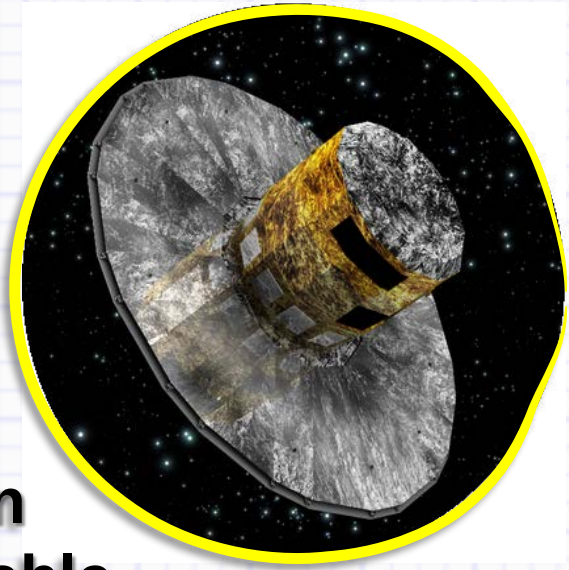
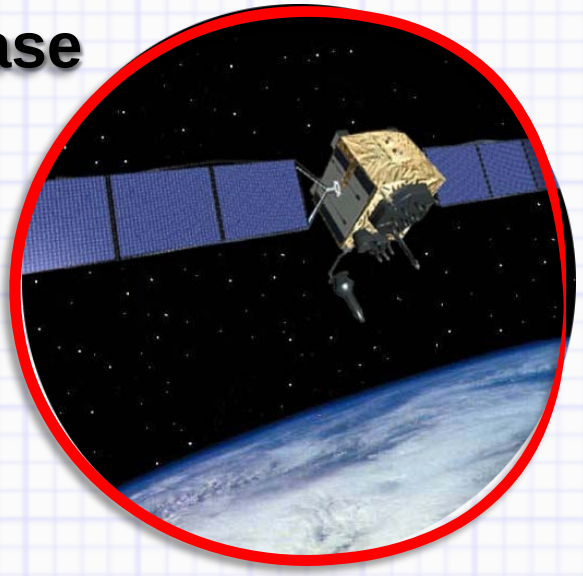






# Recent Developments in Coaxial Interconnection Cable Materials to Minimize Temperature Induced Phase Errors

David Slack
Times Microwave Systems
David.Slack@TimesMicro.com



TIMES MICROWAVE SYSTEMS

# Electrical Length Review

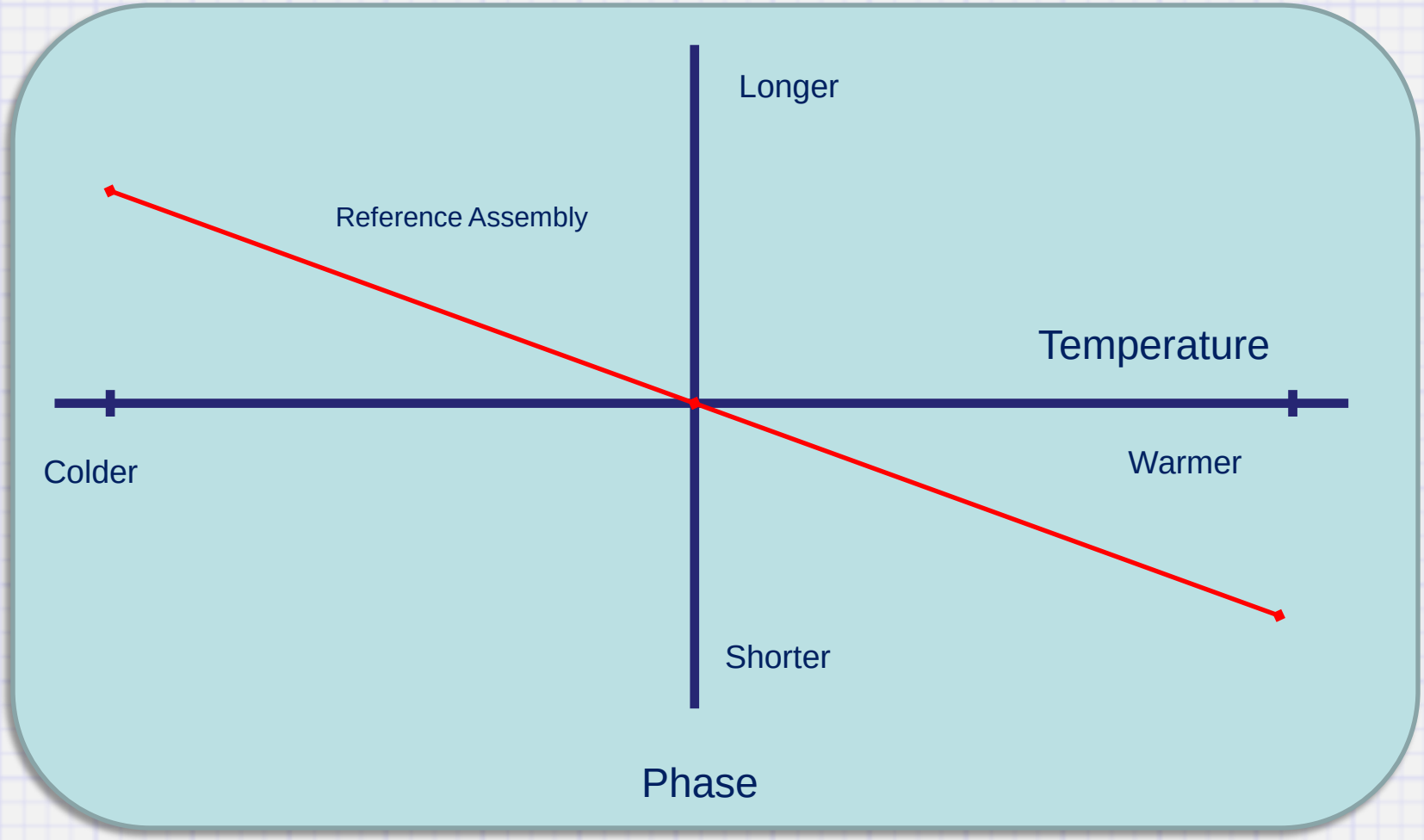
$$\boldsymbol{Electrical\ length\ (deg) = \frac{360\ f_o\ physical\ length}{C\ V_p}}$$

Example:

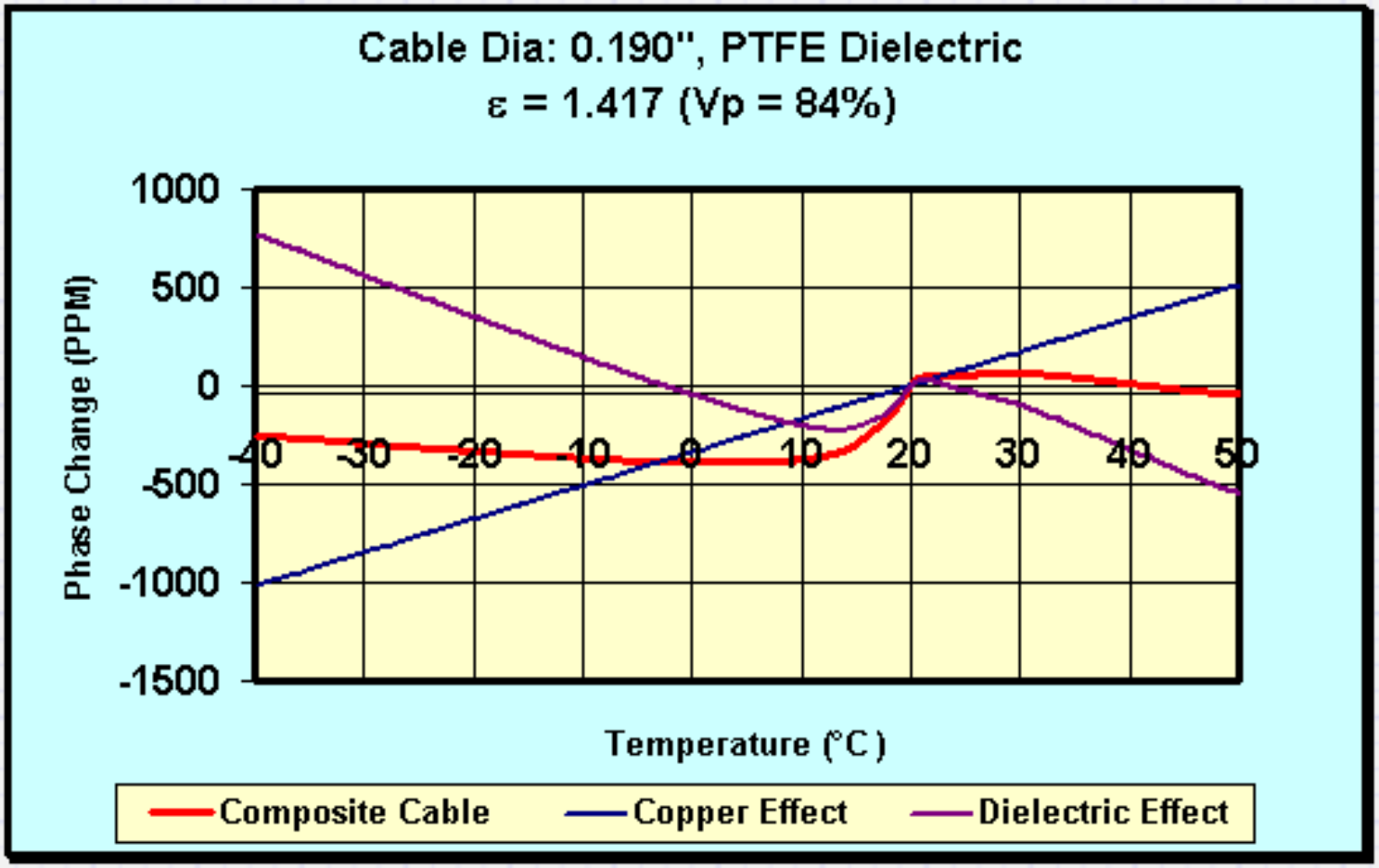
- Operating frequency = 10.0 GHz
- Physical length = 3.0 meters
- Propagation velocity = 83% of the speed of light

