

# Autonomous Reversing of Heavy Goods Vehicles

Amy Rimmer, Andrew Odhams, David Cebon

Cambridge University

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**Setting Future Standards HVTT12**

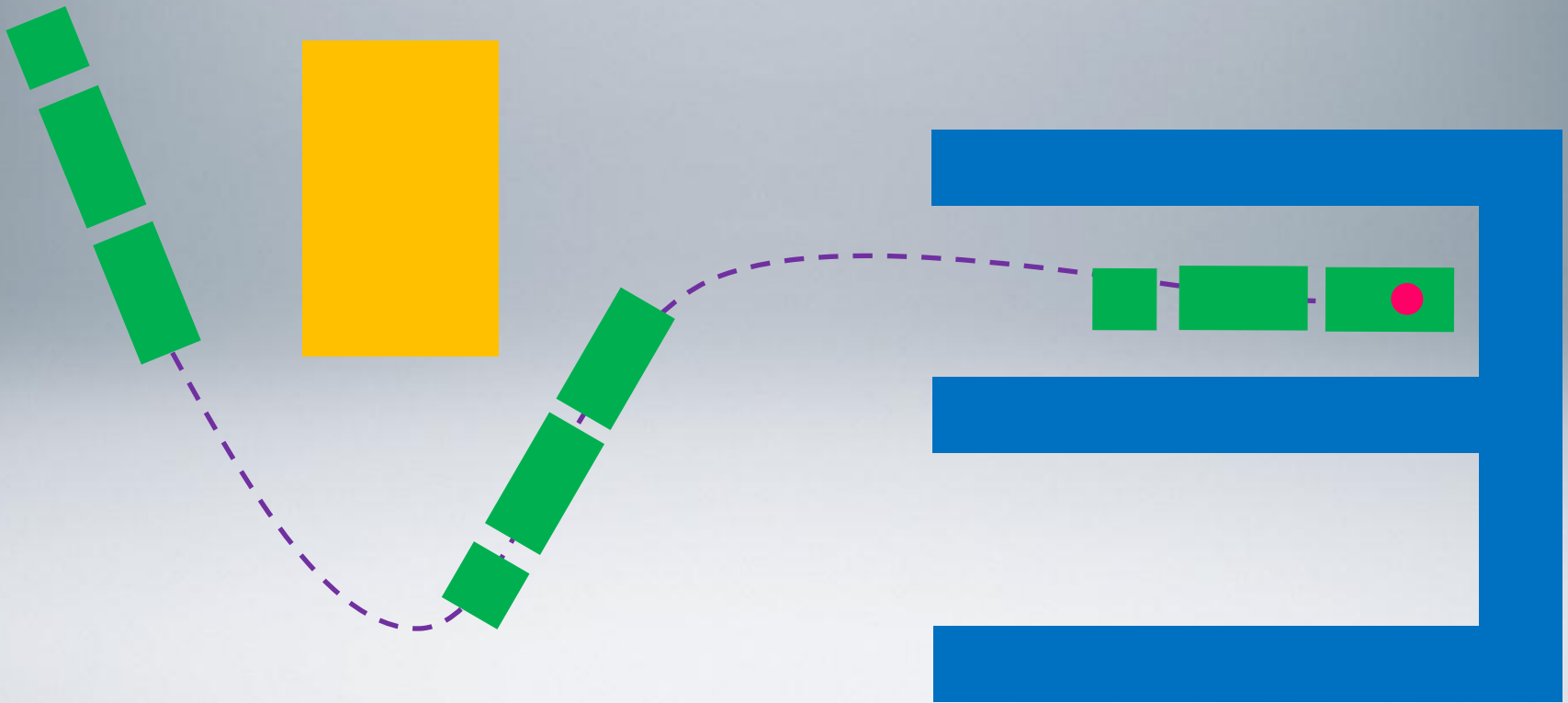
Stockholm, Sweden, 16-19 September 2012

# Presentation Outline

- Objectives and Background
- Modelling and Simulation
- Stability Analysis
- Conclusions and Future Work

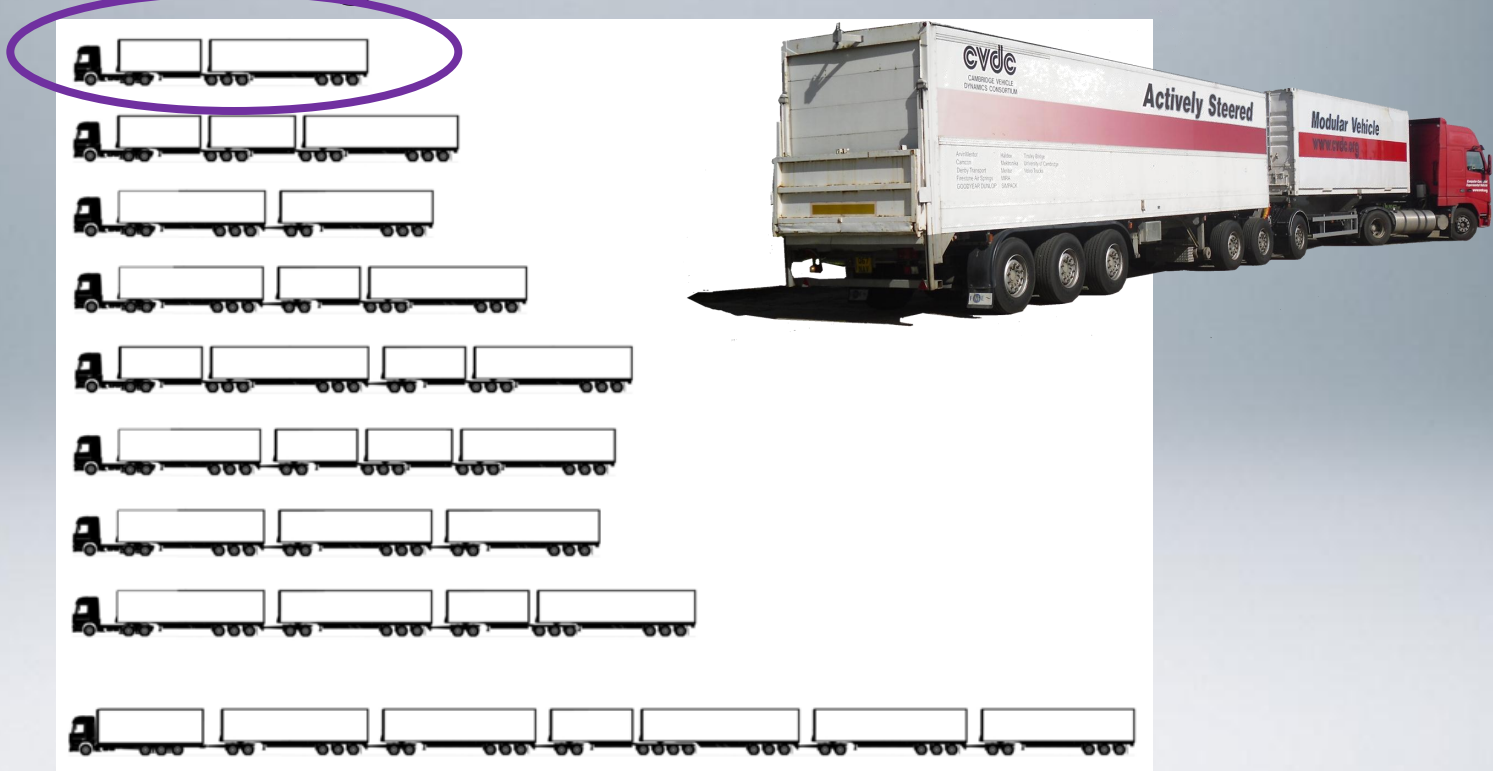
# Project Objective

Design an autonomous controller for reversing long combination vehicles



# Long Combination Vehicles (LCVs)

- What is a Long Combination Vehicle?



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- What is a Long Combination Vehicle?



- Why Long Combination Vehicles?

Performance Measure	Reduction due to LCVs
Freight movements and overall truck-kms	44%
Overall shipping costs	29%
Fuel consumption / greenhouse gas emissions	32%
Road wear	40%

# Long Combination Vehicles (LCVs)

- What is a Long Combination Vehicle?



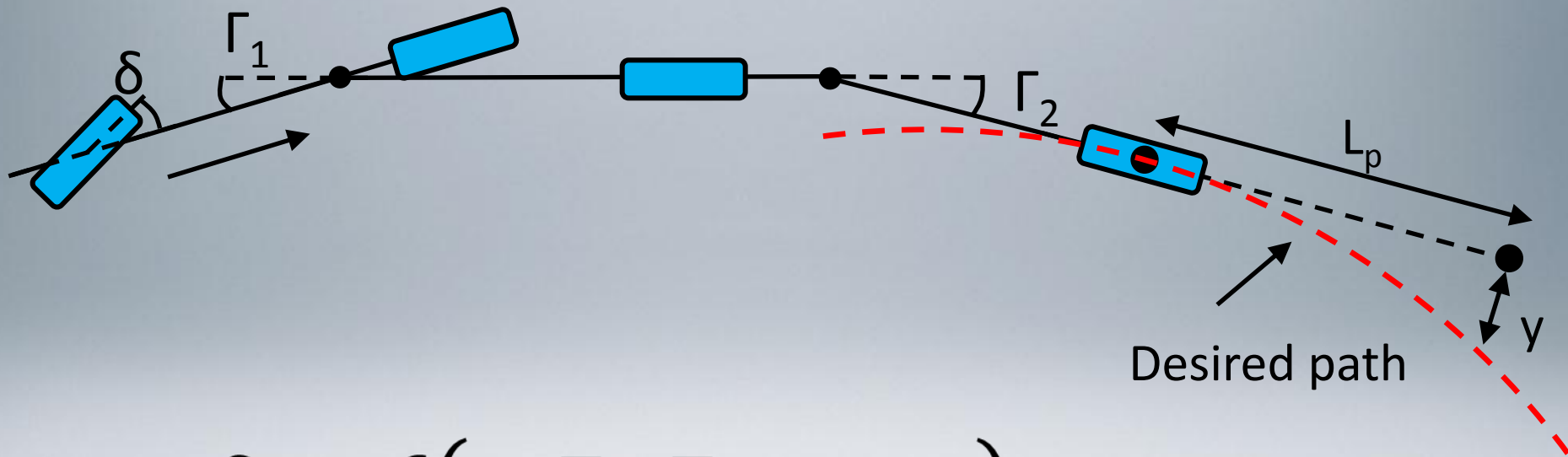
- Why Long Combination Vehicles?
- How are LCVs reversed now?

