OVER 2000 DAYS IN SPACE – THE RAMIS RADIATION DETECTOR ON THE DLR EU:CROPIS MISSION

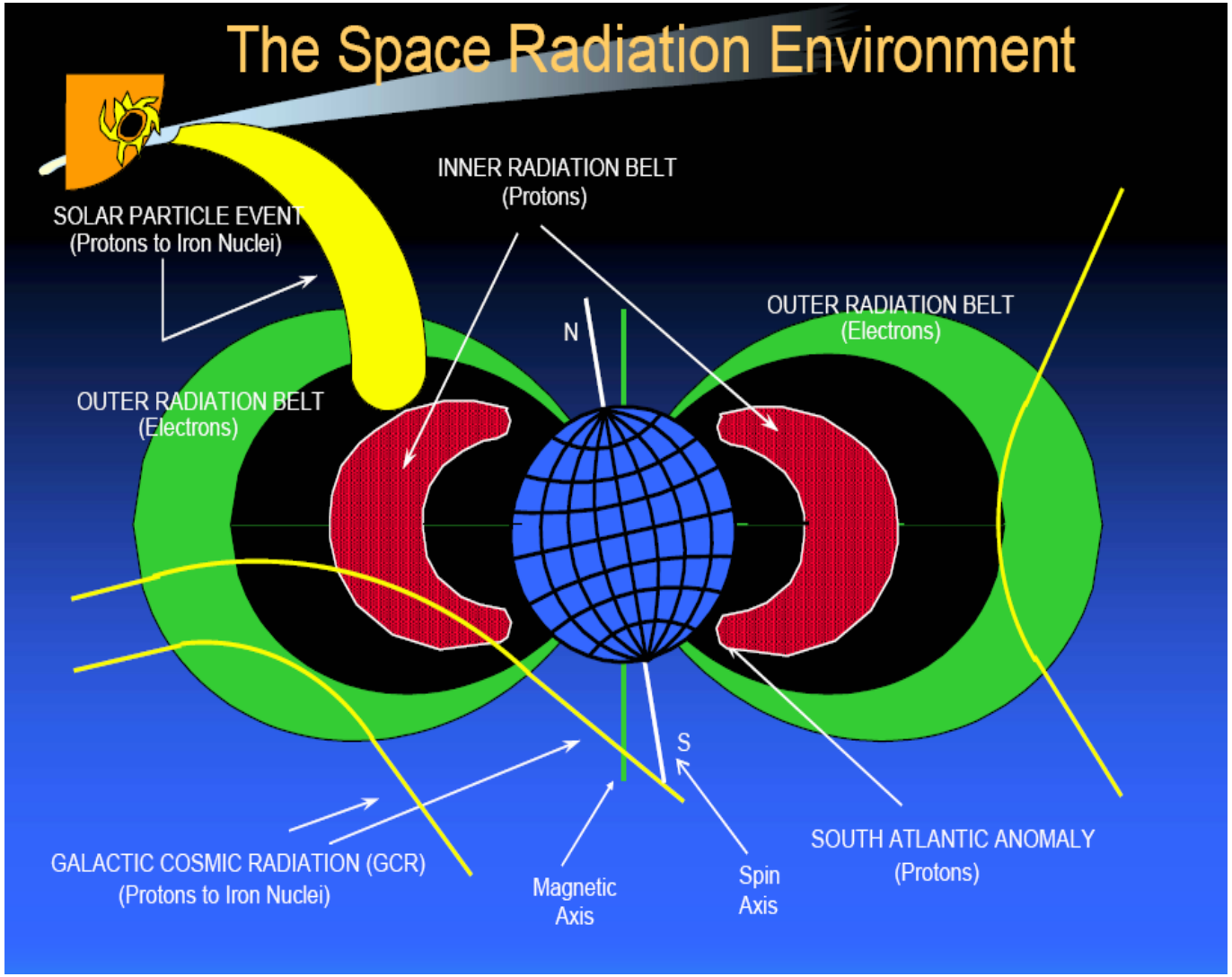
Karel Marsalek for the Eu:CROPIS RAMIS team:

DLR-ME & DLR-MUSC & GSOC-EUC-FLD & DLR-RY

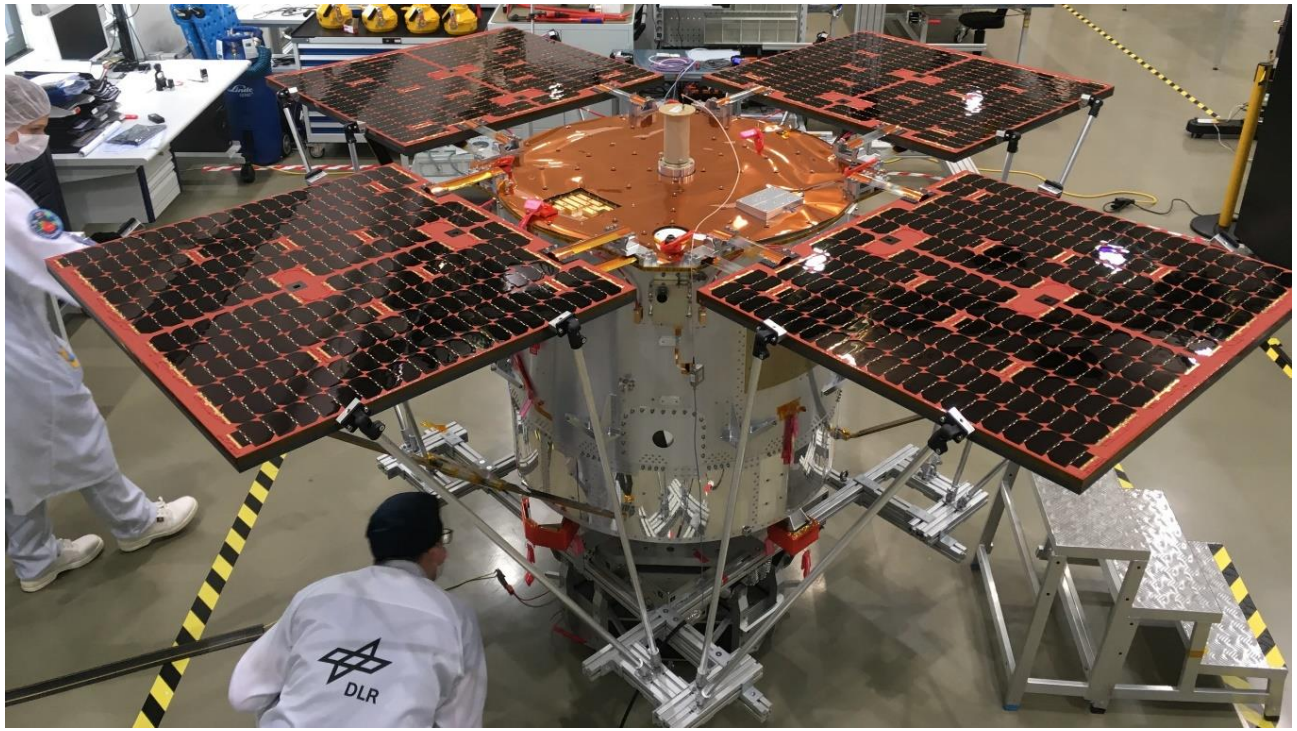
DLR

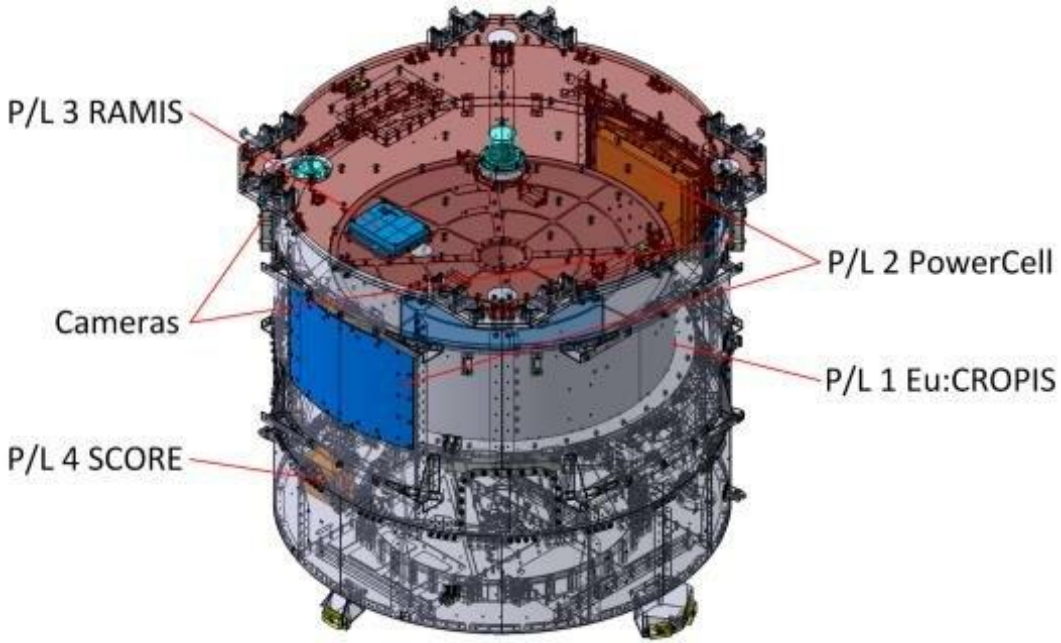
The Space Radiation Environment

- **SUN – Solar Particle Events**
  - SPE
- **Galactic Cosmic Radiation**
  - GCR
- **Trapped Radiation Belts**
  - Van Allen Belts



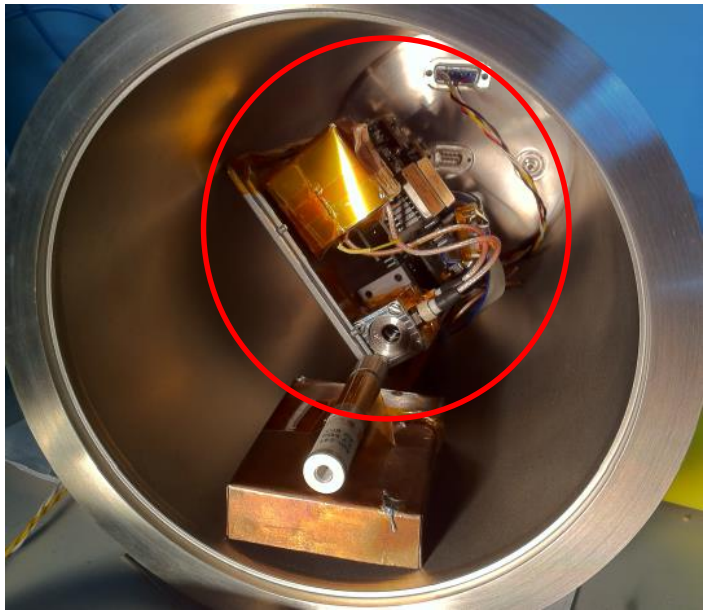
Eu:CROPIS: Compact satellite





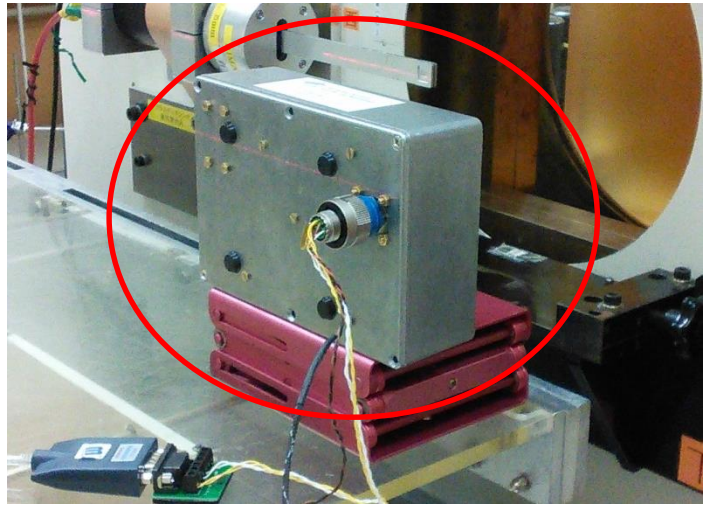
Hauslage, J. et al. (2018) https://doi.org/10.1007/s12217-018-9654-1
https://www.dlr.de/en/research-and-transfer/projects-and-missions/the-eu-cropis-mission

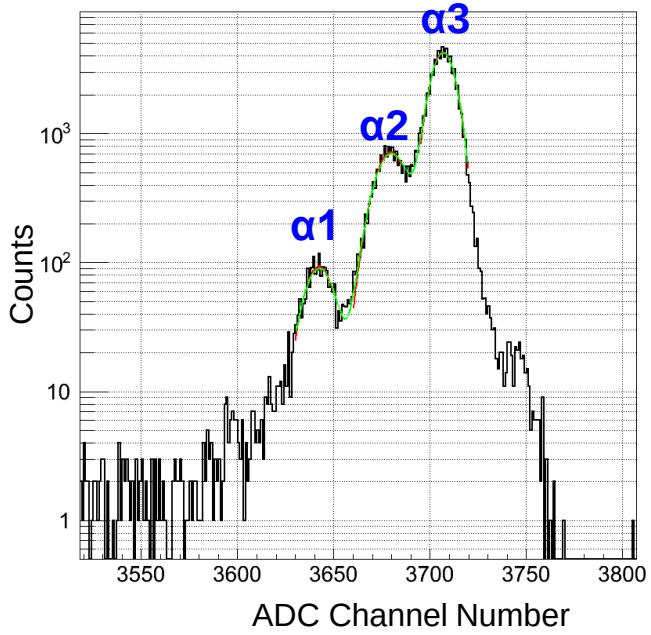
Eu:CROPIS: RAMIS Prototype / Calibrations

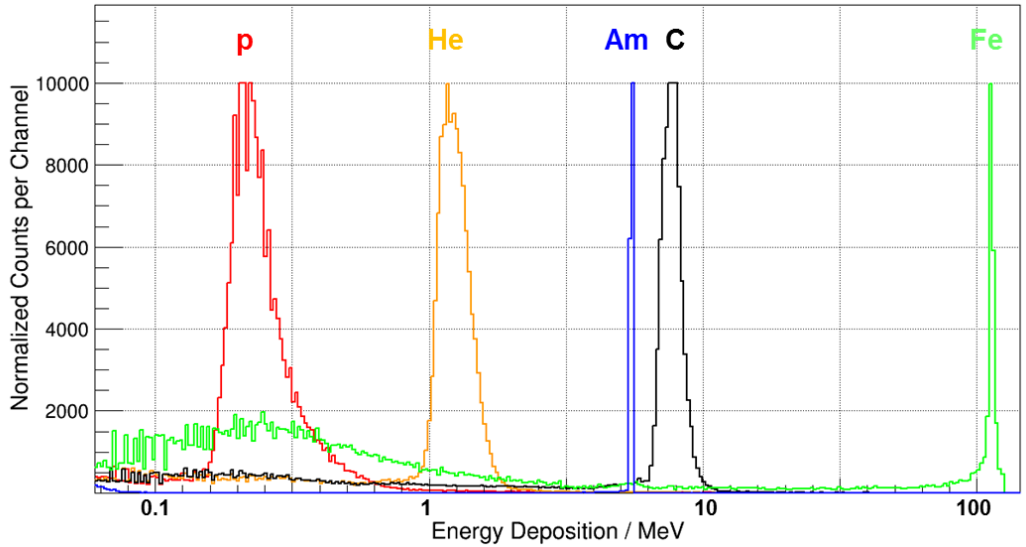


^{241}Am
DLR-ME

Heavy Ions
HIMAC, Japan

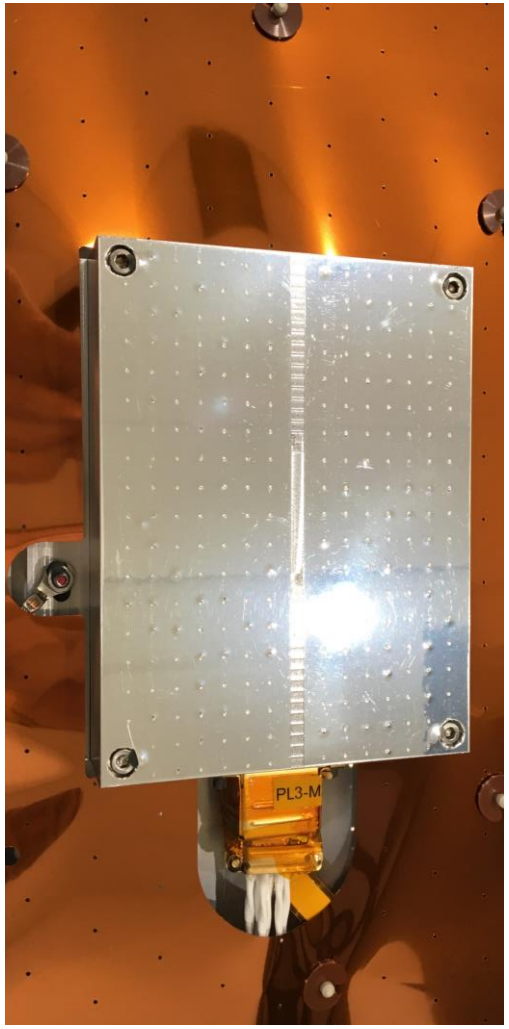


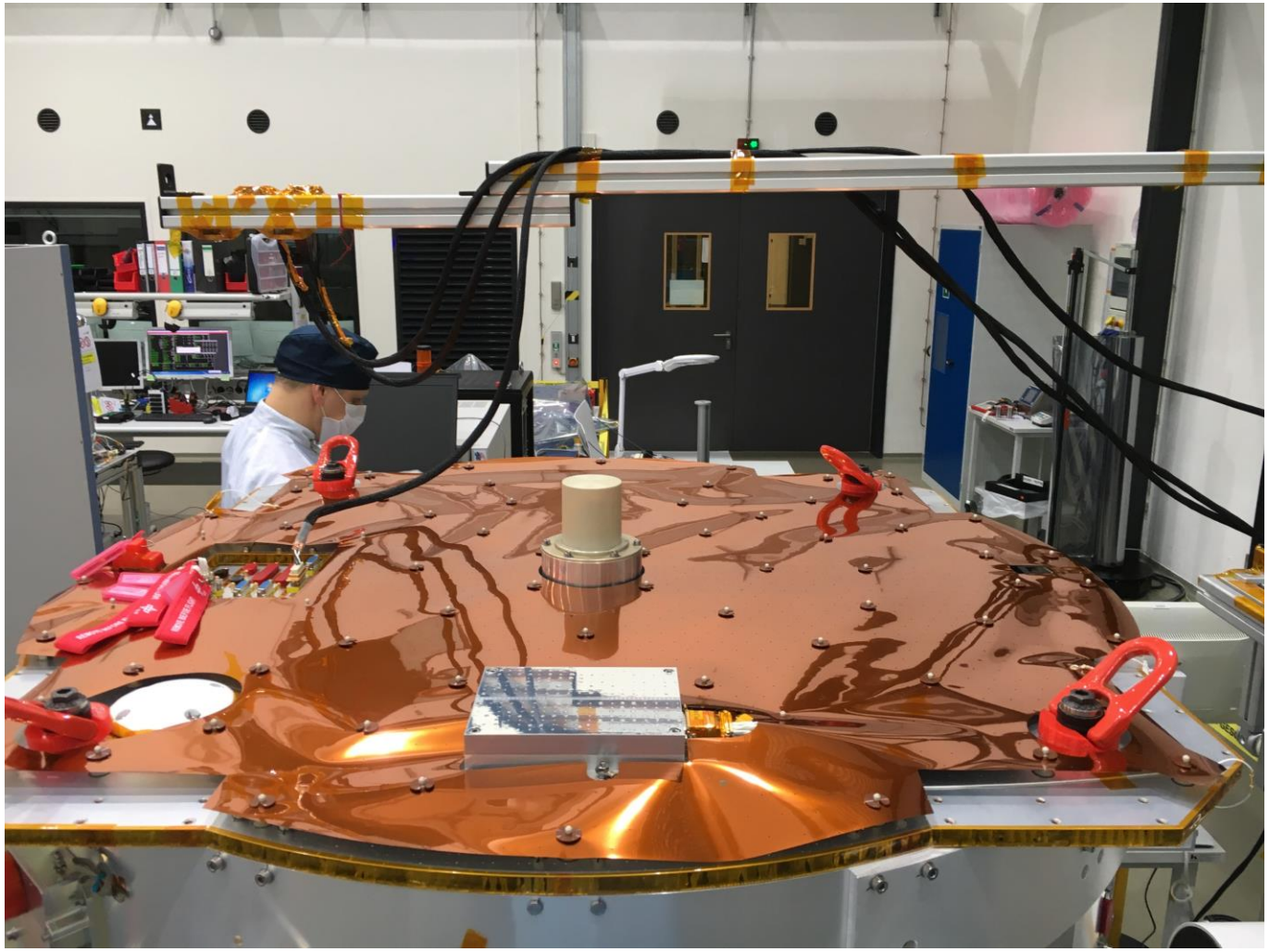




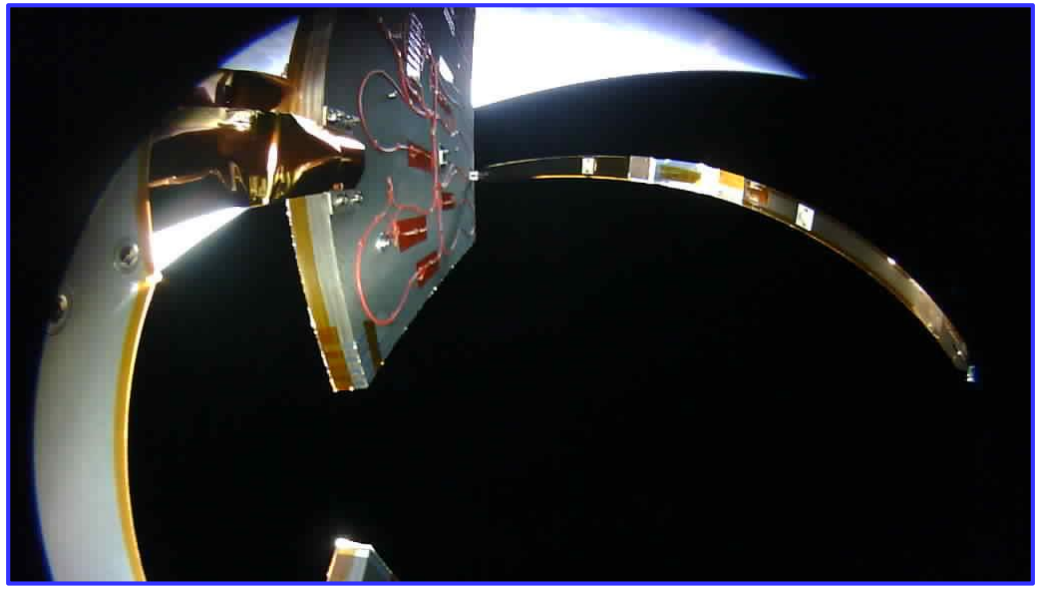
Over 2000 days in space – the RAMIS radiation detector on the DLR Eu:CROPIS mission / WRMISS 2024-09-03

