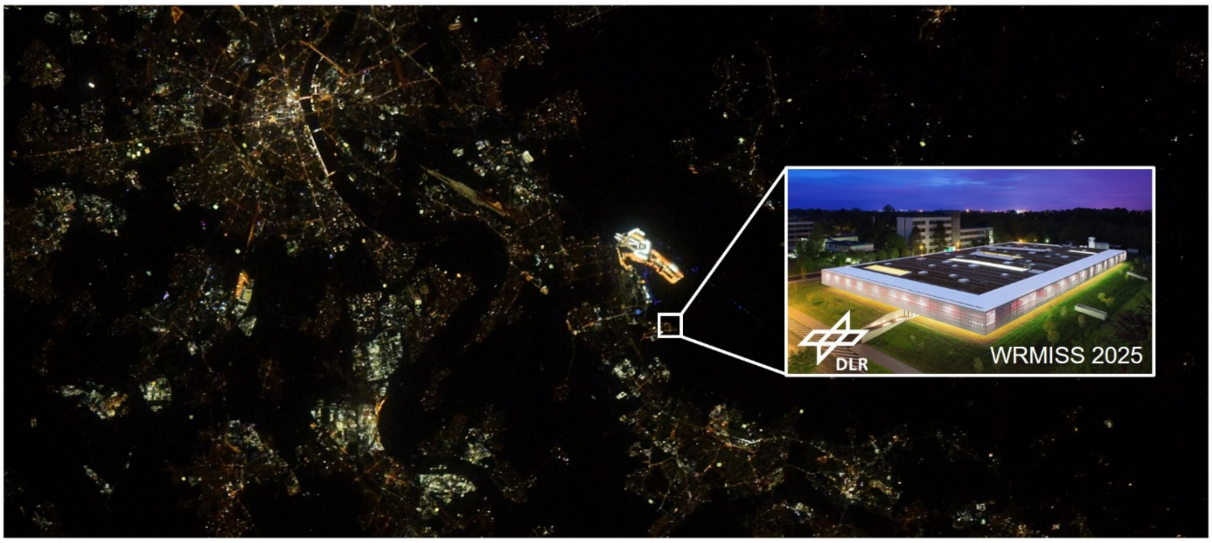

DLR

WRMISS 2025
:envihab

Workshop on Radiation Monitoring on International Space Station *

28th WRMISS

02 - 04 September 2025

WRMISS 2025: Conference Program

final: 28 August 2025

28th WRMISS Conference Program: Tuesday 2nd September 2025

08:30 – 09:00	Registration
09:00 – 09:30	Welcome, organizational Issues
09:30 - 10:30	Scientific Session 1
10.30 – 11:15	Coffee/Tea Break
11.15 – 12:45	Scientific Session 2
12:45 – 13:45	Lunch
13:45 – 15:15	Scientific Session 3
15:15 – 16:15	Coffee/Tea Break
	Guided Tour 1 & 2: LUNA https://luna-analog-facility.de/
16:15– 18:00	Scientific Session 4

Guenther Reitz, Thomas Berger, Christine Hellweg	Welcome, organizational Issues

Scientific Session 1

Guangming Zhou	Reduction of uncertainty of radiation health risk assessment
Naito Masayuki	An application approach of LET- and charge-weighted quality factors to space LET measurements

Scientific Session 2

Ondrej Ploc	ESADOS – ESA Support for Aircrew DOsimetry Services: Developing an Independent Source of Space Weather Data for Aircrew Radiation Dose Assessment
Matthias Meier	Between Sea Level and the ISS: Radiation Measurements in the SAA Region at Flight Altitudes II
Kai Schenetten	The Relevance of the Space Weather Events in May 2024 to Radiation Protection in Aviation

Scientific Session 3

Maximilian Radenhäuser	Almost 2500 days in space – the RAMIS radiation detector on the DLR Eu:CROPIS mission
Carlos Granja	Composition and Spectral Characterization of Space Radiation in LEO Orbit at 600 km and 1200 km onboard JoeySat Satellite with MiniPix-Timepix3
Patrik Pinczés	Presenting the RADCUBE-RADMAG instrument: technology demonstration and measurements

Scientific Session 4

Thomas Berger	DOSIS and DOSIS 3D – active and passive radiation measurements in Columbus from 2009 – 2025
Maximilian Brüdern	DOSIS and DOSIS 3D – data from the DOSTEL instruments focusing on 2024 – 2025 with special emphasis on SPEs measured inside the ISS
Martin Losekamm	Update on the RadMap Telescope
Diego Laramore	ISS-RAD from Solar Cycle 25 Min to Max

28th WRMISS Conference Program: Wednesday 3rd September 2025

09:00 - 10:30	Scientific Session 5
10.30 - 11.15	Coffee/Tea Break
11.15 – 12:45	Scientific Session 6
12.45 - 13:45	Lunch
13:45 – 15:15	Scientific Session 7
15:15 – 16:15	Coffee/Tea Break
	Guided Tour: envihab
16:15 – 17:45	Scientific session 8

Scientific Session 5

Luca Di Fino	Latest LIDAL measurements inside Columbus: particle flux and anisotropy
Virgina Boletti	LIDAL: Decoding Cosmic Radiation One Particle at a Time
Luka Lunati	LIDAL × GCRSimulator: Towards Characterizing simulated Space Radiation at the GSI-FAIR facility

Scientific Session 6

Eric Benton	Progress on Tissue Equivalent Dosimeters being developed at Oklahoma State University
Livio Narici	DOSTEL REM LIDAL Intercomparison 2025
Thomas Campbell-Ricketts	Timepix Measurements on the Space-X Polaris Dawn Flight

Scientific Session 7

Daniel Matthiä	Radiation exposure and shielding effects on the lunar surface
Lembit Sihver	Shielding efficiency of Plasteel
Jack Miller	RadLab status and related database development(s)

Scientific Session 8

Lorenzo Scavarda	ERFNet-DH: A Collaborative Environment for Advancing Space Radiation Research in Support of Human Exploration
Pete Truscott	The Human Interplanetary Exploration Radiation Risk Assessment System (HIERRAS)
Daniel Heynderickx	Demonstration of HIERRAS

28th WRMISS Conference Program: Thursday 4th September 2025

09:00 - 10:30	Scientific Session 9
10.30 - 11.15	Coffee/Tea Break
11.15 – 12:45	Scientific Session 10
12.45 - 13:45	Lunch
13:45 – 15.15	Scientific Session 11
15:15 – 16.15	Coffee/Tea Break
16:15 – 17.45	Scientific Session 12
18:30 - @ https://eltzhof-kulturgut.de/	**Conference Dinner**

Scientific Session 9

Don Hassler	Recent Results from the Surface of Mars with RAD
Gabin Charpentier	Radiation Shielding by Natural Terrain on the Surface of Mars
Pete Truscott	Modelling Martian and Lunar Environments Using the GRAPPA with GRAS

Scientific Session 10

Eddie Semones	Overview of the current NASA Mars Campaign Office (MCO) Radworks project portfolio
Marianthi Fragkopoulou	Ultra-Sensitive dosimeter for Artemis: Enabling Lower Detection Limits in Space Radiation Measurement.
Satoshi Kodaira	Development of on-site passive dosimetry for space application

Scientific Session 11

Leena Tomi	Development of the Canadian Active Neutron Spectrometer for the ISS and Lunar Gateway
Moritz Kasemann	Update on the DLR M-42 instrument family and future missions
Martin Kakona	Czech Personal Active Dosimeter (CZPAD): Dosimetric Support for the First Czech Astronaut Mission
Attila Hirn	MoonRAD mission and science overview

