WRMISS in Mons 2022

Conference Program (Aug 26, 22)

Workshop on Radiation Monitoring on International Space Station *

25th WRMISS

6 – 8 September 2022

25h WRMISS Conference Program: Tuesday 6th September 2022

08:30 – 09:00	Registration
09.00 – 09:30	Opening
09:30 – 10:15	Scientific Session 1
10.15 – 11.00	Coffee/Tea Break
11.00 – 12:00	Scientific Session 2
12:00 – 14:00	Lunch
14.00 – 15:30	Scientific Session 3
15.30 – 16:30	Coffee/Tea Break
16:30 – 17:30	Scientific Session 4

Francois Vallee, Vice-Dean Engineering Faculty of UMONS Hamid Aït Abderrahim SCKEN Deputy Director Frank de Winne (Video Message)	Opening speeches
Guenther Reitz Patrice Megret, Marilina Mura, Olivier Van Hoey	Welcome and Organizational Issues

Scientific Session 1

Alessandro Bartoloni	Astro Particle Experiments to Improve the Radiation Health Risk Assessment for Humans in Space Missions

Scientific Session 2

N.I. Cherkashina	Study of the Radiation Shielding Properties of the Composite Material in the ISS Service Module Crew Cabin
Kerry Lee	Overview of new iRay2Dose Interface for Shielding Analysis and Comparison of Predicted ISS Radiation Exposures with REM2 Measurements

Scientific Session 3

Karel Marsalek	Almost four years of data for the DLR RAMIS measurements in LEO and further updates on the DLR M-42 detector family
Andrea Strádi	Pille Measurements on ISS (July 2019 – March 2022)
Giulia Romoli	LIDAL: exploiting the Bethe Block equation for single particle energy identification

Scientific Session 4

Giorgia Santi Amantini	LIDAL: nuclear discrimination
Luca di Fino	LIDAL: combining spectra and estimating dose

25th WRMISS Conference Program: Wednesday 7th September 2022

09:00 - 10:30	Scientific Session 5
10.30 - 11.15	Coffee/Tea Break
11.15 – 12:15	Scientific Session 6
12.15 - 14:00	Lunch
14:00 – 15:00	Scientific Session 7
15:00 – 16:00	Coffee/Tea Break
16:00 – 17:00	Scientific session 8
20:00 - 23.00	**Conference Dinner:** Martin Le Bistro Martin | Restaurant Insolite | Martin's Dream | Mons (www.martinshotels.com)

Scientific Session 5

Alice Mentana	LIDAL: towards RBE monitoring
Daniel Matthiä	DOSIS/DOSIS3D projects
Andrew Castro	Neutron measurements with ISS-RAD

Scientific Session 6

Thomas Cambell-Rickets,	Operational use of Timepix-based Radiation Environment Monitors on ISS
Livio Narici	LIDAL REM DOSTEL intercomparison

Scientific Session 7

Ramona Gaza	Crew Active Dosemeter Project Overview : ISS Ops , Commercial Crew, Artemis
Bryan M. Hayes	Data Analysis Techniques for the Crew Active Dosimeter on ISS

Scientific Session 8

Bent Ehresmann	Update on radiations measurements on the surface of Mars conducted with MSL/RAD
Nicholas Stoffle	Artemis Hera on Space station

24th WRMISS Conference Program: Thursday 8th September 2019

09:00 - 10:30	Scientific Session 9
10.30 - 11.15	Coffee/Tea Break
11.15 – 12:15	Scientific Session 10
12.15 - 14:00	Lunch
14:00 – 1530	Scientific Session 11
15:30 – 1630	Coffee/Tea Break

Scientific Session 9

Eric Benton	enhanced Active Tissue Equivalent Dosimeter (eATED
Jakub Jirsa	SpacePix Radiation Monitor - a compact multi-layer particle telescope
Prem Saganti	Imaging Radiation Particle Trajectories at Micron Resolution: Applications for ISS and Beyond

Scientific Session 10

Attila Hirn	Space Dosimetry Telescope concept for the MSR Earth Return Orbiter
Marianthi Fragkopoulou	ALMAR Dosimeter for space application

Scientific Session 11

Thomas Berger	MARE on the NASA Artemis 1 mission
Attila Hirn	The Hungarian to Orbit (HUNOR) Astronaut Programme and its relevance to the space dosimetry community
Jack Miller	The Lunar Explorer Instrument for space biology Applications (LEIA)

Abstracts

Astro Particle Experiments to Improve the Radiation Health Risk Assessment for Humans in Space Missions

Alessandro Bartoloni

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In the near future, all the space agencies are working to restart the human exploration of space outside the Low Earth Orbit (LEO). Crewed space missions in this and the next decade will see the presence of humans on the Moon and Mars surface. One of the main showstoppers to be investigated for safe exploration and colonization is the biological effects of ionizing radiation that can compromise the health of astronauts/space workers.

