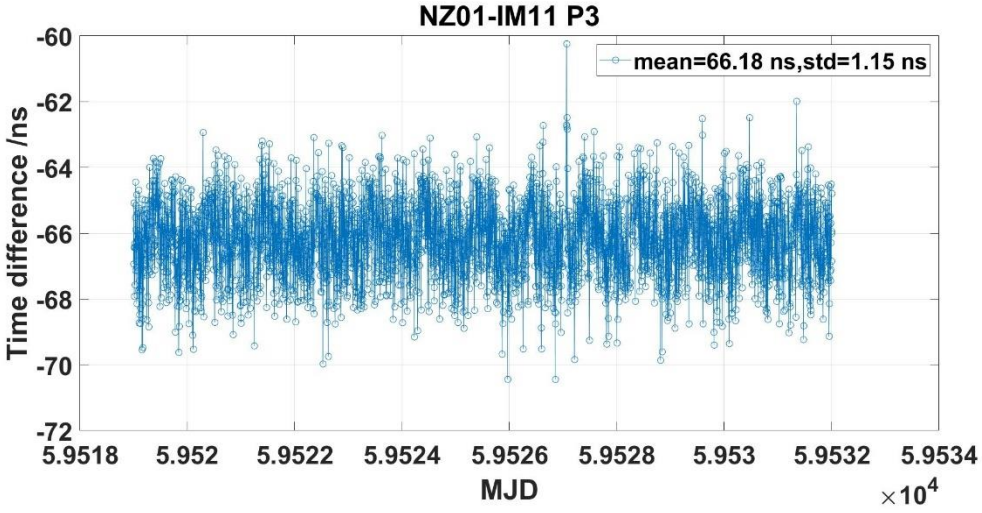


Figure 66. CCD between IM11 and MS01 at MSL(P3)

NZ02-IM09

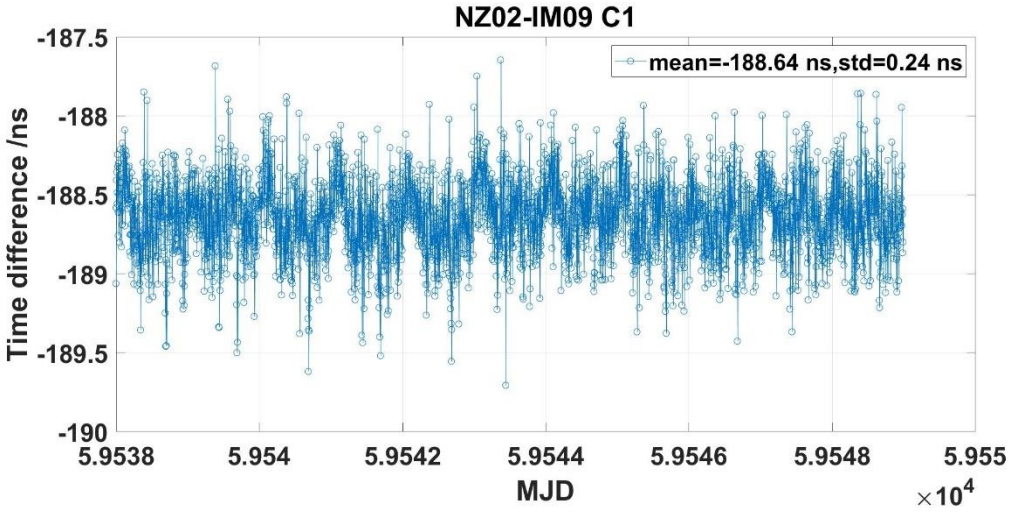


Figure 67. CCD between IM09 and NZ02 at MSL(C1)

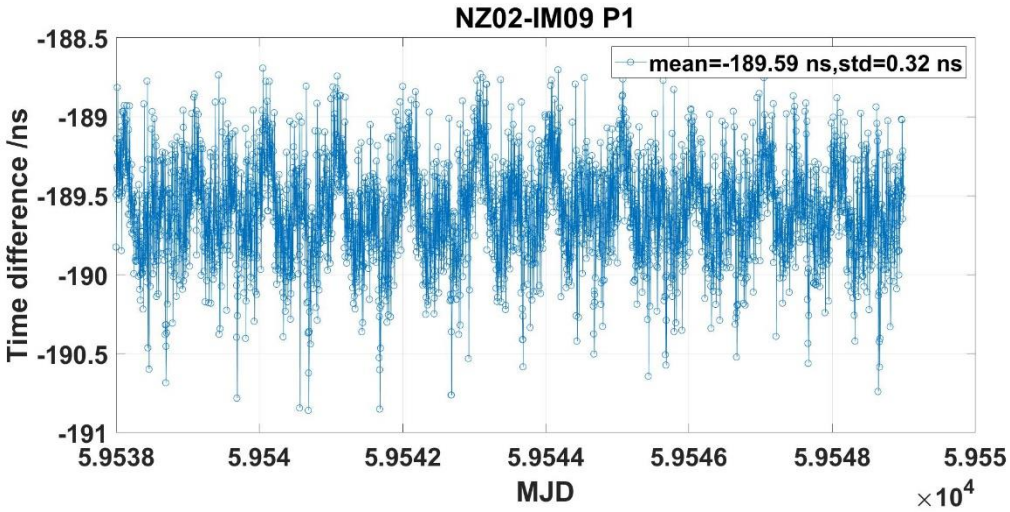


Figure 68. CCD between IM09 and NZ02 at MSL(P1)

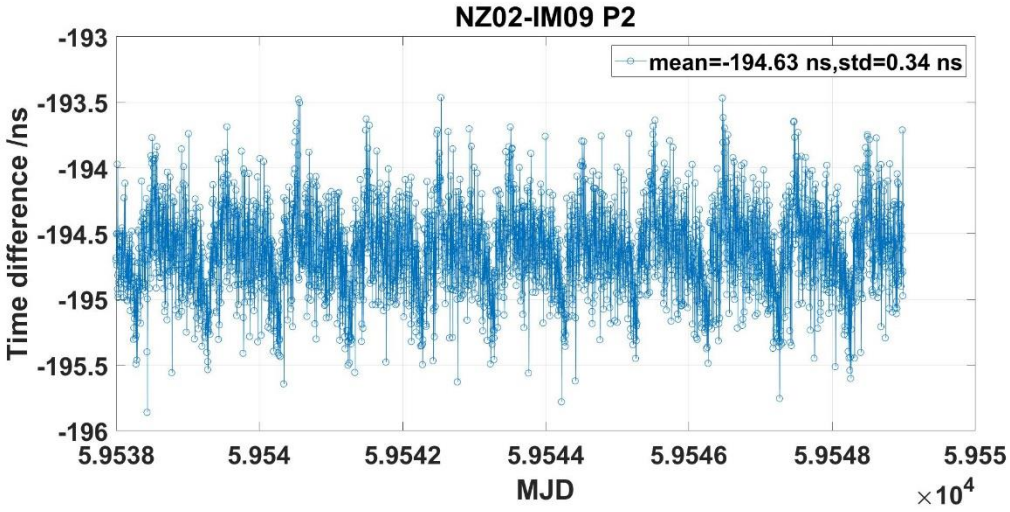


Figure 69. CCD between IM09 and NZ02 at MSL(P2)

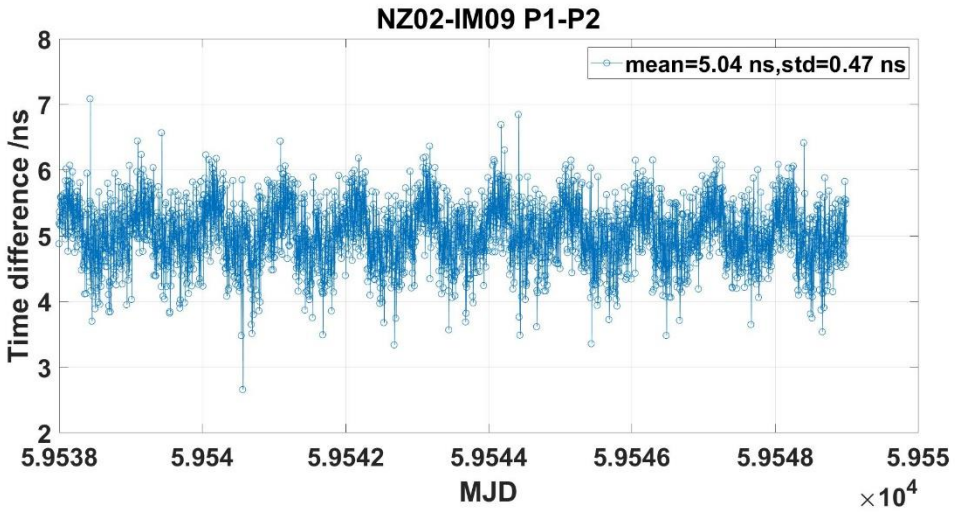


Figure 70. CCD between IM09 and NZ02 at MSL(P1-P2)

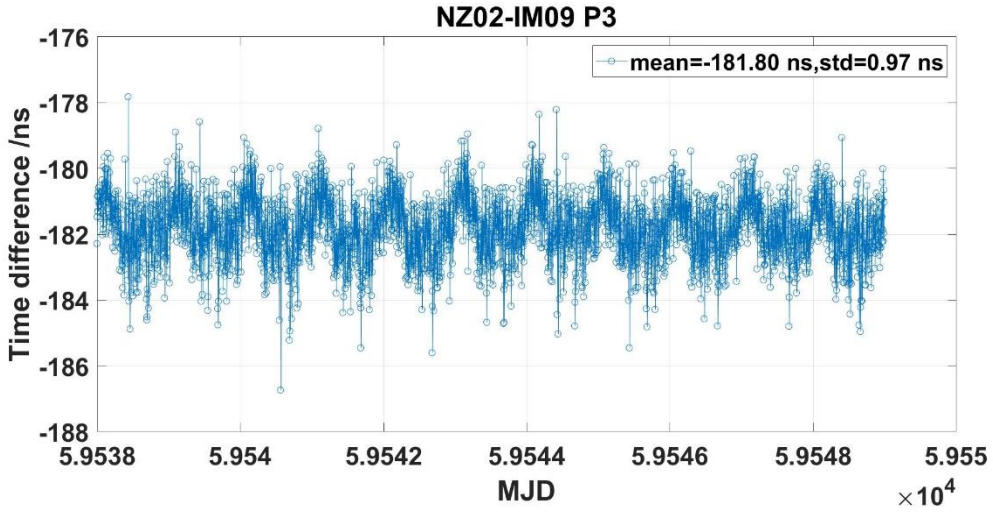


Figure 71. CCD between IM09 and NZ02 at MSL(P3)

NZ02-IM11

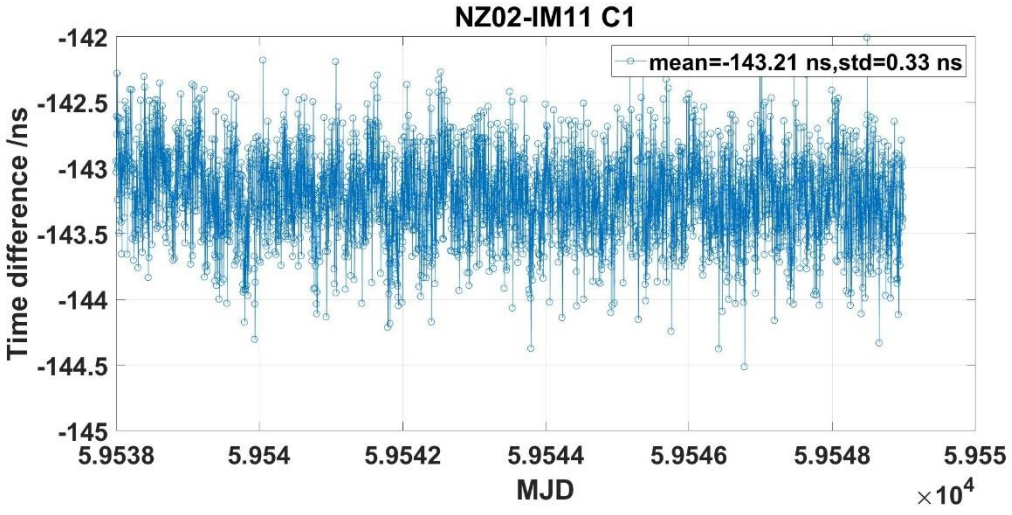


Figure 72. CCD between IM11 and NZ02 at MSL(C1)

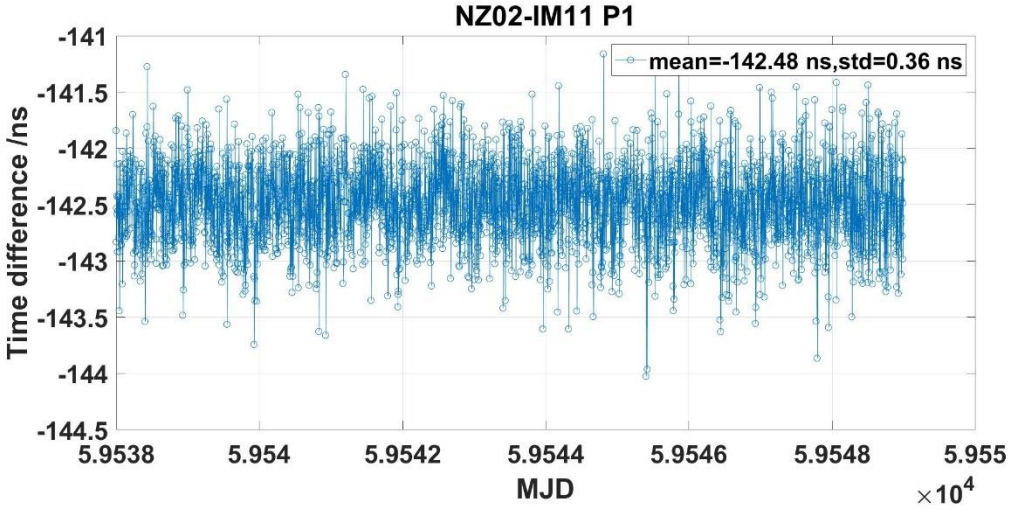


Figure 73. CCD between IM11 and NZ02 at MSL(P1)

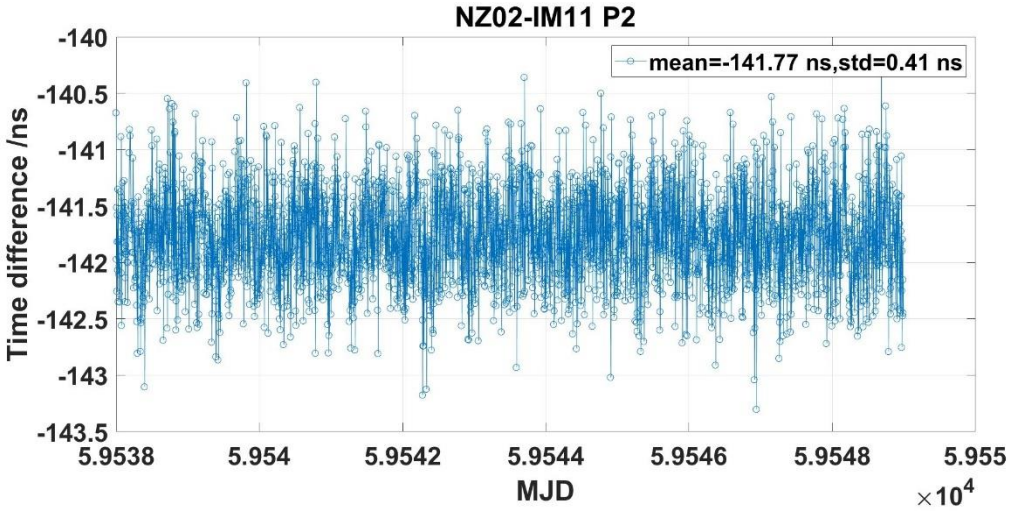


Figure 74. CCD between IM11 and NZ02 at MSL(P2)

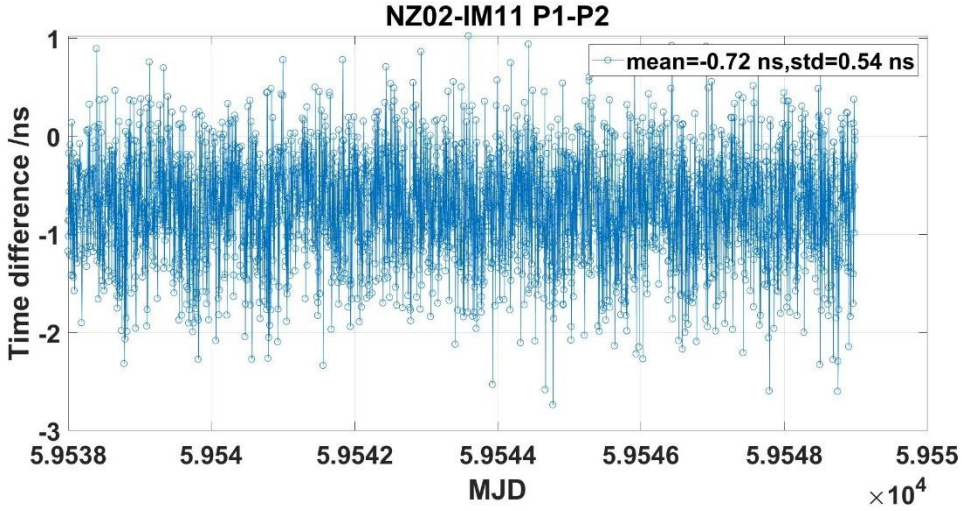


Figure 75. CCD between IM11 and NZ02 at MSL(P1-P2)

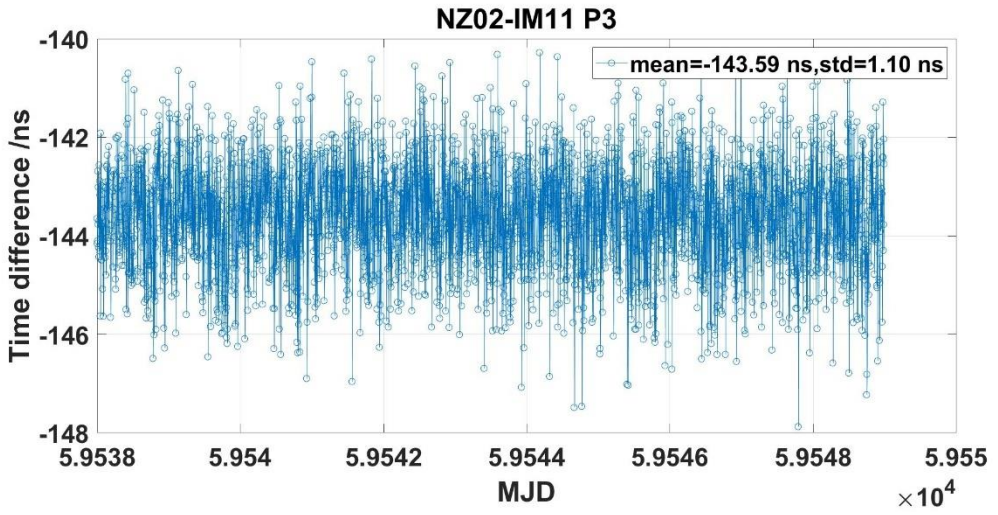


Figure 76. CCD between IM11 and NZ02 at MSL(P3)

NZ03-IM09

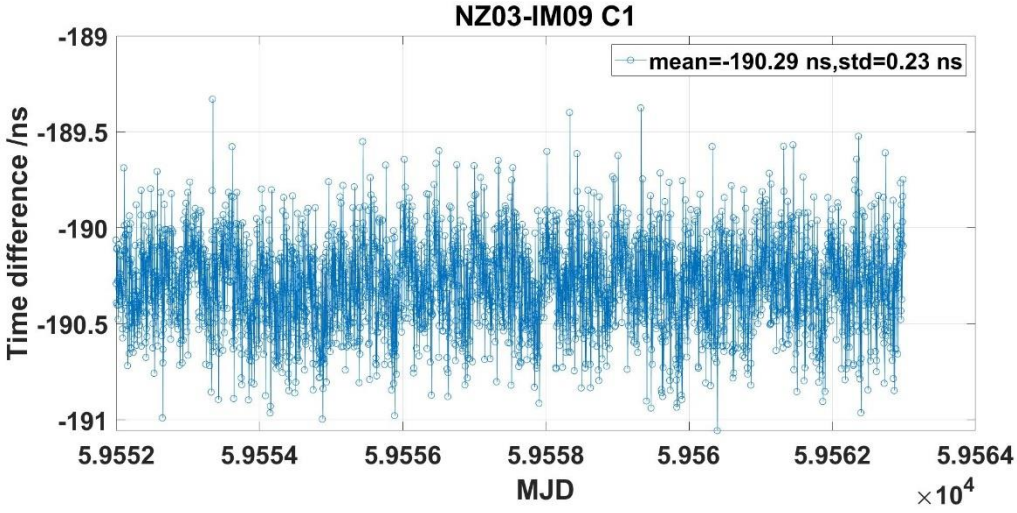


Figure 77. CCD between IM09 and NZ03 at MSL(P1)

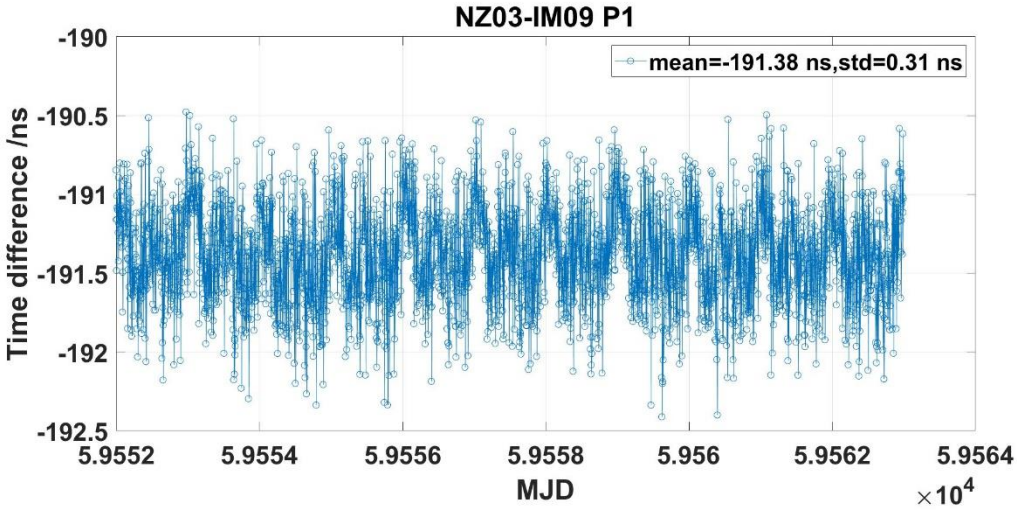


Figure 78. CCD between IM09 and NZ03 at MSL(P1)

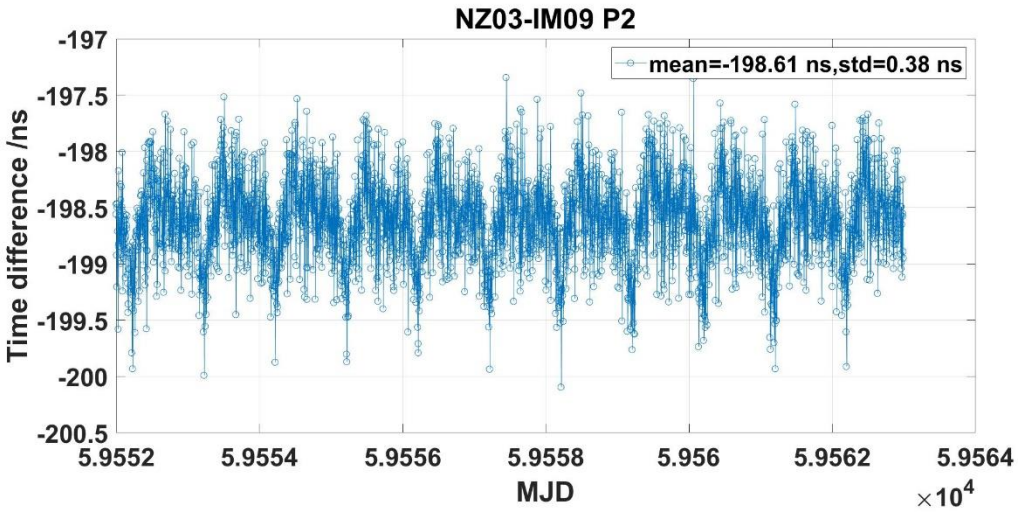


Figure 79. CCD between IM09 and NZ03 at MSL(P2)

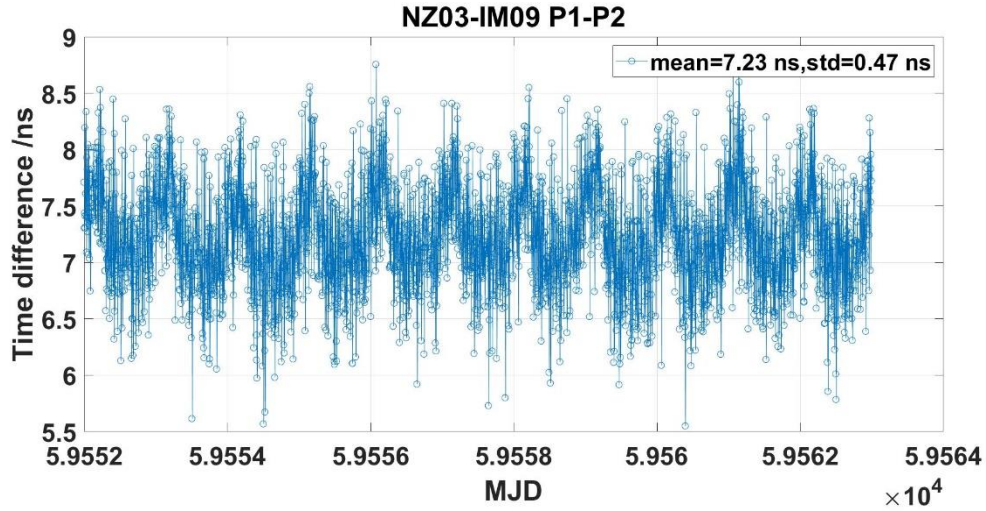


Figure 80. CCD between IM09 and NZ03 at MSL(P1-P2)

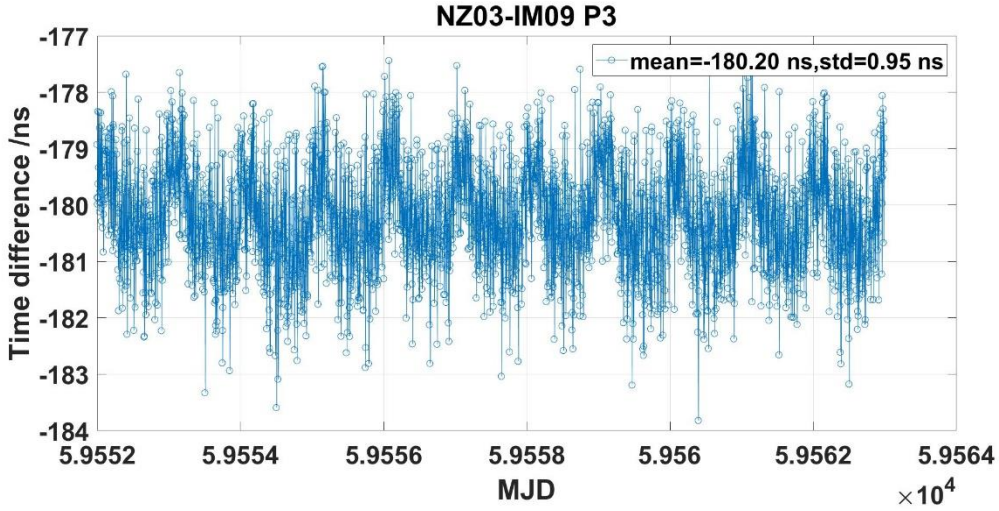


Figure 81. CCD between IM09 and NZ03 at MSL(P3)

NZ03-IM11

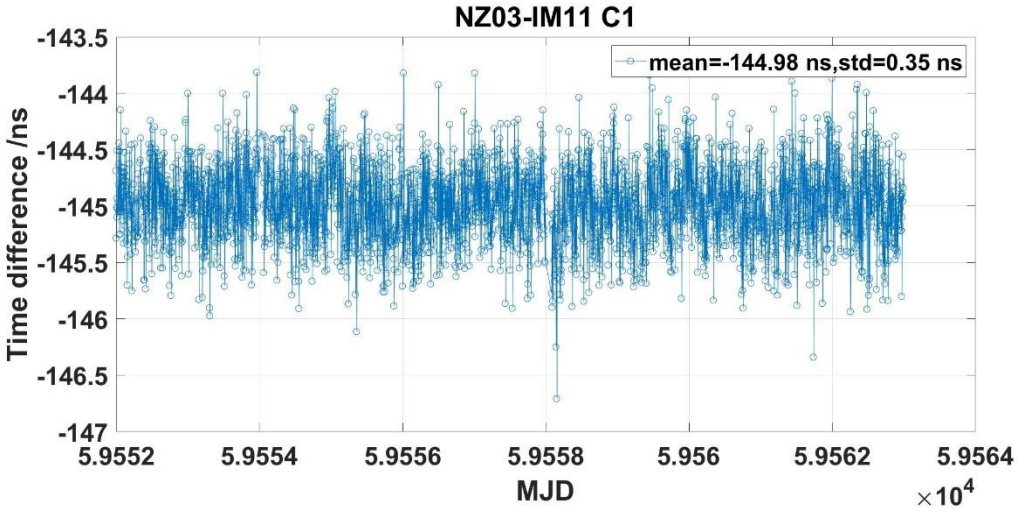


Figure 82. CCD between IM11 and NZ03 at MSL(C1)

