RxPD and TxPD Calibration Trends

| GENERATED FOR LHO_EndX

Report Generated on April 26, 2024

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
D20240229         -0.4610 ± 0.0004
D20240423         -0.4604 ± 0.0004
```

WS/Tx when WS is at Tx (Inner beam) [m1]
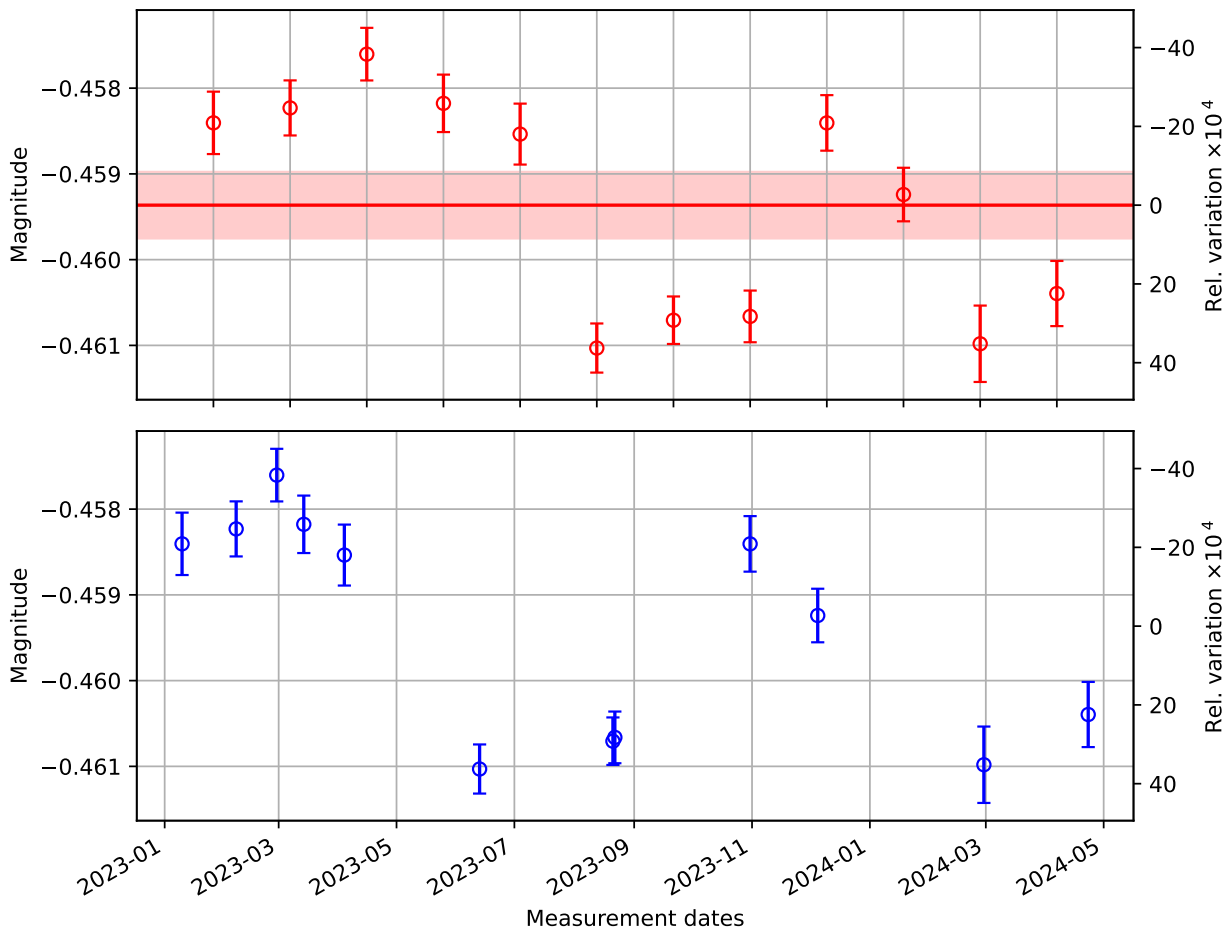

```
Summary of WS/Tx when WS is at Tx (Inner beam) [m1]
                        Mean value:     -0.459364
                 Standard deviation:     0.001289
                    Standard error:      0.000388
           Relative Standard error:     -0.000845
```
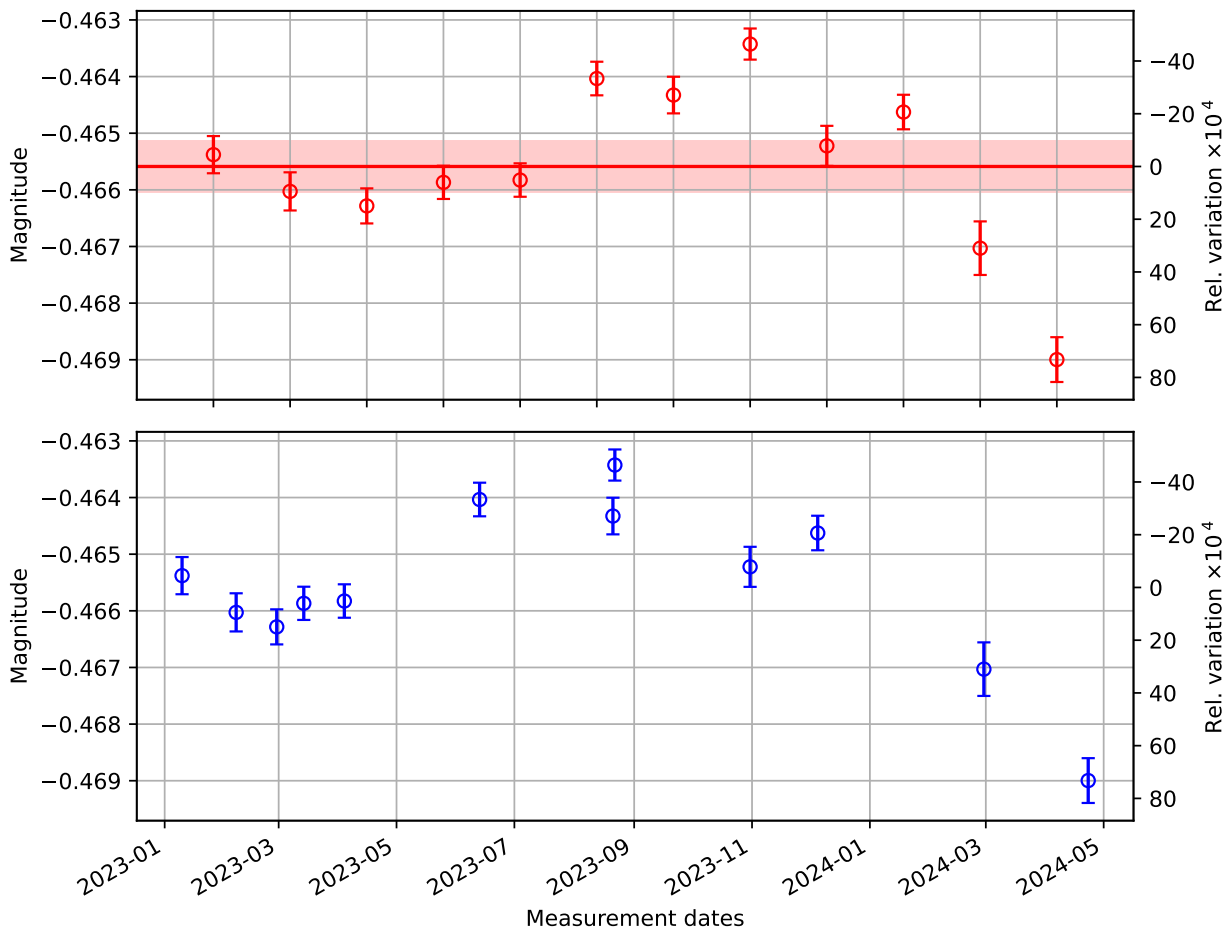
3   WS/Tx Ratio when WS is at Tx (Outer Beam)

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
D20240229       -0.4670 ± 0.0005
D20240423       -0.4690 ± 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:    -0.465587
                Standard deviation:     0.001486
                    Standard error:     0.000448
          Relative Standard error:    -0.000961
```
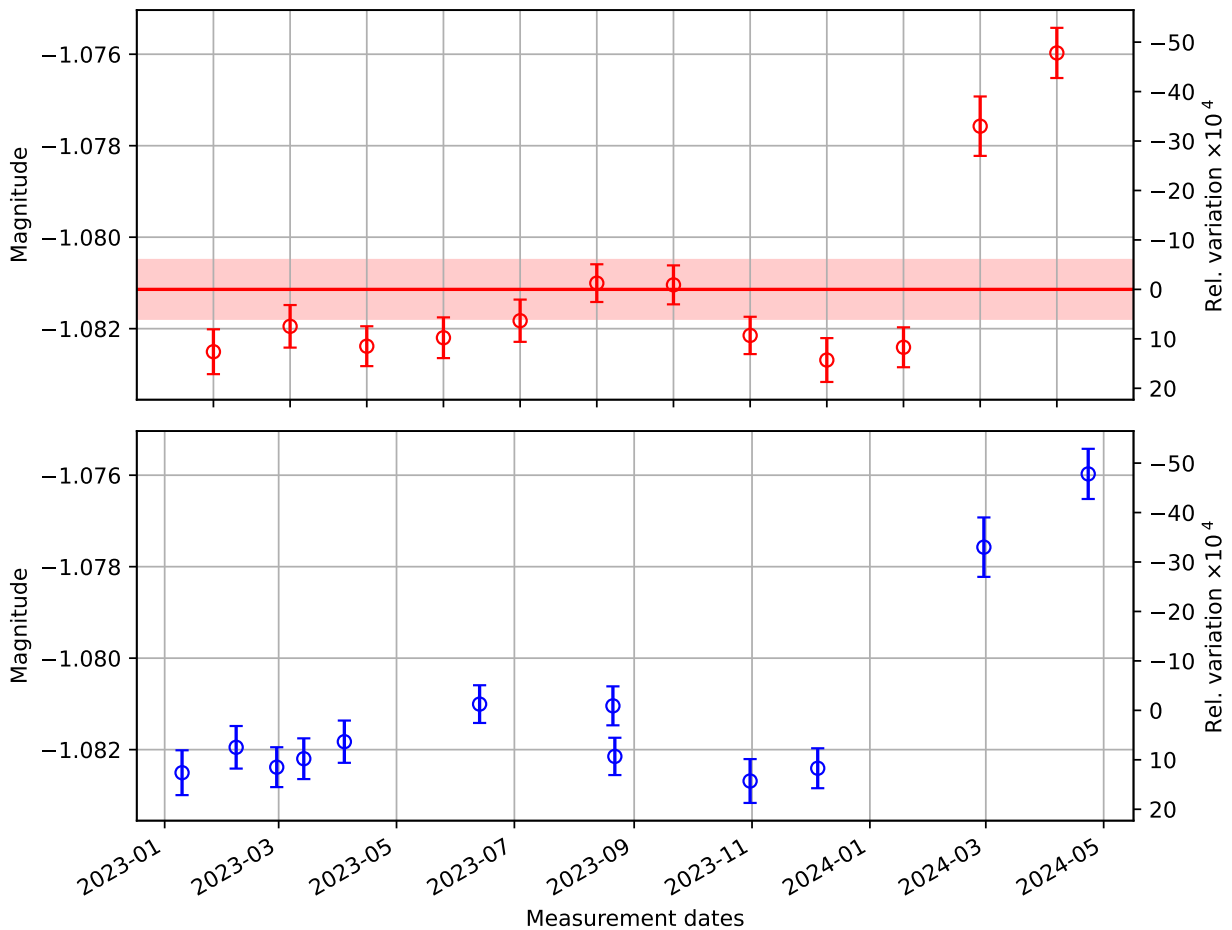
4   Tx/WS responsivity ratio $\alpha_{\mathbf{TW}} = 1/[\mathbf{m1} + \mathbf{m2}]$

