Gas Turbine Combustor Lean Blowout & CFD Working Groups Update

Motivation and Objectives

Lean Blowout (LBO), a combustor stability limit, is a key criteria for alternative jet fuel certification.

The LBO WG aims to predict possible deleterious LBO behavior of alternative jet fuels via identifying the limiting physical processes and properties. This identification is done through experimentation of various NJFCP fuels in various rigs at appropriate conditions.

Identifying these processes and properties and developing test methods can guide fuel development and help streamline the fuel certification process.

Experimental Methods

Fuels

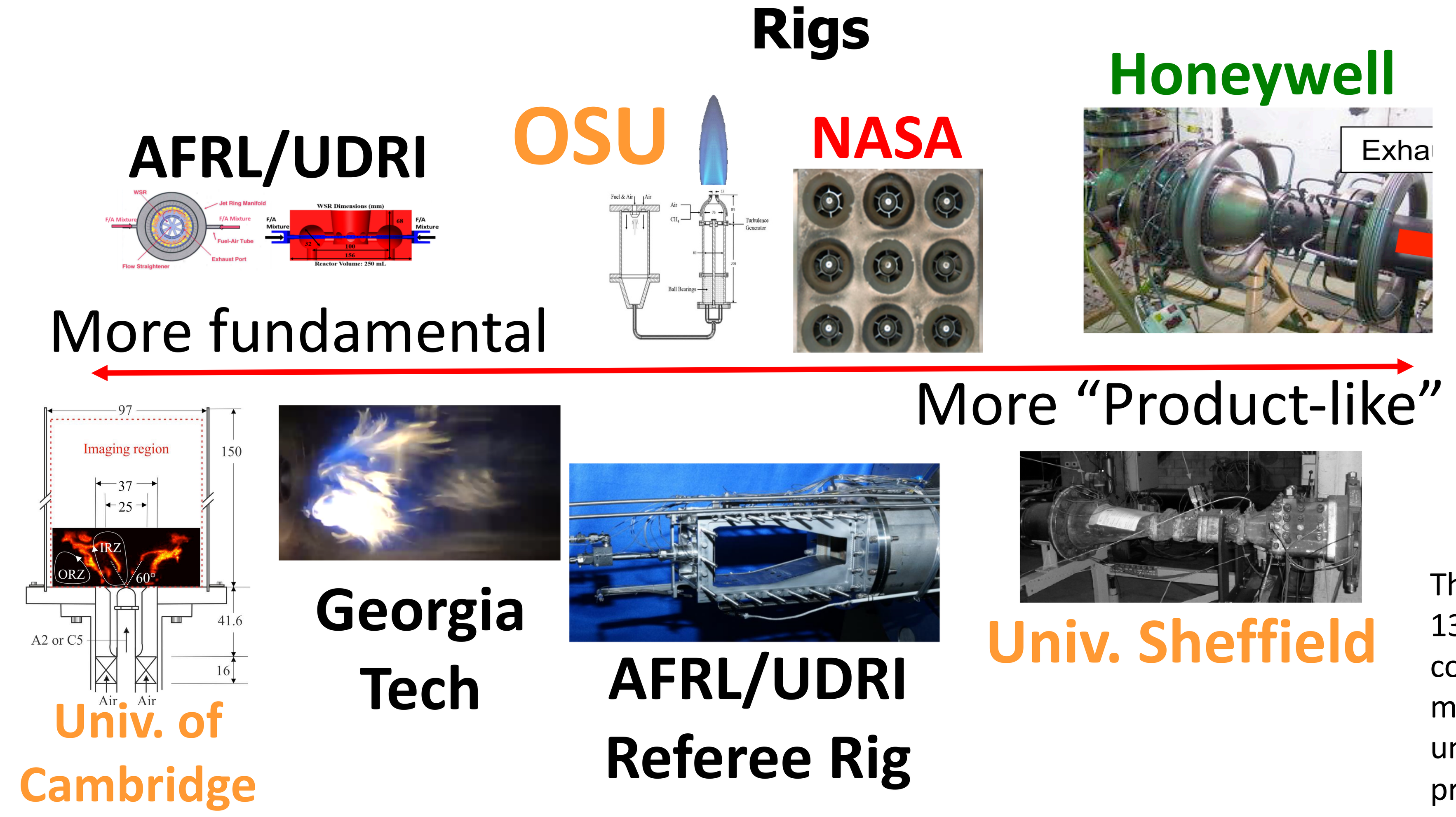
Category A: Three Conventional (Petroleum) Fuels

