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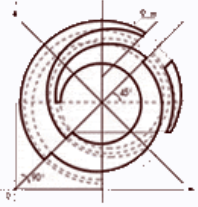
July 2003

Prediction and Control of Combustion  
Instabilities in Industrial Gas Turbines  
'Preccinsta'

Greg Kelsall

International Conference on Gas Turbine Technologies, Brussels,  
July 2003

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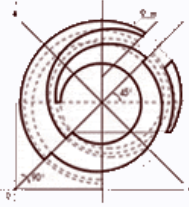


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- Research Topics, focusing on
  - Passive Damping
  - Burner Characterisation for Annular Combustor
- Conclusions

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## Background- Project Drivers

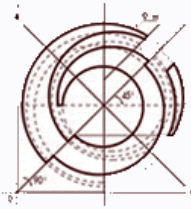
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### EC 'Longer Term' Targets for Gas Turbines

#### Key Action 5.1.3 *'More energy efficient gas turbines'*

- >65% efficiency for combined cycle
- >35% for simple cycle industrial gas turbine
- >97% reliability

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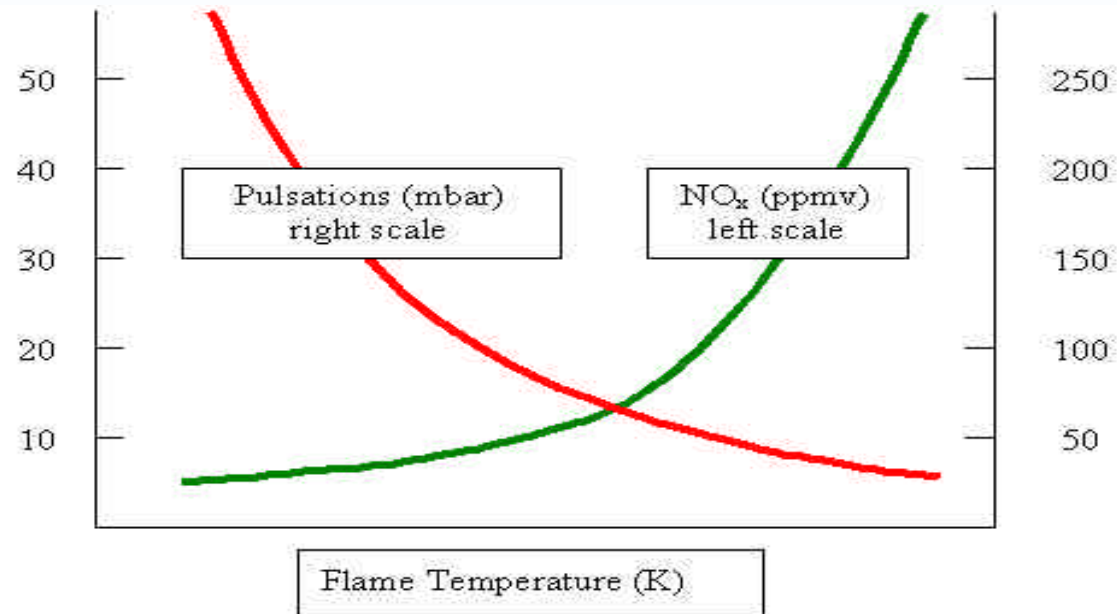


# Background- Impact on Gas Turbine

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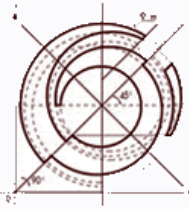
- Control of thermoacoustics is a key enabling technology for highly efficient gas turbines