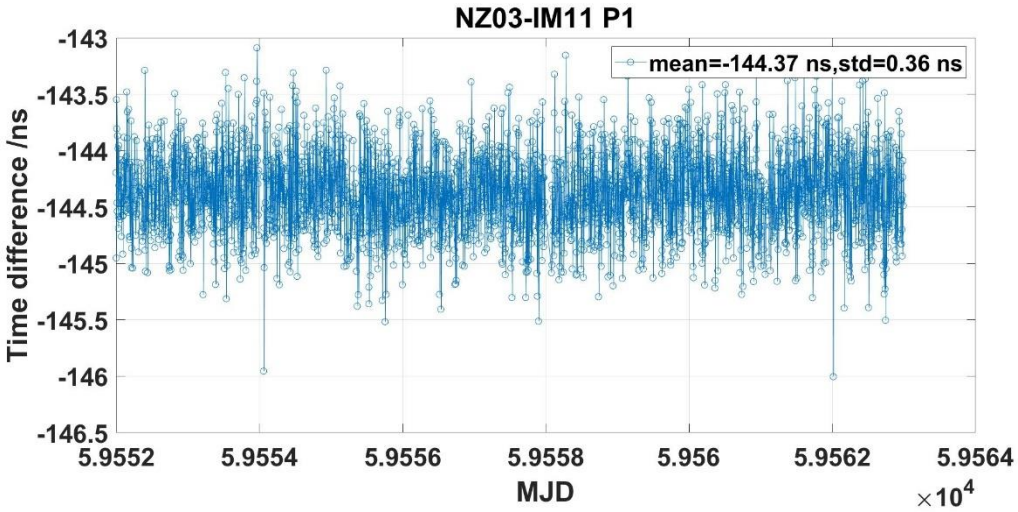


Figure 83. CCD between IM11 and NZ03 at MSL(P1)

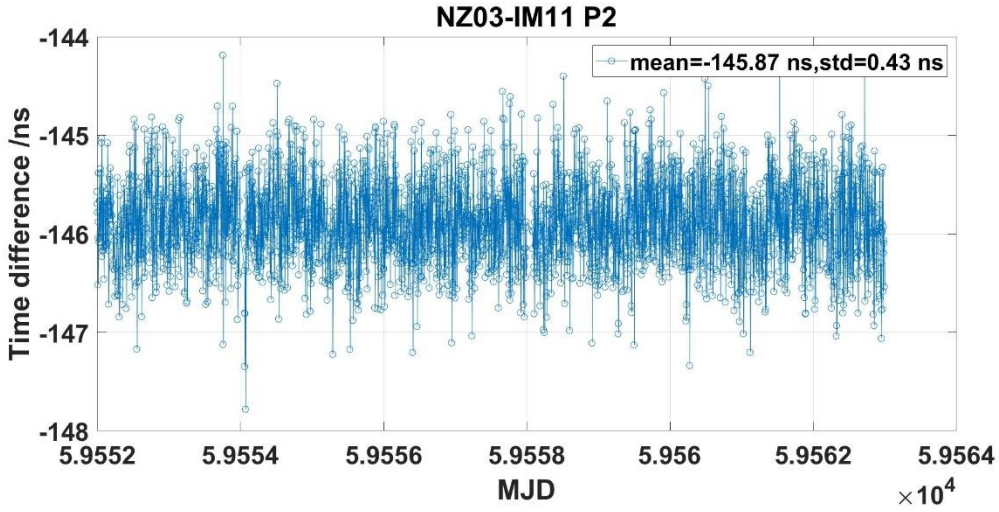


Figure 84. CCD between IM11 and NZ03 at MSL(P2)

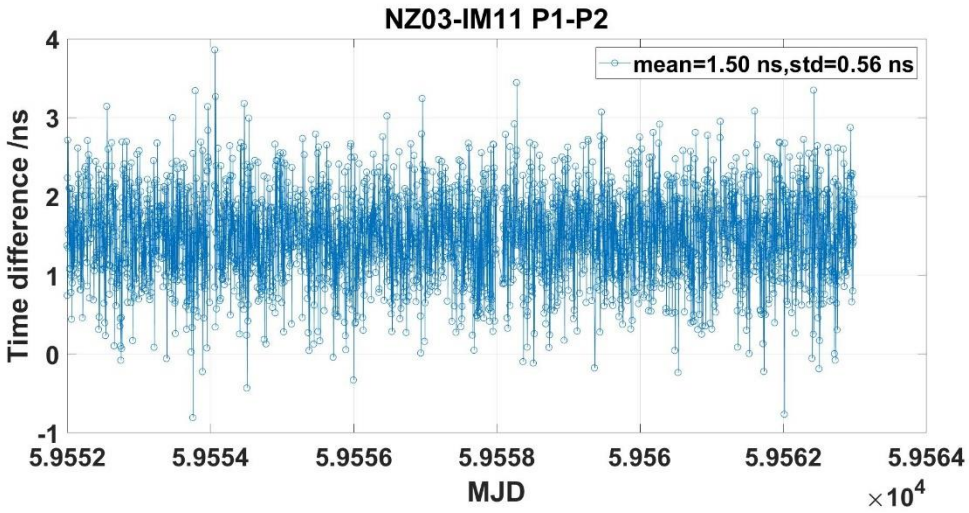


Figure 85. CCD between IM11 and NZ03 at MSL(P1-P2)

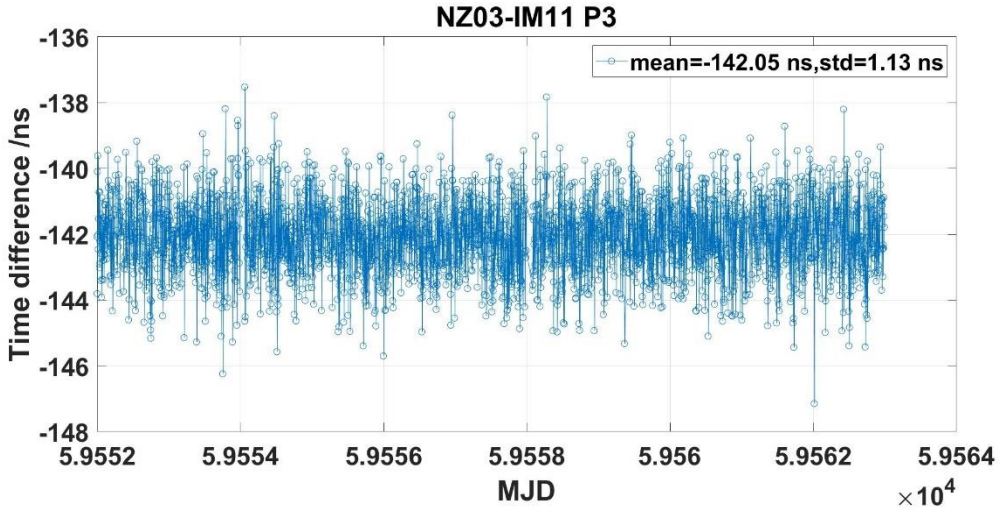


Figure 86. CCD between IM11 and NZ03 at MSL(P3)

3. Closure CCD after calibration

IM09-IM06

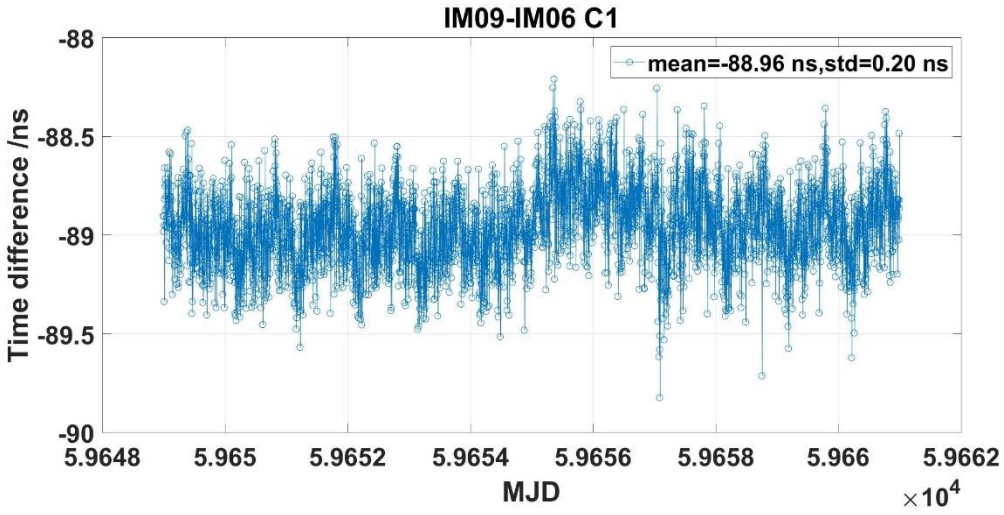


Figure 87. CCD between IM06 and IM09 at NIM(C1)

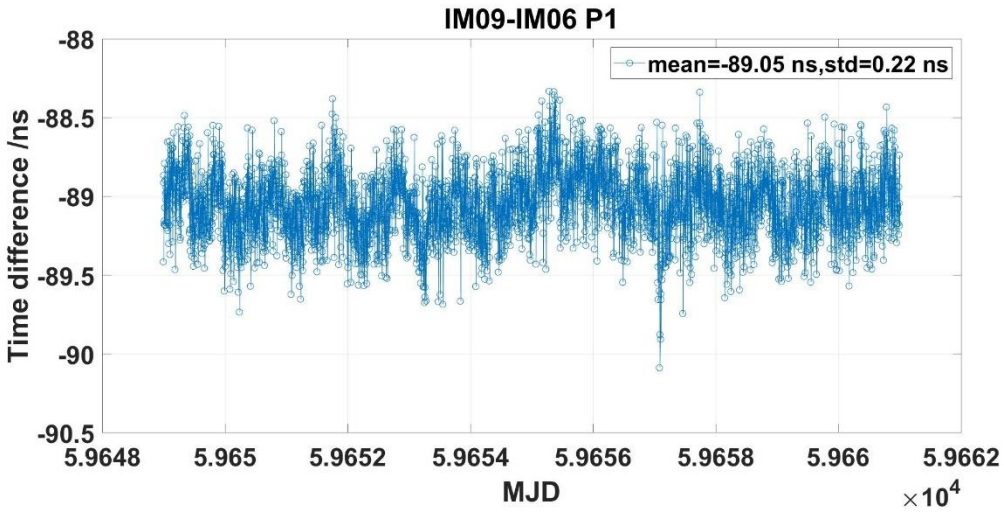


Figure 88. CCD between IM06 and IM09 at NIM(P1)

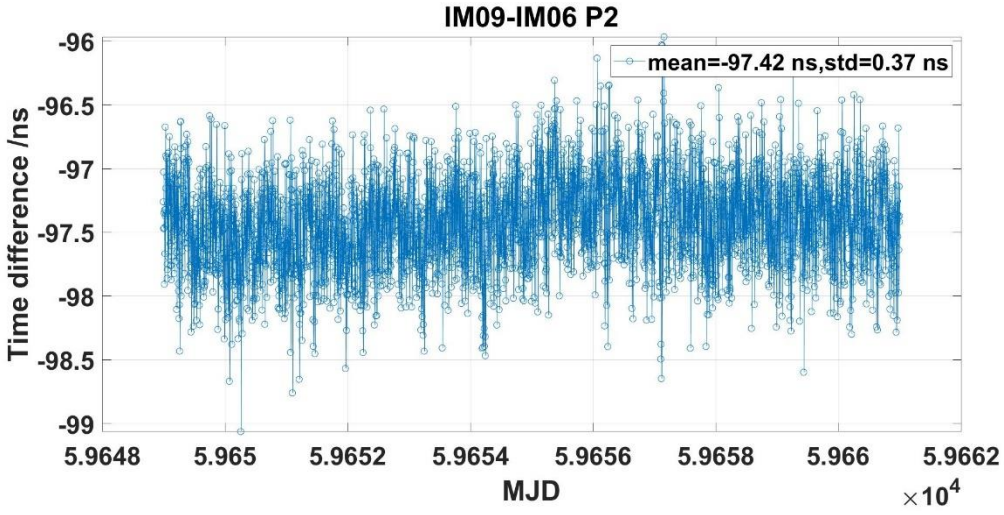


Figure 89. CCD between IM06 and IM09 at NIM(P2)

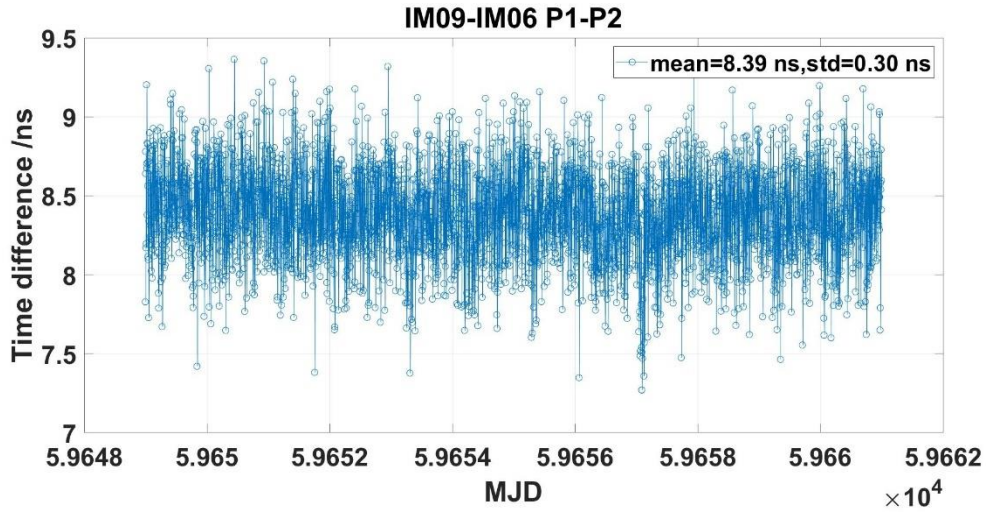


Figure 90. CCD between IM06 and IM09 at NIM(P1-P2)

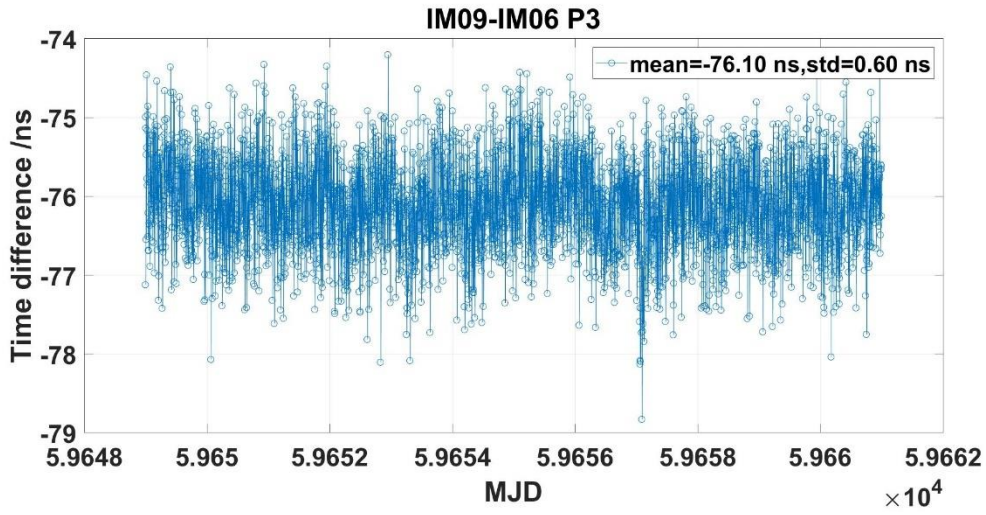


Figure 91. CCD between IM06 and IM09 at NIM(P3)

IM11-IM06

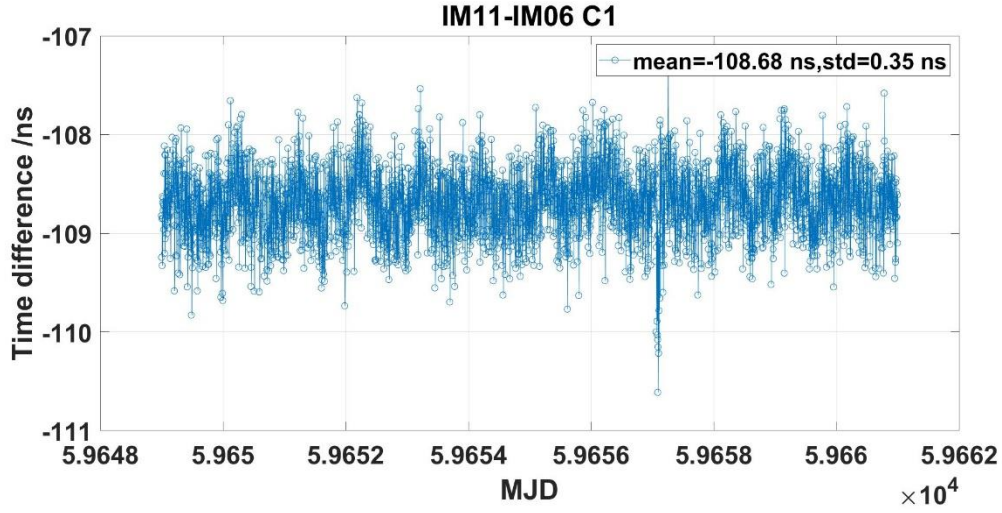


Figure 92. CCD between IM11 and IM06 at NIM(C1)

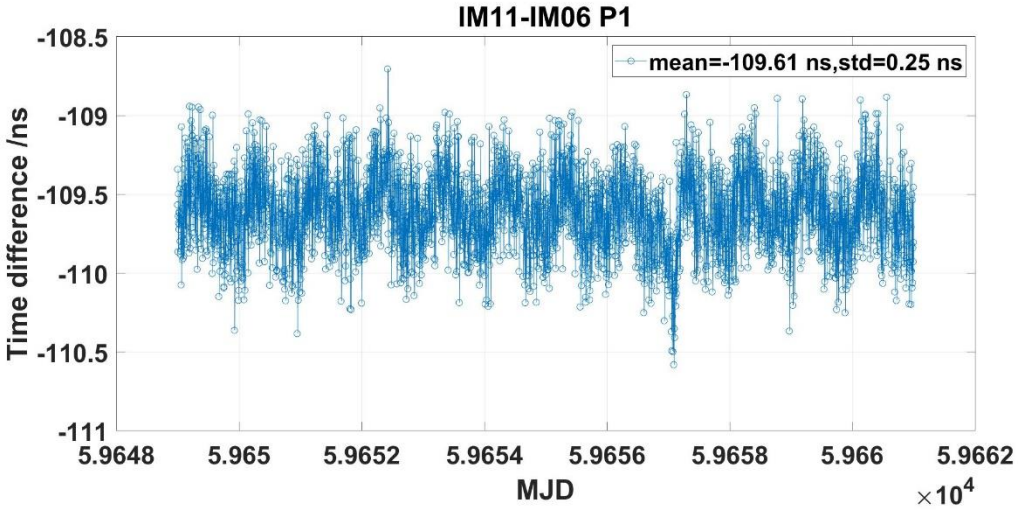


Figure 93. CCD between IM11 and IM06 at NIM(P1)

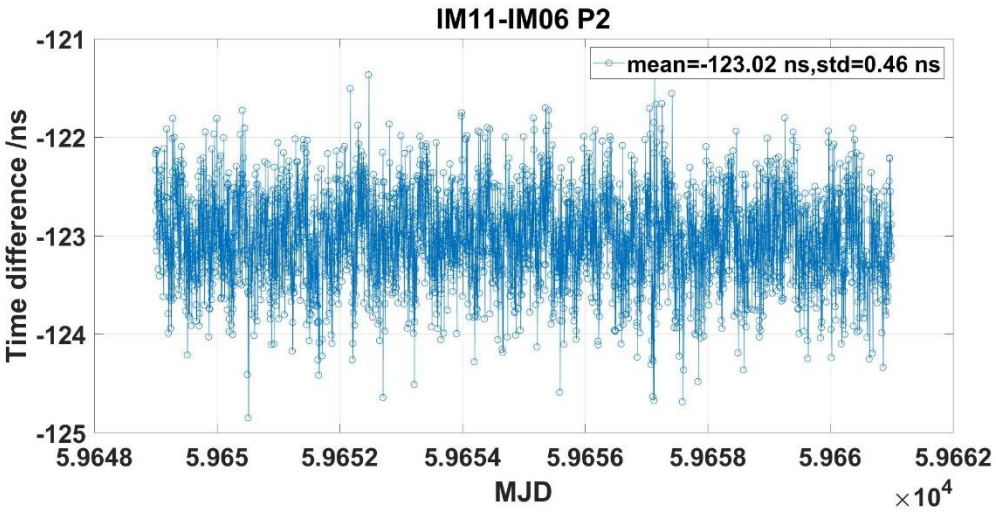


Figure 94. CCD between IM11 and IM06 at NIM(P2)

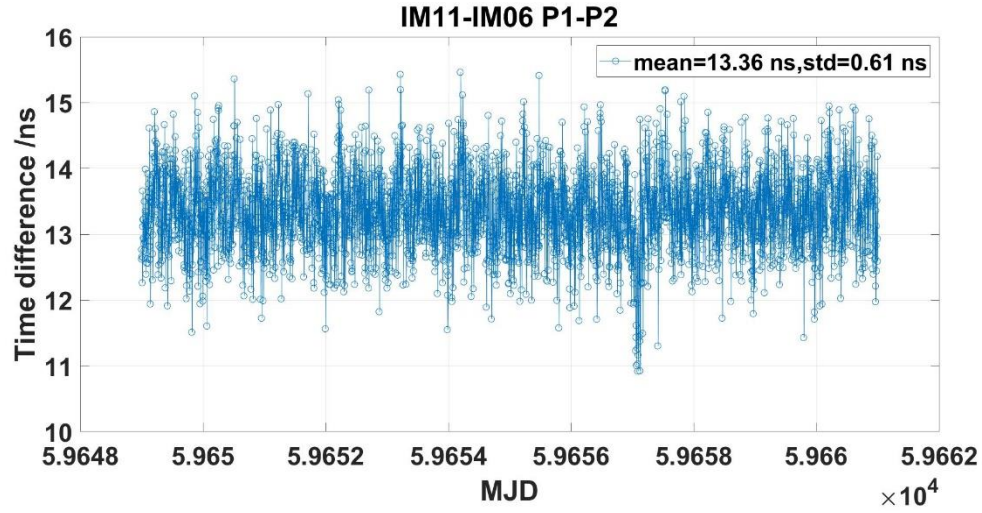


Figure 95. CCD between IM11 and IM06 at NIM(P1-P2)

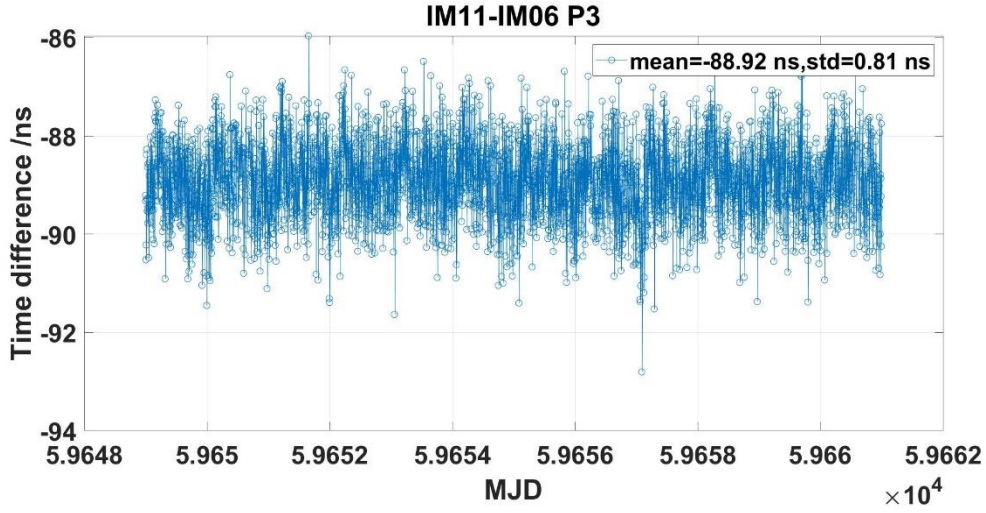


Figure 96. CCD between IM11 and IM06 at NIM(P3)

Annex 3. CCD results for NMIA

1. Start CCD before calibration

IM09-IM06

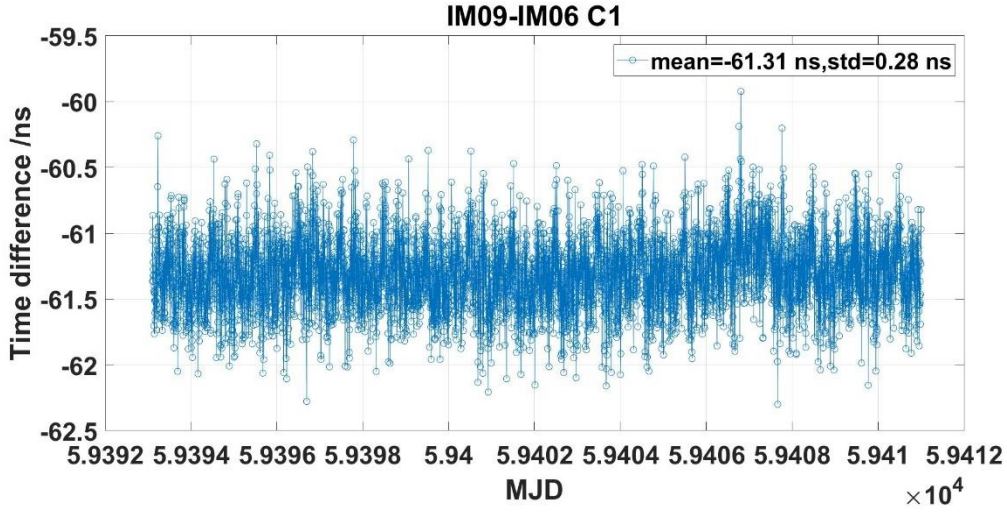


Figure 97. CCD between IM09 and IM06 at NIM(C1)

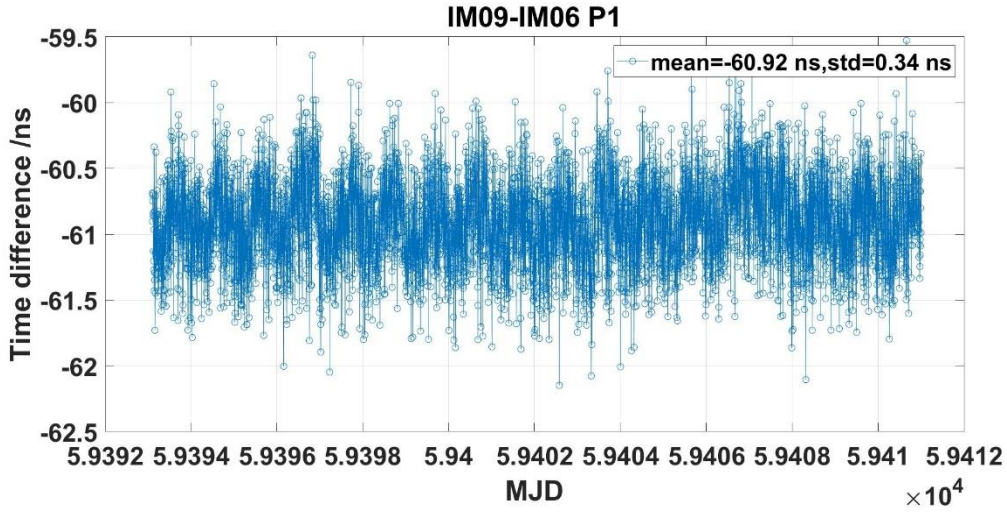


Figure 98. CCD between IM09 and IM06 at NIM(P1)

