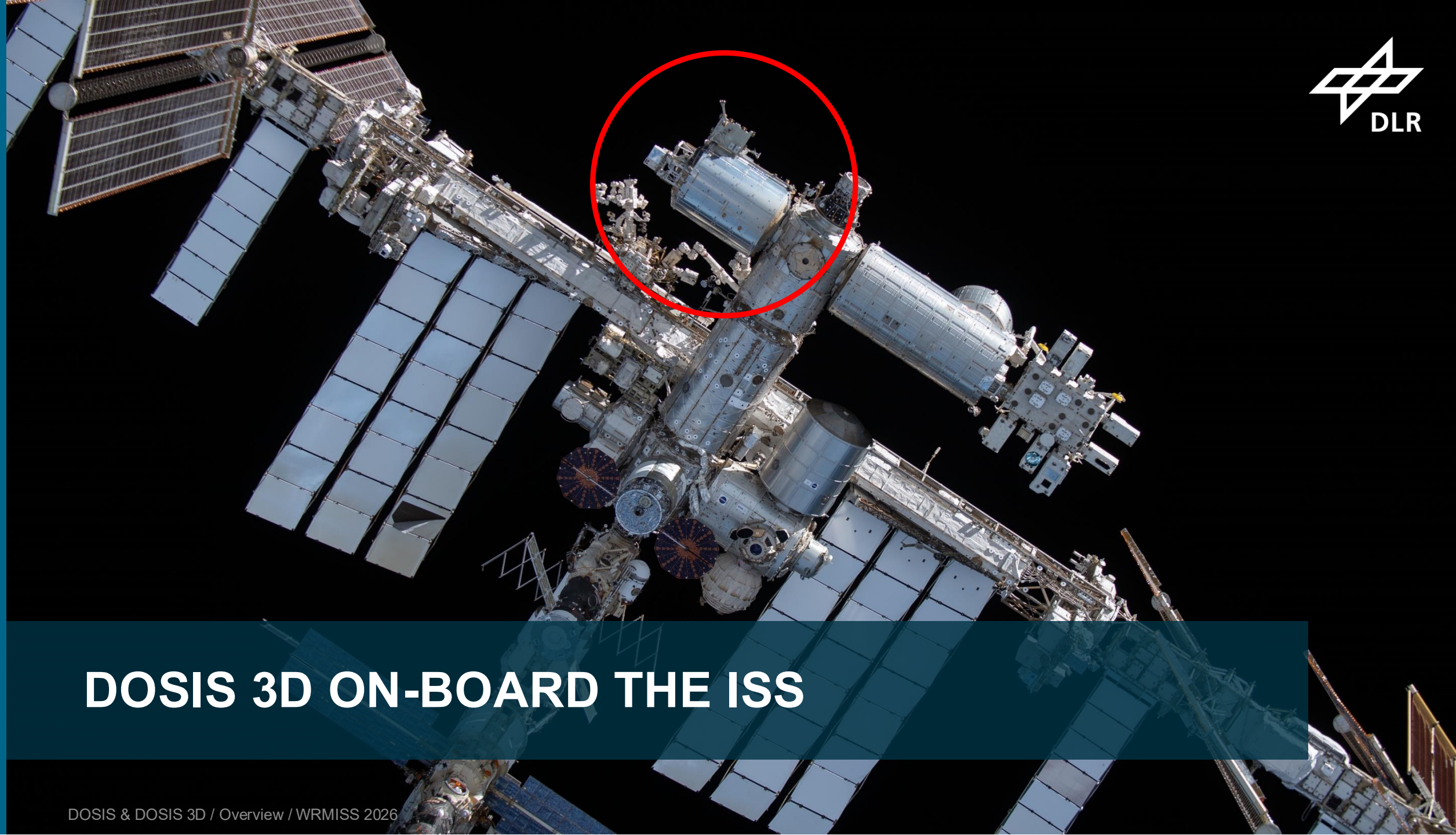
# DOSIS & DOSIS 3D

## Data from the DOSTEL instruments focusing on 2024 – 2026 with special emphasis on SPEs and Electrons measured inside the ISS

**Maximilian Brüdern[1], Thomas Berger[2],**
**Bernd Heber[1], Daniel Matthiä[2], Bartos Przybyla[2]**
[1]Institut für Experimentelle und Angewandte Physik, CAU Kiel
[2]Institut für Luft- und Raumfahrtmedizin, DLR, Köln

***Improving Health Span in Space and on Earth***



# DOSIS 3D ON-BOARD THE ISS

# DOSIS 3D:
# Dose Distribution Inside the ISS 3D

**Aim:**

- To measure the radiation environment in the Columbus Laboratory of the ISS with **two active (DOSTEL-1/-2)** and **eleven passive radiation detector packages (PDP)**
- To compare the data with other instruments as measuring in Columbus and throughout the ISS (e.g. LIDAL/Timepix/ISS-RAD)
- To provide radiation data to biological experiments as performed in the Columbus Laboratory



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estec

European Space Research
and Technology Centre
Keplerlaan 1
2201 AZ Noordwijk
The Netherlands
T +31 (0)71 565 6565
F +31 (0)71 565 6040
www.esa.int

DOCUMENT

Title / OpNom: DOSIS 3D ESR
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|---|---|
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| Book Captain | R. Almeida |
| DPRN No. | 1522 |
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European Space Agency
Agence spatiale européenne

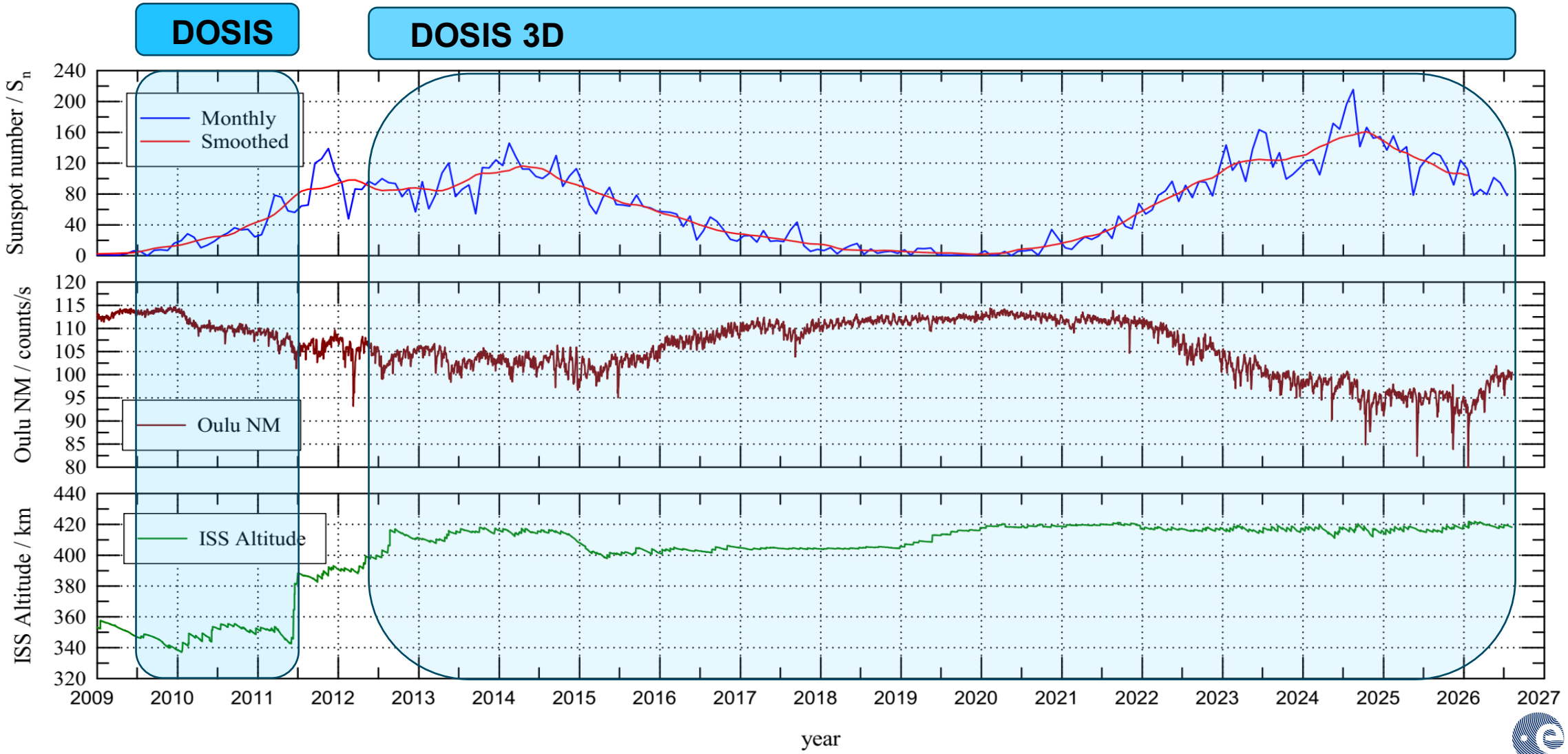
DLR

esa

# DOSIS & DOSIS 3D:

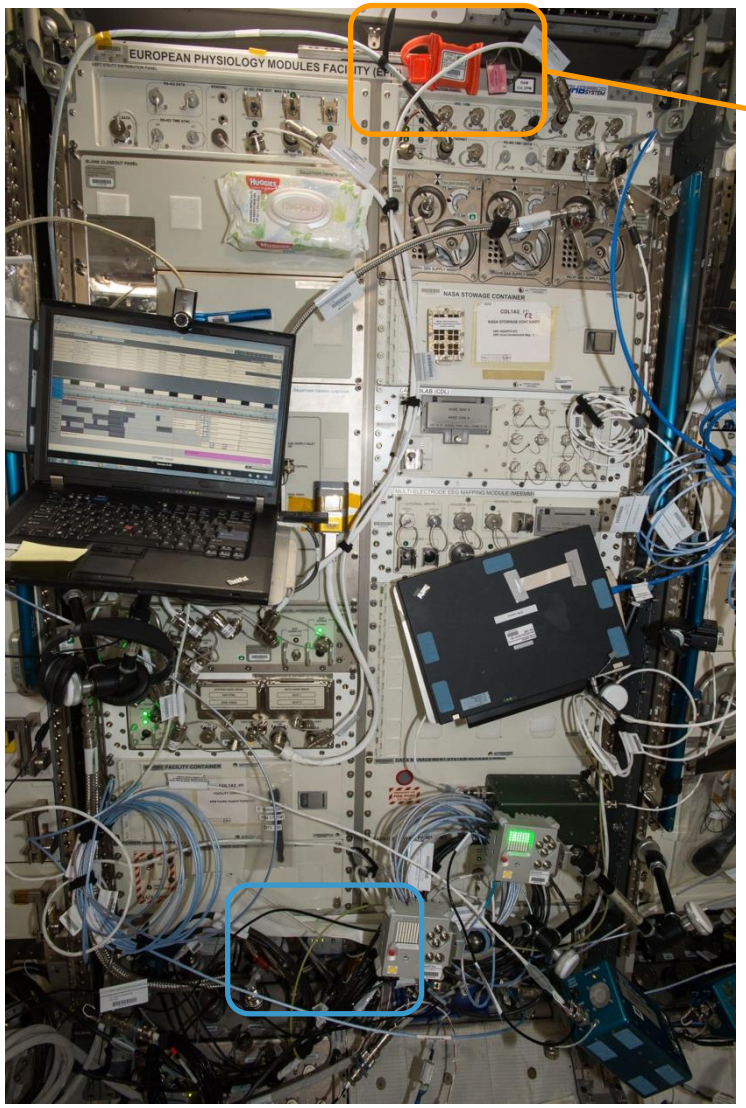
## Radiation data over almost two solar cycles

**Data:** DOSIS (2009 – 2011) / DOSIS 3D (since 2012)



# DOSIS 3D: Dose Distribution Inside the ISS 3D

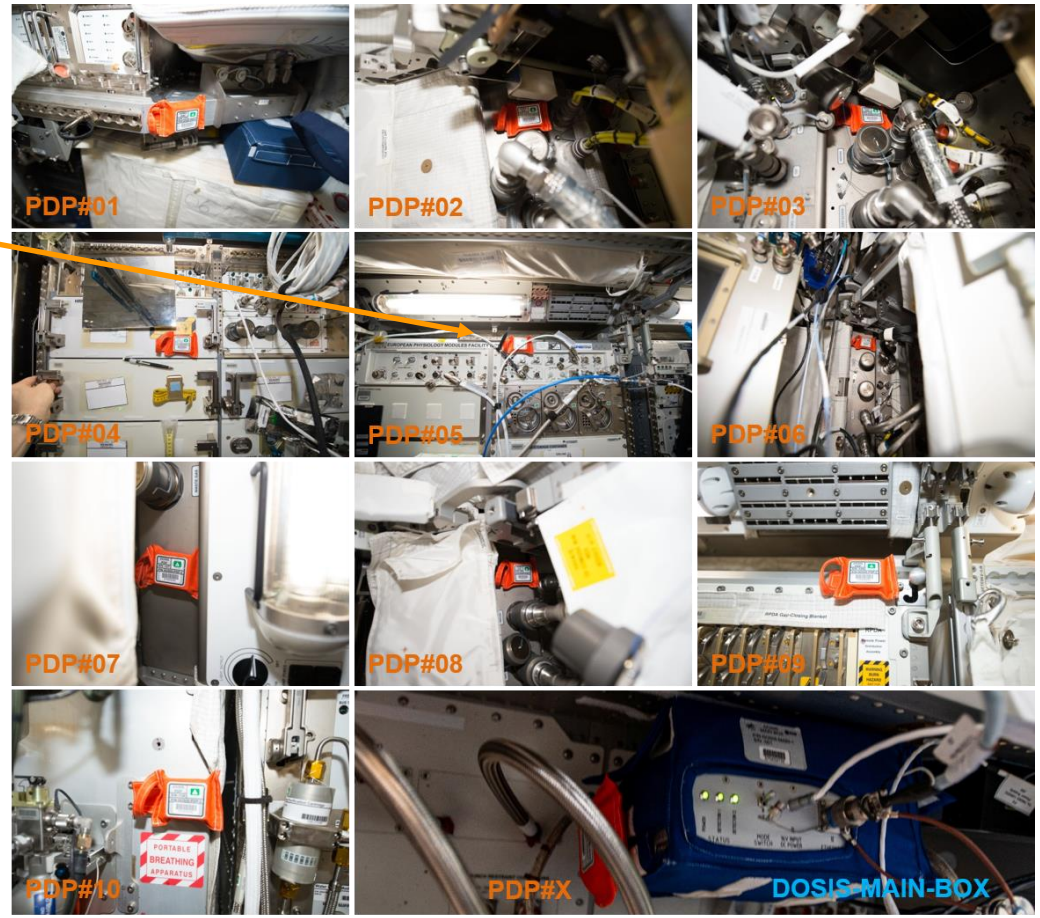
**Experiment aim:** to measure the radiation dose in Columbus with **two active (DOSTEL-1/-2)** and **eleven passive radiation detectors (PDP)**




