ERFNet Data Hub
ALTEC/ESA Project Overview

XVI FOOT Collaboration Meeting, Naples (Italy)

L. Scavarda on behalf of ERFNet Team

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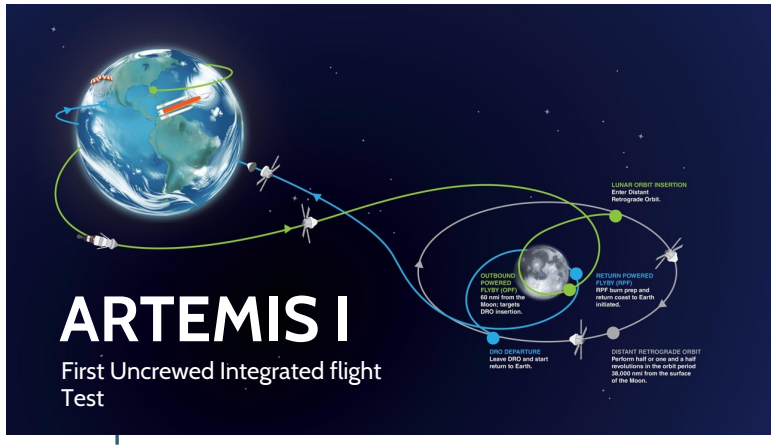
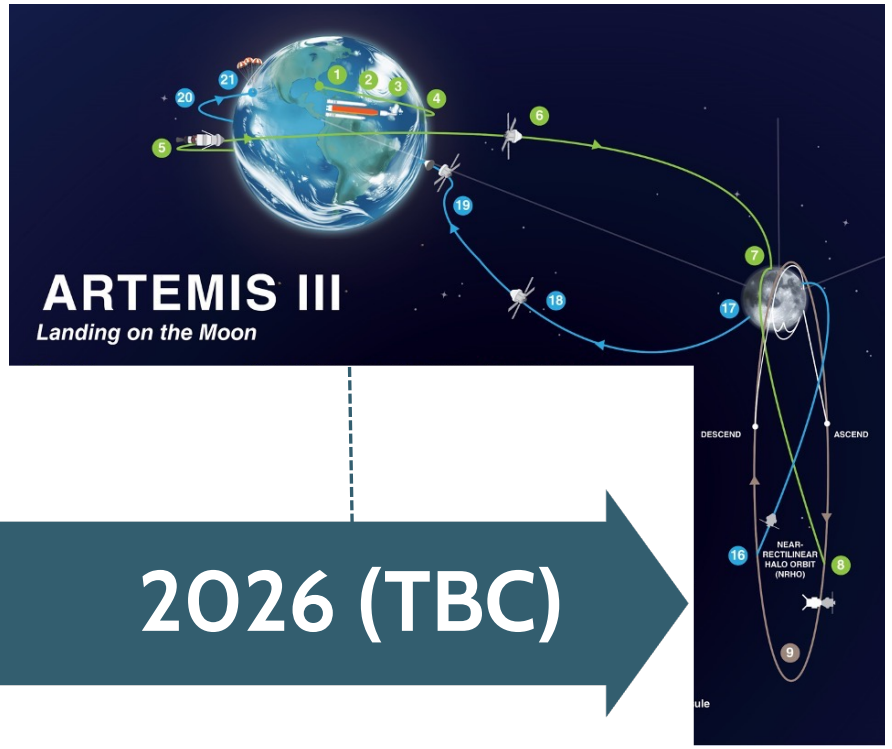
Background

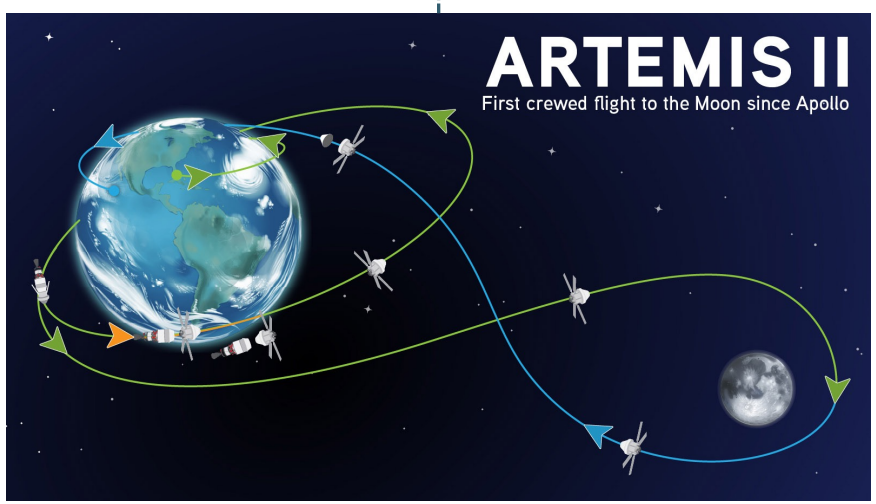
Human Space Exploration – ARTEMIS Program



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.

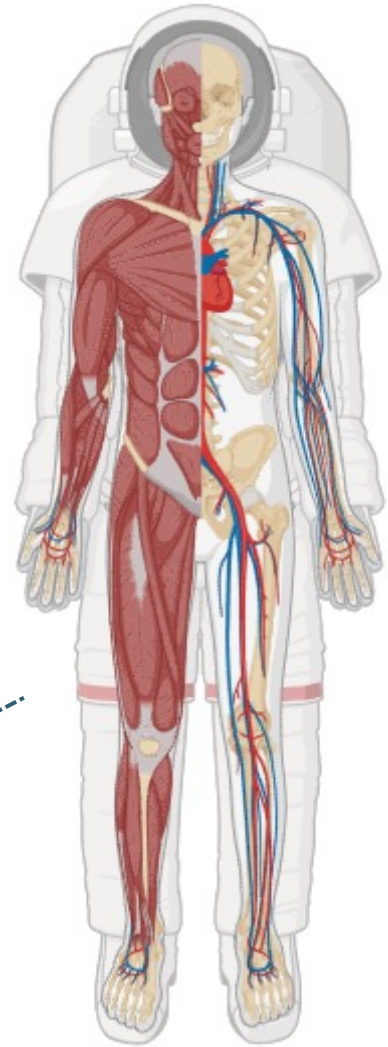
Human Space Exploration

Human Space Exploration

BLOOD

BRAIN

RADIATIONS

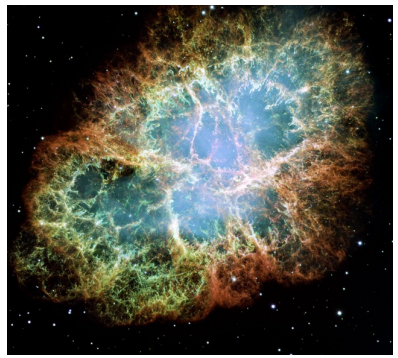
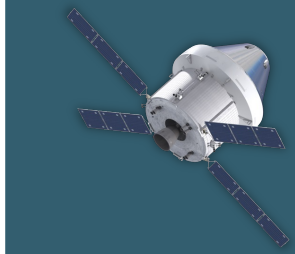
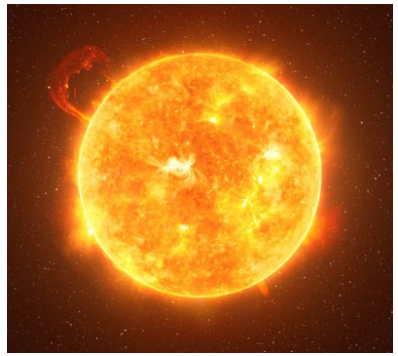
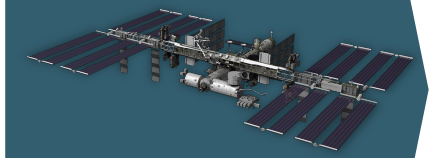
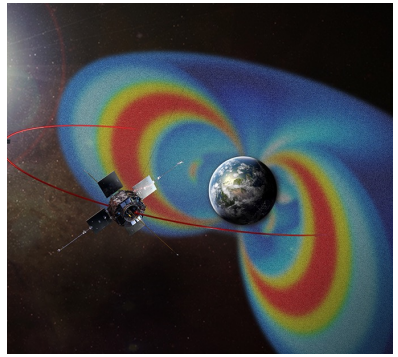


