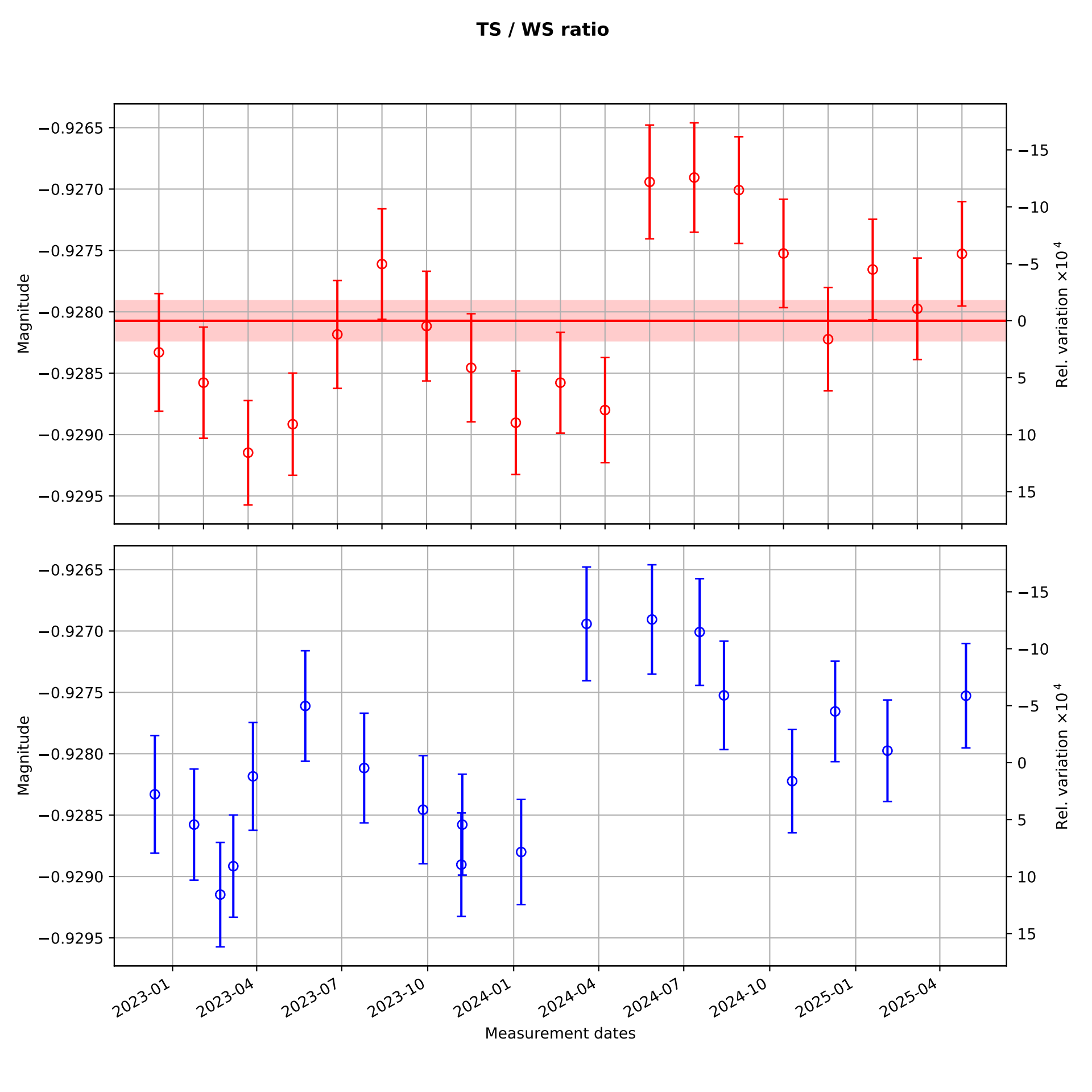
PCAL End Station Measurement Trends

	TXWS
Date	None ± SD_None
D20221213	-0.9283 ± 0.0005
D20230124	-0.9286 ± 0.0005
D20230221	-0.9291 ± 0.0004
D20230307	-0.9289 ± 0.0004
D20230328	-0.9282 ± 0.0004
D20230523	-0.9276 ± 0.0005
D20230725	-0.9281 ± 0.0004
D20230926	-0.9285 ± 0.0004
D20231106	-0.9289 ± 0.0004
D20231107	-0.9286 ± 0.0004
D20240109	-0.9288 ± 0.0004
D20240319	-0.9269 ± 0.0005
D20240528	-0.9269 ± 0.0004
D20240718	-0.9270 ± 0.0004
D20240813	-0.9275 ± 0.0004
D20241025	-0.9282 ± 0.0004
D20241210	-0.9277 ± 0.0004
D20250204	-0.9280 ± 0.0004
D20250429	-0.9275 ± 0.0004

	TXWS
Summary of TS / WS ratio	
Mean value:	-0.928073
Standard deviation:	0.000692
Standard error:	0.000163
Relative Standard error:	-0.000176

Description:

Tx/WS ratio:
This ratio, αTW, is the Tx to Working Standard output with the backgrounds subtracted and is made using M1 - M7