- Electrical length = 43,392 degrees = 120.5 λ
- 1 degree = 23 PPM

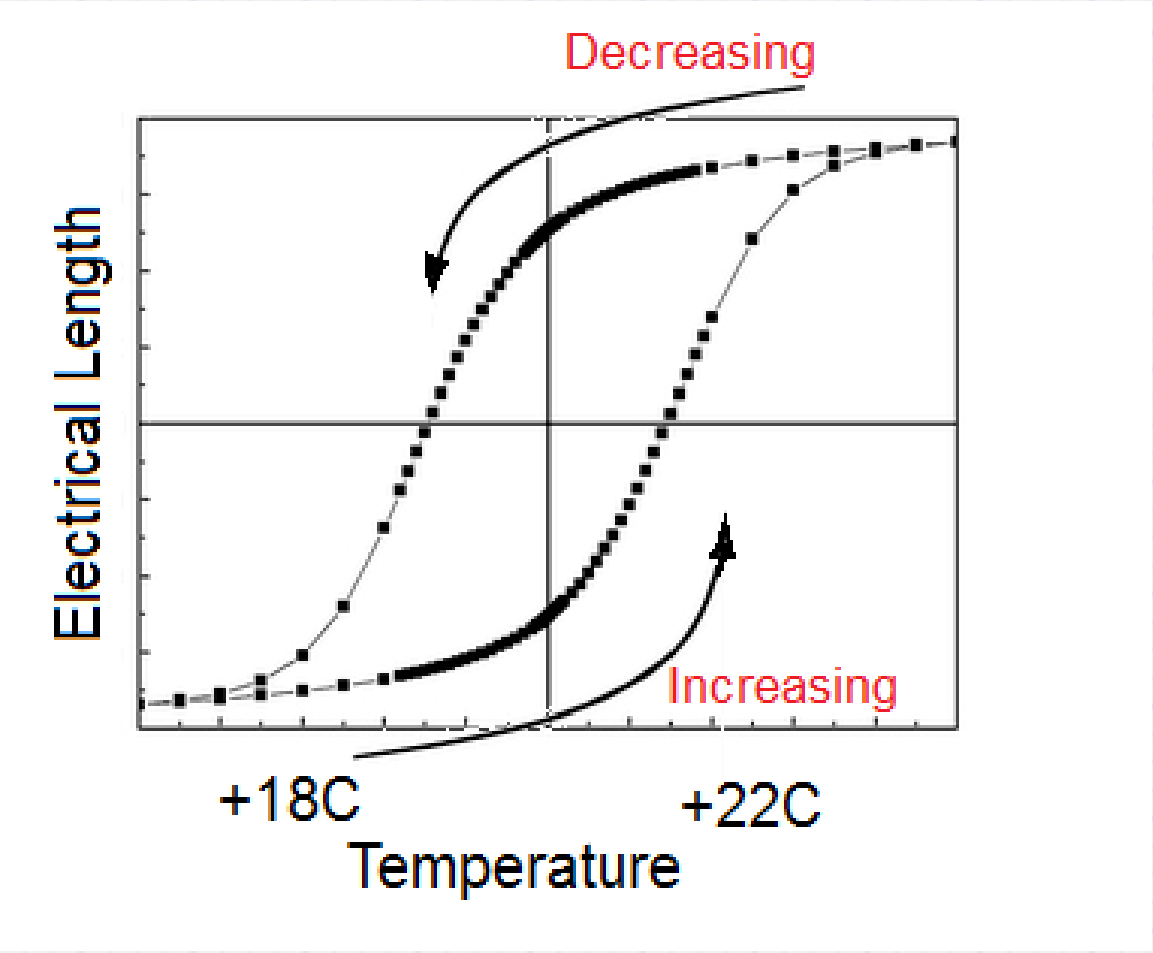
# Phase Change vs. Temperature



# Inverse Electrical Length Temperature Coefficient...

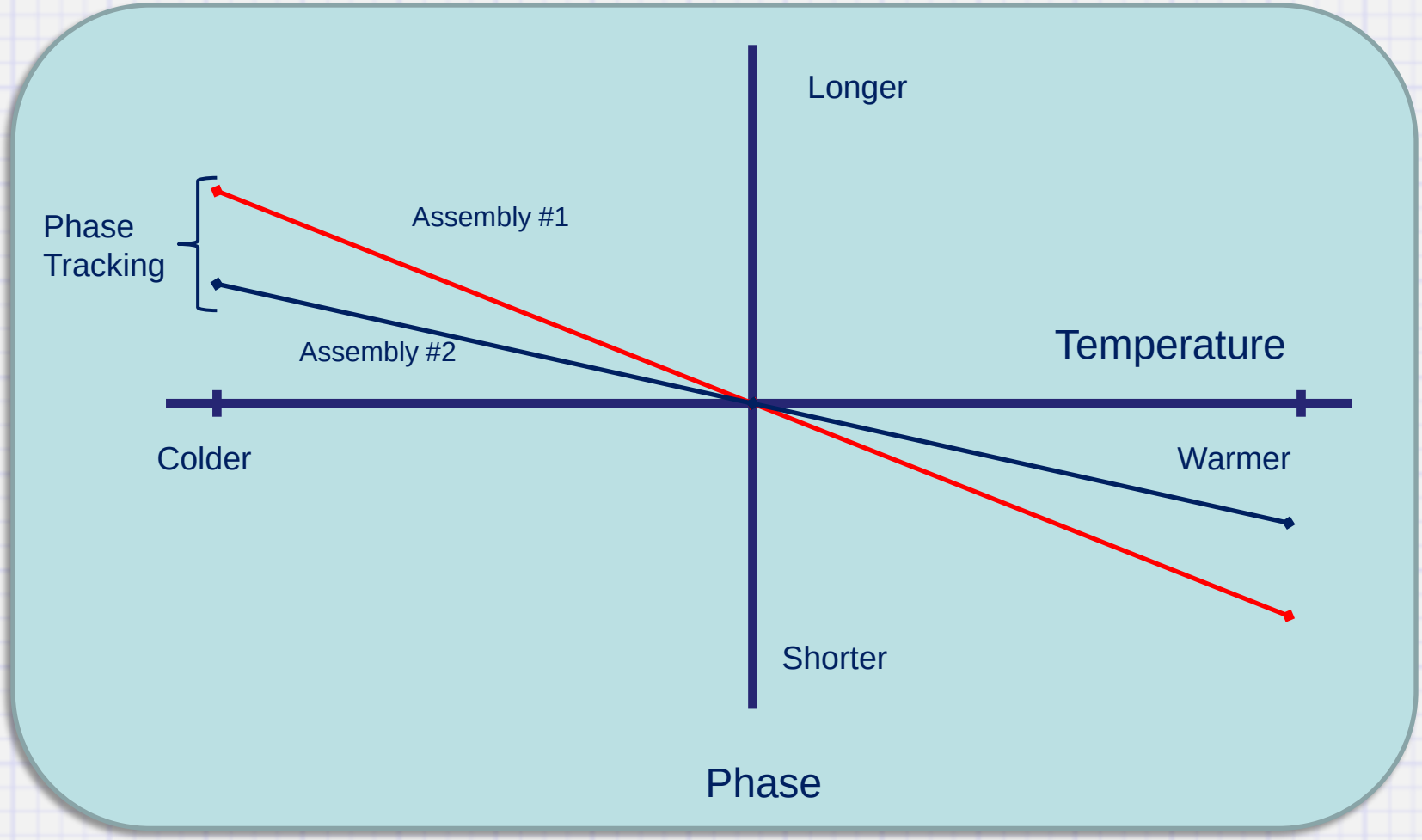


# Phase Hysterisis vs. Temperature

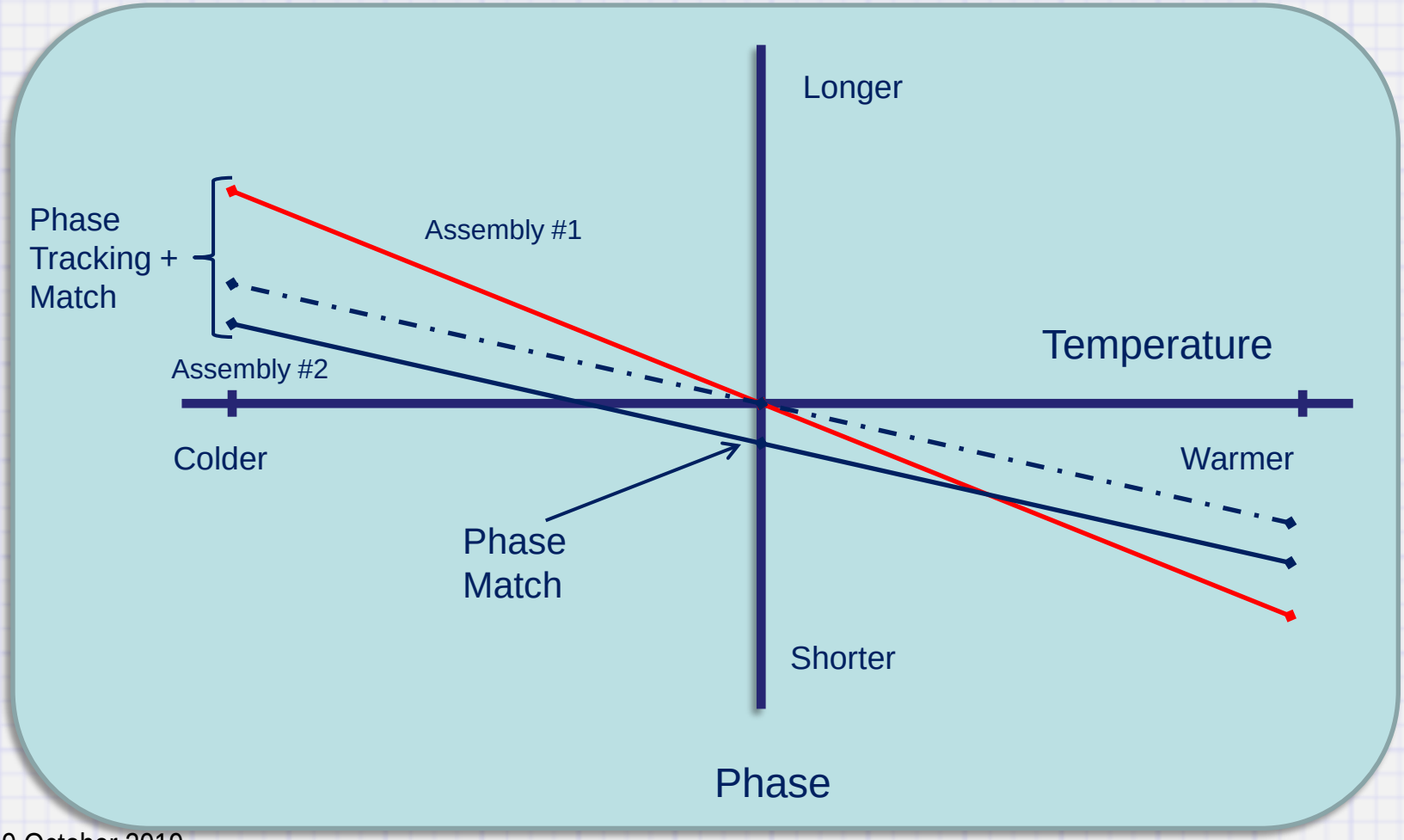


# Phase Change vs. Temperature

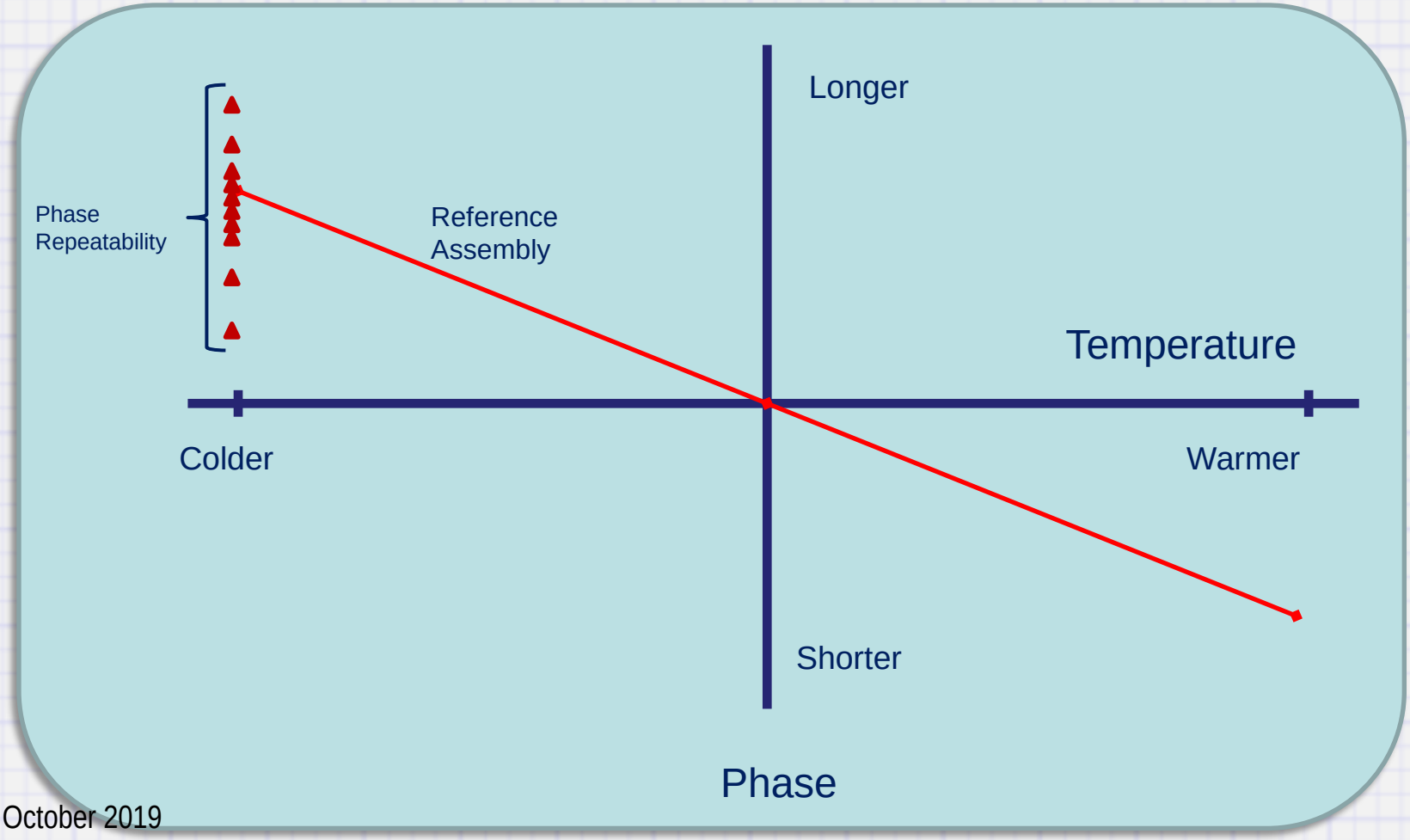
(phase matched assemblies)



