

RxPD and TxPD Calibration Trends

| GENERATED FOR LHO_EndX

Report Generated on November 1, 2023

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1 About

This document contains the Pcal Calibration trends. It includes the ratios measured at the end-station labeled as m1, m2m6 as well as the quantities derived from these six ratio measurements, namely α_{TW} , α_{RW} , optical efficiency and power imbalance. This document also includes the trend of the ADC conversion factor. The sections 17 to 20 shows the trend of the parameters calculated from the derived quantities, which include Input/Output optical efficiency correction factors and Tx/Rx PD calibration factors.

Understanding Each Section

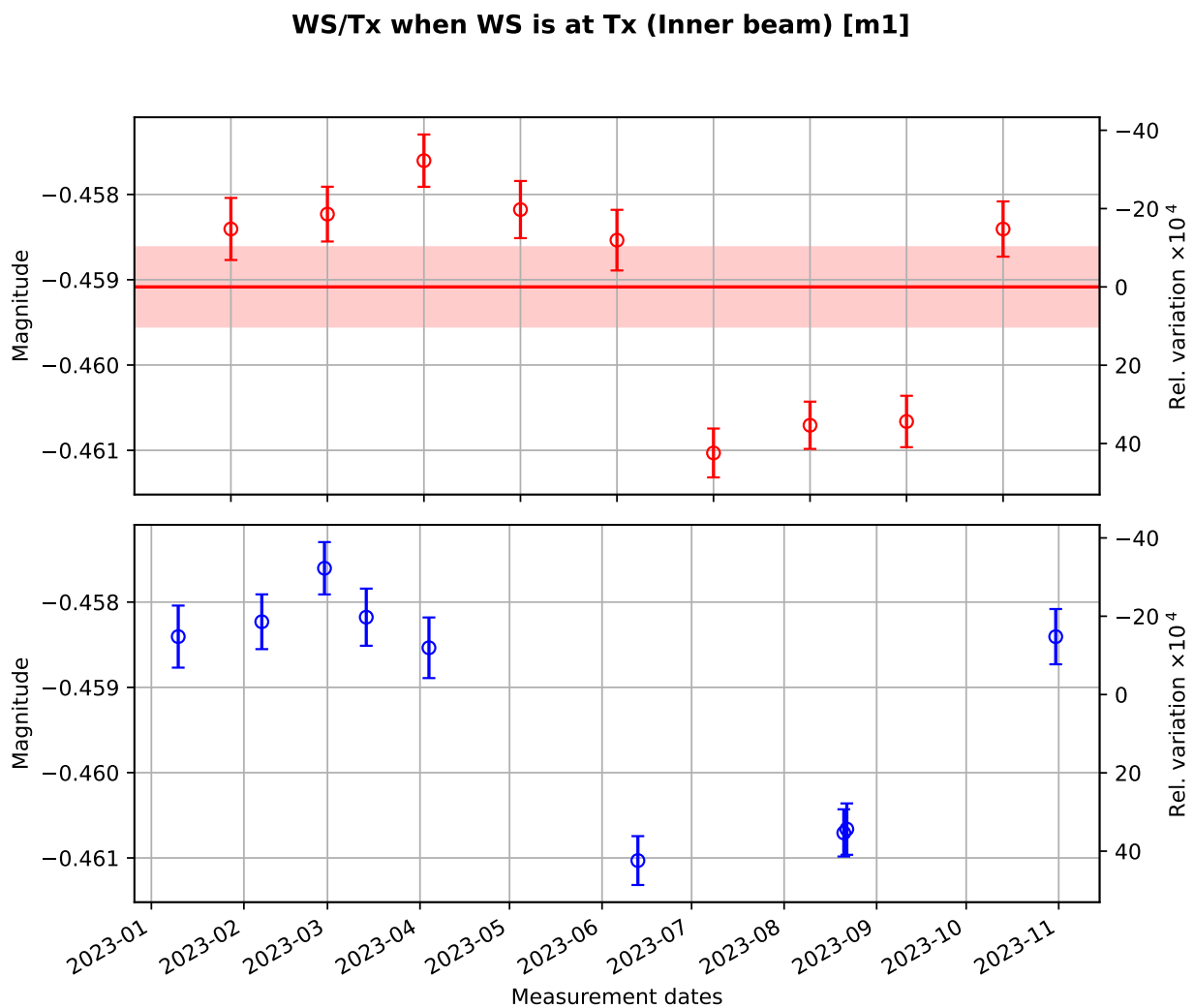
Each section contains a list of measurements with the mean value (m1), standard deviation on the mean (SD_m1) and a ratio of the standard deviation of the quantity and error bars for each measurement (frac). The list is followed by two plot figures with Magnitude on the Y axis and Index on the X axis for the first plot and the Magnitude on the Y axis and time on the X axis for the second. The error bars of each data point is the standard deviation SD_m1. Each section ends with a summary that contains the mean (the red line on the plot) along with their Standard Deviation, Std Err and Rel Err (the pink band on the plot) where each of these terms are defined as:

```
Mean = sum(x(i))/n
Std_Dev = sqrt(sum((x(i)-x_mean)^2)/(n-1))
Std_Err = Std_Dev*Student's_t_correction/sqrt(n)
Rel_Err = Std_Err/Mean
```

2 WS/Tx Ratio when WS is at Tx (Inner Beam)

List of Measurements

Date	m1 $\pm$ SD_m1
D20230110	-0.4584 $\pm$ 0.0004
D20230207	-0.4582 $\pm$ 0.0003
D20230228	-0.4576 $\pm$ 0.0003
D20230314	-0.4582 $\pm$ 0.0003
D20230404	-0.4585 $\pm$ 0.0004
D20230613	-0.4610 $\pm$ 0.0003
D20230821	-0.4607 $\pm$ 0.0003
D20230822	-0.4607 $\pm$ 0.0003
D20231031	-0.4584 $\pm$ 0.0003



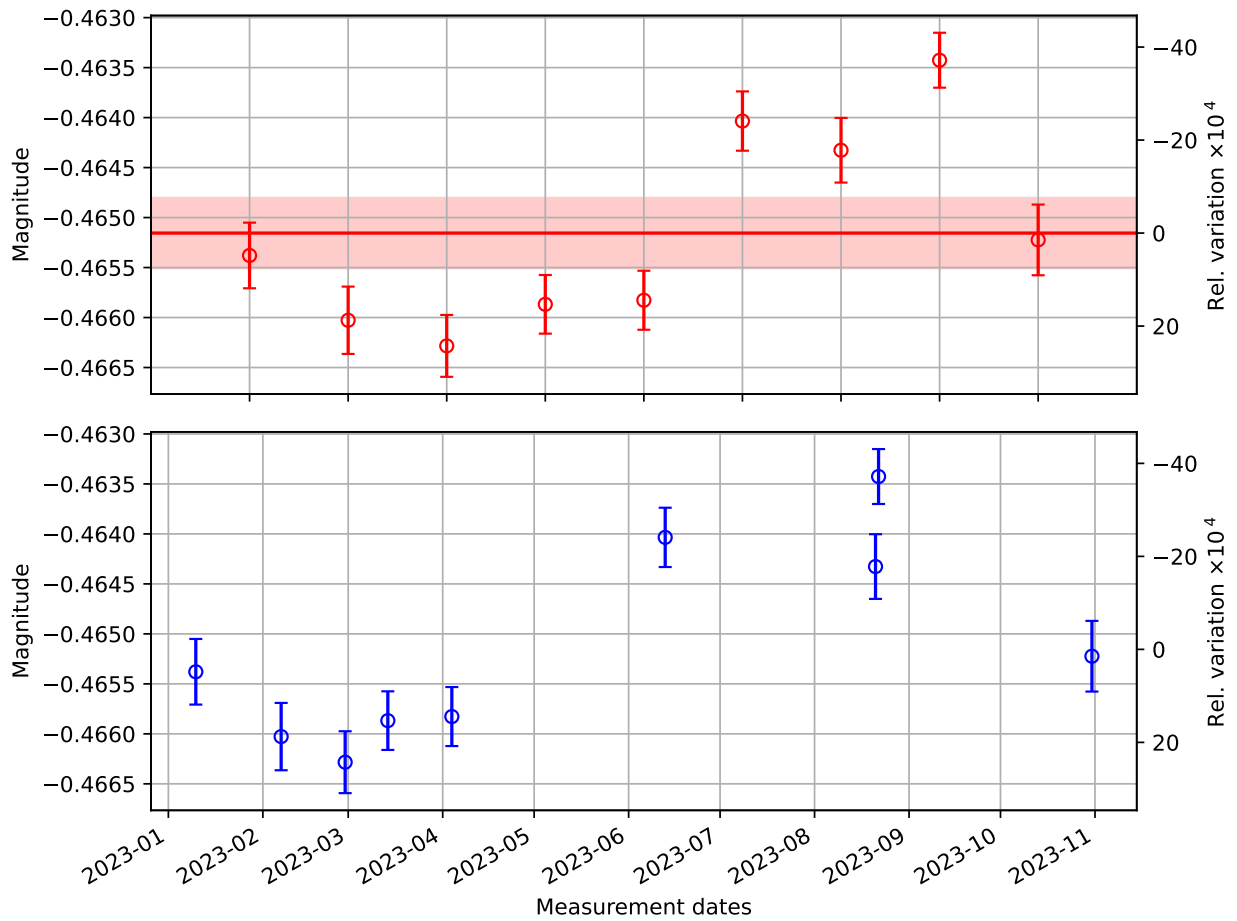
Summary of WS/Tx when WS is at Tx (Inner beam) [m1]		
Mean value:	-0.459084	
Standard deviation:	0.001317	
Standard error:	0.000465	
Relative Standard error:	-0.001012	

3 WS/Tx Ratio when WS is at Tx (Outer Beam)

List of Measurements

Date	m2 $\pm$ SD_m2
D20230110	-0.4654 $\pm$ 0.0003
D20230207	-0.4660 $\pm$ 0.0003
D20230228	-0.4663 $\pm$ 0.0003
D20230314	-0.4659 $\pm$ 0.0003
D20230404	-0.4658 $\pm$ 0.0003
D20230613	-0.4640 $\pm$ 0.0003
D20230821	-0.4643 $\pm$ 0.0003
D20230822	-0.4634 $\pm$ 0.0003
D20231031	-0.4652 $\pm$ 0.0004

WS/Tx when WS is at Tx (Outer Beam) [m2]



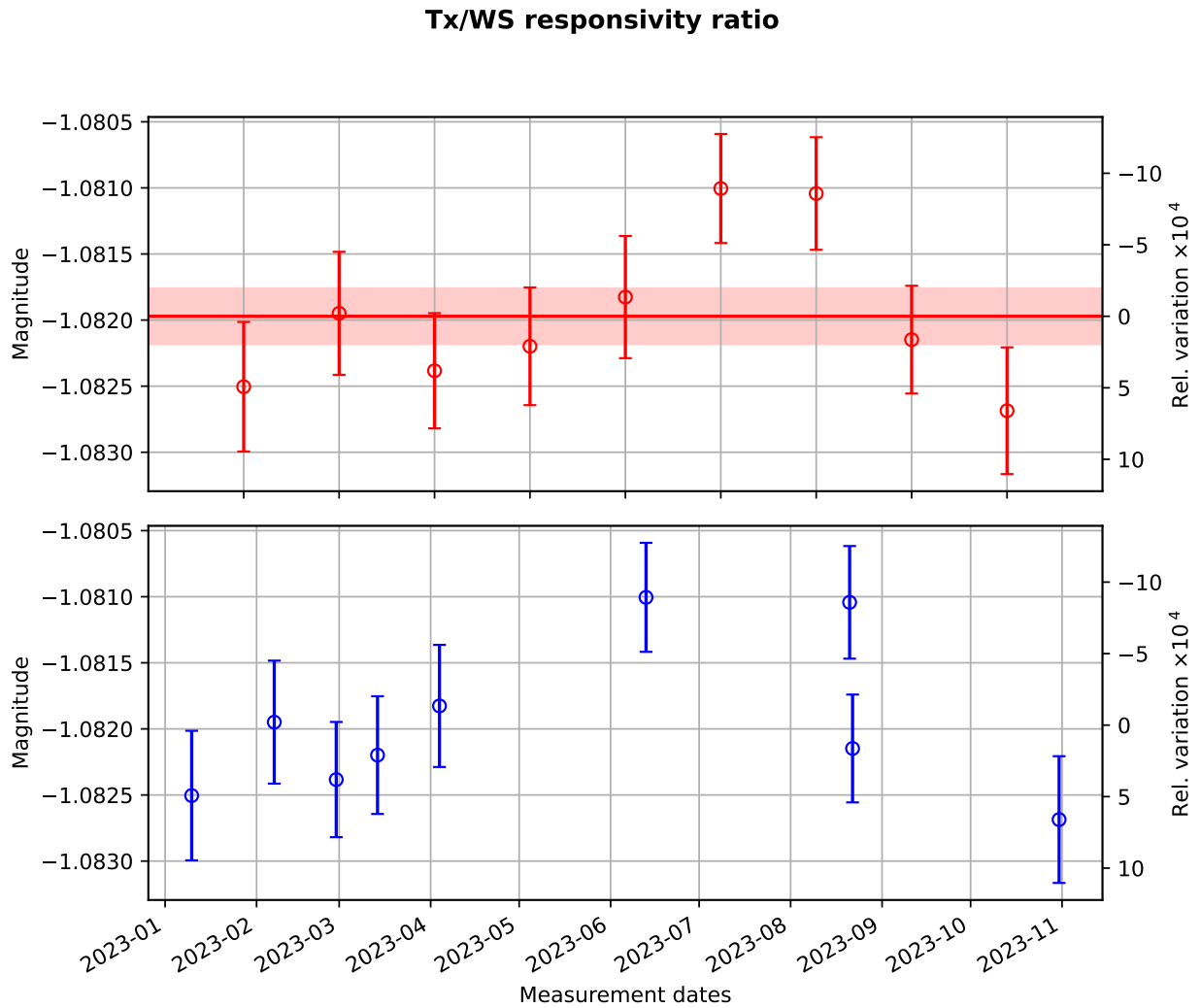
Summary of WS/Tx when WS is at Tx (Outer Beam) [m2]