Eu:CROPIS: RAMIS FM Models (December 2017)





Eu:CROPIS: Launch (03 Dec 2018) / solar p. deployed

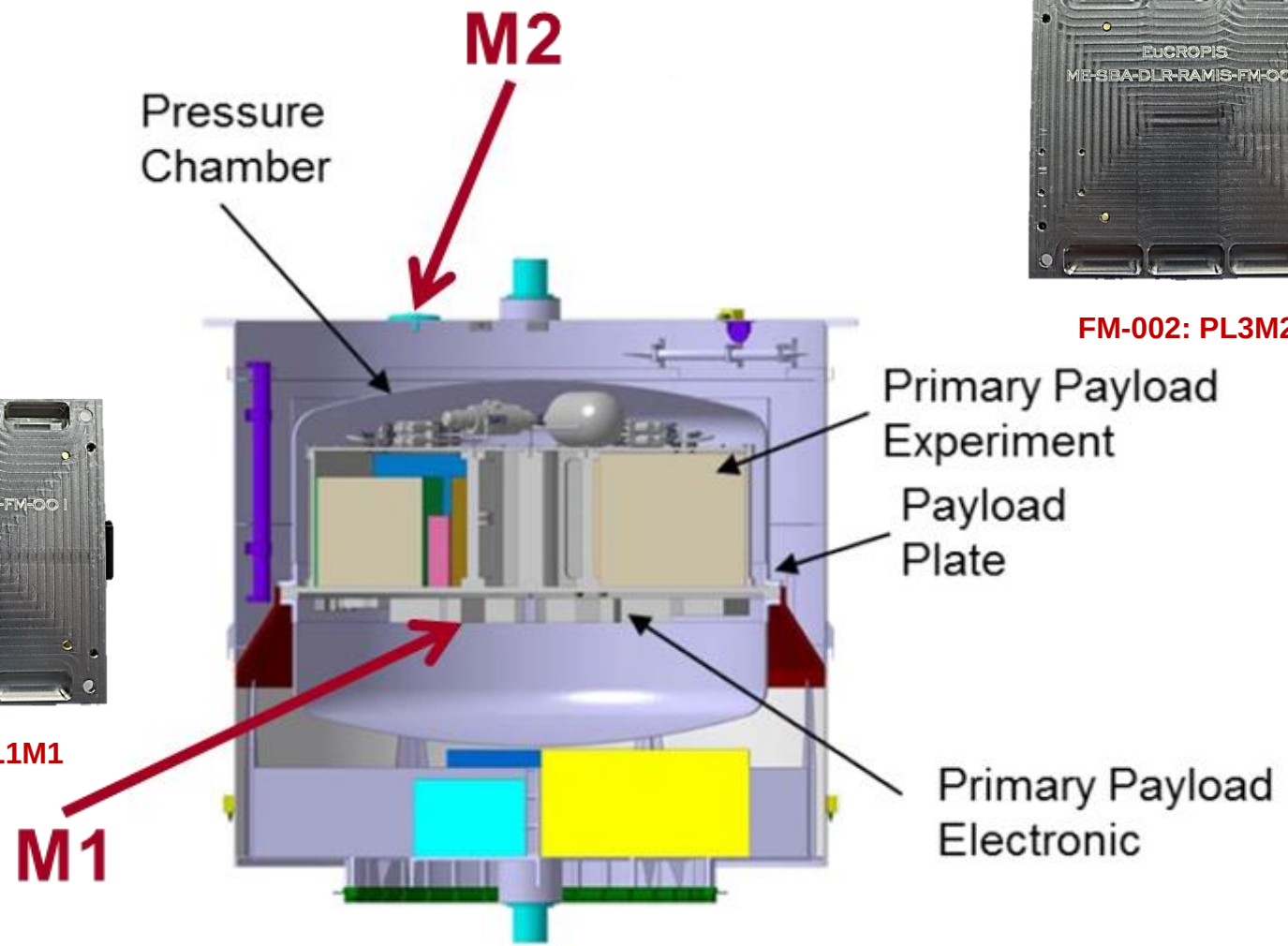


Eu:CROPIS	NORAD ID 2018-099BB		
	Dec. 2018	Aug. 2023	Aug. 2024
Perigee	578.3 km	570.0 km	548.5 km
Apogee	598.2 km	574.7 km	560.9 km
Inclination	97.7°	97.6°	97.5°
Period	96.3 min	96.0 min	95.6 min
Orbits/24h	14.95	15.00	15.06
Semi major axis	**6959 km**	**6943 km**	**6925 km**
Mission duration	2 years TBC	Until the end	

Over 2000 days in space – the RAMIS radiation detector on the DLR Eu:CROPIS mission / WRMISS 2024-09-03

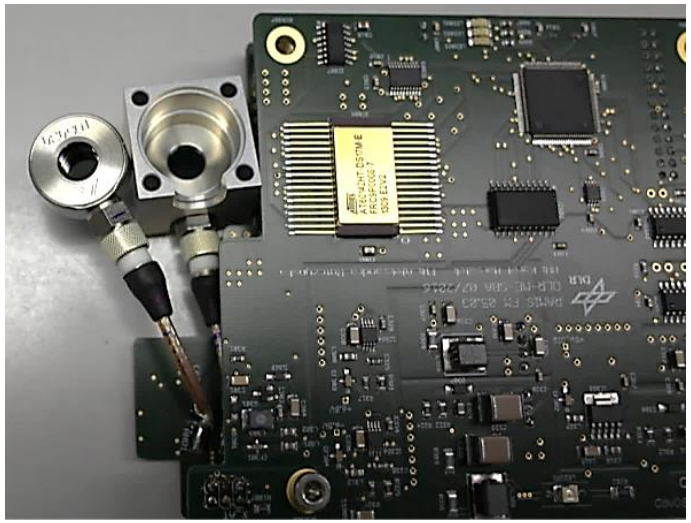
Eu:CROPIS: RAMIS Flight Models

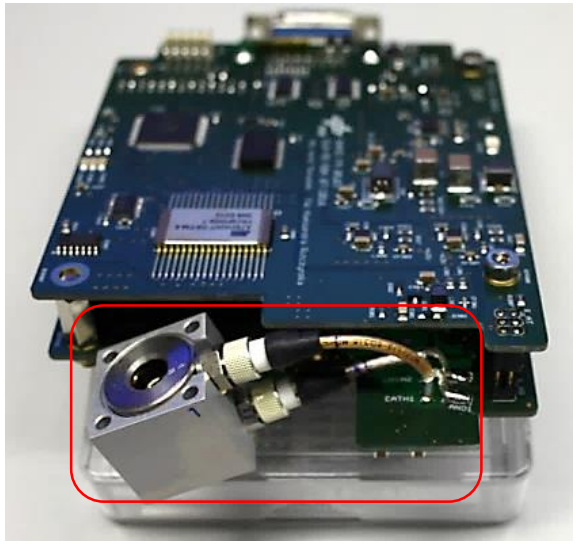
FM-001: PL1M1



FM-002: PL3M2

Eu:CROPIS: RAMIS





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

RAMIS: Fact Sheet II

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

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

Telescope Data		
Distance between the diodes	0,73	cm
Opening angle	109	°
GF	1,423	$sr*cm^2$
Mean path length	335,85	µm

Ranges		
Energy range (in Si)	0.09 – 145	MeV
LET Range (in H2O)	0.15 – 228	keV/µm

RAMIS: Data products

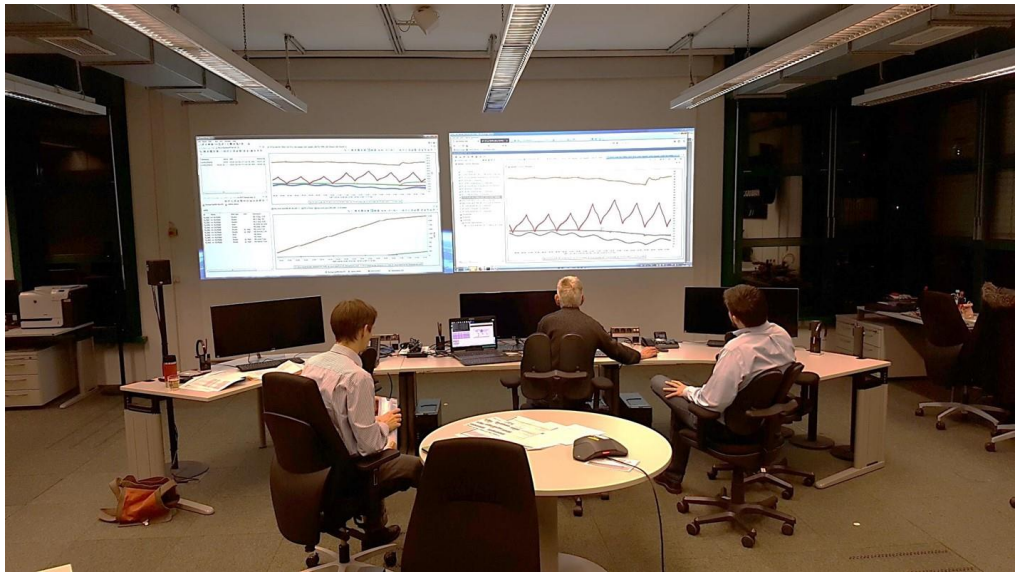
RAMIS	Data	Time resolution
D1	Count and dose rate	1 minute
D1 + D2	Count and dose rate	5 minute
	Energy deposition spectra	5 minute
	LET spectra	5 minute

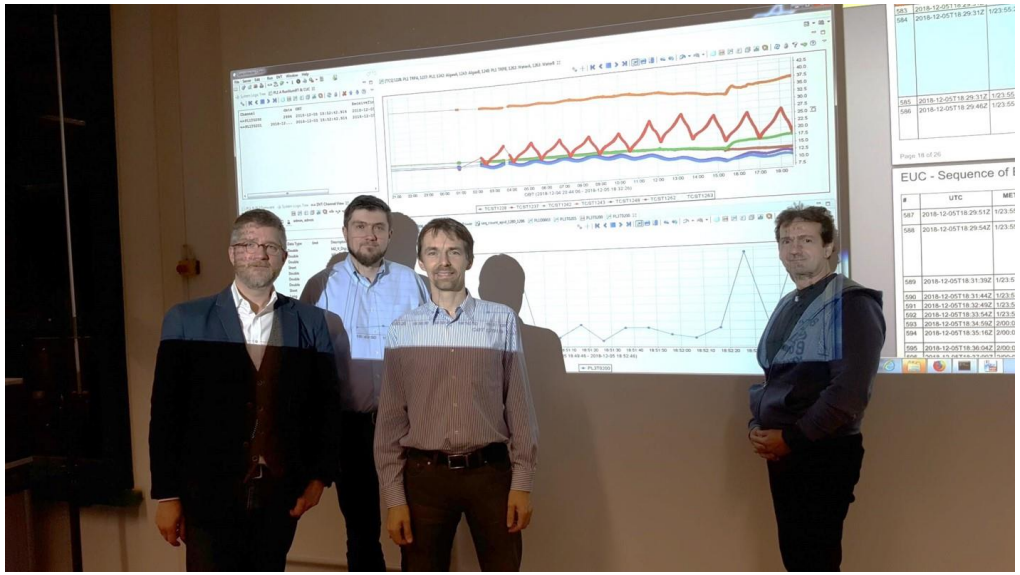
```
Parser Version 1.0.0

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;
```

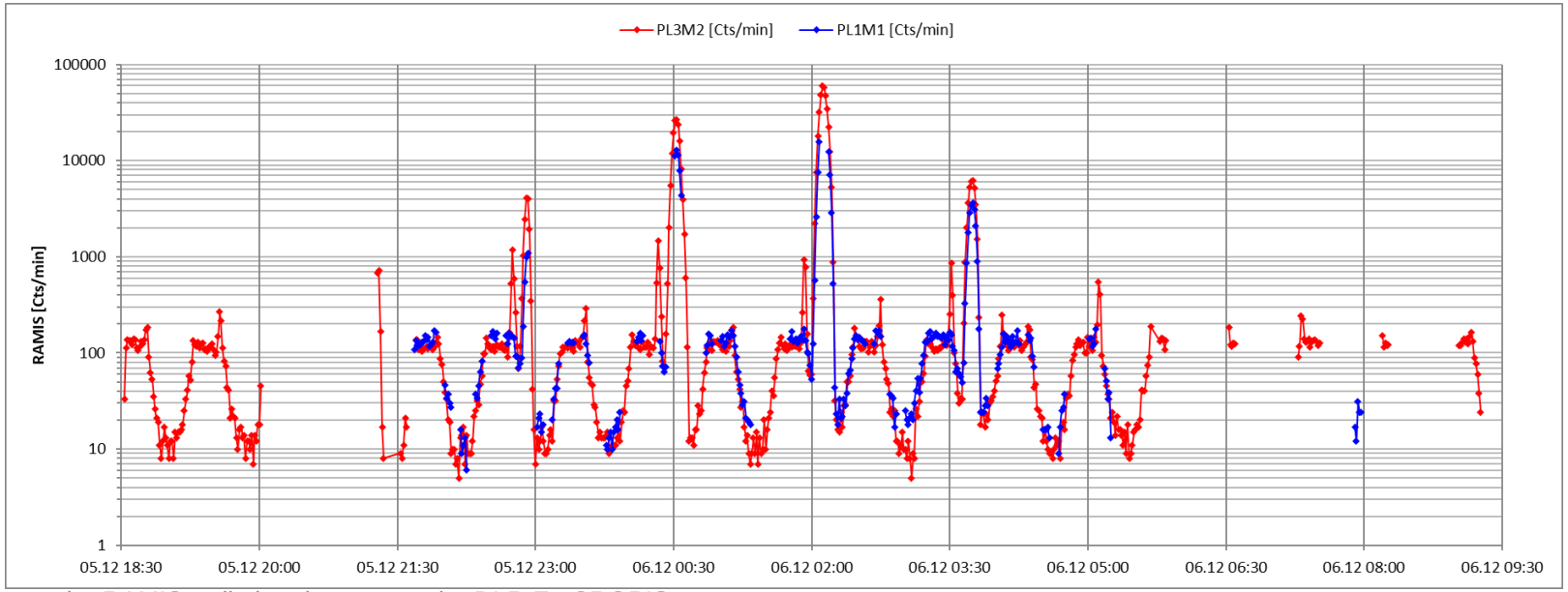
RAMIS Data

- H/K
- Extended H/K
- Spectrum

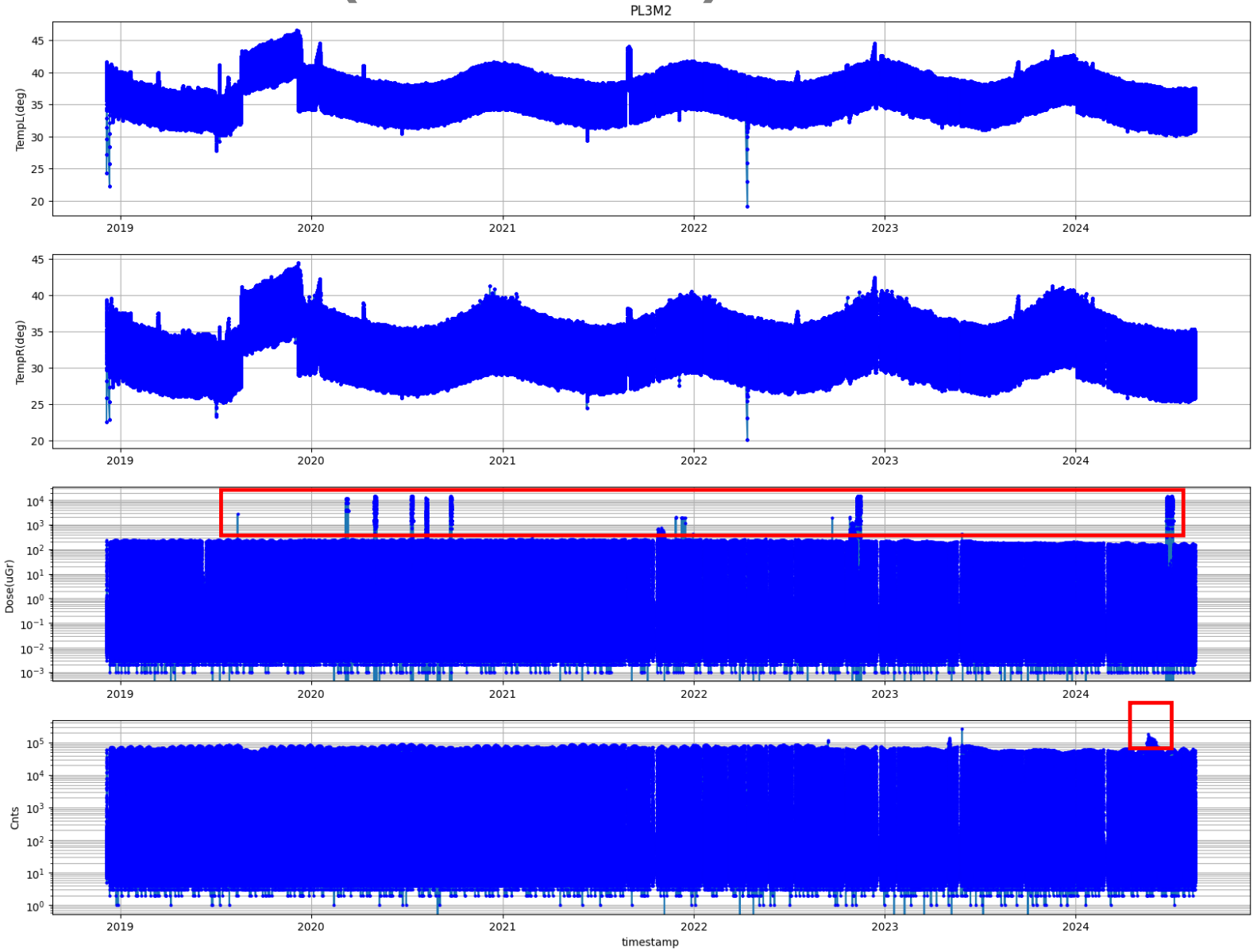
RAMIS: First data (05 December 2018)







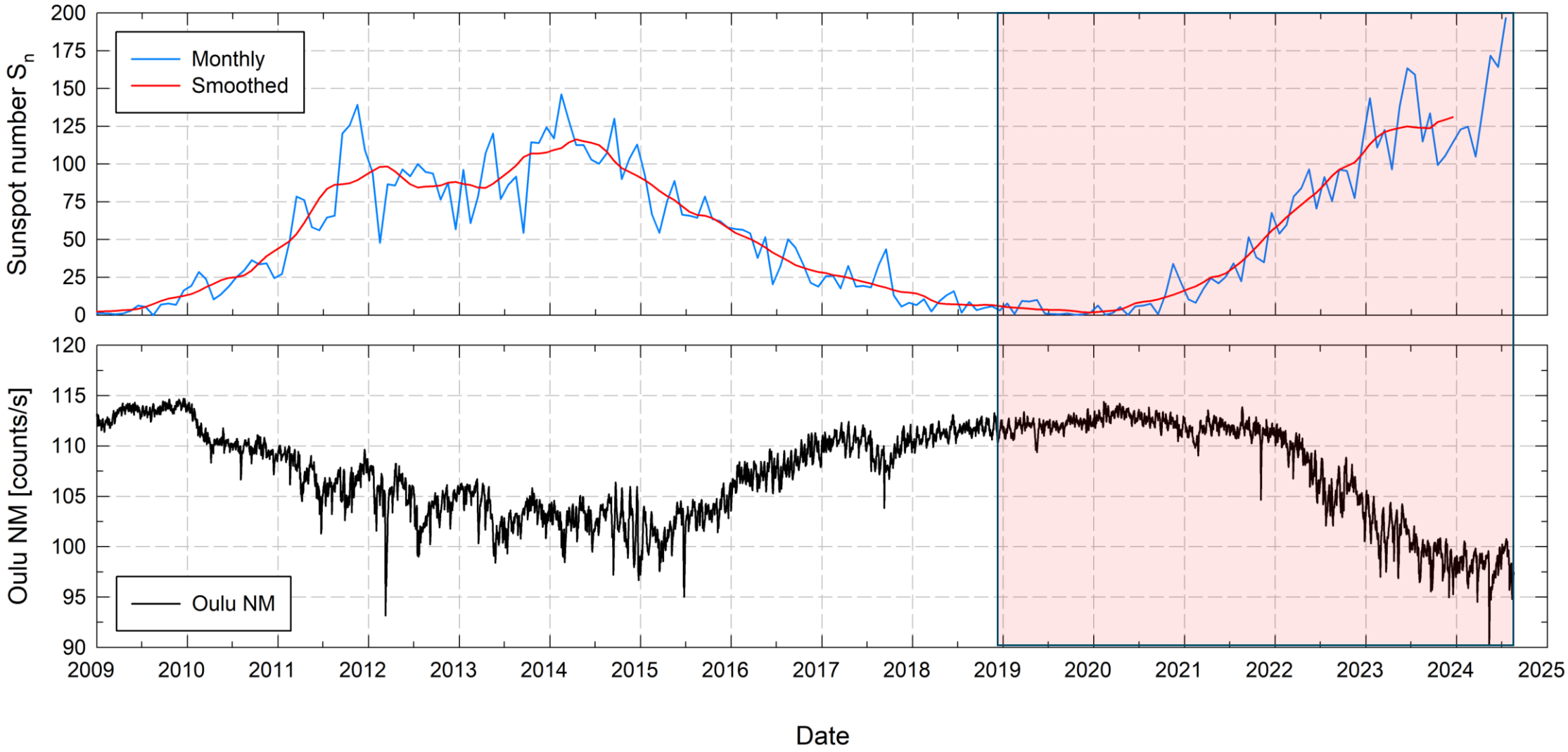
RAMIS: HK / EXT HK (Full mission)



