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Overview of Experimental Activities at the Sandia Spray Labs

Julien Manin and Lyle Pickett

Applied Combustion I (8361)

Combustion Research Facility

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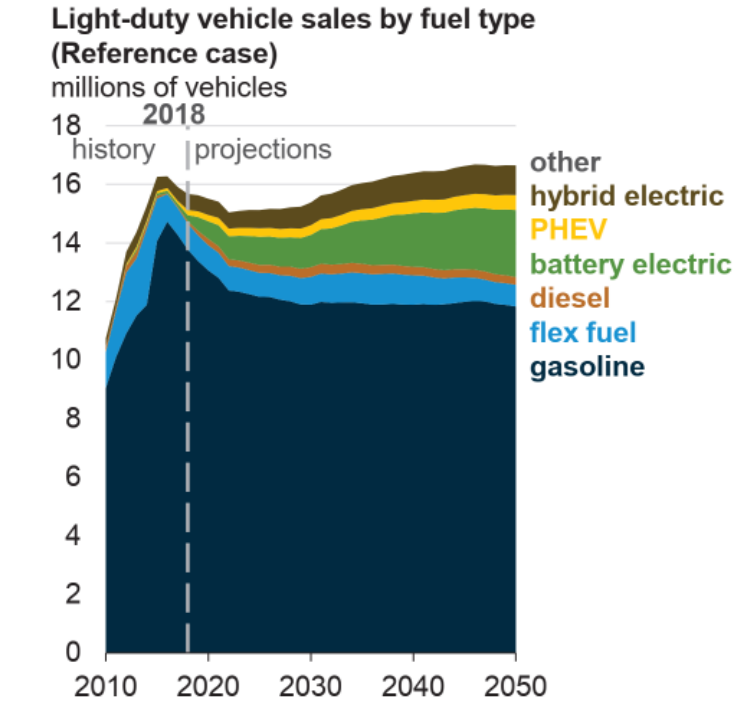
U.S. DEPARTMENT OF ENERGY

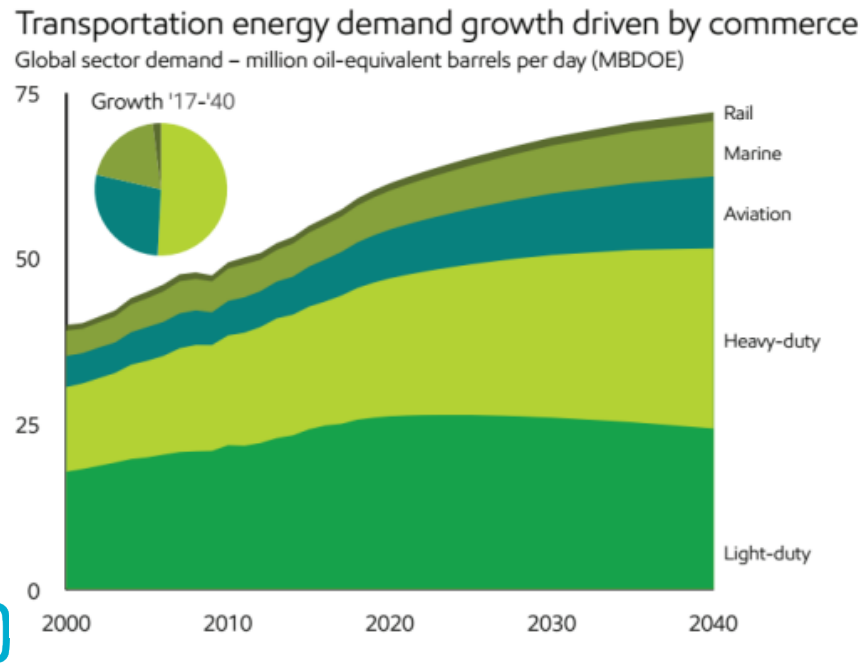
Lab Visit Material

Sandia National Laboratories

Internal combustion engines need to get better

- Transportation is the first consumer of liquid fuel and the largest contributor of CO_2 emissions
- Hybrid and EV vehicles to represent about 20 % of the market share in 30 years
- Gasoline-type vehicles to dominate for the next decades
  - 1 billion gasoline engines to be made over the next 20 years, with still about a 75-% market share by 2050
  - Driven by regulations, projections include significant efficiency gains