# Modelling

Tractor

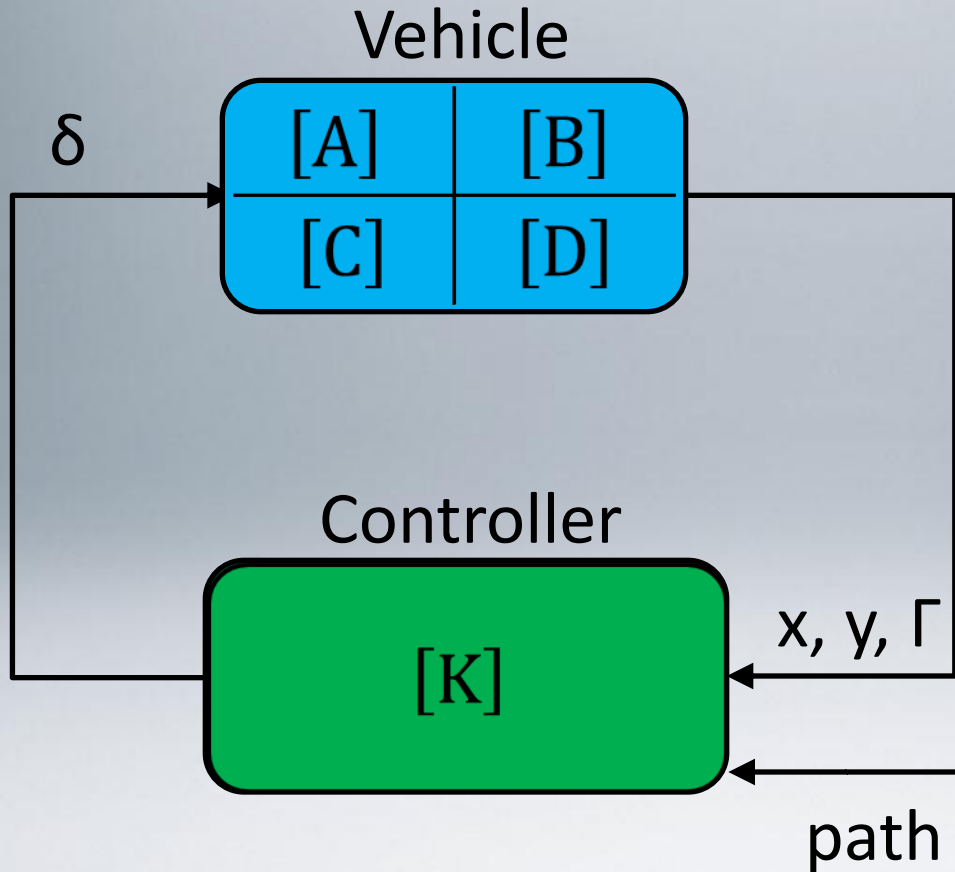
B-link trailer

Semi-trailer



$$\delta = f(y, \Gamma_1, \Gamma_2, L_p, K)$$

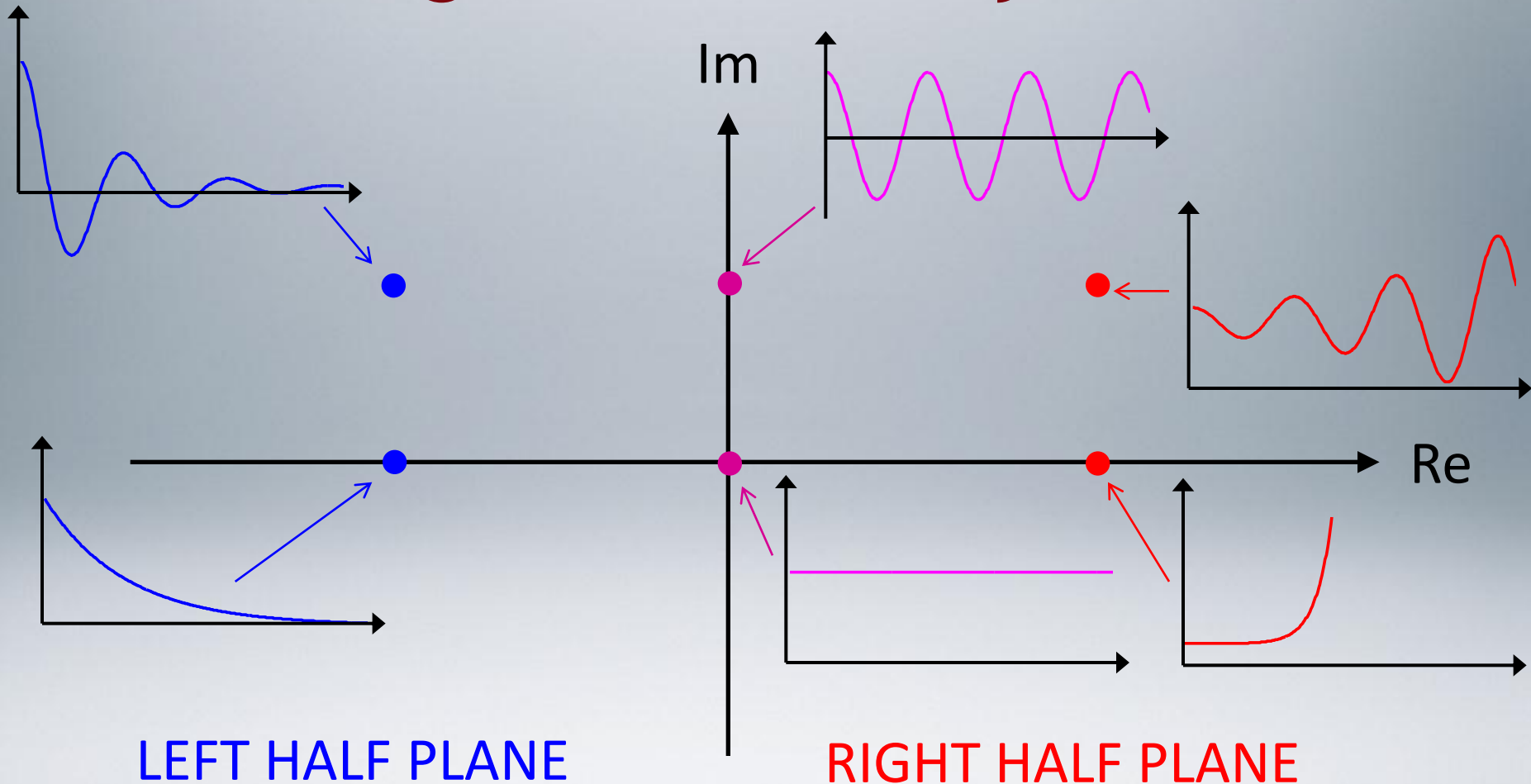
# Stability Analysis



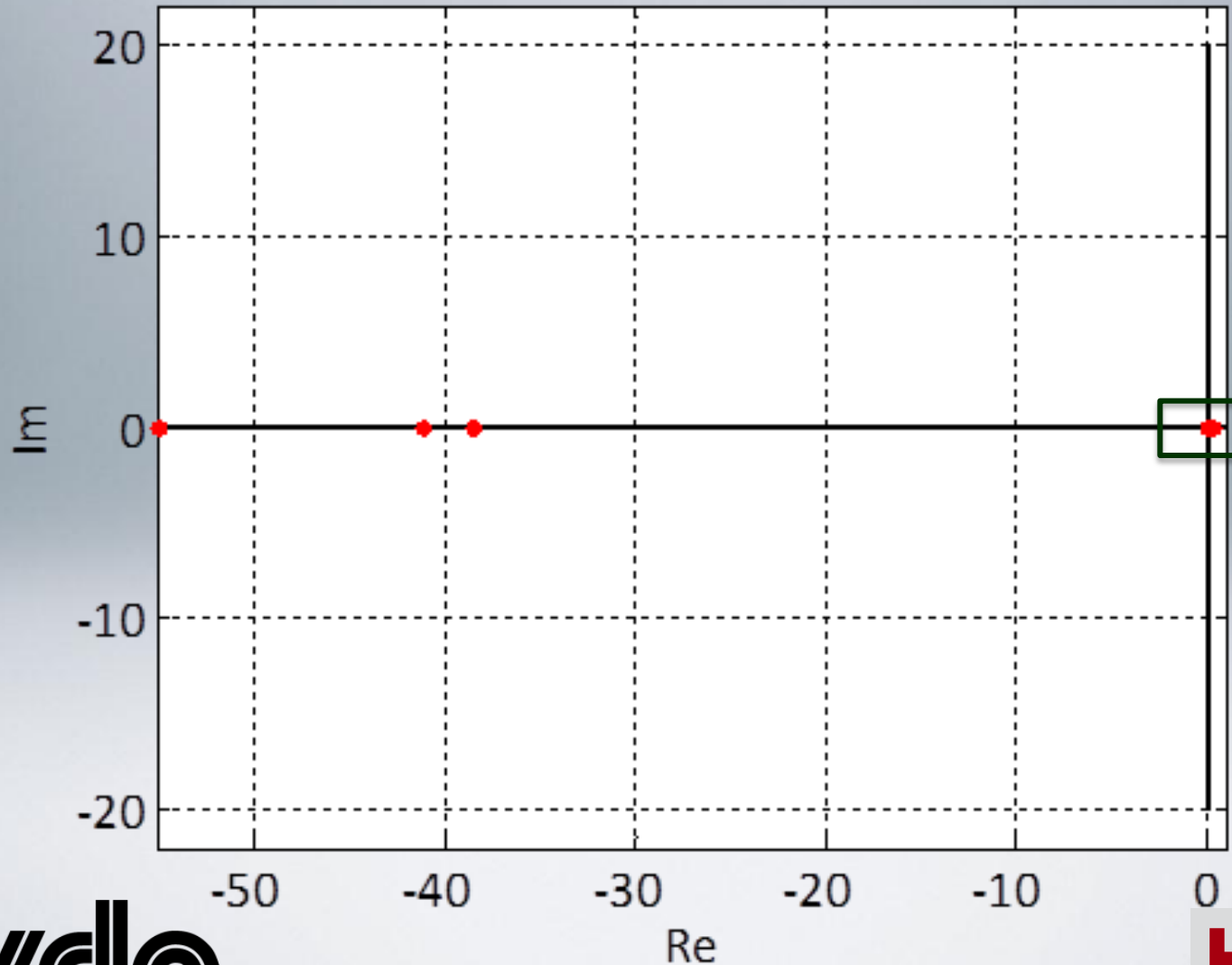
➔  $\dot{z} = Mz$



