STEREO Mission Design - 3

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Mission Design Analysis

- High/Low Drift Rate Orbits
- Sun-Probe-Earth (SPE) Angle Analysis

High/Low Drift Rate Orbits

- Drift rate, $\eta = \pm 5, \pm 45$ deg/year
- High Rate
  - $C3_{min} > 1.0$ km^2/sec^2, ($C3_{min} \approx 1.4$ km^2/sec^2)
  - Limited range of escape angles
  - Greater sensitivity to launch vehicle velocity (C3) dispersions.
- Low Rate
  - Two local maximums with SPE Angle > 90°

Most flexible trajectory designs have $15 \leq |\eta| \leq 30$ *deg/year*

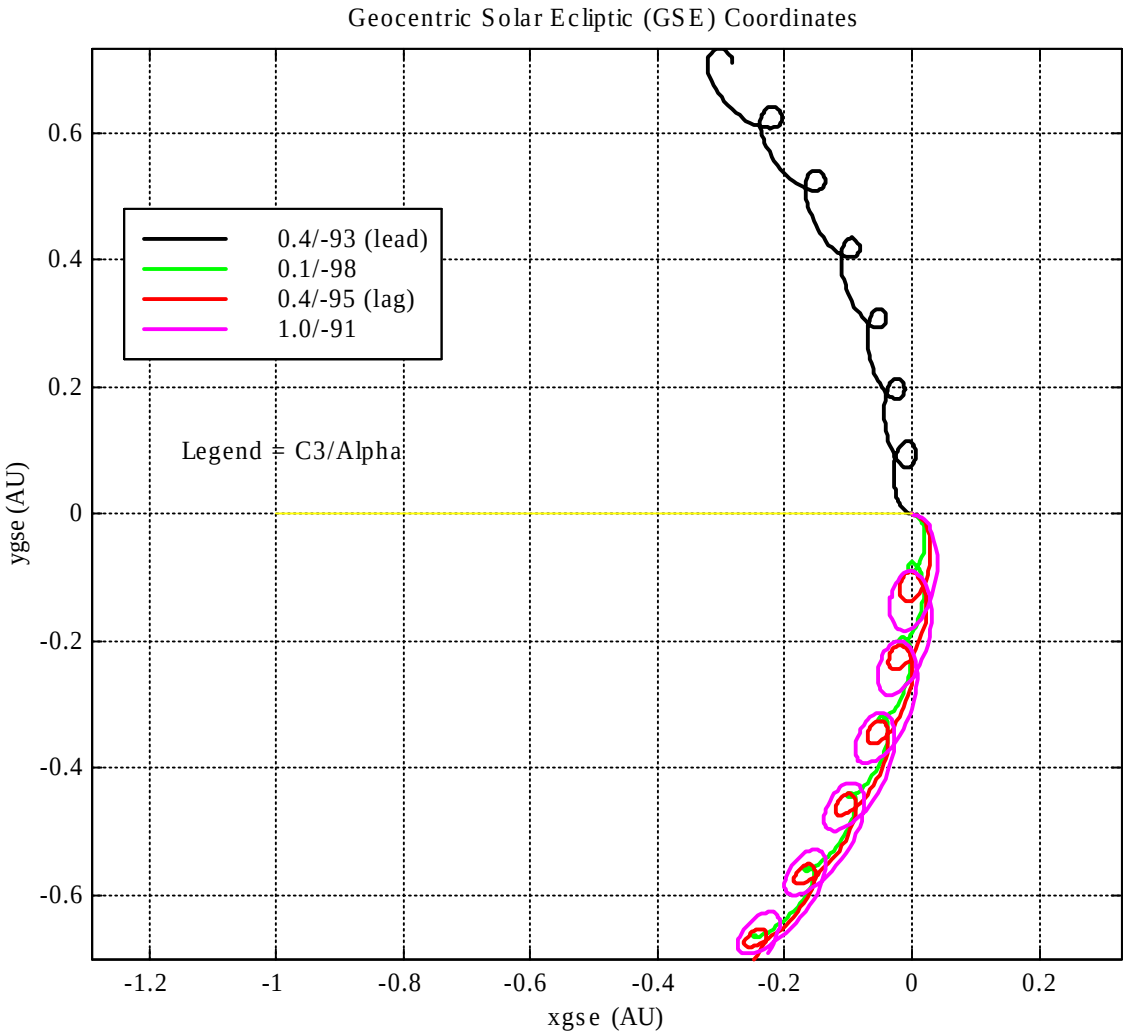
Sun-Probe-Earth (SPE) Angle Analysis

