

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:

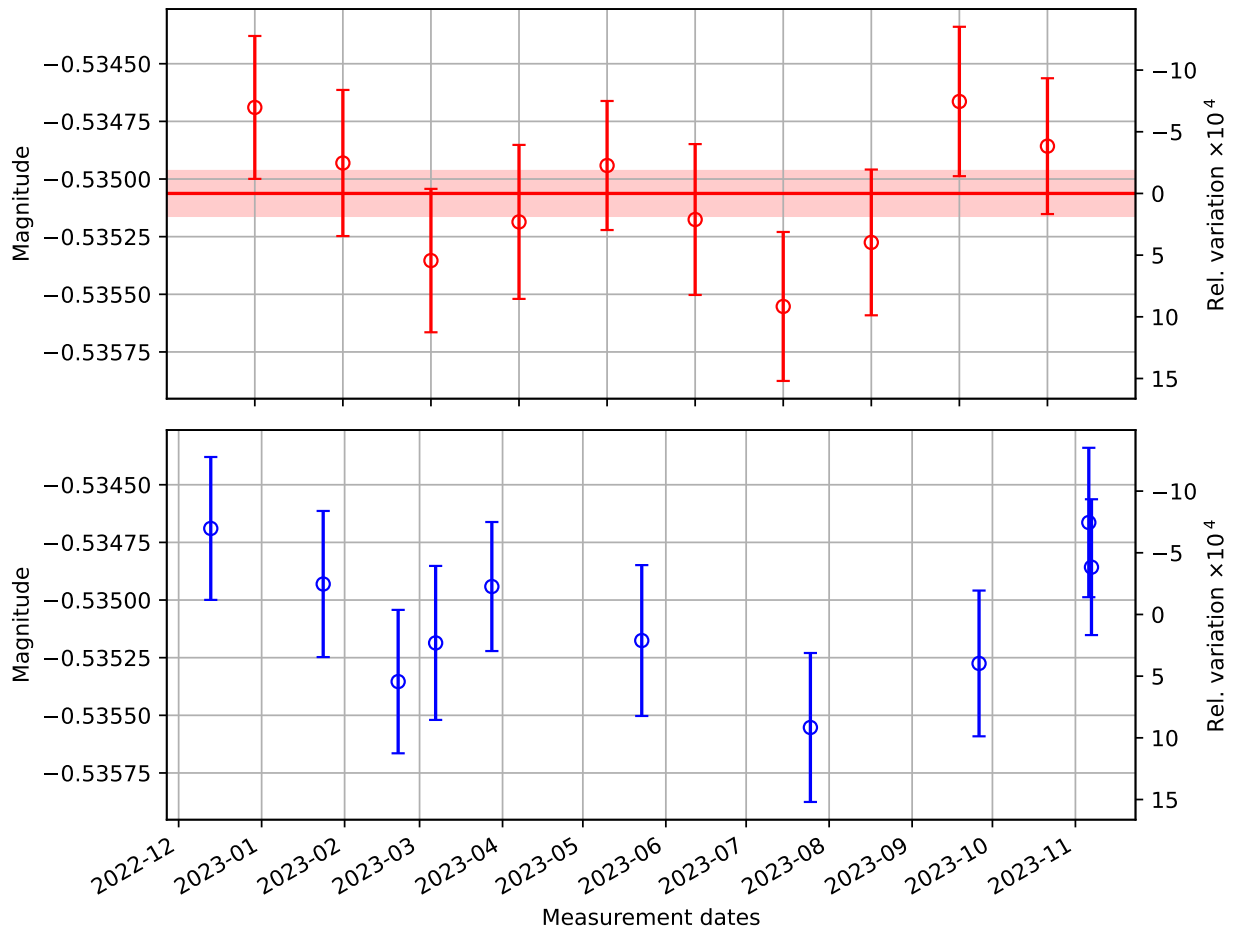
```
Mean = sum(x(i))/n
Std_Dev = sqrt(sum((x(i)-x_mean)^2)/(n-1))
Std_Err = Std_Dev*Student's_t_correction/sqrt(n)
Rel_Err = Std_Err/Mean
```

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
D20231107	-0.5349 $\pm$ 0.0003

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



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

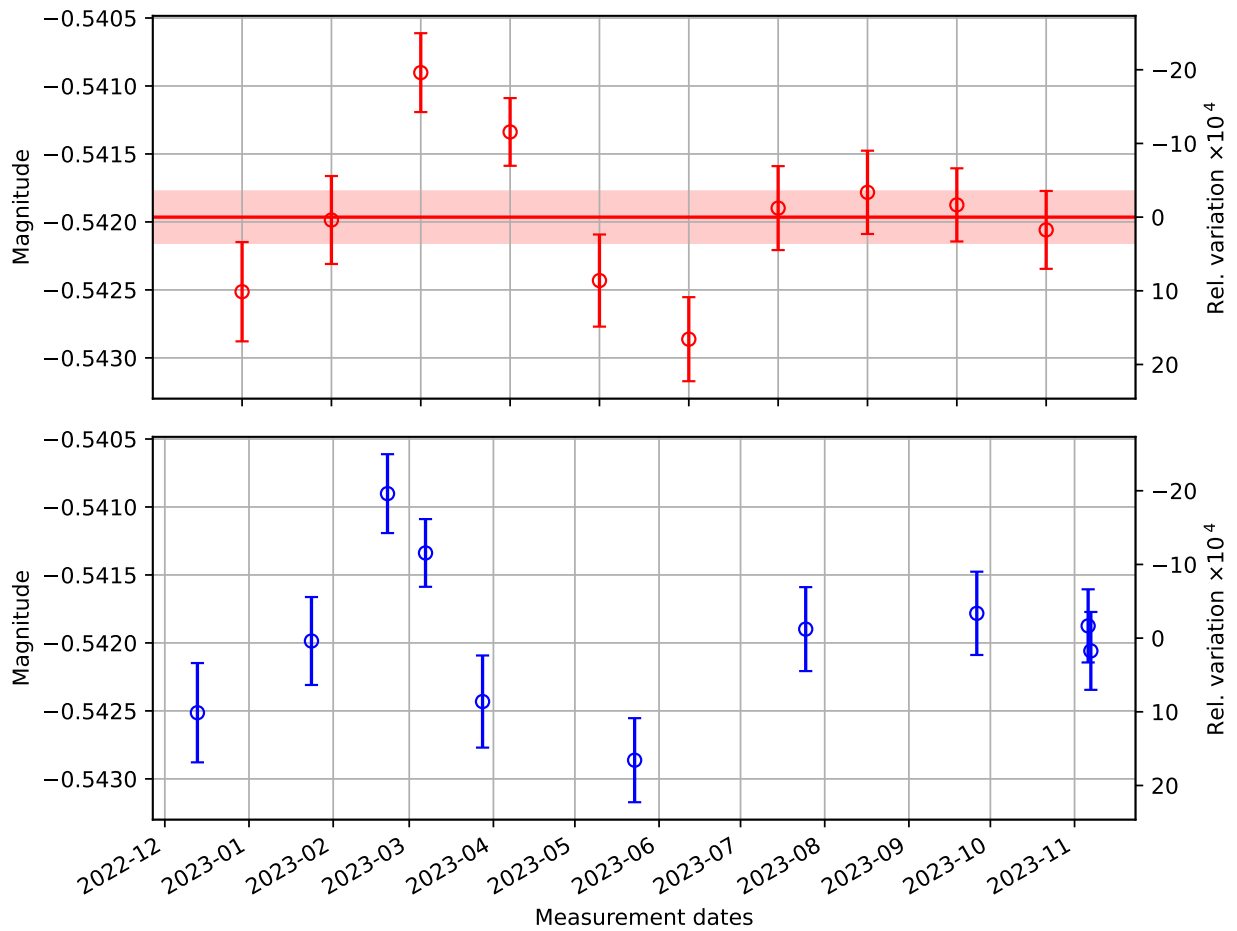
Mean value:	-0.535063
Standard deviation:	0.000293
Standard error:	0.000097
Relative Standard error:	-0.000182

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

List of Measurements

Date	m2 $\pm$ SD_m2
D20221213	-0.5425 $\pm$ 0.0004
D20230124	-0.5420 $\pm$ 0.0003
D20230221	-0.5409 $\pm$ 0.0003
D20230307	-0.5413 $\pm$ 0.0002
D20230328	-0.5424 $\pm$ 0.0003
D20230523	-0.5429 $\pm$ 0.0003
D20230725	-0.5419 $\pm$ 0.0003
D20230926	-0.5418 $\pm$ 0.0003
D20231106	-0.5419 $\pm$ 0.0003
D20231107	-0.5421 $\pm$ 0.0003

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

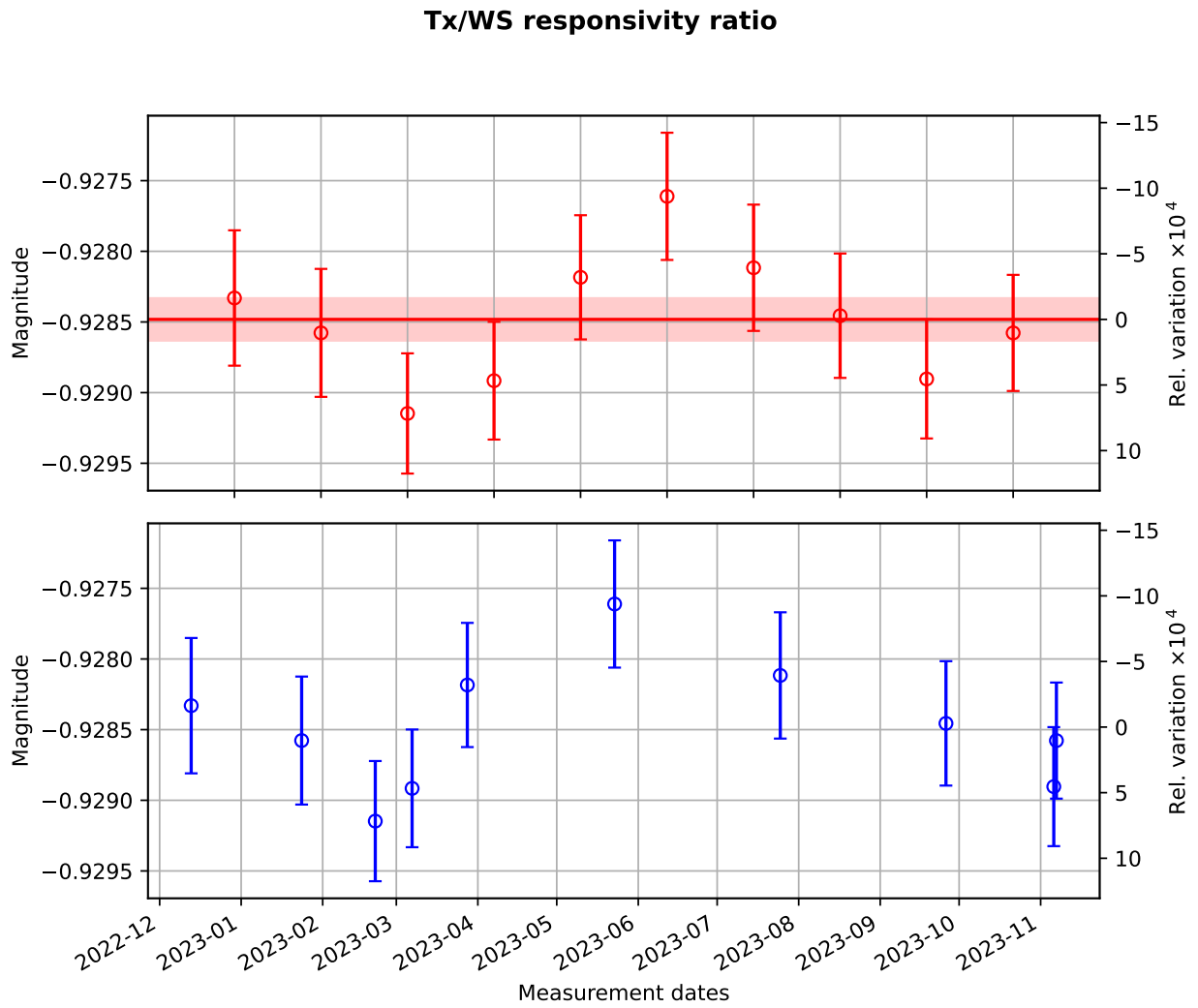


Summary of WS/Tx when WS is at Tx (Outer Beam) [m2]	
Mean value:	-0.541965
Standard deviation:	0.000568
Standard error:	0.000189
Relative Standard error:	-0.000349

