Combustion Process Instability Issues Being Addressed by the Glenn Research Center Active Combustion Team

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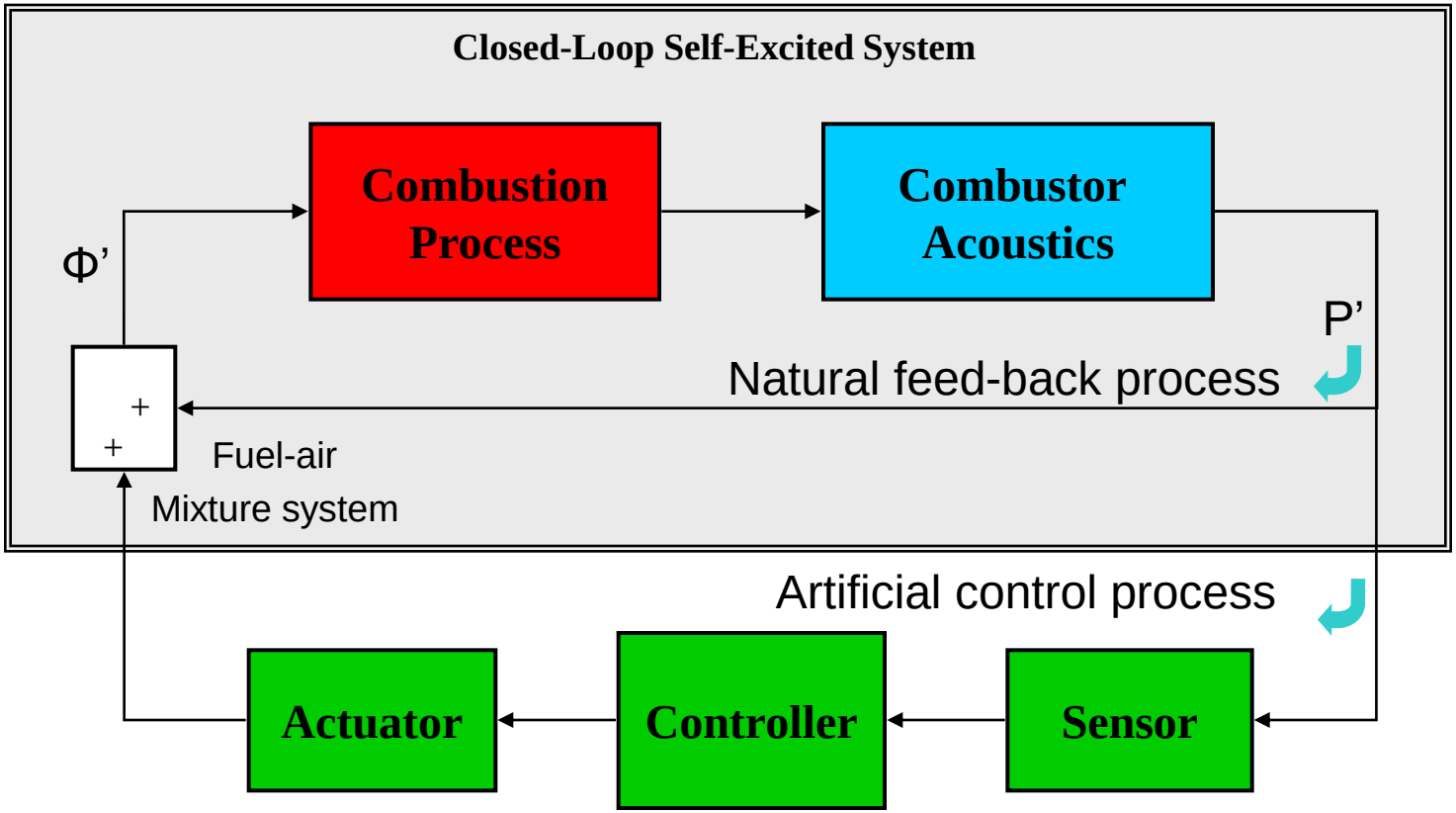
Strategy: Suppress, Modify, Re-channel, or Prevent combustion instabilities when they occur



