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Turbulent combustion with oxygen enrichment and capture of CO₂ in industrial boilers of medium power



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CO₂ EnergiCapt project

- ✓ **Period** : 2010-2015
- ✓ **Support** : ANR French National Research Agency
- ✓ **ANR grant**: 1 261 469€
- ✓ **Subject**: Integration of oxygen-enriched air combustion and CO₂ capture for existing industrial boilers: development of a demonstrator

Project partners

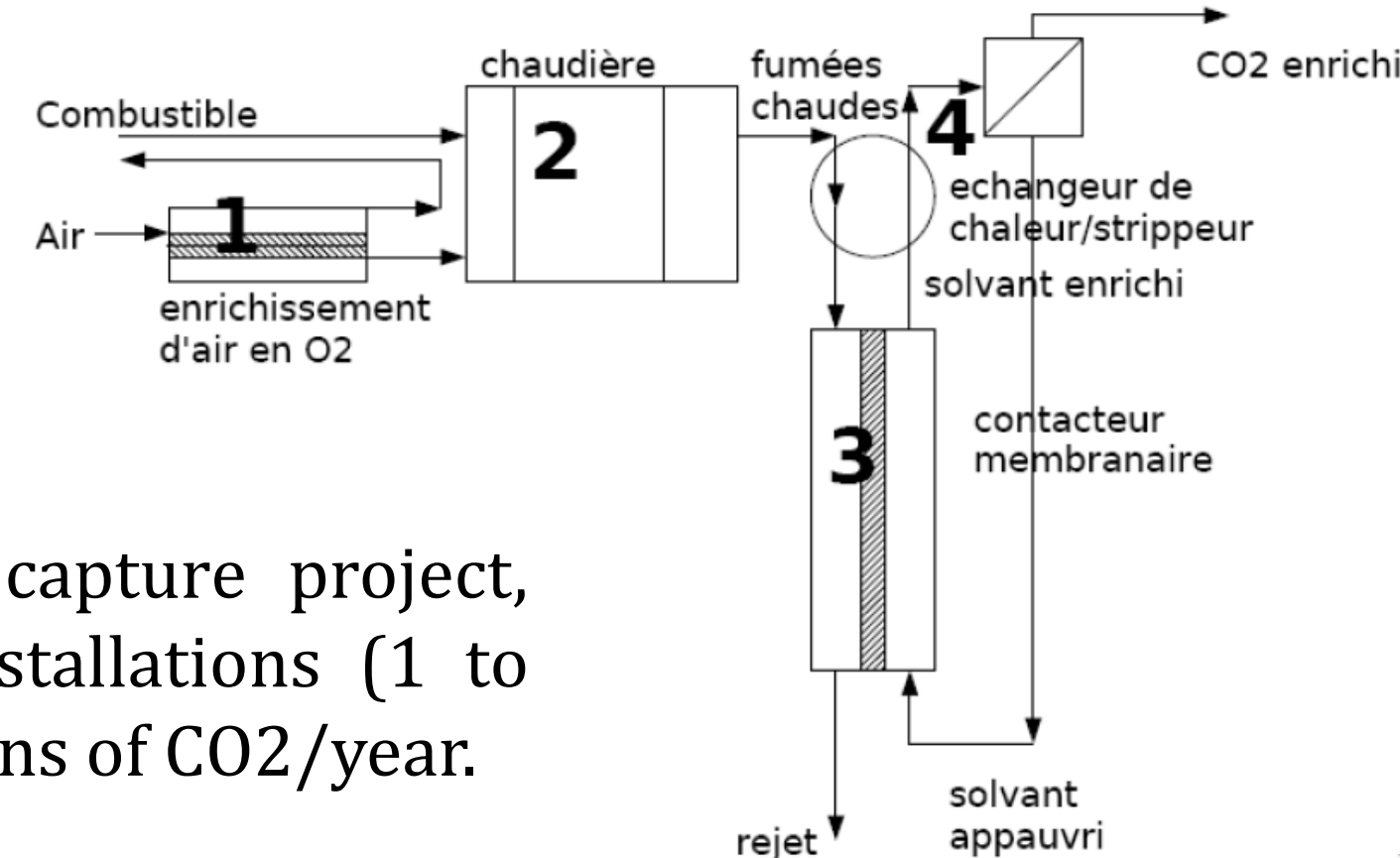
- ✓ **ICARE CNRS**, specialist in combustion
- ✓ **LRGP CNRS**, specialist in capture of CO₂
- ✓ **LLT** «Leroux et Lotz Technologies», manufacturer of industrial equipments
- ✓ **Polymem**, manufacturer of fiber membranes for fluid treatments
- ✓ **CPCU**, operator of boilers of the Paris metropolis

