ASCENT 25: NJFCP – Area #1
Chemical Kinetics Experiments: 2017

STANFORD UNIVERSITY

ASCENT AVIATION SUSTAINABILITY CENTER

Motivation and Objectives

Area #1 experiments seek to provide an extensive kinetics database for selected jet fuels. These data are used as critical input for Area #2 that seeks to develop a new hybrid and detailed kinetics model for jet fuels.

These experiments continue to reveal the sensitivity of combustion properties to variations in fuel composition for ultimate use in simplifying the alternative fuel certification process.

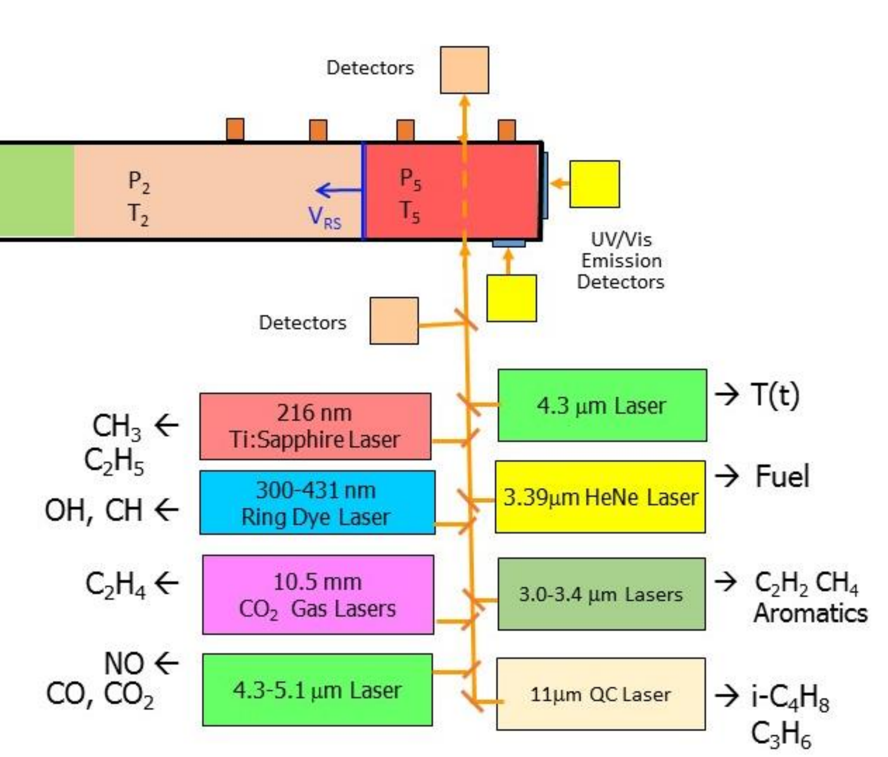
The data provided will also ensure that the combustion models developed in Area #4 to simulate the extinction and ignition processes controlling lean blowout, cold ignition and high altitude relight, are chemically accurate.

Methods and Materials

Shock tube/laser absorption experiments can provide three kinds of fundamental chemical kinetics target data. These data include: ignition delay times; species time-histories; and elementary reaction rate constant data.

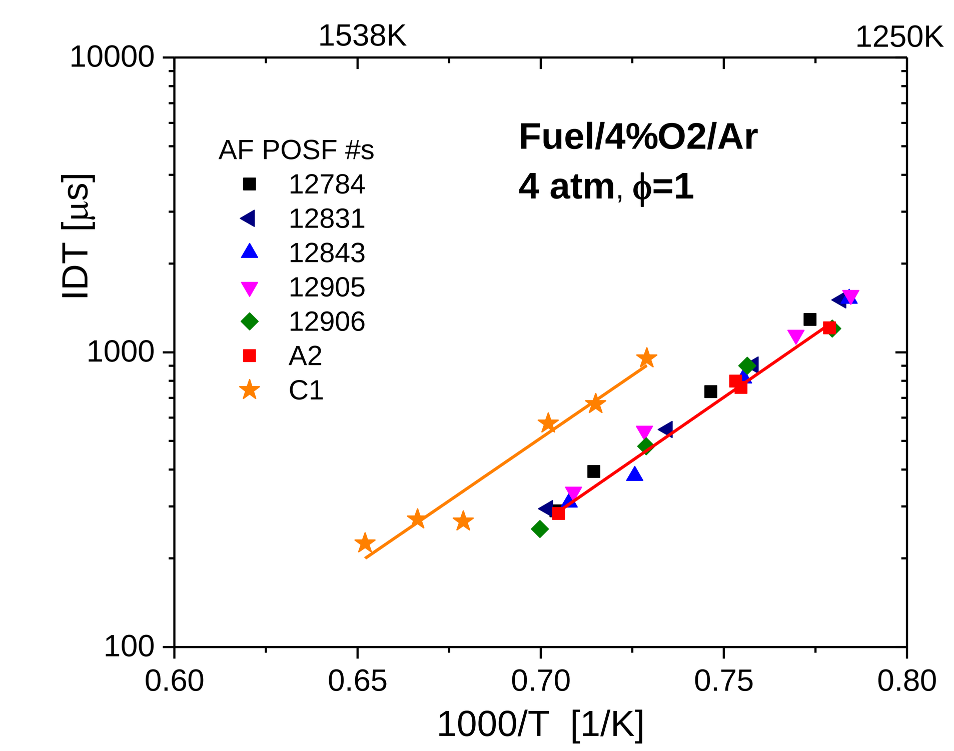
Research this year has focused on the simultaneous measurement of multiple species time-histories using multiple infrared wavelengths. Using this method we are able to simultaneously measure fuel, CH_4, C_2H_4, C_4H_8 and C_3H_6, and work to extend this speciation to aromatic species is planned.