'Typical' Lean Premix Combustor



Can severely limit gas turbine components life

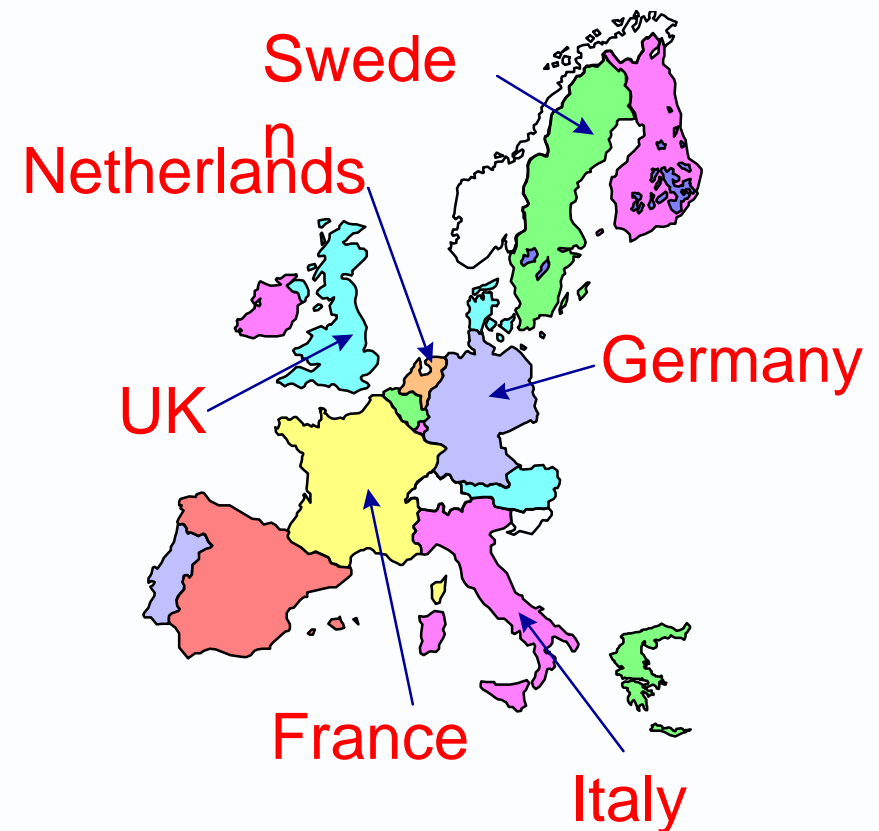
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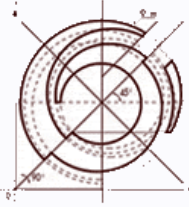
# Preccinsta Project Overview

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- 42 Month Project starting in March 2001
- 7 MEuro budget
- 22 partners in 6 European Countries
  - 13 Industrial
  - 3 Research
  - 6 University



**Vertically integrated consortium with good critical mass**



# Project Objectives



- Investigate physics, prediction and control of combustor instabilities
- Investigate ability to burner a wider range of fuels

## Research Area

## Topics Assessed

Thermoacoustic Interaction  
Fundamentals

Instability Fundamentals at  
Lab-Scale

Fuel Gas Characterisation

Auto-Ignition and Flame  
Propagation

Potential Instability Solutions

Passive and Active Control

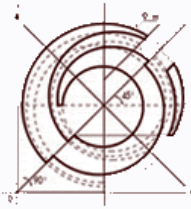
Rig Scale Studies

Can and Annular Combustor

Full-Scale Rig Test and Field  
Experience

Annular Combustor

Wide Ranging Project

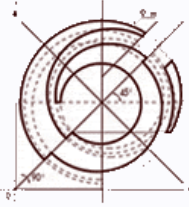


## Instability Fundamentals at lab-scale

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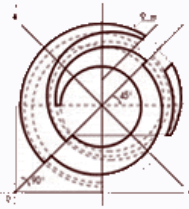
- Investigate unsteady flow characteristics
  - induced by flame stabilisers
  - coupling between flame stabiliser/combustor oscillations
- See paper
  - “*Experimental and numerical investigation of self excited combustion oscillations in a scaled gas turbine*” Day 2, Session 4 -Combustion

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- Generate knowledge of auto-ignition delay times (ADT) for range of conditions/fuels
  - improve understanding of ADT at gas turbine conditions
  - database of ADT's for a range of fuels
  - validated models to predict ADT's
  - impact of renewable fuels in current/future gas turbines



