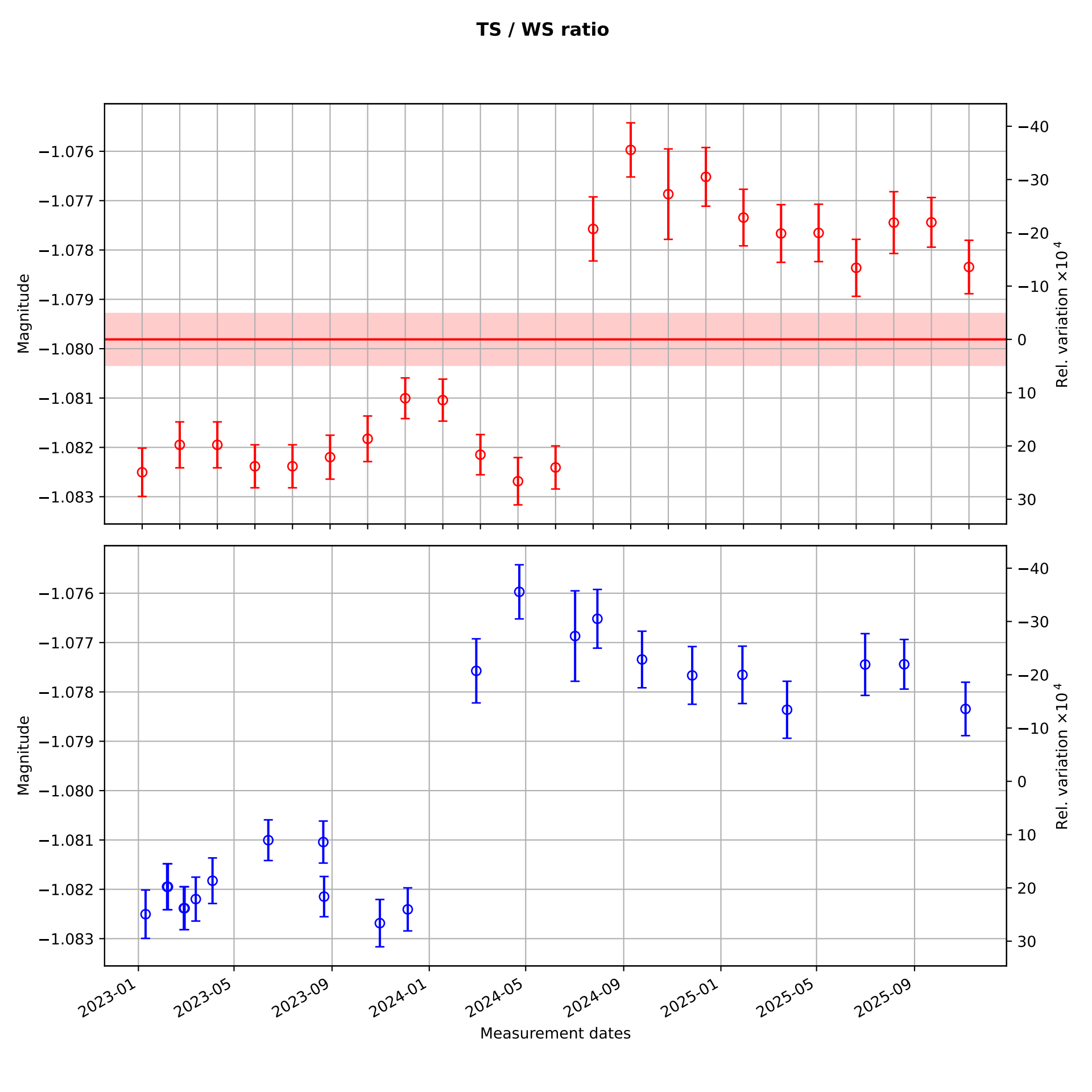
PCAL End Station Measurement Trends

	TXWS
Date	None ± SD_None
D20230110	-1.0825 ± 0.0005
D20230206	-1.0819 ± 0.0005
D20230207	-1.0819 ± 0.0005
D20230227	-1.0824 ± 0.0004
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
D20240702	-1.0769 ± 0.0009
D20240730	-1.0765 ± 0.0006
D20240924	-1.0773 ± 0.0006
D20241126	-1.0777 ± 0.0006
D20250128	-1.0777 ± 0.0006
D20250325	-1.0784 ± 0.0006
D20250701	-1.0774 ± 0.0006
D20250819	-1.0774 ± 0.0005
D20251104	-1.0783 ± 0.0005

	TXWS
Summary of TS / WS ratio	
Mean value:	-1.079812
Standard deviation:	0.002458
Standard error:	0.000524
Relative Standard error:	-0.000485

Description:

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

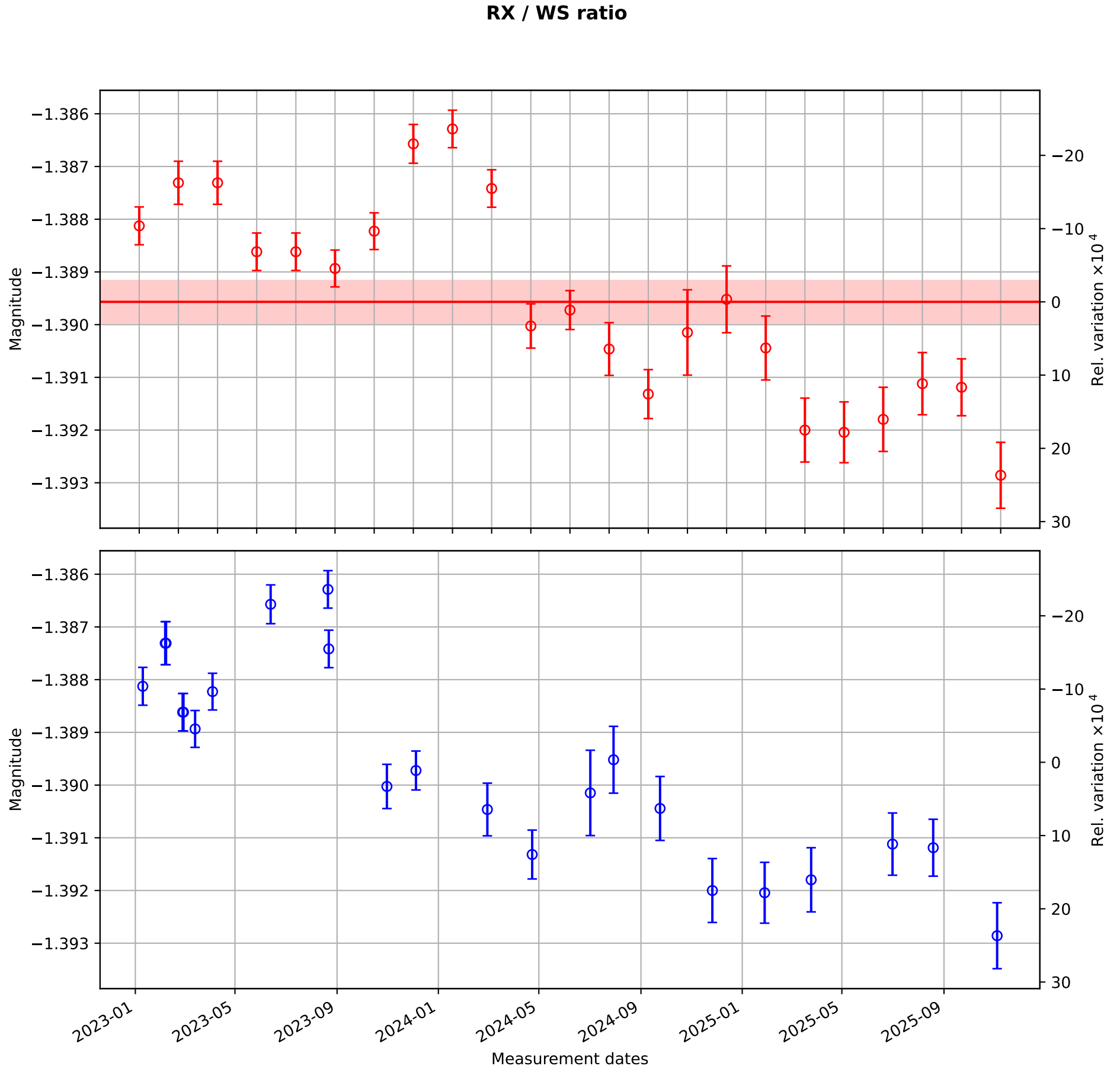

TS / WS ratio
Magnitude
−1.076
−1.077
−1.078
−1.079
−1.080
−1.081
−1.082
−1.083
Rel. variation ×10⁴
−40
−30
−20
−10
0
10
20
30
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

