Extending the Lean Blowout Limits of Low NO_x Gas Turbines by Control of Combustion Instabilities

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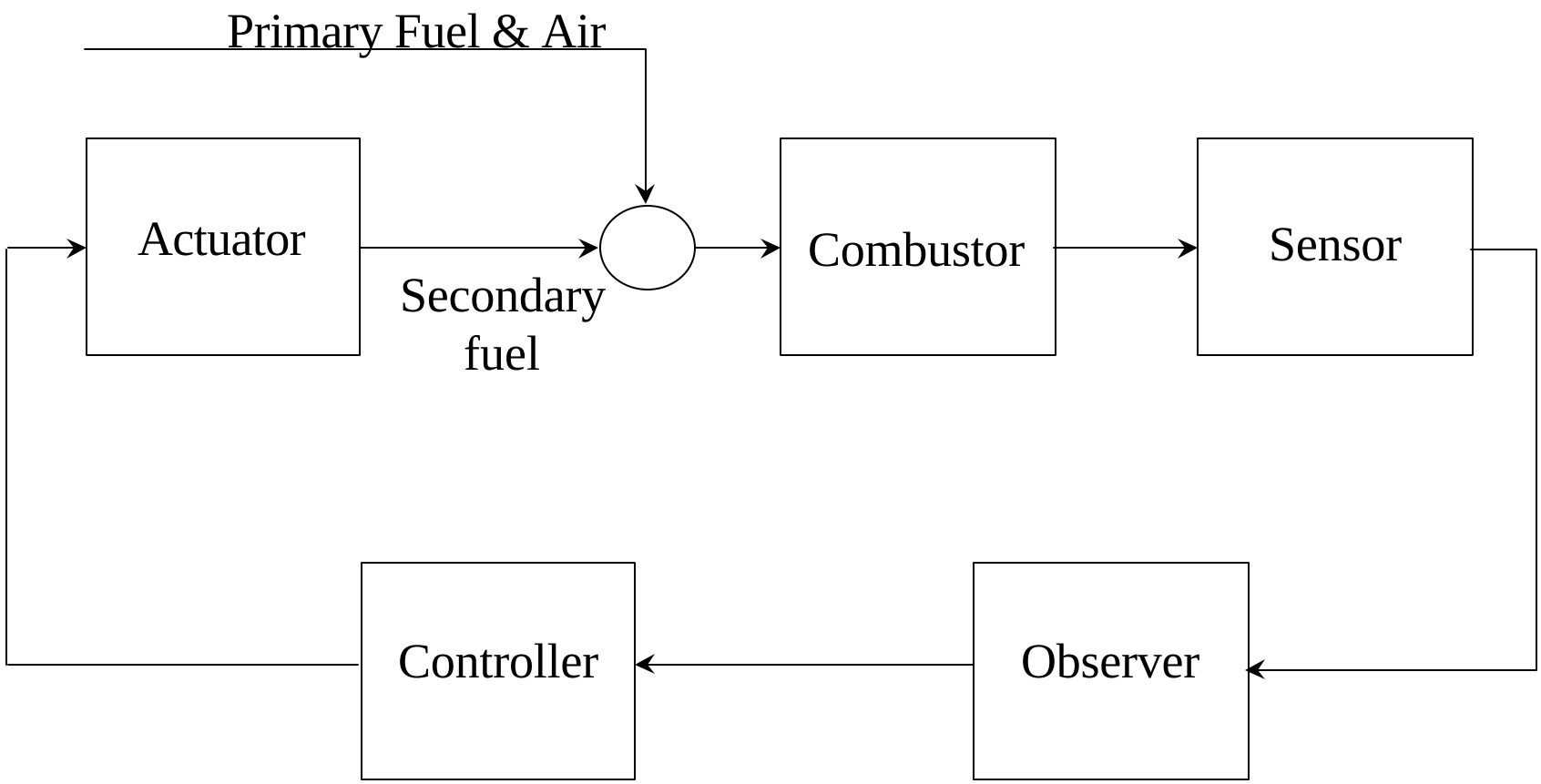
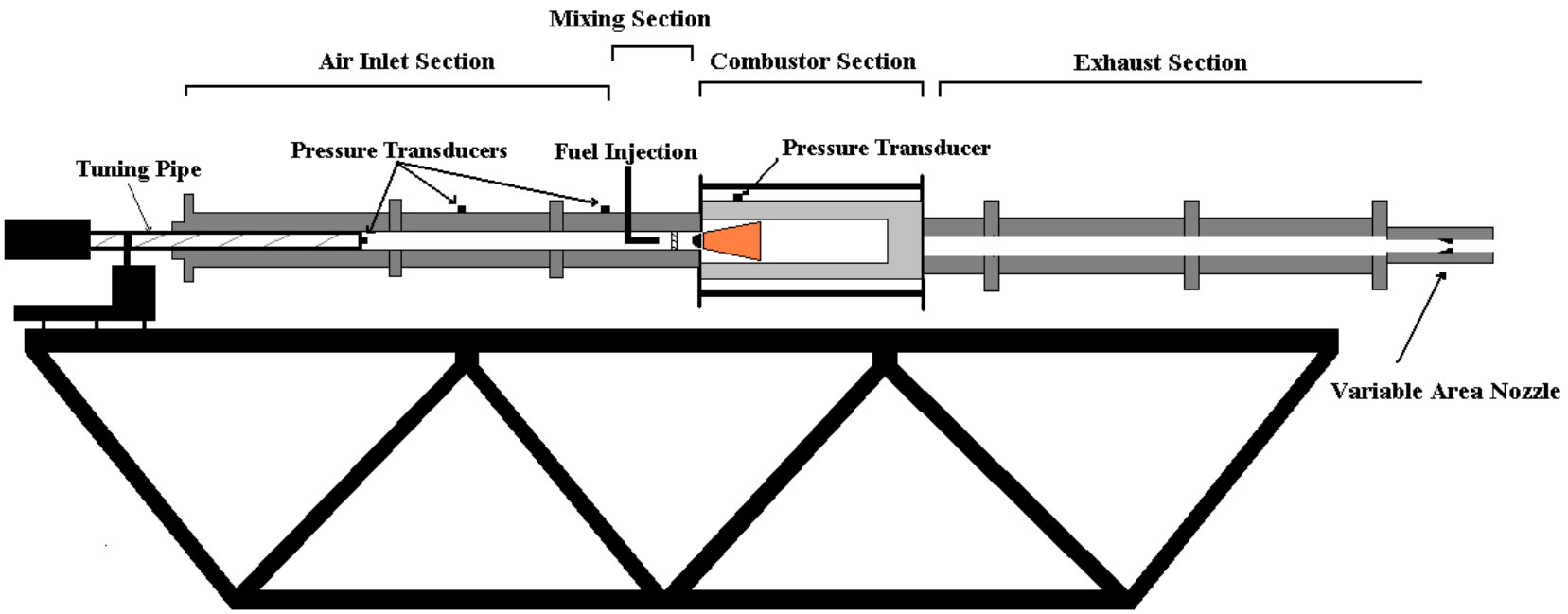
Program Goals