Objective

- ✓ **Optimization of industrial boilers** by the combination of **combustion air enriched** with oxygen and reducing CO₂ by a membrane capture.
- ✓ Development of a **CO₂ capture pilot unit** dedicated to district heating heat production units and validate it on an industrial site

Description of CO₂ EnergiCapt project

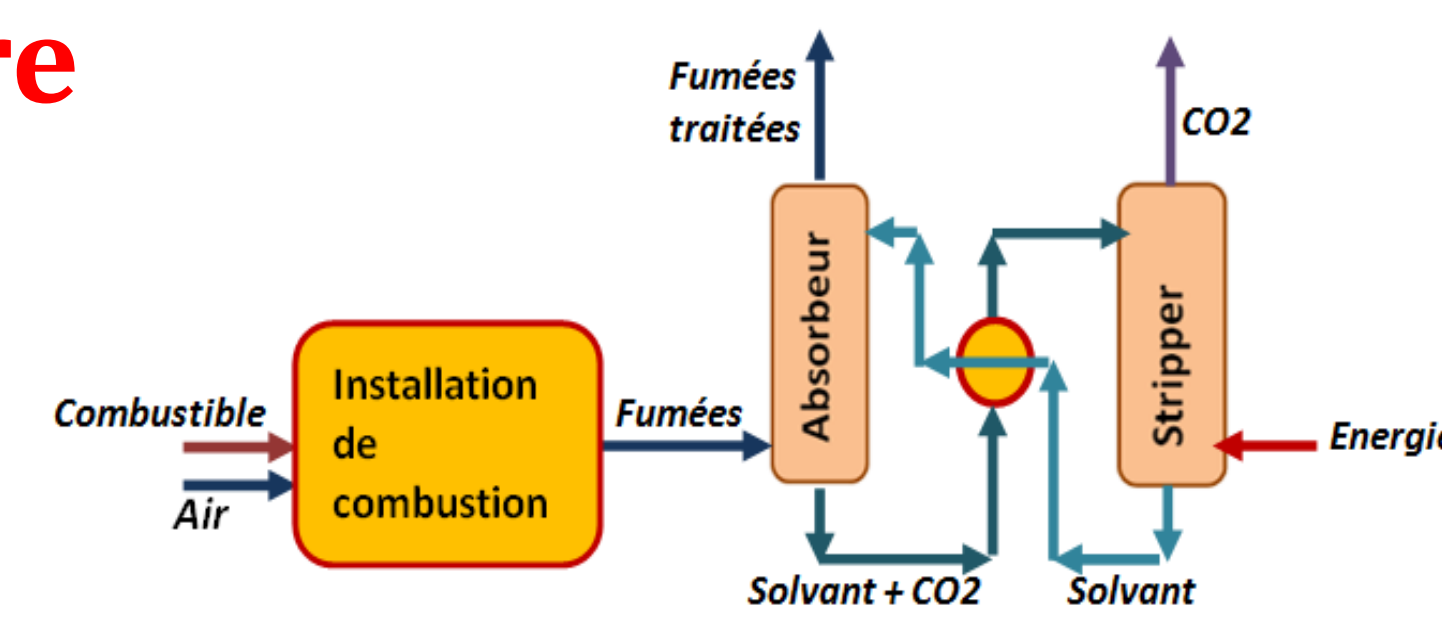
- 1 - Oxygen Enriched Air
- 2 - Combustion
- 3 - CO₂ capture
- 4 - Exchanger for CO₂ separation



✓ CO₂ EnergiCapt is an innovative CO₂ capture project, intended primarily for medium-power installations (1 to 100 MW), i.e. emitting 25,000 to 100,000 tons of CO₂/year.

