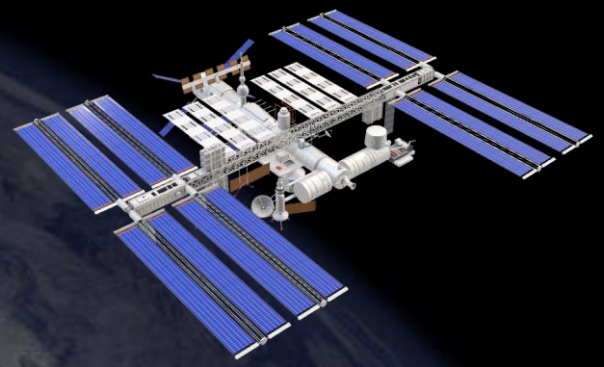
TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA
Dipartimento di Fisica

HSERLAB
Human Space Exploration Radiation LAB



DOSTEL REM LIDAL intercomparison

Livio Narici on behalf of the DORELI collaboration

NASA

DLR

ASI

UNIVERSITÀ
DI PAVIA

Why

Cross calibrations and comparisons of detector measurements is mandatory to exploit the single detector results but also to extract the most information from the space radiation environment

J. Space Weather Space Clim., 7, A18 (2017)
DOI: 10.1051/swsc/2017016

SWSC

RESEARCH ARTICLE OPEN ACCESS

Exploiting different active silicon detectors in the International Space Station: ALTEA and DOSTEL galactic cosmic radiation (GCR) measurements

Livo Narici[1,2,*], Thomas Berger[2], Sönke Burmeister[3], Luca Di Fino[1], Alessandro Rizzo[1], Daniel Matthiä[2], and Günther Reitz[2]

Space Weather

RESEARCH ARTICLE
10.1029/2018SW002103

Accepted article online 11 FEB 2019

Comparisons of High-Linear Energy Transfer Spectra on the ISS and in Deep Space

C. Zeitlin[1], L. Narici[2,3], R. R. Rios[1], A. Rizzo[2], N. Stoffle[1], D. M. Hassler[4], B. Ehresmann[4], R. F. Wimmer-Schweingruber[5], J. Guo[5], N. A. Schwadron[6], and H. E. Spence[6]

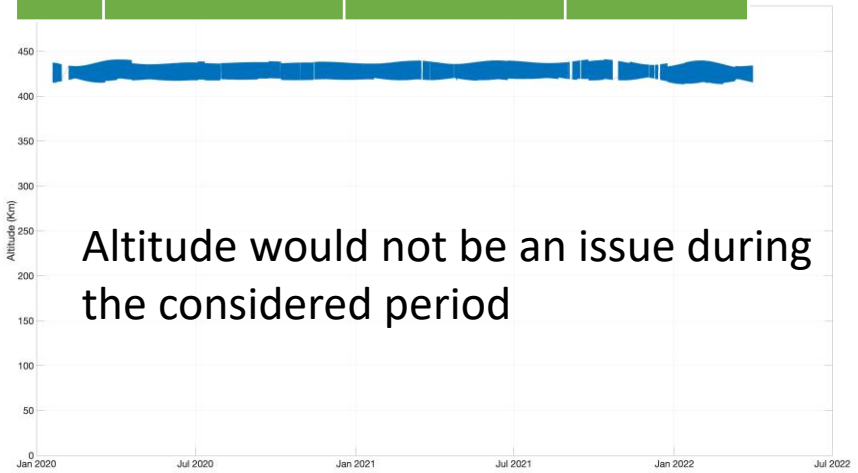
When

Measurement times

- LIDAL from January 19th 2020
- DOSTEL from Jan 1st 2020
- REM from Sept 17 2021

} To May 2022

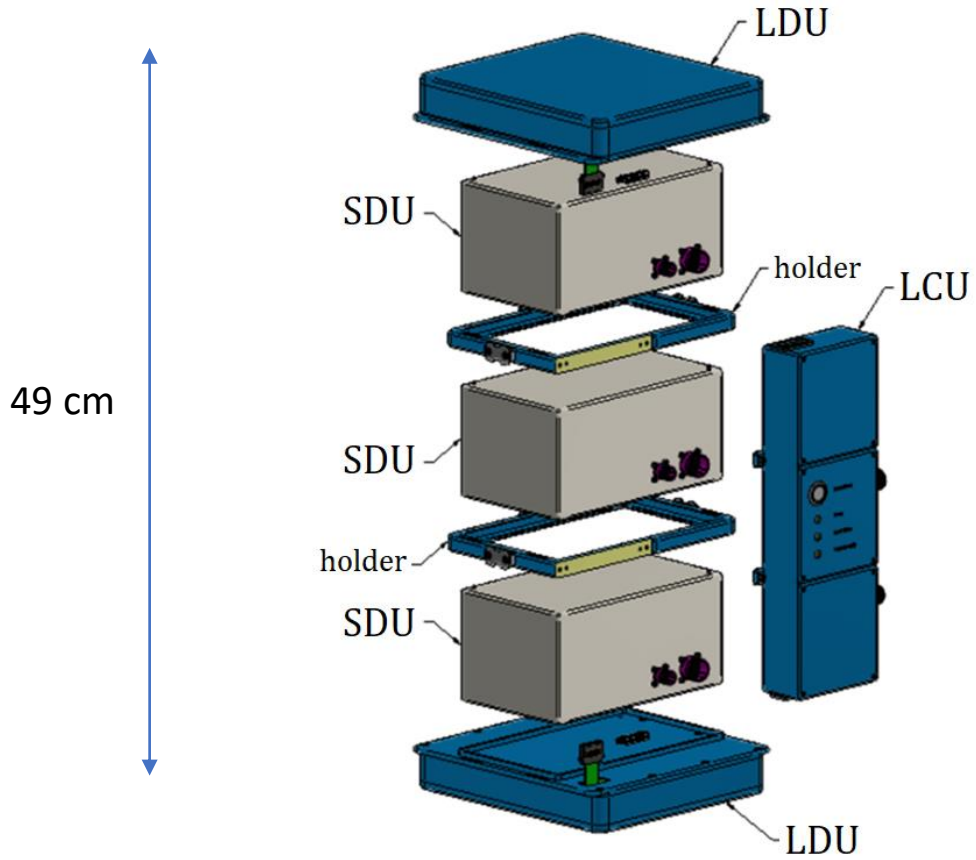
	Start	End	Days
Z	2020/019	2021/043	384
Y	2021/043	2021/259	204
X	2021/259	2021/156	188
Z	2021/156	…	> 46



Altitude would not be an issue during the considered period

		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
	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
2020	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
	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
2021	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
	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
2022	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

What: LIDAL



18 Si planes: [0.038 x (2 x 8) x 8] cm^3

2 Scint. planes.: [0.4 x (8 x 2) x 8] cm^3

GF: 15.32 $cm^2\ sr$ (bi-directional)

What: REM

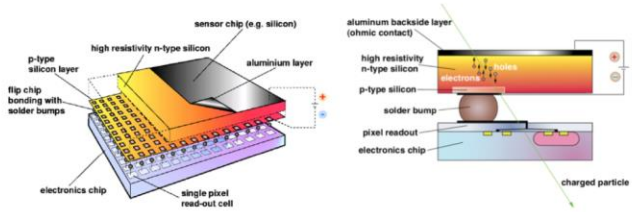
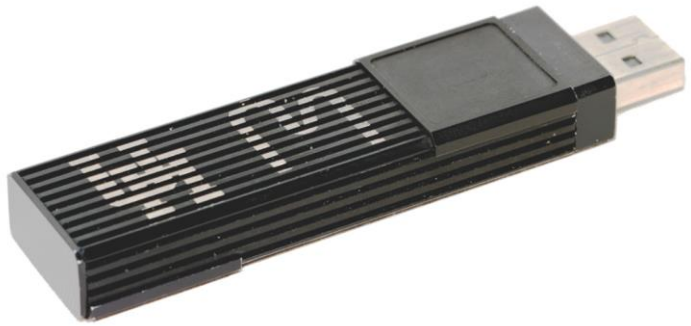
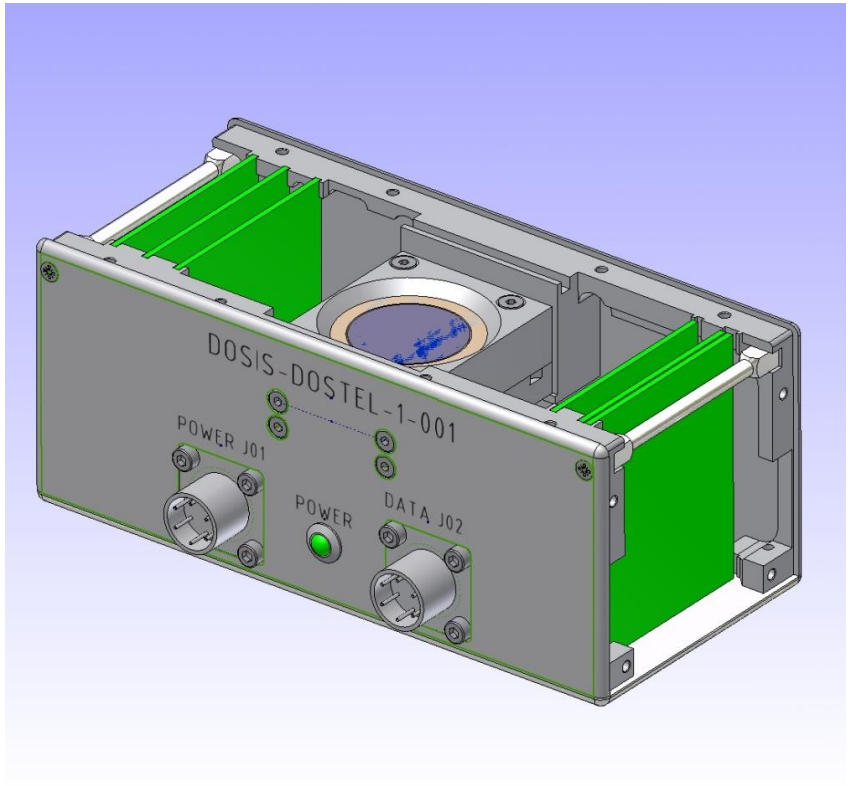


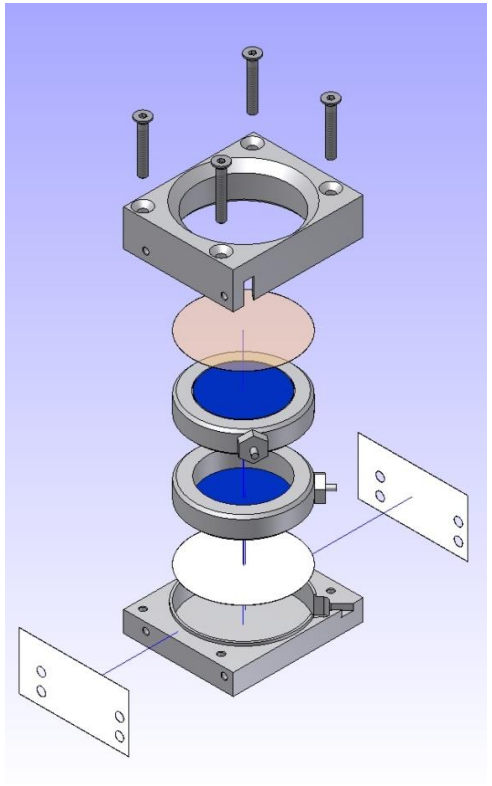
Figure 1: Medipix2 chip and Timepix assembly. (Source: CERN/Medipix.)

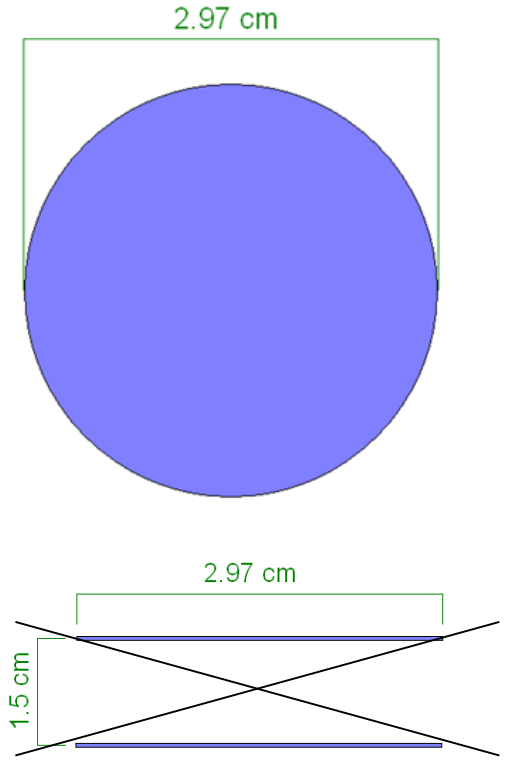


- Hybrid silicon pixel detector utilizing Medipix2/Timepix technology from CERN (medipix.cern.ch).
  - 256×256 pixels, each with a 55μm pitch (1.982cm^2).
  - Opening angle: 4π.
- Low mass/power/cost make it an ideal technology for space applications.

