SPACE RADIATION ENVIRONMENT & EFFECTS @ LIP

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RADIATION ENVIRONMENT IN THE SOLAR SYSTEM

Galactic Cosmic Rays

low flux but highly penetrating

protons & nuclei

Solar Particle Events

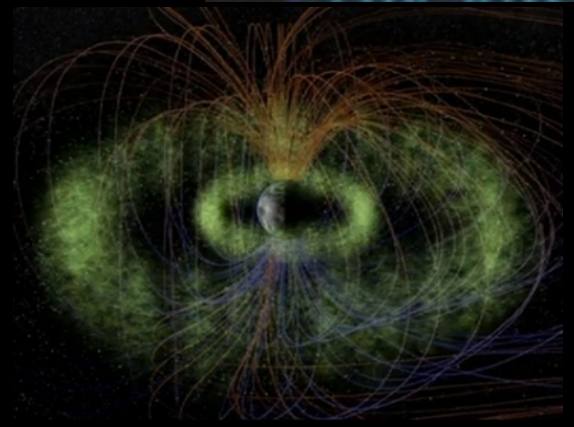
sporadic, intense & dangerous

electrons & protons

Radiation Belts

high radiation dose

electrons , protons & ions



RADIATION ENVIRONMENT MEASUREMENT TECHNOLOGIES

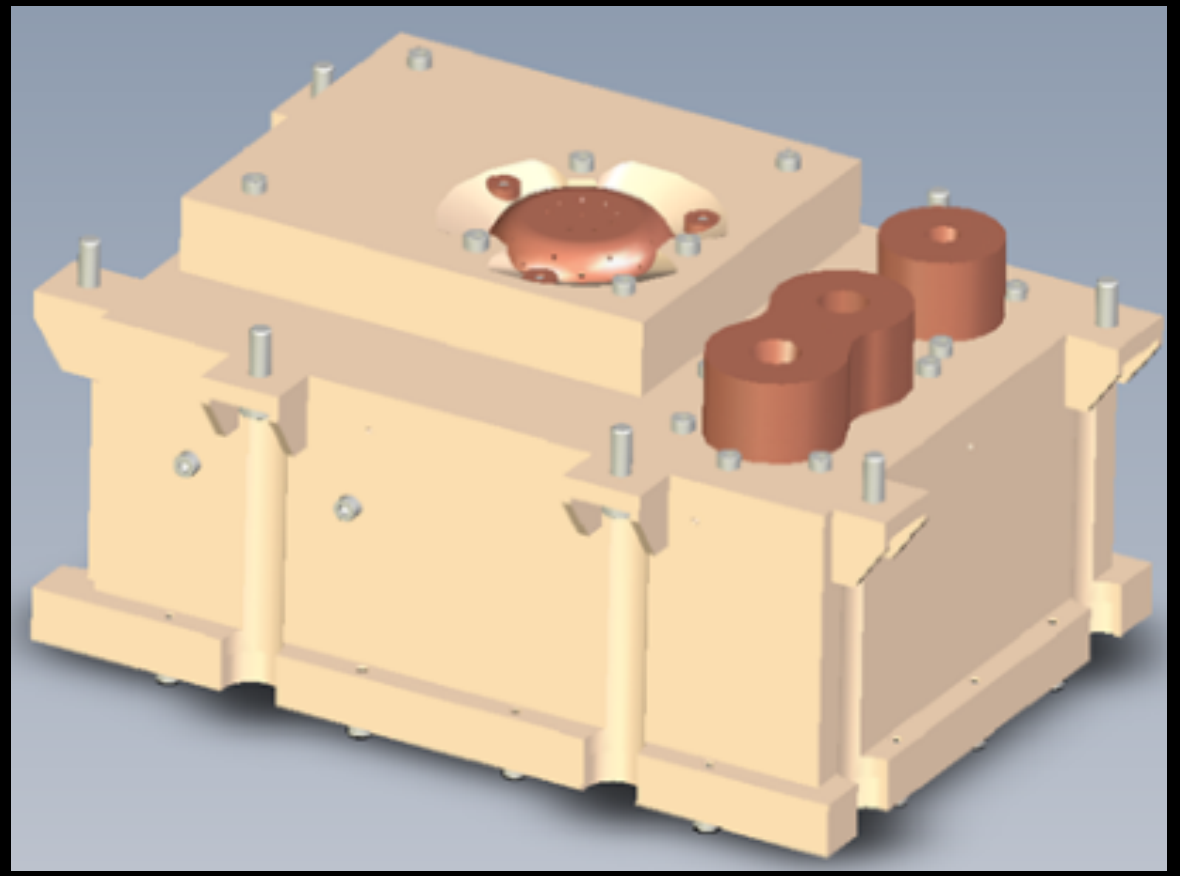
RADEM

Main Objectives

- Ensure mission safety
- Provide valuable scientific data

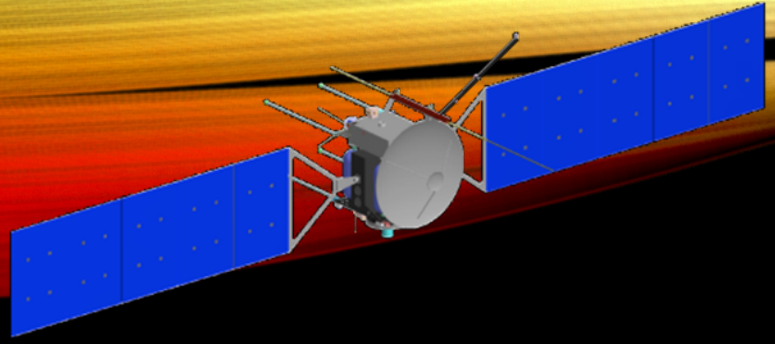
Requirements

- Electron detector
  - Spectral range 300 keV – 40 MeV
  - Peak Flux 10^9 e/cm^2/s
- Proton Detector
  - Spectral range 5 MeV– 250 MeV
  - Peak Flux 10^9 e/cm^2/s
- Particle Separation
  - From Helium to Oxygen
- Dose determination
- Low mass
- Low power consumption