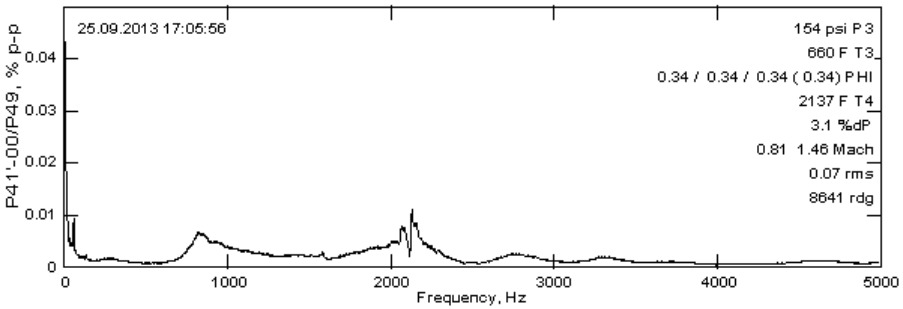
Combustor Dynamics Control Issues

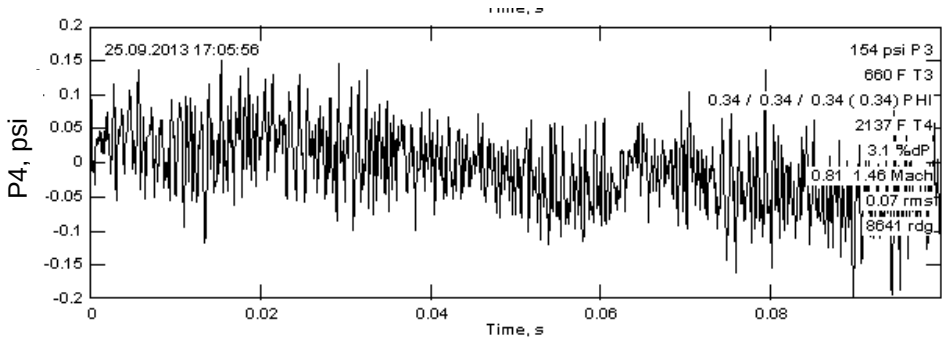
- Combustor
  - Test rig configuration
  - Fluid dynamic sensitivity
  - Staging flexibility
  - Fuel sensitivity
  - Thermo-acoustics
  - Part-load operability
- Sensing
  - Sensible phenomenon
  - Sensor
  - Sensor survival
- Control Smarts
  - Identify coherent dynamics - models
  - Noise rejection
  - Phase matching
  - Disruptive re-channel
- Actuation
  - Actuator
  - Response speed
  - Size

Prevent, modify, re-channel, or suppress

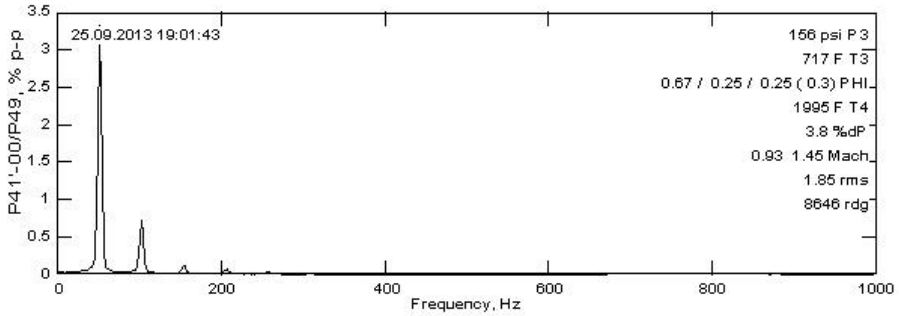
Good boys… sometimes… turn into terrorists

