

PCAL End Station Measurement Trends

TXWS

Date None $\pm$ SD_None

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
D20240109	-0.9288 $\pm$ 0.0004
D20240319	-0.9269 $\pm$ 0.0005
D20240528	-0.9269 $\pm$ 0.0004
D20240718	-0.9270 $\pm$ 0.0004
D20240813	-0.9275 $\pm$ 0.0004
D20241025	-0.9282 $\pm$ 0.0004
D20241210	-0.9277 $\pm$ 0.0004
D20250204	-0.9280 $\pm$ 0.0004
D20250429	-0.9275 $\pm$ 0.0004
D20250722	-0.9277 $\pm$ 0.0005

Description:

Tx/WS ratio:

This ratio, α_{TW} , is the Tx to Working Standard output with the backgrounds subtracted and is made using M1 - M7

TXWS

Summary of TS / WS ratio

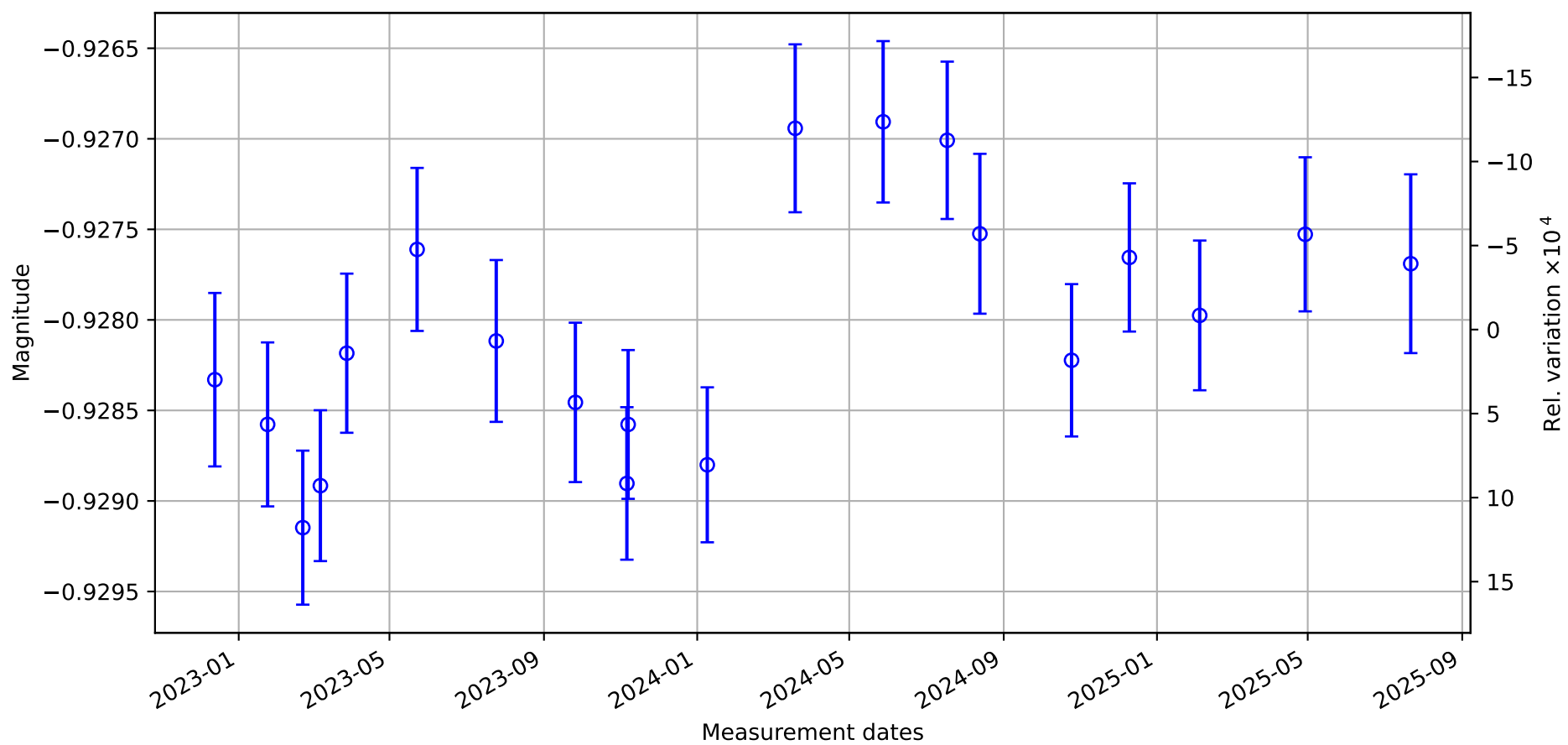
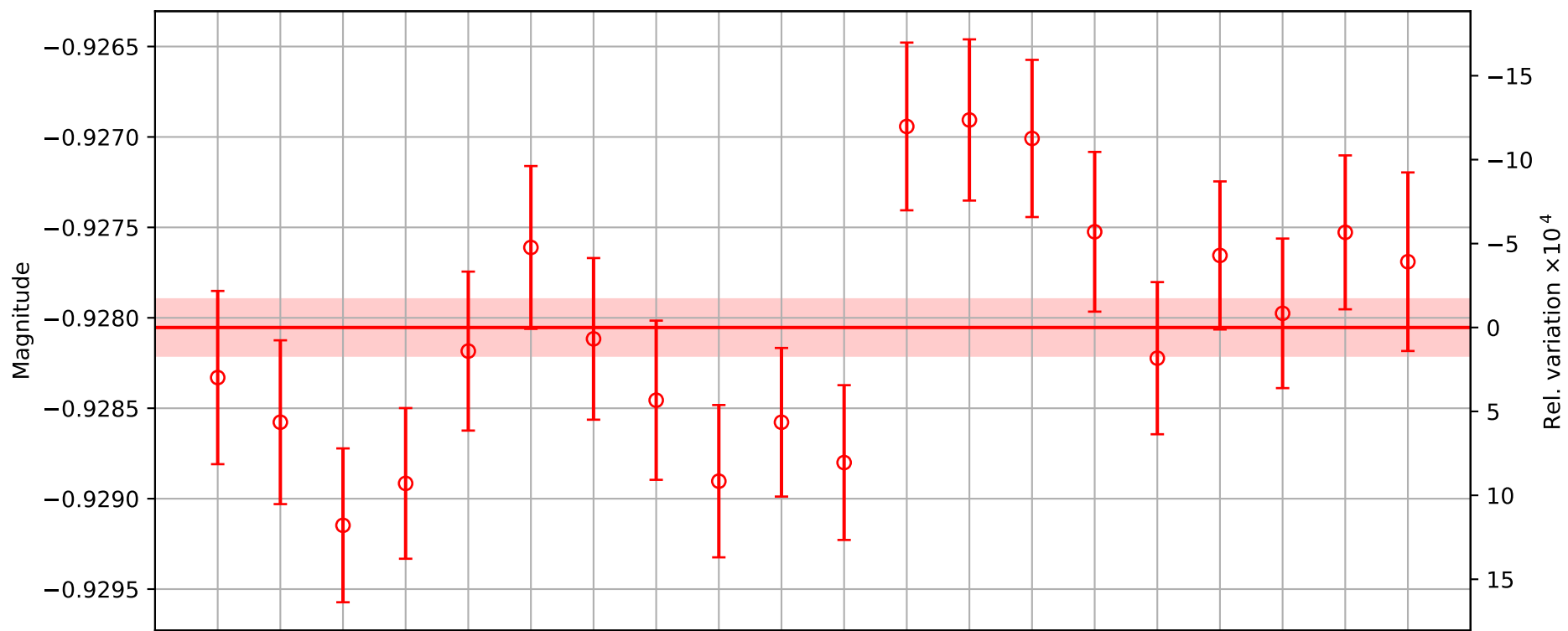
Mean value: -0.928054

Standard deviation: 0.000679

Standard error: 0.000156

Relative Standard error: -0.000168

TS / WS ratio



RXWS

Date None $\pm$ SD_None

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
D20240109	-1.3831 $\pm$ 0.0004
D20240319	-1.3815 $\pm$ 0.0004
D20240528	-1.3831 $\pm$ 0.0007
D20240718	-1.3828 $\pm$ 0.0006
D20240813	-1.3823 $\pm$ 0.0006
D20241025	-1.3837 $\pm$ 0.0006
D20241210	-1.3842 $\pm$ 0.0006
D20250204	-1.3846 $\pm$ 0.0005
D20250429	-1.3836 $\pm$ 0.0006
D20250722	-1.3833 $\pm$ 0.0006

Description:

Rx/WS ratio

This ratio, α_{RW} , is the Rx to Working Standard output with the backgrounds subtracted and is made using M7 - M9.

