

ASTROBOTIC PEREGRINE 1 MISSION DLR M-42 DATA

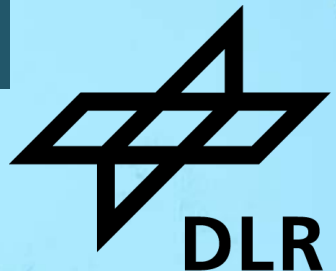
UPDATE ON M-42 INSTRUMENT FAMILY



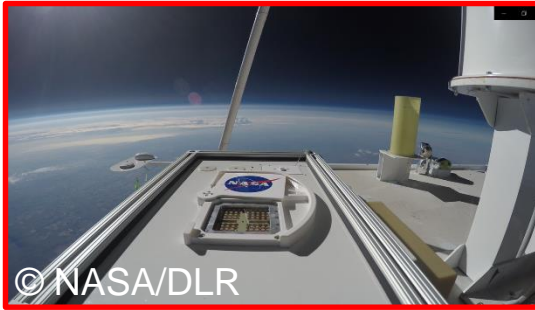
DLR M-42 Team

German Aerospace Center (DLR), DLR-ME & DLR-MUSC, Cologne, Germany

NOTE: All data preliminary and confidential



DLR-ME: Radiation Measurements in Space



© NASA/DLR

36 km

MARSBOX / E-MIST (DLR M-42)



© DLR

250 km

MAPHEUS (DLR M-42)



© DLR

600 km

Eu:CROPIS (DLR RAMIS)



420 km

RadMap (DLR M-42)



© CNSA/CLEP

To the Moon and back

MARE (DLR M-42)



400.000 km

Astrobotic



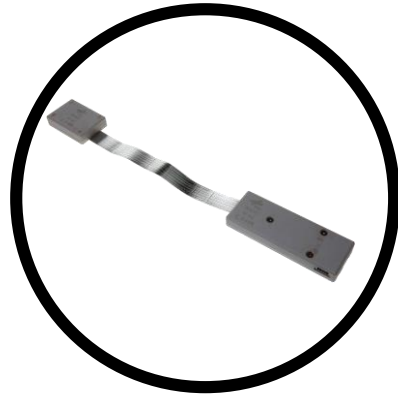
MARSBOX: Berger et al. (2021) <https://doi.org/10.1002/essoar.10506355.1>
Eu:CROPIS: Hauslage et al. (2018) <https://doi.org/10.1007/s12217-018-9654-1>
RAMIS: Guo et al. (2023) <https://doi.org/10.1029/2023GL103069>
RAMIS: Meier et al. (2023) <https://doi.org/10.1038/s41598-023-36190-5>
RadMap: Losekamm et al. (2023) <https://doi.org/10.22323/1.444.0099>



DLR M-42 Detector Family



M-42 Compact



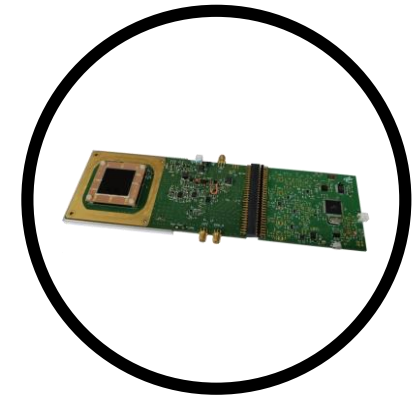
M-42 Split



M-42 Display

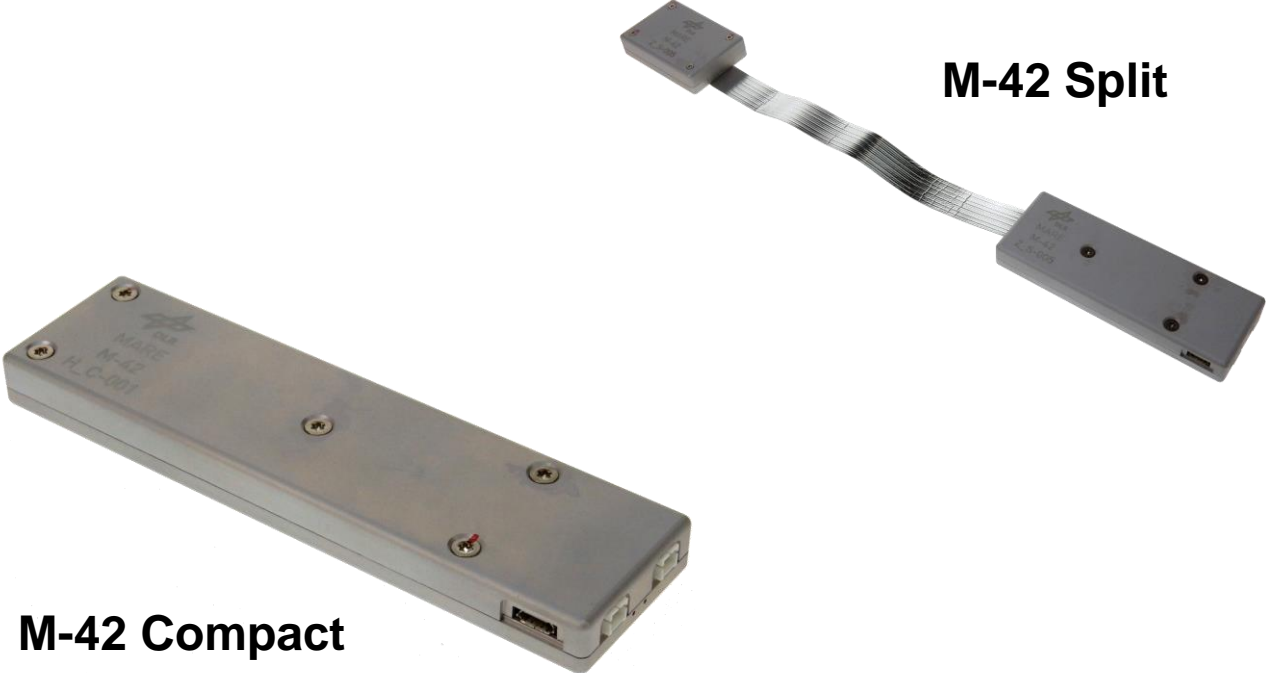


M-42 EXTended



M-42 BIG

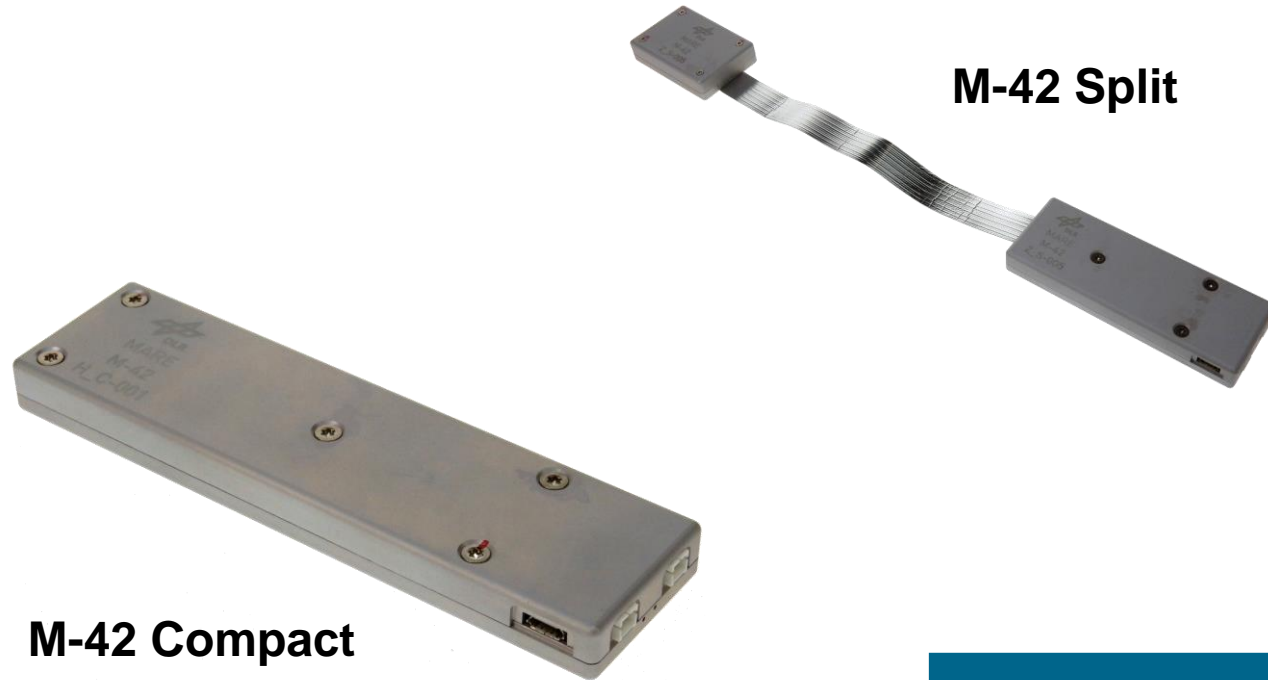
DLR M-42 Detector Family



M-42 Compact

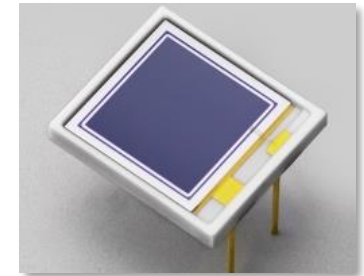
M-42 Split

DLR M-42 Detector Family



M-42 Compact

M-42 Split

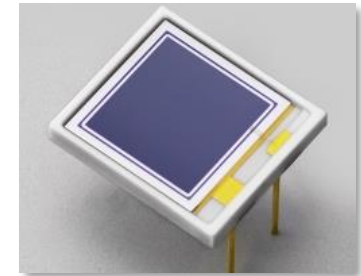


	M-42 Compact/Split
Energy Range (in Si)	0.06 - 20 MeV
Sensor thickness	300 μm
Sensitive Area	1.22 cm^2
Power Consumption	10.44 mW

DLR M-42 Detector Family



M-42 Display

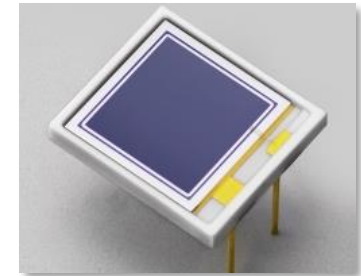


	M-42 Compact	M-42 Display
Energy Range (in Si)	0.06 - 20 MeV	0.06 - 43 MeV
Sensor thickness	300 μm	
Sensitive Area	1.22 cm^2	
Power Consumption	11 mW	36 mW

DLR M-42 Detector Family



M-42 EXTended

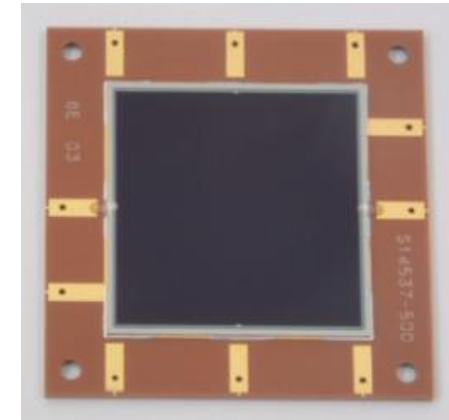
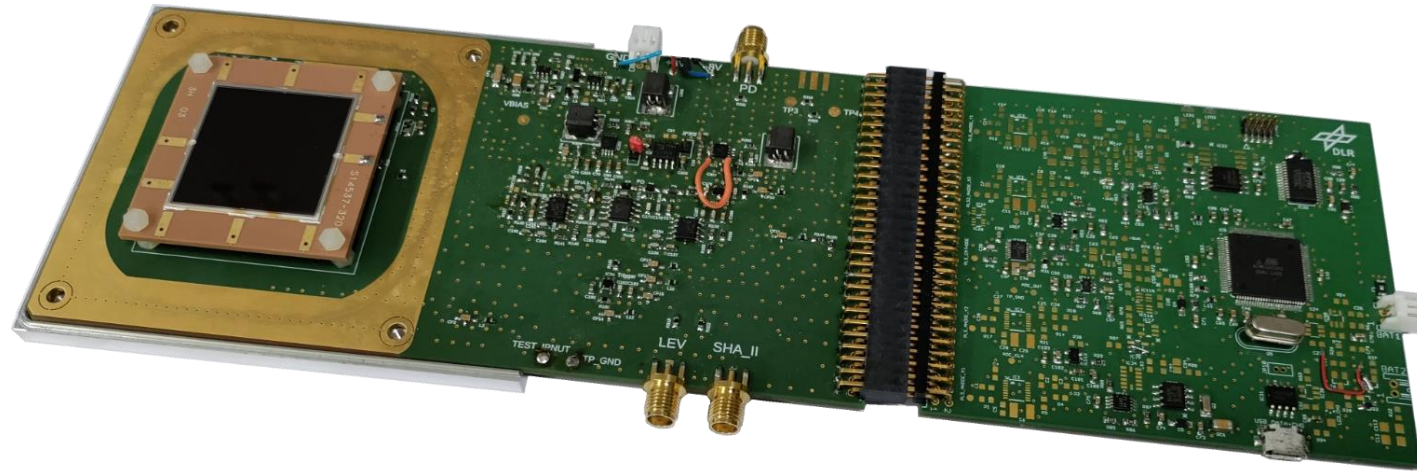


	M-42 Compact	M-42 EXT
Energy Range (in Si)	0.06 - 20 MeV	0.06 - 135 MeV
Sensor thickness	300 μm	
Sensitive Area	1.22 cm^2	
Power Consumption	11 mW	11 mW