The Astroparticle experiments presently operating in space (e.g., AMS02, ACE-Explorer, ...) could play a principal role in this vital task. Such experiments are actual cosmic ray observatories and a source of information crucial to investigating the fundamental physics open problems (e.g., Dark Matter, Antimatter) and improving the knowledge of radiobiology effects in space.

In this paper, a review of the past, present, and planned Astroparticle experiments operating would be presented and highlighted some of the possible contributions and improvements in the space radiobiology research field.

Also, will be presented some examples of progress in understanding the biological effects of radiation in space using the pieces of information acquired for astronomy and Astroparticle science and where such information has been used to enhance the space radiation field characterization and, consequently, improve crucial radiobiological issues in space (e.g., dose-effect models).

Finally, the use of the vast amounts of data taken from such experiments will open a new era of studies performed in different exposure scenarios that will allow a safe human space exploration outside of the Low Earth Orbit by addressing important radiation protection open questions, such as the dose relationship for cancer and non-cancer risk, the possible existence of dose threshold(s) for different biological systems and endpoints, and the possible role of radiation quality in triggering the biological response.

Key words: Astro Particle, Radiation field characterization, Space Radiobiology, Dose effect Models

Study of the Radiation Shielding Properties of the Composite Material in the ISS Service Module Crew Cabin

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In long-term space missions the crewmembers are subjected to essential space radiation exposure as compared with on ground level. The career dose limit of 1 Sv for cosmonauts was established in Russia to keep the expected lifetime shortening caused by space radiation less than 3 years. To minimize total dose per flight the flight duration should be shorter or the spacecraft material shielding more effective. A unique polymer composite material was developed and patented in Russia to protect crewmembers and sensitive electronic components from space radiation in-flight.

On ground studies demonstrated high shielding properties of the composite materials for low energy electron and proton fluxes. The on ground studies were followed by the space experiment in the ISS Russian Segment. On February 17, 2022 two containers from the composite material together with passive detectors were delivered to ISS by Progress-MC-19 cargo spacecraft. The containers have cylindrical form with two leads to allow the detectors placement and retrieval during the flight; the mass of each container is 2 kg, the container wall thickness is 1 cm. the material density is 4 g/cm3. The containers have been located on the wall of the left board Service Module crew cabin. The passive detectors (namely TLDs and SSTDs) are located inside and outside the containers to measure the shielding effect of the composite material. The data from the passive detectors will be obtained only after their returning to the ground in Feb. 2023.

Meantime in several experimental sessions the absorbed doses inside and outside the containers were measured by the Russian crewmembers with Pille-ISS detectors (made in Hungary). The results obtained in recent sessions demonstrate high shielding properties of the composite material as the absorbed dose inside the containers is from 30 to 60 % lower than that outside on the crew cabin wall.

The bubble detectors when available can also be used to study the composite material shielding properties from secondary neutrons produced inside the space station. The study will be continued in 2023.

The work was supported by a project of the Russian Science Foundation No. 19-19-00316 (extension), https://rscf.ru/project/22-19-35003/

Overview of new iRay2Dose Interface for Shielding Analysis and Comparison of Predicted ISS Radiation Exposures with REM2 Measurements

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Abstract TBD

Almost four years of data for the DLR RAMIS measurements in LEO and further updates on the DLR M-42 detector family

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The DLR RAMIS detector telescope has been measuring the radiation environment in a Earth polar orbit at around 600 km altitude since December 2018 in the frame of the DLR Eu:CROPIS mission. For almost four years now the data measured covered the last solar minimum in spring 2020 and now the increasing solar maximum. With RAMIS we could measure the variation of trapped electrons in the outer radiation belts, the solar cycle variation of the galactic cosmic radiation and in the last months also several solar particle events for the new solar cycle.

