

DOSIS and DOSIS 3D – data from the DOSTEL instruments focusing on 2024 – 2025 with special emphasis on SPEs measured inside the ISS

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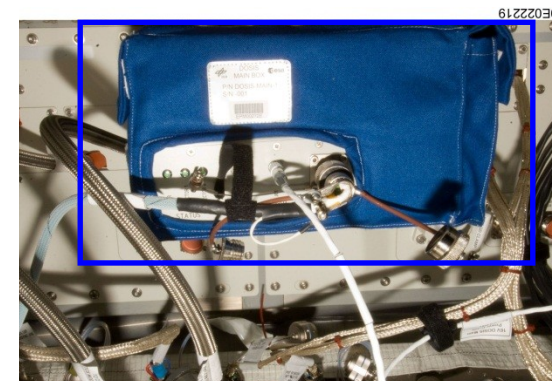
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²Institut für Luft- und Raumfahrtmedizin, DLR, Köln

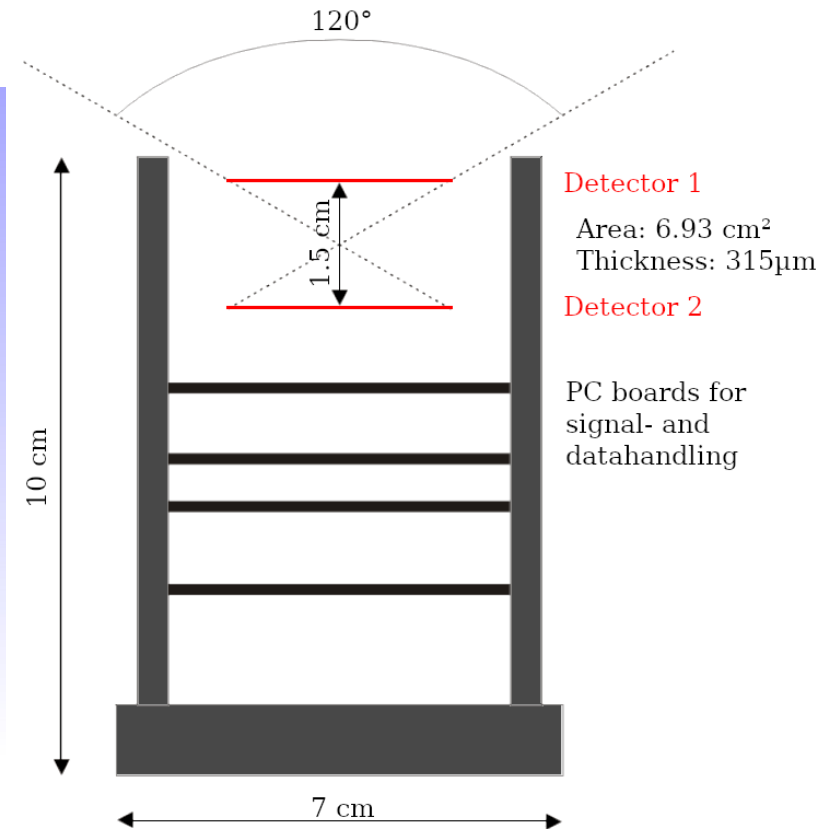
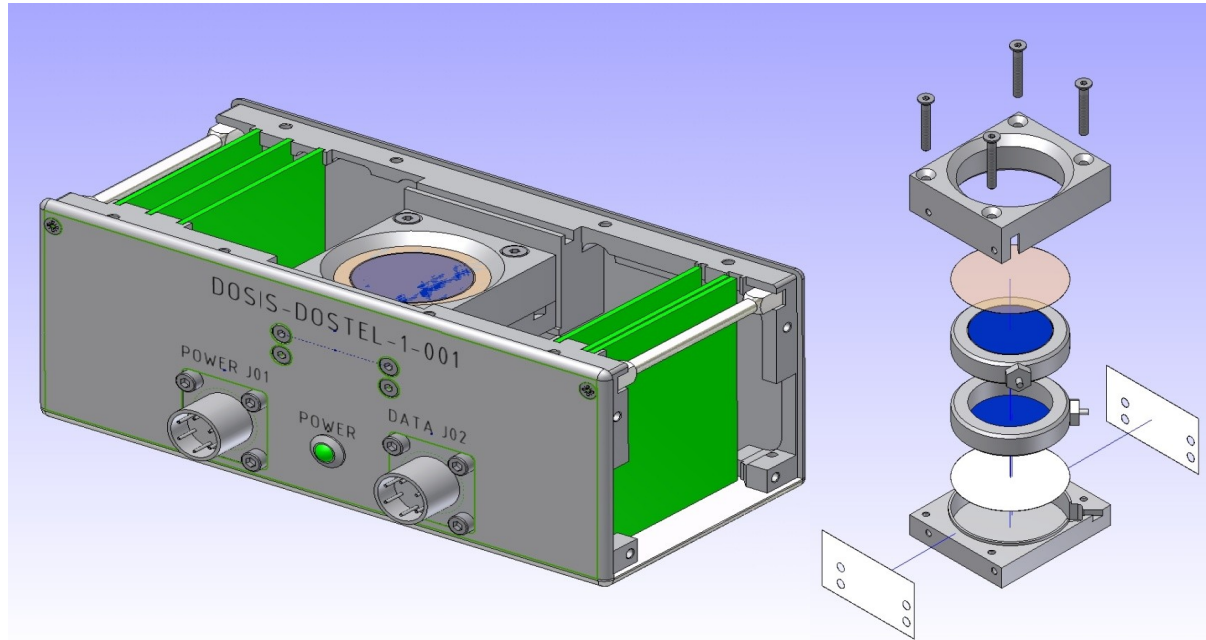
DOSIS and DOSIS 3D mission objectives

Scientific goal

- Absorbed dose and dose equivalent
- temporal and spatial dose distribution
- active and passive dosimetry detectors



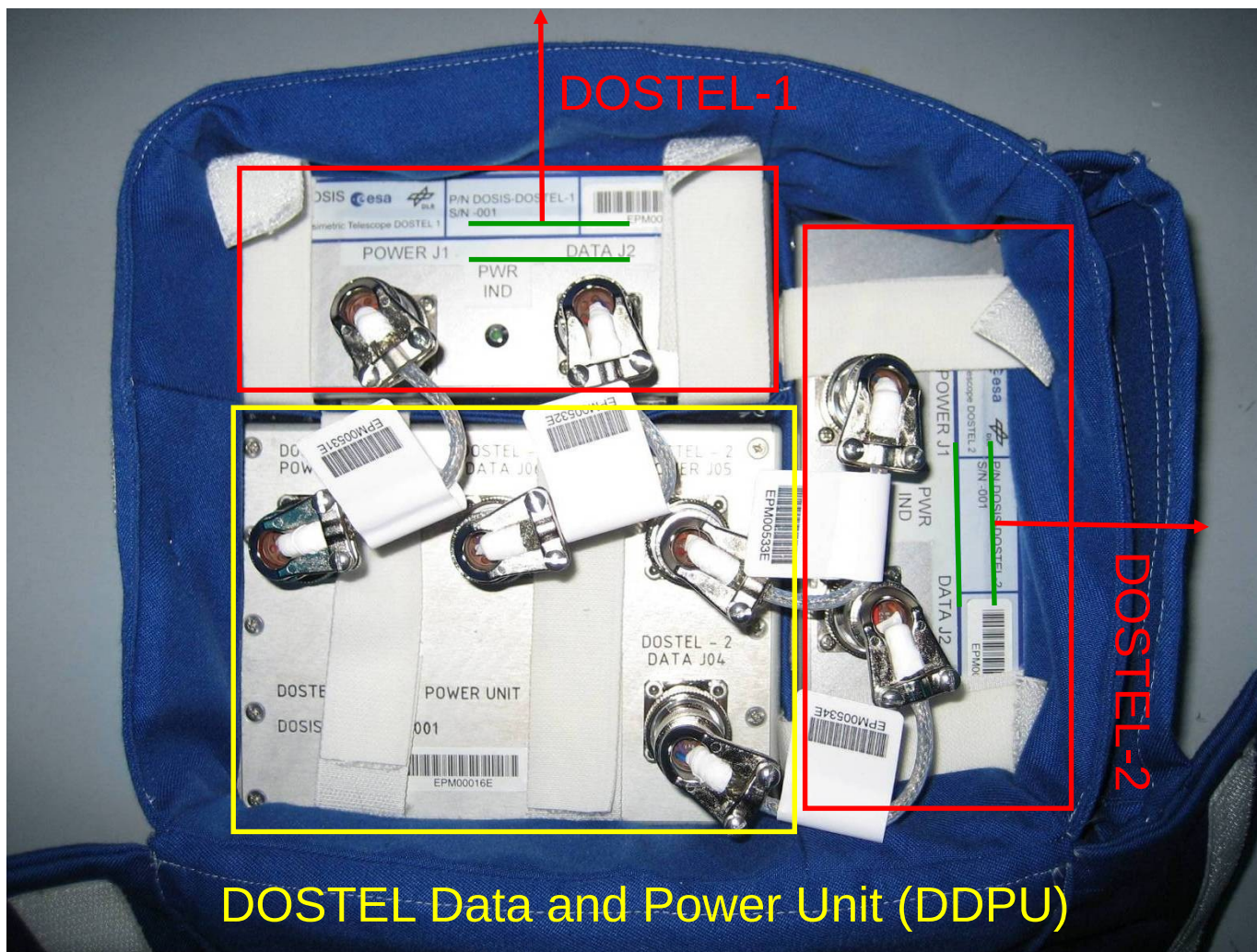
DOSimetry TELeskop (DOSTEL)



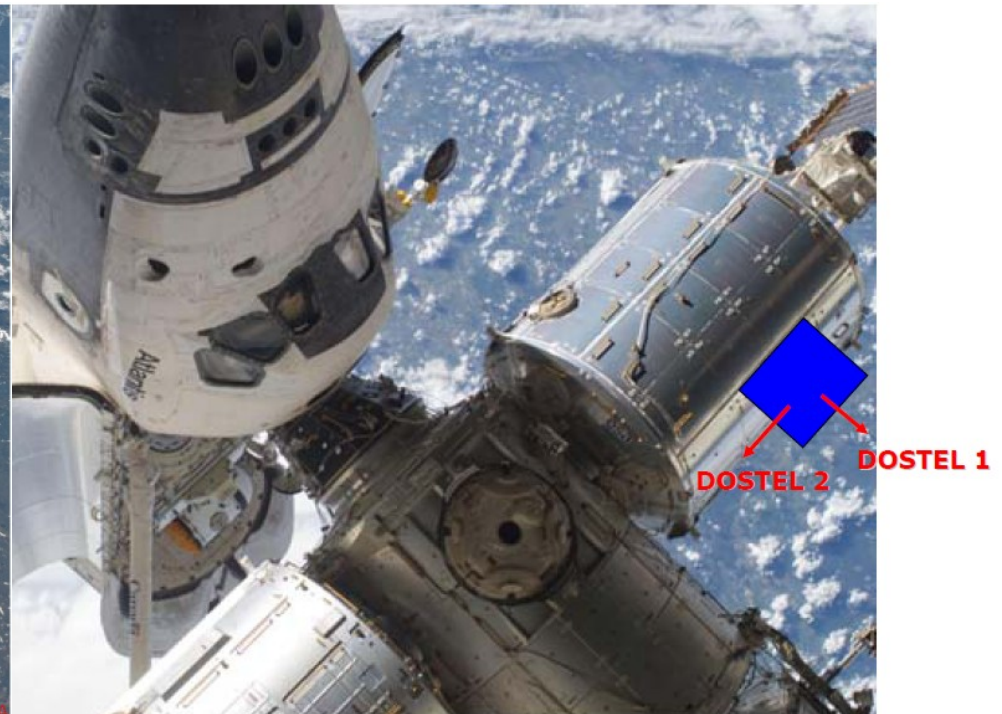
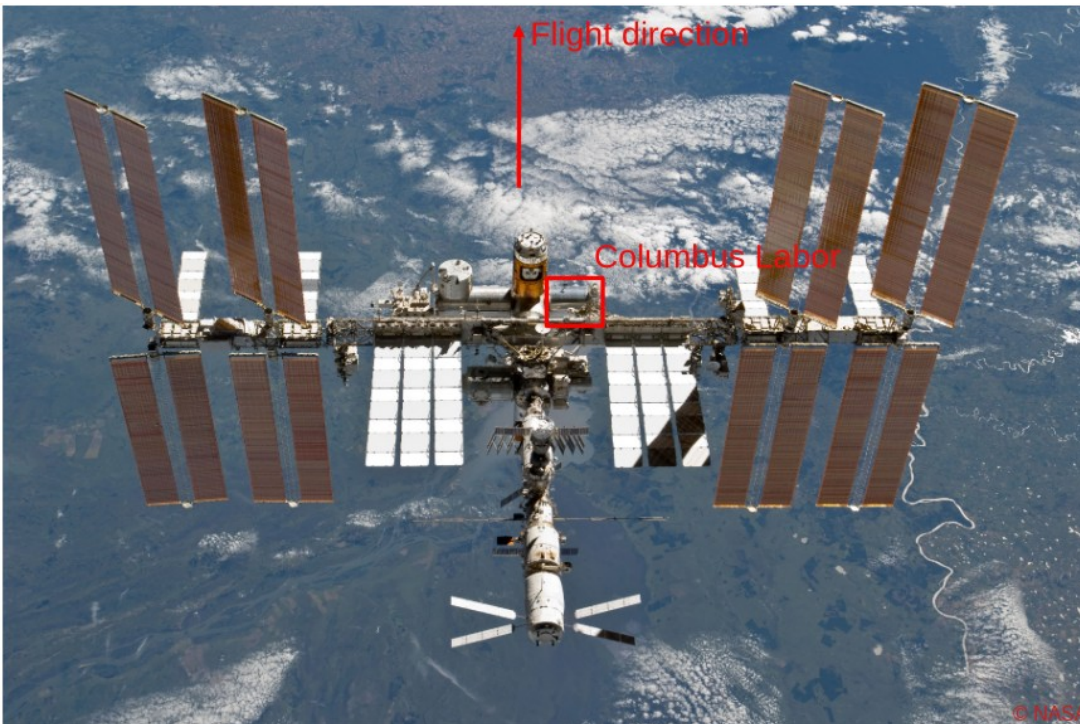
Data products

- Count and dose rate (SAA 20 seconds, GCR 100 seconds)
- Linear energy transfer spectra (SAA 20 minutes, GCR 45 minutes)
- SAA/GCR separation triggered by change in count rate

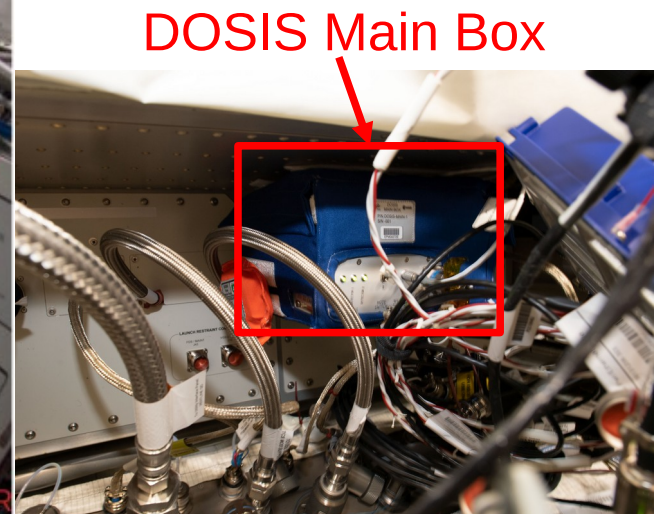
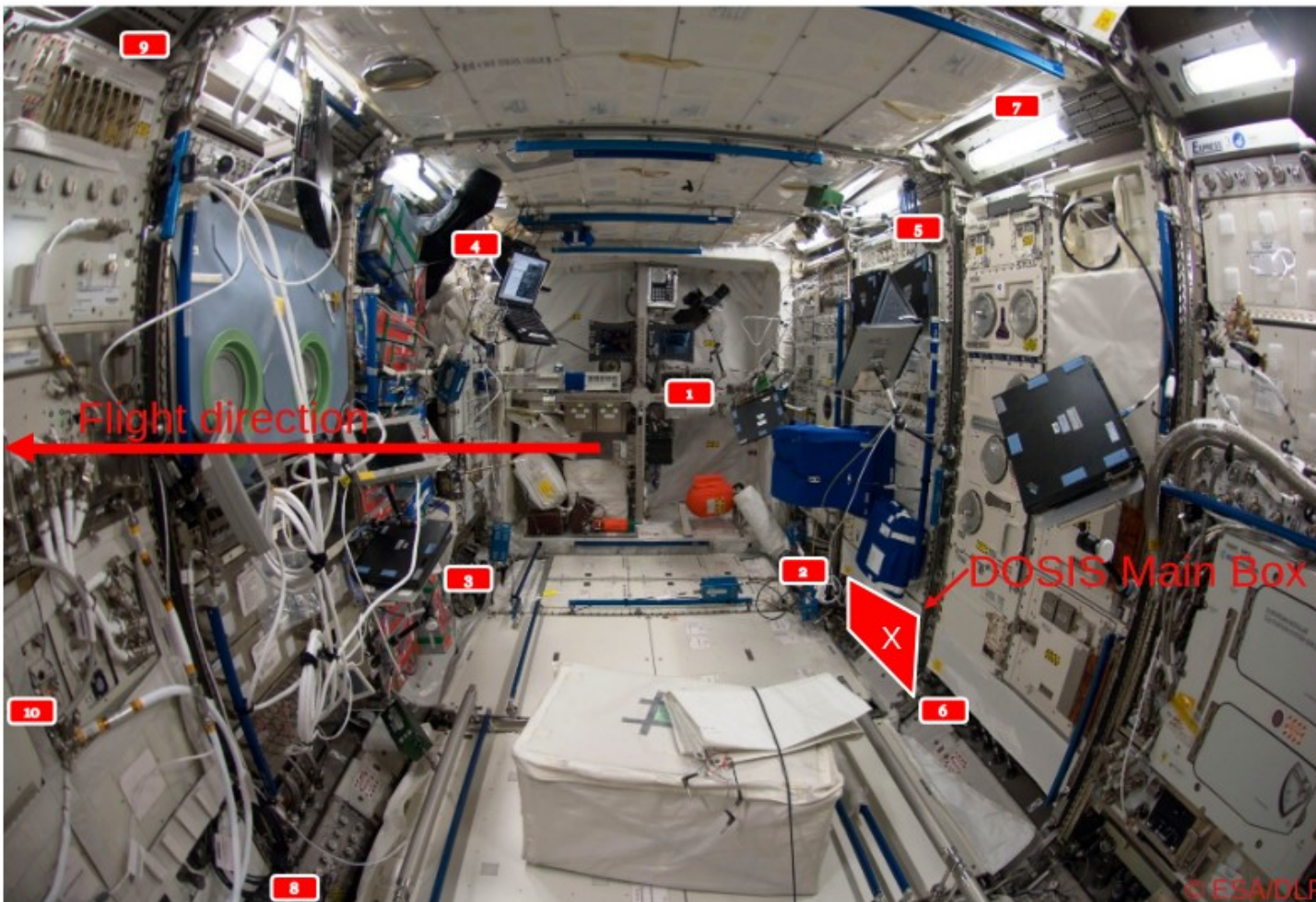
DOSIS Main Box