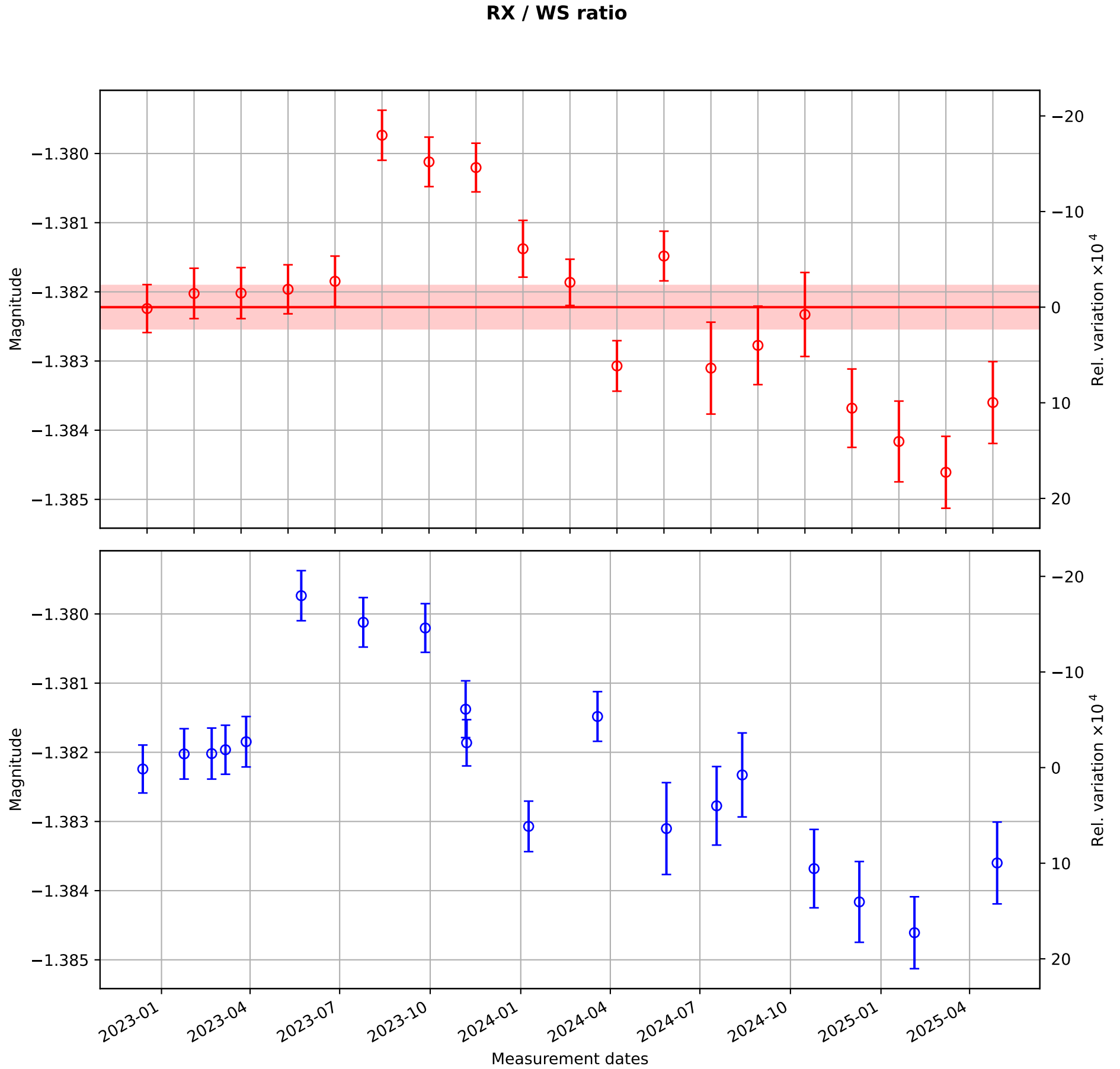

TS / WS ratio
Magnitude
−0.9265
−0.9270
−0.9275
−0.9280
−0.9285
−0.9290
−0.9295
Rel. variation ×10^4
−15
−10
−5
0
5
10
15
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04
Measurement dates

	RXWS
Date	None ± SD_None
D20221213	-1.3822 ± 0.0003
D20230124	-1.3820 ± 0.0004
D20230221	-1.3820 ± 0.0004
D20230307	-1.3820 ± 0.0004
D20230328	-1.3818 ± 0.0004
D20230523	-1.3797 ± 0.0004
D20230725	-1.3801 ± 0.0004
D20230926	-1.3802 ± 0.0004
D20231106	-1.3814 ± 0.0004
D20231107	-1.3819 ± 0.0003
D20240109	-1.3831 ± 0.0004
D20240319	-1.3815 ± 0.0004
D20240528	-1.3831 ± 0.0007
D20240718	-1.3828 ± 0.0006
D20240813	-1.3823 ± 0.0006
D20241025	-1.3837 ± 0.0006
D20241210	-1.3842 ± 0.0006
D20250204	-1.3846 ± 0.0005
D20250429	-1.3836 ± 0.0006

	RXWS
Summary of RX / WS ratio	
Mean value:	-1.382221
Standard deviation:	0.001326
Standard error:	0.000312
Relative Standard error:	-0.000226

Description:

Rx/WS ratio
This ratio, αRW, is the Rx to Working Standard output with the backgrounds subtracted and is made using M7 - M9.


RX / WS ratio
Magnitude
−1.380
−1.381
−1.382
−1.383
−1.384
−1.385
Rel. variation ×10⁴
−20
−10
0
10
20
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04
Measurement dates

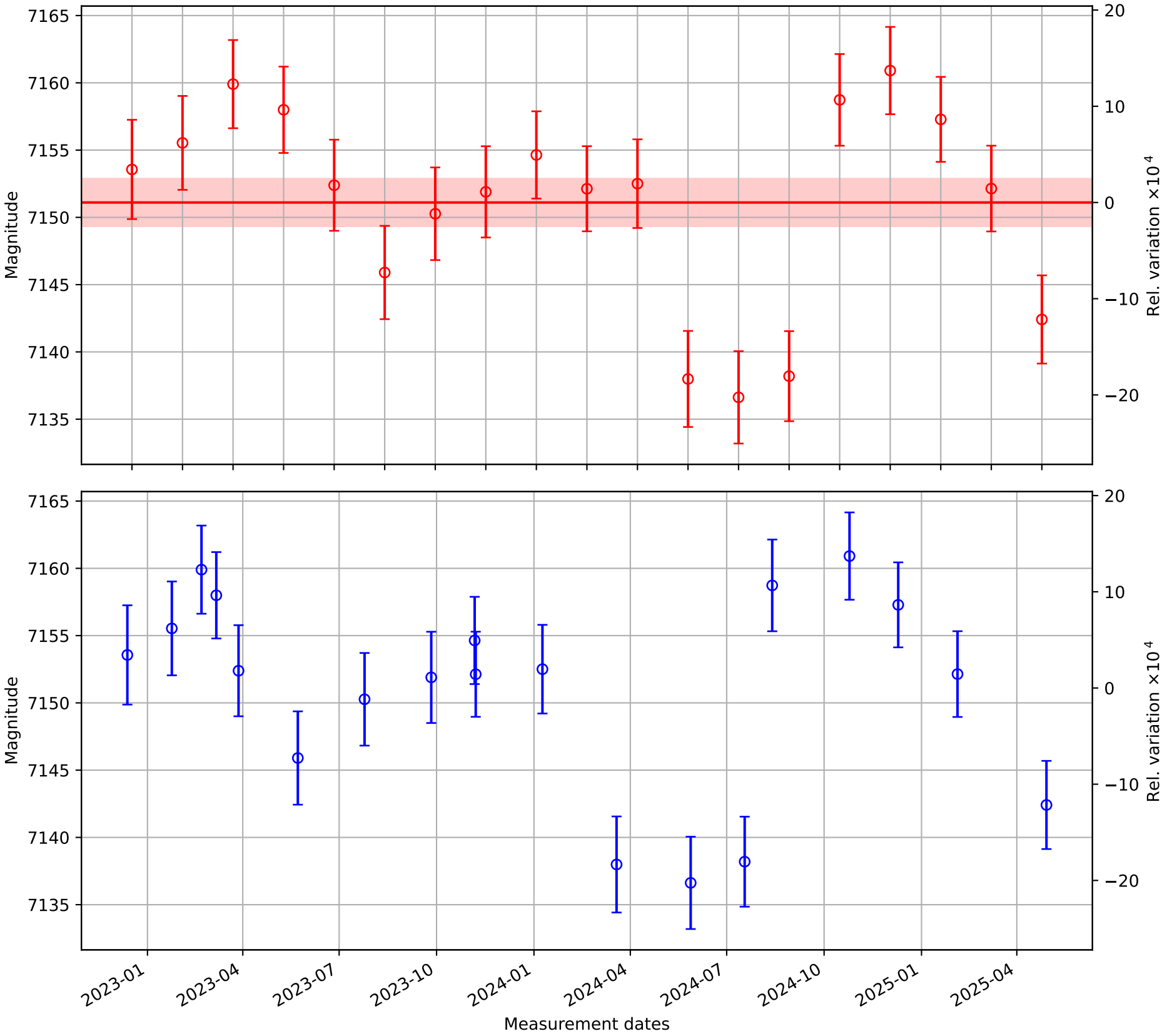
	rho_T
Date	m5 ± SD_m5
D20221213	7153.5622 ± 3.6907
D20230124	7155.5352 ± 3.4892
D20230221	7159.9027 ± 3.2774
D20230307	7157.9979 ± 3.2099
D20230328	7152.3889 ± 3.3863
D20230523	7145.9027 ± 3.4677
D20230725	7150.2673 ± 3.4427
D20230926	7151.8956 ± 3.3903
D20231106	7154.6400 ± 3.2434
D20231107	7152.1267 ± 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

---

	rho_T
Summary of TX Responsivity rho_T	
Mean value:	7151.105961
Standard deviation:	7.504361
Standard error:	1.768132
Relative Standard error:	0.000247

Description:

TX Responsivity rho_T: ρTx = αTW * ρWS The responsivity of the TxPD, calculated using ρWS. 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.


