# LES Simulation of Transient Fluid Flow and Heat Transfer in Continuous Casting Mold

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# Acknowledgements


- Professor B.G.Thomas & Professor S.P. Vanka
- Accumold
- AK Steel
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- Columbus Stainless Steel
- LTV Steel
- Hatch Associates
- Stollberg, Inc
- National Science Foundation
- National Center for Supercomputing Applications

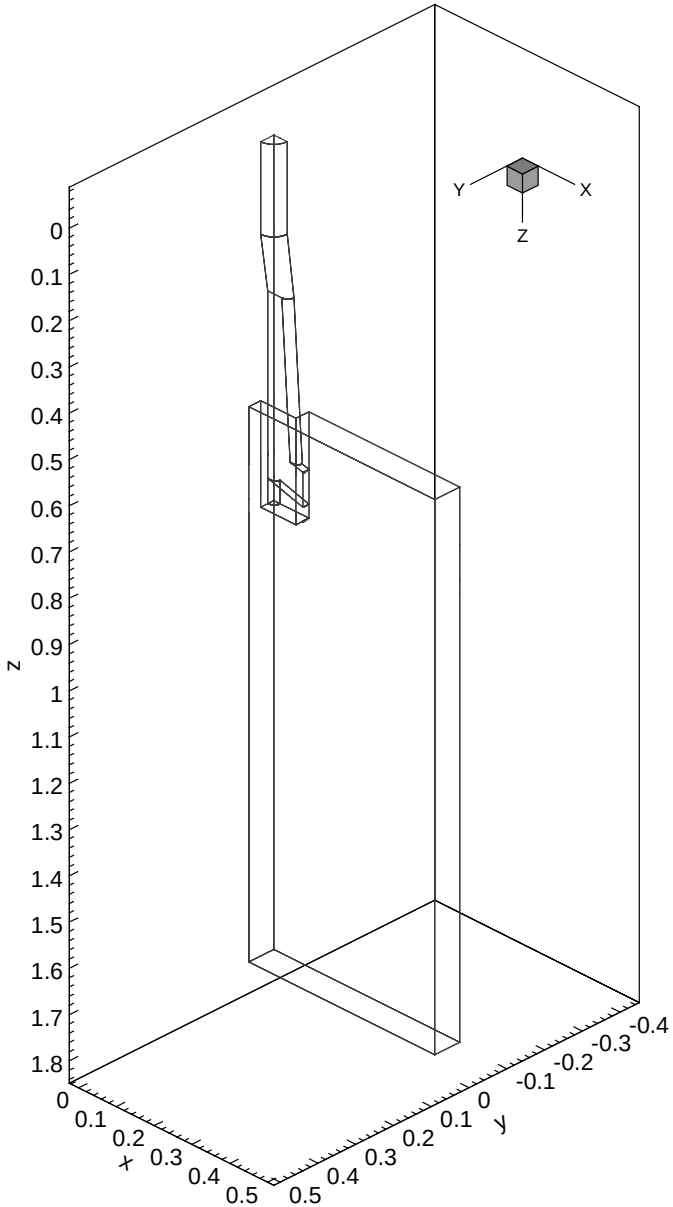
# Objectives

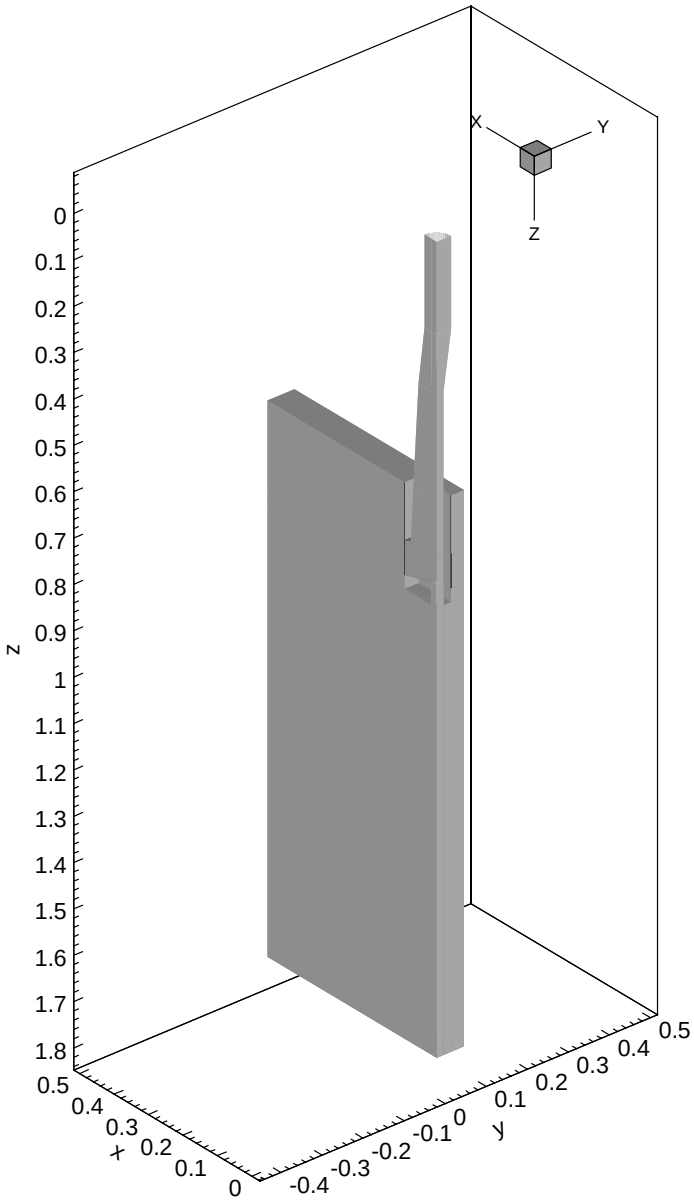
- Study the transient behavior of fluid flow in continuous casting molds.
- Study the turbulent heat transfer characteristic in the casting molds.

# Computation Details

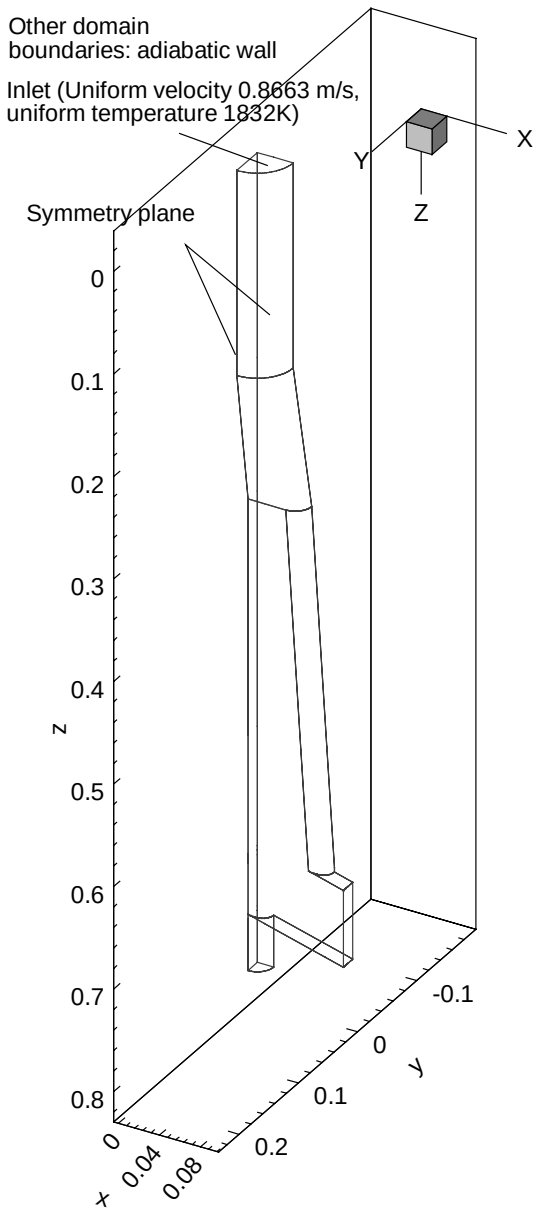
- Solving 3D transient Navior-Stokes Equations
- Second Order accuracy in space and time
- Non-Structured Cartesian collocation grid
- Algebraic Multi-Grid (AMG) solver is used to solve pressure Poisson Equation
- No sub-grid model  (Coarse Grid DNS)
- 3D flux-limited advection scheme
- 852442 finite volume cells
- Time step 0.0005s