Post-combustion CO₂ capture

- ✓ **Step 1 - Absorption**: This step consists in putting the flue gas in contact with a solvent having a chemical affinity with CO₂ in order to absorb it. The flue gas are then evacuated without the initial carbon dioxide.
- ✓ **Step 2 - Desorption**: this step consists of providing energy to break bonds between the CO₂ and the solvent. The latter is then regenerated and reused to absorb CO₂ in step 1. The CO₂ is evacuated from the process.



Originality and application

- ✓ **Technology** : efficient, compact and competitive
- ✓ **Application**: medium power plants (1 to 100 MW). This range of facilities (9% of overall CO₂ production) are almost ignored by CCS projects.
- ✓ **O₂ enriched combustion**: improved combustion ⇒ better thermal efficiency.
- ✓ **Thermal integration** of the solvent regeneration process.
- ✓ **Intensification of mass transfer** and capture by membrane contactors ⇒ better mass transfer.
- ✓ **Conception and realization a pilot**: test and installation on a real boiler.

Experiments and CO₂ capture results

- ✓ Experiments in real conditions allowed to **validate** the performances of the membrane contactor and to **capture CO₂** in the CPCU boiler by the CO₂ EnergiCapt pilot developed.
- ✓ Results are **very promising** in terms of CO₂ capture efficiency and the **robustness** of the pilot in terms of startup and **reactivity**.
- ✓ Tests on 10 and 50 m² contactors showed that the demonstrator has a **CO₂ abatement rate of about 90%** (with or without MEA regeneration) for flue gas flows of 12 and 150 Nm³/h, respectively.

CO₂ capture unit is **currently marketable** by LLT. The unit is **easily integrated** into an existing installation without the need for retrofit.

CO₂ EnergiCapt has won **two national trophies**:

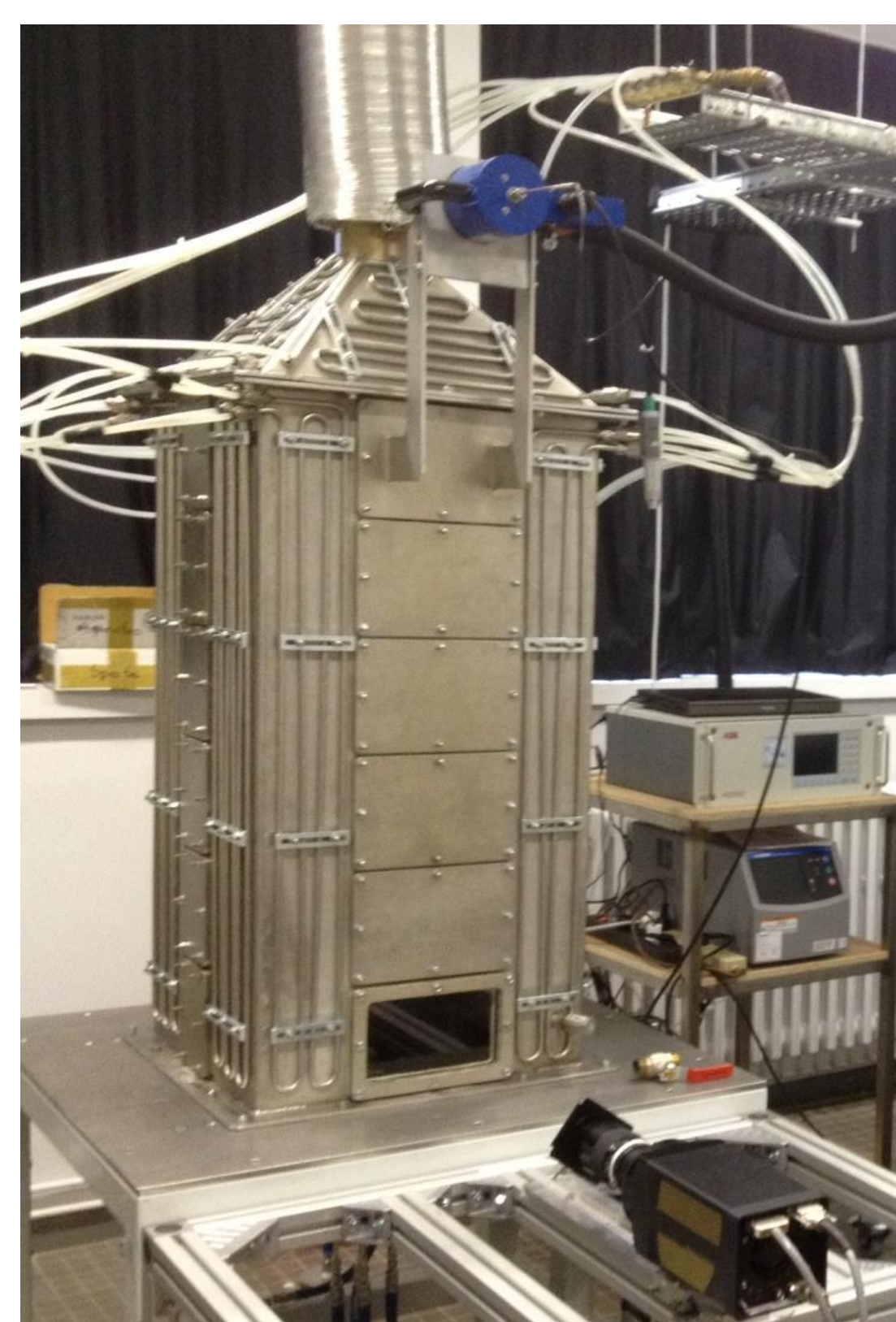
- Trophy for public research on Energy-climate-environment, 2015.
- Energy Transition Trophy in Technology category, 2017.

