A Fundamental Study of the Novel Poppet Valve 2-Stroke Auto-ignition Combustion Engine (2-ACE)

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The Sir Harry Ricardo Laboratories
Centre for Automotive Engineering

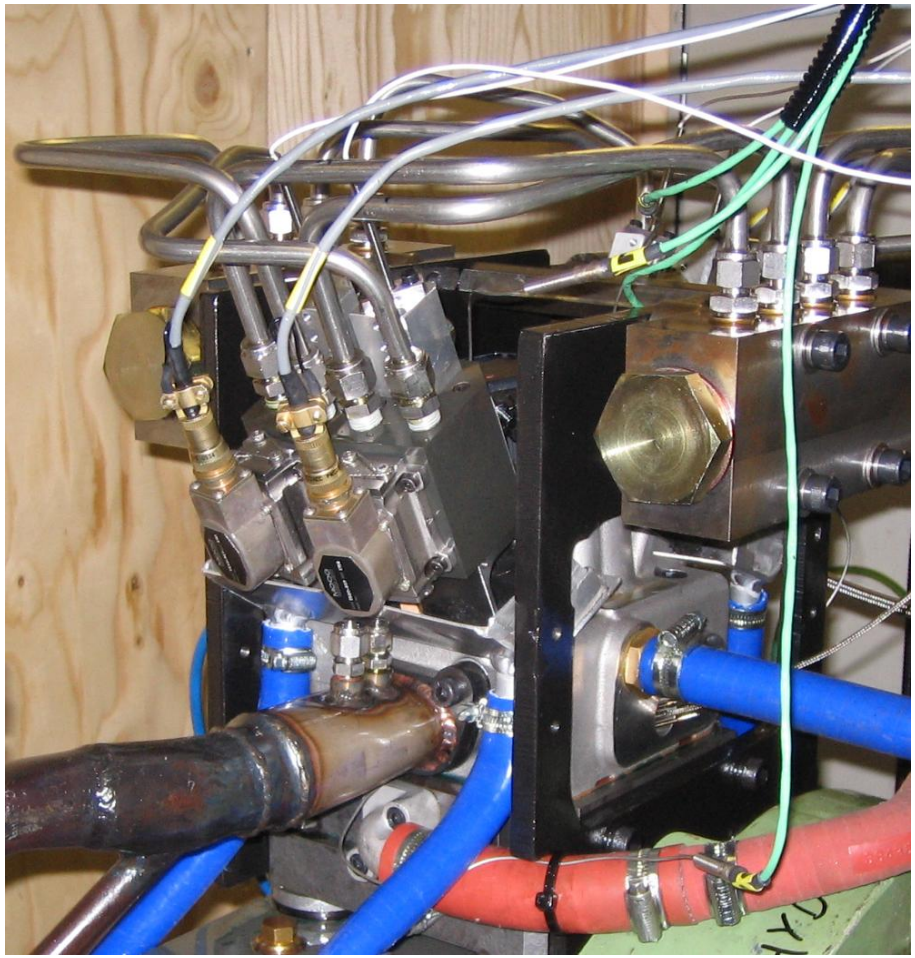
06/04/2009 – Group Meeting

2ACE – Project

Members of Consortium

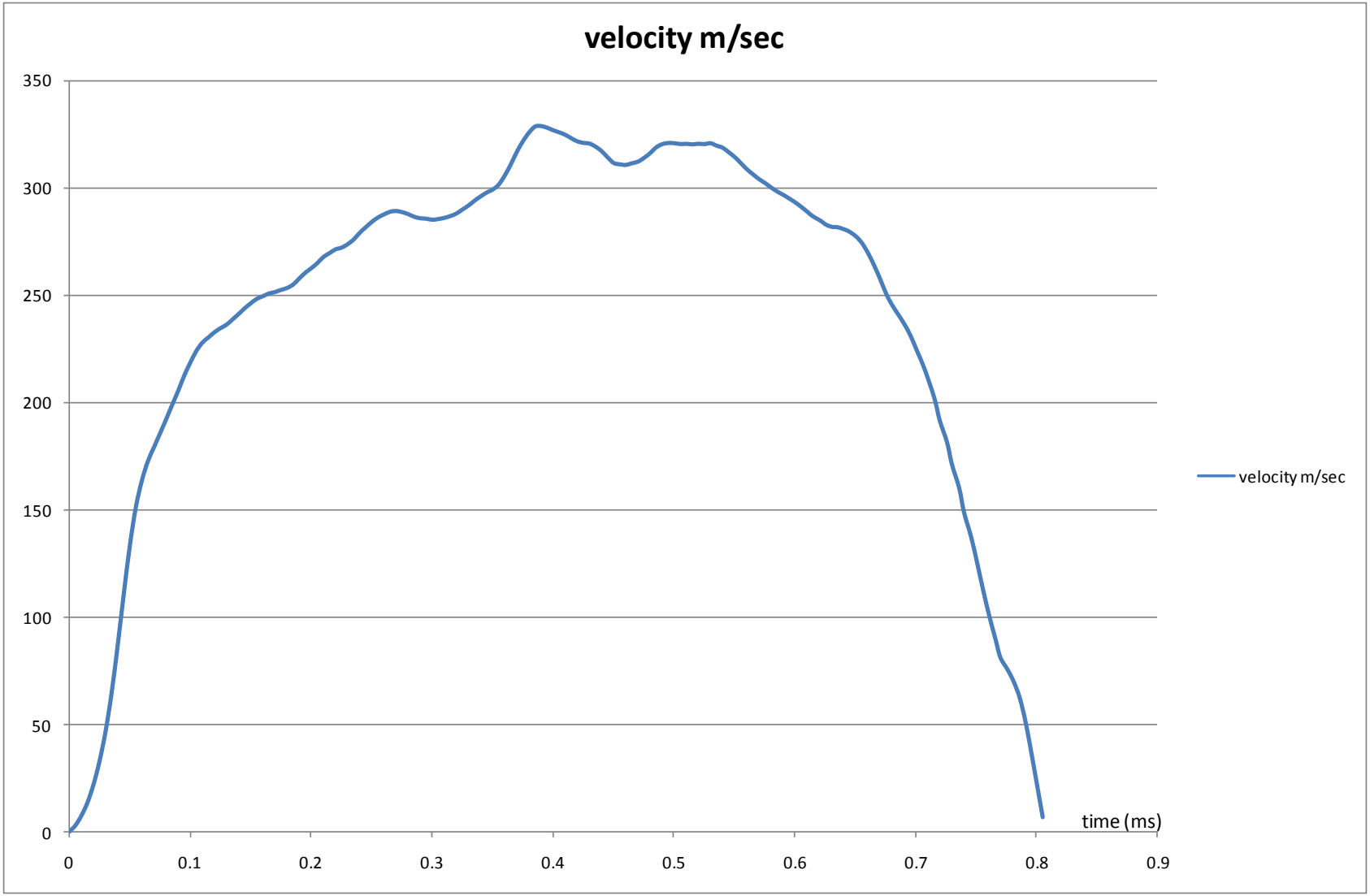
- Brunel University
- University of Brighton
- University of Manchester
- University of Leeds

