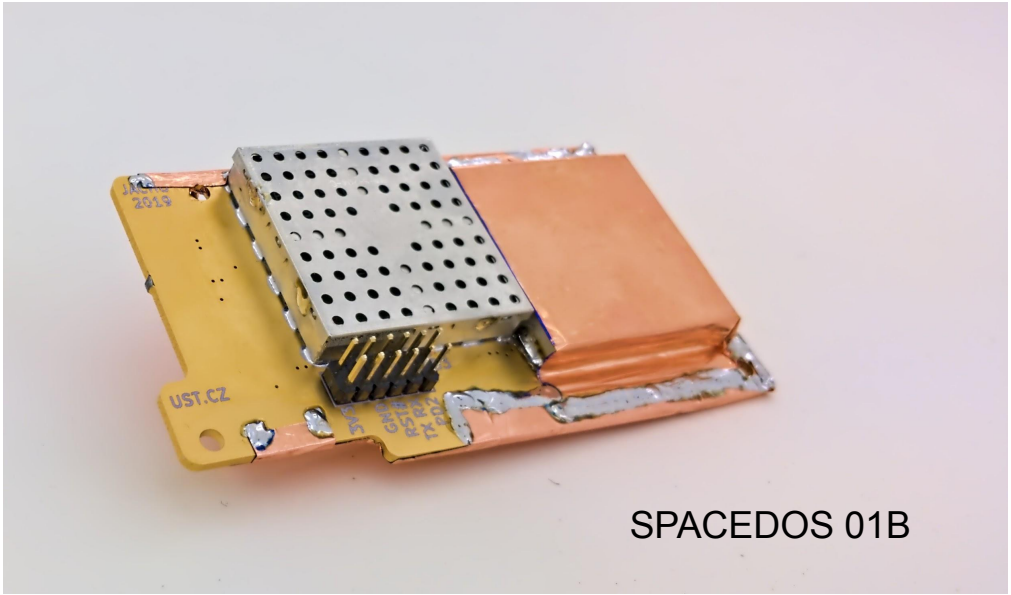


Asymmetry in SPACEDOS Measurements During SAA Transits

M. Kákona[1,2], R. Dvořák[1], J. Kákona[1,3], I. Ambrožová[1], O. Ploc[1], R. Tolochek[4], V. Shurshakov[4], H. Kitamura[5], S. Kodaira[5], K. Grigorev[6,7], L. Narici[8], J. Miller[2,7]

[1] Nuclear Physics Institute of the CAS, Řež, Czech Republic
[2] Lawrence Berkeley National Laboratory, Berkeley, CA, USA
[3] Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic
[4] Institute of Biomedical Problems of the Russian Academy of Sciences, Moscow, Russian Federation
[5] Institute for Radiological Science, QST, Chiba, Japan
[6] Blue Marble Space Institute of Science, Seattle, WA, USA
[7] NASA Ames Research Center, Moffett Field, CA, USA
[8] Department of Physics, University of Rome Tor Vergata, Rome, Italy

SPACEDOS



SPACEDOS 01B



SPACEDOS 02A



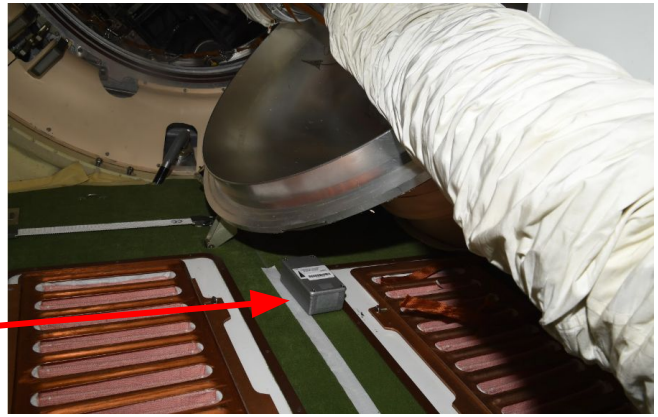
KÁKONA, M, ŠLEGL, J, KYSELOVÁ, D, SOMMER, M, KÁKONA, J, LUŽOVÁ, M, ŠTĚPÁN, V, PLOC, O, KODAIRA, S, CHROUST, J, JOHN, D, AMBROŽOVÁ, I and KRIST, P, 2021. AIRDOS — open-source PIN diode airborne dosimeter. *Journal of Instrumentation*. 1 March 2021. Vol. 16, no. 03, p. T03006. DOI 10.1088/1748-0221/16/03/T03006.

https://github.com/ODZ-UJF-AV-CR/SPACEDOS01

https://github.com/UniversalScientificTechnologies/SPACEDOS02

ISS missions

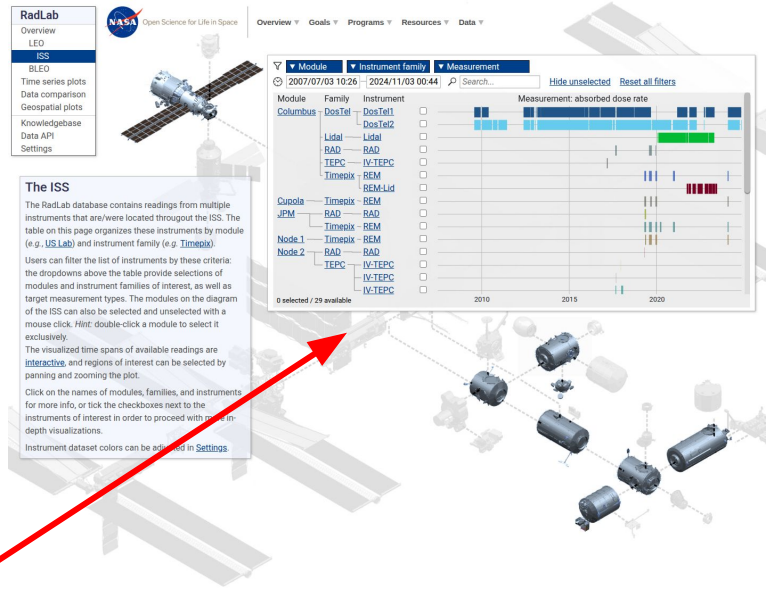


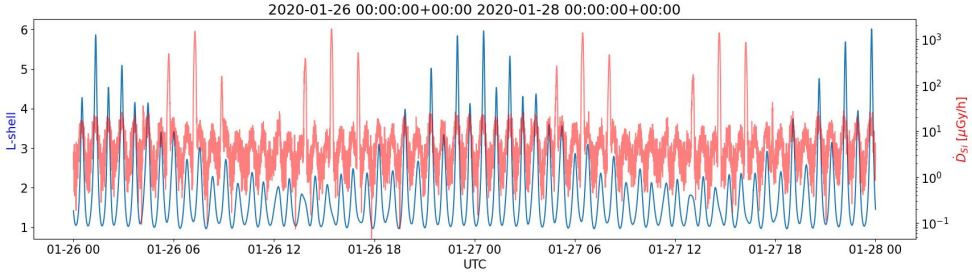


1. **SPACEDOS02** (F)
   a. Launch
      Soyuz MS-15 25 September 2019, 13:57 UTC
      Rocket Soyuz-FG
   b. Landing
      06 February 2020, 09:12 UTC
2. **SPACEDOS02** (S01)
   a. Launch
      Soyuz MS-17 14 October 2020, 05:45 UTC
      Rocket Soyuz-2.1a
   b. Landing
      17 April 2021, 04:55 UTC