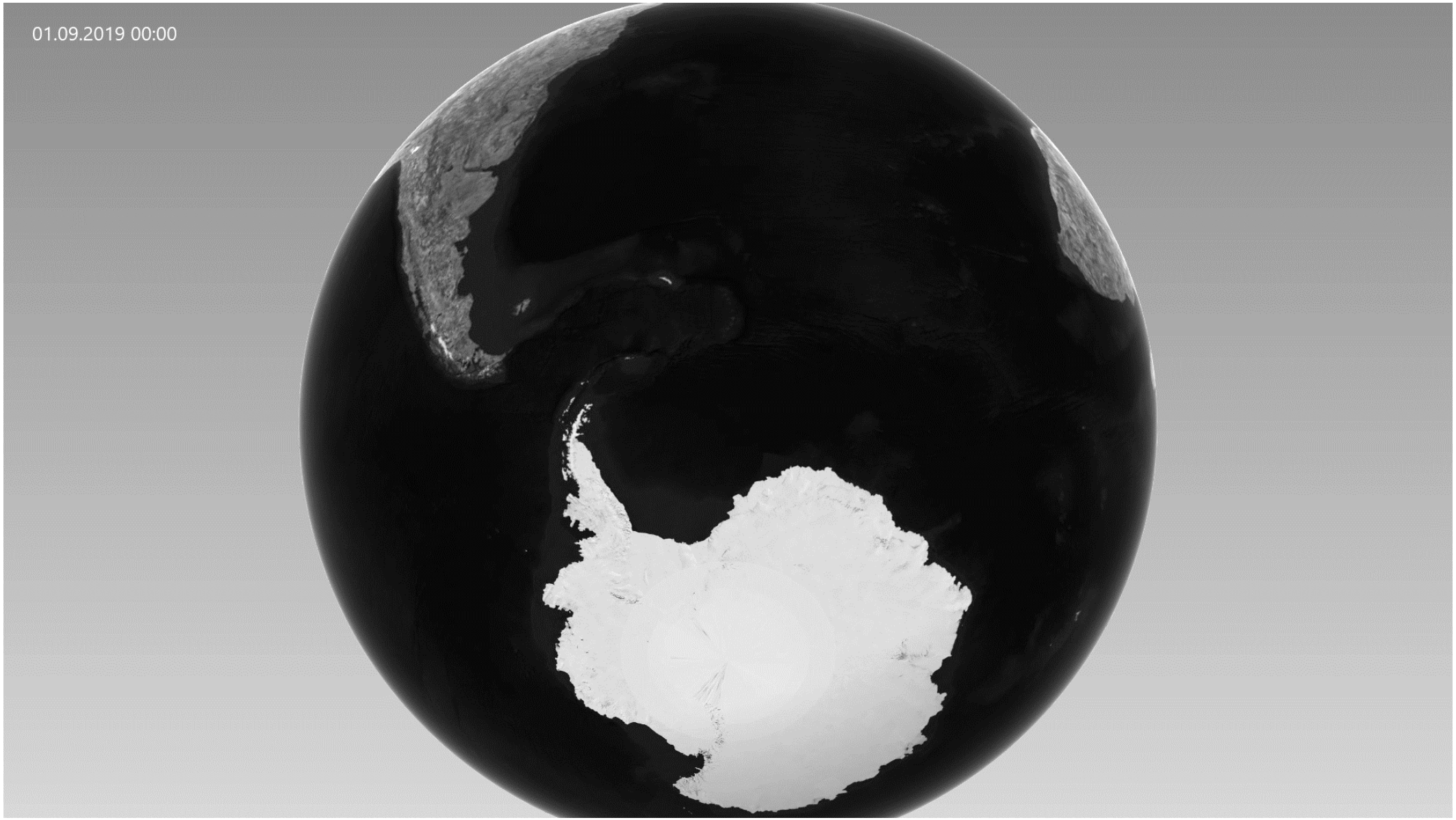
BitFlips

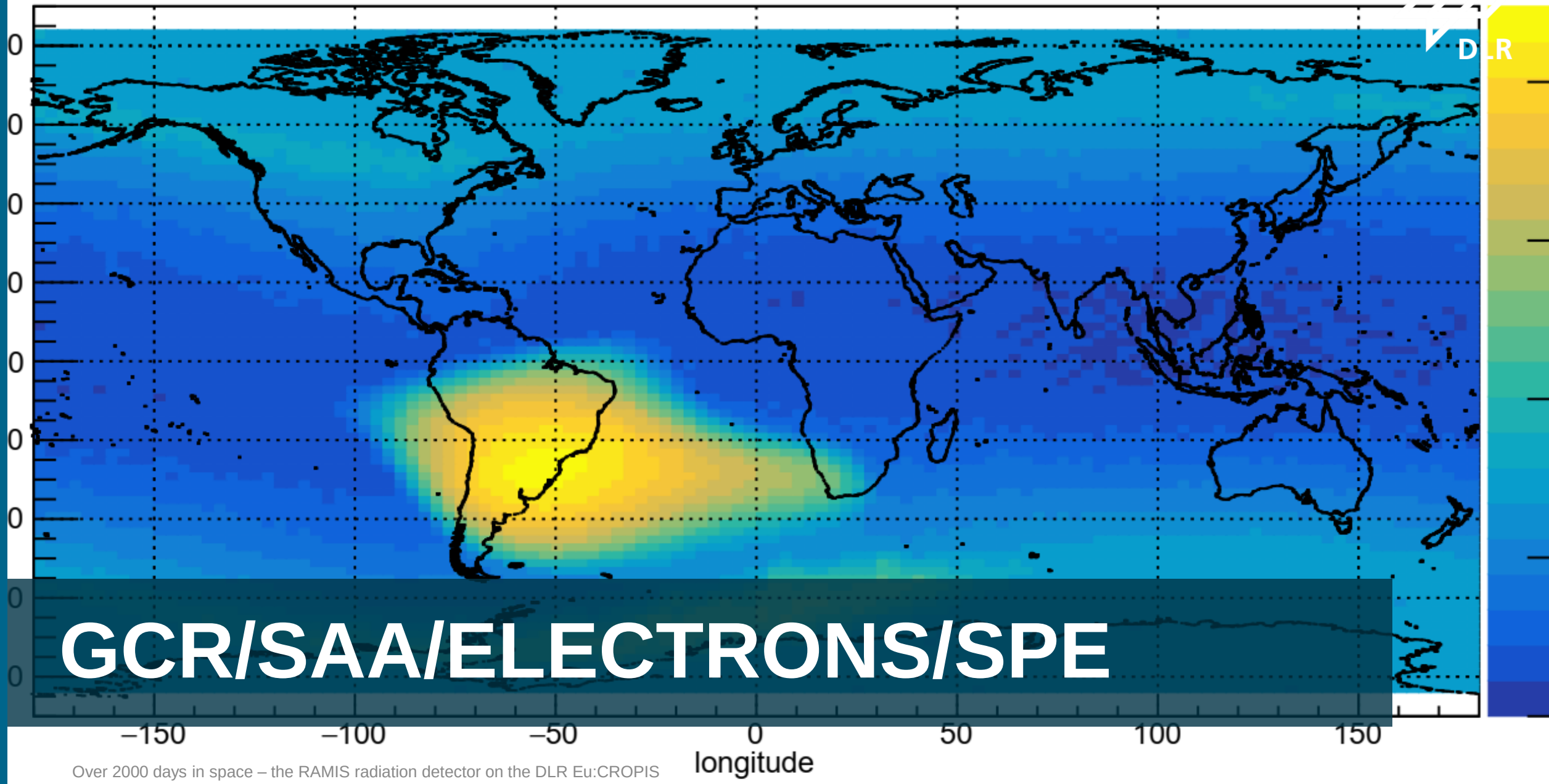
Electrons

RAMIS: Solar Cycle



RAMIS: Extended HK (September 2019)

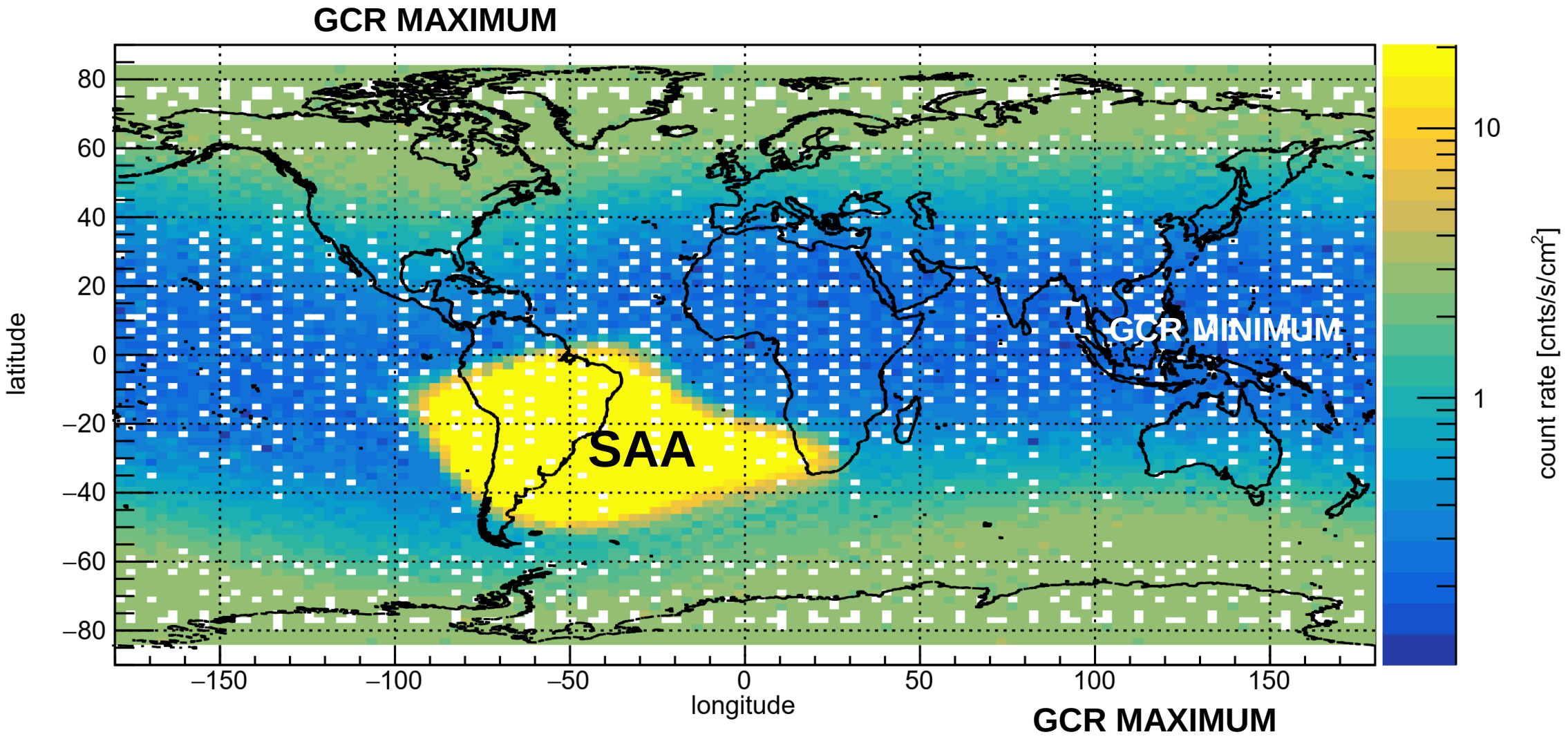




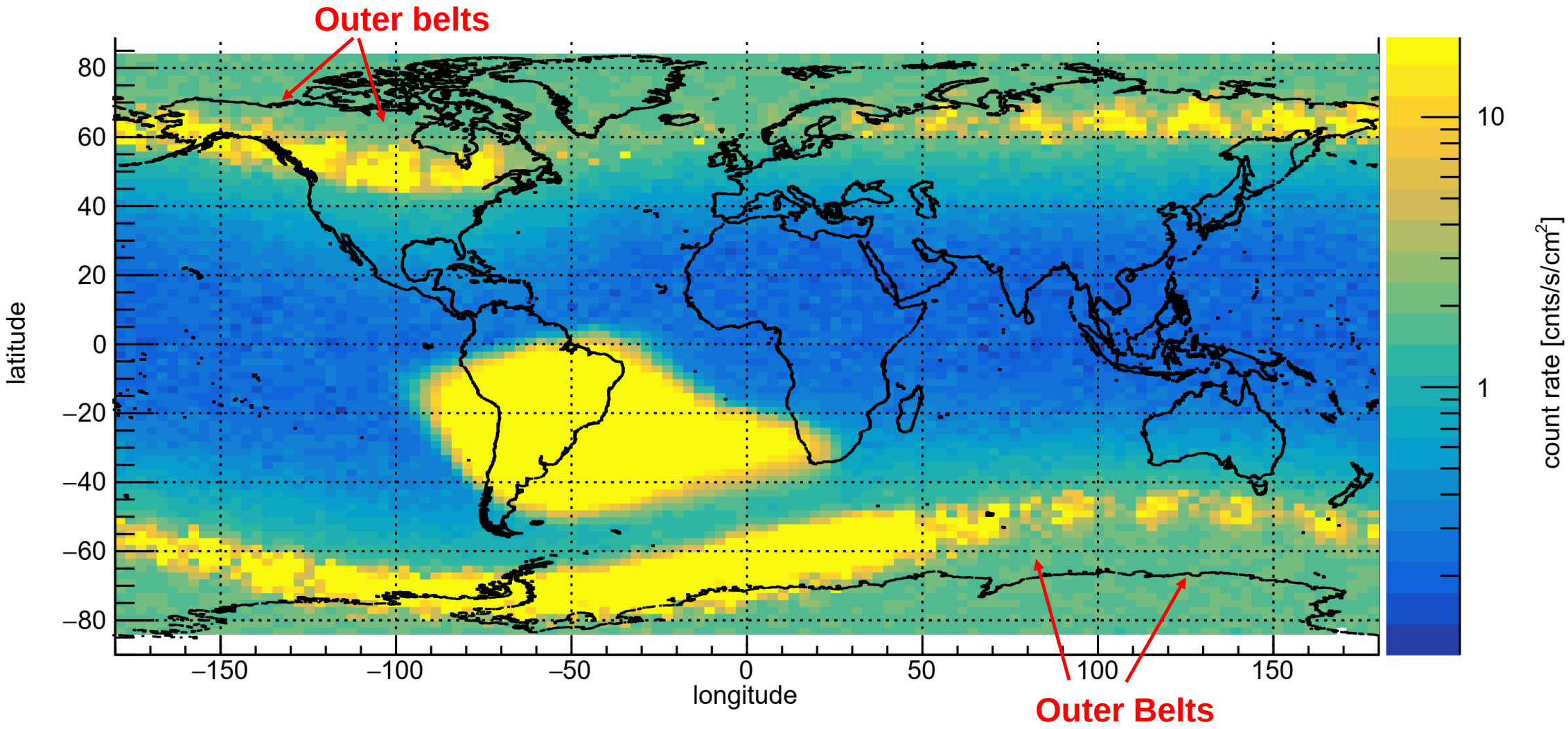
GCR/SAA/ELECTRONS/SPE

RAMIS: Extended HK (June 2020) – GCR/SAA

± 83° Latitude: June 2020

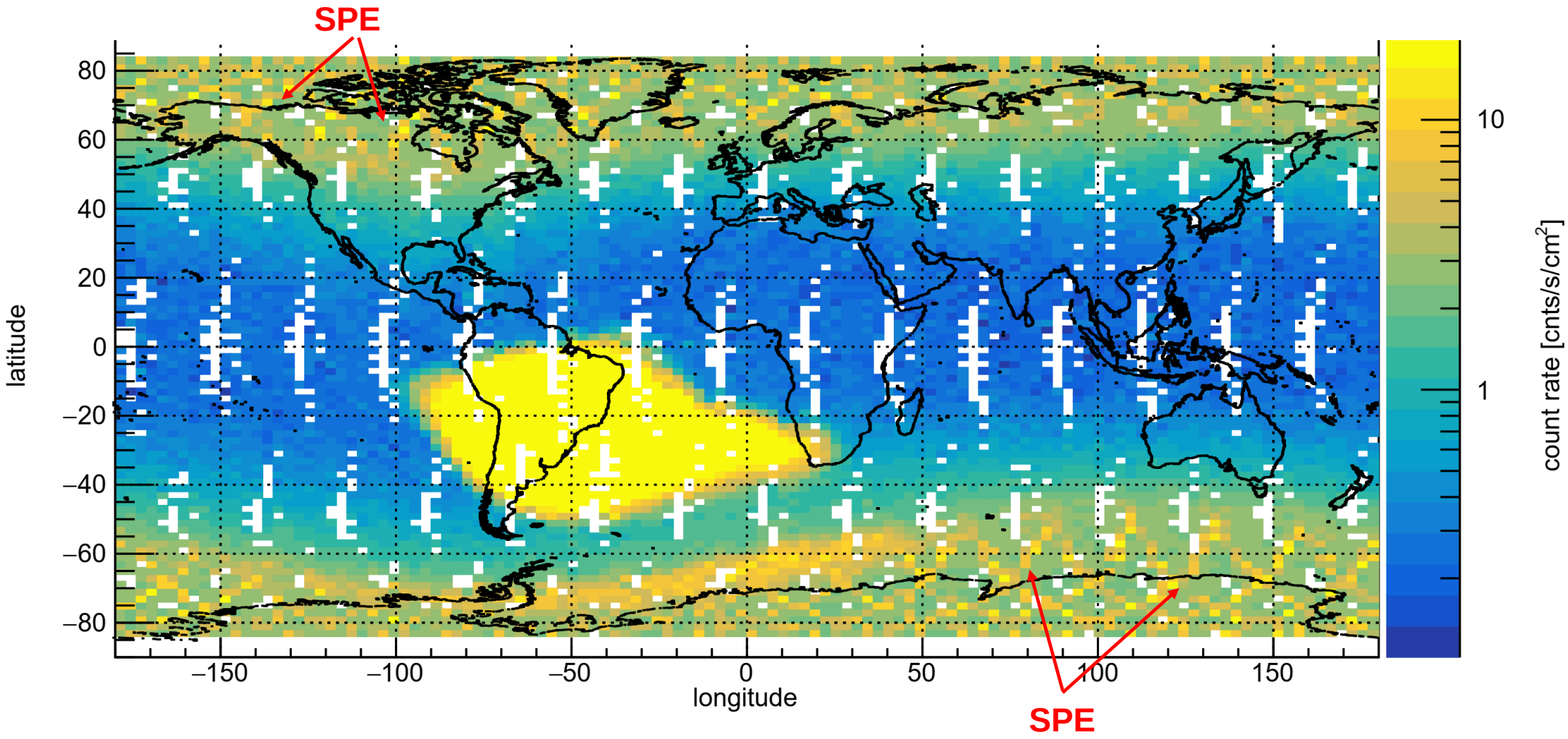


RAMIS: Extended HK (September 2022) – GCR/SAA + Belts
± 83° Latitude: September 2021

