

RxPD and TxPD Calibration Trends

| GENERATED FOR LHO_EndY

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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:

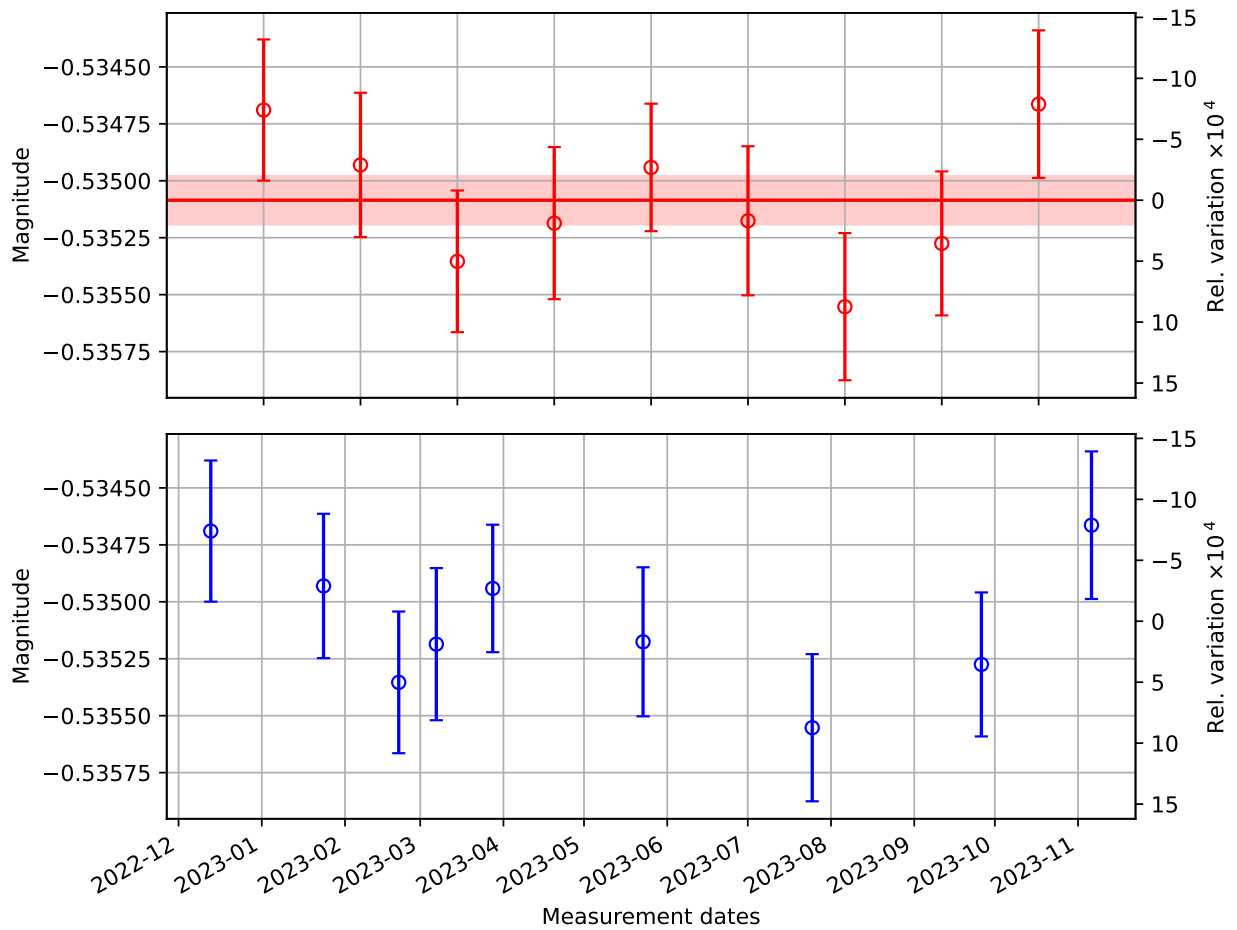
```
Mean = sum(x(i))/n
Std_Dev = sqrt(sum((x(i)-x_mean)^2)/(n-1))
Std_Err = Std_Dev*Student's_t_correction/sqrt(n)
Rel_Err = Std_Err/Mean
```

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

List of Measurements

Date	m1 $\pm$ SD_m1
D20221213	-0.5347 $\pm$ 0.0003
D20230124	-0.5349 $\pm$ 0.0003
D20230221	-0.5354 $\pm$ 0.0003
D20230307	-0.5352 $\pm$ 0.0003
D20230328	-0.5349 $\pm$ 0.0003
D20230523	-0.5352 $\pm$ 0.0003
D20230725	-0.5356 $\pm$ 0.0003
D20230926	-0.5353 $\pm$ 0.0003
D20231106	-0.5347 $\pm$ 0.0003

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



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

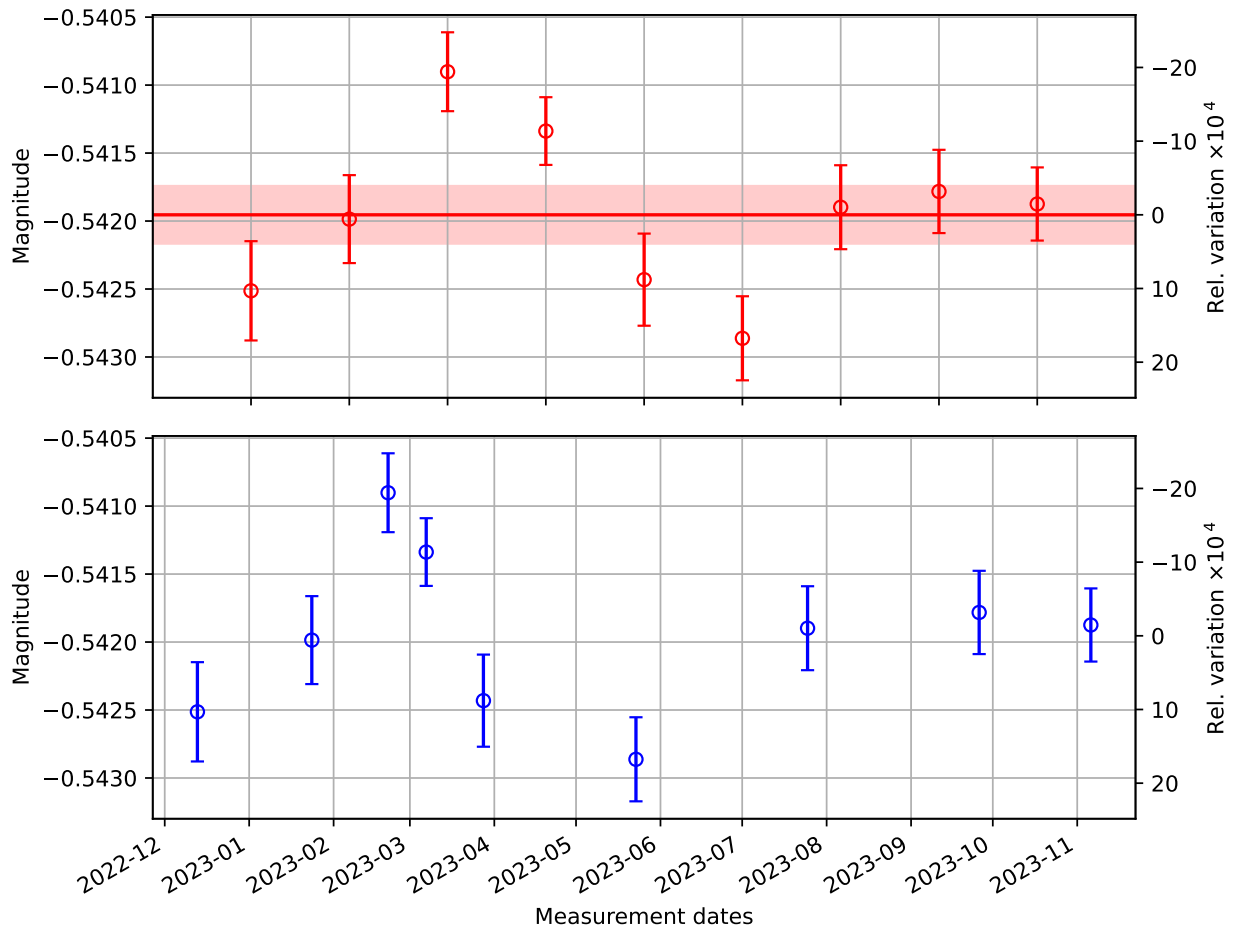
Mean value:	-0.535085
Standard deviation:	0.000301
Standard error:	0.000106
Relative Standard error:	-0.000198

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

List of Measurements

Date	m2 ± SD_m2
D20221213	-0.5425 ± 0.0004
D20230124	-0.5420 ± 0.0003
D20230221	-0.5409 ± 0.0003
D20230307	-0.5413 ± 0.0002
D20230328	-0.5424 ± 0.0003
D20230523	-0.5429 ± 0.0003
D20230725	-0.5419 ± 0.0003
D20230926	-0.5418 ± 0.0003
D20231106	-0.5419 ± 0.0003

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

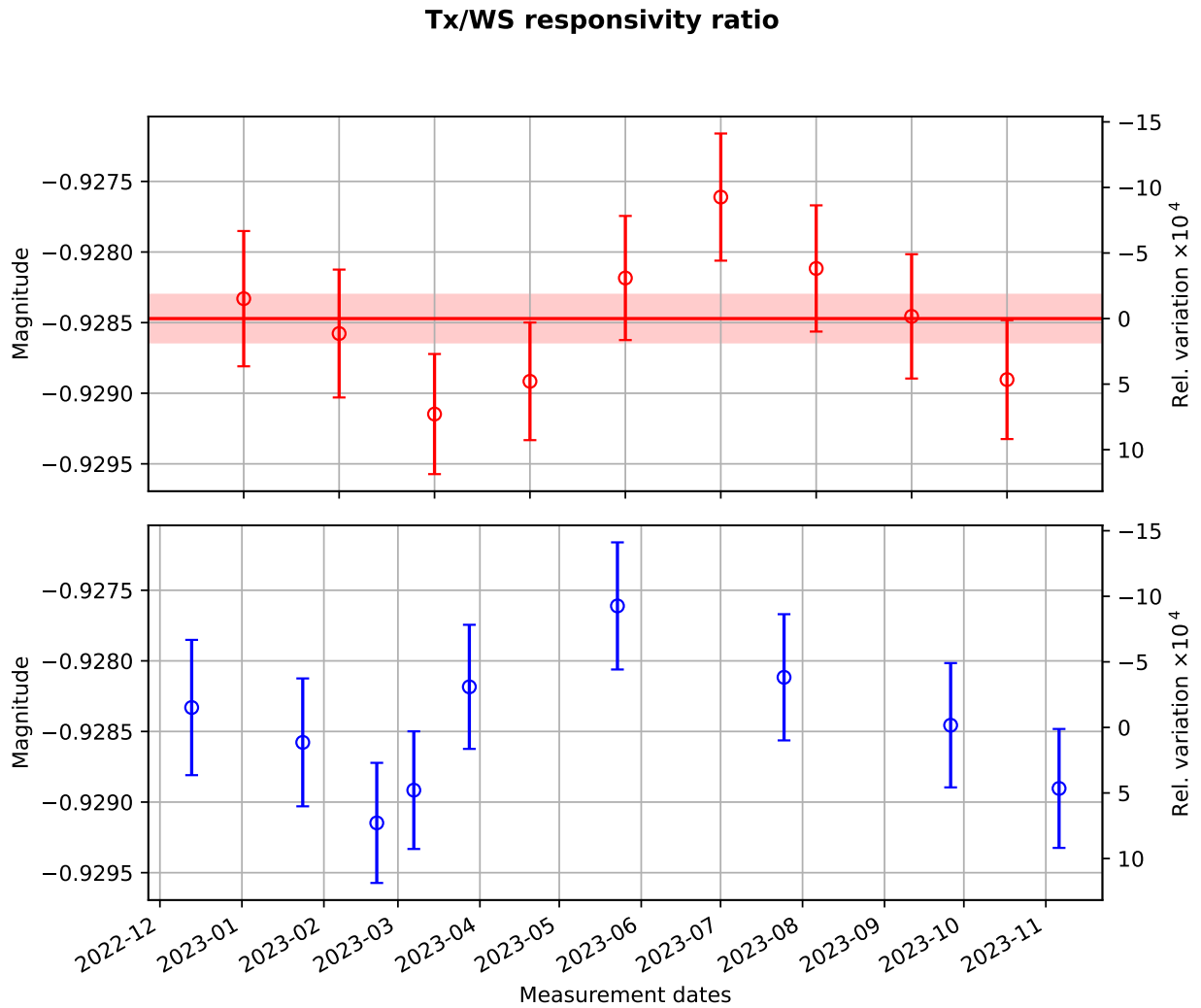


Summary of WS/Tx when WS is at Tx (Outer Beam) [m2]		
Mean value:	-0.541954	
Standard deviation:	0.000601	
Standard error:	0.000212	
Relative Standard error:	-0.000392	

