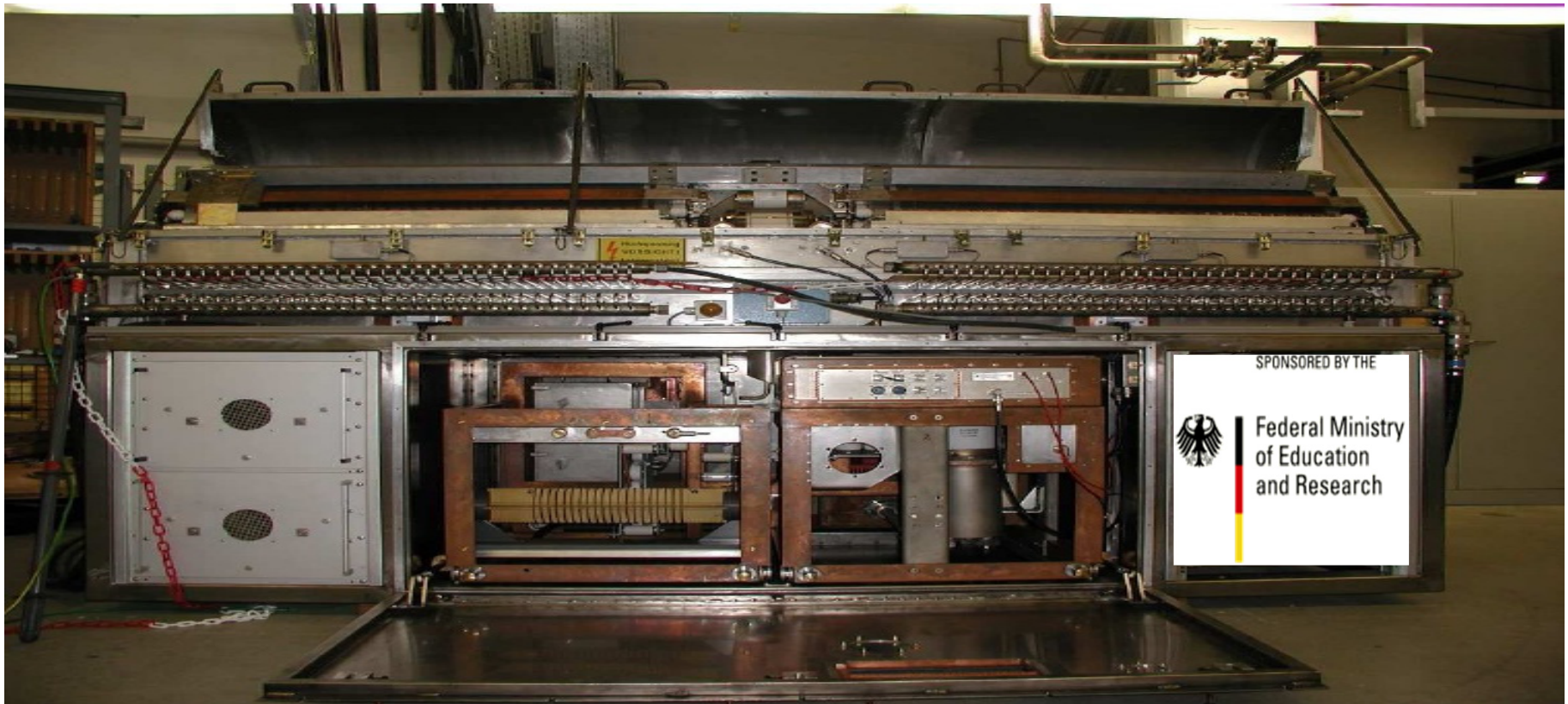


Dynamics of Ferrite Cavities and their Effect on Longitudinal Dipole Oscillations



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Motivation

- The **GSI Helmholtz Centre for Heavy-Ion Research** (GSI) operates the **Heavy Ion Synchrotron SIS18** (circumference 217 m) near Darmstadt, Germany
- A new Synchrotron **SIS100** is being built at GSI (estimated completion: 2016) in the frame of the **FAIR** project.