MUSCLE

BONES

HEART

Space Radiation Environment

Radiation Sources	Energy Range	Primary Particles	Target	Secondary Particles
	100-100000 MeV	87% Protons 12% Helium 1% Heavy Nuclei		Neutrons Protons Electrons X-Rays Y-Rays Recoil Heavy Nuclei
	0.001-100 MeV	92% Protons 6% Helium 2% Heavy Nuclei		
	1k – 12k km: 1-5 MeV 13k-60k km: 10-100 MeV	Electrons & Protons		

Open Questions

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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

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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.

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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.

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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.

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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

ERFNet Keywords

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

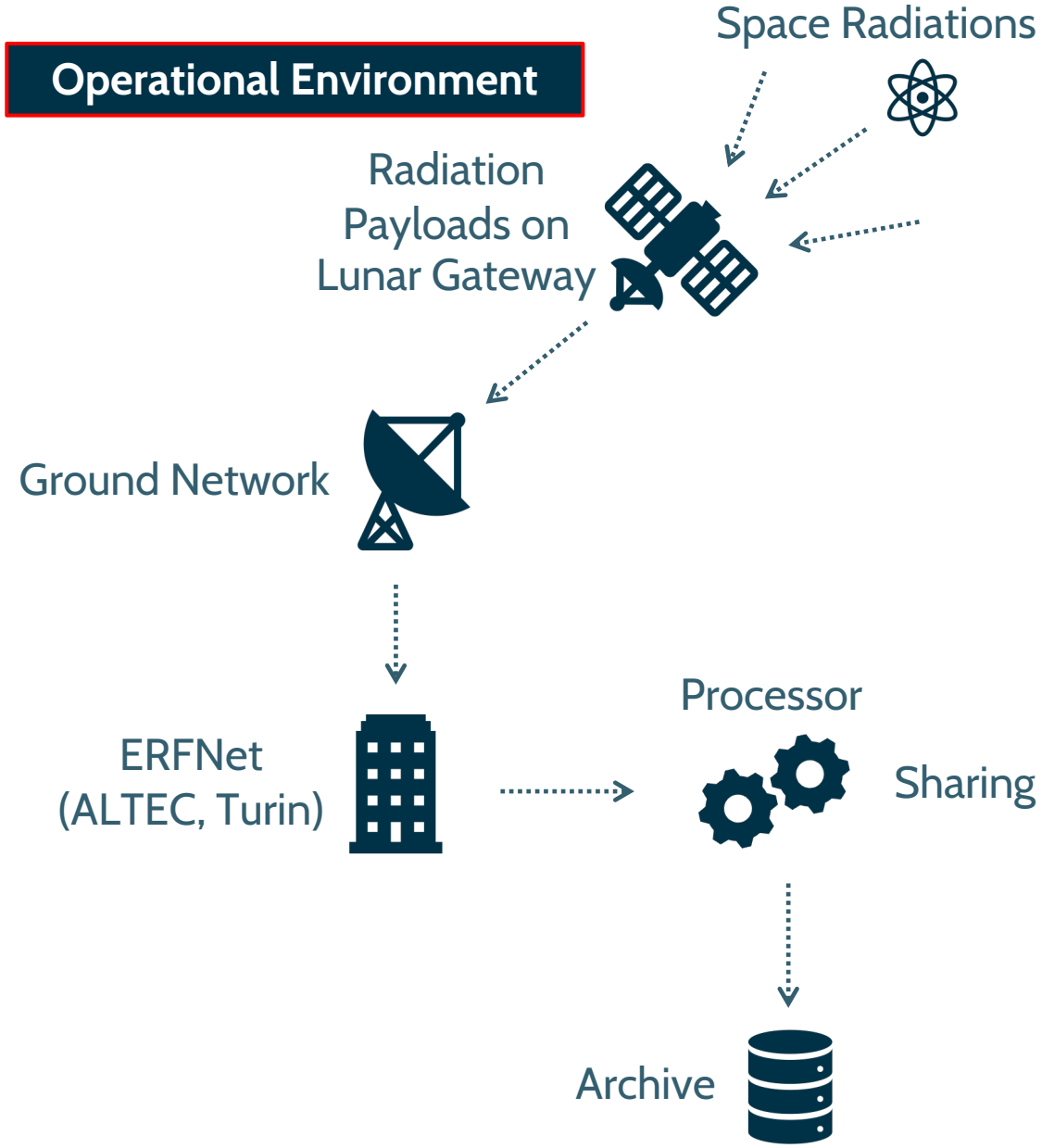
ERFNet offers a collaborative framework where scientists and researchers from diverse disciplines can come together to access and exploit data, write code, perform Monte Carlo simulations, and subsequently share data, projects, and results.