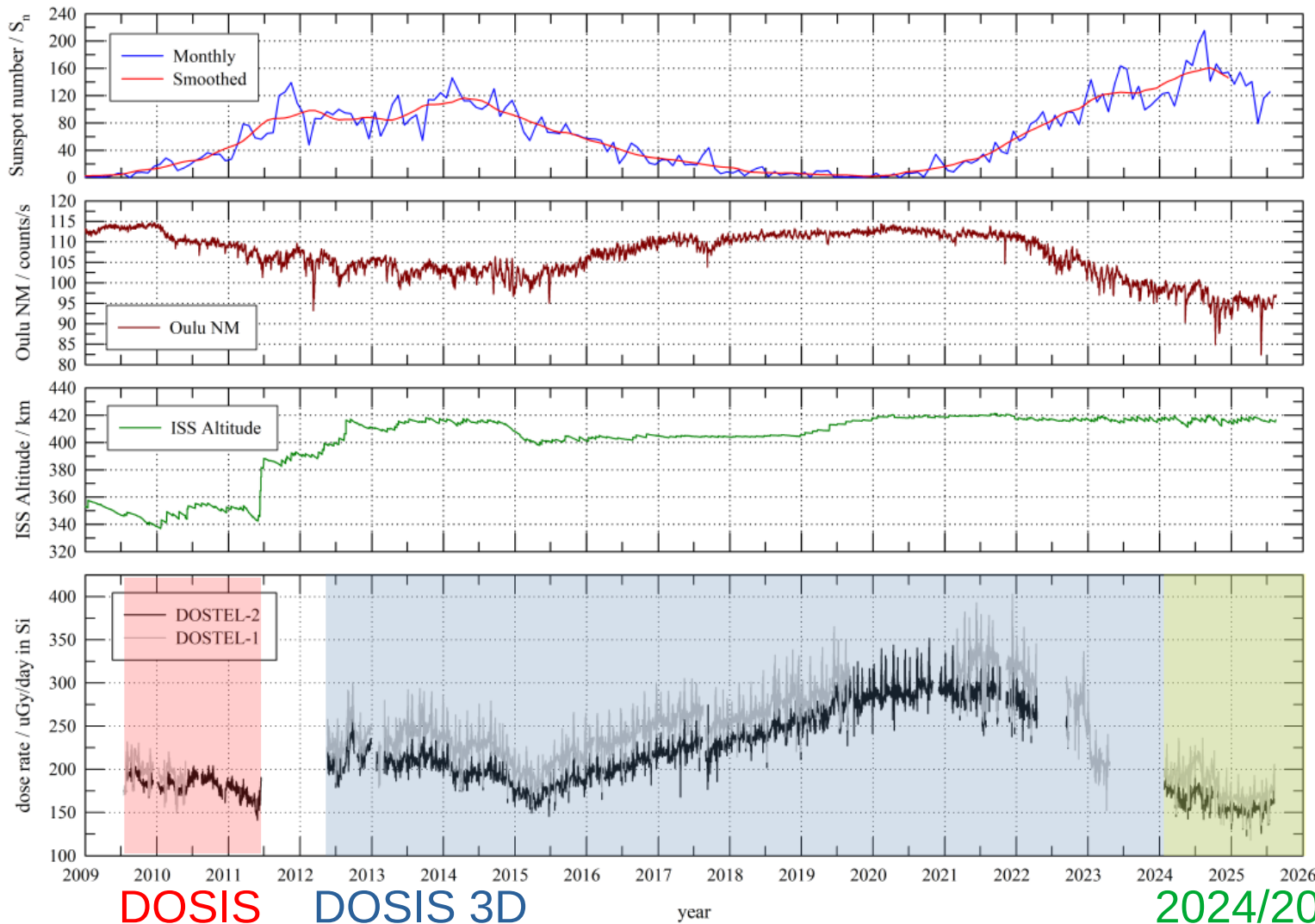
Location & Orientation



Position in Columbus

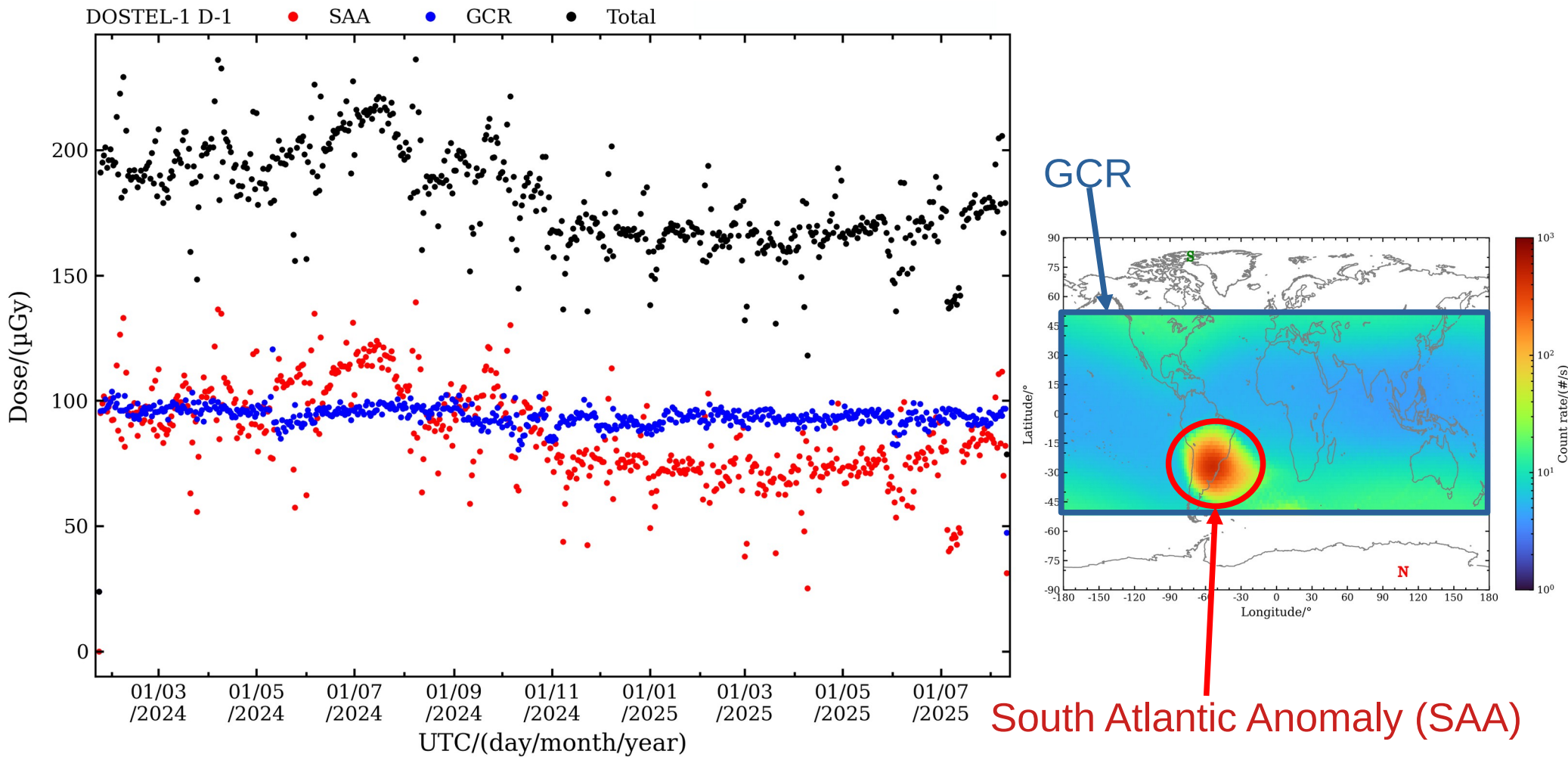


Overview dose measurements

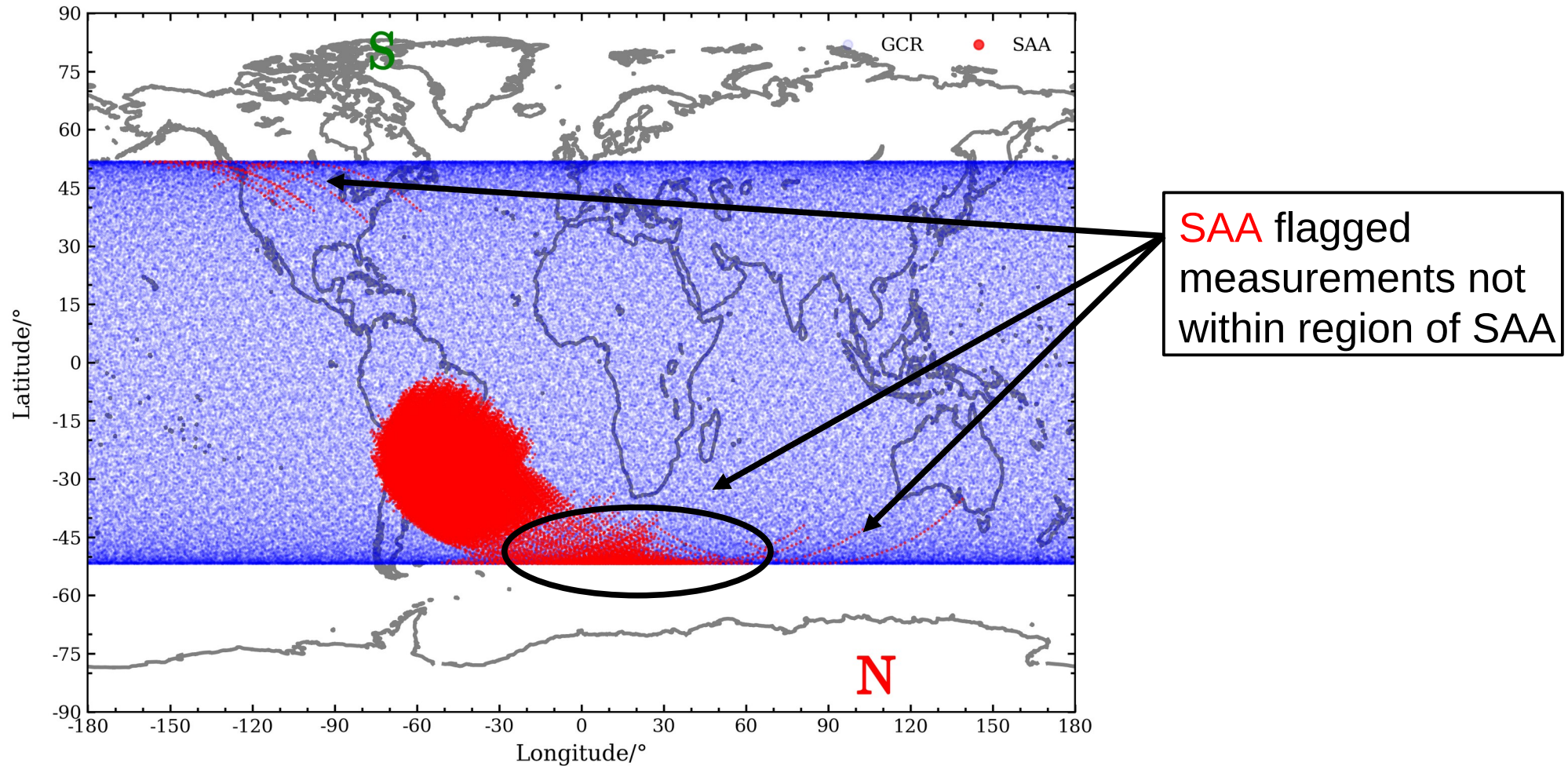


DOSTEL-1: 3927 days
DOSTEL-2: 4593 days
Total: 8520 days

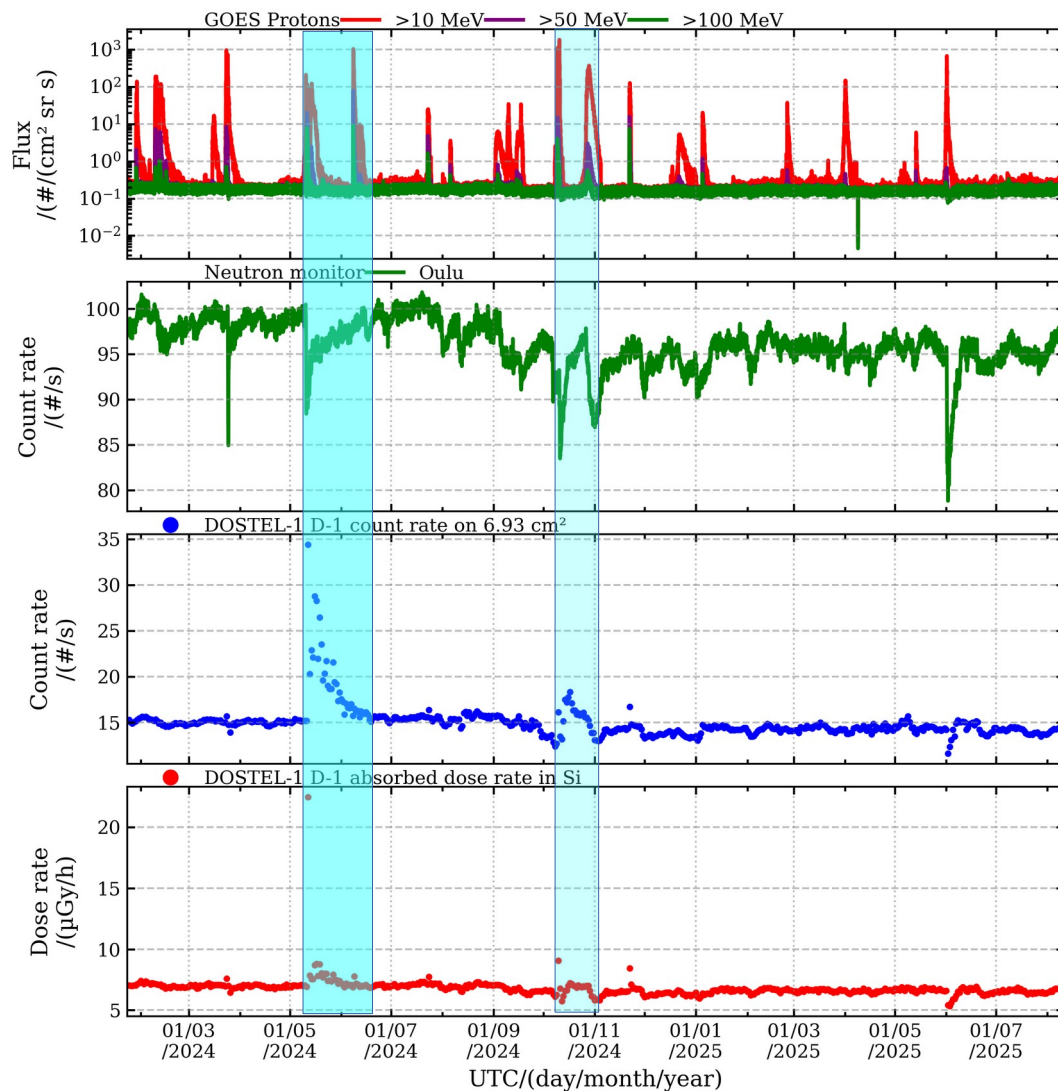
Daily dose for native DOSTEL separation



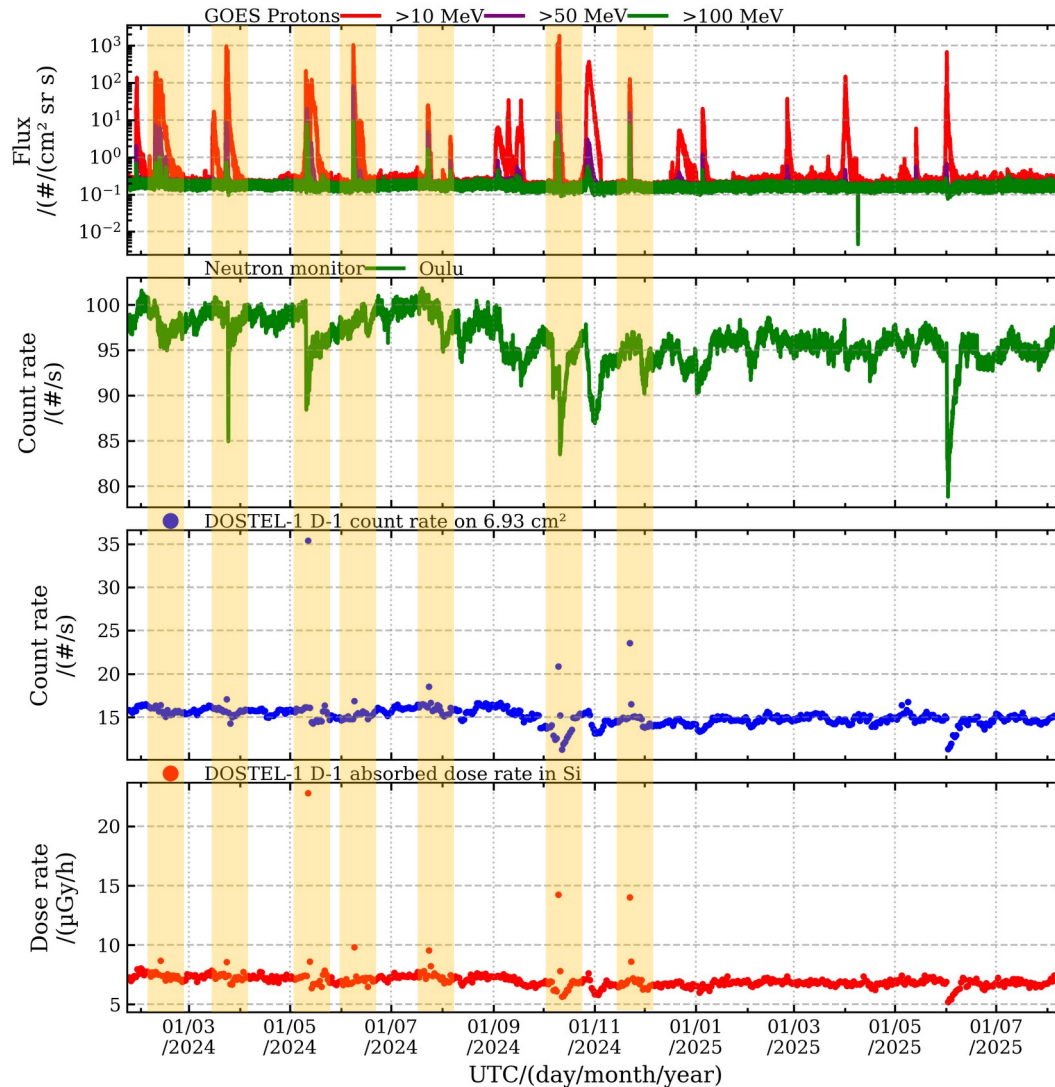
Location of measurement - native GCR and SAA separation



Daily count- and dose rate with $R_c < 2$ GV



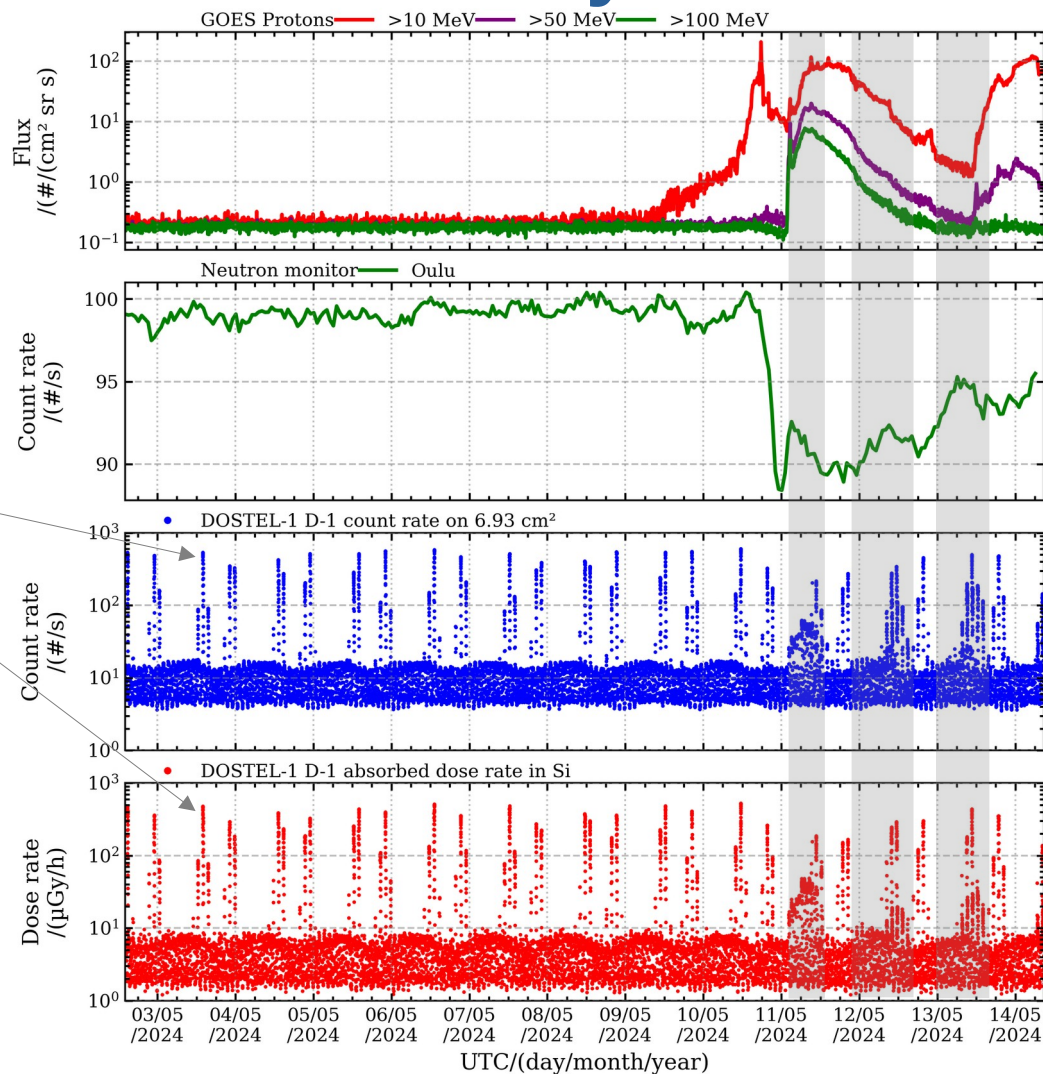
Daily count- and dose rate with $R_c < 0.5$ GV



Solar Particle Events (SPEs)

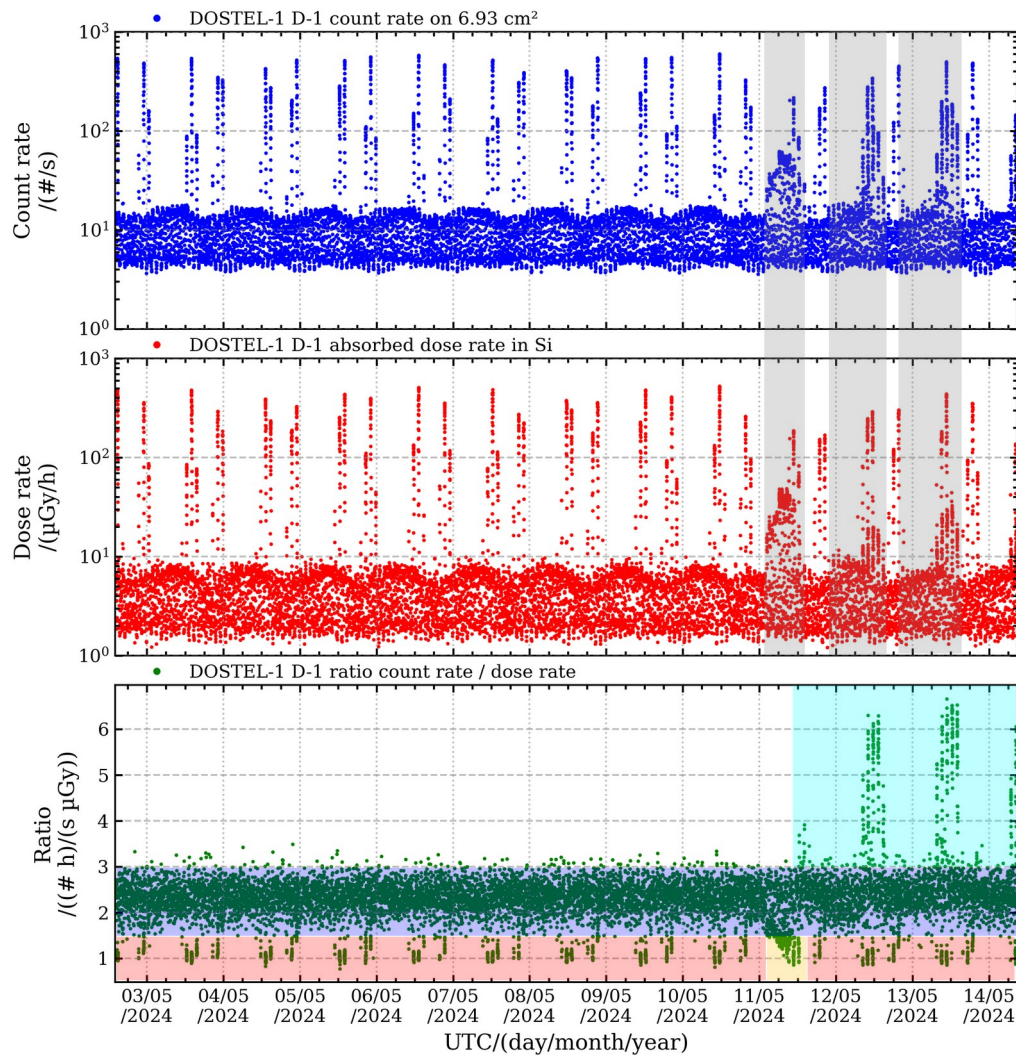