RXWS

Summary of RX / WS ratio

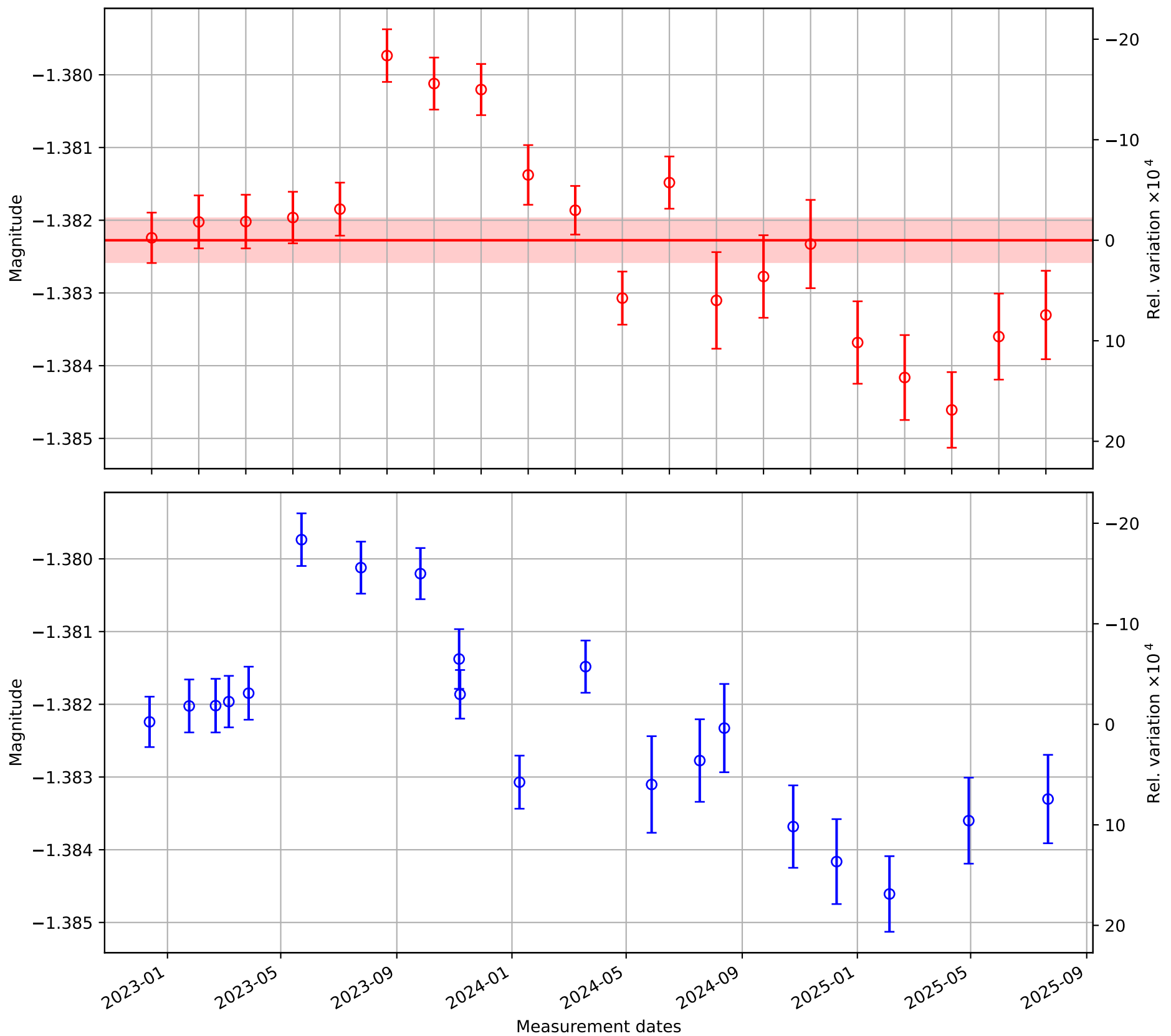
Mean value: -1.382275

Standard deviation: 0.001313

Standard error: 0.000301

Relative Standard error: -0.000218

RX / WS ratio



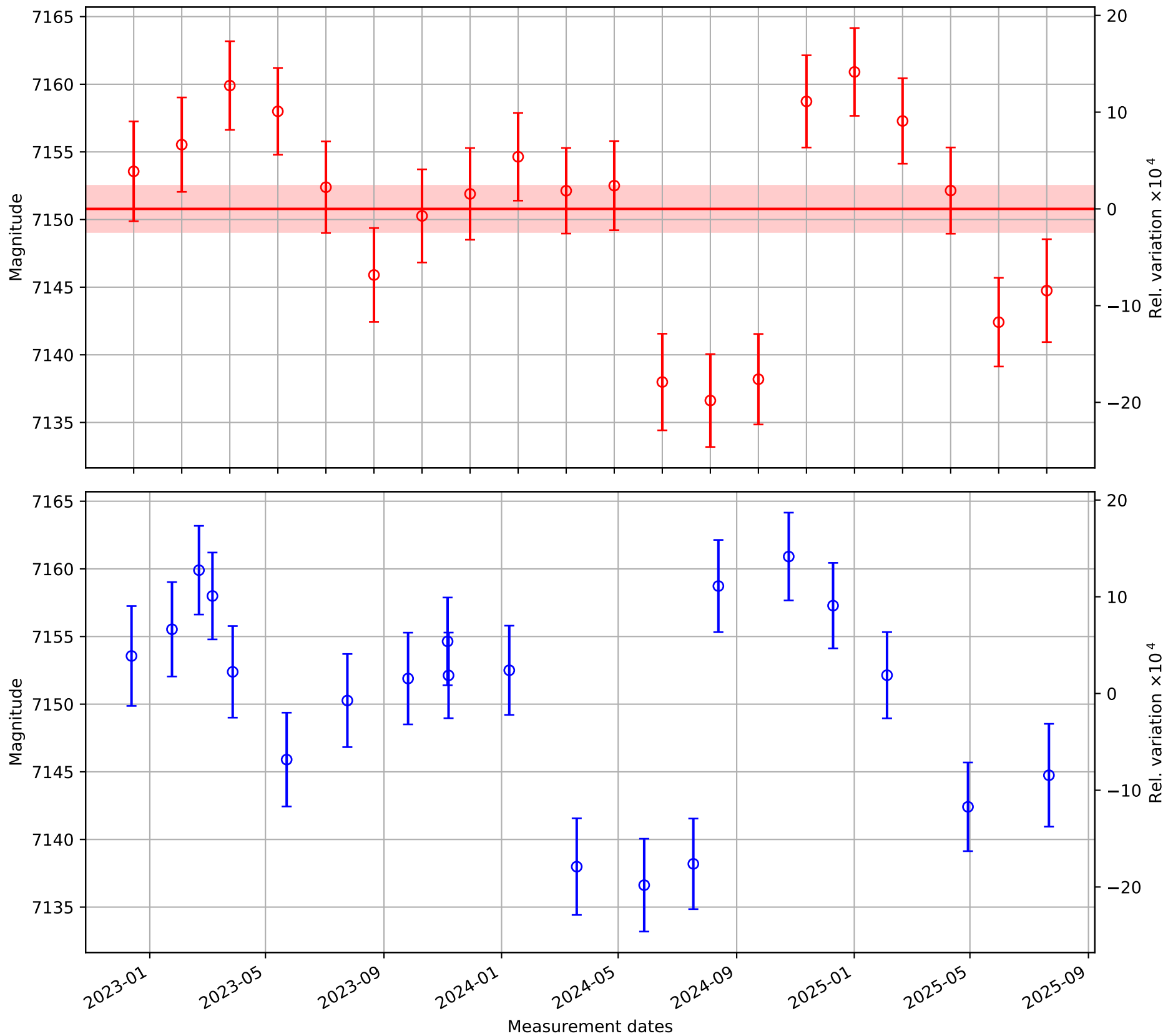
	rho_T
Date m5 ± SD_m5	
D20221213	7153.5622 ± 3.6907
D20230124	7155.5352 ± 3.4892
D20230221	7159.9027 ± 3.2774
D20230307	7157.9979 ± 3.2099
D20230328	7152.3889 ± 3.3863
D20230523	7145.9027 ± 3.4677
D20230725	7150.2673 ± 3.4427
D20230926	7151.8956 ± 3.3903
D20231106	7154.6400 ± 3.2434
D20231107	7152.1267 ± 3.1642
D20240109	7152.5050 ± 3.2952
D20240319	7137.9890 ± 3.5704
D20240528	7136.6224 ± 3.4316
D20240718	7138.1965 ± 3.3466
D20240813	7158.7320 ± 3.4081
D20241025	7160.9116 ± 3.2458
D20241210	7157.2848 ± 3.1588
D20250204	7152.1403 ± 3.1871
D20250429	7142.4125 ± 3.2770
D20250722	7144.7450 ± 3.8020

