



General Introduction

- Speakers and Schedule
- TRAD Mission and Activities
- Radiation Engineering Purpose
- Space Environment
- Radiation Effects
- Radiation Analysis
- Device Testing

Speakers

- Kevin LEMIERE

- Technical contact : kevin.lemiere@trad.fr
- Radiation engineer
- OMERE/FASTRAD software
- Radiation analyses and studies



- Léo COÏC

- Technical contact : leo.coic@trad.fr
- Radiation engineer
- Radiation effects on components
- Radiation analyses and studies



Schedule

Week 49					
	Monday	Tuesday	Wednesday	Thursday	Friday
	04/12	05/12	06/12	07/12	08/12
8					
9			Introduction & Environment [KL] 9:00 - 11:00	OMERE: Environment practice [KL, LC] 09:00 - 11:00	FASTRAD (2/2) [KL, LC] 09:00 - 10:30
10					
11			OMERE presentation [KL] 11:15 - 12:45	OMERE: SEE practice [KL, LC] 11:15 - 12:45	FASTRAD practice [KL, LC] 10:45 - 12:15
12					
13					Radiation analysis practice [KL, LC] 13:30 - 15:30
14			SEE [LC] 14:00 - 16:00	FASTRAD (1/2) [KL, LC] 14:00 - 15:30	
15					
16			RHA [LC] 16:15 - 17:45	FASTRAD practice [KL, LC] 15:45 - 17:15	
17					



TRAD Mission & Activities

Test expertise & facilities

- Complete support for component/board testing (Co60, protons, ions...)

Engineering services

- 3D modeling & dose calculation
- Analysis of component sensitivity
- Support for the entire RHA process

Advanced simulation software



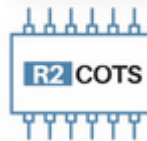
- FASTRAD®
- RayXpert®
- OMERE



Training courses

- Radiation engineering
- TRAD software

R2COTS* – COTS for Space Durable EEE components sourcing



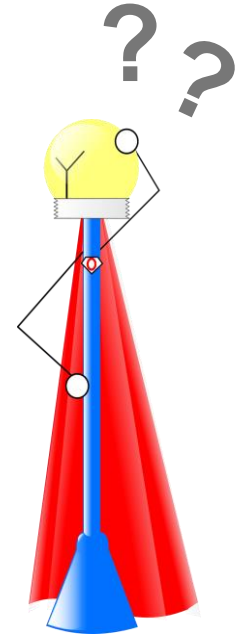
* Radiation Reliability COTS

Introduction

- Radiation engineering consists in being able to understand, study and quantify the effects caused by the radiation environment on space systems.
- These effects will depend on the system electronic device behaviour.
- The starting point of radiation effects is the interaction between the devices involved in space systems, and the incident space environment.
- Electronic devices are typically composed with a integrated circuit which is encapsulated in a standard part package.
- As the active part of electronic components is the integrated circuit, radiation engineering focuses on the interaction between radiation and semi-conductor.
 - Silicon die
 - GaAs die (opto-electronic devices, MMIC)

Radiation Engineering Purpose

- Will the device/equipment work properly during the whole mission ?
- How to test components at ground level to anticipate the degradation in space ?
- How to use the experimental test results to know if the equipments will finish properly the mission ?