Scientific Session 12

Bent Ehresmann	Update on the development of the Miniaturized Fast Neutron Detector (Mini-FND)
Michael G. Ecord	ARES Detector for Radiation Monitoring on the HLS and Gateway Vehicles
Luke Stegeman	Flight Rules for Artemis II: HERA Detector Utilization and Space Weather Mitigation Strategy

WRMISS 2025: Participant List

Surname	Name	Nationality	E-Mail
Aeckerlein	Joachim	Germany	joachim.aeckerlein@dlr.de
Åkerlund	Benjamin	Finland	benjamin.akerlund@asro.fi
Ambrozova	Iva	Czech Republic	ambrozova@ujf.cas.cz
Benton*	Eric	US	eric.benton@okstate.edu
Berger*	Thomas	Austria	thomas.berger@dlr.de
Boretti*	Virginia	Italy	v.boretti@gsi.de
Bruedern*	Maximilian	Germany	bruedern@physik.uni-kiel.de
Campbell-Rickets*	Tom	US	thomas.e.campbell-ricketts@nasa.gov
Charpentier	Gabin	France	Gabin.charpentier2@cnes.fr
Cousineau Daoust	Vincent	Canada	vincent.cousineaudaoust@asc-csa.gc.ca
Di Fino*	Luca	Italy	luca.difino@asi.it
Dvořák	Roman	Czech Republic	dvorak@ujf.cas.cz
Ecord*	Michael	US	Michael.g.ecord@nasa.gov
Ehresmann*	Bent	Germany	ehresmann@boulder.swri.edu
Facius	Rainer	Germany	drreaf@gmx.de
Fogtman	Anna	Poland	Anna.Fogtman@ext.esa.int
Fragkopoulou*	Marianthi	Greece	m.fragkopoulou@herado.eu
Granja*	Carlos	Czech	carlos.granja@advacam.cz
Hassler*	Don	US	hassler@boulder.swri.edu
Hirn	Attila	Hungary	hirn.attila@ek.hun-ren.hu
Heber	Bernd	Germany	bernd.heber@email.uni-kiel.de
Heynderickx*	Daniel	Belgium	dhconsultancy@skynet.be
Jiggens	Piers		Piers.Jiggens@esa.int
Kakona*	Martin	Czech Republic	martin.kakona@odz.ujf.cas.cz
Kasemann *	Moritz	Germany	moritz.kasemann@dlr.de
Kodaira*	Satoshi	Japan	kodaira.satoshi@qst.go.jp
Laramore*	Diego	US	diego.laramore@nasa.gov
Losekamm*	Martin	Germany	MartinJan.Losekamm@esa.int
Lunati*	Luka	Italy	l.lunati@gsi.de
Marsalek	Karel	Czech Republic	karel.marsalek@dlr.de
Matthiae*	Daniel	Germany	daniel.matthiae@dlr.de

Miller*	Jack	US	j_miller@lbl.gov
Meier*	Matthias	Germany	matthias.meier@dlr.de
Naito*	Masayuki	Japan	naito.masayuki@qst.go.jp
Narici*	Livio	Italy	narici@roma2.infn.it
Patecki	Marcin	Poland	mp@sigmalabs.space
Pinczes*	Patrik	Hungary	Pinczes.patrik@ek-cer.hu
Ploc*	Ondrej	Czech Republic	ploc@ujf.cas.cz
Przybyla	Bartos	Germany	Bartos.Przybyla@dlr.de
Radenhäuser*	Maximilian	Germany	maximilian.radenhaeuser@dlr.de
Reitz	Guenther	Germany	guenther.reitz@dlr.de
Rutczynska	Alexsandra	Poland	Aleksandra.Rutczynska@dlr.de
Schenetten*	Kai	Germany	Kai.Schennetten@dlr.de
Scavardi*	Lorenzo	Italy	lorenzo.scavarda@altecspace.it
Semones*	Eddie	US	edward.j.semones@nasa.gov
Sihver*	Lembit	Sweden	lembit.sihver@utrgv.edu
Smith	Martin	Canada	smithm@bubbletech.ca
Stegeman*	Luke	US	luke.a.stegeman@nasa.gov
Tomi*	Leena	Canada	leena.tomi@asc-csa.gc.ca
Truscott**	Pete	UK	PRTruscott@kallistoconsultancy.com
Zhou*	Guangming	China	gmzhou@suda.edu.cn

* = Presenter

WRMISS 2025: Abstracts

Progress on Tissue Equivalent Dosimeters being developed at Oklahoma State University

Eric Benton, Conner Heffernan, Garrett Thornton and Buddy Gersey
Physics Dept., Oklahoma State University, Stillwater, Oklahoma USA

The Radiation Physics Laboratory at OSU with support from NASA SWR2O2R program is developing ionizing radiation dosimeters for use aboard aircraft, UAVs and high altitude balloons. The Atmospheric Ionizing Radiation Tissue Equivalent Dosimeter (AirTED) is a low cost, compact ionizing radiation detector consists of a tissue equivalent proportional counter (TEPC) to measure high LET radiation including secondary neutrons, primary and secondary protons and heavy ions, and a Si PIN photodiode to measure low LET radiation including x-/gamma-rays, electrons and positrons. The Atmospheric ionizing Radiation Silicon Dosimeter (AirSiD) is a light-weight, battery-powered radiation spectrometer using only a Si PIN photodiode. A space-flight qualified version of AirTED (SpaceTED) recently completed a one year experiment aboard the ISS and results from this experiment is being used to develop and refine methods of combining the data measured by the TEPC and Si diode into a single lineal energy spectrum in order to determine total absorbed dose and dose equivalent. Analysis of the nearly one year of data is ongoing. Two test flights of the AirSiD dosimeter aboard stratospheric solar balloons were carried out in summer 2025 over central Oklahoma. Results from these flights were systematically slightly lower than model estimates made using the CARI-7A code, a result that is expected due to the lack of inclusion of the neutron component in the AirSiD measurement. In August 2025, SpaceTED is scheduled to fly on a Blue Origin, New Shepard flight over southwestern Texas. Both AirTED and AirSiD were calibrated at the HIMAC heavy ion accelerator in Japan and AirTED was used to characterize the Neutron Irradiation Facility at TRIUMF in Canada.

DOSIS and DOSIS 3D – active and passive radiation measurements in Columbus from 2009 – 2025

Thomas Berger for the DOSIS 3D Team

German Aerospace Center (DLR), Institute of Aerospace Medicine (ME), Cologne, Germany

The radiation environment encountered in space differs in nature from that on Earth, consisting mostly of highly energetic ions from protons up to iron, resulting in radiation levels far exceeding the ones present on Earth for occupational radiation workers. Since the beginning of the space era the radiation exposure during space missions has been monitored with various passive and active radiation instruments. Also, on-board the International Space Station (ISS) a number of area monitoring devices provide data related to the spatial and temporal variation of the radiation field in – and outside the ISS. The aim of the DOSIS (2009 – 2011) and DOSIS 3D (2012 - ongoing) experiment is the measurement of the radiation environment within the European Columbus Laboratory of the ISS. These measurements are, on the one hand, performed with passive radiation detector packages (PDPs) mounted at eleven locations within Columbus for the determination of the spatial distribution of the radiation field parameters and, on the other hand, with two active radiation detectors (DOSimetry TELescope =DOSTEL) mounted at a fixed position inside Columbus for the determination of the temporal variation of the radiation field parameters. Up to September 2025 a total number of 28 long-term exposures of the PDPs have taken place inside Columbus with a total measurement duration of 5336 days. Data from the two DOSTEL instruments cover a total measurement time of over 8500 days from 2009 – 2025. The talk will give an overview of the current results of the data evaluation performed for the passive and active radiation detectors in the years 2009 – 2025