TX Responsivity rho_T
Magnitude
Rel. variation ×10⁴
Measurement dates
7165
7160
7155
7150
7145
7140
7135
20
10
0
−10
−20
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04

	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

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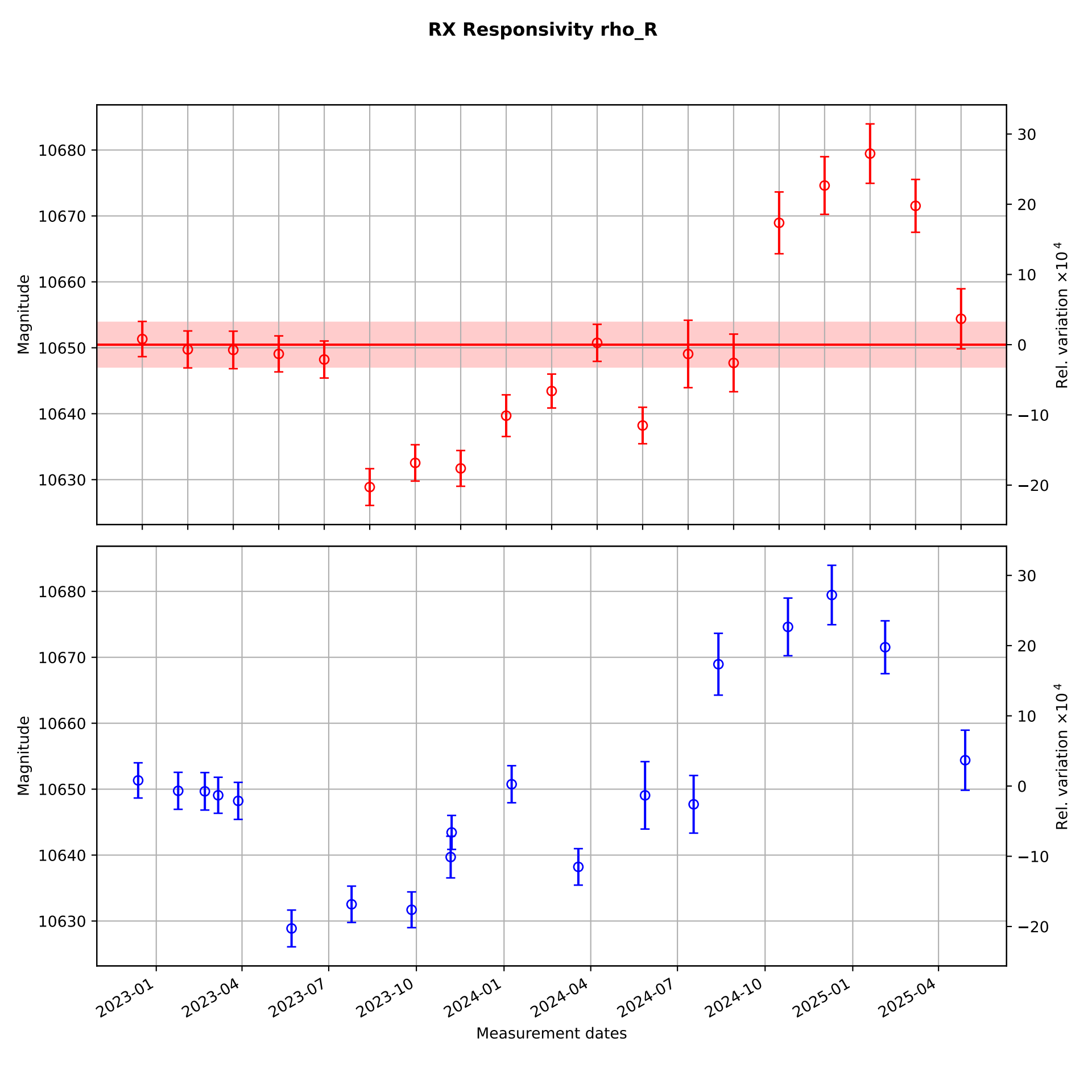
	rho_R
Summary of RX Responsivity rho_R	
Mean value:	10650.471817
Standard deviation:	14.331788
Standard error:	3.376769
Relative Standard error:	0.000317

Description:

RX Responsivity rho_R: ρRx = αRW * ρWS The responsivity of the RxPD, calculated using ρWS. Trending this parameter is useful in estimating how much power is incident on the ETM once corrected for optical losses inside the vacuum chamber.

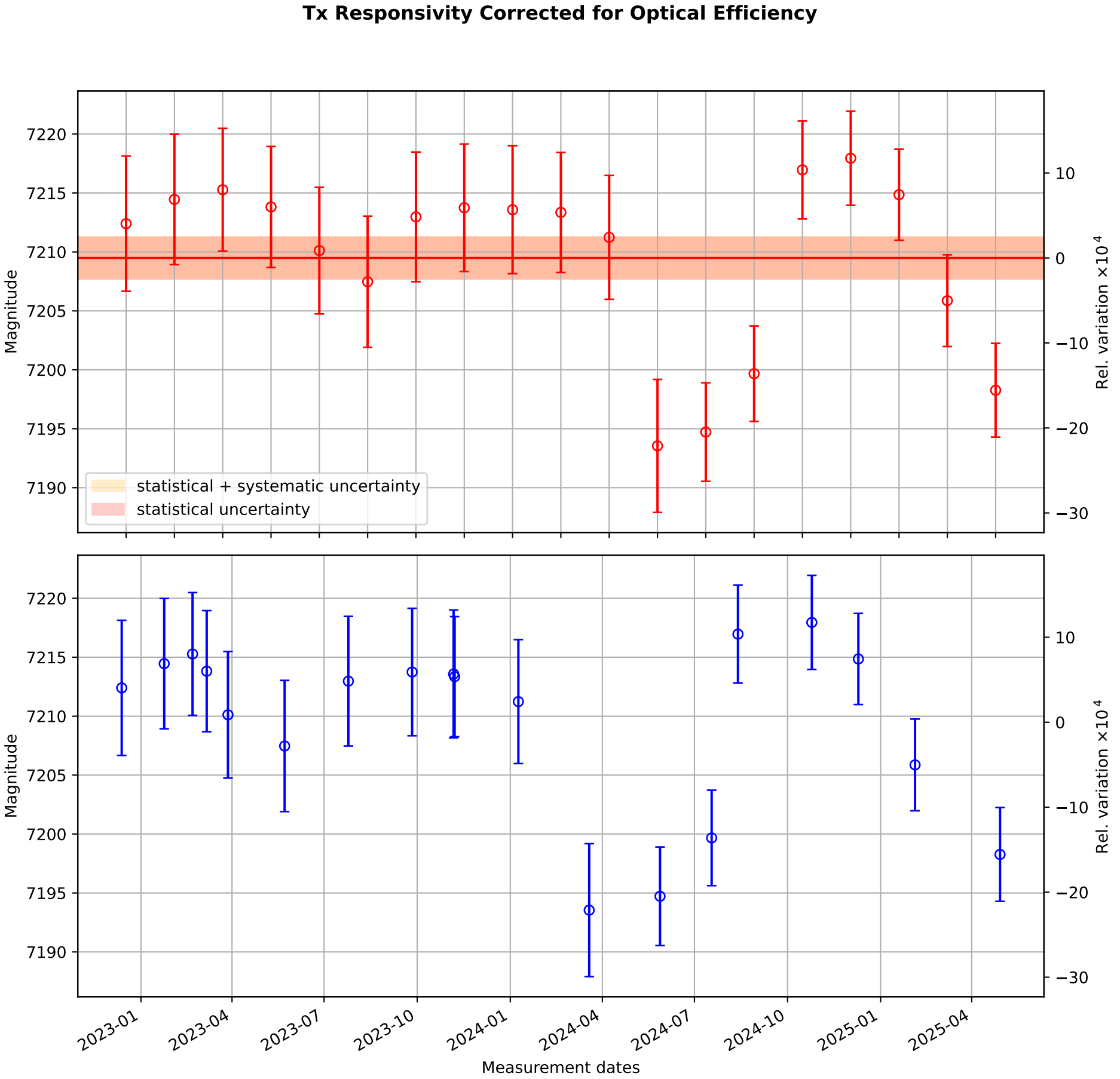

RX Responsivity rho_R
Magnitude
Rel. variation ×10⁴
10680
10670
10660
10650
10640
10630
30
20
10
0
−10
−20
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04
Measurement dates

	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

Summary of Tx Responsivity Corrected for Optical Efficiency	rhoT_prime
Mean value:	7209.486163
Standard deviation:	7.522091
Standard error:	1.772310
Relative Standard error:	0.000246

Description:

Tx Responsivity Corrected for Optical Efficiency:
ρTx ‘ = ρTx * 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.

