Publikationen → B. Symposien

LES and experimental investigation of Helium plumes and hydrocarbon pool fires

[34]

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LES and experimental investigation of Helium plumes and hydrocarbon pool fires

2. Experimental

Small-scale Helium plume experiments: d = 4.6 cm *(Schönbucher)*

Large-scale Helium plume experiments: d = 1m *(SNL)*

Large-scale pool fire experiments: d = 1 m *(SNL)* methane

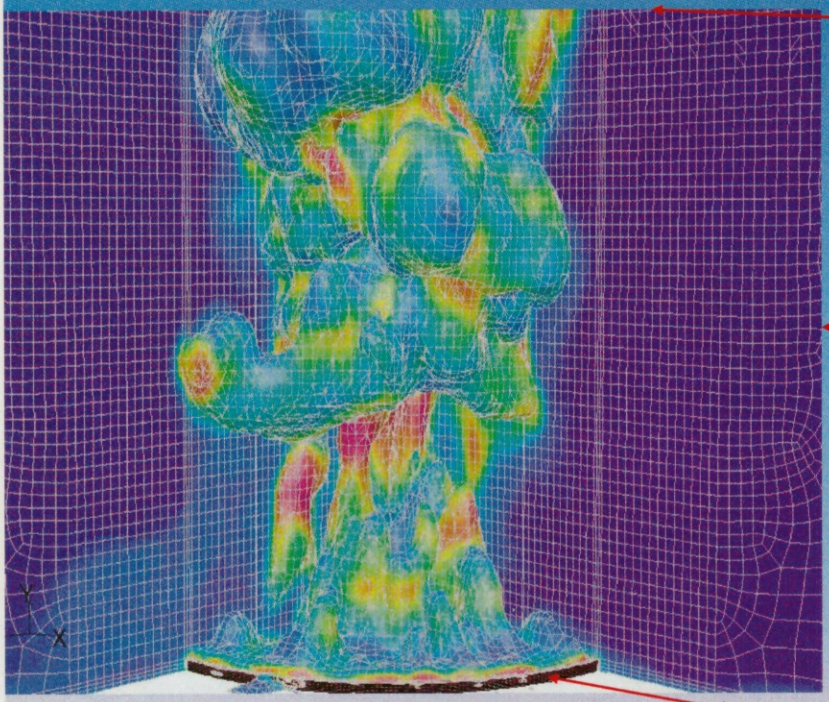
Large-scale pool fire experiments: d = 6 m *(Koseki)* heptane

Holographic real time interferometry (He, d = 4.6 cm)

3. Mesh specifics

- Unstructured non-uniform hexahedral mesh
- Refinement around the pool-rim (boundary layer) and in the plume region
- Coarser mesh outside of the plume (saving cells)
- Mesh adaption in region of high gradients (e.g. velocity, concentration) during simulation

3.2 Mesh for Methane pool-fire and Helium plume (d = 1 m)



Open pressure boundaries

Computational domain:
4 m x 3 m x 4 m

Amount of Cells:
1 600 000

Open pressure boundaries

Cell Size:
20 mm x 20 mm x 20 mm

Refinement around the pool-rim:
15 mm x 2 mm x 4 mm

Pool-rim

Unstructured Hexahedral mesh d = 1 m

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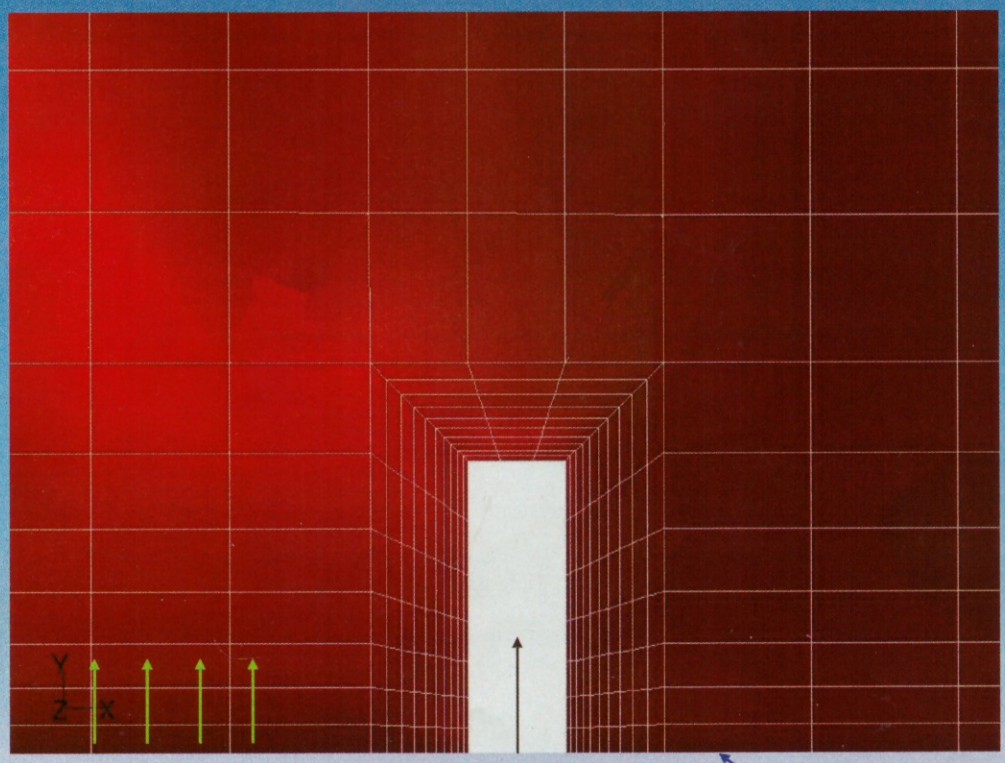
3.4 Mesh refinement around the pool rim



Velocity inlet Pool-rim Ground

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4. Initial and Boundary Conditions
4.1 Helium plume (d = 4.6 cm)

Initial Conditions	Gravitational Acceleration	$g_x = -9.81\ m/s^2$
	Operating Temperature	$\vartheta_0 = 20\ °C$
	Operating Pressure	$p_0 = 1.013\ bar$

Name of surface	Boundary Conditions	Values
Fluid-Inlet	Velocity Inlet	$v_x = 0.1354\ m/s$
		$\vartheta_{tot} = 20\ °C$
		$Y_{He} = 1$
Pool-Rim	Wall	$q = 0$ (adiabatic)
Side	Pressure Inlet	$\vartheta_{tot} = 20\ °C$
		$p_{gauge} = 0\ bar$
		$Y_{air} = 1$
Top	Pressure Inlet	$\vartheta_{tot} = 20\ °C$
		$p_{gauge} = 0\ bar$
		$Y_{air} = 1$

5. CFD-Models
5.1 Helium plumes

- Large-Eddy Simulation
- Dynamic Smargorinsky Subgrid-Model
- Transport Model for Species

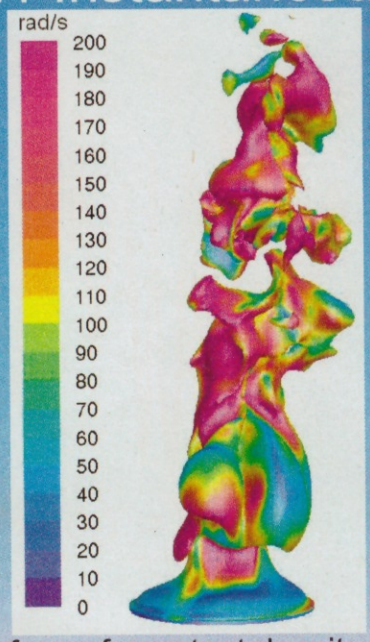
5.2 Methane and Heptane pool fires

- Large-Eddy Simulation
- Dynamic Smargorinsky Subgrid-Model
- Laminar Flamelet Modeling approach for Combustion
- Discrete Ordiante (DO) Model for radiation heat transfer
- Tesner Model for Soot formation

