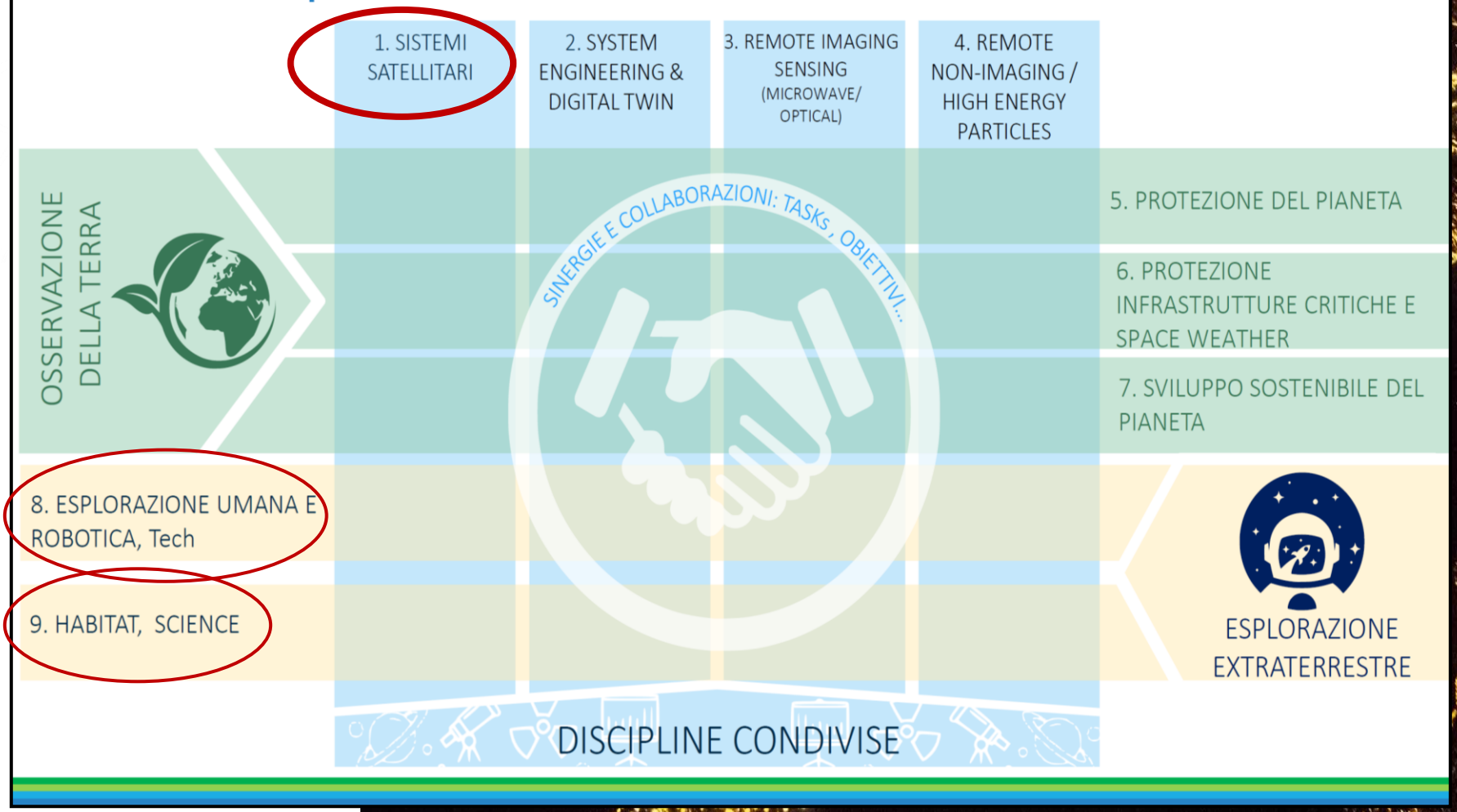
Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