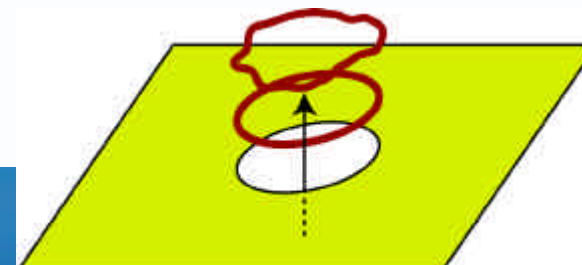
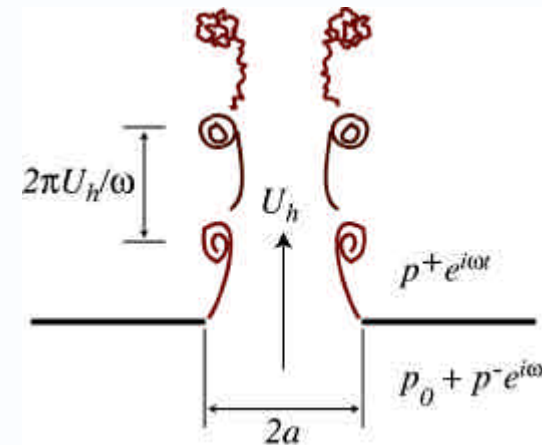