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
D20240229       -1.0776 ± 0.0006
D20240423       -1.0760 ± 0.0005
```

Tx/WS responsivity ratio



```
Summary of Tx/WS responsivity ratio
                    Mean value:     -1.081141
             Standard deviation:     0.002135
                 Standard error:     0.000643
        Relative Standard error:    -0.000595
```

5

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
D20240229         -0.4560 ± 0.0005
D20240423         -0.4552 ± 0.0004
```

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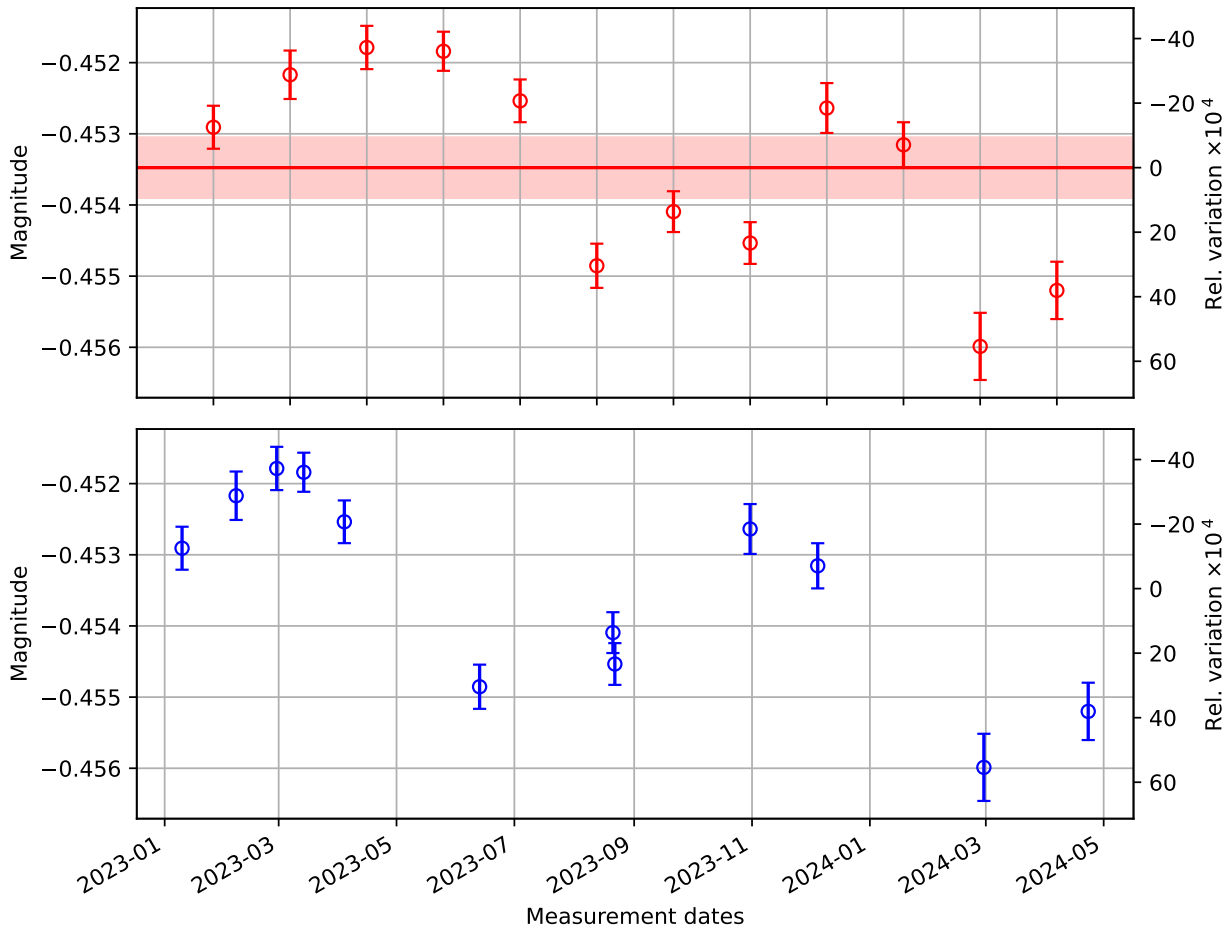

```
Summary of WS/Tx when WS is at Rx (Inner Beam) [m3]
                        Mean value:      -0.453475
                Standard deviation:       0.001412
                    Standard error:       0.000425
           Relative Standard error:      -0.000938
```
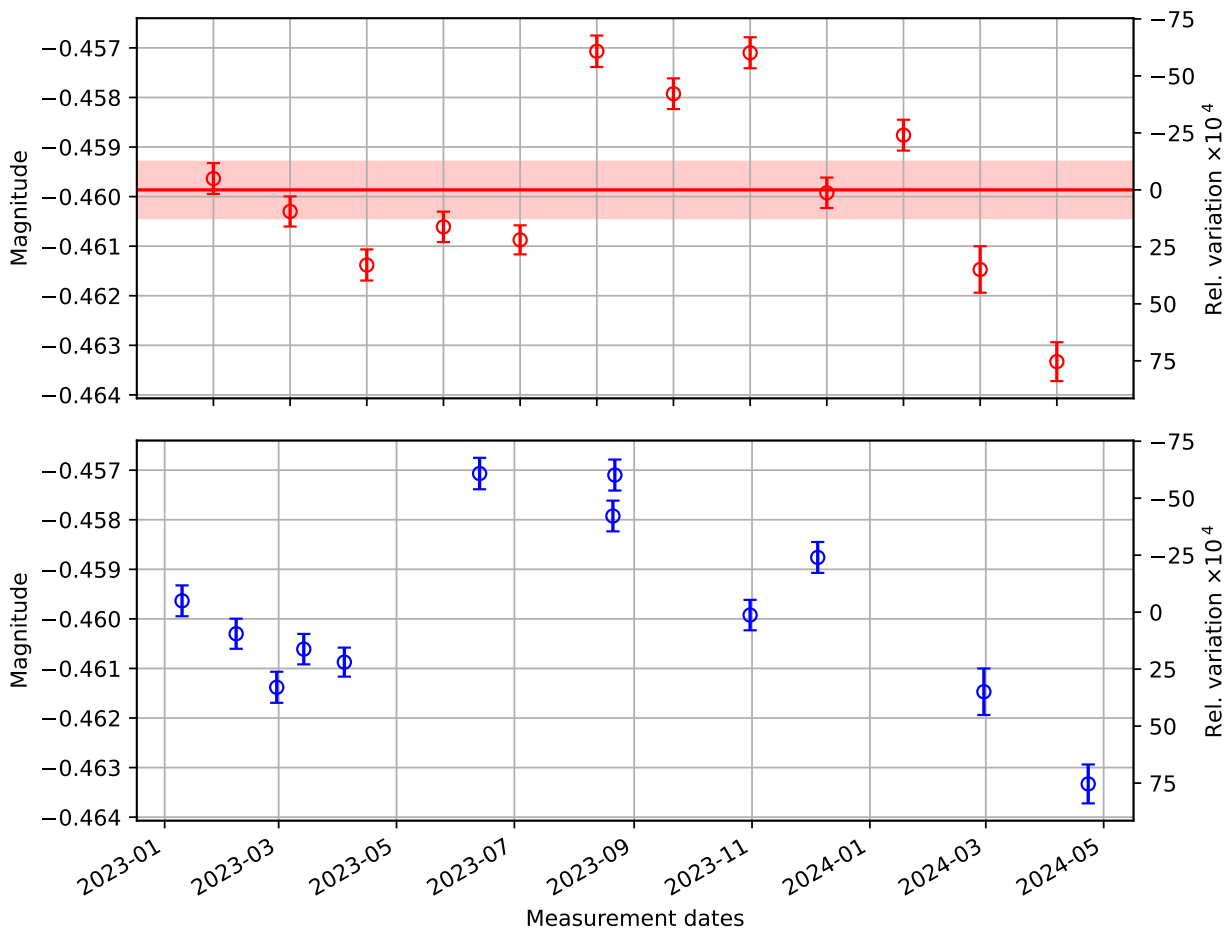
6 WS/Tx Ratio when WS is at Rx (Outer Beam)

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
D20240229       -0.4615 ± 0.0005
D20240423       -0.4633 ± 0.0004
```

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


```
Summary of WS/Tx when WS is at Rx (Outer Beam) [m4]
                          Mean value:    -0.459864
                  Standard deviation:     0.001887
                      Standard error:     0.000568
             Relative Standard error:    -0.001236
```
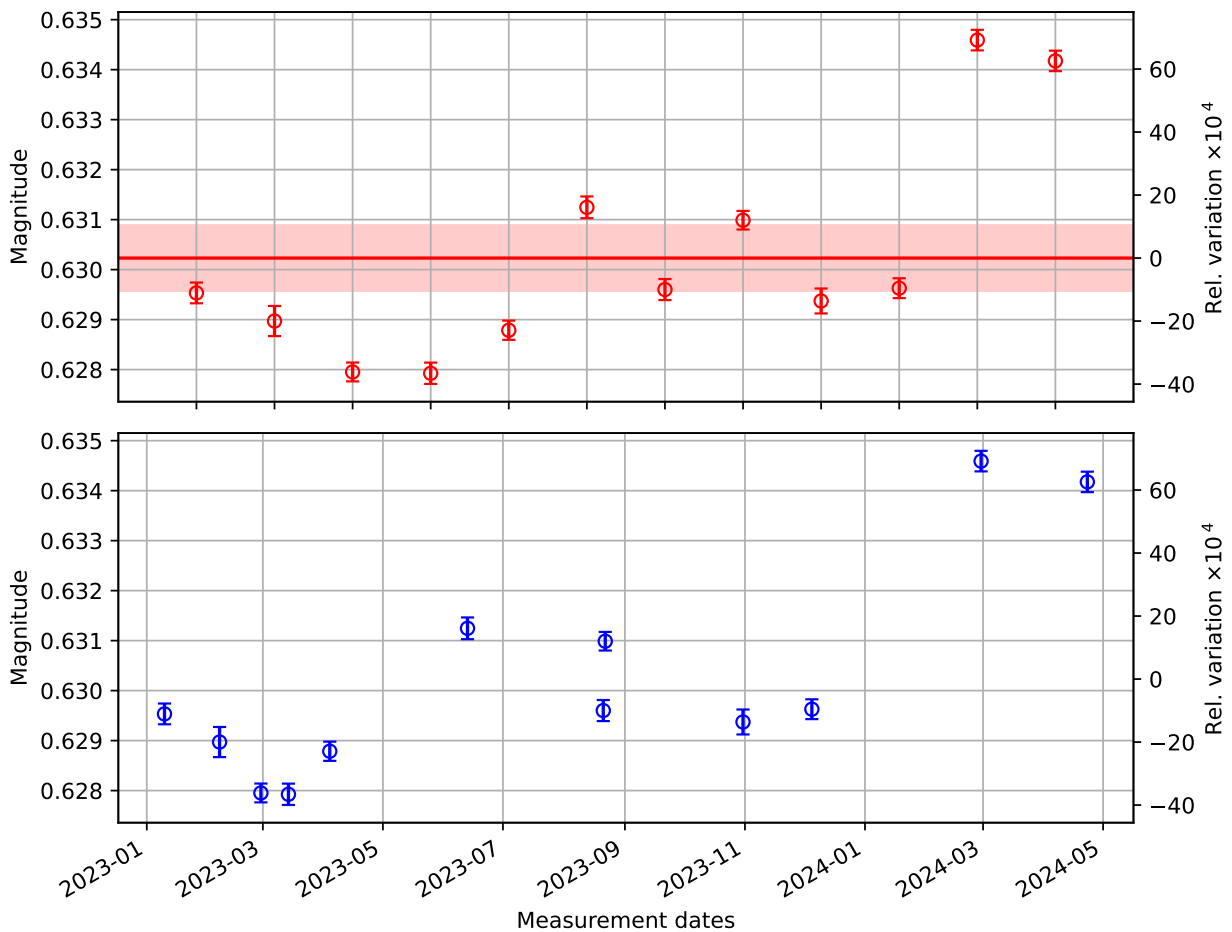
7 RX/TX Ratio (Inner Beam)

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
D20240229       0.6346 ± 0.0002
D20240423       0.6342 ± 0.0002
```