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

Maximilian Brüdern[1], Thomas Berger[2], Bernd Heber[1], Daniel Matthiä[2], Bartos Przyblya[2]

[1]Institut für Experimentelle und Angewandte Physik, CAU Kiel
[2]Institut für Luft- und Raumfahrtmedizin, DLR, Köln

The radiation level in space far exceeds the ones present on Earth and therefore can pose a significant health risk for astronautical space missions. Inside the International Space Station (ISS), the total radiation exposure is often divided into contributions from a) Galactic Cosmic Rays (GCR), b) trapped particles in the inner radiation belt, c) sporadically occurring Solar Particle Events (SPEs) and seldom, but seen d) contributions from trapped particles from the outer radiation belt. With the 11-year solar cycle, the proportions of these contributions to the total exposure changes. Since the ISS is located within the Earth's magnetosphere, GCR and SPE are partially shielded by its magnetic field. This shielding is particularly weak at the Earth's magnetic poles. If the Earth is hit by a strong geomagnetic storm, the Earth's magnetic field is briefly disturbed. This can result in the creation of a third but unstable radiation belt. Within the DOSIS and DOSIS 3D project the two DOSTEL instruments measures the relevant count- and dose rate with a time resolution of 20 or 60 seconds. They also provide relevant energy deposition and linear energy transfer (LET) spectra within certain time intervals. This makes it possible to separate the contributions from a) GCR, b) radiation belt particles, and c) SPEs to the total exposure, because SPEs, for example, are much less shielded in the polar region. The analysis of the DOSTEL data for recent solar maximum conditions in 2024 and 2025 led to the identification of seven SPEs measured inside the ISS which is the highest number of SPEs ever seen since the start of the experiment. In addition, time periods exhibiting signatures of an unstable radiation belt within the ISS could be observed. These results will be presented here, especially with regard to their contribution to the total radiation exposure.

LIDAL: Decoding Cosmic Radiation One Particle at a Time

Virgina Boletti, GSI, Darmstadt

Current models for assessing the effects of radiation exposure in space require detailed knowledge of the radiation environment to which astronauts are subjected. In particular, it is essential to know the kinetic energy spectrum of each type of particle present in the radiation field. However, only a limited number of detectors are capable of performing particle-by-particle measurements and reconstructing energy spectra—especially within a space habitat.

The only instrument currently capable of such detailed measurements is LIDAL (Light Ion Detector for ALtea), installed in the Columbus module aboard the International Space Station (ISS). LIDAL consists of three modules: 3 Silicon Detector Units, each composed by six silicon planes, enclosed between 2 LIDAL Detector Units, each made of a plane of 8 plastic scintillators bars each 80 x 20 x 4 mm3 with a fast-electronic read-out system, constituting the first Time-of-Flight system to ever fly on board a space habitat and a LIDAL Connector Unit for data acquisition. LIDAL's goal is the measurement not only of the energy released by the particle passing through the Silicon detector but also of Time of Flight (ToF) by scintillators.

In this presentation, we introduce newly developed algorithms that leverage LIDAL's measurements to derive, for the first time, the abundance and kinetic energy spectra of particles inside a space habitat. The algorithms exploit the measurement of each silicon plane instead of the average on each SDU in order to consider with more detail the history of the particle. This process has the advantage to allow us to recognize also particles that are stopping inside the detector. These results can be directly integrated into existing radiation risk models to improve exposure assessment and also serve as a benchmark for validating radiation transport models.

Timepix Measurements on the Space-X Polaris Dawn Flight

Thomas Campbell-Ricketts, NASA SRAG

In September 2024, the Space-X Polaris Dawn mission embarked, with a crew of 4, on a five-day, high-altitude space flight, reaching a height of 1400 km. A refurbished HERA unit was supplied by NASA to monitor the space radiation during the flight. The HERA is a Timepix based radiation monitor, designed to accommodate up to four sensors, but in this case, only one silicon sensor was attached. The HERA measures dose, particle flux, LET spectrum, and with access to the raw frame data, directional information on the incident charged-particle field. We averaged a dose rate of 1.1 mGy per day in silicon, which is substantially higher than a typical day on ISS (about 0.25 mGy per day in silicon). The radiation measurements over the flight were compared with predictions based on the modelled radiation environment and the shielding model for the Crew Dragon. The results suggested that we have excellent understanding of the distribution of trapped radiation, but that the vehicle shielding model may have been underestimated.

Radiation Shielding by Natural Terrain on the Surface of Mars

Gabin Charpentier (CNES), Bent Ehresmann (SwRI), Don Hassler (SwRI), Cary Zeitlin (LEIDOS), Robert Wimmer-Schweingruber (CAU Kiel)

Utilizing natural terrain to reduce exposure to radiation on the Martian surface remains a highly desirable and effective approach to limit health risks to future explorers of Mars. We have found that large terrain features such as buttes or cliffs reduce the radiation measured by MSL/RAD on the surface of Mars. The decrease in radiation, thereby, to first degree depends on the amount of sky blockage provided by those features. However, as the surface radiation environment on Mars is highly anisotropic, in particular at angles close to the horizon, we need to assess and understand the specific topography at each given location to make reliable predictions for the radiation exposure at potential future landing sites. While local terrain can shield from the incoming GCR-induced radiation, it will also produce additional secondary, albedo particles (mainly neutrons) that can increase the radiation levels accordingly. Using high resolution 3D terrain data and Monte Carlo simulations, we systematically model shielding and albedo effects, enabling directional flux estimates and comparison with measured neutral count rates. Here, we will present an overview of terrain shielding instances measured by MSL/RAD and put them in context with the average amount of shielding provided at those locations, as well as the influence on the radiation dose and neutron contribution at those locations.

Latest LIDAL measurements inside Columbus: particle flux and anisotropy

Luca Di Fino, ASI, Italy

Humanity is on the verge of a new space age, with plans for sustained lunar bases and crewed missions to Mars becoming increasingly feasible. These ventures, taking place outside Earth's magnetic protection, present unique challenges, particularly the significant risk posed by cosmic radiation. In deep space, astronauts face a complex radiation environment from galactic cosmic rays, solar energetic particles, and secondary particles, which can affect both their health and spacecraft systems. Understanding and addressing cosmic radiation is therefore essential to ensure crew safety and mission success as we prepare for interplanetary exploration.

Progress in this domain relies on precise modeling of radiation fields, detailed biological studies, and advanced detection technologies capable of characterizing the unique exposure profiles encountered beyond low Earth orbit. Concerning the precise characterization of the radiation field, the Italian Space Agency (ASI) funded the development of the LIDAL (Light Ion Detector for ALtea) instrument, realized by Tor Vergata University of Rome. LIDAL is designed to measure ion flux, energy spectra, and time of flight in a space habitat. Active in the Columbus module since January 2020, it will remain operational on the ISS at least until 2028. For the first time in a space habitat, LIDAL integrates a Time of Flight (ToF) detection system, enabling nuclear discrimination, dosimetry, tracking, and kinetic energy measurement of all passing ions.

The LIDAL detector is periodically repositioned along the three orthogonal axes of the ISS (X, Y, Z) to acquire data on the radiation field from multiple directions, taking advantage of its narrow acceptance angle. This feature, combined with the ToF system’s ability to distinguish between forward and backward particles, allows for a detailed analysis of radiation anisotropies, which are strongly influenced by the Station’s mass distribution. Anisotropies in the Y and X directions are mainly attributable to secondary radiation produced by interactions between primary cosmic rays and the Station’s structure, affected by shielding, with further contributions from the external East-West radiation field.