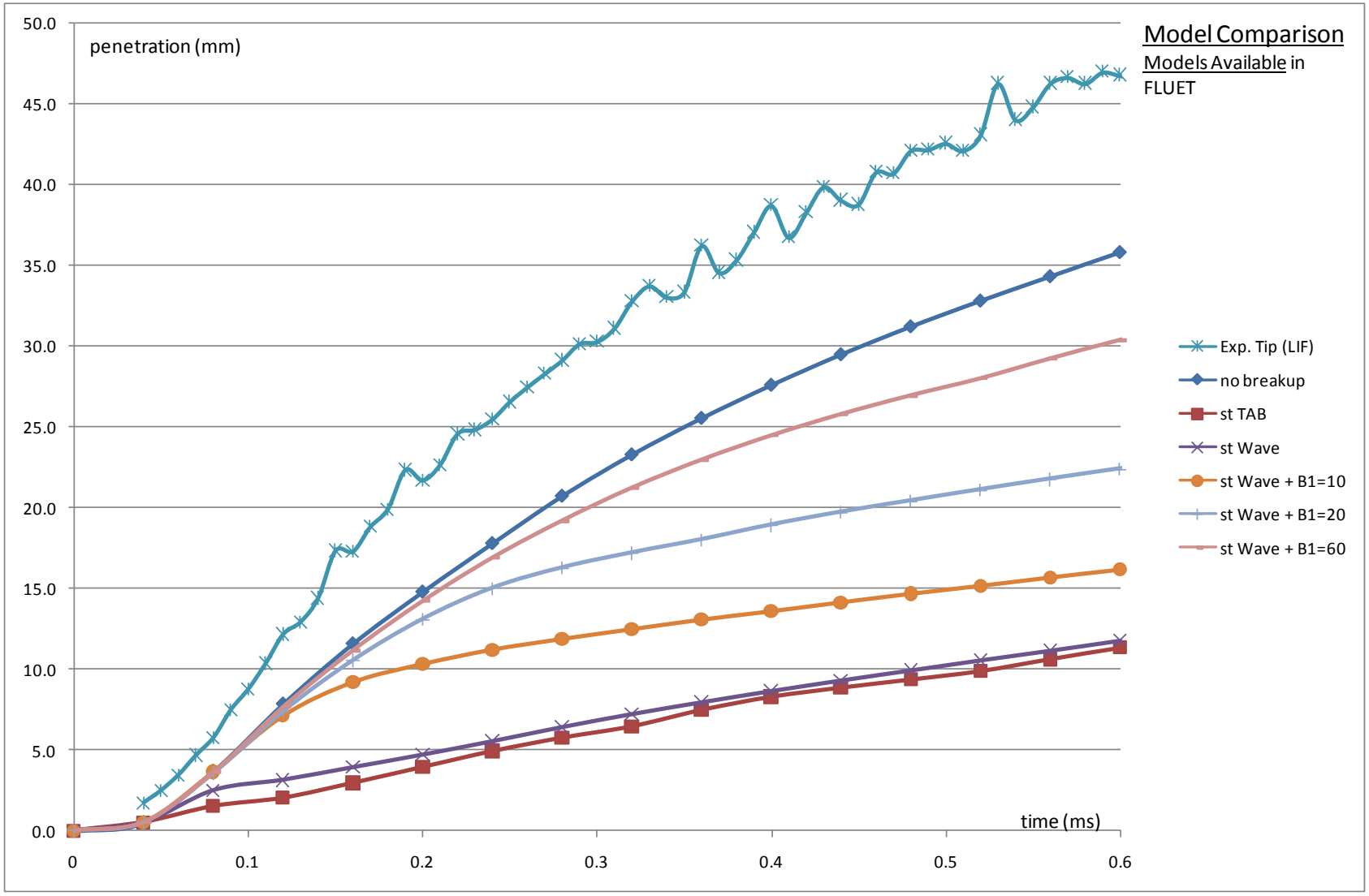
- Ricardo UK
- Innospec



University of Brighton Tasks

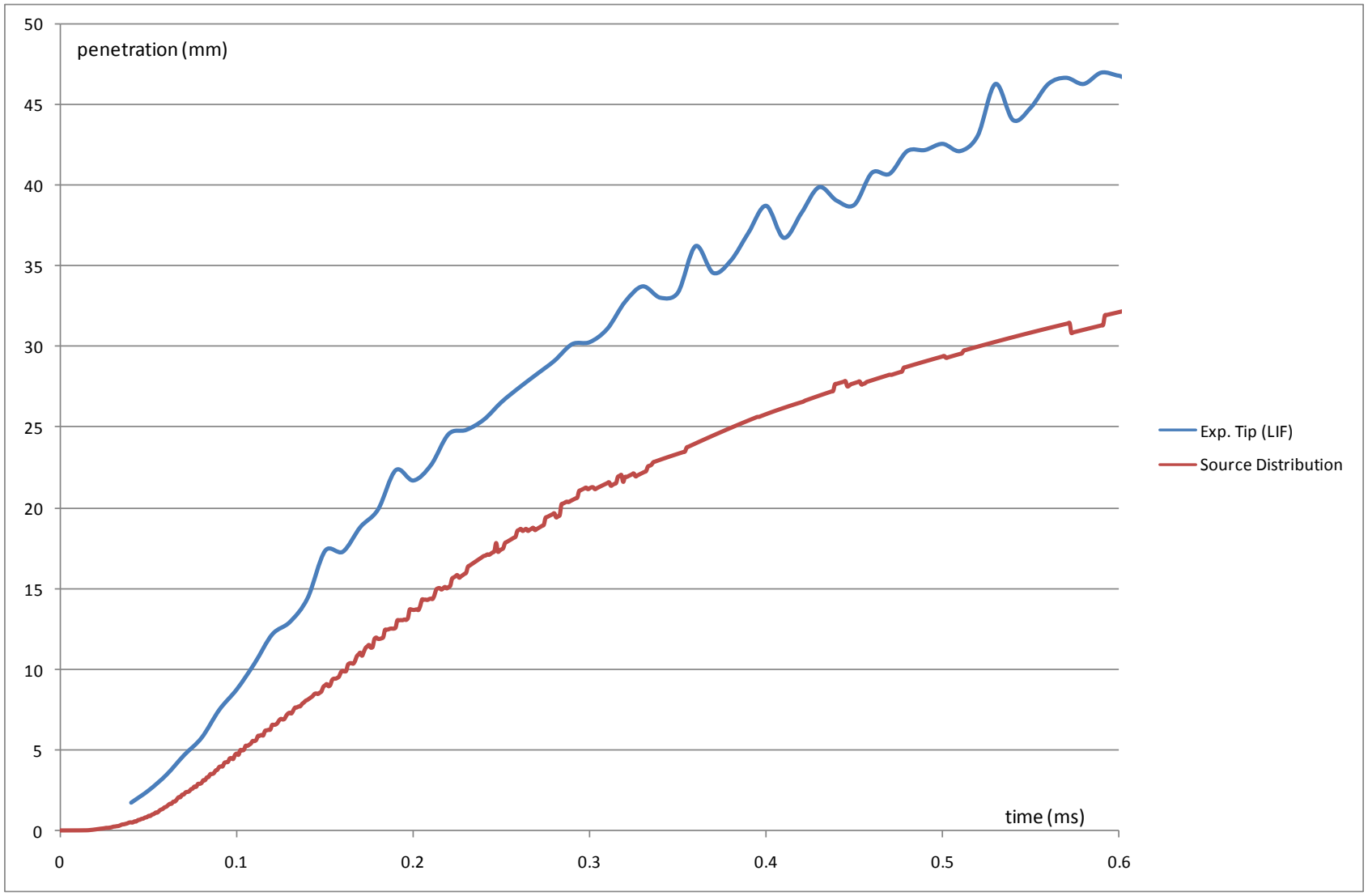
- Develop and apply reactive CFD simulations of the engine
  - Applying newly developed spray models
  - and auto-ignition Chemistry (in cooperation with Leeds)
  - Conducting CFD calculations at different operational regimes looking at HCCI


velocity m/sec
