

Comparison of Ax8 and Ax9 Trapped Environment Models for Various Orbits

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Betty P. Kwan and Timothy B. Guild
Space Sciences Department
Space Science Applications Laboratory

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United States Space Force
483 N. Aviation Blvd.
El Segundo, CA 90245-2808

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Abstract

This report compares the Ax8 mean environment with the Ax9 95% confidence environment for a range of potential mission orbits. It is shown that a commonly held rule of thumb that Ax9 (95%) is roughly 2x the Ax8 mean level is not valid except for GEO behind a typical range of spacecraft shielding. All other missions should carefully evaluate the environment from the Ax9 model instead of relying on an arbitrary scaling from past experiences.



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Introduction

- Background
 - *An updated trapped environment model, AE9/AP9 (or “Ax9”), is replacing the older AE8/AP8 (“Ax8”) models in vehicle requirements*
 - *The Ax9 model provides a statistical uncertainty on the environment*
 - *To ensure that this approach provides at least as much margin on the space environment as in the past, a “rule of thumb” has been circulated to the effect that 1x the Ax9 95% confidence level environment is equivalent to 2x the mean Ax8 environment*
- Purpose
 - *The intent here is to make clear that this “rule of thumb” is not widely applicable*
 - *It works only for a range of typical shielding thicknesses in GEO*
- Bottom line
 - *Comparison of relative margin between Ax8 and Ax9 is not a simple scaling*
 - *Margin should be determined on its own merits without arbitrarily referencing to past experiences*

There is no simple “rule of thumb” for comparing margin between the Ax8 and Ax9 trapped environment models

Orbits Chosen for Study



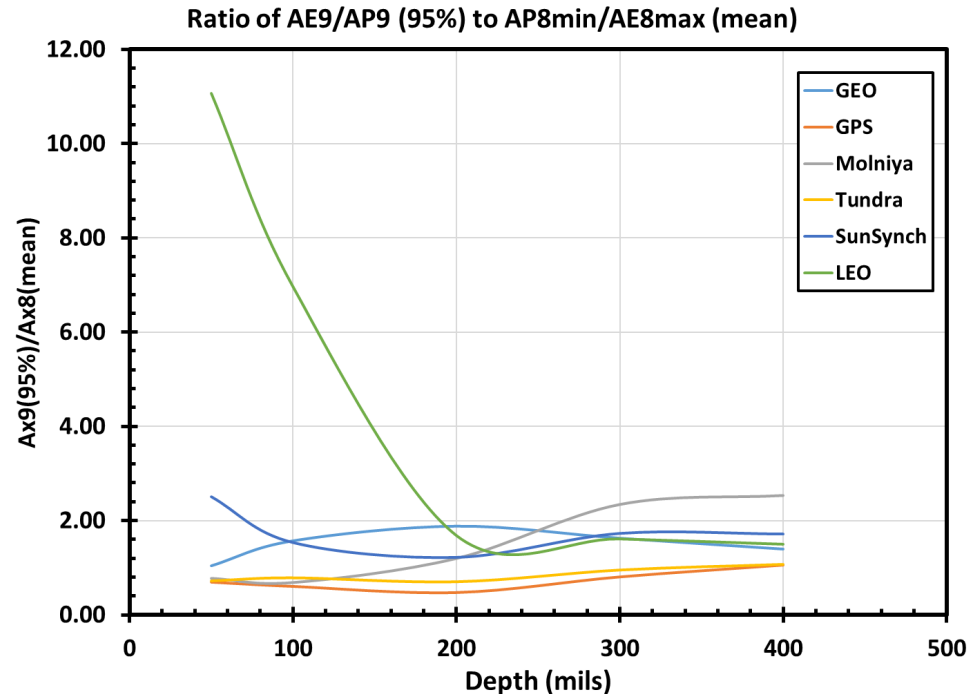
- The table at right shows the orbits studied
 - *Looked at a variety of altitudes and inclinations*
- Dose-depth curves were generated for each orbit from both models
 - *50, 100, 200, 300, 400 mils (Al) shielding*
 - *Ax8 (mean) and Ax9 (95%) from Ax9 v1.50.001 GUI*
 - *Did not include plasma models, GCR*
- The ratio Ax9(95%)/Ax8(mean) was plotted vs. shielding thickness
- Shielding geometry was 4π sr (full sphere)
- The Ax8 model used AP8 (solar minimum) and AE8 (solar maximum) to get a bounding environment over solar cycle