- | | | |
|------|--------------|------|
| I. | 12. February | 2024 |
| II. | 23. March | 2024 |
| III. | 11. May | 2024 |
| IV. | 08. June | 2024 |
| V. | 23. July | 2024 |
| VI. | 09. October | 2024 |
| VII. | 21. November | 2024 |

Event on May 11th 2024



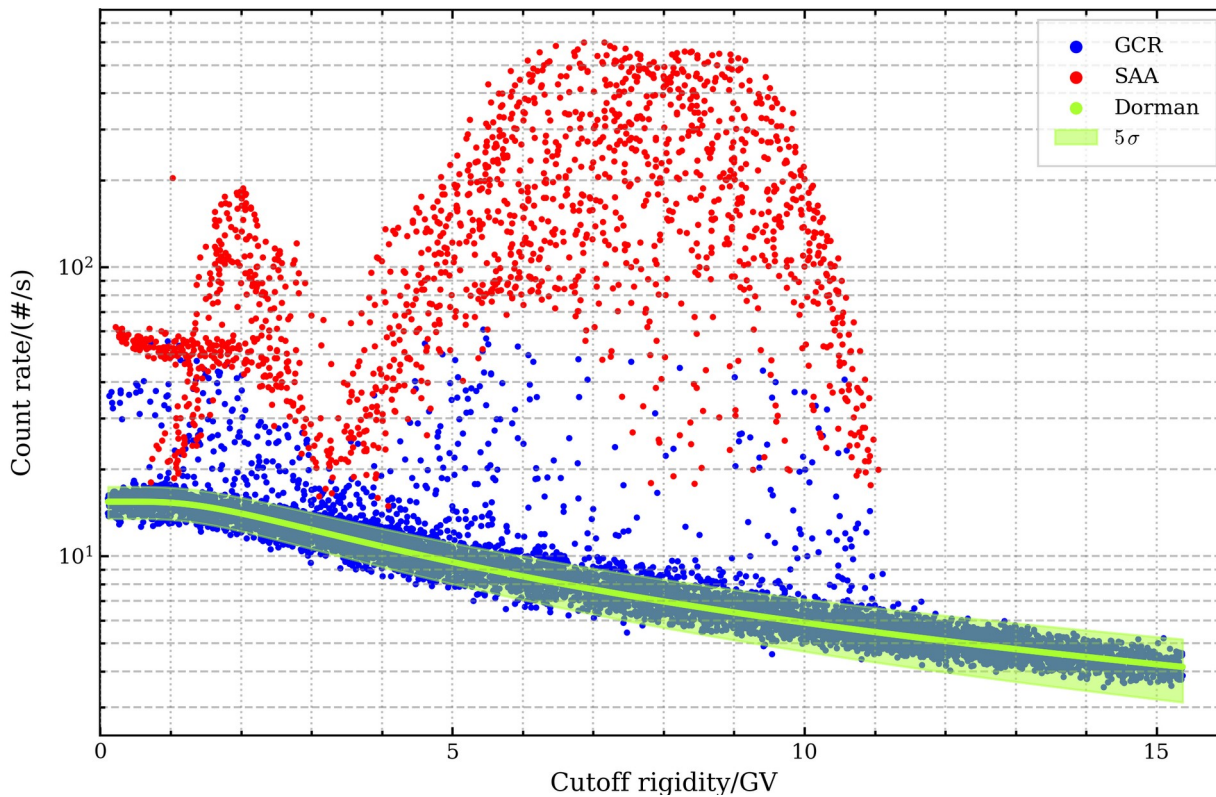
SAA crossings

Event on May 11th 2024



Electrons
GCR
SAA and SPEs

Improving the native GCR and SAA separation



Dorman (1970) function

$$N(R_C) = N_0 \left[1 - \exp(-\alpha R_C^\kappa) \right]$$

With

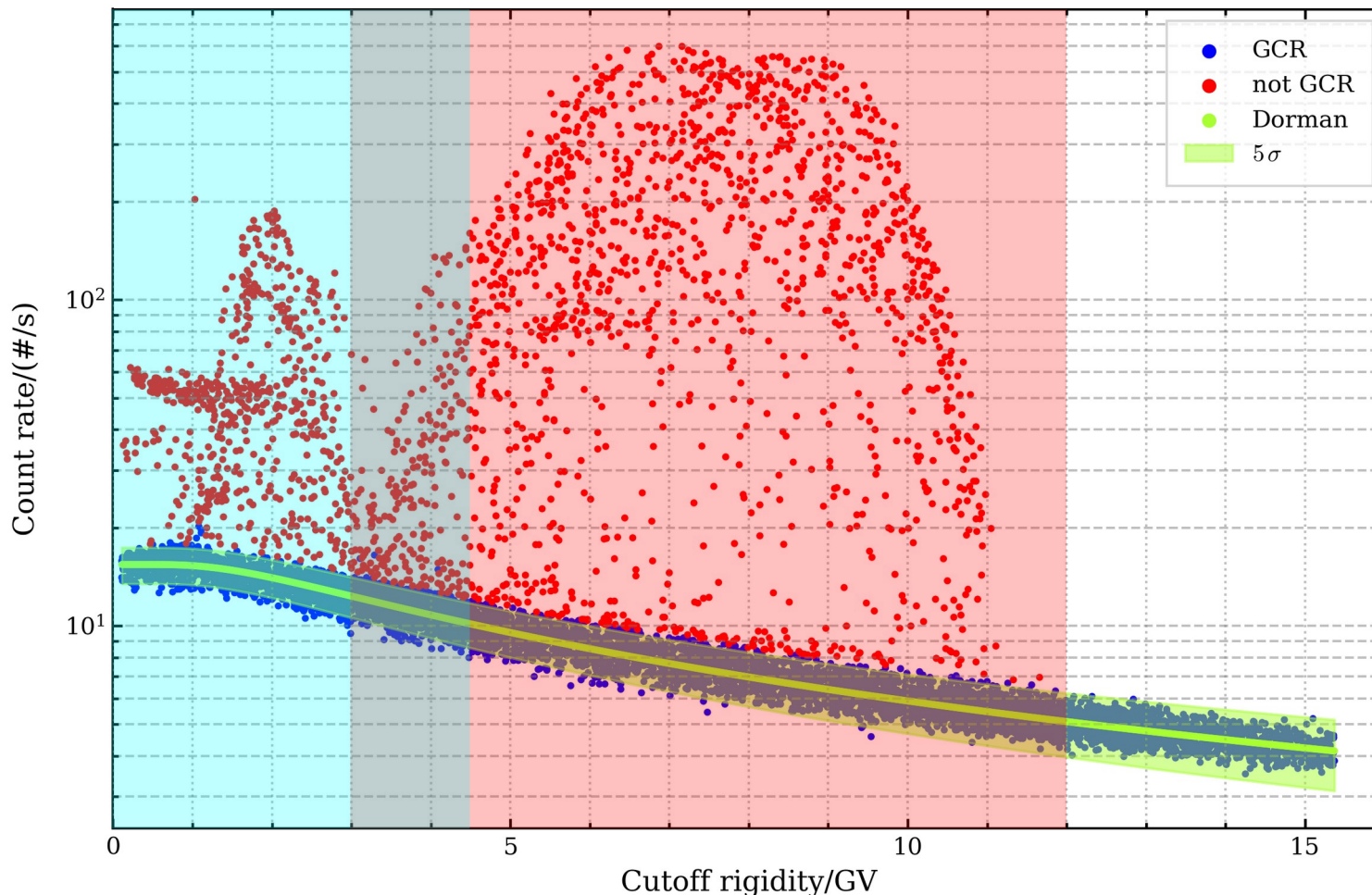
- Count rate $N(R_c)$
- const. Count rate N_0
- Cutoff rigidity R_c
- Free parameters α, κ

