

Performance Benefits of H₂ Doping of a Lean Premixed Gas Turbine Injector

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Advanced Combustion Engineering

August 31, 2007

- **Background and Goals**
- **Project Description**
- **Results**
- **Recommendations**

Determine the effects of injecting small amounts of hydrogen into a natural gas fueled lean premixed injector

- Document Improvements in lean blow out limits
- Assess NOx emissions reductions from the lower flame temperatures
- Determine the optimal location where the Hydrogen should be injected

Good Fuel/Air Mixing + ultra lean operation lowers:

- Flame Temperature
- NOx Concentrations

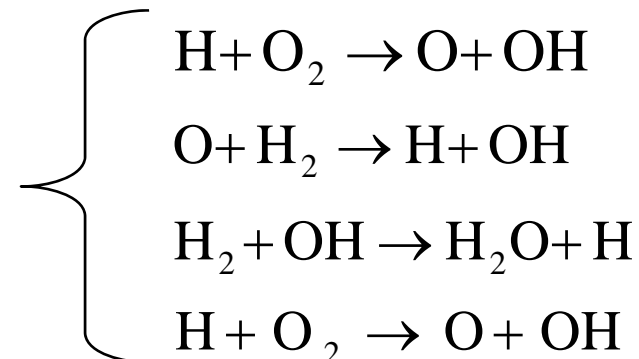
Increasing Restrictions on NOx emissions

- Decrease Flame Temperature Further → H₂ injection

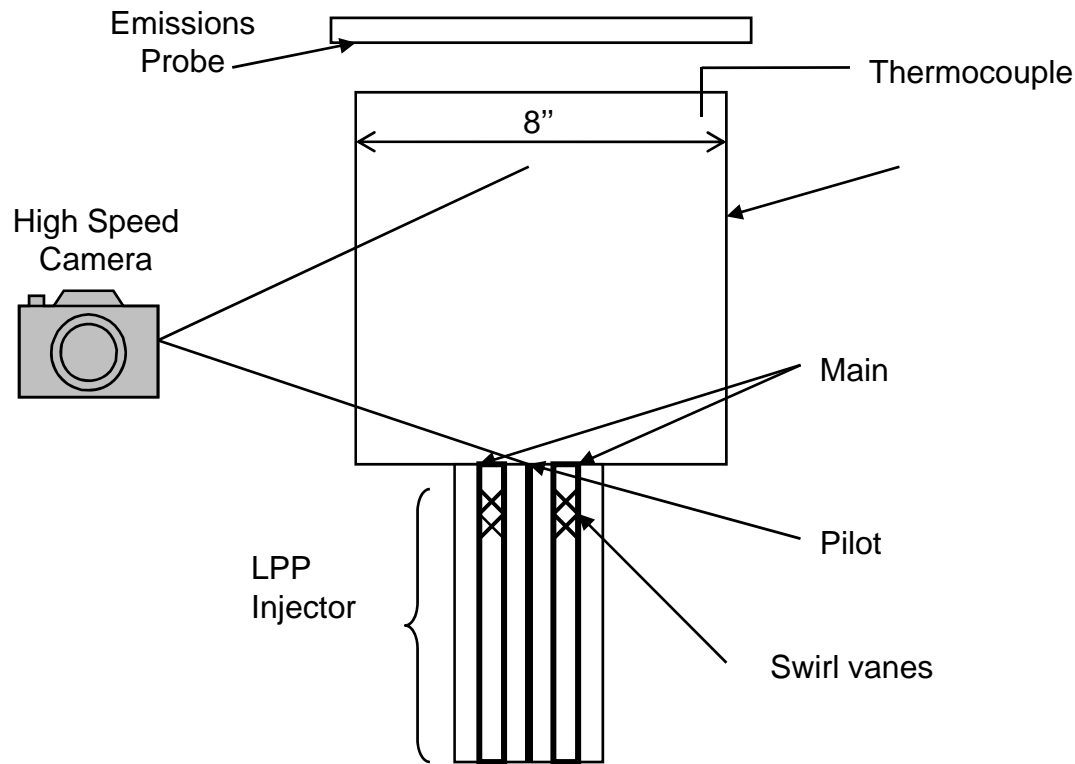
H₂ has the potential to stabilize the flame near Lean Blow Out by enhancing natural gas reaction rates via increases in