Network

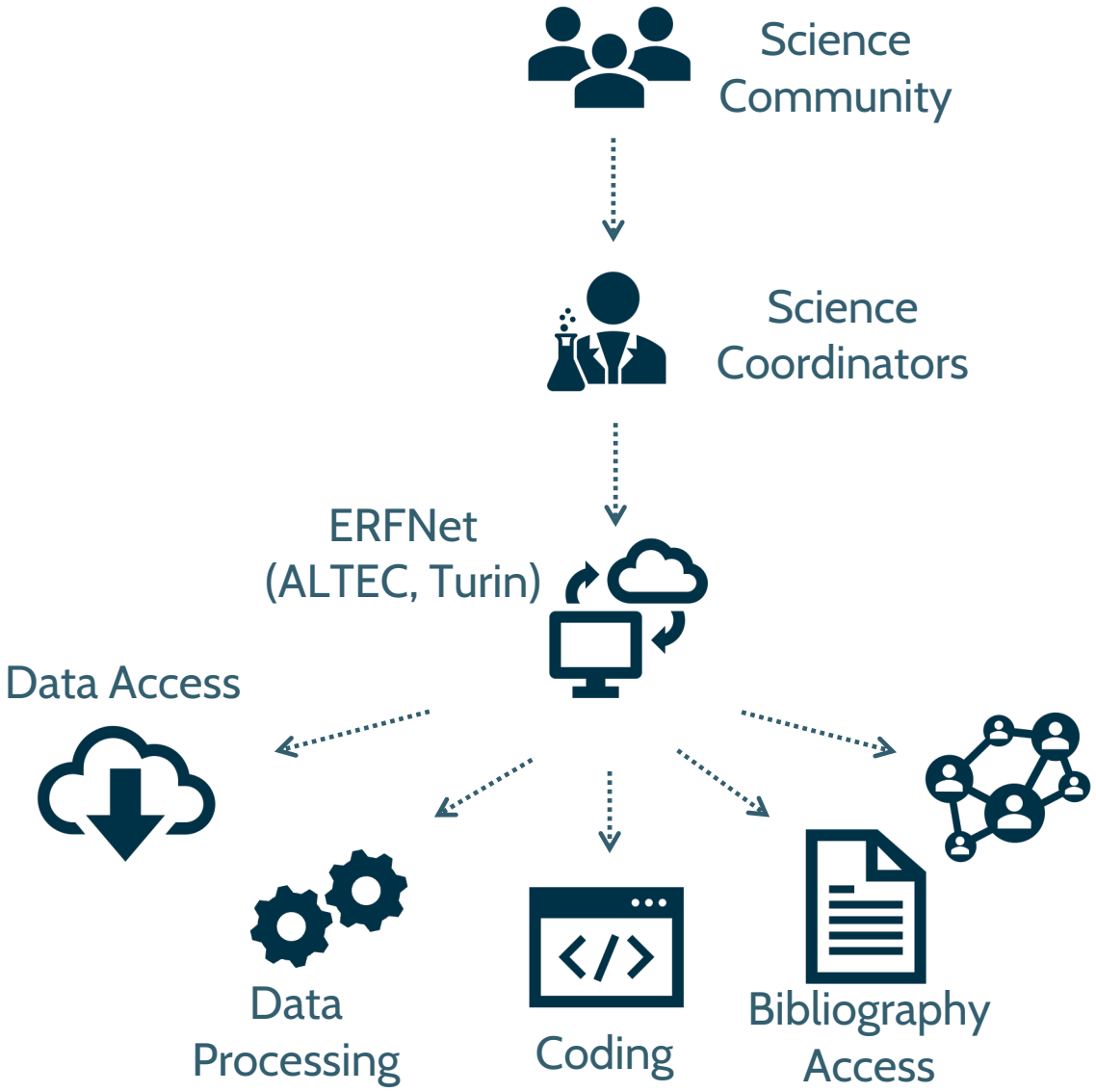
ERFNet serves as a Data Hub for international partnerships, connecting researchers worldwide and facilitating the exchange of expertise and best practices in the field of Space Radiation research.

ERFNet Environments

Operational Environment



Science Environment



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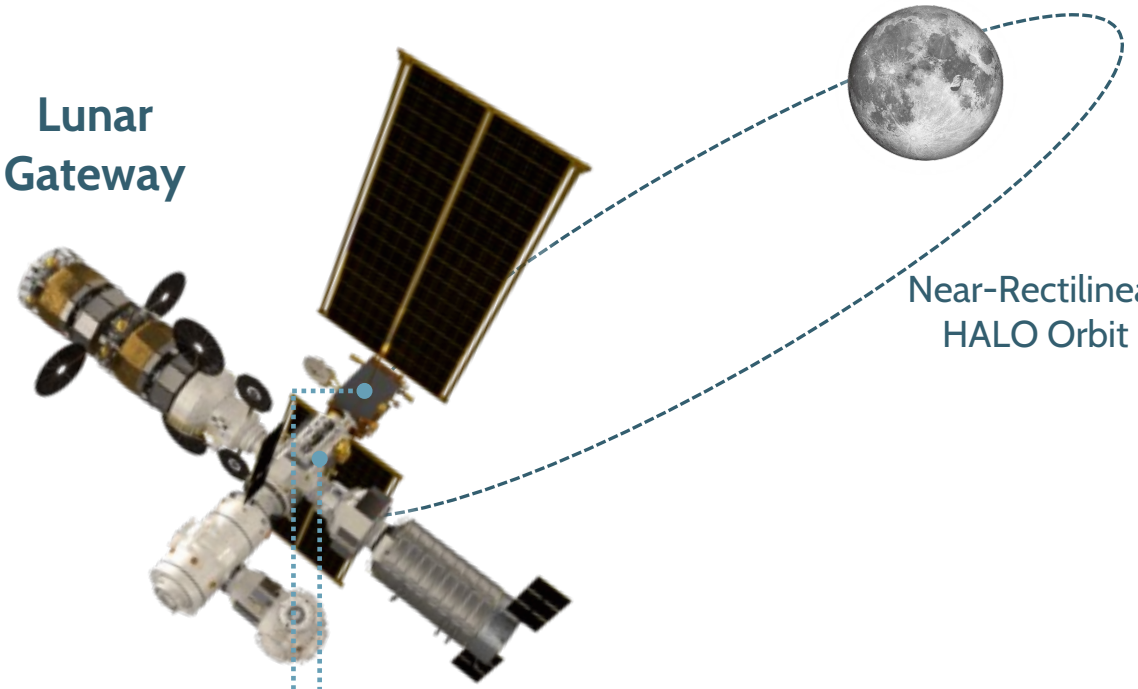
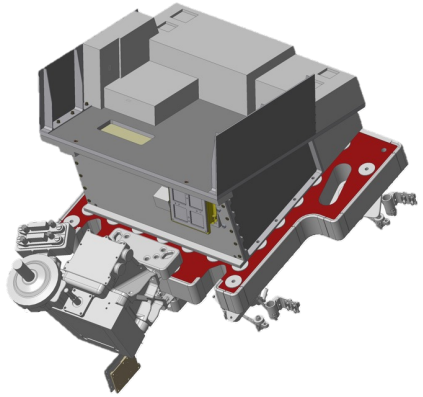


European Radiation Sensor Array (ERSA)

outside PPE module

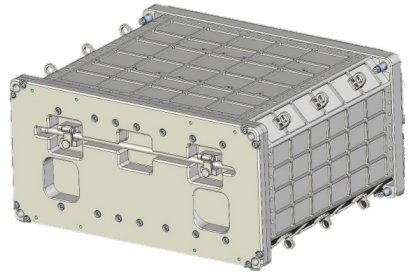


Payload Instruments:
European Active Dosimeter (EAD)
Standard Environment Radiation Monitor (SREM)
Next-Generation Radiation Monitor (NGRM)
ICARE-NG
Time-Pix detector (HardPix)
Magnetometer (MAGIC)

inside HALO

Internal Dosimeter Array (IDA)

