

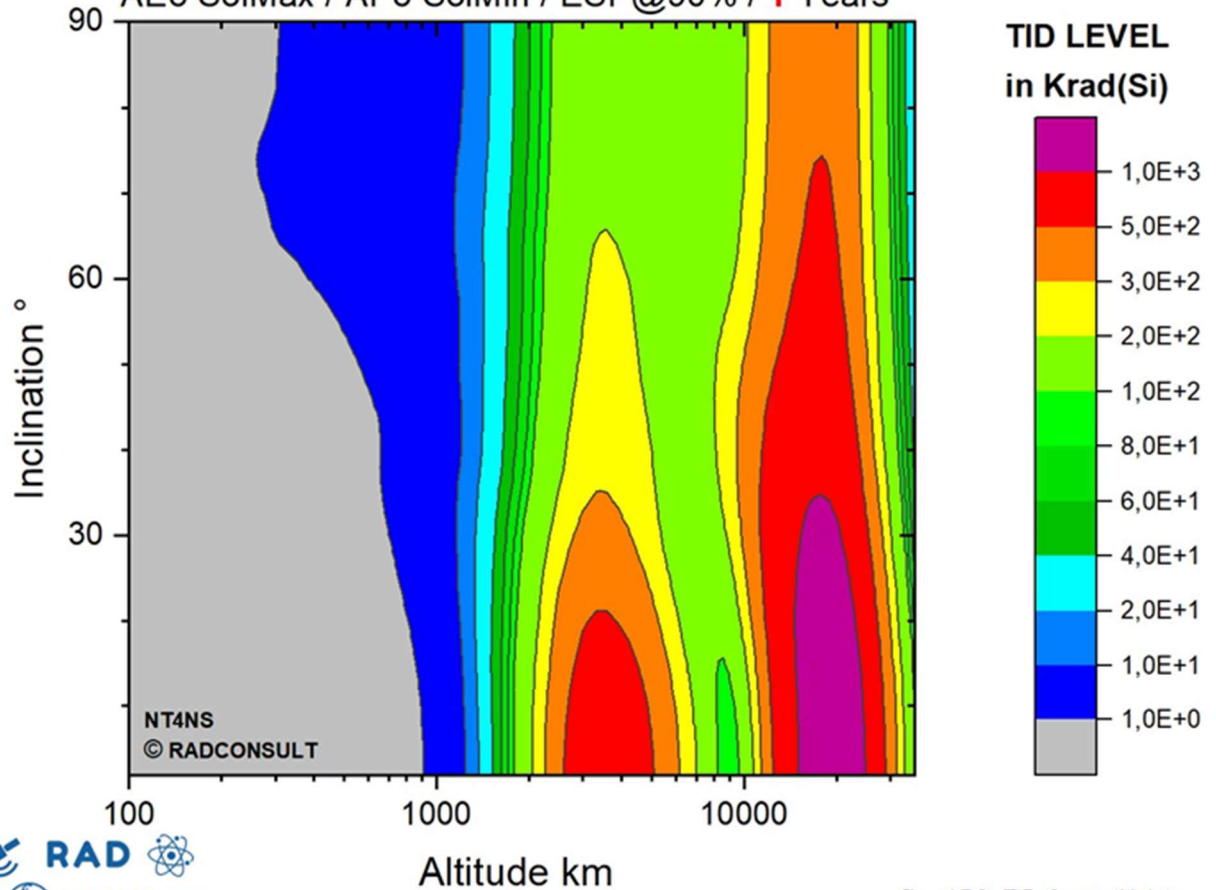
New Tools for New Space

T I D 4 N S

Total Ionizing Dose for New Space

T.I.D. LEVELS - 2 mm Al CUBICAL BOX

AE8 SolMax / AP8 SolMin / ESP@90% / 1 Years



I. TOTAL IONIZING DOSE (TID) FOR NEW SPACE

This TID4NS code can be used by two different space communities:

1. THE NEW SPACE COMMUNITY

Most of New Space (NS) actors don't have accurate and powerful software, and no radiation expert able to run 'correctly' these codes. TID4NS can be run by any project members, in order to get very fast an accurate approximation of their TID level for their mission.

