

# Geant4 at INTA

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## ENGINEERING

### Space Environment Analysis & Specification

- Modeling of realistic S/C geometries
- Environment propagation
- Estimation of radiation levels

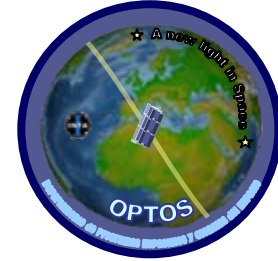
### Shielding Analysis

- Optimization of S/C or P/L designs
- SSAT, FW MC techniques

### Simulation of Irradiation Tests

- To support irradiation campaigns
- Simulation of testing beams & setup configurations

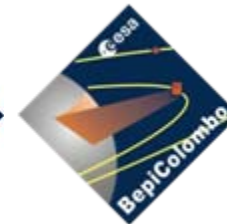
## Spanish Micro/Nano Programmes



## Colaboration with Universities



## ESA Missions



## R & D

### Instrument Design

- Support to radiation sensors design
- Calibration of sensors

### Geant4 Developments

- Parallelization / Cluster implementation
- G4/GRAS developments

### Operational Tools

- Real-time radiation damage for operating missions

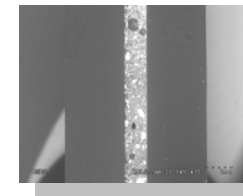
### Semiconductor

- G4 & TCAD simulation of devices

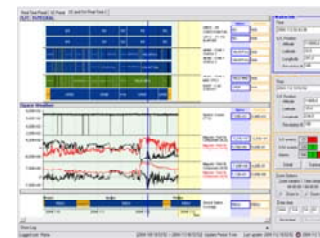
## National Earth Obs – TTT P/L



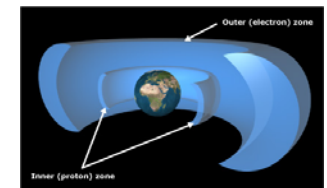
## R&D New Carbon Materials



## ESA Programmes



SEISOP / G4MRES

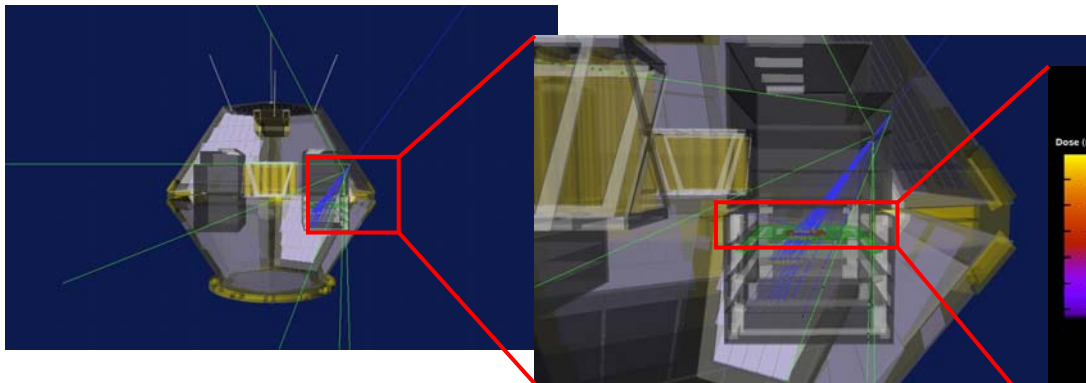
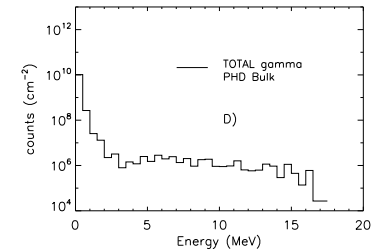
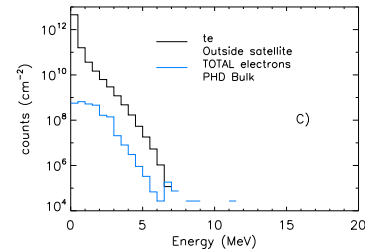
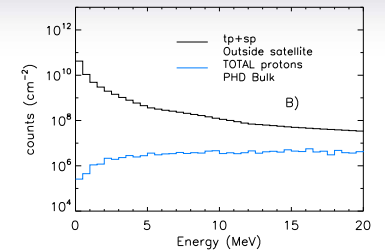
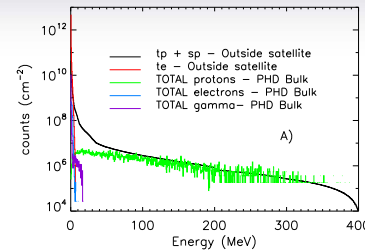