- Develop adaptive active control system (ACS) that can rapidly and effectively suppress combustion instabilities
- Demonstrate ACS on small and large scale lean, premixed combustors over a large range of operating conditions
- Disseminate technology to industry

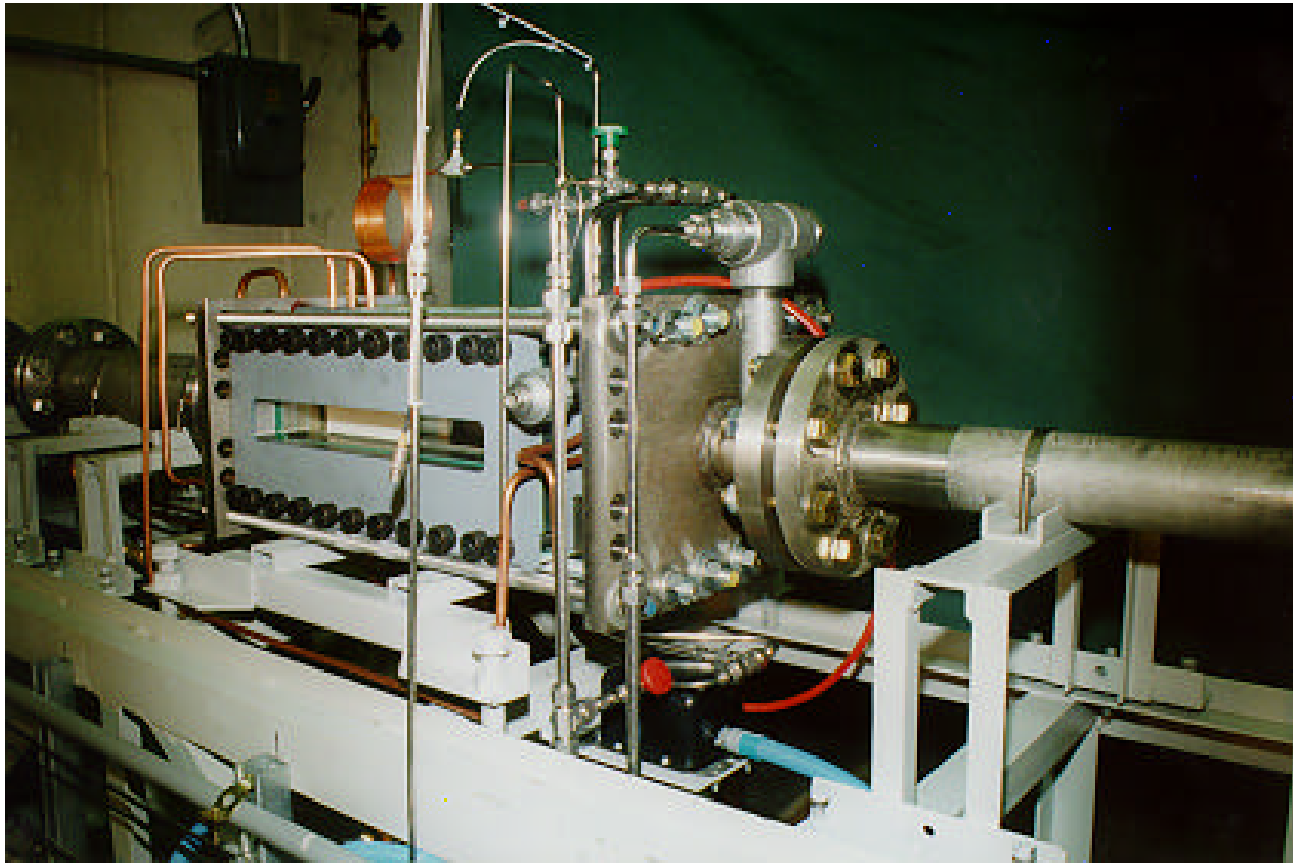
Developed Active Control