This work presents the latest results concerning particle flux and dose rates in the three orthogonal directions in which LIDAL was placed inside the Columbus module, distinguishing between anisotropy effects due to the radiation field and those related to the Station’s uneven shielding.

These results demonstrate that LIDAL provides detailed information on the ISS radiation environment, adding a level of detail beyond the typical averaged dose measurements commonly used to assess astronauts’ exposure to cosmic rays

ARES Detector for Radiation Monitoring on the HLS and Gateway Vehicles

Michael G. Ecord, NASA SRAG

The NASA Active Radiation Environment Sensor (ARES) was developed to support area radiation monitoring for elements on Artemis Program Lunar Mission vehicles. ARES uses Timepix for active monitoring of real-time space environment radiation incident from Solar Particle Events (SPE) and Galactic Cosmic Radiation (GCR). ARES charge particle measurement data meets the absorbed dose, the charged particle flux, LET distribution requirements for Artemis Program vehicles, per NASA-STD-3001. ARES also provides high dose alarm indication for prescribed threshold exceedance.

The talk will cover ARES design and environment certification, ARES planned flights, flight concept of operations and future mission targets.

Update on the development of the Miniaturized Fast Neutron Detector (Mini-FND)

Bent Ehresmann (SwRI), Don Hassler (SwRI), Michael Vincent (SwRI)

The Mini-FND (Miniaturized Fast Neutron Detector) instrument is based on the highly successful ISS/RAD FND instrument that has been operating onboard the ISS since 2016. We reduced volume, mass, and power draw by replacing the original Photo Multiplier Tube (PMT) read-out detector with an array of small-sized, low-voltage Silicon Photo Multipliers (SiPMs). Mini-FND will fly as part of the LEIA (Lunar Explorer Instrument for space biology Applications) instrument suite on NASA's CLPS-22 lunar lander mission. Here, we provide an update on recent progress in the development of the Mini-FND instrument, including environmental testing and preliminary calibration efforts, as well as an outlook on future work before launch.

Ultra-Sensitive dosimeter for Artemis: Enabling Lower Detection Limits in Space Radiation Measurement.

Marianthi Fragkopoulou, HERADO

This work introduces a groundbreaking advancement in dosimeter technology, critically enabling enhanced radiation detection for demanding space applications, particularly the Artemis lunar exploration program. Through the integration of novel reduce technology, the instrument's lower detectable limit (LDL) has been reduced. This unprecedented sensitivity empowers the precise measurement of extremely low-level environmental radiation, a capability vital for ensuring astronaut safety and understanding the deep-space radiation environment. The ability to detect radiation levels lower than conventional systems allows for continuous, highly granular monitoring in environments like the lunar surface and transit to the Moon, where radiation sources (e.g., galactic cosmic rays, solar particle events) can vary significantly in intensity and composition. This development directly supports the Artemis mission's objectives by providing crucial data for real-time radiation exposure assessment, validation of shielding effectiveness, and refinement of radiation risk models for long-duration human missions to the Moon and eventually Mars. The enhanced dosimeter represents a significant leap forward in space radiation monitoring, contributing to safer and more sustainable human exploration beyond low Earth orbit.

Composition and Spectral Characterization of Space Radiation in LEO Orbit at 600 km and 1200 km onboard JoeySat Satellite with MiniPix-Timepix3

Carlos Granja, Advacam, Prague

Processed data and physics data products will be presented of the space radiation field on the telecommunication microsatellite JoeySAT (150 kg, 50 cm size) from OneWeb EUTELSAT measured by Advacam’s MiniPIX-Timepix3 Space detector in LEO orbit at 600 km and 1200 km altitude polar SSO orbit. Processed data consist of the space radiation field characterization (decomposition into broad particle-type classes – based on extensive experimental calibrations at particle accelerator beams and well-defined reference fields) and particle tracking spectrometry (energy loss, LET spectra) with high-resolution radiation imaging and spectral-sensitive visualization of single particle tracks. Detailed results of two-year operation in space are provided in the form of satellite-correlated time distributions and Earth orbit maps of particle fluxes and dose rates for total and partial components (protons + ions, energetic electrons + low-energy gamma rays, low-energy electrons + X rays). Data will be presented for various orbits (600 km, 1200 km, transfer orbit) as well as for quiescent and radiation storm periods including the Mother’s Day May 2024 solar storm. The miniaturized MiniPIX-Timepix3 Space payload will be described including its wide-range operation as high-resolution spacecraft radiation monitor integrated to JoeySAT launched on May 2023 (first Timepix3 in space onboard a spacecraft).

Recent Results from the Surface of Mars with RAD

Don Hassler (SwRI), Bent Ehresmann (SwRI), Cary Zeitlin (NASA), Bob Wimmer-Schweingruber (CAU)

The Radiation Assessment Detector (RAD) on the Mars Rover Curiosity has been effectively serving as a space weather monitor on the surface of Mars since Curiosity landed on the red planet in 2012. RAD has measured the impact of more than a dozen solar storms, with the frequency of events increasing as the Sun approaches solar maximum. We will present results and analysis of recent measurements from RAD, including analysis of RAD's largest event observed to date as part of the May 2024 solar storms that impacted both Earth and Mars. We will discuss these events and their implications for space weather predictions, as well as the need for heliosphere-wide space weather monitoring to support future human exploration to Mars and beyond.

Demonstration of HIERRAS

Daniel Heynderickx, DH consultancy

MoonRAD mission and science overview

Attila Hirn[1], Balázs Zábori[2]
[1)] HUN-REN Centre for Energy Research, Institute for Atomic Energy Research, Budapest, Hungary
[2)] REMRED Space Technologies Ltd., Budapest, Hungary

REMRED Space Technologies Ltd. (REM) in collaboration with HUN-REN Centre for Energy Research (EK) has performed a limited Phase 0 (pre-Phase A) study for a possible Lunar SmallSat mission concept (MoonRAD) addressing space radiation and space weather research and services in the Lunar environment. MoonRAD would be the first Hungarian ESA flagship (SmallSat) programme lead by a Hungarian SmallSat Integrator Prime. The concept has been proposed for implementation within the ESA HRE Directorate to be executed by a consortium with Hungarian majority. The mission objectives are:

- Monitoring Lunar space radiation and plasma environmental characteristics and dynamic processes to support the reference modelling of Moon radiation environment and effects.
- Demonstration of a future European Lunar space weather near real-time operational service provision.
- Securing European market competitiveness in Lunar SmallSat technologies market by considering New Space solutions.

This presentation is a brief overview of the outcome of the pre-Phase A study, including MoonRAD mission definition, implementation approach, strategic alignment, preliminary data products, and potential science payload candidates.

Czech Personal Active Dosimeter (CZPAD): Dosimetric Support for the First Czech Astronaut Mission

Martin Kakona, Nuclear Physics Institute Prague

This contribution presents the Czech Personal Active Dosimeter (CZPAD) experiment, developed for the first Czech astronaut (second Czech cosmonaut), whose mission to the International Space Station is planned for 2027/2028. The experiment consists of four SPACEDOS active dosimeters, evolved from earlier AIRDOS and CANDY instruments. Each SPACEDOS unit features a large-area PIN diode, battery-powered electronics, and industrial-grade SLC SD card data storage. Two independent detection sensors are integrated into each unit, one of which includes a conversion layer for thermal neutron detection utilizing moderation by the astronaut's body.

