EURADOS

Radiation measurements onboard spacecraft and satellites within the CRREAT project

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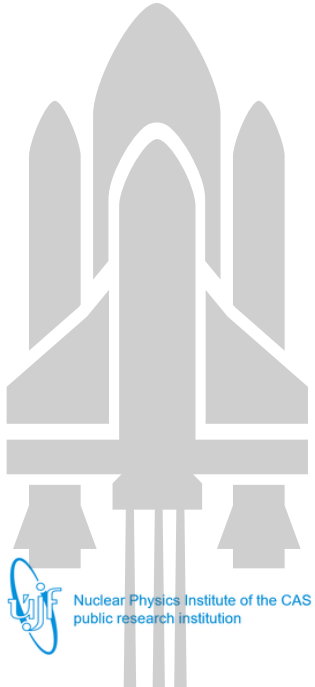
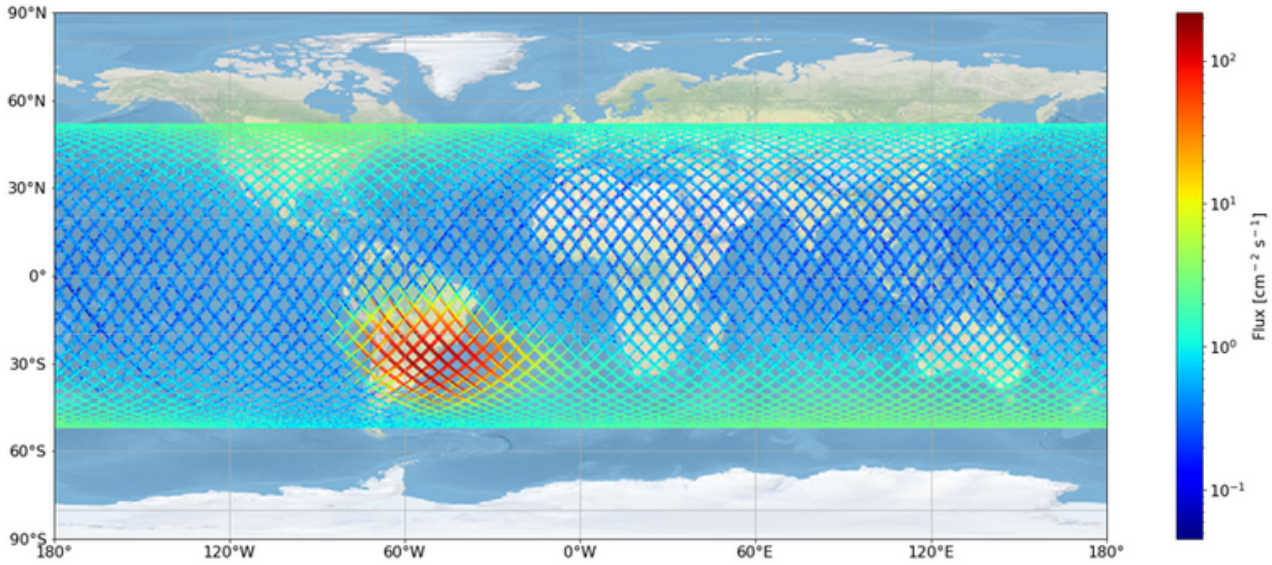


CRREAT
EUROPEAN UNION
European Structural and Investing Funds
Operational Programme Research, Development and Education
MINISTRY OF EDUCATION, YOUTH AND SPORTS
CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE
INSTITUTE OF ATMOSPHERIC PHYSICS CAS
Nuclear Physics Institute of the CAS public research institution