# Phase Change vs. Temperature
(non-phase matched assemblies)

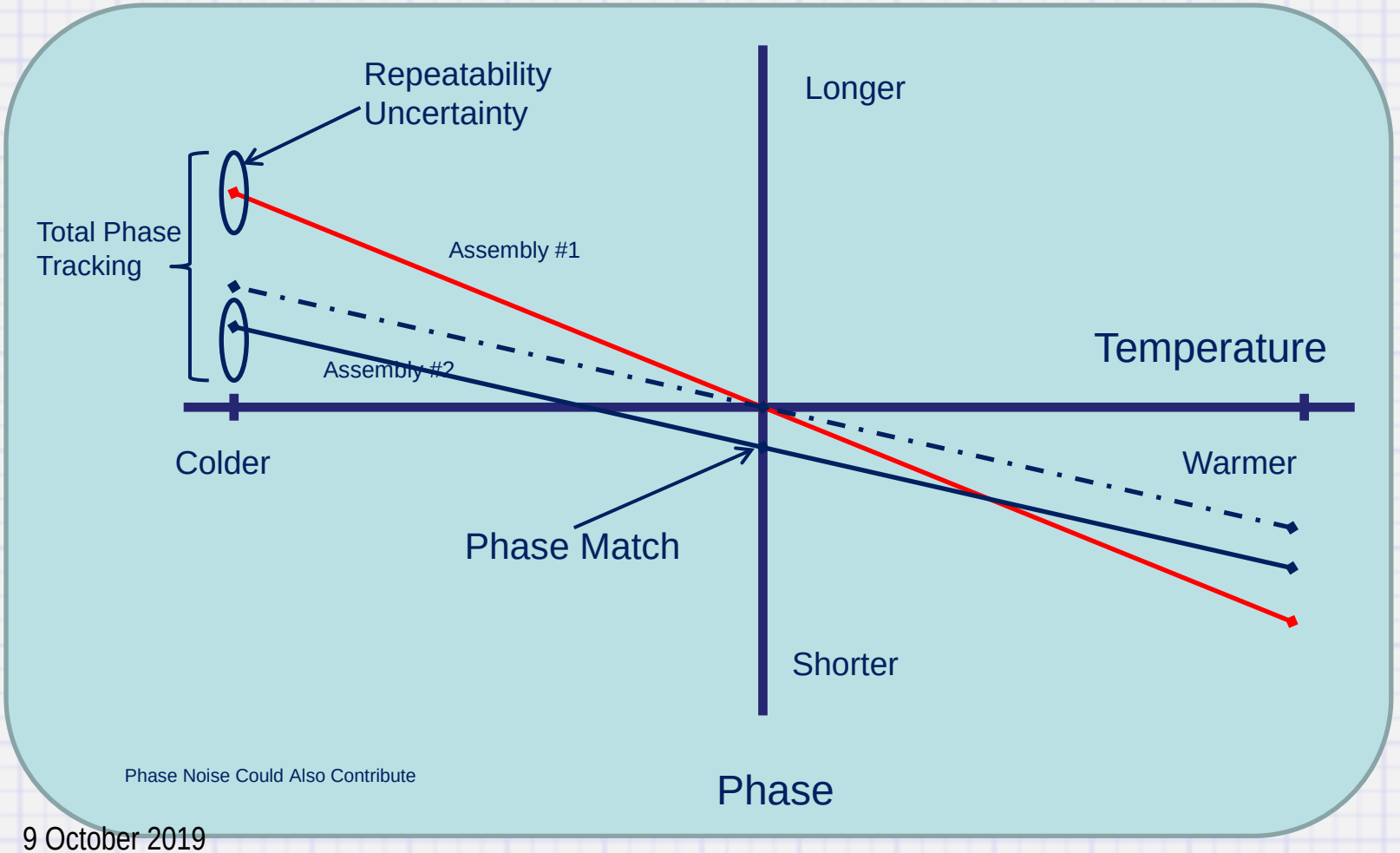


# Phase Repeatability vs. Temperature

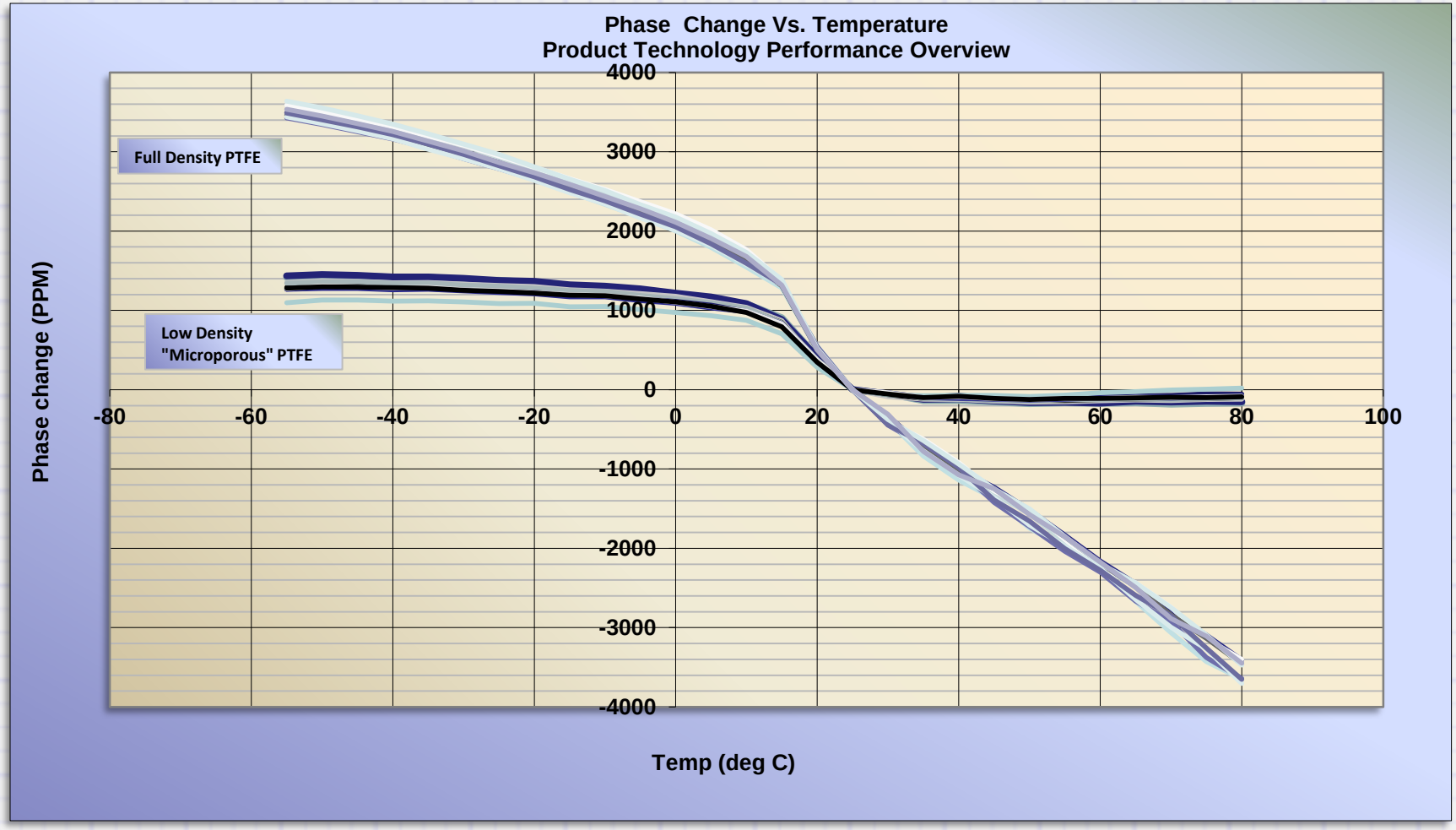


