SERESSA 2022
5th to 9th of December at CERN, Geneva

SpaceRadMon-NG, the new generation version of space Radiation Monitoring Payload

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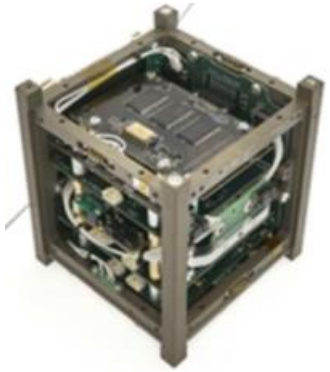
Why developing a new Payload?

2015

CELESTA

- **CE**rn **L**atchup **E**xperiment and **ST**udent s**A**tellite
- The first CERN driven 1U satellite
- Collaboration of CERN and CSU



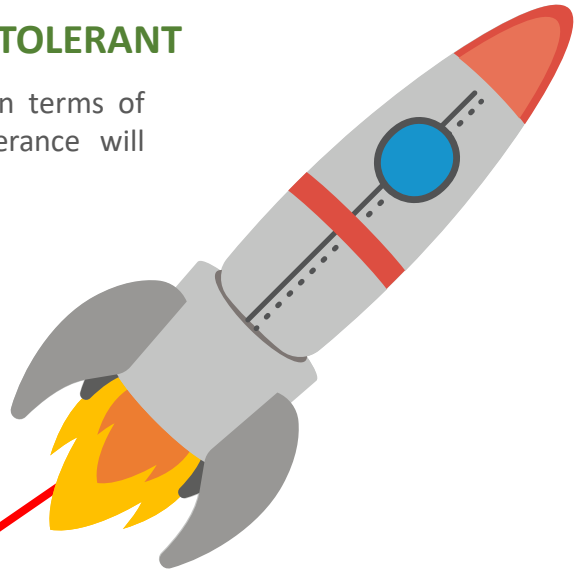
- SRAM Latch-up Experiment: Compare radiation levels between equator and poles
- Comparison of radiation effects between LEO space environment and CHARM
- Nanosatellites radiation qualification procedure at CHARM

HIGHER VERSATILITY

The current CELESTA interface represents a limitation for payload integration in a large number of missions.

LOW POWER AND MORE RAD TOLERANT

A platform with improved capabilities in terms of power consumption and radiation tolerance will allow use in harsher and longer missions.



IMPROVE SENSOR CAPABILITIES

The increased resolution will enable the platform to improve radiation monitoring performance and better characterize the space environment.

New Payload Generation timeline

2015

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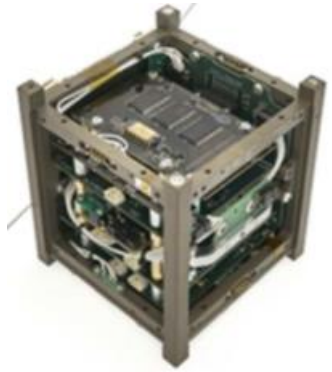

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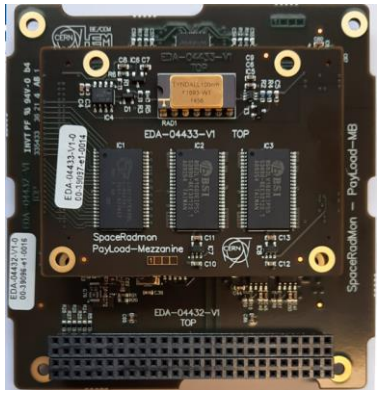


2018

SPACERADMON V2

Space RadMon V2

- While CELESTA was developed for a specific mission, SpaceRadMon is intended to be a platform that can be used by multiple customers.
- Funded by KT

Challenges

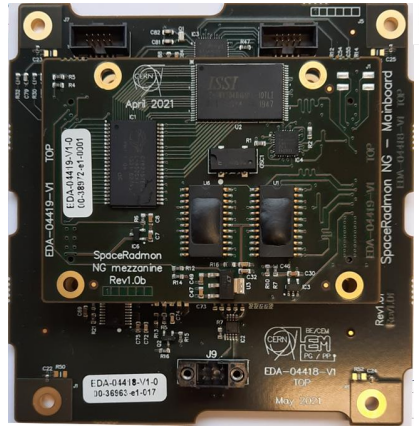
- Low power
- More radiation tolerant
- Better sensor resolution