What: DOSTEL

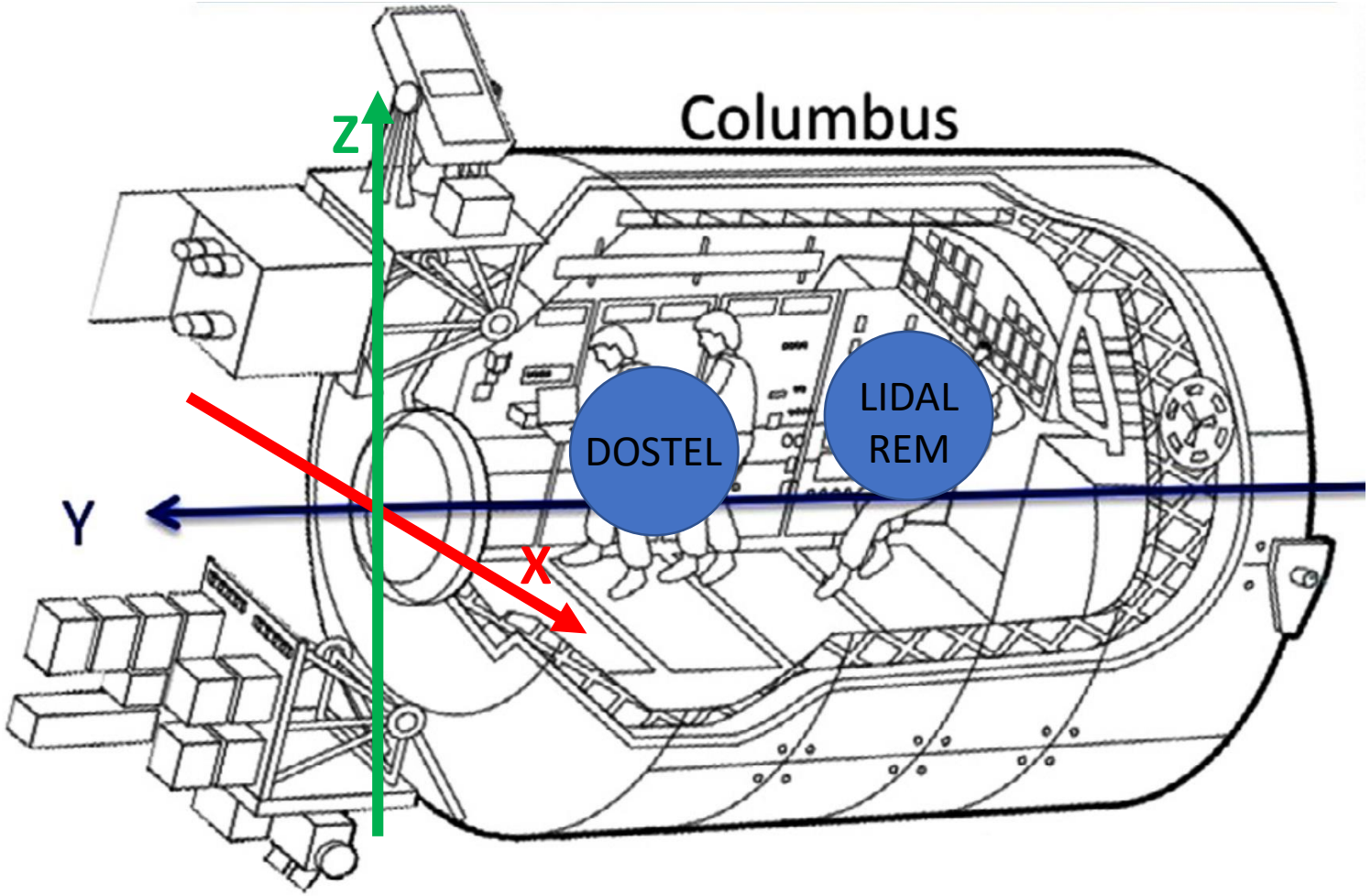




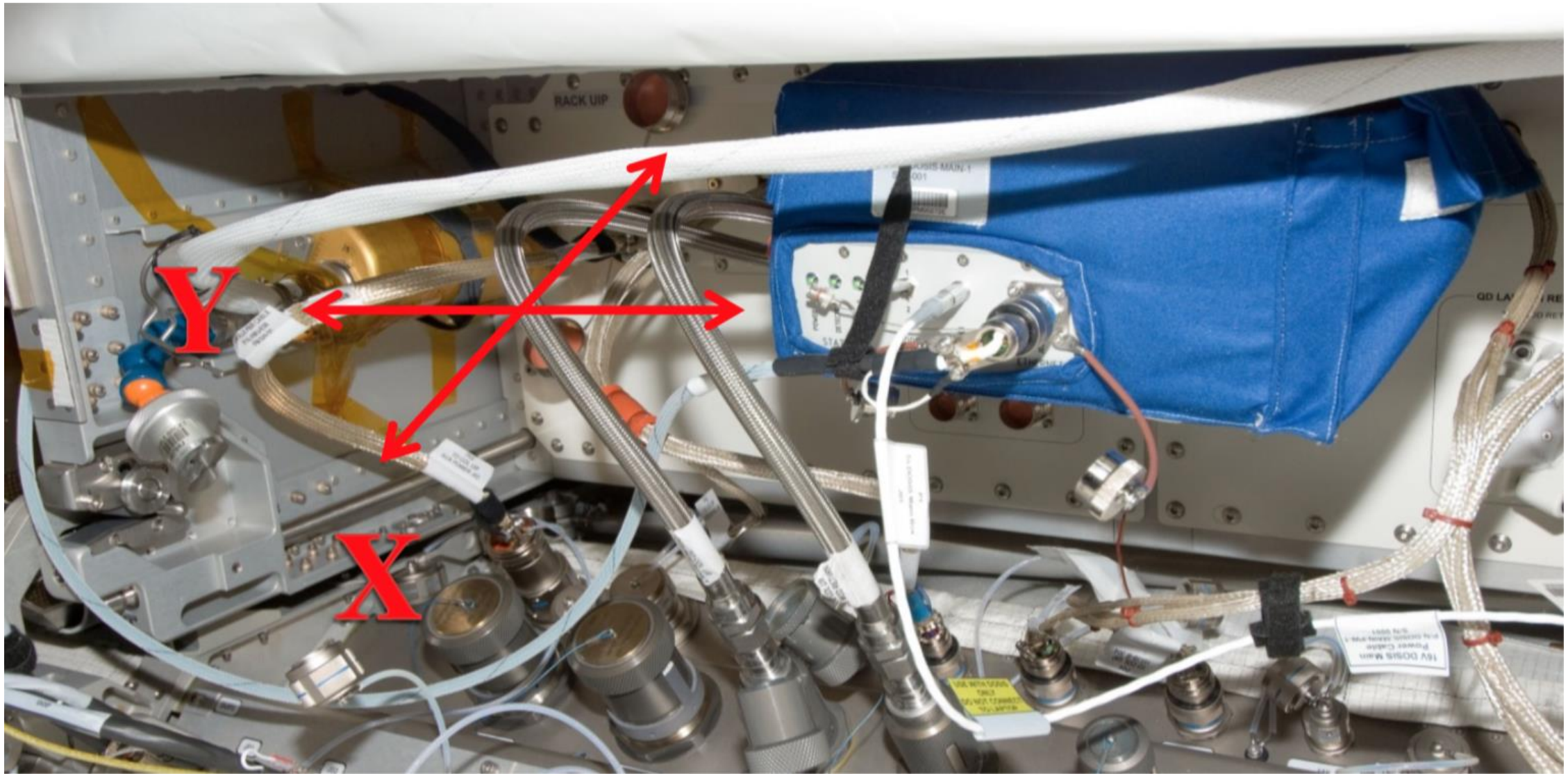


Each DOSTEL consits of two Canberra PIPS (Passivated Implanted Planar Silicon) detectors forming a telescope.
Each detector has a thickness of 315 µm and an active area of 6.93 cm^2.
The distance between the two detecots of 1.5 cm defines an opening angle of 120°.

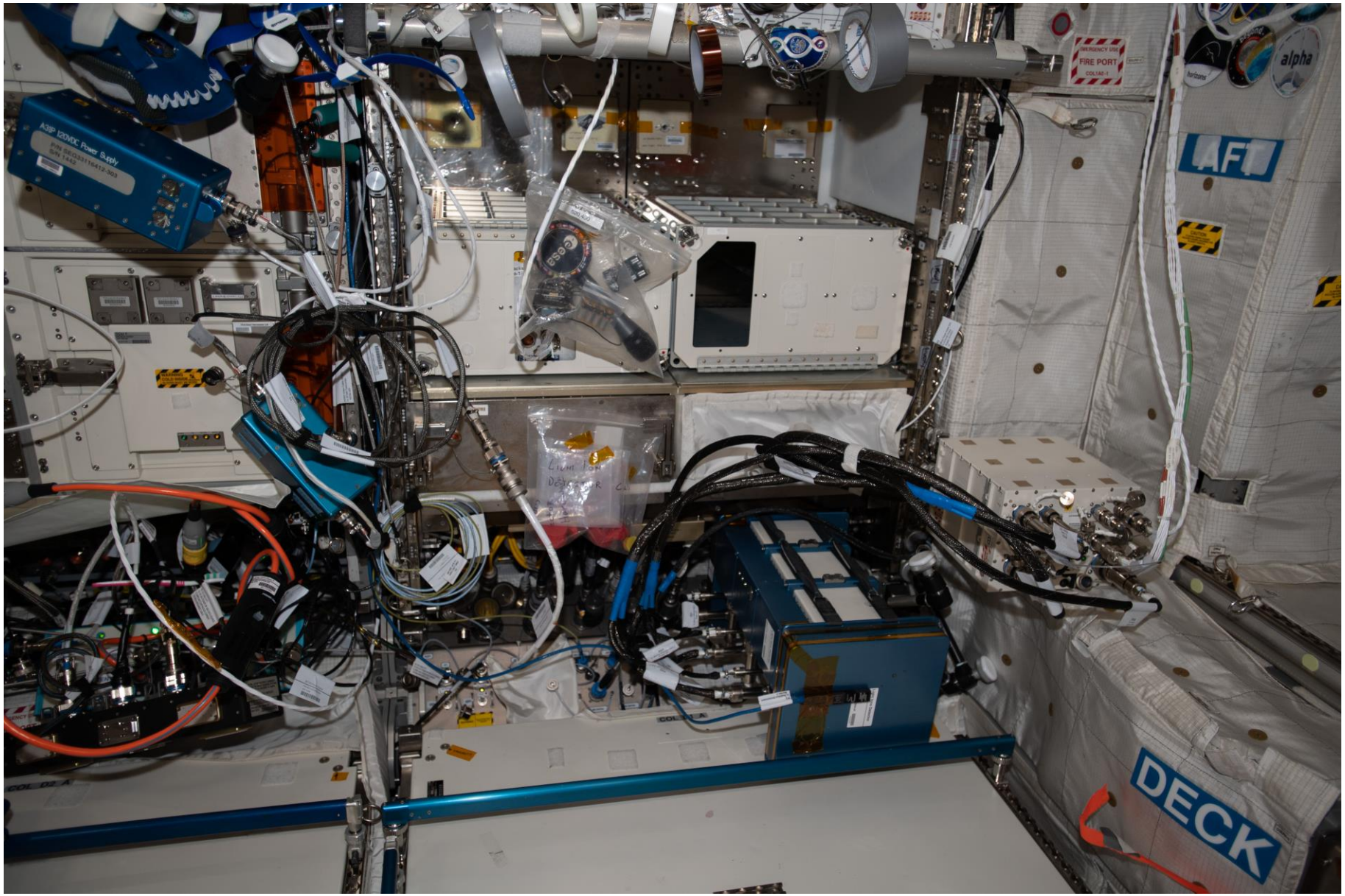
Where



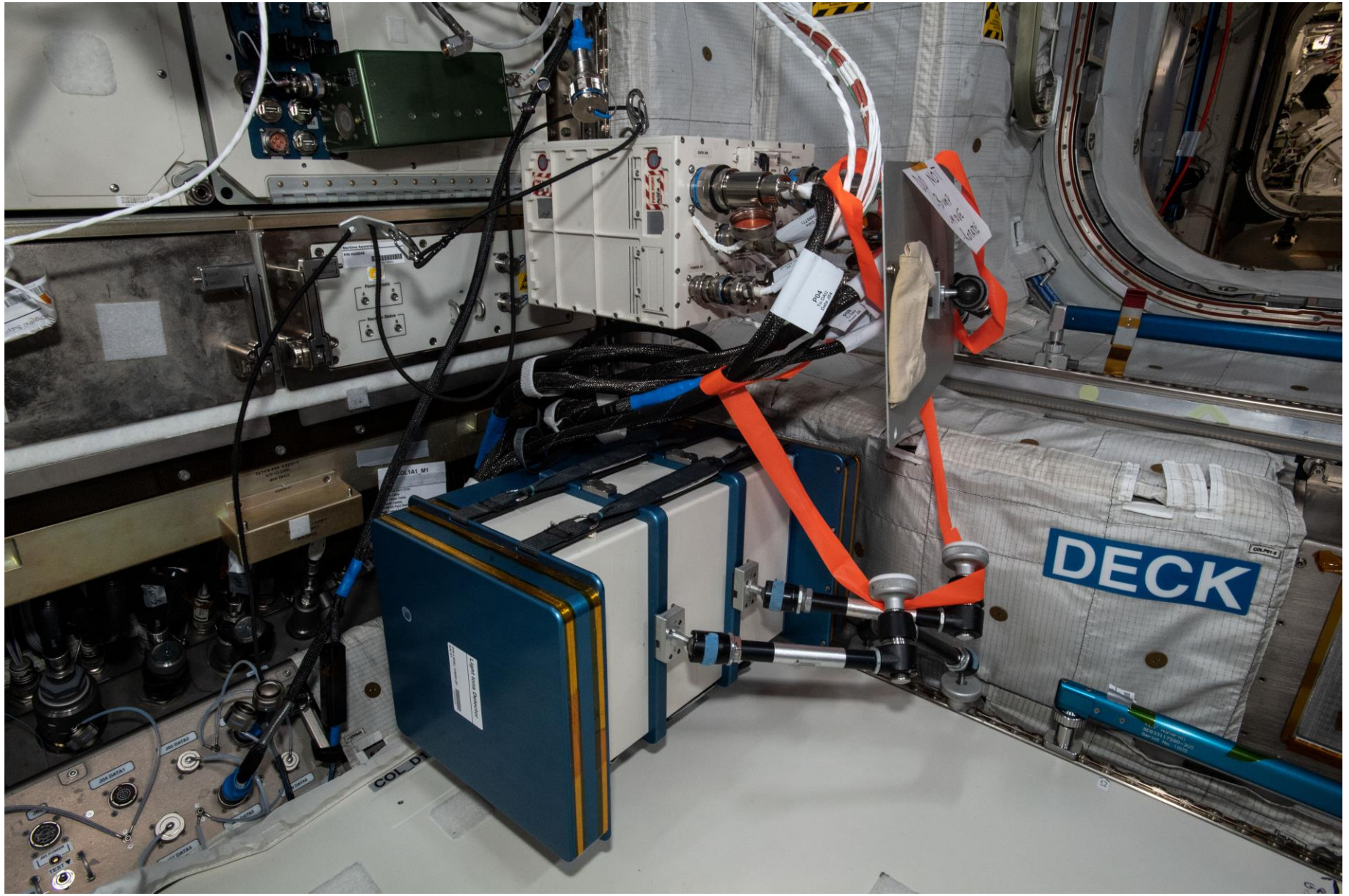
Where: DOSTEL site (fixed)