- "Best" case (A-1)
- "Average" (A-2)
- "Worst" case (A-3)

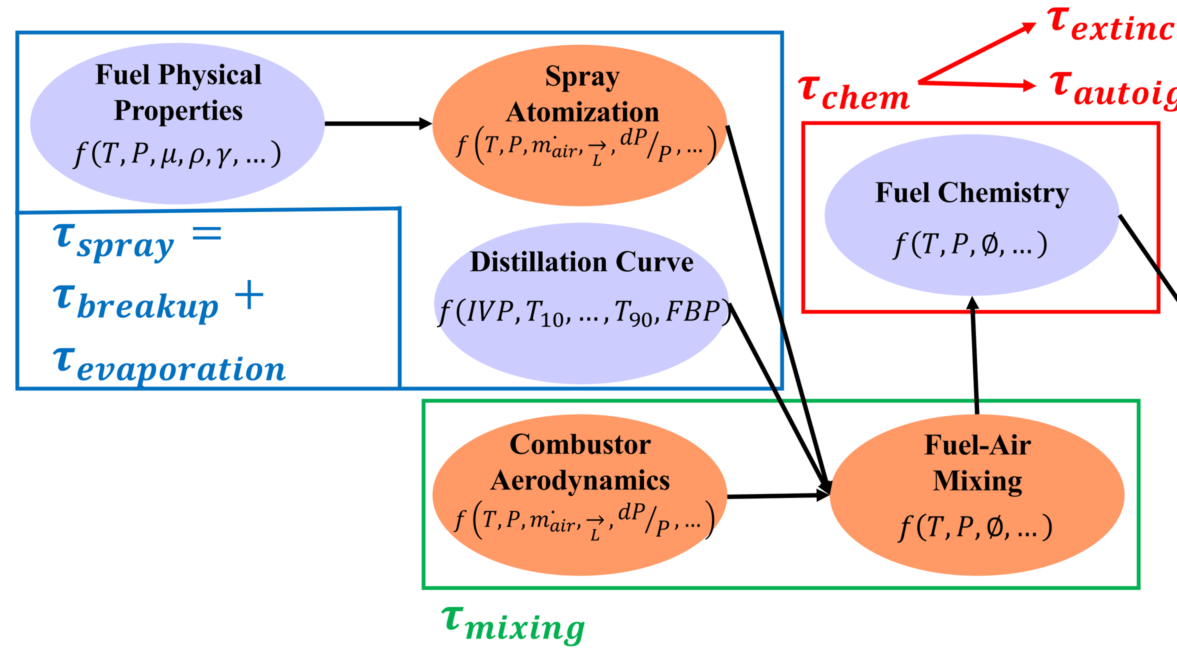
Category C: Nine "Test Fluids" With Unusual Properties

- C-1: low cetane, narrow boiling (downselected)
- C-2: bimodal boiling, aromatic front end
- C-3: high viscosity
- C-4: low cetane, wide boiling
- C-5: narrow boiling, full fuel (downselected)
- C-6 and C-6a: high cycloparaffins (not available)
- C-7 – blended fuel with maximum achievable cycloparaffins (~62 vol%)
- C-8 – blended fuel with maximum aromatics (25 vol%)
- C-9 – modified alternative fuel that has maximum DCN (63)

