RxPD and TxPD Calibration Trends

GENERATED FOR LHO_EndX

Report Generated on December 5, 2023

Contents

1 About

This document contains the Pcal Calibration trends. It includes the ratios measured at the end-station labeled as m1, m2 .....m6 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

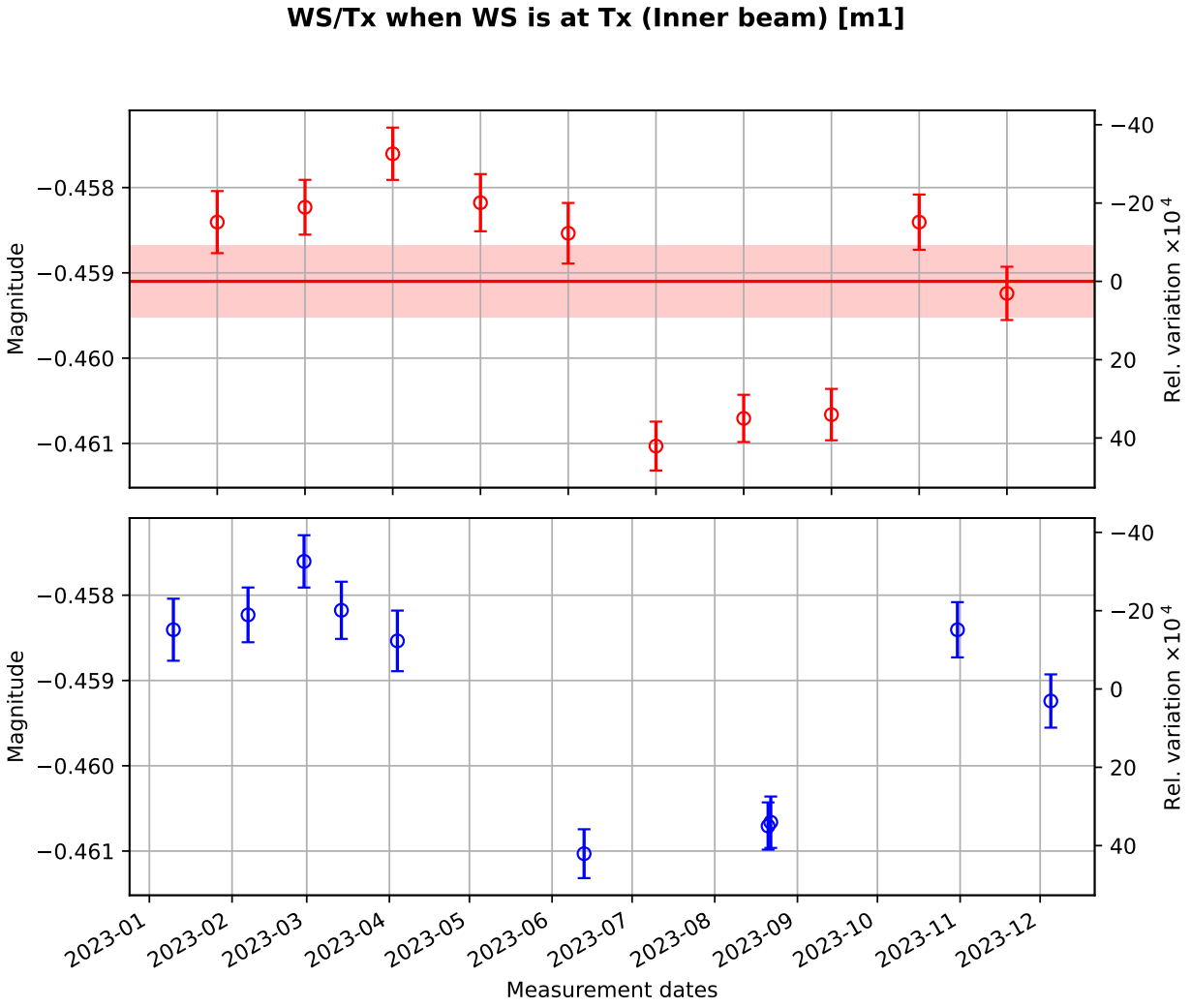
Each section contains a list of measurements with the mean value (m1), standard deviation on the mean (SD_m1) and a ratio of thestandard deviation of the quantity and error bars for each measurement (frac). The list is followed by two plot figures with Magnitude on the Y axis and Index on the X axis 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 ± SD_m1
D20230110	-0.4584 ± 0.0004
D20230207	-0.4582 ± 0.0003
D20230228	-0.4576 ± 0.0003
D20230314	-0.4582 ± 0.0003
D20230404	-0.4585 ± 0.0004
D20230613	-0.4610 ± 0.0003
D20230821	-0.4607 ± 0.0003
D20230822	-0.4607 ± 0.0003
D20231031	-0.4584 ± 0.0003
D20231205	-0.4592 ± 0.0003

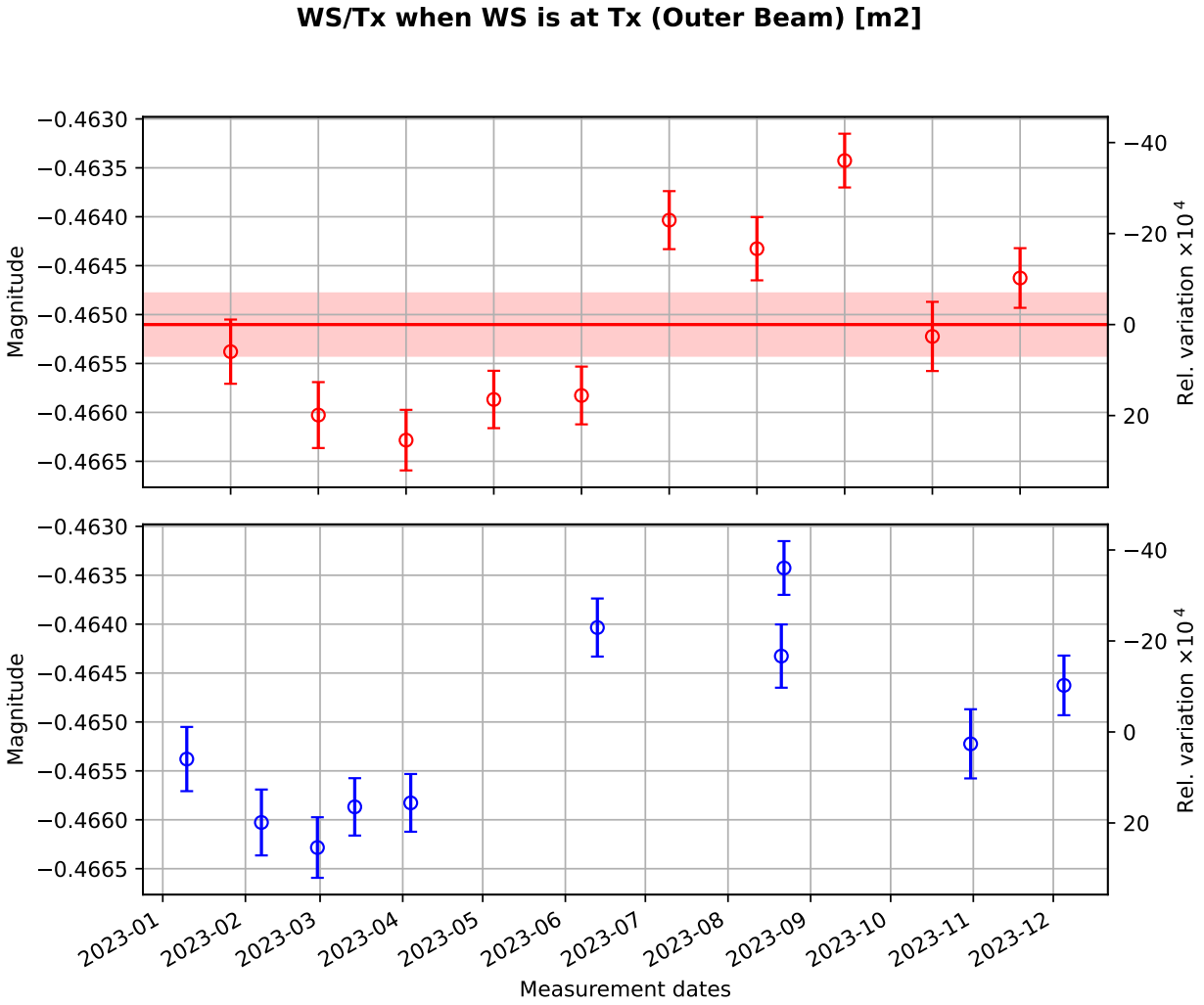


Summary of WS/Tx when WS is at Tx (Inner beam) [m1]	
Mean value:	-0.459100
Standard deviation:	0.001243
Standard error:	0.000414
Relative Standard error:	-0.000901

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

List of Measurements

Date	m2 ± SD_m2
D20230110	-0.4654 ± 0.0003
D20230207	-0.4660 ± 0.0003
D20230228	-0.4663 ± 0.0003
D20230314	-0.4659 ± 0.0003
D20230404	-0.4658 ± 0.0003
D20230613	-0.4640 ± 0.0003
D20230821	-0.4643 ± 0.0003
D20230822	-0.4634 ± 0.0003
D20231031	-0.4652 ± 0.0004
D20231205	-0.4646 ± 0.0003

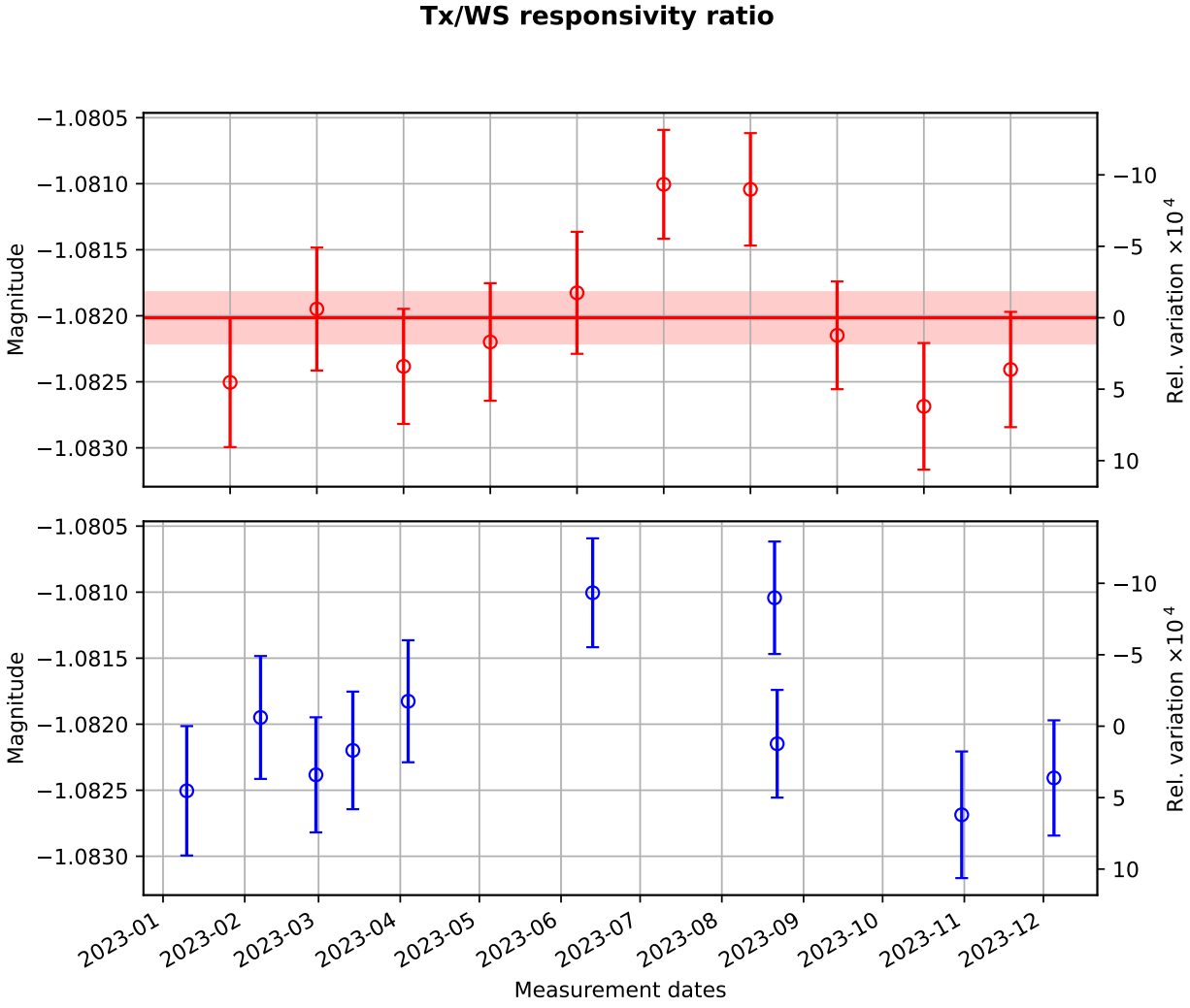


Summary of WS/Tx when WS is at Tx (Outer Beam) [m2]	
Mean value:	-0.465102
Standard deviation:	0.000956
Standard error:	0.000318
Relative Standard error:	-0.000684

