A STUDY ON DIESEL SPRAY TIP PENETRATION AND RADIAL EXPANSION UNDER REACTING CONDITIONS

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

CMT motores térmicos

Author: Tiemin Xuan

Supervisor: José María García Oliver

Programa de Doctorado en Sistemas Propulsivos en Medios de Transporte

MOTIVATION

Detailed knowledge has been known on the transient dynamics of an inert jet.

- Tip penetration can be predicted by momentum conservation
- Cone angle is a quantitative metrics of the radial dispersion (turbulent mixing)

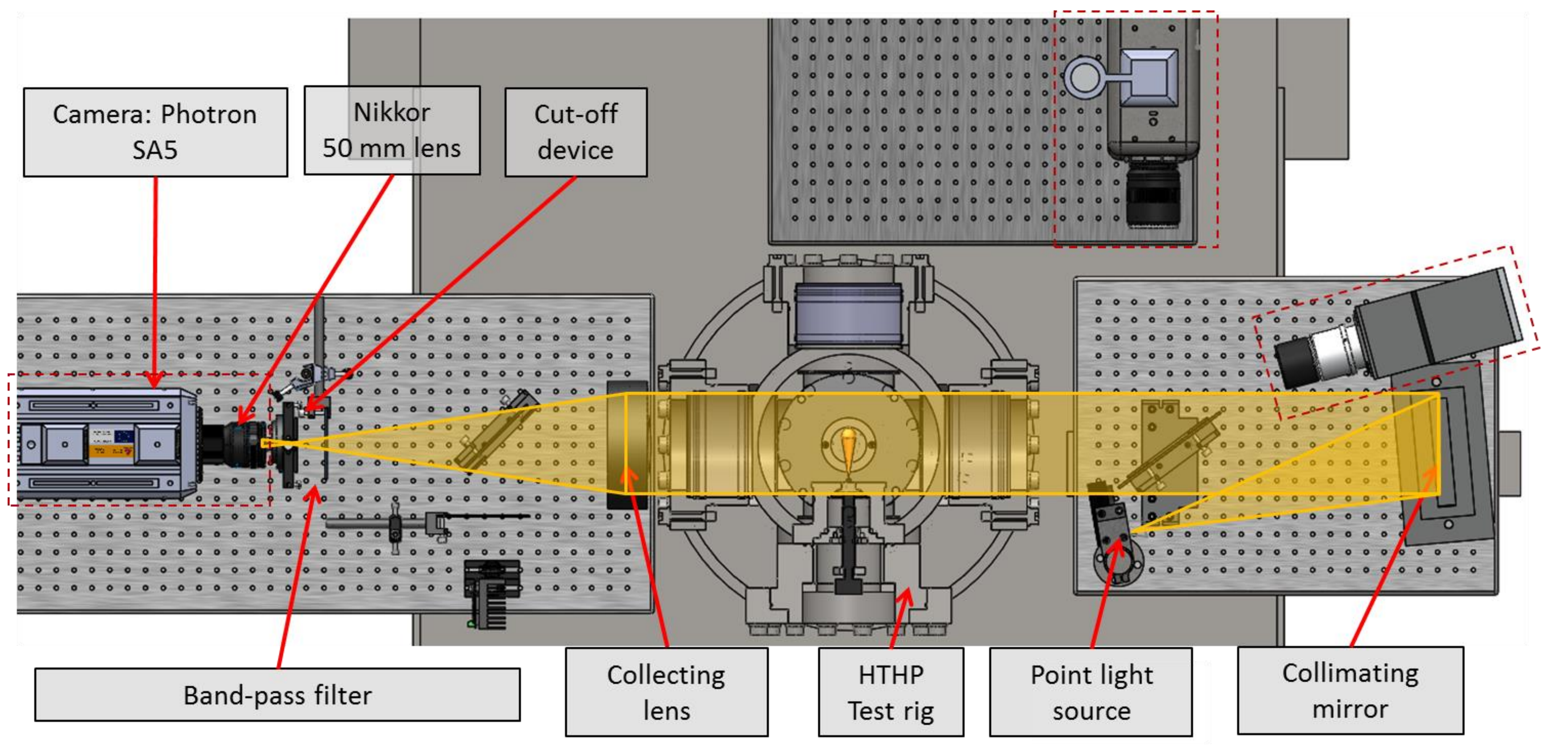
The knowledge on a reacting case is still limited.

- How do tip penetration and radial dispersion evolve with time?
- How can the radial spray dilation be quantified?
- How do operating conditions affect such quantitative parameters?