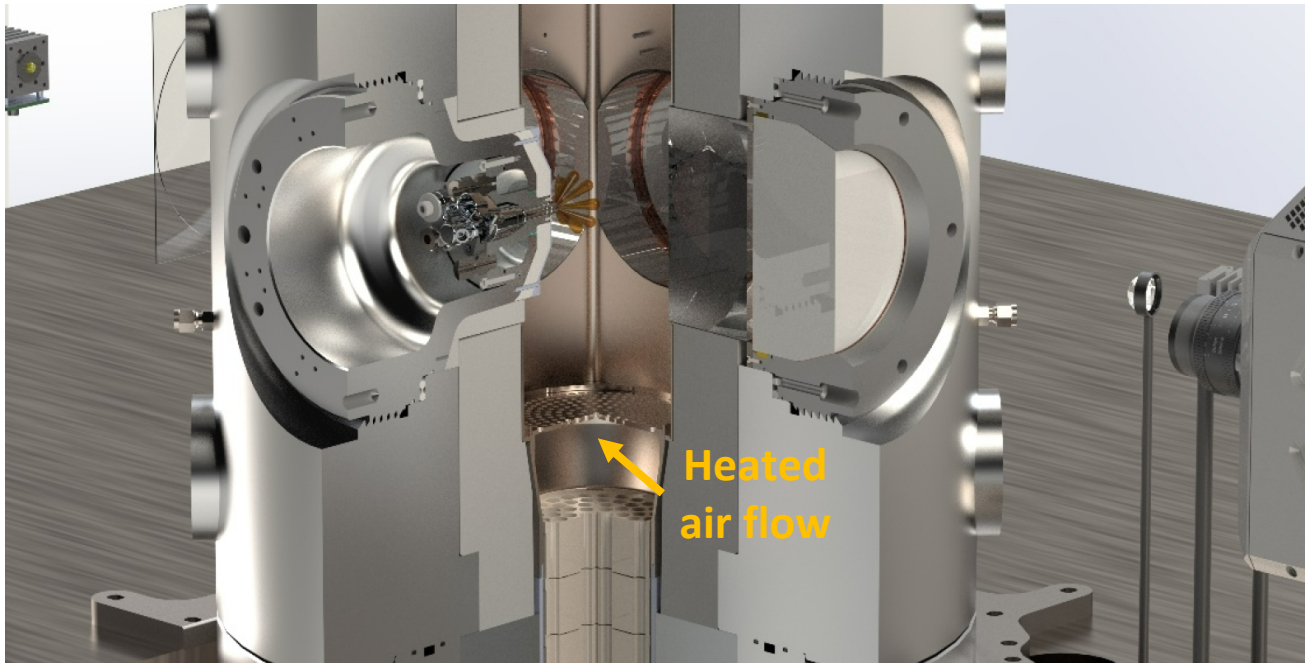




- Heavy-duty diesel engines to become the main fuel demand in transportation in the next few years
- Aviation will experience the largest growth regarding transportation energy demand

- There is no clear path toward efficient electrification for these types of vehicles