Name	Perigee (km)	Apogee (km)	Inclination (deg)
GEO	35768	35768	0
GPS	20200	20200	55
Molniya	400	40000	63.4
Tundra	24476	47110	63.4
SunSynch1	600	600	98
SunSynch2	700	700	98
SunSynch3	800	800	98
SunSynch4	900	900	98
LEO1a	400	400	50
LEO1b	600	600	50
LEO1c	800	800	50
LEO1d	1000	1000	50
LEO1e	1200	1200	50
LEO1f	1400	1400	50
LEO2a	400	400	60
LEO2b	600	600	60
LEO2c	800	800	60
LEO2d	1000	1000	60
LEO2e	1200	1200	60
LEO2f	1400	1400	60
LEO3a	400	400	70
LEO3b	600	600	70
LEO3c	800	800	70
LEO3d	1000	1000	70
LEO3e	1200	1200	70
LEO3f	1400	1400	70

Looking at a range of typical near-Earth orbits

Example Ratios

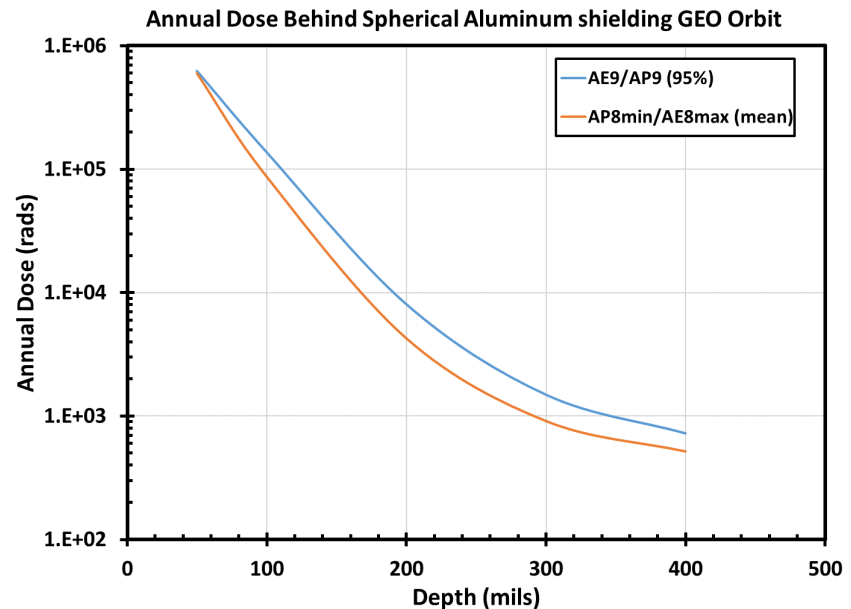
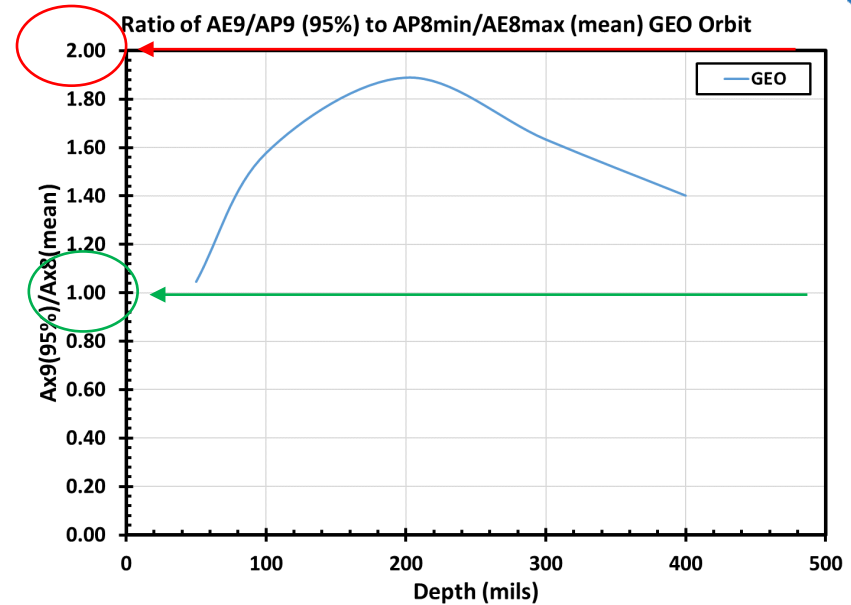
- Some example ratios between Ax9 (95%) and Ax8 (mean) are shown at right
- GEO is the only orbit that follows the “rule of thumb” for typical shielding values
- Several curves show the observation noted elsewhere that Ax9 predicts higher doses behind thick shielding. This is supported by dosimeter data from RPP/Deal
- The large increase for LEO with thin shielding is primarily for low altitude circular orbits. Higher orbits do not have such a pronounced increase in the ratio
- In some cases, the Ax9 (95%) level is lower than the Ax8 mean level, suggesting we have been including far too much margin
- In other cases, the opposite may be true