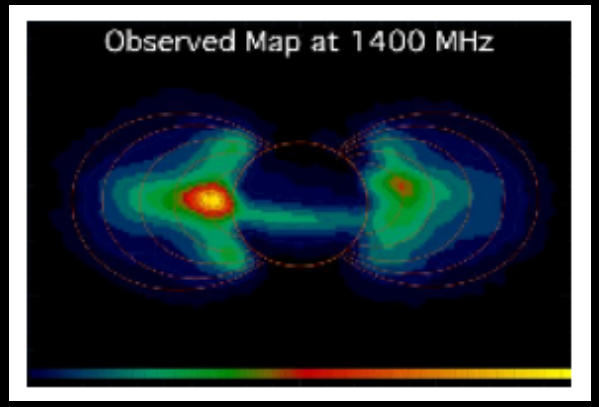


JUICE
THE JUPITER ICY MOONS EXPLORER

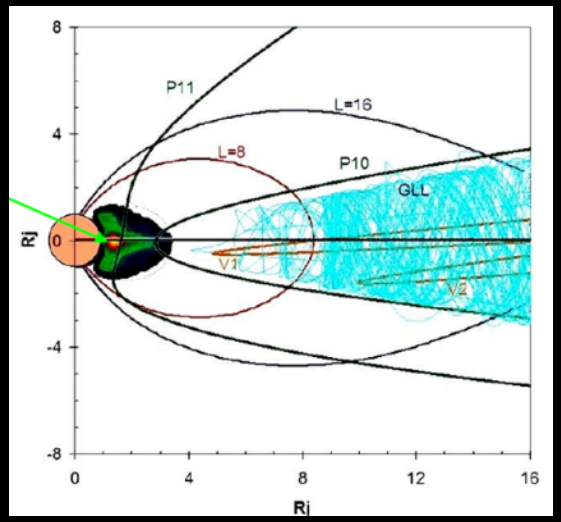
Next Class-L (Large) ESA Mission

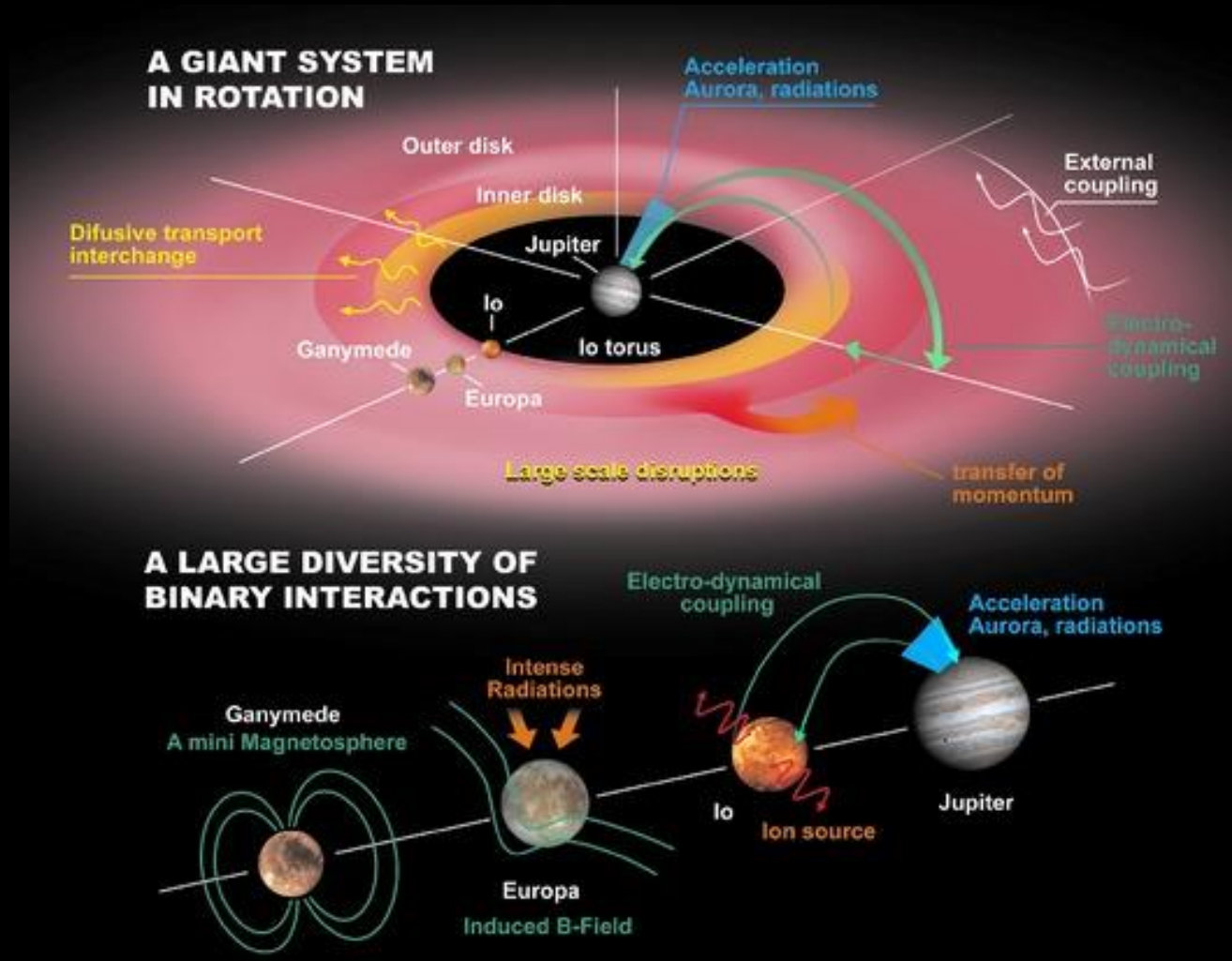


Synchrotron emission observations



& data from Voyagers, Pioneer , Galileo, Cassini



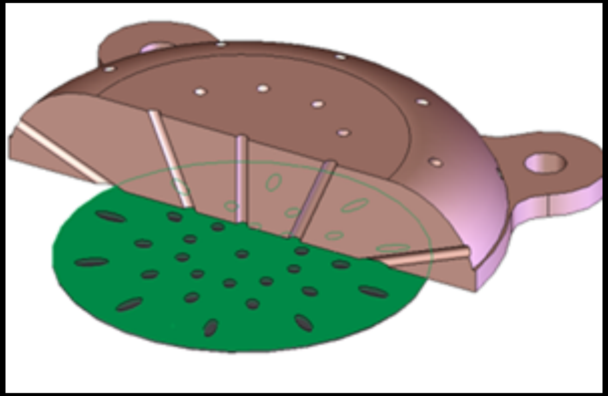


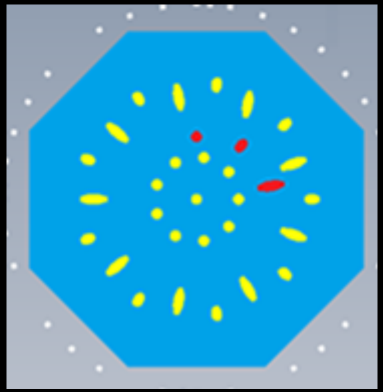
DEVELOPMENT OF THE RADEM DIRECTIONALITY DETECTOR

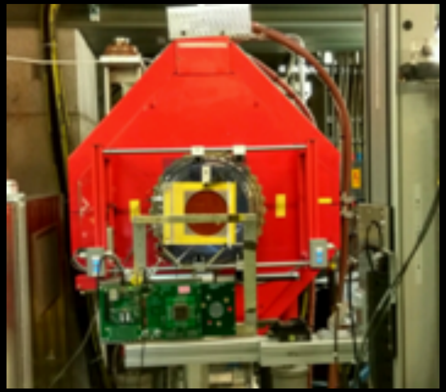
Marco Pinto

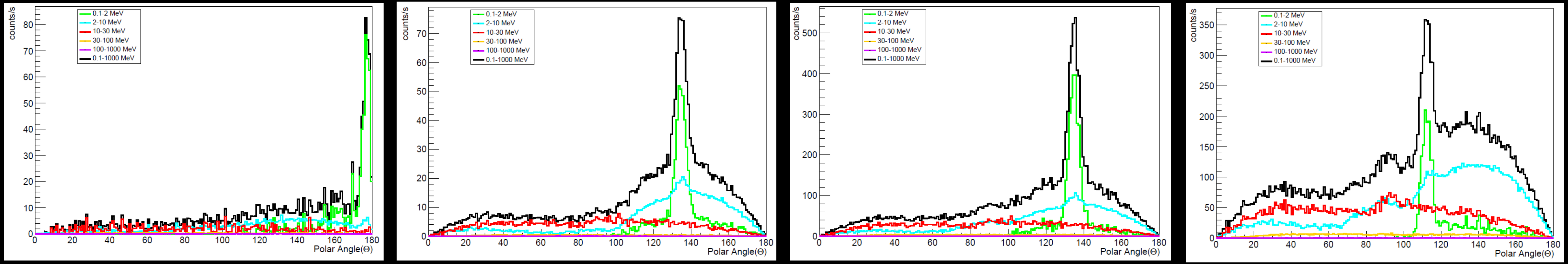
Design, testing and performance:

- Copper Collimator - 28 directions
- Single 505µm Kapton Absorber
- Single Detection Plane
- 28 Si Diodes
- 3 Blind Sensors









RADEM RADIATION ANALYSIS

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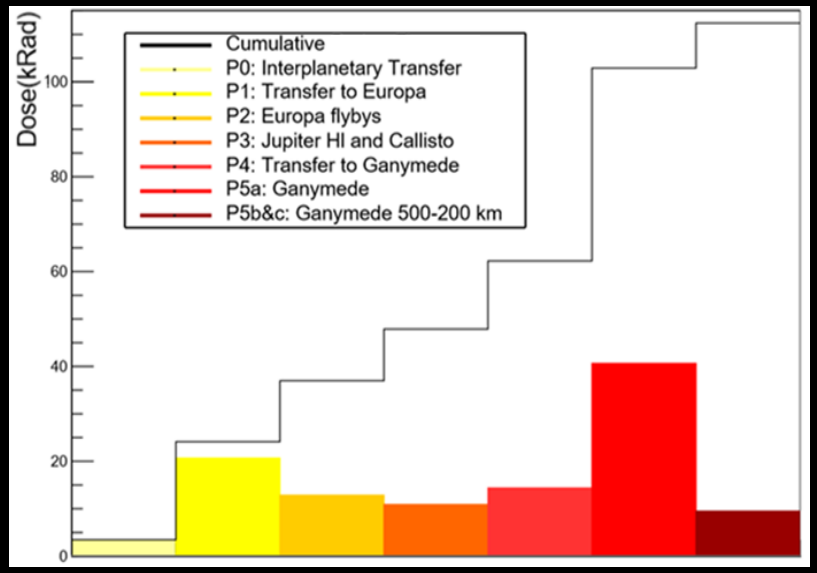
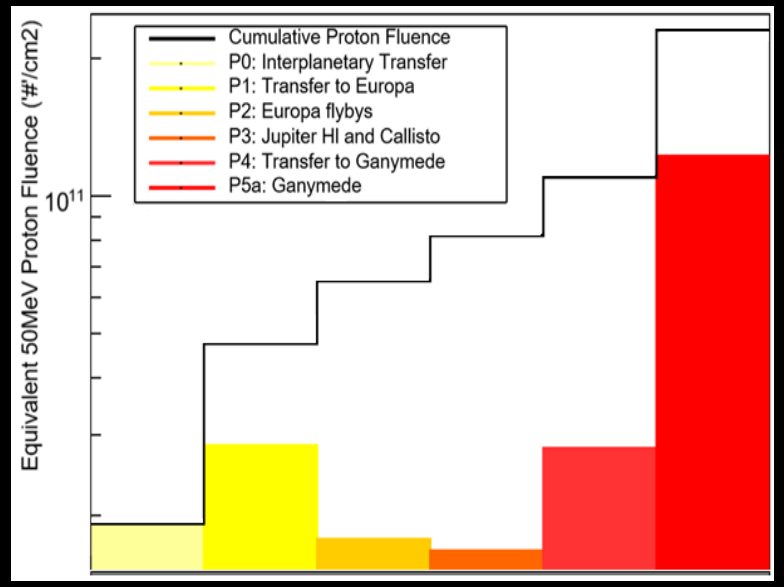
- Analysis at component level:
  - 119 components
  - TID; TNID and SEE