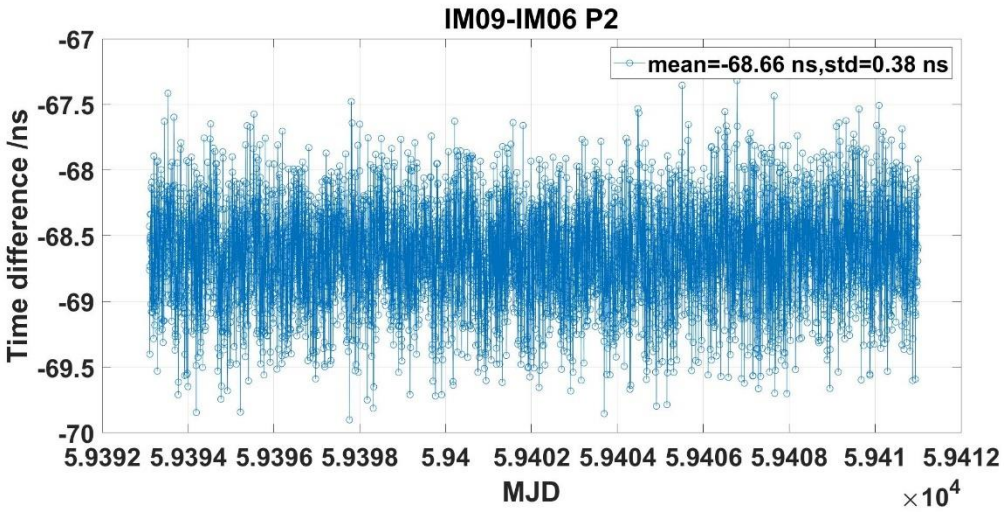


Figure 99. CCD between IM09 and IM06 at NIM(P2)

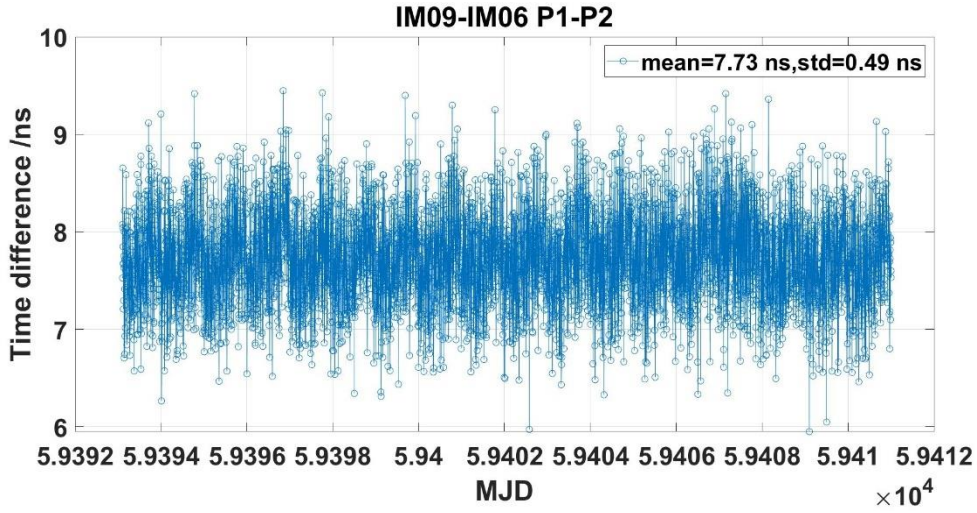


Figure 100. CCD between IM09 and IM06 at NIM(P1-P2)

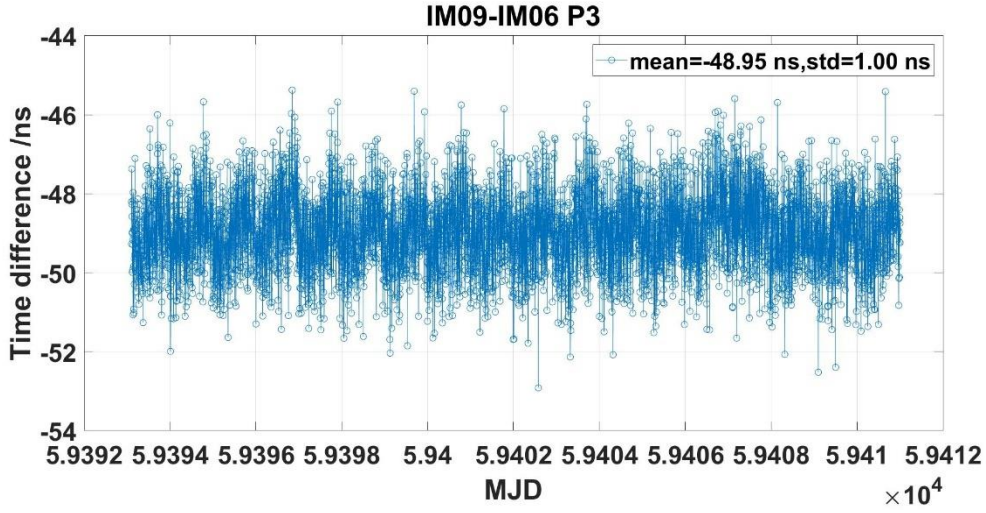


Figure 101. CCD between IM09 and IM06 at NIM(P3)

IM11-IM06

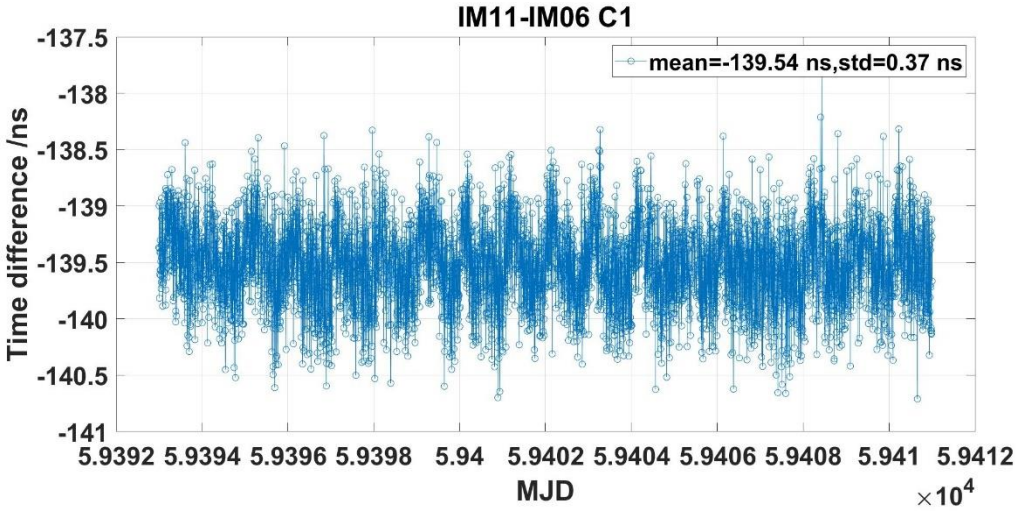


Figure 102. CCD between IM11 and IM06 at NIM(C1)

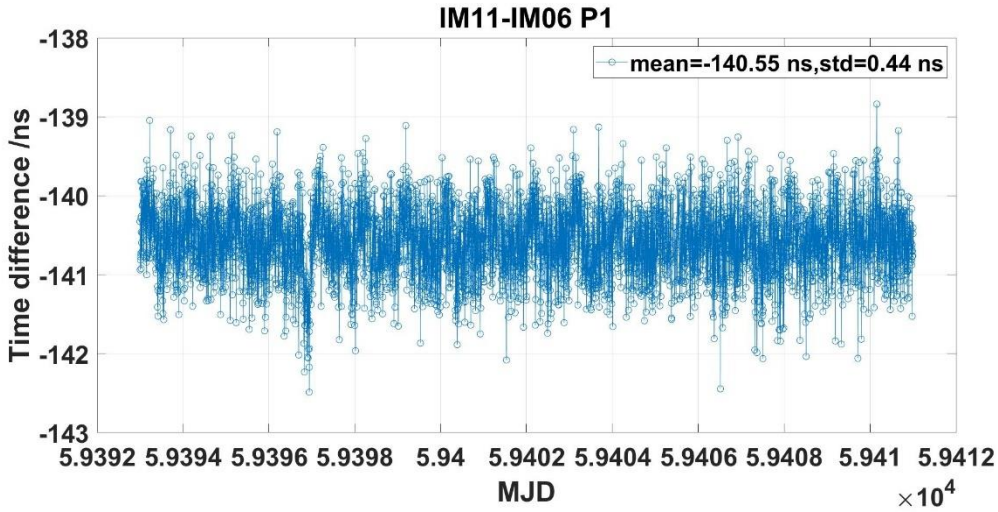


Figure 103. CCD between IM11 and IM06 at NIM(P1)

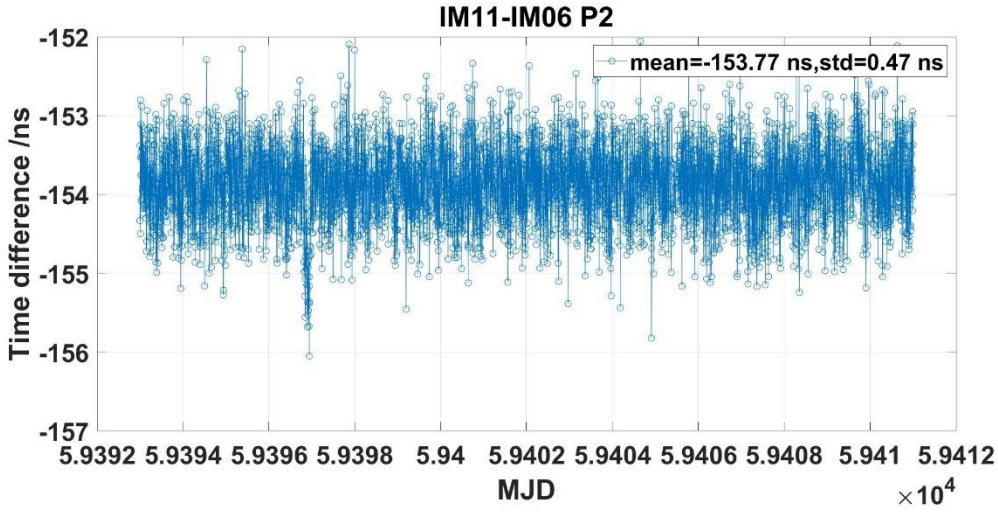


Figure 104. CCD between IM11 and IM06 at NIM(P2)

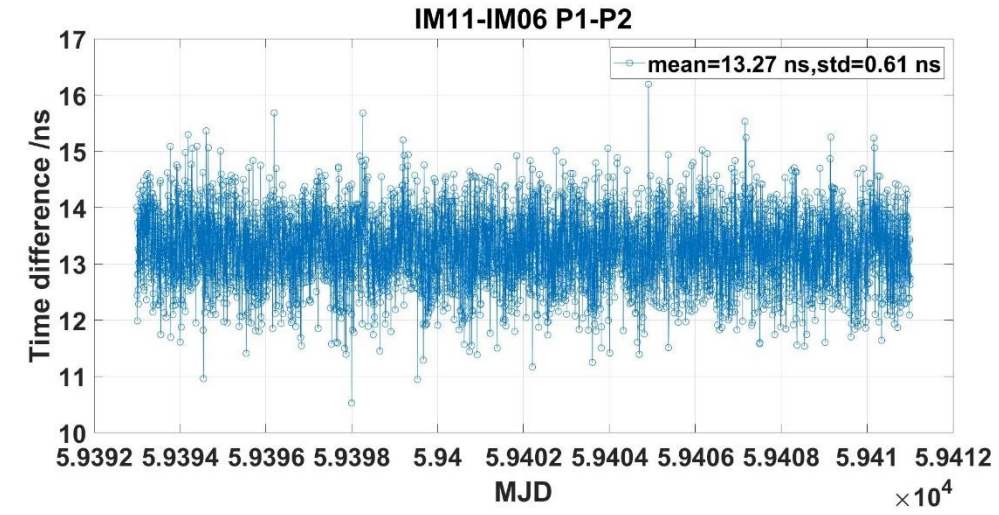


Figure 105. CCD between IM11 and IM06 at NIM(P1-P2)

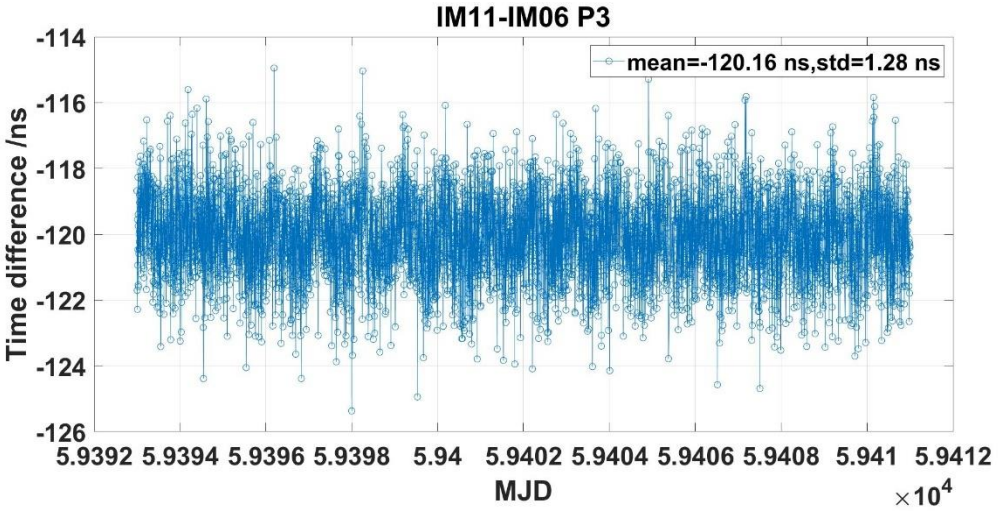


Figure 106. CCD between IM11 and IM06 at NIM(P3)

2. Calibration on site

AU04-IM09

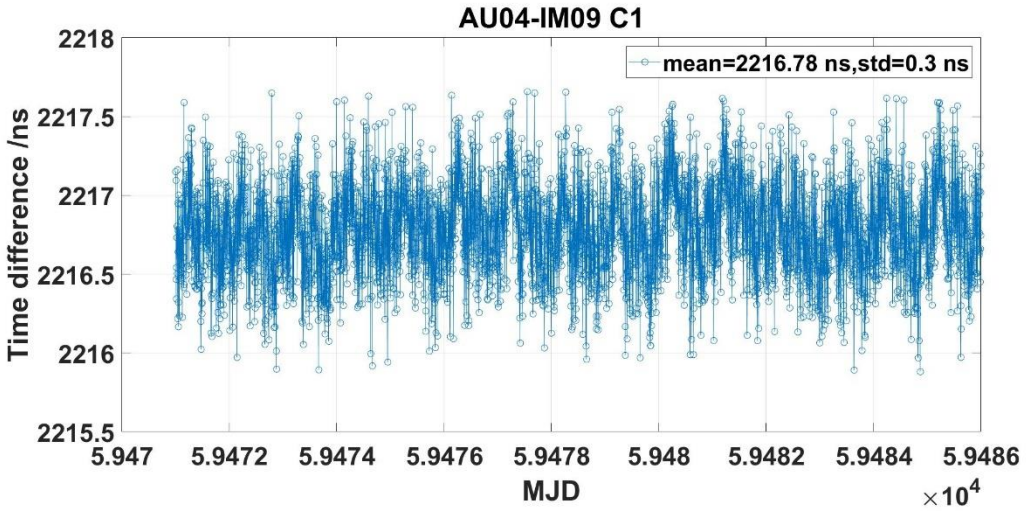


Figure 107. CCD between IM09 and AU04 at NMIA(C1)

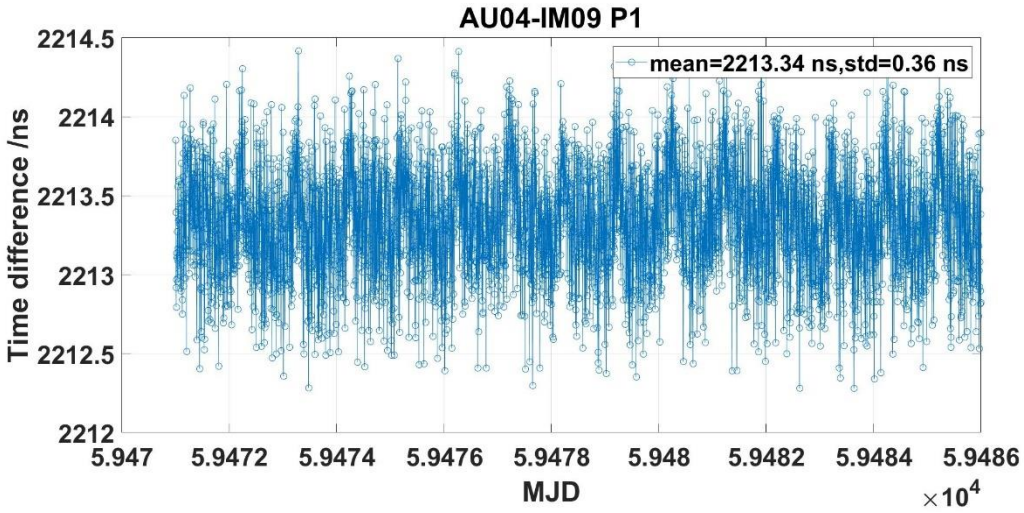


Figure 108. CCD between IM09 and AU04 at NMIA(P1)

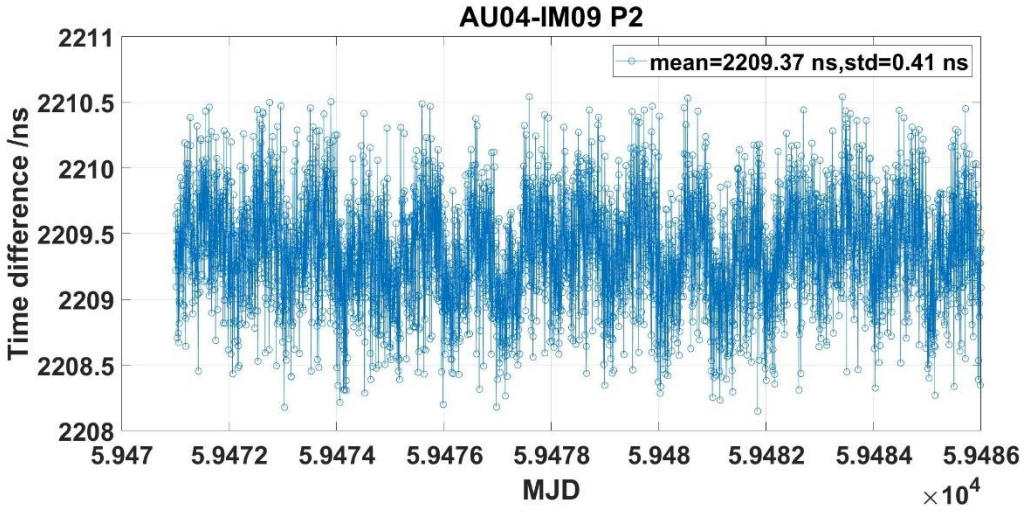


Figure 109. CCD between IM09 and AU04 at NMIA(P2)

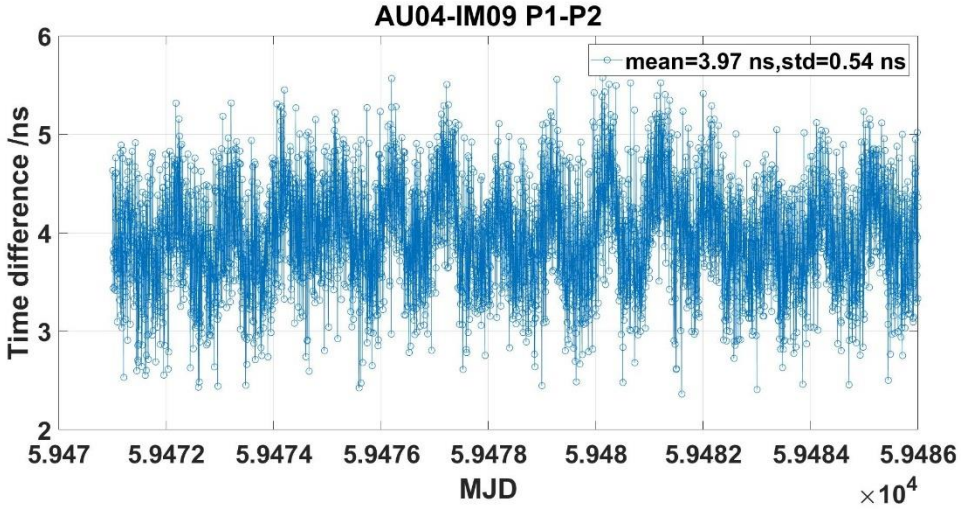


Figure 110. CCD between IM09 and AU04 at NMIA(P1-P2)

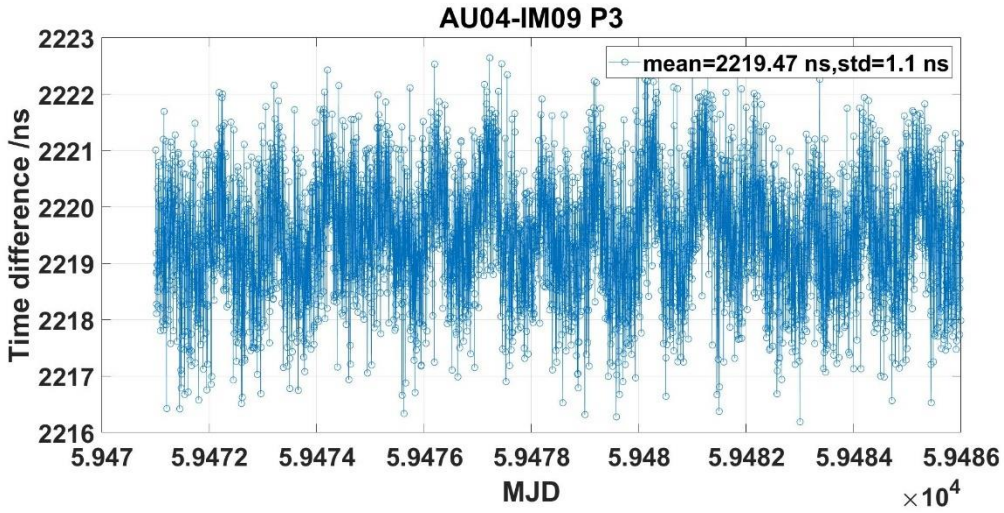


Figure 111. CCD between IM09 and AU04 at NMIA(P3)

AU04-IM11

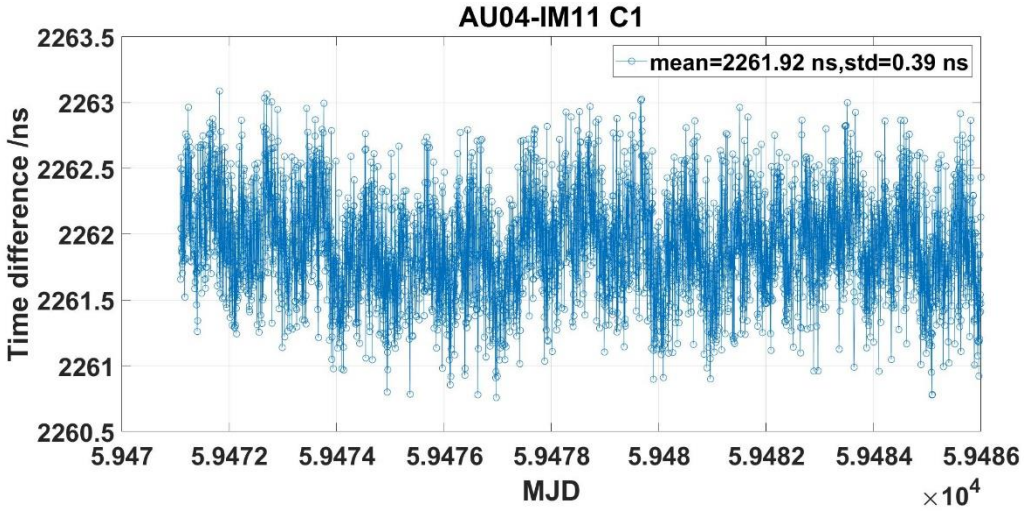


Figure 112. CCD between IM11 and AU04 at NMIA(C1)

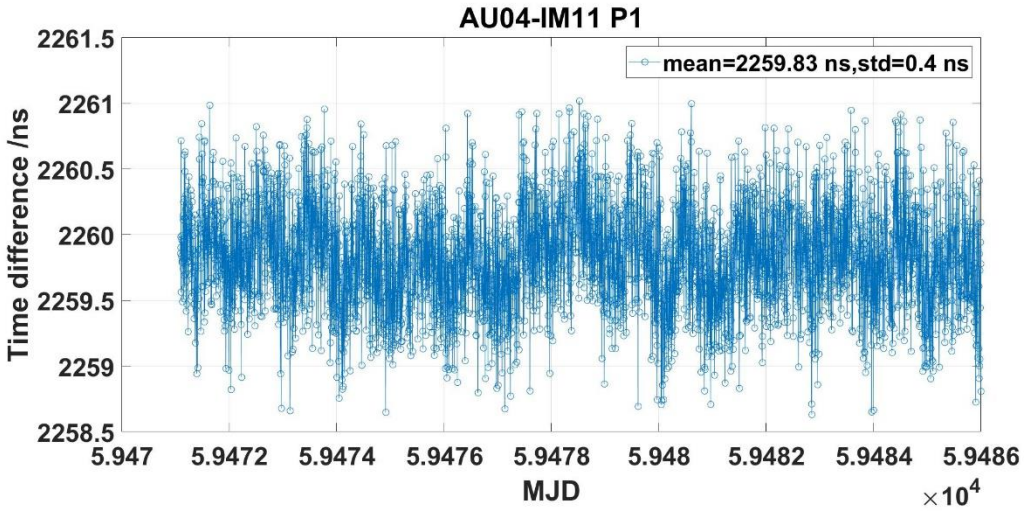


Figure 113. CCD between IM11 and AU04 at NMIA(P1)

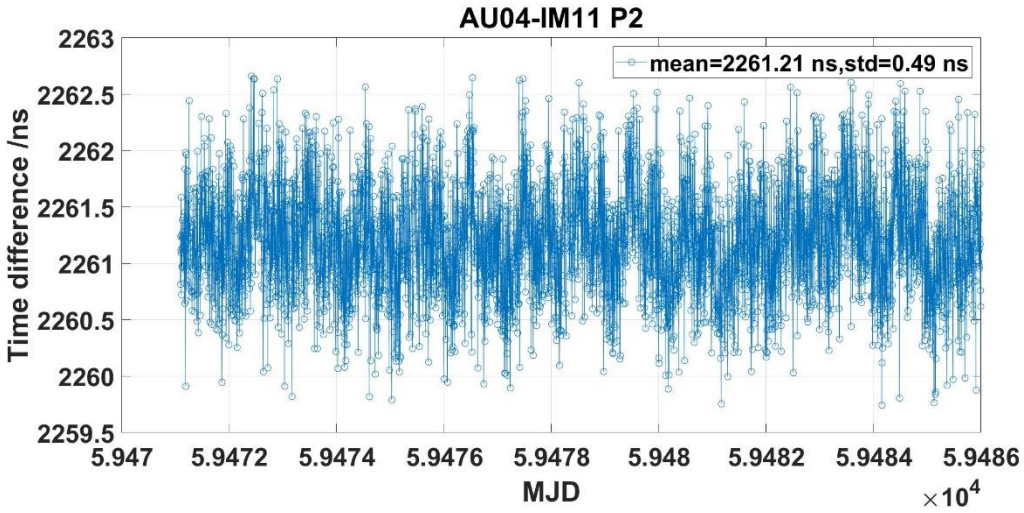


Figure 114. CCD between IM11 and AU04 at NMIA(P2)

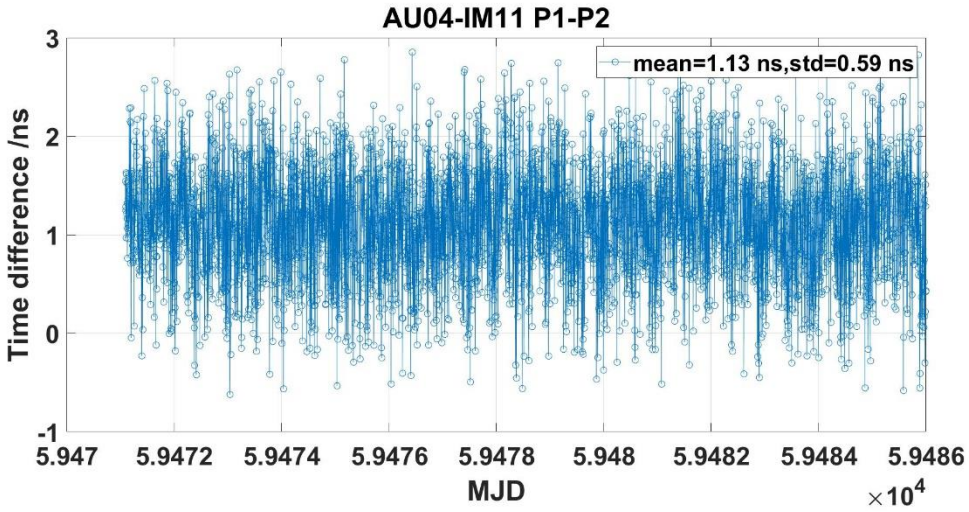


Figure 115. CCD between IM11 and AU04 at NMIA(P1-P2)