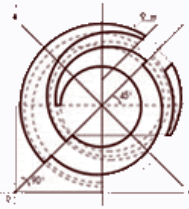
# Acoustic Damping

## Mean-flow perforated liners

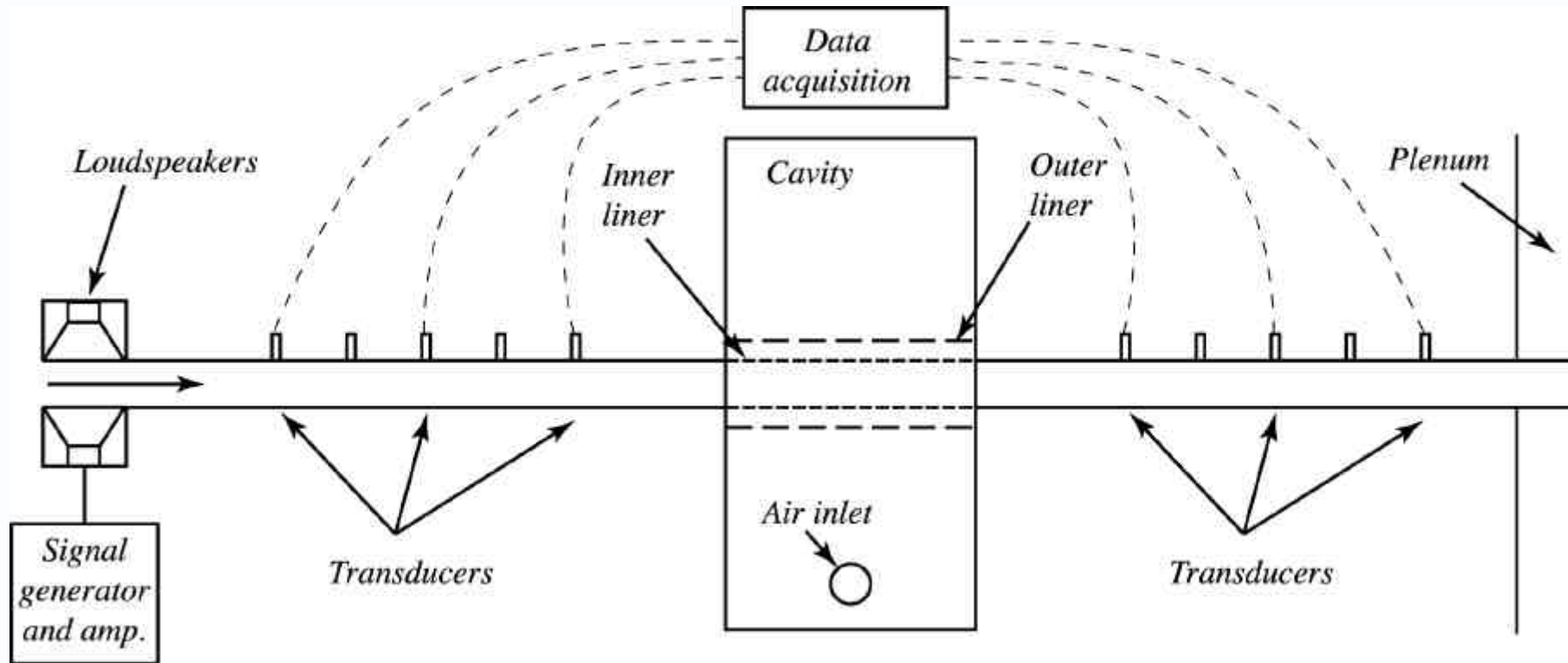


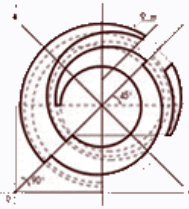
Acoustic energy  
↓  
Vortical energy  
↓  
Dissipation into  
heat





# Experimental set-up

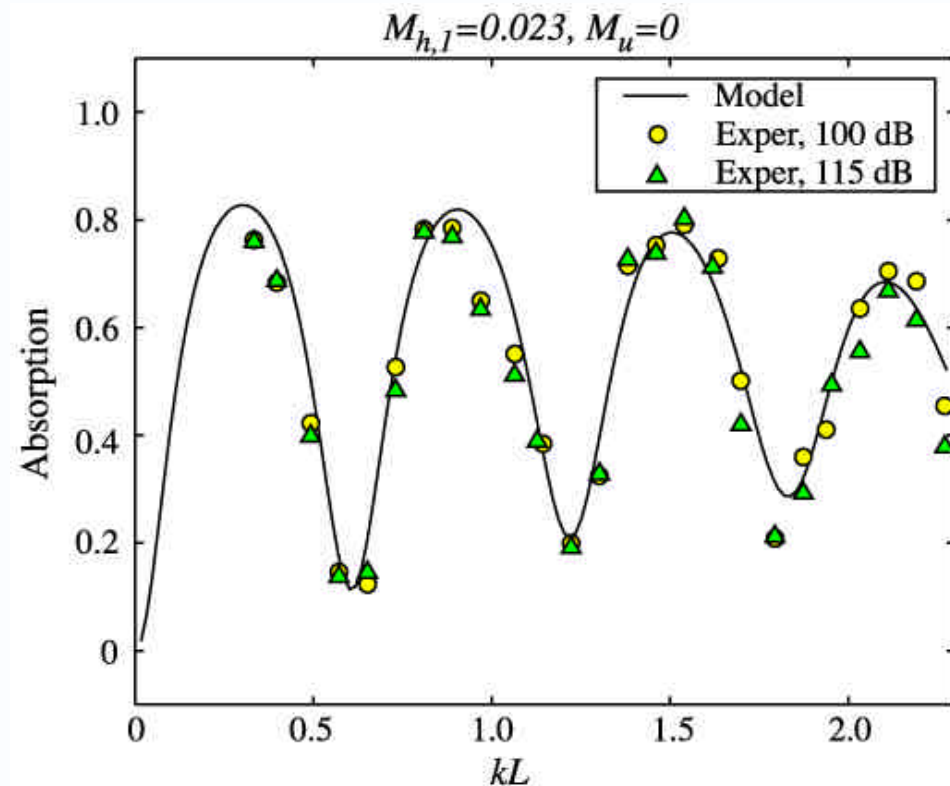


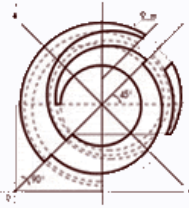


# Acoustic Damper Results

## Essential features:

- Excellent agreement with model
- Independent of amplitude
- Maximum absorption of ~83%

