Space Radiation and Effects @LIP

9 Years of Activity

A. Keating

Space Group

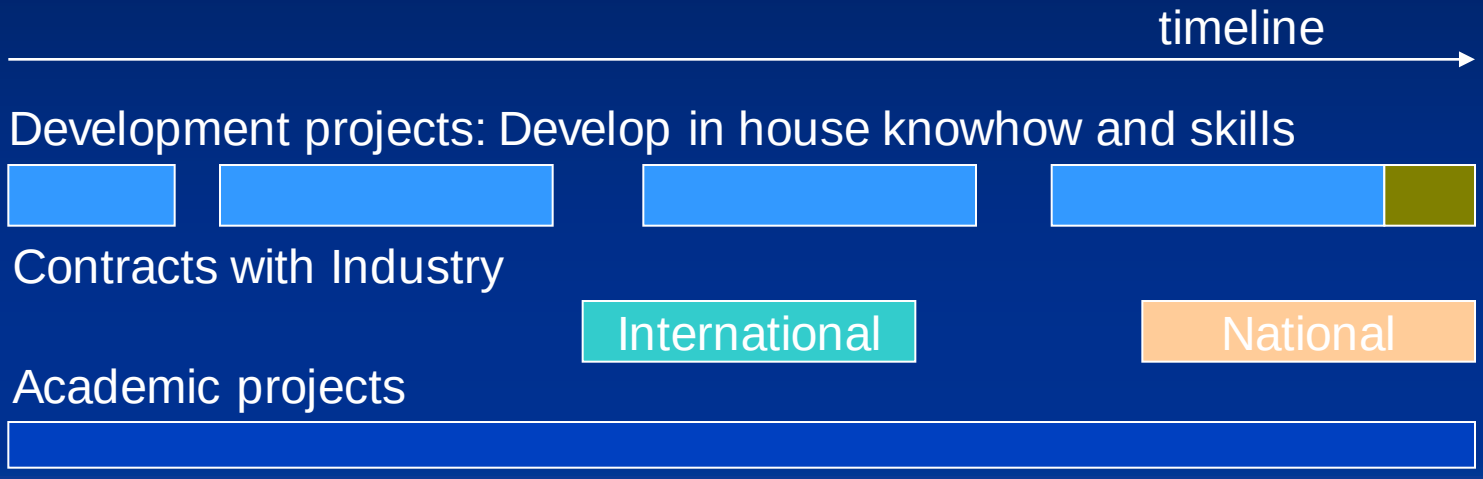
- Patrícia Gonçalves - LIP/IST
- Ana Keating - LIP
- Mário Pimenta - LIP/IST
- Bernardo Tomé - LIP/IST Pedro Brogueira - LIP/IST
- Catarina Espírito Santo - LIP/IST
- Bruno Morgado - IST (PhD Student)
- João Sabino - MIST (Master student)
- Micaela Cunha - (Master)
- Miguel Ferreira - LIP (Technical)

Our vision

- Generate in-house knowledge and know-how
- Become a recognized centre of excellence
- Create international networking
- Develop and Evolve
- Generate increased national capabilities
- Build-up the system to engage higher level science projects

Projects time evolution

- Mainly 1-2 years ESA projects
- Small projects or project extensions (ESA CCN)
- ESA Projects in International Consortium
- ESA Projects in National Consortium (w/ Industry)
- Academic Projects (no or low budget financial support, FCT)
- First negotiations are starting for future participation in scientific instruments

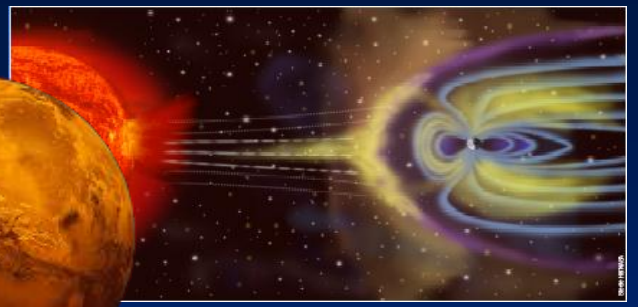


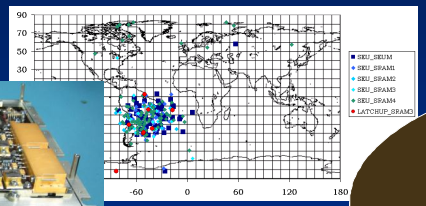
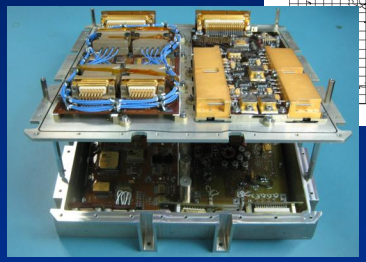
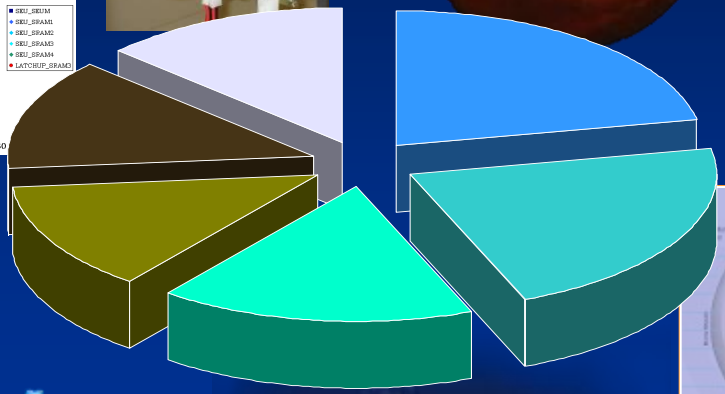
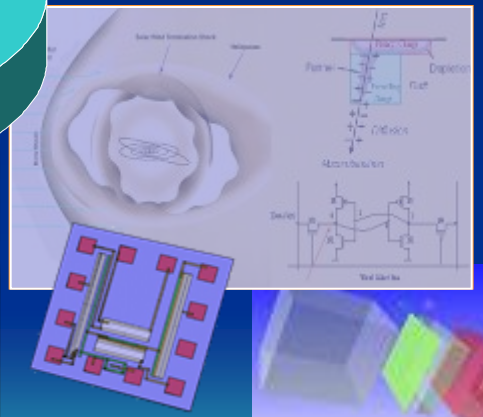
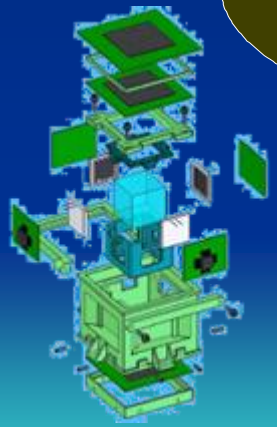
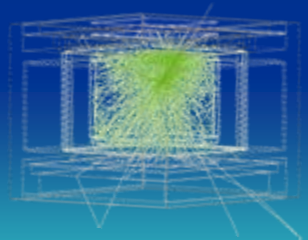
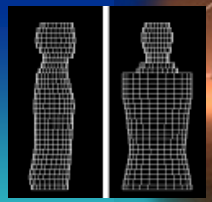
Main Subjects