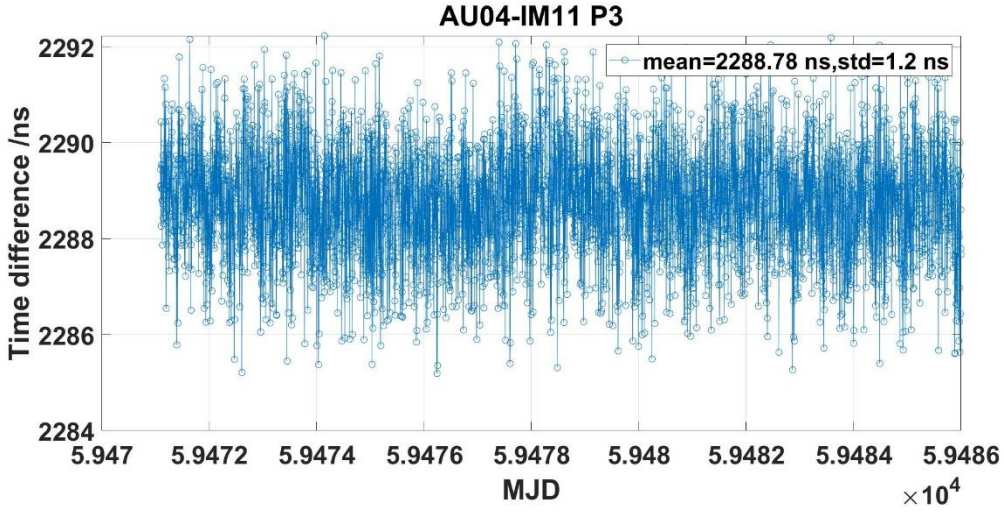


Figure 116. CCD between IM11 and AU04 at NMIA(P3)

AU05-IM09

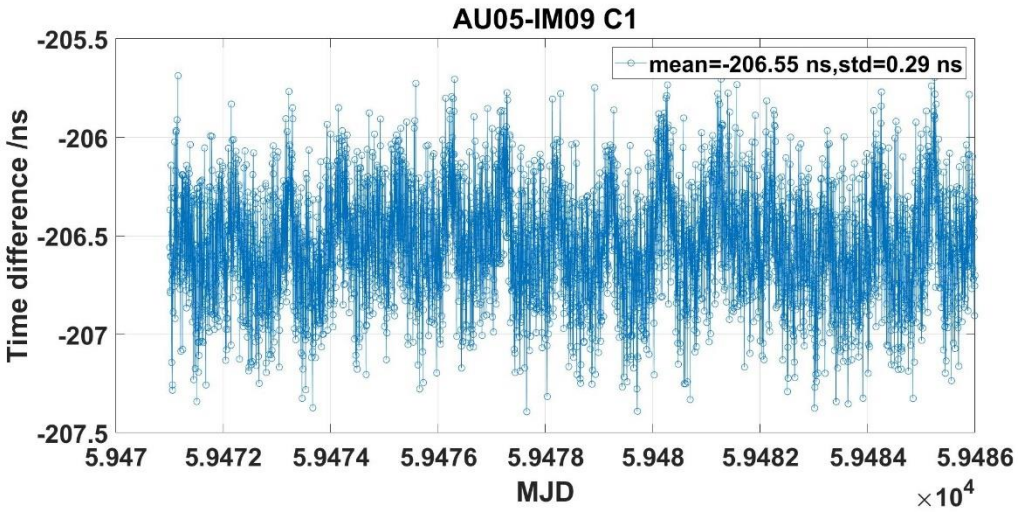


Figure 117. CCD between IM09 and AU05 at NMIA(C1)

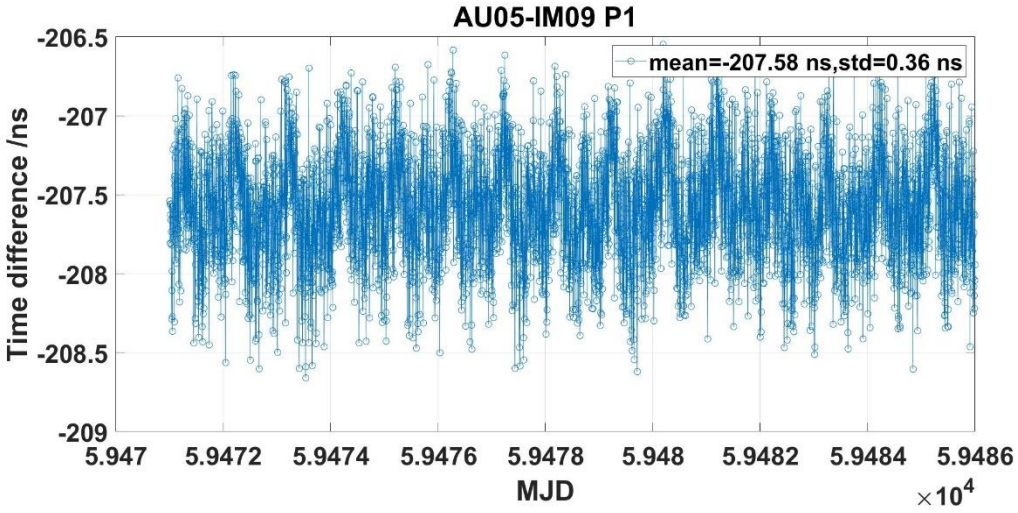


Figure 118. CCD between IM09 and AU05 at NMIA(P1)

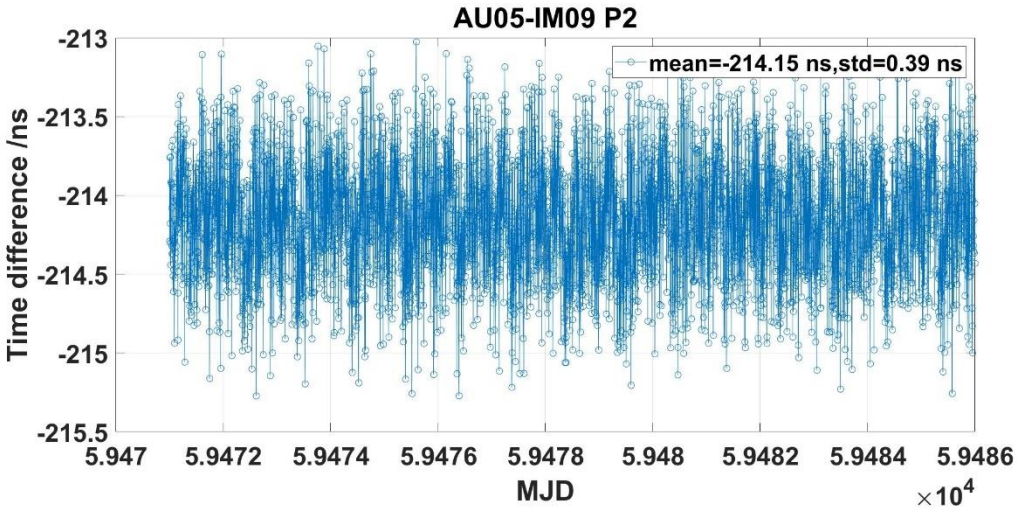


Figure 119. CCD between IM09 and AU05 at NMIA(P2)

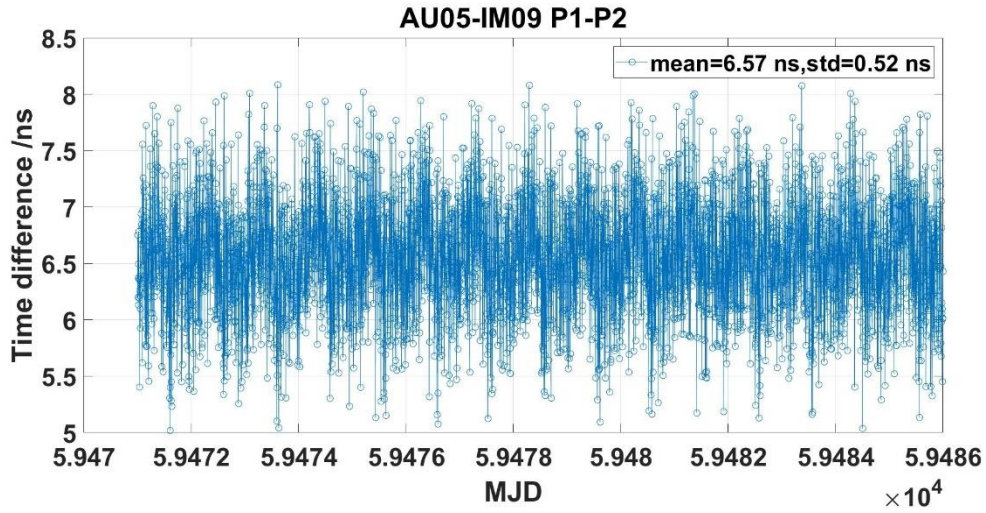


Figure 120. CCD between IM09 and AU05 at NMIA(P1-P2)

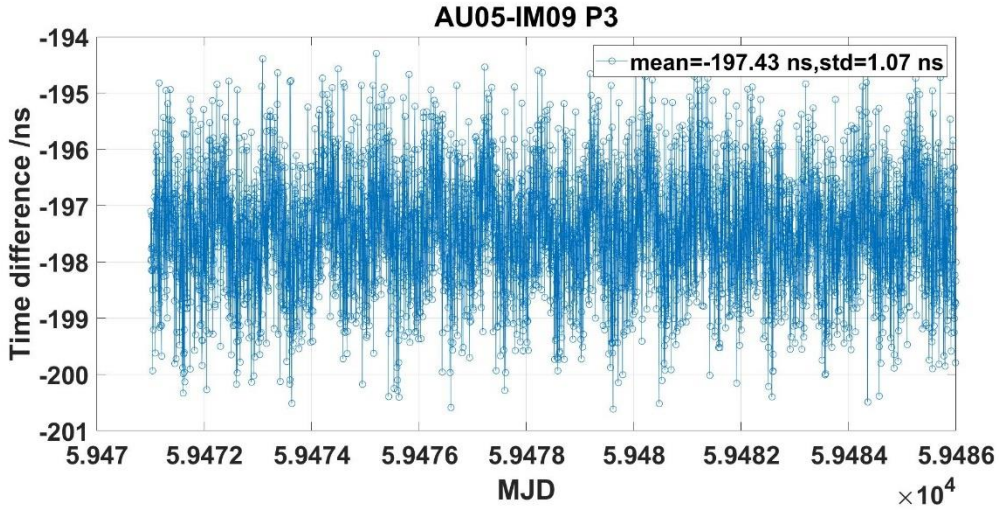


Figure 121. CCD between IM11 and AU05 at NMIA(P3)

AU05-IM11

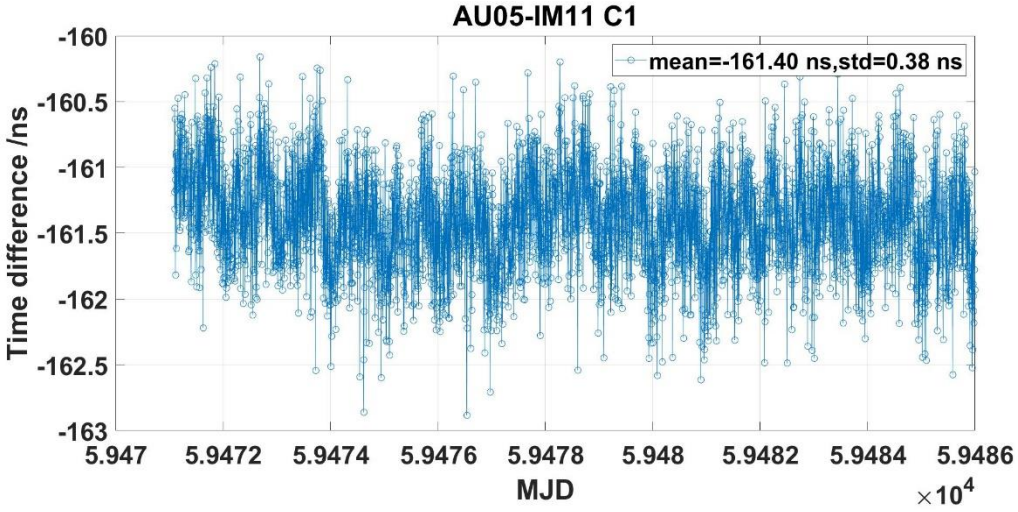


Figure 122. CCD between IM11 and AU05 at NMIA(C1)

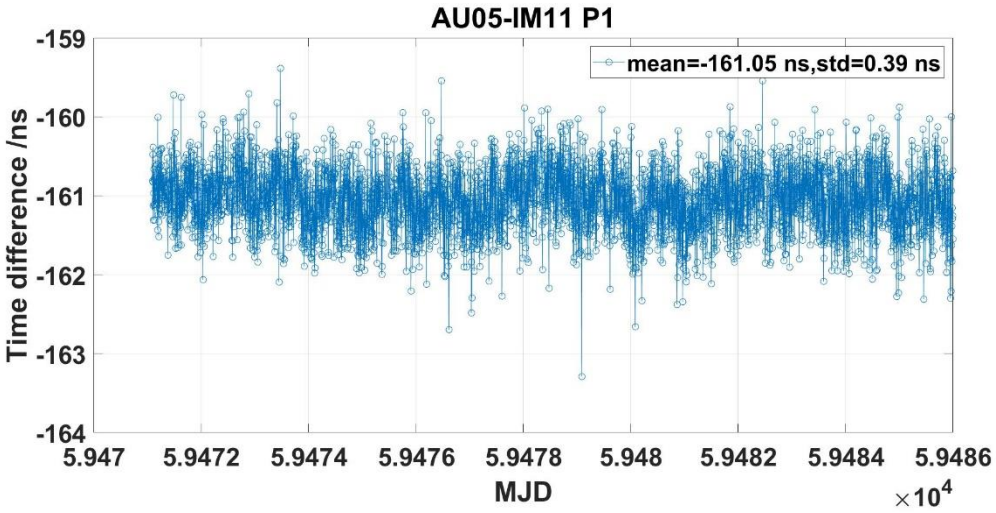


Figure 123. CCD between IM11 and AU05 at NMIA(P1)

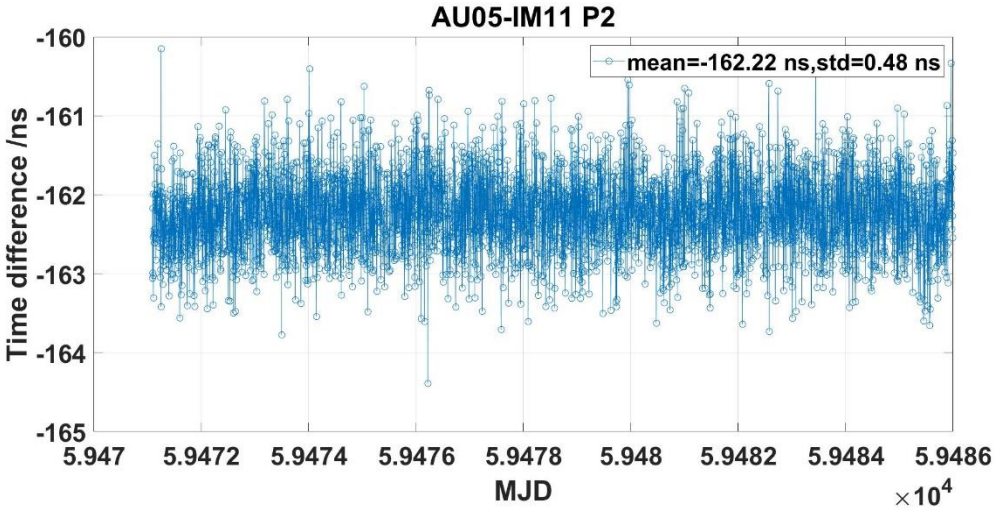


Figure 124. CCD between IM11 and AU05 at NMIA(P2)

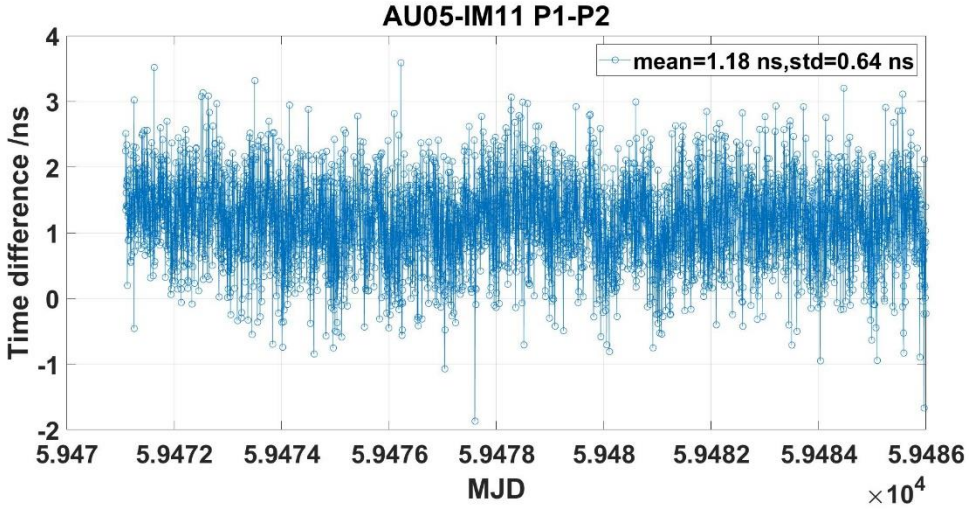


Figure 125. CCD between IM11 and AU05 at NMIA(P1-P2)

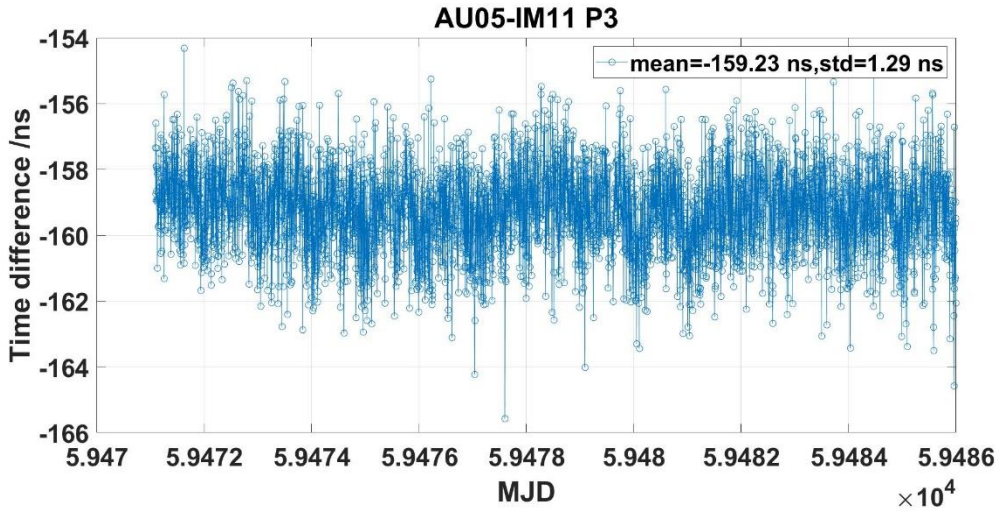


Figure 126. CCD between IM11 and AU05 at NMIA(P3)

AU06-IM09

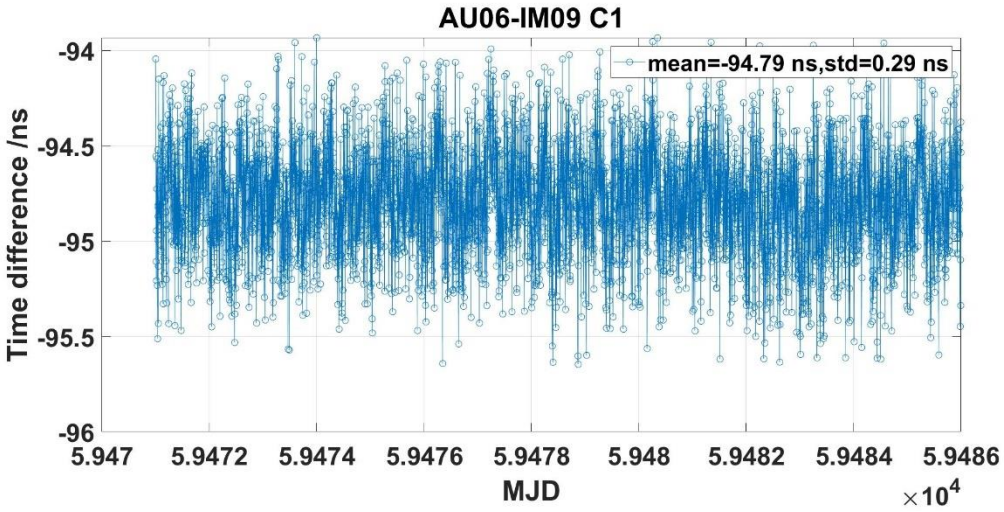


Figure 127. CCD between IM09 and AU06 at NMIA(C1)

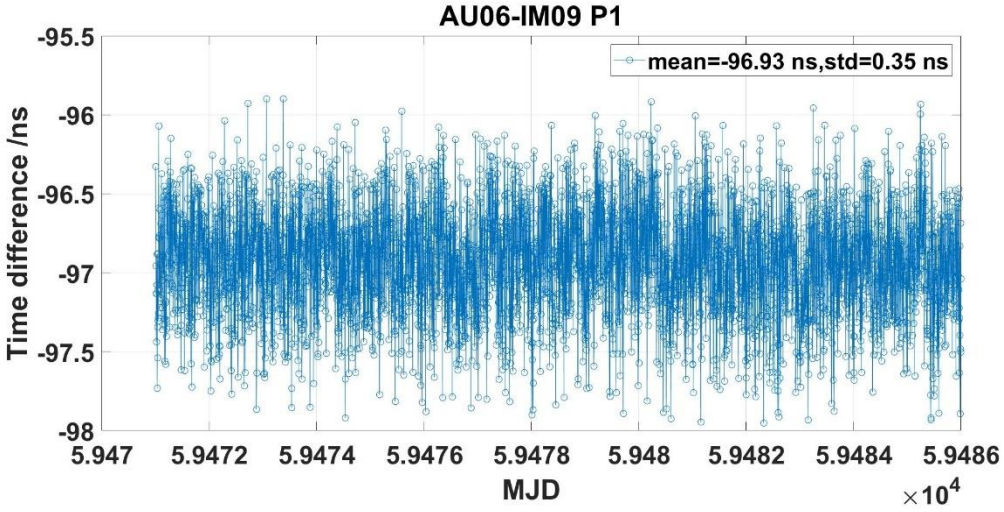


Figure 128. CCD between IM09 and AU06 at NMIA(P1)

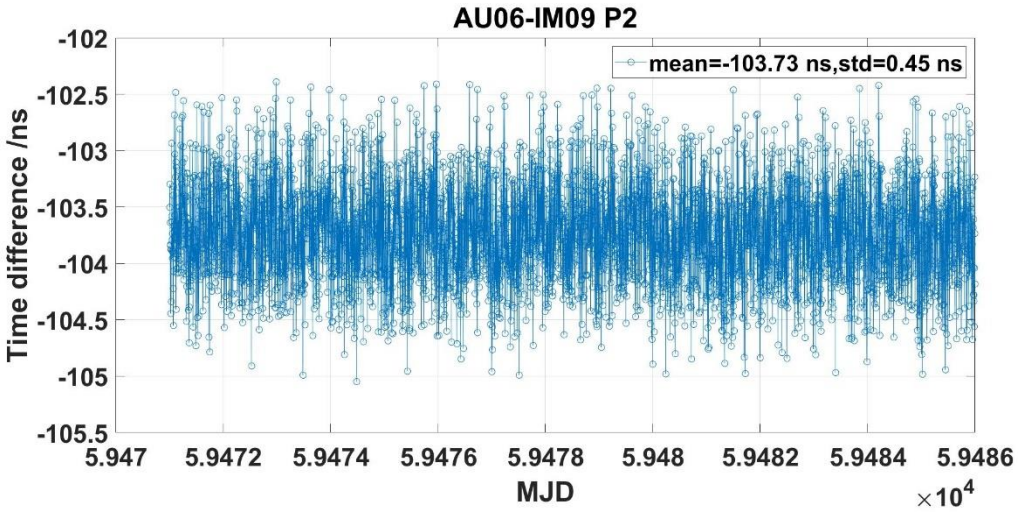


Figure 129. CCD between IM09 and AU06 at NMIA(P2)

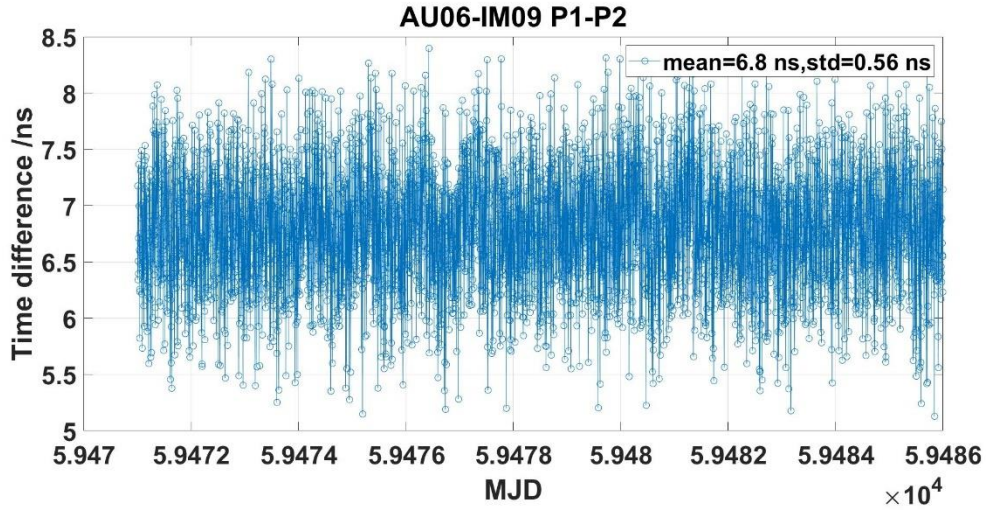


Figure 130. CCD between IM09 and AU06 at NMIA(P1-P2)

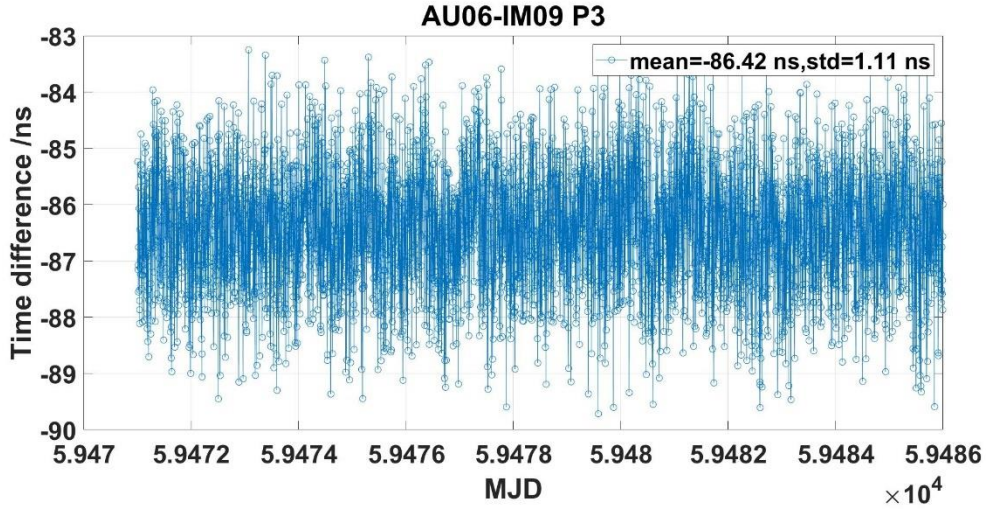


Figure 131. CCD between IM09 and AU06 at NMIA(P3)

