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# Experimental study of premixed ozone-seeded DME/O<sub>2</sub> cool flames on a stagnation plate burner

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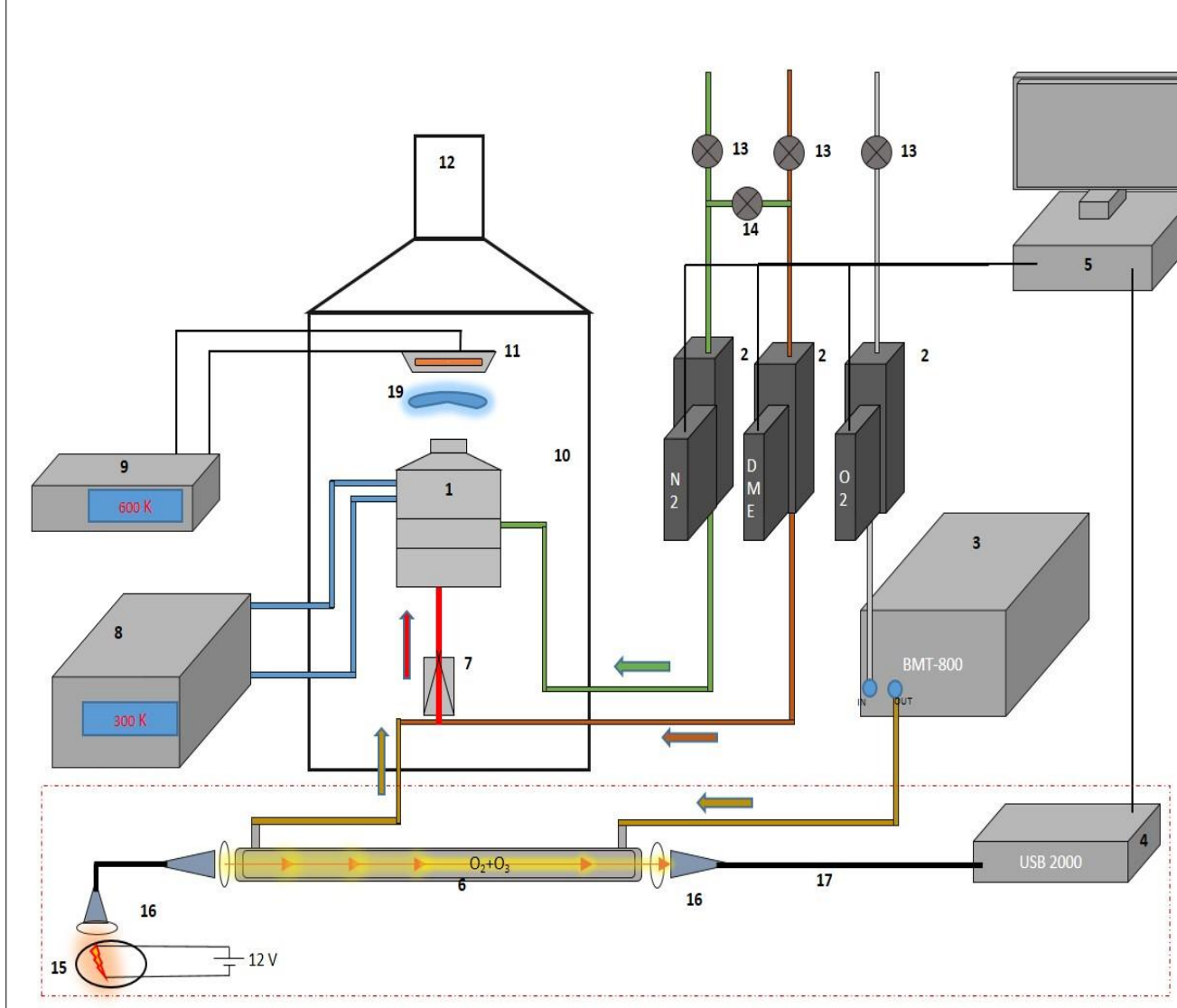
## Introduction

**Context:** Need for research effort on the LTC kinetics to enable new low-emission engine concepts (SACI, PPCI, GCI...)