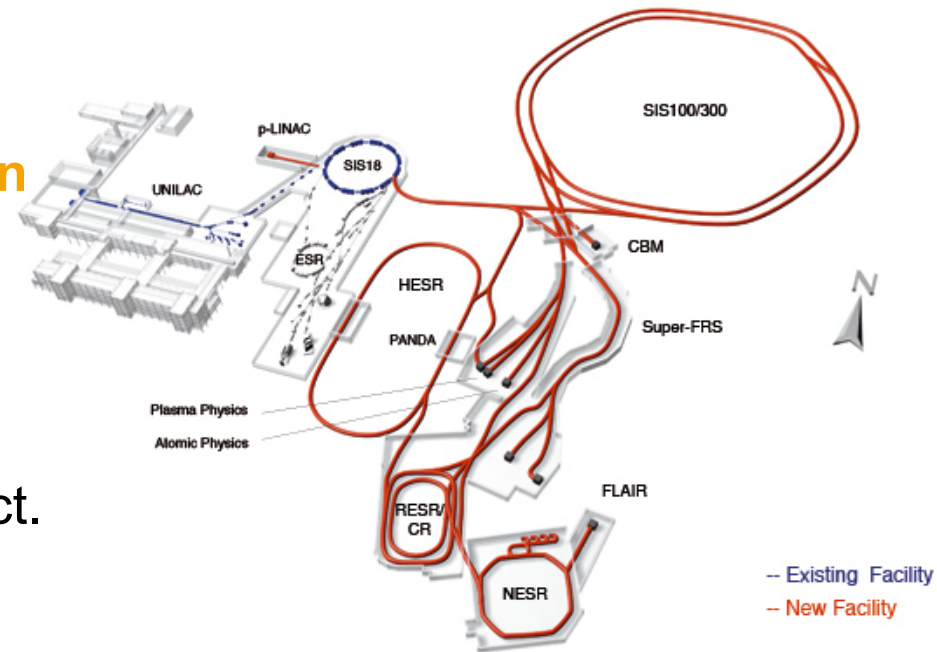
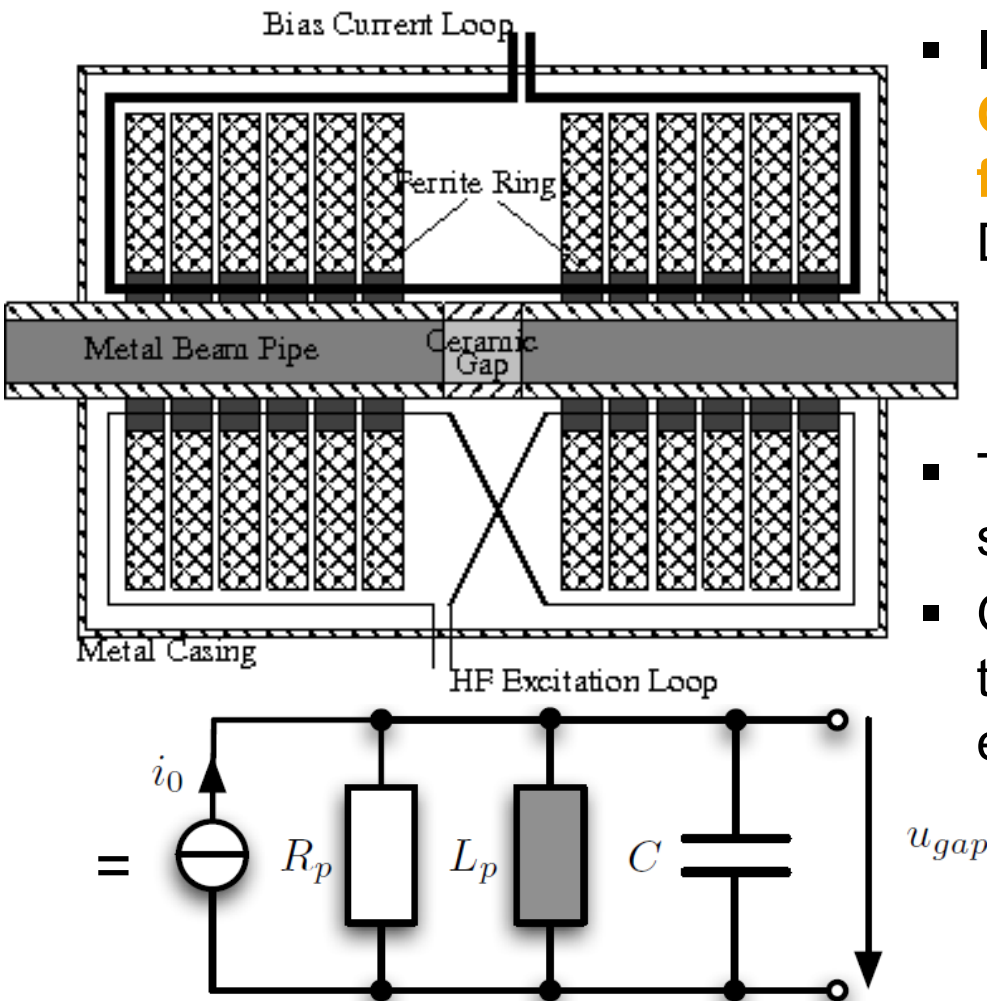


