UNITED NATIONS
Office for Outer Space Affairs

SPACE4SDGS

UNOOSA -
Hypergravity/Microgravity
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Altered gravity platforms in space research

Two applications of *in vitro* space simulations models

Silvana Ferreira da Silva Miranda

sfdsmira@sckcen.be

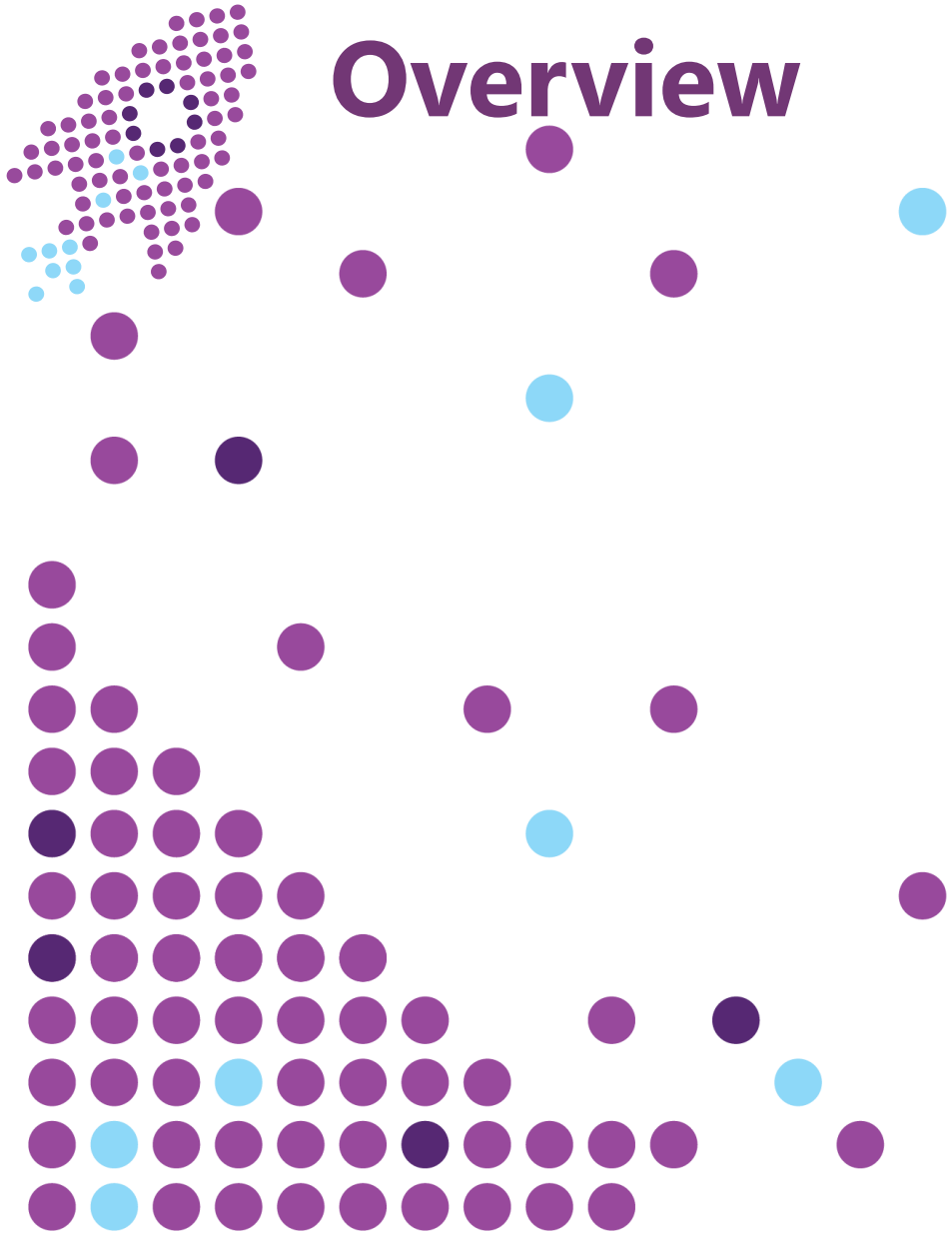
Eline Radstake

eline.radstake@sckcen.be

sck cen
Belgian Nuclear Research Centre

UNIVERSITEIT GENT

Overview



Space environment

Space simulation models

Immune system

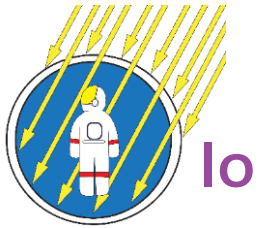
Skin – wound healing

Hypergravity project

Space Environment

Altered gravity

- Acute:
  - Space motion sickness
  - Adaptation process
- Chronic:
  - Deterioration of multiple physiological systems