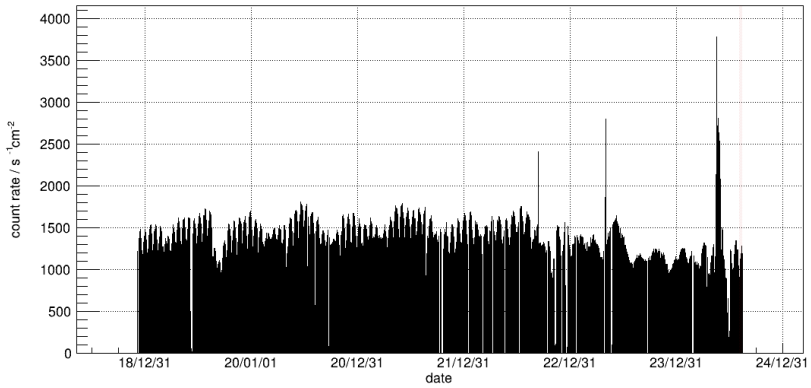


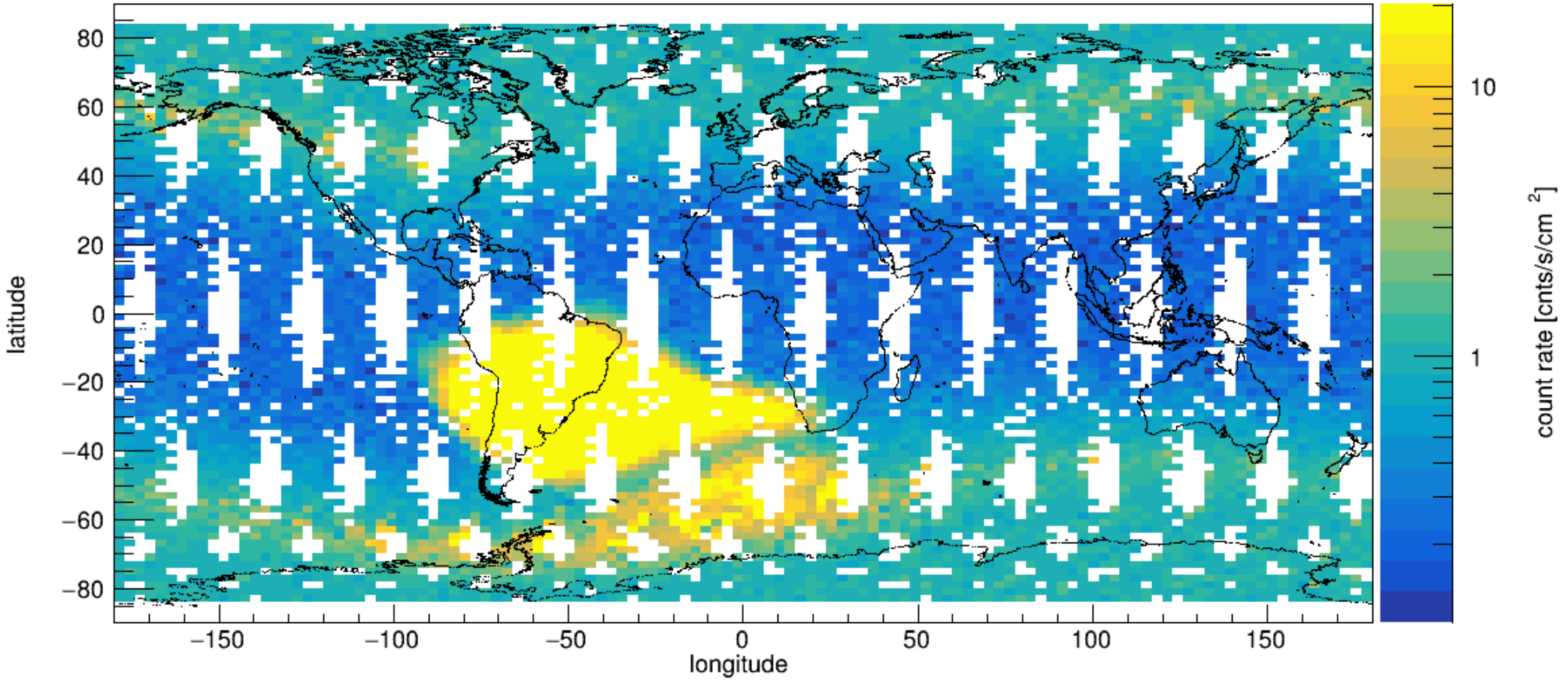
RAMIS: Extended HK (October 2021) – GCR/SAA + SPE

± 83° Latitude: October 2021

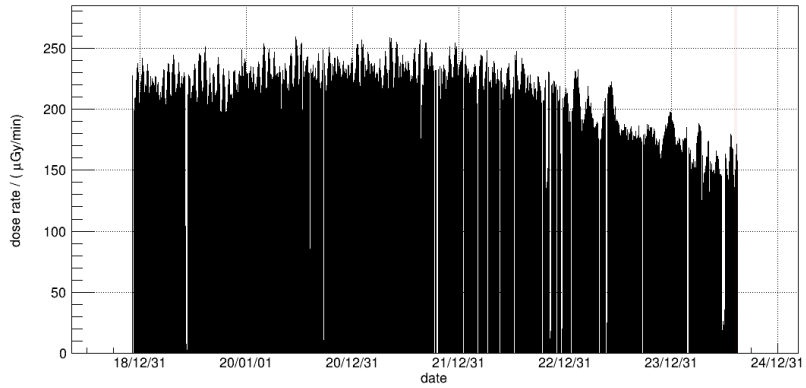


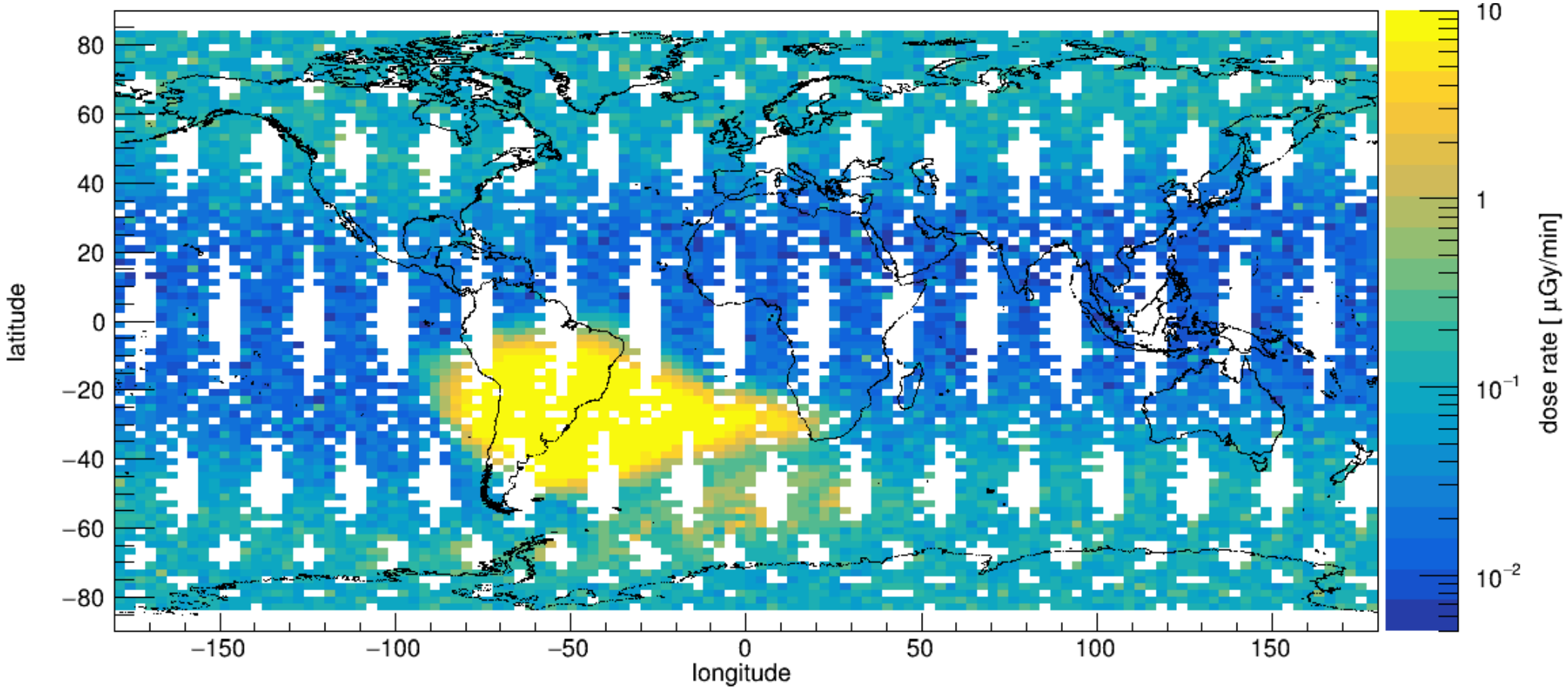
RAMIS: Animated (count rate) till DoM 2082, Aug. 16, 2024

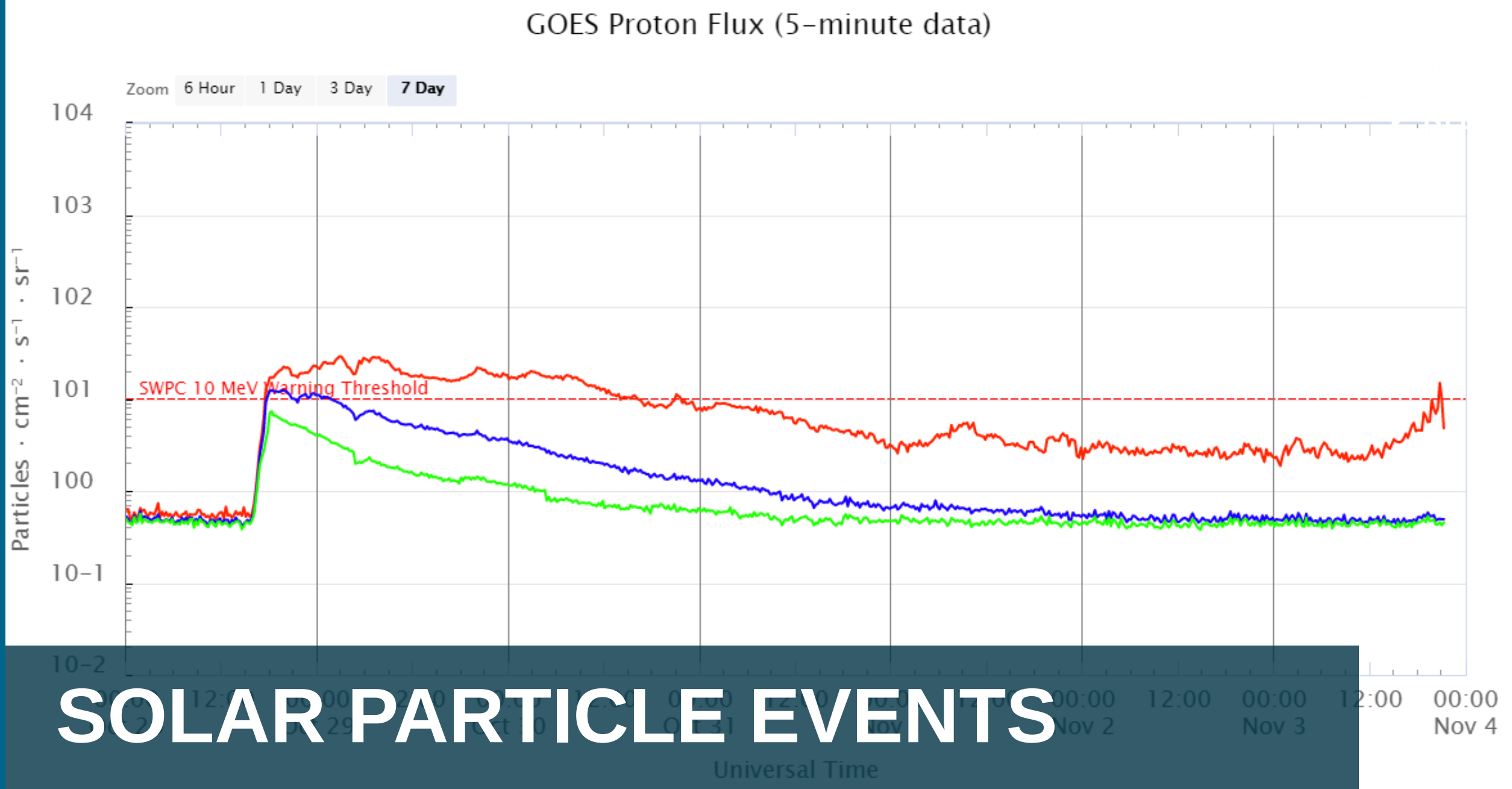




RAMIS: Animated (dose rate)
till DoM 2082, Aug. 16, 2024

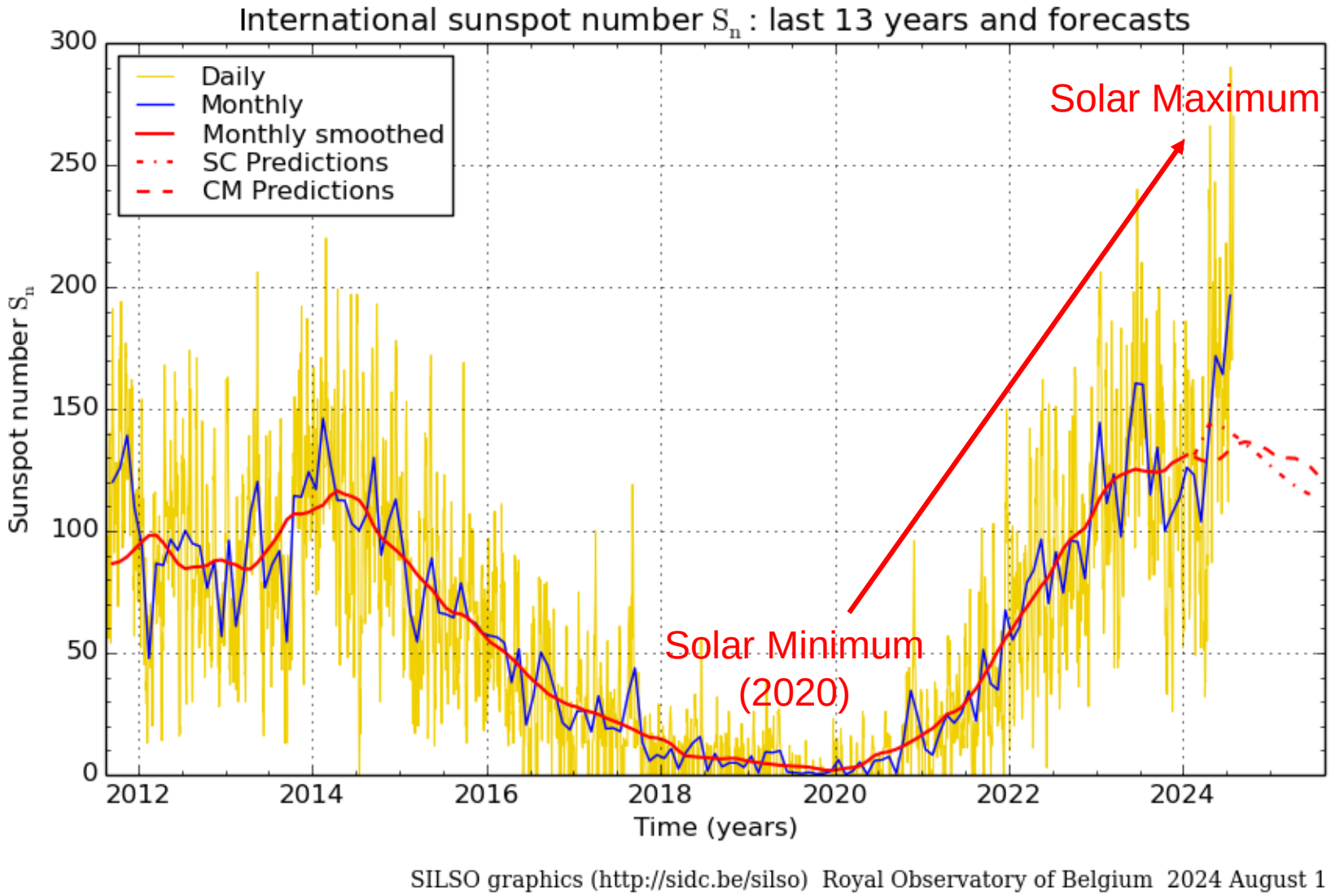




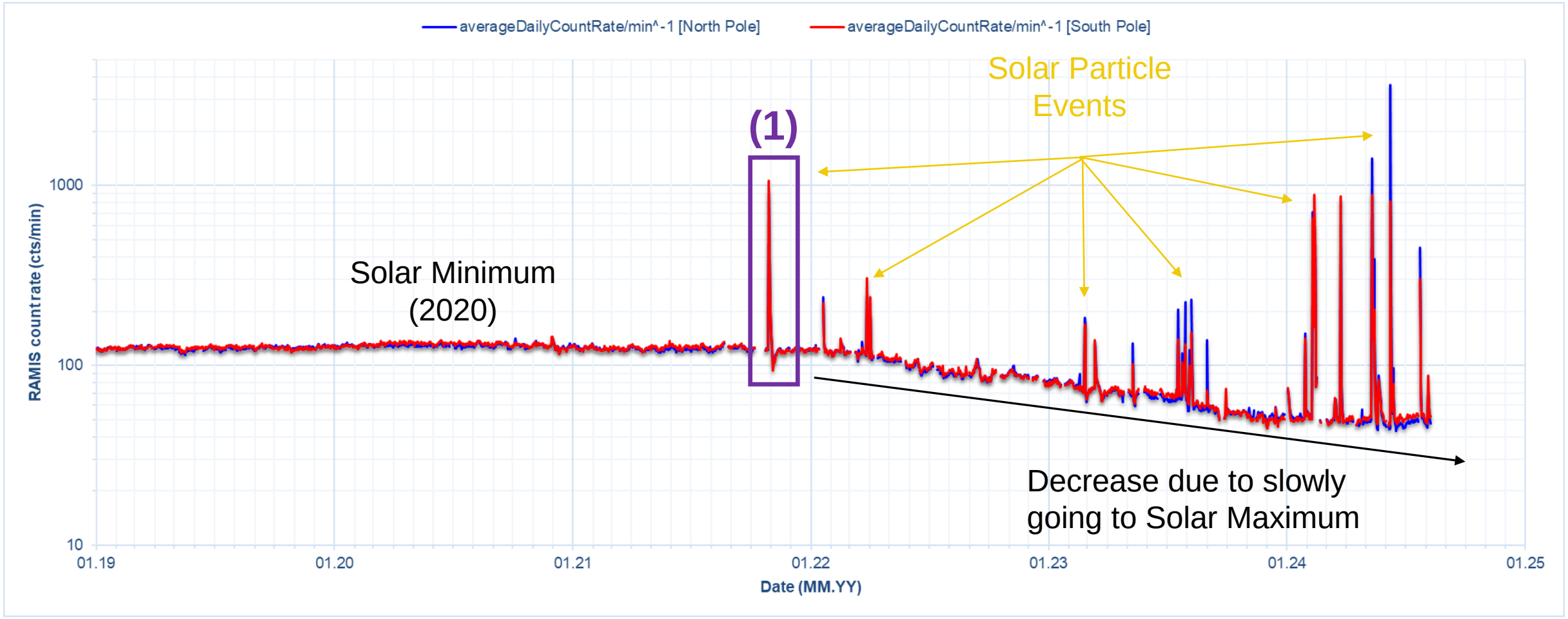


SOLAR PARTICLE EVENTS

RAMIS: Solar Cycle



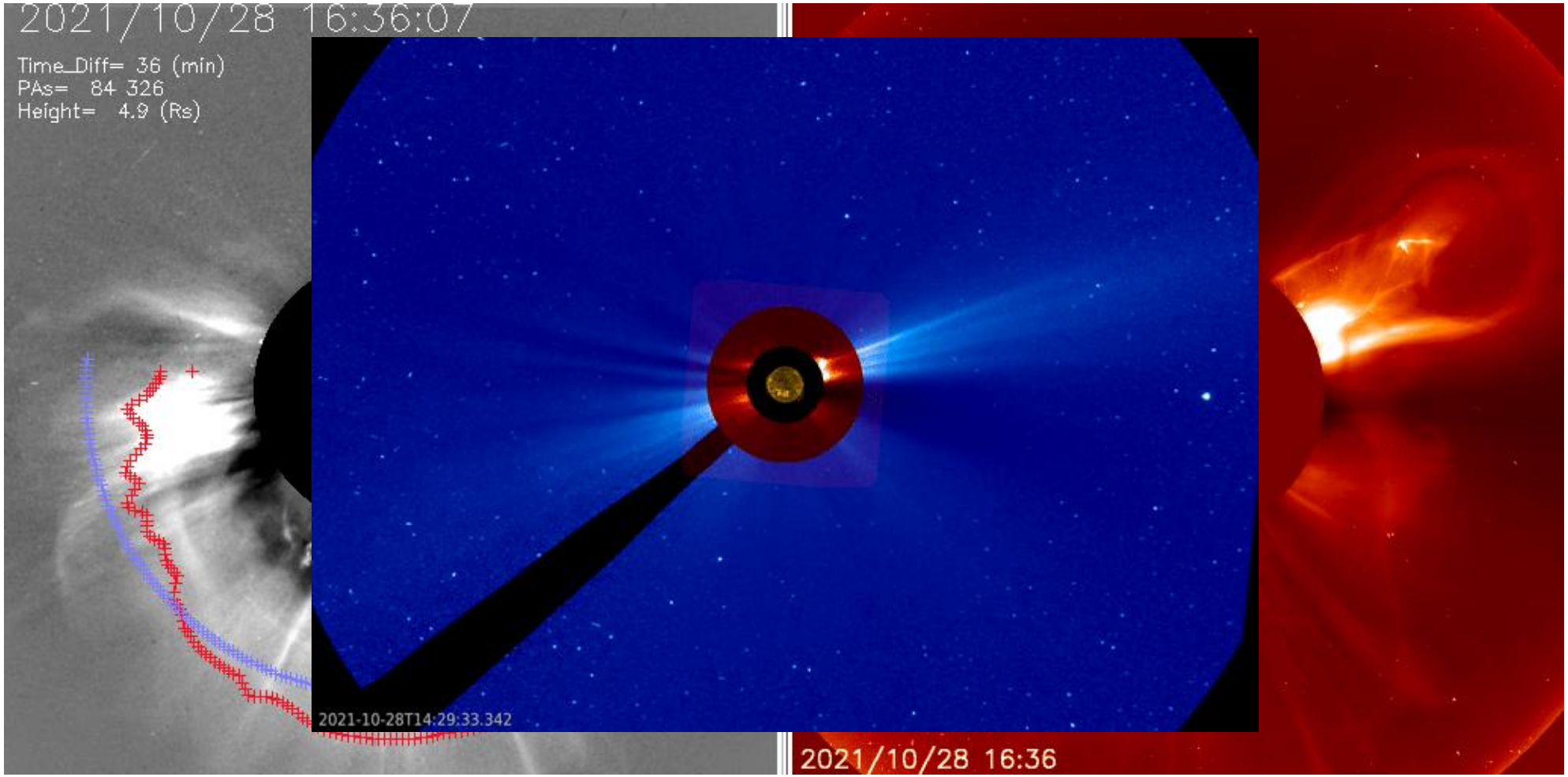
RAMIS: Solar Particle Events



(1)

