More than three years of LIDAL measurement onboard the ISS Columbus Module

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Livio Narici[*+]

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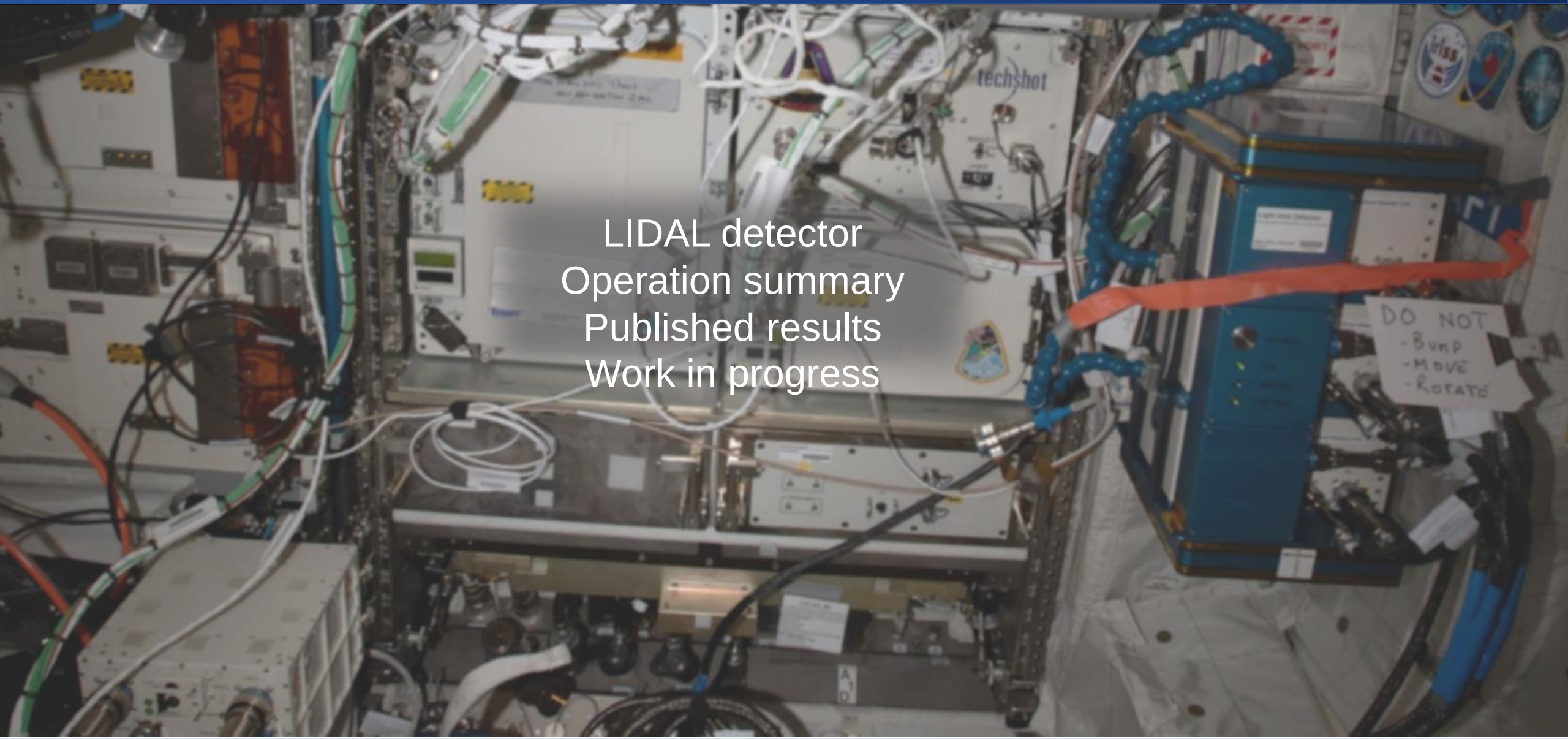
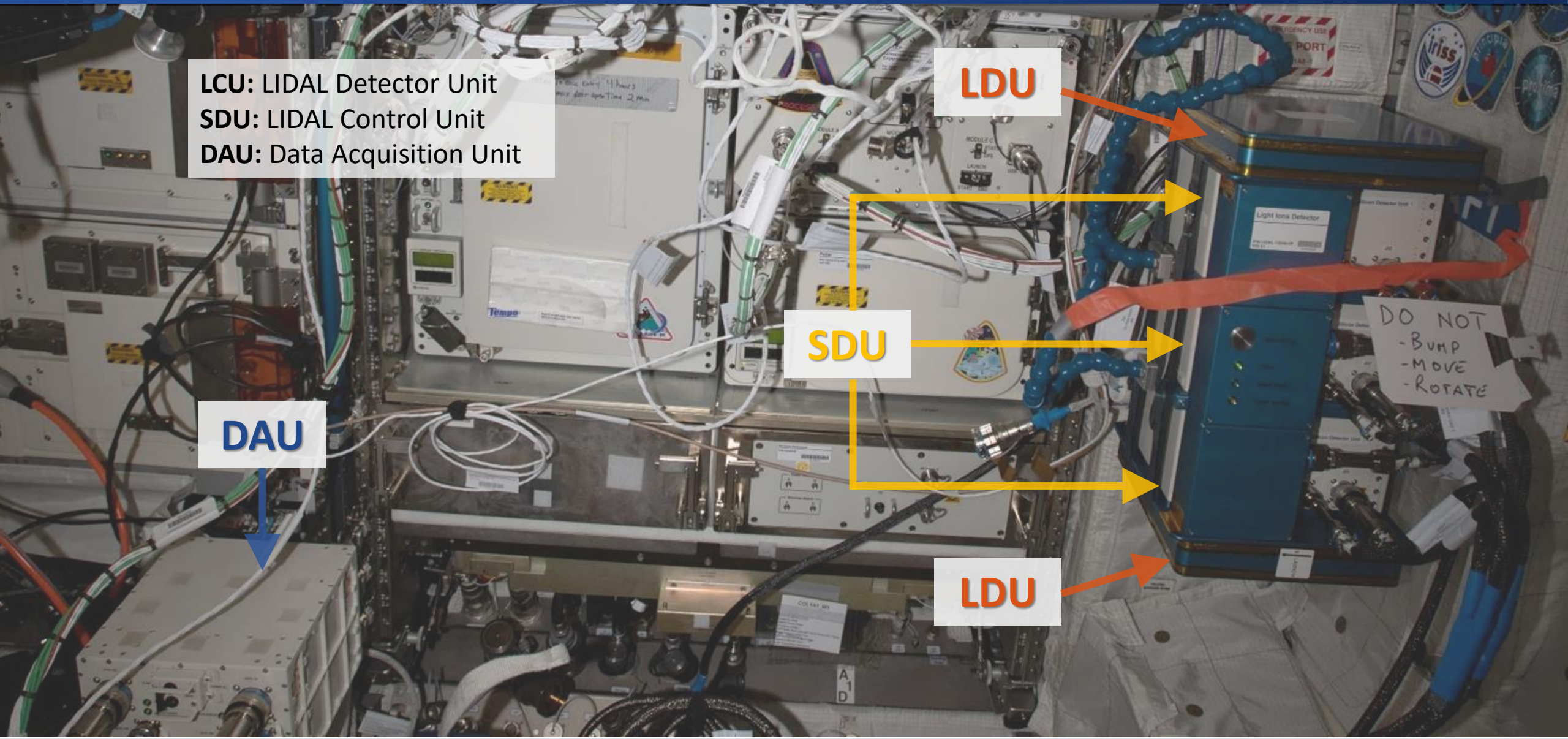
26th WRMISS in Rome, 5 – 7 September 2023

Overview



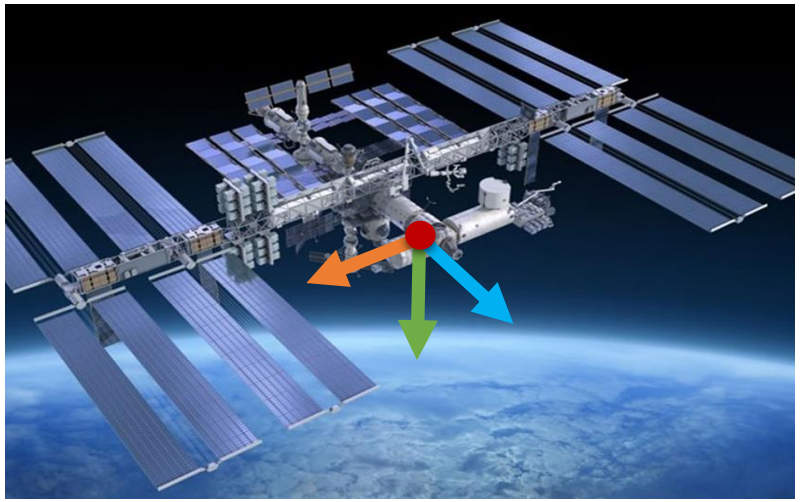
LIDAL detector
Operation summary
Published results
Work in progress

LIDAL description



Operation summary

ISS - Columbus module



Activated in 2020, Jan 19th by Italian astronaut Luca Parmitano (ESA Beyond Mission)

Active days

~ 1291 working days

Effective working time

~ 1.1 10^8 s (1218 days)

Total triggers

~ 1.39 10^9 triggers

Raw data size

~ 1.4-2.1 GB/day

~ 3.0 TB total

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2020	January	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	February	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		
	March	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
	April	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	
	May	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152
	June	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	
	July	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213
	August	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244
	September	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	
	October	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305
	November	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	
	December	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366
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	February	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59			
	March	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
	April	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	
	May	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151
	June	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	
	July	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212
	August	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243
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	October	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304
	November	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	
	December	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365
2022	January	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	February	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59			
	March	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
	April	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	
	May	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151
	June	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	
	July	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212
	August	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243
	September	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	
	October	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304
	November	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	
	December	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365
2023	January	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	February	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59			
	March	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
	April	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	
	May	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151
	June	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	
	July	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212
	August	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243
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	October	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304
	November	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	
	December	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365

Legenda
OFF (Nominal)
OFF
Z Direction
Y Direction
X Direction

More than three years of LIDAL measurement onboard the ISS Columbus Module

Published results

ARTICLE IN PRESS

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Radiation measurements in the International Space Station, Columbus module, in 2020–2022 with the LIDAL detector

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A B S T R A C T

The Light Ion Detector for ALTEA (LIDAL) is a new instrument designed to measure flux, energy spectra and Time of Flight of ions in a space habitat. It was installed in the International Space Station (Columbus) on January 19, 2020 and it is still operating. This paper presents the results of LIDAL measurements in the first 17 months of operation (01/2020–05/2022). Particle flux, dose rate, Time of Flight and spectra are presented and studied in the three ISS orthogonal directions and in the different geomagnetic regions (high latitude, low latitude, and South Atlantic Anomaly, SAA). The results are consistent with previous measurements. Dose rates range between 1.8 nGy/s and 2.4 nGy/s, flux between 0.21 particles/(sr cm^2 s) and 0.32 particles/(sr cm^2 s) as measured across time and directions during the full orbit. These data offer insights concerning the radiation measurements in the ISS and demonstrate the capabilities of LIDAL as a unique tool for the measurement of space radiation in space habitats, also providing novel information relevant to assess radiation risks for astronauts.

1. Introduction

In the next few decades human beings will return to the Moon and reach Mars for the first time. Among the hazards that the crew will face,

The radiation measurements which are the object of this paper are performed with a new detector specifically developed to provide information on the radiation environment in a space habitat (ISS) with a degree of detail aimed at satisfying the most recent requirements of the

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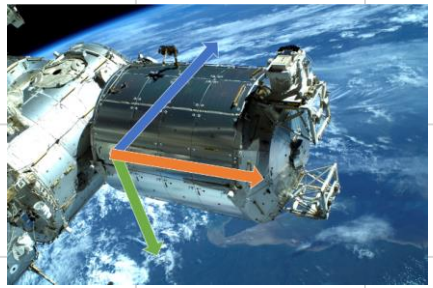
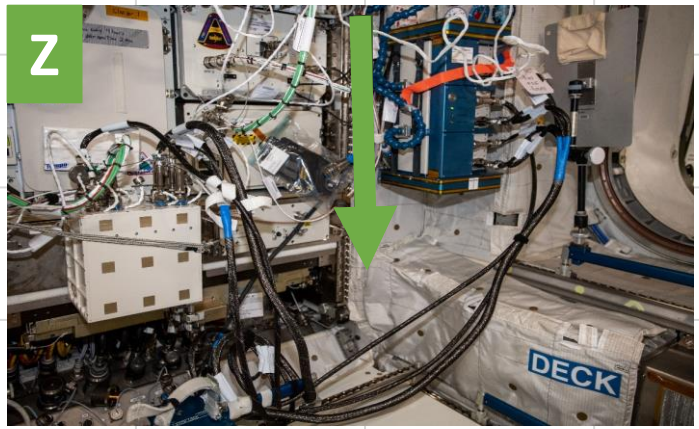
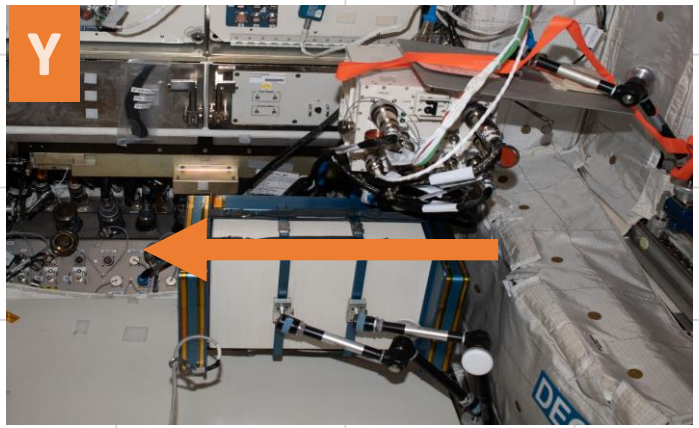
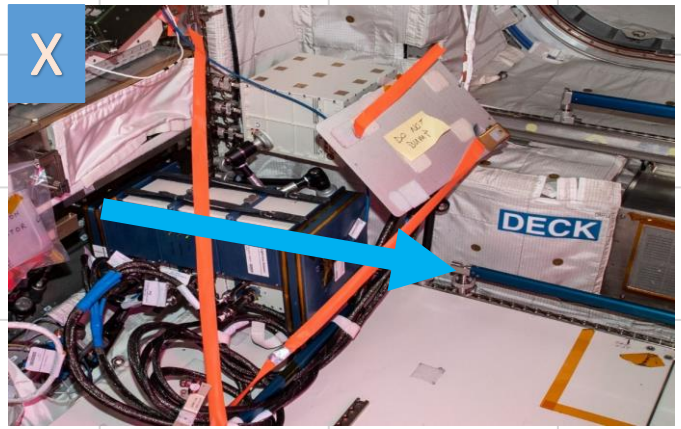
Daily Flux