	RXWS
Date	None ± SD_None
D20230110	-1.3881 ± 0.0004
D20230206	-1.3873 ± 0.0004
D20230207	-1.3873 ± 0.0004
D20230227	-1.3886 ± 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
D20240702	-1.3901 ± 0.0008
D20240730	-1.3895 ± 0.0006
D20240924	-1.3904 ± 0.0006
D20241126	-1.3920 ± 0.0006
D20250128	-1.3920 ± 0.0006
D20250325	-1.3918 ± 0.0006
D20250701	-1.3911 ± 0.0006
D20250819	-1.3912 ± 0.0005
D20251104	-1.3929 ± 0.0006

	RXWS
Summary of RX / WS ratio	
Mean value:	-1.389568
Standard deviation:	0.001892
Standard error:	0.000403
Relative Standard error:	-0.000290

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
−1.386
−1.387
−1.388
−1.389
−1.390
−1.391
−1.392
−1.393
Rel. variation ×10⁴
−20
−10
0
10
20
30
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

Date	rho_T m5 ± SD_m5
D20230110	8335.8363 ± 3.7737
D20230206	8331.4346 ± 3.5832
D20230207	8331.5608 ± 3.5832
D20230227	8335.2565 ± 3.3557
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
D20240702	8288.5717 ± 7.0540
D20240730	8301.2386 ± 4.5879
D20240924	8305.0146 ± 4.4201
D20241126	8310.1994 ± 4.5070
D20250128	8294.6229 ± 4.4760
D20250325	8298.1767 ± 4.4438
D20250701	8289.5025 ± 4.8182
D20250819	8293.0446 ± 3.8730
D20251104	8300.0920 ± 4.1682

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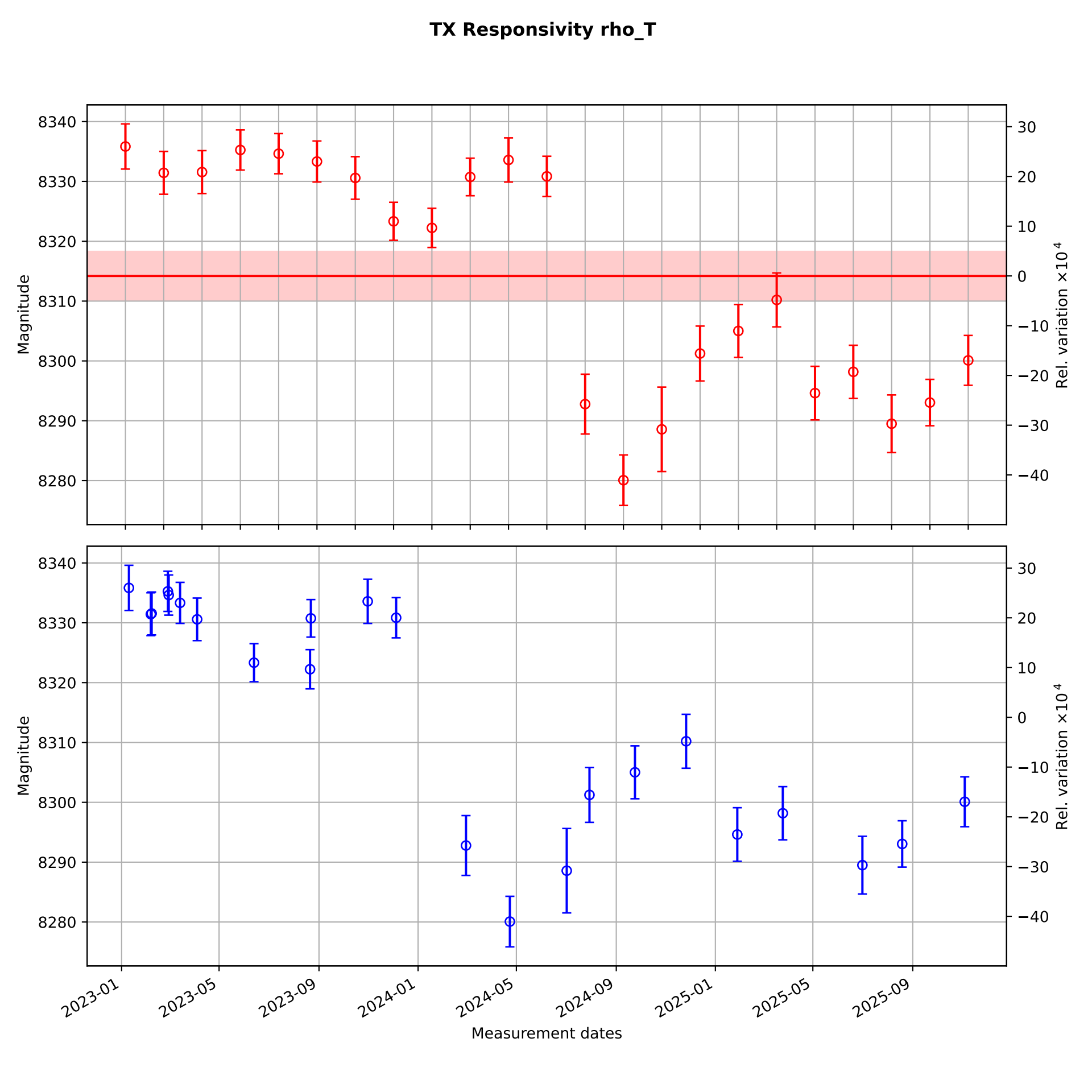
	rho_T
Summary of TX Responsivity rho_T	
Mean value:	8314.204139
Standard deviation:	19.166234
Standard error:	4.085224
Relative Standard error:	0.000491

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
8340
8330
8320
8310
8300
8290
8280
30
20
10
0
−10
−20
−30
−40
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

	rho_R
Date	None ± SD_None
D20230110	10689.2786 ± 2.7664
D20230206	10682.8253 ± 3.1470
D20230207	10682.9872 ± 3.1471
D20230227	10693.5125 ± 2.7393
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
D20240702	10699.8690 ± 6.2313
D20240730	10714.8547 ± 4.8884
D20240924	10718.6424 ± 4.6756
D20241126	10734.1288 ± 4.6754
D20250128	10714.4497 ± 4.4426
D20250325	10710.1187 ± 4.6850
D20250701	10702.8135 ± 4.5407
D20250819	10707.9670 ± 4.1548
D20251104	10720.9199 ± 4.8150

