





A Radiation qualification procedure for nanosatellites and high energy applications at the CHARM facility at CERN

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Introduction

The CELeSTA Cubesat Project

The RadMon V6

CHARM facility for system qualification

Preliminary test results

Conclusions and Future Work

Introduction

What is a Nano-Satellite?

CubeSat 1U: 10x10x10 cm cube

Started in 1999 as a standard nanosatellite for space science.

Low cost platform.

Growing interest and market.







Introduction

What has CERN to do with CubeSat?

CubeSat Needs :

- Radiation Monitoring
 - CERN Radiation Monitor (RadMon)
- Qualification for Radiation Hardness
 - CERN Radiation test facility (CHARM).

CERN Interest :

- Developing RadMon version for CubeSat missions
- Proof that LEO radiation qualification can be done at the new CHARM facility
- > Investigate in additional dosimetry/ measurement option for CERN & CubeSat missions

CELESTA (CERN Latchup STudent sAtellite)



RadMon V6 System

CELeSTa Mission

Radiation qualification at CHARM

- Comparison between space environment and CHARM
- Proof that radiation qualification is possible at CHARM for LEO Cubesat mission.

Radiation Monitor

- CubeSat version of CERN RadMon
- Compare radiation level between equator and poles

Latch-up test station

Highlight high-energy dependency (with several memories if possible) for different orbits.

Collaboration and Partial funding

- University of Montpellier
- Van Allen Foundation funding
- CERN R2E



Mission Environment

TID = ~ 500 Gy for 2 years. 1mm shielding. Mean dose rate : 30 mGy/h (up to 1 Gy/h)



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Payload

Constraints

<u>System:</u> Size : 100 x 100 x 100 mm

Mass : 1 kg

Power:1W

<u>Remaining for the payload</u>: Size : 80 x 76 x 7.65 mm Mass : 200 g Power : 300 mW



RadMon V6 – Main Architecture



RadMon V6 – Top View

- TID Measurement
- Displacement Damage (P-i-n Diodes)
- Two Memory Banks: Cypress and Toshiba SRAM
- Withstand up to 200 Gy (ADC is the bottleneck)
- Connection to Deported Module
- ALL ICs previously tested at PSI.



The CELESTA Test Board V1



- SEU: Cypress CY62157EV.
- Dose: Tyndall RadFet 100 nm.
- SEL: Brilliance BS62LV1600EIP.
- Latchup Detection via 16 bit ADC.
- Board Dimensions: 13.5cm x 10cm.
- Communication via UART RS422, using MODBUS protocol.
- All ICs on Board have been tested at PSI as on the RadMON.
- **Timings:** SRAM + Radfet scanned every <u>Two minutes</u>.
- ADC sampling period 1ms.

CHARM Facility

> Unique radiation test facility.

- Representative test environment.
- Component, batch and full system tests.
- > Detailed calibration (monitoring system, calculations).

Large range of dose rate (from low dose rates to highlight ELDRS effect to high dose rate for accelerated tests)

First operation: October through December 2014

CHARM Facility



CHARM Facility

Representative Environment



CHARM Test Area



CHARM Test Area, Copper Target, No Shielding, h=130cm, I_s =3E11, n_s=3, I_{ss} =32

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Setup in the Test Area

- Two Boards Tested.
- RadMON V6 + Deported Module in the same Test Location.







Setup in the Test Area



Preliminary Test Results – TID

• Experimental tests ran from Nov 24 to Dec 12 2014



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Preliminary Test Results – TID



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Preliminary Test Results – SEUs and MBUs



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Preliminary Test Results – SELs

- Latchup Threshold set to 15 mA.
- ADC with 1 ms sampling period. Waiting time before Memory deactivation = 2 ms.



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Conclusions and Future Work

CHARM facility

- > Qualification of Components and full systems in a representative Space-Like Environment.
- > Qualification of **Cubesats** and devices for LEO Orbit Missions.
- Provide a reliable payload module for dosimetry on 1U Cubesats.

CELESTA TestBoard

- > Developed from **RadMON V6** concept, for Cubesat Missions.
- > First prototype Board, moving towards the final PCB.
- > Measurement of **TID**, **HEH fluence** and evaluation of **SEL**s.

Preliminary Results

- > Benchmark with **FLUKA** simulation results and RadMon V5 Data recorded.
- > The analysis of the Radfet Voltage needs temperature compensation.

Hardware Modifications and Improvements

- > Other **memory candidates** for SEL.
- > TID measurement (other RadFet options, FGDOS?) and use of **FastRad**.
- > Towards a Final Version of the Board (reduce Power, Dimensions, CAN bus, etc...)



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