Georgia Tech LNGT Simulator

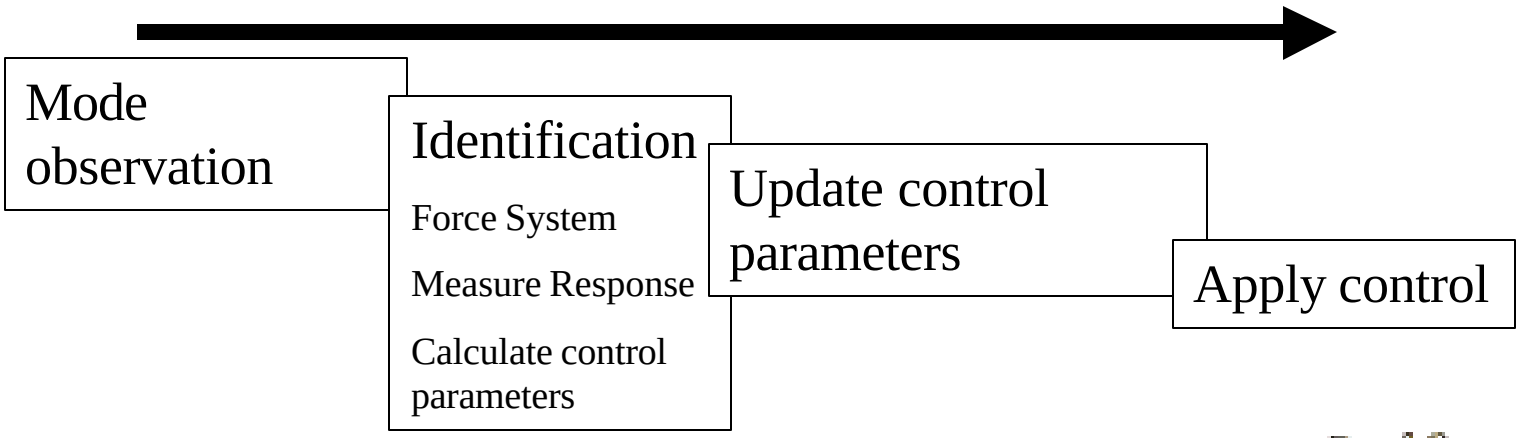


Georgia Tech LNGT Simulator



Online Identification of Instability Characteristics for Adaptive Control

- Methodology:
  - Force the system with a small control signal
  - Correlate system response
  - Apply phase correction to control signal