**Rx/Tx (Inner Beam) [m5]**


```
Summary of Rx/Tx (Inner Beam) [m5]
                    Mean value:     0.630231
             Standard deviation:    0.002181
                 Standard error:    0.000657
        Relative Standard error:    0.001042
```

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
D20240229         0.6411 ± 0.0002
D20240423         0.6438 ± 0.0003
```

Rx/Tx (Outer Beam) [m6]
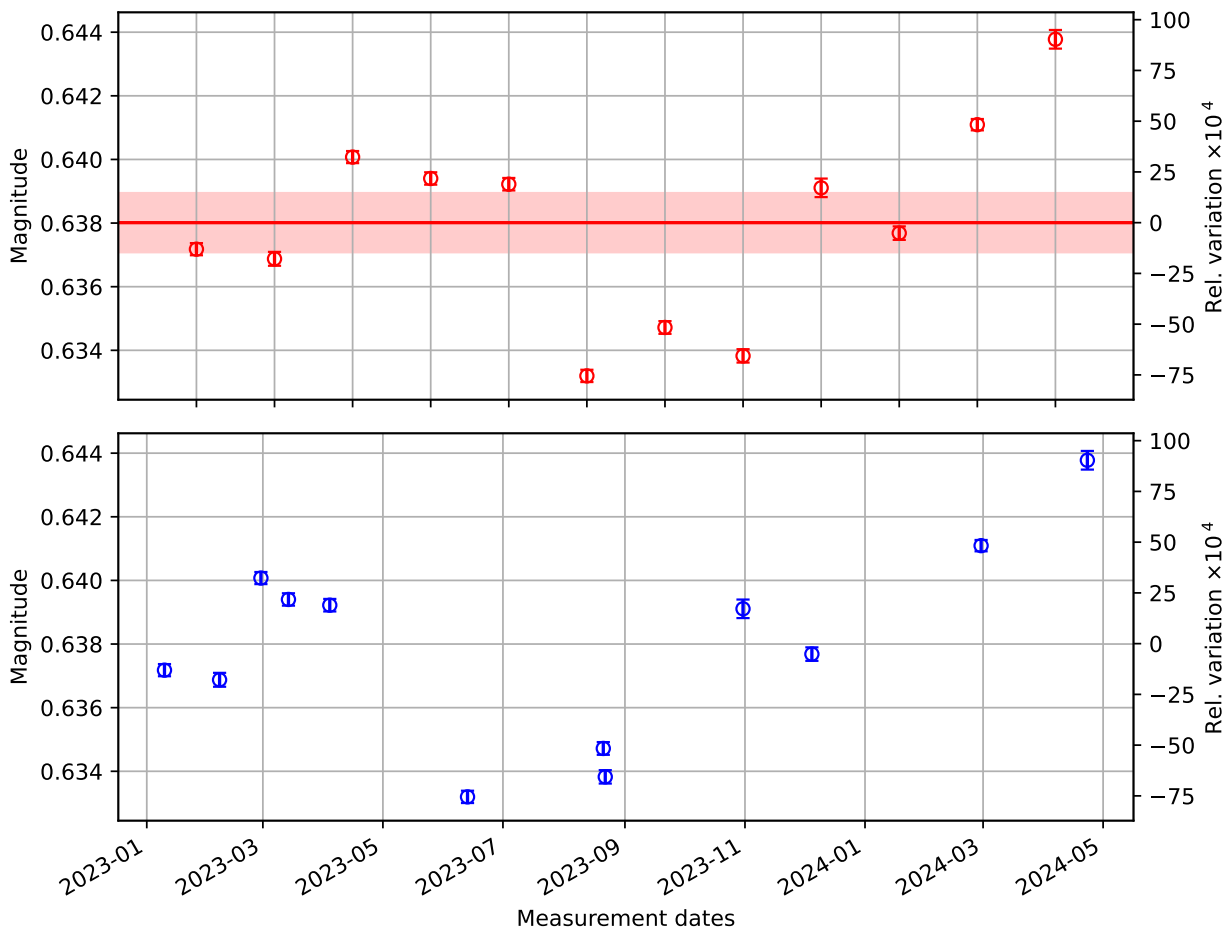


```
Summary of Rx/Tx (Outer Beam) [m6]
                        Mean value:      0.638013
                Standard deviation:      0.003093
                   Standard error:      0.000932
          Relative Standard error:      0.001460
```

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
D20240229     -1.3917 ± 0.0005
D20240423     -1.3932 ± 0.0005
```
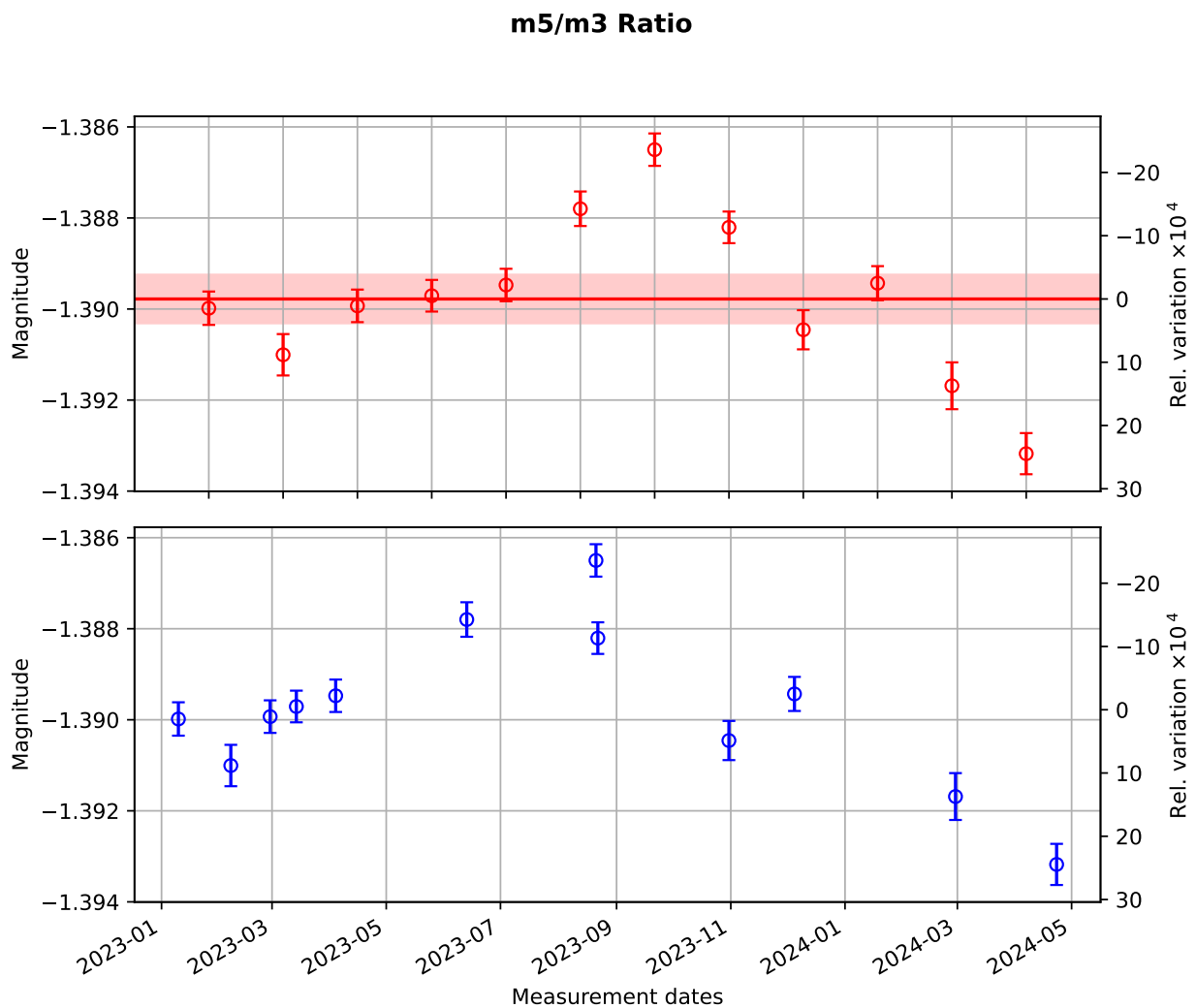
m5/m3 Ratio


```
Summary of m5/m3 Ratio
                    Mean value:    -1.389779
             Standard deviation:    0.001773
                 Standard error:    0.000534
        Relative Standard error:   -0.000384
```

