Space Radiation Environment & Effects

Marco Pinto

Jornadas do LIP 2016
Universidade do Minho – Braga, 19-21 de Fevereiro

Contents

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- RADEM
- ECo60-JUICE
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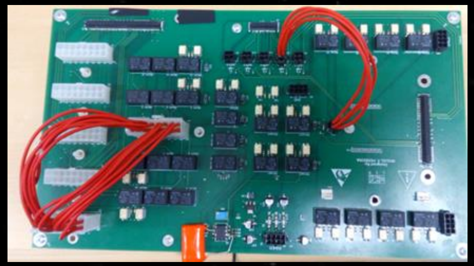
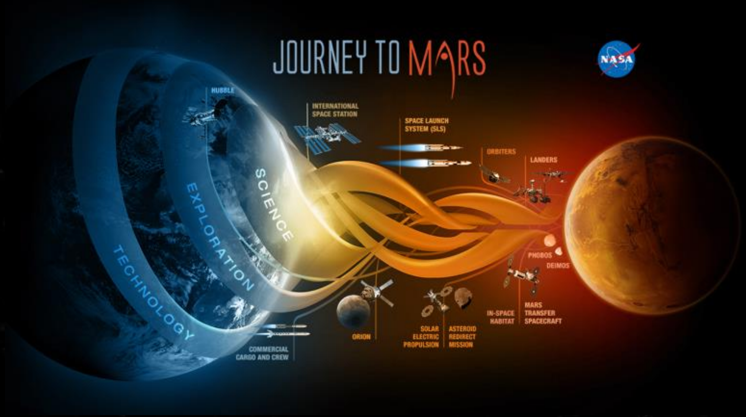
- Mars Radiation





Activities

- Radiation Environments → In Space / On the surface of planets / In-Orbit
- Detector simulation and design
- Component degradation and modelling

The team:

Researchers
- Patrícia Gonçalves (coordinator)
- Jorge Sampaio
- Luísa Arruda
- Pedro Assis
- Bernardo Tomé

1 PhD Student
- Marco Pinto

2 Master Students
- Pedro Magalhães
- Ana Luísa Casimiro

Techinicians
- Miguel Ferreira
- José Carlos Nogueira

JUPITER ICY MOONS EXPLORER

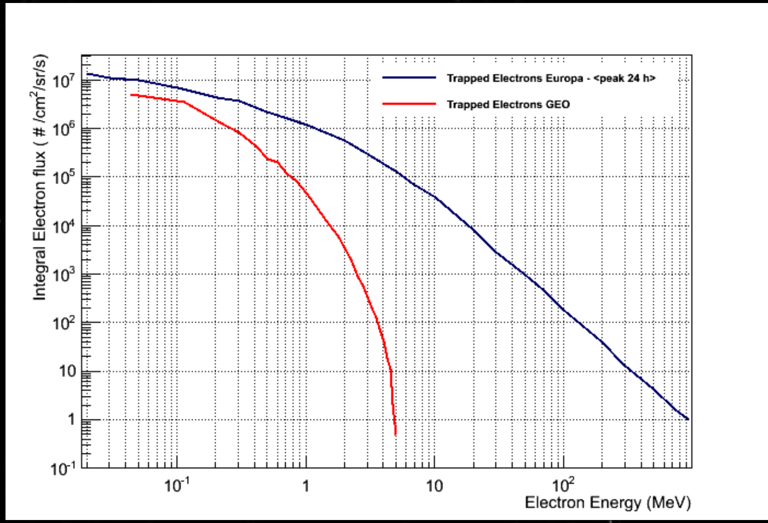
Next Class-L (Large) ESA Mission

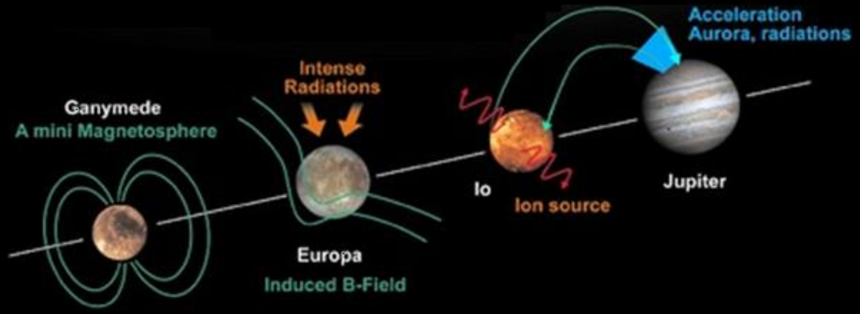
What are the conditions for planet formation and emergence of life?

- Emergence of habitable worlds around gas giants.

How does the Solar System work?

- Jupiter system as an archetype for gas giants





Development	Launch	Cruise	Arrival	End of Mission
	2022		2030	2033

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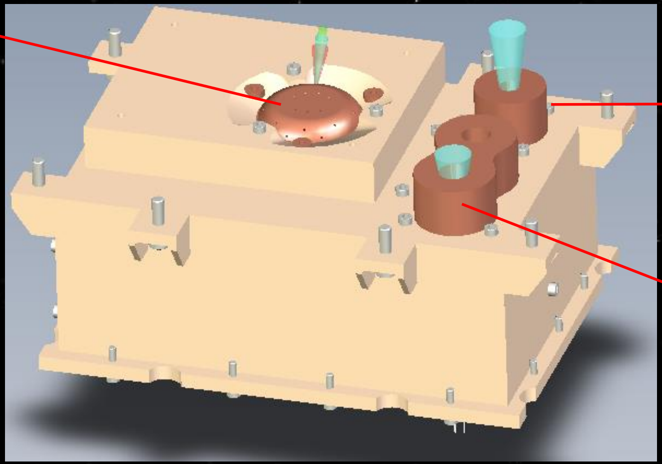
RADEM

Patrícia Gonçalves

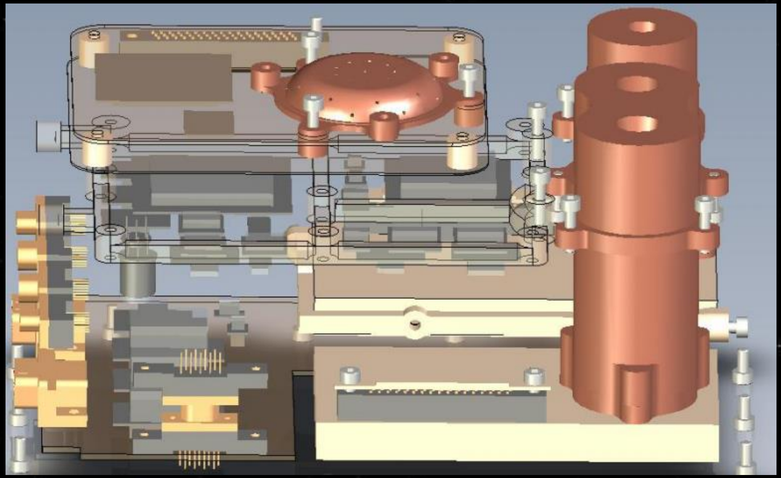


Main Objectives

- Ensure mission safety
- Provide valuable scientific data

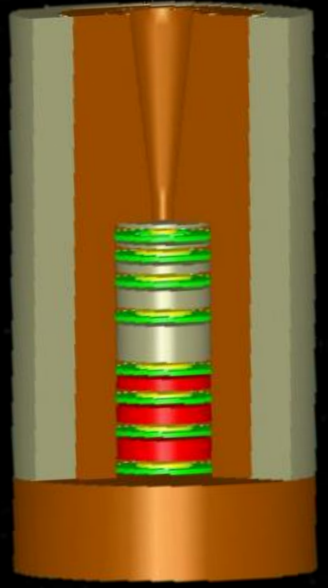
Requirements:

- Electron detector
  - Spectral range 300 keV – 40 MeV
  - Peak Flux 10^9 e/cm2/s
- Proton Detector
  - Spectral range 5 MeV– 250 MeV
  - Peak Flux 10^9 p/cm2/s
- Particle Separation
  - From Helium to Oxygen
- Dose determination