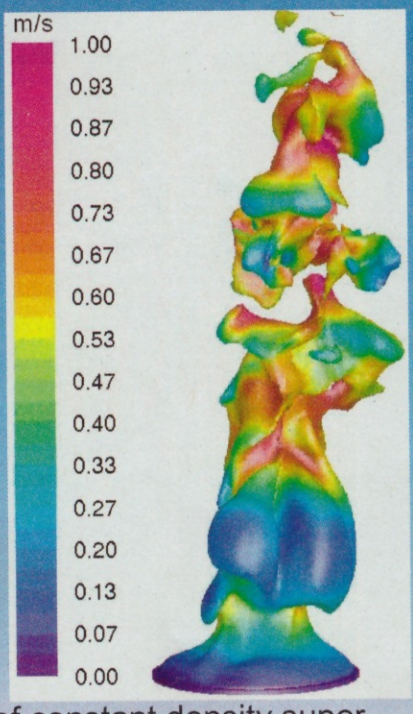
6. Results and Discussion

6.1 Helium plume (d = 4.6 cm)

6.1.1 Instantaneous properties

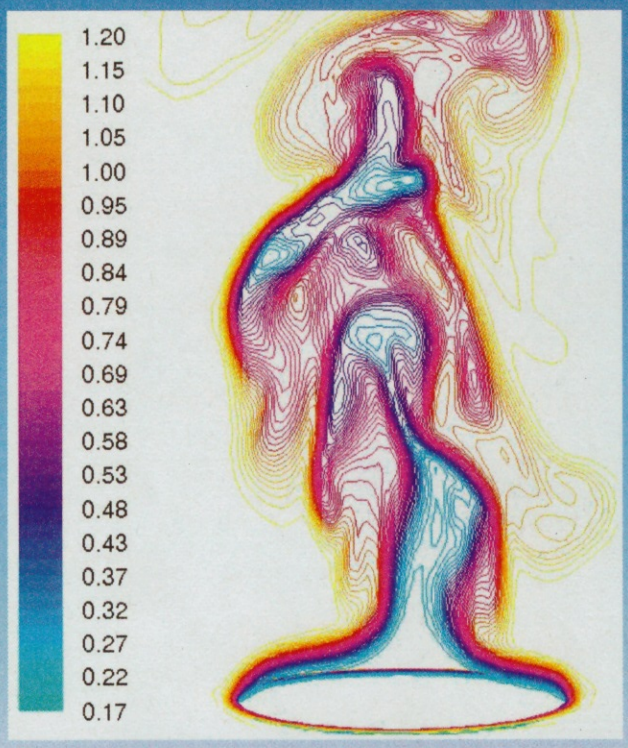


Isosurface of constant density super-imposed with vorticity (Helium d = 4.6 cm)



Isosurface of constant density super-imposed with velocity (Helium d = 4.6 cm)

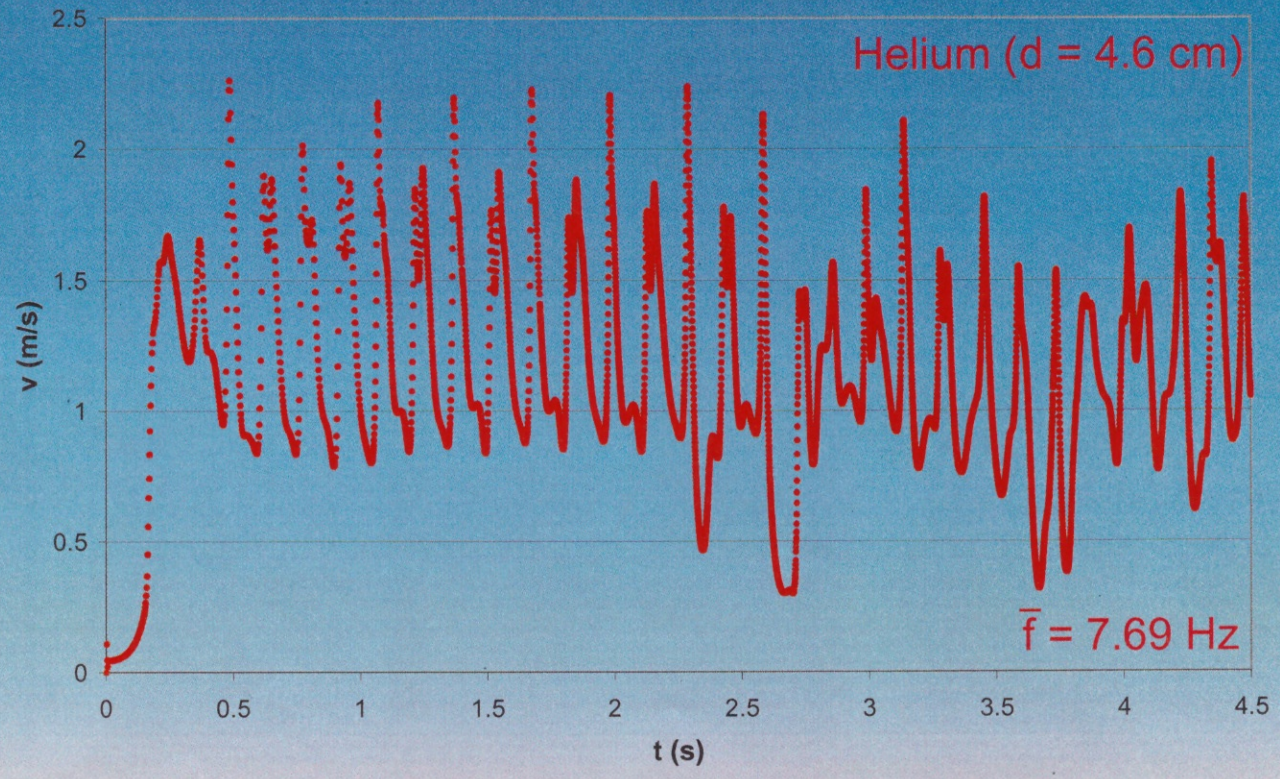
6.1.1 Instantaneous properties



Simulated isolines of mass density (Helium d = 4.6 cm)

Experimental interferometric isolines of mass density (Helium d = 4.6 cm) *(Schönbucher)*

6.1.1 Instantaneous properties



Time dependent vertical velocity at r/d = 0, x/d = 0.5

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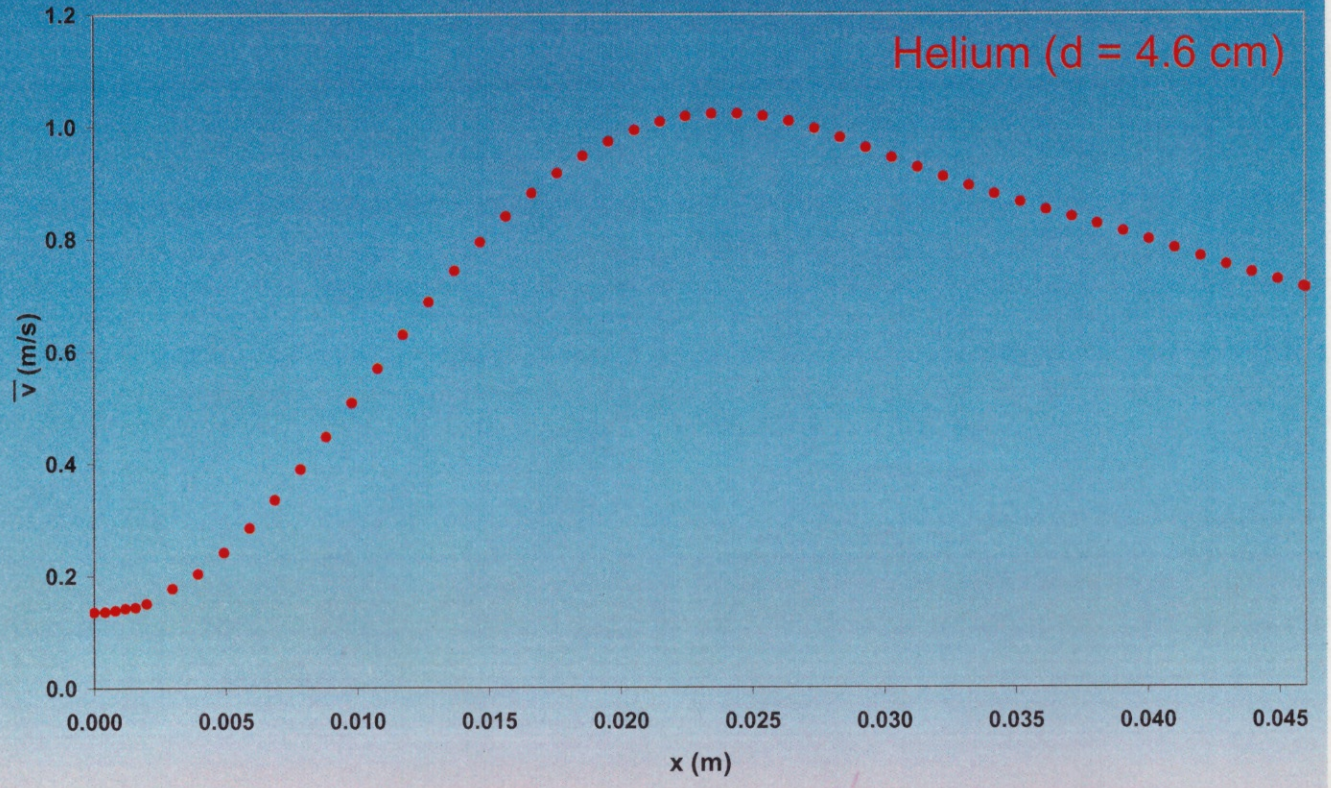
6.1.3 Time averaged profiles