ENERGETIC E- R&D



## NANOSAT - 01

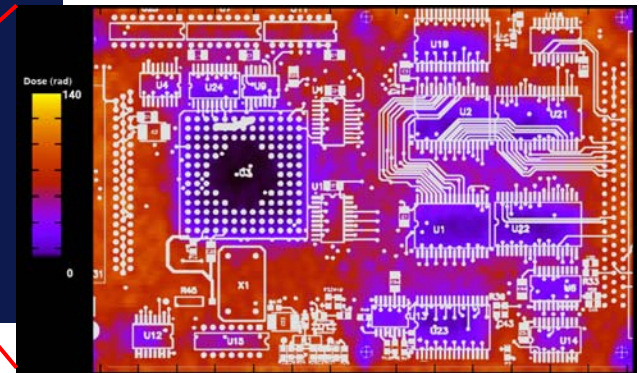
- Launched: 2004 (still flying)
- LEO Sun-Sync – ~800 km
- Full S/C Geant4 model
- Geant4 activities:
  - Radiation levels estimation for P/L
  - Shielding analysis / Dose Mapping
  - OWLS modules detailed analysis



**Environment simulation over Nanosat-01 S/C**

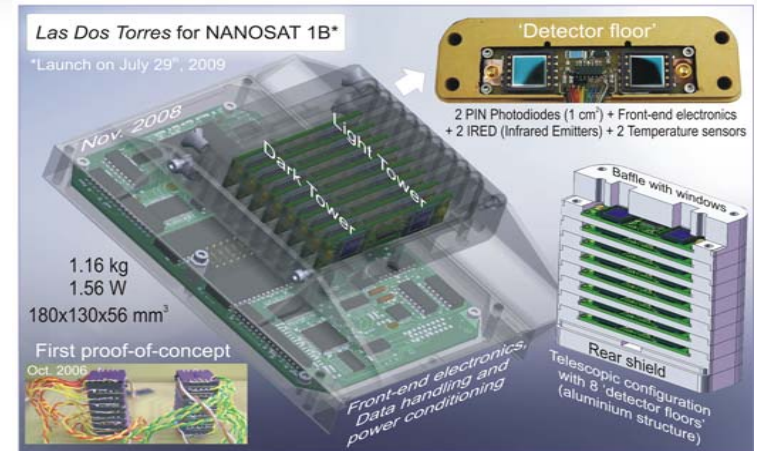
**Propagation of particles**

### Particle/Dose levels at P/L



## NANOSAT – 1B

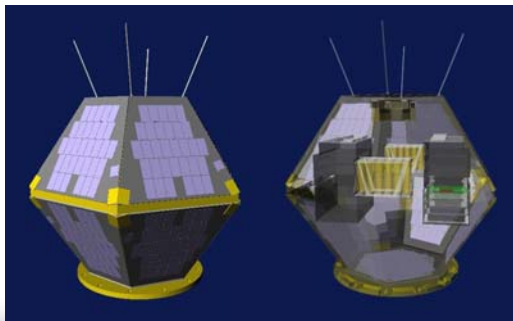
- Launched: 2009
- LEO Sun-Sync – ~800 km
- Radiation P/L
  - TID – RadFET sensors
  - NIEL – Photodiode Towers (TTT)
  - Accidentally SET detection
- Full S/C Geant4 model
- Geant4 activities:
  - Radiation levels estimation for P/L
  - Correlation with on-board TID and NIEL sensors



**The Two Towers Precursor.**  
Developed by INTA Optoelectronics Lab



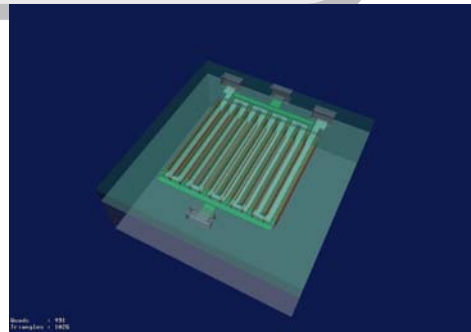
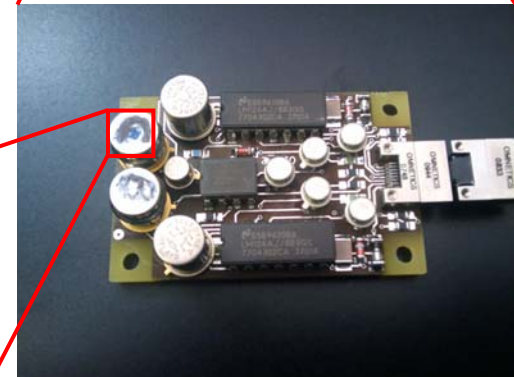
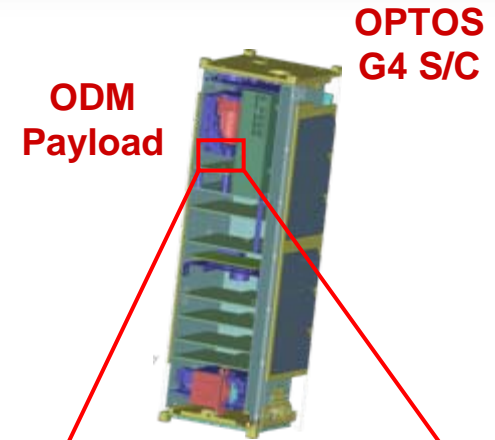
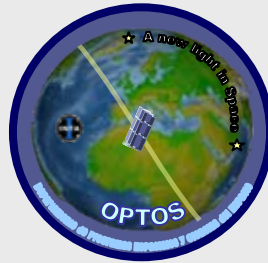
**SET events experienced in Nanosat-1B.**  
Courtesy of INTA Optoelectronics Lab