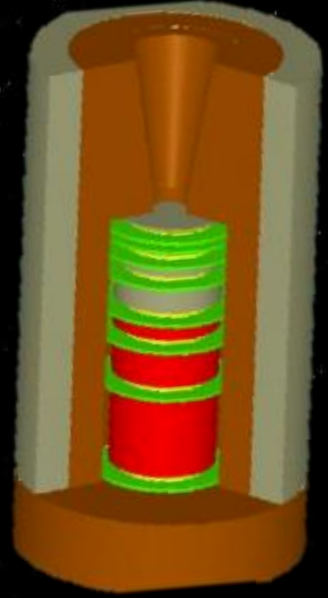
RADEM – Motivation for DD

ESD



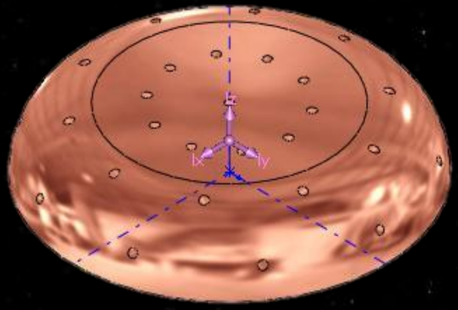
FOV = 7.5º

PSD

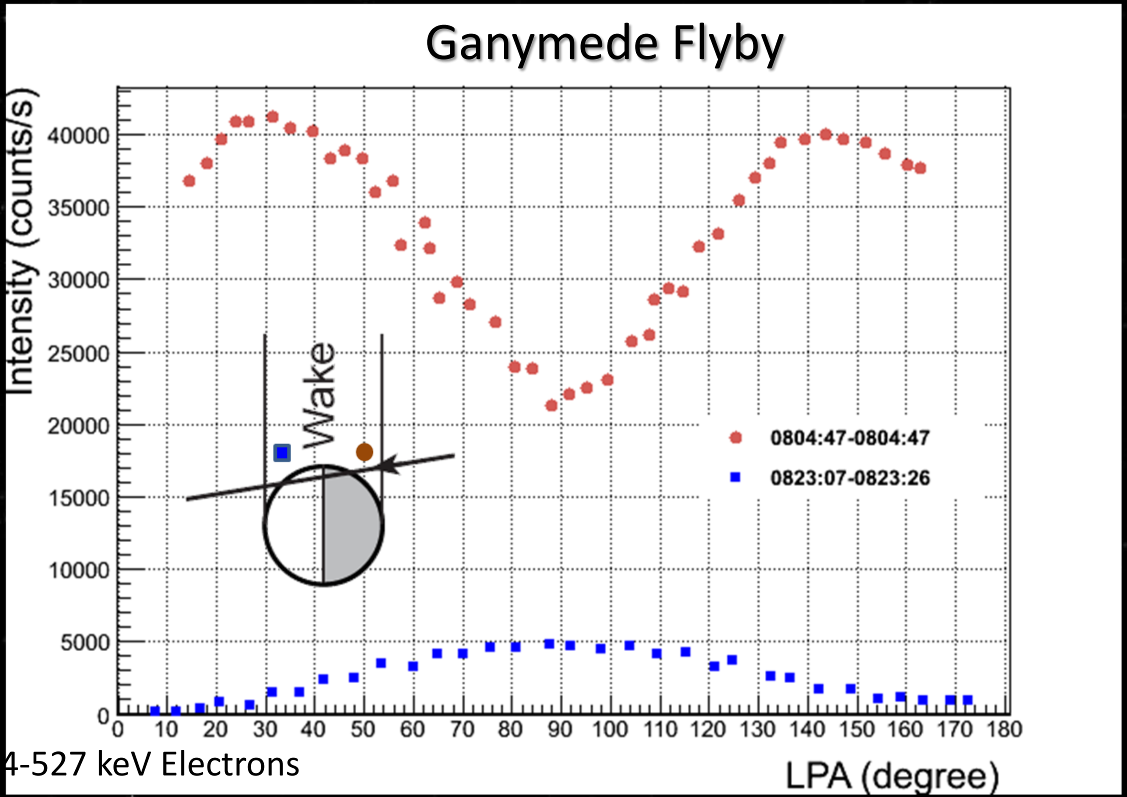


FOV = 10º

DD

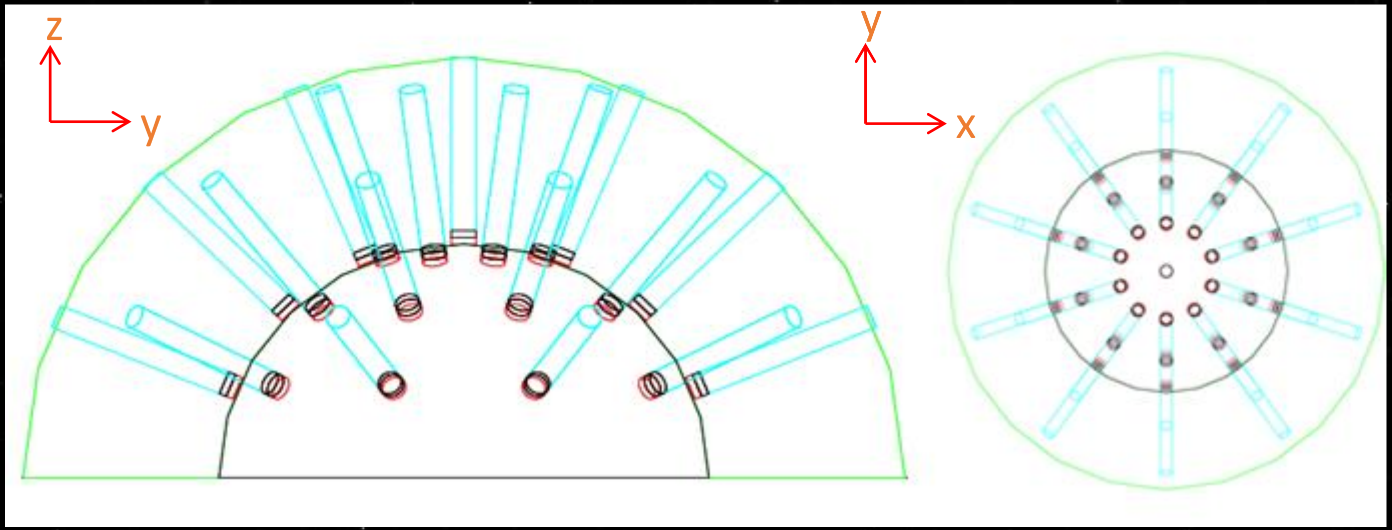


FOV ~220º



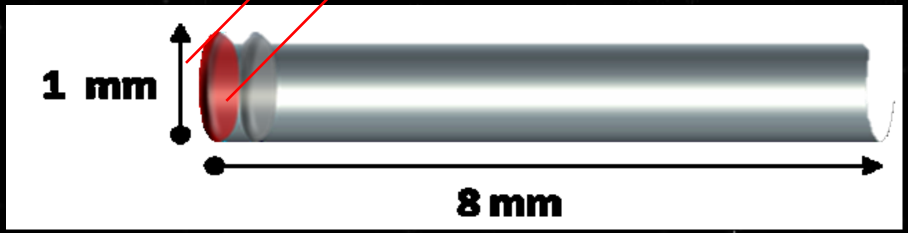
RADEM – Directionality Detector

First Concept



31 directions $\Delta\theta$=22.5º, $\Delta\varphi$=36º

Good Spatial Resolution



<300 keV e^-

<6 MeV protons

One sensor per direction

Low energy Resolution

Collimator FOV ~7.2º → **DD FOV~62%**

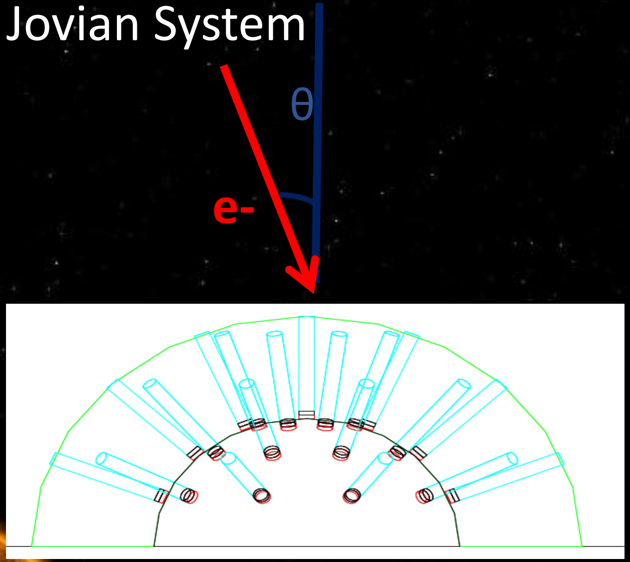