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

List of Measurements

Date	TXWS ± SD_TXWS
D20230110	-1.0825 ± 0.0005
D20230207	-1.0819 ± 0.0005
D20230228	-1.0824 ± 0.0004
D20230314	-1.0822 ± 0.0004
D20230404	-1.0818 ± 0.0005
D20230613	-1.0810 ± 0.0004
D20230821	-1.0810 ± 0.0004
D20230822	-1.0821 ± 0.0004
D20231031	-1.0827 ± 0.0005
D20231205	-1.0824 ± 0.0004



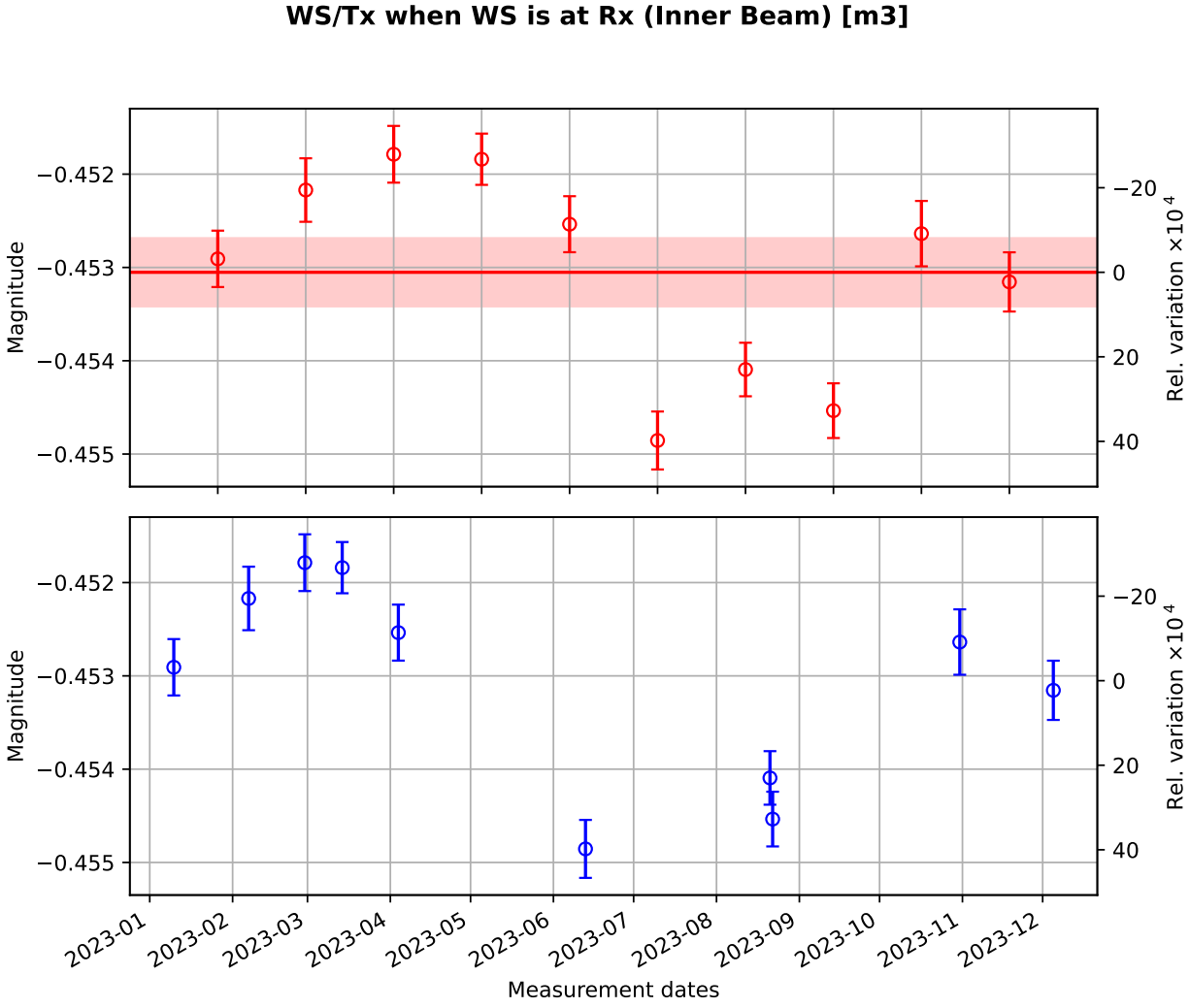
Summary of Tx/WS responsivity ratio

Mean value:	-1.082015
Standard deviation:	0.000581
Standard error:	0.000193
Relative Standard error:	-0.000179

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

List of Measurements

Date	m3 ± SD_m3
D20230110	-0.4529 ± 0.0003
D20230207	-0.4522 ± 0.0003
D20230228	-0.4518 ± 0.0003
D20230314	-0.4518 ± 0.0003
D20230404	-0.4525 ± 0.0003
D20230613	-0.4549 ± 0.0003
D20230821	-0.4541 ± 0.0003
D20230822	-0.4545 ± 0.0003
D20231031	-0.4526 ± 0.0004
D20231205	-0.4532 ± 0.0003

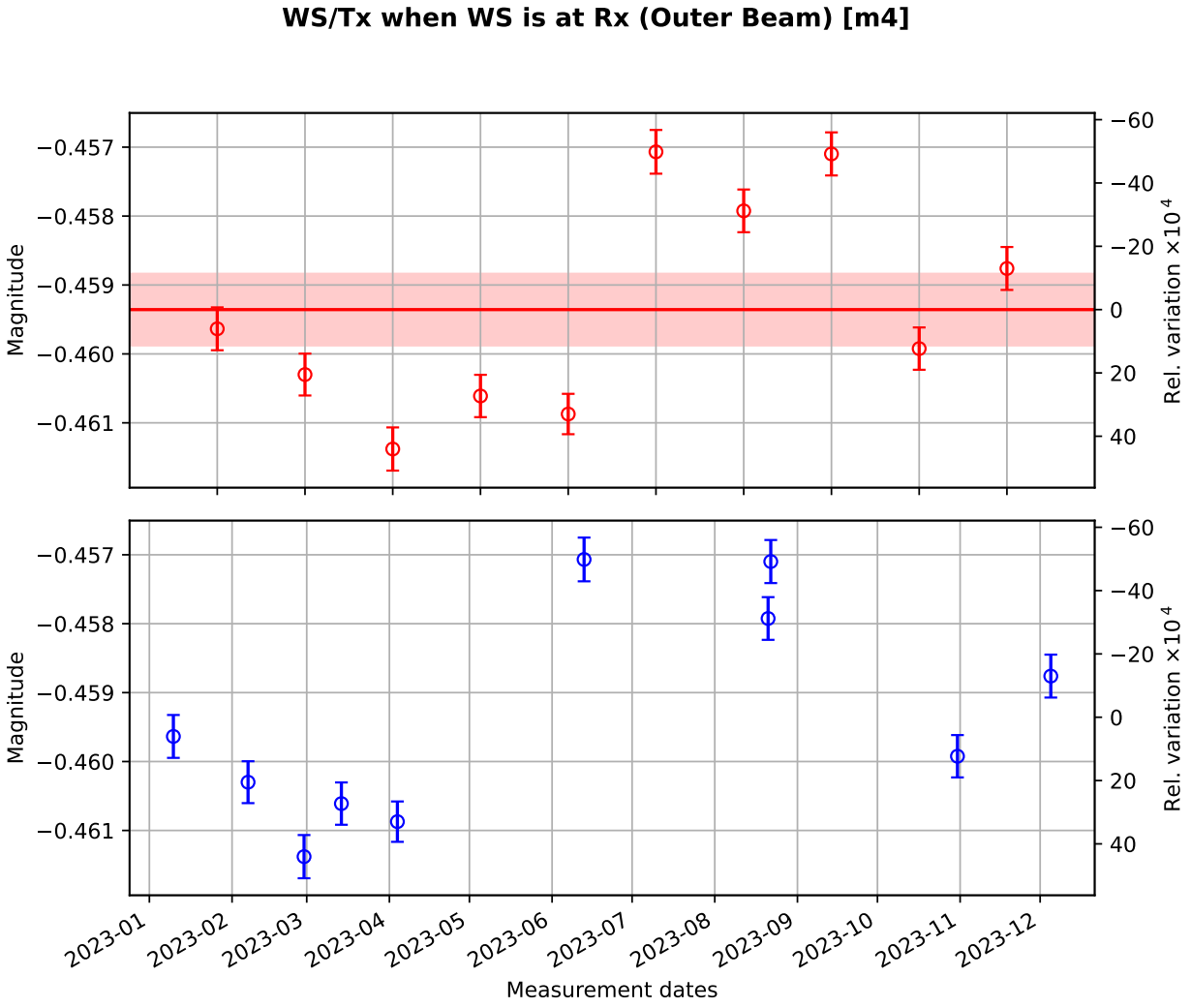


Summary of WS/Tx when WS is at Rx (Inner Beam) [m3]	
Mean value:	-0.453052
Standard deviation:	0.001098
Standard error:	0.000365
Relative Standard error:	-0.000807

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

List of Measurements

Date	m4 ± SD_m4
D20230110	-0.4596 ± 0.0003
D20230207	-0.4603 ± 0.0003
D20230228	-0.4614 ± 0.0003
D20230314	-0.4606 ± 0.0003
D20230404	-0.4609 ± 0.0003
D20230613	-0.4571 ± 0.0003
D20230821	-0.4579 ± 0.0003
D20230822	-0.4571 ± 0.0003
D20231031	-0.4599 ± 0.0003
D20231205	-0.4588 ± 0.0003



