



The RAMIS radiation detector of the DLR Eu:CROPIS mission – data from first 8 months at 600 km orbit

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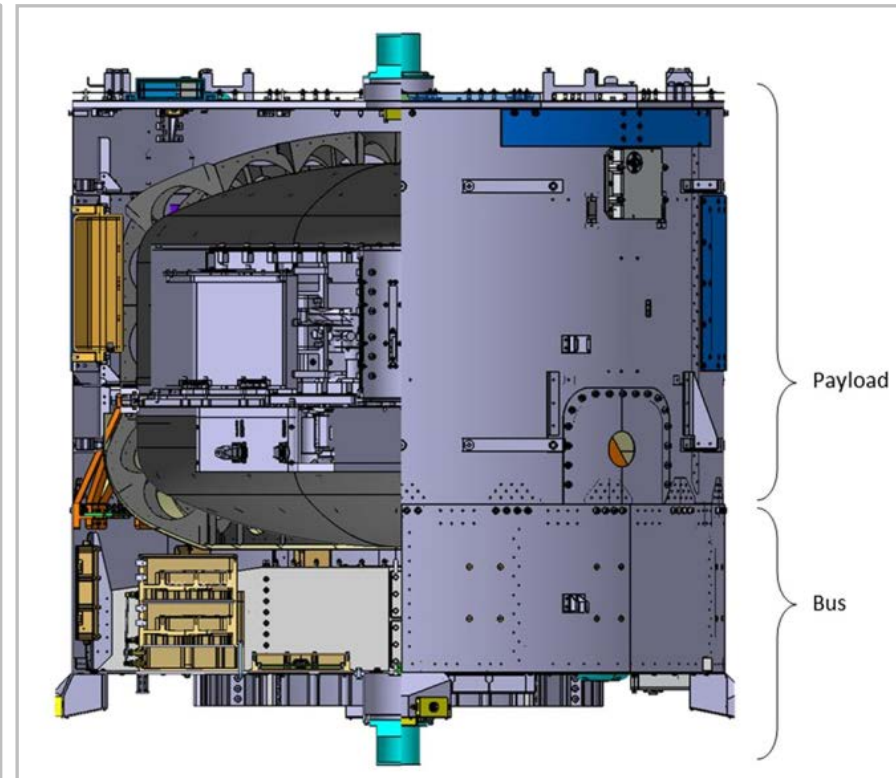
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Germany



Knowledge for Tomorrow



Eu:CROPIS: New Compact Satellite Class by DLR



<https://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-11082/>
<https://www.dlr.de/irs/en/desktopdefault.aspx/tabid-11288/#gallery/29952>



Eu:CROPIS: Mission Goal

Microgravity-Science and Technology
<https://doi.org/10.1007/s12217-018-9654-1>

ORIGINAL ARTICLE



Eu:CROPIS – “*Euglena gracilis*: Combined Regenerative Organic-food Production in Space” - A Space Experiment Testing Biological Life Support Systems Under Lunar And Martian Gravity

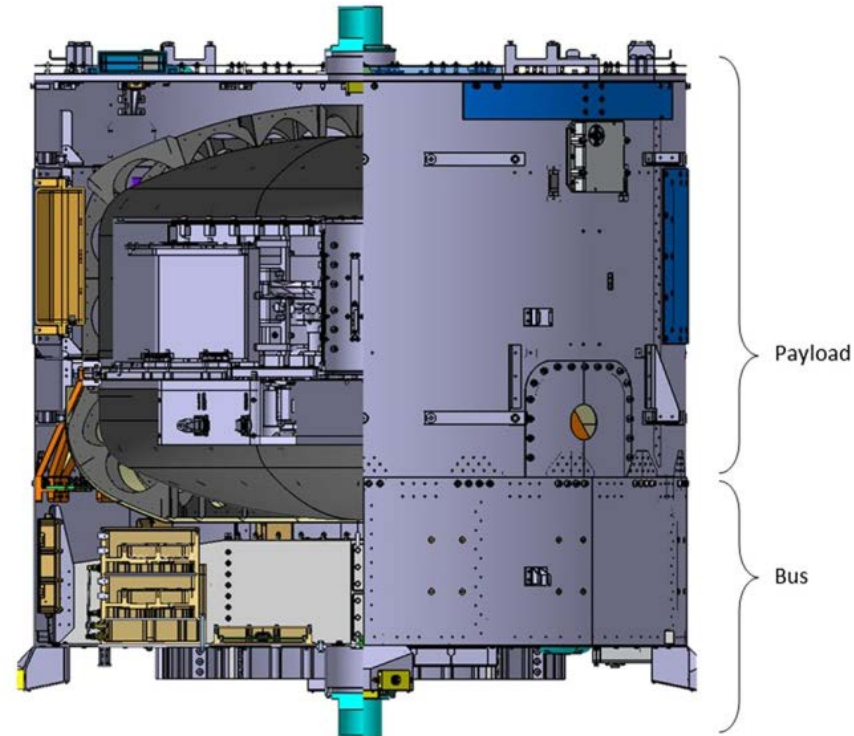
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Received: 7 August 2018 / Accepted: 7 September 2018
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Abstract

Human space exploration needs stable life support systems for the supply of oxygen, water and food for each human explorer due to long term missions. The most promising approach for building stable life support systems is a combination of physico-chemical and biological systems. These hybrid systems combine the reliability of physico-chemical and the sustainability of biological life support systems. Also the disadvantages, which are the finite resources of physico-chemical and the imperfect reliability of biological systems, are mutually balanced. To improve the reliability of biological life support systems, a combination of different biological systems may stabilize the whole approach during long term operations. The satellite mission Eu:CROPIS (*Euglena gracilis*: Combined Regenerative Organic-food Production In Space) is a testbed for investigating the behavior of combined biological life support systems under the influence of altered gravity, here, Lunar and Martian gravity. The core systems are a biological trickle filter for processing urine into a fertilizer solution via nitrification and *Euglena gracilis*, a photosynthetic protist which is able to produce oxygen and biomass while protecting the whole system against high ammonia concentrations.

Keywords Compact satellite · Life support system · Moon · Mars · Reduced gravity · Nitrification



<https://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-11082/>
<https://www.dlr.de/irs/en/desktopdefault.aspx/tabid-11288/#gallery/29952>



Eu:CROPIS: Launch

Launch: 3rd December 2018

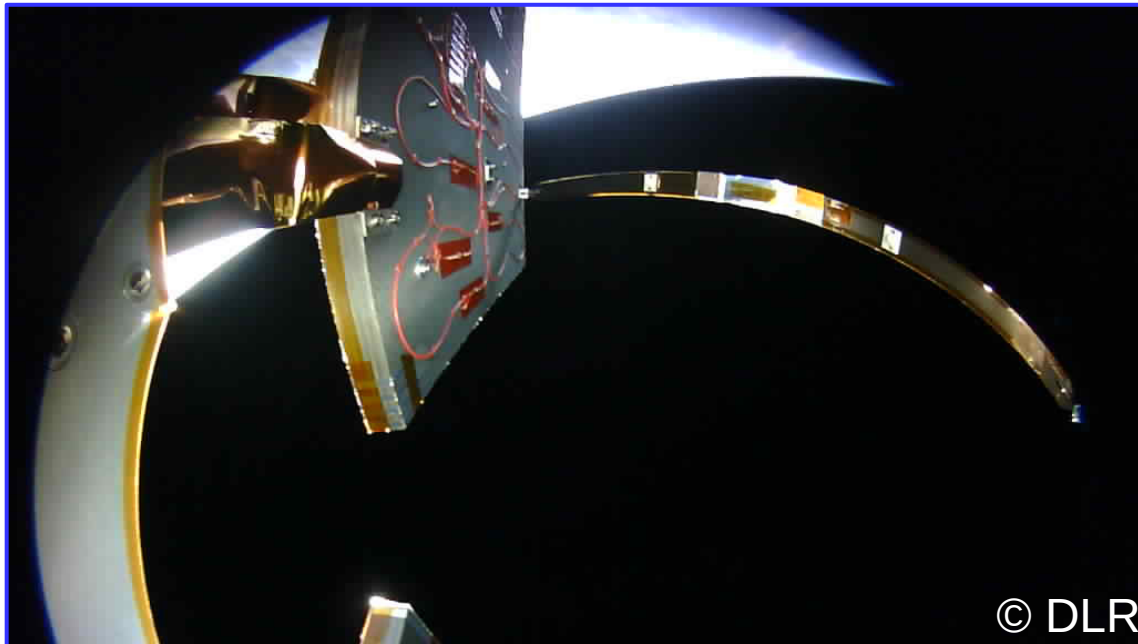


Eu:CROPIS	NORAD ID 2018-099BB
Perigee	578.3 km
Apogee	598.2 km
Inclination	97.7°
Period	96.3 min
Semi major axis	6959 km
Mission duration	2 years

<https://www.n2yo.com/satellite/?s=43807>



Eu:CROPIS: Solar panel deployed

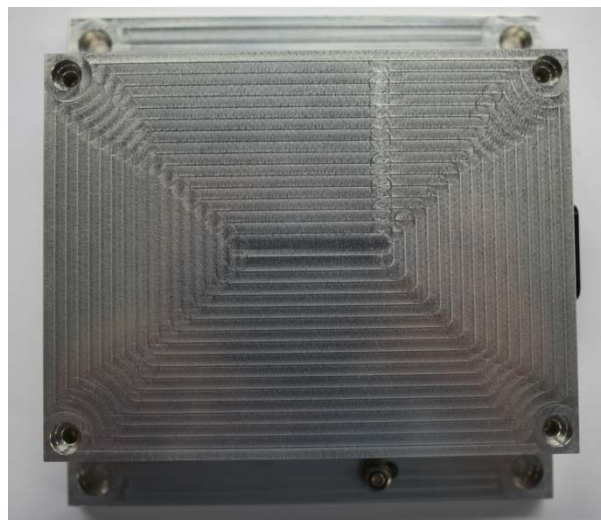


Eu:CROPIS	NORAD ID 2018-099BB
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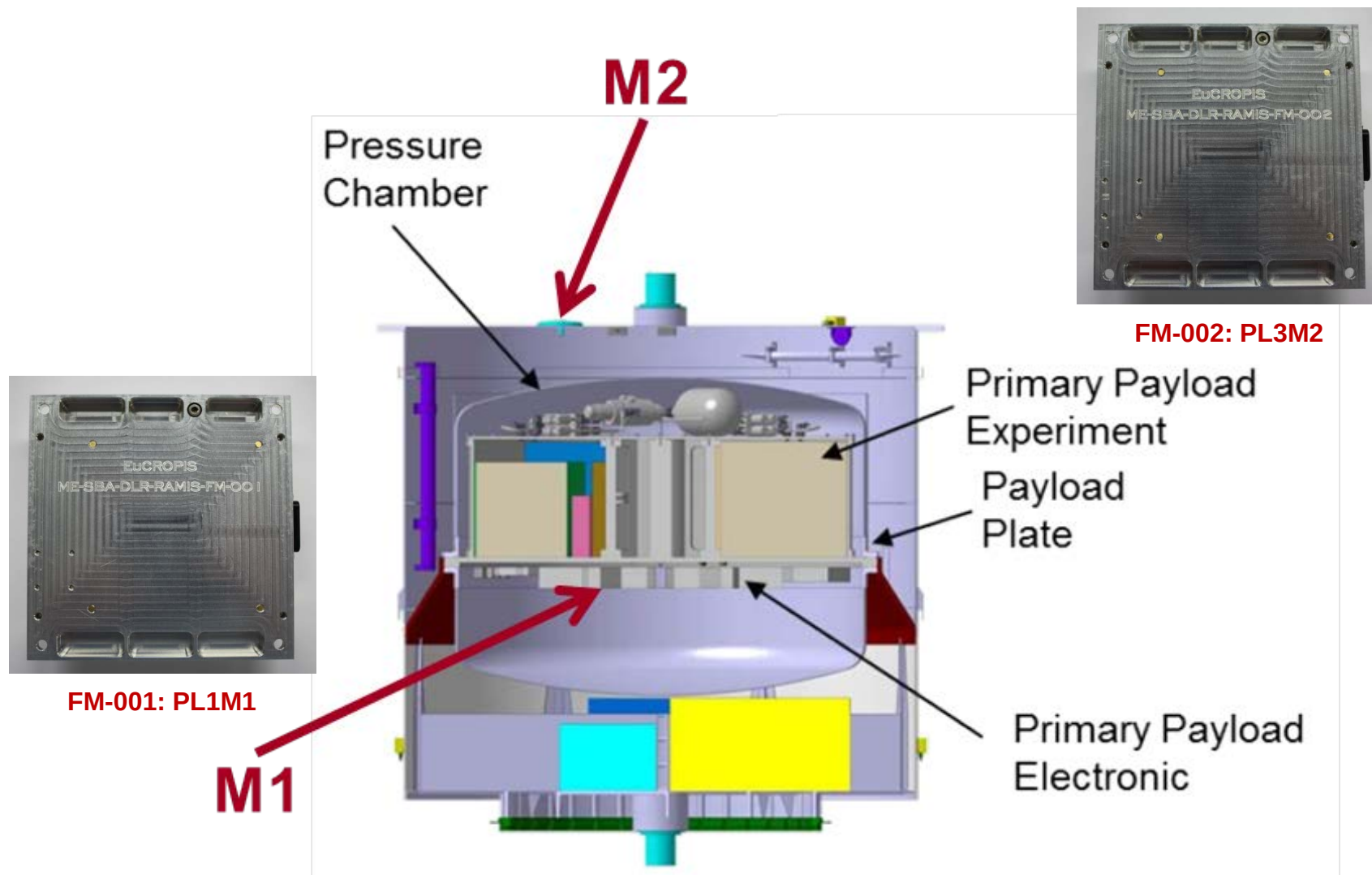
Eu:CROPIS: **RAMIS** (RAdiation Measurements In Space)



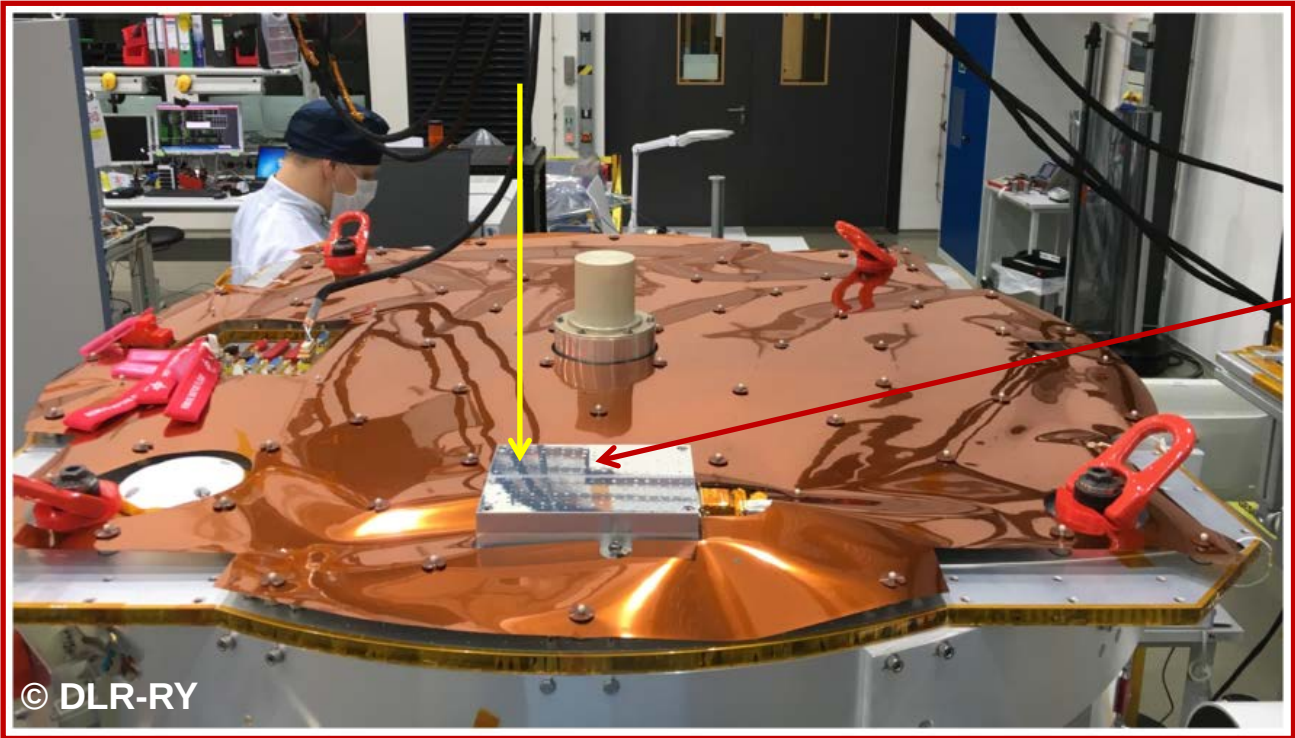
RAMIS	FM	Position
PL1M1	ME-SBA-DLR-RAMIS-FM-001	Inside Eu:CROPIS as sensor for PL1
PL3M2	ME-SBA-DLR-RAMIS-FM-002	Outside Eu:CROPIS



Eu:CROPIS: **RAMIS** Mounting Locations



Eu:CROPIS: RAMIS Fact Sheet I



RAMIS	FM	
Dimensions	140 x 140 x 35	mm ³
Mass	608	g
Supply voltage	28	V
Power consumption	1.82	W

PL3M2	D1 (upper diode)	D2 (lower diode)
Electron Energy [MeV]	1.38	1.48
Proton Energy [MeV]	24.3	25.6



Eu:CROPIS: **RAMIS** Fact Sheet II



Single Detector Data		
Radius	0,51	cm
Thickness	300	μm
Area	0,817	cm^2
Mass	57,11	mg
GF	5,133	$\text{sr} \cdot \text{cm}^2$

Telescope Data		
Distance between the diodes	0,73	cm
Opening angle	109	$^\circ$
GF	1,423	$\text{sr} \cdot \text{cm}^2$
Mean path length	335,85	μm

Ranges		
Energy range (in Si)	0.09 – 145	MeV
LET Range (in H ₂ O)	0.15 – 228	keV/ μm



Eu:CROPIS: RAMIS Data Product



RAMIS Data

H/K

Extended H/K

Spectrum

```

Parser Version 1.0.0

Inputfile:
- Name       : 20181205_183849_1280_0.1280
- Dir        : ..\Data\PL3M2\2018\12\05
- Size       : 16467

Outputfile:
- Name       : 20181205_183849_1280_0.1280.txt
- Generated  : Mon Feb 11 23:31:46 CET 2019

**** CCSDS
APID = 1280
Packet length = 16460
Service Type = 160
Service Subtype = 1
obt = 2018-12-05 18:38:49.464 +0000 UTC

**** Housekeeping
VoltD3P3 = 3.312 V
VoltD5 = 5.034 V
VoltA6P5 = 6.636 V
VoltA6M5 = -6.522 V
VoltBias = 82.676 V
LocalTemp = 24.25 deg
RemoteTemp = 22.562 deg
Status Byte = 0x0

**** Extended Housekeeping
Timestamp (BCD) = 2018.12.05 18:37:00
Threshold Diode 1 = 77.674 mV
Threshold Diode 2 = 83.144 mV
ParamTable Version = 3.2
Firmware Version = 3.0
Dose incr. [5 mins] = 1.026 uGy
Dose incr. [0] = 0.042 uGy
Dose incr. [1] = 0.271 uGy
Dose incr. [2] = 0.547 uGy
Dose incr. [3] = 0.77 uGy
Dose incr. [4] = 1.026 uGy
Countrate [0] = 33.0
Countrate [1] = 145.0
Countrate [2] = 283.0
Countrate [3] = 418.0
Countrate [4] = 552.0

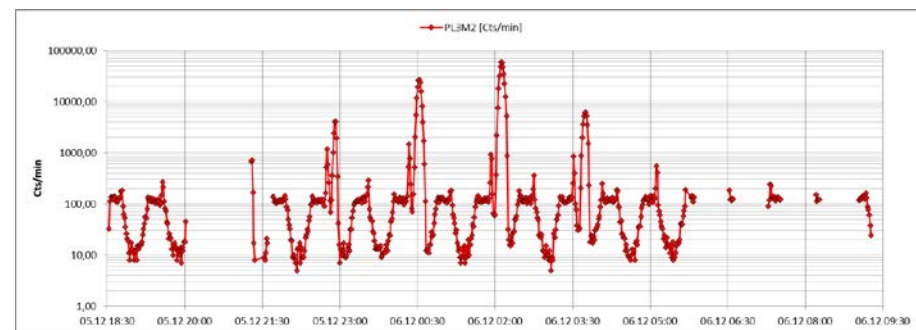
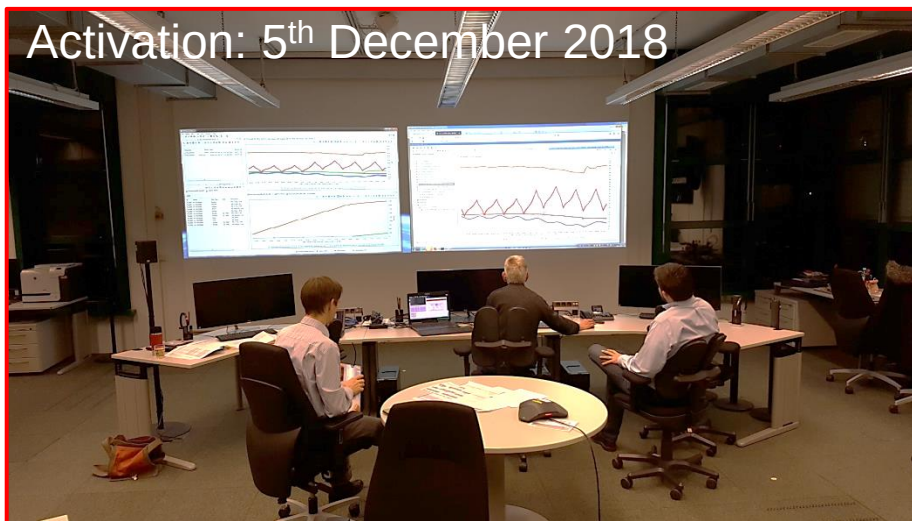
**** Spectrum
Ch; HG1 n; LG1 n; HG2 n; LG2 n; HG1 c; LG1 c; HG2 c; LG2 c;
0; 3; 308; 0; 335; 0; 0; 0; 0;
1; 91; 221; 0; 196; 0; 45; 0; 40;
2; 160; 113; 257; 97; 0; 27; 0; 34;
3; 20; 51; 54; 45; 0; 12; 0; 18;
4; 5; 22; 8; 29; 0; 10; 0; 6;
5; 2; 12; 5; 14; 0; 6; 0; 5;
6; 6; 12; 1; 10; 0; 5; 0; 4;
7; 1; 6; 1; 10; 0; 4; 0; 2;
8; 3; 6; 2; 8; 0; 2; 0; 0;
9; 7; 2; 2; 9; 0; 1; 0; 3;
10; 10; 1; 7; 8; 0; 1; 0; 4;