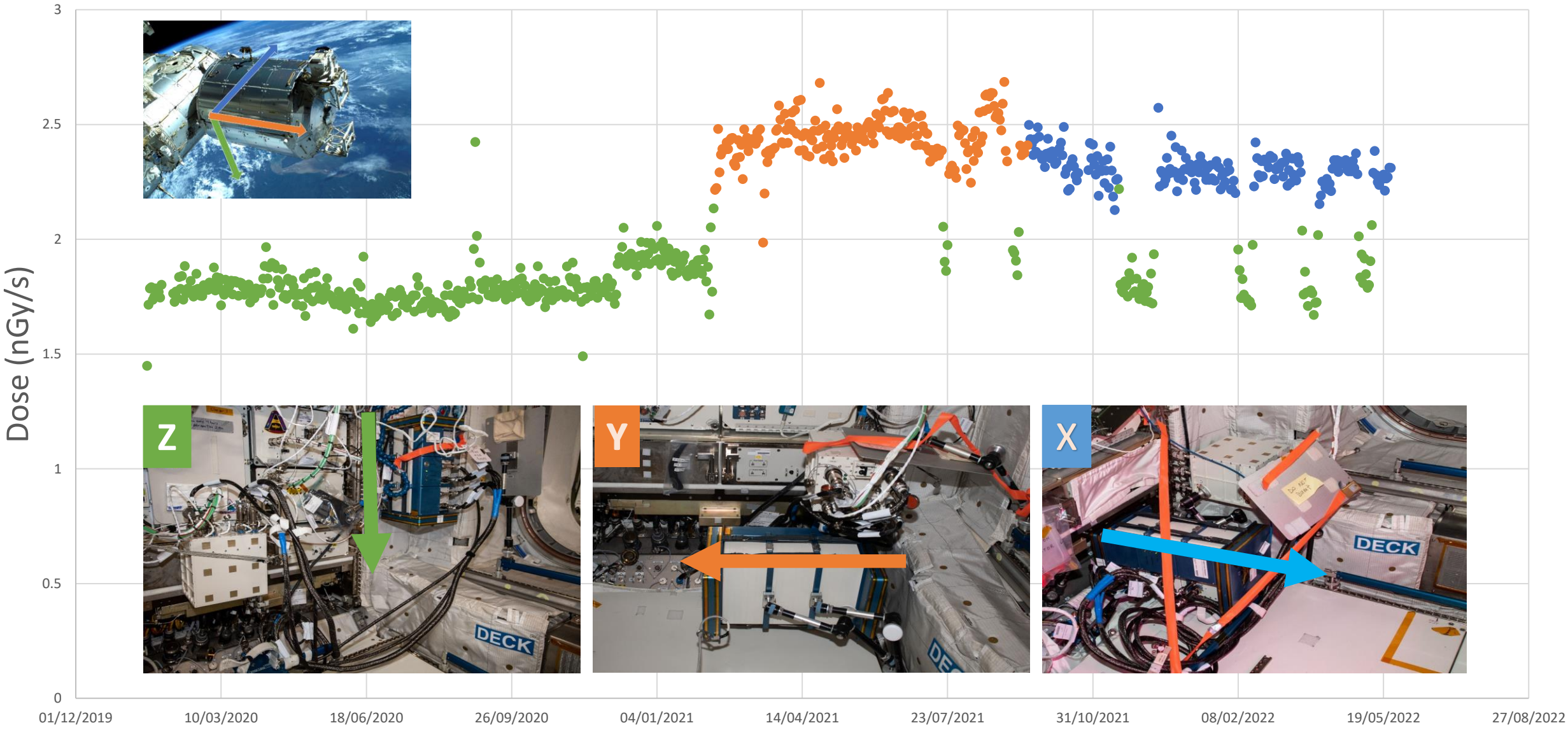


Particle flux (#/s cm^2 sr)

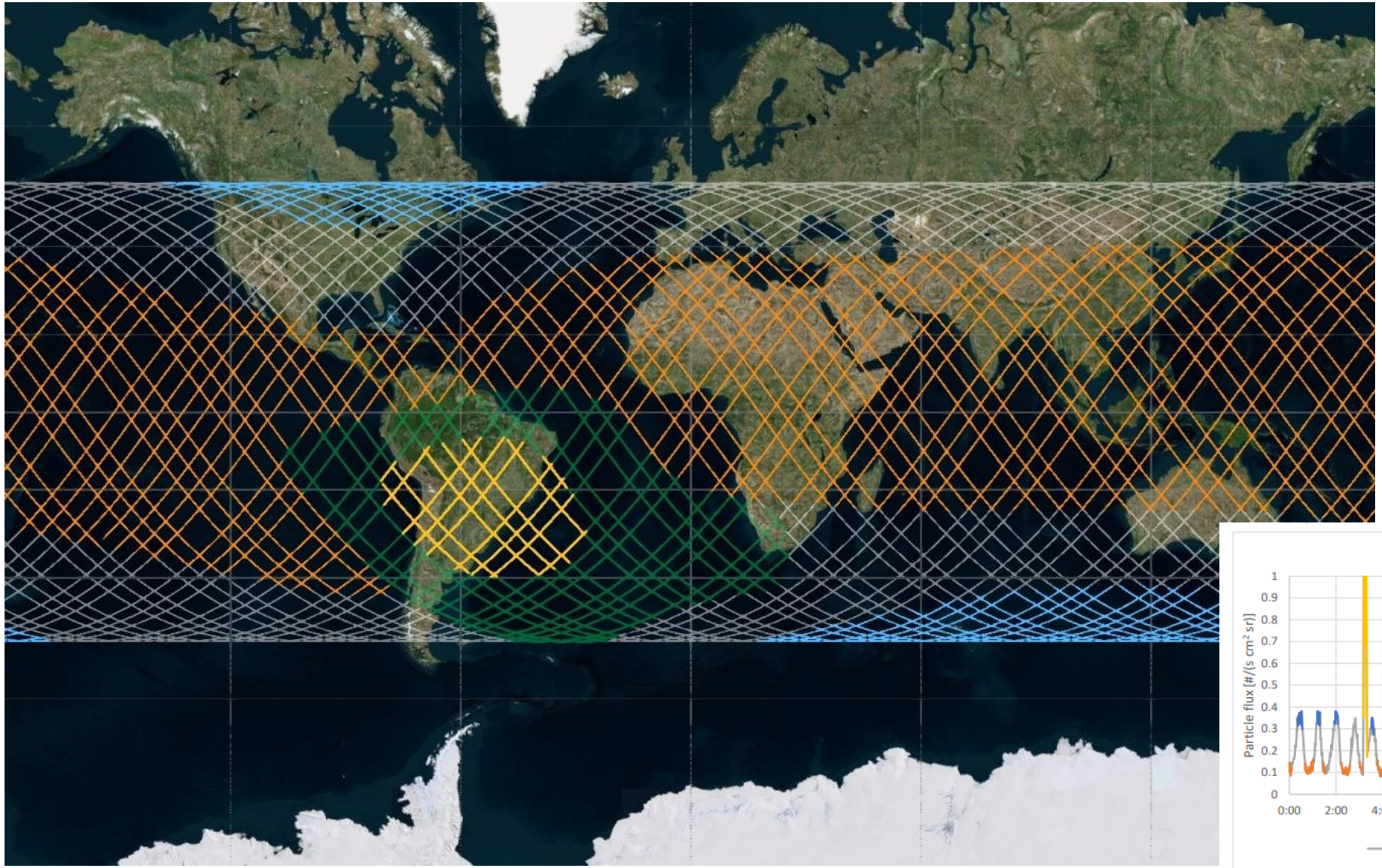
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0

01/12/2019
10/03/2020
18/06/2020
26/09/2020
04/01/2021
14/04/2021
23/07/2021
31/10/2021
08/02/2022
19/05/2022
27/08/2022

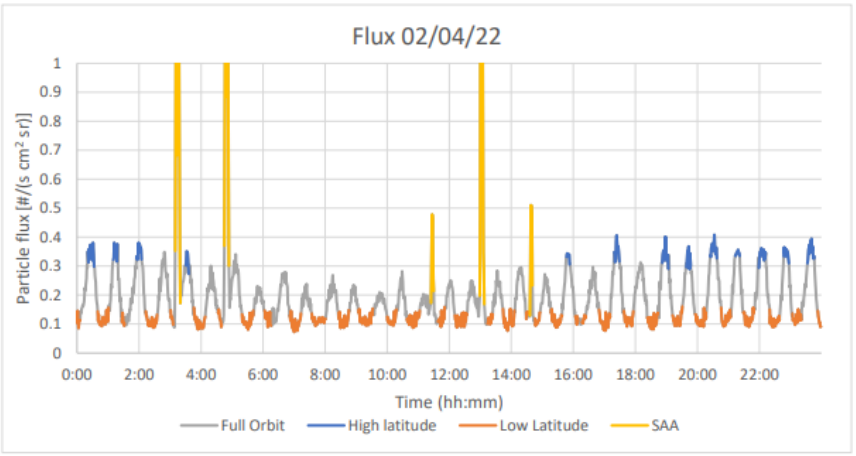
Daily Dose


Dose (nGy/s)
3
2.5
2
1.5
1
0.5
0
01/12/2019
10/03/2020
18/06/2020
26/09/2020
04/01/2021
14/04/2021
23/07/2021
31/10/2021
08/02/2022
19/05/2022
27/08/2022
Z
Y
X
DECK
DECK