- Radiation Environments
- Rad. Effects EEE
- Rad. Effects Human Sp. Flight

} Models

- Detectors Simulation
- In-flight Data Analysis
- Ground based Irradiation Testing


Space Science / Space Engineering / Space Politics

Planetary

Atmospheres
Geology
Magnetosphere
Planetary evolution

Semiconductor

EEE component
Degradation
mechanisms:
testing (ground/space)
modelling

Detectors

design and optimisation
Simulation
data analysis

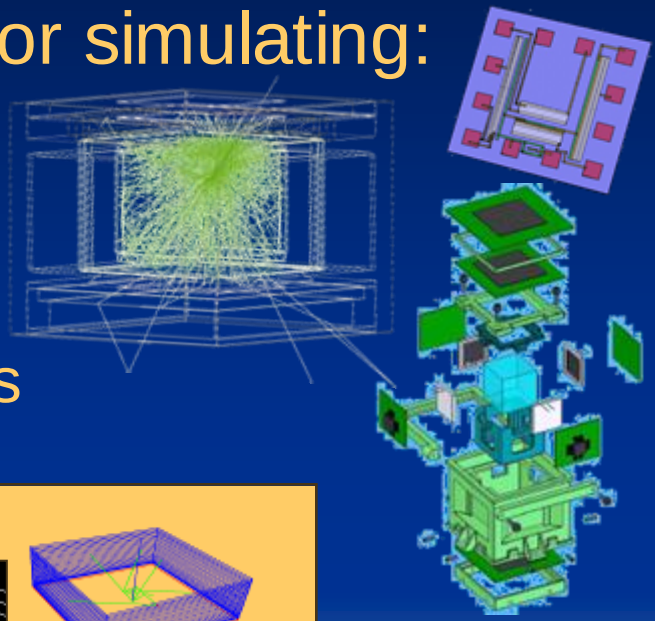
Heliosphere

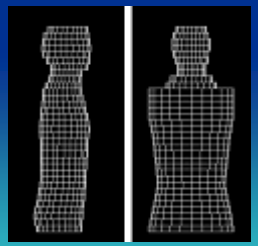
Interaction Radiation with Matter

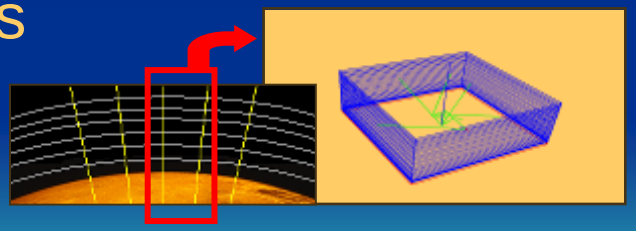
Main Tool

GEANT4

- Particle physics simulation, for particle transport and interaction with matter used for simulating:
  - Detector and component materials
  - Planetary atmospheres and surfaces
  - Dose & Human Phantoms







Main Characteristics & Lessons Learned

- Area of Interfaces

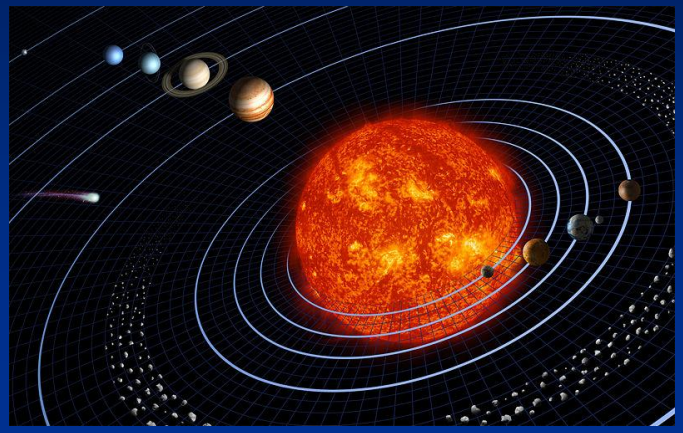
Advantages

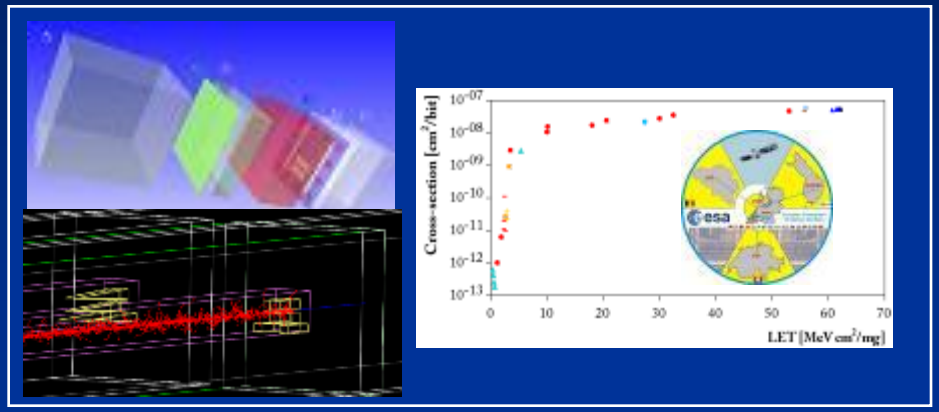
- Different Physics involved
- Development of different skills and competences
- Development of a large International network
- Increased complexity required
- Different applications
- Working with ESA : Fin. Autonomy

Disadvantages

- Extremely high organizational skills
- Number of people is never enough
- Work overload
- Increased complexity required
- Short term projects
  - Difficulty in assuring long term contract with PhD students

Activities



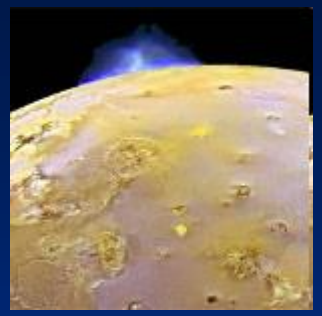

Cross-section [cm²/bit]
10⁻⁰⁷
10⁻⁰⁸
10⁻⁰⁹
10⁻¹⁰
10⁻¹¹
10⁻¹²
10⁻¹³
0
10
20
30
40
50
60
70
LET [MeV cm²/mg]
esa