```



Eu:CROPIS: **RAMIS** Activation and 1st data

Activation: 5th December 2018



Eu:CROPIS: **RAMIS** Data Set for PL3M2 + PL1M1

RAMIS	Data	Time resolution
D1	Count and dose rate	1 minute
D1 + D2	Count and dose rate	5 minute
	Energy deposition spectra	5 minute
	LET spectra	5 minute

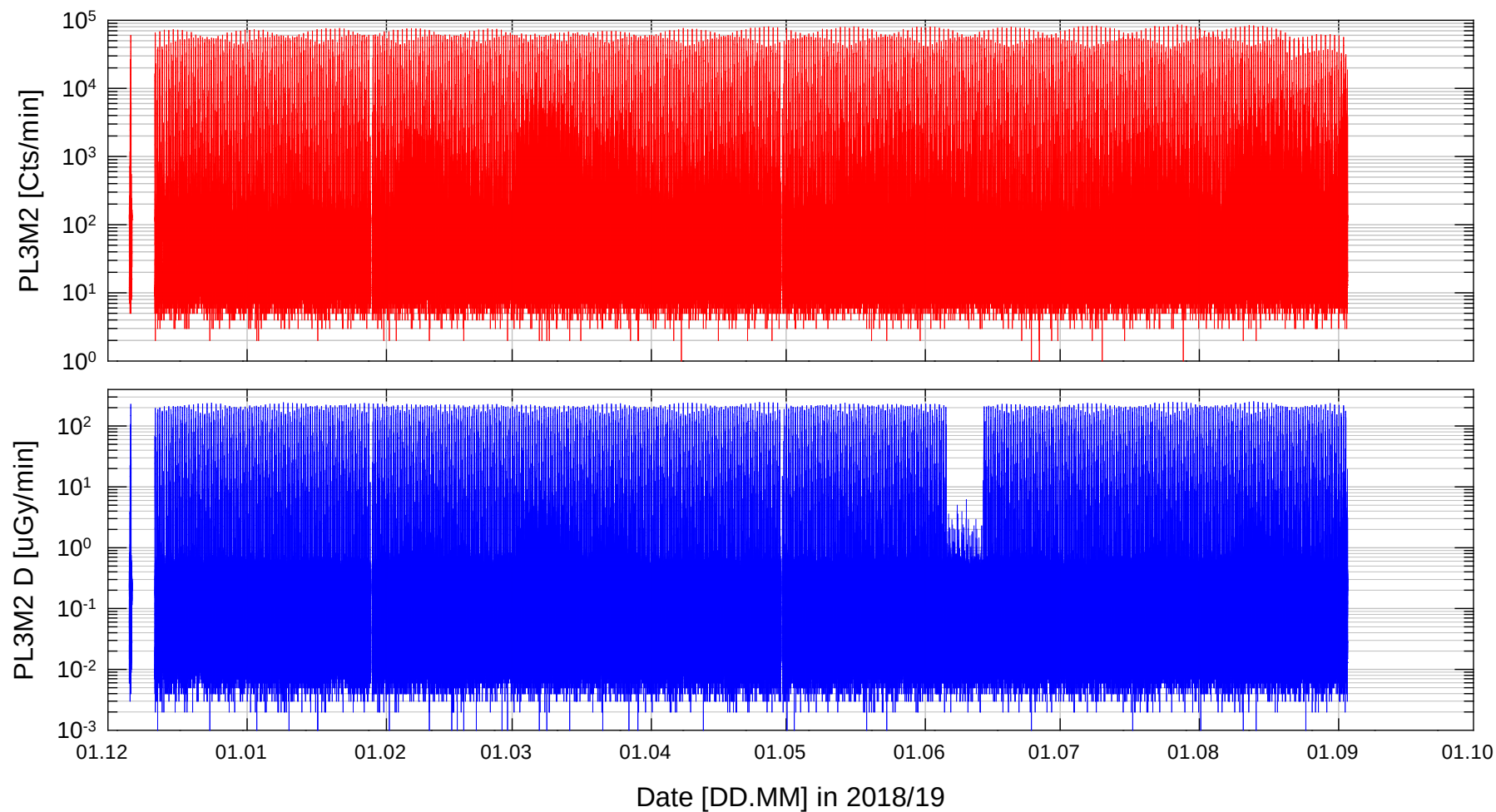


RAMIS PL3M2 – 1 minute data

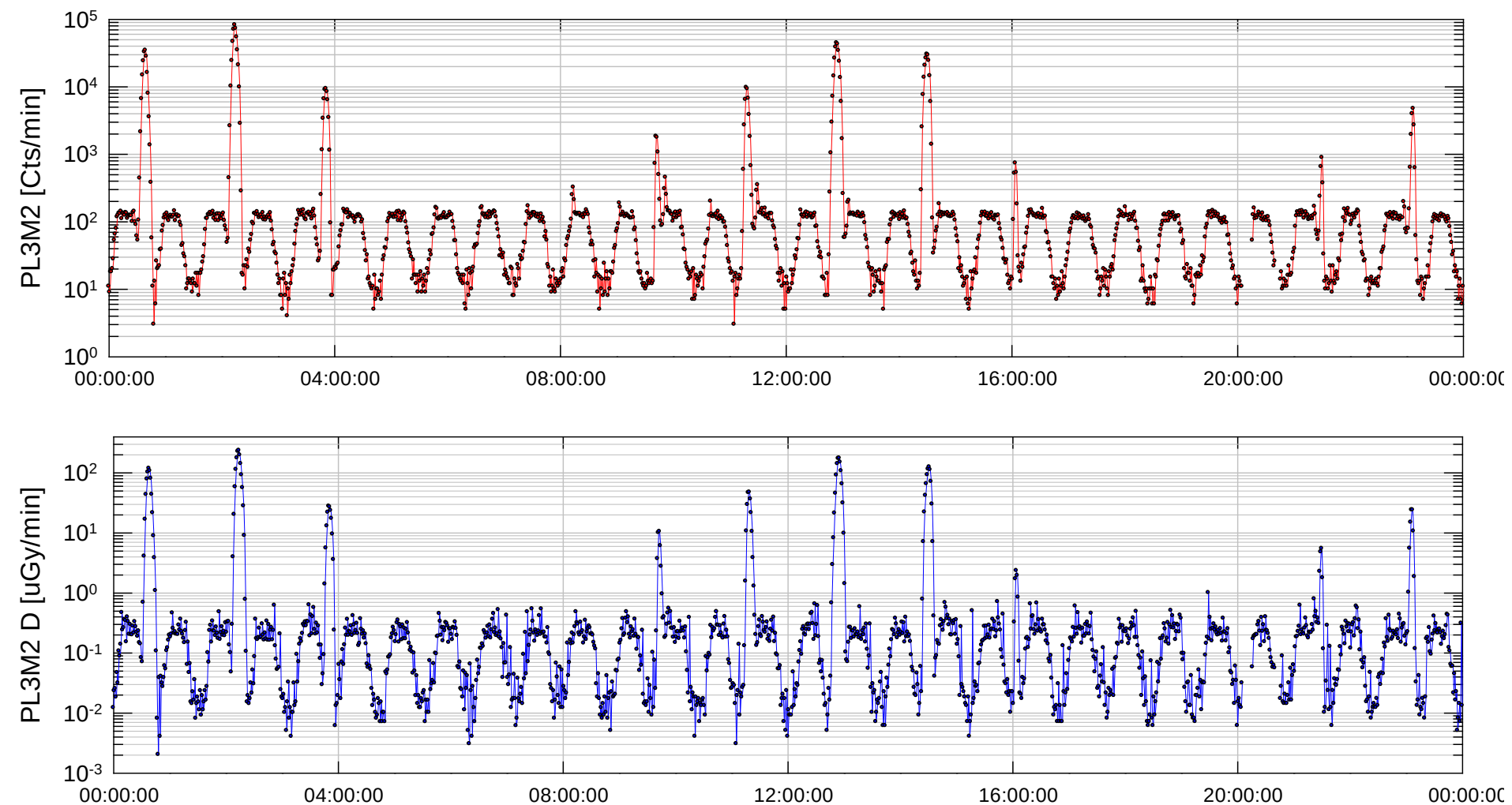
- Count rates [cts/min]
- Dose rates [$\mu\text{Gy}/\text{min}$]
- Orbit correlation for [cts/min] and D [$\mu\text{Gy}/\text{min}$]
- R_c [GV] and Latitude [$^\circ$] dependence



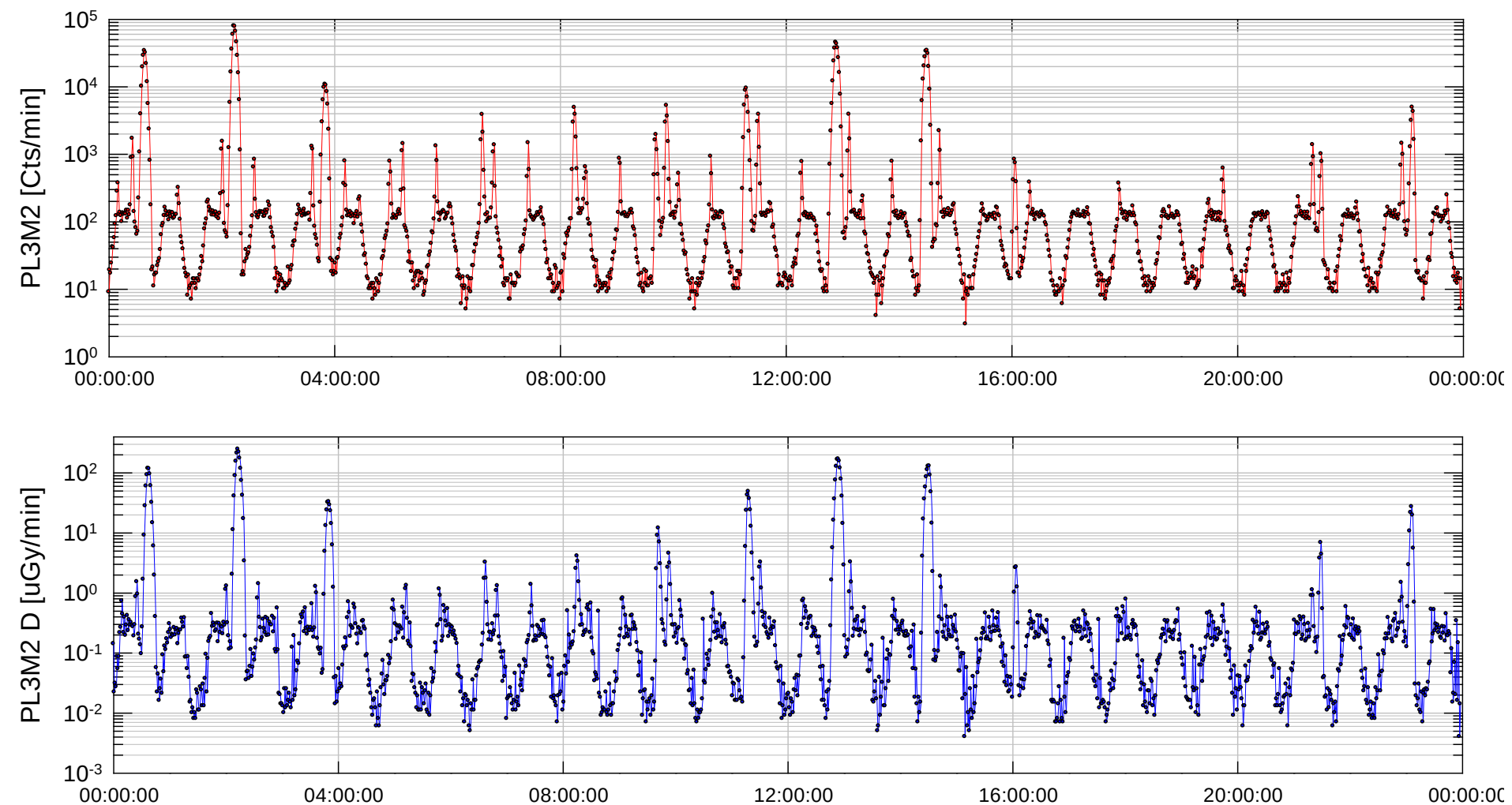
DLR Eu:CROPIS: RAMIS PL3M2 Full Data Set → Cts and dose rate



Eu:CROPIS: RAMIS PL3M2 → “quiet day” 07 July 2019

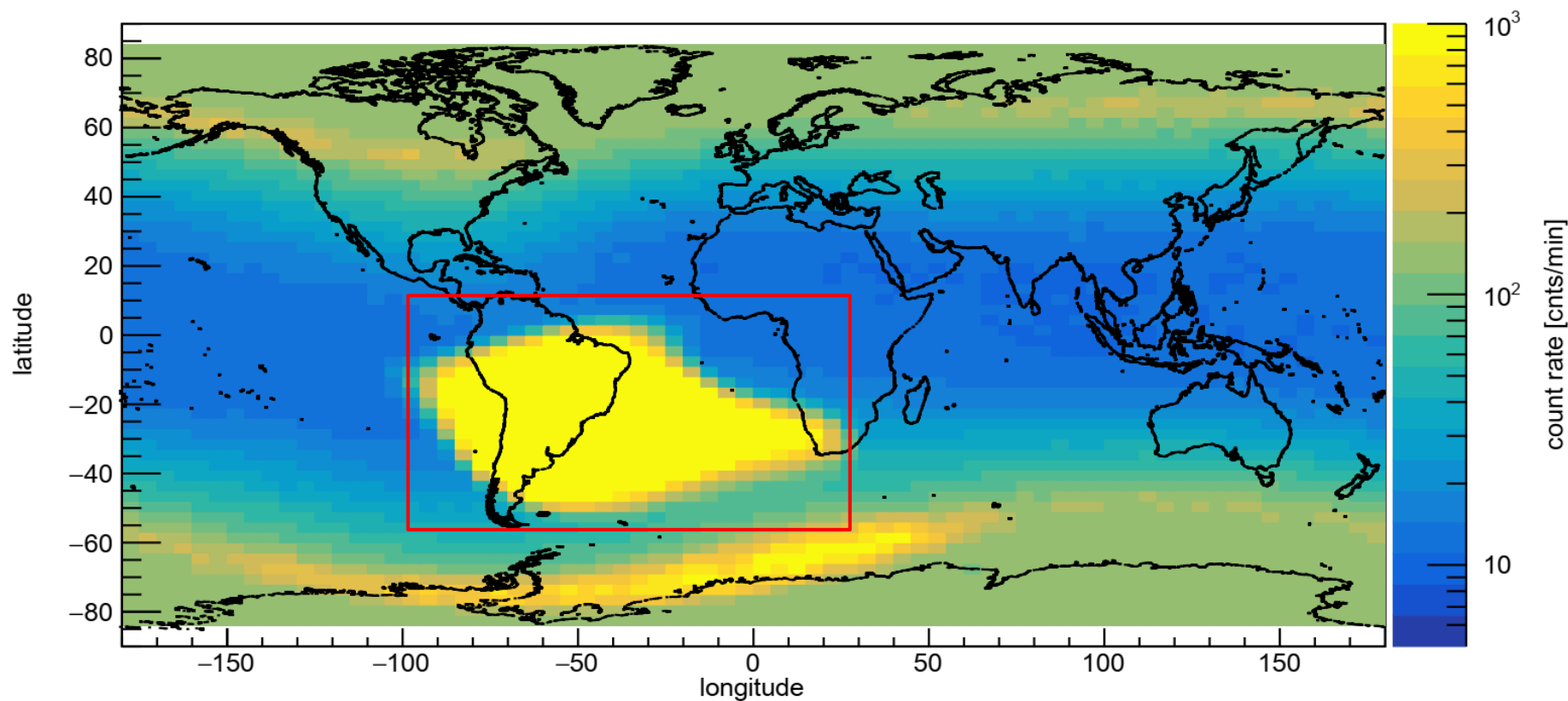


Eu:CROPIS: RAMIS PL3M2 → “disturbed day” 14 August 2019



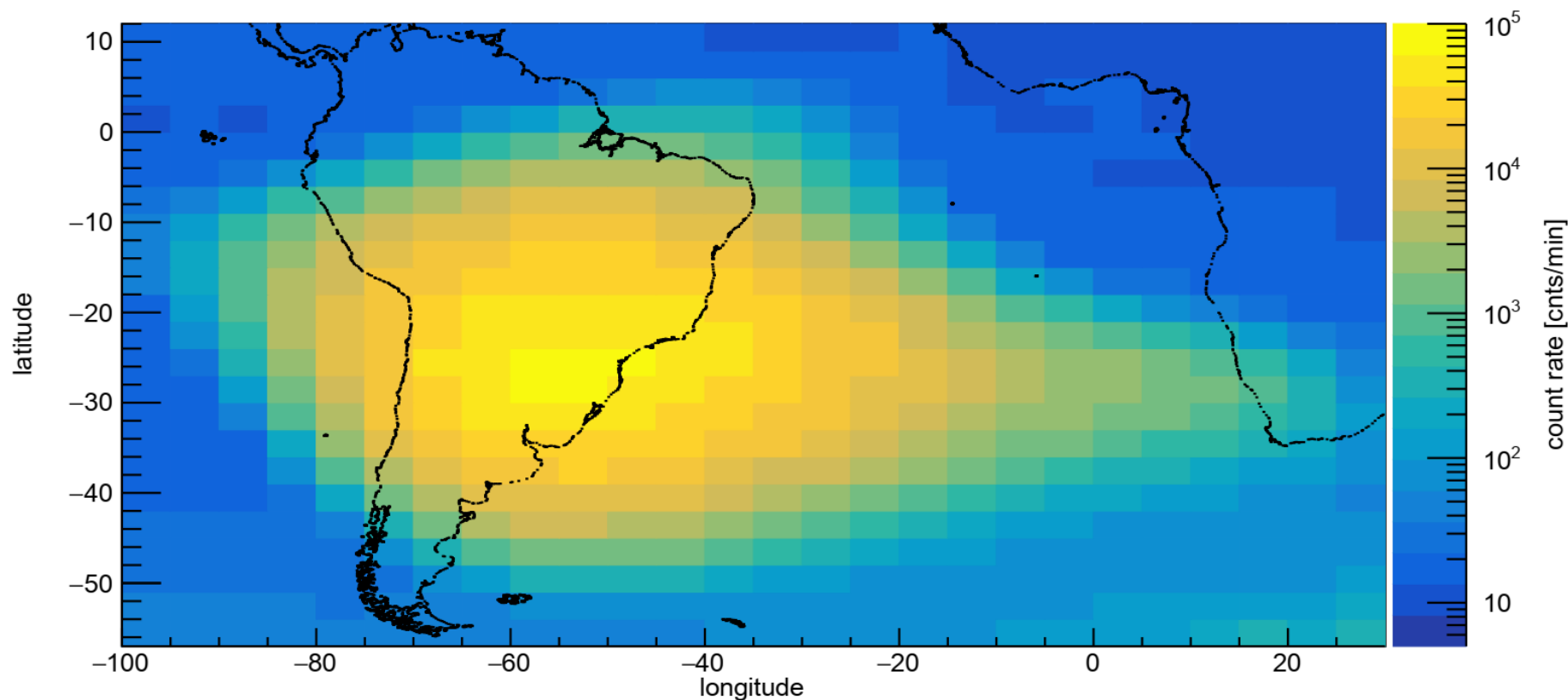
Eu:CROPIS: RAMIS PL3M2 Full Data Set → Orbit [cts/min]

