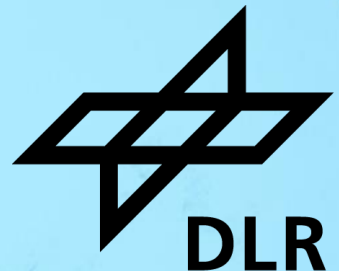


DOSIS 3D – CURRENT STATUS AND SCIENCE UPDATED

Thomas Berger for the DOSIS 3D Team

*Improving Health Span
in Space and on Earth*



DOSIS 3D ON-BOARD THE ISS

DOSIS 3D: Dose Distribution Inside the ISS 3D

Experiment aim: to measure the radiation dose in the Columbus Laboratory of the ISS with two active (DOSTEL-1/-2) and eleven passive radiation detectors (PDP) and combine/compare with data from other instruments

ESR: Issue 7/May 2023

ESA UNCLASSIFIED – For ESA Official Use Only



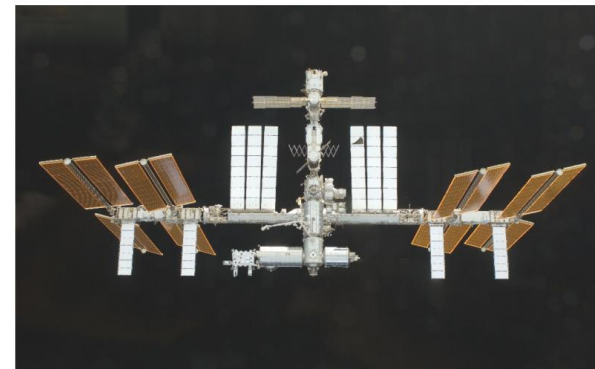
estec

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
ILSRA-2009-07788**



Author(s)	R. Demets (HRE-RSB) & T. Berger
Book Captain	R. Almeida
DPRN No.	1522
Reference	ESA-HSO-ESR-DOSIS 3D
Issue	7
Revision	0
Date of Issue	2023-05-01
Status	Approved
Document Type	Experiment Scientific Requirement (ESR) document – Physical Sciences
Category	SciSpacE
Distribution	HRE-RS/-RU/-RI /-OT /-OE /-OO/ -OG / (-OM (if human-subject research))
ESR Template	ESA-HRE-R-TPL-0003 Iss.1 Rev.0 (baselined – date: 2019-03-14)

European Space Agency
Agence spatiale européenne

DOSIS 3D: Dose Distribution Inside the ISS 3D

Experiment aim: to measure the radiation dose in the Columbus Laboratory of the ISS with two active (DOSTEL-1/-2) and eleven passive radiation detectors (PDP) and combine/compare with data from other instruments

ESR: Extension up to 2024



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



Dr Thomas Berger
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
Institute of Aerospace Medicine
Linder Hoehe
51147 Cologne
Germany

Our ref. ESA-HRE-RS-LE-0003

Noordwijk, 25/04/2018

Subject: Continuation of DOSIS-3D Experiment (ILSRA-2009-0778) until 2024

Dear Dr Berger,

Last year the the LSWG & UIB recommendation to continue implementation of the DOSIS-3D experiment with implementation confirmed until the end of 2019 (Letter dated 05/12/2017, our reference ESA-HRE-UB-LE-0001). Further to recent discussions we confirm our intention to continue implementation of DOSIS-3D until 2024, contingent of the availability of ISS resources.

Please let me know if you have any additional questions.

Yours Sincerely,

Jason Hatton
Head of the Biology and Environmental Monitoring Science Office

DOSIS 3D: Dose Distribution Inside the ISS 3D

Experiment aim: to measure the radiation dose in the Columbus Laboratory of the ISS with two active (DOSTEL-1/-2) and eleven passive radiation detectors (PDP) and combine/compare with data from other instruments

LSWG: Review April/May 2023

Extension: “end of lifetime” ISS

Berger, Thomas

Von: Rodrigo Coutinho De Almeida <Rodrigo.CoutinhodeAlmeida@ext.esa.int>
Gesendet: Mittwoch, 19. Juli 2023 15:45
An: Berger, Thomas
Betreff: [DOSIS-3D] Approval for project extension

Priorität: Hoch

Kategorien: DOSIS

Dear Thomas,

I happy to inform you that the UIB approved DOSIS-3D extension and upload of the new device.

Please let me know if you have any questions or if you need something from my side.
Christopher told me that you would need a letter of confirmation.
Could let me know what do you need on this letter?

Best regards,

Rodrigo

Rodrigo Almeida, PhD
Project Scientist – Space Biology
SciSpacE Team (HRE-RS)
Directorate of Human Spaceflight and Robotic Exploration Programmes
ESTEC
Keplerlaan 1, PO Box 299, Office NB112
NL-2201 AZ Noordwijk, The Netherlands
rodrigo.coutinhodealmeida@ext.esa.int | www.esa.int | T +31 (0) 71 565 58858

Science in the Space Environment (SciSpacE)
scispac@esa.int | scispac.esa.int

Telespazio Belgium S.R.L. for ESA - European Space Agency

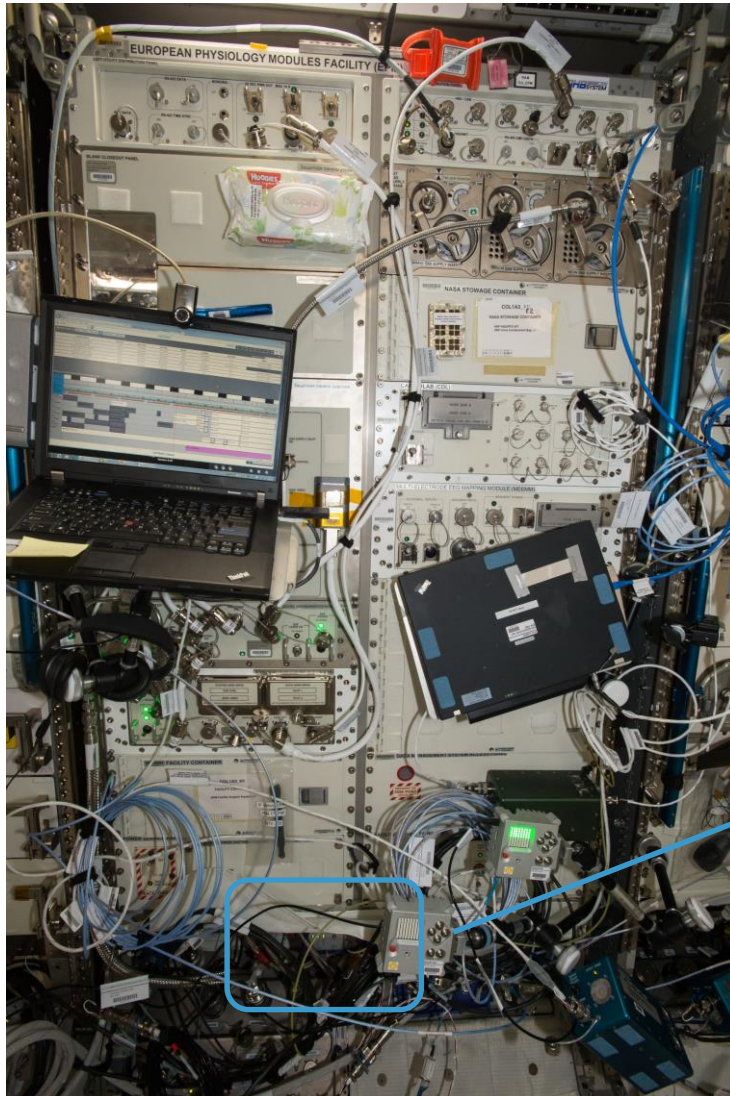
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[Seite]