Image Source: GSI

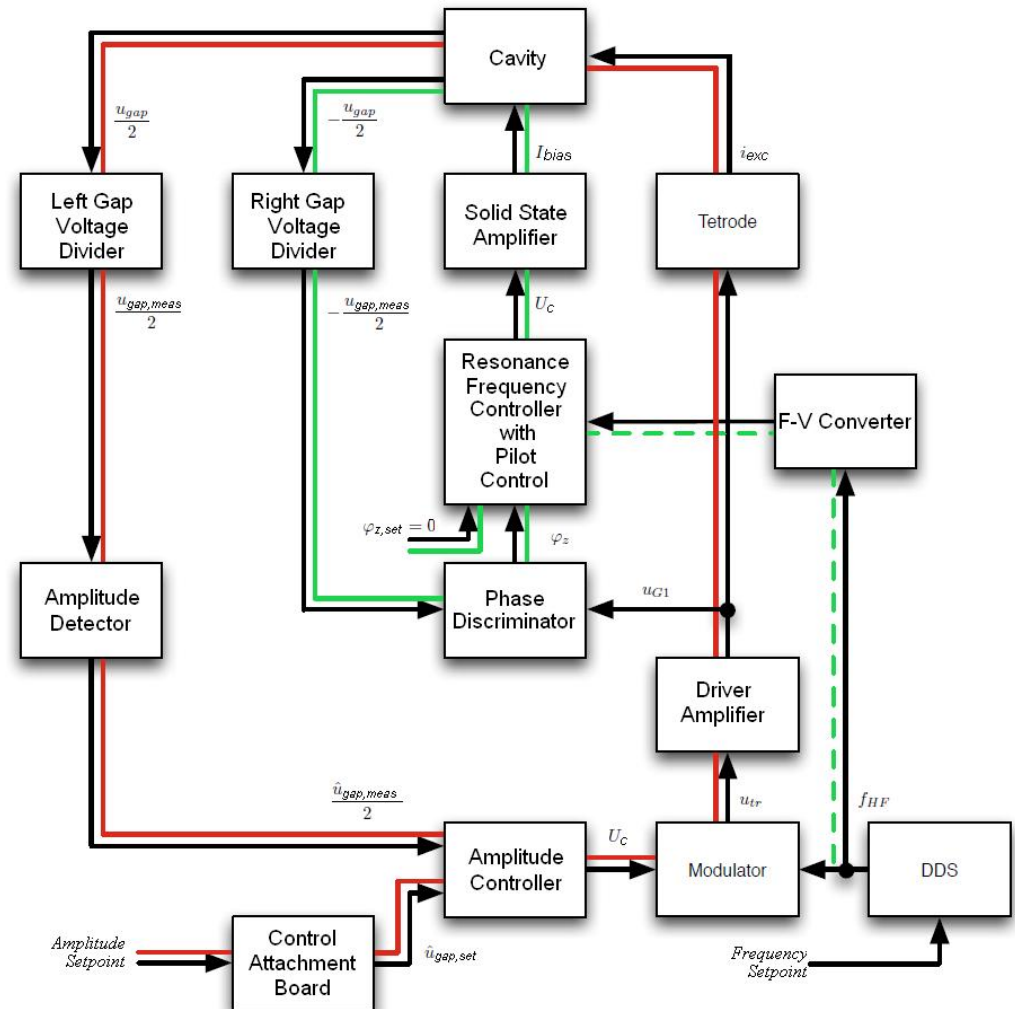
Ferrite Cavities



- In both synchrotrons, **Ferrite Cavities** are used whose **resonance frequency** can be tuned by varying a DC bias current.
- The harmonic frequency is relatively small (< 10 MHz) and variable.
- Optimum performance is achieved if the resonance frequency equals the excitation frequency.

Local Control Loops

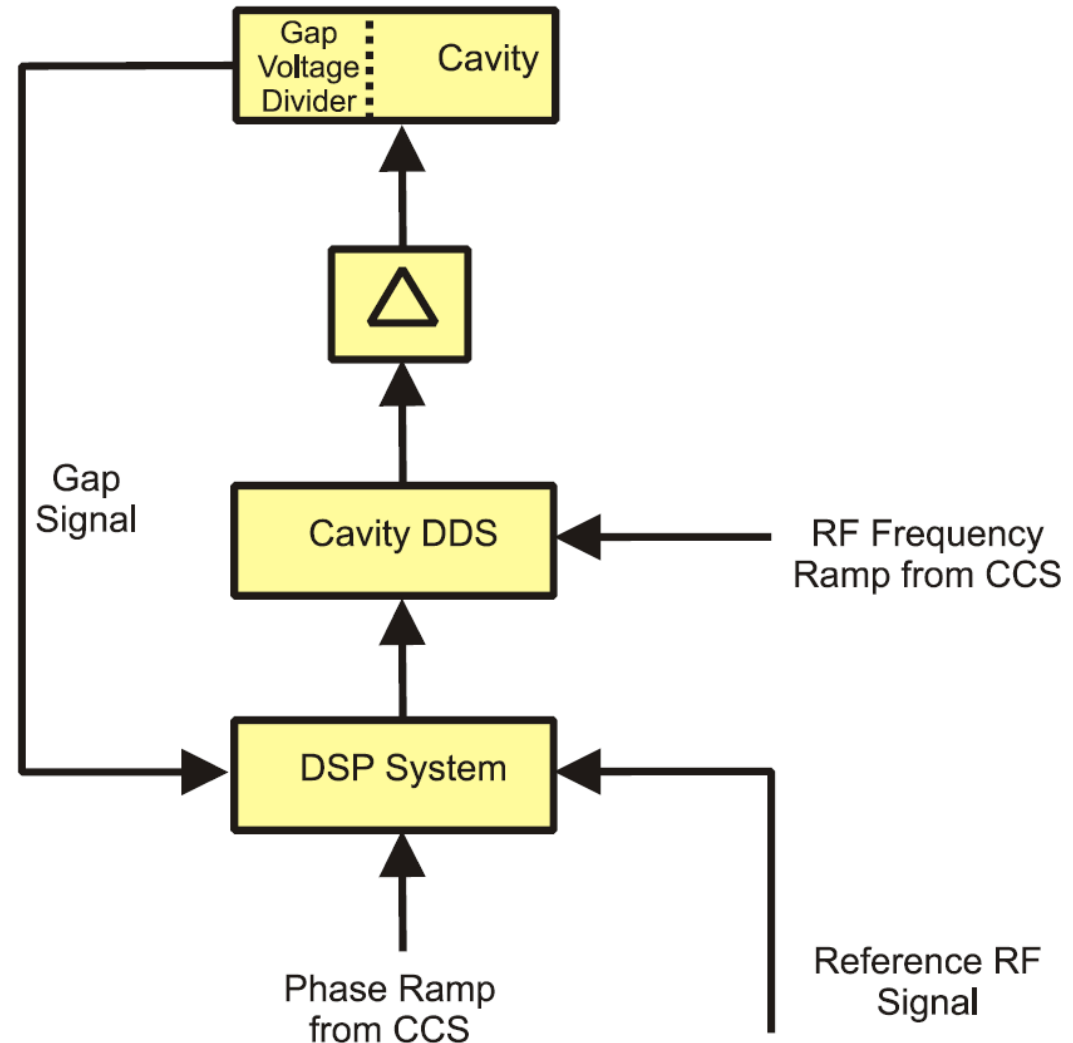
- Each cavity is equipped with
 - a **resonance frequency control loop** (green)
 - an **amplitude control loop** (red)
- both control loops have pilot control paths
 - control doesn't work at zero excitation current
 - only deviations from the ideal plant model need to be controlled



