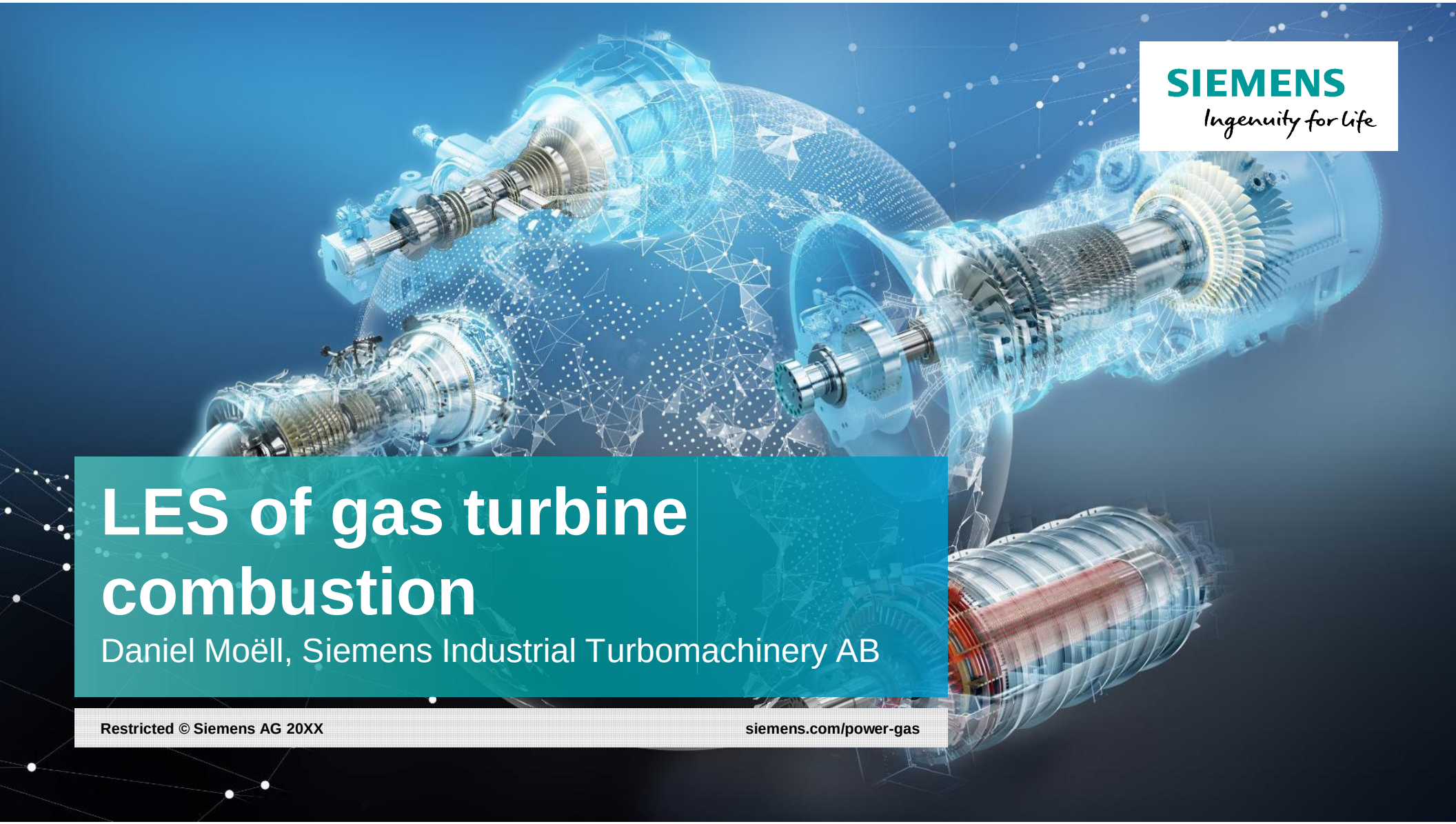

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LES of gas turbine combustion

Daniel Moëll, Siemens Industrial Turbomachinery AB

Outline

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- Introduction
- Atmospheric combustion rig description
- Computational model description
- Computational results
- Summary

Introduction
Background

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Increasing demand on fuel flexibility on the gas turbine market.