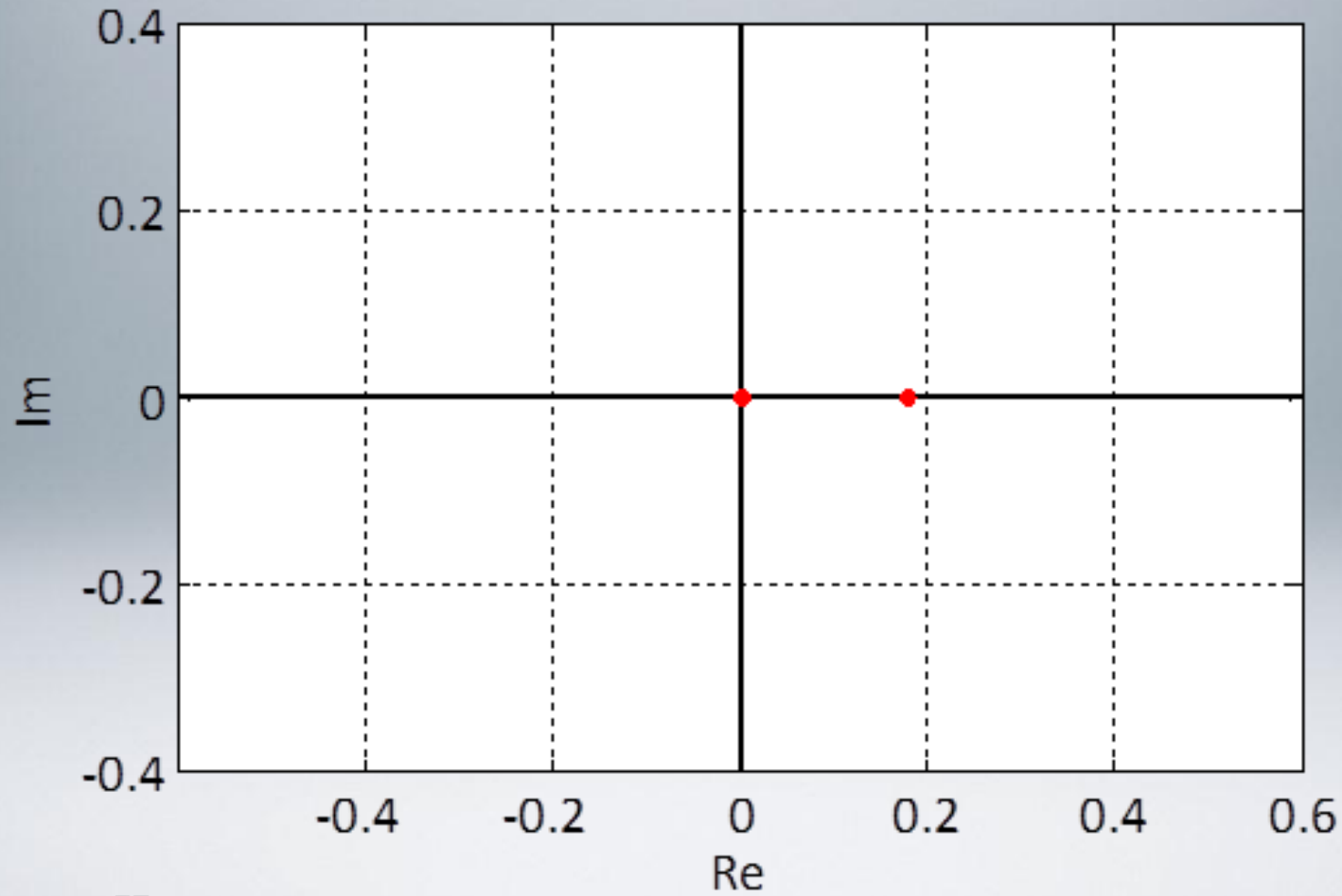
# Eigenvalue Analysis



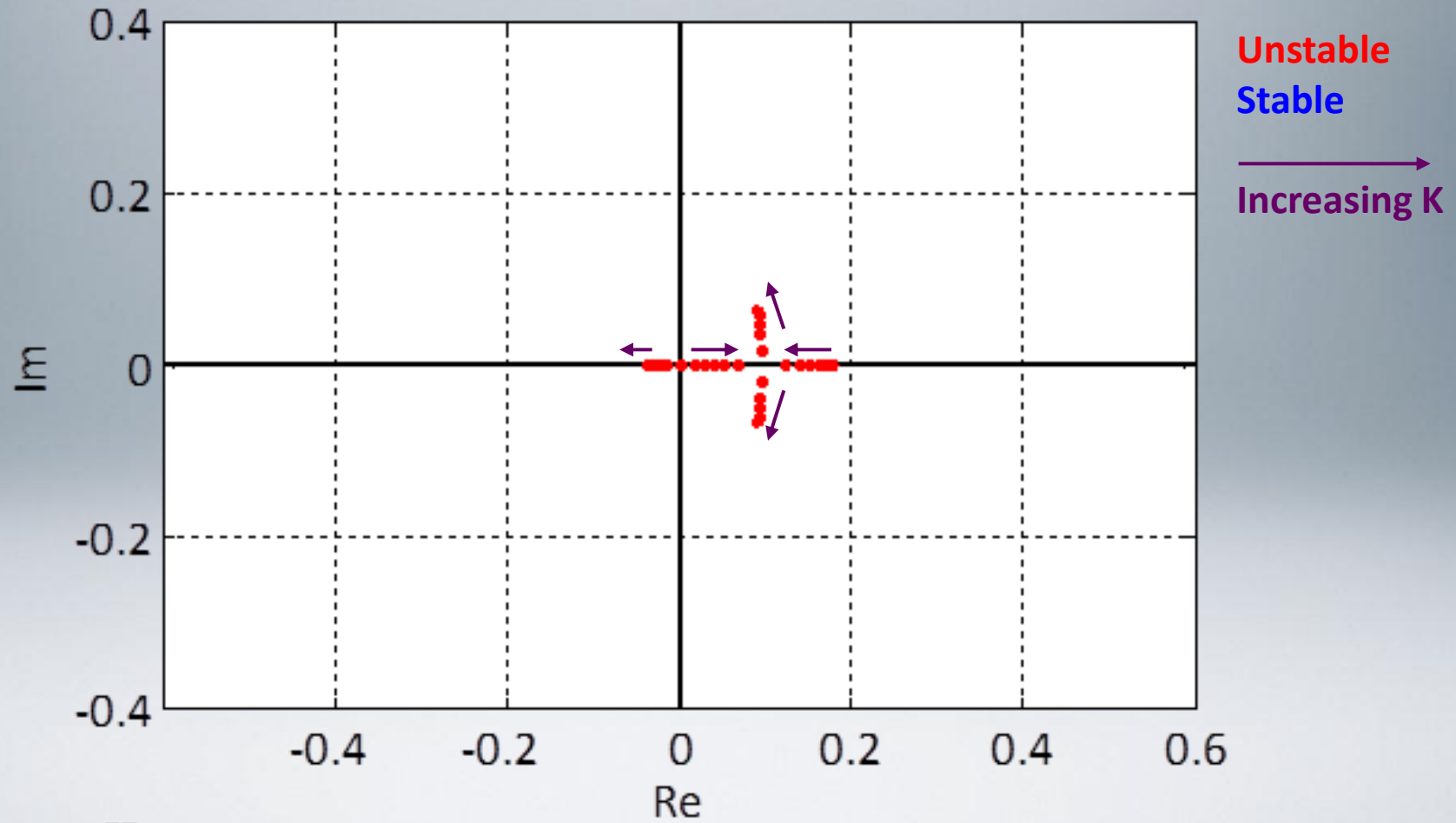
# Semi-Trailer: Root Locus



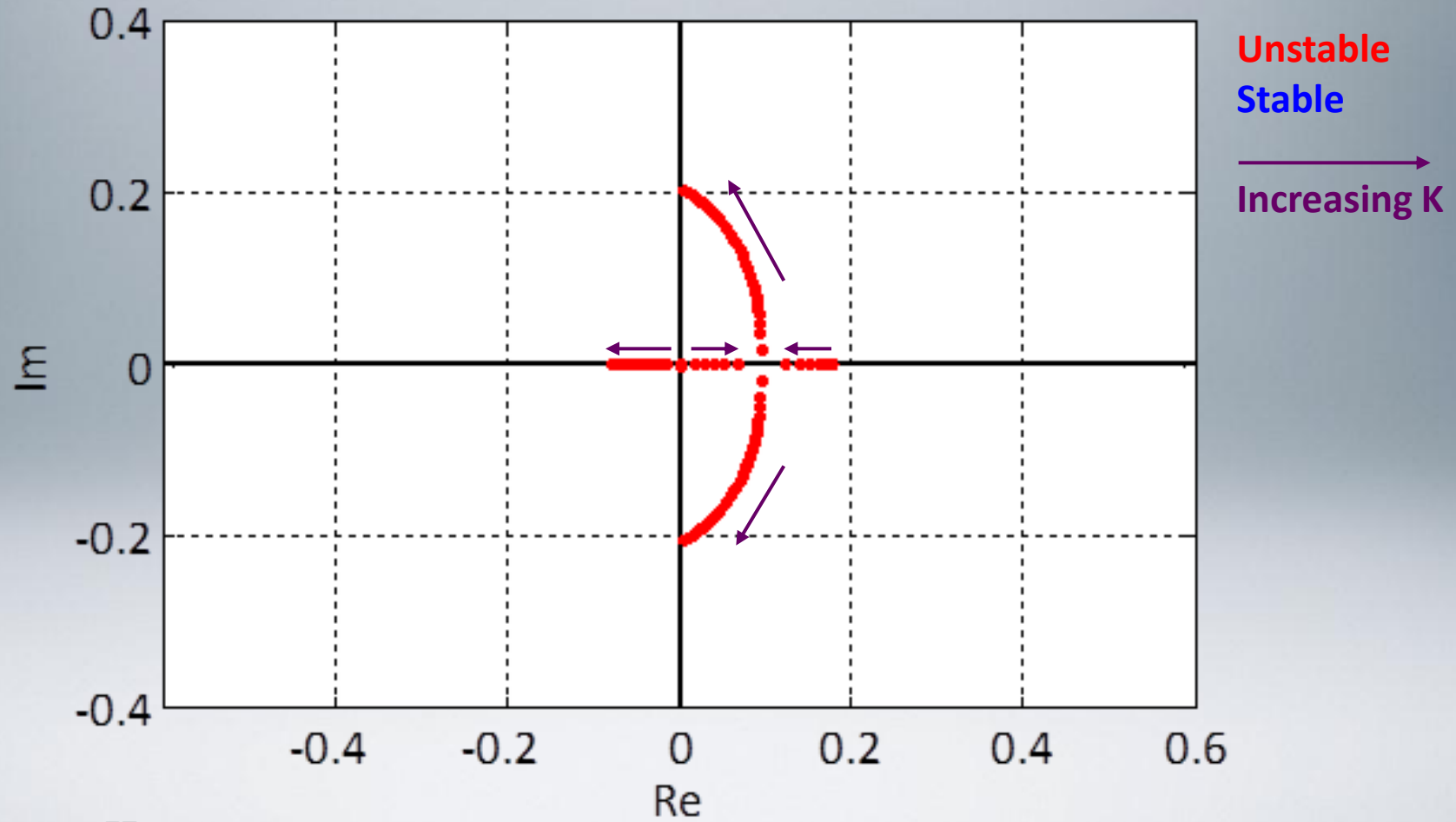
# Semi-Trailer: Root Locus



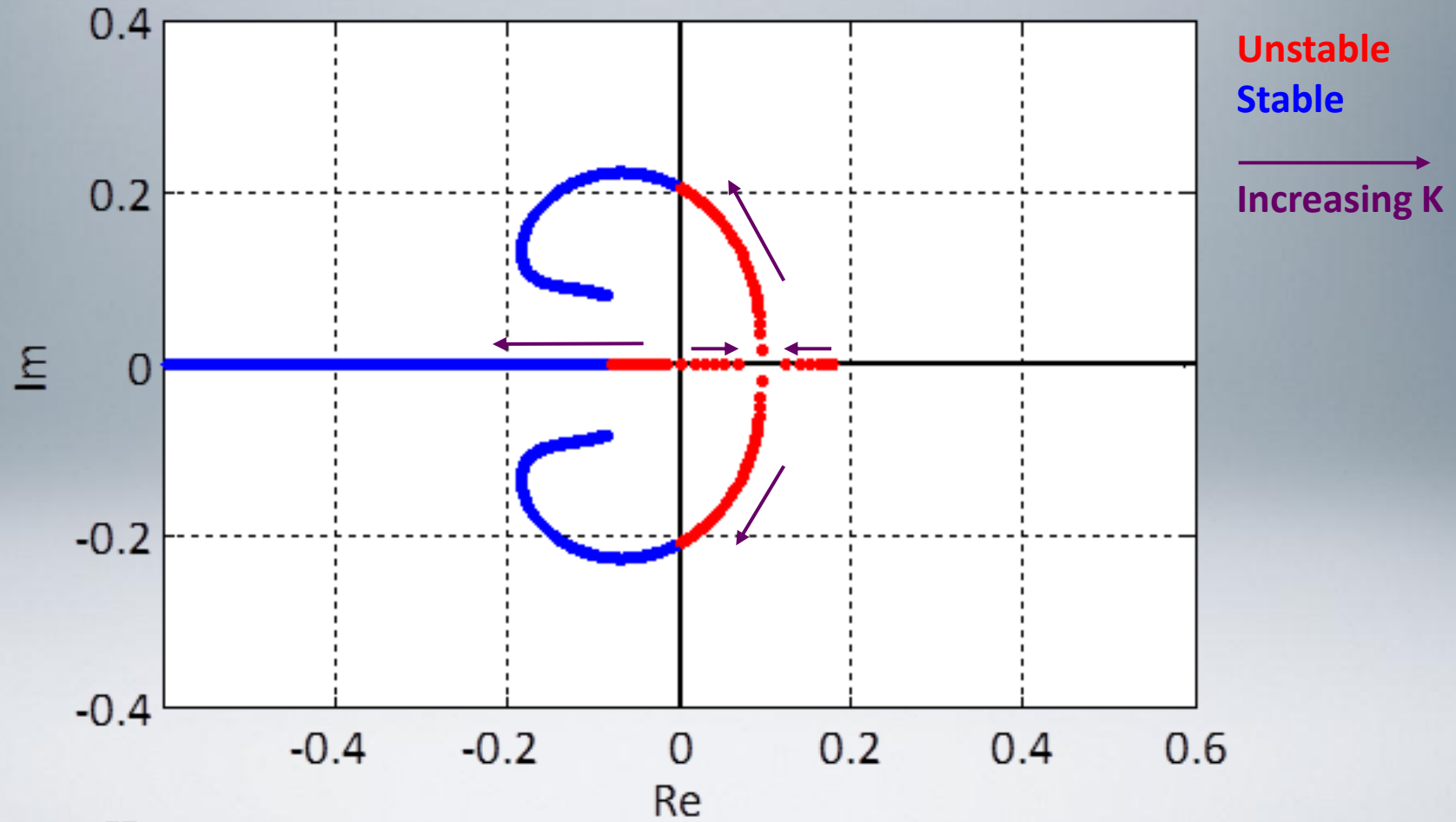