- Synopsis
  - 1-D, 2-D, 3-D refer to parameterization, all results are based on 3-D high fidelity trajectory simulations.
  - 1-D Trajectories
    - Design parameters: C3, α (Escape angle)
    - Parameter constraints
      - C3 = [0, 2] km^2/sec^2
        - » Payload mass
        - » Launch vehicle selection
      - α = 0° (lagging), 180 ° (leading) $\therefore$ $C3 = C3_{min}$
    - Results
      - Family of planar trajectories, $15 \leq |\eta| \leq 30$ deg/year
      - Identified design parameters sensitivities
      - ∗ Identified SPE angle > 90° for leading trajectories

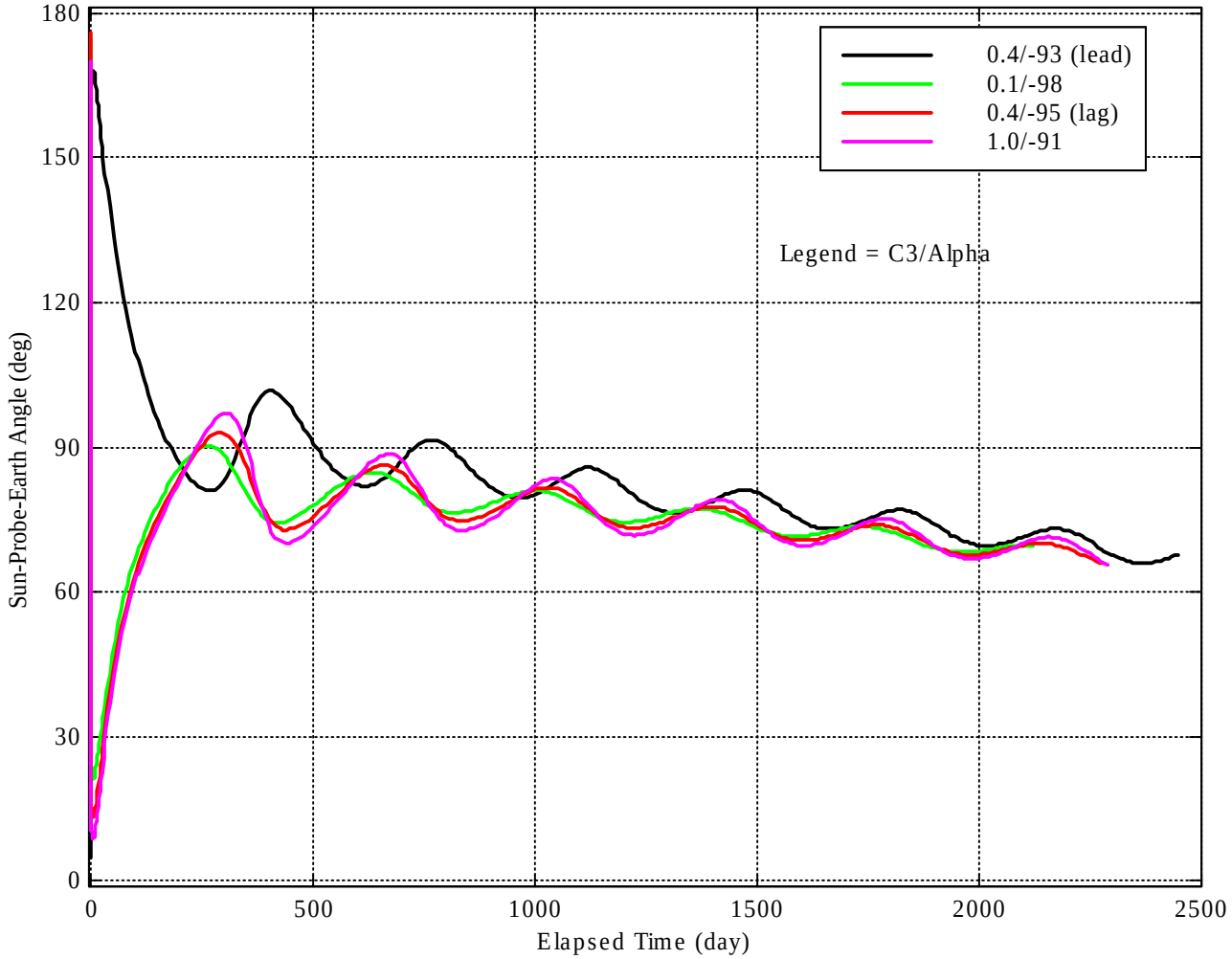
SPE Angle Analysis (cont'd)