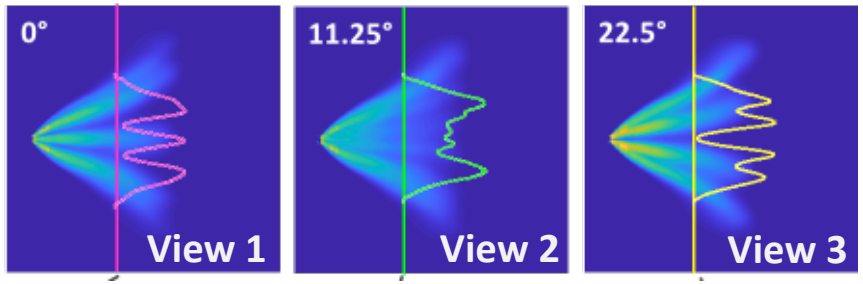
High-pressure continuous-flow chamber



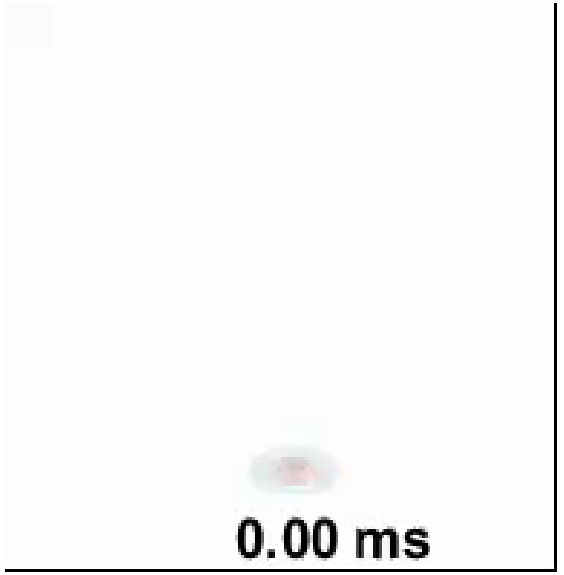
- High-throughput spray chamber with continuously flowing heated air flow
  - Ambient temperature up to 1100 K
  - Ambient pressure from vacuum to 150 atm.
- High-repetition-rate enables time-resolved 3-D tomography on multi-plume sprays
  - Prior Sandia capabilities made statistic-dependent diagnostic near impossible
- Many advanced diagnostics are not applicable at the required high-speeds yet

Raw data

Ensemble-average (300 injections)