SPACEDOS at ISS



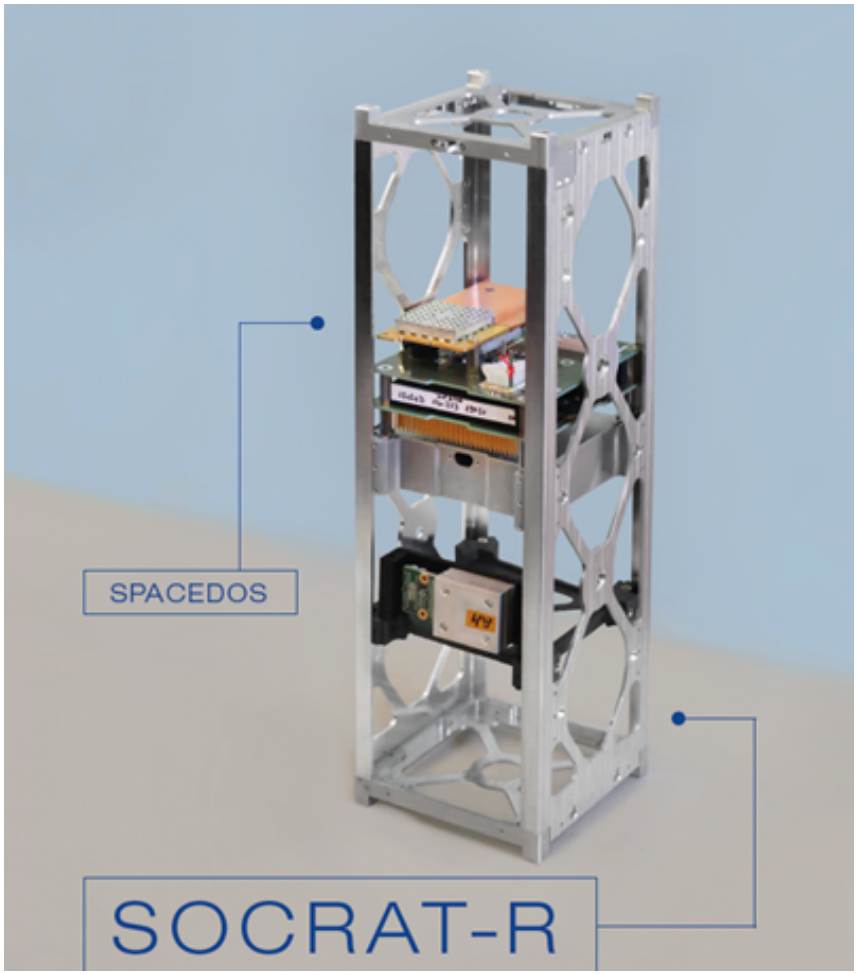
Campaign 61
September 26, 2019 - February 3, 2020
Campaign 63/64
October 14, 2020 - April 13, 2021

SPACEDOS

Open-source
Energy channels: 240
Deposited energy range: 0.2-8.5 MeV
Energy resolution: < 50 keV/channel
Power supply: 3.3 V / 3 mA (4 months operation on battery)

