

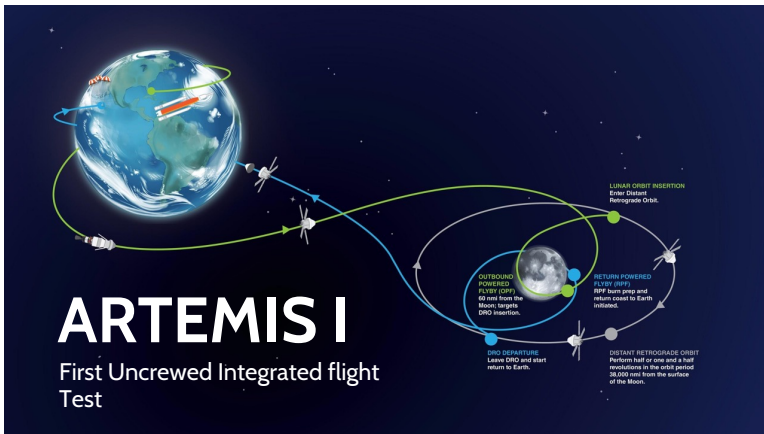
ERFNet Data Hub ALTEC/ESA Project Overview

XVI FOOT Collaboration Meeting, Naples (Italy)

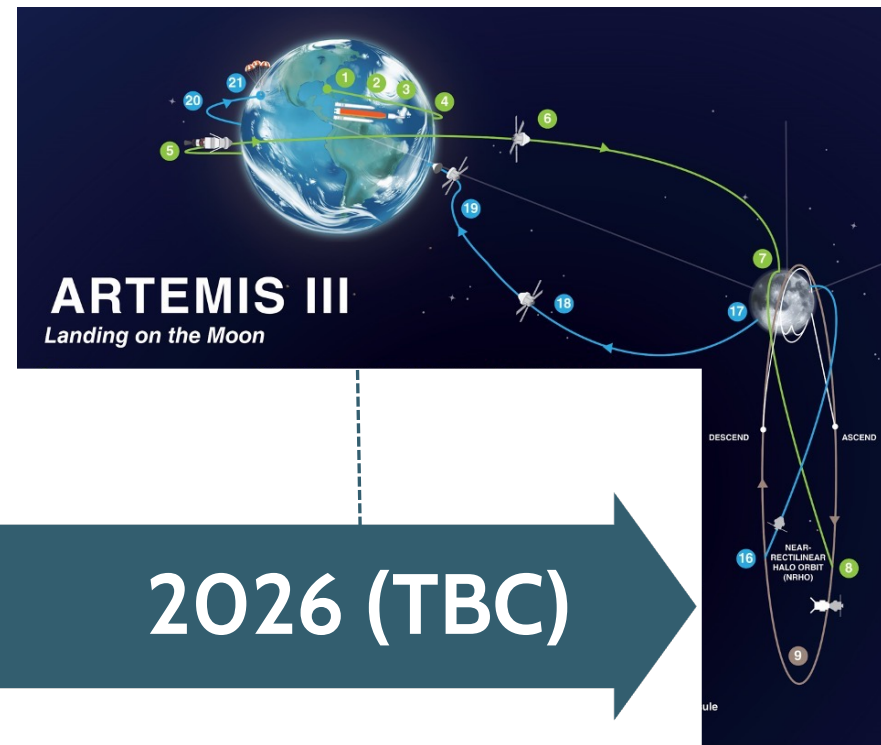
L. Scavarda on behalf of ERFNet Team

ALTEC UNCLASSIFIED – For Official Use Only

Background



ARTEMIS I mission aimed to test the Space Launch System (SLS) rocket and Orion spacecraft in preparation for future crewed lunar missions, serving as a crucial step towards NASA's Artemis program



2022

2025 (TBC)

2026 (TBC)

ARTEMIS II will be the first crewed mission of NASA's Artemis program, sending astronauts aboard the Orion spacecraft on a journey around the Moon, opening the way for future human exploration missions.



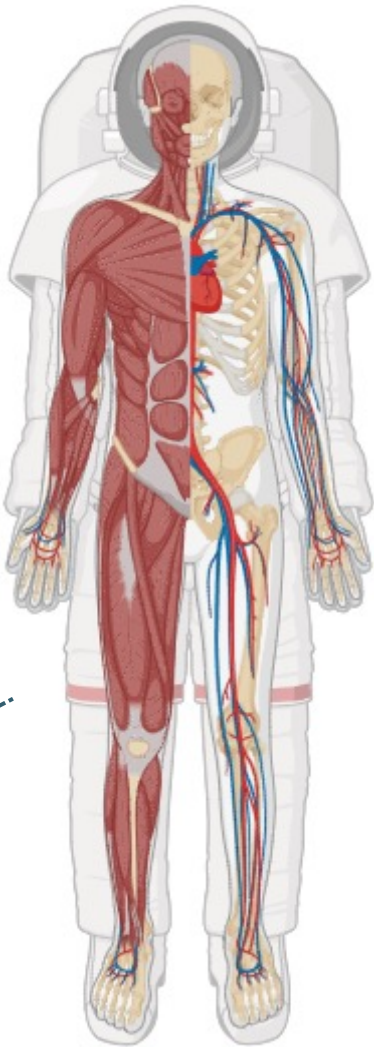
ARTEMIS III will mark the return of humans to the lunar surface, with astronauts landing near the Moon's South Pole. They will conduct scientific research and test technologies for sustainable lunar exploration.



BLOOD 

BRAIN 

RADIATIONS 



 MUSCLE

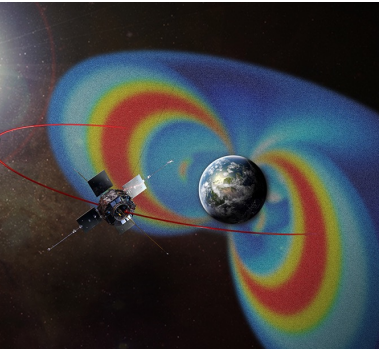
 BONES

 HEART

Space Radiation Environment



Radiation Sources



Energy Range

100-100000 MeV

0.001-100 MeV

1k – 12k km: 1-5 MeV
13k-60k km: 10-100 MeV

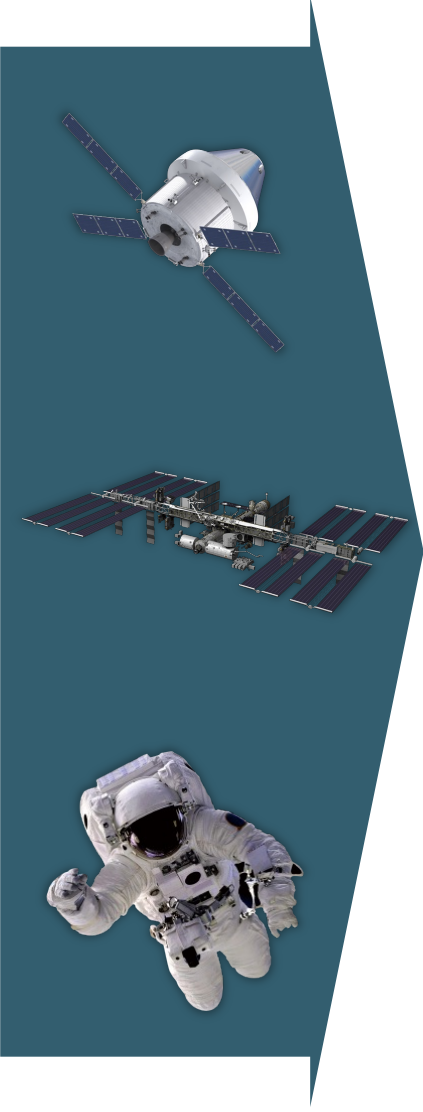
Primary Particles

87% Protons
12% Helium
1% Heavy Nuclei

92% Protons
6% Helium
2% Heavy Nuclei

Electrons &
Protons

Target



Secondary Particles

Neutrons
Protons
Electrons
X-Rays
Y-Rays
Recoil Heavy Nuclei

Open Questions

The shift from LEO to deep space has important implications for radiation research and there is the need to improve space radiological protection strategy and risk assessment for astronaut missions:

Radiation Environment Measurement

Need to improve knowledge on radiation environment for mission planning and design

More particle and energy deposit spectra are needed to validate and update models

It is required to develop new instrumentation, capable of providing the relevant information and also the analysis of data from existing detector systems, both on the surface of the Moon and on other locations, to intercompare and intercalibrate the new devices data

The shift from LEO to deep space has important implications for radiation research and there is the need to improve space radiological protection strategy and risk assessment for astronaut missions:

Radiation Environment Measurement

Need to improve knowledge on radiation environment for mission planning and design

More particle and energy deposit spectra are needed to validate and update models

It is required to develop new instrumentation, capable of providing the relevant information and also the analysis of data from existing detector systems, both on the surface of the Moon and on other locations, to intercompare and intercalibrate the new devices data

Dosimetry and radiation risk estimation

For exploration missions actively powered radiation detectors for the crew are required, which provide both “real time dose readings” and physical parameters for risk estimation.

Individual bio-dosimetry needs to be implemented and compared with the results of radiation detectors in order to contribute to the risk estimation.

The shift from LEO to deep space has important implications for radiation research and there is the need to improve space radiological protection strategy and risk assessment for astronaut missions:

Radiation Environment Measurement

Need to improve knowledge on radiation environment for mission planning and design

More particle and energy deposit spectra are needed to validate and update models

It is required to develop new instrumentation, capable of providing the relevant information and also the analysis of data from existing detector systems, both on the surface of the Moon and on other locations, to intercompare and intercalibrate the new devices data

Dosimetry and radiation risk estimation

For exploration missions actively powered radiation detectors for the crew are required, which provide both “real time dose readings” and physical parameters for risk estimation.

Individual bio-dosimetry needs to be implemented and compared with the results of radiation detectors in order to contribute to the risk estimation.

Radiation propagation tools and models

Radiation propagation tools provide significant calculated radiation data for a specific planned mission scenario and can be benchmarked with data from sensors measuring relevant parameters in new environments.

GCR and SPE models also demand a detailed benchmarking against each other and against measurements.

Transport codes, based on Monte Carlo (GEANT4, FLUKA, PHITS) or on deterministic (HZETRN) codes need further developments including updates for missing data in nuclear cross section measurements.

The shift from LEO to deep space has important implications for radiation research and there is the need to improve space radiological protection strategy and risk assessment for astronaut missions:

Radiation Environment Measurement

Need to improve knowledge on radiation environment for mission planning and design

More particle and energy deposit spectra are needed to validate and update models

It is required to develop new instrumentation, capable of providing the relevant information and also the analysis of data from existing detector systems, both on the surface of the Moon and on other locations, to intercompare and intercalibrate the new devices data

Dosimetry and radiation risk estimation

For exploration missions actively powered radiation detectors for the crew are required, which provide both “real time dose readings” and physical parameters for risk estimation.

Individual bio-dosimetry needs to be implemented and compared with the results of radiation detectors in order to contribute to the risk estimation.

Radiation propagation tools and models

Radiation propagation tools provide significant calculated radiation data for a specific planned mission scenario and can be benchmarked with data from sensors measuring relevant parameters in new environments.

GCR and SPE models also demand a detailed benchmarking against each other and against measurements.

Transport codes, based on Monte Carlo (GEANT4, FLUKA, PHITS) or on deterministic (HZETRN) codes need further developments including updates for missing data in nuclear cross section measurements.

Radiation storm forecasting

Forecasting SPEs is very important for deep space operations for efficient planning and use of countermeasures complying with the “As Low As Reasonable Achievable” (ALARA) principle for astronaut protection.

SPE forecasting utilizes knowledge of solar physics and particle radiation dynamics either by radiation transport models or by analytical models.

Forecasting from physics based models lacks the accuracy needed for human protection.

Now-casting, based on precursor measurements combined with studies of previous SPEs, are essential for effective warnings

Development priorities include a system to exploit forecast methods and accurate measurements of the external field for now-casting and data assimilative forecasts.

The shift from LEO to deep space has important implications for radiation research and there is the need to improve space radiological protection strategy and risk assessment for astronaut missions:

Radiation Environment Measurement

Need to improve knowledge on radiation environment for mission planning and design

More particle and energy deposit spectra are needed to validate and update models

It is required to develop new instrumentation, capable of providing the relevant information and also the analysis of data from existing detector systems, both on the surface of the Moon and on other locations, to intercompare and intercalibrate the new devices data

Dosimetry and radiation risk estimation

For exploration missions actively powered radiation detectors for the crew are required, which provide both “real time dose readings” and physical parameters for risk estimation.

Individual bio-dosimetry needs to be implemented and compared with the results of radiation detectors in order to contribute to the risk estimation.

Radiation propagation tools and models

Radiation propagation tools provide significant calculated radiation data for a specific planned mission scenario and can be benchmarked with data from sensors measuring relevant parameters in new environments.

GCR and SPE models also demand a detailed benchmarking against each other and against measurements.

Transport codes, based on Monte Carlo (GEANT4, FLUKA, PHITS) or on deterministic (HZETRN) codes need further developments including updates for missing data in nuclear cross section measurements.

Radiation storm forecasting

Forecasting SPEs is very important for deep space operations for efficient planning and use of countermeasures complying with the “As Low As Reasonable Achievable” (ALARA) principle for astronaut protection.

SPE forecasting utilizes knowledge of solar physics and particle radiation dynamics either by radiation transport models or by analytical models.

Forecasting from physics based models lacks the accuracy needed for human protection.

Now-casting, based on precursor measurements combined with studies of previous SPEs, are essential for effective warnings

Development priorities include a system to exploit forecast methods and accurate measurements of the external field for now-casting and data assimilative forecasts.

An **European Radiation Risk Model (ERMM)** to better characterize mission radiation risks to astronauts is required.



Only through a harmonized and cohesive Scientific Community we will be able to fill these gaps.

European Radiation Facility Network – Data Hub

Collaboration

ERFNet fosters interdisciplinary collaboration, enabling experts in medicine, physics, biology, engineering, and other fields to exchange knowledge and insights, ultimately advancing our understanding of space radiation effects and enhancing our ability to mitigate risks for future space exploration missions.

