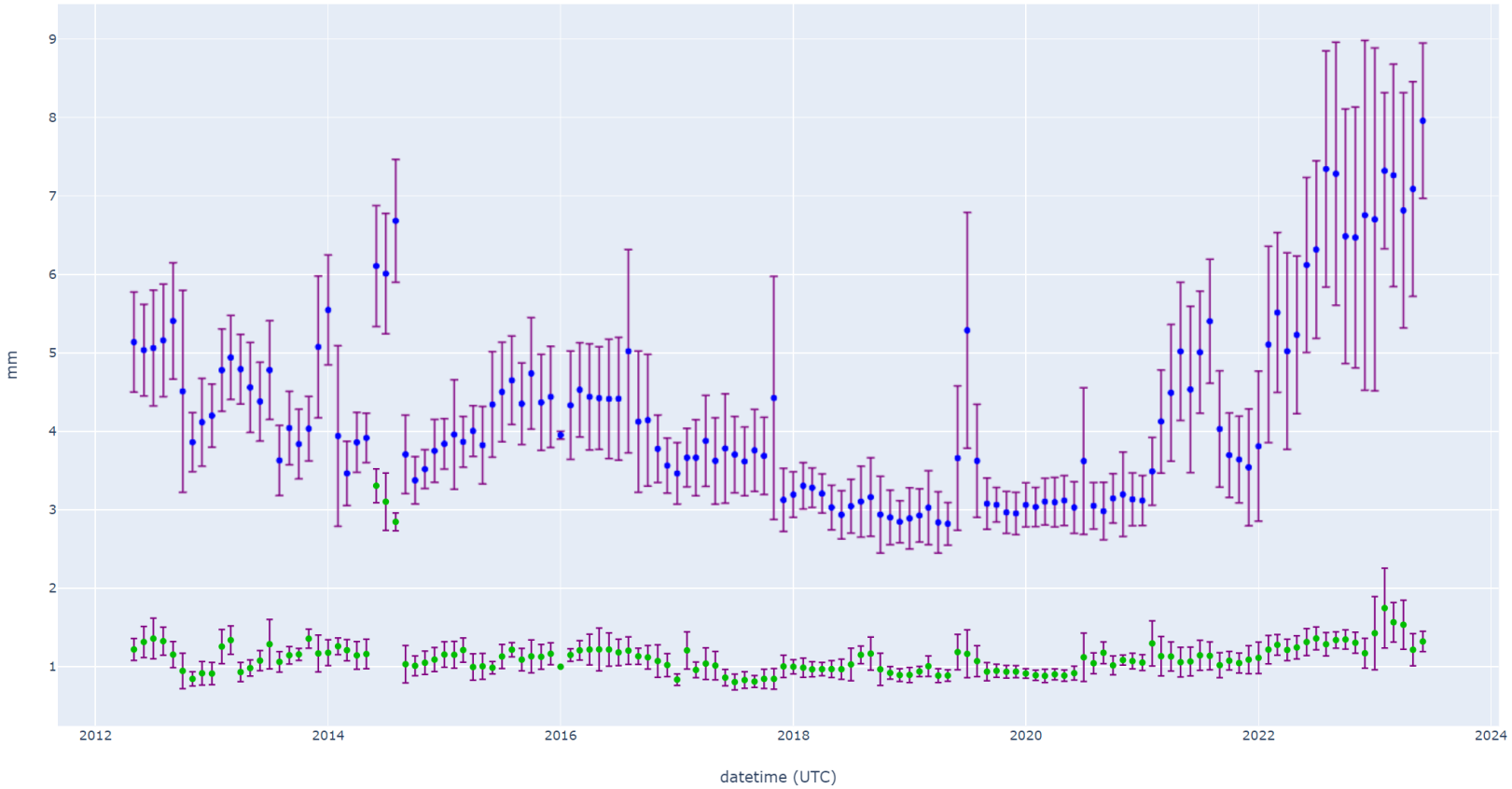
7941 MATM Analysis Update

Van Husson

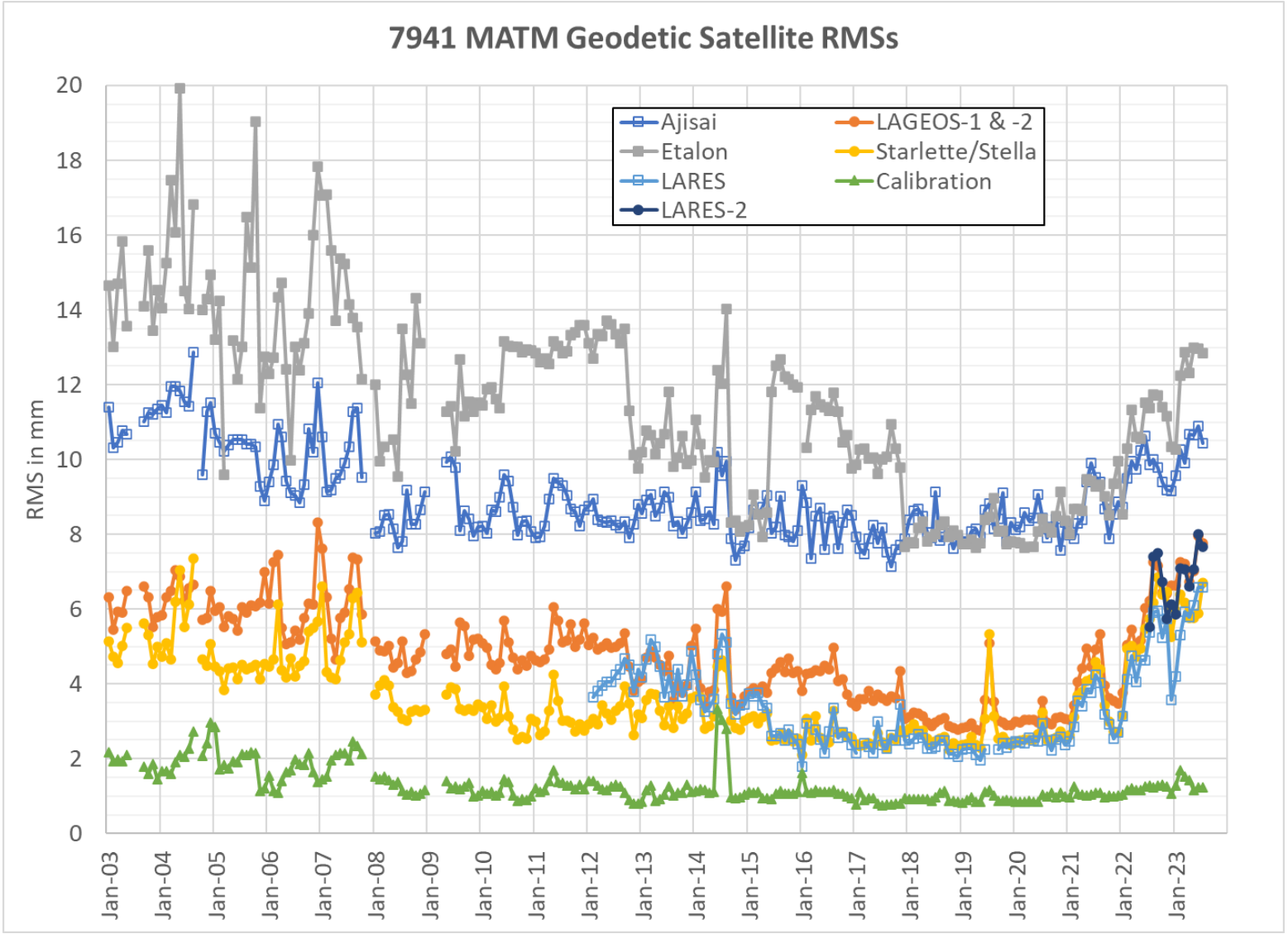
September 2023

7941 MATM Monthly LAGEOS and Calibration Single Shot RMSs



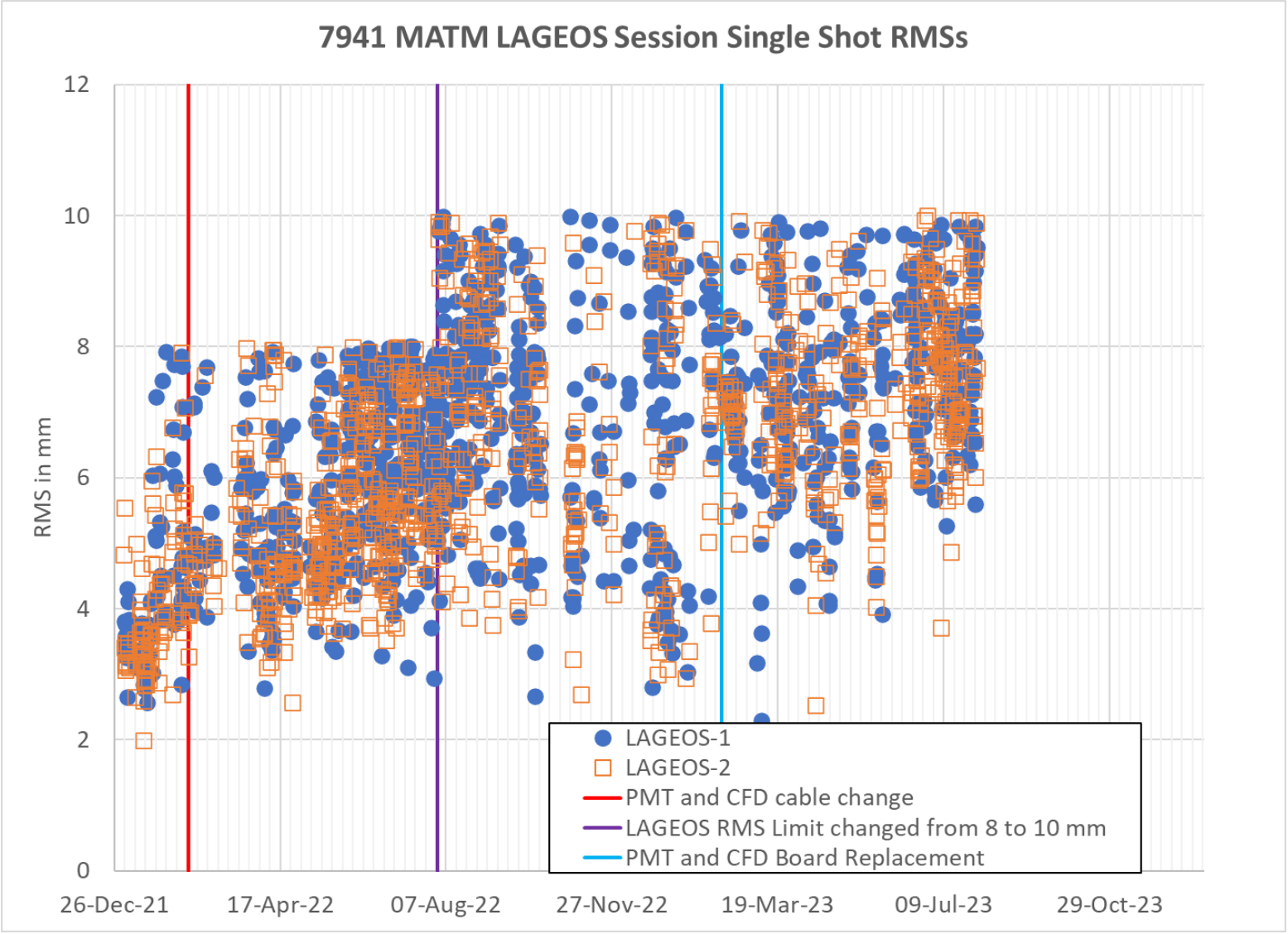
- 7941 MATM monthly LAGEOS and calibration RMSs available on the ILRS website at: https://ilrs.gsfc.nasa.gov/network/stations/active/MATM_station_info.html?LAG