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

List of Measurements

Date	TXWS $\pm$ SD_TXWS
D20221213	-0.9283 $\pm$ 0.0005
D20230124	-0.9286 $\pm$ 0.0005
D20230221	-0.9291 $\pm$ 0.0004
D20230307	-0.9289 $\pm$ 0.0004
D20230328	-0.9282 $\pm$ 0.0004
D20230523	-0.9276 $\pm$ 0.0005
D20230725	-0.9281 $\pm$ 0.0004
D20230926	-0.9285 $\pm$ 0.0004
D20231106	-0.9289 $\pm$ 0.0004



Summary of Tx/WS responsivity ratio

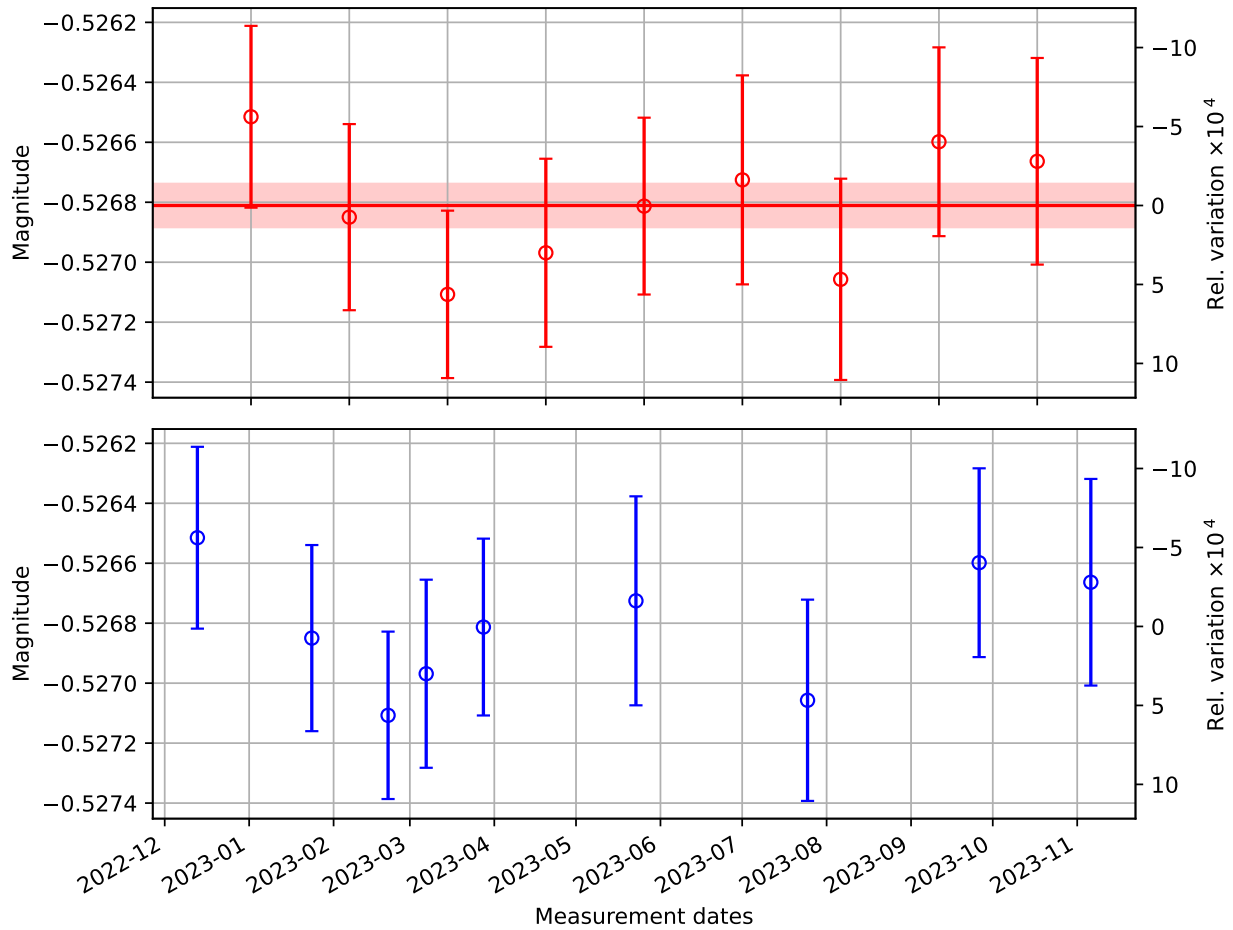
Mean value:	-0.928471
Standard deviation:	0.000477
Standard error:	0.000168
Relative Standard error:	-0.000181

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

List of Measurements

Date	m3 $\pm$ SD_m3
D20221213	-0.5265 $\pm$ 0.0003
D20230124	-0.5268 $\pm$ 0.0003
D20230221	-0.5271 $\pm$ 0.0003
D20230307	-0.5270 $\pm$ 0.0003
D20230328	-0.5268 $\pm$ 0.0003
D20230523	-0.5267 $\pm$ 0.0003
D20230725	-0.5271 $\pm$ 0.0003
D20230926	-0.5266 $\pm$ 0.0003
D20231106	-0.5267 $\pm$ 0.0003

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



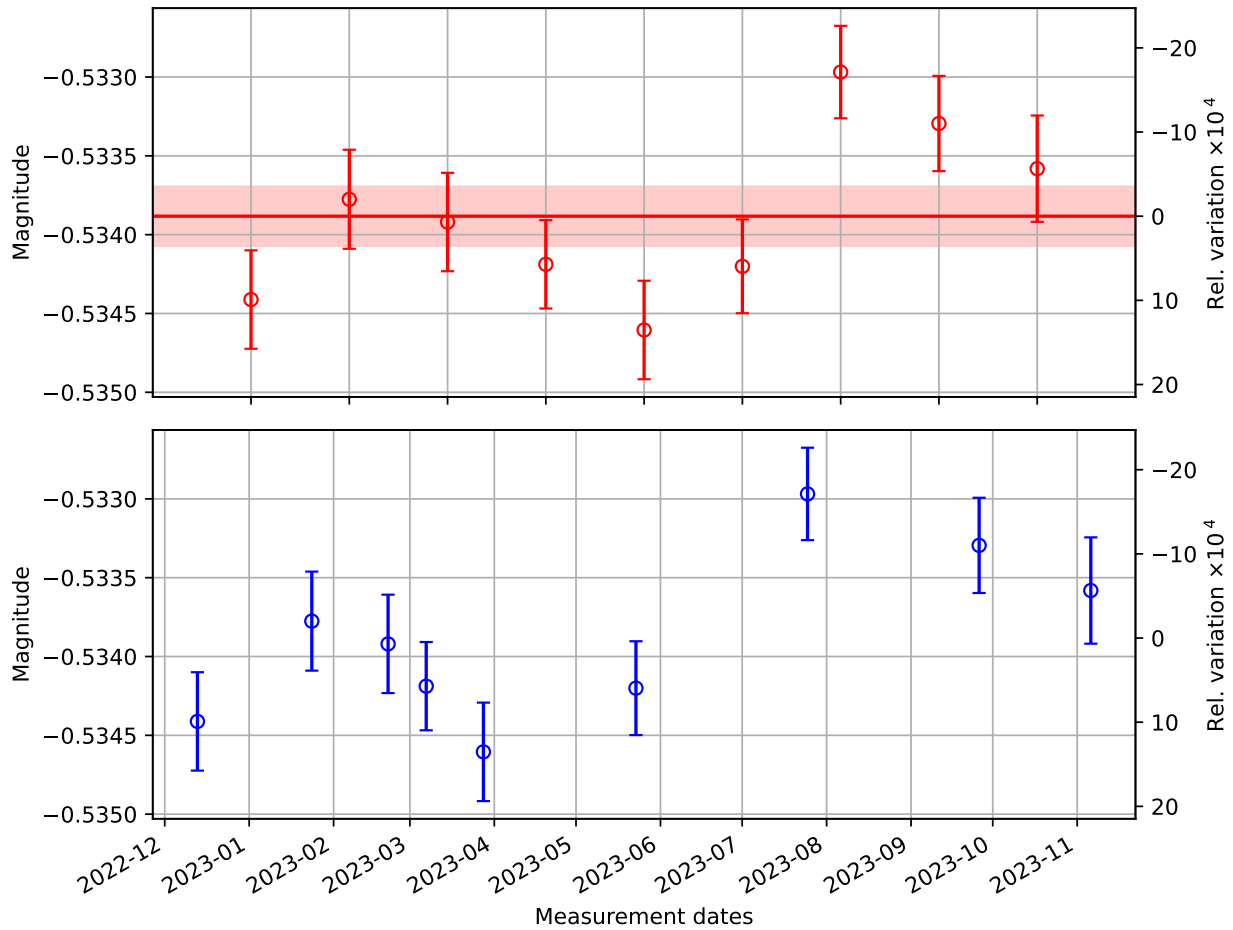
Summary of WS/Tx when WS is at Rx (Inner Beam) [m3]	
Mean value:	-0.526811
Standard deviation:	0.000205
Standard error:	0.000072
Relative Standard error:	-0.000137

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

List of Measurements

Date	m4 $\pm$ SD_m4
D20221213	-0.5344 $\pm$ 0.0003
D20230124	-0.5338 $\pm$ 0.0003
D20230221	-0.5339 $\pm$ 0.0003
D20230307	-0.5342 $\pm$ 0.0003
D20230328	-0.5346 $\pm$ 0.0003
D20230523	-0.5342 $\pm$ 0.0003
D20230725	-0.5330 $\pm$ 0.0003
D20230926	-0.5333 $\pm$ 0.0003
D20231106	-0.5336 $\pm$ 0.0003

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



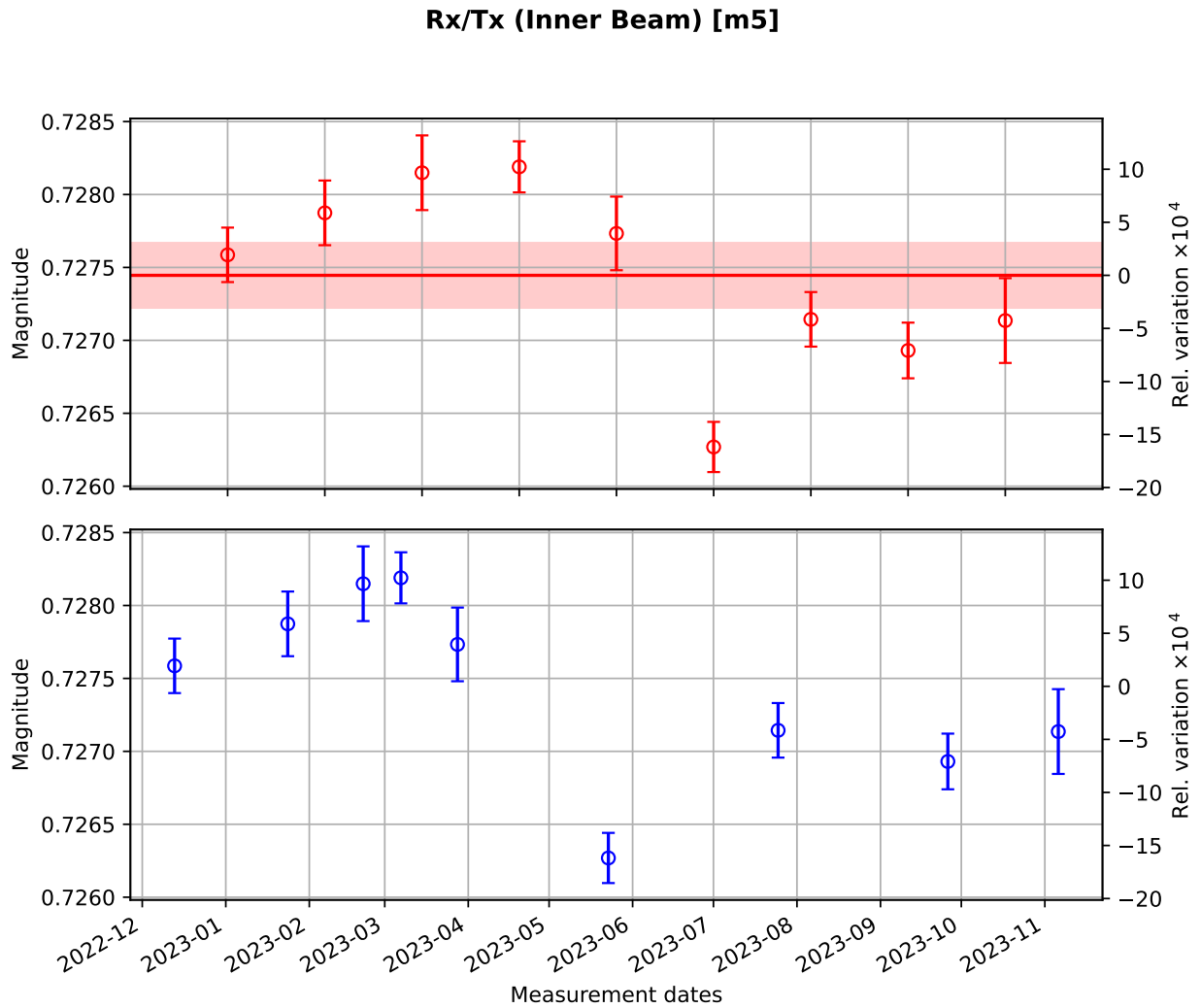
Summary of WS/Tx when WS is at Rx (Outer Beam) [m4]