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
D20231107	-0.9286 $\pm$ 0.0004



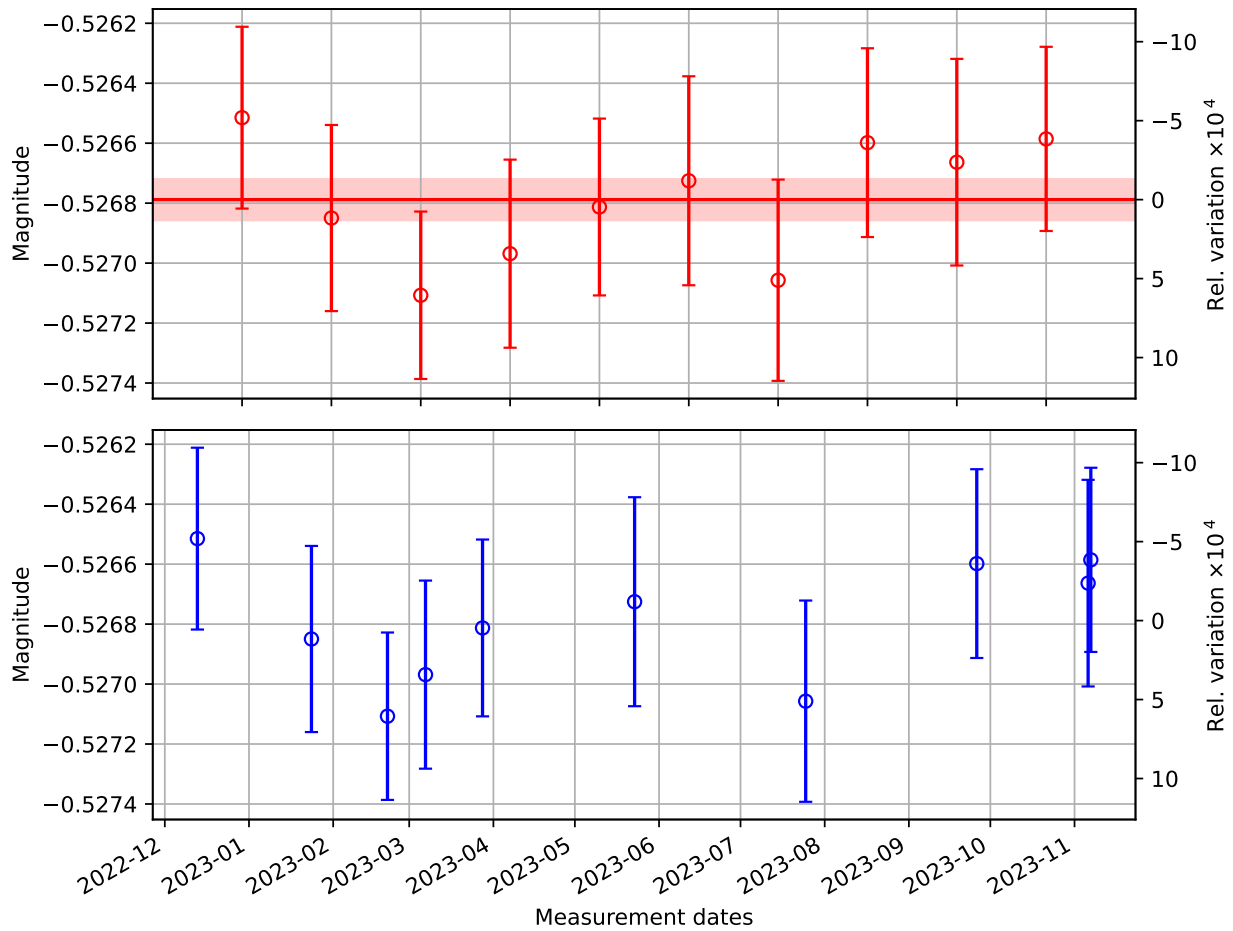
Summary of Tx/WS responsivity ratio		
Mean value:	-0.928482	
Standard deviation:	0.000451	
Standard error:	0.000150	
Relative Standard error:	-0.000162	

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
D20231107	-0.5266 $\pm$ 0.0003

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



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

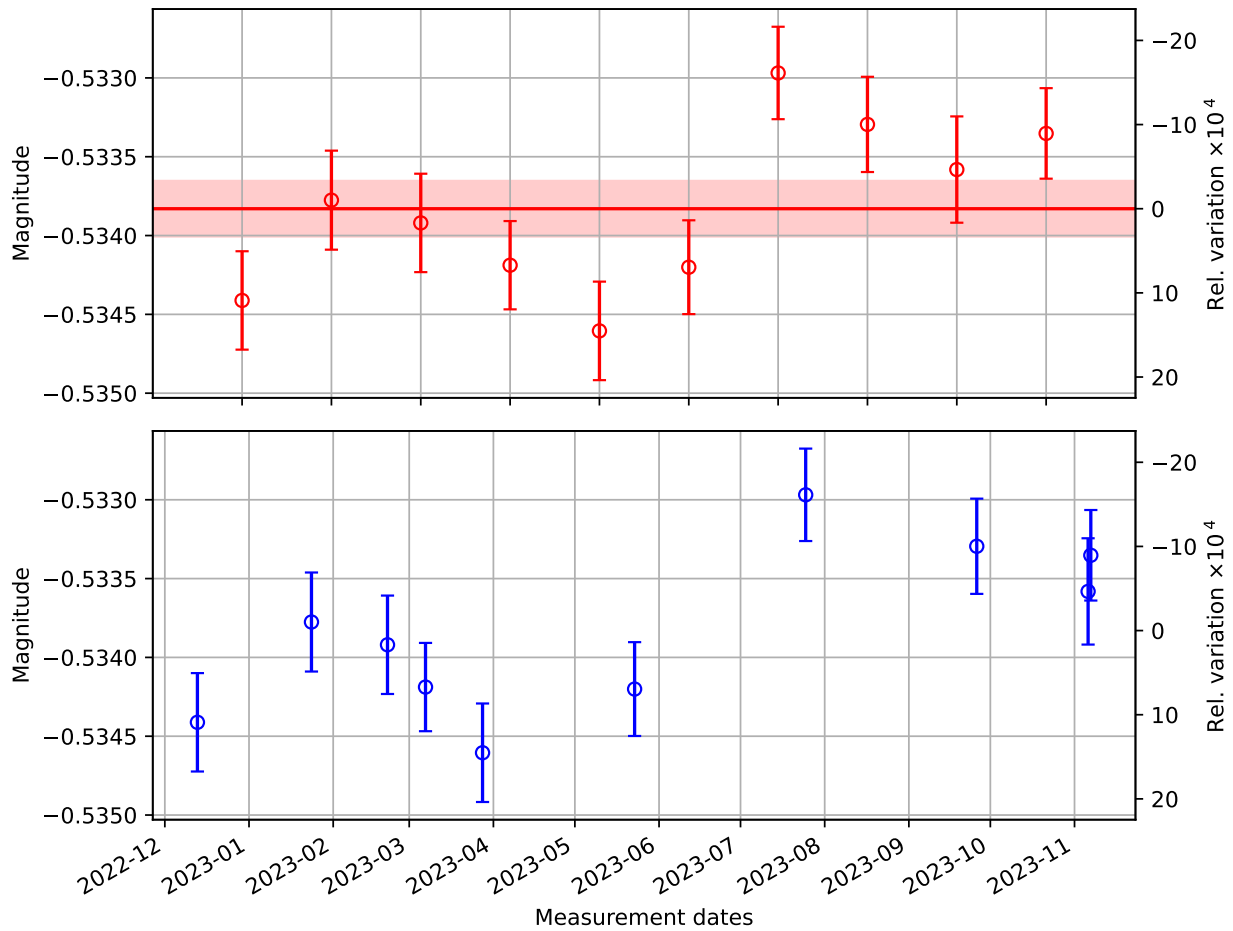
Mean value:	-0.526788
Standard deviation:	0.000206
Standard error:	0.000069
Relative Standard error:	-0.000130

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
D20231107	-0.5334 $\pm$ 0.0003