# Semi-Trailer: Root Locus



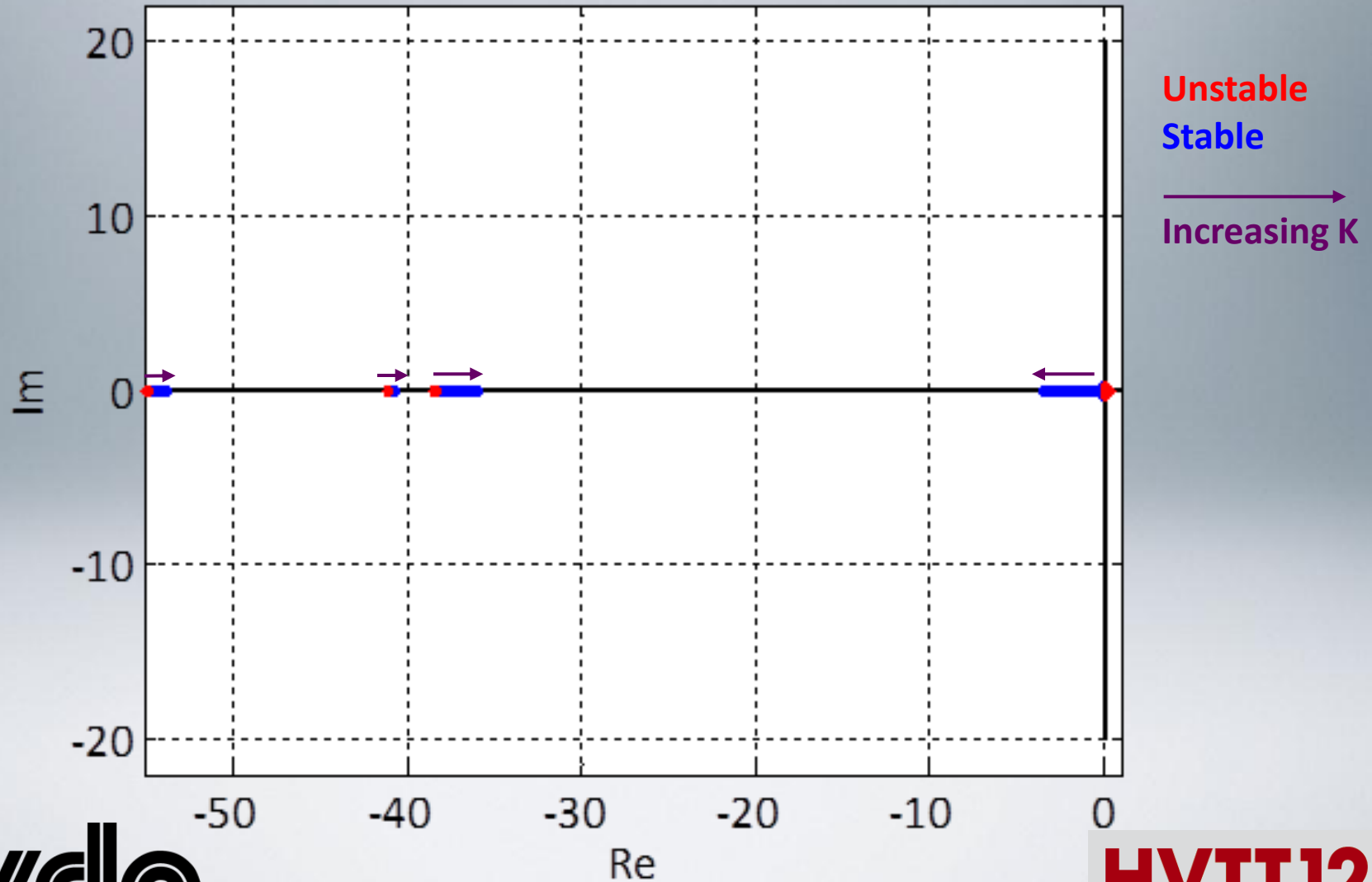
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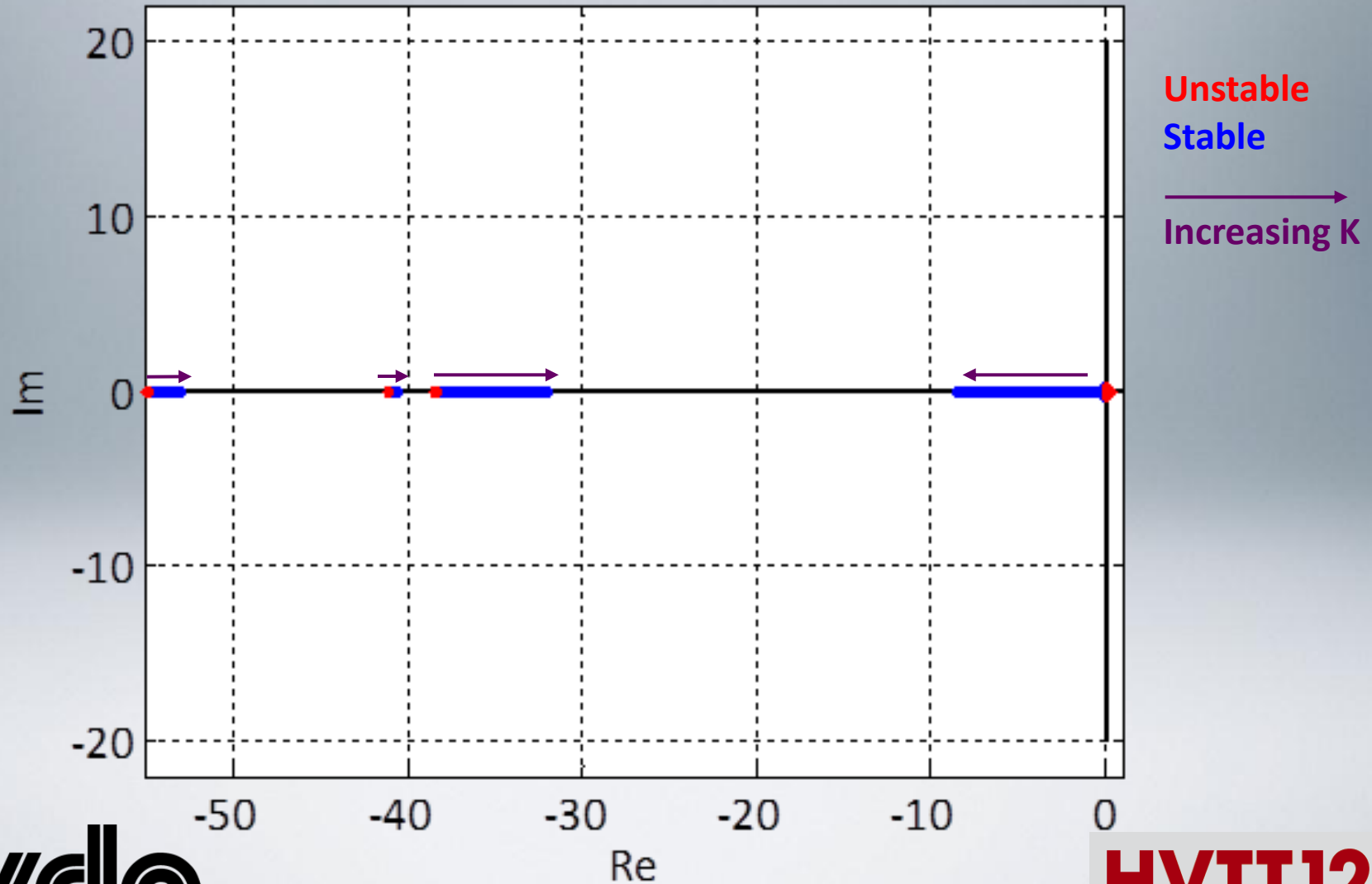
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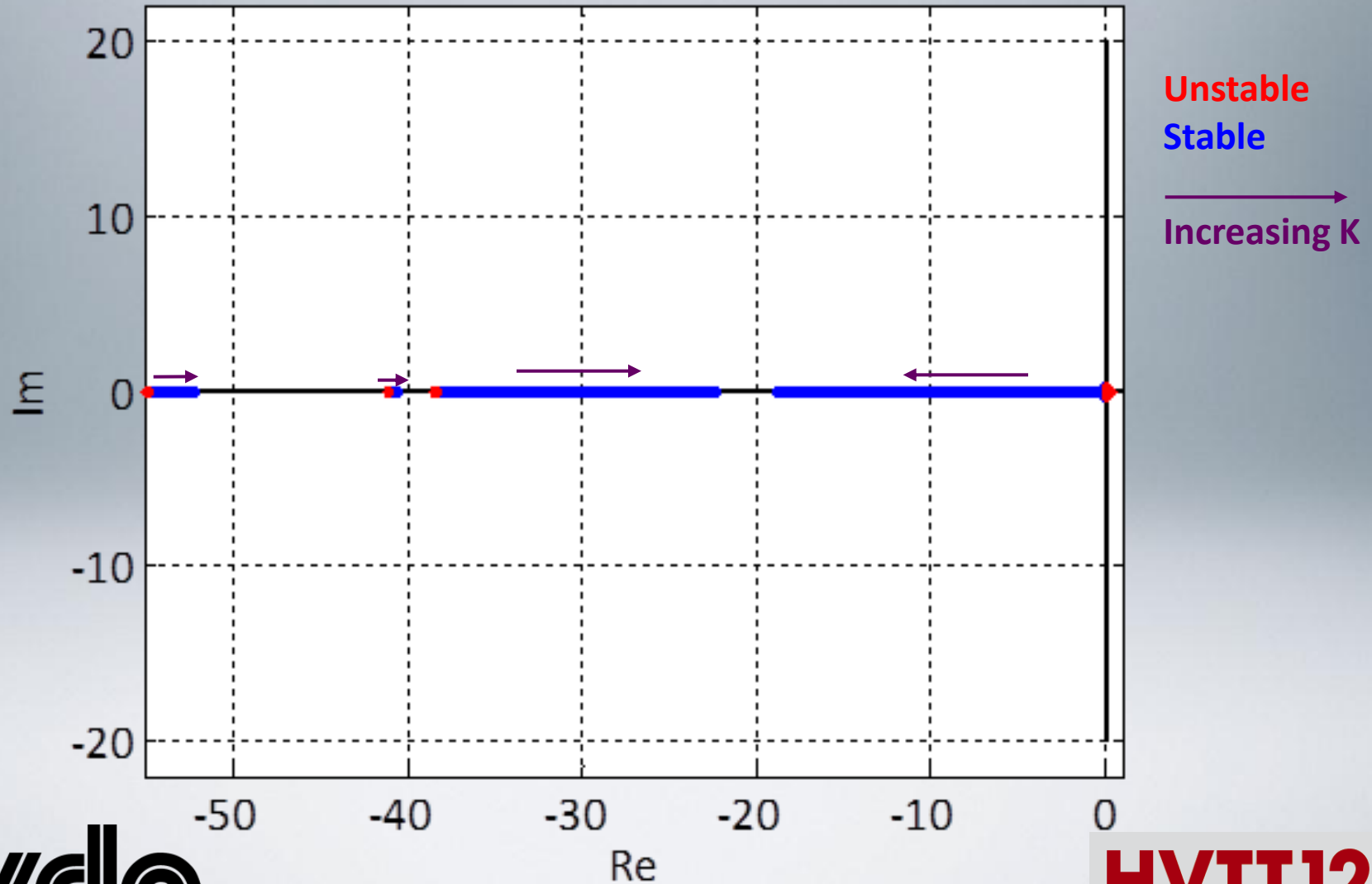