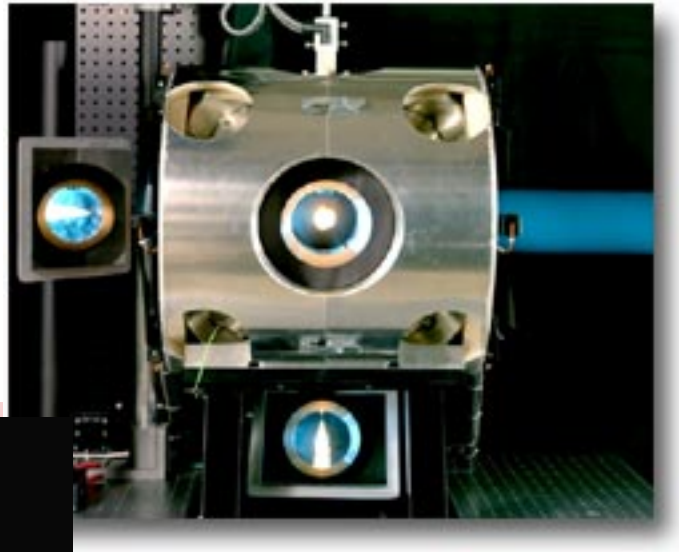


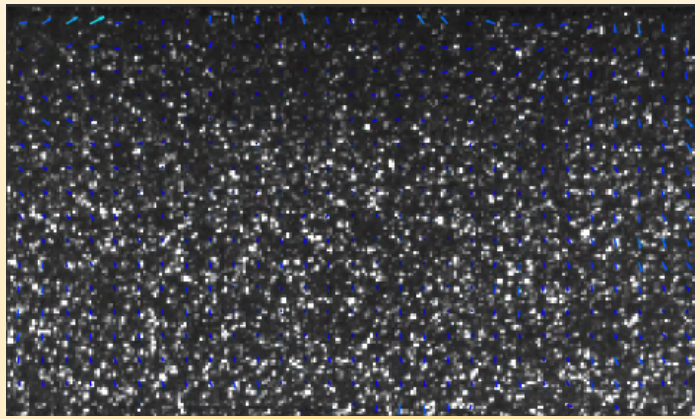
Tomographic reconstruction



Constant volume vessel

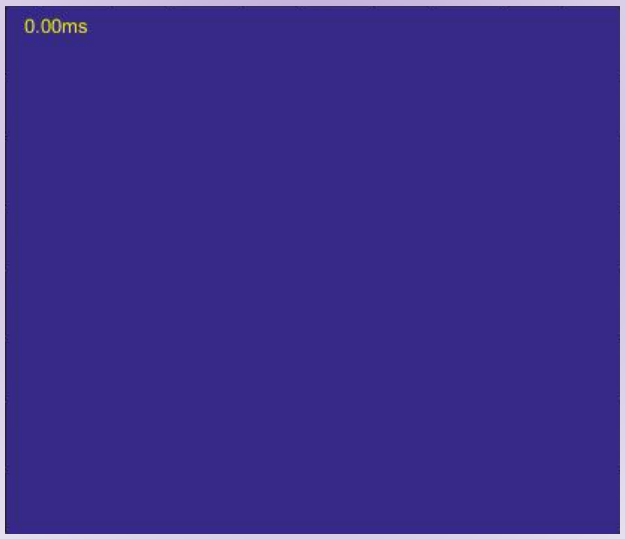
- Constant-volume chamber with high pressure and temperature capabilities
  - Ambient temperature up to 1800 K
  - Ambient pressure from 1 to 350 atm.
- Advanced laser and optical diagnostics to study spray and combustion processes under relevant conditions in a fundamental manner
  - Combines with the continuous flow chamber activities to extend Sandia's capabilities





Time-resolved Particle Image Velocimetry (PIV) for air entrainment

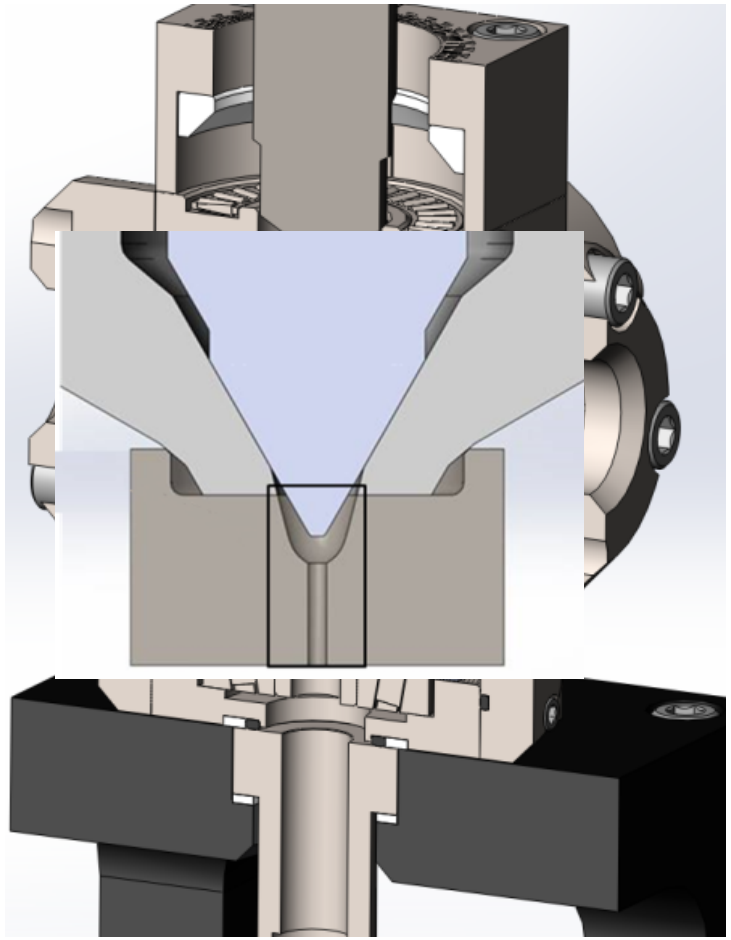
High-speed mixing measurements using Rayleigh scattering