Rigs

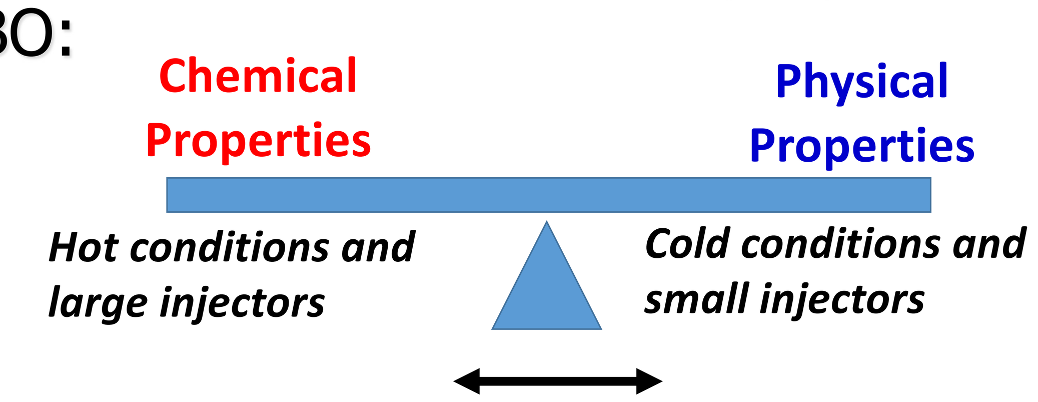


Conceptual LBO Model



$$\phi(LBO) \sim \left(\frac{1}{\tau_{chem}} + \frac{1}{\tau_{evap}} + \frac{1}{\tau_{mix}}\right)^{-1}$$

Two time scales relate fuel properties to LBO:



Summary

Two categorical limits are observed with one hierarchical unifying conceptual model (**Physical** and **Chemical**) using four fuel properties representative of $\tau_{breakup}$, $\tau_{evaporation}$ and $\tau_{autoignition}$, $\tau_{extinction}$.

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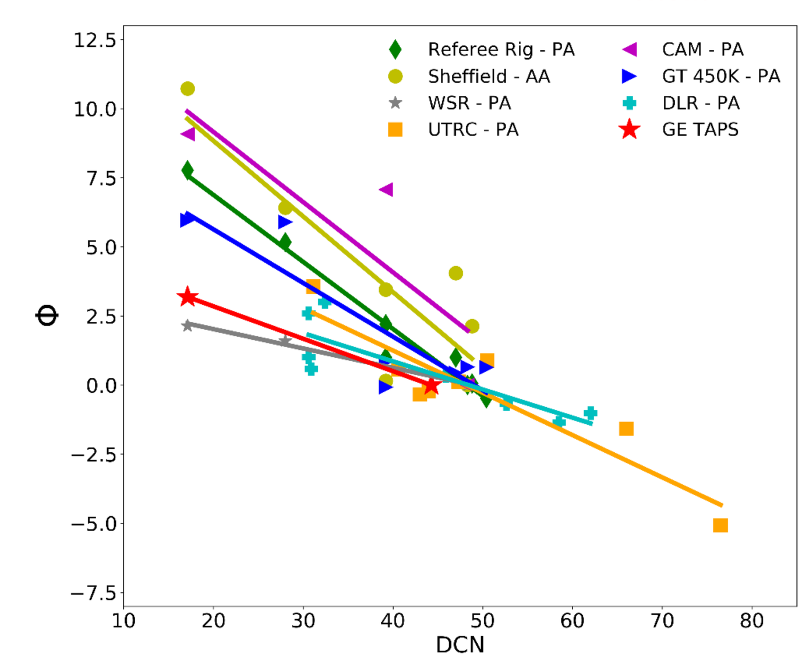
October 9-10, 2018