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



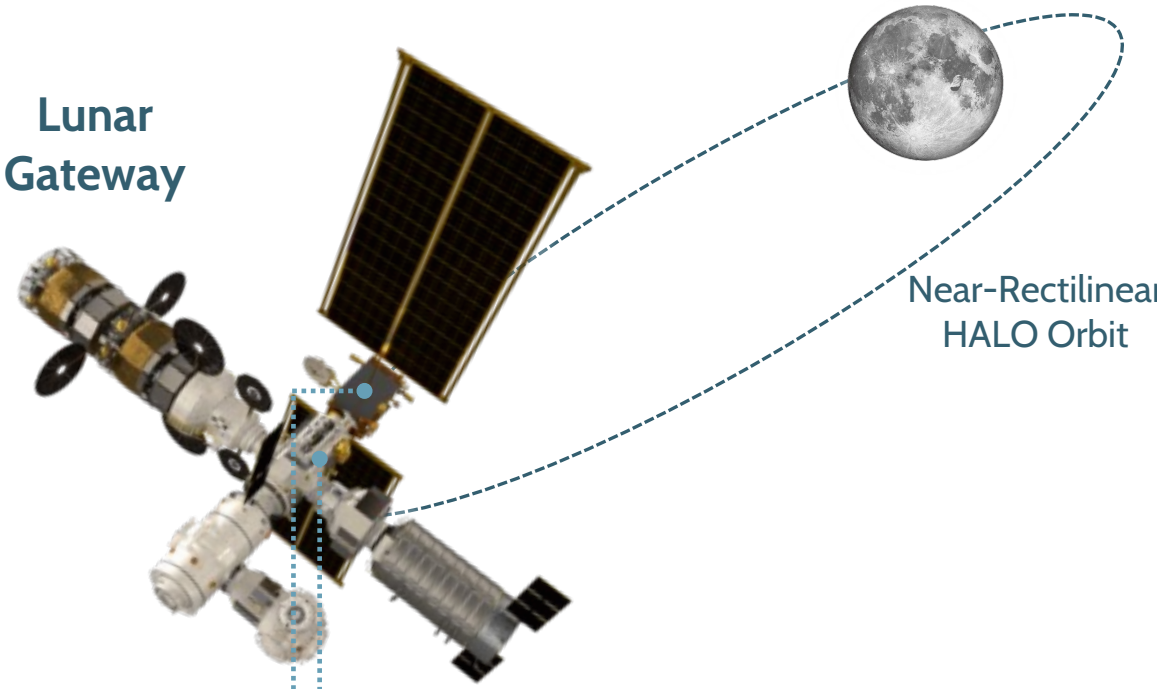
Operational Environment

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 (L0) 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



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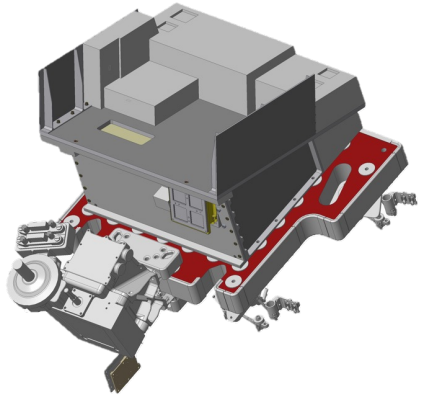

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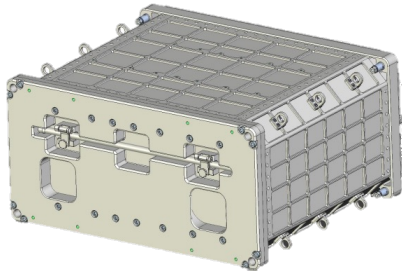
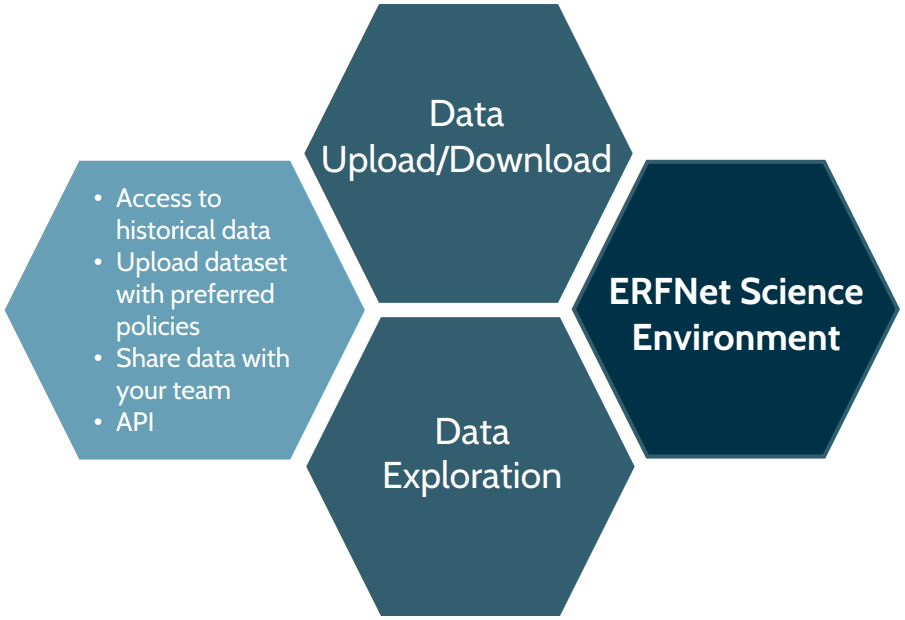


Scientific Environment

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



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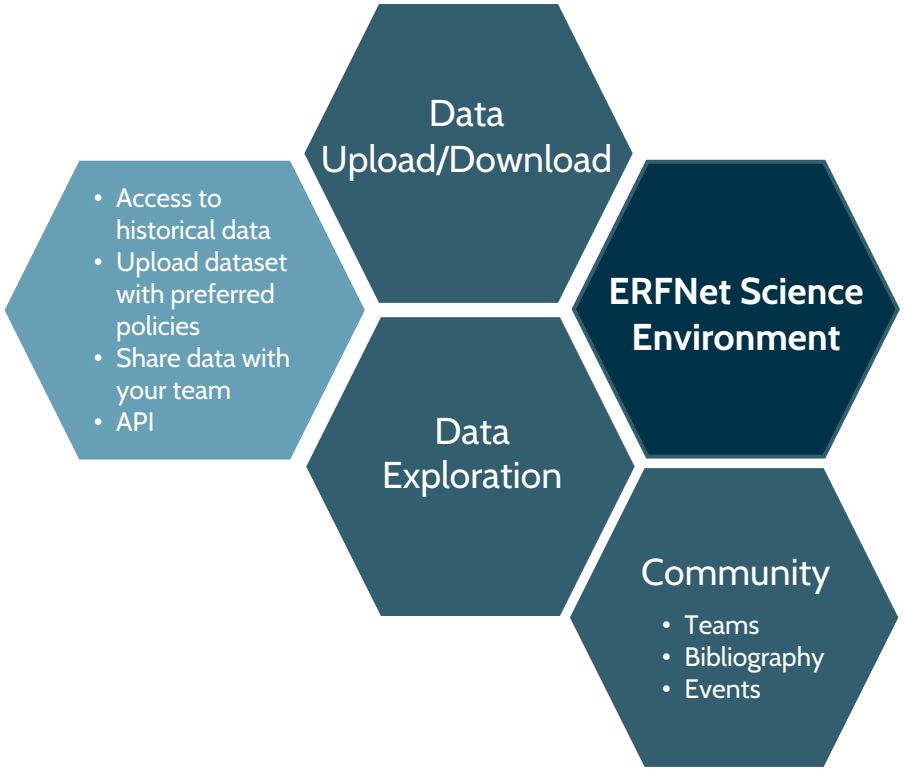
- **Reach scientists around Europe and beyond**: find new contacts, chat and exchange idea, insights, etc.
- **Researches sharing**: upload, share papers, presentation, results and reach more experts
- **Find or submit new events**, conferences, workshop in Space Radiation and Radioprotection fields