DLR M-42 Detector Family



M-42 BIG

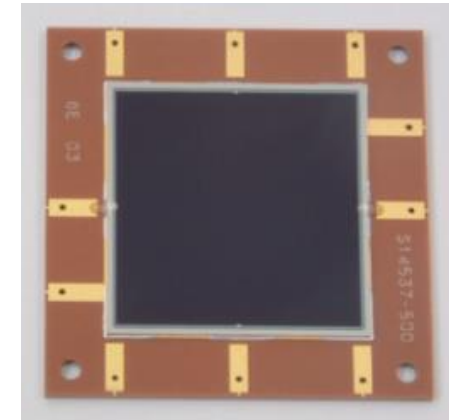
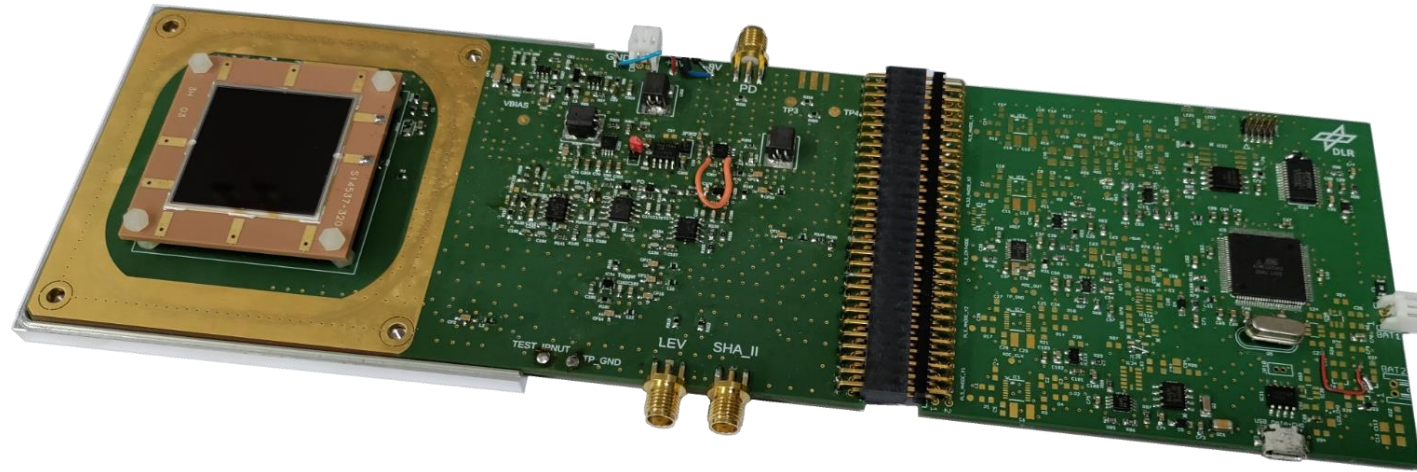


	M-42 EXT	M-42 BIG
Energy Range (in Si)	0.06 - 135 MeV	
Sensor thickness	300 μm	320 μm
Sensitive Area	1.22 cm^2	7.84 cm^2
Power Consumption	11 mW	

DLR M-42 Detector Family



M-42 BIG

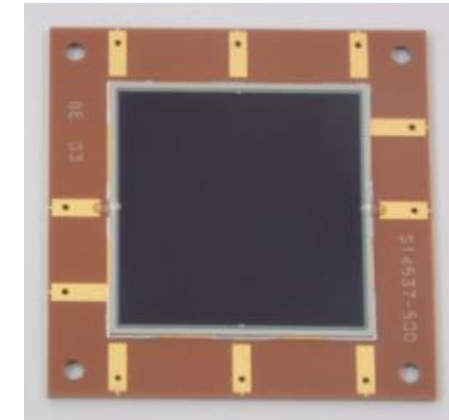
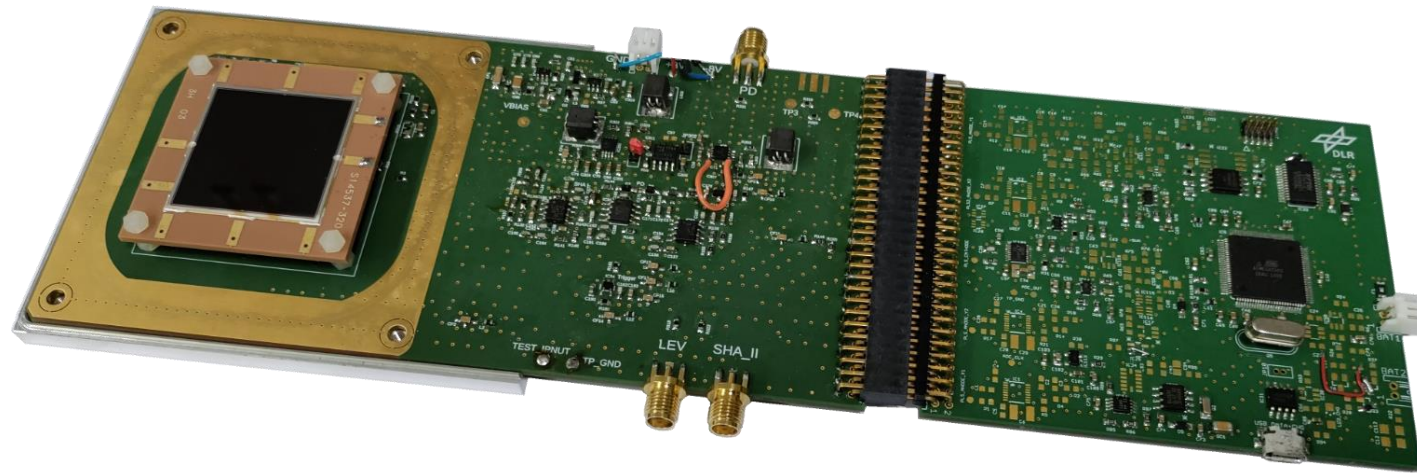


	M-42 EXT	M-42 BIG
Energy Range (in Si)	0.06 - 135 MeV	0.06 - 250 MeV
Sensor thickness	300 μm	320 μm
Sensitive Area	1.22 cm^2	7.84 cm^2
Power Consumption	11 mW	

DLR M-42 Detector Family



M-42 BIG

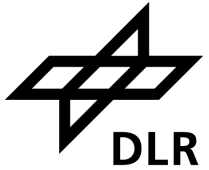


RAMIS

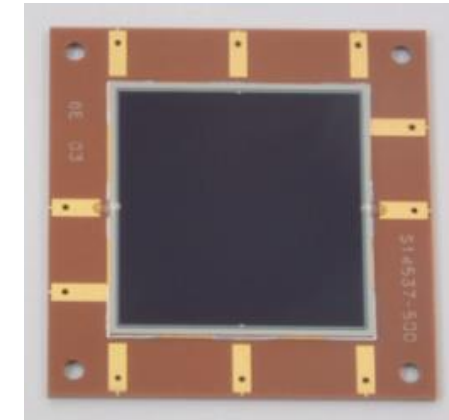
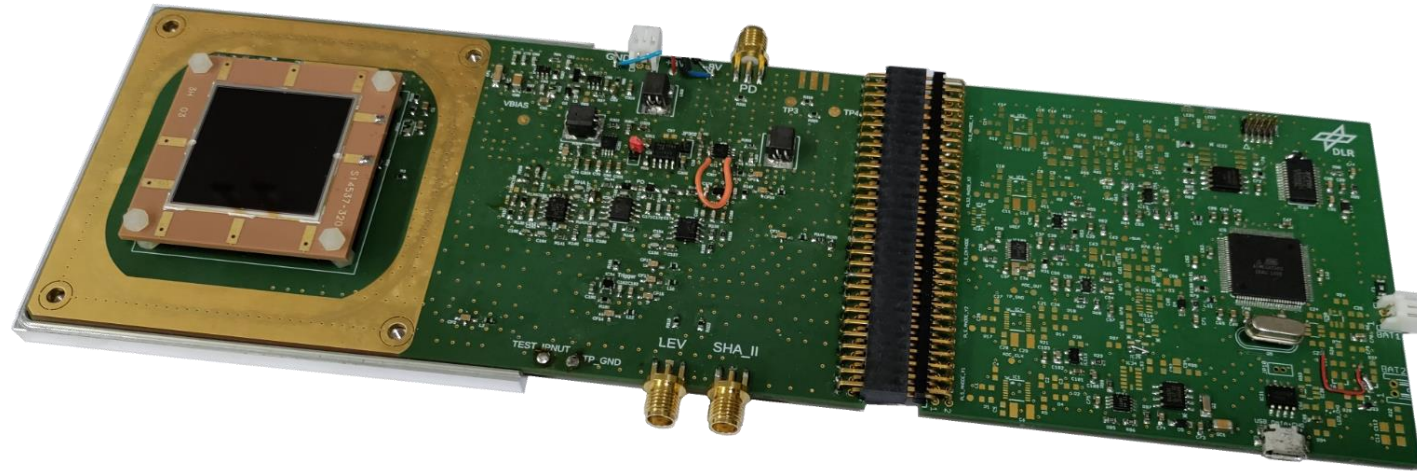


	M-42 EXT	M-42 BIG
Energy Range (in Si)	0.06 - 135 MeV	0.06 - 250 MeV
Sensor thickness	300 μm	320 μm
Sensitive Area	1.22 cm^2	7.84 cm^2
Power Consumption	11 mW	

DLR M-42 Detector Family



M-42 BIG



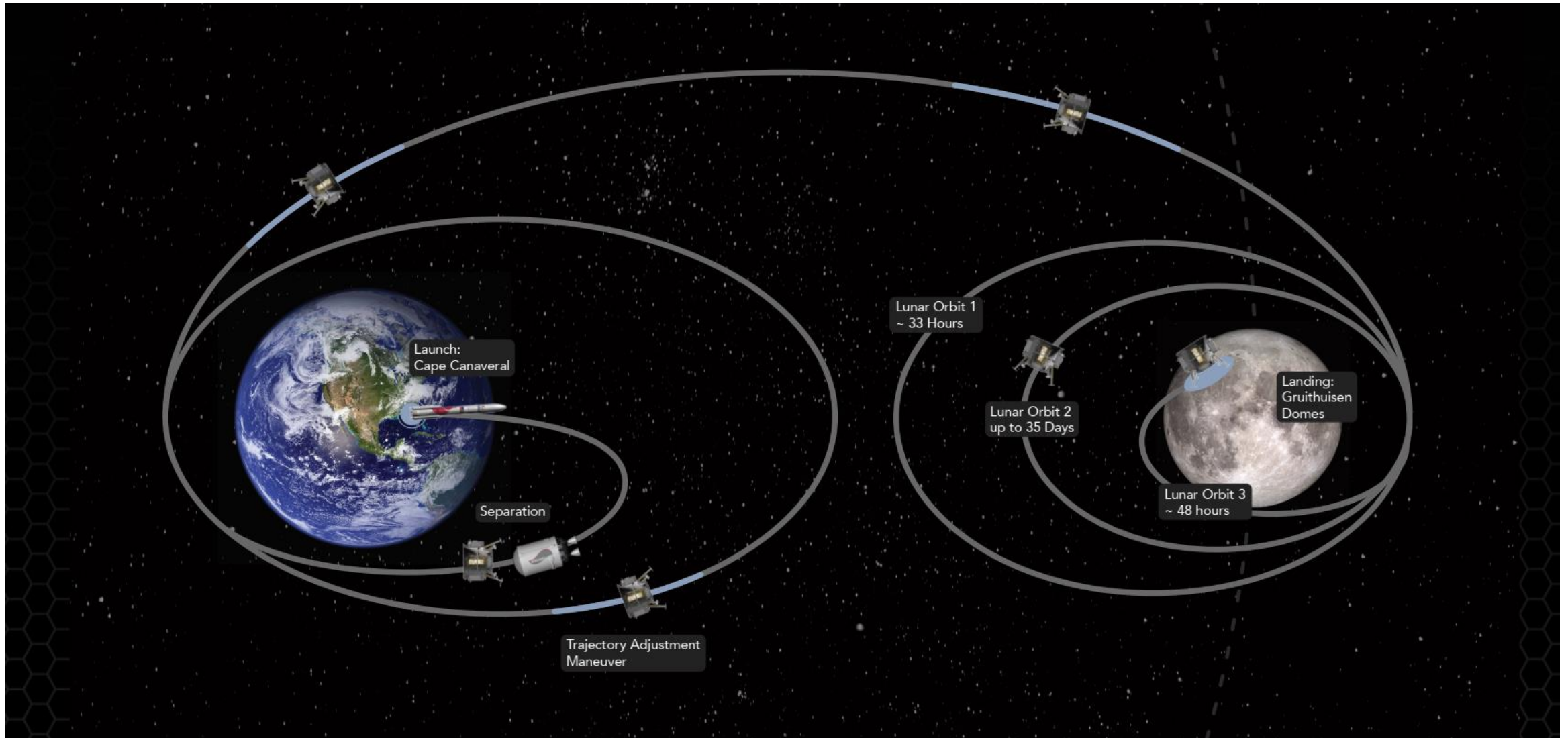
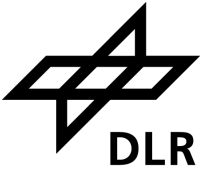
RAMIS



	M-42 EXT	M-42 BIG
Energy Range (in Si)	0.06 - 135 MeV	0.06 - 250 MeV
Sensor thickness	300 μm	320 μm
Sensitive Area	1.22 cm^2	7.84 cm^2
Power Consumption	11 mW	500 mW