350
300
250
200
150
100
50
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
time (ms)
velocity m/sec

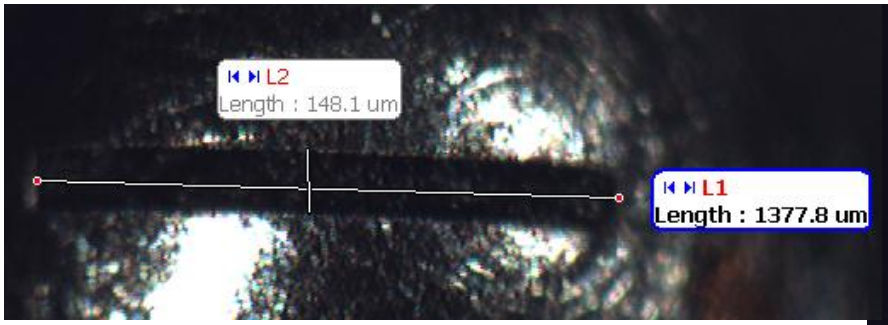

penetration (mm)
time (ms)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
0.1
0.2
0.3
0.4
0.5
0.6
Model Comparison
Models Available in FLUET
Exp. Tip (LIF)
no breakup
st TAB
st Wave
st Wave + B1=10
st Wave + B1=20
st Wave + B1=60