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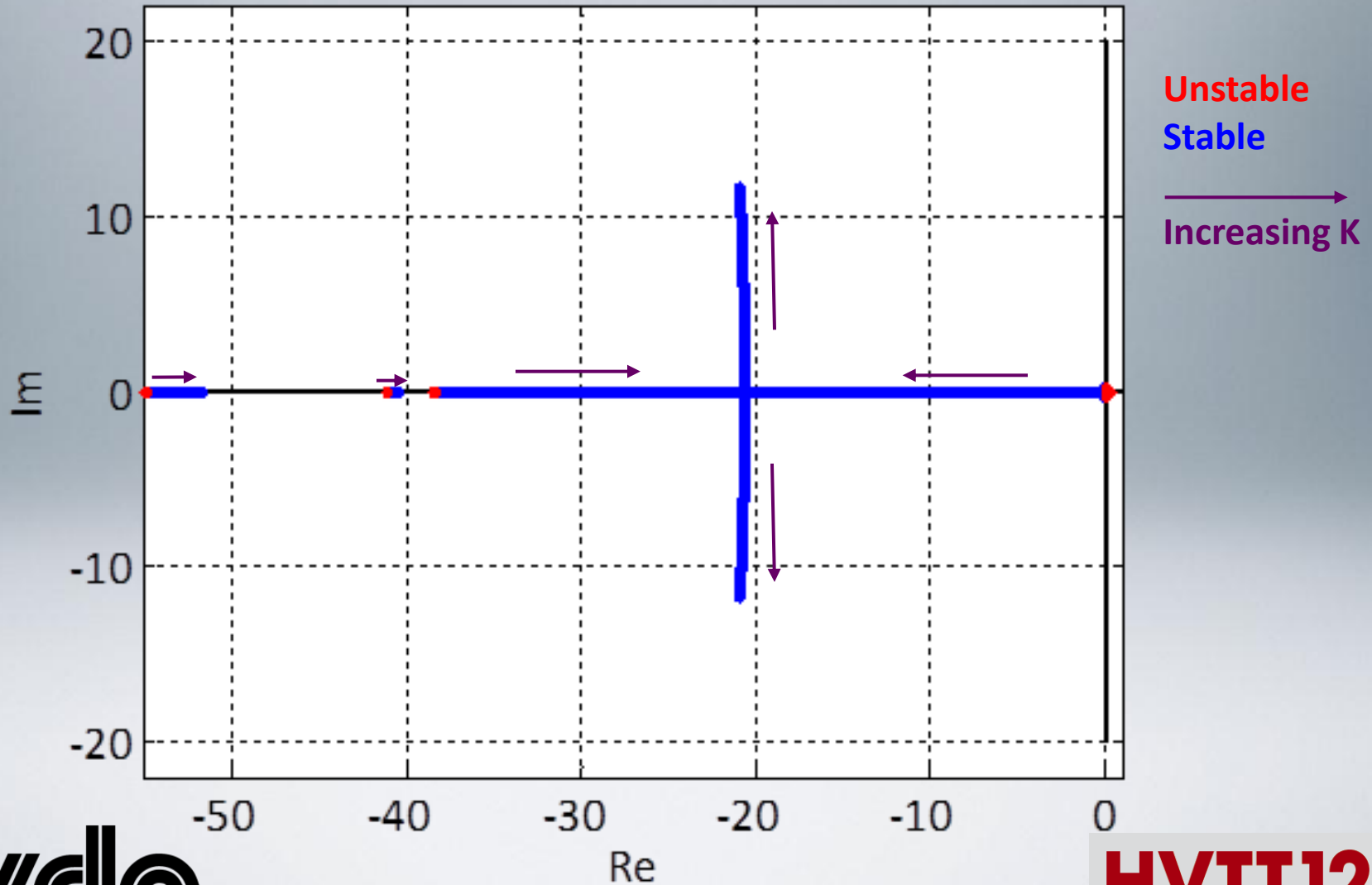




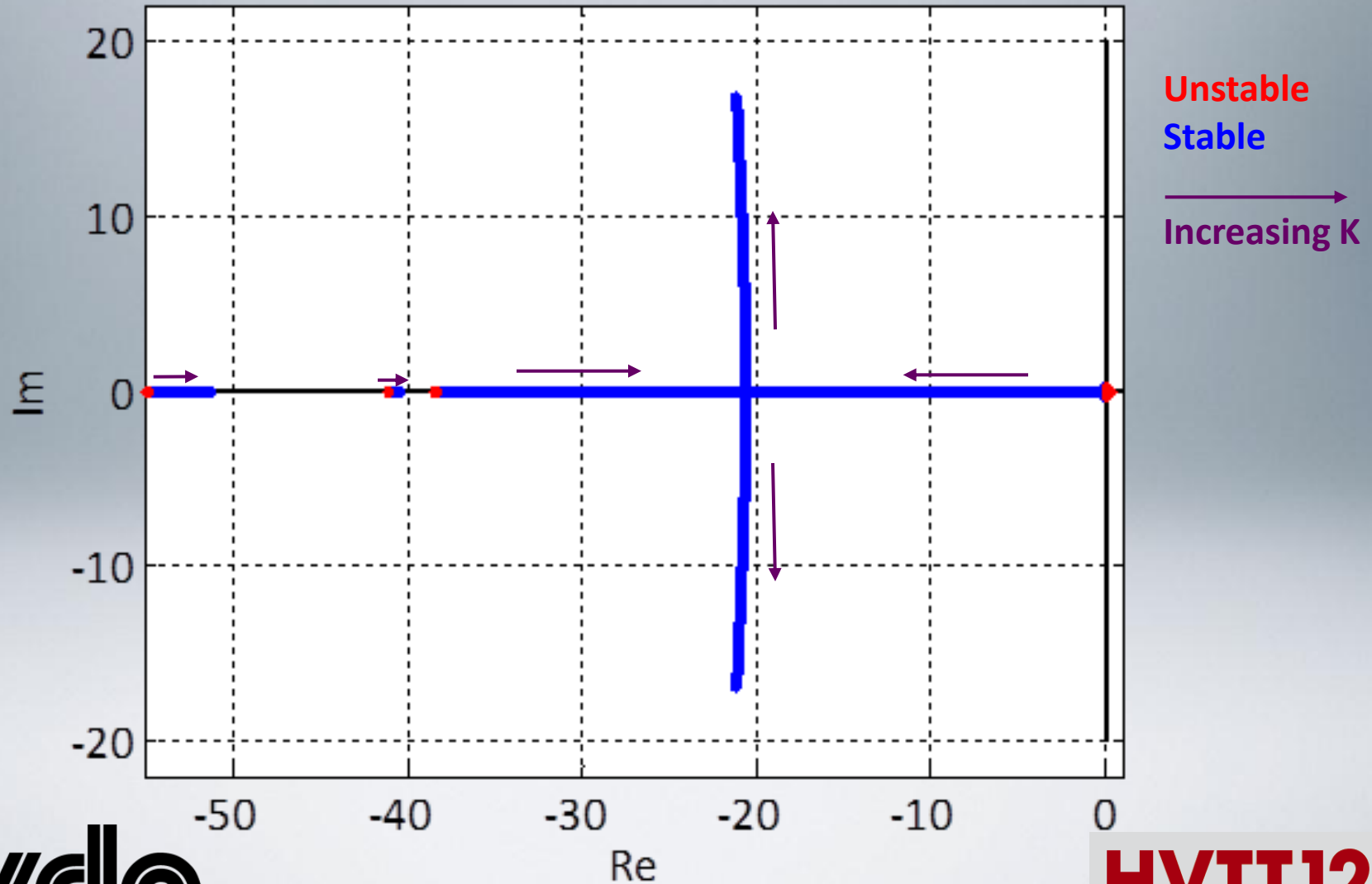
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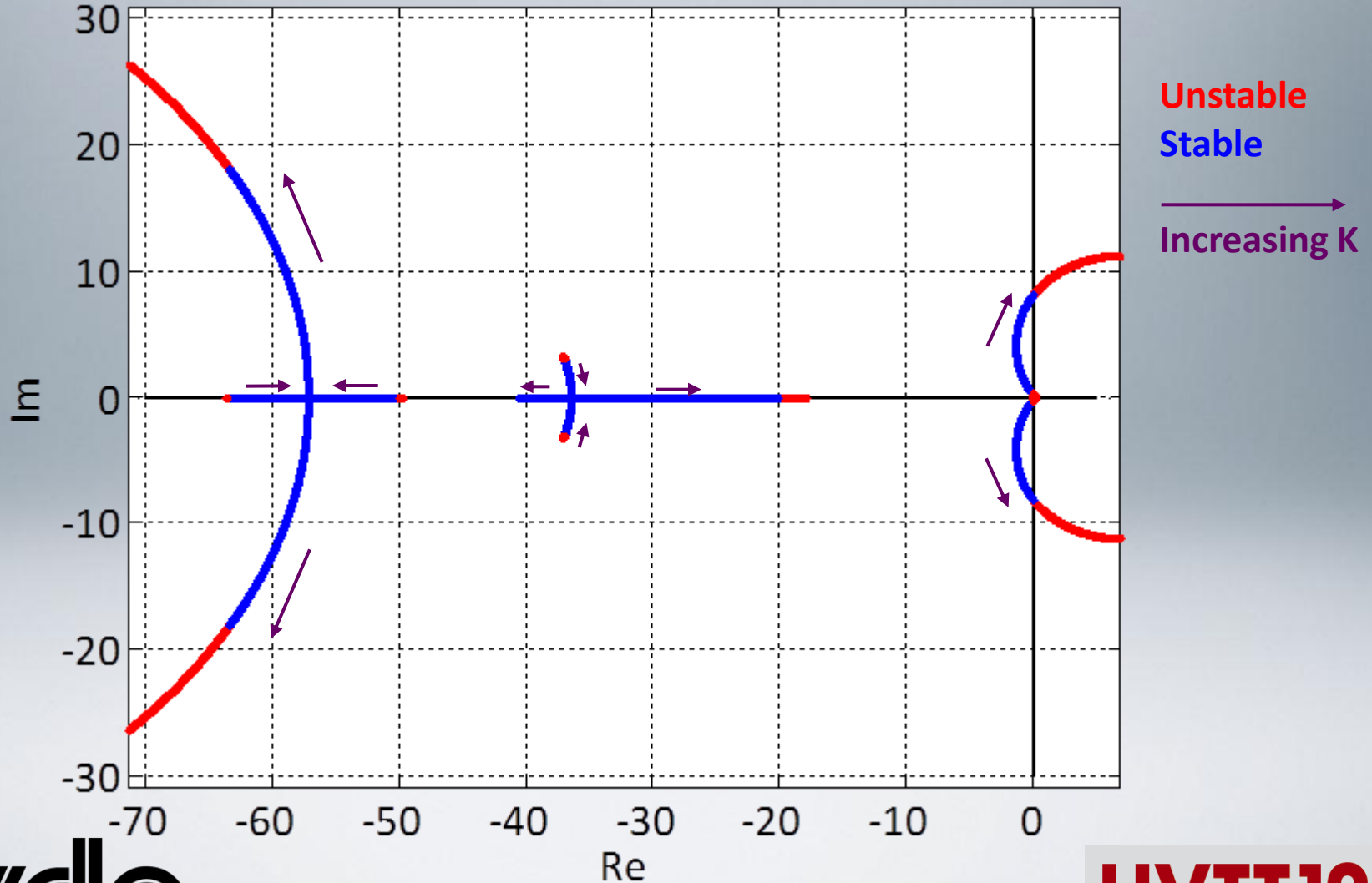
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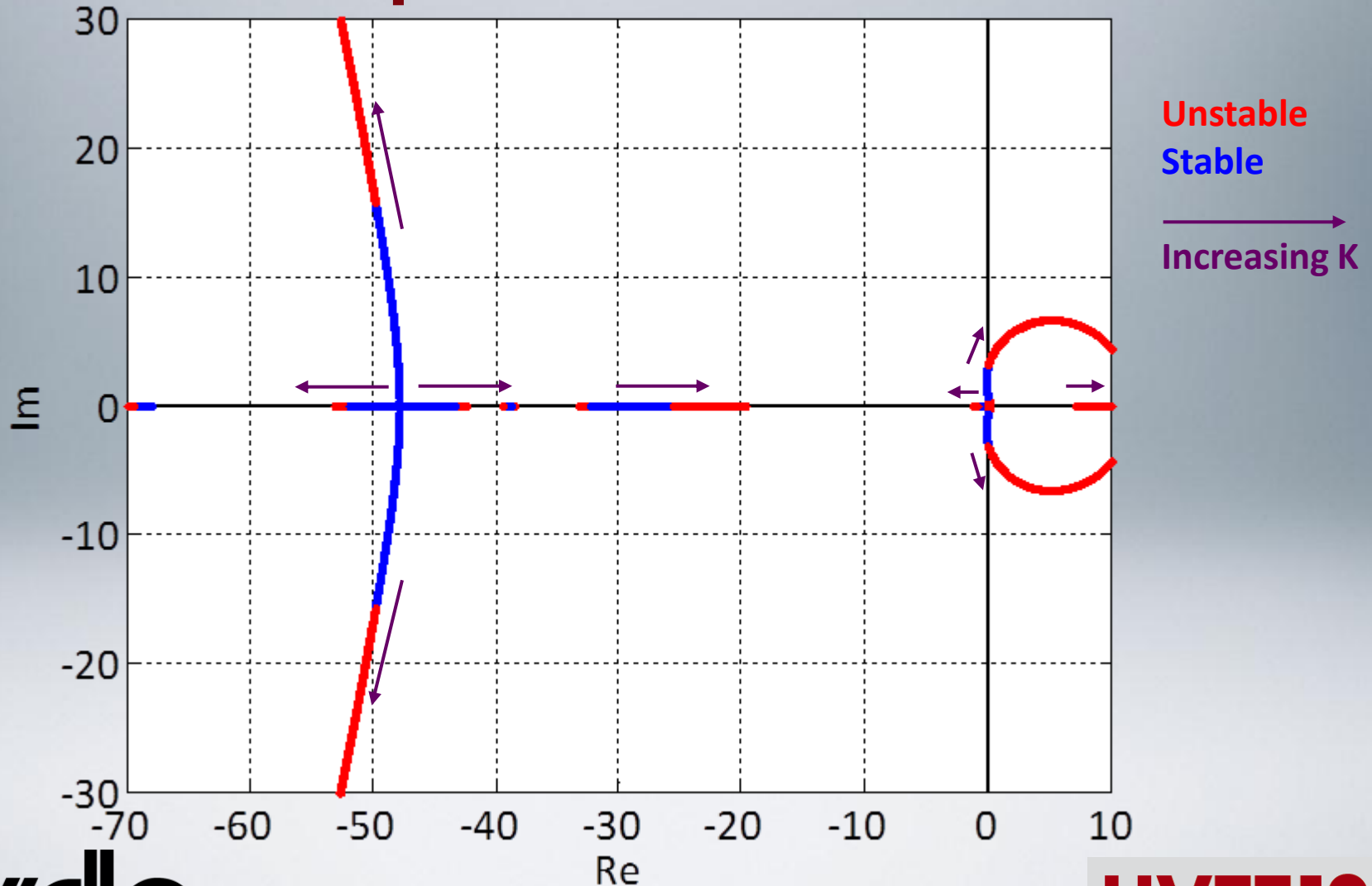
# Semi-Trailer: Root Locus