Data Hub

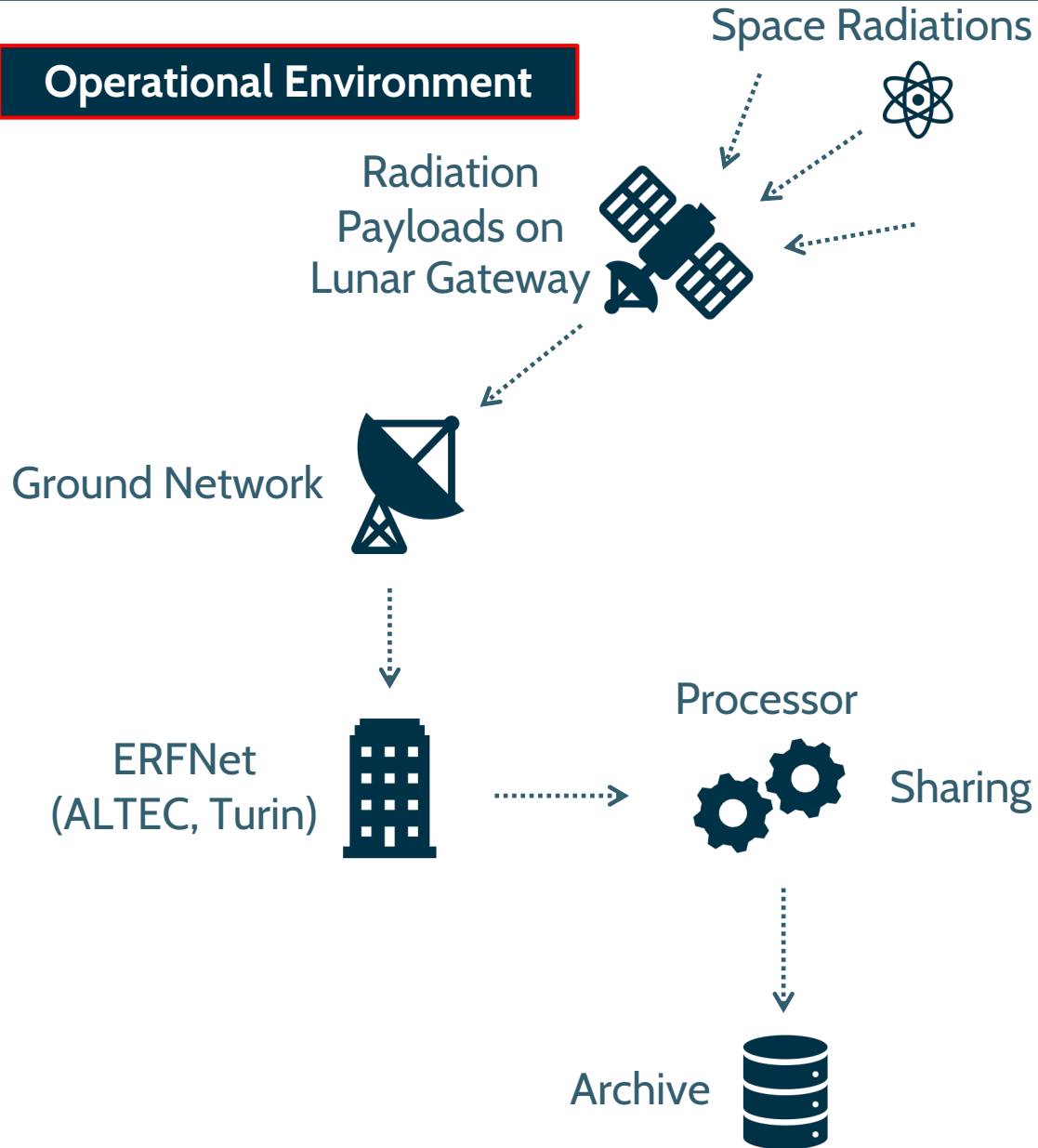
ERFNet offers a collaborative framework where scientists and researchers from diverse disciplines can come together to access and exploit data, write code, perform Monte Carlo simulations, and subsequently share data, projects, and results.

Network

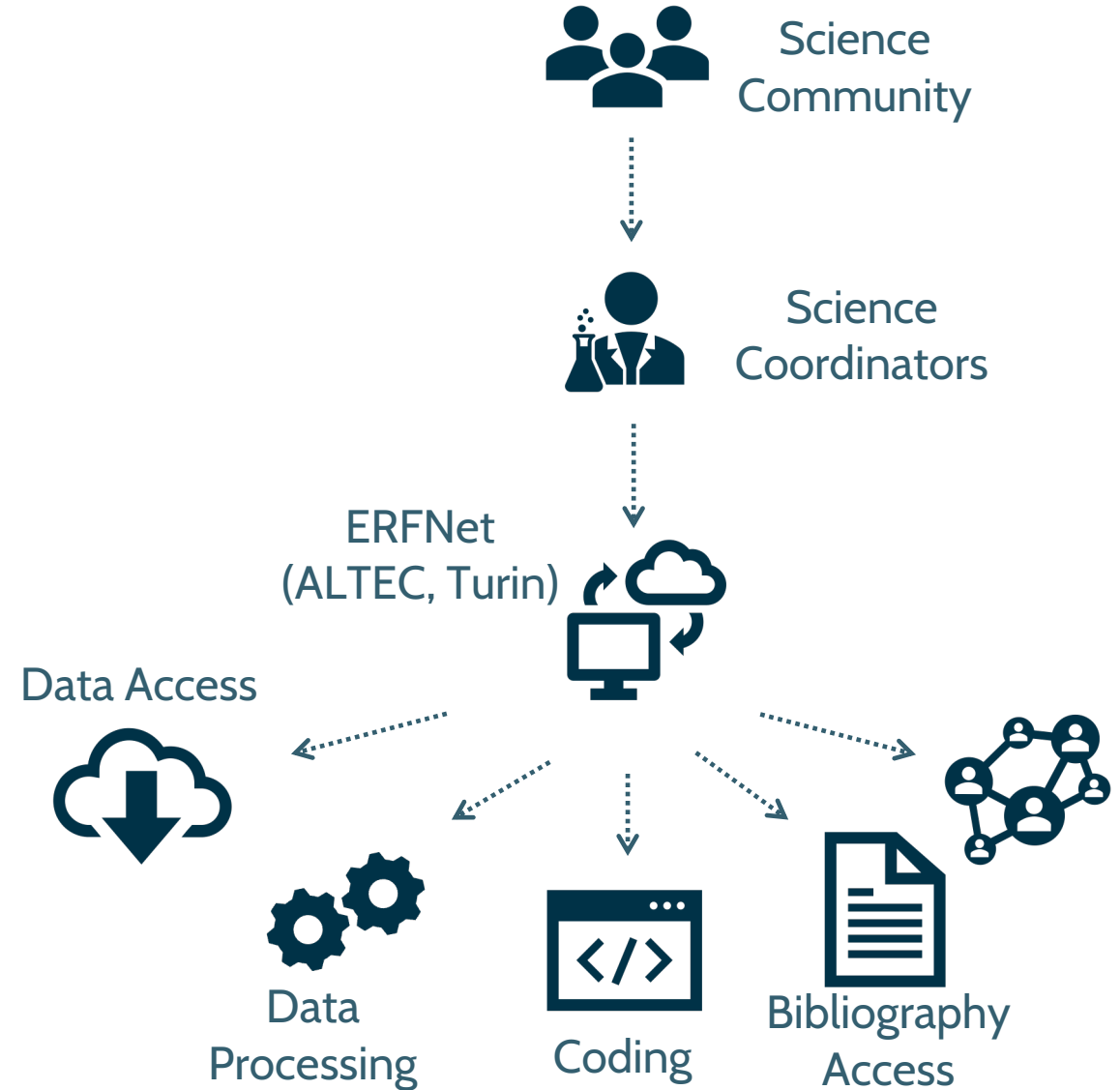
ERFNet serves as a Data Hub for international partnerships, connecting researchers worldwide and facilitating the exchange of expertise and best practices in the field of Space Radiation research.