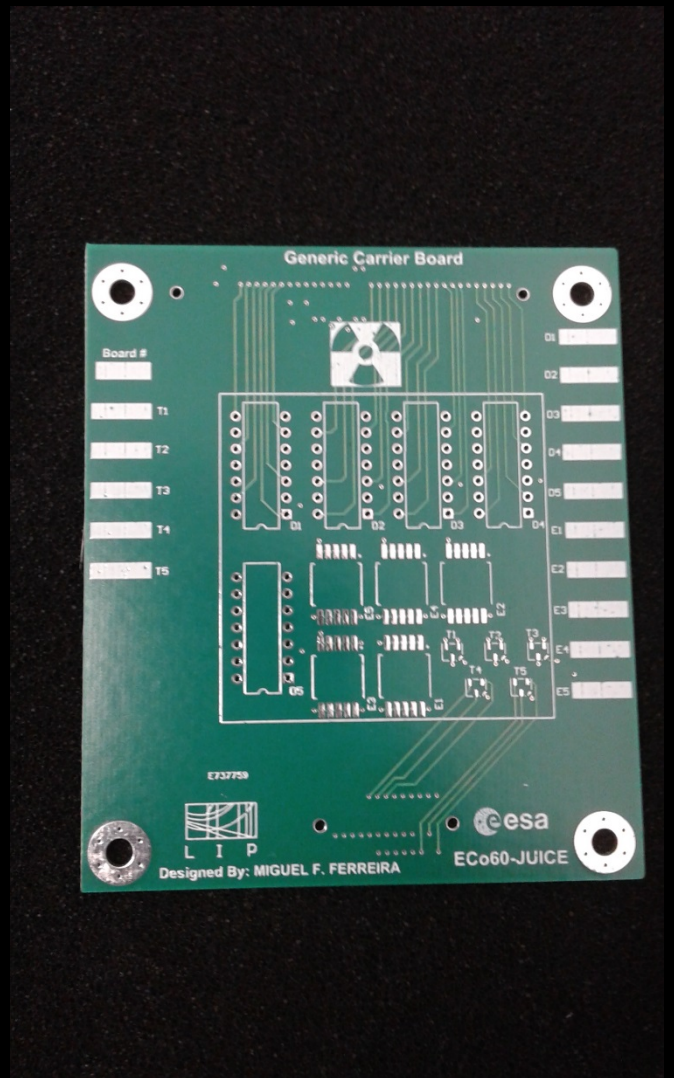
  for the whole JUICE mission
- Shielding optimization
- ASIC TID testing
  - To be performed

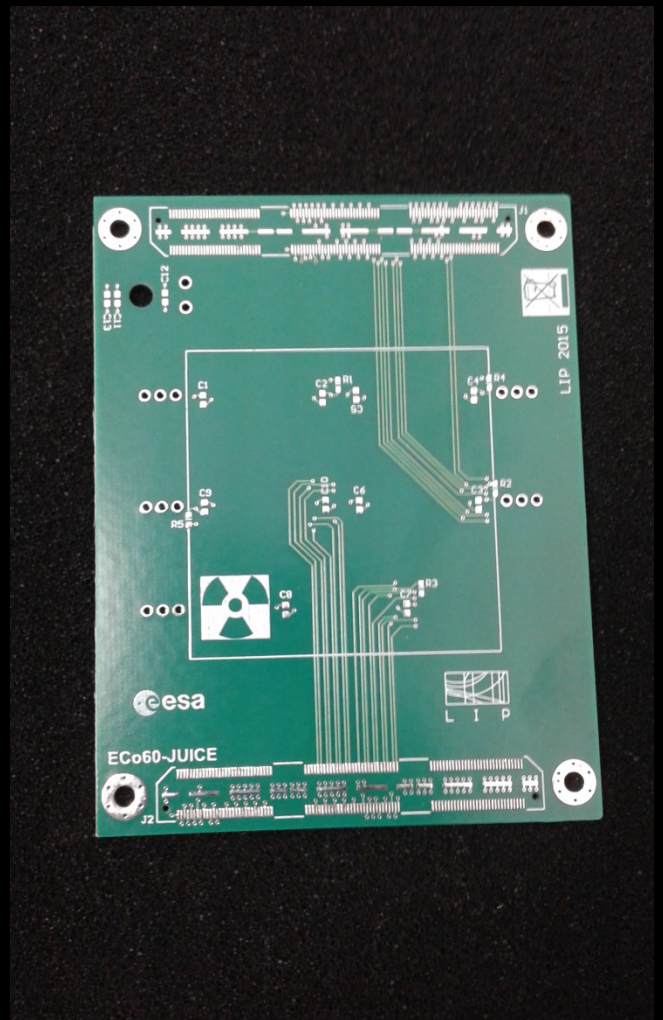


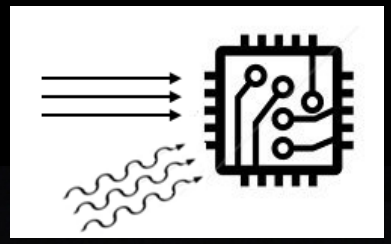


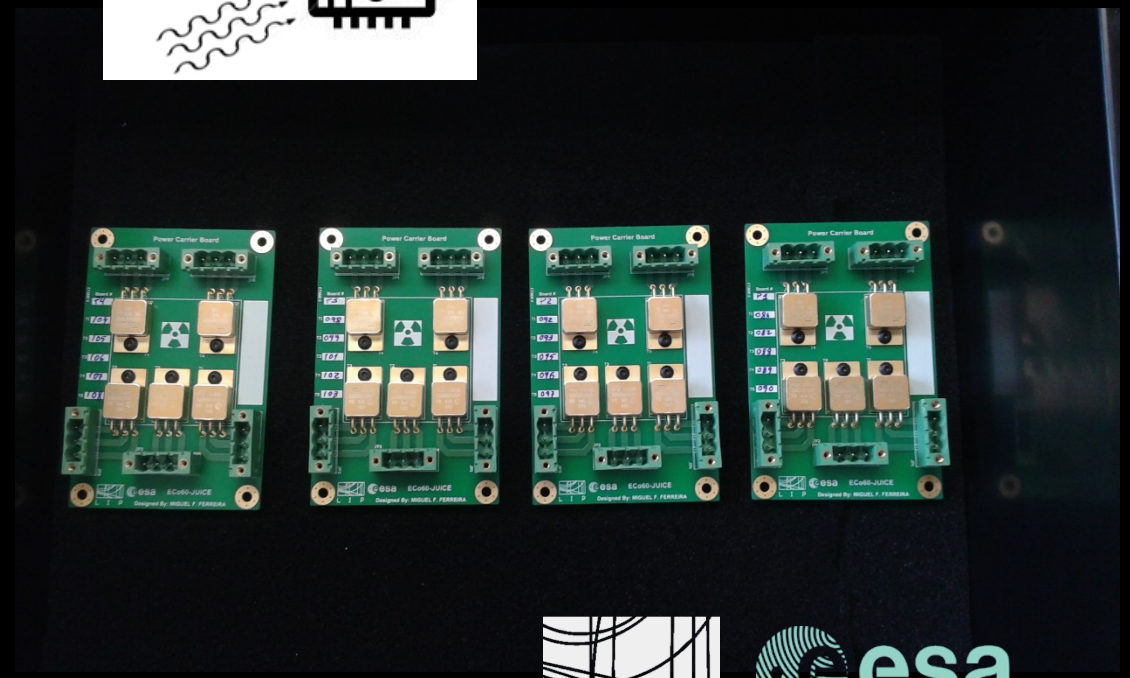
TID and TNID phase evolution in two critical EEE components