count rate between 2018-12-05 18:33 and 2019-08-04 10:06

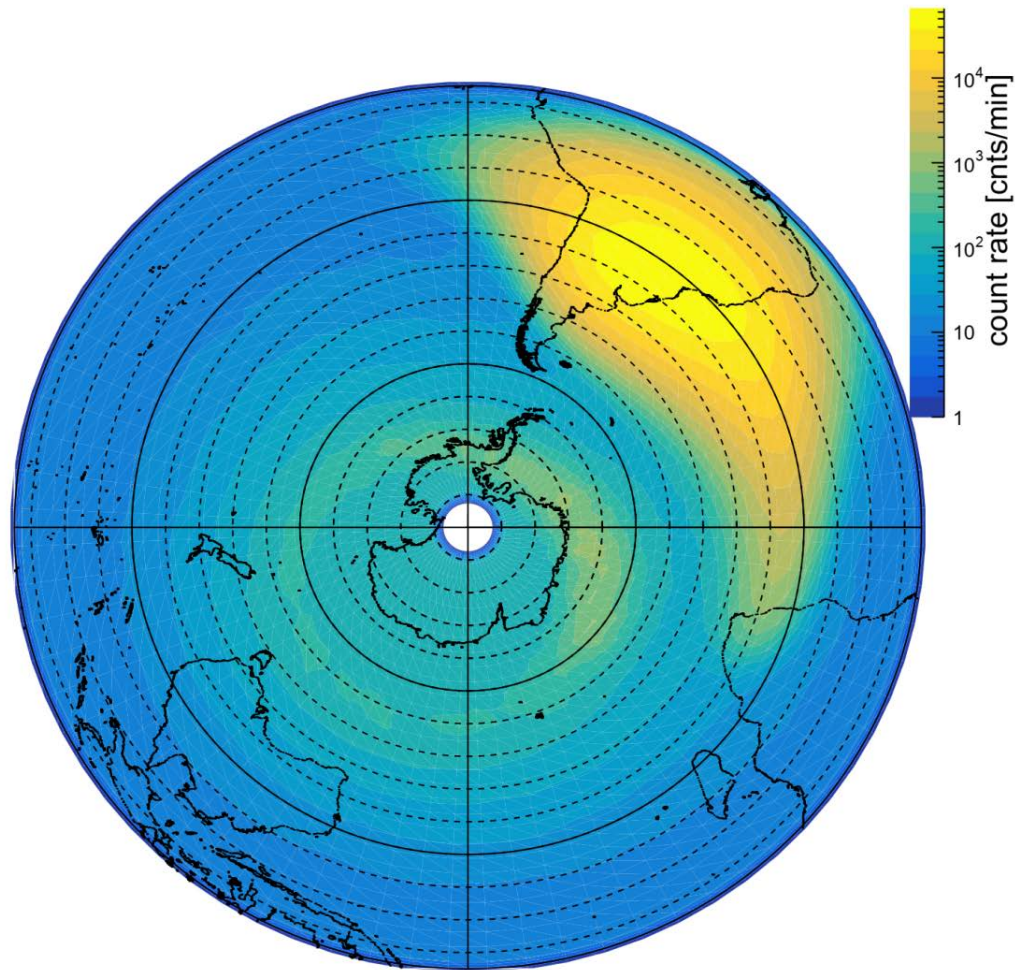


Eu:CROPIS: RAMIS PL3M2 Full Data Set → Orbit [cts/min]

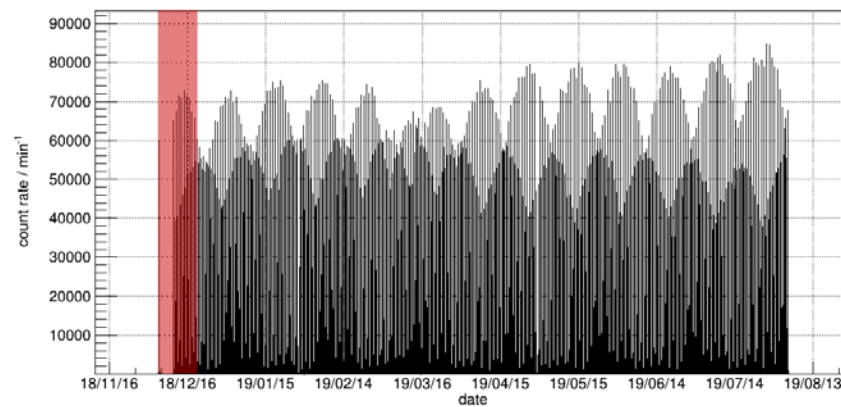
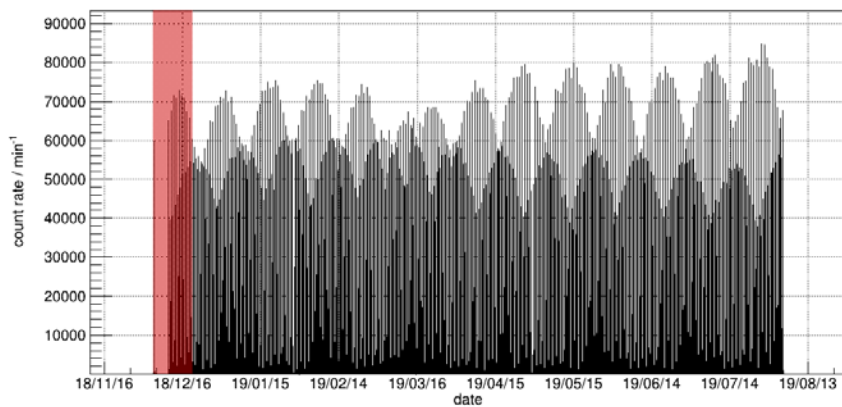
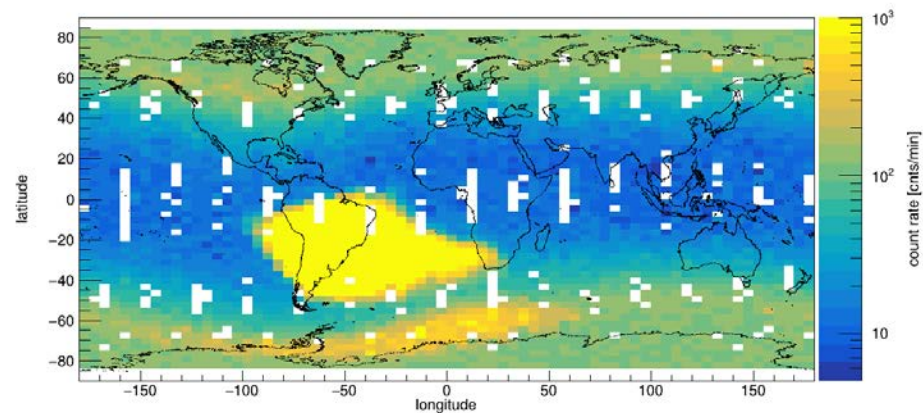
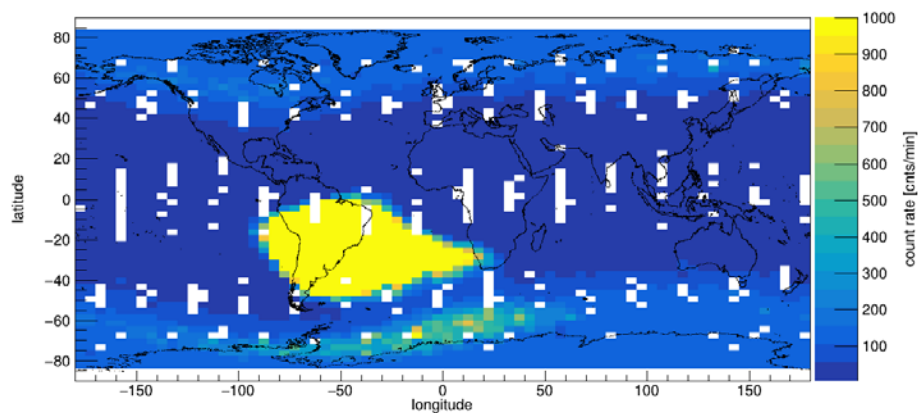
count rate between 2018-12-05 18:33 and 2019-08-04 10:06



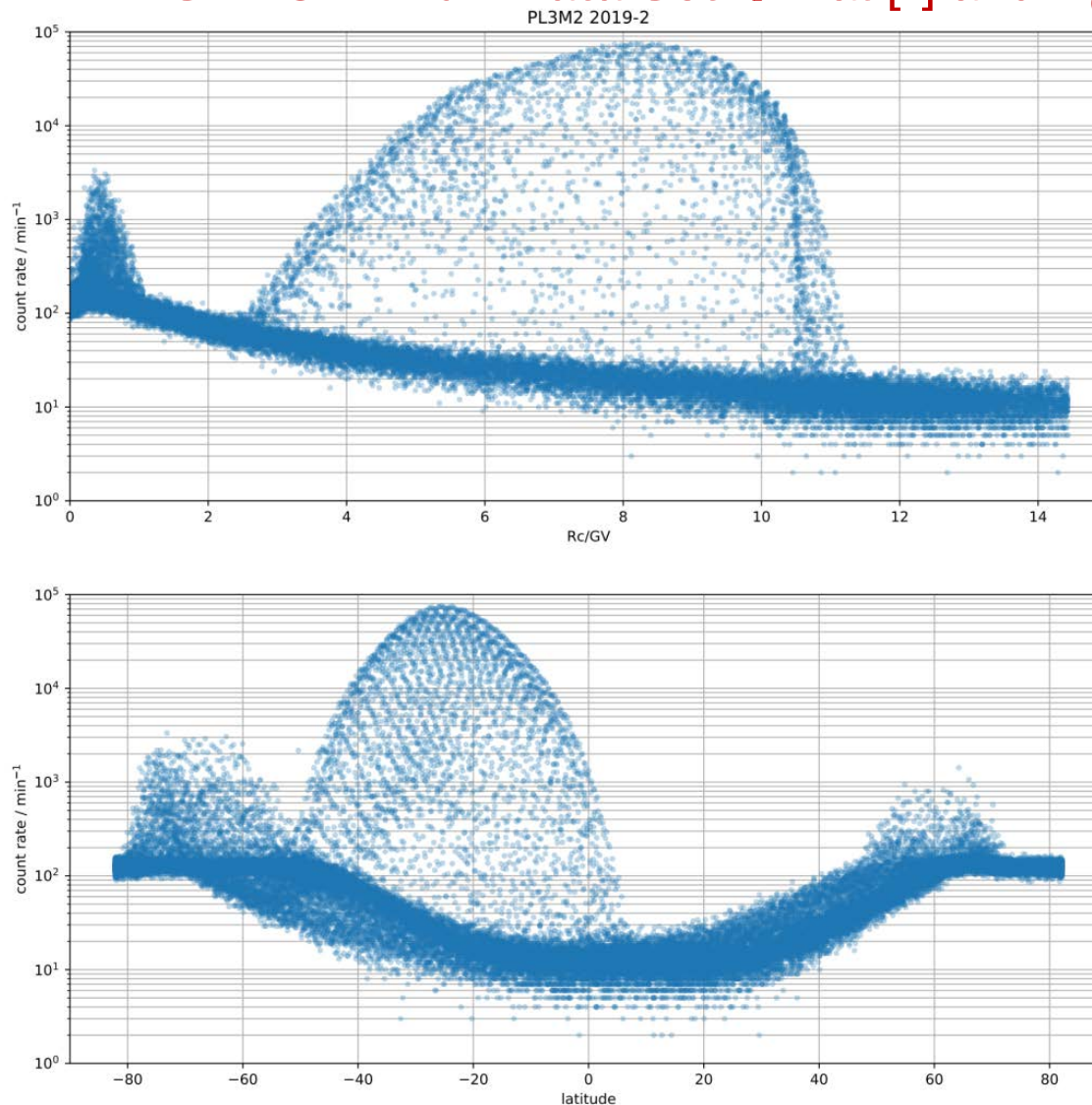
Eu:CROPIS: **RAMIS PL3M2 Full Data Set** → Orbit [cts/min]



Eu:CROPIS: RAMIS PL3M2 Full Data Set → Orbit [cts/min]



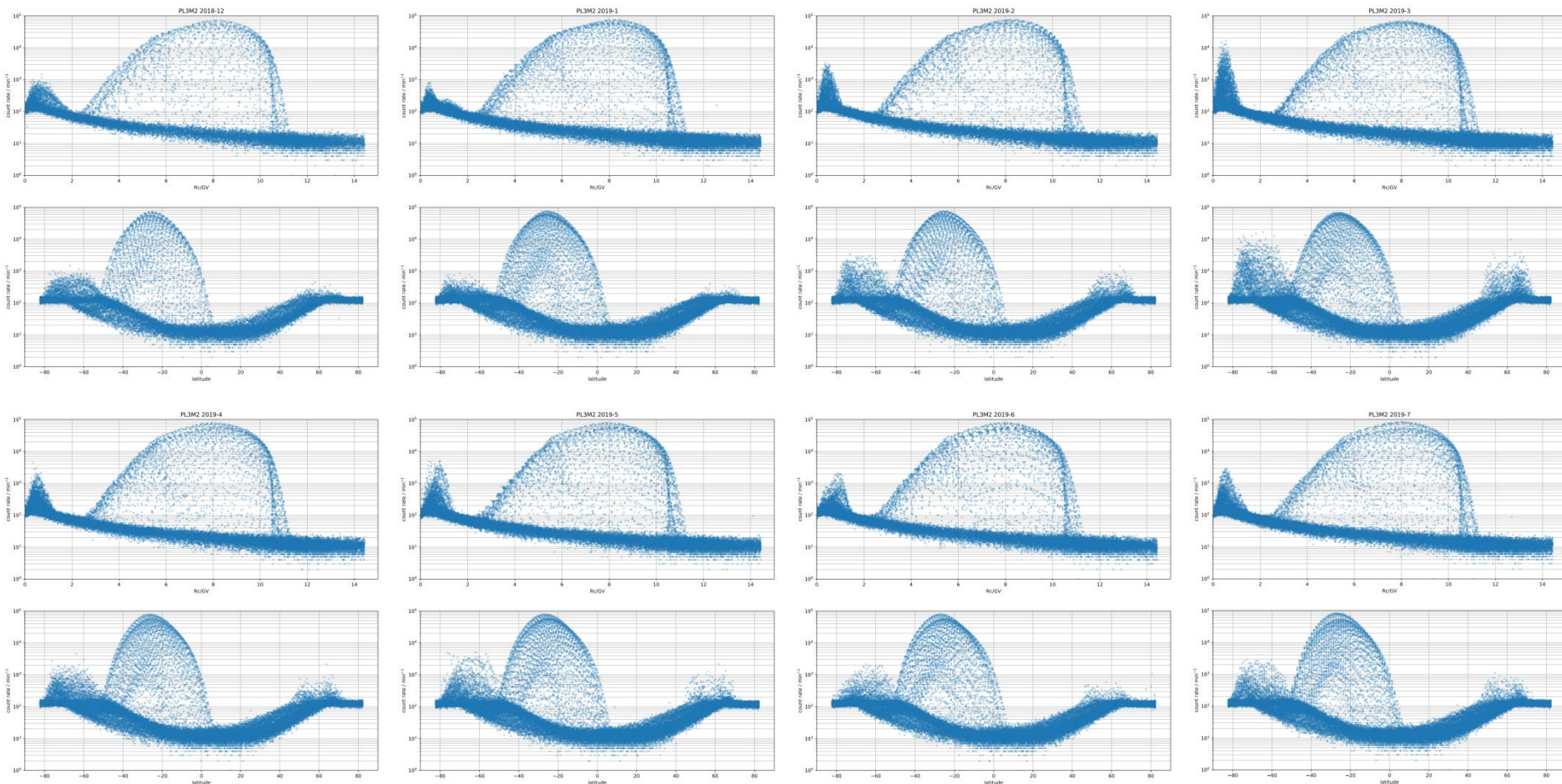
Eu:CROPIS: RAMIS PL3M2 Full Data Set → Lat [°] and R_c [GV]



March 2019



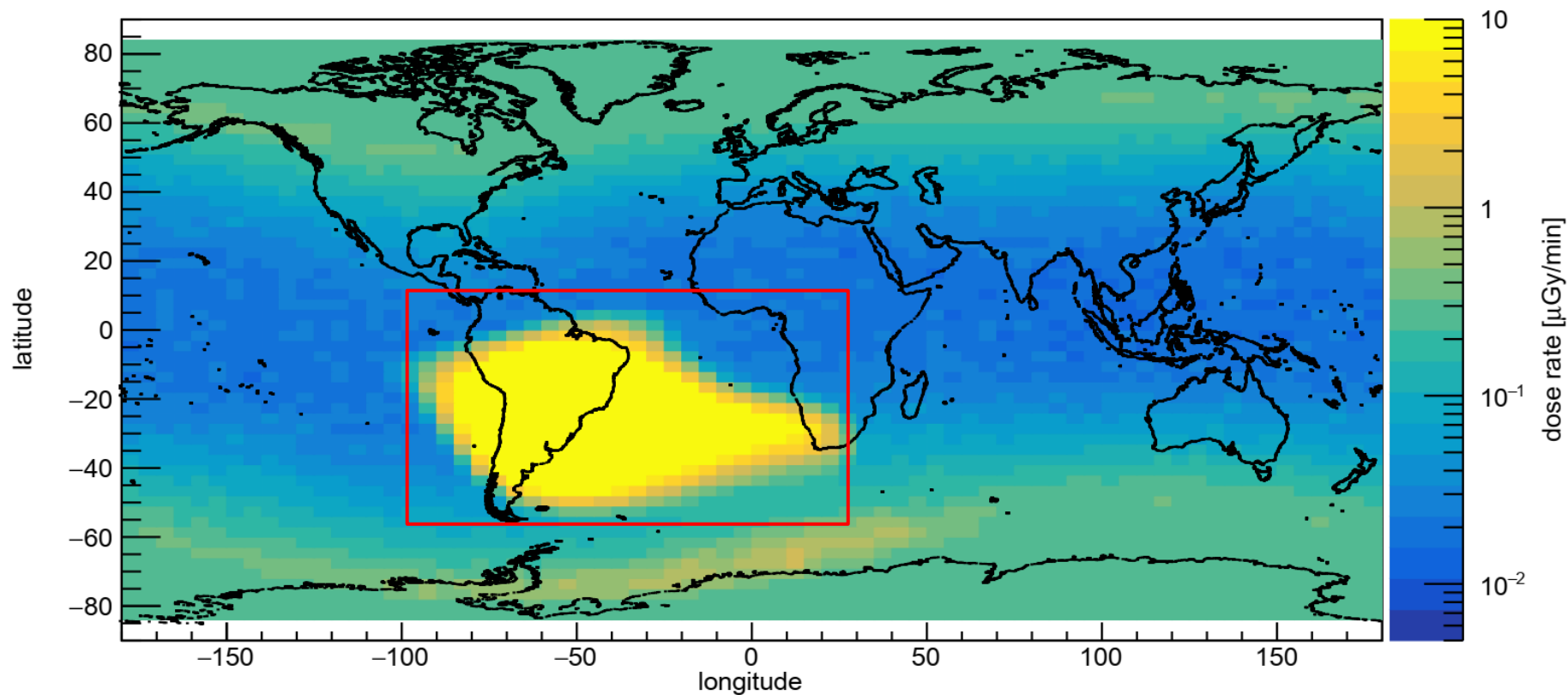
Eu:CROPIS: RAMIS PL3M2 Full Data Set → Lat [°] and R_c [GV]