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

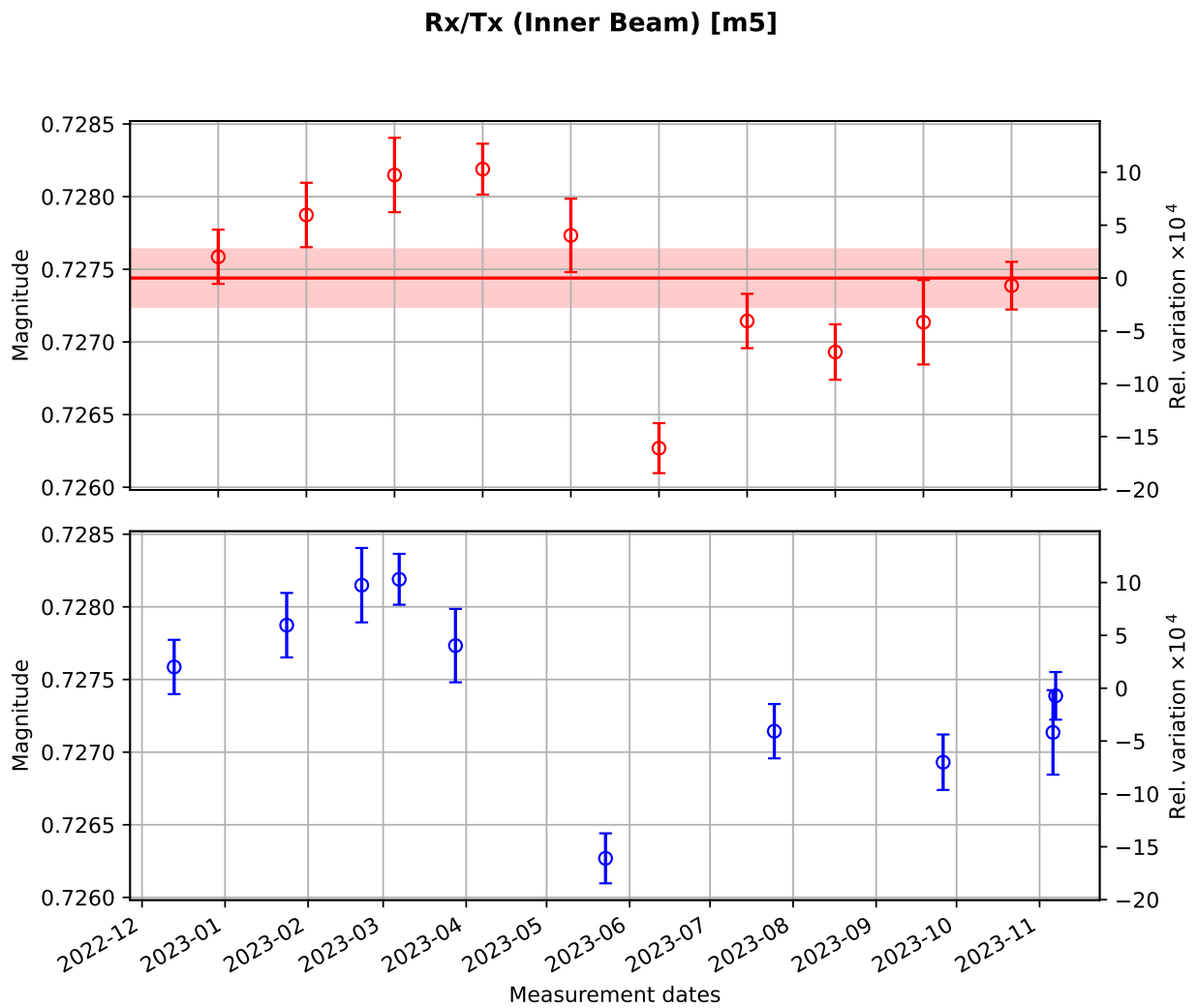


Summary of WS/Tx when WS is at Rx (Outer Beam) [m4]		
Mean value:	-0.533830	
Standard deviation:	0.000531	
Standard error:	0.000177	
Relative Standard error:	-0.000331	

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
D20231107	0.7274 $\pm$ 0.0002

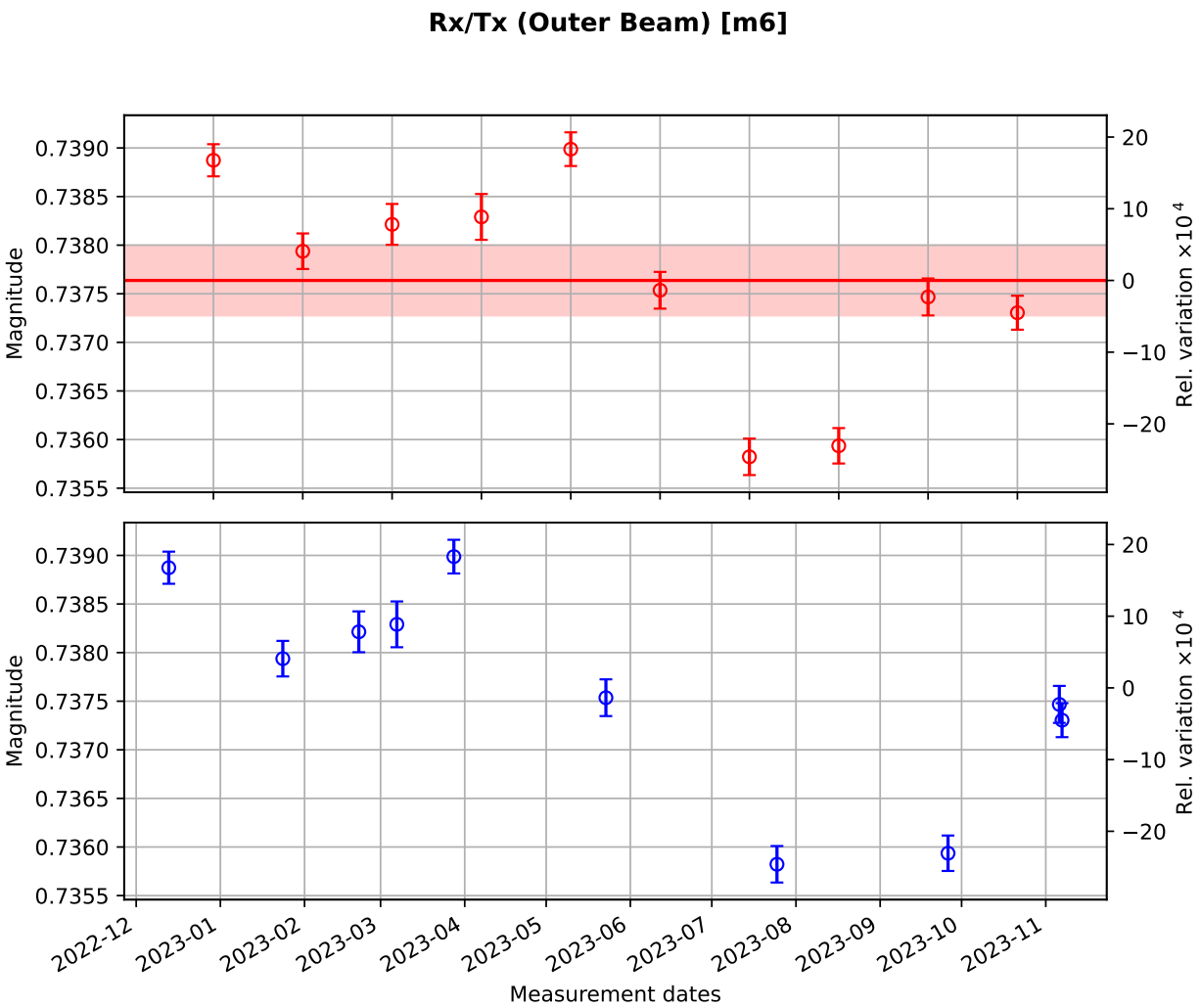


Summary of Rx/Tx (Inner Beam) [m5]		
Mean value:	0.727440	
Standard deviation:	0.000594	
Standard error:	0.000198	
Relative Standard error:	0.000272	

8 Rx/Tx Ratio (Outer Beam)

List of Measurements

Date	m6 ± SD_m6
D20221213	0.7389 ± 0.0002
D20230124	0.7379 ± 0.0002
D20230221	0.7382 ± 0.0002
D20230307	0.7383 ± 0.0002
D20230328	0.7390 ± 0.0002
D20230523	0.7375 ± 0.0002
D20230725	0.7358 ± 0.0002
D20230926	0.7359 ± 0.0002
D20231106	0.7375 ± 0.0002
D20231107	0.7373 ± 0.0002

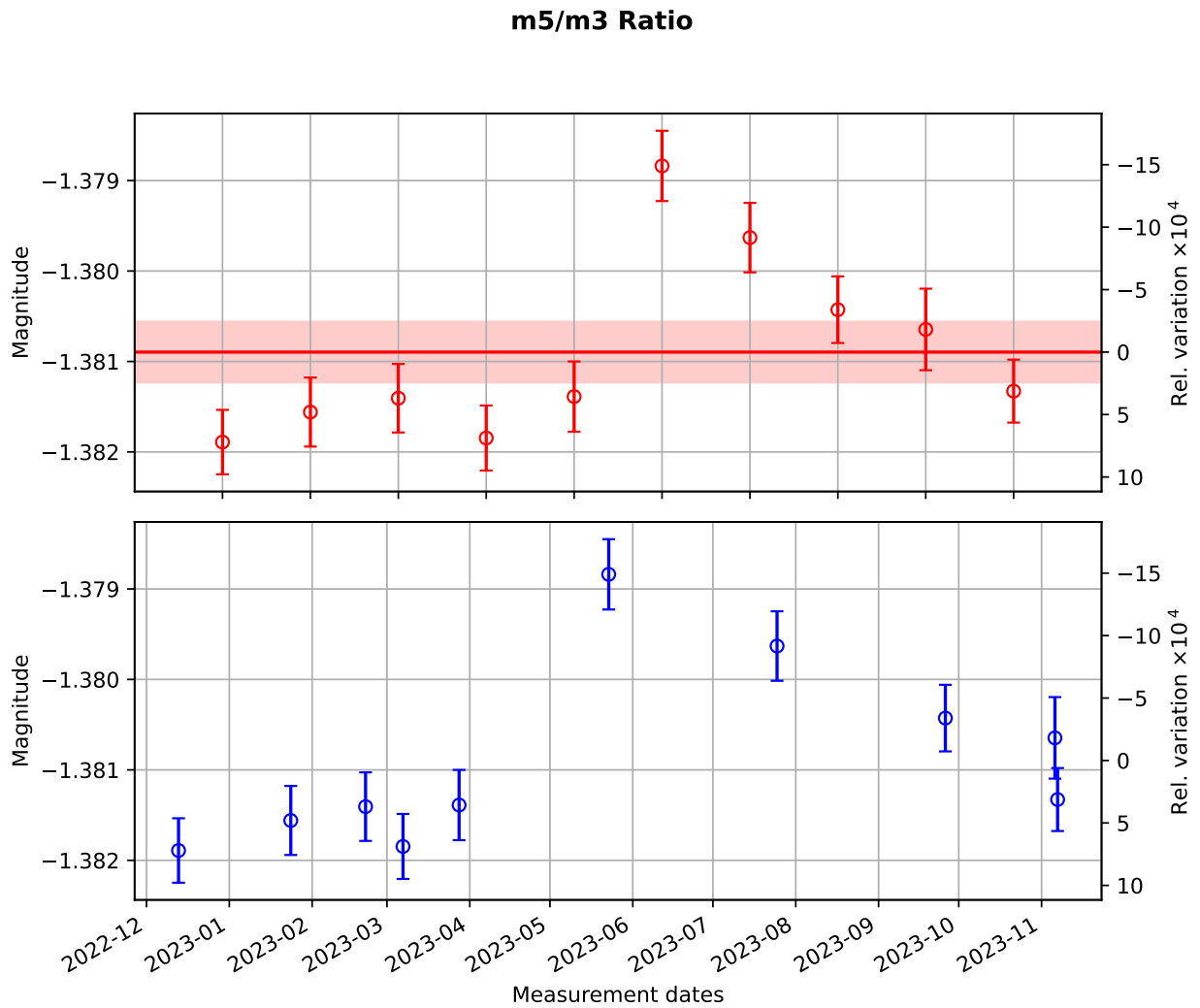


Summary of Rx/Tx (Outer Beam) [m6]		
Mean value:	0.737637	
Standard deviation:	0.001082	
Standard error:	0.000360	
Relative Standard error:	0.000488	

9 m5/m3 Ratio

List of Measurements

Date	RiTWrIT $\pm$ SD_RiTWrIT
D20221213	-1.3819 $\pm$ 0.0004
D20230124	-1.3816 $\pm$ 0.0004
D20230221	-1.3814 $\pm$ 0.0004
D20230307	-1.3818 $\pm$ 0.0004
D20230328	-1.3814 $\pm$ 0.0004
D20230523	-1.3788 $\pm$ 0.0004
D20230725	-1.3796 $\pm$ 0.0004
D20230926	-1.3804 $\pm$ 0.0004
D20231106	-1.3806 $\pm$ 0.0005
D20231107	-1.3813 $\pm$ 0.0003