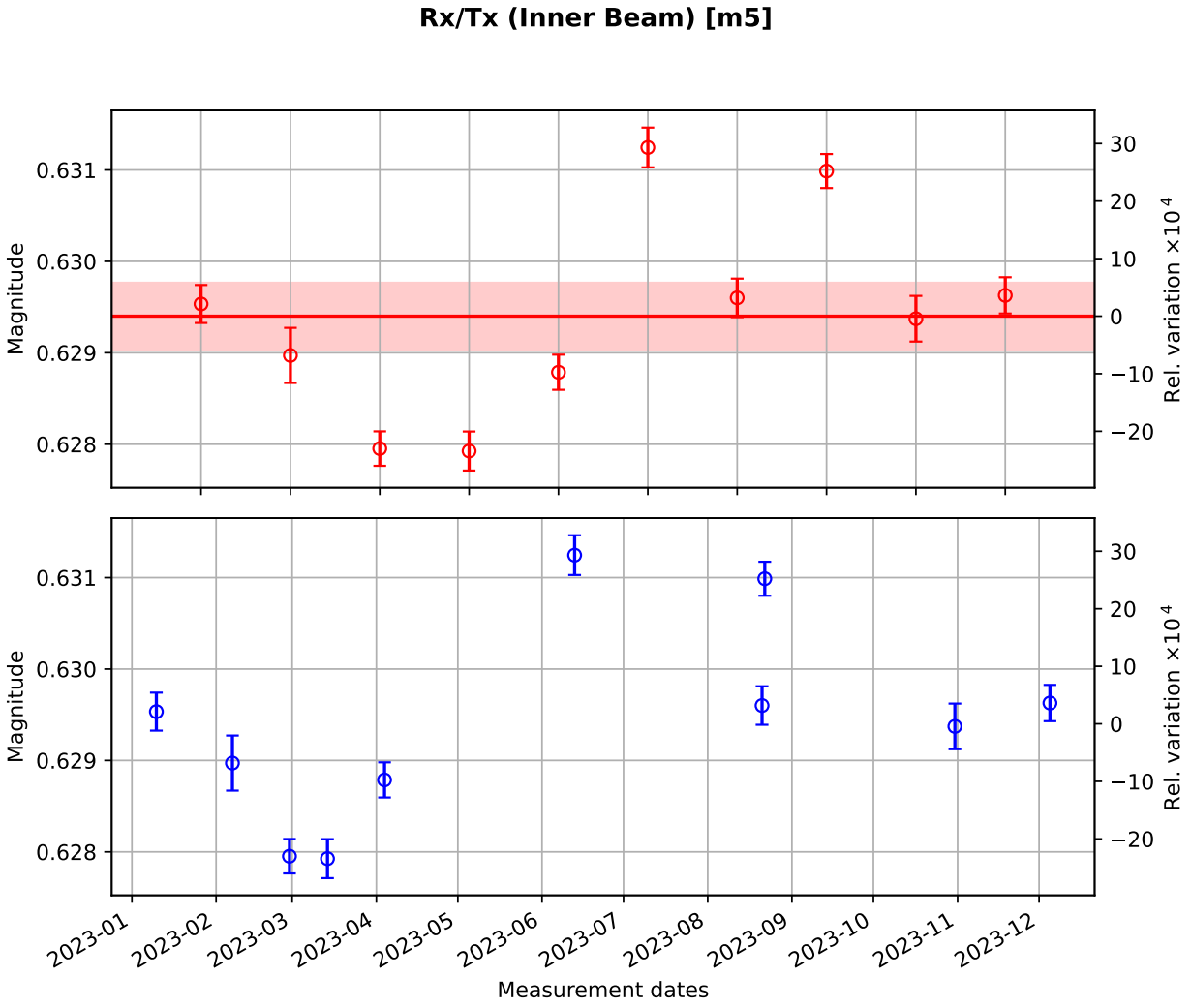
Summary of WS/Tx when WS is at Rx (Outer Beam) [m4]

Mean value:	-0.459357
Standard deviation:	0.001563
Standard error:	0.000520
Relative Standard error:	-0.001133

7 RX/TX Ratio (Inner Beam)

List of Measurements

Date	m5 ± SD_m5
D20230110	0.6295 ± 0.0002
D20230207	0.6290 ± 0.0003
D20230228	0.6280 ± 0.0002
D20230314	0.6279 ± 0.0002
D20230404	0.6288 ± 0.0002
D20230613	0.6312 ± 0.0002
D20230821	0.6296 ± 0.0002
D20230822	0.6310 ± 0.0002
D20231031	0.6294 ± 0.0002
D20231205	0.6296 ± 0.0002



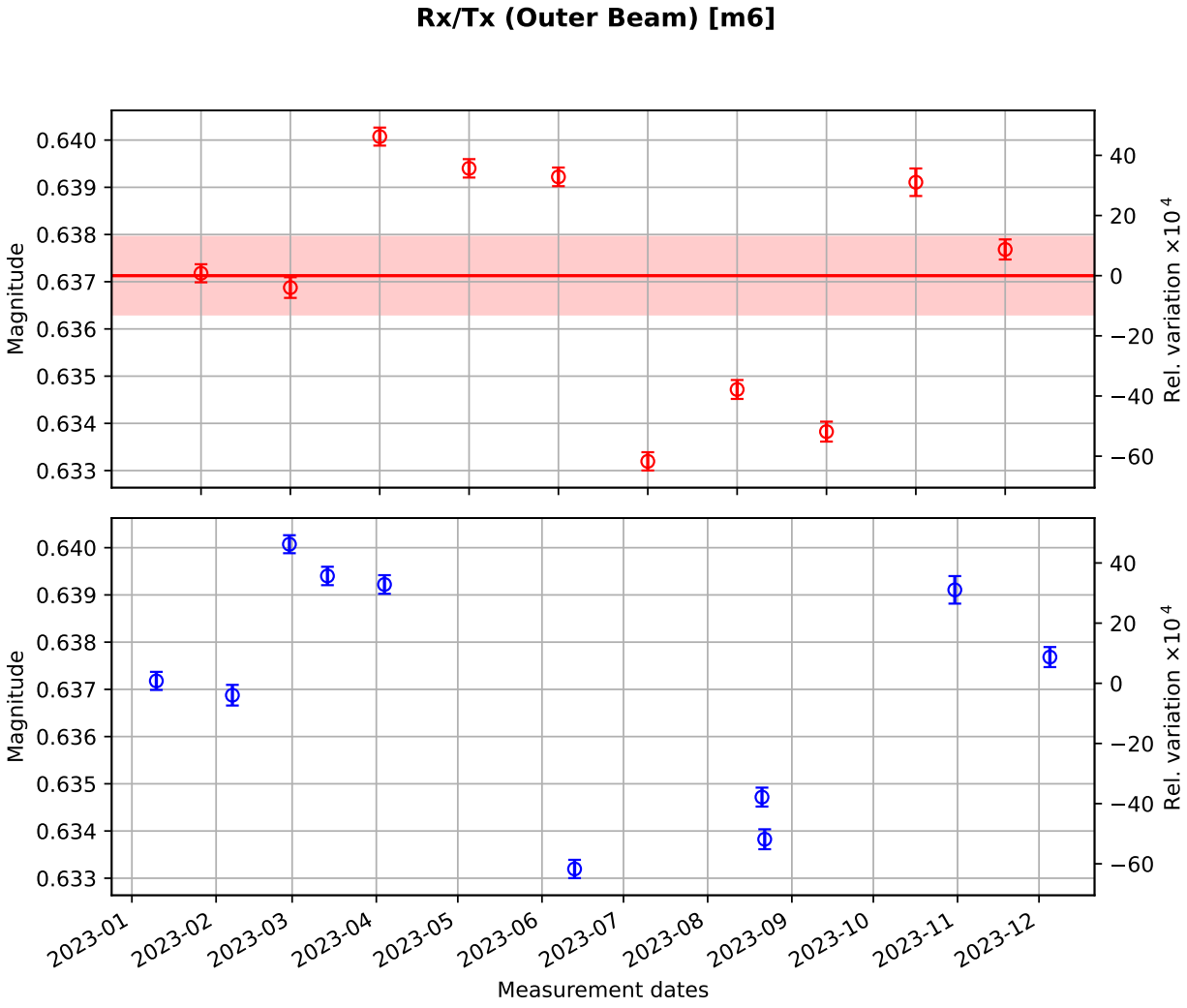
Summary of Rx/Tx (Inner Beam) [m5]

Mean value:	0.629401
Standard deviation:	0.001099
Standard error:	0.000366
Relative Standard error:	0.000581

8 Rx/Tx Ratio (Outer Beam)

List of Measurements

Date	m6 ± SD_m6
D20230110	0.6372 ± 0.0002
D20230207	0.6369 ± 0.0002
D20230228	0.6401 ± 0.0002
D20230314	0.6394 ± 0.0002
D20230404	0.6392 ± 0.0002
D20230613	0.6332 ± 0.0002
D20230821	0.6347 ± 0.0002
D20230822	0.6338 ± 0.0002
D20231031	0.6391 ± 0.0003
D20231205	0.6377 ± 0.0002



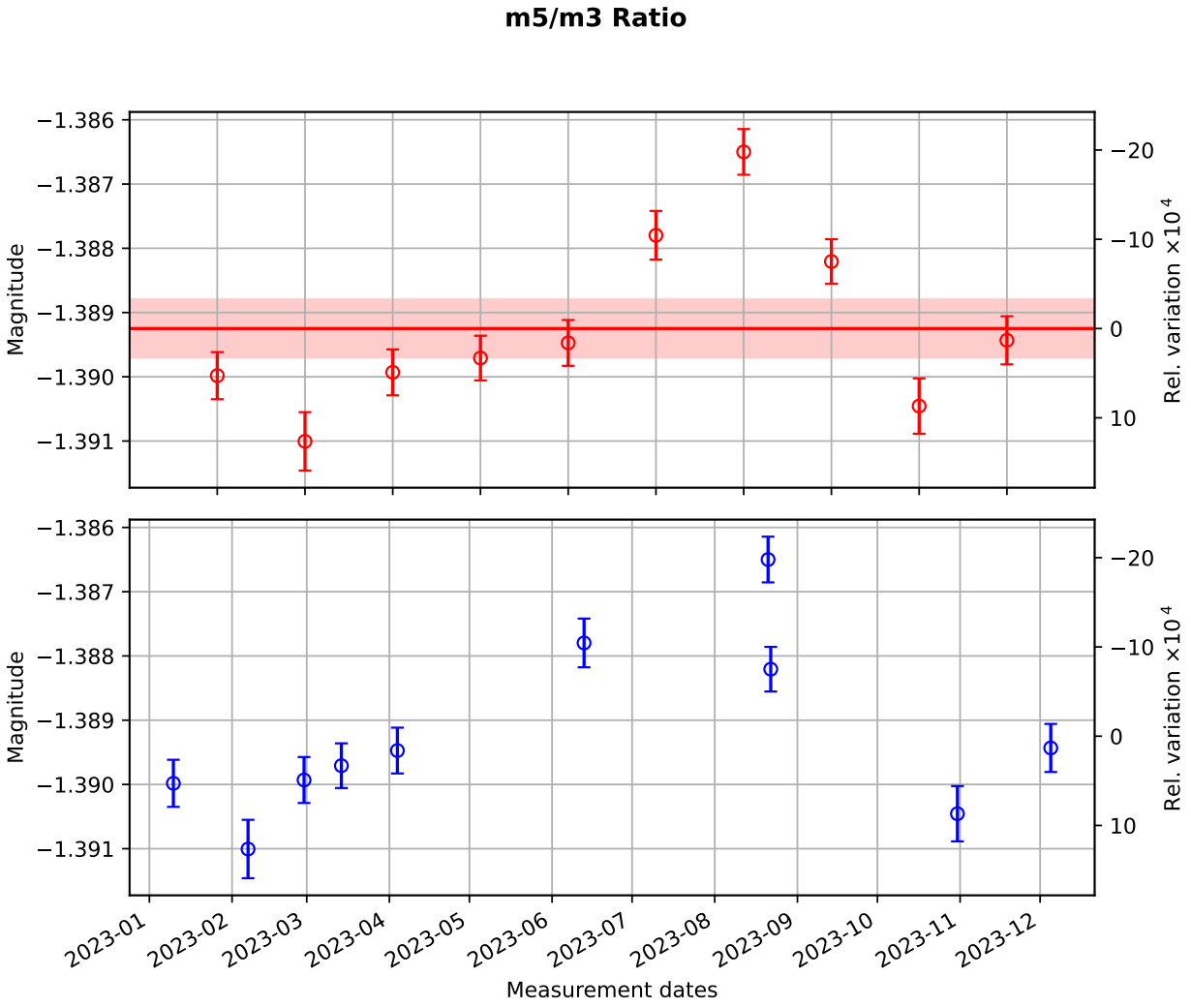
Summary of Rx/Tx (Outer Beam) [m6]

Mean value:	0.637128
Standard deviation:	0.002465
Standard error:	0.000821
Relative Standard error:	0.001288

9 m5/m3 Ratio

List of Measurements

Date	RiTWriT ± SD_RiTWriT
D20230110	-1.3900 ± 0.0004
D20230207	-1.3910 ± 0.0005
D20230228	-1.3899 ± 0.0004
D20230314	-1.3897 ± 0.0003
D20230404	-1.3895 ± 0.0004
D20230613	-1.3878 ± 0.0004
D20230821	-1.3865 ± 0.0004
D20230822	-1.3882 ± 0.0003
D20231031	-1.3905 ± 0.0004
D20231205	-1.3894 ± 0.0004