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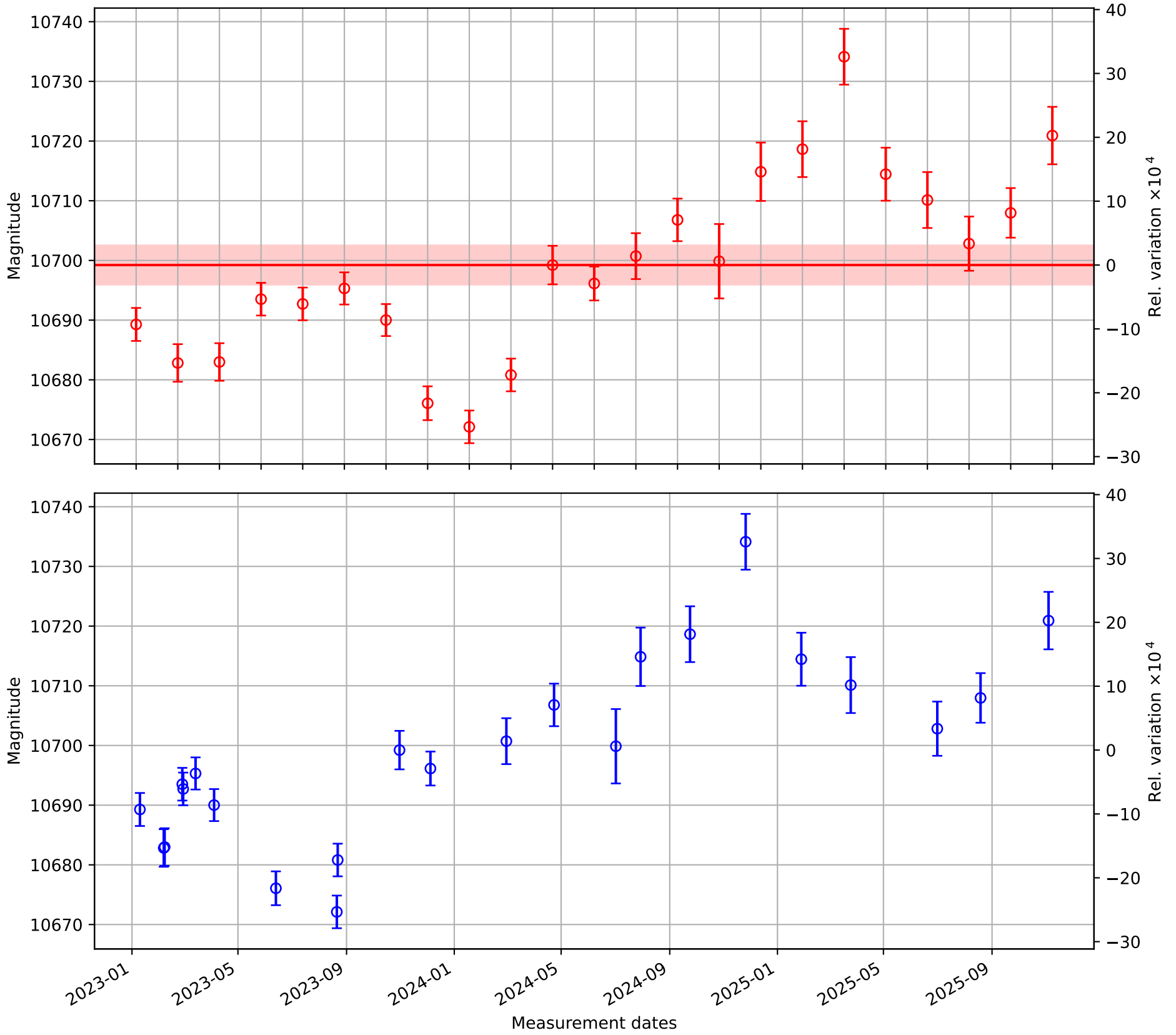
	rho_R
Summary of RX Responsivity rho_R	
Mean value:	10699.229899
Standard deviation:	15.427116
Standard error:	3.288243
Relative Standard error:	0.000307

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.

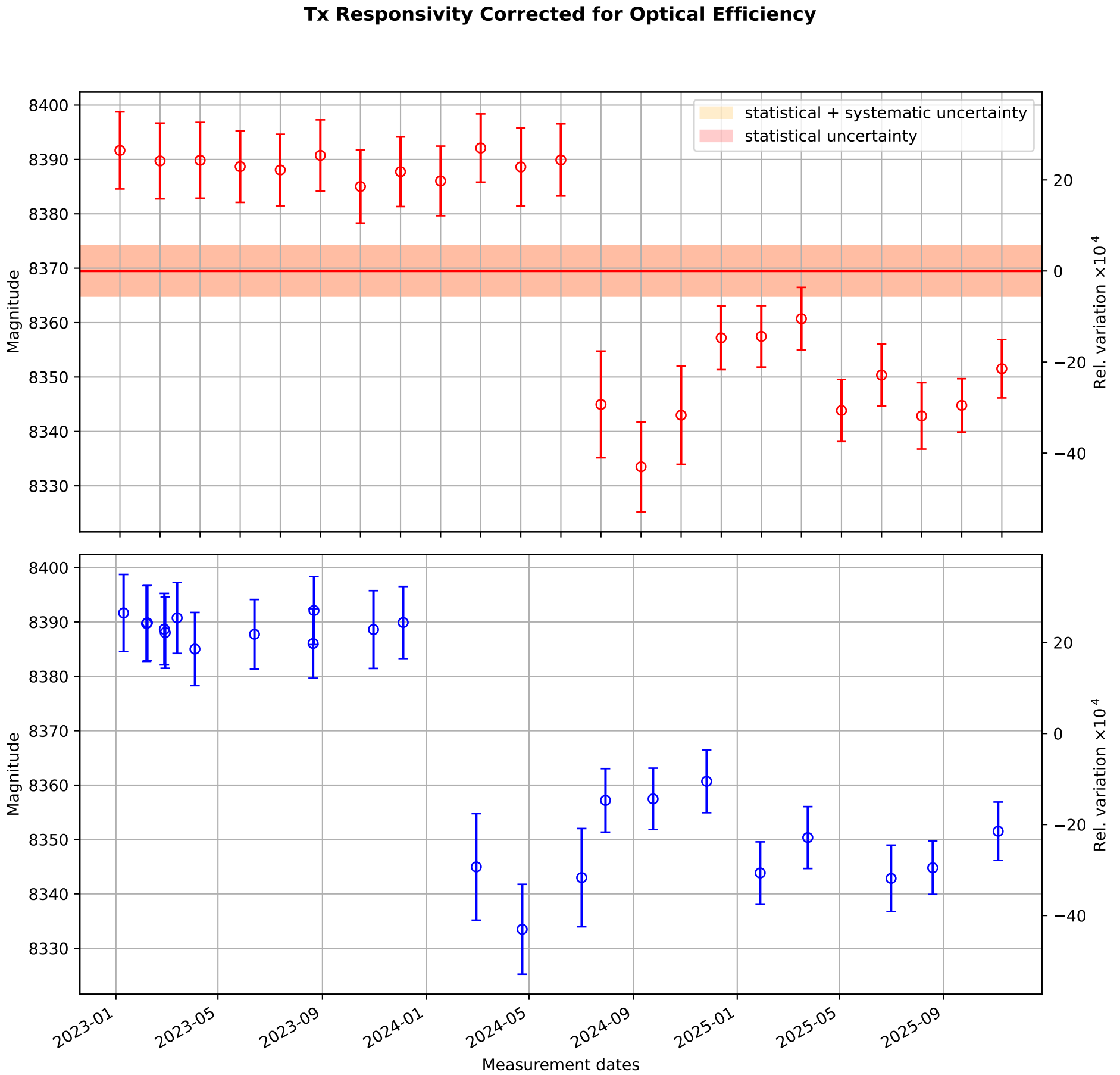

RX Responsivity rho_R
Magnitude
Rel. variation ×10⁴
Measurement dates
10740
10730
10720
10710
10700
10690
10680
10670
40
30
20
10
0
−10
−20
−30
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09

Date	rhoT_prime None ± SD_None
D20230110	8391.6574 ± 7.0818
D20230206	8389.7169 ± 6.9611
D20230207	8389.8439 ± 6.9612
D20230227	8388.6783 ± 6.5688
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
D20240702	8342.9862 ± 9.0346
D20240730	8357.1960 ± 5.8391
D20240924	8357.4704 ± 5.6429
D20241126	8360.7000 ± 5.7712
D20250128	8343.8479 ± 5.7107
D20250325	8350.3545 ± 5.6914
D20250701	8342.8482 ± 6.1068
D20250819	8344.7947 ± 4.8963
D20251104	8351.5242 ± 5.3638

Summary of Tx Responsivity Corrected for Optical Efficiency	rhoT_prime
Mean value:	8369.490278
Standard deviation:	21.595282
Standard error:	4.602968
Relative Standard error:	0.000550

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.