Description:

TX Responsivity rho_T: $\rho_{Tx} = \alpha_{TW} * \rho_{WS}$ The responsivity of the TxPD, calculated using ρ_{WS} . Trending this parameter is useful in determining if there has been a change in the input Laser Power and for estimating how much power is incident on the ETM once corrected for optical losses inside the vacuum chamber.

rho_T
Summary of TX Responsivity rho_T
Mean value: 7150.787914
Standard deviation: 7.441407
Standard error: 1.706601
Relative Standard error: 0.000239

TX Responsivity ρ_T



	rho_R
Date	None ± SD_None
D20221213	10651.3278 ± 2.6712
D20230124	10649.7487 ± 2.8058
D20230221	10649.6738 ± 2.8433
D20230307	10649.0726 ± 2.7307
D20230328	10648.2216 ± 2.8093
D20230523	10628.8739 ± 2.7884
D20230725	10632.5382 ± 2.7567
D20230926	10631.7067 ± 2.7108
D20231106	10639.7032 ± 3.1608
D20231107	10643.4386 ± 2.5757
D20240109	10650.7508 ± 2.8108
D20240319	10638.2119 ± 2.7655
D20240528	10649.0628 ± 5.1137
D20240718	10647.7038 ± 4.3711
D20240813	10668.9500 ± 4.6864
D20241025	10674.6112 ± 4.3725
D20241210	10679.4512 ± 4.5056
D20250204	10671.5263 ± 4.0079
D20250429	10654.3914 ± 4.5562
D20250722	10653.7194 ± 4.6842

Description:

RX Responsivity rho_R: $p_{Rx} = \alpha_{RW} * p_{WS}$ The responsivity of the RxPD, calculated using p_{WS} . Trending this parameter is useful in estimating how much power is incident on the ETM once corrected for optical losses inside the vacuum chamber.

rho_R

Summary of RX Responsivity rho_R

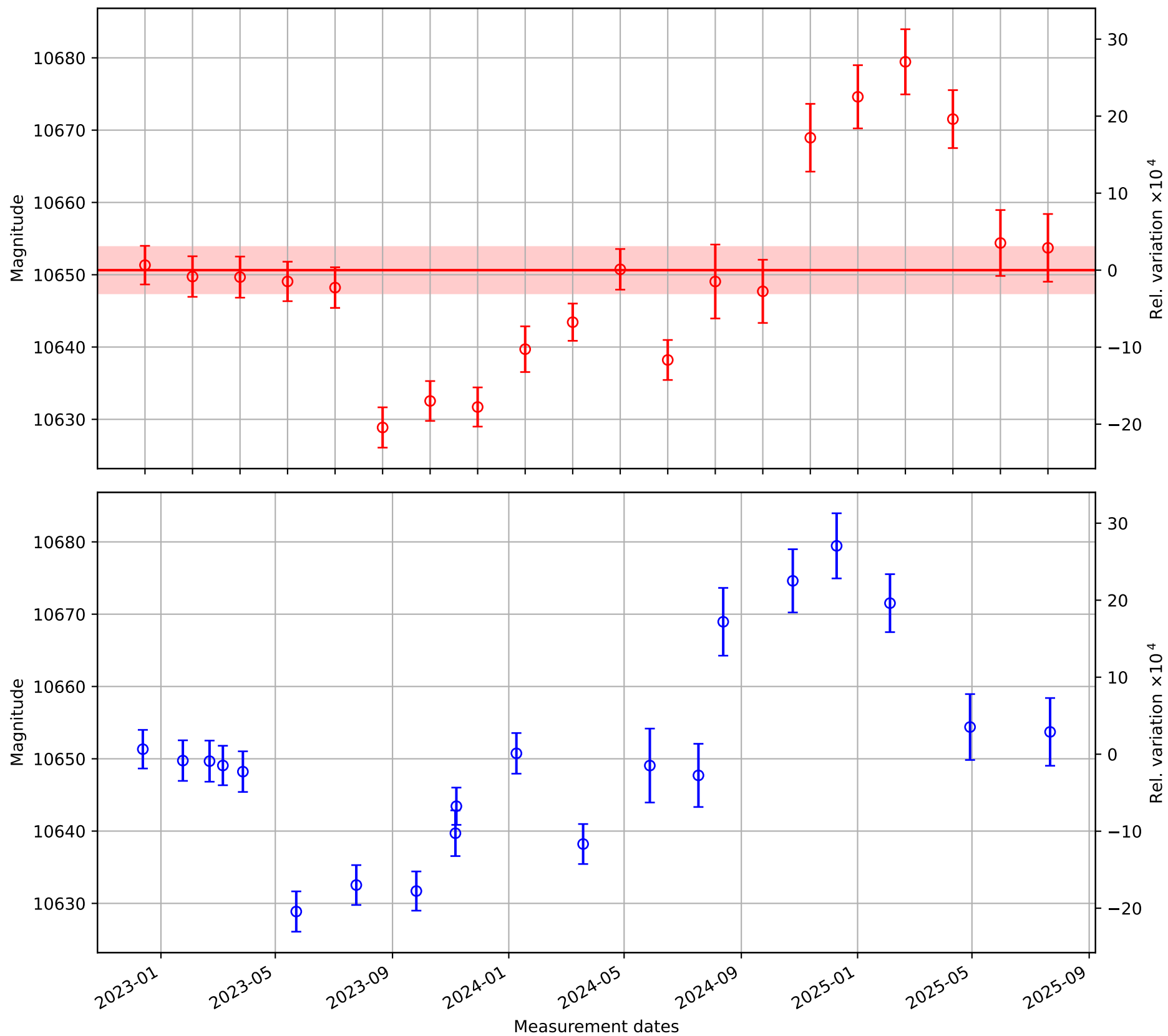
Mean value: 10650.634199

Standard deviation: 13.968427

Standard error: 3.203498

Relative Standard error: 0.000301

RX Responsivity ρ_R



	rhoT_prime
Date	None ± SD_None
D20221213	7212.3975 ± 5.7342
D20230124	7214.4524 ± 5.5318
D20230221	7215.2736 ± 5.2105
D20230307	7213.8139 ± 5.1408
D20230328	7210.1146 ± 5.3686
D20230523	7207.4696 ± 5.5664
D20230725	7212.9695 ± 5.4961
D20230926	7213.7446 ± 5.4039
D20231106	7213.5775 ± 5.4235
D20231107	7213.3527 ± 5.0937
D20240109	7211.2352 ± 5.2532
D20240319	7193.5442 ± 5.6431
D20240528	7194.7219 ± 4.1823
D20240718	7199.6725 ± 4.0493
D20240813	7216.9582 ± 4.1529
D20241025	7217.9497 ± 3.9950
D20241210	7214.8532 ± 3.8621
D20250204	7205.8673 ± 3.8934
D20250429	7198.2687 ± 3.9789
D20250722	7203.9108 ± 4.5463