**Nanosat Platform**  
**Geant4 Model**

## OPTOS / ODM

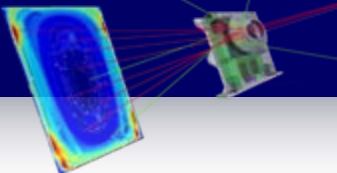
- Launch: end 2010
- LEO Sun-Sync – ~600 km
- Radiation P/L
  - Dosimetry – Multiple RadFET sensors
- Full S/C Geant4 model
- Geant4 activities:
  - Radiation levels estimation
  - Environment models vs. On-board data
  - RadFET simulation



**High sensitivity dose sensors (CNRS LAAS RadFETs)**

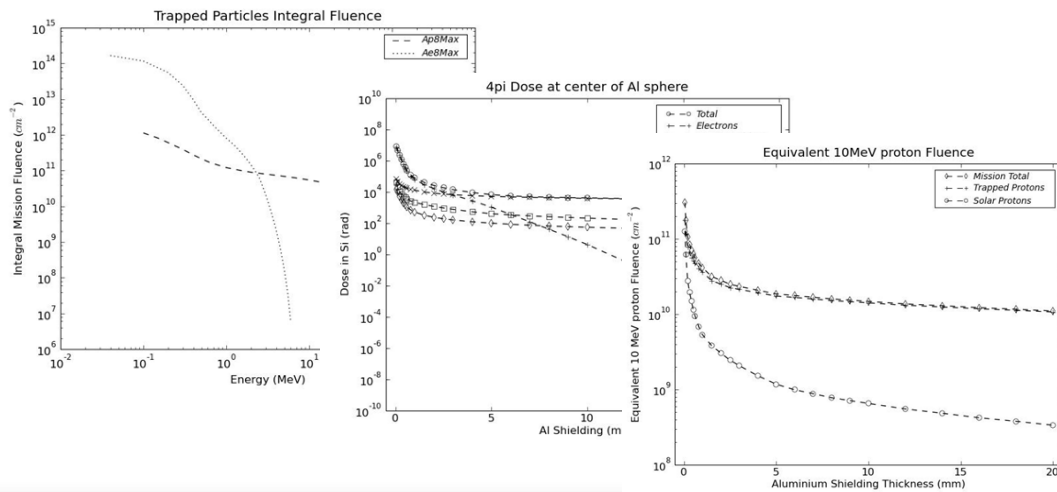
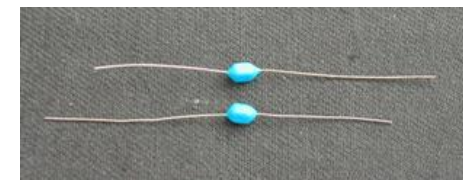
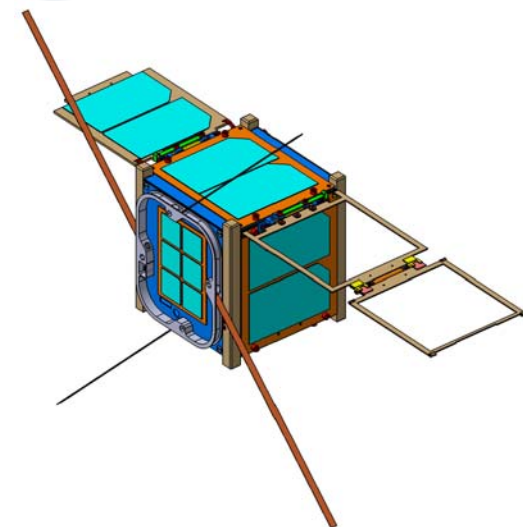
**ODM Engineering Model**