Summary of m5/m3 Ratio

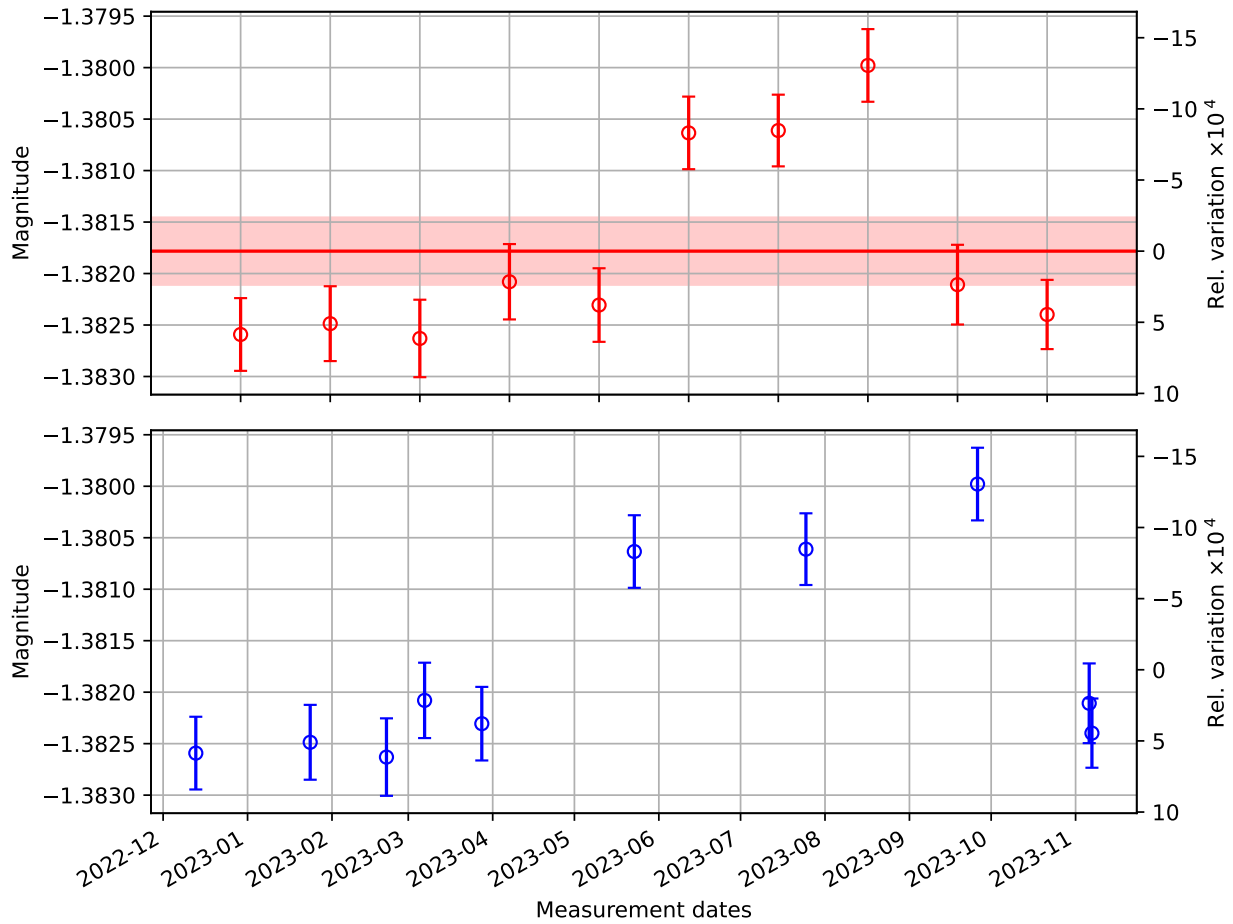
Mean value:	-1.380896
Standard deviation:	0.001008
Standard error:	0.000335
Relative Standard error:	-0.000243

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
D20231107	-1.3824 $\pm$ 0.0003

m6/m4 Ratio



Summary of m6/m4 Ratio

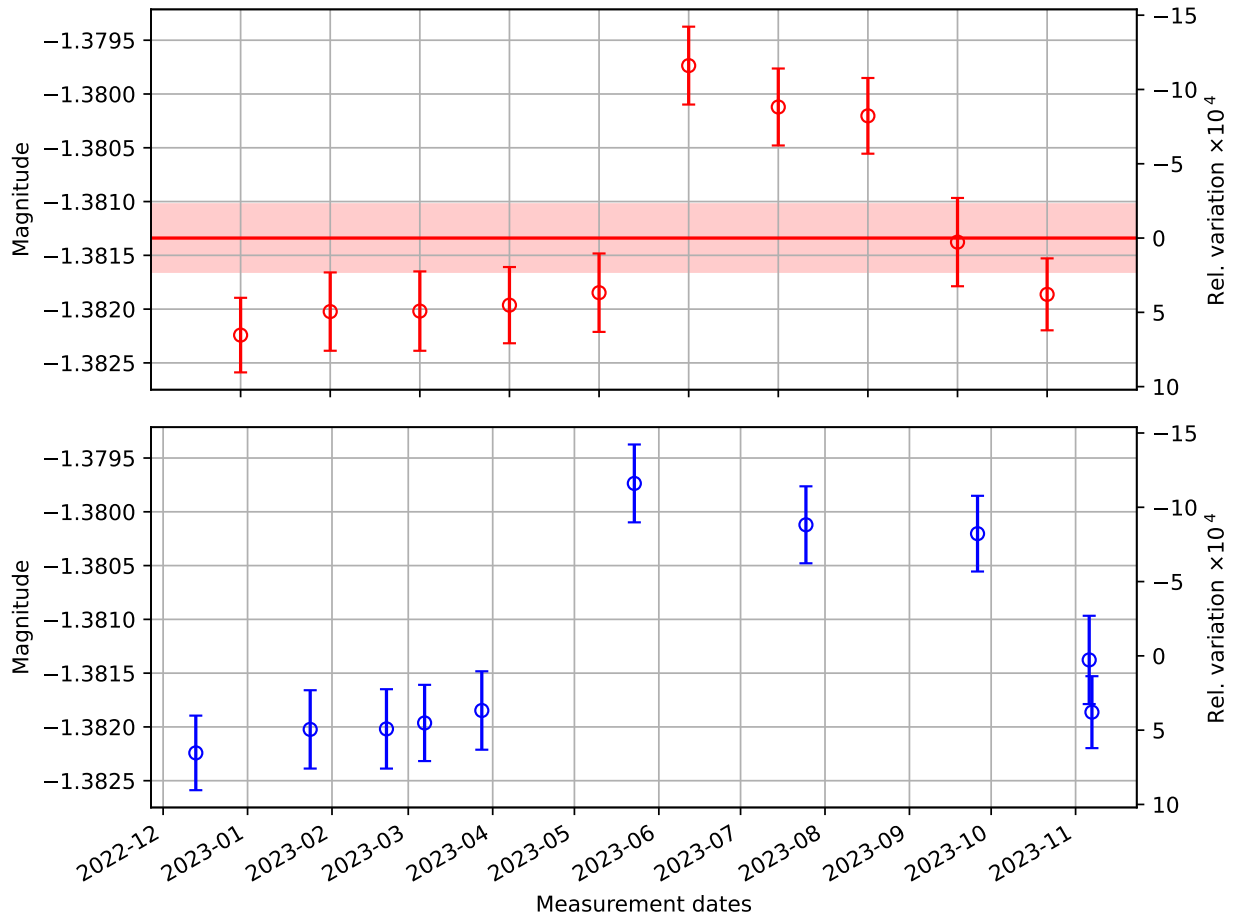
Mean value:	-1.381782
Standard deviation:	0.000981
Standard error:	0.000327
Relative Standard error:	-0.000236

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
D20231107	-1.3819 $\pm$ 0.0003

Rx/WS responsivity ratio



Summary of Rx/WS responsivity ratio

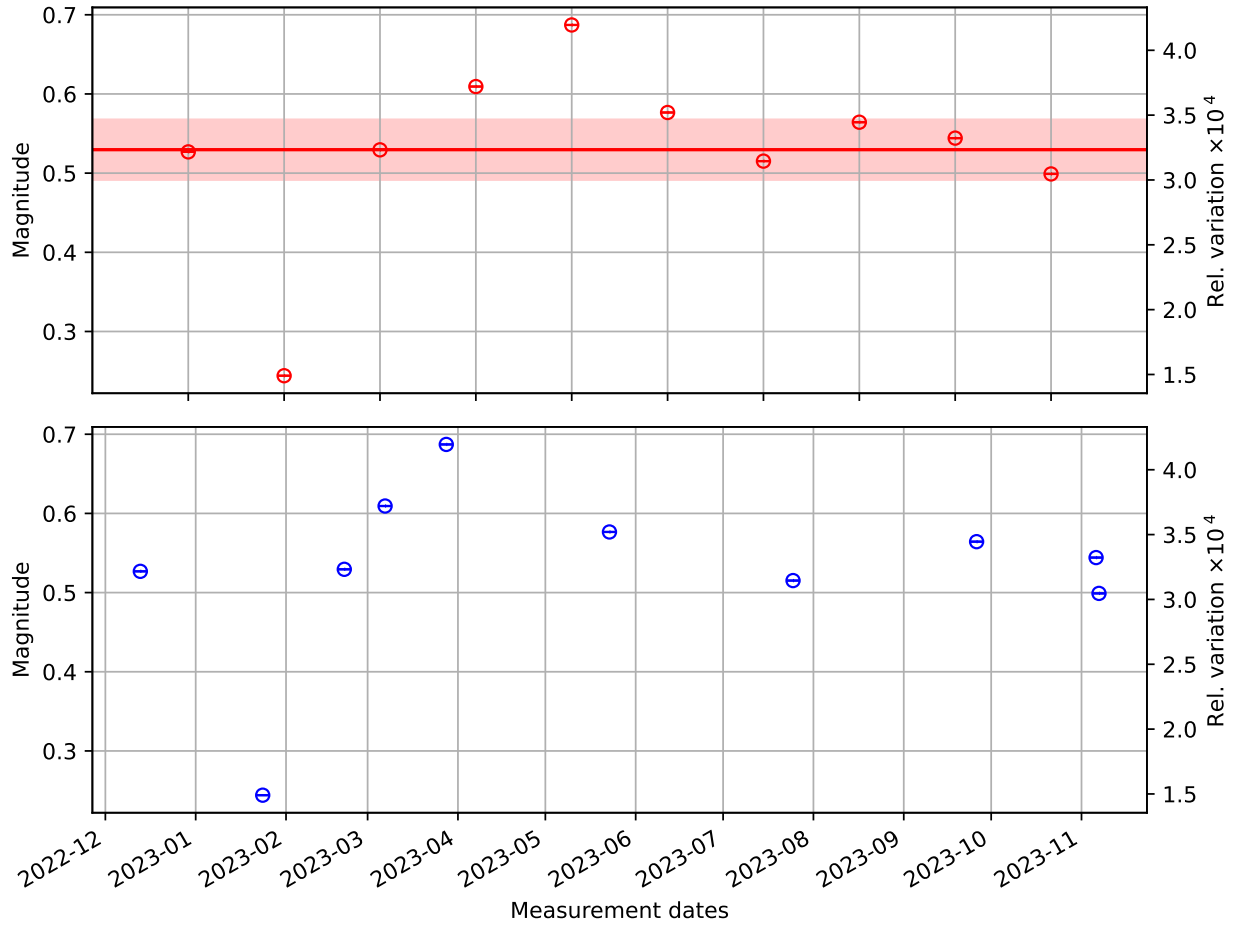
Mean value:	-1.381339
Standard deviation:	0.000943
Standard error:	0.000314
Relative Standard error:	-0.000227