Progetti di ricerca ENEA nel partenariato *SPACE-IT-UP!*

Anna Sytchkova

5 Novembre, 2024 **ENEA-INFN: collaborazioni in essere e sviluppi futuri**

PE15 - 9 Spokes



ENEA Spoke involvement

Spoke 1: **Enabling Technologies for Novel Near-earth and Exploration Missions**

WP1.2 - Very Low-Earth Orbit Platforms: Pushing the Envelope of Earth Observation

WP Leader: L: UNIPI, CL: Poliba, Unina, Unitn, CNR, **ENEA**, CIRA

- *ENEA: Task 2.1 Advanced materials for harsh environment*
- *Task 2.2 Air-breathing propulsion*
- *ENEA: Task 2.3 System-environment interaction multi-disciplinary simulation and testing.*
- *Task 2.4 Fine attitude and orbit control systems.*

- ***ENEA:*** D2.1 Report on advanced materials

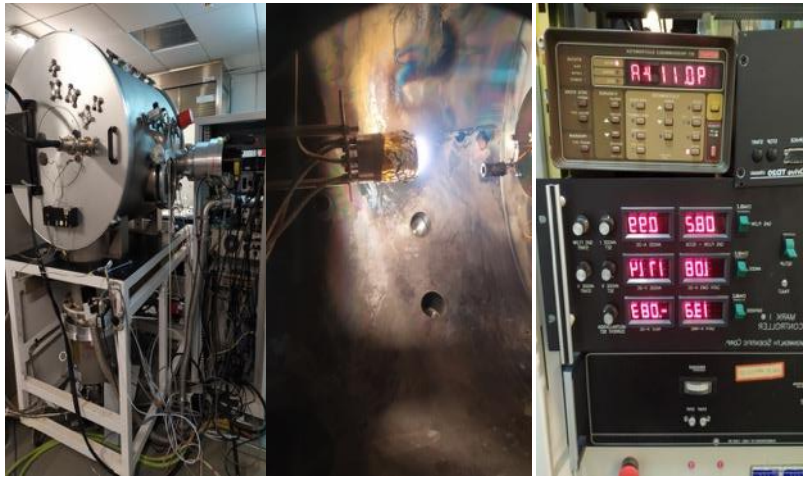
  *(*Unipi, Poliba, Unina, Unitn, CNR, **ENEA**, CIRA*)*

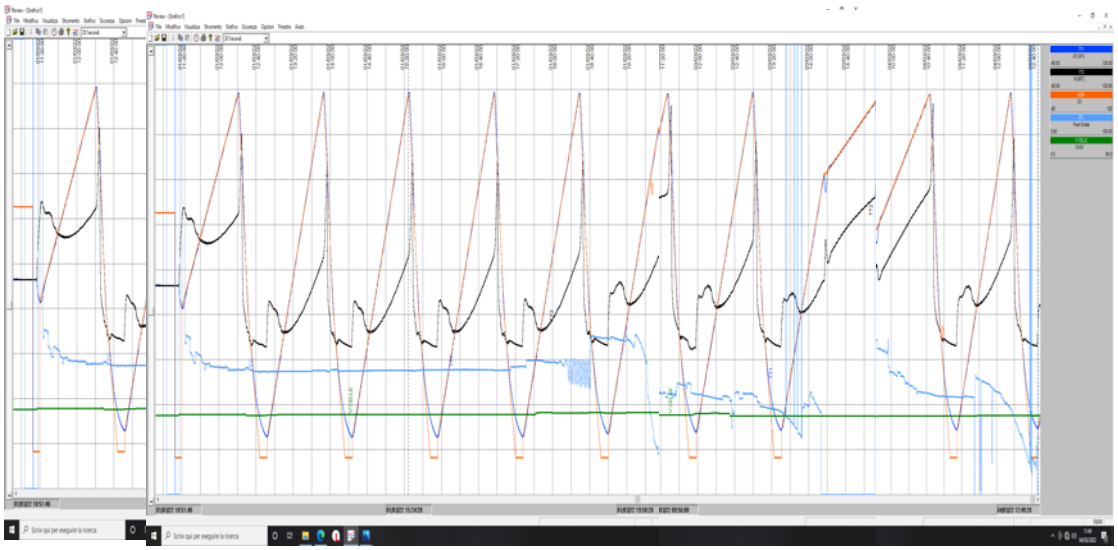
WP1.2 - Very Low-Earth Orbit Platforms: Pushing the Envelope of Earth Observation