RADEM - Directionality Detector

First Concept

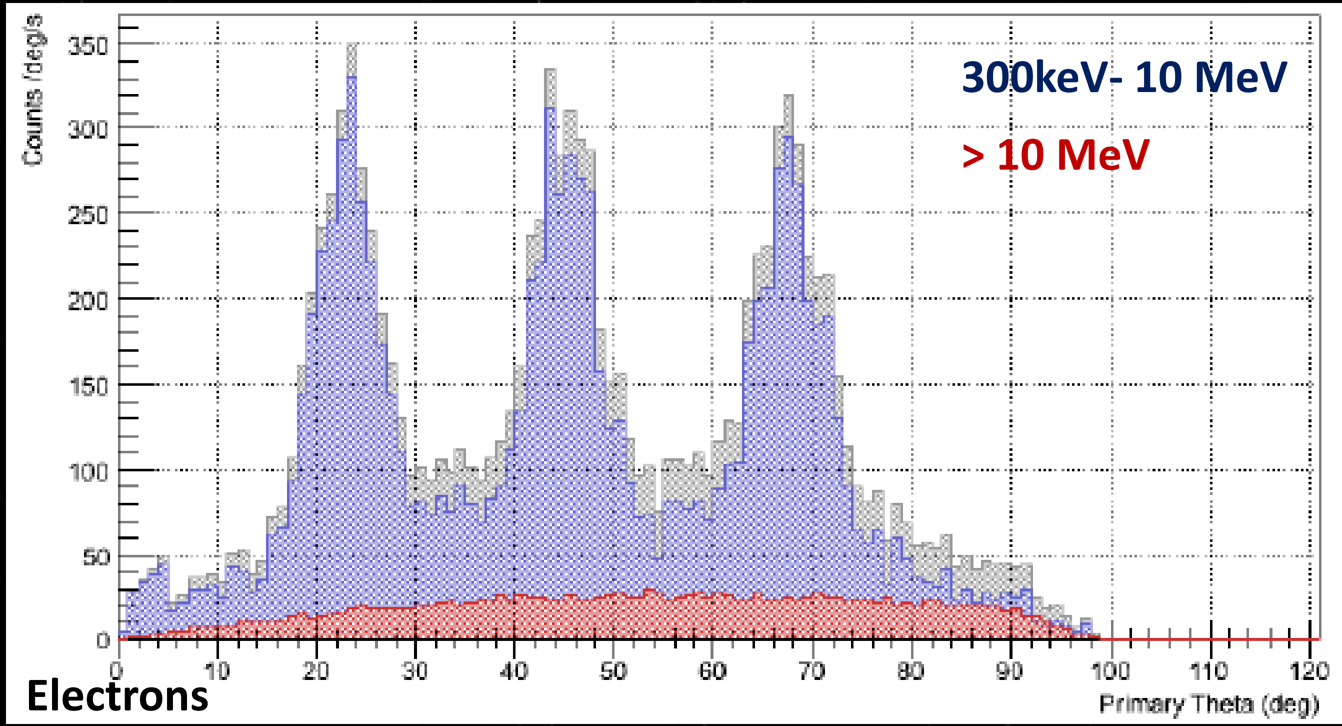
Geant4

- Detector Geometry

- Electron source spectra by the JOSE model in several locations of the Jovian System



Primary Electron Incident angle θ (deg)

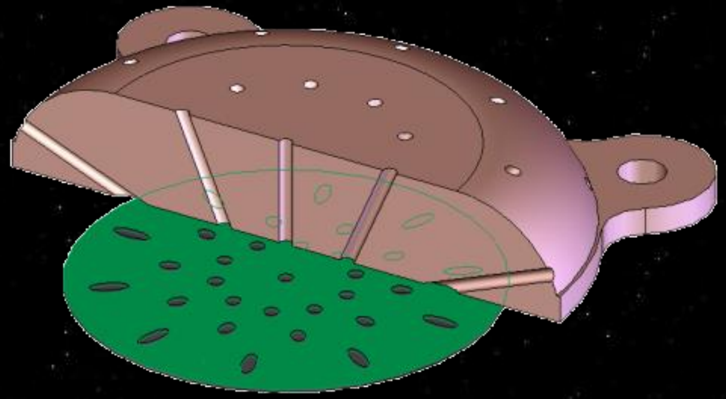


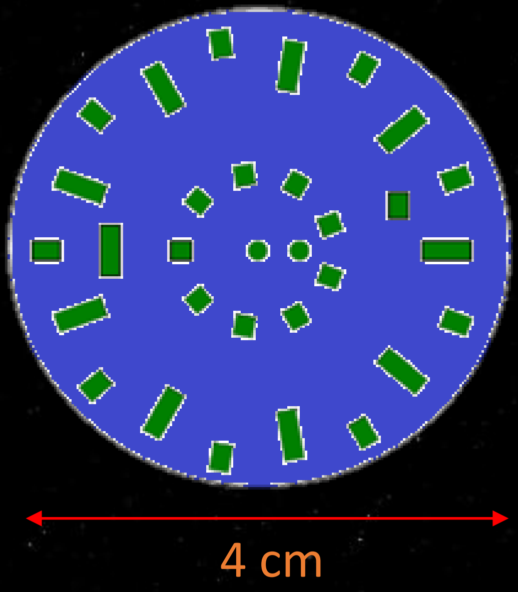
RADEM - Directionality Detector

Current Version

Sensors moved to a detection plane

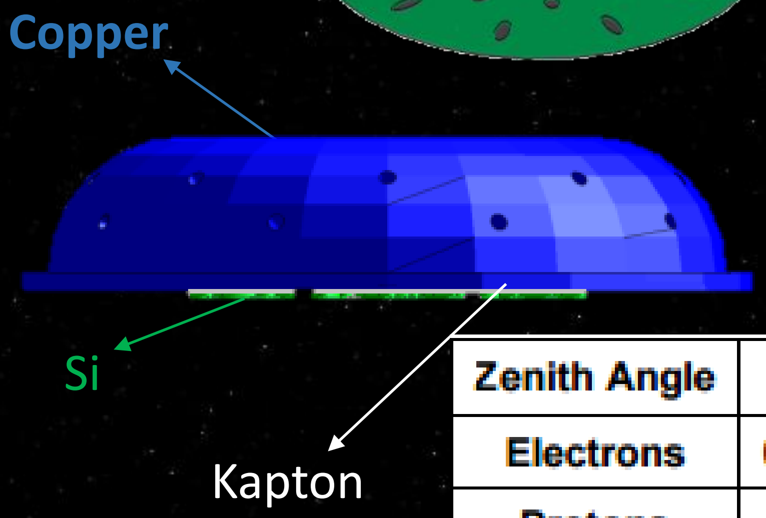
- Rectangular sensors with different sizes due to the inclination
- 28 directions
- 3 blind sensors