In the last years DLR also developed the M-42 radiation detector family as baseline detector for the application during the MARE experiment on the NASA Artemis 1 mission scheduled to fly in summer 2022. Updates on new M-42 developments (for example: increasing energy deposition range) and data from flown balloon flight campaigns over Antarctica and during the DLR MAPHEUS missions will be provided.

Pille Measurements on ISS (July 2019 – March 2022)

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O. Gorokhova3, O. Ivanova2, V. Mitrikas2, I. V. Nikolaev3, V. A. Shurshakov2, V.V. Tsetlin2

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Pille was developed as the first and to date the only thermoluminescent dosimeter system contain ning on-board reader designed specifically for spacefaring humans. Since its very first launch in 1980, the Pille system has been providing cosmic radiation measurements from aboard every space station. It has been continuously used on board the International Space Station (ISS) since October 2003 under the supervision of the Institute for Biomedical Problems (IBMP) as an essential part of the service dosimeter system of the Russian Zvezda module. In the past 19 years the dosimeter system was utilized for routine dose measurements inside the ISS and during Extra-vehicular Activities (EVAs).

The Pille system consists of a lightweight reader device and a number of TL dosimeters ($CaSO_4$:Dy). It provides monthly dose data obtained in different locations of the Russian module. Three dosimeters are dedicated to EVA measurements (two for the astronaut pairs, one inside the ISS for reference), and one is read out in every 90 minutes automatically to provide high time resolution data. In June 2018, a new Pille reader (with 5 additional dosimeters) were delivered to ISS to replace the “old” but still perfect reader operating on board since 2003. Commissioning of the new system started in July 2019 including cross-comparison measurements with the “old” system.

In our presentation the latest results (including several EVAs) and the assessment of dosimeter degradation and the on-board cross-calibrations will be detailed, together with comparisons of data from different missions.

LIDAL: exploiting the Bethe Block equation for single particle energy identification

Giulia Romoli on behalf of the LIDAL collaboration

LIDAL is a particle detector currently operating on-board the International Space Station. It can be divided in three ALTEA stripped silicon particle detectors and two LIDAL Detector Units, each made of eight fast timing plastic scintillators with time sensitivity of about 80 ps. LIDAL has been designed to get the first measure of particles' time of flight in space, improving the former ALTEA-space detector capabilities to identify particles from protons to irons.

To this end, we present here an algorithm that implements an approximate analytical solution of the Bethe-Bloch equation for protons and heavy charged particles. Monte-Carlo packages like SRIM, FLUKA, GEANT4 and others are often employed with great success to understand the interaction of ions with the matter they traverse. The developed algorithm overcomes their significant computational cost and time delay, and can be rapidly applied to particles traversing a prior-defined set of materials, yielding estimates of their energy profile, velocity and time of flight.

After introducing the way in which the Bethe-Bloch algorithm has been implemented, this work presents the results that the algorithm provides when particles at different energies and traversing the LIDAL detector are simulated. An innovative tool by which it is possible to get estimated particle energy releases from measured time of flight values has been developed. In this way, LIDAL real-time particle identification has been improved by assessing particles' kinetic energies. Moreover, under-threshold energy releases for particles triggering the scintillator planes have been computed, thus allowing a more realistic estimate of the effective dose from light ions inside the International Space Station.

LIDAL: nuclear discrimination

Giorgia Santi Amantini on behalf of the LIDAL collaboration

In the study for radiation risks for astronauts SPE (solar Particle Events) with high proton flux and GCR (Galactic Cosmic Ray) with particle flux from proton to iron are of interest. This radiation is partly shielded by the Terrestrial Geomagnetic Field and pass through the space station producing secondary radiation. Therefore, a detailed understanding of the radiation environment in space habitats is a needed step toward a comprehensive risk assessment and an optimization of the countermeasures for radiation risk mitigation during long-duration human voyages in the solar system. In order to obtain information about radiation in the ISS, we used LIDAL (Light Ion Detector for ALTEA), an upgrade of the ALTEA detector system. 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 mm^3 with a fast electronic read-out system 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 talk we will discuss a selection of LIDAL data, focusing on the nuclear discrimination capability of the detector. First, an enhanced probabilistic procedure to estimate in real time the charge and kinetic energy of each incoming particle will be described. Then, the ToF provided by the system will be used to better define charge and energy. The nuclear discrimination procedure is effective and fast. Identifying the ions, and consequently, measuring the incident kinetic energy, is a welcomed step for the most effective use of risk models.