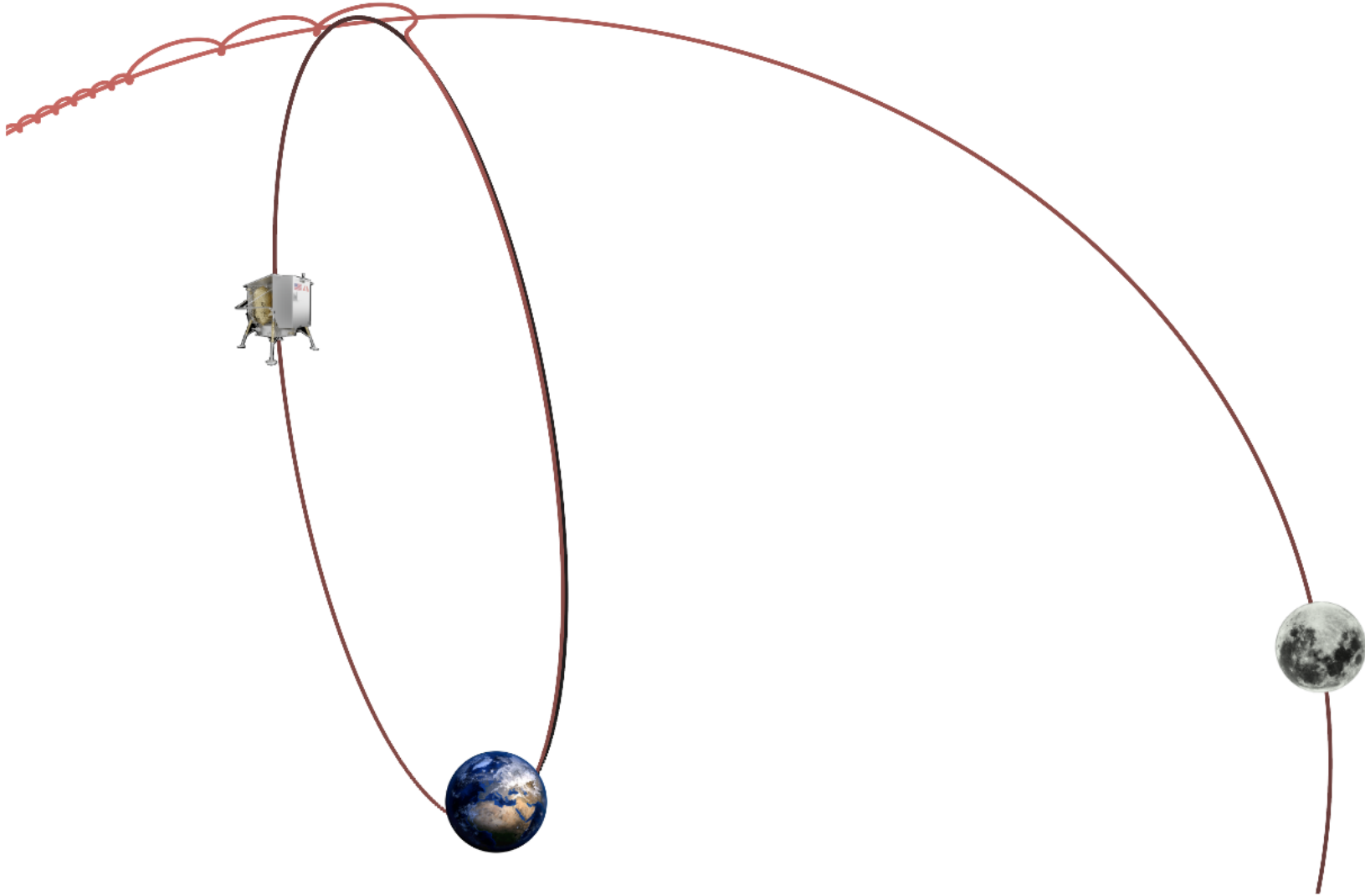
ASTROBOTIC PEREGRINE MISSION 1

Planned Flight Path



ASTROBOTIC PEREGRINE MISSION 1

Planned Flight Path



ASTROBOTIC PEREGRINE MISSION 1

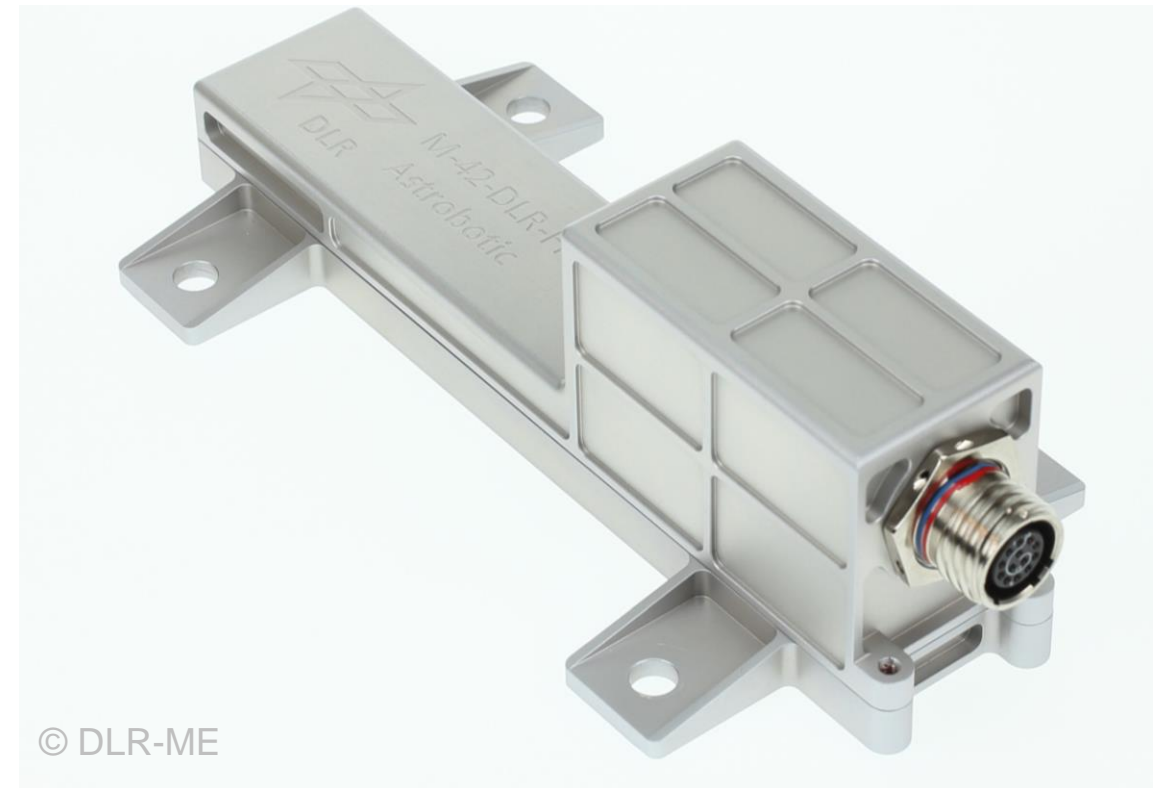
DLR M-42 Radiation Detector



Technical data DLR M-42

- Silicon Detector
 - Area: 1.22 cm²
 - Thickness: 300 μm
- Science Data
 - Energy deposition spectra in 182 log-bins
 - Energy range (E_{DEP} in Si: 0.08 – 20.77 MeV)
 - Overflow bin at: 20.77 MeV
 - Time resolution: 300 seconds

DLR M-42 Astrobotic FM

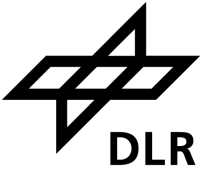


© DLR-ME

Berger, T. et al. (2019). The German Aerospace Center M-42 radiation detector – a new development for applications in mixed radiation fields. *Review of Scientific Instruments*, 90, 125115. <https://doi.org/10.1063/1.5122301>

ASTROBOTIC PEREGRINE MISSION 1

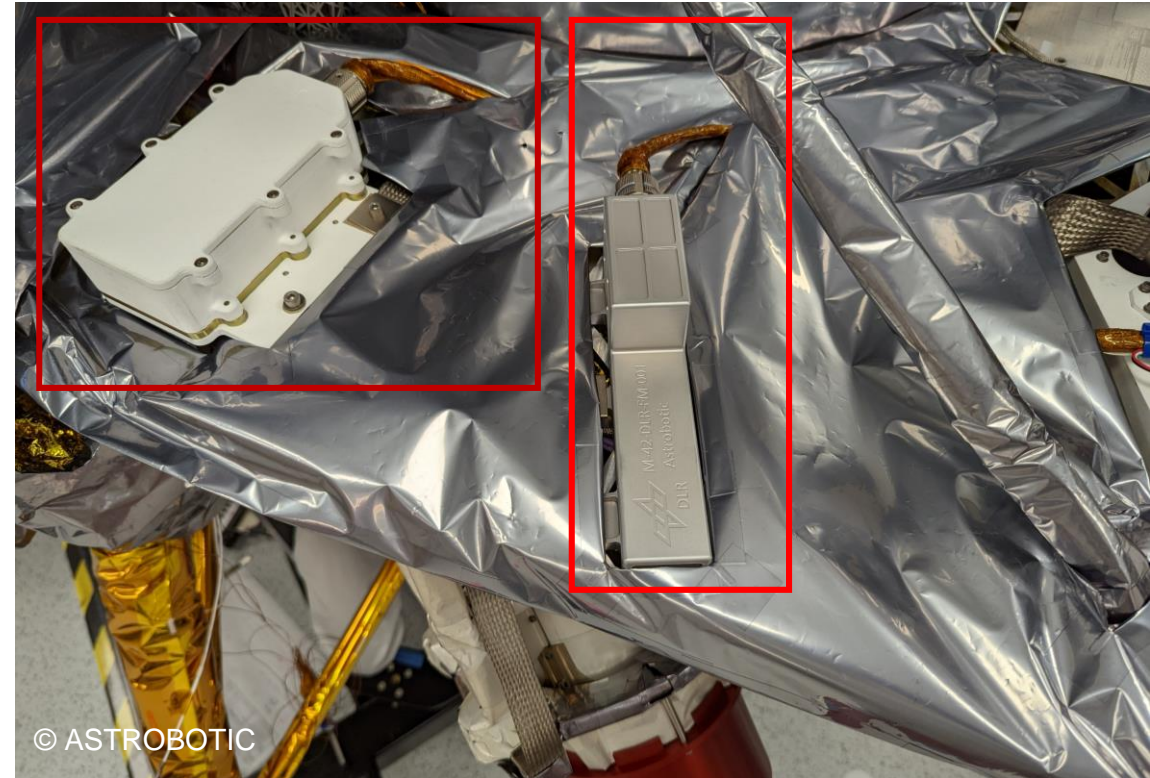
NASA LETS + DLR M-42 (Deck D) radiation detectors



Peregrine



NASA LETS + DLR M-42 radiation detectors



Vulcan- Launch

- Launch:
 - 2024-01-08 **07:18:38**
- M-42 Power On:
 - 2024-01-08 **09:30:22**
(shortly after Peregrine separation)



ASTROBOTIC PEREGRINE MISSION 1

DLR M-42 Radiation Detector



M-42 Communication

- Commanding:
 - DLR-MUSC → Pittsburgh → Peregrine
- Data rate:
 - Free Space: 10 bits/second
 - Moon: 8 kbits/second
- First data packet received:
 - **2024-01-08 12:10:14**

DLR M-42 Mission OPS

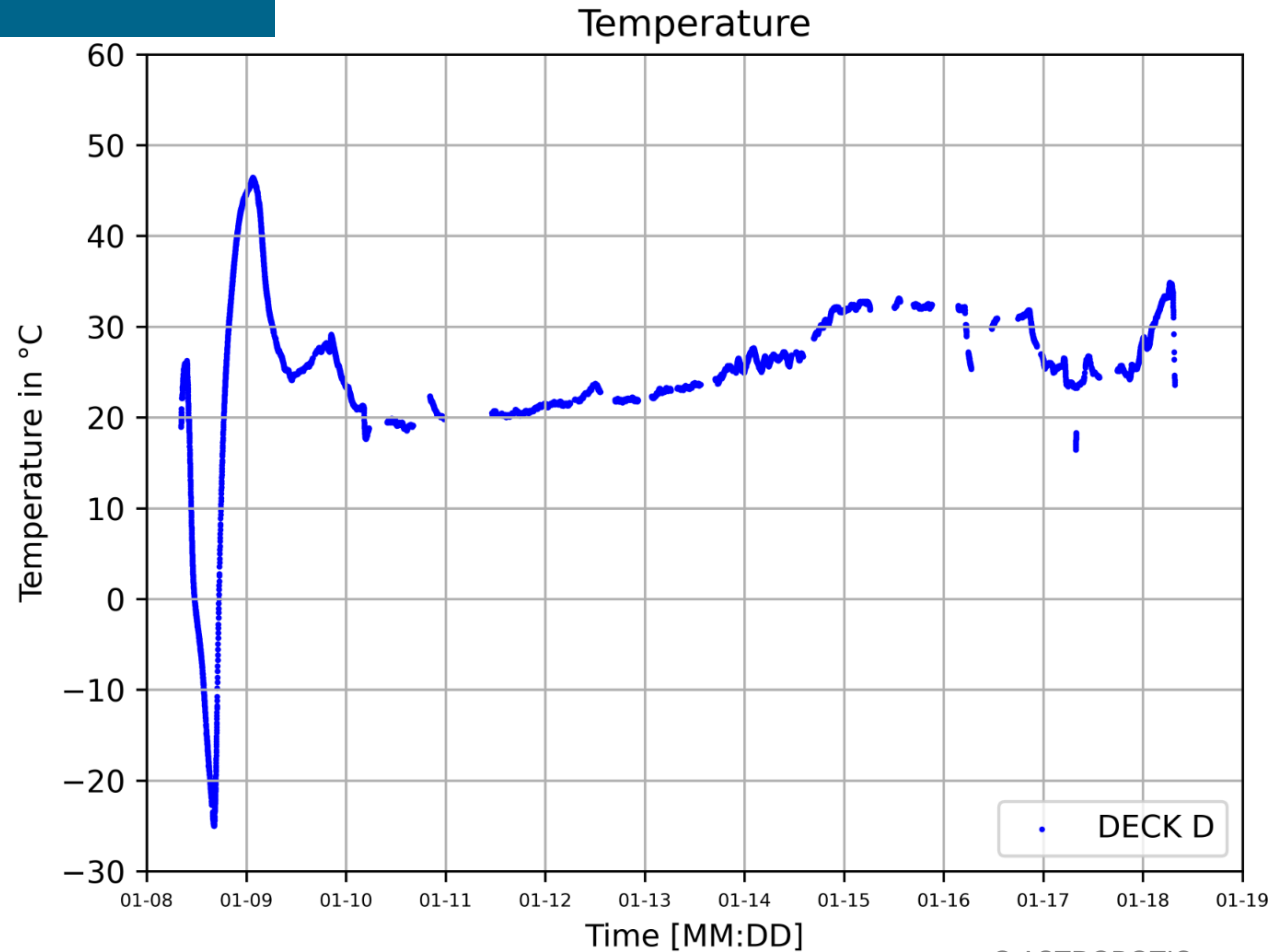


ASTROBOTIC PEREGRINE MISSION 1

DLR M-42: Housekeeping data (temperature)