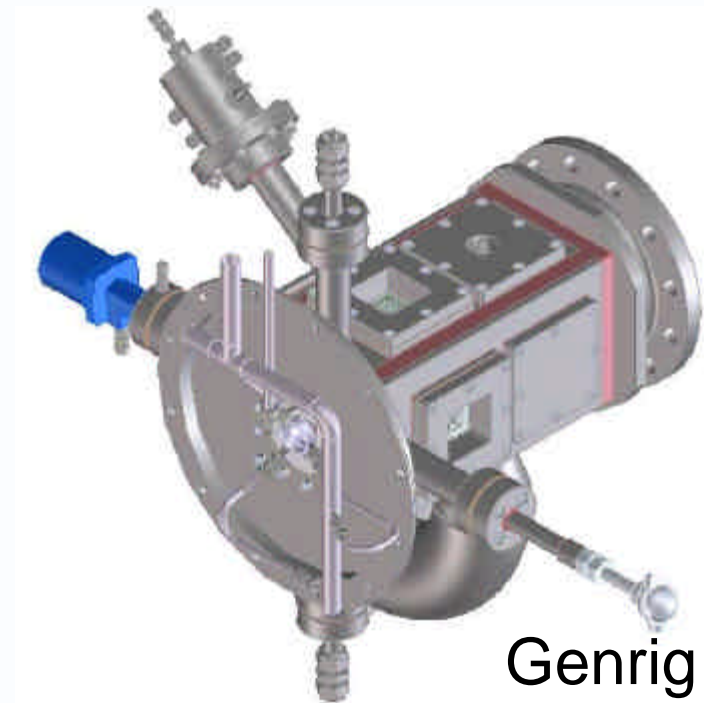




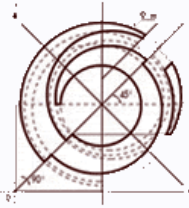
# Rig Scale Studies- Tubular Combustor

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- Purpose built Generic Combustion Rig (Genrig)
- Represent essential features of a lean-premix combustor
- Understand basic phenomena
- Data for model development
- Apply results during engine tests