**Days of data:**
~5500

30 x PDP
⇑⇓
(up/down)

Currently:
Crew-12






https://www.esa.int/ESA_Multimedia/Images/2020/10/Hidden_science

# DOSIS 3D: PDP

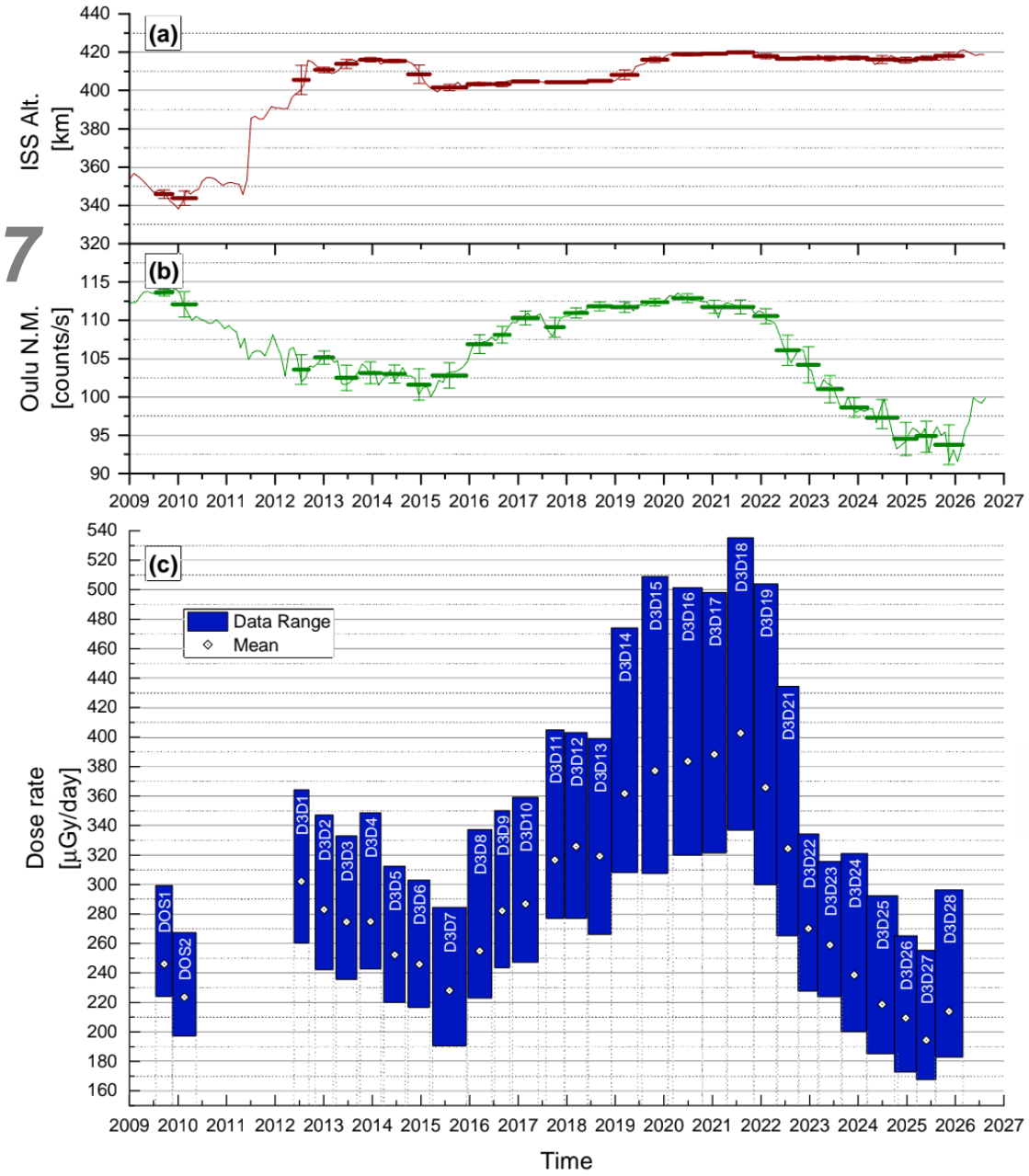

BUSBOX
BSSPCM
https://www.flickr.com/photos/soph_astro/55153995257/

# Results: DOSIS PDP *DOS01/02* + DOSIS 3D PDP *D3D01 - 27*

***DOSIS 3D: D3D6***

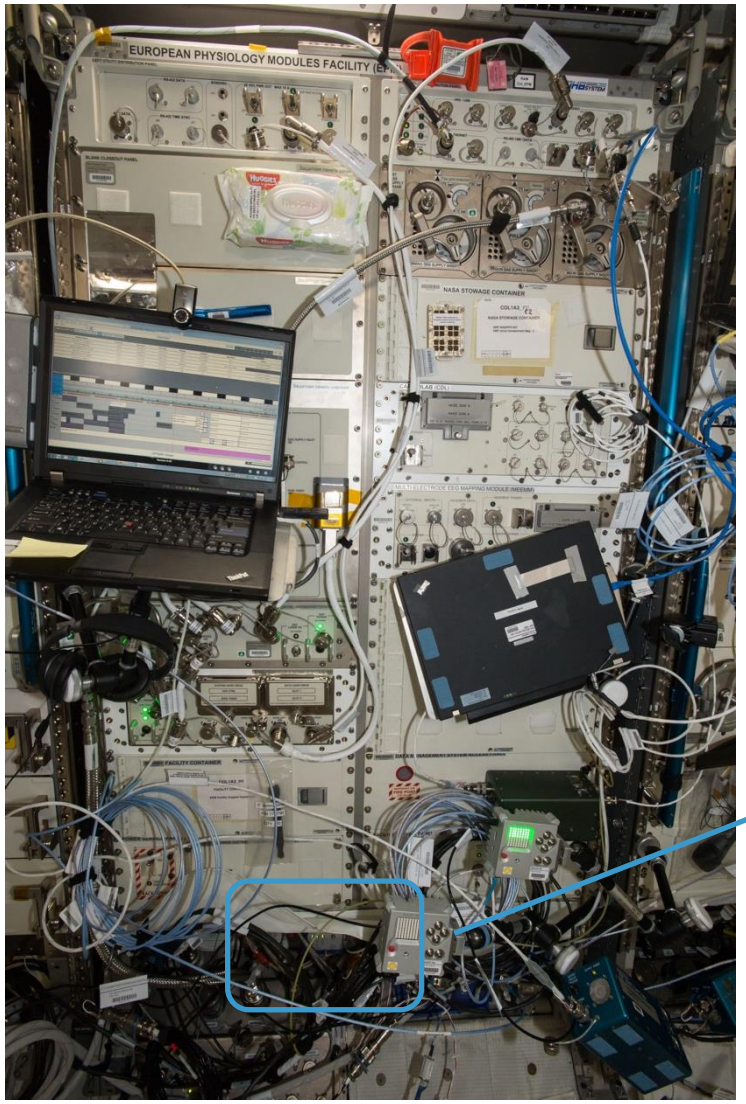
Berger, T., B. Przybyla, D. Matthiä, G. Reitz, S. Burmeister, J. Labrenz, P. Bilski, T. Horwacik, A. Twardak, M. Hajek, M. Fugger, C. Hofstätter, L. Sihver, J. Palfalvi, J. Szabo, A. Stradi, I. Ambrozova, J. Kubancak, K. Pachnerova Brabcova, F. Vanhavere, V. Cauwels, O. Van Hoey, W. Schoonjans, A. Parisi, R. Gaza, E. Semones, E. Yukihara, E. Benton, B. Doull, Y. Uchihori, S. Kodaira, H. Kitamura, M. Boehme *DOSIS & DOSIS 3D: Long term dose monitoring onboard the Columbus Laboratory of the International Space Station (ISS)* J. Space Weather Space Clim., 6, A39, 2016, https://doi.org/10.1051/swsc/2016034

Berger et al. (2026) The radiation environment in the Columbus laboratory of the ISS: from 2009 – to 2025 (4986 days of measurements) ***JSWSC***



# DOSIS 3D: Dose Distribution Inside the ISS 3D

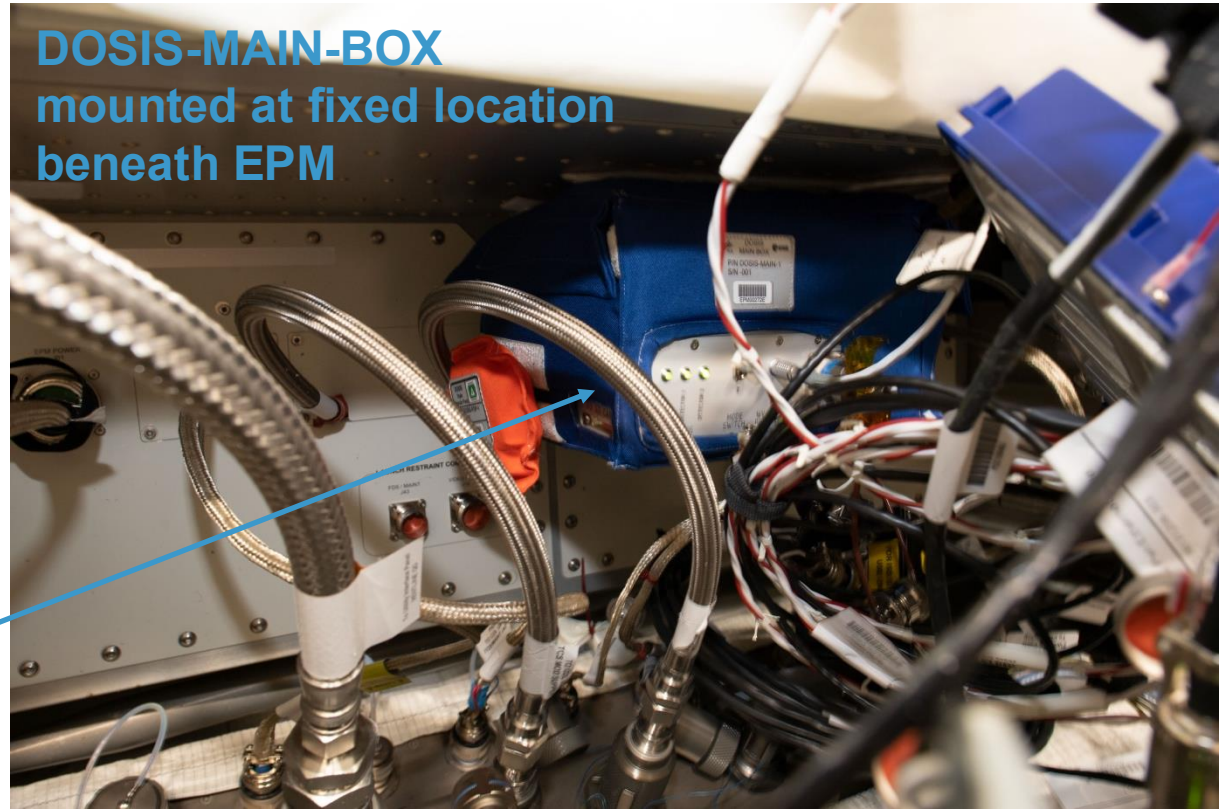
**Experiment aim:** to measure the radiation dose in Columbus with **two active (DOSTEL-1/-2)** and eleven passive radiation detectors (PDP)