Mean value:	-0.465155
Standard deviation:	0.000999
Standard error:	0.000352
Relative Standard error:	-0.000758

4 Tx/WS responsivity ratio $\alpha_{TW} = 1/[m1 + m2]$

List of Measurements

Date	TXWS $\pm$ SD_TXWS
D20230110	-1.0825 $\pm$ 0.0005
D20230207	-1.0819 $\pm$ 0.0005
D20230228	-1.0824 $\pm$ 0.0004
D20230314	-1.0822 $\pm$ 0.0004
D20230404	-1.0818 $\pm$ 0.0005
D20230613	-1.0810 $\pm$ 0.0004
D20230821	-1.0810 $\pm$ 0.0004
D20230822	-1.0821 $\pm$ 0.0004
D20231031	-1.0827 $\pm$ 0.0005



Summary of Tx/WS responsivity ratio

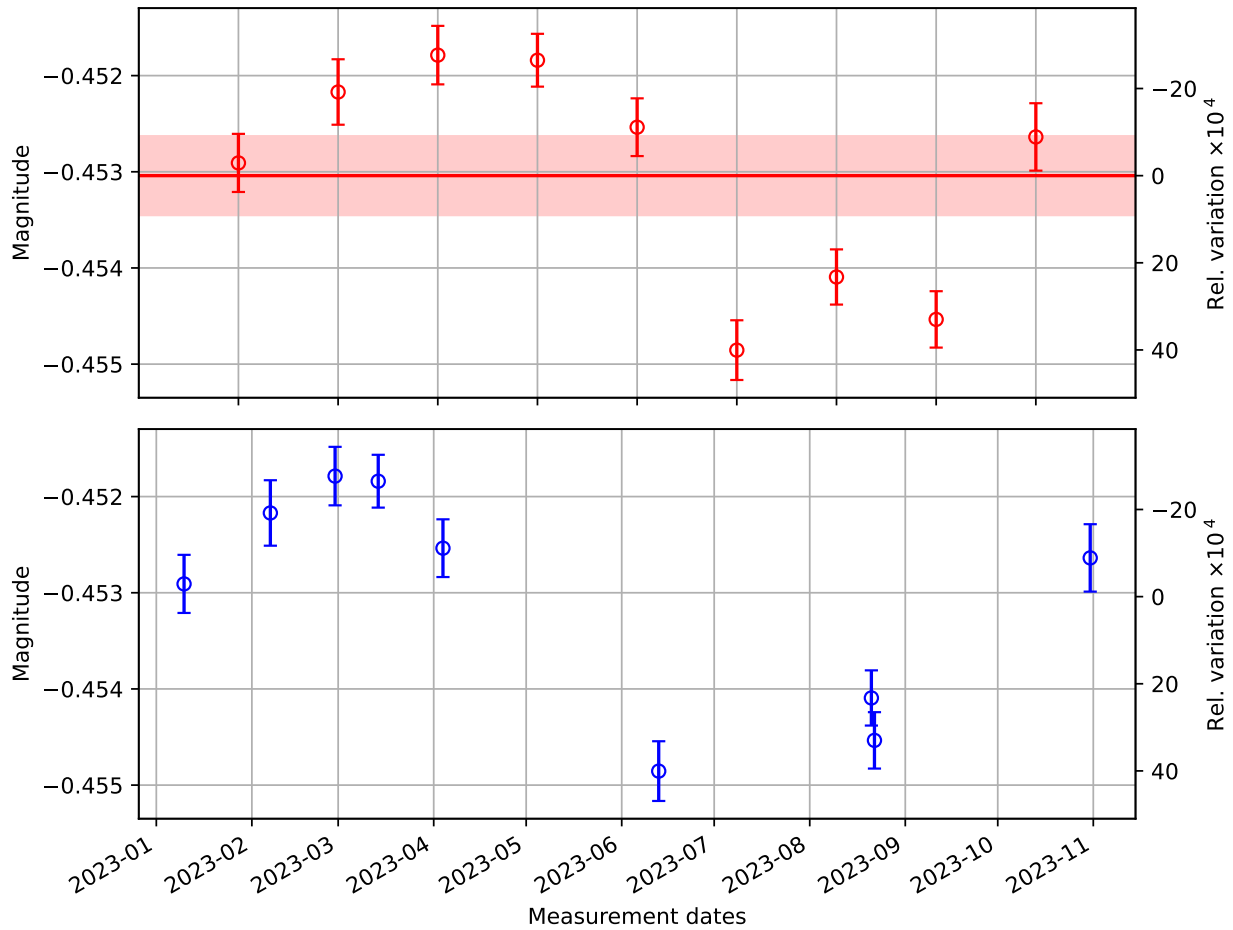
Mean value:	-1.081971
Standard deviation:	0.000599
Standard error:	0.000211
Relative Standard error:	-0.000195

5 WS/Tx Ratio when WS is at Rx (Inner Beam)

List of Measurements

Date	m3 $\pm$ SD_m3
D20230110	-0.4529 $\pm$ 0.0003
D20230207	-0.4522 $\pm$ 0.0003
D20230228	-0.4518 $\pm$ 0.0003
D20230314	-0.4518 $\pm$ 0.0003
D20230404	-0.4525 $\pm$ 0.0003
D20230613	-0.4549 $\pm$ 0.0003
D20230821	-0.4541 $\pm$ 0.0003
D20230822	-0.4545 $\pm$ 0.0003
D20231031	-0.4526 $\pm$ 0.0004

WS/Tx when WS is at Rx (Inner Beam) [m3]



Summary of WS/Tx when WS is at Rx (Inner Beam) [m3]

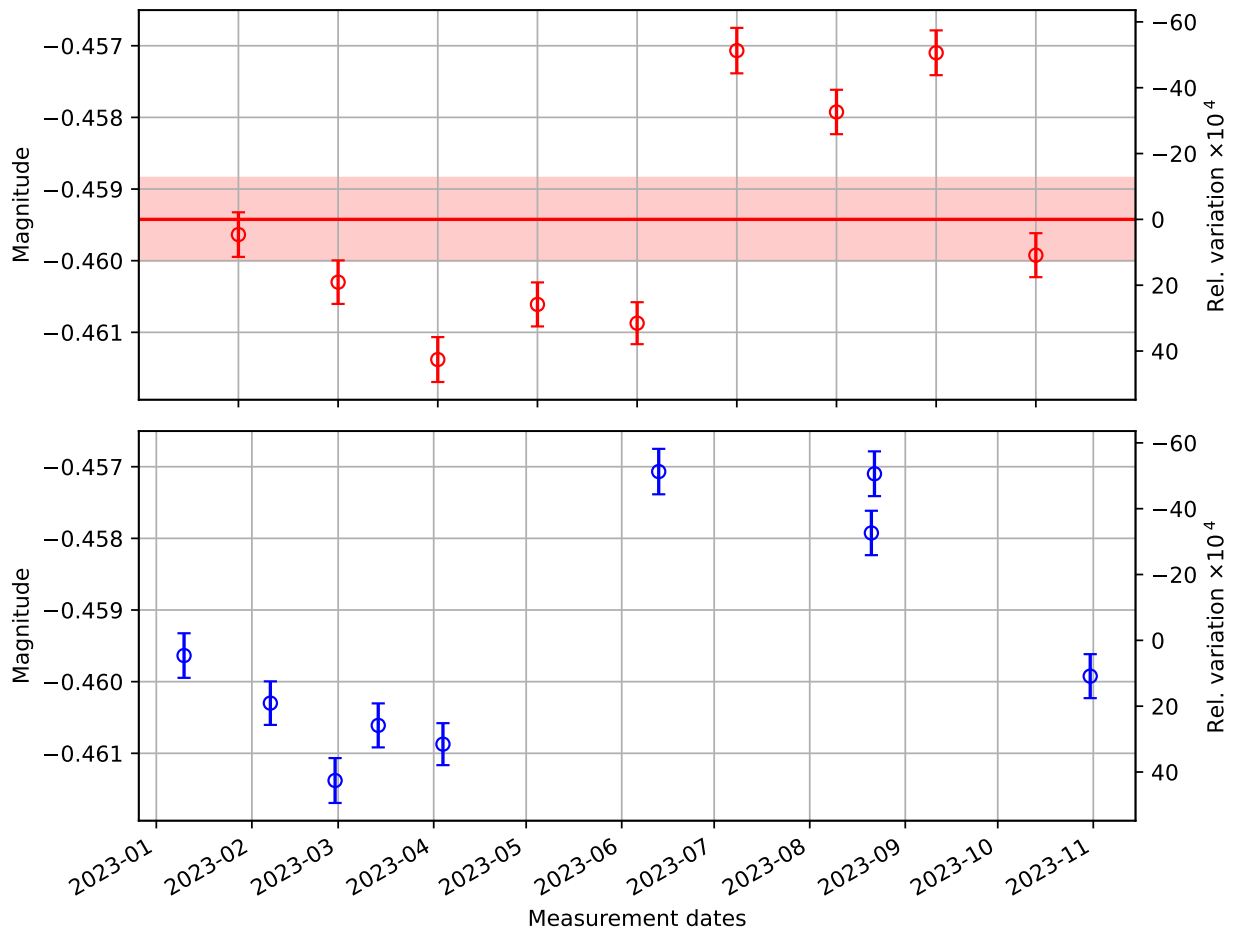
Mean value:	-0.453040
Standard deviation:	0.001164
Standard error:	0.000411
Relative Standard error:	-0.000907

6 WS/Tx Ratio when WS is at Rx (Outer Beam)

List of Measurements

Date	m4 $\pm$ SD_m4
D20230110	-0.4596 $\pm$ 0.0003
D20230207	-0.4603 $\pm$ 0.0003
D20230228	-0.4614 $\pm$ 0.0003
D20230314	-0.4606 $\pm$ 0.0003
D20230404	-0.4609 $\pm$ 0.0003
D20230613	-0.4571 $\pm$ 0.0003
D20230821	-0.4579 $\pm$ 0.0003
D20230822	-0.4571 $\pm$ 0.0003
D20231031	-0.4599 $\pm$ 0.0003

WS/Tx when WS is at Rx (Outer Beam) [m4]



