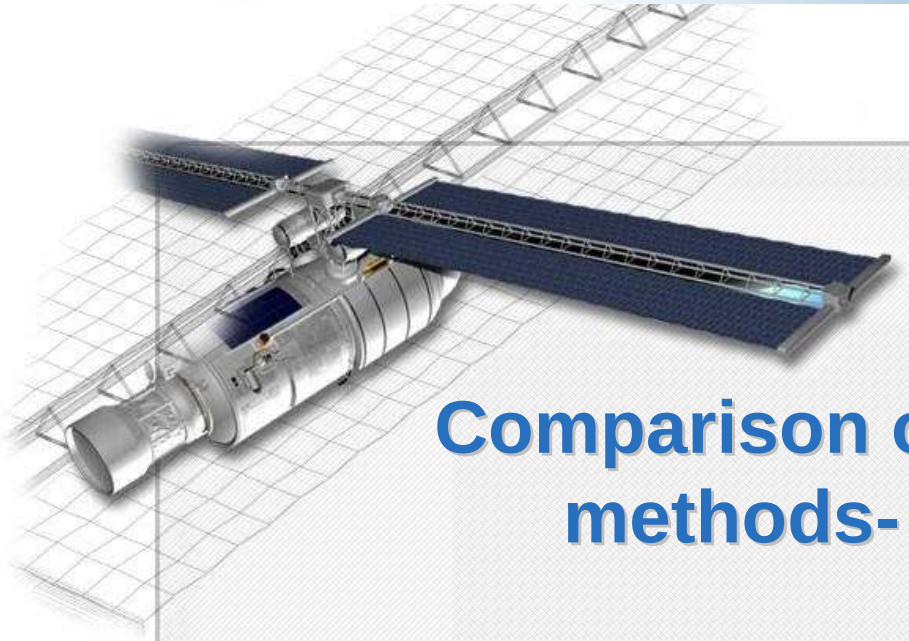


Comparison of TNID calculation methods- FASTRAD® 3.7

P. Pourrouquet, A. Varotsou and A. Privat (TRAD)

D. Standarovski (CNES)

Context

- **Different calculation methods exist for TNID:**
  - What is the impact of the method choice?
  - Are they equivalent?

- **Follows a similar R&T study for TID Monte Carlo calculation using FASTRAD [RADECS 2016, Pourrouquet et al., Comparative Study Between Monte-Carlo Tools for Space Applications]**

- **Release of a TNID Monte Carlo module in the latest FASTRAD version**
  - Taking into account the detector material

Outline

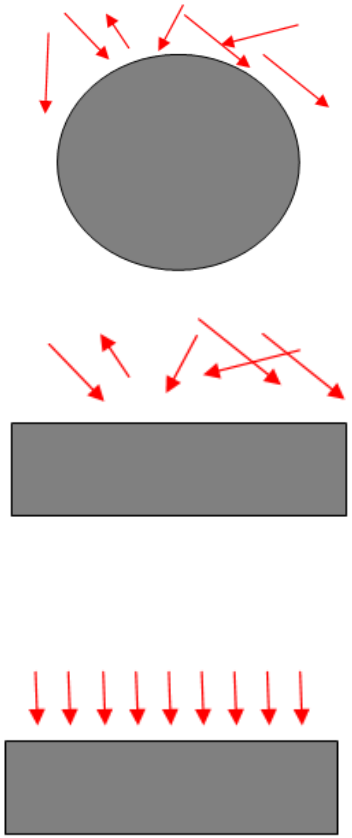
- **Calculation methods & radiation models definition**
- **Calculation results**
  - RT methods
  - RMC comparison
- **Conclusions**