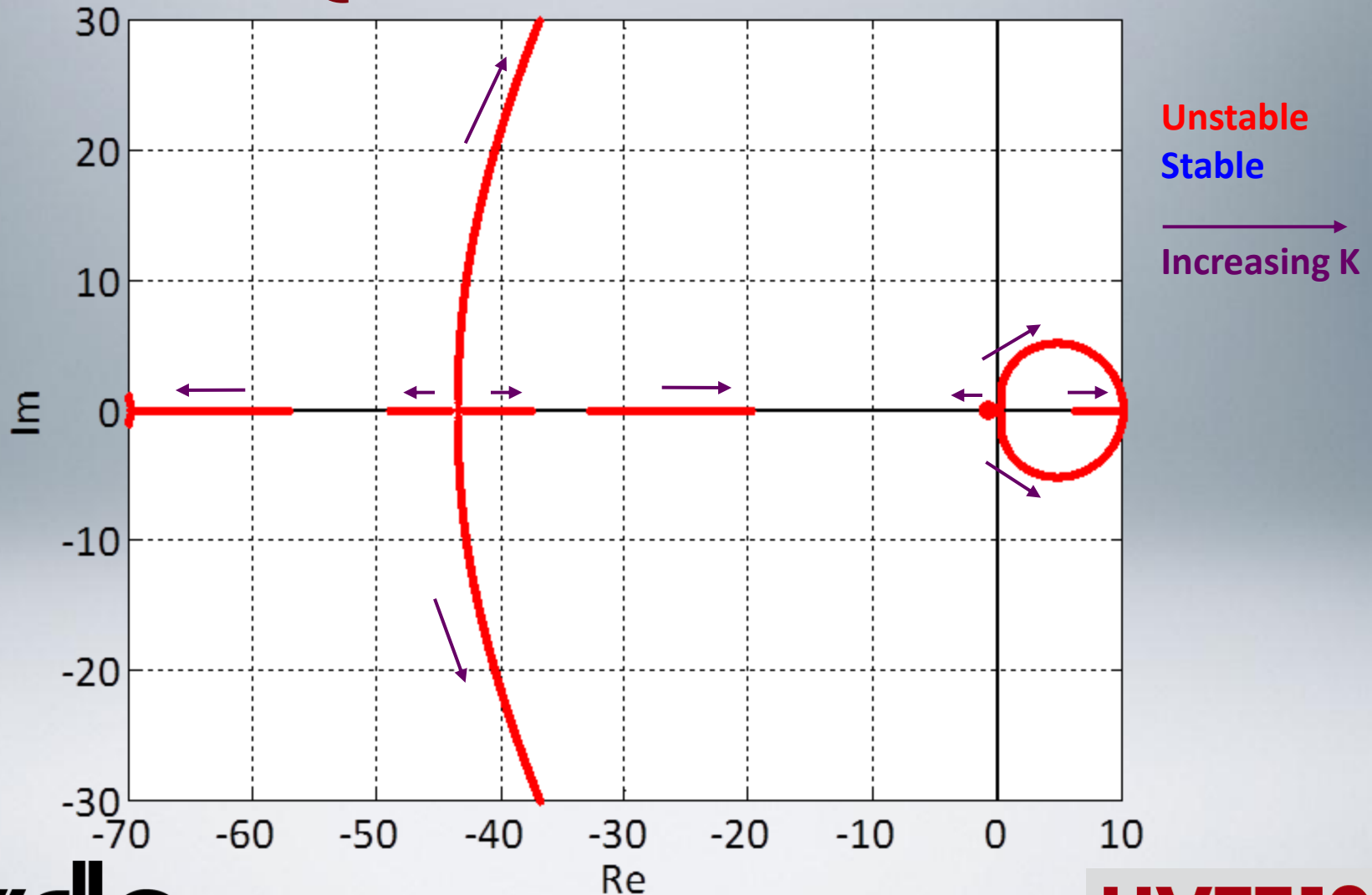
# B-Double: Root Locus



# B-Triple: Root Locus

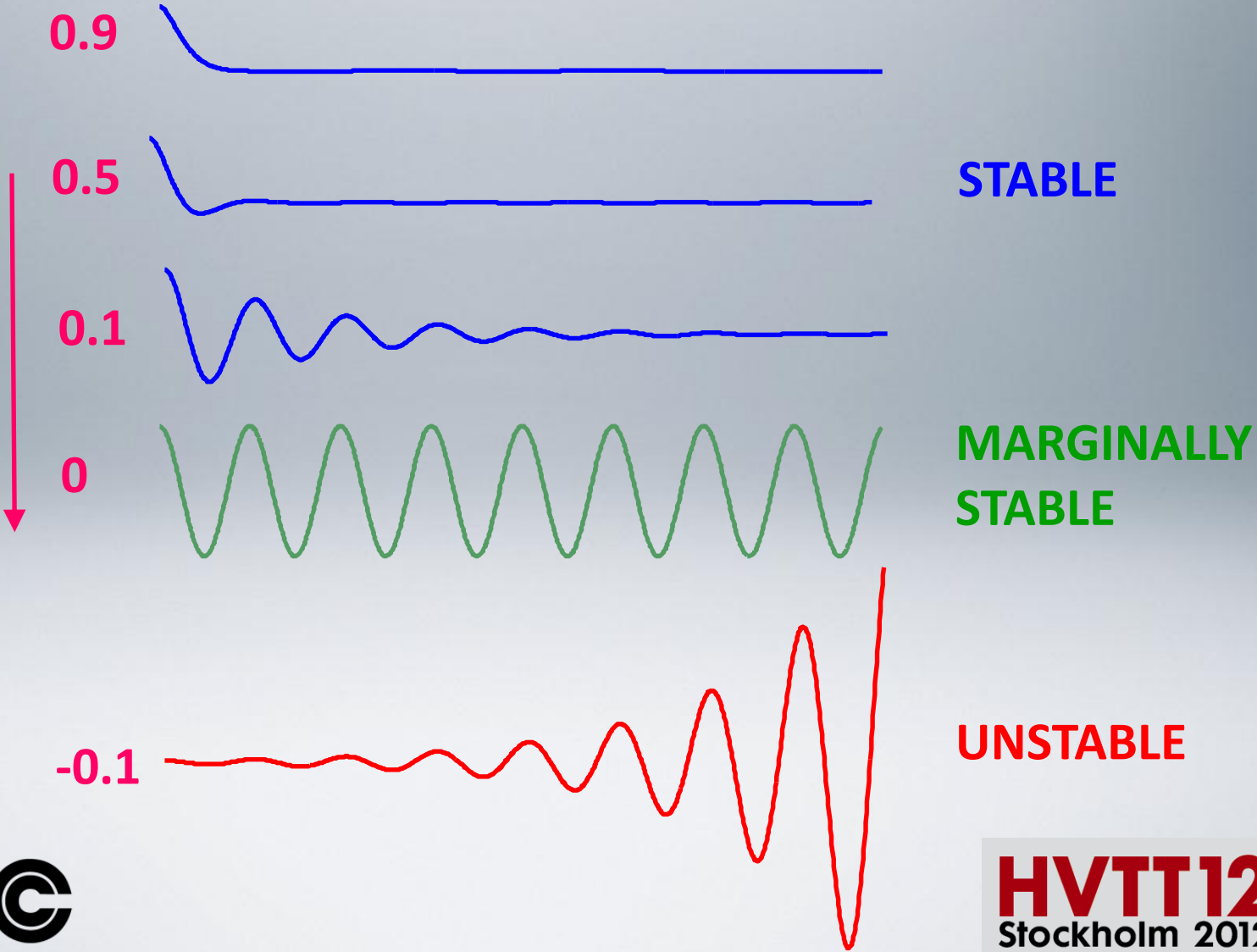


# B-Quad: Root Locus

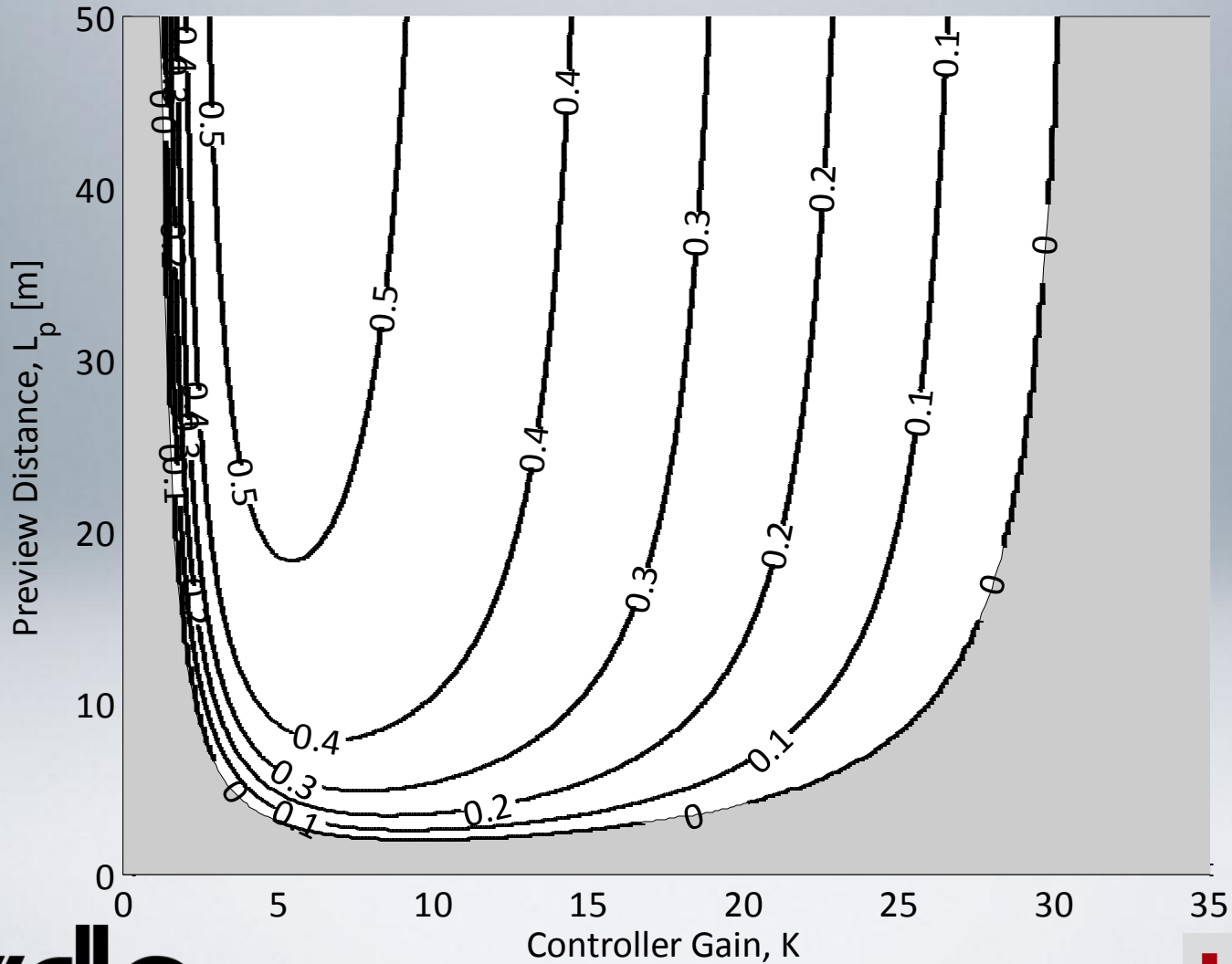