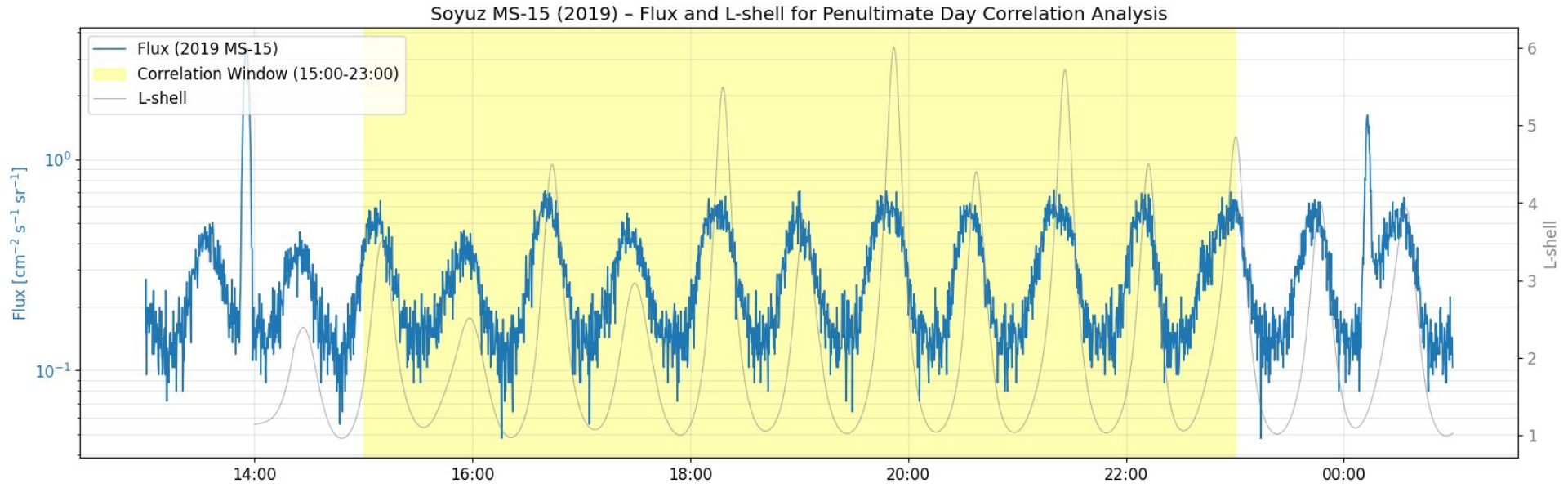


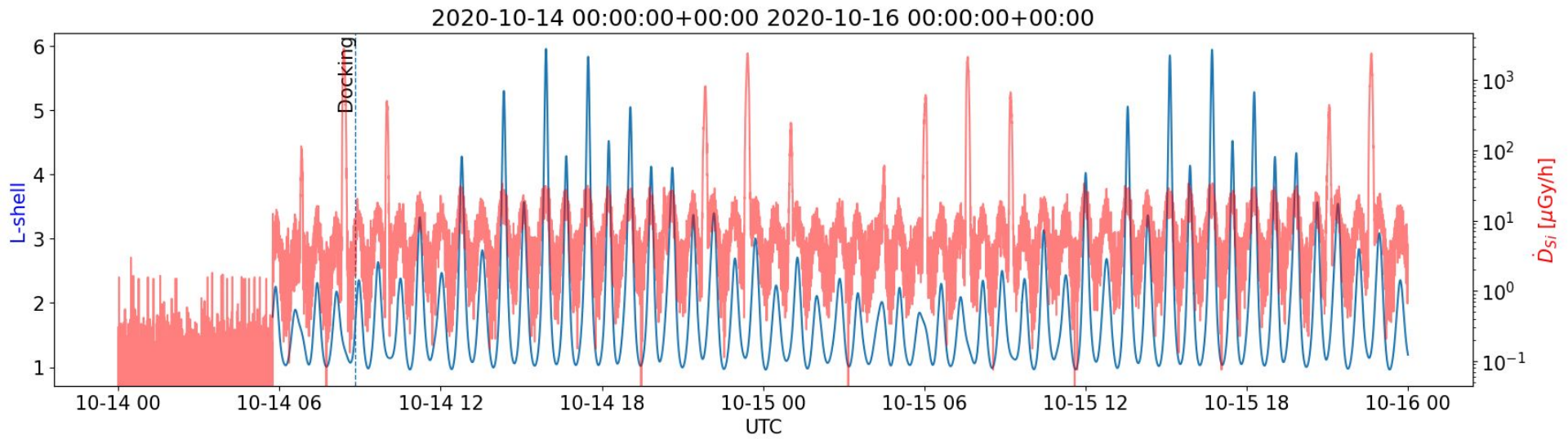
Data Integration to RadLab

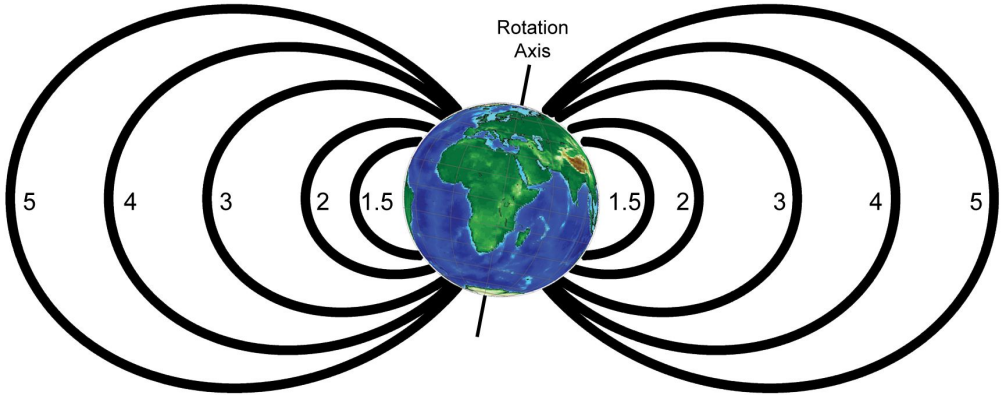


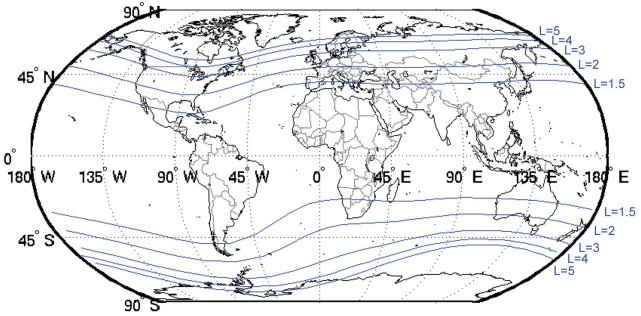


Time Shift

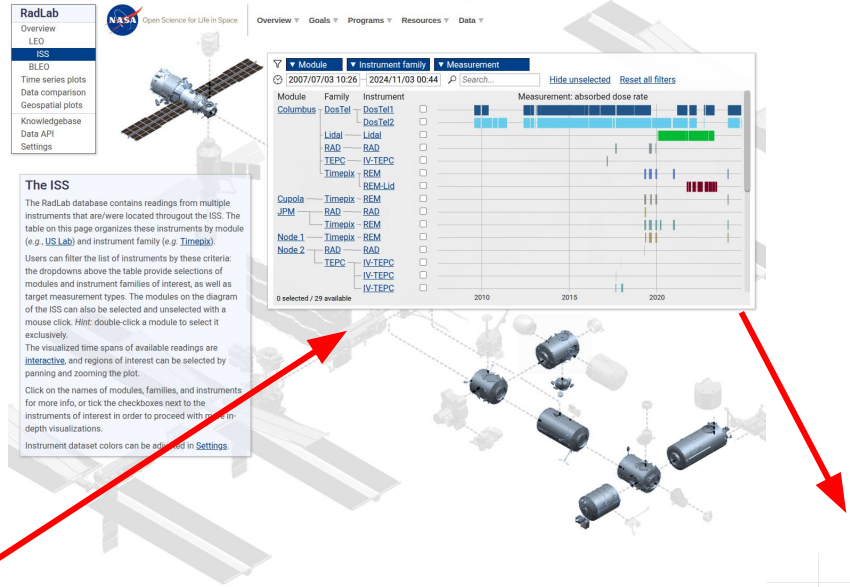

Soyuz MS-15 (2019) – Flux and L-shell for Penultimate Day Correlation Analysis
Flux (2019 MS-15)
Correlation Window (15:00-23:00)
L-shell
Flux [cm⁻² s⁻¹ sr⁻¹]
L-shell
10⁰
10⁻¹
14:00
16:00
18:00
20:00
22:00
00:00
1
2
3
4
5
6

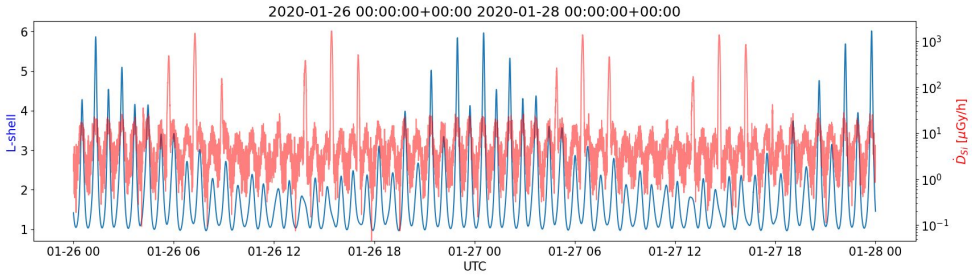

2020-10-14 00:00:00+00:00 2020-10-16 00:00:00+00:00
Docking
L-shell
$\dot{D}_{Si}$ [μGy/h]
10-14 00
10-14 06
10-14 12
10-14 18
10-15 00
10-15 06
10-15 12
10-15 18
10-16 00
UTC