- Blue and green circles are LAGEOS and calibration RMSs; respectively
- The LAGEOS RMS and calibration RMSs have been trending upwards

7941 MATM Monthly Single Shot Geodetuc Satellite and Calibration RMSs



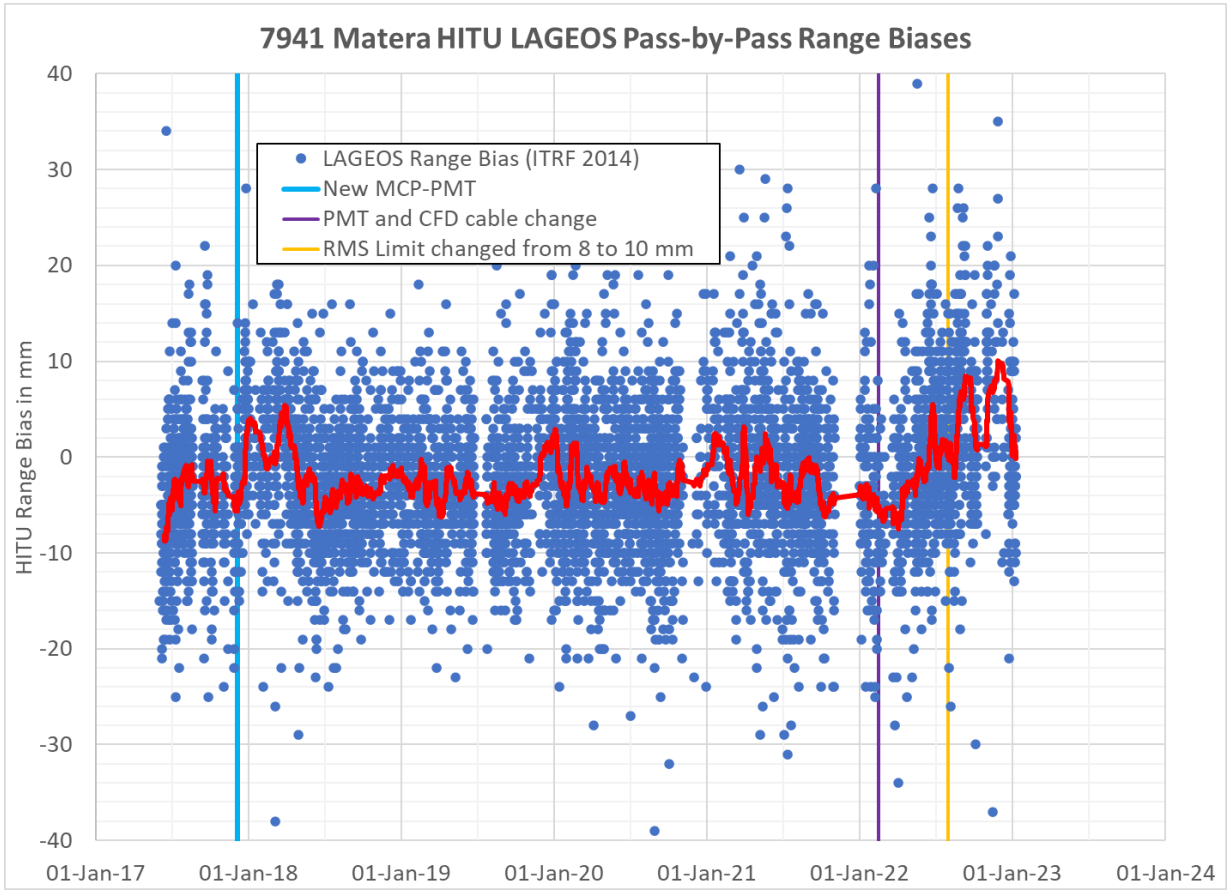
- **The lowest RMSs were achieved in 2018 and 2020. Since the beginning of 2021, RMSs have been trending upward**

