



HAL
open science

Characteristics of non-premixed oxygen enriched flames from a swirl burner with a radial fuel injection

N. Merlo, T. Boushaki, C. Chauveau, S. de Persis, I. Gökalp

► **To cite this version:**

N. Merlo, T. Boushaki, C. Chauveau, S. de Persis, I. Gökalp. Characteristics of non-premixed oxygen enriched flames from a swirl burner with a radial fuel injection. 35th International Symposium on Combustion, Aug 2014, San Francisco, California, United States. hal-02063334

HAL Id: hal-02063334

<https://hal.science/hal-02063334>

Submitted on 11 Mar 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Characteristics of non-premixed oxygen enriched flames from a swirl burner with a radial fuel injection

N. Merlo, T. Boushaki*, C. Chauveau, S. de Persis, I. Gökalp

CNRS, ICARE, Institut de Combustion, Aérothermique, Réactivité et Environnement, 1C, avenue de la Recherche Scientifique, 45071 Orléans Cedex 2, France

* toufik.boushaki@cnrs-orleans.fr



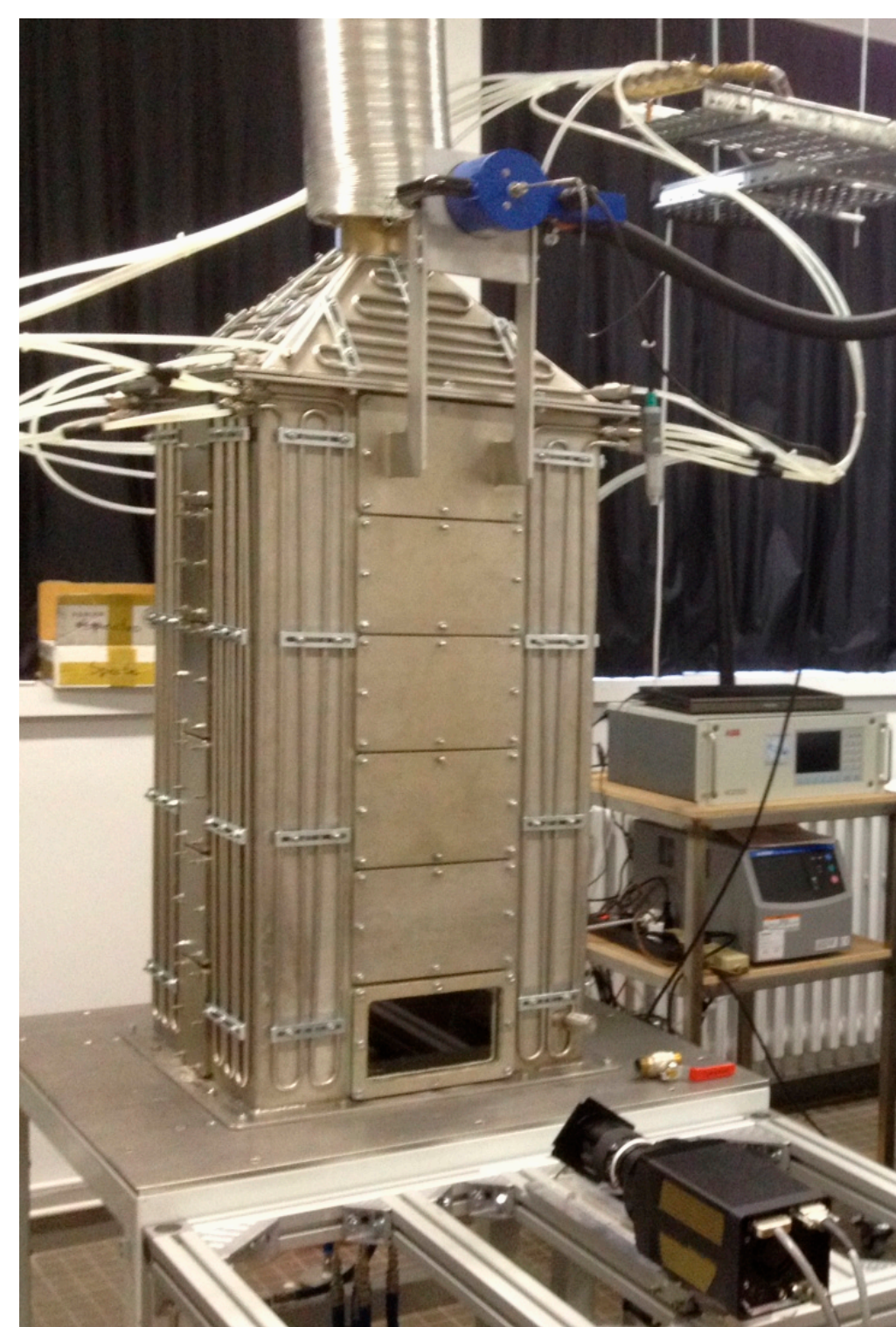
Context

- ✓ The study is motivated by **CO₂ capture applications** further to the increase of CO₂ concentration by the O₂ enrichment.
- ✓ **Support** : French National Research Agency (ANR), CO₂-EnergiCapt project.

Objective

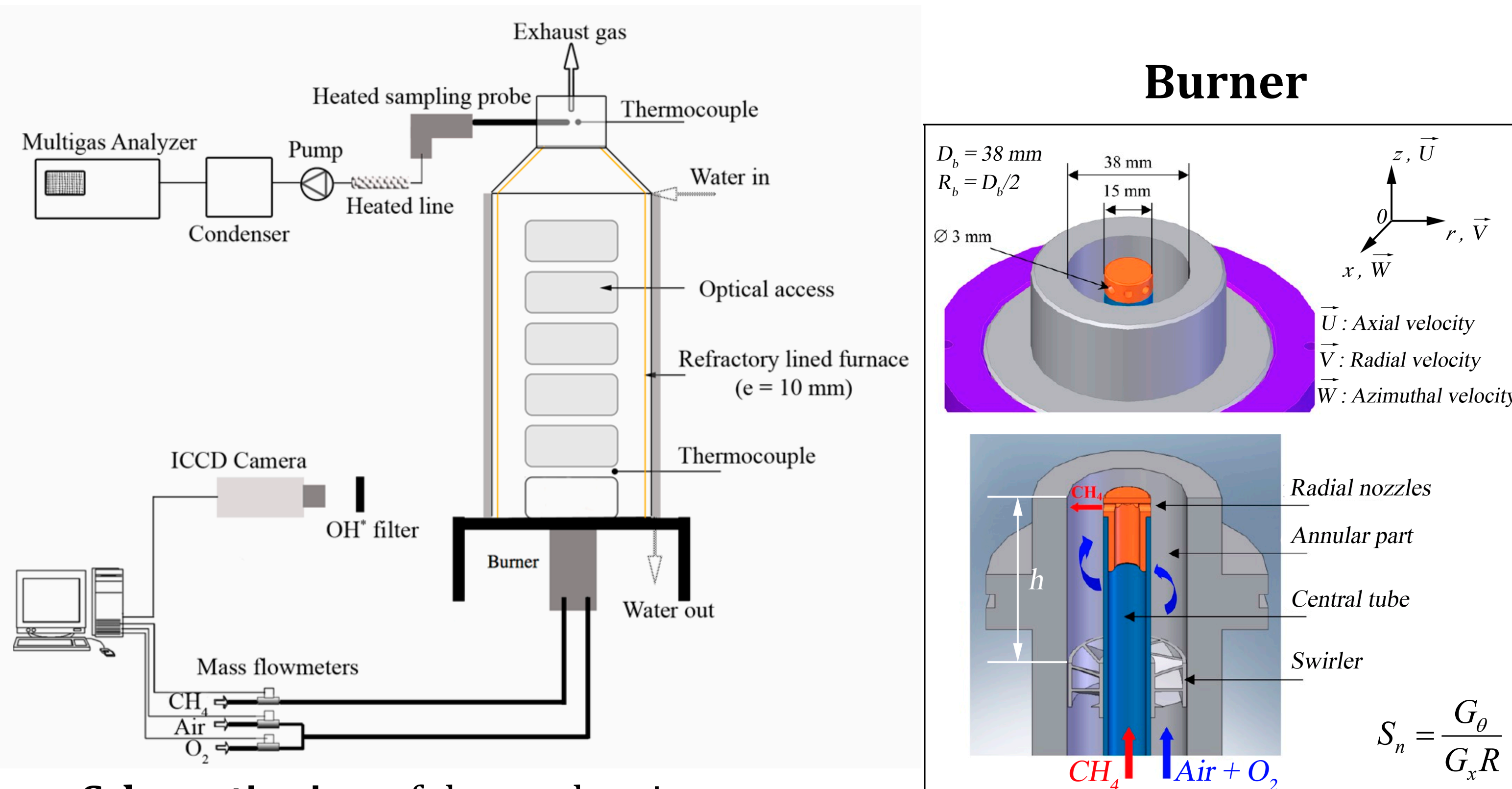
- ✓ Optimization of **industrial boilers** by the combination of combustion air enriched with oxygen and reducing CO₂ by a membrane capture.
- ✓ Study the characteristics of turbulent CH₄-air flames with O₂ enrichment : **Flame stability, Pollutant emissions (CO, NO_x, CO₂), Velocity fields.**