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
D20240229	-1.3892 ± 0.0005
D20240423	-1.3895 ± 0.0005

m6/m4 Ratio


```
Summary of m6/m4 Ratio
                    Mean value:    -1.387390
             Standard deviation:    0.001960
                 Standard error:    0.000590
        Relative Standard error:   -0.000425
```
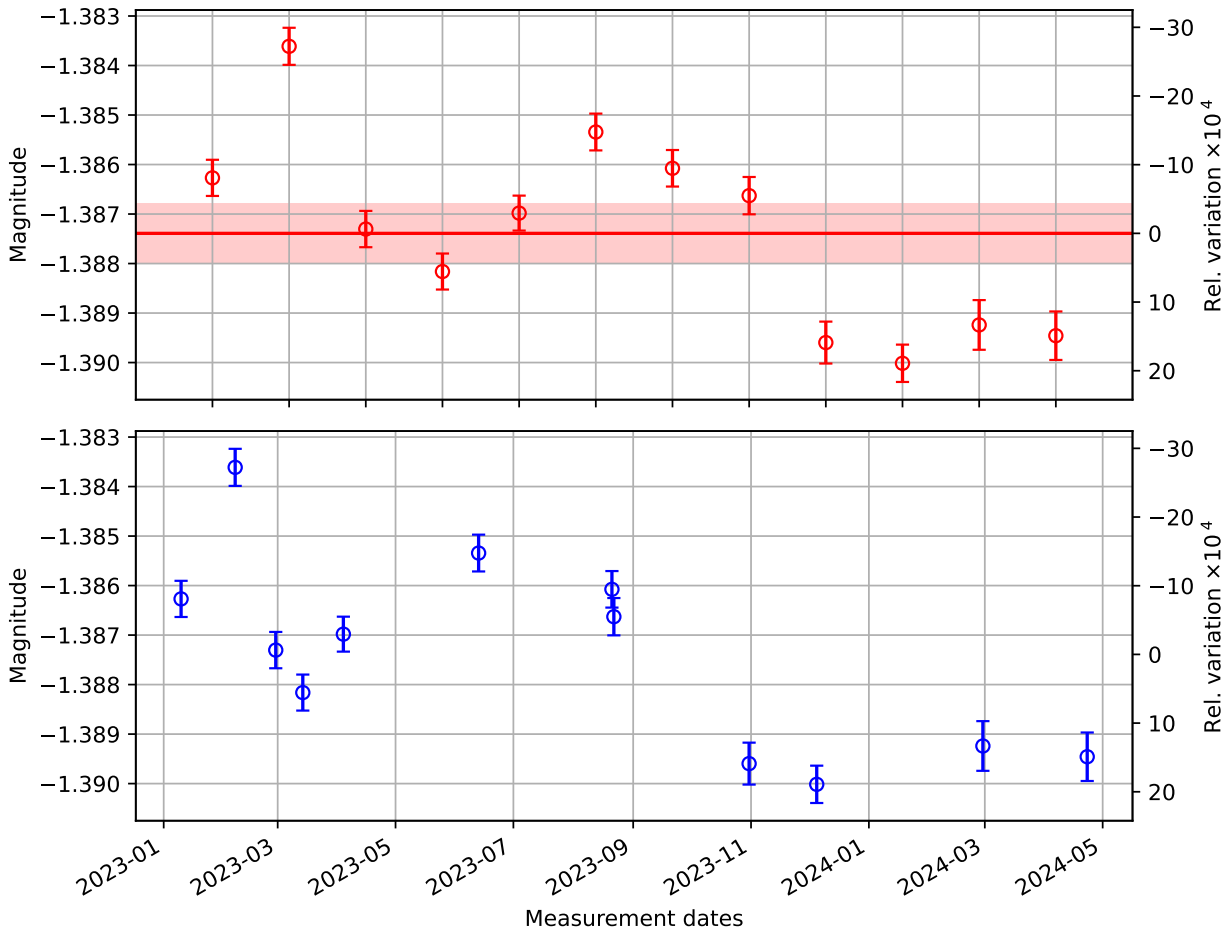
11 Rx/WS responsivity ratio $\alpha_{\mathbf{RW}} = \frac{1}{2}\left[\mathbf{m5/m3} + \mathbf{m6/m4}\right]$

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
D20240229       -1.3905 ± 0.0005
D20240423       -1.3913 ± 0.0005
```

Rx/WS responsivity ratio
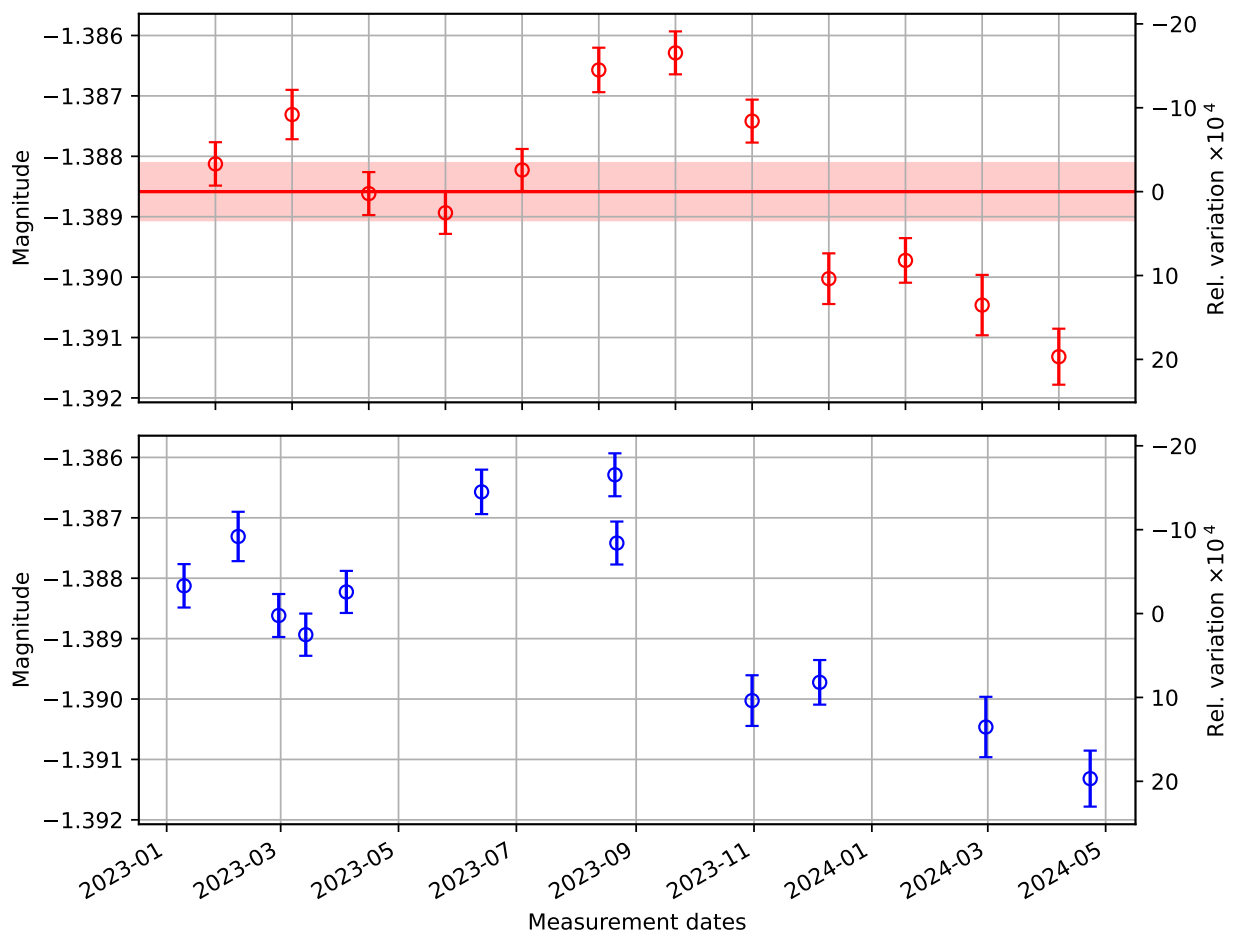


```
Summary of Rx/WS responsivity ratio
                    Mean value:      -1.388585
             Standard deviation:      0.001571
                 Standard error:      0.000473
        Relative Standard error:     -0.000341
```

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
D20240229       1.6369e+03 ± 1.0000e-09
D20240423       1.6369e+03 ± 1.0000e-09
```

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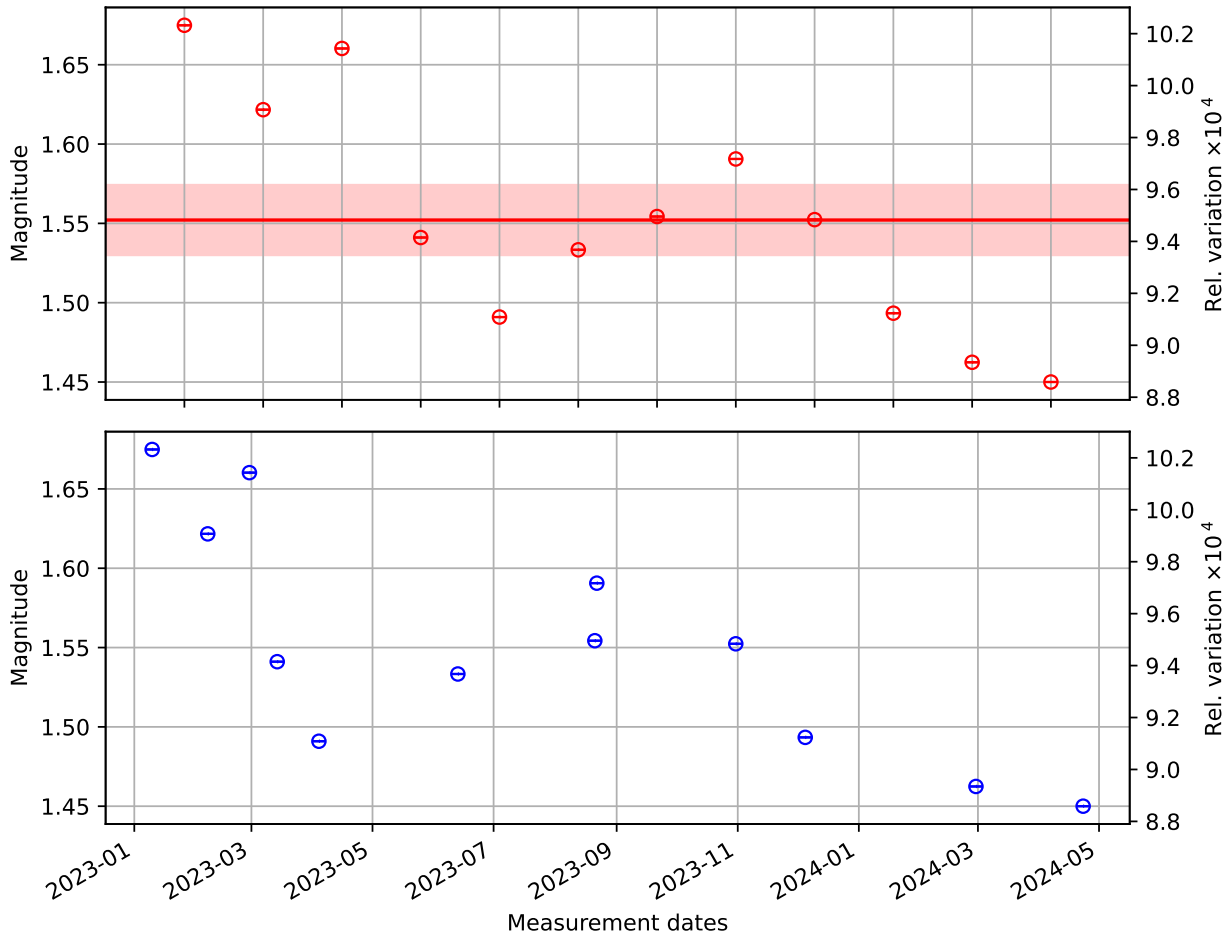

```
Summary of ADC conversion factor discrepancy
```