# Practical Phase Tracking vs. Temperature

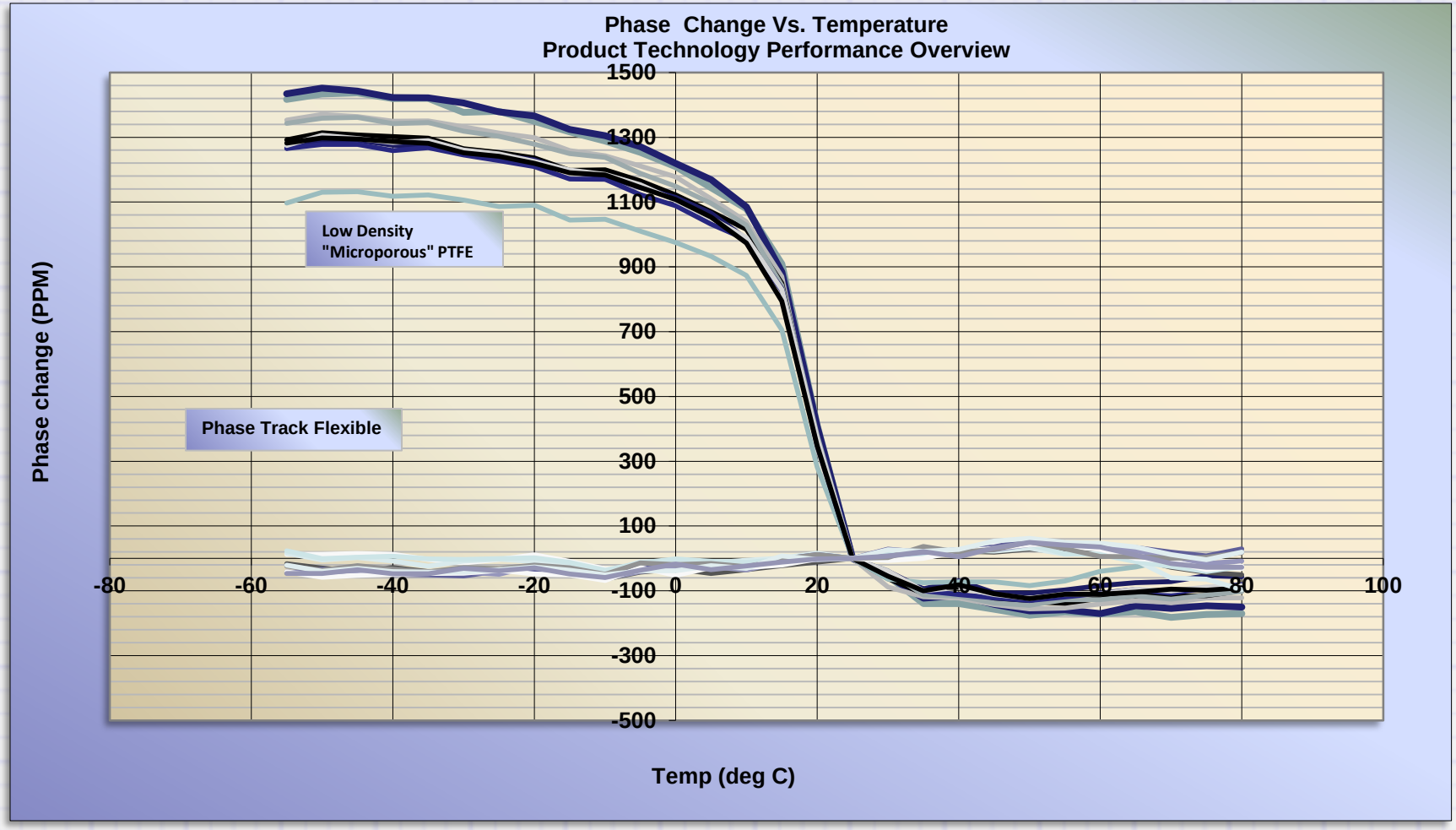
(Includes phase match + tracking + repeatability)



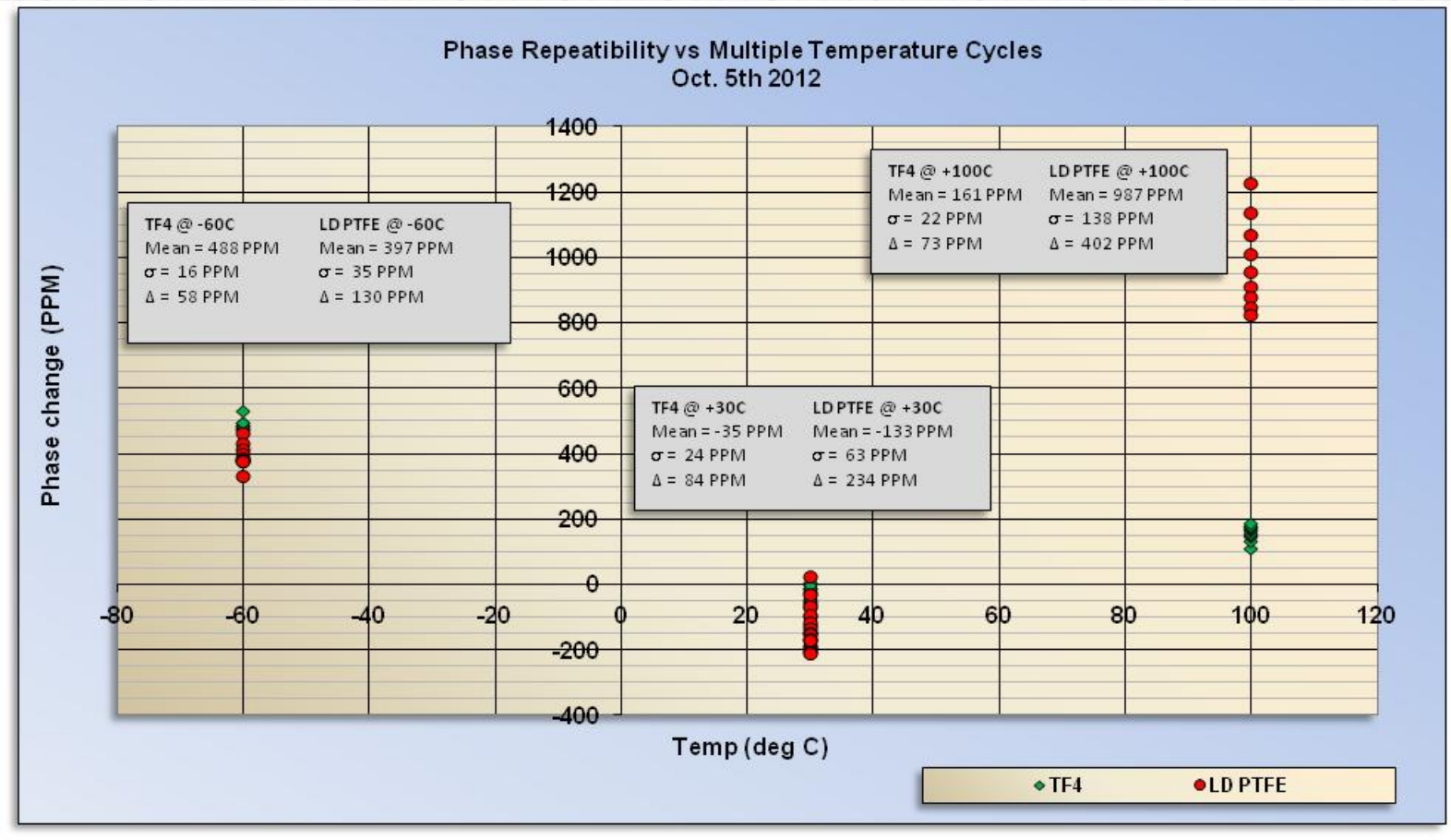
# Electrical Length Comparison of Dielectric Technologies