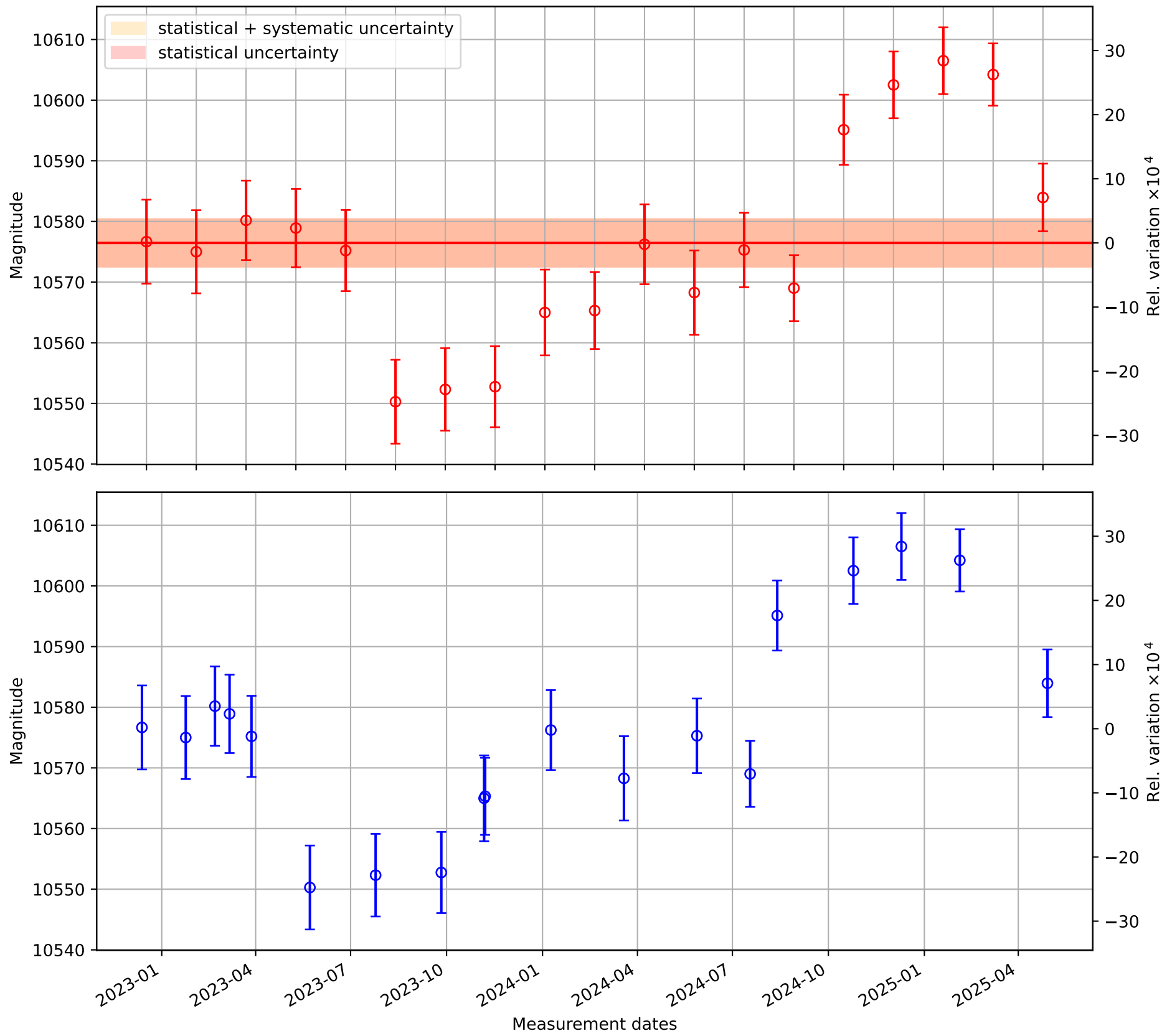

Tx Responsivity Corrected for Optical Efficiency
Magnitude
Rel. variation ×10⁴
statistical + systematic uncertainty
statistical uncertainty
Measurement dates
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04

	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

Summary of Rx Responsivity Corrected for Optical Efficiency	rhoR_prime
Mean value:	10576.461048
Standard deviation:	16.650898
Standard error:	3.923184
Relative Standard error:	0.000371

Description:

Rx Responsivity Corrected for Optical Efficiency:
ρRx ‘ = ρRx /ER
Rho_Rx^Prime is the estimated responsivity of the Rx integrating sphere if the Rx Sphere were to be located at ETM.