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	$1.6379\text{e}+03 \pm 1.0000\text{e}-09$
D20231107	$1.6379\text{e}+03 \pm 1.0000\text{e}-09$

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



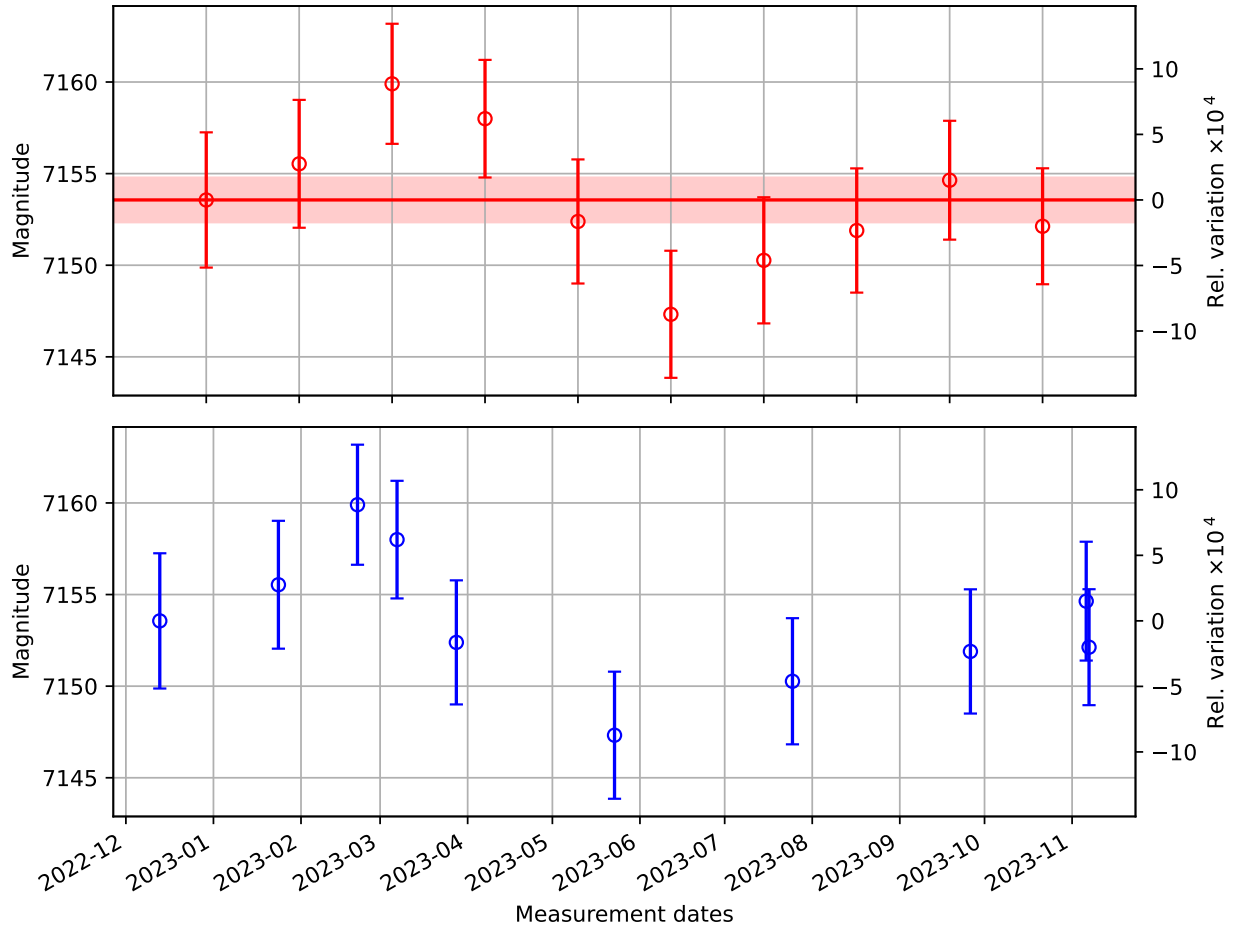
| Summary of ADC conversion factor discrepancy

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
D20231107	7152.1267 $\pm$ 3.1642

TxPD calibration (ct/W)



Summary of TxPD calibration (ct/W)

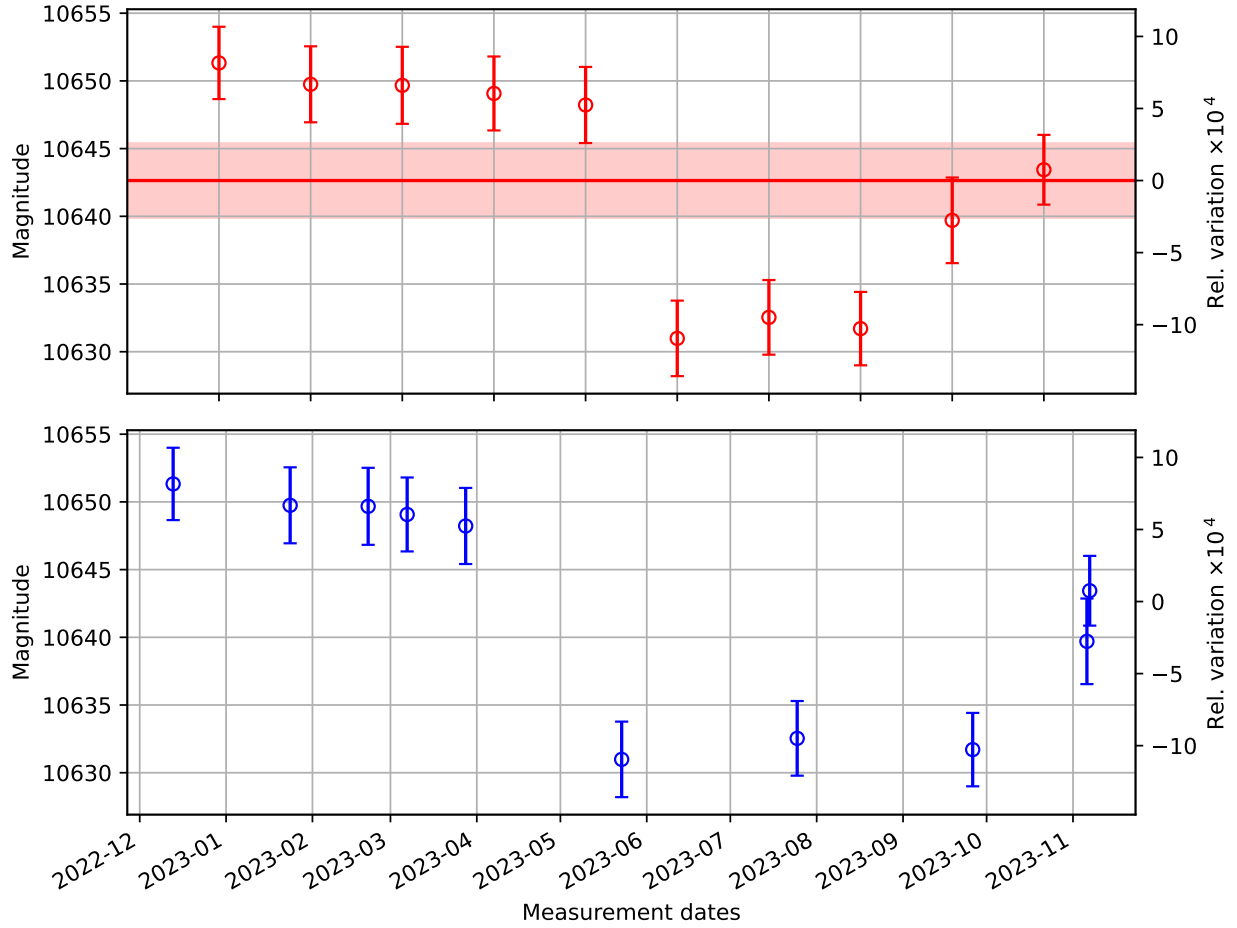
Mean value:	7153.563889
Standard deviation:	3.665735
Standard error:	1.220138
Relative Standard error:	0.000171

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
D20231107	10643.4386 $\pm$ 2.5757

RxPD calibration (ct/W)



Summary of RxPD calibration (ct/W)

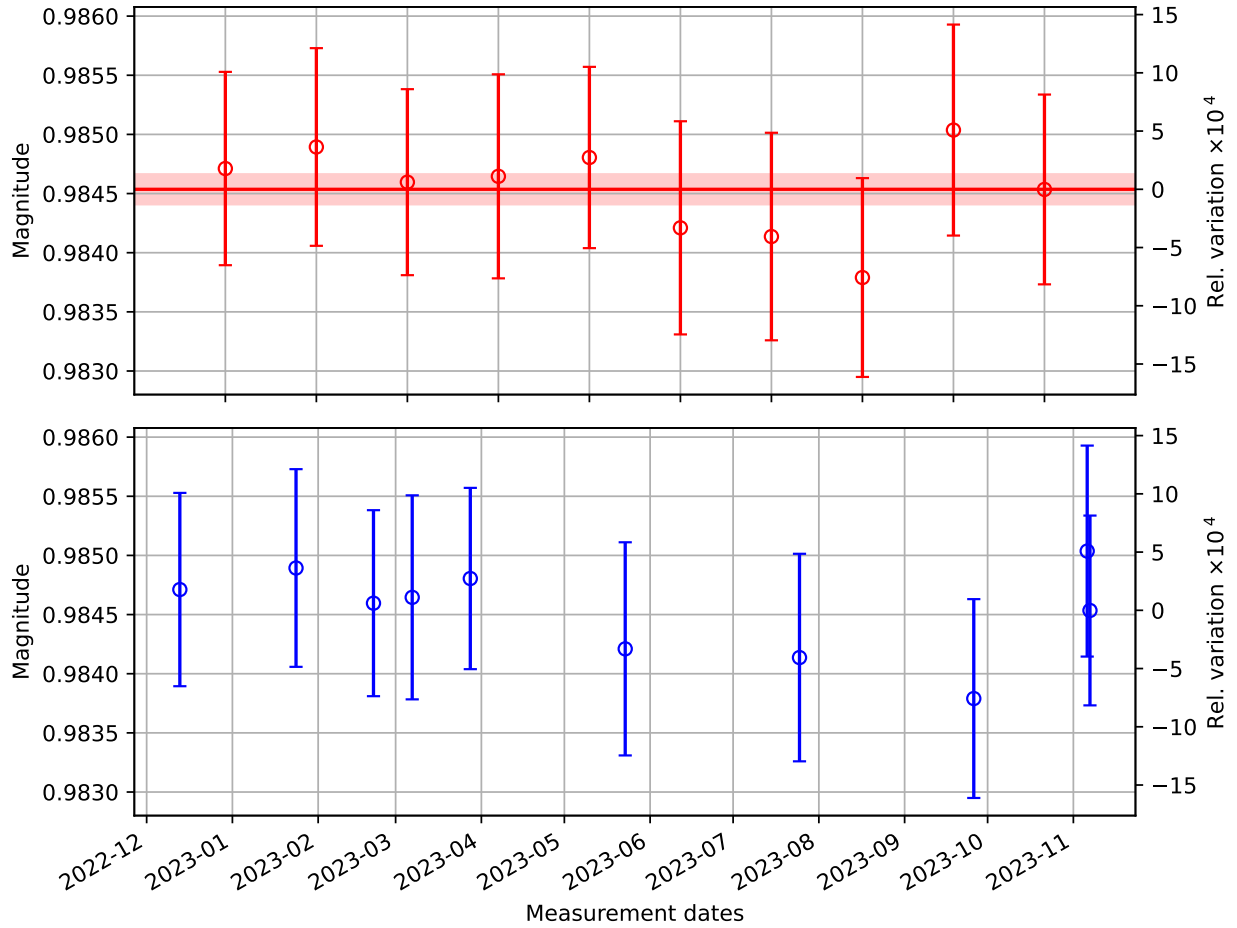
Mean value:	10642.641680
Standard deviation:	8.264314
Standard error:	2.750772
Relative Standard error:	0.000258