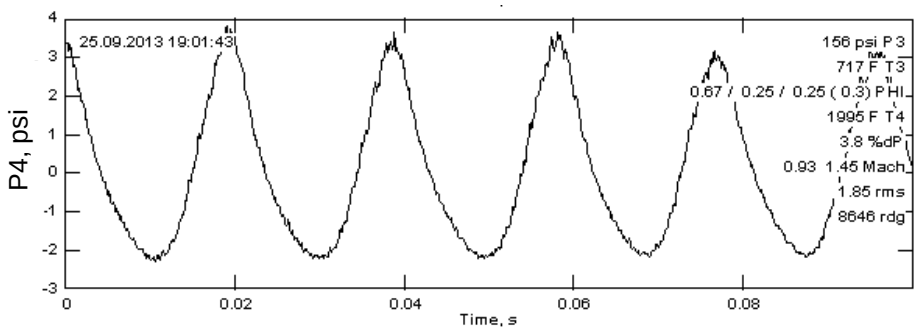
Normal combustor noise

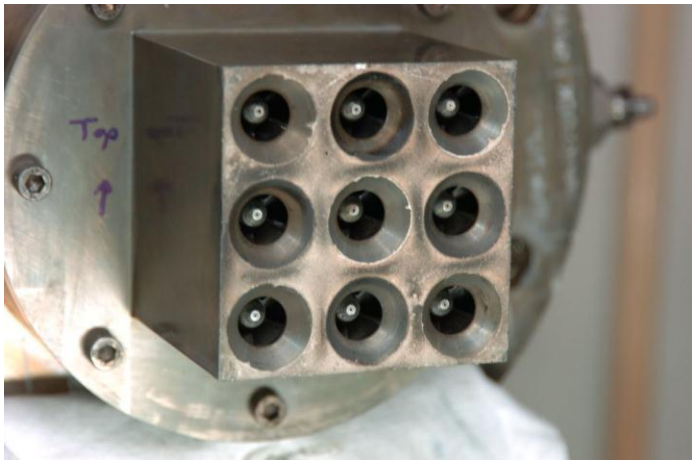




Abnormal instability



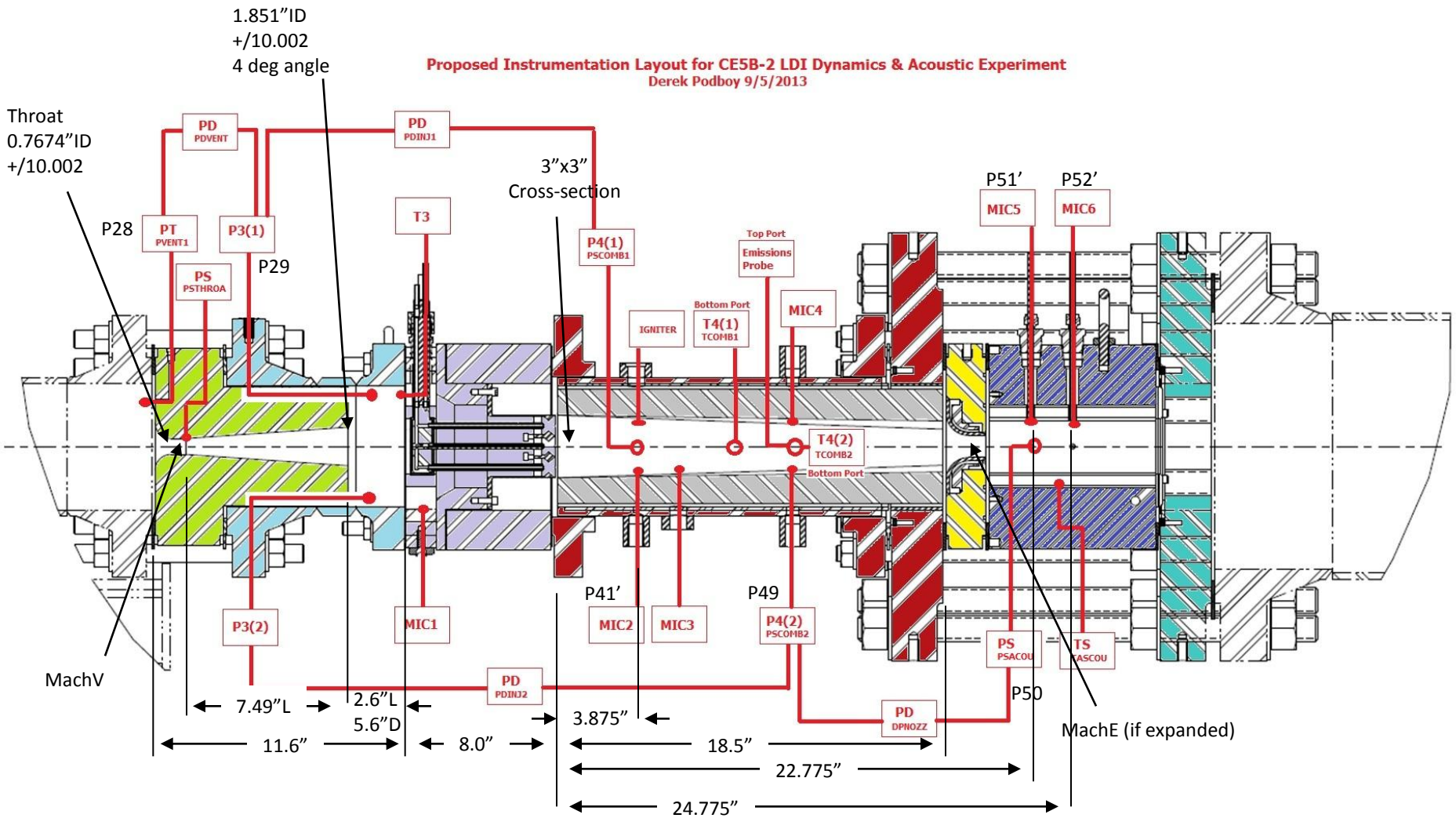




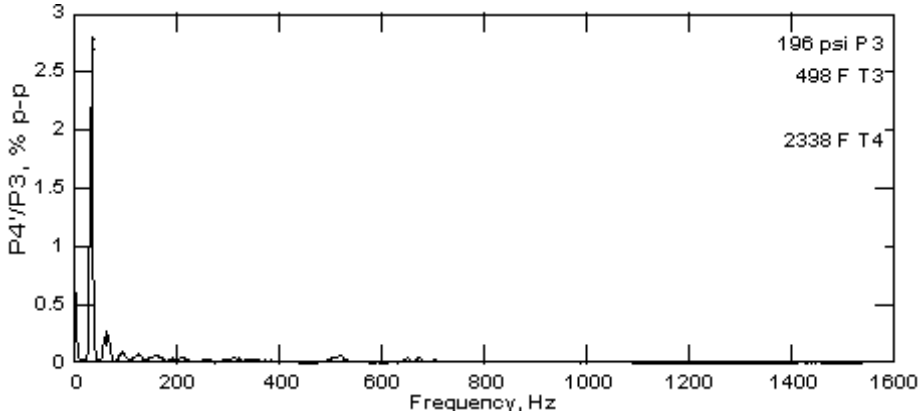
So…What happened?