- Temperature
- Radical Concentration

H₂ quickly decomposes forming a radical pool of OH, H, and O via the reactions

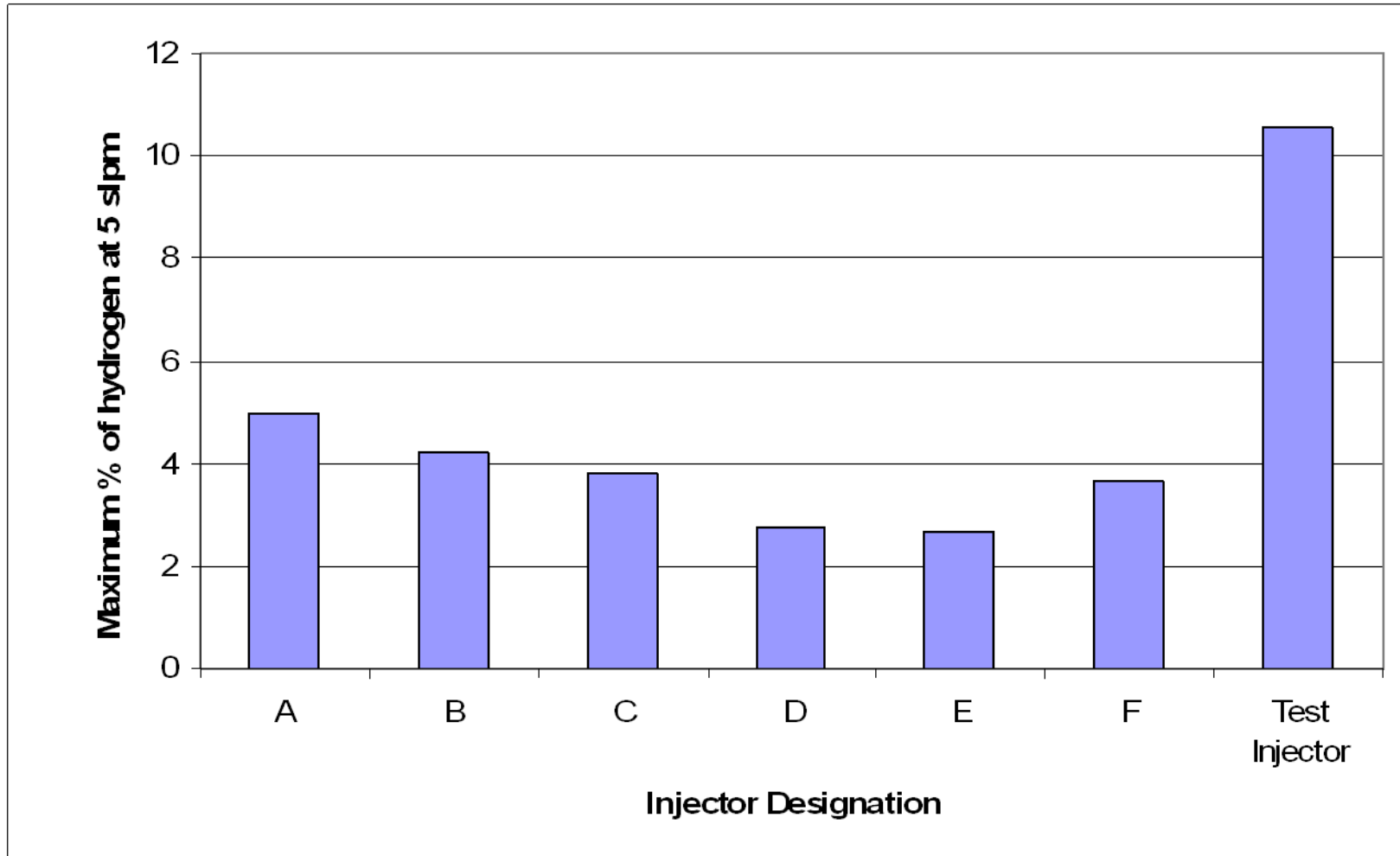


Hardware



- Variable Geometry LPP Injector ($A_e = 0.8 - 1.8 \text{ in}^2$)
- 8" quartz tube combustor

Choice of Injector



Used DOE to focus on the most important parameters

Preliminary Parameter Space

- % DP
- % pilot
- % hydrogen
- Inlet temperature
- Hydrogen injection location

- Data were analyzed
- Regressions were developed
- Low Confidence Intervals
- The variables displayed strong interrelations