For a given mission (altitude; inclination; lifetime), and a for a given small satellite characterized by 6 'equivalent thicknesses' in mm Al, TID4NS will return, very fast in few seconds, the Total Ionizing Dose level deposited within a Silicon detector, located inside a Solid Cube Box.

Of course, this TID level could be considered as a worst-case value. Here, the innovation is to get the Solid Cube TID level, for any orbit in few seconds, and not the Solid Sphere TID level as it is done currently, leading to a huge overestimation of the TID level.

In appendix, example of TID curves for Solid Cube and Solid Sphere are given to show the relative factor

2. THE 'CLASSIC' SPACE COMMUNITY

Even if they have accurate and powerful radiation software, and radiation experts able to run it correctly, TID4NS can be very useful for project engineers, quality engineers, parts procurement engineers as well.

- Typing 5-7 mm Al, TID4NS will return a reliable TID range for a classical satellite
- Typing 20 mm Al, TID4NS will return the minimum TID Level requirement for your mission

II. HOW TO RUN TID4NS

When you run TID4NS for the first time, a Digital Key will be asked, only once.

Mission Description :

- Step 1: Type the altitude in km. 100 km ≤ altitude ≤ 36000 km
- Step 2: Type the inclination in ° 0 ° ≤ inclination ≤ 98 °
- Step 3: Type the lifetime in years Lifetime > 0 year

Satellite Solid Cube Description :

- Step 4: Type 6 'equivalent thicknesses' along each direction, different or the same 0.1 mm Al ≤ thickness ≤ 100 mm Al

Total Ionizing Dose Calculation :

Step 5: Run TID4NS, type <enter> : TID4NS will return immediately :

- Each TID contribution in Krad(Si) coming from each direction (Over $4\pi / 6$)
- The Total Ionizing Dose Level in Krad(Si), inside the Solid Cube Box (over 4π)

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RADCONSULT          ***** TOTAL IONIZING DOSE 4 NEW SPACE *****
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**** ORBIT DESCRIPTION ( 200 orbits & 300 nts/orbit ) ****
ALTIMUDE : 1650.0 km ; INCLINATION : 36.0 deg ; LIFETIME 5.00 years

***** CUBICAL BOX THICKNESSES *****          **** ENVIRONMENT ****
CUBE          Thickness          TID / Face          Trapped Particles :
FACE          mm Al              Krad(Si)             - Electron : AEB Solar Maximum
- Proton    : AP8 Solar Minimum
Solar Particles :
- Proton    : ESP @ 90% C.L.
0.10 mm Al < e_cube < 100 mm Al
Solid Sphere Dose : SHIELDSE-2
Solid Cube Dose  : RADCONSULT

X +          2.30                +3.23E+01
X -          3.40                +2.05E+01
Y +          2.80                +2.56E+01
Y -          3.40                +2.05E+01
Z +          6.20                +1.27E+01
Z -          4.00                +1.70E+01

TID LEVEL inside SOLID CUBE= +1.29E+02 Krad(Si)/4pi  New Box (Y/N):? ->?

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Step 6: New Box ? : Type "Y" or "N"