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
D20240229       8292.7841 ± 4.9992
D20240423       8280.0701 ± 4.2208
```

TxPD calibration (ct/W)
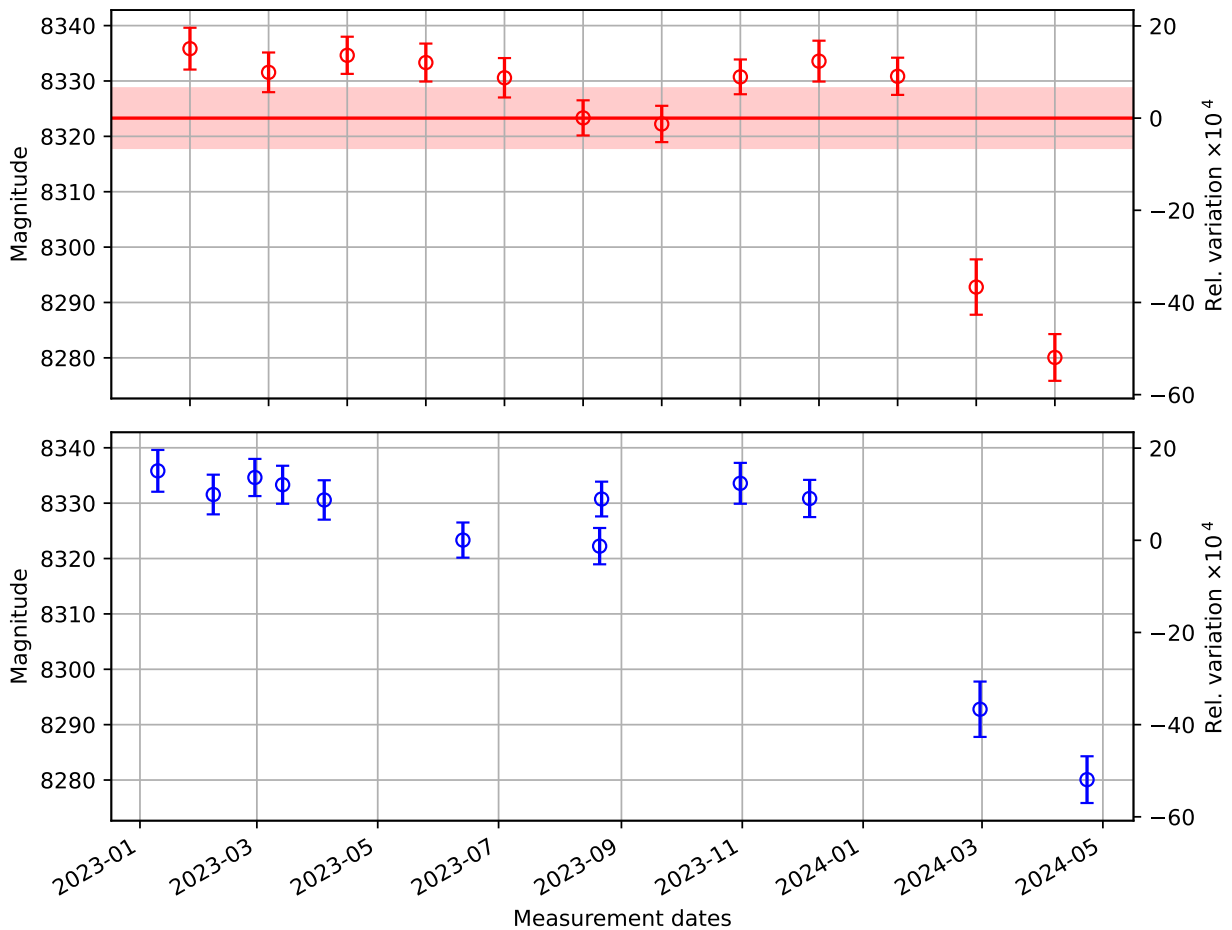

```
Summary of TxPD calibration (ct/W)
                        Mean value:    8323.295090
                Standard deviation:      17.905765
                    Standard error:       5.393482
           Relative Standard error:       0.000648
```

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
D20240229         10700.7205 ± 3.8462
D20240423         10706.7924 ± 3.5673
```

RxPD calibration (ct/W)
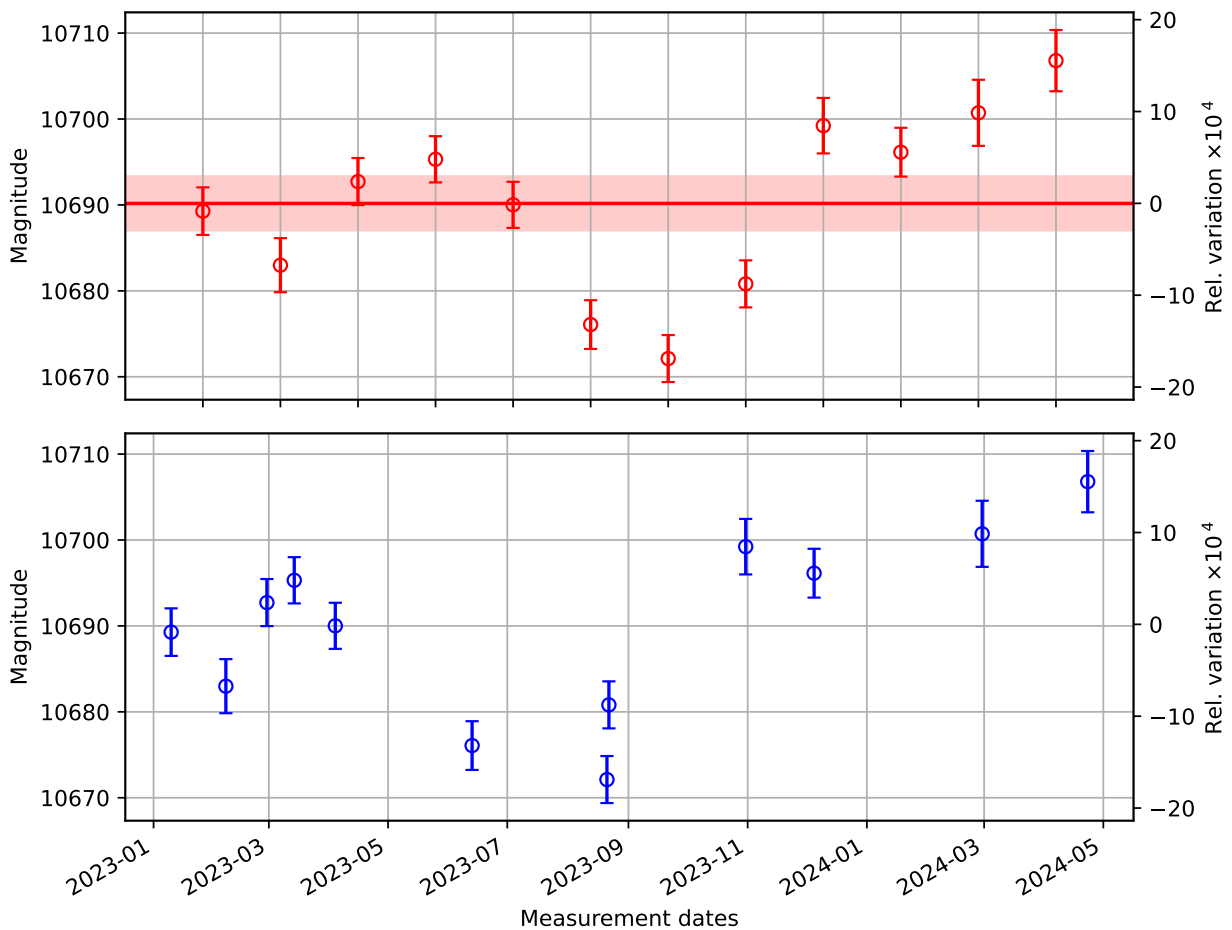


```
Summary of RxPD calibration (ct/W)
                       Mean value:    10690.182190
                Standard deviation:      10.456040
                   Standard error:       3.149515
          Relative Standard error:       0.000295
```

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
D20240229       0.9892 ± 0.0014
D20240423       0.9887 ± 0.0012
```

Optical Efficiency (Inner Beam)
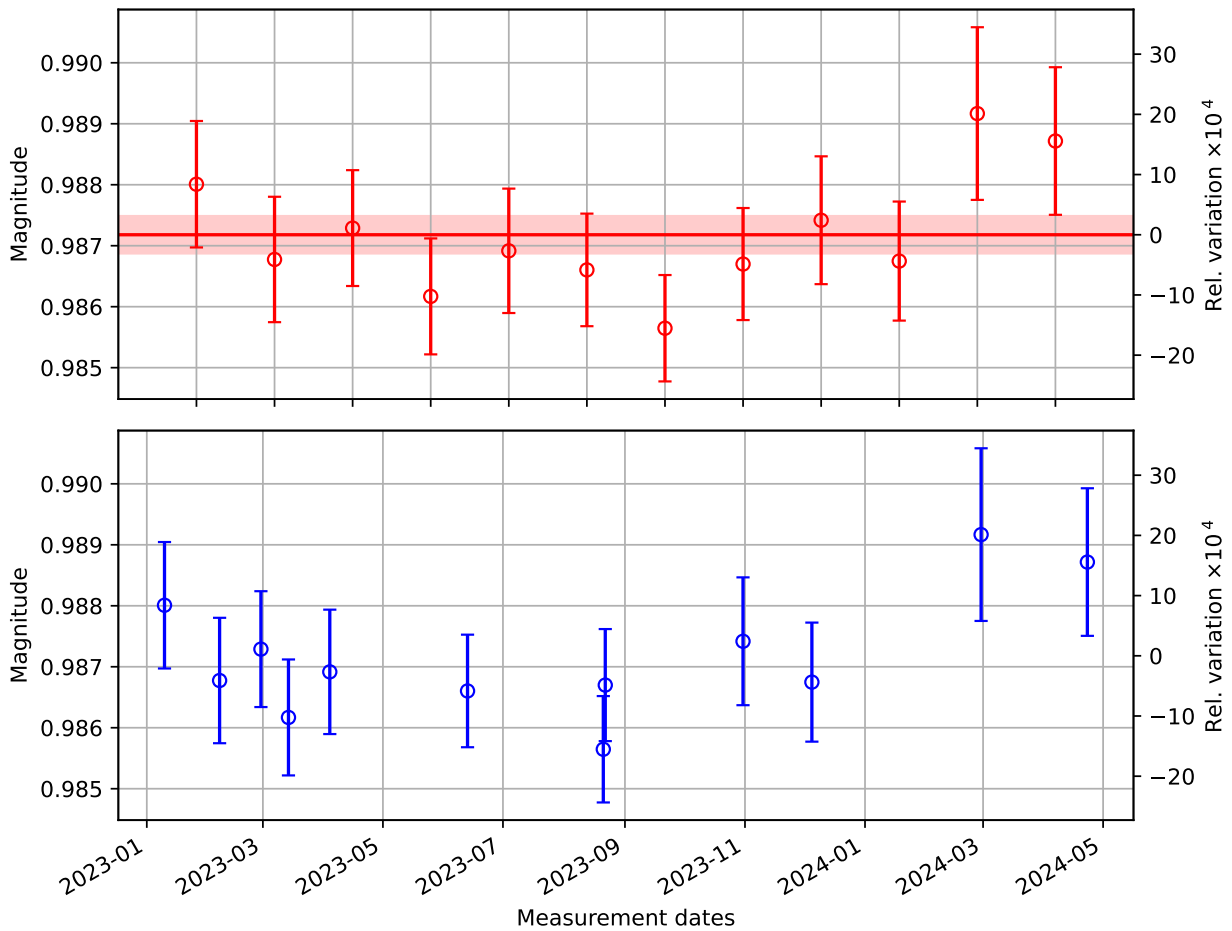

