Hydrogen Combustion Research for Gas Turbine Engines

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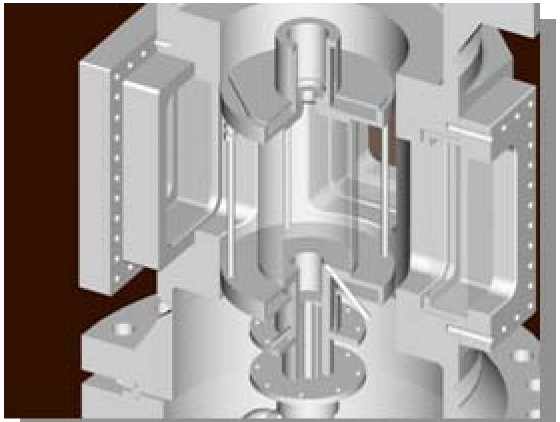
Partnering with National Energy Technology Laboratory (NETL)

Approach:

- **Extend data base for lean premixed swirl burners to realistic pressures and temperature. Emphasis on H_2-enriched fuels.**
- **Atmospheric-pressure tests in SimVal burner at Sandia; high-pressure tests at NETL.**
- **Utilize Sandia's diagnostic expertise for the development of high pressure diagnostics in realistic gas turbine environments.**