Combustion chamber



Combustion chamber : 25 kW, dimensions 0.5x0.5x1 m³

Experimental setup



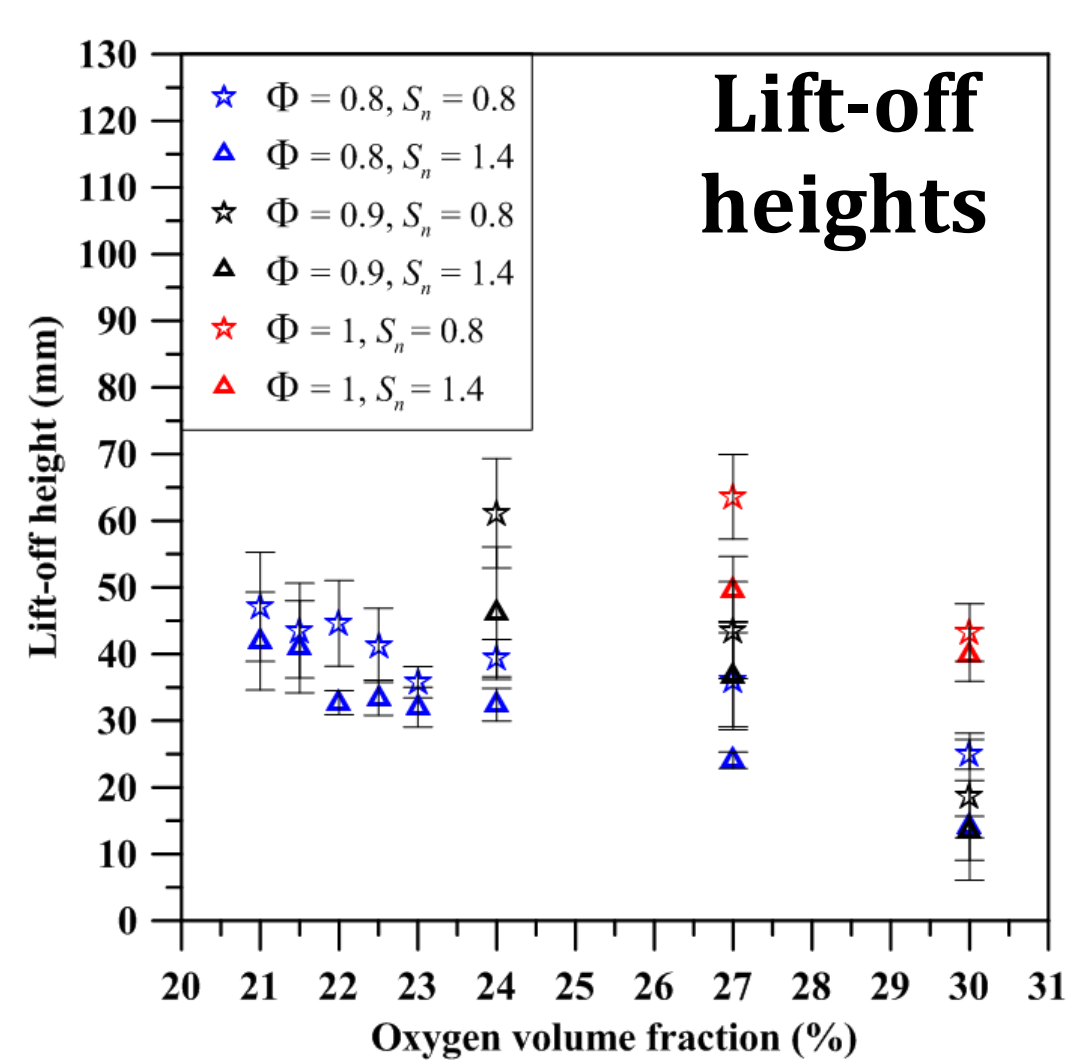
Schematic view of the combustion chamber with the OH Chemiluminescence system and the gas analyzer