a) Condition count rates

$$\text{non GCR} \leftarrow N_i > N(R_{c,i}) + 5\sigma_{N(R_{c,i})}$$

where the index i labels each measurement data point

Improving the native GCR and SAA separation



b) Condition for R_c

SAA

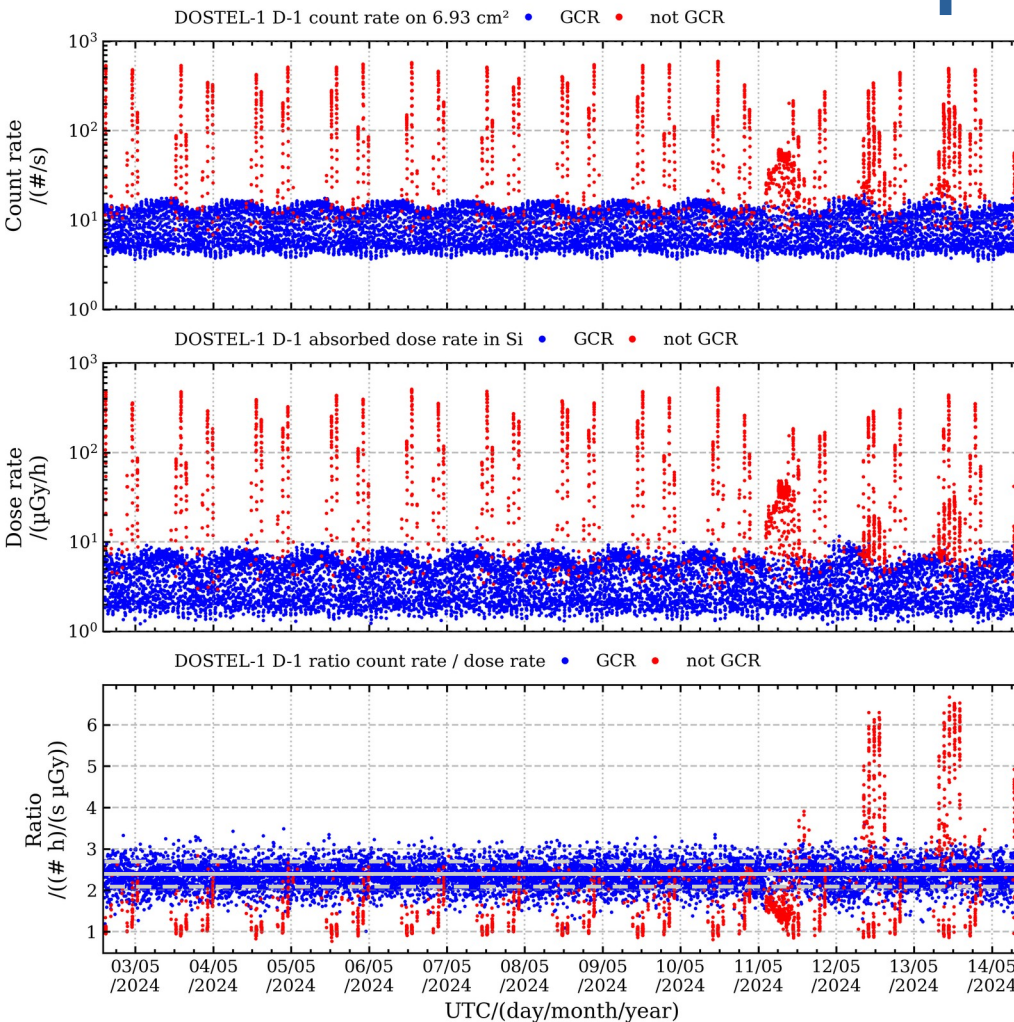
$$3 \text{ GV} < R_{c,i} < 12 \text{ GV}$$

SPEs or Electrons

$$0 \text{ GV} < R_{c,i} < 4.5 \text{ GV}$$

where the index i labels each measurement data point

Improving the native GCR and SAA separation



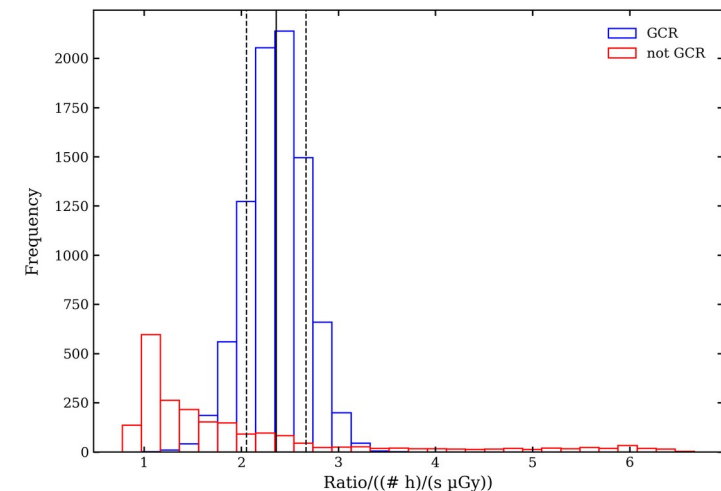
c) Condition count- to dose rate ratio r

Electrons $\leftarrow r_{\text{not GCR},i} > \mu_{\text{GCR}} + \sigma_{\text{GCR}}$

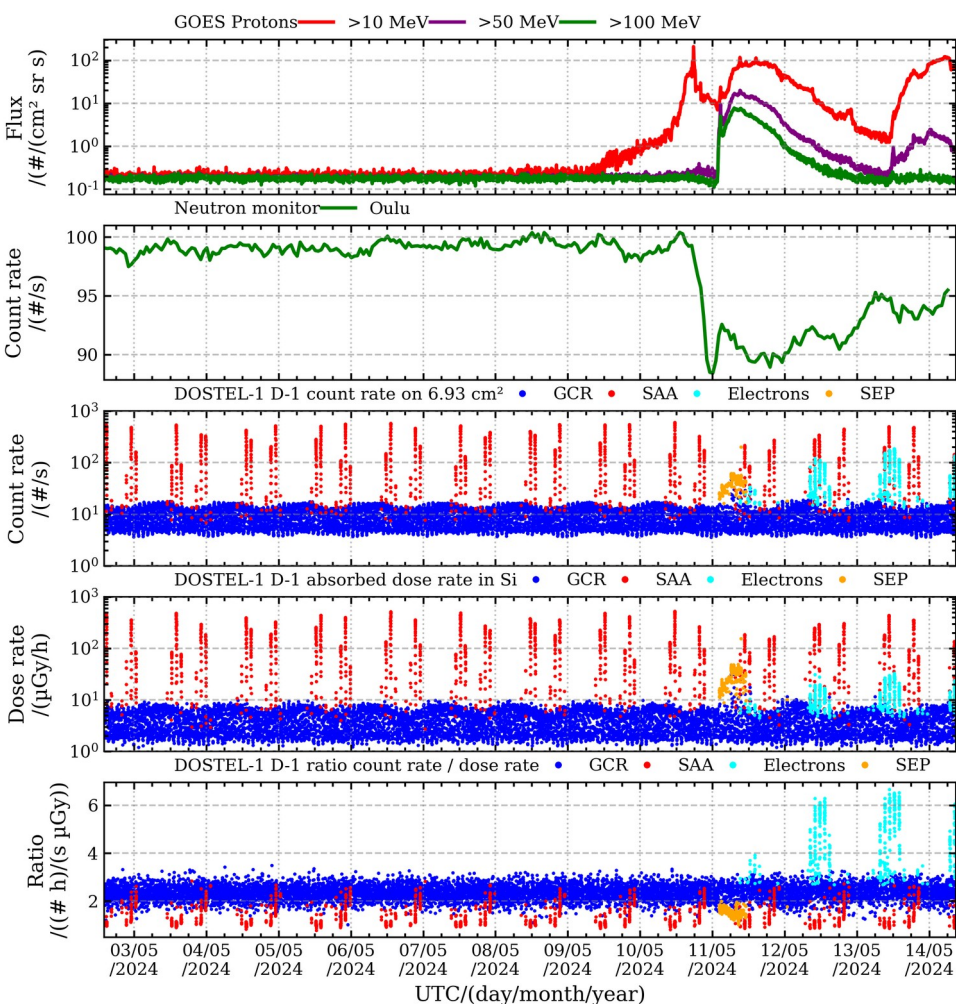
SPEs or SAA $\leftarrow r_{\text{not GCR},i} < \mu_{\text{GCR}} + \sigma_{\text{GCR}}$

With

- μ_{GCR} average of r_{GCR}
- σ_{GCR} standard deviation of r_{GCR}



Improving the native GCR and SAA separation - Result



a) Condition non GCR count rates

$$\text{non GCR} \leftarrow N_i > N(R_{c,i}) + 5\sigma_{N(R_{c,i})}$$

b) Condition cutoff rigidity

$$\text{SAA} \leftarrow 3 \text{ GV} < R_{c,i} < 12 \text{ GV}$$

$$\text{SPEs or Electrons} \leftarrow 0 \text{ GV} < R_{c,i} < 4.5 \text{ GV}$$

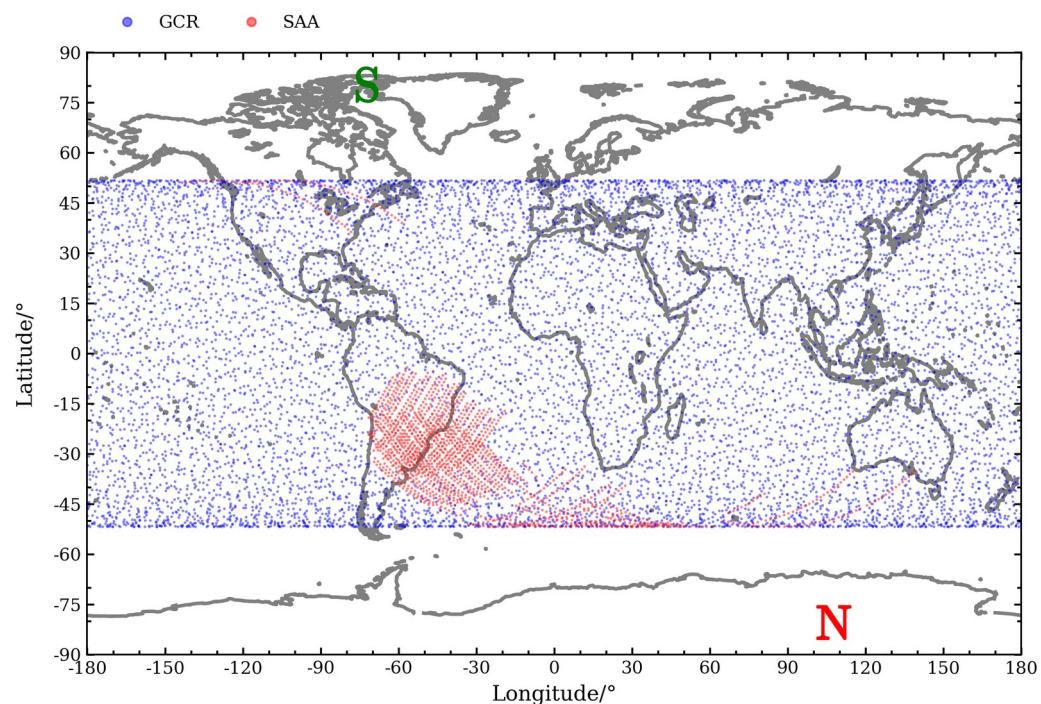
c) Condition count- to dose rate ratio r

$$\text{Electrons} \leftarrow r_{\text{not GCR},i} > \mu_{\text{GCR}} + \sigma_{\text{GCR}}$$

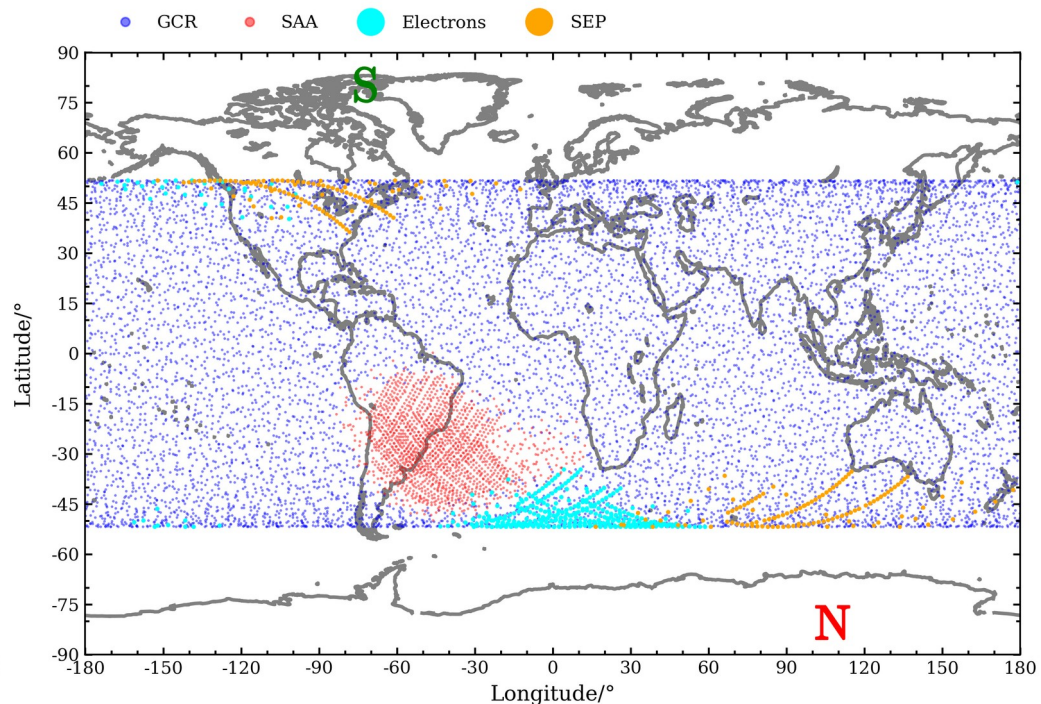
$$\text{SPEs or SAA} \leftarrow r_{\text{not GCR},i} < \mu_{\text{GCR}} + \sigma_{\text{GCR}}$$