A wristwatch-style Dosimeter Display Unit (DDU) will also be developed as a technology demonstrator for real-time radiation monitoring.

The presentation outlines the experiment's primary objectives and challenges, including the evaluation of optimal dosimeter placement on the astronaut's body, assessment of the system's effectiveness in measuring the neutron component of the radiation field, and the ability to characterize the contribution of galactic cosmic rays (GCR). These aspects are particularly relevant for deep space missions, where the contribution of high charge and energy (HZE) particles is crucial.

Opportunities for collaboration and data sharing within the international space radiation research community, including contribution to NASA's RadLab database, will also be discussed.

Update on the DLR M-42 instrument family and future missions

Moritz Kasemann, Thomas Berger, Karel Marsalek, Bartos Przyblya, Daniel Matthiä, Joachim Aeckerlein, Maximilian Radenhäuser, Aleksandra Rutczynska, Markus Rohde

German Aerospace Center (DLR), Institute of Aerospace Medicine (ME), Cologne, Germany

The space radiation environment is the most complex natural radiation environment one can encounter. It not only poses a threat to spacecraft and their electronics, but can also harm humans who venture into deep space. A flight to the Moon or to Mars would first have to pass the Earth's radiation belts (Van Allen Belts) with the inner (proton and electron) and the outer (electron) belt and then in free space the relevant spacecraft (and possible humans inside) is exposed to the galactic cosmic radiation (GCR) environment. Measuring the radiation load in space provides valuable data to protect astronauts. The data can further be applied to benchmark radiation transport codes and used to design new shielding materials.

Within the last decade the Biophysics working group of the Radiation Biology Department has developed, built, tested and flown a set of active radiation detector systems in various missions. These consist of the M-42 detector family (M-42 compact, M-42 split, M-42 display, M-42 EXT, M-42 BIG, M-42 PSD) - successfully applied on several airplane flights, NASA balloon flights over Antarctica, MAPHEUS (sounding rocket) flights, within the RadMap experiment on-board the International Space Station (ISS), the NASA Artemis I mission and the Astrobotic Peregrine I flight.

To gain deeper insights into the rather complex space radiation environment, the M-42 Detector family is under constant development. This includes the development of detectors with higher energy range and larger sensors but also the development of new measurement methods regarding the Linear Energy Transfer (LET). This talk will give an overview of the M-42 detector family and its further development.

Development of on-site passive dosimetry for space applications

Satoshi Kodaira, NIRS, Japan

To evaluate radiation doses in space, it is essential to measure the Linear Energy Transfer (LET) of incident particles. Currently operational passive dosimeters, composed of plastic nuclear track detectors and luminescence detectors on the ISS, require special processing, making it necessary to retrieve them on Earth, rendering them unsuitable for deep space exploration. Therefore, as a new dosimetry technology to replace conventional passive dosimeters, this research aims to practicalize a reliable on-site dose assessment technique using silver-activated phosphate glass chips capable of detecting incident particles as fluorescent tracks and identifying their LET. The study explores a method to simultaneously read the fluorescent tracks of high-LET particles and the total fluorescence derived from low-LET particles within the same glass chip. The idea and its development status will be presented.

ISS-RAD from Solar Cycle 25 Min to Max

Diego Laramore, Cary Zeitlin, Shaowen Hu, SRAG

ISS-RAD has now been operating in a semi-fixed position on ISS USLab since May 2020, correlating well with the start of Solar Cycle 25 the previous year. ISS-RAD has made consistent measurements of the ambient radiation environment in LEO as the solar cycle progresses for both charged particles and neutrons. GCR and SAA dose rates had steadily reduced for both the CPD and FND detectors on ISS-RAD throughout the Solar Cycle until the current solar maximum. The powerful May 2024 solar storm as measured by ISS-RAD showed markedly increased dose rates at high latitude portions of the ISS trajectory. Dosimetric models compared to data collected by ISS-RAD for this event show that the transient solar activity (e.g. planetary K-index) can dramatically affect the expected dose from SPE's in LEO.

Update on the RadMap Telescope

Martin Losekamm, ESA

The RadMap Telescope is an experiment for demonstrating new radiation-monitoring technologies. It comprises two sensors: and tracking calorimeter built from scintillating-plastic fibers and a copy of the German Aerospace Center's M-42 dosimeter. The instrument operated in three modules of the International Space Station between April 2023 and January 2024. I will present an update on the ongoing analysis of the data collected during that time.

LIDAL × GCRSimulator: Towards Characterizing simulated Space Radiation at the GSI-FAIR facility

Luka Lunati, GSI, Darmstadt

Space Radiation is one of the major showstoppers for the human exploration of the Solar System. Understanding and characterizing both biological and non-biological risks associated with radiation exposure is therefore crucial. While ground-based experiments are essential, replicating the full complexity of the space radiation environment on Earth remains a significant challenge. Traditional accelerator-based studies rely on sequential, mono-energetic, single-ion irradiations, neglecting eventual synergistic effects of the mixed radiation fields found in space .To address these limitations, an innovative GCR Simulator was developed and successfully validated at GSI-FAIR (Germany) in May 2025. This novel system marks a new frontier for ground-based space radiation research in Europe. The GCR Simulator employs a hybrid active-passive approach: the energy of primary ^{56}Fe beam is actively switched from 1 GeV/u down to 0.35 GeV/u in combination with complex-shape, custom-designed, passive beam modulators and slab targets. Six optimized hardware configurations reproduce different regions of the GCR kinetic energy spectra. By properly weighting these configurations, it is possible to replicate GCR-like spectra that closely mimic both the kinetic energy and LET (Linear Energy Transfer) distributions at 1 AU during solar minimum conditions, behind 10 g/cm2 aluminum shielding—representative of a lightly shielded space habitat. Changes in heliospheric conditions can be simulated by adjusting the configuration weights via software alone, without modifying the hardware. Shielding effects can also be studied by physically adding materials of varying composition and thickness along the beamline.

Experimental validation of the simulator requires detectors capable of measuring both particle kinetic energy and LET simultaneously. The LIDAL (Light Ion Detector for ALTEA) Flight detector— operating aboard the ISS since January 2020—meets this requirement. LIDAL is a compact active particle telescope combining 18 silicon stripped planes from the former ALTEA detector (2006-2012) with two segmented plastic scintillator planes placed at each end, enabling simultaneous Time-of-Flight and energy depositions measurements. For the first time in a space habitat, this allows the direct estimation of kinetic energy for individual particles. The ground model, LIDAL Ground, is now operational at GSI and will serve as the reference detector in upcoming GCR Simulator experimental campaigns starting in 2026. These campaigns aim to fully characterize the GCR-like field at different positions from the source and behind various shielding materials and thicknesses. In this talk, a comprehensive overview of the GCR Simulator will be given, together with preliminary results from LIDAL Ground, obtained during the May 2025 campaign, which will be shown and compared with in-orbit LIDAL measurements. An unprecedented opportunity is on the horizon: the first-ever simultaneous radiation measurements on Earth and in space using two functionally identical LIDAL detectors. Such a breakthrough will enable a new class of experiments where ground-based results can be directly validated against in-orbit measurements—providing critical insights for future deep space missions

An application approach of LET- and charge-weighted quality factors to space LET measurements

Naito Masayuki, QST/NIRS, Japan

We suggest a practical application of particle linear energy transfer (LET)- and charge (Z)-weighted quality factors, based on the track structure model such as QNASA, for LET-based radiation dosimetry in space. Z contribution factors varying with the galactic cosmic rays (GCRs) was evaluated based on the Monte Carlo calculation to derive LET- and Z-weighted quality factors (Q*). The Q* values under solar minimum conditions in free space differs by only a few percent from values obtained with spacecraft shielding or during the solar maximum spectrum. The contribution of GCR heavy components under Q* is approximately 9% smaller compared to QICRP of ICRP-60. While this variation is not substantially large considering ambiguities in dose evaluation in space, the Q* approach provides practical dose evaluation using LET measurements.