SOCRAT-R 3U Cubesat

Soyuz-2.1b rocket on June 5, 2019
Inclination 97.5°
Altitude 520 km



Goals
Testing of microprocessors in space environment

Testing of radiation detectors

Radiation detector
SPACEDOS - open-source pin diode

Still operational and functional

We received only part of data

Lucky-7 1U Cubesat

Soyuz-2.1b rocket on June 5, 2019
Inclination 97.5°
Altitude 520 km

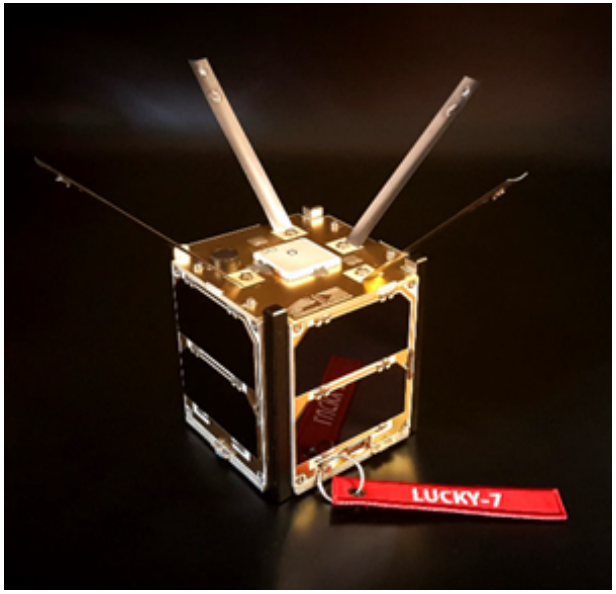
Goals

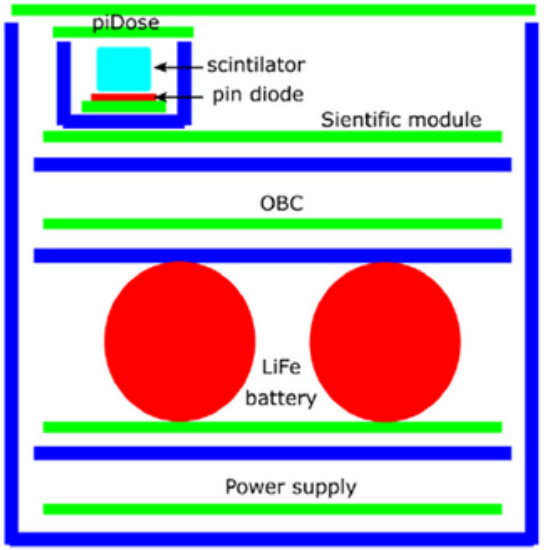
Testing of electronics, GPS receiver, and communication system in LEO orbit