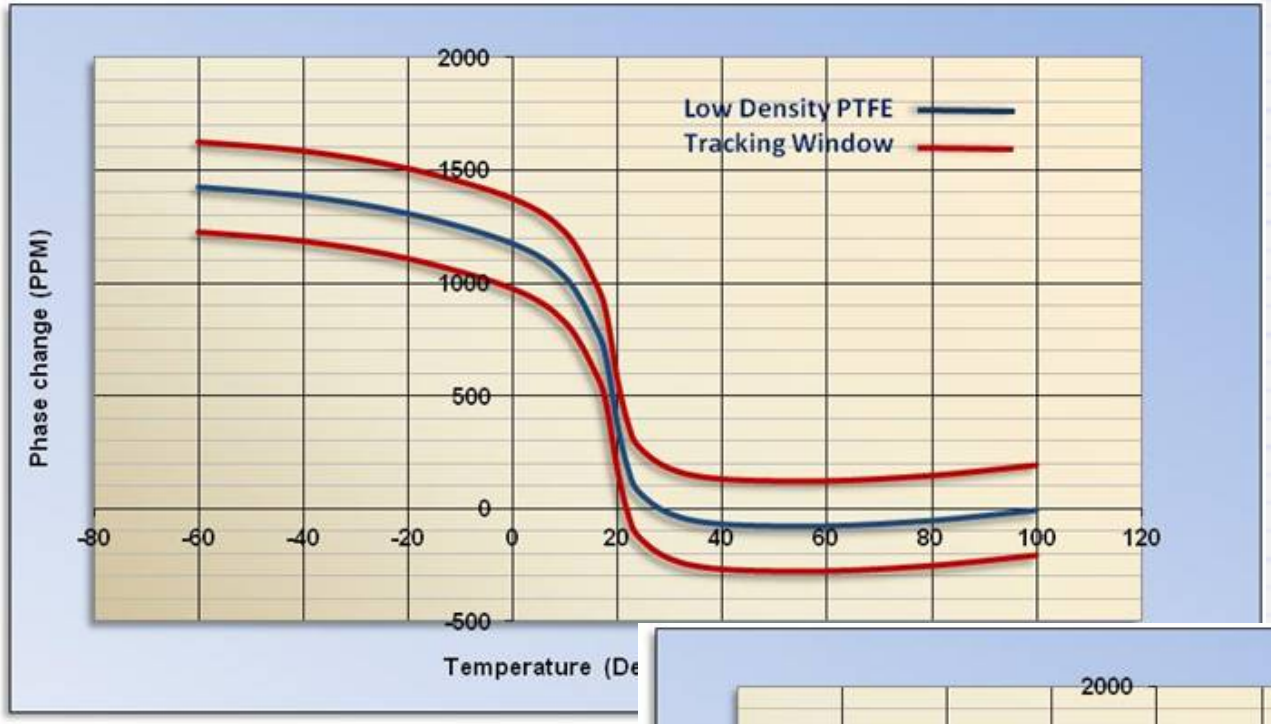
# Electrical Length Comparison of Dielectric Technologies