The Ax9 model predictions can be very different from the Ax8 model depending on orbit location and shielding level

GEO

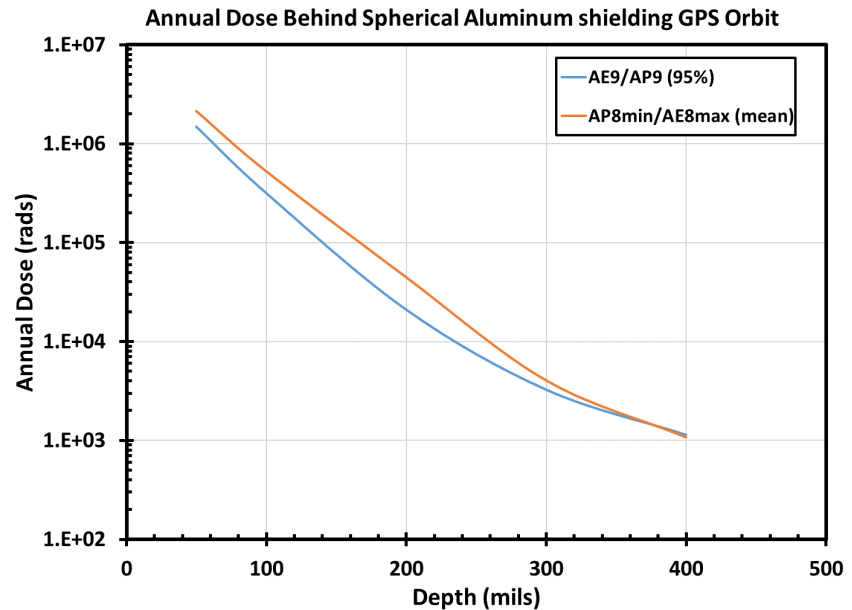
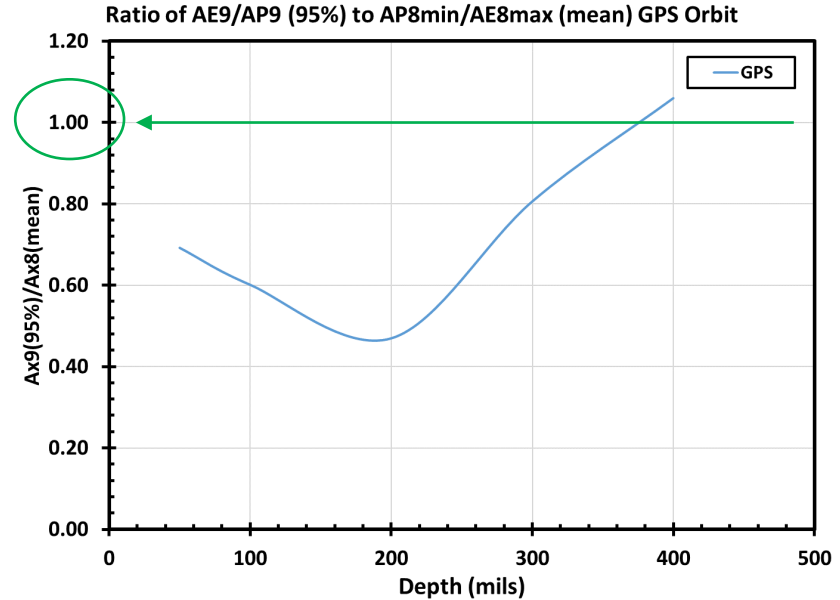
- GEO comparison shown at right
- Ax9 (95%) is about 2x Ax8(mean) for typical shielding (100-250 mils Al)