Measurement of the space radiation

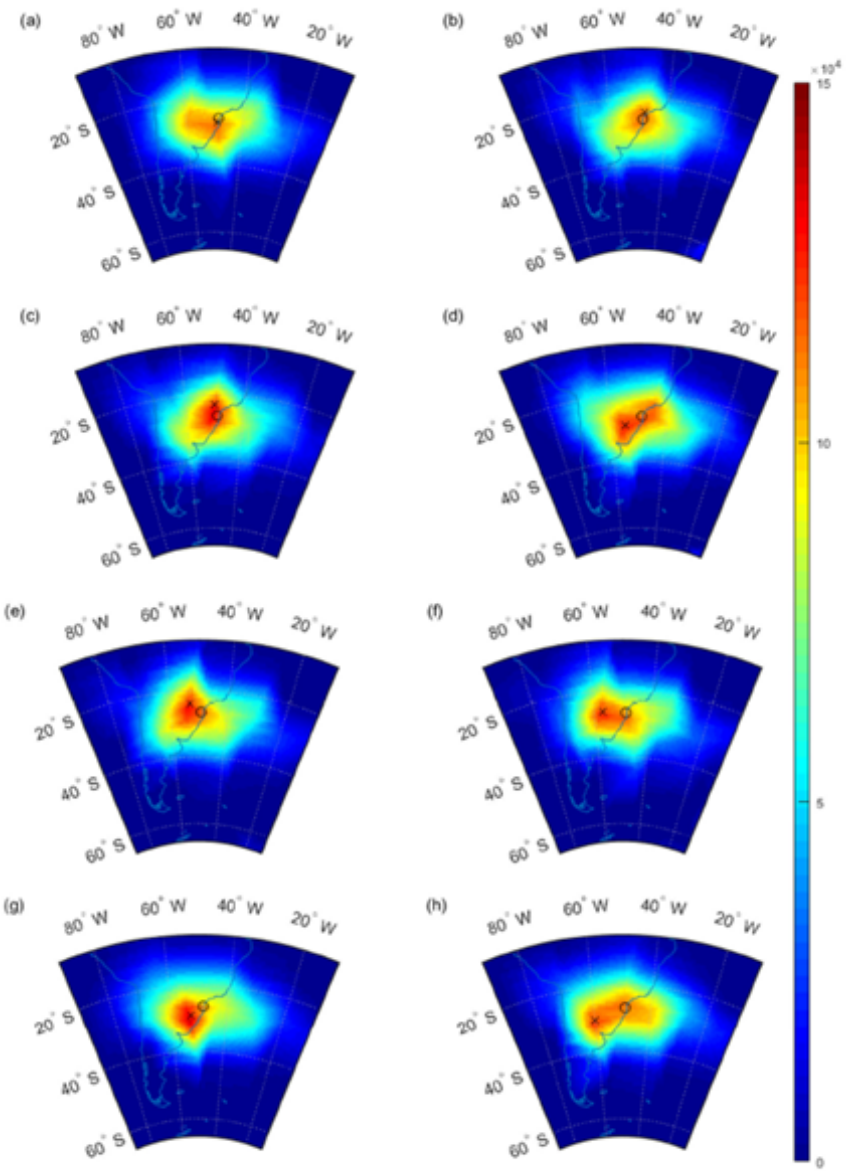
Radiation detector

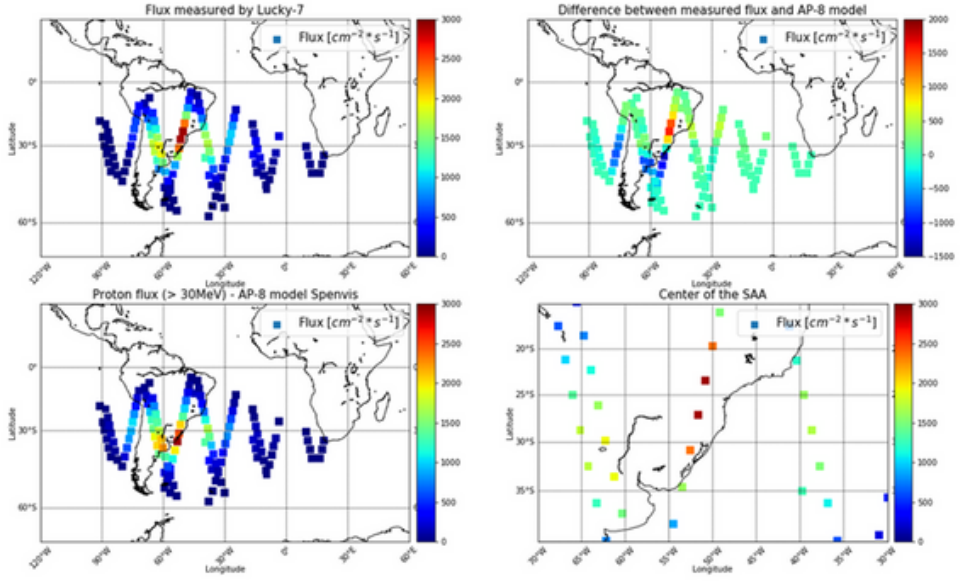
CsI(Tl) scintillator with pin diode X100-7