Ionizing radiation

- Acute:
  - Solar particle events: increased dose, high energy protons
- Chronic:
  - Galactic cosmic rays: highly charged, energetic atomic nuclei (HZE) particles

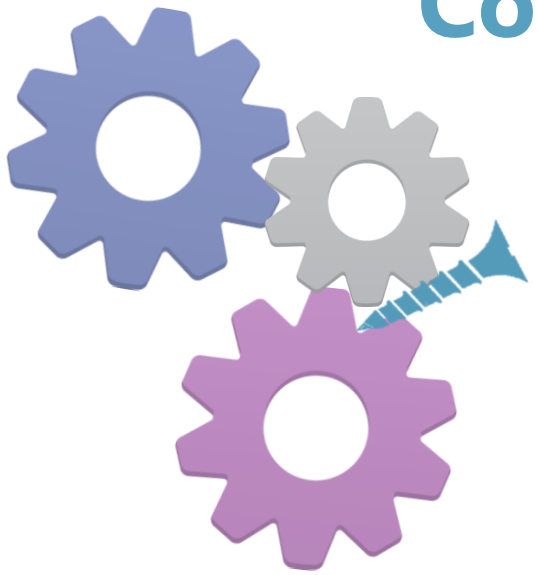
Psychological stress

- Acute:
  - Adrenal gland releases adrenaline and cortisol
  - Fight-or-flight
  - Goal: restore allostasis
- Chronic:
  - Prolonged exposure to cortisol
  - Maladaptive

Space Environment

Mechanisms?

Countermeasures?