The “rule of thumb” does work in GEO for typical shielding thicknesses

GPS

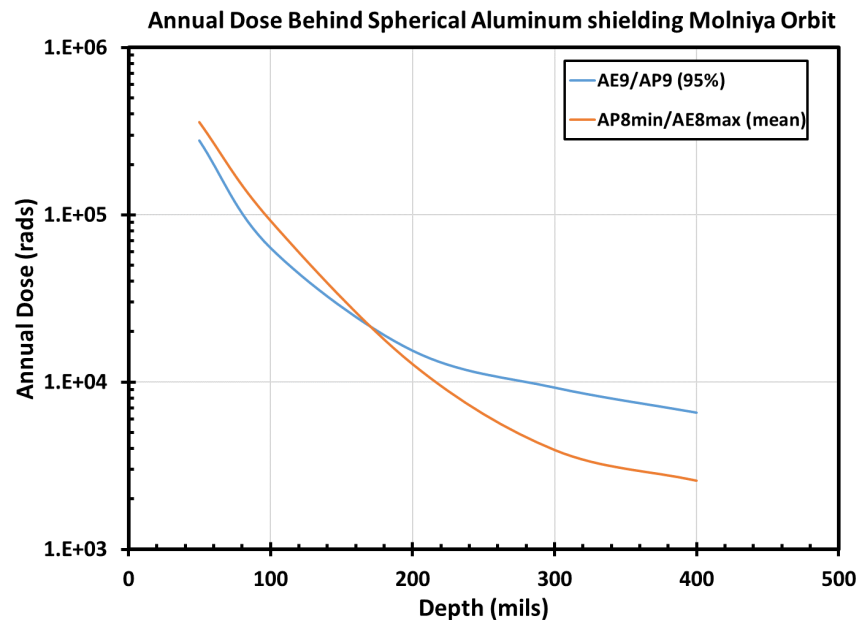
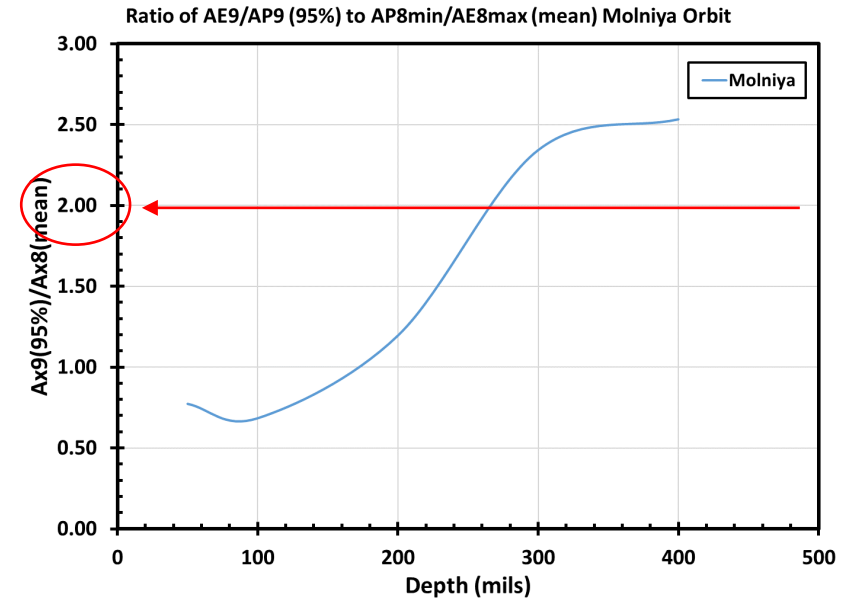
- GPS comparison shown at right
- The Ax9 (95%) predictions are lower than the Ax8 mean values over most shielding thicknesses