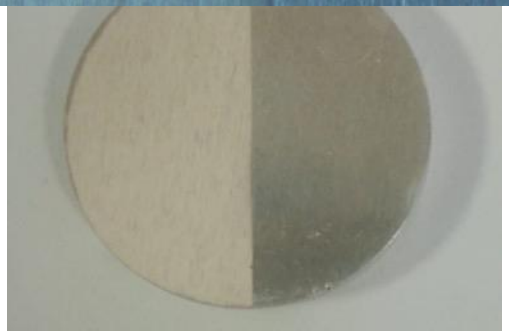
- *ENEA: Task 2.3 System-environment interaction multi-disciplinary simulation and testing.*

- ***ENEA:*** D2.3 Report on system-environment simulation

  (Polimi, Unipi, **Poliba**, Unina, ENEA, CIRA, SITAEL)







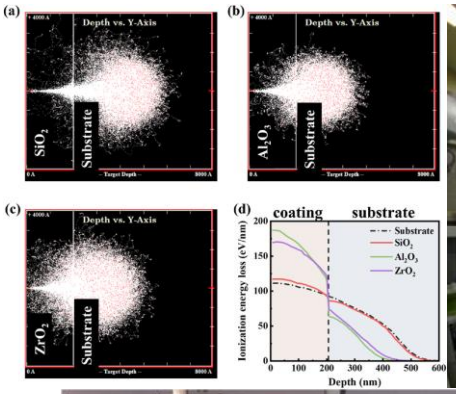
WP 1.4 - Deep-Space Exploration with Miniaturized Platforms: Democratizing the Outer Space Accessible

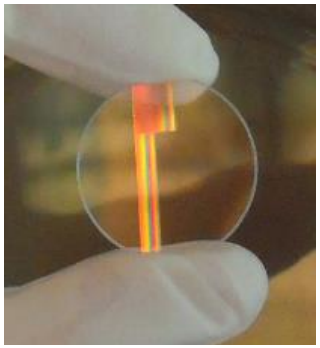
WP Leader: L: POLIMI, CL: UNIBO

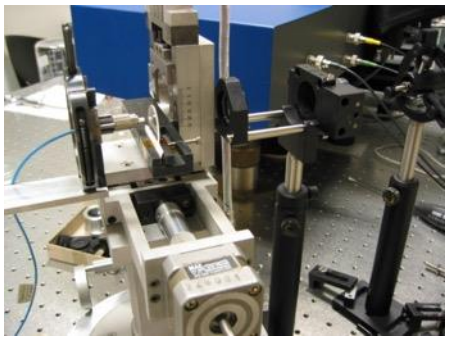
- *Task 1.4.1 Autonomous operations of miniaturized platforms in deep space*
- *Task 1.4.2 Technologies for resources extraction, manipulation, and utilization*
- ***ENEA:** Task 1.4.3 Radiation-tolerant, miniaturized components*

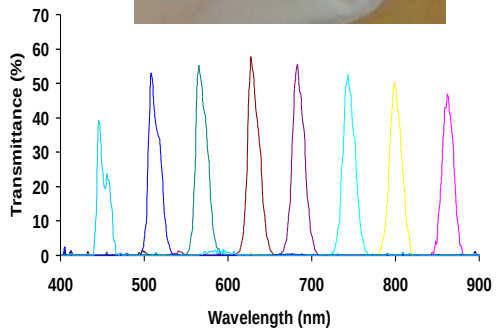
  (TL: PoliBa)
- *Task 1.4.4 Enabling technologies for deep-space, miniaturized platforms*

T1.4.3 **Goal**:
To demonstrate the validity of miniaturized technologies for deep-space exploration.