Nozzle velocity

- % DP
- inlet Temperature

% Hydrogen

- % DP
- inlet Temperature
- % pilot

Preliminary Parameter Space

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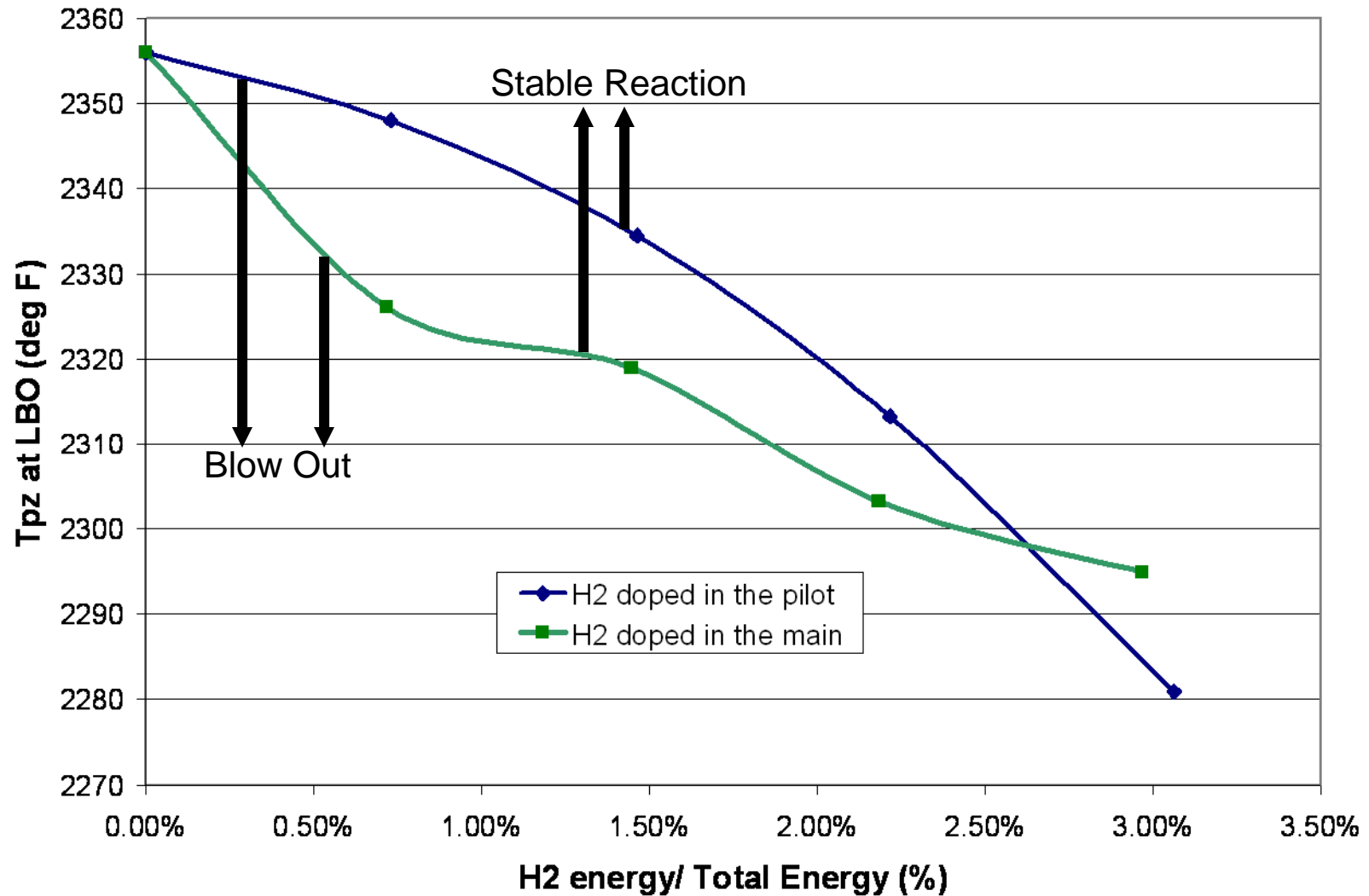
Too many variables
with interrelating
effects