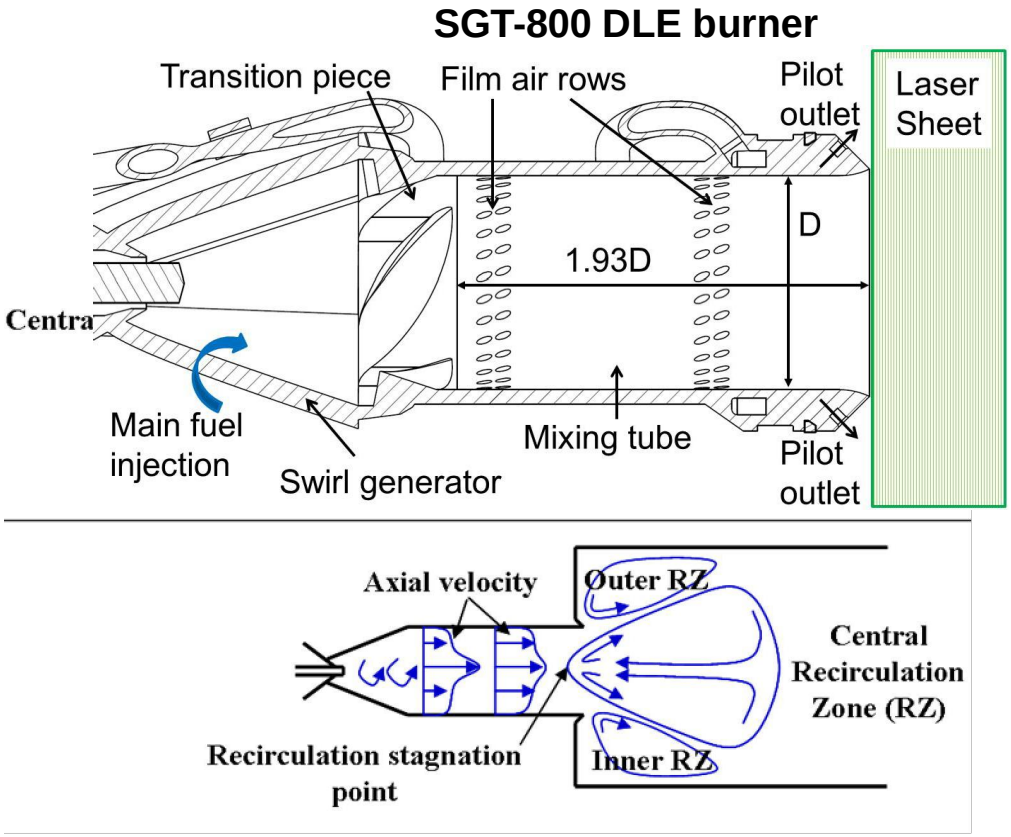
- Accurate CFD predictions are becoming more and more important to predict primary and secondary effects of fuel flexibility
- Importance of good simulation models to predict secondary effects of combustion, such as