EVENTS

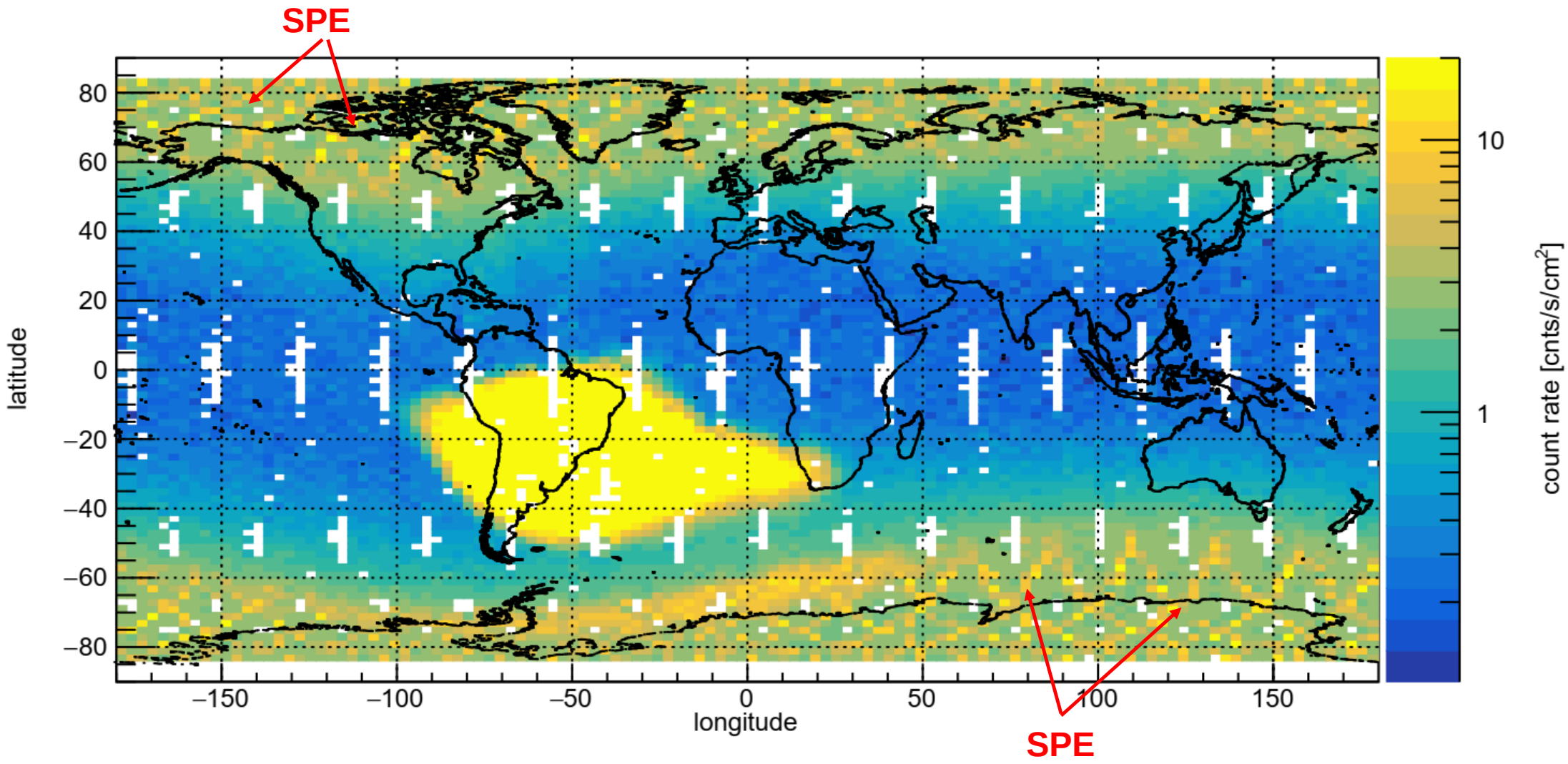
Fast moving, partial halo CME generated by an X1.0 solar flare around AR 2887 on Thursday October 28th. Main trajectory is south of the Sun-Earth line, however a noteworthy impact past Earth is still expected by Saturday, October 30th. Moderate (G2) to Strong (G3) geomagnetic storming in the forecast



https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/ExoMars/Giant_solar_eruption_felt_on_Earth_Moon_and_Mars

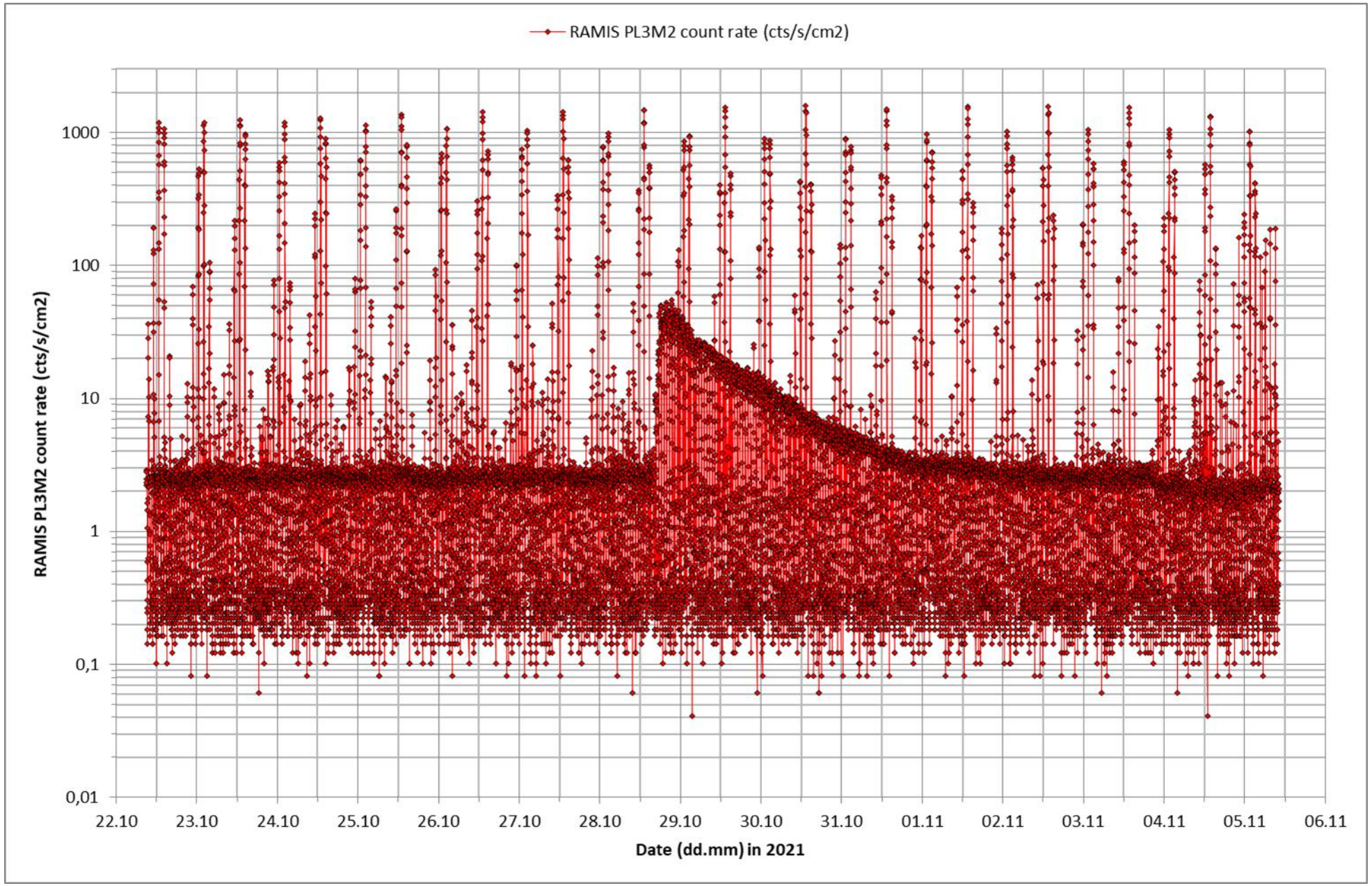
RAMIS count rate (cts/s/cm^2) 01 October – 03 November 2021

(1)



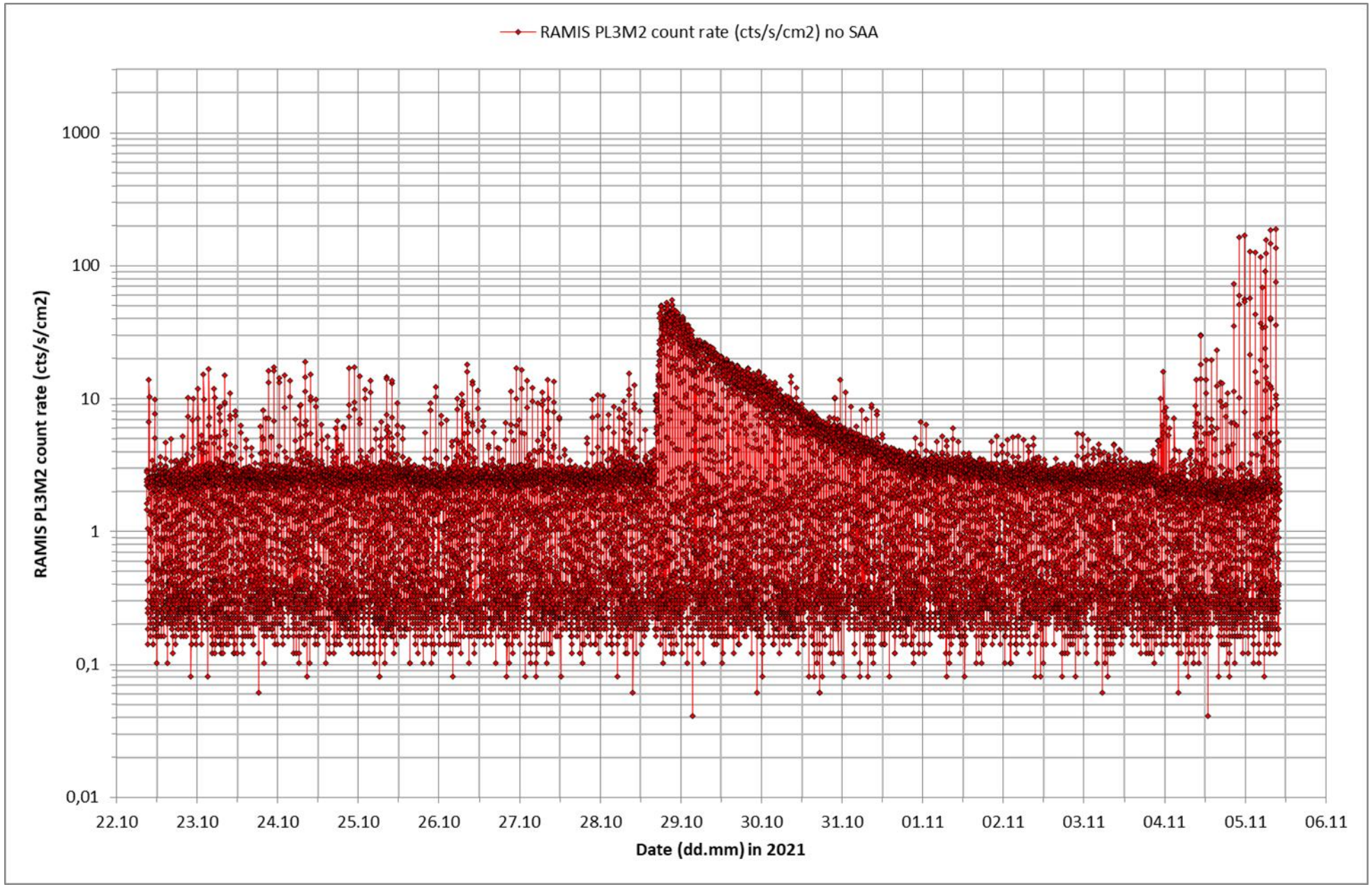
RAMIS count rate (cts/s/cm^2) 22 October – 06 November 2021

(1)



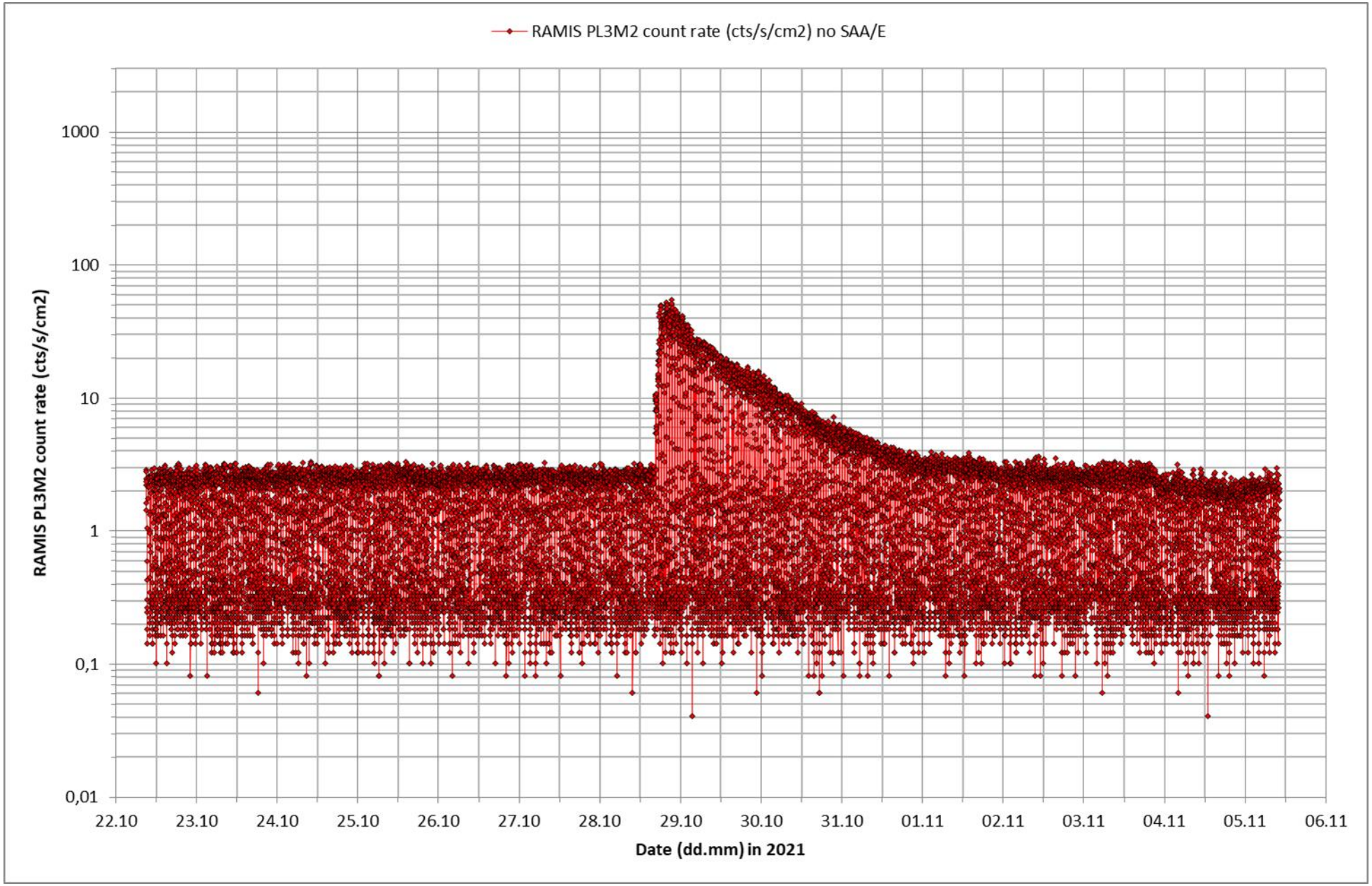
SAA removed

(1)



SAA removed + Electrons from outer belt removed

(1)

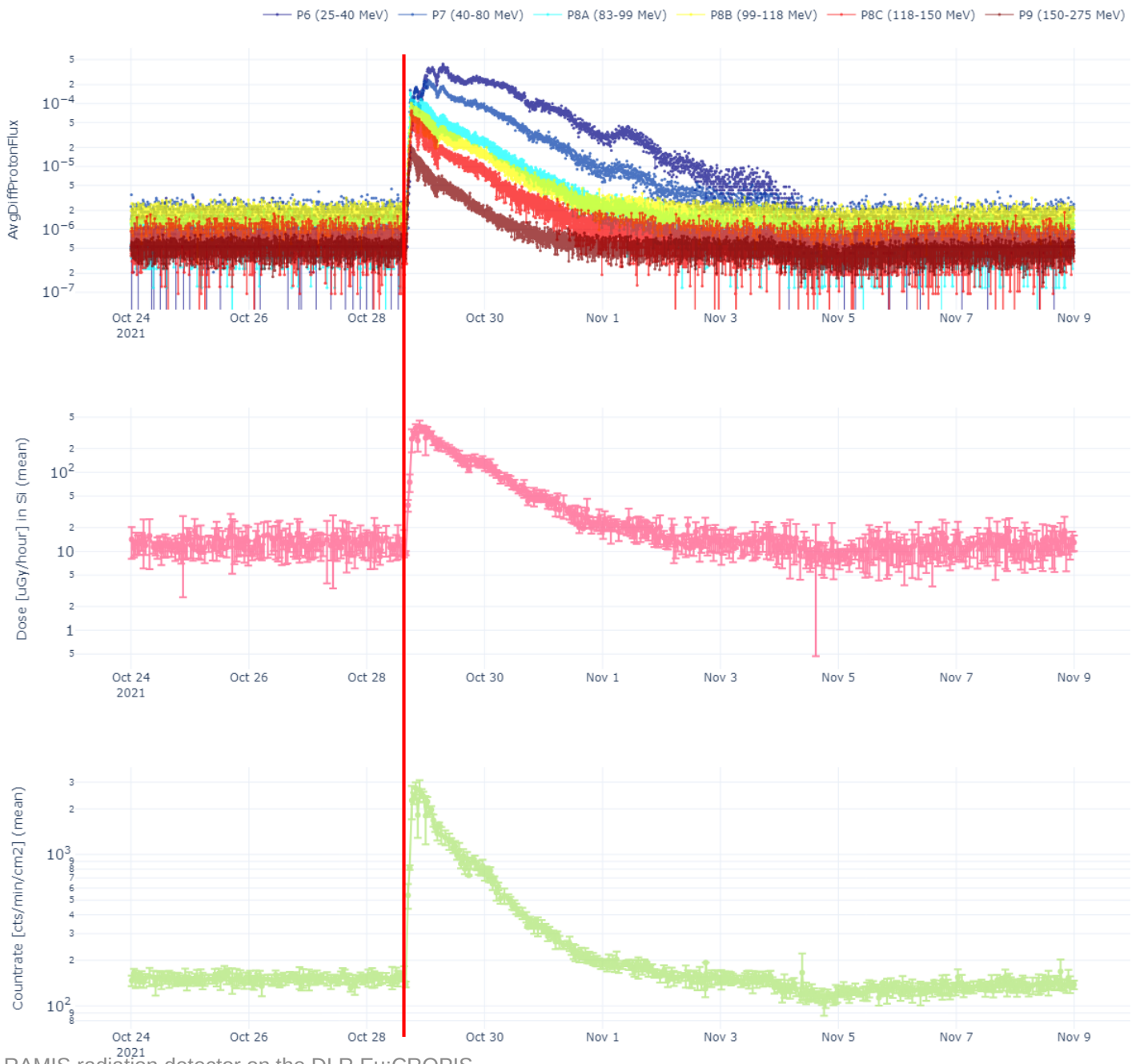


(1)