Time-averaged vertical velocity profile along the x-axis

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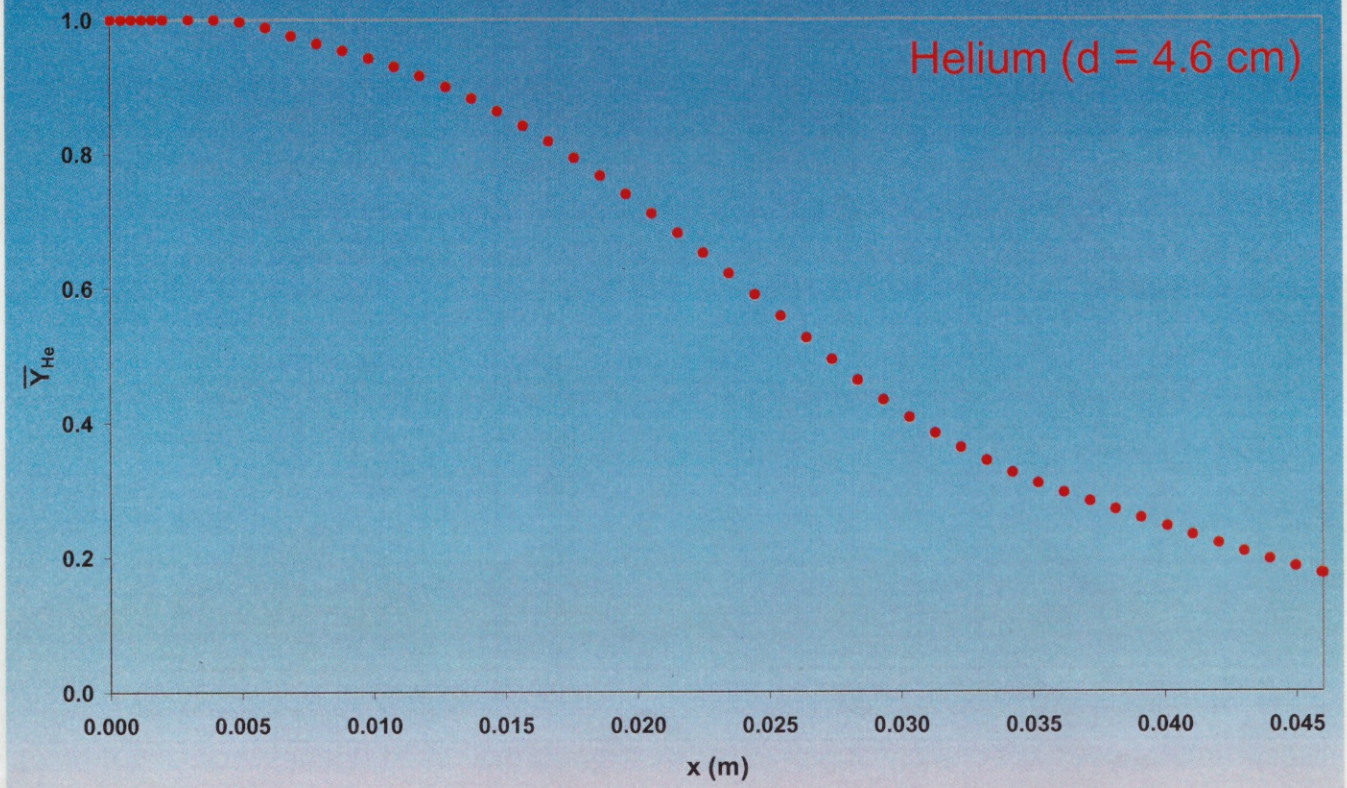
6.1.3 Time averaged profiles



Time-averaged helium mass fraction profile along the x-axis

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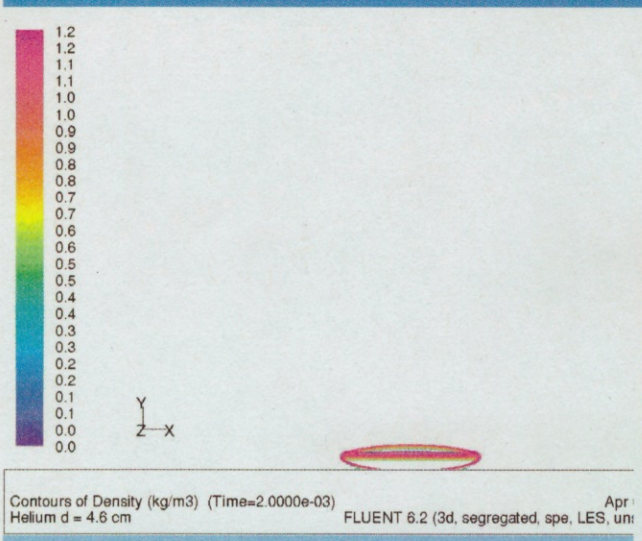
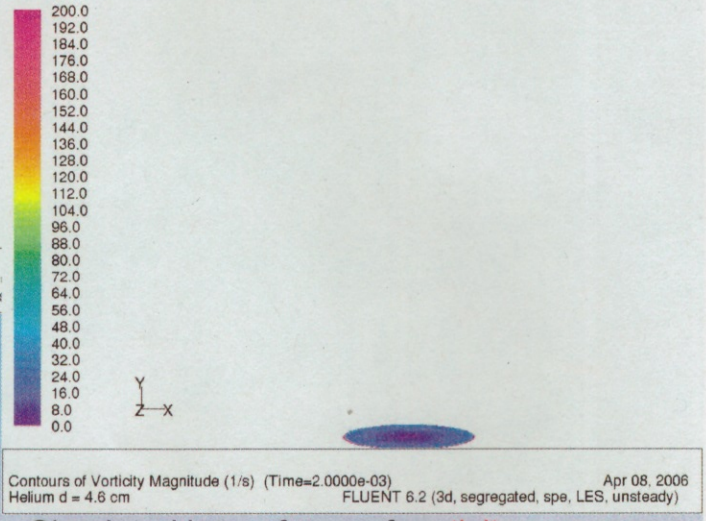
6.1.4 Animation of Helium plume d = 4.6 cm

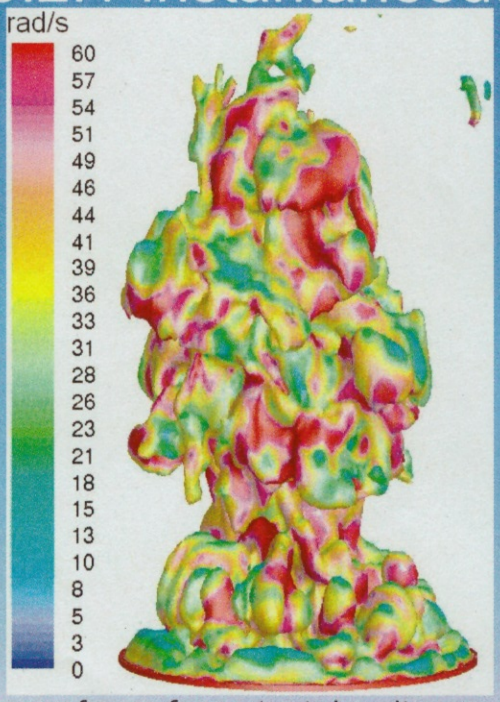


Simulated isolines of mass density (Helium d = 4.6 cm)



Simulated isosurfaces of vorticity (Helium d = 4.6 cm)

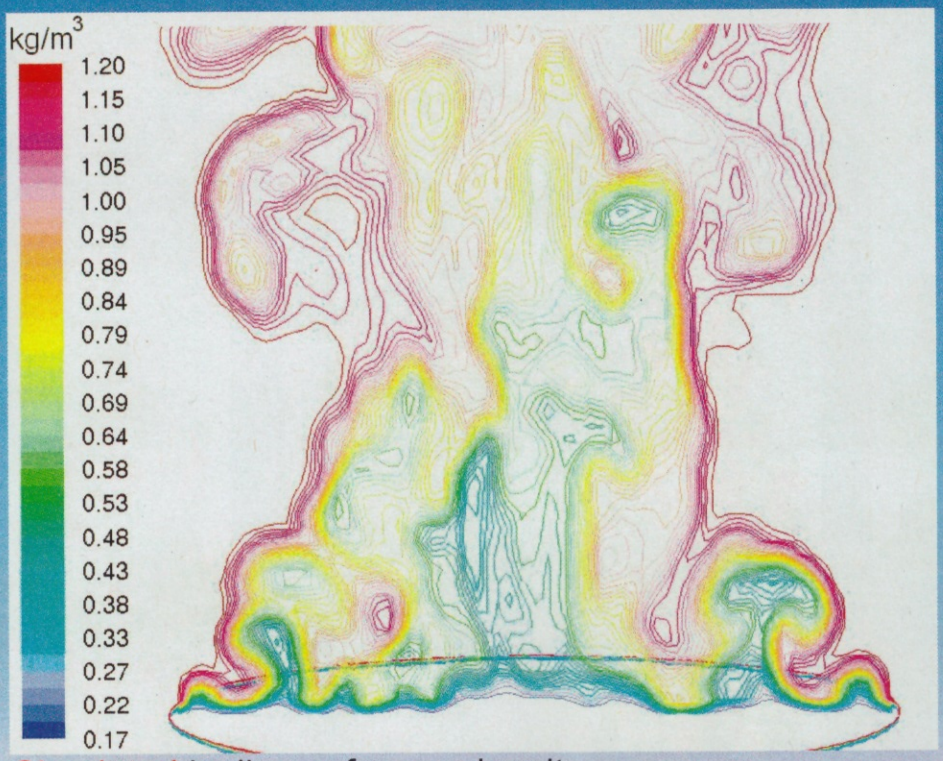
6.2 Helium plume (d = 1 m)
6.2.1 Instantaneous properties