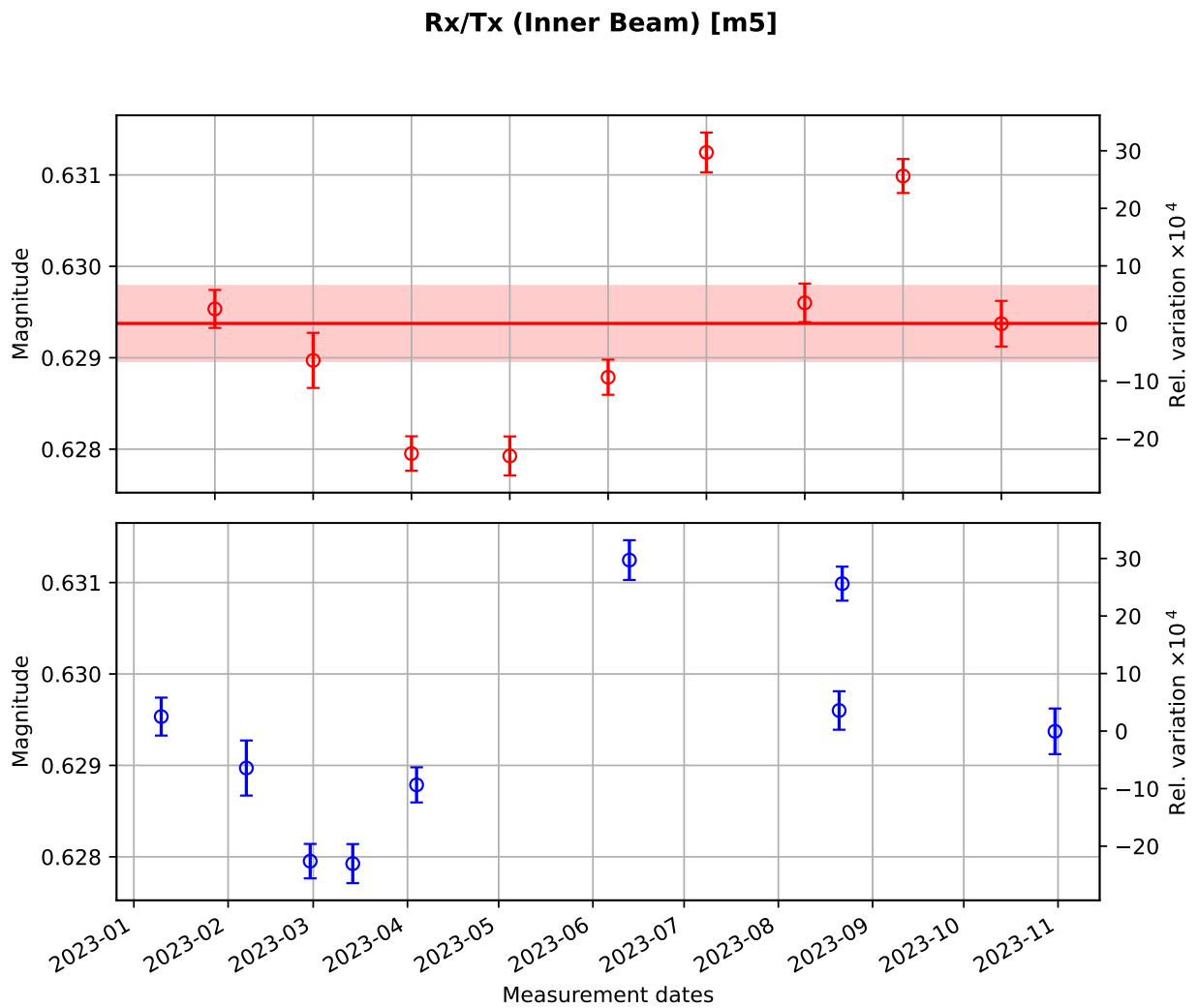
Summary of WS/Tx when WS is at Rx (Outer Beam) [m4]

Mean value:	-0.459423
Standard deviation:	0.001643
Standard error:	0.000580
Relative Standard error:	-0.001262

7 RX/TX Ratio (Inner Beam)

List of Measurements

Date	m5 $\pm$ SD_m5
D20230110	0.6295 $\pm$ 0.0002
D20230207	0.6290 $\pm$ 0.0003
D20230228	0.6280 $\pm$ 0.0002
D20230314	0.6279 $\pm$ 0.0002
D20230404	0.6288 $\pm$ 0.0002
D20230613	0.6312 $\pm$ 0.0002
D20230821	0.6296 $\pm$ 0.0002
D20230822	0.6310 $\pm$ 0.0002
D20231031	0.6294 $\pm$ 0.0002

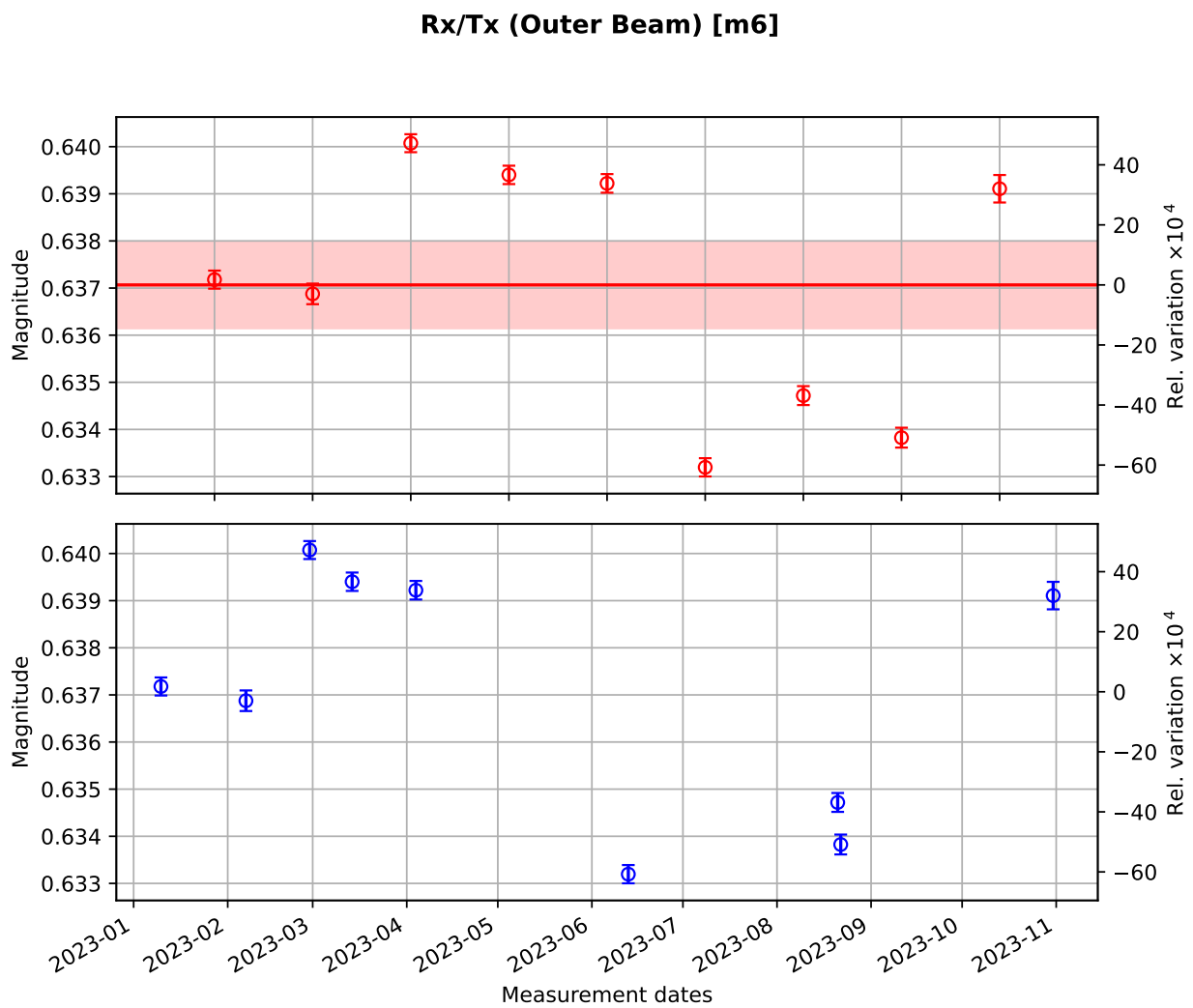


Summary of Rx/Tx (Inner Beam) [m5]		
Mean value:	0.629375	
Standard deviation:	0.001162	
Standard error:	0.000410	
Relative Standard error:	0.000652	

8 Rx/Tx Ratio (Outer Beam)

List of Measurements

Date	m6 $\pm$ SD_m6
D20230110	0.6372 $\pm$ 0.0002
D20230207	0.6369 $\pm$ 0.0002
D20230228	0.6401 $\pm$ 0.0002
D20230314	0.6394 $\pm$ 0.0002
D20230404	0.6392 $\pm$ 0.0002
D20230613	0.6332 $\pm$ 0.0002
D20230821	0.6347 $\pm$ 0.0002
D20230822	0.6338 $\pm$ 0.0002
D20231031	0.6391 $\pm$ 0.0003

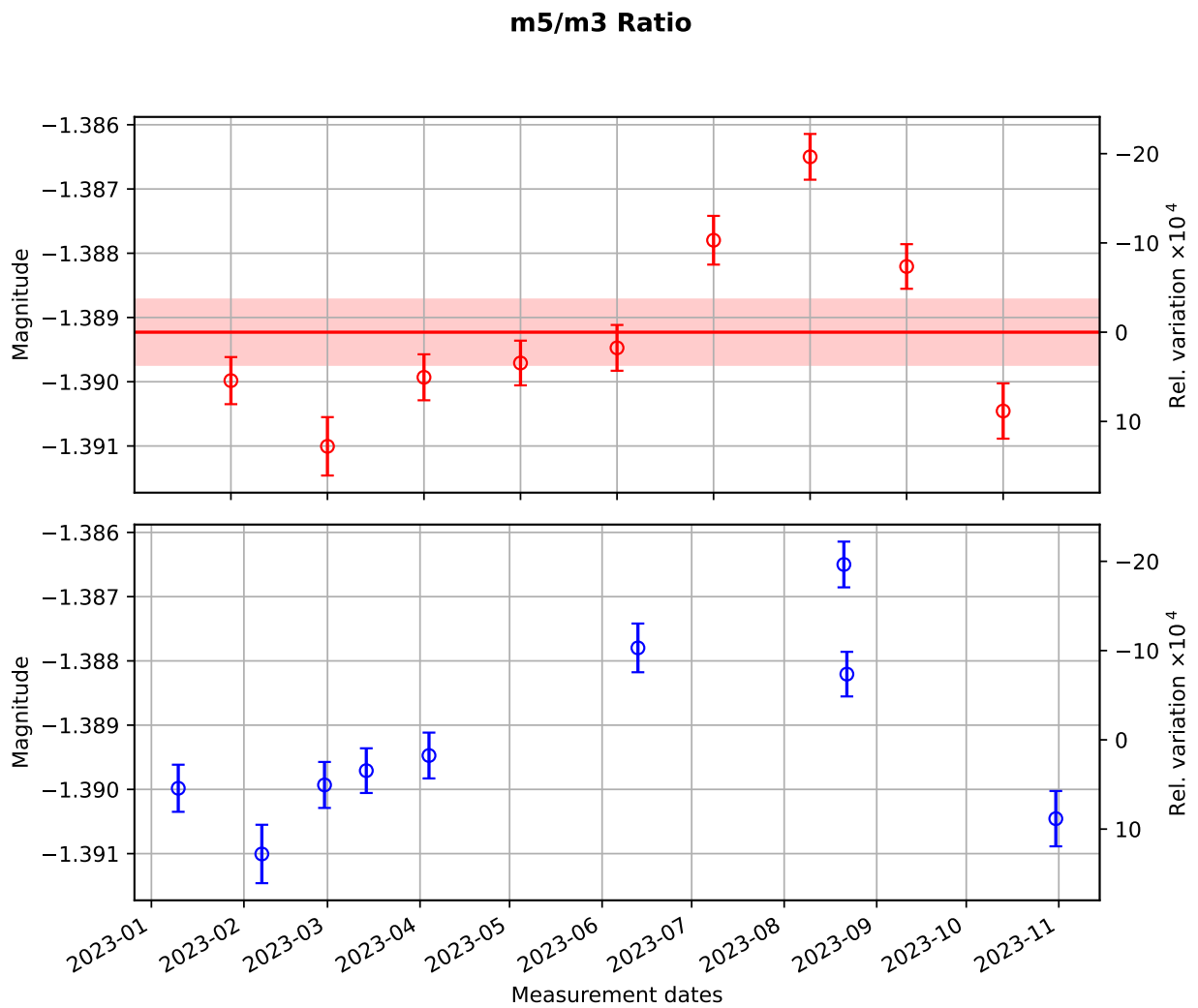


Summary of Rx/Tx (Outer Beam) [m6]		
Mean value:	0.637066	
Standard deviation:	0.002607	
Standard error:	0.000920	
Relative Standard error:	0.001444	

9 m5/m3 Ratio

List of Measurements

Date	RiTWrIT $\pm$ SD_RiTWrIT
D20230110	-1.3900 $\pm$ 0.0004
D20230207	-1.3910 $\pm$ 0.0005
D20230228	-1.3899 $\pm$ 0.0004
D20230314	-1.3897 $\pm$ 0.0003
D20230404	-1.3895 $\pm$ 0.0004
D20230613	-1.3878 $\pm$ 0.0004
D20230821	-1.3865 $\pm$ 0.0004
D20230822	-1.3882 $\pm$ 0.0003
D20231031	-1.3905 $\pm$ 0.0004