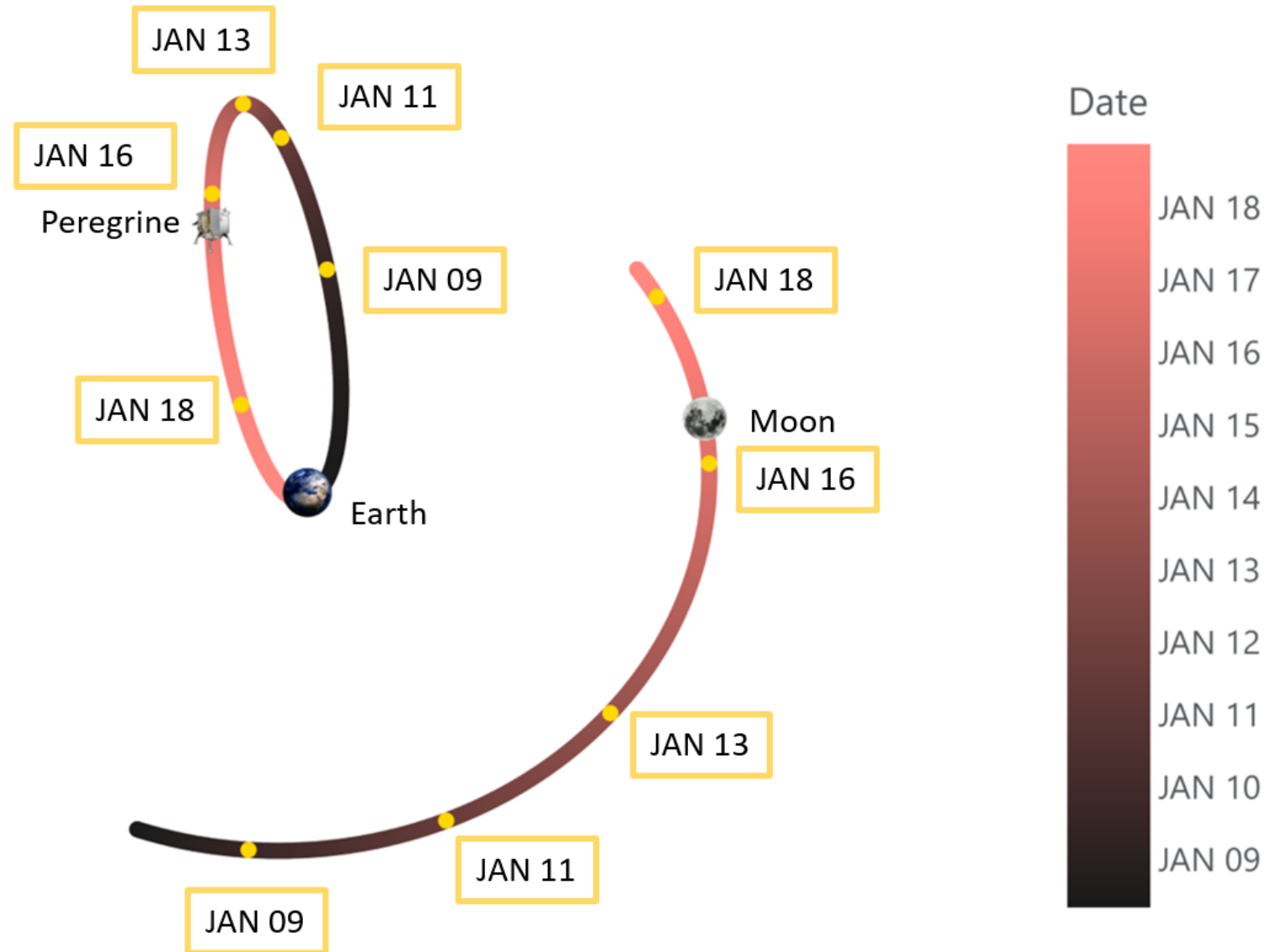
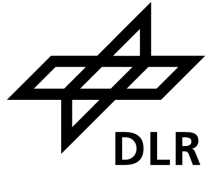
Temperature (°C)



© ASTROBOTIC

ASTROBOTIC PEREGRINE MISSION 1

Actual Flight Path



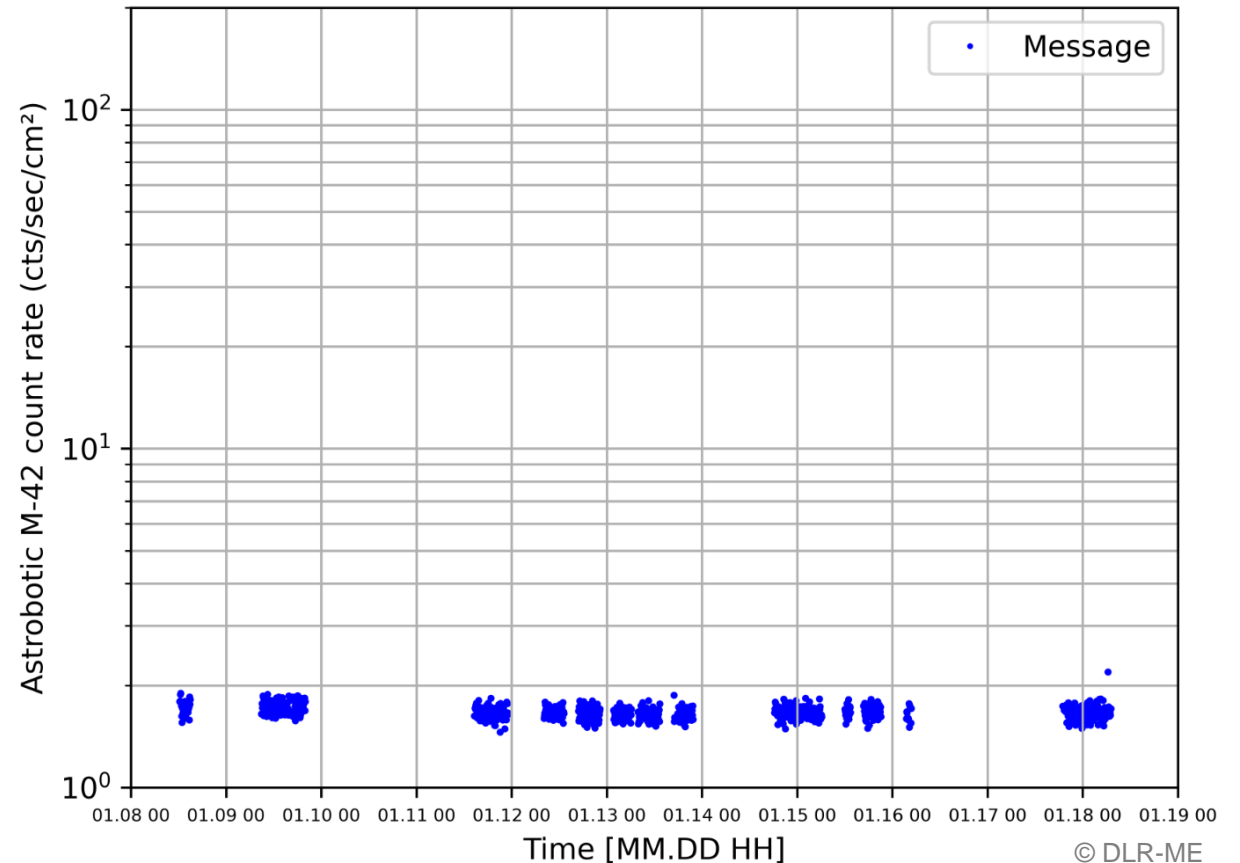
ASTROBOTIC PEREGRINE MISSION 1

DLR M-42: Science data (count rates)



Count rate (cts/sec/cm²)

- MESSAGES
 - M-42 instrument sends out energy deposition spectra every 300 seconds to the Peregrine Payload OBC for downlink to Earth



- Data: MESSAGES (M-42 sends data every 300 seconds)

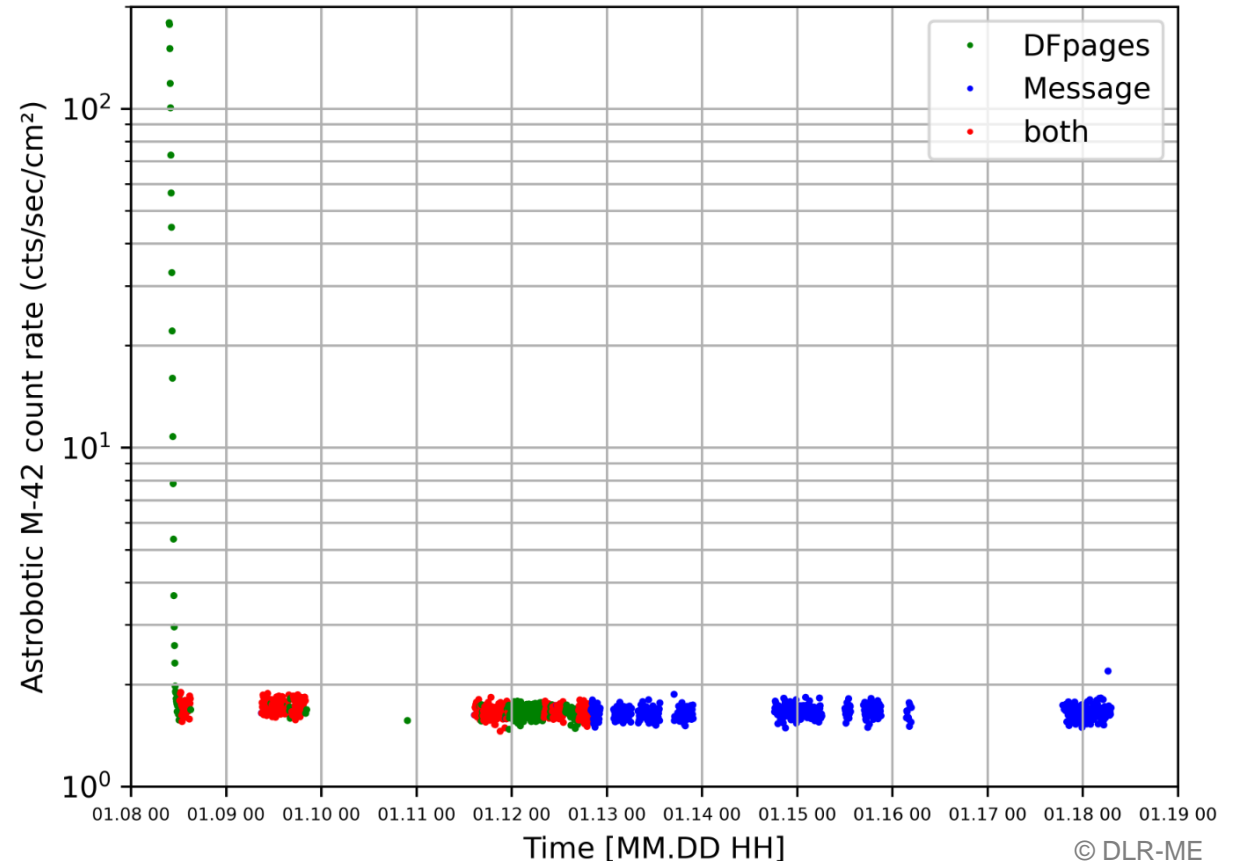
ASTROBOTIC PEREGRINE MISSION 1

DLR M-42: Science data (count rates)



Count rate (cts/sec/cm²)

- MESSAGES
 - M-42 instrument sends out energy deposition spectra every 300 seconds to the Peregrine Payload OBC for downlink to Earth
- DATA FLASH
 - M-42 stores measured data in the internal data flash
 - Stored data is downlinked to ground via relevant commanding from DLR-MUSC → Pittsburgh → Peregrine



- Data: MESSAGES (M-42 sends data every 300 seconds) and DF PAGES (M-42 is commanded to provide data from in-built memory)

ASTROBOTIC PEREGRINE MISSION 1

DLR M-42: Summary 1111 Spectra = 5555 minutes of science data

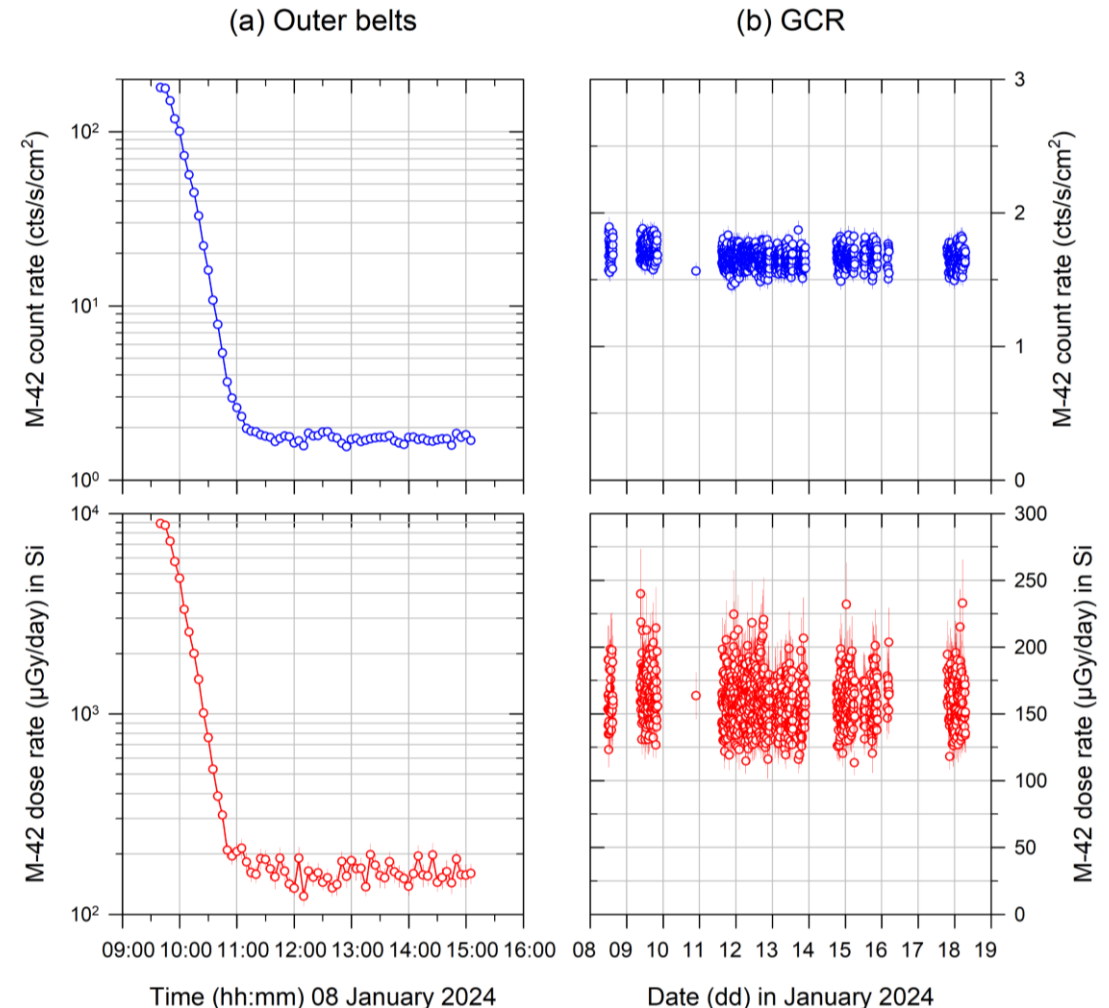


Count rate (cts/sec/cm²)