Isosurface of constant density superimposed with vorticity (Helium d = 1 m)

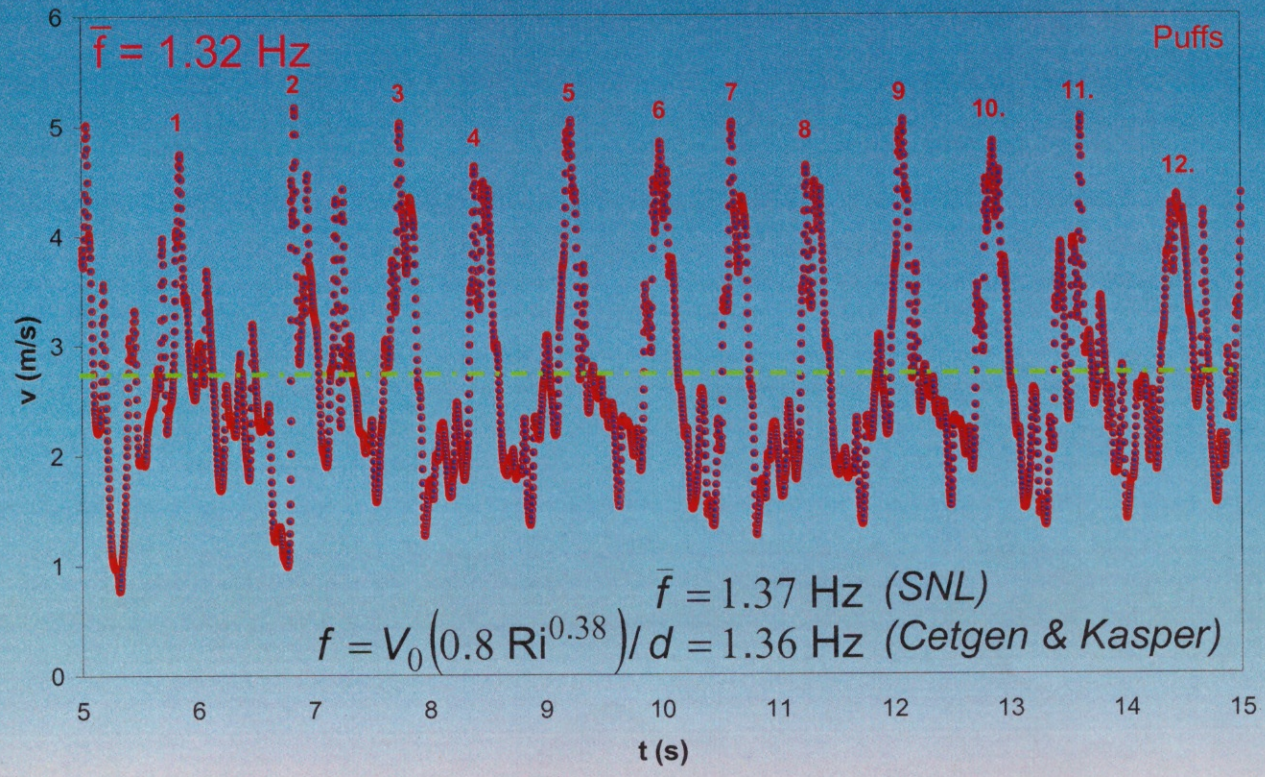
Isosurface of constant density superimposed with velocity (Helium d = 1 m)

6.2.1 Instantaneous properties



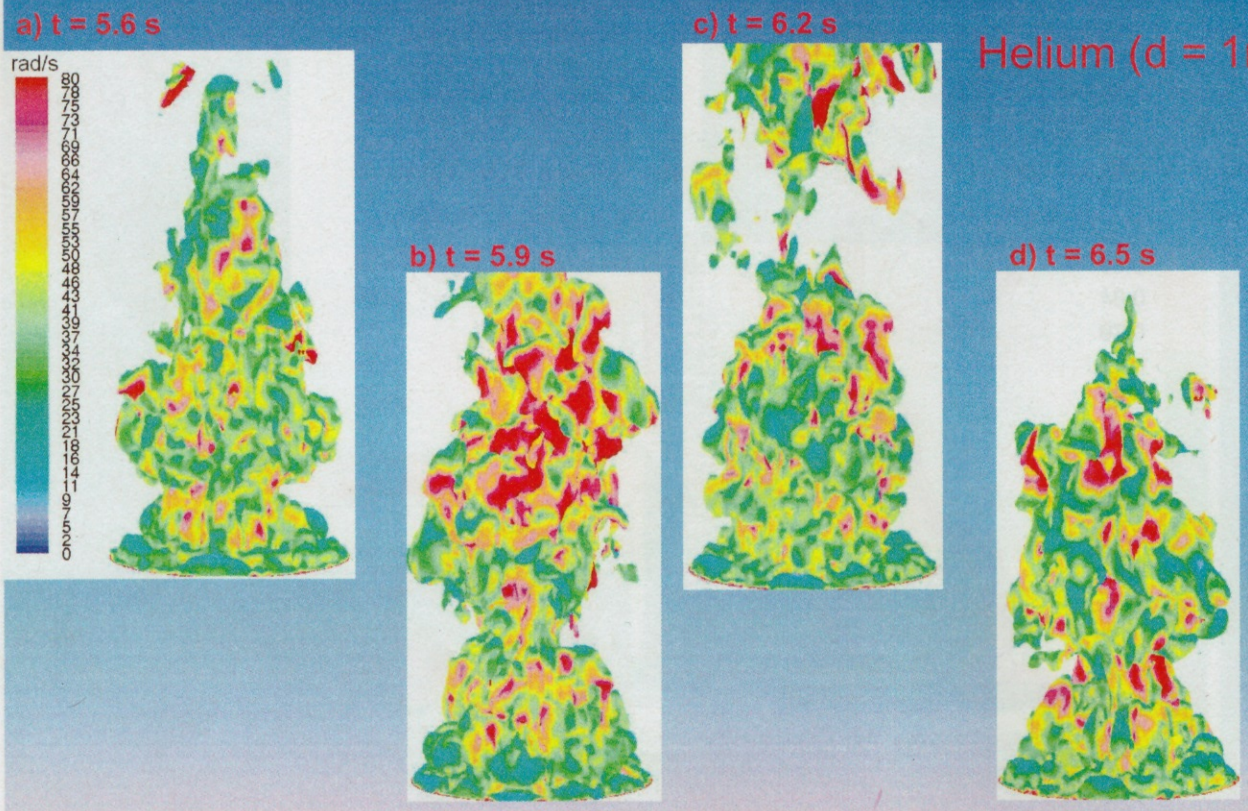
Simulated isolines of mass density
(Helium d = 1 m)

6.2.1 Instantaneous properties Helium (d = 1m)



Time dependent vertical velocity at r/d = 0, x/d = 0.5

6.2.1 Instantaneous properties



Snapshots of puff cycles showing isosurfaces of vorticity

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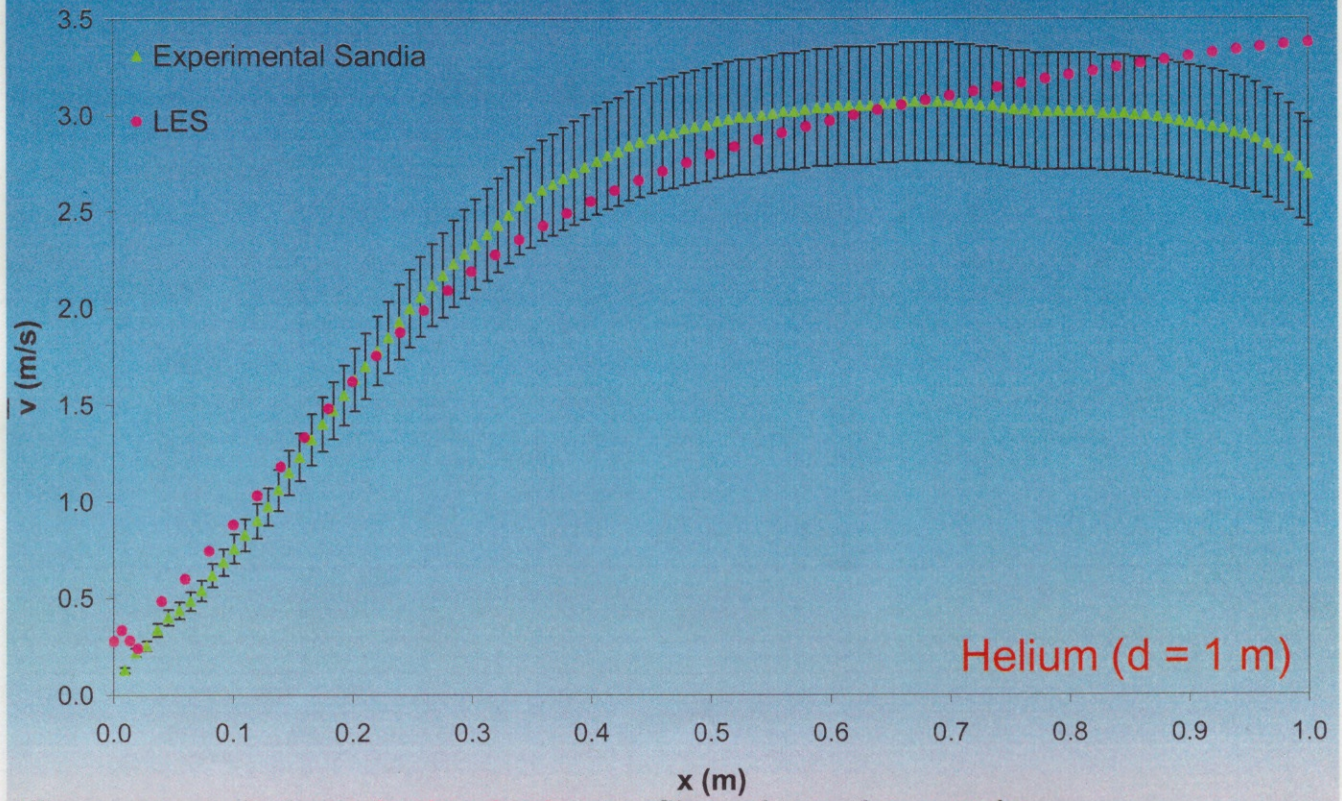
6.2.3 Time averaged profiles