WP 1.3 – Distributed Space Systems: A Novel Paradigm for Earth Observation

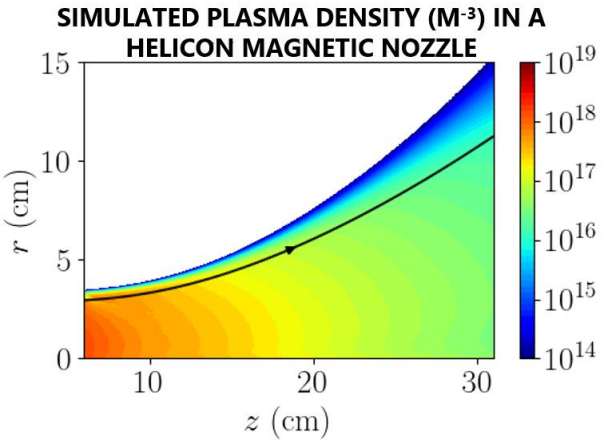
WP Leader: POLIMI

Task 1.3.4 – Enabling technologies for near-Earth satellites (TL UniTN)

- Promotes the advancement enabling technologies for distributed platform.

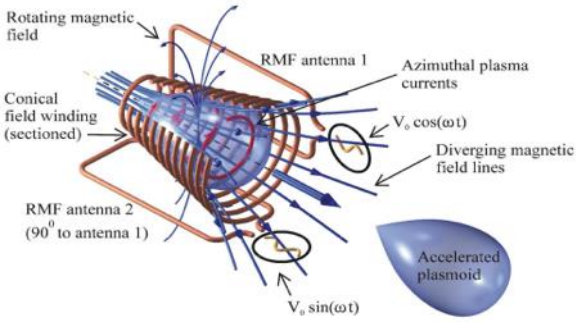
T1.3.4 ENEA Goal:

- Development of high-efficiency, innovative, electric plasma thrusters for near-Earth satellites.



SP²ICE
Space Plasma Propulsion for Interplanetary and Cislunar Exploration

- ✓ New research team **SP²ICE** (**S**pace **P**lasma **P**ropulsion for **I**nterplanetary and **C**islunar **E**xploration), main activities:
  1. Simulation, design and manufacturing of a **Helicon thruster prototype**
  2. Development of the **Phoenix test facility** for optimizing plasma generation with Helicon waves → ionization stage in plasma propulsion, plasma sources
  3. Ongoing work to start a **new experimental laboratory** (start date: mid-late 2025)
  4. Feasibility study, simulation and development of **Electrodeless Lorentz Force (ELF)** thrusters with **rotating magnetic fields** and emission of **plasmoids**
- ✓ Possible collaboration with INFN in **magnetic measurements in thruster prototypes**



ELF THRUSTER CONCEPT
Plasma Sci. Technol. 19 (2017) 083001 (24pp)

ENEA Spoke involvement

Spoke 8: **Robotic and Human Exploration of Extraterrestrial Habits, Architectures and Infrastructures**

WP 8.5 – Development of enabling systems and technologies for extraterrestrial habitats

WP Leader: L: UNIBO, CL: POLITO

Task 8.5.1 – Technologies, equipment and processes for space habitats

- Development of novel technologies, equipment and processes, including regenerative technologies.