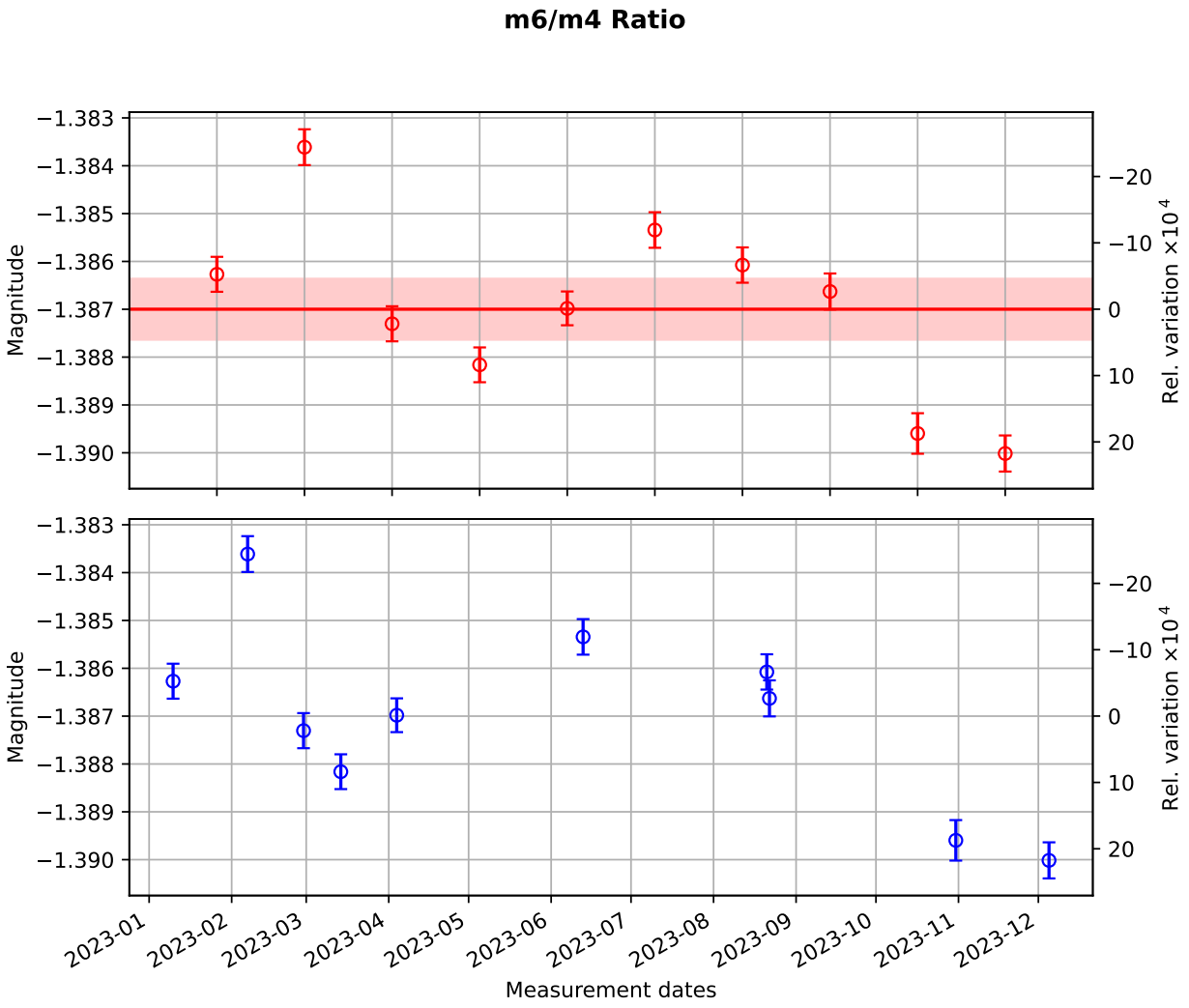
Summary of m5/m3 Ratio

Mean value:	-1.389249
Standard deviation:	0.001358
Standard error:	0.000452
Relative Standard error:	-0.000325

10 m6/m4 Ratio

List of Measurements

Date	RoTWroT ± SD_RoTWroT
D20230110	-1.3863 ± 0.0004
D20230207	-1.3836 ± 0.0004
D20230228	-1.3873 ± 0.0004
D20230314	-1.3882 ± 0.0004
D20230404	-1.3870 ± 0.0004
D20230613	-1.3853 ± 0.0004
D20230821	-1.3861 ± 0.0004
D20230822	-1.3866 ± 0.0004
D20231031	-1.3896 ± 0.0004
D20231205	-1.3900 ± 0.0004



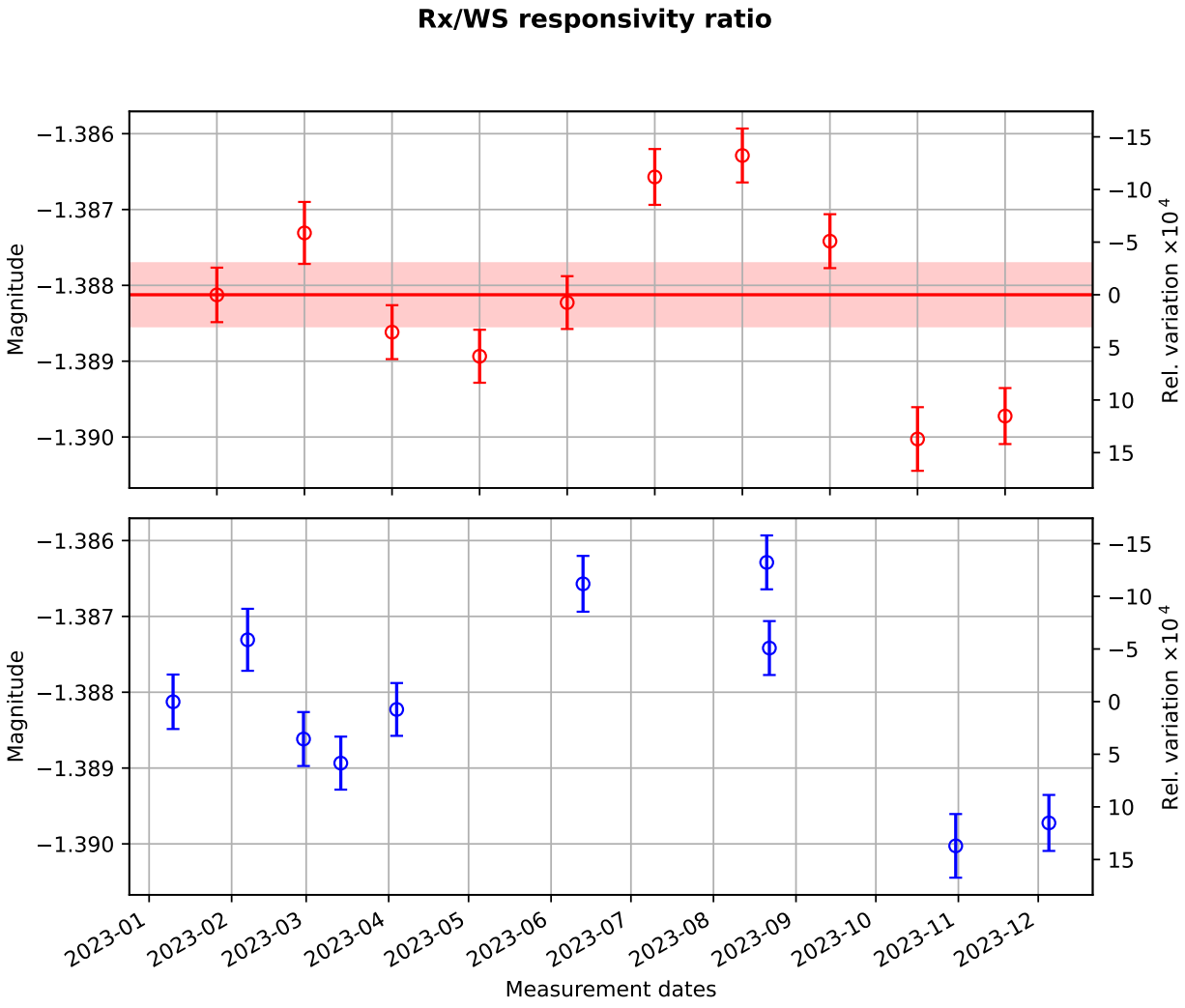
Summary of m6/m4 Ratio

Mean value:	-1.386999
Standard deviation:	0.001915
Standard error:	0.000638
Relative Standard error:	-0.000460

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

List of Measurements

Date	RXWS ± SD_RXWS
D20230110	-1.3881 ± 0.0004
D20230207	-1.3873 ± 0.0004
D20230228	-1.3886 ± 0.0004
D20230314	-1.3889 ± 0.0003
D20230404	-1.3882 ± 0.0003
D20230613	-1.3866 ± 0.0004
D20230821	-1.3863 ± 0.0004
D20230822	-1.3874 ± 0.0004
D20231031	-1.3900 ± 0.0004
D20231205	-1.3897 ± 0.0004



Summary of Rx/WS responsivity ratio

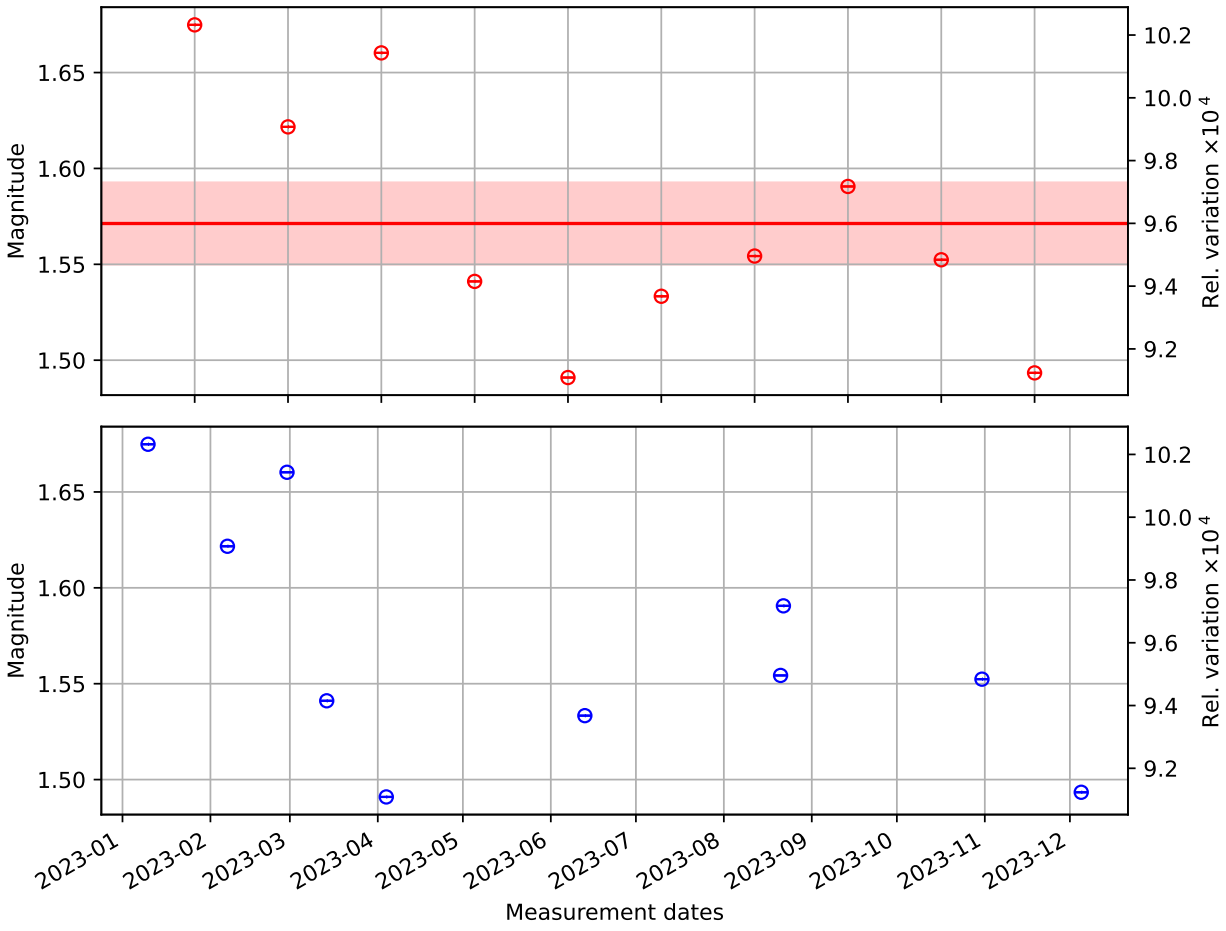
Mean value:	-1.388124
Standard deviation:	0.001249
Standard error:	0.000416
Relative Standard error:	-0.000299