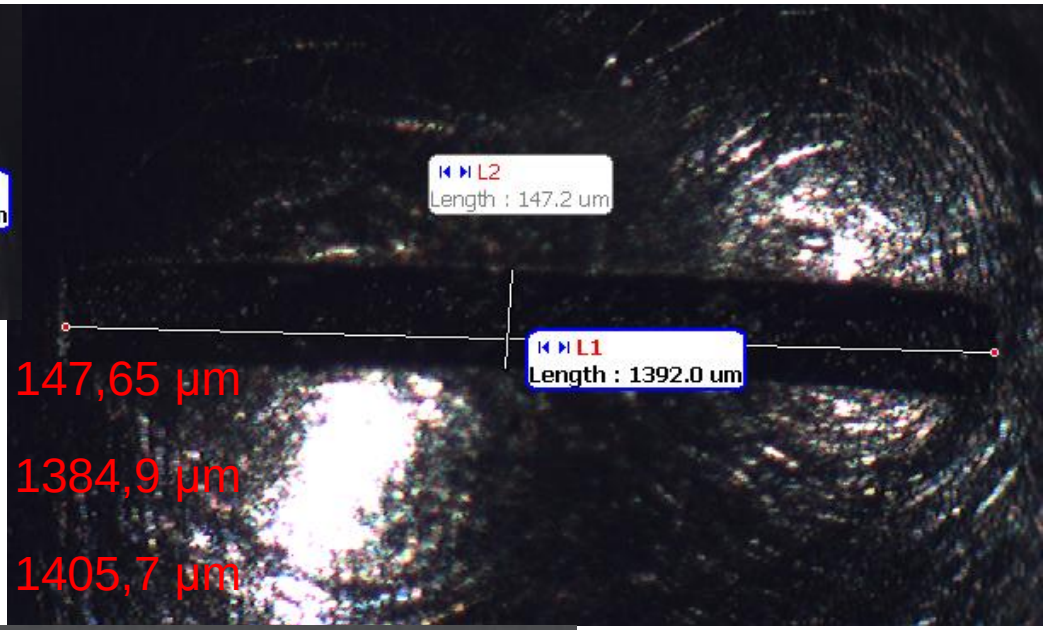
Further improvement of Spray models in FLUENT®

- Source terms distribution over neighbouring cells allows to:
  - decrease dramatically the mesh size
  - improve the spray penetration prediction
- Modified WAVE model + rigid body concept
- Droplet heating and evaporation:
  - Conduction limit model
  - Effective Thermal Conductivity (ETC) model

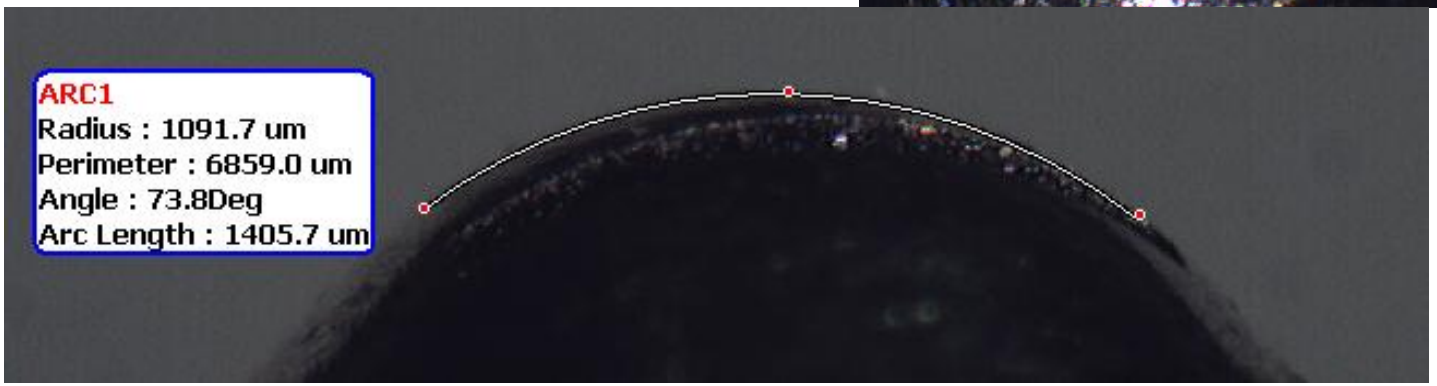

penetration (mm)
50
45
40
35
30
25
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
time (ms)
Exp. Tip (LIF)
Source Distribution

Fan Injector Slot's Dimensions Measured by Optical Microscopy





- Average Width = 147,65 µm
- Average Length = 1384,9 µm
- Arc Length = 1405,7 µm



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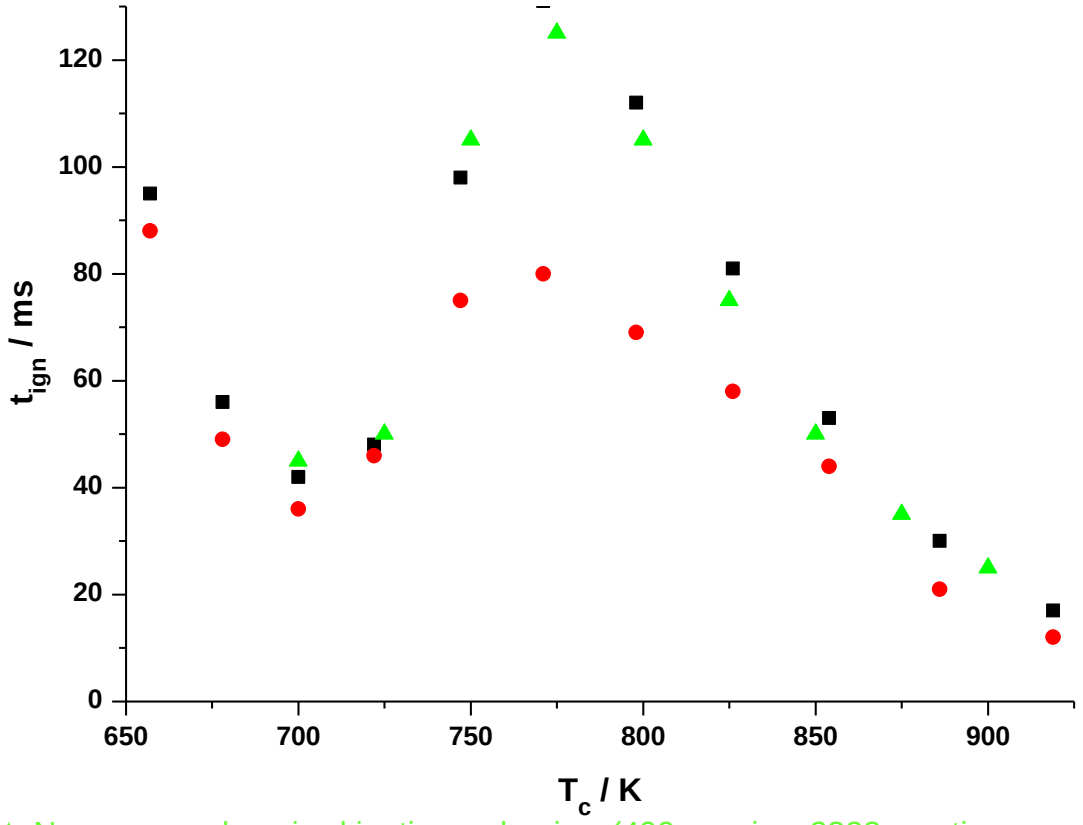
Cyclo-Hexane as reference fuel