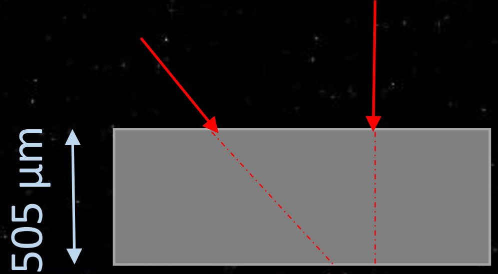




Single 505 µm Kapton absorber

- Different energy thresholds

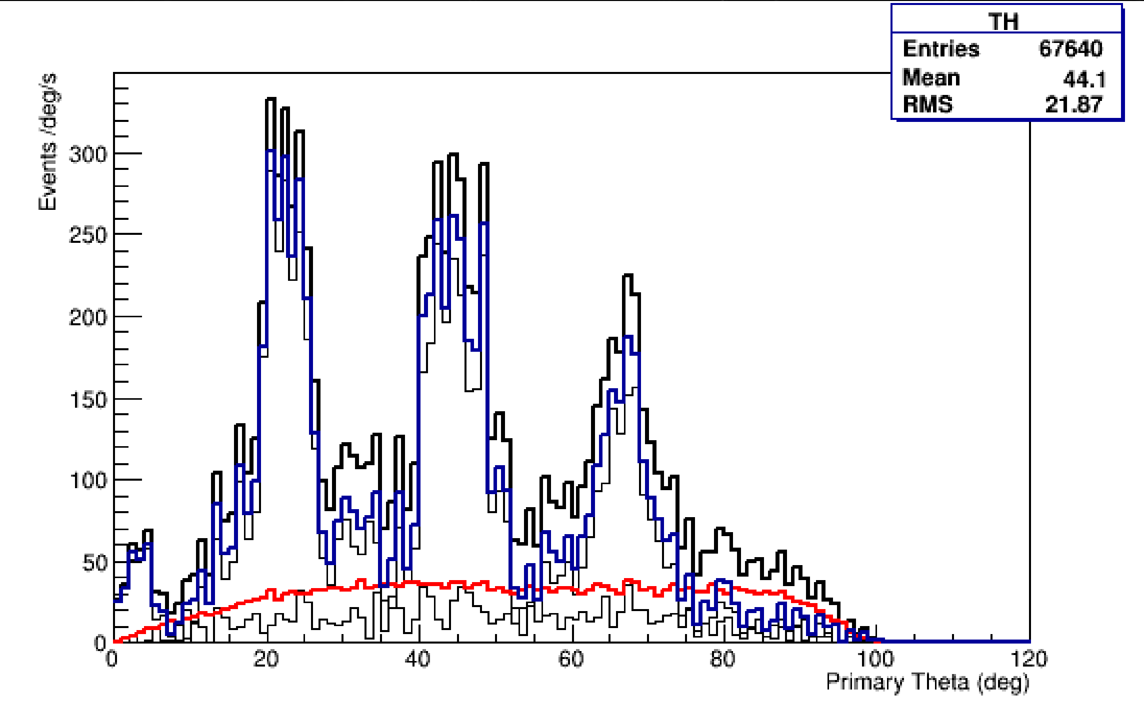


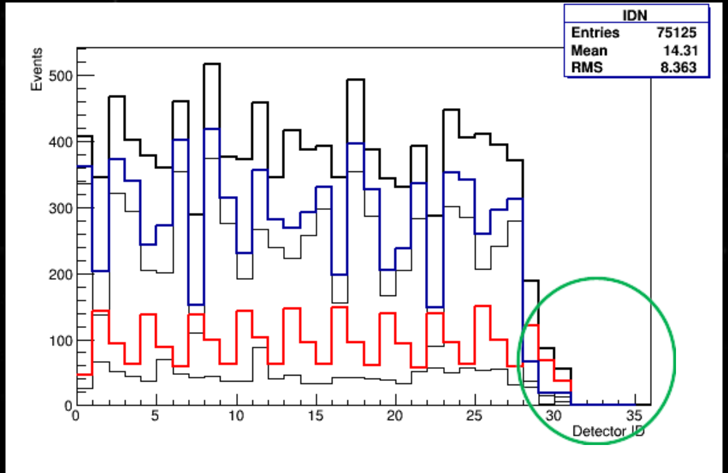


Zenith Angle	0 deg	22.5 deg	45 deg	67.5 deg
Electrons	0.3 MeV	0.3 MeV	0.35 MeV	0.5 MeV
Protons	7 MeV	7 MeV	8.5 MeV	12.5 MeV

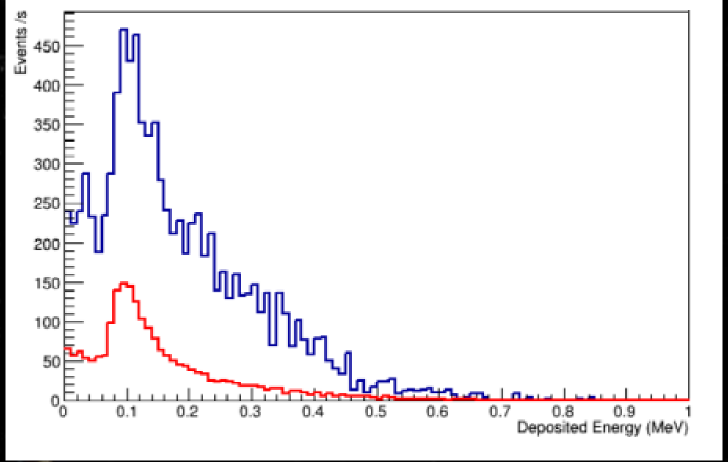
RADEM - Directionality Detector

Current Version





3 blind sensors

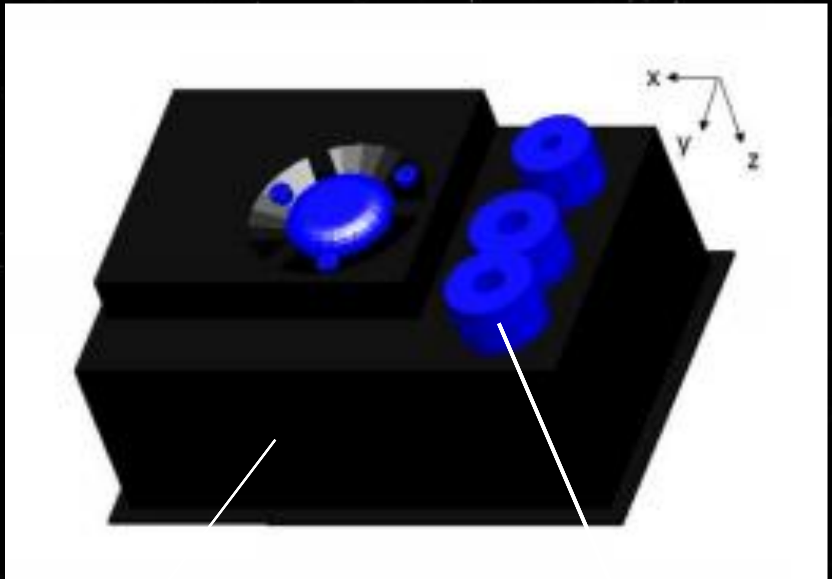


Zenital angle (wrt vertical)
Results are worst for steeper angles!