Radiation in sub-solar systems

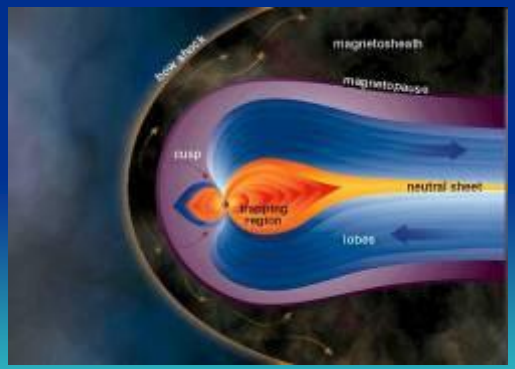
Jovian System

- Active volcanism
- Active Moons

➢ Production of Jovian Radiation (electrons, protons and ions)



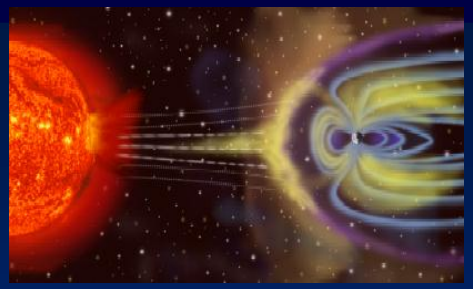
- Strong and Complex magnetosphere

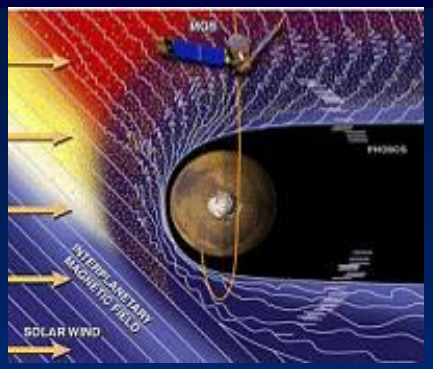


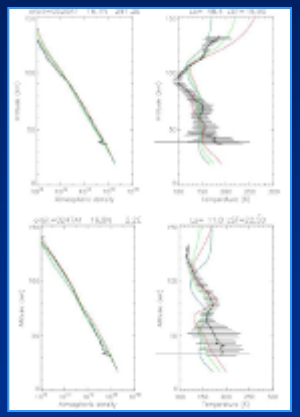
➢ Modulation of Cosmic, Jovian and Solar radiation

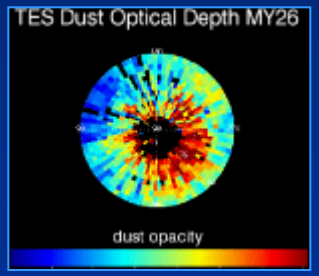
Planetary Radiation

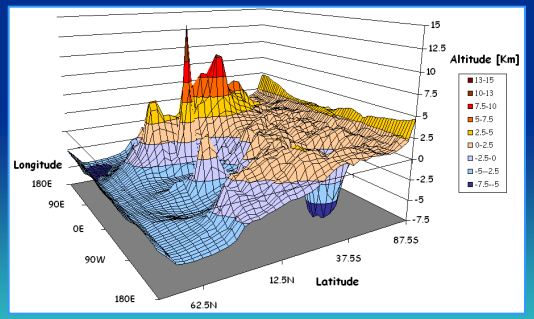
- Magnetosphere
- Atmosphere
- Soil
- Topology
- Time Evolution