combustion dynamics and other transient phenomenon

The aim of the performed work is to:

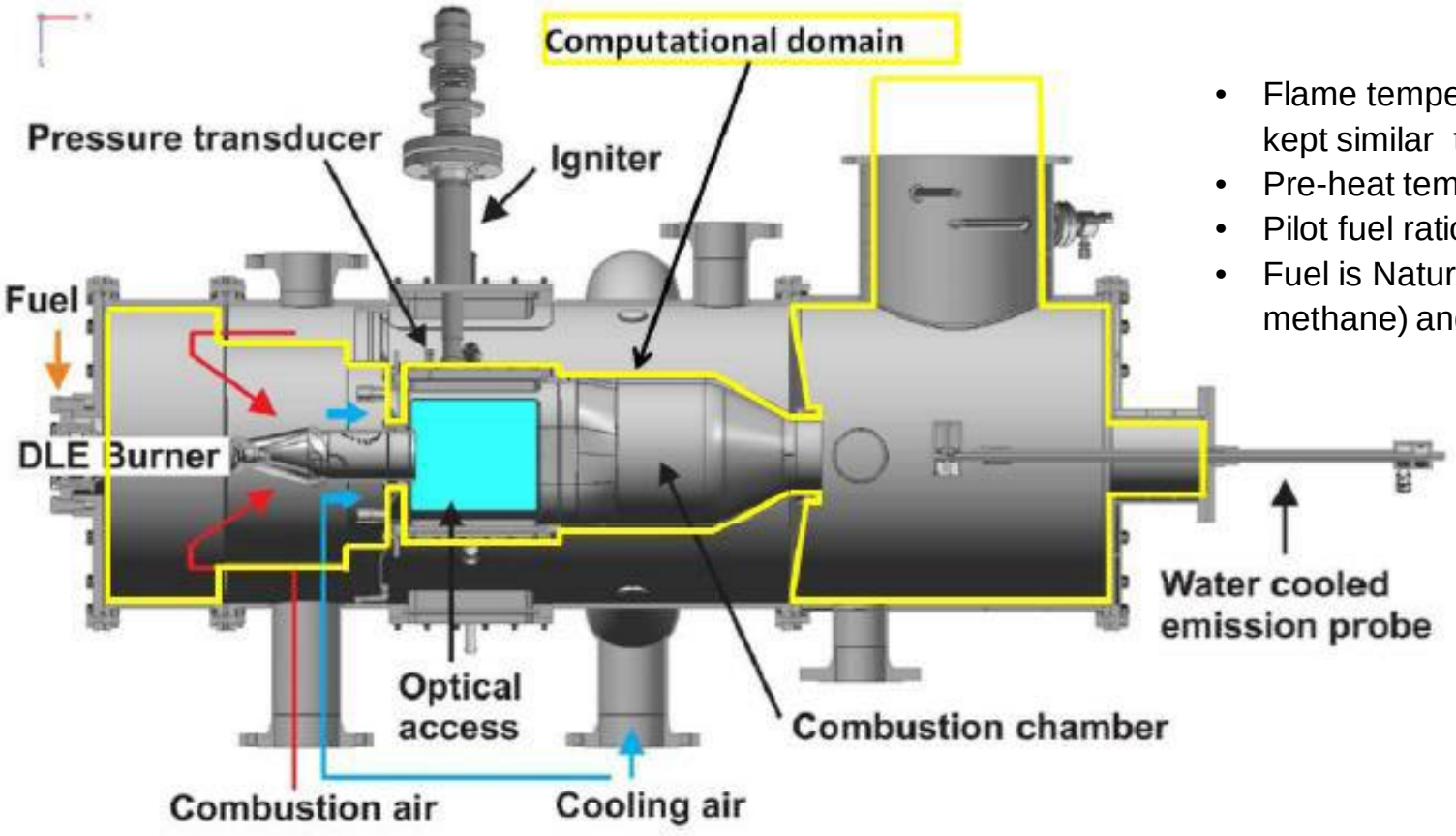
- Investigate the predictive capabilities of unsteady CFD with respect to flame shape and position as well as flame dynamics