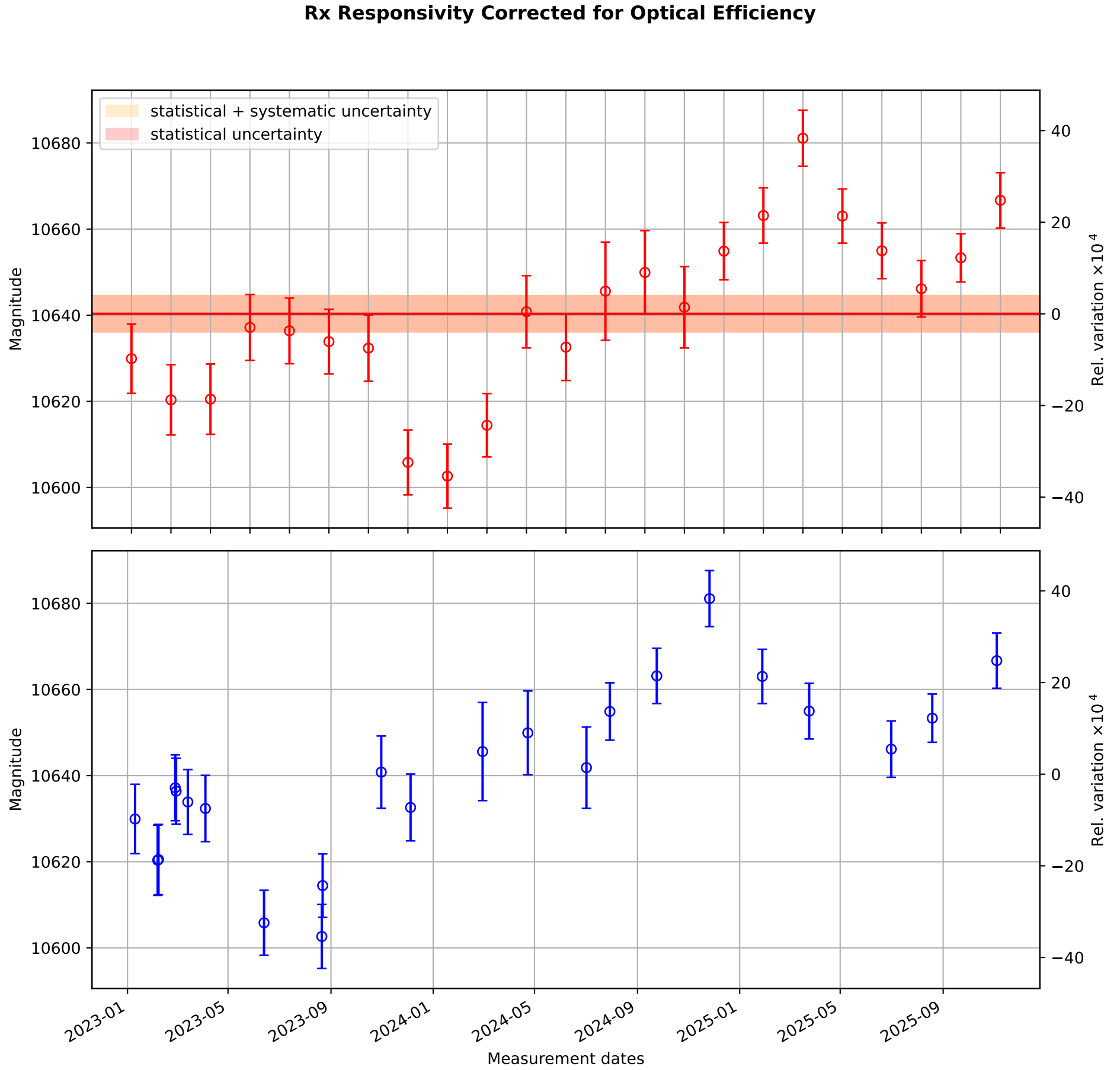

Tx Responsivity Corrected for Optical Efficiency
statistical + systematic uncertainty
statistical uncertainty
Magnitude
Rel. variation ×10⁴
8400
8390
8380
8370
8360
8350
8340
8330
20
0
−20
−40
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

	rhoR_prime
Date	None ± SD_None
D20230110	10629.9242 ± 8.0551
D20230206	10620.3530 ± 8.1594
D20230207	10620.5139 ± 8.1595
D20230227	10637.1713 ± 7.6462
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
D20240702	10641.8462 ± 9.4440
D20240730	10654.8891 ± 6.6613
D20240924	10663.1539 ± 6.4237
D20241126	10681.0993 ± 6.5151
D20250128	10663.0264 ± 6.3007
D20250325	10654.9740 ± 6.4735
D20250701	10646.1462 ± 6.5451
D20250819	10653.3380 ± 5.6041
D20251104	10666.6871 ± 6.4178

Summary of Rx Responsivity Corrected for Optical Efficiency	rhoR_prime
Mean value:	10640.329899
Standard deviation:	19.674162
Standard error:	4.193488
Relative Standard error:	0.000394

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
10680
10660
10640
10620
10600
40
20
0
−20
−40
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

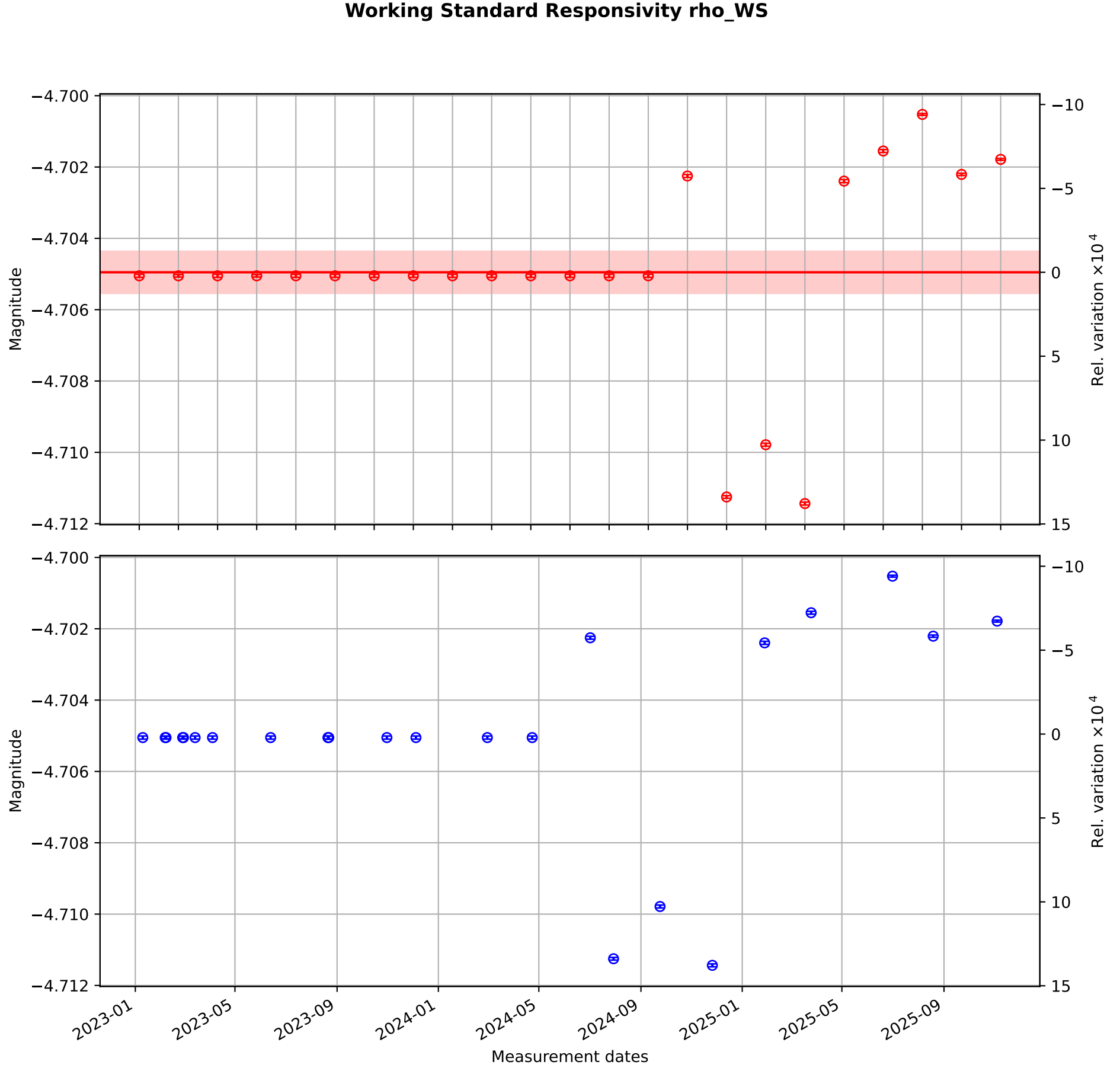
Date	WS ± SD_WS
D20230110	-4.7051 ± 0.0000
D20230206	-4.7051 ± 0.0000
D20230207	-4.7051 ± 0.0000
D20230227	-4.7051 ± 0.0000
D20230228	-4.7051 ± 0.0000
D20230314	-4.7051 ± 0.0000
D20230404	-4.7051 ± 0.0000
D20230613	-4.7051 ± 0.0000
D20230821	-4.7051 ± 0.0000
D20230822	-4.7051 ± 0.0000
D20231031	-4.7051 ± 0.0000
D20231205	-4.7051 ± 0.0000
D20240229	-4.7051 ± 0.0000
D20240423	-4.7051 ± 0.0000
D20240702	-4.7023 ± 0.0000
D20240730	-4.7113 ± 0.0000
D20240924	-4.7098 ± 0.0000
D20241126	-4.7114 ± 0.0000
D20250128	-4.7024 ± 0.0000
D20250325	-4.7016 ± 0.0000
D20250701	-4.7005 ± 0.0000
D20250819	-4.7022 ± 0.0000
D20251104	-4.7018 ± 0.0000