TEST, CHARACTERIZATION AND RADIATION HARDNESS ASSURANCE OF EEE COMPONENTS









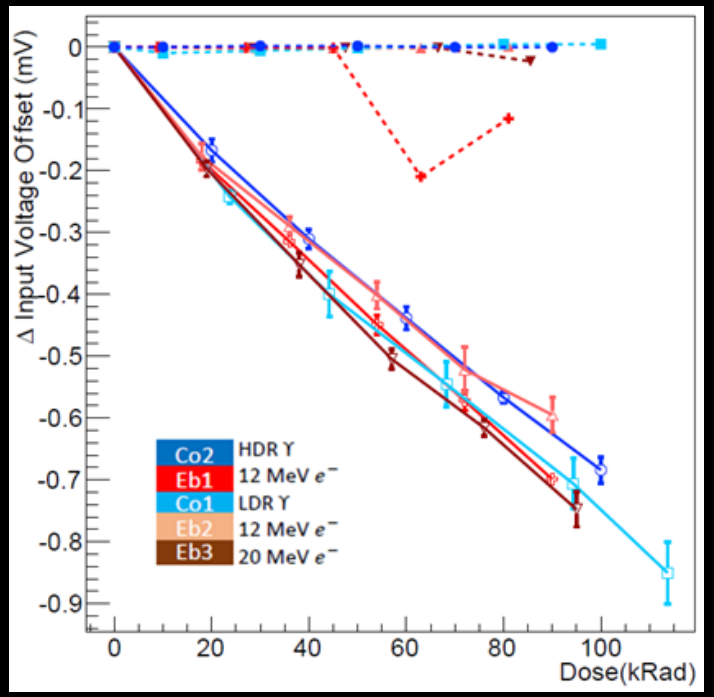
LIP esa

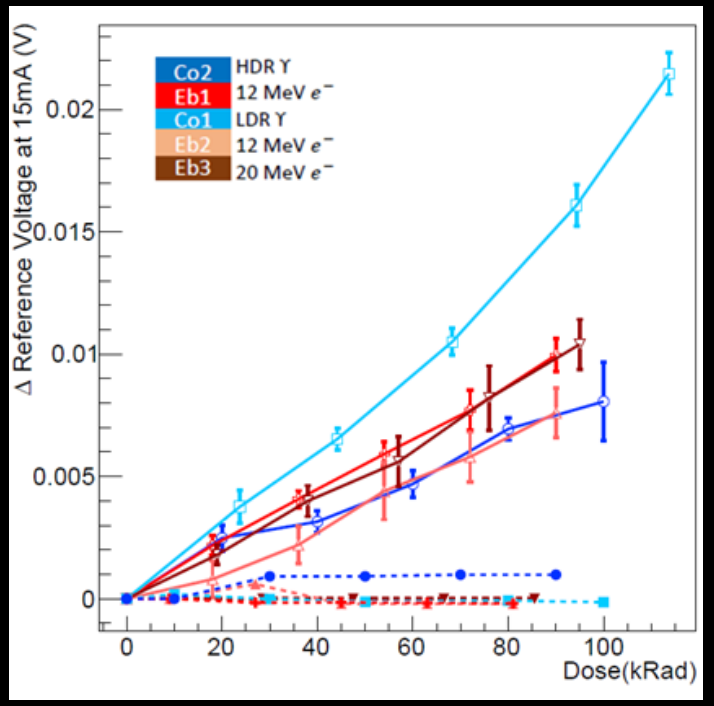
ECO-60

REPRESENTATIVENESS OF ^{60}CO TESTING FOR EEE COMPONENTS FLOWN TO THE JOVIAN SYSTEM

1. Circuit design and testing
2. Measurement automation
3. Radiation campaigns
4. Annealing
5. Data analysis

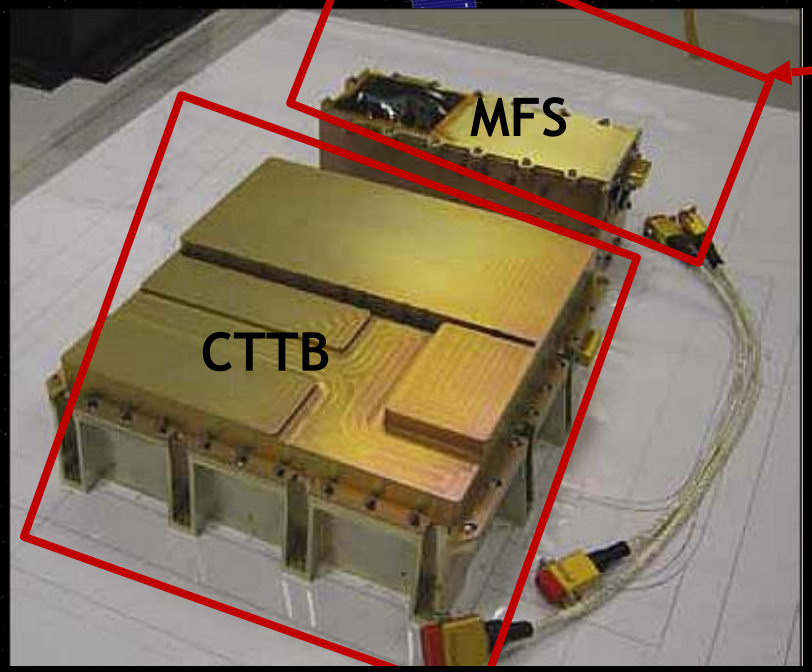
- ✓ Co60 testing representativeness verified – project concluded
- ✓ Results published in NSREC RDW 2017
- ✓ LIP lead project
- ✓ Collaboration between SPACE group and ECRLab



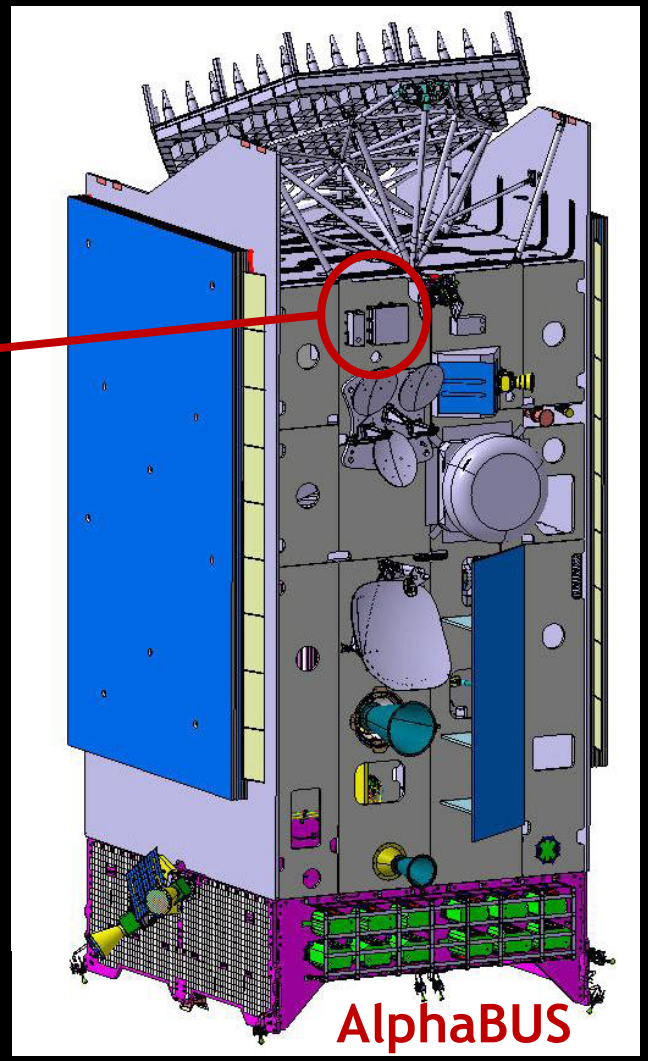


DATA ANALYSIS & TOOLS: THE MFS & THE CTTB ON ALPHASAT

- The AlphaSat was launched to GEO July 2013 carrying the AEEF
- AEEF (TDP8) = MFS + CTTB
- The two units are installed on X-panel of the AlphaSat



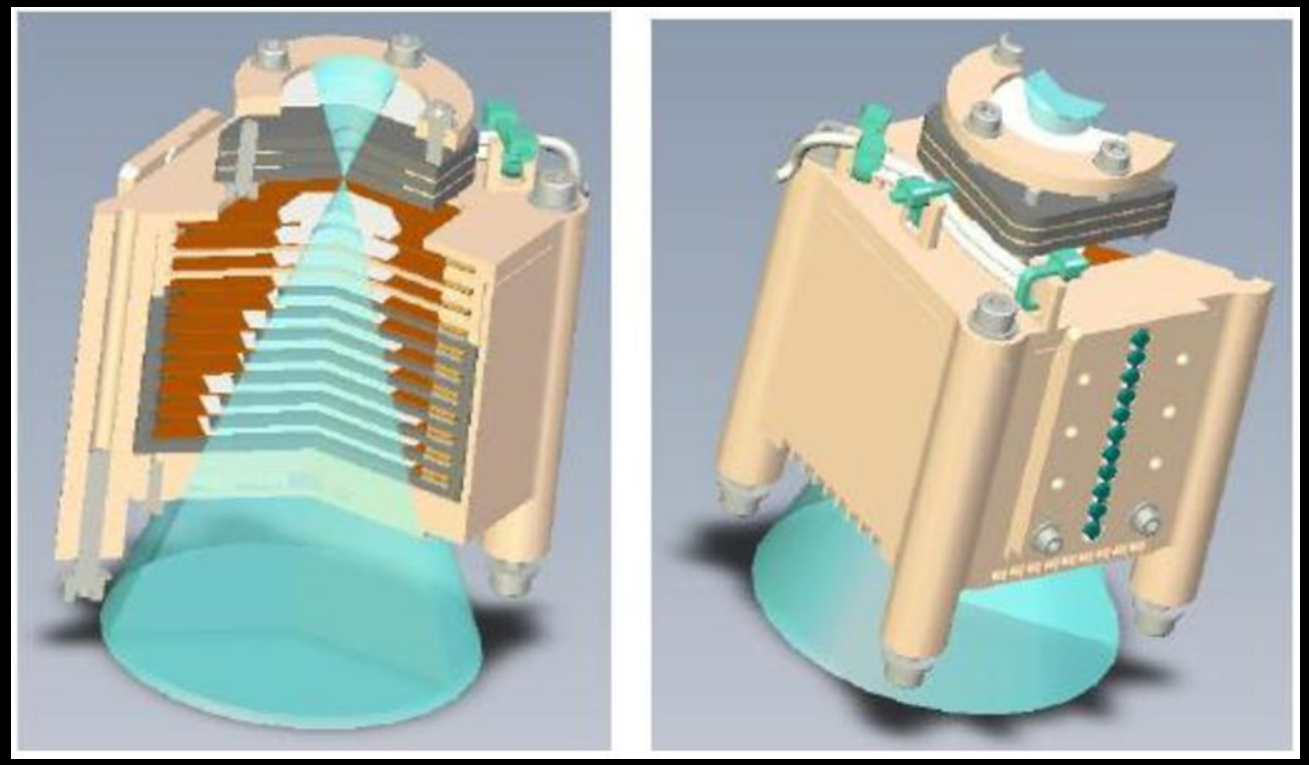
MFS: MultiFunctional Spectrometre
CTTB: Component Technology Test Bed

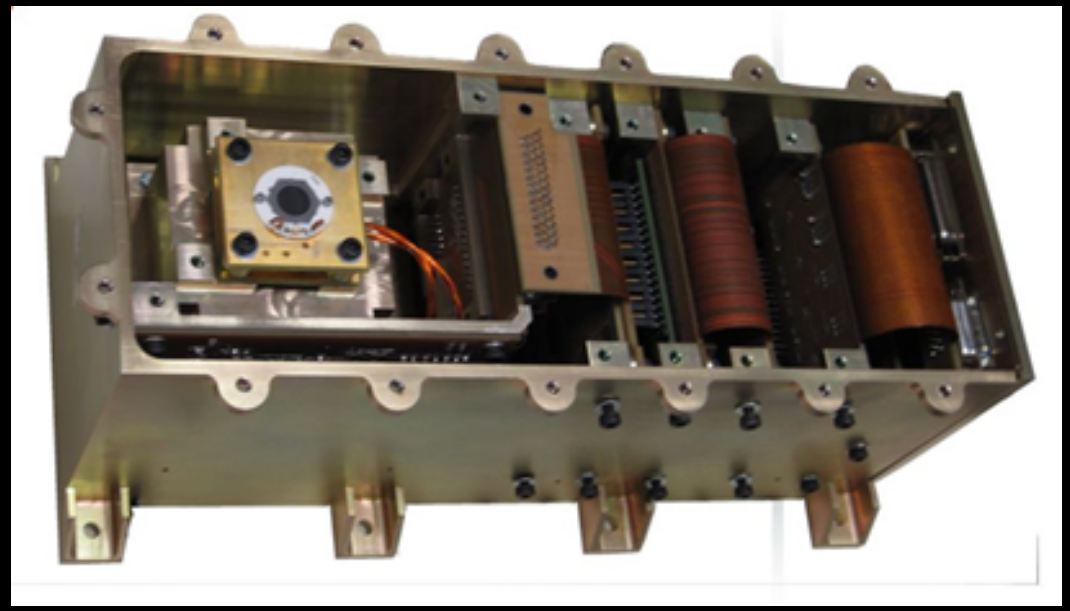


THE MULTIFUNCTIONAL SPECTROMETER

MFS requirements

- Electrons *300 KeV– 7 MeV*
- Protons *1 MeV – 200 MeV*
- Alpha particles *5 MeV – 200 MeV*
- Heavy Ions *5 MeV/nuc – 50 MeV/nuc*