AU06-IM11

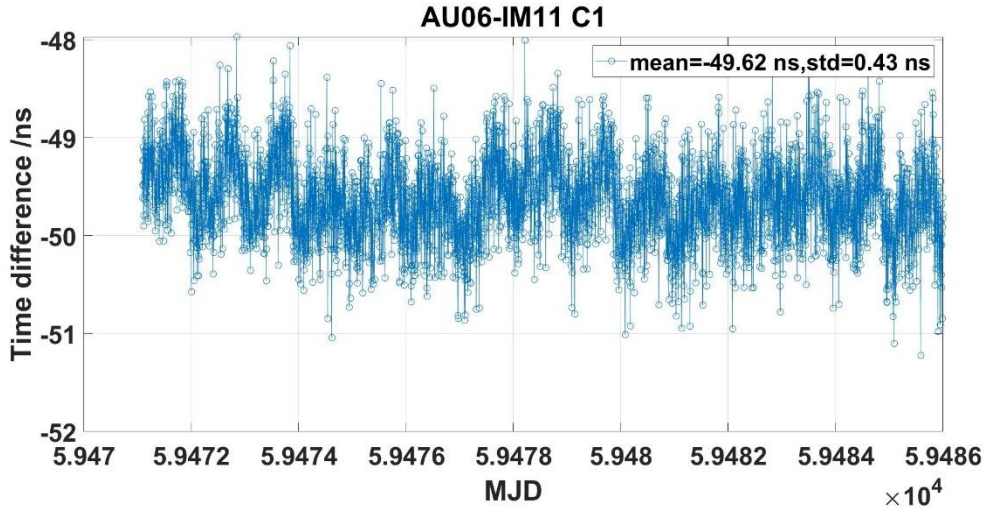


Figure 132. CCD between IM11 and AU06 at NMIA(C1)

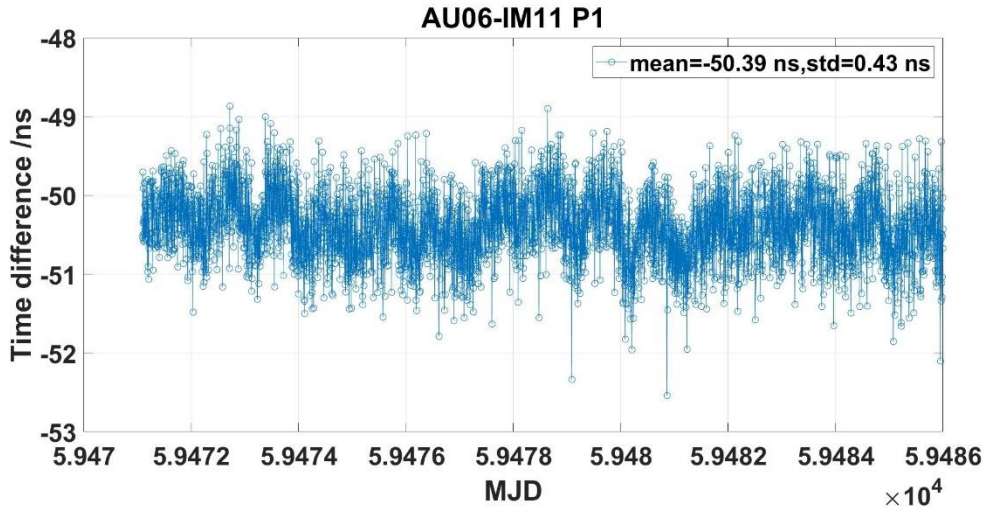


Figure 133. CCD between IM11 and AU06 at NMIA(P1)

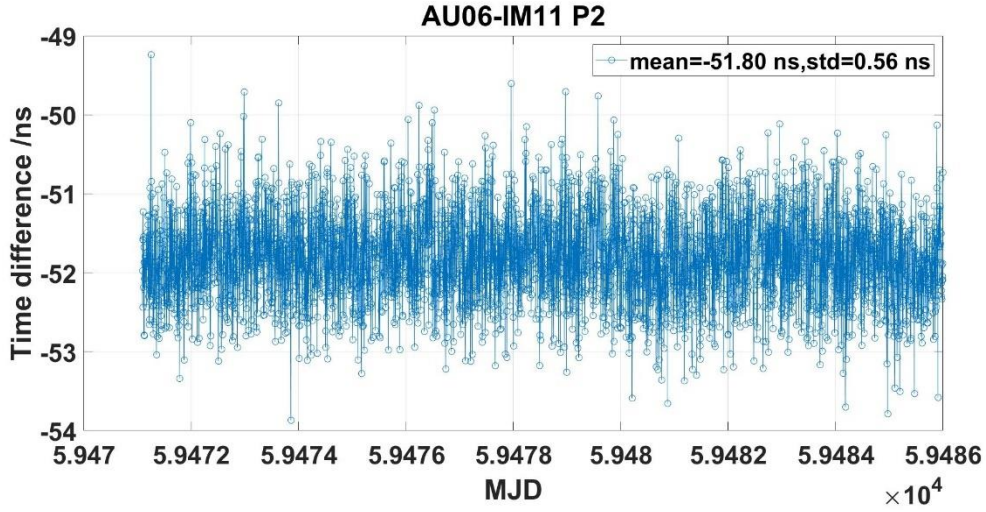


Figure 134. CCD between IM11 and AU06 at NMIA(P2)

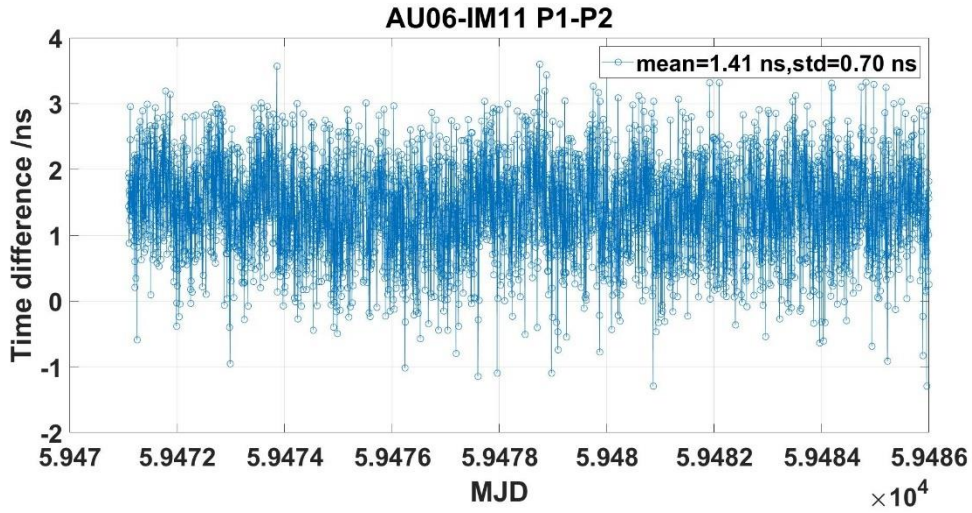


Figure 135. CCD between IM11 and AU06 at NMIA(P1-P2)

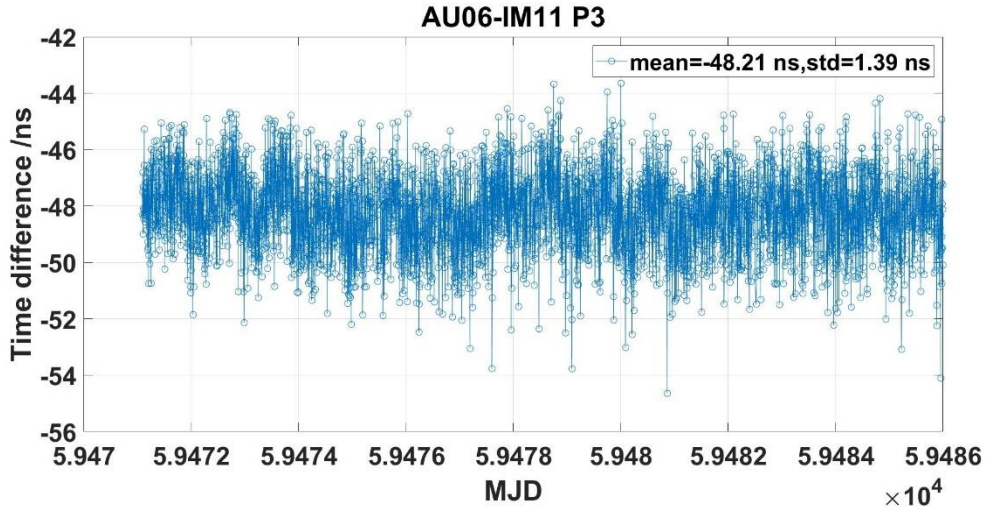


Figure 136. CCD between IM11 and AU06 at NMIA(P3)

3. Closure CCD after calibration

IM09-IM06

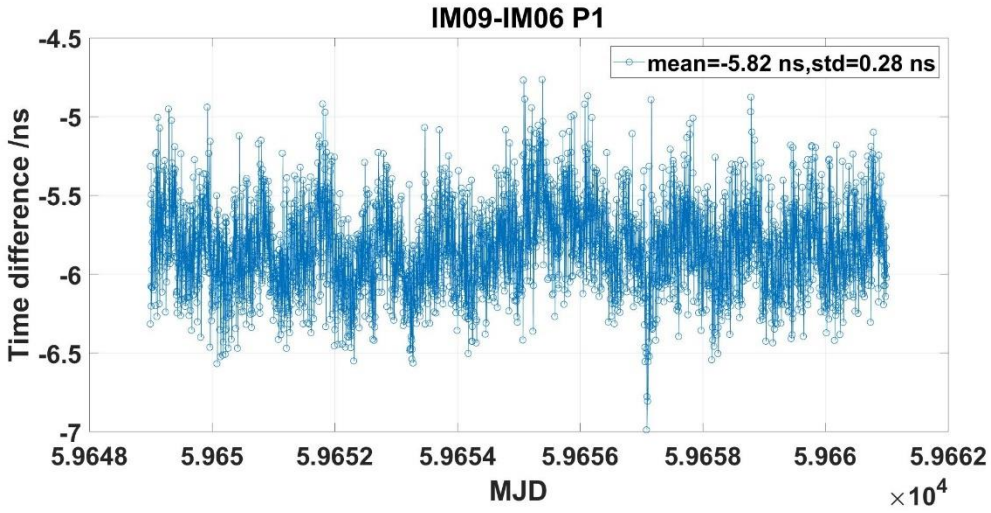


Figure 137. CCD between IM06 and IM09 at NIM(P1)

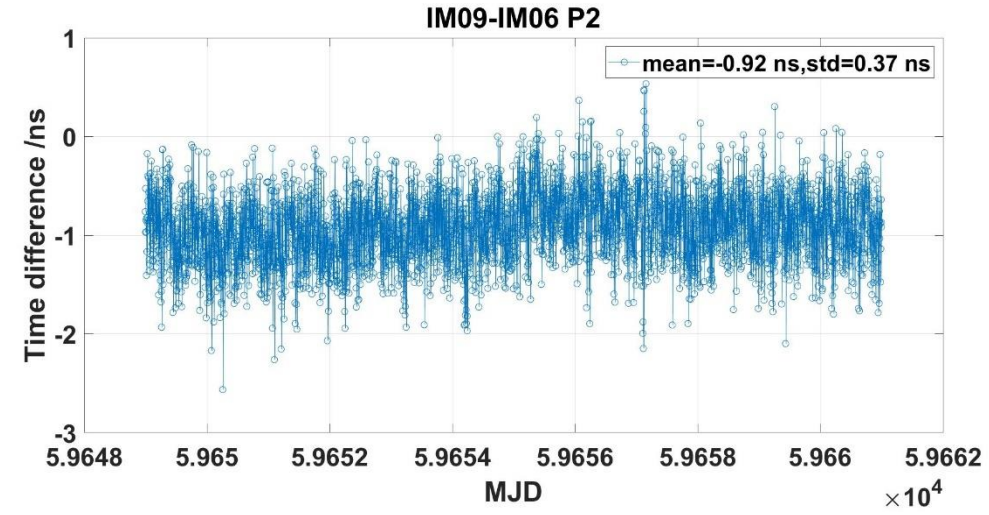


Figure 138. CCD between IM06 and IM09 at NIM(P2)

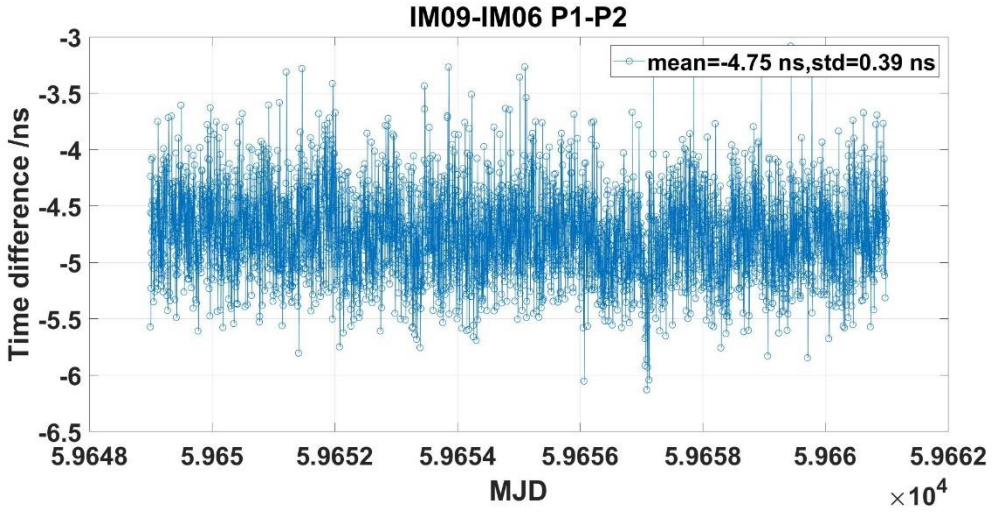


Figure 139. CCD between IM06 and IM09 at NIM(P1-P2)

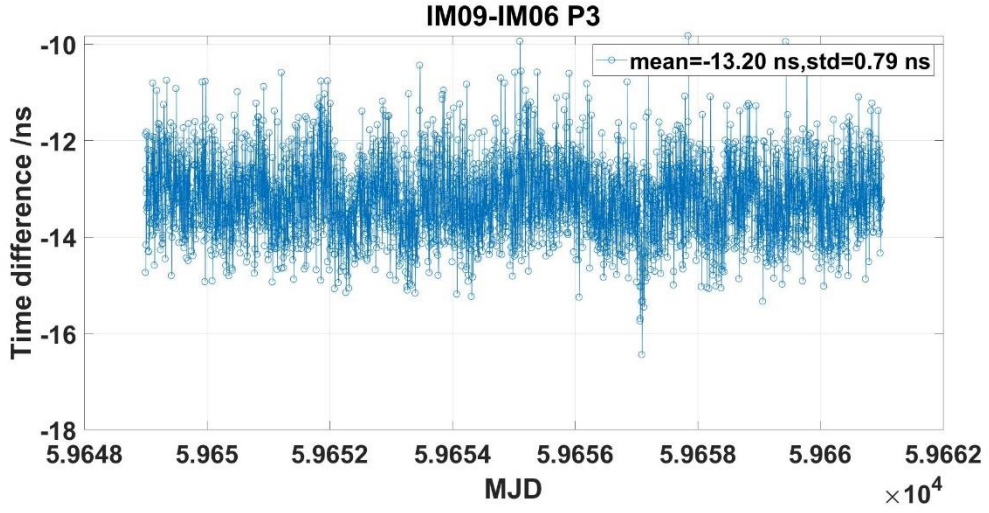


Figure 140. CCD between IM06 and IM09 at NIM(P3)

IM11-IM06

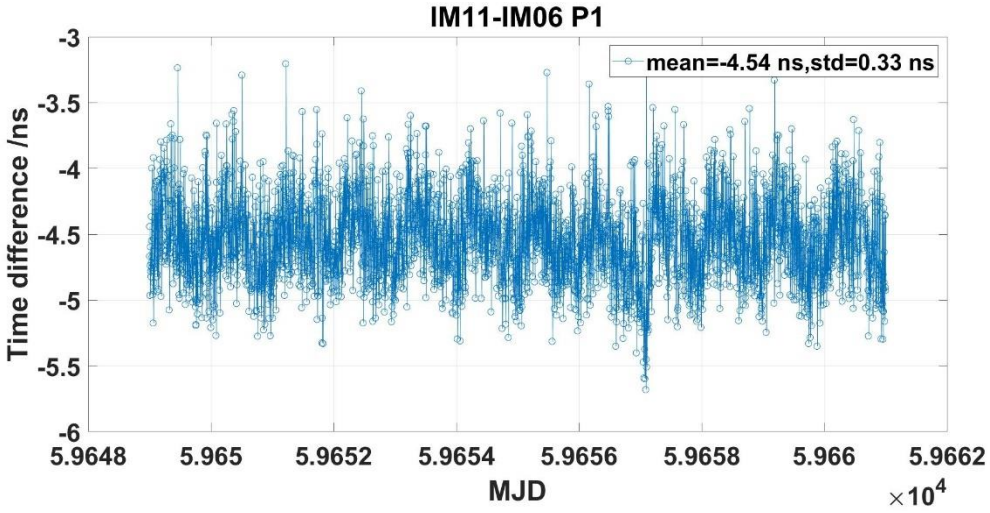


Figure 141. CCD between IM11 and IM06 at NIM(P1)

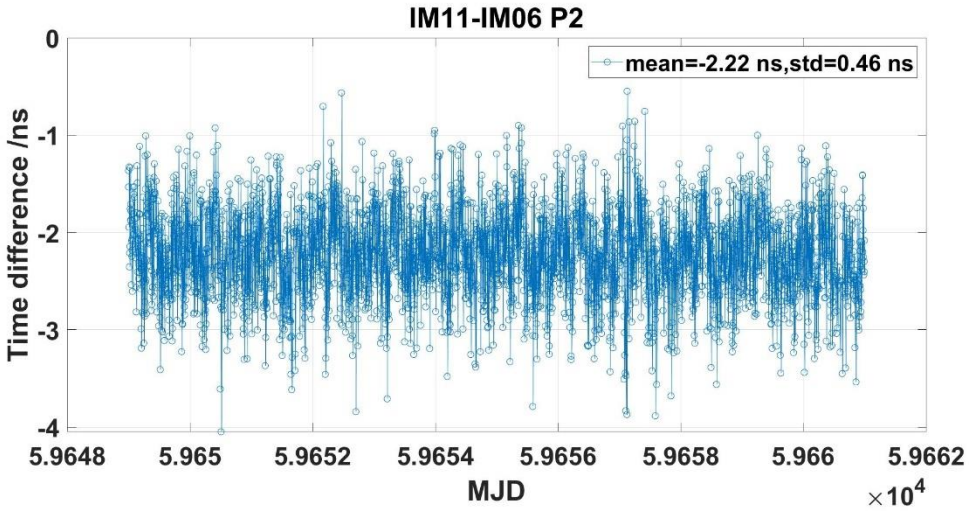


Figure 142. CCD between IM11 and IM06 at NIM(P2)

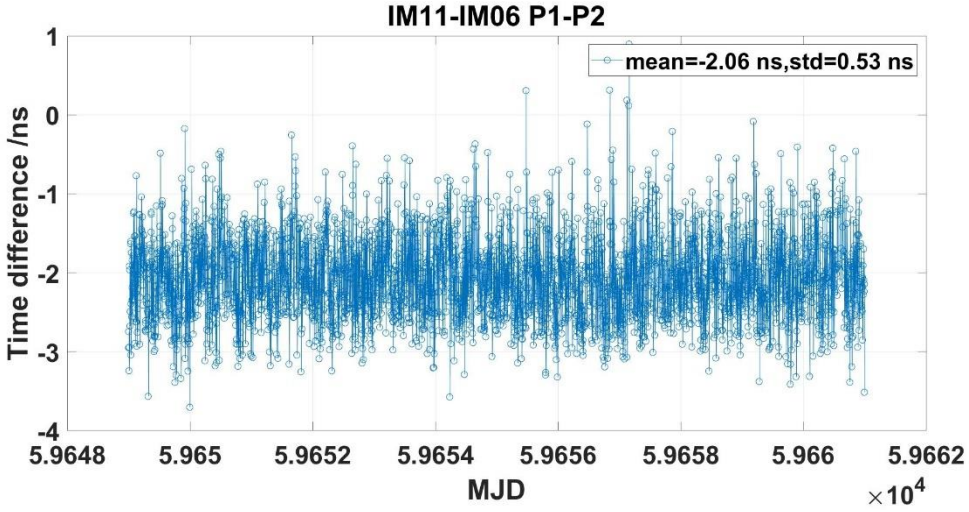


Figure 143. CCD between IM11 and IM06 at NIM(P1-P2)

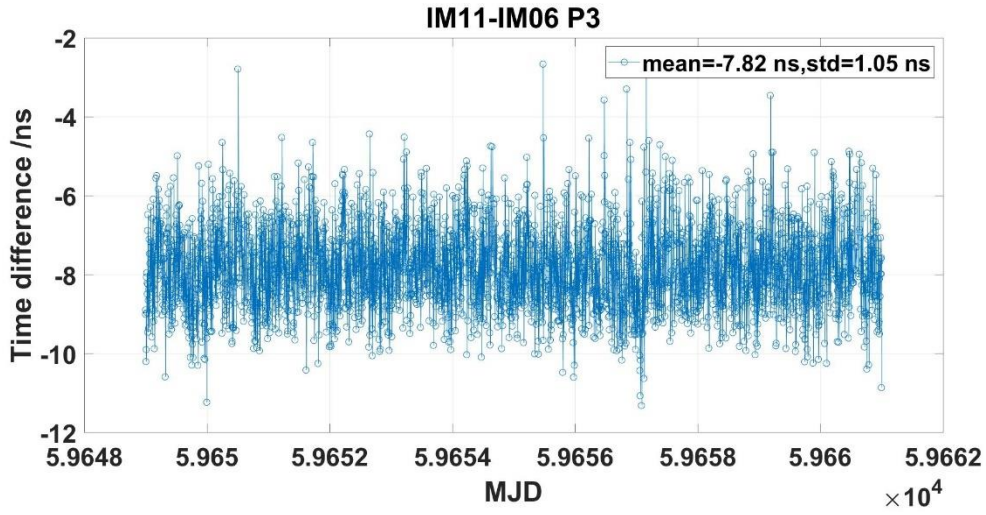


Figure 144. CCD between IM11 and IM06 at NIM(P3)

IM11-IM09

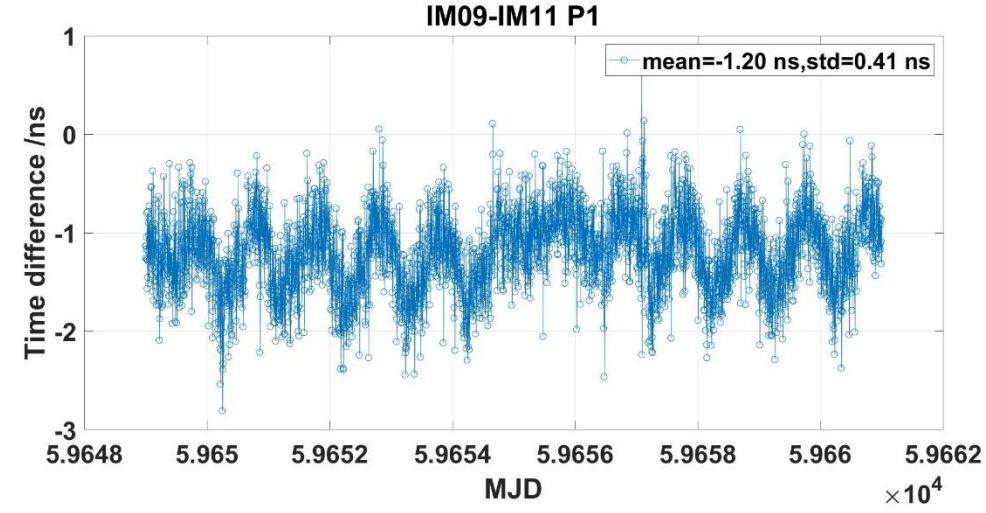


Figure 145. CCD between IM11 and IM09 at NIM(P1)

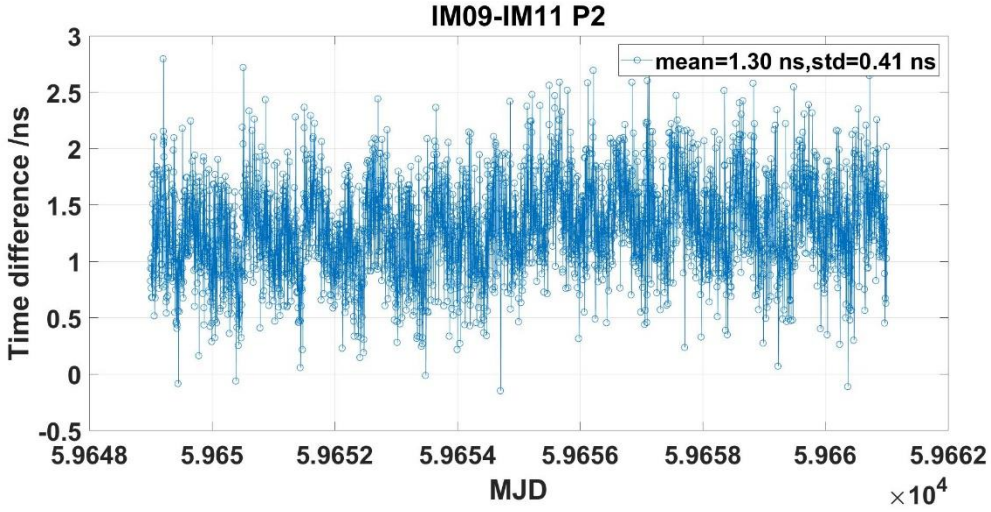


Figure 146. CCD between IM11 and IM09 at NIM(P2)

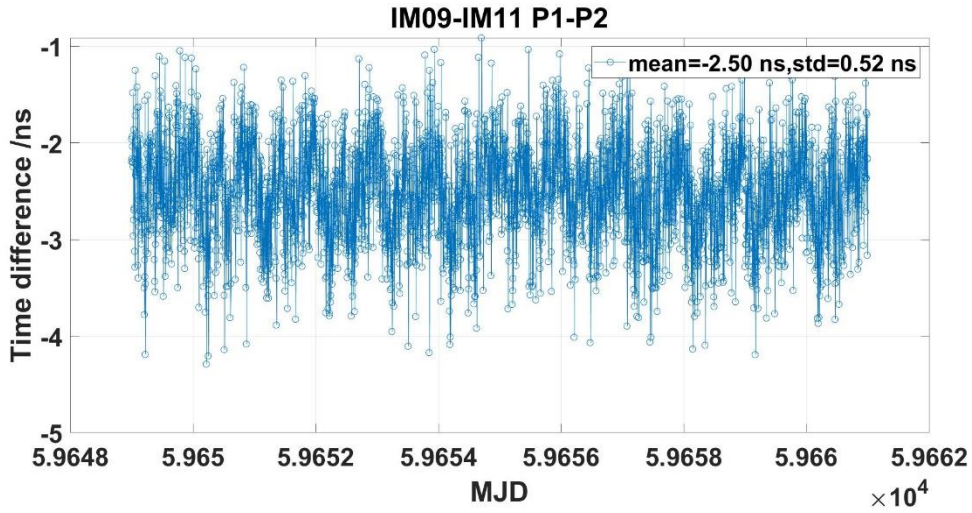


Figure 147. CCD between IM11 and IM09 at NIM(P1-P2)

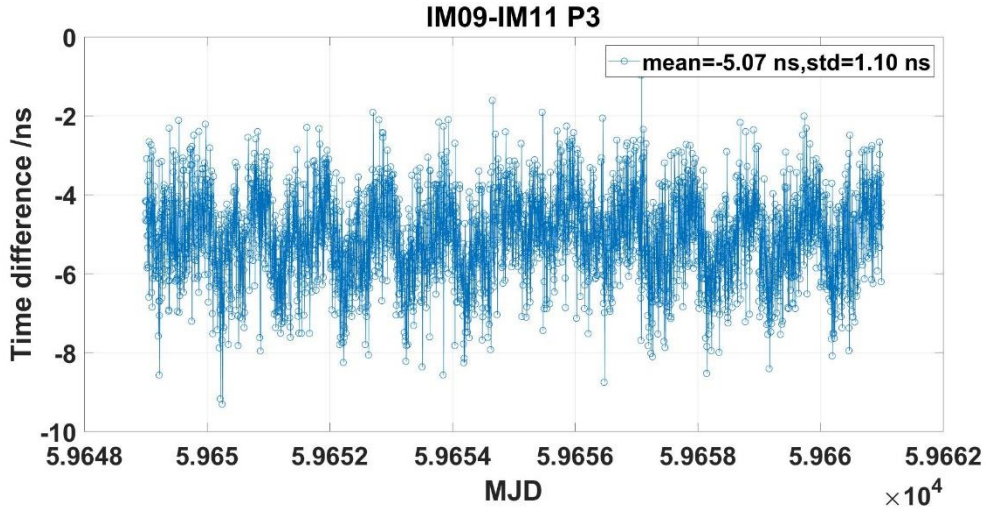


Figure 148. CCD between IM11 and IM09 at NIM(P3)

Annex 3 - Information Sheets

Information Sheet

(to be repeated for each calibrated system)

Laboratory：	KRISS
Date and hour of the beginning of measurements:	13/Aug/2021, 00 h 00 m 00 s (UTC)
Date and hour of the end of measurements:	22/Aug/2021, 23 h 59 m 59 s (UTC)

Information on the system

	Local:	**Travelling:**
4-character BIPM code	KRP1	IM09 IM11
Receiver maker and type: Receiver serial number：	Septentrio, PolaRx5TR S/N: 4701203	TF-GNSS-2 S/N: 201401 DICOM, GTR-51 S/N: 1405004
1 PPS trigger level /V:	0.5 V	1 V
Antenna cable maker and type: Phase stabilised cable (Y/N):	Andrew, FSJ1-50A Phase stabilised: No	Andrew, FSJ1-50A Phase stabilised: No
Length outside the building /m:	~ 30 m	~ 30 m
Antenna maker and type: Antenna serial number:	AeroAntenna, SEPCHOKE_B3E6 S/N: 5174	AeroAntenna, AT200-GNSS S/N: 5098 Novatel, GPS-703-GGG S/N: NEG14100010
Temperature (if stabilised) /° C		

Measured delays /ns

	Local:	**Travelling:**
Delay from local UTC to receiver 1 PPS-in:	123.34 ns	121.85 ns (beginning) 121.86 ns (end) 121.94 ns (beginning)

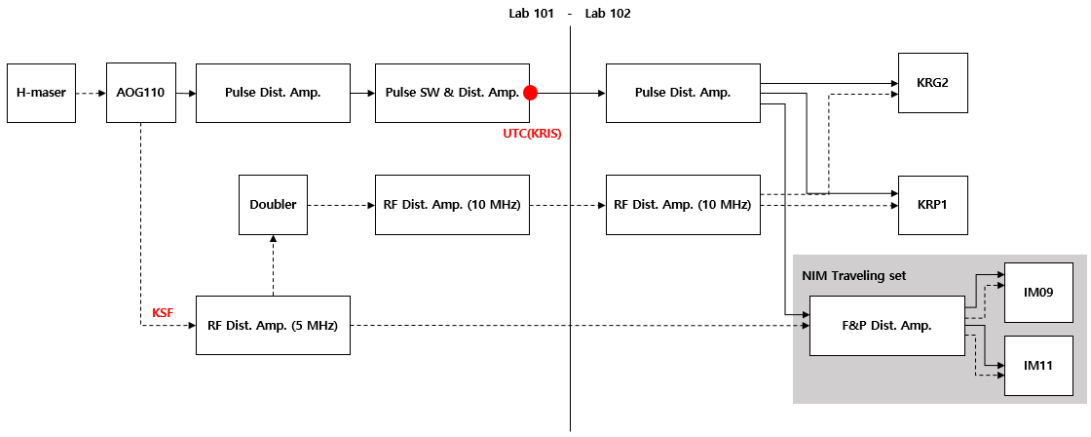
		121.88 ns (end)
Delay from 1 PPS-in to internal Reference (if different):	46.48 ns	Unknown
Antenna cable delay:	187.8 ns	192.9 ns 184.1 ns
Splitter delay (if any):	N/A	N/A
Additional cable delay (if any):	N/A	N/A

Data used for the generation of CGGTTS files	
INT DLY (GPS) /ns:	0 ns (P1), 0 ns (P2)
INT DLY (GLONASS) /ns:	N/A
CAB DLY /ns:	187.8 ns
REF DLY /ns:	169.82 ns
Coordinates reference frame:	ITRF
Latitude or X /m:	-3120374.21 m
Longitude or Y /m:	4085236.30 m
Height or Z /m:	3763090.59 m

General information	
Rise time of the local UTC pulse	
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	23.2 °C, 0.1 °C (1σ)
Set humidity value and uncertainty:	46.8 %, 0.8 % (1σ)

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

Diagram of the experiment set-up



Log of Events / Additional Information

Date (UTC)	Log of Events
03/Aug/2021	Arrival.
04/Aug/2021 ~ 05/Aug/2021	Measure cable delays. Set up instruments.
06/Aug/2021 ~ 12/Aug/2021	Insert precise ECEF position to receivers. Test operation.
13/Aug/2021 ~ 23/Aug/2021	Measurement.
24/Aug/2021	Pack instruments.
25/Aug/2021	Departure.