Summary of Working Standard Responsivity rho_WS	WS
Mean value:	-4.704952
Standard deviation:	0.002762
Standard error:	0.000589
Relative Standard error:	-0.000125

Description:

WS

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

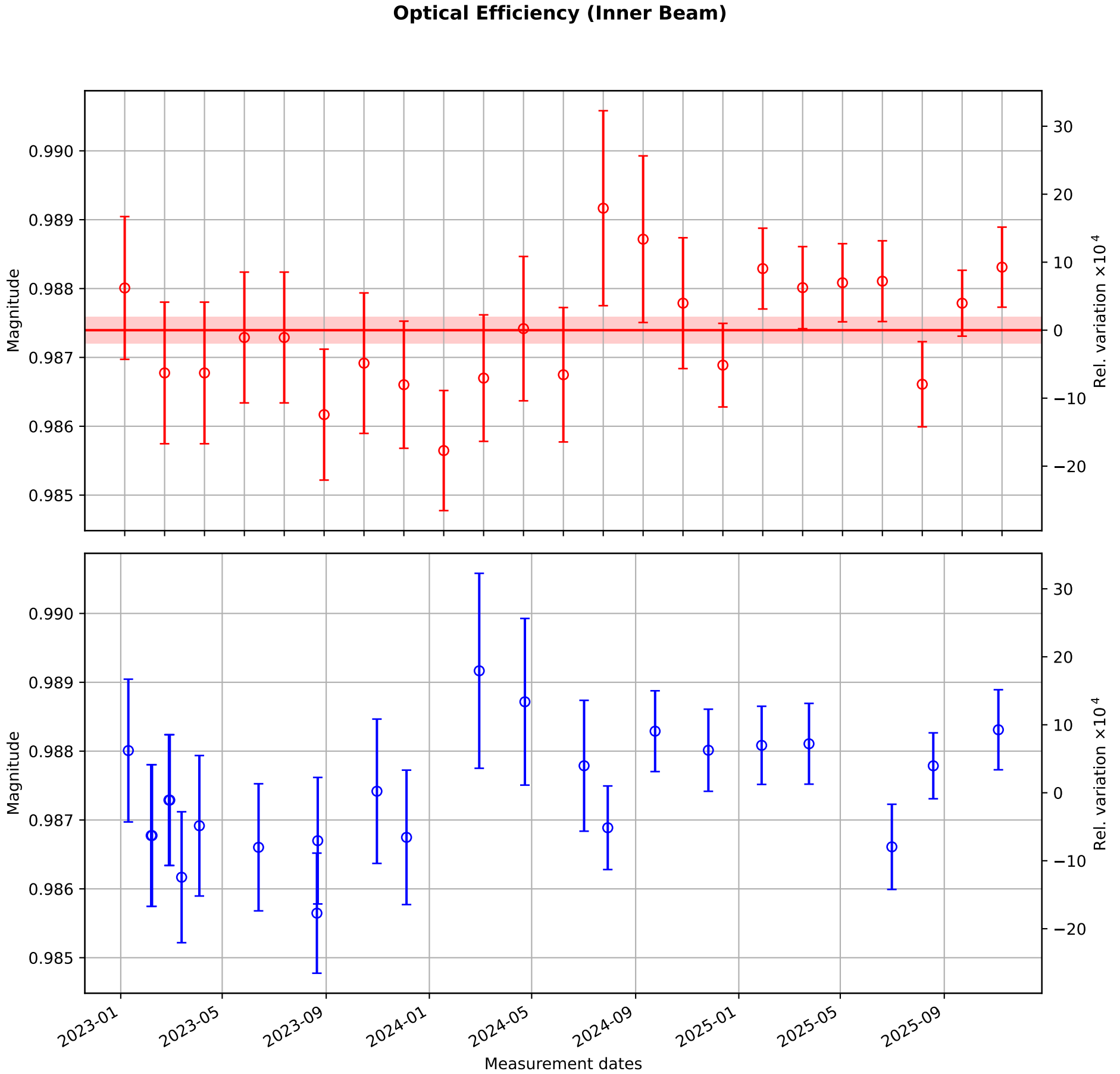

Working Standard Responsivity rho_WS
Magnitude
Rel. variation ×10⁴
−4.700
−4.702
−4.704
−4.706
−4.708
−4.710
−4.712
−10
−5
0
5
10
15
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

Date	e_i ± SD_e_i
D20230110	0.9880 ± 0.0010
D20230206	0.9868 ± 0.0010
D20230207	0.9868 ± 0.0010
D20230227	0.9873 ± 0.0009
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
D20240702	0.9878 ± 0.0010
D20240730	0.9869 ± 0.0006
D20240924	0.9883 ± 0.0006
D20241126	0.9880 ± 0.0006
D20250128	0.9881 ± 0.0006
D20250325	0.9881 ± 0.0006
D20250701	0.9866 ± 0.0006
D20250819	0.9878 ± 0.0005
D20251104	0.9883 ± 0.0006

Summary of Optical Efficiency (Inner Beam)	e_i
Mean value:	0.987396
Standard deviation:	0.000868
Standard error:	0.000185
Relative Standard error:	0.000187

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.