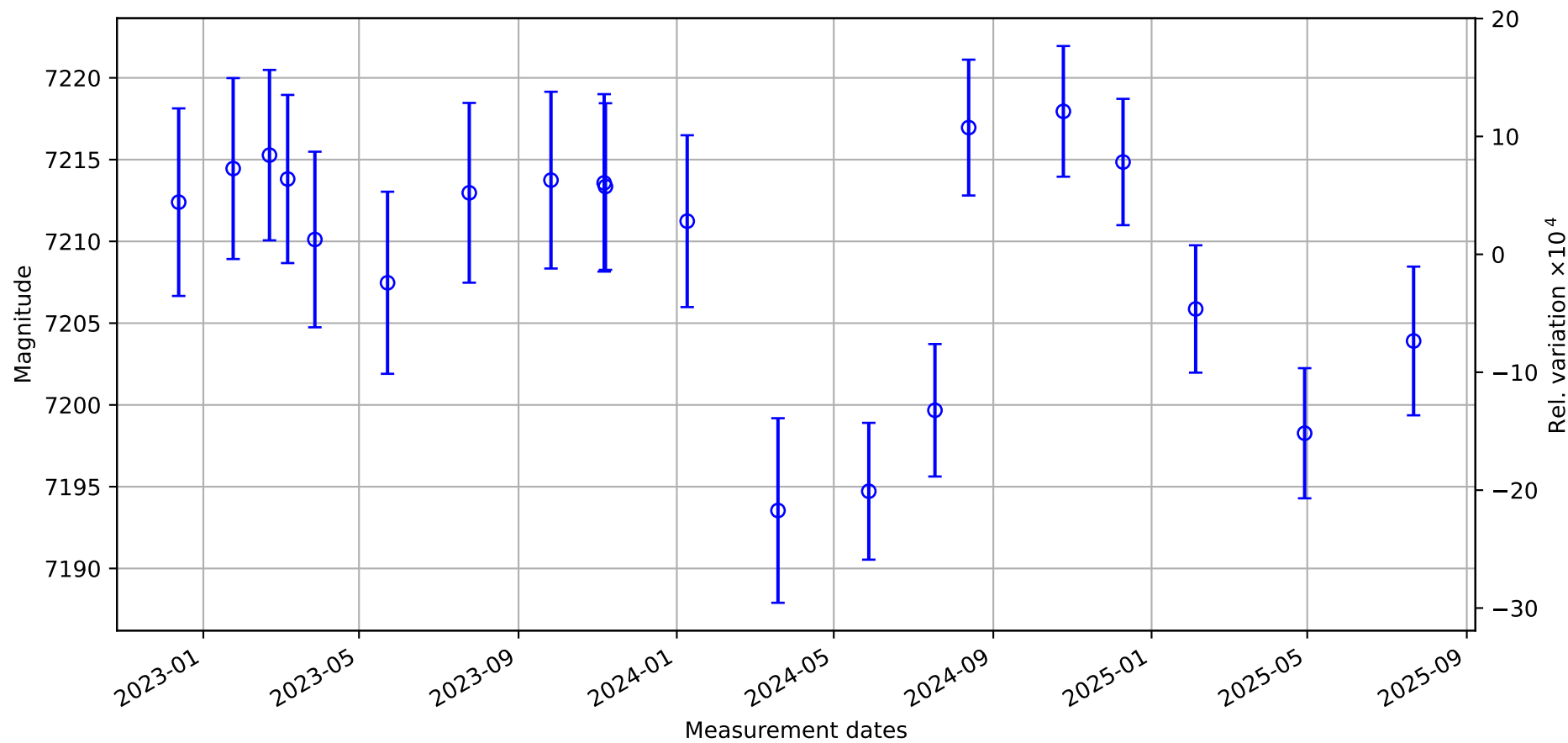
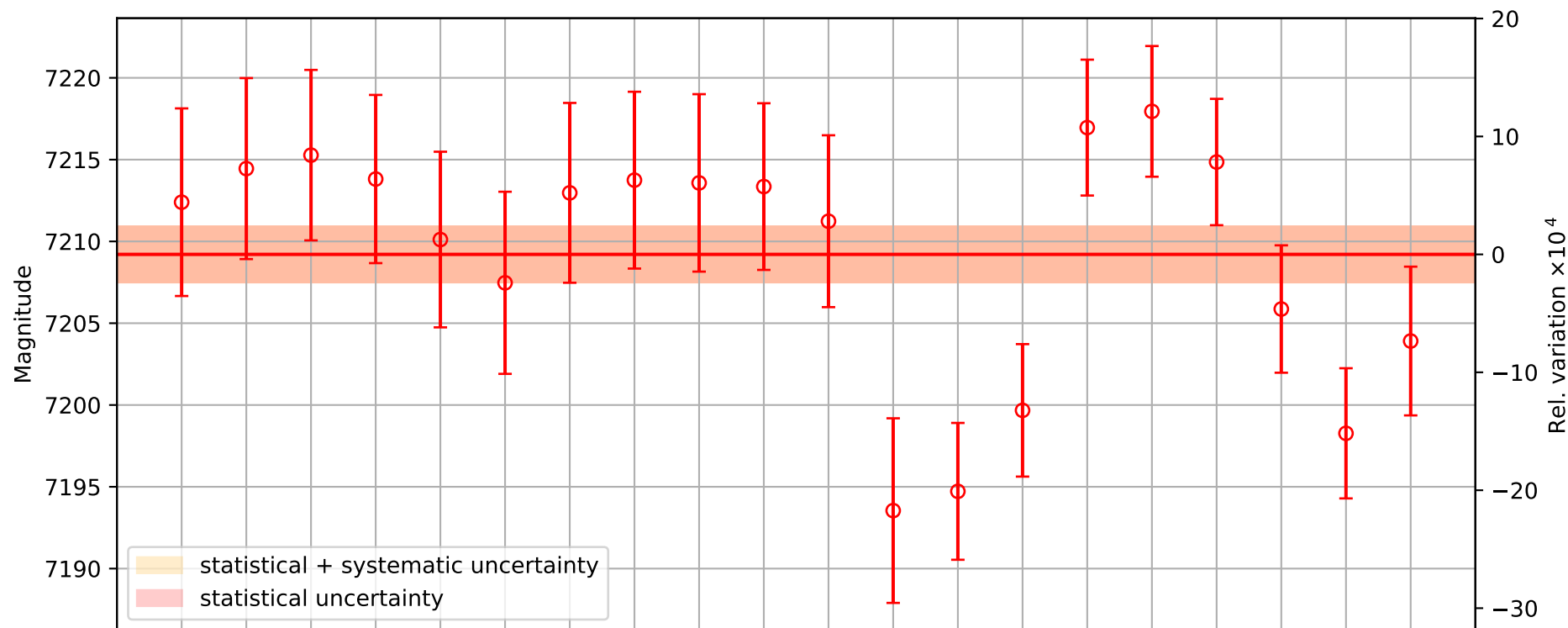
Description:

Tx Responsivity Corrected for Optical Efficiency:
 $\rho_{Tx}' = \rho_{Tx} * ET$
 Rho_Tx^Prime is the estimated responsivity of the Tx integrating sphere if the Tx Sphere were to be located at ETM. This provides a nice sanity check for the Rx Sphere, which historically has been the main sensor for calibration.

Summary of Tx Responsivity Corrected for Optical Efficiency

Mean value: 7209.207397
 Standard deviation: 7.426848
 Standard error: 1.703262
 Relative Standard error: 0.000236

Tx Responsivity Corrected for Optical Efficiency



	rhoR_prime
Date	None ± SD_None
D20221213	10576.6698 ± 6.9261
D20230124	10575.0054 ± 6.8499
D20230221	10580.1815 ± 6.5500
D20230307	10578.9098 ± 6.4566
D20230328	10575.1983 ± 6.6872
D20230523	10550.2810 ± 6.9166
D20230725	10552.3120 ± 6.8061
D20230926	10552.7557 ± 6.6864
D20231106	10564.9900 ± 7.0717
D20231107	10565.3157 ± 6.3522
D20240109	10576.2380 ± 6.5885
D20240319	10568.2745 ± 6.9523
D20240528	10575.2974 ± 6.1418
D20240718	10569.0076 ± 5.4413
D20240813	10595.1249 ± 5.7782
D20241025	10602.5180 ± 5.4958
D20241210	10606.5031 ± 5.5089
D20250204	10604.2216 ± 5.1342
D20250429	10583.9556 ± 5.5794
D20250722	10578.4528 ± 5.8748

Description:

Rx Responsivity Corrected for Optical Efficiency:

$\rho_{Rx}' = \rho_{Rx} / ER$

Rho_Rx^Prime is the estimated responsivity of the Rx integrating sphere if the Rx Sphere were to be located at ETM.