Time-averaged vertical velocity profiles along the x-axis

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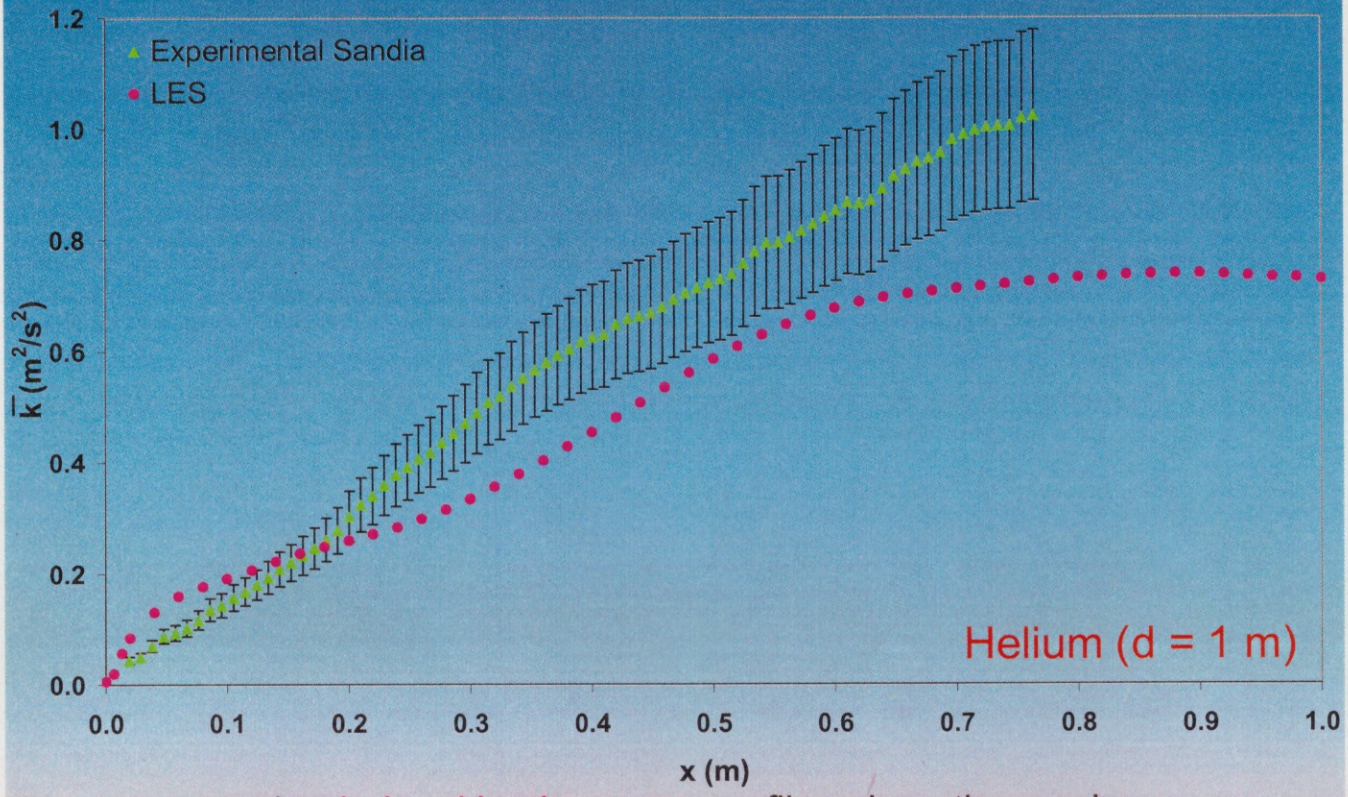
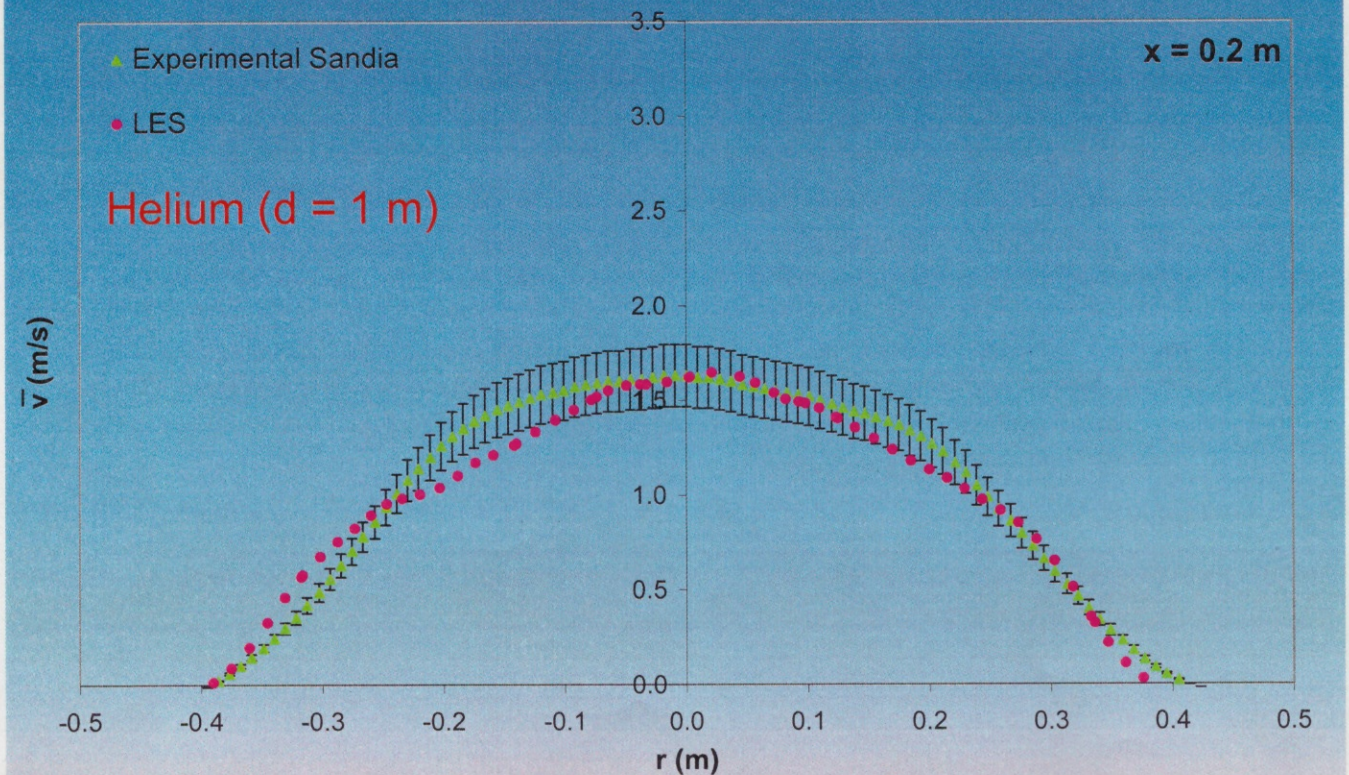
6.2.3 Time averaged profiles