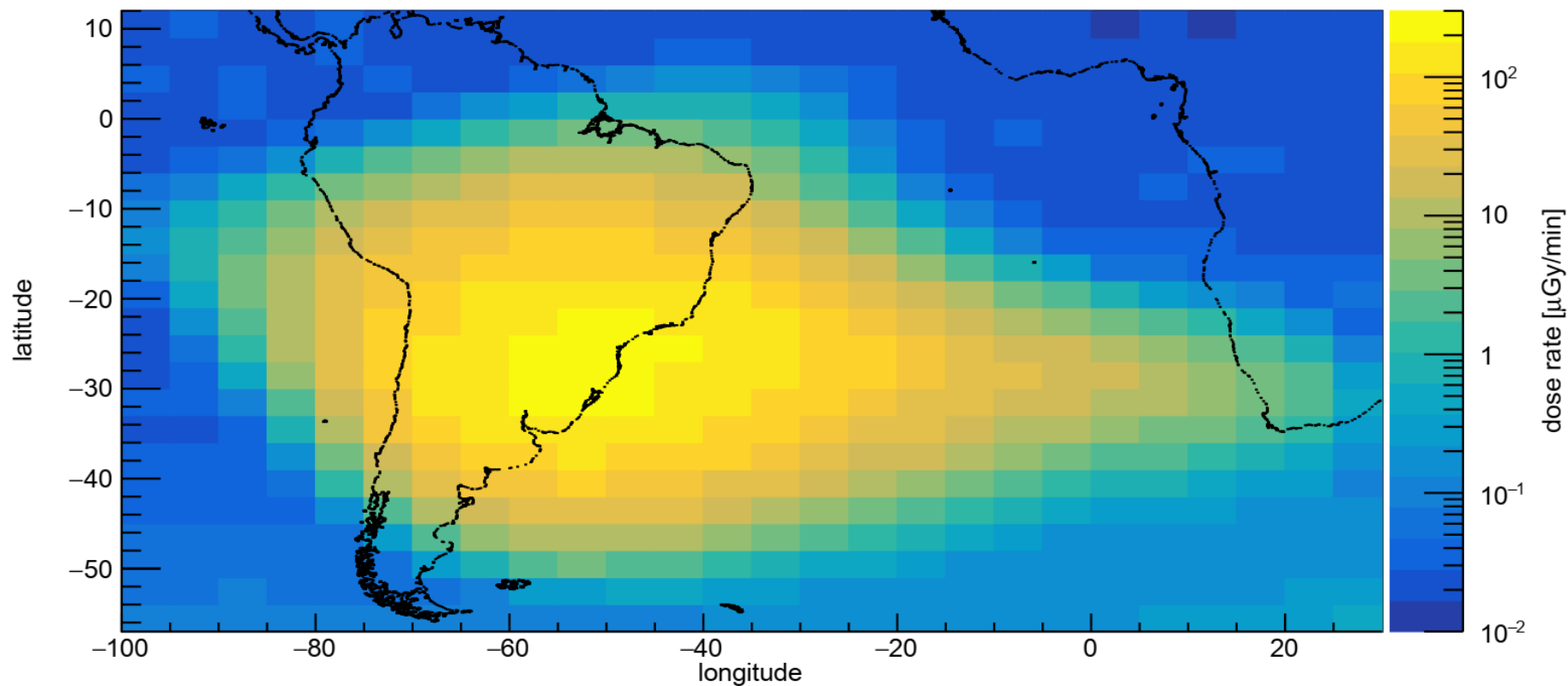
Monthly plots



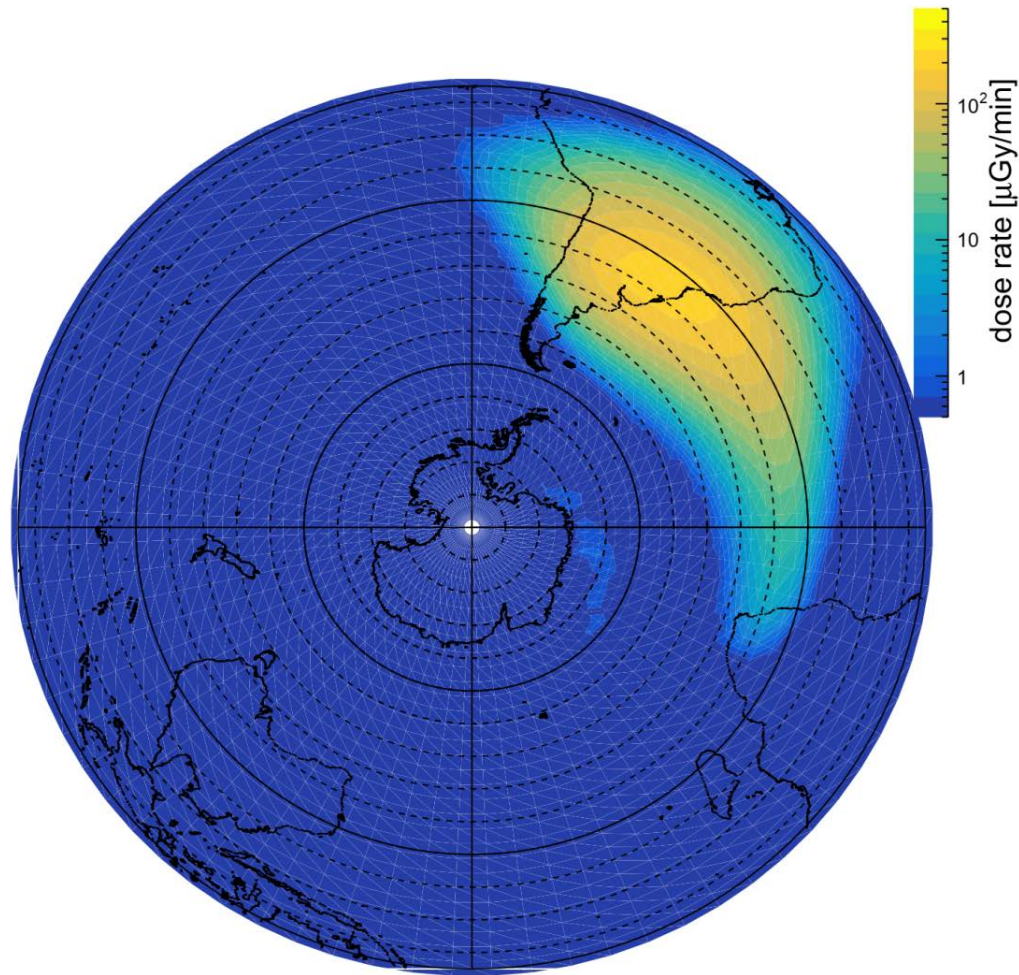
Eu:CROPIS: RAMIS PL3M2 Full Data Set → Orbit D [$\mu\text{Gy}/\text{min}$]



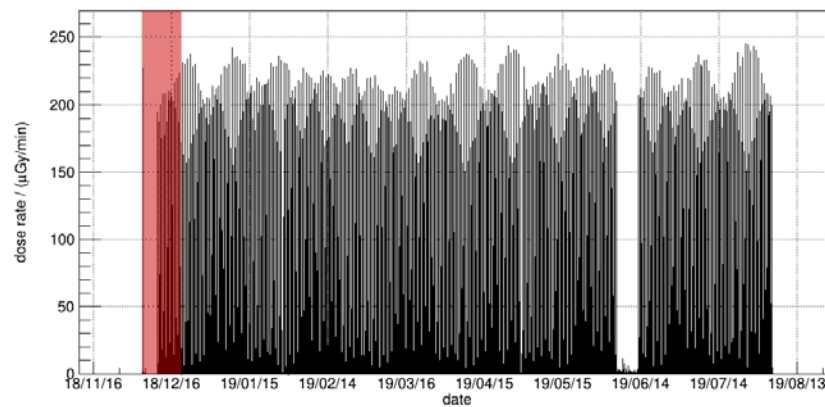
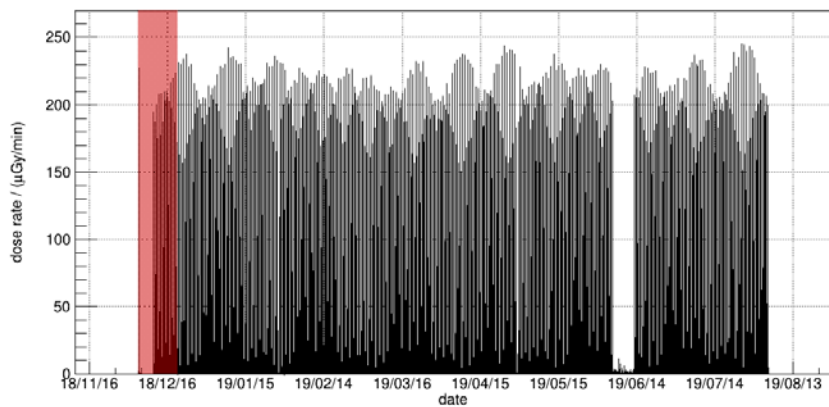
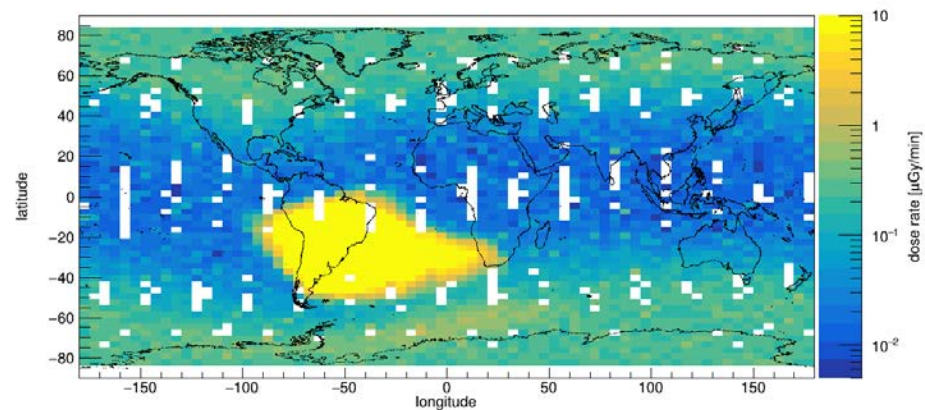
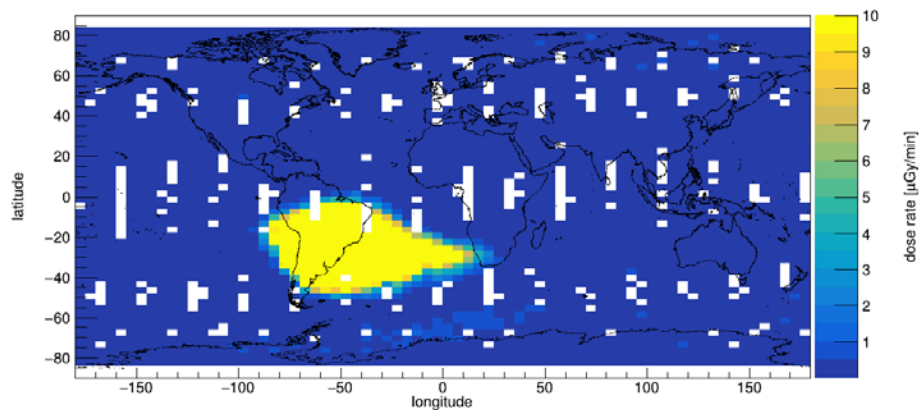
Eu:CROPIS: RAMIS PL3M2 Full Data Set → Orbit D [$\mu\text{Gy}/\text{min}$]



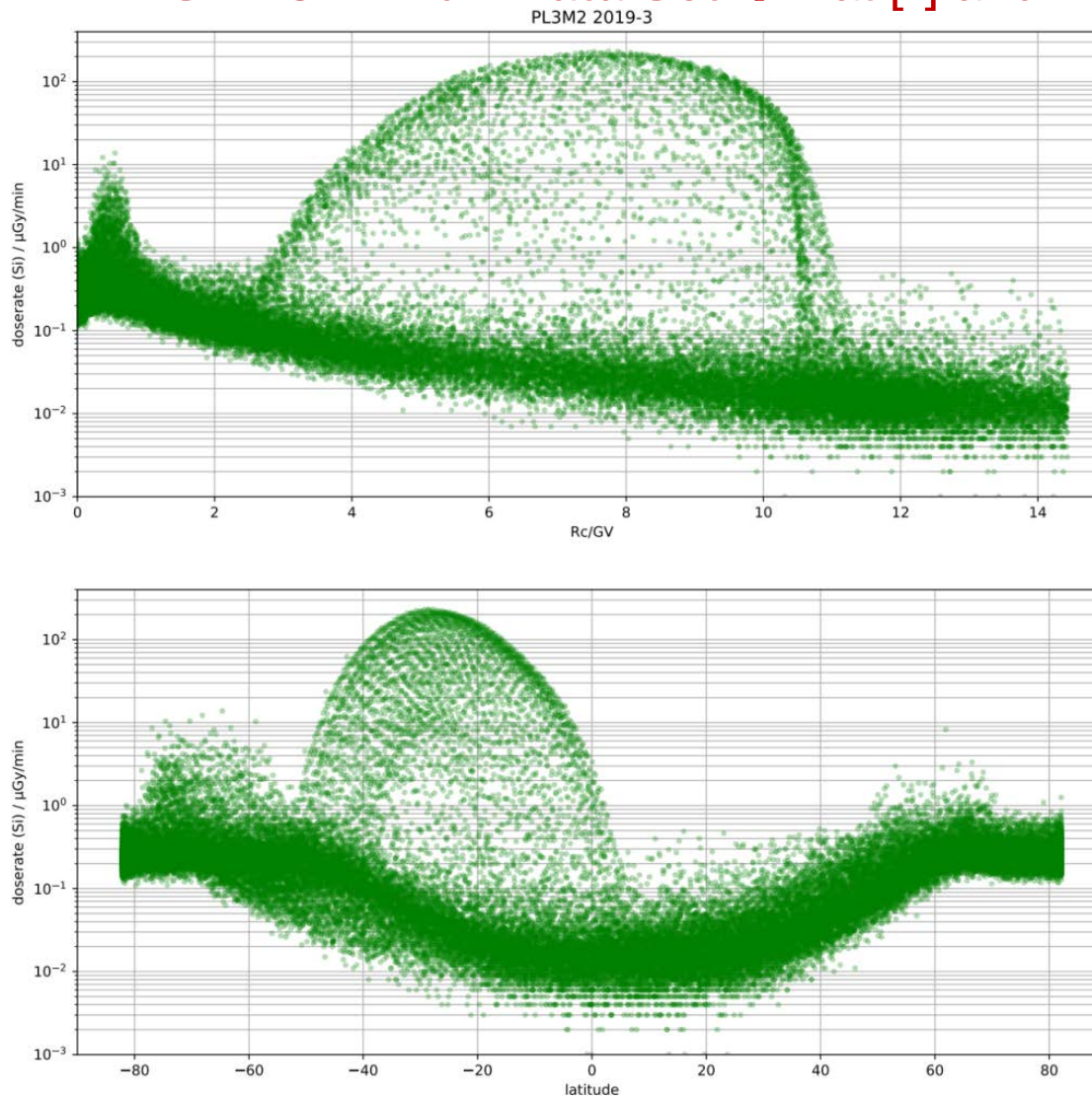
Eu:CROPIS: RAMIS PL3M2 Full Data Set → Orbit D [$\mu\text{Gy}/\text{min}$]



Eu:CROPIS: RAMIS PL3M2 Full Data Set → Orbit D [$\mu\text{Gy}/\text{min}$]



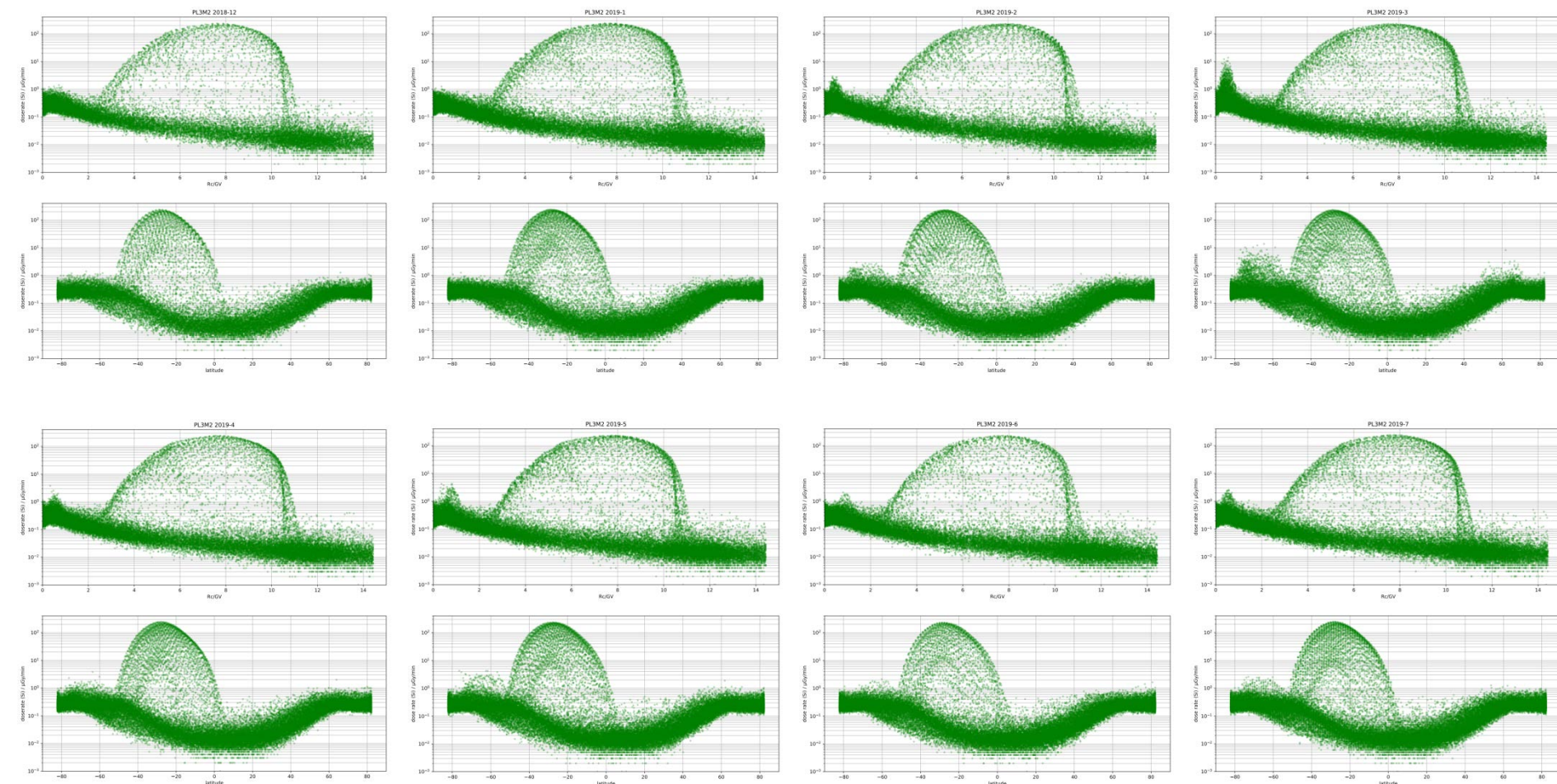
Eu:CROPIS: RAMIS PL3M2 Full Data Set → Lat [°] and R_c [GV]



March 2019



Eu:CROPIS: RAMIS PL3M2 Full Data Set → Lat [°] and R_c [GV]



Monthly plots



RAMIS PL3M2 – 1 minute data

On the GCR/SAA/Electron separation

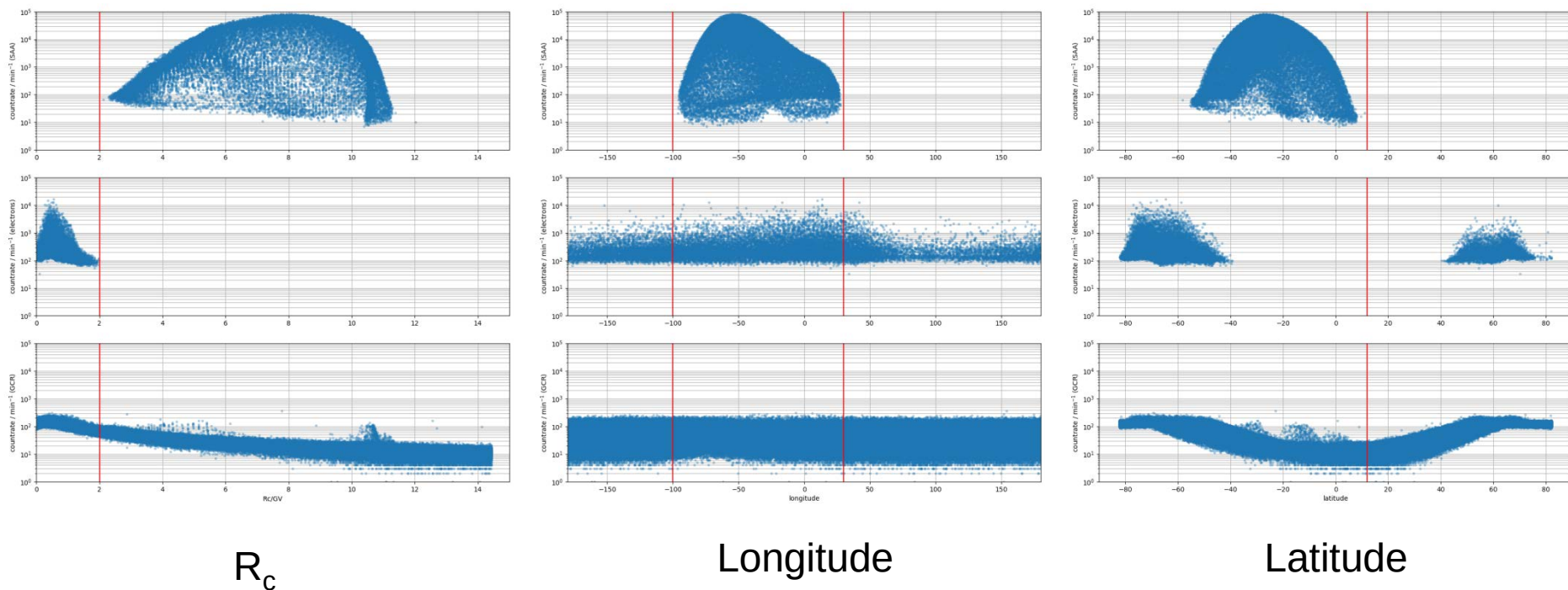


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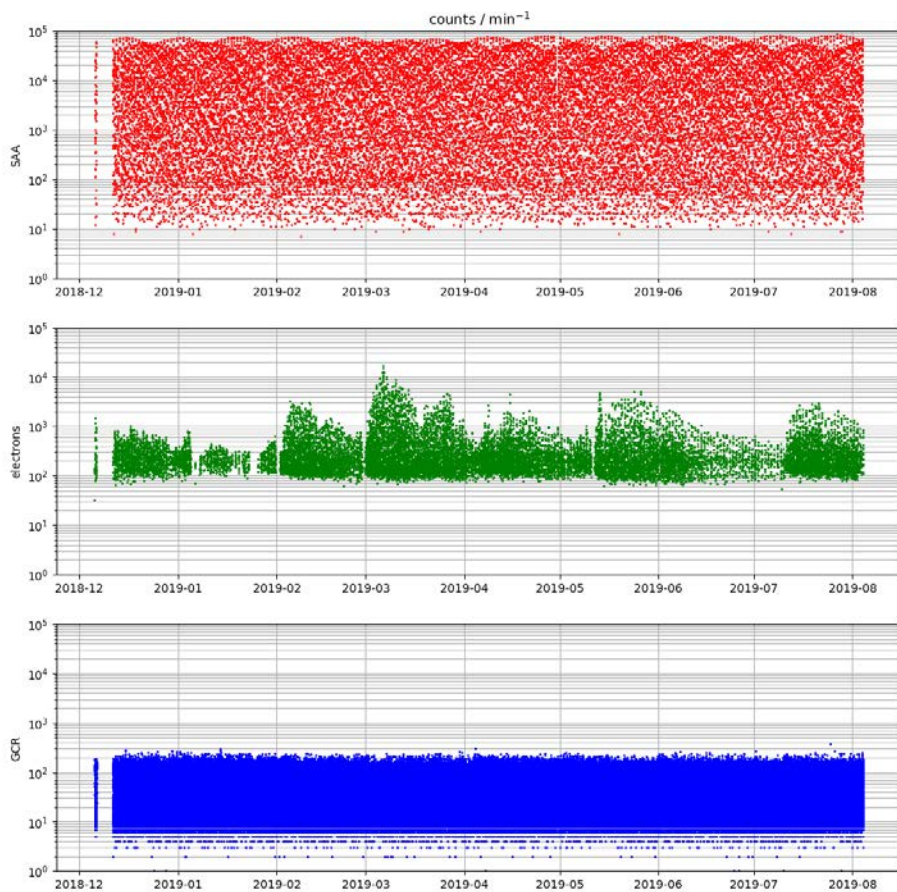