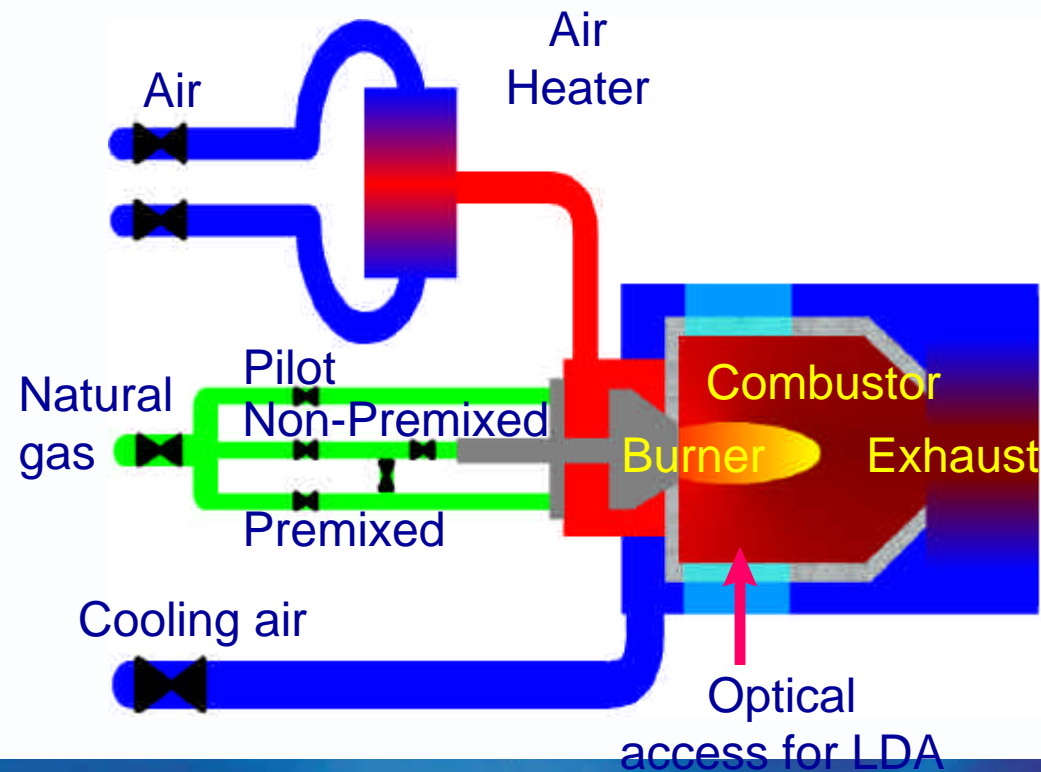


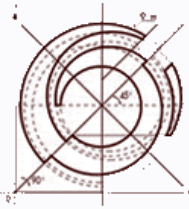
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# Rig Scale Studies- Annular Combustor

- Detailed analysis of reacting and non-reacting flow field
  - atmospheric pressure