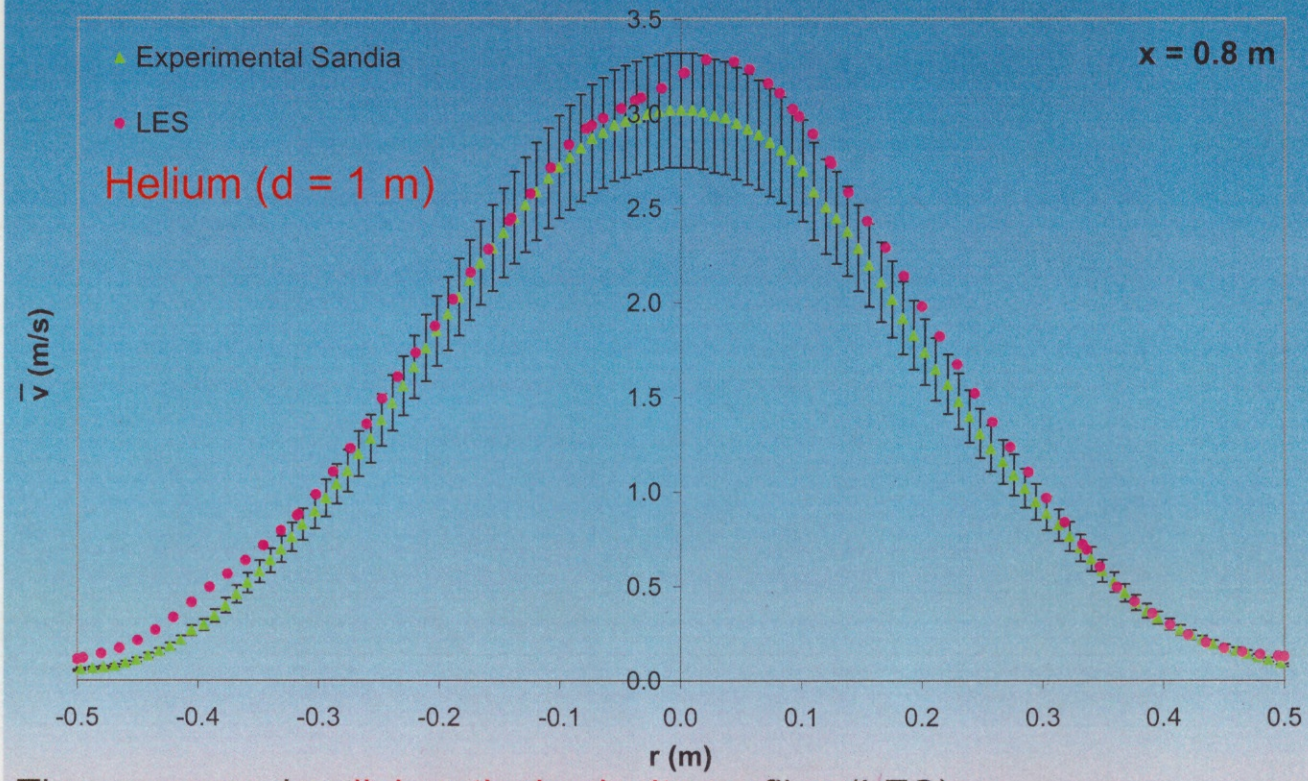
Time-averaged turbulent kinetic energy profiles along the x-axis

6.2.3 Time averaged profiles



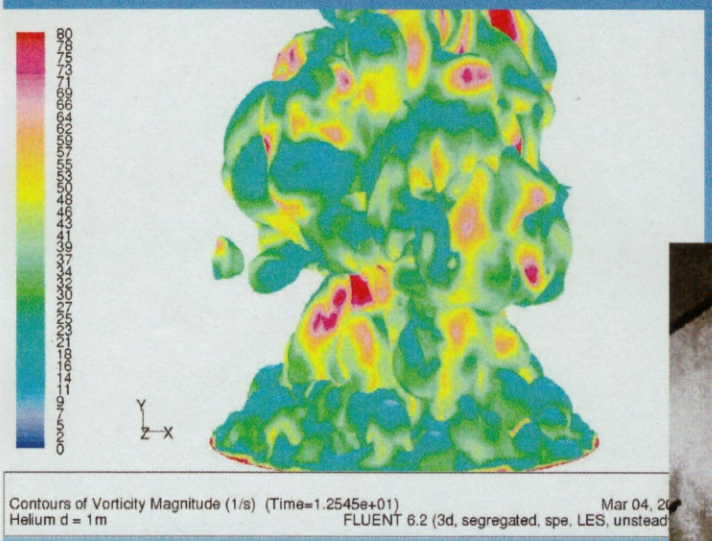
Time-averaged radial vertical velocity profiles (LES)

6.2.3 Time averaged profiles



Time-averaged radial vertical velocity profiles (LES)

6.2.4 Animation of Helium plume d = 1 m

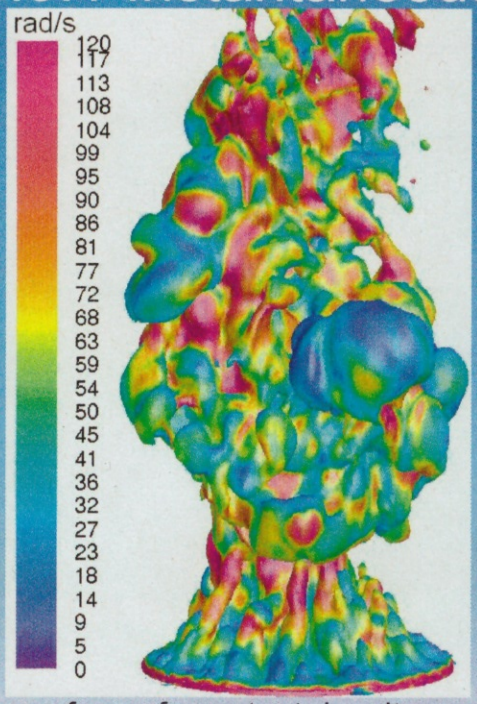


Simulated isosurface of mass density superimposed with vorticity (Helium d = 1 m)

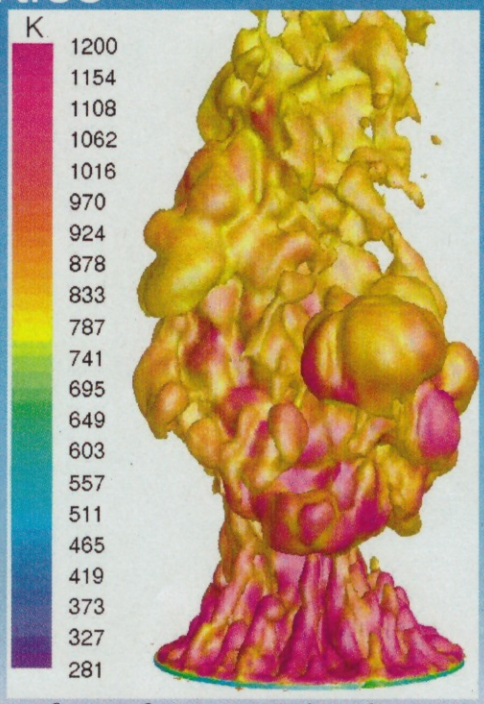
Experimental PIV images *(SNL)* (Helium d = 1 m)