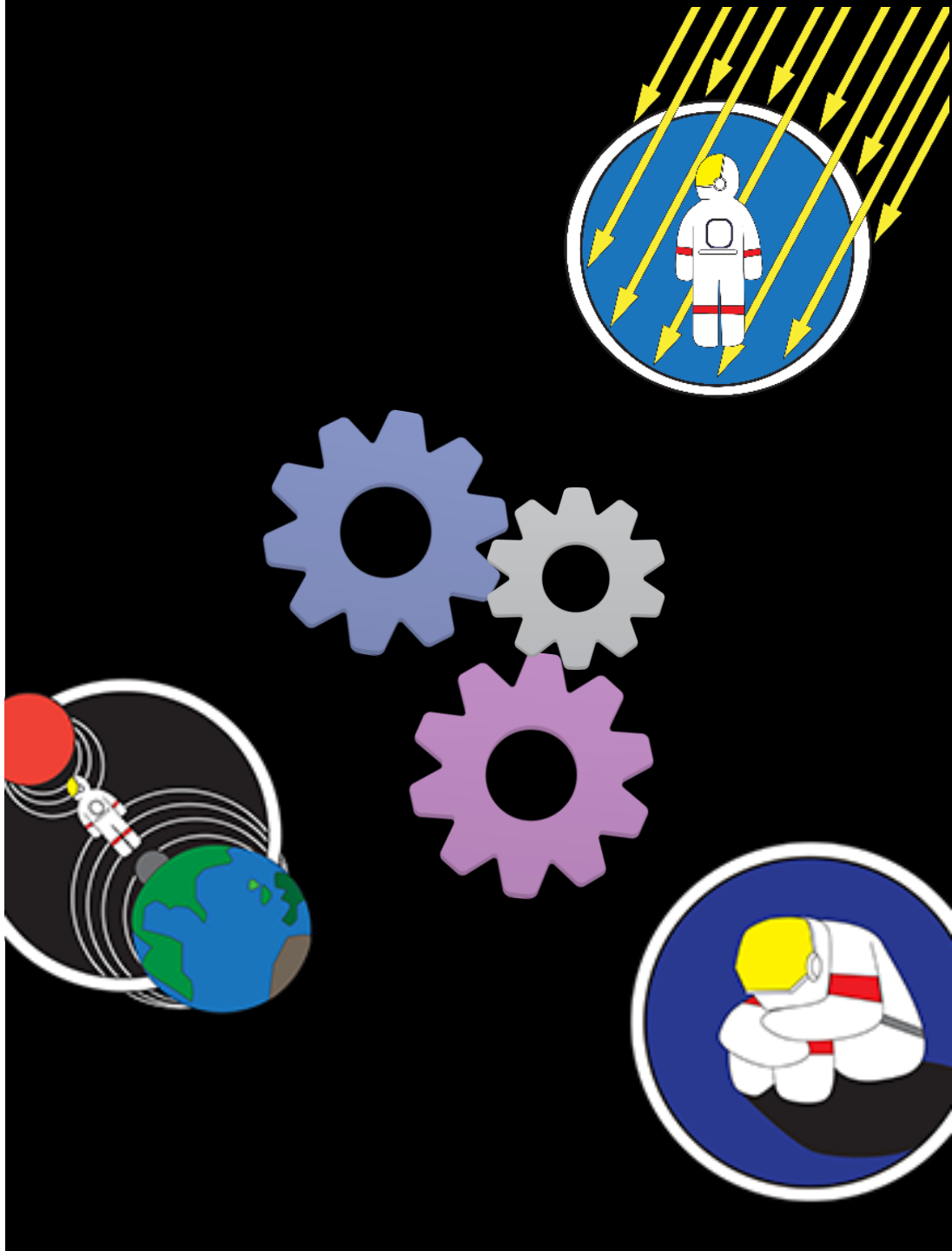


Space simulation model

Limitations ISS/spaceflight studies:

- Small sample sizes
- ISS missions vs. interplanetary missions
  - Duration
  - Space radiation field
- Effect of spaceflight stressors alone vs. in combination

➔ Development of ***in vitro*** model to investigate cellular responses to the combined spaceflight environment



Ground Control to Major T-Cell

T-Cells as models for space immune dysfunction

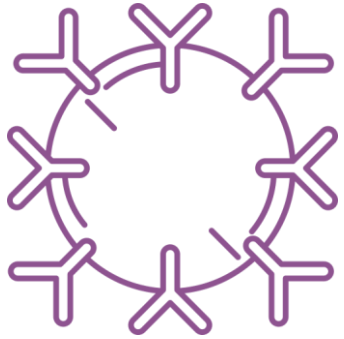
T-Cells

Key regulators of the cellular immune response

Kill infected cells

Activate other immune cells

Provide memory immunity



Space immune dysfunction

Reduced T-Cell activity

Diminished cell numbers

Increased reactivity (e.g. Allergies)

Interaction between µG and radiation

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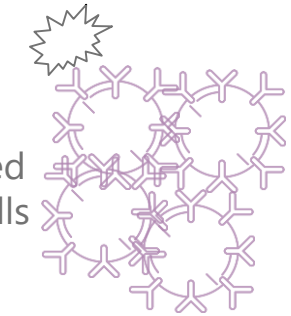
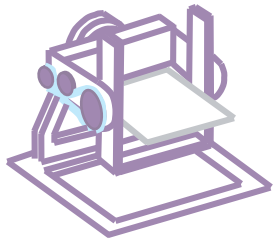
Yatagai, F., et al. (2019). "Biological effects of space environmental factors: A possible interaction between space radiation and microgravity." Life Sciences in Space Research **20**: 113-123.