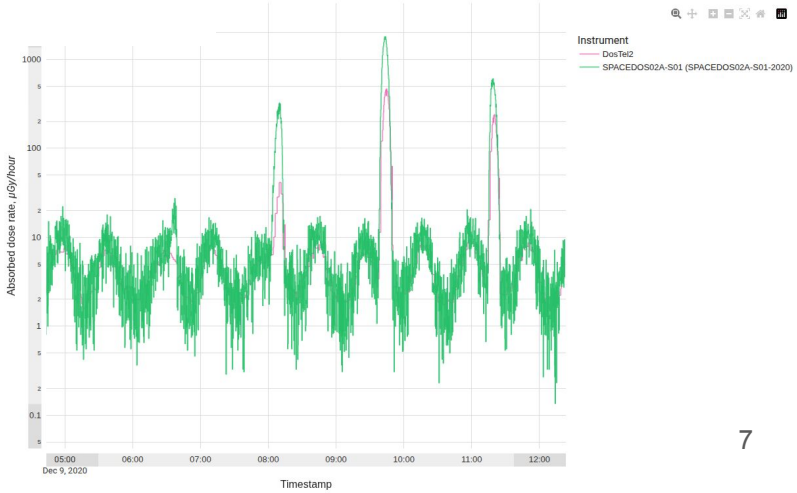

Rotation
Axis
5
4
3
2
1.5
1.5
2
3
4
5

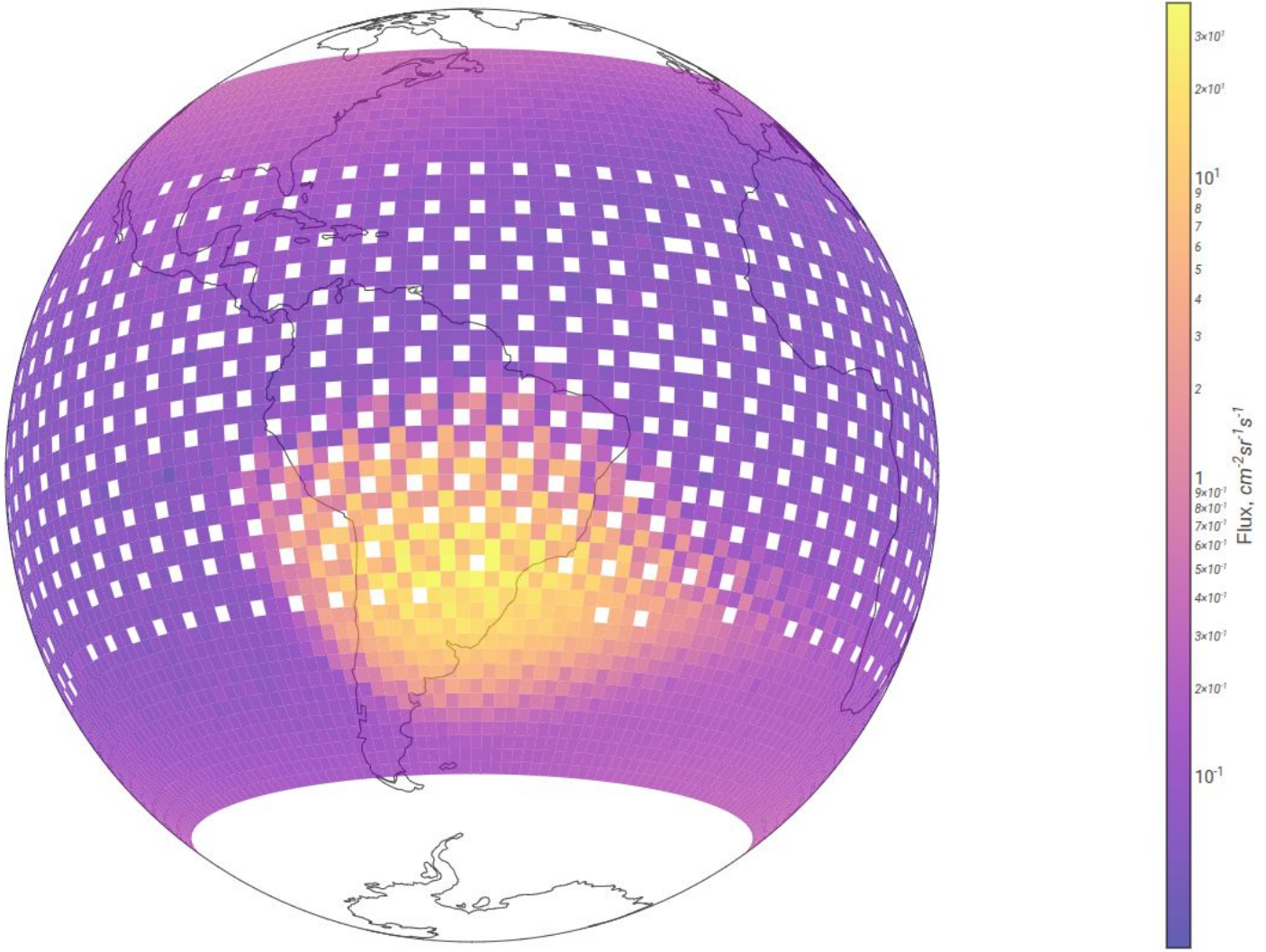

90° N
45° N
0°
45° S
90° S
180° W
135° W
90° W
45° W
0°
45° E
90° E
135° E
180° E
L=5
L=4
L=3
L=2
L=1.5

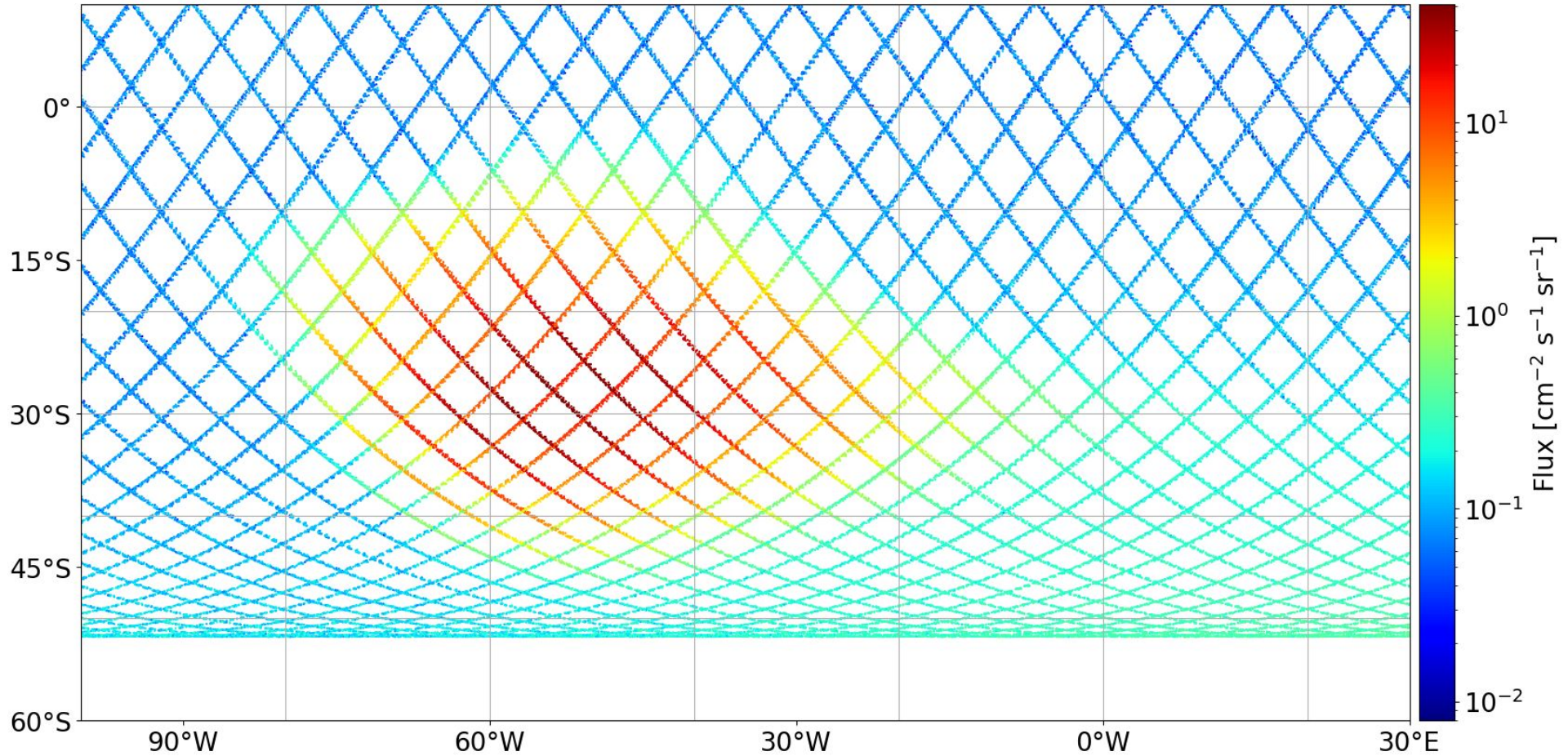