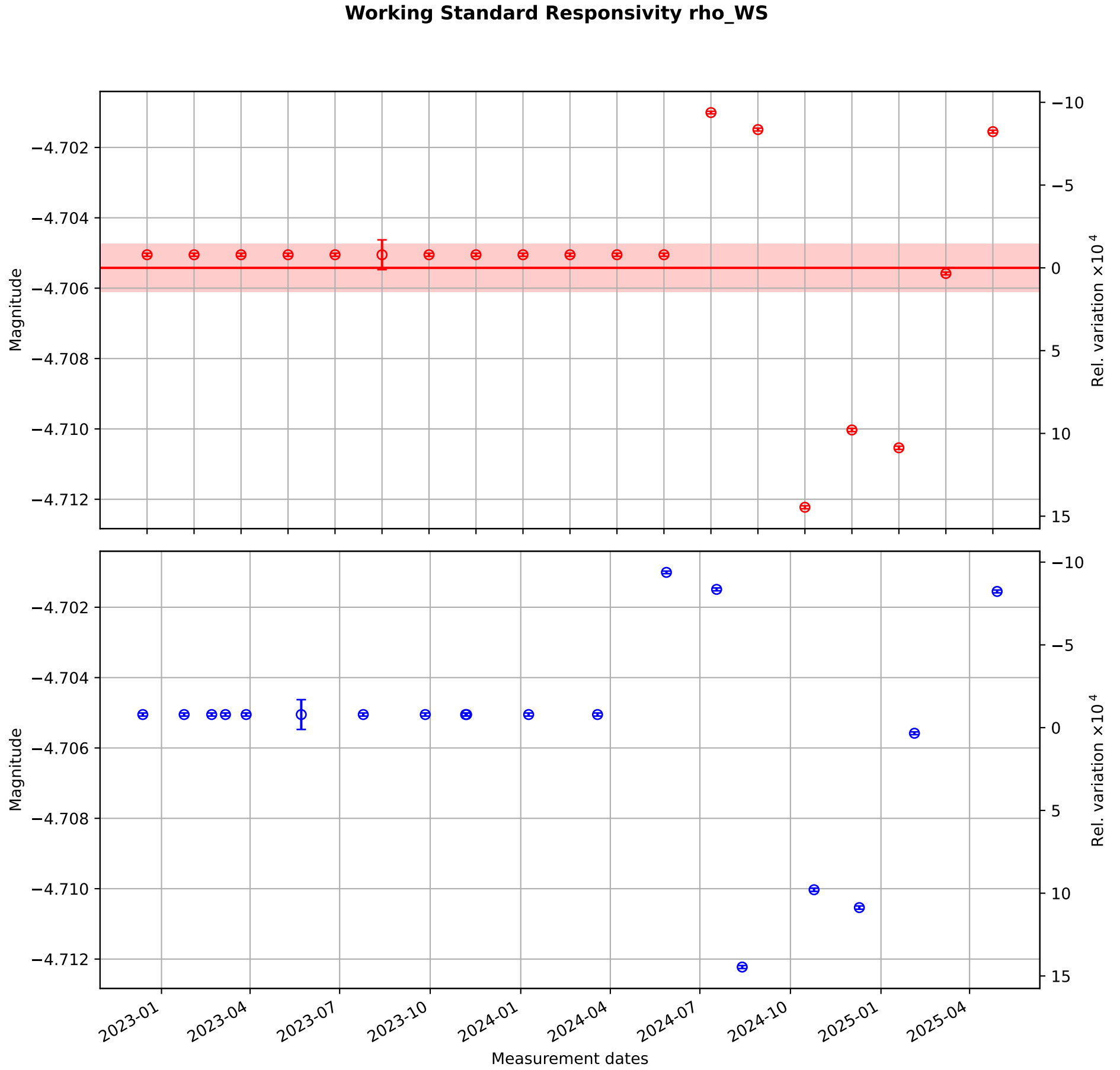

Rx Responsivity Corrected for Optical Efficiency
statistical + systematic uncertainty
statistical uncertainty
Magnitude
Rel. variation ×10⁴
Measurement dates
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04

Date	WS ± SD_WS
D20221213	-4.7051 ± 0.0000
D20230124	-4.7051 ± 0.0000
D20230221	-4.7051 ± 0.0000
D20230307	-4.7051 ± 0.0000
D20230328	-4.7051 ± 0.0000
D20230523	-4.7051 ± 0.0004
D20230725	-4.7051 ± 0.0000
D20230926	-4.7051 ± 0.0000
D20231106	-4.7051 ± 0.0000
D20231107	-4.7051 ± 0.0000
D20240109	-4.7051 ± 0.0000
D20240319	-4.7051 ± 0.0000
D20240528	-4.7010 ± 0.0000
D20240718	-4.7015 ± 0.0000
D20240813	-4.7122 ± 0.0000
D20241025	-4.7100 ± 0.0000
D20241210	-4.7105 ± 0.0000
D20250204	-4.7056 ± 0.0000
D20250429	-4.7016 ± 0.0000

Summary of Working Standard Responsivity	WS rho_WS
Mean value:	-4.705423
Standard deviation:	0.002841
Standard error:	0.000669
Relative Standard error:	-0.000142

Description:

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

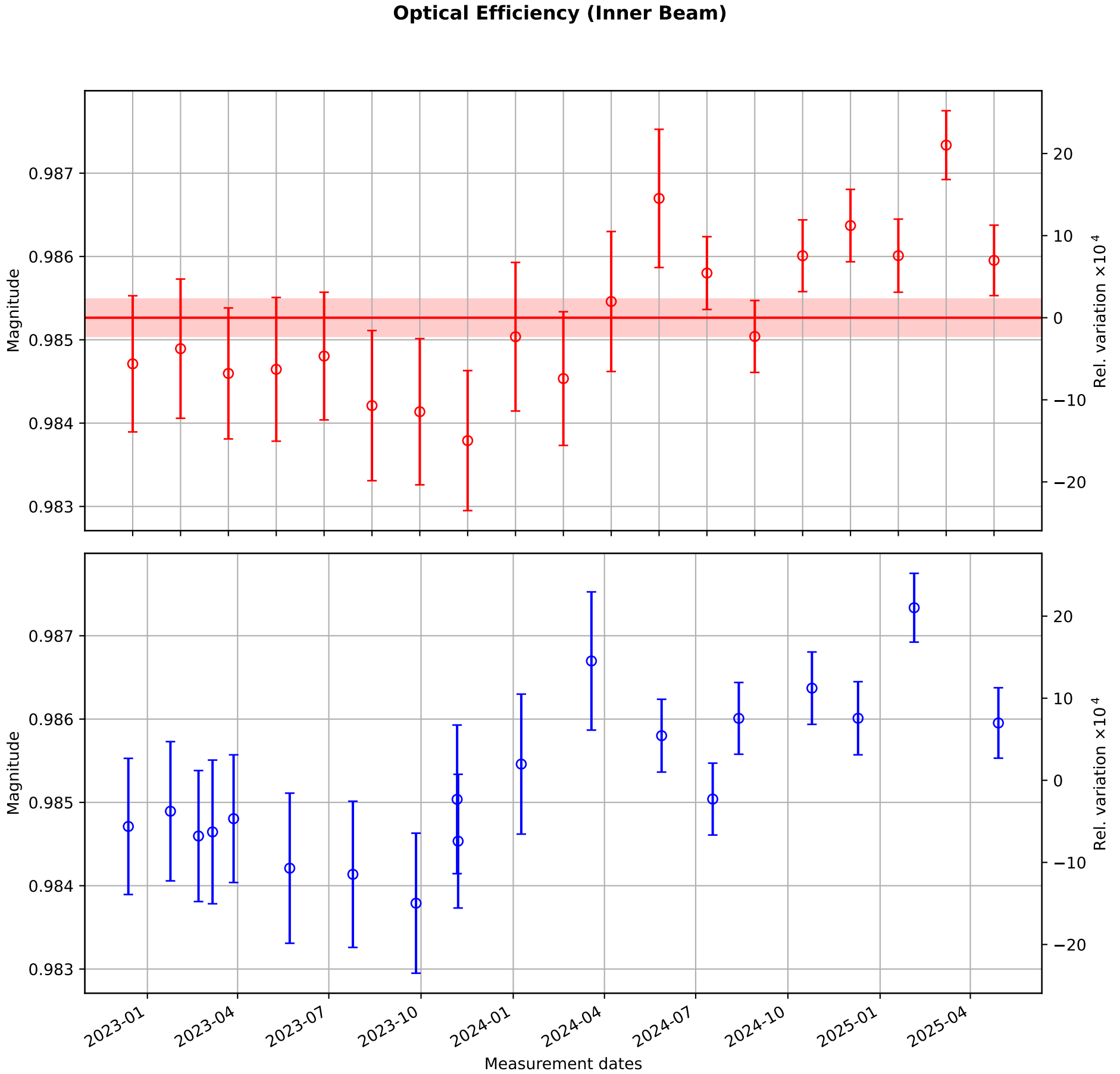

Working Standard Responsivity rho_WS
Magnitude
−4.702
−4.704
−4.706
−4.708
−4.710
−4.712
−10
−5
0
5
10
15
Rel. variation ×10⁴
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04
Measurement dates

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

Summary of Optical Efficiency (Inner Beam)	e_i
Mean value:	0.985265
Standard deviation:	0.000947
Standard error:	0.000223
Relative Standard error:	0.000227

Description:

Optical Efficiency (Inner beam): e_i = (Wri/Tti) / (Wti/Tti)
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.