Burner : two concentric tubes with a **swirler** in the annular part

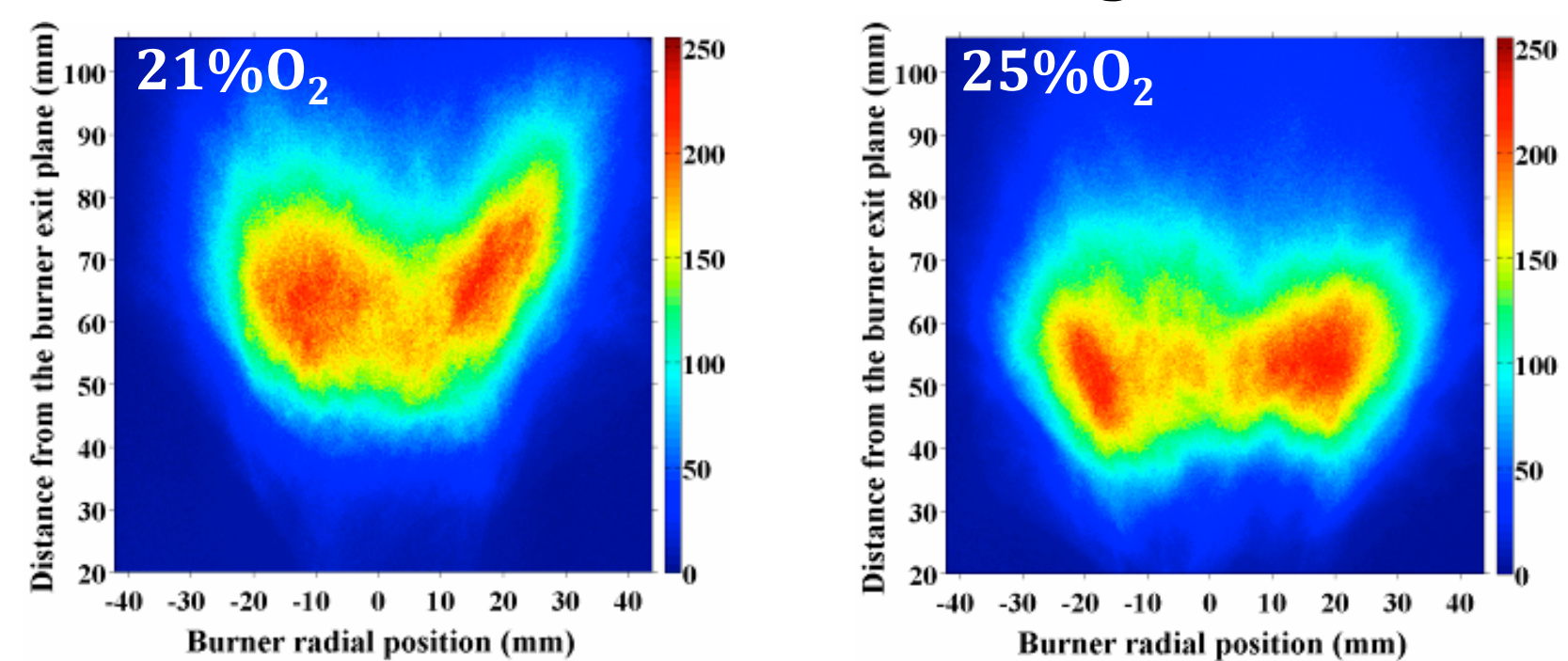
Details of measurement techniques

- ✓ **Multi-gas analyzer** : NO_x, CO, CO₂, O₂, SO₂
- ✓ **OH chemiluminescence**: ICCD camera, a 105 mm UV lens, a 306 nm filter.
- ✓ **Stereo-PIV system** : a double-pulsed Nd:YAG laser (25 mJ/pulse) at 532 nm, 10 Hz. 2 TSI Powerview Plus 4MP, 2048 x 2048 px², Scheimpflug adaptaters. Seeding : Al₂O₃ 0.5-1 μm.