Eu:CROPIS: **GCR/SAA/Electron Separation** → Baseline cuts

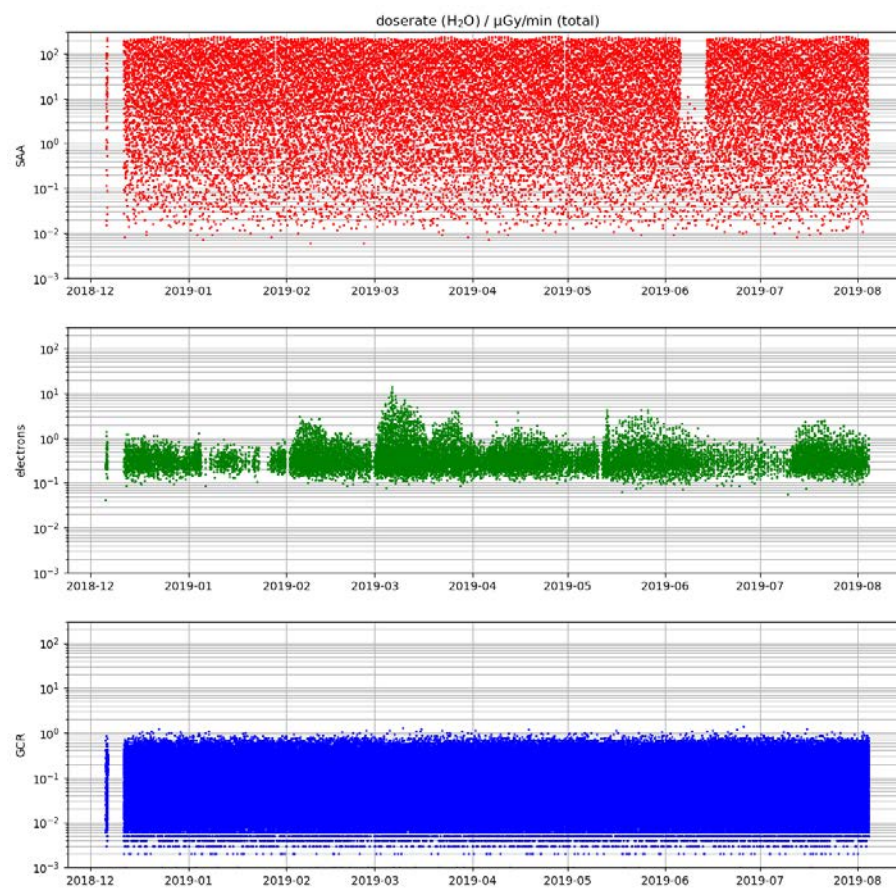
Count rate + first derivative of count rate



Eu:CROPIS: GCR/SAA/Electron Separation → [cts/min] & D [μGy/min]

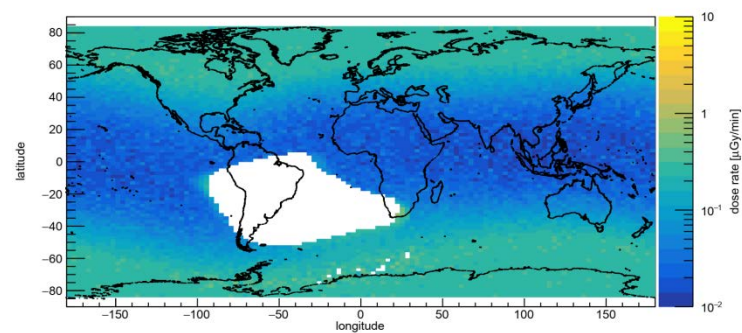
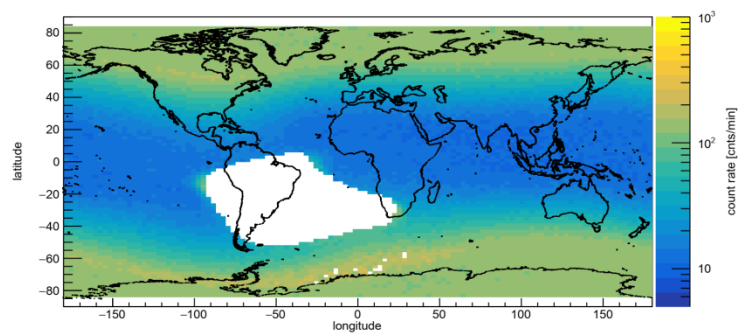
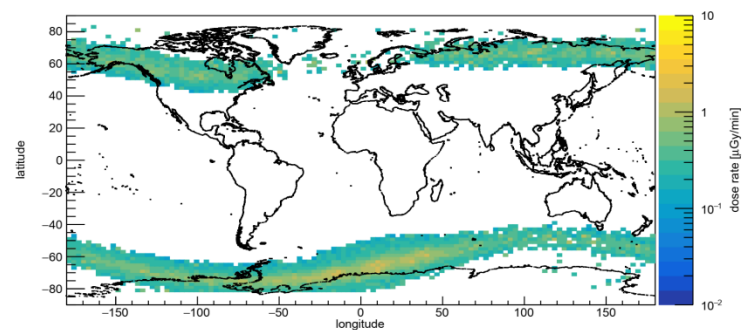
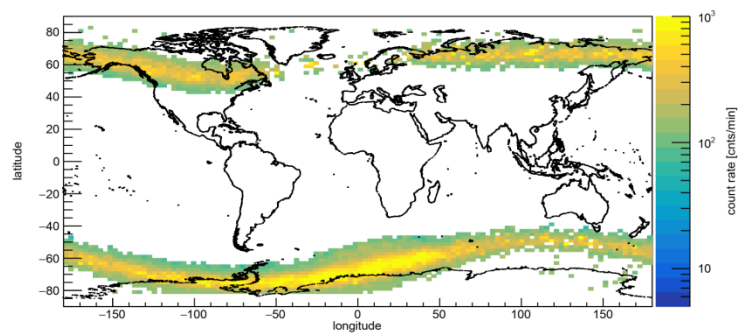
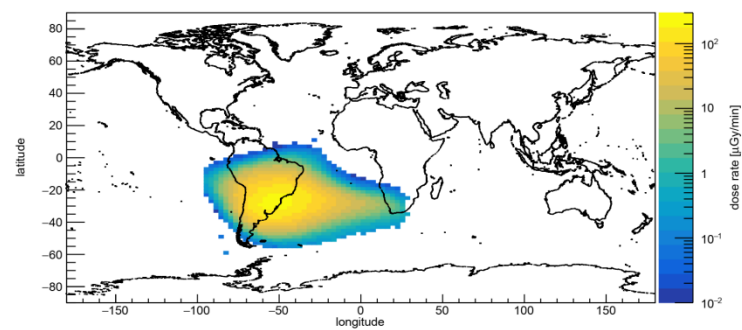
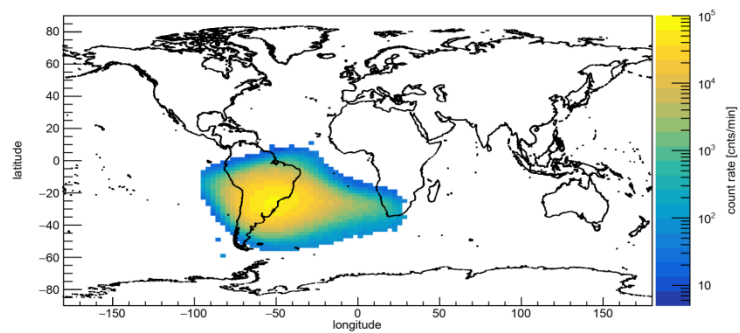


PL3M2 [Cts/min] SAA/e/GCR



PL3M2 D [μGy/min] SAA/e/GCR



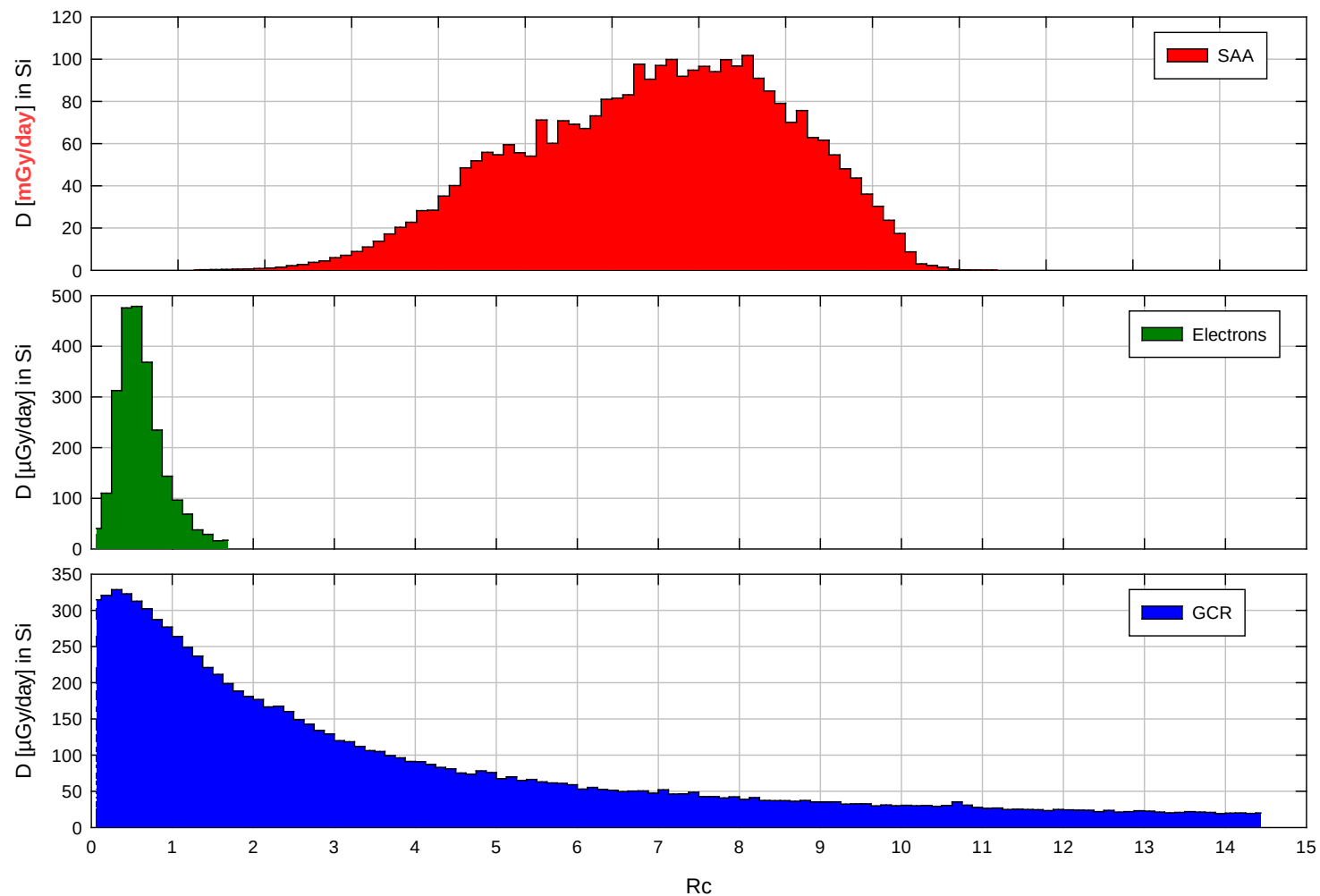


PL3M2 [Cts/min] SAA/e/GCR

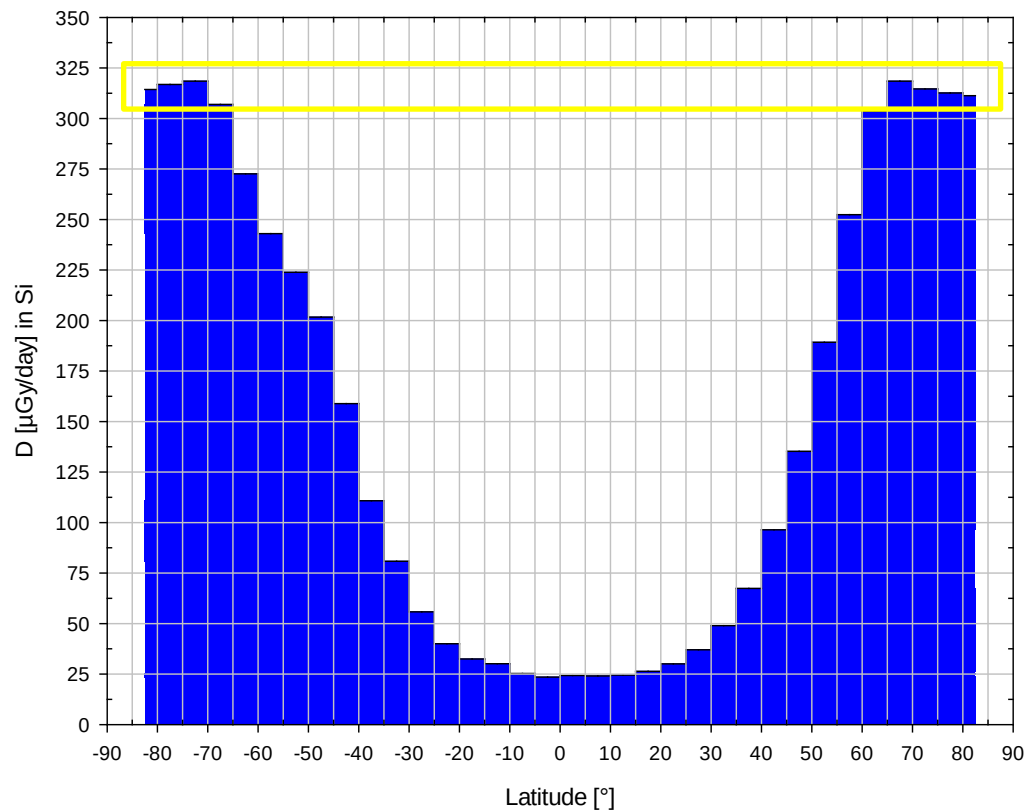
PL3M2 D [μ Gy/min] SAA/e/GCR



Eu:CROPIS: GCR/SAA/Electron Separation → D [μ Gy/day] in Si



Eu:CROPIS: GCR/SAA/Electron Separation → D [$\mu\text{Gy/day}$] in Si



RAMIS PL3M2	$\mu\text{Gy/day}$ in Si
High latitude	314
→ Free space	442
→ Moon surface	221



RAMIS PL3M2 – 5 minute data

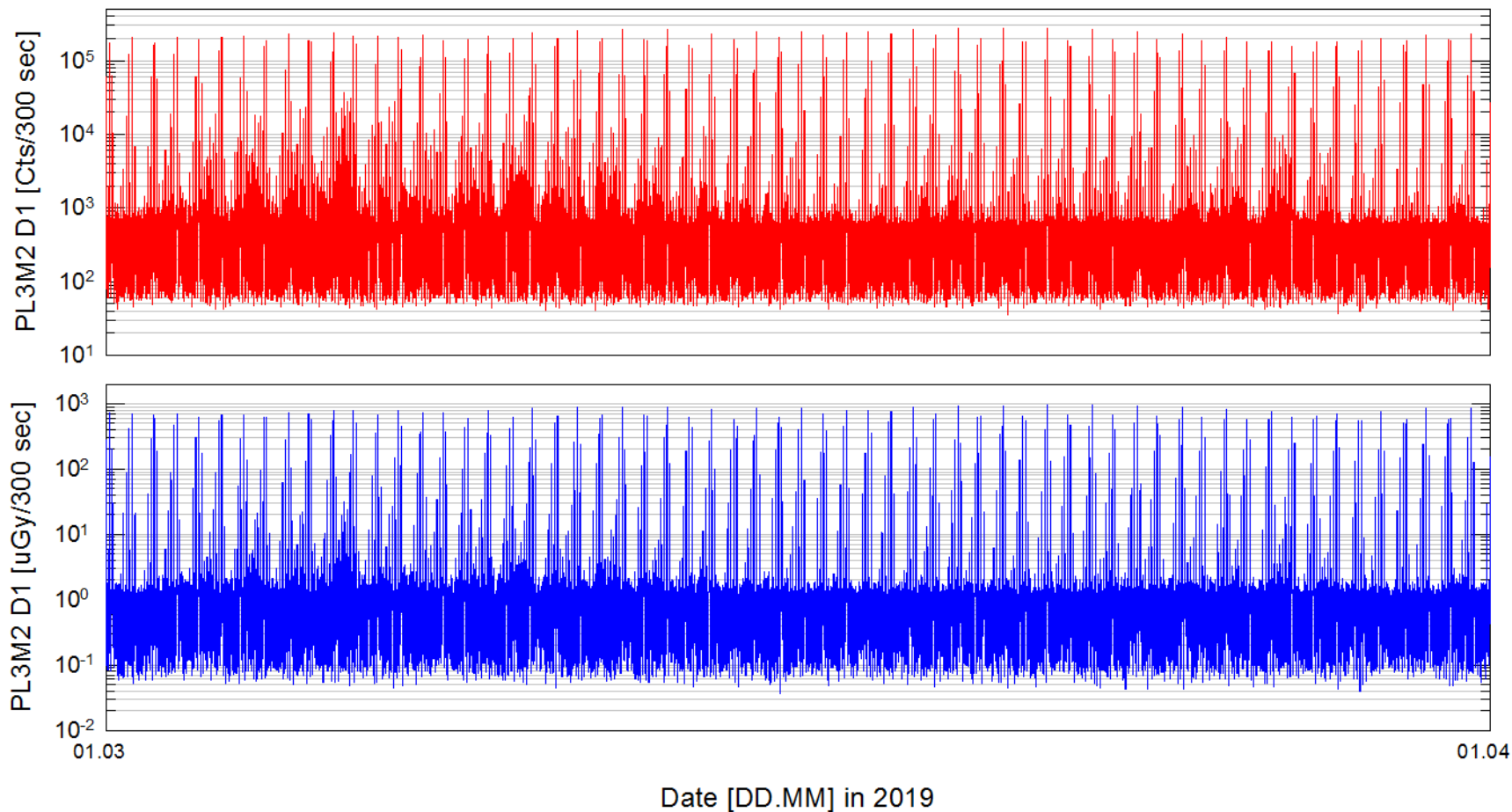
Differences D1 and D2

Energy deposition spectra

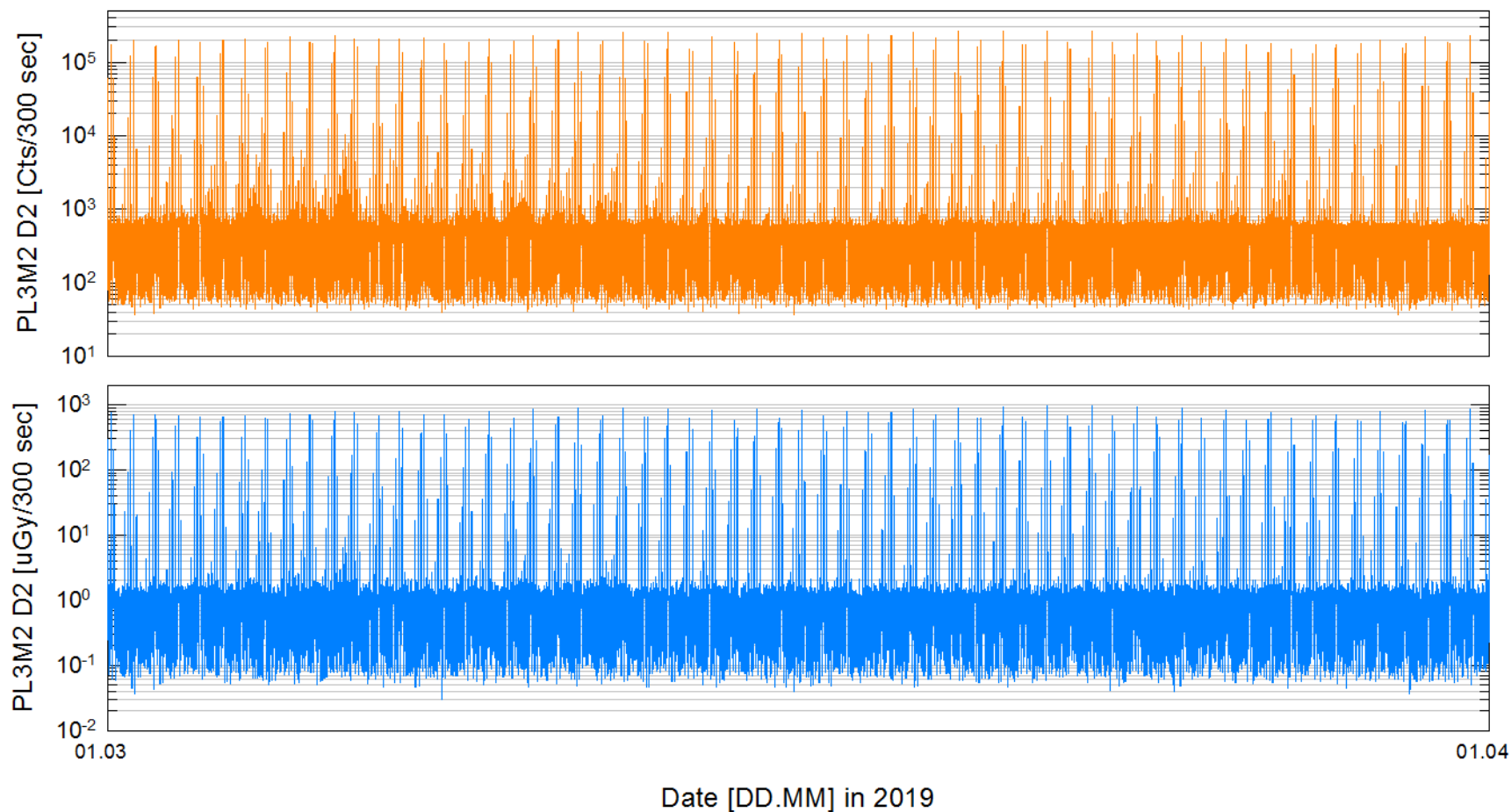
LET Spectra

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Eu:CROPIS: RAMIS PL3M2 D1 and D2 data

