



## Comparison of TNID calculation methods- FASTRAD® 3.7

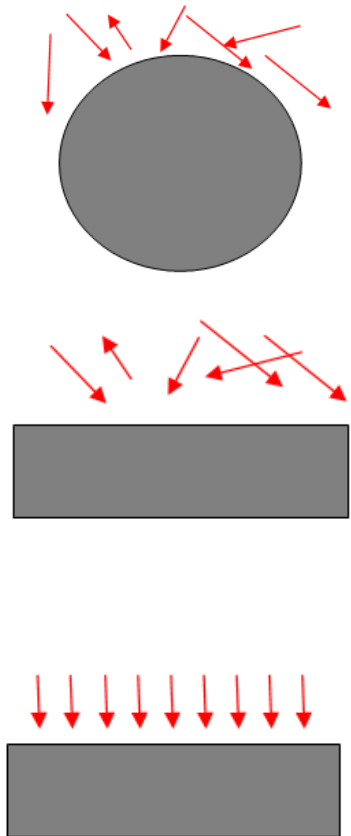
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**D. Standarovski (CNES)**

- **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

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

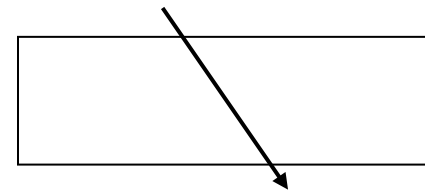
# Calculation methods & radiation models definition

## Input TNID depth curves

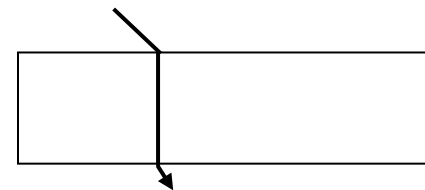


## Calculation methods

### Slant path

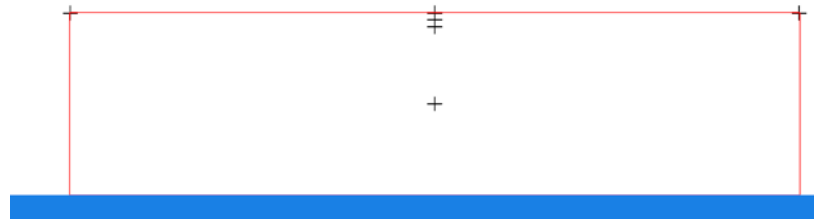


### Normal path

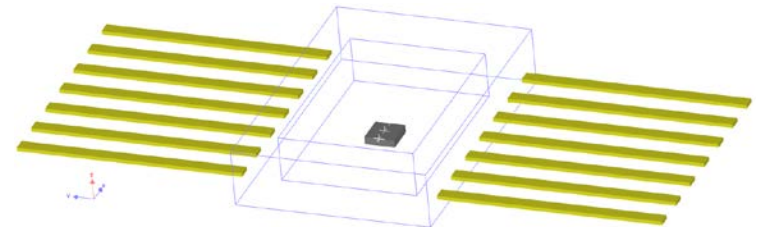
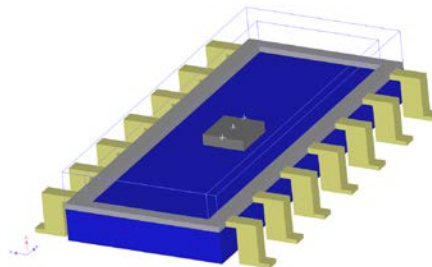
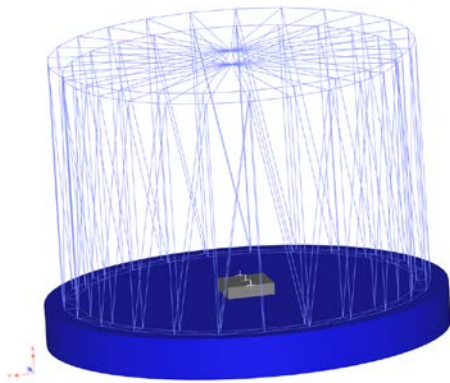


## Component models

- Silicon die

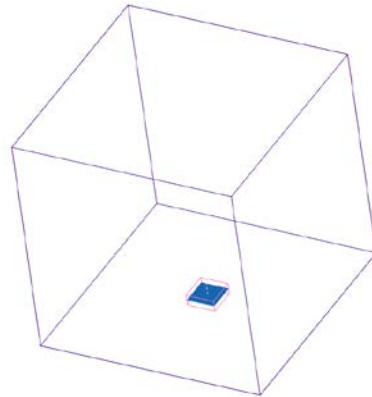


- Realistic packages

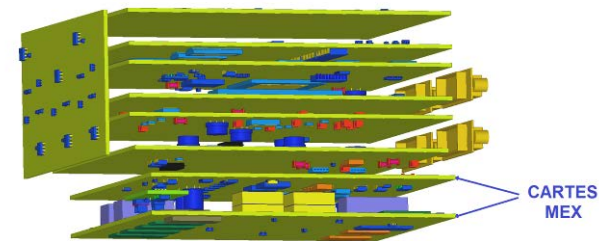
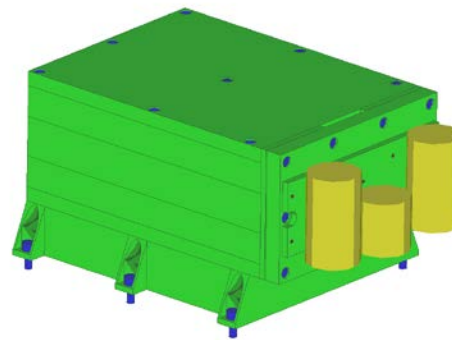
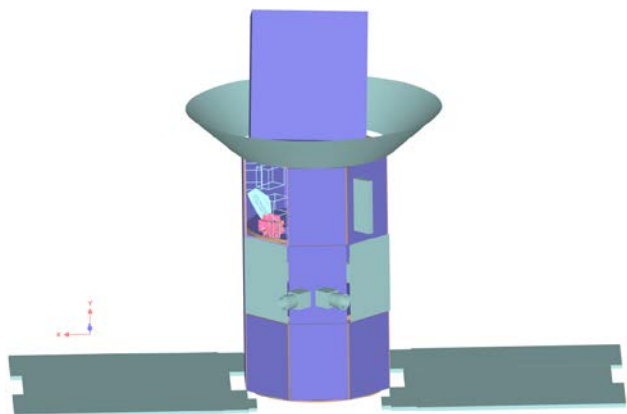


## Satellite & equipment shielding models

- Equivalent Aluminum boxes



- Realistic satellite platform





# Calculation 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

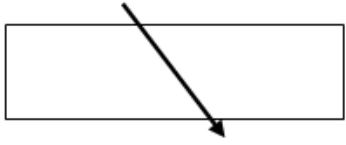
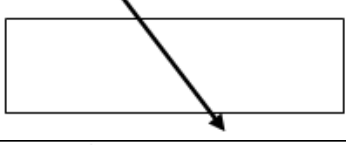
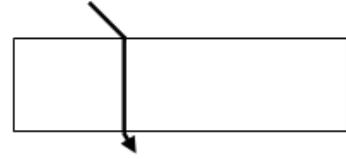
- Different geometrical complexities

| 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

- **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**

- **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**