GOES

RAMIS Dose rate

RAMIS Count rate



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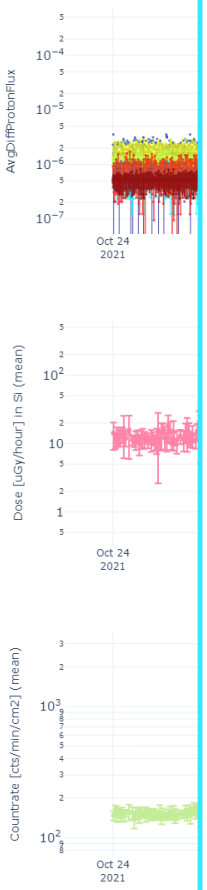
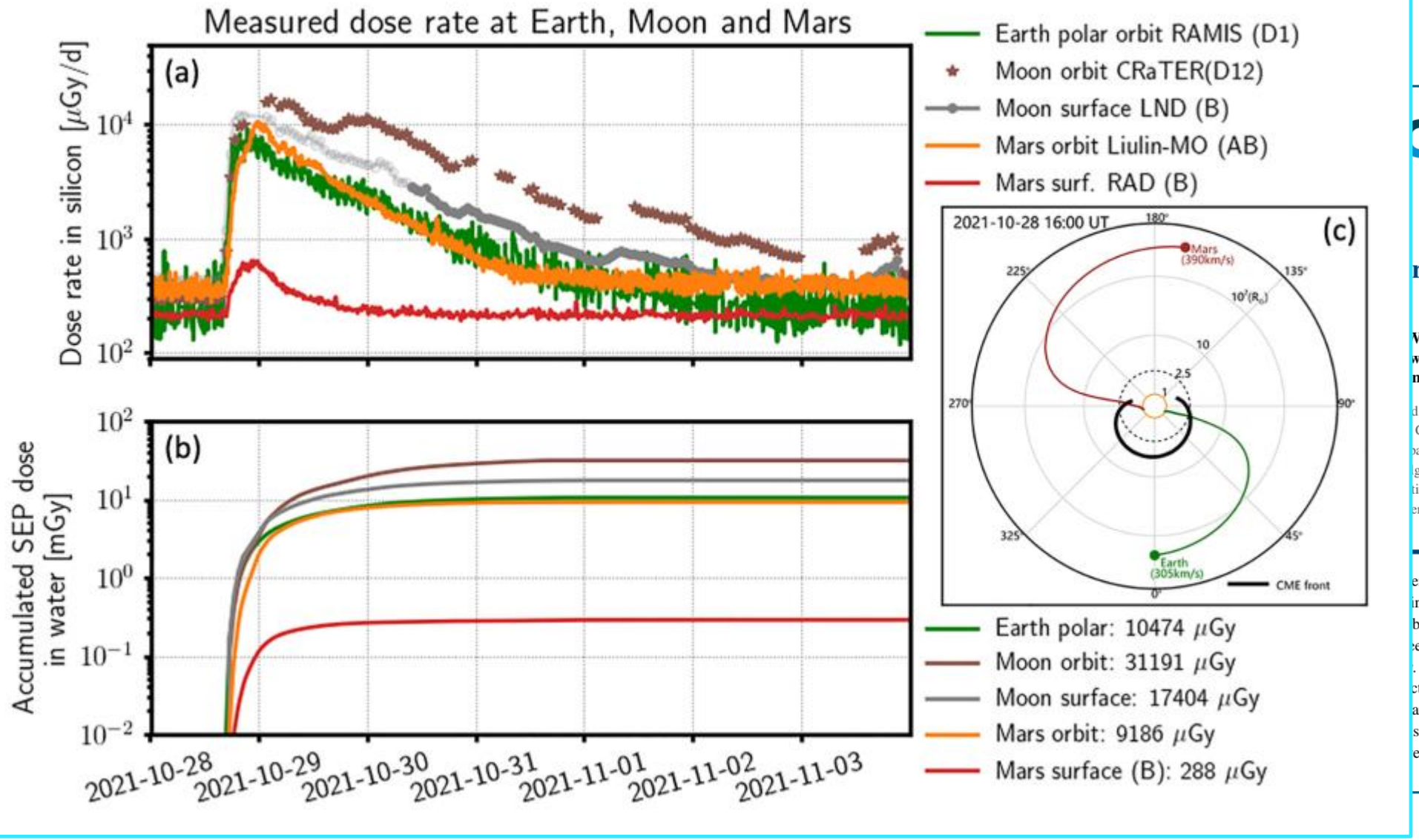
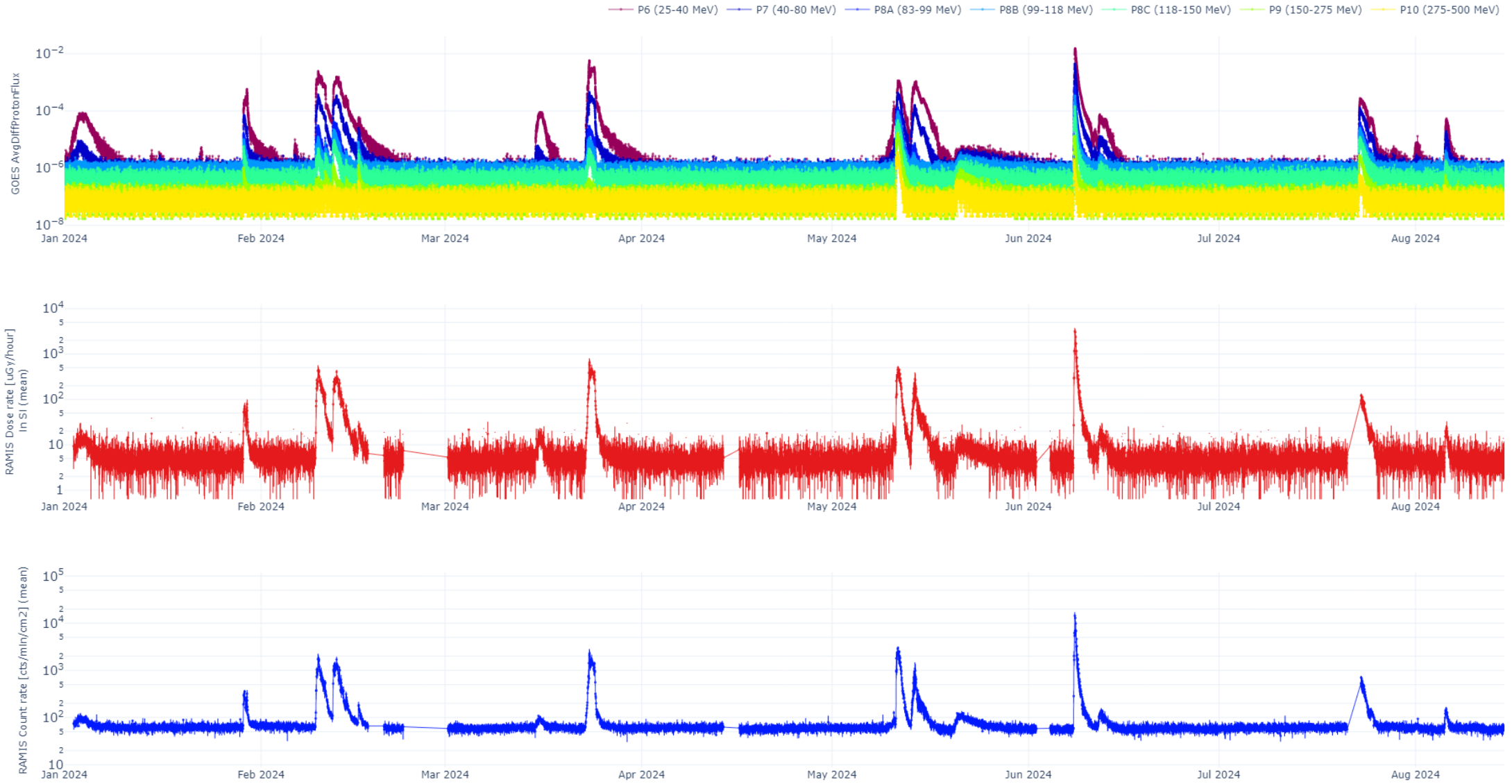




https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/ExoMars/Giant_solar_eruption_felt_on_Earth_Moon_and_Mars

RAMIS: L >= 8: 2024

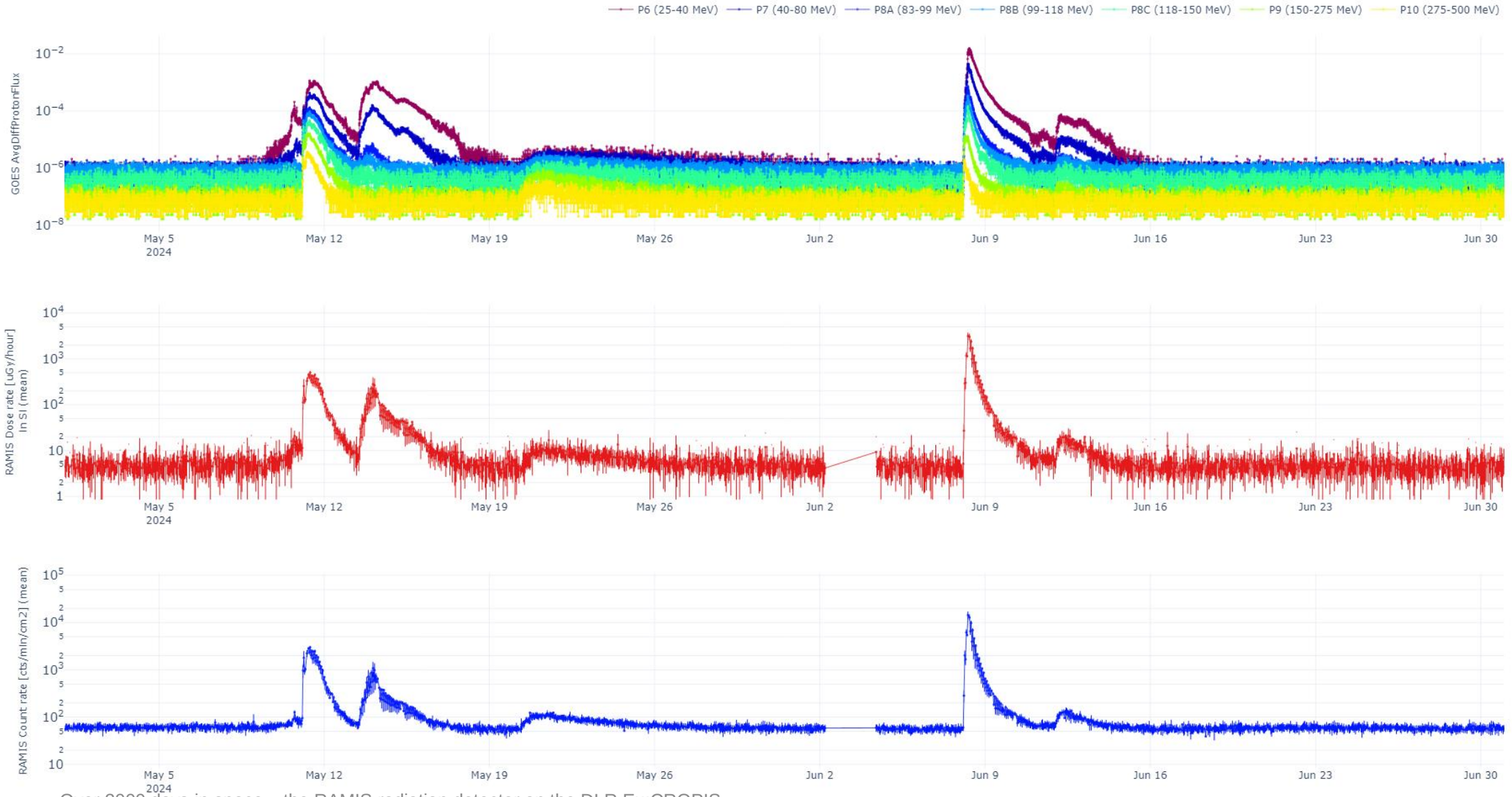
GOES / Count rate / Dose rate (averaged)



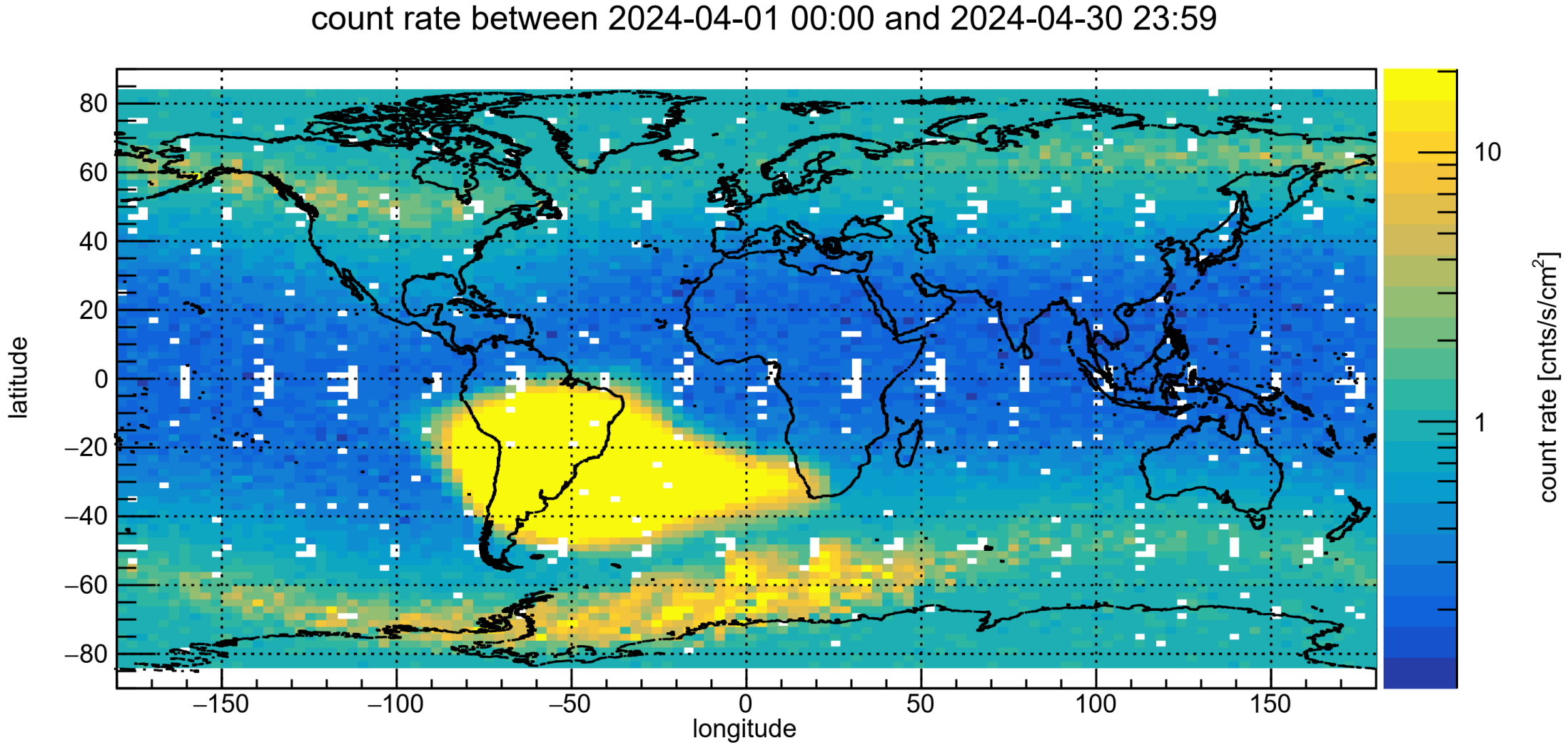
Over 2000 days in space – the RAMIS radiation detector on the DLR Eu:CROPIS mission / WRMISS 2024-09-03

RAMIS: L >= 8: 2024: May/June

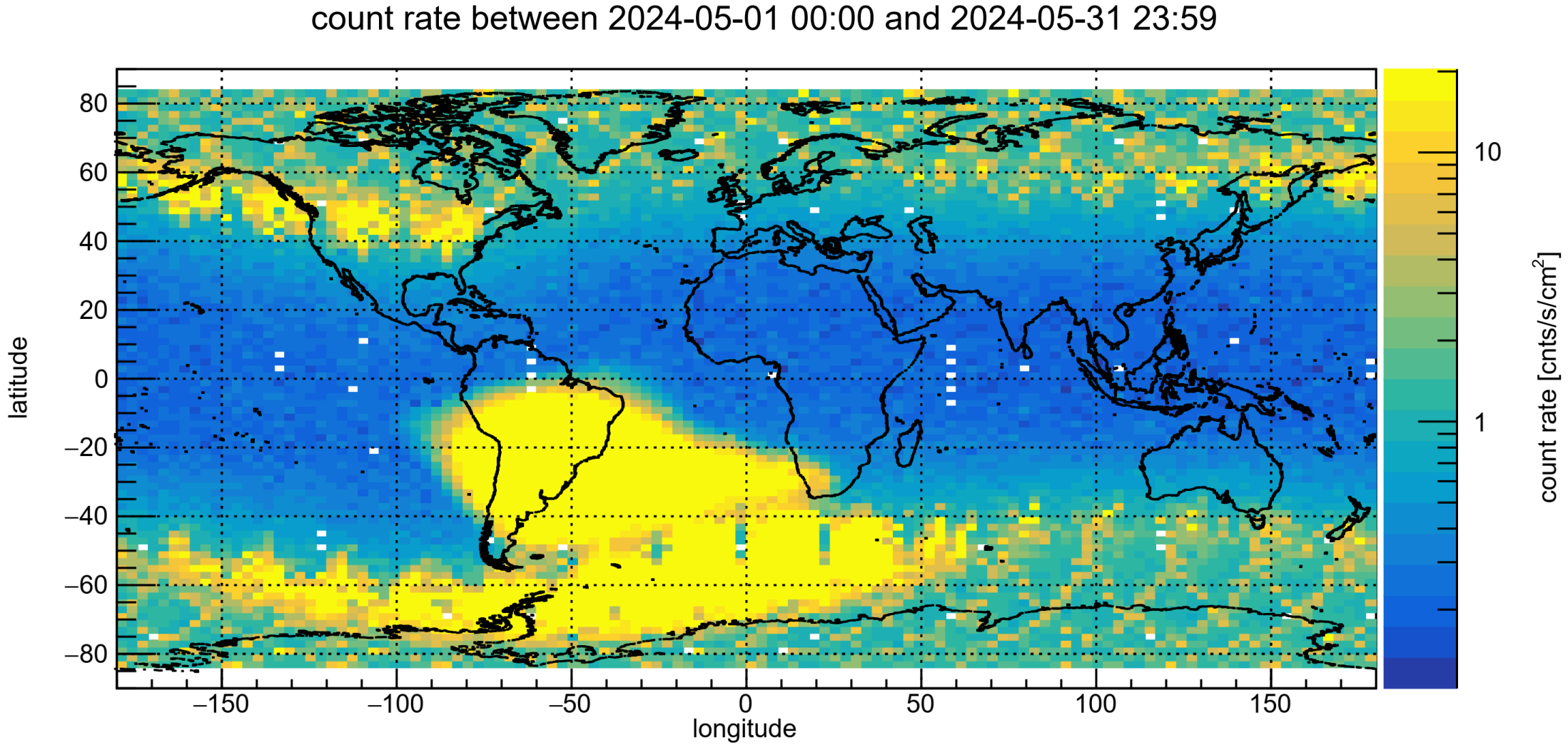
GOES / Count rate / Dose rate (averaged)