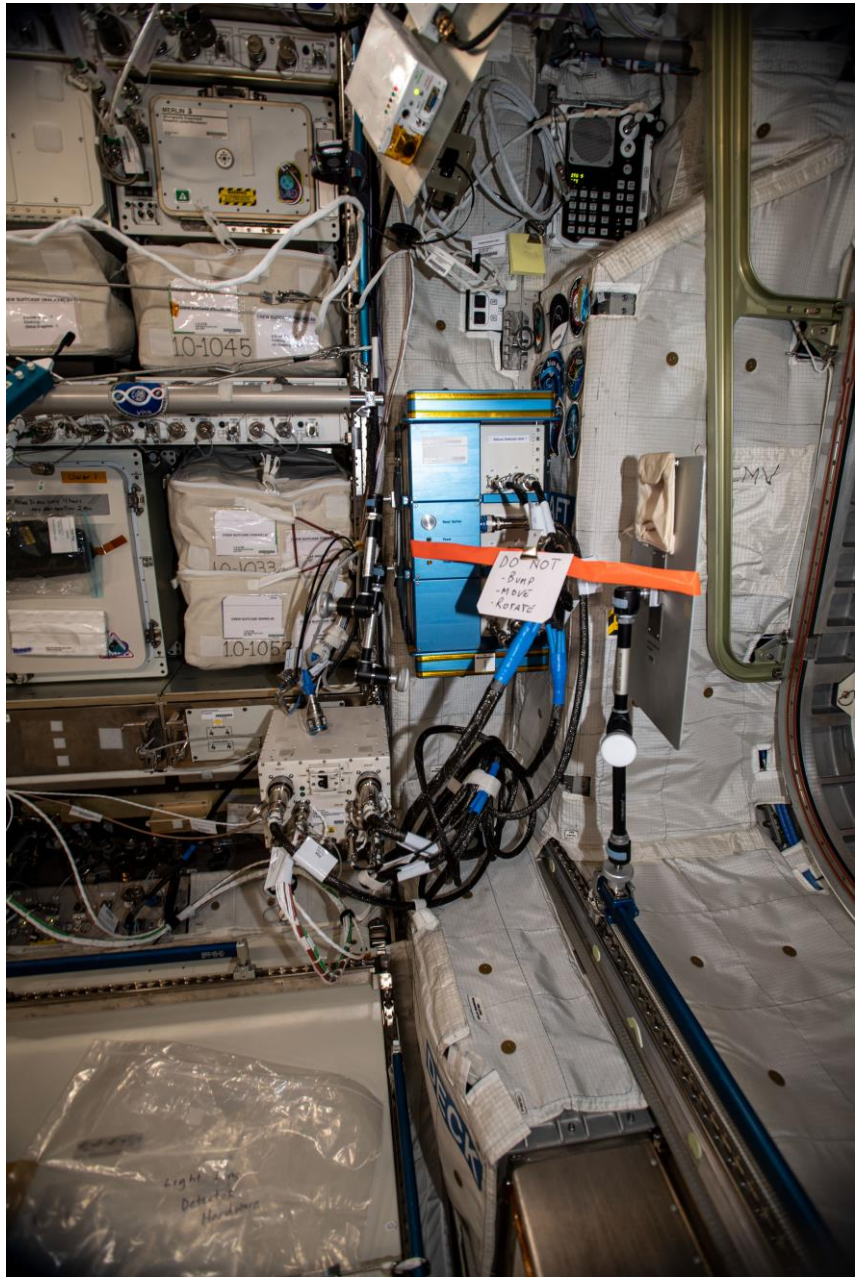
Where: LIDAL X / REM



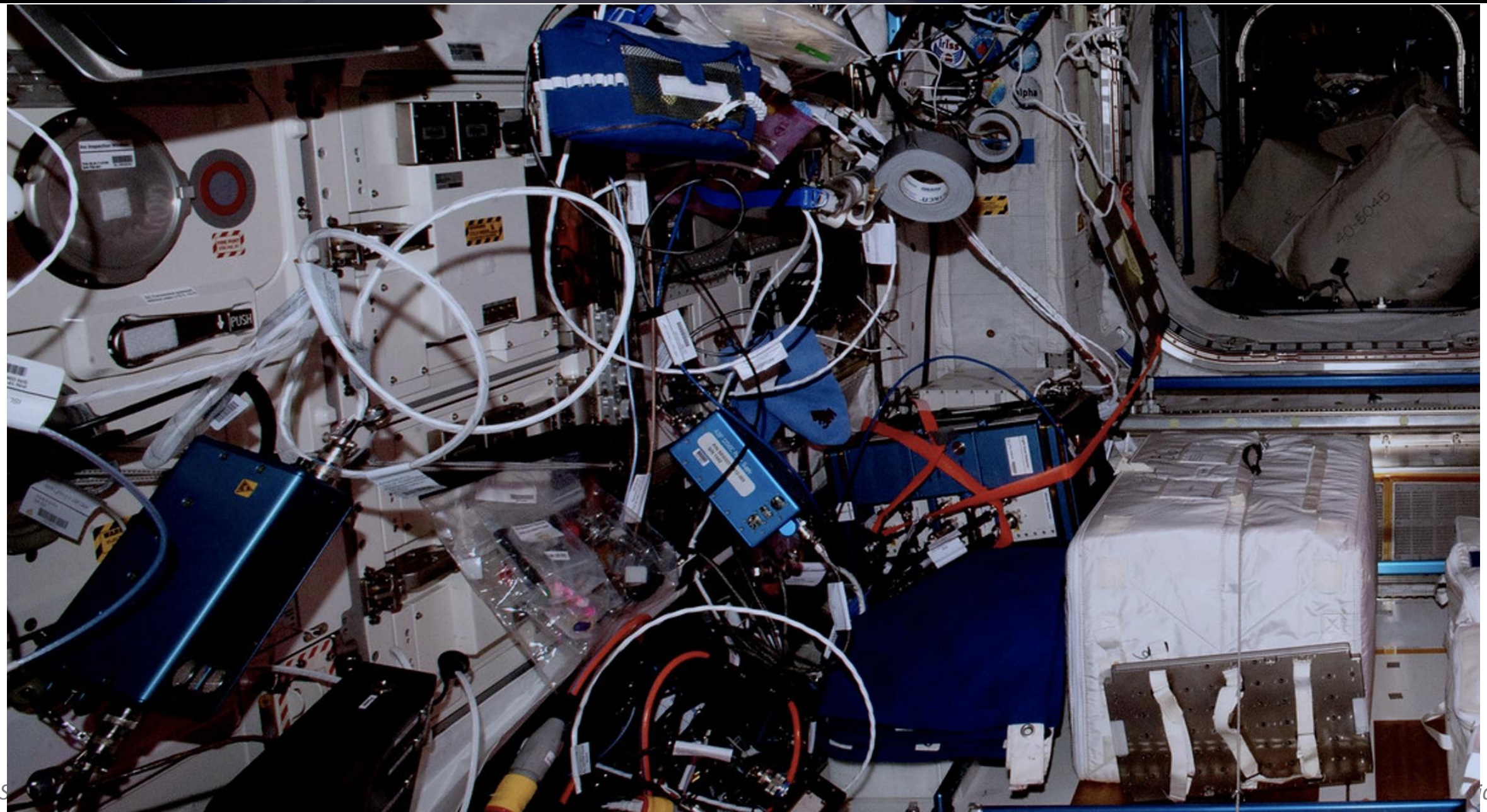
Where: LIDAL Y



Where: LIDAL Z/REM



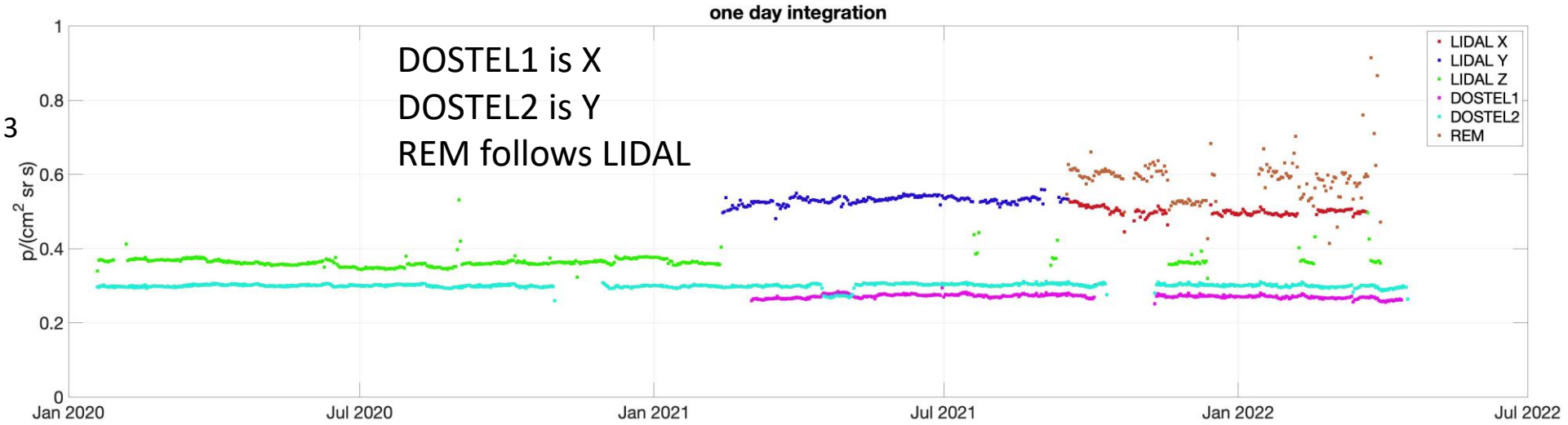
LIDAL X 2



Flux/Dose rate 1 day

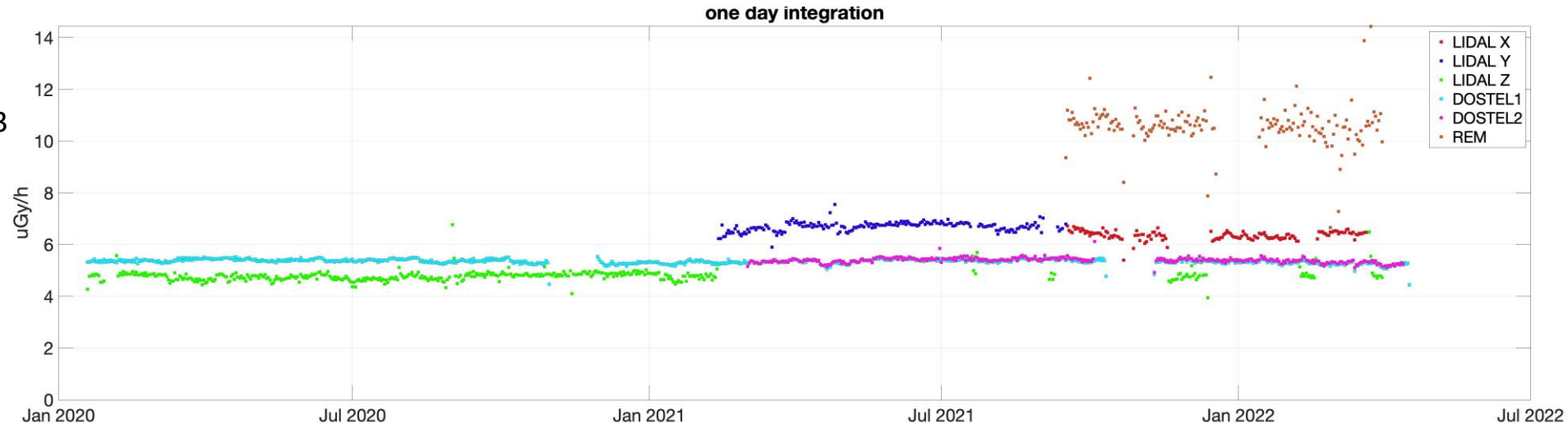
Flux
Same orders of magnitude
Differences within a factor ≤ 3

Dx > Dy but Lx < Ly
Dx, Dy < Lz
REM follows L, X <-> Z
Dx Dy 'inversion' in 2021
REM > LIDAL
REM 'noisy"?