Ground Control to Major T-Cell
Methodology



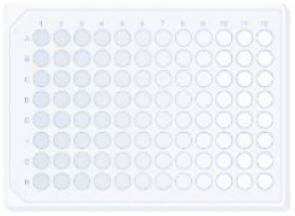
Stimulated Jurkat Cells



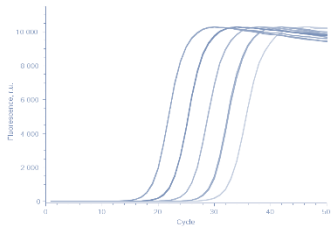
Altered Gravity

Ionizing Radiation

Stress hormones

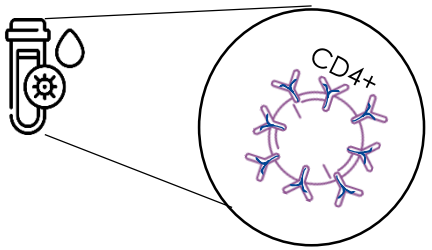


IL-2 Concentration

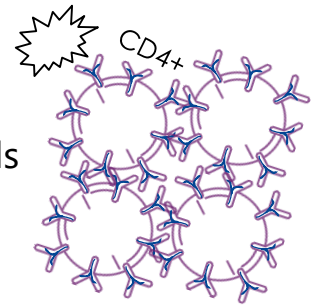


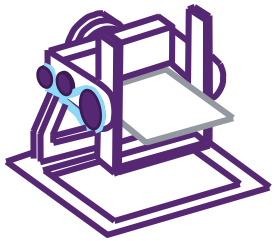
IL-2 gene expression

CD4+ T-Cell extraction



CD4+ T-Cells stimulated





Altered Gravity

Ionizing Radiation

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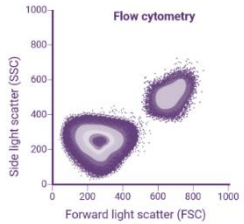
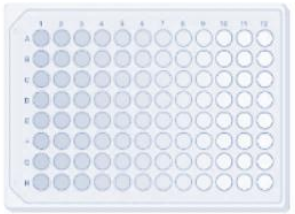
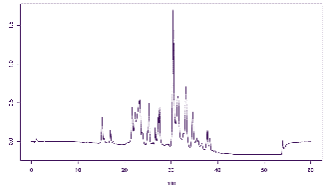


Flow cytometry



Cytokine profiling

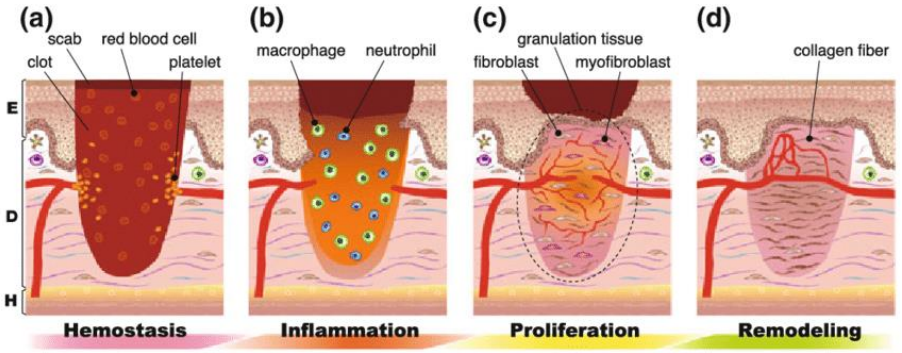
Proteomics



Transcriptomics

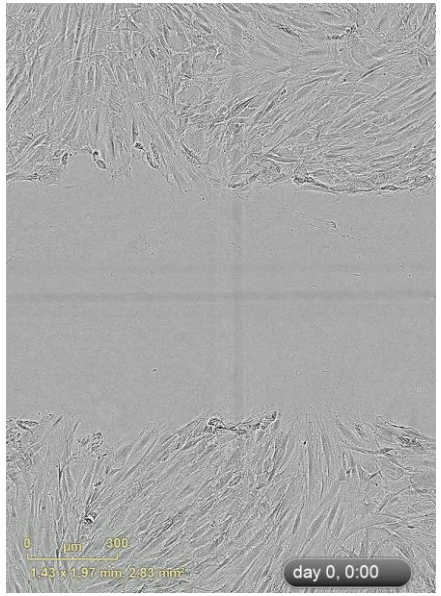
Wound healing in space

Astronauts report delayed cutaneous wound healing during spaceflight



- Interference in complex process of wound healing leads to defective repair
- Fibroblast migration to wound site and interaction with ECM is crucial for wound healing process