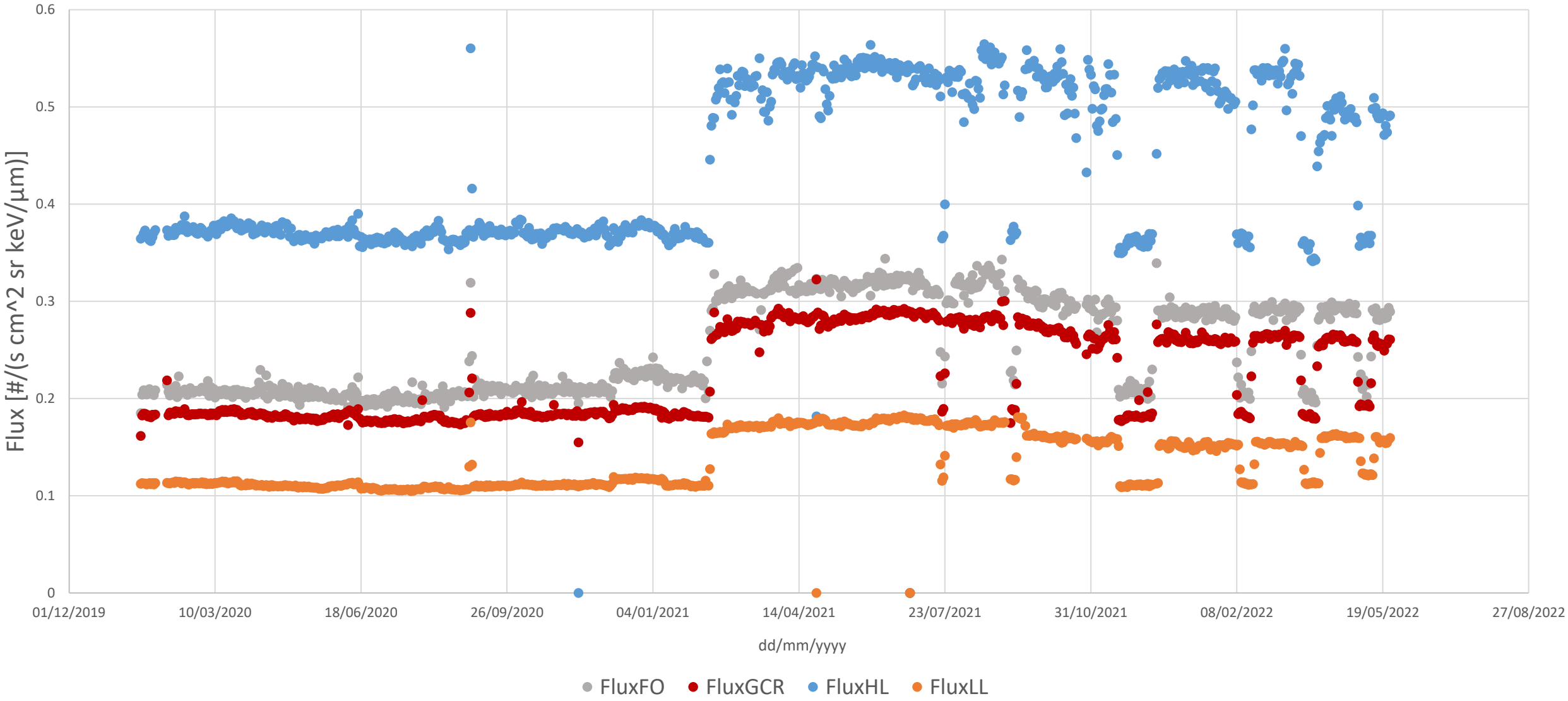
Geomagnetical regions



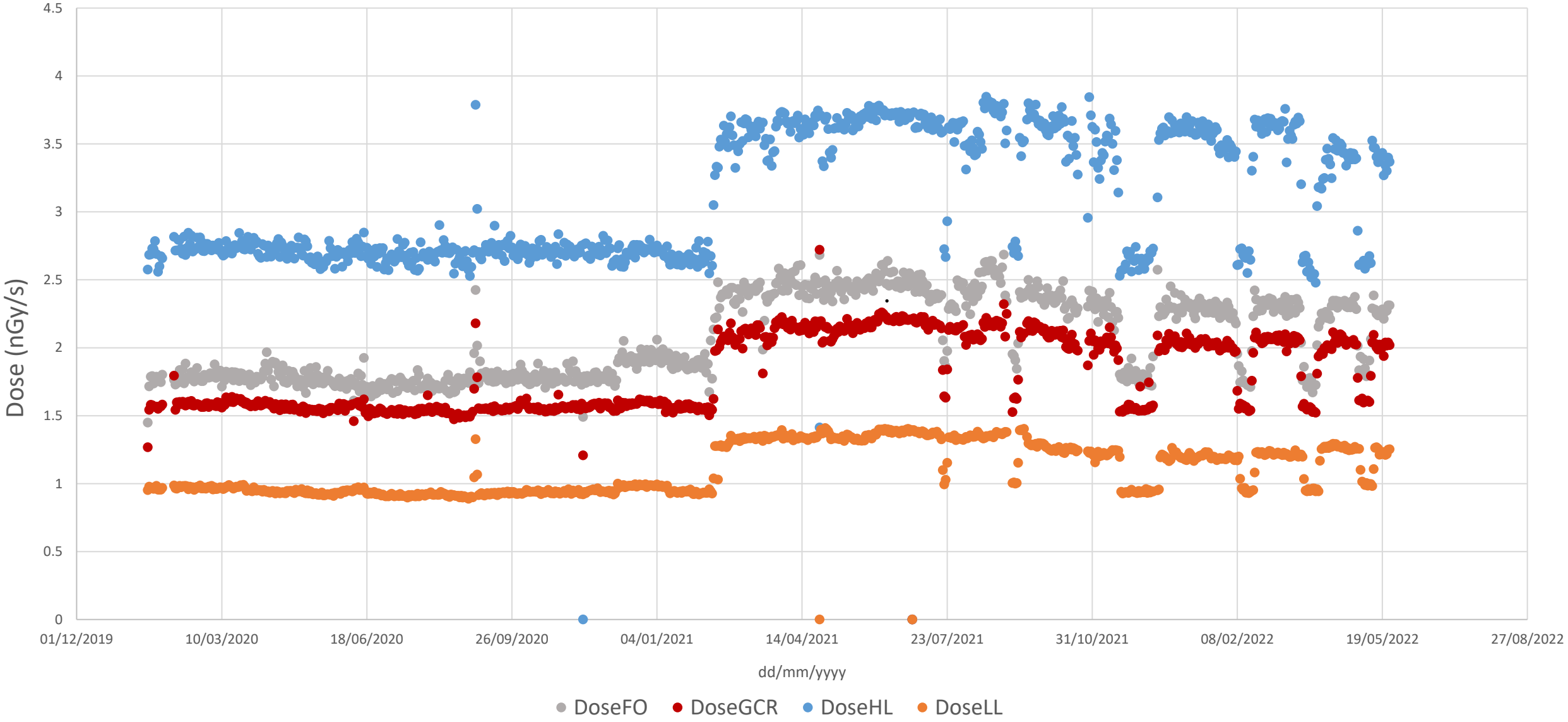
	B (nT)	L
Low Latitude:	≥ 23500	≤ 1.5
High Latitude:	any	> 3
South Atlantic Anomaly:	< 23500	< 2.4



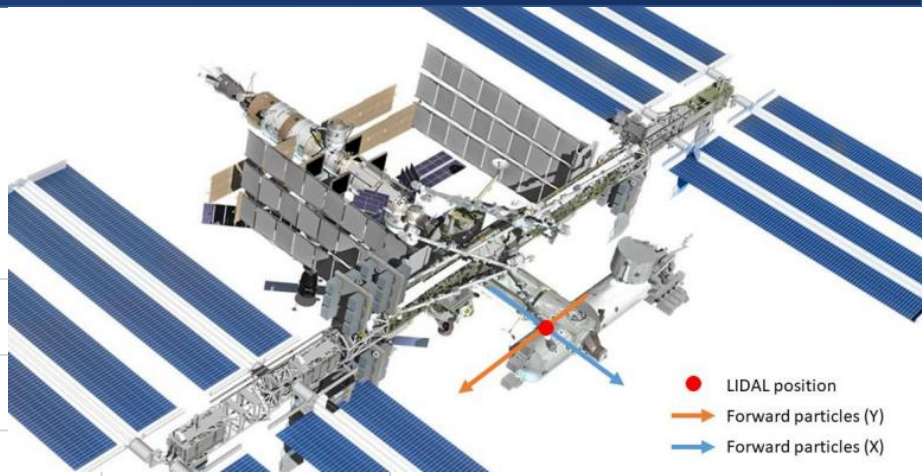
Daily Flux per geomagnetical region

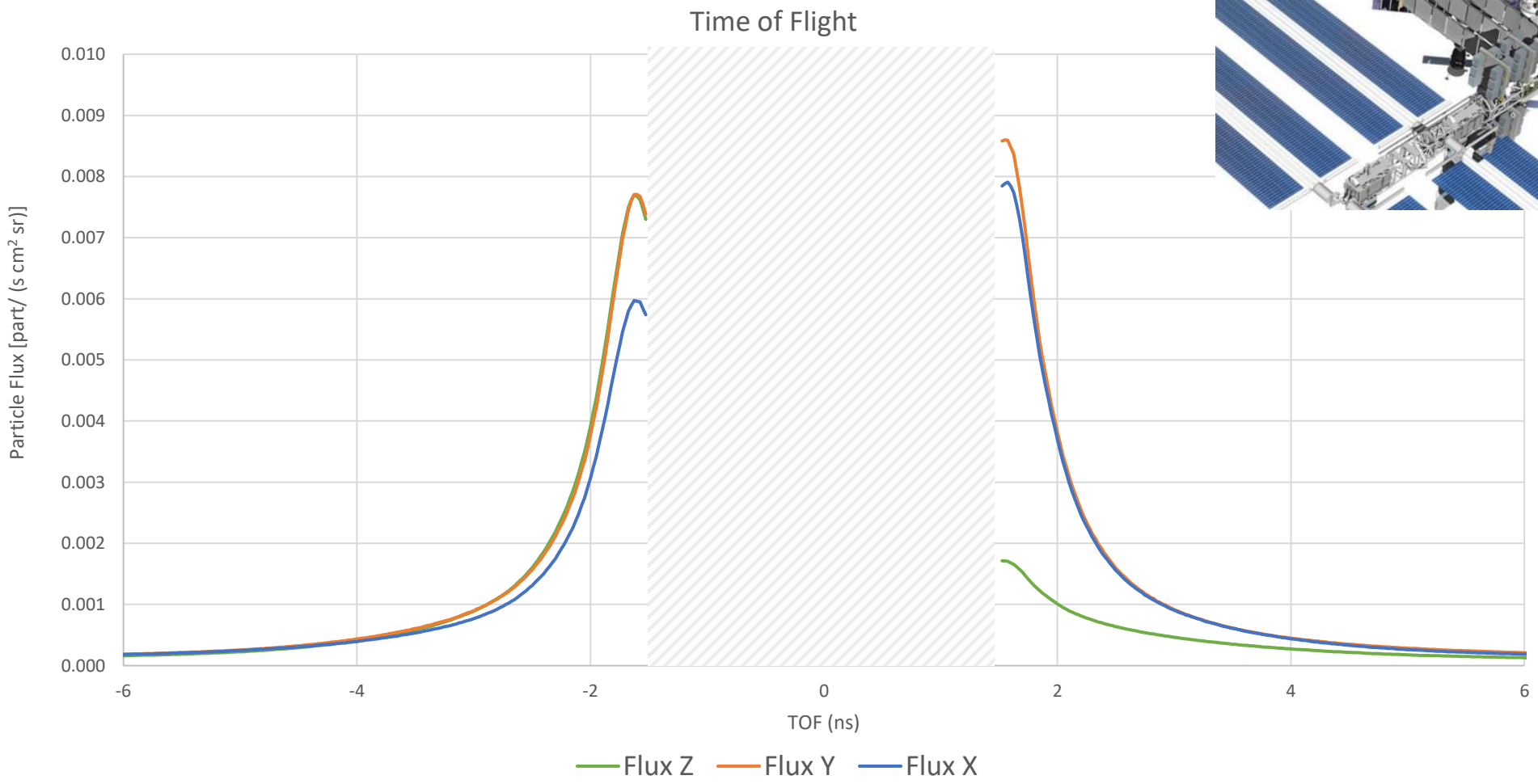


Daily Dose per geomagnetical region

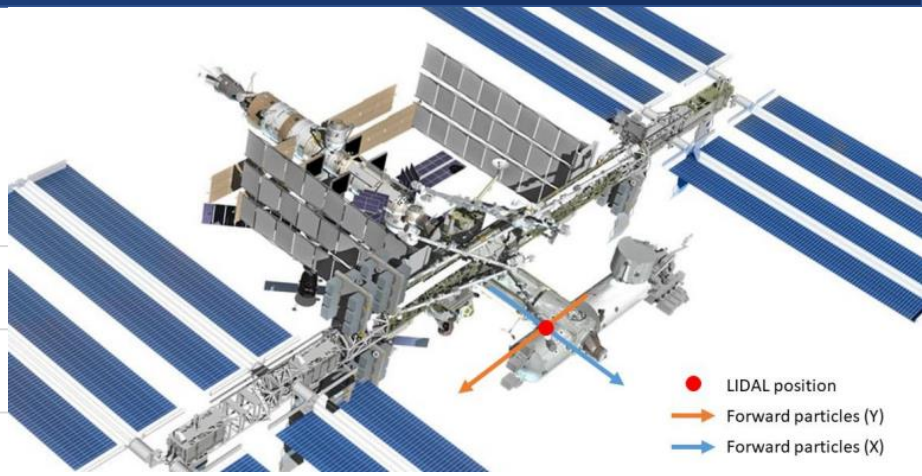


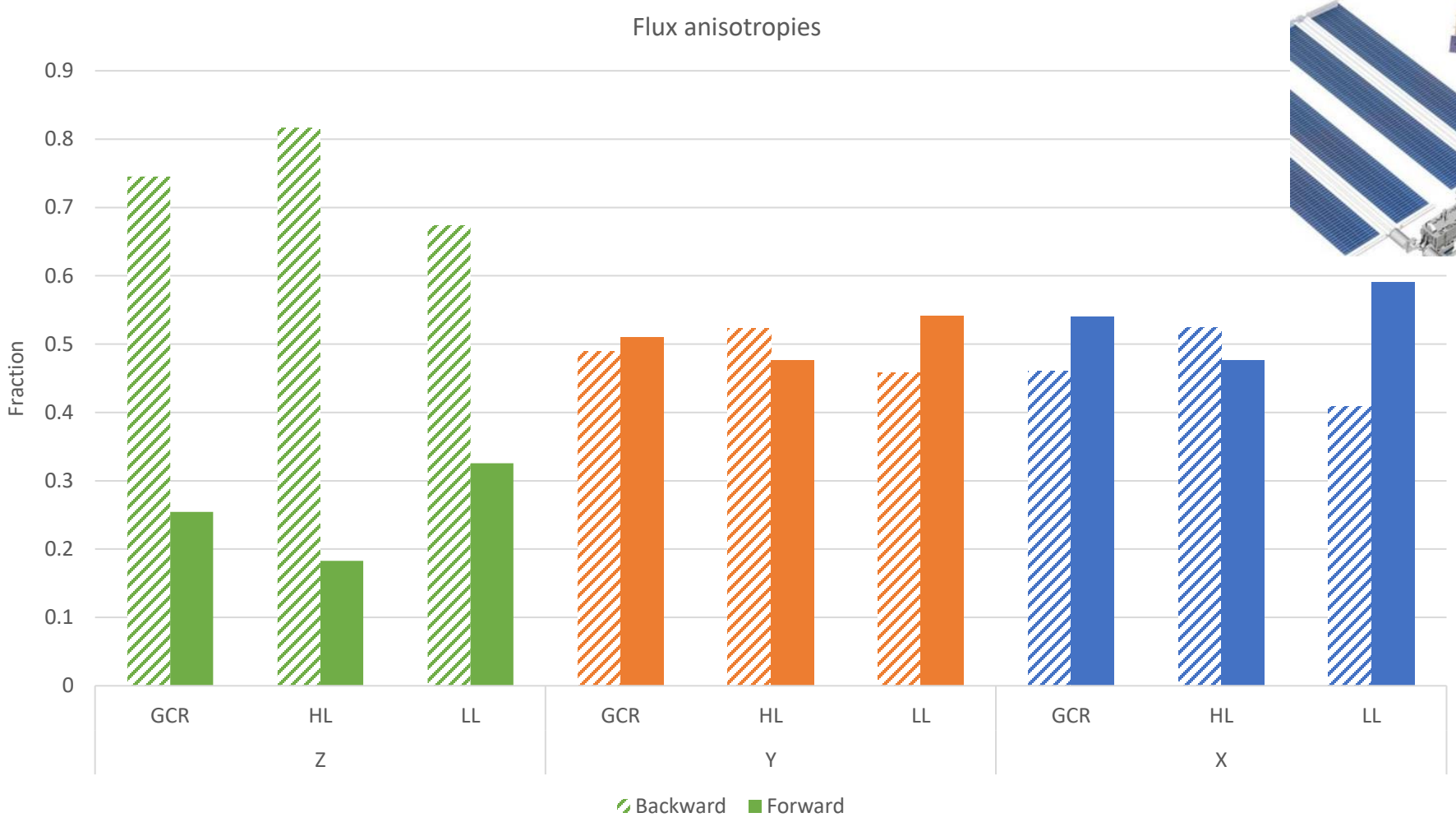
ToF spectra


LIDAL position
Forward particles (Y)
Forward particles (X)