2020

SPACERADMON NG

Space RadMon NG

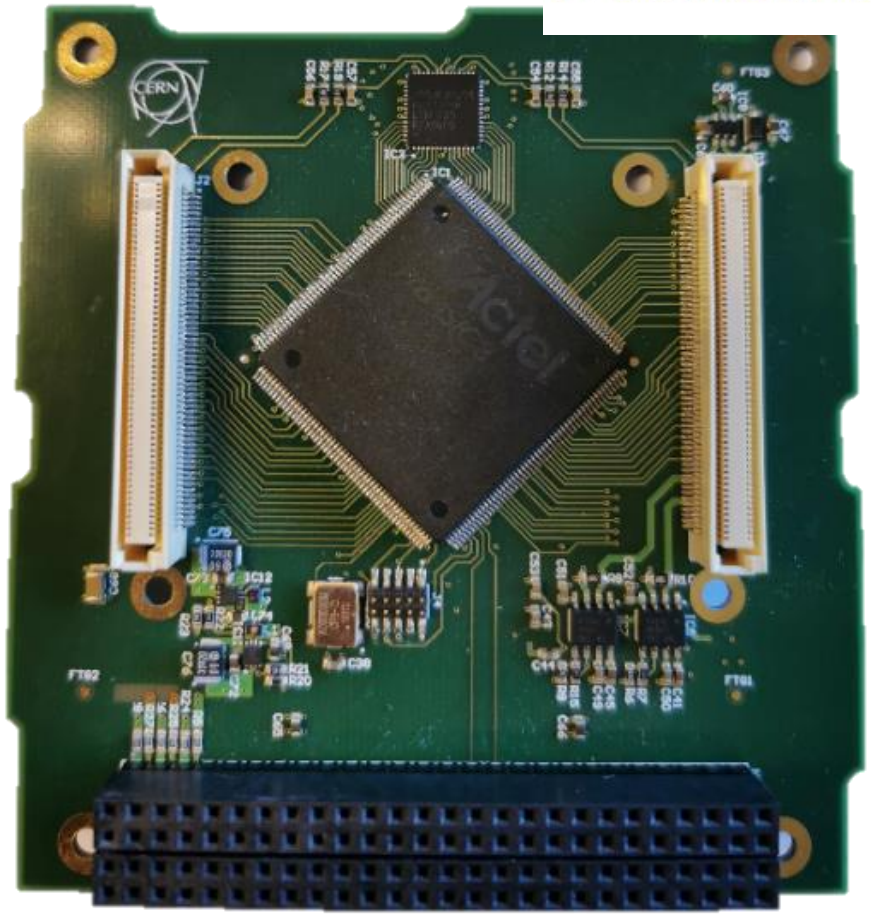
- These features make it the first example of a new generation of payloads for radiation monitoring in space, making it attractive for a larger number of missions.
- Funded by KT



SpaceRadMon V2

- SpaceRadMon V2 is the first successor of CELESTA
- CELESTA monitoring performance and most of the hardware have been retained in this version
- Based on **qualified COTS**.
- CAN Interface has been replaced by I^2C
  - Easier integration.
  - More flexible interface.
- Complies with PC/104 standard
  - High Customer requests.

Can we do better in terms of Electrical and Monitoring Performances?



What is still missing?

HIGHER RELIABILITY

A **mechanical weakness** was experienced in SpaceRadMon V2

MORE RADIATION TOLERANT

The **lifetime** of SpaceRadMon V2 is still **limited to 250 Gy** because of the ADC used.