(to be repeated for each calibrated system)

Laboratory：	KRISS
Date and hour of the beginning of measurements:	13/Aug/2021, 00 h 00 m 00 s (UTC)
Date and hour of the end of measurements:	22/Aug/2021, 23 h 59 m 59 s (UTC)

Information on the system

	Local:	**Travelling:**
4-character BIPM code	KRG2	IM09 IM11
Receiver maker and type: Receiver serial number：	DICOM, GTR-51 S/N: 1803012	TF-GNSS-2 S/N: 201401 DICOM, GTR-51 S/N: 1405004
1 PPS trigger level /V:	0.5 V	1 V
Antenna cable maker and type: Phase stabilised cable (Y/N):	Andrew, FSJ1-50A Phase stabilised: No	Andrew, FSJ1-50A Phase stabilised: No
Length outside the building /m:	~ 30 m	~ 30 m
Antenna maker and type: Antenna serial number:	Leica, AR25 S/N: 727008	AeroAntenna, AT200-GNSS S/N: 5098 Novatel, GPS-703-GGG S/N: NEG14100010
Temperature (if stabilised) /° C		

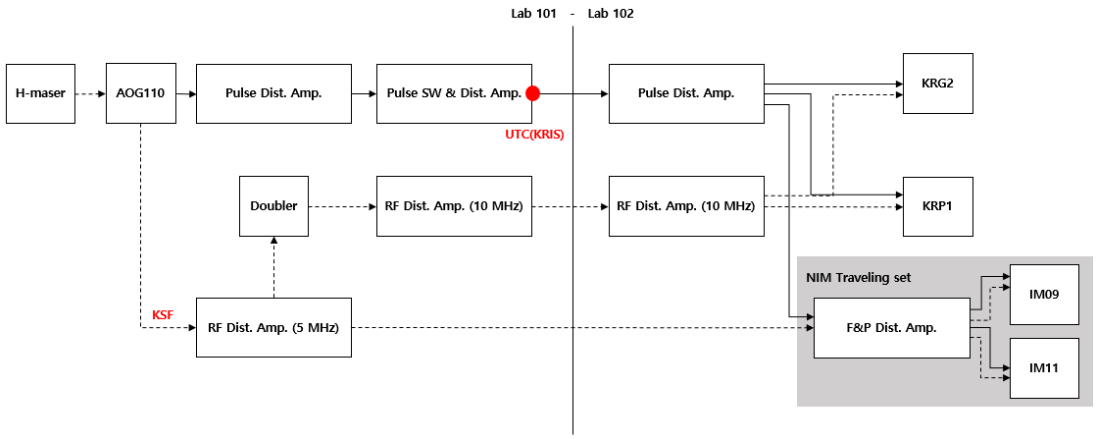
Measured delays /ns		
	Local:	**Travelling:**
Delay from local UTC to receiver 1 PPS-in:	111.6 ns	121.85 ns (beginning) 121.86 ns (end) 121.94 ns (beginning) 121.88 ns (end)
Delay from 1 PPS-in to internal Reference (if different):	N/A	Unknown
Antenna cable delay:	182.6 ns	192.9 ns 184.1 ns
Splitter delay (if any):	N/A	N/A
Additional cable delay (if any):	N/A	N/A

Data used for the generation of CGGTTS files	
INT DLY (GPS) /ns:	33.2 ns (P1), 26.1 ns (P2)
INT DLY (GLONASS) /ns:	N/A
CAB DLY /ns:	182.6 ns
REF DLY /ns:	111.6 ns
Coordinates reference frame:	ITRF
Latitude or X /m:	-3120375.39 m
Longitude or Y /m:	4085235.57 m
Height or Z /m:	3763090.66 m

General information	
Rise time of the local UTC pulse	
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	23.2 °C, 0.1 °C (1σ)
Set humidity value and uncertainty:	46.8 %, 0.8 % (1σ)

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

Diagram of the experiment set-up



Log of Events / Additional Information

Date (UTC)	Log of Events
03/Aug/2021	Arrival.
04/Aug/2021 ~ 05/Aug/2021	Measure cable delays. Set up instruments.
06/Aug/2021 ~ 12/Aug/2021	Insert precise ECEF position to receivers. Test operation.
13/Aug/2021 ~ 23/Aug/2021	Measurement.
24/Aug/2021	Pack instruments.
25/Aug/2021	Departure.

(to be repeated for each calibrated system)

Laboratory:	Measurement Standards Laboratory of New Zealand
Date and hour of the beginning of measurements:	2021-11-01 00:00 UTC
Date and hour of the end of measurements:	2021-11-14 00:00 UTC

Information on the system

	Local:	**Travelling:**
4-character BIPM code	MS01	IM09 IM11
Receiver maker and type: Receiver serial number:	Septentrio PolaRx5TR 4701338	NIM NIMTFGNSS-02 SN201401 DICOM GTR51 1405004
1 PPS trigger level /V:	1 V	1V

Antenna cable maker and type: Phase stabilised cable (Y/N):	Huber + Suhner SPUMA 400-UF No	NIM supplied IM09 cable NIM supplied IMEK cable, with NIM supplied lightning arrester and flexible cable.
Length outside the building /m:	~16 meters	~19 meters 27 meters
Antenna maker and type: Antenna serial number:	Septentrio SEPCHOKE_B3E6 5588	NIM supplied – AeroAntenna AT200-GNSS 5098 NIM supplied – Novatel GPS-703-GGG NEG14100010
Temperature (if stabilised) /° C	18.6 degC in lab	18.6 degC in lab

Measured delays /ns

	Local:	**Travelling:**
Delay from local UTC to receiver 1 PPS-in:	80.1 ns	36.4 ns 36.5 ns
Delay from 1 PPS-in to internal Reference (if different):	Above delay value is from UTC(MSL)' to receiver internal reference	Not stated
Antenna cable delay:	80.8 ns	203.3 ns 176.5 ns
Splitter delay (if any):	No splitter used	No splitter used
Additional cable delay (if any):	Not applicable	Not applicable

Data used for the generation of CGGTTS files

INT DLY (GPS) /ns:	0 ns, to be calibrated
INT DLY (GLONASS) /ns:	0 ns
CAB DLY /ns:	80.8 ns
REF DLY /ns:	80.1 ns
Coordinates reference frame:	ITRF2014
Latitude or X /m:	-4784577.053 m

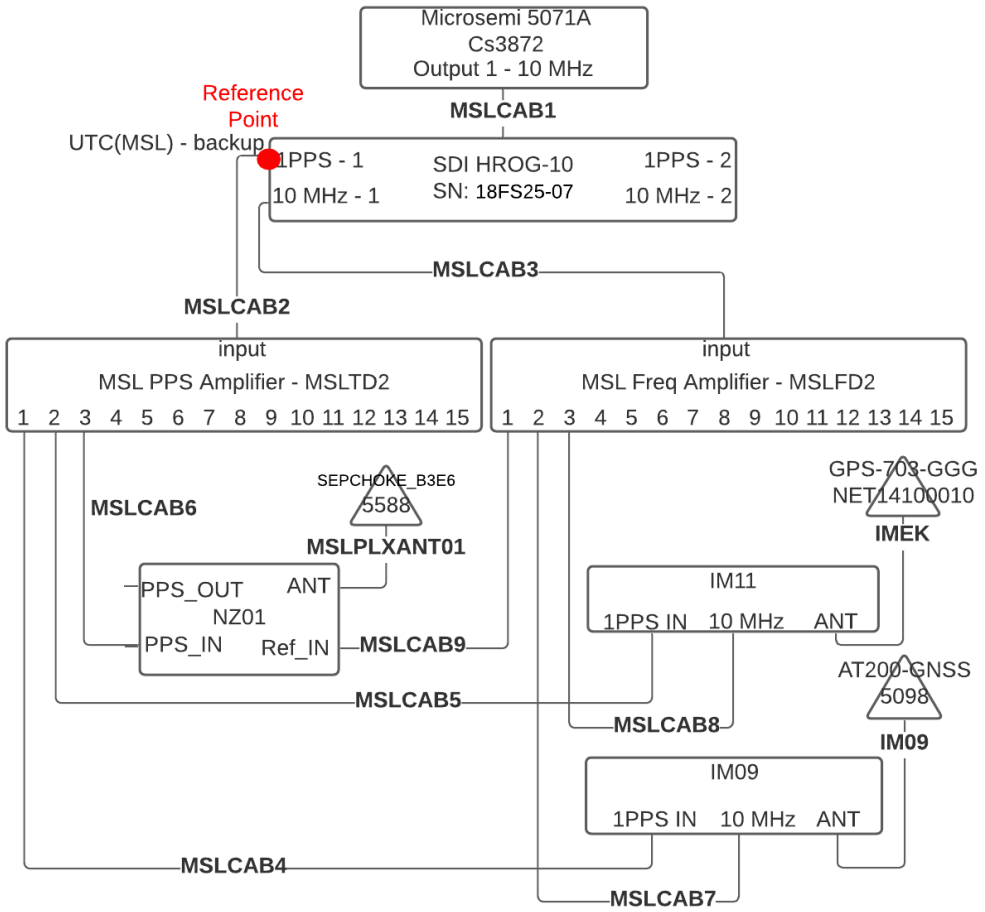
Longitude or Y /m:	425539.724 m
Height or Z /m:	-4182083.999 m

General information

Rise time of the local UTC pulse	< 1 ns
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	20 ± 2 degC
Set humidity value and uncertainty:	50 % ± 20 %

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

Diagram of the experiment set-up



Log of Events / Additional Information

(to be repeated for each calibrated system)

Laboratory：	Measurement Standards Laboratory of New Zealand
Date and hour of the beginning of measurements:	2021-11-20 00:00 UTC
Date and hour of the end of measurements:	2021-11-30 00:00 UTC

Information on the system

	Local:	**Travelling:**
4-character BIPM code	NZ02	IM09 IM11
Receiver maker and type: Receiver serial number：	Septentrio PolaRx4TR 3006020	NIM NIMTFGNSS-02 SN201401 DICOM GTR51 1405004
1 PPS trigger level /V:	1 V	1V
Antenna cable maker and type: Phase stabilised cable (Y/N):	Huber + Suhner SPUMA 400-UF No	NIM supplied IM09 cable NIM supplied IMEK cable, with NIM supplied lightning arrester and flexible cable.
Length outside the building /m:	~16 meters	~19 meters ~27 meters
Antenna maker and type: Antenna serial number:	Septentrio SEPCHOKE_MC 5410	NIM supplied – AeroAntenna AT200-GNSS 5098 NIM supplied – Novatel GPS-703-GGG NEG14100010
Temperature (if stabilised) /° C	18.6 degC in lab	18.6 degC in lab

Measured delays /ns

	Local:	**Travelling:**
Delay from local UTC to	176.05 ns	36.3 ns

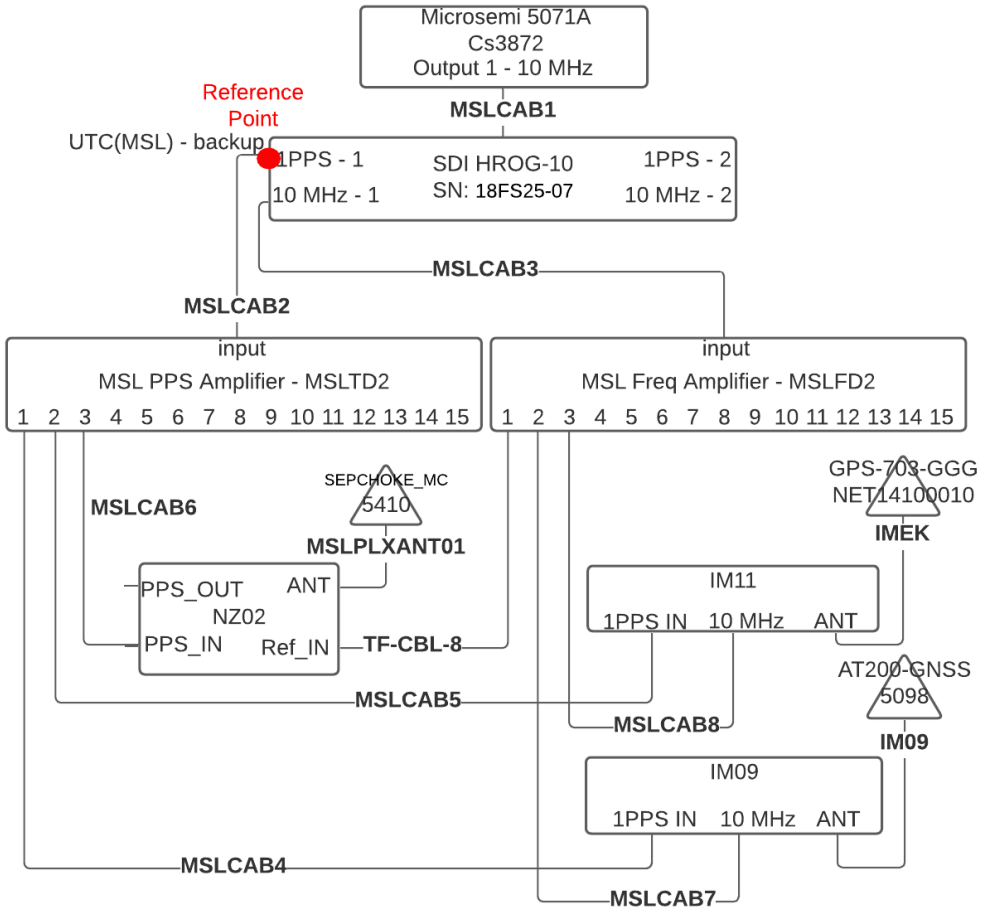
receiver 1 PPS-in:		36.44 ns
Delay from 1 PPS-in to internal Reference (if different):	Above delay value is from UTC(MSL)' to receiver internal reference	Not stated
Antenna cable delay:	80.8 ns	203.3 ns 176.5 ns
Splitter delay (if any):	No splitter used	No splitter used
Additional cable delay (if any):	Not applicable	Not applicable

Data used for the generation of CGGTTS files	
INT DLY (GPS) /ns:	0 ns, to be calibrated
INT DLY (GLONASS) /ns:	0 ns
CAB DLY /ns:	80.8 ns
REF DLY /ns:	176.05 ns
Coordinates reference frame:	ITRF2014
Latitude or X /m:	-4784577.053 m
Longitude or Y /m:	425539.724 m
Height or Z /m:	-4182083.999 m

General information	
Rise time of the local UTC pulse	< 1 ns
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	20 ± 2 degC
Set humidity value and uncertainty:	50 % ± 20 %

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

Diagram of the experiment set-up



Log of Events / Additional Information

(to be repeated for each calibrated system)

Laboratory:	Measurement Standards Laboratory of New Zealand
Date and hour of the beginning of measurements:	2021-12-04 00:00 UTC
Date and hour of the end of measurements:	2021-12-14 00:00 UTC

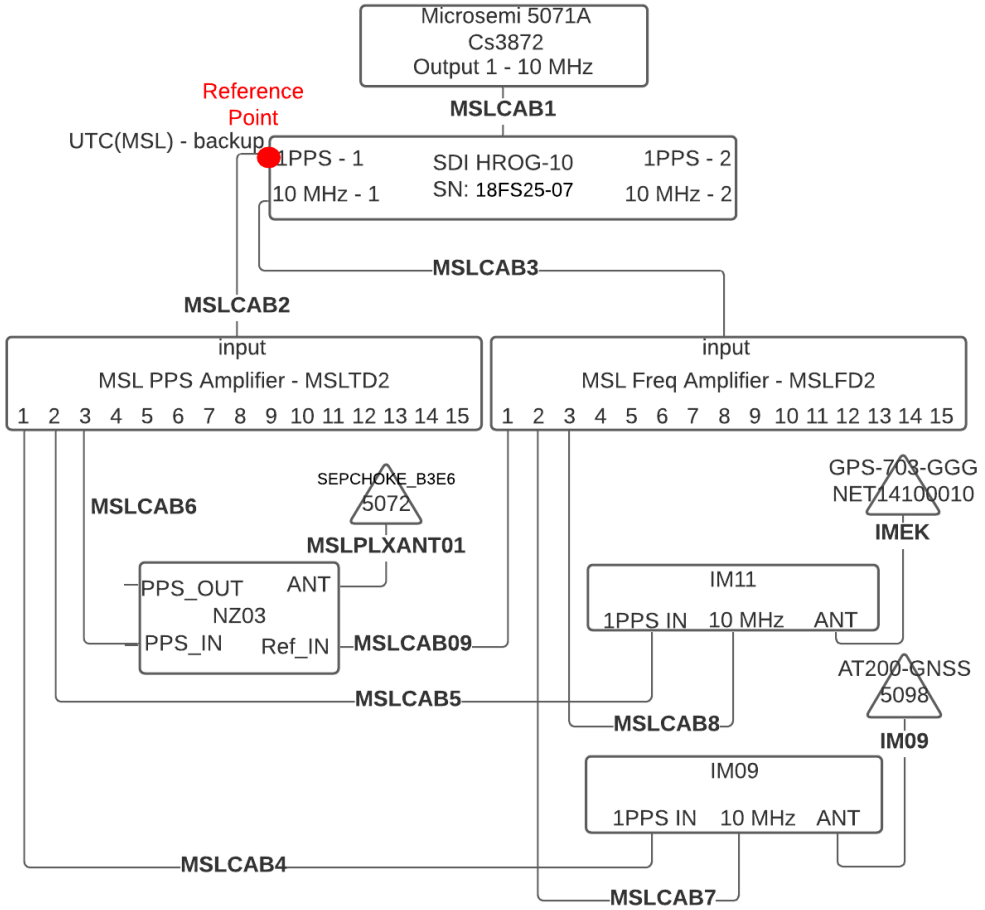
Information on the system		
	Local:	**Travelling:**
4-character BIPM code	NZ03	IM09 IM11

Receiver maker and type: Receiver serial number：	Septentrio PolaRx4TR 3009572	NIM NIMTFGNSS-02 SN201401 DICOM GTR51 1405004
1 PPS trigger level /V:	1 V	1V
Antenna cable maker and type: Phase stabilised cable (Y/N):	Huber + Suhner SPUMA 400-UF No	NIM supplied IM09 cable NIM supplied IMEK cable, with NIM supplied lightning arrester and flexible cable.
Length outside the building /m:	~16 meters	~19 meters ~27 meters
Antenna maker and type: Antenna serial number:	Septentrio SEPCHOKE_B3E6 5072	NIM supplied – AeroAntenna AT200-GNSS 5098 NIM supplied – Novatel GPS-703-GGG NEG14100010
Temperature (if stabilised) /° C	18.6 degC in lab	18.6 degC in lab
Measured delays /ns		
	Local:	**Travelling:**
Delay from local UTC to receiver 1 PPS-in:	180.70 ns	36.3 ns 36.46 ns
Delay from 1 PPS-in to internal Reference (if different):	Above delay value is from UTC(MSL)' to receiver internal reference	Not stated
Antenna cable delay:	80.8 ns	203.3 ns 176.5 ns
Splitter delay (if any):	No splitter used	No splitter used
Additional cable delay (if any):	Not applicable	Not applicable
Data used for the generation of CGGTTS files		
INT DLY (GPS) /ns:	0 ns, to be calibrated	

INT DLY (GLONASS) /ns:	0 ns
CAB DLY /ns:	80.8 ns
REF DLY /ns:	180.70 ns
Coordinates reference frame:	ITRF2014
Latitude or X /m:	-4784577.053 m
Longitude or Y /m:	425539.724 m
Height or Z /m:	-4182083.999 m
General information	
Rise time of the local UTC pulse	< 1 ns
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	20 ± 2 degC
Set humidity value and uncertainty:	50 % ± 20 %

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

Diagram of the experiment set-up



Log of Events / Additional Information

(to be repeated for each calibrated system)

Laboratory:	National Measurement Institute, Australia
Date and hour of the beginning of measurements:	2021-09-13 01:33 (UTC)
Date and hour of the end of measurements:	2021-09-29 00:00 (UTC)

Information on the system

	Local:	**Travelling:**
4-character BIPM code	AU04	IM09
Receiver maker and type: Receiver serial number:	Septentrio PolaRx2eTR 3252	NIM NIMTFGNSS-2 SN201401

1 PPS trigger level /V:	1 V	1 V
Antenna cable maker and type: Phase stabilized cable (Y/N):	Mixed No	IM09 Lynxtrend, 5D-FB No
Length outside the building /m:	~ 250 m	~20 m
Antenna maker and type: Antenna serial number:	Ashtech, 701945C_M CR519994908	AeroAntenna, AT200-GNSS 5098
Temperature (if stabilized) /°C	Not applicable	Not applicable

Measured delays /ns

	Local:	**Travelling:**
Delay from local UTC to receiver 1 PPS-in:	XP = 79.4 ns	38.51 ns
Delay from 1 PPS-in to internal Reference (if different):	XO = 257.8 ns [XP + X0 = 337.2 ns]	Not applicable
Antenna cable delay:	2484.6 ± 1 ns (see Additional Information)	203.2 ns
Splitter delay (if any):	Included in antenna delay	Not applicable
Additional cable delay (if any):	Not applicable	Not applicable

Data used for the generation of CGGTTS files

INT DLY (GPS) /ns:	224.1 ns (GPS C1), 220.9 ns (GPS P1), 222.0 ns (GPS P2)
INT DLY (GLONASS) /ns:	Not known
CAB DLY /ns:	2480.6 ns
REF DLY /ns:	345.3 ns
Coordinates reference frame:	ITRF
Latitude or X /m:	X: -4648240.87 m
Longitude or Y /m:	Y: +2560636.49 m
Height or Z /m:	Z: -3526317.92 m

General information

Rise time of the local UTC pulse	≤ 5 ns
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	(20 ± 1) °C
Set humidity value and uncertainty:	Not controlled

Log of Events / Additional Information

(to be repeated for each calibrated system)

Laboratory：	National Measurement Institute, Australia
Date and hour of the beginning of measurements:	2021-09-13 01:33 (UTC)
Date and hour of the end of measurements:	2021-09-29 00:00 (UTC)

Information on the system

	Local:	**Travelling:**
4-character BIPM code	AU04	IM11
Receiver maker and type: Receiver serial number：	Septentrio PolaRx2eTR 3252	DICOM GTR51 1405004
1 PPS trigger level /V:	1V	1V
Antenna cable maker and type: Phase stabilised cable (Y/N):	Mixed No	IMEK No
Length outside the building /m:	~ 250 m	~20m
Antenna maker and type: Antenna serial number:	Ashtech, 701945C_M CR519994908	Novatel GPS-703-GGG NEG14100010
Temperature (if stabilised) /°C	Not applicable	Not applicable

Measured delays /ns

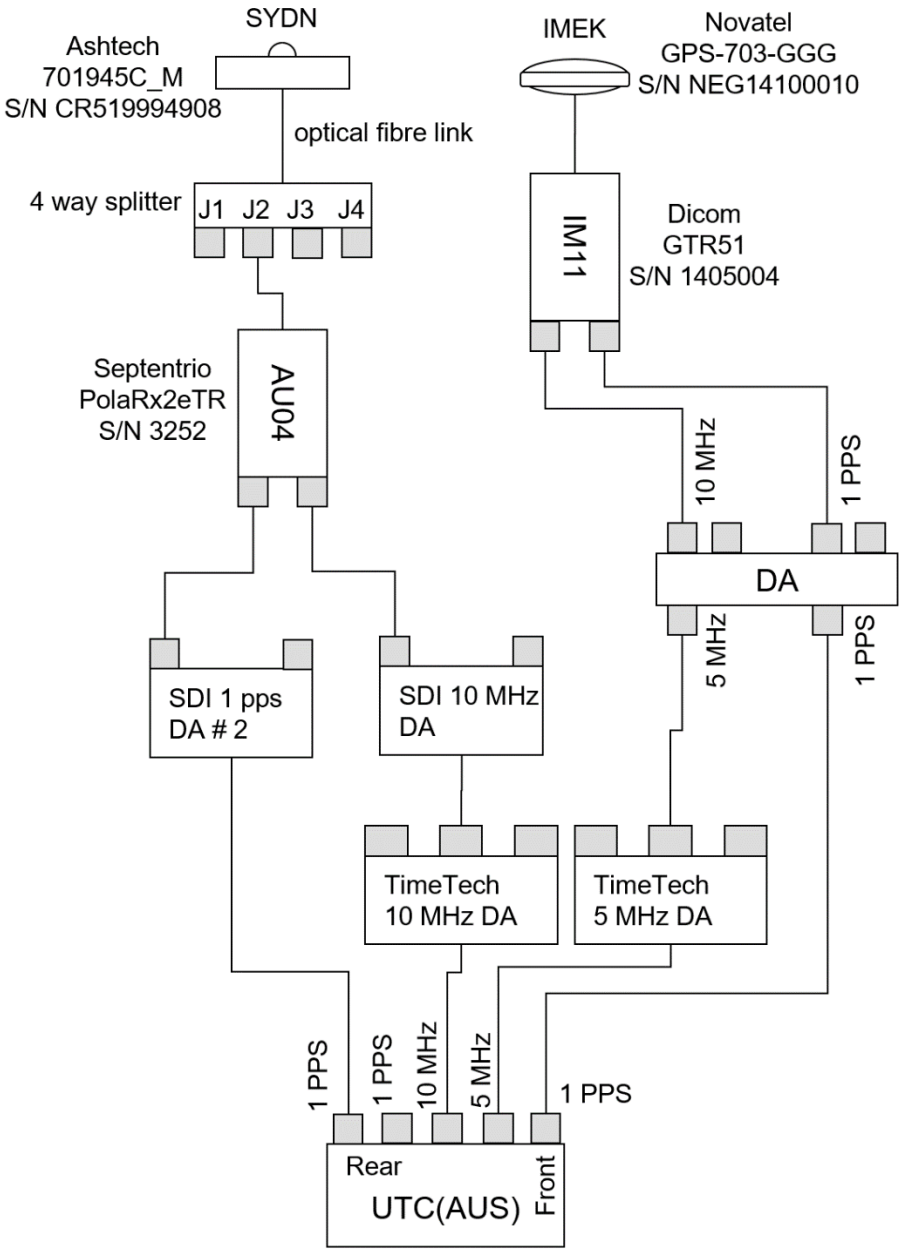
	Local:	**Travelling:**
Delay from local UTC to receiver 1 PPS-in:	XP = 79.4 ns	38.55 ns
Delay from 1 PPS-in to internal Reference (if different):	XO = 257.8 ns [XP + XO = 337.2 ns]	Not applicable.
Antenna cable delay:	2484.6 ± 1 ns (see Additional Information)	176.2
Splitter delay (if any):	Not applicable	Not stated
Additional cable delay (if any):	Not applicable	Not stated

Data used for the generation of CGGTTS files	
INT DLY (GPS) /ns:	224.1 ns (GPS C1), 220.9 ns (GPS P1), 222.0 ns (GPS P2)
INT DLY (GLONASS) /ns:	Not known
CAB DLY /ns:	2480.6 ns
REF DLY /ns:	345.3 ns
Coordinates reference frame:	ITRF
Latitude or X /m:	X: -4648240.87 m
Longitude or Y /m:	Y: +2560636.49 m
Height or Z /m:	Z: -3526317.92 m

General information	
Rise time of the local UTC pulse	≤ 5 ns
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	(20 ± 1) °C
Set humidity value and uncertainty:	Not controlled

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

Diagram of the experiment set-up



Log of Events / Additional Information

1. Measurement of the delay of the optical fibre link is more complex than a simple cable delay measurement, involving two time-transfer measurements. The nominal uncertainty is assigned as 1 ns.