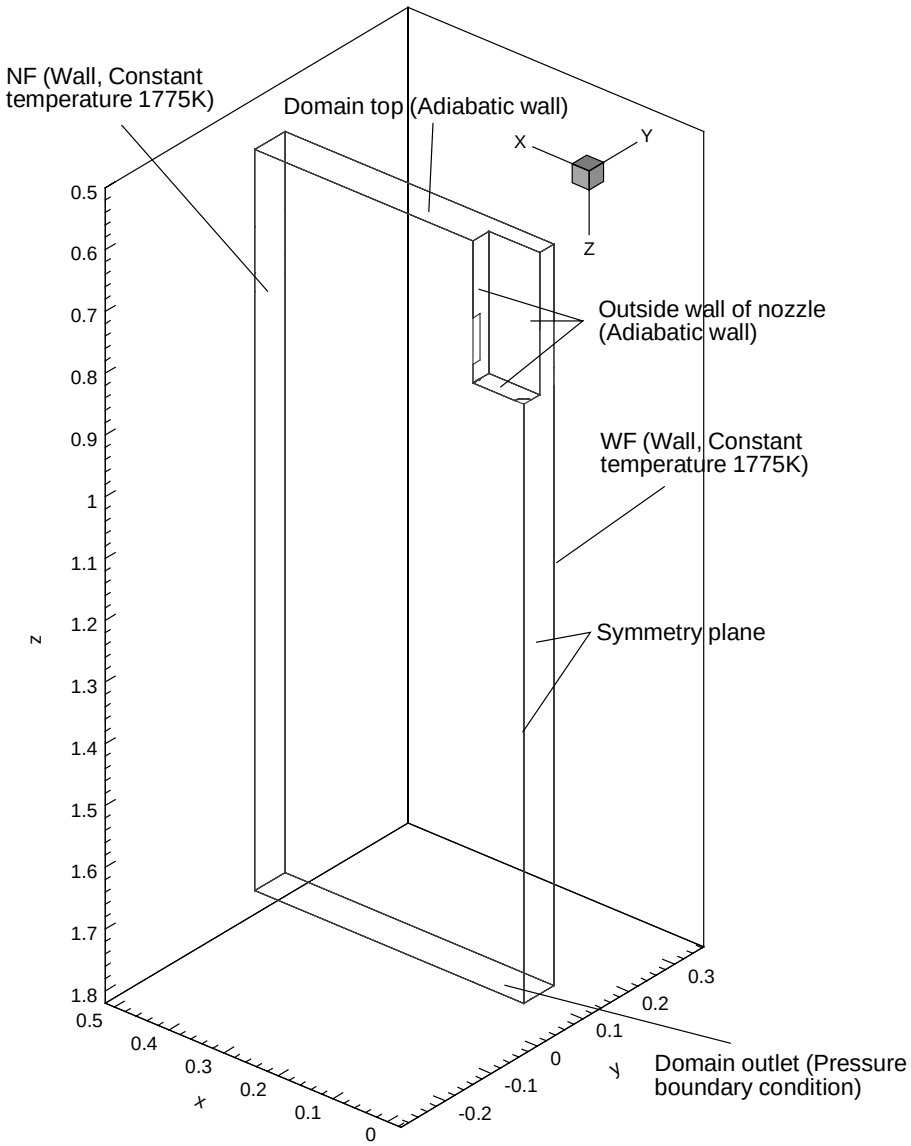
# Simulation domain



# Boundary conditions



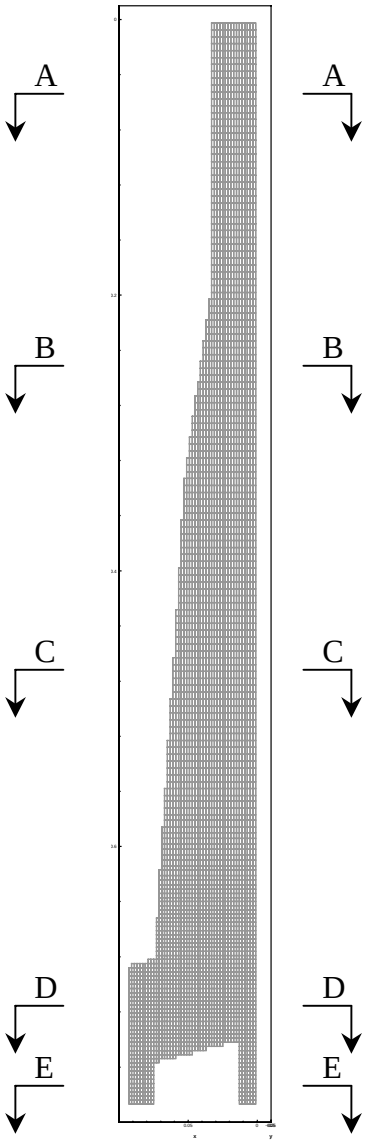



# Simulation parameters

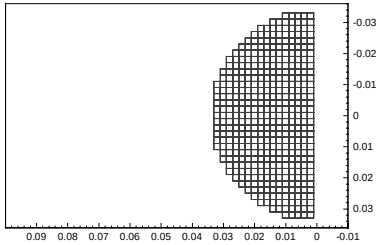
| | |
|---|---|
| Casting speed | 25.4 mm/s |
| Mold thickness | 132 mm |
| Mold width | 984 mm |
| Mold length | 1,200 mm |
| Nozzle inlet diameter* | 70mm |
| SEN submerge depth | 127 mm |
| Pouring temperature | 1832 K |
| Solidifying temperature | 1775 K |
| Steel density | 7020 $kg/m^3$ |
| Molecular viscosity | 0.0056 kg/m·s |
| Heat conductivity | 26 W/m·K |
| Prandtl number | 0.1 |

* Nozzle geometry based on blueprints

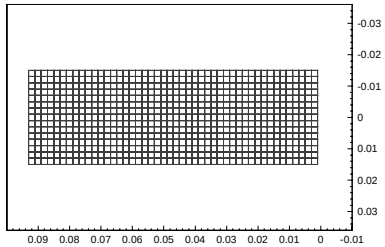
# Mesh for the nozzle part (half, ¼ actually used)