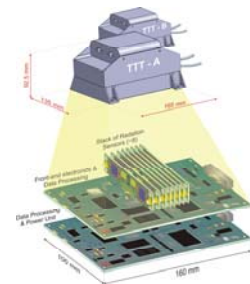
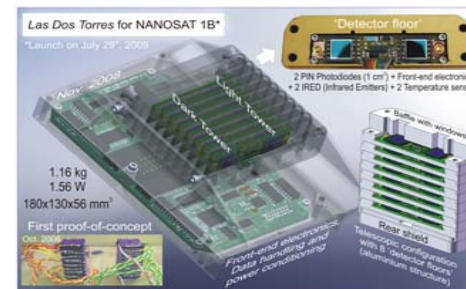
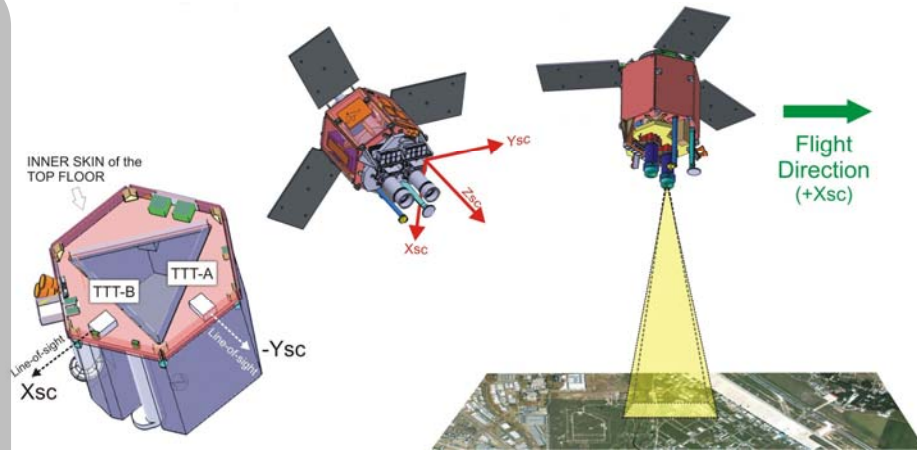
## XatCobeco

- Launch: 2010? 2011? VEGA
- Radiation P/L
  - NIEL Dosimetry – Multiple PIN Diodes
- Full S/C Geant4 model
- Geant4 activities:
  - Radiation levels estimation
  - Environment models vs. NIEL On-board data



## INGENIO / TTT Payload

- Launch: ~2012
- Earth observation mission
- Radiation P/L : TTT+ (The Two Towers 2G)
  - NIEL & TID
  - Multiple env. sensing technologies
- Geant4 activities
  - TTT Geant4 model
  - TTT design and calibration
  - Radiation levels estimation at TTT
  - Correlation with on-board data

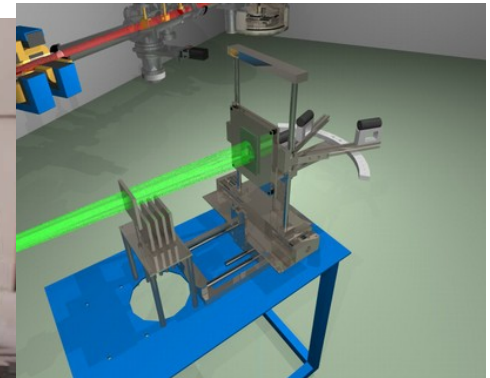
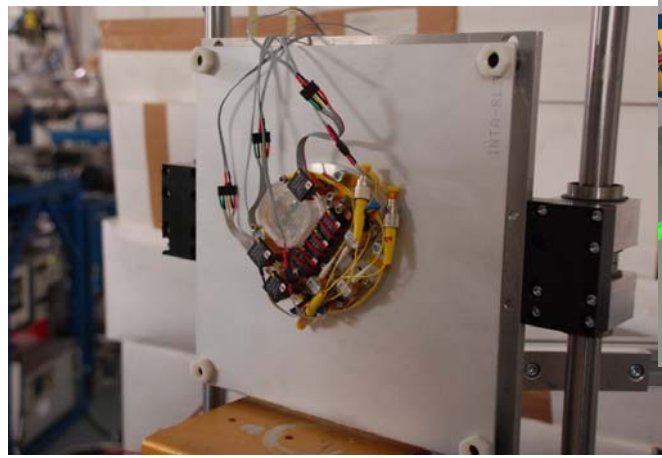
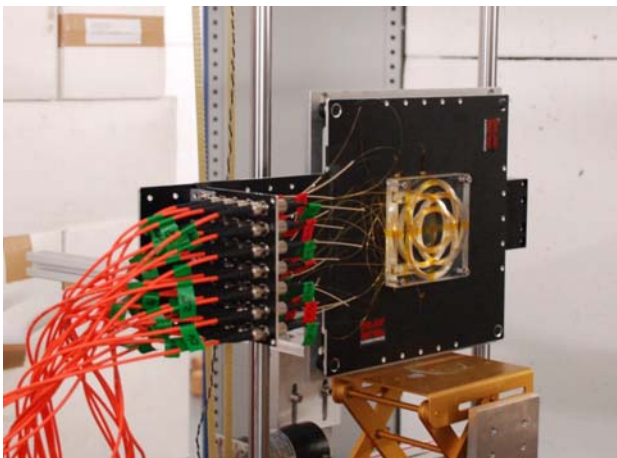