**Days of data since 2009:**
9208

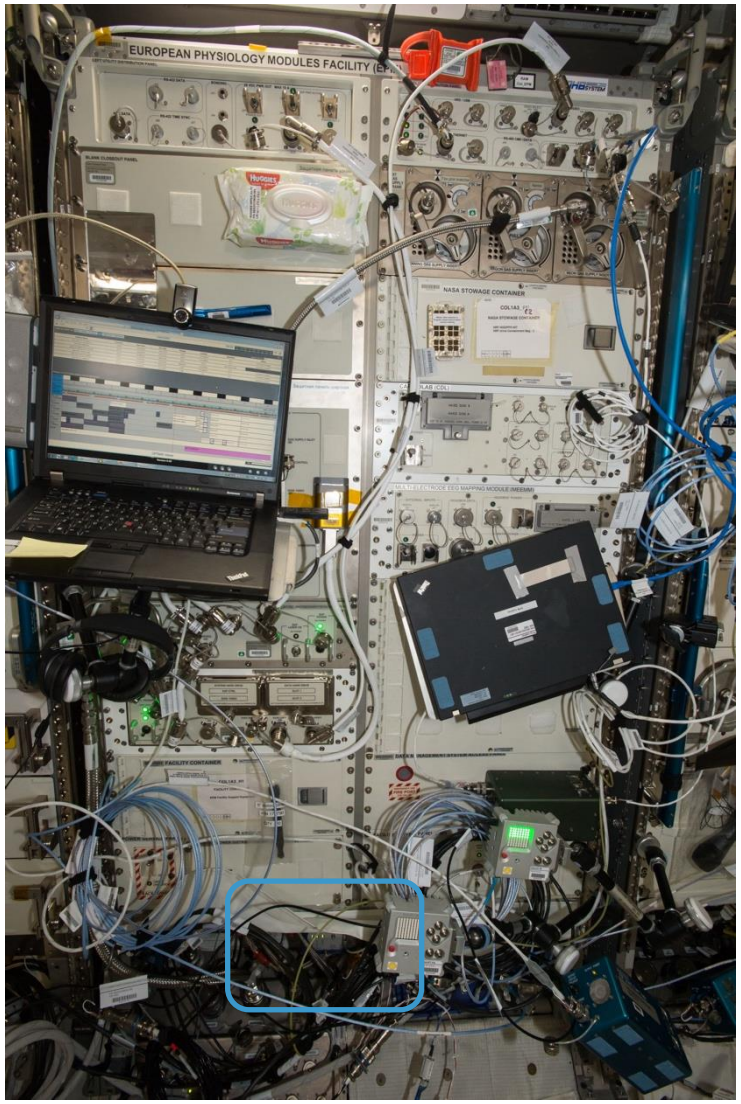
**DOSTEL-1:** 4268
**DOSTEL-2:** 4940

**Date:**
06 August 2026



# DOSIS 3D: Dose Distribution Inside the ISS 3D

**Experiment aim:** to measure the radiation dose in Columbus with **two active (DOSTEL-1/-2)** and eleven passive radiation detectors (PDP)




**Days of data since 2009:**
9208

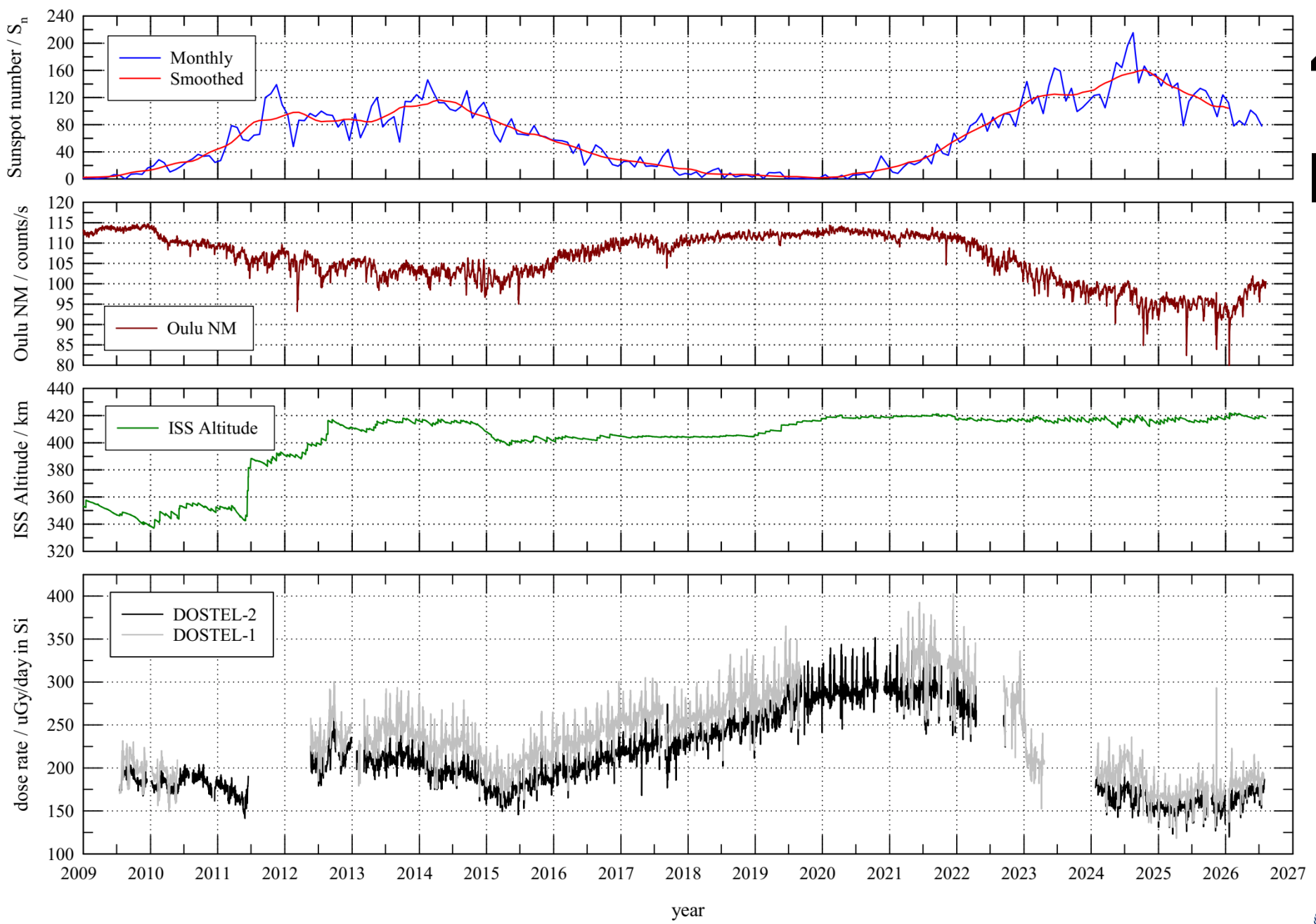
**DOSTEL-1:** 4268
**DOSTEL-2:** 4940

**Date:**
06 August 2026

| | | DOSTEL-2 | DOSTEL-1 | DOSTEL-1 + DOSTEL-2 |
|---|---|---|---|---|
| DOSIS | Start | 17.07.2009 | 17.07.2009 | |
| | End | 16.06.2011 | 27.05.2010 | |
| | | | | |
| | Days of data DOS | 644 | 290 | 934 |
| | | | | |
| DOSIS 3D | Start | 21.05.2012 | 21.05.2012 | |
| | | | | |
| | Days of data D3D (Download#156) | 4296 | 3978 | 8274 |
| | Download #156: 06 August 2026 | | | |
| | | | | |
| | **Days of data DOS & D3D (Total)** | **4940** | **4268** | **9208** |

# Results:

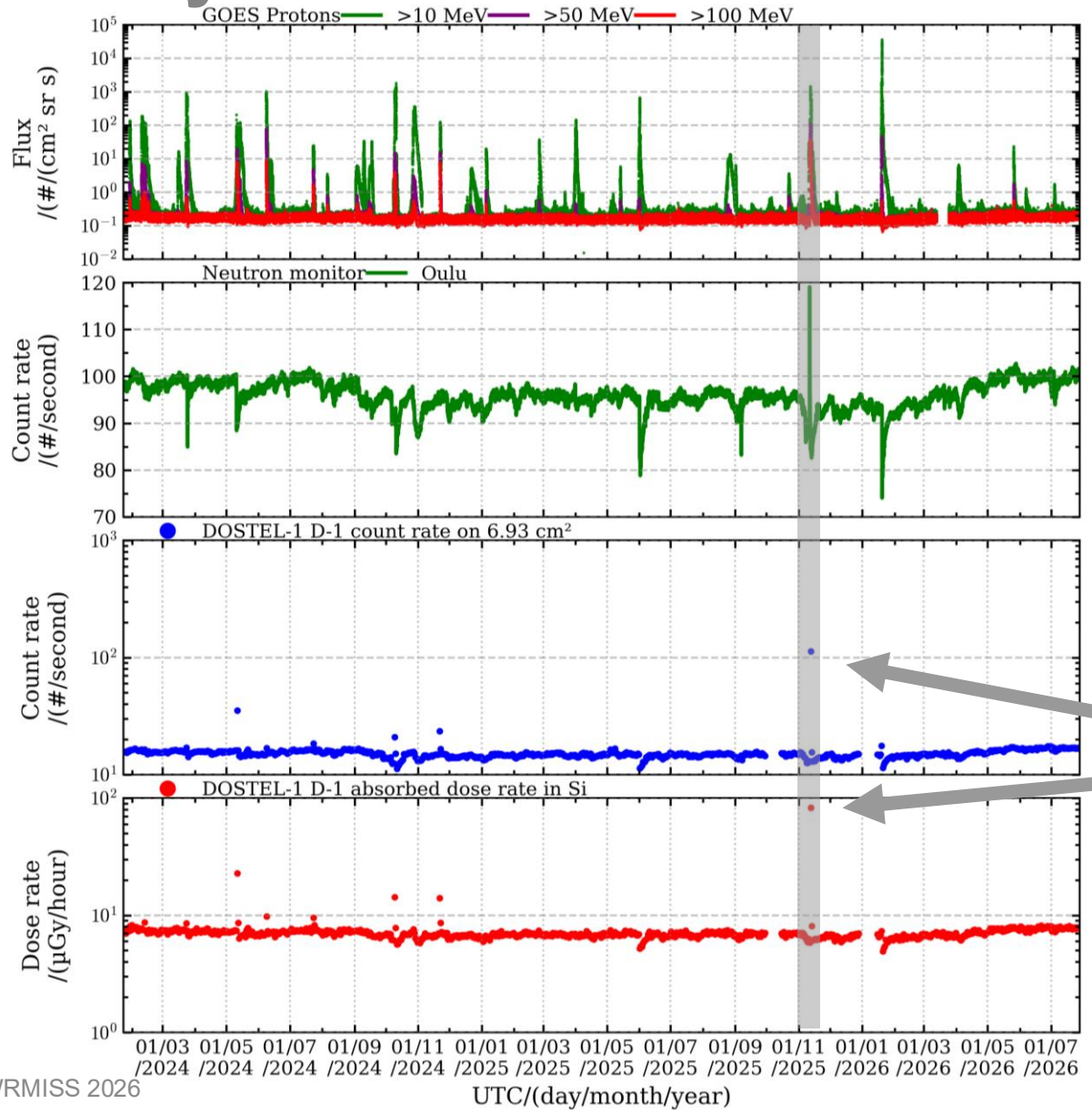
## DOSIS
## *DOSTEL-1*
## *DOSTEL-2*
## +
## DOSIS 3D
## *DOSTEL-1*
## *DOSTEL-2*
## *(#156)*




Absorbed dose rate (µGy/day) in Si

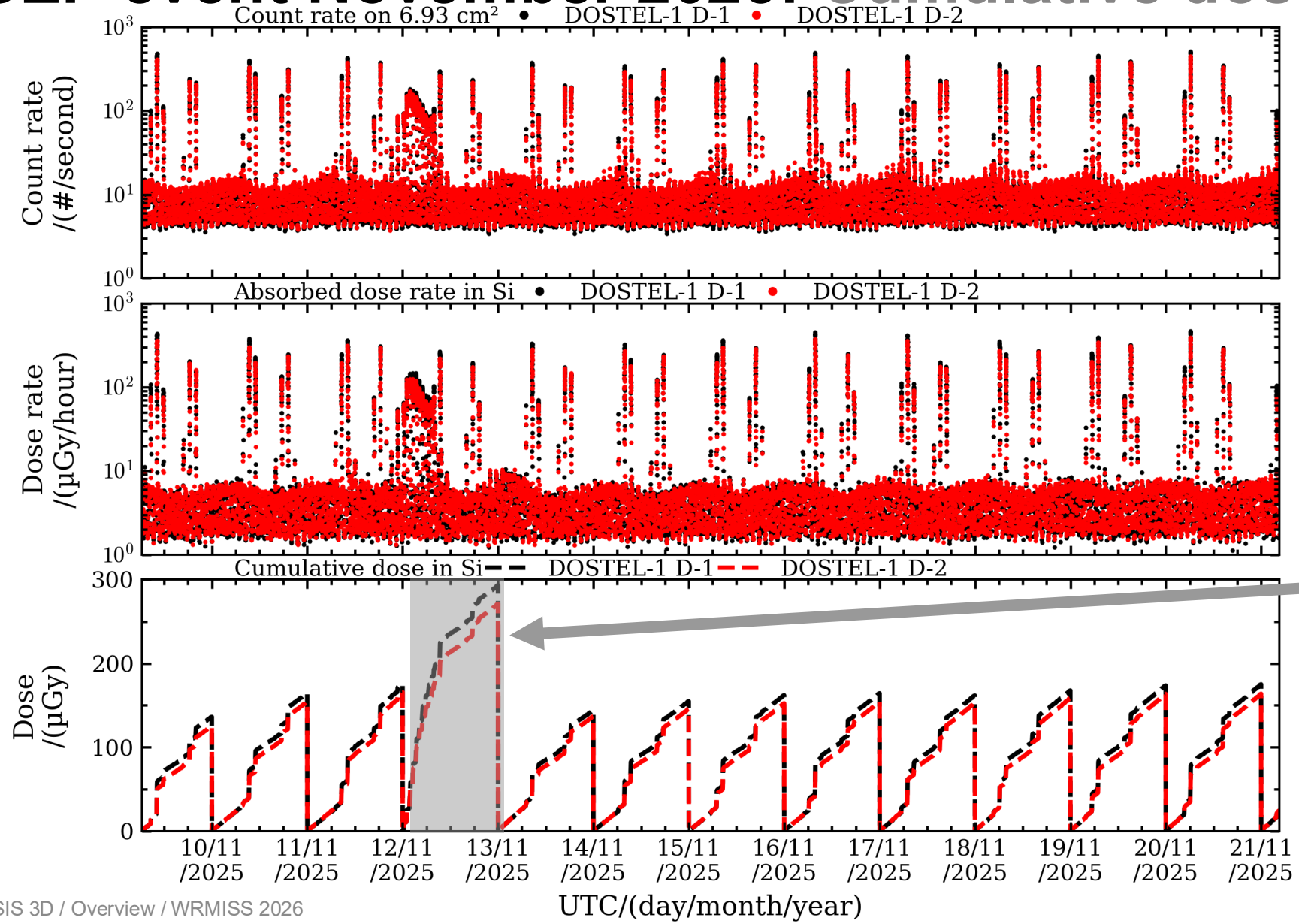
Matthiä, D., Burmeister, S., Przybyla, B., Berger, T. (2023) Active radiation measurements over one solar cycle with two DOSTEL instruments in the Columbus laboratory of the International Space Station. Life Sciences in Space Research, 39, 14-25. https://doi.org/10.1016/j.lssr.2023.04.002