LOW POWER

The system's power consumption is not reduced compared to CELESTA and, like its predecessor, it does **not** have a **power-saving mode** to reduce consumption according to the needs

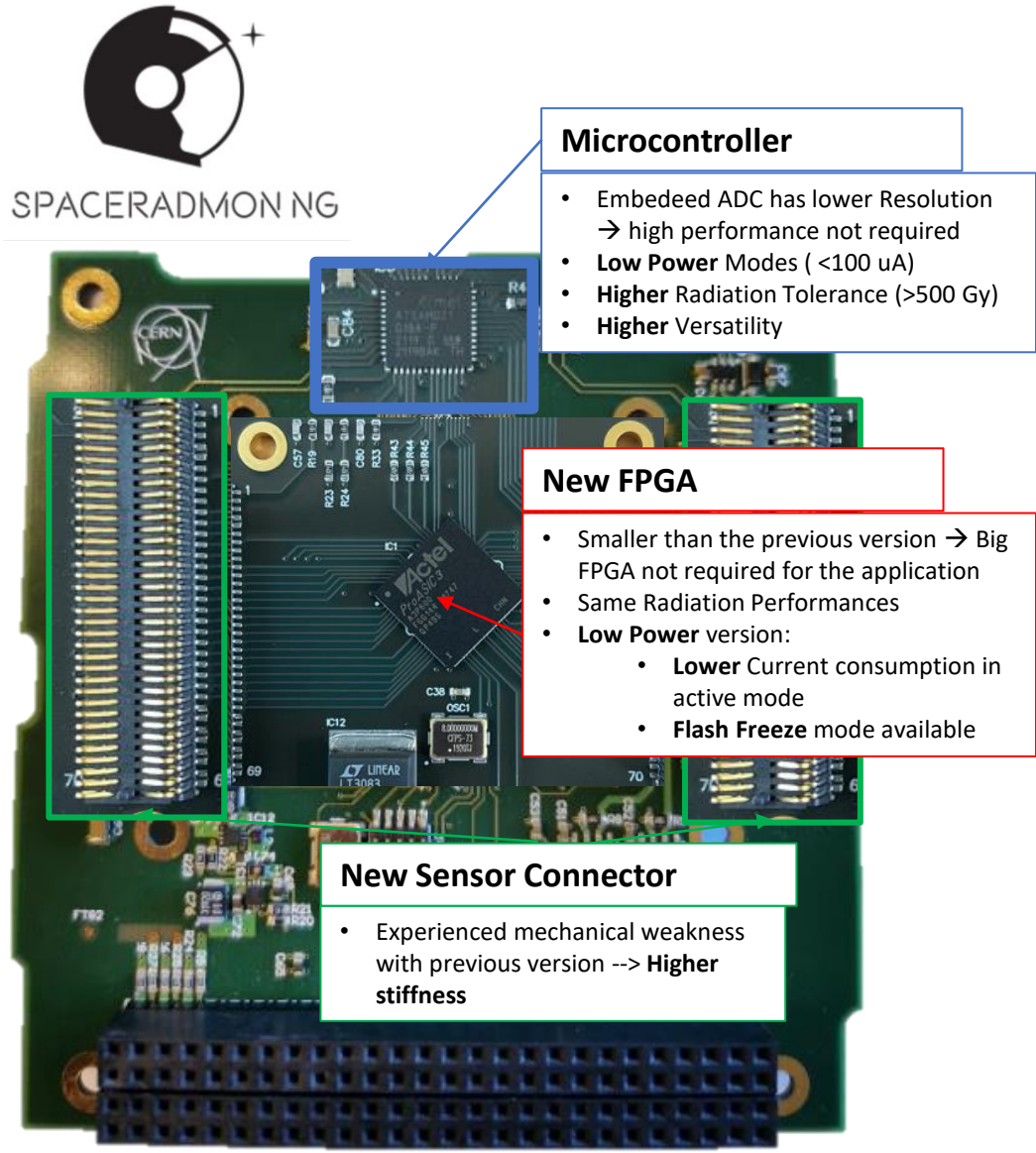
BETTER SENSOR RESPONSE

SpaceRadMon V2 share the **same** sensor board of CELESTA → No improvements

SpaceRadMon NG overcomes all these challenges

SpaceRadMon NG

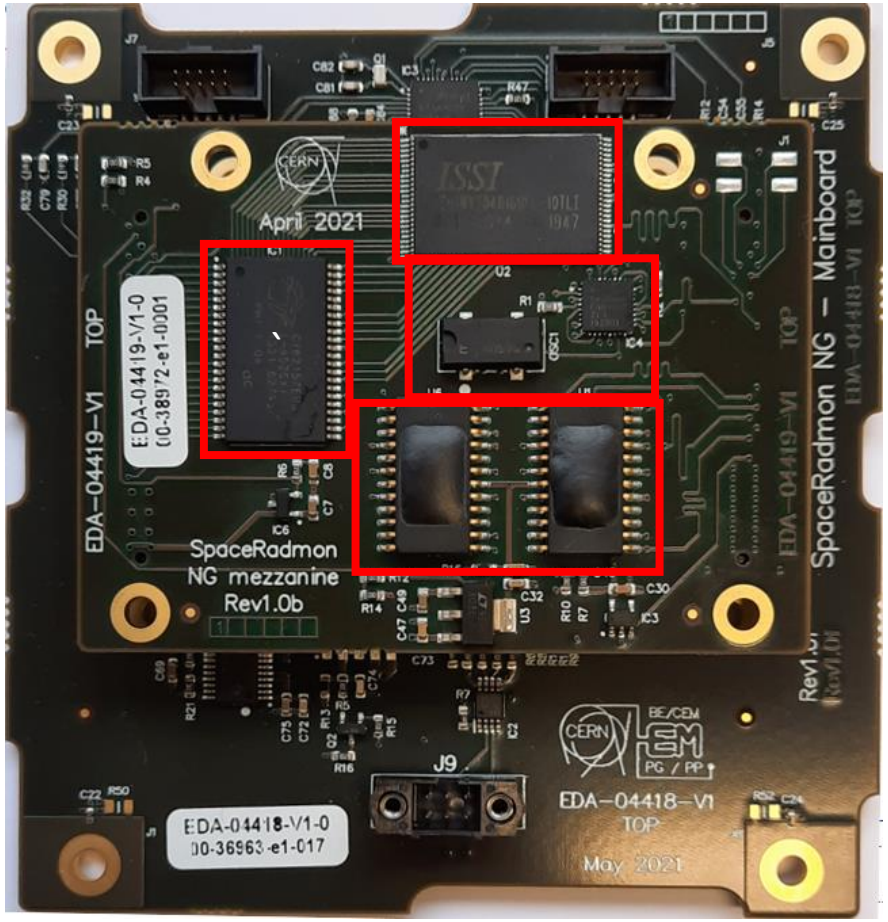
- SpaceRadMon NG is the first example of a new generation of low-power payloads for radiation monitoring in space
- Based on **qualified COTS**.
- A low-power design:
  - ➢ ADC has been replaced by a Microcontroller
  - ➢ New Low Power FPGA
- Higher reliability