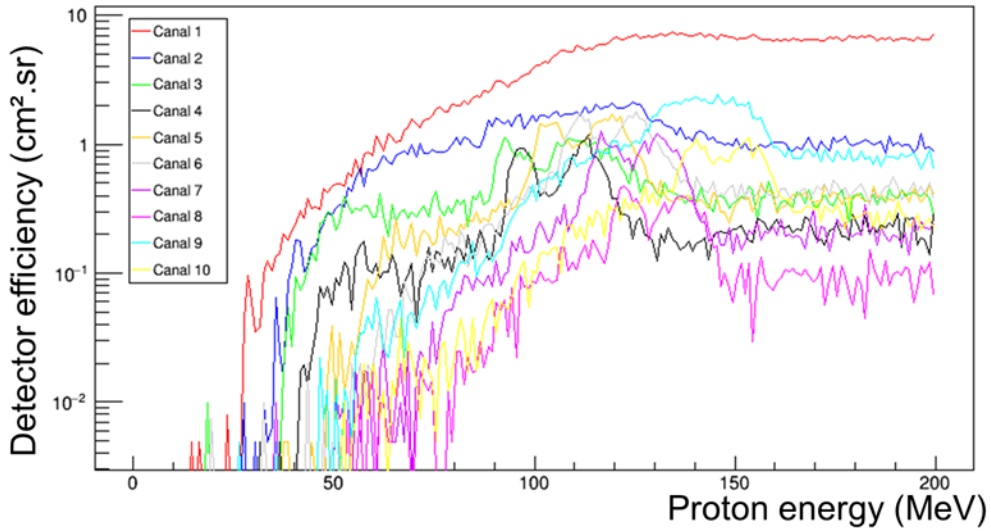




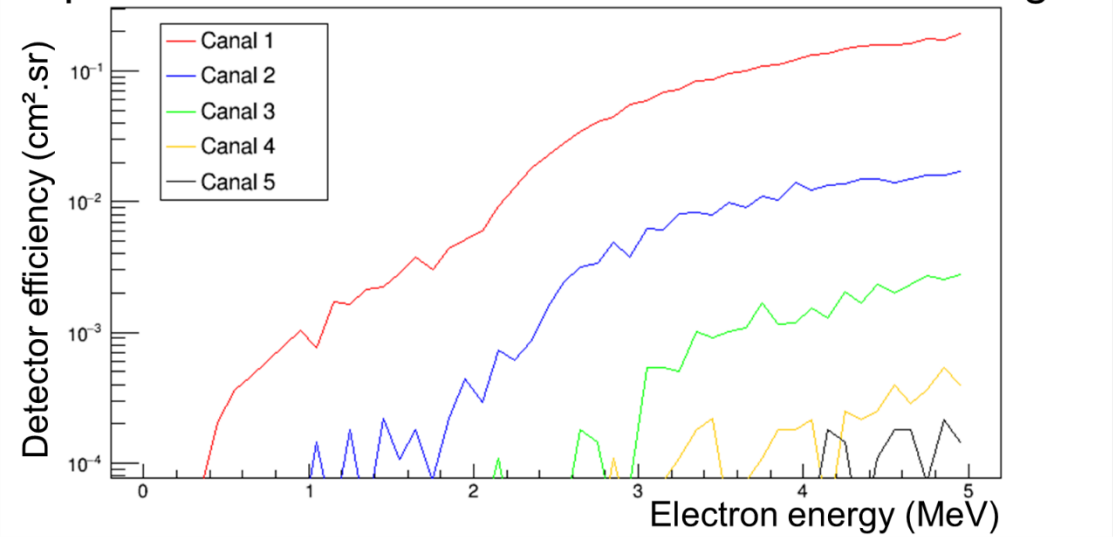
MFS RESPONSE FUNCTIONS

Obtained with Geant4 detailed simulation and analysis of the MFS response

Response function of proton channels to incoming protons



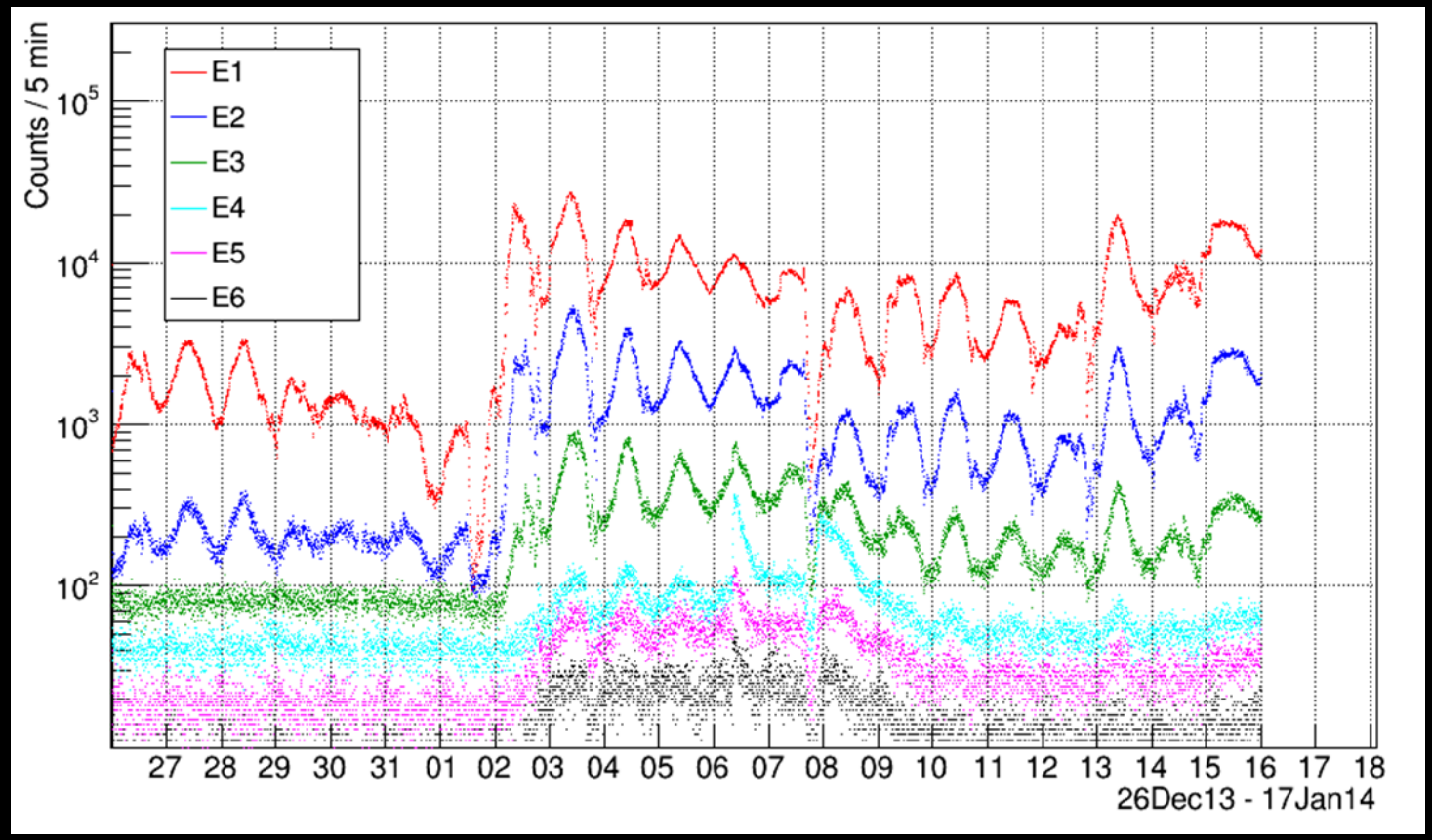
Response function of electron channels to incoming electrons