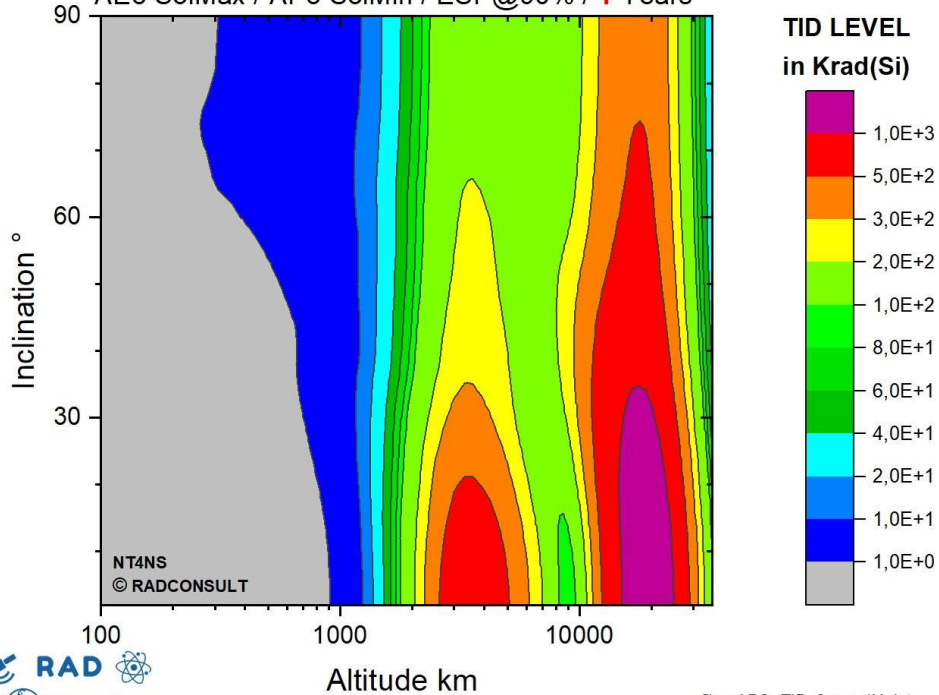
Step 7: New Mission ? : Type "Y" or "N"

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III. EXAMPLE SOLID CUBE ISODOSE CONTOURS