- Its advanced hardware with **greater capabilities and better features**, enables this platform to outperform its predecessor in terms of electrical performance.



SpaceRadMon NG: Sensor

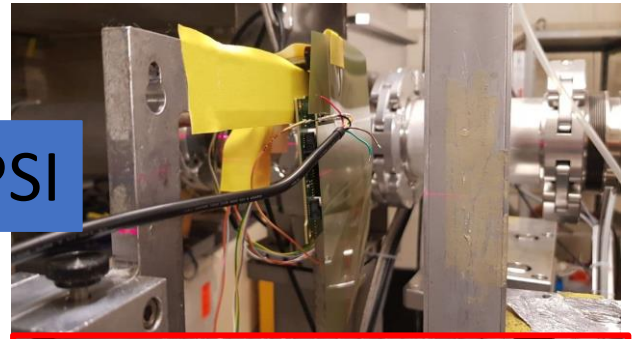
SPACERADMON NG

- While **SpaceRadMon** V2 shares the same sensor board as CELESTA, SpaceRadMon NG aims to outperform its predecessor not only in electrical performance but also in monitoring.
- RadFET has been replaced by the Floating Gate Dosimeter (FGDOS):
  - Linear radiation response
  - High Sensitivity (resolution < 2 mGy)
- Cypress 90 nm SRAM kept → On-board **burst detection** algorithm added in the FPGA design to improve measurement accuracy
- SEL Memories have been replaced by 3 SRAMs to increase HeH sensitivity:
  - 1 COTS SRAM
  - 2 ASICs SRAM developed by KU Leuven