- 0D simulations of cyclo-hexane auto-ignition behaviour
  - Rapid compression machine (data from Lille)
  - Full chemical mechanism (obtained by Nancy in shock tube experiments)
  - Reducing the complete mechanism in a skeleton mechanism suitable to be implemented in a CFD code
- Implementation of the Dynamic Decomposition Technique
- Investigating Shell-like model

0D results from Leeds partner on Cyclo-Hexane

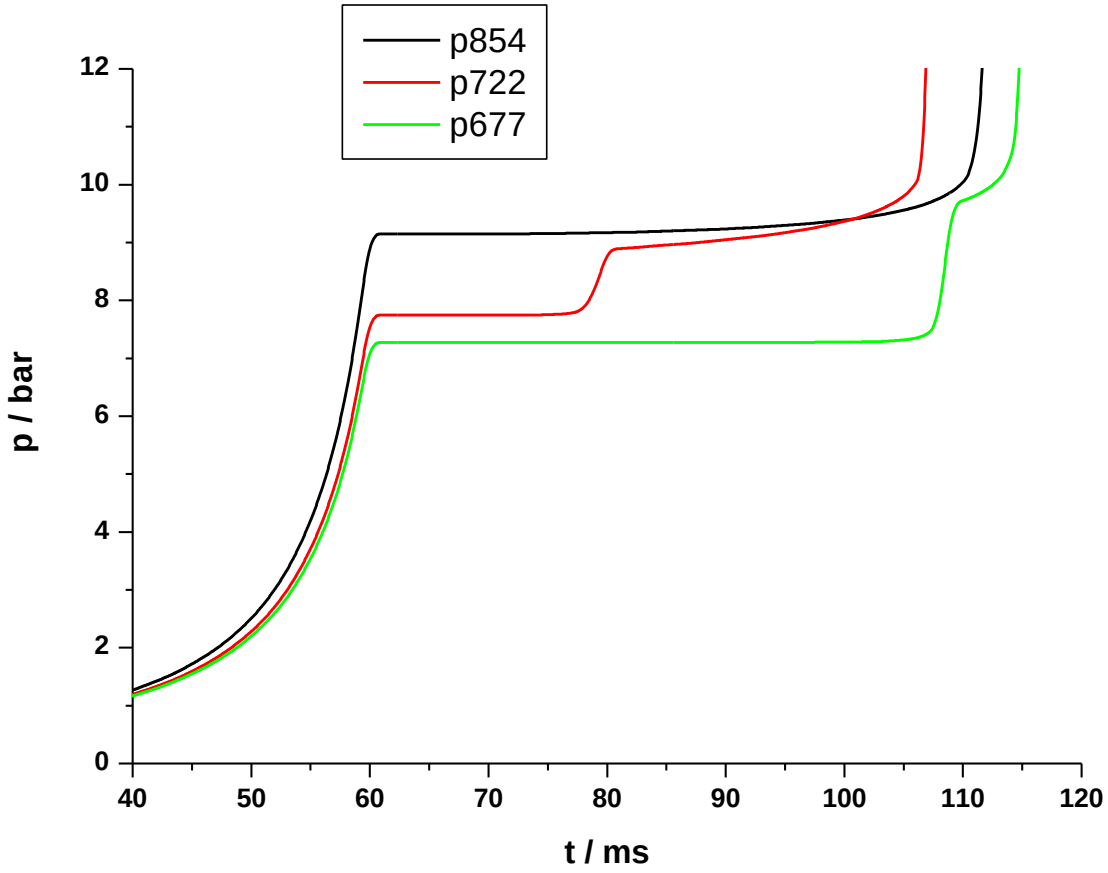


▲ Nacy comprehensive kinetic mechanism (499 species, 2323 reactions

■ Reduction to “skeleton 1” (116 species, 845 reactions)

● Reduction by Quasi-Steady State Analysis QSSA (35 species, 238 reactions)

0D results from Leeds partner on Cyclo-Hexane



Temperature-time profile using “skeleton 1” (116 species, 845 reactions)