# DOSTEL: Daily count- and dose rate $R_c$ < 0.5 GV



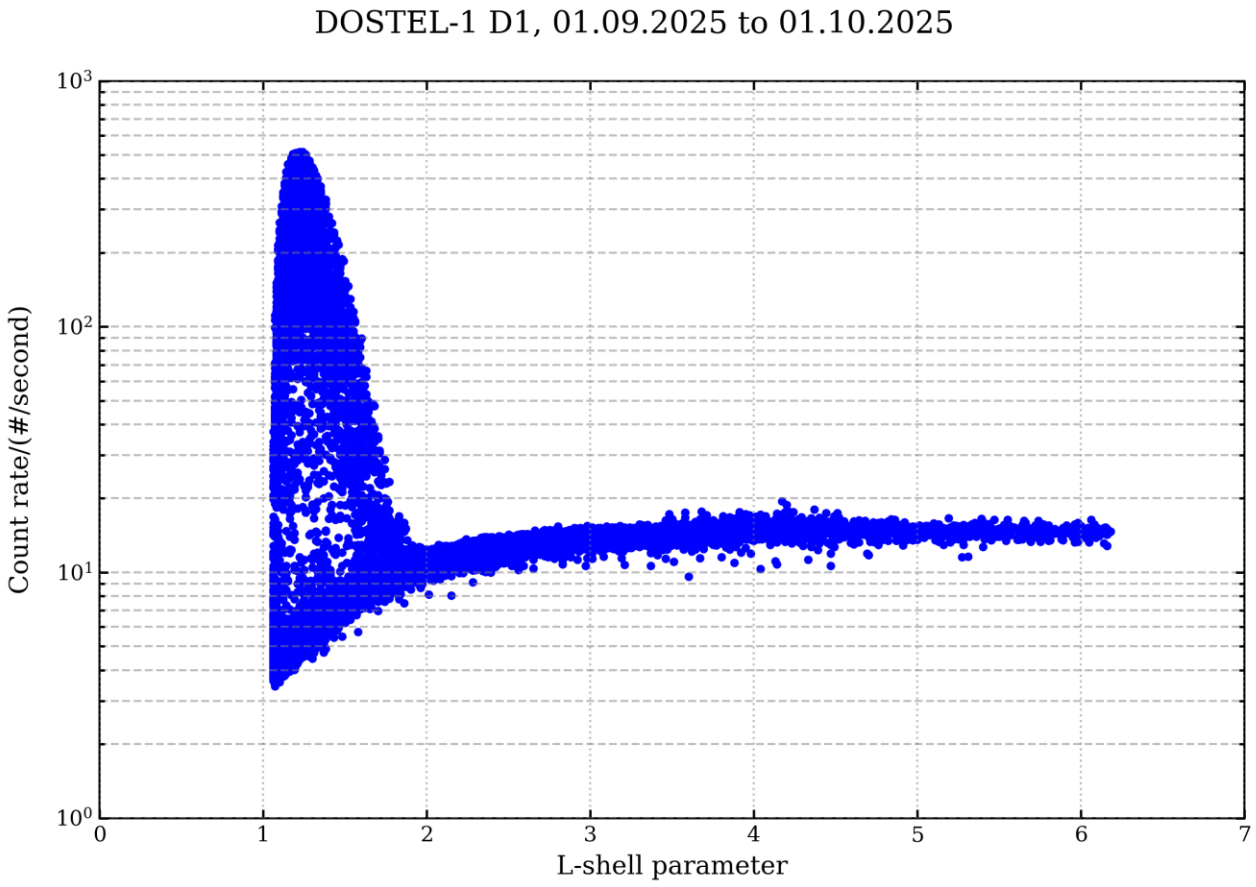

huge increase in count- and dose rate in November 2025

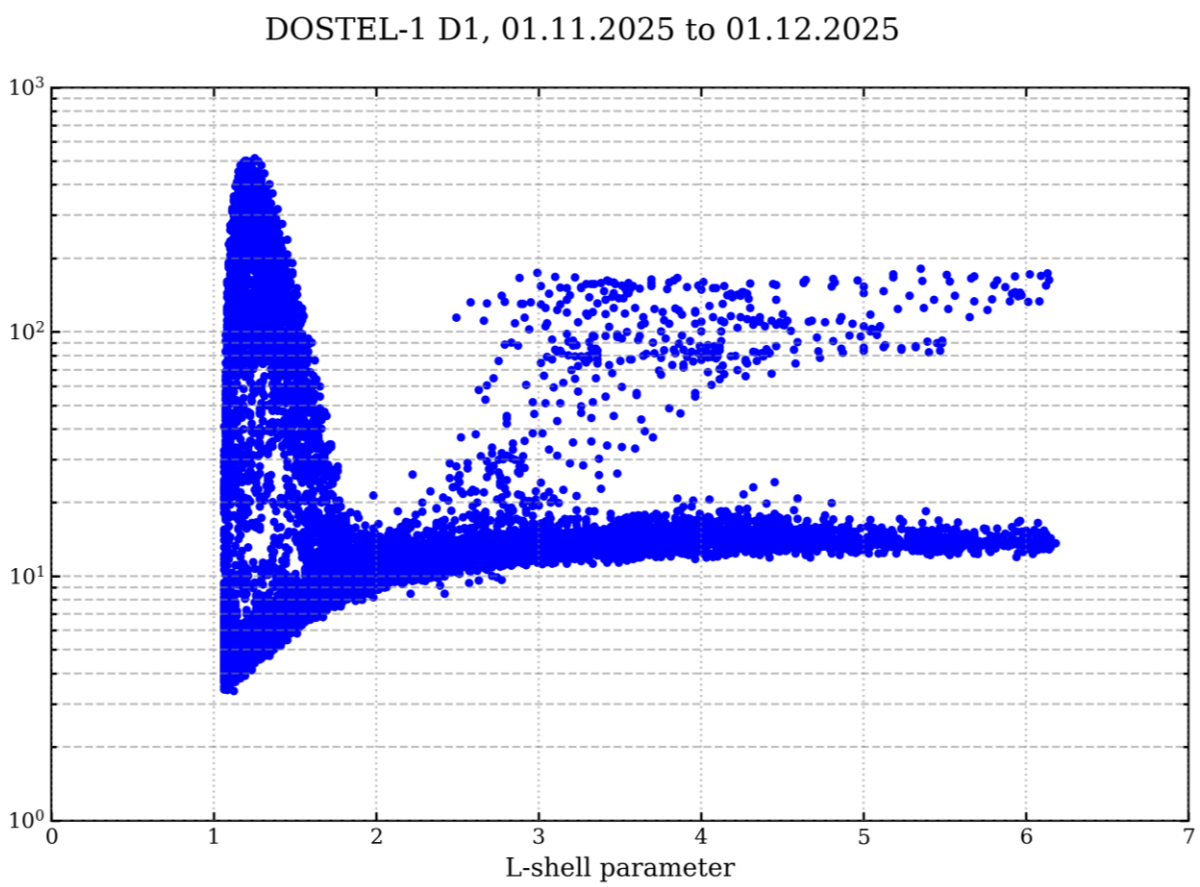
# SEP event November 2025: Cumulative dose



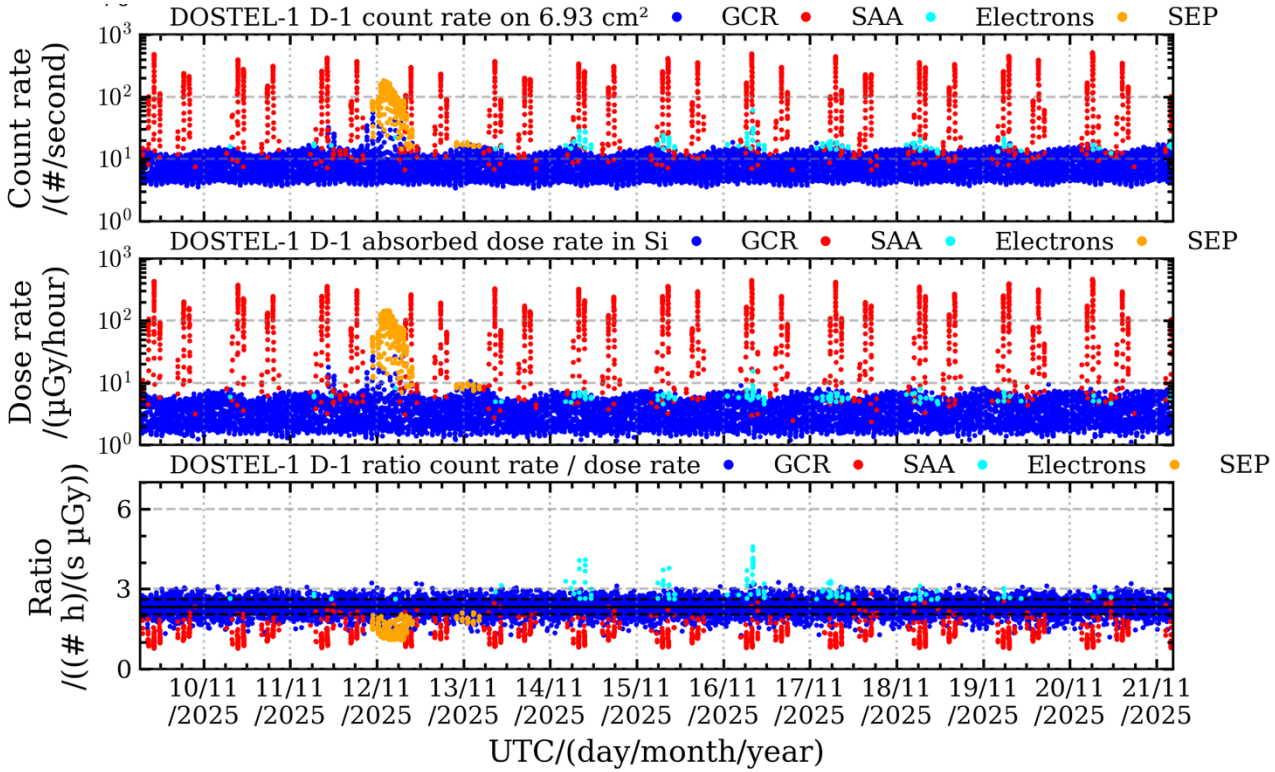

Approx. double the daily dose
~150µGy → ~300µGy

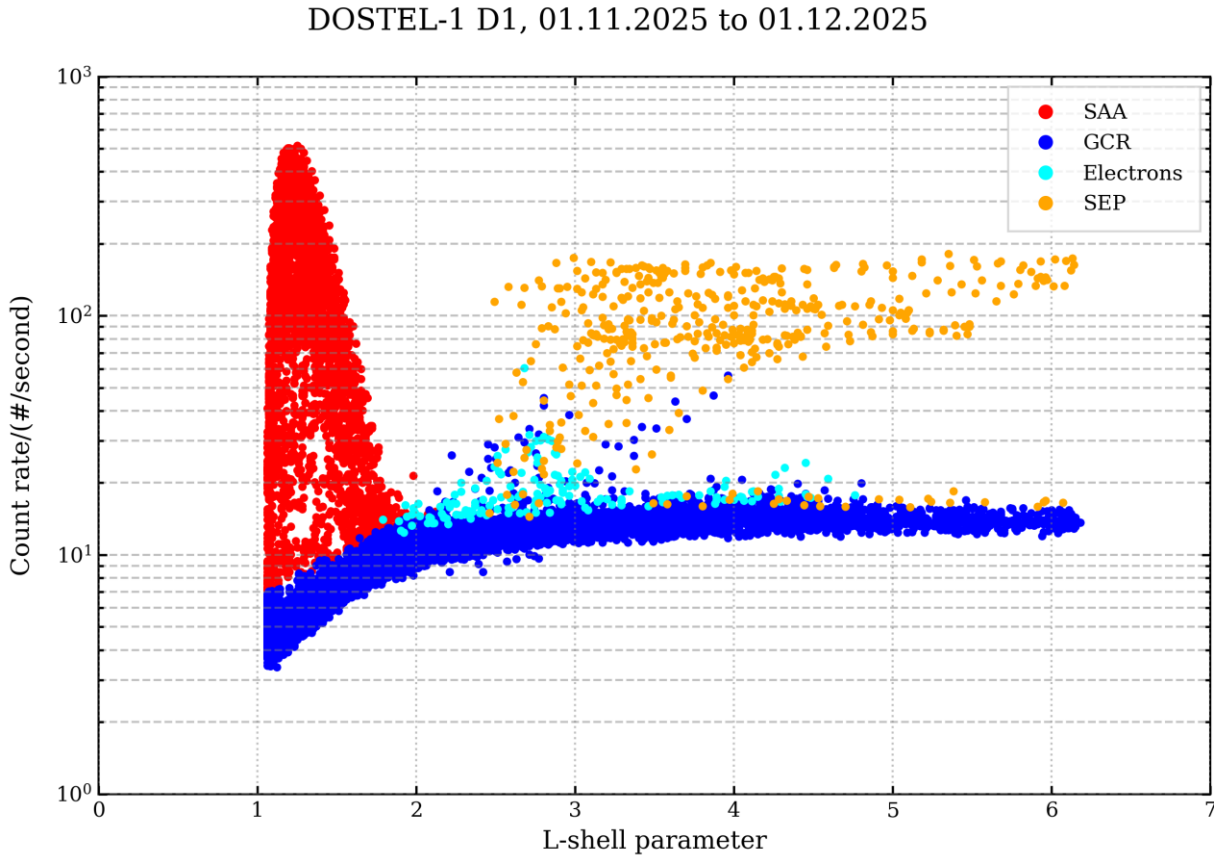
# SEP event November 2025: Count rate vs L-Shell