(to be repeated for each calibrated system)

Laboratory：	National Measurement Institute, Australia
Date and hour of the	2021-09-13 01:33 (UTC)

beginning of measurements:	
Date and hour of the end of measurements:	2021-09-29 00:00 (UTC)

Information on the system

	Local:	**Travelling:**
4-character BIPM code	AU05	IM09
Receiver maker and type: Receiver serial number:	Septentrio PolaRx4TR PRO 3102181	NIM, NIMTFGNSS-2 SN201401
1 PPS trigger level /V:	1 V	1 V
Antenna cable maker and type: Phase stabilized cable (Y/N):	NML05A Times Microwave LMR400 No	IM09 Lynxtrend 5D-FB No
Length outside the building /m:	~ 15 m	~20 m
Antenna maker and type: Antenna serial number:	Septentrio SEPCHOKE_MC SPKE 5394	AeroAntenna AT200-GNSS 5098
Temperature (if stabilized) /°C	Not applicable	Not applicable

Measured delays /ns

	Local:	**Travelling:**
Delay from local UTC to receiver 1 PPS-in:	XP = 81.7 ns	38.51 ns
Delay from 1 PPS-in to internal Reference (if different):	XO = 134.7 ns XP + XO = 216.4 ns	Not applicable
Antenna cable delay:	101.6 ns	203.2 ns
Splitter delay (if any):	Not applicable	Not stated
Additional cable delay (if any):	Not applicable	Not stated

Data used for the generation of CGGTTS files

INT DLY (GPS) /ns:	52.3 ns (GPS C1), 51.4 ns (GPS P1), 49.6 ns (GPS P2)
INT DLY (GLONASS) /ns:	Not known
CAB DLY /ns:	101.6 ns
REF DLY /ns:	217.4 ns
Coordinates reference frame:	ITRF
Latitude or X /m:	X: -4648198.70 m
Longitude or Y /m:	Y: +2560482.05 m

Height or Z /m:	Z: -3526508.46 m

General information	
Rise time of the local UTC pulse	≤ 5 ns
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	(20 ± 1) °C
Set humidity value and uncertainty:	Not controlled

(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

None.

(to be repeated for each calibrated system)

Laboratory：	National Measurement Institute, Australia
Date and hour of the beginning of measurements:	2021-09-13 01:33 (UTC)
Date and hour of the end of measurements:	2021-09-29 00:00 (UTC)

Information on the system		
	Local:	**Travelling:**
4-character BIPM code	AU05	IM11
Receiver maker and type: Receiver serial number：	Septentrio PolaRx4TR PRO 3102181	DICOM, GTR51 1405004
1 PPS trigger level /V:	1V	1V
Antenna cable maker and type: Phase stabilised cable (Y/N):	NML05A Times Microwave LMR400 No	IMEK No
Length outside the building /m:	~ 15 m	~20m
Antenna maker and type: Antenna serial number:	Septentrio SEPCHOKE_MC SPKE 5394	Novatel GPS-703-GGG NEG14100010
Temperature (if stabilised) /°C	Not applicable	Not applicable

Measured delays /ns

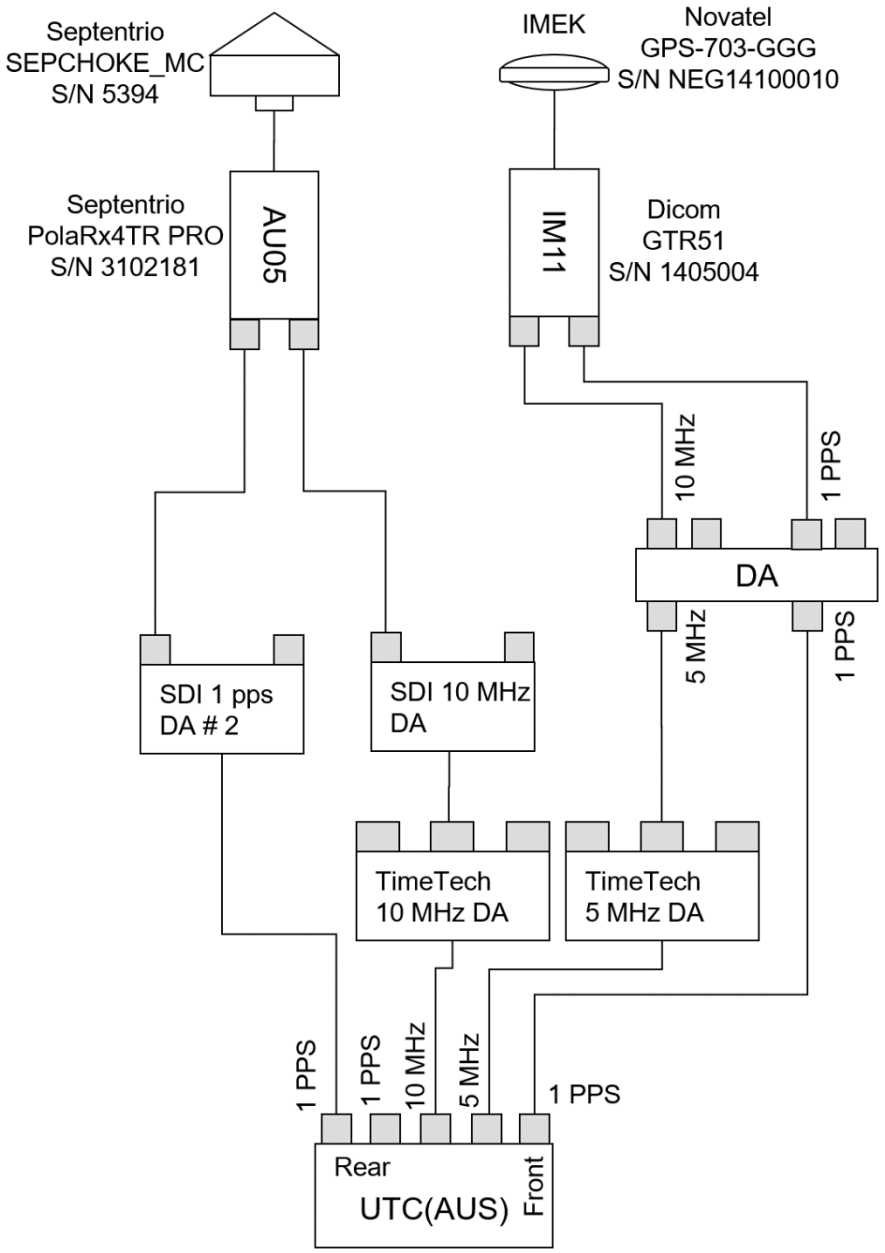
	Local:	**Travelling:**
Delay from local UTC to receiver 1 PPS-in:	XP = 81.7 ns	38.55 ns
Delay from 1 PPS-in to internal Reference (if different):	XO = 134.7 ns XP + XO = 216.4 ns	Not applicable
Antenna cable delay:	101.6 ns	176.2 ns
Splitter delay (if any):	Not applicable	Not stated
Additional cable delay (if any):	Not applicable	Not stated

Data used for the generation of CGGTTS files	
INT DLY (GPS) /ns:	52.3 ns (GPS C1), 51.4 ns (GPS P1), 49.6 ns (GPS P2)
INT DLY (GLONASS) /ns:	Not known
CAB DLY /ns:	101.6 ns
REF DLY /ns:	217.4 ns
Coordinates reference frame:	ITRF
Latitude or X /m:	X: -4648198.70 m
Longitude or Y /m:	Y: +2560482.05 m
Height or Z /m:	Z: -3526508.46 m

General information	
Rise time of the local UTC pulse	≤ 5 ns
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	(20 ± 1) °C
Set humidity value and uncertainty:	Not controlled

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

Diagram of the experiment set-up



Log of Events / Additional Information

None

(to be repeated for each calibrated system)

Laboratory：	National Measurement Institute, Australia
Date and hour of the beginning of measurements:	2021-09-13 01:33 (UTC)
Date and hour of the end of measurements:	2021-09-29 00:00 (UTC)

Information on the system		
	Local:	**Travelling:**
4-character BIPM code	AU06	IM09
Receiver maker and type: Receiver serial number:	Septentrio PolaRx5TR 3048136	NIM NIMTFGNSS-2 SN201401
1 PPS trigger level /V:	1 V	1 V
Antenna cable maker and type: Phase stabilized cable (Y/N):	Times Microwave LMR400 PLX5ANT01 No	IM09 Lynxtrend, 5D-FB No
Length outside the building /m:	~ 15 m	~20 m
Antenna maker and type: Antenna serial number:	Septentrio SEPCHOKE_B3E6 SPKE s/n 5616	AeroAntenna AT200-GNSS 5098
Temperature (if stabilized) /°C	Not applicable	Not applicable

Measured delays /ns		
	Local:	**Travelling:**
Delay from local UTC to receiver 1 PPS-in:	XP = 109.8 ns	38.51 ns
Delay from 1 PPS-in to internal Reference (if different): without 1 PPS auto-compensation	XO = 45.3 ns XP + XO = 155.1 ns	Not applicable.
Antenna cable delay:	173.9 ns	203.2 ns
Splitter delay (if any):	Not applicable	Not applicable
Additional cable delay (if any):	Not applicable	Not applicable

Data used for the generation of CGGTTS files	
INT DLY (GPS) /ns:	29.6 ns (GPS C1), 27.7 ns (GPS P1), 26.4 ns (GPS P2)
INT DLY (GLONASS) /ns:	Not known
CAB DLY /ns:	173.9 ns
REF DLY /ns:	155.5 ns
Coordinates reference frame:	ITRF
Latitude or X /m:	X: -4648199.41 m
Longitude or Y /m:	Y: +2560480.72 m
Height or Z /m:	Z: -3526508.68 m

General information	
Rise time of the local UTC pulse	≤ 5 ns
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	(20 ± 1) °C
Set humidity value and uncertainty:	Not controlled

(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

None

(to be repeated for each calibrated system)

Laboratory：	National Measurement Institute, Australia
Date and hour of the beginning of measurements:	2021-09-13 01:33 (UTC)
Date and hour of the end of measurements:	2021-09-29 00:00 (UTC)

Information on the system		
	Local:	**Travelling:**
4-character BIPM code	AU06	IM11
Receiver maker and type: Receiver serial number：	Septentrio PolaRx5TR 3048136	DICOM GTR51 1405004
1 PPS trigger level /V:	1V	1V
autocompesation mode for the PPSIN internal delay	off	/
Antenna cable maker and type: Phase stabilised cable (Y/N):	Times Microwave LMR400 PLX5ANT01 No	IMEK No
Length outside the building /m:	~ 15 m	~20m
Antenna maker and type: Antenna serial number:	Septentrio SEPCHOKE_B3E6 SPKE s/n 5616	Novatel GPS-703-GGG NEG14100010

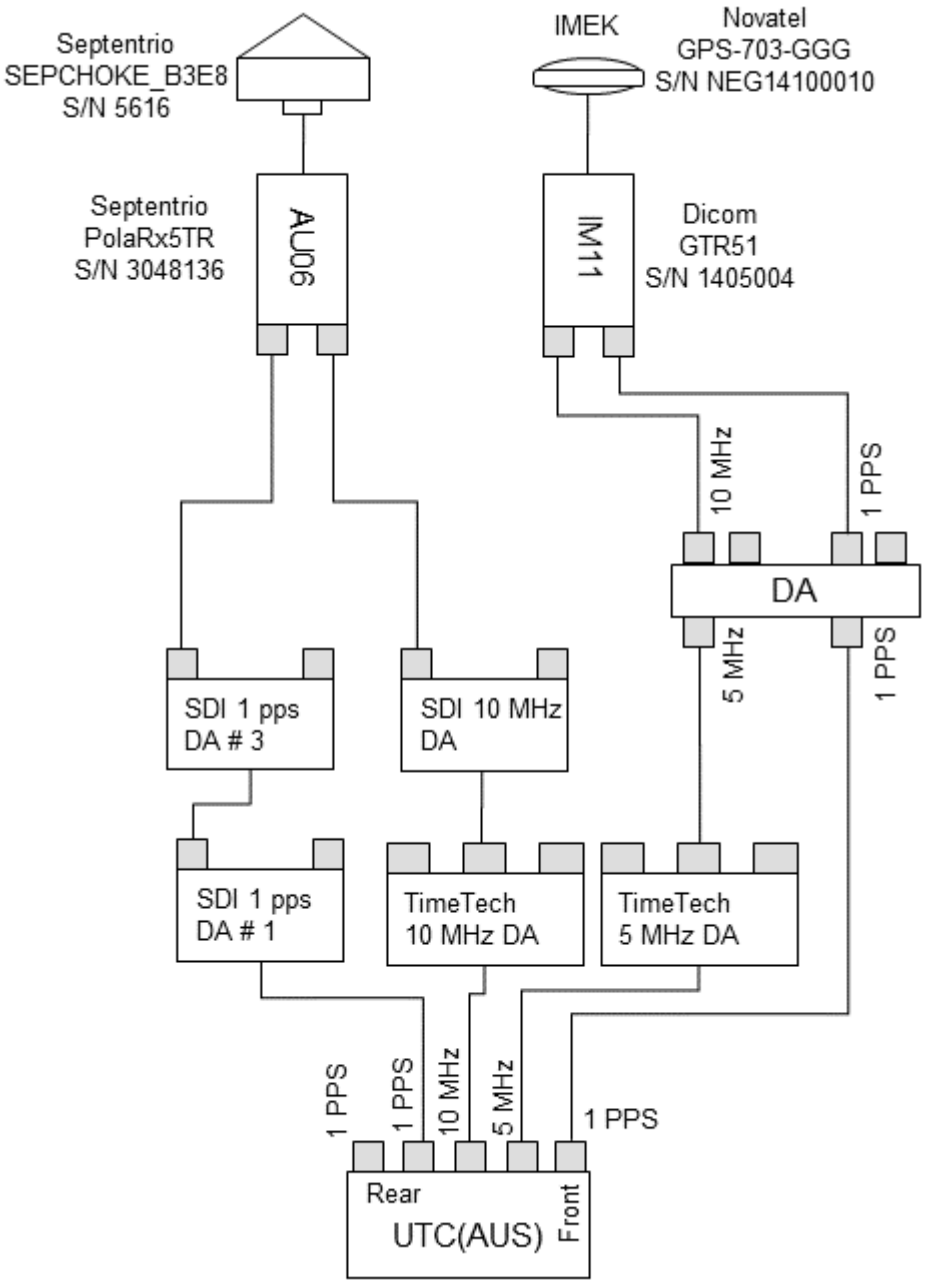
Temperature (if stabilised) /°C	Not applicable	Not applicable
Measured delays /ns		
	Local:	**Travelling:**
Delay from local UTC to receiver 1 PPS-in:	XP = 109.8 ns	38.55 ns
Delay from 1 PPS-in to internal Reference (if different): without 1 PPS auto-compensation	XO = 45.3 ns [XP + XO = 155.1 ns]	Not applicable.
Antenna cable delay:	173.9 ns	176.2 ns
Splitter delay (if any):	Not applicable	Not stated
Additional cable delay (if any):	Not applicable	Not stated

Data used for the generation of CGGTTS files	
INT DLY (GPS) /ns:	29.6 ns (GPS C1), 27.7 ns (GPS P1), 26.4 ns (GPS P2)
INT DLY (GLONASS) /ns:	Not known
CAB DLY /ns:	173.9 ns
REF DLY /ns:	155.5 ns
Coordinates reference frame:	ITRF
Latitude or X /m:	X: -4648199.41 m
Longitude or Y /m:	Y: +2560480.72 m
Height or Z /m:	Z: -3526508.68 m

General information	
Rise time of the local UTC pulse	≤ 5 ns
Is the laboratory air conditioned	Yes
Set temperature value and uncertainty:	(20 ± 1) °C
Set humidity value and uncertainty:	Not controlled