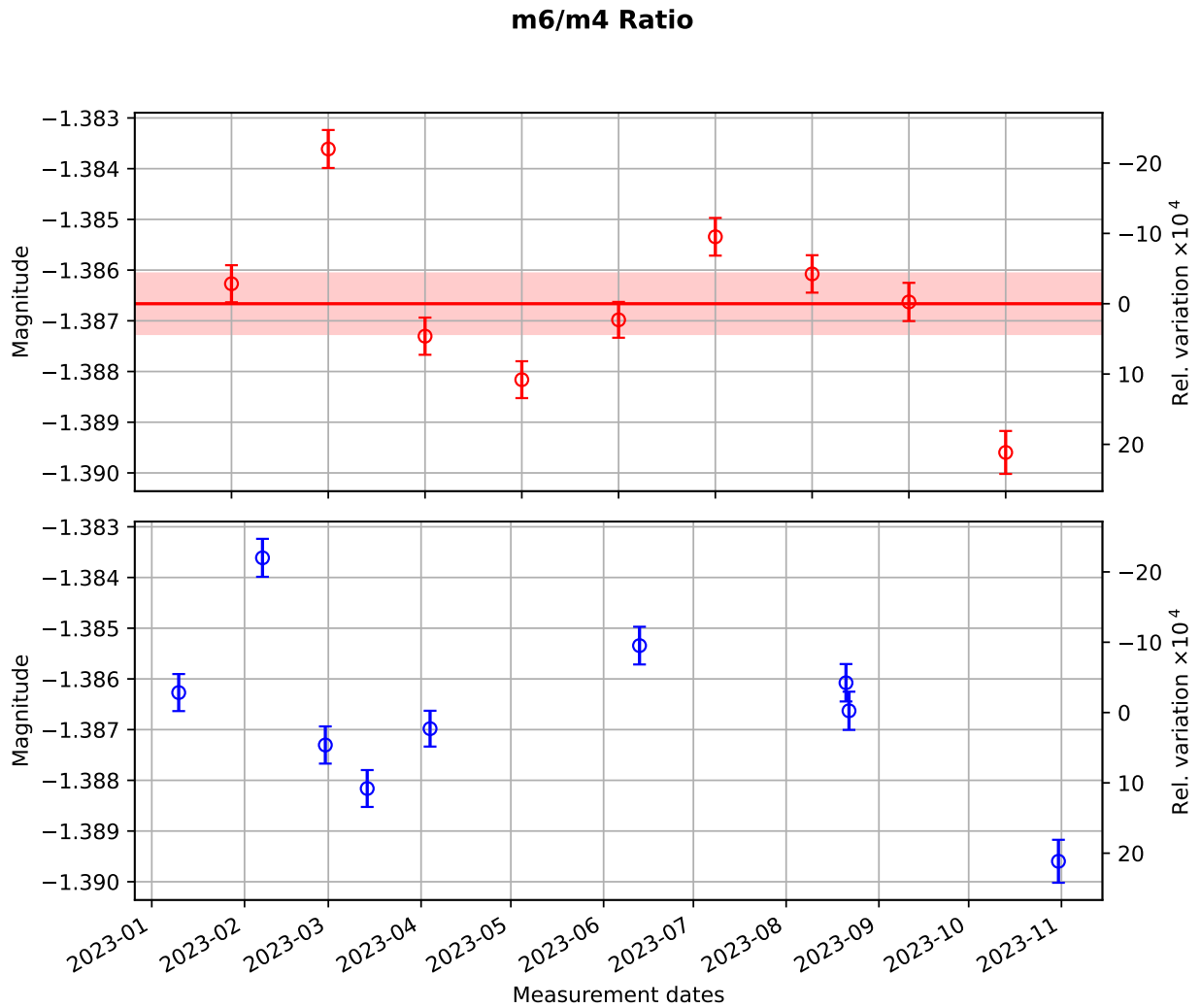
Summary of m5/m3 Ratio

Mean value:	-1.389229
Standard deviation:	0.001439
Standard error:	0.000508
Relative Standard error:	-0.000365

10 m6/m4 Ratio

List of Measurements

Date	RoTWroT $\pm$ SD_RoTWroT
D20230110	-1.3863 $\pm$ 0.0004
D20230207	-1.3836 $\pm$ 0.0004
D20230228	-1.3873 $\pm$ 0.0004
D20230314	-1.3882 $\pm$ 0.0004
D20230404	-1.3870 $\pm$ 0.0004
D20230613	-1.3853 $\pm$ 0.0004
D20230821	-1.3861 $\pm$ 0.0004
D20230822	-1.3866 $\pm$ 0.0004
D20231031	-1.3896 $\pm$ 0.0004

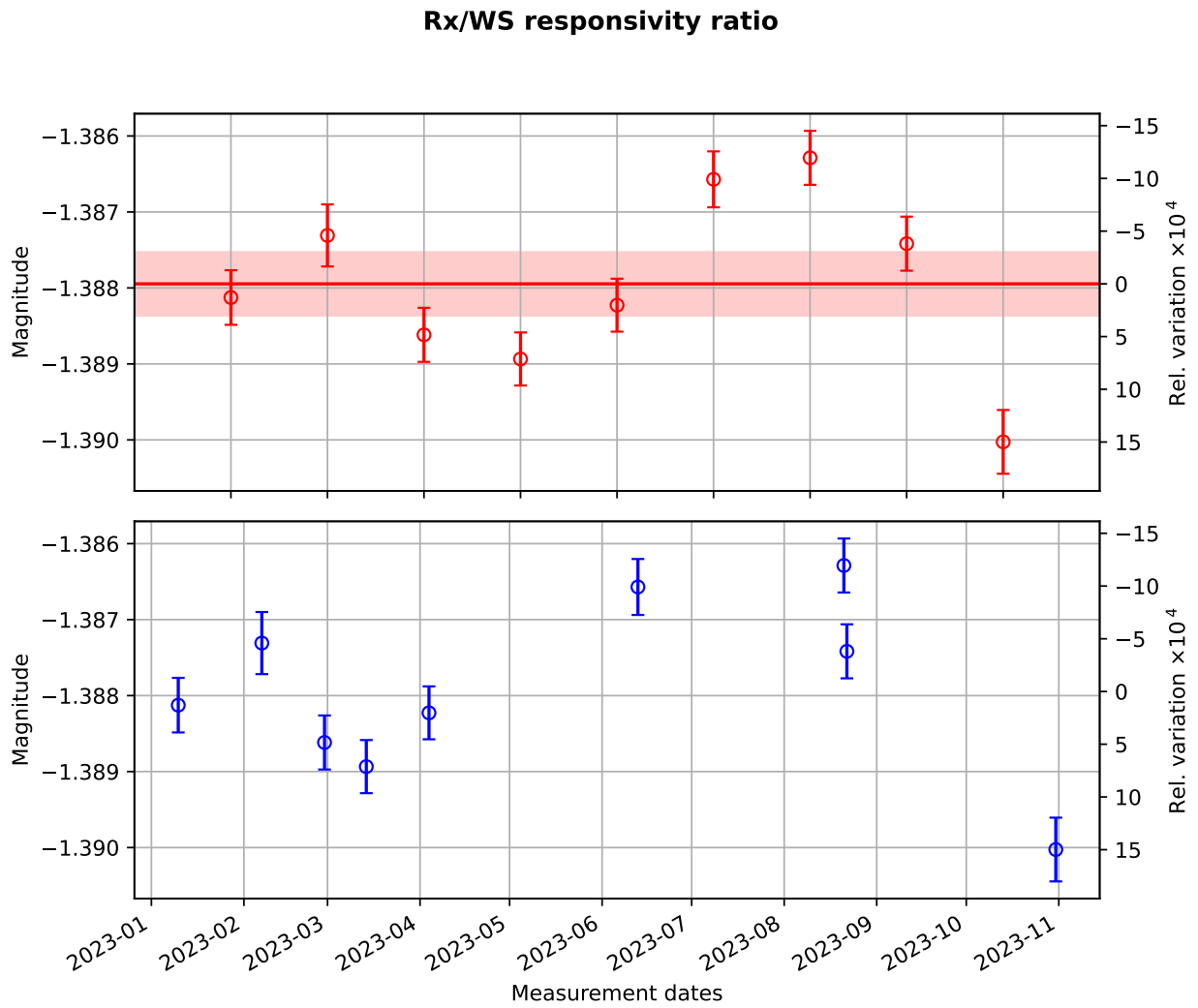


Summary of m6/m4 Ratio		
Mean value:	-1.38664	
Standard deviation:	0.001692	
Standard error:	0.000597	
Relative Standard error:	-0.000431	

11 Rx/WS responsivity ratio $\alpha_{RW} = \frac{1}{2} [m5/m3 + m6/m4]$

List of Measurements

Date	RXWS $\pm$ SD_RXWS
D20230110	-1.3881 $\pm$ 0.0004
D20230207	-1.3873 $\pm$ 0.0004
D20230228	-1.3886 $\pm$ 0.0004
D20230314	-1.3889 $\pm$ 0.0003
D20230404	-1.3882 $\pm$ 0.0003
D20230613	-1.3866 $\pm$ 0.0004
D20230821	-1.3863 $\pm$ 0.0004
D20230822	-1.3874 $\pm$ 0.0004
D20231031	-1.3900 $\pm$ 0.0004



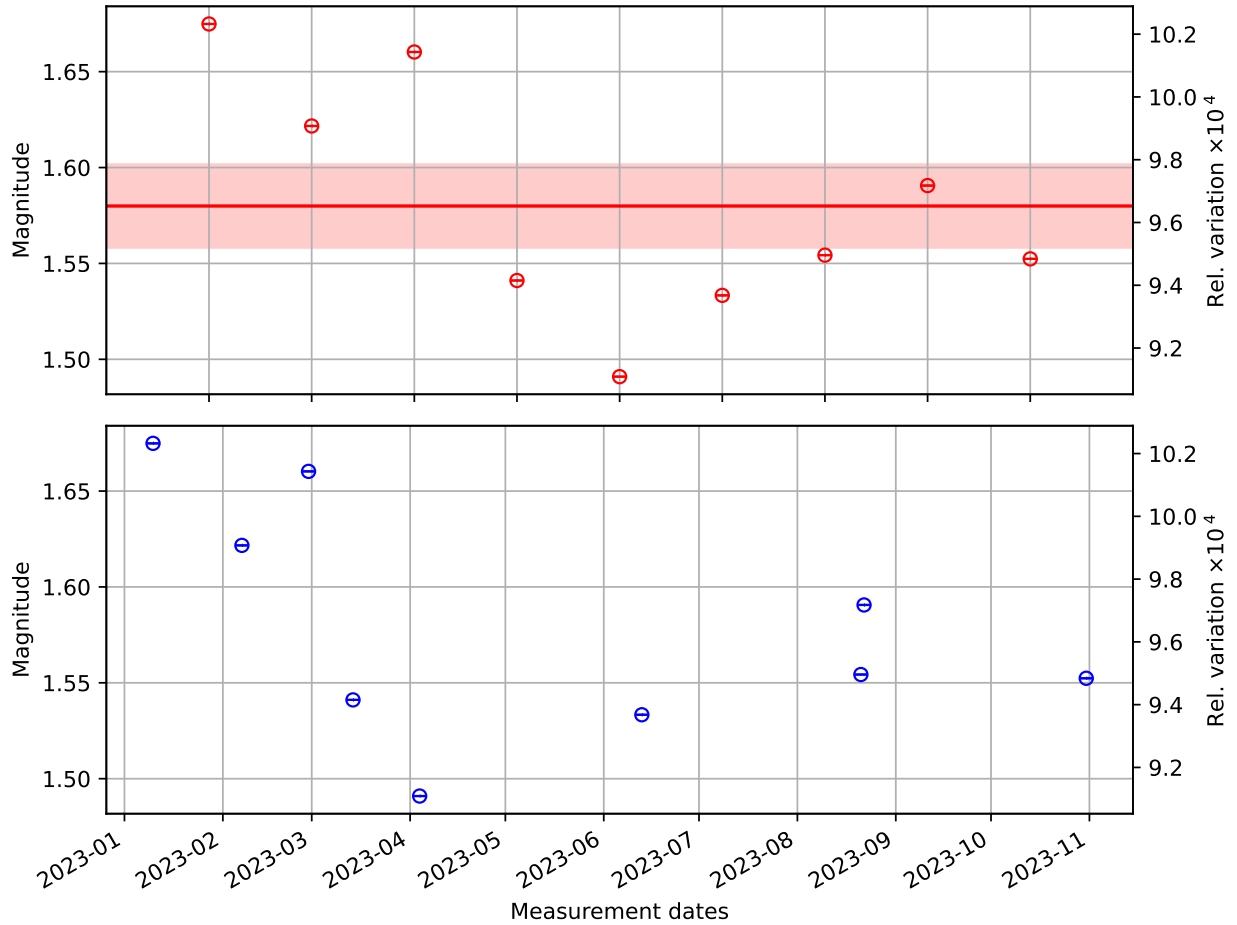
Summary of Rx/WS responsivity ratio		
Mean value:	-1.387946	
Standard deviation:	0.001183	
Standard error:	0.000417	
Relative Standard error:	-0.000301	