Data Integration to RadLab

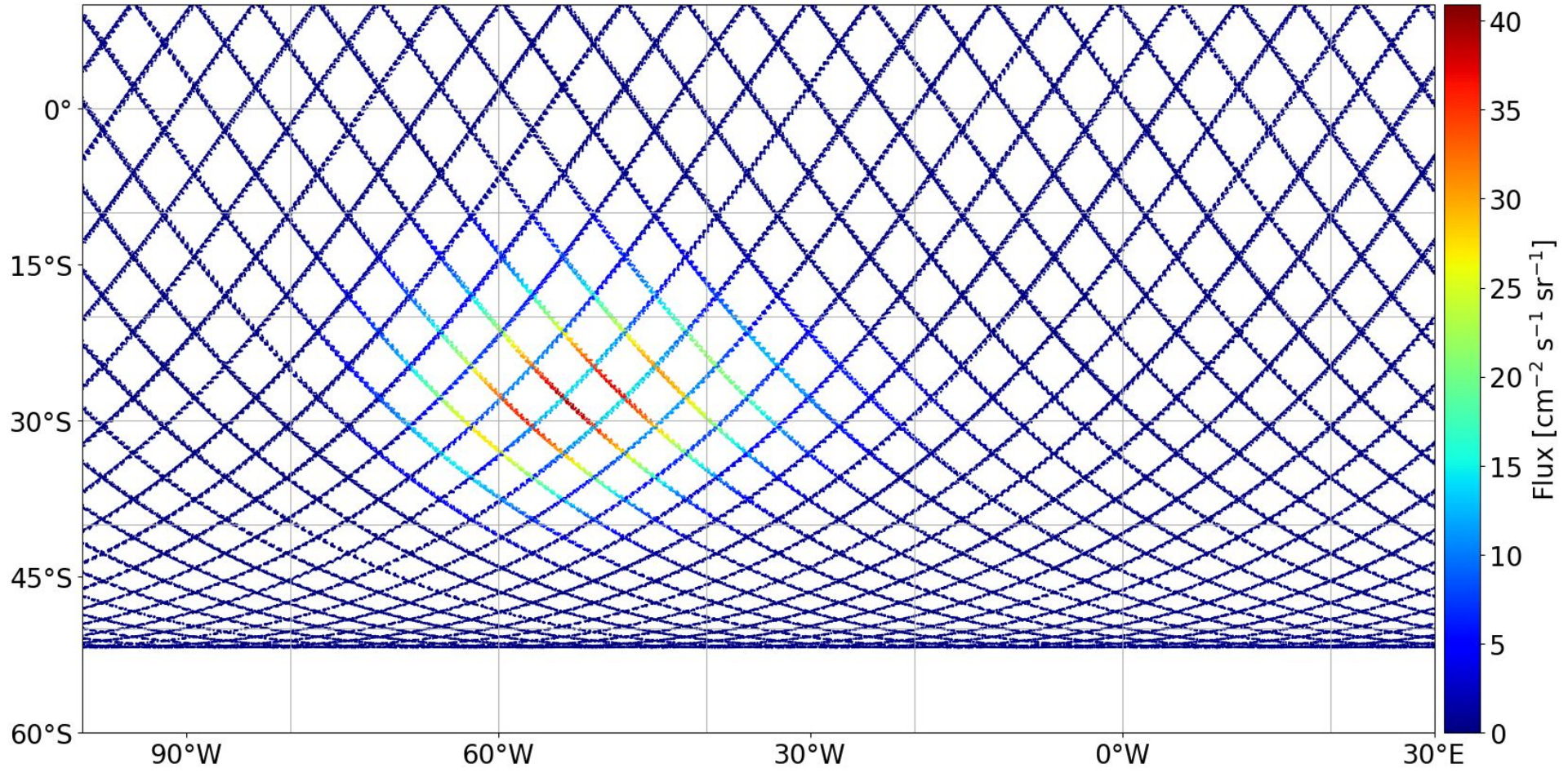







Flux, $cm^{-2}sr^{-1}s^{-1}$
3×10^{1}
2×10^{1}
10^{1}
9
8
7
6
5
4
3
2
1
9×10^{-1}
8×10^{-1}
7×10^{-1}
6×10^{-1}
5×10^{-1}
4×10^{-1}
3×10^{-1}
2×10^{-1}
10^{-1}