6.3 Methane pool-fire (d = 1 m)

6.3.1 Instantaneous properties

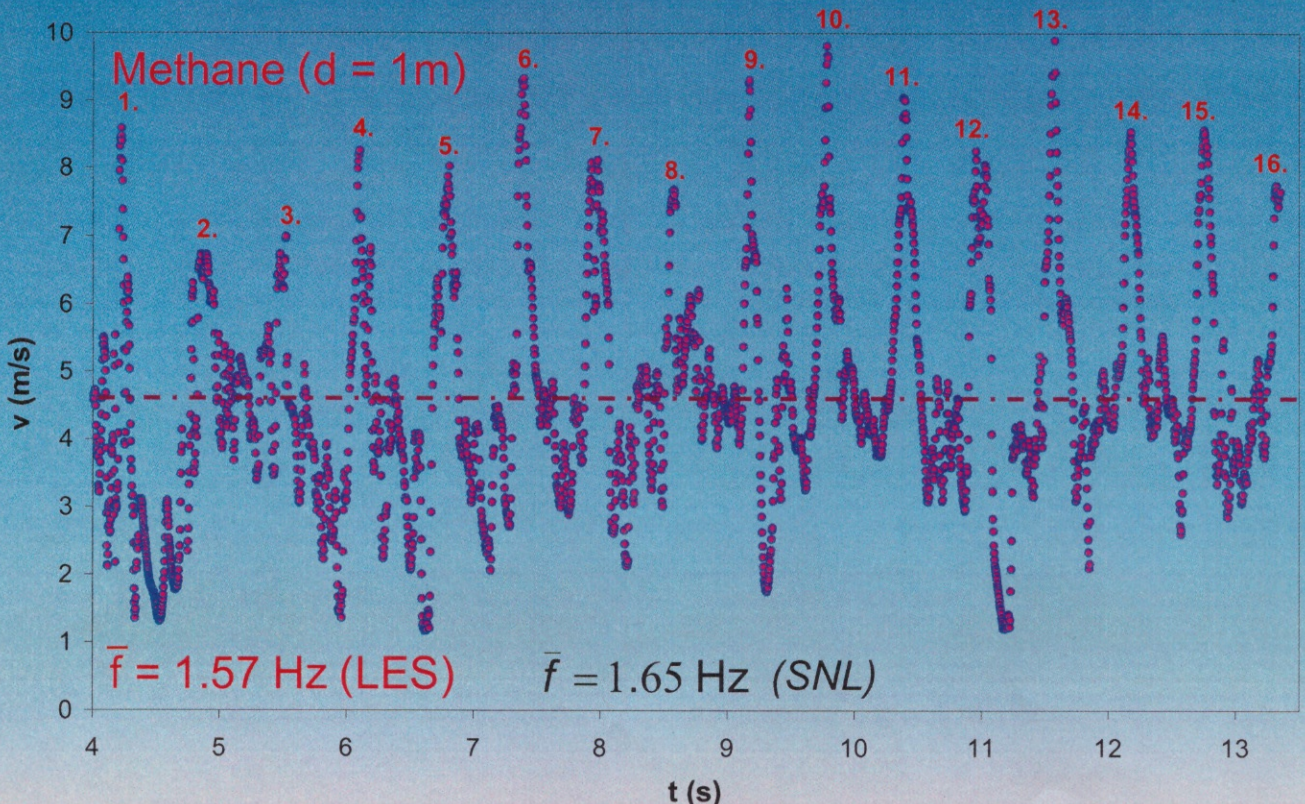


Isosurface of constant density superimposed with vorticity (Methane d = 1 m)



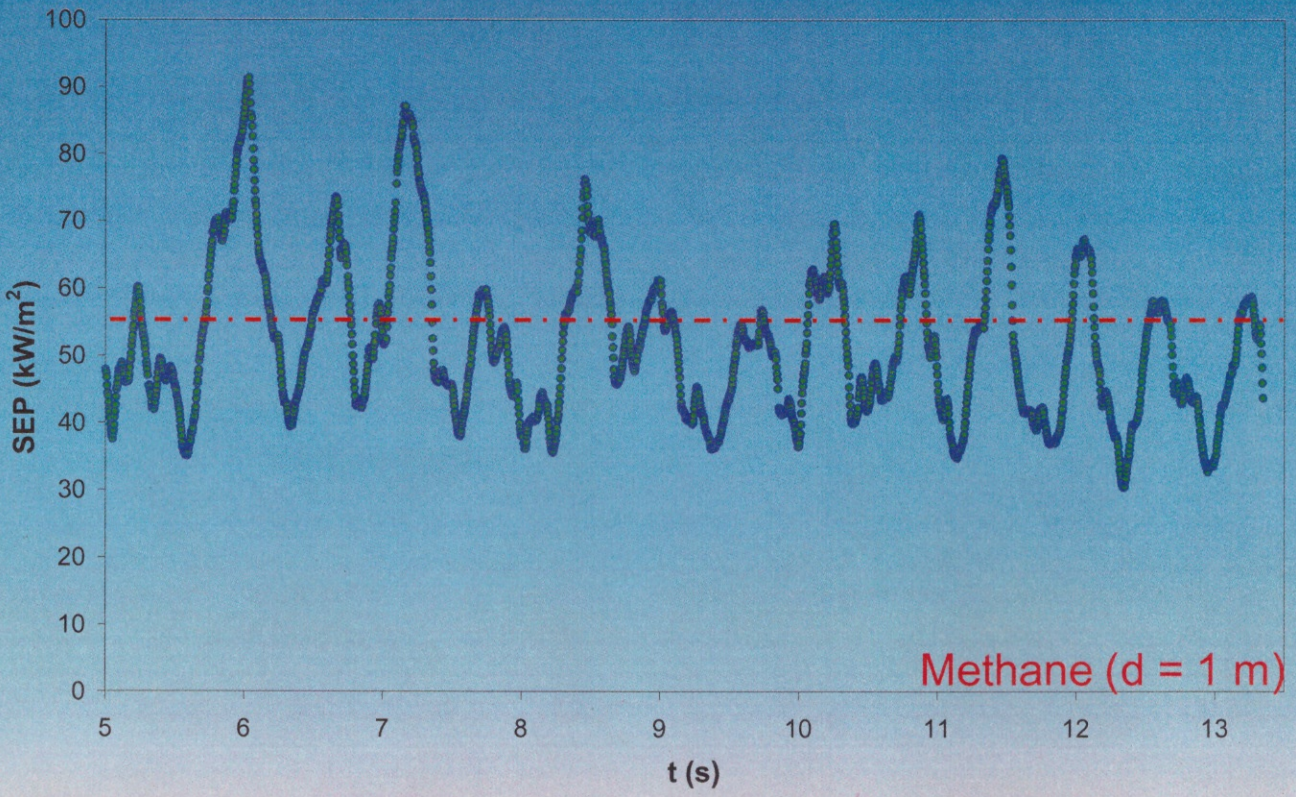
Isosurface of constant density superimposed with temperature (Methane d = 1 m)

6.3.1 Instantaneous properties



Time dependent vertical velocity at r/d = 0, x/d = 0.5

6.3.1 Instantaneous properties



Transient Surface Emissive Powers at Δy/d = 0, x/d = 0.25

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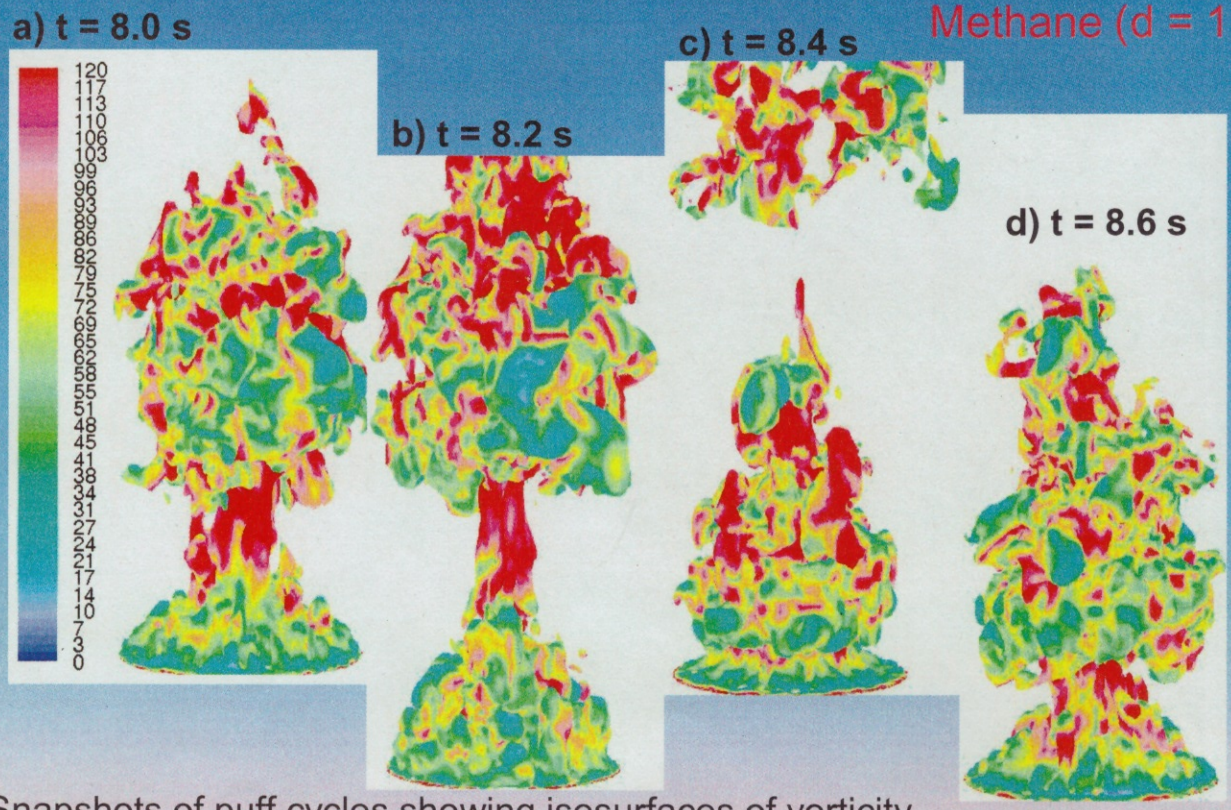
6.3.1 Instantaneous properties