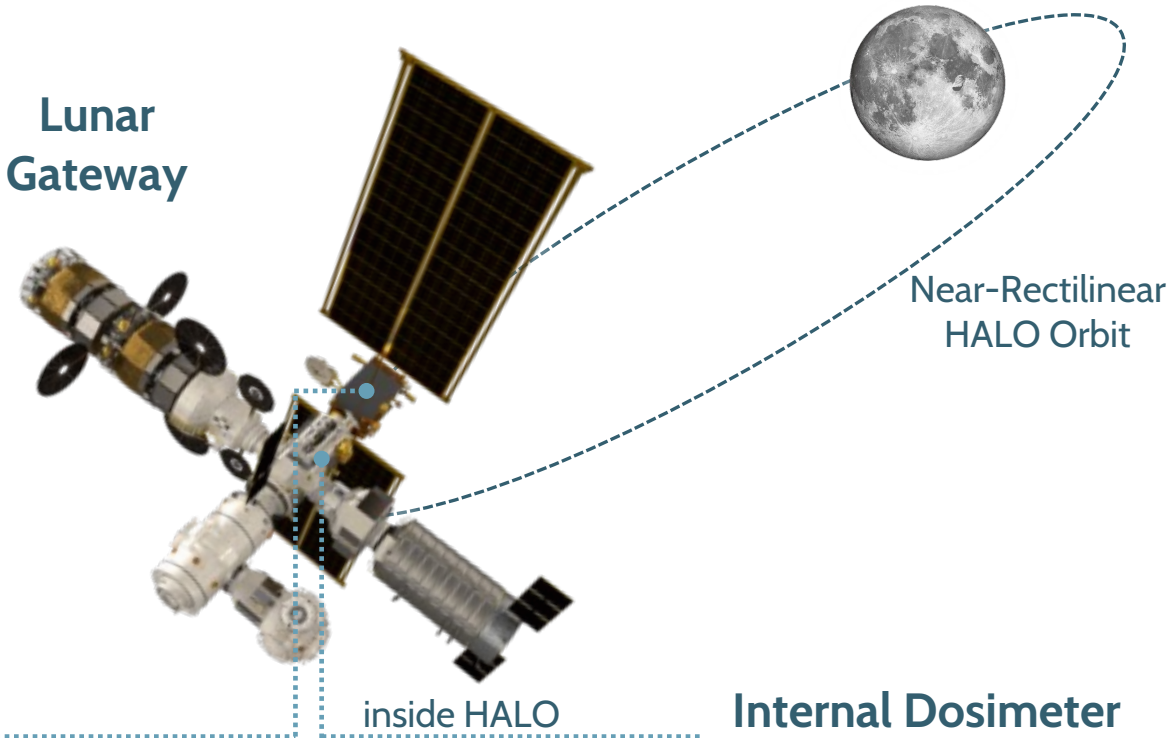


Operational Environment

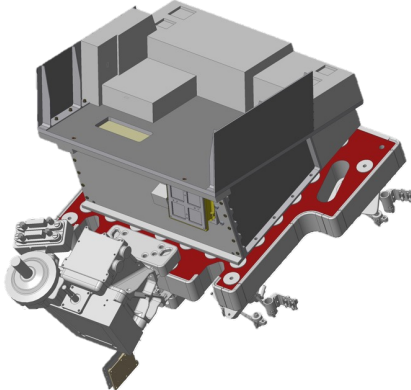


Science Environment





European Radiation Sensor Array (ERSA)



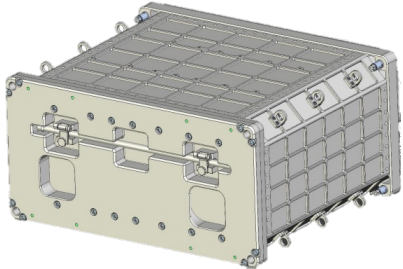
outside PPE module

- Payload Instruments:**
- European Active Dosimeter (EAD)
 - Standard Environment Radiation Monitor (SREM)
 - Next-Generation Radiation Monitor (NGRM)
 - ICARE-NG
 - Time-Pix detector (HardPix)
 - Magnetometer (MAGIC)

inside HALO

- Payload Instruments:**
- European Active Dosimeter (EAD)
 - Time-Pix detector (MediPix)
 - TRITEL
 - DSPACE+PADLES

Internal Dosimeter Array (IDA)



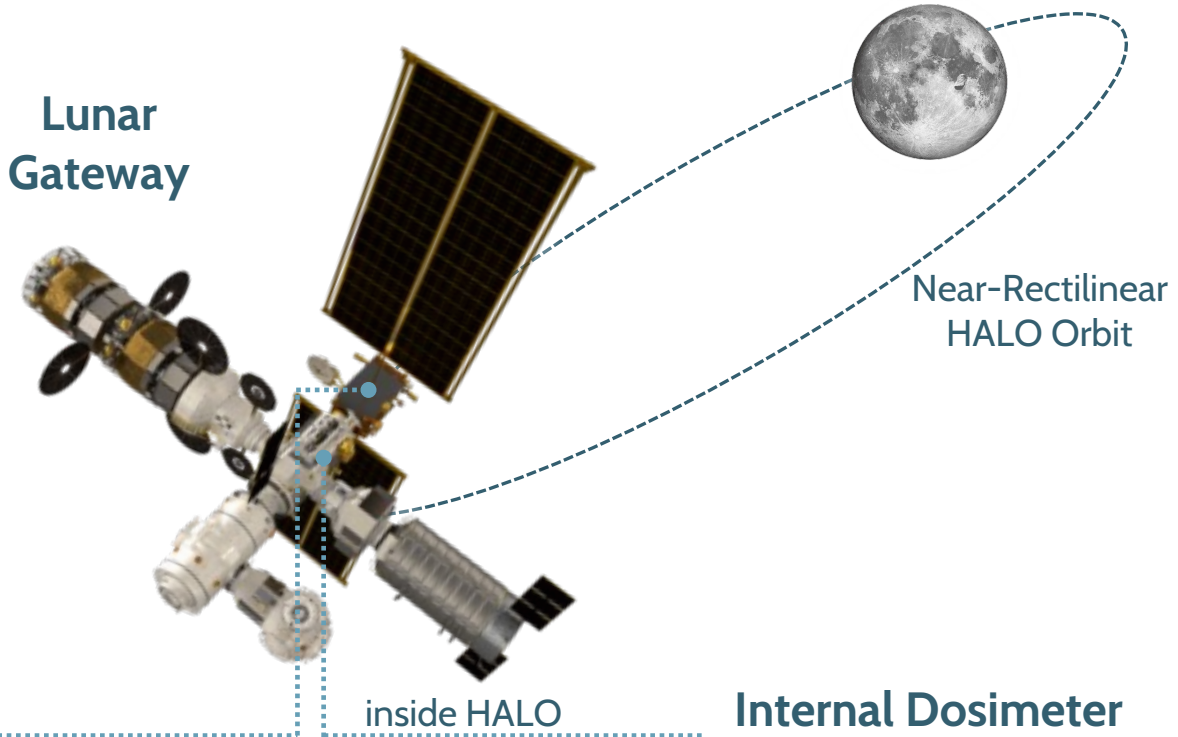
Lunar Gateway will host two ESA payloads: ERSA and IDA which are a collection of particle detectors

ERFNet will receive the raw ERSA and IDA telemetry and it will handle the IDA and ERSA (TBC) data processing from the engineering levels (LO) to the scientific levels (L2)

The data will be accessible to limited group of users , such as ESA point of contacts, Instrument Teams and Science Teams

Not later than 6 months the data will be forwarded to the Science Environment and available to the broader Scientific Community for downloading and science exploitation

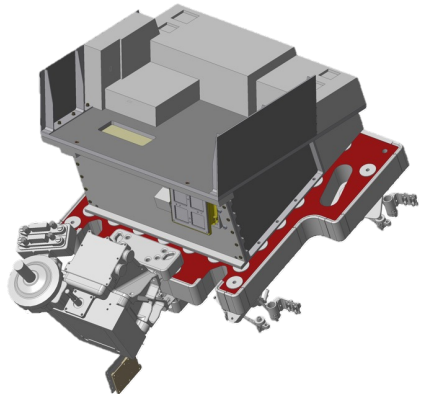
Lunar Gateway



Near-Rectilinear HALO Orbit

European Radiation Sensor Array (ERSA)

outside PPE module



Payload Instruments:

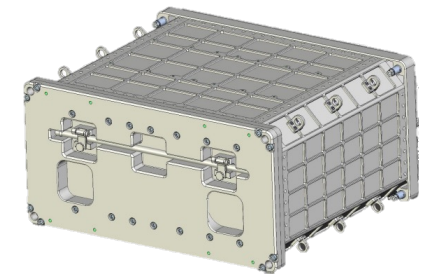
- European Active Dosimeter (EAD)
- Standard Environment Radiation Monitor (SREM)
- Next-Generation Radiation Monitor (NGRM)
- ICARE-NG
- Time-Pix detector (HardPix)
- Magnetometer (MAGIC)

inside HALO

Internal Dosimeter Array (IDA)