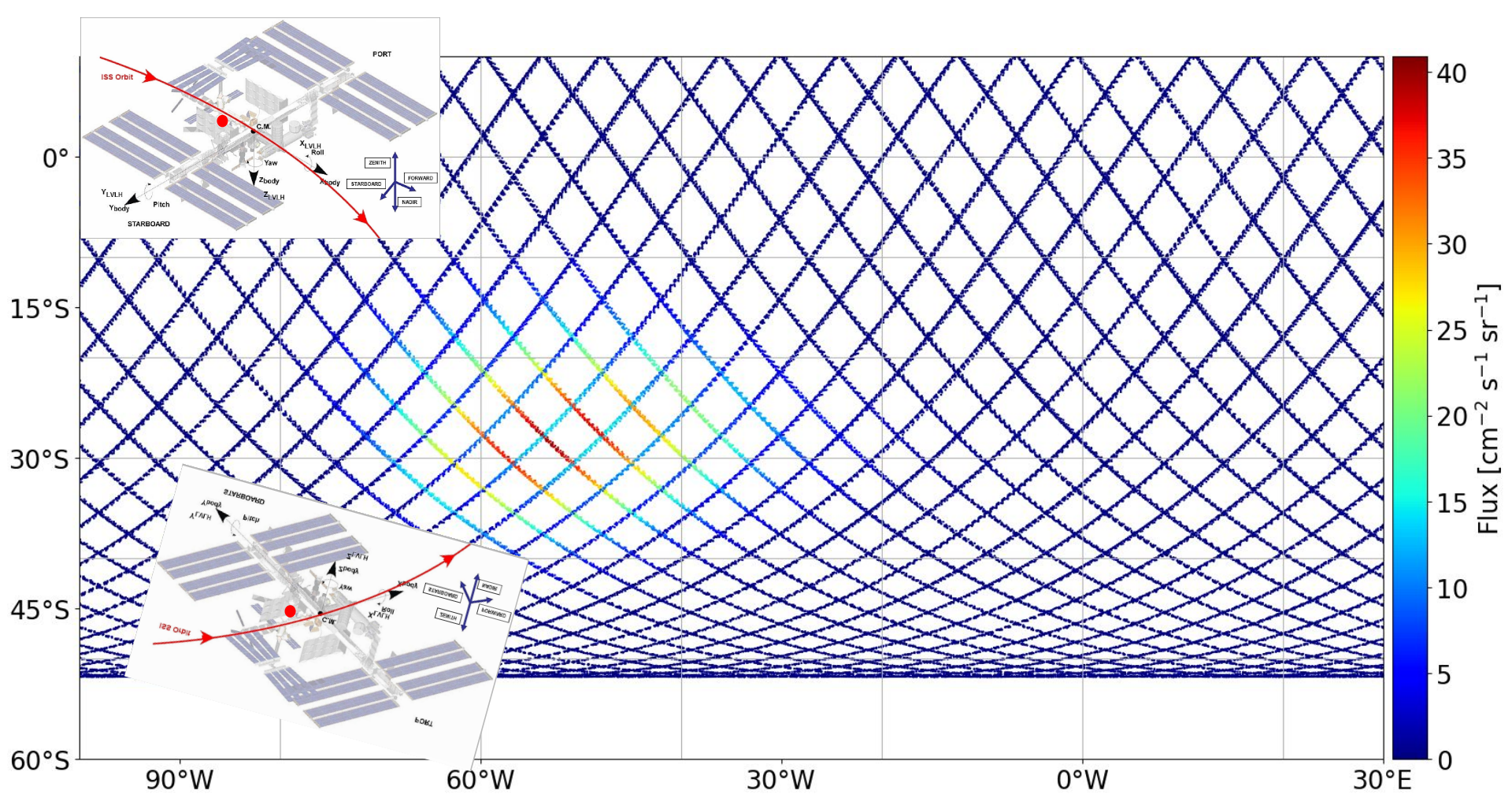

0°
15°S
30°S
45°S
60°S
90°W
60°W
30°W
0°W
30°E
10^{1}
10^{0}
10^{-1}
10^{-2}
Flux [cm^{-2} s^{-1} sr^{-1}]