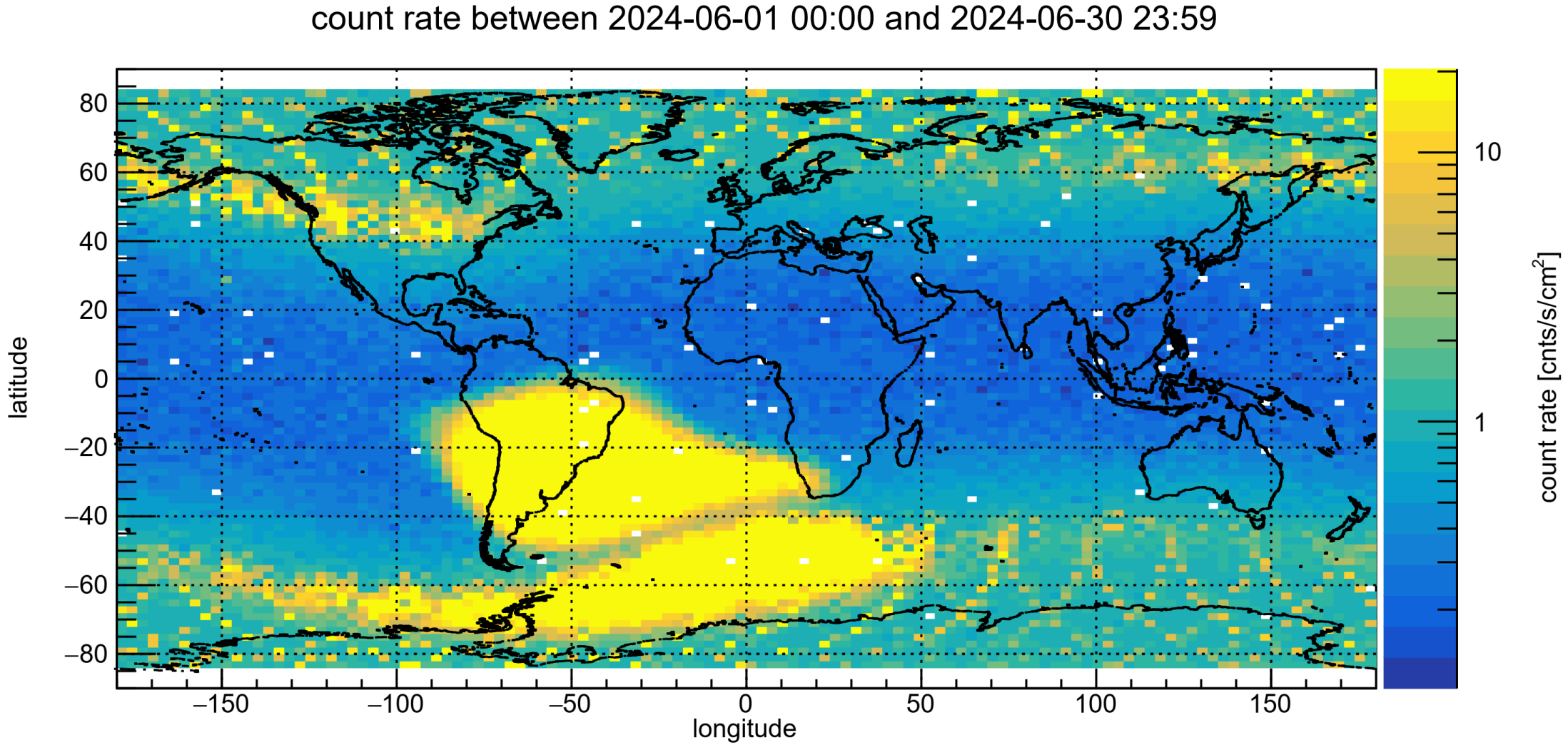
RAMIS: Monthly (count rate): April 2024



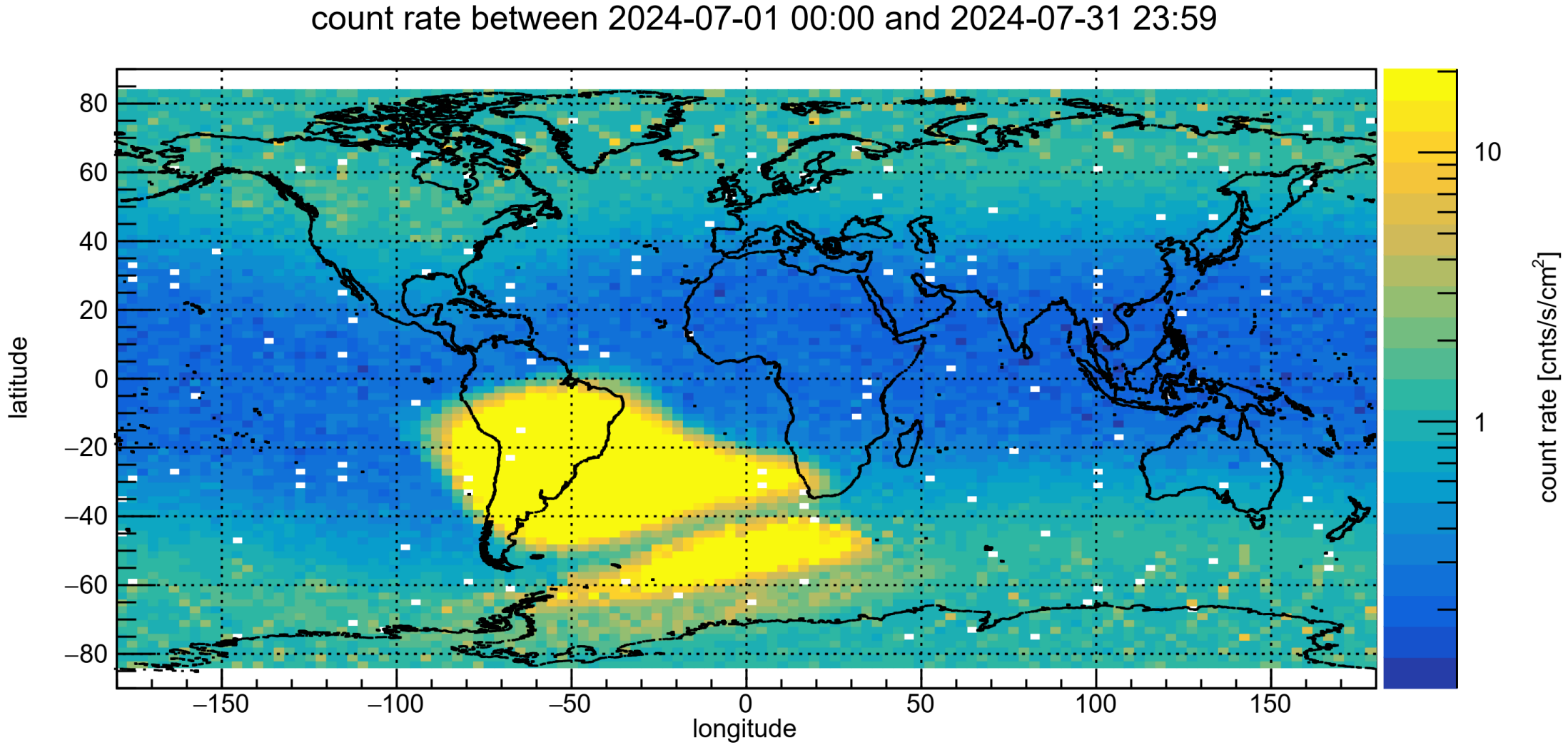
RAMIS: Monthly (count rate): May 2024



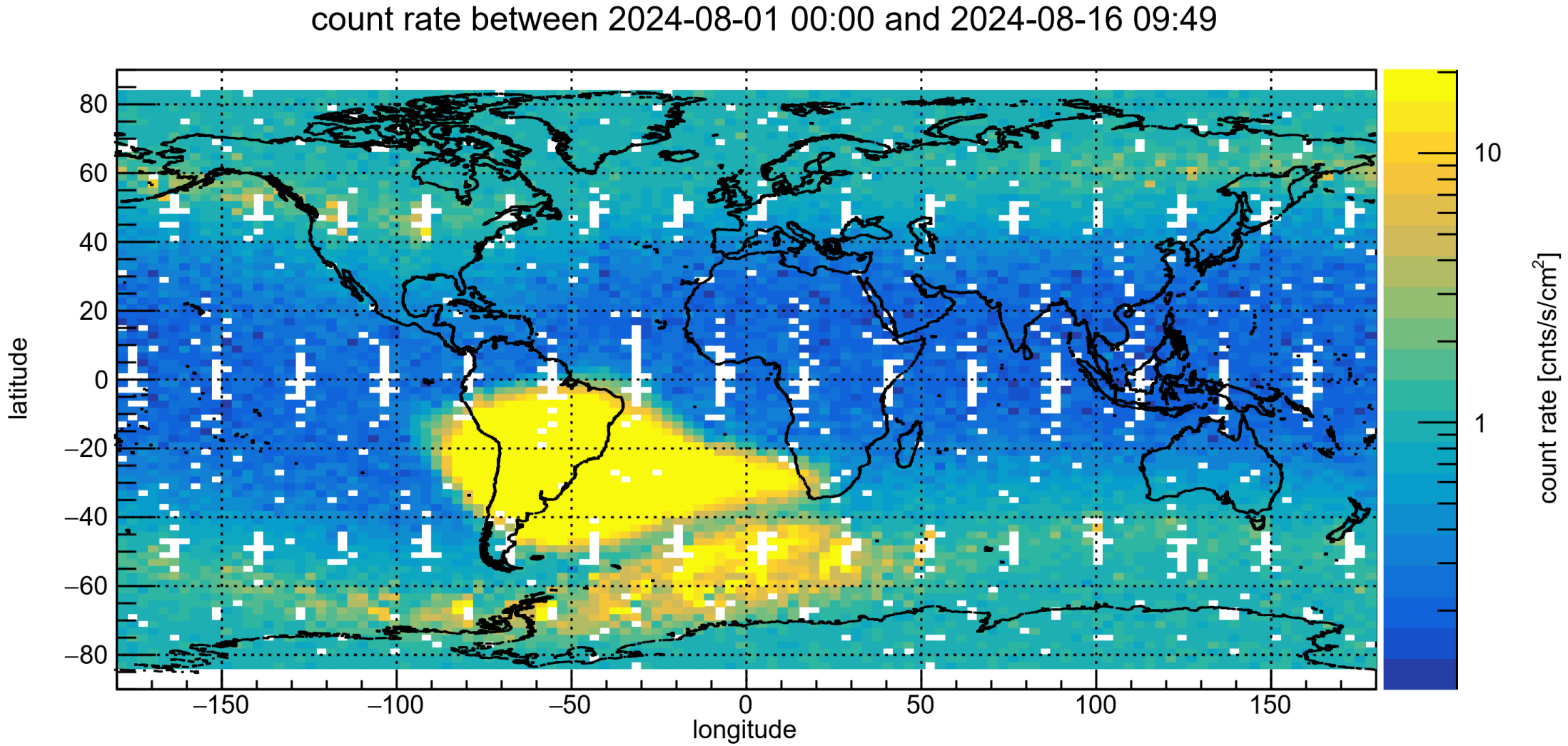
RAMIS: Monthly (count rate): June 2024



RAMIS: Monthly (count rate): July 2024



RAMIS: Monthly (count rate): August 2024



RAMIS: ”Third“ van Allen belt (slot region) after SPE 05/2024

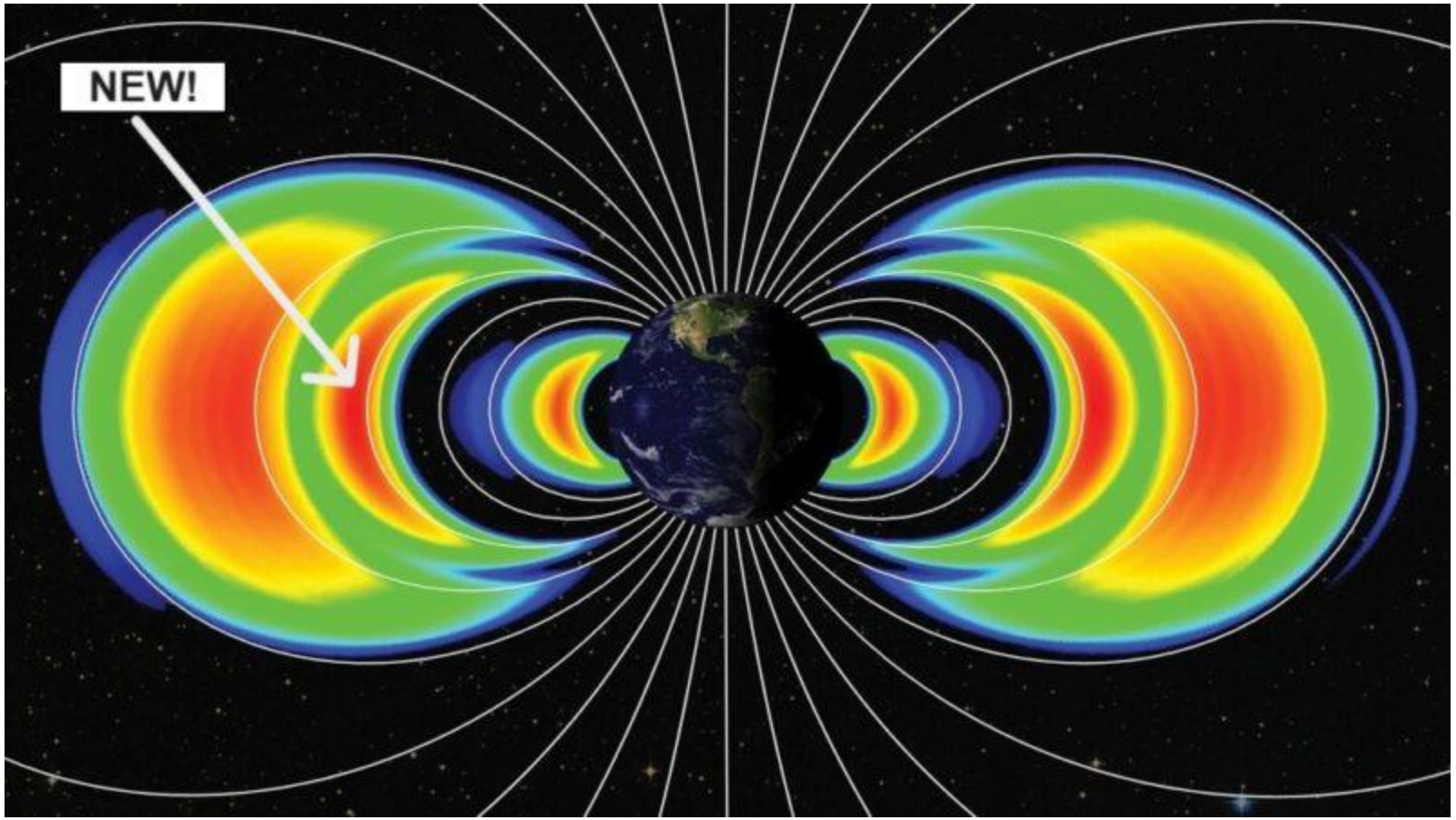
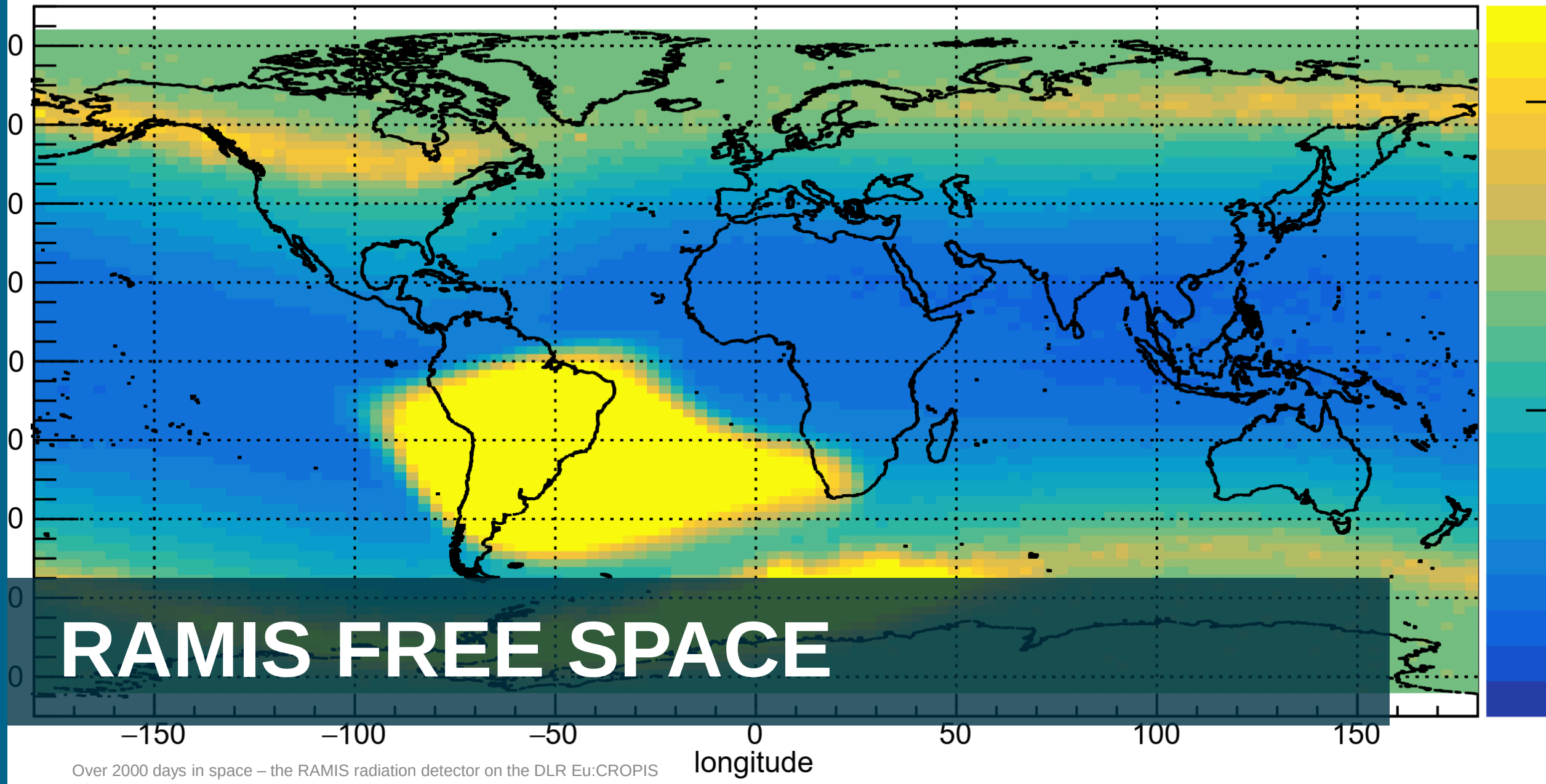


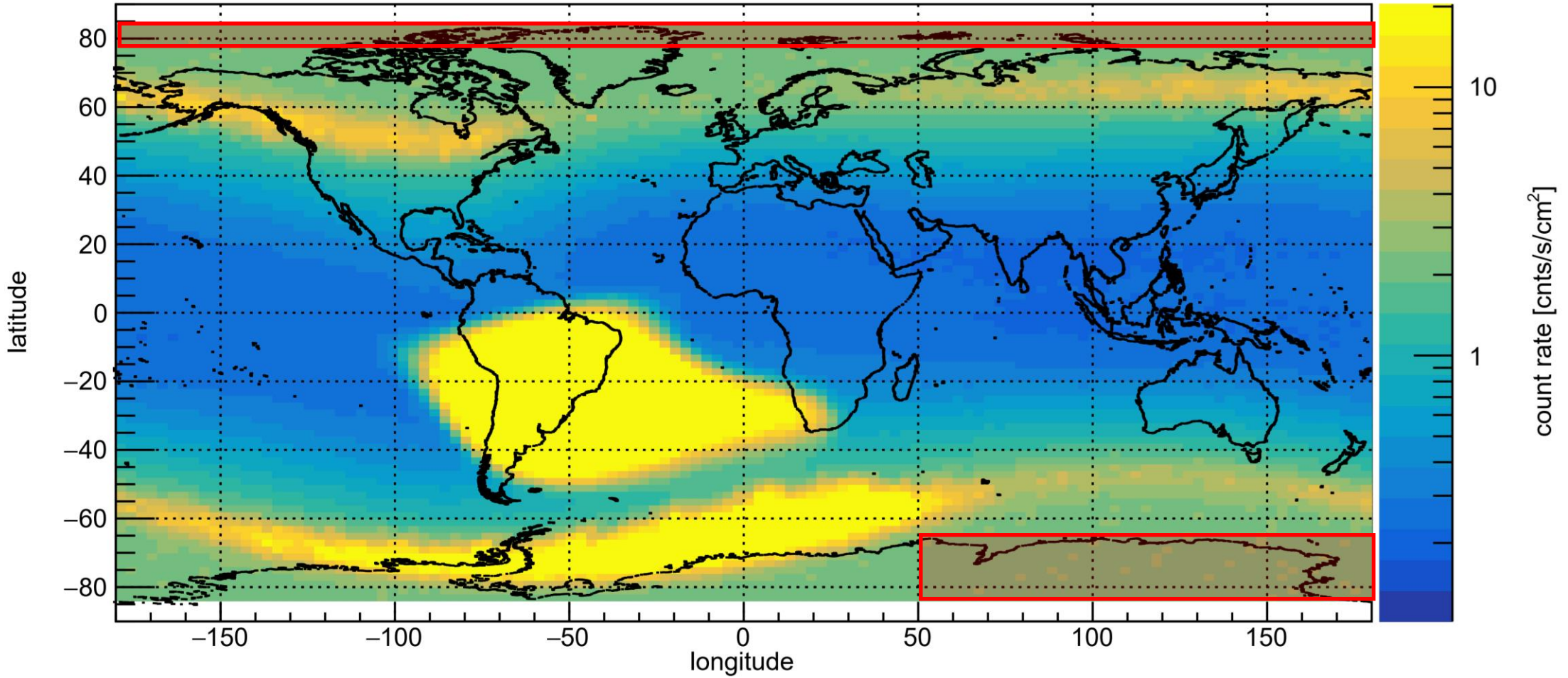
Image NASA



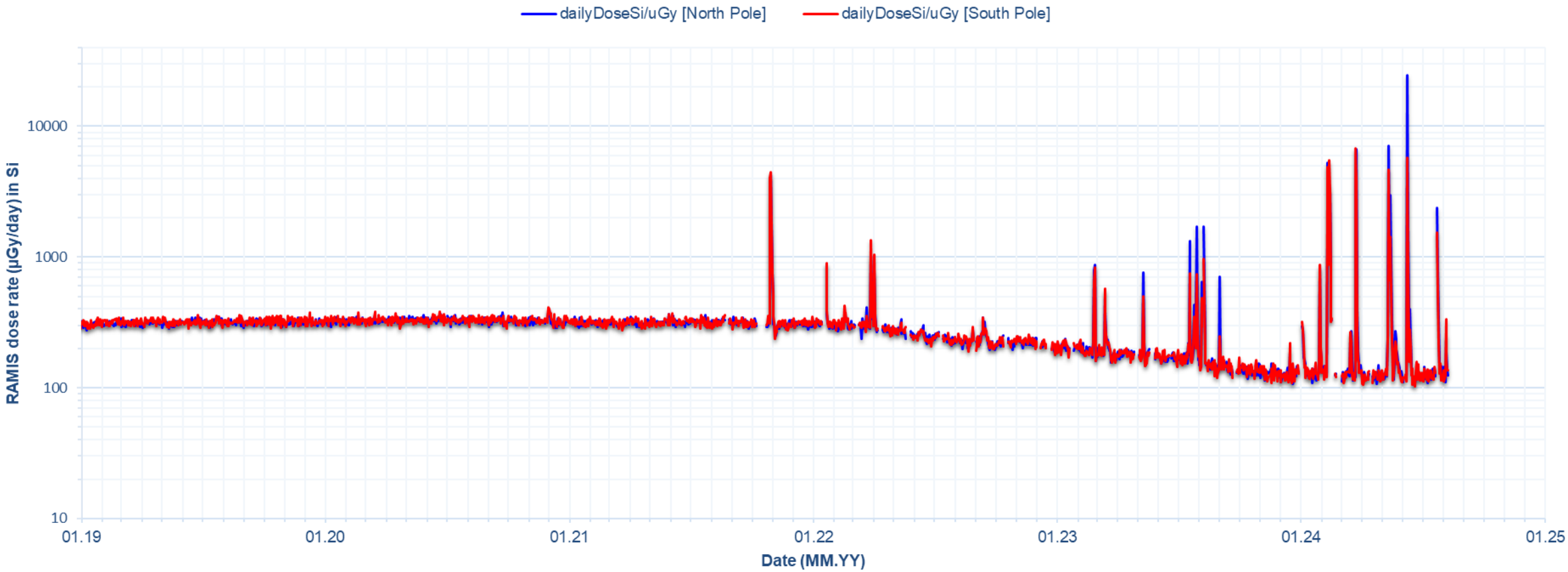
RAMIS FREE SPACE

Over 2000 days in space – the RAMIS radiation detector on the DLR Eu:CROPIS mission / WRMISS 2024-09-03