LIDAL: combining spectra and estimating dose

Luca di Fino

The LIDAL telescope system has been continuously measuring the radiation environment in the Columbus modulus of the International Space Station since Jan 19th, 2020. During these two years the site and direction of LIDAL has been changed four times, each time parallel to one of the three axes of the ISS. The LIDAL (Light Ion Detector for ALTEA) telescope features two planes, each made of 8 fast scintillator bars (80 x 20 x 4 mm3), coupled with a fast-electronic read-out system (based on HPTDC and NINO chips) for a time sensitivity (sigma) of about 80 ps. These scintillator planes are positioned before and after a stack of three ALTEA particle telescopes (SDU, Silicon Detector Unit). Each SDU is composed by six silicon planes, alternately striped in the X and Y direction. This detector system is able to measure and study all the charged components of the deep-space radiation environment with tracking, spectra and nuclear identification capability. The LIDAL scintillators provide also, for the first time in the ISS, measurement of the time of flight (ToF) of the passing through particles.

In this paper we are presenting the results and the methods used to combine data from both the TOF and silicon systems to extend LET spectra to low LET particles, thus a selection LIDAL measurements from these two years of operations will be provided: the modulation of the radiation orbital flux, the spectral features, including the differences measured in the three ISS directions and at last dose and dose equivalent estimates.

LIDAL: towards RBE monitoring

A.Mentana on behalf of LIDAL collaboration

In this work, we aim at a quantitative evaluation of the biological effectiveness of the radiation environment on the International Space Station. To this end, modelling is of fundamental importance, since it is extremely difficult to reproduce the characteristics of space radiation in ground-based experiments.

We use the transport code PHITS [1] to simulate the exposure of an ICRU44 soft tissue spherical phantom, representative of the human trunk, to energy spectra of different radiation qualities, relevant in the ISS environment (as protons, C ions, neutrons). Such spectra are derived from LIDAL [2] (Light Ion Detector for ALTEA) apparatus measurements on-board ISS.

Transport simulations allow to characterize the radiation field induced by radiation at different depths in the phantom. Analytical functions of DNA damage vs. LET, obtained with the biophysical code PARTRAC, are then applied to obtain the induced DNA damage [3].

Information from radiation transport and DNA damage induced by particle tracks can be finally used to derive the relative biological effectiveness (RBE) of the different radiation qualities considered for DNA damage induction. As a first crucial example, for neutrons the RBE has been determined as a function of the energy and of the depth in the phantom [4]. The consideration of different depths in the phantom makes it possible to link a specific value of the RBE to a specific organ/tissue. The convolution of the physical dose with the RBE gives the so-called RBE-weighted dose, which provides a good indicator of the neutron biological effectiveness in the ISS exposure scenario, an essential information for an improved risk assessment and mitigation.

[1] T. Sato et al., Features of Particle and Heavy Ion Transport code System (PHITS) version 3.02. J Nucl Sci Technol. Vol. 55, 6, pp. 684-690 (2019).

[2] A. Rizzo et al., LIDAL (Light Ion Detector for ALTEA): a compact Time-Of-Flight detector for radiation risk assessment in space. J. Phys.: Conf. Ser. 1226 012024 (2019).

[3] P. Kundrát et al., Analytical formulas representing track-structure simulations on DNA damage induced by protons and light ions at radiotherapy-relevant energies. Sci. Rep. 10, 15775 (2020).

[4] G. Baiocco et al., The origin of neutron biological effectiveness as a function of energy. Sci. Rep. 6, 34033 (2016).

Update on DOSTEL measurements in COLUMBUS within the DOSIS/DOSIS3D projects

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Two Silicon-detector based DOSimetry TELescopes (DOSTELs) have been measuring the cosmic radiation in the COLUMBUS module of the International Space Station since 2009 and have now recorded data over more than one solar cycle covering the maxima of galactic cosmic ray intensity in 2009 and 2020 and the intensity minimum in between. Dose rates in the ISS orbit from galactic cosmic radiation and trapped particles from the radiation belt in the South Atlantic Anomaly over this time are presented. The variation of dose rates over the solar cycle and the dependency on the geomagnetic shielding quantified by the cut-off rigidity are investigated. Using dose rates measured at low geomagnetic shielding and correcting for the altitude dependent shielding from Earth against cosmic radiation, the expected dose and dose equivalent rates from galactic cosmic radiation in near-Earth interplanetary space are derived.