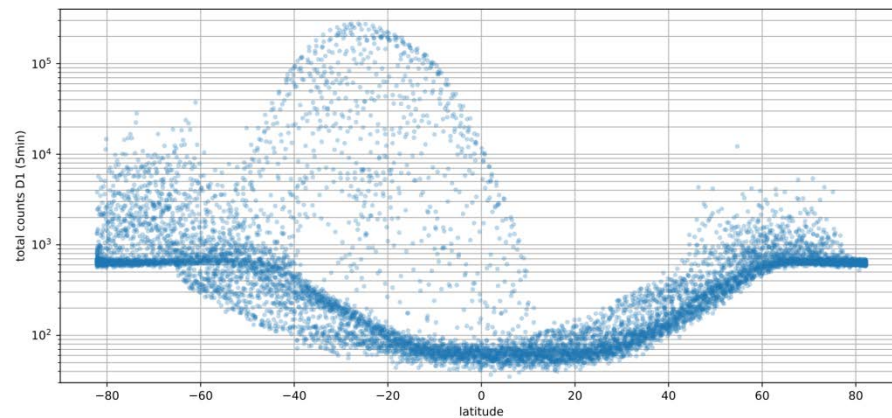
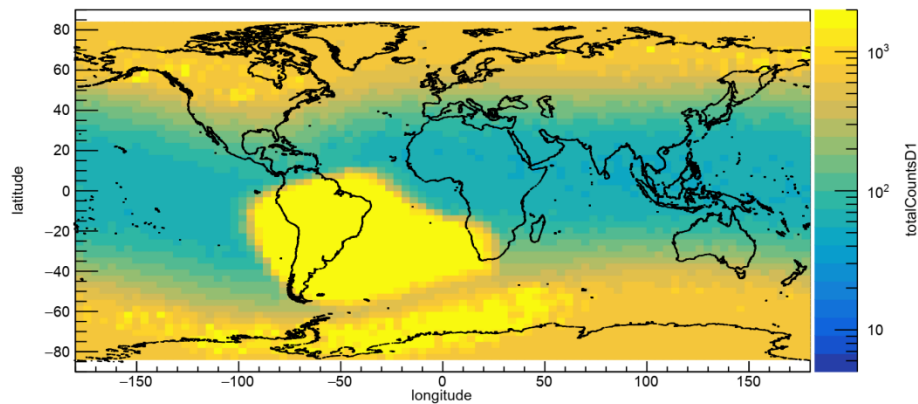


Eu:CROPIS: RAMIS PL3M2 D1 and D2 data

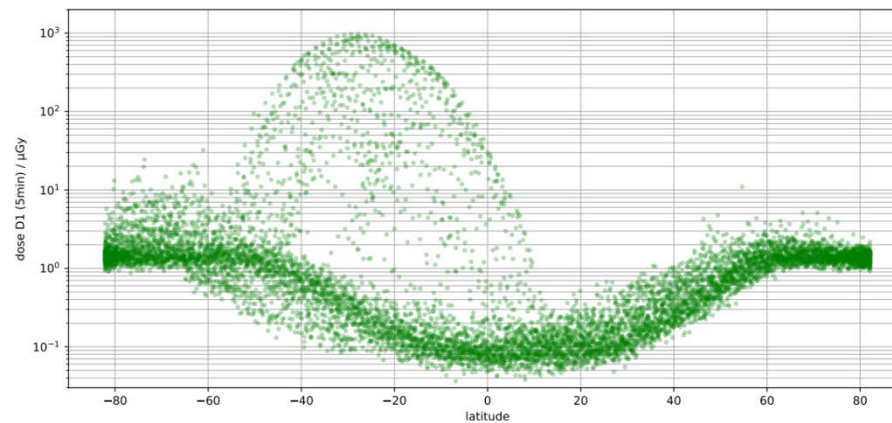
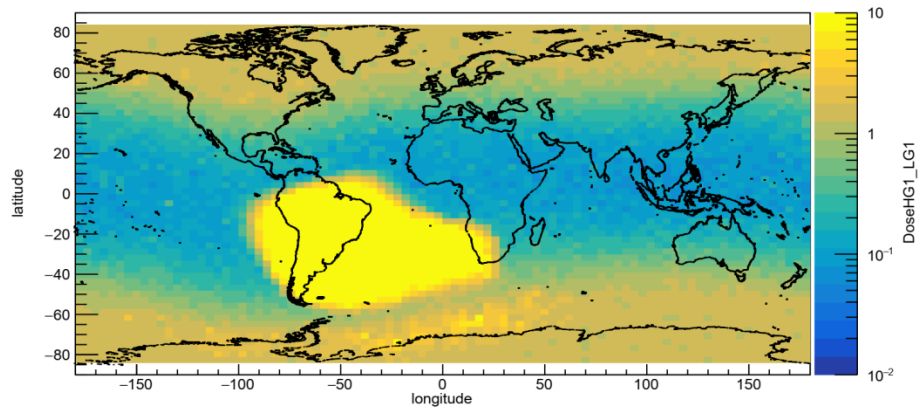


Eu:CROPIS: RAMIS PL3M2 D1 and D2 data

totalCountsD1 between 2018-12-05 18:34 and 2019-05-04 23:56

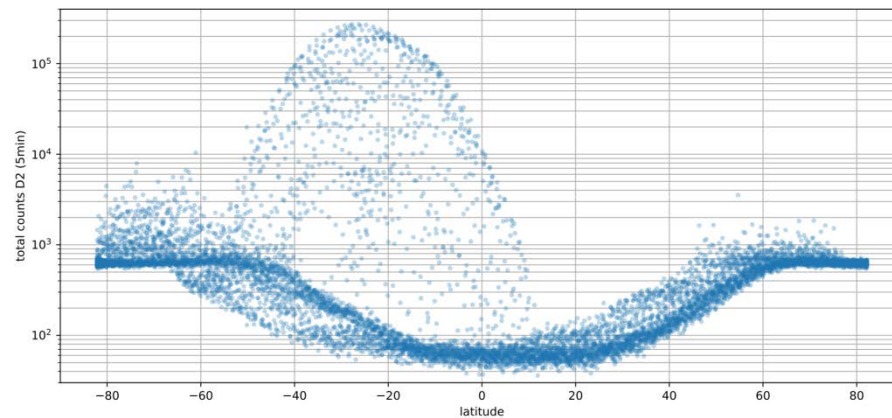
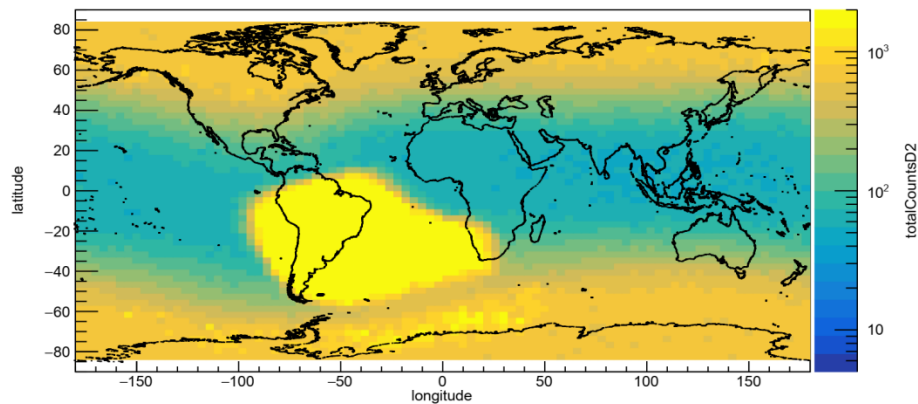


DoseHG1_LG1 between 2018-12-05 18:34 and 2019-05-04 23:56

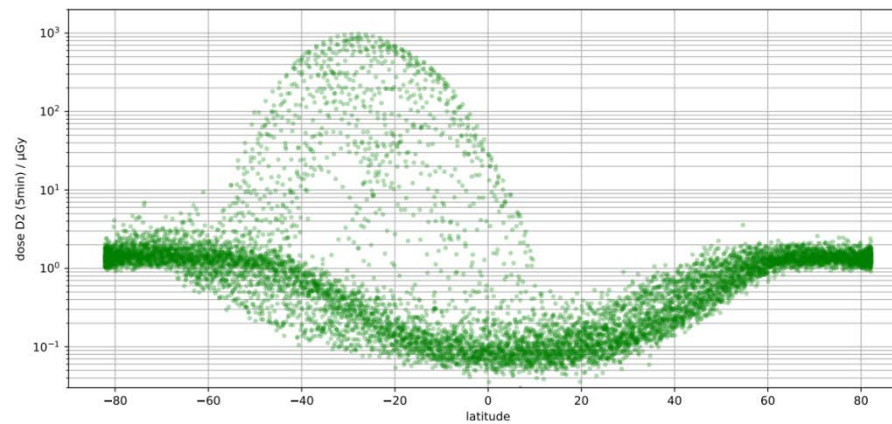
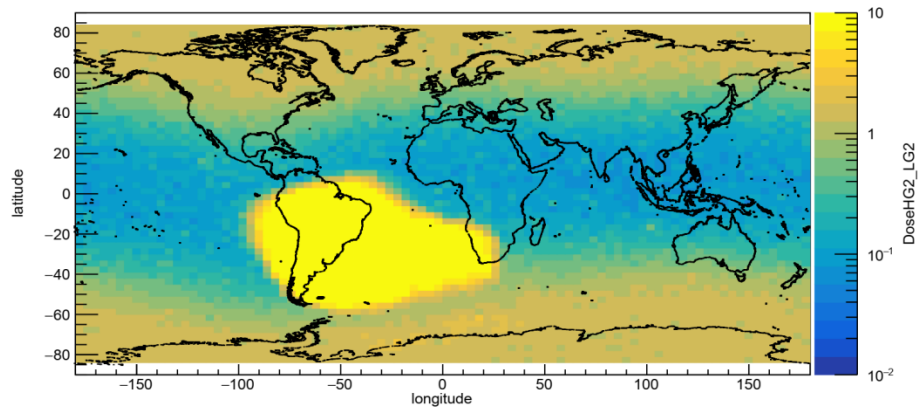


Eu:CROPIS: RAMIS PL3M2 D1 and D2 data

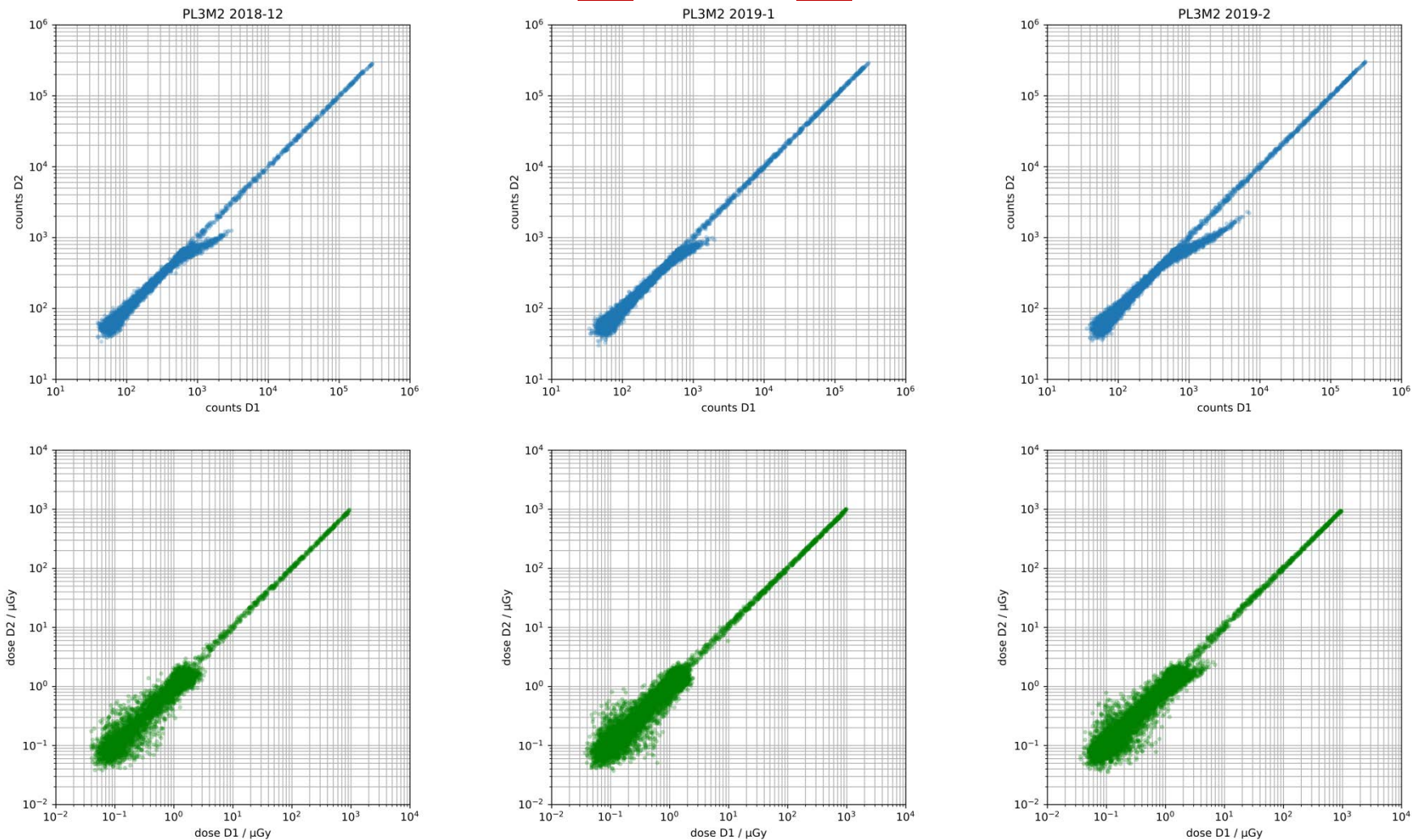
totalCountsD2 between 2018-12-05 18:34 and 2019-05-04 23:56



DoseHG2_LG2 between 2018-12-05 18:34 and 2019-05-04 23:56



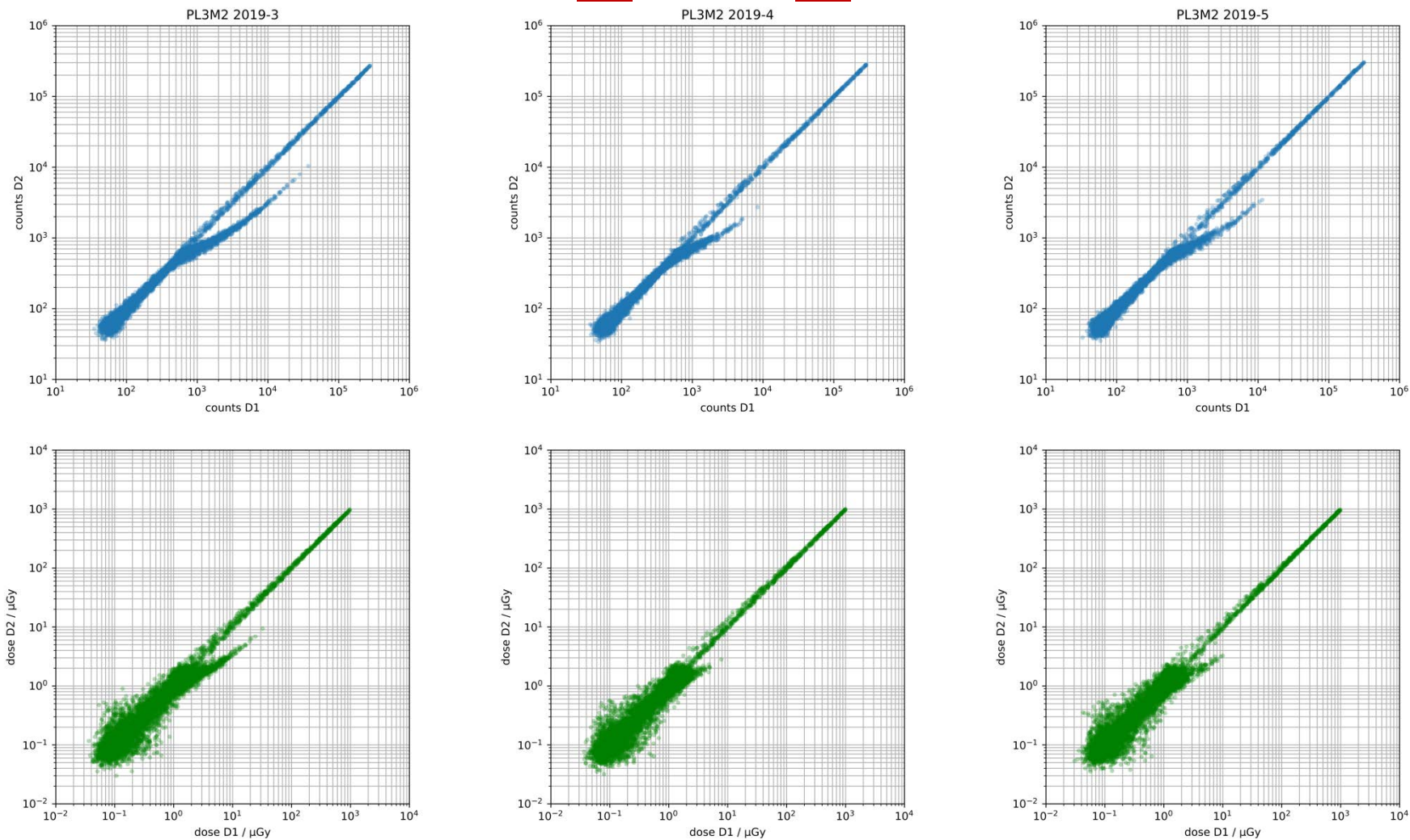
Eu:CROPIS: RAMIS PL3M2 D1 versus D2 data