12 ADC conversion factor (ζ)

List of Measurements

Date	$\zeta \pm \text{SD}_\zeta$
D20230110	$1.6367\text{e}+03 \pm 1.0000\text{e}-09$
D20230207	$1.6368\text{e}+03 \pm 1.0000\text{e}-09$
D20230228	$1.6367\text{e}+03 \pm 1.0000\text{e}-09$
D20230314	$1.6369\text{e}+03 \pm 1.0000\text{e}-09$
D20230404	$1.6369\text{e}+03 \pm 1.0000\text{e}-09$
D20230613	$1.6369\text{e}+03 \pm 1.0000\text{e}-09$
D20230821	$1.6368\text{e}+03 \pm 1.0000\text{e}-09$
D20230822	$1.6368\text{e}+03 \pm 1.0000\text{e}-09$
D20231031	$1.6368\text{e}+03 \pm 1.0000\text{e}-09$

ADC conversion factor discrepancy ($1638.4 - \zeta$ (ct/V))



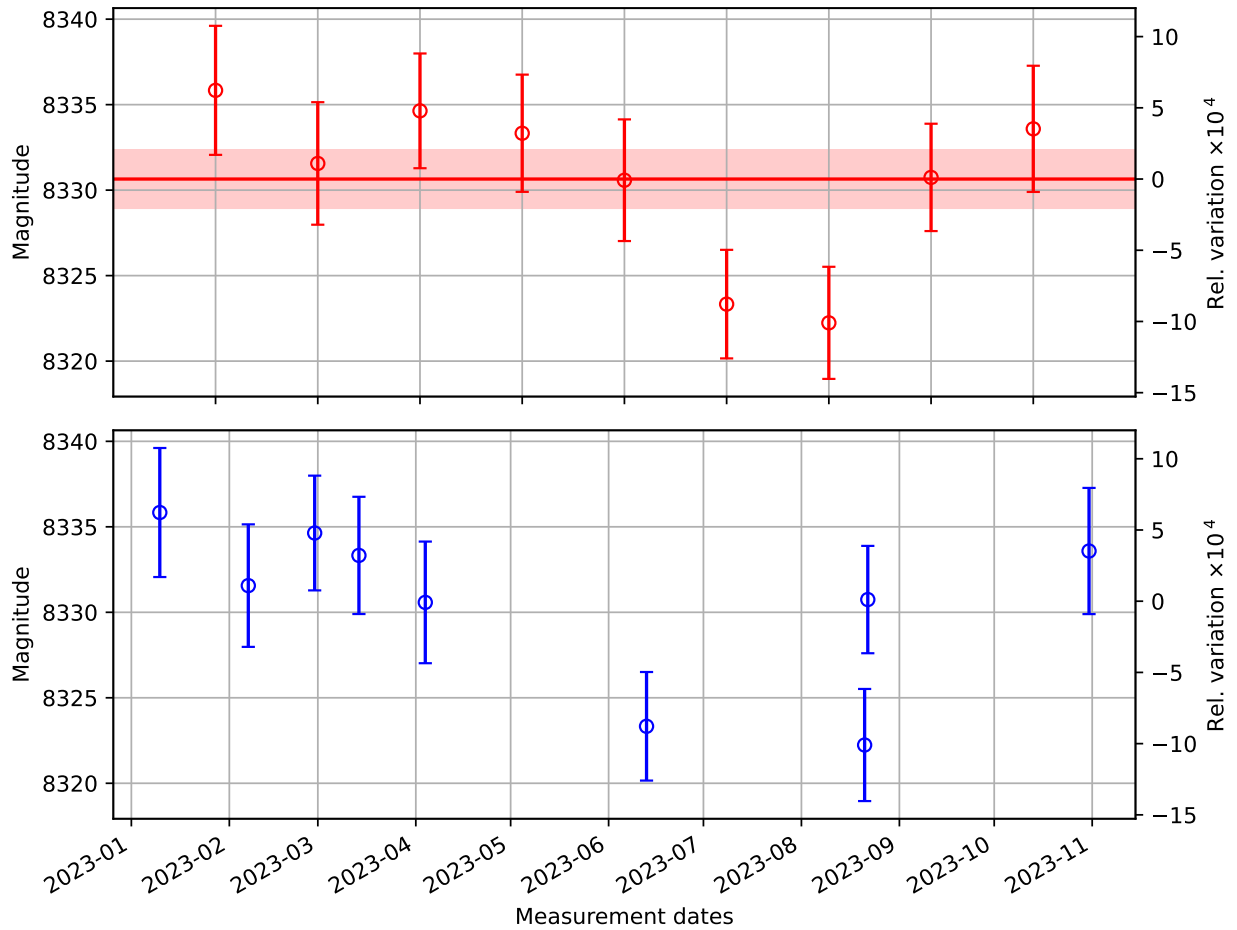
| Summary of ADC conversion factor discrepancy

13 TxPD calibration ($\rho_{Tx} = \rho_G \cdot \alpha_{WG} \cdot \alpha_{TW} \cdot \zeta$)

List of Measurements

Date	rhoTx $\pm$ SD_rhoTx
D20230110	8335.8363 $\pm$ 3.7737
D20230207	8331.5608 $\pm$ 3.5832
D20230228	8334.6371 $\pm$ 3.3555
D20230314	8333.3272 $\pm$ 3.4285
D20230404	8330.5796 $\pm$ 3.5576
D20230613	8323.3328 $\pm$ 3.1747
D20230821	8322.2378 $\pm$ 3.2788
D20230822	8330.7448 $\pm$ 3.1393
D20231031	8333.5847 $\pm$ 3.6905

TxPD calibration (ct/W)



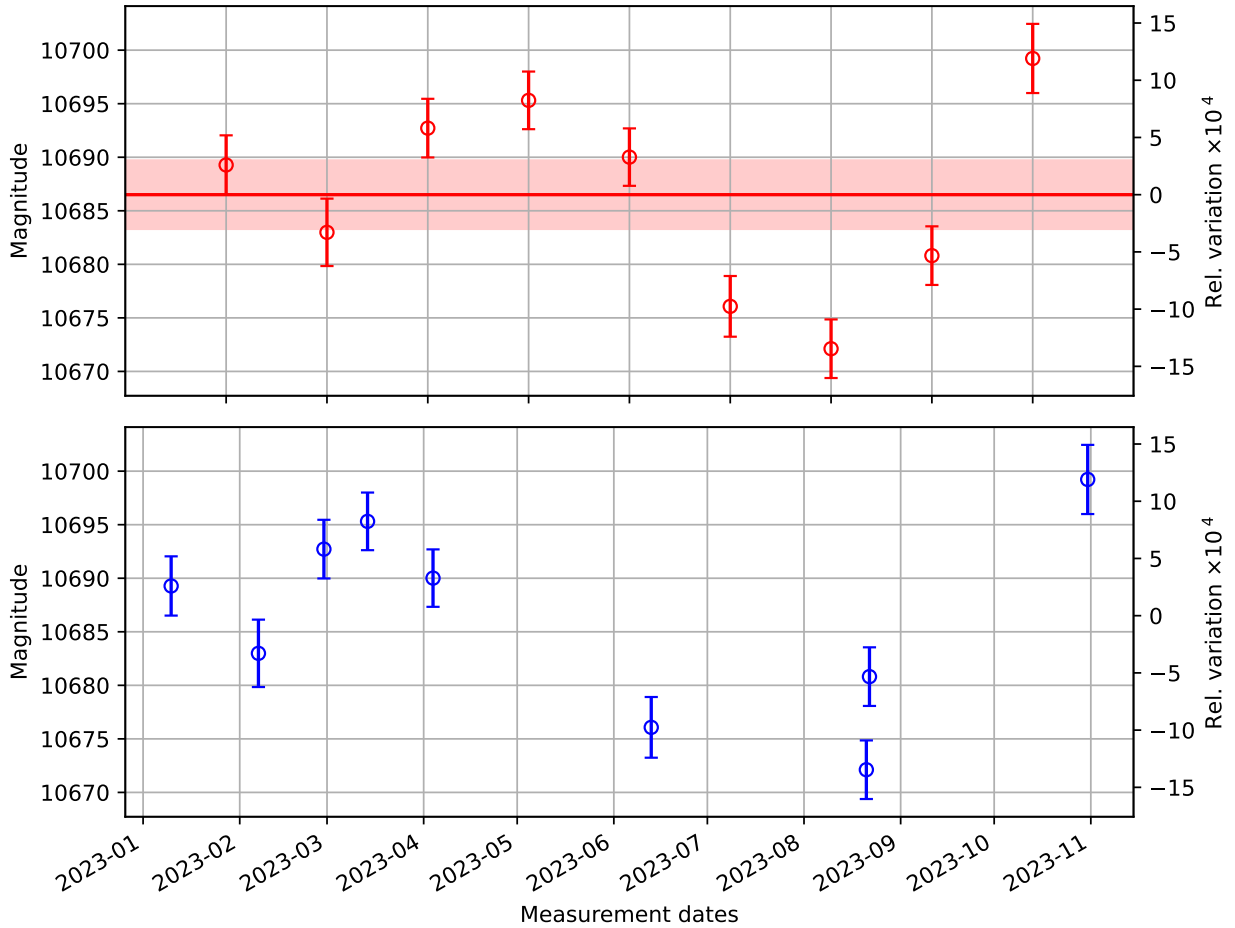
Summary of TxPD calibration (ct/W)		
Mean value:	8330.649006	
Standard deviation:	4.792254	
Standard error:	1.691231	
Relative Standard error:	0.000203	

14 RxPD calibration ($\rho_{Rx} = \rho_G \cdot \alpha_{WG} \cdot \alpha_{RW} \cdot \zeta$)

List of Measurements

Date	rhoRx $\pm$ SD_rhoRx
D20230110	10689.2786 $\pm$ 2.7664
D20230207	10682.9872 $\pm$ 3.1471
D20230228	10692.7178 $\pm$ 2.7391
D20230314	10695.3109 $\pm$ 2.6911
D20230404	10690.0120 $\pm$ 2.6817
D20230613	10676.0753 $\pm$ 2.8342
D20230821	10672.1188 $\pm$ 2.7358
D20230822	10680.8116 $\pm$ 2.7371
D20231031	10699.2242 $\pm$ 3.2295

RxPD calibration (ct/W)



Summary of RxPD calibration (ct/W)

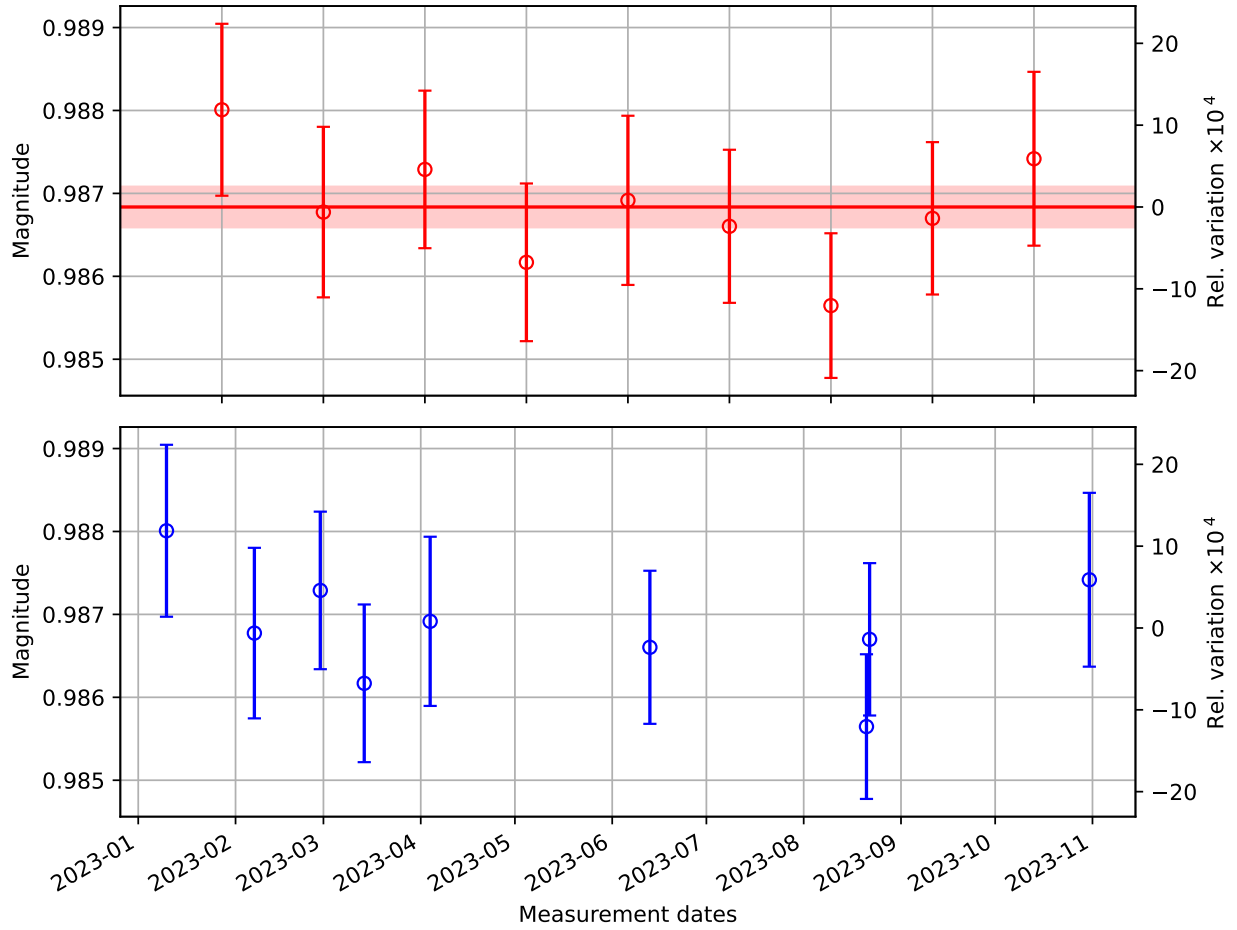
Mean value:	10686.504041
Standard deviation:	9.072234
Standard error:	3.201675
Relative Standard error:	0.000300