Rule of thumb significantly overestimates

Molniya

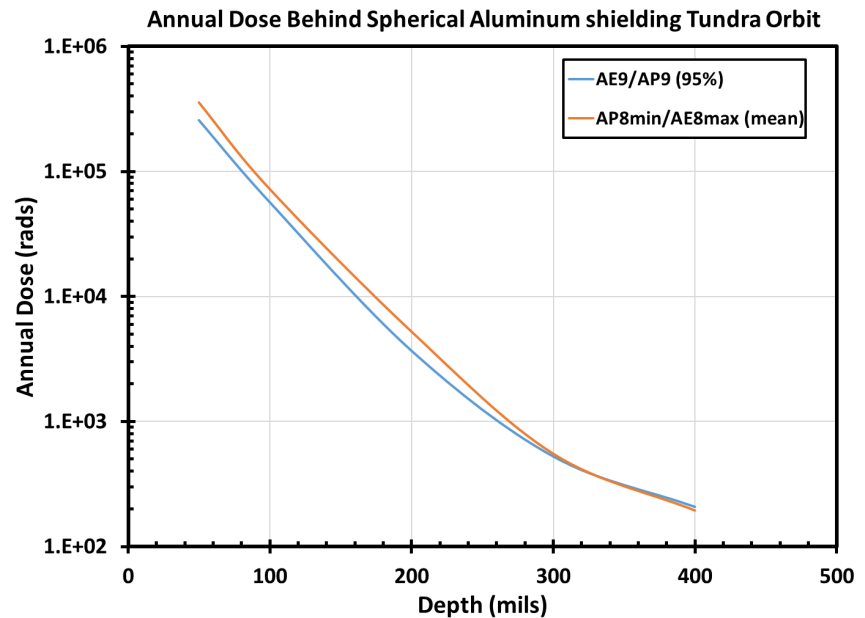
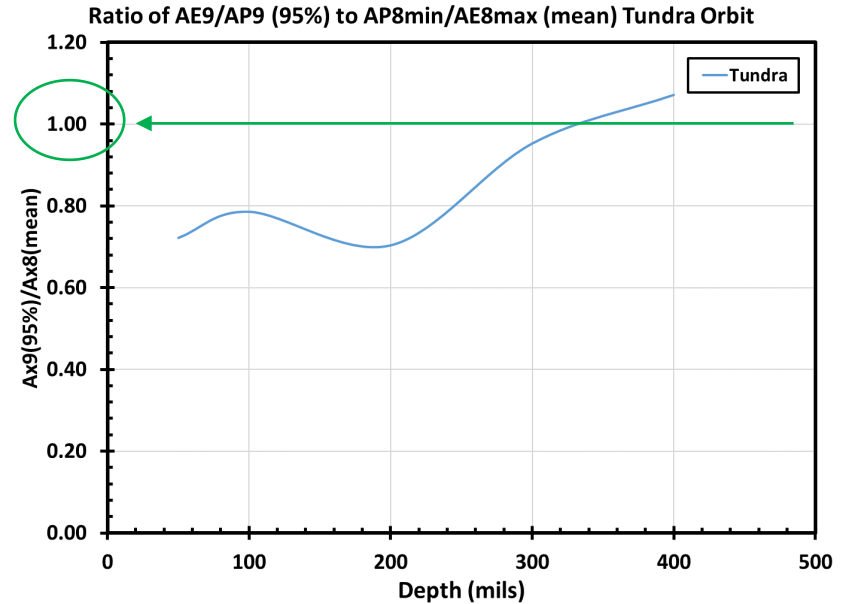
- Molniya comparison shown at right
- The Ax9 higher predicted dose for thick shielding is clearly seen



Rule of thumb violated for thick depths

Tundra

- Tundra comparison shown at right
- The Ax9 (95%) predictions are lower than the Ax8 mean values over most shielding thicknesses