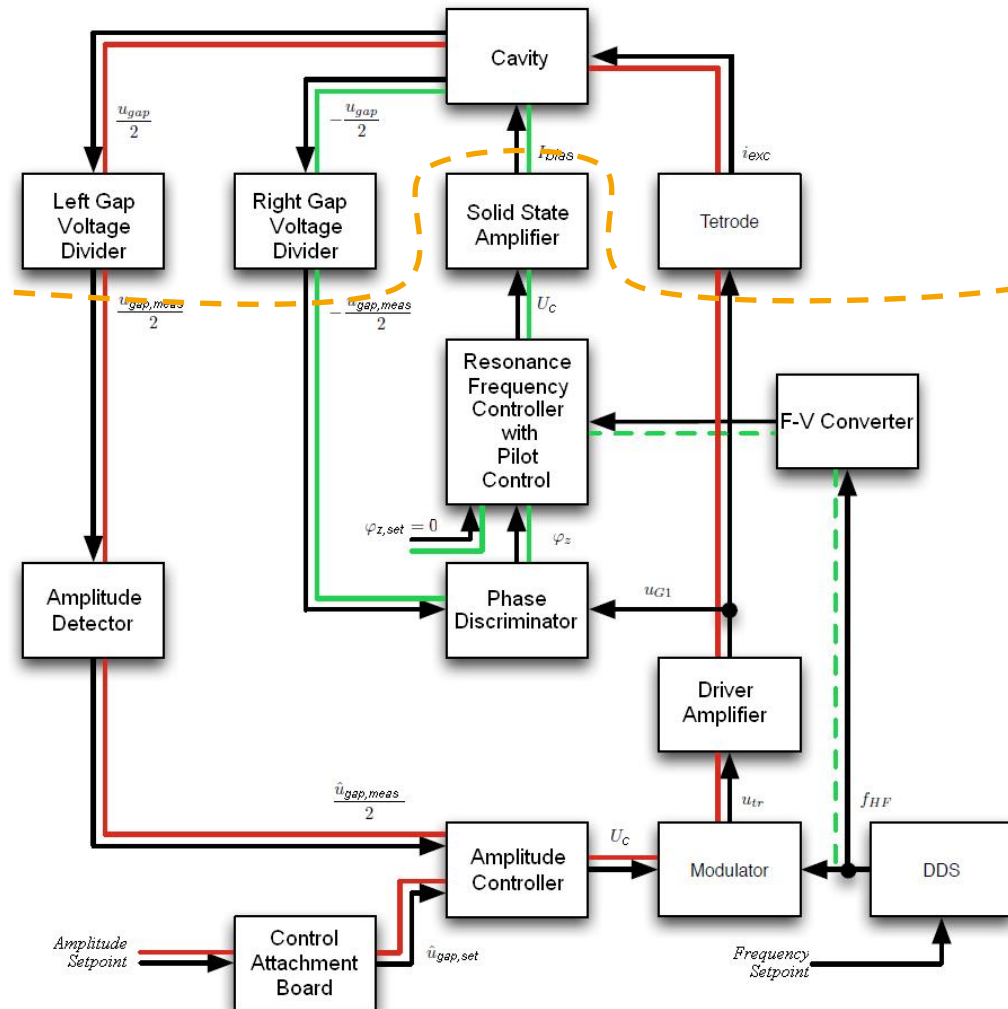
Local Control Loops

Each cavity is also equipped with a **cavity synchronization loop**

- to synchronize the phase of the gap voltage to a reference signal
- cavity synchronization interacts with resonance frequency control