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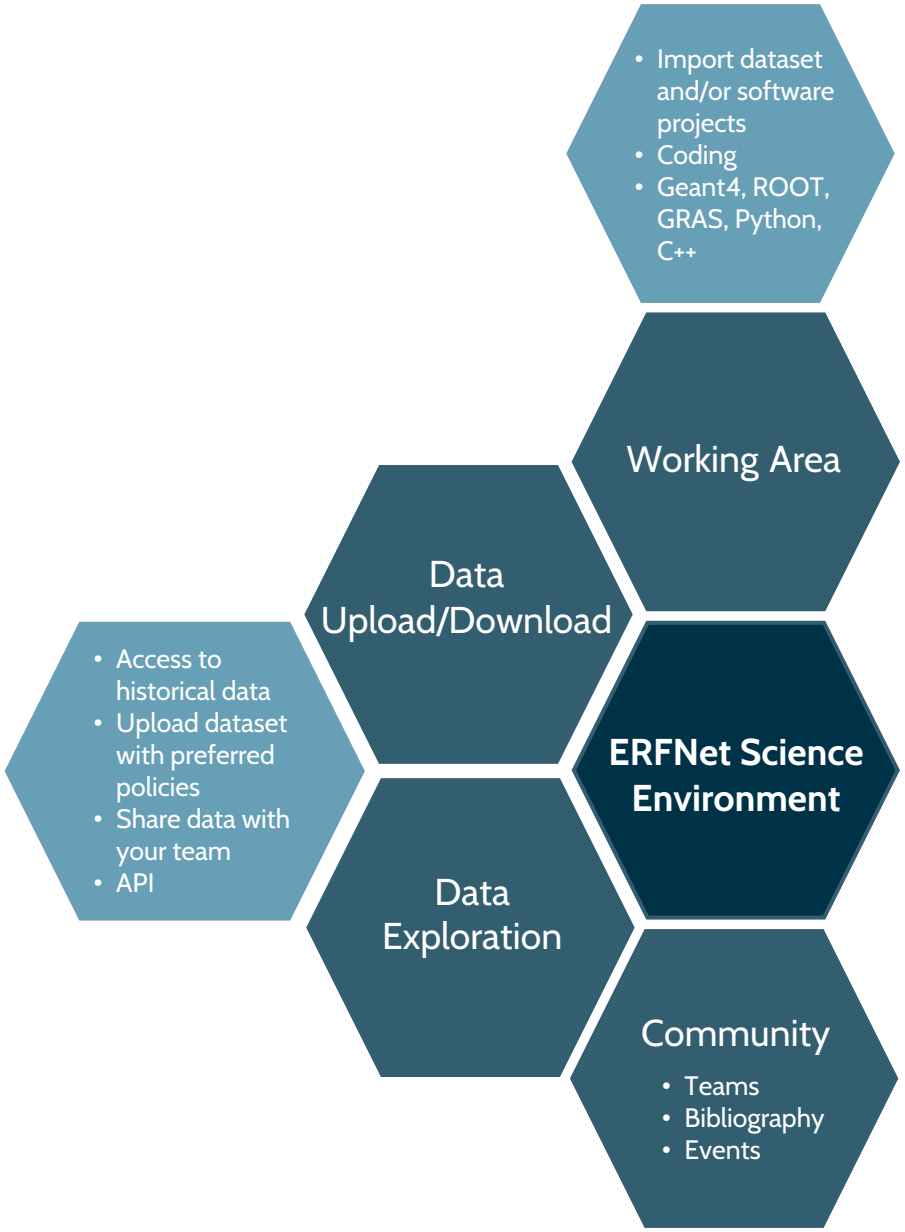
In addition, the environment provides:

- 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



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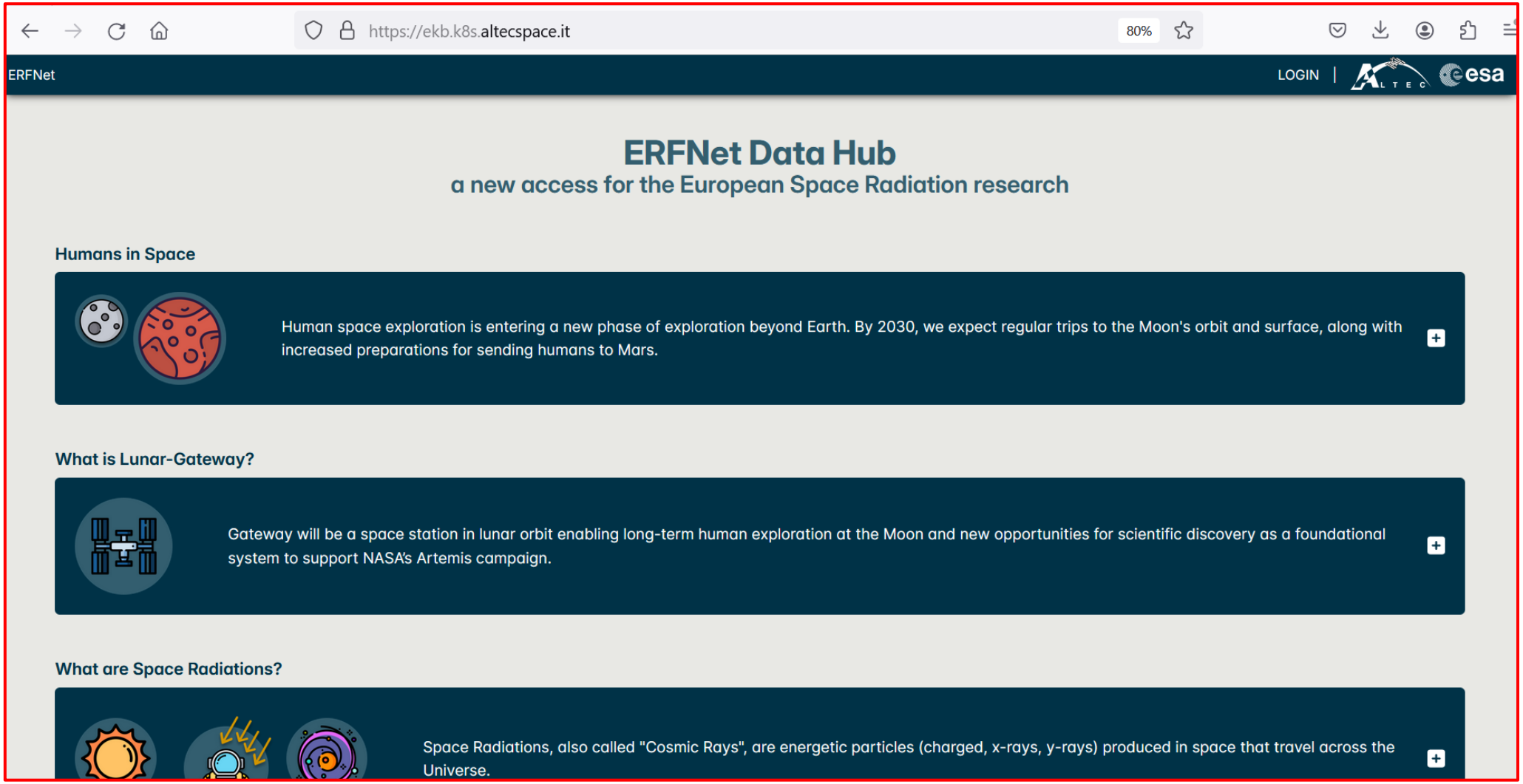
- Availability of computational resources to submit batch mode analysis and simulation tasks
- APIs to run analysis/simulation tasks, access to data, etc.