Radiation exposure and shielding effects on the lunar surface

Daniel Matthiä, Thomas Berger

German Aerospace Center (DLR), Institute of Aerospace Medicine (ME), Cologne, Germany

The Moon could be a primary target for human space exploration in the near future. A limiting factor for a crewed mission to the Moon is the radiation dose during their stay on the lunar surface. While the total dose is expected to be dominated by the galactic cosmic radiation, the potential occurrence of large solar energetic particle events may lead to severe short-term effects and endanger the success of the mission. This work investigated the expected dose rates for maximum galactic cosmic radiation intensity and the total dose from several historical solar energetic particle events, including the NASA reference event, through the application of numerical simulations with the Geant4 Monte-Carlo framework. An evaluation of the shielding effect of lunar regolith was carried out. For the solar particle events a shielding of more than 4 g/cm2 of regolith would reduce the expected dose to below the current 30-day limits and a shielding of more than 10 g/cm2 would result in a safety margin factor of two. For galactic cosmic radiation adding additional mass shielding did not reduce the absorbed dose significantly. The estimated total dose equivalent received utilizing around 180 g/cm2 of regolith amounted to 200 mSv/year, which is only about 25% below the corresponding estimates for an unshielded environment. The comparison to model and experimental data from literature showed reasonable agreement to measurements but the analysis of various earlier model results revealed, that substantial differences between the models exist, despite all improvements that have been achieved in recent years.

Between Sea Level and the ISS: Radiation Measurements in the SAA Region at Flight Altitudes II

Matthias M. Meier[1], Thomas Berger[1], Thomas Jahn[2], Moritz Kasemann[1], Daniel Matthiä[1], Karel Marsalek[1], Kai Schennetten[1]

[1]German Aerospace Center, Institute of Aerospace Medicine, Radiation Biology, Cologne, Germany
[2]Lufthansa German Airlines, Lufthansa Basis, Frankfurt/Main, Germany

The South Atlantic Anomaly (SAA) is a geographical region over the South Atlantic Ocean where the inner Van Allen radiation belt extends down particularly close to Earth. This leads to highly increased levels of ionizing radiation and related impacts on spacecraft in Low Earth Orbits (LEOs), e.g., correspondingly increased radiation exposure of astronauts and electronic components on the International Space Station. According to an urban legend, the SAA is also supposed to affect the radiation field in the atmosphere even down to the altitudes of civil aviation. In order to identify and quantify any additional contributions to the omnipresent radiation exposure due to the Galactic Cosmic Radiation (GCR) at flight altitudes, comprehensive measurements were performed crossing the geographical region of the SAA at an altitude of 13 km during the last solar minimum in a unique flight mission—Atlantic Kiss. The results were presented at the WRMISS 2023 in Rome.

RadLab status and related database development(s)

Jack Miller, NASA Ames Research Center

The growing emphasis on open science is stimulating development of databases that are both user- and AI/ML-friendly. A multi-year effort at NASA Ames Research Center has produced the NASA Open Science Data Repository (OSDR), which provides access to life sciences data from ground-based and space flight investigations. Informed analysis of these data depends on detailed knowledge of the environments in which flight experiments are conducted as well as details of the instrumentation and experimental hardware employed. RadLab, a compendium of space radiation data relevant to life sciences, can be used to characterize the radiation environment of a given experiment as well as for general space radiation studies. To meet the need for detailed information on flight hardware and instrumentation a new database, the Space Physical and Life sciences Archive of Scientific Hardware (SPLASH) is under development. RadLab is currently accessible through OSDR, and SPLASH will become available through OSDR in the coming months. We will report on the current status of RadLab and SPLASH, and discuss their role in OSDR.

DOSTEL REM LIDAL Intercomparison 2025

Livio Narici for the DORELI collaboration

An investigation aimed at comparing four silicon radiation detectors has been ongoing for more than five years. The DORELI program (DOSTEL, REM, LIDAL) focuses on data collected aboard the International Space Station (Columbus module) by four detectors: LIDAL (ASI/URTV), DOSTEL1 & DOSTEL2 (DLR/CAU), and REM (NASA). These detectors are 'quasi-co-located' on the same side of Columbus. The comparison work now spans half a solar cycle.
In this talk, we will present these extensive results. Additionally, given the length of the dataset, we are able to compare yearly averaged data. Yearly integration comparisons capture most of the features visible in shorter integration periods, while enhancing the visibility of overall similarities and differences. We will show flux and dose rate data for both GCR and complete orbits, as well as for the South Atlantic Anomaly (SAA) contribution alone. For GCR, the maximum flux differences between detectors in X and Y directions does not exceed about 20%, while the maximum dose rate differences remain within about 15%. We will discuss the significant contribution of the SAA to the yearly averaged flux, which can almost reach 50% for flux and about 60% for dose rate. There are also indications that the main SAA radiation direction is close to the XYZ bisector.

We will also present a preliminary evaluation of the general discrepancies among detectors. This is meant to assist radiobiology experiments that rely on radiation environment measurements from a single nearby detector. When considering GCR only, the mean discrepancy is 10% for data integrated over 5-minute intervals, decreasing to 5% for daily integrations. It is reasonable to expect that this discrepancy would remain similar in deep space, potentially serving as a guideline for experiments conducted during missions such as travel to Mars or stays on the planet. If SAA contributions are included, the peak discrepancy for 5-minute integrated data reaches about 13%, while the daily mean discrepancy is approximately 23%.

Presenting the RADCUBE-RADMAG instrument: technology demonstration and measurements

Patrik Pinczés, Attila Hirn, Thomas Berger, Daniel Matthiä, Karel Marsalek, Markus Rohde, Maximilian Radenhäuser, Moritz Kasemann, Bartos Przybyla

The RadMag is a compact and adaptable Cosmic Radiation and Magnetic Field Instrument Package (RadMag) designed primarily by HUN-REN EK, and is the primary payload of the RADCUBE mission. The primary goal of the RADCUBE mission is to demonstrate through successful mission operation the future use and applicability of the RadMag scientific/commercial instrument, in strategically important fields in the future, such as space weather research, data service capability, forecast, and radiation environment monitoring for commercial radiation damage assessment. The advanced version of RADMAG will be present on multiple space missions. The focus of the presentation is the radiation measurement, the magnetometer’s data will not be presented.

The instrument was operational between 2021-10-05 and 2022-05-03 in addition it was switched back on in 2024 for several days. The presentation will provide details on the dose and count rate measurements, LET values.
A cross-validation and measurement comparison with Eu:CROPIS RAMIS instrument with similar orbital parameters were performed. The comparison will be presented.

In the last 3 minutes of my presentation I would like to also present the Pille-ISS EVA measurements final version if its possible. It would be interesting to hear the community’s opinion on the results.