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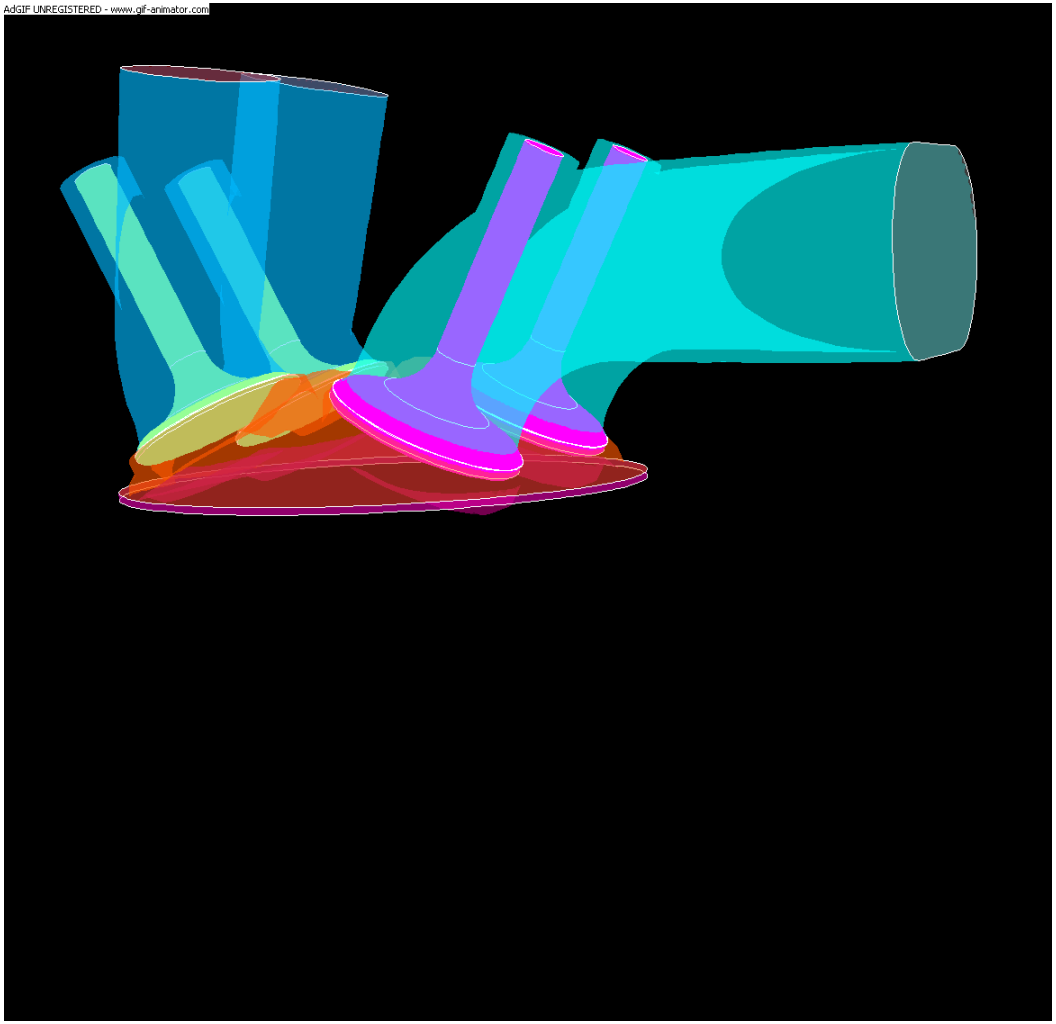