Introduction: Burner description
SGT-800 3rd generation DLE burner

- Swirl stabilized main flame with 12 pilot flames (not in the picture)
- **Motivation**
  - Emissions
  - Turndown
  - Higher TET
  - Liner heat load



Introduction: Atmospheric combustion rig description



- Flame temperature and burner reference velocity kept similar to engine conditions
- Pre-heat temperature is 693K
- Pilot fuel ratio is 3%
- Fuel is Natural gas in experiments (>90% methane) and methane in the simulations

Computational Model Description

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Turbulence treatment:
- LES – Smagorinsky

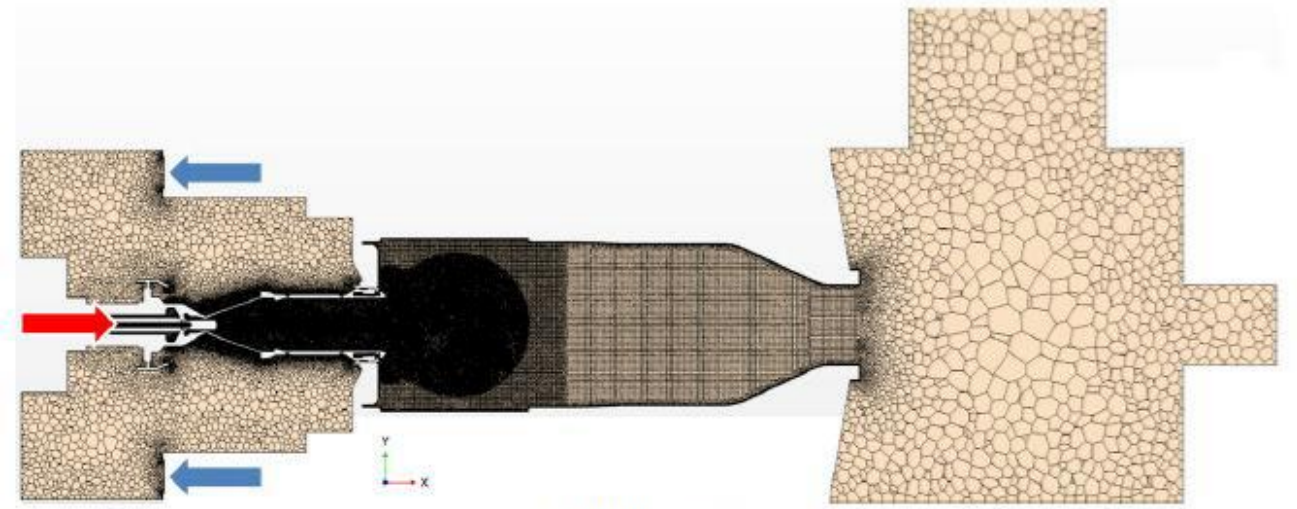
Chemistry treatment:
- FGM + PDF integration