Mean value:	-0.533883
Standard deviation:	0.000534
Standard error:	0.000188
Relative Standard error:	-0.000353

7 RX/TX Ratio (Inner Beam)

List of Measurements

Date	m5 $\pm$ SD_m5
D20221213	0.7276 $\pm$ 0.0002
D20230124	0.7279 $\pm$ 0.0002
D20230221	0.7281 $\pm$ 0.0003
D20230307	0.7282 $\pm$ 0.0002
D20230328	0.7277 $\pm$ 0.0003
D20230523	0.7263 $\pm$ 0.0002
D20230725	0.7271 $\pm$ 0.0002
D20230926	0.7269 $\pm$ 0.0002
D20231106	0.7271 $\pm$ 0.0003

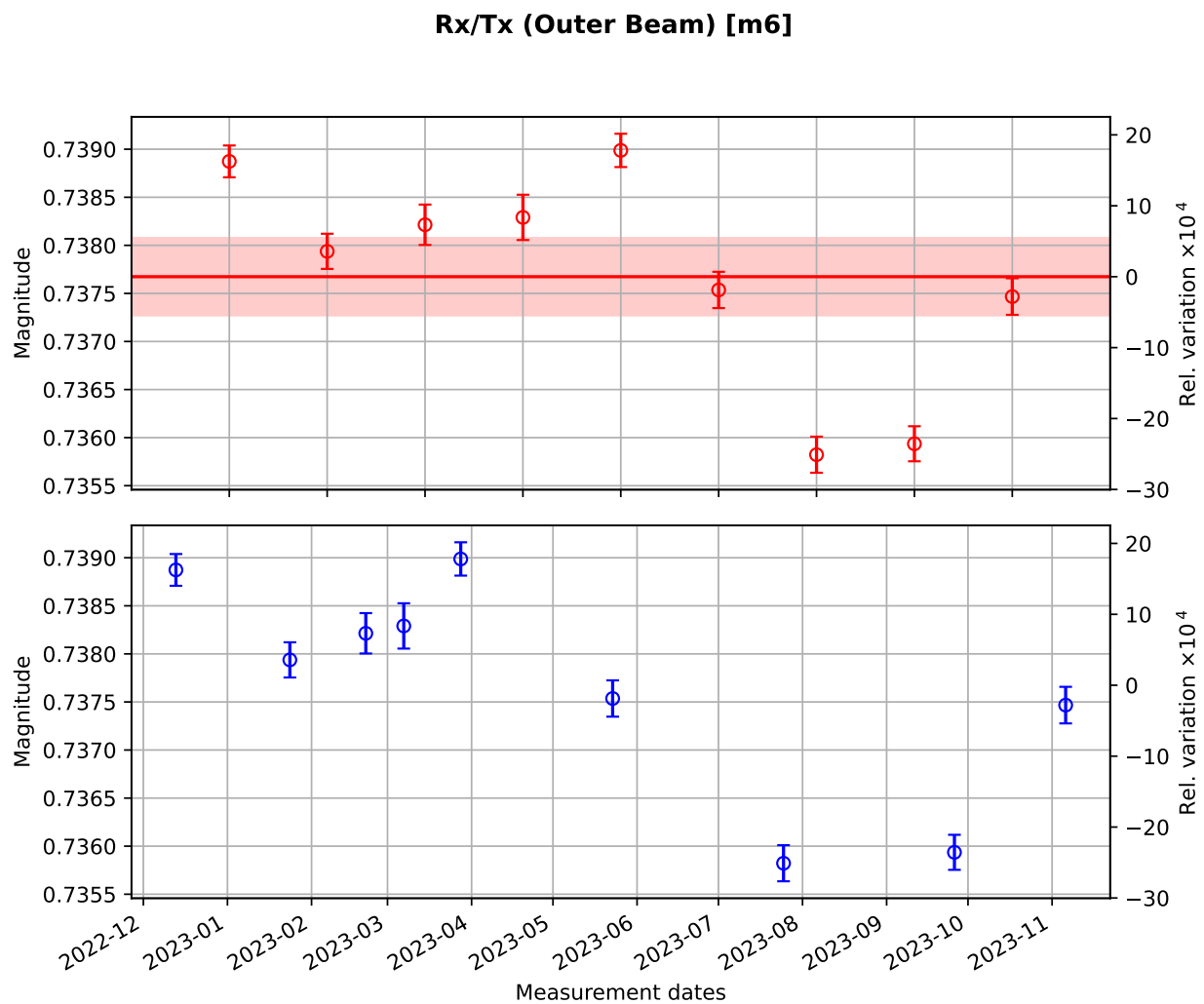


Summary of Rx/Tx (Inner Beam) [m5]		
Mean value:	0.727446	
Standard deviation:	0.000630	
Standard error:	0.000222	
Relative Standard error:	0.000305	

8 Rx/Tx Ratio (Outer Beam)

List of Measurements

Date	m6 $\pm$ SD_m6
D20221213	0.7389 $\pm$ 0.0002
D20230124	0.7379 $\pm$ 0.0002
D20230221	0.7382 $\pm$ 0.0002
D20230307	0.7383 $\pm$ 0.0002
D20230328	0.7390 $\pm$ 0.0002
D20230523	0.7375 $\pm$ 0.0002
D20230725	0.7358 $\pm$ 0.0002
D20230926	0.7359 $\pm$ 0.0002
D20231106	0.7375 $\pm$ 0.0002

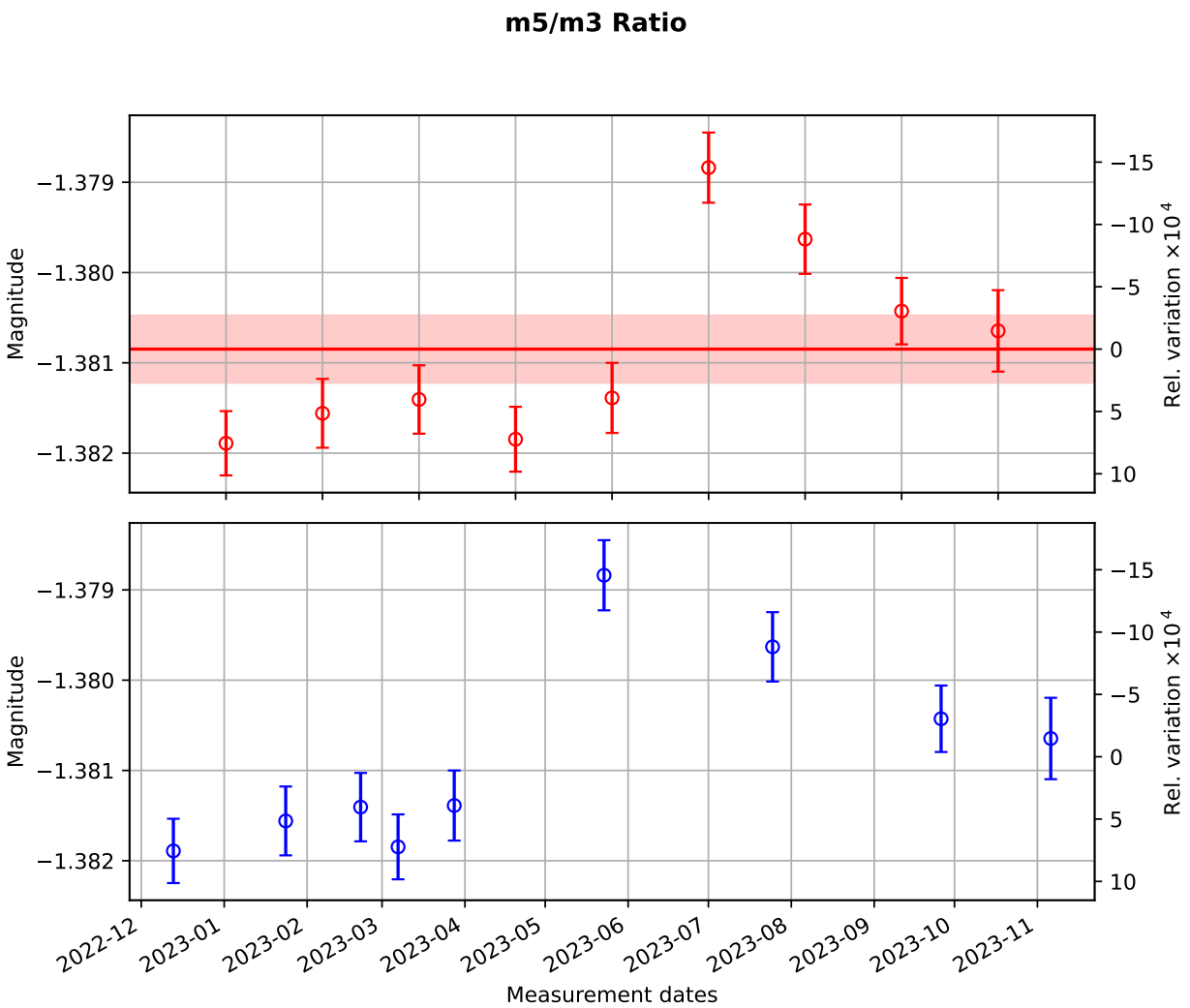


Summary of Rx/Tx (Outer Beam) [m6]		
Mean value:	0.737674	
Standard deviation:	0.001141	
Standard error:	0.000403	
Relative Standard error:	0.000546	

9 m5/m3 Ratio

List of Measurements

Date	RiTWrIT ± SD_RiTWrIT
D20221213	-1.3819 ± 0.0004
D20230124	-1.3816 ± 0.0004
D20230221	-1.3814 ± 0.0004
D20230307	-1.3818 ± 0.0004
D20230328	-1.3814 ± 0.0004
D20230523	-1.3788 ± 0.0004
D20230725	-1.3796 ± 0.0004
D20230926	-1.3804 ± 0.0004
D20231106	-1.3806 ± 0.0005