ESADOS – ESA Support for Aircrew DOsimetry Services: Developing an Independent Source of Space Weather Data for Aircrew Radiation Dose Assessment

Ondřej Ploc1, Roman Dvořák1, Martin Kákona1, Ronald Langer2, Igor Strhárský2, Šimon Mackovjak2, and Jan Kubančák2

1 Nuclear Physics Institute of the CAS, Řež, Czechia
2 Institute of Experimental Physics of the Slovak Academy of Sciences, Košice, Slovakia

At the Nuclear Physics Institute of the CAS, we have been involved in aircrew radiation dosimetry since 1998. The cornerstone of our service has been the use of the CARI software, currently in its CARI-7 version, to compute effective doses of cosmic radiation received during flight. In this contribution, we present a comprehensive overview of aircrew radiation exposures evaluated over the past 27 years, radiation measurements onboard aircraft, and an introduction of the ESADOS project.

To enhance our autonomy and increase the robustness of our service, we have joined the ESADOS (ESA Support for Aircrew DOsimetry Services) project initiated by the Institute of Experimental Physics of the Slovak Academy of Sciences (IEP). The IEP operates a neutron monitor at the Lomnický Štít observatory, which will serve as the basis for an independent determination of the heliocentric potential—a key input parameter for CARI dose calculations. The goal of ESADOS is to create an online platform providing both current and forecasted heliocentric potential values derived from long-term neutron monitor data. This will mitigate the risk of data unavailability from the existing single-source solution and support aircrew radiation protection services across Europe. The project includes the development of a theoretical model, its validation using flight measurements, and the publication of data as a one of modules of the ESA SWESNET web site. Further details and validation methodology will be provided in the presentation.

Almost 2500 days in space – the RAMIS radiation detector on the DLR Eu:CROPIS mission

Maximilian Radenhäuser1*, Thomas Berger1, Karel Marsalek1, Bartos Przyblya1, Daniel Matthiä1, Joachim Aeckerlein1, Moritz Kasemann1, Aleksandra Rutczynska1, Markus Rohde1, Michael Wirtz1, Stephan Sous2, Hans-Herbert Fischer2, Sven Jansen2

1German Aerospace Center, Institute of Aerospace Medicine (ME), Cologne, Germany
2German Aerospace Center, Microgravity Support Center (MUSC), Cologne, Germany

RAMIS (size: 140x140x35mm3, mass: 608 gram, power consumption 1.8 Watt) is a radiation detector developed for the DLR Eu:CROPIS satellite mission. RAMIS uses an arrangement of two silicon detectors in telescope geometry and maps the radiation environment in the course of the mission. For this RAMIS stores count- and dose rate data with a 1-minute and energy deposition spectra with a 5-minute cadence. Eu:CROPIS was launched on December 03rd 2018 into a polar orbit circling around Earth at an average altitude of ~600 km. RAMIS is located on the outside of the satellite and was activated on December 05th 2018 and has continuously provided data during the course of the mission. Due to the polar orbit of the satellite RAMIS measures a) the variation of galactic cosmic radiation (GCR) in dependence on the orbit, b) the contributions of protons in the inner Earth radiation (Van Allen), c) variations of the trapped electron intensity during crossings of the outer radiation belt and finally (d) the changes in the radiation environment due to the changes in the solar cycle as seen in a high number of detected Solar Particle Events (SPE). Due to the high complexity of the radiation environment and the various particle contributions a separation of GCR, SAA, Electrons and SPEs becomes a challenge. We tackled this problem by using for the first time a machine learning approach classifying data points based on a random forest algorithm. For this a trainings data set was defined and used as input for the radiation environment classification. This enabled the correct attribution/mapping of the various particle populations. First results applying this machine learning tool will be presented focusing on SPEs as measured with RAMIS in the course of the mission with a focus on the year 2024.

ERFNet-DH: A Collaborative Environment for Advancing Space Radiation Research in Support of Human Exploration

Lorenzo Scavarda, Altecspace, Italy

As human spaceflight advances beyond Low Earth Orbit (LEO), the need for accurate radiation monitoring and modeling becomes increasingly critical. Ensuring astronaut safety in the face of ionizing radiation—from Galactic Cosmic Rays (GCRs) and Solar Particle Events (SPEs)—is a top priority for upcoming long duration missions to the Moon, Mars, and beyond. These radiation sources can significantly impact crew health, system functionality, and mission operations.

In this context, the European Radiation Facility Network – Data Hub (ERFNet-DH) has been developed to strengthen scientific collaboration and accelerate research in space radiation. Funded and coordinated by ESA and ASI, and implemented by ALTEC (Turin, Italy), ERFNet-DH is a digital platform designed to provide solutions on space radiation and radiation protection by fostering international collaboration.

First, it offers a ready-to-use computational environment for radiation simulations and data analysis, with pre-installed tools such as Geant4, FLUKA, ROOT, and scripting environments. Users can run Monte Carlo simulations and custom workflows directly via a browser-based interface or in batch mode, without the need for local infrastructure.

Second, it serves as collaborative hub that enables the scientific community to upload and share datasets, software, publish results, and discuss key challenges and methodologies related to space radiation and radiation protection. ERFNet fosters interdisciplinary interaction among physicists, biologists, medical researchers, engineers, and data scientists, contributing to the development of a harmonized European approach to radiation risk assessment. By providing a shared infrastructure for accessing, analyzing, and simulating radiation environments, ERFNet can also support ISS-related research by enabling comparative analysis of in-flight data, validation of radiation transport models, etc.The platform facilitates benchmarking between different onboard instruments and helps refine operational thresholds and risk mitigation strategies. Moreover, it encourages collaboration across disciplines, paving the way for harmonized approaches to radiation monitoring in low Earth orbit and beyond. A key milestone was achieved on July 23rd, 2025, with the public release of ERFNet Version 1.

At the 2025 Workshop on Radiation Monitoring for the International Space Station (WRMISS), we aim to present the capabilities and architecture of the ERFNet-DH platform with a p I.

The Relevance of the Space Weather Events in May 2024 to Radiation Protection in Aviation

Kai Schennetten, Daniel Matthiä, Matthias M. Meier, Thomas Berger and Michael Wirtz

German Aerospace Center, Institute of Aerospace Medicine, Radiation Biology, Cologne, Germany

A number of space weather events occurred during a very active phase of the Sun in May 2024 including several strong M and X class X-ray flares. Following these X-ray flares and the associated Coronal Mass Ejections (CME), elevated levels of highly energetic protons were measured in Earth Orbit and had the potential to increase the dose rate at aviation altitudes. One of the events, however, also caused a temporary reduction in the intensity of galactic cosmic radiation measured by ground-based neutron monitors during a Forbush decrease. During this period of temporary decreased intensity of cosmic radiation, another event in turn led to a small increase in neutron monitor count rates, a Ground Level Enhancement (GLE), the first of its kind since October 2021.

The complex evolution of the different components of these space weather events was analyzed with the PANDOCA model, developed at the German Aerospace Center for the assessment of radiation exposure in aviation. The expected impact on the radiation field and the related variations in the effective dose at aviation altitudes were calculated and compared to quiet space weather conditions. The calculations were based on measurements of the integral proton flux by the Geostationary Operational Environmental Satellites (GOES) and count rates of ground-based neutron monitors during the critical phases of the events. The calculated dose rates at aviation altitudes were compared to RAMIS measurements in LEO to demonstrate the shielding capabilities of the atmosphere.

Overview of the current NASA Mars Campaign Office (MCO) Radworks project portfolio

Edward Semones, NASA-SRAG, US

An overview of the current NASA Mars Campaign Office (MCO) Radworks project portfolio will be given, including a description of the main elements: charged particle detectors, Space Weather forecasting/nowcasting scoreboards, HZETRN radiation transport updates, and neutron measurement instruments.