Time of Flight
Particle Flux [part/ (s cm² sr)]
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
-6
-4
-2
0
2
4
6
TOF (ns)
Flux Z
Flux Y
Flux X

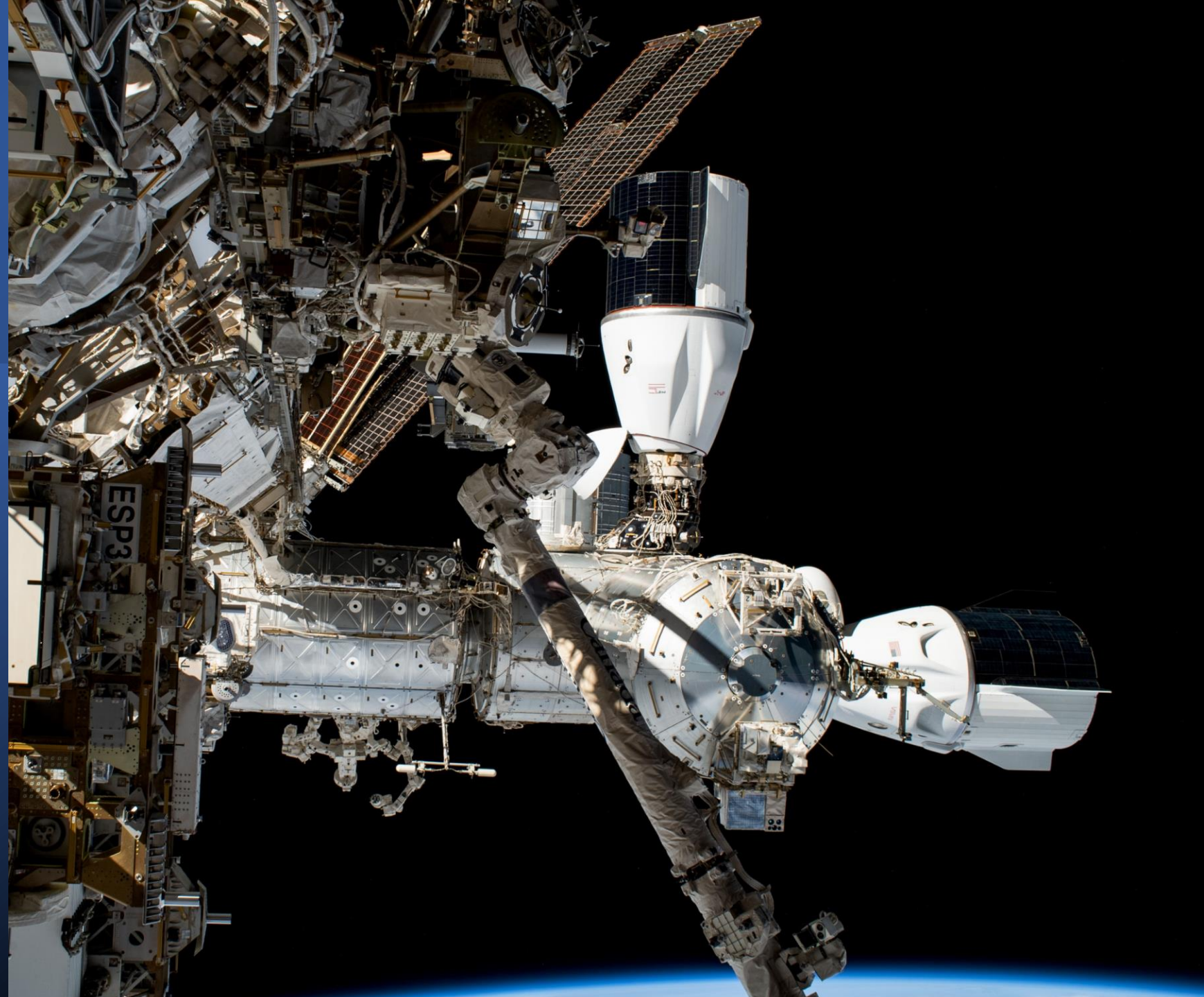
Flux Anisotropies



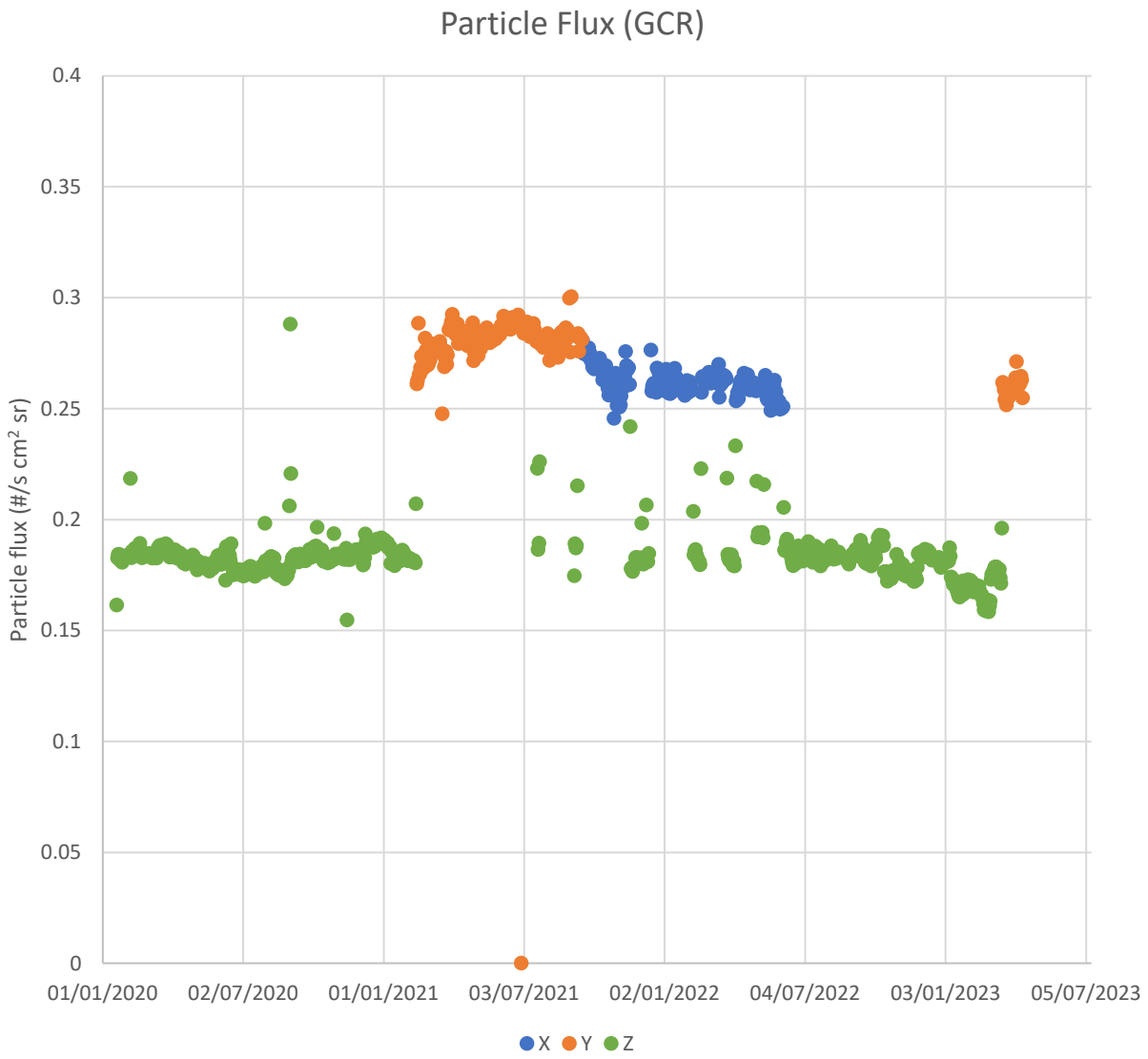


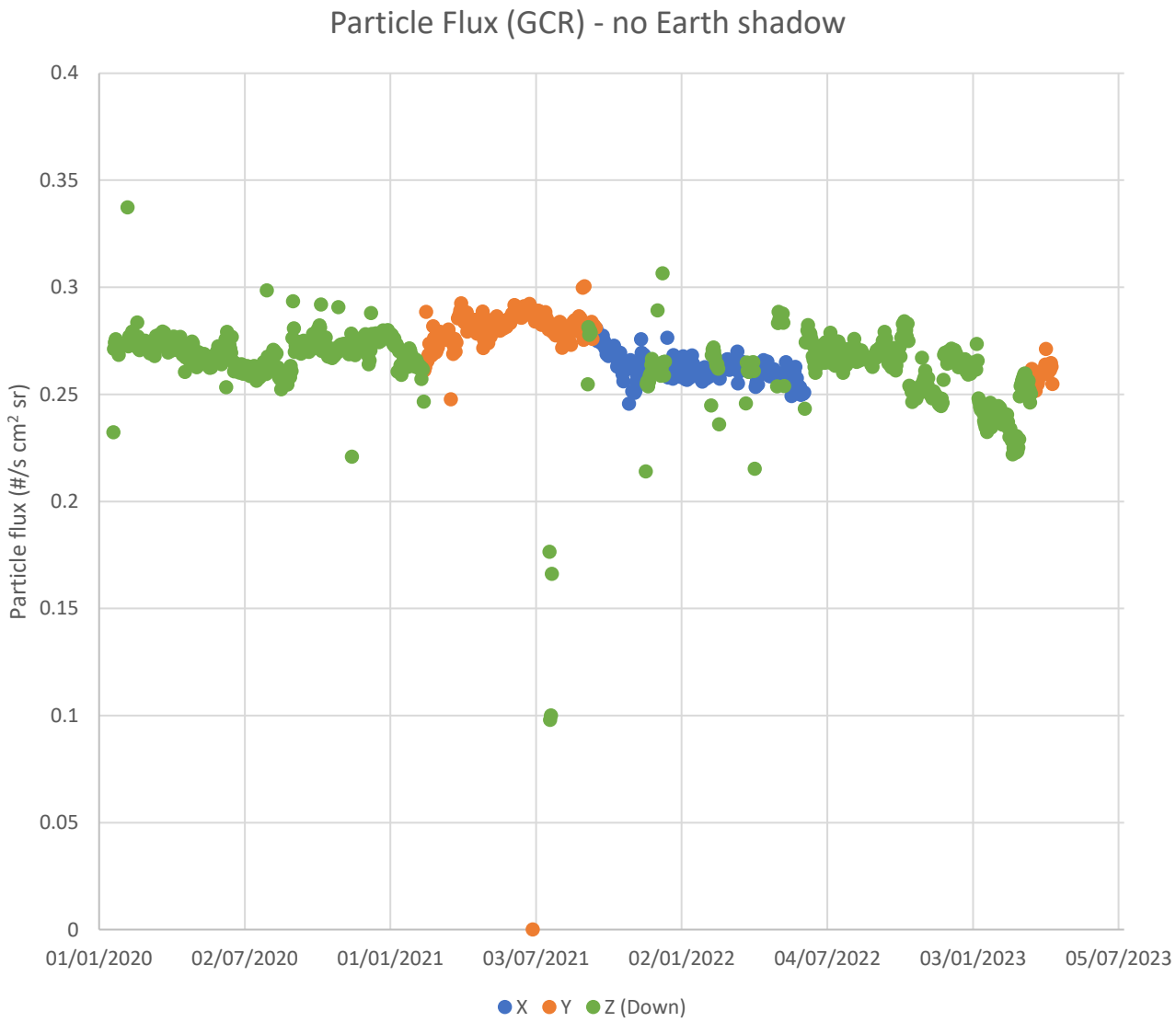
More than three years of LIDAL measurement onboard the ISS Columbus Module

