# Experimental Study of the Behavior of the Combustion in Multi-hole Diesel Injectors

**Author: Santiago Cardona Vargas | Advisor: Jaime Gimeno García**

## Summary

Two experimental campaigns were carried out into a new constant pressure flow facility, testing two piezoelectric multi-hole injectors using n-heptane and diesel as fuels in reactive conditions and employing different optical techniques for:

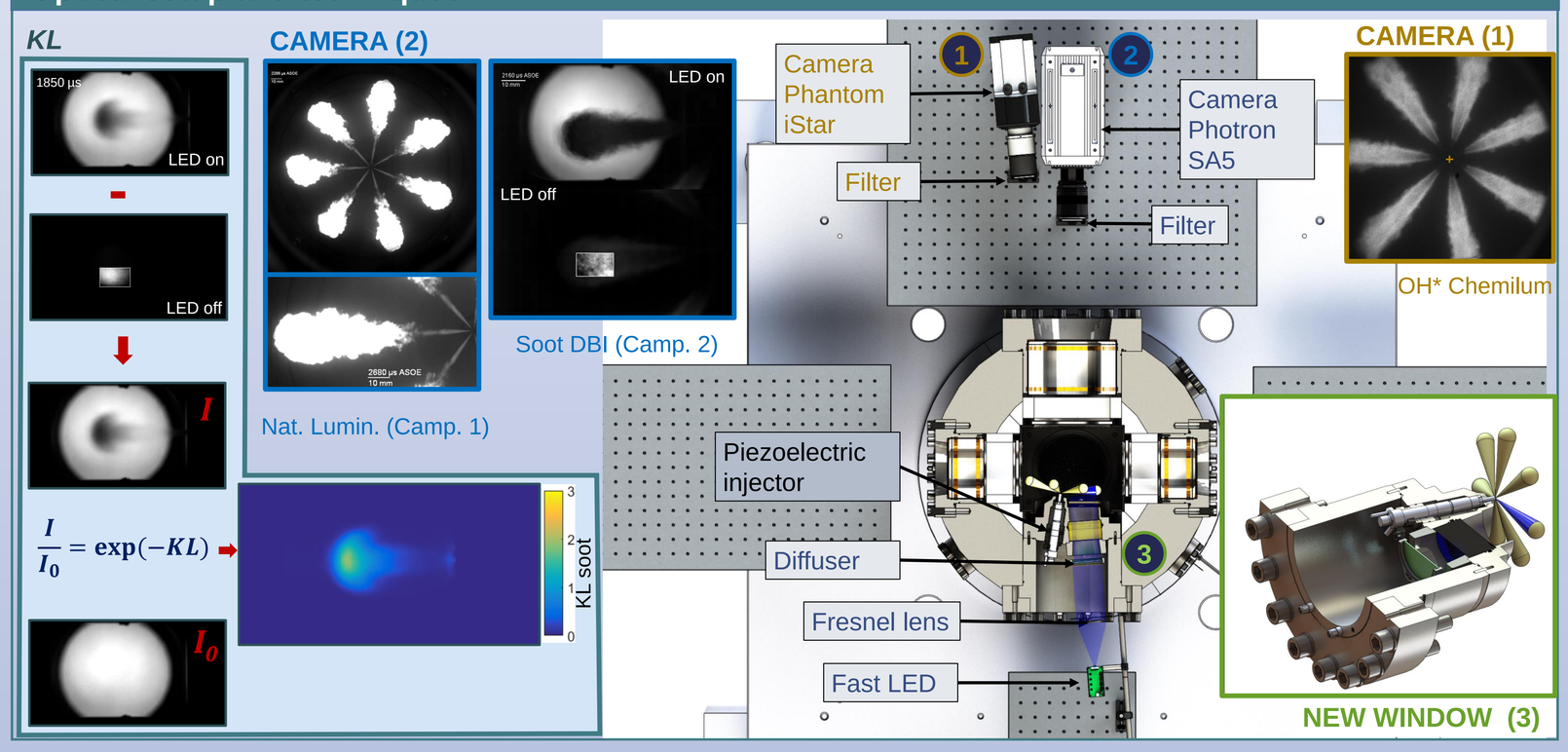
- Measurements of Ignition delay and lift-off length.
- Measurements of the soot concentration using a high-speed color diffused back illumination.