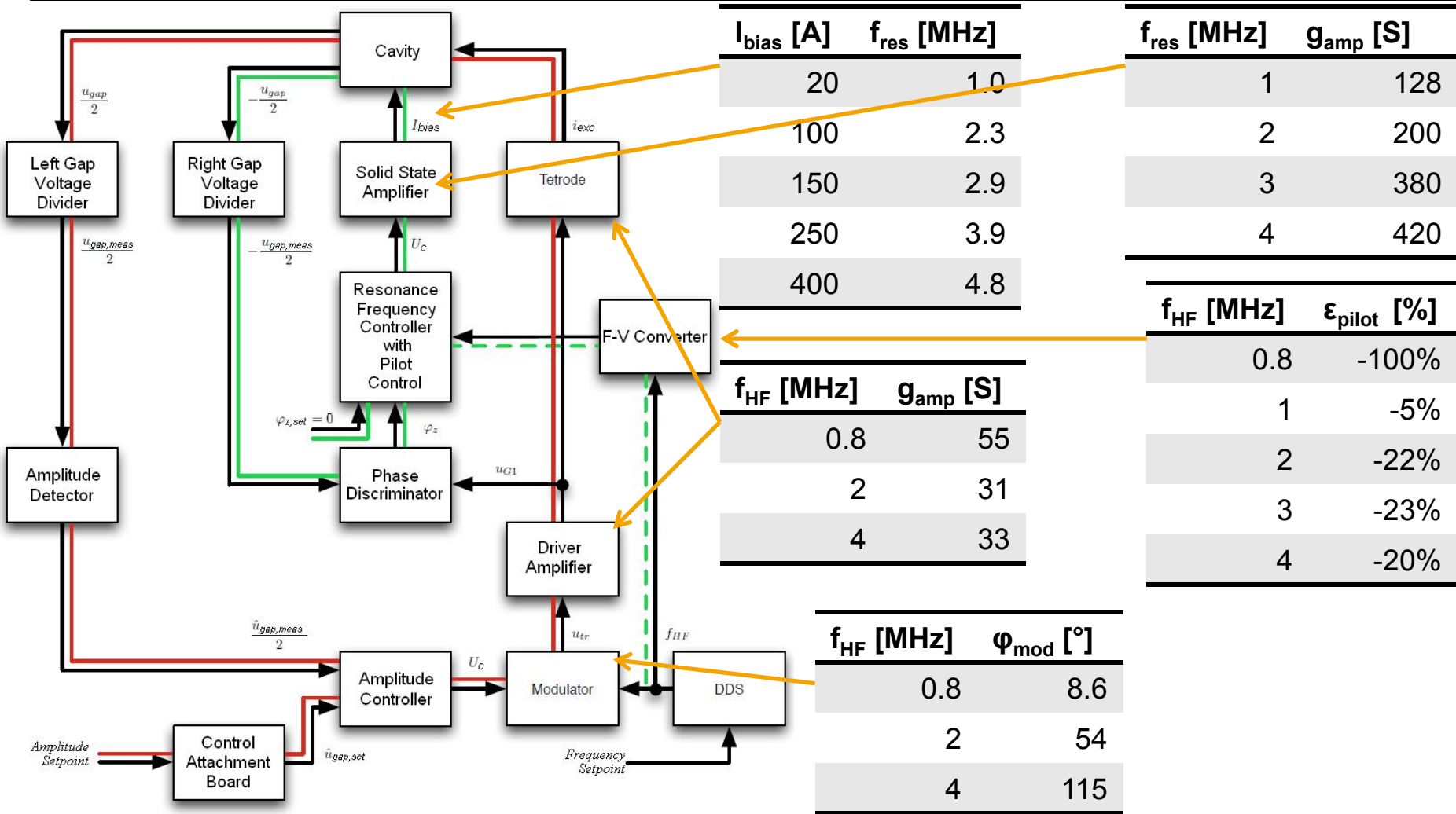


Cable Delays

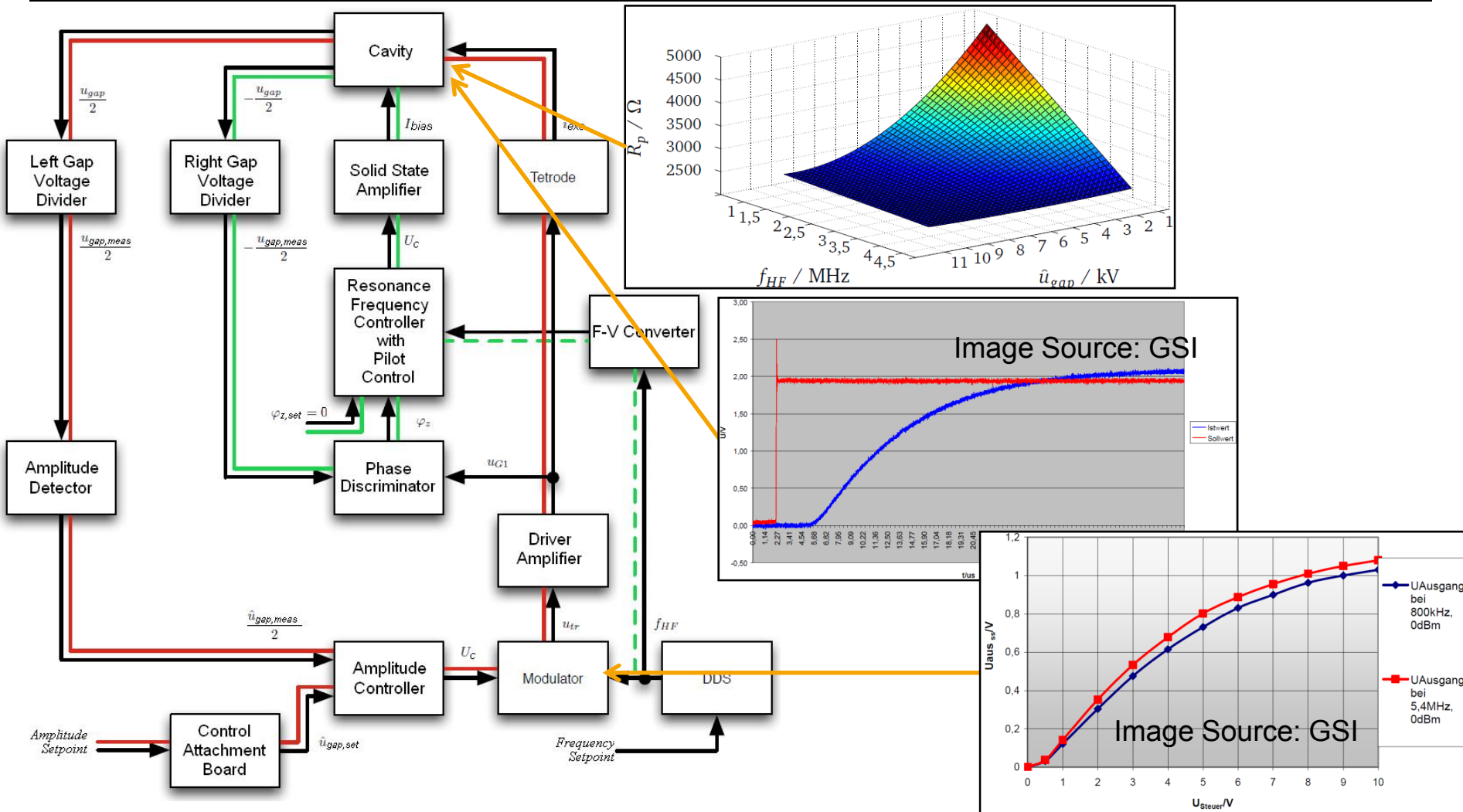


- all control equipment is located in **supply rooms**
- distance to cavity: up to 100 m
- → 500 ns delay in co-ax cable