ELECTRONS DURING JANUARY 2014 SEP EVENT

MFS Electron counts

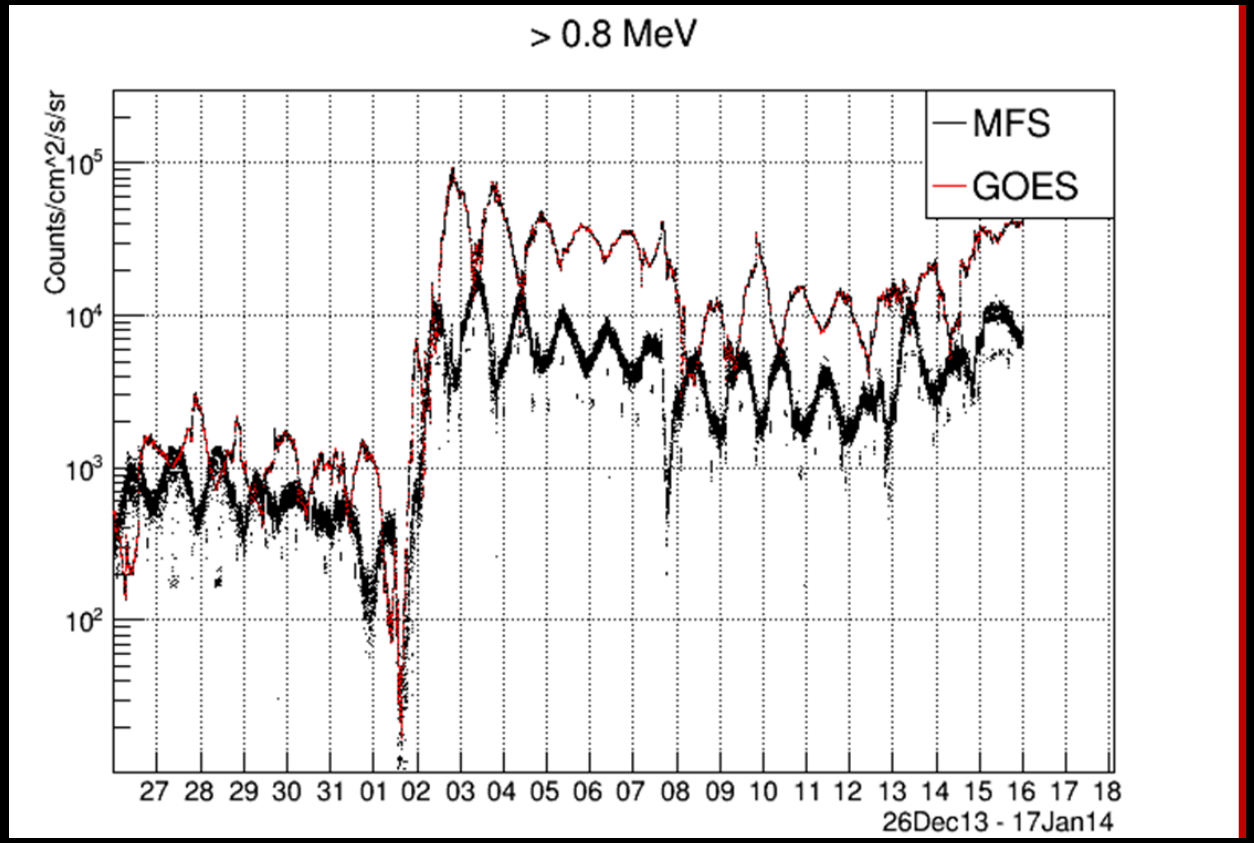
Filipe Máximo

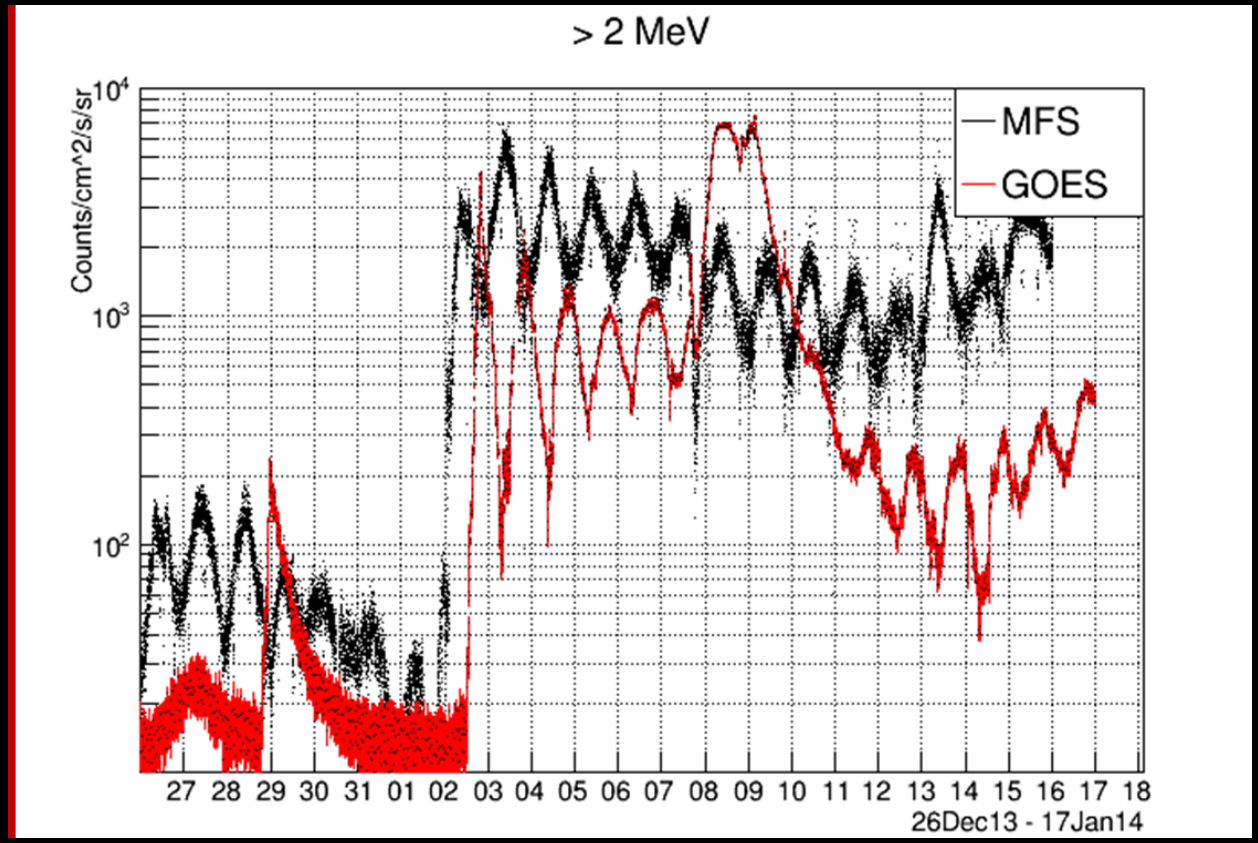


ELECTRON FLUX DURING JAN 2014 SEP EVENT

Electron Integral Fluxes vs Time :
electron channel data deconvoluted from detector electron response functions