## Motivations (○) and objectives (✓)

- ○ Study of the combustion behavior in multi-hole diesel injectors and development of a new procedure to study soot formation in multi-hole nozzle using high-speed color diffused back illumination technique.
- ✓ The study of the Ignition delay, Lift-off length and soot formation phenomena, of two piezoelectric multi-orifice injectors operating with diesel and n-heptane fuels.
- ✓ Characterize quantitatively soot formation variating the operating conditions.

## Methodology

### Optical setup and techniques




## Hardware

- High-pressure and high-temperature test rig.
- Optical material:
  - Cameras.
  - Beam-splitters.
  - LEDs.
  - Lens.
  - Filters.
  - Diffusers.
- 2 piezoelectric multi-hole injectors.
- Injection system:
  - Common-rail.
  - Air-driven pump
- Injector tip cooling.

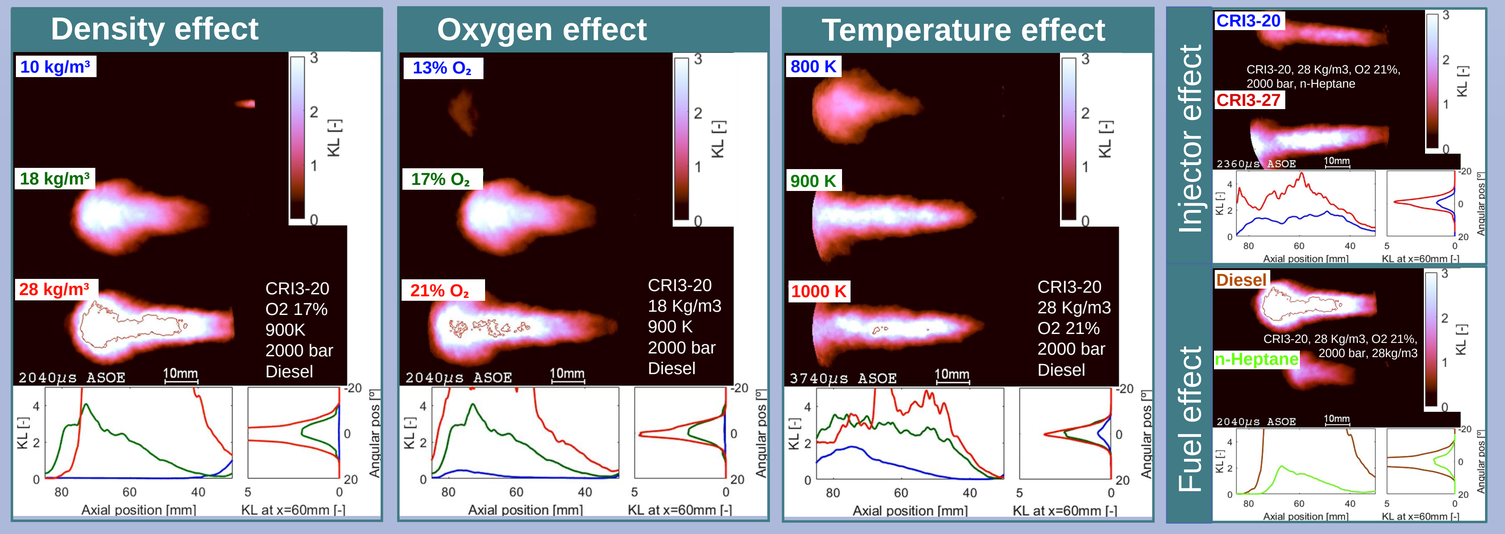
Test rig

Injectors

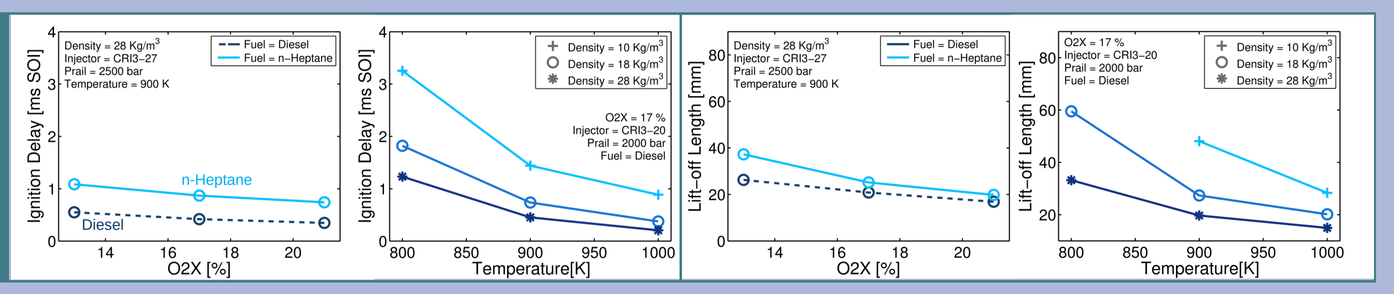
Air-driven pump

## Results

### 2nd Campaign: Soot DBI




### 1st Campaign : Ignition Delay and Lift-off length




### Lift-off length

- ↑Density = ↓LOL
- ↑Injection pressure = ↑LOL
- ↑Temperature = ↓LOL
- ↑Oxygen concentration= ↓LOL
- ↑Orifice diameter = ↑LOL
- n-Heptane= ↑LOL than diesel

### Ignition Delay

- ↑Density = ↓ID
- ↑Injection pressure ≈ ID
- ↑Temperature = ↓ID
- ↑Oxygen concentration= ↓ID
- ↑Orifice diameter = ↑ID
- n-Heptane= ↑ID than diesel

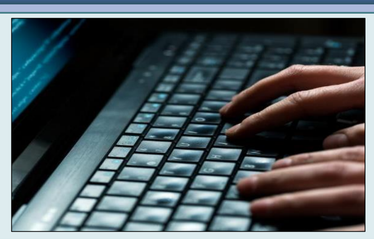
Ignition delay and lift-off length results follow the trends in literature

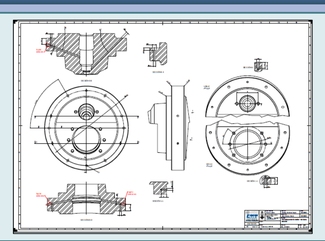
### Soot-DBI

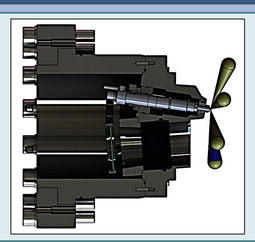