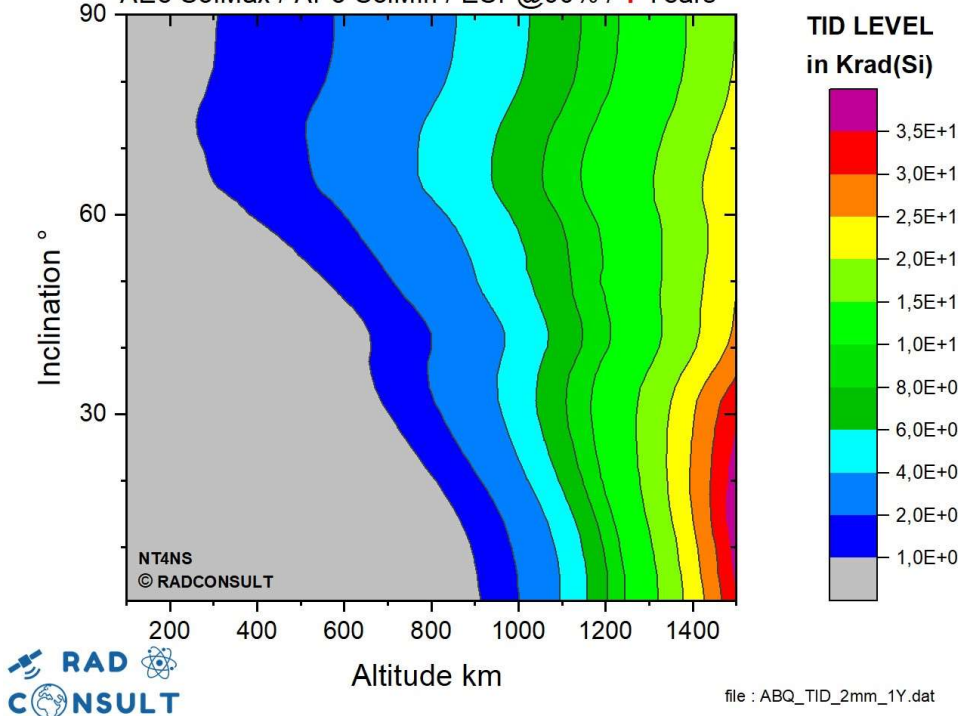
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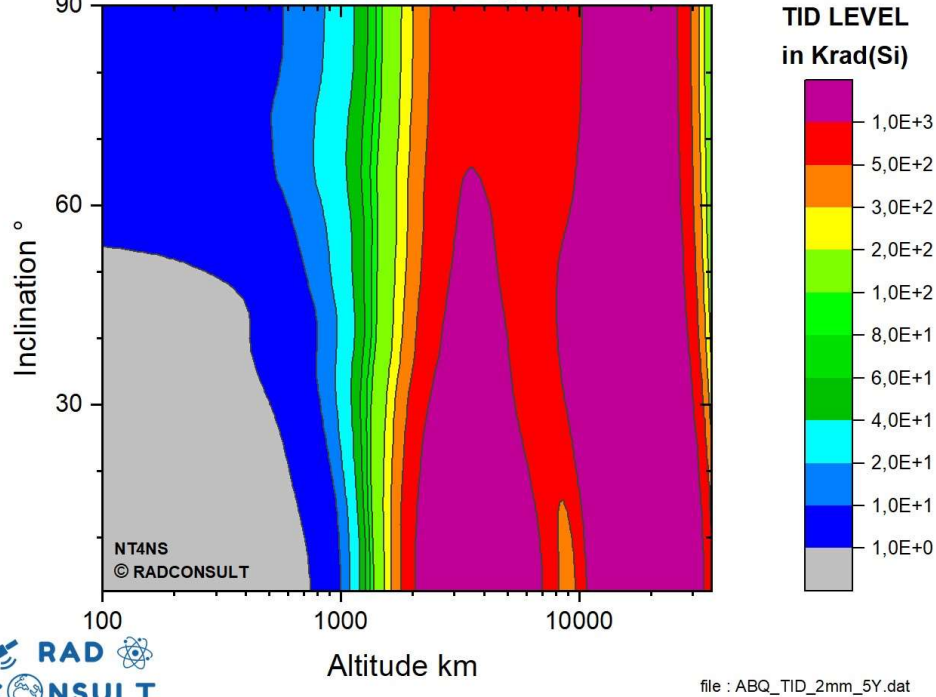
T.I.D. LEVELS - 2 mm Al CUBICAL BOX