Summary of Rx Responsivity Corrected
for Optical Efficiency

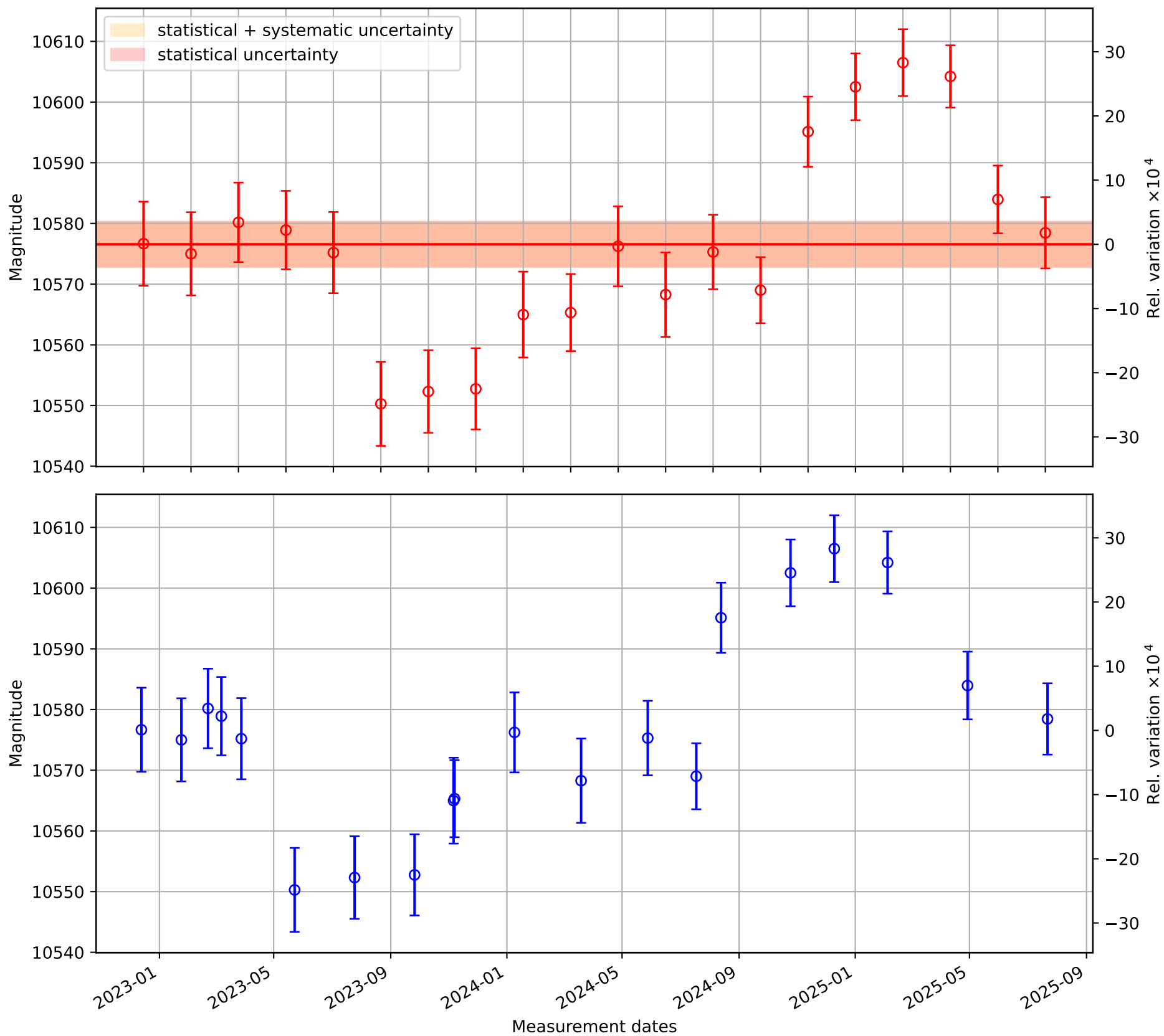
Mean value: 10576.560635

Standard deviation: 16.212913

Standard error: 3.718244

Relative Standard error: 0.000352

Rx Responsivity Corrected for Optical Efficiency



WS

Date WS $\pm$ SD_WS

D20221213	-4.7051 $\pm$ 0.0000
D20230124	-4.7051 $\pm$ 0.0000
D20230221	-4.7051 $\pm$ 0.0000
D20230307	-4.7051 $\pm$ 0.0000
D20230328	-4.7051 $\pm$ 0.0000
D20230523	-4.7051 $\pm$ 0.0004
D20230725	-4.7051 $\pm$ 0.0000
D20230926	-4.7051 $\pm$ 0.0000
D20231106	-4.7051 $\pm$ 0.0000
D20231107	-4.7051 $\pm$ 0.0000
D20240109	-4.7051 $\pm$ 0.0000
D20240319	-4.7051 $\pm$ 0.0000
D20240528	-4.7010 $\pm$ 0.0000
D20240718	-4.7015 $\pm$ 0.0000
D20240813	-4.7122 $\pm$ 0.0000
D20241025	-4.7100 $\pm$ 0.0000
D20241210	-4.7105 $\pm$ 0.0000
D20250204	-4.7056 $\pm$ 0.0000
D20250429	-4.7016 $\pm$ 0.0000
D20250722	-4.7022 $\pm$ 0.0000

Description:

WS

WS is the Working standard Responsivity as measured from the Gold standard in the lab.

Summary of Working Standard

Responsivity rho_WS

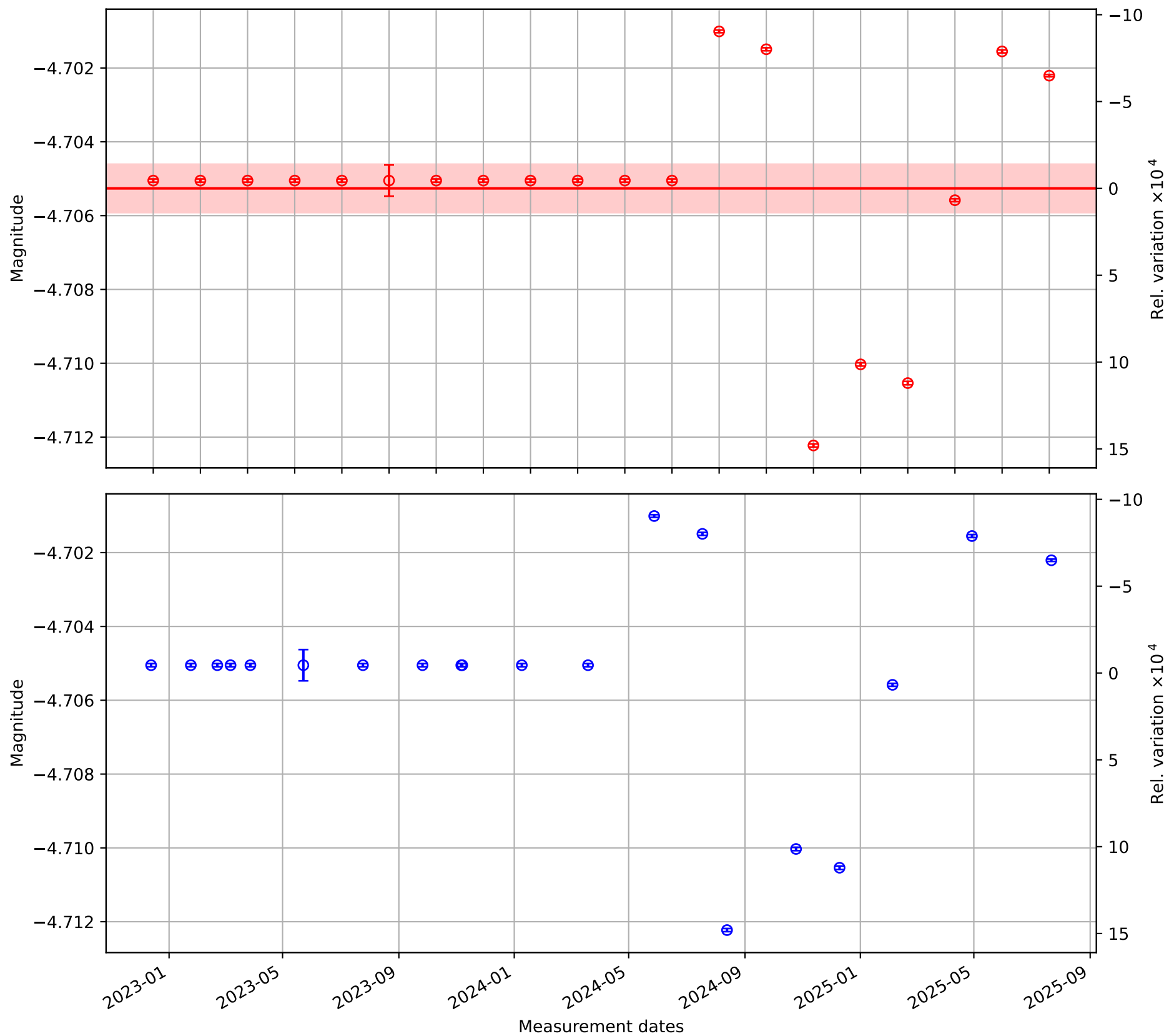
Mean value: -4.705262

Standard deviation: 0.002857

Standard error: 0.000655

Relative Standard error: -0.000139

Working Standard Responsivity rho_WS



	e _i
Date	e _i ± 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
D20240109	0.9855 ± 0.0008
D20240319	0.9867 ± 0.0008
D20240528	0.9858 ± 0.0004
D20240718	0.9850 ± 0.0004
D20240813	0.9860 ± 0.0004
D20241025	0.9864 ± 0.0004
D20241210	0.9860 ± 0.0004
D20250204	0.9873 ± 0.0004
D20250429	0.9860 ± 0.0004
D20250722	0.9861 ± 0.0005