In addition to the data as measured with the DOSTEL instruments a short update for the data as measured with the passive radiation detectors in the frame of the DOSIS and DOSIS 3D projects will be provided as well.

Neutron Measurements with the ISS-RAD

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Abstract TBD

Operational use of Timepix-based Radiation Environment Monitors on ISS

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In February 2019, the Radiation Environment Monitors (REMs) came into operational service on ISS. These compact, Timepix-based devices provide dose measurements and LET spectra at several positions throughout the station. In addition, thanks to their pixel architecture, each REM serves as a planar particle telescope with more than 65,000 sensor elements and a 4π field of view. As such, they provide high quality information on track morphology and directionality of the radiation field. Routinely generated data products for these instruments will be discussed, together with their capabilities as 'single-layer telescopes', and some observations arising from the ever-growing body REM data

LIDAL REM DOSTEL intercomparison

Livio Narici on behalf of the LIDAL REM DOSTEL collaboration

The knowledge of the radiation environment in space habitats is a needed information to validate model and to support the countermeasures optimization.

Radiation measurements in the ISS are performed with several active radiation detectors, all based on silicon. Understanding the peculiarities of each of these detectors is a mandatory step for the exploitation of the results, and this understanding can only come from a detailed comparison among the detectors themselves.

LIDAL (Light Ion Detector for ALTEA) is an upgrade of the ALTEA detector system, which measured radiation in the ISS from 2006 to 2012 and it is operating since January 2020 in the Columbus modulus. LIDAL measures the time of flight through the detector, as well as the trajectory and the energy delivered for each of the impinging particles in 18 striped silicon planes.

One REM (NASA-SRAG) detector has be attached on the LIDAL lid in its field of view. The DOSIS 3D DOSTEL (DLR/CAU) detectors are nearby at about 1 m distance. A collaboration has been set up to study these three detectors in a comparative mode. Dose per day as well as flux per day and per minute have been compared during the 2.5 y of LIDAL operation (REM data on LIDAL lid start from Sept 16th 2021).

This comparison and eventual cross calibration is therefore meant to provide tools to exploit each of the detectors as well as to have grounds for their synergistic use.

Consideration of the Solar Particle Events measured inside the ISS during the measurement period will be provided.

Crew Active Dosimeter Project Overview: ISS Ops, Commercial Crew, Artemis I

Ramona Gaza on behalf of the CAD Project Team

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Monitoring space radiation is of vital importance for risk reduction strategies in human space exploration. Crew worn active dosimeters providing time-resolved dose data are required for long-term Exploration Class Missions to Moon and Mars.

Thus, the Space Radiation Analysis Group at NASA Johnson Space Center has developed the Crew Active Dosimeter (CAD) to be the designated personal dosimeter for Artemis 2+ missions. The CAD device, based on direct ion storage technology, was developed in collaboration with Mirion Technologies, USA to meet NASA's specific design requirements for Exploration missions outside low-Earth orbit (LEO). The CAD is a battery-operated, small volume, compact device equipped with a display that tracks the mission cumulative dose and dose rate. Following a successful Technology Demonstration on the International Space Station (ISS) in 2018, the CAD has been certified for ISS Flight Operations and fully implemented since 2020 on all SpaceX crewed missions. In addition, multiple CADs have been delivered in August 2022 to support several of the Orion Artemis I flight Secondary Payloads: Commander "Moonikin" Campos, the Matroshka AstroRad Radiation Experiment (MARE) and BioExpt-1.

This presentation will include an overview of the CAD Project and certification process for the ISS and Orion Programs, CAD radiation dosimetry report overview and future work.

Data Analysis Techniques for the Crew Active Dosimeter on ISS

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The Crew Active Dosimeter (CAD) is the first NASA crew worn real-time detector used for ISS operations. Several CADs have been deployed on ISS since 2020 as a means of quantifying individual absorbed doses to crew while in LEO. CADs autonomously collect and send absorbed dose, detector health metrics, and environmental data to Space Station Computers (SSCs) for downlink. This allows for real-time monitoring of crew absorbed dose values during a crew member's mission. Currently, the NASA Space Radiation Analysis Group (SRAG) reports this data on a weekly basis for data monitoring and quality assurance. Examples of the weekly report as well as the process for collection, processing and analysis will be presented. In addition, a detailed ongoing comparison between CAD and the Radiation Assessment Detector (RAD) with preliminary results will be shown.