```
Summary of Optical Efficiency (Inner Beam)
                          Mean value:      0.987180
                   Standard deviation:     0.001019
                      Standard error:      0.000307
             Relative Standard error:      0.000311
```
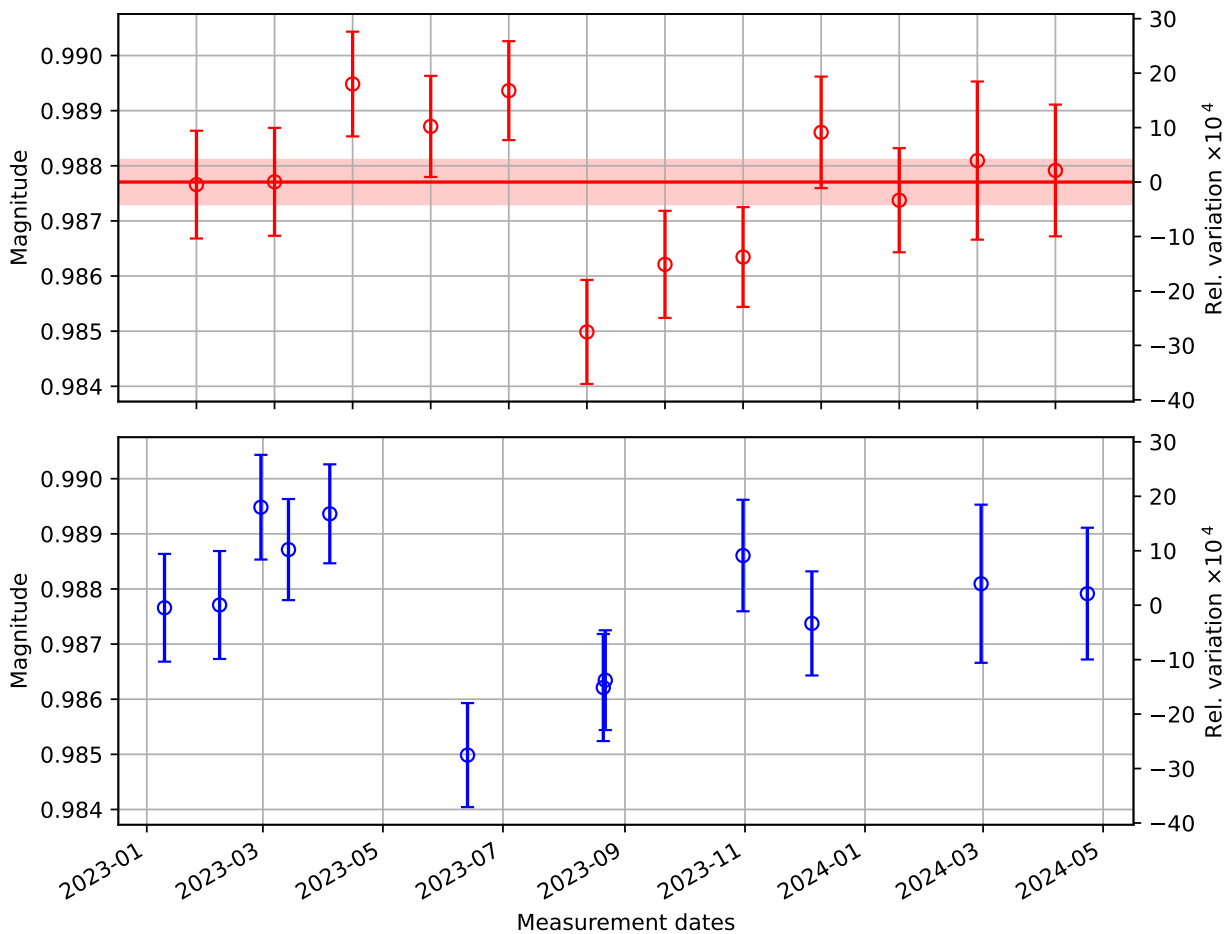
16 Optical Efficiency of Outer Beam e^o = m4/m2

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
D20240229       0.9881 ± 0.0014
D20240423       0.9879 ± 0.0012
```

Optical Efficiency (Outer Beam)



```
Summary of Optical Efficiency (Outer Beam)
                    Mean value:       0.987705
             Standard deviation:      0.001332
                Standard error:       0.000401
       Relative Standard error:       0.000406
```

17 Total Optical Efficiency 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
D20240229       0.9886 ± 0.0010
D20240423       0.9883 ± 0.0008
```

Overall Optical Efficiency
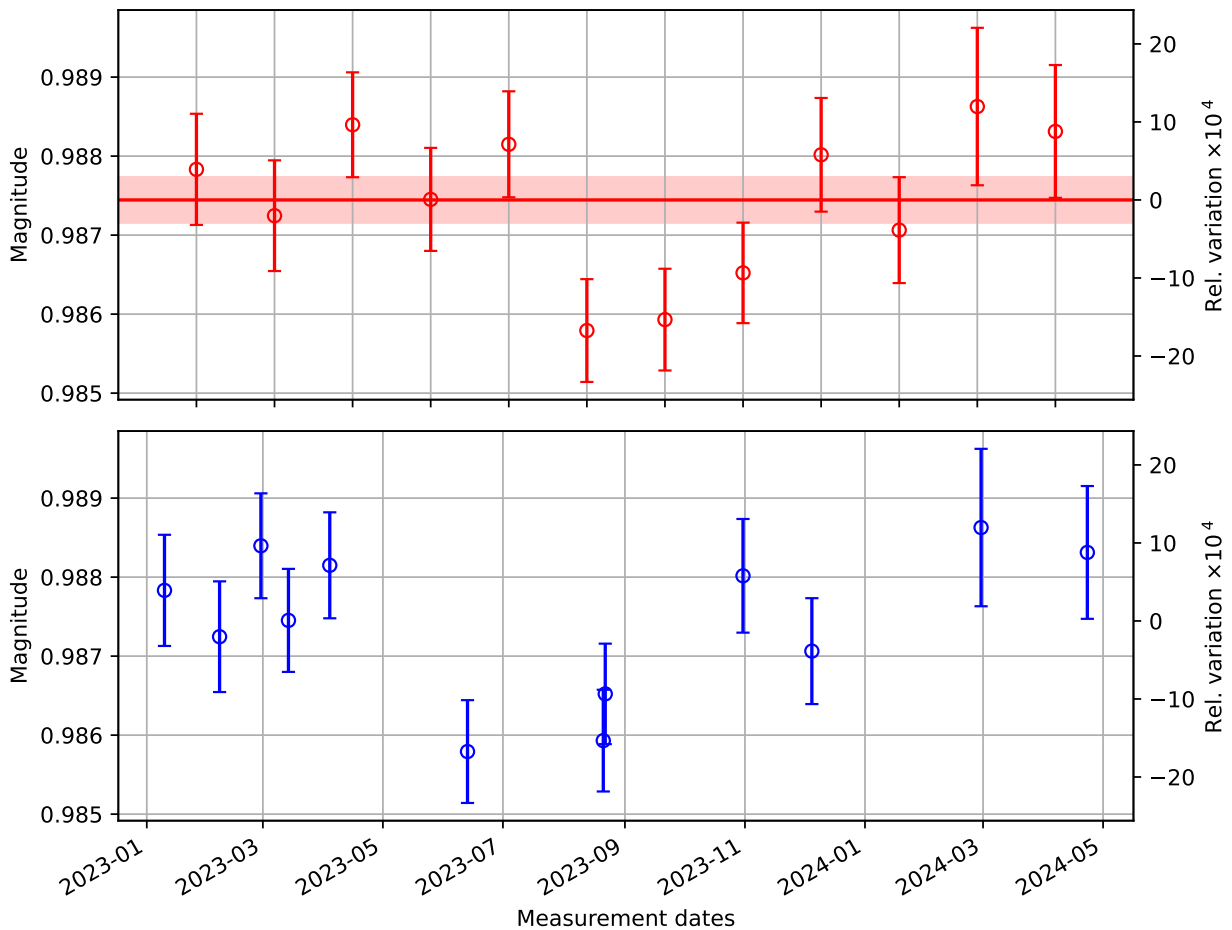

```
Summary of Overall Optical Efficiency
                        Mean value:      0.987445
                 Standard deviation:     0.000958
                     Standard error:     0.000289
            Relative Standard error:     0.000292
```

18

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
D20240229       9.9889e-01 ± 1.0000e-09
D20240423       9.9889e-01 ± 1.0000e-09
```
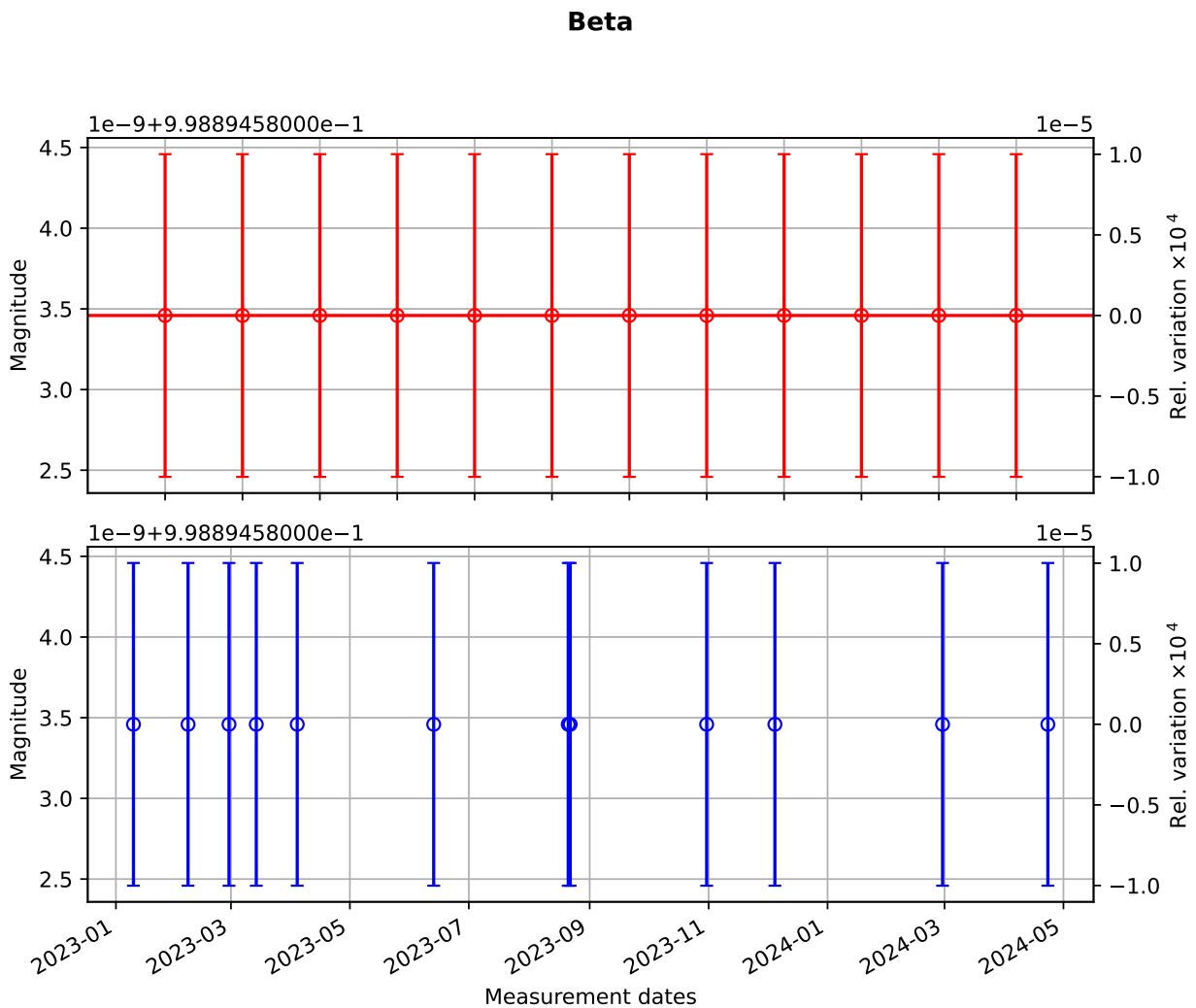
Beta


```
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
D20240229       0.9937 ± 0.0010
D20240423       0.9936 ± 0.0008
```