CO₂-EnergiCapt demonstrator installed at the CPCU (LLT ®)



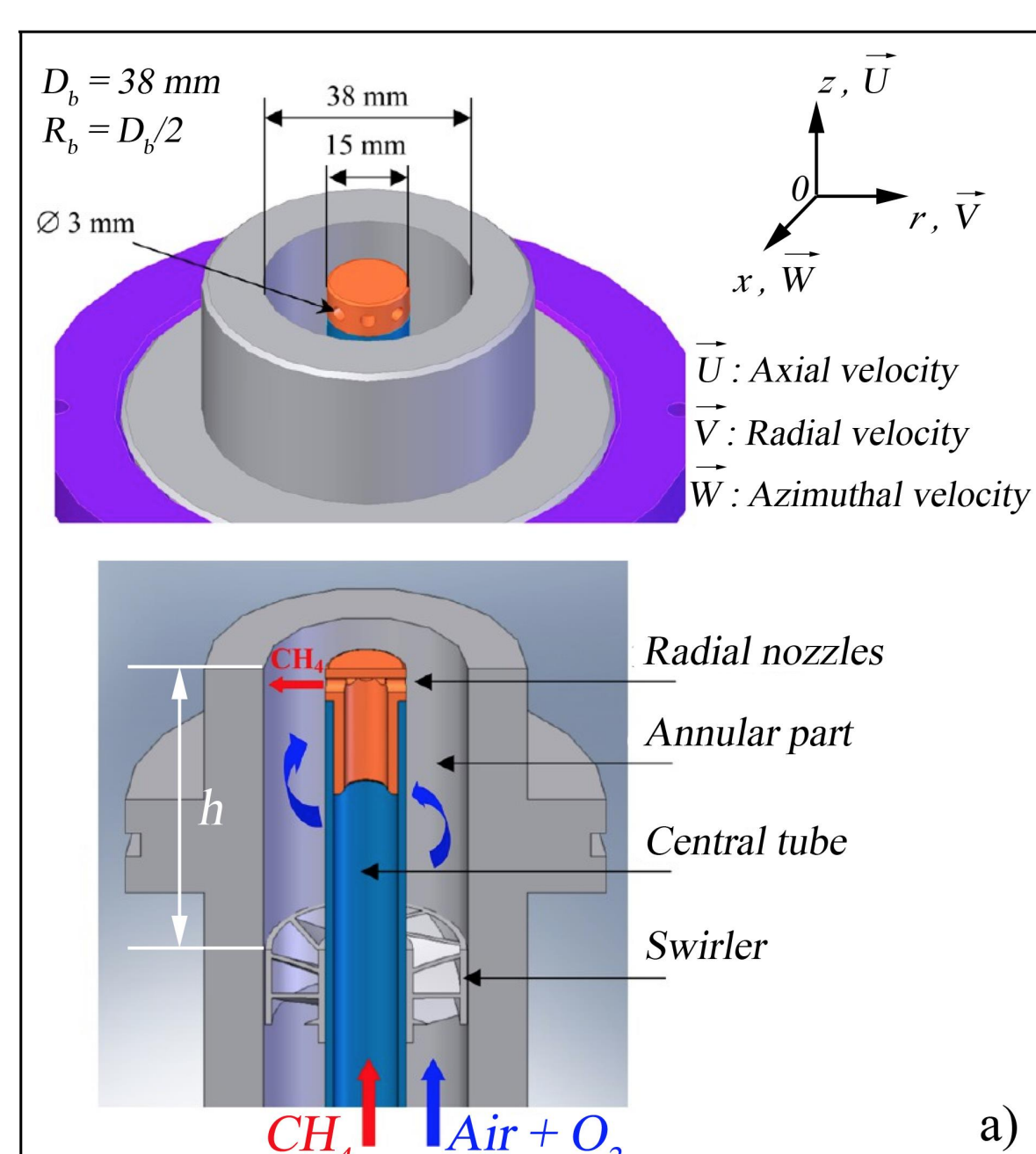
ICARE-CNRS research results

Combustion chamber



Combustion chamber with the OH* Chemiluminescence system and gas analyzers.
Dimensions 0.5x0.5x1 m³
Power 25 kW.