- ✓ **V3V system of TSI**: V3V-9000-TS probe, 3 cameras 4MP-HS, 2 Evergreen 200 mJ PIV lasers.

Flame behavior



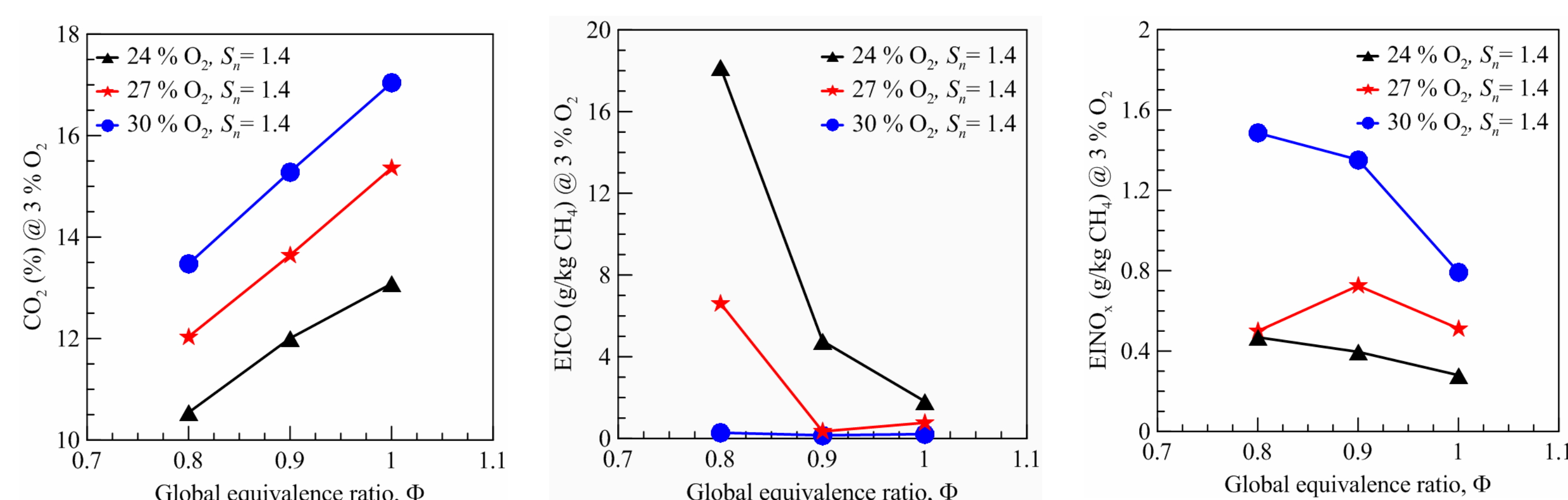
Instantaneous OH* images



➔ **Flame stability is enhanced with oxygen addition even for low oxygen enrichment rates.**

- ✓ Lift-off heights \downarrow with O₂ addition.
- ✓ Fluctuations of lift-off heights \downarrow with O₂ addition.
- ✓ Lift-off heights \downarrow with swirl number (S_n).
- ✓ Lift-off heights \downarrow when equivalence ratio (Φ) \downarrow .