- Development of a new burner stabilized premixed cool flame setup,
- Burner characterization as a function of strain rate, equivalence ratio and ozone concentration,
- Development and validation of new kinetic models (the first tests are with : DME+ O<sub>2</sub> + 0 to 6,84 mol% O<sub>3</sub>)

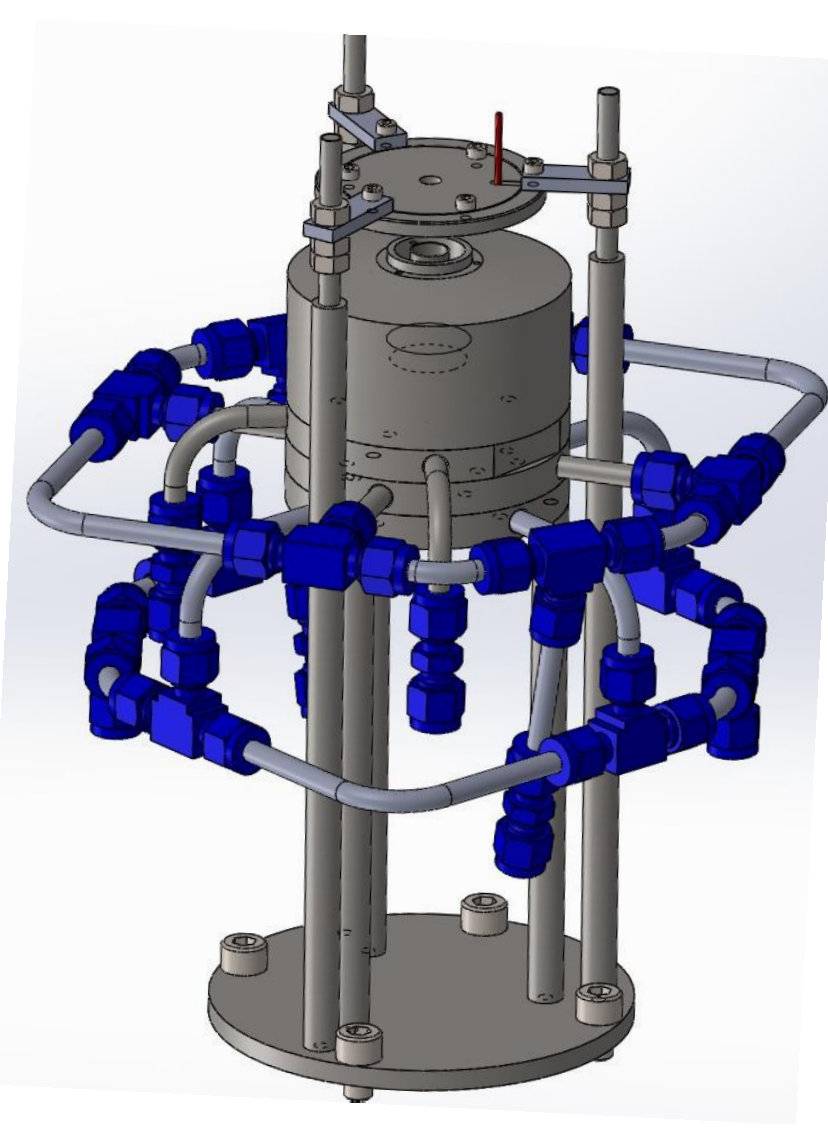
## Experimental setup and procedure

### Stagnation plate stabilized cool flame experimental setup



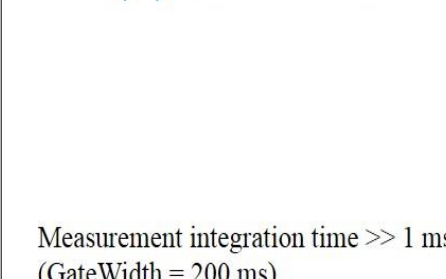
1. Pre-mix burner
2. Gas flow meters
3. Ozone generator
4. Spectrometer USB2000
5. Acquisition Unit
6. Optical cell (1 m)
7. Check valve (10 mbar)
8. Water cooler
9. temperature controller
10. Insulation and protection frame
11. Heated plate
12. Extraction of burned gases
13. Valves
14. Purge valve (for DME)
15. Lamp
16. Collimator
17. Optical fiber
18. O<sub>3</sub> measurement system
19. Cool-Flame