Choked 9-point LDI Array Dynamics

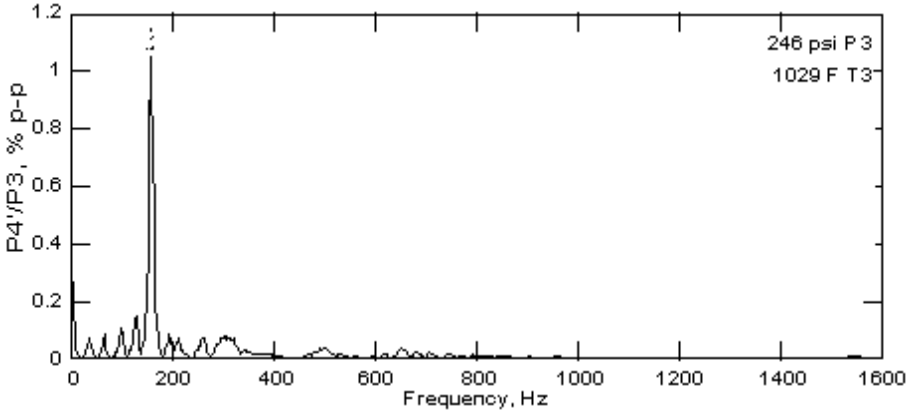
Boundary Conditions Matter!



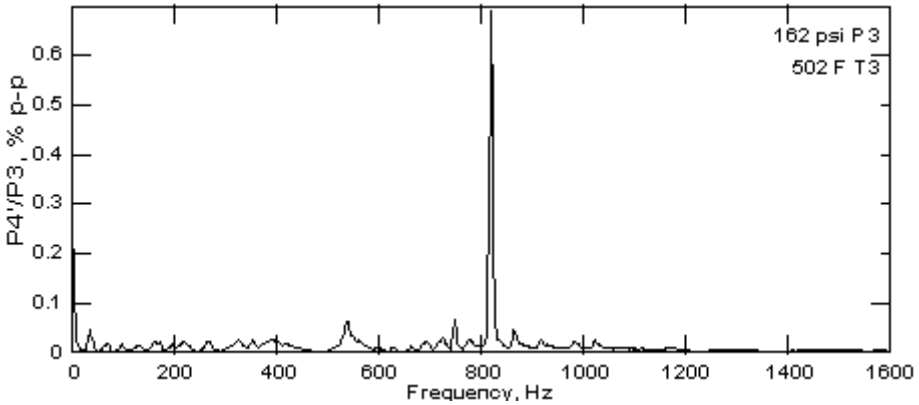
Multiple Modes May co-exist



Helmholtz Resonator mode (?)



Longitudinal mode?