RADEM - Directionality Detector

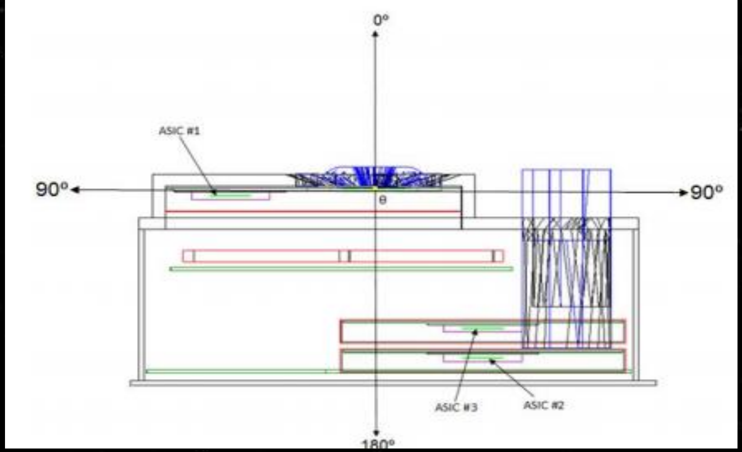
Radiation Analysis

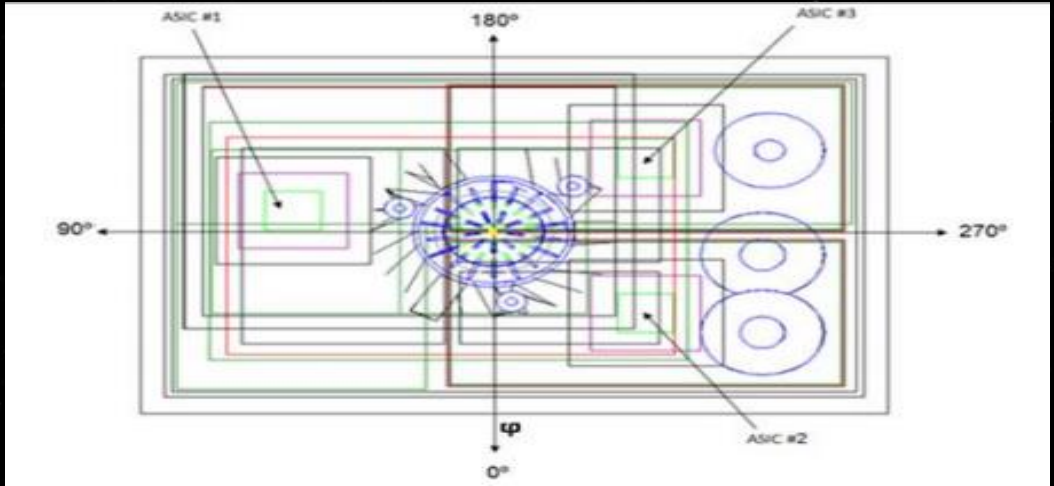
Geant4 Model



Aluminum

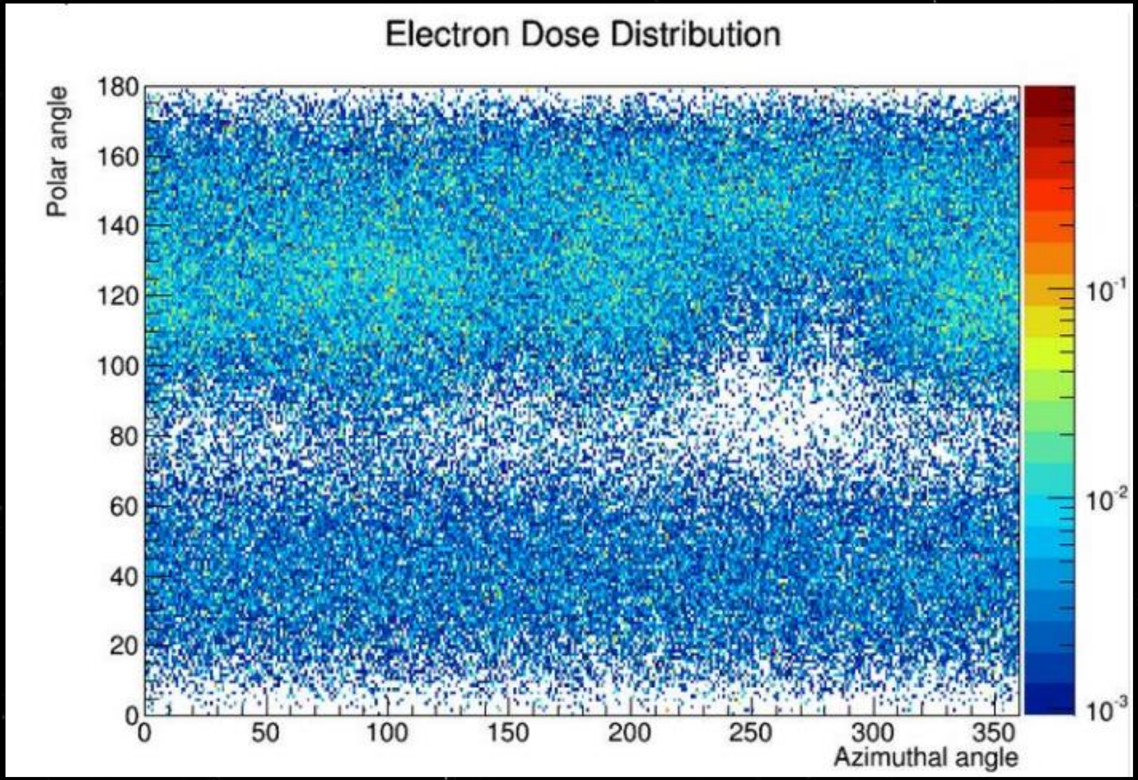
Copper

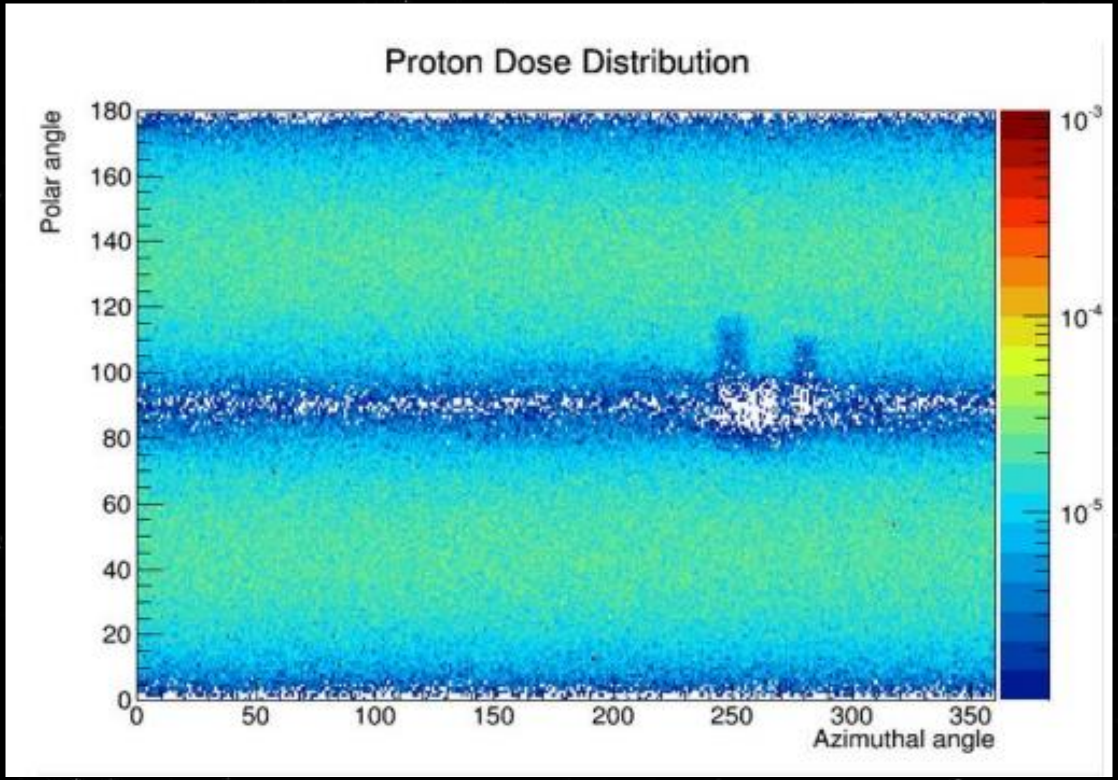




RADEM

Radiation Doses

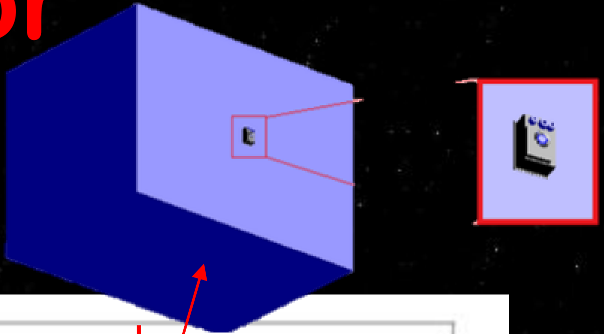


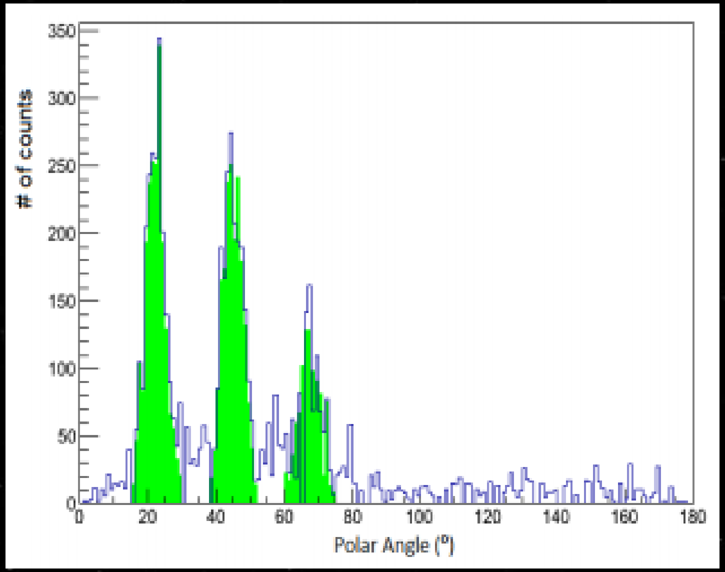


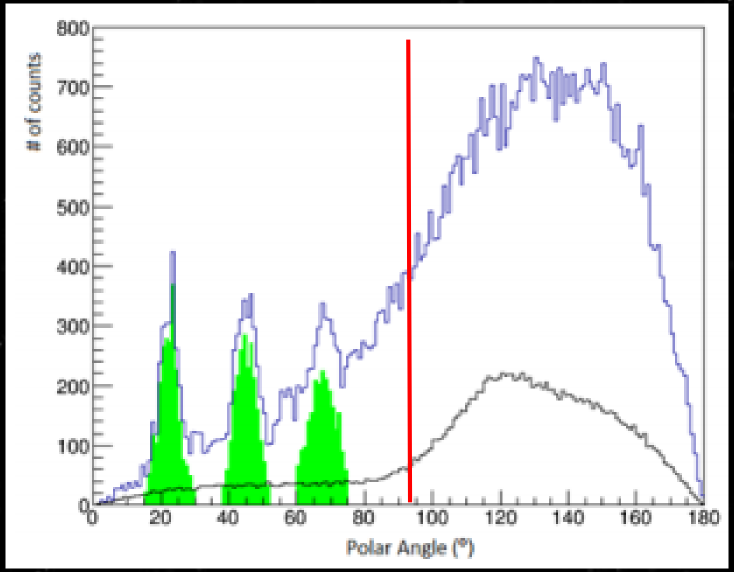
Doses computed for the entire mission

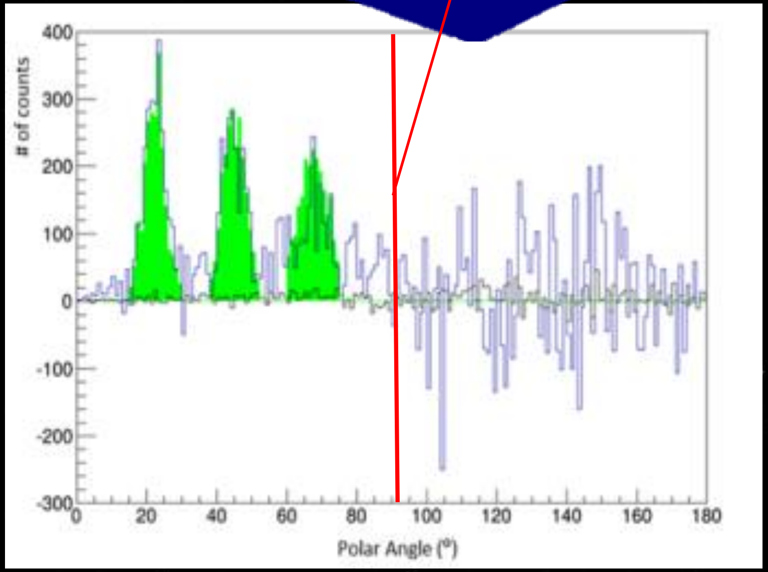
RADEM - Directionality Detector