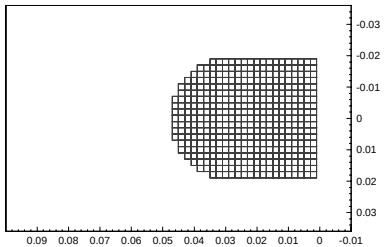

A-A



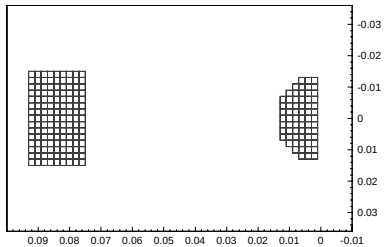

D-D



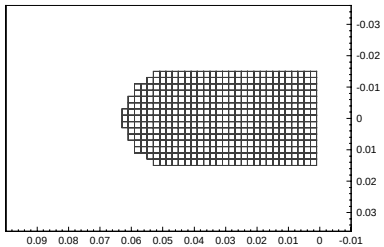

B-B



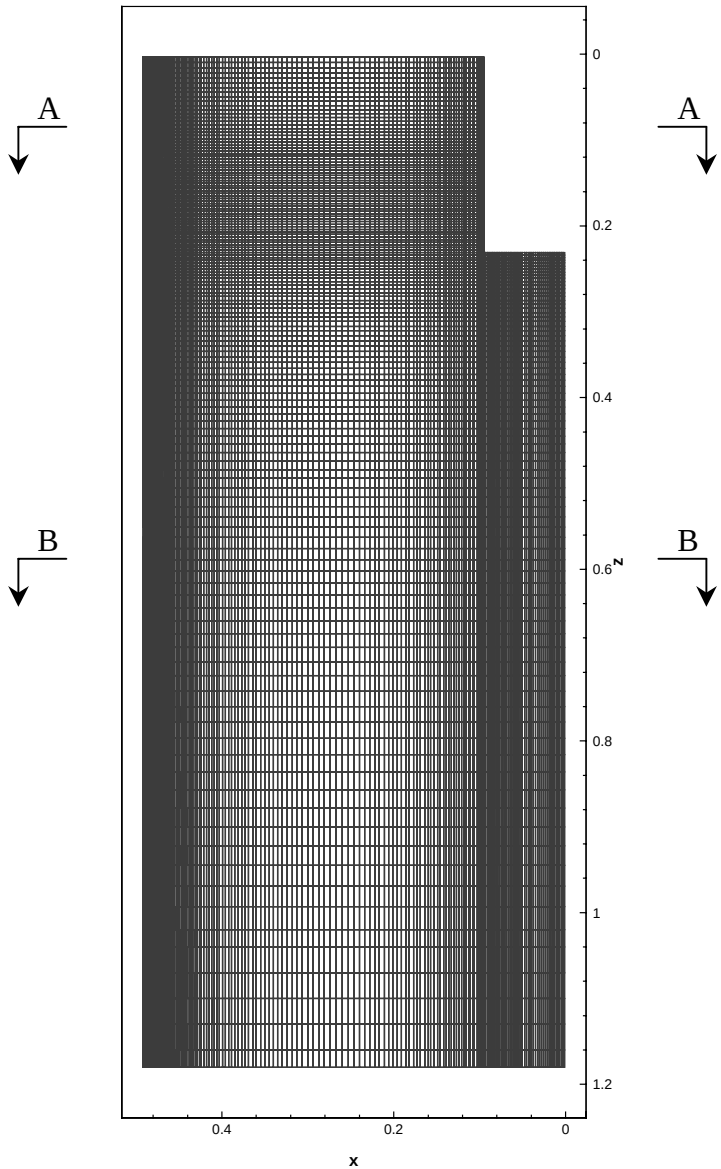

E-E

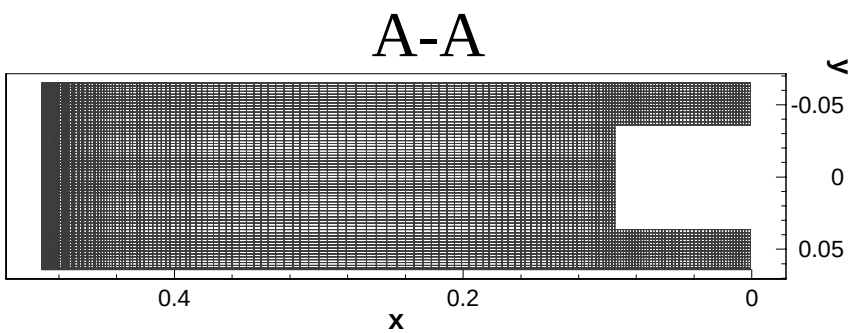


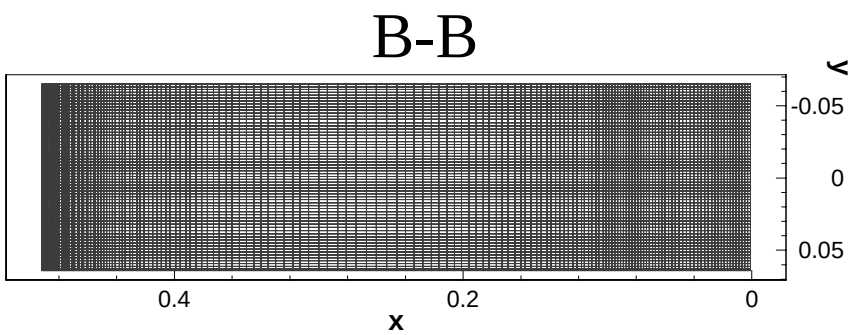

C-C



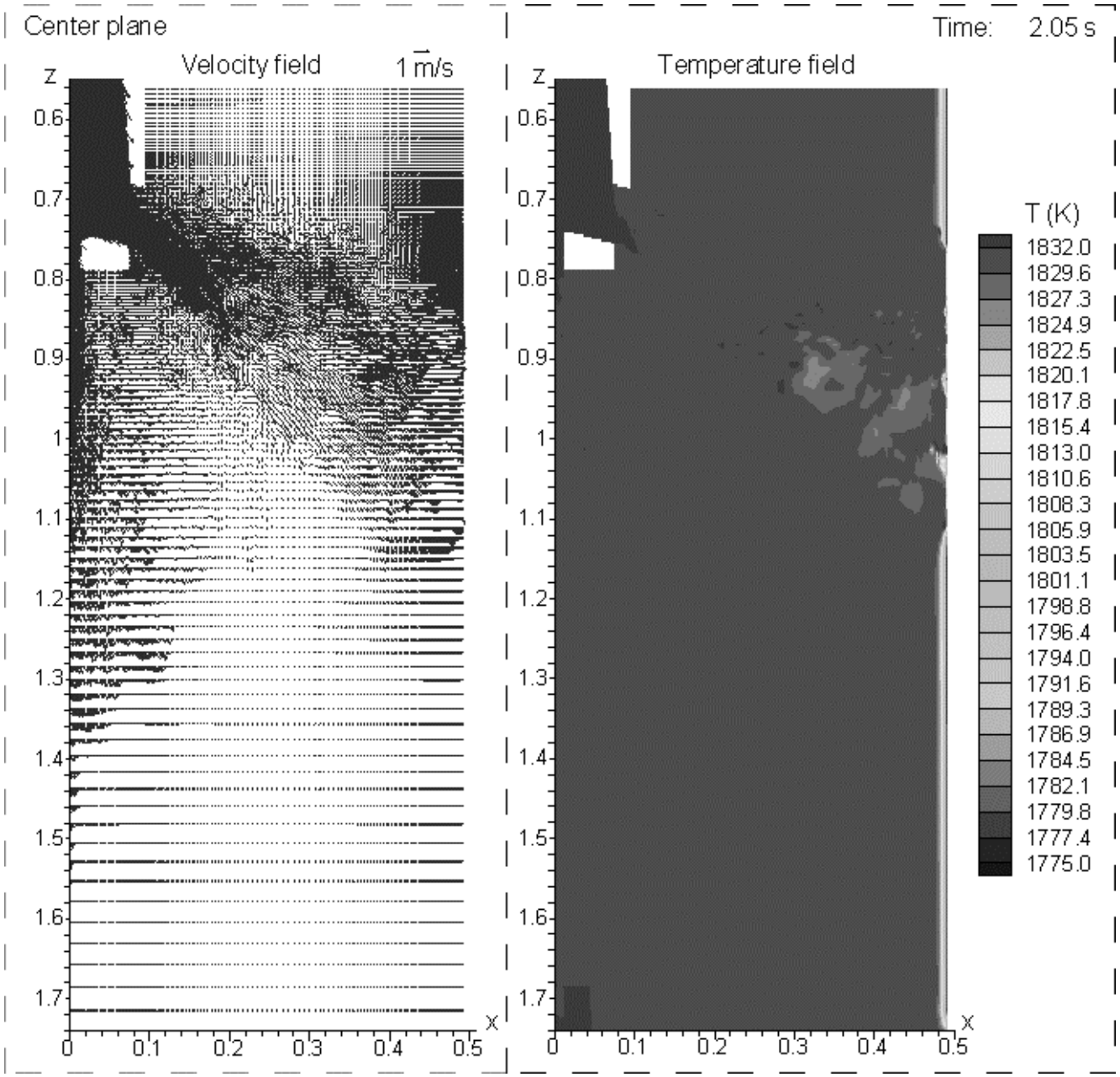
# Mesh for the mold part (half, ¼ actually used)