- Outer electron belts (maximum):
 - 179 ± 0.7 cts/s/cm²
- Free space (GCR) (average):
 - 1.67 ± 0.07 cts/s/cm²

Dose rate (μ Gy/day) in Si

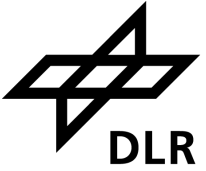
- Outer electron belts (maximum):
 - 8909 ± 257 μ Gy/day
- Free space (GCR) (average):
 - 158 ± 24 μ Gy/day
 - Extrapolated (overflow): ~ 173 μ Gy/day



© DLR-ME

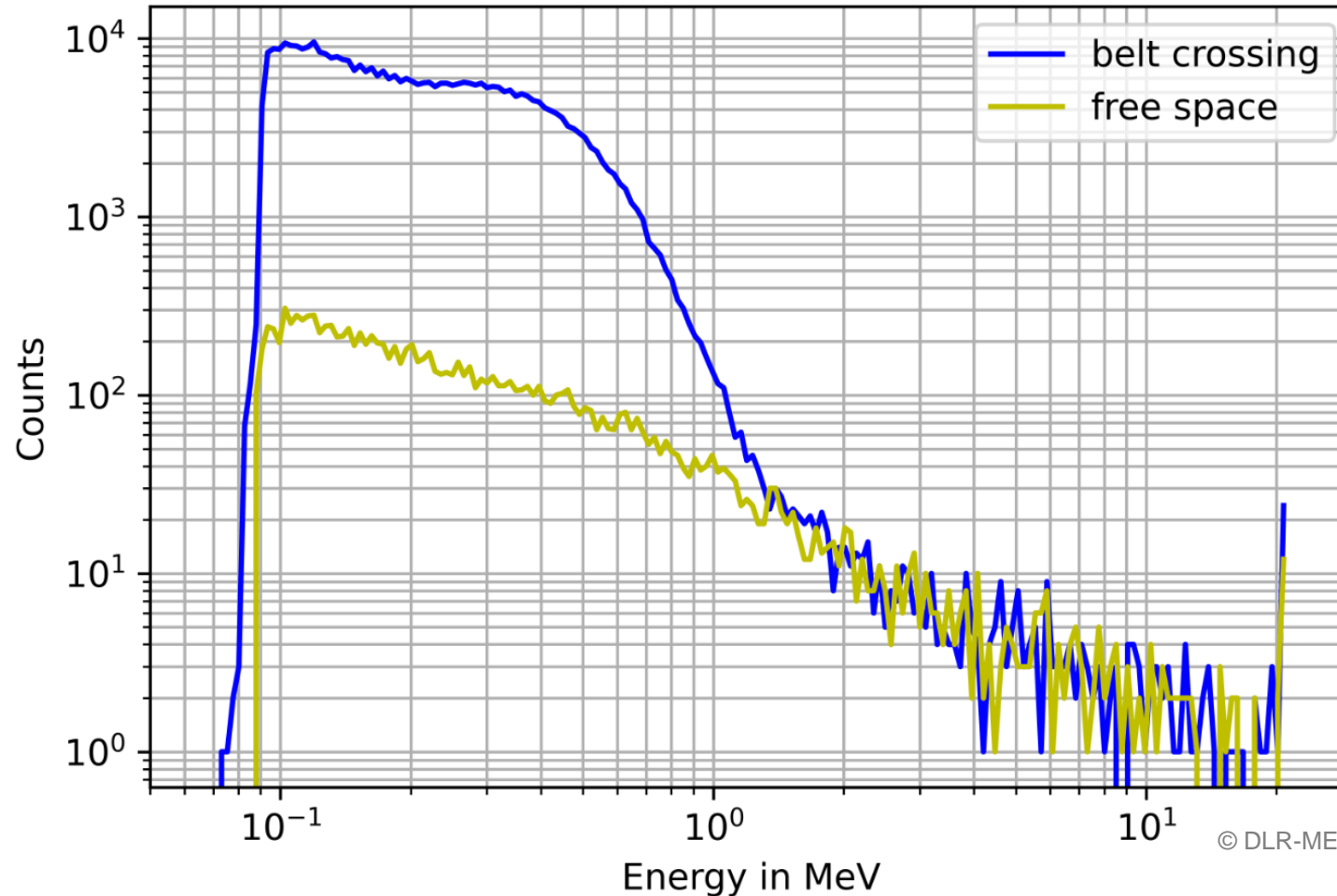
ASTROBOTIC PEREGRINE 1: M-42 Data

Belt crossing vs. free space



Spectra: Belts / GCR

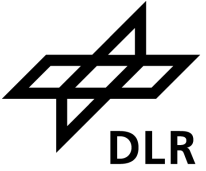
belt vs free space



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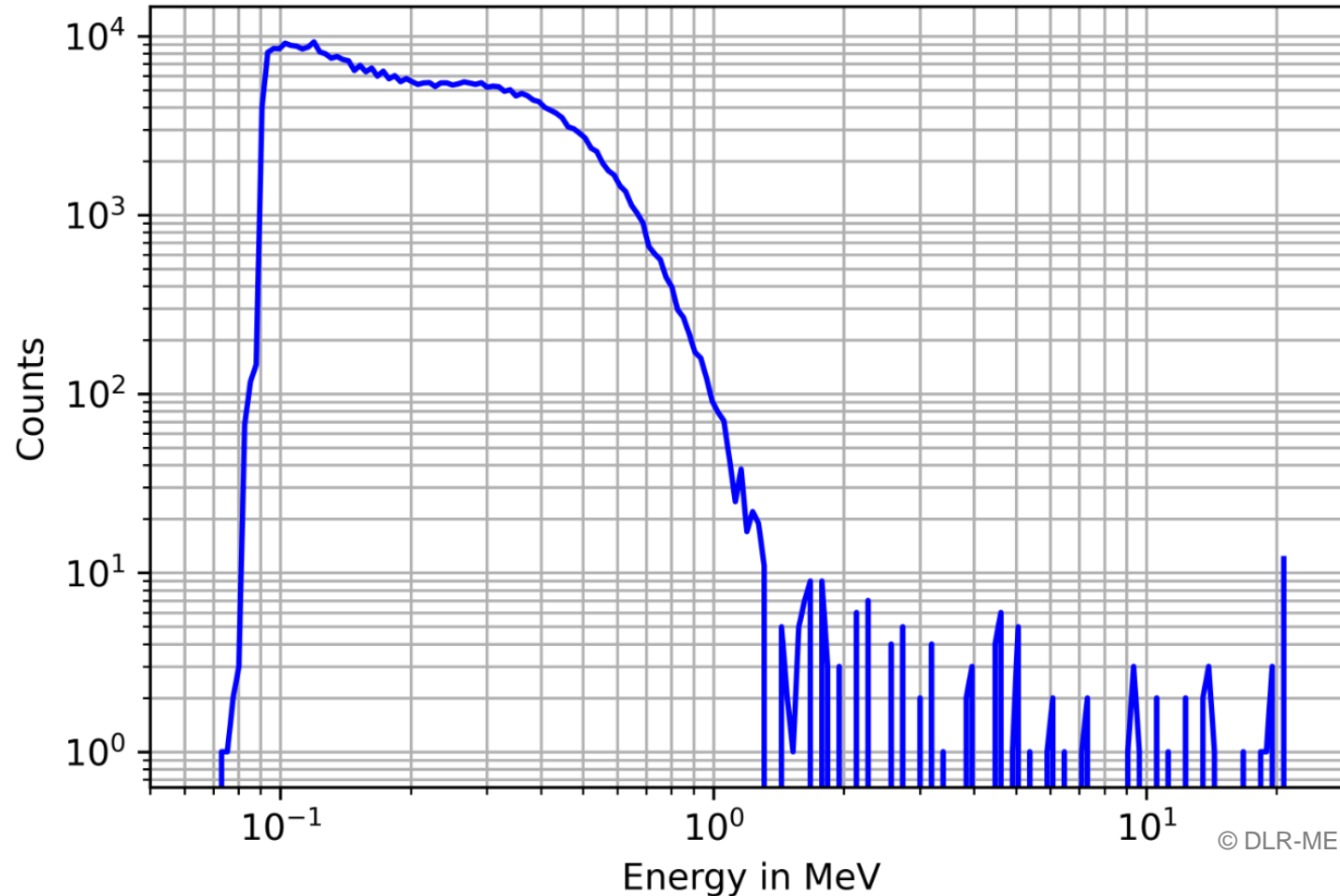
ASTROBOTIC PEREGRINE 1: M-42 Data

Belt crossing vs. free space



Spectra: Belts - GCR

belt - free space



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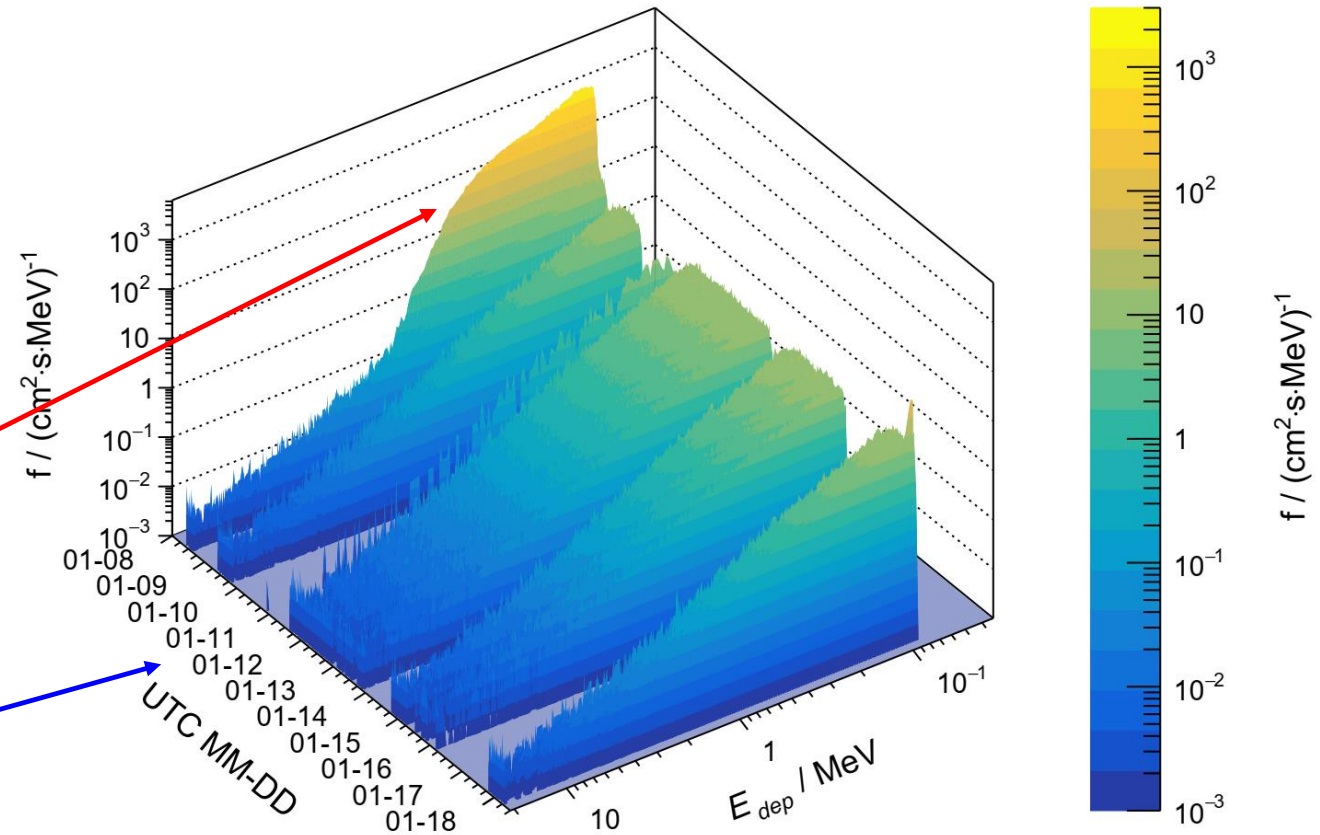
ASTROBOTIC PEREGRINE MISSION 1

DLR M-42: Summary 1111 Spectra = 5555 minutes of science data



Energy deposition spectra

- Variation of the energy deposition spectra as measured with the M-42 instrument over mission duration
 - Observed high peak in the lower energy deposition range (up to 1 MeV) for the first 1 ½ hours of the mission → Outer belt electrons
 - Nominal „stable“ energy deposition spectra for the time spend in free space → Galactic Cosmic Radiation