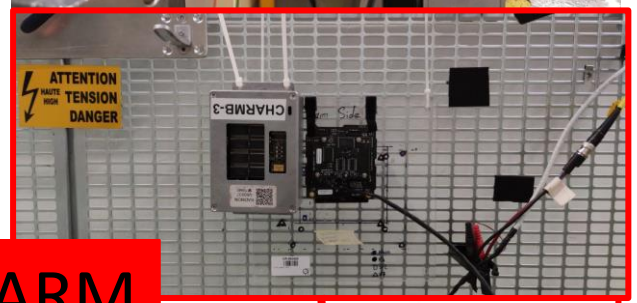


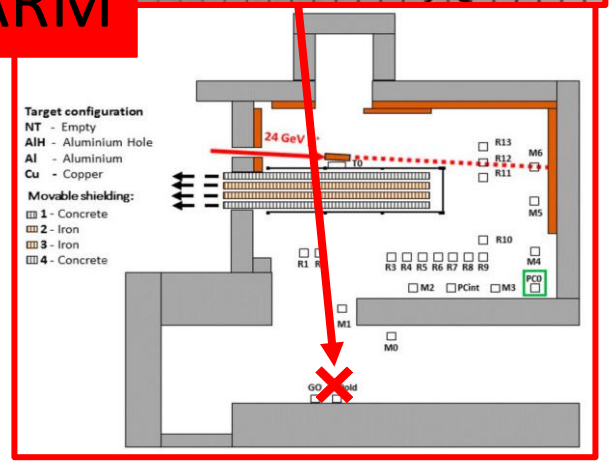
Radiation qualification

PSI



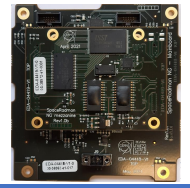
CHARM





1st NG prototype

Hardware and firmware finalized, and radiation test can start



Co60 Test

A first radiation campaign was performed at CO60 facility to test the whole system under only TID → No SEE

PSI Test

4 Radiation Campaigns performed at PSI allowed to test system:

- Test lifetime and sensitivity inducing all TID, DD, and SEE
- Evaluate efficiency of the mitigation schemes

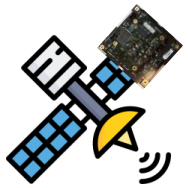
SYSTEM LIFETIME > 418 GY NO SEFI OBSERVED

CHARM

Using the RadMon instrument as a reference, it was possible to assess the system quality of measurement performance and verify the functioning of the burst detection algorithm.

SUCCESSFUL TEST WITH MEASUREMENTS COMPATIBLE RESPECT THE ONE OF THE REFERENCE

System ready to be used

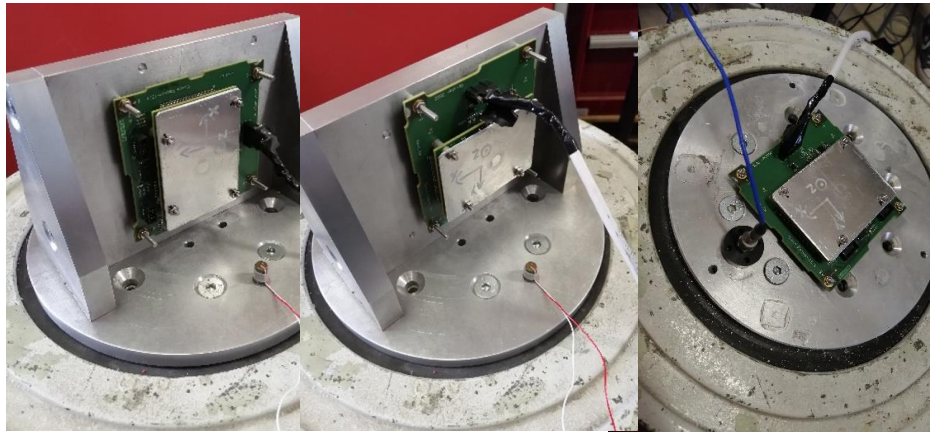


2020 - 2021 | **July 2021** | **July – Oct. 2021** | **March – Nov. 2022** | **December 2022**