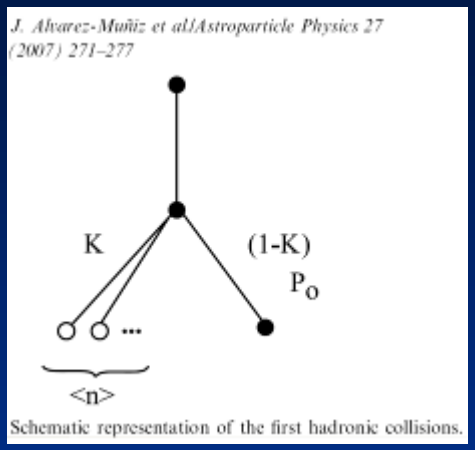


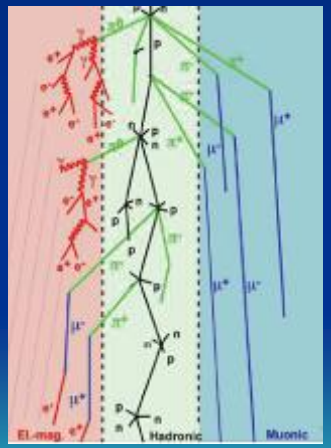


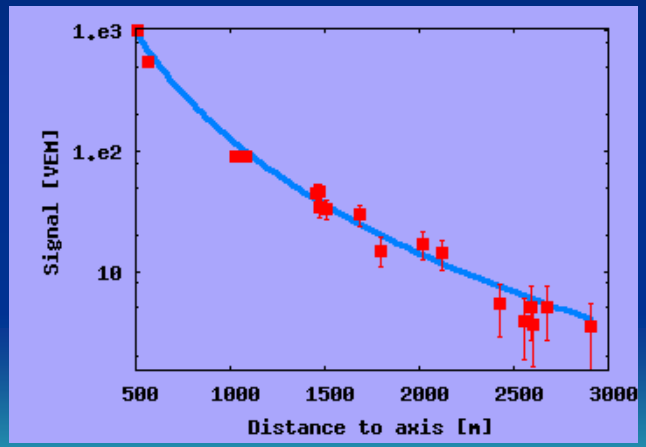


Radiation Cascade

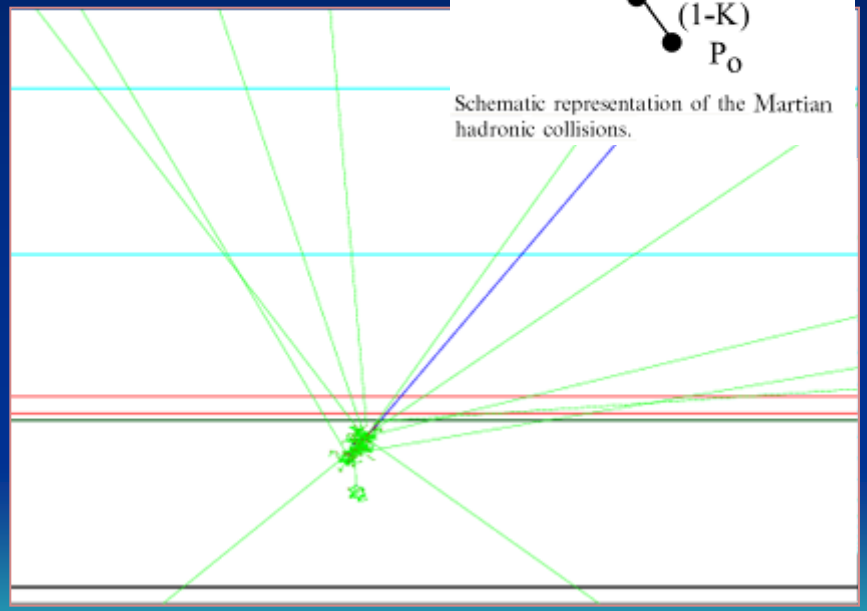
- Earth



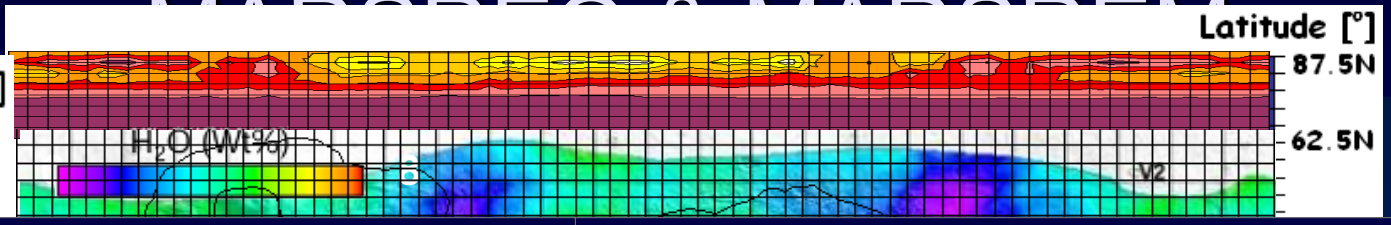




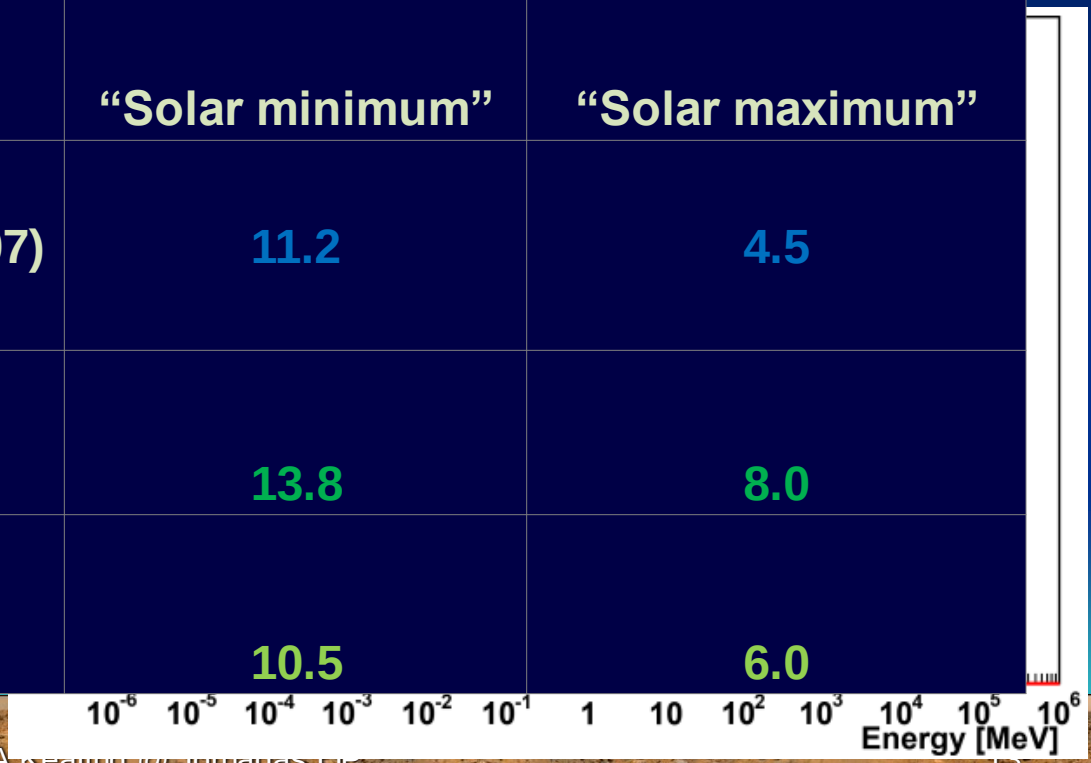
- Mars