12 ADC conversion factor (ζ)

List of Measurements

Date	zeta ± SD_zeta
D20230110	1.6367e+03 ± 1.0000e-09
D20230207	1.6368e+03 ± 1.0000e-09
D20230228	1.6367e+03 ± 1.0000e-09
D20230314	1.6369e+03 ± 1.0000e-09
D20230404	1.6369e+03 ± 1.0000e-09
D20230613	1.6369e+03 ± 1.0000e-09
D20230821	1.6368e+03 ± 1.0000e-09
D20230822	1.6368e+03 ± 1.0000e-09
D20231031	1.6368e+03 ± 1.0000e-09
D20231205	1.6369e+03 ± 1.0000e-09

ADC conversion factor discrepancy (1638.4 - ζ (ct/V))

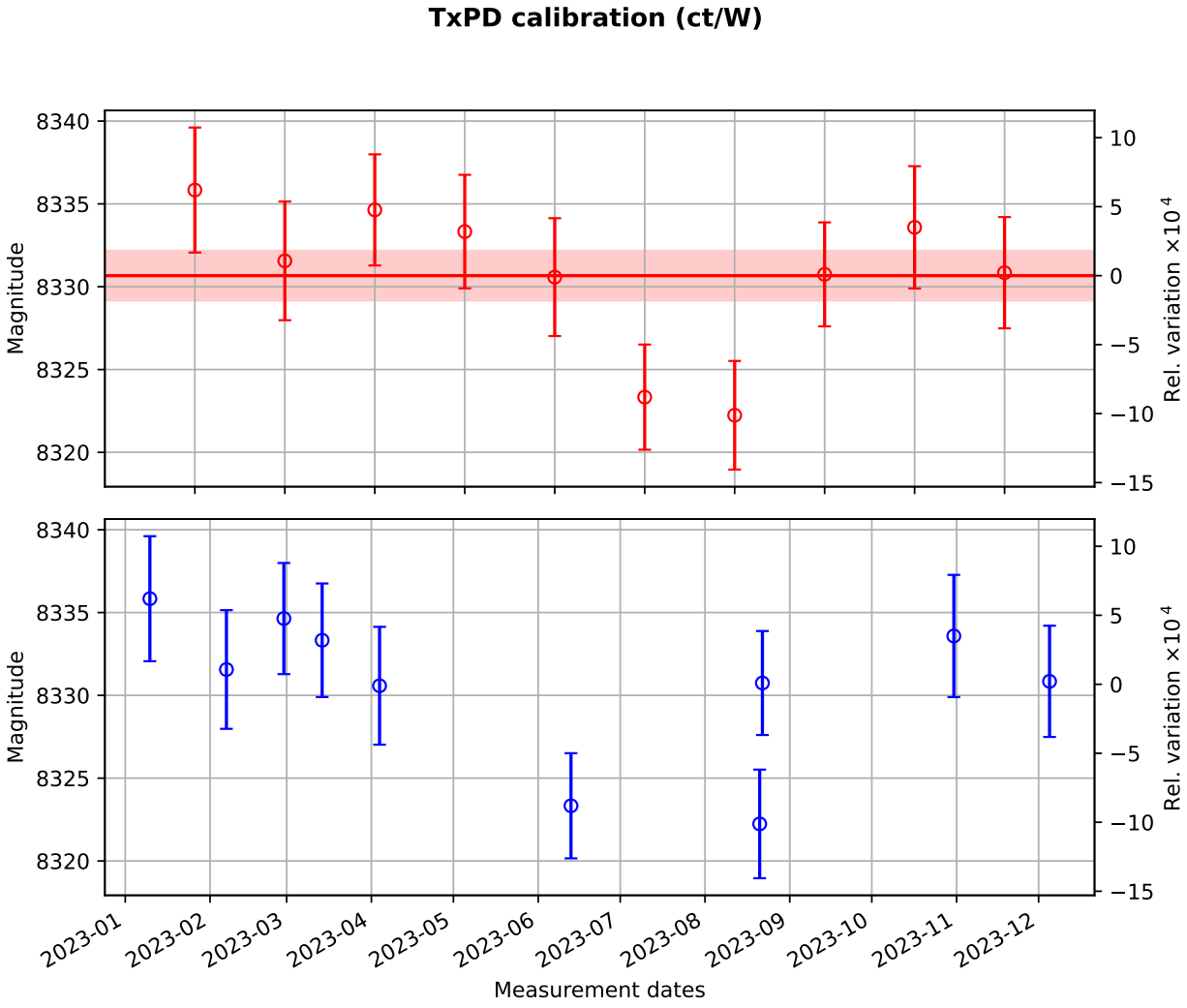


Summary of ADC conversion factor discrepancy

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

List of Measurements

Date	rhoTx ± SD_rhoTx
D20230110	8335.8363 ± 3.7737
D20230207	8331.5608 ± 3.5832
D20230228	8334.6371 ± 3.3555
D20230314	8333.3272 ± 3.4285
D20230404	8330.5796 ± 3.5576
D20230613	8323.3328 ± 3.1747
D20230821	8322.2378 ± 3.2788
D20230822	8330.7448 ± 3.1393
D20231031	8333.5847 ± 3.6905
D20231205	8330.8458 ± 3.3593



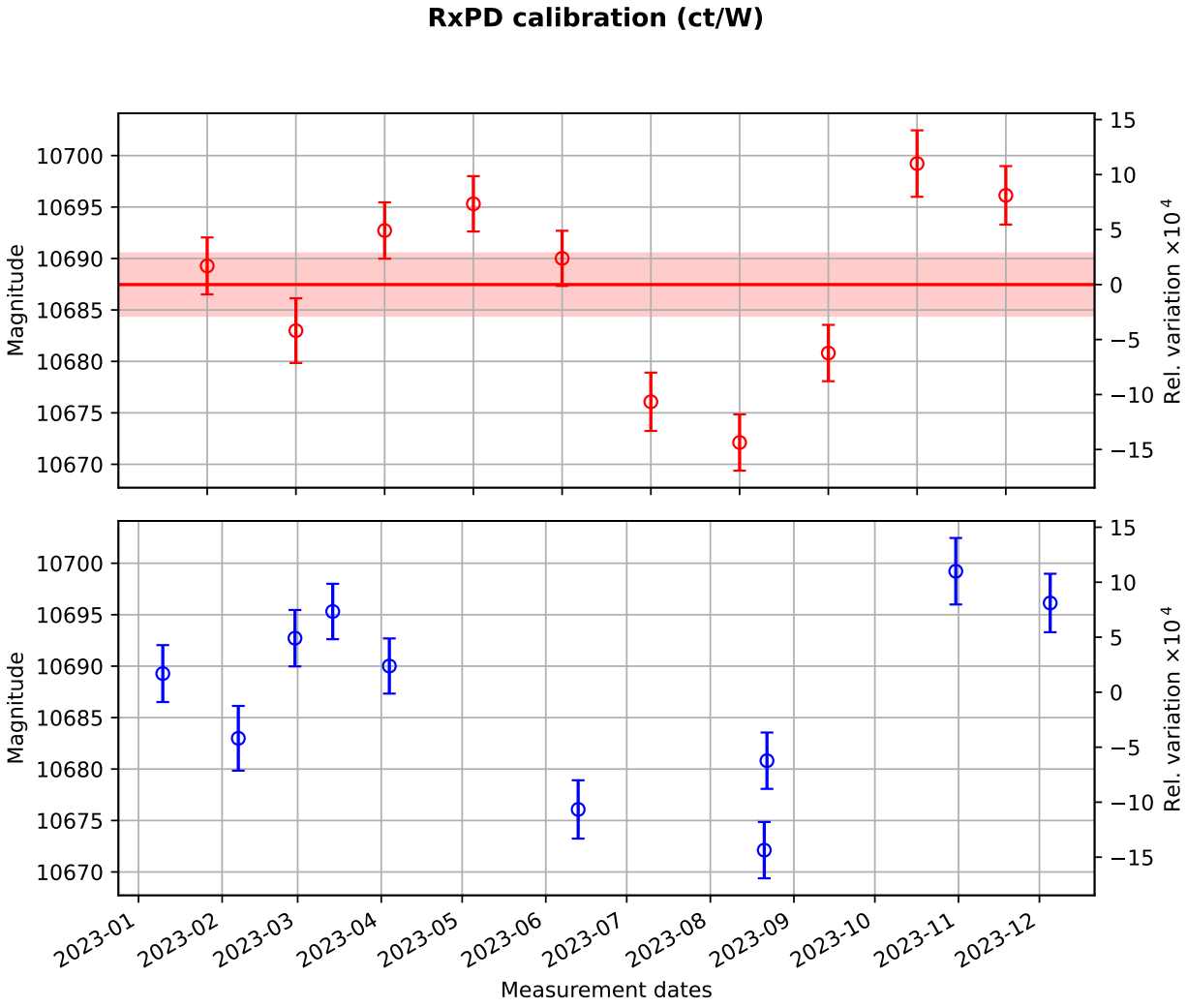
Summary of TxPD calibration (ct/W)

Mean value:	8330.668689
Standard deviation:	4.518609
Standard error:	1.504017
Relative Standard error:	0.000181

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

List of Measurements

Date	rhoRx ± SD_rhoRx
D20230110	10689.2786 ± 2.7664
D20230207	10682.9872 ± 3.1471
D20230228	10692.7178 ± 2.7391
D20230314	10695.3109 ± 2.6911
D20230404	10690.0120 ± 2.6817
D20230613	10676.0753 ± 2.8342
D20230821	10672.1188 ± 2.7358
D20230822	10680.8116 ± 2.7371
D20231031	10699.2242 ± 3.2295
D20231205	10696.1371 ± 2.8415

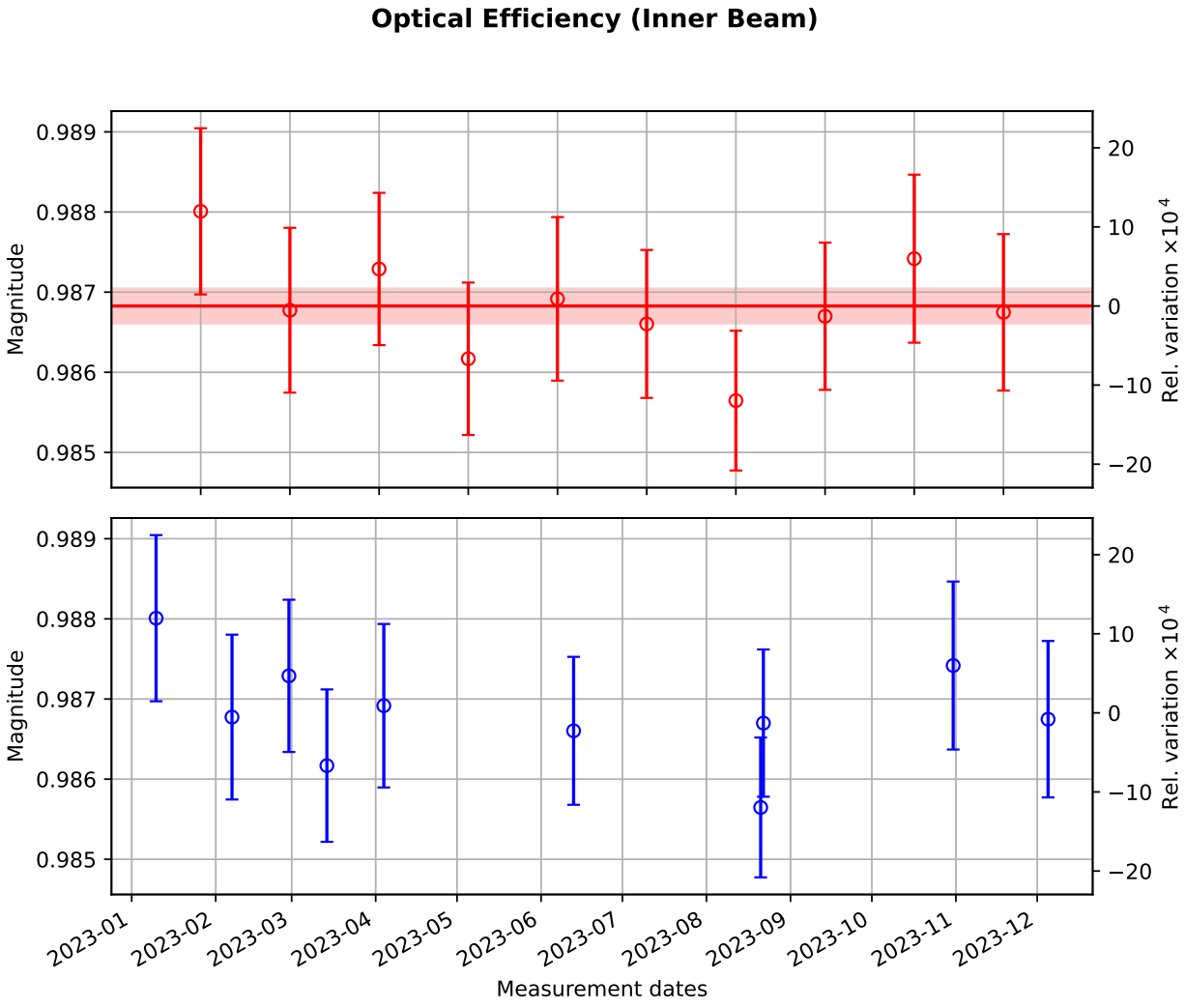


Summary of RxPD calibration (ct/W)	
Mean value:	10687.467345
Standard deviation:	9.079644
Standard error:	3.022154
Relative Standard error:	0.000283