Mesh:
- 29M polys

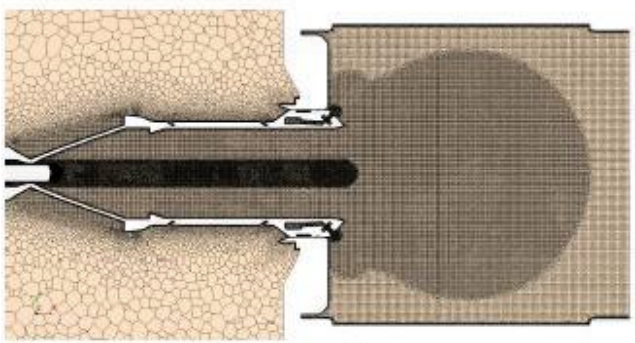
Air inlet:
- Blue arrow

Main Fuel Inlet
- Red arrow

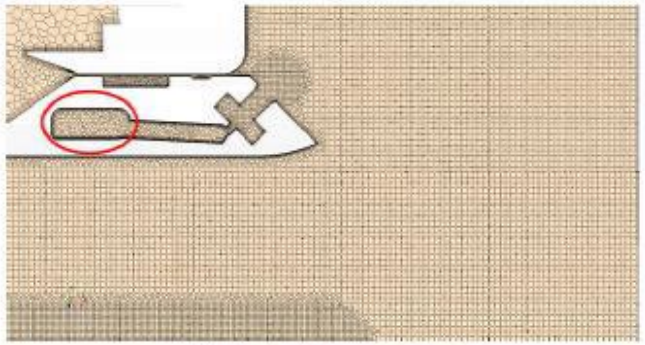
Pilot fuel inlet
- Red circle



(a) Mesh overview



(b) Mixing and reaction



(c) Pilot flame region

Results

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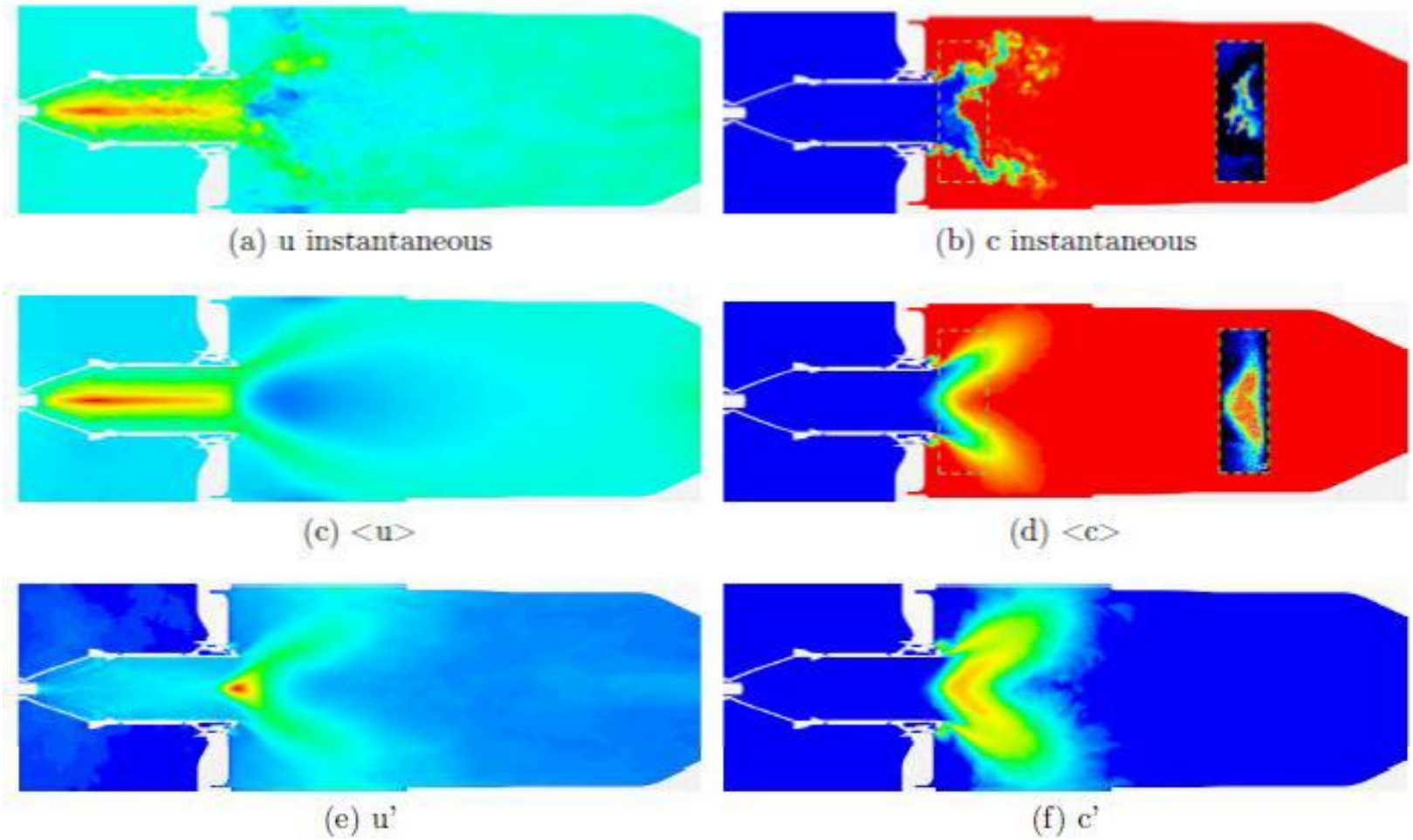