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
D20231107	0.9845 ± 0.0008

Optical Efficiency (Inner Beam)



Summary of Optical Efficiency (Inner Beam)

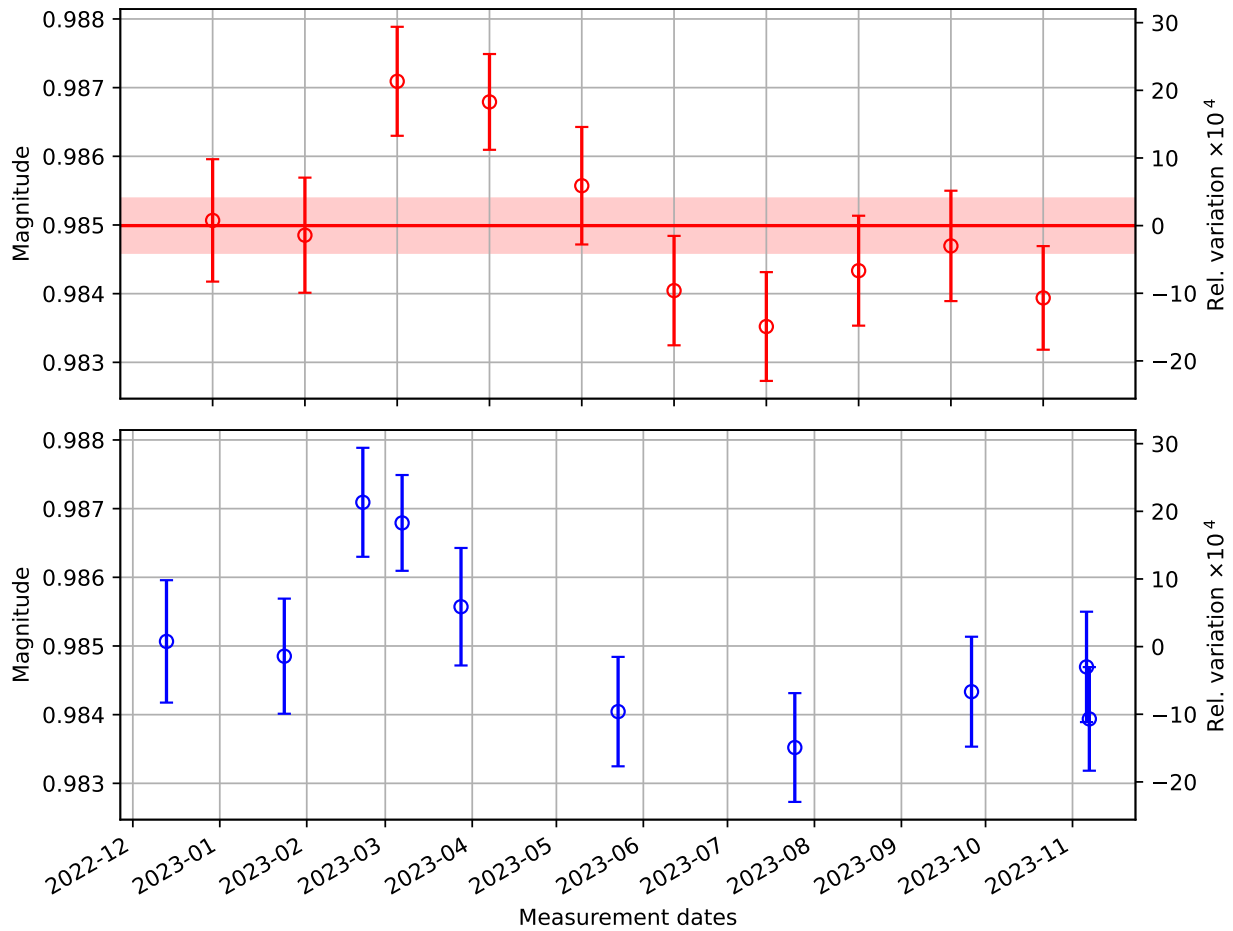
Mean value:	0.984536
Standard deviation:	0.000383
Standard error:	0.000127
Relative Standard error:	0.000129

16 Optical Efficiency of Outer Beam $e^0 = m_4/m_2$

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
D20231107	0.9839 ± 0.0008

Optical Efficiency (Outer Beam)



Summary of Optical Efficiency (Outer Beam)

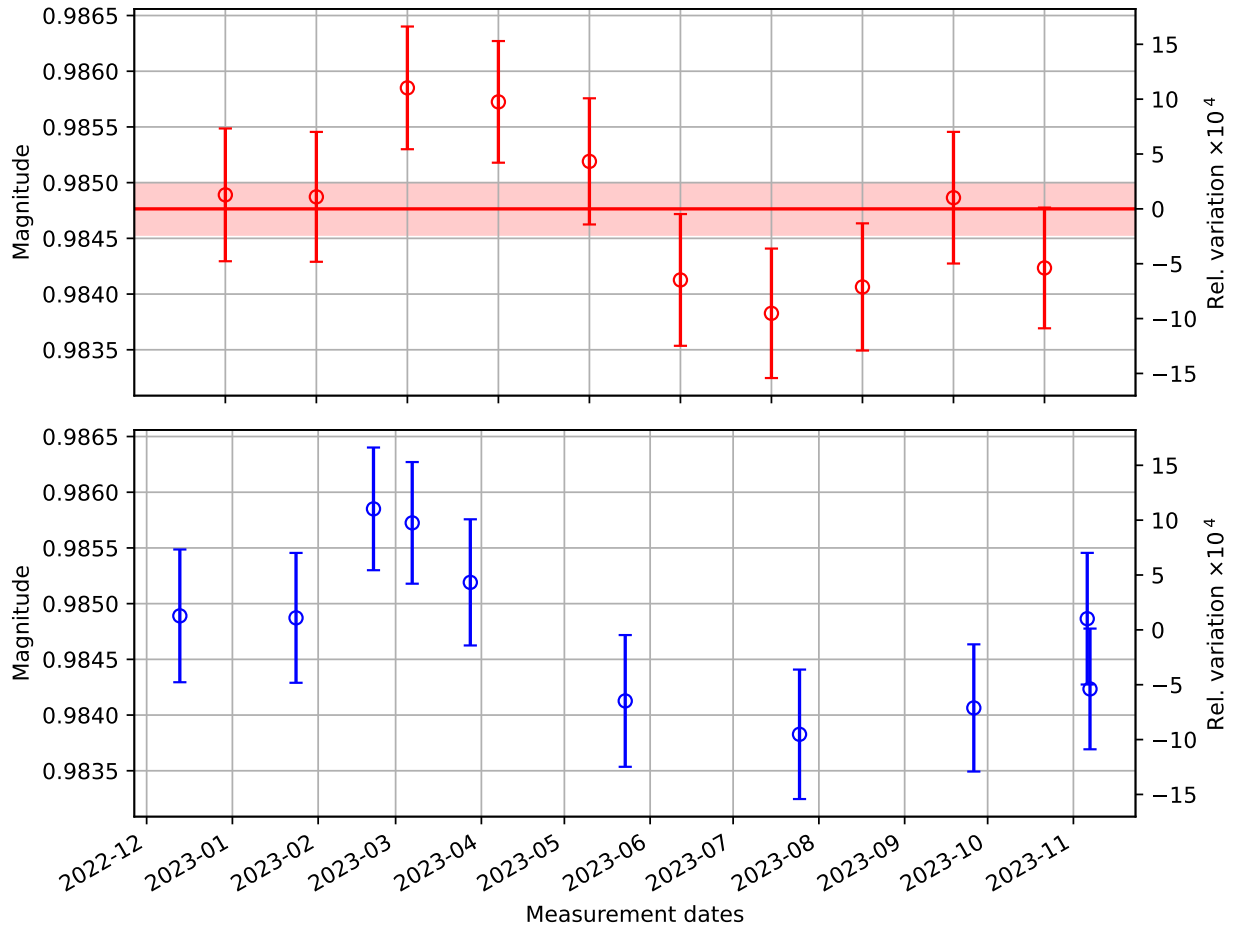
Mean value:	0.984991
Standard deviation:	0.001188
Standard error:	0.000395
Relative Standard error:	0.000401