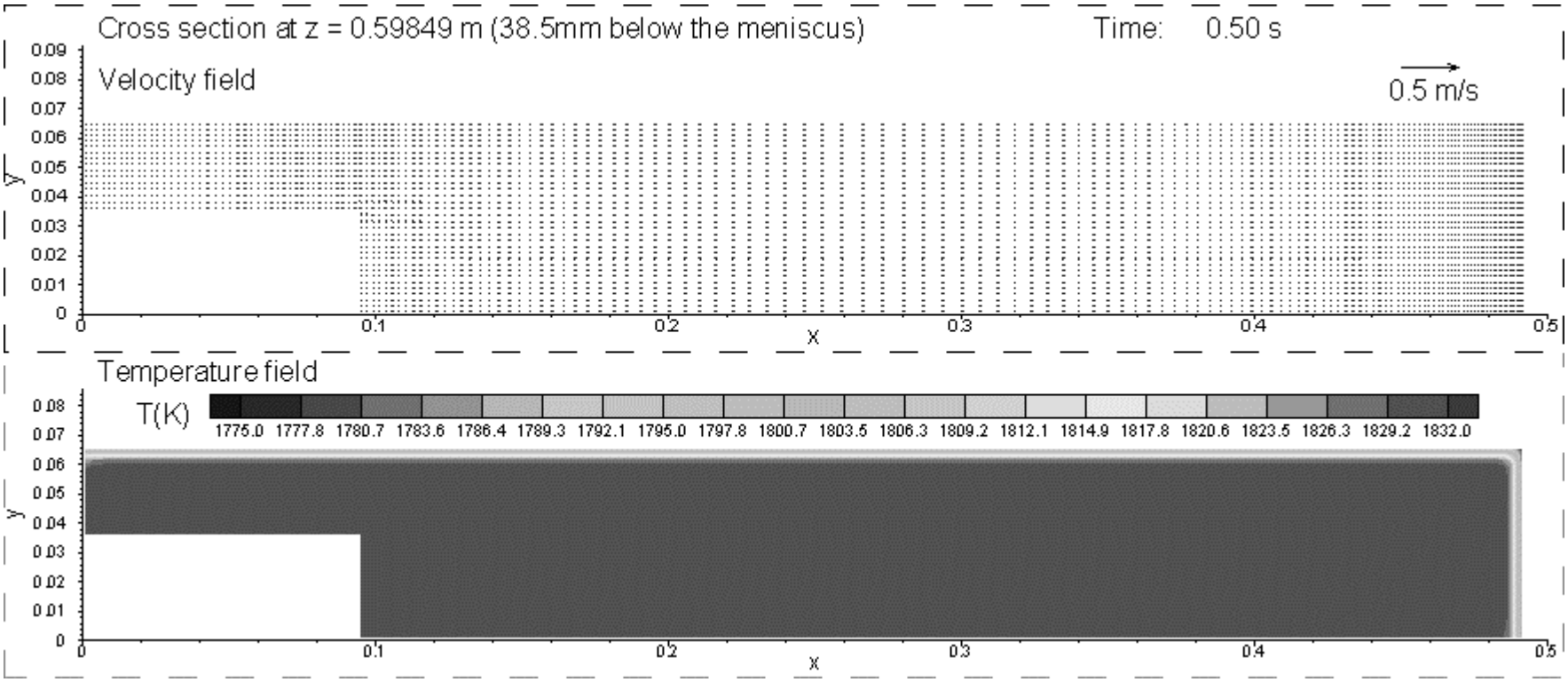



# Instantaneous velocity and temperature field (I)

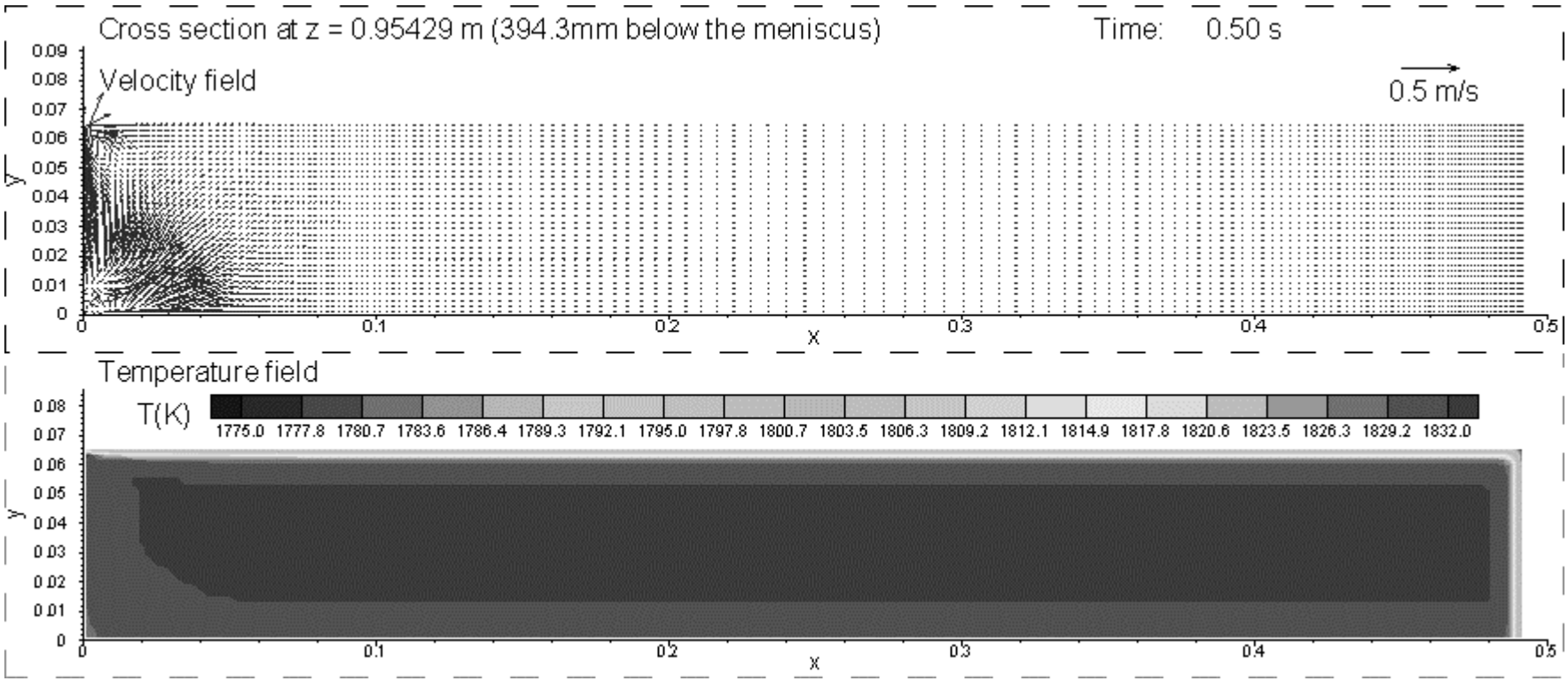


# Instantaneous velocity and temperature field (II)



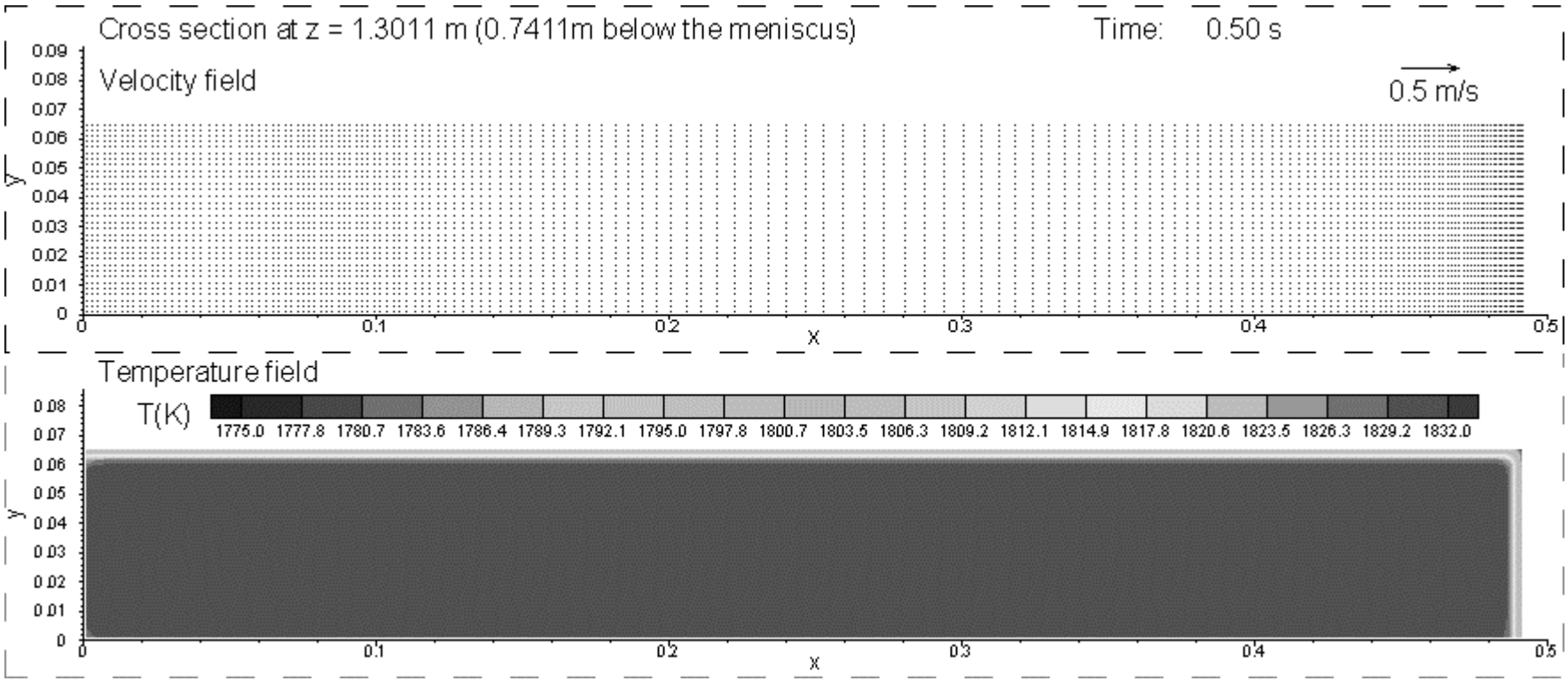

Velocity and temperature fields close to the meniscus

# Instantaneous velocity and temperature field (III)




Velocity and temperature fields close to impingement point

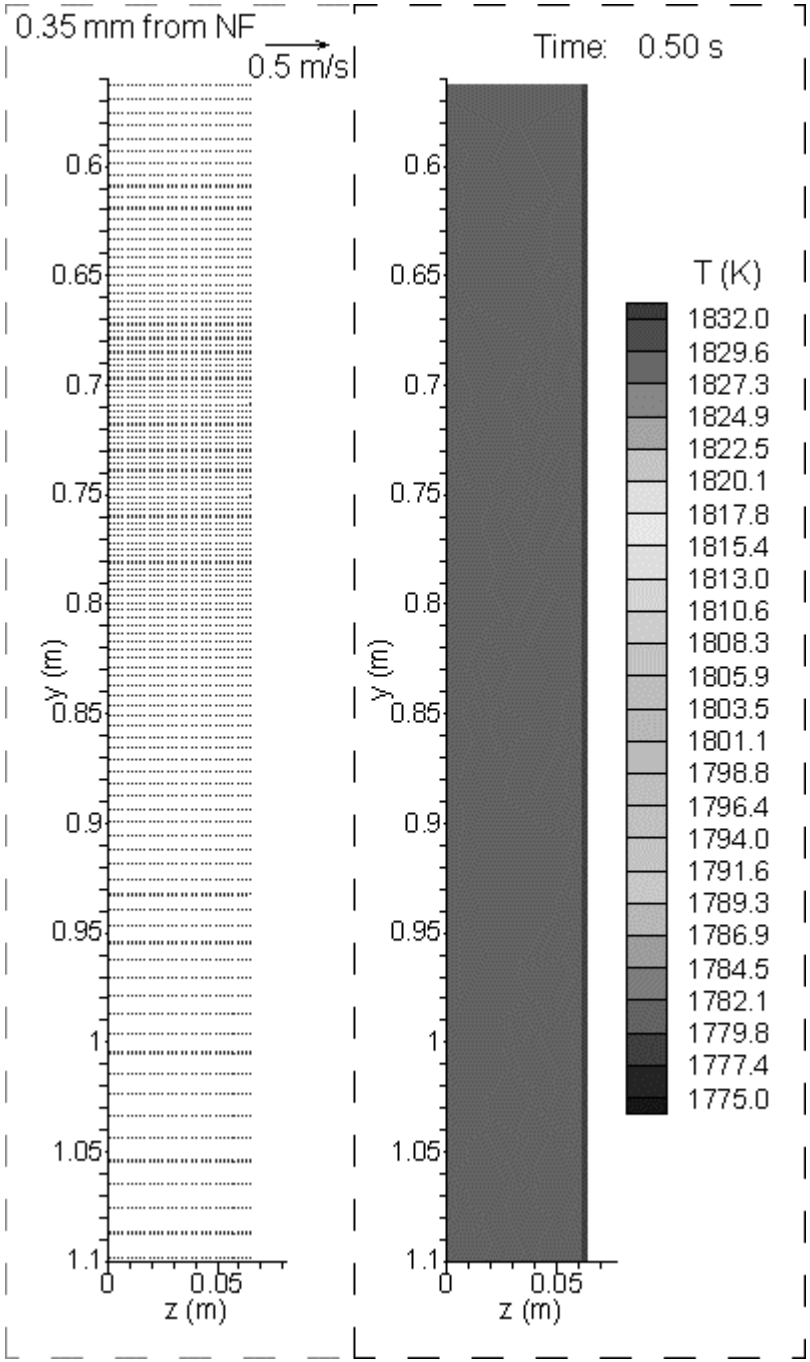
# Instantaneous velocity and temperature field (IV)