(a) u instantaneous

(b) c instantaneous

(c) <u>

(d) <c>

(e) u'

(f) c'

Axial velocity (left)

Reaction progress (right)

CFD Results
LES Dynamics

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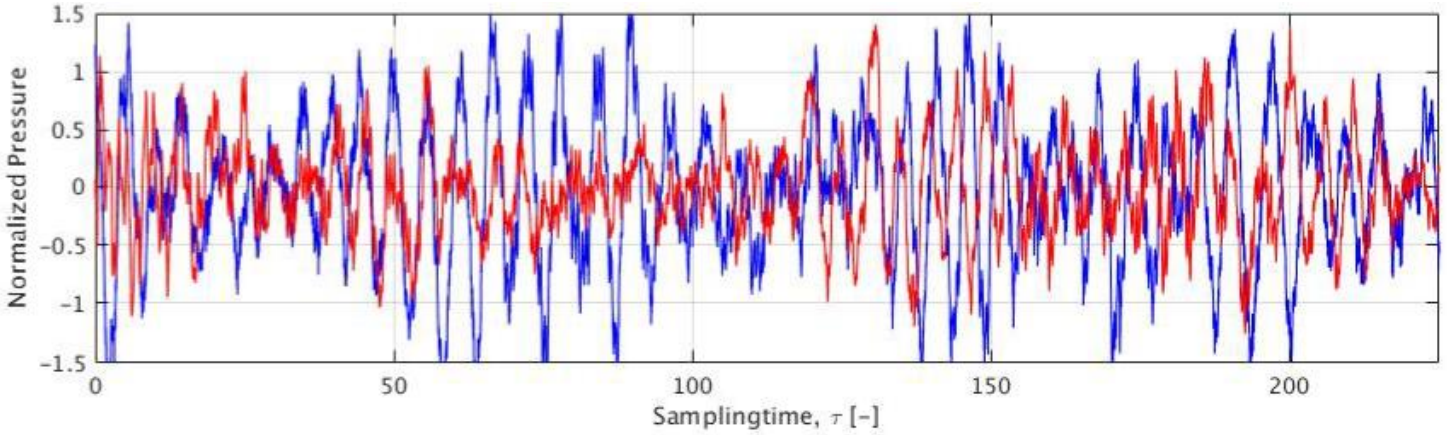
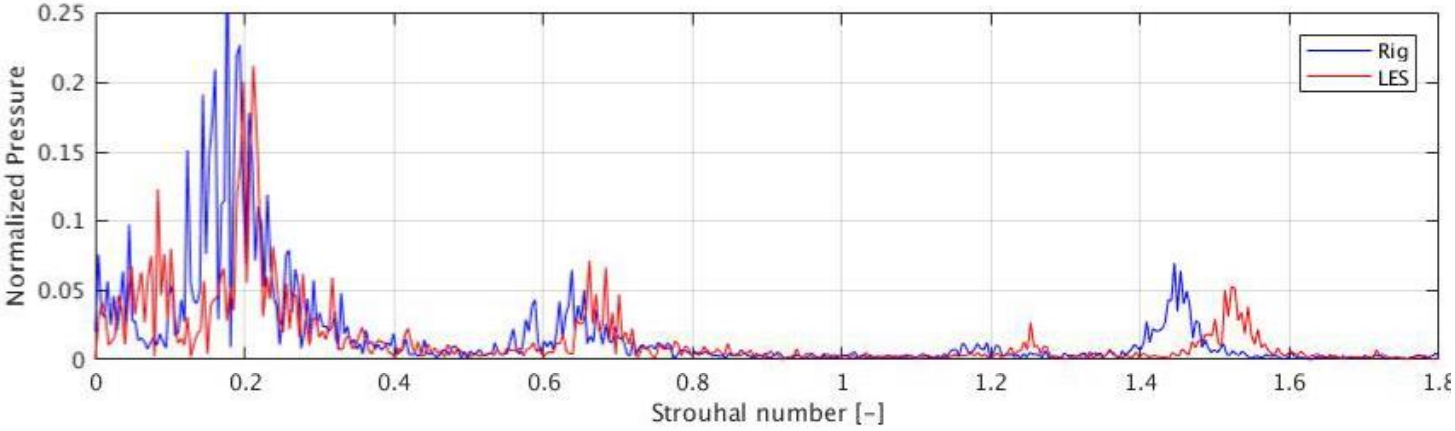
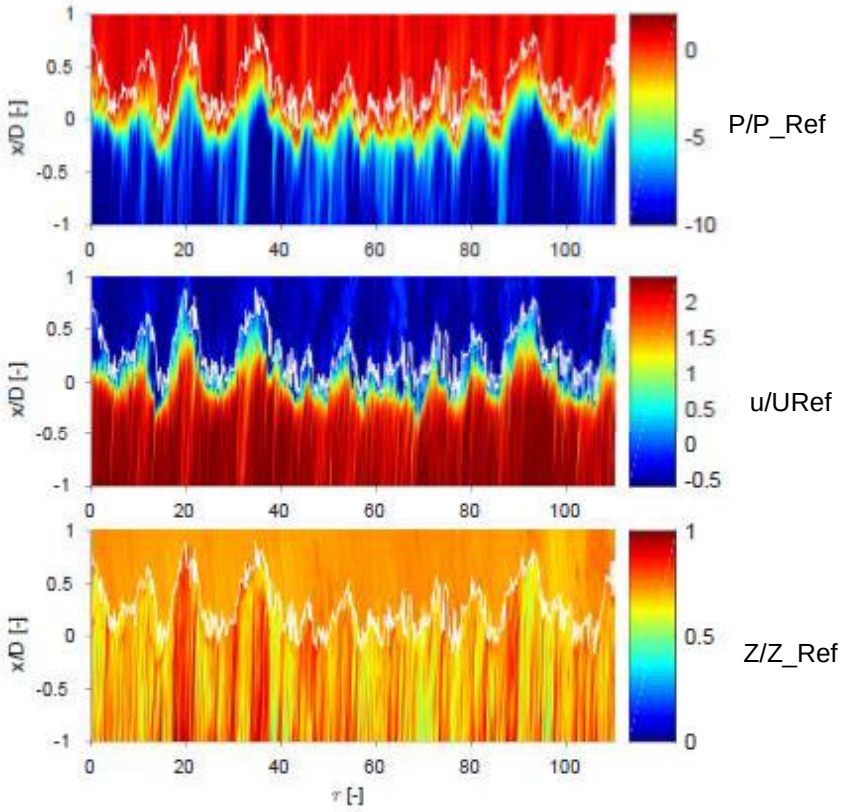