Lucky-7 results

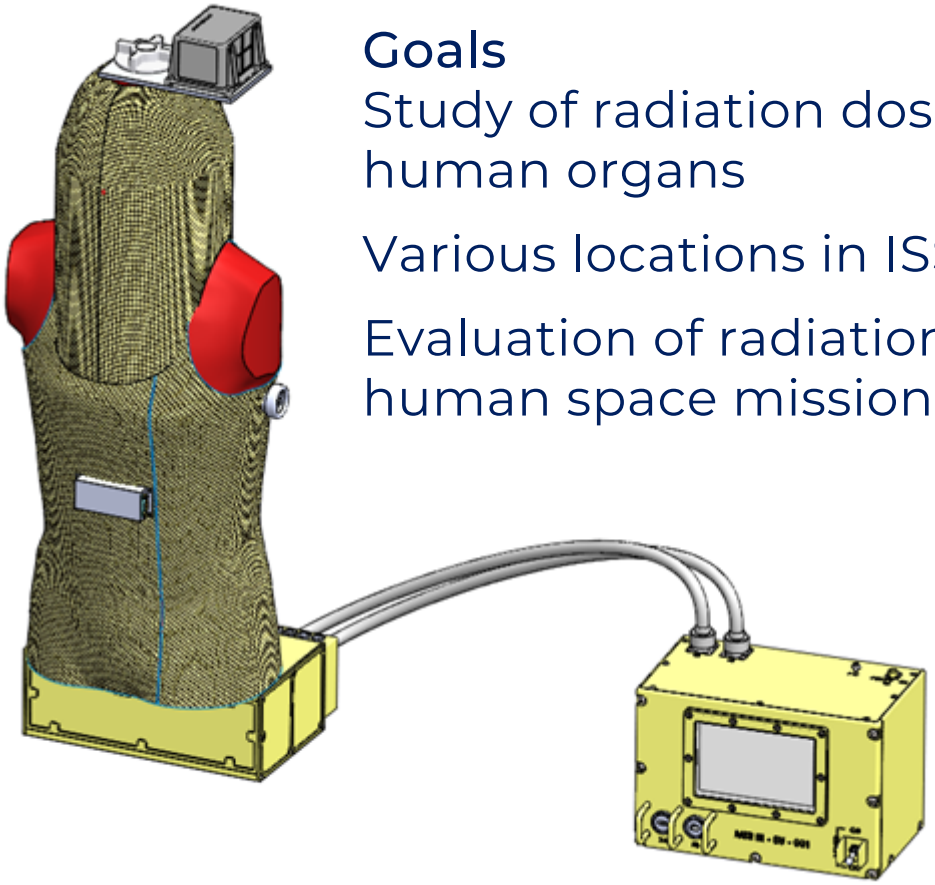




Kovář P., Sommer, M., Matthiae, D., & Reitz, G. (2020). Measurement of cosmic radiation in leo by 1U cubesat. Radiation Measurements, 139, 106471.

Kovář, P., & Sommer, M. (2021). CubeSat Observation of the Radiation Field of the South Atlantic Anomaly. Remote Sensing, 13(7), 1274.