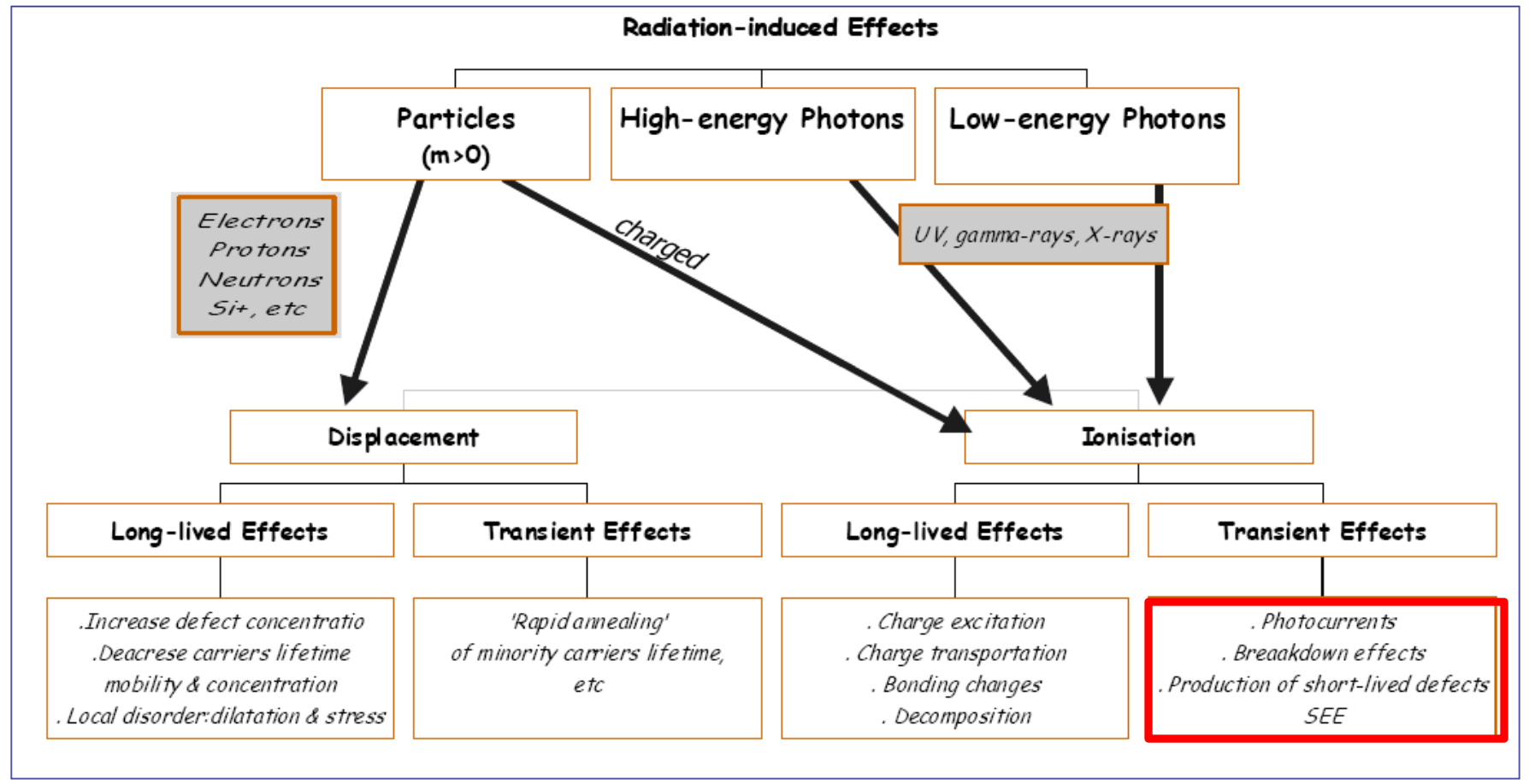
Mars Radiation Environment

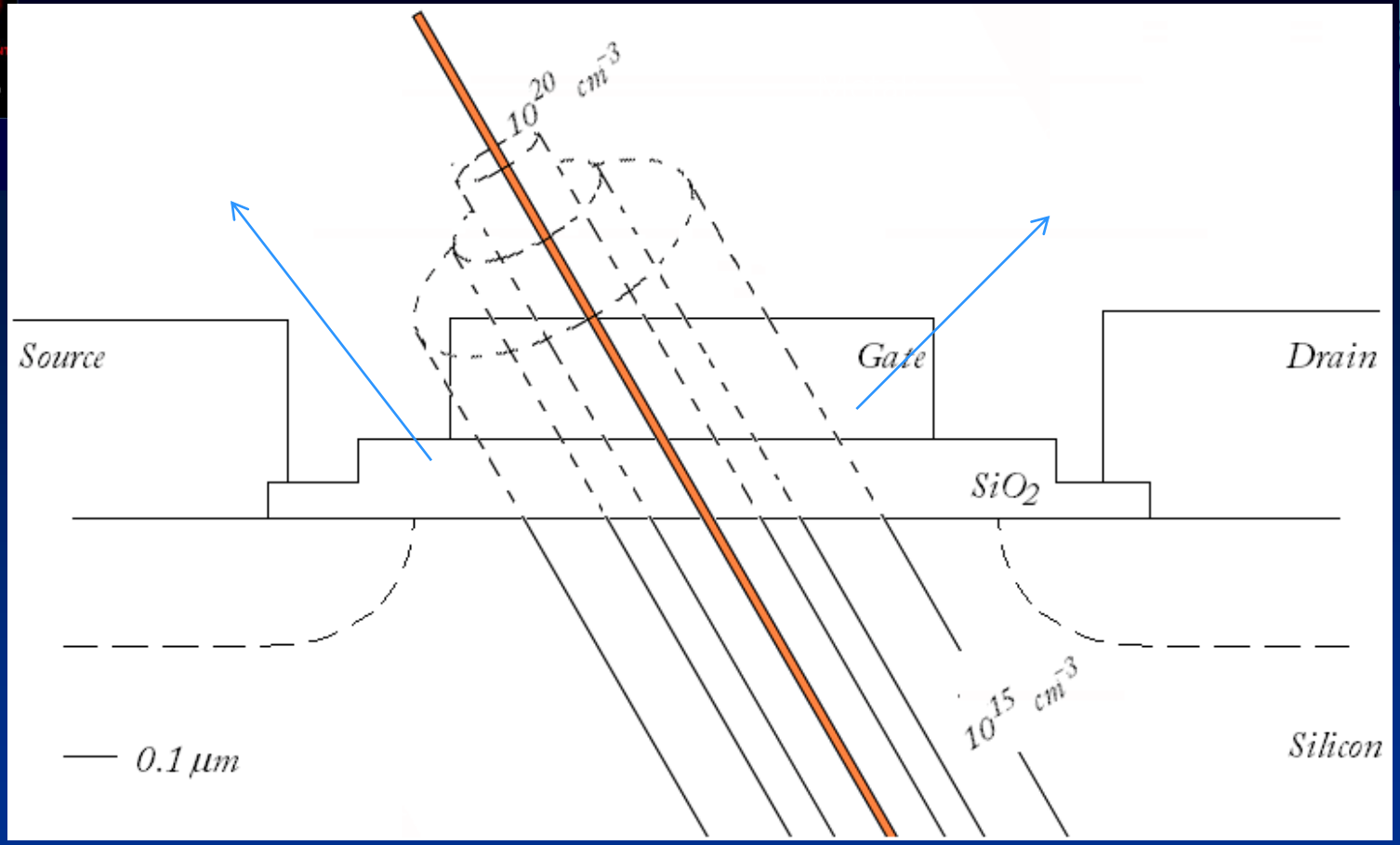


Regolith soil type	Dose Equivalent (mSv)	
	"Solar minimum"	"Solar maximum"
HZETRN (De Angelis et al.,2007)	11.2	4.5
eMEREM – Viking 1*	13.8	8.0
dMEREM – Viking 1*	10.5	6.0