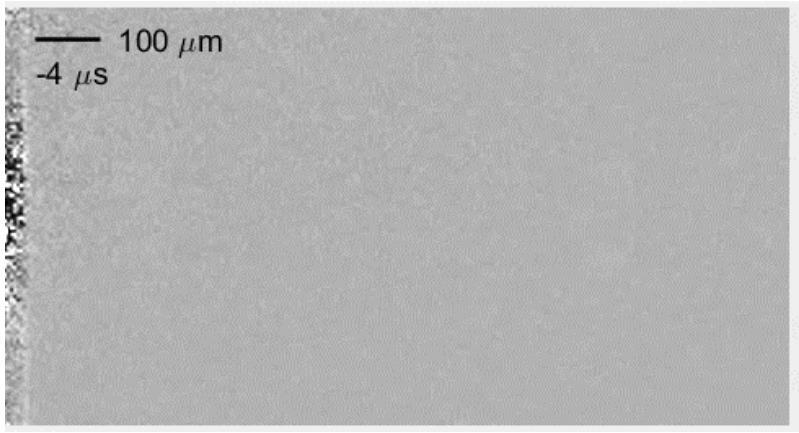
High-speed PAH LIF experiments to monitor soot precursors

Quantitative soot volume fraction measurements under pyrolysis conditions

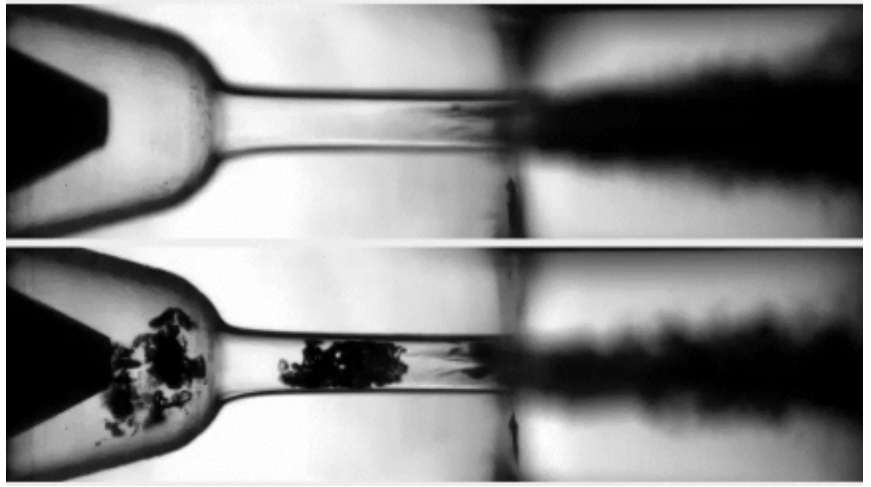
Internal flow and spray experiments



- Real-size transparent nozzles made of cast acrylic to replace actual metal nozzle tip
  - Nozzle design can withstand real injection pressure operation (1000+ bar)
  - Installed in pressure chamber for vacuum or high-pressure (100 atm.) conditions



- Nozzle support slotted to allow near-nozzle spray visualization and air entrainment
- High-speed stereoscopic microscopy can reconstruct the 3-D field and connect internal nozzle flow to spray features



A wide range of partnerships

- Work closely with the US industry and DOE to set research directions
  - Conversation as part of the Advanced Engine Consortium (AEC) or the Advanced Combustion and Emission Control (ACEC)

- Sandia is leading the largest international research effort on spray and combustion relevant to engines
  - The Engine Combustion Network (ECN) was launched over 10 years ago
    https://ecn.sandia.gov/

- Various projects directly funded by industry
  - Spray Combustion Consortium (Sandia-led)
  - Research projects funded by injector, fuel or engine manufacturers