# Damping Ratio

DECREASING  
DAMPING  
RATIO

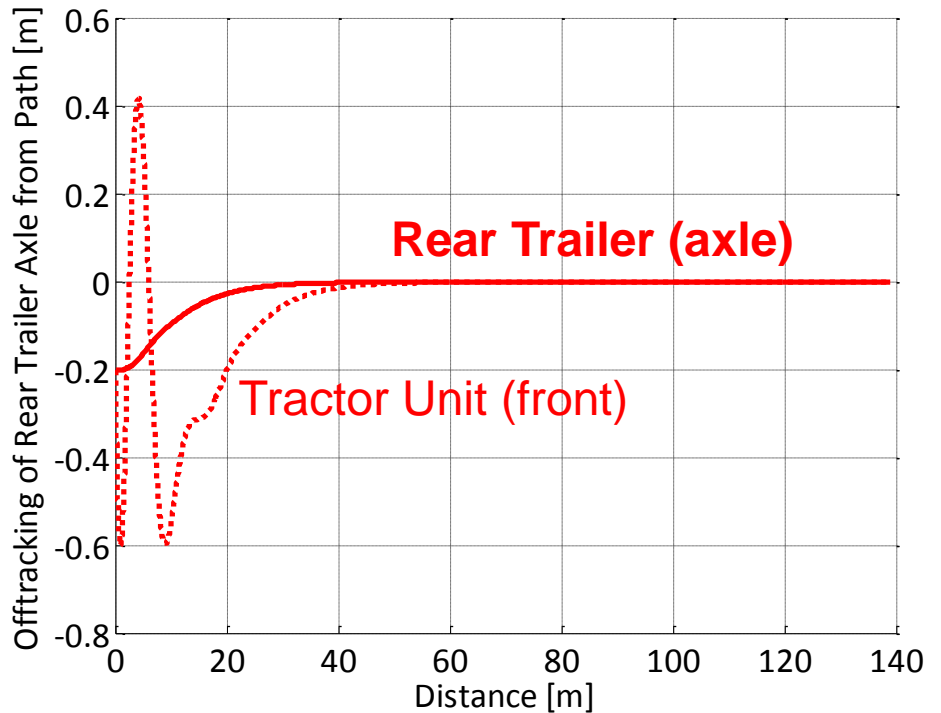
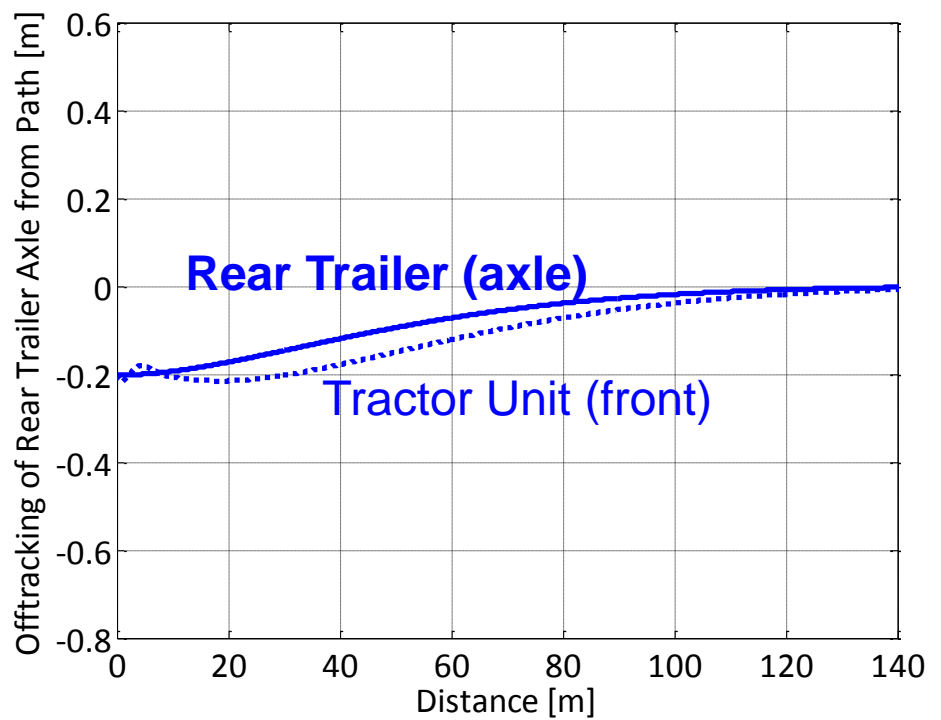
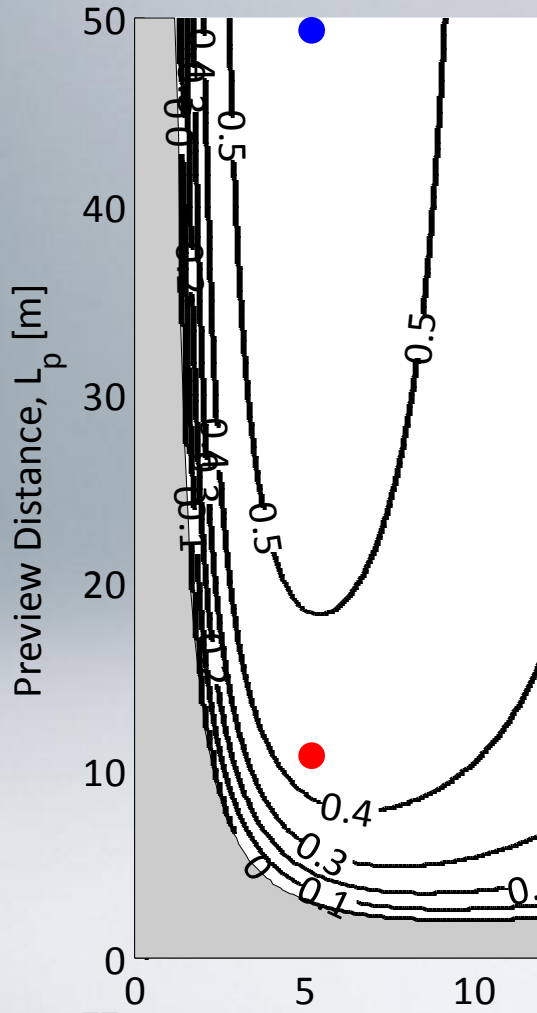