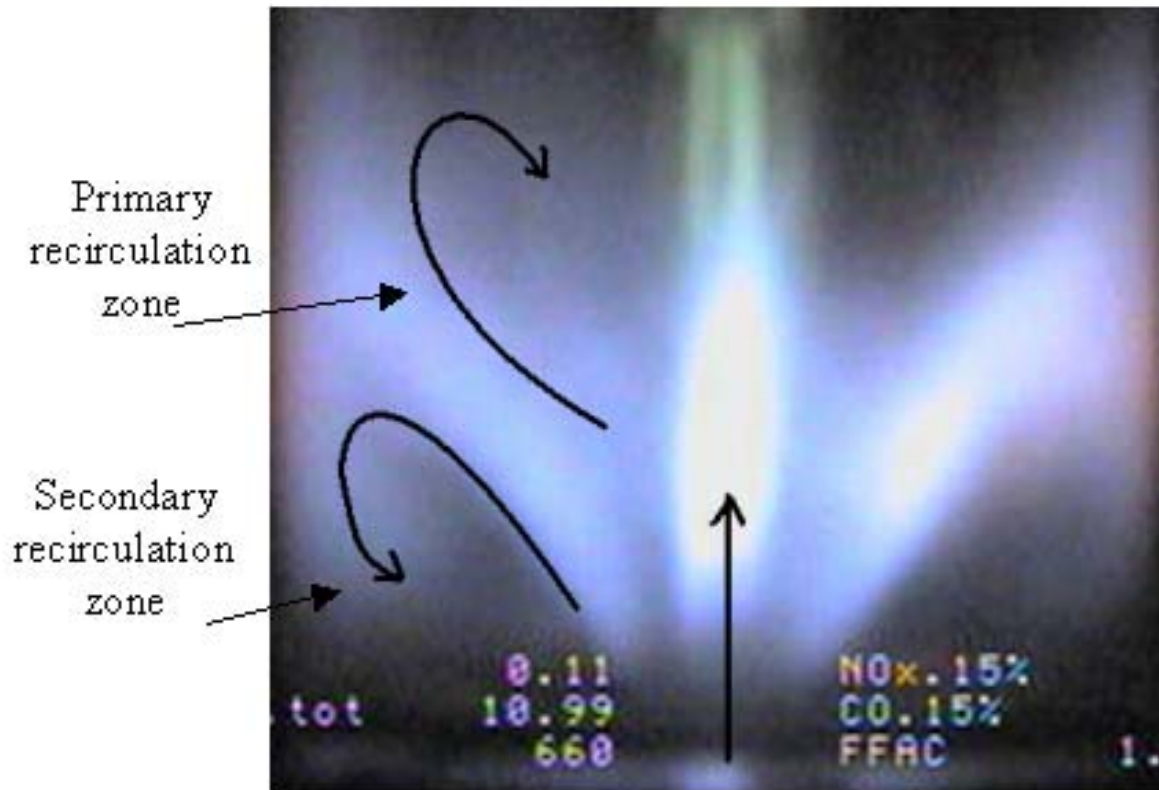
New parameter Space

- % hydrogen
- Hydrogen injection location

- **LBO Flame Temperature**
- **Flame Structure/Injection Location**
- **Emissions**