Input Side Optical Efficiency correction factor
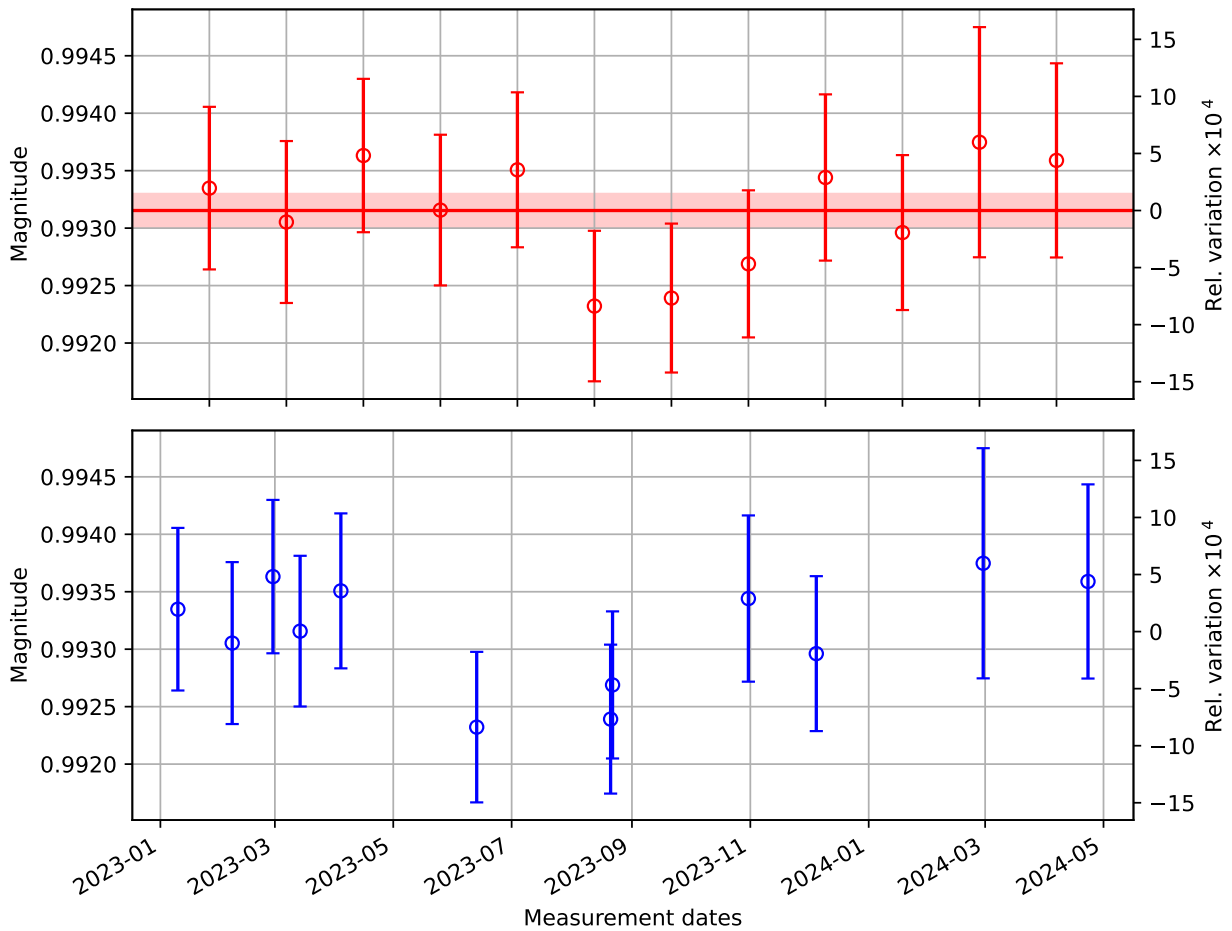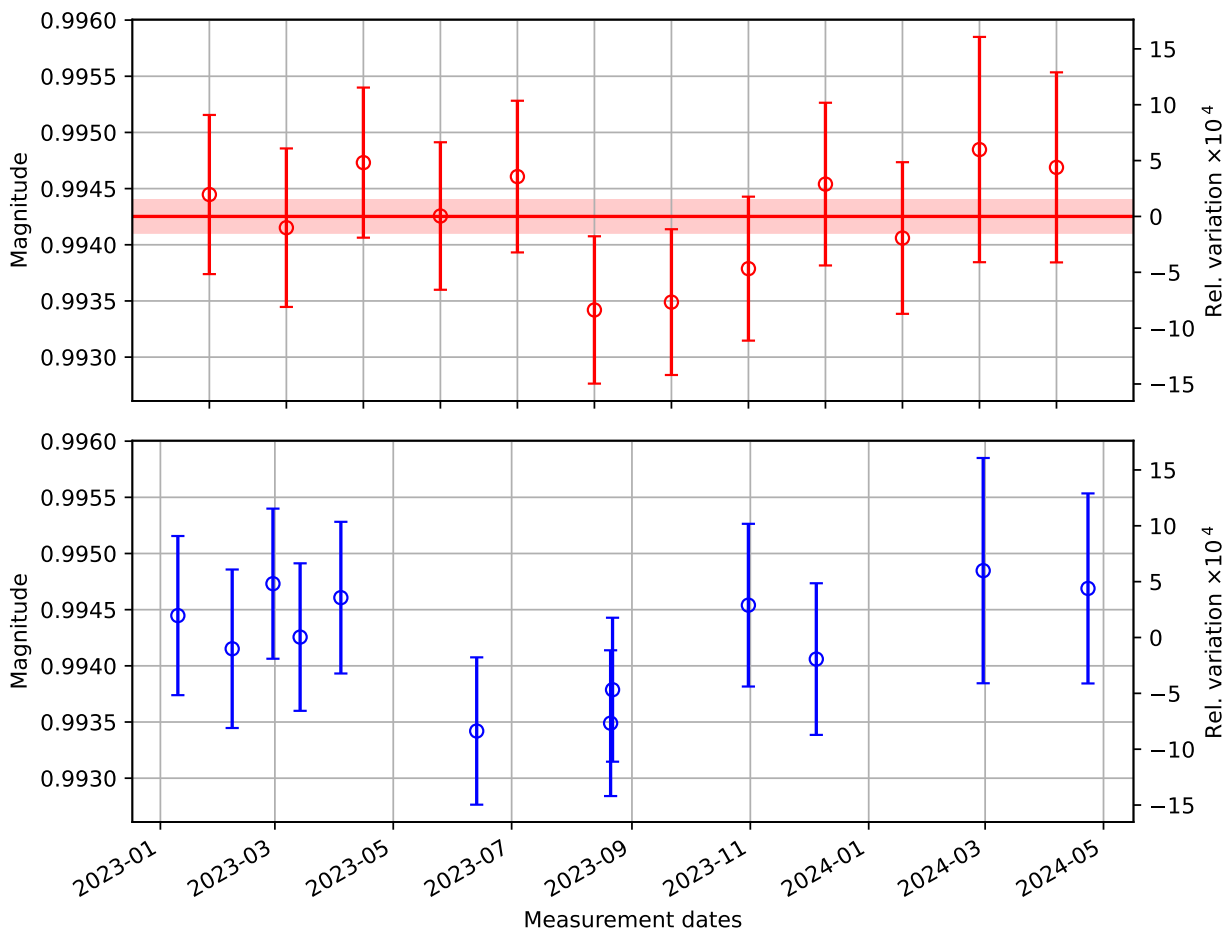


```
Summary of Input Side Optical Efficiency correction factor
                        Mean value:    0.993153
                 Standard deviation:    0.000482
                     Standard error:    0.000145
            Relative Standard error:    0.000146
```

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
D20240229      0.9948 ± 0.0010
D20240423      0.9947 ± 0.0008
```

Output Side Optical Efficiency correction factor