Improving the native GCR and SAA separation - Result

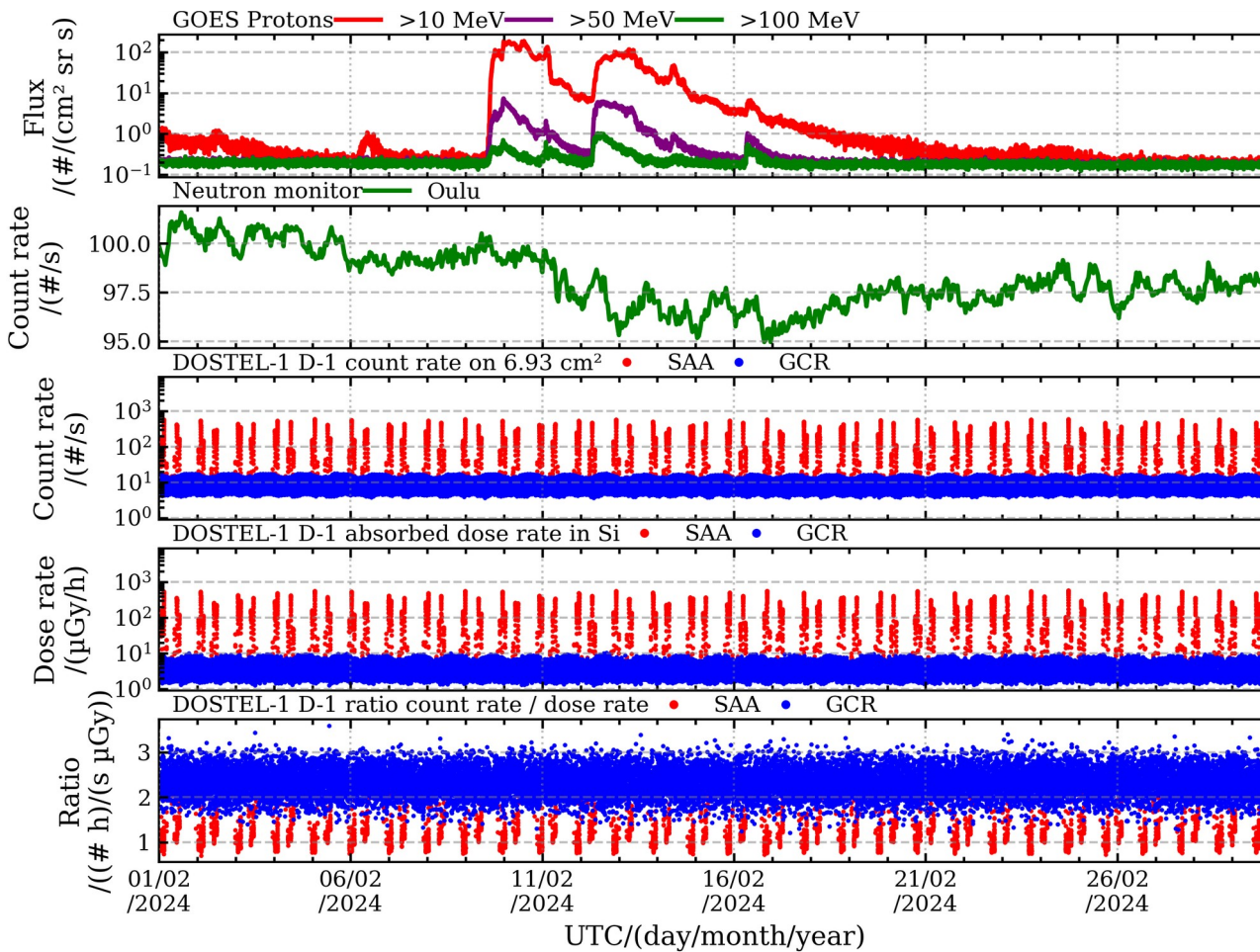
Native



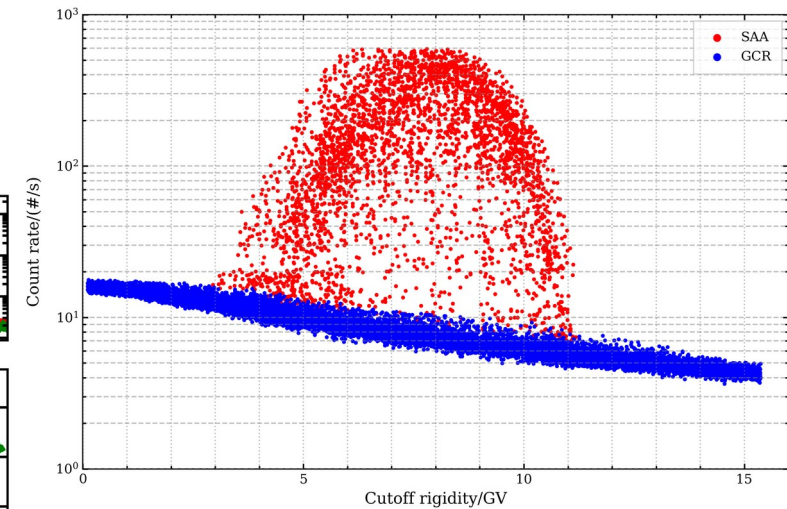
Improved



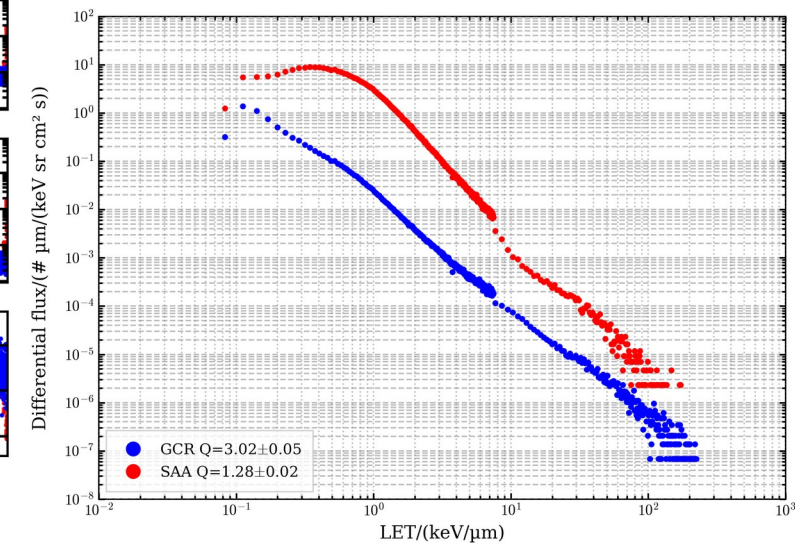
12. February 2024



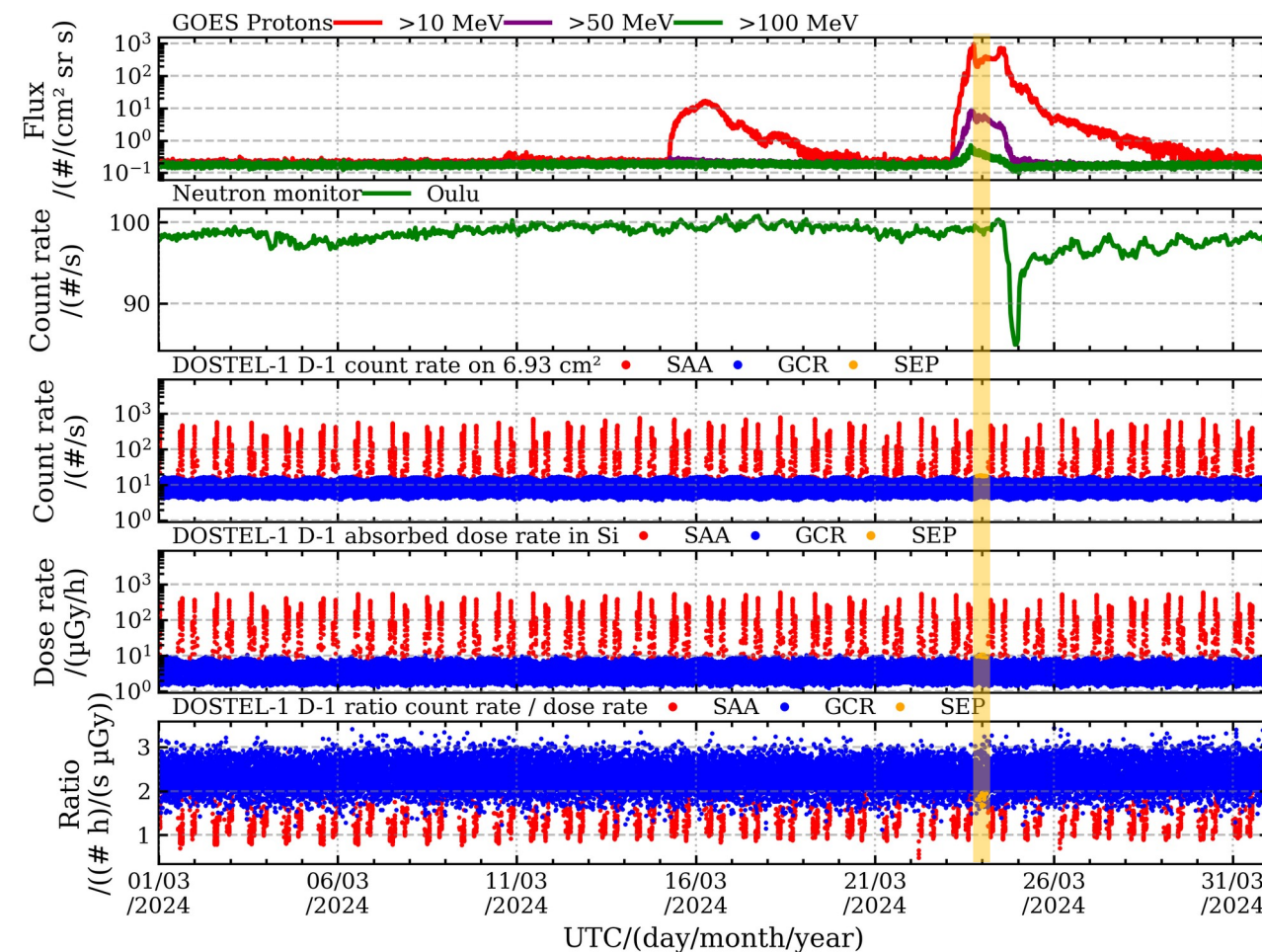
DOSTEL-1 D1, 01.02.2024 to 01.03.2024



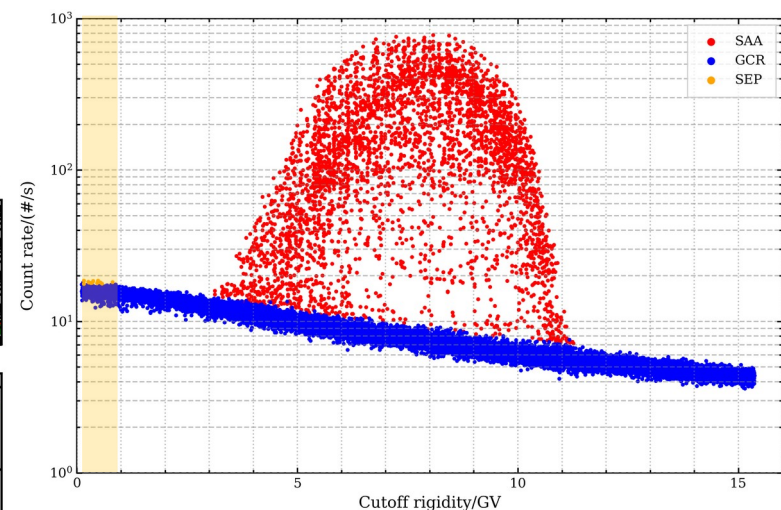
DOSTEL-1 D-1 LET-spectra from 2024-02-01 to 2024-02-29



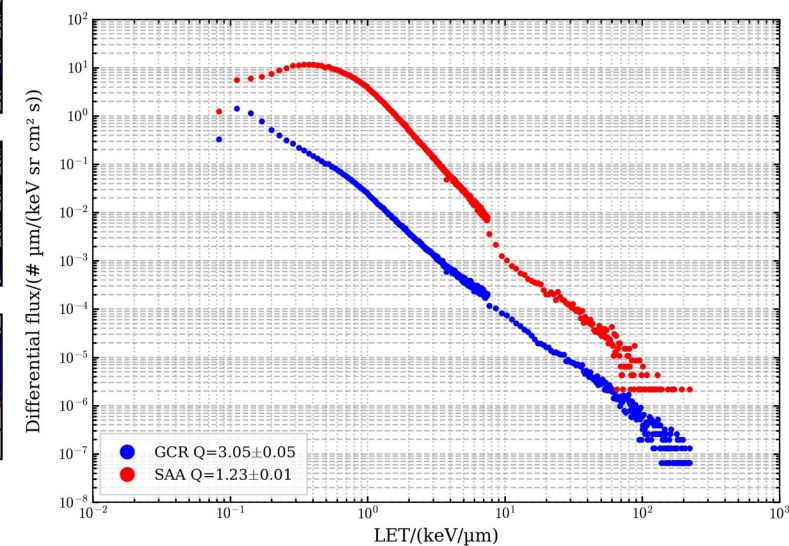
23. March 2024



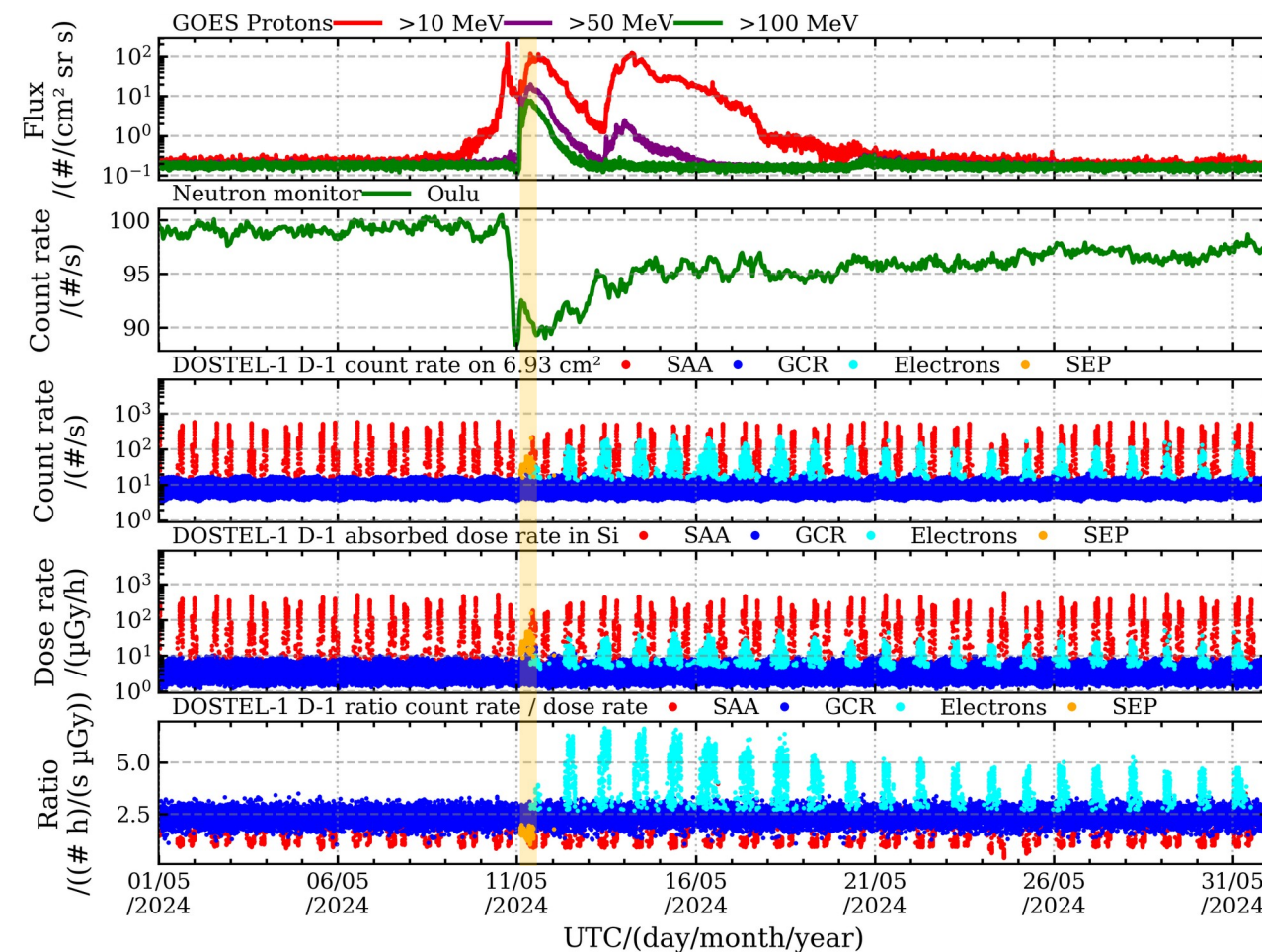
DOSTEL-1 D1, 01.03.2024 to 01.04.2024



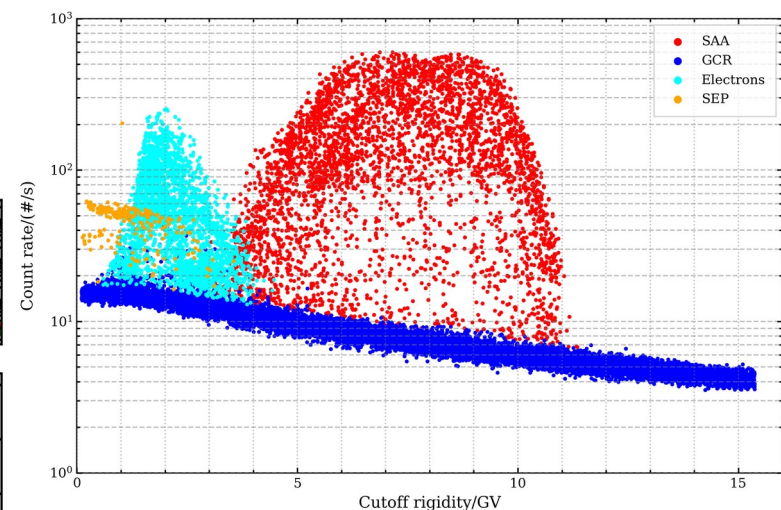
DOSTEL-1 D-1 LET-spectra from 2024-03-01 to 2024-03-31