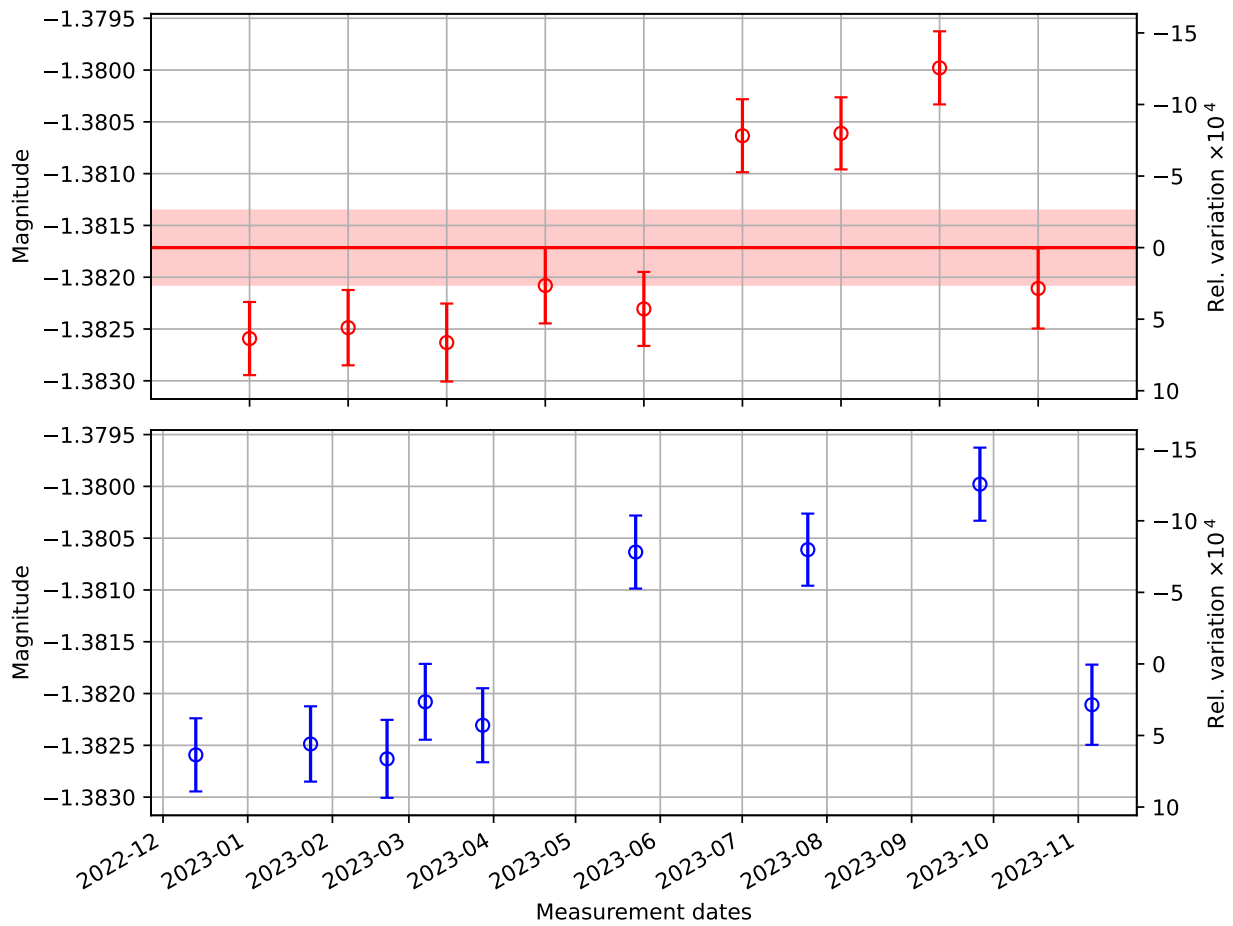
Summary of m5/m3 Ratio		
Mean value:	-1.380848	
Standard deviation:	0.001057	
Standard error:	0.000373	
Relative Standard error:	-0.000270	

10 m6/m4 Ratio

List of Measurements

Date	RoTWroT $\pm$ SD_RoTWroT
D20221213	-1.3826 $\pm$ 0.0004
D20230124	-1.3825 $\pm$ 0.0004
D20230221	-1.3826 $\pm$ 0.0004
D20230307	-1.3821 $\pm$ 0.0004
D20230328	-1.3823 $\pm$ 0.0004
D20230523	-1.3806 $\pm$ 0.0004
D20230725	-1.3806 $\pm$ 0.0003
D20230926	-1.3800 $\pm$ 0.0004
D20231106	-1.3821 $\pm$ 0.0004

m6/m4 Ratio



Summary of m6/m4 Ratio

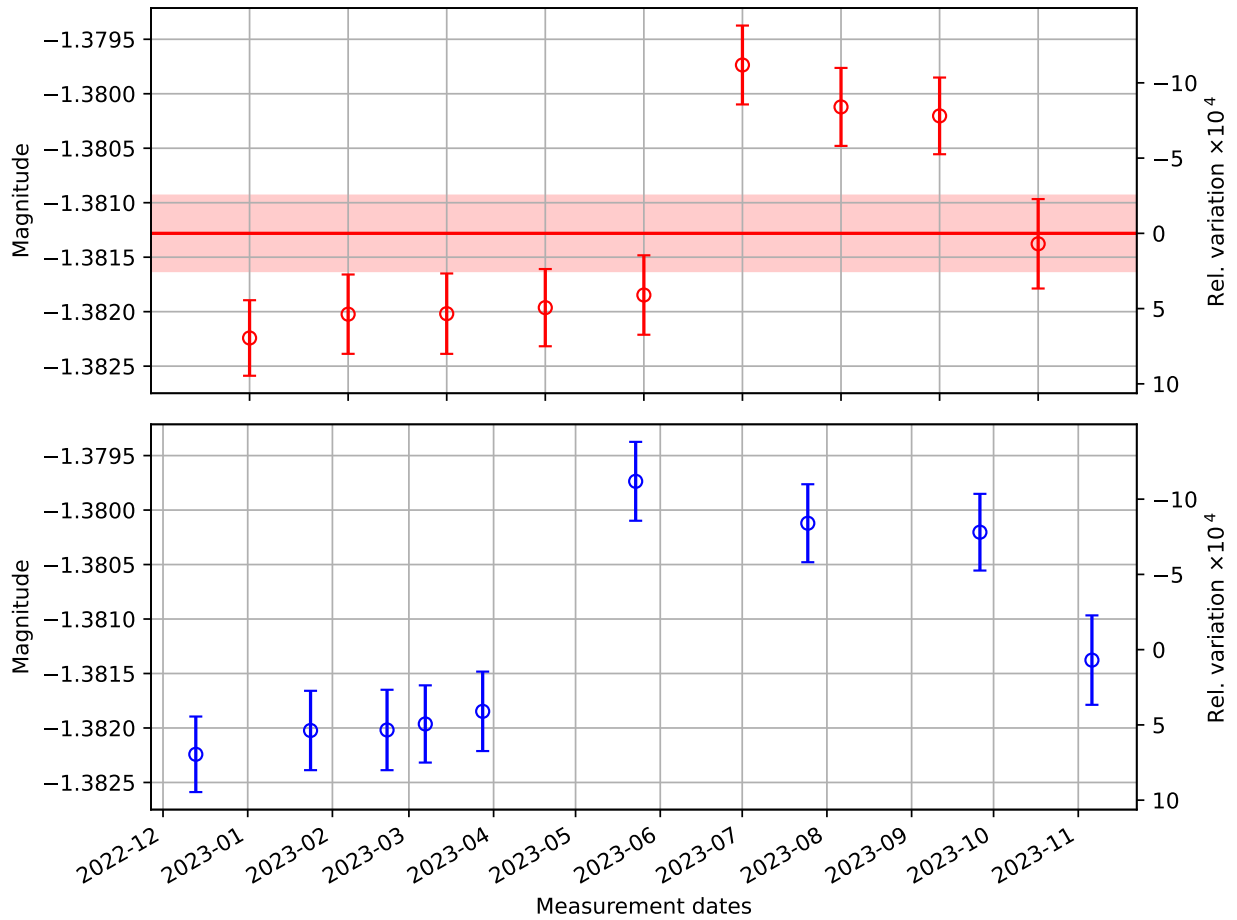
Mean value:	-1.381714
Standard deviation:	0.001015
Standard error:	0.000358
Relative Standard error:	-0.000259

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

List of Measurements

Date	RXWS $\pm$ SD_RXWS
D20221213	-1.3822 $\pm$ 0.0003
D20230124	-1.3820 $\pm$ 0.0004
D20230221	-1.3820 $\pm$ 0.0004
D20230307	-1.3820 $\pm$ 0.0004
D20230328	-1.3818 $\pm$ 0.0004
D20230523	-1.3797 $\pm$ 0.0004
D20230725	-1.3801 $\pm$ 0.0004
D20230926	-1.3802 $\pm$ 0.0004
D20231106	-1.3814 $\pm$ 0.0004

Rx/WS responsivity ratio



Summary of Rx/WS responsivity ratio

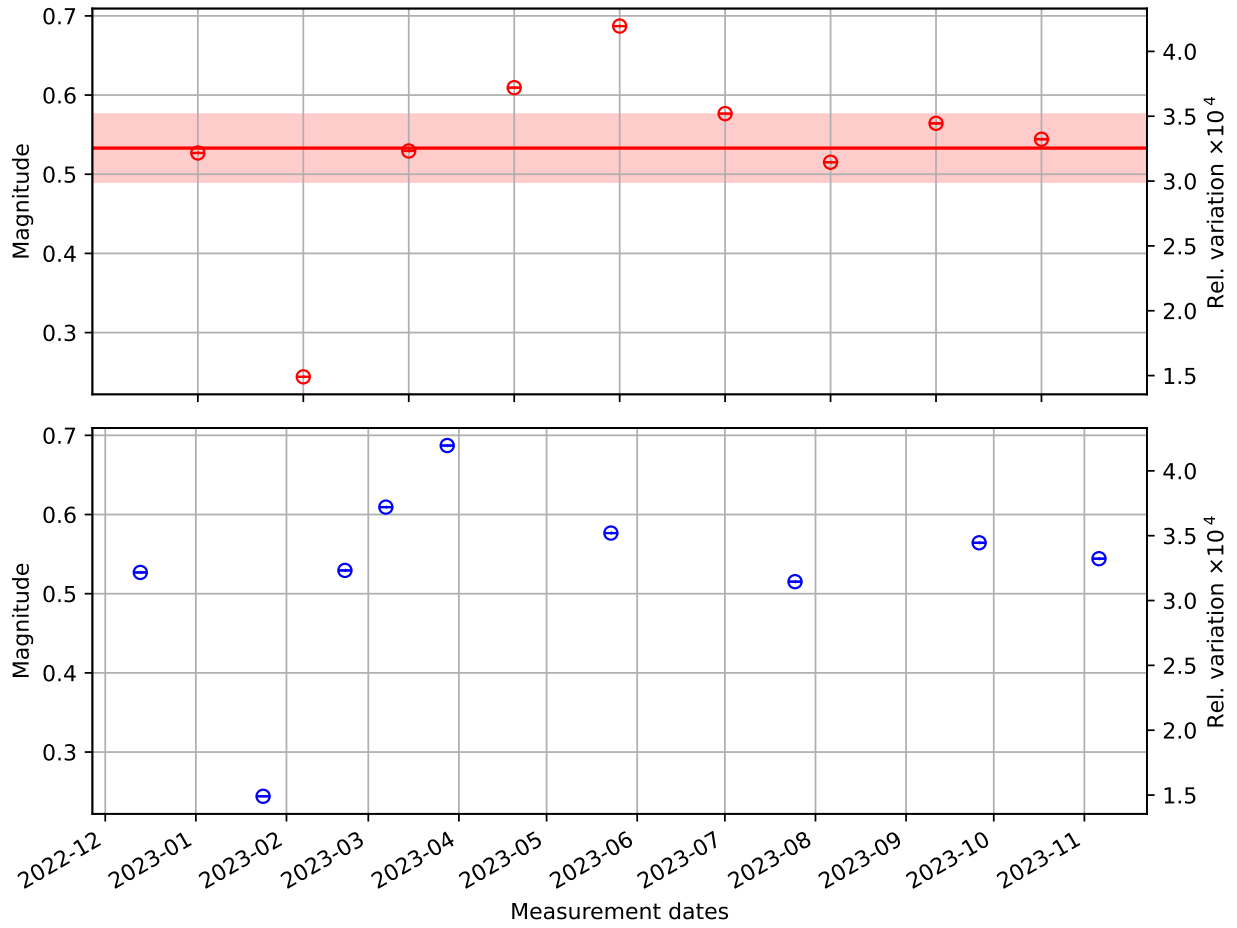
Mean value:	-1.381281
Standard deviation:	0.000981
Standard error:	0.000346
Relative Standard error:	-0.000251

12 ADC conversion factor (ζ)

List of Measurements

Date	$\zeta \pm \text{SD}_\zeta$
D20221213	$1.6379\text{e}+03 \pm 1.0000\text{e}-09$
D20230124	$1.6382\text{e}+03 \pm 1.0000\text{e}-09$
D20230221	$1.6379\text{e}+03 \pm 1.0000\text{e}-09$
D20230307	$1.6378\text{e}+03 \pm 1.0000\text{e}-09$
D20230328	$1.6377\text{e}+03 \pm 1.0000\text{e}-09$
D20230523	$1.6378\text{e}+03 \pm 1.0000\text{e}-09$
D20230725	$1.6379\text{e}+03 \pm 1.0000\text{e}-09$
D20230926	$1.6378\text{e}+03 \pm 1.0000\text{e}-09$
D20231106	$1.6379\text{e}+03 \pm 1.0000\text{e}-09$