Monthly plots



Eu:CROPIS: RAMIS PL3M2 D1 versus D2 data

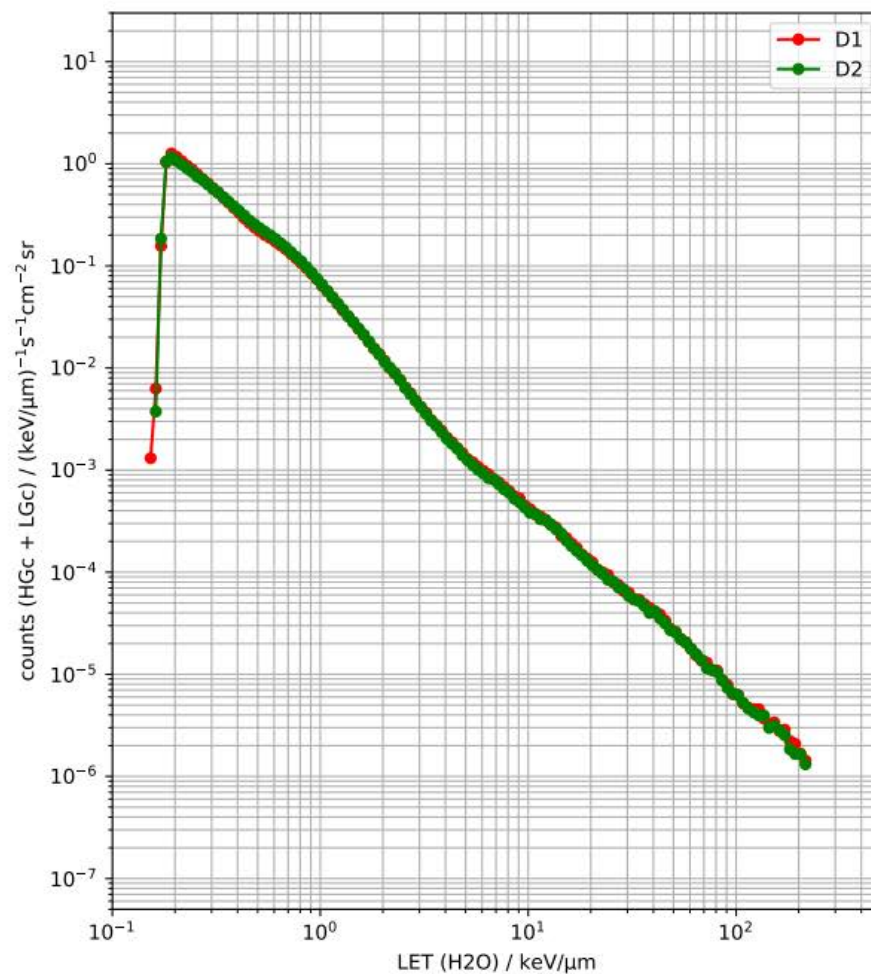
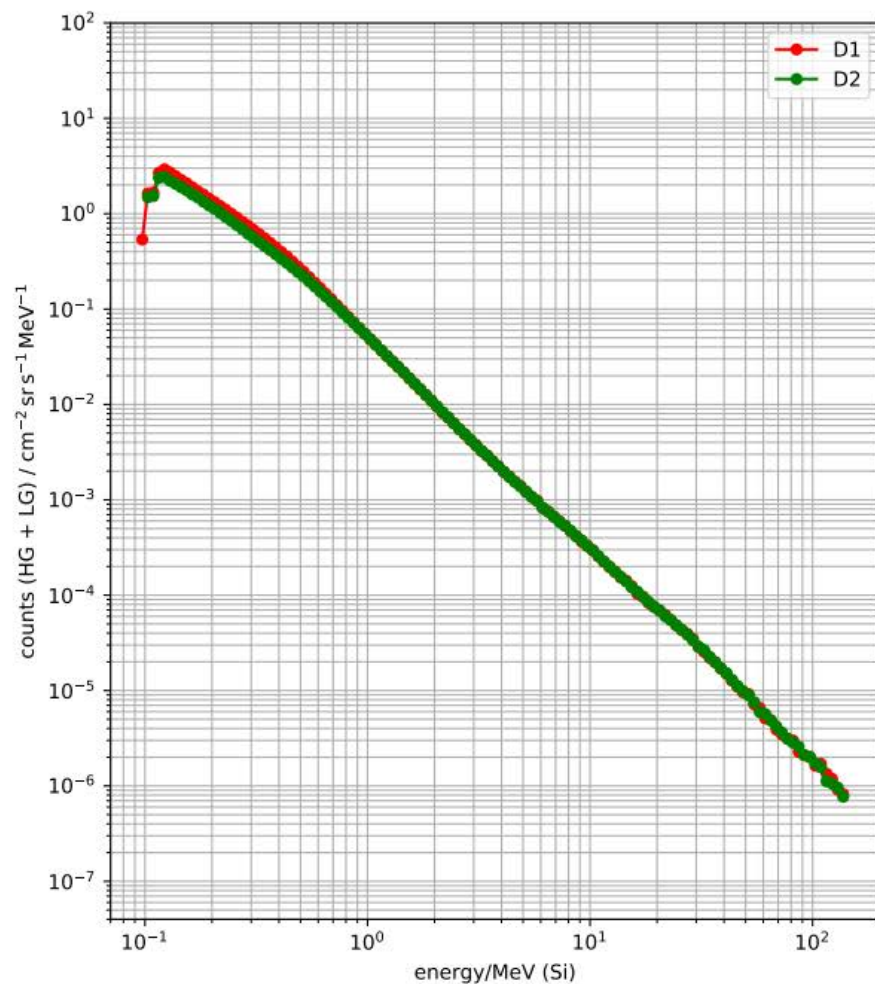


Monthly plots



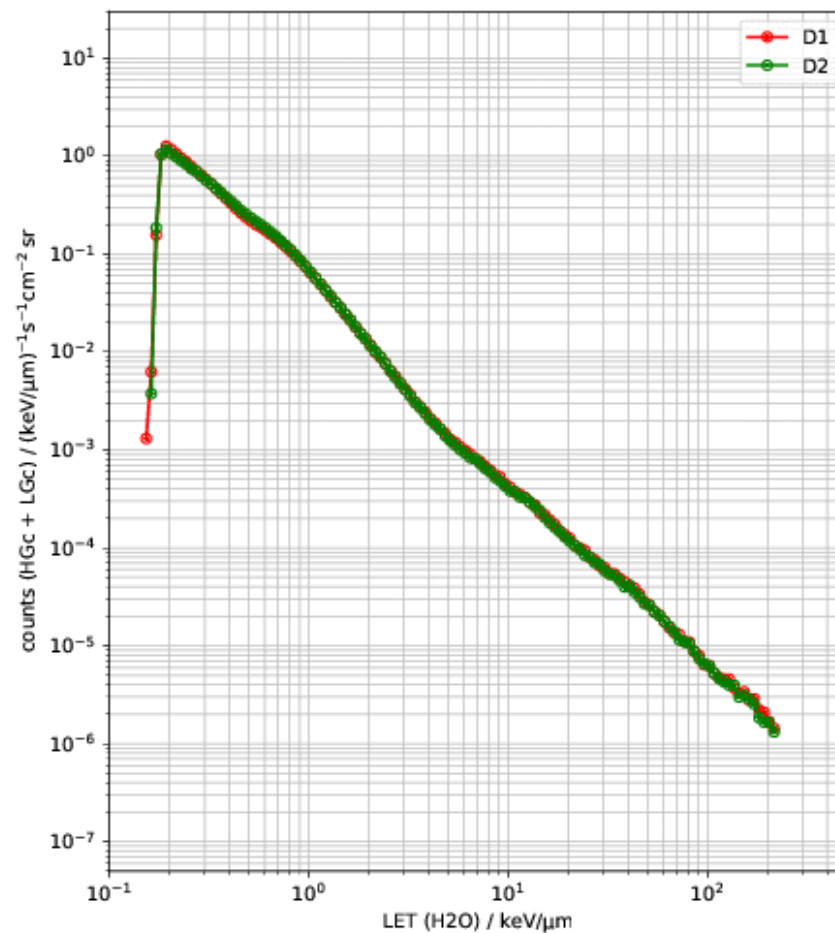
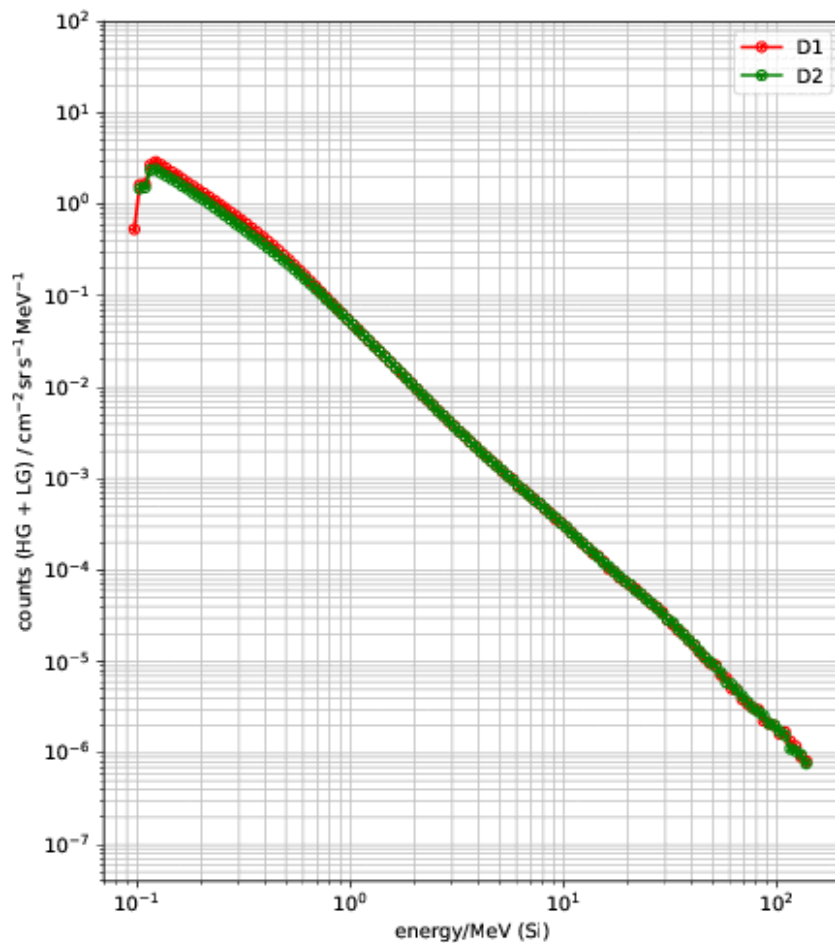
Eu:CROPIS: RAMIS PL3M2 Energy deposition + LET spectra