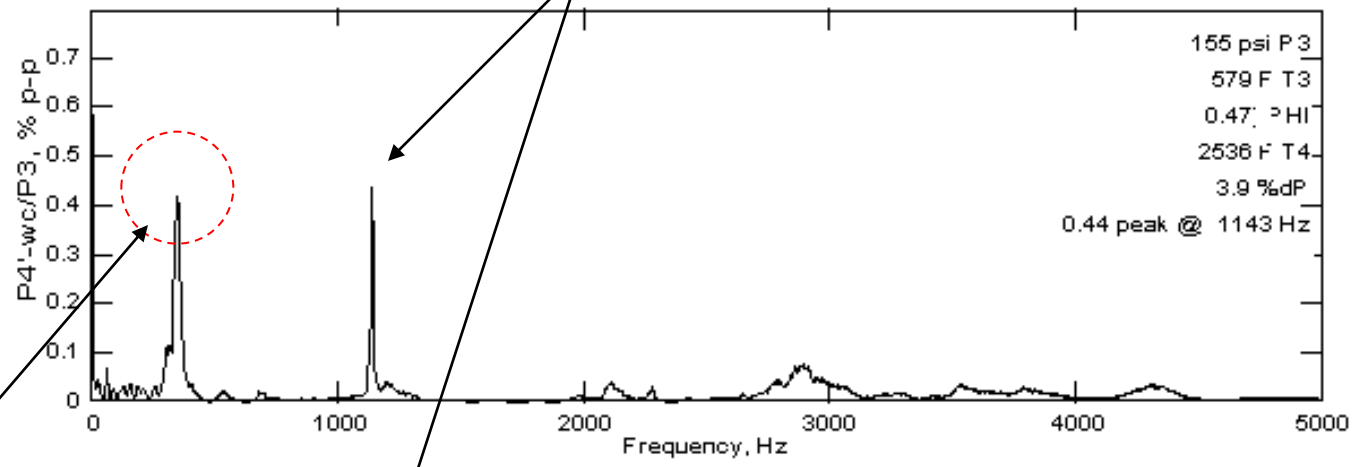


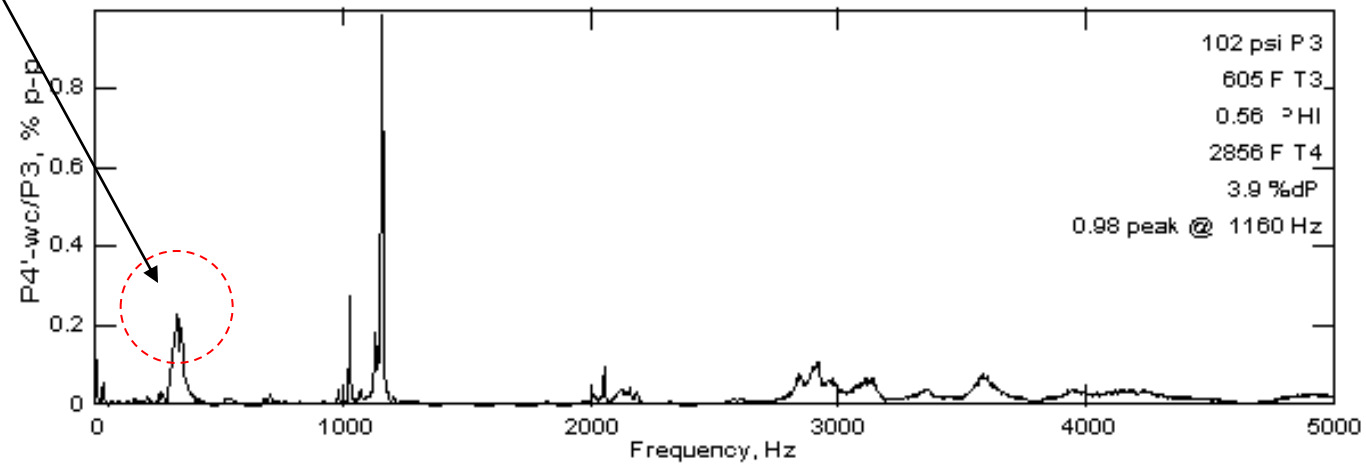
Vortex Precession mode (?)

Sensor installation Matter!