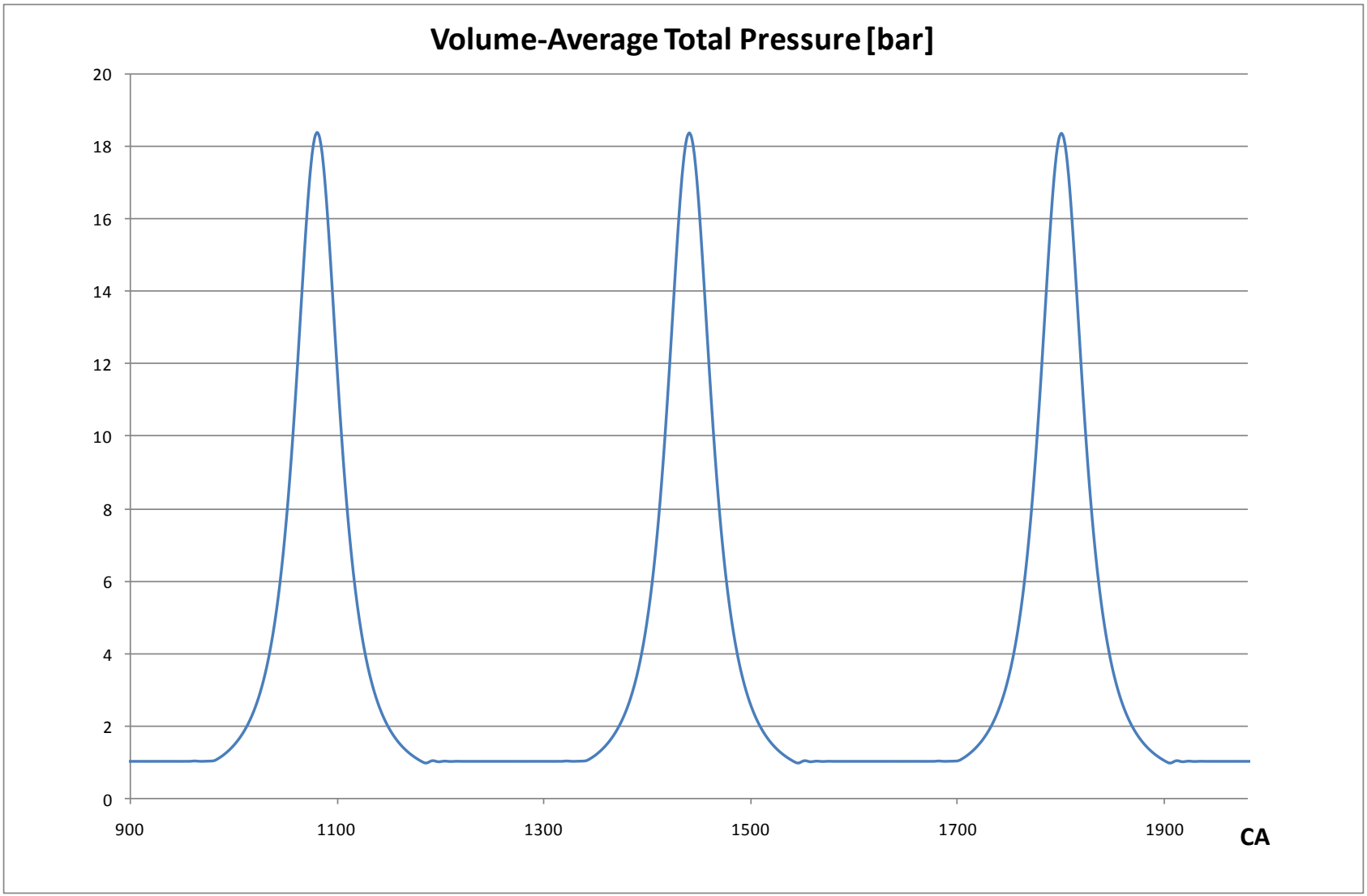
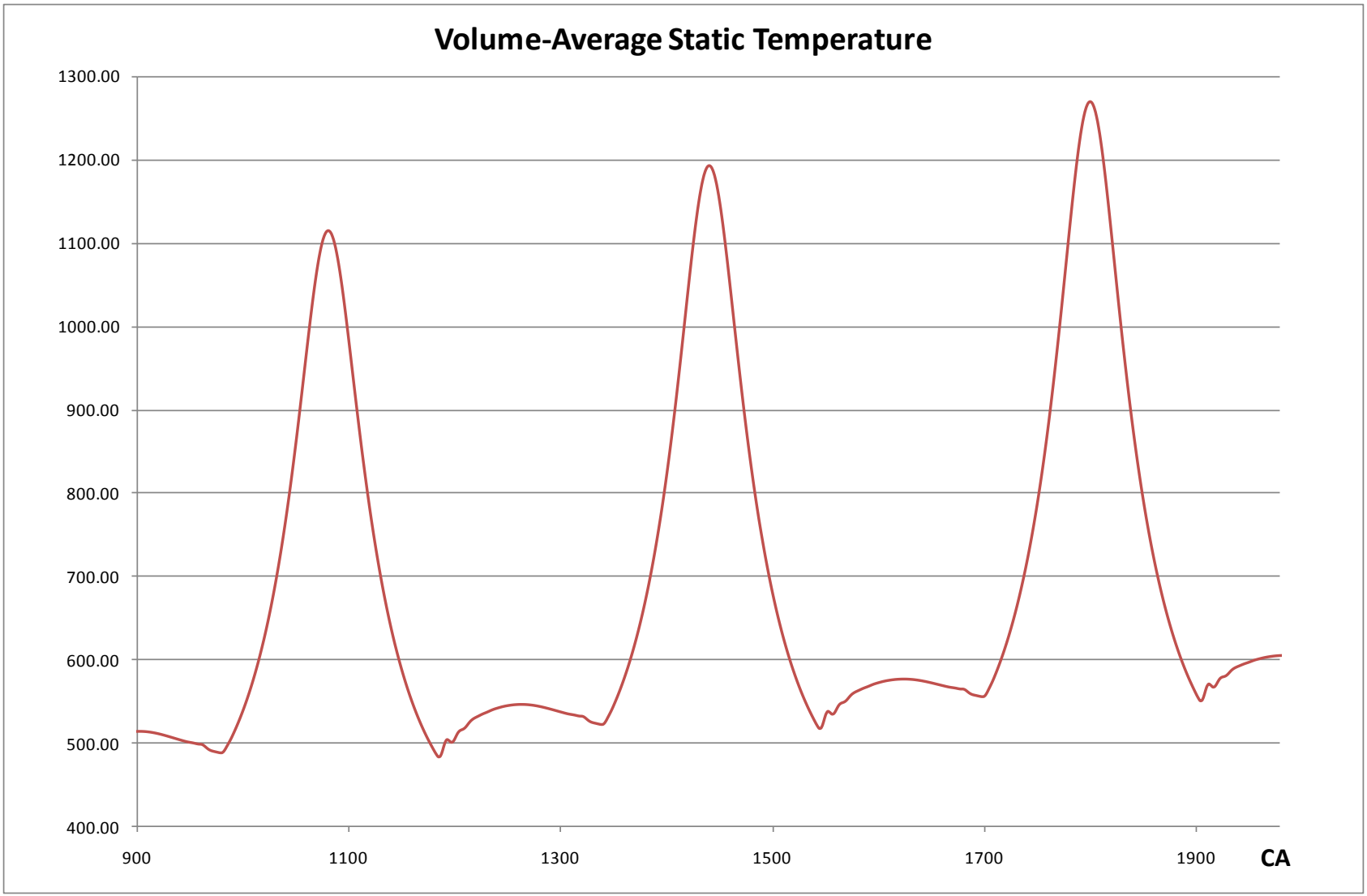
Preliminary simulations of the 2-ACE engine