15 Optical Efficiency of Inner Beam $e^i = m3/m1$

List of Measurements

Date	$e_i \pm SD_{e_i}$
D20230110	0.9880 ± 0.0010
D20230207	0.9868 ± 0.0010
D20230228	0.9873 ± 0.0009
D20230314	0.9862 ± 0.0010
D20230404	0.9869 ± 0.0010
D20230613	0.9866 ± 0.0009
D20230821	0.9856 ± 0.0009
D20230822	0.9867 ± 0.0009
D20231031	0.9874 ± 0.0010

Optical Efficiency (Inner Beam)



Summary of Optical Efficiency (Inner Beam)

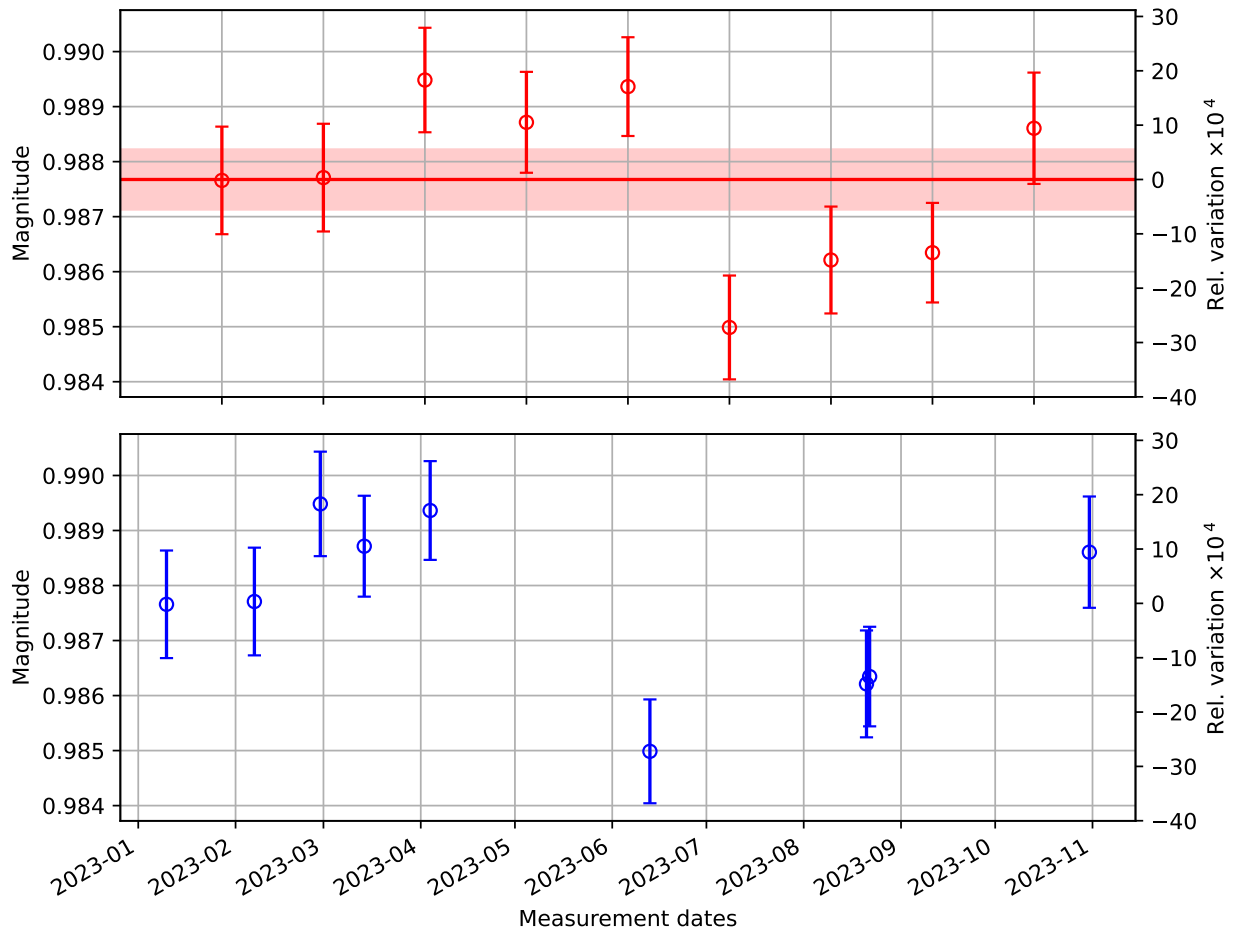
Mean value:	0.986836
Standard deviation:	0.000695
Standard error:	0.000245
Relative Standard error:	0.000248

16 Optical Efficiency of Outer Beam $e^o = m_4/m_2$

List of Measurements

Date	$e_o \pm SD_{e_o}$
D20230110	0.9877 ± 0.0010
D20230207	0.9877 ± 0.0010
D20230228	0.9895 ± 0.0009
D20230314	0.9887 ± 0.0009
D20230404	0.9894 ± 0.0009
D20230613	0.9850 ± 0.0009
D20230821	0.9862 ± 0.0010
D20230822	0.9863 ± 0.0009
D20231031	0.9886 ± 0.0010

Optical Efficiency (Outer Beam)



Summary of Optical Efficiency (Outer Beam)

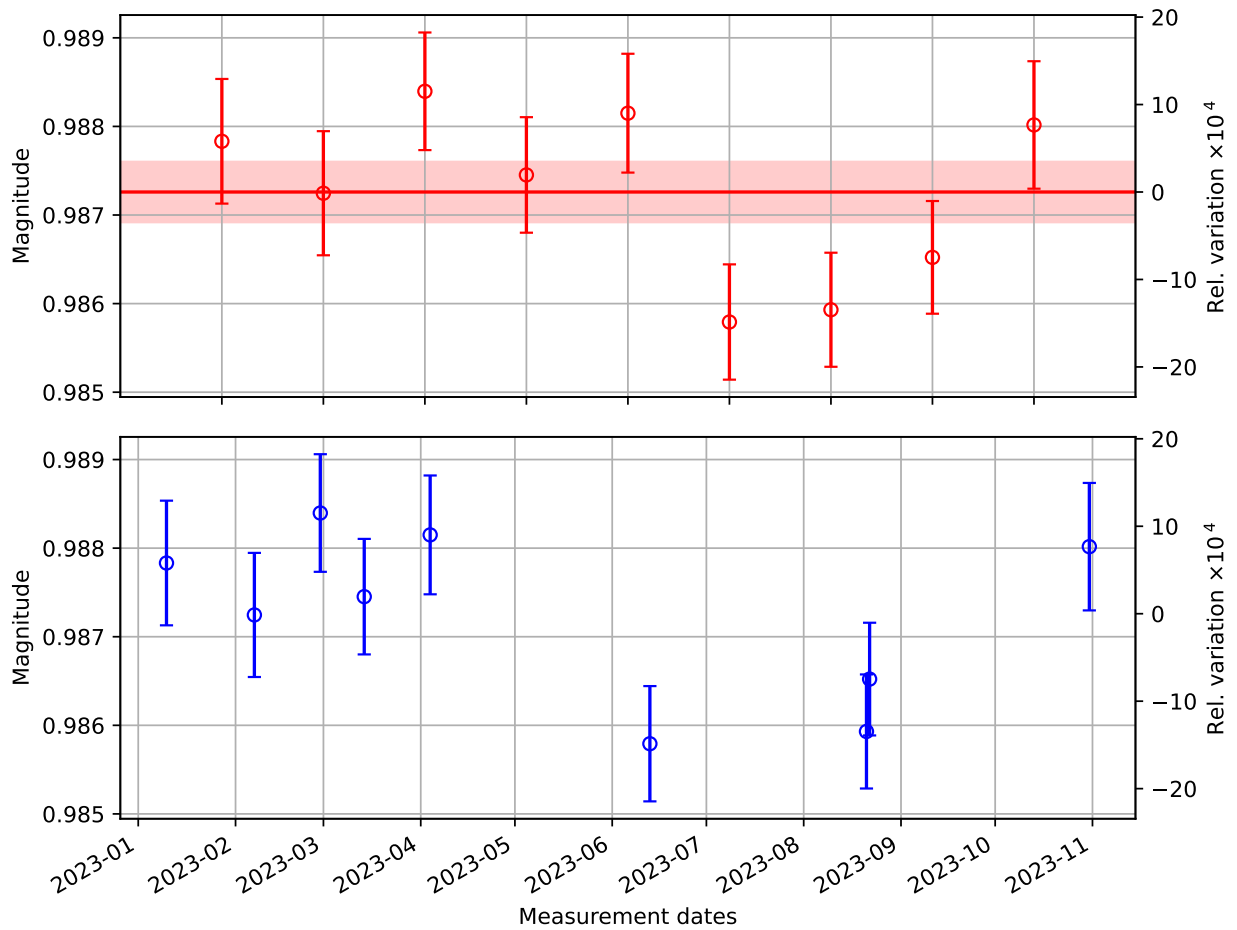
Mean value:	0.987676
Standard deviation:	0.001549
Standard error:	0.000547
Relative Standard error:	0.000554

17 Total Optical Efficiency $e = (m3 + m4)/(m1 + m2)$

List of Measurements

Date	$e \pm SD_e$
D20230110	0.9878 ± 0.0007
D20230207	0.9872 ± 0.0007
D20230228	0.9884 ± 0.0007
D20230314	0.9875 ± 0.0007
D20230404	0.9881 ± 0.0007
D20230613	0.9858 ± 0.0007
D20230821	0.9859 ± 0.0006
D20230822	0.9865 ± 0.0006
D20231031	0.9880 ± 0.0007

Overall Optical Efficiency



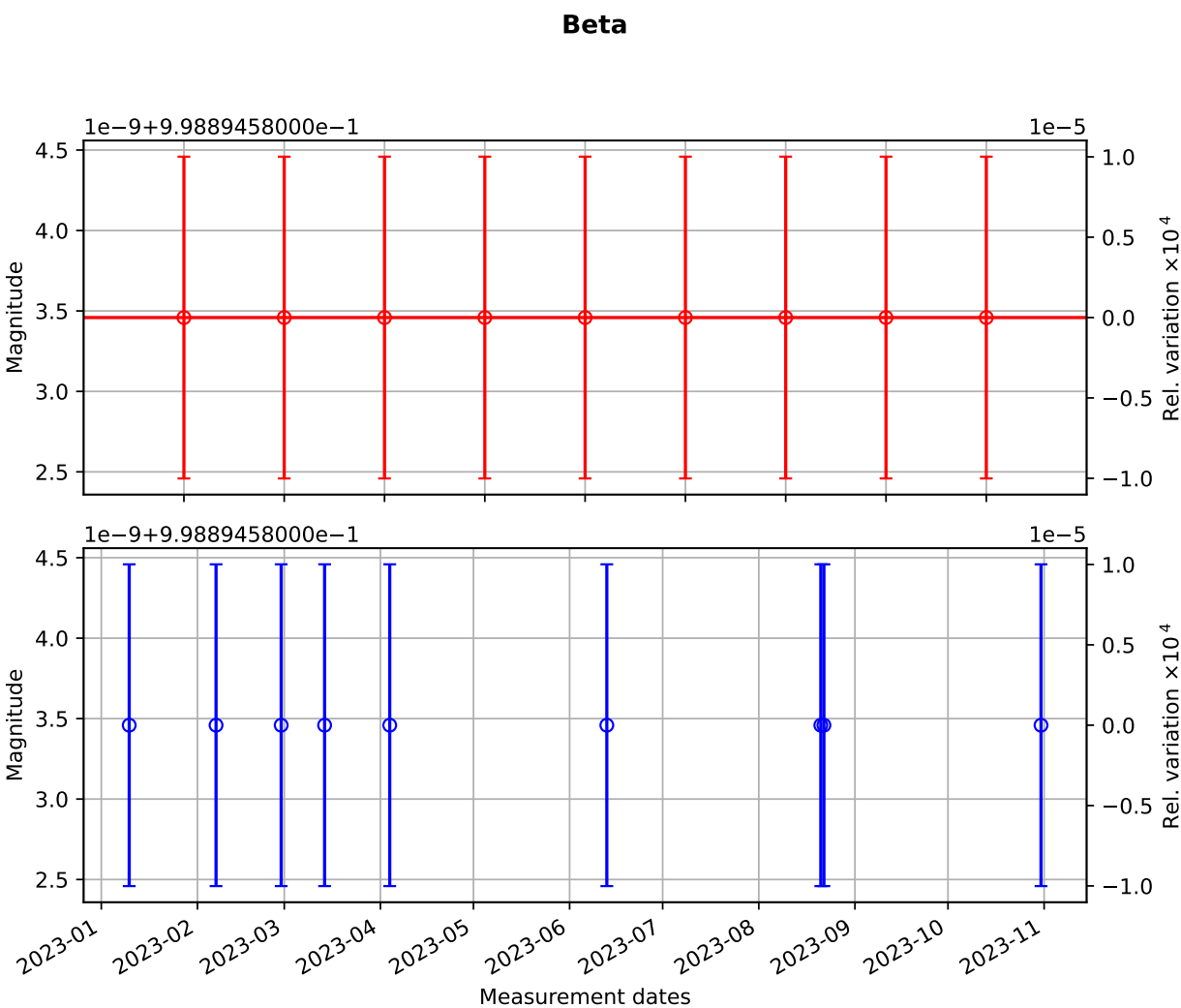
Summary of Overall Optical Efficiency

Mean value:	0.987260
Standard deviation:	0.000967
Standard error:	0.000341
Relative Standard error:	0.000346