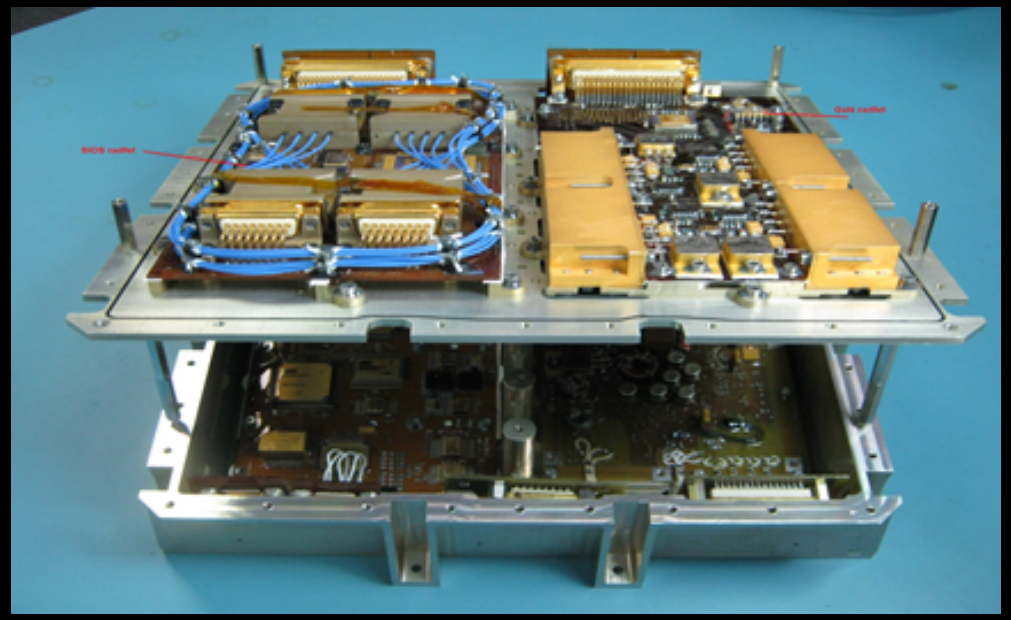
Filipe Máximo





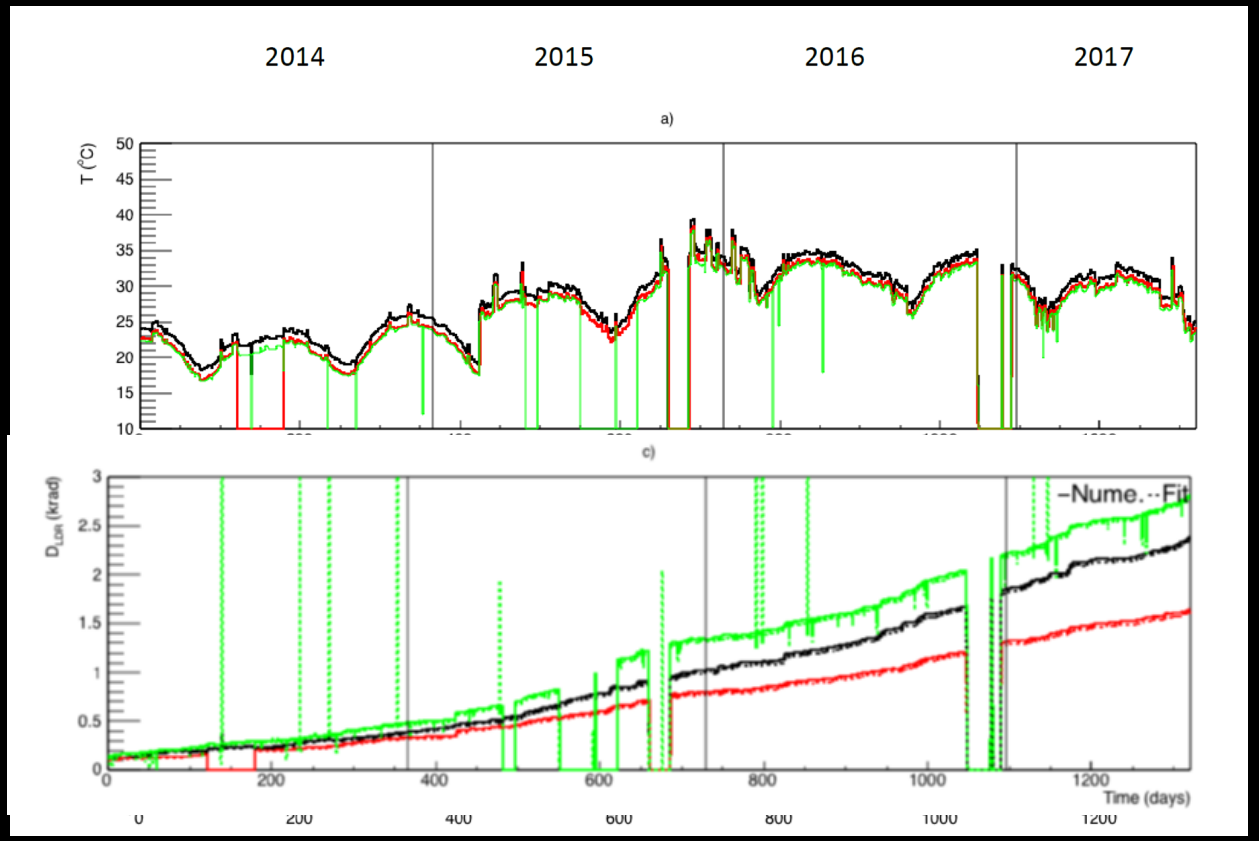
CTTB DATA ANALYSIS

Component Technology Test Bed



3 experiments:

- GaN Sensors (Aveiro)
- Optical Links (Valencia)
- Memories



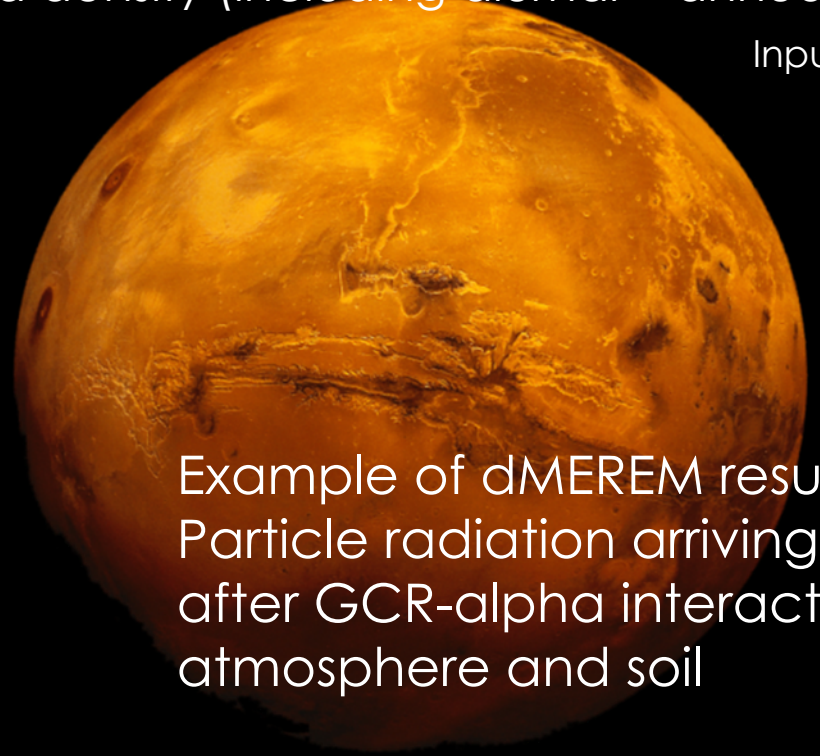
RADFET Total Ionizing Dose for each CTTB experiment
January 2014-September 2017

RADIATION ENVIRONMENT MODELING

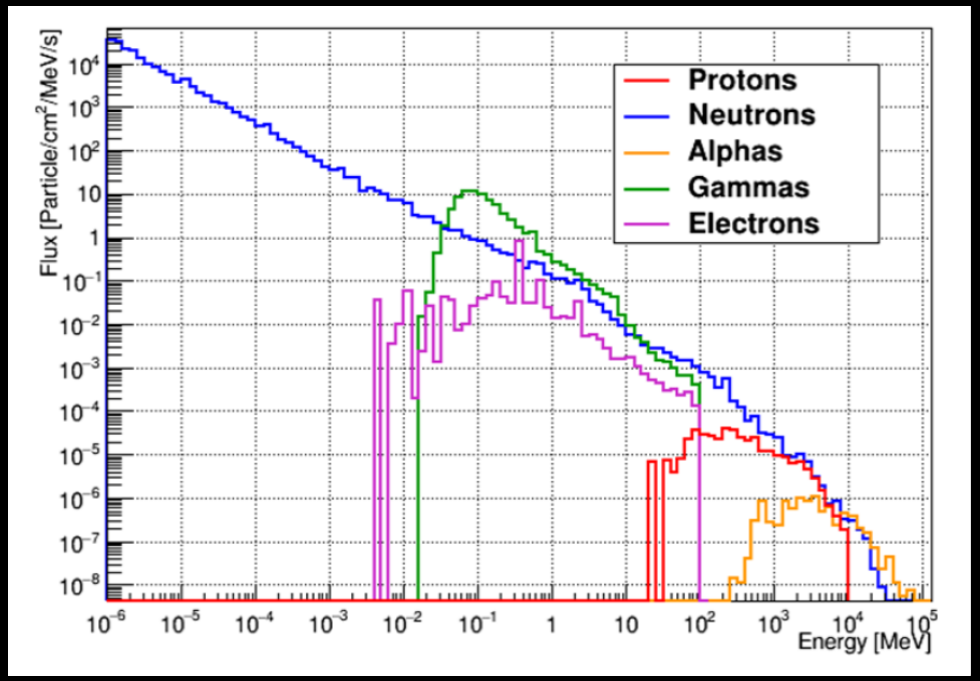
MARSREM: THE MARS ENERGETIC RADIATION ENVIRONMENT MODELS

LIP developed **dMEREM,** a **Geant4 based model for the radiation environment on Mars, Phobos and Deimos**, including local treatment of surface topography and composition, atmospheric composition and density (including diurnal + annual variations) and local magnetic fields.

Inputs given as a function of latitude, longitude, in a 5 x 5 degree grid, and season.

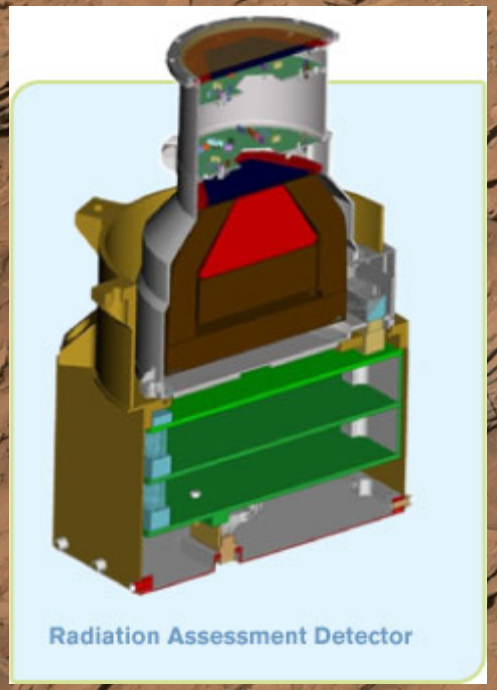


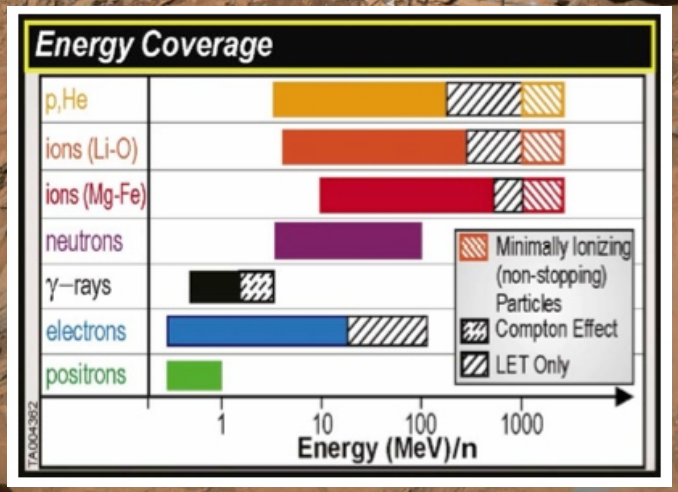
Example of dMEREM results:
Particle radiation arriving on Mars surface after GCR-alpha interaction with atmosphere and soil