```
Summary of Output Side Optical Efficiency correction factor
                        Mean value:      0.994252
                 Standard deviation:     0.000482
                    Standard error:      0.000145
           Relative Standard error:      0.000146
```
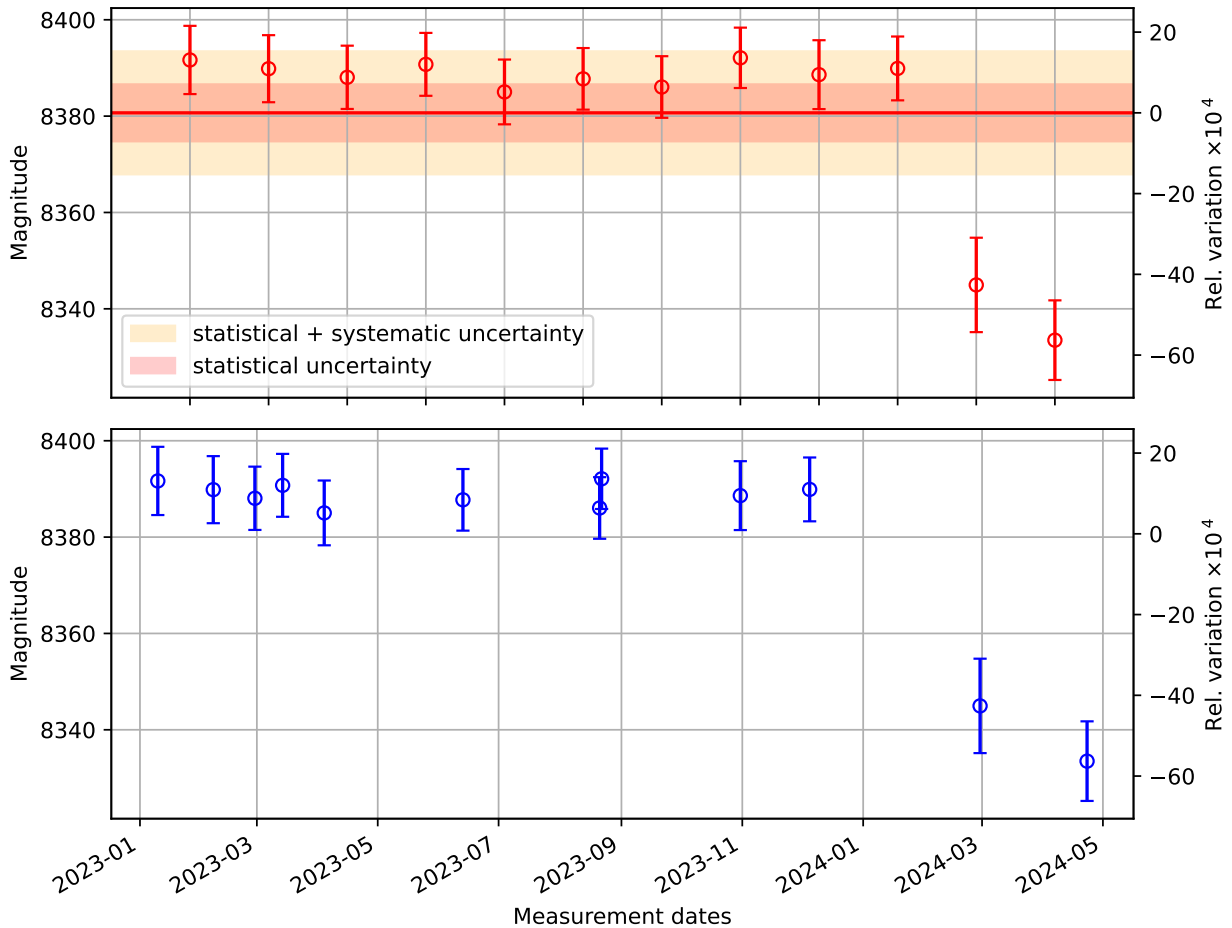
21 TxPD calibration at ETM ($\rho\prime_{Tx} = \rho_T.\eta_T.\zeta$)

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
D20240229       8344.9589 ± 9.7997
D20240423       8333.4924 ± 8.2620
```

TxPD calibration corrected for optical efficiency (ct/W)
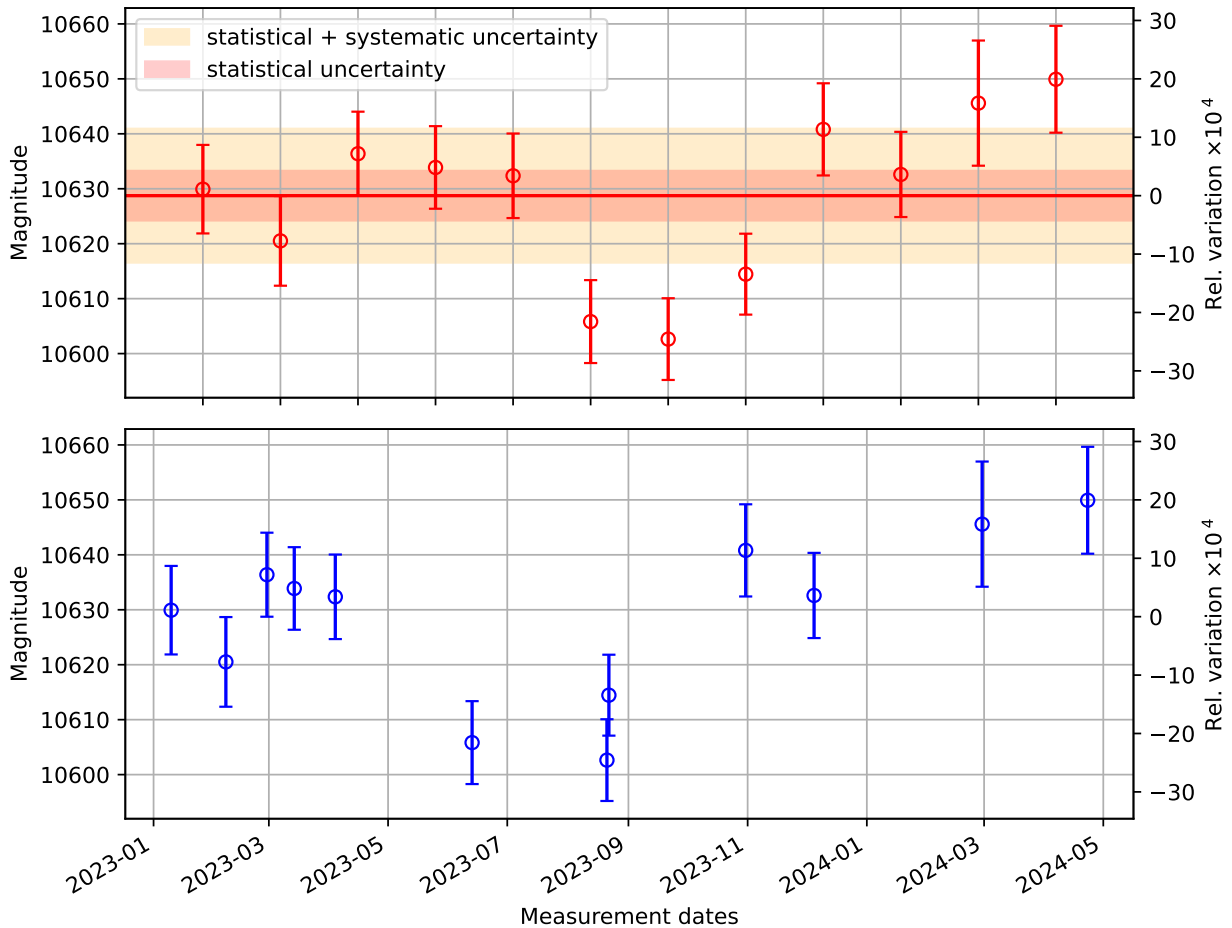


```
Summary of TxPD calibration corrected for optical efficiency (ct/W)
                        Mean value:      8380.679948
                 Standard deviation:       19.629546
                    Standard error:         5.912711
           Relative Standard error:         0.000706
```

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

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
D20240229       10645.5847 ± 11.3904
D20240423       10649.9286 ± 9.7264
```

RxPD calibration corrected for optical efficiency (ct/W)


```
Summary of RxPD calibration corrected for optical efficiency (ct/W)
                        Mean value:     10628.741931
                 Standard deviation:       14.986366
                     Standard error:        4.514116
            Relative Standard error:        0.000425
```

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
D20240229      0.9873 ± 0.0014
D20240423      0.9815 ± 0.0011
```

Power Imbalance
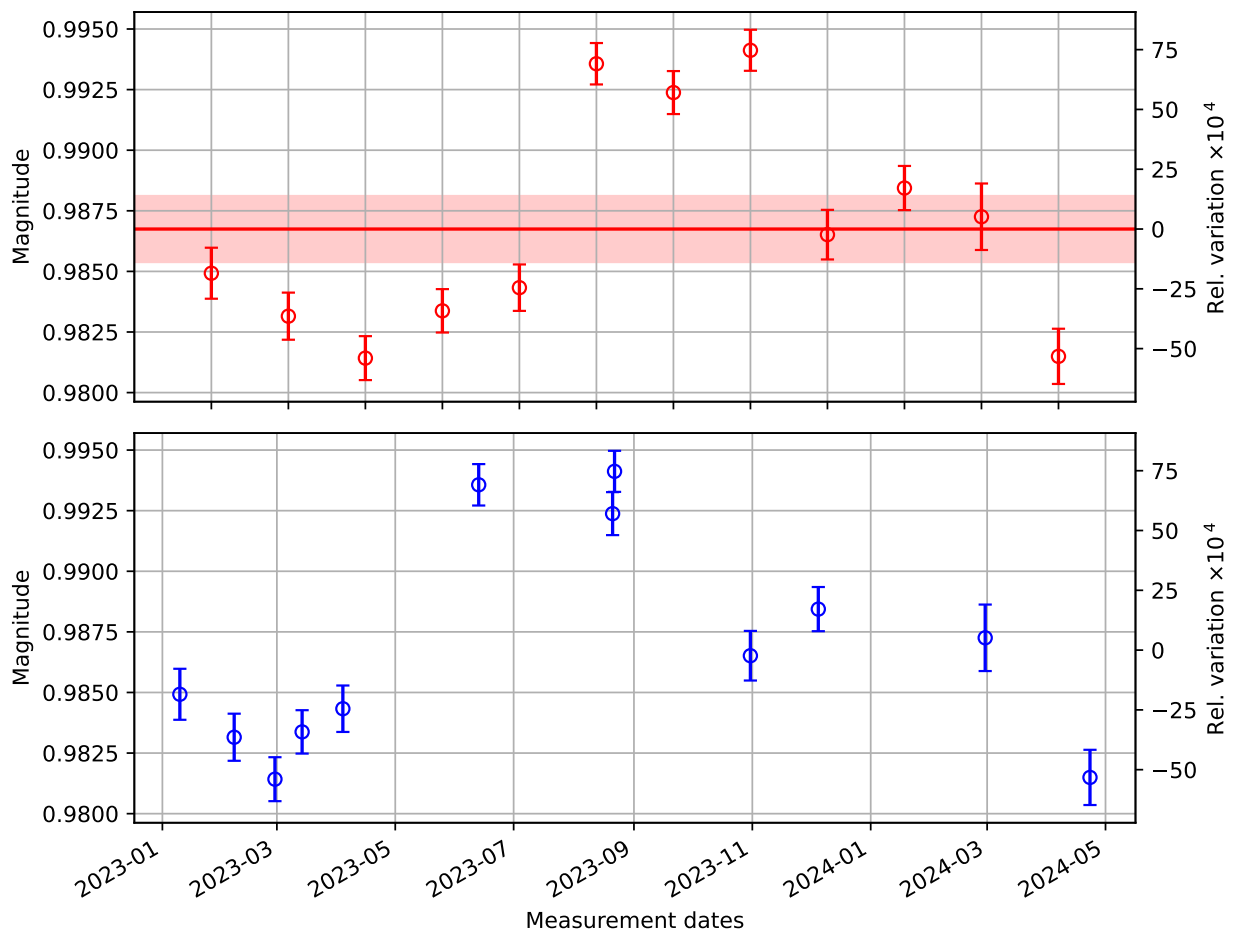

```
Summary of Power Imbalance
                    Mean value:    0.986748
             Standard deviation:   0.004524
                Standard error:    0.001363
       Relative Standard error:    0.001381
```