Calculation methods
& radiation models definition

Ray-Tracing calculation methods

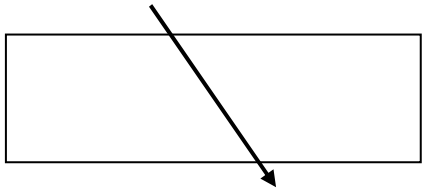
Input

TNID depth curves

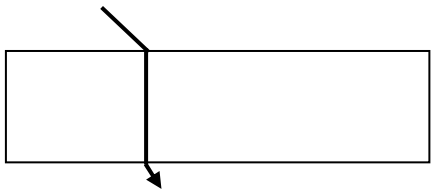


Calculation methods

Slant path



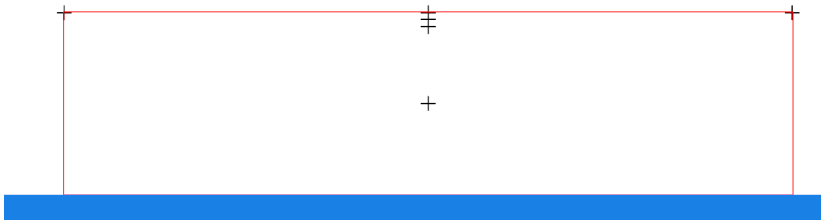
Normal path



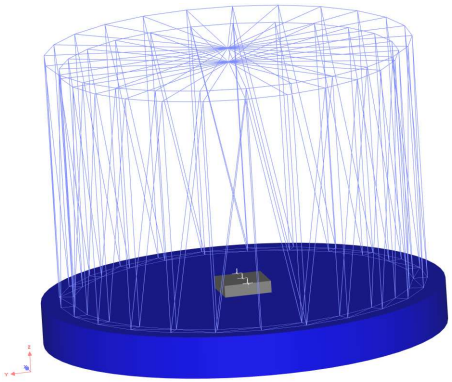
3D Models

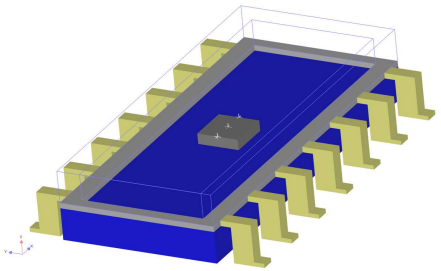
Component models

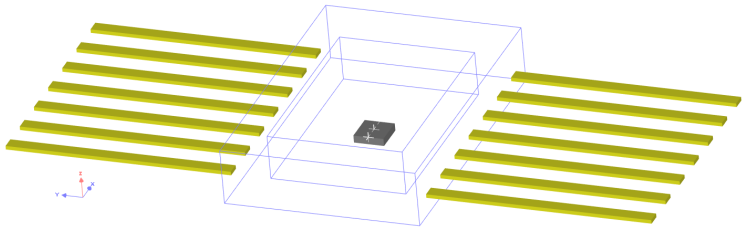
- **Silicon die**



- **Realistic packages**



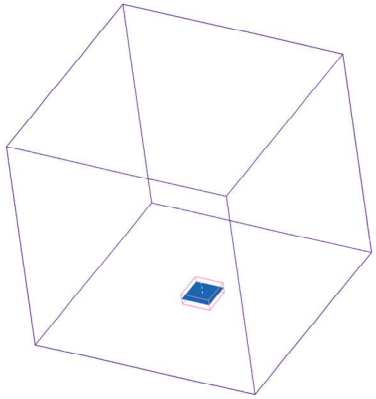




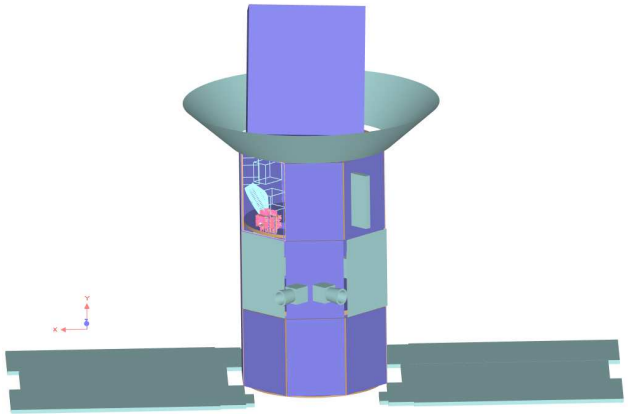
3D Models

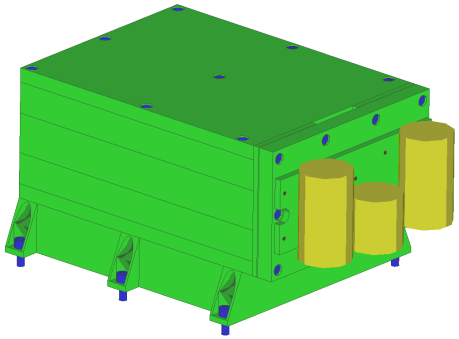
Satellite & equipment shielding models

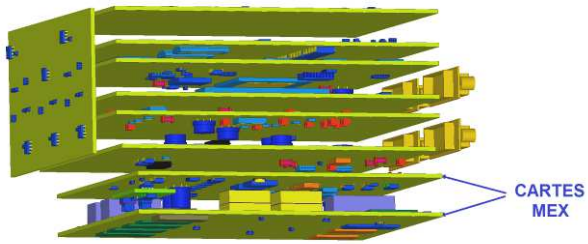
- **Equivalent Aluminum boxes**



- **Realistic satellite platform**







R&T Systèmes Spatiaux cnes

Calculation results

Ray Tracing results

Calculation method impact, RT or RMC, on TNID (FASTRAD 3.7)

Reference for all comparisons: Solid sphere / Slant path

- **Comparison using different methods for TNID depth curve and RT calculations**

TNID depth curve	Slab + normal incidence		Slab + isotropic incidence	
RT method	Slant path	Normal path	Slant path	Normal path
Simple satellite Mean Difference	1%	61%	-34%	4%
Realistic satellite Mean Difference	8%	62%	-39%	8%

- **No effect of detector location on results**

RMC / RT comparison

- **Different geometrical complexities**

Satellite	Electronic parts	RMC/RT Difference
equivalent satellite	Silicon die w/o package	-4%
	Metal package (Iron)	17%
	Plastic package	6%
	Ceramic package	7%
complete satellite	Realistic package?	16%

Density different from Al

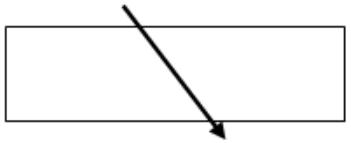
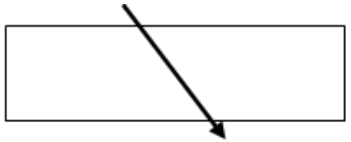
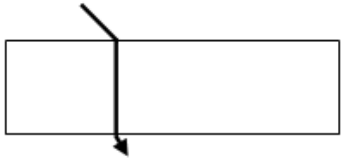
• different interactions

=> Secondary creation

Slight impact of a 3D complex geometry

Conclusions

- **Equivalence of RT calculation methods for the studied LEO environment**

Case	TNID depth curve	RT calculation method
1	Sphere + isotropic incidence	Slant path - 
2	Slab + normal incidence	Slant path - 
3	Slab + isotropic incidence	Normal path · 

- **No effect of the detector location**

Conclusions & Perspectives

- **Material importance**
  - Small impact of the package material on TNID (17%)

- **Study performed on a single LEO orbit**
  - No general recommendation possible at this point
  - Need to sample all the possible environments (GEO, MEO, GTO, EOR…) in future studies

- **Comparison with flight data will allow to complete the study**

Thank you for your attention