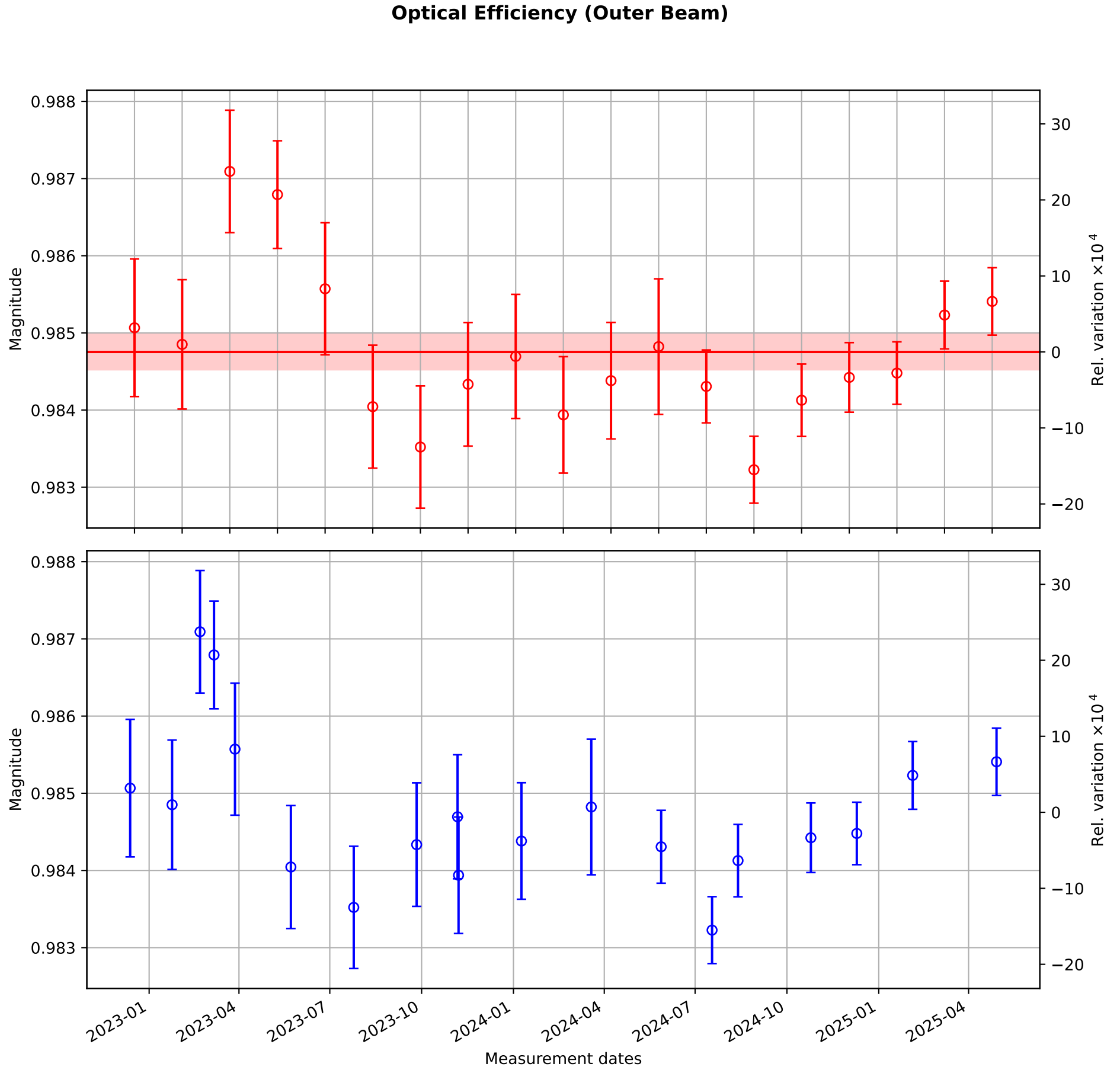

Optical Efficiency (Inner Beam)
Magnitude
0.987
0.986
0.985
0.984
0.983
Rel. variation ×10⁴
20
10
0
−10
−20
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04
Measurement dates

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

Summary of Optical Efficiency (Outer Beam)	e_o
Mean value:	0.984754
Standard deviation:	0.000977
Standard error:	0.000230
Relative Standard error:	0.000234

Description:

Optical Efficiency (Outer beam): e_o = (Wro/Tto) / (Wto/Tto)
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.


Optical Efficiency (Outer Beam)
Magnitude
0.988
0.987
0.986
0.985
0.984
0.983
Rel. variation ×10⁴
30
20
10
0
−10
−20
Magnitude
0.988
0.987
0.986
0.985
0.984
0.983
Rel. variation ×10⁴
30
20
10
0
−10
−20
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04
Measurement dates

e

Date	None ± SD_None
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
D20240109	0.9849 ± 0.0006
D20240319	0.9858 ± 0.0006
D20240528	0.9851 ± 0.0006
D20240718	0.9841 ± 0.0006
D20240813	0.9851 ± 0.0006
D20241025	0.9854 ± 0.0006
D20241210	0.9852 ± 0.0006
D20250204	0.9863 ± 0.0006
D20250429	0.9857 ± 0.0006

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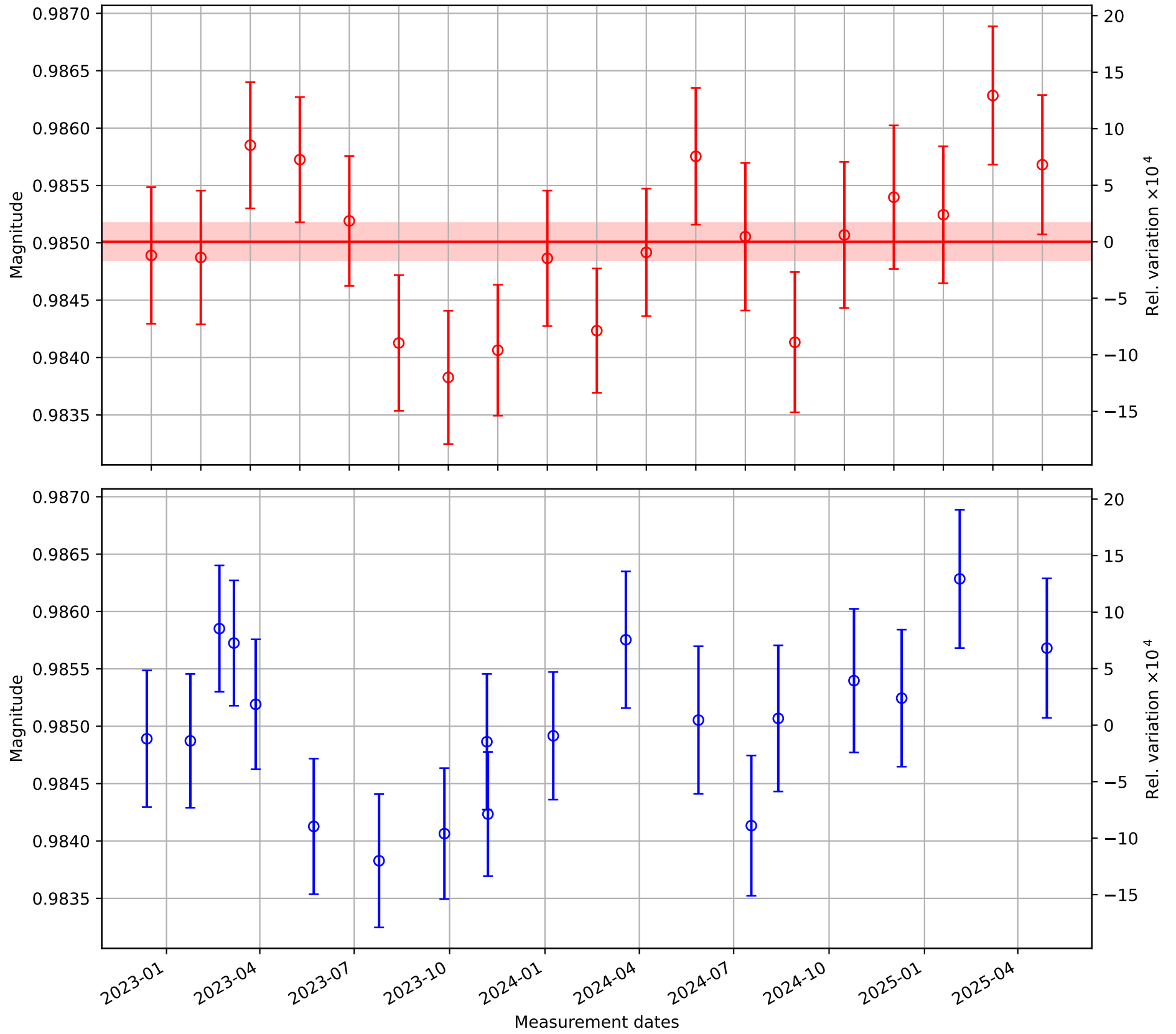
e