➢ **Investigate migration capacity and ECM protein expression of fibroblasts exposed to simulated spaceflight environment**

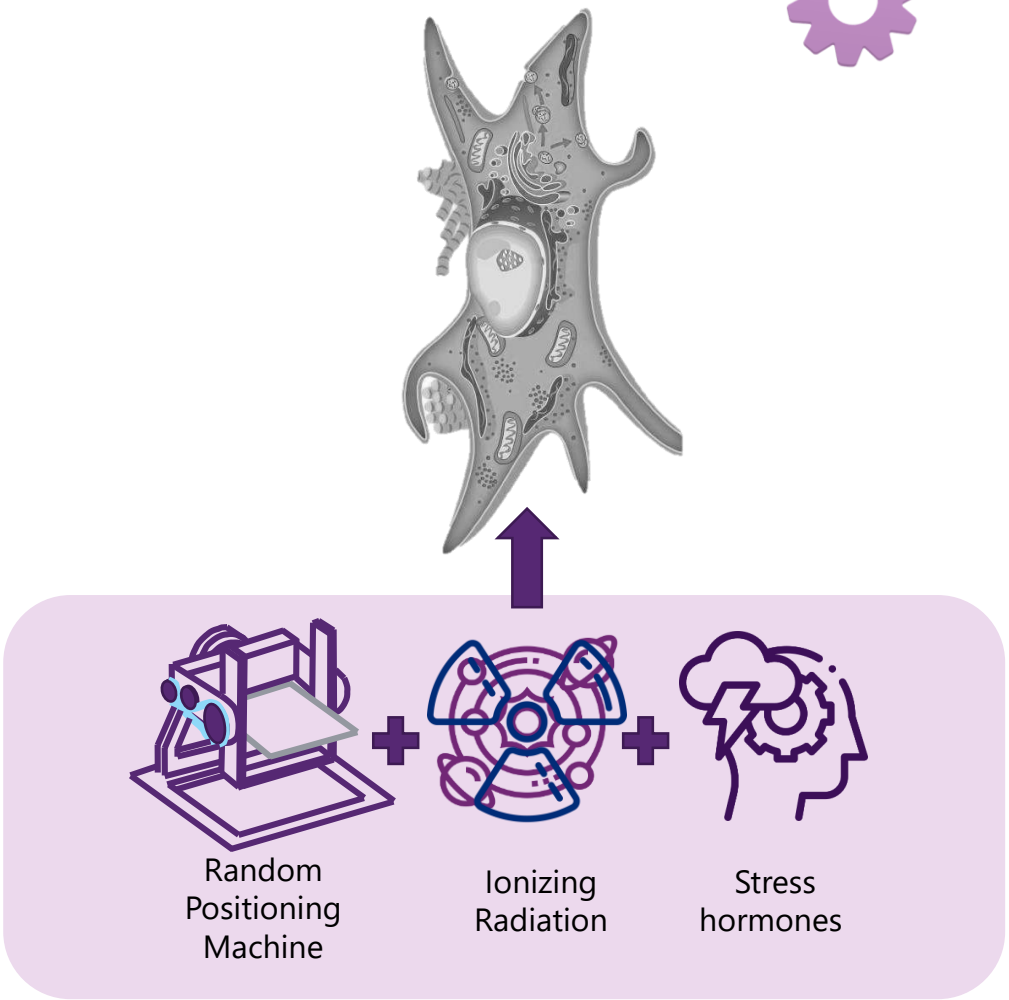


[Gontcharov et al. 2005]

Wound healing in space
Methodology

- Human primary dermal fibroblasts ➔ major cellular component of the dermis

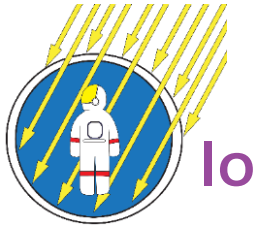
- Simulated spaceflight stressors:
  - Random Positioning Machine for micro- and partial gravity simulation
  - Ionizing radiation, high- vs. low LET
  - Hydrocortisone exposure in the medium