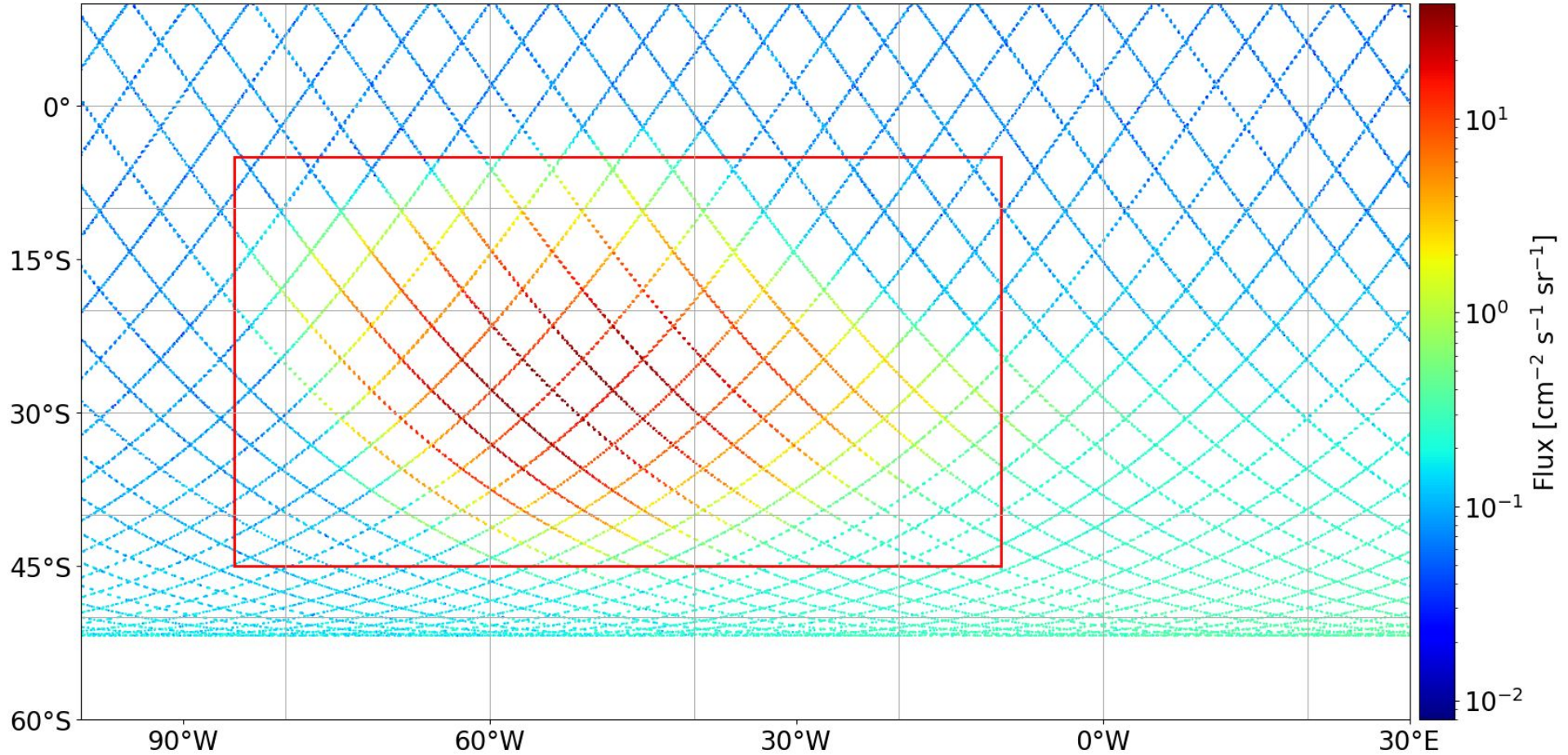

0°
15°S
30°S
45°S
60°S
90°W
60°W
30°W
0°W
30°E
Flux [cm^{-2} s^{-1} sr^{-1}]
0
5
10
15
20
25
30
35
40

Possible explanations

- East-West Anisotropy (magnetic E-W, gyration, reflection,...)
- SAA is not static
- Different shielding of the vehicle
- Spatial sensitivity of the sensor




ISS Orbit
PORT
STARBOARD
C.M.
Roll
Yaw
Pitch
ZENITH
FORWARD
STARBOARD
NADIR
0°
15°S
30°S
45°S
60°S
90°W
60°W
30°W
0°W
30°E
Flux [cm^{-2} s^{-1} sr^{-1}]
0
5
10
15
20
25
30
35
40

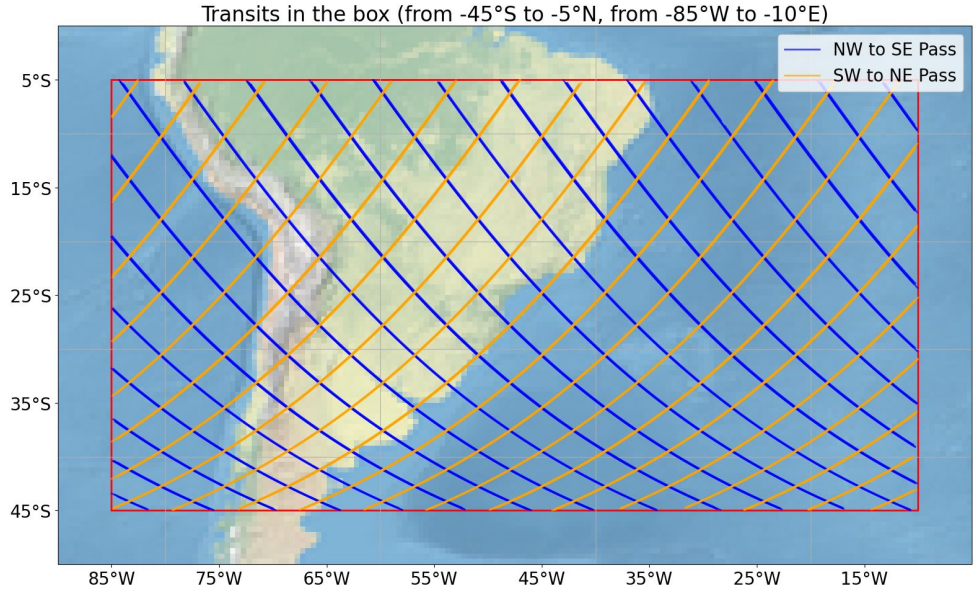

0°
15°S
30°S
45°S
60°S
90°W
60°W
30°W
0°W
30°E
10^{1}
10^{0}
10^{-1}
10^{-2}
Flux [cm^{-2} s^{-1} sr^{-1}]