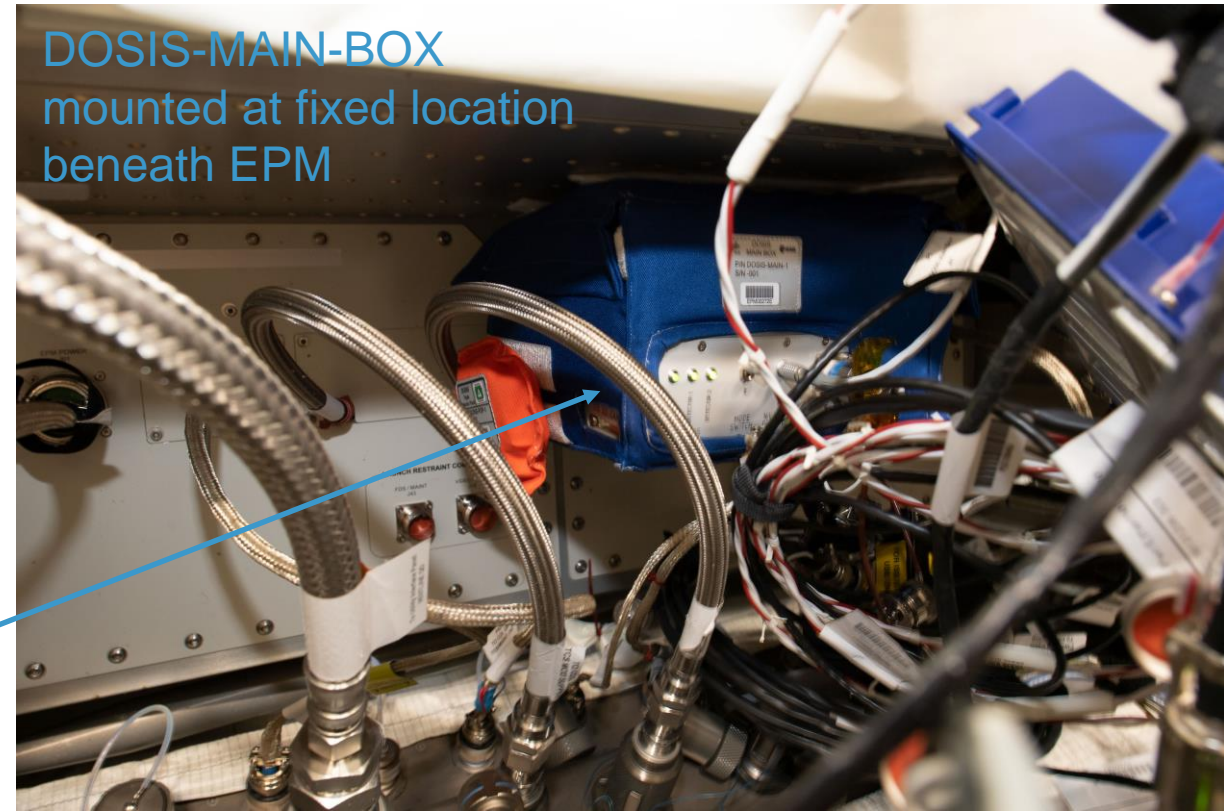


DOSIS 3D: Dose Distribution Inside the ISS 3D

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



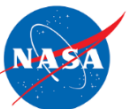
Over 7400 days of data for DOSTEL-1 and DOSTEL-2



THE HENRYK NIEWODNICZAŃSKI
INSTITUTE OF NUCLEAR PHYSICS
POLISH ACADEMY OF SCIENCES

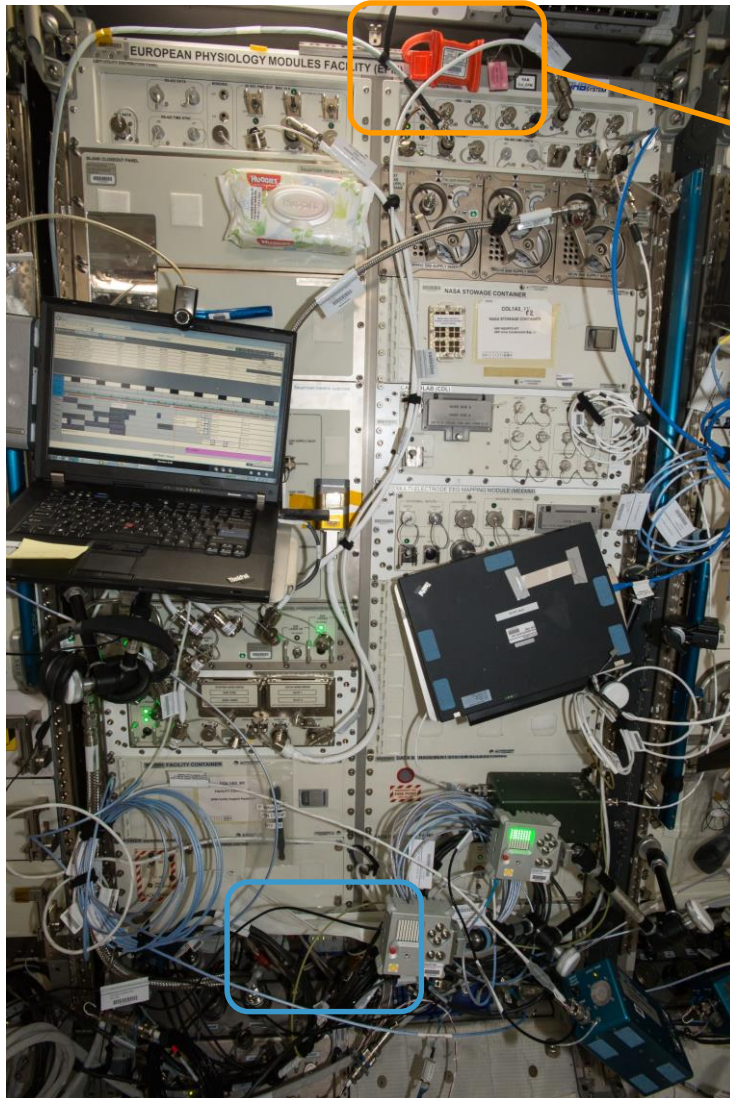


Centre for
Energy Research



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)** and combine/compare with data from other instruments