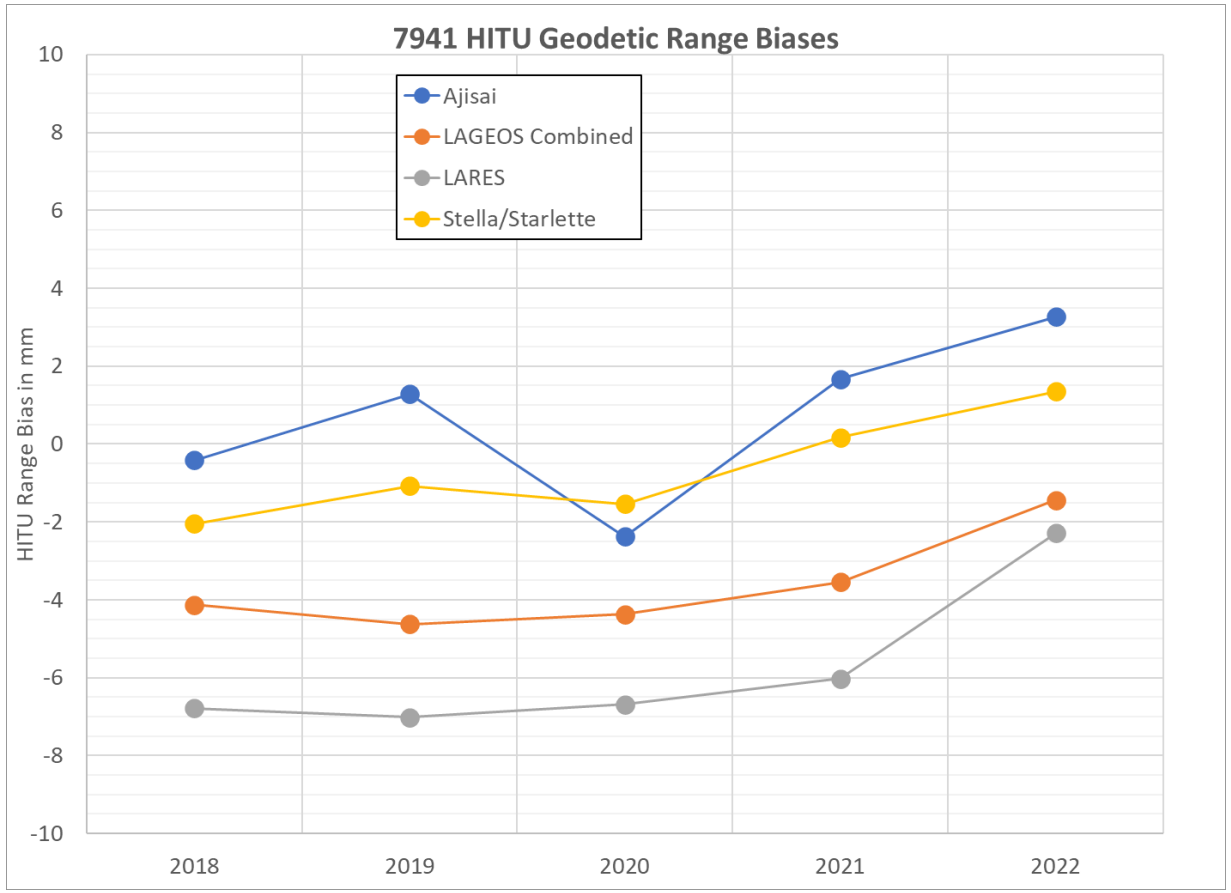
7941 MATM 2022 LAGEOS-1, -2 Single Shot Session RMSs



- On August 1, 2022 the 8 mm editing threshold was raised to 10 mm
- The PMT and CFD changes noted in the chart did not appear to have any impact on the LAGEOS RMSs