Additional details in the backup slides

Scientific Environment

- 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



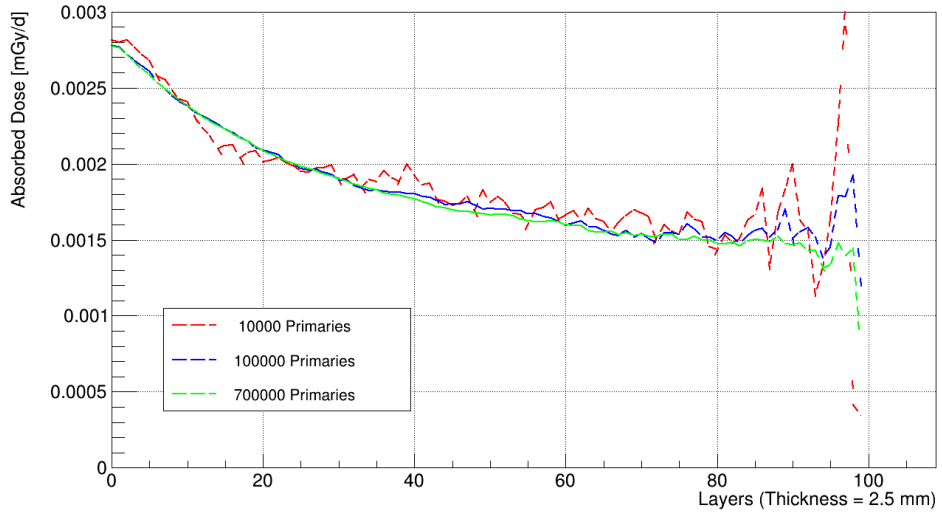
Project on ERFNet - Example

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

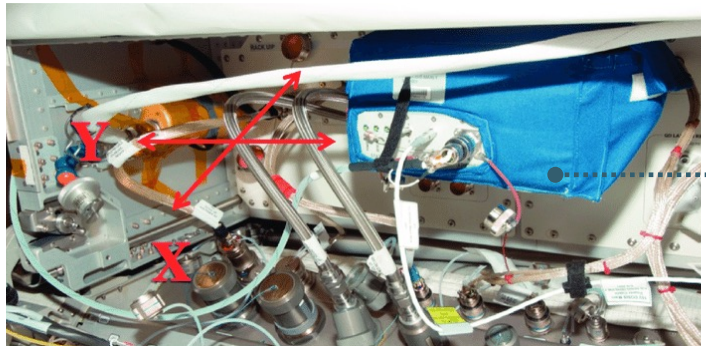
Preliminary steps:

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

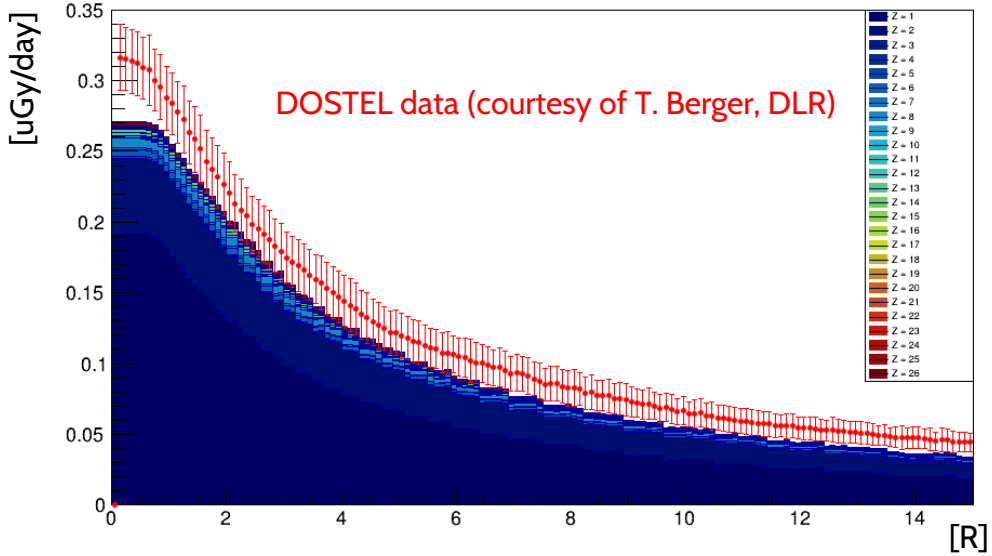


Part of Valetti PhD Thesis



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]



ERFNet Schedule and Community

- 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

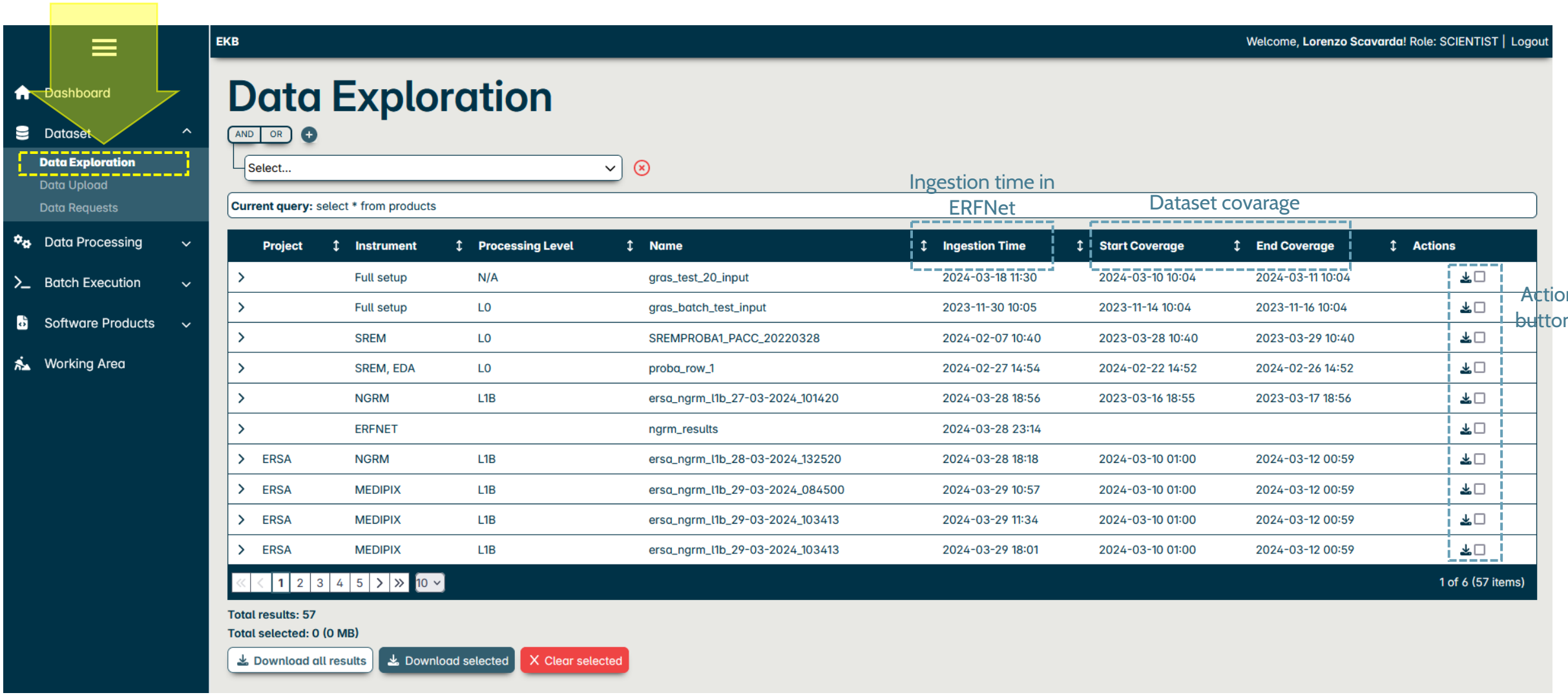
<u>Ambitious and challenging goal:</u>

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!