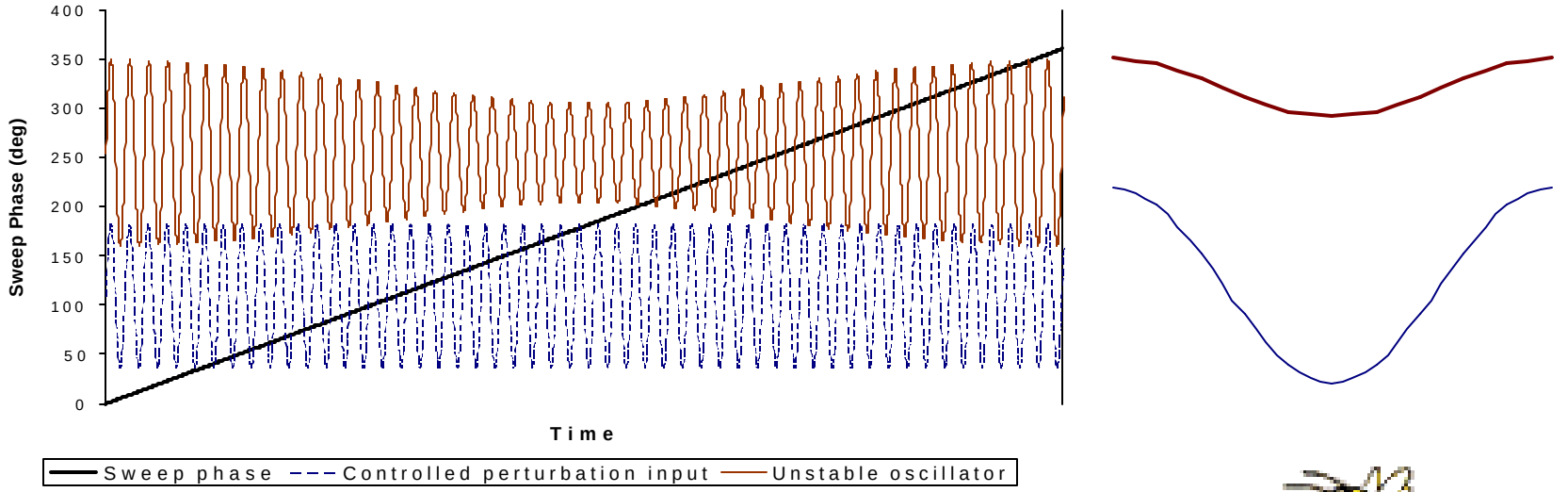


Online Identification Concept

- Goal: determine optimum control parameters
- Method:
  - Sweep through possible control phases, holding control input amplitude constant
  - Use observer to measure system response to control forcing

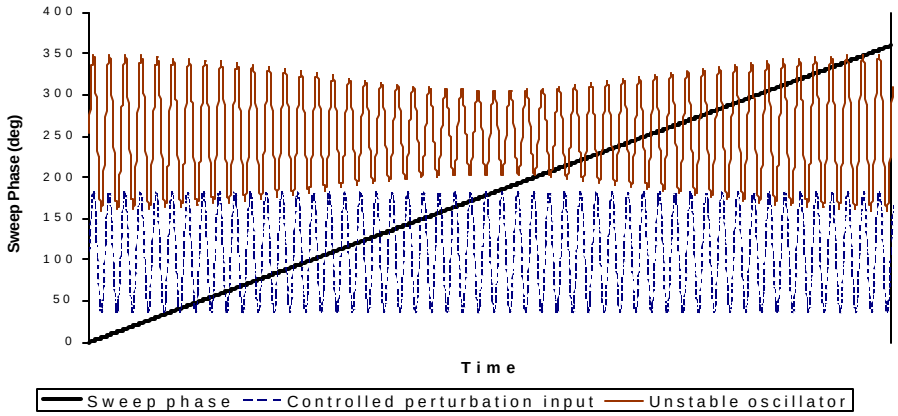
$$\text{Forcing} \sim \cos(2pf_i) \qquad \text{Response} \sim \cos(2pf_i - f)$$