27 x PDP
↑↓
(up/down)

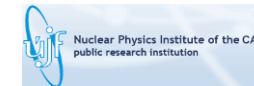
Currently
Crew-7



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POLISH ACADEMY OF SCIENCES



Centre for
Energy Research



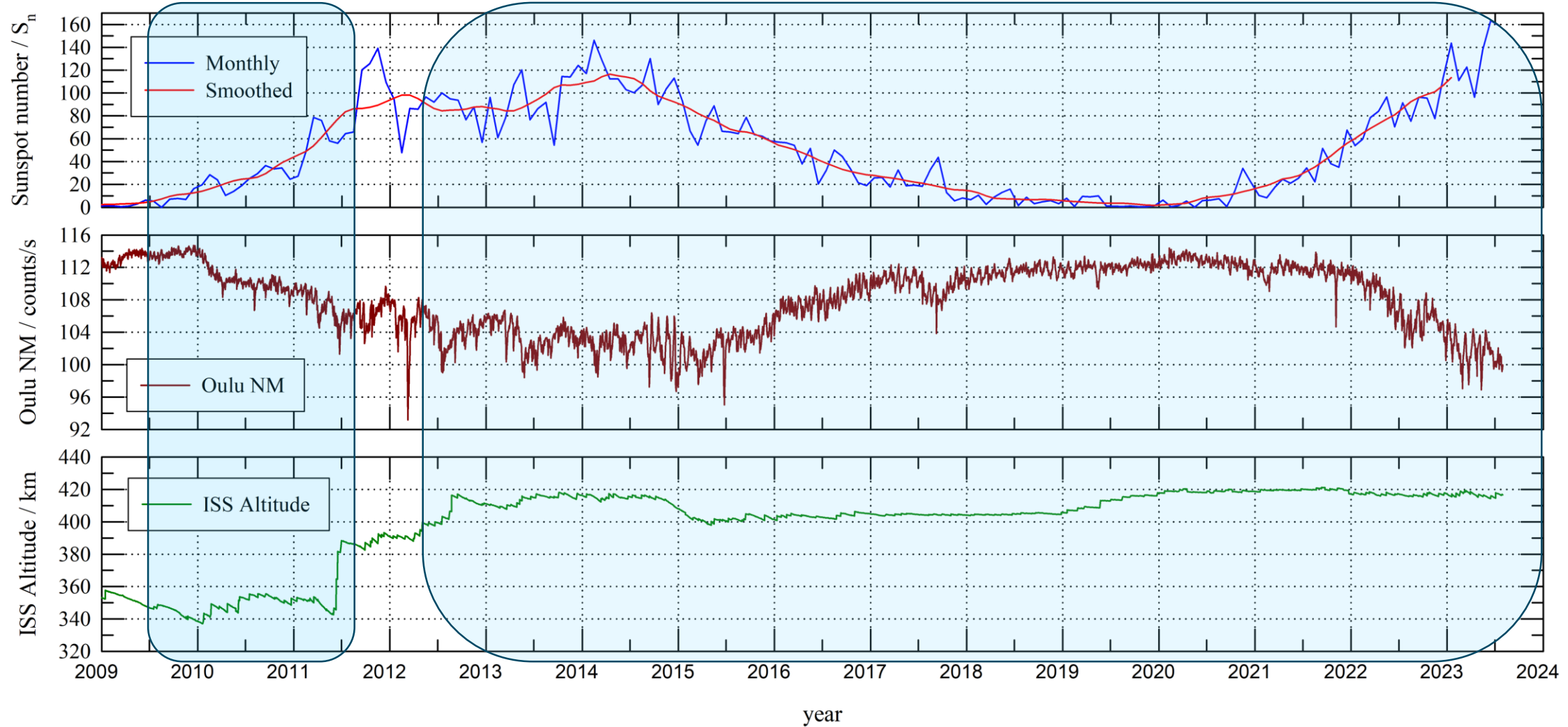
DOSIS & DOSIS 3D: Radiation data over one full solar cycle