Nonlinearities

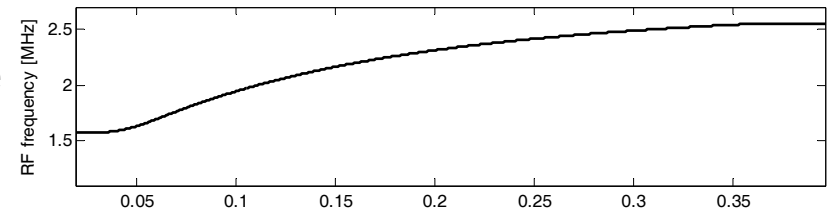


Cavity Dynamics

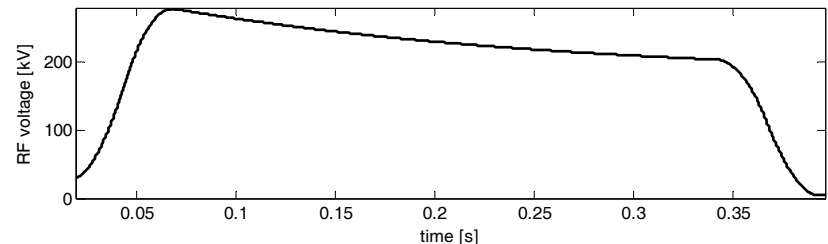


Simulation Setup

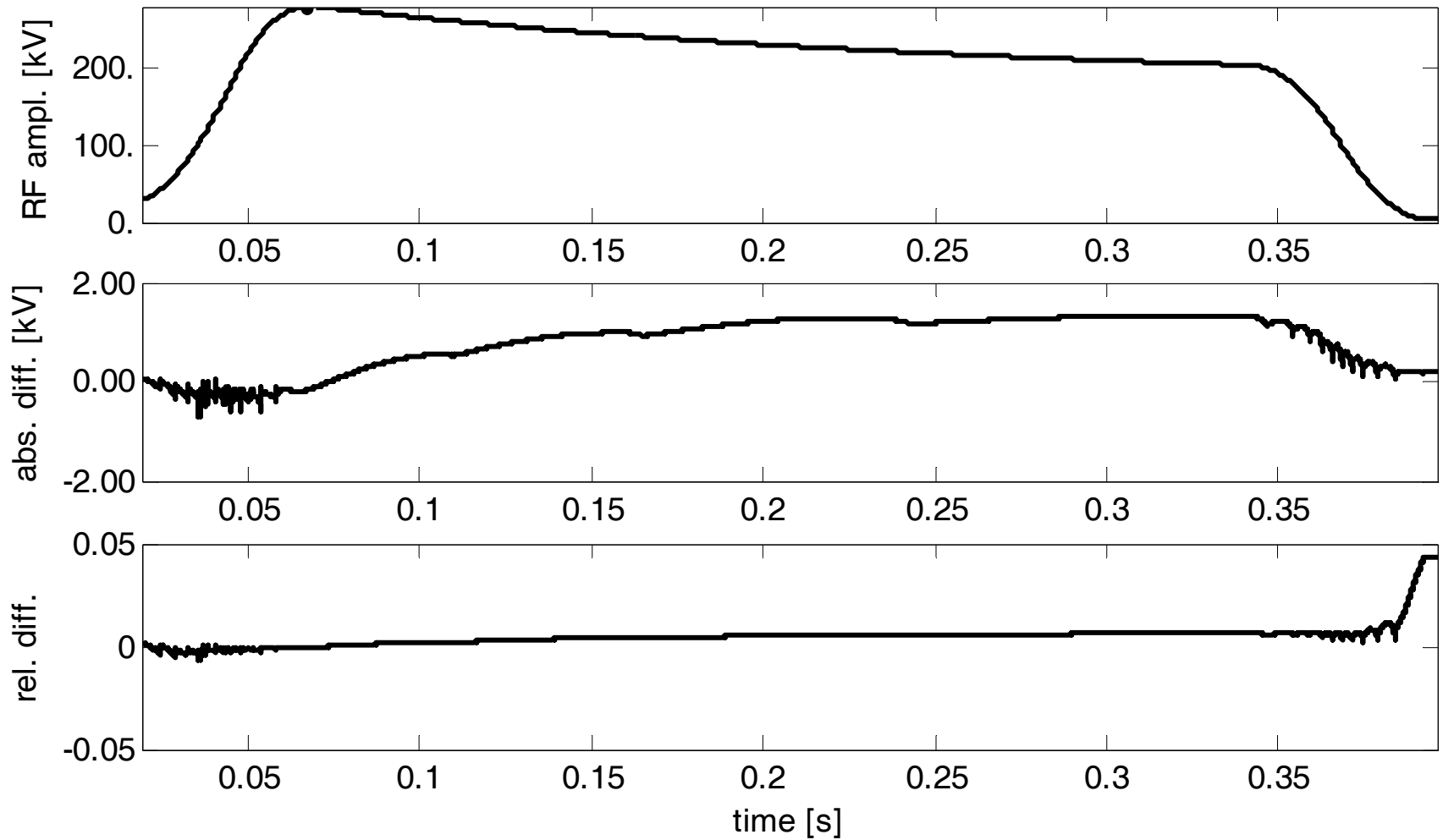
- The simulation model contained 14 cavities with **random parameter deviations** ($\pm 20\%$)
- RF frequency / amplitude ramps for the SIS100 were used as setpoints.
- A linear model was derived by choosing constant gains such that
 - the constant gain of a linear element is the **minimum gain** of the corresponding nonlinear element, hence
 - the **closed-loop time constant** of the linear model equals the **worst-case time constant** of the nonlinear model.