  - Online correlation of system envelope response to identification phase

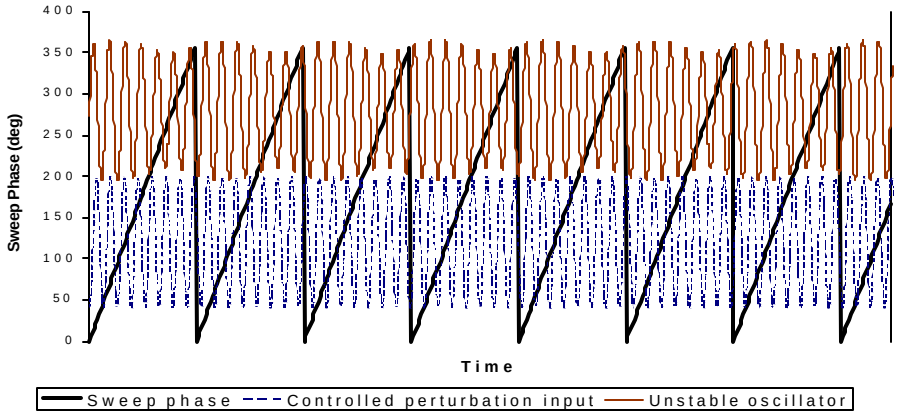


Online Identification Concept

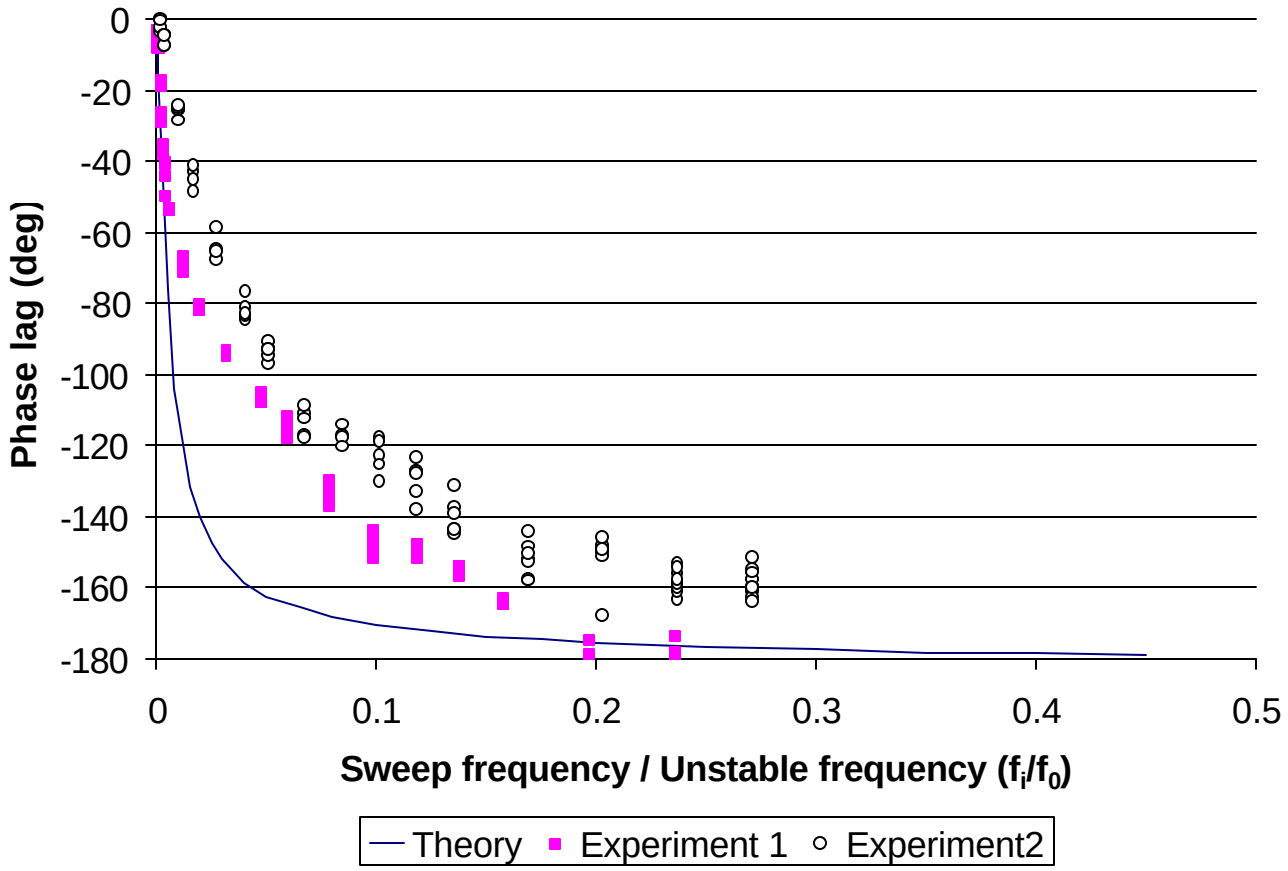
- Slow sweep of identification control phase
  - quasi-steady system response
  - minimal phase delay