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

List of Measurements

Date	e_i ± 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
D20231205	0.9867 ± 0.0010

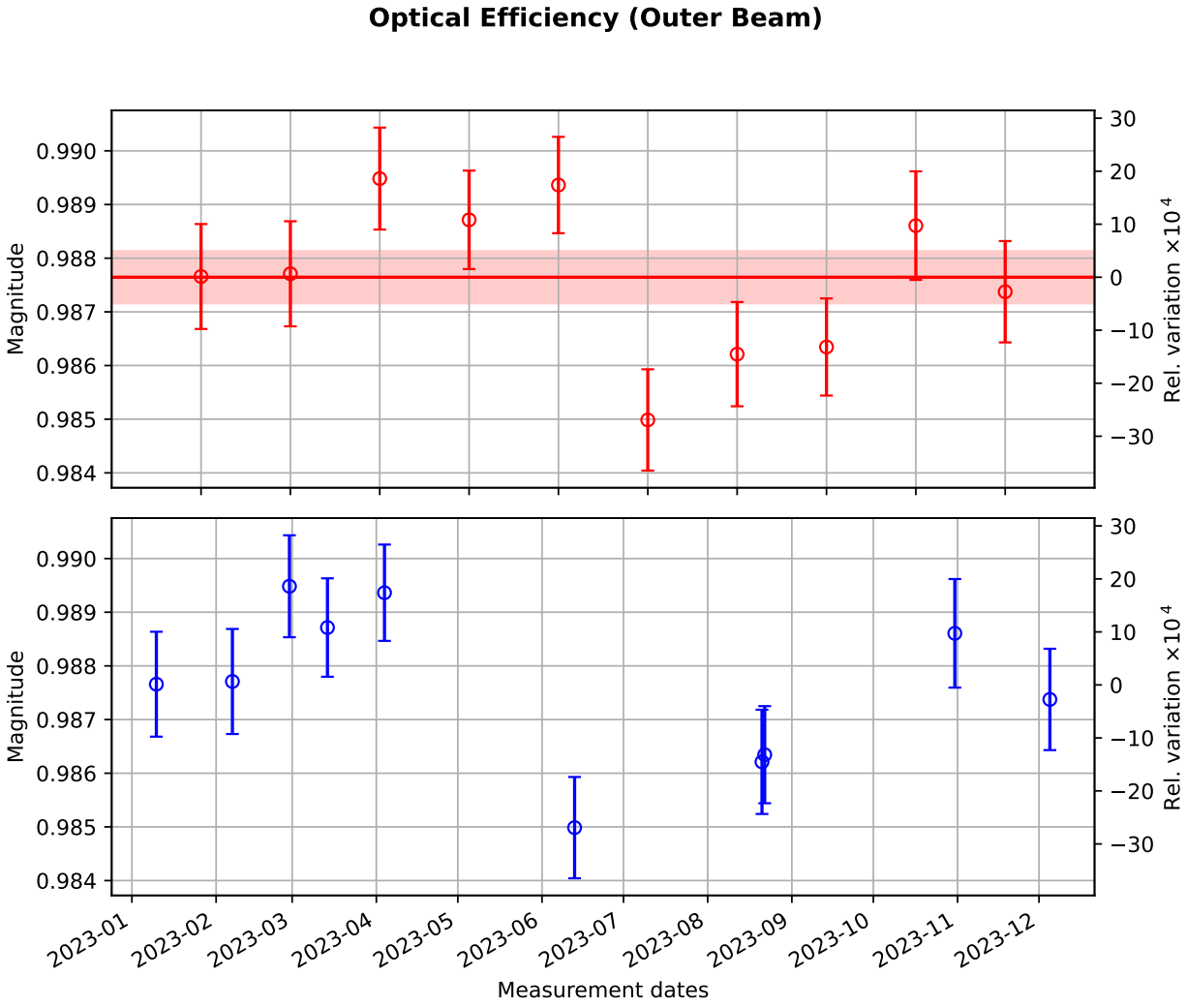


Summary of Optical Efficiency (Inner Beam)	
Mean value:	0.986827
Standard deviation:	0.000656
Standard error:	0.000218
Relative Standard error:	0.000221

16 Optical Efficiency of Outer Beam $e^o = m4/m2$

List of Measurements

Date	e_o ± 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
D20231205	0.9874 ± 0.0009

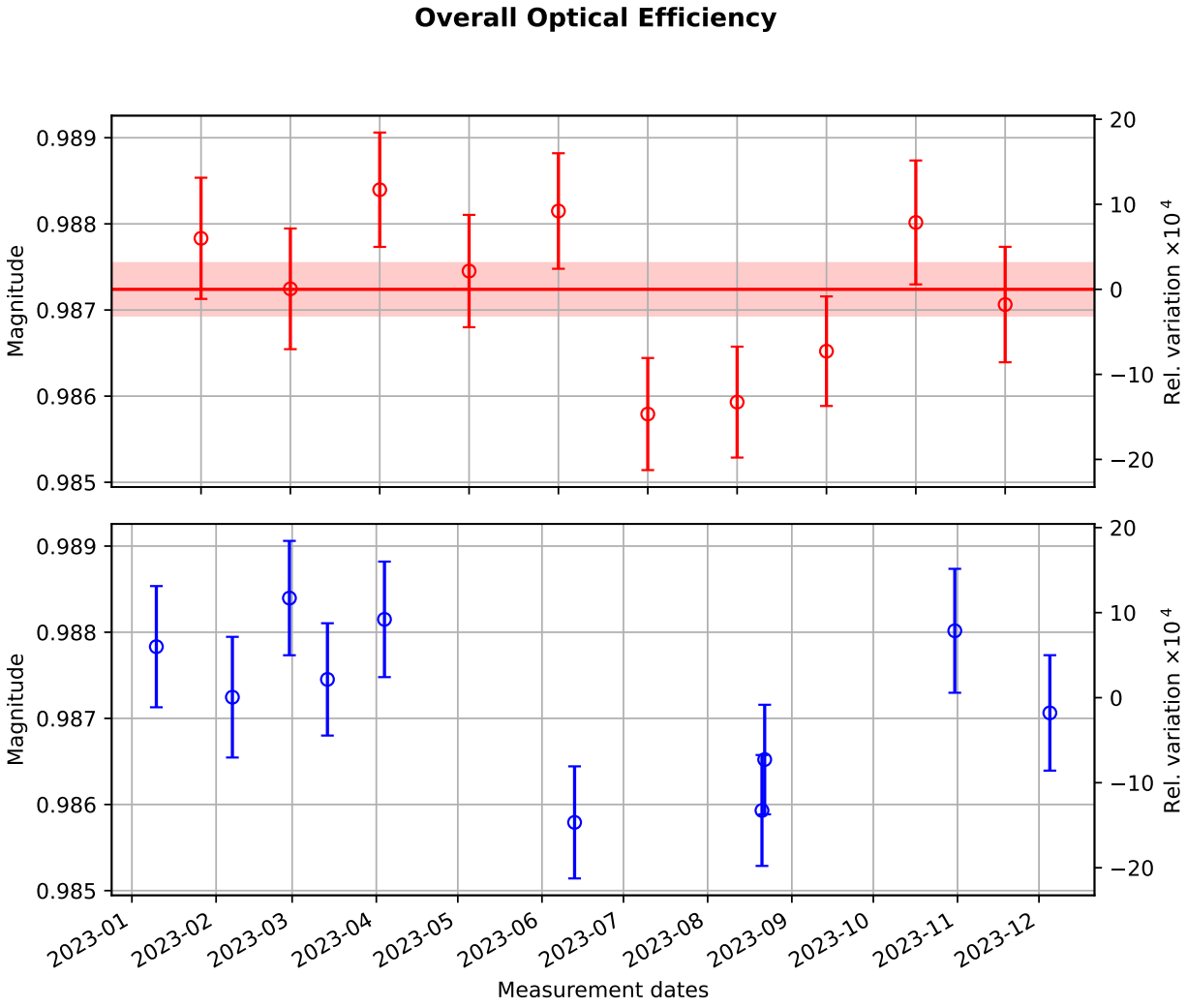


Summary of Optical Efficiency (Outer Beam)	
Mean value:	0.987645
Standard deviation:	0.001464
Standard error:	0.000487
Relative Standard error:	0.000493

17 Total Optical Efficiency $\mathbf{e = (m3 + m4)/(m1 + m2)}$

List of Measurements

Date	e ± 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
D20231205	0.9871 ± 0.0007



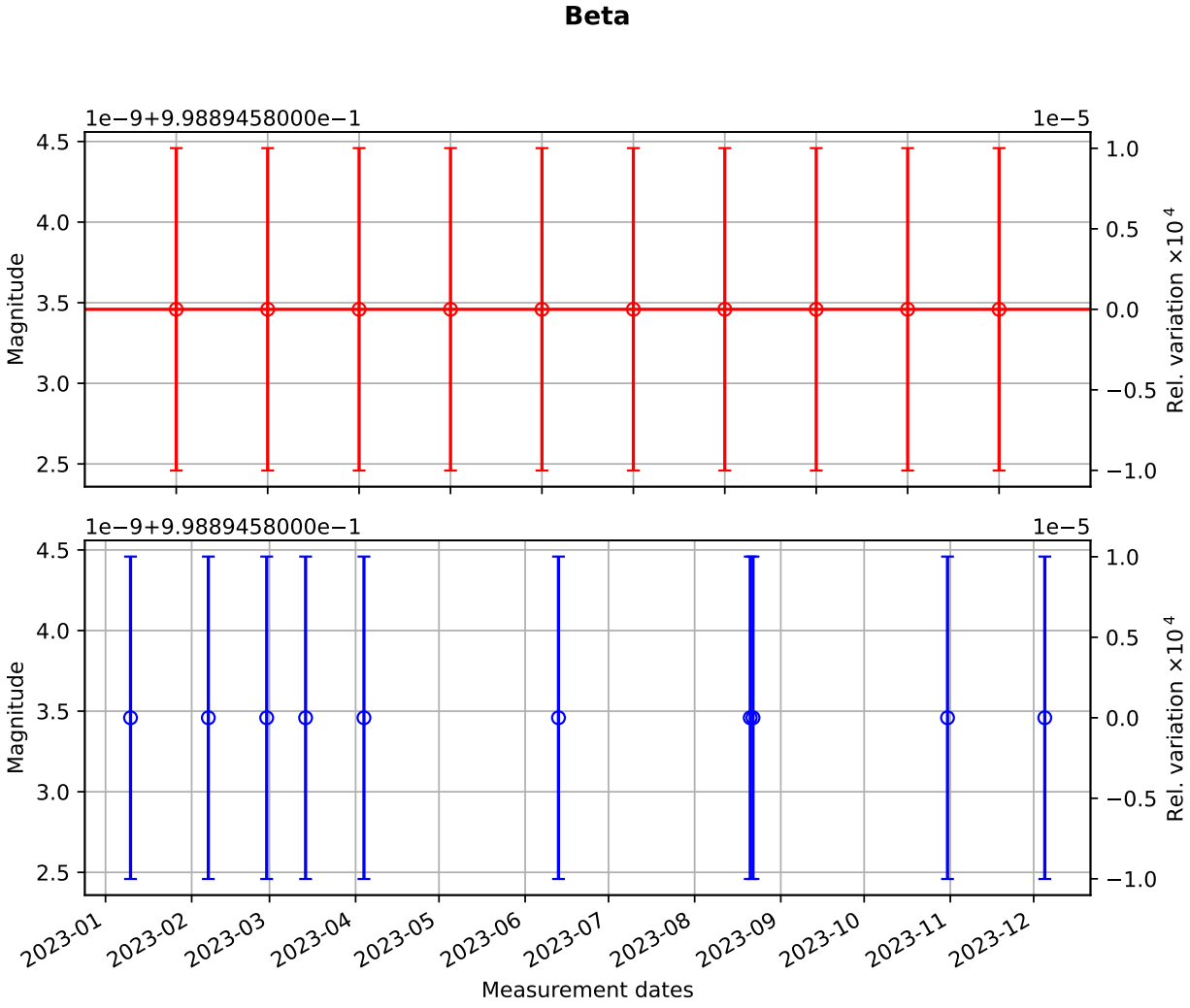
Summary of Overall Optical Efficiency

Mean value:	0.987240
Standard deviation:	0.000914
Standard error:	0.000304
Relative Standard error:	0.000308