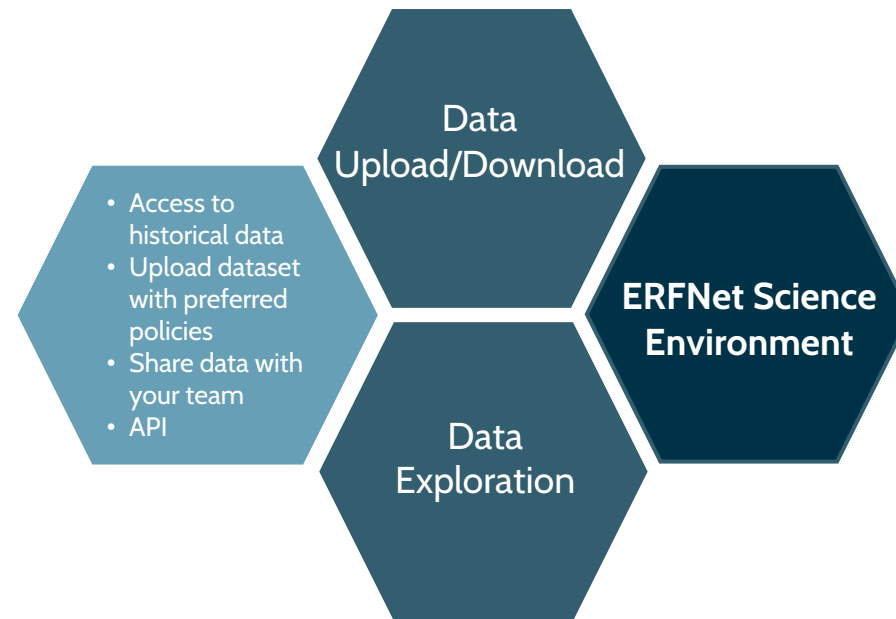
Payload Instruments:

- European Active Dosimeter (EAD)
- Time-Pix detector (MediPix)
- TRITEL
- DSPACE+PADLES



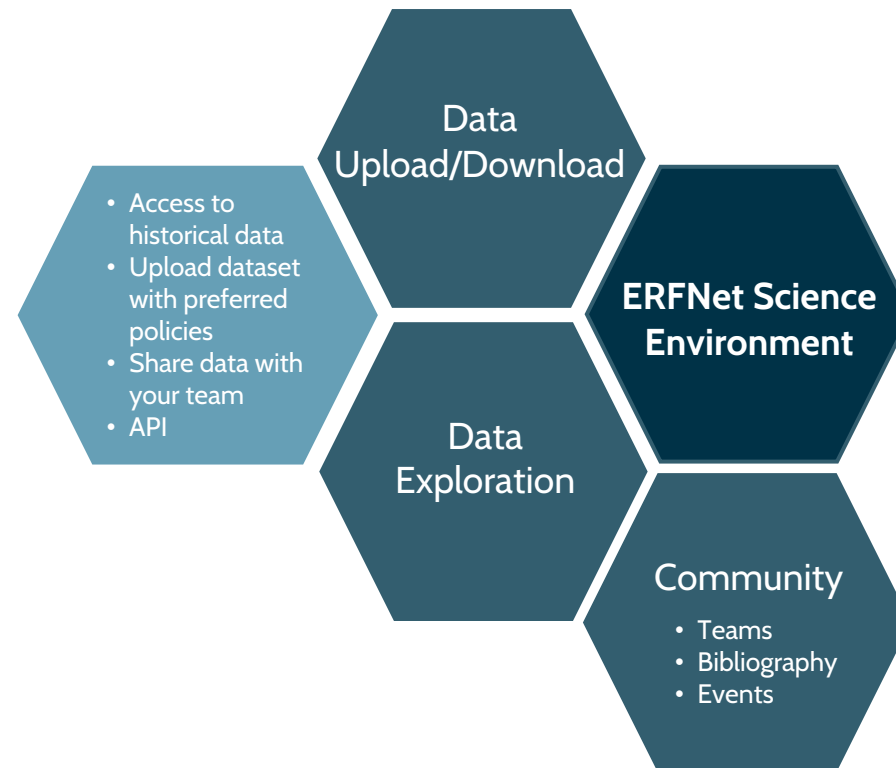
The environment wants to foster new collaboration among scientists and harmonize the existing knowledge via:

- **Data sharing:** access, upload, download data from present and historical dataset



The environment wants to foster new collaboration among scientists and harmonize the existing knowledge via:

- **Data sharing:** access, upload, download data from present and historical dataset
- **Teams:** create and/or join teams of scientists and share data, software products, etc.
- **Reach scientists around Europe and beyond:** find new contacts, chat and exchange idea, insights, etc.
- **Researches sharing:** upload, share papers, presentation, results and reach more experts
- **Find or submit new events,** conferences, workshop in Space Radiation and Radioprotection fields

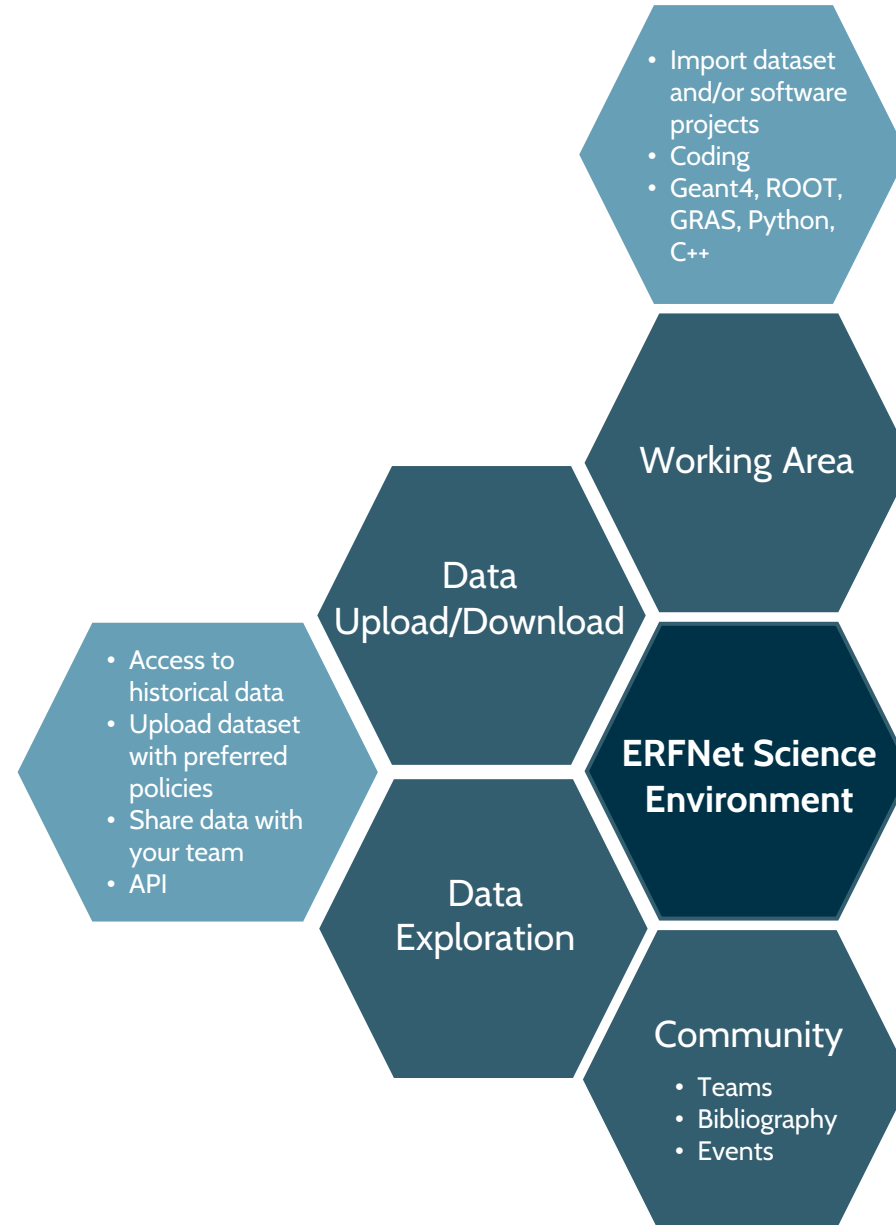


The environment wants to foster new collaboration among scientists and harmonize the existing knowledge via:

- **Data sharing:** access, upload, download data from present and historical dataset
- **Teams:** create and/or join teams of scientists and share data, software products, etc.
- **Reach scientists around Europe and beyond:** find new contacts, chat and exchange idea, insights, etc.
- **Researches sharing** upload, share papers, presentation, results and reach more experts
- **Find or submit new events,** conferences, workshop in Space Radiation and Radioprotection fields

In addition, the environment provides:

- Personal working areas to store datasets and create own projects: an online remote desktop to import user assets, coding and to benefit of data analysis and MC simulation tools pre-configured in the environment. This allows easy access to software tools such as ROOT, G4, GRAS, etc. acting also as an easy tool for workshop preparation, tutorial and training



The environment wants to foster new collaboration among scientists and harmonize the existing knowledge via:

- **Data sharing:** access, upload, download data from present and historical dataset
- **Teams:** create and/or join teams of scientists and share data, software products, etc.
- **Reach scientists around Europe and beyond:** find new contacts, chat and exchange idea, insights, etc.
- **Researches sharing:** upload, share papers, presentation, results and reach more experts
- **Find or submit new events,** conferences, workshop in Space Radiation and Radioprotection fields

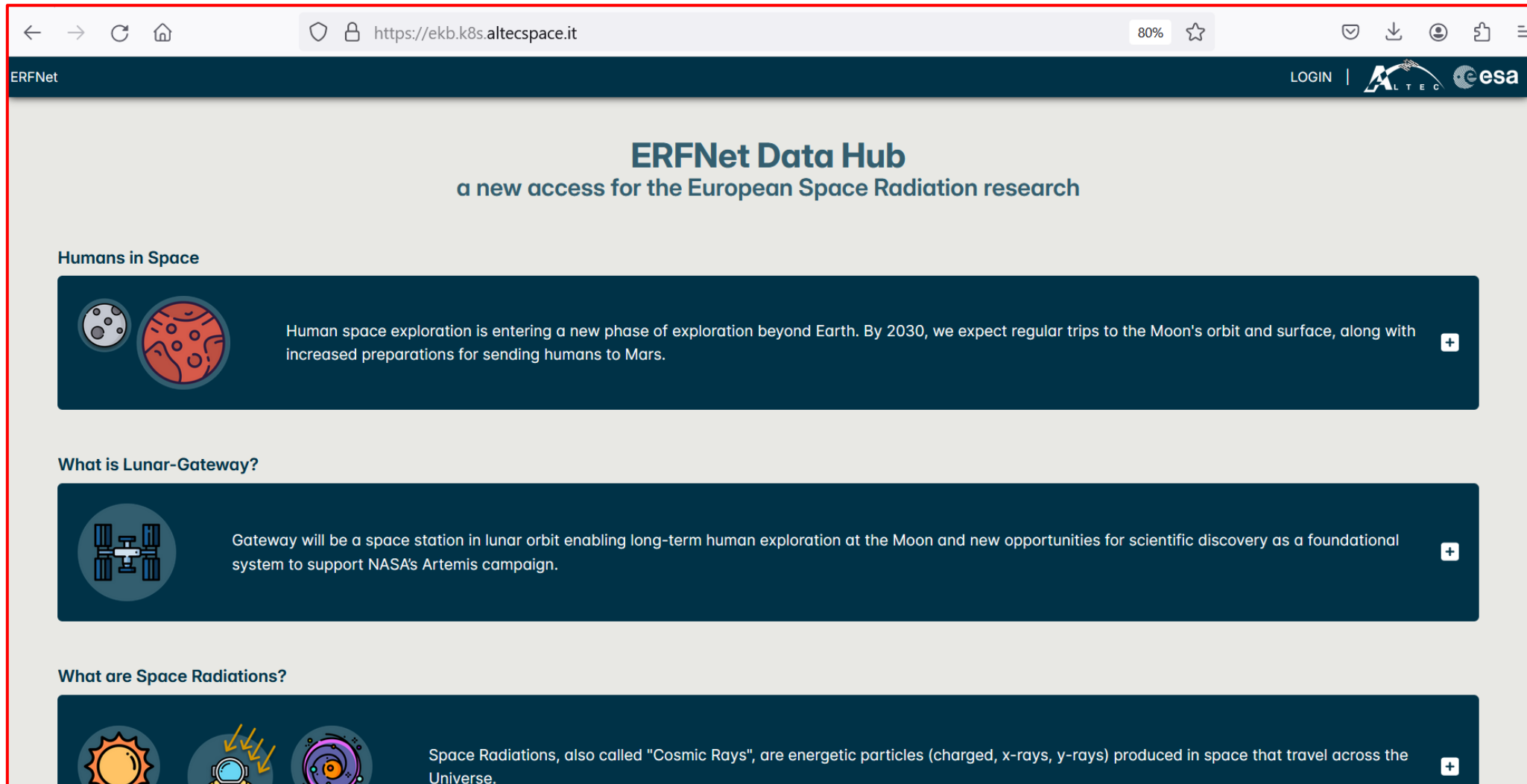
In addition, the environment provides:

- Personal working areas to store datasets and create own projects: an online remote desktop to import user assets, coding and to benefit of data analysis and MC simulation tools pre-configured in the environment. This allows easy access to software tools such as ROOT, G4, GRAS, etc. acting also as an easy tool for workshop preparation, tutorial and training.
- Availability of computational resources to submit batch mode analysis and simulation tasks
- APIs to run analysis/simulation tasks, access to data, etc.



[Additional details in the backup slides](#)

- The Scientific Environment is open to the broader Science Community involved in the field
- Through the public Community Webpage, via <https://ekb.ersse.altecspace.it>, the access credential (username and password) can be requested



The screenshot shows a web browser window with the URL <https://ekb.k8s.altecspace.it>. The page is titled "ERFNet Data Hub" and is described as "a new access for the European Space Radiation research". The page features three main sections:

- Humans in Space:** Human space exploration is entering a new phase of exploration beyond Earth. By 2030, we expect regular trips to the Moon's orbit and surface, along with increased preparations for sending humans to Mars.
- What is Lunar-Gateway?:** Gateway will be a space station in lunar orbit enabling long-term human exploration at the Moon and new opportunities for scientific discovery as a foundational system to support NASA's Artemis campaign.
- What are Space Radiations?:** Space Radiations, also called "Cosmic Rays", are energetic particles (charged, x-rays, y-rays) produced in space that travel across the Universe.