- Synopsis (cont'd)
  - 2-D Trajectories
    - Design Parameters: C3, α
    - Parameter Constraints
      - C3 = [0, 2] km^2/sec^2
      - α is around the Ecliptic pole ($\mathbf{V}_\infty$ is in the Ecliptic plane)
    - Results
      - Family of planar trajectories, $5 \leq |\eta| \leq 45$ deg/year
      - Identified time of 1st local maximum SPE angle > 90° as function of α
      - Identified drift rate limits based on 2nd local maximum SPE angle > 90°

5 Deg/yr Orbits (2-D)



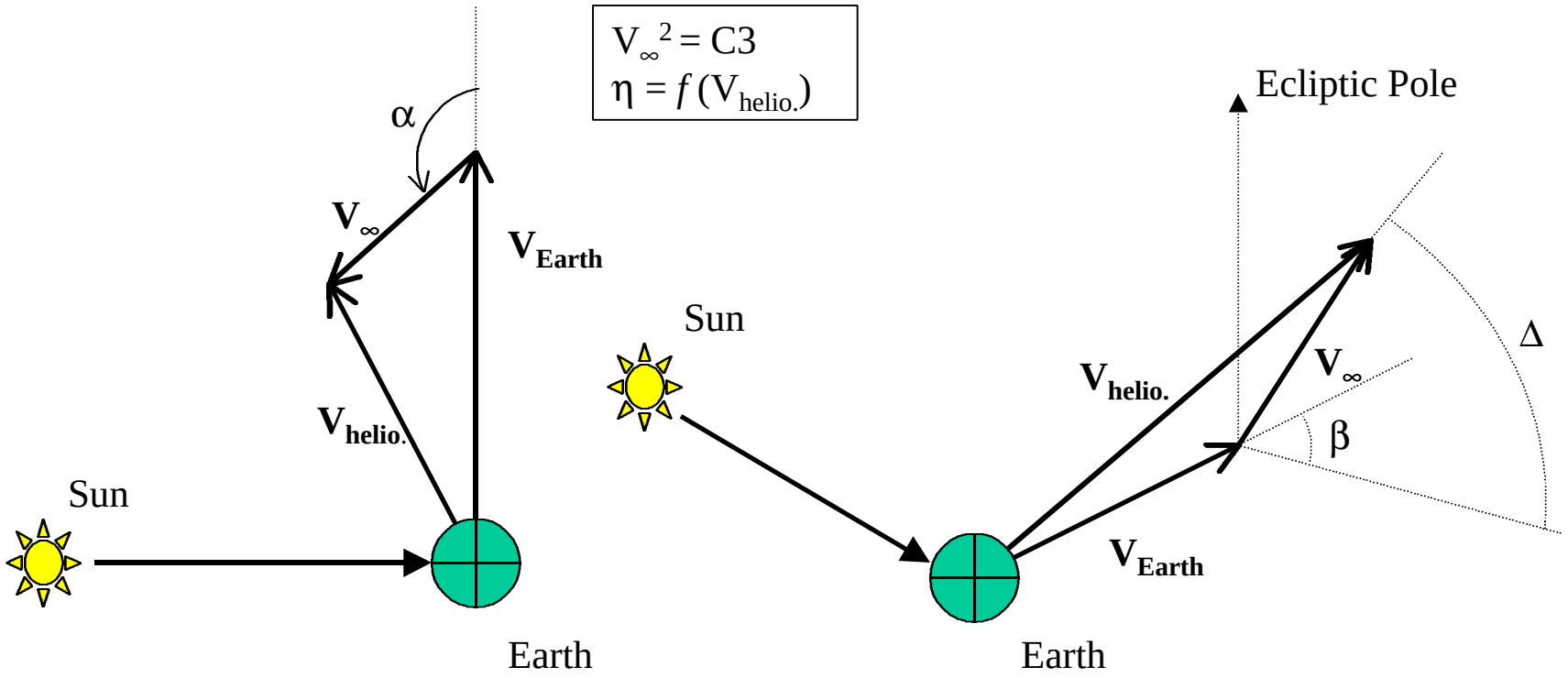
5 Deg/yr Orbits SPE Angle (2-D)