Update on radiations measurements on the surface of Mars conducted with MSL/RAD

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We present recent measurements of the Martian surface radiation conducted with the Radiation Assessment Detector (RAD) aboard NASA's Curiosity rover. We will cover new findings from the past two years, including: (1) RAD measurements of recent Solar Energetic Particle (SEP) events in Gale crater on the surface of Mars: The recent 28 October, 2021 & 15/16 February 2022 SEP events delivered the highest dose rates detected by RAD on the Martian surface to date; (2) RAD measurements of the radiation shielding effect caused by natural terrain on Mars: When RAD (and the Curiosity rover) are traversing close to steep cliff sides, rock walls, or narrow canyons, RAD measures a distinct drop in the surface radiation dose rate. This is attributed to the surrounding rock material shielding the rover & RAD from incoming galactic cosmic radiation and their secondary byproducts... We will present measurements from several instances where the surrounding rocky terrain shielded RAD from the incoming GCR radiation.

Artemis HERA on Space Station

N. Stoffle

on behalf of the Space Radiation Analysis Group Science Team

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Abstract TBD

enhanced Active Tissue Equivalent Dosimeter (eATED)

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Based on lessons learned form our 2018 ATED experiment on ISS, we are preparing to fly the enhanced Active Tissue Equivalent Dosimeter (eATED) on ISS for a six-month experiment. Launch to ISS is schedule for June 2023 on SpaceX-28. eATED futures a new, low cost, dual input spectrometer, and a newly designed detector head for the tissue equivalent proportional counter. This new design is based on boring two hemispherical cavities into standard acrylic cylinder stock, joining the cavities together to form a hollow sphere and threading a 2-mil tungsten wire through the sphere to serve as a anode. This new TEPC detector head design substantially reduces microphonic noise, provides better electronic equilibrium and is substantially easier to fabricate compared to our original design. We have also added a Si PIN photodiode to simultaneously measure low-LET radiation. A similar instrument we are called AirTED is currently flying on a NASA WB-57 high altitude research aircraft and is scheduled to fly on a Blue Origin New Shepard suborbital mission in the latter half of 2023.

SpacePix Radiation Monitor - a compact multi-layer particle telescope

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The advance of semiconductors technologies allowed full integration of sensing diodes together with analog front-end electronics and digital readout system on the ASIC. The SpacePix2 is a high voltage monolithic active pixel detector (HVMAPS) which can measure variable particle flux and total energy deposition. The resolution of SpecePix2 is 64 x 64 pixels with 60 µm pixel pitch. In addition, SpacePix2 features the backside pulse digitization, which greatly increases its dynamic range.

The SXRM is a compact multi-layer particle telescope based on five SpacePix2 ASICs which are interleaved with a copper ionization energy absorbers. Thus each SpacePix2 allows sampling of dE/dx losses between layers. Using pattern recognition techniques allows reconstruction of incoming particle trajectory, particle identification and its energy estimation. The SXRM is currently being tested on-board the VZLUSAT2 mission.

Imaging Radiation Particle Trajectories at Micron Resolution: Applications for ISS and Beyond

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Recently, we developed and expanded a CMOS (complementary metal oxide) based radiation Track Structure Detector (TSD) system for capturing and analyzing heavy ion tracks at cellular dimensions with a 1.67 microns per pixel resolution and more than 10 M pixels on a 0.6 x 0.4 cm sensor.

To characterize the heavy ion particle tracks at micron level, we collected data with several heavy ions of varying energies including carbon ions at NASA Space Radiation Laboratory (NSRL) of the Brookhaven National Laboratory (BNL). Also, we collected data with carbon ions at the at the HIMAC (Heavy Ion Medical Accelerator in Chiba) facility in Japan.

e present track structure image data of carbon ions (300 MeV and 55 MeV) from NSRL and carbon ions (290 MeV) from HIMAC. All our experiments with detector systems are augmented with biological samples making use of a custom-built chamber slide adopter designed to reside atop of the sensor unit for correlating spatial distribution of the track structure and trajectory impact at cell dimensions of the neuronal cells.

For long duration space expeditions at ISS and beyond, it may be more prudent to incorporate heavy ion radiation particle track data as part of the radiation risk assessment.