The Two Towers Precursor at NS-01 and next generation for INGENIO mission  
 Developed by INTA Optoelectronics Lab



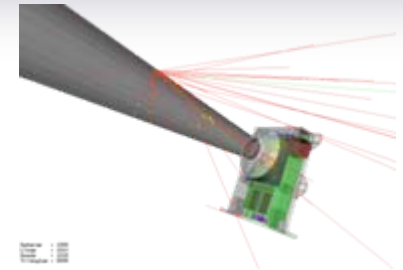
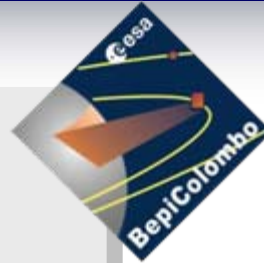
## EXOMARS / RLS Payload

- Launch: ~2018
- Raman Laser Spectrometer (RLS)
- Geant4 activities
  - Simulation of radiation tests for components (Lasers, Optic fibers, Photodiodes)
  - Particle & RHU propagation on exomars rover and RLS payload

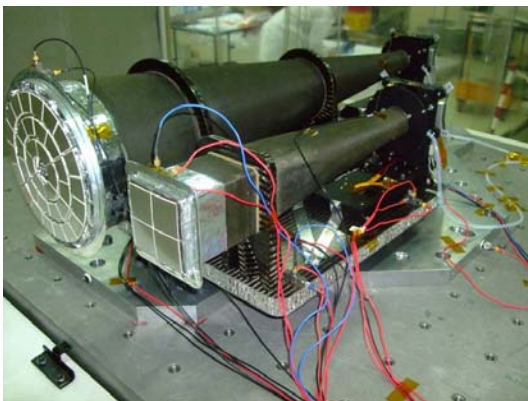
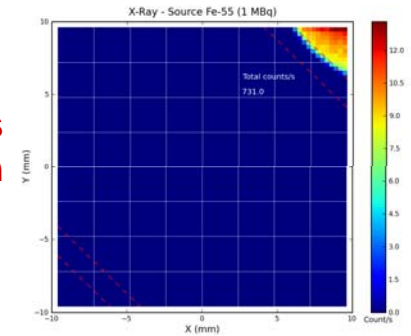


## BepiColombo / MIXS

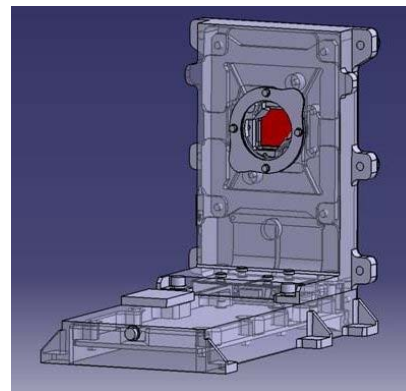
- Launch: ~2014
- Mercury Imager X-ray Spectrometer (MIXS)
- Geant4 activities
  - Shielding analysis of MIXS instrum
  - X-Ray sources simulation
  - Environment propagation
  - Particle focusing / Deflecting