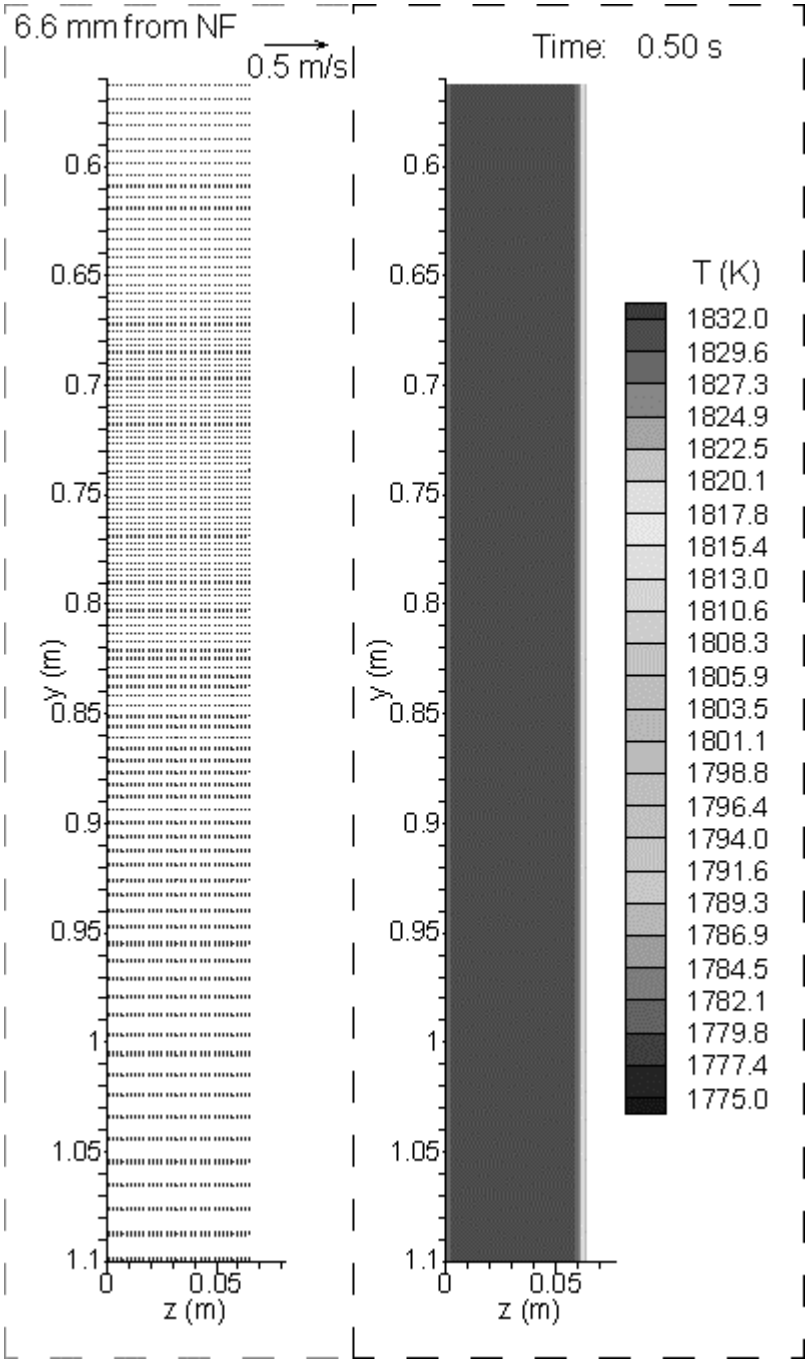

Velocity and temperature fields at lower part of the mold

# Instantaneous velocity and temperature field (V)

Velocity and temperature fields at NF



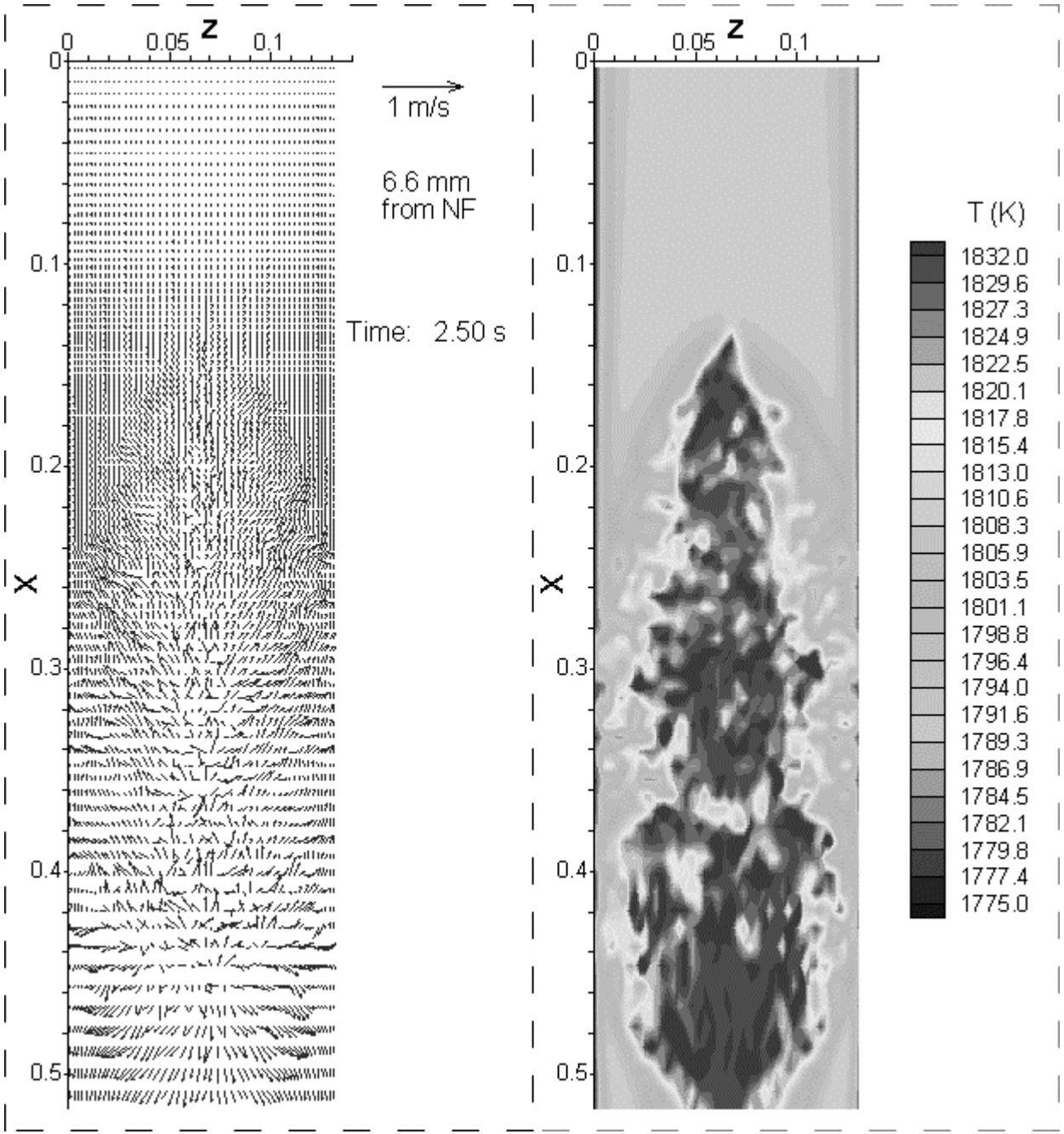
# Instantaneous velocity and temperature field (VI)



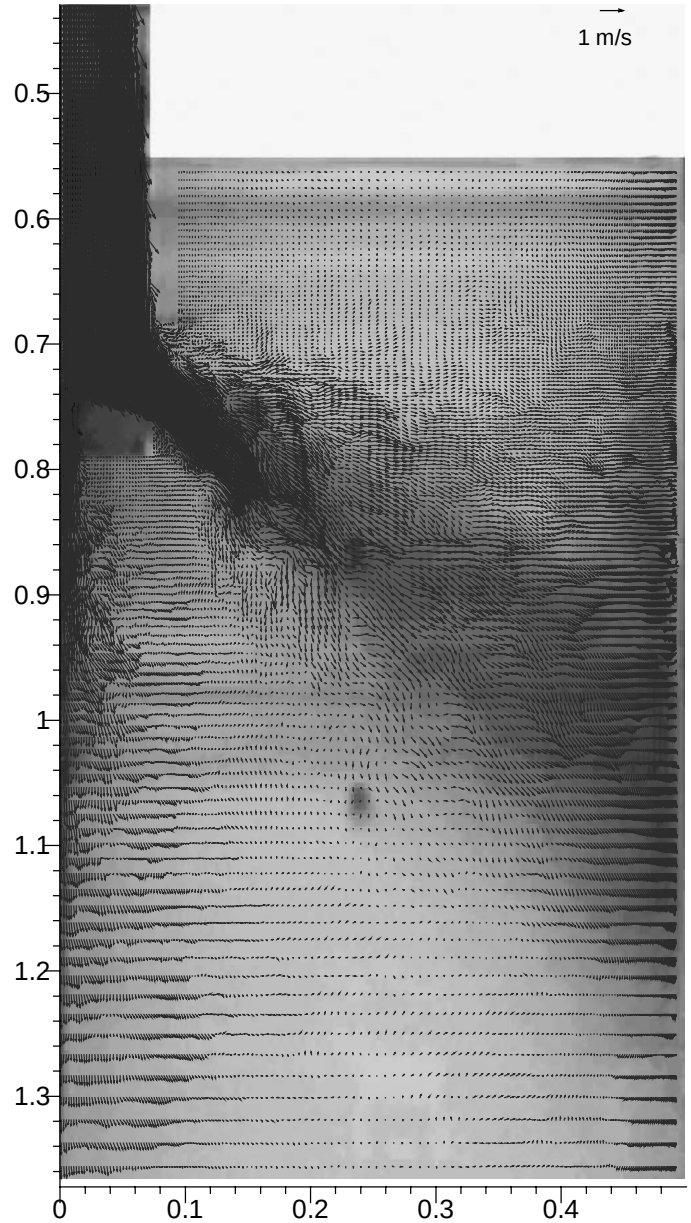

Velocity and temperature fields near NF

# Instantaneous velocity and temperature field (VII)

Velocity and temperature fields near NF (Simulation of a half mold with uniform velocity at the mold inlet) showing WF-WF oscillation of the jet



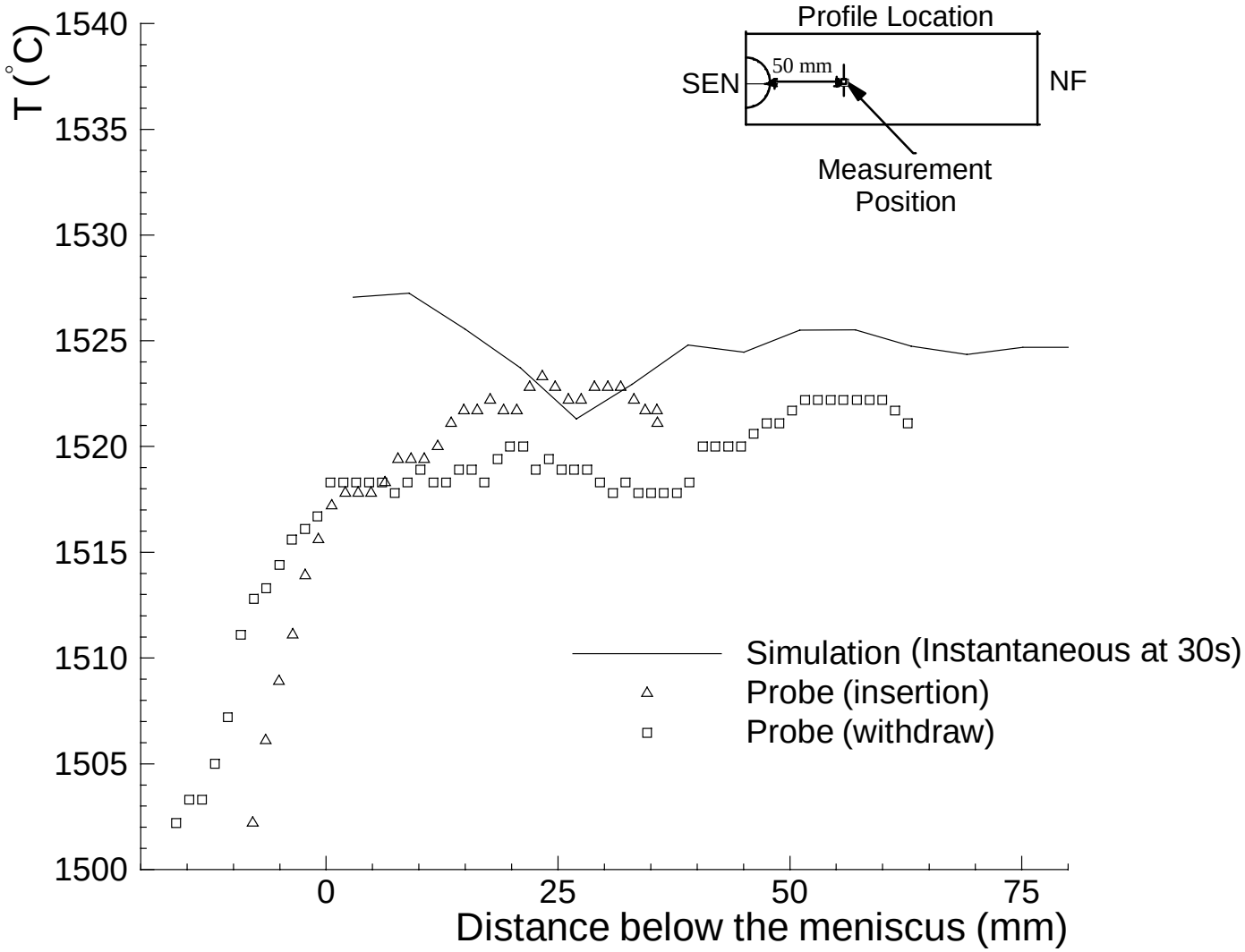
# Instantaneous velocity field on dye injection experiment