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



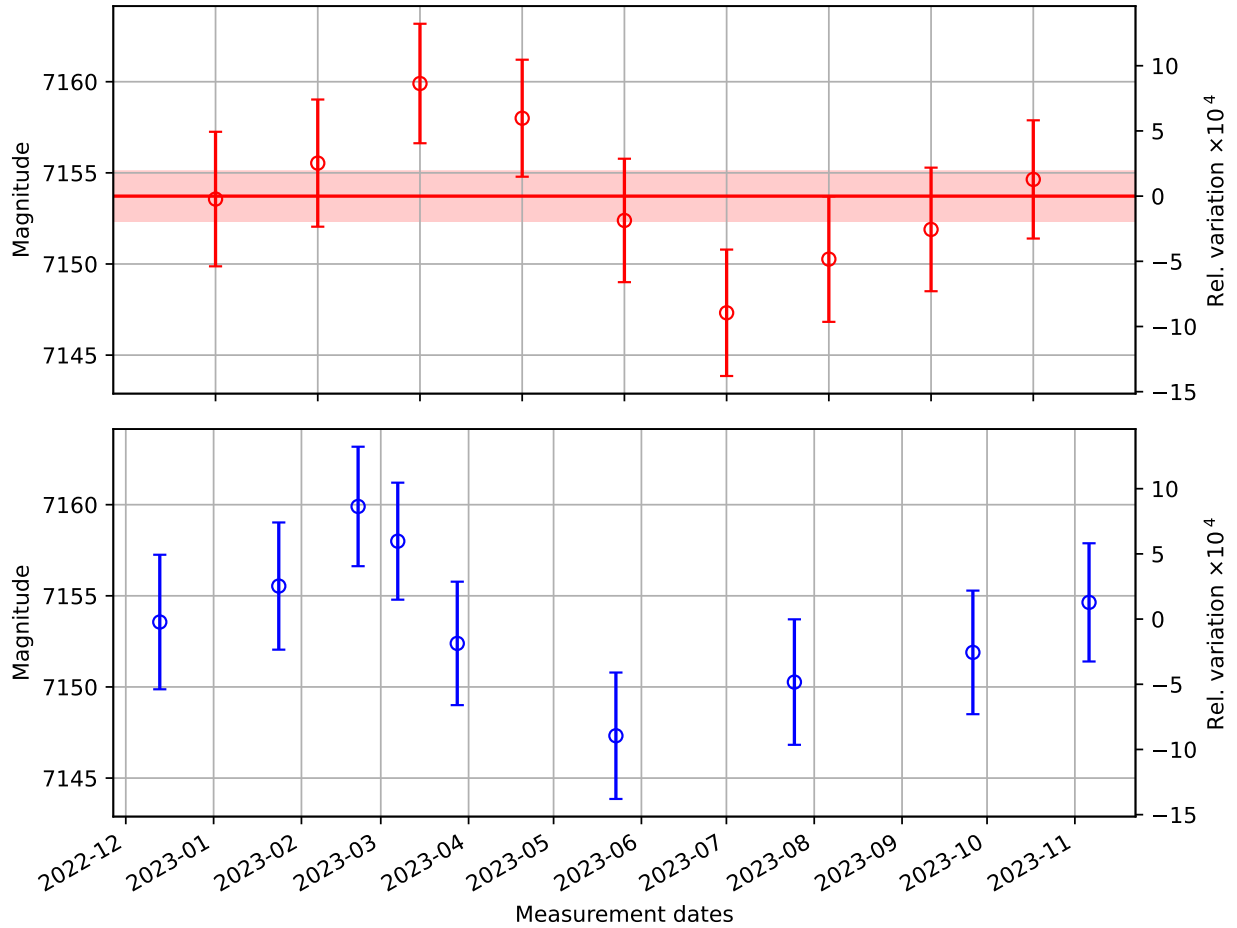
| Summary of ADC conversion factor discrepancy

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

List of Measurements

Date	rhoTx $\pm$ SD_rhoTx
D20221213	7153.5622 $\pm$ 3.6907
D20230124	7155.5352 $\pm$ 3.4892
D20230221	7159.9027 $\pm$ 3.2774
D20230307	7157.9979 $\pm$ 3.2099
D20230328	7152.3889 $\pm$ 3.3863
D20230523	7147.3224 $\pm$ 3.4684
D20230725	7150.2673 $\pm$ 3.4427
D20230926	7151.8956 $\pm$ 3.3903
D20231106	7154.6400 $\pm$ 3.2434

TxPD calibration (ct/W)



Summary of TxPD calibration (ct/W)

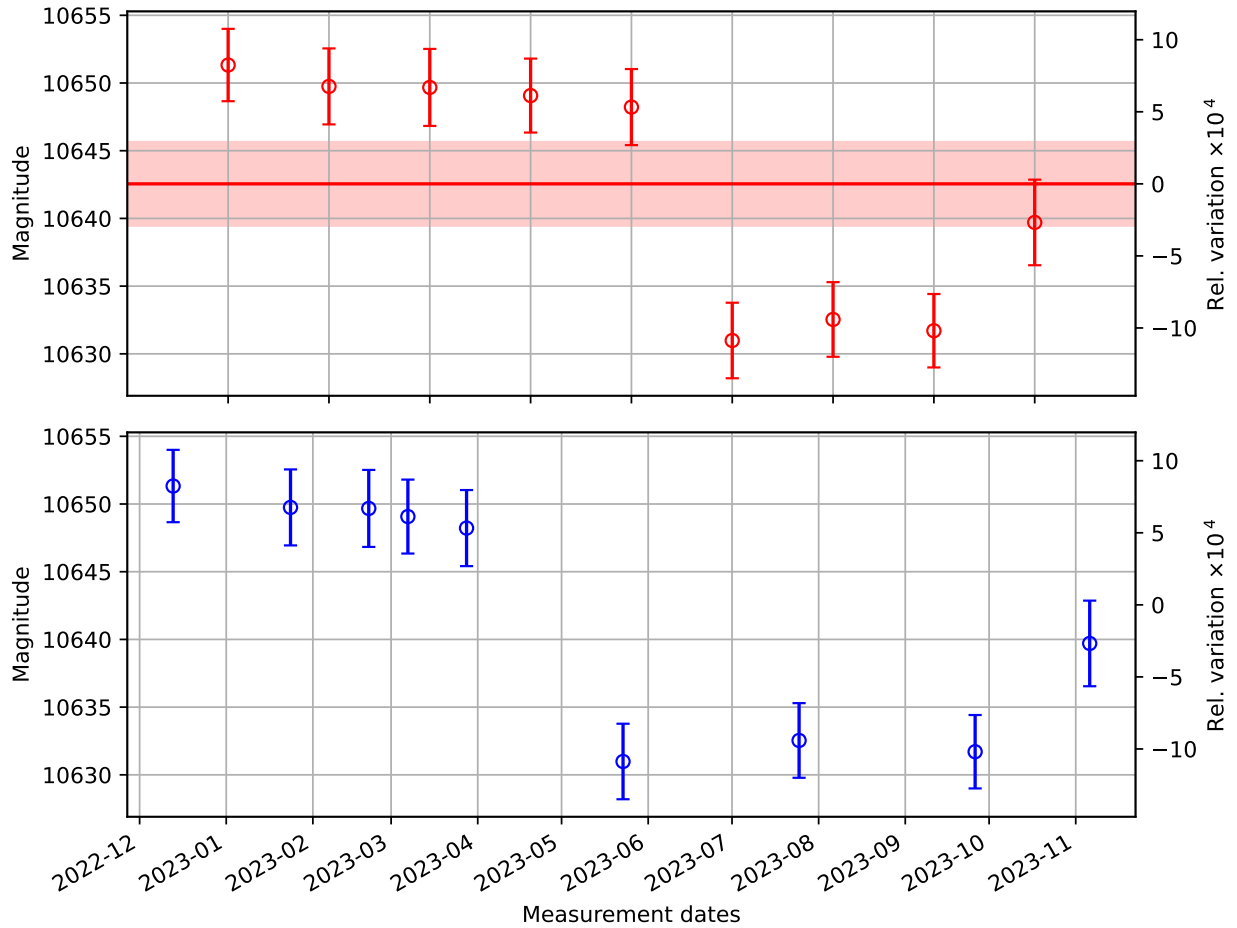
Mean value:	7153.723580
Standard deviation:	3.851030
Standard error:	1.359064
Relative Standard error:	0.000190

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

List of Measurements

Date	rhoRx $\pm$ SD_rhoRx
D20221213	10651.3278 $\pm$ 2.6712
D20230124	10649.7487 $\pm$ 2.8058
D20230221	10649.6738 $\pm$ 2.8433
D20230307	10649.0726 $\pm$ 2.7307
D20230328	10648.2216 $\pm$ 2.8093
D20230523	10630.9855 $\pm$ 2.7890
D20230725	10632.5382 $\pm$ 2.7567
D20230926	10631.7067 $\pm$ 2.7108
D20231106	10639.7032 $\pm$ 3.1608

RxPD calibration (ct/W)



Summary of RxPD calibration (ct/W)

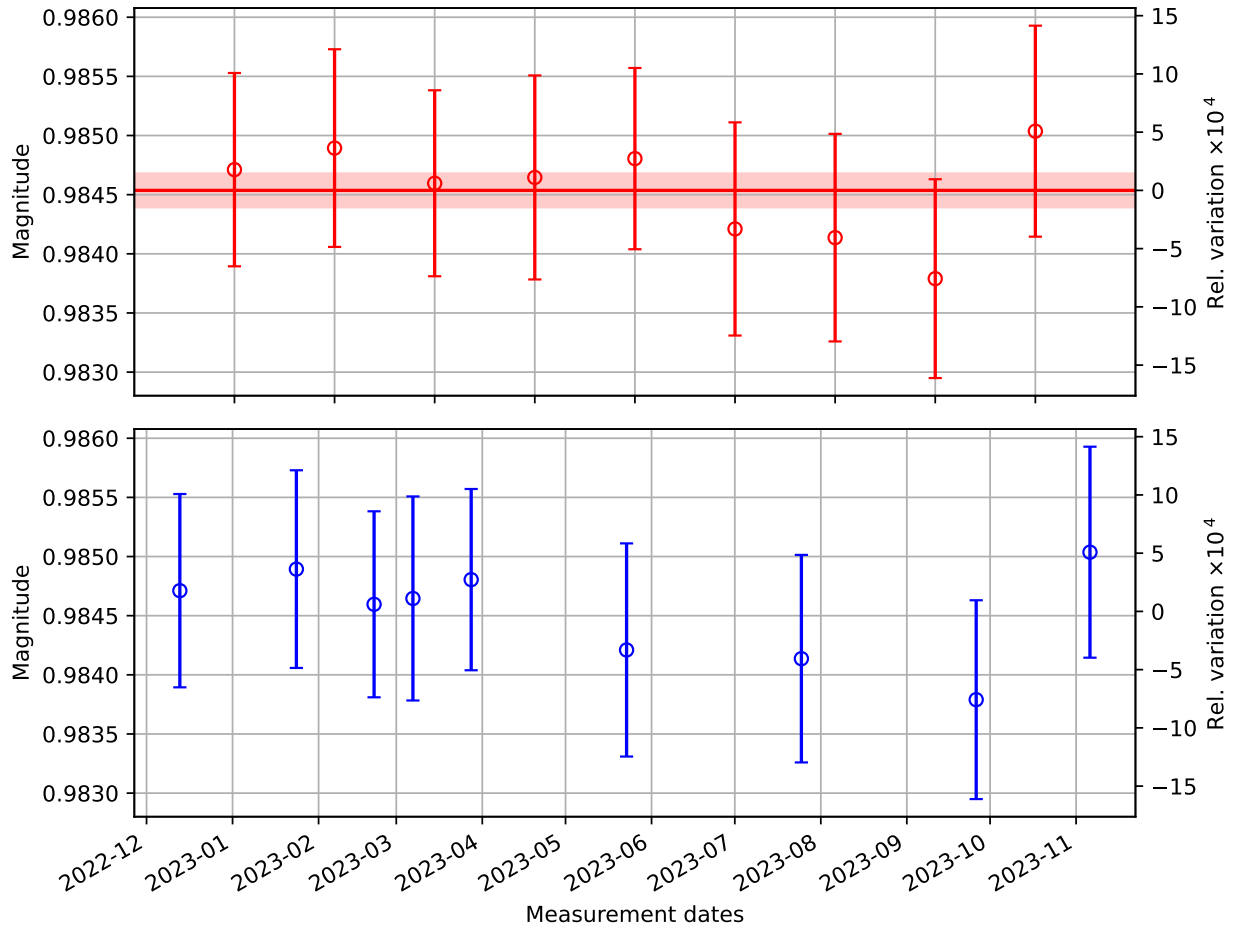
Mean value:	10642.553138
Standard deviation:	8.760596
Standard error:	3.091695
Relative Standard error:	0.000291