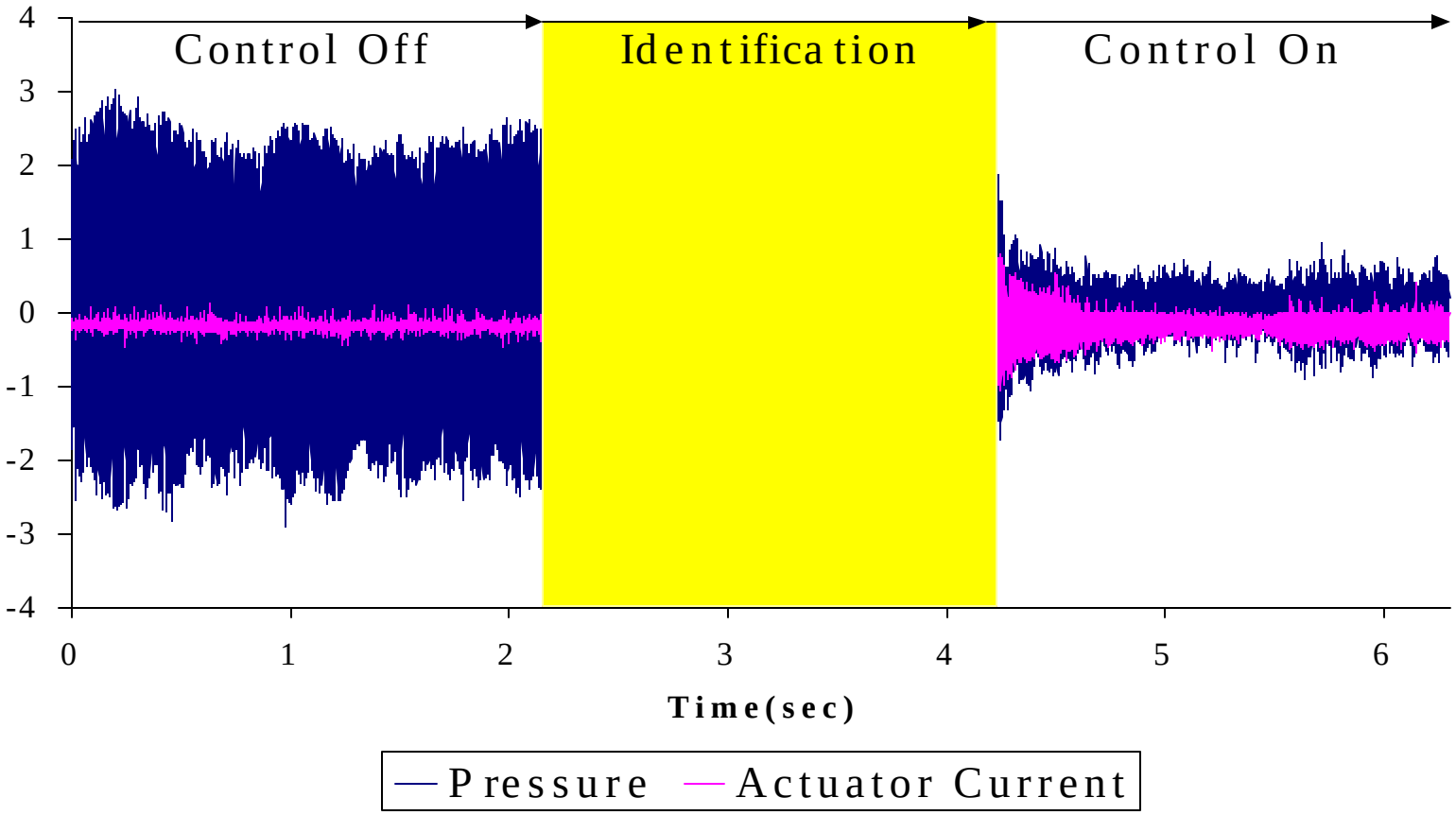
- Fast sweep of identification control phase
  - Faster identification - more desirable
  - must account for identification phase delay
  - must account for reduced amplitude response