Direction Response









0.1-2 MeV

With bkg

0.1-100 MeV

W/o bkg

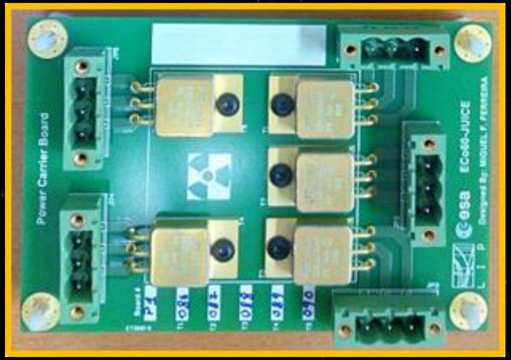
Eco60-JUICE

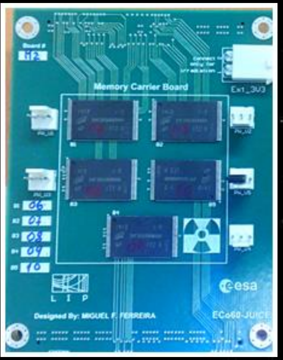
Summary

- Validation of ^{60}Co irradation tests for EEE components flown in the Jovian System

- Currently under development at E-CRLAB

- 5 components
  - BJT
  - MOSFET
  - AMPOP
  - Flash-Memory
  - Shunt Voltage





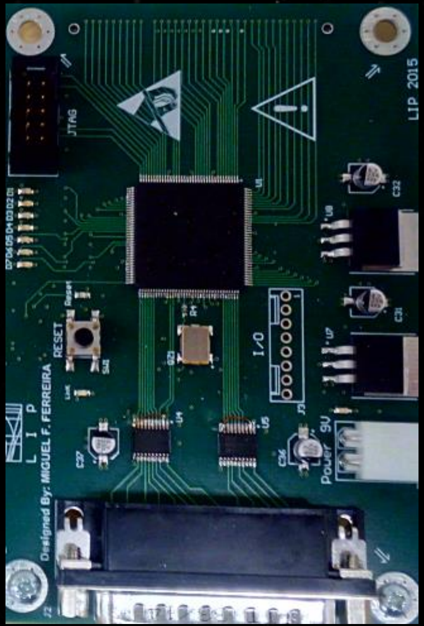
- 3 Phases
  1. Selection of EEE Components
  2. Preparation of Radiation Tests
  3. Radiation Test Campaign