Final Goal: Parameterization of the dosimetric contribution of trapped protons as a function of rigidity

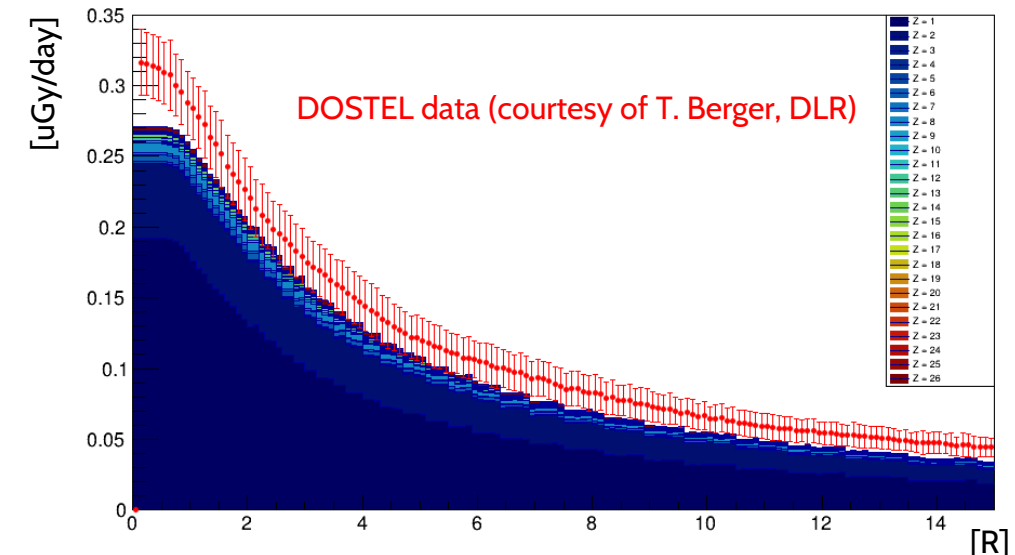
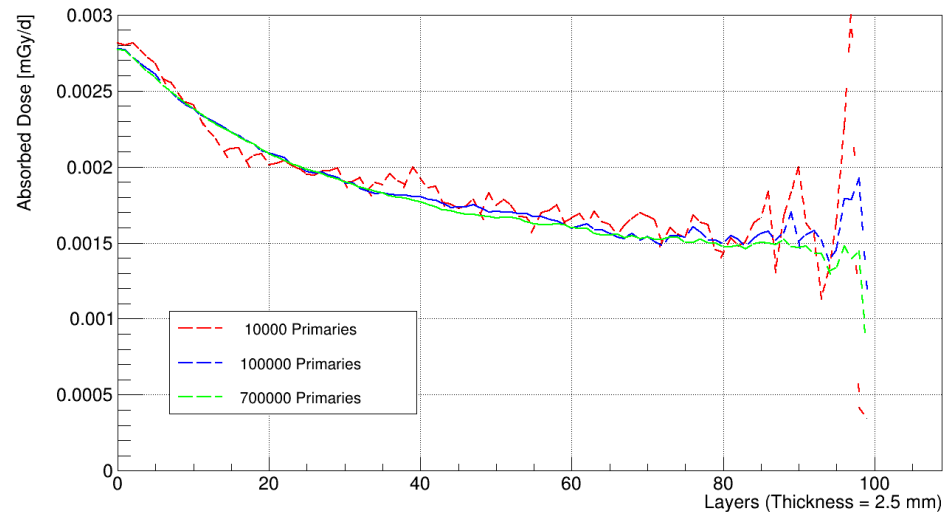
Preliminary steps:

1. Statistics quality test
 2. Once found the more stable statistic for primary particles, it was tried to replicate a well-known case: the absorbed dose data acquired on ISS from DOSTEL instrument
 3. The simulation predictions were validated with absorbed dose data collected by DOSTEL provided by DLR team (T. Berger and D. Matthiä)
 4. DOSTEL equivalent dose comparison
- Source: Fe spectra from DLR models. Simulation with 10k, 100k, 700k primaries
 - Target: 100 concentric water layers of 2.5 mm each
 - Score: absorbed dose as function of target layer



DOSTEL

- Source: GCR DLR spectra was used to generate 800k primary particles from H to Fe
- Shielding: Columbus-like shielding
- Target: water sphere of 25 cm
- Score: absorbed dose as function of rigidity/energy
- DOSTEL data: Comparison with DOSTEL data of [2019-06-01, 2019-09-01]



Part of Valetti PhD Thesis

- Demo of ERFNet v0 to ESA: 30/11/2023
- Demo of ERFNet beta version to ESA and Instrument Teams: 18/04/2024
- ERFNet beta version released on: Q2/Q3 2024
- Current Beta Users from:
 - Space Environment and Effects, ESTEC, ESA
 - Space Exploration Innovation Hub, JAXA
 - Imperial College, London
 - ADVACAM Radiation Imaging Solutions, Prague
 - Space Applications & Research Consultancy (SPARC), Athens
 - Institute of Aerospace Medicine, DLR, Cologne
 - University of Turin - Physics Department
- ERFNet v1 will be released in September (TBC) with a following testing period

Ambitious and challenging goal:

ERFNet aims at becoming a support tool for scientist and researches involved in the Space Radiation/Radioprotection fields to face the upcoming challenges (to the Moon and beyond). ERFNet wants to boost the Scientific Community cohesiveness, in order to work towards answering the questions still open in the field.



Thank you for your attention!

Backup

- Dashboard
- Dataset
- Data Exploration**
 - Data Upload
 - Data Requests
- Data Processing
- Batch Execution
- Software Products
- Working Area

Data Exploration

AND OR +
Select... ✕

Current query: select * from products

Ingestion time in
ERFNet

Dataset coverage

Project	Instrument	Processing Level	Name	Ingestion Time	Start Coverage	End Coverage	Actions
>	Full setup	N/A	gras_test_20_input	2024-03-18 11:30	2024-03-10 10:04	2024-03-11 10:04	↓ □
>	Full setup	L0	gras_batch_test_input	2023-11-30 10:05	2023-11-14 10:04	2023-11-16 10:04	↓ □
>	SREM	L0	SREMPROBA1_PACC_20220328	2024-02-07 10:40	2023-03-28 10:40	2023-03-29 10:40	↓ □
>	SREM, EDA	L0	proba_row_1	2024-02-27 14:54	2024-02-22 14:52	2024-02-26 14:52	↓ □
>	NGRM	L1B	ersa_ngrm_l1b_27-03-2024_101420	2024-03-28 18:56	2023-03-16 18:55	2023-03-17 18:56	↓ □
>	ERFNET		ngrm_results	2024-03-28 23:14			↓ □
>	ERSA	NGRM	ersa_ngrm_l1b_28-03-2024_132520	2024-03-28 18:18	2024-03-10 01:00	2024-03-12 00:59	↓ □
>	ERSA	MEDIPIX	ersa_ngrm_l1b_29-03-2024_084500	2024-03-29 10:57	2024-03-10 01:00	2024-03-12 00:59	↓ □
>	ERSA	MEDIPIX	ersa_ngrm_l1b_29-03-2024_103413	2024-03-29 11:34	2024-03-10 01:00	2024-03-12 00:59	↓ □
>	ERSA	MEDIPIX	ersa_ngrm_l1b_29-03-2024_103413	2024-03-29 18:01	2024-03-10 01:00	2024-03-12 00:59	↓ □

Action buttons

« < 1 2 3 4 5 > » 10 ▾ 1 of 6 (57 items)

Total results: 57
Total selected: 0 (0 MB)

[Download all results](#) [Download selected](#) [Clear selected](#)

- Users are able to apply filters
- Users are able to inspect each dataset expanding the row

Current search query and results

AND OR + Search filters

Instrument Equal NGRM

Current query: select * from products where Spase.NumericalData.InstrumentID = "NGRM"

Project	Instrument	Processing Level	Name	Ingestion Time	Start Coverage	End Coverage	Actions
>	NGRM	L1B	ersa_ngrm_l1b_27-03-2024_101420	2024-03-28 18:56	2023-03-16 18:55	2023-03-17 18:56	📄
∨ ERSA	NGRM	L1B	ersa_ngrm_l1b_28-03-2024_132520	2024-03-28 18:18	2024-03-10 01:00	2024-03-12 00:59	📄

Table JSON Switch between "compact" and "metadata" view

Files name: FPDO.csv, FPDO_Quality.csv, FEIO.csv, FEIO_Quality.csv
Formats: csv, csv, csv, csv
Size: 0.62 MB
Description: L1B NGRM Bundle generated from ersa_ngrm_l1b processor

Dataset information (compact view)

<< < 1 > >> 10

Total results: 2
Total selected: 0 (0 MB)

Download all results Download selected Clear selected

1 of 1 (2 items)

- Dashboard
- Dataset
- Data Exploration
- Data Upload**
- Data Requests
- Data Processing
- Batch Execution
- Software Products
- Working Area

EKB

Welcome, Lorenzo Scavarda! Role: SCIENTIST | Logout

Dataset Upload

Data

Upload Type*

Select a upload type

Direct upload or via SFTP

Project Name* ?