Space Radiative Environment

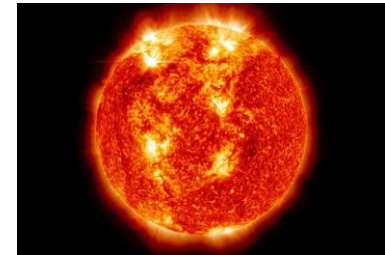
- Van Allen radiation belts

Protons	Electrons
keV- 500 MeV	eV ~ 10 MeV



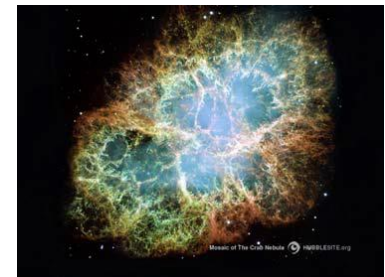
- Solar particles

Protons	Ions
keV- 500 MeV	1-100 MeV/n



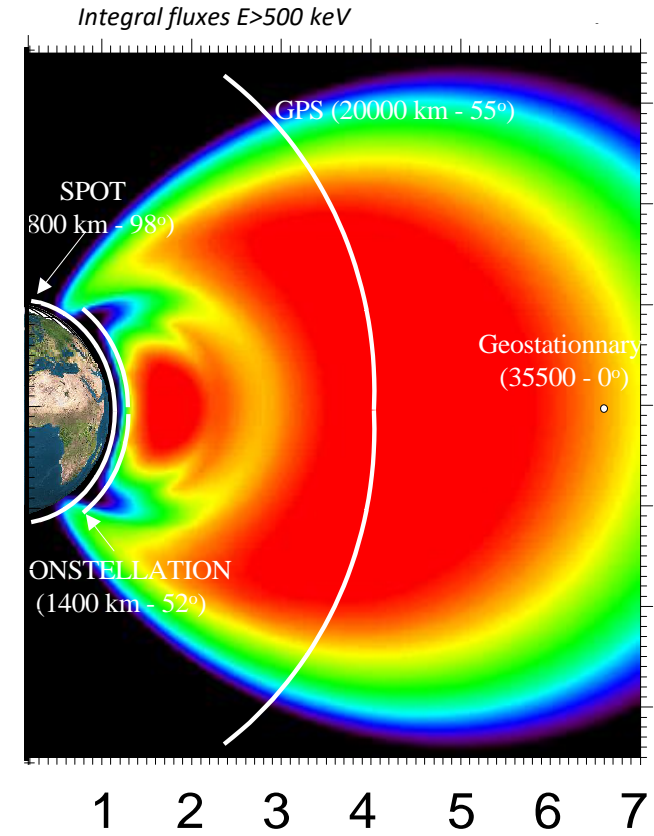
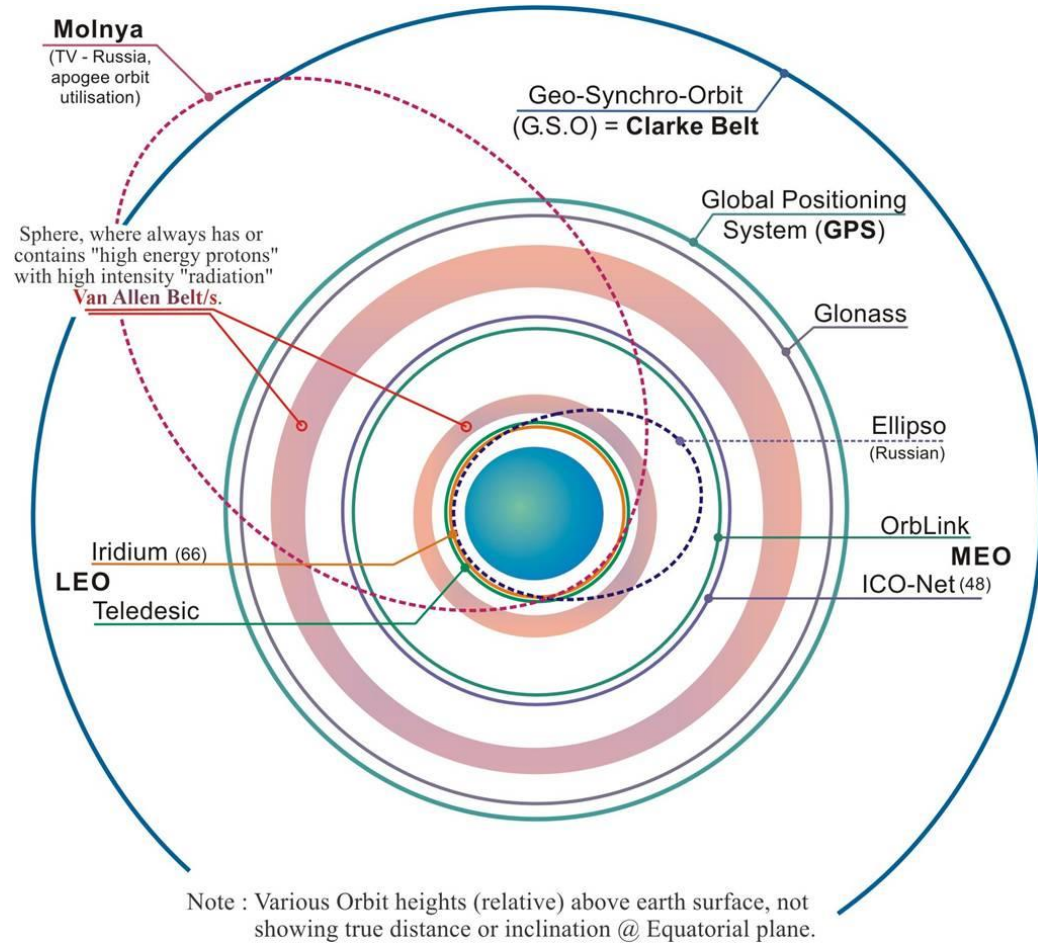
- Galactic Cosmic Rays