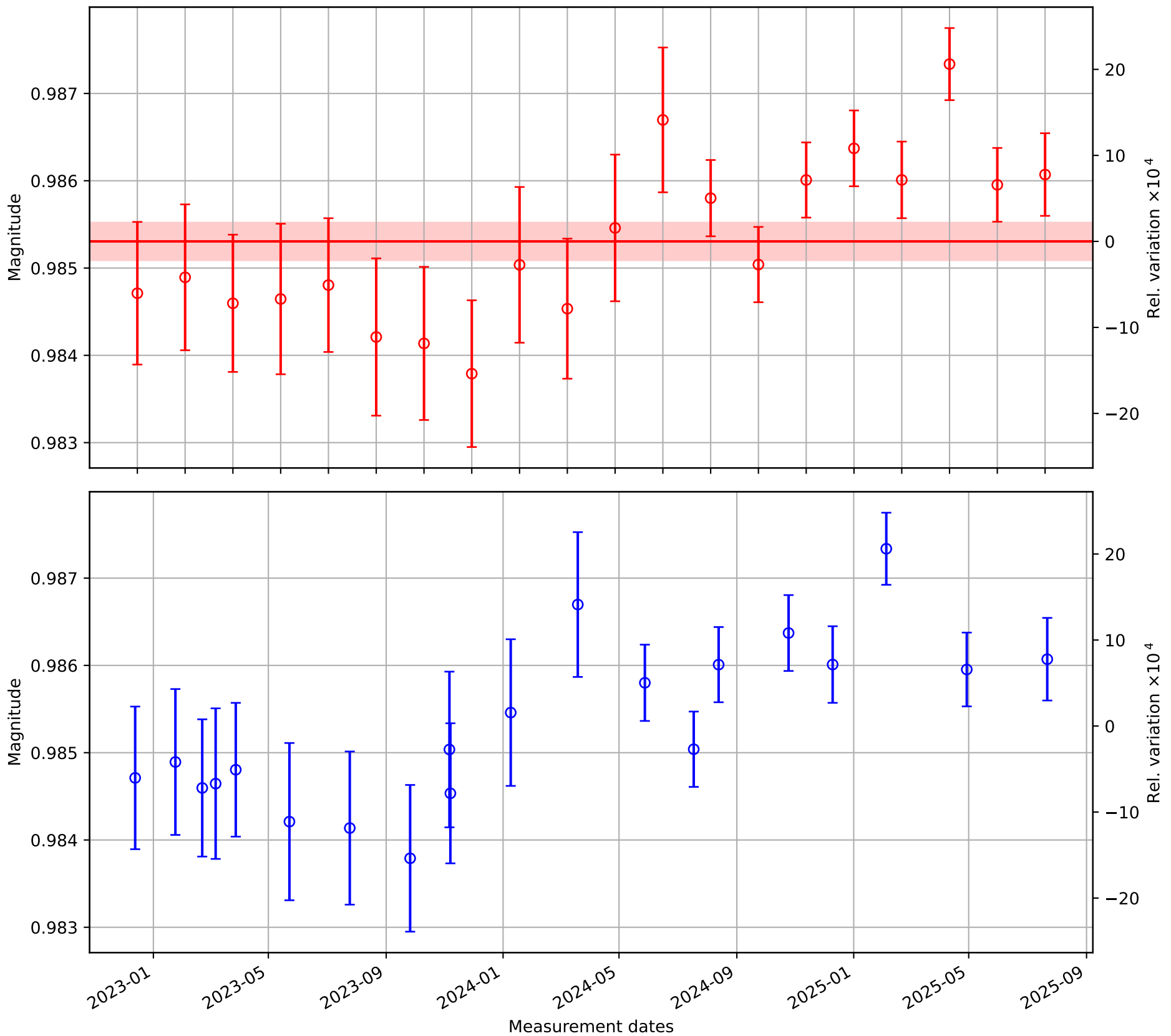
Description:

Optical Efficiency (Inner beam): e_i = (W_{ri}/T_{ti}) / (W_{ti}/T_{ti})
 This parameter is the ratio of the Working Standard (WS) output in both the Rx module and Tx module with only the inner beam on it, normalized by the Tx Output. This parameter involves M1 and M5 and is useful for determining overall optical Efficiency.

Summary of Optical Efficiency (Inner Beam)

Mean value:	0.985305
Standard deviation:	0.000940
Standard error:	0.000215
Relative Standard error:	0.000219

Optical Efficiency (Inner Beam)



	e_o
Date	e_o ± 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
D20240109	0.9844 ± 0.0008
D20240319	0.9848 ± 0.0009
D20240528	0.9843 ± 0.0005
D20240718	0.9832 ± 0.0004
D20240813	0.9841 ± 0.0005
D20241025	0.9844 ± 0.0005
D20241210	0.9845 ± 0.0004
D20250204	0.9852 ± 0.0004
D20250429	0.9854 ± 0.0004
D20250722	0.9835 ± 0.0005

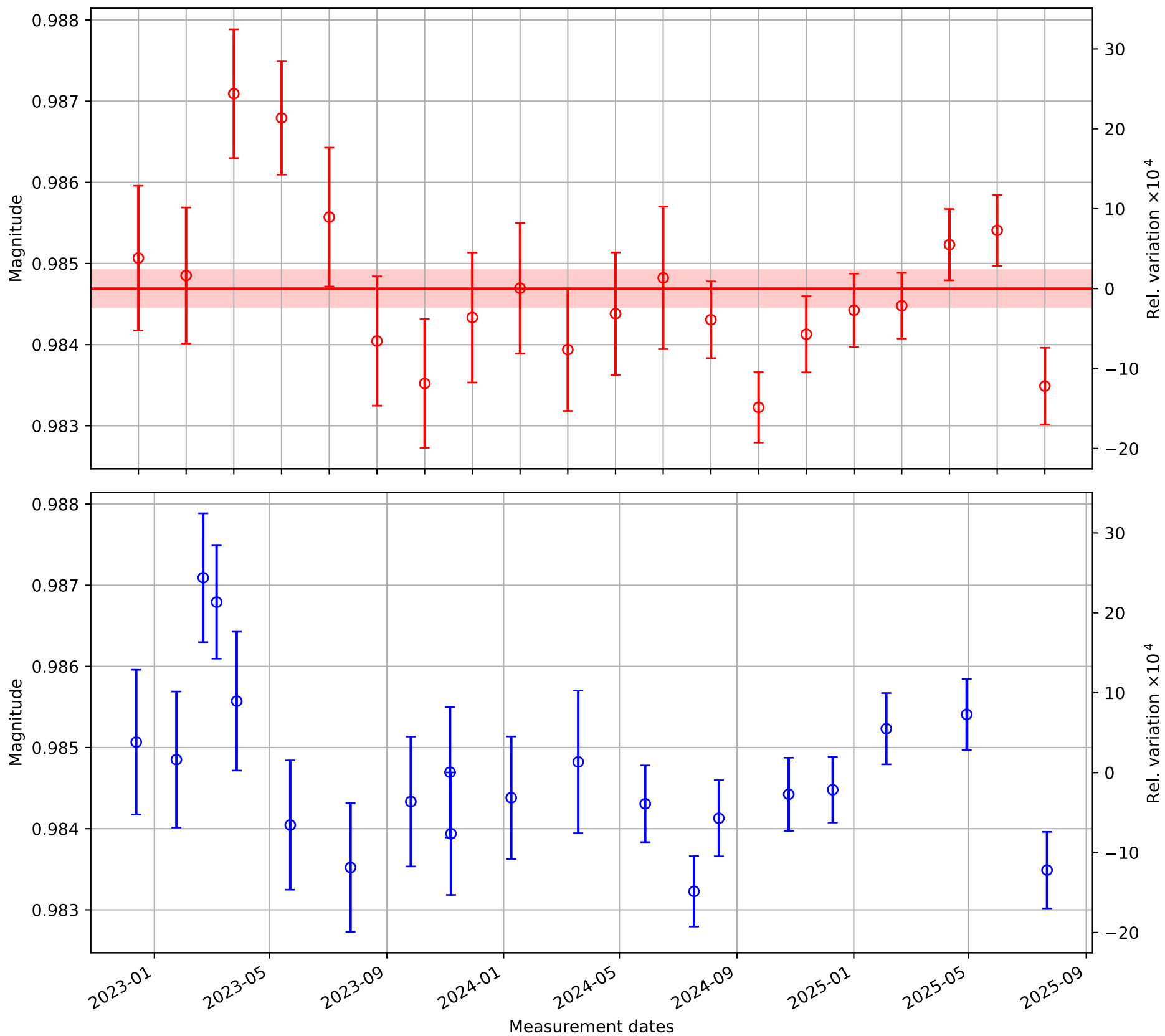
Description:

Optical Efficiency (Outer beam): $e_o = (W_{ro}/T_{to}) / (W_{to}/T_{to})$
 This parameter is the ratio of the Working Standard (WS) output in both the Rx module and Tx module with only the outer beam on it, normalized by the Tx Output. This parameter involves M2 and M4 and is useful for determining overall optical Efficiency.