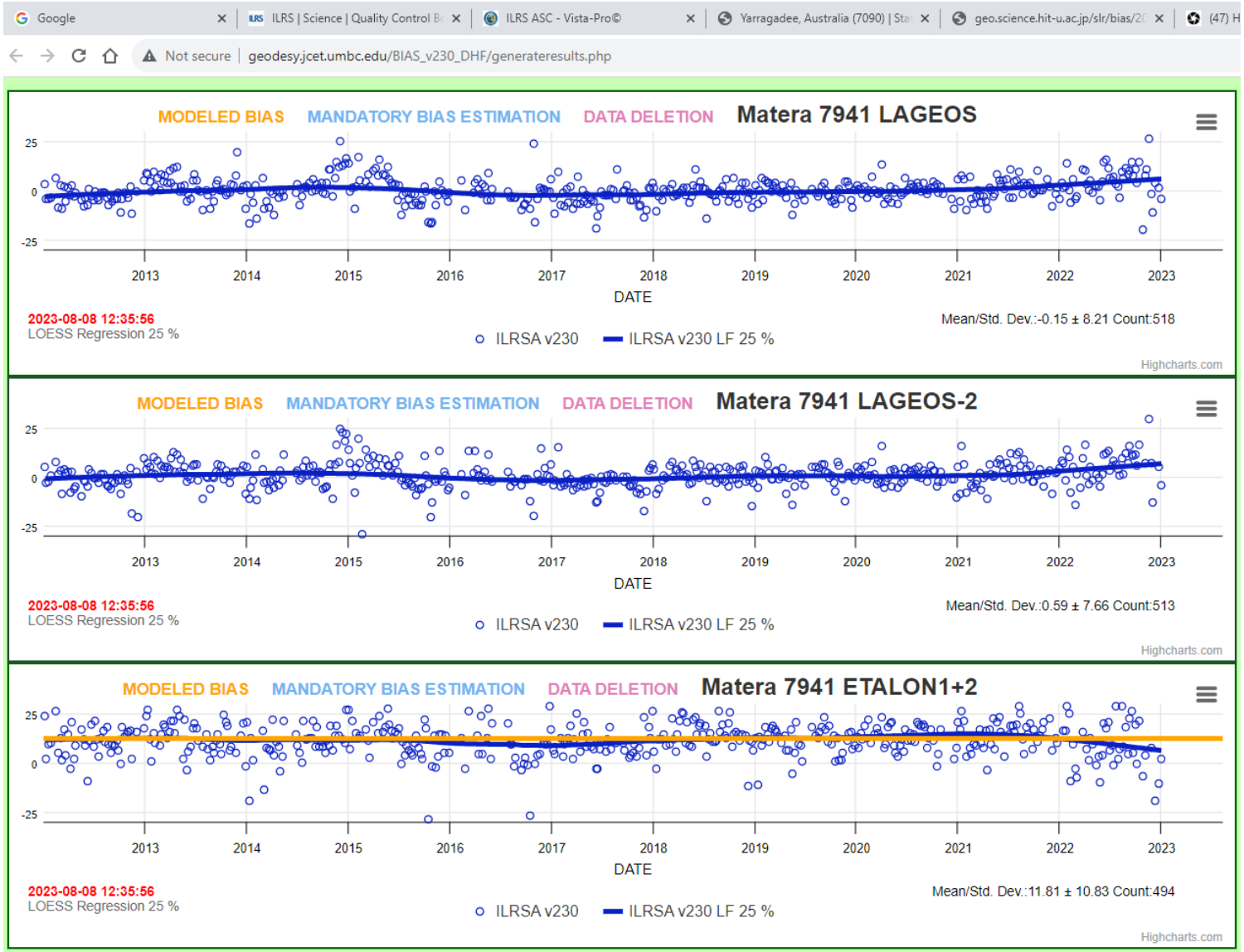
7941 MATM HITU Geodetic Range Biases





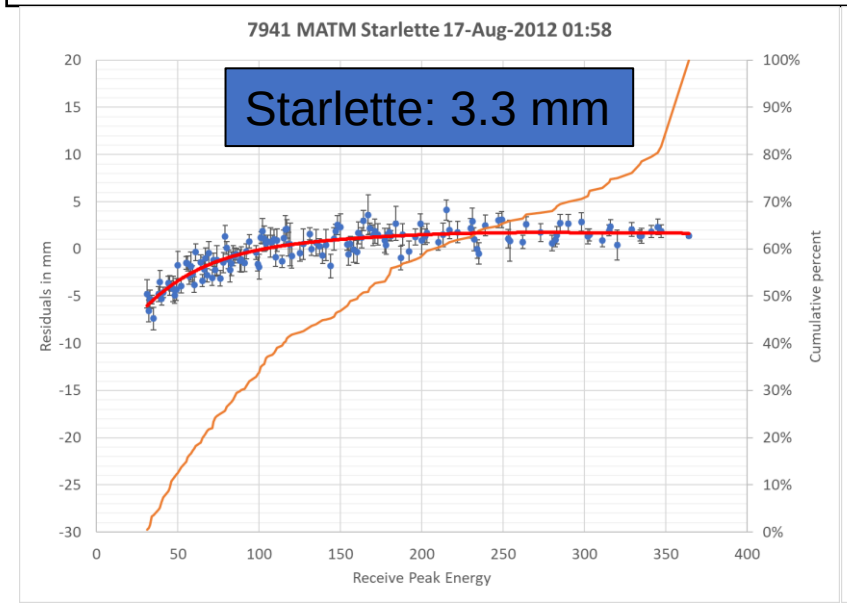
- Left chart: HITU LAGEOS pass-by-pass range bias estimates (ITRF 2014 coordinates)
- Right chart: HITU yearly geodetic ranges biases
- For 2018-2020 the yearly geodetic range bias were stable, but started to drift positive in 2021 as the single shot RMSs increased after PMT and CFD changes

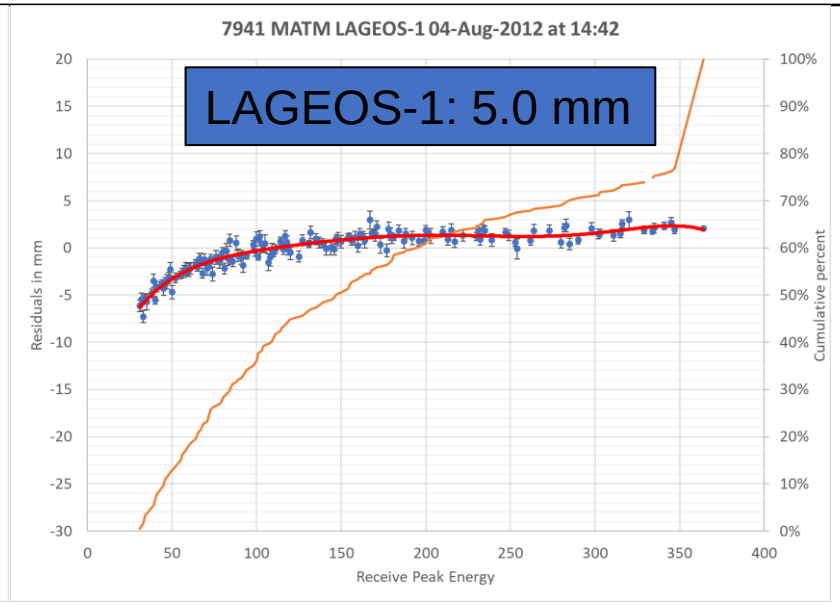
7941 MATM SSEM Range Bias Estimates

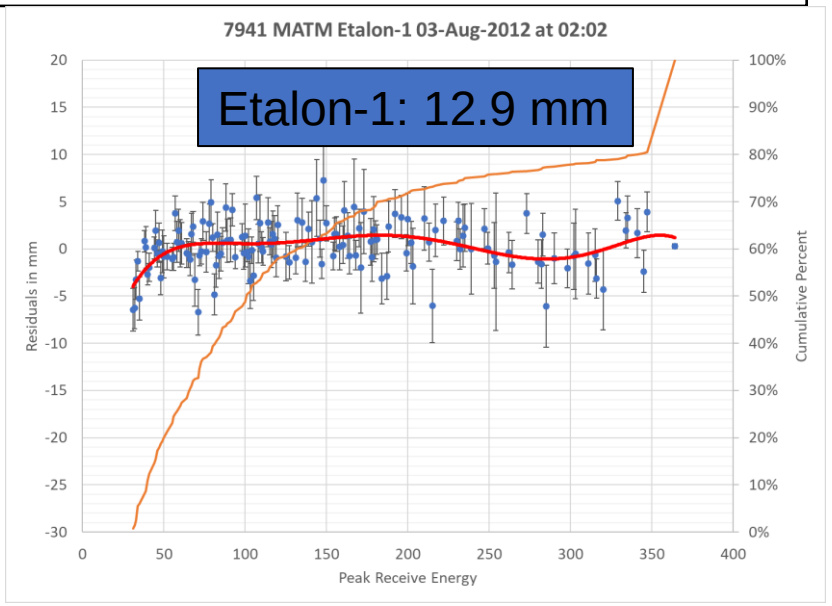


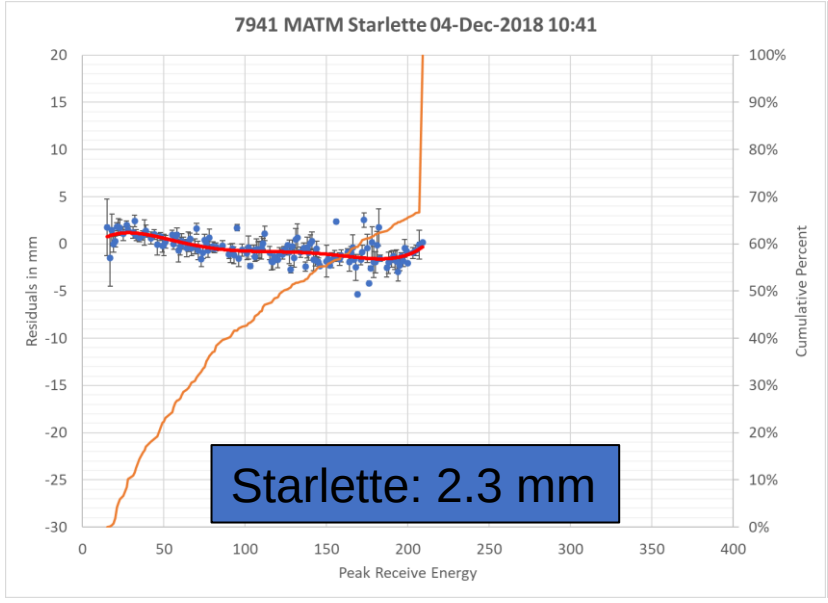
- **In 2022, the SSEM LAGEOS range bias appears to be increasing, while the SSEM Etalon range bias appears to be decreasing**

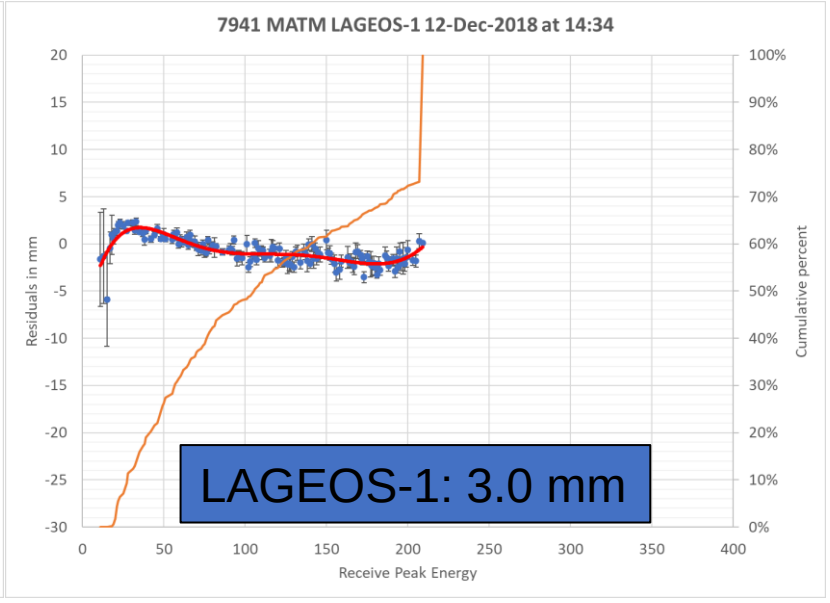
7941 MATM Receive Timewalk and RMSs in 2012 and 2018