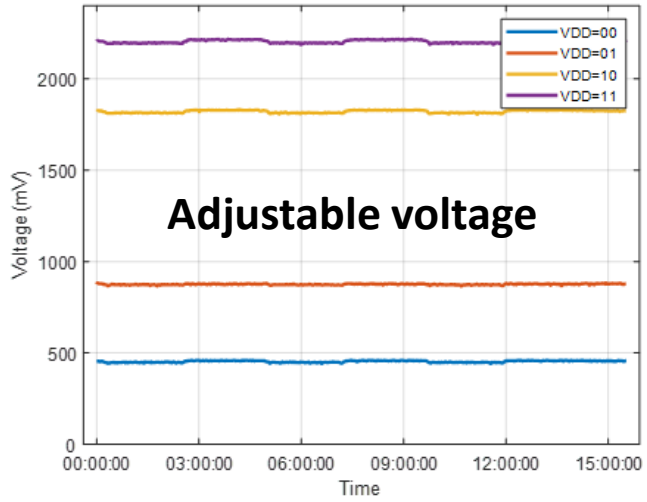
Tests at KU Leuven

KU LEUVEN

- Vibration tests using 1 dimension shaker at the KU Leuven Noise and Vibration research lab
  - Resonance survey, Sine vibration, Random vibration, Sine burst, Shock tests
- Thermal stress tests using a Climate Testing Chamber
  - 3 x Thermal cycles from -30 to 60 °C (board not active)
  - 3 x Thermal cycles from -20 to 50 °C (board active)
- EMC tests
  - According to US military standard (MIL-STD-461G)
  - Scanned range: 10kHz – 6GHz
- Results: No functional or mechanical failures