Radiation induced effects

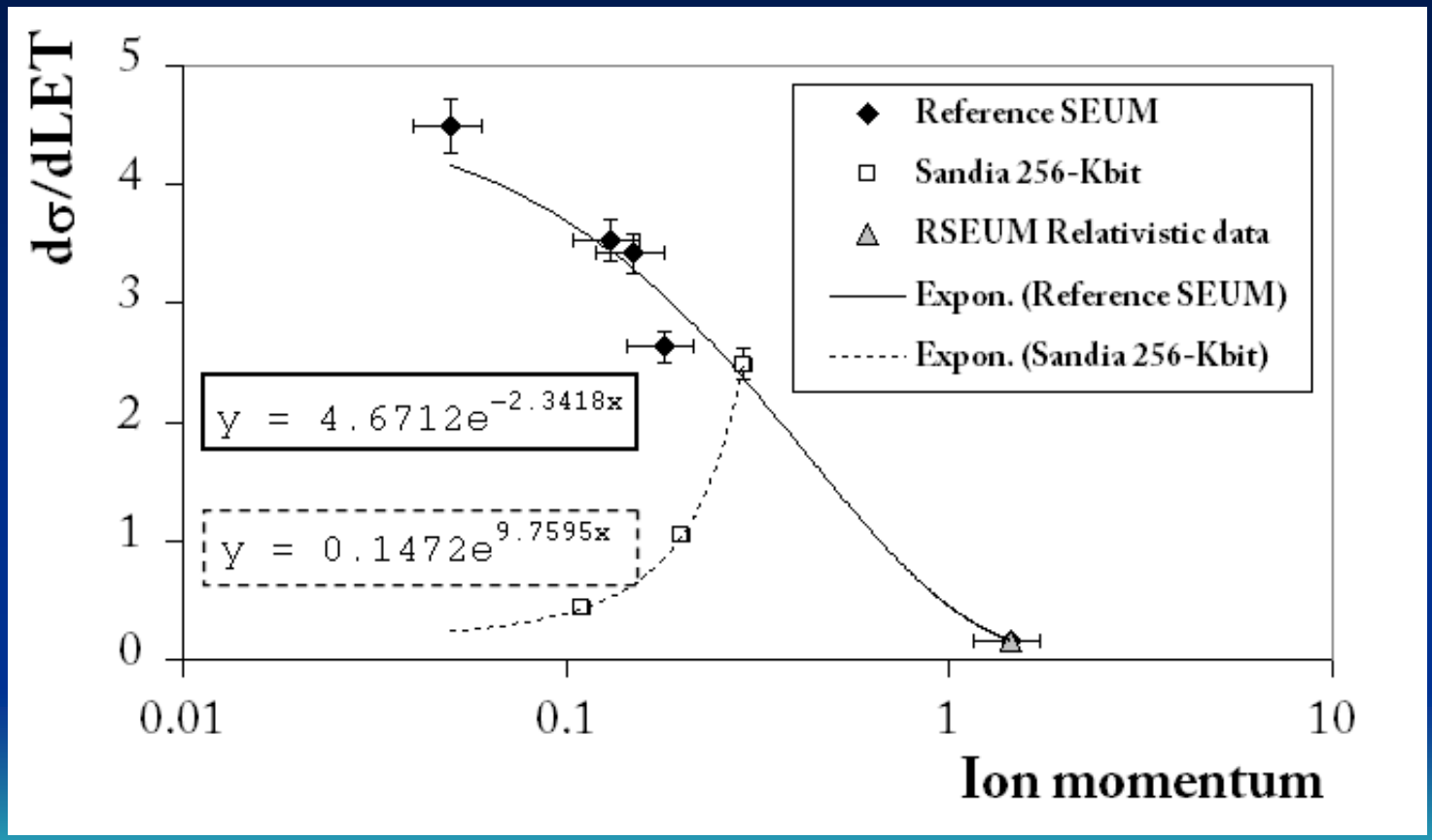




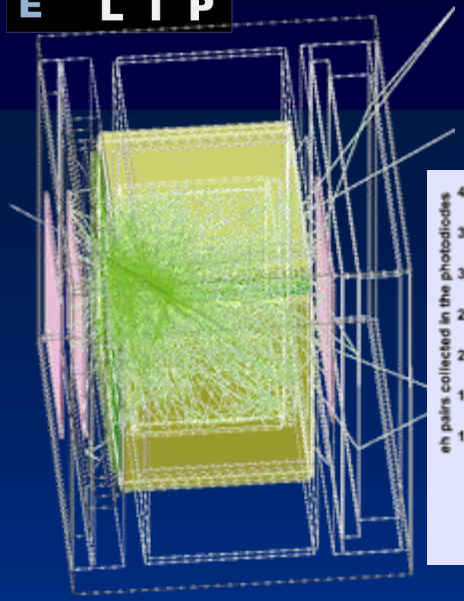
Material	Mobliity [(m²/(V s)]	Effect
Metal	10^{5}	Instant recombination
Oxide	Electrons 10^{-4} – 10^{-3} ; Holes 10^{-5}—10^{-12}	Long-lived cumulative effects (TID)
Semiconductor	10^{-1} – 1	Creation of electron-hole pairs -> Transient effects (SEE)

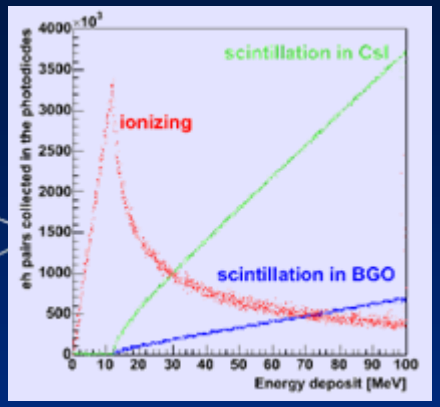
CODES
COmponent DEgradation Simulation tool

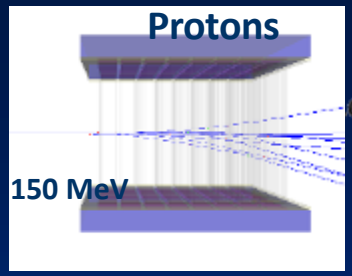
software framework providing tools for analyzing and predicting radiation effects.