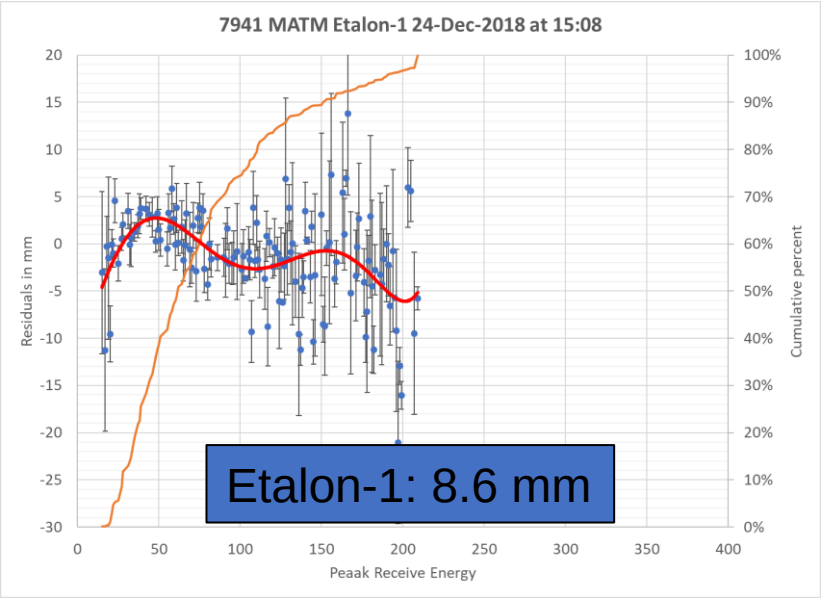




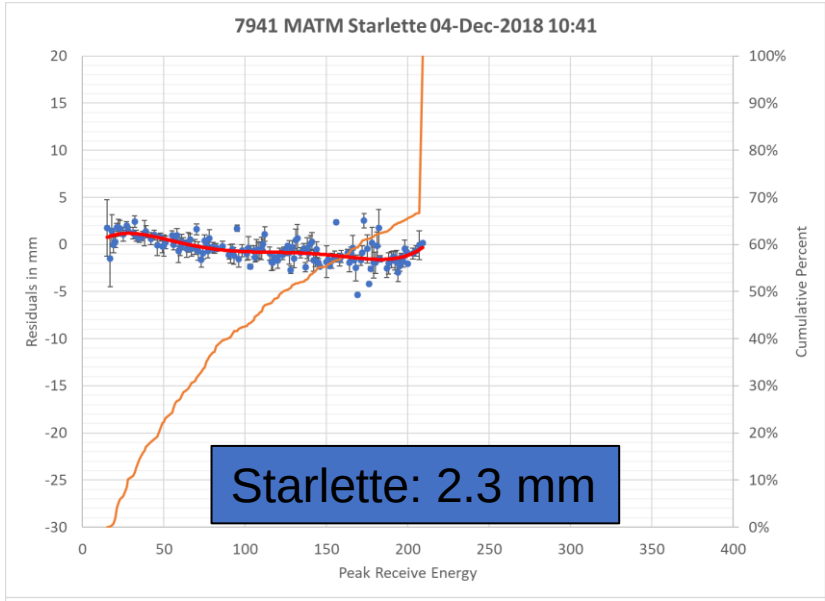


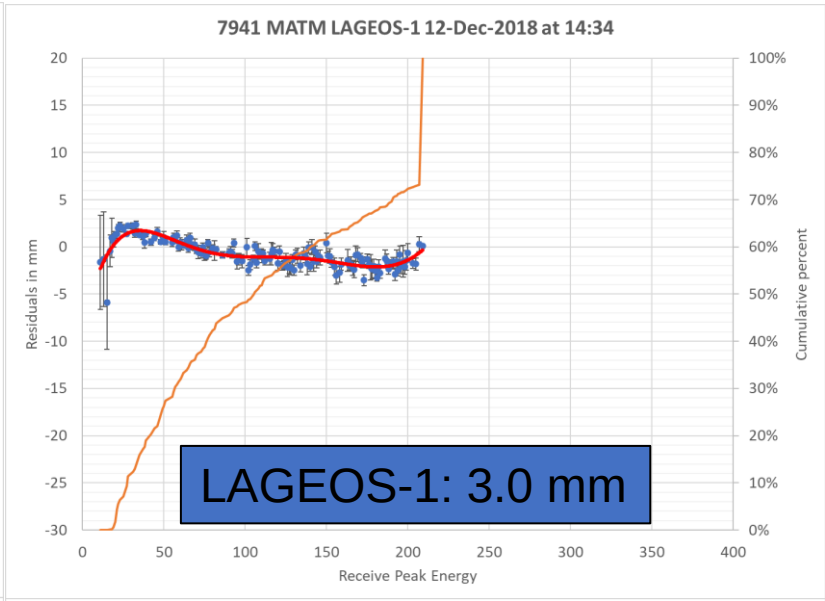


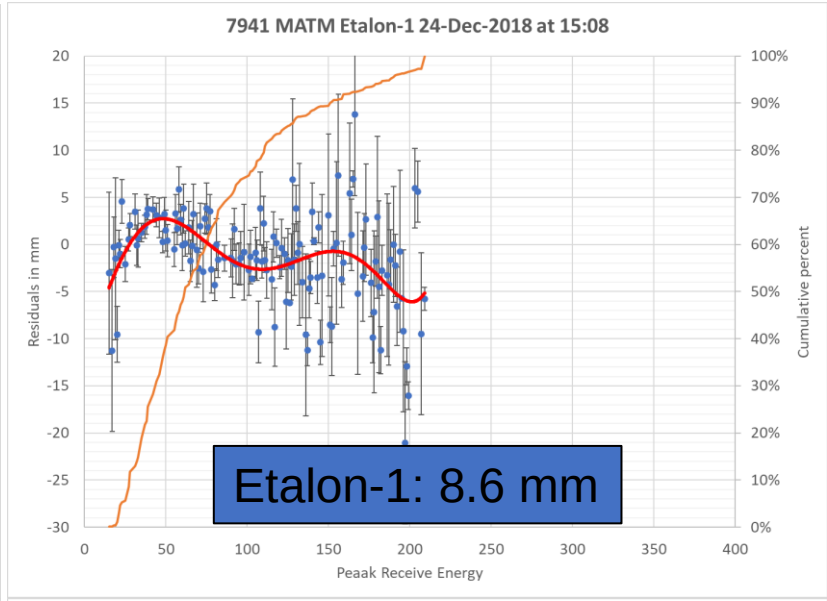


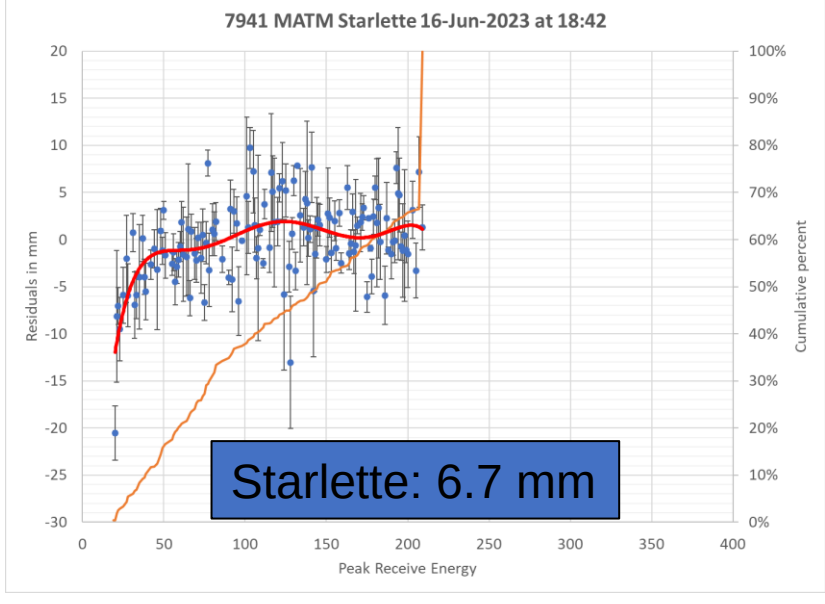


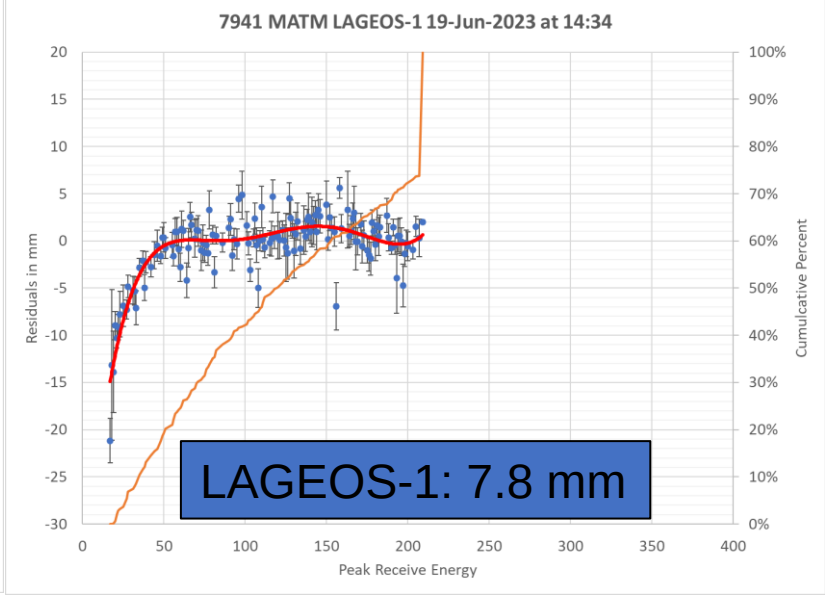
7941 MATM Receive Timewalk and RMSs in 2018 and 2023

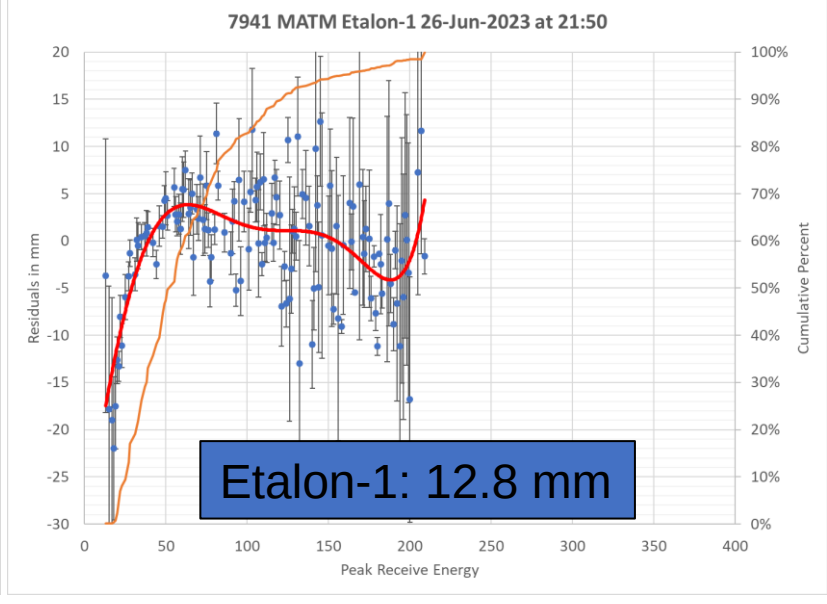




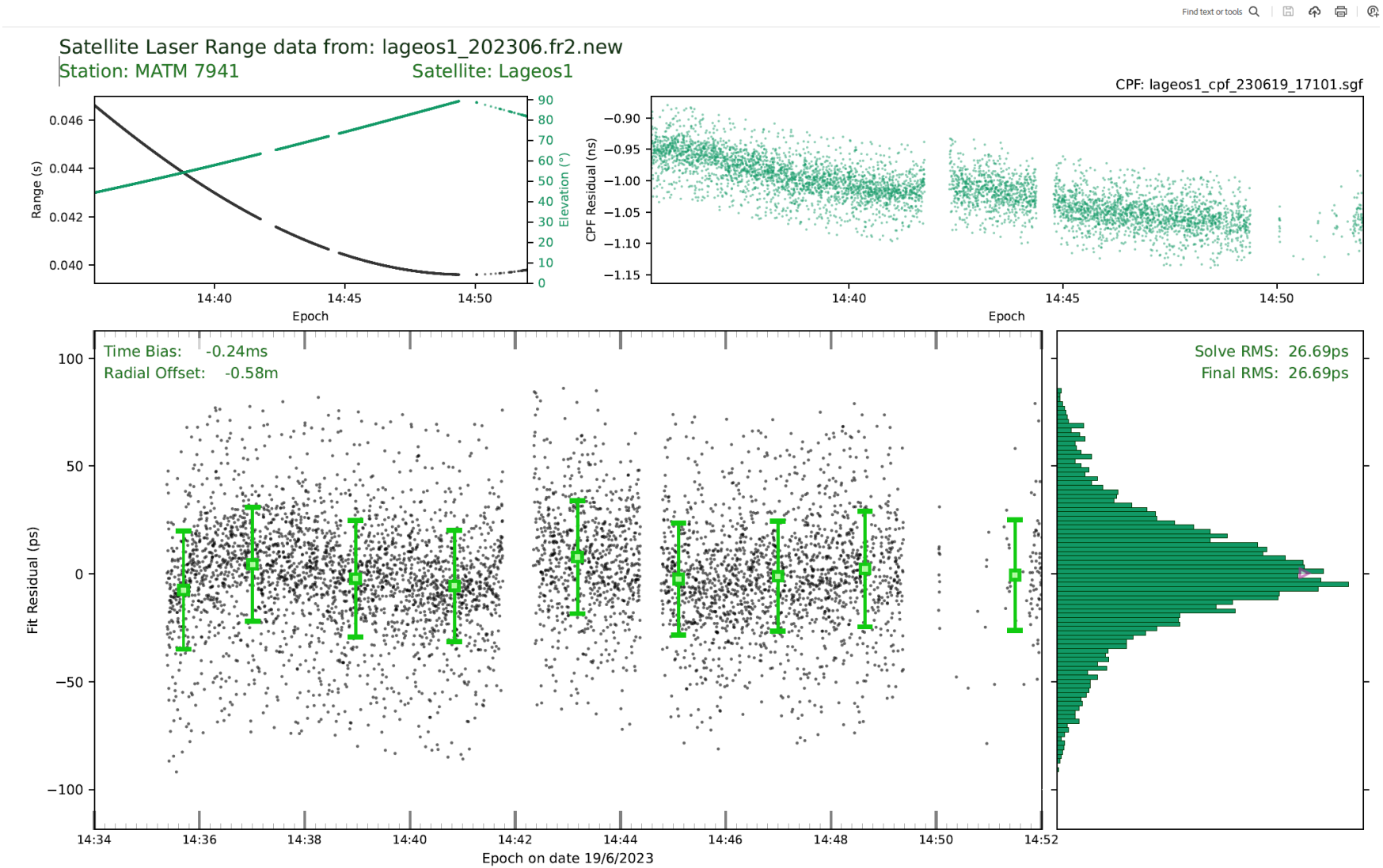








7941 MATM OrbitNP LAGEOS Residuals (19-Jun-2023 at 14:35)



Summary

- Some of the legacy core ILRS systems are old (i.e. 20+ to 40+ years old) and keeping them operational is challenging due to component obsolescent. A failing component or interface can induce a change in a station's bias (i.e. range and/or epoch). One indicator of a failing component is an increase and/or instability in single shot RMSs and/or system delay. Determining which component is failing is not always easy

- The increase in 7941 MATM single shot RMSs have altered their range bias at the mm level

- The 7941 MATM receive peak energy measurement upper bound has decreased over time. Is the automatic receive peak energy timewalk correction working properly?