Matroshka-III



Goals

Study of radiation doses received by human organs

Various locations in ISS

Evaluation of radiation risks for human space missions

Scheduled launch 2023

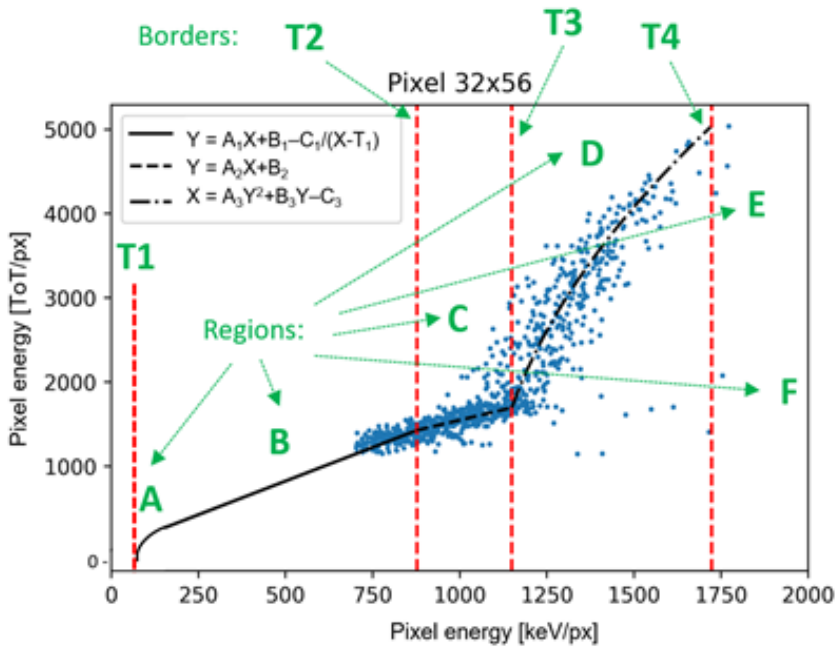
Parties involved

Russia, Germany, Czech Republic, Hungary, Bulgaria, Poland, Canada, Japan

Radiation detectors

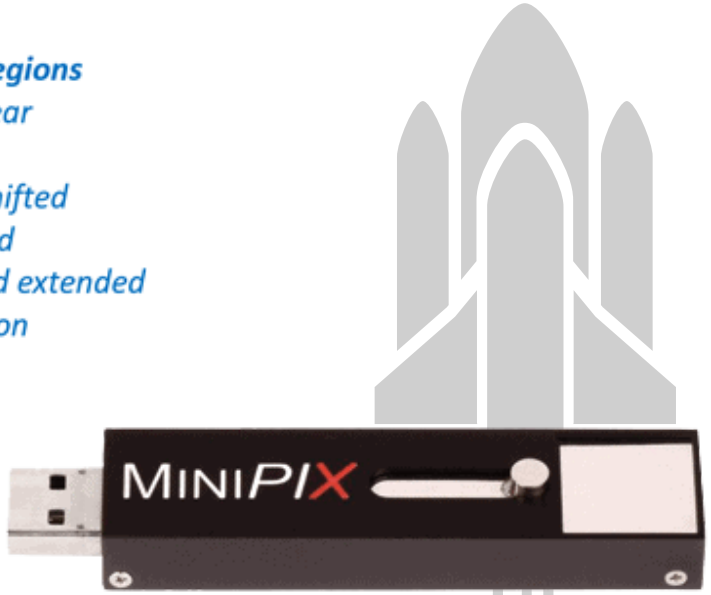
Two Minipix Timepix detectors (on the surface and inside of phantom), TLDs, and TEDs

Minipix Timepix



Response regions

***A** = non-linear*
***B** = linear*
***C** = linear shifted*
***D** = distorted*
***E** = distorted extended*
***F** = saturation*



Dynamic frame rate

That should have covered large fluences in SAA as well as low fluences of GCR

High-energy per-pixel calibration

Correct assessment of absorbed dose from heavy ions (850 keV/px → 1700 keV/px)

Stability of per-pixel calibration

Ongoing issue

Sommer, M., Granja, C., Kodaira, S., & Ploc, O. (2022). High-energy per-pixel calibration of timepix pixel detector with laboratory alpha source. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 1022, 165957.

BION-M2

Scheduled launch in 2023, altitude of 800 km

Duration of mission 30 days

The satellite will carry 75 mice

Supporting radiation measurements should have been carried out by CZENDA – LET spectrometer, SPACEDOS, Si pixel detector and passive detectors

CZENDA collaboration

Nuclear Physics Institute CAS

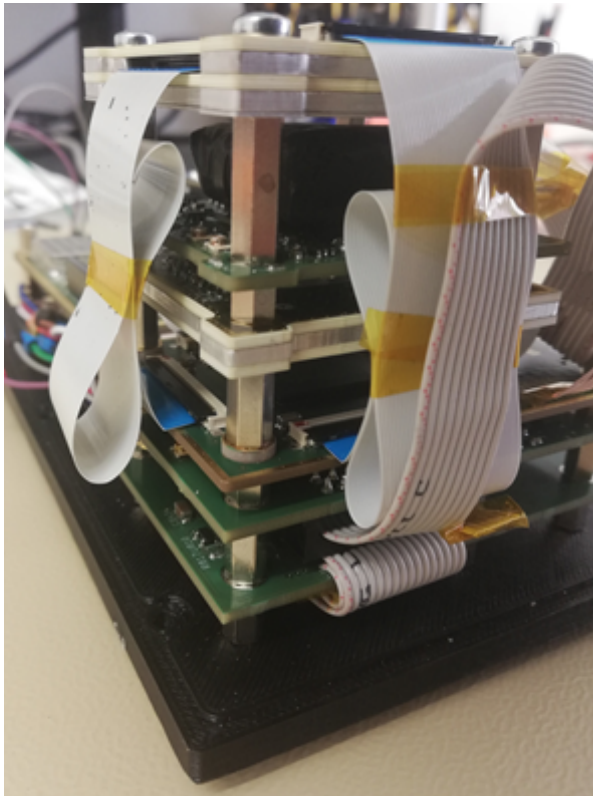
Faculty of Nuclear Sciences and Physical Engineering CTU