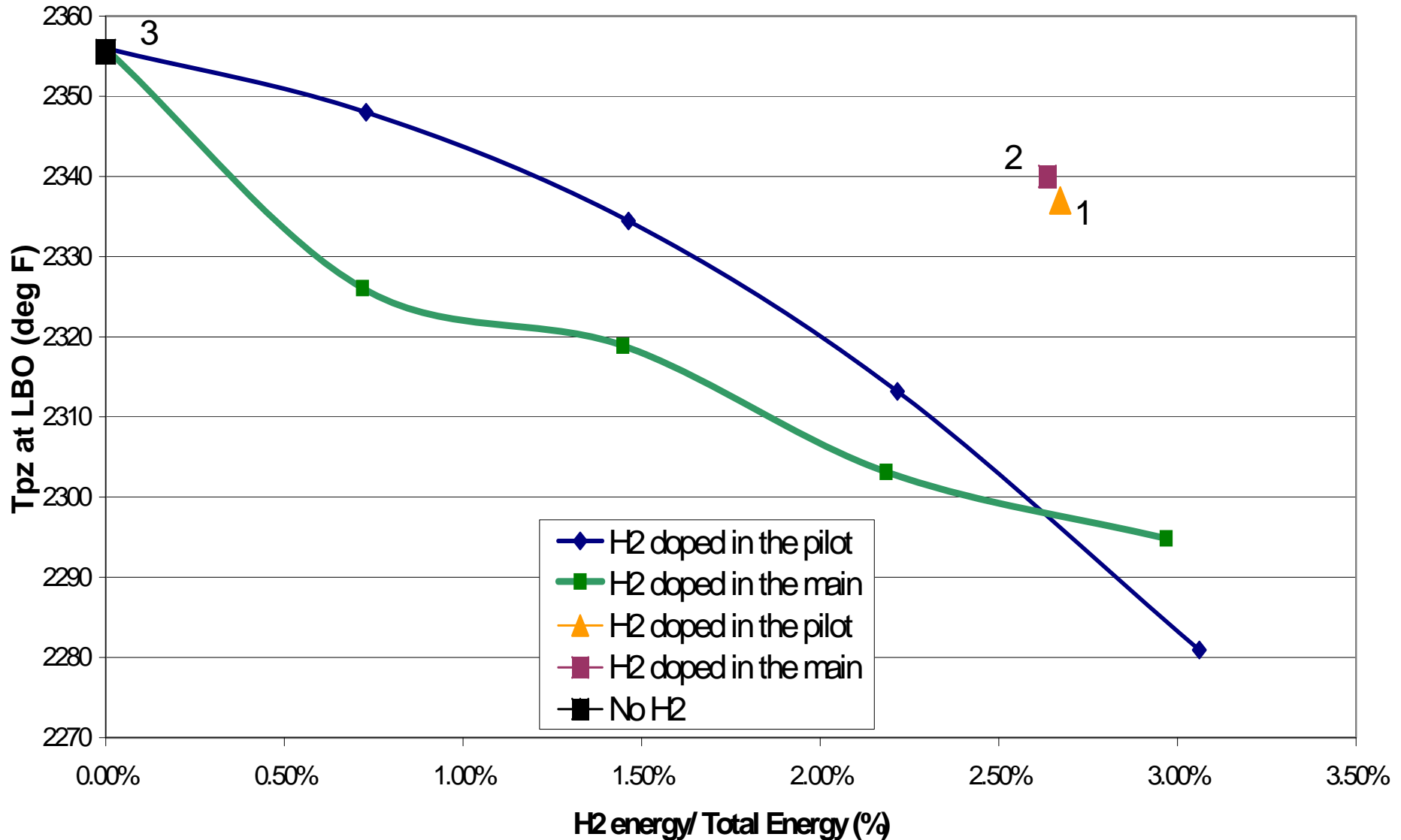
Lean Blow Out Extension



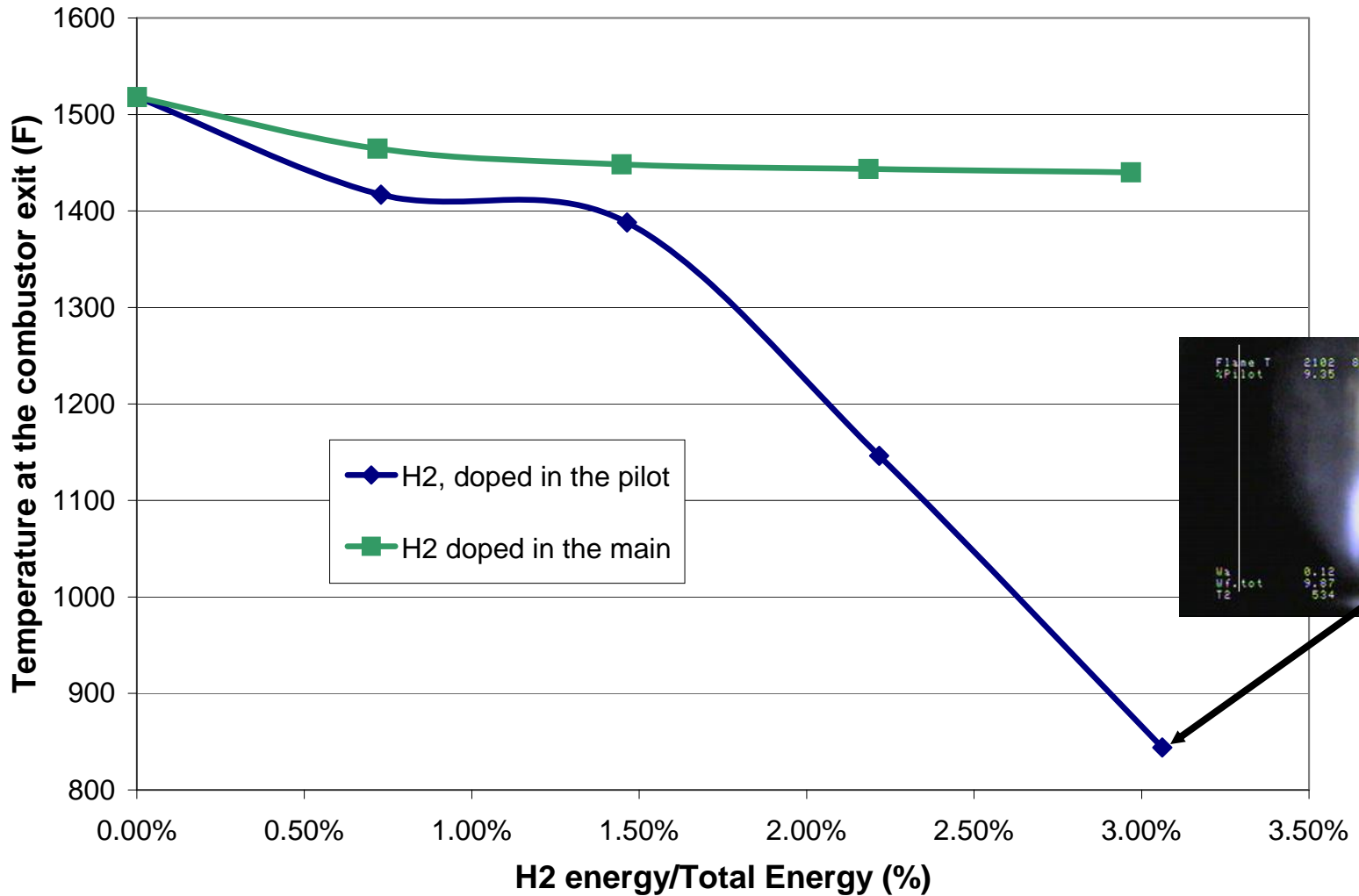


Pilot

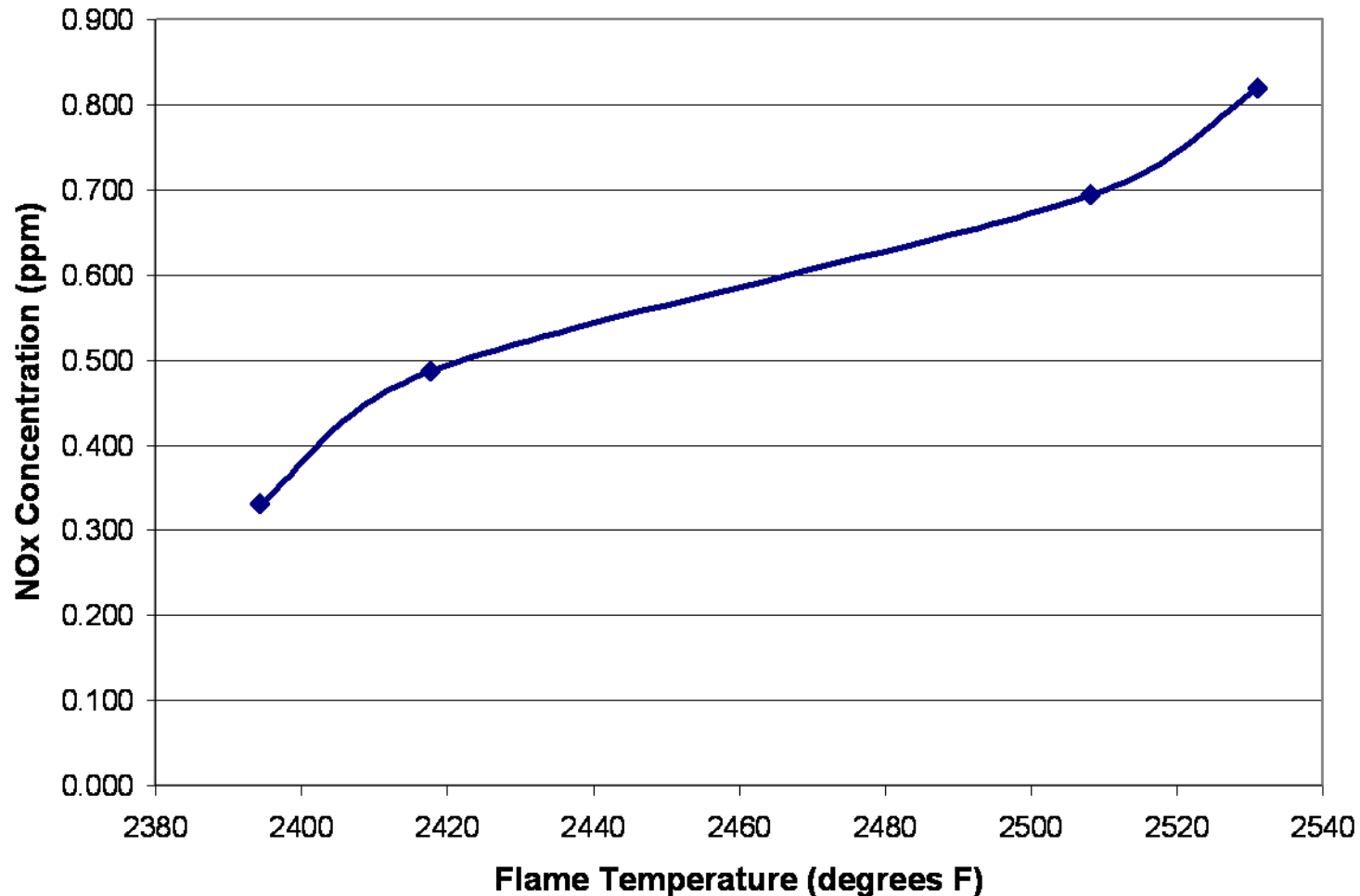
Hydrogen Injection Location



Combustor Exit Temperature



100% of the hydrogen flow injected into the main, while turning down the main Natural Gas