T8.5.1 ENEA Goal:
- Radiation hardness study and development of advanced materials for habitats using ISRU.
- Feasibility studies of energy production by nuclear small modular reactors

Energy production

Needs of heat and electricity

to keep the operational temperature of instrumentation and communication systems and to supply energy

Spontaneous radioactive decay (Pu-238, U-235)

Radioisotope Heater Units (RHU) → *Low power ranges* (up to few Watts) ← Radioisotope Thermoelectric Generators (RTG)

Thermal

Electrical

Space (or Surface) Nuclear Reactors (SNR)

Fission

High power ranges
(early examples for satellites, NASA Kilopower: 40 kWe by 2028)

ENEA ASI Agenzia Spaziale Italiana

SELENE Project

Concept of Moon Energy Hub, responsible for the production, storage and transmission of electrical/thermal energy with one, or more, SNRs at its centre.

WP 8.5 – Development of enabling systems and technologies for extraterrestrial habitats

Task 8.5.2 – Human space protection systems

- Study of novel systems to support human exploration.

T8.5.2 ENEA Goal:

- Protection and radiation shielding tests of optical coating and ISRU materials.
- Study of novel detection for radiation monitoring.

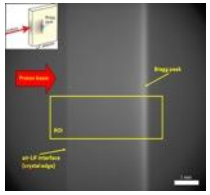
Radiation hardness & damage on:

- Materials (opticals, polymers, solid matrices)
- Systems, devices
- Instruments

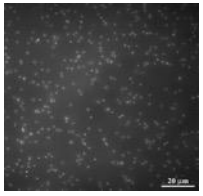
LITHIUM FLUORIDE RADIATION DETECTORS

Optical read-out solid-state ionizing radiation detectors and dosimeters based on lithium fluoride (LiF):

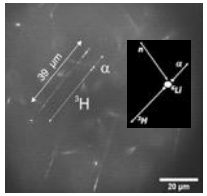
- ❑ Diagnostics of protons beams (TOP-IMPLART project)
- ❑ Fluorescent Nuclear Track Detectors (FNTD) for protons, ions and neutrons for nuclear energy, radiobiology (BIOTRACK project) and aerospace (space weather)



Bragg curve imaging *of proton beams in a LiF crystal*



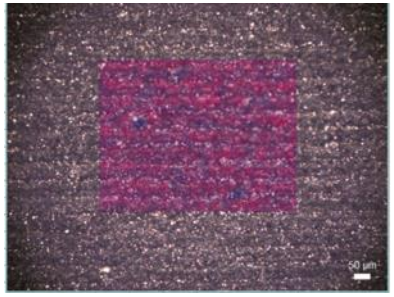
Fluorescent nuclear track detectors *based on LiF crystals for* ***protons***

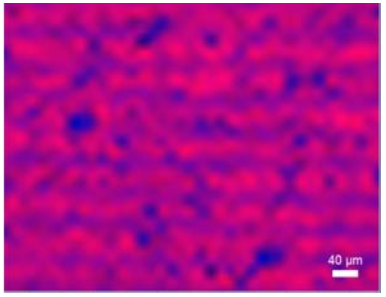


Fluorescent nuclear track detectors *based on LiF enriched crystals for* ***thermal neutrons***

ADVANCED COMPOSITE MATERIALS FOR RADIATION SHIELDING

- ❑ Fabrication and microstructure characterization of graphene - based polymer composites
- ❑ Evaluation and optimization of radiation shielding properties of graphene composites





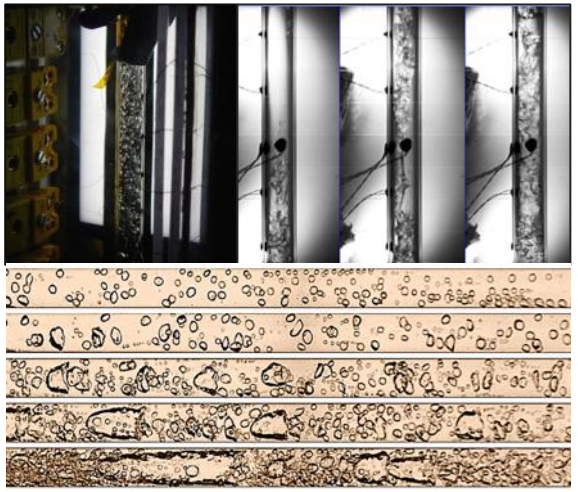
Raman spectral image of kapton (blue) and graphene (red) composite