Dose rate
Same orders of magnitude
Differences within a factor ≤ 3

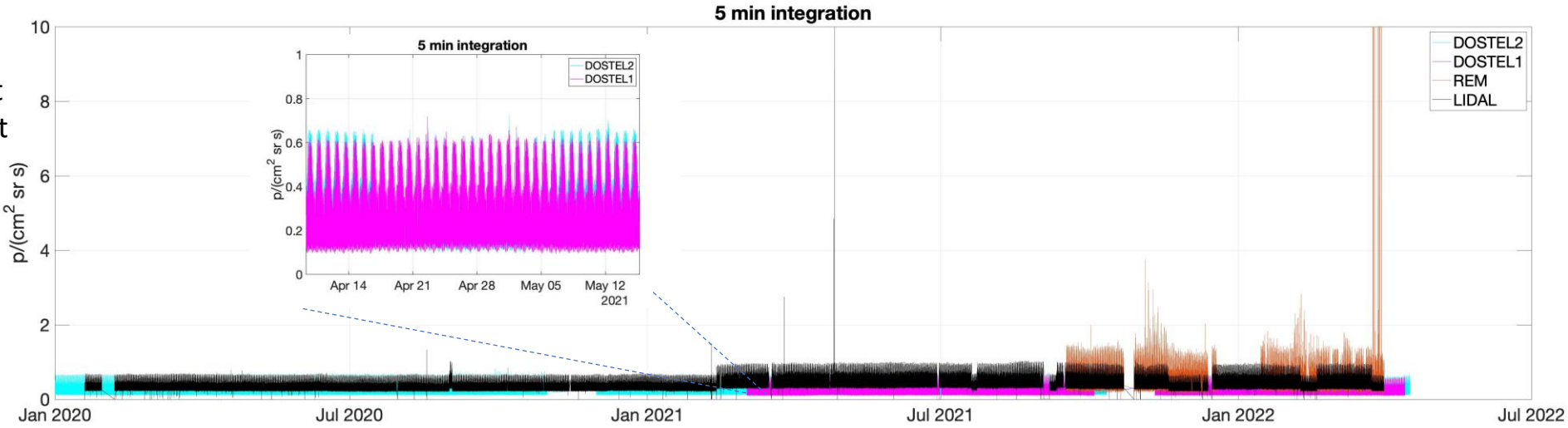
Dx = Dy but Lx < Ly
Dx, Dy > Lz
REM doesn't follow L, X <-> Z
No 2021 inversion for D
REM>>LIDAL
REM 'noisy'?



Flux/Dose rate 5 min

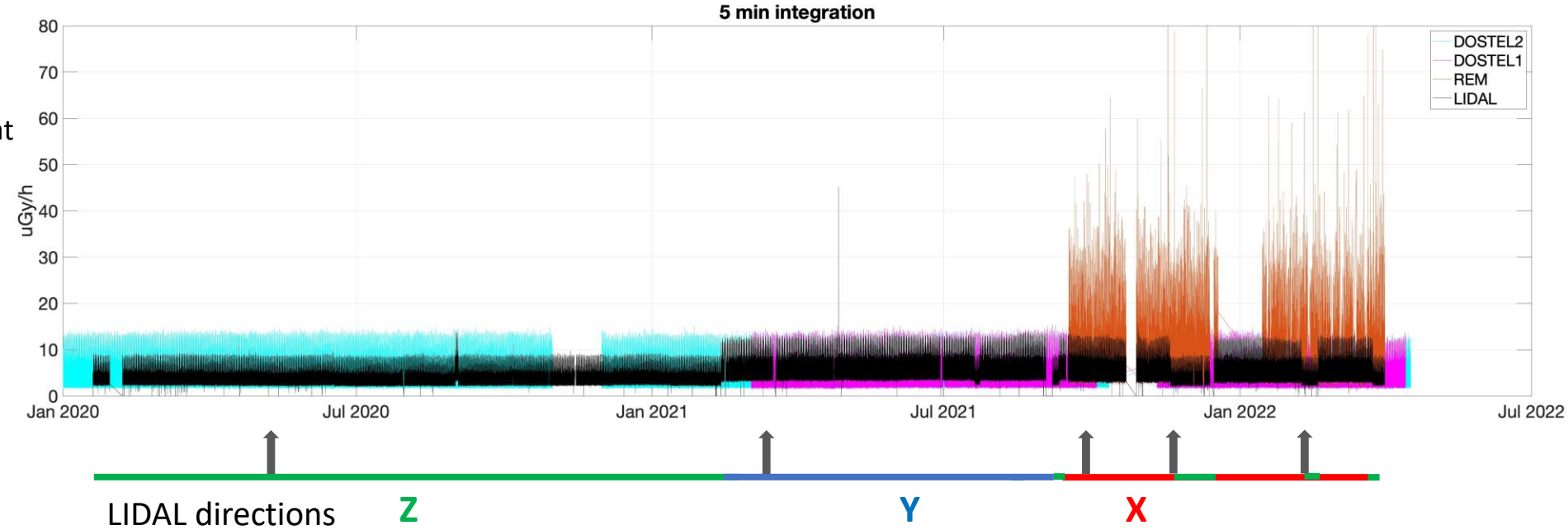
Flux

LIDAL & REM>DOSTEL at low lat
LIDAL and REM similar at low lat
Lz at high lat ≈ Dy, Dx
Ly at high lat > Dy, Dx
REM high lat >> LIDAL, DOSTEL

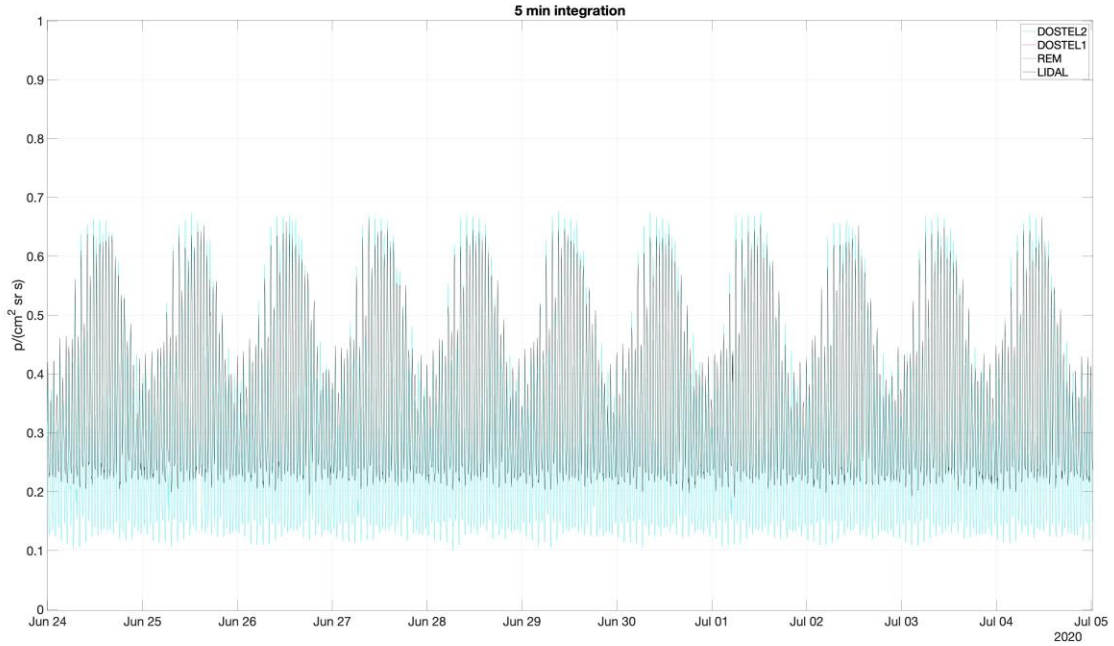


Dose

Lz measure ≈ Dx Dy at low lat
Lx Ly measure > Dx Dy at low lat
LIDAL & REM similar at low lat
Lz at high lat << Dy, Dx
Ly at high lat ≈ Dy, Dx
REM high lat >> LIDAL, DOSTEL



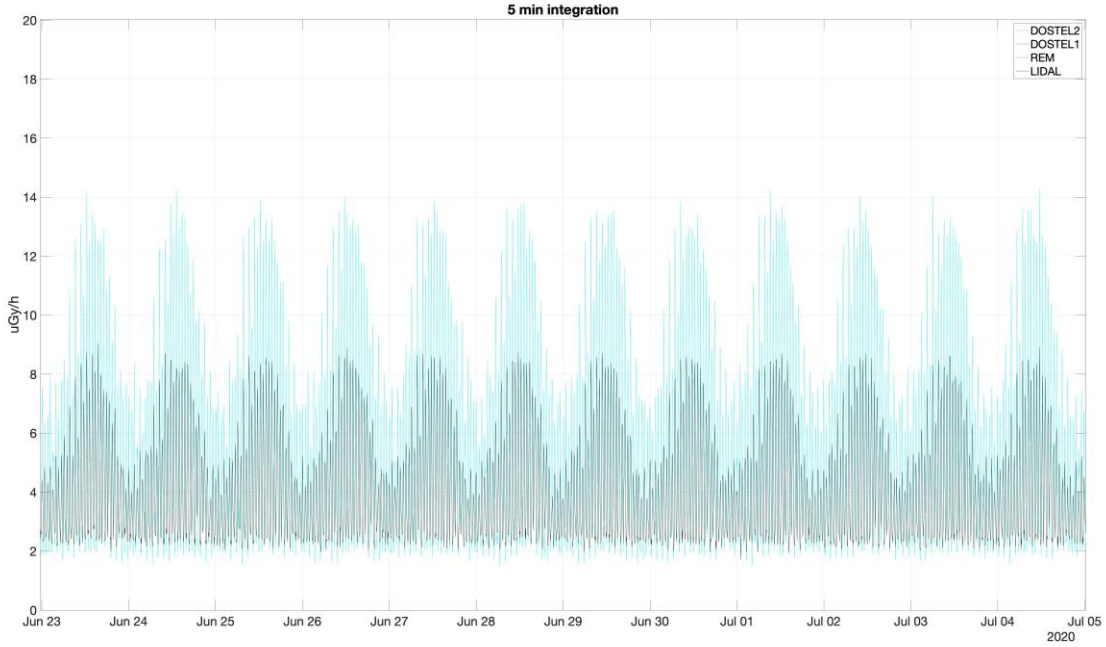
June 29th 2020



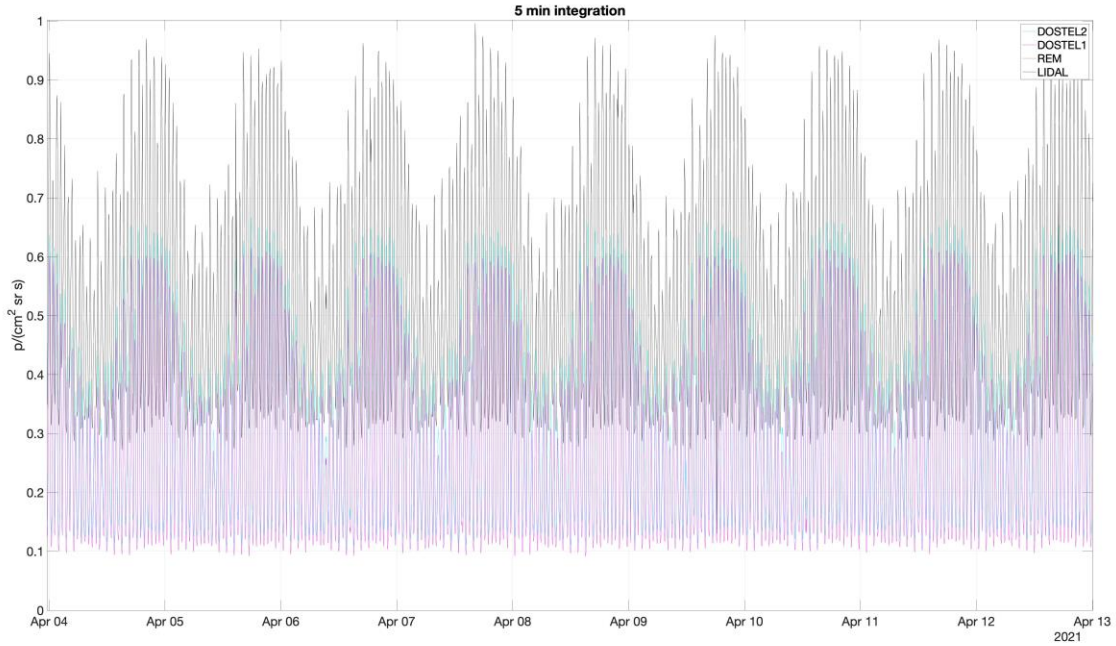
LIDAL in Z, DOSTEL2 (Y)

Flux:
LIDAL(Z) ≈ DOSTEL2(Y) high lat
LIDAL(Z) > DOSTEL2(Y) low lat
→ LIDAL(Z) > DOSTEL2(Y) in the average

Dose rate:
LIDAL(Z) ≈ DOSTEL2(Y) low lat
LIDAL(Z) < DOSTEL2(Y) high lat
→ LIDAL(Z) < DOSTEL2(Y) in the average