Select project

Project (ERSA, IDA, other, ...)

Instrument* ?

Select instrument

Type of instrument (SREM, NGRM, other, ...)

Discipline* ?

Select discipline

Discipline (dosimetry, space radiations, other, ...)

Description* ?

Set description

Brief description

Type

Experiment Location* ?

Ground Experiment or Space Mission

Select location

Data Level* ?

Data Level (LO, L1A, etc...)

Select level

Measurement Type* ?

Select measurement type

Measurement type (abs dose, eq. dose, differential flux, etc ...)

Acquisition Time (start)* ?

Set start date

Acquisition Time (end)* ?

Set end date

Configurations

Access Policy* ?

Select policy

Privacy level:

- Private: only you
- Public: everyone
- Team: a limited group of people

Submit

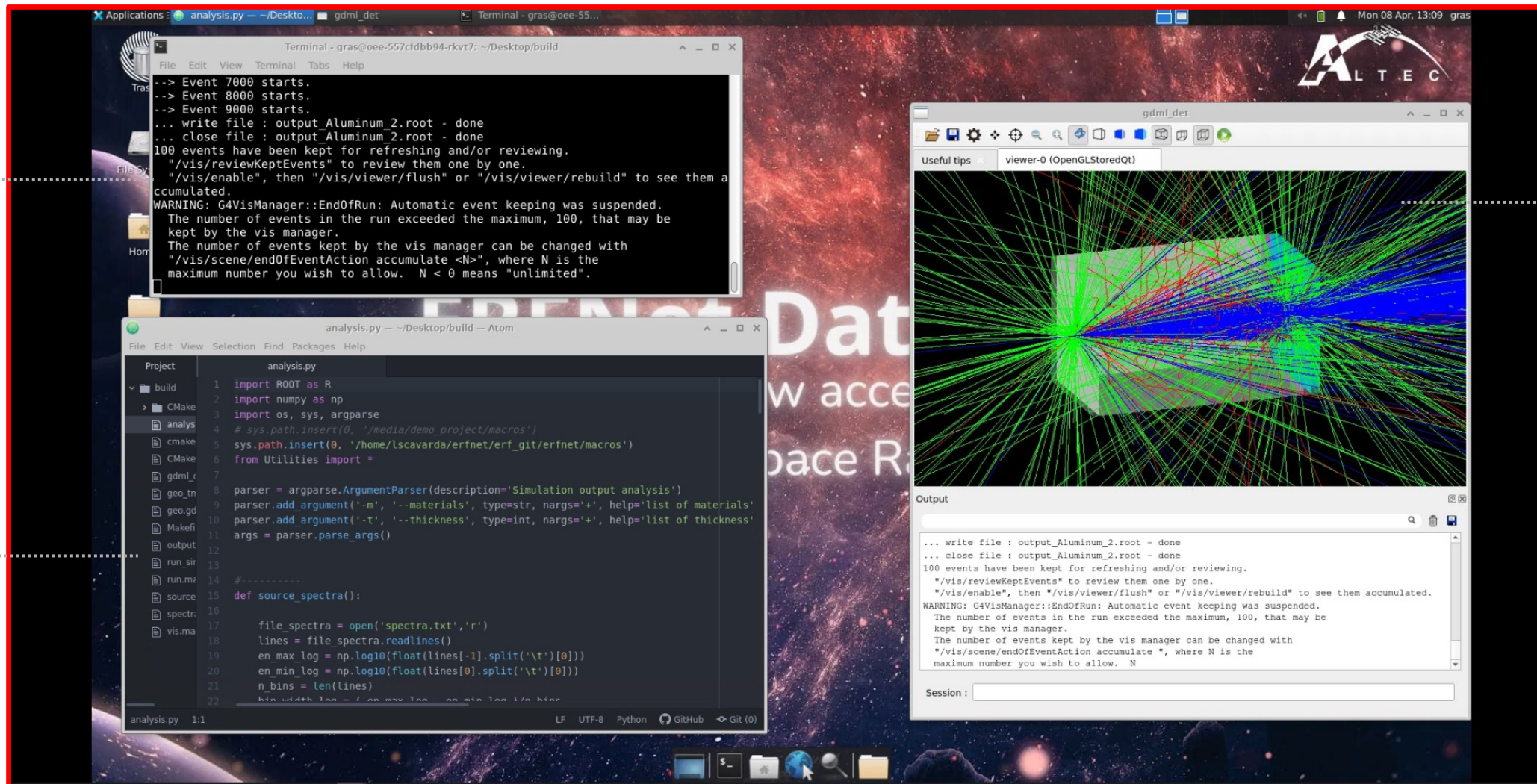
The user personal area where create projects (MC simulation or analysis task), access data, share data outputs, etc.

The screenshot displays the 'Working Area' interface. On the left is a dark sidebar with a menu containing 'Dashboard', 'Dataset', 'Data Processing', 'Batch Execution', 'Software Products', and 'Working Area' (highlighted with a dashed yellow box). The main content area has a top header with 'EKB' and 'Welcome, Lorenzo Scavarda! Role: SCIENTIST | Logout'. Below the header is the title 'Working Area'. There are three main sections: 1. 'Explore ERSSE Data Products' with a subtext 'Explore datasets available in ERSSE database'. 2. 'Your Assets' with a subtext 'The «user assets» are private data can which be used as inputs in any project'. 3. 'Your Projects' with a subtext 'Simulation and/or Data Analysis projects' and resource usage 'Resources: RAM 50%(max 8GB) - CPU 33% - FS 43%(max 100GB)'. A 'New Project' button is present. Three project cards are shown: 'Innovative Shielding' (numerical-simulation, ACTIVE), 'NGRM Data Analysis' (radiation-analysis, ACTIVE), and 'MPX Data Analysis' (radiation-analysis, ACTIVE). Each card has a trash icon, a refresh icon, and a play icon. Callouts point to these icons: 'Delete project' (trash), 'Promote output as User Assets' (refresh), and 'Run the desktop environment' (play). A 'Resources of personal area' callout points to the resource usage text.

- Geant4 simulation example: study dose reduction for different shielding materials and thickness

Remote Desktop

Command Line
(bash, python,
C++, ...)



Geant4 GUI

Text Editor

New Simulation

General

Profile*
Default Execution Profile

Run

Tool* Simulation tool selection (GRAS, GEANT4, etc.)

GRAS

Memory*
8GB

Duration*
120

Schedule Type*
Immediate

Command to run the simulation

CMD*
gras \${MainInput}/main.g4mac

CPU*
4

Working Dir*
.

Working directory. For Beta testing period use: .

Inputs

Input paths* Input path. For Beta testing period use: /test
/test

Additional input properties

MainInput ⓘ
2d9baad7-2c6a-4220-9765-10bf61fb47df

product.id of software products. For beta testing period run the example provided: 2d9baad7-2c6a-4220-9765-10bf61fb47df or upload your softwares from the Data Upload page

Time of job submission (now or scheduled)

Outputs

Visibility*
Private

Output paths*
output

Output name. For Beta testing period use: output (See slide 38)

Additional output properties

Another ⓘ
Another

Submit

Only GRAS is enabled for beta version

Configure processing parameters. Autofilled for beta version

- Privacy level:
- Private: only you
 - Public: everyone
 - Team: a limited group of people