U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

# Co-Optimization of Fuels & Engines

FOR TOMORROW'S ENERGY-EFFICIENT VEHICLES

# Thrust II engine studies

*Jointly conducted under the Fuel Properties and Advanced Engine Development Teams*

# Thrust II

## Advanced Compression Ignition Engines

- Encompasses both gasoline-like and diesel like fuels
- Examines compatibility of Thrust I fuels with Thrust II engine technologies
- Seeks to accelerate Thrust II technology development
- Cross-cutting projects with Thrust I examining sprays, aftertreatment, and PM formation

# Objectives

## ***Discovery***

What are the important fuel properties or performance metrics?

How do we measure/compute them?

- Work that identifies new, or combined metrics for autoignition not captured in RON, MON, or CN
- Clarification of which fuel properties dominate specific performance measures (*e.g.* particulate formation)

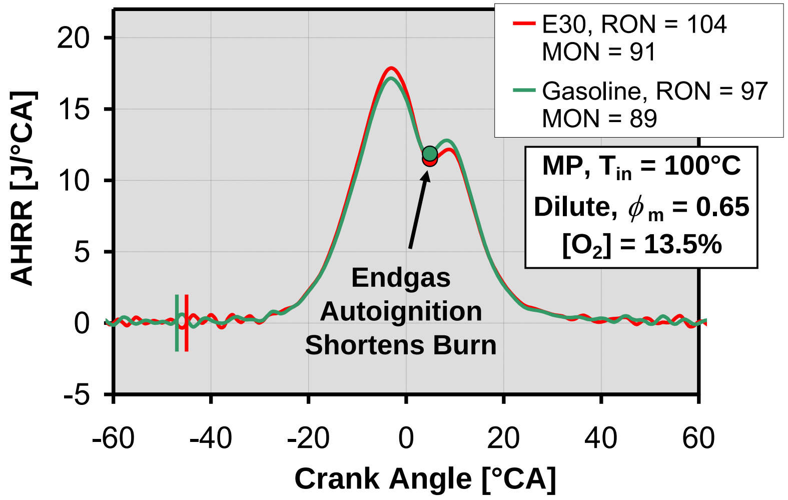
## ***Engineering***

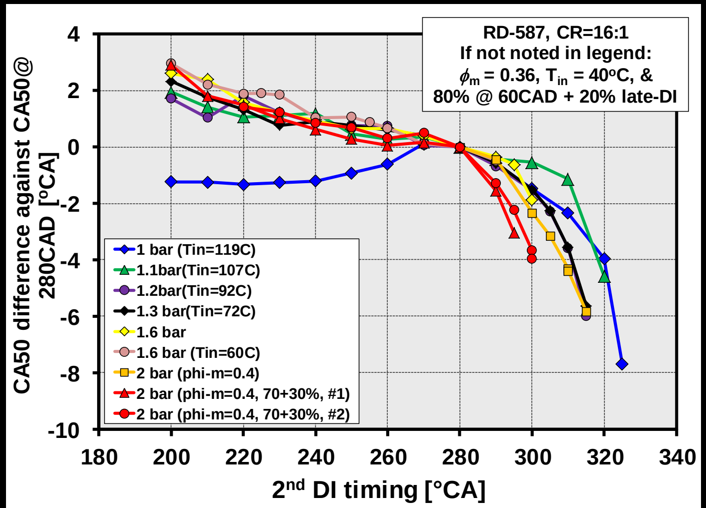
How do fuel properties and engine design/operating parameters interact?

How can these interactions be leveraged to optimize efficiency?