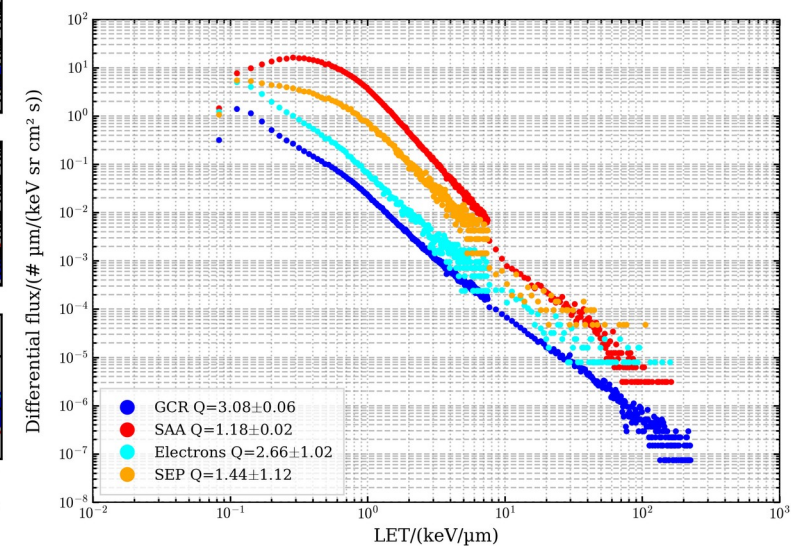
11. May 2024



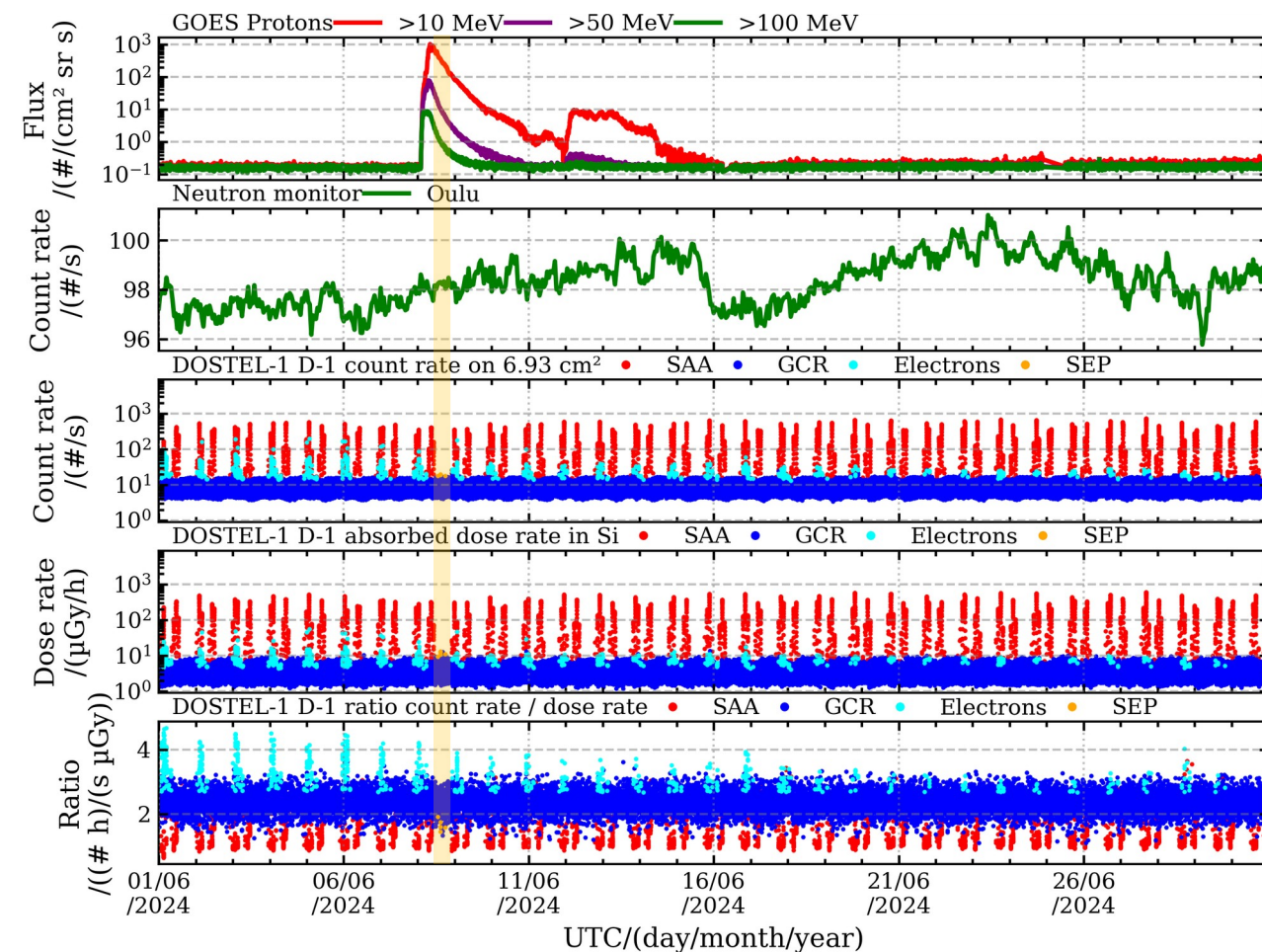
DOSTEL-1 D1, 01.05.2024 to 01.06.2024



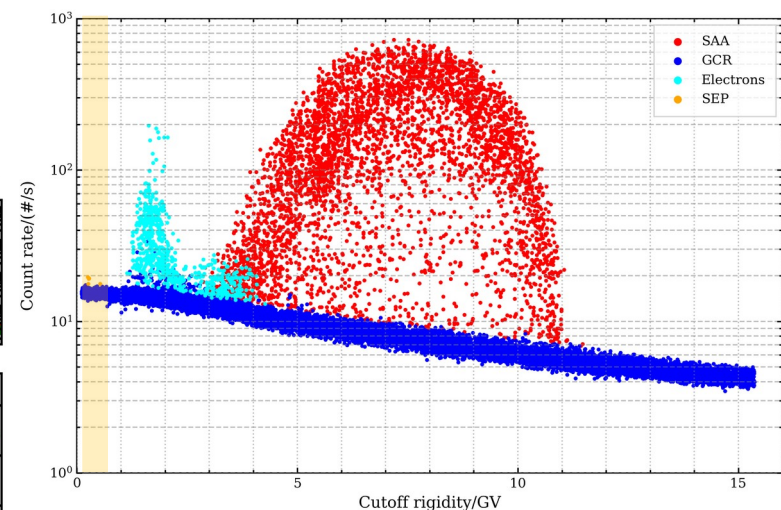
DOSTEL-1 D-1 LET-spectra from 2024-05-01 to 2024-05-31



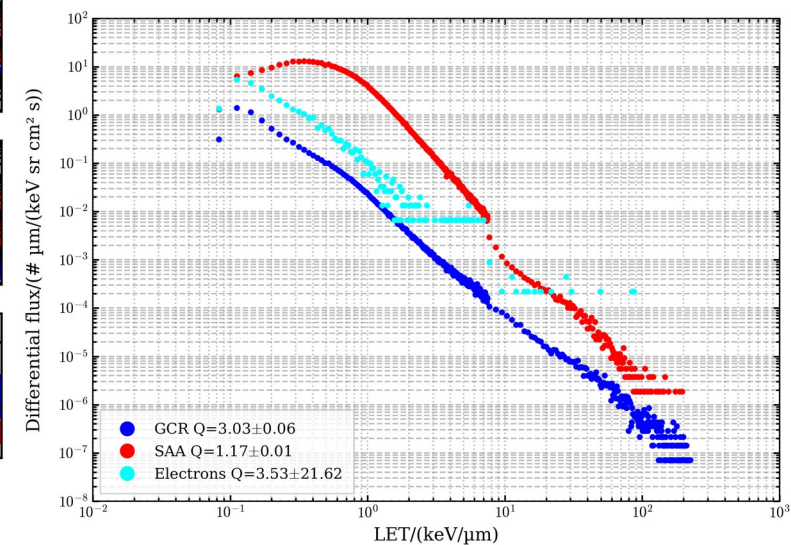
08. June 2024



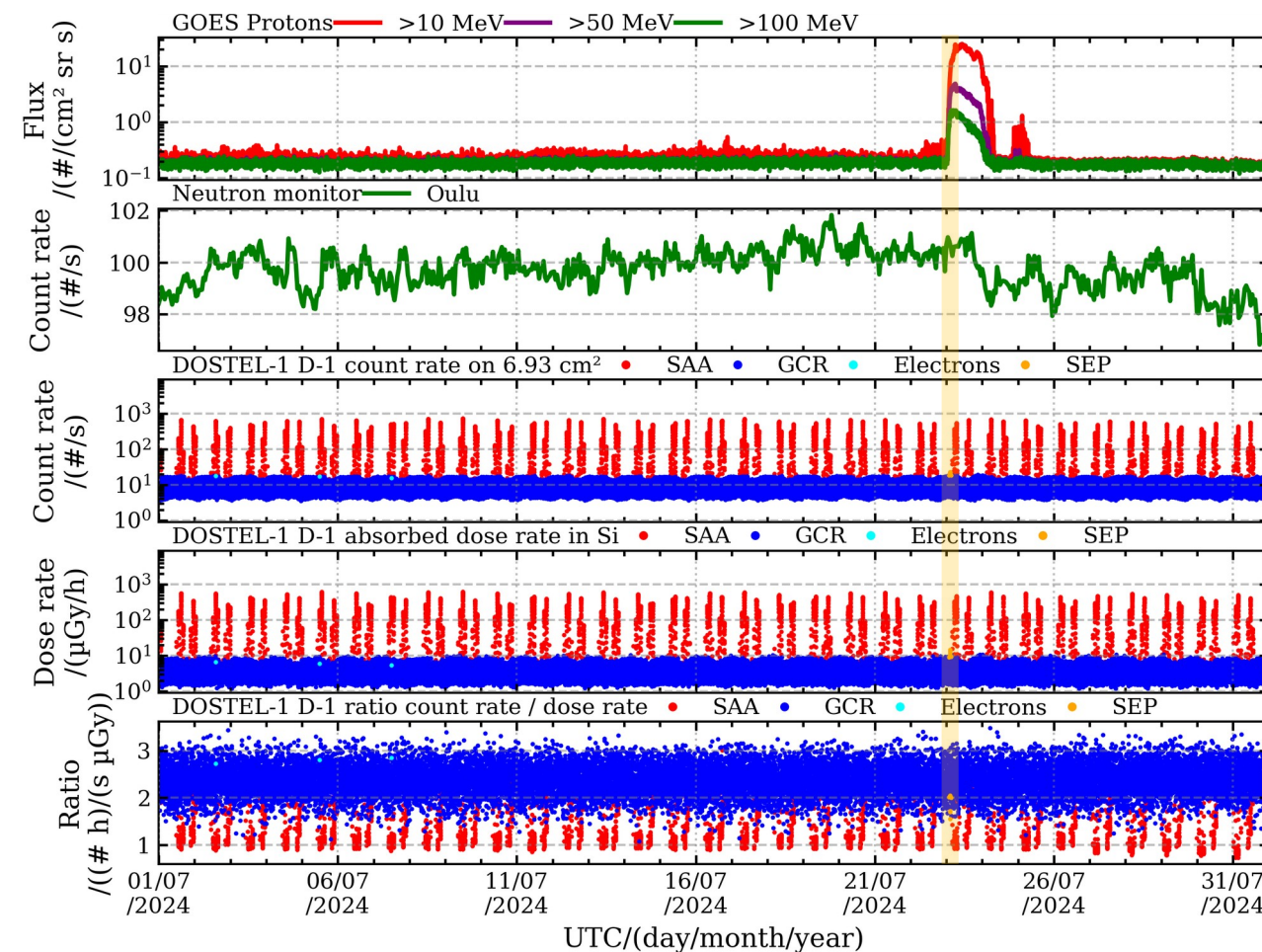
DOSTEL-1 D1, 01.06.2024 to 01.07.2024



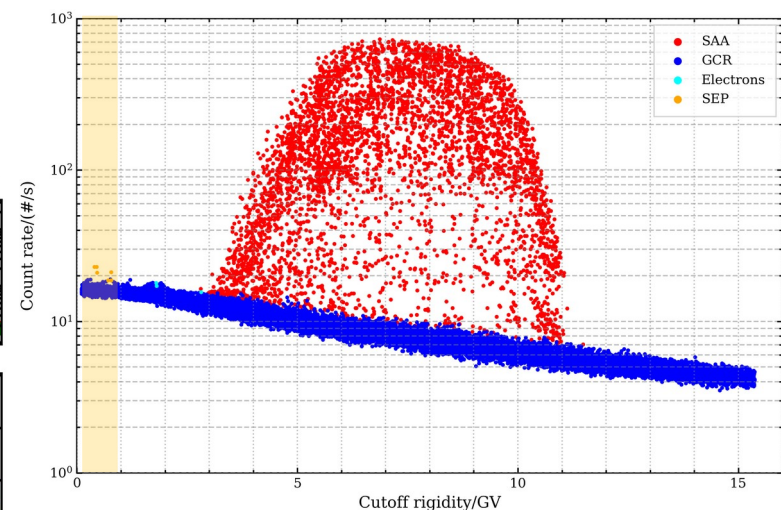
DOSTEL-1 D-1 LET-spectra from 2024-06-01 to 2024-06-30



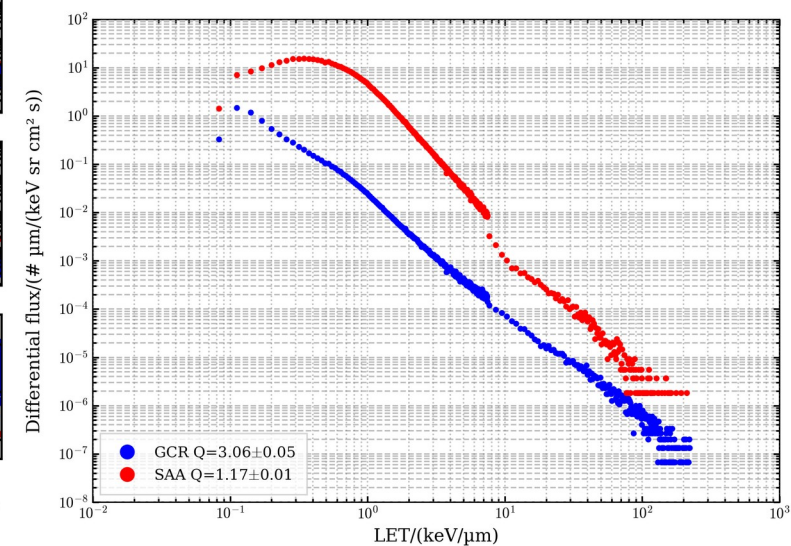
23. July 2024



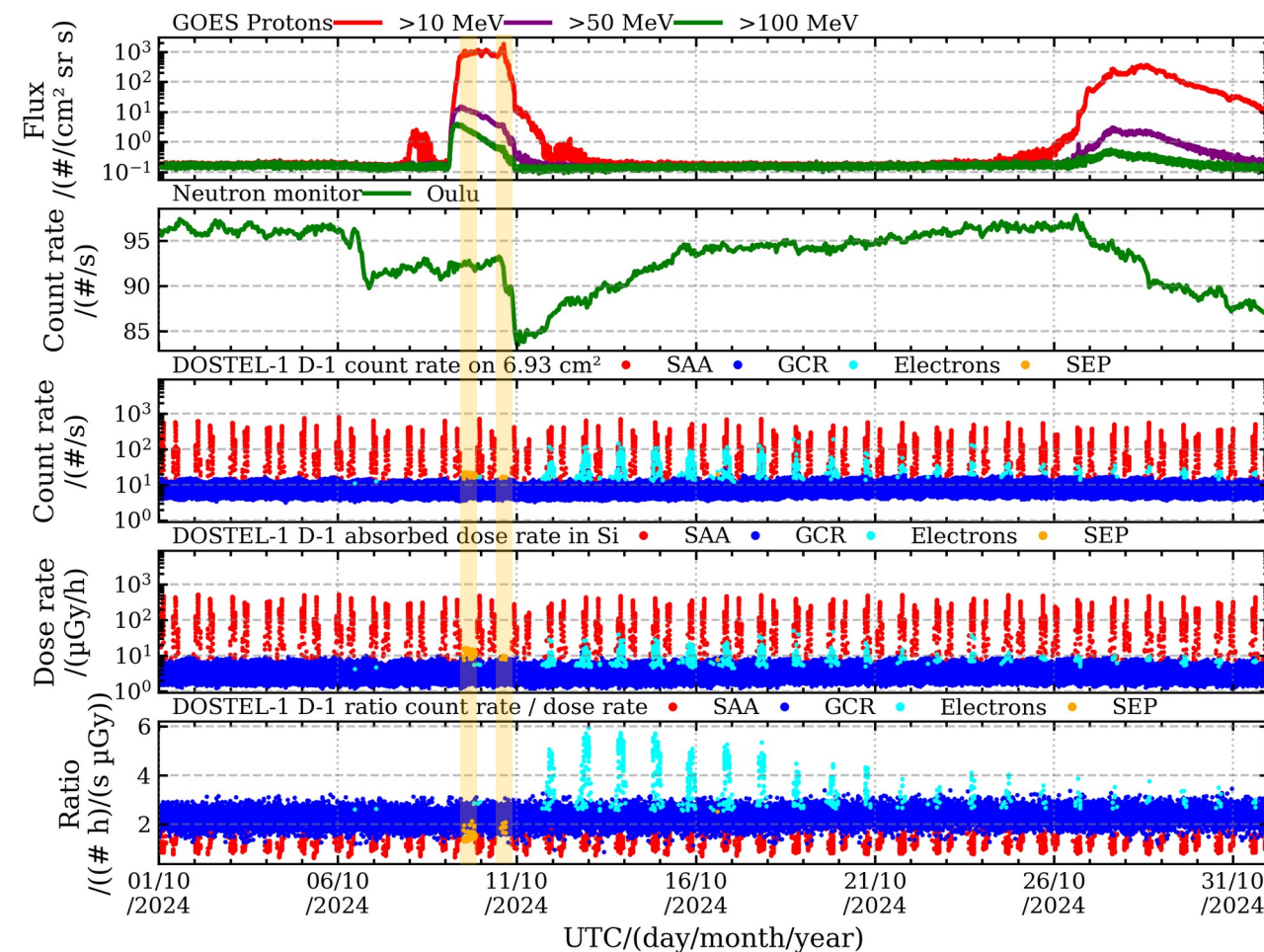
DOSTEL-1 D1, 01.07.2024 to 01.08.2024



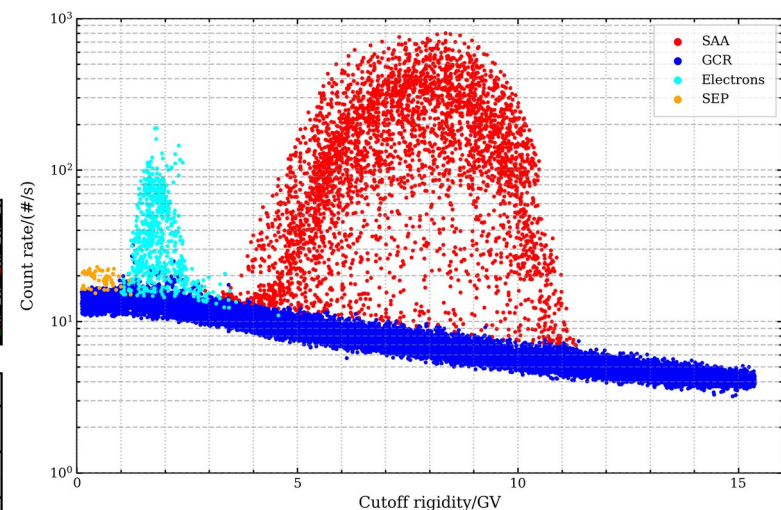
DOSTEL-1 D-1 LET-spectra from 2024-07-01 to 2024-07-31