18 Input/Output optical efficiency ratio (β)

List of Measurements

Date	beta $\pm$ SD_beta
D20230110	9.9889e-01 $\pm$ 1.0000e-09
D20230207	9.9889e-01 $\pm$ 1.0000e-09
D20230228	9.9889e-01 $\pm$ 1.0000e-09
D20230314	9.9889e-01 $\pm$ 1.0000e-09
D20230404	9.9889e-01 $\pm$ 1.0000e-09
D20230613	9.9889e-01 $\pm$ 1.0000e-09
D20230821	9.9889e-01 $\pm$ 1.0000e-09
D20230822	9.9889e-01 $\pm$ 1.0000e-09
D20231031	9.9889e-01 $\pm$ 1.0000e-09



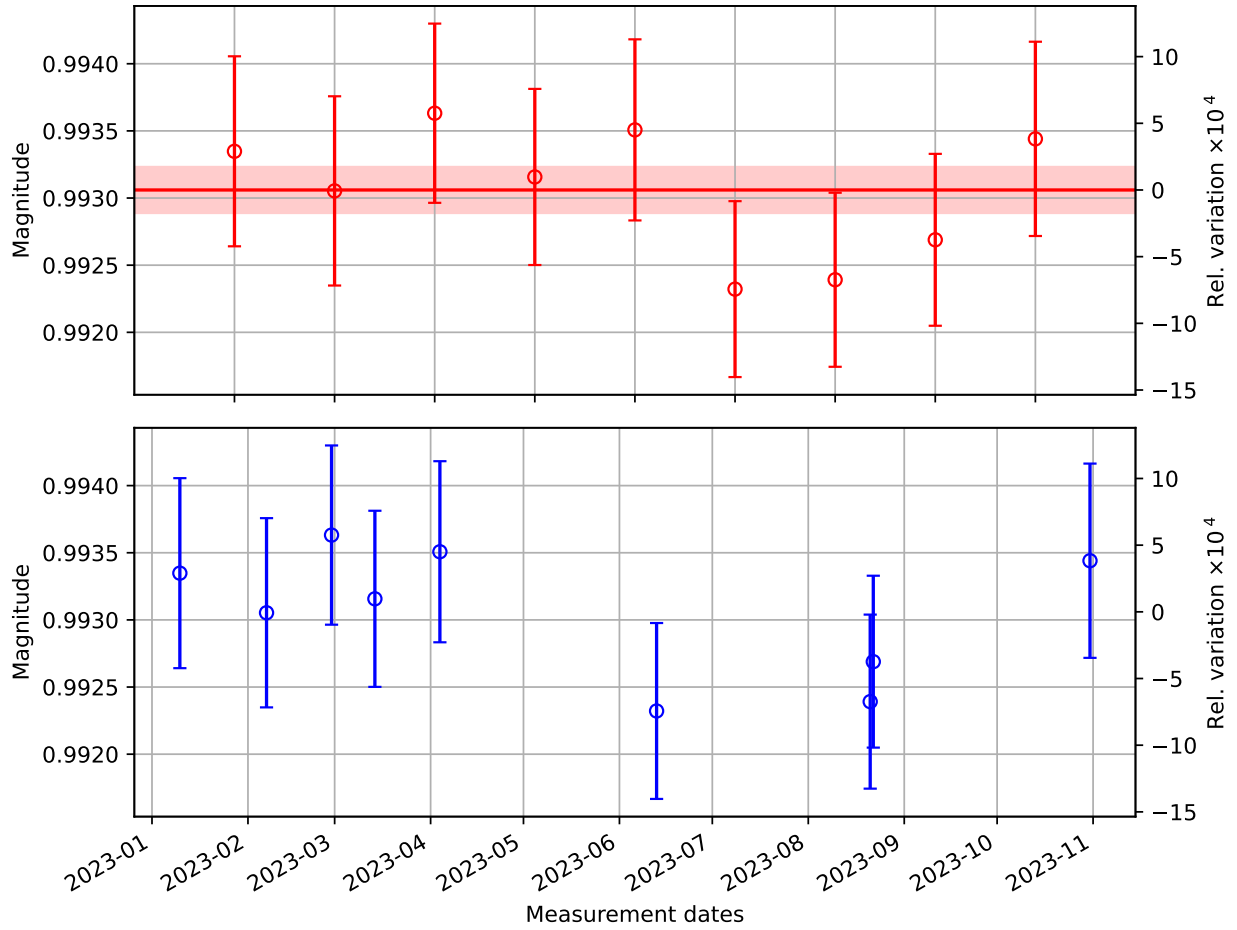
Summary of Beta	
Mean value:	0.998895
Standard deviation:	0.000000
Standard error:	0.000000
Relative Standard error:	0.000000

19 Input Optical efficiency correction factor ($\eta_T = \sqrt{e \cdot \beta}$)

List of Measurements

Date	E_T $\pm$ SD_E_T
D20230110	0.9933 $\pm$ 0.0007
D20230207	0.9931 $\pm$ 0.0007
D20230228	0.9936 $\pm$ 0.0007
D20230314	0.9932 $\pm$ 0.0007
D20230404	0.9935 $\pm$ 0.0007
D20230613	0.9923 $\pm$ 0.0007
D20230821	0.9924 $\pm$ 0.0006
D20230822	0.9927 $\pm$ 0.0006
D20231031	0.9934 $\pm$ 0.0007

Input Side Optical Efficiency correction factor



Summary of Input Side Optical Efficiency correction factor

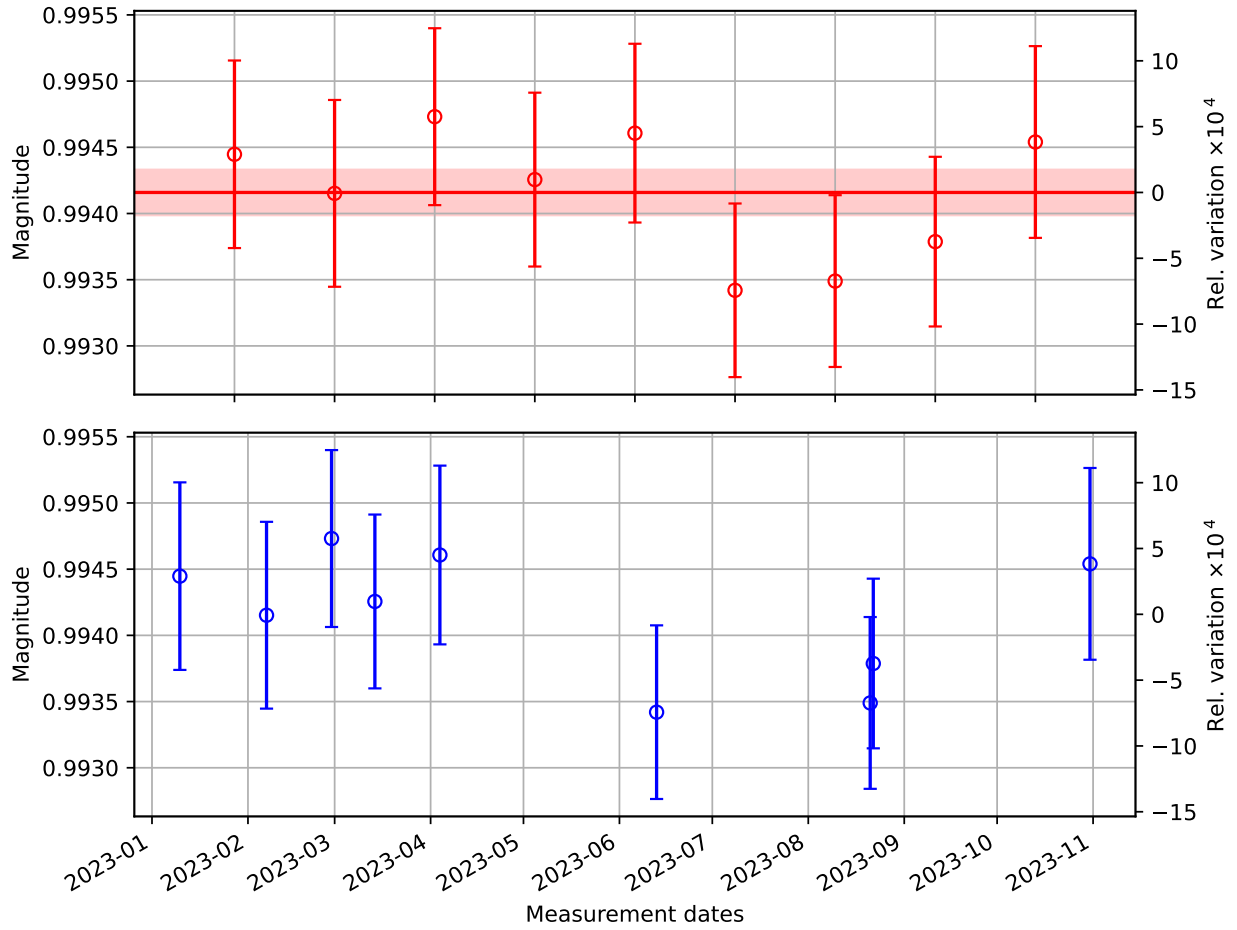
Mean value:	0.993060
Standard deviation:	0.000487
Standard error:	0.000172
Relative Standard error:	0.000173

20 Output Optical efficiency correction factor ($\eta_R = \sqrt{e/\beta}$)

List of Measurements

Date	E_R $\pm$ SD_E_R
D20230110	0.9944 $\pm$ 0.0007
D20230207	0.9942 $\pm$ 0.0007
D20230228	0.9947 $\pm$ 0.0007
D20230314	0.9943 $\pm$ 0.0007
D20230404	0.9946 $\pm$ 0.0007
D20230613	0.9934 $\pm$ 0.0007
D20230821	0.9935 $\pm$ 0.0006
D20230822	0.9938 $\pm$ 0.0006
D20231031	0.9945 $\pm$ 0.0007