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

List of Measurements

Date	$e_i \pm SD_{e_i}$
D20221213	0.9847 ± 0.0008
D20230124	0.9849 ± 0.0008
D20230221	0.9846 ± 0.0008
D20230307	0.9846 ± 0.0009
D20230328	0.9848 ± 0.0008
D20230523	0.9842 ± 0.0009
D20230725	0.9841 ± 0.0009
D20230926	0.9838 ± 0.0008
D20231106	0.9850 ± 0.0009

Optical Efficiency (Inner Beam)



Summary of Optical Efficiency (Inner Beam)

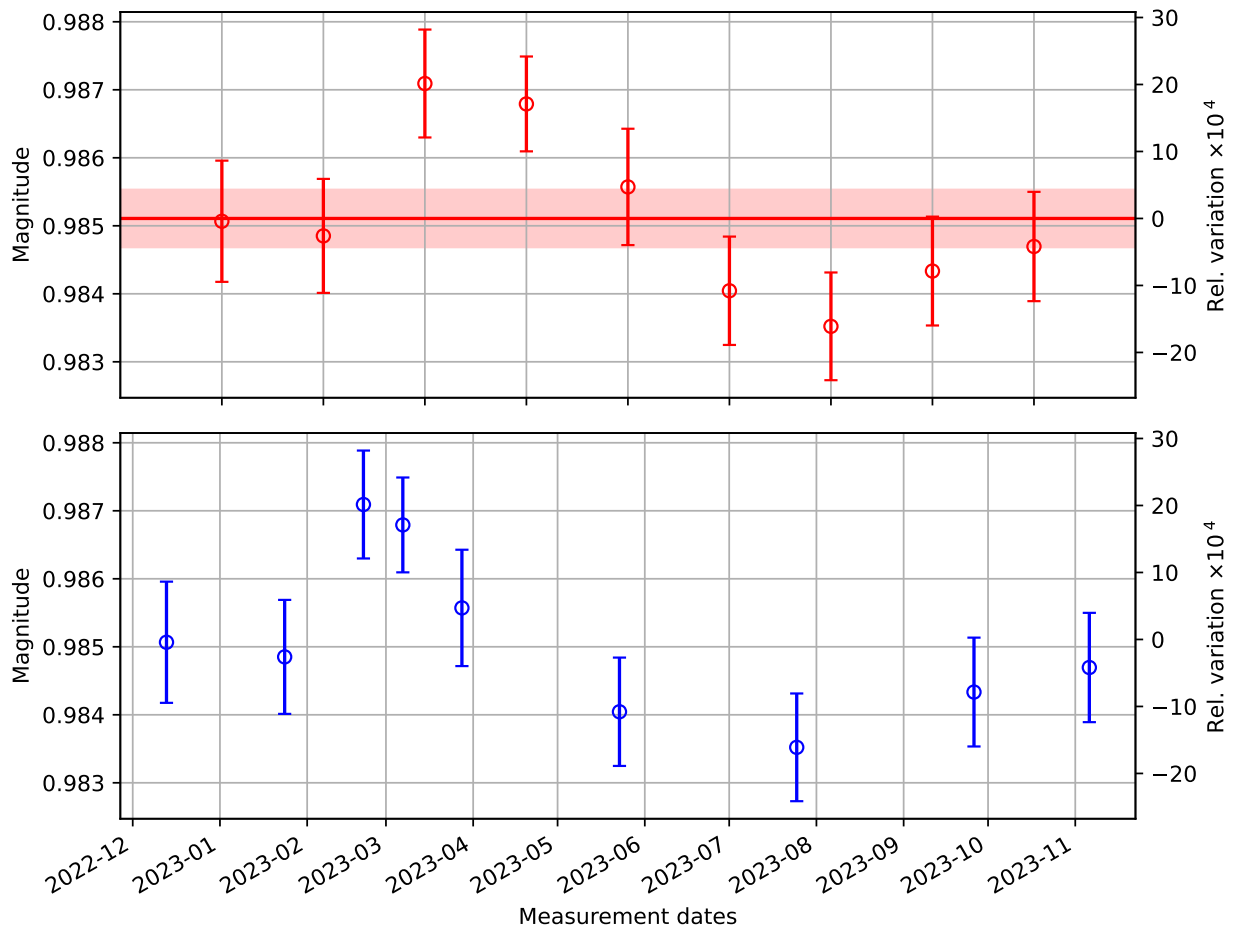
Mean value:	0.984536
Standard deviation:	0.000406
Standard error:	0.000143
Relative Standard error:	0.000146

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

List of Measurements

Date	$e_o \pm SD_{e_o}$
D20221213	0.9851 ± 0.0009
D20230124	0.9849 ± 0.0008
D20230221	0.9871 ± 0.0008
D20230307	0.9868 ± 0.0007
D20230328	0.9856 ± 0.0009
D20230523	0.9840 ± 0.0008
D20230725	0.9835 ± 0.0008
D20230926	0.9843 ± 0.0008
D20231106	0.9847 ± 0.0008

Optical Efficiency (Outer Beam)



Summary of Optical Efficiency (Outer Beam)

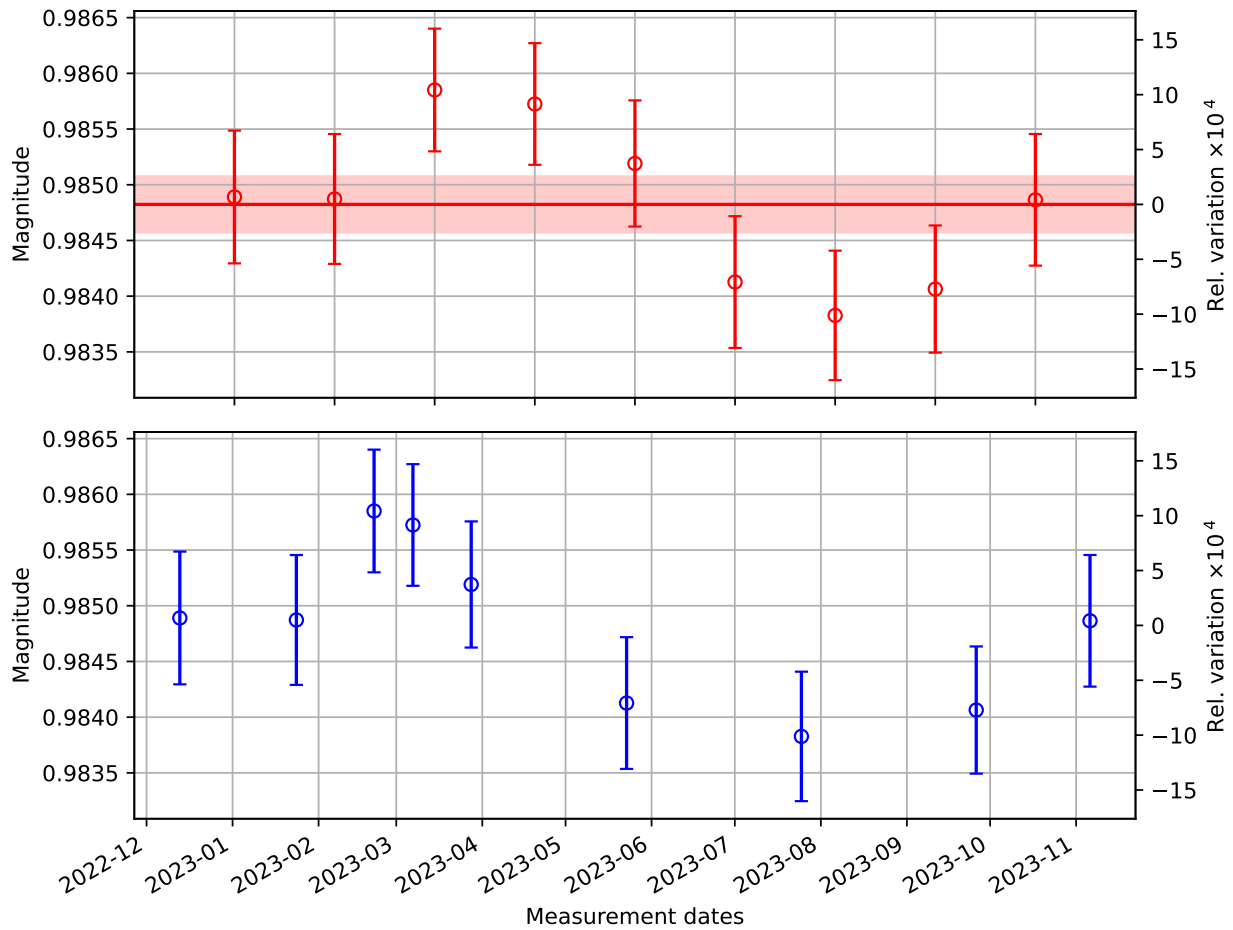
Mean value:	0.985108
Standard deviation:	0.001198
Standard error:	0.000423
Relative Standard error:	0.000429

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

List of Measurements

Date	$e \pm SD_e$
D20221213	0.9849 ± 0.0006
D20230124	0.9849 ± 0.0006
D20230221	0.9859 ± 0.0006
D20230307	0.9857 ± 0.0005
D20230328	0.9852 ± 0.0006
D20230523	0.9841 ± 0.0006
D20230725	0.9838 ± 0.0006
D20230926	0.9841 ± 0.0006
D20231106	0.9849 ± 0.0006

Overall Optical Efficiency



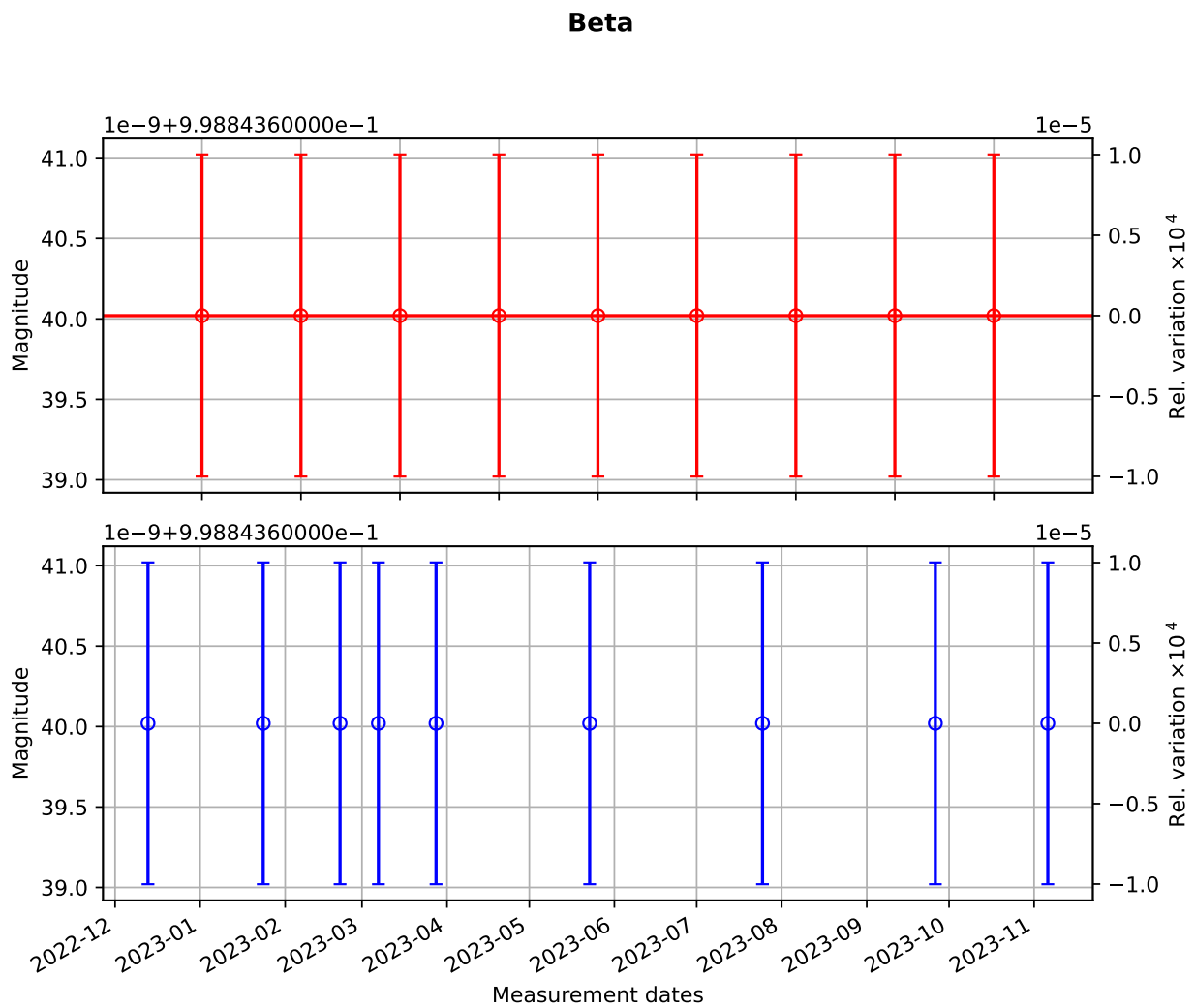
Summary of Overall Optical Efficiency

Mean value:	0.984824
Standard deviation:	0.000713
Standard error:	0.000252
Relative Standard error:	0.000255