- Motored engine results speed 1000 RPM (atmospheric pressure condition at the intake and exhaust)

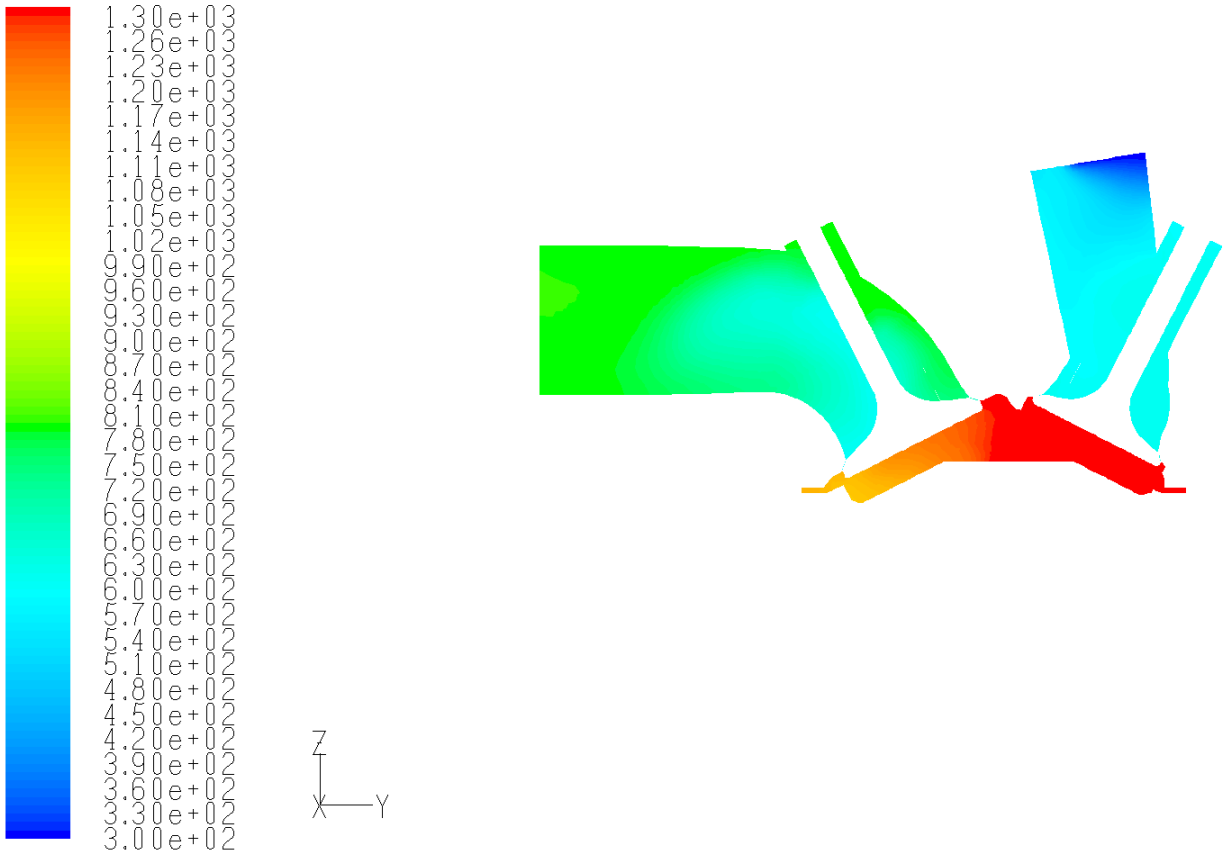
Preliminary simulations of the 2-ACE engine



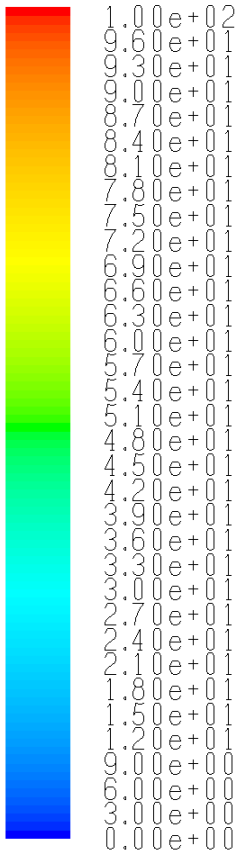

Volume-Average Total Pressure [bar]
20
18
16
14
12
10
8
6
4
2
0
900
1100
1300
1500
1700
1900
CA


Volume-Average Static Temperature
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
900
1100
1300
1500
1700
1900
CA

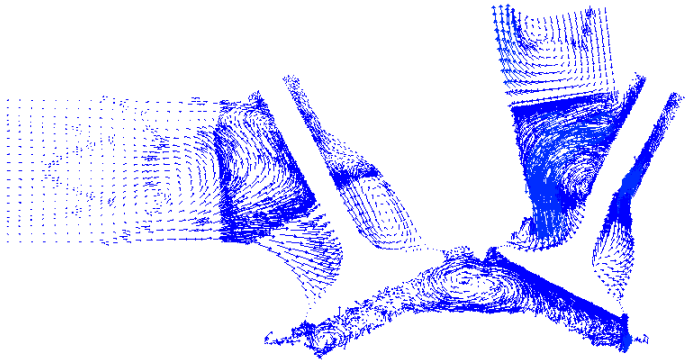
The Sir Harry Ricardo Laboratories



Contours of Static Temperature (k) (Time=3.0000e-01) Mar 30, 2009
Crank Angle=1799.99(deg) FLUENT 6.3 (3d, dp, pbns, dynamesh, ske, unsteady)



1.00e+02
9.60e+01
9.30e+01
9.00e+01
8.70e+01
8.40e+01
8.10e+01
7.80e+01
7.50e+01
7.20e+01
6.90e+01
6.60e+01
6.30e+01
6.00e+01
5.70e+01
5.40e+01
5.10e+01
4.80e+01
4.50e+01
4.20e+01
3.90e+01
3.60e+01
3.30e+01
3.00e+01
2.70e+01
2.40e+01
2.10e+01
1.80e+01
1.50e+01
1.20e+01
9.00e+00
6.00e+00
3.00e+00
0.00e+00



Velocity Vectors Colored By Velocity Magnitude (m/s) (Time=3.0000e-01) Mar 30, 2009
Crank Angle=1799.99(deg) FLUENT 6.3 (3d, dp, pbns, dynamesh, ske, unsteady)

Thank You for Your Attention...

Renzo Piazzesi

Centre for Automotive Engineering

www.brighton.ac.uk/cae

University of Brighton