acc. spectrum, $0.0 \leq R_C < 0.5$



Eu:CROPIS: RAMIS PL3M2 Energy deposition + LET spectra

acc. spectrum, $0.0 \leq R_C < 0.5$



RAMIS PL3M2 versus PL1M1

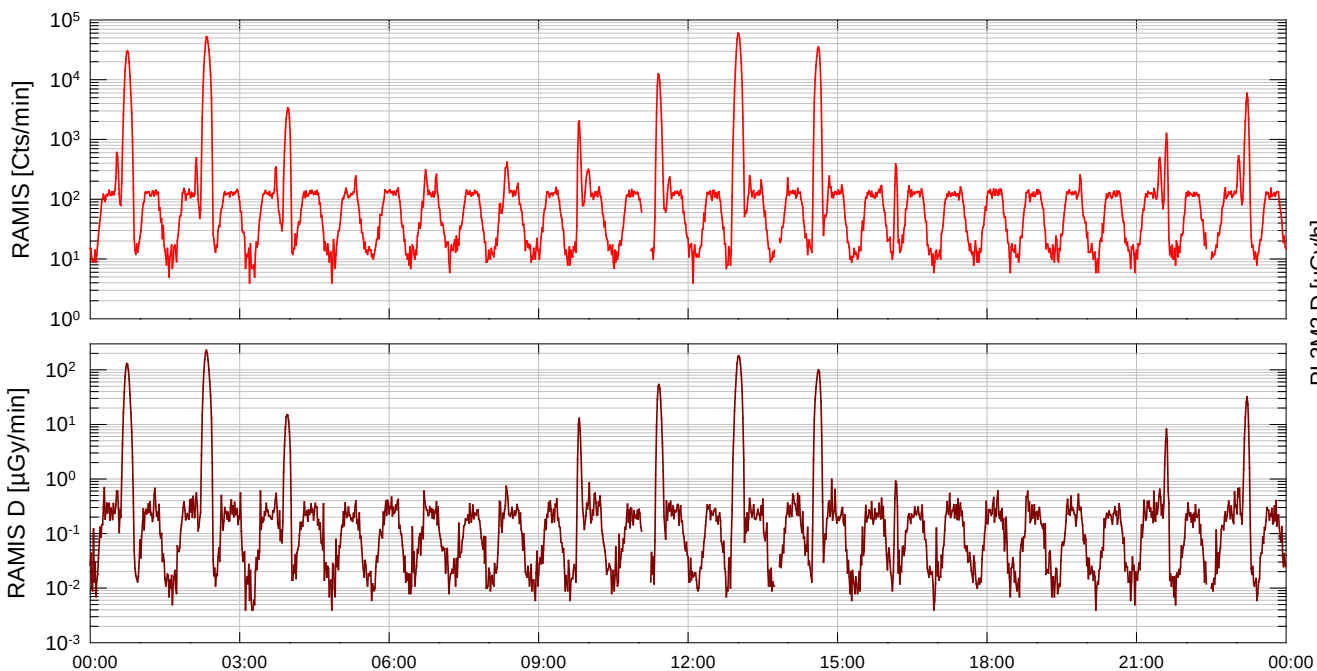
Differences count and dose rate



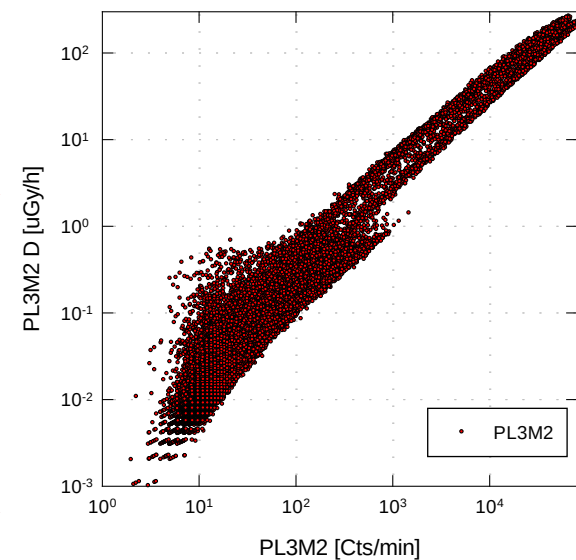
Knowledge for Tomorrow



Eu:CROPIS: RAMIS → PL3M2



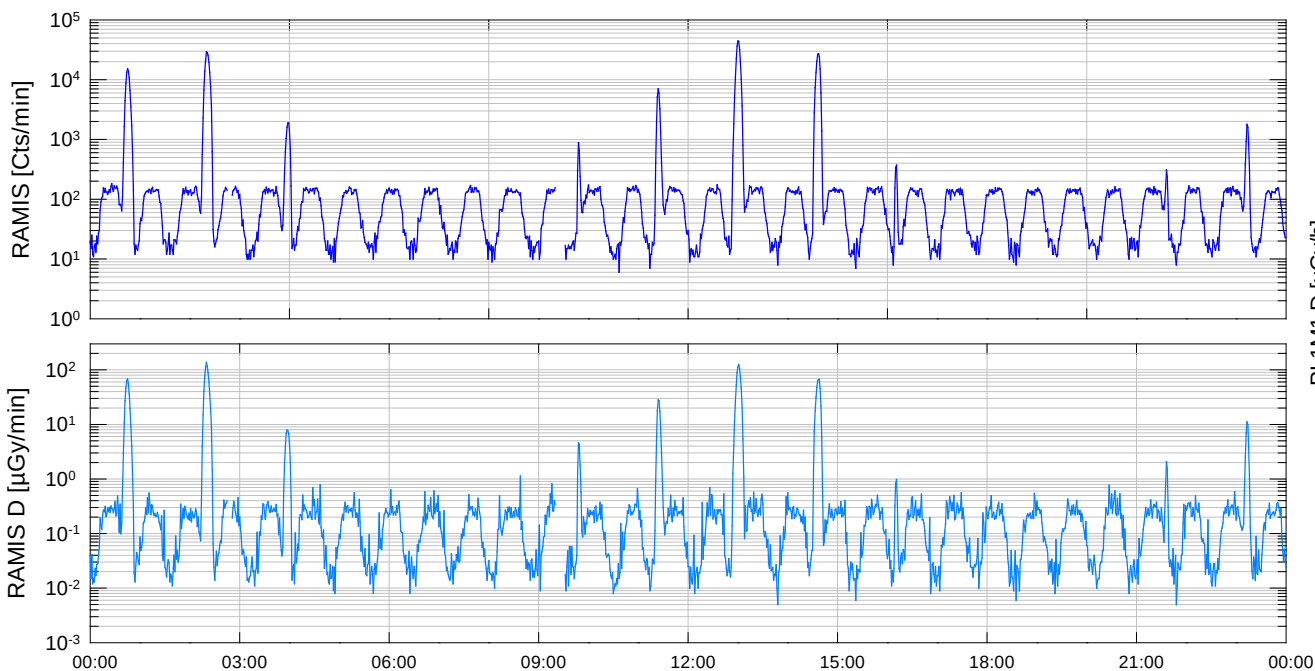
26 December 2018



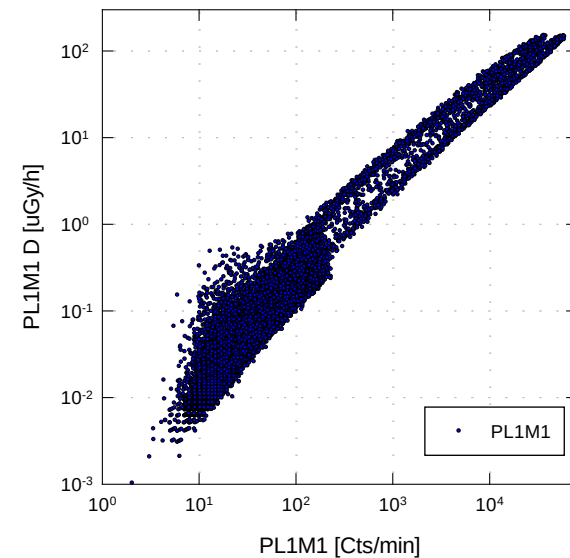
Dec. 2018 + Jan. 2019



Eu:CROPIS: RAMIS → PL1M1



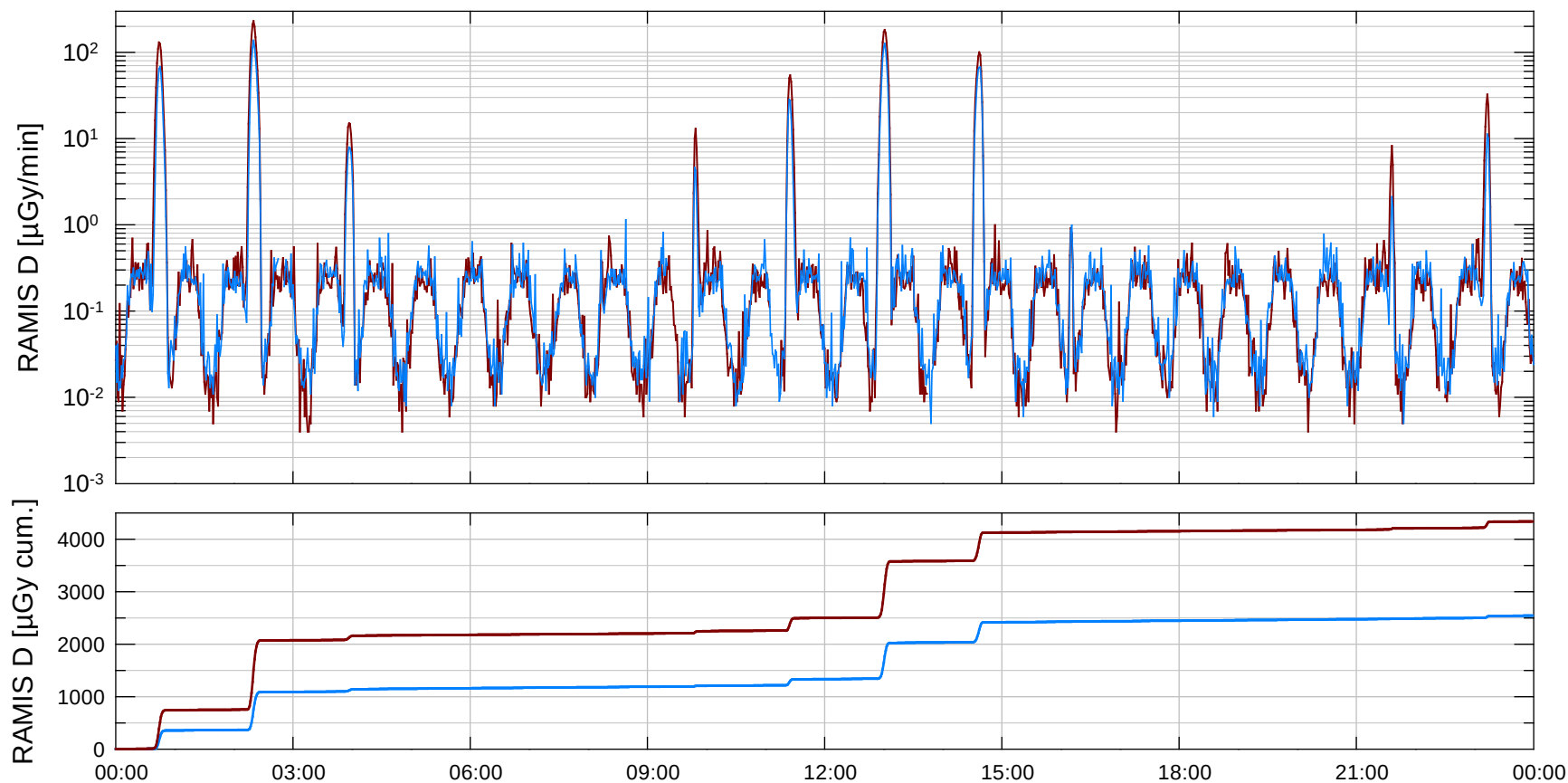
26 December 2018



Dec. 2018 + Jan. 2019



Eu:CROPIS: RAMIS → PL1M1 and PL3M2



26 December 2018

PL3M2: 4333 μGy

PL1M1: 2541 μGy



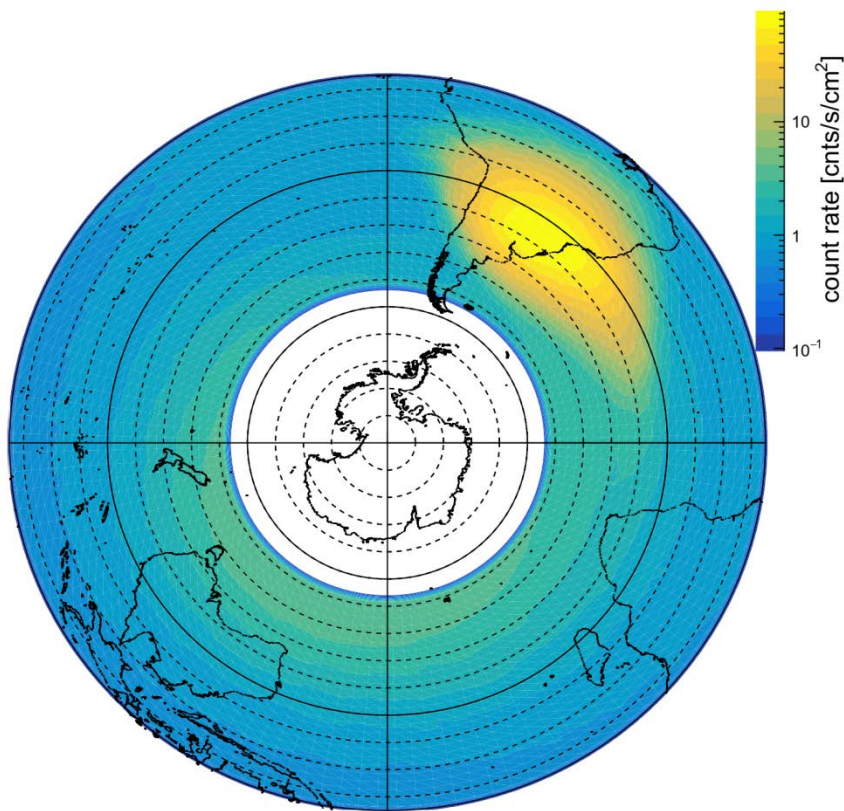
RAMIS PL3M2 versus DOSIS 3D DOSTEL-1 (ISS)



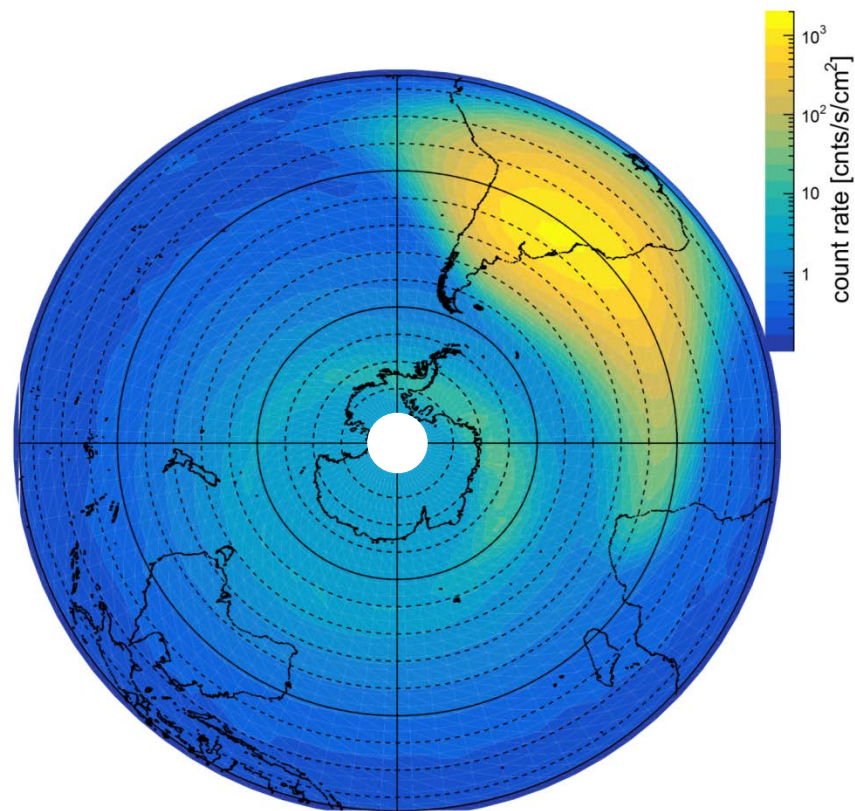
Knowledge for Tomorrow



Eu:CROPIS: DOSIS 3D DOSTEL-1 / RAMIS PL3M2



DOSIS 3D DOSTEL-1

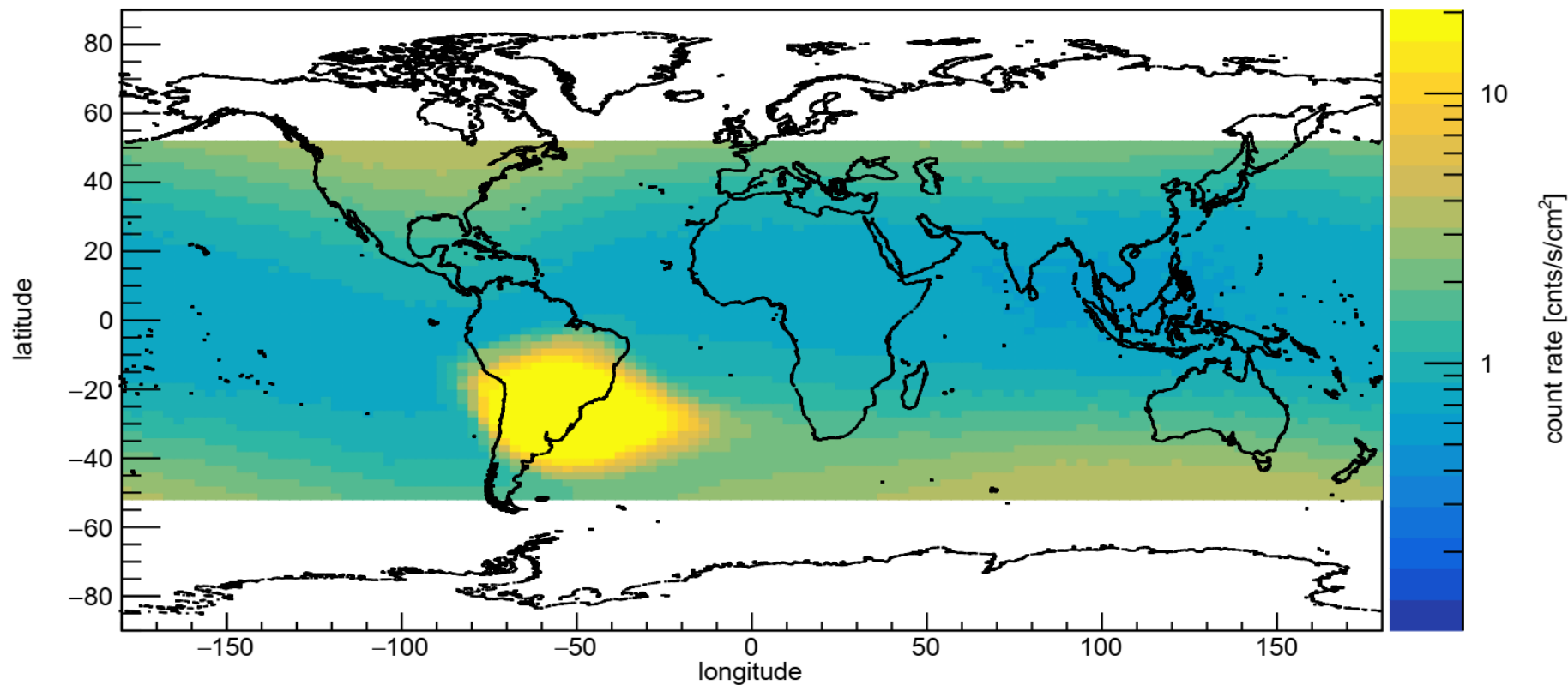


RAMIS PL3M2



Eu:CROPIS: DOSIS 3D DOSTEL-1 / RAMIS PL3M2

count rate between 2019-01-01 00:01 and 2019-07-07 17:20

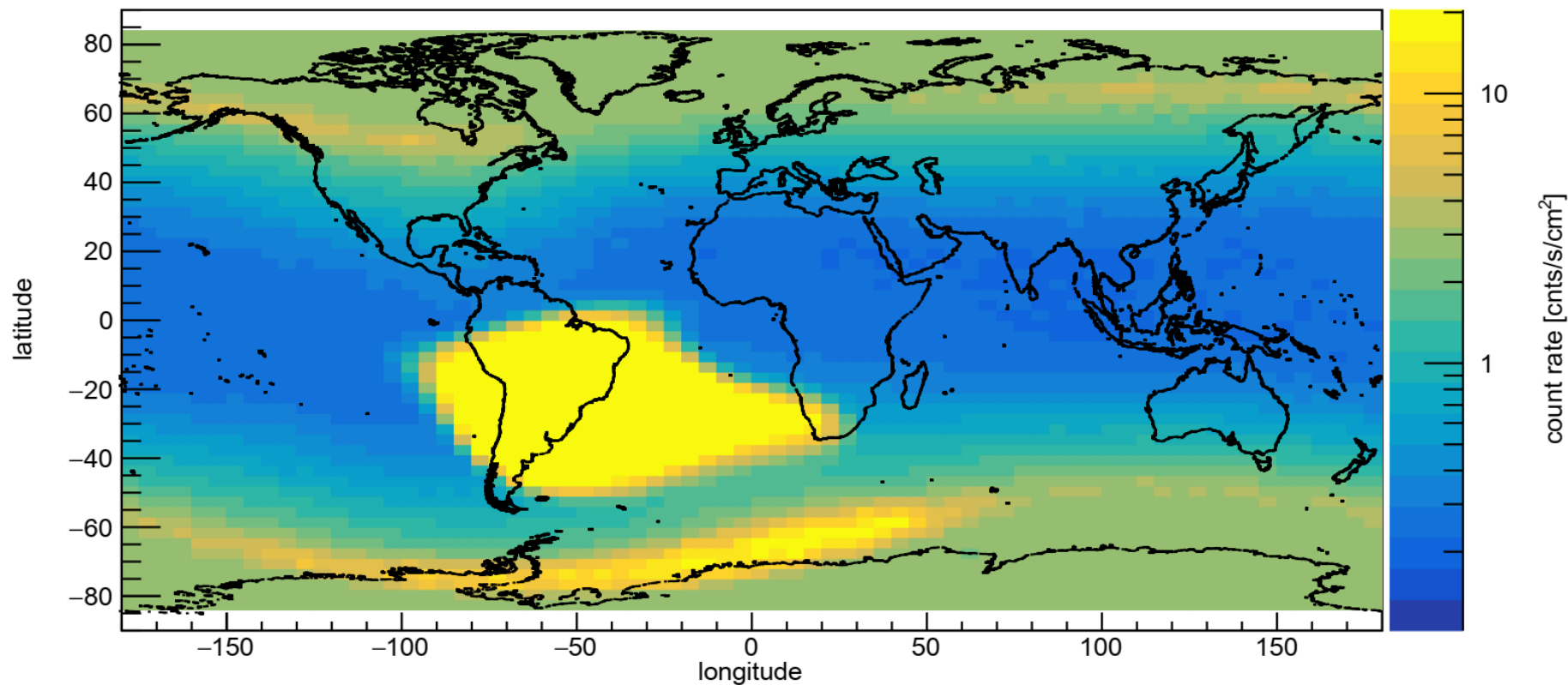


DOSIS 3D DOSTEL-1



Eu:CROPIS: DOSIS 3D DOSTEL-1 / RAMIS PL3M2

count rate between 2018-12-05 18:33 and 2019-08-11 10:42



Eu:CROPIS: RAMIS – Work to do (a lot...)

- GCR/SAA/Belt separation
- Comparison with data from the Van Allen Probes
- Comparison with AP9 and AE9 Models (AP8 fails...)
- GCR long term variation → Oulu comparison
- LET Spectra PL1M1 comparison with PL3M2
- Update GEANT4 calculations
-comparison with other similar missions...





Acknowledgements

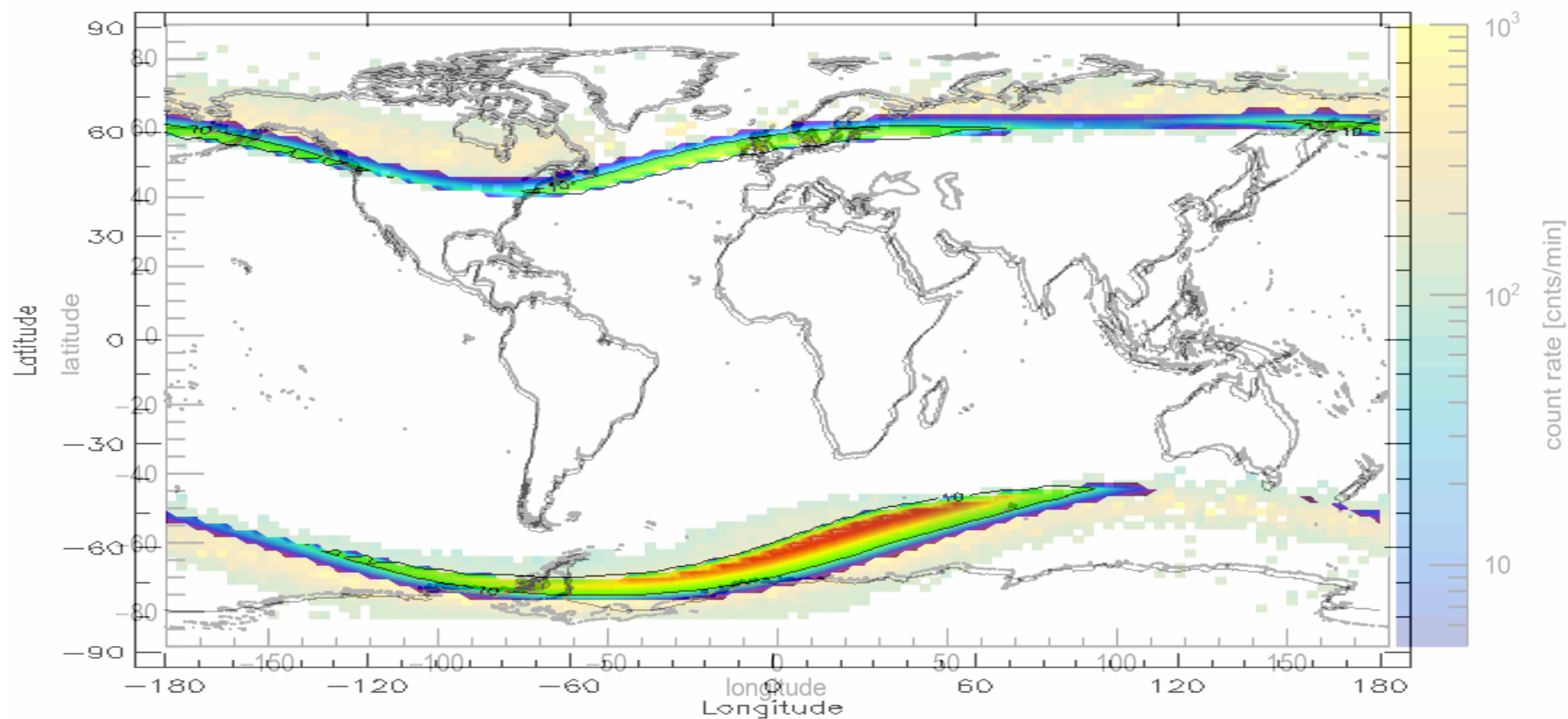
- DLR-ME-SBA: Birgit Ritter, Aleksandra Rutczynska
- DLR-ME-BIO: Jens Hauslage, Ruth Hemmersbach
- DLR-MUSC: Stephan Sous, Hans-Herbert Fischer
- DLR-RY: Hartmut Müller, Falk Nohka, Olaf Eßmann, Toni Delovski, Claudia Philpot, Catherin Düvel, Fabian Greif
- DLR-RB: Gary Morfill, Lukas Grillmayer, Daniel Schulze, Stephan Borek
- University of Erlangen: Michael Lebert, Ferdinand Haag
- NIRS, HIMAC: Calibration of RAMIS was performed within the HIMAC Research Project H282. A special thanks to Satoshi Kodaira and Hisashi Kitamura.

The work for RAMIS was funded by DLR F&E under the program FuW EuCROPIS 2475156

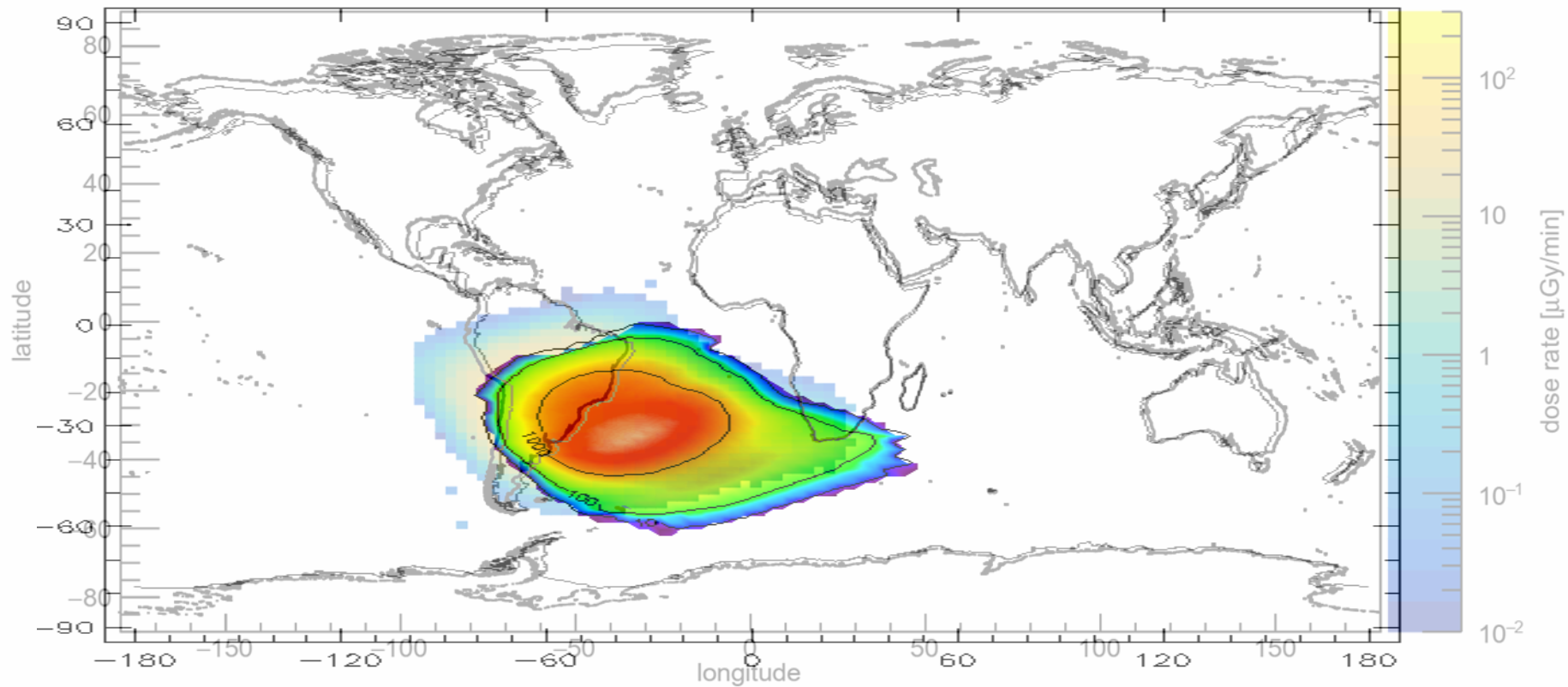


Backup: AE8

count rate between 2018-12-05 19:33 and 2019-05-14 22:47



Backup: AP8



Backup: Oulu