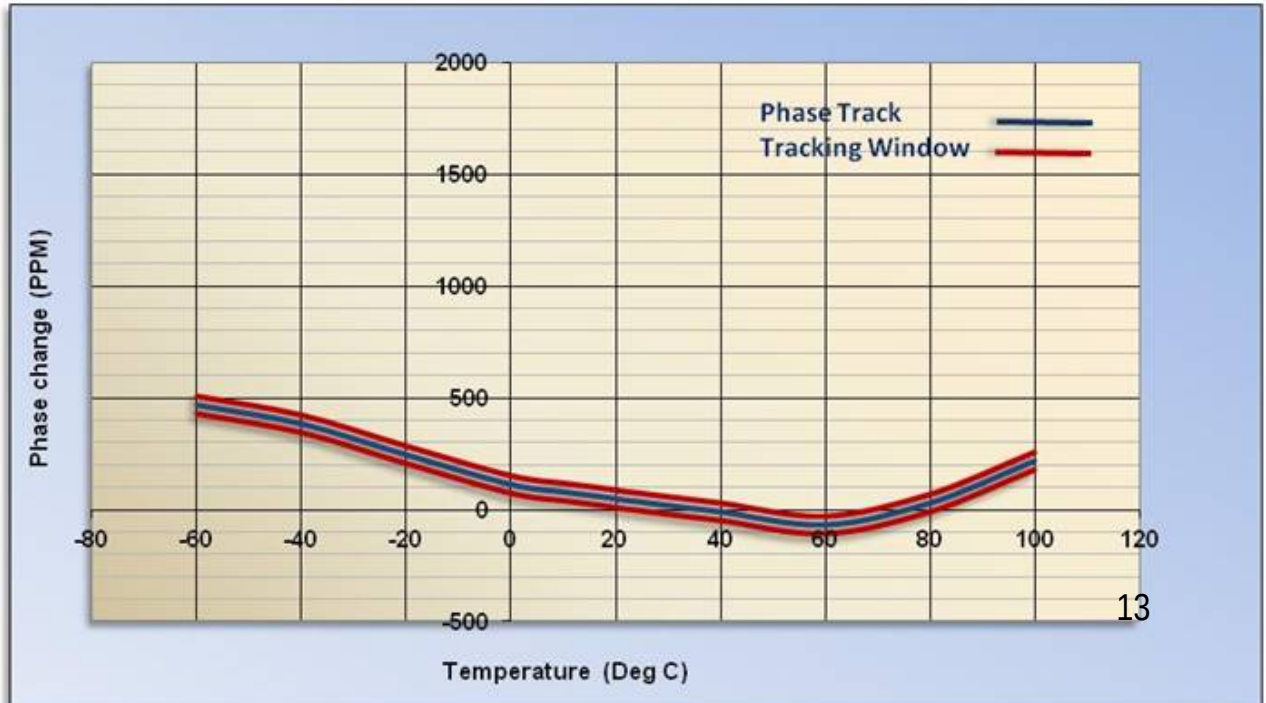


# Phase Repeatability

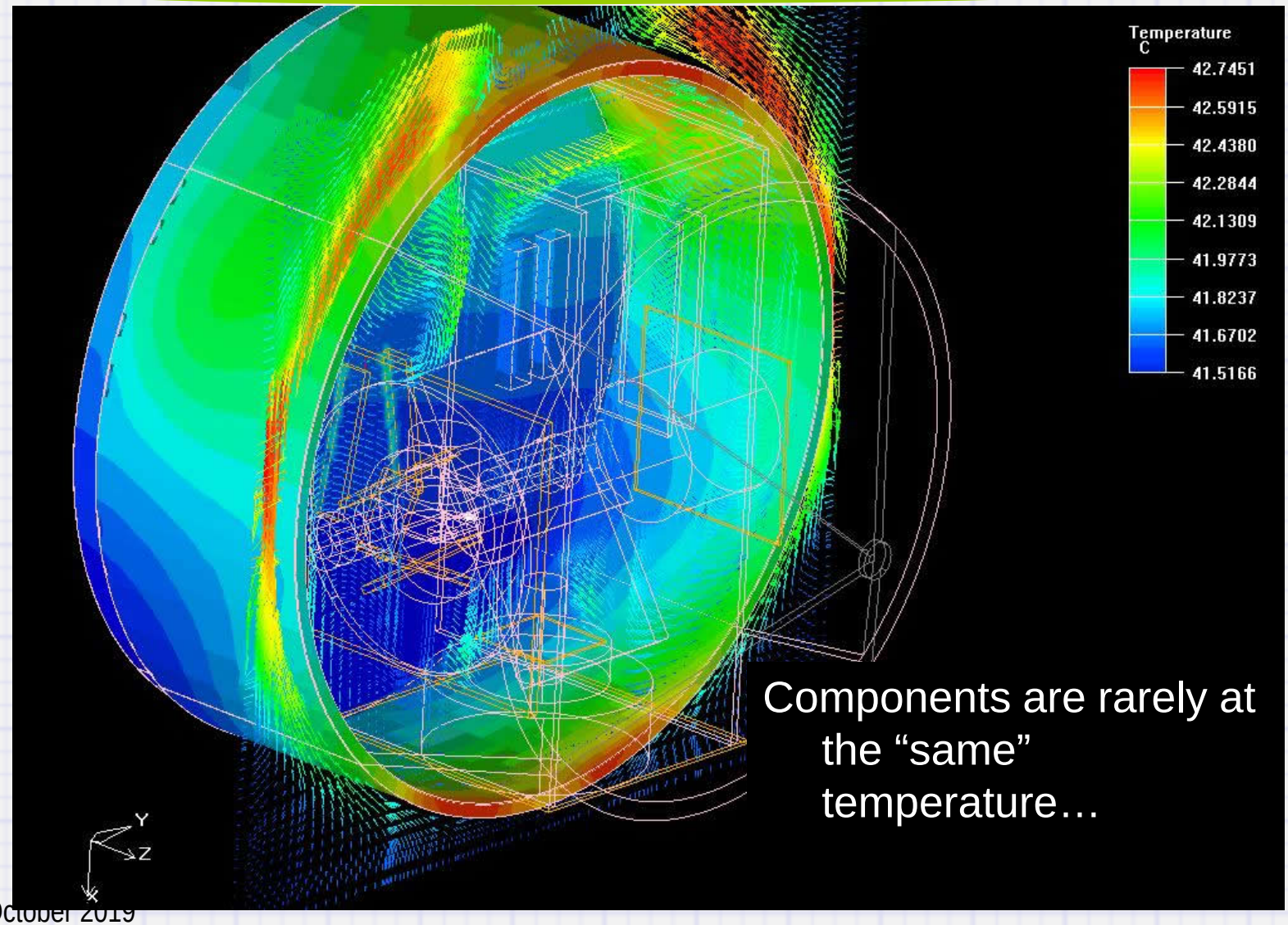


# Phase Tracking:



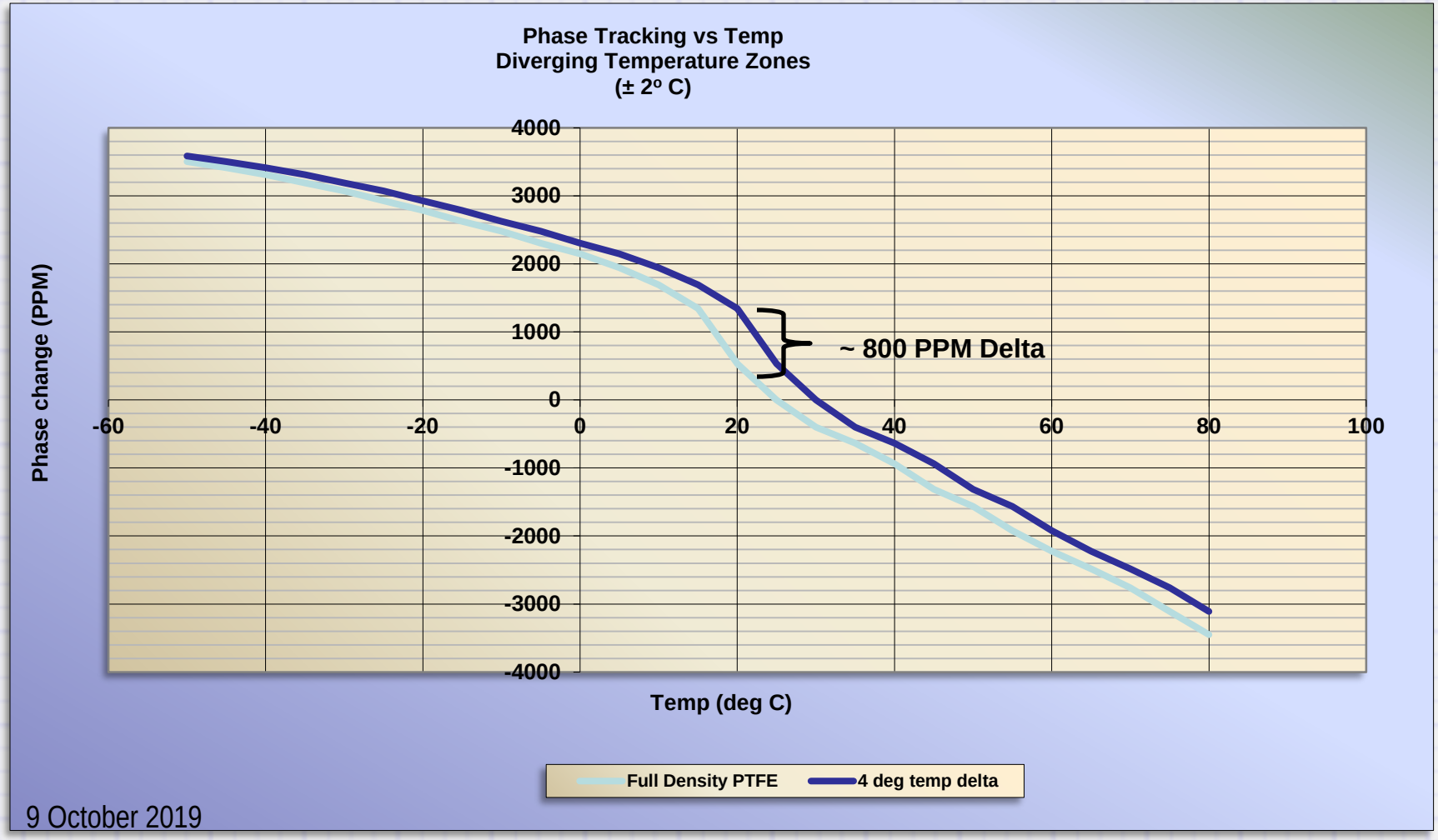
# Divergent Temperature Zones




Components are rarely at the “same” temperature…

# Two Phase Matched Cables; 4º C Difference in Temperature

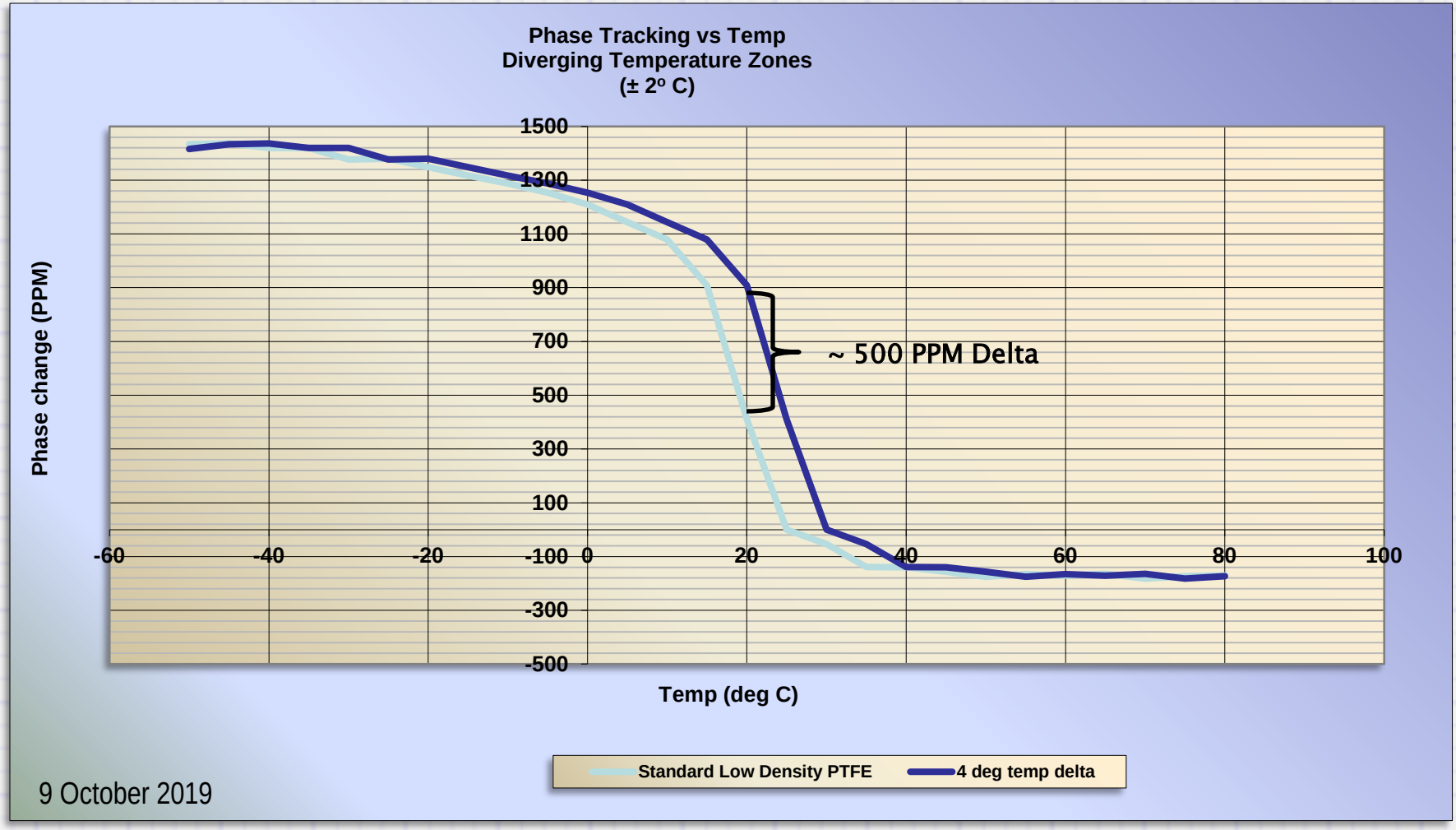
(Standard Full Density “Solid” PTFE)