Ions
max ~ 300 MeV/n



Space Radiative Environment

- The radiation constraint strongly depends on the mission.



Radiation Effects

- **Cumulated effects**

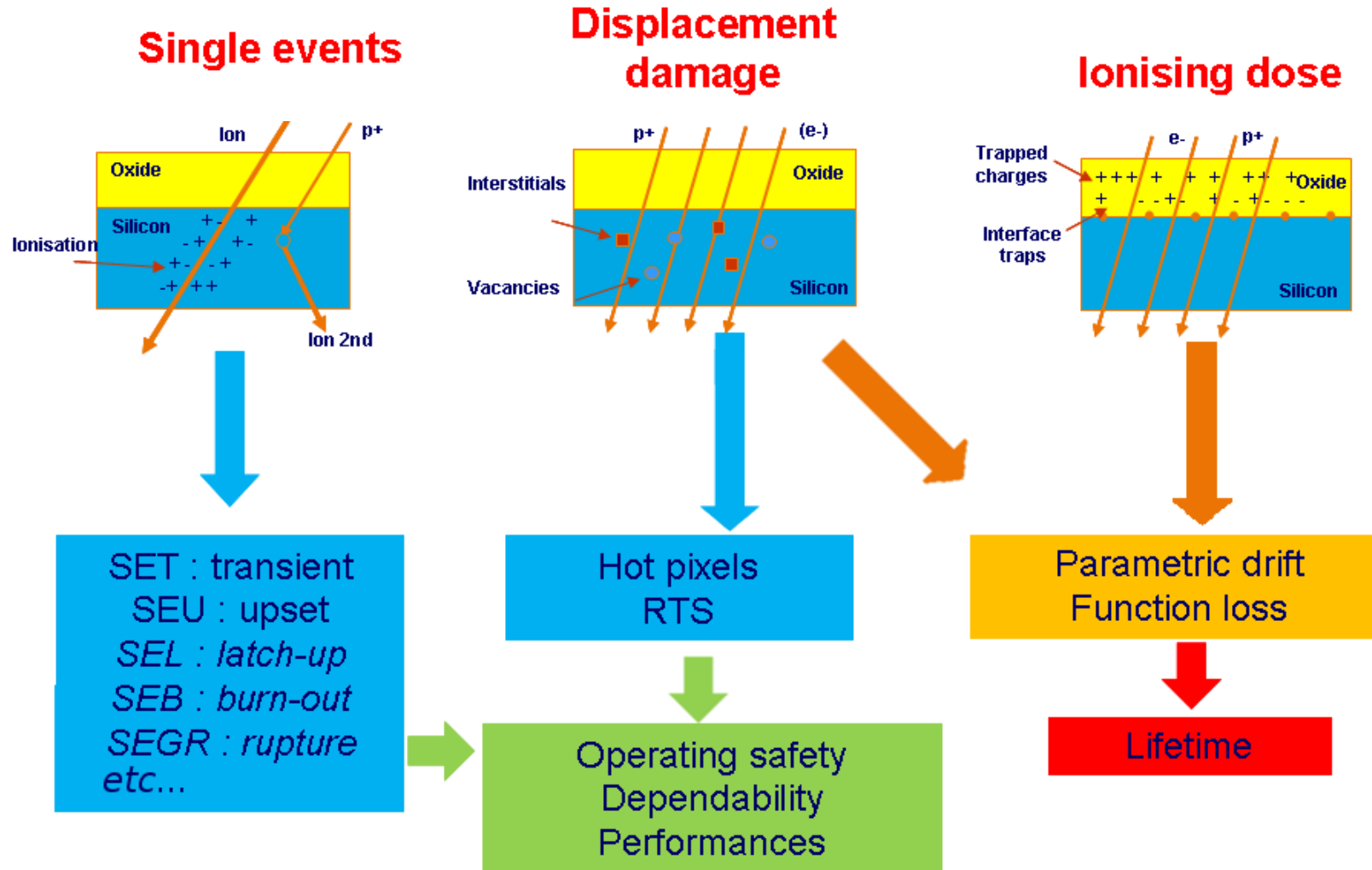
- Due to long-term exposure to a large number of incident particles
- Related to the mission duration
- TID (Total Ionizing Dose)
- TNID (Total Non-Ionizing Dose, also called Atomic Displacement Damage)