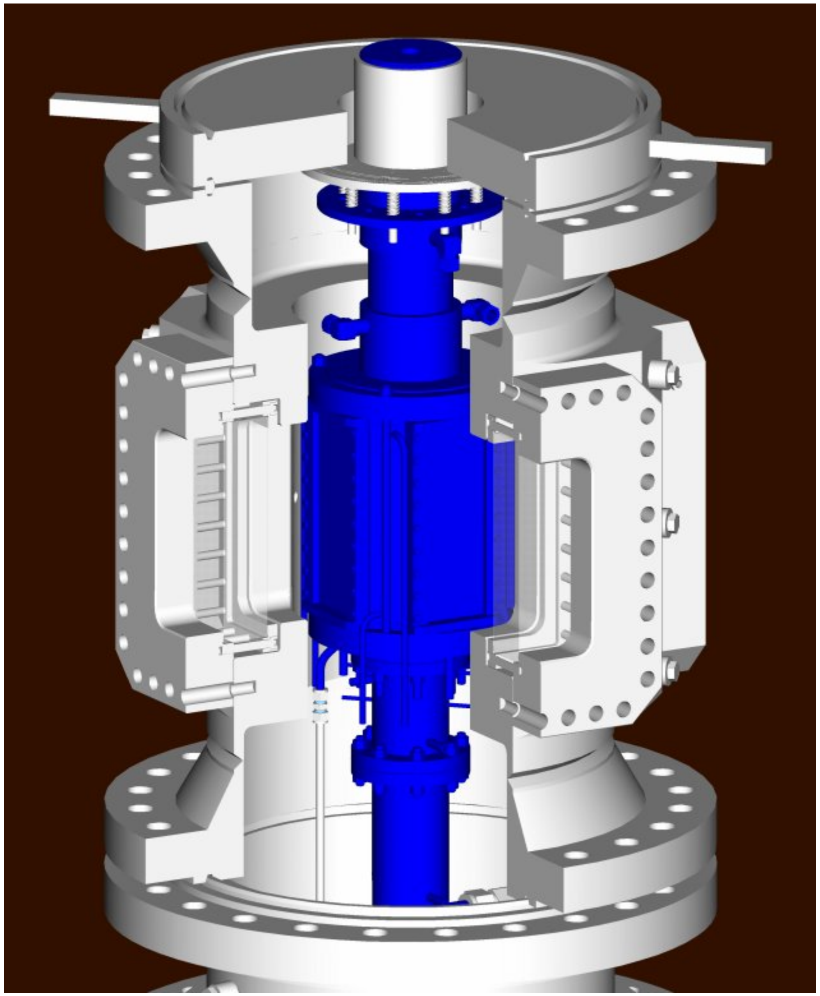
Sandia Burner

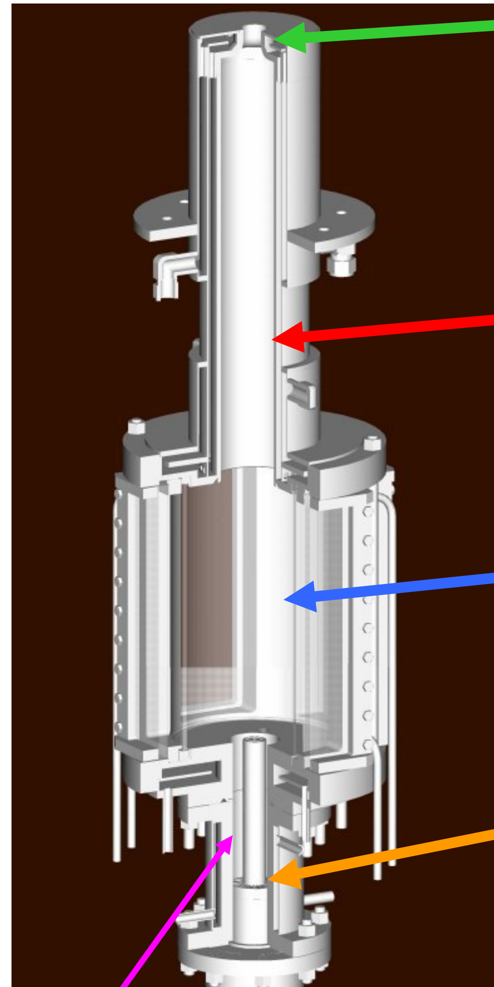
- **Atmospheric pressure operation**
- **Design optimized for Sandia CRF laboratory facilities**
- **Full optical access for optimal use advanced diagnostics**

NETL Burner

- **Operation to 30 atmospheres**
- **Inlet temperature to 800 K**
- **Optical access**
- **Limited datasets at elevated pressure**

SimVal Combustor Geometry





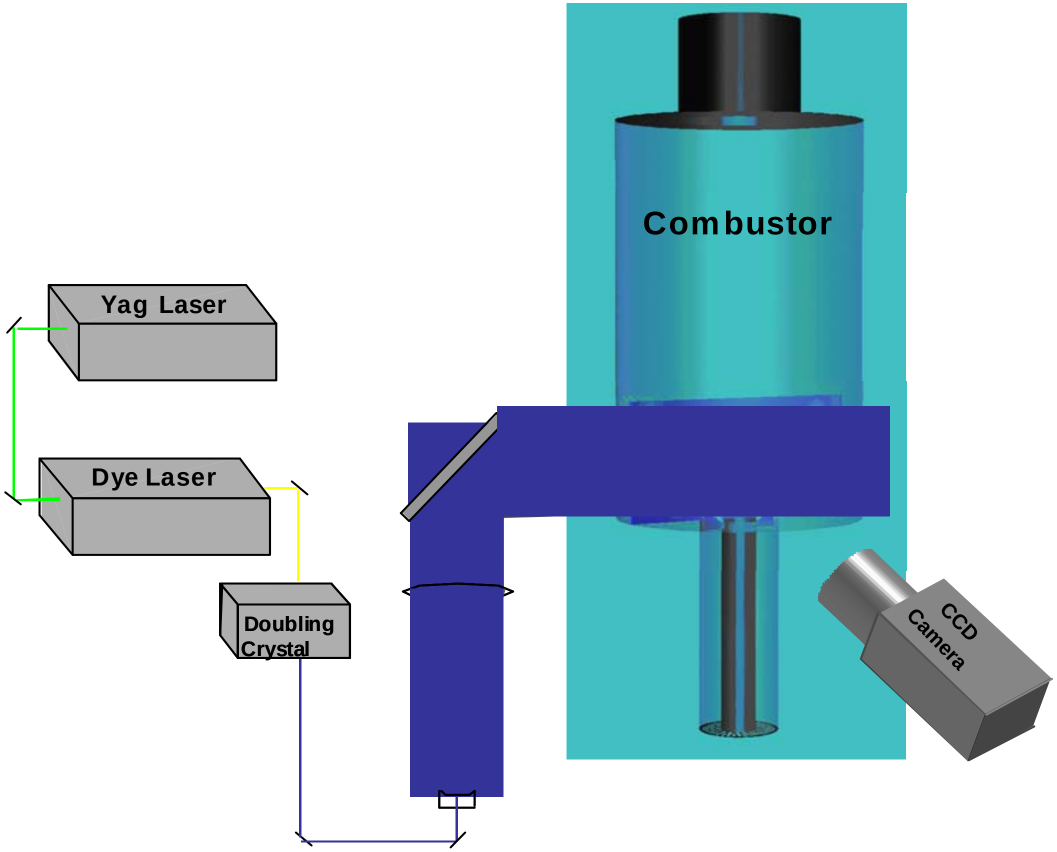
SimVal Project Goals

- Provide data sets for the validation of CFD (LES) simulations to aid the development of advanced gas turbine combustors
  - Gather data at elevated combustor pressures
  - Emissions
  - Dynamic modes and pressures
  - Flow field characterization
  - Boundary condition characterization
  - Dynamic events and transitions
    - Lean Blow-Off
    - Flashback
    - Abrupt changes in dynamics and emissions
  - Effects of fuel variability on emissions, dynamics, lean blow-off, and flashback.