- Work that clarifies engine performance and emissions behavior as engine parameters (CR, intake T & P, etc.) or fuel properties (RON, HoV, S, etc.) vary
- Studies that seek to clarify/refine the efficiency merit function

# Birds-eye view of Thrust II projects






# Autoignition processes

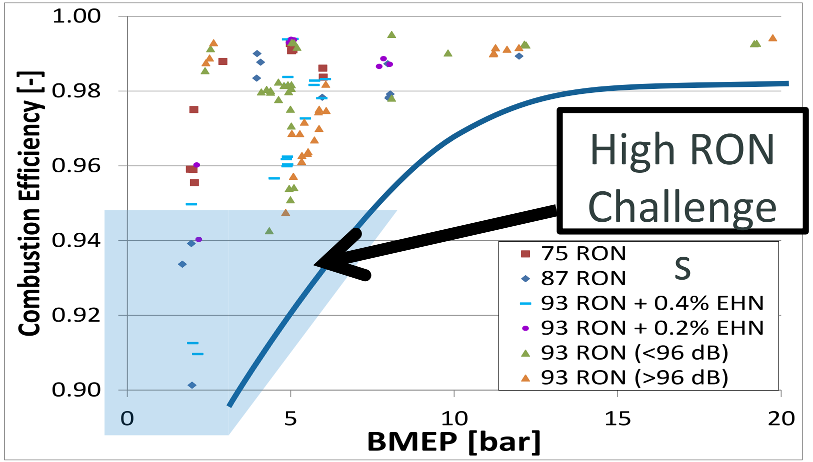
- Are RON and MON adequate predictors of autoignition behavior in lean or dilute HCCI-like engines or in multi-mode SI combustion systems?

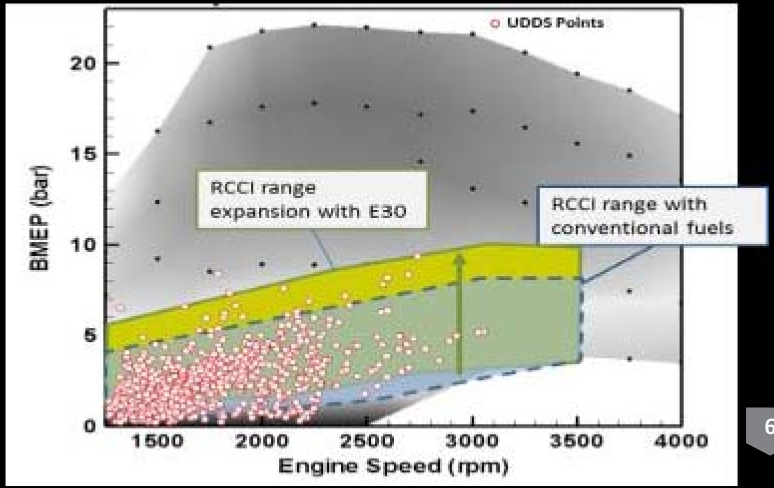
- Combustion phasing control in stratified HCCI combustion systems
  - o Employs ϕ sensitivity of ignition delay
  - o Provides well-characterized data for kinetic model development and validation

# Accelerate development of ACI combustion systems

- Gasoline Compression Ignition (GCI) Systems:
  - o Focus on challenges impacting low-load operation

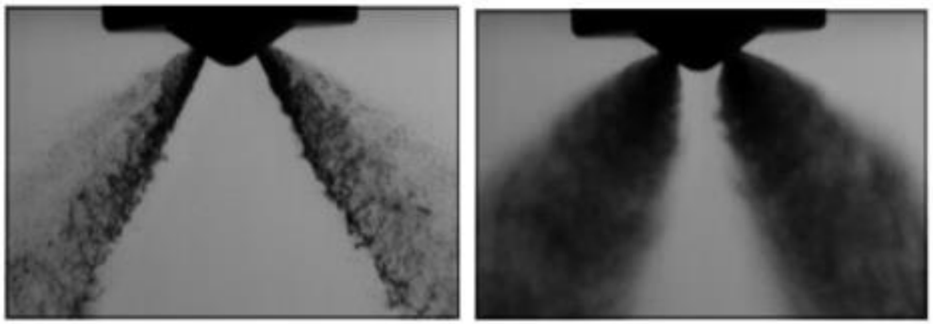
- Reactivity-Controlled Compression Ignition (RCCI):
  - o Fuels enabling load-range extension
  - o Fuel impacts on phasing control