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
D20231107	0.9842 ± 0.0005

Overall Optical Efficiency



Summary of Overall Optical Efficiency

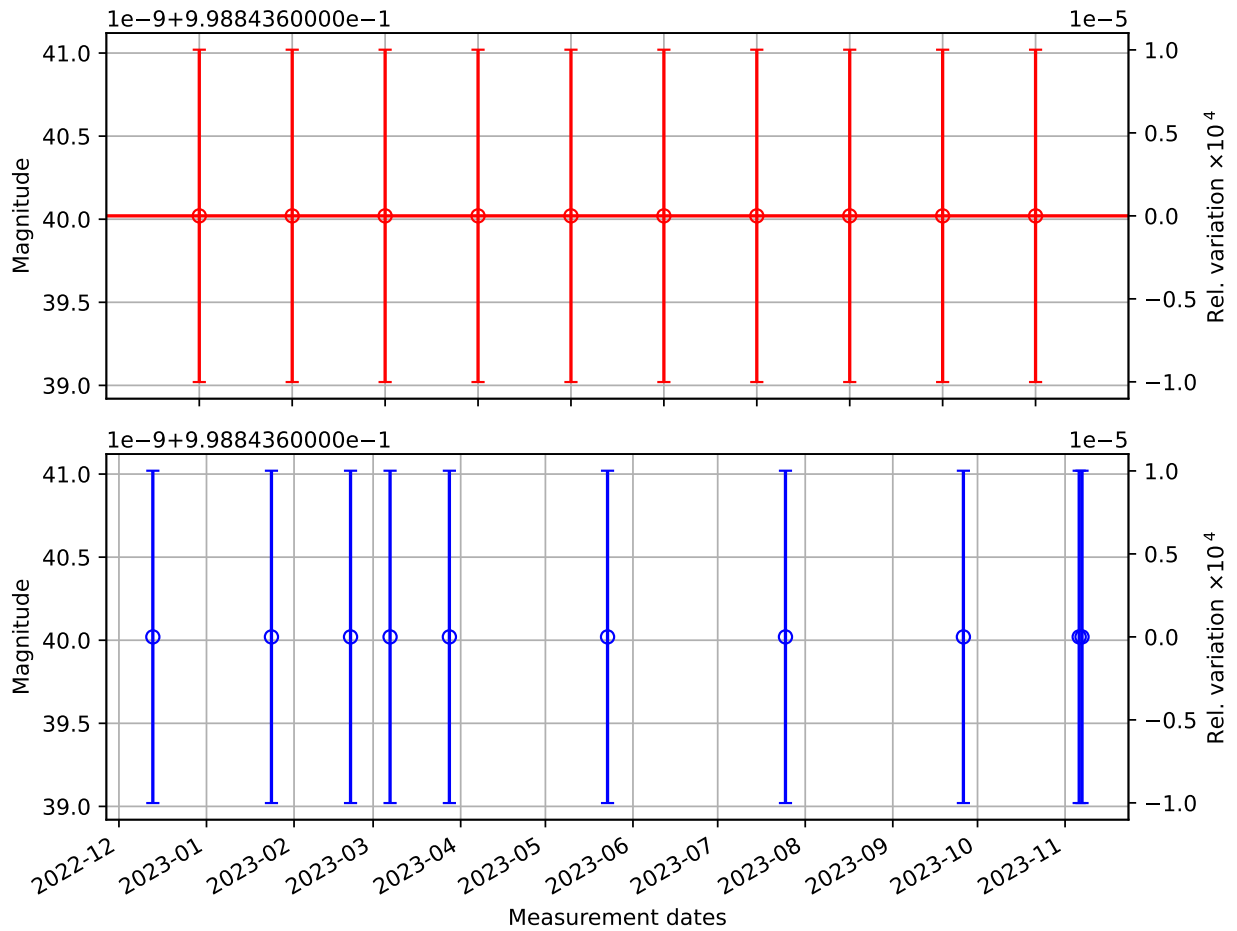
Mean value:	0.984765
Standard deviation:	0.000698
Standard error:	0.000232
Relative Standard error:	0.000236

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
D20231107	9.9884e-01 $\pm$ 1.0000e-09

Beta



Summary of Beta

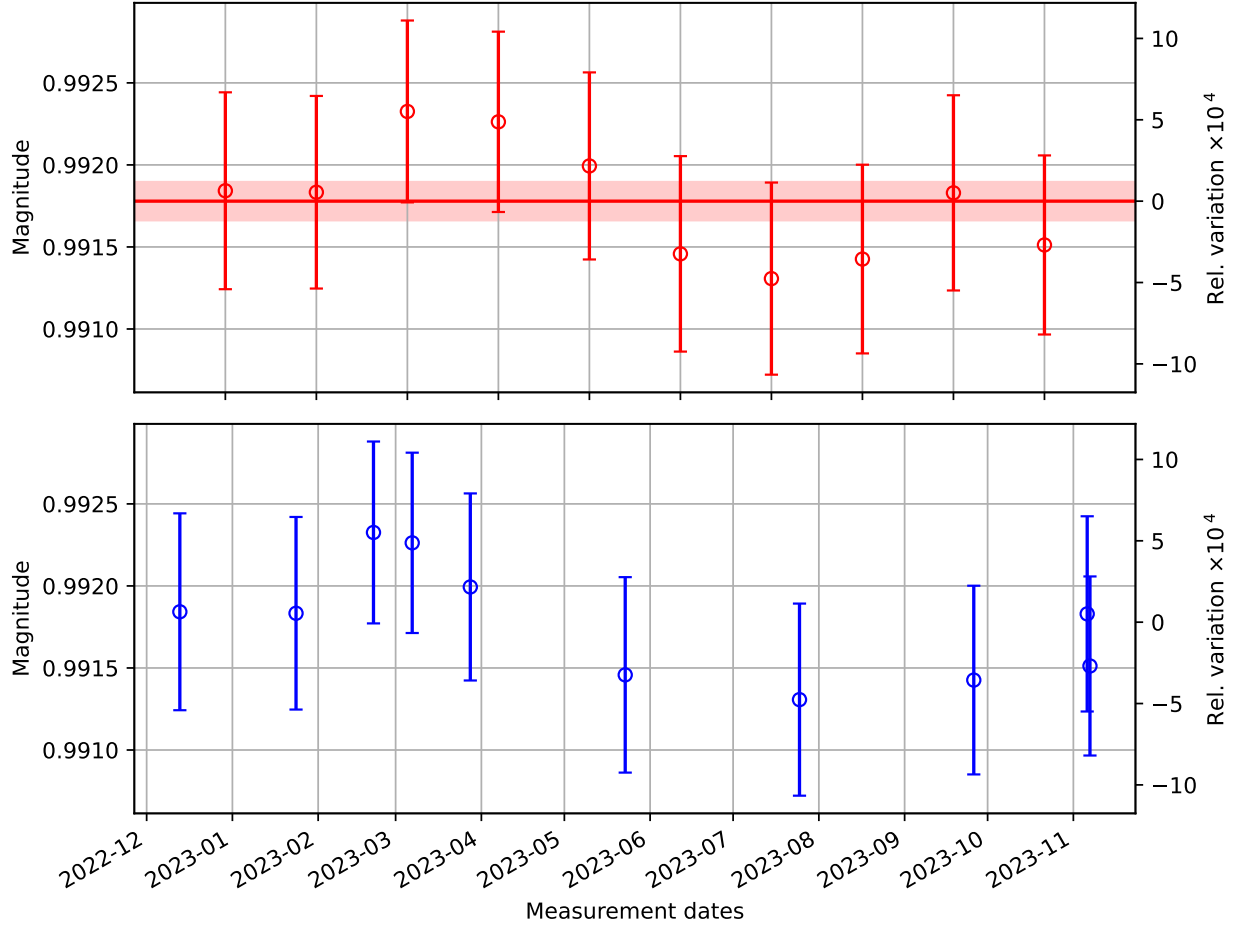
Mean value:	0.998844
Standard deviation:	0.000000
Standard error:	0.000000
Relative Standard error:	0.000000

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
D20231107	0.9915 $\pm$ 0.0005

Input Side Optical Efficiency correction factor



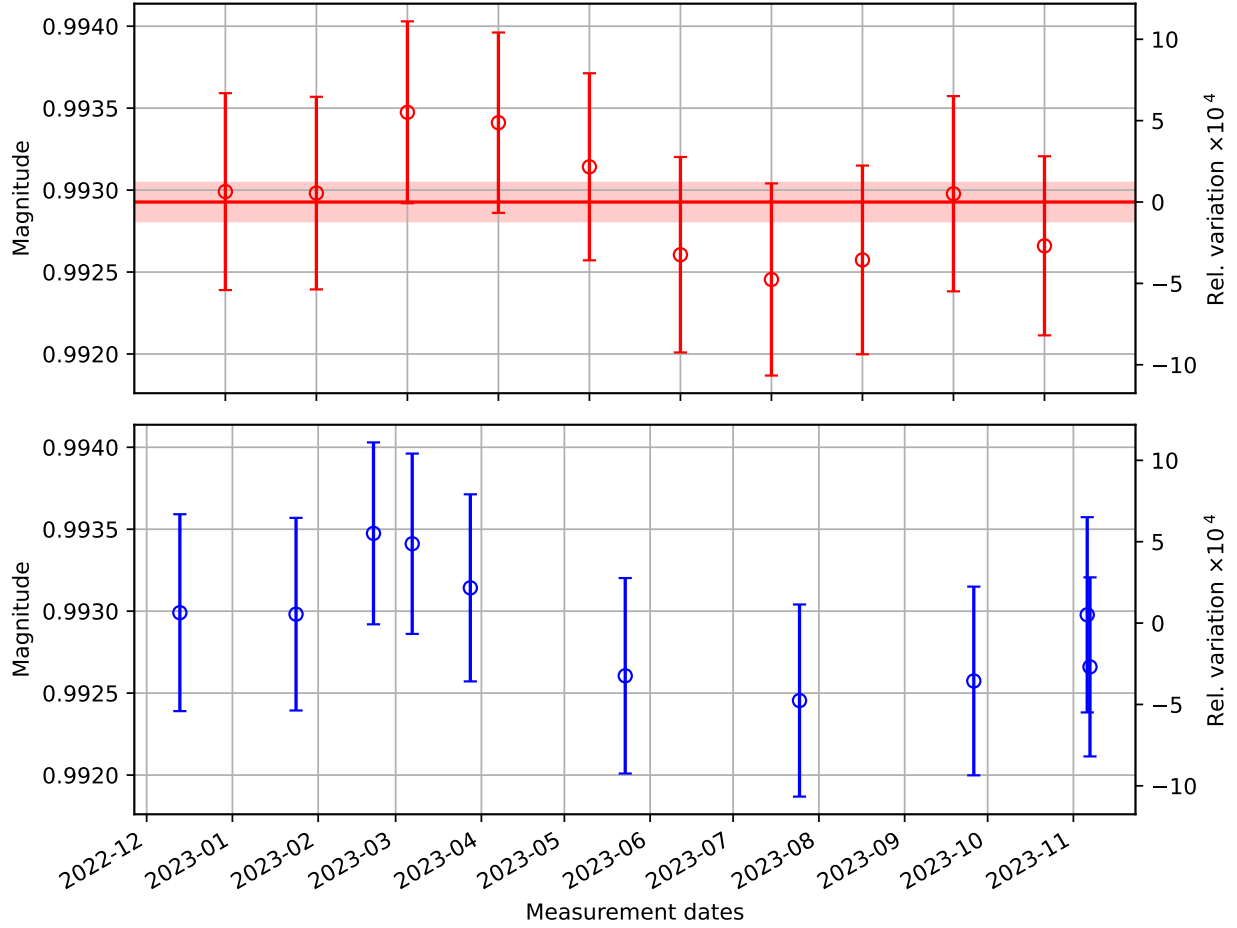
Summary of Input Side Optical Efficiency correction factor		
Mean value:	0.991779	
Standard deviation:	0.000351	
Standard error:	0.000117	
Relative Standard error:	0.000118	

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
D20231107	0.9927 $\pm$ 0.0005