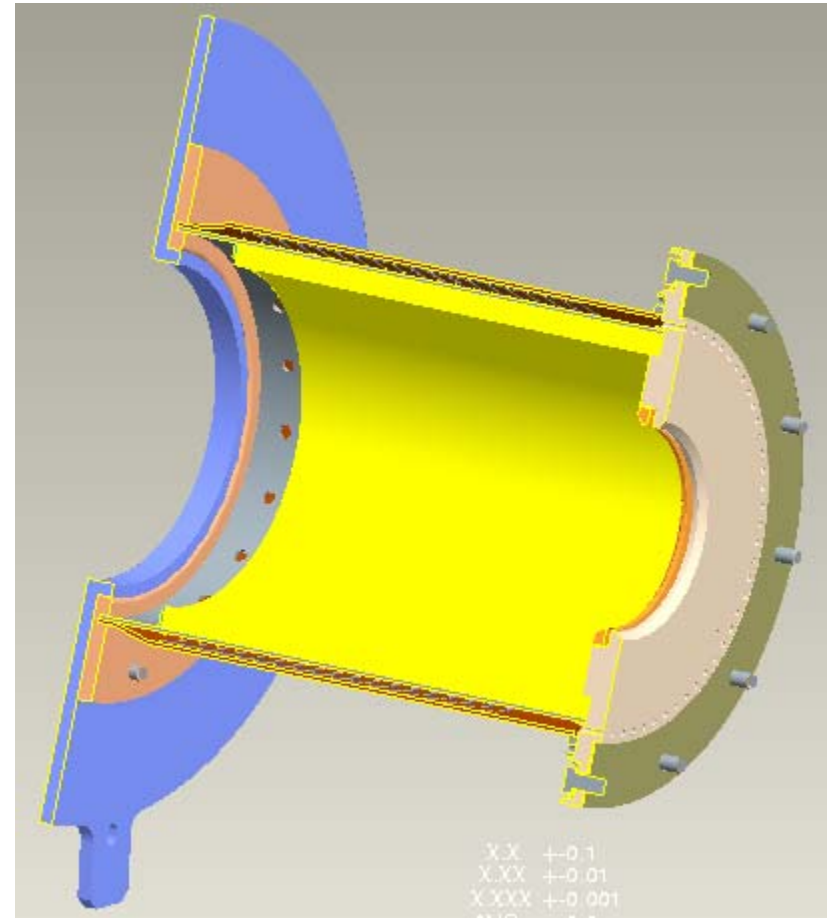
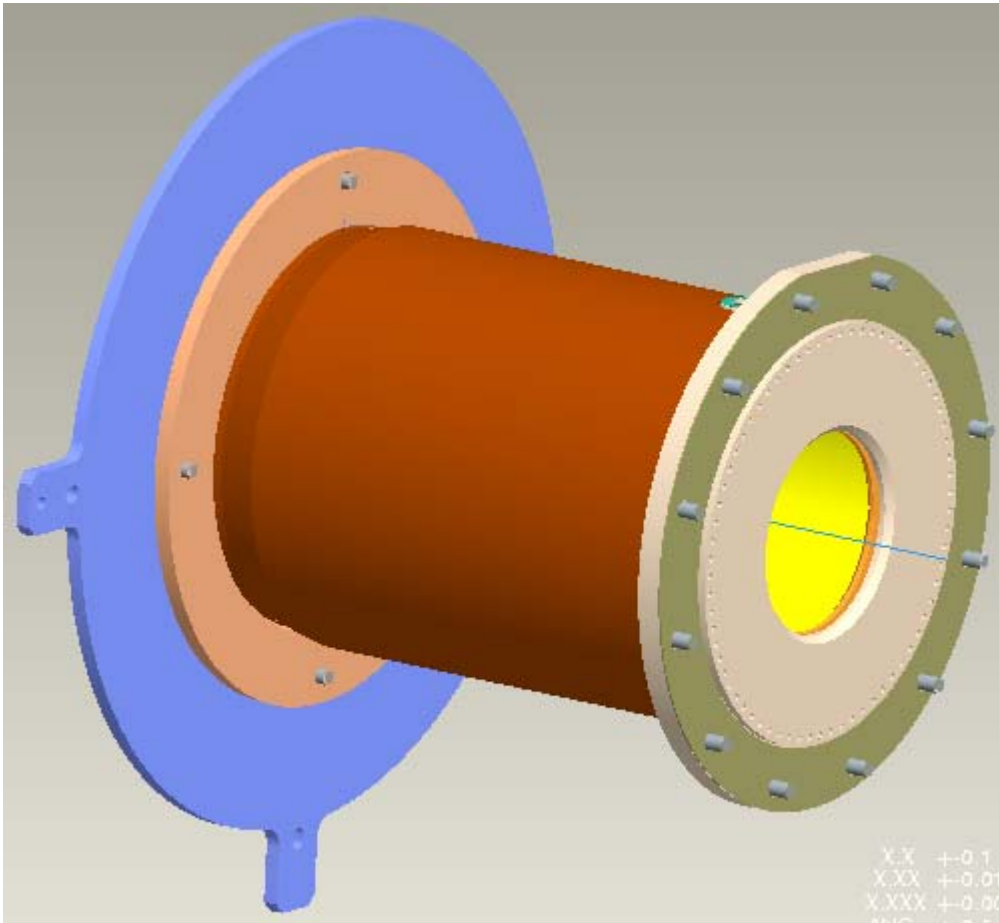
- **Negligible changes in NO_x concentrations at LBO conditions at 1 atm**
- **Conduct LBO experiments at high pressure**
 - ~ Baseline NO_x at 9 ppm
- **Test other Product Lines**
- **Measure radical concentrations and actual temperature using optical techniques:**
 - ~ Chemiluminescence
 - ~ LIF

- **Leonel Arellano and Ken Smith**
- **Everyone in the Advanced Combustion Group**
- **Mel Woods and the Combustion Test Group**
- **University Turbine Systems Research (UTSR)**