SimVal Facility Test Capabilities

- **Combustion Air**
  - **Flow Rate: 0 - 70,000 slm (0 – 1.1 kg/s)**
  - **Preheat Temperature: 0 – 800 °K**
- **Natural Gas**
  - **Flow Rate: 0 - 4,700 slm**
- **Hydrogen**
  - **Hydrogen flow rate: 0 - 470 slm**
- **Test Section Operating Conditions**
  - **Pressure: 0 - 2,200 kPa (22 atm)**
  - **Temperature: 0 – 800 °K**

Experimental System



Test Conditions

Pressure 1-8 atm

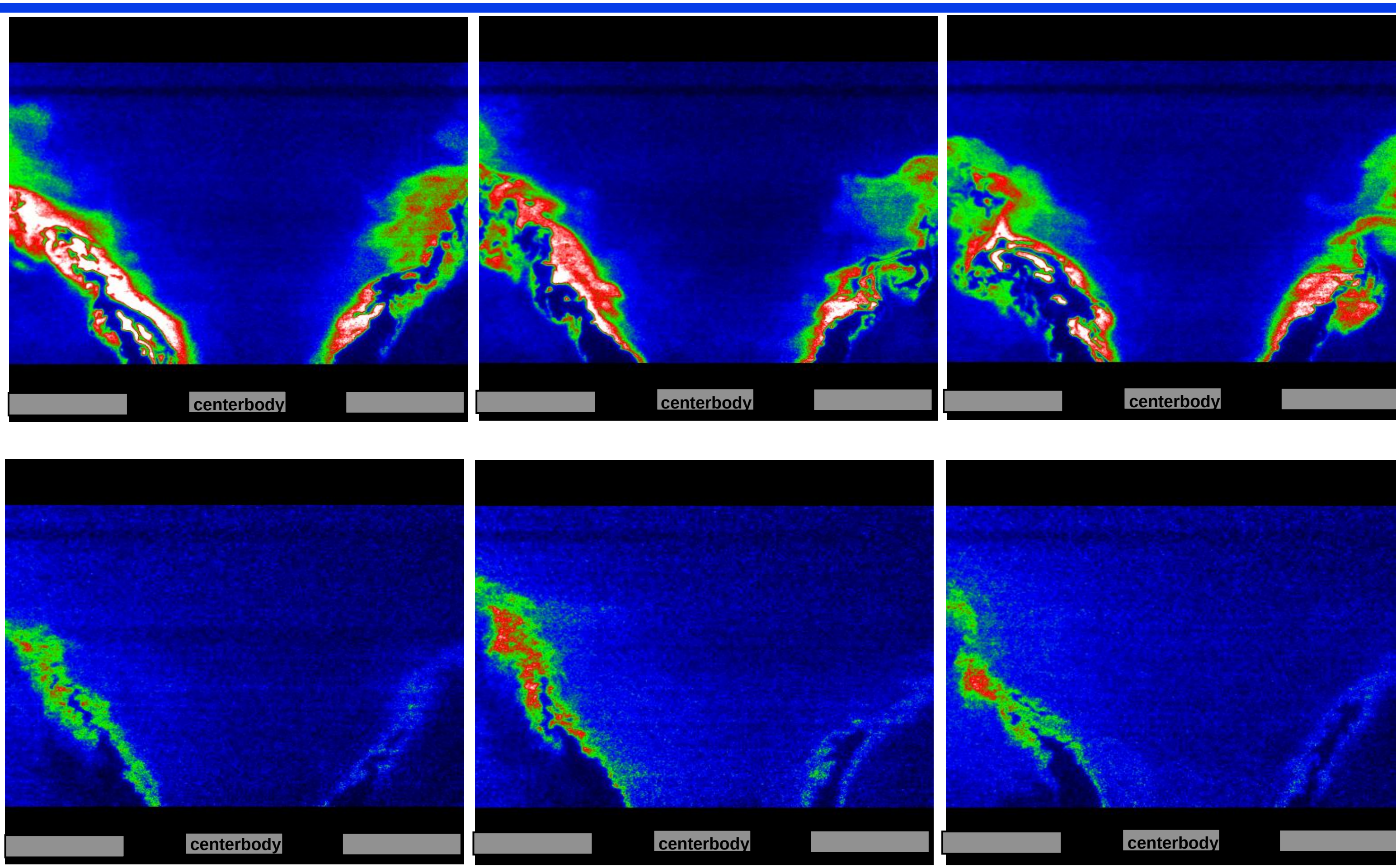
Preheat 520-600 K

H_2 addition 0-60% in NG

Equivalence ratio 0.5-0.6

Effect of Pressure

60% H2 / 40% NG   Φ=0.6   Tin= 522-580K   V=40 m/s

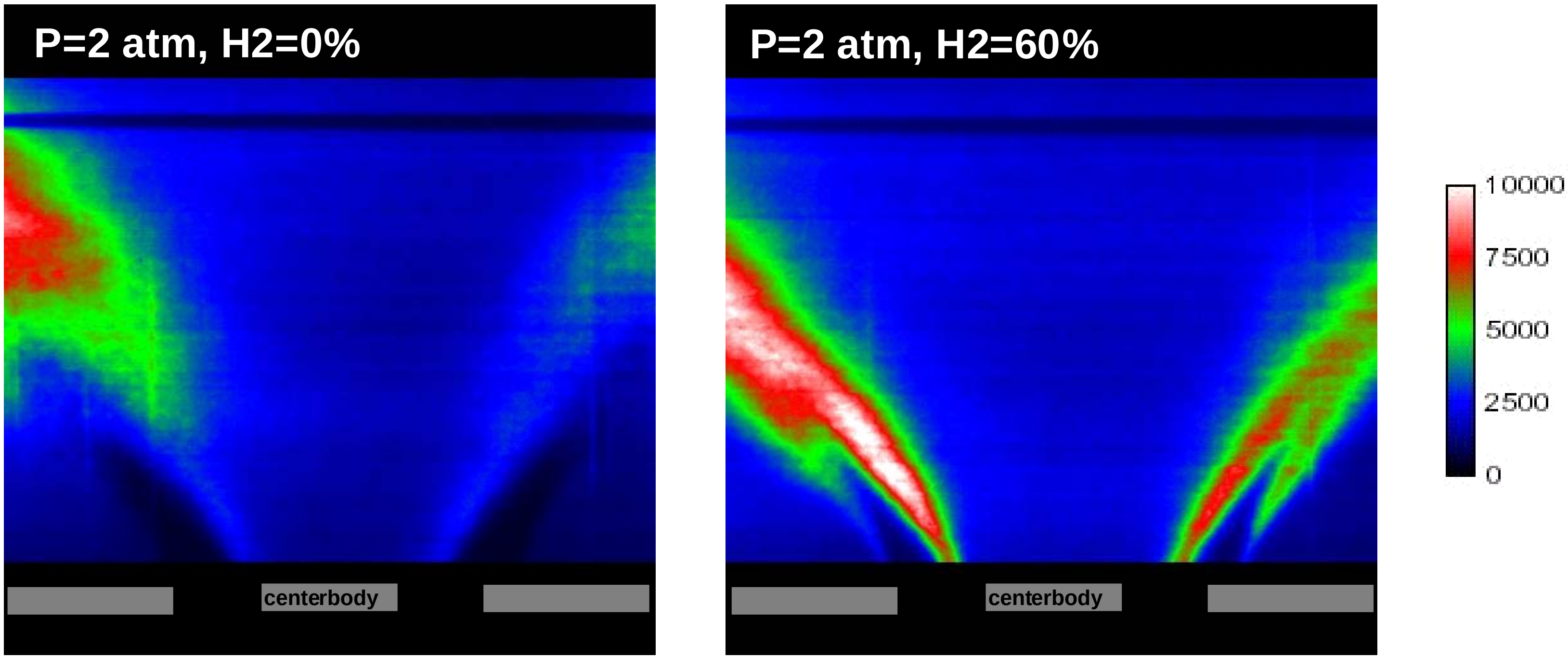


P=1atm
Scaled
0-20,000

P=8atm
(50% H2)
Scaled
0-5,000

- **Increased pressure reduces flame thickness**

Effect of H_2 Addition



- H_2 addition reduces flame thickness and moves flame stabilization point farther upstream