&

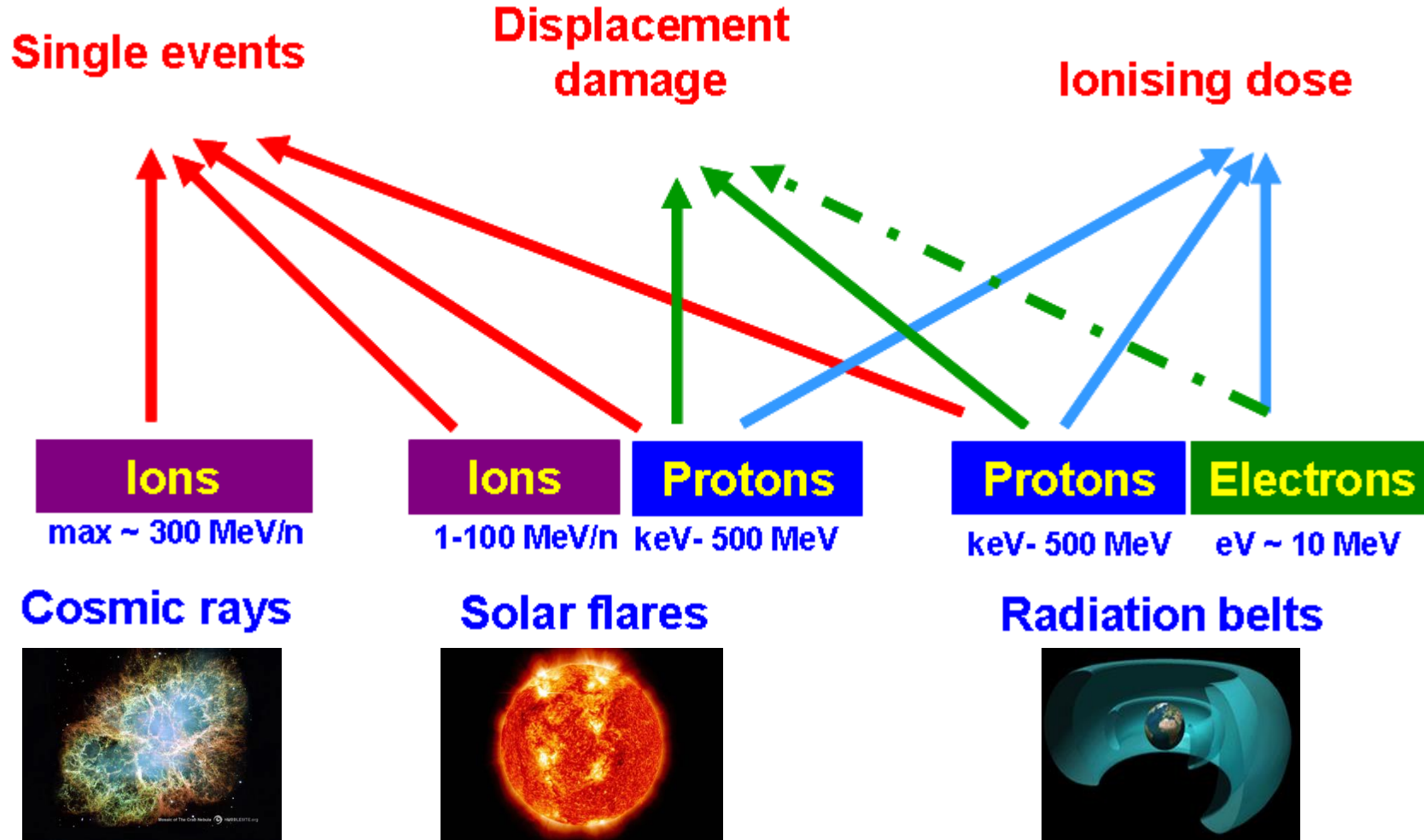
- **Single Event Effects (SEE)**

- Functional perturbation or failure due to a single incident particle
- SEU, SEL, SET...