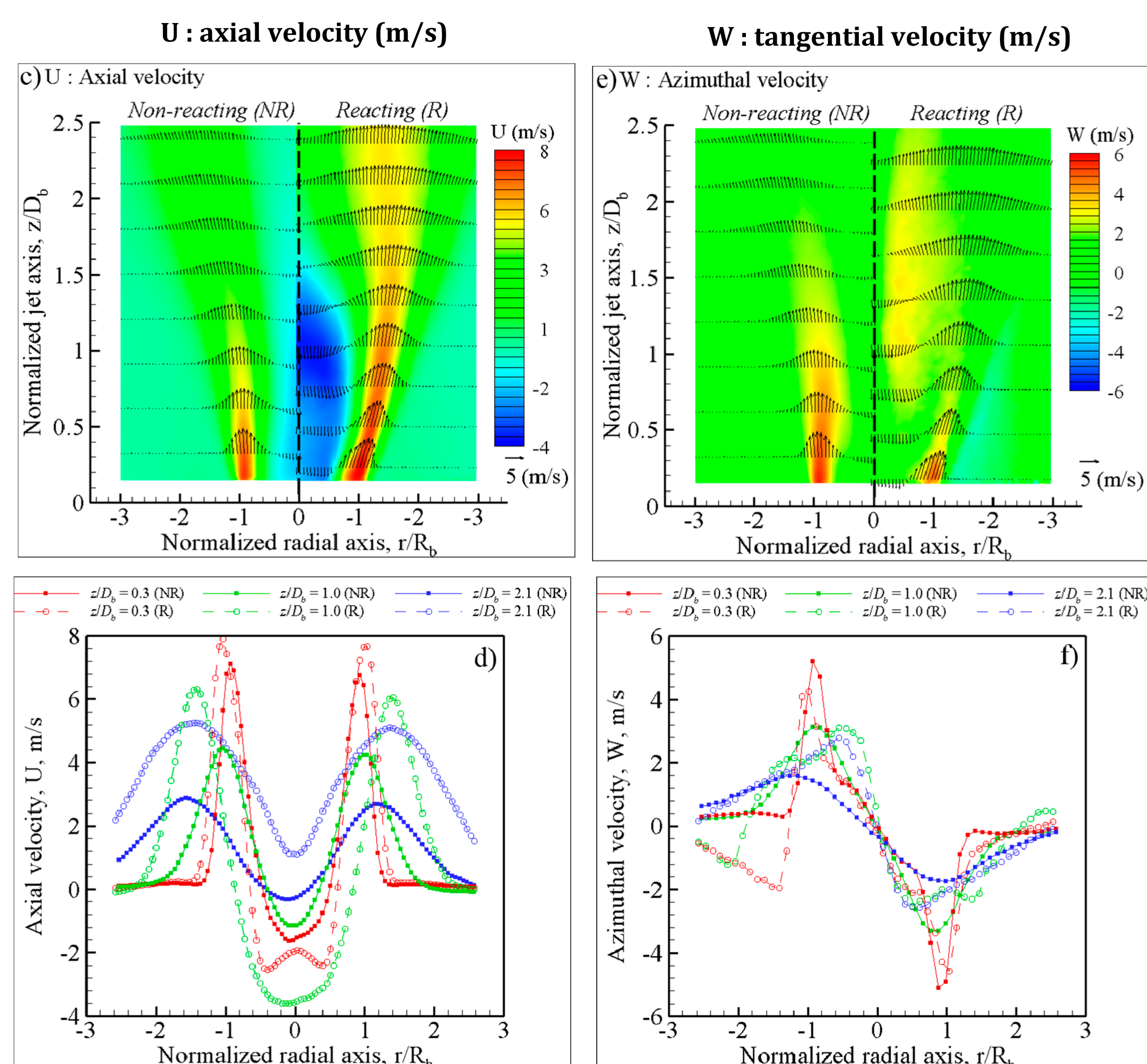
Pollutant emissions



- ✓ CO₂ concentrations increase with O₂ addition and global equivalence ratio (a).
- ✓ CO emissions largely decrease with O₂ addition and global equivalence ratio (b).
- ✓ NO_x emissions increase with oxygen addition, and decrease with equivalence ratio (c).