Eco60-JUICE

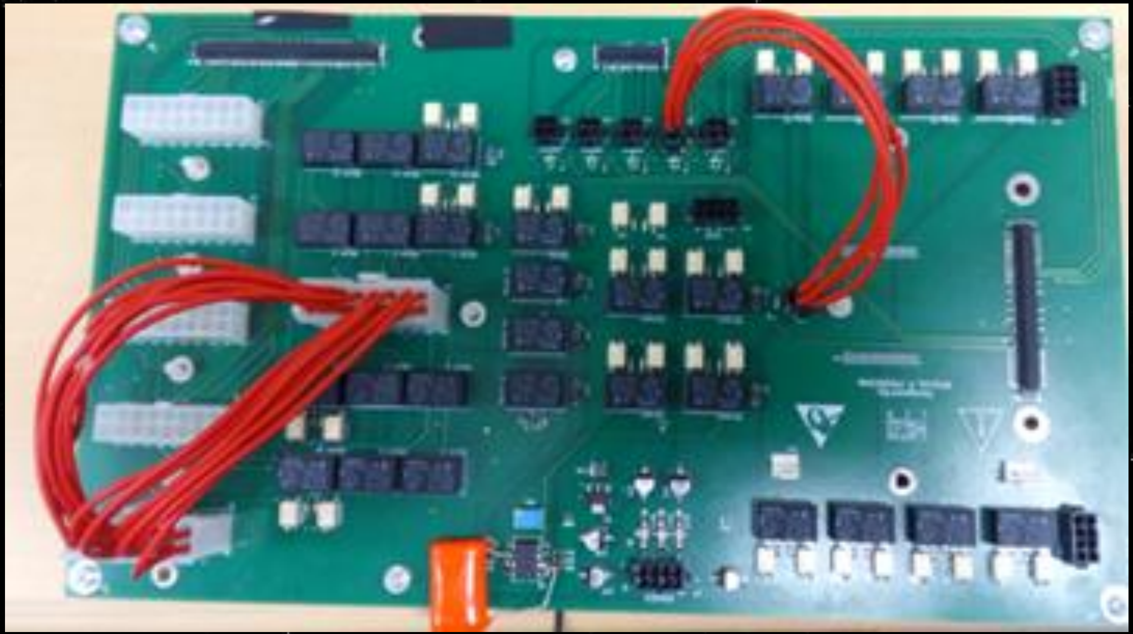
Preparation of Irradiation Tests @ E-CRLAB at LIP

Measuring Units

Control Board



Test Board



Eco60-JUICE

Radiation Test Campaign

3 tests:

- High dose rate Electron irradiation (2 energies – 10 and 15 MeV) → 24kRad/h → Santa Maria Hospital
- High dose rate ^{60}Co irradation (1.1732 MeV) → 24kRad/h → CTN
- Low dose rate ^{60}Co irradation (1.1732 MeV) → 36 Rad/h → ESA-ESTEC

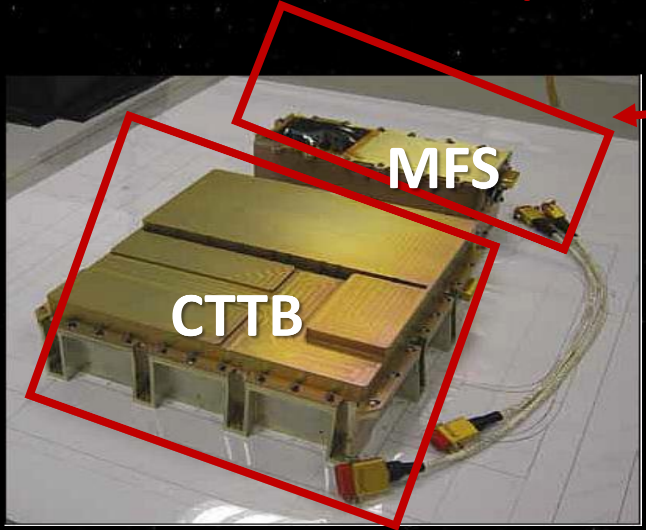
10 kRad steps up to 100 kRad → Annealing → 8 months / 6 months

AlphaSat

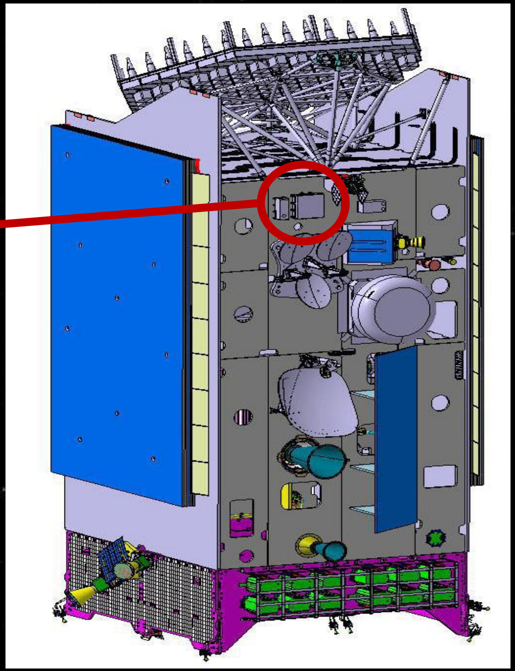
The AEEF: AlphaSat Environment and Effects Facility

- The AlphaSat was launched to GEO in 25th July 2013 carried the AEFF (TDP8).
- MFS + CTTB make AEEF-TDP8.
- Installed on X-panel of the AlphaSat

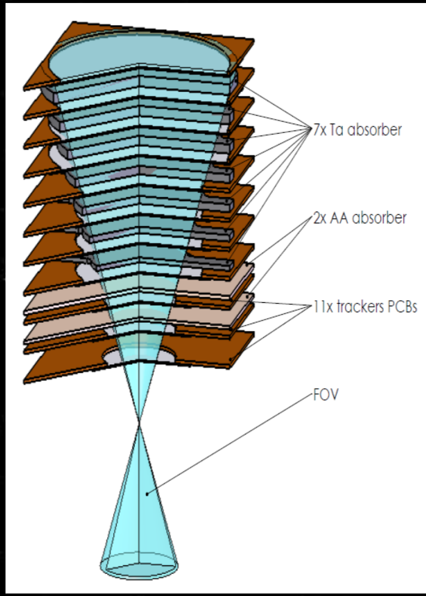
CTTB: Component Technology Test Bed



AlphaBUS



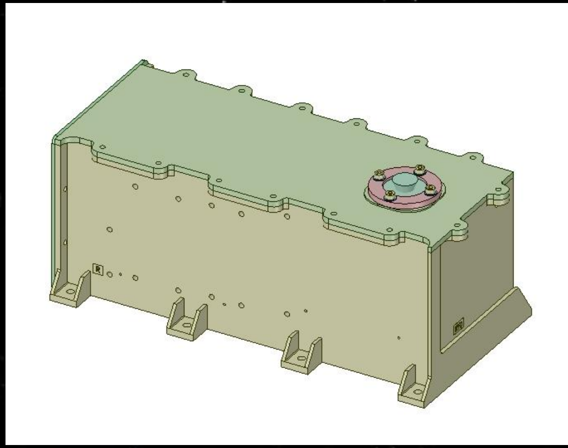
MFS

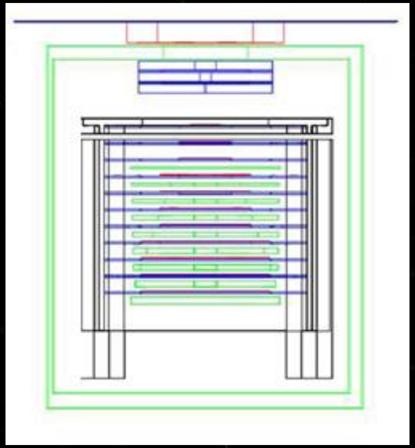


MFS

Geant4 simulation

- MC simulation of MFS was implemented with the description for :
  - Detector's geometry
  - Materials
  - Calibrations and front-end electronics response



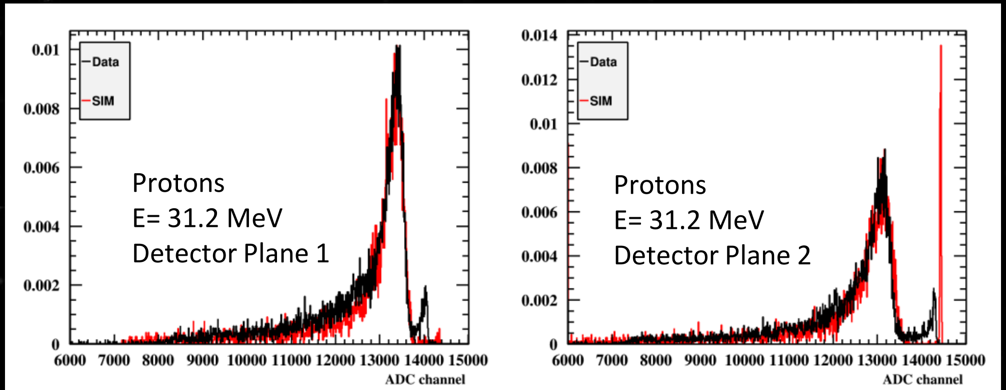


MFS Ground Test Data Analysis

Tested at PSI (2010) at the Proton Irradiation Facility (PIF) and with the mono-chromatic chamber using ^{90}Sr to provide a mono-energetic electron beam.