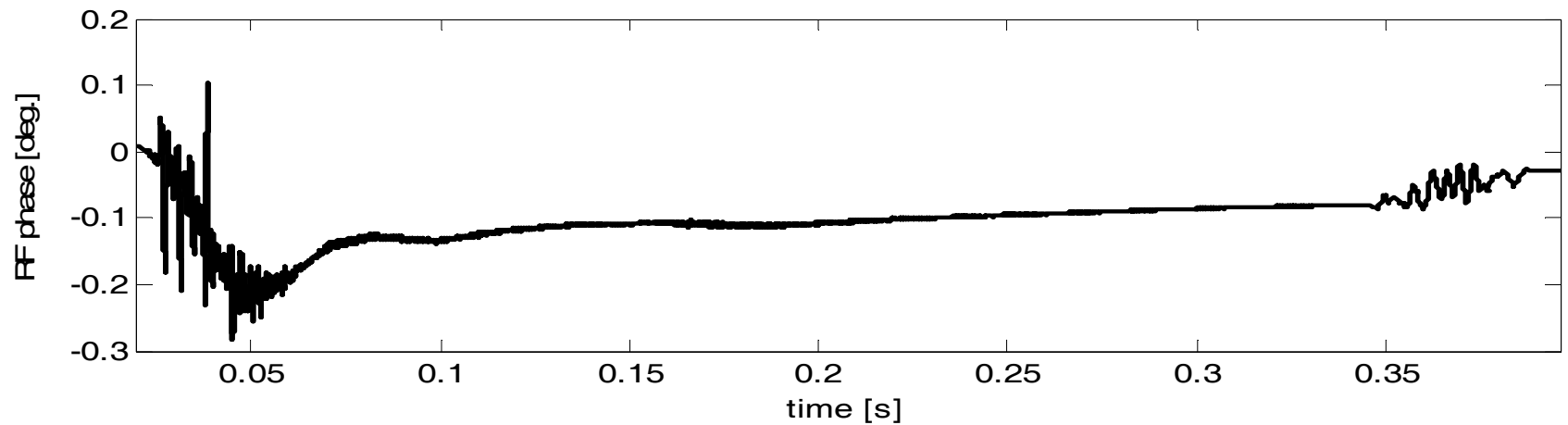
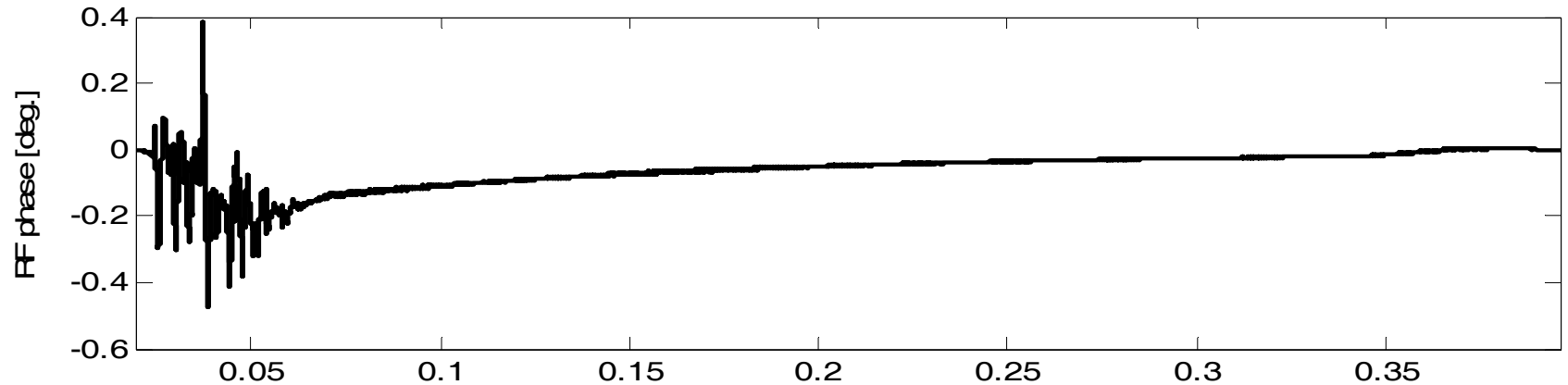
Data Courtesy GSI



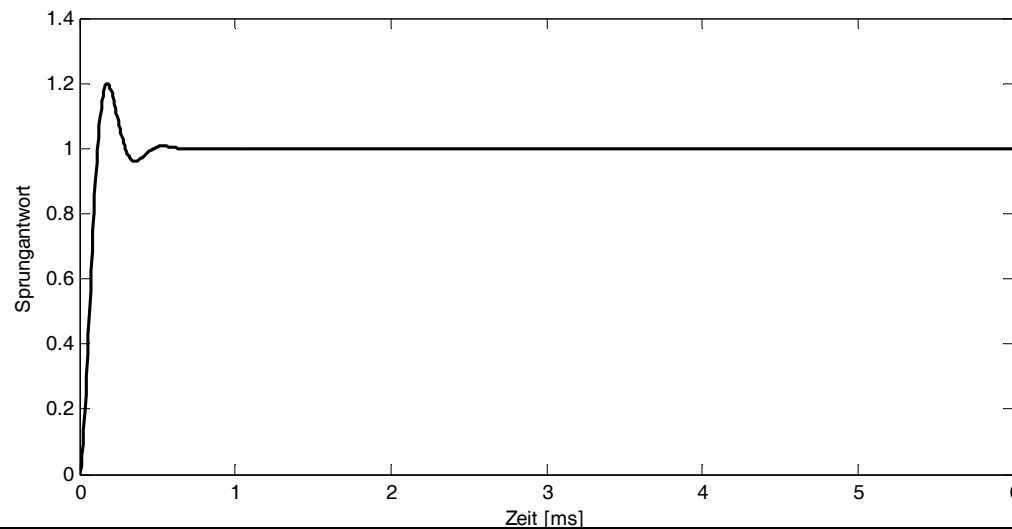
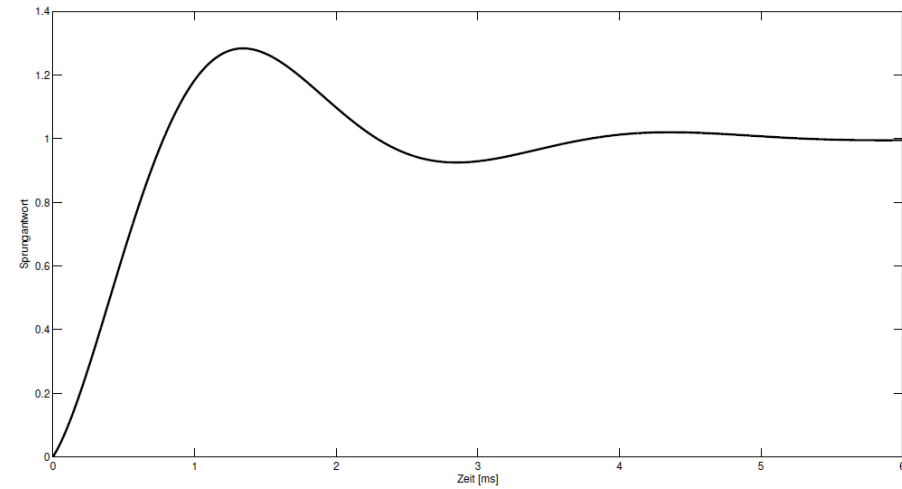
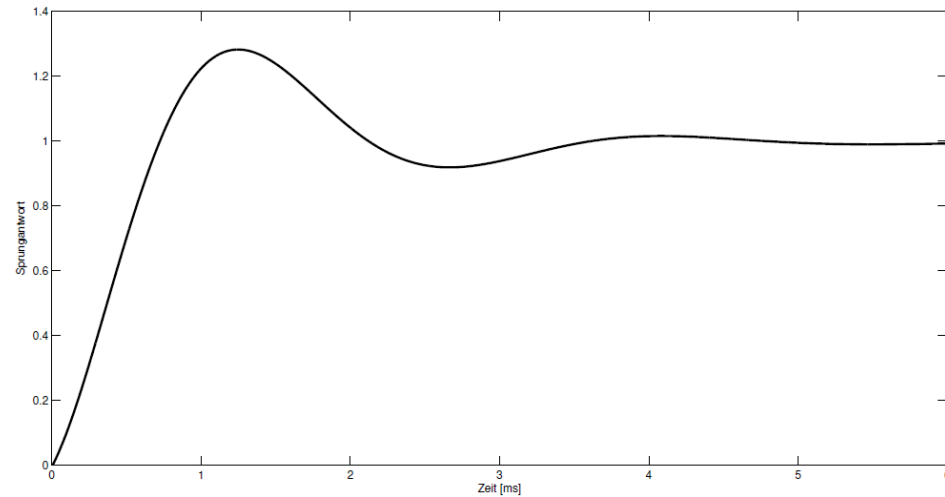
Simulation Results