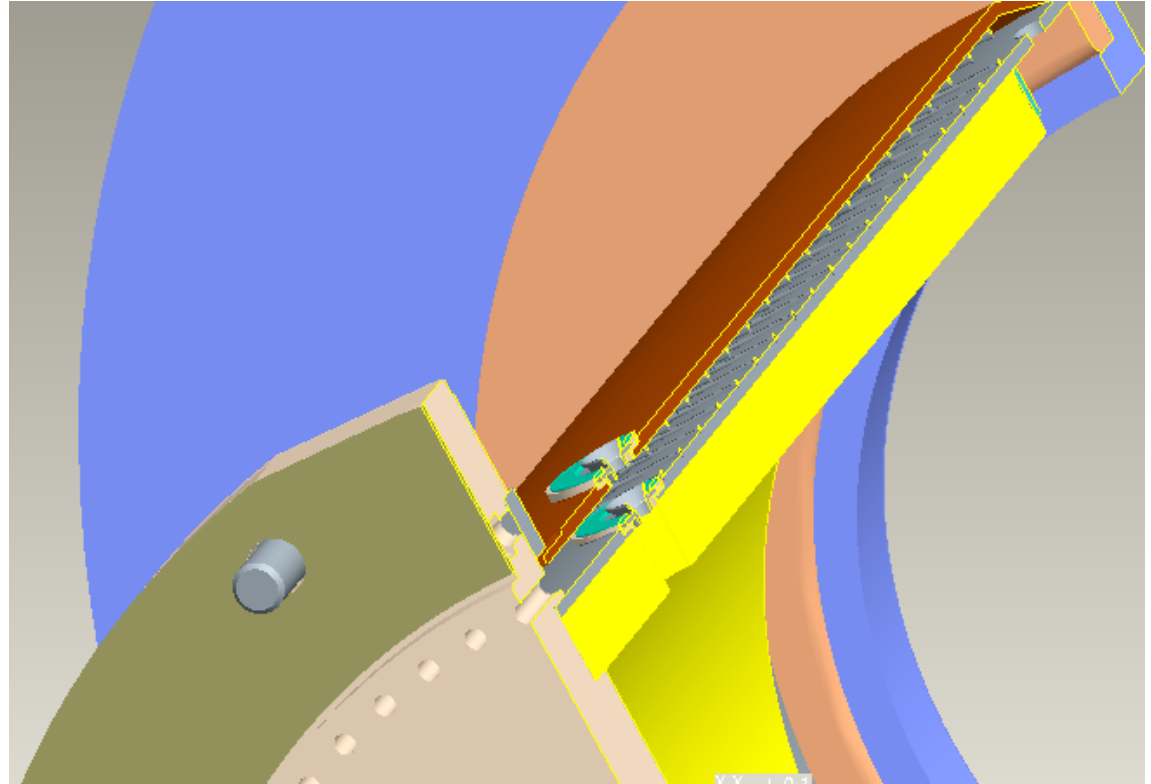
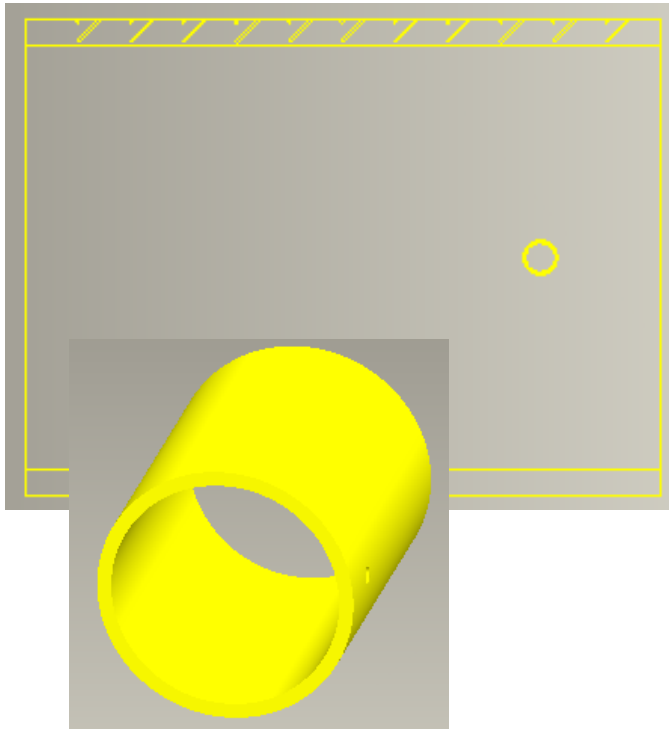
Thank you

Questions?

Backside Cooled Ceramic Combustor for HT Studies



Backside Cooled Ceramic Combustor for HT Studies



Ceramic Combustor With TC Ports
To Measure Temperature Drop Across Wall