April 9th 2021

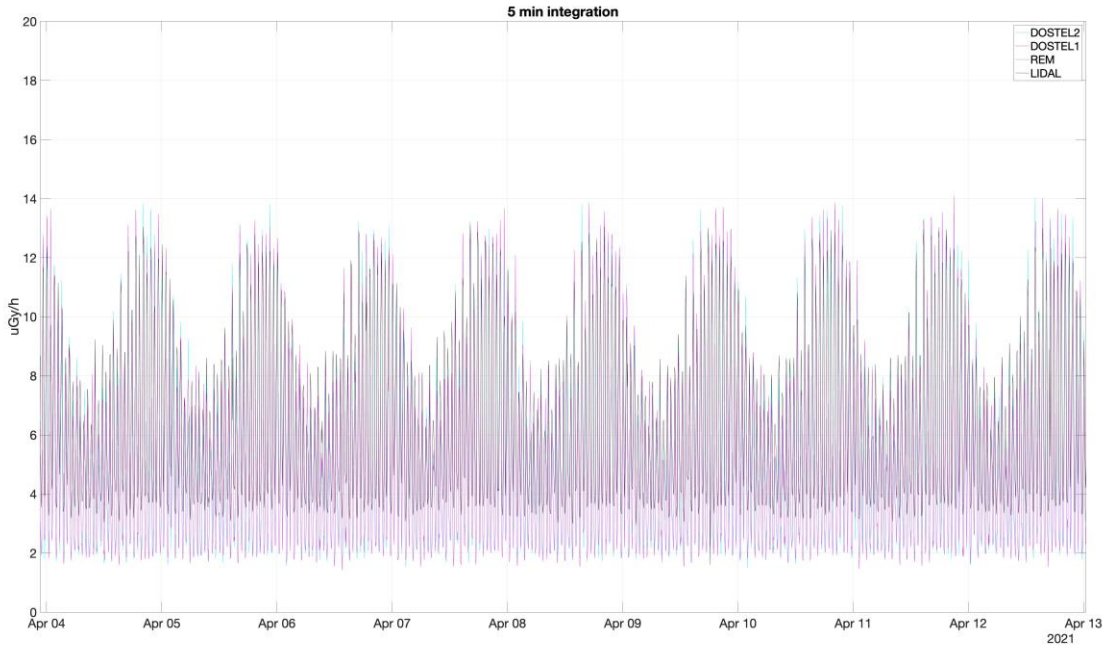


LIDAL in Y, DOSTEL2 (Y), DOSTEL1 (X)

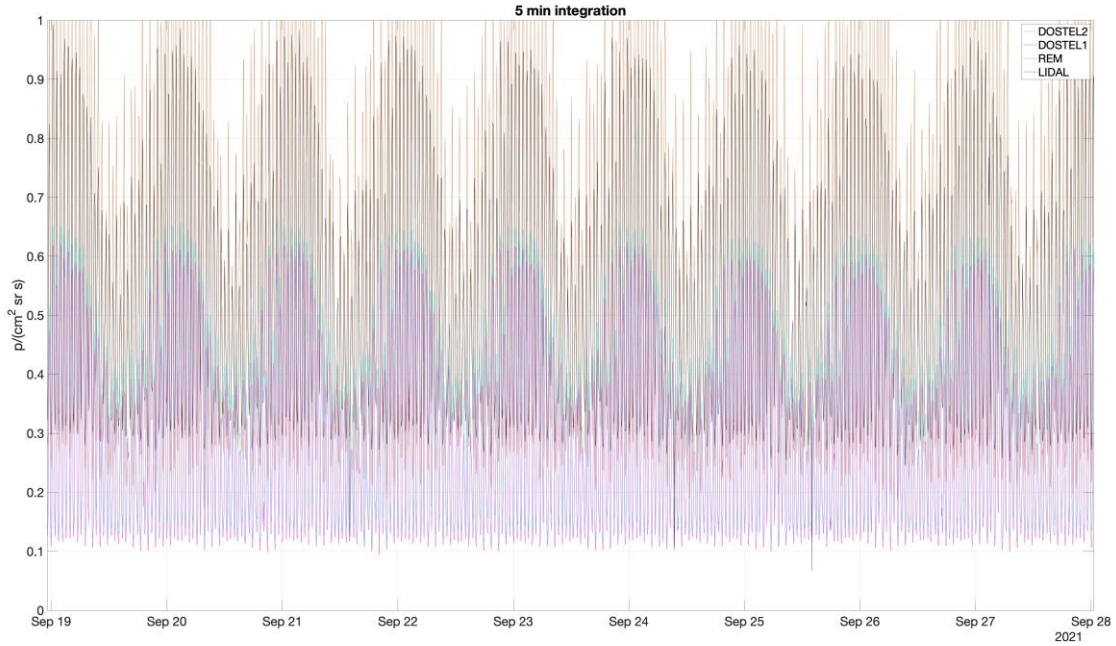
Flux:
LIDAL(Y) > DOSTEL2(Y) high lat
LIDAL(Y) > DOSTEL2(Y) low lat
→ LIDAL(Y) > DOSTEL2(Y) in the average

DOSTEL2 ≈ DOSTEL1

Dose rate:
LIDAL(Y) ≈ DOSTEL2(Y) low lat
LIDAL(Y) > DOSTEL2(Y) high lat
→ LIDAL(Y) > DOSTEL2(Y) in the average



September 23rd 2021

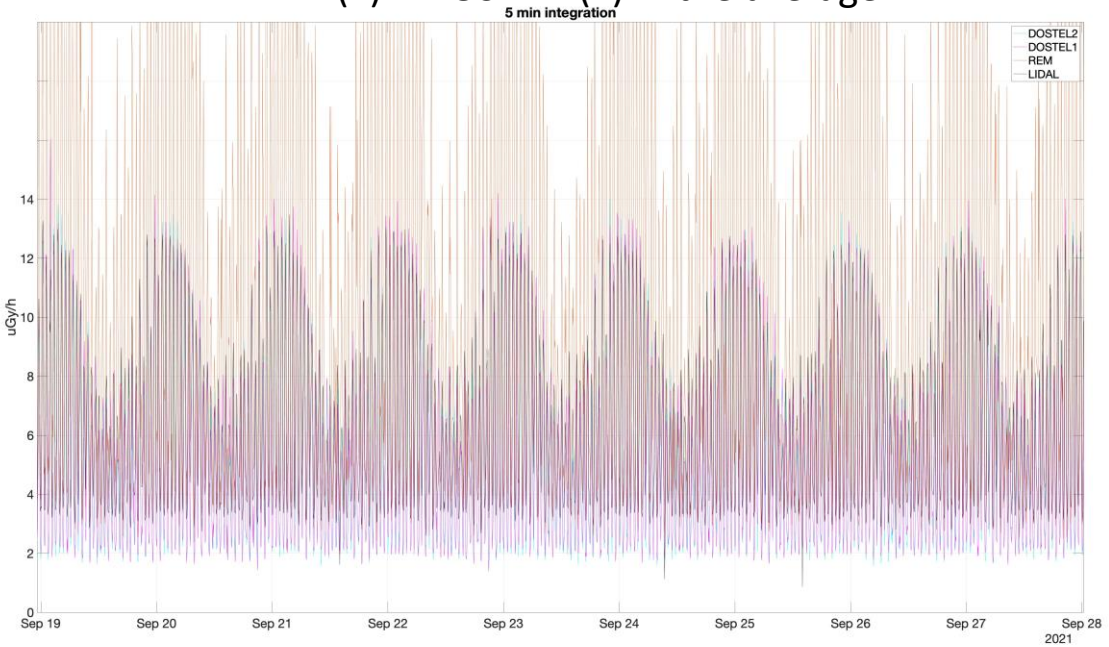


LIDAL in X, REM IN X, DOSTEL2 (Y), DOSTEL1 (X)

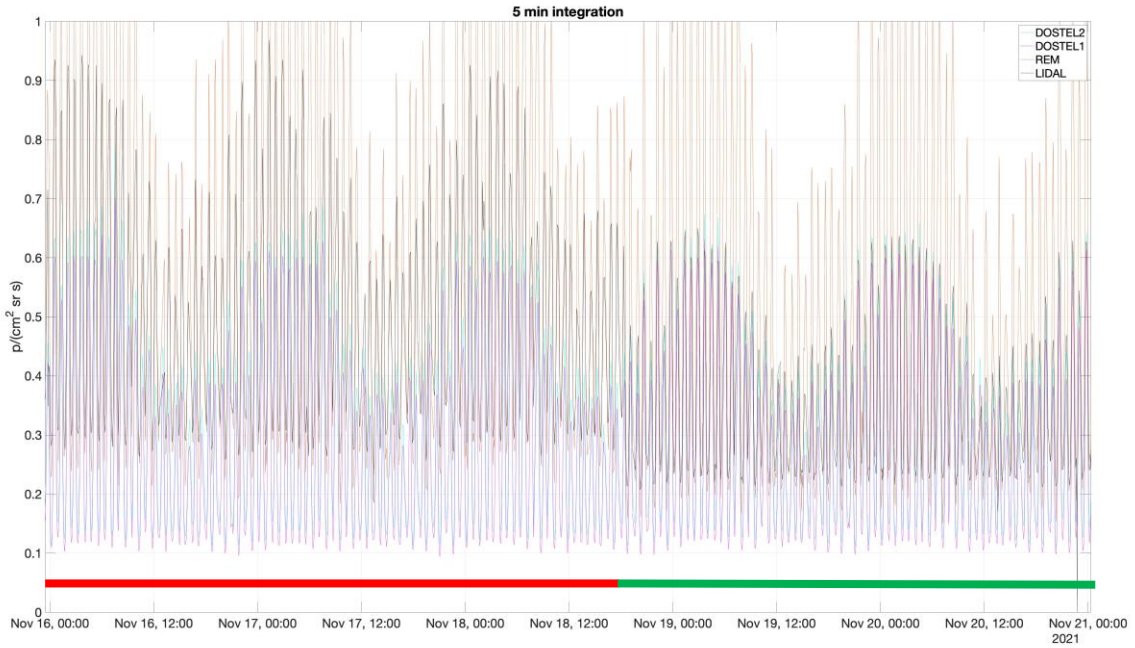
Flux:
Low lat REM ≈ LIDAL
LIDAL(X) > DOSTEL2(Y) high lat
LIDAL(X) > DOSTEL2(Y) low lat
→ LIDAL(X) > DOSTEL2(Y) in the average

DOSTEL2 ≈ DOSTEL1

Dose rate:
Low lat REM ≈ LIDAL
LIDAL(X) > DOSTEL2(Y) low lat
LIDAL(X) ≈ DOSTEL2(Y) high lat
→ LIDAL(Y) > DOSTEL2(Y) in the average

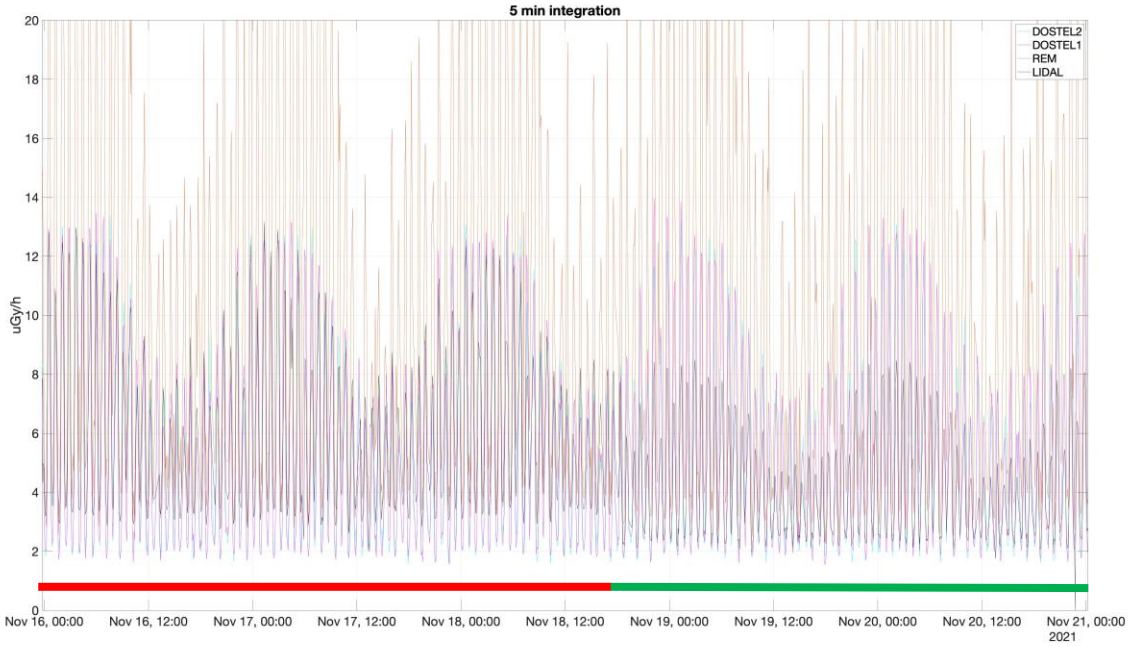


November 18th 2021



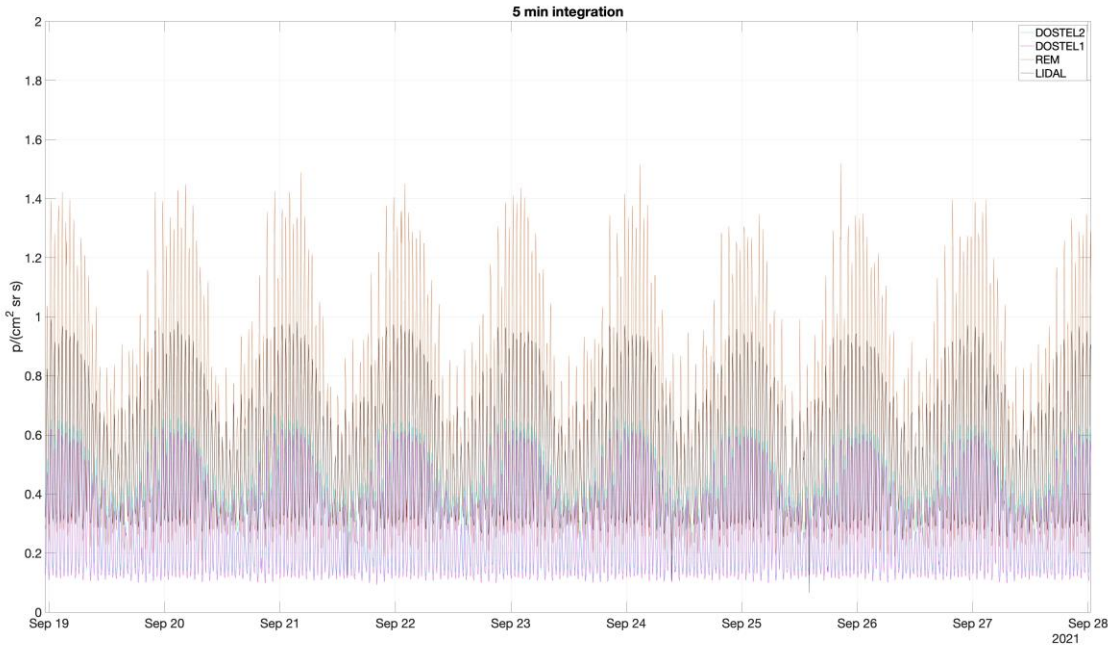
LIDAL & REM from X to Z, DOSTEL2 (Y), DOSTEL1 (X)