18 Input/Output optical efficiency ratio (β)

List of Measurements

Date	beta ± SD_beta
D20230110	9.9889e-01 ± 1.0000e-09
D20230207	9.9889e-01 ± 1.0000e-09
D20230228	9.9889e-01 ± 1.0000e-09
D20230314	9.9889e-01 ± 1.0000e-09
D20230404	9.9889e-01 ± 1.0000e-09
D20230613	9.9889e-01 ± 1.0000e-09
D20230821	9.9889e-01 ± 1.0000e-09
D20230822	9.9889e-01 ± 1.0000e-09
D20231031	9.9889e-01 ± 1.0000e-09
D20231205	9.9889e-01 ± 1.0000e-09



Summary of Beta

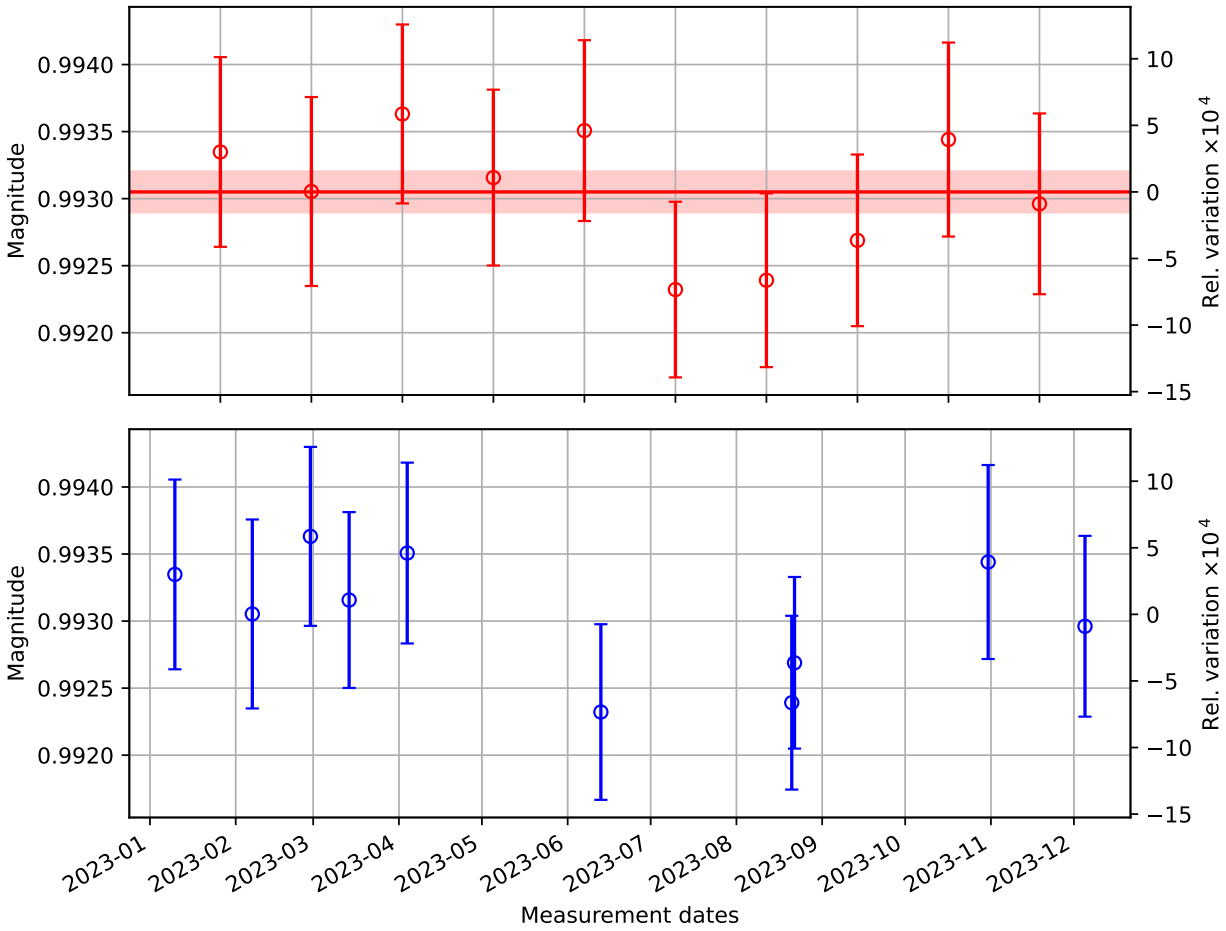
Mean value:	0.998895
Standard deviation:	0.000000
Standard error:	0.000000
Relative Standard error:	0.000000

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

List of Measurements

Date	E_T ± SD_E_T
D20230110	0.9933 ± 0.0007
D20230207	0.9931 ± 0.0007
D20230228	0.9936 ± 0.0007
D20230314	0.9932 ± 0.0007
D20230404	0.9935 ± 0.0007
D20230613	0.9923 ± 0.0007
D20230821	0.9924 ± 0.0006
D20230822	0.9927 ± 0.0006
D20231031	0.9934 ± 0.0007
D20231205	0.9930 ± 0.0007

Input Side Optical Efficiency correction factor



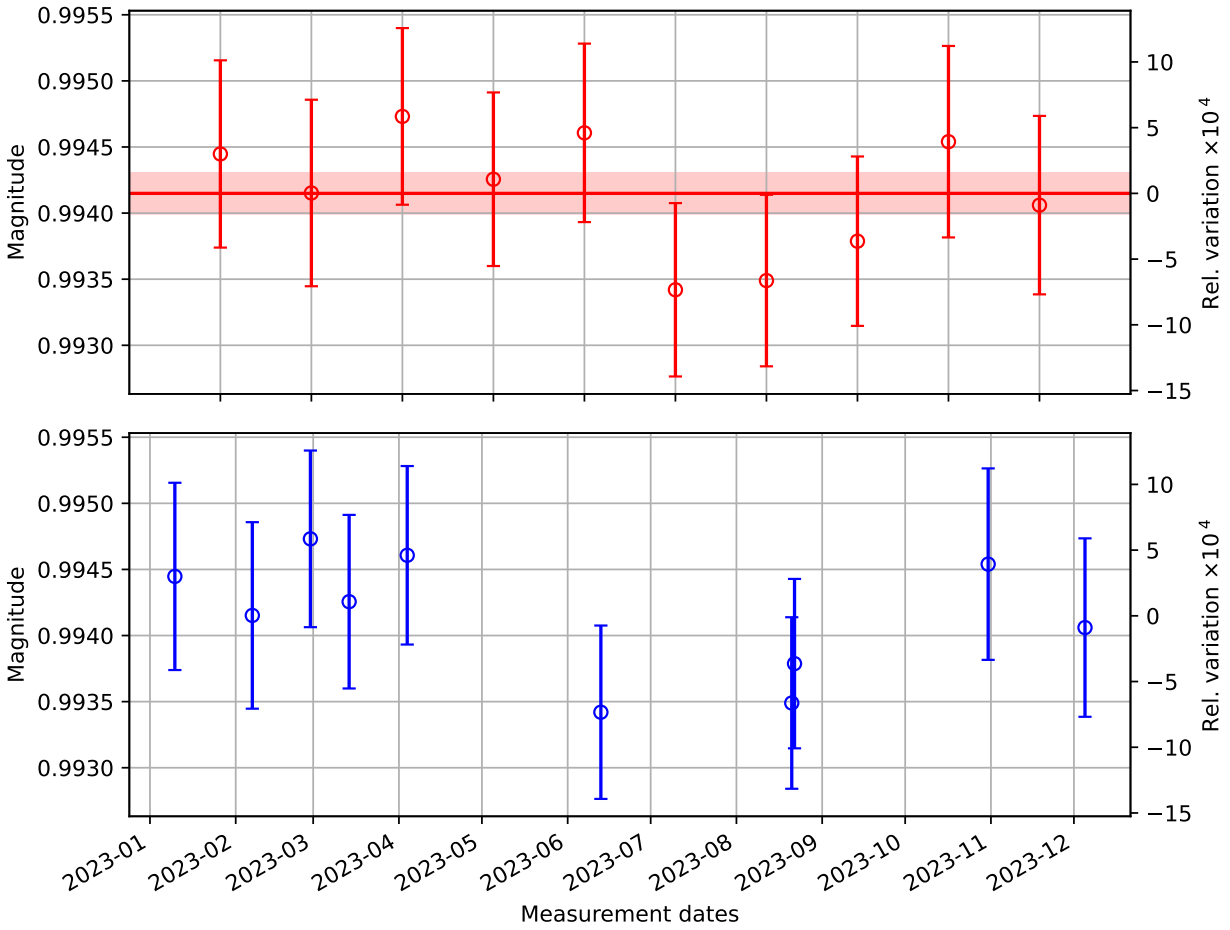
Summary of Input Side Optical Efficiency correction factor	
Mean value:	0.993050
Standard deviation:	0.000460
Standard error:	0.000153
Relative Standard error:	0.000154

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

List of Measurements

Date	E_R ± SD_E_R
D20230110	0.9944 ± 0.0007
D20230207	0.9942 ± 0.0007
D20230228	0.9947 ± 0.0007
D20230314	0.9943 ± 0.0007
D20230404	0.9946 ± 0.0007
D20230613	0.9934 ± 0.0007
D20230821	0.9935 ± 0.0006
D20230822	0.9938 ± 0.0006
D20231031	0.9945 ± 0.0007
D20231205	0.9941 ± 0.0007