SPE Angle Analysis (cont'd)

- Synopsis (cont'd)
  - 3-D Trajectories
    - Design Parameters: C3, β, Δ
      - β is around the Ecliptic pole (offset from Earth's velocity vector)
      - Δ is declination of $\mathbf{V}_\infty$ to the Ecliptic plane
      - Escape angle, $\alpha = f(\beta, \Delta)$
    - Parameter Constraints
      - C3 = [0, 2] km^2/sec^2
      - Δ
        - » Launch date $\Rightarrow$ Declination of Earth's velocity to the Equator
        - » Launch vehicle $\Rightarrow$ Launch azimuth (inclination) vs. Payload mass

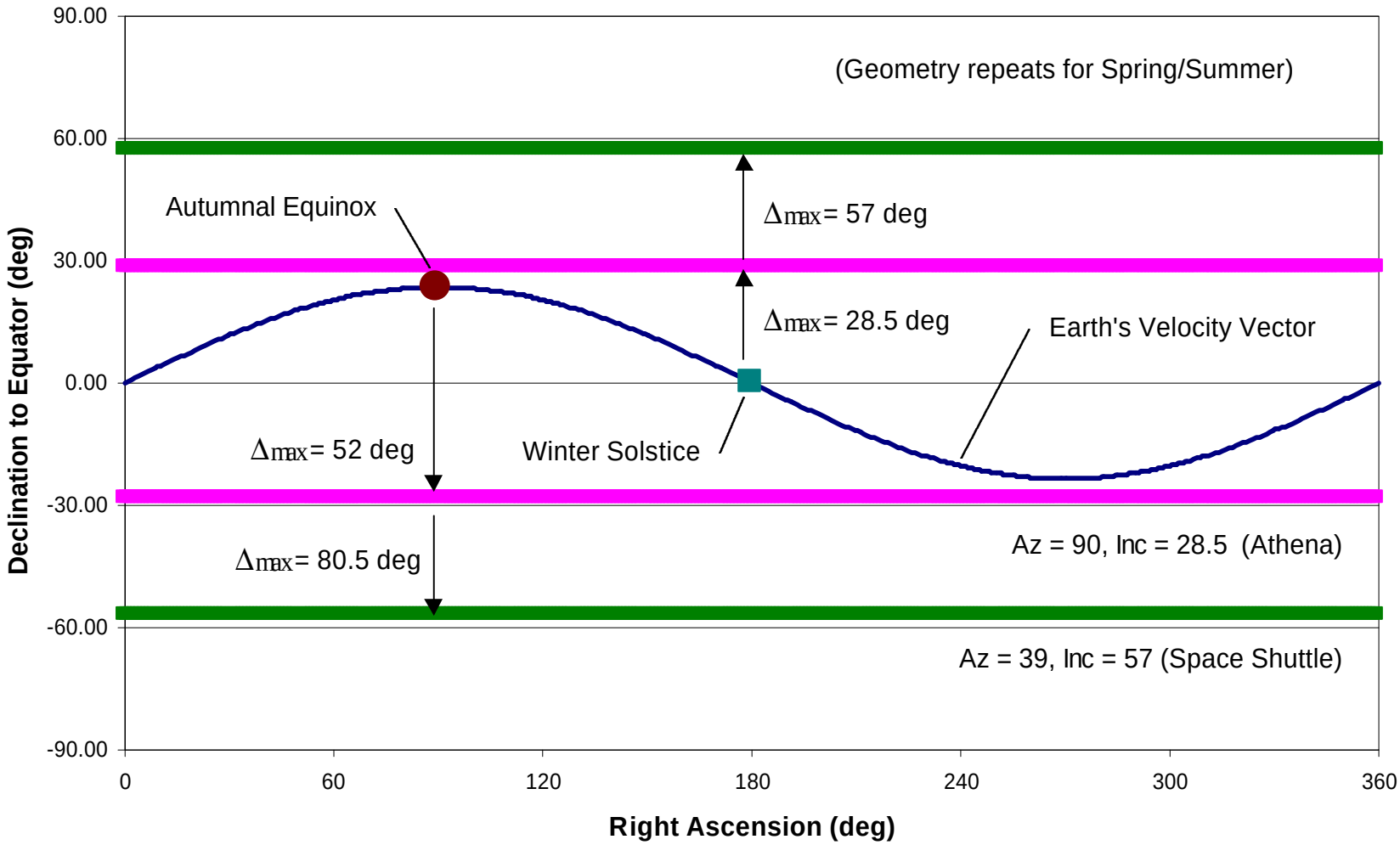
SPE Angle Analysis (cont'd)