Shielding efficiency of Plasteel

Lembit Sihver, Cosmic Shielding Cooperaton

Cosmic Shielding Corporation (CSC) has developed a hydrogen-rich nanoparticle-doped Multifunctional Shielding Polymer (MSP), with the trading name Plasteel™, which can protect sensitive electronics and humans from both the primary and secondary components of space radiation. The hydrogen component of MSP/Plasteel optimizes the energy deposition of the primary charged particles in the shield, reduces the production of secondary radiation, and slows down fast neutrons. Then, the nano dopants in the MSP/Plasteel™ reduces the secondary radiation even more. MSP/Plasteel™ has also good thermal and mechanical properties, and it provides better shielding for space radiation than thermoplastics such as polyethylene and PEEK. The shielding properties of MSP have been extensively verified by simulations and measurements using protons and heavy ions at different ground-based accelerator facilities. Extensive accelerator-based measurements of non-destructive and destructive Single Event Effects (SEEs) on NxN Edge Computing Modules Running on a COTS NVIDIA Jetson Orin System-On-Chip (SOC) have also been performed. These measurements have verified that behind MSP/Plasteel™ the SEEs are significantly reduced in COTS electronics compared to behind e.g. aluminum. The shielding properties have also been verified on the ISS and during several in-orbit customer demo missions. The manufacturing of MSP/Plasteel™ is versatile and can be done with various techniques such as additive manufacturing, molding and thermoforming.

Flight Rules for Artemis II: HERA Detector Utilization and Space Weather Mitigation Strategy

Luke Stegeman, SRAG, US

NASA's Space Radiation Analysis Group (SRAG) is responsible for monitoring and characterizing the space radiation environment, managing onboard radiation instruments, and providing console support to protect crew health during NASA human spaceflight missions. In anticipation of Artemis II, SRAG has developed a set of mission-specific flight rules that guide SRAG's operational response to any different-than-nominal radiation environment conditions during the mission. These flight rules make use of real-time in situ measurements collected by the Artemis II Hybrid Electronic Radiation Assessor (HERA) detector (among other indicators) to determine SRAG's radiation protection recommendations to the crew and to the wider Flight Control Team during elevated radiation environment conditions, such as a significant solar particle event.

The proposed talk will discuss 1) Artemis II flight rules that pertain to radiation protection, 2) the use of the HERA detector in Artemis II operations, and 3) the actions that the SRAG console, the Flight Control Team, and the crew might take during elevated radiation environment conditions.

Development of the Canadian Active Neutron Spectrometer for the ISS and Lunar Gateway

Vinvent Cousineau Daoust and Leena Tomi for the Canadian Space Agency CANS Team
Canadian Space Agency

The Canadian Space Agency is developing the Canadian Active Neutron Spectrometer (CANS), a scientific instrument that builds on national expertise in neutron dosimetry and spectrometry. CANS is designed to monitor the radiation environment within the Gateway Habitation and Logistics Outpost (HALO) module. It will measure neutrons in the energy range of 0.5 MeV to 100 MeV and discriminate neutron signals from those produced by charged particles and gamma/x-rays. These measurements will complement data from the European Space Agency's Internal Dosimeter Array and can be used to inform medical operations.

Phase A of the project has been recently concluded, with Phase B scheduled to begin in late 2025. CANS is currently planned for deployment as a technology demonstration aboard the International Space Station in 2027/2028. This presentation will outline the objectives, current status, and conceptual design of CANS. It will also detail the data sharing and partnership plan with the ISS and Gateway partners, followed by a discussion on data user requirements and opportunities for future collaboration.

The Human Interplanetary Exploration Radiation Risk Assessment System (HIERRAS)

Pete Truscott, Daniel Heynderickx, Fan Lei, Daniel Matthiä, Thomas Berger, Osku Raukunen, Rami Vainio, Antonis Tsigkanos, Ingmar Sandberg, Piers Jiggens, and Simon Clucas

Under the European Space Agency's HIERRAS Project a consortium led by DH Consultancy has developed a comprehensive, web-based system for predicting human and spacecraft system radiation exposures for future interplanetary missions to the Moon and Mars. The HIERRAS System includes models and data sources to treat:

- Spacecraft orbit generation based on Keplerian elements, as well as the ability to read OEM trajectory files generated by other mission planning software.
- Standard cosmic ray and solar energetic particle (SEP) environment models, and also models for Earth's trapped radiation belts. The Magnetic Shielding Model (MSM) is included to treat geomagnetic shielding effects in the near-Earth environment.
- In addition to environment models, cleaned and cross-calibrated reference data from GOES proton and He detectors may be used as an external radiation source to calculate exposures for historic SEP events.
- Geant4-based as well as non-Monte Carlo models to simulate spacecraft shielding, planetary environments, and effects. These include 1D models such as MULASSIS, SHIELDOSE-2/-2Q, EQFLUX, and full 3D particle Monte Carlo simulation models such as GRAS and GRAPPA.
- Calculation of human radiation exposures based on conversion coefficients for fluence to whole body dose quantities, or alternatively using organ absorbed doses from human phantom calculations using GRAS.
- Facilities to define missions and mission segments comprising a variety of different trajectory phases.
- A user-friendly GUI to allow control of the model runs and calculation flow, and visualization of all results.

This paper describes the HIERRAS System and its applications to orbital, interplanetary transit and planetary surface radiation exposure calculations.

Modelling Martian and Lunar Environments Using the GRAPPA with GRAS

Pete Truscott, Daniel Heynderickx, Daniel Matthiä, Fan Lei, Piers Jiggens, and Simon Clucas

The interactions of galactic cosmic and solar energetic particle radiation with planetary atmospheres and surface regolith/bedrock may lead to significant modification to the local surface particle field due to the attenuation of the primary radiation and secondary particle production in the materials. This paper describes the GRAS Pre-processor for Planetary bodies and Asteroids (GRAPPA) developed under the ESA HIERRAS Project to generate GDML geometries and other associated inputs needed to perform 3D GRAS simulations of Martian and Lunar radiation environments. The geometries generated by GRAPPA are position-, seasonal- and local time-dependent based on:

1. The European Mars Climate Database (MCD) v5.3 to define the Martian atmospheric composition and density as well as the surface precipitates.
2. γ-ray spectrometer observations from Mars Odyssey have previously been used by Gonçalves et al to define the Mars surface soil composition database, SOILCOMPI. Both SOILCOMPI and an equivalent dataset for the Lunar surface (based on Lunar Prospector γ-ray data) are available to GRAPPA.
3. Martian local magnetic field models of Cain et al or Purucker et al.

Geometries from "local" scales (~10s metres) to planetary scales may be generated by GRAPPA. For local scale surface geometries, recent changes to GRAS allow the user to easily overlay GDML-defined habitat geometries, mission equipment and anthropomorphic phantoms, thus allowing very detailed analyses of the local radiation environment on astronauts for different operational and shielding conditions. The design of GRAPPA also allows relatively easy extension of the software to treat Earth or other planets and moons.

Reduction of uncertainty of radiation health risk assessment

Guangming Zhou, Soochow University, China

In order to reduce the uncertainty of the health risk assessment of space radiation environment to astronauts, abundant experimental dose-response data are essential. Our group dedicated to the quantitative studies on the biological effects of simulated space radiation environment. Our results show that 1) low dose rate exposure does not increase the incidence but the malignancy of tumors induced by space radiation; 2) high LET diminishes the difference in radio sensitivity of quiescent cells to exponentially growing cells; 3) hypo-magnetic field increases cellular radio resistance of cells; 4) microgravity enhances the tumorigenesis of space radiation above 0.5 Gy but reduces that of lower doses. These findings are preliminary but provide considerable data for the risk assessment of the space radiation environment. articular focus on its role in supporting collaborative research.