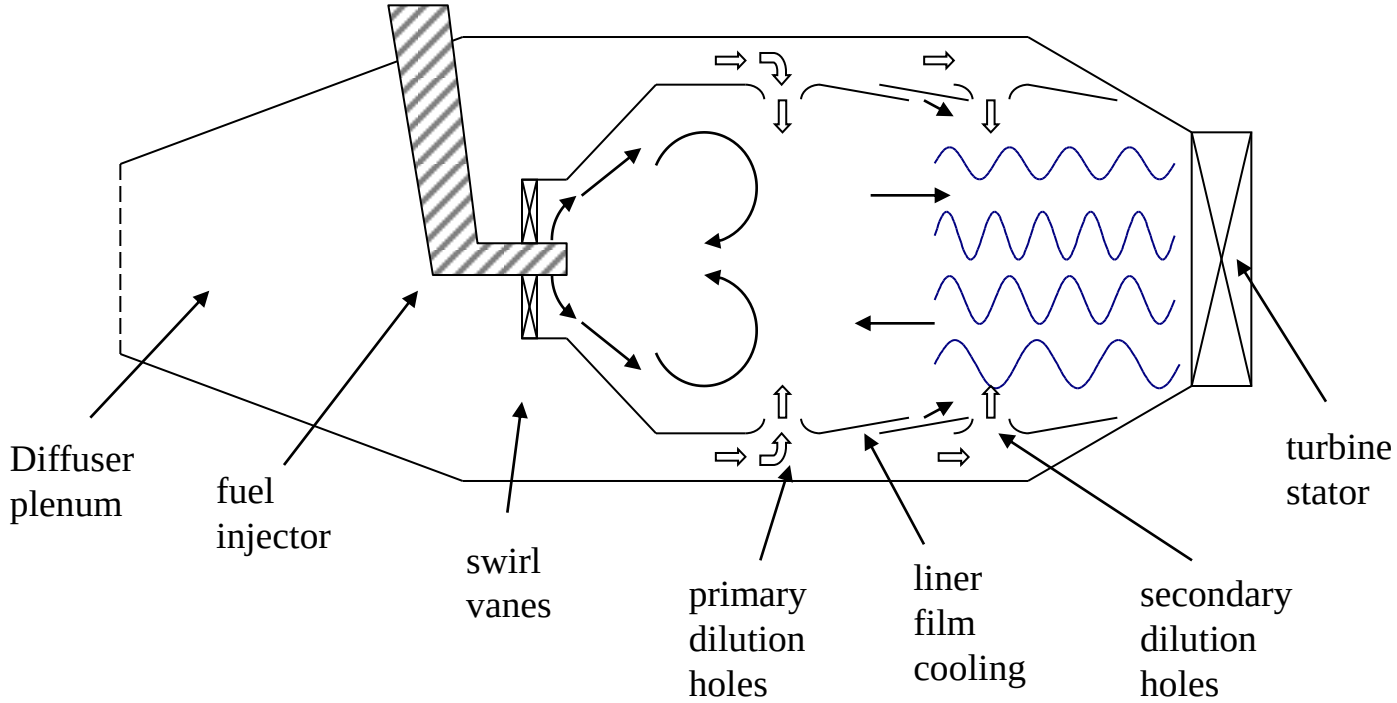
Instability

Sensor Resonance Cavity





Issues that Affect Combustor Instability & Acoustics



1. Well-defined acoustic boundary conditions

2. Perturbations from fuel-nozzle turbulence

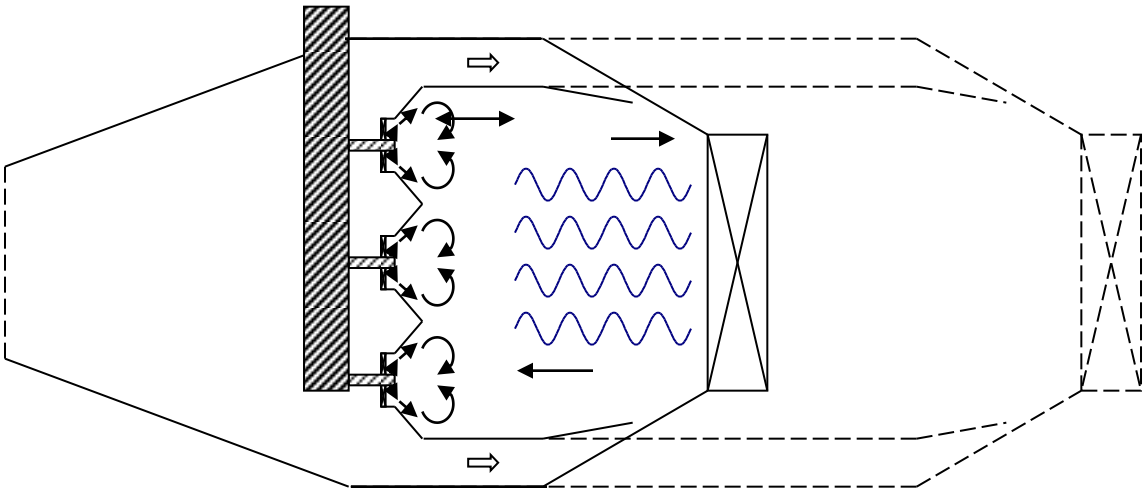
3. Recirculation vortex provides flame-holding

4. Liner film-cooling provides damping

5. Multiple temperature zones

6. Φ' interaction with P'