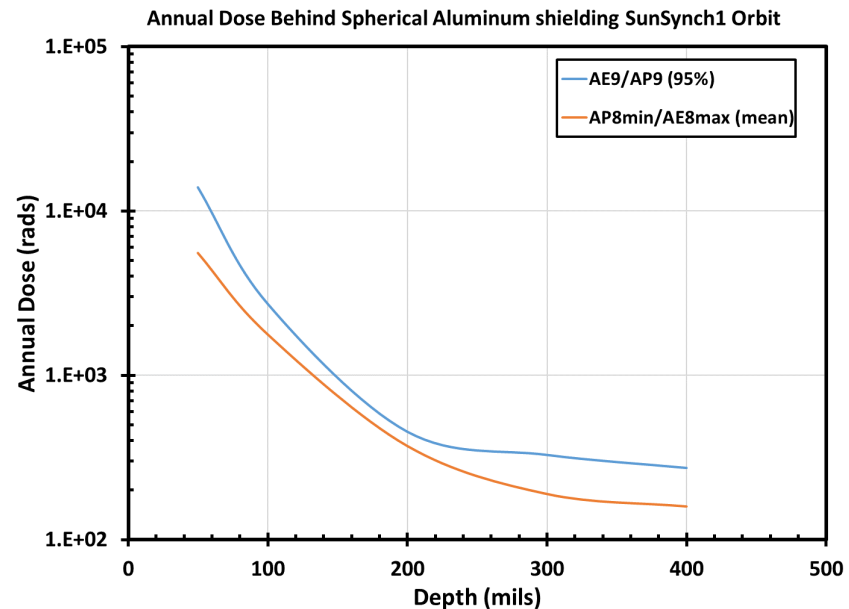
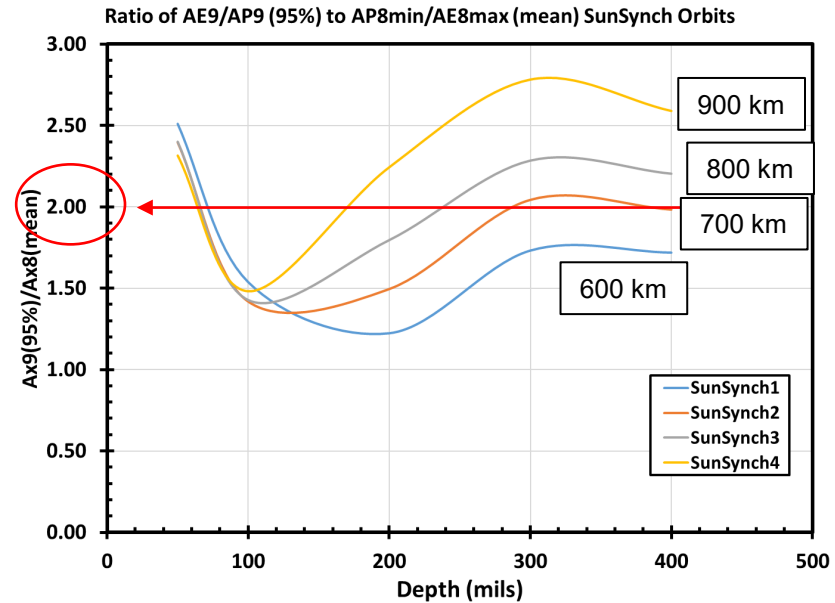


Rule of thumb significantly overestimates

Sun-Synchronous



- Sun-synchronous comparison shown at right
- The curves show that Ax9 has a greater increase in dose with altitude than Ax8 for these orbits