Wound healing in space

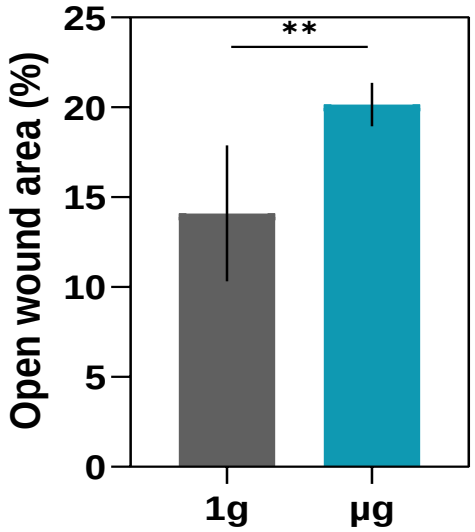
Preliminary results

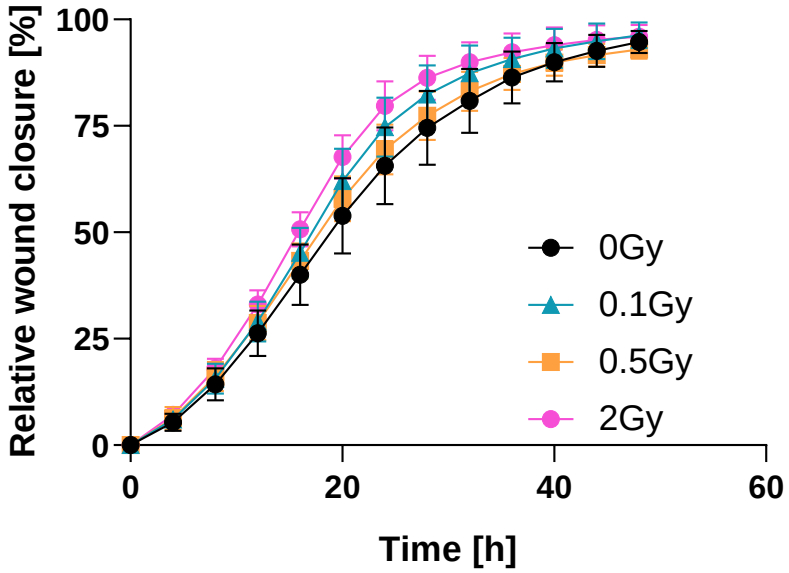
Altered gravity

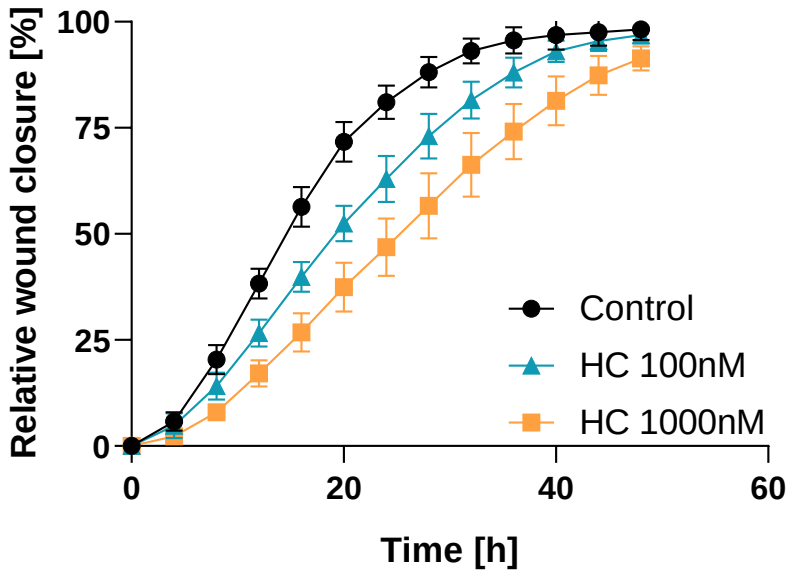


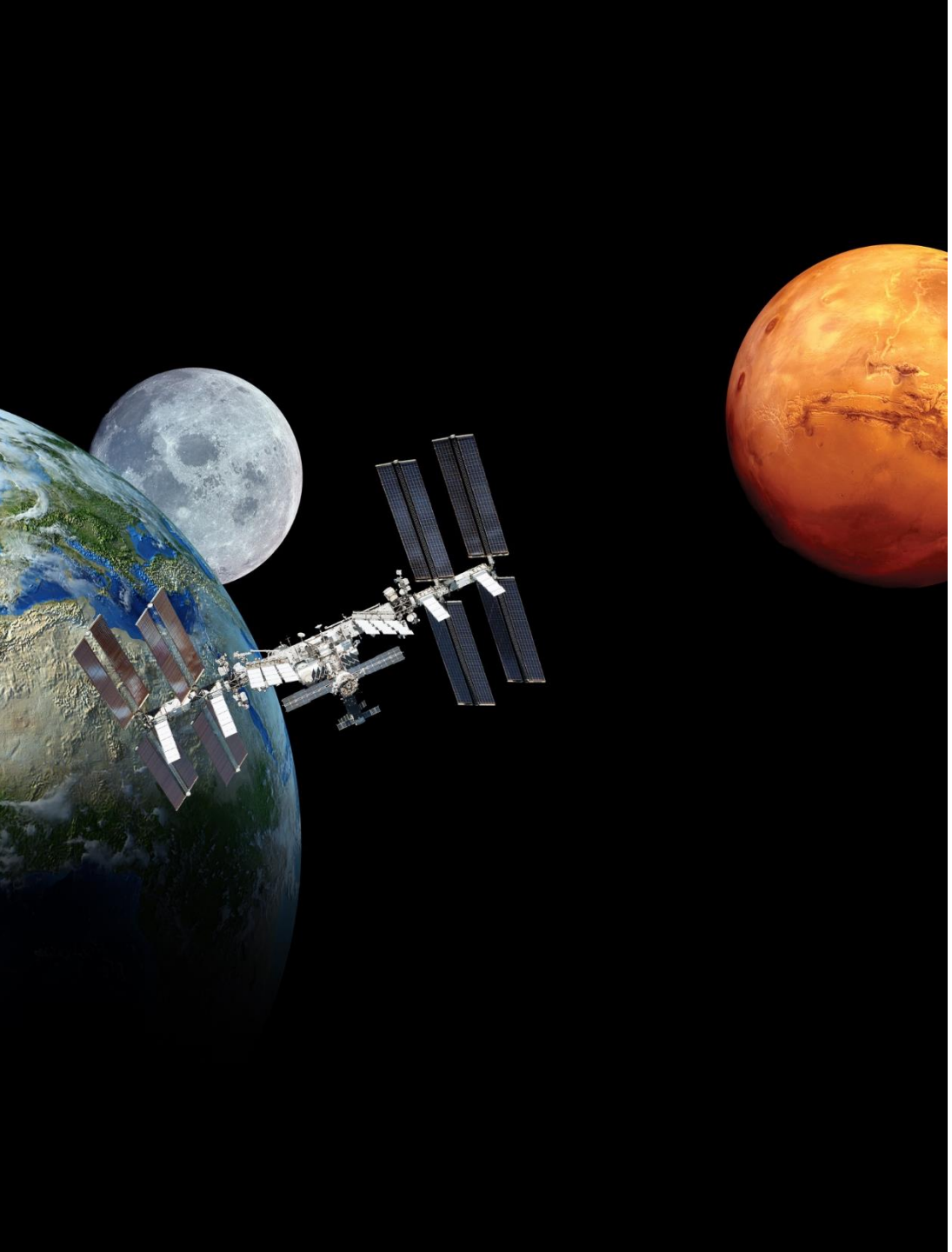
Ionizing radiation

Psychological stress









Long-duration spaceflight

Case report of skin sensitivity after one-year space mission

- Erythema and skin sensitivity
- Gravity-dependent areas
- Interruption of post-flight activities

➔ Development of effective countermeasures

[Law et al. 2020]

Countermeasures?
Objectives SYT! 2021 project

Hypergravity exposure using the **Large Diameter Centrifuge (LDC).**

- Investigate the potential of hypergravity to **counteract** spaceflight-induced **delayed wound healing**

- Document **space-related defects** in wound healing and a possible interplay with elevated stress levels experienced in space