9 October 2019

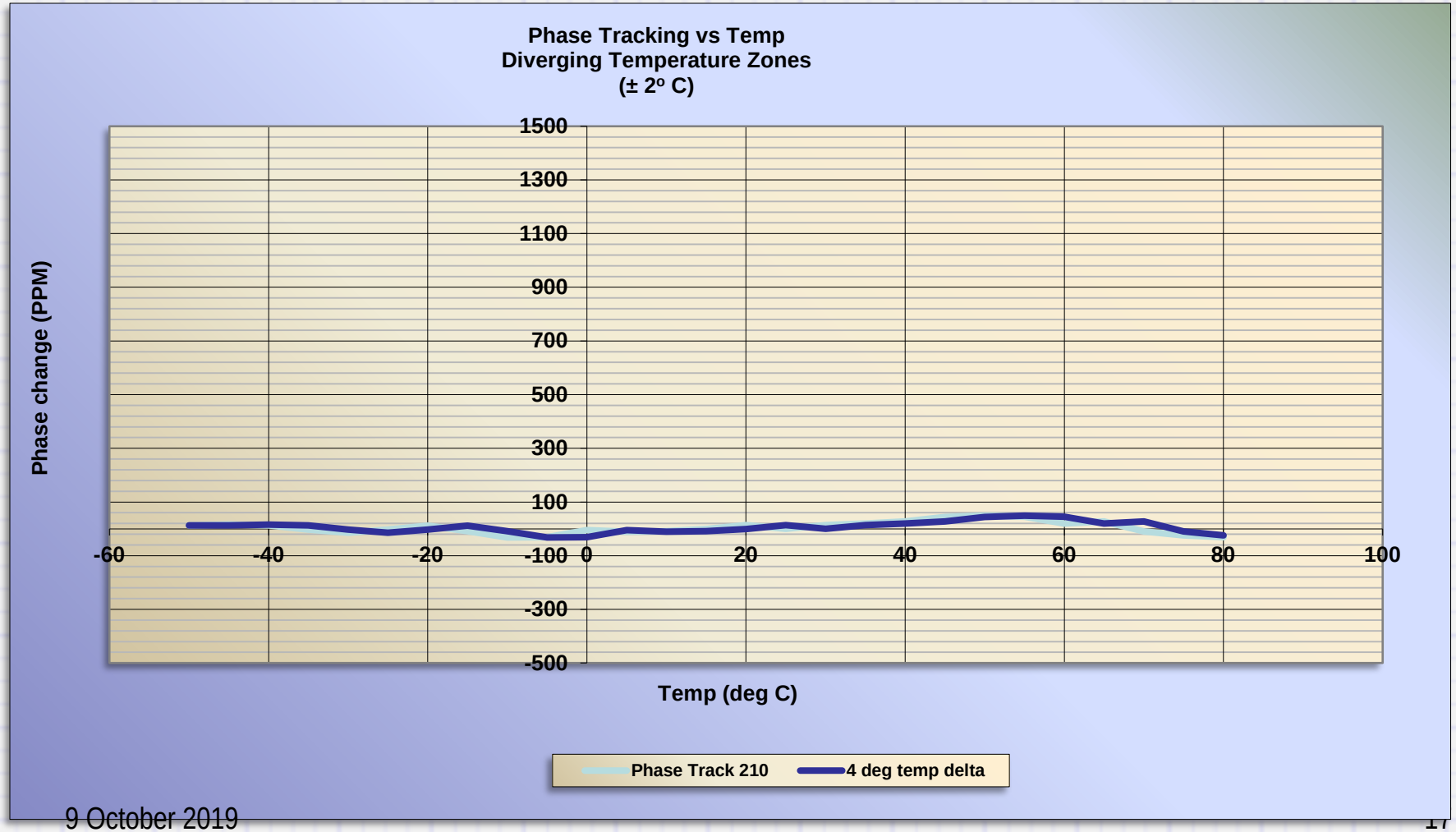
# Two Phase Matched Cables; 4º C Difference in Temperature

(Standard Low Density “Microporous” PTFE)



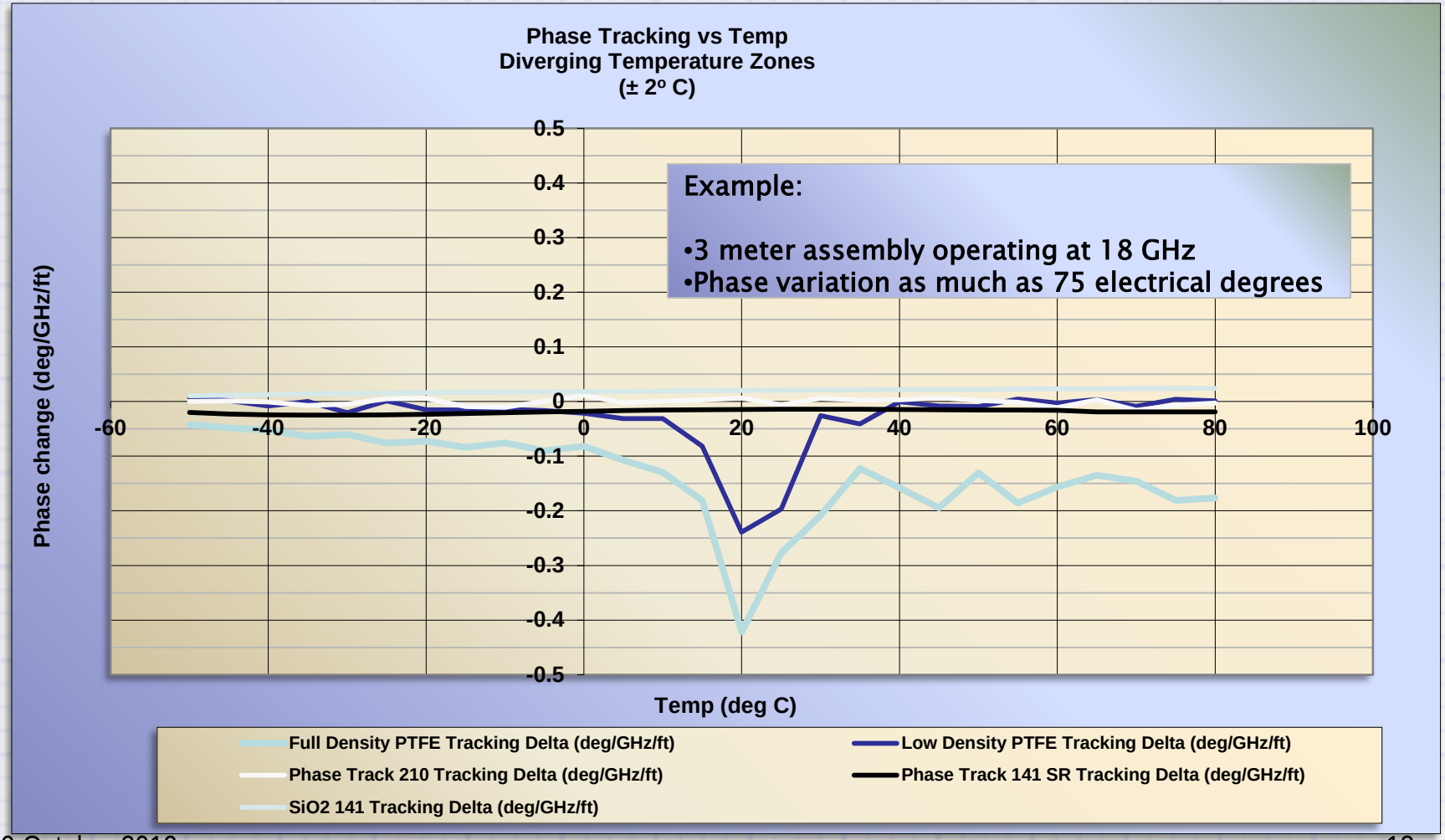
# Two Phase Matched Cables; 4º C Difference in Temperature

(Phase Track™ 210)