# SEP event November 2025: Separation



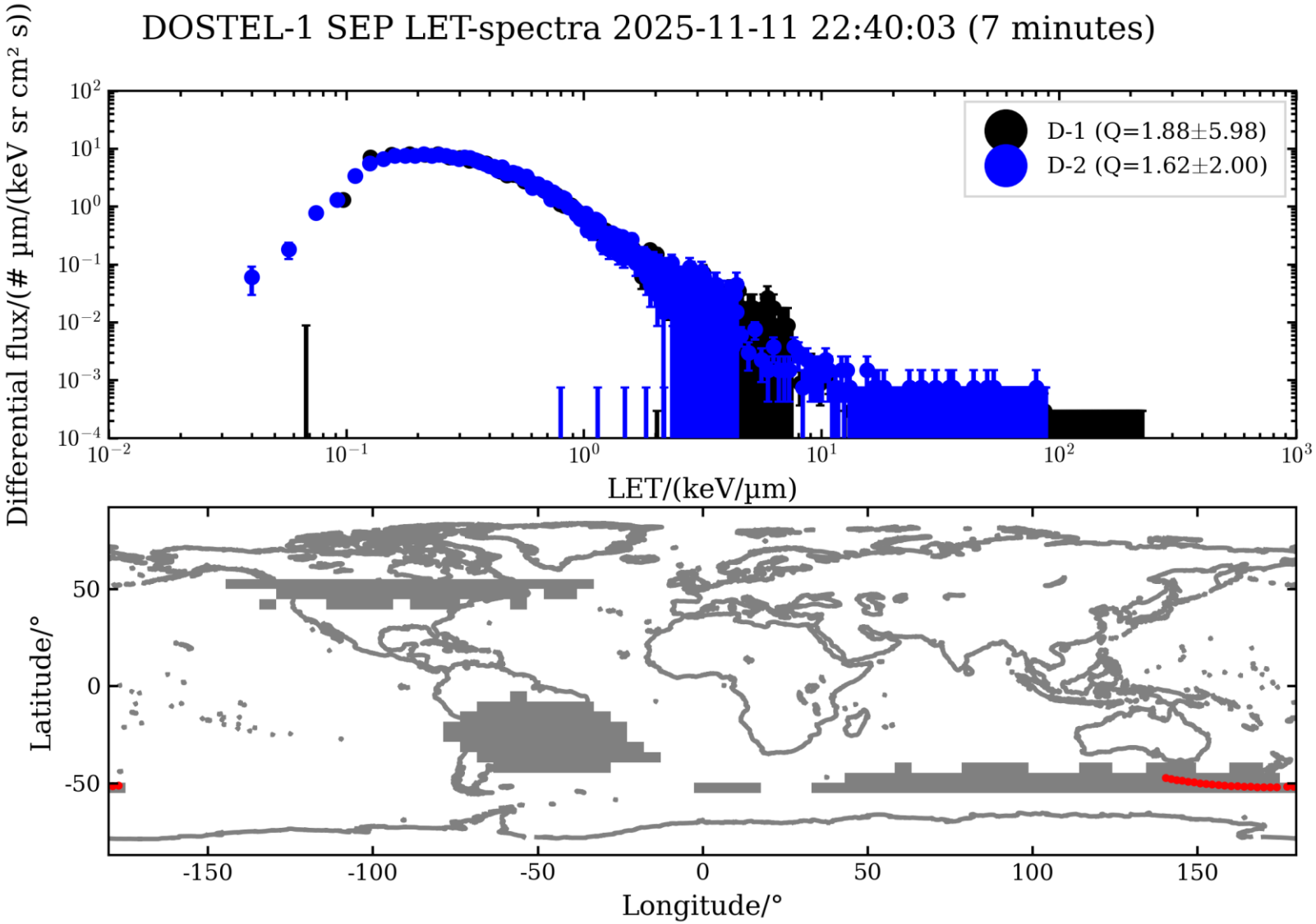




## SEP Dose:

SEP + GCR background→ 184 micro Gray in Si

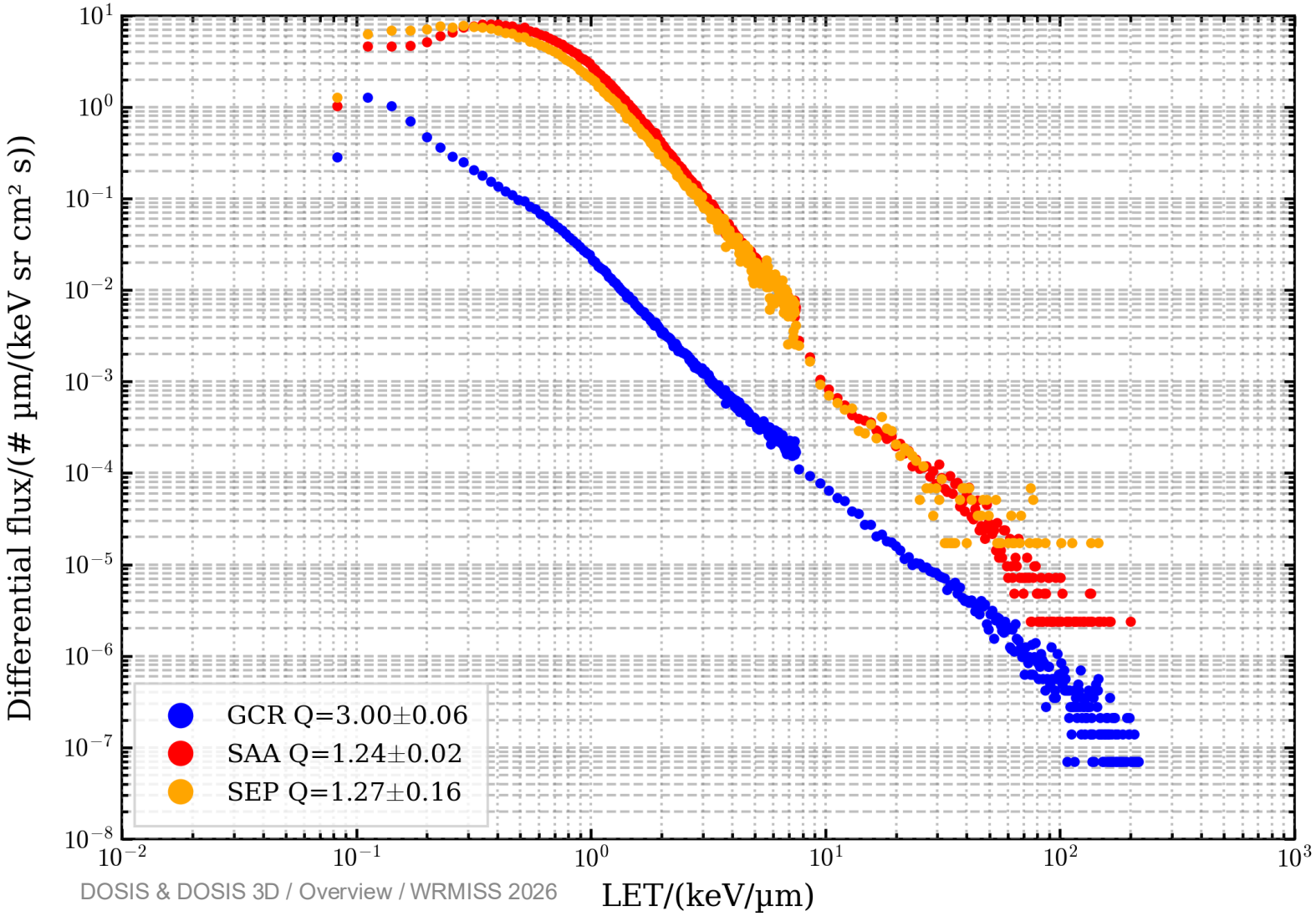
SEP - GCR background → 163 micro Gray in Si