Space Dosimetry Telescope concept for the MSR Earth Return Orbiter

A. Hirn1, B. Erdős1, B. Zábori1, G. Gutay2, J. Szőke3

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Space radiation poses one of the most important risks during long-term crewed missions, especially those going beyond low Earth orbit. Earth Return Orbiter (ERO) of the Mars Sample Return (MSR) program, being the first spacecraft planned to travel from Earth to Mars and back again, represents a unique opportunity to characterize the return-trip radiation environment in order to inform future missions. Space radiation measurements conducted in the past in the interplanetary space between Earth and Mars, and in Mars orbit either focused only on determining dosimetry quantities or providing space weather data products (particle spectra measurements); no direct simultaneous measurements have been performed so far on the same spacecraft. The Centre for Energy Research Space Research Department (EK-UKL) provided the technical feasibility, high-level requirements, and development roadmap of a Space Dosimetry Telescope (SDT) for implementation on MSR-ERO. The primary objectives of the SDT are:

- to determine the time series of dosimetric quantities (LET spectra, absorbed dose rate, dose equivalent rate, mean quality factor of the charged particle component of the space radiation) for the Earth-Mars cruise, the Mars orbit and Mars-Earth return mission segments of the MSR-ERO mission behind different typical shielding thicknesses expected for astronauts, in order to support radiation health risk assessment and mitigation for future human space missions; and

- to determine the time series of the charged particle flux and energy spectra of space radiation for the Earth-Mars cruise, the Mars orbit and Mars-Earth return mission segments of the MSR-ERO mission, in order to support radiation environment modelling of future human space missions.

The data products of charged particle flux and energy spectra of space radiation will enable deeper assessment of dosimetric data products to be estimated based on energy deposition measurements. In our presentation a brief overview is given of the system level concept of the payload and the preliminary design, the targeted data products to be measured, and the results of calculations on the expected measurement performance.

ALMAR Dosimeter for space applications

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Radiation is an invisible but a real but unseen threat to space crew health and safety and to uccessful spacecraft operation. The trend towards more advanced and compact electronics increases the risk of satellites to both temporary and permanent damage in space. In many cases each individual electronic processor contains transistors than an entire satellite carried 20 years ago, making modern space systems much more powerful and versatile, but at the same time more sensitive to radiation. Measurements of the mixed radiation environment represent an excellent opportunity to improve our understanding and develop countermeasures to enhance space mission safety.
HERADO has developed an innovative compact system having small dimension, low weight and high accuracy to measure the mix field of the space radiation environment. HERADO dosimeters will be included in the MARE (Matroshka AstoRad Radiation Experiment) project with Orion NASA vehicle. MARE is a radiation science payload that will fly on Artemis by German Aerospace Center (DLR) and the Israel Space Agency (ISA) supported by Lockheed Martin. The status of this dosimetry system will be presented.

MARE on the NASA Artemis 1 mission

Thomas Berger for the MARE team

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After years of planning the NASA Artemis 1 mission flying with the Orion spacecraft to the Moon and back is scheduled to be launched at the end of August 2022 for a mission duration of up to 42 days. The talk will provide an overview on the MARE hardware to be flown on the NASA Artemis 1 mission (https://www.dlr.de/content/en/missions/mare.html) both for the passive and the active radiation detectors and will further hopefully show already the first pictures of the MARE phantom as mounted in the Orion spacecraft. MARE is an international endeavor flying two female anthropomorphic phantoms (Helga & Zohar) to the moon and back. Zohar will be equipped with a newly developed (by StemRad) radiation protection vest (AstroRad). Both phantoms are equipped with thousands of passive radiation detectors as well as with a suite of active detectors.

The Hungarian to Orbit (HUNOR) Astronaut Program and its relevance to the space dosimetry community

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With the spaceflight of cosmonaut Bertalan Farkas back in 1980, Hungary became the seventh nation to send an astronaut or cosmonaut into space. Bertalan Farkas was launched on the 5th of May 1980 with Soyuz 36. He performed his mission on board the Salyut-6 Soviet orbital space station in the frame of the Intercosmos program. A set of Hungarian experiments were conducted by Bertalan Farkas in the field of space dosimetry, life science, material science, and Earth observation. Several Hungarian research and development groups and small companies were formed as a result of the mission. Several generations of the Pille instrument developed for the flight of the first Hungarian cosmonaut flew later on board the Salyut-7, the Mir and the International Space Station (ISS) and on the Space Shuttle as well. The latest version has been operating as part of dosimetry service system on the Russian Segment of the ISS since 2003.