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



DOSIS

DOSIS 3D

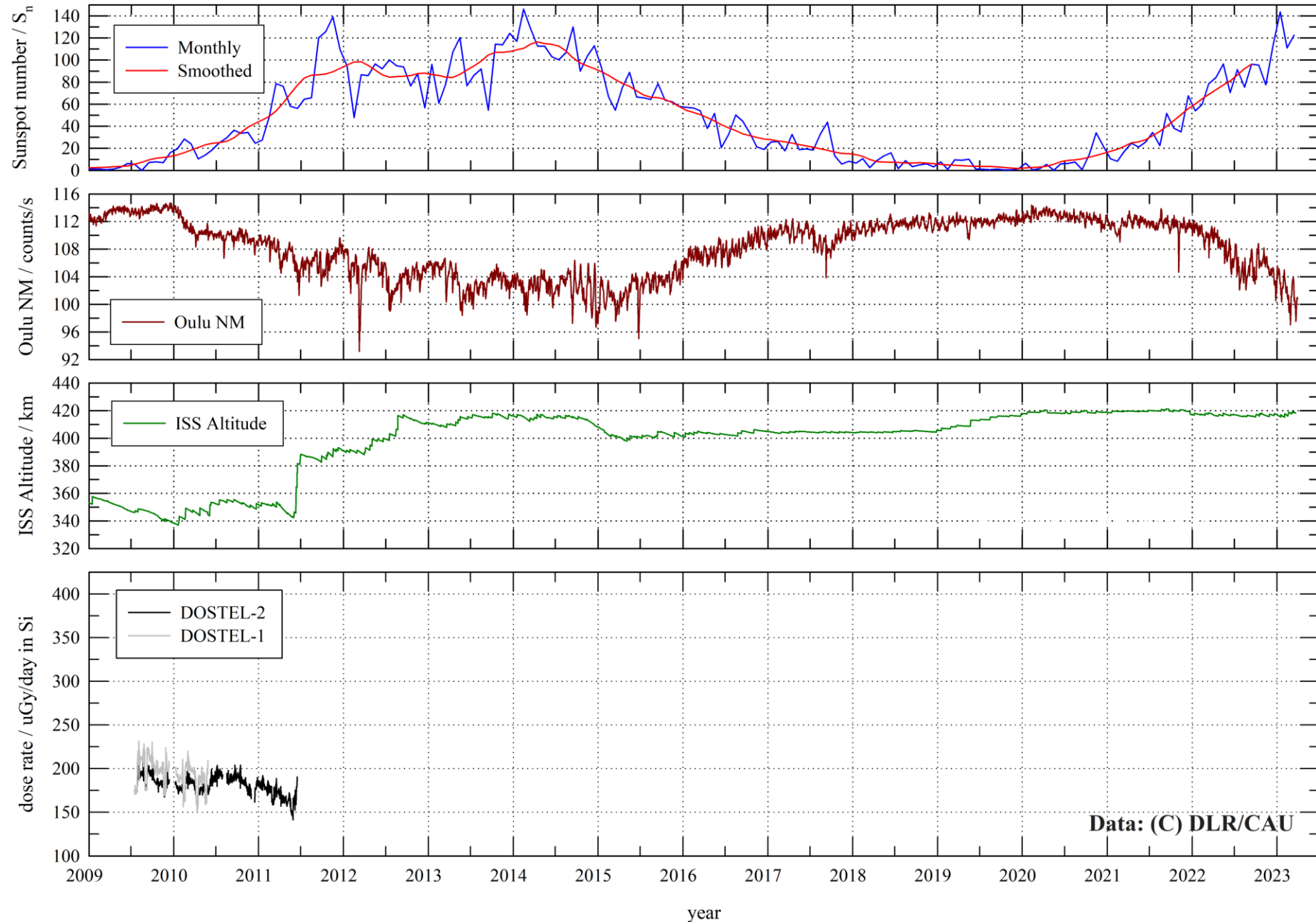




RESULTS FROM THE ISS

Results:

DOSIS
DOSTEL-1
DOSTEL-2



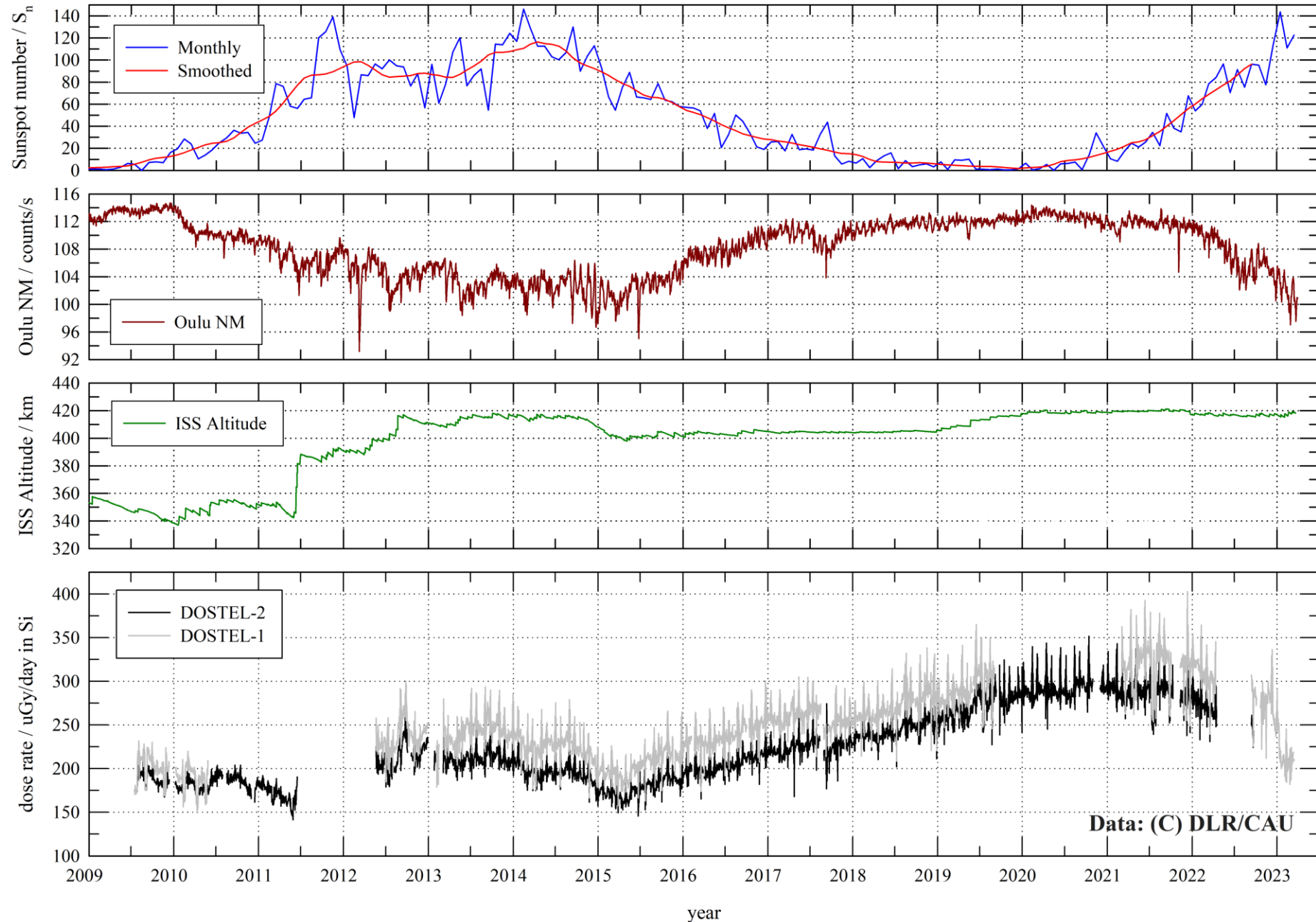
Matthiä, D., Burmeister, S., Przybyla, B., Berger, T. (2023) Active radiation measurements over one solar cycle with two DOSTEL instruments in the Columbus laboratory of the International Space Station. *Life Sciences in Space Research*

<https://doi.org/10.1016/j.lsr.2023.04.002>

Results:

DOSIS
DOSTEL-1
DOSTEL-2

+
DOSIS 3D
DOSTEL-1
DOSTEL-2



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*

<https://doi.org/10.1016/j.lsr.2023.04.002>

DOSIS 3D: DOSIS and DOSIS 3D

New data: DOSTEL data fully new evaluated



- See:

Sönke Burmeister et. al. *DOSTEL measurements as part of DOSIS/DOSIS3D: An update 26th WMRISS, 5 – 7 September 2023, Rome, Italy*

DOSIS 3D: TLD + CR-39

Comparison: Long term TLD + CR-39 data



- See:

Patrick Princzes et. al. *Radiation Measurements with Passive Detectors in the Columbus Module over One Solar Cycle within the DOSIS and DOSIS 3D projects.*

26th WMRISS, 5 – 7 September 2023, Rome, Italy

HIGHLIGHTS

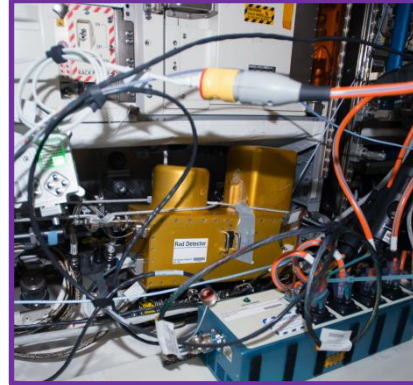
DOSIS 3D: DATA COMPARISON

Experiment aim: correlate data with data from other instruments



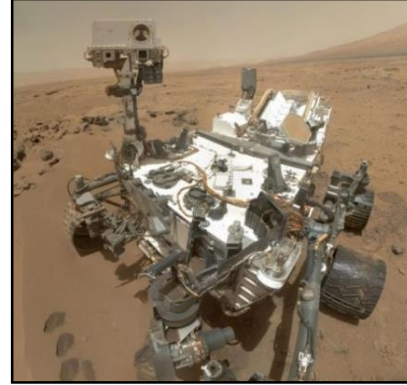
ASI ALTEA

Narici, L., Berger, T., Burmeister, S. et al. Exploiting different active silicon detectors in the International Space Station: ALTEA and DOSTEL Galactic Cosmic Radiation (GCR) measurements. *J. Space Weather Space Clim.* 7, A18, 2017, <https://doi.org/10.1051/swsc/2017016>



NASA ISS-RAD

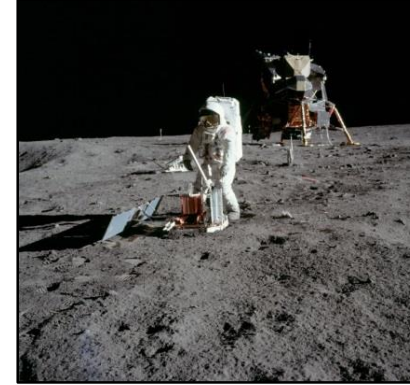
Berger, T., Matthiä, D., Burmeister, et al. (2018). The Solar Particle Event on 10 September 2017 as observed on-board the International Space Station (ISS), *Space Weather*, 16, 1173-1189. <https://doi.org/10.1029/2018SW001920>



MSL-RAD

Berger T, Matthiä D, Burmeister S, Zeitlin C, Rios R, Stoffle N, Schwadron NA, Spence HE, Hassler DM, Ehresmann B, Wimmer-Schweingruber RF, (2020) Long term variations of galactic cosmic radiation on board the International Space Station, on the Moon and on the surface of Mars. *J. Space Weather Space Clim.* 10:34 <https://doi.org/10.1051/swsc/2020028>

S. Zhang, R. F. Wimmer-Schweingruber, J. Yu, C. Wang, Q. Fu, Y. Zou, Y. Sun, C. Wang, D. Hou, S. I. Böttcher, S. Burmeister, L. Seimetz, B. Schuster, V. Knierim, G. Shen, B. Yuan, H. Lohf, J. Guo, Z. Xu, J. L. Freiherr von Forstner, S. R. Kulkarni, H. Xu, C. Xue, J. Li, Z. Zhang, H. Zhang, T. Berger, D. Matthiä, C. E. Hellweg, X. Hou, J. Cao, Z. Chang, B. Zhang, Y. Chen, H. Geng, Z. Quan, *First measurements of the radiation dose on the lunar surface. Sci. Adv.* 6, eaaz1334 (2020). <https://doi.org/10.1126/sciadv.aaz1334>



CRaTER / LND

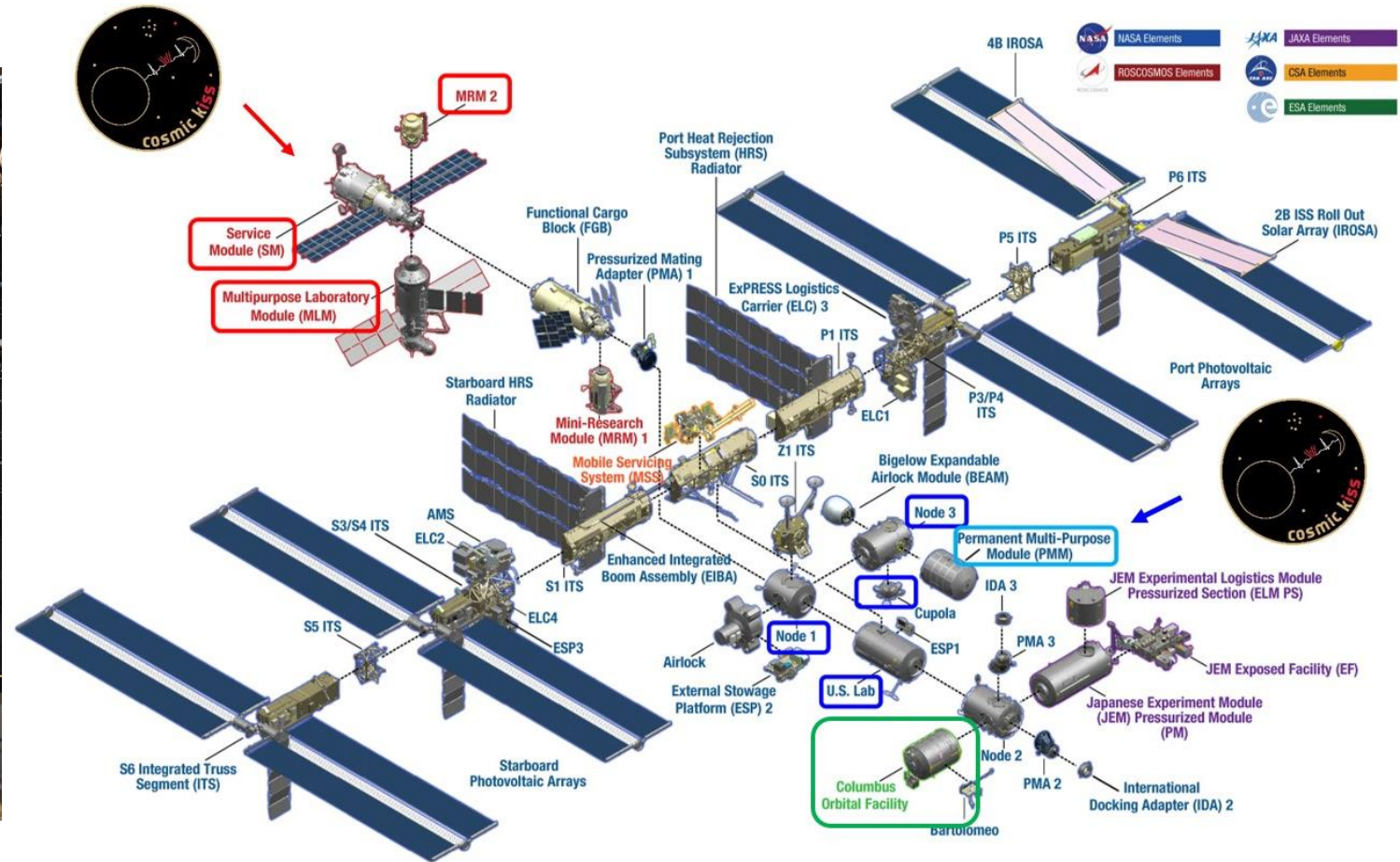
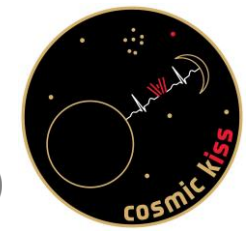