ESC Aerospace

Hybrid silicon/scintillator LET spectrometer

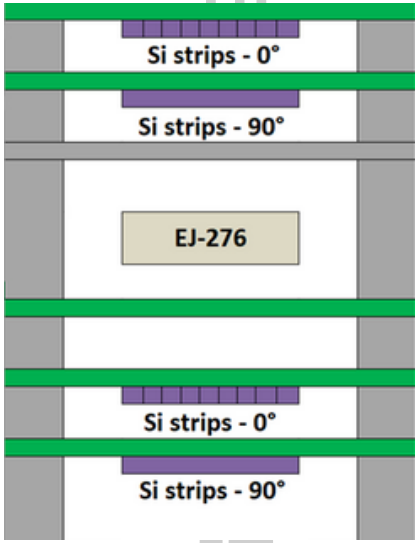
64 silicon strips in each layer
Strip 19.0 x 0.25 mm^2
Active volume 20.0 x 20.0 x 0.5 mm^3

Silicon strips in criss cross pattern
Allows to determine the incident angle of particle if particle traversed through all 4 layers



Plastic scintillator EJ-276 (Eljen Technology)

- Pulse shape discrimination (PSD)
- Size 20 x 20 x 6 mm^3
- 2 sets of SiPM (35 µm and 20 µm)



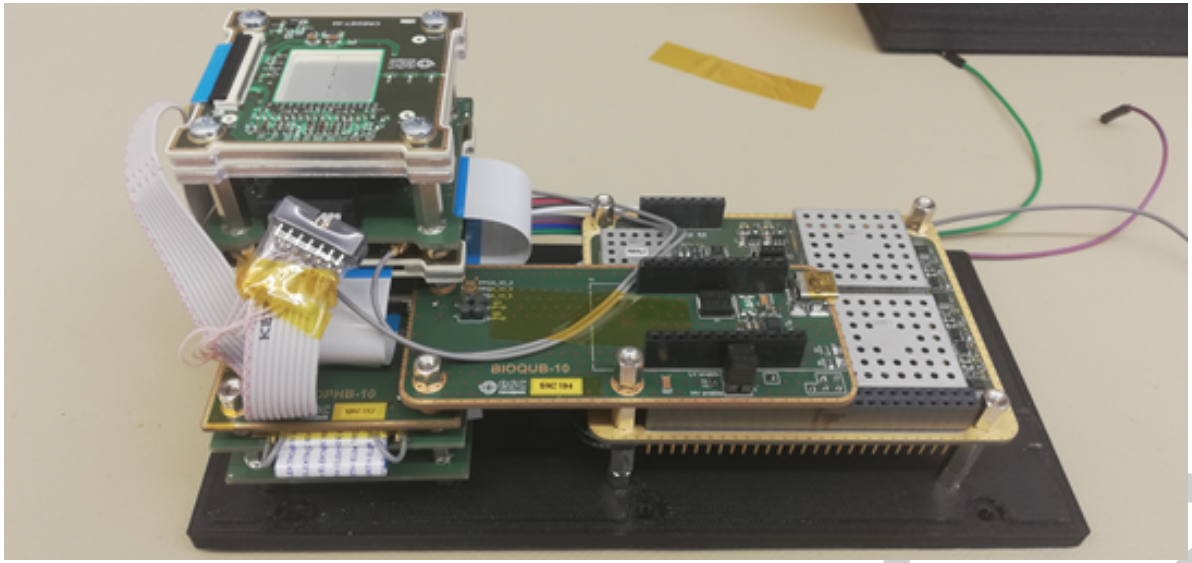
Hybrid silicon/scintillator LET spectrometer

Combination of information from silicon strips and plastic scintillator should give us complete image of radiation dose in space environment

Neutron sensitive - EJ-276 PSD

LET spectra - conversion factors

Dose equivalent



Sommer, M., Krist, P., Kákona, M., & Ploc, O. (2021). Novel Model for Analysis and Optimization of Silicon Photomultiplier-Based Scintillation Systems. IEEE Transactions on Nuclear Science, 68(12), 2771-2778.

Conclusion

Three successful space missions

SPACEDOS at ISS, SOCRAT-R, Lucky-7

Two missions in advanced state of progress but will most likely not be realized

Matroshka-III, BION-M2