OBJECTIVES

- Evaluate the reacting spray expansion in axial and radial direction
- Find a way to quantify the reacting spray dilation
- Figure out the effects of operating conditions on reacting spray evolution

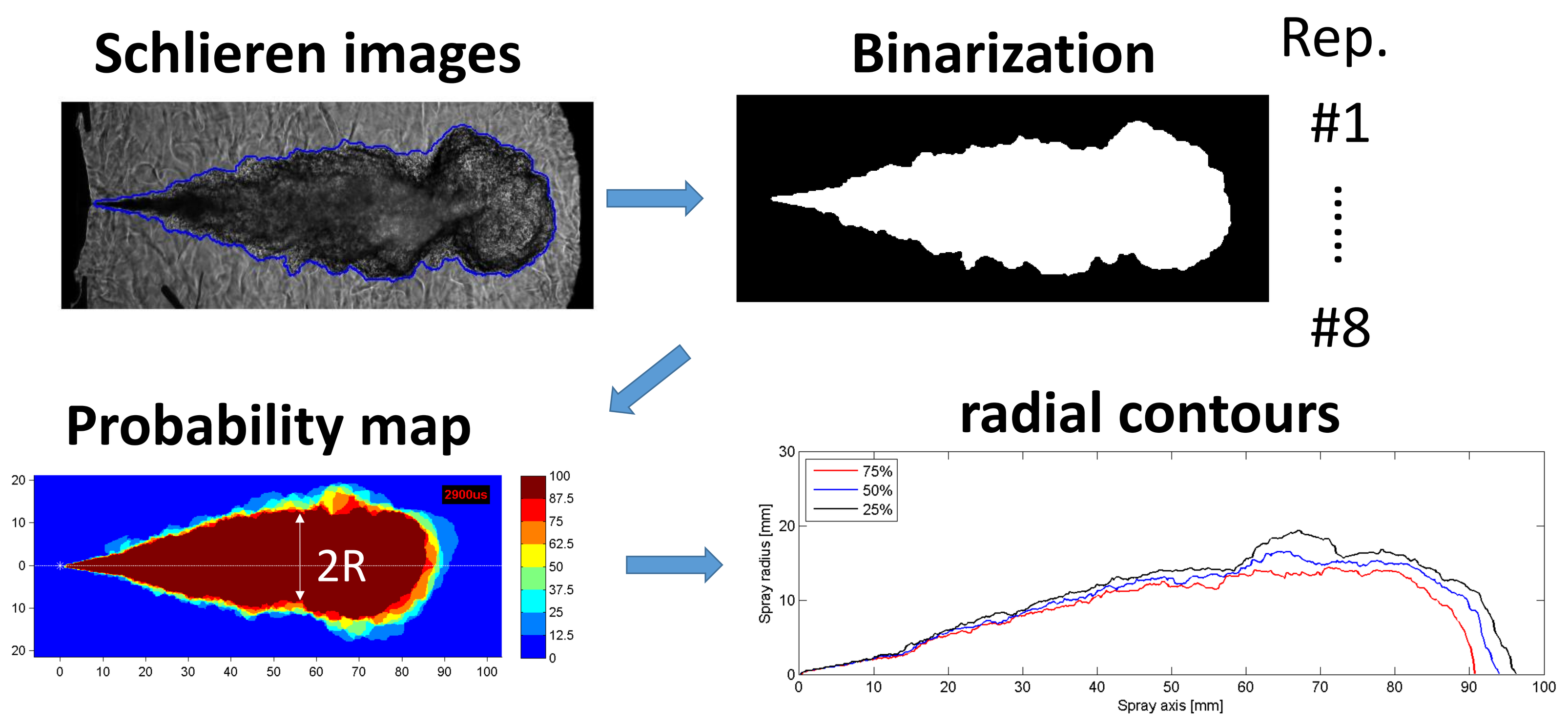
EXPERIMENTAL SETUP



TEST MATRIX

Parameters	values	units
Fuel	n-Dodecane	-
Injector	675	-
Nozzle diameter	89	μm
Injection pressure	500,1000,1500	bar
Ambient gas temperature	800,850,900	K
Ambient density	7.6, 15.2, 22.8	kg/m^3
Oxygen concentration	0,15,21	%(vol)