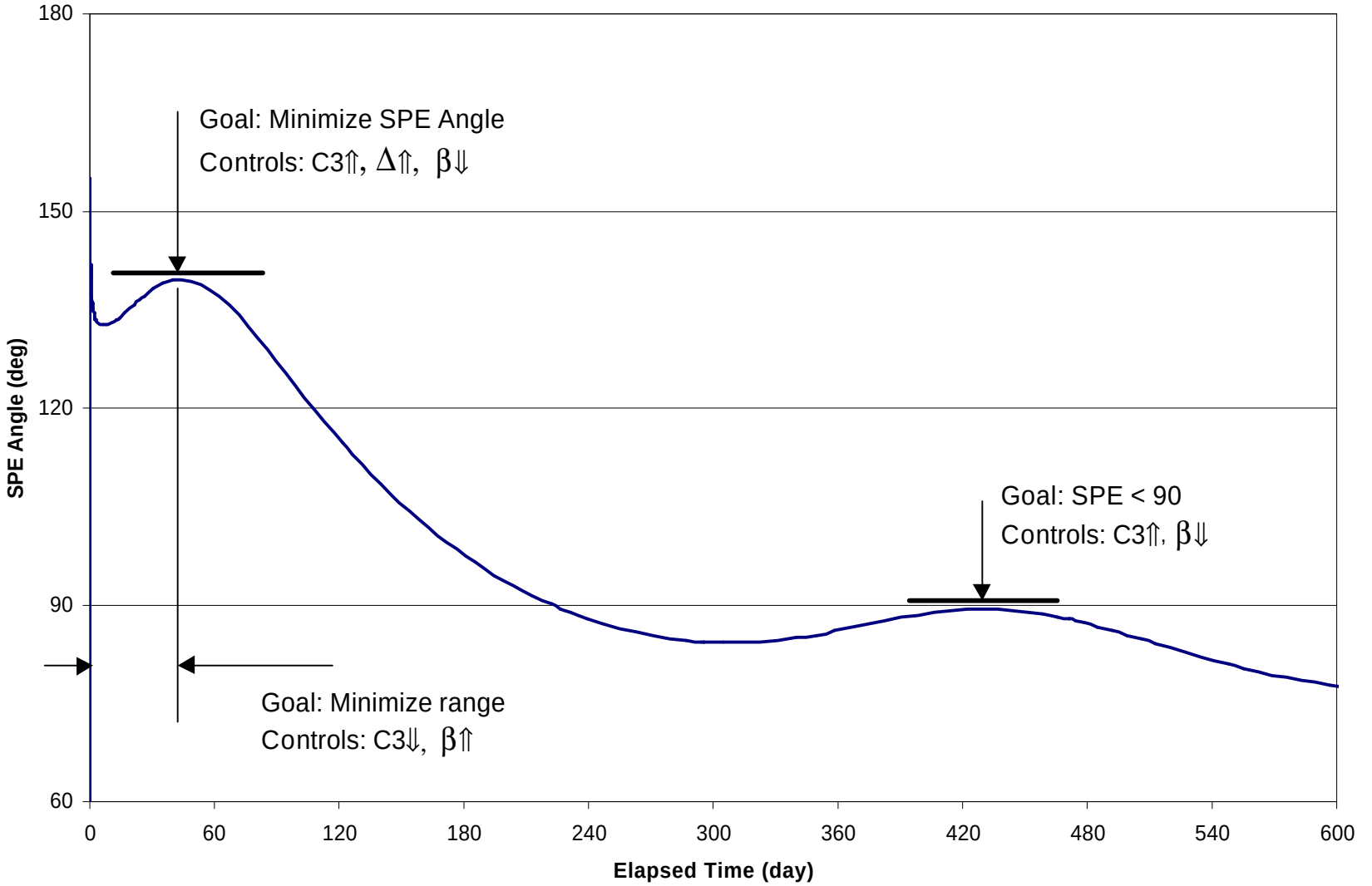
2-D (1-D for α = 0, 180)