Snapshots of puff cycles showing isosurfaces of vorticity

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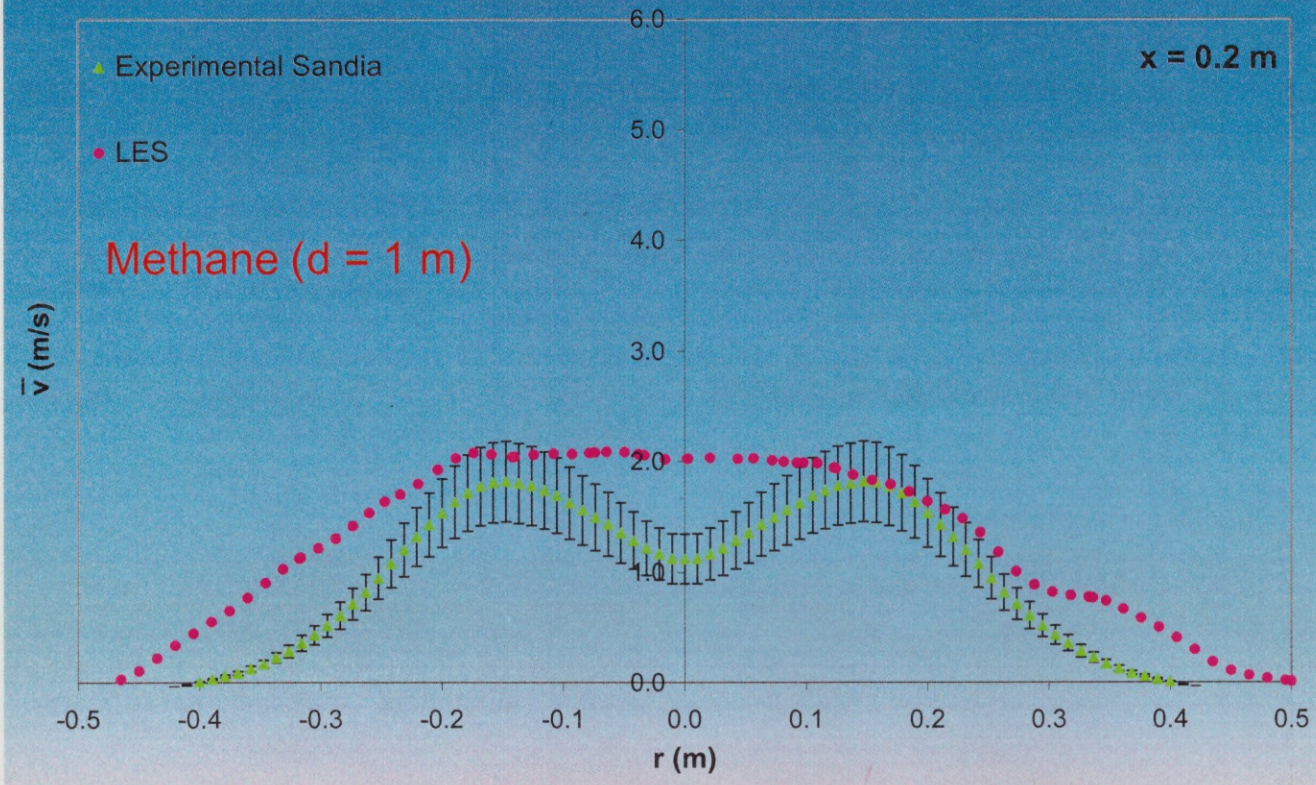
6.3.3 Time averaged profiles



Time-averaged radial vertical velocity profiles (LES)

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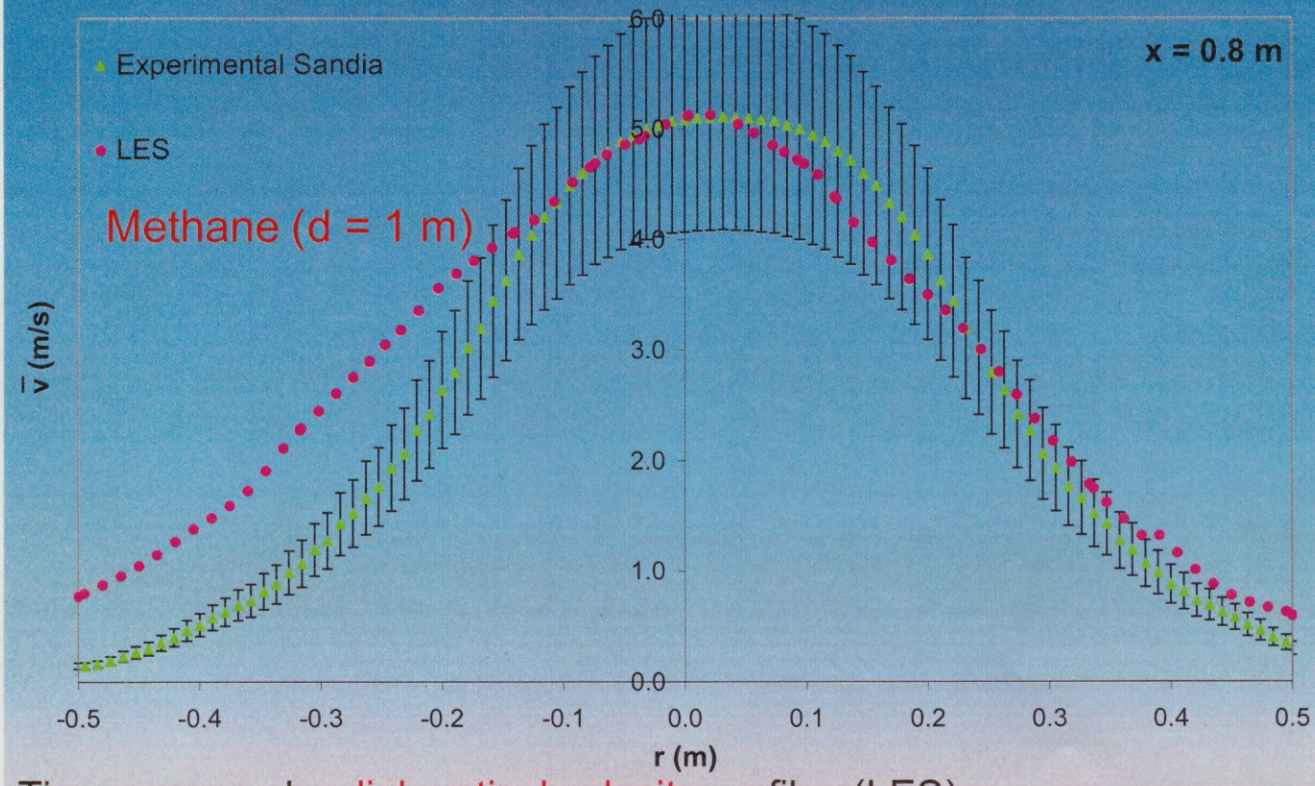
6.3.3 Time averaged profiles



Time-averaged radial vertical velocity profiles (LES)

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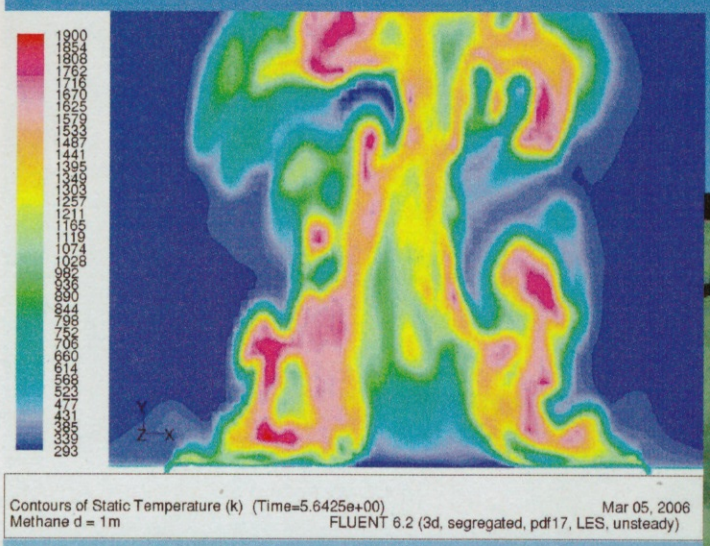
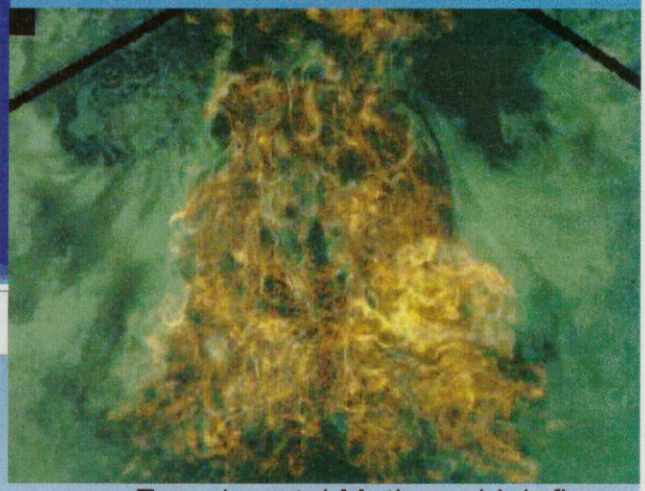
6.3.4 Animation of Methane pool-fire d = 1 m



Simulated transient temperature field
(Methane d = 1 m)



Experimental Methane high flow
PIV overlay (*SNL*)
(Helium d = 1 m)

7. Outlook

Lacks exist e.g. in

- Prediction of smoke blockage effect
- Optical properties of soot parcels
- Measurements of temperature-, velocity- and concentration fields in large pool fires
- Wind influence