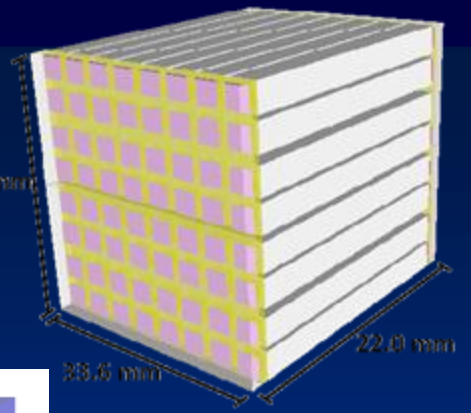


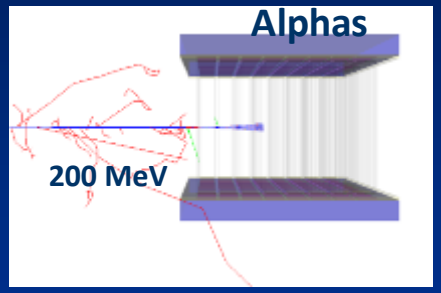
Radiation Monitors

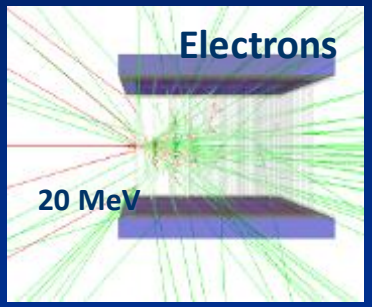


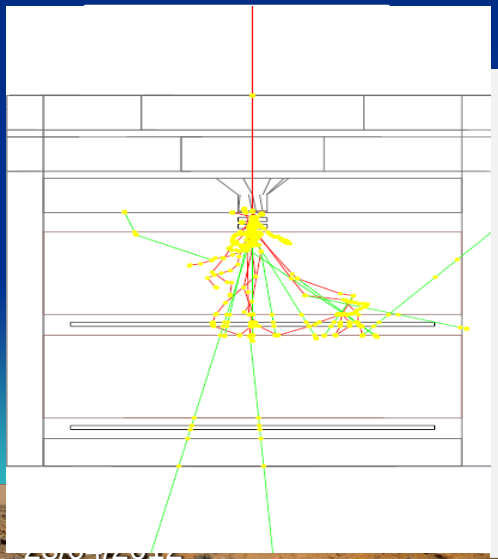


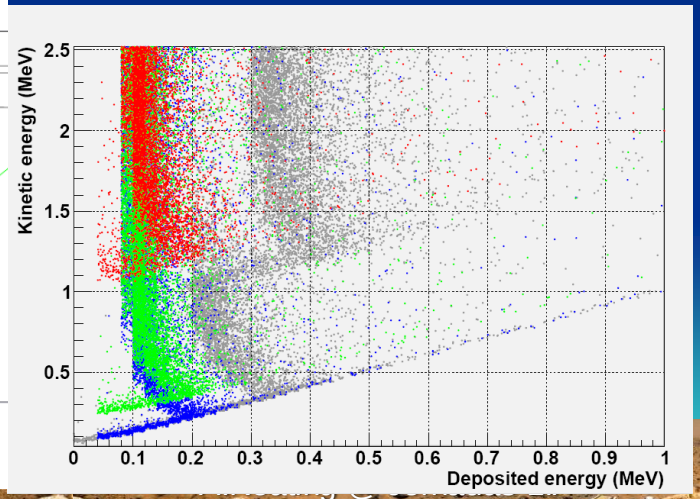












Design optimization

Bruno Morgado

Configuração geométrica e dos materiais para conjuntos de especificações.

Especificações

Id. Partículas, intervalos de energia, número de canais, número de elementos de detector

Algoritmo

Física:
parametrização dos mecanismos de perda de energia e de interacção das partículas com a matéria

Ajuste de geometria e materiais

Configuração ajustada

input

Simulação

Geant4:
ferramenta de simulação do transporte e interacção da radiação com a matéria

validação

verificação

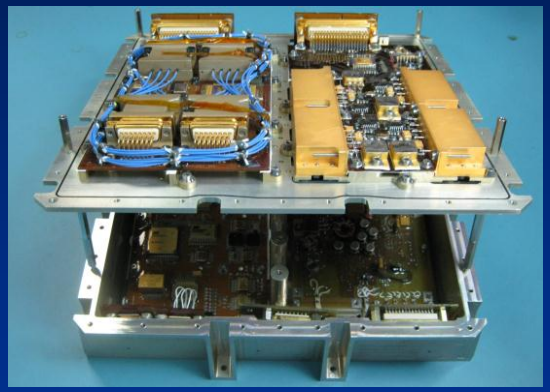
output

Simulação completa da configuração escolhida

In-flight Data

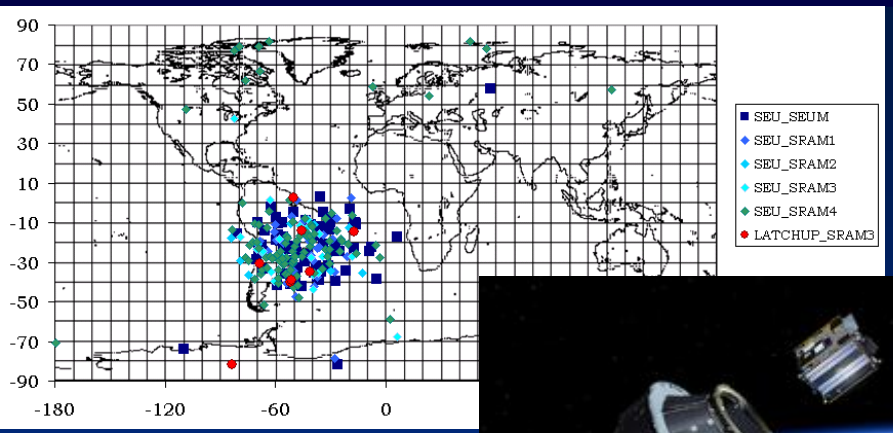
ESA project 6403/10/NL/SFe

- CTTB is a Component Test Bed to fly components. It was developed by EFACEC for ESA. CTTB is expected to flight on ALPHASAT 2012



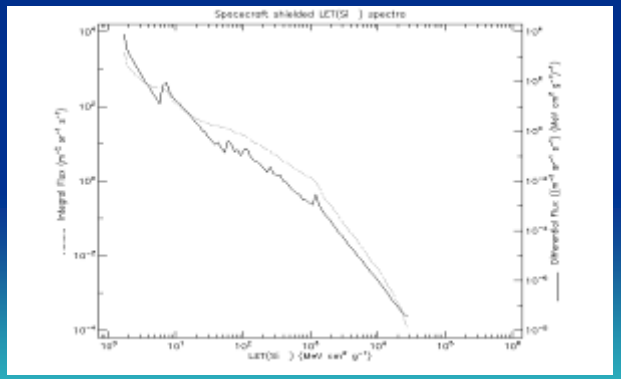
- Preparation of CTTB In-flight data analysis
  - Characterization temperature dependent TID effects of flight lot RADFETS
  - Ground based test data analysis in preparation for flight data analysis

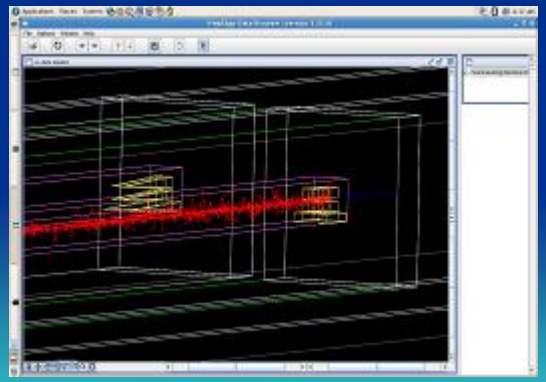
TDM PROBA II in-flight data



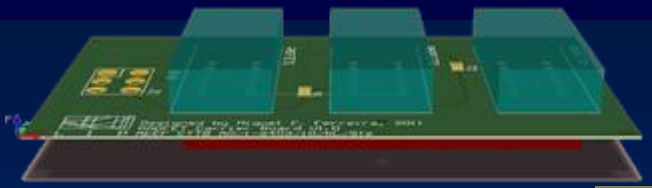
Location of all TDM SEUs and SELs observed during the month of April 2010 [10.1109/TNS.2010.2095468]