# SEP event November 2025: SEP spectra



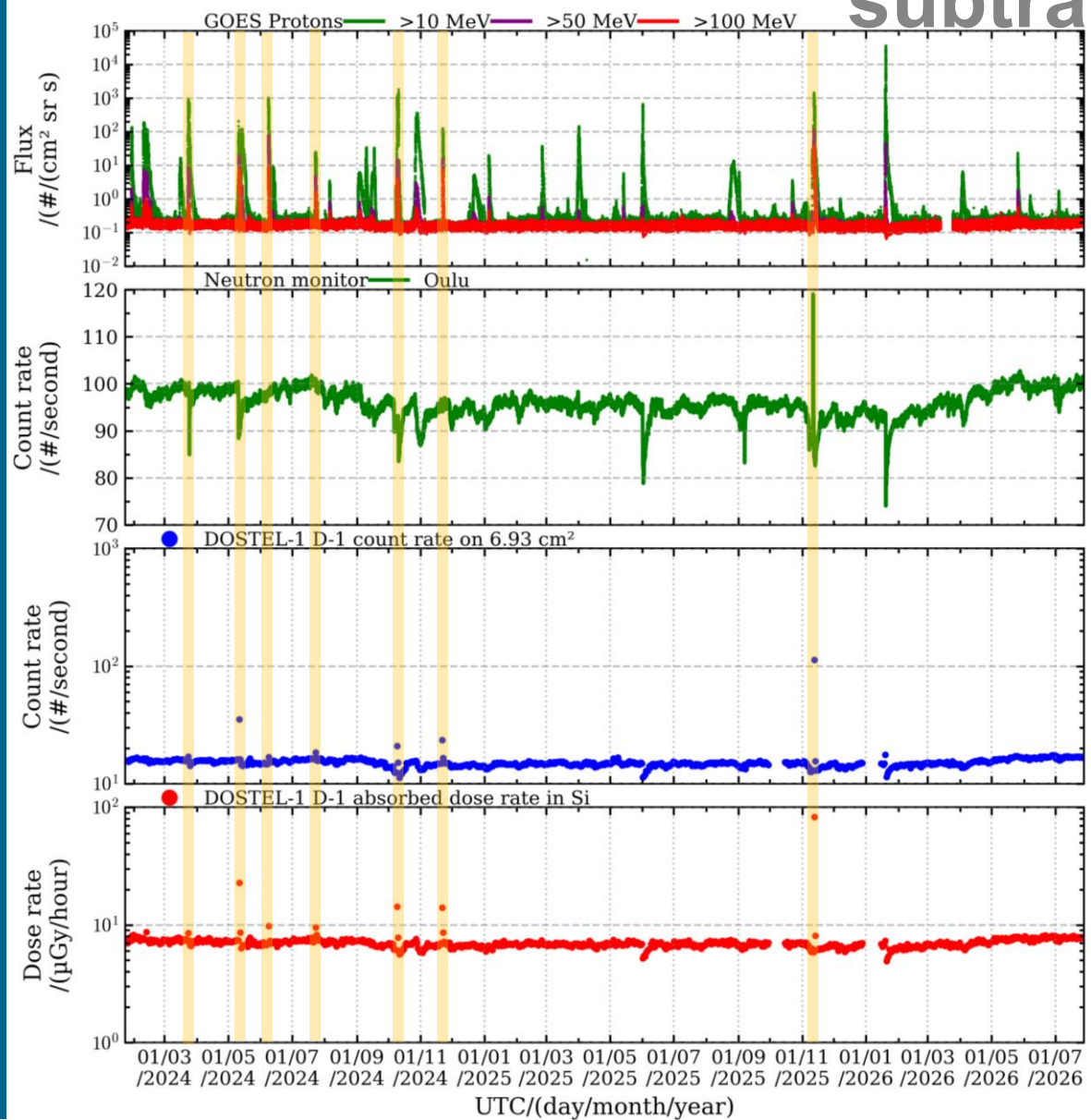
# SEP event November 2025: SEP spectra

DOSTEL-1 D-1 LET-spectra from 2025-11-01 to 2025-11-30



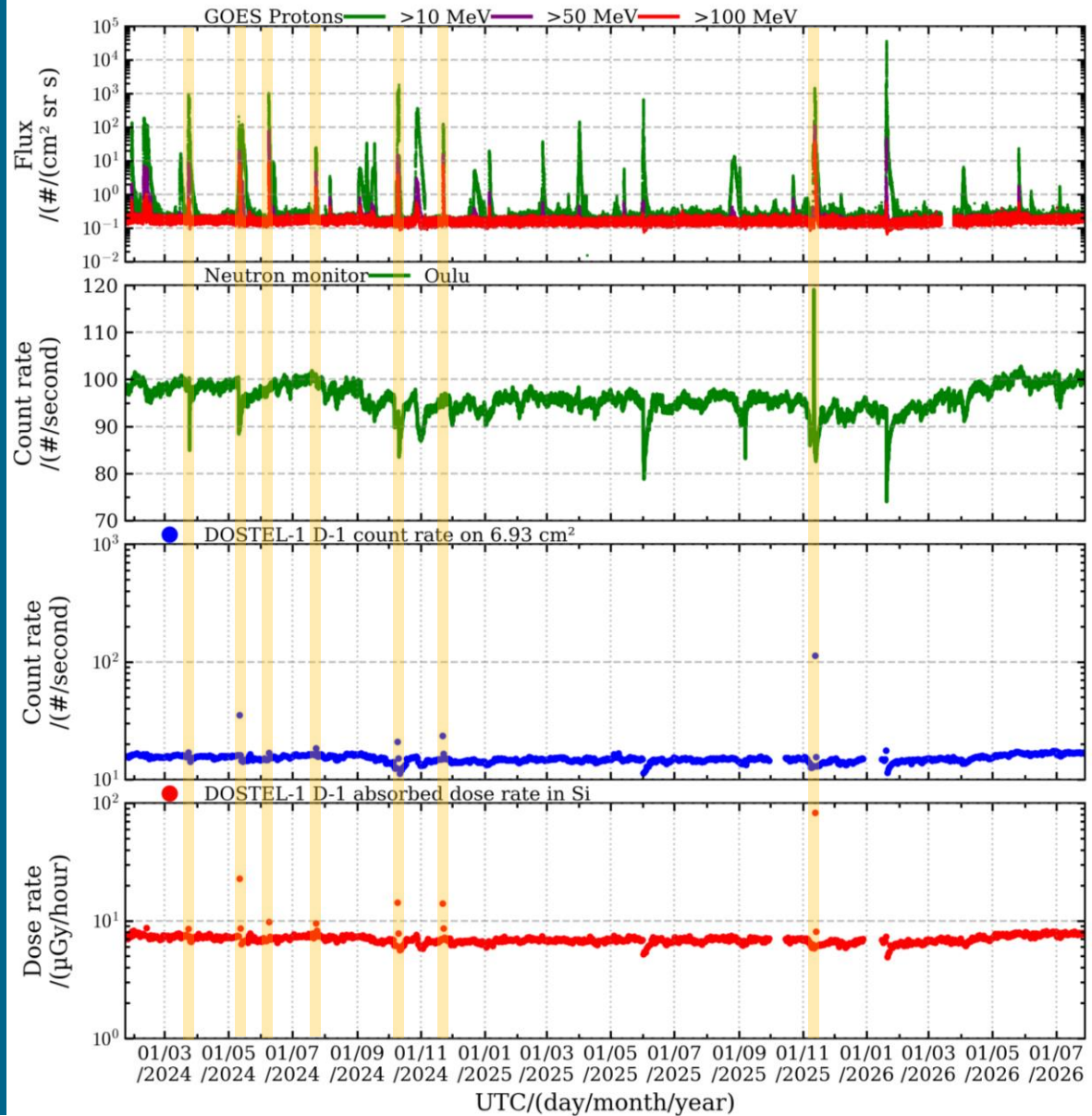

| | Absorbed dose in Si/µGy | Dose equivalent in $H_2O$/µSv |
|---|---|---|
| SEP + GCR background | 184 | 282.8 |
| GCR background | 21 | 76.2 |
| SEP (GCR background subtracted) | 163 | 250.5 |

# SEP events: Dose – without GCR background subtraction



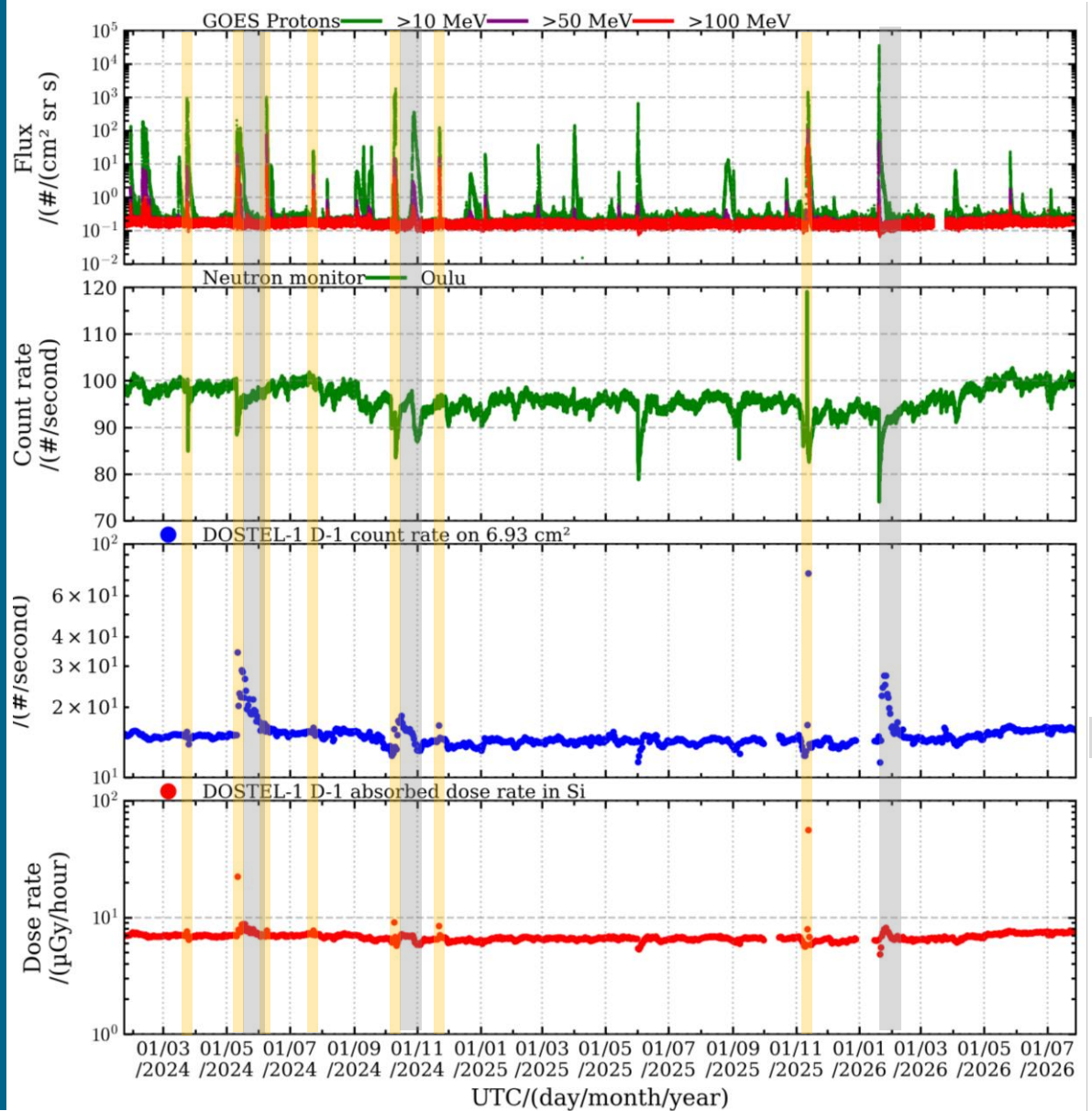

| No GCR background subtracted | Absorbed dose in $H_2O$/µGy | Dose equivalent in $H_2O$/µSv |
|---|---|---|
| 23.03.24 | 4.4 | 6.3 |
| 11.05.24 | 88.9 | 128 |
| 08.06.24 | 1.9 | 2.8 |
| 23.07.24 | 2.3 | 3.3 |
| 09.10.24 | 23.7 | 34.1 |
| 21.11.24 | 17.8 | 25.6 |
| 12.11.25 | 222.6 | 282.8 |
| **Total** | **361.6** | **481.8** |

# SEP events: Dose – GCR background subtracted



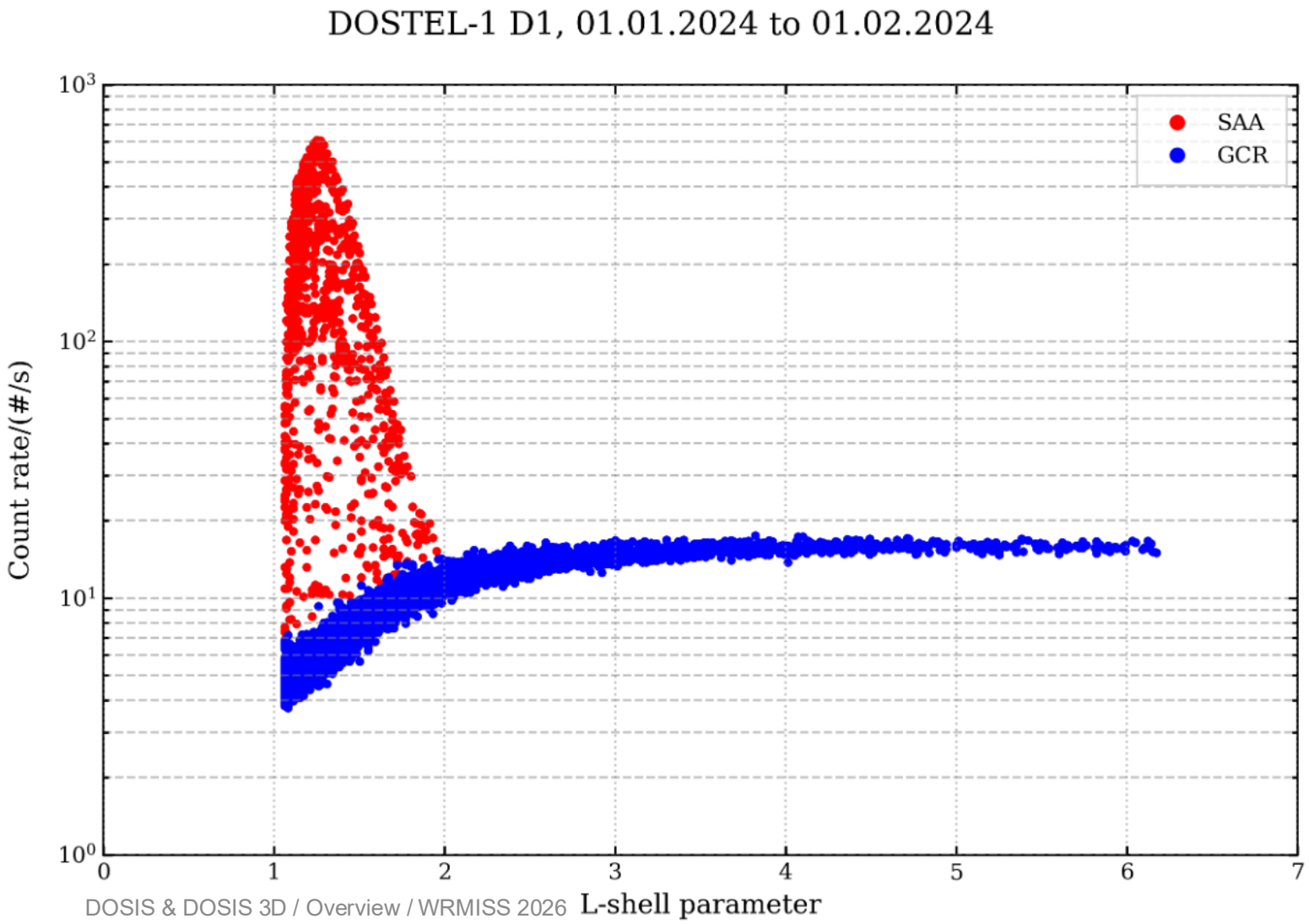

| GCR background subtracted | Absorbed dose in $H_2O$/µGy | Dose equivalent in $H_2O$/µSv |
|---|---|---|
| 23.03.24 | 1.2 | 1.7 |
| 11.05.24 | 65.6 | 94.5 |
| 08.06.24 | 0.7 | 1 |
| 23.07.24 | 0.8 | 1.2 |
| 09.10.24 | 11.3 | 16.3 |
| 21.11.24 | 9.3 | 13.4 |
| 12.11.25 | 197.2 | 250.5 |
| **Total** | **286.1** | **378.6** |

# DOSTEL: Daily count- and dose rate $R_c$ < 2 GV



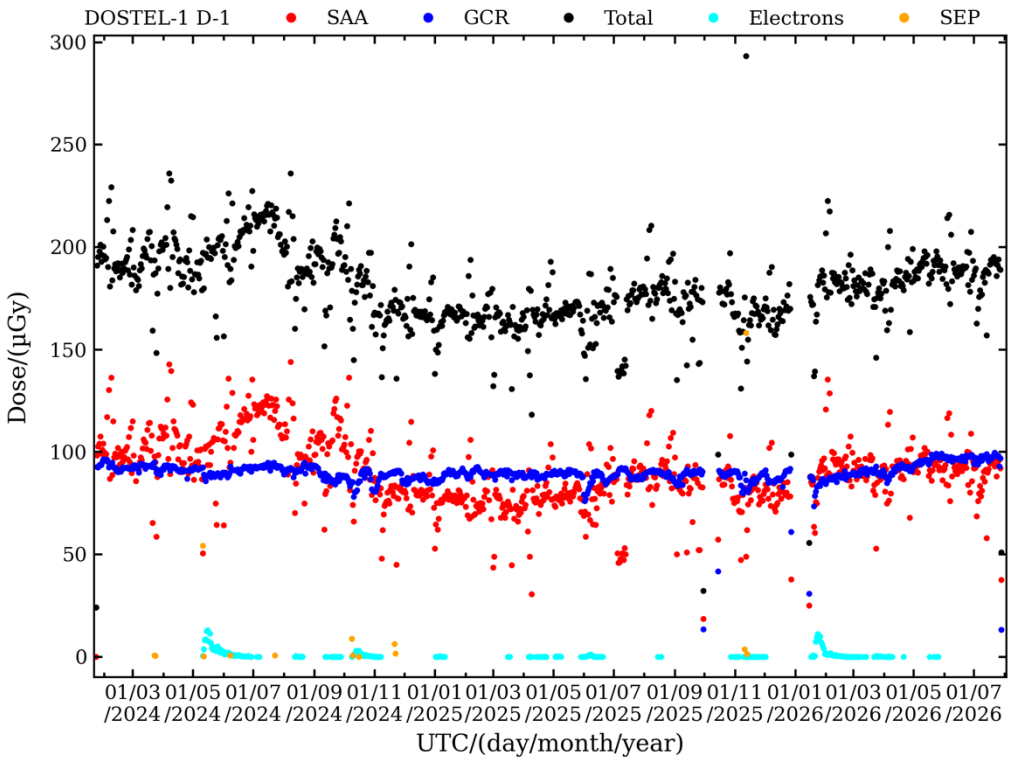

Time periods with high count- & low dose rates:
→ Bremsstrahlung - Slot-Belt-Electrons