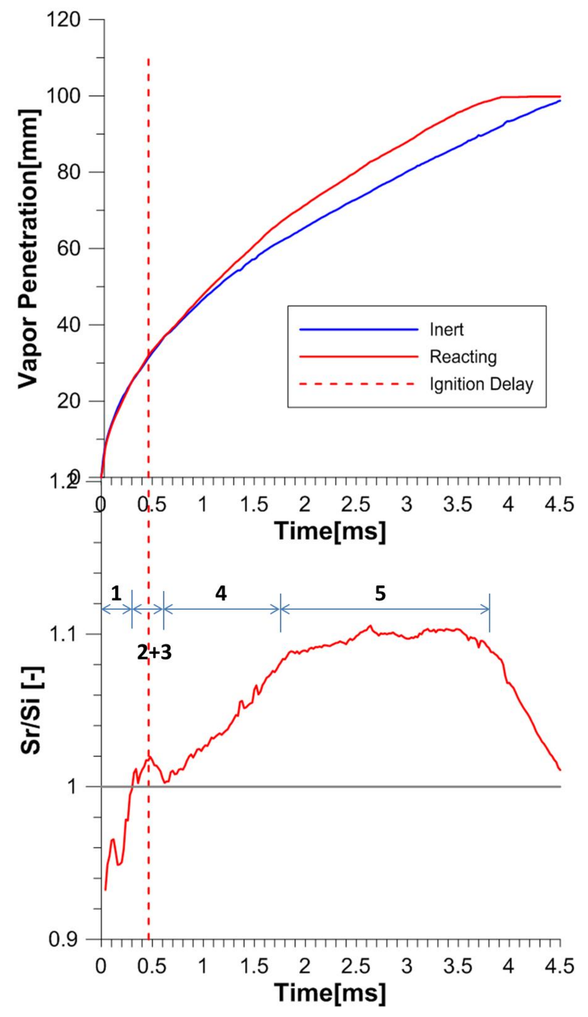
PROCESSING METHODOLOGY



RESULTS

BASELINE SPRAY A CONDITION

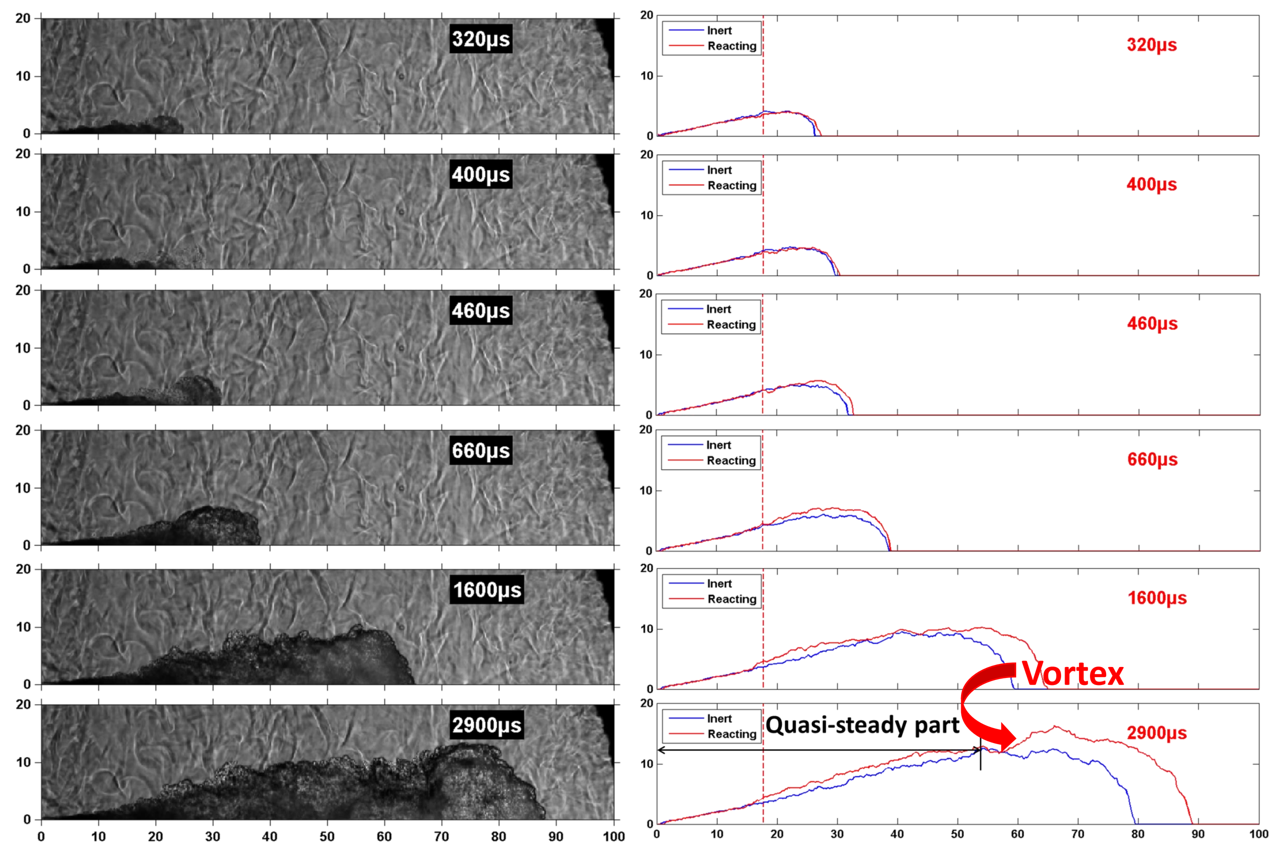
REACTIVE VS INERT PENETRATION



1. Non-reacting; 2. Autoignition; 3.Stabilization; 4. Acceleration 5. Quasi-steady

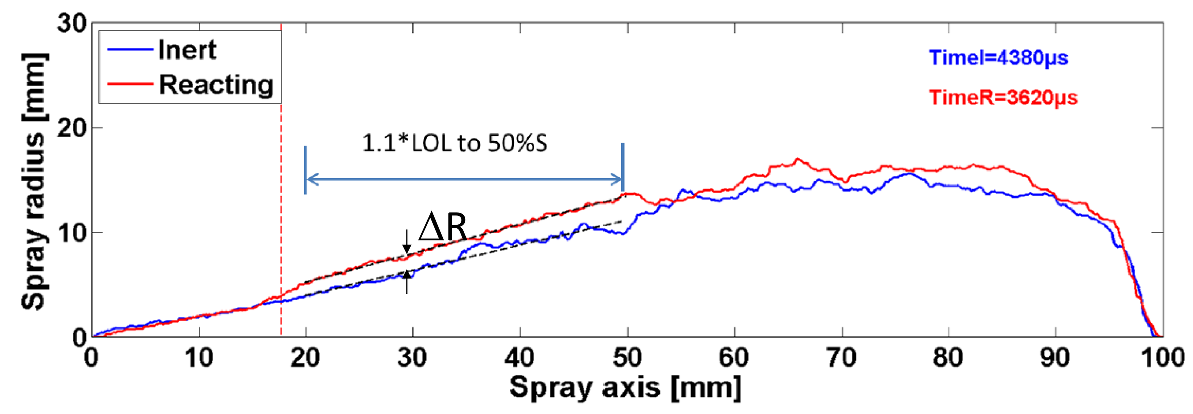
- The results are consistant with previous work: Desantes et al., Combustion and Flame, 2014