- ESA's Large Diameter Centrifuge
- 8m diameter
- Up to 20 times Earth's gravity

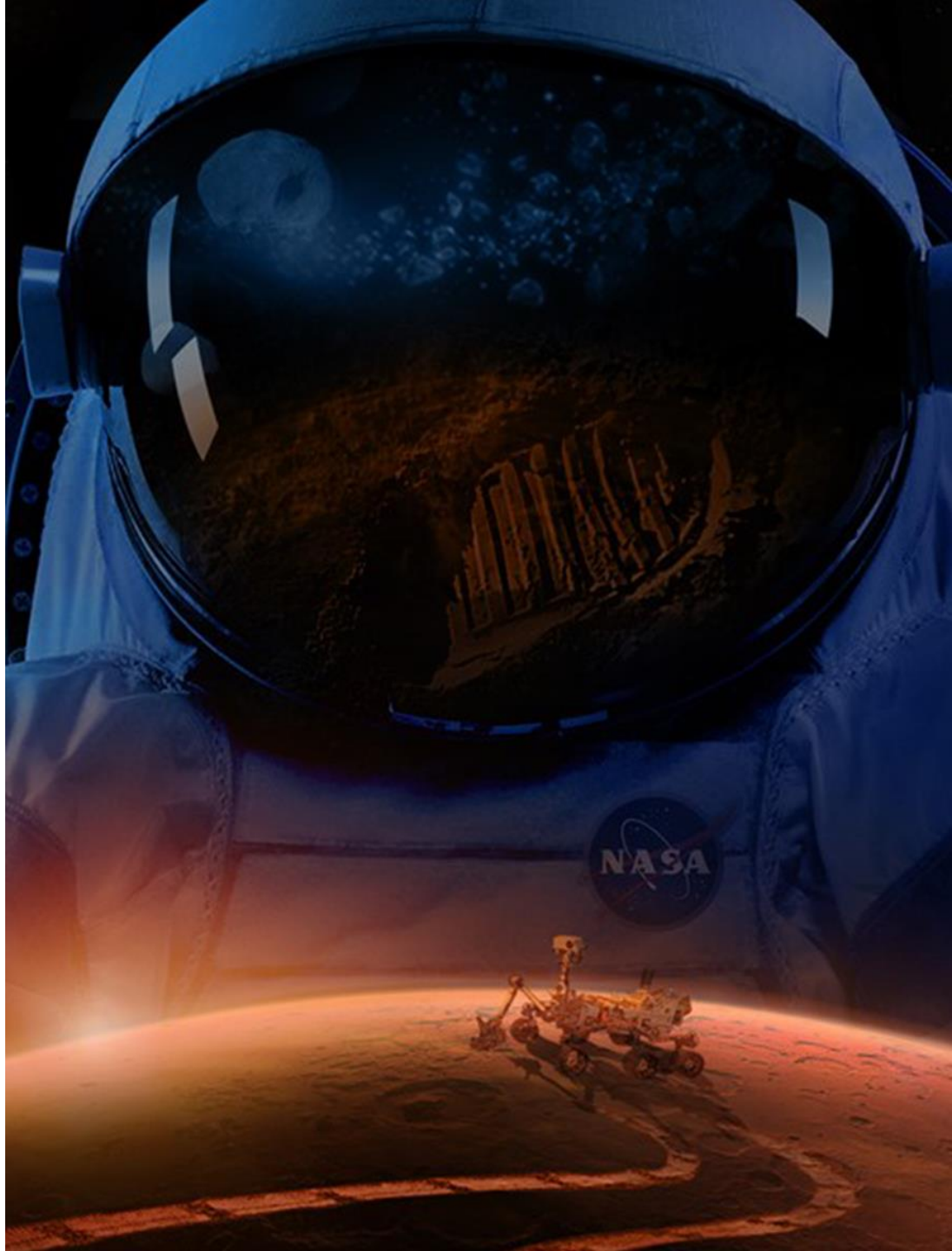
Conclusion

Better risk assessment for deep-space exploration

- More insights into possible interaction effects of spaceflight stressors
  - Synergistic, antagonistic, or additive effects

Better insights into gravity dependent fibroblast functions related to wound healing

- Reveal altered cellular functioning
  - Indication for possible countermeasure development



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Literature

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