Compiled 10/17/2006 by FGL & CN from ILRS site logs on web.

Name	Location	Num ID	Event Timer	Date Installed	date rem	Target dist m	2-way ToF microsecs	Calib val microsecs	Total ToF microsecs	Est. Cal Err mm	Est Max err at LAGEOS	Est Total err for LAGEOS
Operational sites												
AREQ	Arequipa	7403	HP5370B	7/10/1992								
BEIL	Beijing	7249	Stanford SR620	1/20/2001		"188.7"	"1.26"	"0.12"	"1.38"	"12"	"10"	"22"
BORL	Borowiecz	7811	Stanford SR620	5/7/2002		"241.1"	"1.61"	"0.00"	"1.61"	"9"	"0" measure	"9"
BORL	Borowiecz	7811	Warsaw Univ. Technology, PS500	9/28/1994	5/7/2002							
BREF	Brest	7604	Stanford SR620	7/1/2001		"181.0"	"1.21"		"1.21"	"10"	"10"	"20"
CHAL	Changchun	7237	HP5370B	1/1/1992								
CONL	Concepcion,	7405	Peso Consulting, PET4	7/1/2000								
GLSV	Kiev	1824	Stanford SR620	11/10/1999		"121.0"	"0.81"	"0.14"	"0.95"	"6"	"10"	"16"
GMSL	Tangeshima	7358	Honeywell	12/1/2004								
GODL	Goddard	7839	HP5370B	3/31/1986								
GRAZ	Graz, Austria	7839	Dassault	8/1/2000								
GRSM	Grasse	7845	Dassault	8/1/1995								
HA4T	Haleakala (T	7119	HP5370B	3/1/2005								
HARL	Hartebeesth	7501	HP5370B	6/9/2000								
HELW	Helwan	7831	Stanford SR620	5/15/1999		"1.0"	"0"		"0.1"	"0"	"10"	"10"
HERL	Herstmoncea	7840	Stanford SR620	1/1/1995		"120.0"	"0.8"	"0.10"	"0.9"	"7"	"0" **	"7"
KOGC	Koganei	7308	EOS/MRCS KSP	9/20/2002								
KOML	Komsomolsk	1868	?????	????								
KTZL	Katzively, UI	1893	Stanford SR620	6/20/1998		"0.0"	"0.0"	"0.05"	"0.05"	"0"	"10"	"10"
KUNL	Kunming, Ch	7820	Stanford SR620	5/20/1998		"202.5"	"1.35"	"-"	"1.35"	"9"	"10"	"19"
LV1L	Lviv, Ukraine	1831	Latvian Univ A911-E	10/1/1998								
MAID	Maidenak 1	1863	?????	????								
MAIL	Maidenak 2	1864	?????	????								
MATM	Matera	7941	HTSI	1/1/2000								
MDOL	Mcdonald	7080	EGG TD811	6/6/1990								
MDVL	Mendeleevo	1870	?????	4/17/1994								
METL	Metsahovi	7806	Latvian Univ, Comtis 911E	10/15/1996								
MONP	Monument P	7110	HP5370B	3/31/1986								
POT3	Potsdam	7841	Stanford SR620	7/20/2001	2/19/2004	"2.0"	"0"	"0.08"	"0.08"	"0"	"10"	"10"
POT3	Potsdam	7841	IECS Riga AO31ET	2/19/2004								
POTL	Potsdam	7836	Stanford SR620	5/8/1992		"2.5"	"0"	"0.05"	"0.05"	"0"	"5" measure	"10"
RIGL	Riga, Latvia	1884	Latvian Univ, SETIC-9801	2/8/1999								
RIYL	Riyadh	7832	EOS V.3	1/1/1992								
SFEL	San Fernand	7824	HP5370A	8/1/1999	8/10/2001							
SFEL	San Fernand	7824	Stanford SR620i	8/10/2001		"2.3"	"0"	"0.06"	"0.06"	"0"	"8" measure	"8"
SHA2	Shanghai	7821	HP5370B	7/10/2005								
SIML	Simeiz, Ukra	1873	HP5370B	8/1/2000								
SISL	Simosato, Ja	7838	HP5370B	0/0/1998	6/30/2004							
SISL	Simosato, Ja	7838	Stanford SR620	7/1/2004		"1414.7"	"9.43"	"0.0"	"9.43"	"-1"	"10"	"9"
SJUL	San Juan	7406	Stanford SR620	1/20/2006		"2.1"	"0"	"0.05"	"0.05"	"0"	"10"	"10"
STL3	Mt Stromlo	7825	EOS	4/8/2004								
THTL	Tahiti	7124	HP5370B	8/1/1997								
WETL	Wettzell	8834	Peso Consulting, PET4	10/12/2000								
WETL	Wettzell	8834	LeCroy 2229	3/1/1989	10/12/2000							
WUHL	Wuhan	7231	Stanford SR620	1/1/1999		"0.7"	"0"	"0.03"	"0.03"	"0"	"10"	"10"
YARL	Yarragadee	7090	HP5370B	1/16/1998								
ZIML	Zimmerwald	7810	Stanford SR620	1/1/1997		"2.5","659"	"0", "4.4"	"0.11"	"0.11","4.51	"0","3"	"8" measure	"11"
ZIML	Zimmerwald	7810	IECS Riga AO32ET	3/22/2006								
Mobile sites												
FTLRS	Mobile		Stanford SR620	7/1/2001								
TROS	Mobile		Stanford SR620	2/1/2000		"0.6"	"0"		"0.1"	"0"	"10"	"10"
Closed sites												
BEIA	Beijing	7357	HP5370B	7/20/1994								
CGLL	Cagliari	7548	HP5370B	9/30/1987								
GRSL	Grasse	7835	Stanford SR620	9/1/1995		"1.9"	"0"	"0.19"	"0.19"	"1"	"10"	"11"
HALL	Haleakala	7210	HP5370B	8/14/2000								
KASL	Kashima, Ja	7335	EOS/MRCS KSP	4/1/1997								
KOGL	Koganei	7328	EOS/MRCS KSP	4/1/1997								
STRL	Mt Stromlo,	7849	EOS/MRCS KSP	6/19/1998								
SHAL	Shanghai	7837	HP5370	4/1/1990								
TATL	Tateyama, J	7339	EOS/MRCS KSP	4/1/1997								
WETT	Wettzell (TI	7594	Peso Consulting, PET4	7/1/2000							** table of corrections in SLRMail "0891"	

ITRF 2014 and 2020 SLR Site Velocity Comparisons

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ILRS QCB

Peraton

ITRF SLR Site Up Velocity Comparisons

PAD ID	Location	ITRF 2014 Up Velocity in mm/year	ITRF2020 Up Velocity in mm/year	ITRF2020-ITRF2014 Up Velocity in mm/year
1824	Golosiiv, Ukraine	-17.81	-0.34	-17.47
1868	Komsomolsk-na-Amure, Russia	2.26	-1.08	3.35
1873	Simeiz, Ukraine	3.06	0.16	2.90
1884	Riga, Latvia	-8.58	0.31	-8.89
1893	Katzively, Ukraine	3.05	0.15	2.90
7080	McDonald Observatory, Texas	-1.07	-0.53	-0.54
7090	Yarragadee, Australia	-0.48	-0.83	0.35
7105	Greenbelt, Maryland	-0.91	-1.36	0.45
7119	Haleakala, Hawaii	-0.24	-1.10	0.86
7124	Tahiti, French Polynesia	-0.88	-0.50	-0.39
7237	Changchun, China	-4.04	-0.89	-3.16
7249	Beijing, China	0.87	3.83	-2.96
7501	Hartebeesthoek, South Africa	1.92	1.44	0.47
7810	Zimmerwald, Switzerland	0.70	0.86	-0.16
7811	Borowiec, Poland	-2.09	-0.42	-1.67
7821	Shanghai, China	-2.15	-2.04	-0.11
7824	San Fernando, Spain	0.28	-1.11	1.40
7825	Mt Stromlo, Australia	-0.02	-0.06	0.04
7838	Simosato, Japan	3.25	-0.81	4.06
7839	Graz, Austria	0.56	-0.24	0.81
7840	Herstmonceux, United Kingdom	-0.17	-0.63	0.46
7841	Potsdam, Germany	-0.51	0.11	-0.62
7845	Grasse, France (LLR)	-0.33	-0.58	0.25
7941	Matera, Italy (MLRO)	-0.08	0.14	-0.22
8834	Wettzell, Germany	0.80	0.00	0.80