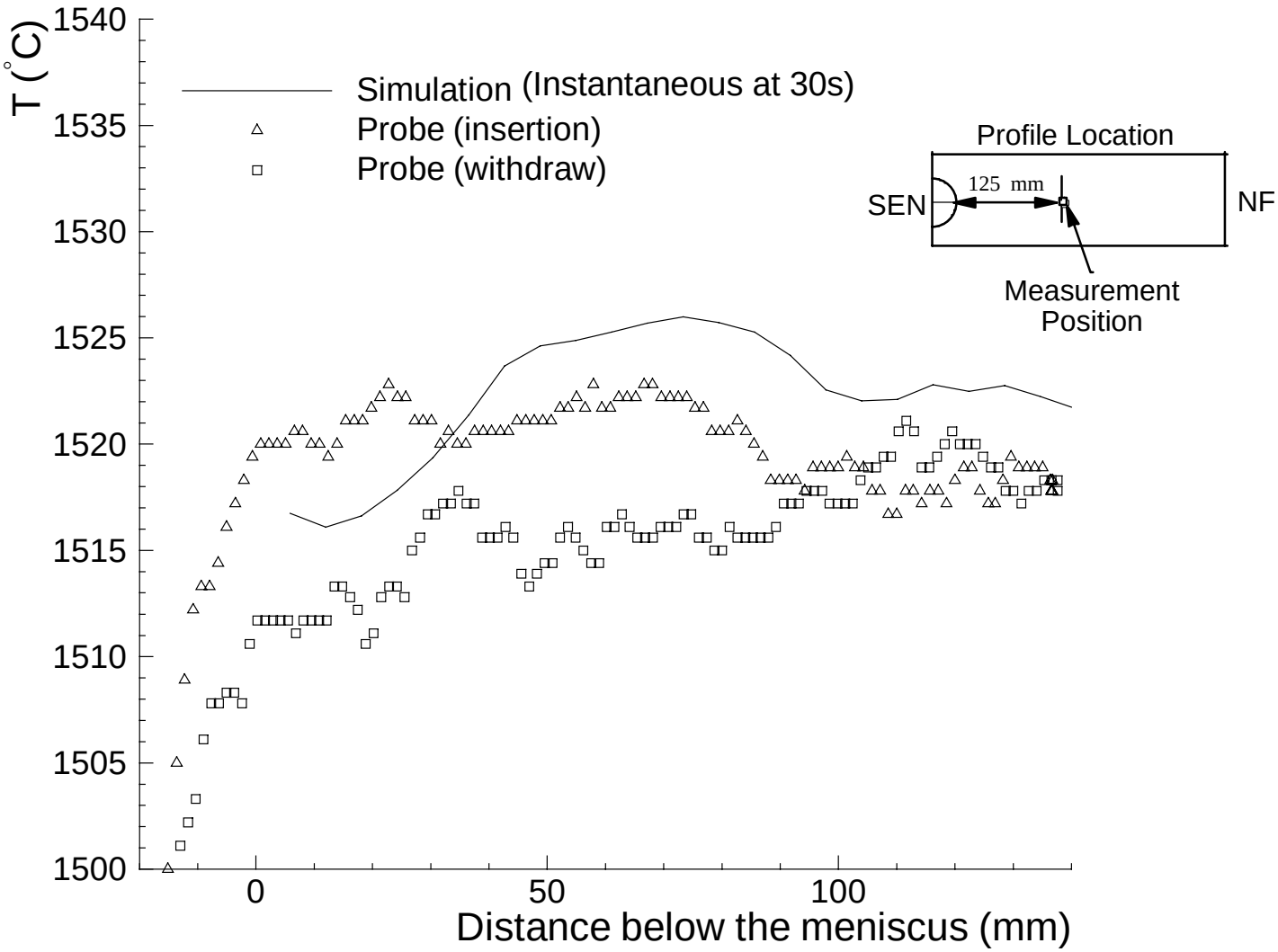

Instantaneous velocity field at 30s

Dye injection experiment by R. O'Malley (Armco, Inc)

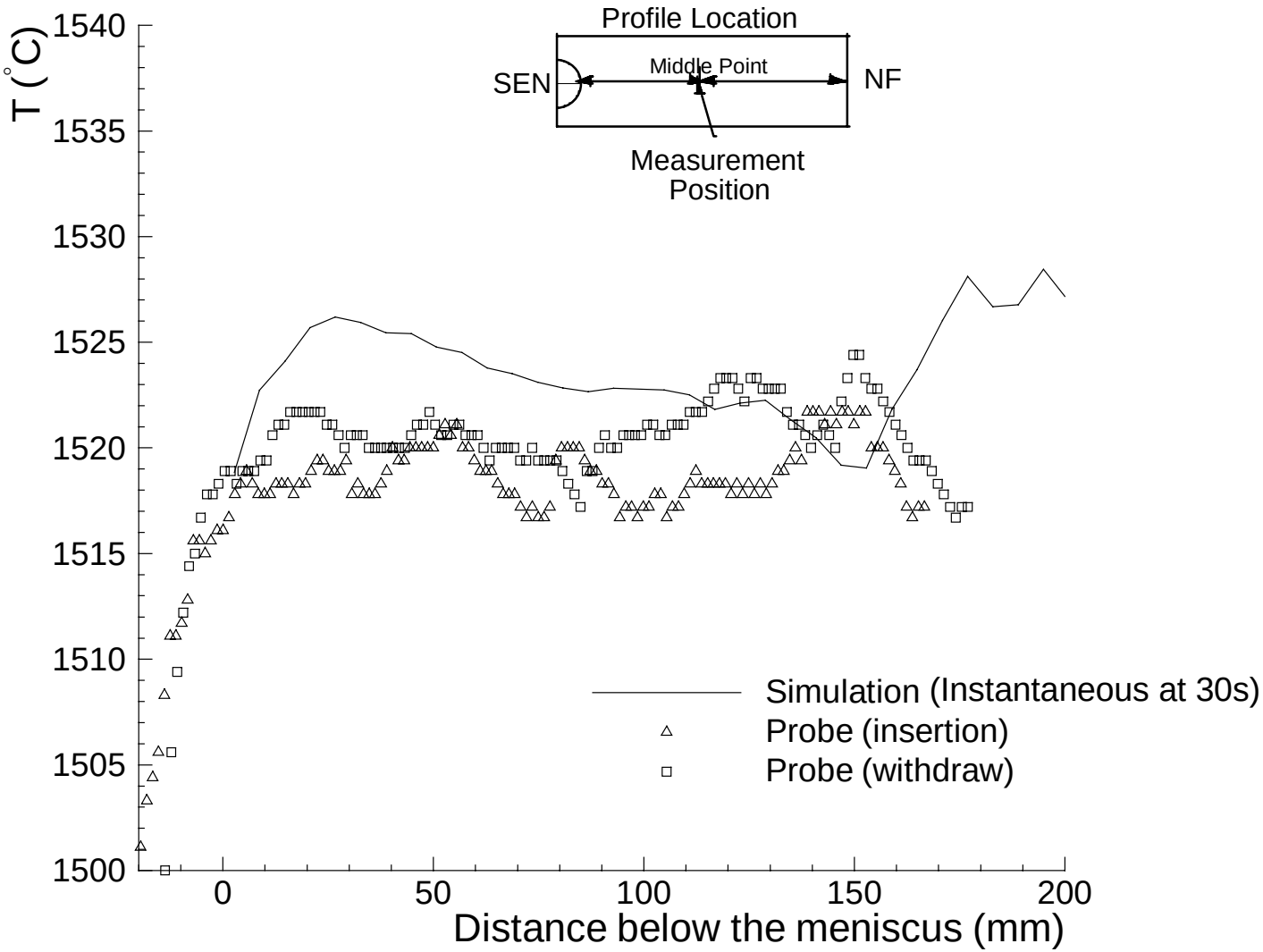
# Temperature profile comparison (I)



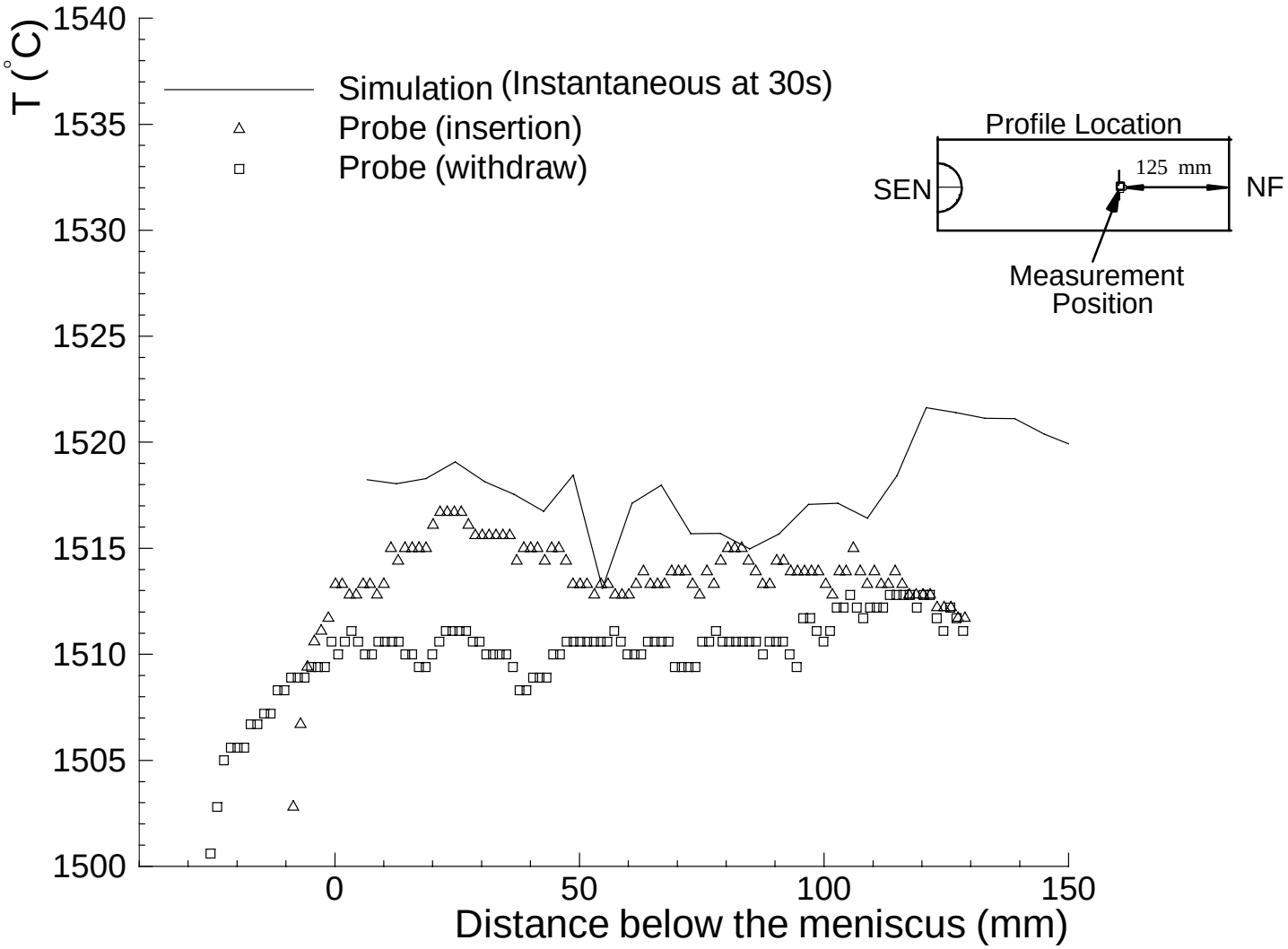
# Temperature profile comparison (II)