ESA EAD

Straube, U., Berger, T., Dieckmann, M. (2023) The ESA Active Dosimeter (EAD) system onboard the International Space Station (ISS). *Zeitschrift für Medizinische Physik* <https://doi.org/10.1016/j.zemedi.2023.03.001>

DOSIS 3D: DOSIS 3D + DOSIS 3D MINI (Crew-3)

Crew-3 (Matthias Maurer): DOSIS 3D (Columbus) + DOSIS 3D MINI (outside Columbus)



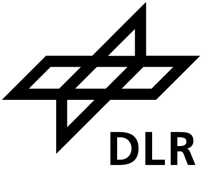
<https://www.flickr.com/photos/matthiasmaurer/51690954364/in/album-72157720150914824/>

Thomas Berger / DOSIS 3D / 26th WRMIS / Rome, Italy, 5-7 September 2023

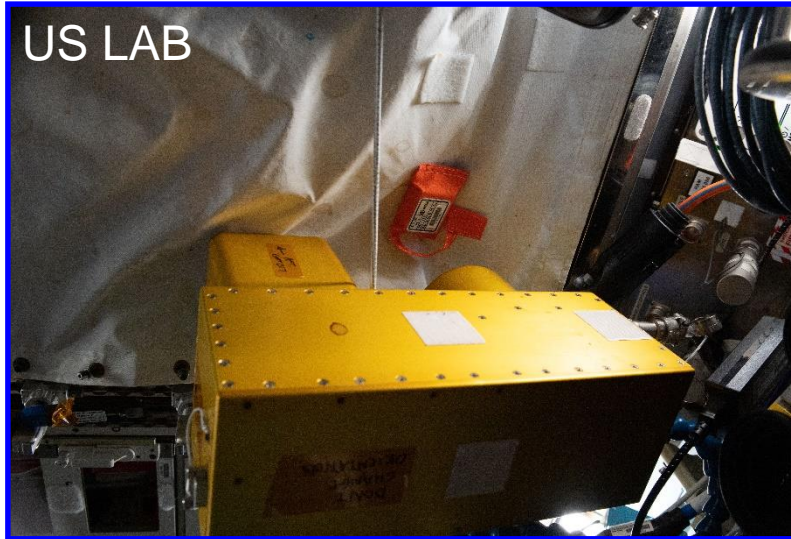


DOSIS 3D: DOSIS 3D + DOSIS 3D MINI (Crew-3)

Crew-3 (Matthias Maurer): DOSIS 3D (Columbus) + DOSIS 3D MINI (outside Columbus)



Columbus (PBA)



US LAB



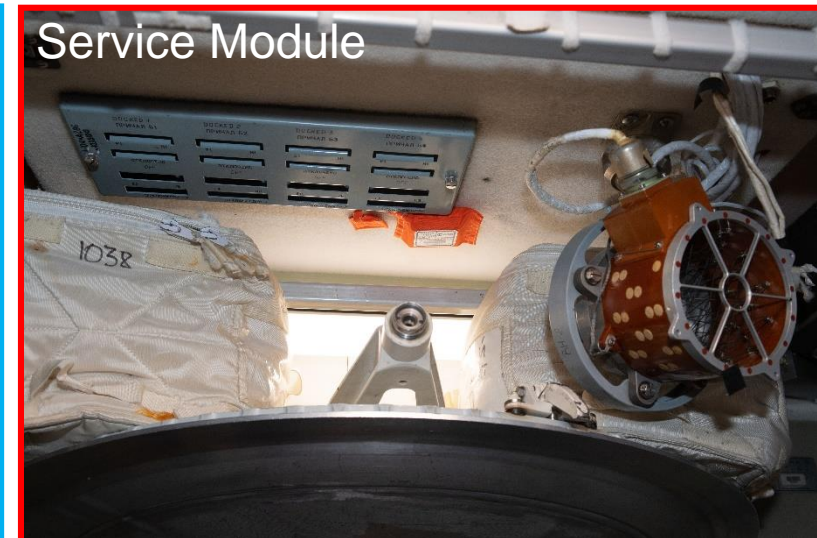
Cupola



Columbus (EPM)