X position **Y position** **Z position**

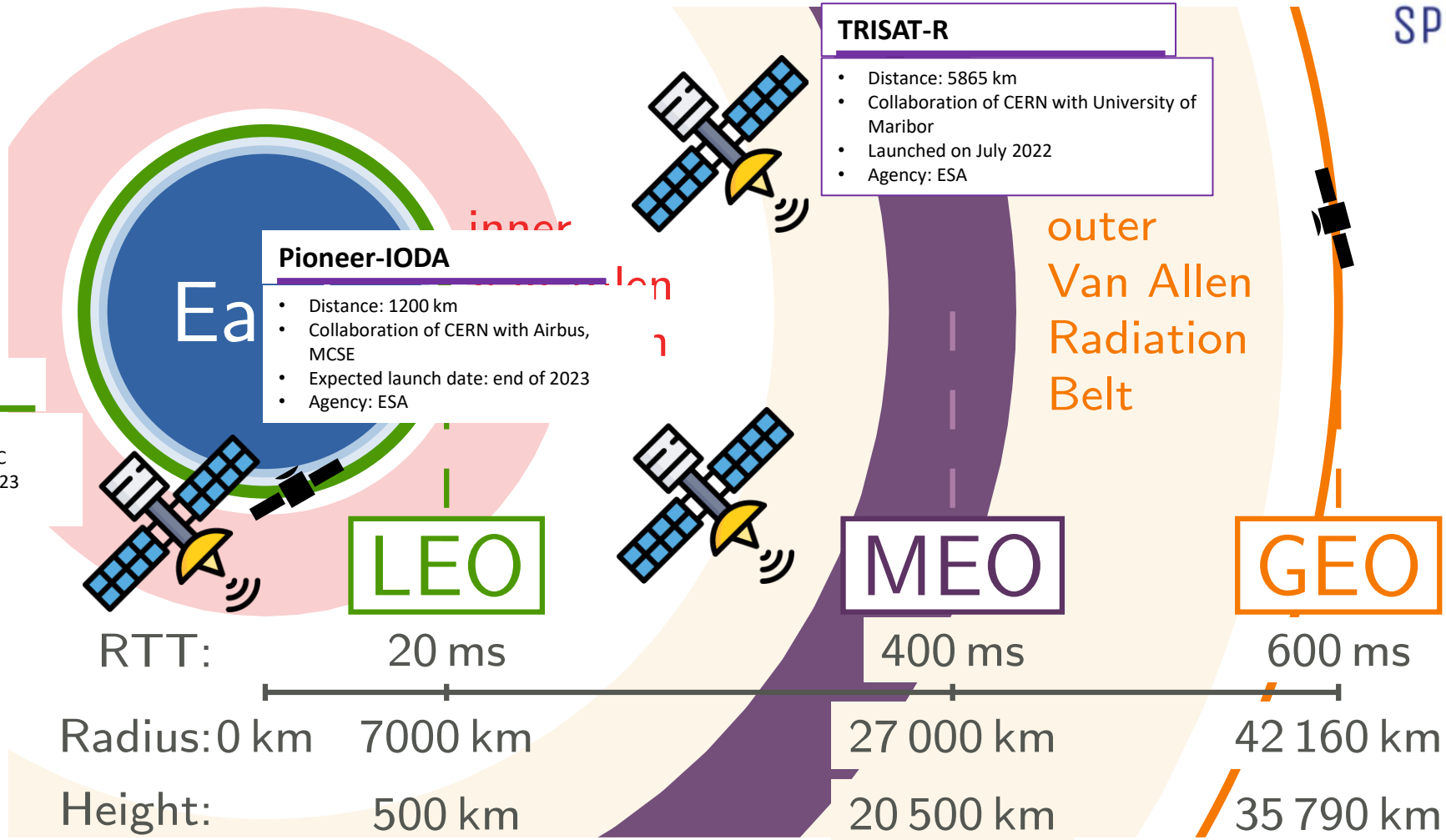


SpaceRadMon V2 vs NG

What we succeeded:

Characteristics	V2	NG
Tolerance	250 Gy	> 418 Gy
Power consumption	165 mW	63.5 mW Idle - 45.0 mW Sleep
Mass	60 g	57.5 g
TID Sensor	Radiation Field Effect Transistor	Floating Gate Dosimeter
Resolution (TID)	57 mGy	2 mGy
SRAMs	1 SEU and 2 SEL	4 SEUs (2 commercial and 2 custom with adjustable voltage)
Voltage monitoring	No	Yes
Temperature monitoring	Yes	Yes
Communication protocol	I^2C	I^2C