Radiation Effects

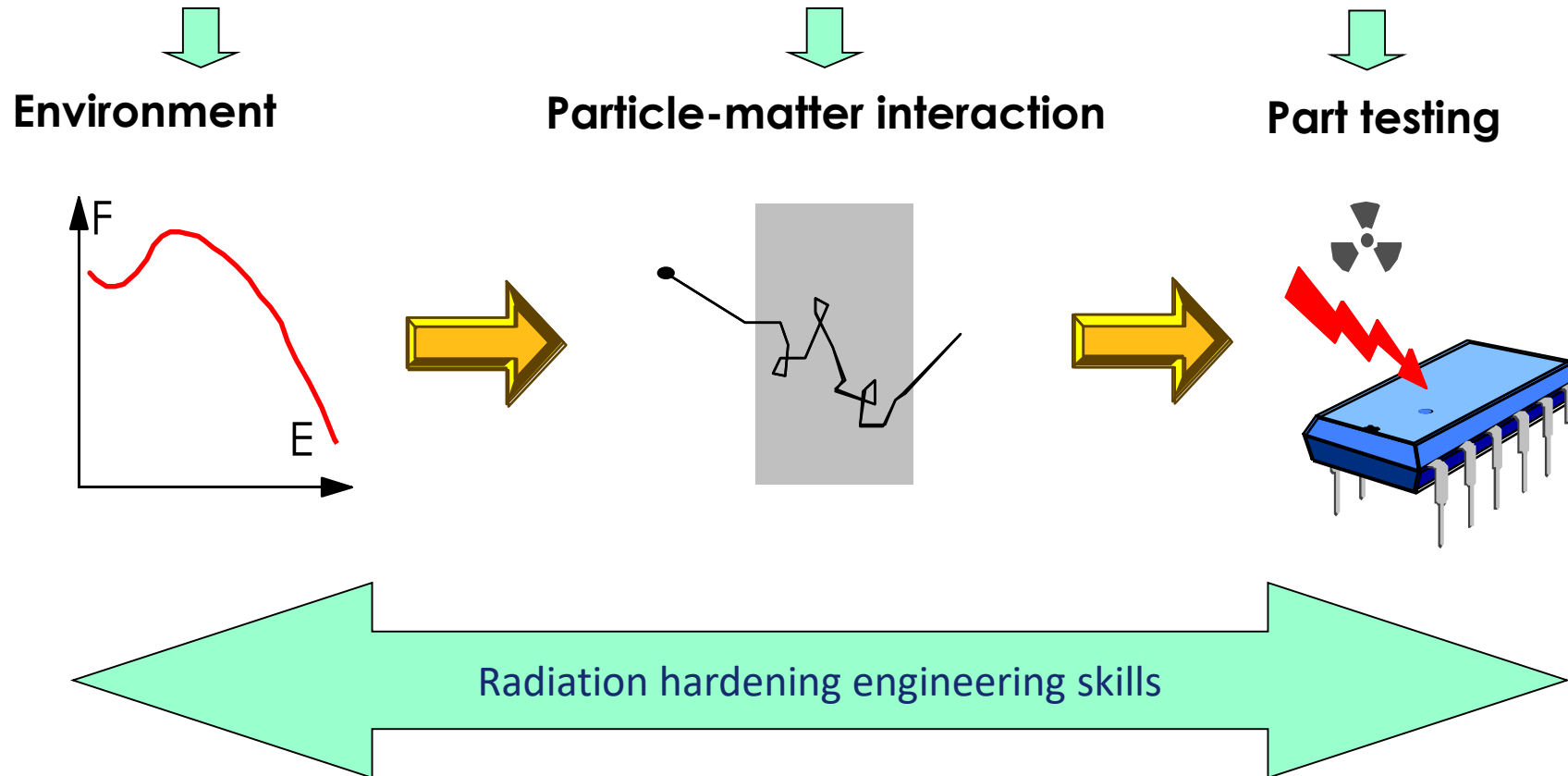


Environment Sources and Radiation Effects

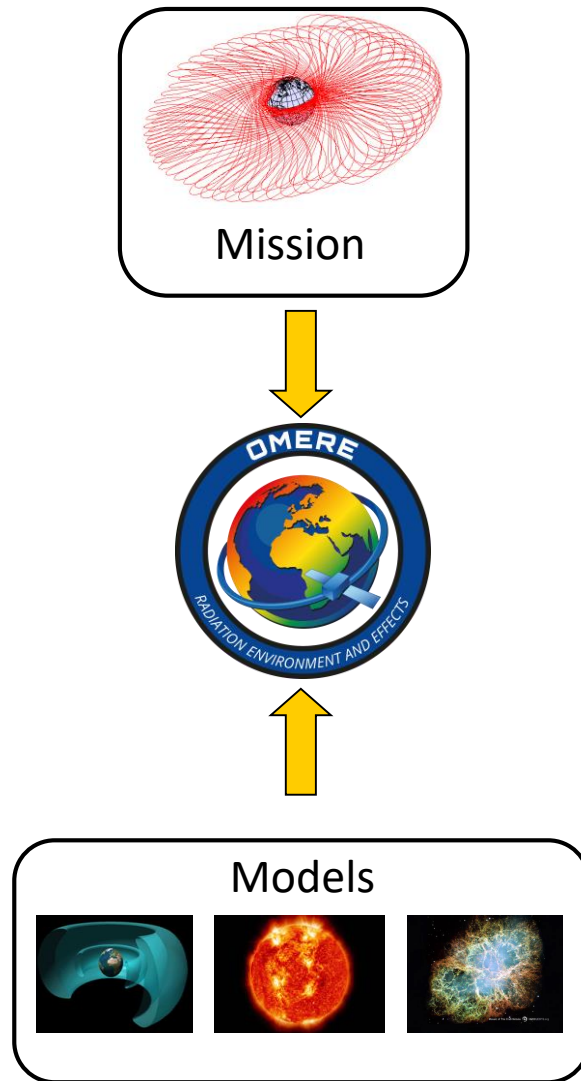



Radiation Analysis Process

- Industrial risk assessment
 - 3 analysis steps



Industrial process



SEE rates with 

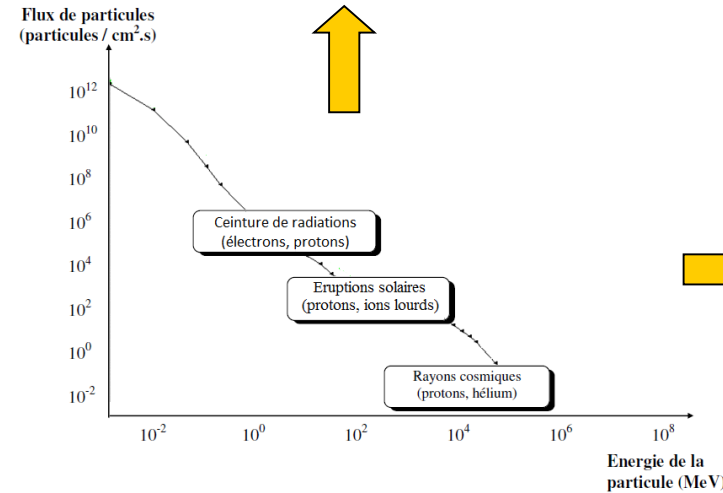

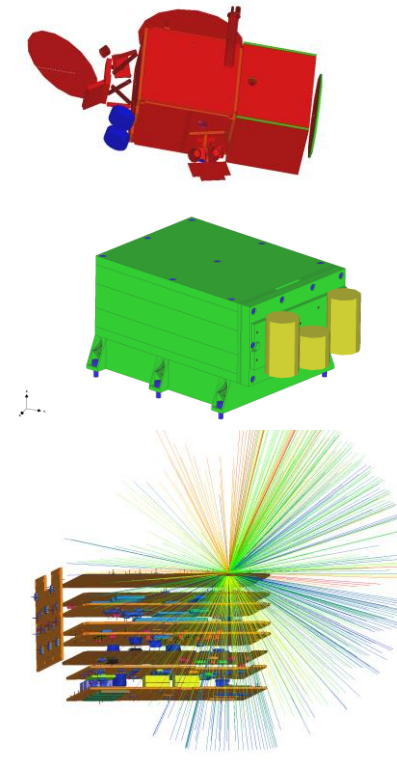


Figure 1-7 : Description des différentes composantes de l'environnement radiatif spatial. Variations des flux de particules en fonction de leur énergie [ANAPRO].

Dose computation with 