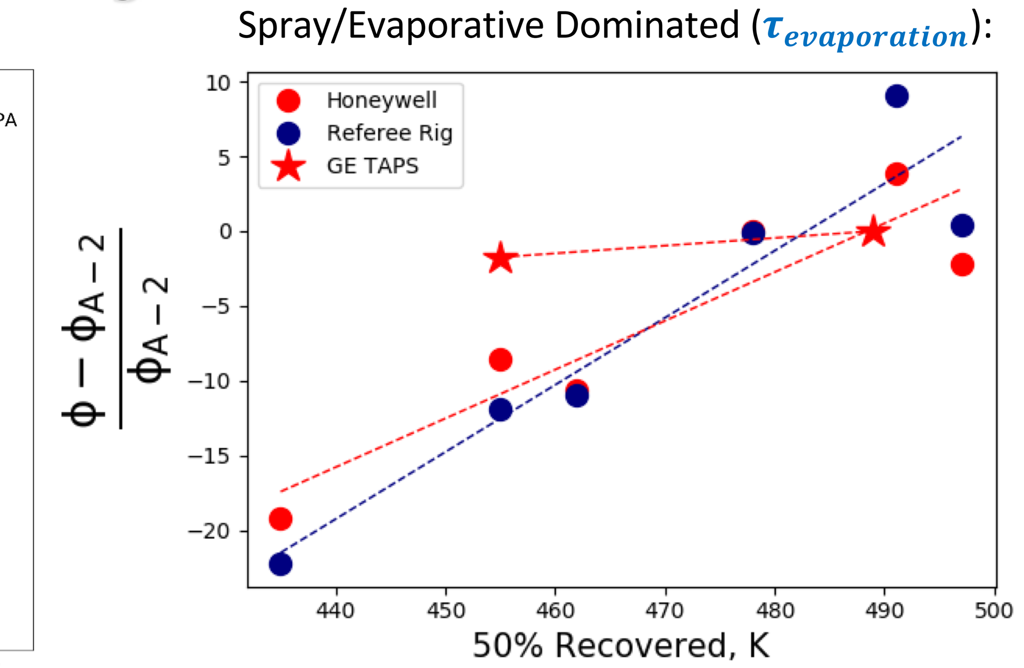
Results and Discussion

Two Regimes

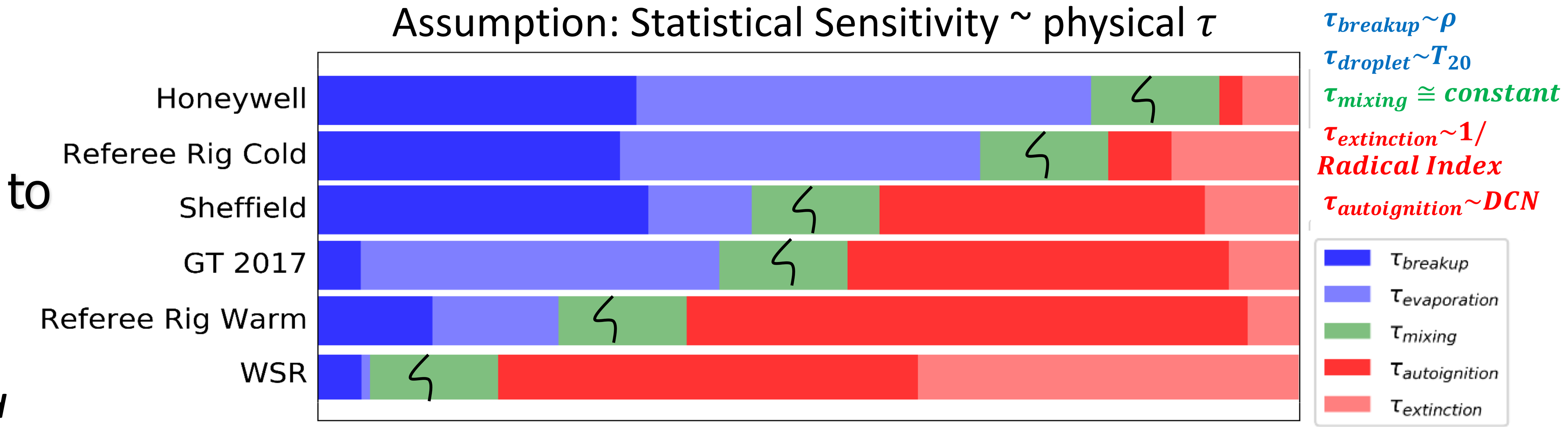
Chemically Dominated (τ_{chem}):