- **ITRF2020 SLR Site Up Velocities appear to be much more realistic for several active SLR sites**
- **An up-velocity change of 1 mm/year is a 31 mm height change since LAGEOS-2 launch (October 1992 to October 2023)**
- **Solving for range biases in ITRF2020 has made some significant improvements in site up velocities**
- **When the ILRS analysis centers, which generate the pass-by-pass range bias reports, update to ITRF2020 coordinates, the range biases estimates should be closer to the truth**

ITRF SLR Site North Velocity Comparisons

PAD ID	Location	ITRF 2014 North Velocity in mm/year	ITRF2020 North Velocity in mm/year	ITRF2020-ITRF2014 North Velocity in mm/year
1824	Golosiiv, Ukraine	13.85	16.29	2.44
1868	Komsomolsk-na-Amure, Russia	-13.46	-13.87	-0.41
1873	Simeiz, Ukraine	8.47	7.59	-0.88
1884	Riga, Latvia	14.24	13.32	-0.91
1893	Katzively, Ukraine	8.48	7.60	-0.88
7080	McDonald Observatory, Texas	-5.40	-5.32	0.08
7090	Yarragadee, Australia	57.96	57.78	-0.18
7105	Greenbelt, Maryland	3.89	4.03	0.14
7119	Haleakala, Hawaii	34.76	34.56	-0.20
7124	Tahiti, French Polynesia	34.21	34.25	0.03
7237	Changchun, China	-11.81	-12.18	-0.38
7249	Beijing, China	-11.72	-10.05	1.67
7501	Hartebeesthoek, South Africa	17.99	17.74	-0.25
7810	Zimmerwald, Switzerland	16.36	16.22	-0.14
7811	Borowiec, Poland	15.07	14.70	-0.38
7821	Shanghai, China	-12.27	-12.72	-0.45
7824	San Fernando, Spain	17.54	17.53	-0.02
7825	Mt Stromlo, Australia	55.32	55.31	-0.01
7838	Simosato, Japan	n/a	n/a	
7839	Graz, Austria	15.67	15.55	-0.12
7840	Herstmonceux, United Kingdom	16.46	16.32	-0.14
7841	Potsdam, Germany	15.30	15.21	-0.09
7845	Grasse, France (LLR)	16.36	16.02	-0.33
7941	Matera, Italy (MLRO)	19.17	19.15	-0.02
8834	Wettzell, Germany	15.82	15.37	-0.45

- **A velocity change of 1 mm/year is a 31 mm change since LAGEOS-2 launch (October 1992 to October 2023)**
- **Based on a LAGEOS range rate of 3mm/μseconds, a 31 mm change would equate to an epoch timing error of ~10 μseconds**
- **This is why is it important to for SLR stations to maintain epoch accuracy to <= 0.1 μseconds/100 nanoseconds**

ITRF SLR Site East Velocity Comparisons

PAD ID	Location	ITRF 2014 East Velocity in mm/year	ITRF2020 East Velocity in mm/year	ITRF2020-ITRF2014 East Velocity in mm/year
1824	Golosiiv, Ukraine	21.58	20.66	-0.92
1868	Komsomolsk-na-Amure, Russia	19.08	20.11	1.03
1873	Simeiz, Ukraine	25.61	24.70	-0.91
1884	Riga, Latvia	21.28	20.51	-0.77
1893	Katzively, Ukraine	25.61	24.70	-0.91
7080	McDonald Observatory, Texas	-12.59	-12.41	0.18
7090	Yarragadee, Australia	38.74	38.90	0.17
7105	Greenbelt, Maryland	-14.58	-14.60	-0.02
7119	Haleakala, Hawaii	-62.35	-62.09	0.26
7124	Tahiti, French Polynesia	-66.13	-65.92	0.21
7237	Changchun, China	26.97	26.35	-0.62
7249	Beijing, China	30.20	31.13	0.93
7501	Hartebeesthoek, South Africa	17.94	17.80	-0.14
7810	Zimmerwald, Switzerland	19.72	19.72	0.00
7811	Borowiec, Poland	19.81	20.13	0.32
7821	Shanghai, China	32.11	32.09	-0.02
7824	San Fernando, Spain	16.81	16.62	-0.19
7825	Mt Stromlo, Australia	18.12	18.48	0.36
7838	Simosato, Japan	n/a	n/a	
7839	Graz, Austria	21.67	21.77	0.10
7840	Herstmonceux, United Kingdom	16.98	17.16	0.18
7841	Potsdam, Germany	19.12	19.23	0.12
7845	Grasse, France (LLR)	20.45	20.39	-0.06
7941	Matera, Italy (MLRO)	19.12	19.23	0.12
8834	Wettzell, Germany	20.14	20.20	0.07

- **A velocity change of 1 mm/year is a 31 mm change since LAGEOS-2 launch (October 1992 to October 2023)**
- **Based on a LAGEOS range rate of 3mm/μseconds, a 31 mm change would equate to an epoch timing error of ~10 μseconds**
- **This is why is it important to for SLR stations to maintain epoch accuracy to <= 0.1 μseconds/100 nanoseconds**

Table 1. History Log Voids by Station (2023.09.26)

Station Location	CDP #	Time Gap(s)*				Last entry
Kiev	1824	000120-080302	080402-110515			141410
Komsomolsk	1868	NO DATA				
Simeiz	1873	NO DATA				
Mendeleevo	1874	NO DATA				
Altay	1879	NO DATA				
Riga	1884					230919
Arkhyz	1886	NO DATA				
Baikonur	1887	NO DATA				
Svetloe	1888	NO DATA				
Zelenchukskaya	1889	NO DATA				
Badary	1890	NO DATA				
Irkutsk	1891	NO DATA				
Katzively	1893	NO DATA				
Yarragadee	7090					230913
Greenbelt	7105					230426
Monument_Peak	7110					230630
Haleakala	7119					230809
Tahiti	7124	020825-080414	130321-191022			230520
Changchun	7237	950101-970802	020714-051002	180410-210106		211215
Beijing	7249	881101-940301	940301-981116	981116-211013		230425
Tsukuba	7306					230404
Sejong	7394	NO DATA				
Wuhan	7396	NO DATA				
Arequipa	7403	920718-951023	951023-981130	981130-010523		200629
San Juan, Argentina	7406	NO DATA				
Brasilia	7407	NO DATA				
Hartebeesthoek_HARL	7501	020409-081105				230711
Hartebeesthoek_HRTL	7503	NO DATA				
Izana	7701					230406
Zimmerwald_532	7810	030905-060203	080715-100901			230713
Borowiec	7811	030329-071227	080205-131218			211005
Kunming	7819					221212
Shanghai_2	7821	140222-170315	170720-190811			210922
San_Fernando	7824	900703-930222	971216-010124	090302-110601	180801-210518	220830
Mount_Stromlo_2	7825					210901
Wettzell_SOSW	7827	140501-160511	160511-190528	200424-230607		230607
Simosato	7838	900701-950810	950810-991007	991019-040701	080401-181212	211209
Graz	7839	150504-190311				230630
Herstmonceux	7840					230427
Potsdam_3	7841	040906-081026	081026-110501	170303-200303		211229
Grasse_MEO	7845	010601-200818				230215
Matera_MLRO	7941	140902-171204	171206-210629			230209
Wettzell	8834	980720-001012	001012-090324	090324-131021	170407-190604	210115

* Assuming at least 2 year data gap

Status 2022.10.19