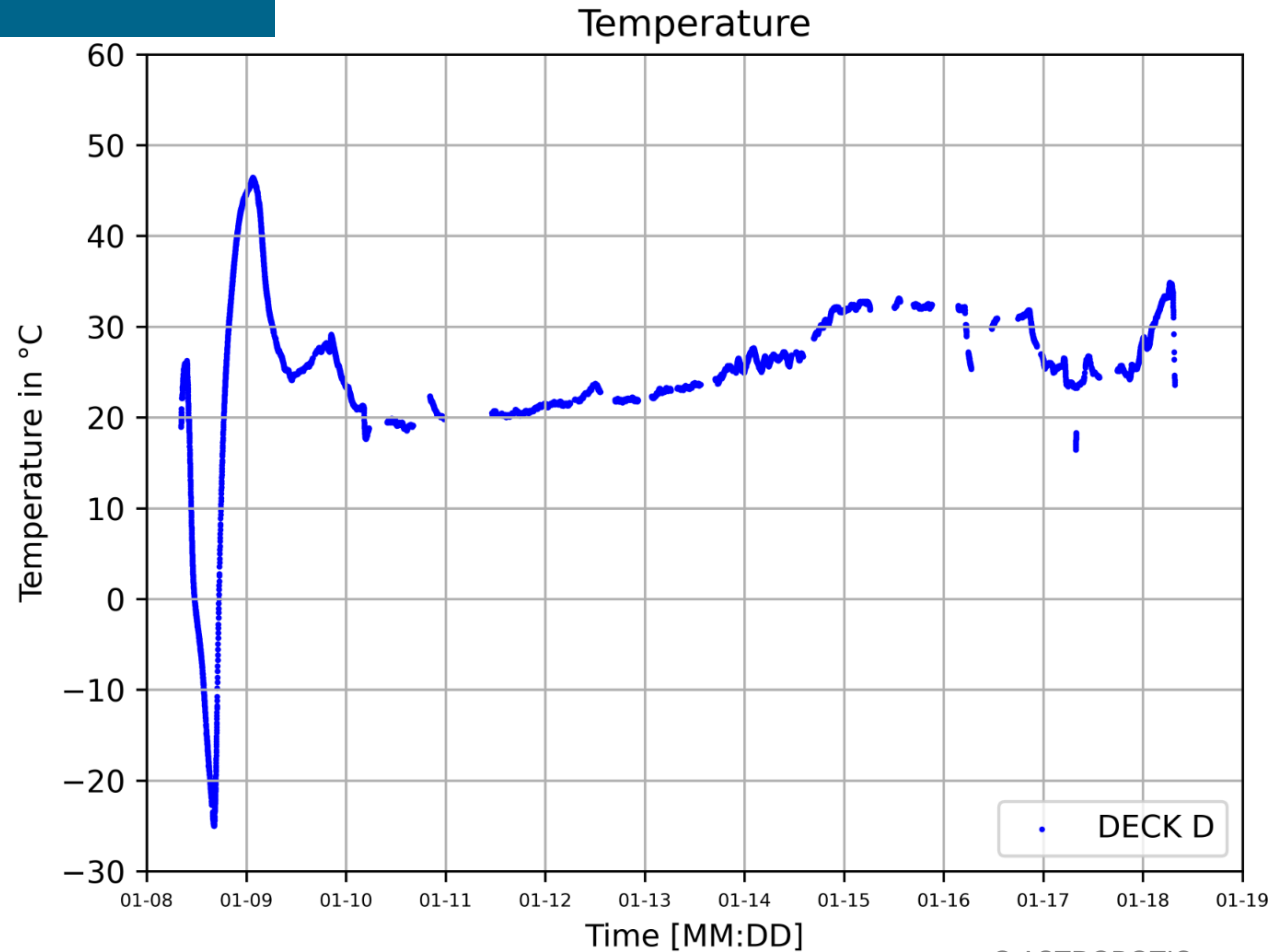
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ASTROBOTIC PEREGRINE MISSION 1

DLR M-42: Housekeeping data (temperature)



Temperature (°C)



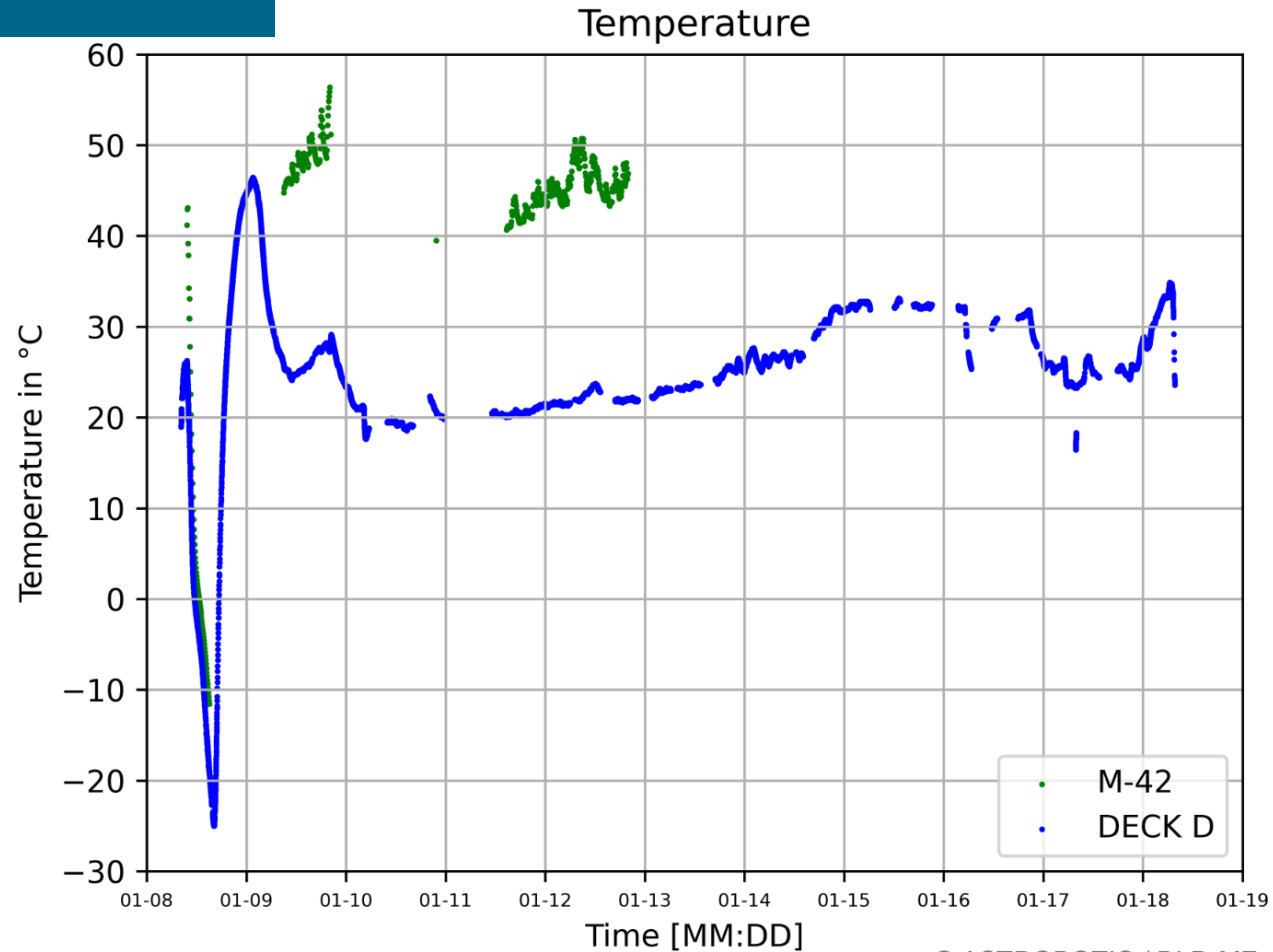
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ASTROBOTIC PEREGRINE MISSION 1

DLR M-42: Housekeeping data (temperature)



Temperature (°C)



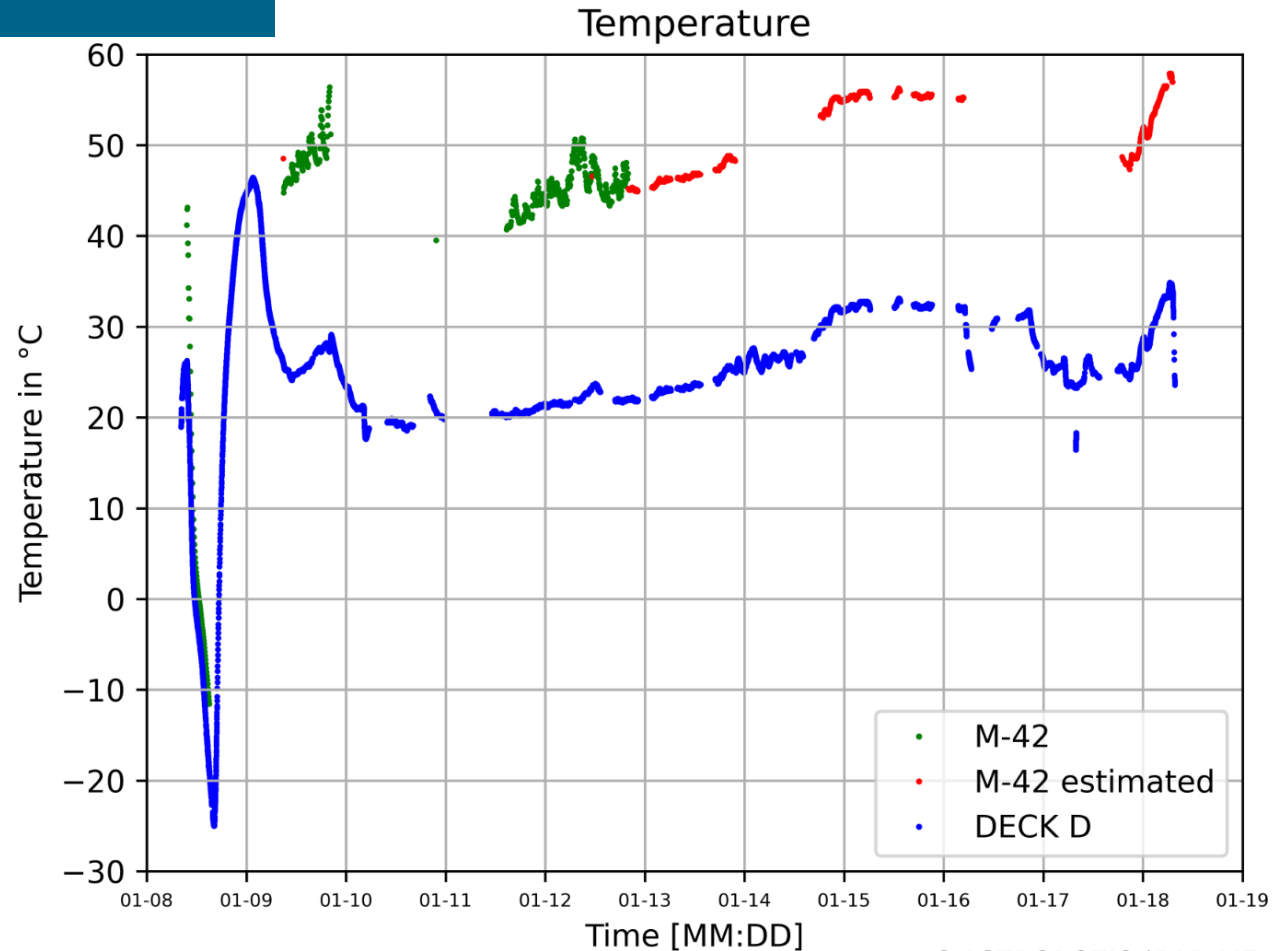
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ASTROBOTIC PEREGRINE MISSION 1

DLR M-42: Housekeeping data (temperature)



Temperature (°C)



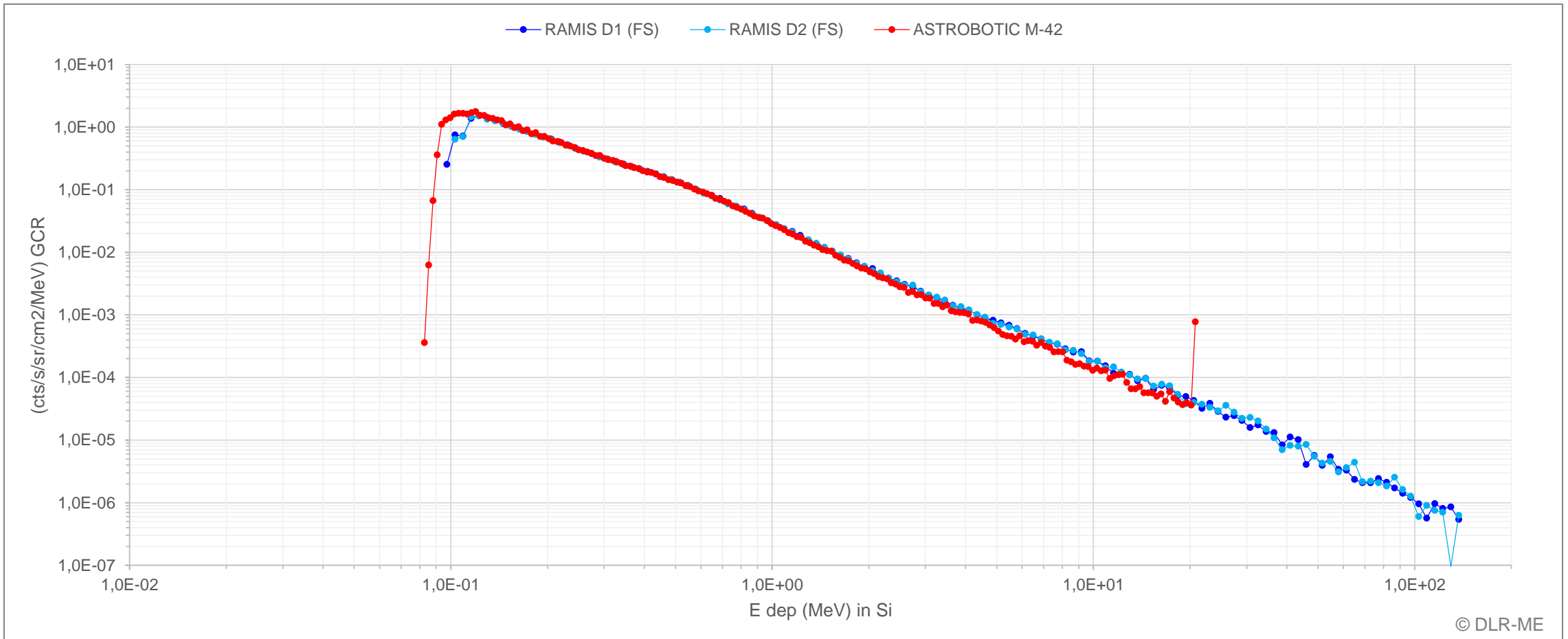
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ASTROBOTIC PEREGRINE 1: M-42 Data