Shock Tube/Laser Absorption Facility



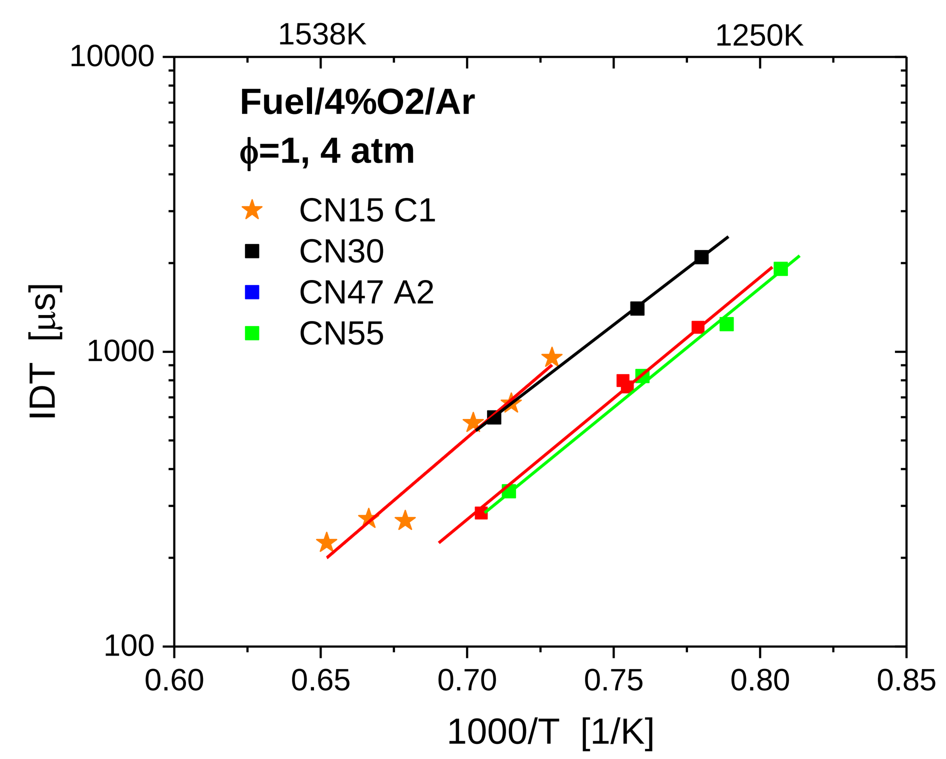
Recent Measurements

Shock Tube Ignition Delay Time Measurements



5 Jet fuels from geographically varying areas
Fuel/air, ϕ=1.0
1.5 atm

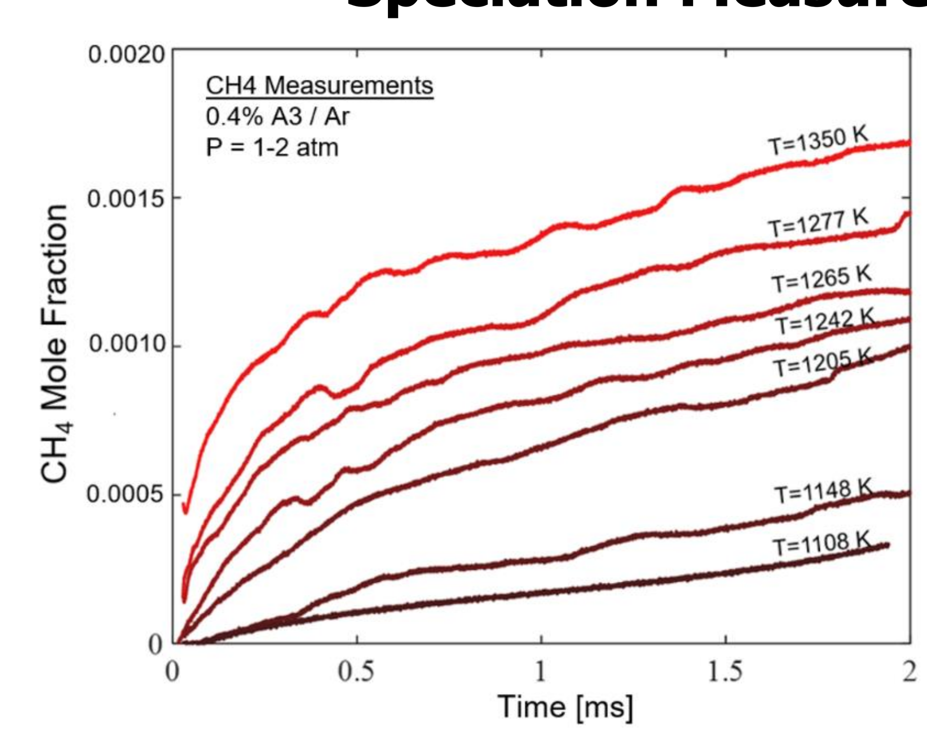
IDT values are effectively identical to Cat A2 (Jet A) fuel