### Stagnation plate burner



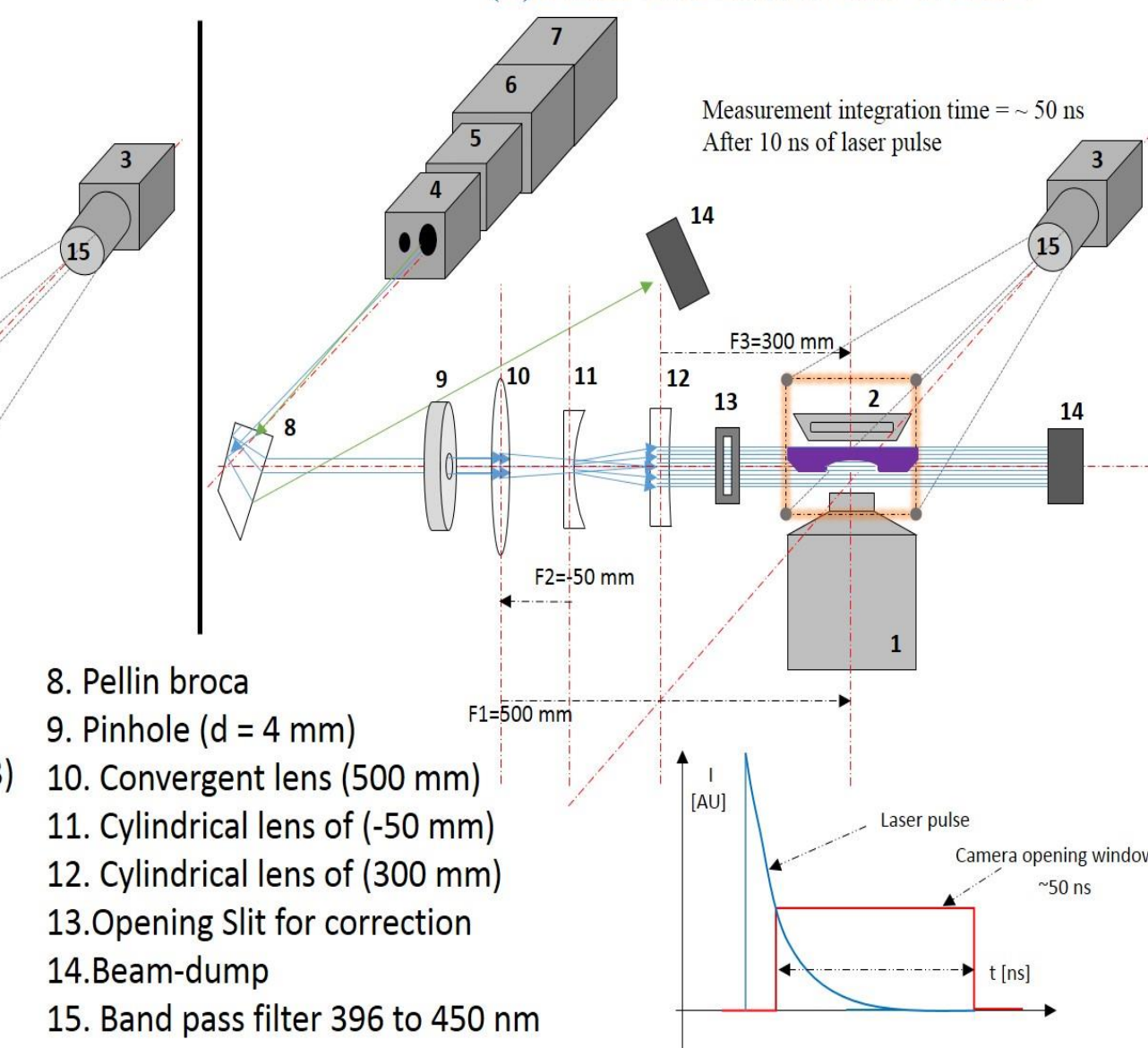
### Diagnostic methods used

#### (A) Chemiluminescence of CH<sub>2</sub>O



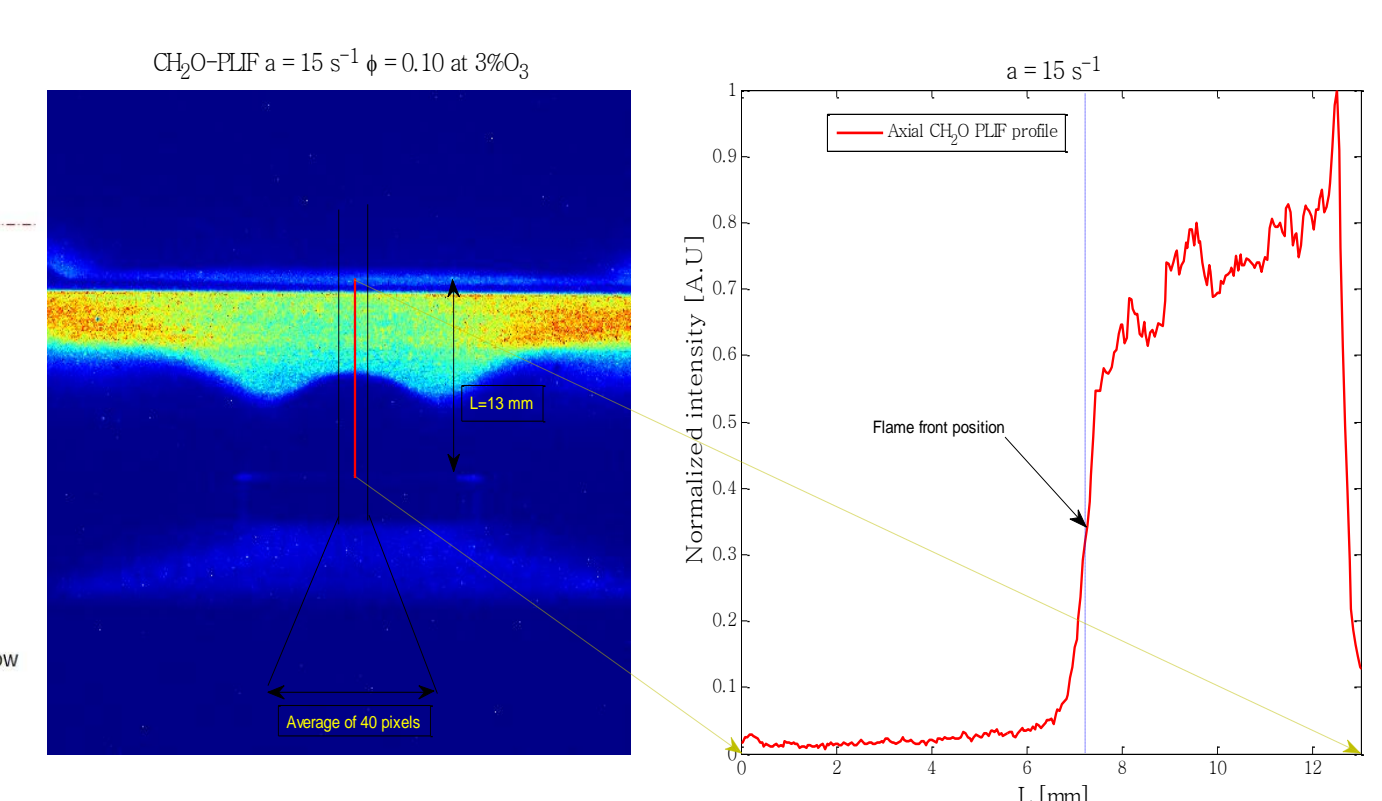
1. Pre-mix burner
2. Heated plate
3. Intensified camera (ICCD PIMAX 3)
4. Third harmonic (355 nm)
5. Second harmonic (532 nm)
6. Laser Shutter
7. Laser Nd-YAG 1064 nm

#### (B) Planar laser fluorescence of CH<sub>2</sub>O



8. Pellin broca
9. Pinhole (d = 4 mm)
10. Convergent lens (500 mm)
11. Cylindrical lens of (-50 mm)
12. Cylindrical lens of (300 mm)
13. Opening Slit for correction
14. Beam-dump
15. Band pass filter 396 to 450 nm

### Principle of analyses of the CH<sub>2</sub>O PLIF images: determination of the flame front position



Ozone concentration:

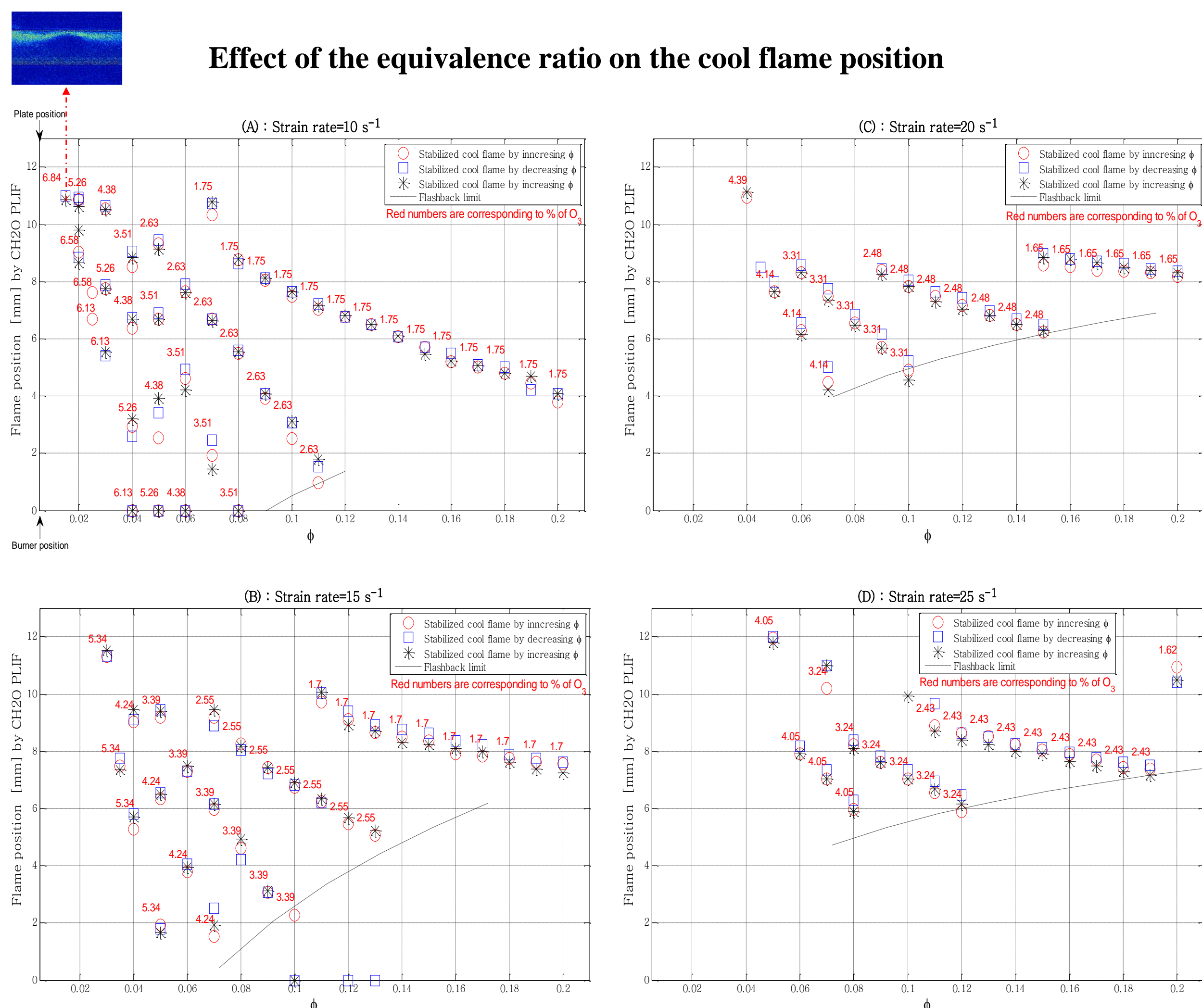
$$c [g/m^3] = -\frac{10^6 M}{\sigma l N_a} \ln \left( \frac{I}{I_0} \right) \quad (1)$$

Strain rate:

$$\alpha [s^{-1}] = \frac{V}{L} \quad (2)$$

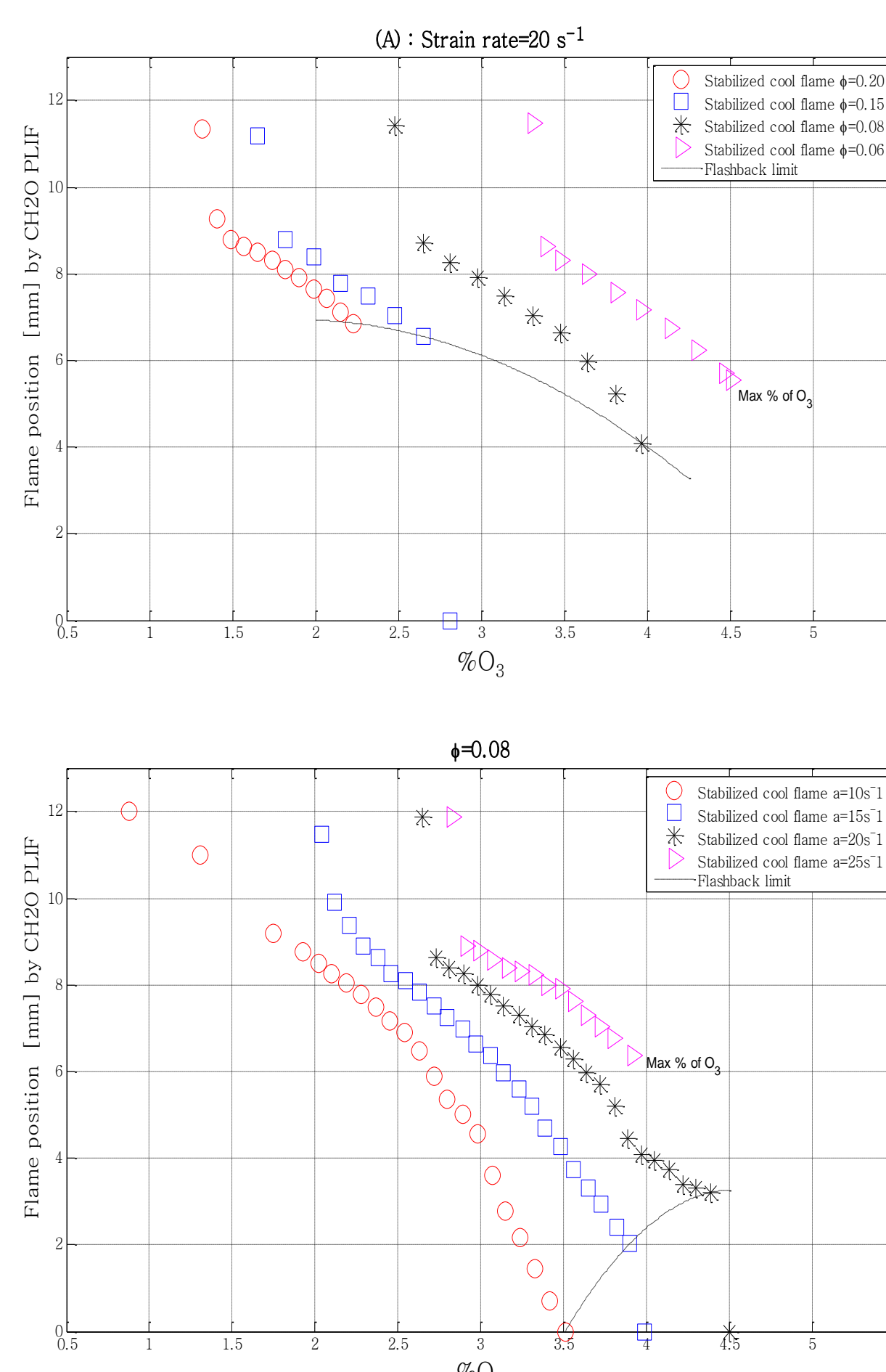
## Results

### Effect of the equivalence ratio on the cool flame position



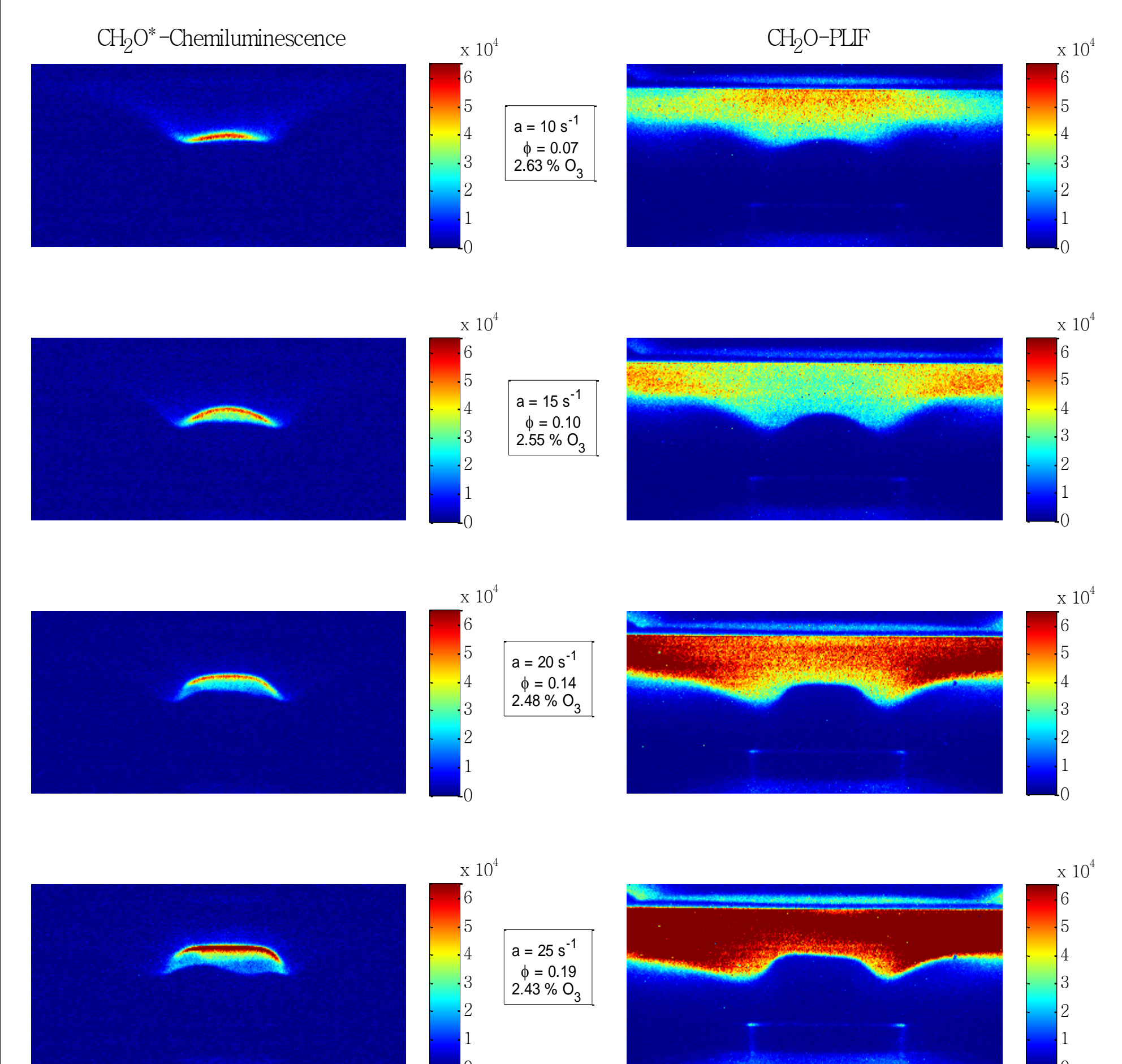
- Good reproducibility within a large range of operating conditions ( $\alpha$ ,  $\phi$  and %O<sub>3</sub>).
- Flame front position decreases as the equivalence ratio increases.
- Increase of the strain rate enables the occurrence of flashback, especially at the highest equivalence ratios ( $\phi > 0.10$ ).
- Flashback domain tends to move towards the plate as the value of the strain rate increases

### Effect of the ozone mole fraction



- As the equivalence ratio decreases, the necessary ozone for cool flame stabilization increases.
- As the strain rate increases, the necessary ozone for cool flame stabilization increases.

### Chemiluminescence vs CH<sub>2</sub>O-PLIF (Cool-Flame characteristics)



- Intensity of the CH<sub>2</sub>O-PLIF and CH<sub>2</sub>O\* signals increases with the strain rate and equivalence ratio.
- The shape of the flame front is more flat as the strain rate increases.

## Conclusions

- The novel stagnation plate burner designed for the study of LTC reactivity is now functional
- An experimental database of flame front positions has been constituted
- Good reproducibility of the results in large range of  $\alpha$ ,  $\phi$ , and %O<sub>3</sub>
- Ozone is strongly efficient in facilitating the LTC reactivity

## Outlooks

Next step will be dedicated to the experimental study of the chemical aspects of the stabilized cool flames, by means of ex-situ (i.e., after sampling) methods. The current and future experimental data will be used as a validation target for kinetic models.

## Acknowledgments

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