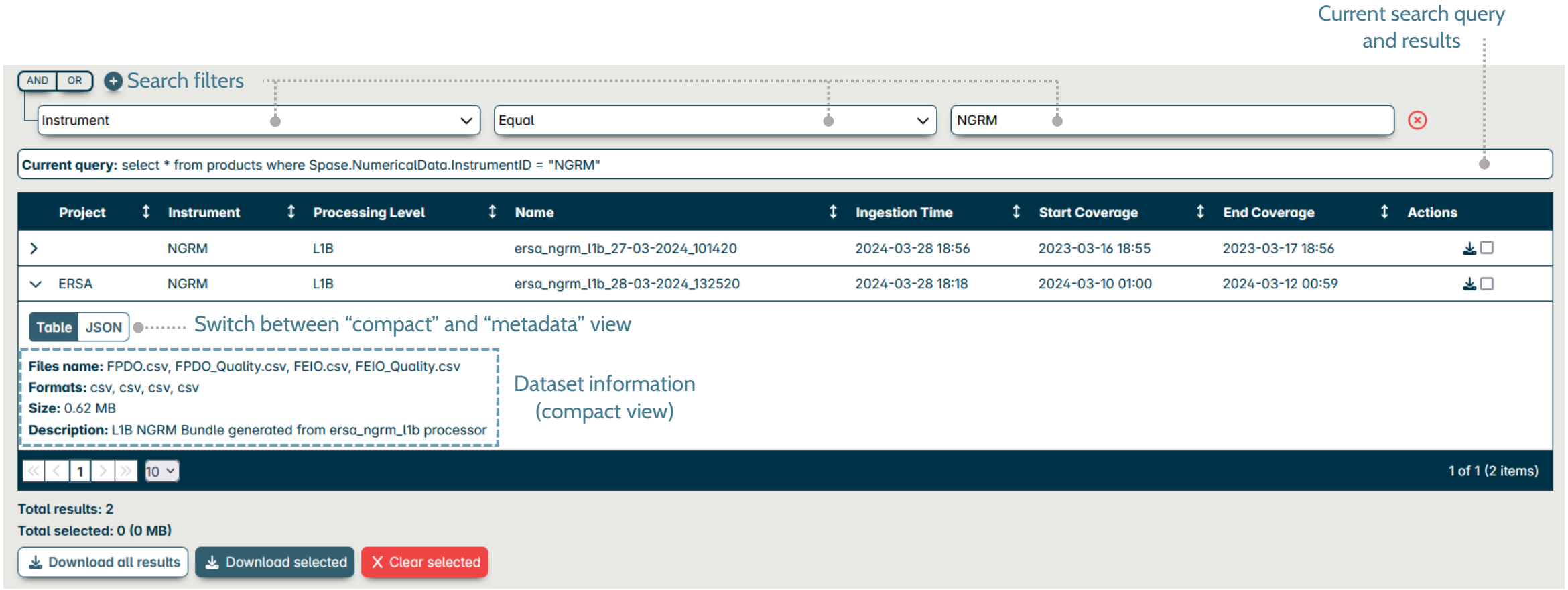
Backup

Data Exploration (1)

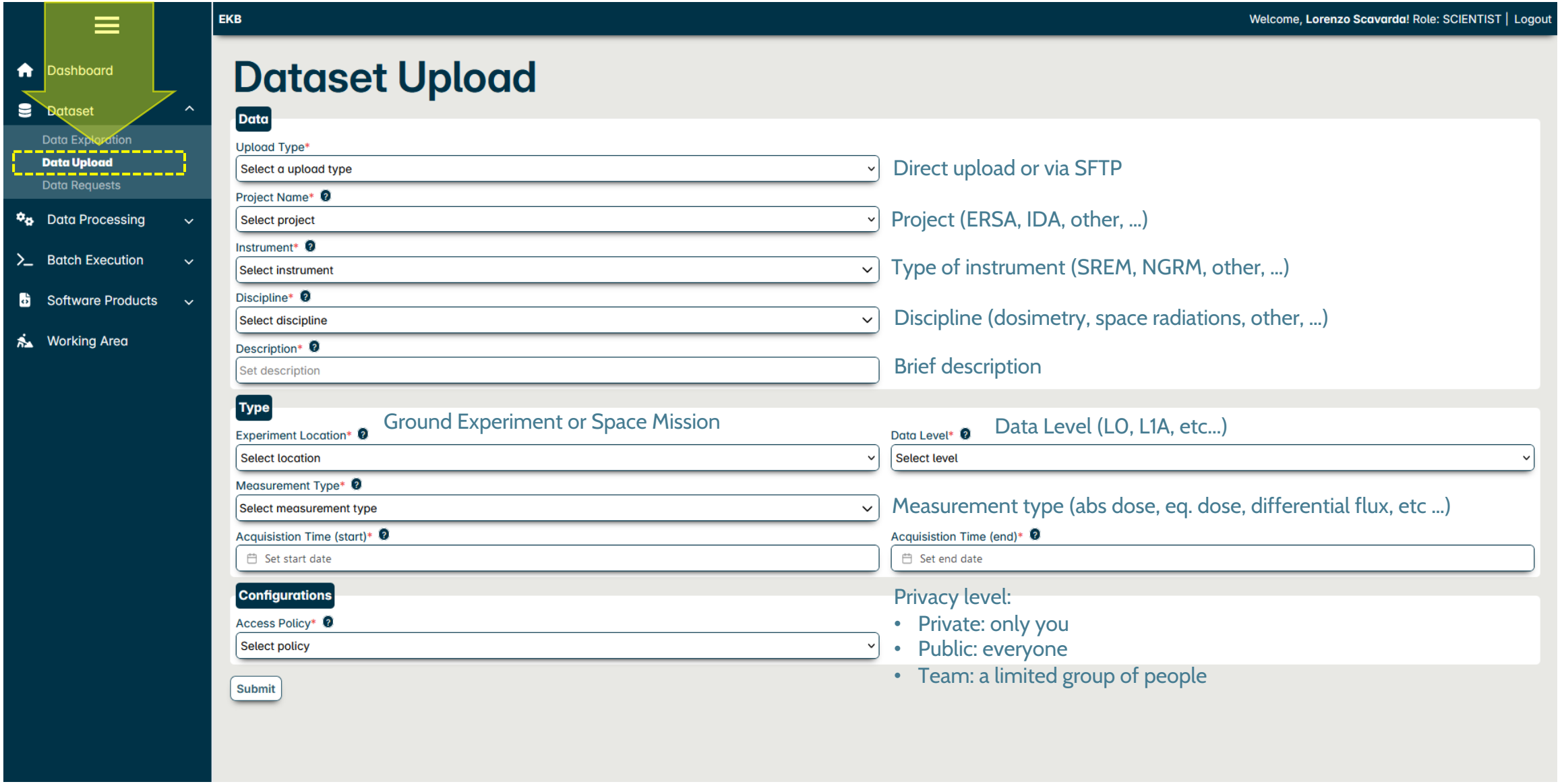


Data Exploration (2)