3 Jet fuels with varying Cetane Number (CN)
Fuel/0.4% O2/Ar
1.2 atm, ϕ=1

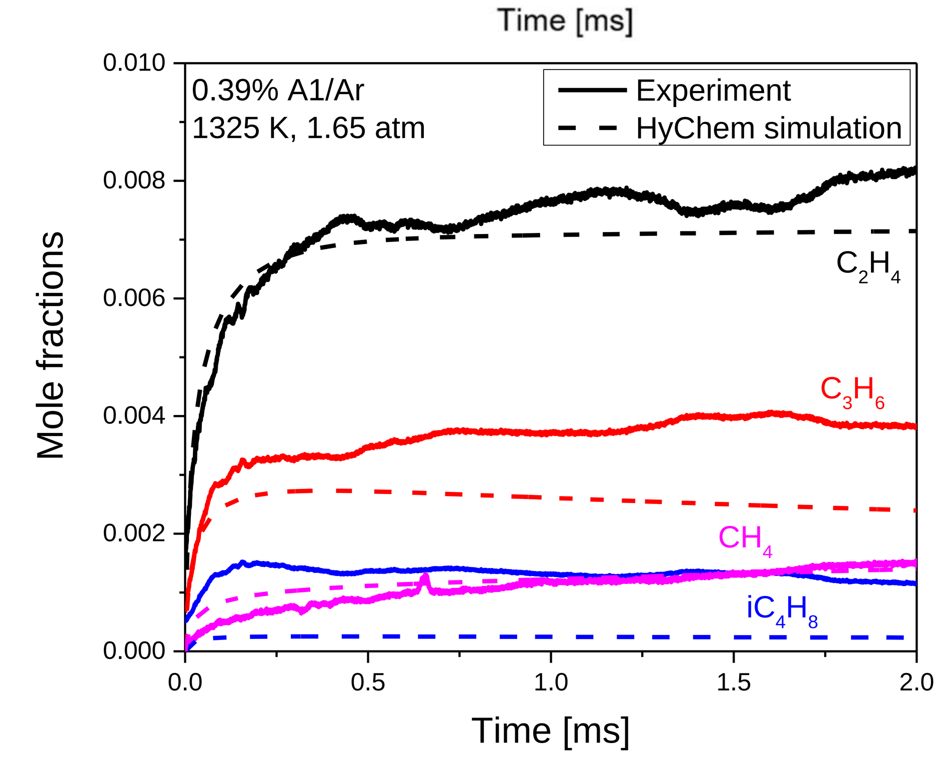
IDT values show some variation with CN

Speciation Measurements



Cat A3 Pyrolysis CH4 Time-Histories
0.4% A3/Argon, 1.5 atm

Low noise data over a wide temperature range



Multi-Species Data Cat A1 Pyrolysis
0.39% A1/Argon
1325K, 1.5 atm

Good agreement with HyChem model seen for C2H4, C3H6 & CH4. Refinement needed for C4H8

Results and Discussion

Fuel studies were originally performed in a large diameter shock tube using laser absorption, pressure and OH* emission measurements.

To investigate the influence of fuel variability on ignition delay times (IDT), 5 fuels from geographically varying areas (over the US and possessions) were studied. High temperature IDT values were found to be indistinguishable from the Cat A2 standard used in the FAA tests.

To investigate the influence of Cetane Number (CN) on IDT, 6 fuels with varying CN were investigated. Some evidence of variation from Cat A2 standard fuel was seen in very low CN fuels.

Conclusions and Next Steps

Good agreement exists between HyChem simulations and IDT measurements over a wide range of different jet fuels.

Future work will monitor a broader range of species in shock tube experiments including butene and propene and aromatics. The extension to this fuller species set should enable accounting for the majority (>90%) of the fuel carbon in the pyrolysis products.

These experiments will be performed on a variety of fuels to stress the HyChem model outside of the original optimization envelope.

Lead investigator: R. K. Hanson, Stanford University
Project managers: A. Jardine & C. Shaw, FAA

This work was funded by the US Federal Aviation Administration (FAA) Office of Environment and Energy as a part of ASCENT Project 25 under FAA Award Number: 13-C-AJFE-SU-008 . 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.