18 Input/Output optical efficiency ratio (β)

List of Measurements

Date	beta $\pm$ SD_beta
D20221213	9.9884e-01 $\pm$ 1.0000e-09
D20230124	9.9884e-01 $\pm$ 1.0000e-09
D20230221	9.9884e-01 $\pm$ 1.0000e-09
D20230307	9.9884e-01 $\pm$ 1.0000e-09
D20230328	9.9884e-01 $\pm$ 1.0000e-09
D20230523	9.9884e-01 $\pm$ 1.0000e-09
D20230725	9.9884e-01 $\pm$ 1.0000e-09
D20230926	9.9884e-01 $\pm$ 1.0000e-09
D20231106	9.9884e-01 $\pm$ 1.0000e-09



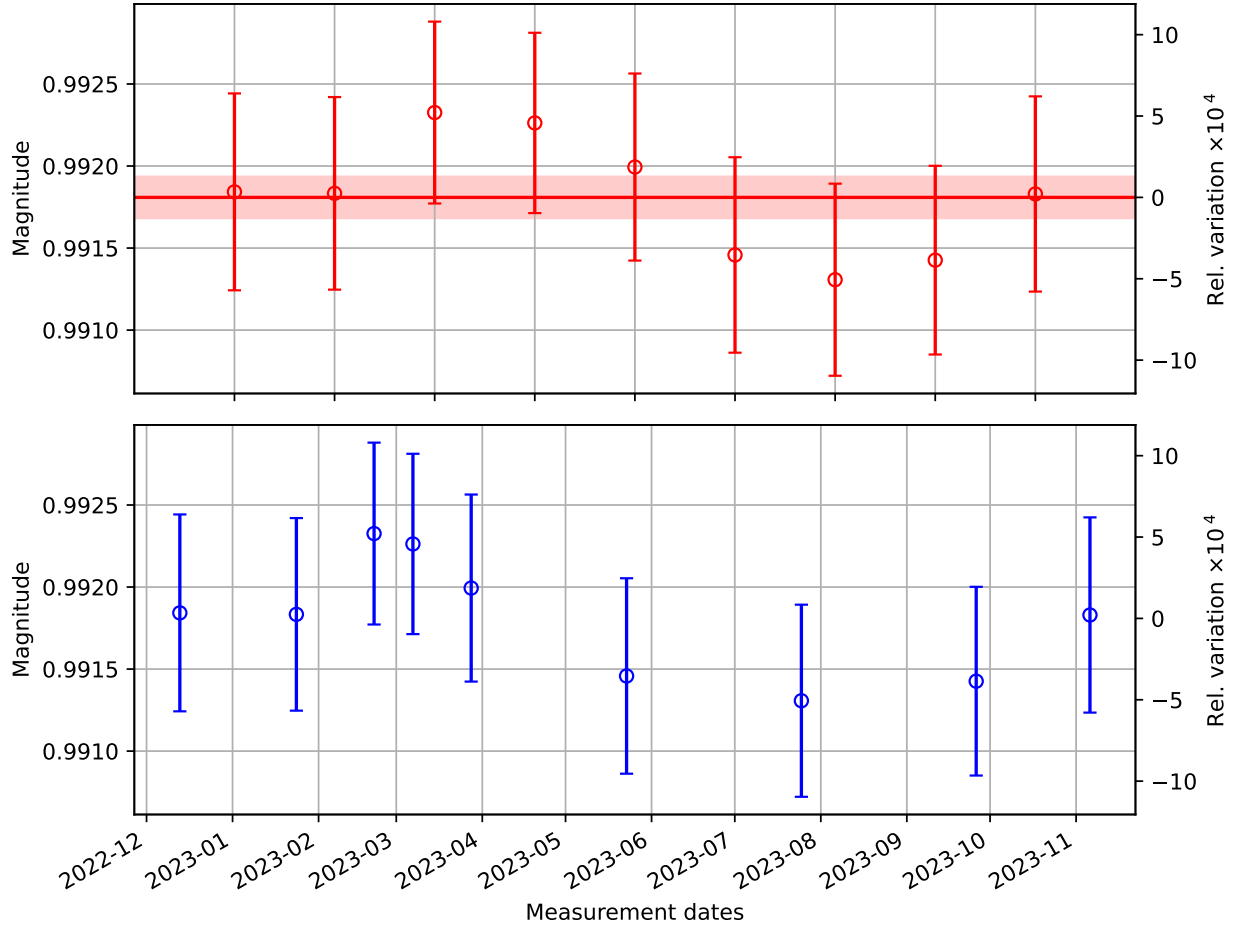
Summary of Beta		
	Mean value:	0.998844
	Standard deviation:	0.000000
	Standard error:	0.000000
	Relative Standard error:	0.000000

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

List of Measurements

Date	E_T $\pm$ SD_E_T
D20221213	0.9918 $\pm$ 0.0006
D20230124	0.9918 $\pm$ 0.0006
D20230221	0.9923 $\pm$ 0.0006
D20230307	0.9923 $\pm$ 0.0005
D20230328	0.9920 $\pm$ 0.0006
D20230523	0.9915 $\pm$ 0.0006
D20230725	0.9913 $\pm$ 0.0006
D20230926	0.9914 $\pm$ 0.0006
D20231106	0.9918 $\pm$ 0.0006

Input Side Optical Efficiency correction factor



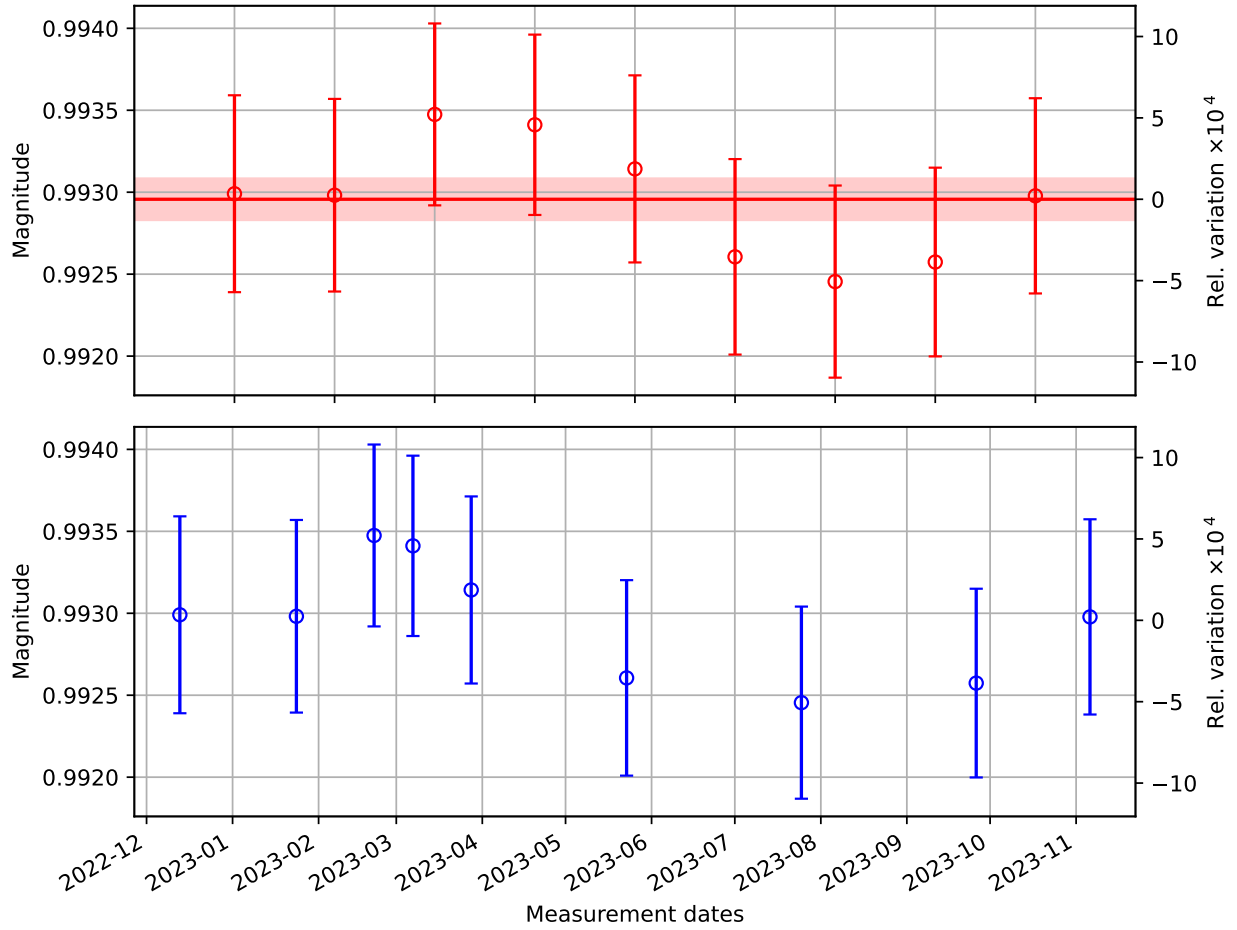
Summary of Input Side Optical Efficiency correction factor		
Mean value:	0.991809	
Standard deviation:	0.000359	
Standard error:	0.000127	
Relative Standard error:	0.000128	

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

List of Measurements

Date	E_R $\pm$ SD_E_R
D20221213	0.9930 $\pm$ 0.0006
D20230124	0.9930 $\pm$ 0.0006
D20230221	0.9935 $\pm$ 0.0006
D20230307	0.9934 $\pm$ 0.0006
D20230328	0.9931 $\pm$ 0.0006
D20230523	0.9926 $\pm$ 0.0006
D20230725	0.9925 $\pm$ 0.0006
D20230926	0.9926 $\pm$ 0.0006
D20231106	0.9930 $\pm$ 0.0006