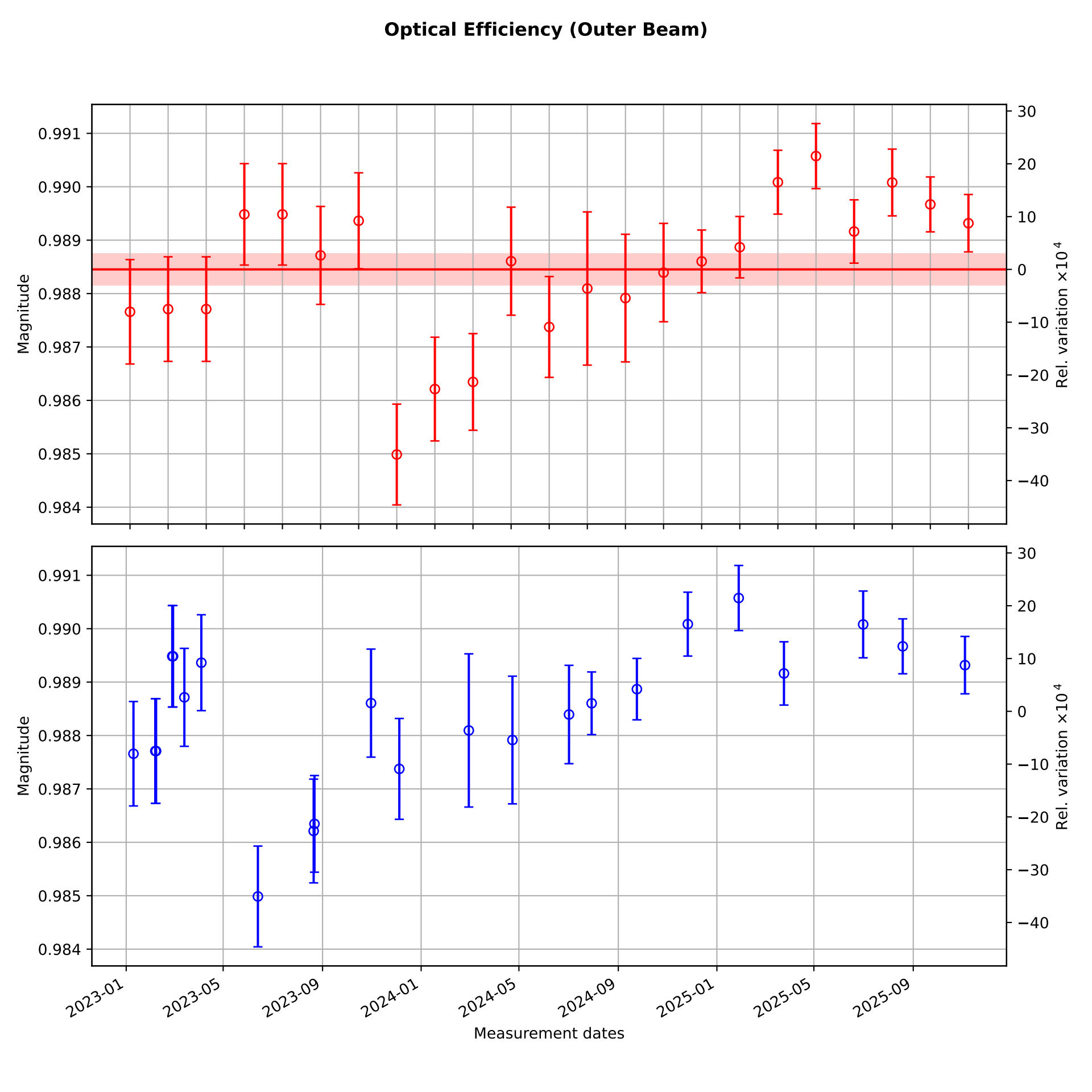

Optical Efficiency (Inner Beam)
Magnitude
0.990
0.989
0.988
0.987
0.986
0.985
Rel. variation ×10⁴
30
20
10
0
−10
−20
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

Date	e_o ± SD_e_o
D20230110	0.9877 ± 0.0010
D20230206	0.9877 ± 0.0010
D20230207	0.9877 ± 0.0010
D20230227	0.9895 ± 0.0009
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
D20240702	0.9884 ± 0.0009
D20240730	0.9886 ± 0.0006
D20240924	0.9889 ± 0.0006
D20241126	0.9901 ± 0.0006
D20250128	0.9906 ± 0.0006
D20250325	0.9892 ± 0.0006
D20250701	0.9901 ± 0.0006
D20250819	0.9897 ± 0.0005
D20251104	0.9893 ± 0.0005

Summary of Optical Efficiency (Outer Beam)	e_o
Mean value:	0.988453
Standard deviation:	0.001358
Standard error:	0.000289
Relative Standard error:	0.000293

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.

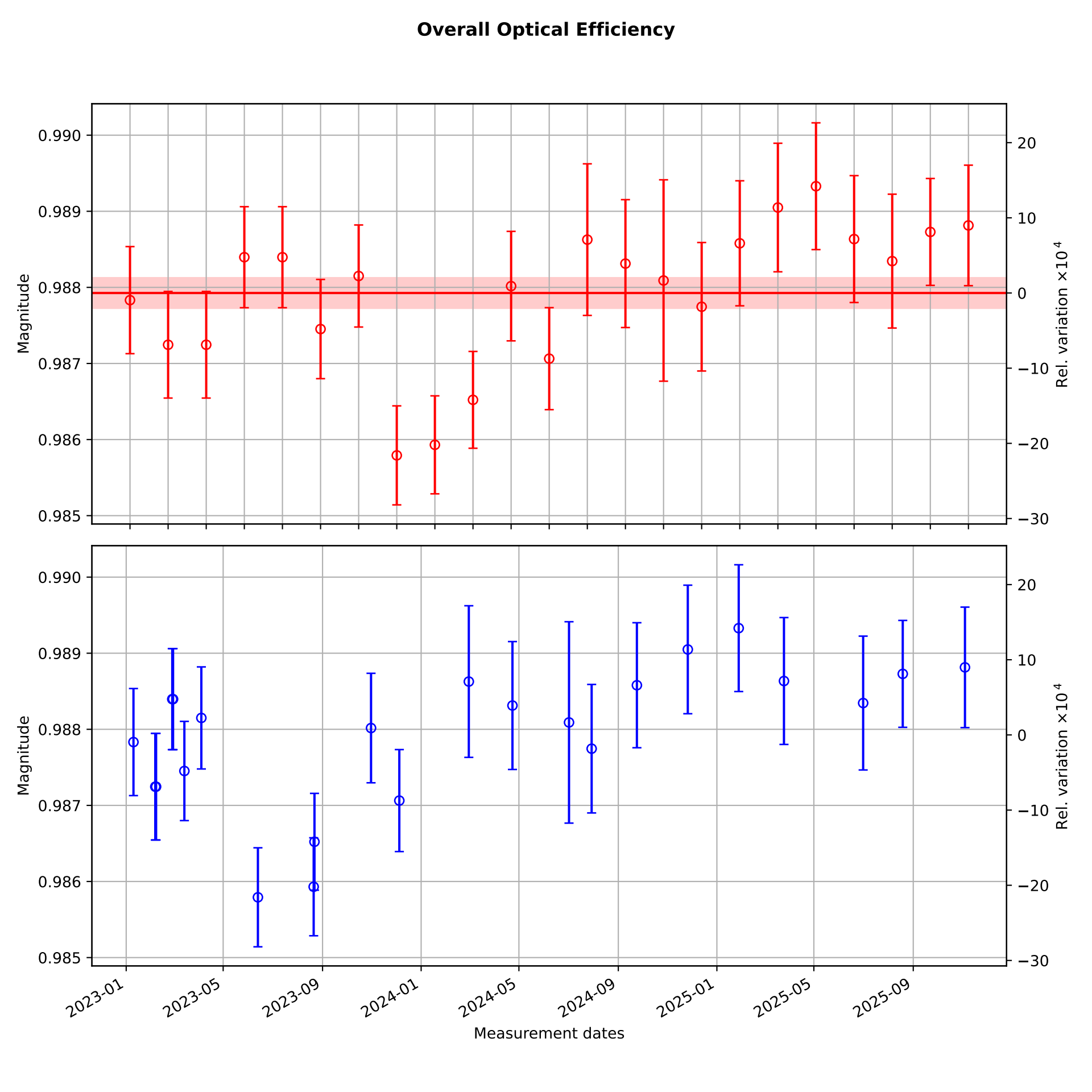

Optical Efficiency (Outer Beam)
Magnitude
Rel. variation ×10⁴
0.991
0.990
0.989
0.988
0.987
0.986
0.985
0.984
30
20
10
0
−10
−20
−30
−40
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

Date	e None ± SD_None
D20230110	0.9878 ± 0.0007
D20230206	0.9872 ± 0.0007
D20230207	0.9872 ± 0.0007
D20230227	0.9884 ± 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
D20240702	0.9881 ± 0.0013
D20240730	0.9877 ± 0.0008
D20240924	0.9886 ± 0.0008
D20241126	0.9890 ± 0.0008
D20250128	0.9893 ± 0.0008
D20250325	0.9886 ± 0.0008
D20250701	0.9883 ± 0.0009
D20250819	0.9887 ± 0.0007
D20251104	0.9888 ± 0.0008

Summary of Overall Optical Efficiency	e
Mean value:	0.987926
Standard deviation:	0.000939
Standard error:	0.000200
Relative Standard error:	0.000202

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.