Pressure trace from experiments and corresponding location in CFD

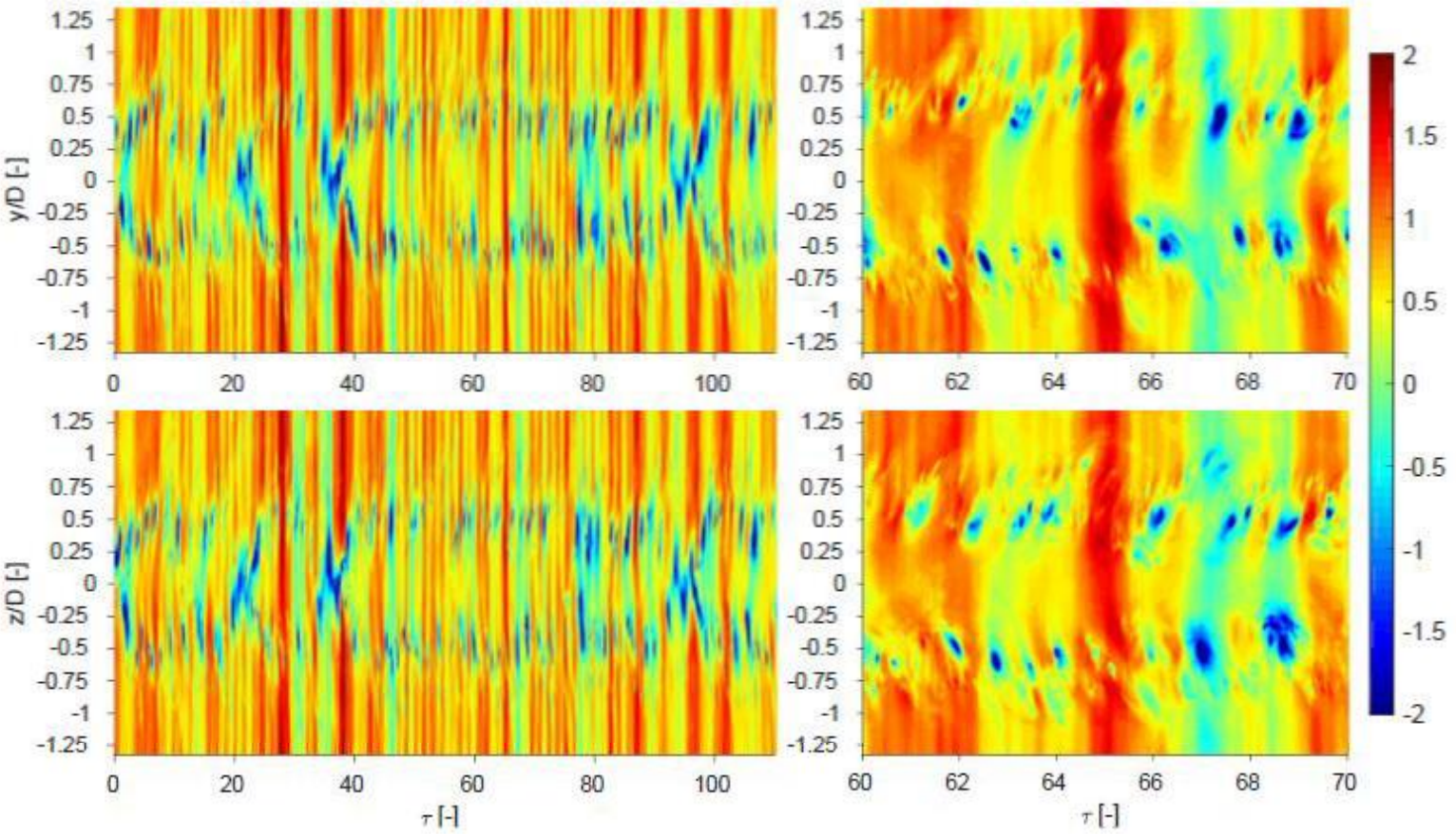
CFD Results
LES Dynamics



Data along the center line plotted as function of time:

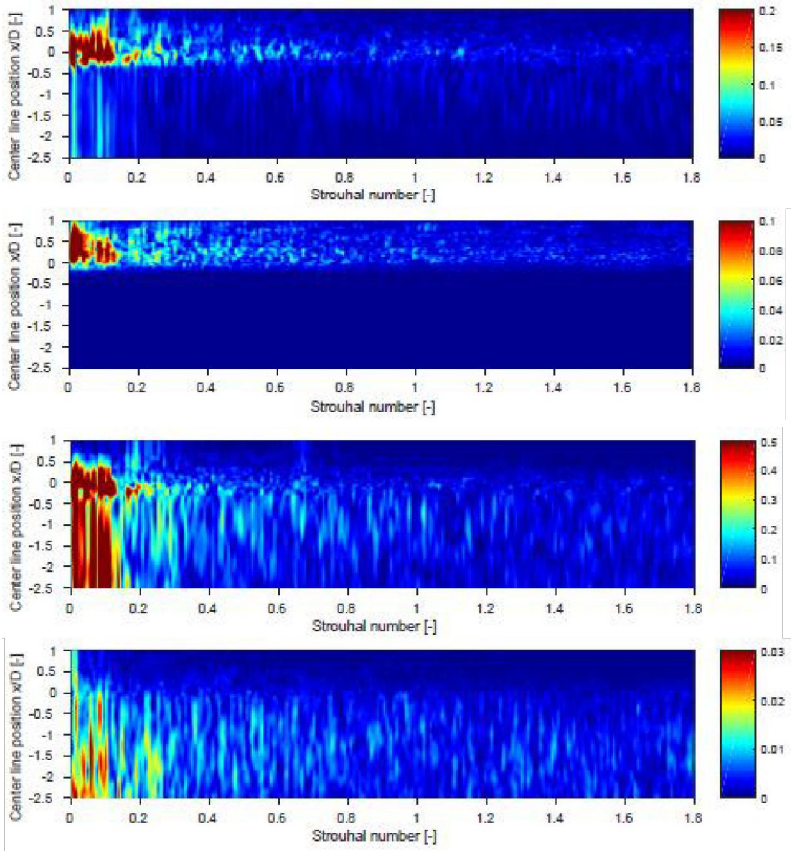
- Forward stagnation point is moving around the burner exit.
- Flame is pulsing axially.
- Fluctuations in composition upstream the flame.