LIDAL
Low lat: larger decrease in flux than in dose rate
High lat: decrease in flux & dose rate
→ Decrease in flux and dose rate

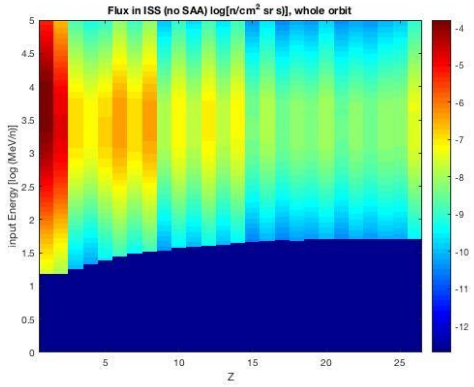


DOSTEL REM

September 23rd 2021 large scale



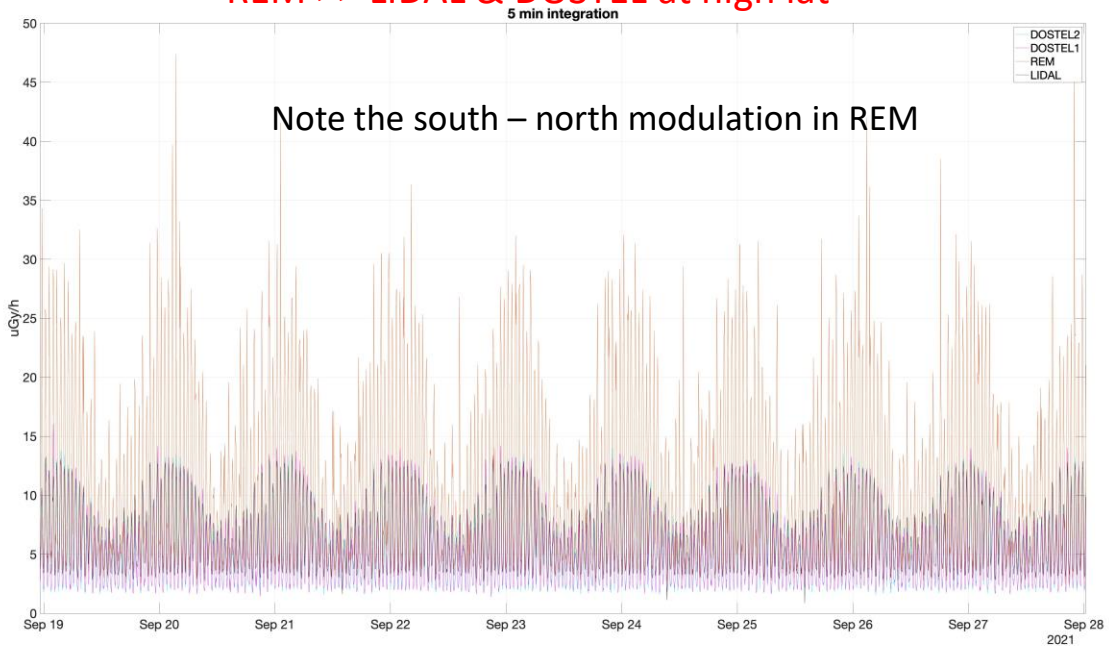
LIDAL in X, REM IN X, DOSTEL2 (Y), DOSTEL1 (X)



Why REM so larger?
Could it be triggering limits?
Yes, for LIDAL
Probably no, for DOSTEL

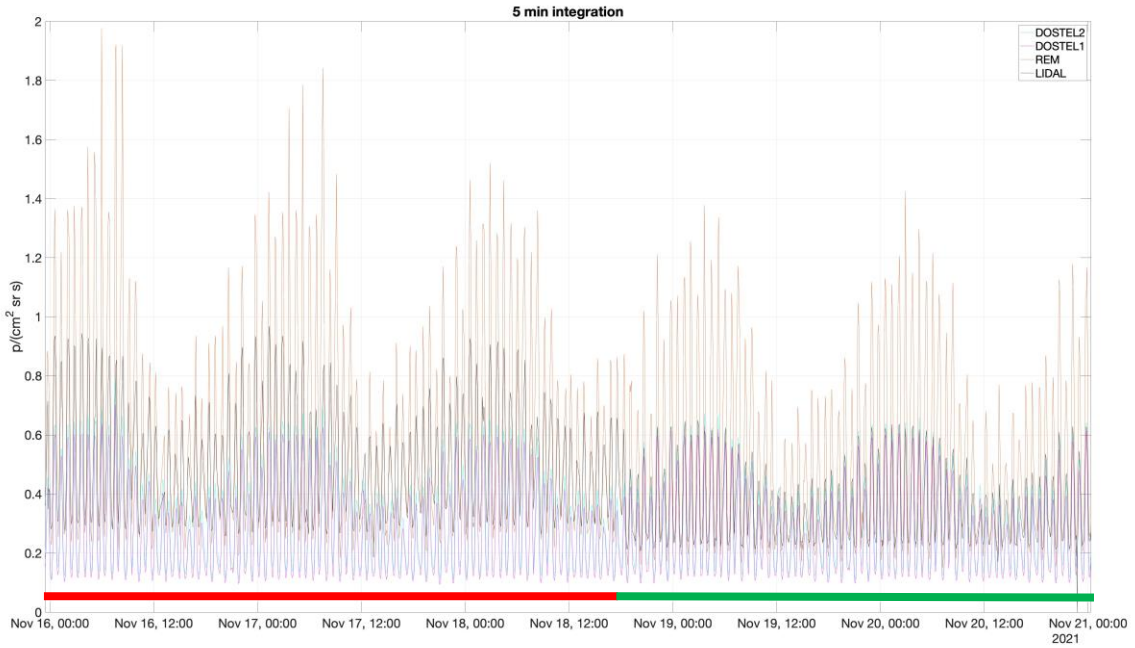
Flux:
Low lat REM ≈ LIDAL
LIDAL(X) > DOSTEL2(Y) high lat
LIDAL(X) > DOSTEL2(Y) low lat
→ LIDAL(X) > DOSTEL2(Y) in the average
REM > LIDAL & DOSTEL at high lat

Dose rate: DOSTEL2 ≈ DOSTEL1
Low lat REM ≈ LIDAL
LIDAL(X) > DOSTEL2(Y) low lat
LIDAL(X) ≈ DOSTEL2(Y) high lat
→ LIDAL(Y) > DOSTEL2(Y) in the average
REM >> LIDAL & DOSTEL at high lat



Note the south – north modulation in REM

November 18th 2021 large scale



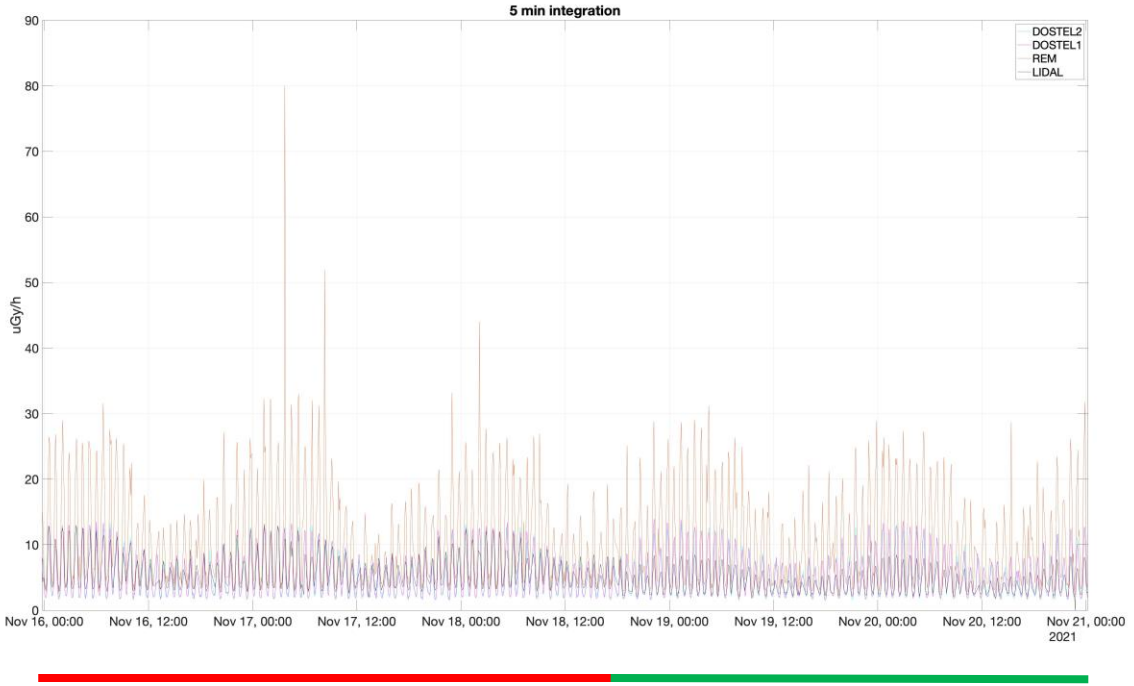
LIDAL & REM from X to Z, DOSTEL2 (Y), DOSTEL1 (X)

LIDAL

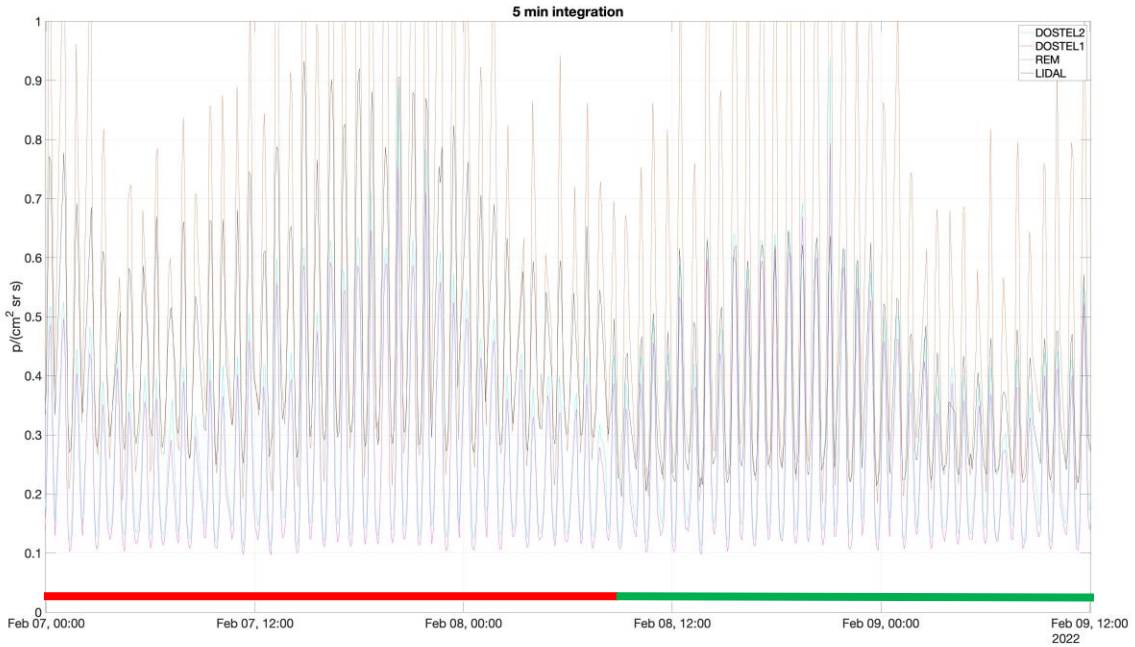
Low lat: larger decrease in flux than in dose rate
High lat: decrease in flux & dose rate
→ Decrease in flux and dose rate

REM

Low lat: larger decrease in flux than in dose rate
High lat: small decrease in flux, dose rate constant



February 8th 2022



LIDAL & REM from X to Z, DOSTEL2 (Y), DOSTEL1 (X)