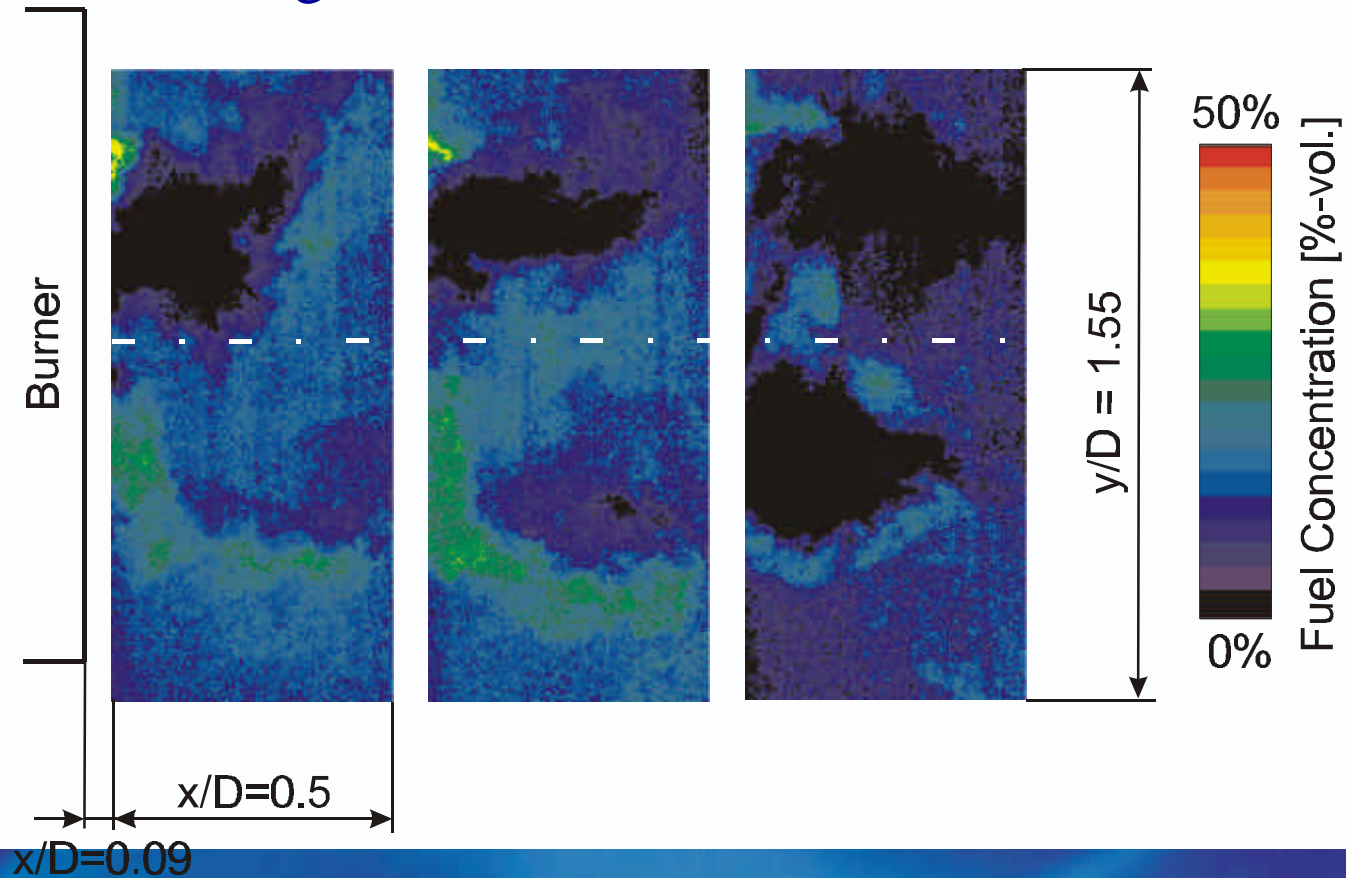




# Non-Reacting Flow Analysis

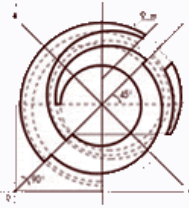


- Alternating rich/lean pattern
  - vortex shedding



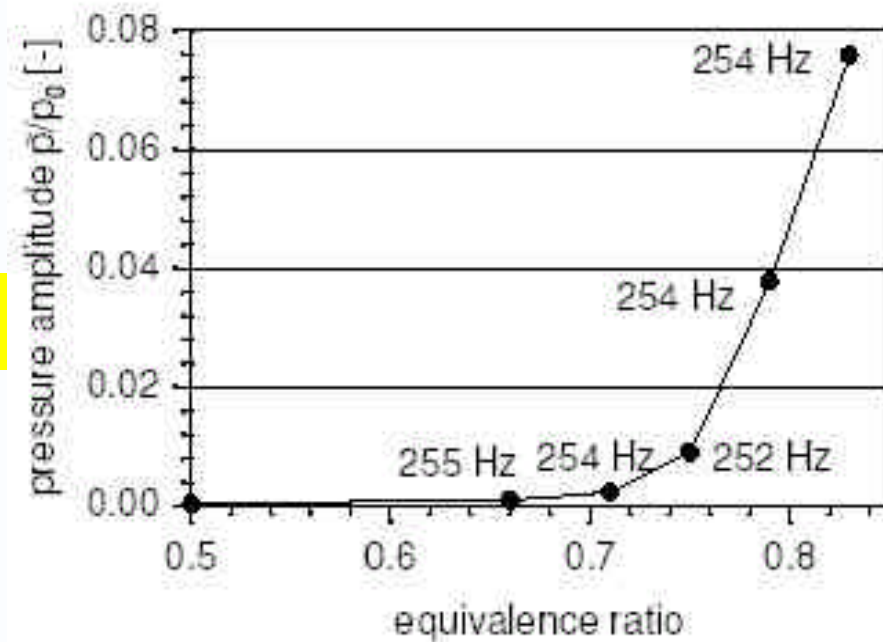
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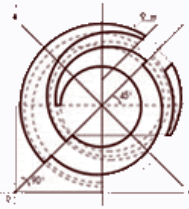




# Reacting Flow Analysis

- Pressure fluctuations increase with increasing equivalence ratio
- Amplitude grows steadily





# Full-scale Engine Testing



- Full scale testing in an annular combustor



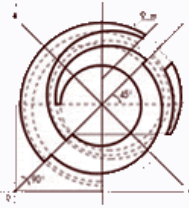
1.5 m



Application to commercial V94.3

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## Conclusions

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- Control of thermoacoustics is a key requirement for highly efficient gas turbines
- Preccinsta project addresses this:
  - Investigate physics, prediction and control of combustor instabilities
  - Investigate ability to burner a wider range of fuels
  - Strong European Consortium
- Good results being produced
  - Passive damper with 83% absorption

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