WP 8.6 – Experimental research for advanced space exploration

WP Leader: L: POLITO, CL: INAF

Task 8.6.2 – Prototyping and experimental testing

- prototyping and testing of selected items up to TRL4/5, including tests in Moon/Mars physical analogues and/or in simulated environmental and living extraterrestrial habitats

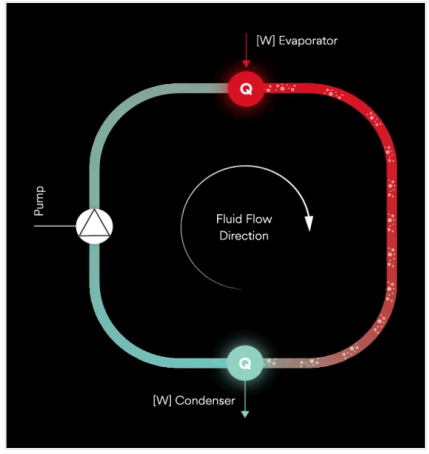


T8.6.2 ENEA Goal:

- Innovative two-phase flow cooling system for thermal management of space equipment (space greenhouse, power electronics, etc.)

Research activities

- Development of a Two-phase cooling system for space applications
- Two-phase thermal control of power electronic components for satellites and systems operating in reduced gravity conditions
- Integration with a space greenhouse for waste heat recovery



ENEA Spoke involvement

Spoke 9: Habitat Space and Science

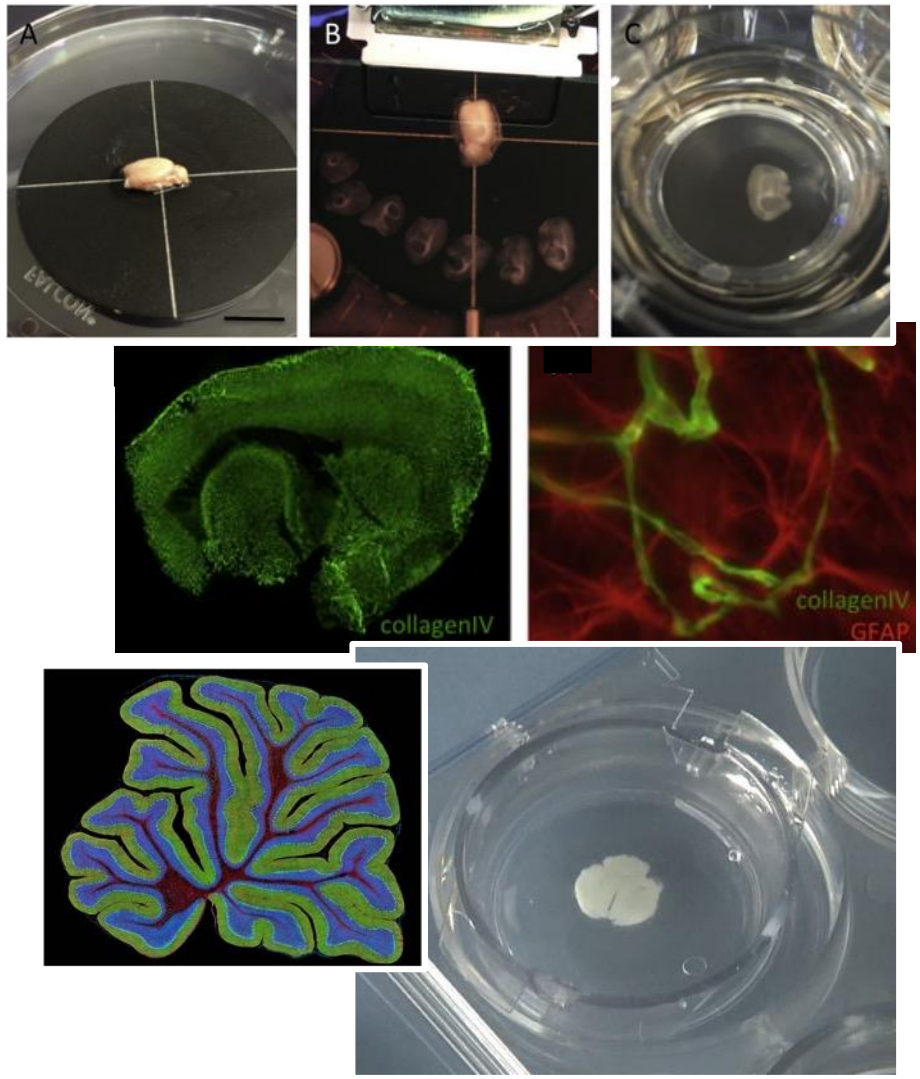
WP 9.4 - Human Life Science & Space Medicine