✓ verification and calibration of the equipment.

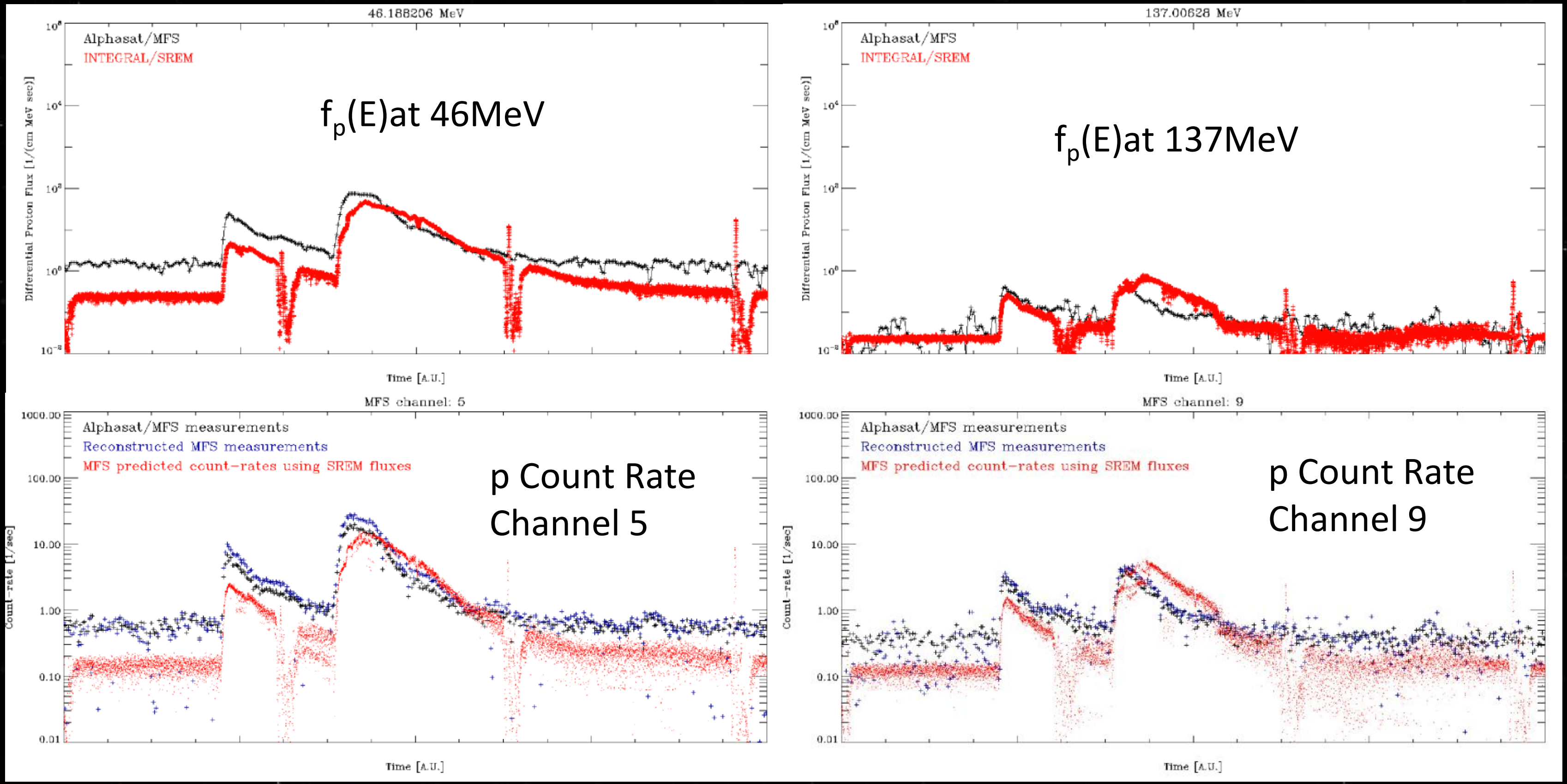
✓ PFM design approval. **Simulation results in very good agreement with test beam data**



MFS – Flux Spectra Reconstruction

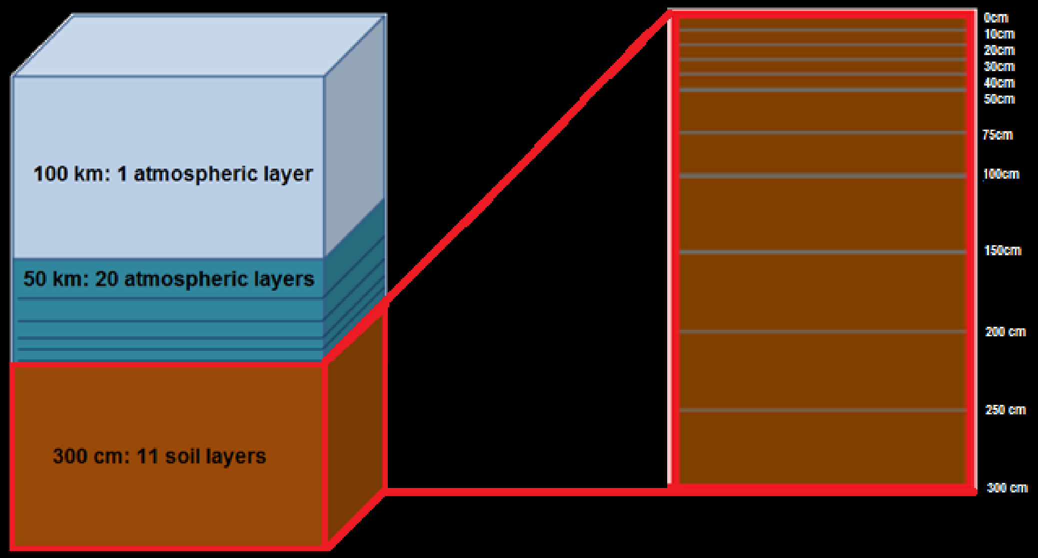
SEP Nov 2013/Fev 2014

The Single Value Deconvolution (SVD) technique applied to calculate p and e^- differential fluxes $f_{p,e}(E)$

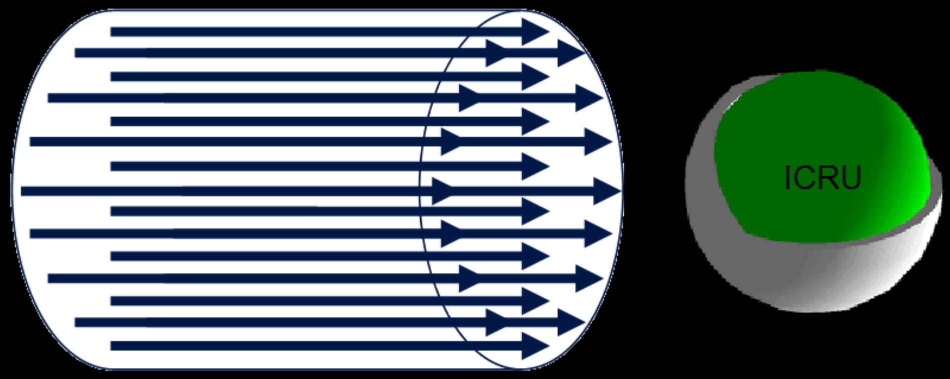


Mars Radiation Environment

<u>Pedro Magalhães:</u>
Martian Radiation Environment and its effects on the Martian surface and underground



<u>Ana Luísa Casimiro:</u>
Space Radiation Environment effects on manned missions to Mars



Outline

LIP Space Radiation Environment & Effects Activity is consolidated (ongoing for more than 10 years)

4 ongoing projects:

- RADEM
- ECo60-JUICE
- MFS
- CTTB (Just starting)

Other work:

Mars Radiation Environment (dMEREM)

More oportunities exist