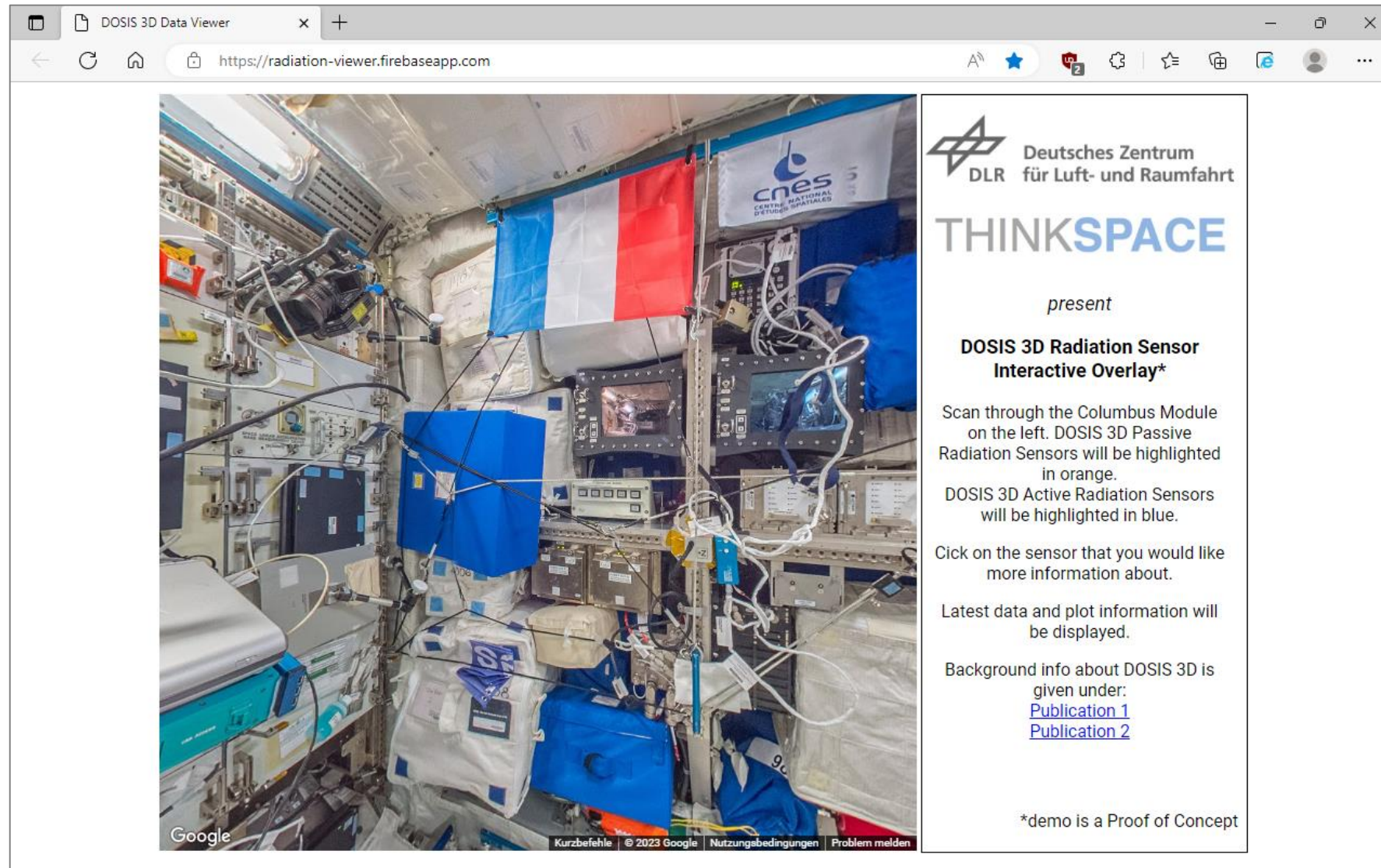
Leonardo



Service Module

DOSIS 3D: DATA VIEWER (concept)

Experiment aim: relate ISS „street view application“ with real science data



DOSIS 3D Data Viewer

https://radiation-viewer.firebaseio.com

Deutsches Zentrum
DLR für Luft- und Raumfahrt

THINKSPACE

present

**DOSIS 3D Radiation Sensor
Interactive Overlay***

Scan through the Columbus Module on the left. DOSIS 3D Passive Radiation Sensors will be highlighted in orange.
DOSIS 3D Active Radiation Sensors will be highlighted in blue.

Click on the sensor that you would like more information about.

Latest data and plot information will be displayed.

Background info about DOSIS 3D is given under:
[Publication 1](#)
[Publication 2](#)

*demo is a Proof of Concept

DOSIS & DOSIS 3D: Biology

Data: Provision of dosimetric data for relevant biological experiments performed on ISS



Experiment	On-orbit	Report
Endothelial Cells	4.-11. September 2015	DOSIS-3D-DLR-REP-BIO-001
Extremophiles	May – August 2017	DLR-ME-SBA-DOSIS 3D - BIO-Extremophiles-2017
ARTHROSPIRA-B	15.12.2017 – 24.01.2018	DLR-ME-SBA-DOSIS 3D - BIO-2018
BIOROCK	30.7. 2019 - 20.8.2019	DOSIS-3D-DLR-REP-BIOROCK-001
Rotifer B1	9 – 16 December 2019	DOSIS-3D-DLR-REP-ROTIFER-B1-001
BioAsteroid	8 to 19 December 2020	DOSIS-3D-DLR-REP-BioAsteroid-001
Rotifer B2	20 th December 2020 - 8 th January 2021	DOSIS-3D-DLR-REP-Rotifer B2-001
CANES	03 rd March 2020 - 12 th January 2021	DOSIS-3D-DLR-REP-CANES-001
MOLECULAR MUSCLE 2	05 th - 11 th June 2021.	DOSIS-3D-DLR-REP-MOLECULAR MUSCLE 2-001
BIOFILMS-1 / -2 / -3	29th August - 30th September 2021	DOSIS-3D-DLR-REP-BIOFILMS-001 DOSIS-3D-DLR-REP-BIOFILMS-002 DOSIS-3D-DLR-REP-BIOFILMS-003
Thermo Mini	06.12.2021 17:18 – 08.12.2021 10:18 22.11.2021 07:50 – 24.11.2021 08:05 15.11.2021 17:37 – 17.11.2021 08:00	DOSIS-3D-DLR-REP-ThermoMini-001