Comparison with RAMIS-Data



RAMIS / Astrobotic



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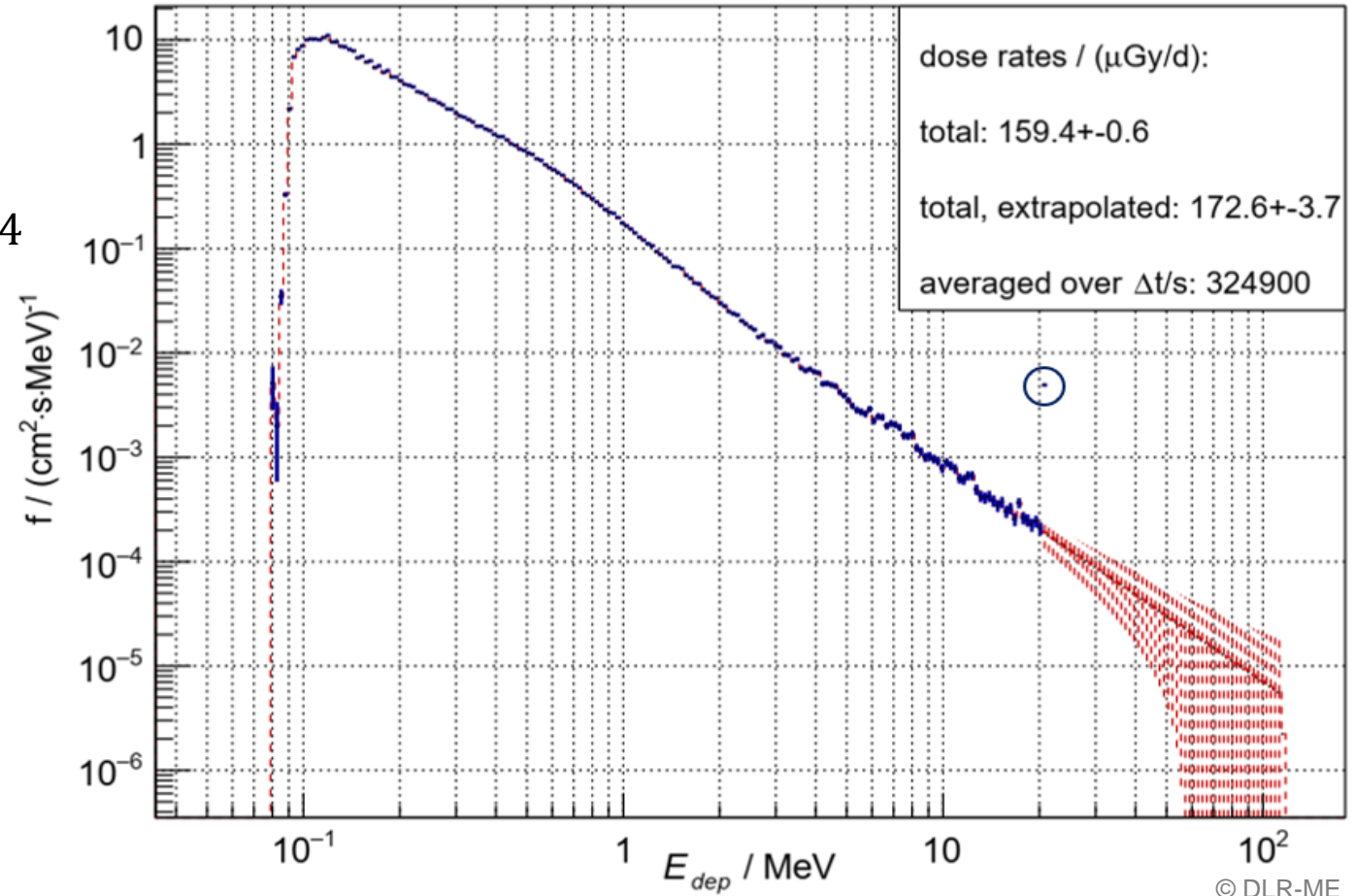
ASTROBOTIC PEREGRINE 1: M-42 Data

Overflow Channel Extrapolation



RAMIS / Astrobotic

- Dose rate measured:
 - $159.4 \pm 0.6 \mu\text{Gy/d}$
- Dose rate extrapolated:
 - $172.6 \pm 3.7 \mu\text{Gy/d}$

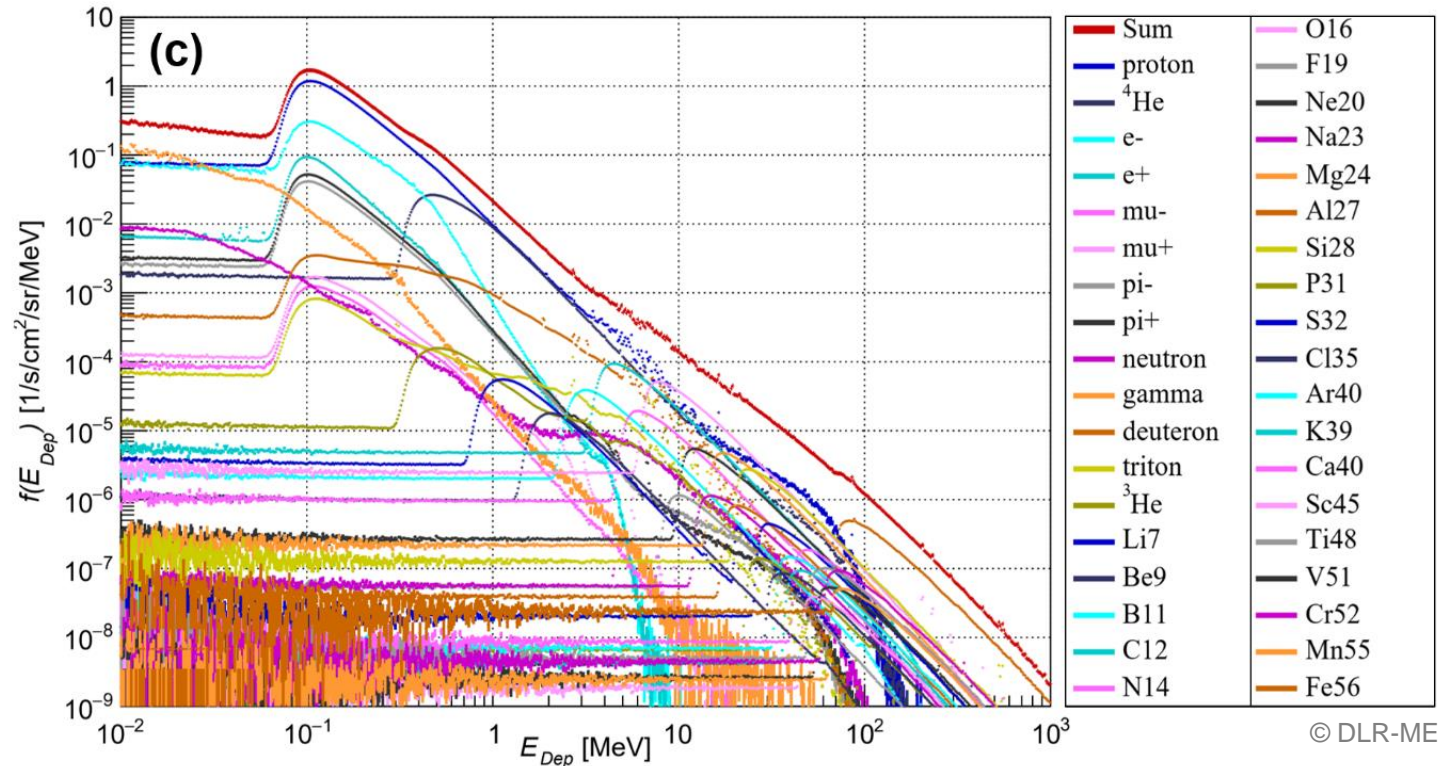


ASTROBOTIC PEREGRINE 1: M-42 Data

GEANT4 Simulation model



Simulation model

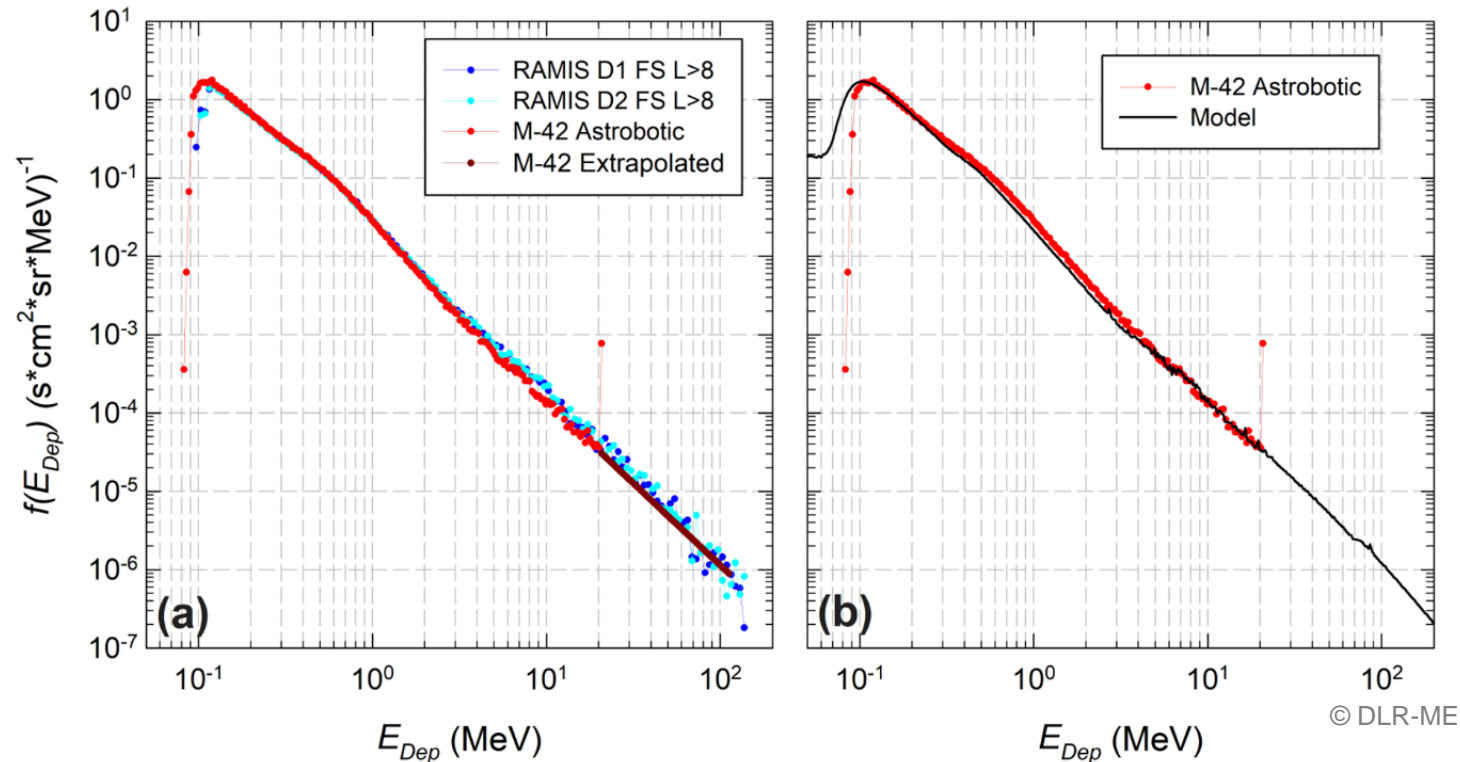


■ Simulated GCR spectrum

ASTROBOTIC PEREGRINE 1: M-42 Data

Comparison with RAMIS-Data and Simulation model

RAMIS / Astrobotic



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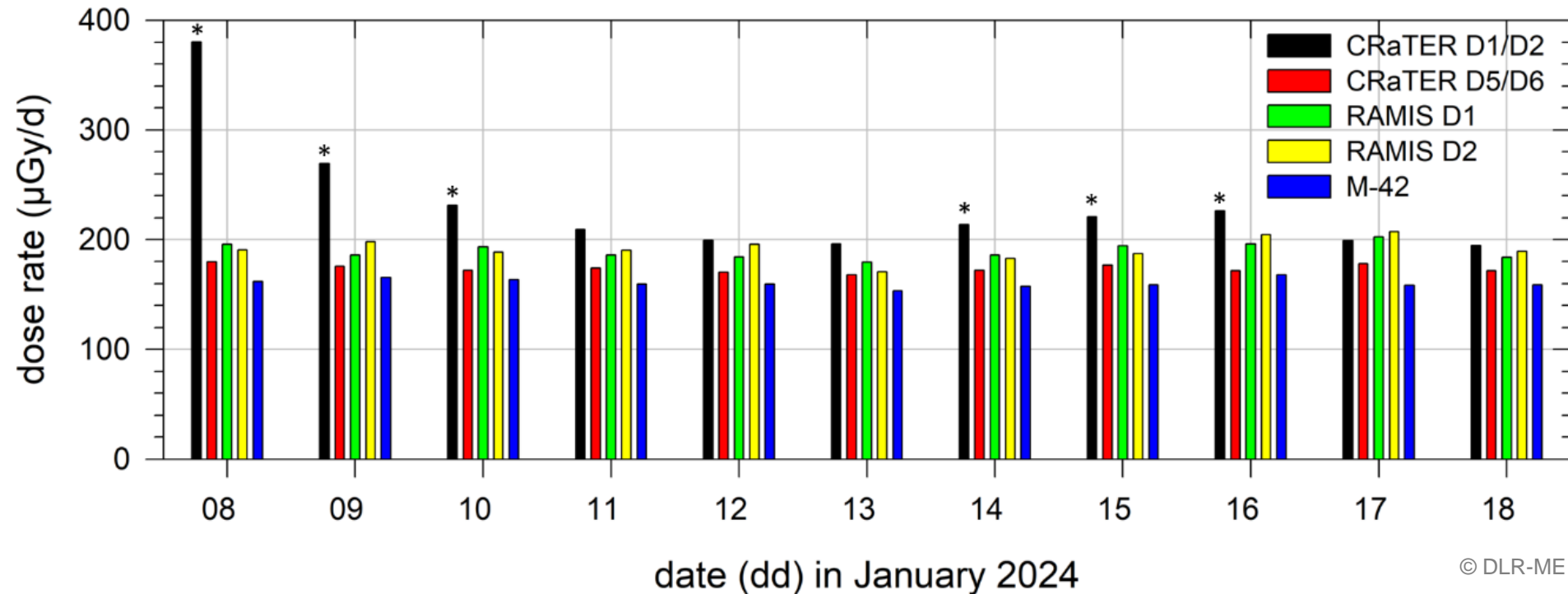
- a) Comparison of RAMIS-Data with L>8 with Astrobotic data
- b) Comparison of Simulation model with gathered data