# B-Double: Damping Ratio

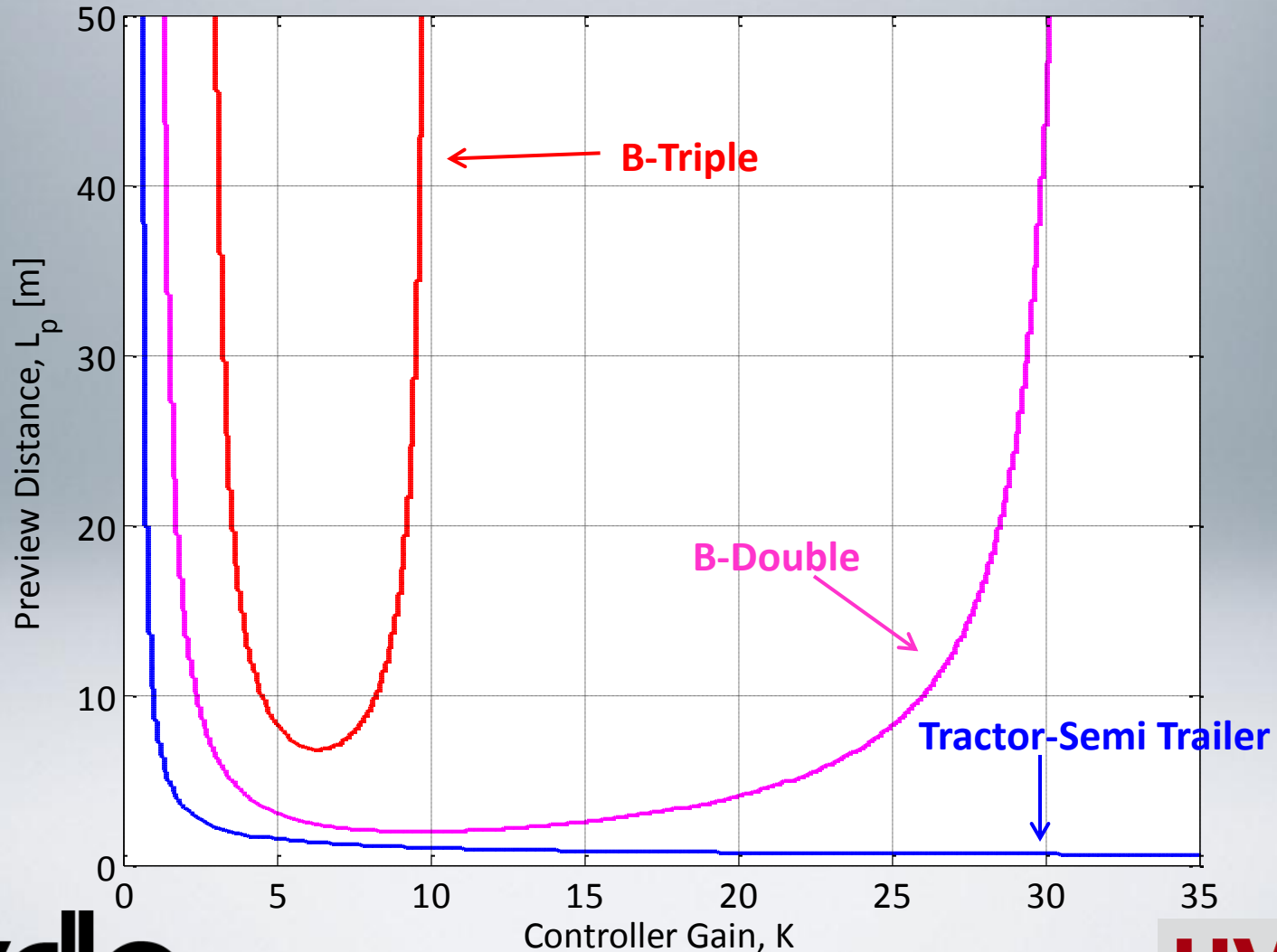




# B-Double

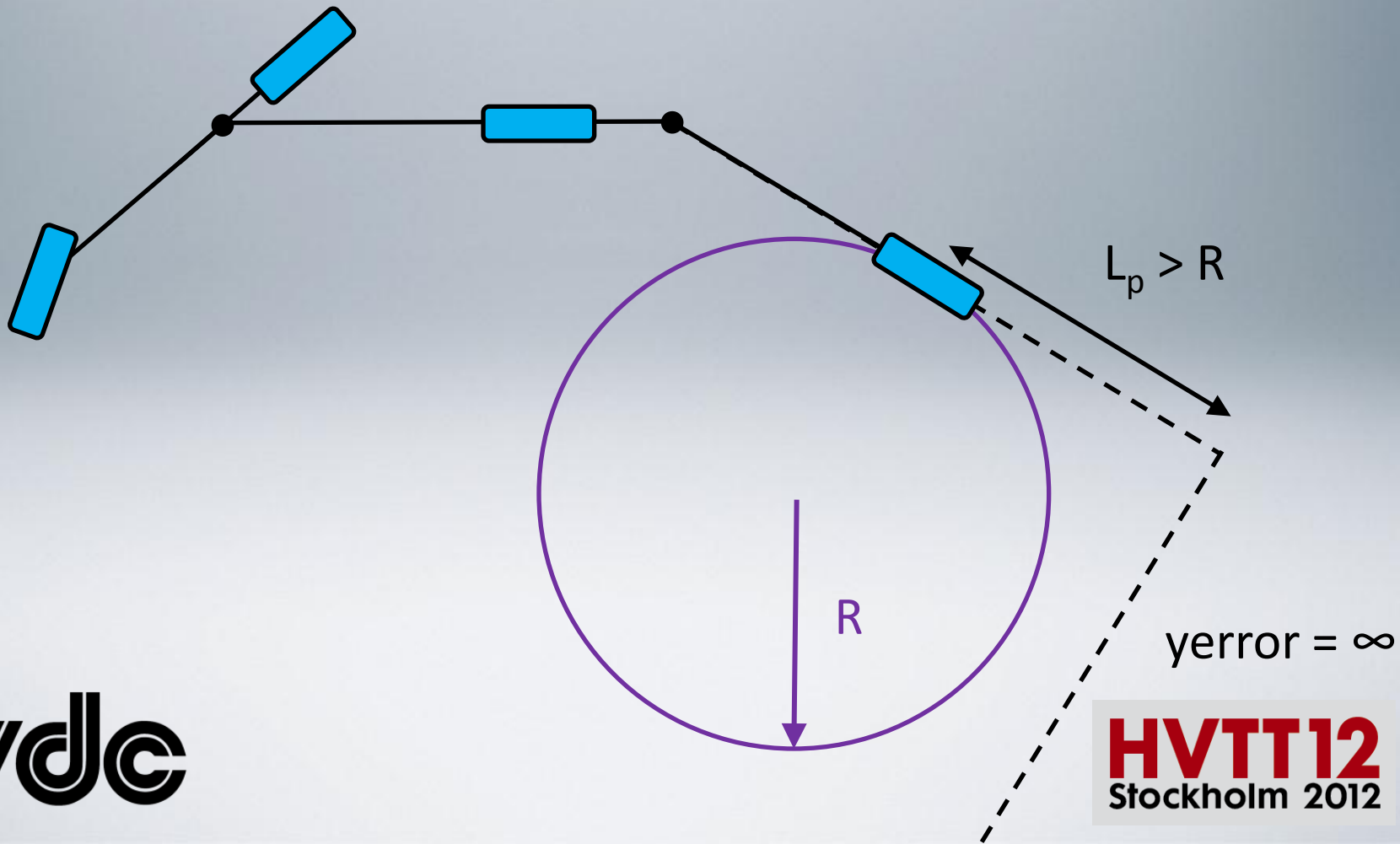


# Stability Thresholds ( $\zeta=0$ )



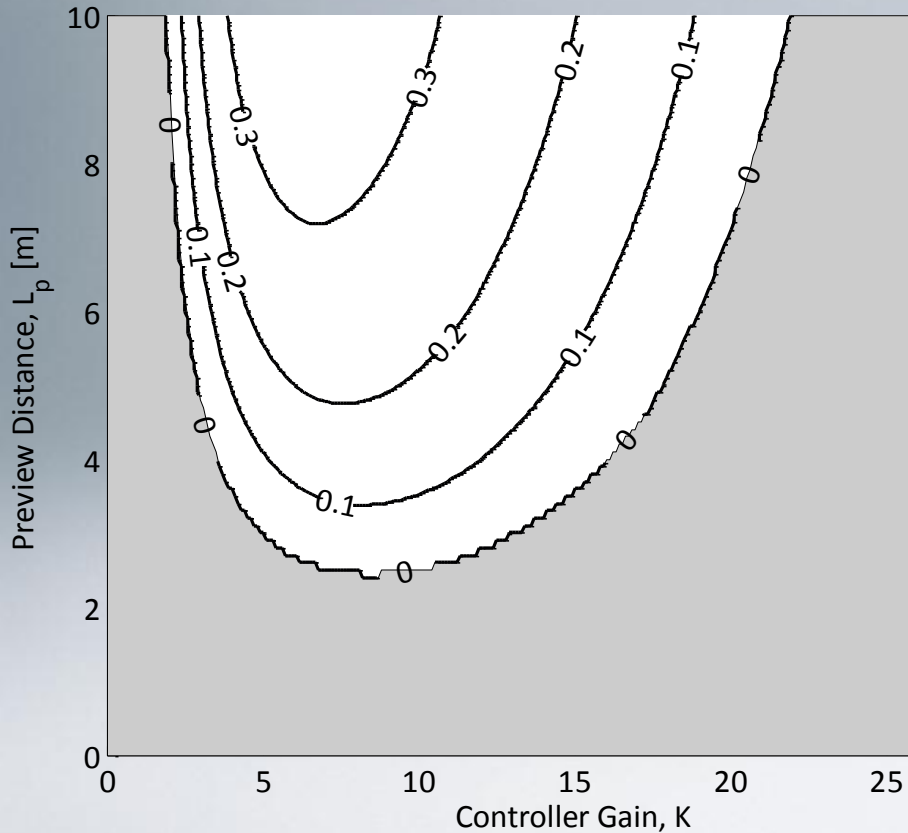
# Stability on a Curve

- Maximum preview distance  $\sim R$

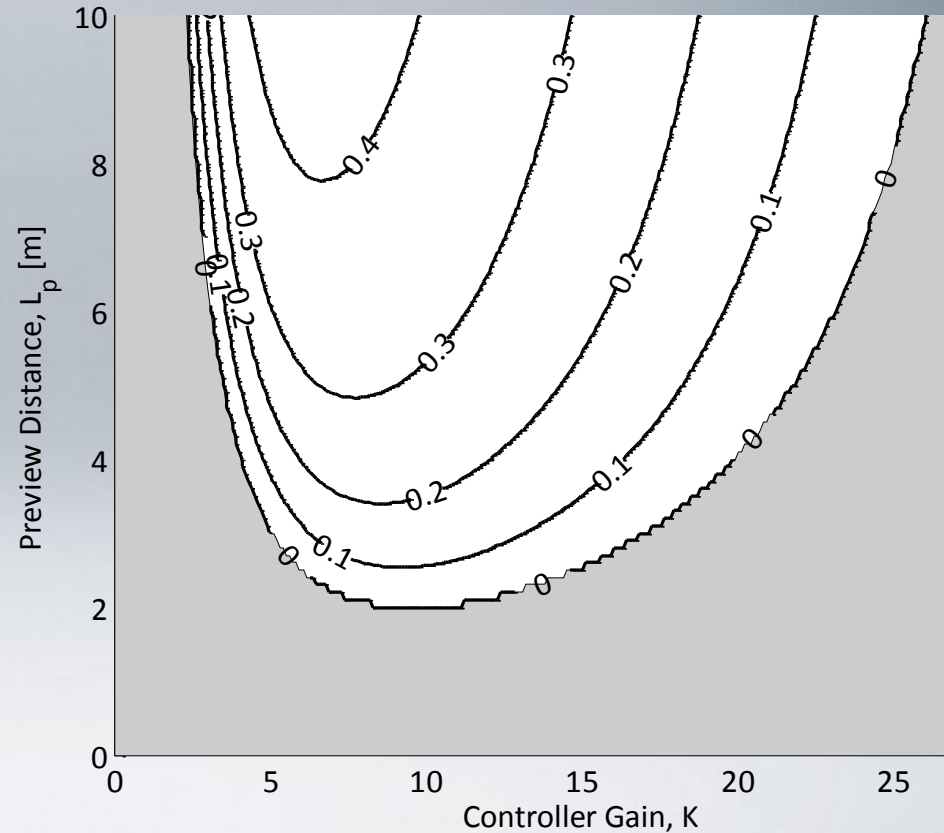


# B-Double: Damping Ratio Comparison

R = 10



Straight Line



# Conclusions

- Controller stable for up to three trailers
- Stability decreases as number of trailers increases
- Trade-off between settling time and damping
- Control parameters can be tuned using straight line analysis

# Future Work

- Develop alternative controllers
- Implement controller on test vehicle