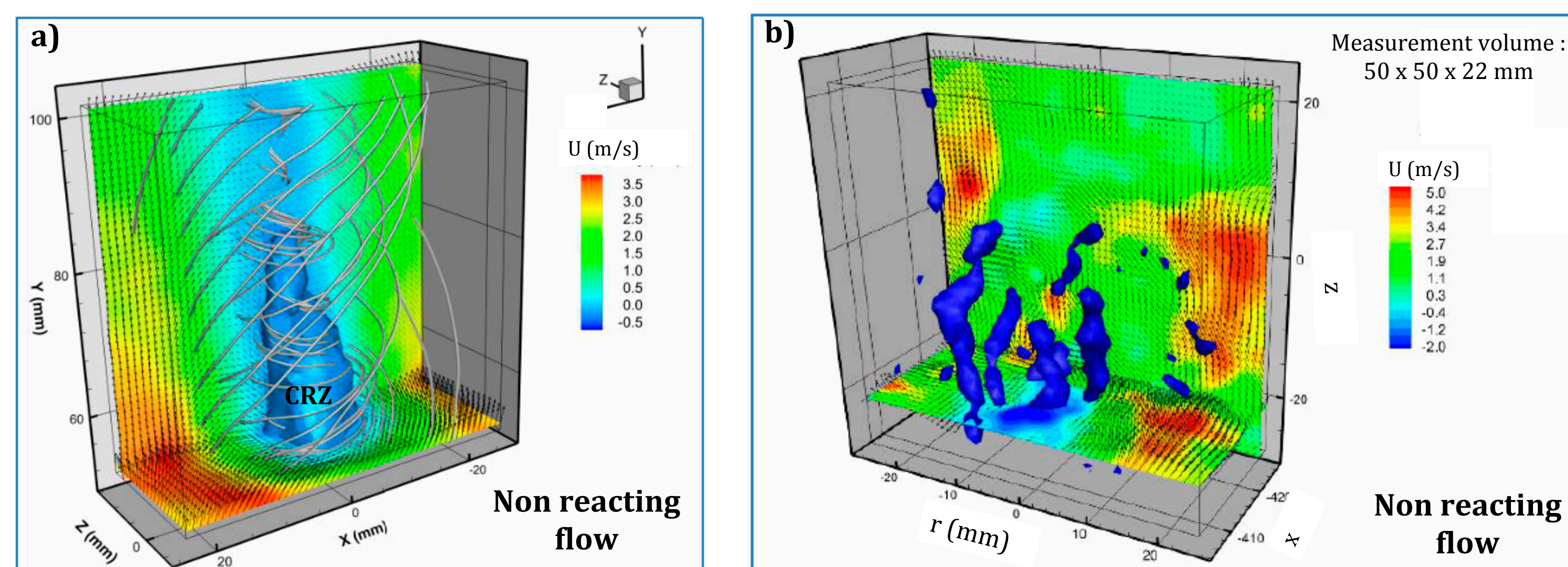
Stereo-PIV results of non reacting and reacting flow

Case : Swirl number $S_n=0.8$, equivalence ratio $\Phi=0.8$



Flow analysis by stereo-PIV and V3V* system

First results of V3V measurements _ Collaboration with TSI® on 2014



Swirling flow demonstrated by the streamlines

Plot of Q-criteria showing counter-rotating vortices extending from the center of the burner

- ✓ The presence of flame increases the central recirculation zone (CRZ) (c, d) compared to non reactive cases
- ✓ Strong axial expansion is induced by combustion (c, d)
- ✓ In the reacting the azimuthal velocity field tends to show that the intensity of the swirling motion is lower than the motion originally imposed to the flow (e, f)
- ✓ Increasing $S_n \Rightarrow$ Increasing reverse flow velocities