Sensitivity from uniformity



1. Higher-performance fuel injectors: more turbulence

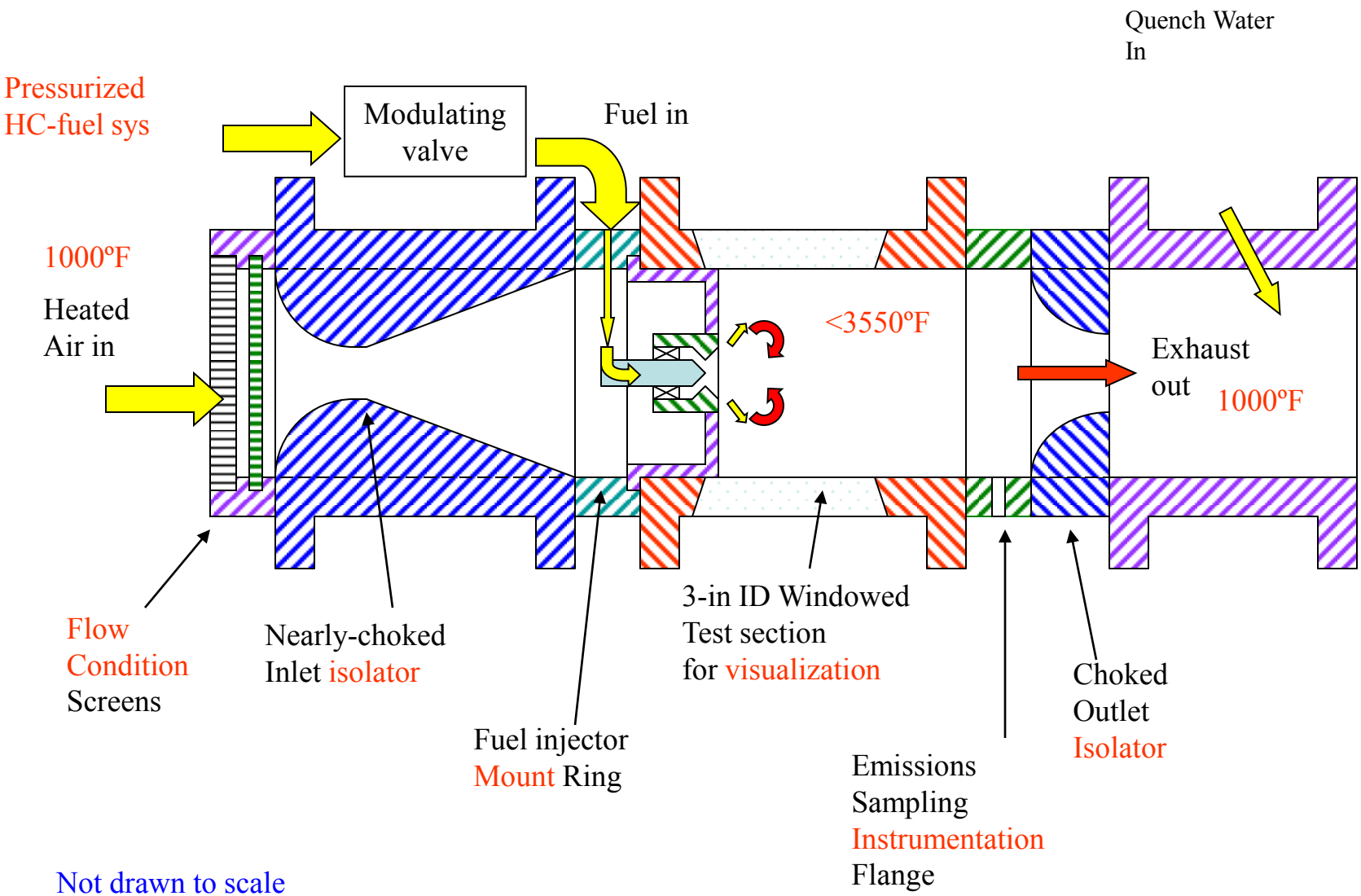
2. Reduced film cooling: reduced damping