AE8 SolMax / AP8 SolMin / ESP@90% / 1 Years



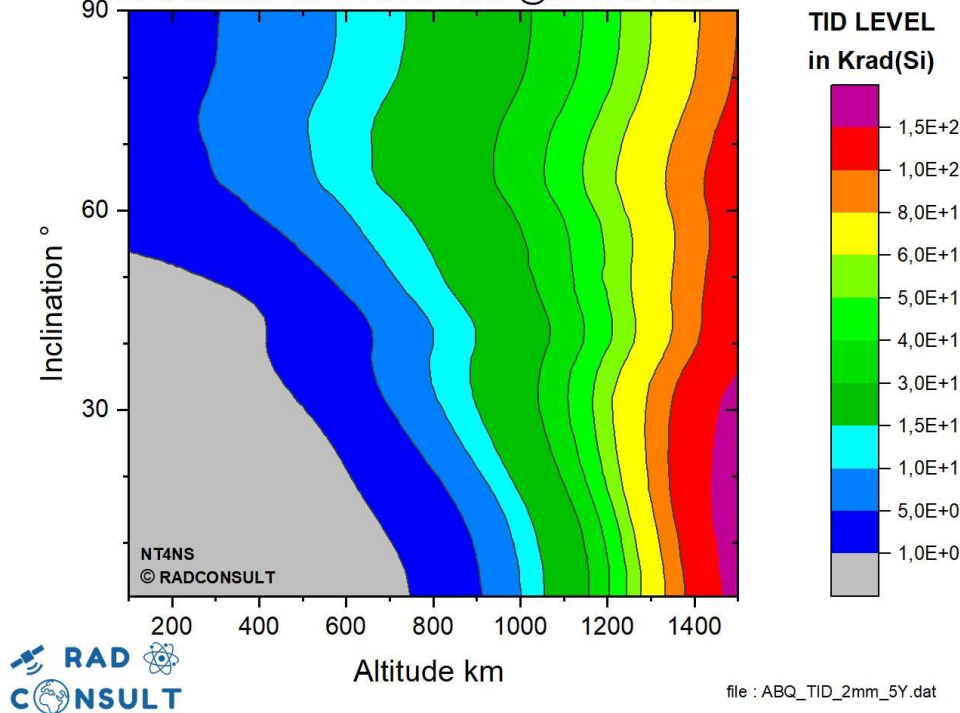
T.I.D. LEVELS - 2 mm Al CUBICAL BOX

AE8 SolMax / AP8 SolMin / ESP@90% / 5 Years



T.I.D. LEVELS - 2 mm Al CUBICAL BOX

AE8 SolMax / AP8 SolMin / ESP@90% / 5 Years

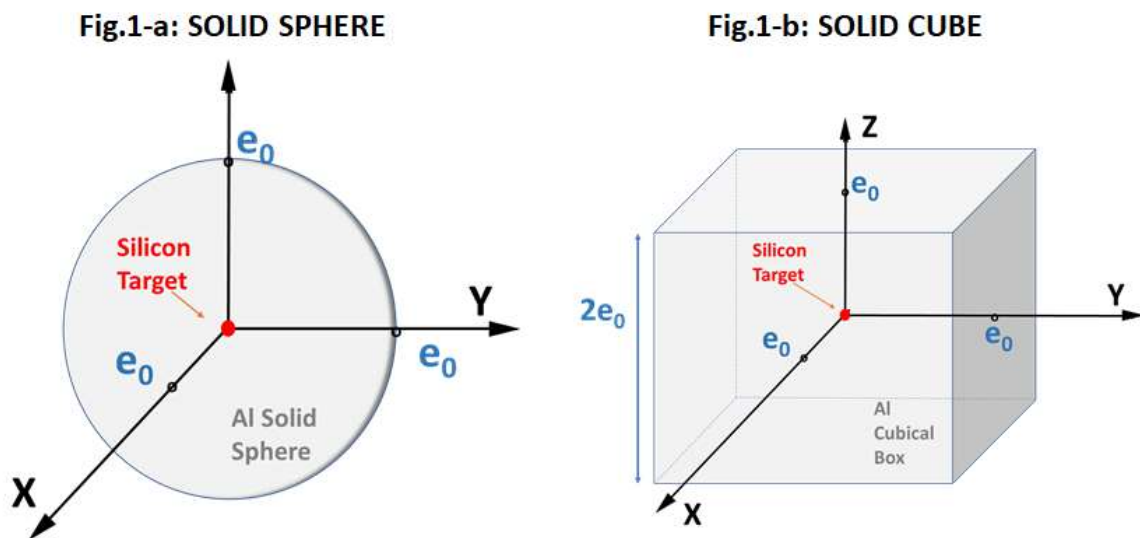


IV. APPENDIX : SOLID CUBE versus SOLID SPHERE

The full Inclination vs Altitude "orbit space" is investigated. Each point is a full mission (200 orbits & 300 points/orbit) in order to characterize the South Atlantic Anomaly on LEO orbits. Environment models used are:

- Trapped electrons: **AE8** Solar Maximum /
- Trapped Protons: **AP8** Solar Minimum /
- Solar protons: **ESP** model @ 90% confidence level /
- Lifetime **11 years**, to cover a full solar cycle

In order to be more representative of the reality, and to avoid TID level over-estimation **TID Levels are calculated at the center of an Al Solid Cube** (fig.1-b), and not inside a Solid Sphere (fig.1-a). As a reminder, TID Depth Curves for both shielding Solid Sphere & Solid Cube is given (fig.2)