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Low lat: larger decrease in flux than in dose rate
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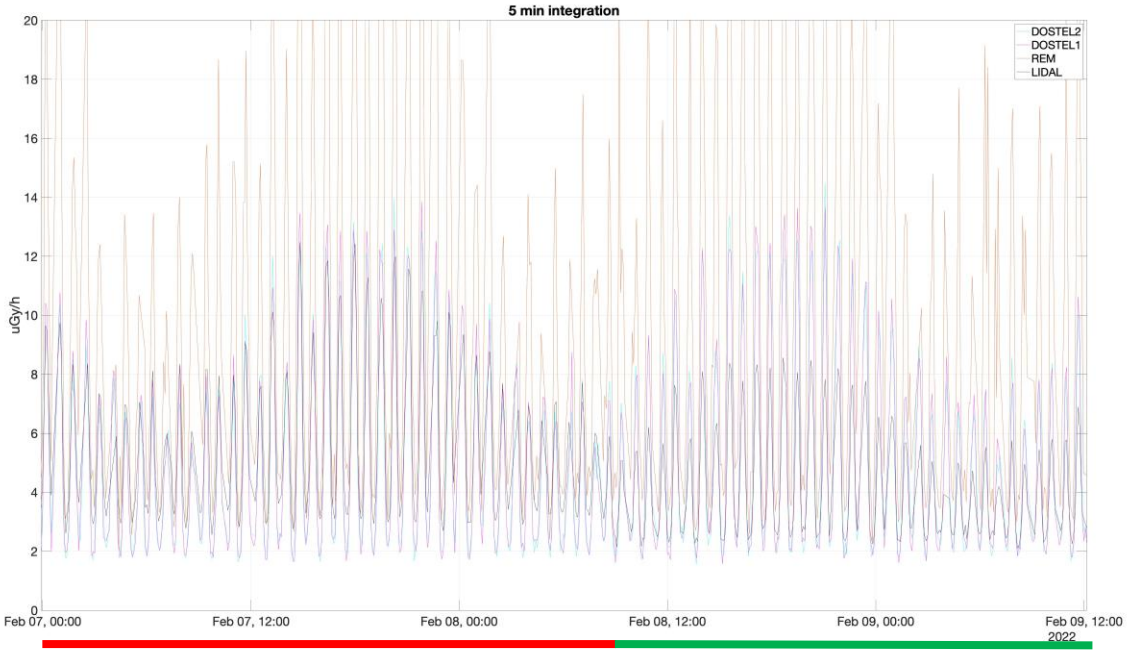
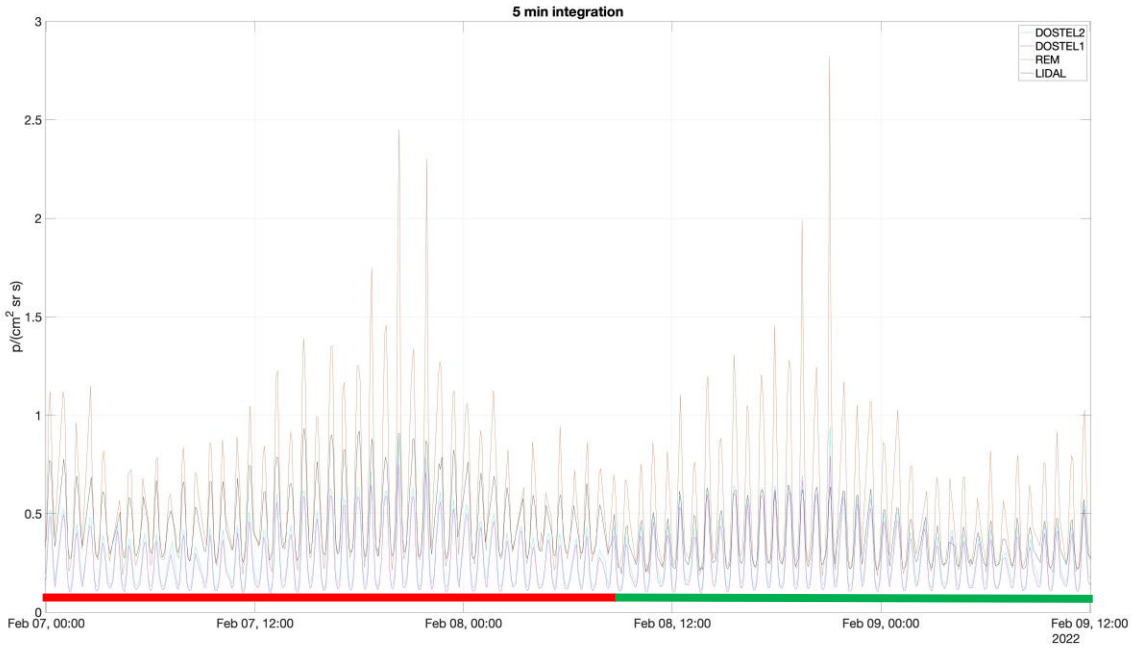


February 8th 2022 large scale



LIDAL & REM from X to Z, DOSTEL2 (Y), DOSTEL1 (X)

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Low lat: larger decrease in flux than in dose rate
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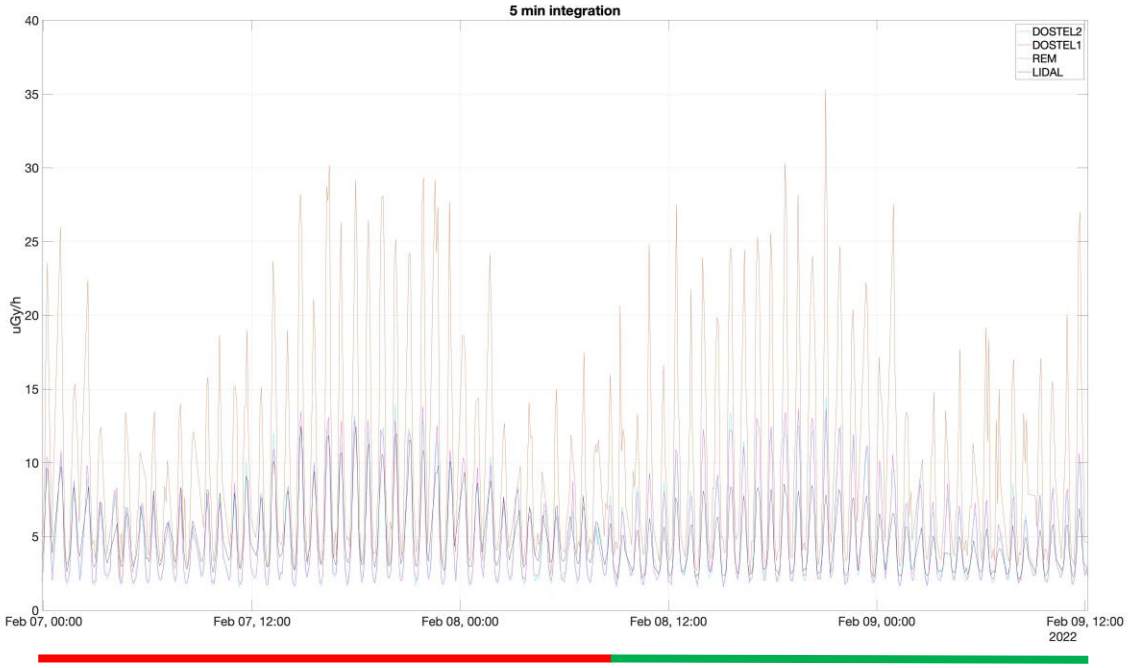
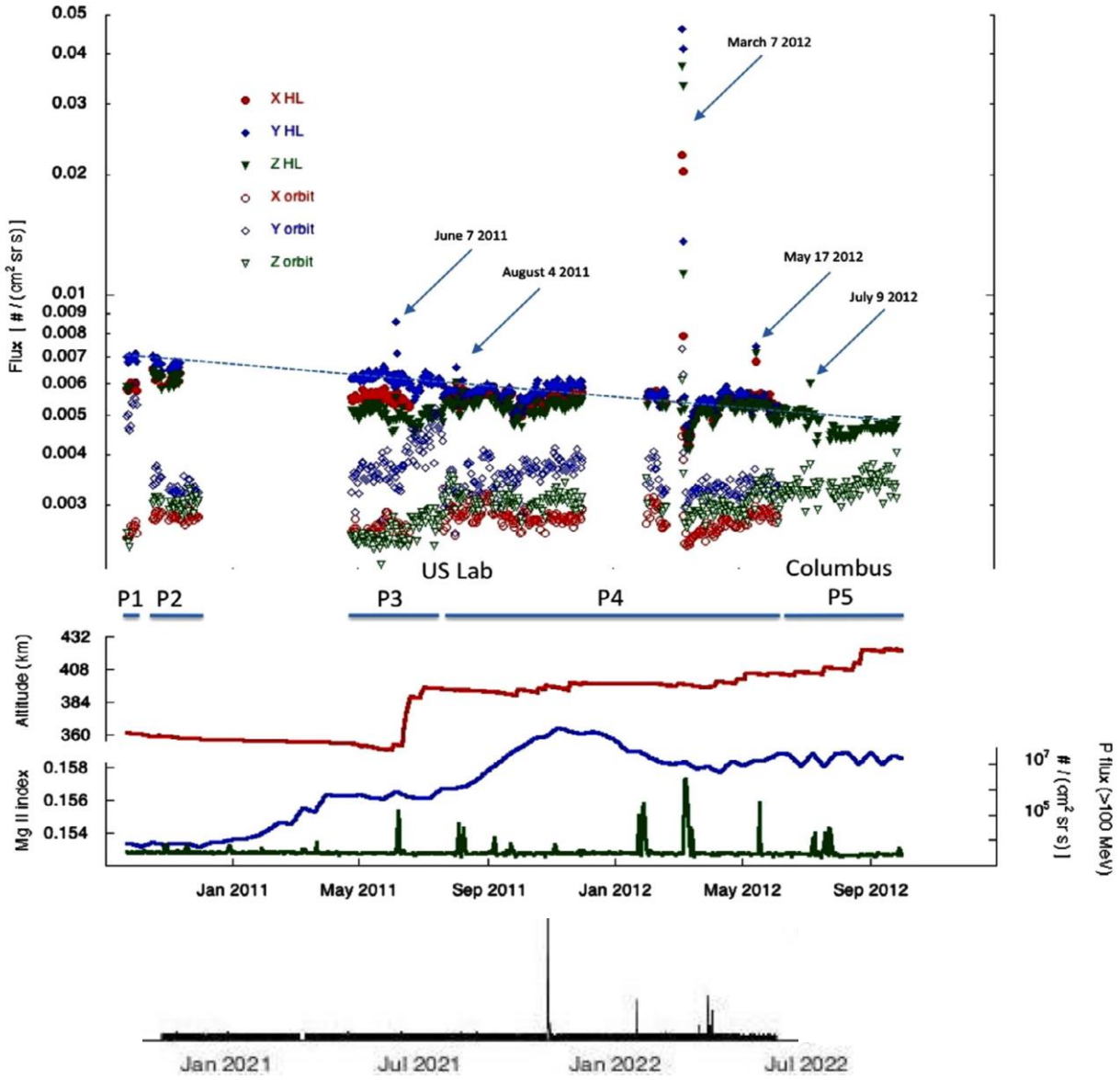
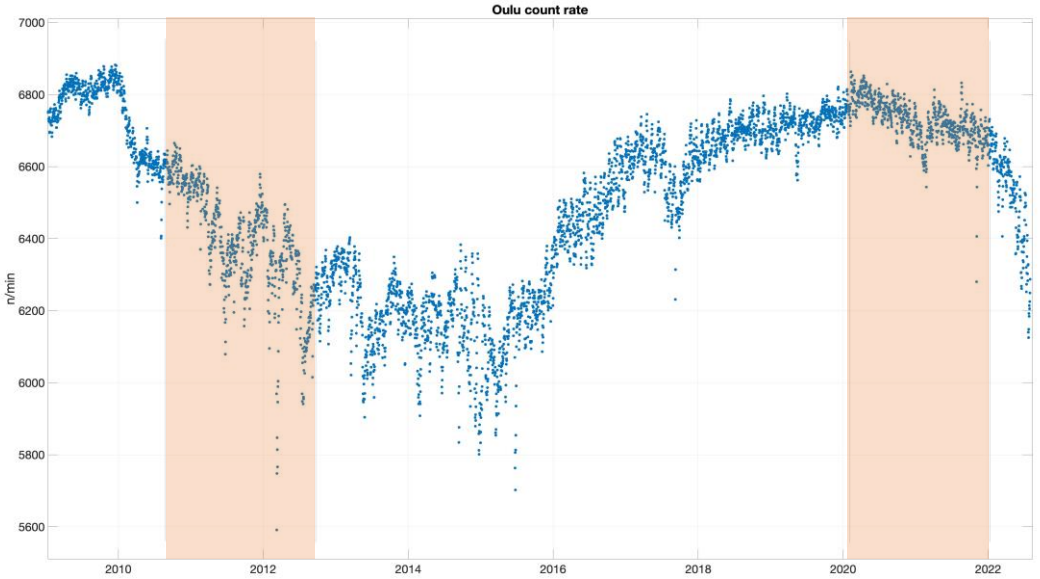