Output Side Optical Efficiency correction factor



Summary of Output Side Optical Efficiency correction factor

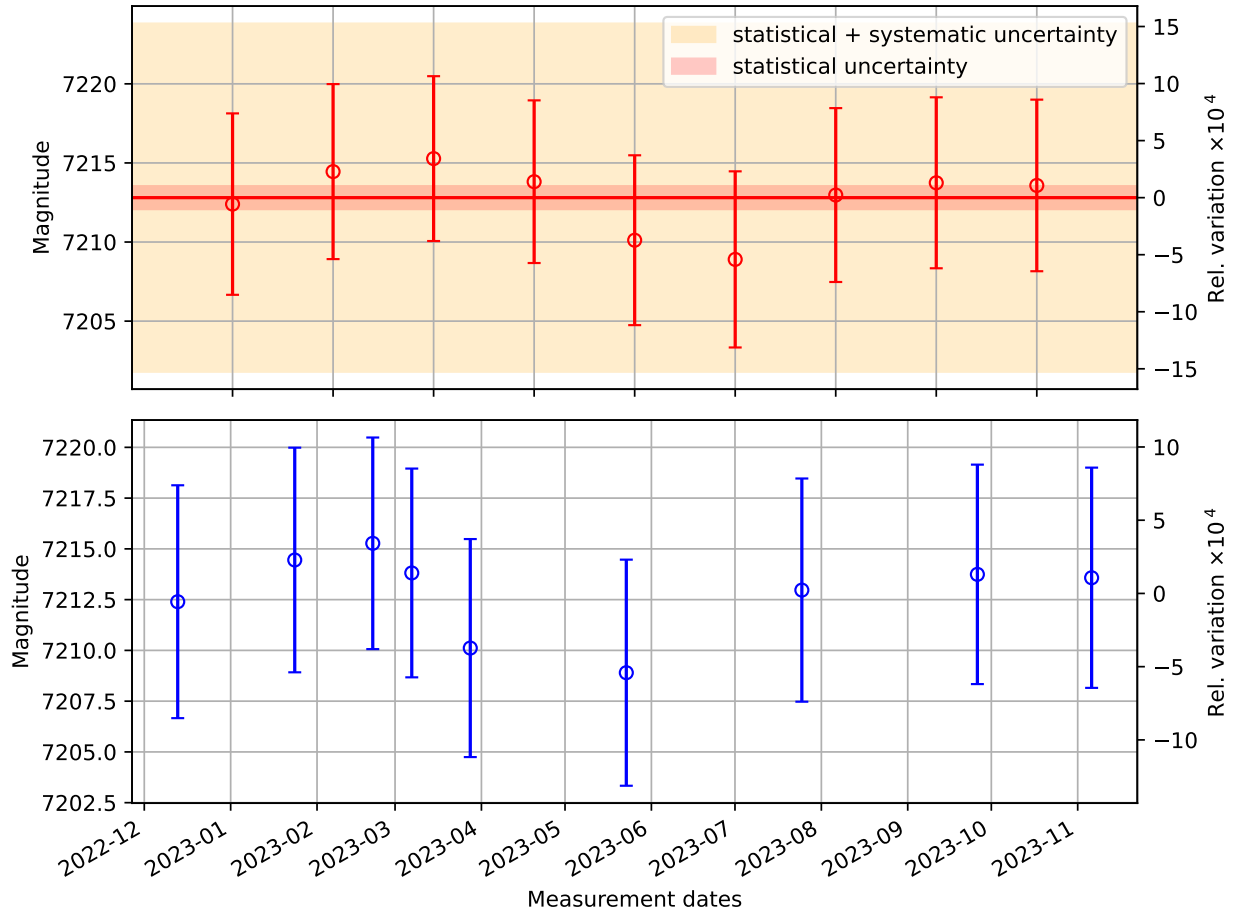
Mean value:	0.992957
Standard deviation:	0.000359
Standard error:	0.000127
Relative Standard error:	0.000128

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

List of Measurements

Date	rhoT_prime $\pm$ SD_rhoT_prime
D20221213	7212.3975 $\pm$ 5.7342
D20230124	7214.4524 $\pm$ 5.5318
D20230221	7215.2736 $\pm$ 5.2105
D20230307	7213.8139 $\pm$ 5.1408
D20230328	7210.1146 $\pm$ 5.3686
D20230523	7208.9015 $\pm$ 5.5675
D20230725	7212.9695 $\pm$ 5.4961
D20230926	7213.7446 $\pm$ 5.4039
D20231106	7213.5775 $\pm$ 5.4235

TxPD calibration corrected for optical efficiency (ct/W)



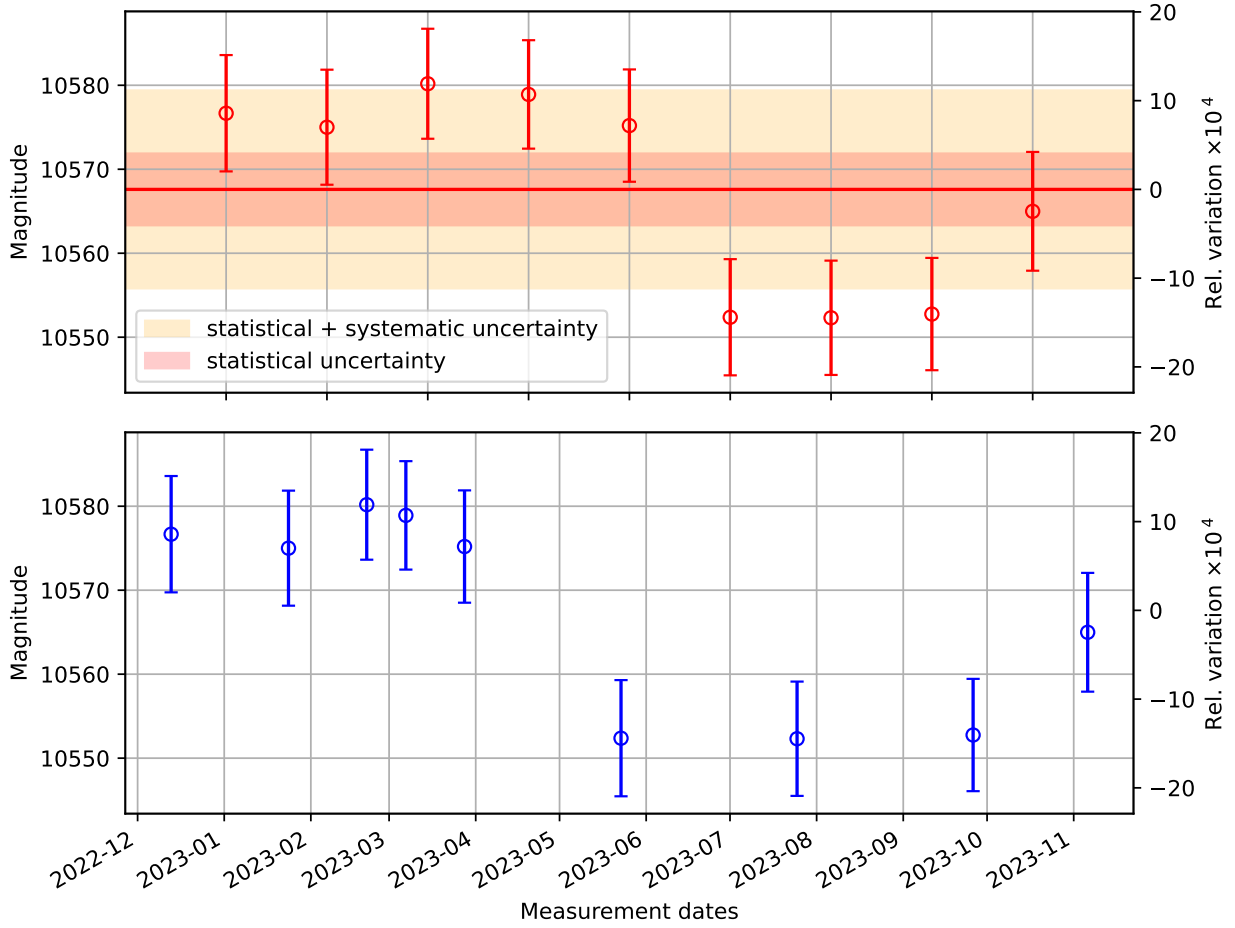
Summary of TxPD calibration corrected for optical efficiency (ct/W)	
Mean value:	7212.805022
Standard deviation:	2.060762
Standard error:	0.727262
Relative Standard error:	0.000101

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

List of Measurements

Date	rhoR_prime $\pm$ SD_rhoR_prime
D20221213	10576.6698 $\pm$ 6.9261
D20230124	10575.0054 $\pm$ 6.8499
D20230221	10580.1815 $\pm$ 6.5500
D20230307	10578.9098 $\pm$ 6.4566
D20230328	10575.1983 $\pm$ 6.6872
D20230523	10552.3770 $\pm$ 6.9180
D20230725	10552.3120 $\pm$ 6.8061
D20230926	10552.7557 $\pm$ 6.6864
D20231106	10564.9900 $\pm$ 7.0717

RxPD calibration corrected for optical efficiency (ct/W)



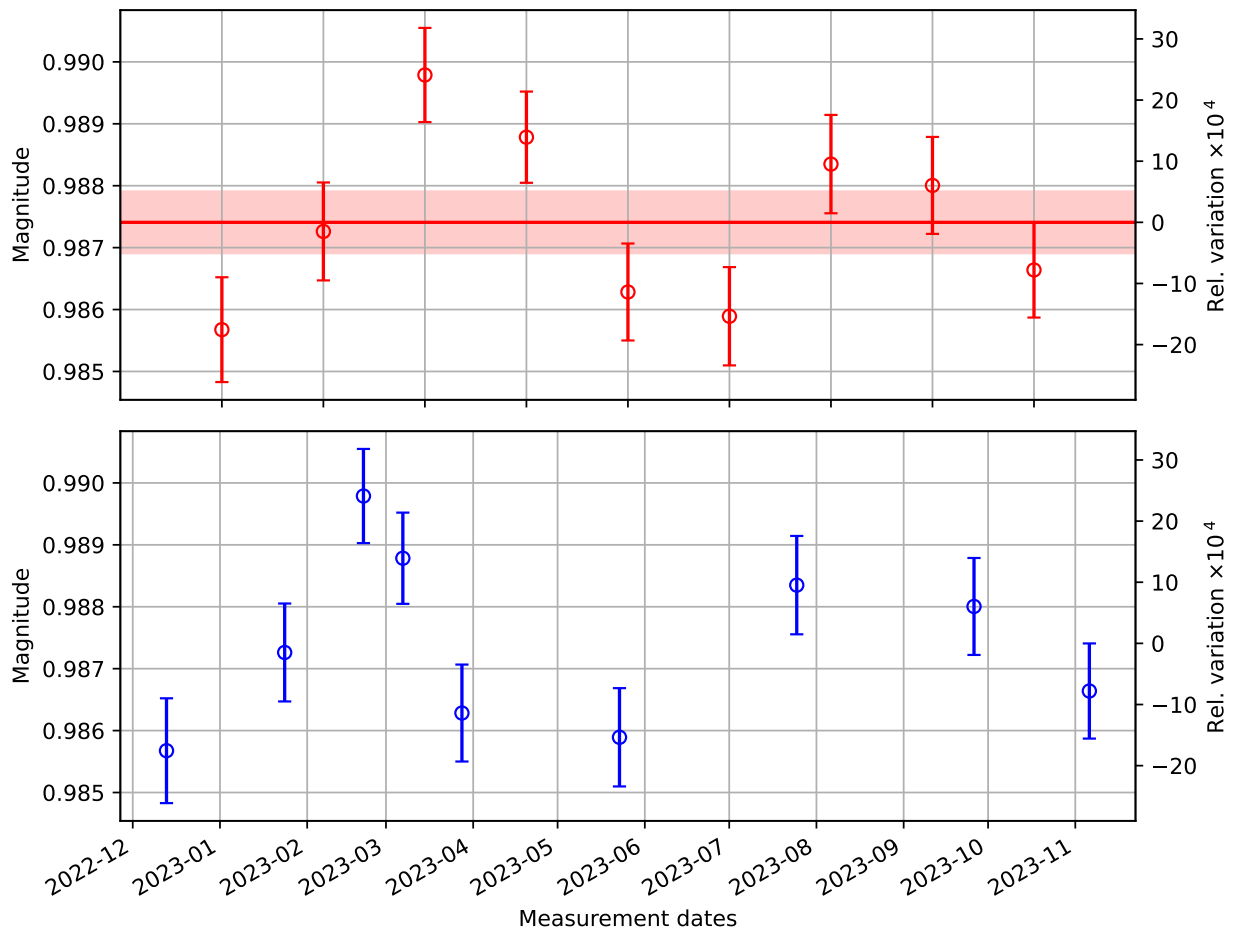
Summary of RxPD calibration corrected for optical efficiency (ct/W)	
Mean value:	10567.599943
Standard deviation:	12.112327
Standard error:	4.274552
Relative Standard error:	0.000404

23 Power Imbalance

List of Measurements

Date	PI $\pm$ SD_PI
D20221213	0.9857 $\pm$ 0.0008
D20230124	0.9873 $\pm$ 0.0008
D20230221	0.9898 $\pm$ 0.0008
D20230307	0.9888 $\pm$ 0.0007
D20230328	0.9863 $\pm$ 0.0008
D20230523	0.9859 $\pm$ 0.0008
D20230725	0.9883 $\pm$ 0.0008
D20230926	0.9880 $\pm$ 0.0008
D20231106	0.9866 $\pm$ 0.0008

Power Imbalance



Summary of Power Imbalance

Mean value:	0.987409
Standard deviation:	0.001413
Standard error:	0.000499
Relative Standard error:	0.000505