Work in progress

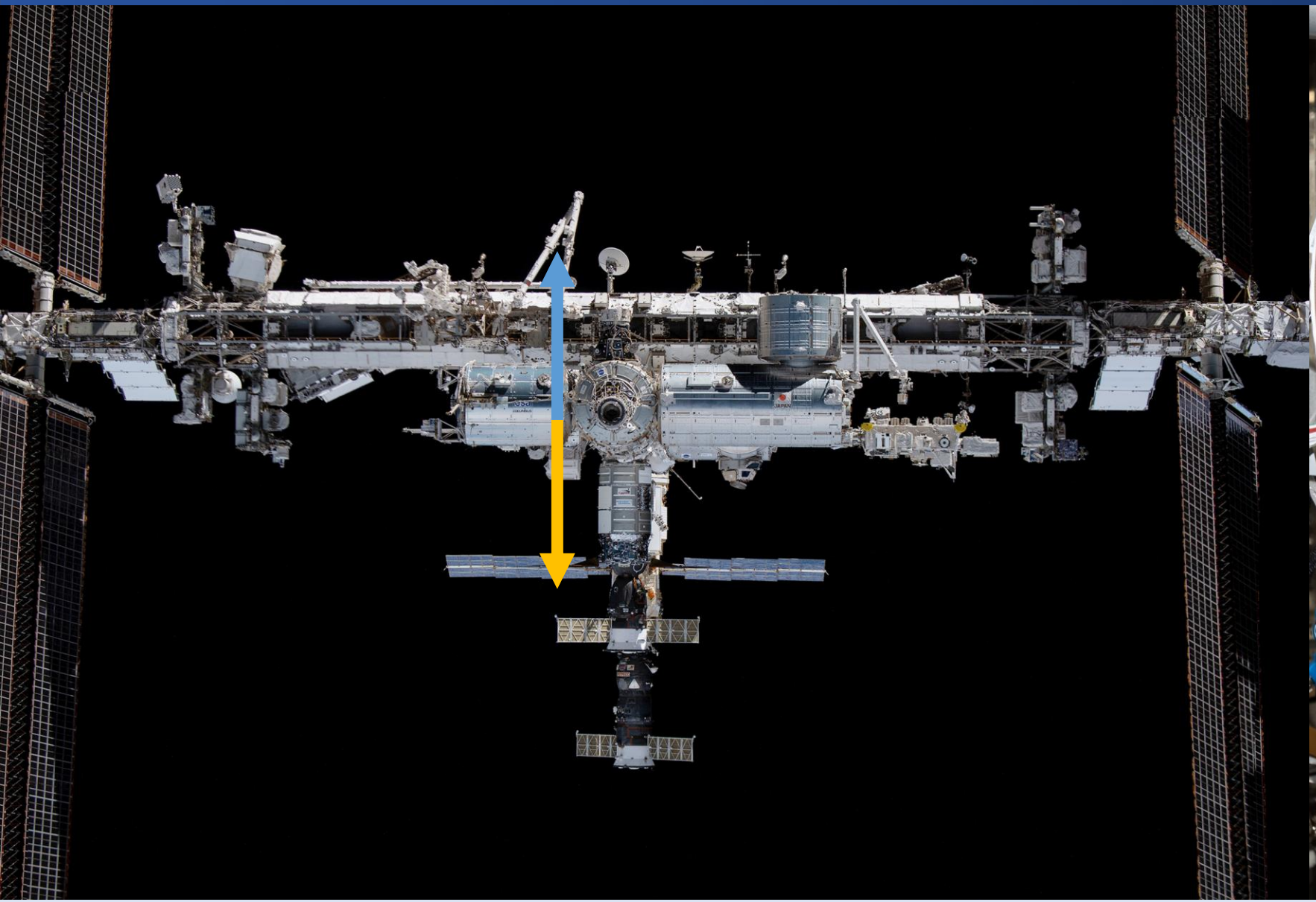


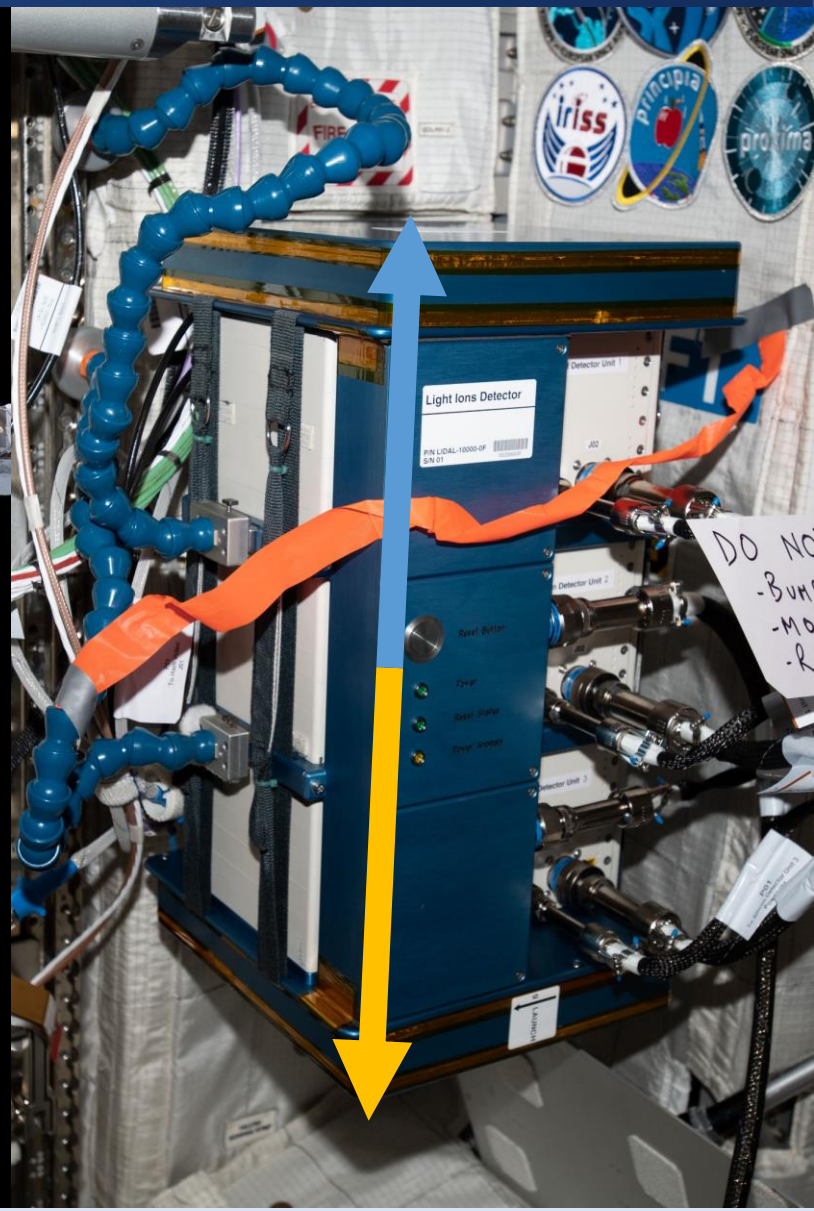
Particle flux (GCR)