Output Side Optical Efficiency correction factor



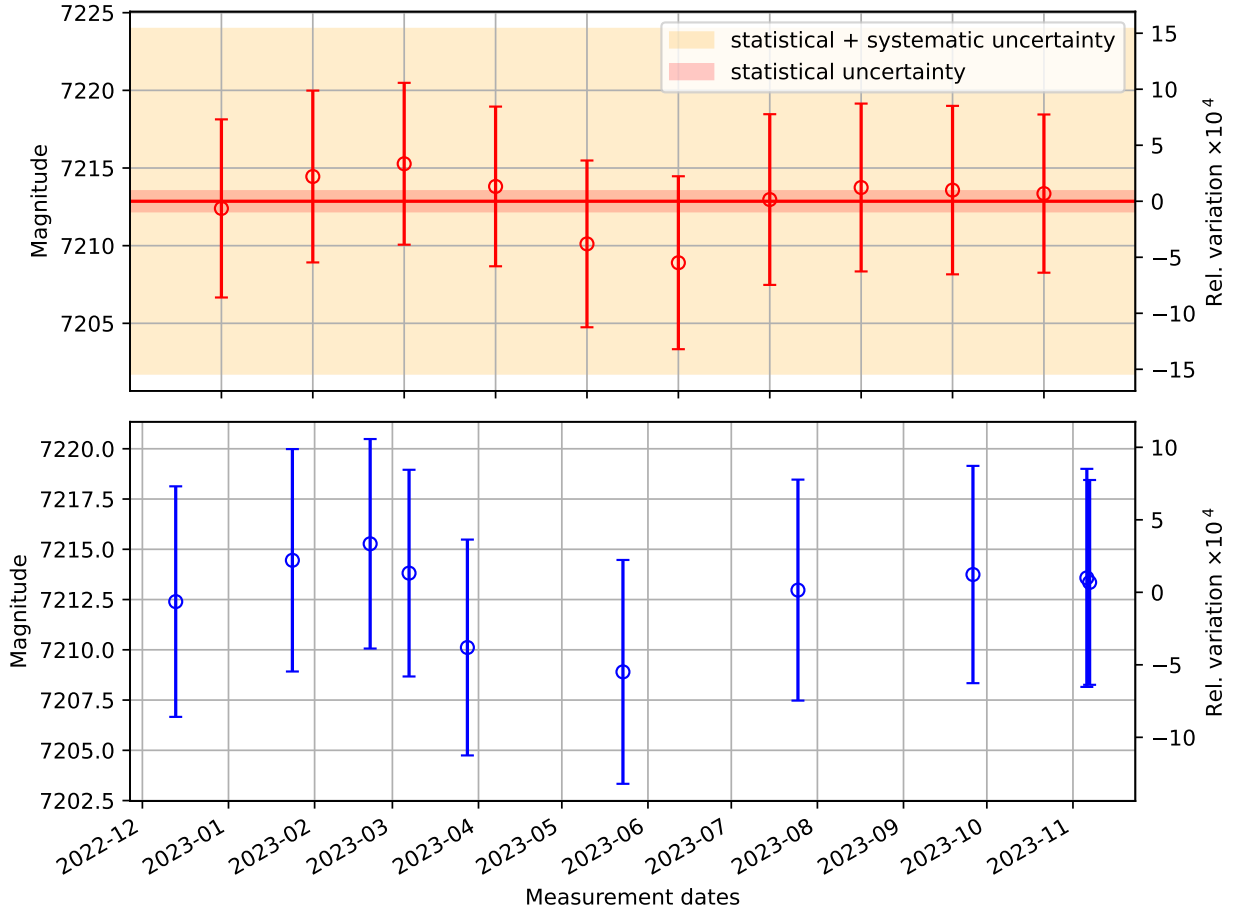
Summary of Output Side Optical Efficiency correction factor		
Mean value:	0.992927	
Standard deviation:	0.000352	
Standard error:	0.000117	
Relative Standard error:	0.000118	

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
D20231107	7213.3527 $\pm$ 5.0937

TxPD calibration corrected for optical efficiency (ct/W)



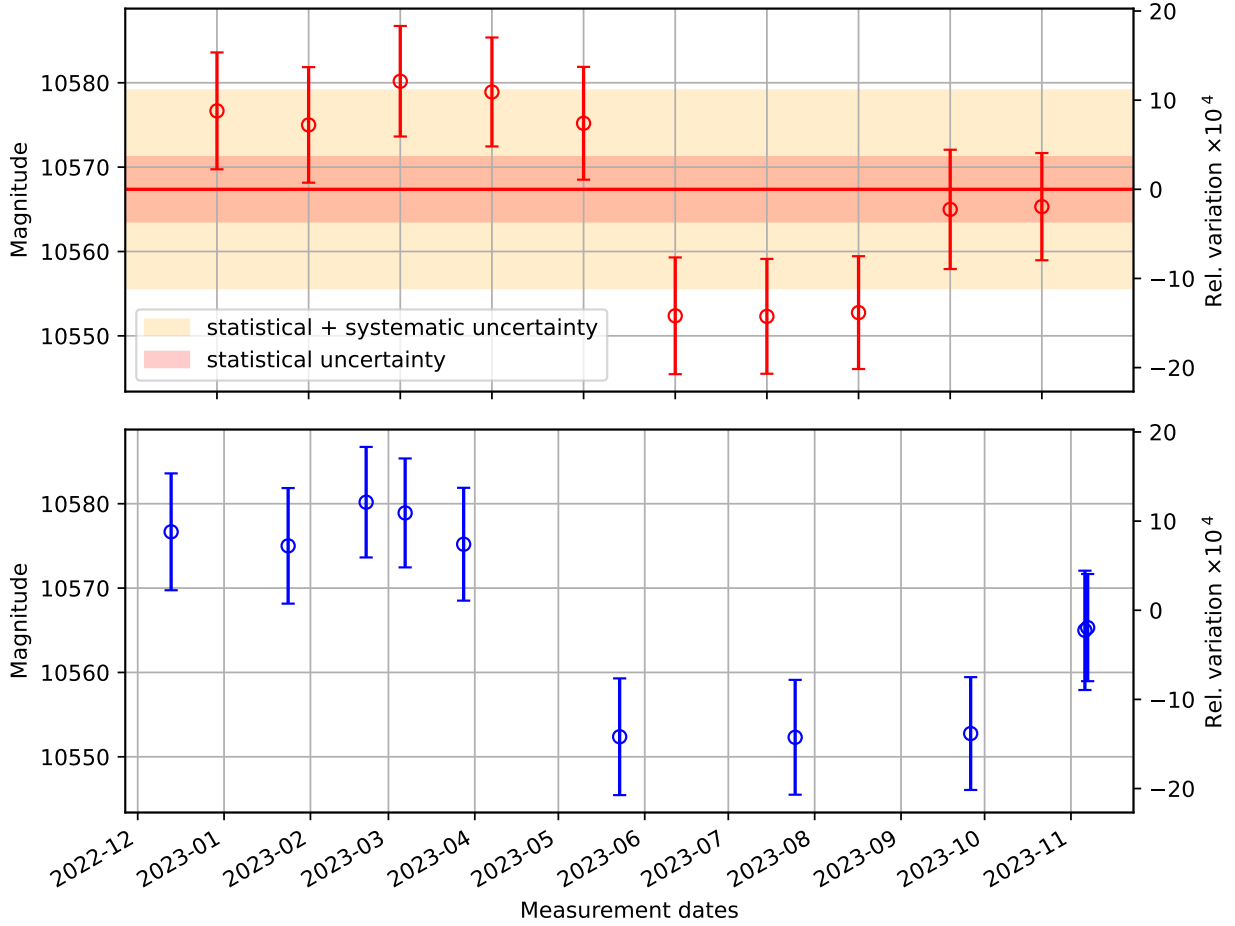
Summary of TxPD calibration corrected for optical efficiency (ct/W)		
Mean value:	7212.859793	
Standard deviation:	1.950610	
Standard error:	0.649259	
Relative Standard error:	0.000090	

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
D20231107	10565.3157 $\pm$ 6.3522

RxPD calibration corrected for optical efficiency (ct/W)

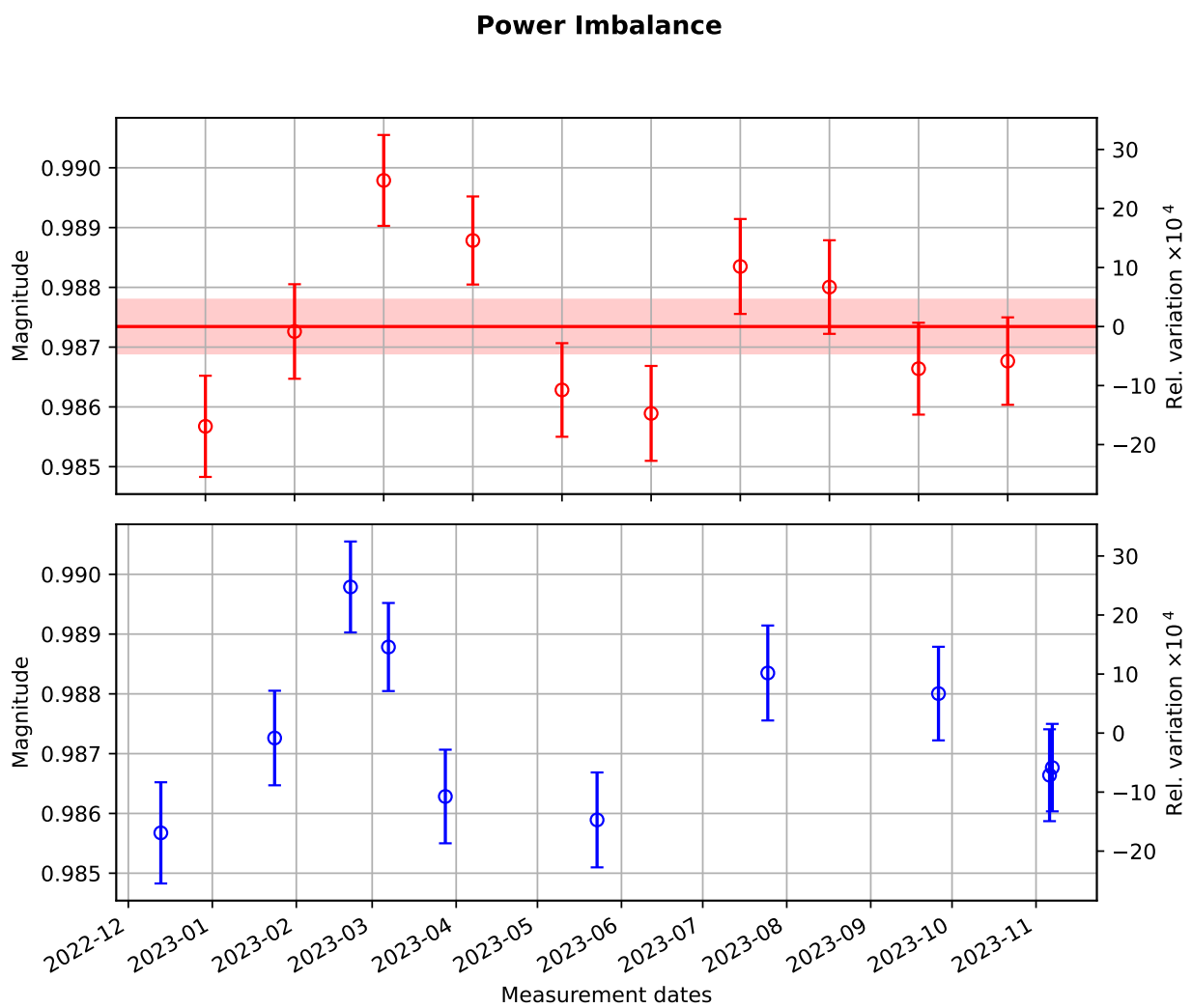


Summary of RxPD calibration corrected for optical efficiency (ct/W)	
Mean value:	10567.371514
Standard deviation:	11.442435
Standard error:	3.808608
Relative Standard error:	0.000360

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
D20231107	0.9868 $\pm$ 0.0007



Summary of Power Imbalance		
Mean value:	0.987344	
Standard deviation:	0.001348	
Standard error:	0.000449	
Relative Standard error:	0.000454	