# Slot-Belt-Electrons (2024 – 2026): Dose




| 278 days | Absorbed dose in $H_2O$/µGy |
|---|---|
| Electrons + GCR background | 984 |
| GCR background | 678.4 |
| Electrons (GCR background subtracted) | 305.6 |

# Results for 2024 – 2026: Dose - GCR background subtracted



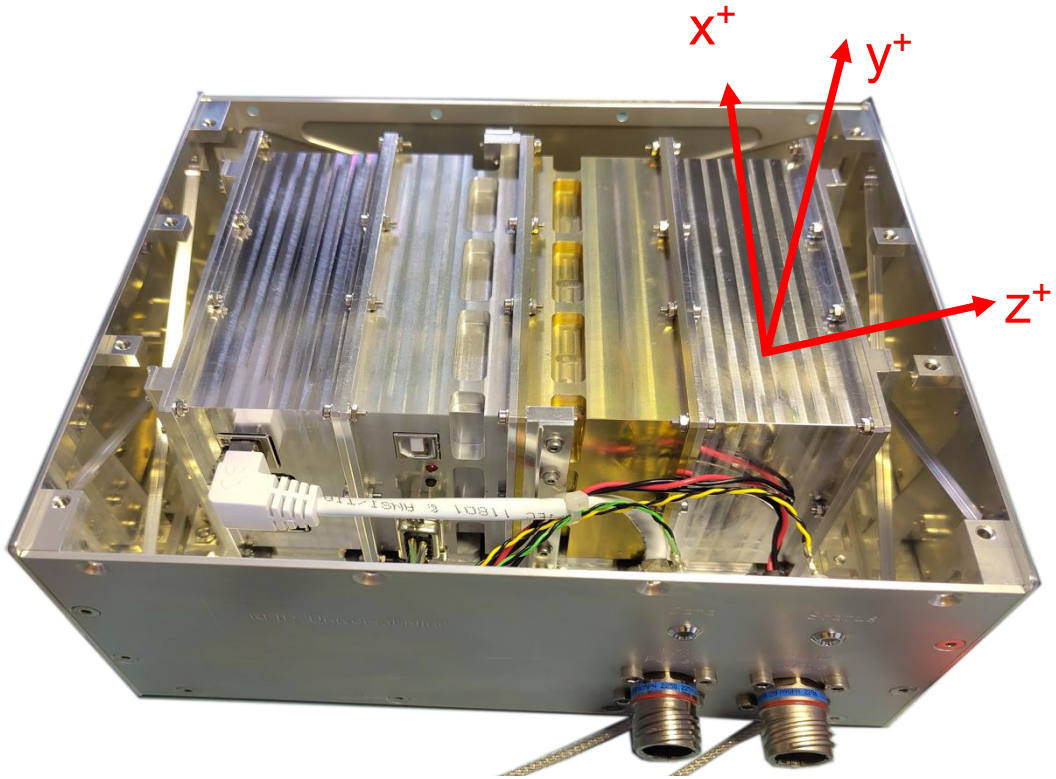

| 24.01.2024 - 29.07.2026 (916 days) | SAA | GCR | Electrons | SPEs | Total |
|---|---|---|---|---|---|
| Absorbed dose in $H_2O$/mGy | 96.1 | 96.1 | 0.31 | 0.29 | 192.8 |
| Qualityfactor | 1.2 | 3. | TBD | 1.44 (May 24) 1.27 (Nov. 25) | / |
| Dose equivalent in $H_2O$/mSv | 115.3 | 288.3 | TBD | 0.41 | 404 |

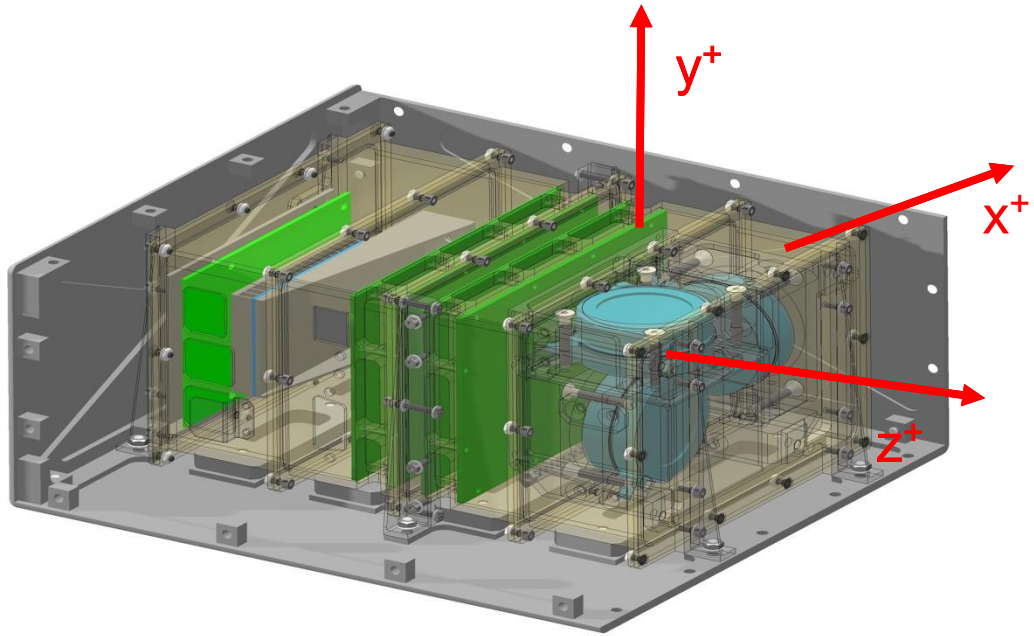
# DOSTEL 3D

## Improvements

- Three telescopes (xyz-configuration)
- Time synchronisation
- Real time data
- Single particles (no manual mode switch)



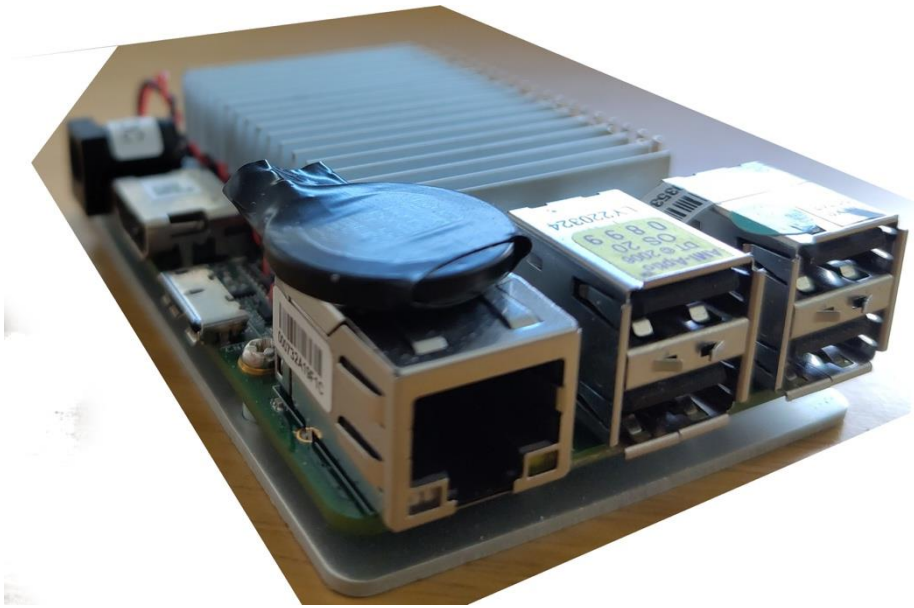



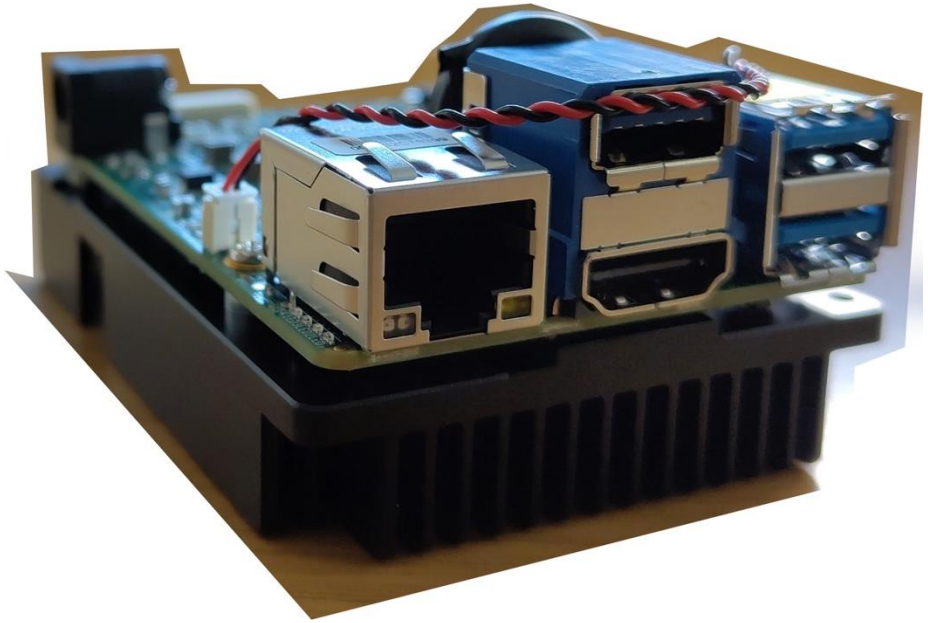



# DOSTEL 3D

**Problem previous concept design:** OBC end of life

| | Previous OBC | New OBC |
|---|---|---|
| Name | UP Board | UP 7000 |
| Processor | Intel Atom x5-Z8350 (end of life) | Intel N100 (formerly Alder Lake-N) |
| Power Consumption* | 13 W | 30 – 36 W |