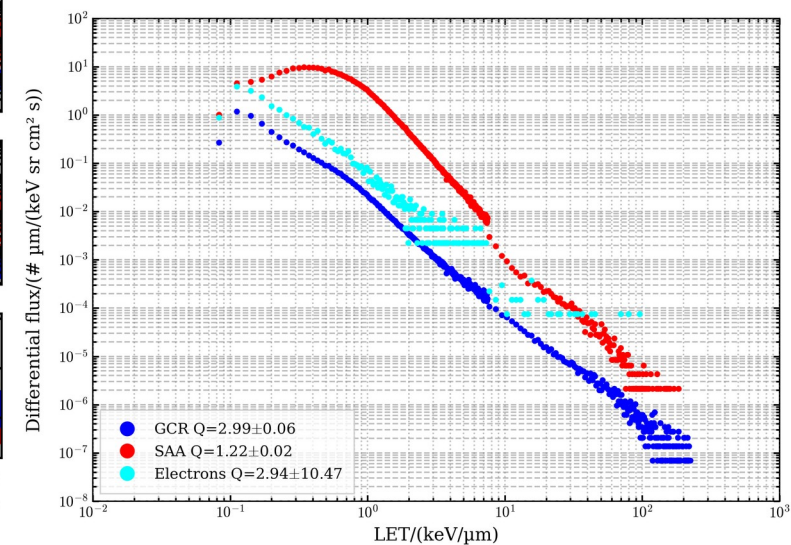
09. October 2024



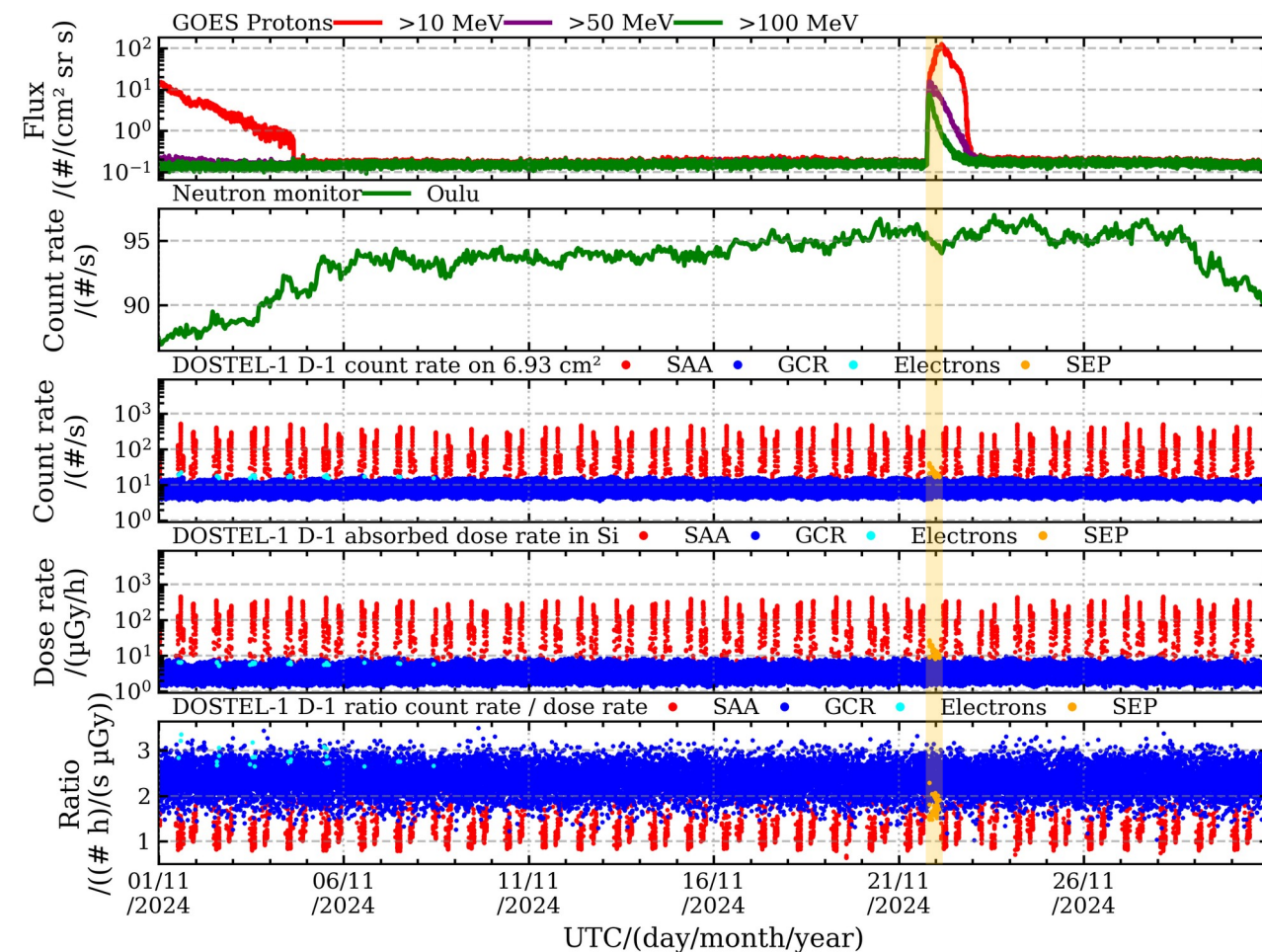
DOSTEL-1 D1, 01.10.2024 to 01.11.2024



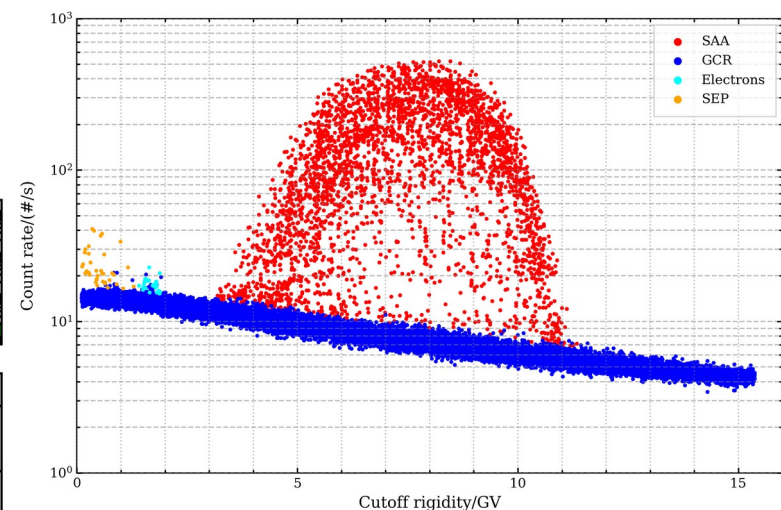
DOSTEL-1 D-1 LET-spectra from 2024-10-01 to 2024-10-31



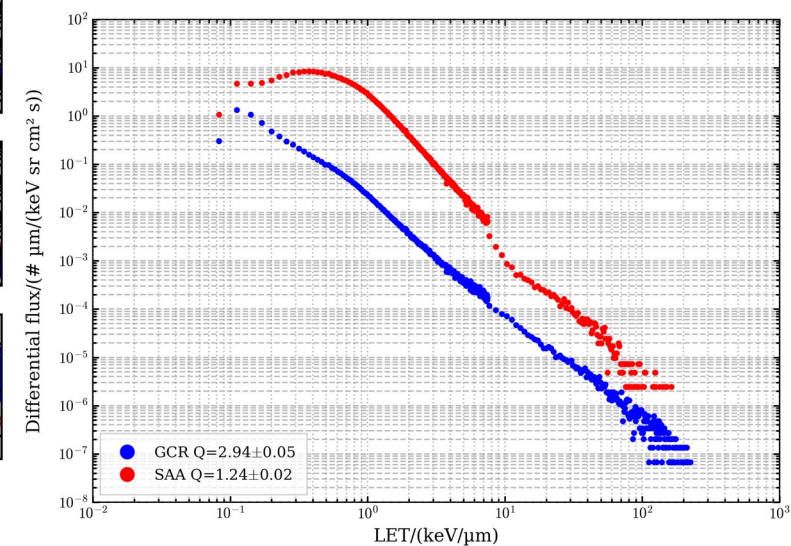
21. November 2024



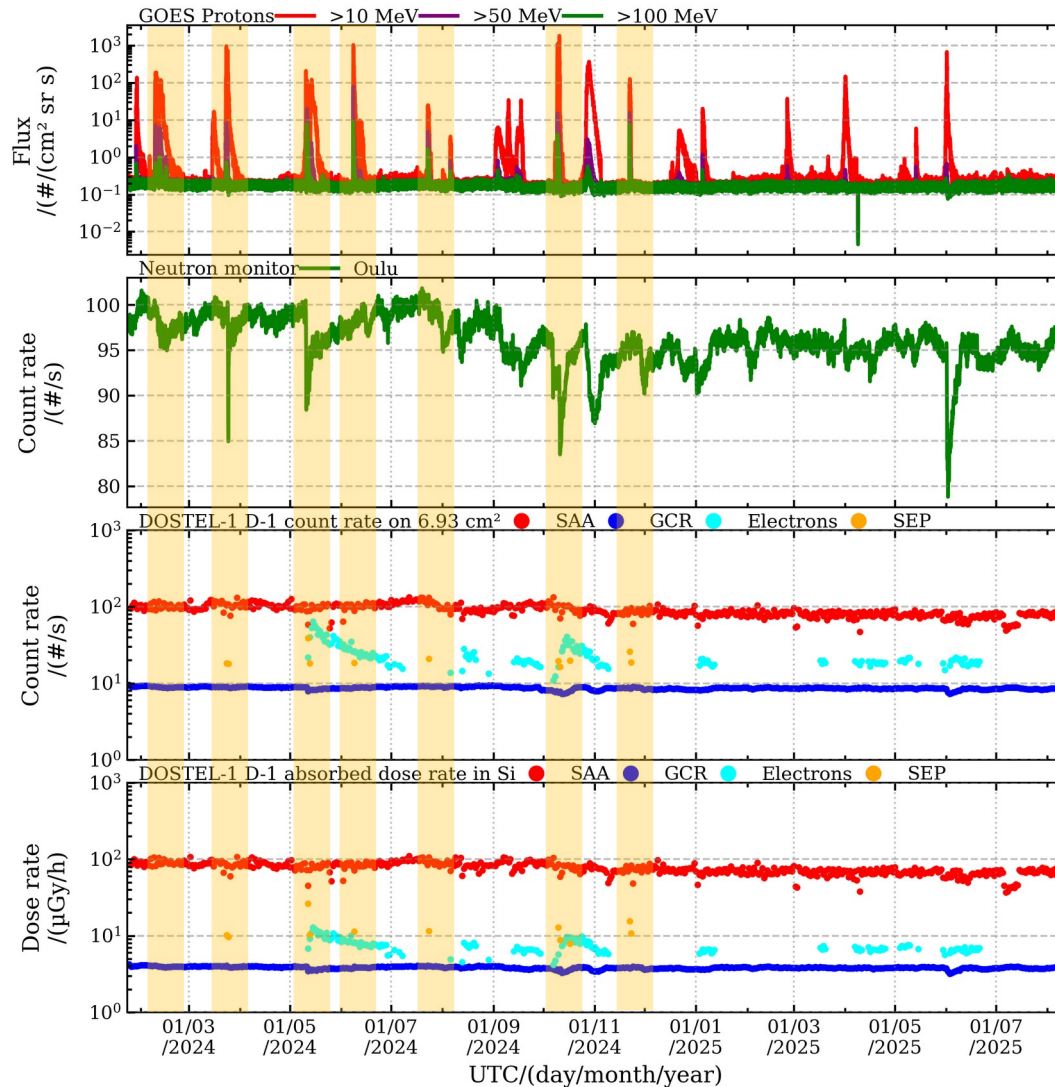
DOSTEL-1 D1, 01.11.2024 to 01.12.2024



DOSTEL-1 D-1 LET-spectra from 2024-11-01 to 2024-11-30



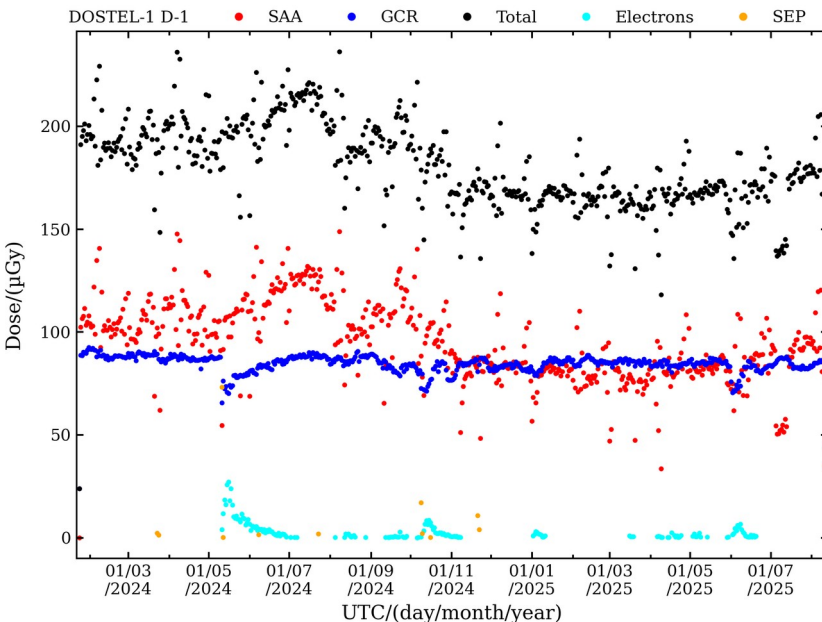
Improved separation daily count- and dose rate



SPEs in 2024	Absorbed dose in $\text{H}_2\text{O}/\mu\text{Gy}$	Dose equivalent in $\text{H}_2\text{O}/\mu\text{Sv}$
12. February	0.0	0.0
23. March	4.4	6.3
11. May	88.9	128.0
08 June	1.9	2.8
23. July	2.3	3.3
09. October	23.7	34.1
21. November	17.8	25.6
Total	139	200.1

DOSTEL-1 D-1 results for 2024 and 2025

Improved daily dose in Si



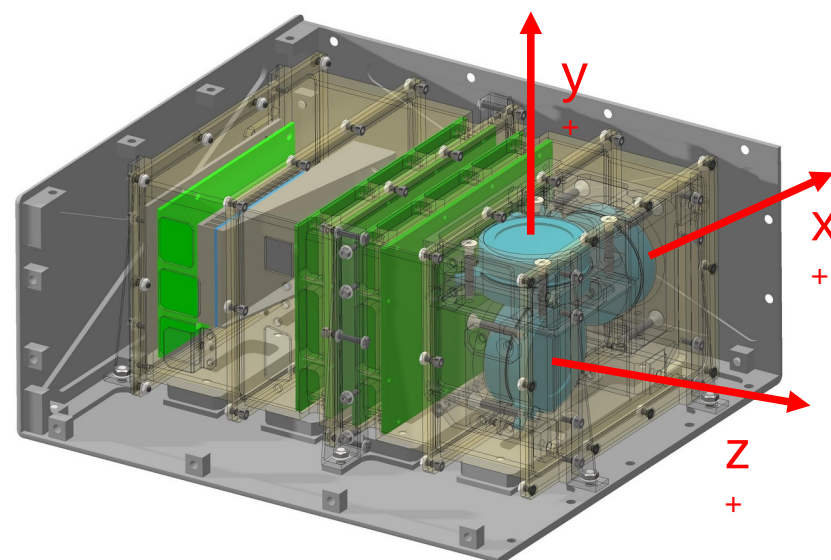
24.01.2024 - 11.08.2025 (565 days)	SAA	GCR	Electrons (preliminary)	SPEs	Total
Absorbed dose in H ₂ O/mGy	64.9	57.8	0.66	0.14	123.6
Q	1.2	3.0	2.66	1.44	/
Dose equivalent in H ₂ O/mSv	77.9	173.5	1.8	0.2	253.4