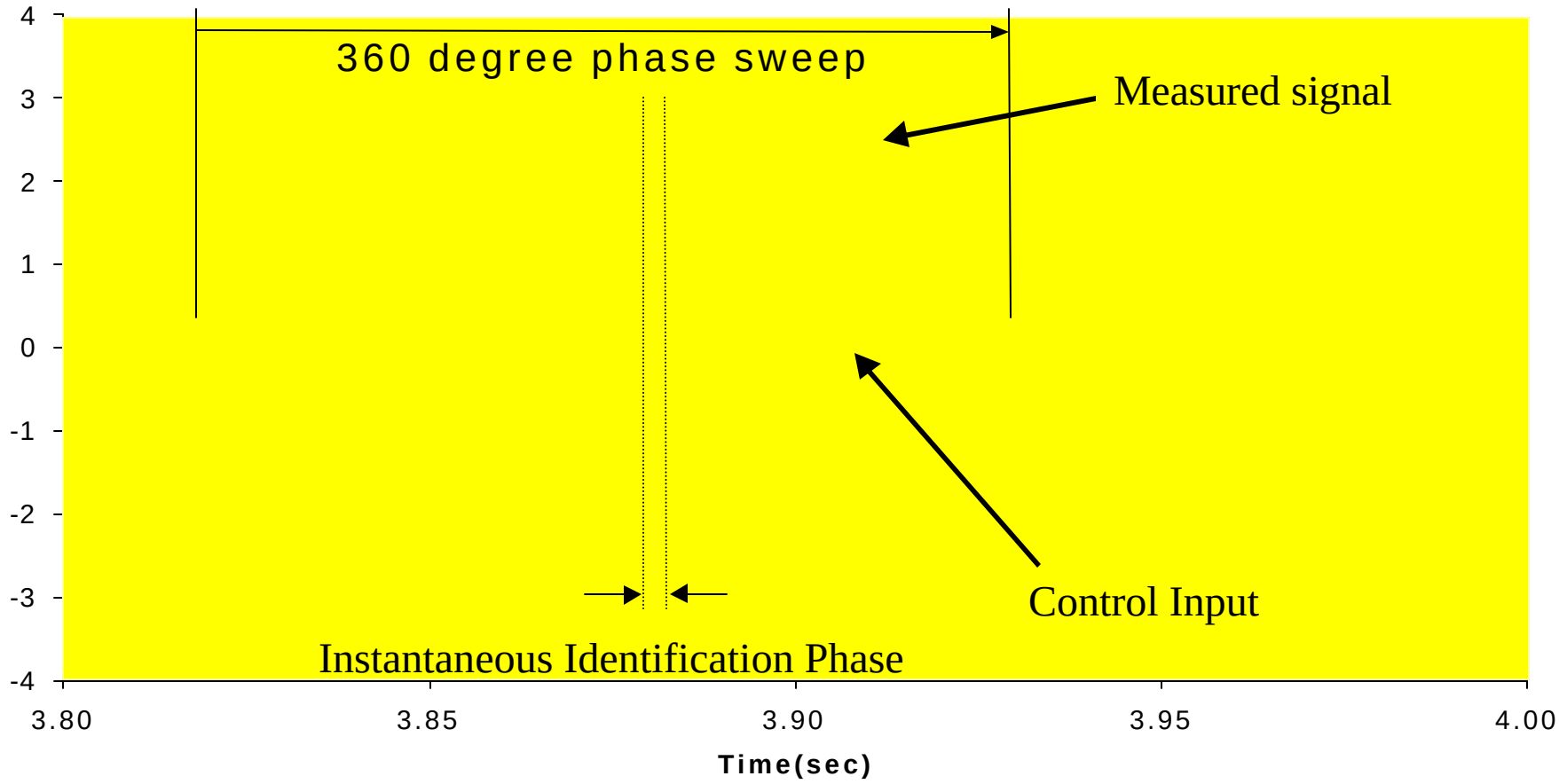
Phase Lag Dependence on Sweep Frequency



Identification and Control: Lean-premixed Combustor



Expanded View of Instability Identification



Program Accomplishments

- Developed online identification scheme for determining instability characteristics and optimal control parameters
- Implemented online identification scheme into an adaptive control system
- Demonstrated up to 15 dB reductions in instability amplitude on both a laboratory combustor and a single can of a full scale gas turbine combustor with the developed adaptive active control system