Burner

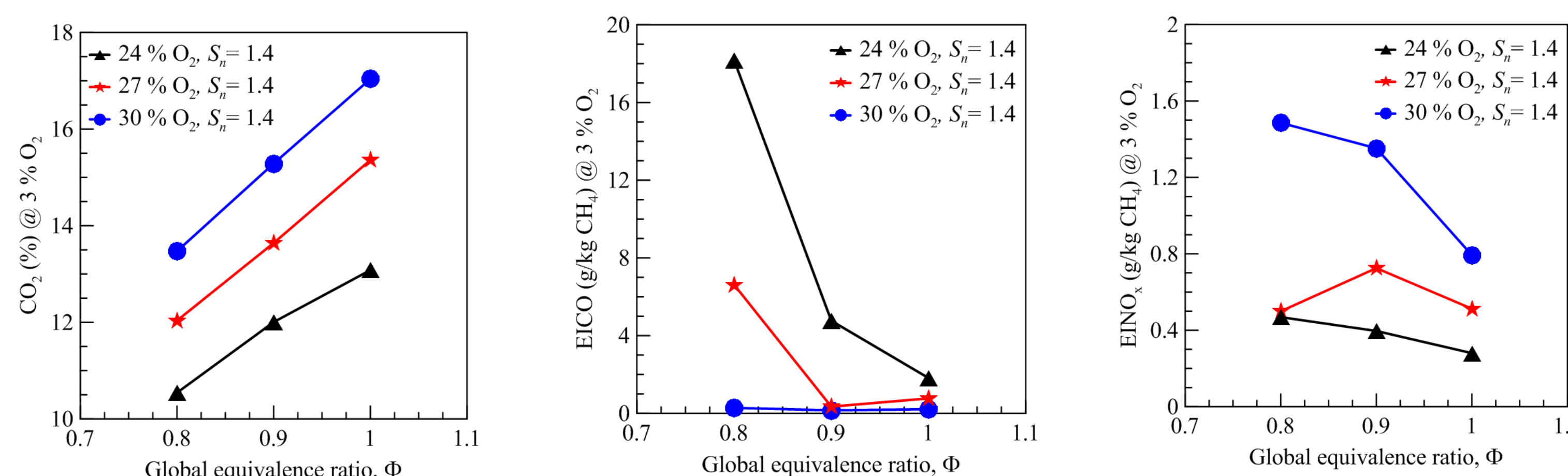


Two concentric tubes with a **swirler** in the annular part

Example of flame

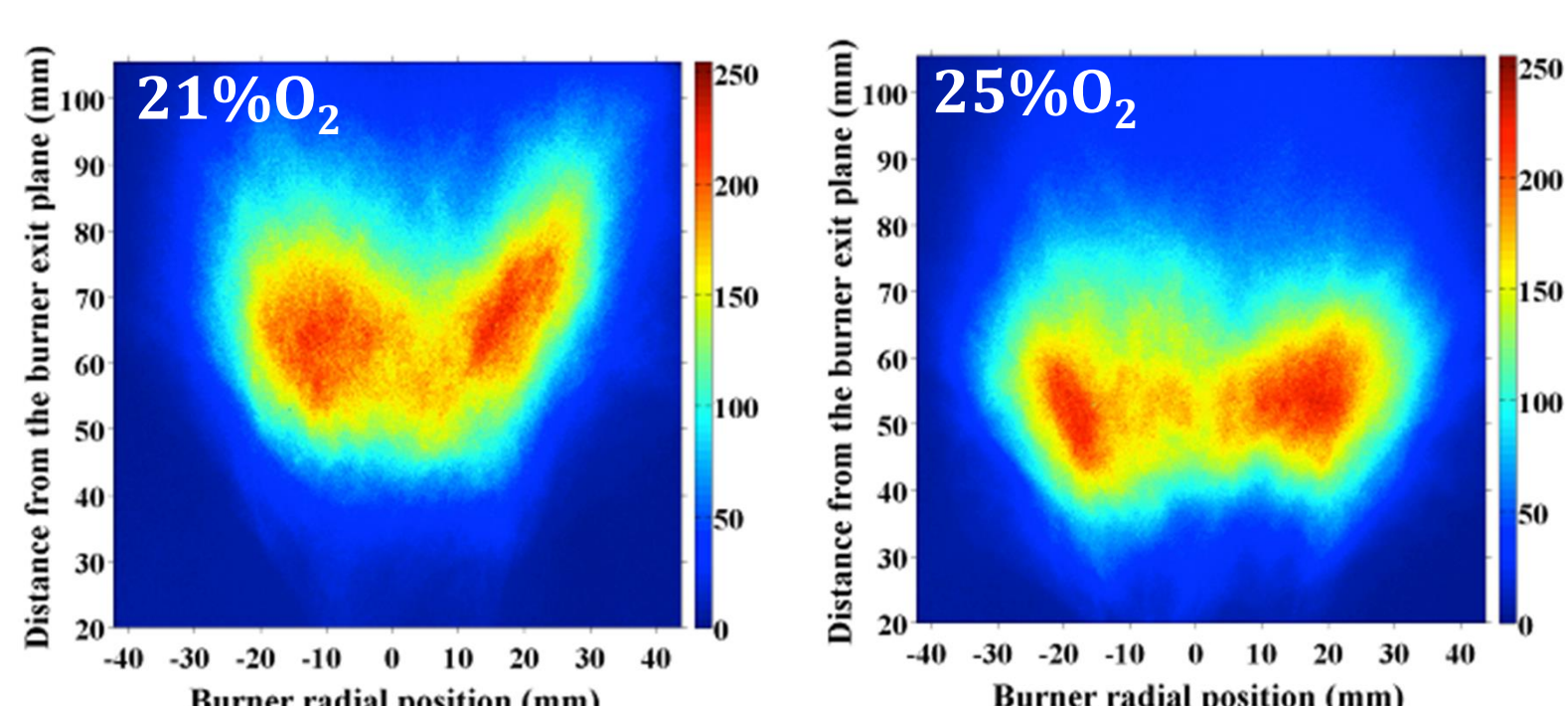