In 2021, the Government of Hungary announced the Hungarian to Orbit (HUNOR) program, the aim of which is to send the next Hungarian astronaut to the ISS for a 30-60-day-long mission in 2024. The Government of Hungary signed an agreement with US company Axiom Space to achieve this goal. The HUNOR program is coordinated by the Centre of Energy Research, part of the Eötvös Loránd Research Network in Hungary, which has more than 50 years of heritage in space research and development of space equipment. The objectives of the HUNOR program are to conduct science and research on ISS, to foster space technology demonstration and domestic space industry development, to strengthen and create new Hungarian competences in astronautics and space life sciences and perform public outreach and education activities.

A brief overview of the HUNOR program and the two pre-selected dosimetry-related experiments will be given in the talk. Members of the WRMISS community are welcome to propose potential joint experiments for the next Hungarian astronaut during his/her flight.

The Lunar Explorer Instrument for space biology Applications (LEIA)

Jack Miller

NASA Gene Lab, Berkeley

The Lunar Explorer Instrument for space biology Applications (LEIA) is a suite of biological samples and radiation instruments that will be delivered to the lunar south pole by a Commercial Lunar Payload Services (CLPS) lander. LEIA will investigate the response of the model organism yeast to the lunar gravity and radiation environment. I will briefly review the LEIA design and aims, with an emphasis on the measurements of ionizing radiation on the lunar surface.

Participant List: WRMISS 2022

Participant name	Country	Affiliation	Present.	Remarks	Dinner
On-side participants					
Amantini. Giorgia Santi	Italy	University of Rome Tor Vergata	Y		Y
Benton , Eric R.	USA	Oklahoma State University, Stillwater	Y		Y
Berger, Thomas	Germany	German Aerospace Center, Köln	2 x Y		Y
Bartoloni, Alessandro	Italy	INF Roma// CERN	Y		Y
Campell-Ricketts, Thomas	USA	NASA JSC, Leidos, Houston	Y		Y
Castro, Andrew	USA	NASA JSC/Leidos	Y		Y
Di Fino, Luca	Italy	University of Rome Tor Vergata	Y		Y
Ehresmann, Bent	USA	South West Research Institute, Boulder	Y		Y
Fragkopoulou, Marianthi	Greece	Herado, Athens	Y		2 x Y
Gaza, Ramona	USA	NASA JSC, Leidos, Houston	Y		Y
Hayes,Bryan M.	USA	NASA JSC, Leidos, Houston	Y		Y
Hirn, Attila	Hungary	Hungarian Academy of Sciences, Budapest	2 x Y		Y
Heynderickx, Daniel	Belgium	DH Consultancy, Leuven		Partly ?	
Jirsa, Jakub	Czech Rep.	Czech Technical University in Prague (CTU)	Y		y
Lee, Kerry	USA	NASA Johnson, SRAG, Houston	Y		Y
Marsalek, Karel	Germany	German Aerospace Center, Köln	Y		Y
Mentana, Alice	Italy	University of Pavia	y		Y
Matthiä, Daniel	Germany	German Aerospace Center , Köln	Y		Y
Megret, Patrice	Belgium	Mons University			Y
Miller, Jack	USA	NASA Gene Lab, Berkeley			Y
Mura, Marilina	Belgium	Mons University			Y
Narici, Livio	Italy	University of Rome	Y		y
Reitz, Guenther	Germany	DLR; Soochow University			Y
Romoli, Giulia	Italy	University of Rome Tor Vergata	Y		Y
Saganti , Premkumar	USA	Texas A&M University, Houston	Y		Y
Semones, Eddie	USA	NASA JSC, SRAG, Houston			Y
Stoffle, Nicolas	USA	NASA JSC ,SRAG, Houston,	Y		Y
Stradi,Andrea	Hungary	MTA Centre or Energy Research, Budapest	Y		Y
Tabury, Kevin	Belgium	Belgian Nuclear Research Center SCK CEN			Y
Van Hoey, Olivier	Belgium	Belgian Nuclear Research Center SCK CEN			Y
Online Participants					
Aiko Nagamatsu	Japan	JAXA			
Bartlett, David	UK	Consultant			
Boretti, Virginia	Italy	University of Roma			
Cherkashina, N I	Russia	Belgorod State Technological University	Y		
Lunati, Luca	Italy	University of Roma			
Xu, Xiaojing	USA	NASA Langley, Hampton			
		Preliminary number	**36**		

List of participants: Status 21-08-2022