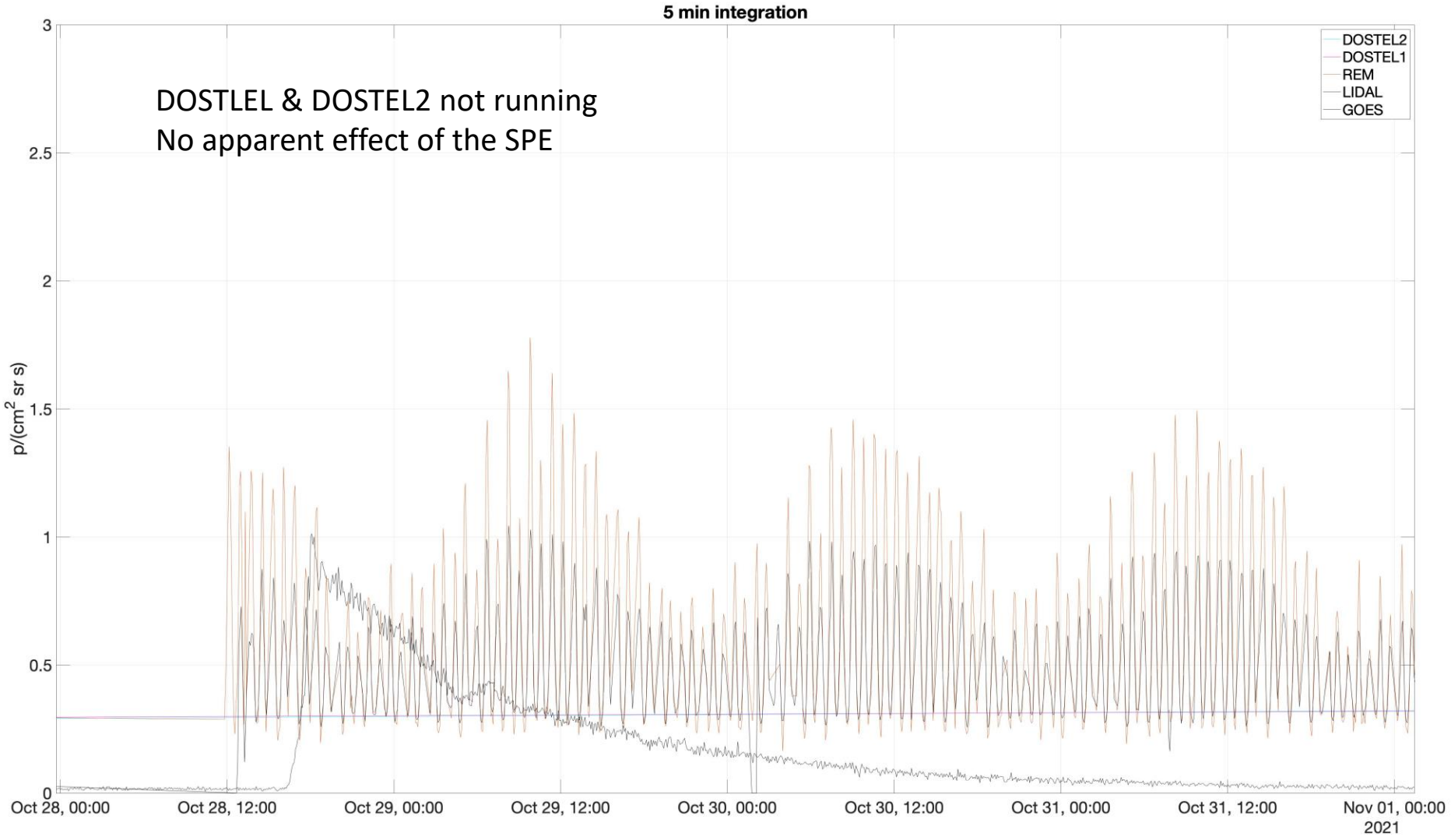
Solar cycles



With respect with one solar cycle ago fewer SPEs and almost none in a period to be measured inside the ISS



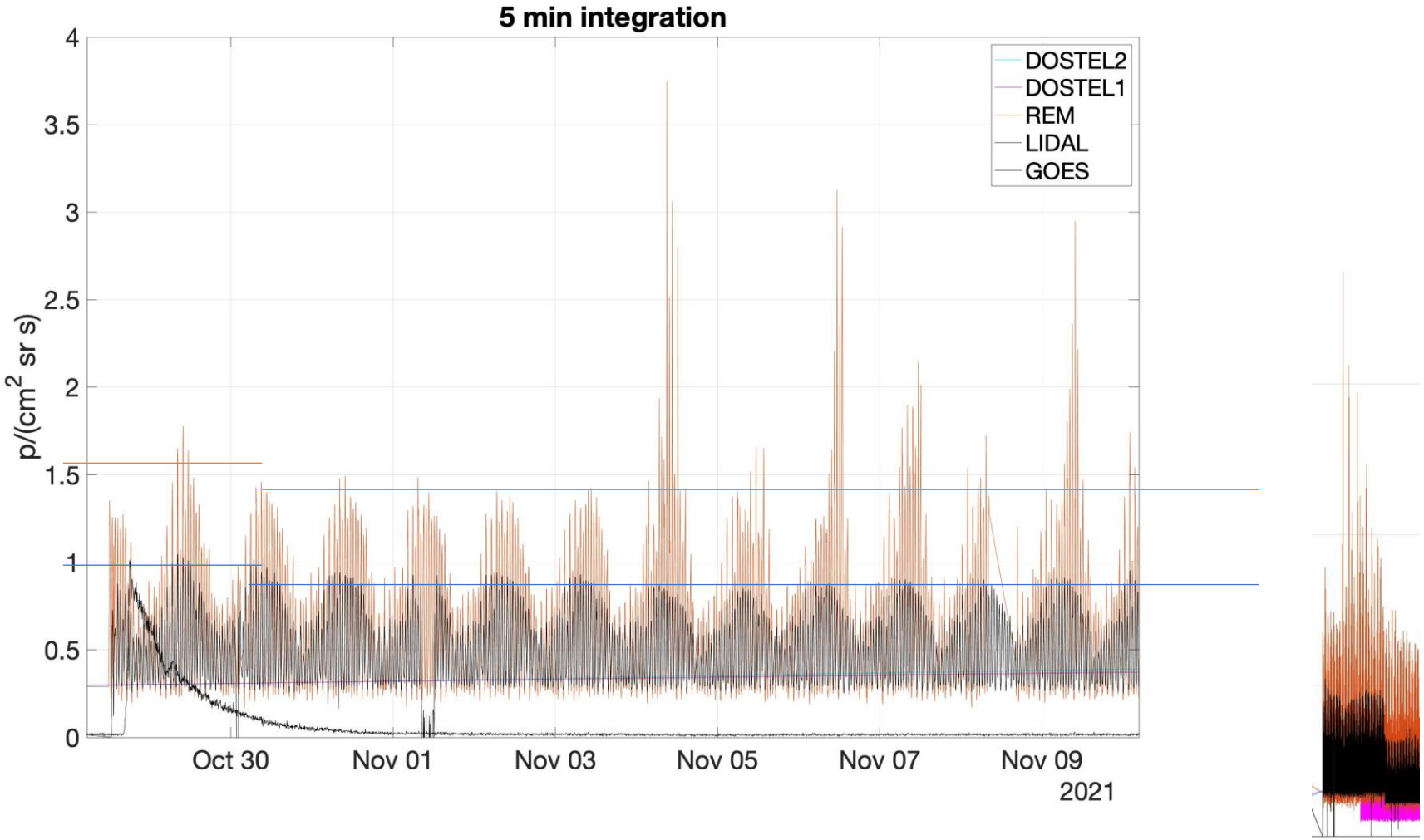
SPE October 28th 2021



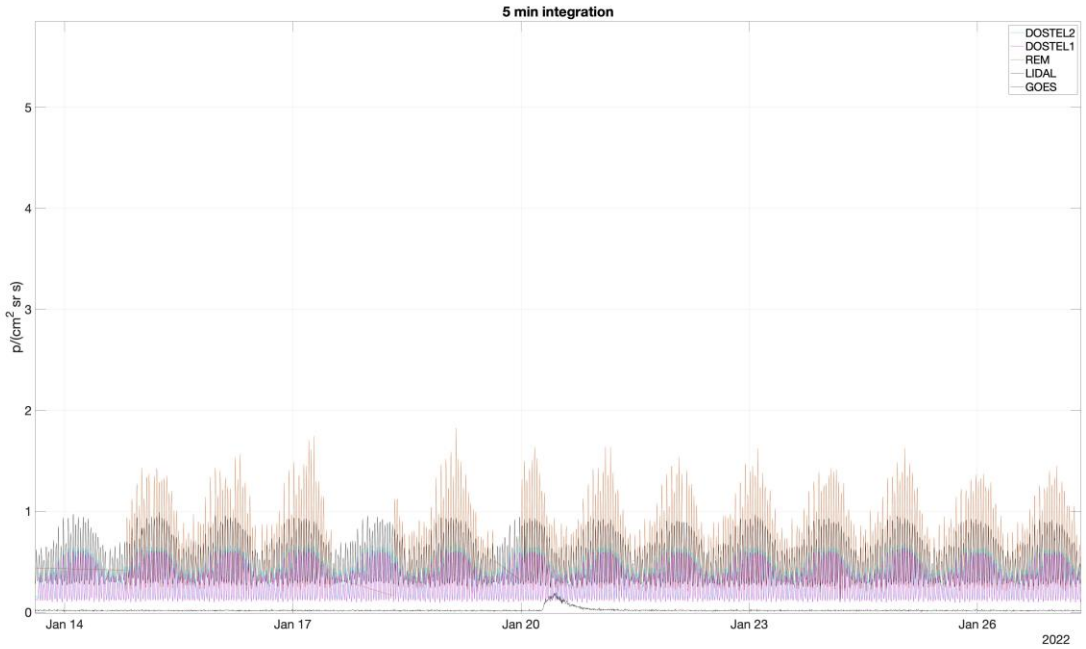
DOSTLEL & DOSTEL2 not running
No apparent effect of the SPE

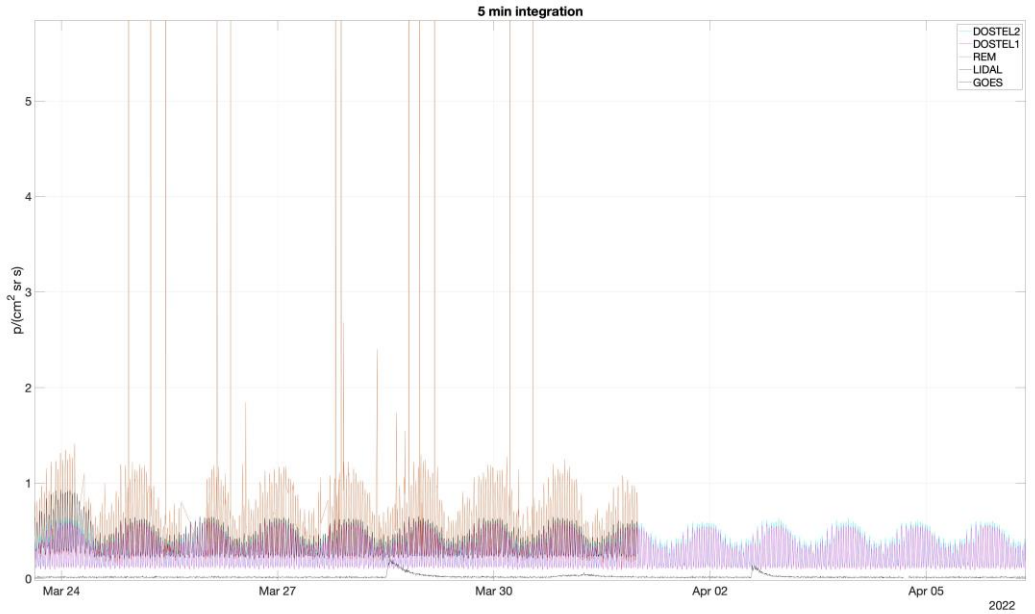
SPE October 28th 2021

Forbush effect?



SPEs January 20th, March 28th, April 2nd 2022





In all cases the SPE appears in a period of maximum magnetic shielding

Open points

The issues to be addressed are many

- Differences in geometrical acceptance of the detectors
- Differences in the triggering modes
- Reconstruction algorithms (especially for LIDAL and REM)
- How to consider the Earth shadow

- Information provided by the differences in flux vs dose rates
- Information provided by the differences in low vs high latitude
- Why are REM data larger at high latitude (noisy? But some of the dynamic appears correct!)
- How big could be the 'reasonable' difference between REM/LIDAL and DOSTEL, due to the different detector locations?
- Why the low latitude data from DOSTEL are generally lower (than LIDAL & REM)?

- SPE: is the statistic acceptable for this period of solar cycle? (very few, none entering the ISS)

- SAA still to be worked out

Take home messages and TDL

Trivial things ←→ lengthy process:
- Measurement units
- Date units
- Not availability of data for some periods (‘holes’)
- Ancillary data (Alt Lon Lat B L) {…. are all ancillary data OK?}

Obvious messages ←→ good to repeat
- Even among silicon detectors the differences can be large if not adequately described (→ factor ≈ 2)
- Metadata are important

Initial proposal for a To Do List
- Effort to **write** metadata and procedure (algorithms) in a usable (for all) and comparable way
- Study possible ways to provide ‘best matching data’ (e.g. same geometrical acceptance) to minimize hardware differences
- Work all on the same set of cleaned data
- Set up a ‘fast cycle’ analysis group
- … understand the differences … (starting from flux?)

Further
- Spectra
- SAA
- ‘Real time’
- Etc …

The teams

LIDAL team

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Giorgia Santi Amantini
Giorgio Baiocco
Alice Mentana
Virginia Boretti
Luca Lunati

REM team

Kerry Lee
George Stuart
Nic Stoffle
Tom Campbell-Ricketts
Andy Castro

DOSTEL team

Thomas Berger
Daniel Matthiae
Bartos Przybyla
Sönke Burmeister

Thank you for your attention

and … please

COMMENTS! QUESTIONS!!