WP Leader: UNIROMA2

Tasks ENEA: SSPT-BIOTEC-RED

Task 9.4.2 – Experimental model to study radiation-induced neural effects

- Developing new *in vitro* organotypic brain slice cultures to study space radiation effects on 3D brain models
- Investigate the mechanisms through which radiation induces damage leading to cognitive impairment in the mouse brain ex vivo



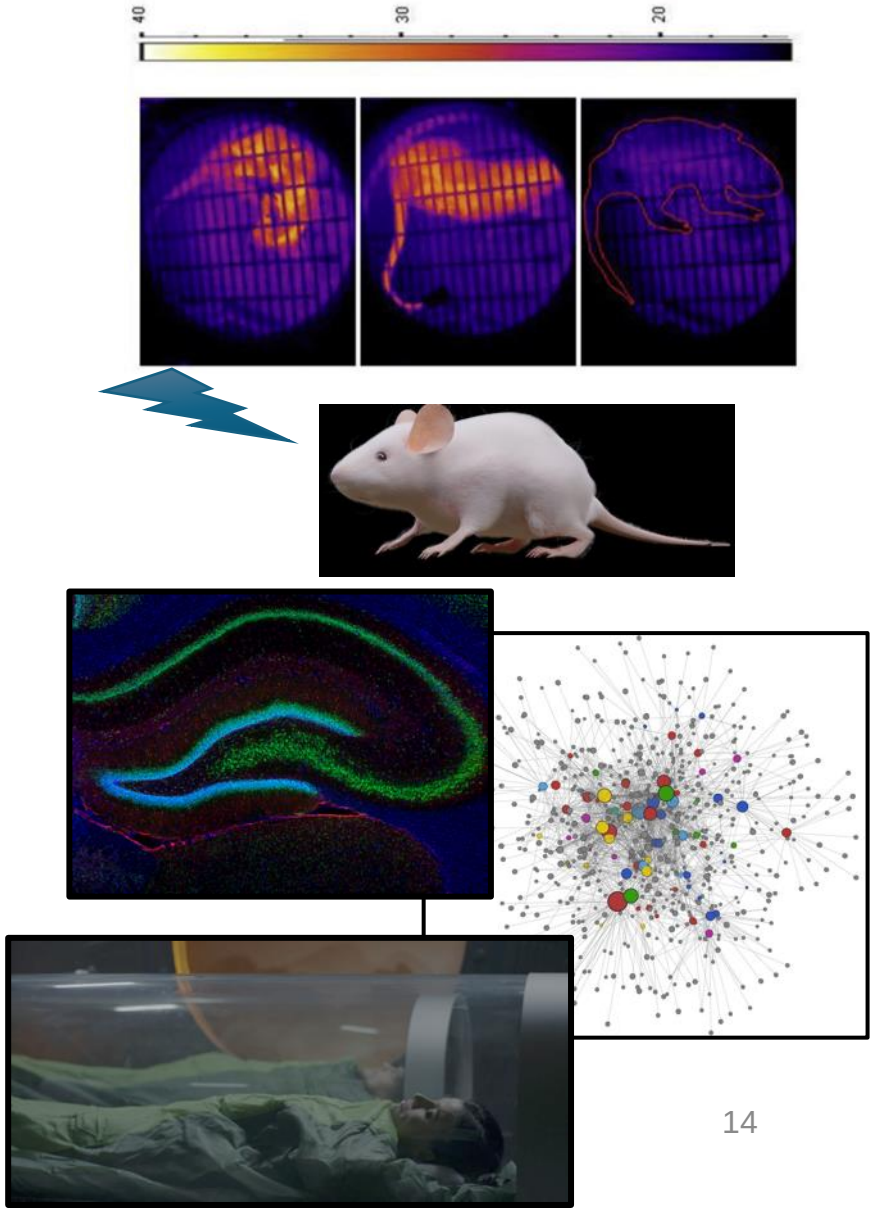
WP 9.4 - Human Life Science & Space Medicine