Output Side Optical Efficiency correction factor



Summary of Output Side Optical Efficiency correction factor

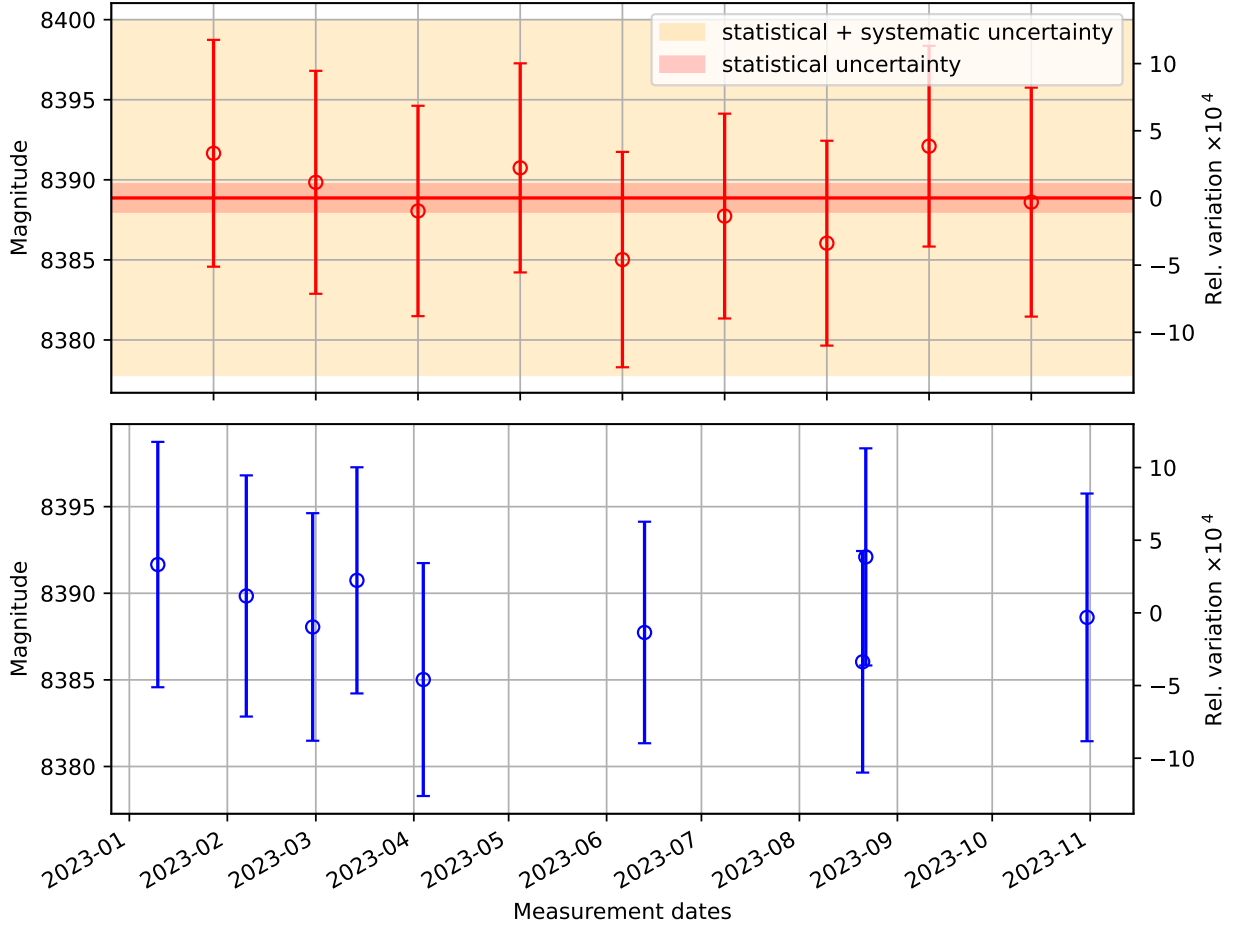
Mean value:	0.994159
Standard deviation:	0.000487
Standard error:	0.000172
Relative Standard error:	0.000173

21 TxPD calibration at ETM ($\rho'_{Tx} = \rho_T \cdot \eta_T \cdot \zeta$)

List of Measurements

Date	rhoT_prime $\pm$ SD_rhoT_prime
D20230110	8391.6574 $\pm$ 7.0818
D20230207	8389.8439 $\pm$ 6.9612
D20230228	8388.0549 $\pm$ 6.5683
D20230314	8390.7454 $\pm$ 6.5279
D20230404	8385.0193 $\pm$ 6.7238
D20230613	8387.7359 $\pm$ 6.3941
D20230821	8386.0437 $\pm$ 6.3956
D20230822	8392.0998 $\pm$ 6.2670
D20231031	8388.6083 $\pm$ 7.1489

TxPD calibration corrected for optical efficiency (ct/W)



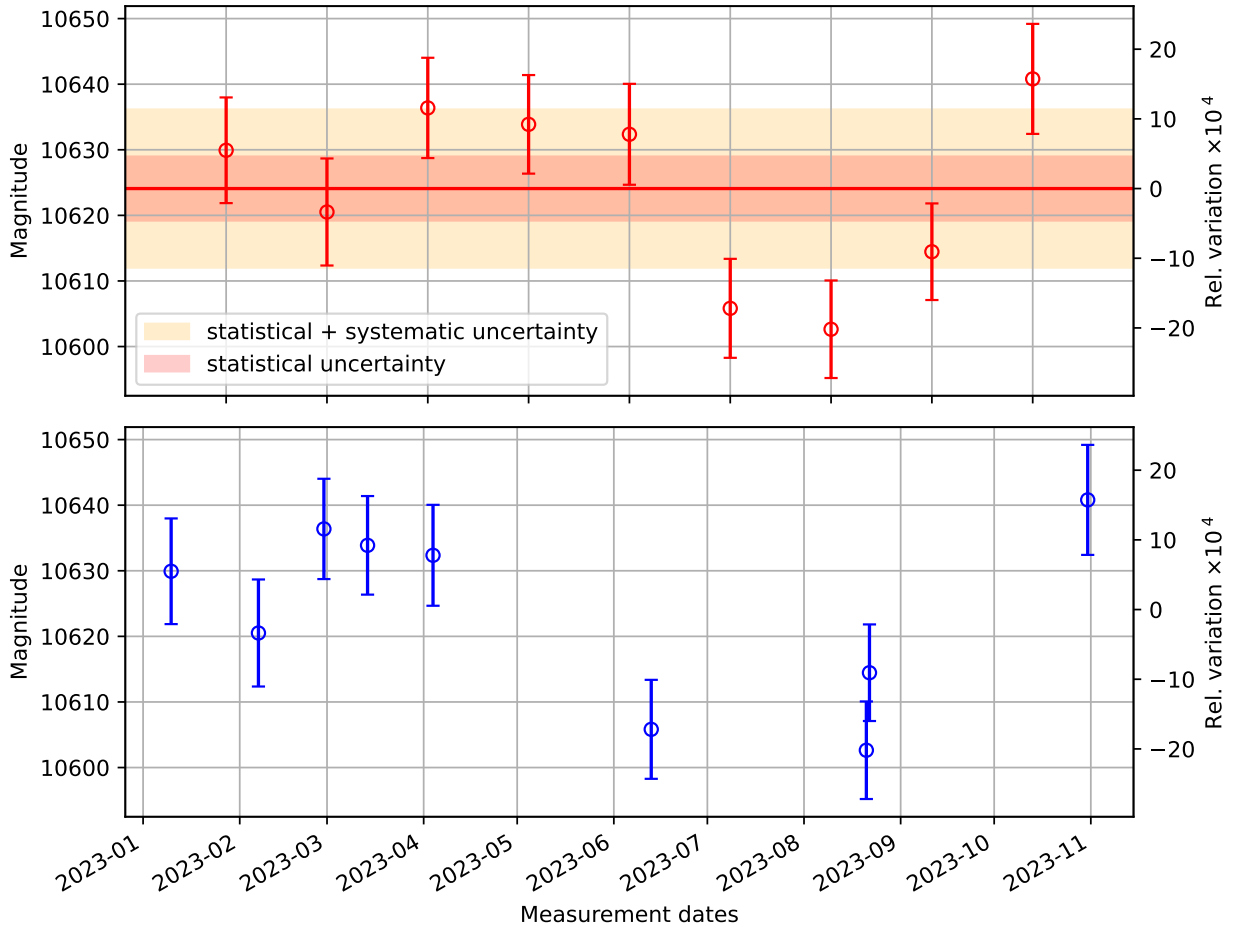
Summary of TxPD calibration corrected for optical efficiency (ct/W)	
Mean value:	8388.867619
Standard deviation:	2.436752
Standard error:	0.859952
Relative Standard error:	0.000103

22 RxPD calibration at ETM ($\rho'_{Rx} = \rho_R \cdot \eta_R \cdot \zeta$)

List of Measurements

Date	rhoR_prime $\pm$ SD_rhoR_prime
D20230110	10629.9242 $\pm$ 8.0551
D20230207	10620.5139 $\pm$ 8.1595
D20230228	10636.3809 $\pm$ 7.6456
D20230314	10633.8774 $\pm$ 7.5141
D20230404	10632.3603 $\pm$ 7.6934
D20230613	10605.8257 $\pm$ 7.5452
D20230821	10602.6395 $\pm$ 7.4380
D20230822	10614.4571 $\pm$ 7.3641
D20231031	10640.8070 $\pm$ 8.3872

RxPD calibration corrected for optical efficiency (ct/W)



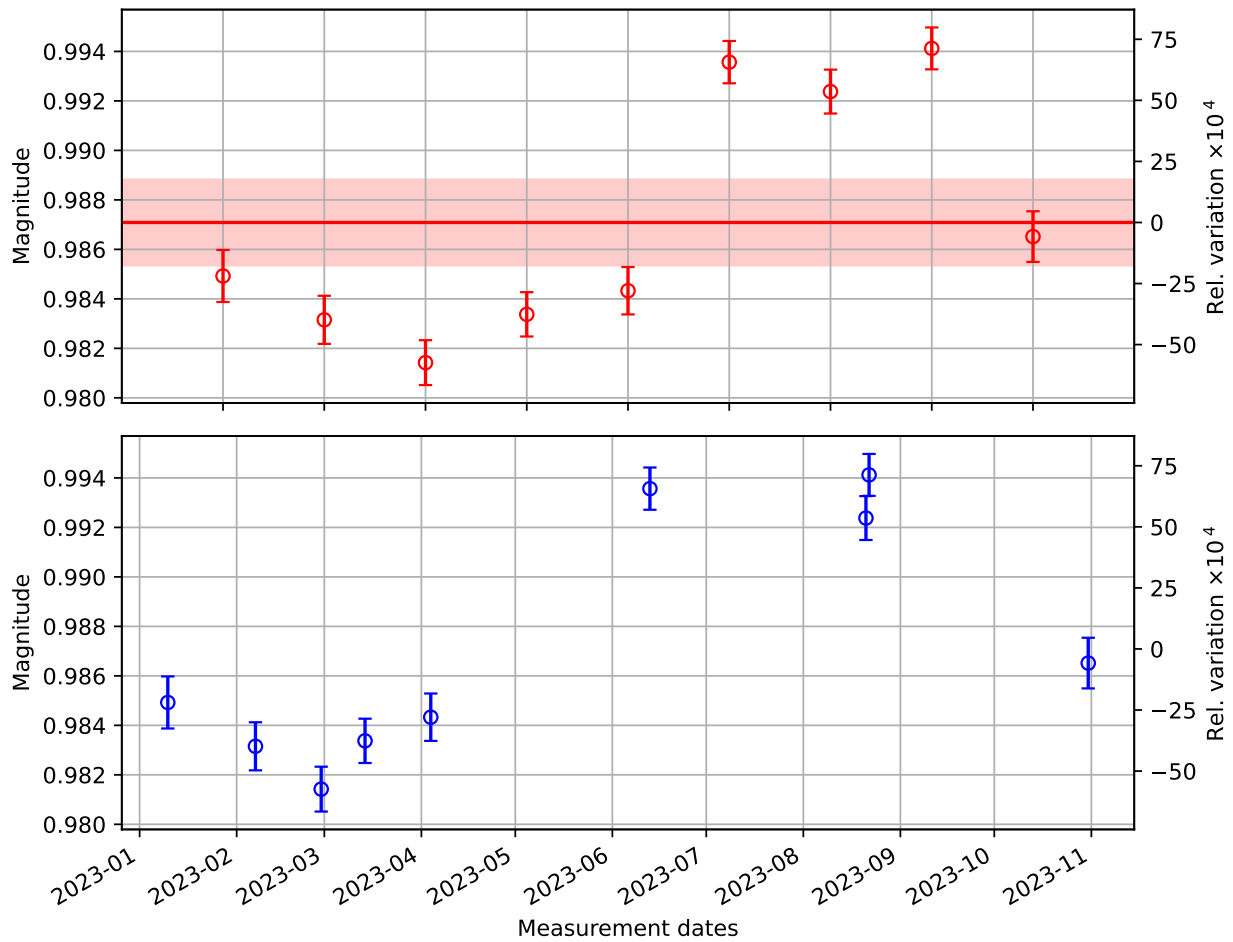
Summary of RxPD calibration corrected for optical efficiency (ct/W)	
Mean value:	10624.087329
Standard deviation:	13.820490
Standard error:	4.877379
Relative Standard error:	0.000459

23 Power Imbalance

List of Measurements

Date	PI $\pm$ SD_PI
D20230110	0.9849 $\pm$ 0.0011
D20230207	0.9832 $\pm$ 0.0010
D20230228	0.9814 $\pm$ 0.0009
D20230314	0.9834 $\pm$ 0.0009
D20230404	0.9843 $\pm$ 0.0010
D20230613	0.9936 $\pm$ 0.0009
D20230821	0.9924 $\pm$ 0.0009
D20230822	0.9941 $\pm$ 0.0008
D20231031	0.9865 $\pm$ 0.0010

Power Imbalance



Summary of Power Imbalance

Mean value:	0.987087
Standard deviation:	0.004917
Standard error:	0.001735
Relative Standard error:	0.001758