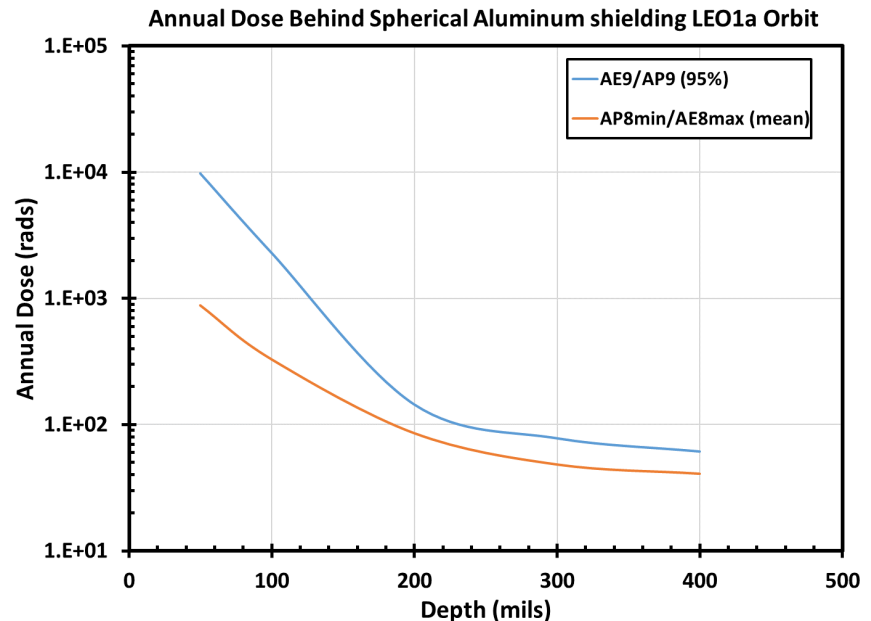
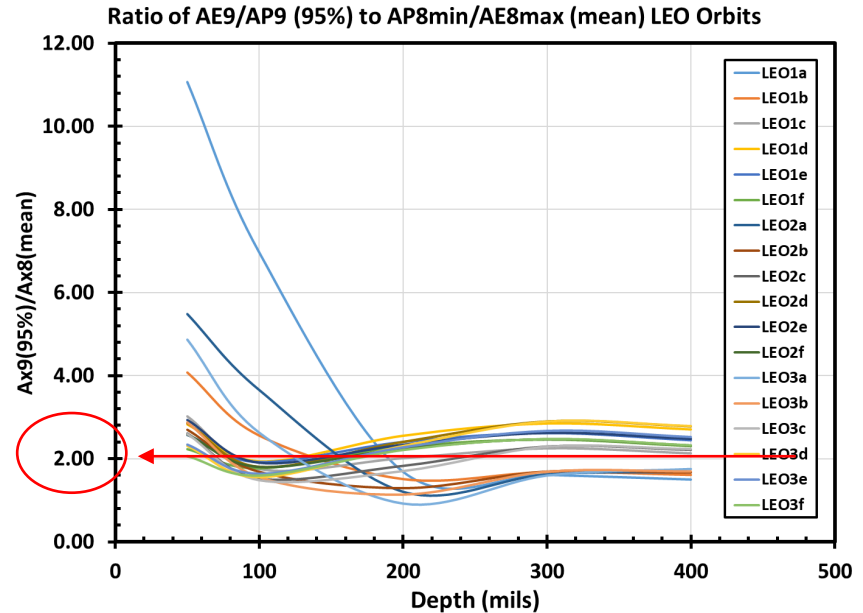