Pollutant emissions



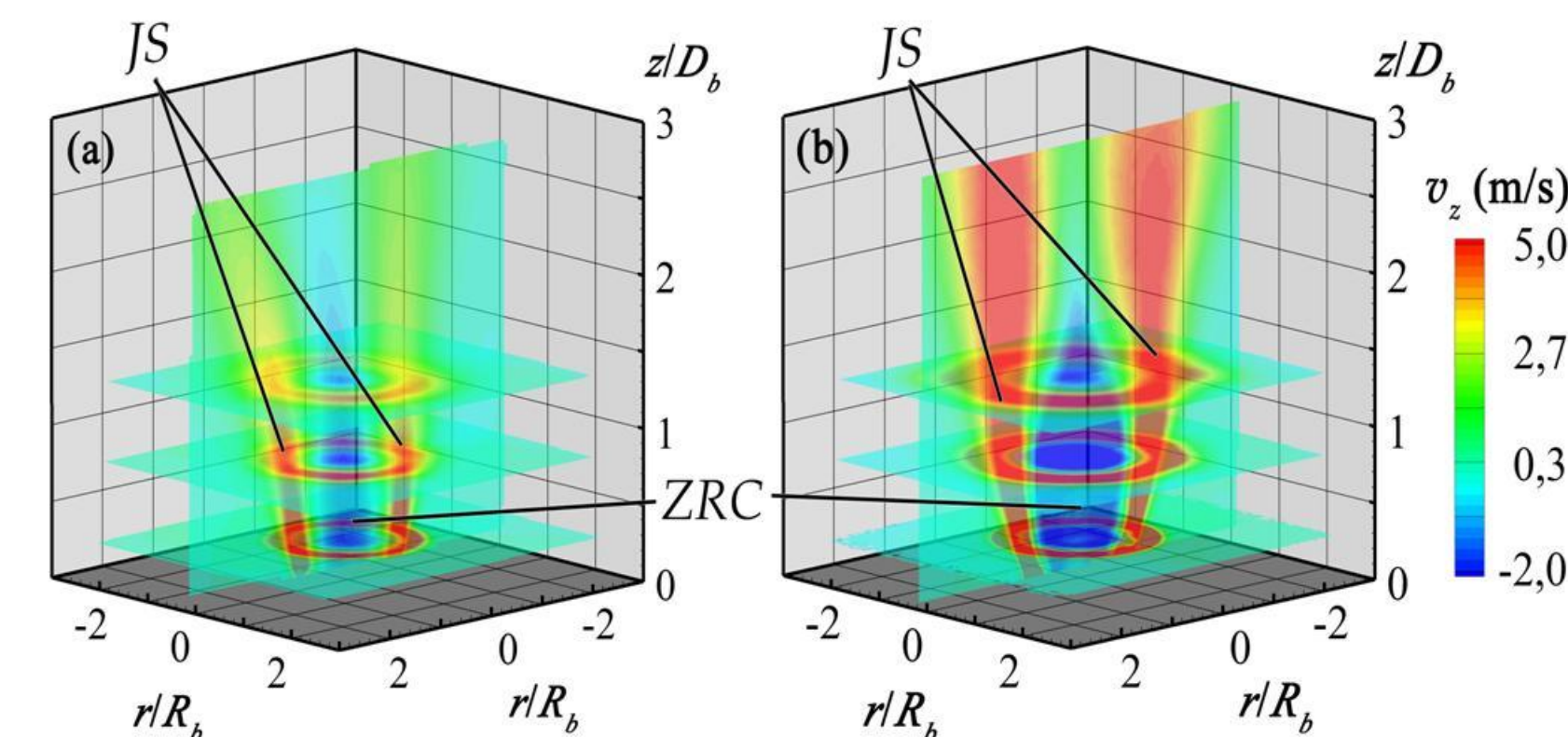
✓ With O₂ enrichment : CO₂ increases, CO decreases, NO_x increases

Instantaneous OH* images



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

Velocity mean fields of non reacting and reacting flows



➔ Recirculation zone at the flow center, and the swirling jet in the peripheral flow