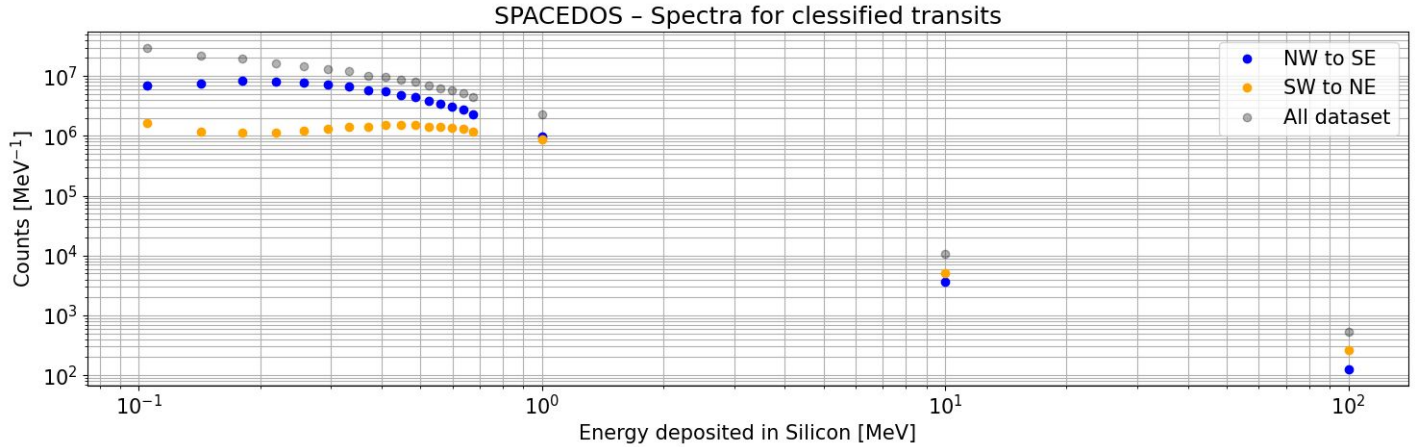
Energy Spectra & Dose

Mean dose rate NW-SE: 413 uGy/h

Mean dose rate SW-NE: 307 uGy/h

Mean dose rate difference (NW-SE vs SW-NE): **34 %**





State of the art of the SAA separation

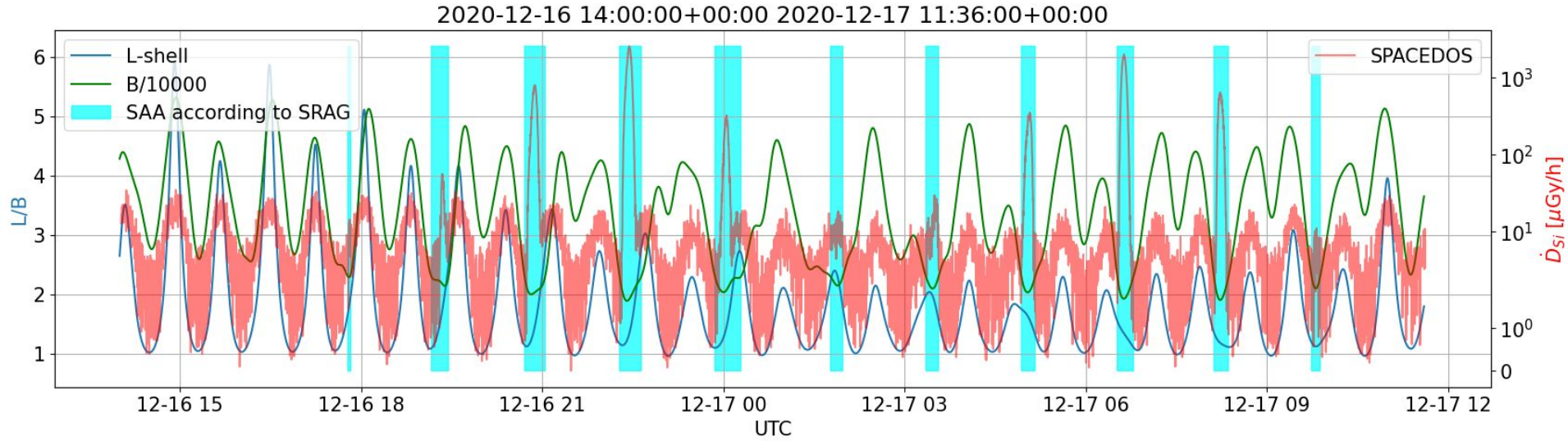
Sec. 4.2 of this paper: https://doi.org/10.1051/swsc/2020028 .

Thomas Berger et al., Long term variations of galactic cosmic radiation on board the International Space Station, on the Moon and on the surface of Mars

Short-term variations: https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2015JA021312 (120 days)

Hong Zou et al., Short-term variations of the inner radiation belt in the South Atlantic anomaly

SRAG note: SRAG-INT-DET-2018-002, section 1.2



State of the art of the SAA separation

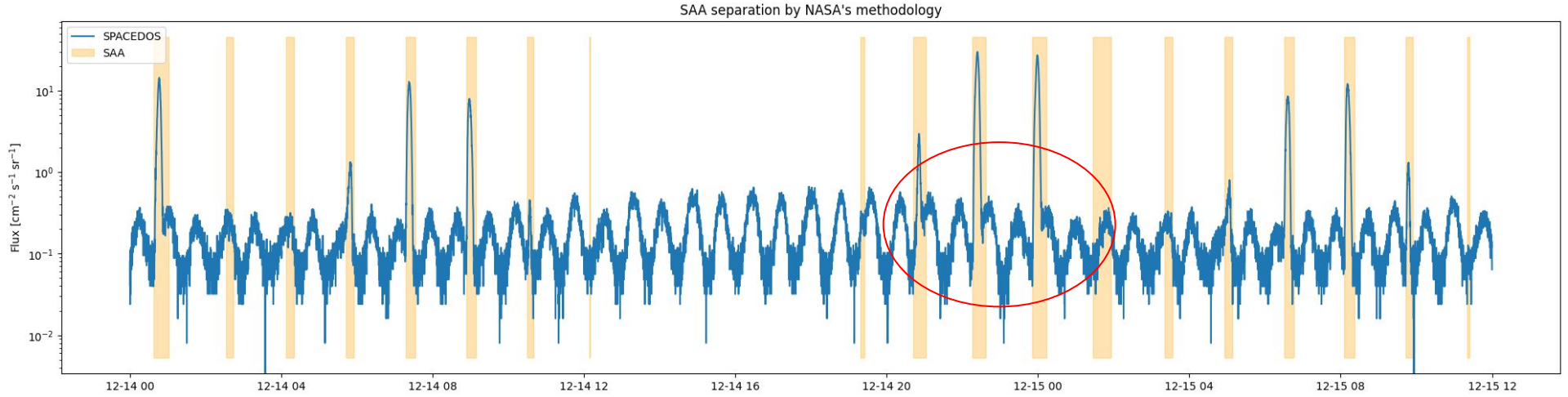
Sec. 4.2 of this paper: https://doi.org/10.1051/swsc/2020028 .

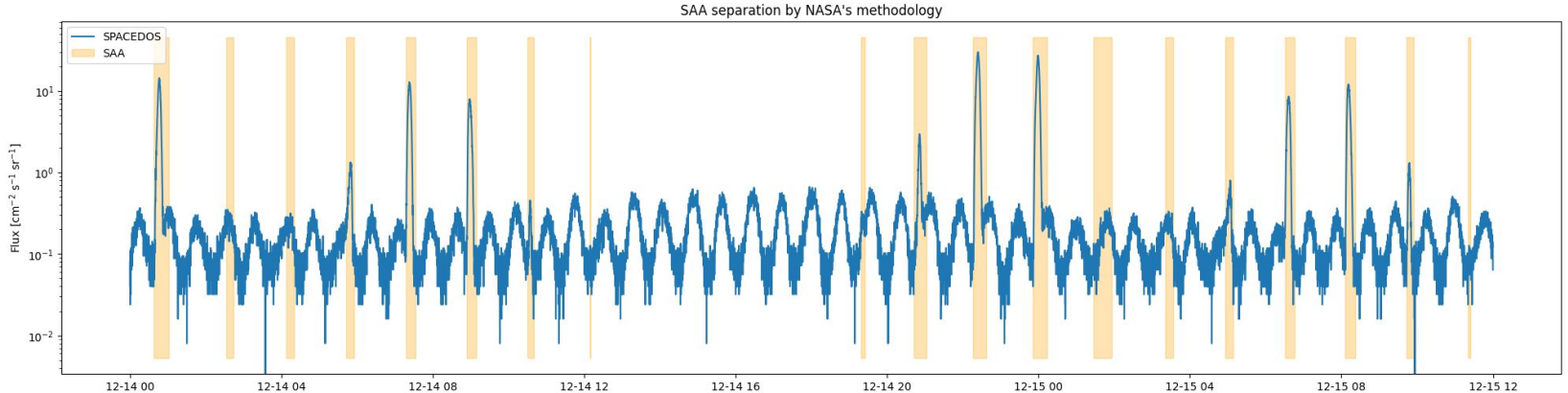
Thomas Berger et al., Long term variations of galactic cosmic radiation on board the International Space Station, on the Moon and on the surface of Mars

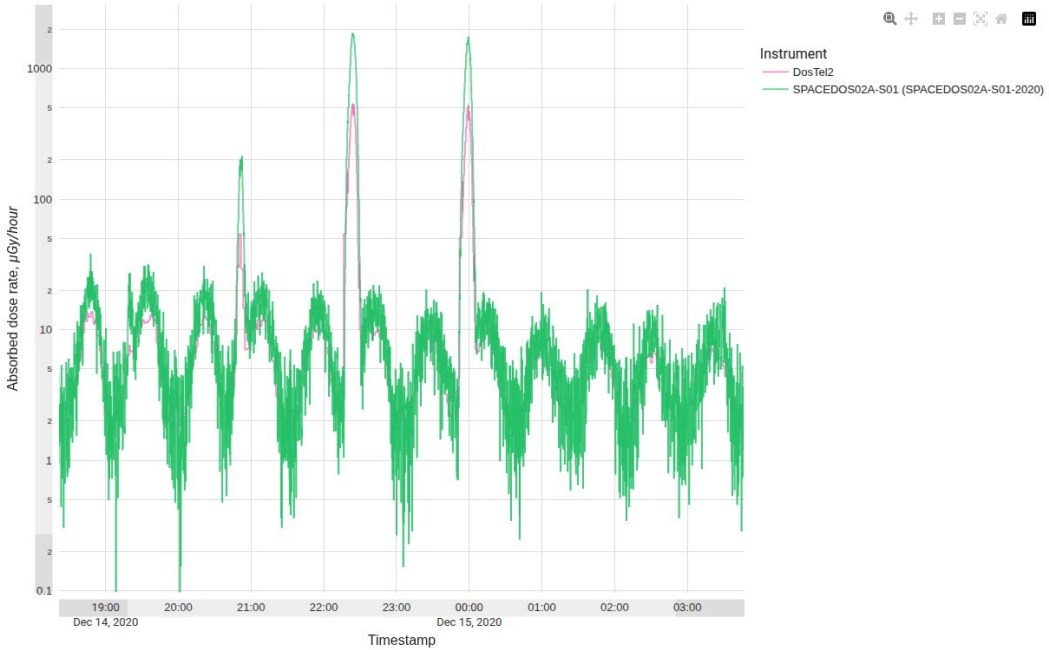
Short-term variations: https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2015JA021312 (120 days)