TEMPORAL EVOLUTION OF THE SPRAY CONTOUR



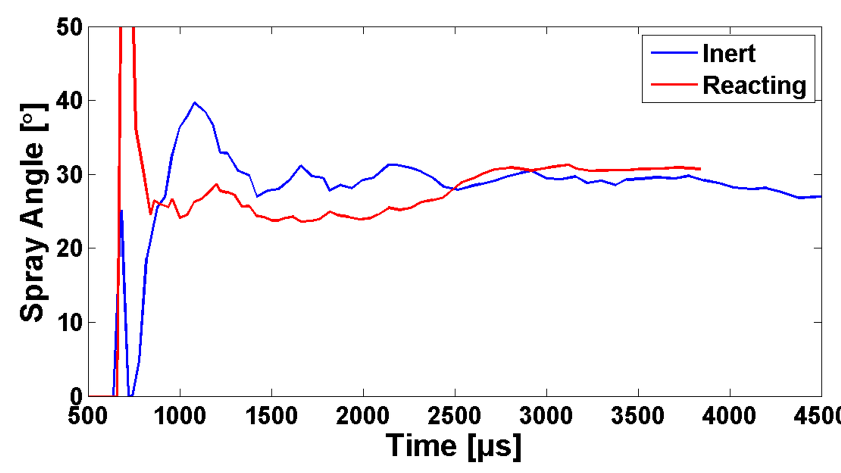
- At 460μs ASOI ignition takes place, which directly leads a separation of the penetration and radial expansion in the front part of the spray.
- The reacting spray has a quasi-steady part from the nozzle up to around 50% of the penetration. An apparent vortex came up after the jet head .