3-D

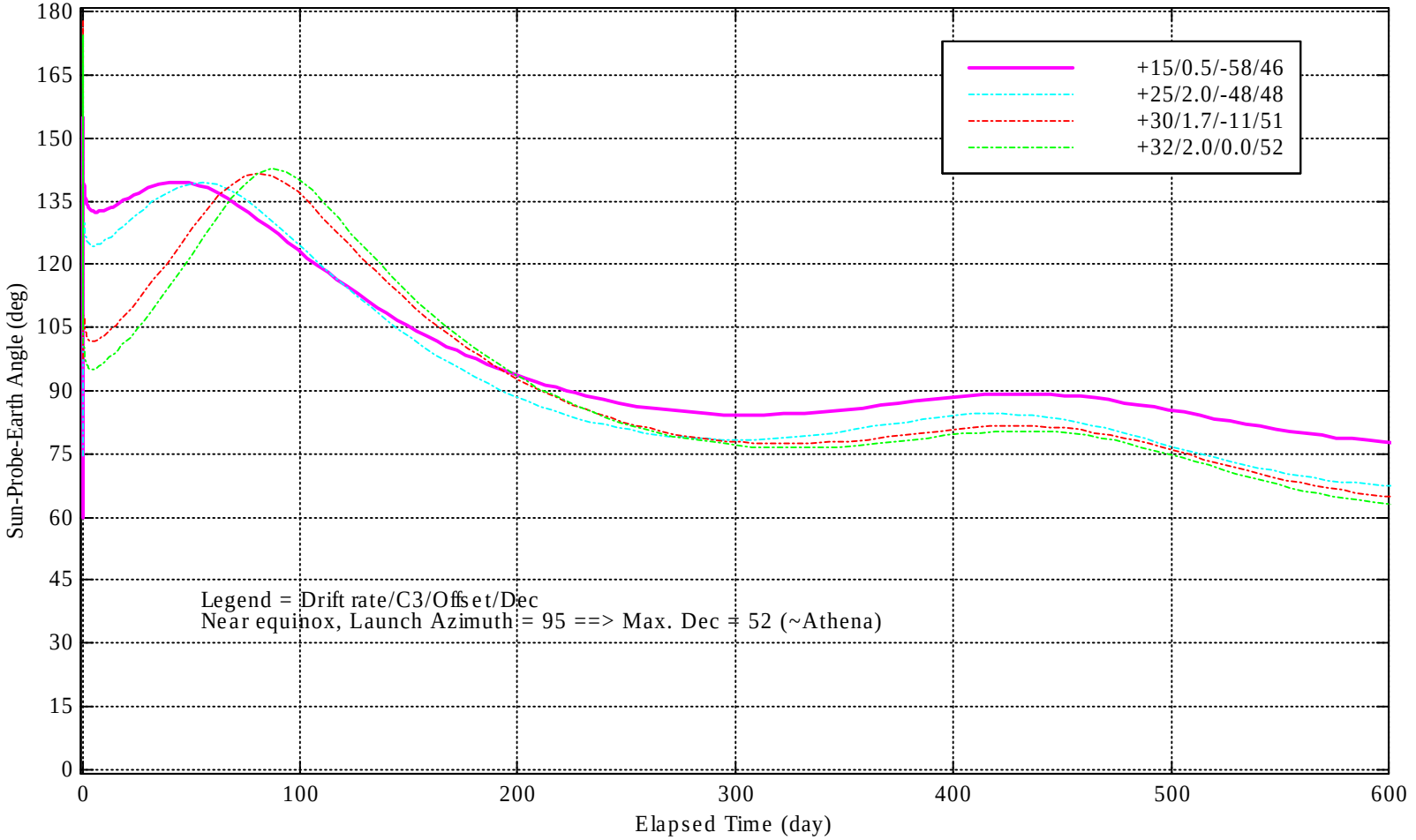
V_∞ Declination Constraints



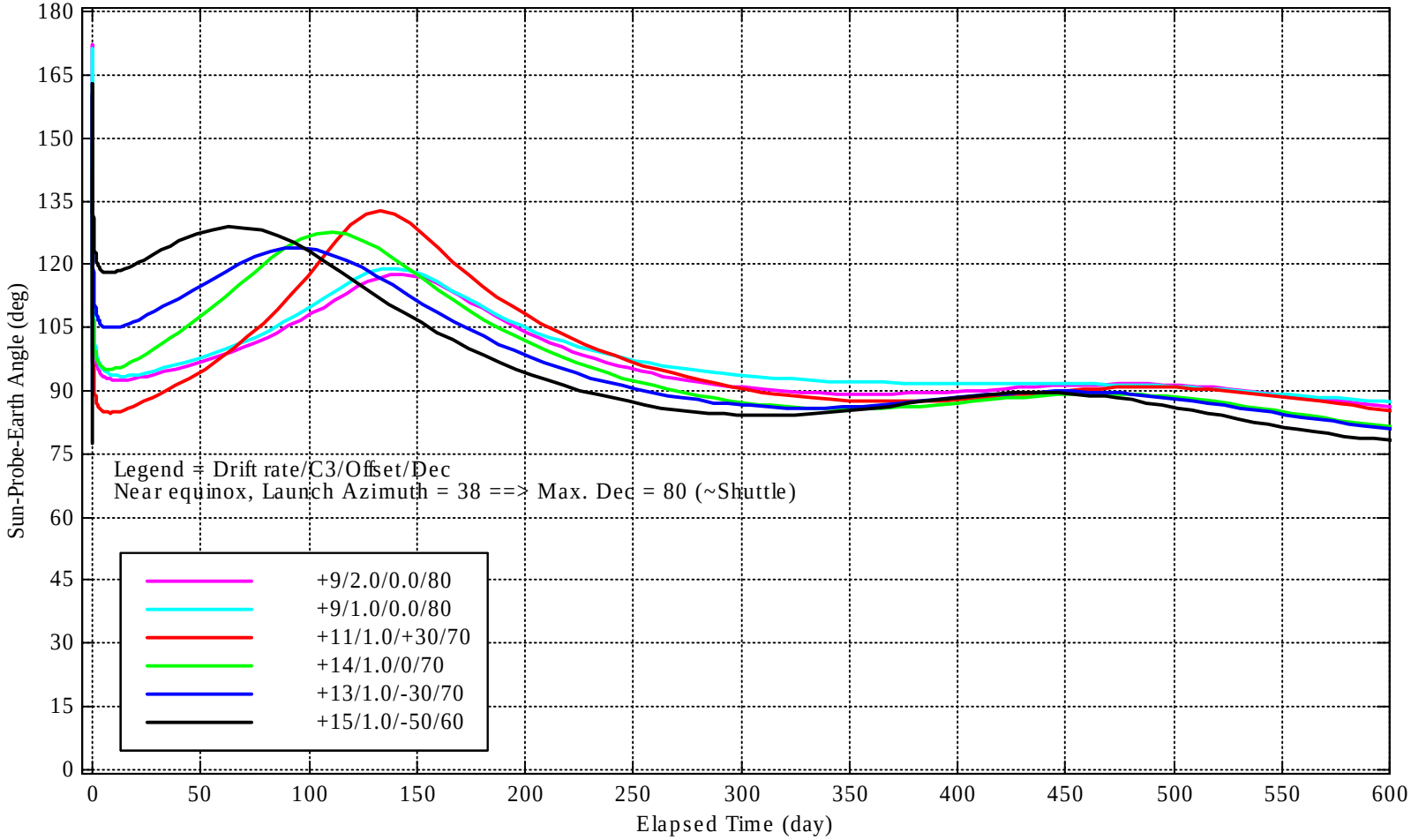
SPE Parameter Trades



SPE Minimization (3-D): Athena Scenarios



SPE Minimization (3-D): Shuttle Scenarios



SPE Minimization Summary

- ELV (e.g. Athena)
  - Launch azimuth near 90° to maximize payload mass
  - Smallest SPE @ first local maximum ≈140°
  - Optimum launch window near Equinox (September & March)
- Space Shuttle
  - Allows approximately 30 ° increase in Ecliptic declination versus typical ELV profile
  - SPE @ first local maximum, 120° ~ 130°
  - Extended launch window vs. typical ELV profile.
  - Impact of 2-on-1 sequencing (1 Shuttle flight) is TBD.
- Effects of launch vehicle dispersions on SPE is TBD.
- 2-Trailing S/C orbit configuration may be more flexible