Summary of Overall Optical Efficiency

Mean value:	0.985009
Standard deviation:	0.000691
Standard error:	0.000163
Relative Standard error:	0.000165

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.

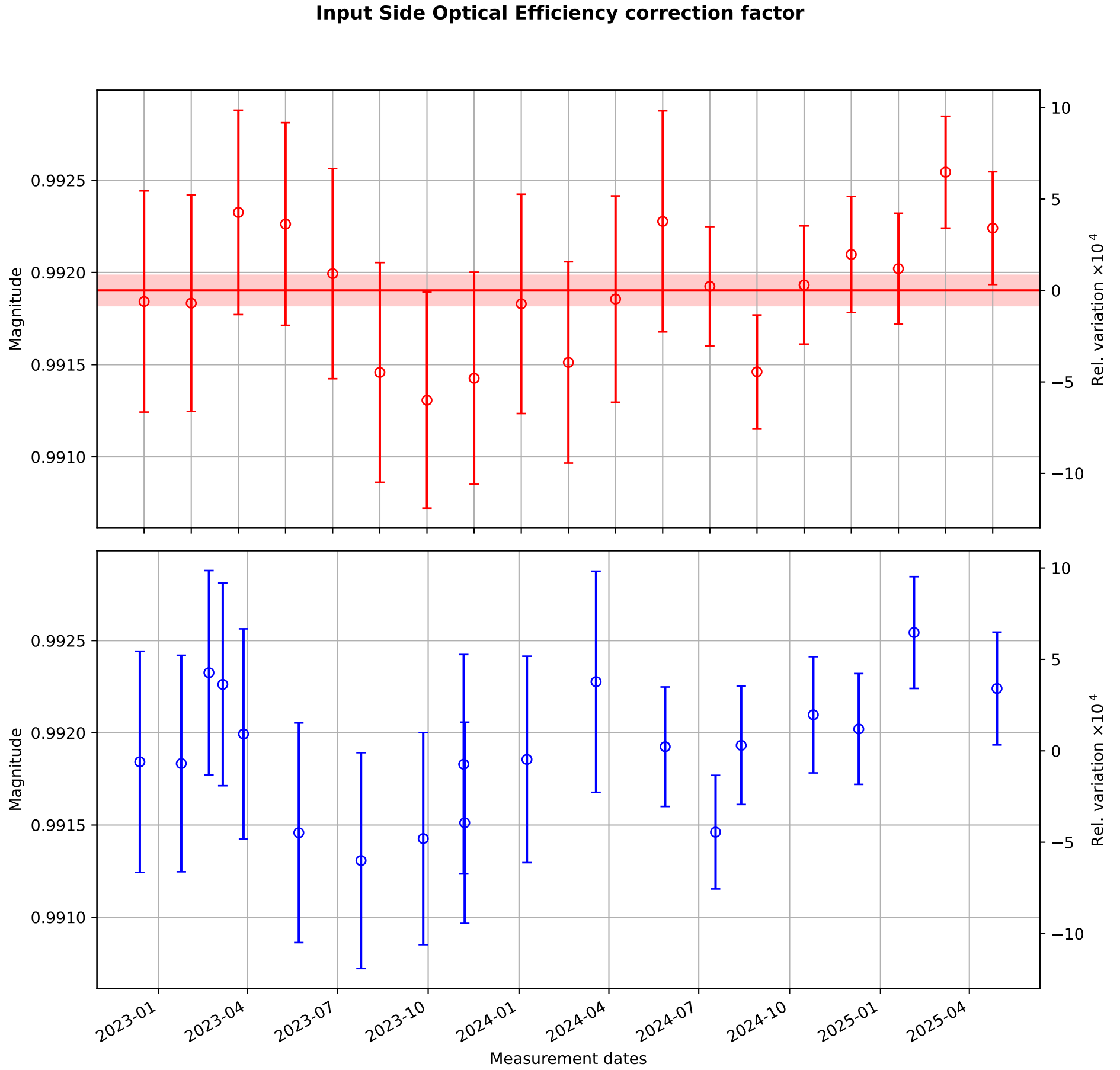

Overall Optical Efficiency
Magnitude
Rel. variation ×10⁴
0.9870
0.9865
0.9860
0.9855
0.9850
0.9845
0.9840
0.9835
20
15
10
5
0
−5
−10
−15
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04
Measurement dates

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

Summary of Input Side Optical Efficiency correction factor	E_T
Mean value:	0.991902
Standard deviation:	0.000348
Standard error:	0.000082
Relative Standard error:	0.000083

Description:

Tx side Optical Efficiency Correction Factor: E_T = sqrt(e* β)
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.