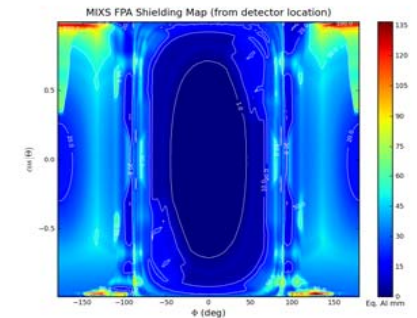
**Radiation studies  
MIXS FPA Design**



**BepiColombo MIXS Instrument**

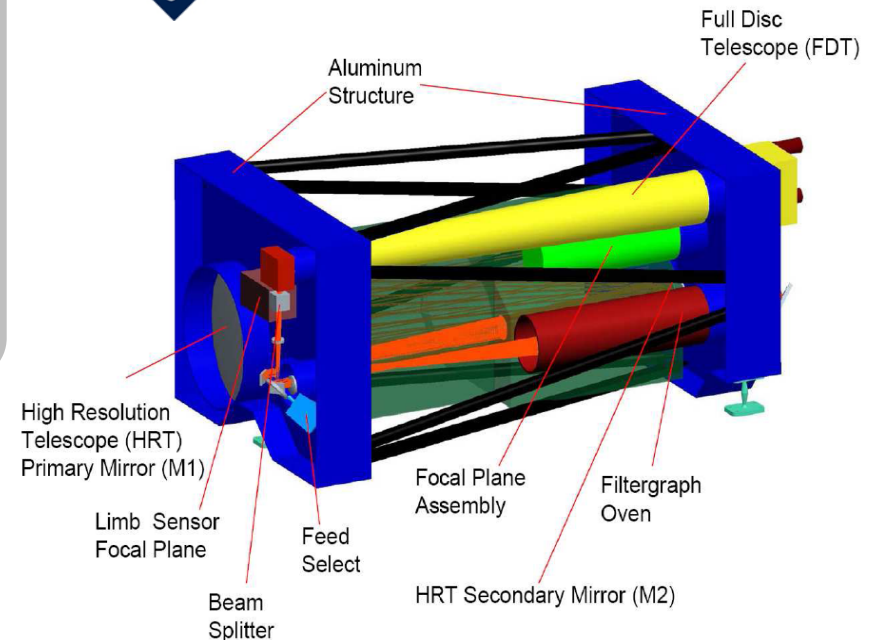
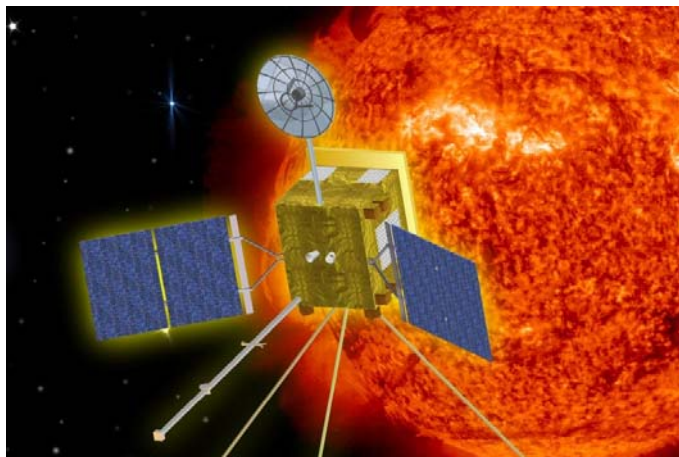


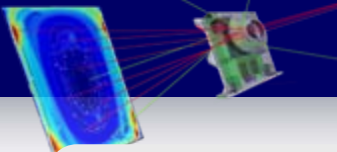
**FPA G4 Model**



## Solar Orbiter / PHI

- Launch: ~2017 / 2018
- Polarimetric and Heliosismic Imager (PHI)
  - FDT – Full Disk Telescope
- Geant4 activities
  - Simulation of irradiation tests for Optical Components (LCVRs)
  - Environment propagation on FDT
  - Radiation levels estimation for FDT





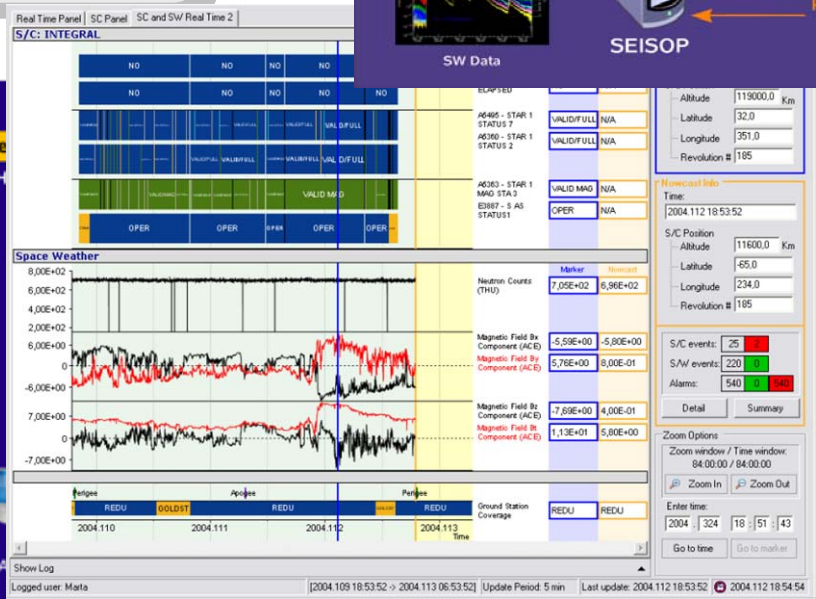
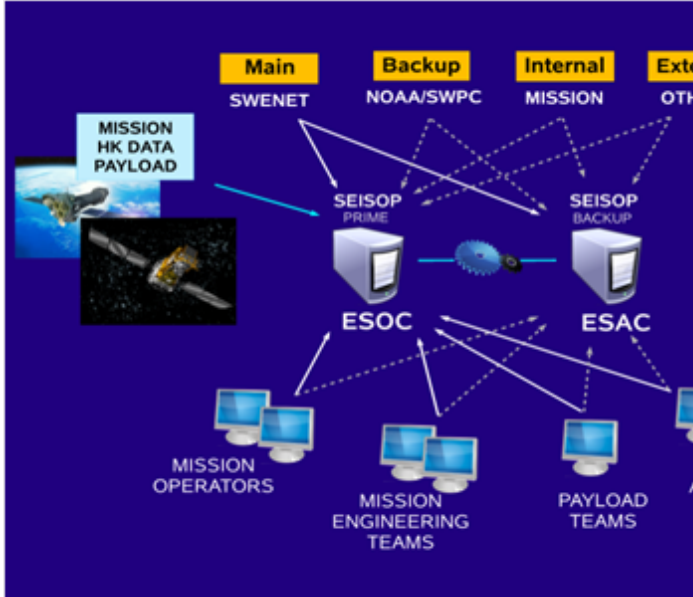
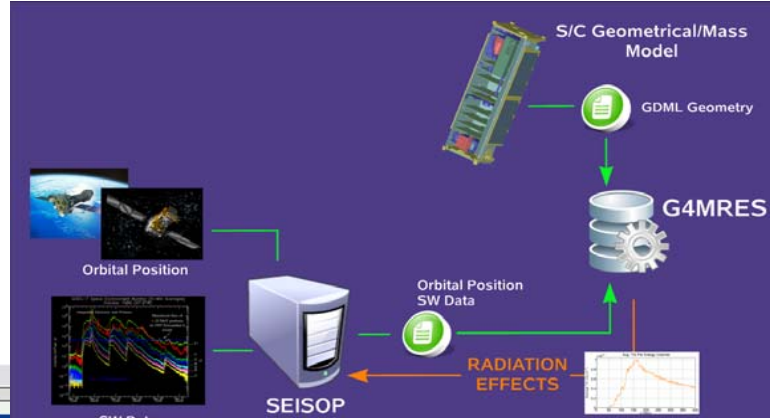
## SEISOP / G4MRES