average daily dose equivalent
→ 253.4 mSv / 565 days = 0.45 mSv / day

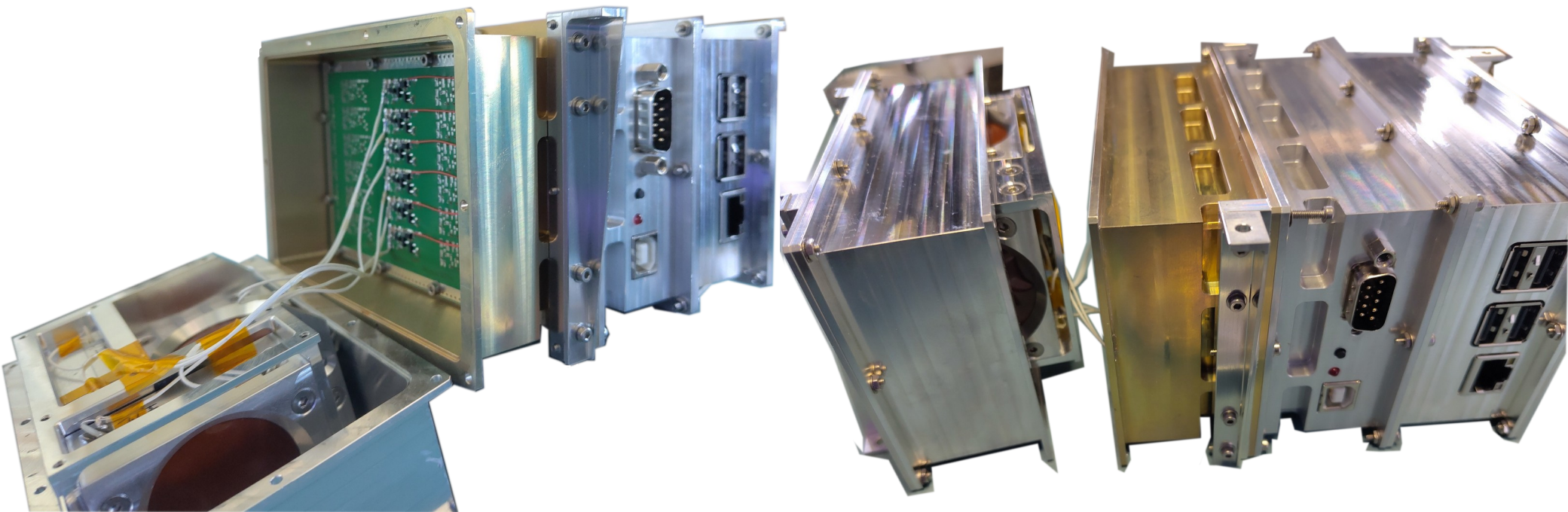
DOSTEL3D

Improvements

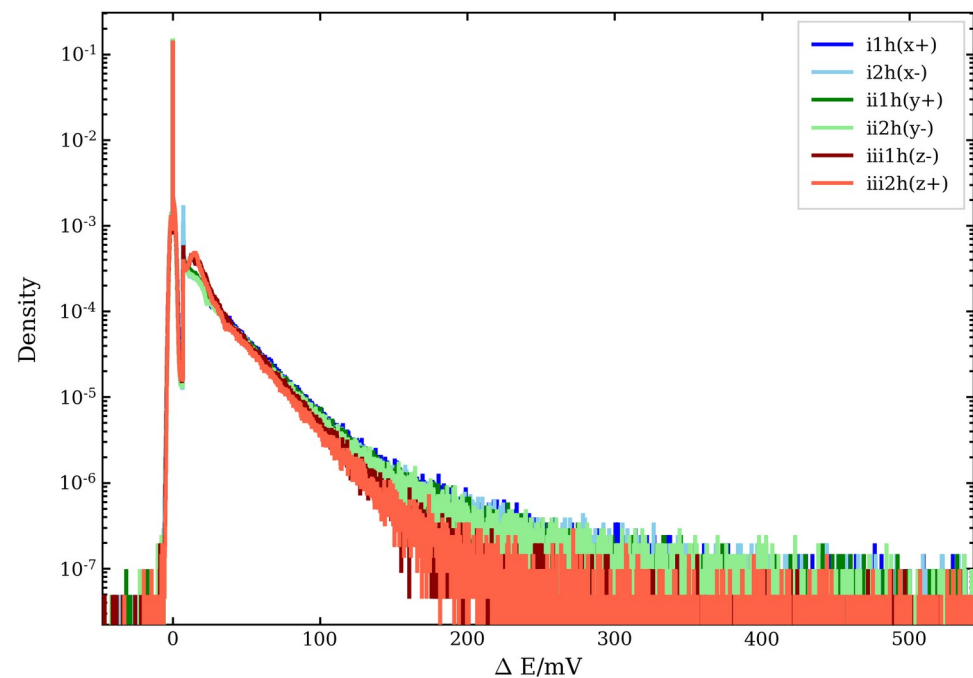
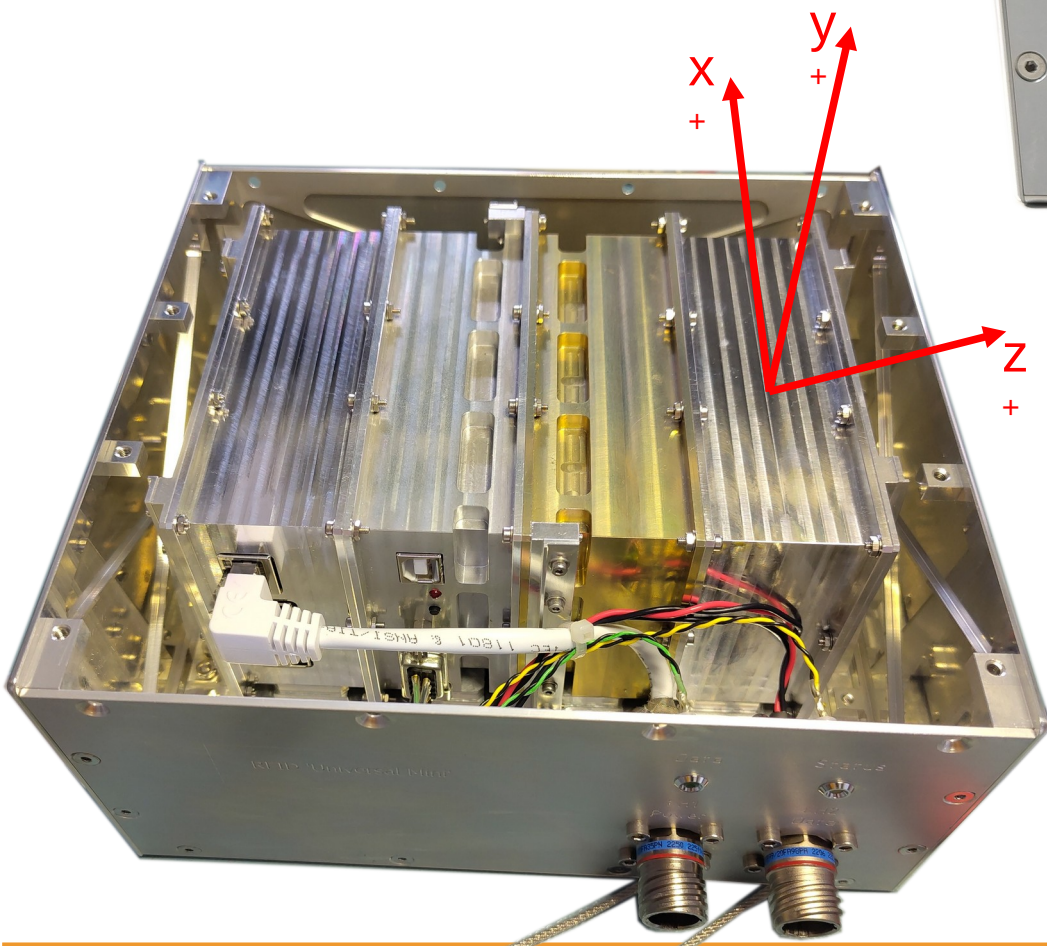
- Three telescopes (xyz-configuration)
- Time synchronisation
- Real time data
- Single particles (no manual mode switch)



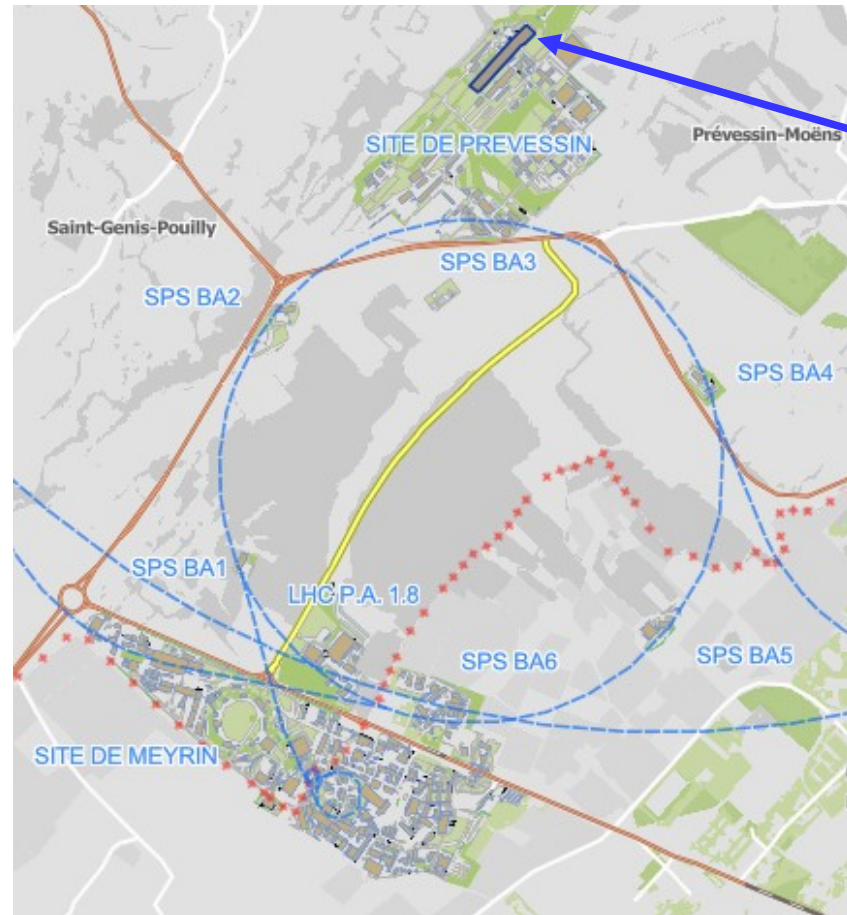
DOSTEL3D - Engineering model



Engineering model



CERN May 2025 - CERF run



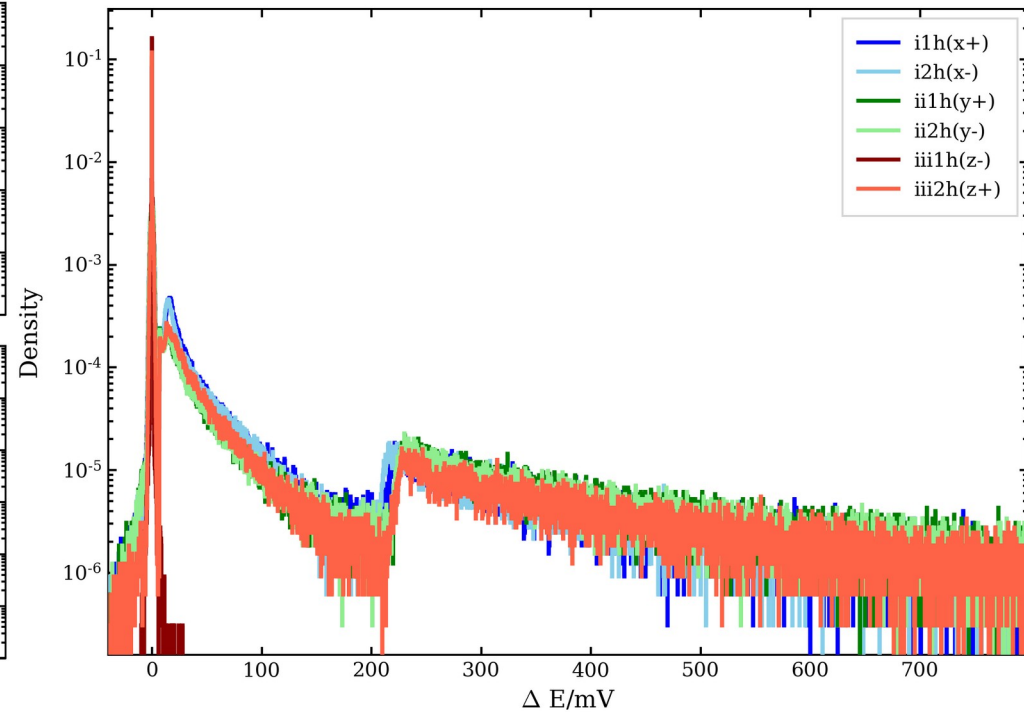
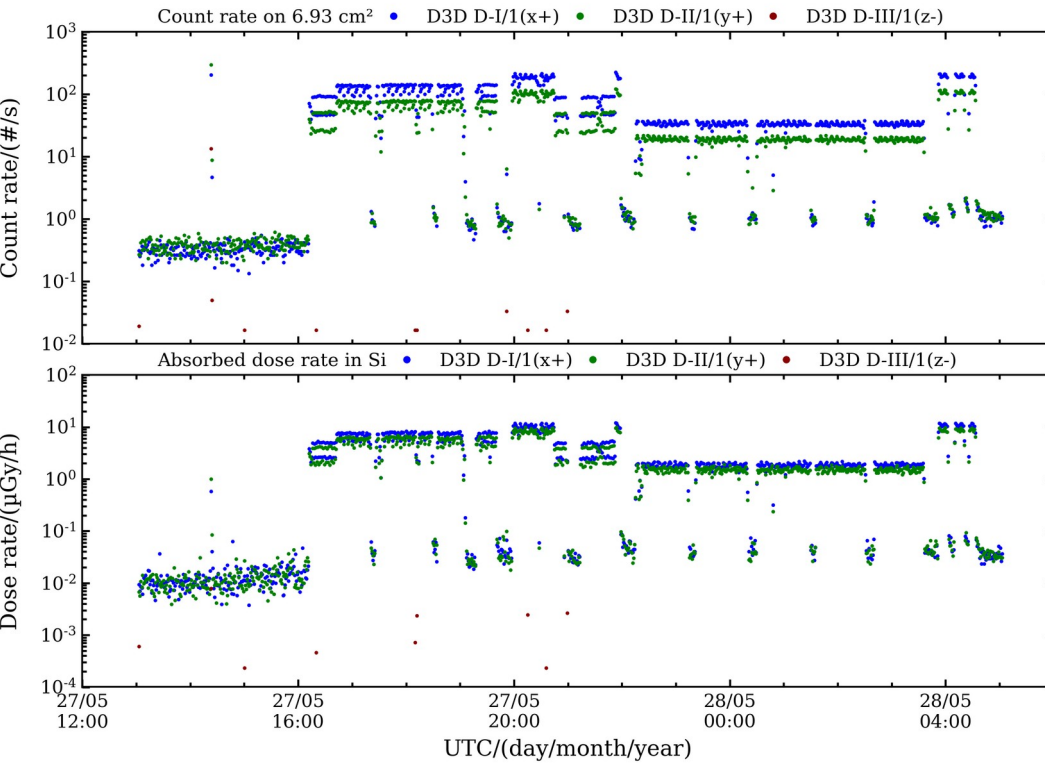
Building 887



CERF beam line

DOSTEL3D

CERF run - early results



Summary and Outlook

- Since 2009 DOSTEL measures the radiation environment onboard the ISS within the Columbus laboratory.
- The native separation of GCR and SAA DOSTEL measurements has been improved to also identify SPEs and Slot-Belt-Electrons.
- For the DOSTEL data in 2024 and 2025 seven SPEs and Slot-Belt-Electrons over 168 days could be identified.
- DOSTEL3D is targeted to launch with SpX-35 in late 2026.

Acknowledgment

The CAU work on DOSIS and DOSIS3D has been supported under grants 50WB0826, 50WB1026, 50WB1232, 50WB1533 and 50WB1817 by Federal Ministry of Economics and Technology.

Supported by:

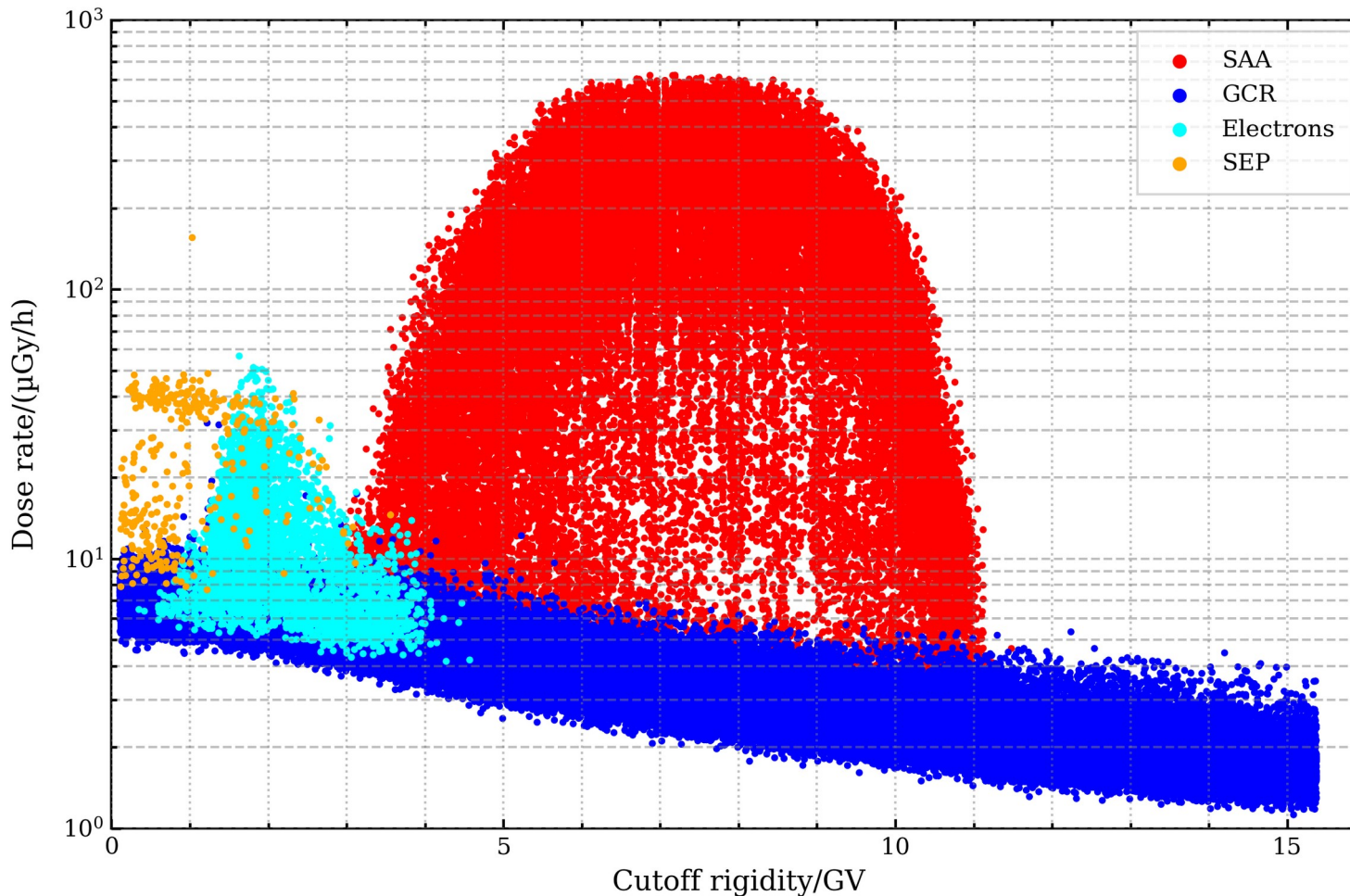


Federal Ministry
of Economics
and Technology

on the basis of a decision
by the German Bundestag

Dose rate vs cutoff rigidity

DOSTEL-1 D1, 01.01.2024 to 31.12.2024



Dose rate vs cutoff rigidity

DOSTEL-1 D1, 01.01.2025 to 31.12.2025