3. More uniform temperature and composition

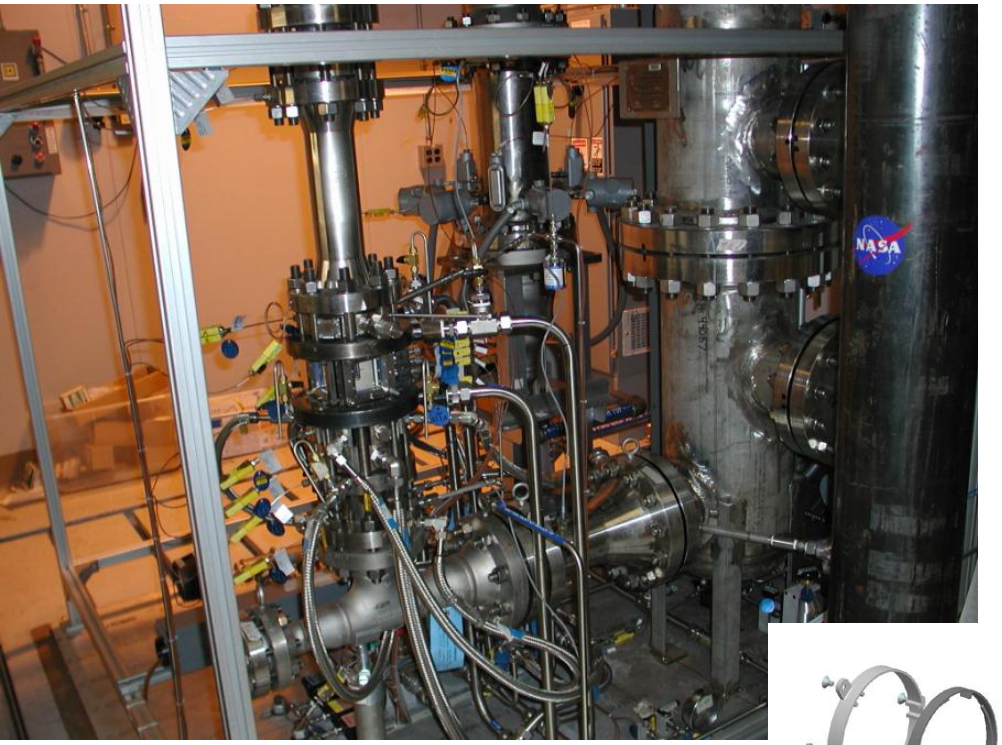
4. No dilution holes: reduced flame-holding

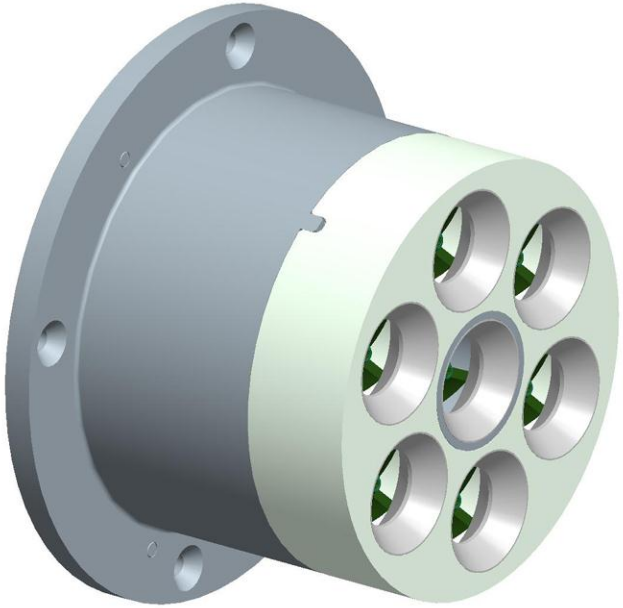
Q: How much non-uniformity is enough for disruption?
Q: What happens if some of the injectors are recessed?
Q: Asymmetrical, non-repetitive components

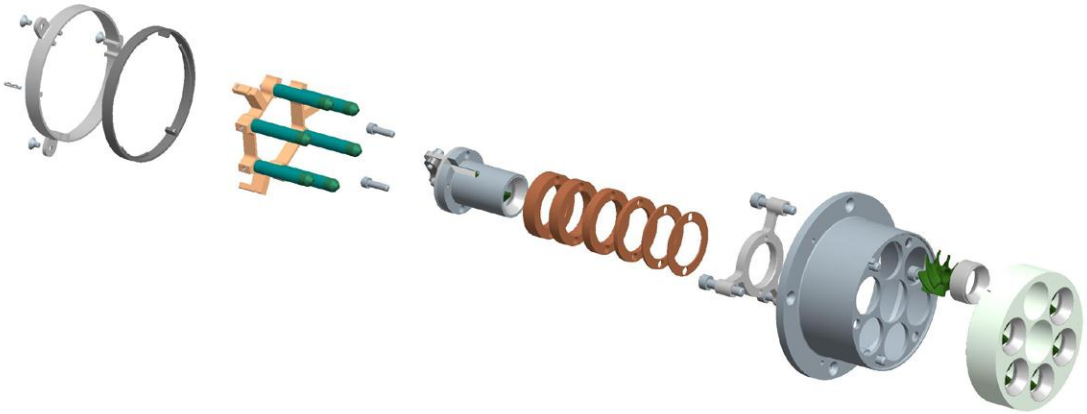
CE-13C Dynamics Screening Rig Operational (Took us long enough!)



CE-13C Piloted 7-point LDI







- Recessed piloting
- Injector variation
- Array interaction
- Fuel reactivity