### SEISOP Objective

provides satellite operators, mission teams and scientists with a multi-mission environment, modular and expandable, capable to supply, in a structured manner, information and extracted knowledge related to the space environment and its effects on the monitored spacecraft

### G4MRES Objective

provides satellite operators,.. with an estimation of the effects of real-time SW

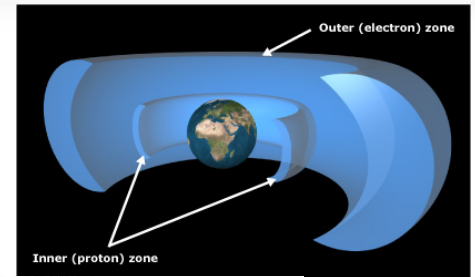


## Energetic Electron Shielding, Charging and Radiation Effects and Margins

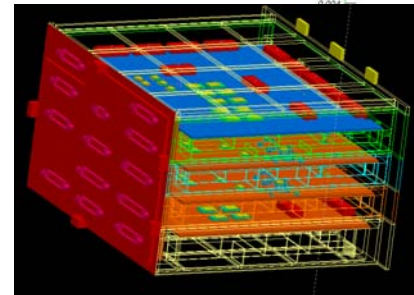
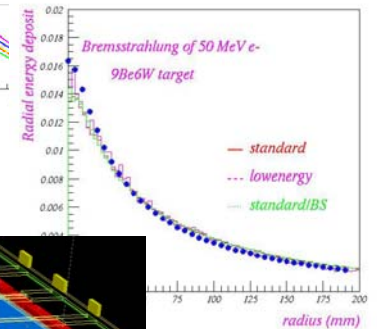
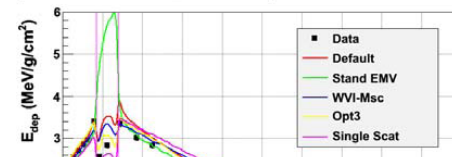
AO/1-6049/09/NL/AT

(THALES ALENIA SPAIN, G4AI, TRAD, ONERA, ARTENUM & INTA)

- Review of EM physics (energetic electron emphasis)
- Comparison of codes & tools
- Validation of new EM models / Beam testing
- Focused on internal e- charging
- New interfaces/updates: SPENVIS, FASTRAD, ESABASA, Geant4/GRAS, MULASSIS, GEMAT,...
- SHIELDOSE update
- Shielding analysis for common configurations
  - Multi-Layer, real E-box, lcs, ...
- Margins analysis and reduction