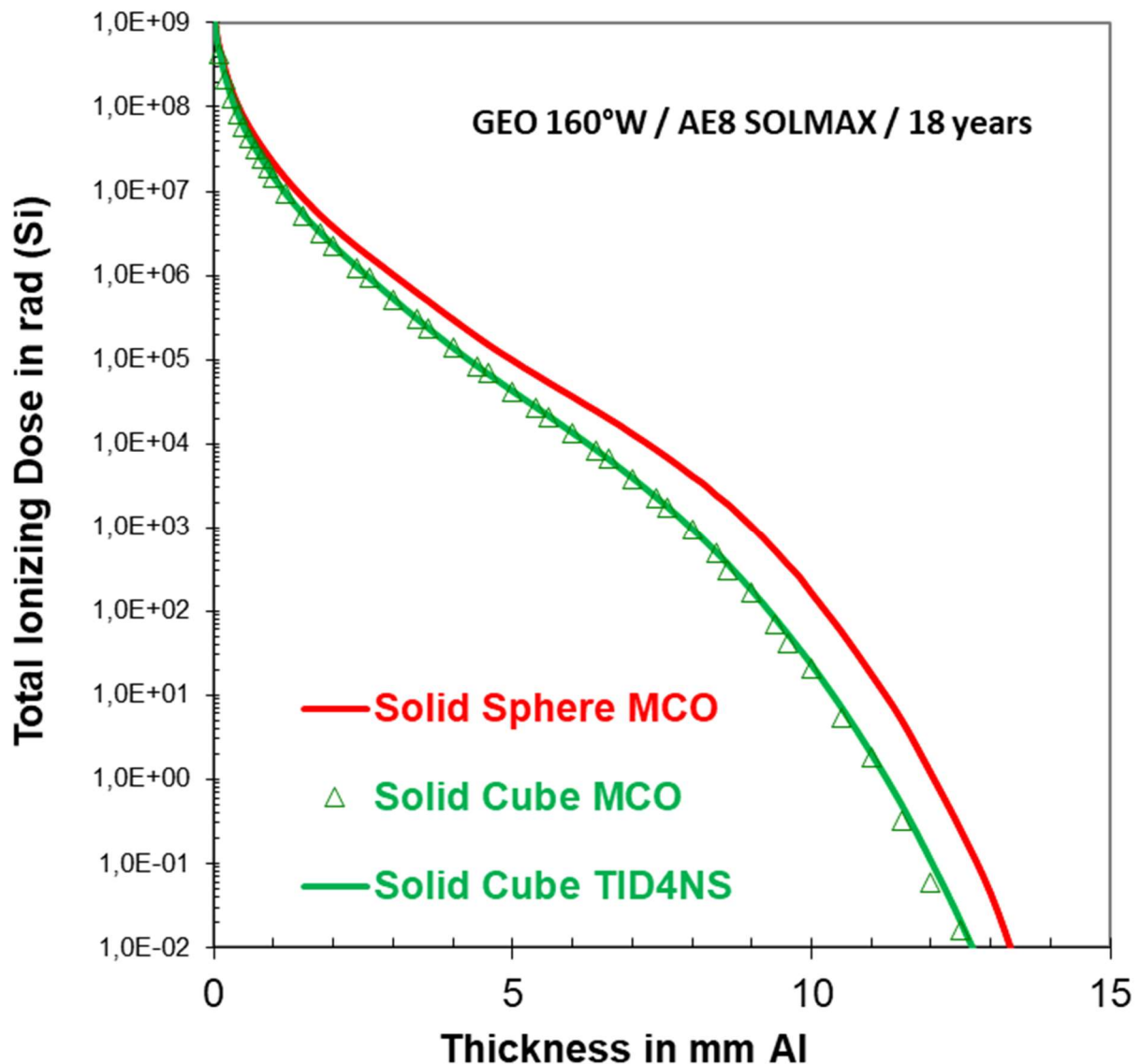
A CubeSat satellite, or minisat, is a compact structure and looks like a Solid Cube Box.

In early 1980's, the Six Sectors method was currently used: Estimate each thickness along each direction (X+ , X- , Y+ , Y- , Z+ & Z-), read the dose arriving through each face ($4\pi/6$) on the Solid Sphere Depth Curve. Using the Solid Sphere curve will provide an important TID level overestimation.

From few years, we observe that New Space companies are back to this old 80'method, in order to save engineering and software expenses.

Then, TID4NS is based on this 80's method, but the Ray Tracing for a solid cube is integrated, and then, the return TID level is given at a center of a Solid Cube by an analytical formula.

Example: Based on a Geostationary environment, considering only the trapped electron AE8 Solar maximum, results are as follow:



Red Line : Solid Sphere calculated by 3D Monte Carlo Reverse method

Green Line : Solid Cube calculated by analytical ray tracing formula, used in TID4NS

Green Triangle : Solid Cube calculated by 3D Monte Carlo Reverse method

<end>