WP Leader: UNIROMA2

Tasks ENEA: SSPT-BIOTEC-RED

Task 9.4.3 – Development of countermeasures to mitigate radiation-induced effects

- Developing new protocols to induce syntetic torpor in radiosensitive mouse models
- Study the effects of syntetic torpor as radioprotector in animal models
- Explore the mechanisms by which synthetic torpor can safeguard animal from the harmful effects of cosmic radiation.



WP 9.4 - Human Life Science & Space Medicine

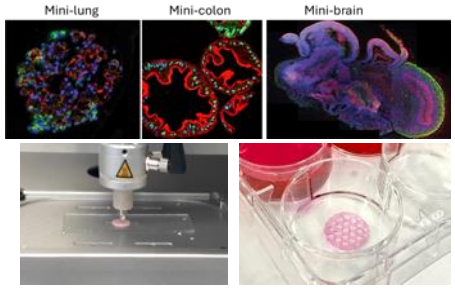
WP Leader: UNIROMA2

Tasks ENEA: SSPT-BIOTEC-RED

Task 9.4.4 – Identification of biomarkers of radiation exposure

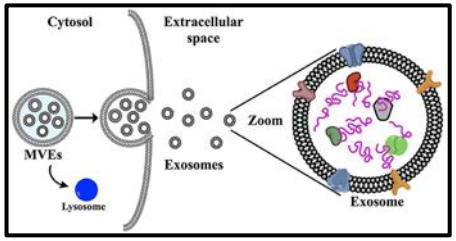
- Developing *in vitro* and *in vivo* models to explore new potential biomarkers of cosmic radiation exposure
- Irradiation of *in vitro* and *in vivo* models with protons and/or other charged particles to identify new biomarkers

2D e 3D cellular models



Mouse models

Integrated approach



New biomarkers identification and validation

Development of exposure tests

Development of specific treatments to counteract the effects induced by space radiation

WP 9.5 - Study and prototyping of technologies for the human being

WP Leader: UNINA

Tasks ENEA: SSPT-AGROS-AGRI4.0

Task 9.5.1 - Production of fresh food

- Developing high-tech controlled systems to guarantee safe and high-quality products
- Selection of plant species and varieties to ensure the correct nutritional intake.
- Study plants resistance to space radiation
- Role of gravity on seed-to-seed cycle

WP 9.5 - Study and prototyping of technologies for the human being

WP Leader: UNINA

Tasks ENEA: SSPT-AGROS-AGRI4.0

Task 9.5.2 - Bioregenerative life support systems (BLSSs)

- *In situ* recycling of the organic waste substance through appropriate bioconversion processes that return fertilizers and substrates for plant growth
- Selection of decomposing organisms involved in BLSSs
- Defining a self-sufficient and efficient system based on bio-recycling processes

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