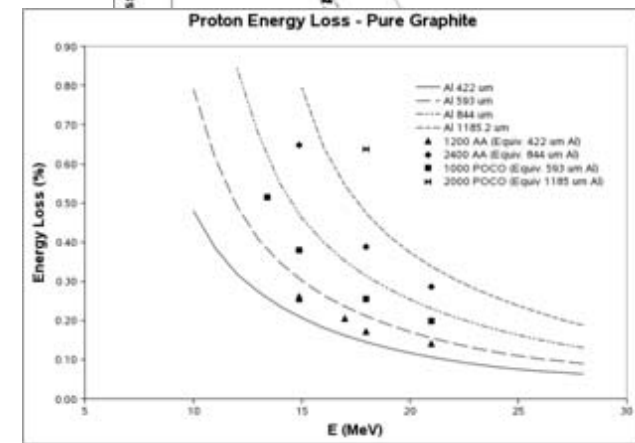
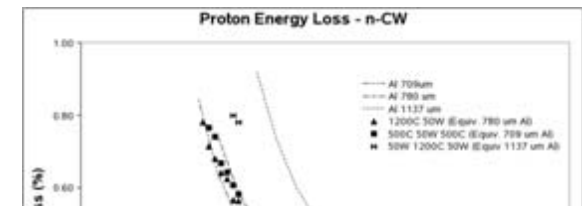
e<sup>-</sup> 1.0 MeV in AlAuAl, Geant4 9.2



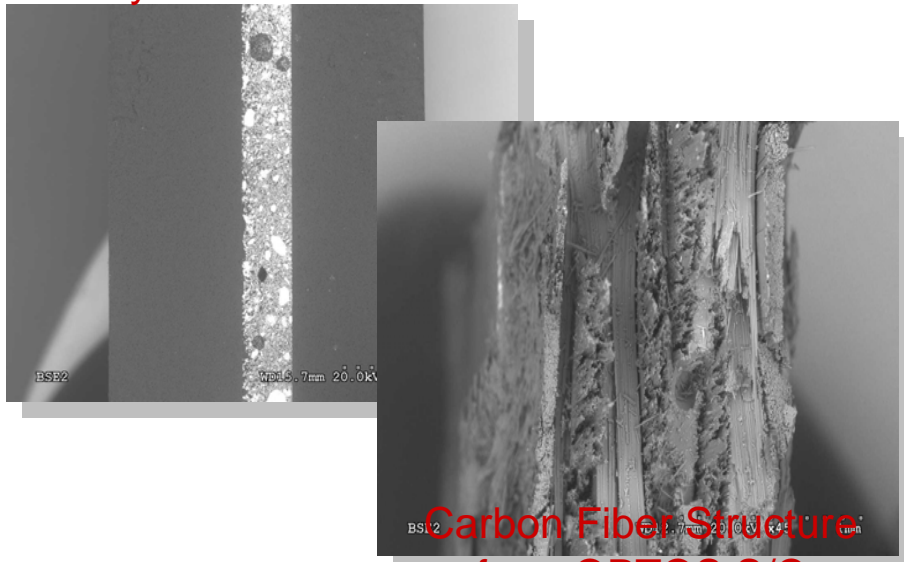
## CMRS

(INTA, Alicante Univ. & Granada Univ.)

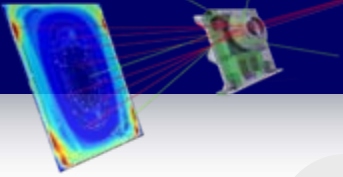
- Objective
  - Synthesis, simulation and testing of Carbon-Metal multilayer structures for radiation shielding
- Geant4 Activities
  - Simulation of structures and beam tests



## Multi-layer Carbon + Tantalum

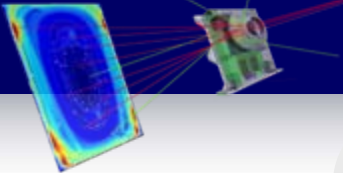


Carbon Fiber Structure from OPTOS S/C



## Summary

- INTA is applying Geant4 as standard Radiation Tool
  - Many different programmes supported
  - Spreading this methodology to the space industry
- Main scenarios of successful application
  - Engineering support to missions
  - Instrument design and calibration
  - Geant4 R&D and new tools
- However for industrial applications, still some needs:
  - CAD interfacing, computational speed, physics interfacing, accuracy, margins, usability, ...



## Future of Geant4 at INTA

- MISSIONS supported with G4:
  - OPTOS 2G  
Space Weather payloads are foreseen: Ionospheric sensors (TEC)
  - INTA Microsat (150 kg) & Nanosat-2 (22 kg)  
Next generation INTA missions
  
- R&D, Operational Tools
  - G4MRES next generation, open to G4 community?
  - G4 + TCAD analysis of sensors
  
- Participation / Supporting related forums (G4SUW, SEENoTC,...)
  
- Supporting of ESA programmes:
  - SO/PHI, Exomars/RLS, BepiColombo/MIXS, etc.