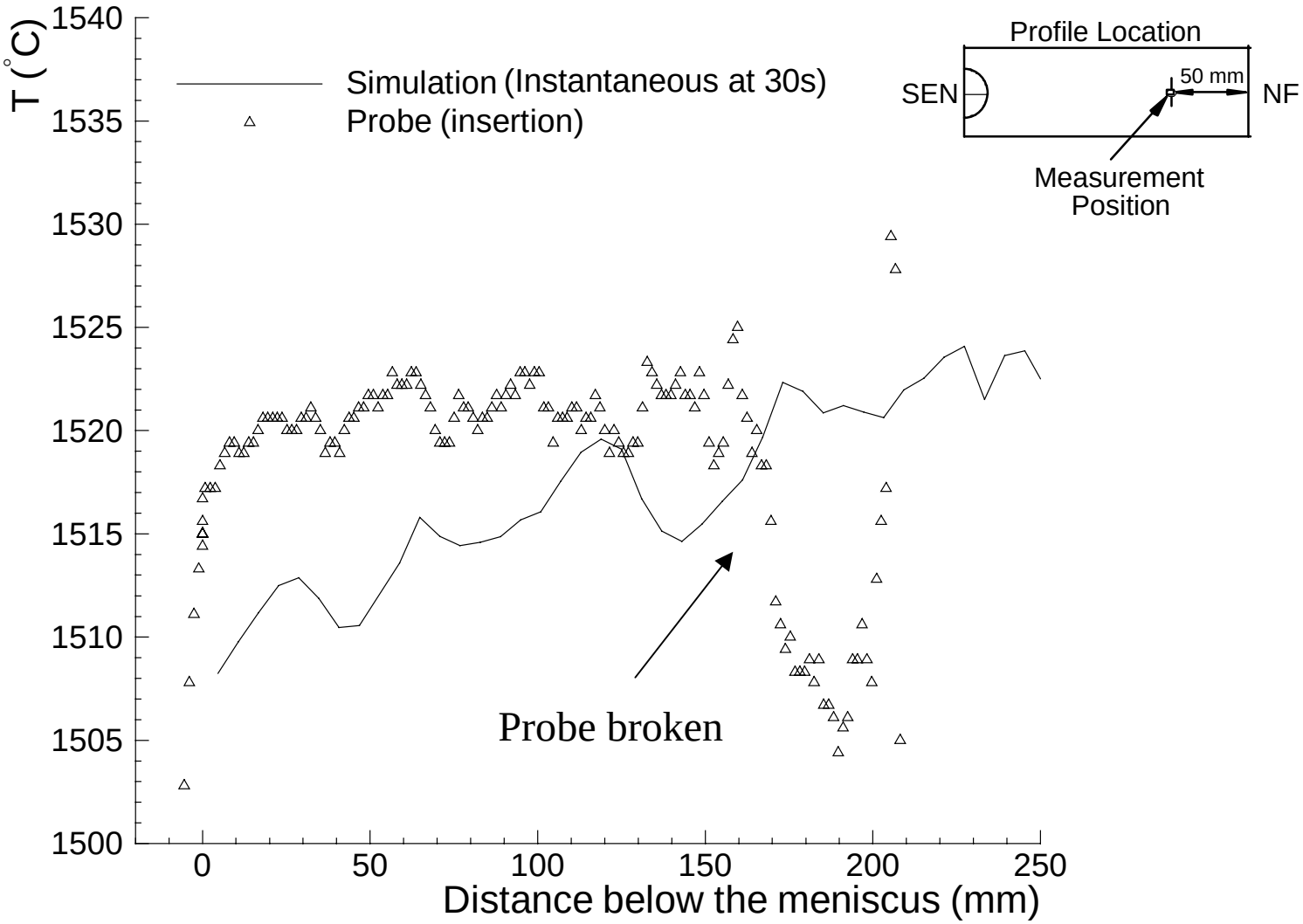
# Temperature profile comparison (III)



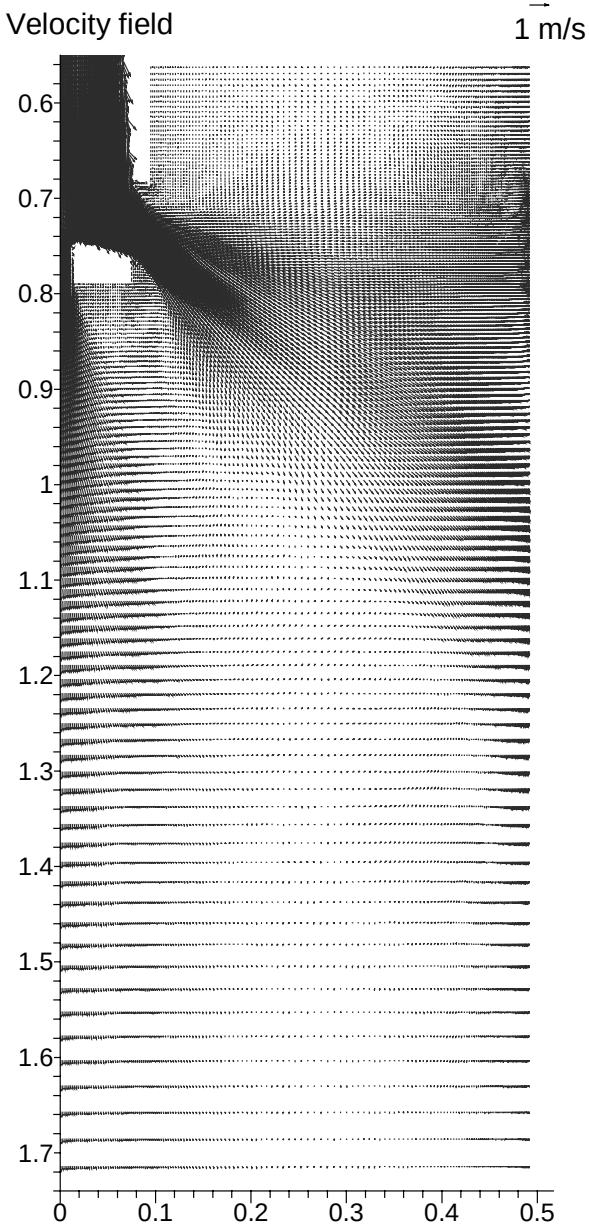
# Temperature profile comparison (IV)