Output Side Optical Efficiency correction factor



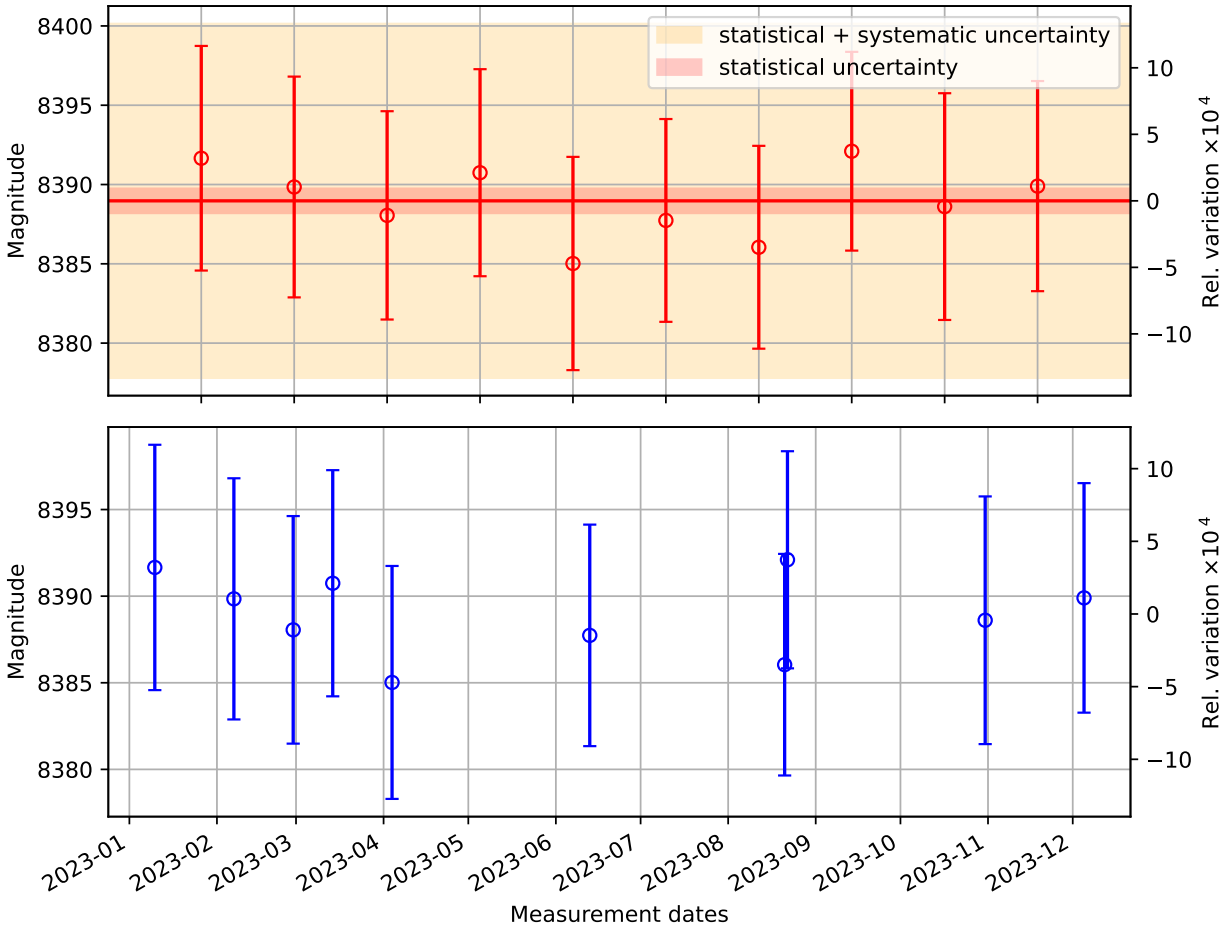
Summary of Output Side Optical Efficiency correction factor	
Mean value:	0.994149
Standard deviation:	0.000460
Standard error:	0.000153
Relative Standard error:	0.000154

21 TxPD calibration at ETM ($\rho\prime_{Tx} = \rho_T.\eta_T.\zeta$)

List of Measurements

Date	rhoT_prime ± SD_rhoT_prime
D20230110	8391.6574 ± 7.0818
D20230207	8389.8439 ± 6.9612
D20230228	8388.0549 ± 6.5683
D20230314	8390.7454 ± 6.5279
D20230404	8385.0193 ± 6.7238
D20230613	8387.7359 ± 6.3941
D20230821	8386.0437 ± 6.3956
D20230822	8392.0998 ± 6.2670
D20231031	8388.6083 ± 7.1489
D20231205	8389.8996 ± 6.6251

TxPD calibration corrected for optical efficiency (ct/W)



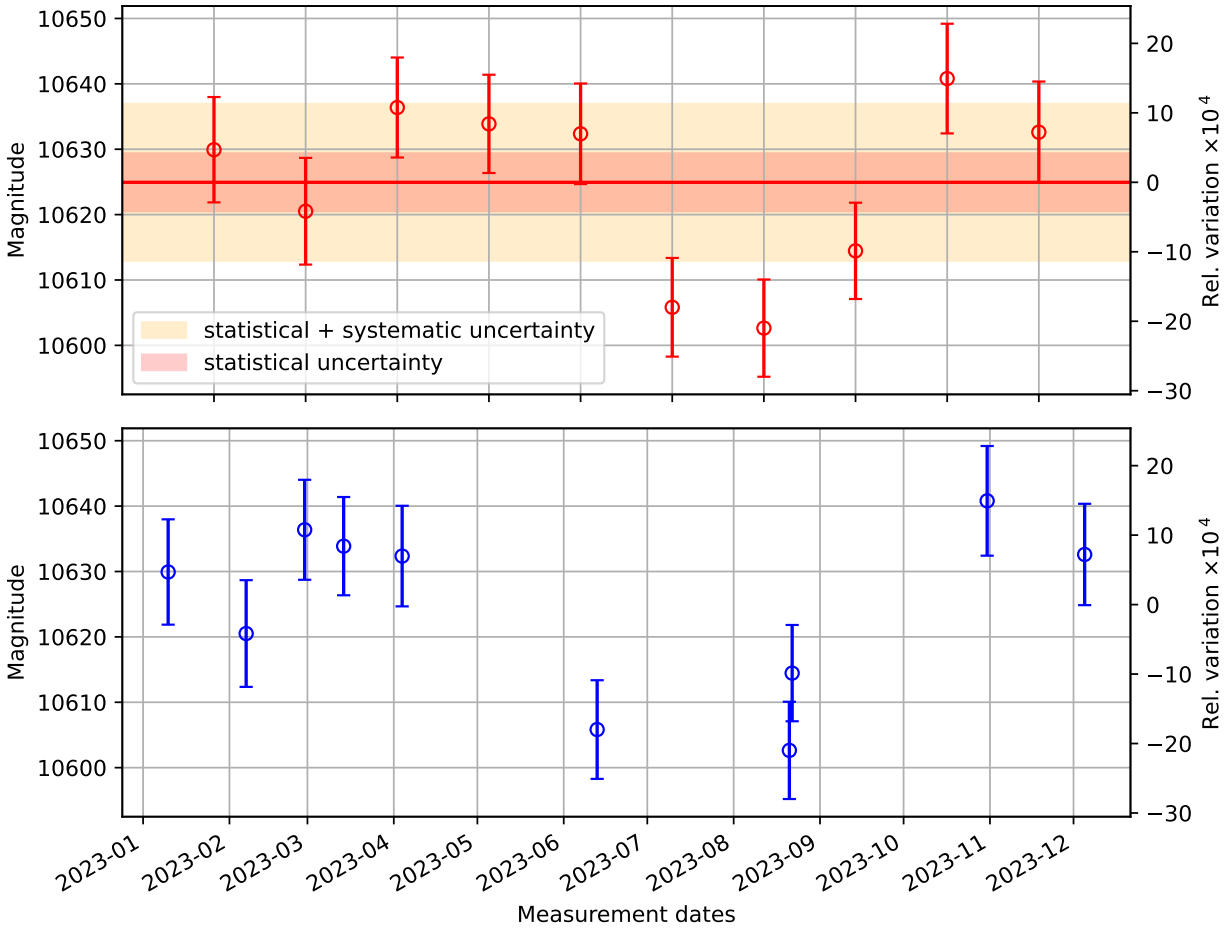
Summary of TxPD calibration corrected for optical efficiency (ct/W)	
Mean value:	8388.970815
Standard deviation:	2.320454
Standard error:	0.772362
Relative Standard error:	0.000092

22 RxPD calibration at ETM ($\rho\prime_{Rx} = \rho_R.\eta_R.\zeta$)

List of Measurements

Date	rhoR_prime ± SD_rhoR_prime
D20230110	10629.9242 ± 8.0551
D20230207	10620.5139 ± 8.1595
D20230228	10636.3809 ± 7.6456
D20230314	10633.8774 ± 7.5141
D20230404	10632.3603 ± 7.6934
D20230613	10605.8257 ± 7.5452
D20230821	10602.6395 ± 7.4380
D20230822	10614.4571 ± 7.3641
D20231031	10640.8070 ± 8.3872
D20231205	10632.6039 ± 7.7518

RxPD calibration corrected for optical efficiency (ct/W)



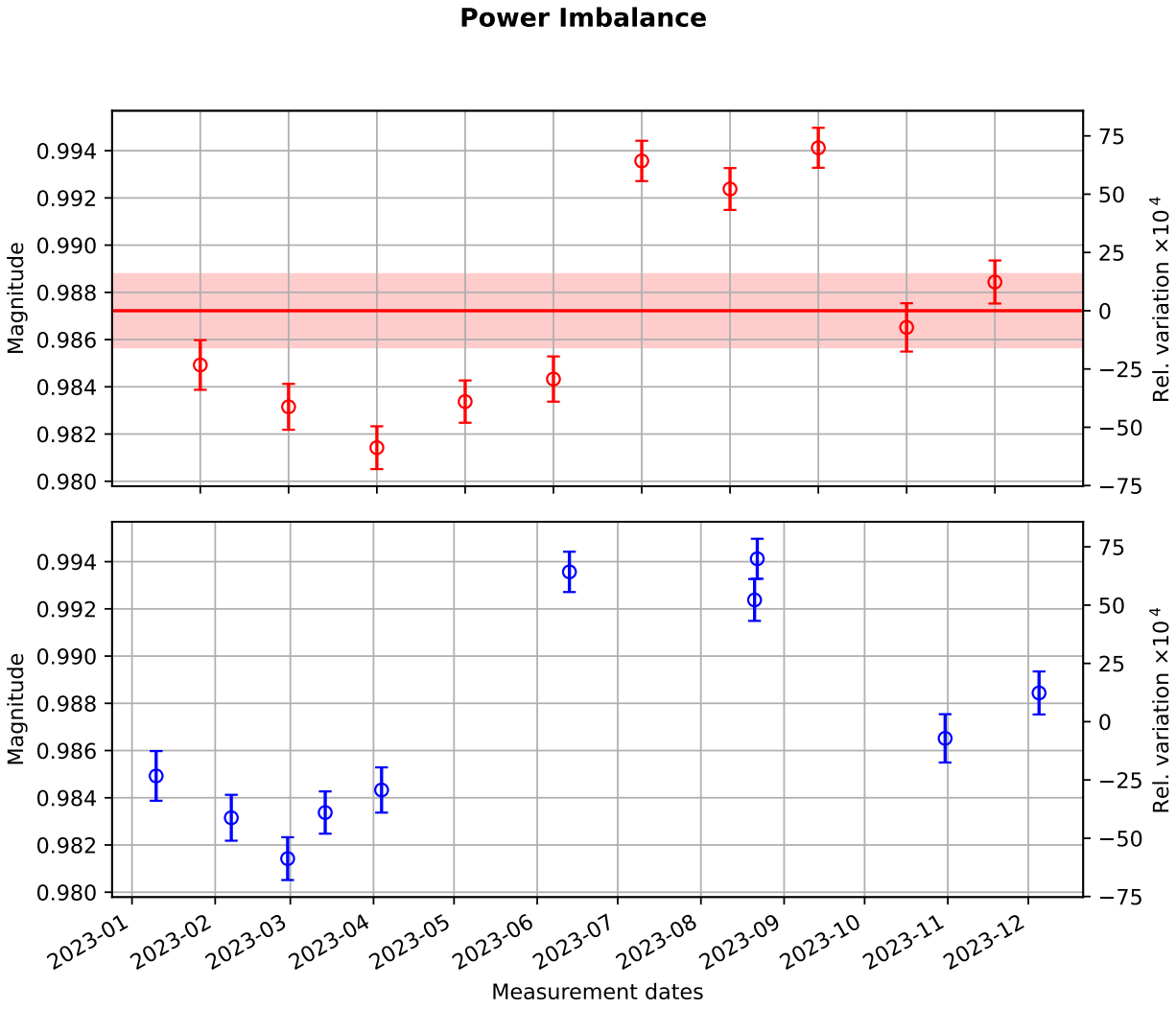
Summary of RxPD calibration corrected for optical efficiency (ct/W)

Mean value:	10624.938991
Standard deviation:	13.305501
Standard error:	4.428729
Relative Standard error:	0.000417

23 Power Imbalance

List of Measurements

Date	PI ± SD_PI
D20230110	0.9849 ± 0.0011
D20230207	0.9832 ± 0.0010
D20230228	0.9814 ± 0.0009
D20230314	0.9834 ± 0.0009
D20230404	0.9843 ± 0.0010
D20230613	0.9936 ± 0.0009
D20230821	0.9924 ± 0.0009
D20230822	0.9941 ± 0.0008
D20231031	0.9865 ± 0.0010
D20231205	0.9884 ± 0.0009



Summary of Power Imbalance	
Mean value:	0.987223
Standard deviation:	0.004656
Standard error:	0.001550
Relative Standard error:	0.001570