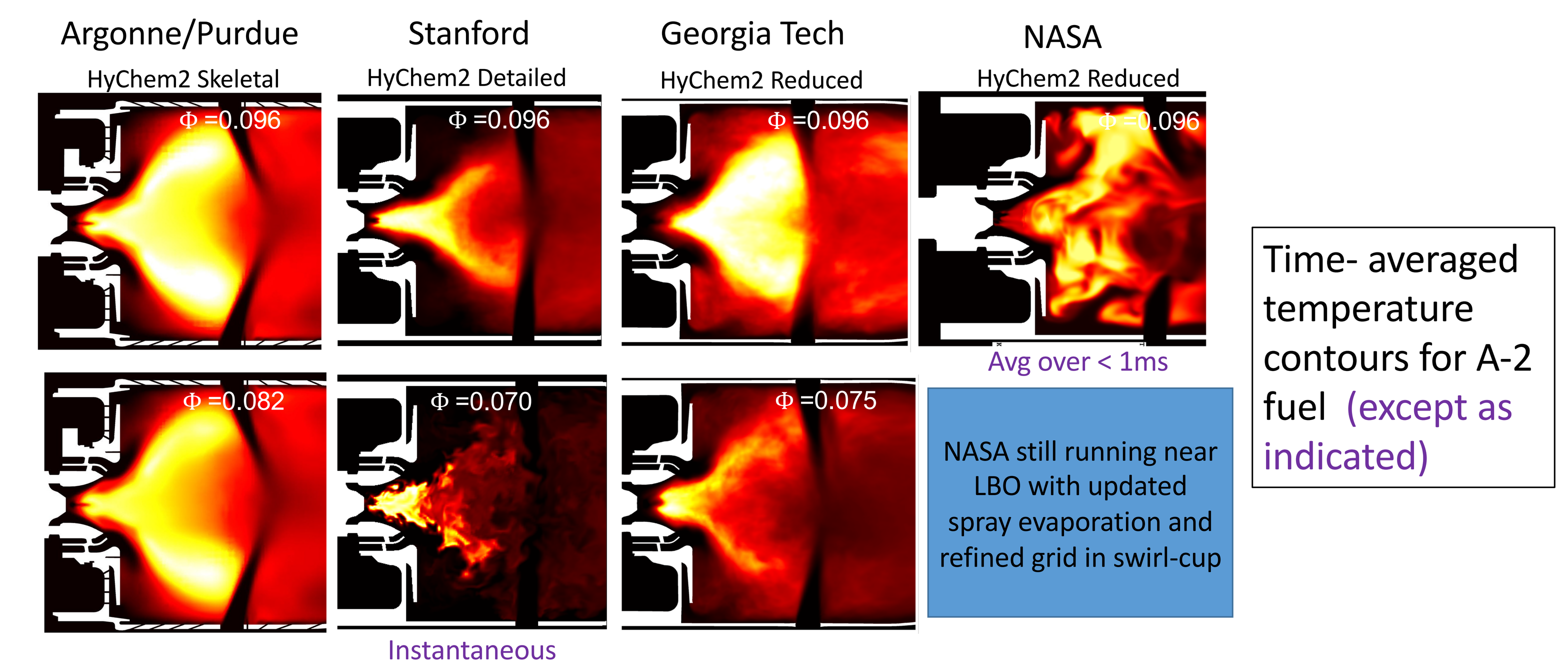
Spray/Evaporative Dominated ($\tau_{evaporation}$):



Assumption: Statistical Sensitivity ~ physical τ



CFD



- Detailed analysis underway of existing CFD results at near LBO condition and approach to LBO for Referee Rig
- One team achieved correct LBO fuel trend with two chemistry mechanisms

Next Steps

- Complete AIAA Book Chapters
- Additional LBO test campaigns
- Detailed analysis of CFD LBO results
- Several archival papers are in progress

This work was funded by the US Federal Aviation Administration Office of Environment and Energy as a part of ASCENT Projects 27, 28, 30, and 34 under FAA Award Numbers 13-C-AJFE-UD-018, 13-C-AJFE-GIT-09 and 13-C-AJFE-SU-05, and by the National Aeronautics and Space Administration under agreement numbers NNX15AV04A and NNX15AU91A. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the FAA or other ASCENT Sponsors.