DORELI

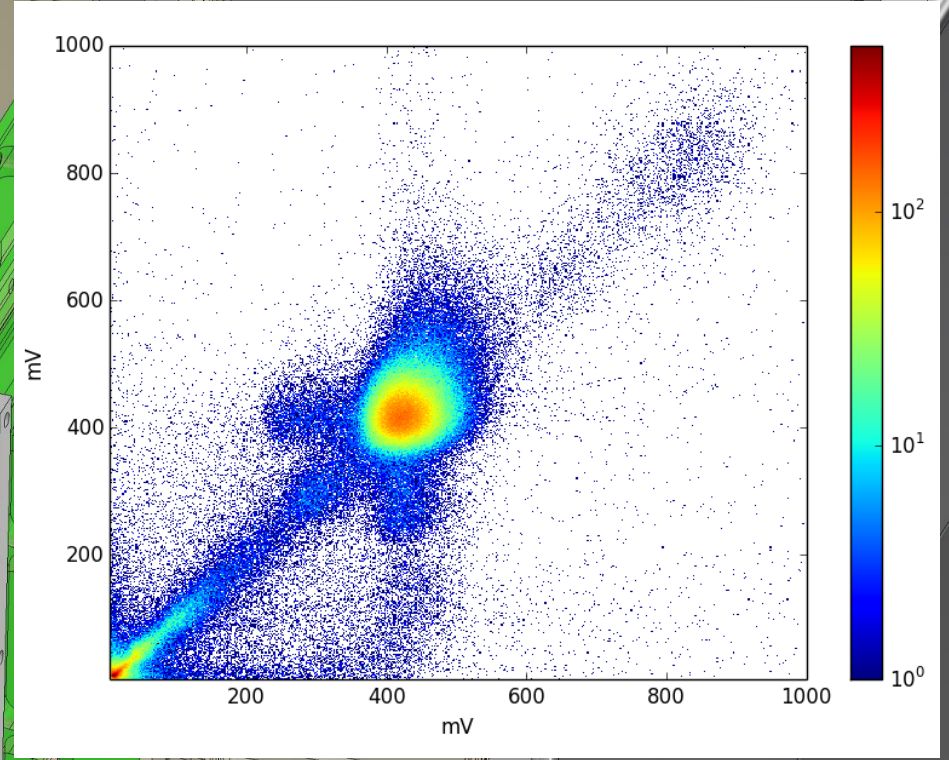
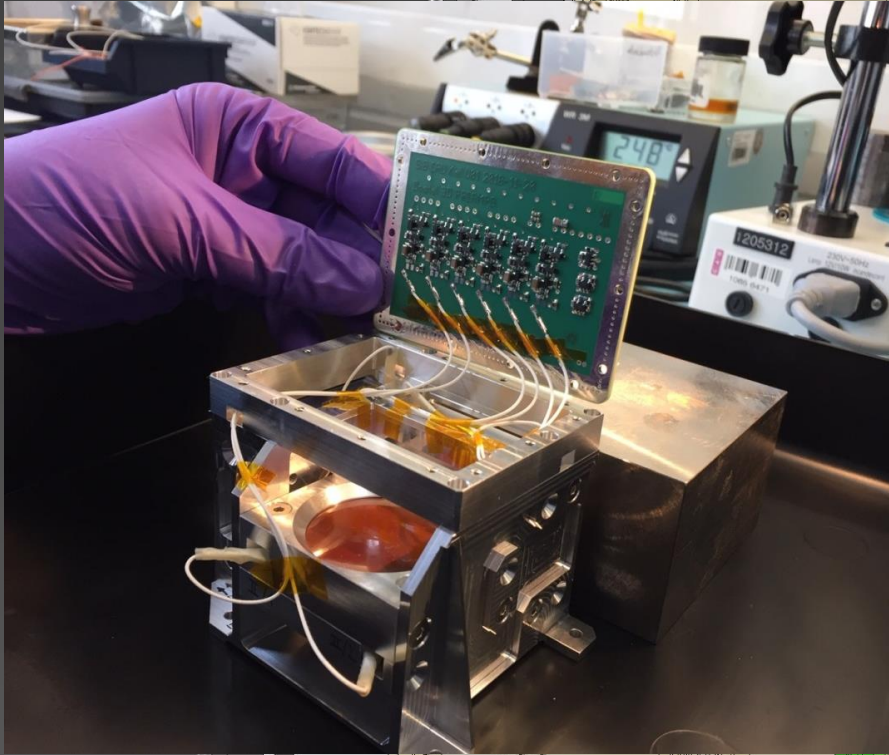
DOSIS 3D: DORELI

Comparison: LIDAL/DOSTEL/REM



- See:

Livio Narici et. al. *DORELI: advances in the flight comparison of three silicon detector in the COLUMBUS modulus of the ISS. Learning lessons 26th WMRISS, 5 – 7 September 2023, Rome, Italy*



FUTURE PLAN: DOSTEL 3D

DOSIS 3D: DOSTEL 3D

Concept design: a new DOSTEL 3D instrument



- See:

Sönke Burmeister et. al. *DOSTEL measurements as part of DOSIS/DOSIS3D: An update 26th WMRISS, 5 – 7 September 2023, Rome, Italy*

DOSIS & DOSIS 3D: Summary and Outlook

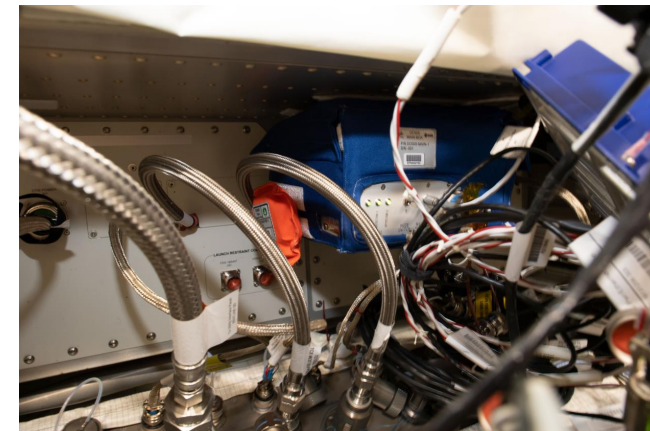
PDP

- 27 x PDP ↑↓
- DOSIS 3D MINI outside Columbus
- Crew-7 launched 26th August 2023
- All missions fully successful
- Next publication in preparation



DOSTEL

- Data from 2009 – 2011 and from 2012 onwards
- Over 7400 days of science data
- DOSTEL-1 successfully repaired and re-flown
- DOSTEL-2 and DOSIS-MAIN-BOX on Earth for repair
- DOSIS-MAIN-BOX Upload with NG-20



DOSIS & DOSIS 3D: Acknowledgements

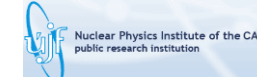


ESA/CADMOS/DLR-MUSC/OHB

- We gratefully acknowledge the steady help and support of ESA, especially Jason Hatton, Rene Demets, Chiara Lombardi, Christiane Hahn, Lukas De Smet, Christopher Puhl as well as all the work performed by colleagues from CADMOS, Toulouse, France, DLR-MUSC (→ DOSIS-OPS), Cologne, Germany and colleagues from OHB, Bremen, Germany.

ASTRONAUTS

- DOSIS and DOSIS 3D would not have been possible without all the support and work performed by the astronauts on-board the ISS: Frank de Winne, Tracy Caldwell-Dyson, Shannon Walker, Ron Garan, Mike Fossum, Andre Kuipers, Joe Acaba, Sunita Williams, Chris Hadfield, Chris Cassidy, Luca Parmitano, Michael Hopkins, Rick Mastracchio, Koichi Wakata, Alexander Gerst, Samantha Cristoforetti, Scott Kelly, Timothy Peake, Jeffrey Williams, Takuya Onishi, Thomas Pesquet, Jack Fischer, Mark Vande Hei, Norishige Kanai, Andrew Feustel, Matthias Maurer, Anton Schkaplerow, Denis Matveyev, Andreas Mogensen



- Topic:** **DOSIS 3D – Current Status and Science Updated**
- Date:** 26th WRMISS, 5 – 7 September 2023, Rome, Italy
- Authors:** Thomas Berger for the DOSIS 3D team
- Institute:** Institute of Aerospace Medicine, German Aerospace Center
(DLR), Cologne, Germany
- Credits:** NASA, ESA, „DLR (CC BY-NC-ND 3.0)“