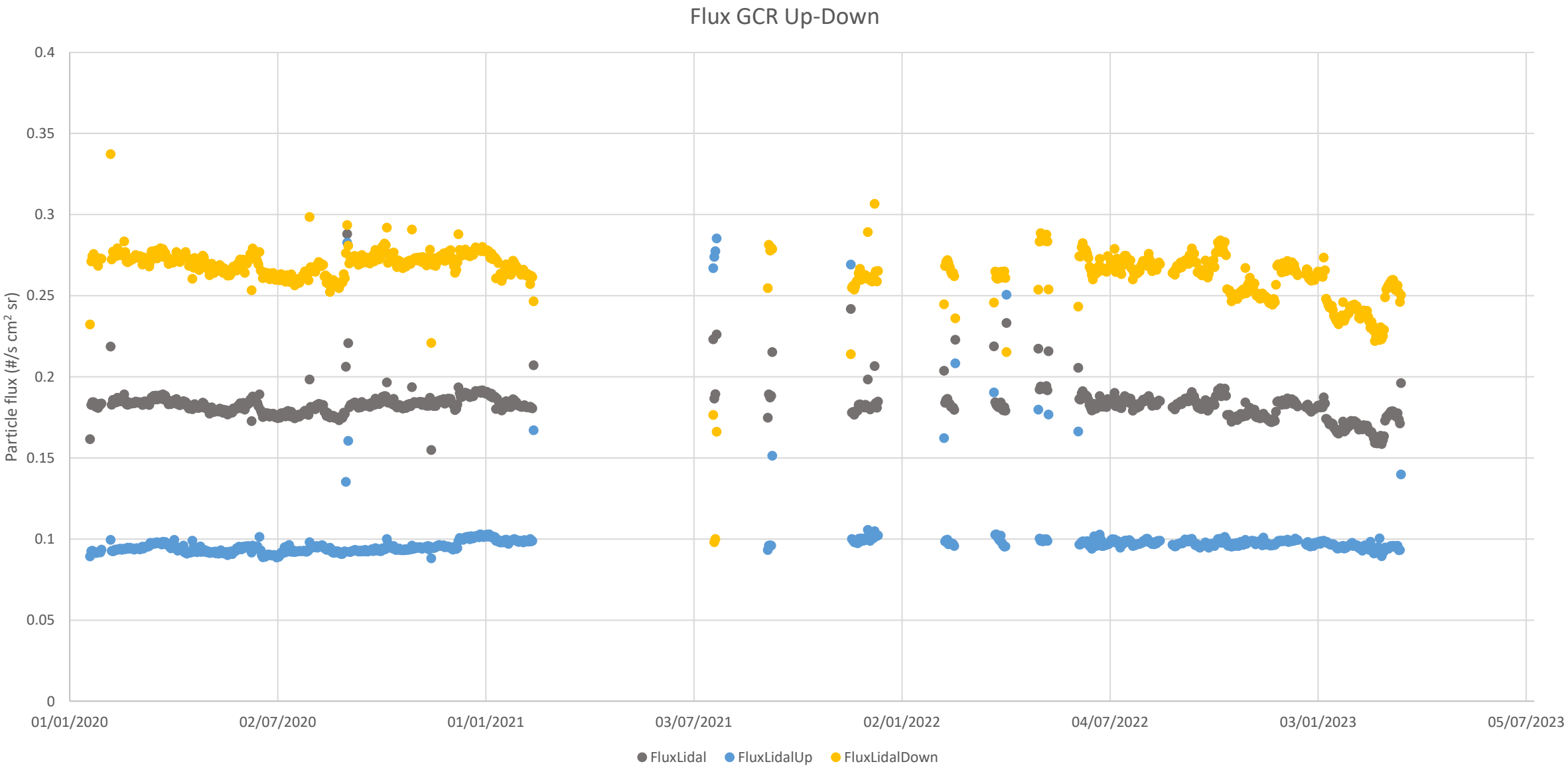


Z direction

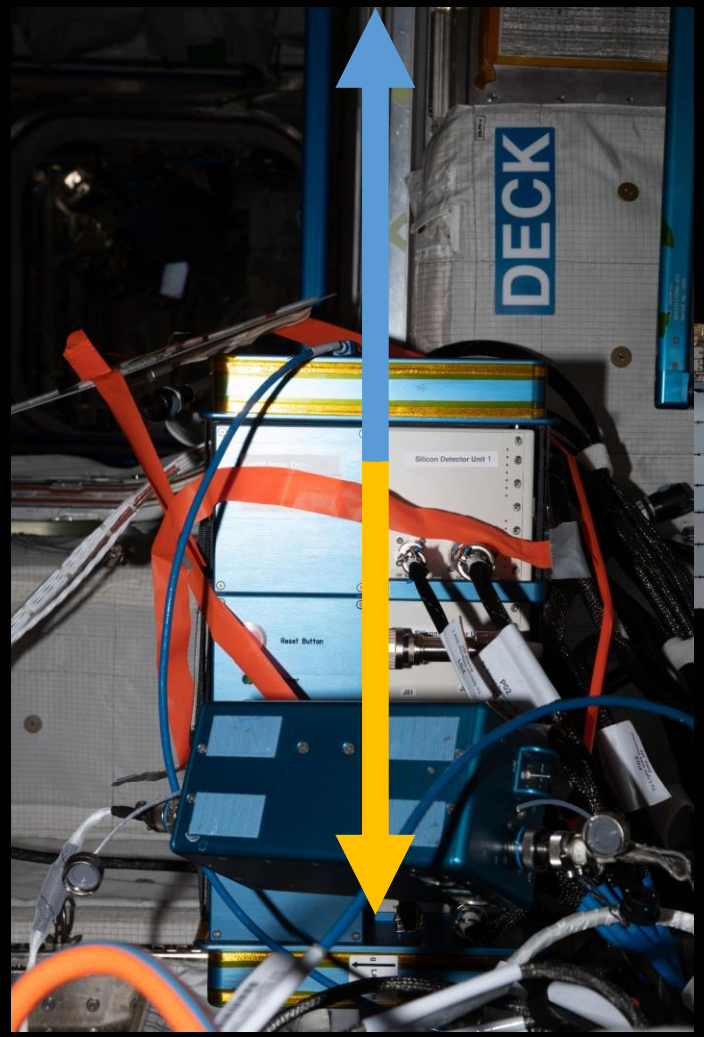


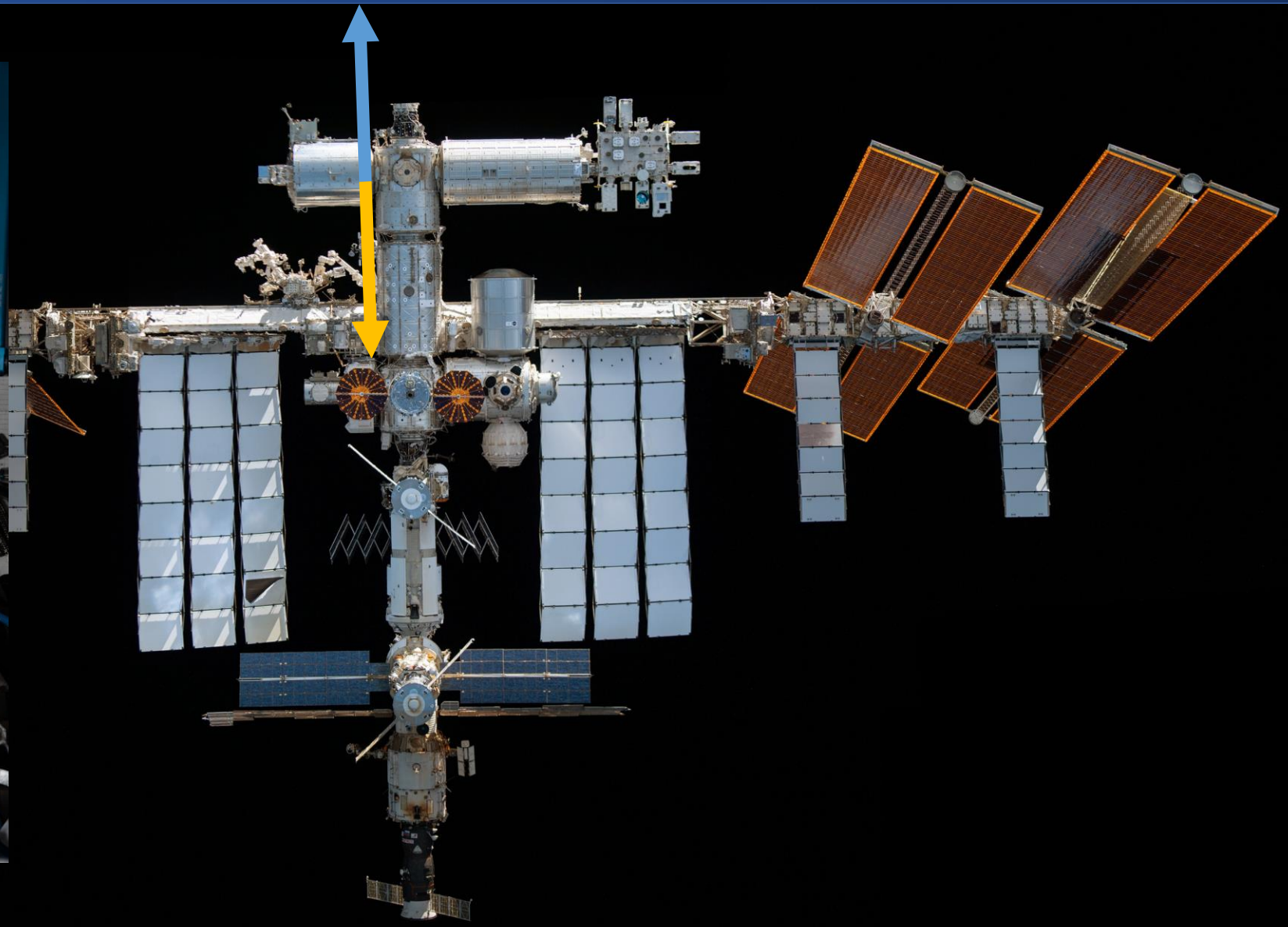


Z direction

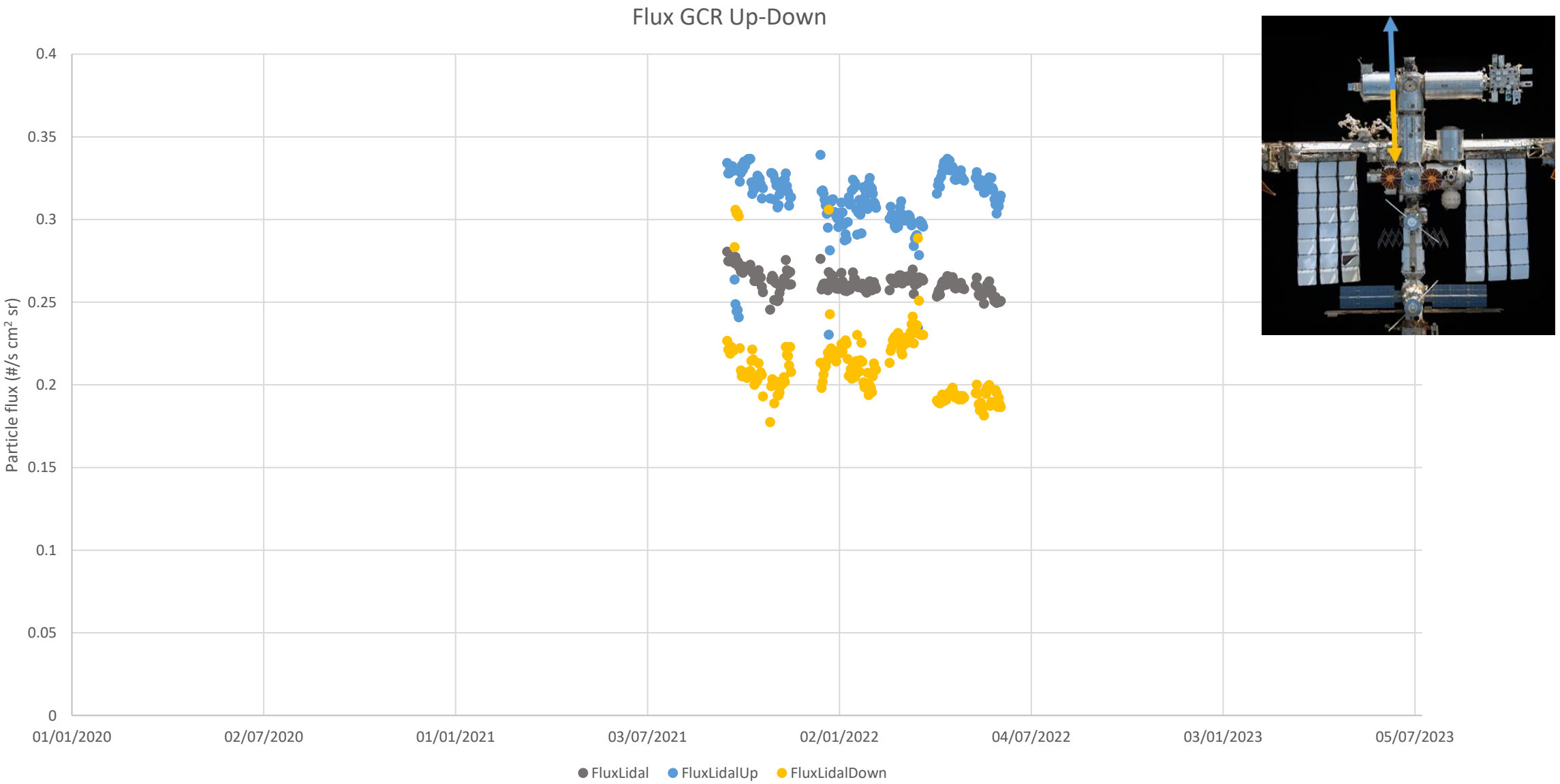

Flux GCR Up-Down
Particle flux (#/s cm² sr)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01/01/2020
02/07/2020
01/01/2021
03/07/2021
02/01/2022
04/07/2022
03/01/2023
05/07/2023
FluxLidal
FluxLidalUp
FluxLidalDown

X direction

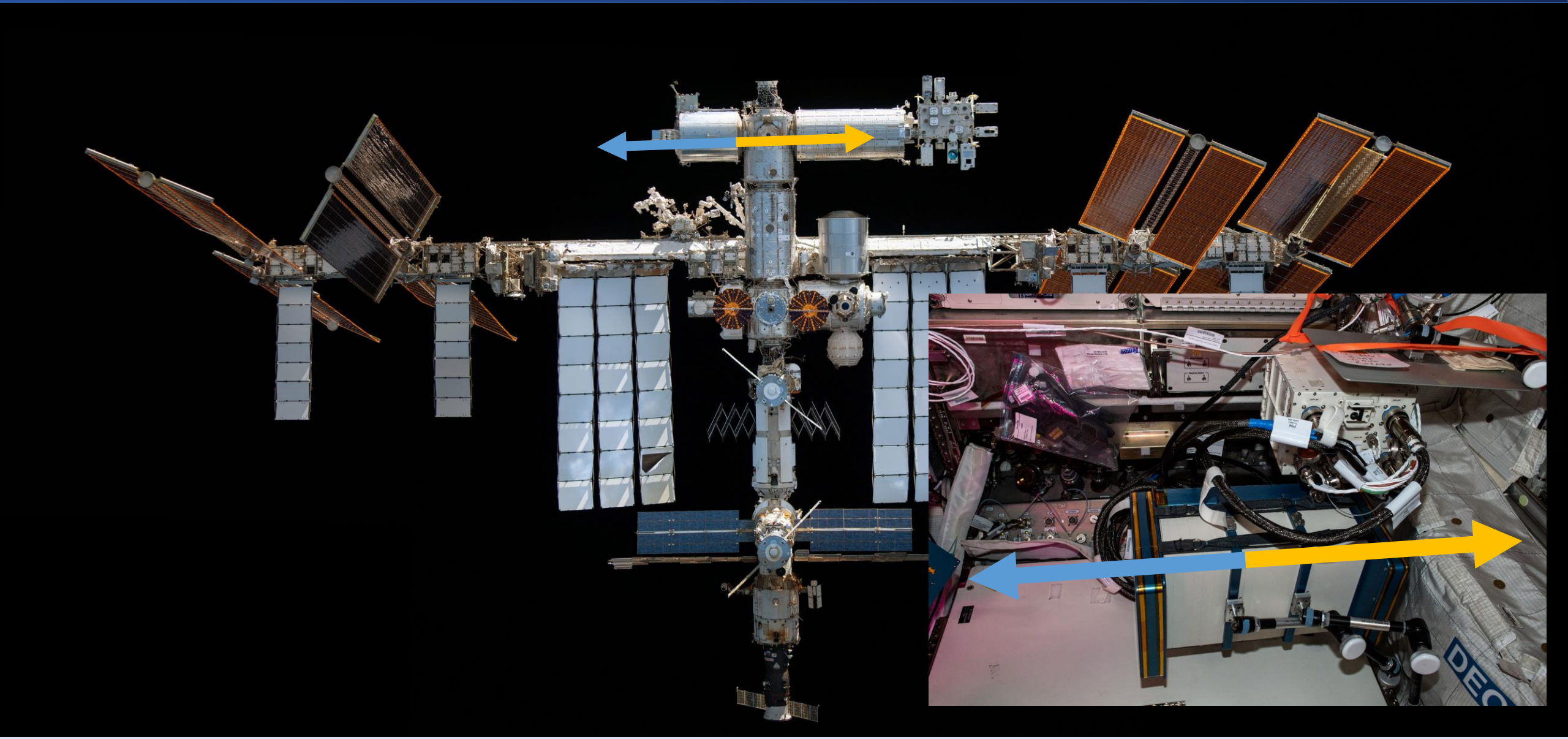




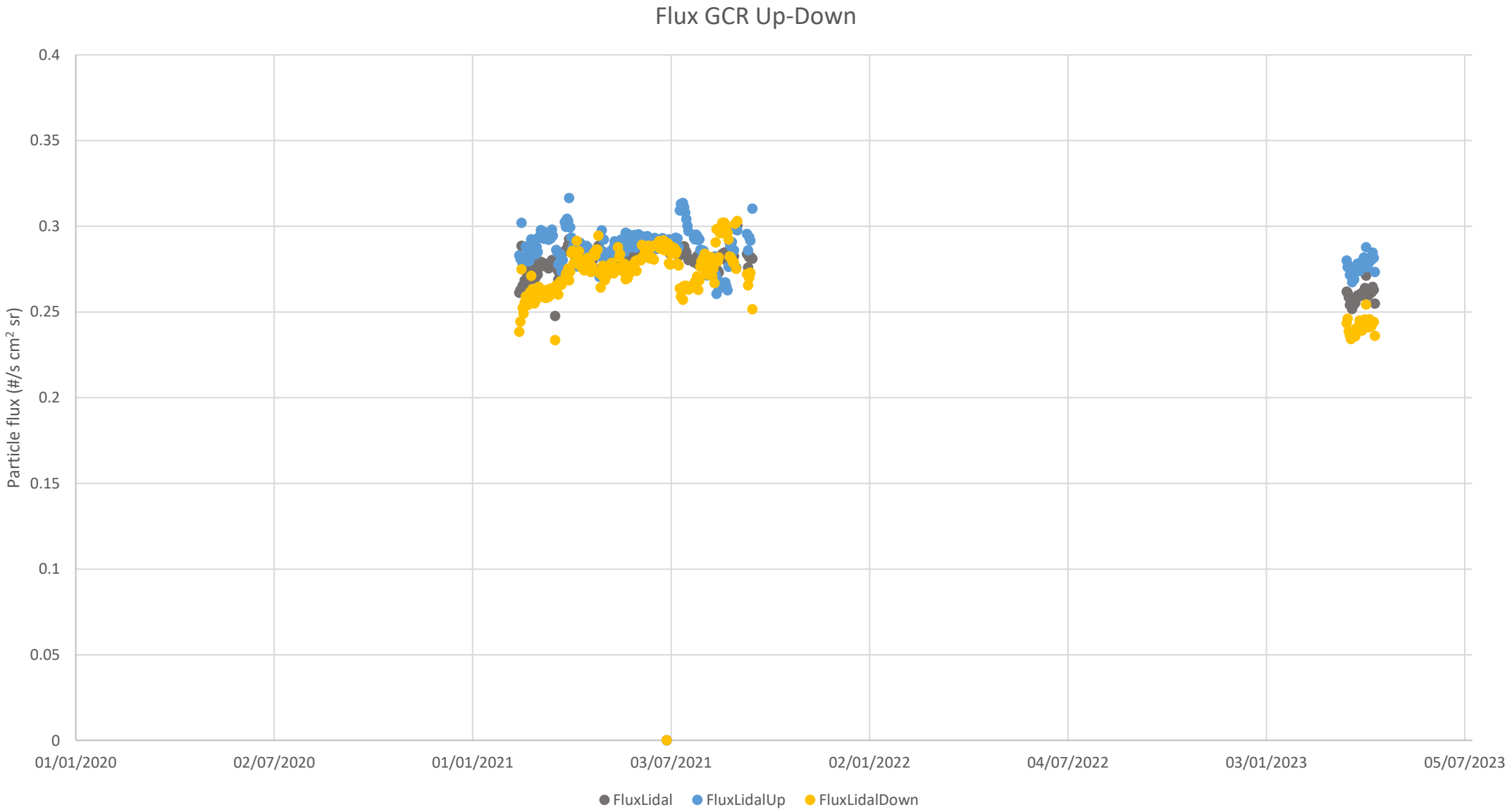
X direction


Flux GCR Up-Down
Particle flux (#/s cm² sr)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01/01/2020
02/07/2020
01/01/2021
03/07/2021
02/01/2022
04/07/2022
03/01/2023
05/07/2023
FluxLidal
FluxLidalUp
FluxLidalDown