- TDM is a technology demonstration Module
- Fly SEE monitors
  - Use real environment conditions, input radiation
  - Use detailed simulation for data reconstruction
  - Use experimental test data

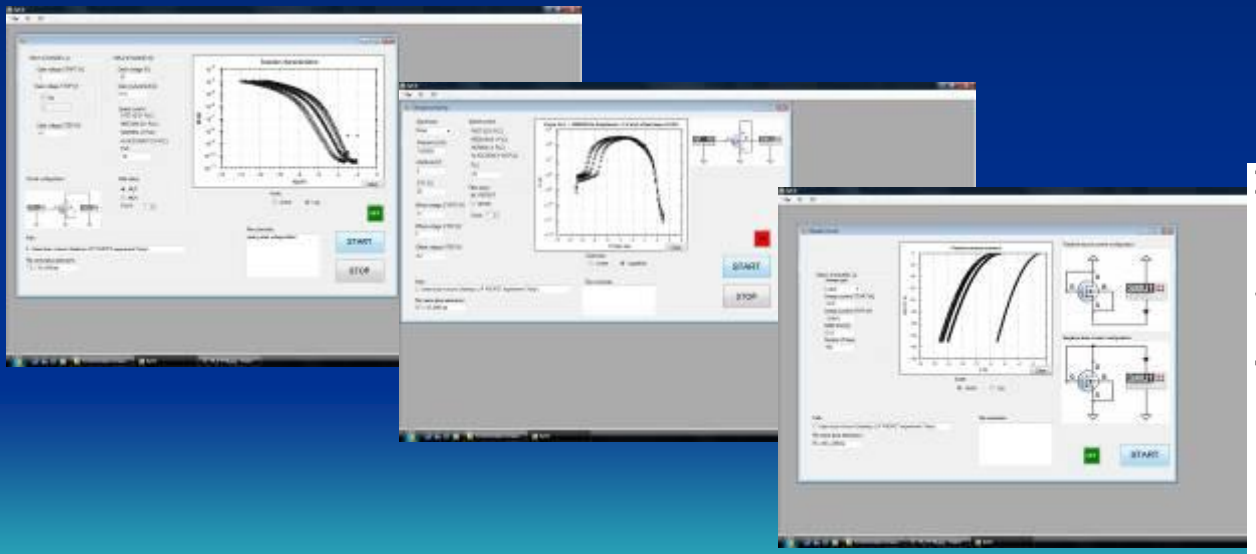


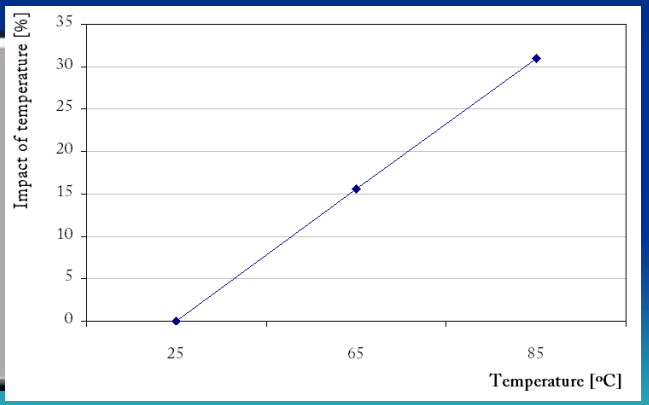


Ground based Device Testing



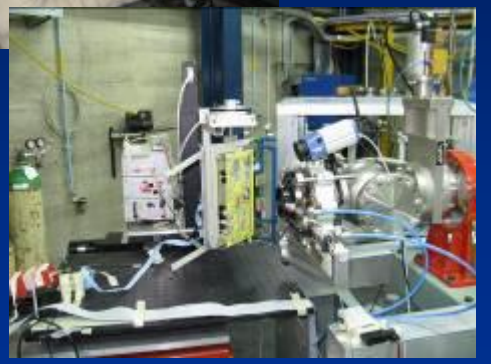
- RADFET Testing
  - Irradiation test plan
  - Board design
  - Test implementation and maintenance



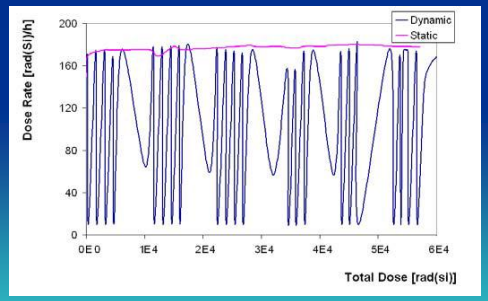


Ion Testing, C252 & Co-60

- SEU Monitor Testing
  - C252
  - LNS Catania, Ion testing Ne and Xe
  - UCL, Louvain, low penetration He, O



- R&D ELDRS Effect



Projects Summary

- ESA- LIP

Project	Subcontractors	Contract Number	Budget (K€)	Duration (month)	Starting Date
GEANT4	---				2003
MARSREC	---	18121/04/NL/CH	100	24	2004
CODES	---	18121/04/NL/CH	100	24	2006
CODES	Cyberoffice (Pt)	22381/09/NL/PA	150	24	2009
			20	5	2012

- LIP- Consortiums- ESA

Project	Partners	Contract Number	Budget (K€)	Duration (month)	Starting Date
MARSREM	QinetiQ *(UK) BIRA (Be) Space It (CH) DHConsultancy(Be)	19770/06/NL/JD	78	18	2006
PIPS	EFACEC COSINE	19100/05/NL/HB	23	18	2005
CTTB	EFACEC * (Pt)	18121/04/NL/CH	50	18	2011

- FCT/Universities

Project/collaboration	Contract	Budget (K€)	Duration (month)	Starting Date
Heliospheric Network				
Leicester University	Agreement	---	24	2010

Highlight Statistics

- Students
  - Started with 1 PhD project
  - In the last years : ~3 Student projects/year
- Publications
  - 9 International journals
  - 1 Book
  - Over 50 conferences/workshops/international meetings
  - Participation in International Standards Organization

2005 -1 paper IF 1.11 → **2011/2012 : 1pp IF 3.82, 2 pp IF 2.31, 1pp IF2.04**

- Reviews in international journals : IEEE TNS, PSS