SPATIAL EVOLUTION OF THE SPRAY CONTOUR



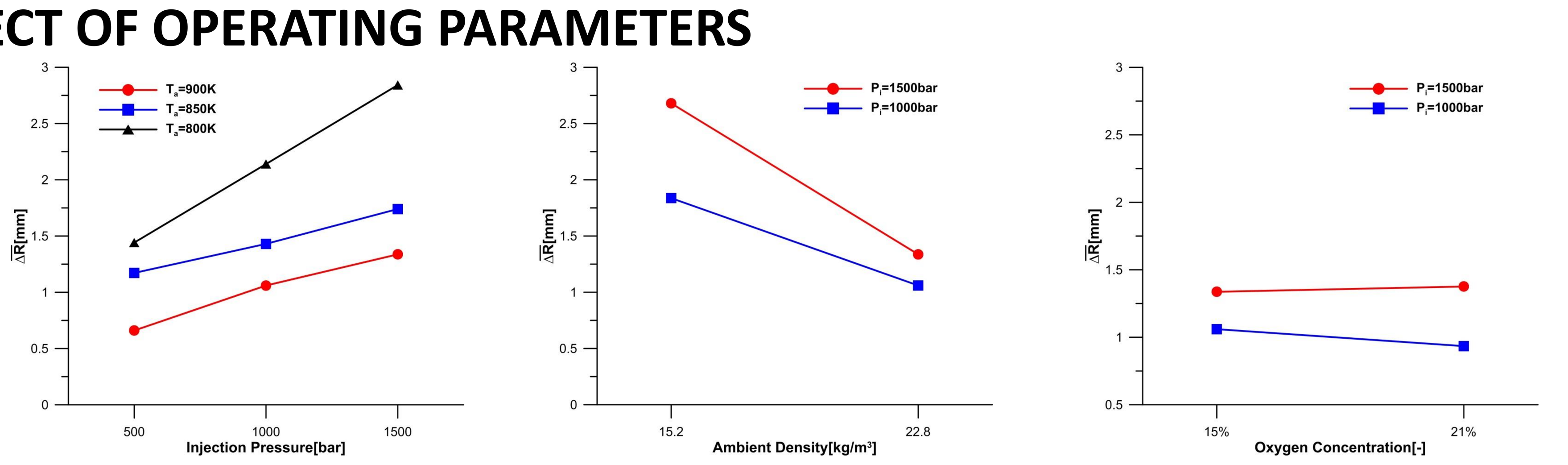
- The quasi-steady part can be divided into inert and reacting parts
- A liner fitting to the reacting contour was done from lift-off length to 50% of penetration
- The slope of the inert and reacting parts are similar, i.e. there is a shift in the radius

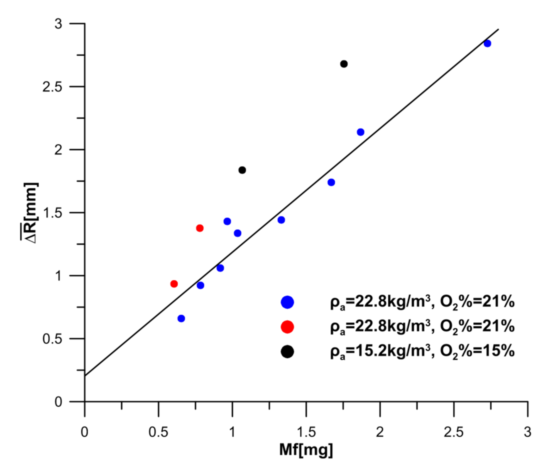
TIME EVOLUTION OF THE SPRAY ANGLE



- Reacting spray angle eventually converges to the inert one

EFFECT OF OPERATING PARAMETERS





- The average value of the radius width difference $\overline{\Delta R}$ between inert and reacting conditions at every penetration from 1.1·LOL to 50% of the spray tip
- Radial expansion seems to be linked to the amount of fuel located at Start of Combustion downstream of LOL

CONCLUSIONS

- The spatial evolution of the reacting spray can be divided into three parts:
  - I. Quasi-steady inert part, from nozzle tip to the Lift-off length.
  - II. Quasi-steady reacting part, from lift-off length to the position where the contour becomes flat.
  - III. Transient part, from the end of last part to the spray tip.
- The contour at the quasi-steady part of the reacting spray is almost parallel to the inert case. An average width difference of this part during the acceleration phase mentioned above was calculated to evaluate the radial expansion of reacting spray.
- Parametric trends of the radial expansion have been quantified. This combustion indicator seems to be linked to the amount fo fuel located at Start of Combustion downstream of LOL