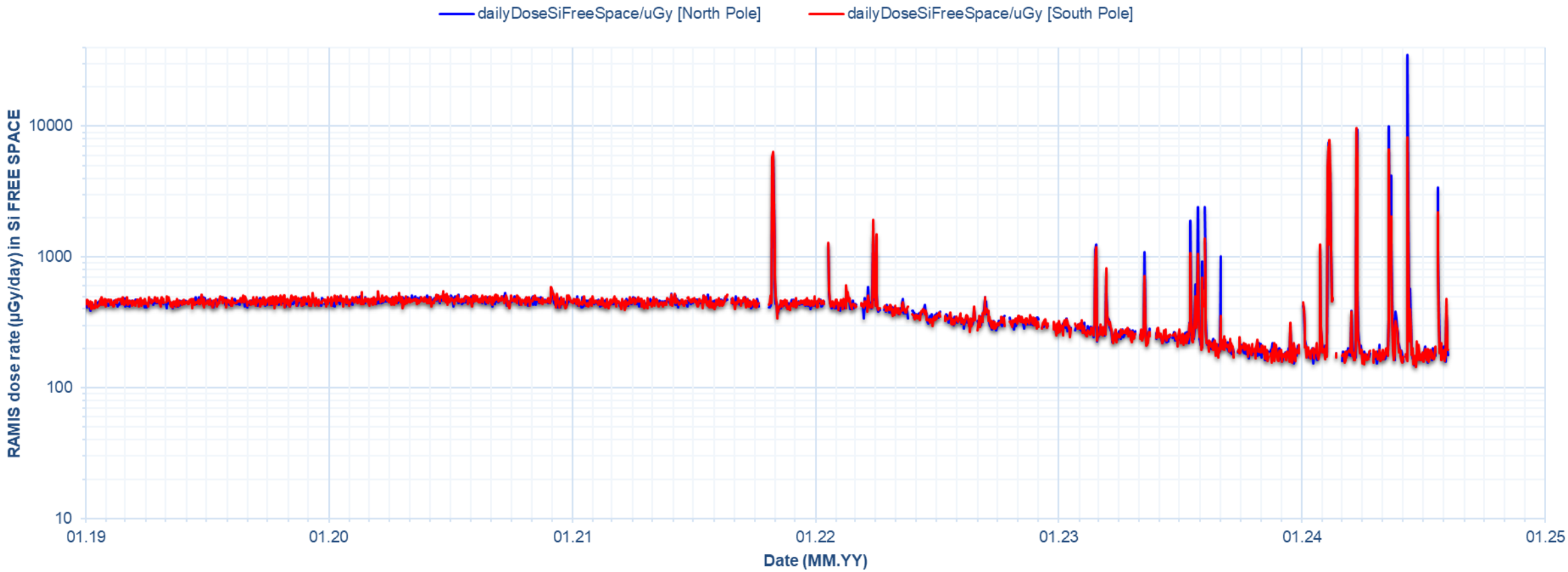
RAMIS: Free Space
North/South Pole Cut



RAMIS: Free Space: RAMIS North/South Pole
dose rate (µGy/day)

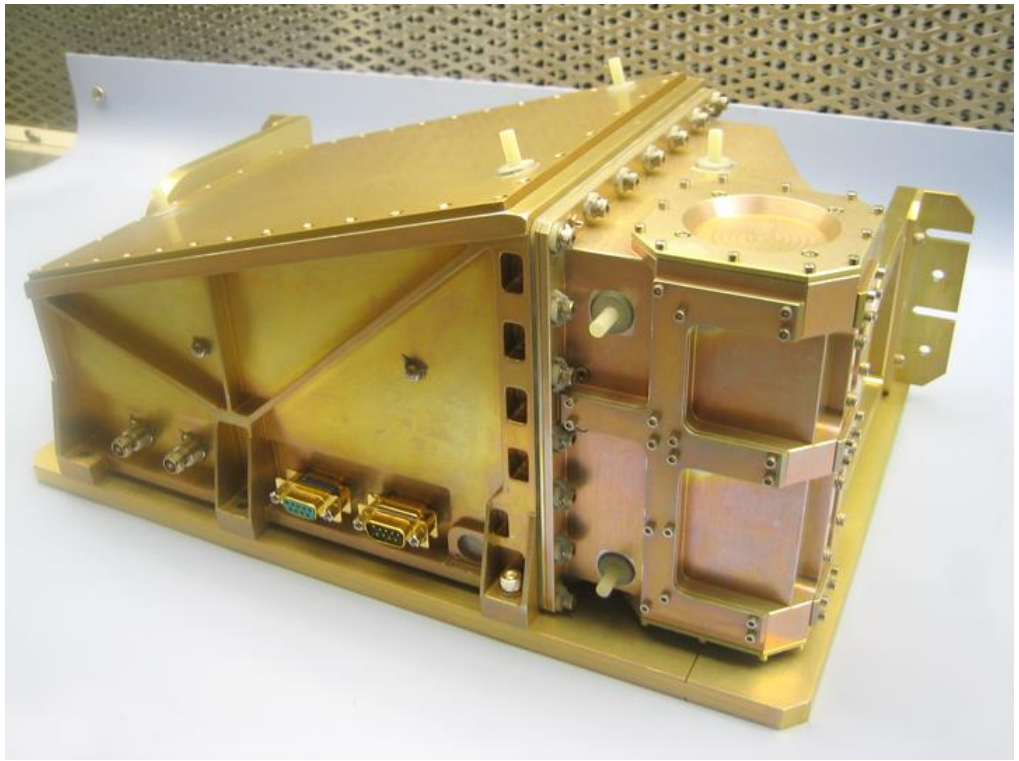


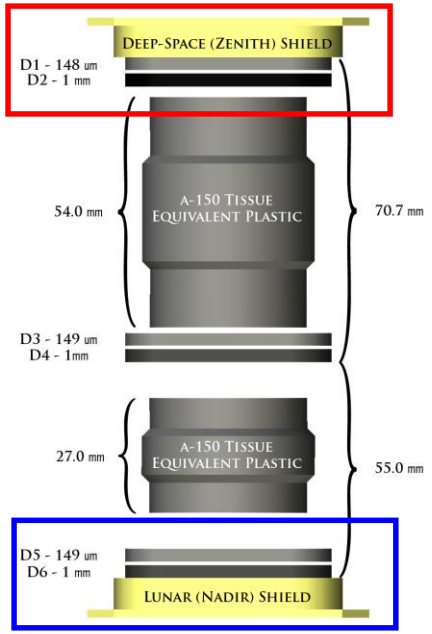
RAMIS: Free Space: RAMIS
dose rate (µGy/day) in Free Space



RAMIS: Comparison with CRaTER

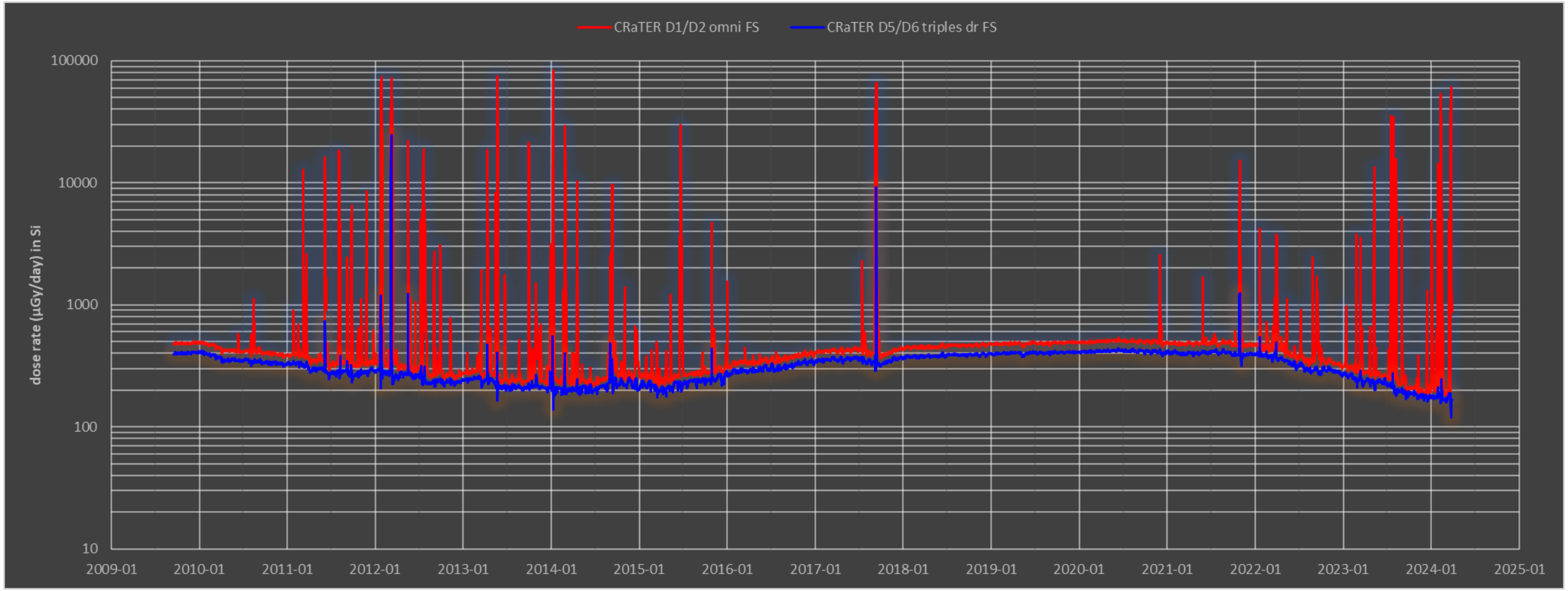
https://crater.unh.edu/instrument.shtml

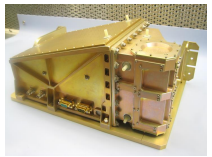




RAMIS: Comparison with CRaTER I

CRaTER D1/D2 + CRaTER D5/D6

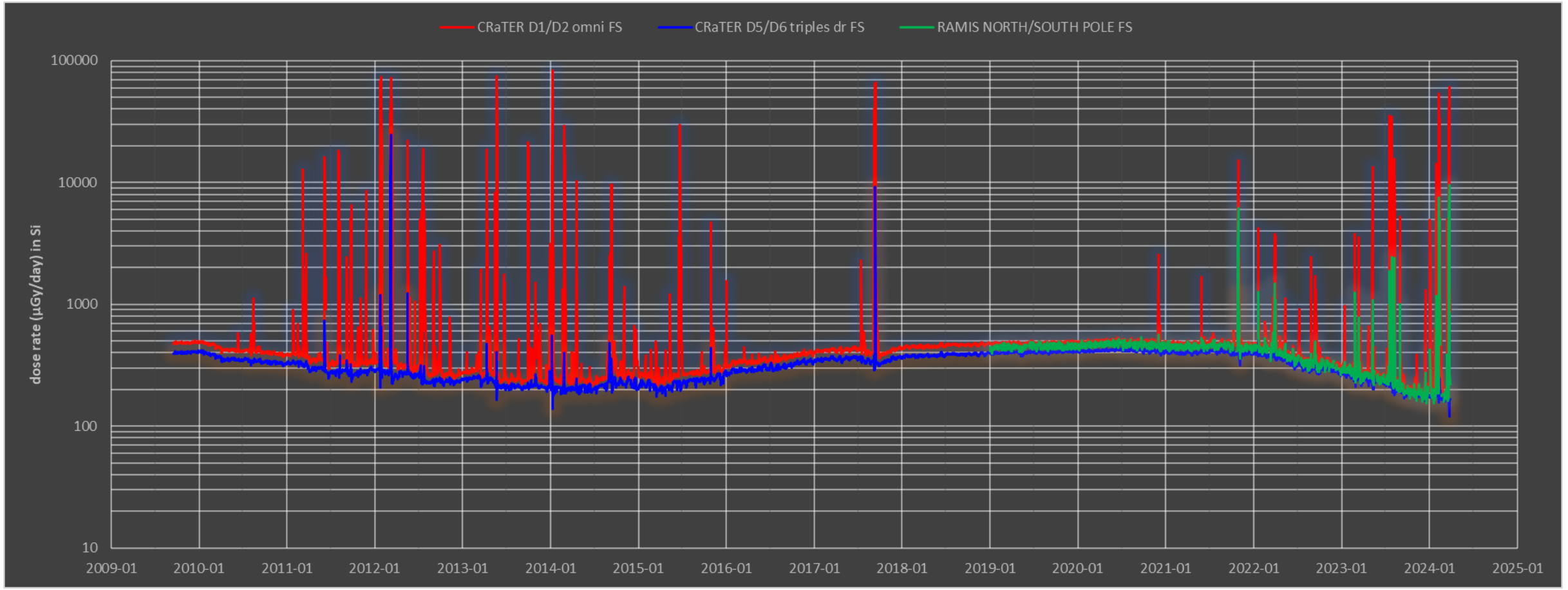


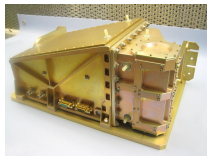


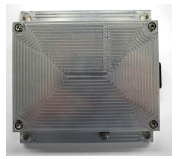
Over 2000 days in space – the RAMIS radiation detector on the DLR Eu:CROPIS mission / WRMISS 2024-09-03

RAMIS: Comparison with CRaTER II

CRaTER D1/D2 + CRaTER D5/D6 + RAMIS NORTH/SOUTH FS



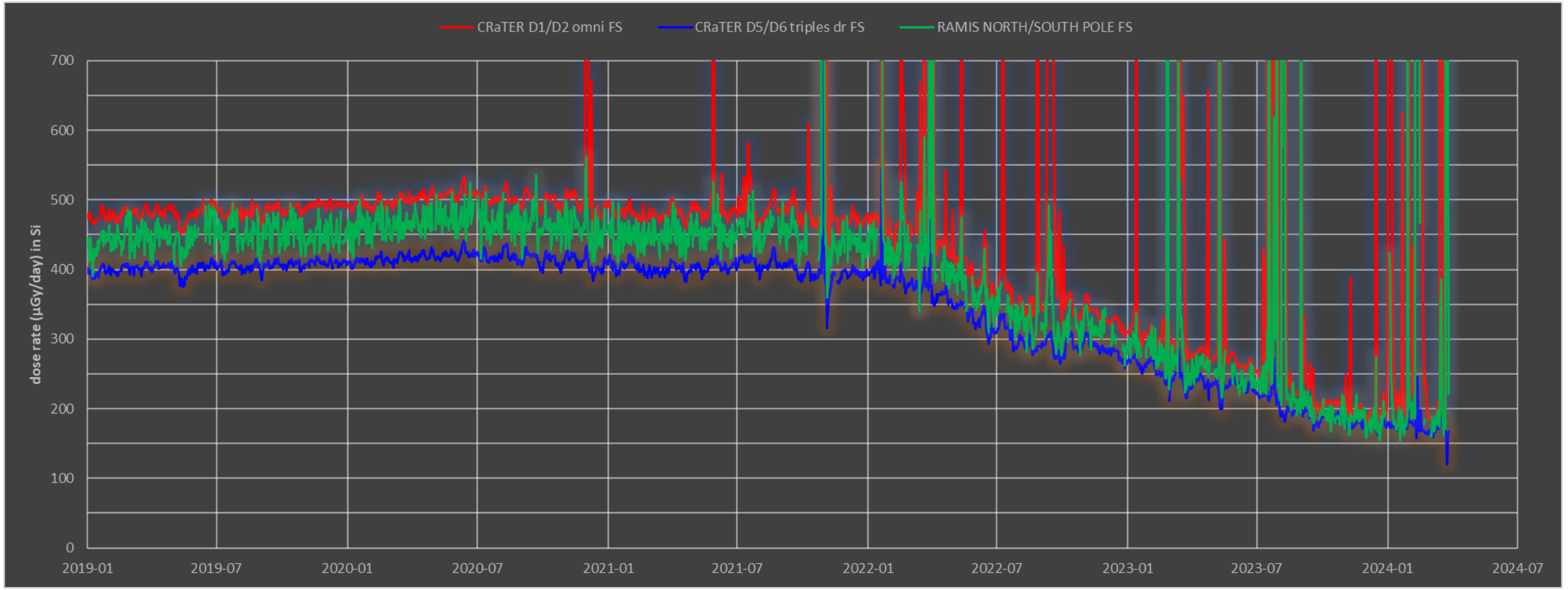


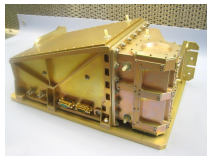


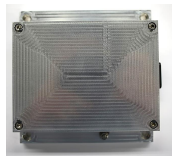
Over 2000 days in space – the RAMIS radiation detector on the DLR Eu:CROPIS mission / WRMISS 2024-09-03

RAMIS: Comparison with CRaTER III

CRaTER D1/D2 + CRaTER D5/D6 + RAMIS NORTH/SOUTH FS

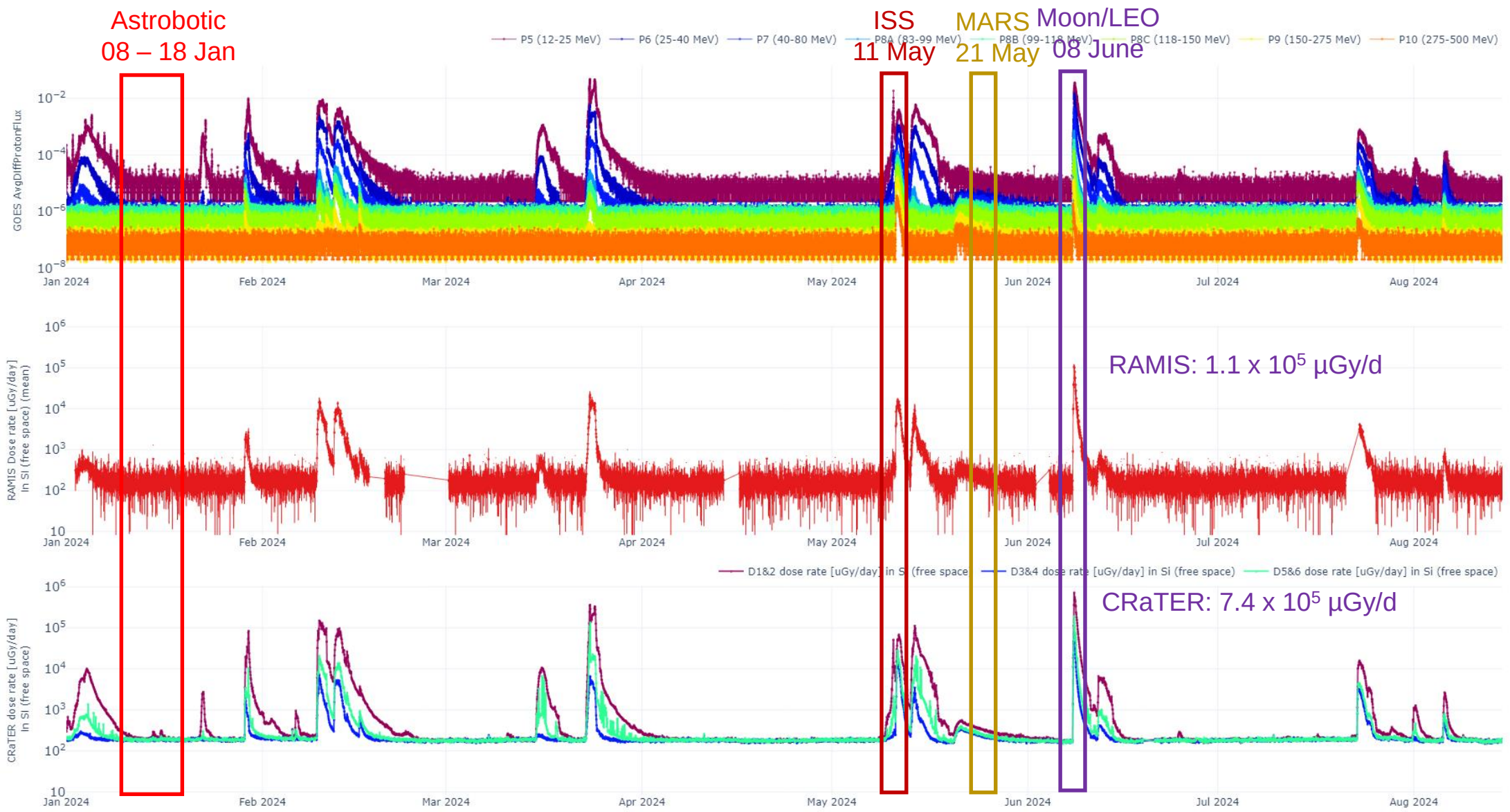






Over 2000 days in space – the RAMIS radiation detector on the DLR Eu:CROPIS mission / WRMISS 2024-09-03

RAMIS: L >= 8 + CRaTER: D1&D2 / D3&D4 / D5&D6 Free space



Over 2000 days in space – the RAMIS radiation detector on the DLR Eu:CROPIS mission / WRMISS 2024-09-03

Summary: 2081 days RAMIS on Eu:CROPIS

2081 days in space

- 1936 days of science data
- 93 % mission coverage
- Some BitFlips…
- A lot of Solar Particle Events (2021 – 2024)
- Measurements during Solar Minimum (2020)
- Measurements during almost Solar Maximum
- Good comparison with other instruments
- 6.6 Gy (in Si) over the current mission duration
- Still working…☺