Rule of thumb violated for thick depths at higher LEO orbits

LEO

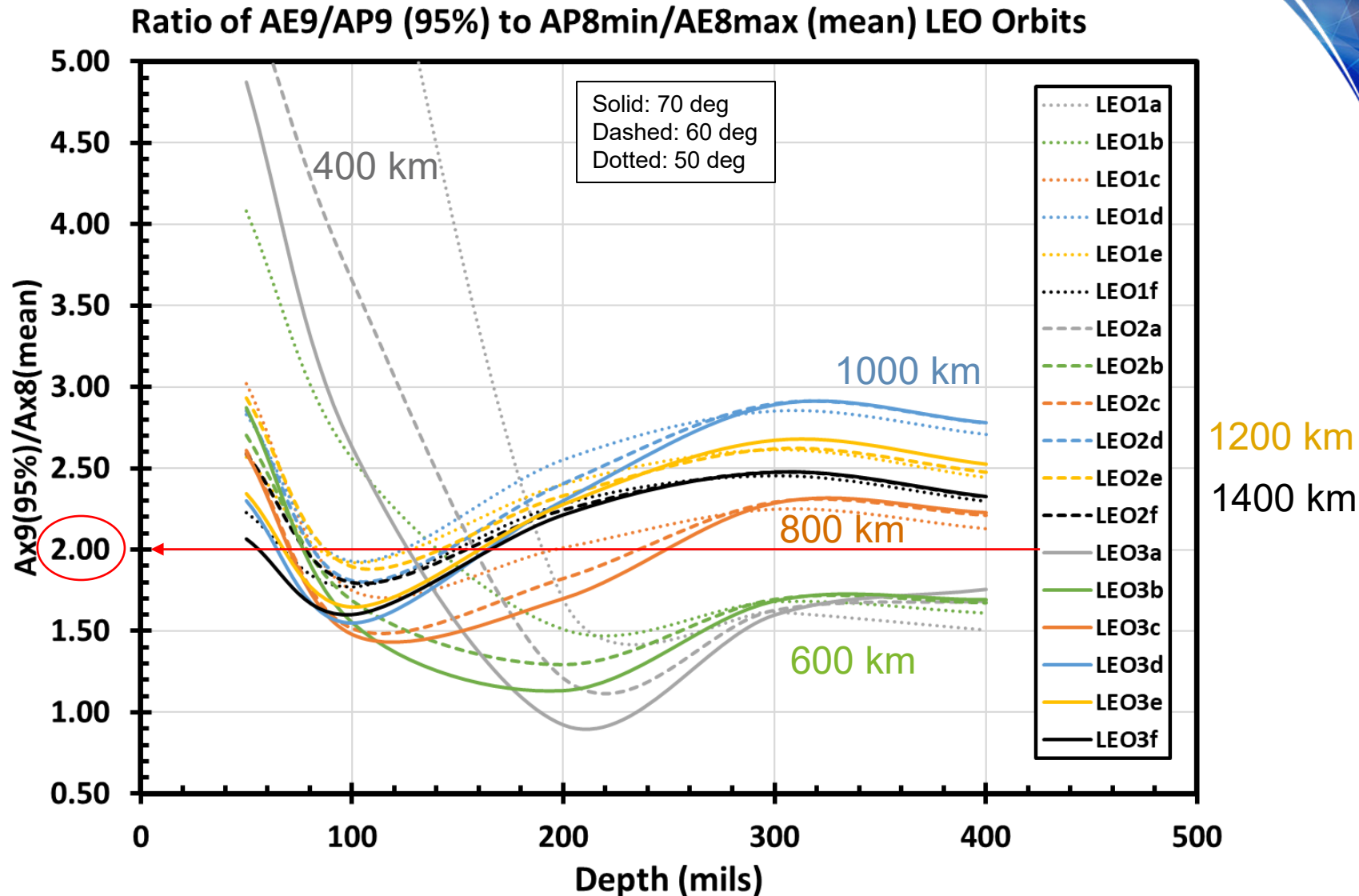


- LEO comparison shown at right
- For higher altitudes, the ratio is relatively constant, suggesting the models show differences in the lower edges of the South Atlantic Anomaly
- Zoom in, further interpretation on next chart



Rule of thumb violated in complex ways

Color-Coded by Altitude, Zoom-In of Ratio



Rule of thumb violated for low LEOs at thin depths, high LEOs at thick depths, not in order of increasing altitude

Conclusions



- The “2x” rule of thumb is not valid except for GEO using typical shielding
- In some cases, Ax9(95%) predicts a much higher environment than Ax8 (mean)
 - *This may require more shielding or high dose tolerance for proposed parts*
- In some cases, Ax9 (95%) predicts a much lower environment than Ax8 (mean)
 - *This allows relaxing of some constraints*
- The conclusion we draw is not to be fixed on maintaining a specific margin level relative to previous models
 - *Ax9 is a model with new and improved data. Ax8 was not a gold standard*
 - *The 2x margin used with Ax8 included other types of uncertainty, not just from environment*
 - *Best to use the uncertainty provided by Ax9 for environment and then look at how to add in other margin for part variation and other factors*

Expecting an arbitrary scaling between Ax8 and Ax9 will not work in most orbits

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Approved Electronically by:

Robert D. Rutledge, DIRECTOR - DEPARTMENT
SPACE SCIENCE APPLICATIONS LABORATORY
PHYSICAL SCIENCES LABORATORIES
ENGINEERING & TECHNOLOGY GROUP

Cognizant Program Manager Approval:

Joseph E. Mazur, PRINCIPAL DIRECTOR
PHYSICAL SCIENCES LABORATORIES
ENGINEERING & TECHNOLOGY GROUP

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Aerospace Corporate Officer Approval:

Todd M. Nygren, SENIOR VP ENGINEERING & TECHNOLOGY
OFFICE OF EVP

Content Concurrence Provided Electronically by:

Betty P. Kwan, RESEARCH SCIENTIST
MAGNETOSPHERIC & HELIOSPHERIC SCIENCES
SPACE SCIENCES DEPARTMENT
ENGINEERING & TECHNOLOGY GROUP

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