CURIOSITY ROVER ON MARS

RADIATION ASSESSMENT DETECTOR

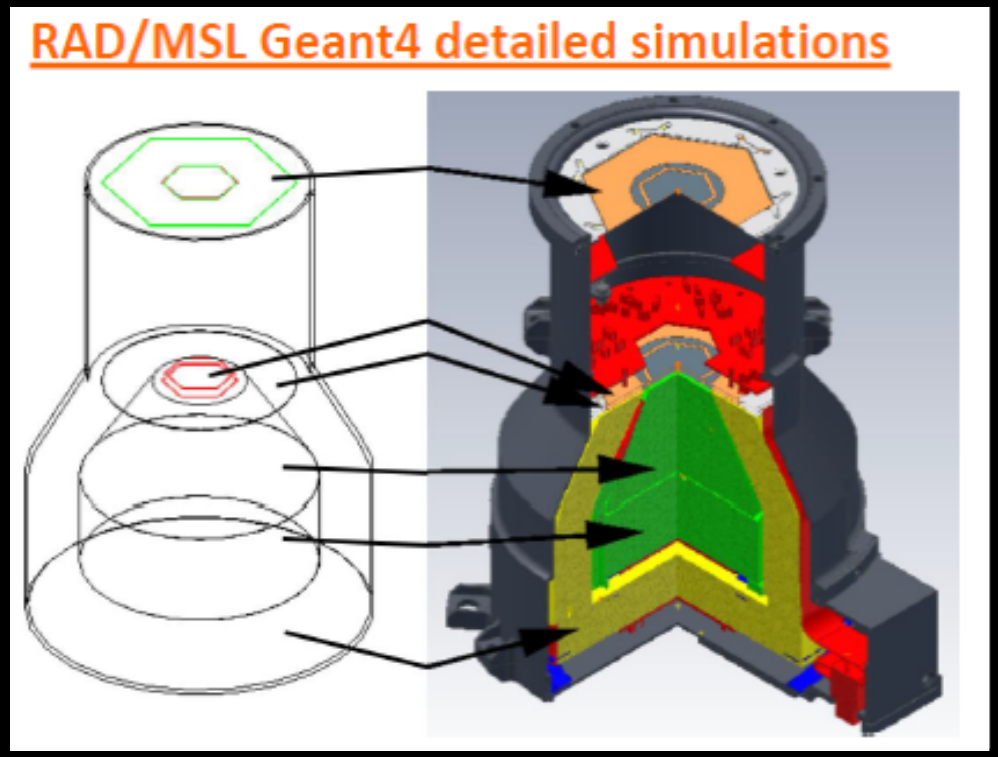




ASSESSMENT OF RADIATION EXPOSURE IN MANNED MISSIONS TO MARS

Ana Luísa Casimiro

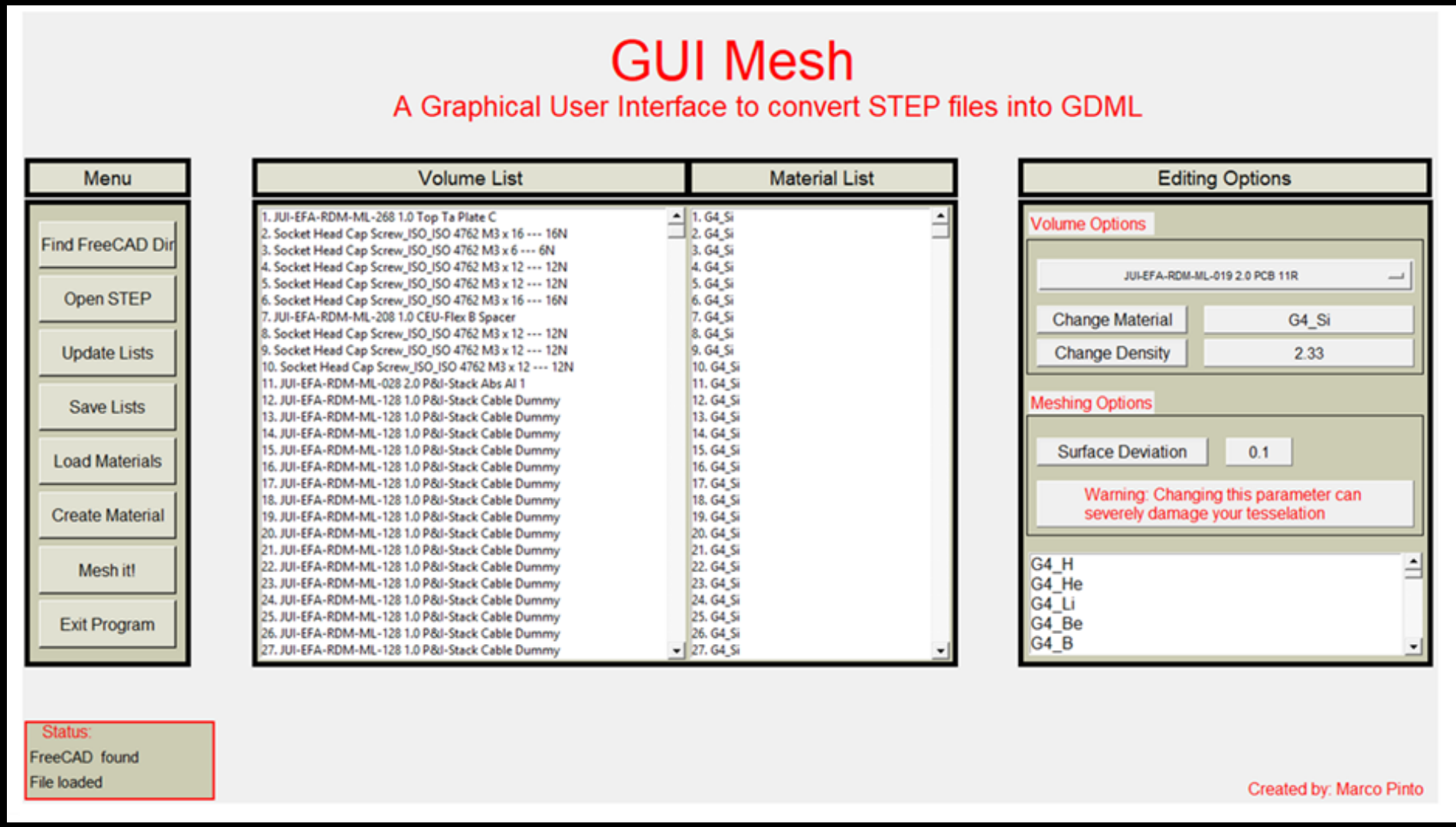
Using dMEREM and RAD data (aboard Curiosity) to predict radiation hazards in manned missions to Mars



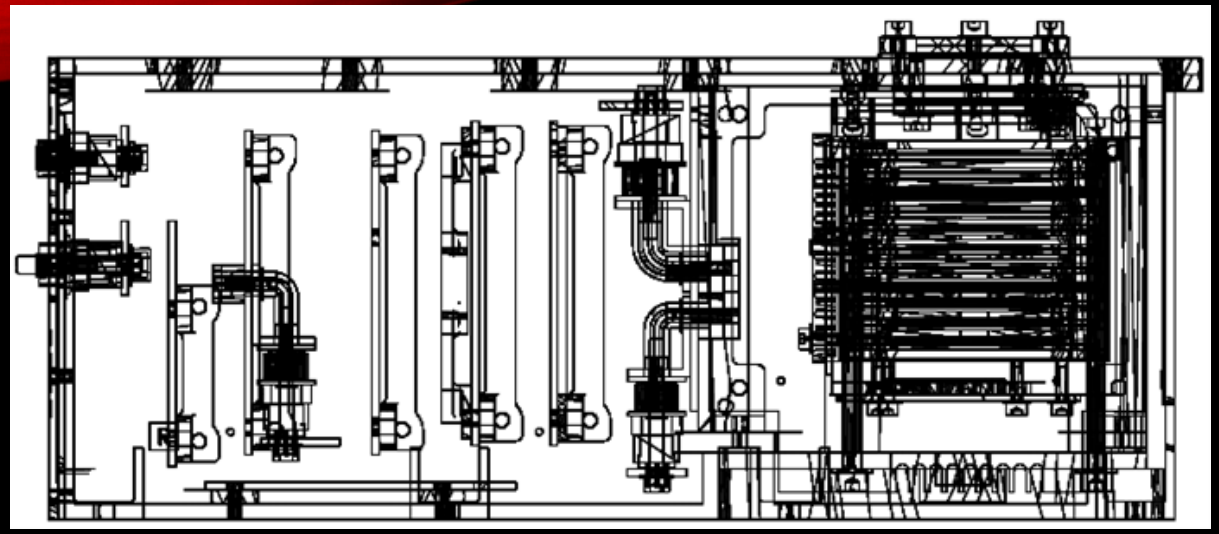
Ongoing Geant4 simulation of RAD/MSL

- Replicate previous spectra and obtained new spectra during transit and on Mars' surface
- Use published spectra results to re-do previous simulations using 2 phantoms:
  - ICRU sphere
  - ICRP reference anthropomorphic models

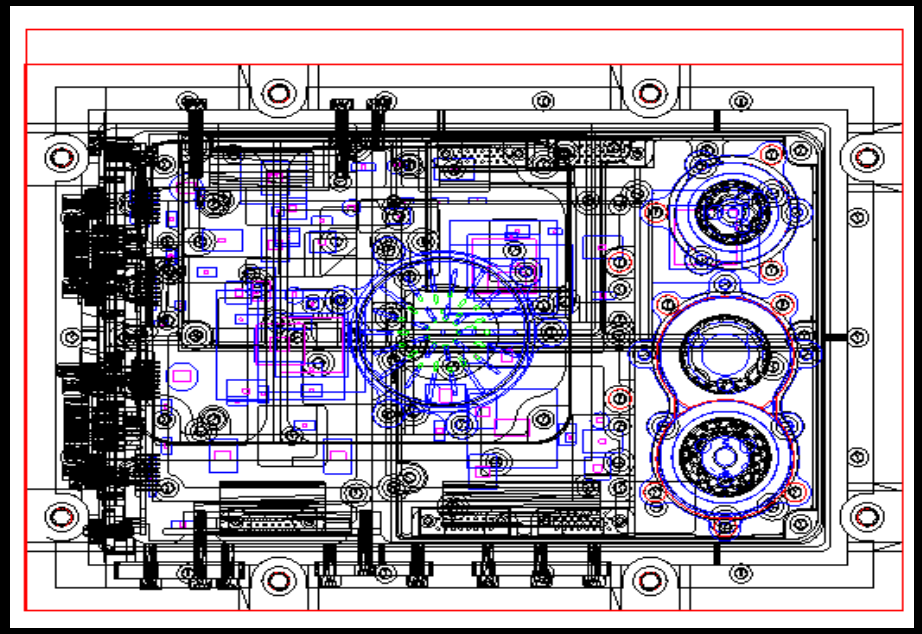
FROM CAD TO GDML TO G4 GUIMESH



MFS



RADEM



CTTB