Summary of Optical Efficiency (Outer Beam)

Mean value:	0.984690
Standard deviation:	0.000992
Standard error:	0.000227
Relative Standard error:	0.000231

Optical Efficiency (Outer Beam)



	e
Date	None $\pm$ SD_None
D20221213	0.9849 $\pm$ 0.0006
D20230124	0.9849 $\pm$ 0.0006
D20230221	0.9859 $\pm$ 0.0006
D20230307	0.9857 $\pm$ 0.0005
D20230328	0.9852 $\pm$ 0.0006
D20230523	0.9841 $\pm$ 0.0006
D20230725	0.9838 $\pm$ 0.0006
D20230926	0.9841 $\pm$ 0.0006
D20231106	0.9849 $\pm$ 0.0006
D20231107	0.9842 $\pm$ 0.0005
D20240109	0.9849 $\pm$ 0.0006
D20240319	0.9858 $\pm$ 0.0006
D20240528	0.9851 $\pm$ 0.0006
D20240718	0.9841 $\pm$ 0.0006
D20240813	0.9851 $\pm$ 0.0006
D20241025	0.9854 $\pm$ 0.0006
D20241210	0.9852 $\pm$ 0.0006
D20250204	0.9863 $\pm$ 0.0006
D20250429	0.9857 $\pm$ 0.0006
D20250722	0.9848 $\pm$ 0.0007

Description:

Overall Optical Efficiency: $e = (e_o + e_i)/2$
 This parameter is just the average efficiency of both the inner and outer beams. This uses M1 ,M2, M4, & M5 and is used to determine how much power is lost inside the vacuum chamber.

 e

Summary of Overall Optical Efficiency

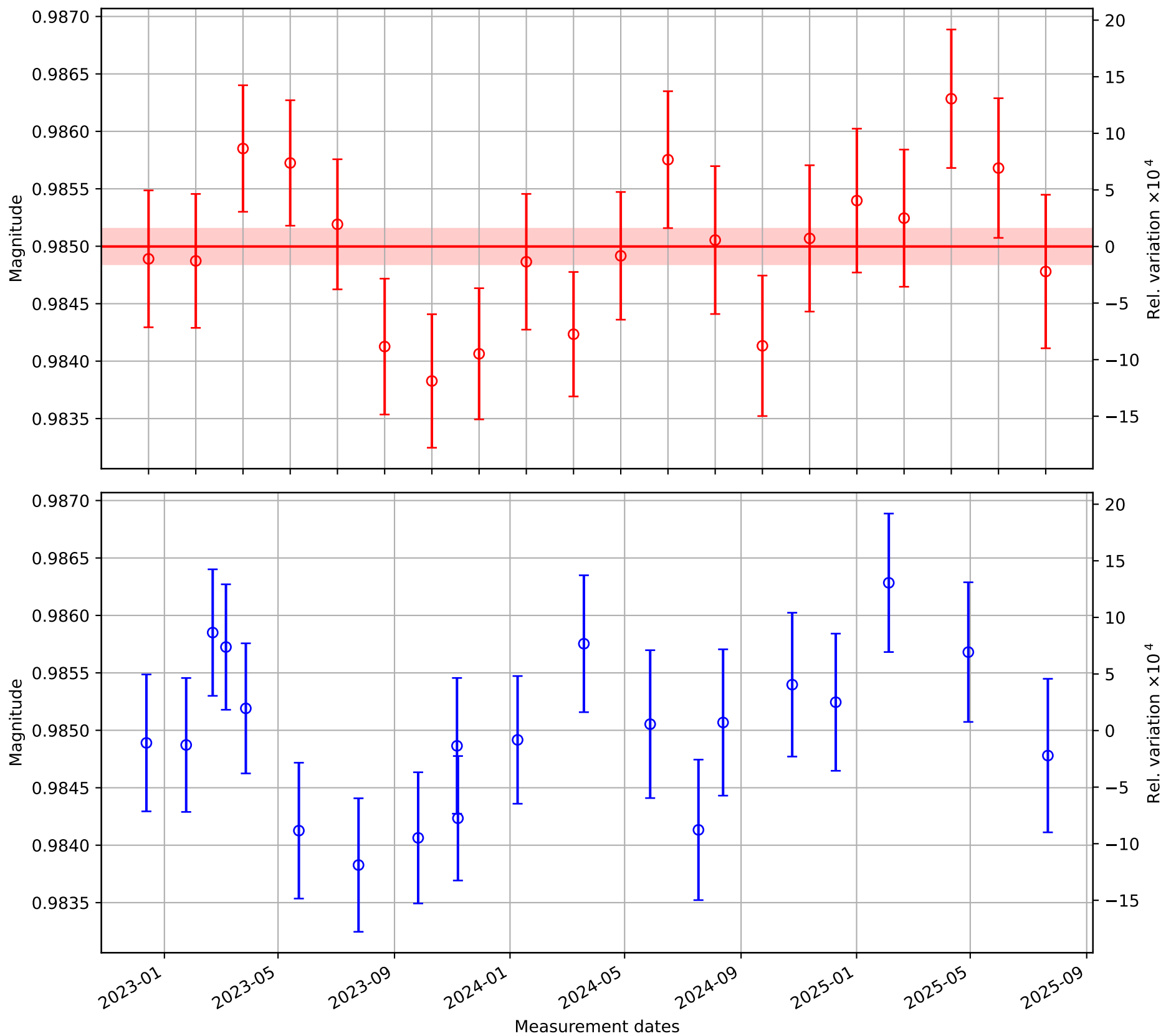
Mean value: 0.984998

Standard deviation: 0.000674

Standard error: 0.000155

Relative Standard error: 0.000157

Overall Optical Efficiency



	E_T
Date	E_T ± SD_E_T
D20221213	0.9918 ± 0.0006
D20230124	0.9918 ± 0.0006
D20230221	0.9923 ± 0.0006
D20230307	0.9923 ± 0.0005
D20230328	0.9920 ± 0.0006
D20230523	0.9915 ± 0.0006
D20230725	0.9913 ± 0.0006
D20230926	0.9914 ± 0.0006
D20231106	0.9918 ± 0.0006
D20231107	0.9915 ± 0.0005
D20240109	0.9919 ± 0.0006
D20240319	0.9923 ± 0.0006
D20240528	0.9919 ± 0.0003
D20240718	0.9915 ± 0.0003
D20240813	0.9919 ± 0.0003
D20241025	0.9921 ± 0.0003
D20241210	0.9920 ± 0.0003
D20250204	0.9925 ± 0.0003
D20250429	0.9922 ± 0.0003
D20250722	0.9918 ± 0.0003

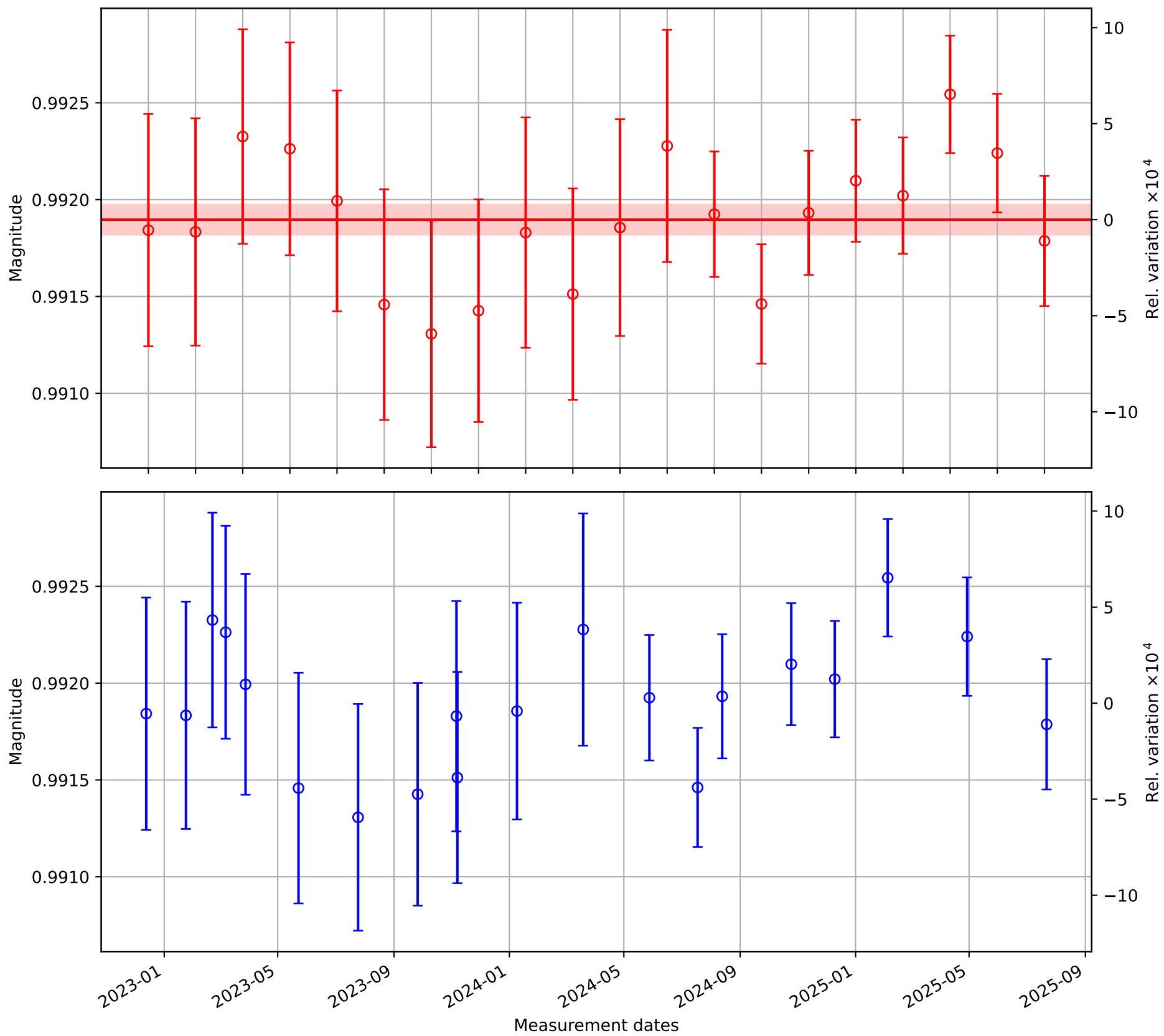
Description:

Tx side Optical Efficiency Correction Factor: $E_T = \sqrt{e \cdot \beta}$
This parameter is used to apportion the optical loss inside the vacuum chamber to before the ETM and after the ETM, and uses the Optical Efficiency (e) along with the last in-chamber measurements (DCC- T1800107). The in-chamber measurements yield a ratio of optical efficiencies between the Tx side and Rx side, referred to as β , which we assume have not changed. Applying this correction factor corrects for the optical loss on the Tx side, providing the Rx and Tx responsivities at the ETM.

Summary of Input Side Optical Efficiency
correction factor

Mean value: 0.991897
Standard deviation: 0.000340
Standard error: 0.000078
Relative Standard error: 0.000079

Input Side Optical Efficiency correction factor



	E_R
Date	None $\pm$ SD_None
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
D20240109	0.9930 $\pm$ 0.0006
D20240319	0.9934 $\pm$ 0.0006
D20240528	0.9931 $\pm$ 0.0003
D20240718	0.9926 $\pm$ 0.0003
D20240813	0.9931 $\pm$ 0.0003
D20241025	0.9932 $\pm$ 0.0003
D20241210	0.9932 $\pm$ 0.0003
D20250204	0.9937 $\pm$ 0.0003
D20250429	0.9934 $\pm$ 0.0003
D20250722	0.9929 $\pm$ 0.0003

Summary of Output Side Optical Efficiency correction factor

Mean value: 0.993045

Standard deviation: 0.000340

Standard error: 0.000078

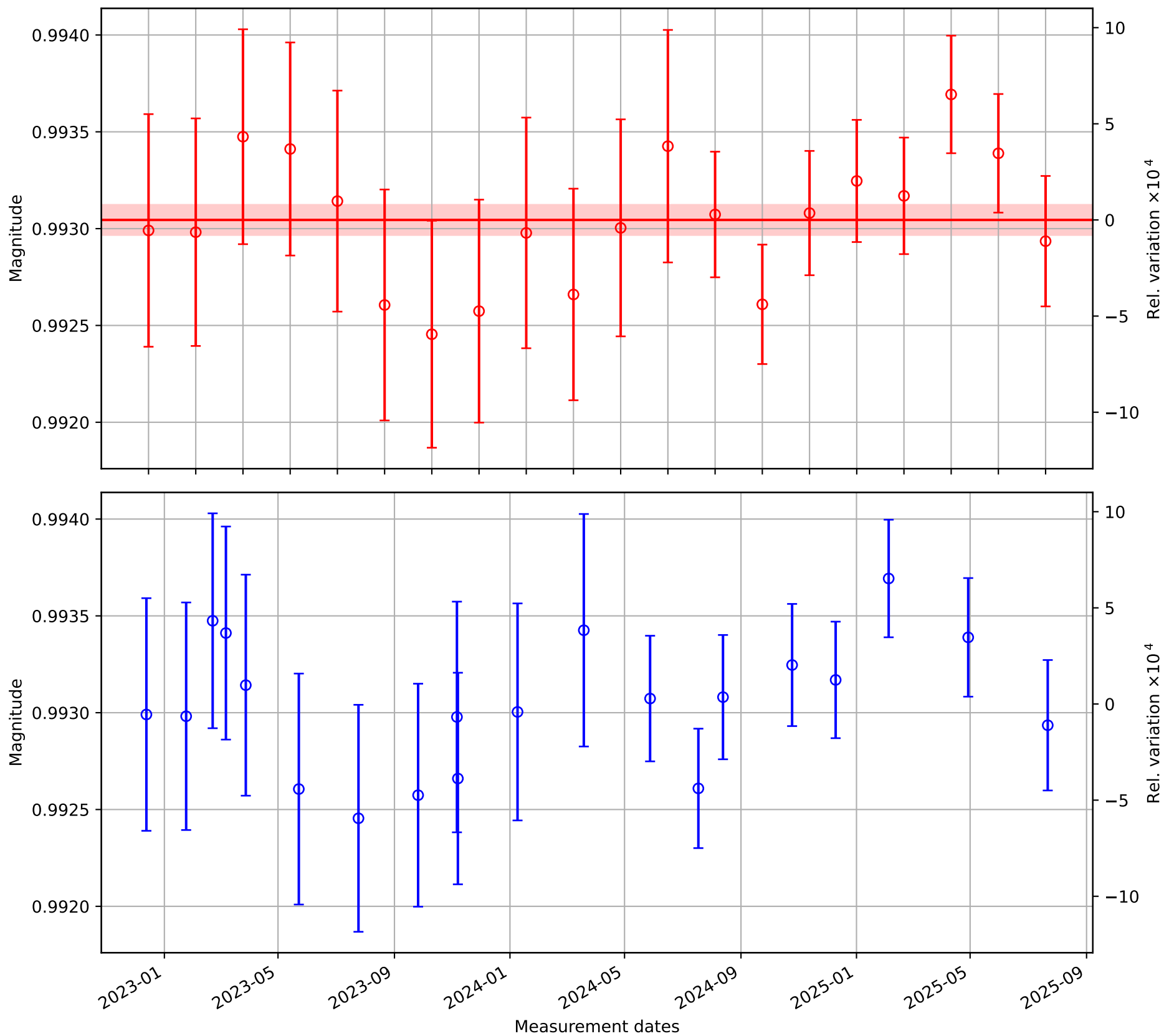
Relative Standard error: 0.000079

Description:

Rx side Optical Efficiency Correction Factor: $E_R = \sqrt{e/\beta}$

This parameter is used to apportion the optical loss inside the vacuum chamber to before the ETM and after the ETM, and uses the Optical Efficiency (e) along with the last in-chamber measurements (DCC- T1800107). The in-chamber measurements yield a ratio of optical efficiencies between the Tx side and Rx side, referred to as β , which we assume have not changed. Applying this correction factor corrects for the optical loss on the Rx side, providing the Rx and Tx responsivities at the ETM.

Output Side Optical Efficiency correction factor



	PowerImbalance
Date	None $\pm$ SD_None
D20221213	0.9855 $\pm$ 0.0005
D20230124	0.9870 $\pm$ 0.0005
D20230221	0.9897 $\pm$ 0.0004
D20230307	0.9886 $\pm$ 0.0004
D20230328	0.9862 $\pm$ 0.0004
D20230523	0.9858 $\pm$ 0.0005
D20230725	0.9883 $\pm$ 0.0005
D20230926	0.9880 $\pm$ 0.0004
D20231106	0.9867 $\pm$ 0.0004
D20231107	0.9867 $\pm$ 0.0004
D20240109	0.9862 $\pm$ 0.0004
D20240319	0.9870 $\pm$ 0.0005
D20240528	0.9855 $\pm$ 0.0005
D20240718	0.9858 $\pm$ 0.0004
D20240813	0.9860 $\pm$ 0.0004
D20241025	0.9840 $\pm$ 0.0008
D20241210	0.9841 $\pm$ 0.0007
D20250204	0.9811 $\pm$ 0.0008
D20250429	0.9848 $\pm$ 0.0008
D20250722	0.9842 $\pm$ 0.0009

Description:

Power Imbalance:
 The Power imbalance is a measurement of Inner Beam Power divided by Outer Beam Power, as measured by the Working Standard inside the TX module. M1/M2.

	PowerImbalance
Summary of Power Imbalance	
Mean value:	0.986055
Standard deviation:	0.001911
Standard error:	0.000438
Relative Standard error:	0.000445

Power Imbalance