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

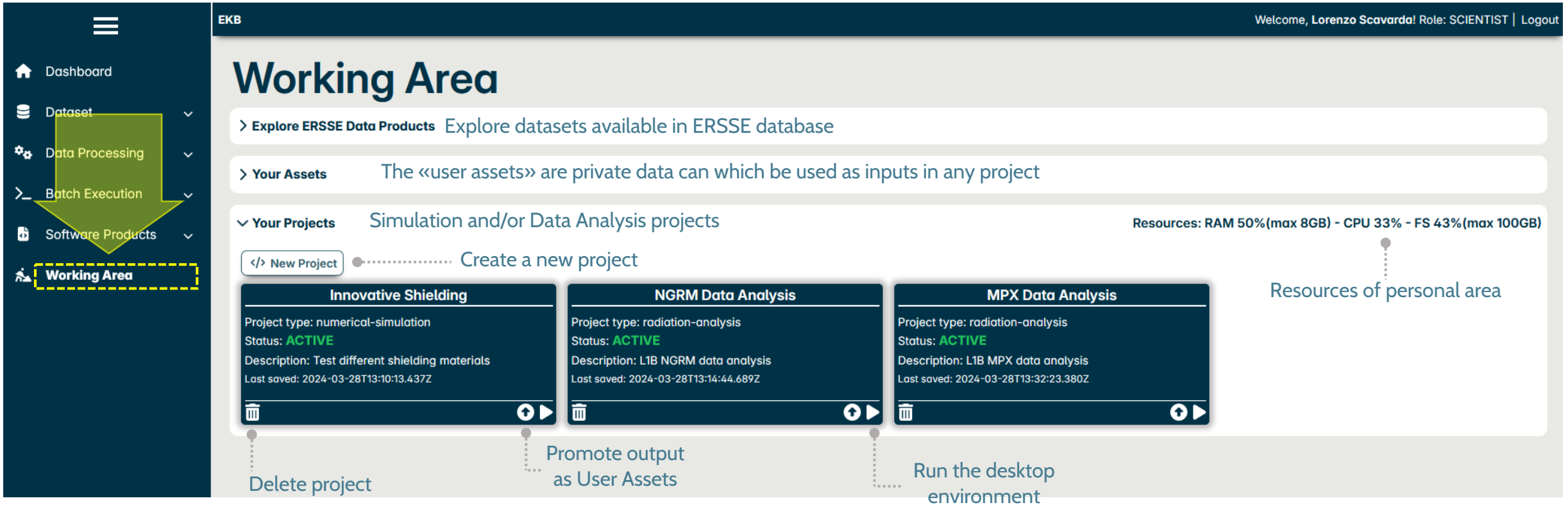


Data Upload


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 (L0, 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

Working Area (1)

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



Working Area (2)

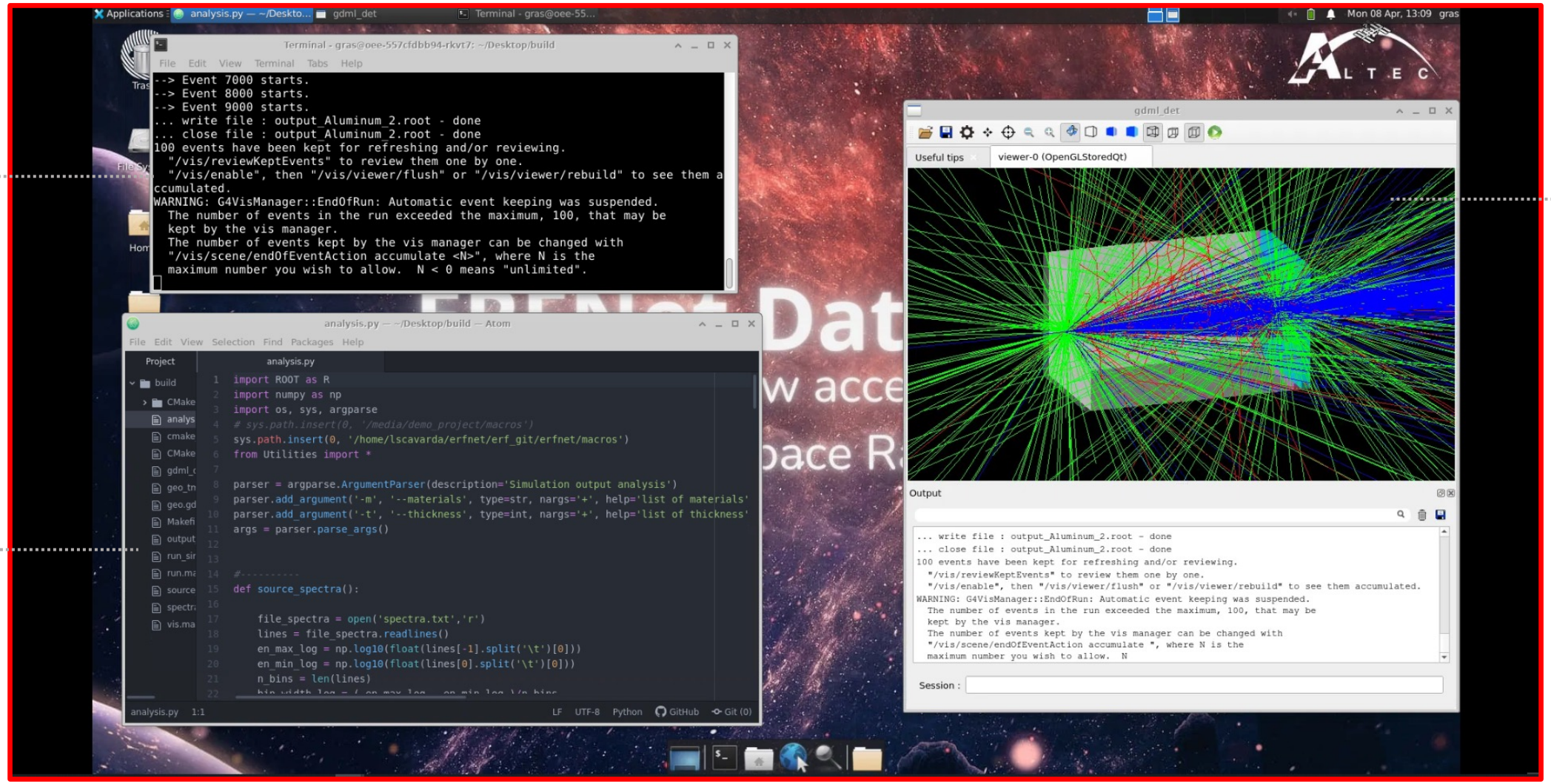
- Geant4 simulation example: study dose reduction for different shielding materials and thickness

Remote Desktop

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

Text Editor

Geant4 GUI



Batch Execution

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