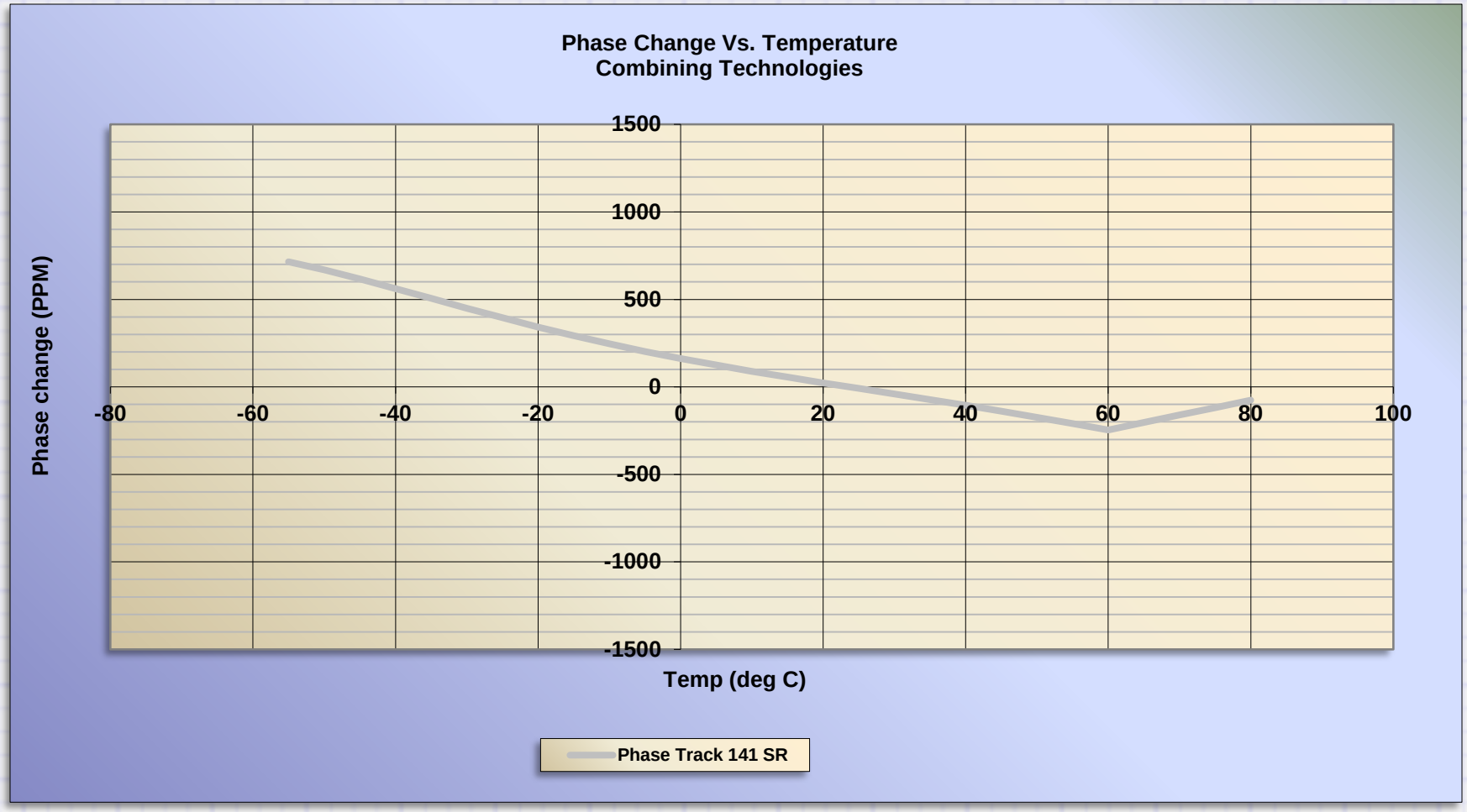


# Two Phase Matched Cables; 4º C Difference in Temperature

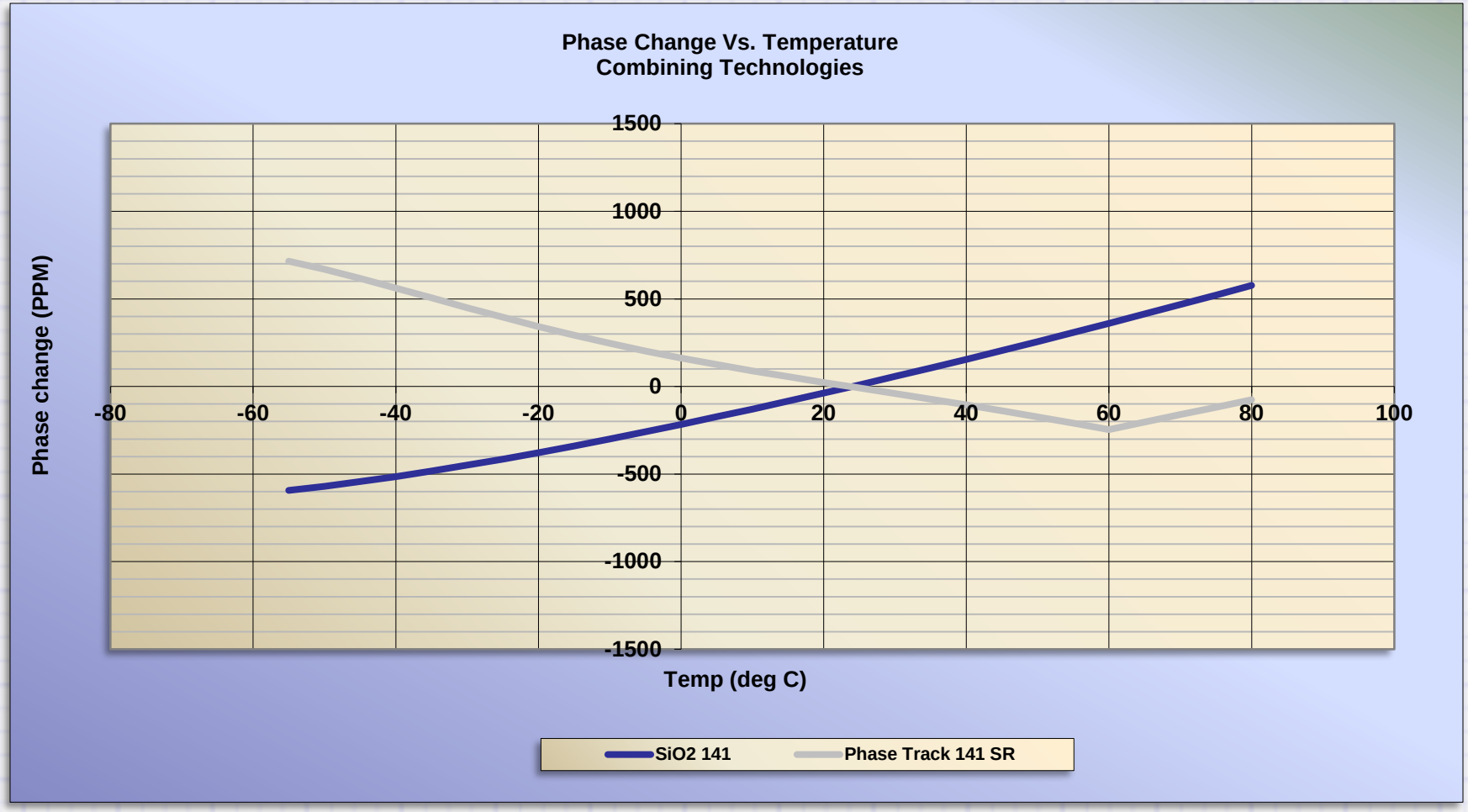
(Comparison of five dielectric technologies)



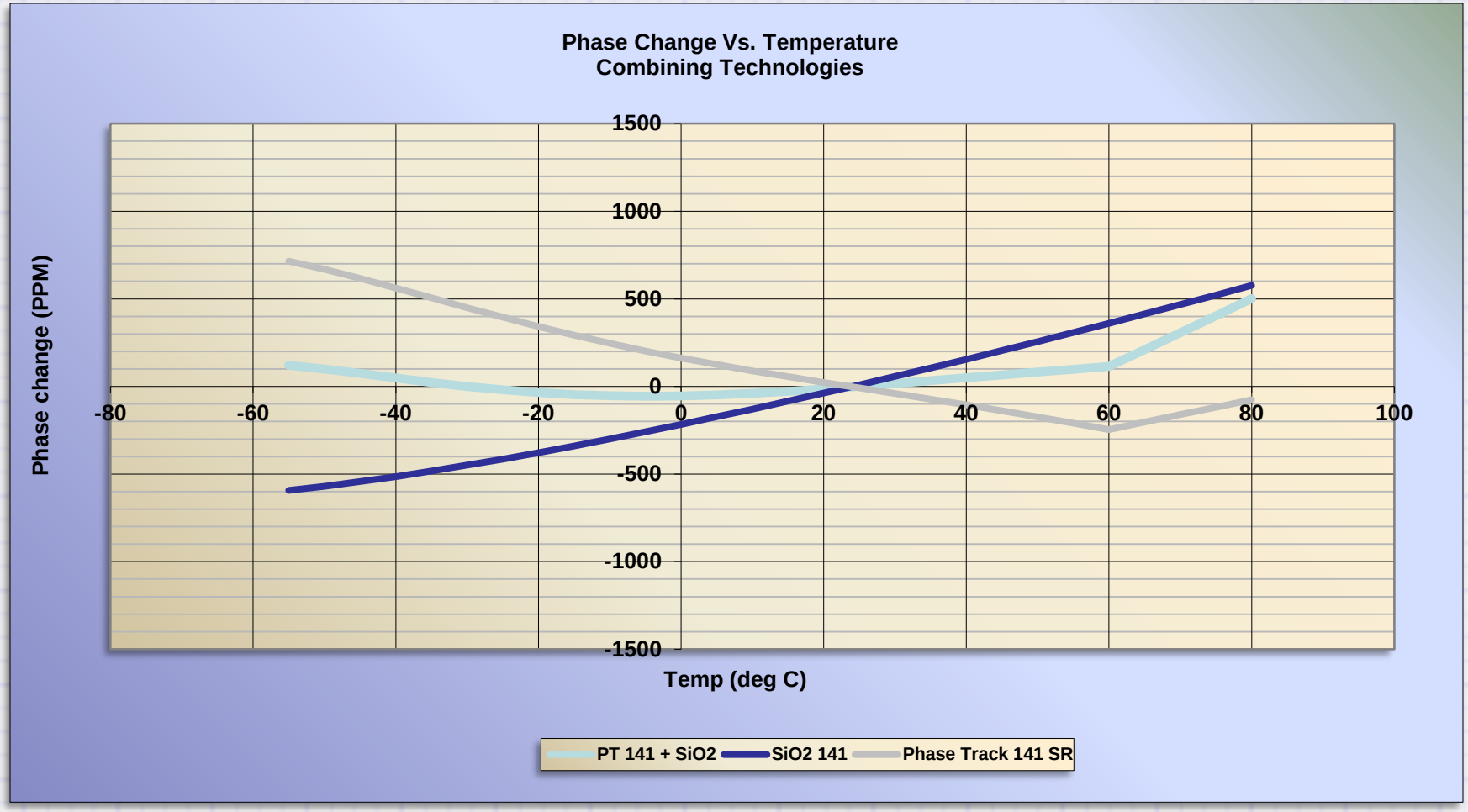
# Combining Technologies



# Combining Technologies



# Combining Technologies



# In Conclusion:

- Metal and plastic affects have opposite thermal coefficients of electrical length and can be balanced
- Practical systems often require much more than an initial phase match; they need to match at all temperatures
- Minor thermal variance can be the cause of larger than expected phase variations
- Multiple technologies are available to best fit the application; sometimes a combination of technologies can extend performance benefits

THANKS
FOR
LISTENING