The Precessing Vortex Core



PVC Frequency around St = 0.7

CFD Results
LES Dynamics



u'/URef

Reaction Progress

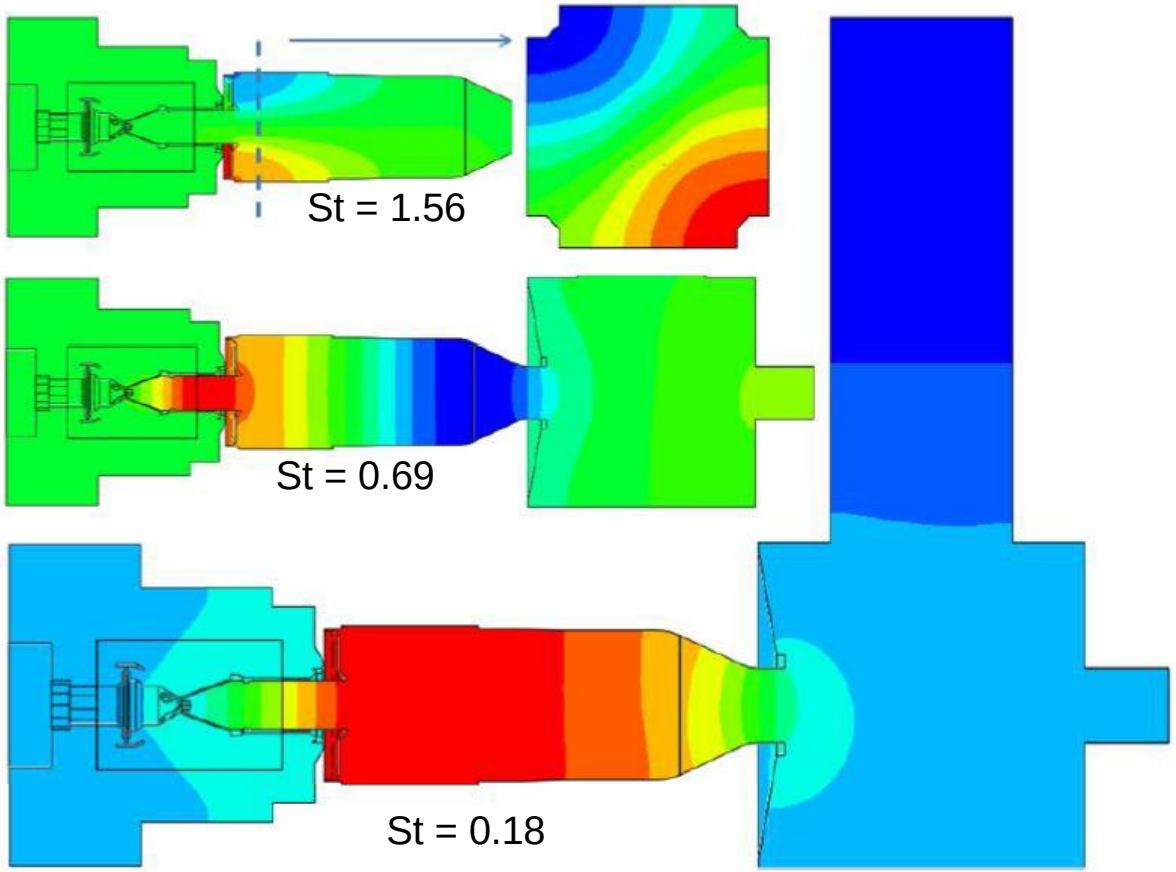
P'/P_Ref

Z'/Z_Ref

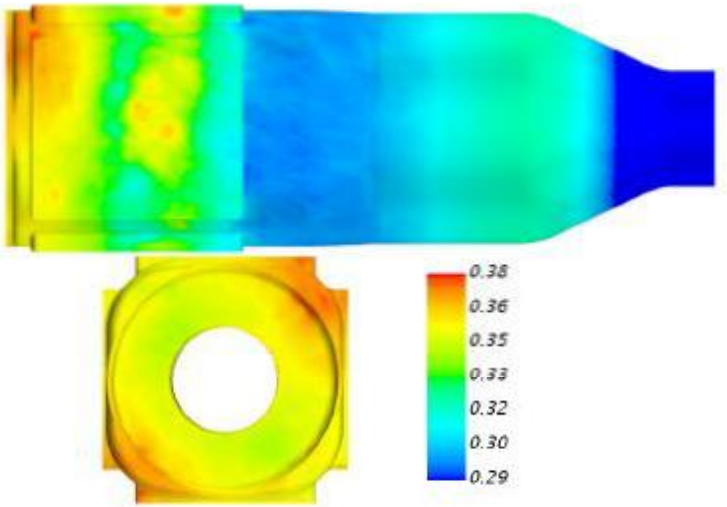
FFT of the center line data:

- Broadband noise upstream the flame, only distinct Strouhal numbers (frequencies) downstream the flame

Acoustic eigenmodes



LES pressure fluctuations on combustion chamber walls



Summary

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LES + FGM has been used successfully to predict the flame behavior in a Siemens gas turbine burner fitted to an atmospheric combustion rig

- Flame shape and position agrees well with OH-PLIF measured data
- Pressure trace agrees well between CFD and Experiments
- The flame dynamics is studied in detail revealing details of which frequencies may be dominant for a specific burner.
- The acoustics is well predicted with the LES model

Thank you for your attention!

SGT-800