Hong Zou et al., Short-term variations of the inner radiation belt in the South Atlantic anomaly

SRAG note: SRAG-INT-DET-2018-002, section 1.2




SAA separation by NASA's methodology
SPACEDOS
SAA
Flux [cm^{-2} s^{-1} sr^{-1}]
10^{1}
10^{0}
10^{-1}
10^{-2}
12-14 00
12-14 04
12-14 08
12-14 12
12-14 16
12-14 20
12-15 00
12-15 04
12-15 08
12-15 12

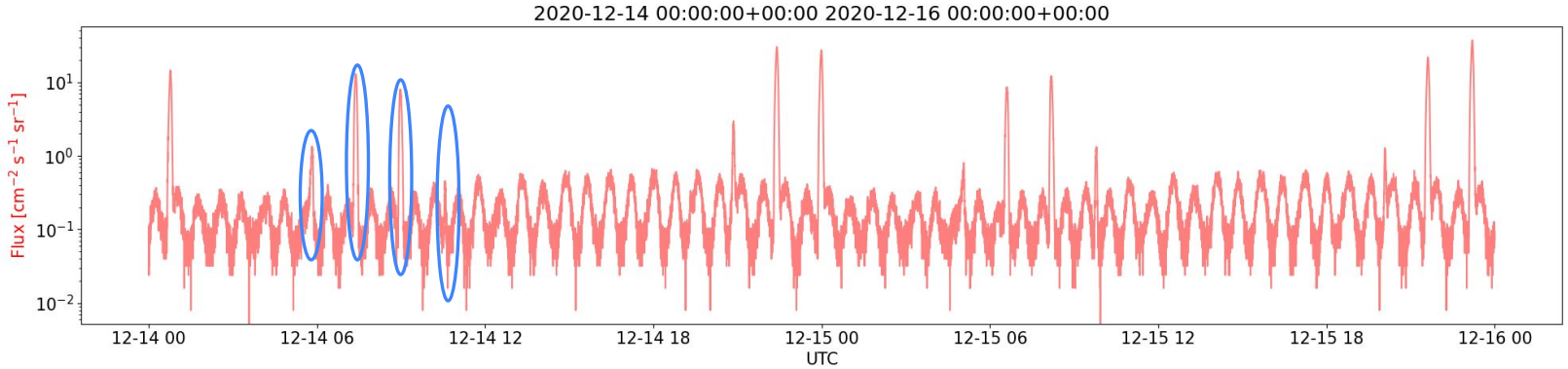

Instrument
DosTel2
SPACEDOS02A-S01 (SPACEDOS02A-S01-2020)
Absorbed dose rate, μGy/hour
2
1000
5
2
100
5
2
10
5
2
1
5
2
0.1
19:00
Dec 14, 2020
20:00
21:00
22:00
23:00
00:00
Dec 15, 2020
01:00
02:00
03:00
Timestamp

OSDR AWG

LEO Dosimetry – SAA/GCR Separation Using ML

The NASA
Open Science Data Repository (OSDR)
Analysis Working Groups (AWG)

On behalf of:
https://awg.osdr.space/t/leo-dosimetry-saa-gcr-separation-using-ml-new-subgroup/3665/114



OSDR AWG

LEO Dosimetry – SAA/GCR Separation Using ML

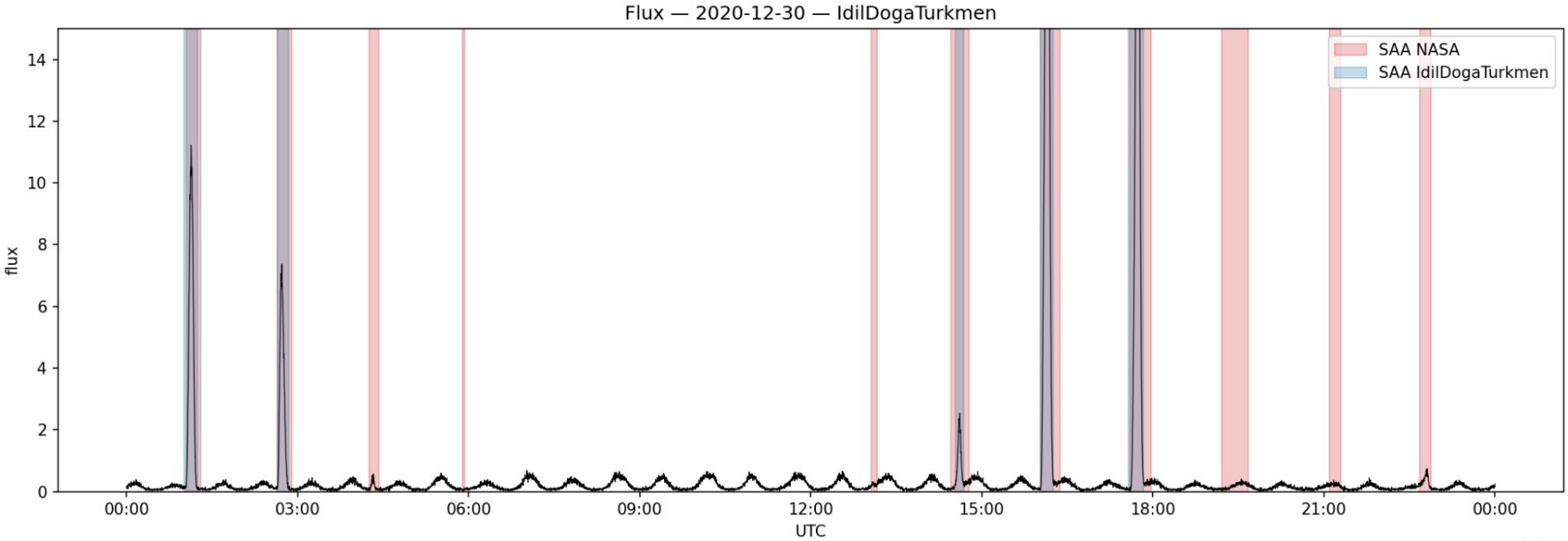


The NASA
Open Science Data Repository (OSDR)
Analysis Working Groups (AWG)

On behalf of:
https://awg.osdr.space/t/leo-dosimetry-saa-gcr-separation-using-ml-new-subgroup/3665/114

OSDR AWG

LEO Dosimetry – SAA/GCR Separation Using ML



Shielding by body

p^+ <150 MeV ⟶ ~15.8 cm (range in tissue)



Conclusion



Proposal for a new experiment (question of 34 %)

- 3× SPACEDOS remain on ISS after our CZPAD experiment
- Too valuable to discard → propose follow-up
- Co-locate with other teams' detectors already on ISS
- Cross-calibration / inter-comparison of dose data