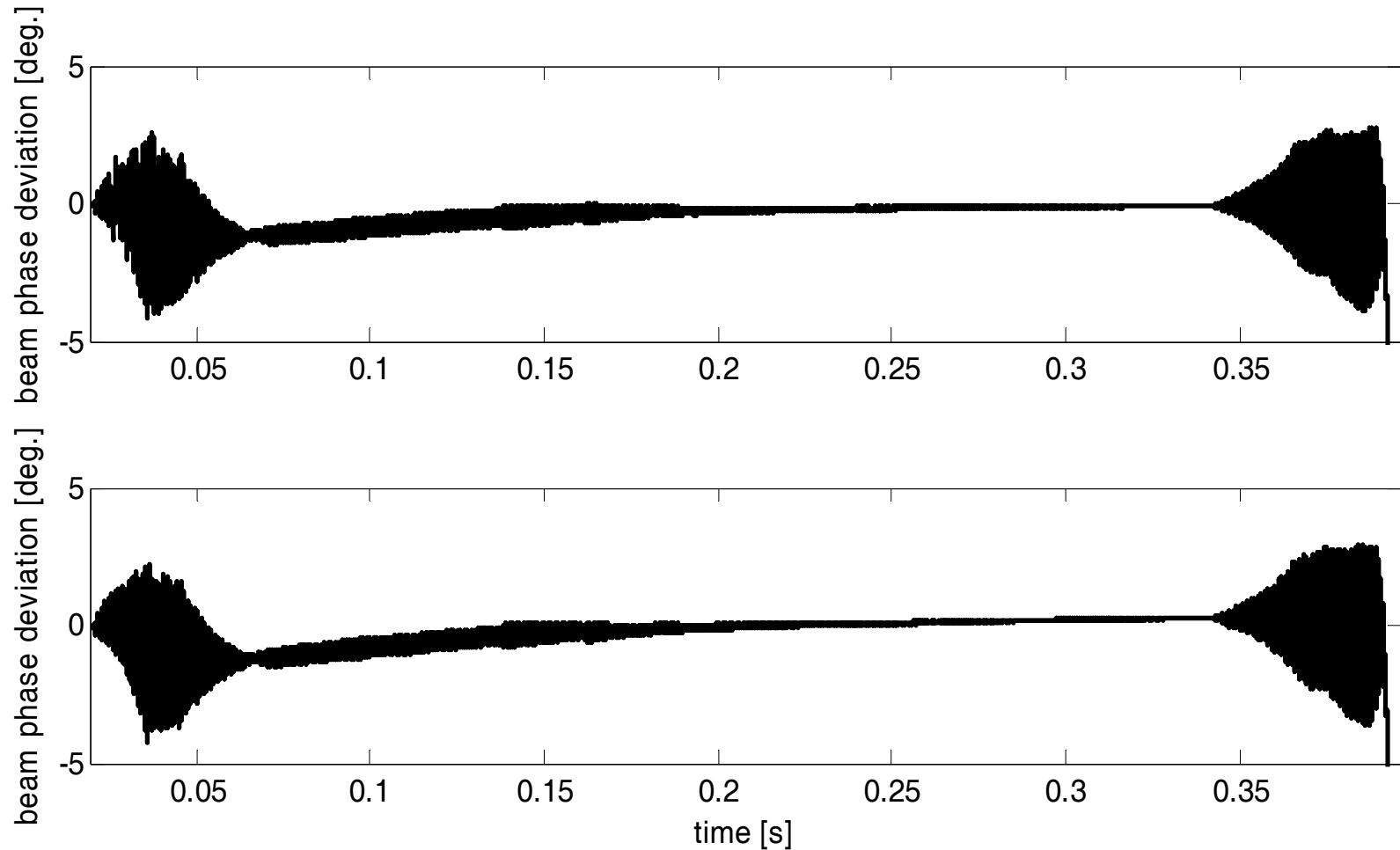
Simulation Results



Simulation Results



Simulation Results





Thank you for your attention!