ASTROBOTIC PEREGRINE 1: M-42 Data

Comparison with RAMIS-Data and Simulation model



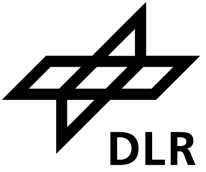
RAMIS / Astrobotic



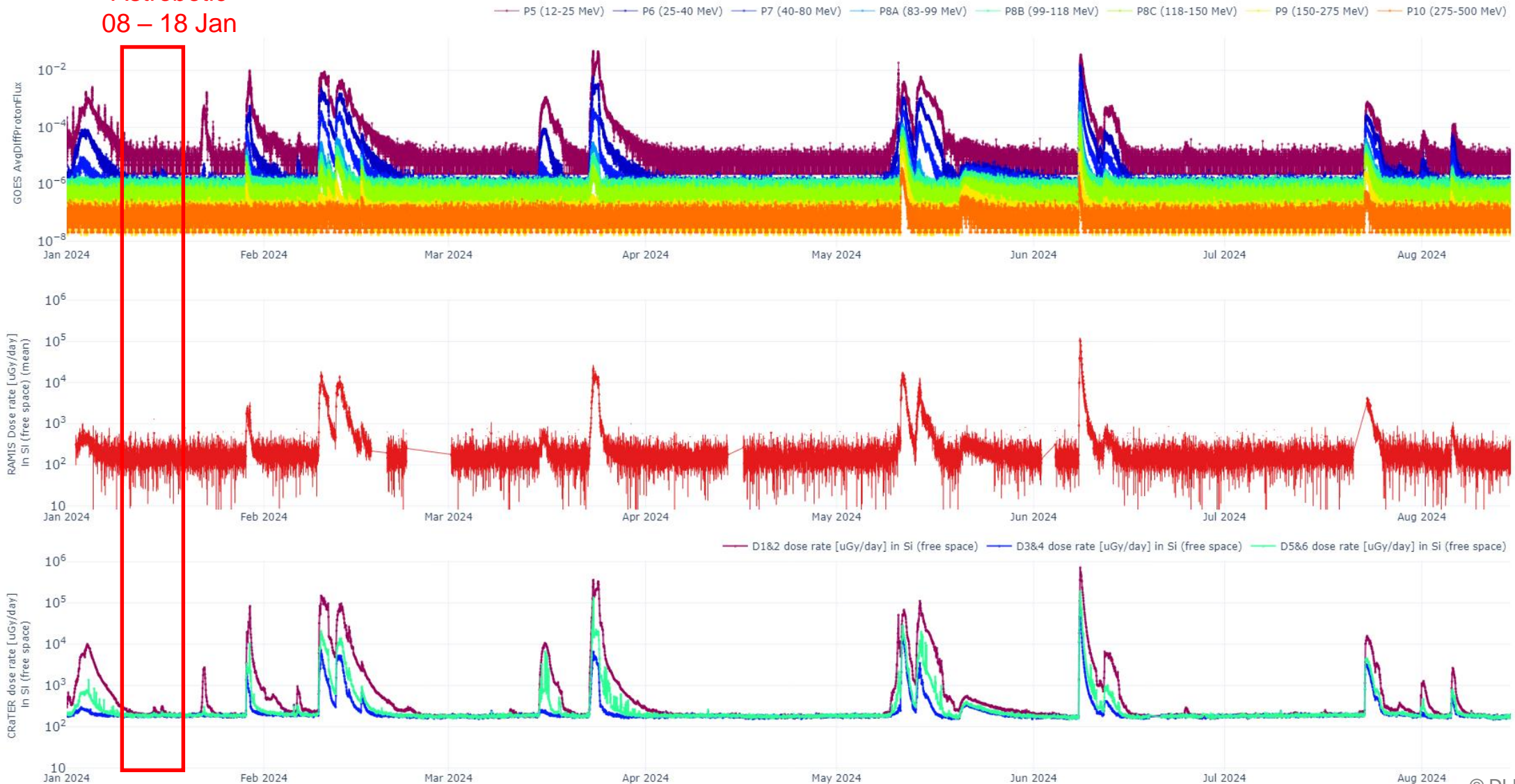
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- Daily dose rate measured with CRaTER, RAMIS and M-42 Astrobotic

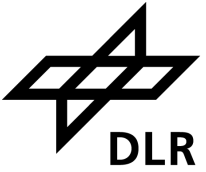
RAMIS: L \geq 8 + CRaTER: D1&D2 / D3&D4 / D5&D6 Free space



Astrobotic
08 – 18 Jan

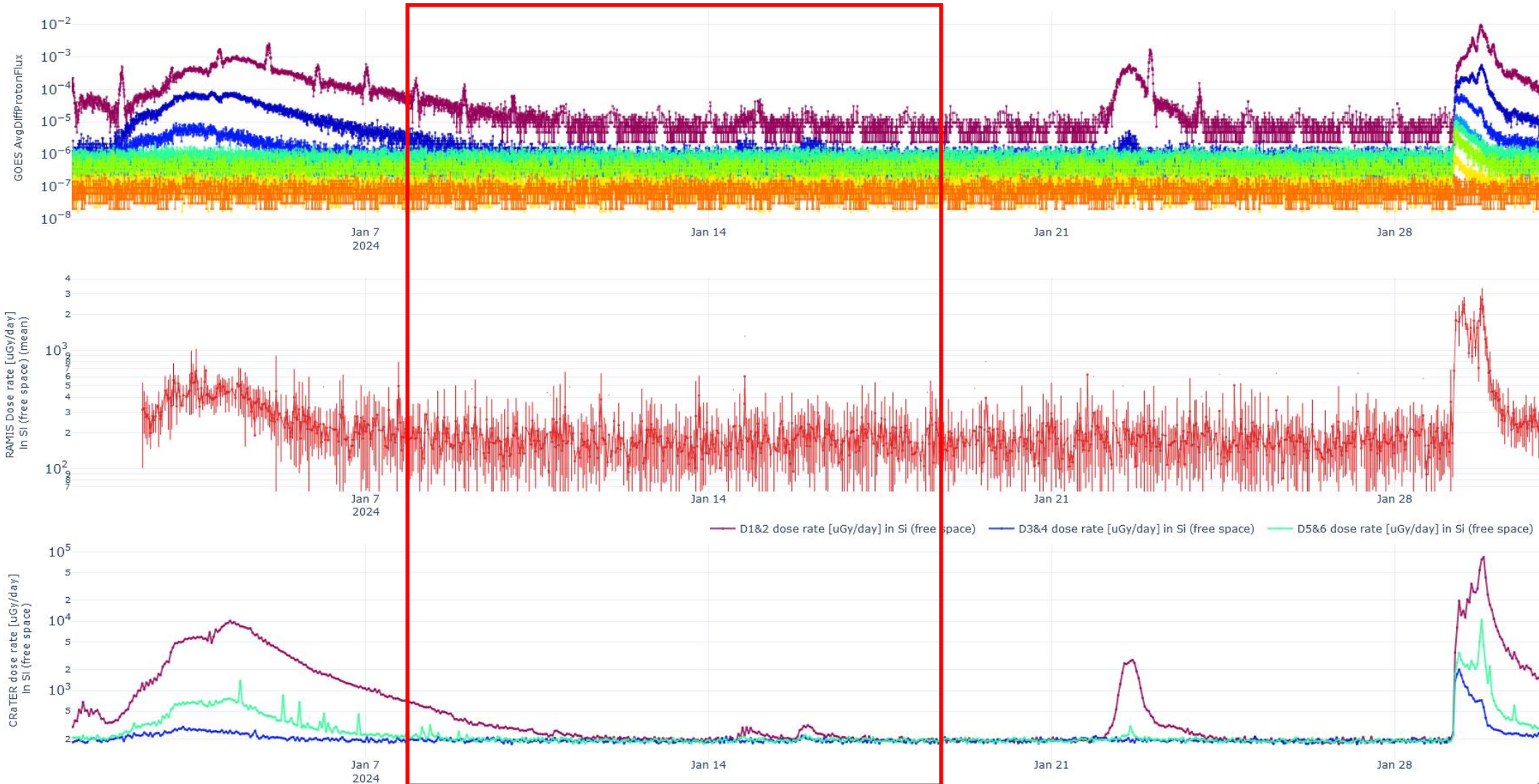


RAMIS: L \geq 8 + CRaTER: D1&D2 / D3&D4 / D5&D6 Free space



Astrobotic
08 – 18 Jan

— P5 (12-25 MeV) — P6 (25-40 MeV) — P7 (40-80 MeV) — P8A (83-99 MeV) — P8B (99-118 MeV) — P8C (118-150 MeV) — P9 (150-275 MeV) — P10 (275-500 MeV)

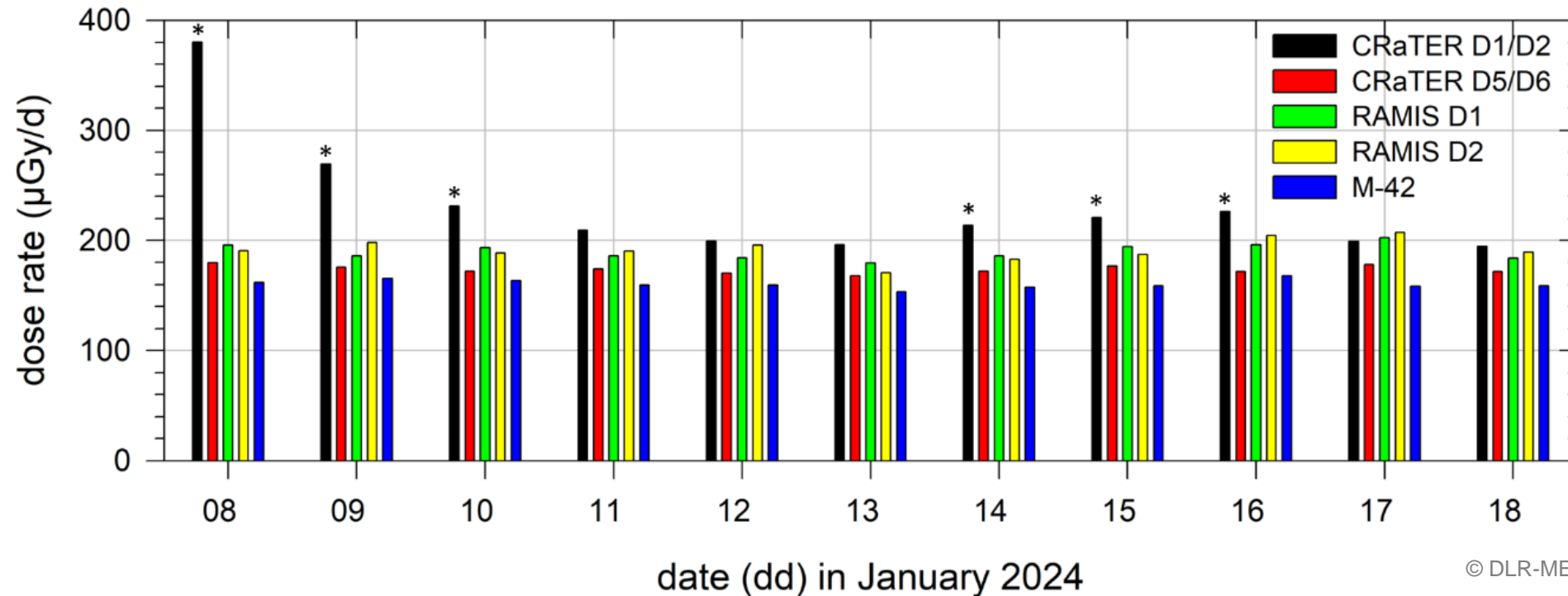


ASTROBOTIC PEREGRINE 1: M-42 Data

Comparison with RAMIS-Data and Simulation model



RAMIS / Astrobotic



© DLR-ME

- Daily dose rate measured with CRaTER, RAMIS and M-42 Astrobotic

Topic: **ASTROBOTIC PEREGRINE 1 DLR M-42**
WRMISS 27, Boulder, CO, USA

Date: 2024-09-04

DLR-Team: Thomas Berger, Bartos Przybyla, Joachim Aeckerlein, Karel Marsalek, Moritz Kasemann, Markus Rohde, Daniel Matthiä, Michael Wirtz, Maximilian Radenhäuser, Stephan Sous, Nico Maas, Cinzia Fantinati, Oliver Küchemann

Institutes: DLR-ME / DLR-MUSC

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