- Results applying this technique are promising and the modifications made in the test rig to carry out this study were satisfactory, motivating the study of the soot formation in multi-hole nozzles in order to understand the behavior of this phenomena and allowing to compare with results reported for single-hole nozzles.
- The new window fulfilled its function allowing the study of the soot evolution between 30 to 85 mm from the injector tip.
- Back-illumination technique can't determine the soot concentration in conditions of high soot formation due to the high extinction by the soot cloud, blocking the LED illumination and reducing the ability of the technique.

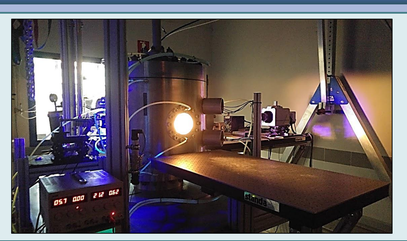
## Contributions

- Methodology to process the Soot-DBI results from multi-hole injector.
- New parts for the high-pressure and high-temperature vessel that allow the study of the soot concentration in multi-hole injectors.
- The first project that was carried out in the new test rig.









## Current disclosure of the work

○ Raul Payri, Jaime Gimeno, **Santiago Cardona**, Sridhar Ayyapureddi, Measurement of soot concentration in a piezoelectric multi-hole Diesel injector, 2017. Currently submitted to *SAE 2017 International Powertrains, Fuels & Lubricants Meeting.*

○ Raul Payri, Jaime Gimeno, **Santiago Cardona,** Sridhar Ayyapureddi, Experimental study of the influence of the fuel and boundary conditions over the soot formation in multi-hole diesel injectors using high-speed color diffused back illumination technique. Applied Thermal Engineering, doi: 10.1016/J.APPLTHERMALENG.2019.113746.

**Ph.D. Program in Transport Propulsion Systems**
**CMT – Motores Térmicos. Universitat Politècnica de València**