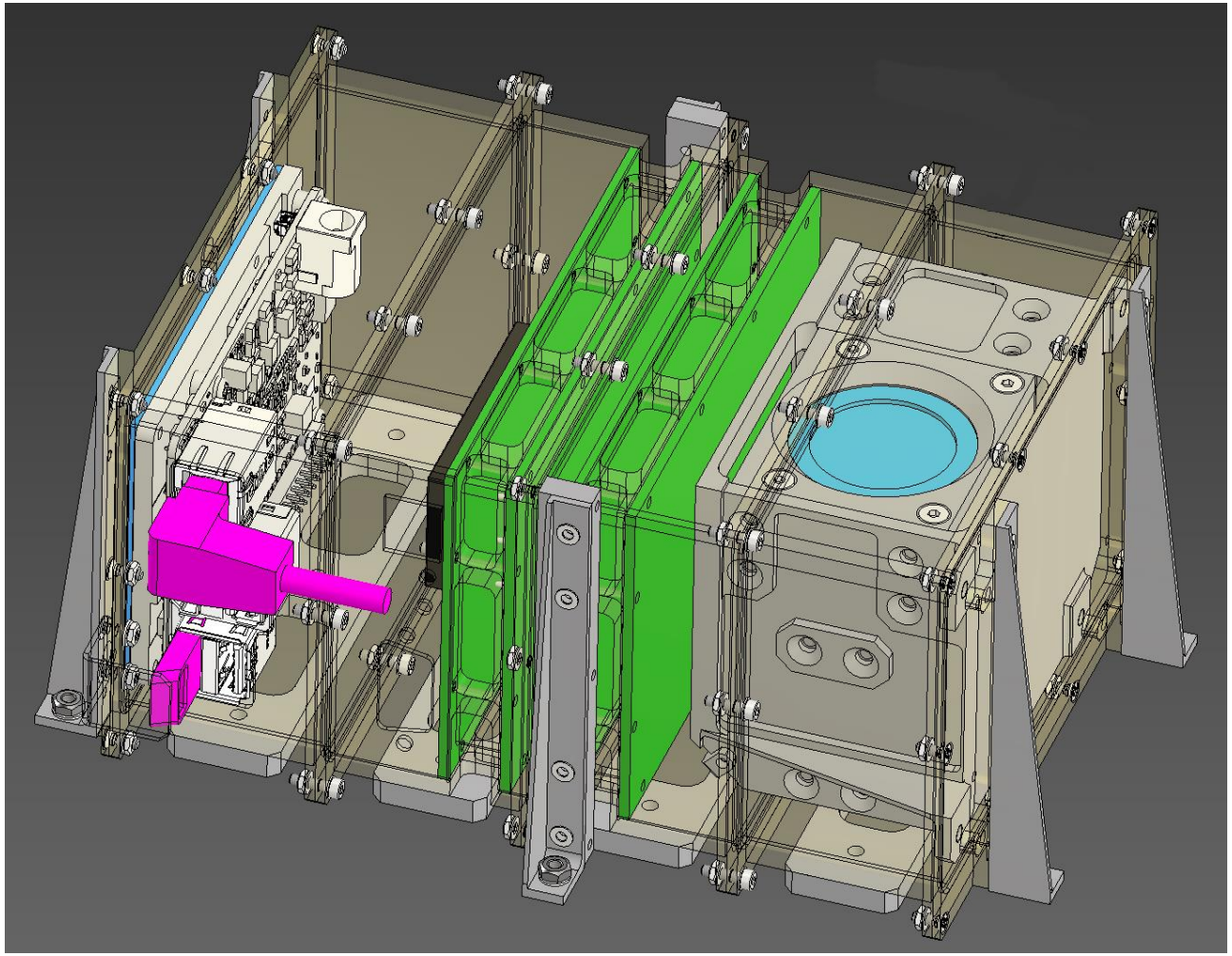




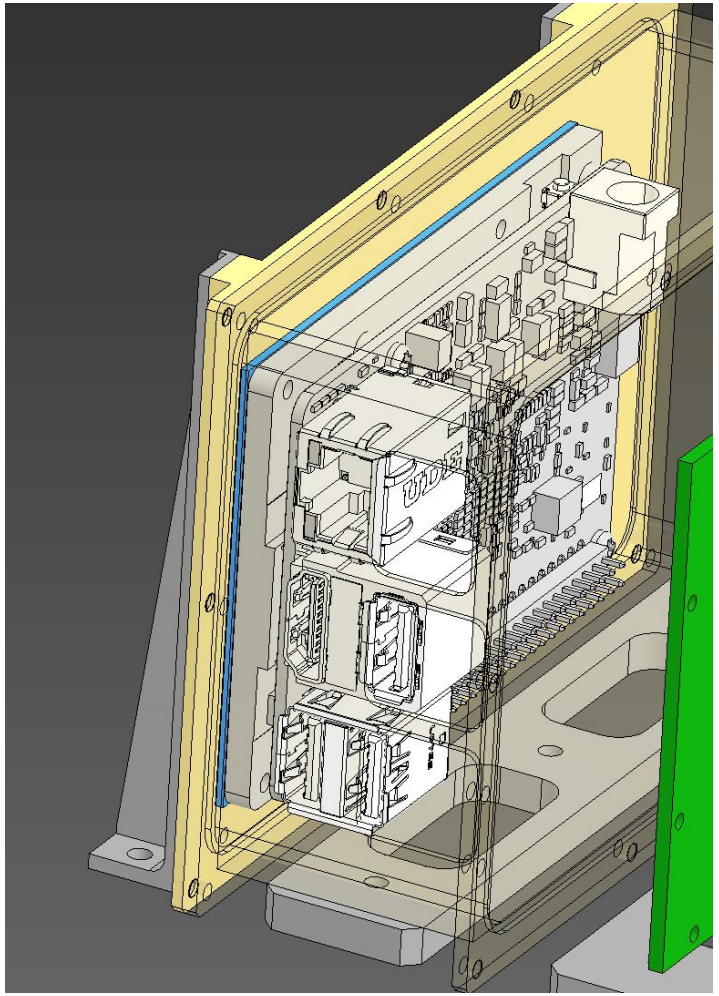
* accordingly to manufacturer

# DOSTEL 3D

## New concept design: Adjusting mechanics



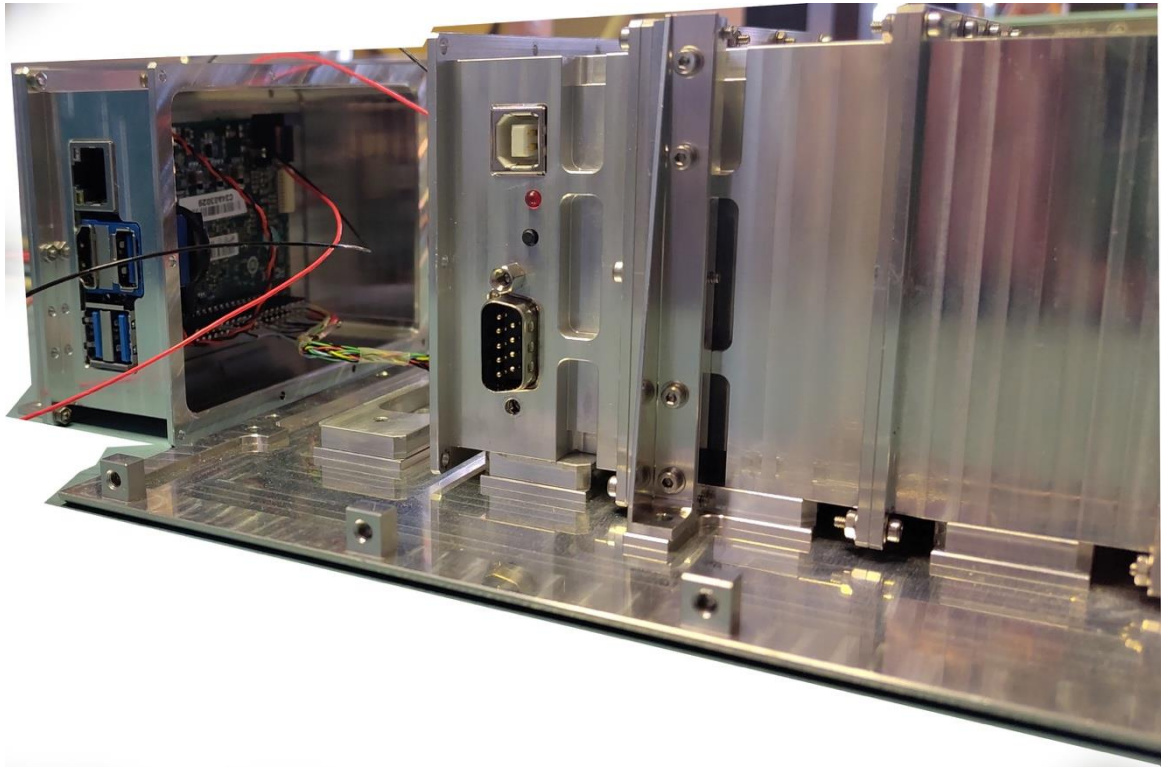
New OBC heatspreader opposing side



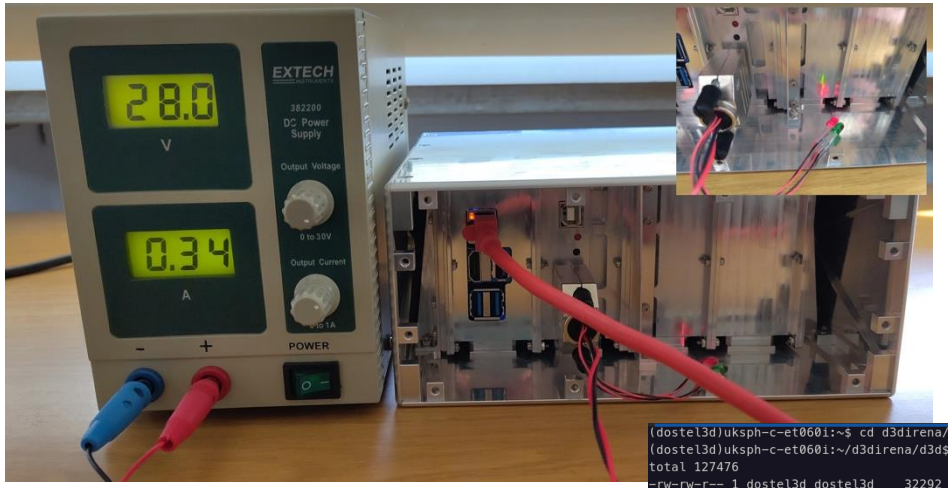
Close up: new OBC

# DOSTEL 3D

## New OBC: Integrating new OBC & data connection test



Integrating new OBC




Power on DOSTEL3D

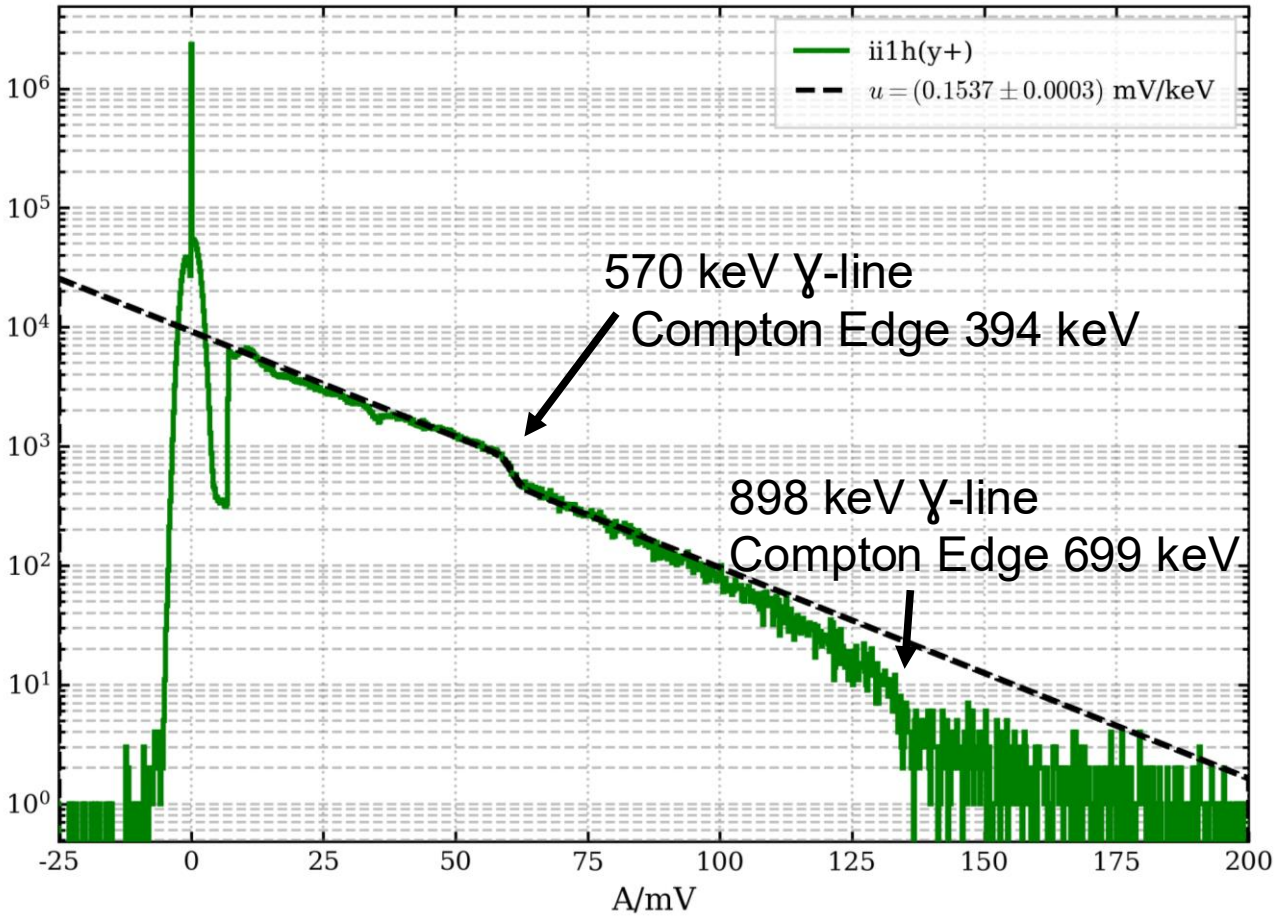
```
(dostel3d)uksph-c-et060i:~$ cd d3direna/d3d/
(dostel3d)uksph-c-et060i:~/d3direna/d3d$ ll
total 127476
-rw-rw-r-- 1 dostel3d dostel3d    32292 Mär 11 18:02 irena-2026-03-11T16:06:48Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   174908 Mär 11 18:02 irena-2026-03-11T16:06:48Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    34653 Mär 11 19:02 irena-2026-03-11T17:02:06Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   193174 Mär 11 19:02 irena-2026-03-11T17:02:06Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    34389 Mär 11 20:02 irena-2026-03-11T18:02:04Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   191810 Mär 11 20:02 irena-2026-03-11T18:02:04Z.dat
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-rw-rw-r-- 1 dostel3d dostel3d    34304 Mär 11 22:02 irena-2026-03-11T20:02:01Z.hst
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-rw-rw-r-- 1 dostel3d dostel3d    34331 Mär 11 23:02 irena-2026-03-11T21:02:06Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   189504 Mär 11 23:02 irena-2026-03-11T21:02:06Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    34313 Mär 12 00:02 irena-2026-03-11T22:02:01Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   194876 Mär 12 00:02 irena-2026-03-11T22:02:01Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    34345 Mär 12 01:02 irena-2026-03-11T23:02:03Z.hst
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-rw-rw-r-- 1 dostel3d dostel3d    34238 Mär 12 05:02 irena-2026-03-12T03:02:03Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   184172 Mär 12 05:02 irena-2026-03-12T03:02:03Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    34097 Mär 12 06:02 irena-2026-03-12T04:02:03Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   187940 Mär 12 06:02 irena-2026-03-12T04:02:03Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    34150 Mär 12 07:02 irena-2026-03-12T05:02:01Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   187402 Mär 12 07:02 irena-2026-03-12T05:02:01Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    34132 Mär 12 08:02 irena-2026-03-12T06:02:06Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   185454 Mär 12 08:02 irena-2026-03-12T06:02:06Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    34171 Mär 12 09:02 irena-2026-03-12T07:02:03Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   192784 Mär 12 09:02 irena-2026-03-12T07:02:03Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    34721 Mär 12 10:02 irena-2026-03-12T08:02:06Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   335514 Mär 12 10:02 irena-2026-03-12T08:02:06Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    35271 Mär 12 11:02 irena-2026-03-12T09:02:01Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   547652 Mär 12 11:02 irena-2026-03-12T09:02:01Z.dat
-rw-rw-r-- 1 dostel3d dostel3d    35381 Mär 12 12:02 irena-2026-03-12T10:02:02Z.hst
-rw-rw-r-- 1 dostel3d dostel3d   548586 Mär 12 12:02 irena-2026-03-12T10:02:02Z.dat
```

Successfully data transfer:
D3D electronics → OBC

# DOSTEL 3D: In house calibration – work in progress

Bismuth 207





# Summary & Outlook

- Since 2009 DOSTEL measures the radiation environment onboard the ISS within the Columbus laboratory.

- For the DOSTEL data from 2024 to 2026 we detected
  - at least seven SEPs events
  - And Slot-Belt-Electrons for 217 total days.

- DOSTEL 3D next steps: ESA Software Security → EMC Test @ ESA

# Acknowlegment

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