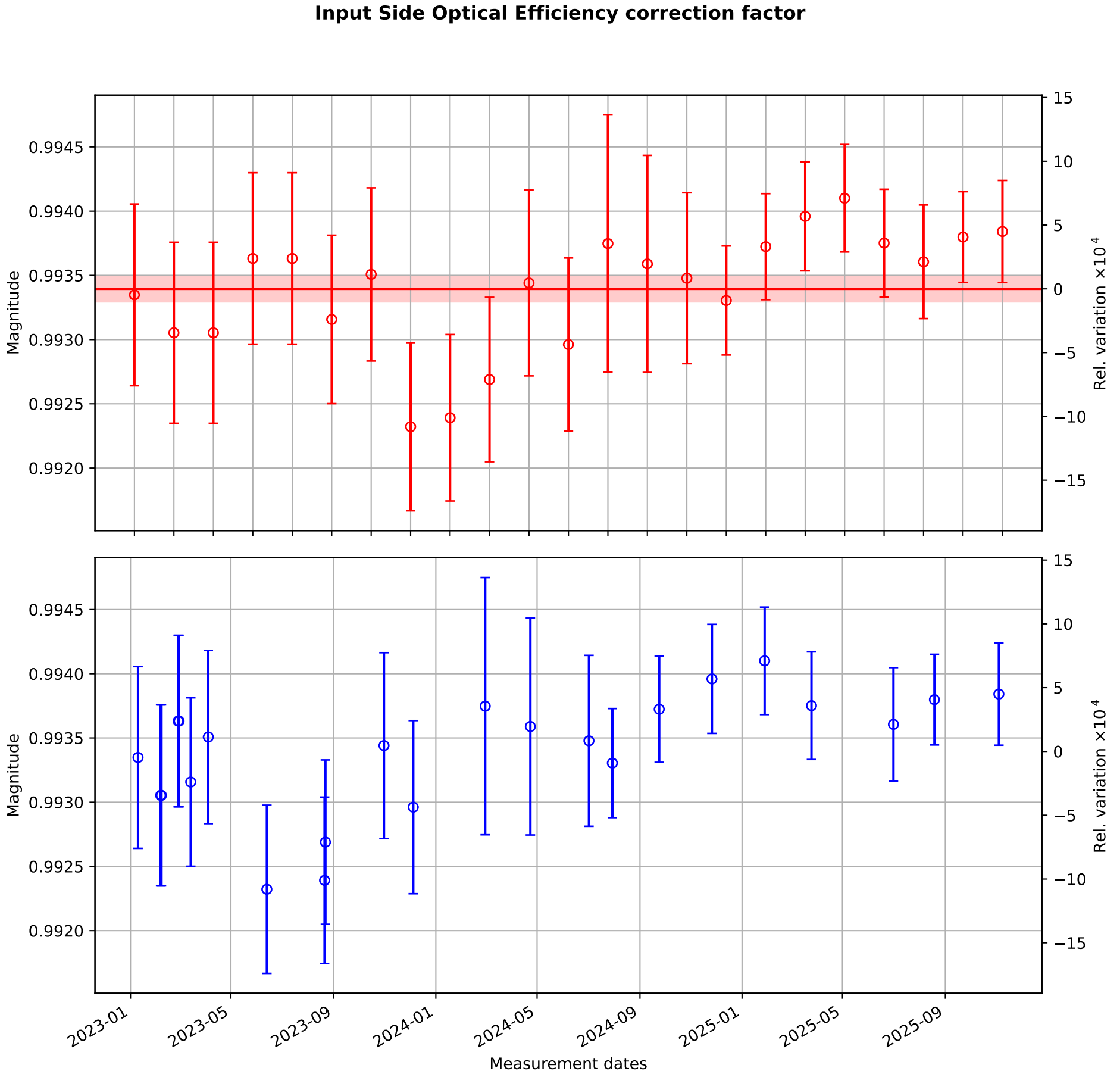

Overall Optical Efficiency
Magnitude
Rel. variation ×10⁴
0.990
0.989
0.988
0.987
0.986
0.985
20
10
0
−10
−20
−30
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

Date	E_T ± SD_E_T
D20230110	0.9933 ± 0.0007
D20230206	0.9931 ± 0.0007
D20230207	0.9931 ± 0.0007
D20230227	0.9936 ± 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
D20240702	0.9935 ± 0.0007
D20240730	0.9933 ± 0.0004
D20240924	0.9937 ± 0.0004
D20241126	0.9940 ± 0.0004
D20250128	0.9941 ± 0.0004
D20250325	0.9938 ± 0.0004
D20250701	0.9936 ± 0.0004
D20250819	0.9938 ± 0.0004
D20251104	0.9938 ± 0.0004

Summary of Input Side Optical Efficiency correction factor	E_T
Mean value:	0.993395
Standard deviation:	0.000472
Standard error:	0.000101
Relative Standard error:	0.000101

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.