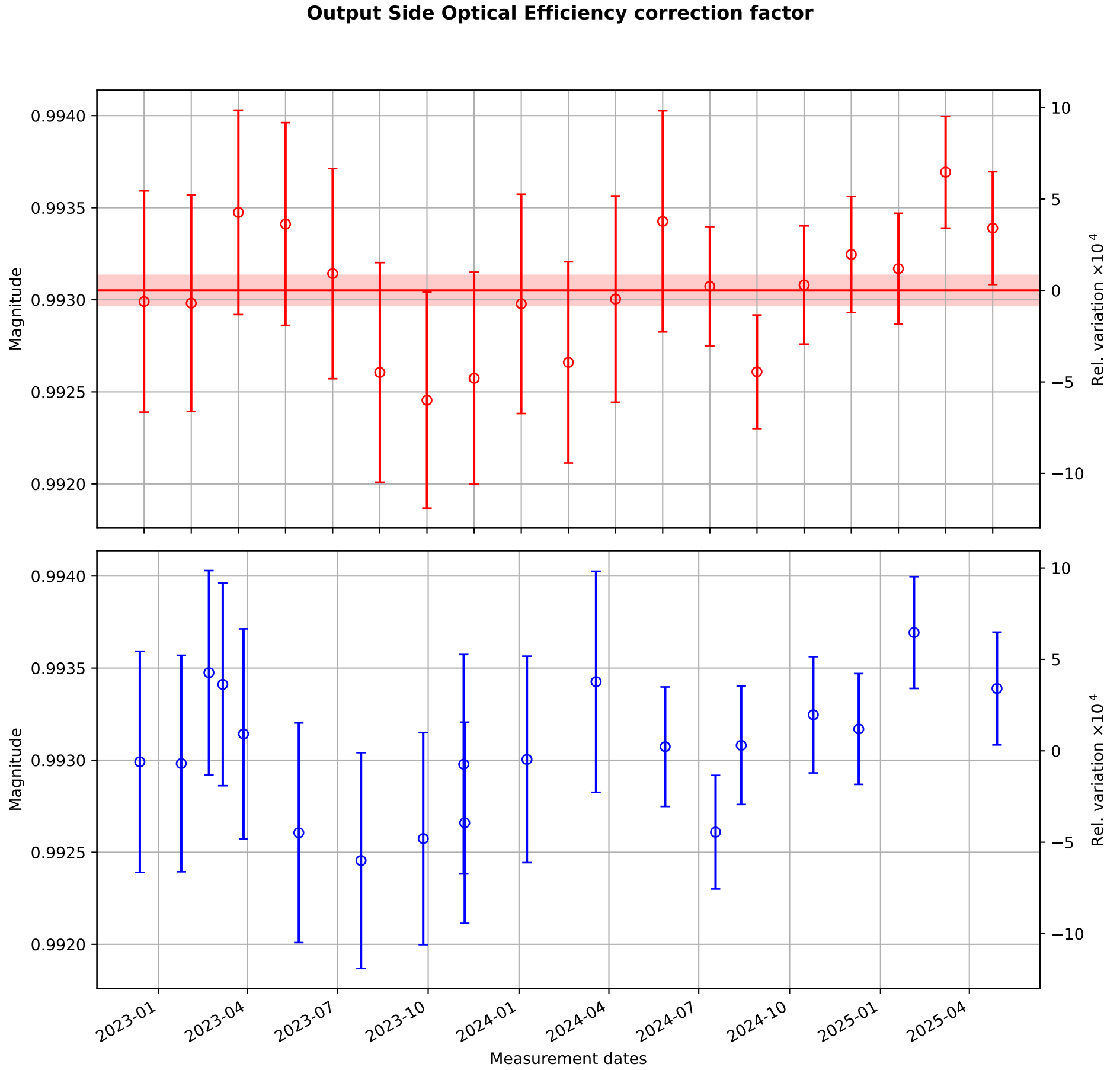

Input Side Optical Efficiency correction factor
Magnitude
0.9925
0.9920
0.9915
0.9910
Rel. variation ×10⁴
10
5
0
−5
−10
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04
Measurement dates

	E_R
Date	None ± SD_None
D20221213	0.9930 ± 0.0006
D20230124	0.9930 ± 0.0006
D20230221	0.9935 ± 0.0006
D20230307	0.9934 ± 0.0006
D20230328	0.9931 ± 0.0006
D20230523	0.9926 ± 0.0006
D20230725	0.9925 ± 0.0006
D20230926	0.9926 ± 0.0006
D20231106	0.9930 ± 0.0006
D20231107	0.9927 ± 0.0005
D20240109	0.9930 ± 0.0006
D20240319	0.9934 ± 0.0006
D20240528	0.9931 ± 0.0003
D20240718	0.9926 ± 0.0003
D20240813	0.9931 ± 0.0003
D20241025	0.9932 ± 0.0003
D20241210	0.9932 ± 0.0003
D20250204	0.9937 ± 0.0003
D20250429	0.9934 ± 0.0003

Summary of Output Side Optical Efficiency correction factor	E_R
Mean value:	0.993051
Standard deviation:	0.000348
Standard error:	0.000082
Relative Standard error:	0.000083

Description:

Rx side Optical Efficiency Correction Factor:E_R = sqrt(e/ β)
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.

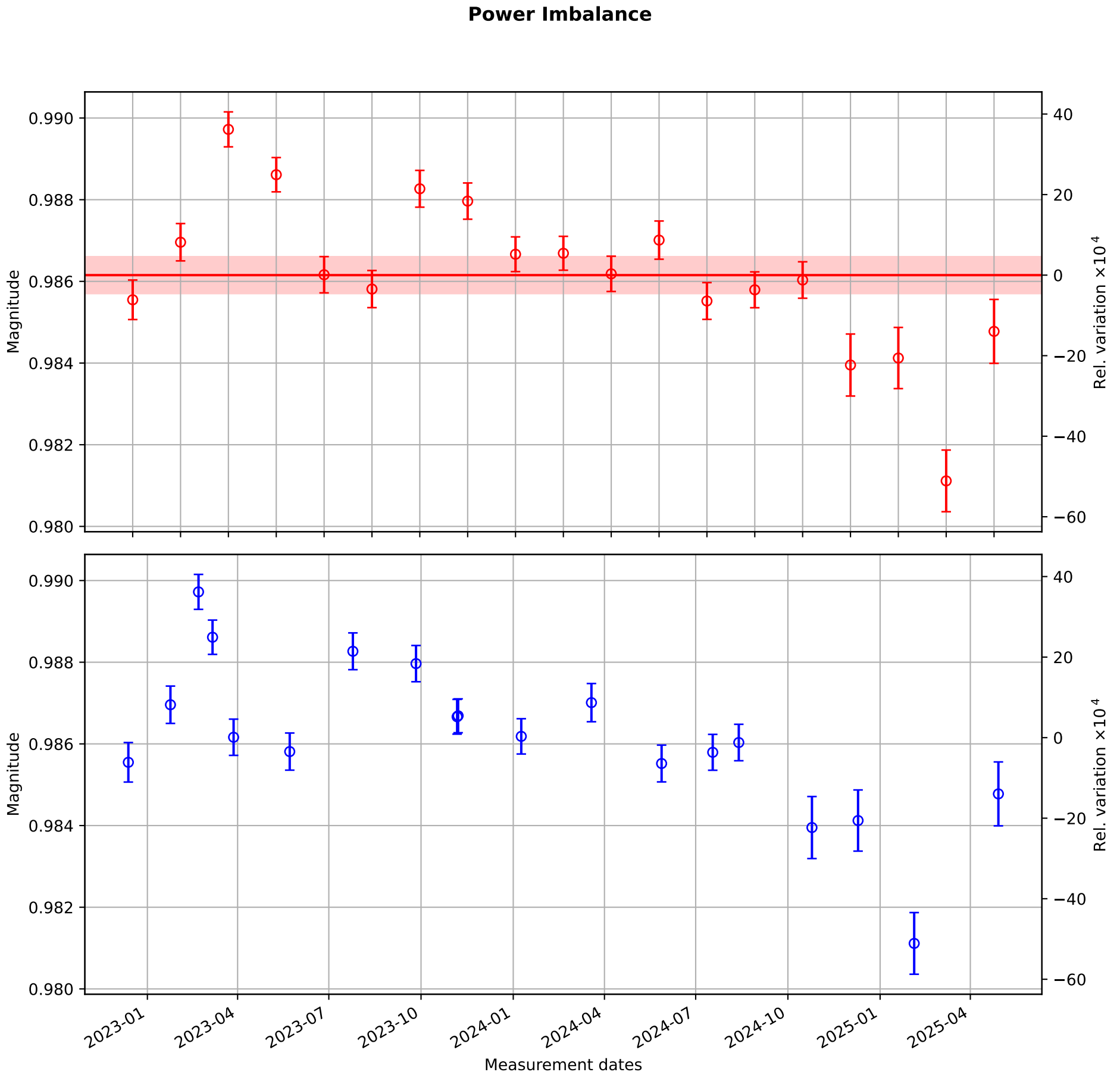

Output Side Optical Efficiency correction factor
Magnitude
Rel. variation ×10⁴
0.9940
0.9935
0.9930
0.9925
0.9920
10
5
0
−5
−10
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04
Measurement dates

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

PowerImbalance	
Summary of Power Imbalance	
Mean value:	0.986153
Standard deviation:	0.001911
Standard error:	0.000450
Relative Standard error:	0.000457

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.


Power Imbalance
Magnitude
Rel. variation ×10⁴
0.990
0.988
0.986
0.984
0.982
0.980
40
20
0
−20
−40
−60
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01
2025-04
Measurement dates