Y direction



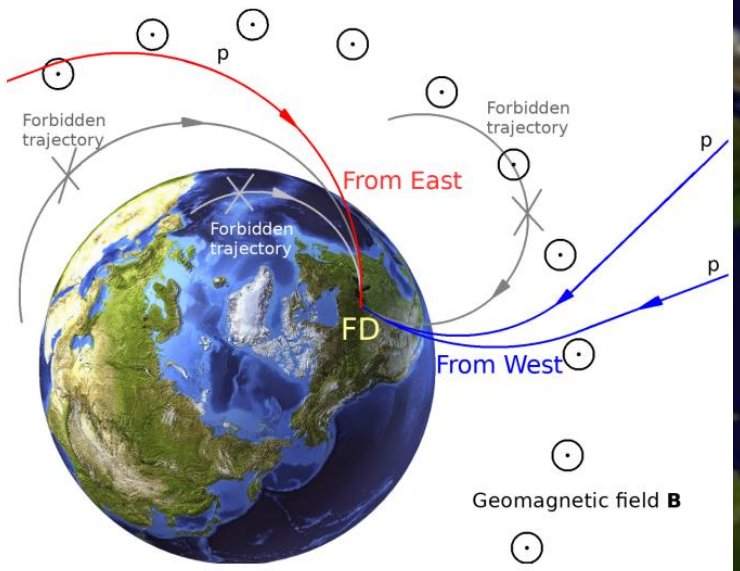
Y direction


Flux GCR Up-Down
Particle flux (#/s cm² sr)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01/01/2020
02/07/2020
01/01/2021
03/07/2021
02/01/2022
04/07/2022
03/01/2023
05/07/2023
FluxLidal
FluxLidalUp
FluxLidalDown

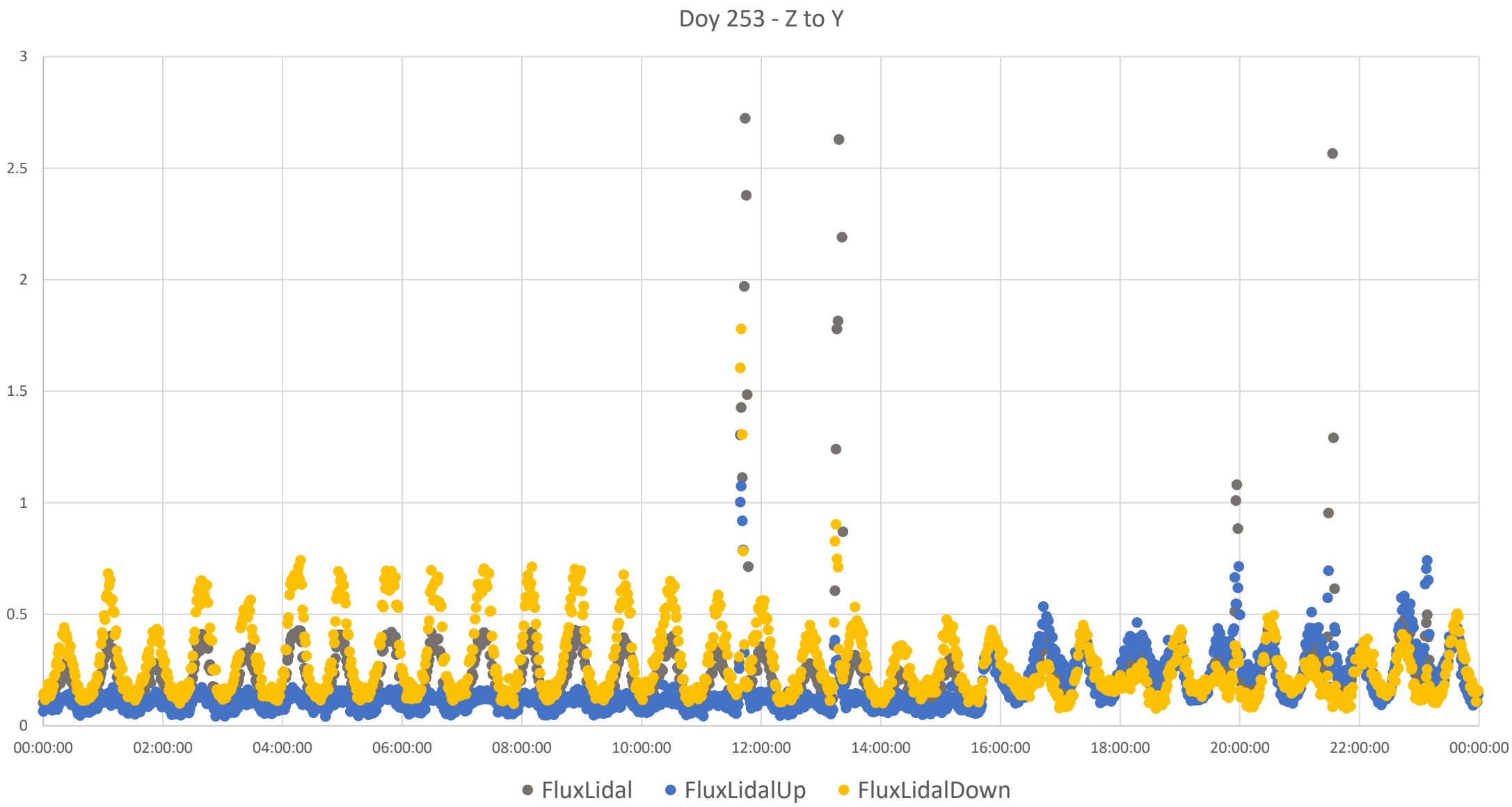
Y direction

Y direction

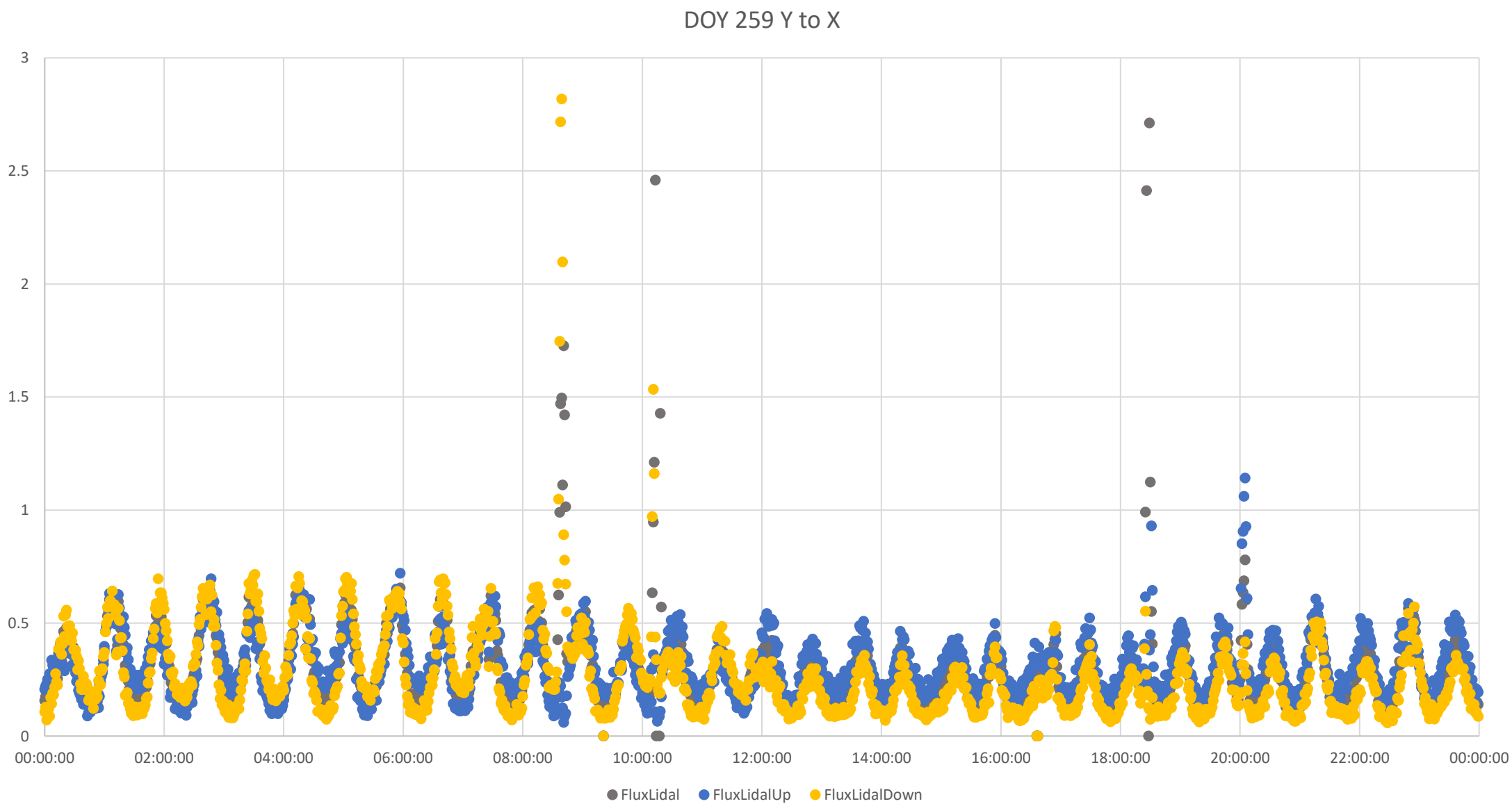
East-West Asymmetry



Y direction

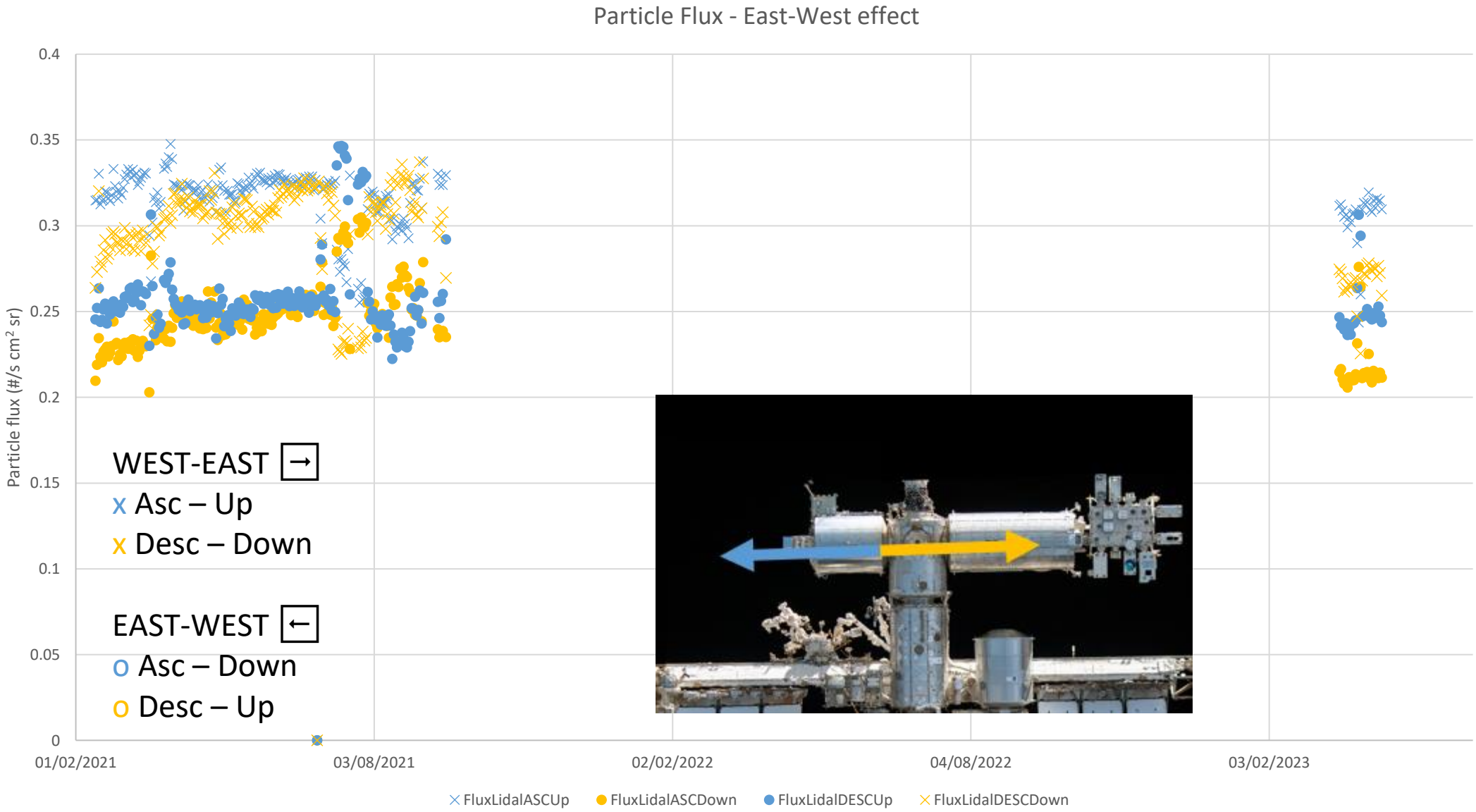

Doy 253 - Z to Y
3
2.5
2
1.5
1
0.5
0
00:00:00
02:00:00
04:00:00
06:00:00
08:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
00:00:00
FluxLidal
FluxLidalUp
FluxLidalDown