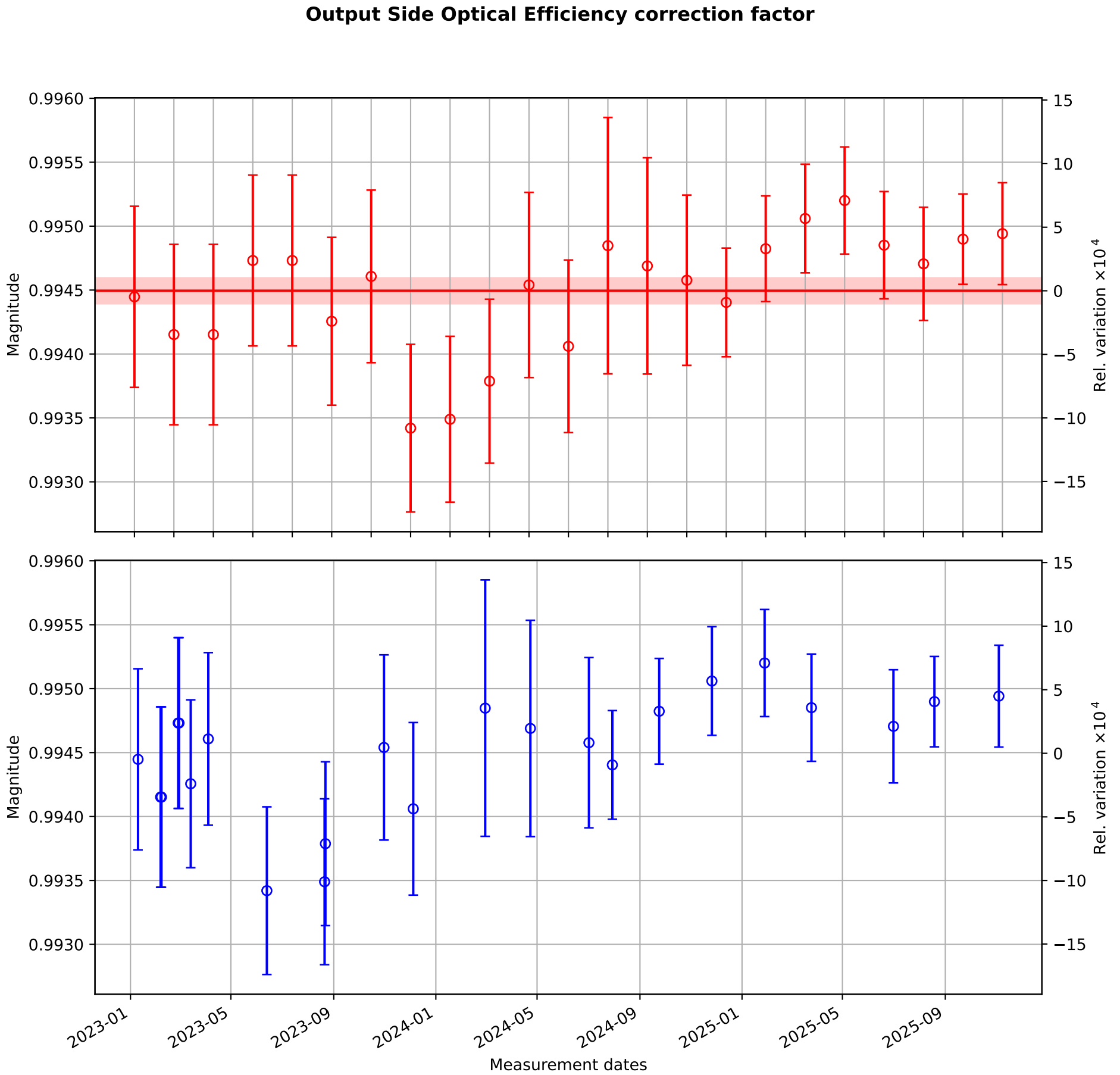

Input Side Optical Efficiency correction factor
Magnitude
Rel. variation ×10⁴
0.9945
0.9940
0.9935
0.9930
0.9925
0.9920
15
10
5
0
−5
−10
−15
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

Date	E_R None ± SD_None
D20230110	0.9944 ± 0.0007
D20230206	0.9942 ± 0.0007
D20230207	0.9942 ± 0.0007
D20230227	0.9947 ± 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
D20240702	0.9946 ± 0.0007
D20240730	0.9944 ± 0.0004
D20240924	0.9948 ± 0.0004
D20241126	0.9951 ± 0.0004
D20250128	0.9952 ± 0.0004
D20250325	0.9949 ± 0.0004
D20250701	0.9947 ± 0.0004
D20250819	0.9949 ± 0.0004
D20251104	0.9949 ± 0.0004

Summary of Output Side Optical Efficiency correction factor	E_R
Mean value:	0.994494
Standard deviation:	0.000472
Standard error:	0.000101
Relative Standard error:	0.000101

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.

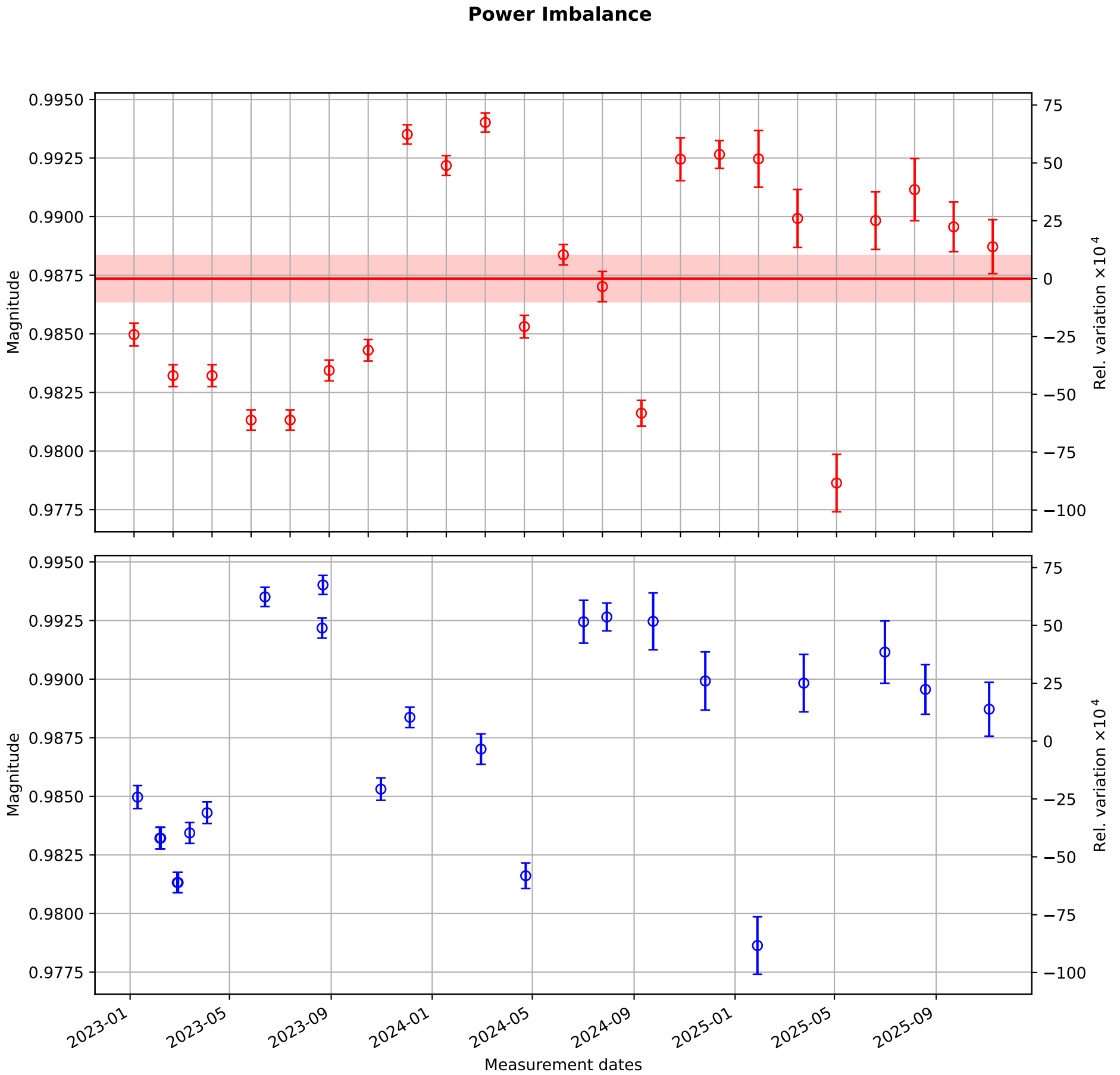

Output Side Optical Efficiency correction factor
Magnitude
Rel. variation ×10⁴
0.9960
0.9955
0.9950
0.9945
0.9940
0.9935
0.9930
15
10
5
0
−5
−10
−15
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates

	PowerImbalance
Date	None ± SD_None
D20230110	0.9850 ± 0.0005
D20230206	0.9832 ± 0.0005
D20230207	0.9832 ± 0.0005
D20230227	0.9813 ± 0.0004
D20230228	0.9813 ± 0.0004
D20230314	0.9834 ± 0.0004
D20230404	0.9843 ± 0.0005
D20230613	0.9935 ± 0.0004
D20230821	0.9922 ± 0.0004
D20230822	0.9940 ± 0.0004
D20231031	0.9853 ± 0.0005
D20231205	0.9884 ± 0.0004
D20240229	0.9870 ± 0.0006
D20240423	0.9816 ± 0.0005
D20240702	0.9924 ± 0.0009
D20240730	0.9927 ± 0.0006
D20240924	0.9925 ± 0.0012
D20241126	0.9899 ± 0.0012
D20250128	0.9786 ± 0.0012
D20250325	0.9898 ± 0.0012
D20250701	0.9912 ± 0.0013
D20250819	0.9896 ± 0.0011
D20251104	0.9887 ± 0.0012

	PowerImbalance
Summary of Power Imbalance	
Mean value:	0.987356
Standard deviation:	0.004629
Standard error:	0.000987
Relative Standard error:	0.000999

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
0.9950
0.9925
0.9900
0.9875
0.9850
0.9825
0.9800
0.9775
75
50
25
0
−25
−50
−75
−100
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Measurement dates