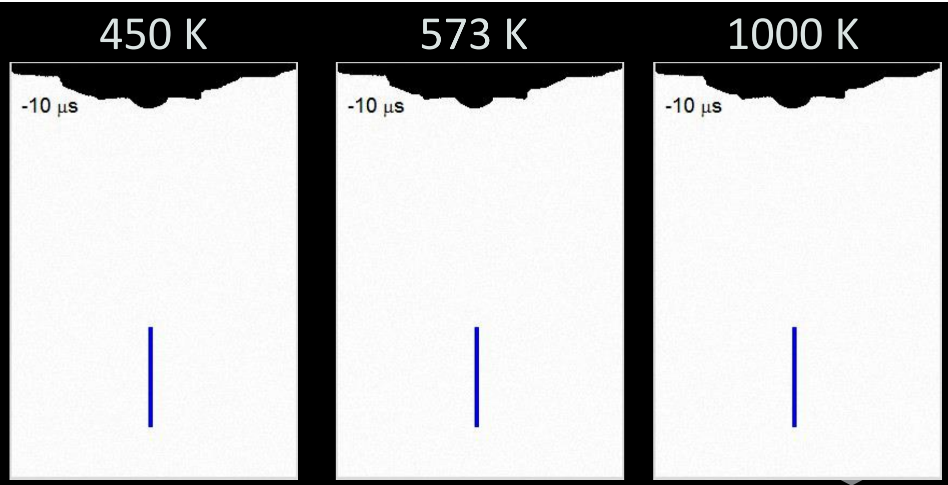



# Sprays & mixture formation

- Macroscopic spray characteristics are strongly impacted by fuel properties
- Proper spray behavior & subsequent mixture formation is central to combustion system design
- Capturing spray behavior is foundational to engine combustion simulation



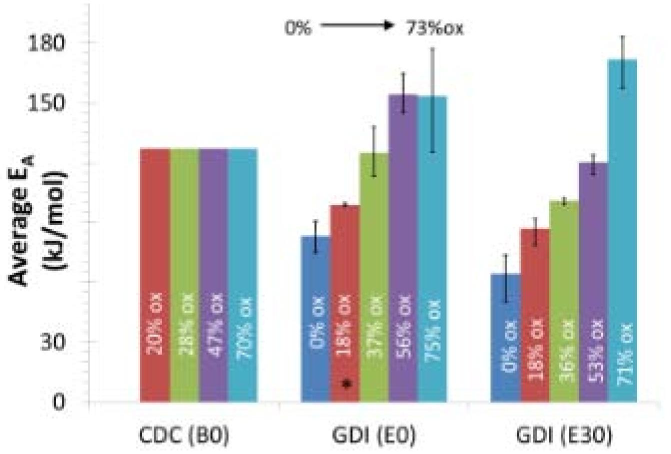
Effect of fuel temperature on spray structure
Weber and Leick, ILASS Europe 2014




Effect of ambient temperature

# Aftertreatment projects

Regeneration Impact on $E_A$





- Assesses impact of fuel or combustion system induced PM structural changes on regeneration strategies

- Biodiesel impurities (~ 1 ppm) can impact catalysts
    - Na and K displace Cu in zeolite framework
    - Results in Cu-oxide on surface of washcoat

# New metrics for fuel effects on particulate formation

- Existing metrics are not predictive for some oxygenated compounds
- Investigating modifications to PMI
  - Replacing DBE with Yield Sooting Index or Oxygen Extended Sooting Index
  - Apply a heat of vaporization factor

$$PMI = \sum_{i=1}^{n}\left[\frac{(DBE_i + 1)}{VP(443K)_i} \times Wt_i\right]$$

$$DBE = \frac{2C+2-H}{2}$$