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

Diagram of the experiment set-up



Log of Events / Additional Information

None

Annex 4 –TDEV for CCD results at KRISS

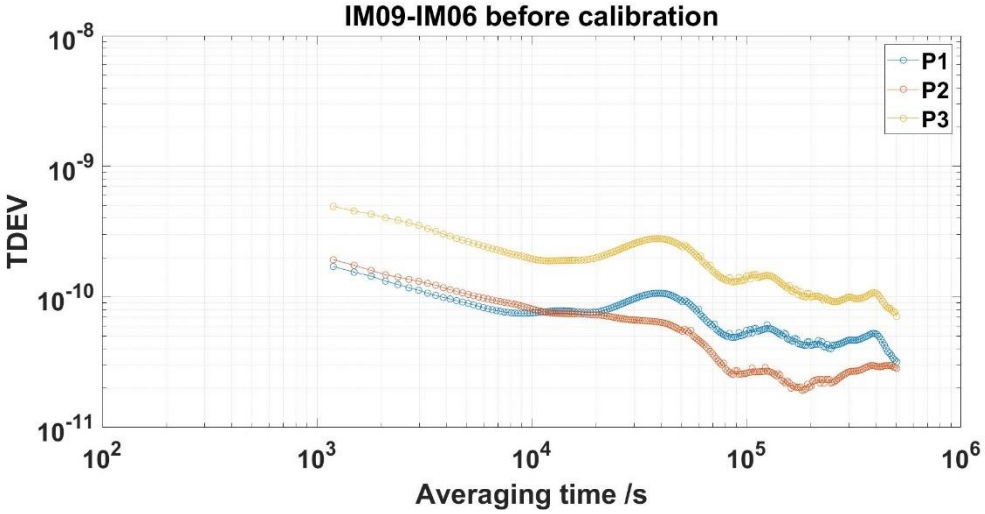


Figure 135. TDEV between IM09 and IM06 receivers at NIM before calibration

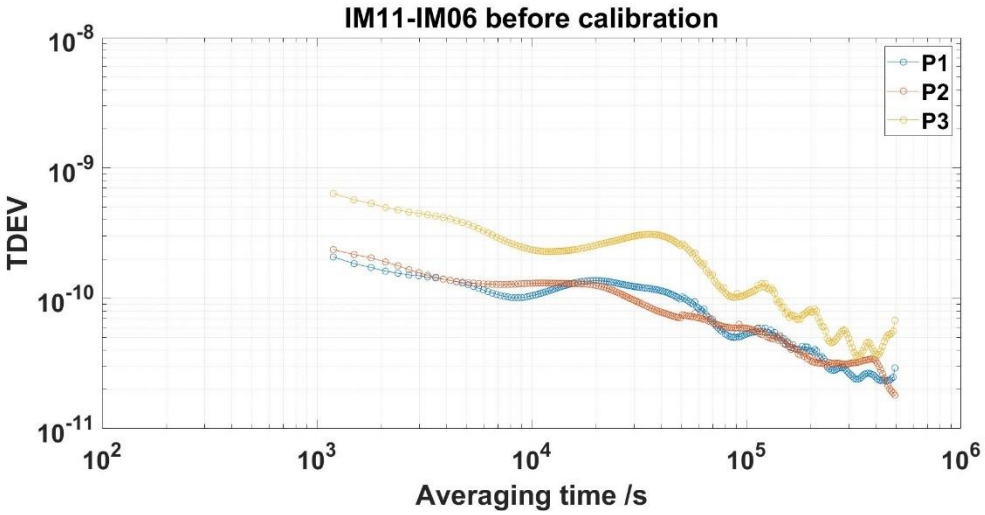


Figure 136. TDEV between IM11 and IM06 receivers at NIM before calibration

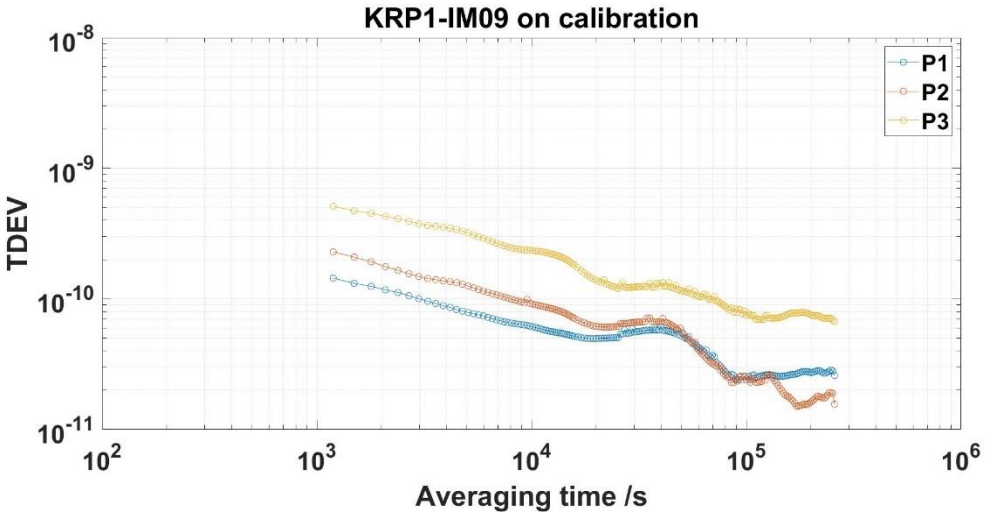


Figure 137. TDEV between KRP1 and IM09 receivers at NIM before calibration

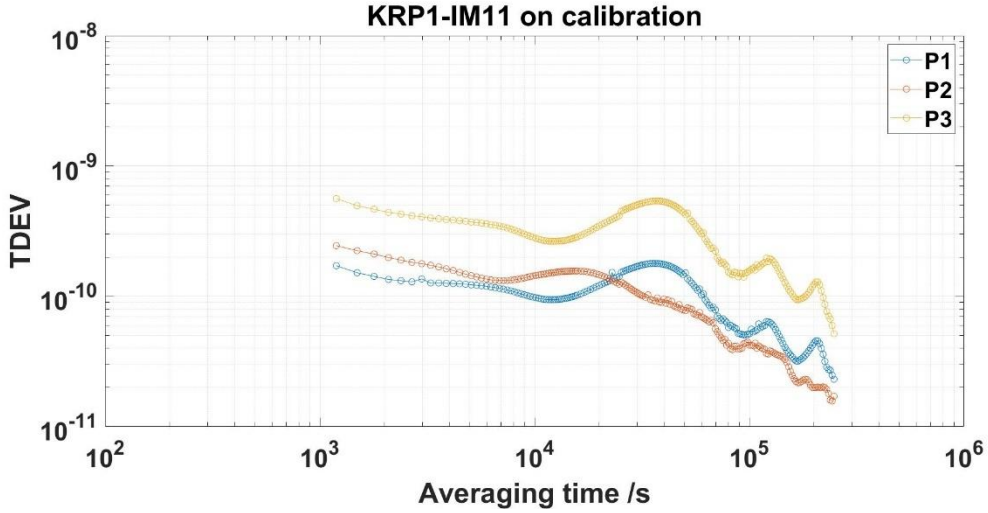


Figure 138. TDEV between KRP1 and IM11 receivers at KRISS during calibration

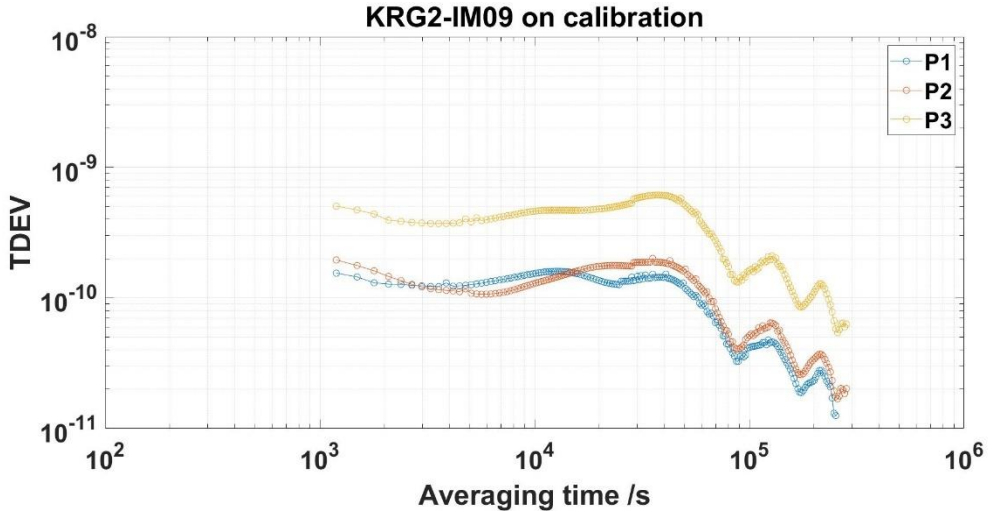


Figure 139. TDEV between KRG2 and IM09 receivers at KRISS during calibration

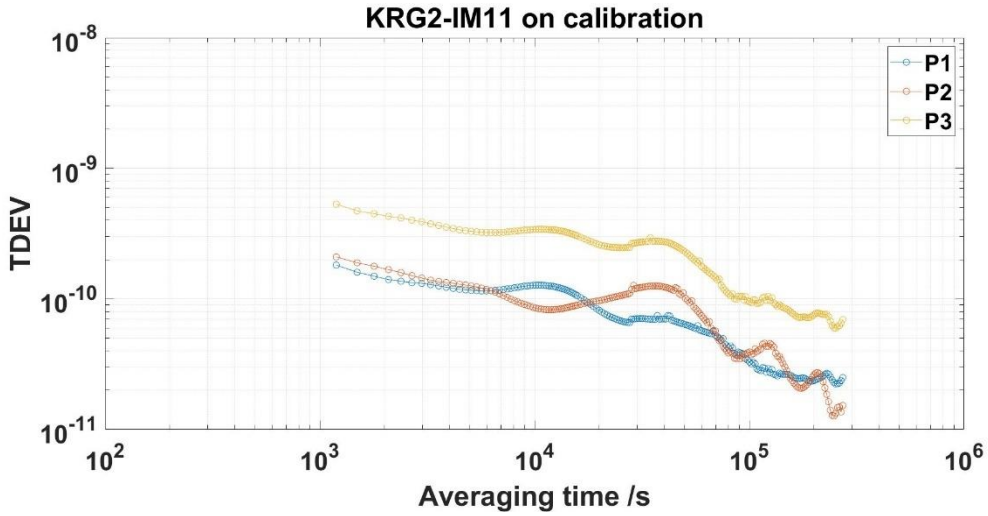


Figure 140. TDEV between KRG2 and IM11 receivers at KRISS during calibration

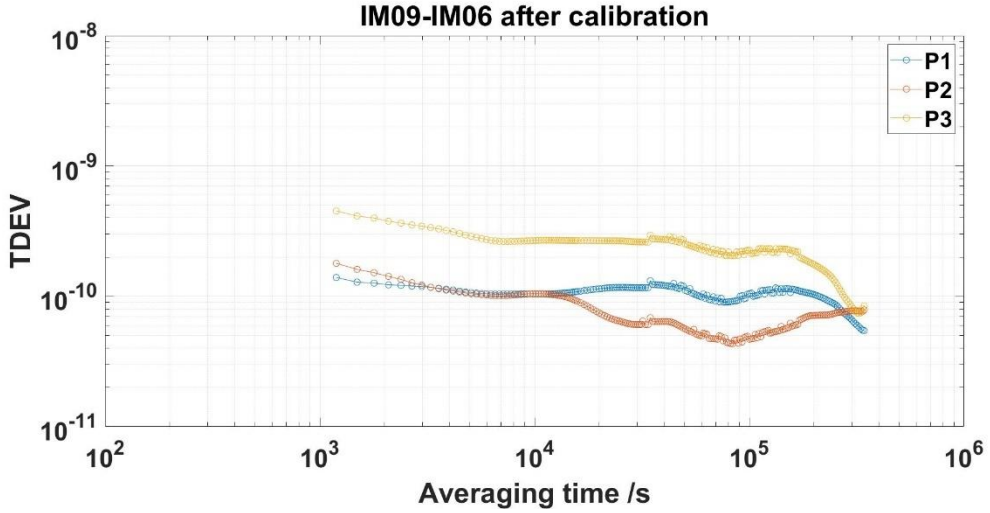


Figure 141. TDEV between IM09 and IM06 receivers at NIM after calibration

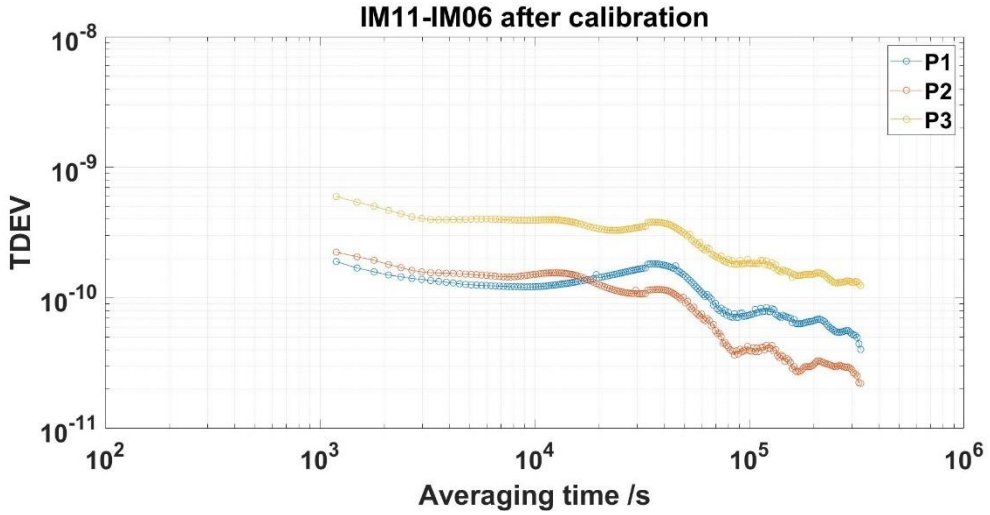


Figure 142. TDEV between IM11 and IM06 receivers at NIM after calibration

Annex 5 –TDEV for CCD results at MSL

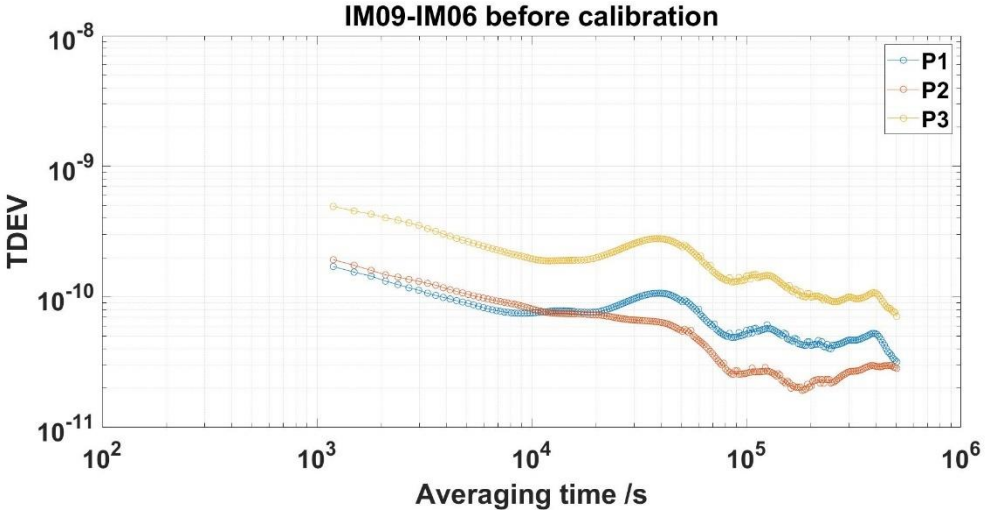


Figure 143. TDEV between IM09 and IM06 receivers at NIM before calibration

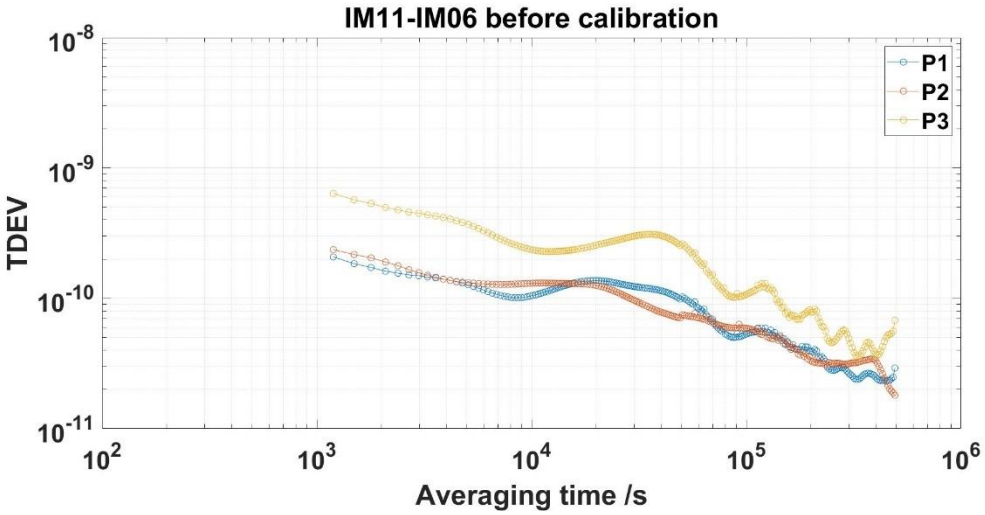


Figure 144. TDEV between IM11 and IM06 receivers at NIM before calibration

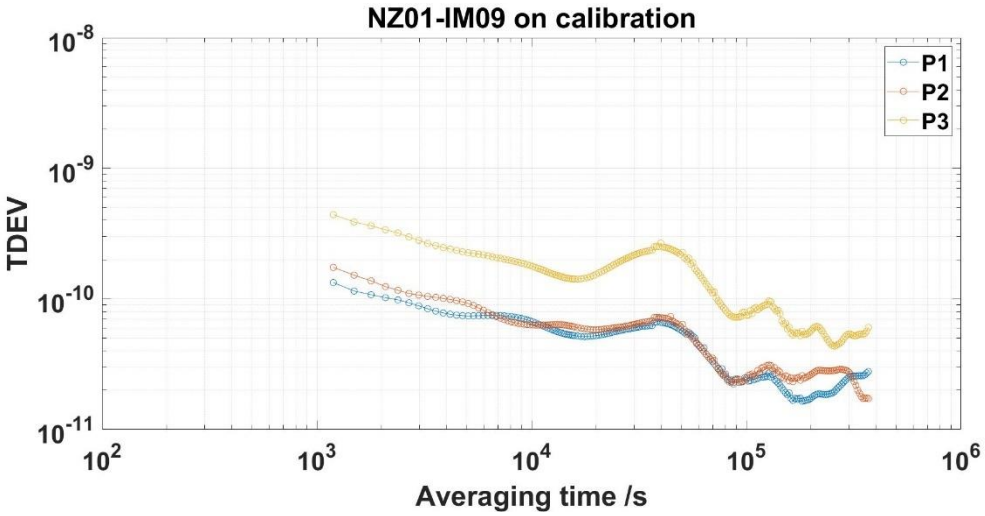


Figure 145. TDEV between MS01 and IM09 receivers at MSL on calibration

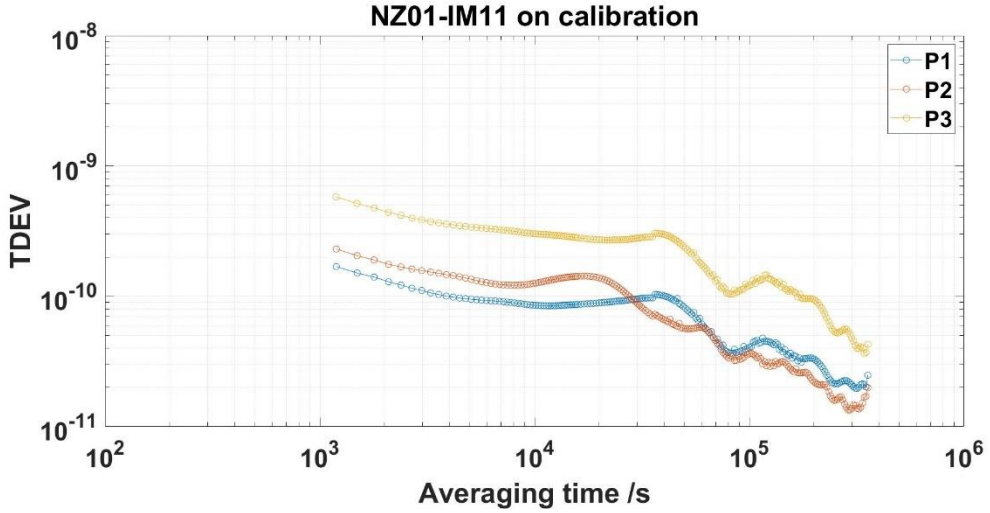


Figure 146. TDEV between MS01 and IM11 receivers at MSL on calibration

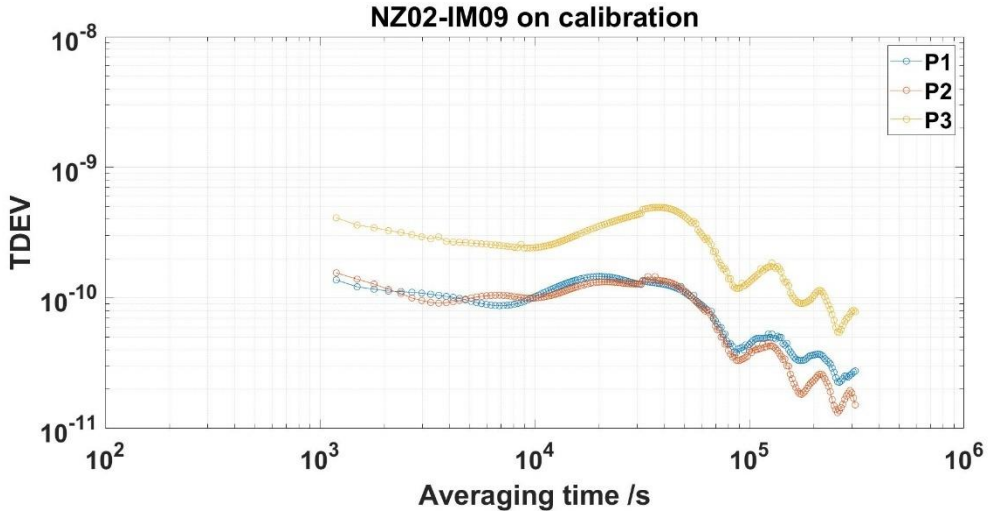


Figure 147. TDEV between NZ02 and IM09 receivers at MSL on calibration

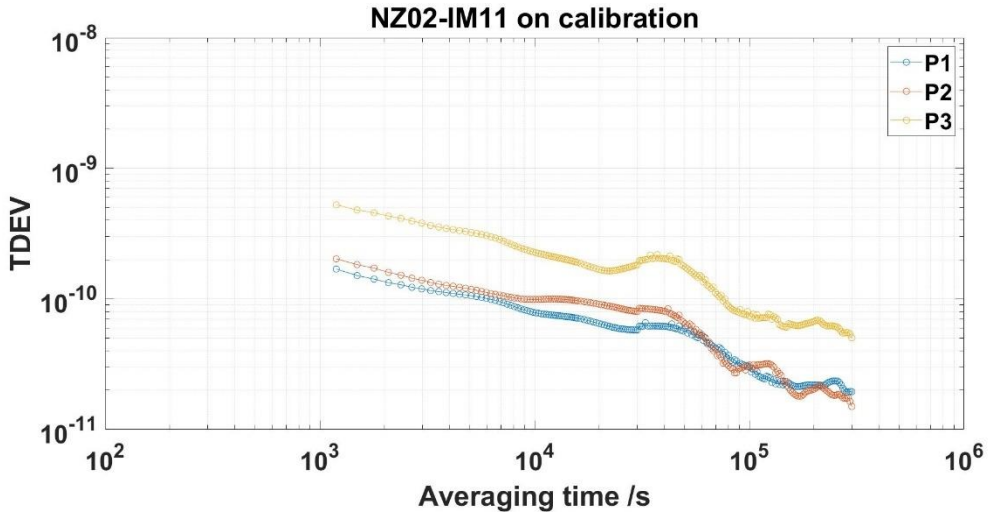


Figure 148. TDEV between NZ02 and IM11 receivers at MSL on calibration

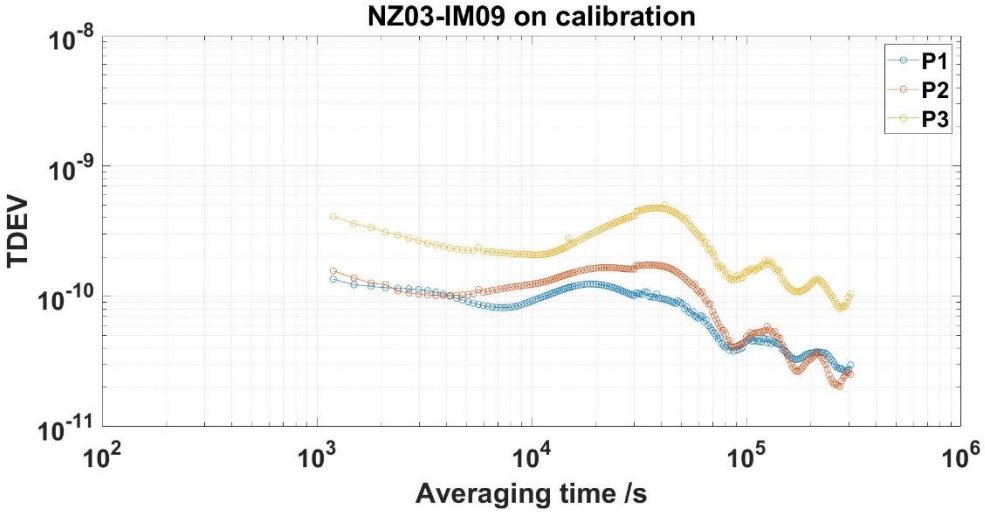


Figure 149. TDEV between NZ03 and IM09 receivers at MSL on calibration

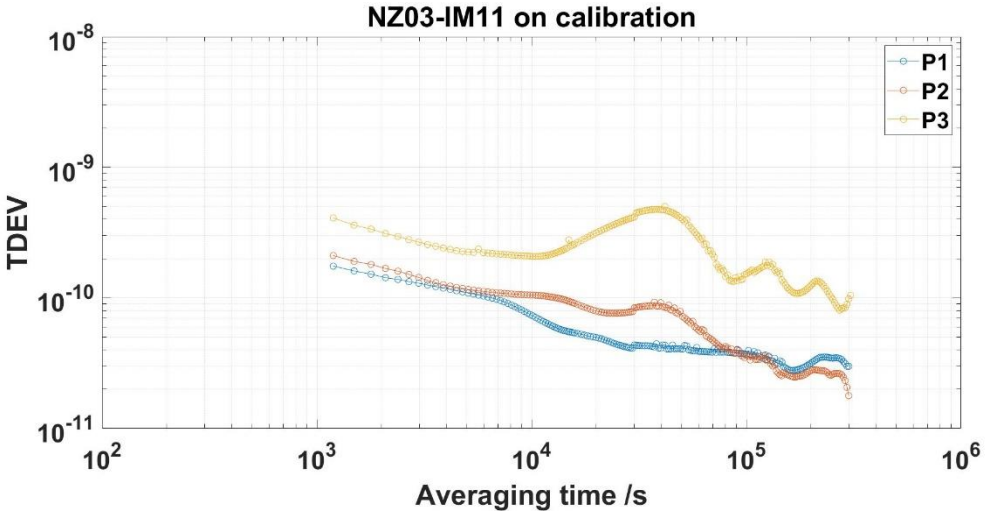


Figure 150. TDEV between NZ03 and IM11 receivers at MSL on calibration

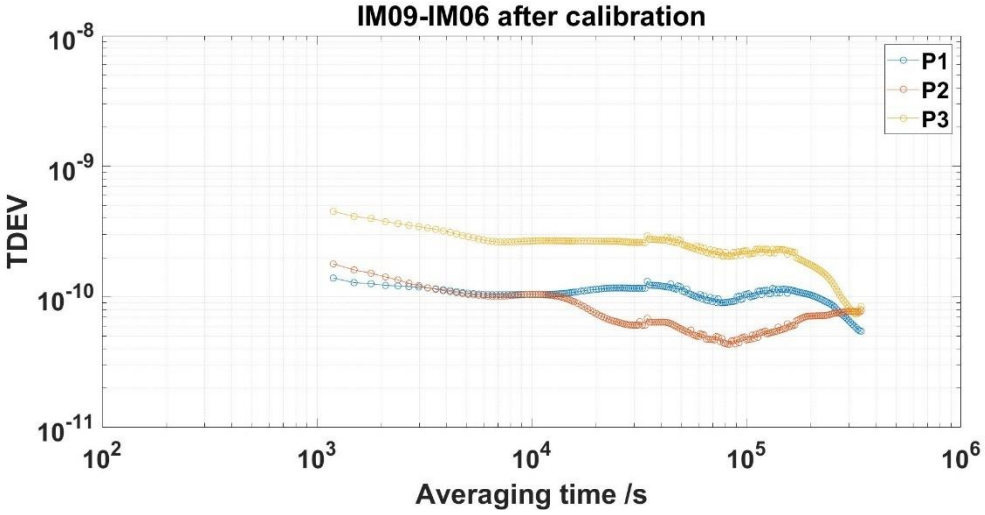


Figure 151. TDEV between IM09 and IM06 receivers at NIM after calibration

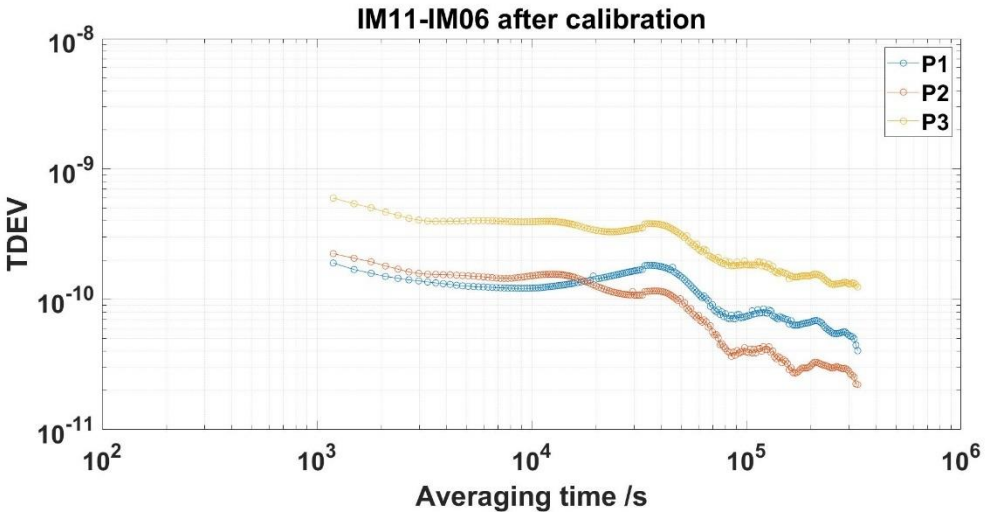


Figure 152. TDEV between IM11 and IM06 receivers at NIM after calibration

Annex 6 –TDEV for CCD results at NMIA

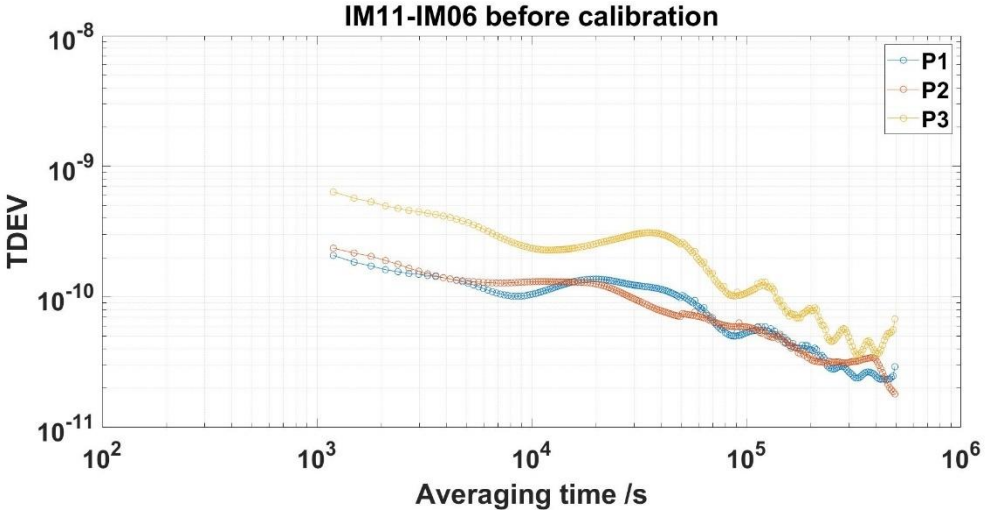


Figure 153. TDEV between IM11 and IM06 receivers at NIM before calibration

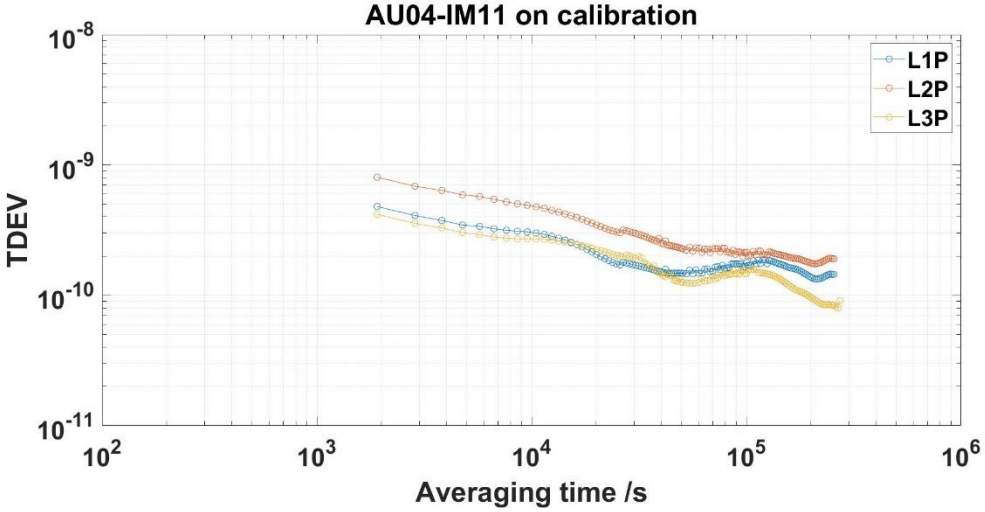


Figure 154. TDEV between AU04 and IM11 receivers at NMIA on calibration

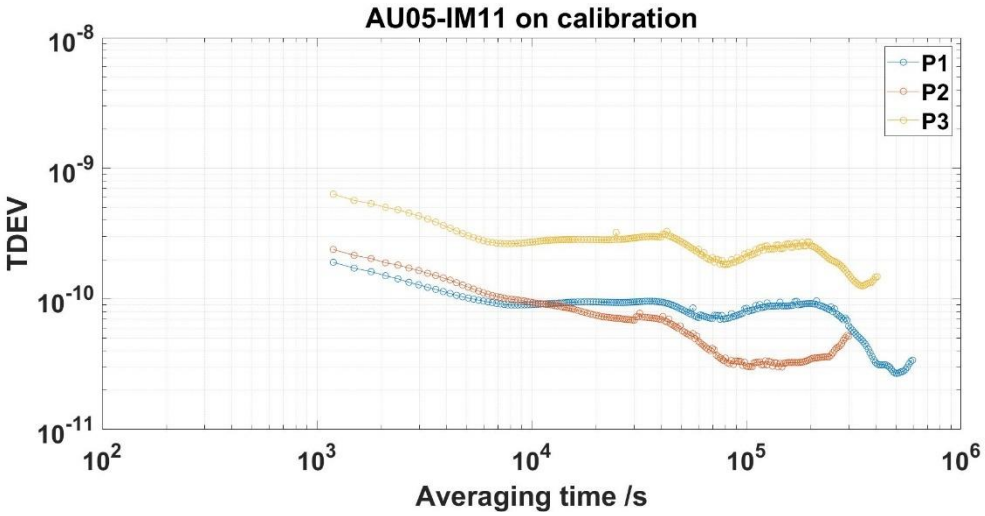


Figure 155. TDEV between AU05 and IM11 receivers at NMIA on calibration

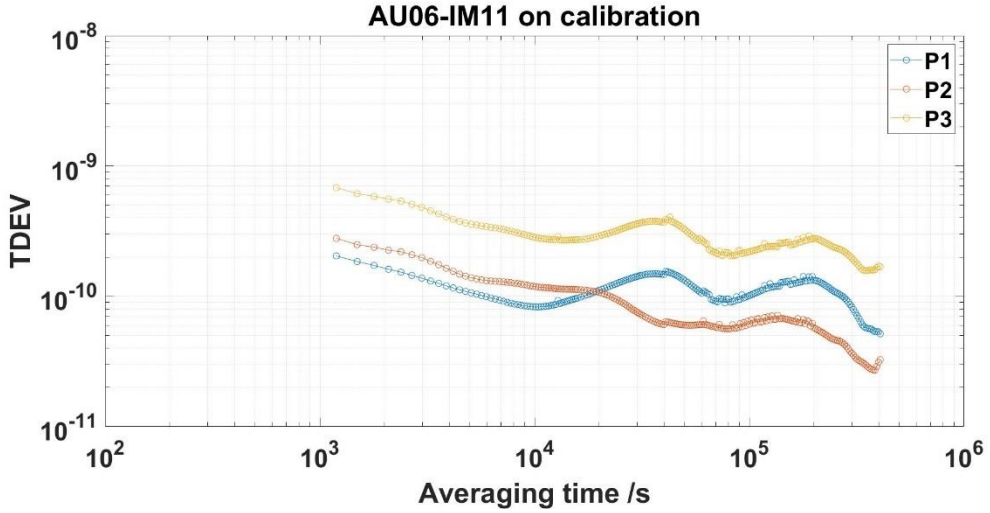


Figure 156. TDEV between AU06 and IM11 receivers at NMIA on calibration

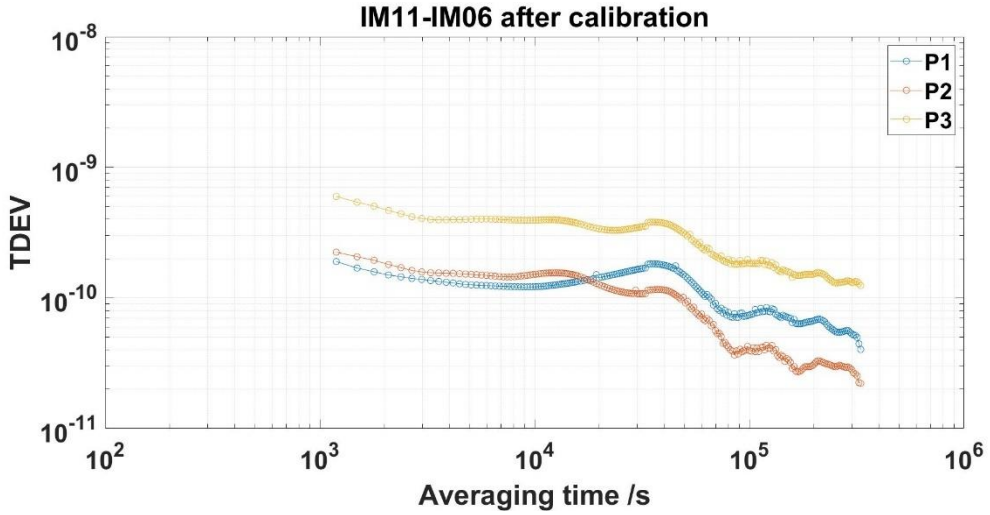


Figure 157. TDEV between IM11 and IM06 receivers at NIM after calibration