SpaceRadMon V2 arranged missions



SpaceRadMon NG arranged missions

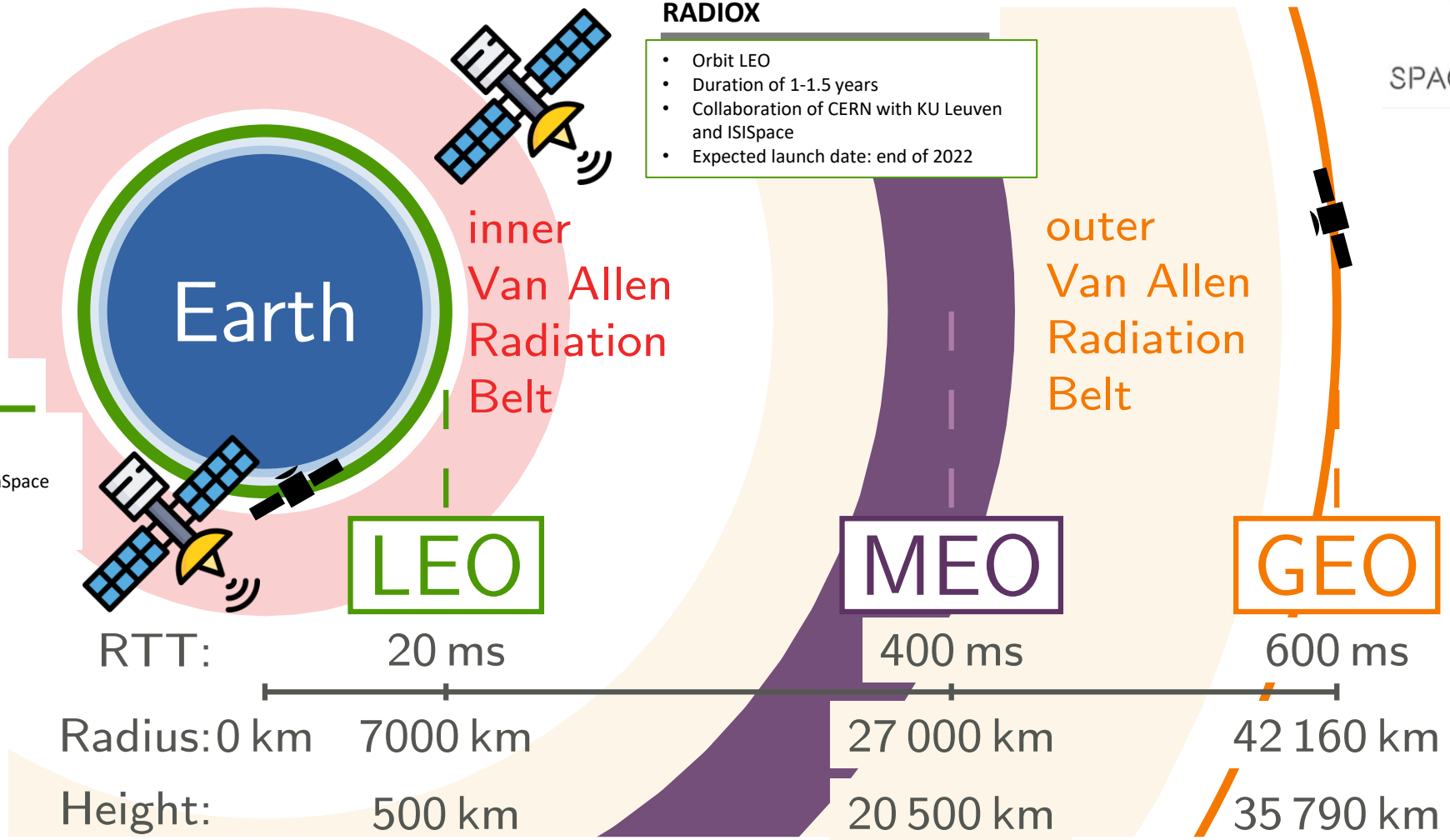
SPACERADMON NG

RADIOX

- Orbit LEO
- Duration of 1-1.5 years
- Collaboration of CERN with KU Leuven and ISISpace
- Expected launch date: end of 2022

GOMX-5

- Orbit LEO
- Duration of 3-5 years
- Collaboration of CERN with GomSpace
- Expected launch date: mid 2024
- Agency: ESA



SpaceRadMon EM-QM/FM distribution

- Produced 30 V2 and 30 NG modules
  - ➢ Qualification/Engineer Models (QM/EM) are used for system validation
  - ➢ Flying Model (FM) for system integration
  - ➢ Tested 4 under radiation
- ISISpace : Delivered 2 QM/EM and 1 FM modules (NG version)
- CNES : 2 QM/EM modules, 1 FM to be delivered (V2 version)
- GOMSpace : Delivered 1 QM/EM module (NG Version)
- Skylabs : Delivered 2 V2 and 4 NG QM/EM modules
- Provide detail Interface Control Document + continuous support to the users

SpaceRadMon NG Interface Control Document

SpaceRadMon NG.ICD
Version 1.0

Release information

Written by:	Alessandro Zimmaro/Panagiotis Gkountoumis
Checked by:	
Approved by:	
Distribution List:	

Conclusions

- In this presentation, we introduced SpaceRadMon NG, an innovative radiation monitoring payload for space applications that aims to represent a new generation of low-power designs for space.
  - **Low Power**
  - **Enhanced radiation tolerance**
  - **Improved sensor resolution**
- Extensively tested and fully qualified for space missions
- Its flexible design and improved electrical and monitoring performance allowed it to be chosen as the payload for CubeSat for long term mission→ **Already selected for several missions**
- SpaceRadMon NG will **be CERN's future payload** for radiation monitoring in Space and will allow the CHARM facility to be validated once again as a **radiation testing environment for Space.**

SERESSA 2022

5th to 9th of December at CERN, Geneva

Thank you for your attention!

A. Zimmaro, S. Danzeca, J. Dijks, P. Gkountoumis (BE-CEM-EPR)

E. Chesta (IPT-KT-BD)

SpaceRadMon

- SpaceRadmon is a radiation monitor device with high TID resolution and low power consumption designed for CubeSats
- It was developed with the support of KT, profiting of the knowledge/ experience gained from RadMon system used for radiation monitoring in the harsh environment of LHC
- It is a flexible payload platform for Cubesat satellites, that can be embedded in several missions with little effort.
- Integrates specific sensors for space applications
- Attractive solution for space missions – close collaboration with many companies and universities

RadMon