- Estimation of the impact of radiations on the components inside the spacecraft

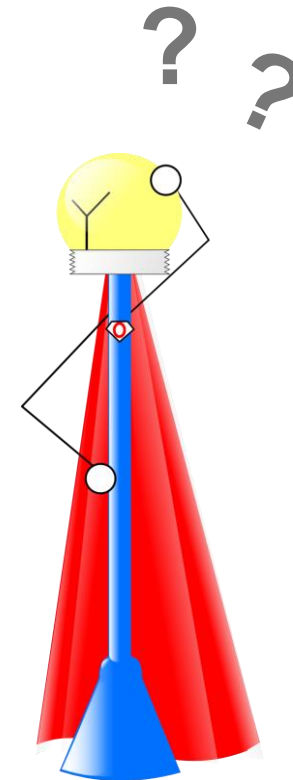
Device Testing

- It is not possible to test components with a space radiation spectrum
 - Accelerate testing has to be performed
 - For each effect a specific test has to be performed
 - For each effect a specific facility has to be used
- Total ionizing dose testing
 - ^{60}Co facility
- Single event effect testing
 - Particles accelerator, Laser, ^{252}Cf source
- Total non ionizing dose testing
 - Particles accelerator or fission reactor (neutrons)
- Two different approaches for testing
 - Parametric test for TID and TNID
 - Functional test for SEE

Purpose of the present training

- Understand and characterize the effects of space radiation on spacecraft
 - Description of the environment
 - Engineering methods
 - Calculations and softwares

How to take them into account ?



For further information on:

www.trad.fr – www.fastrad.net
www.rayxpert.com – www.r2cots.com



TRAD Tests & Radiations
@TRAD_Officiel



trad@trad.fr



+33 (0)5 61 00 95 60