Y direction

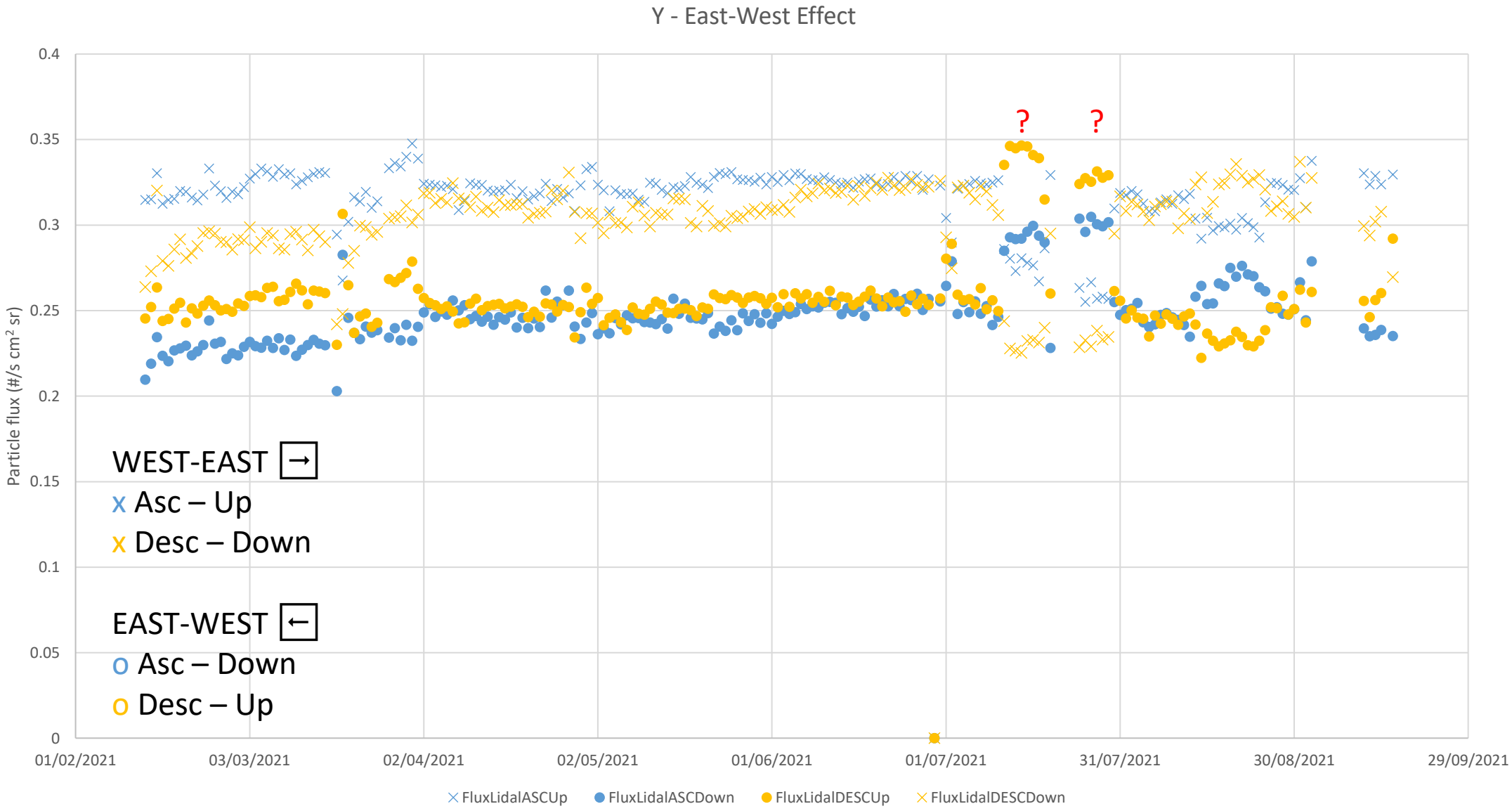

DOY 259 Y to X
3
2.5
2
1.5
1
0.5
0
00:00:00
02:00:00
04:00:00
06:00:00
08:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
00:00:00
FluxLidal
FluxLidalUp
FluxLidalDown

Y direction

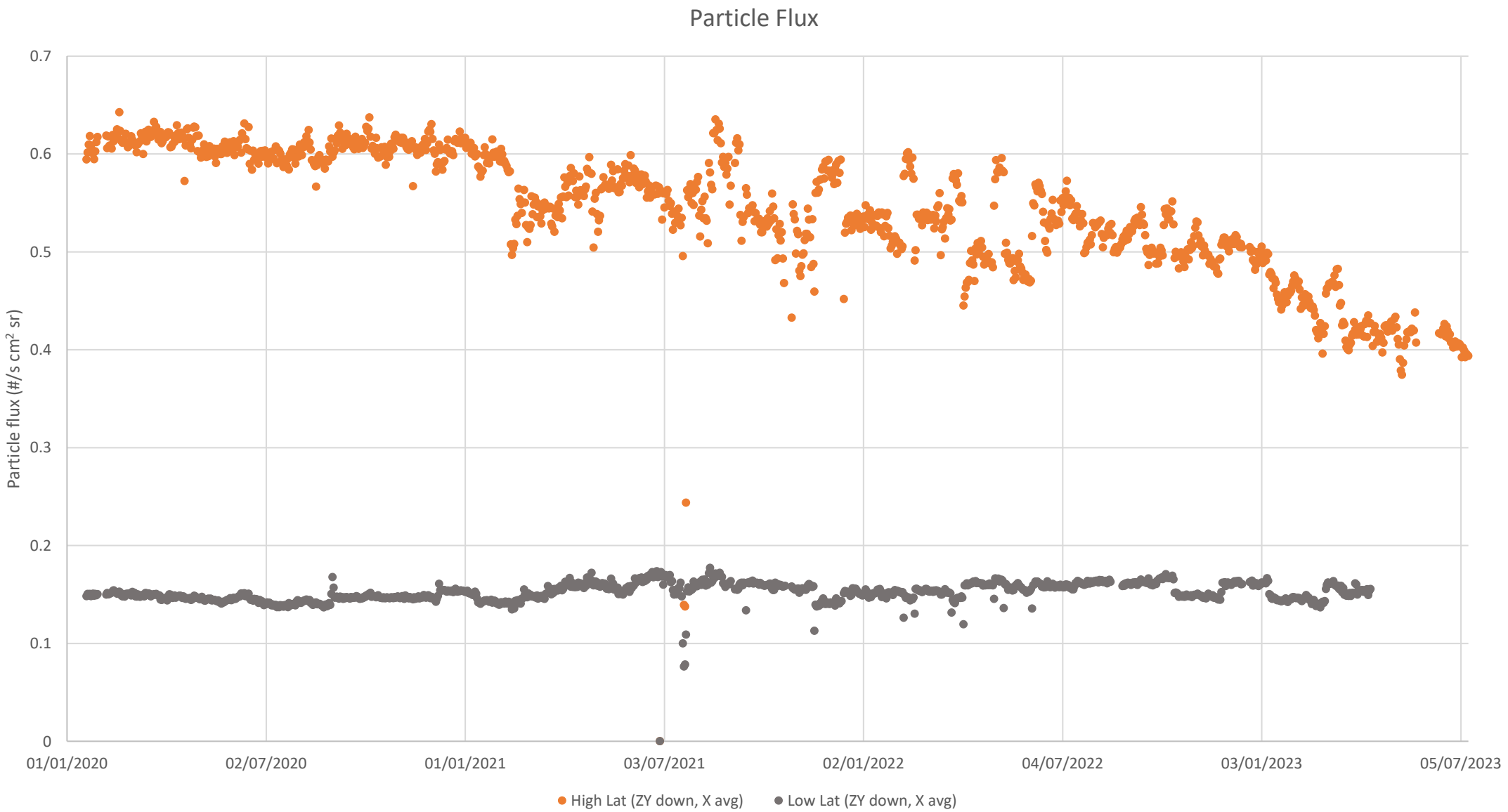
Y direction


Particle Flux - East-West effect
Particle flux (#/s cm² sr)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01/02/2021
03/08/2021
02/02/2022
04/08/2022
03/02/2023
WEST-EAST →
x Asc – Up
x Desc – Down
EAST-WEST ←
o Asc – Down
o Desc – Up
FluxLidalASCUp
FluxLidalASCDown
FluxLidalDESCUp
FluxLidalDESCDown

Y direction


Y - East-West Effect
Particle flux (#/s cm² sr)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01/02/2021
03/03/2021
02/04/2021
02/05/2021
01/06/2021
01/07/2021
31/07/2021
30/08/2021
29/09/2021
?
?
WEST-EAST →
x Asc – Up
x Desc – Down
EAST-WEST ←
o Asc – Down
o Desc – Up
FluxLidalASCUp
FluxLidalASCDown
FluxLidalDESCUp
FluxLidalDESCDown

Particle flux (high lat vs low lat)



Conclusions

- Beware of the isotropic flux assumption!
- Anisotropies up to 50% due to primary flux (East-West effect) or shielding/secondary production
- Detectors can be affected by attitude changes
- Asymmetric detectors could lead to weird measurements

THANK YOU FOR THE ATTENTION!

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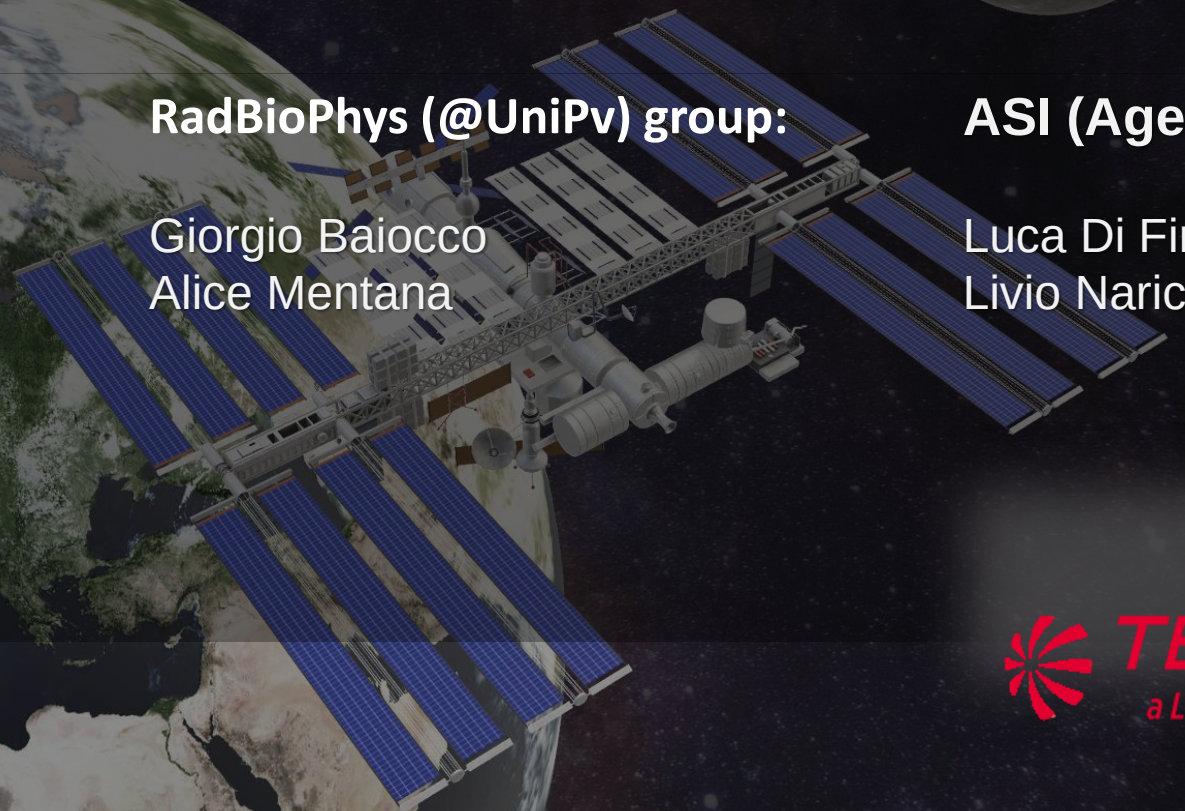

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