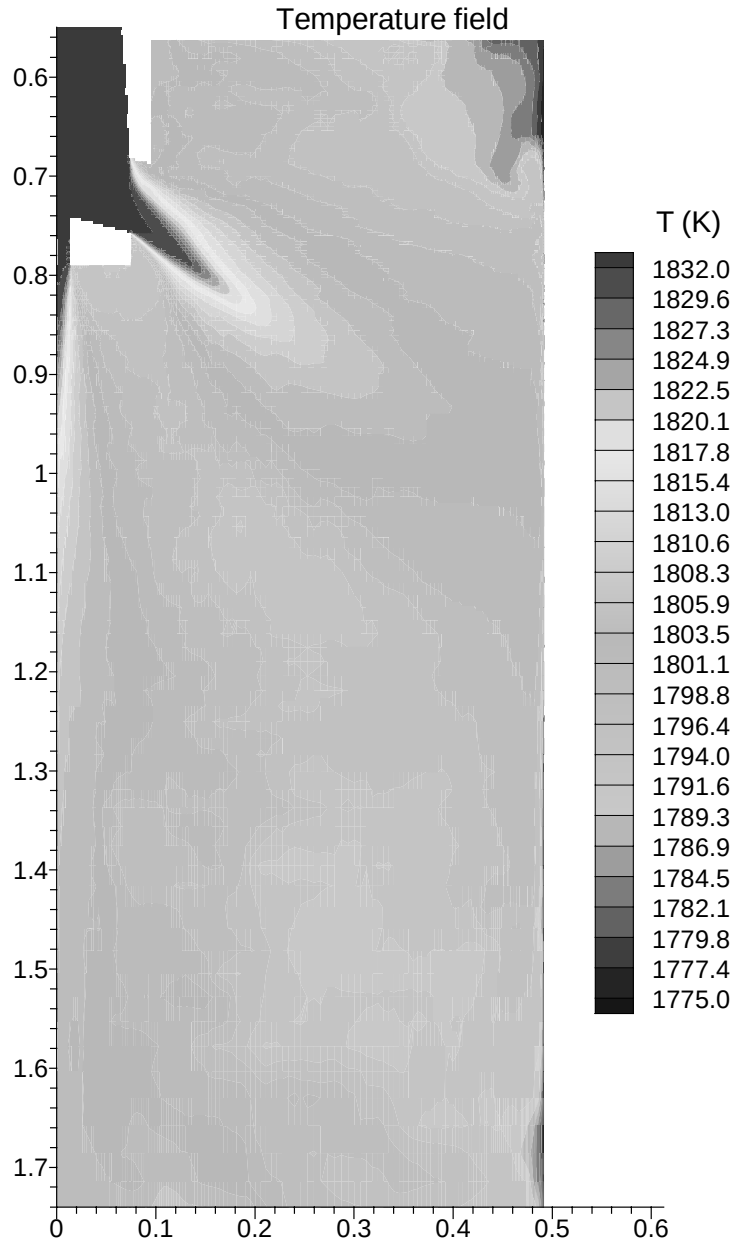


# Temperature profile comparison (V)

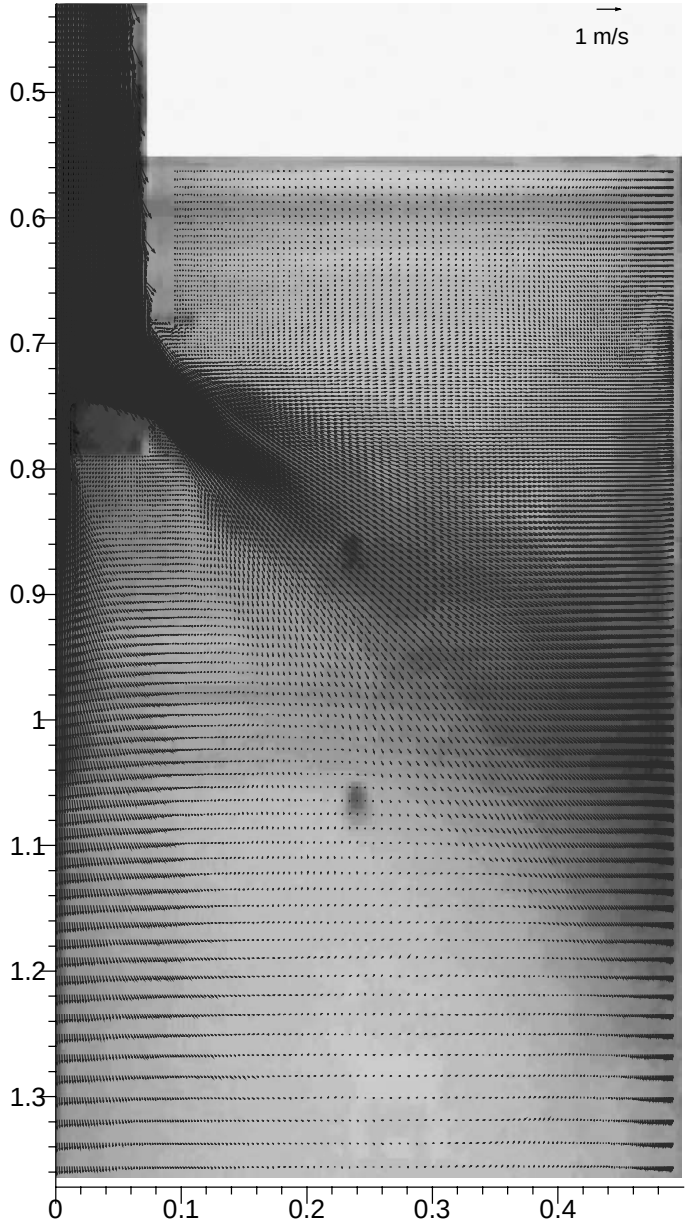


# Mean fields (averaged from 25s to 30s)



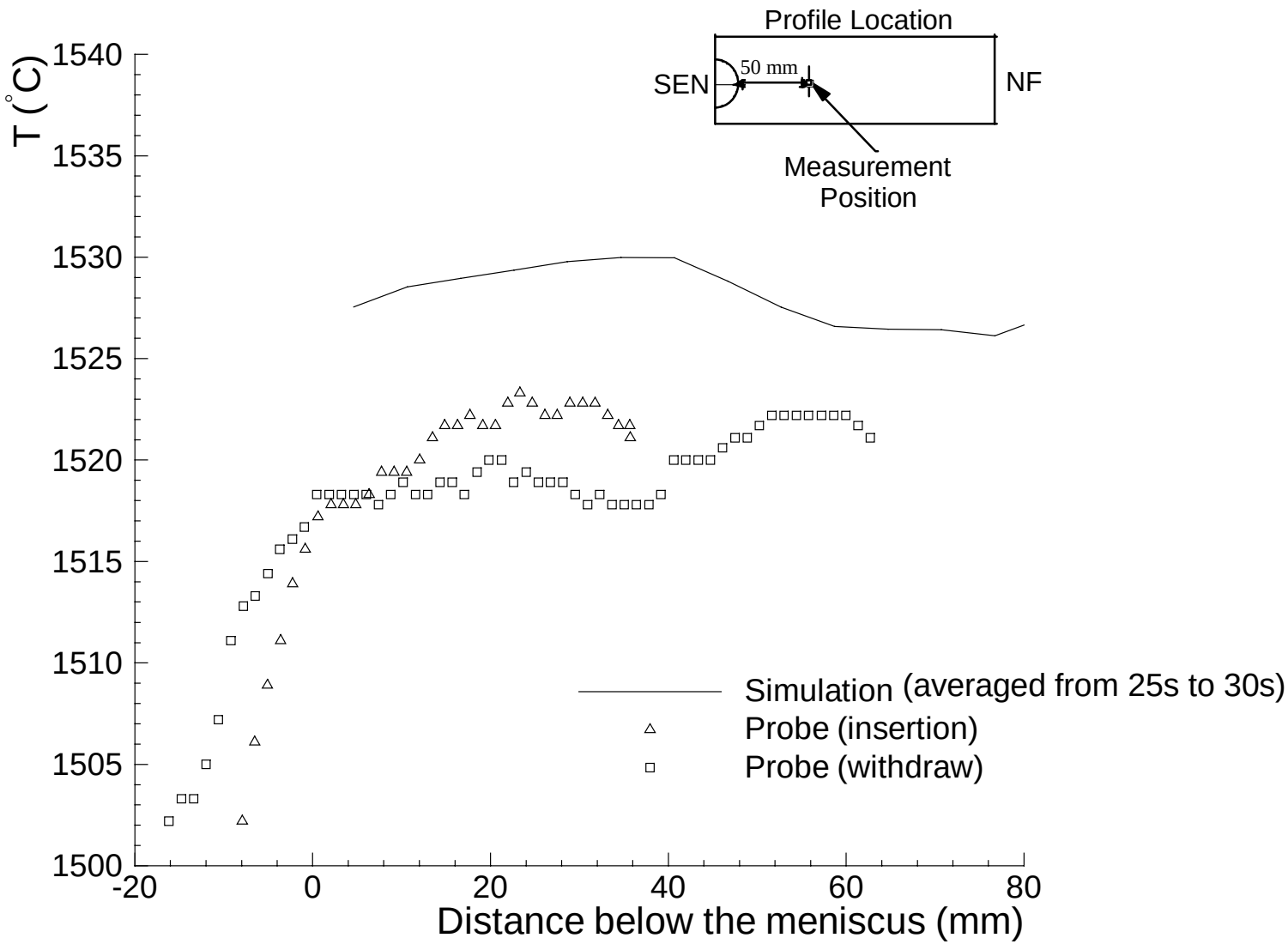
# Averaged velocity field on dye-injection experiment



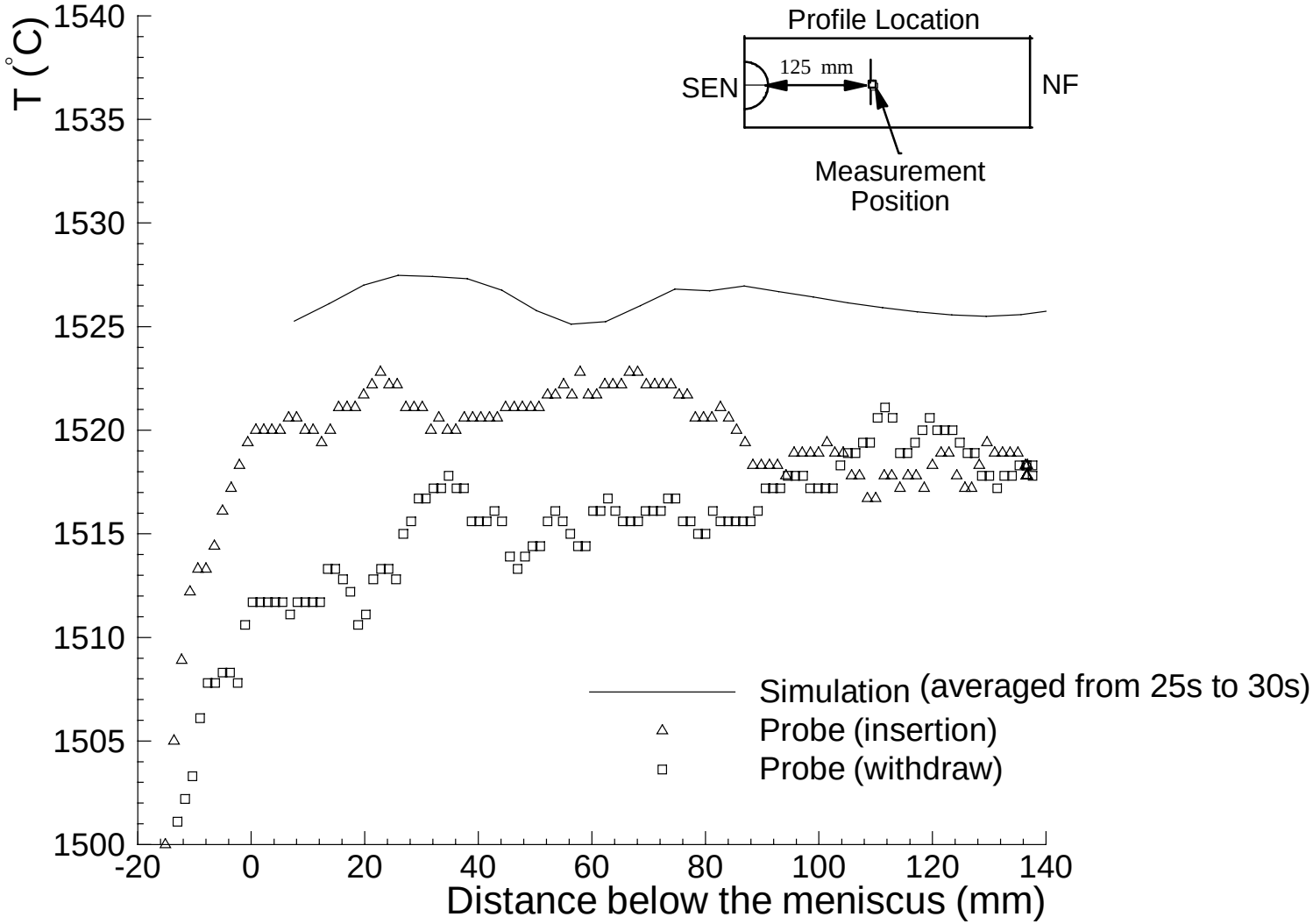

Velocity field averaged from 25s to 30s

Dye injection experiment by R. O'Malley (Armco, Inc)

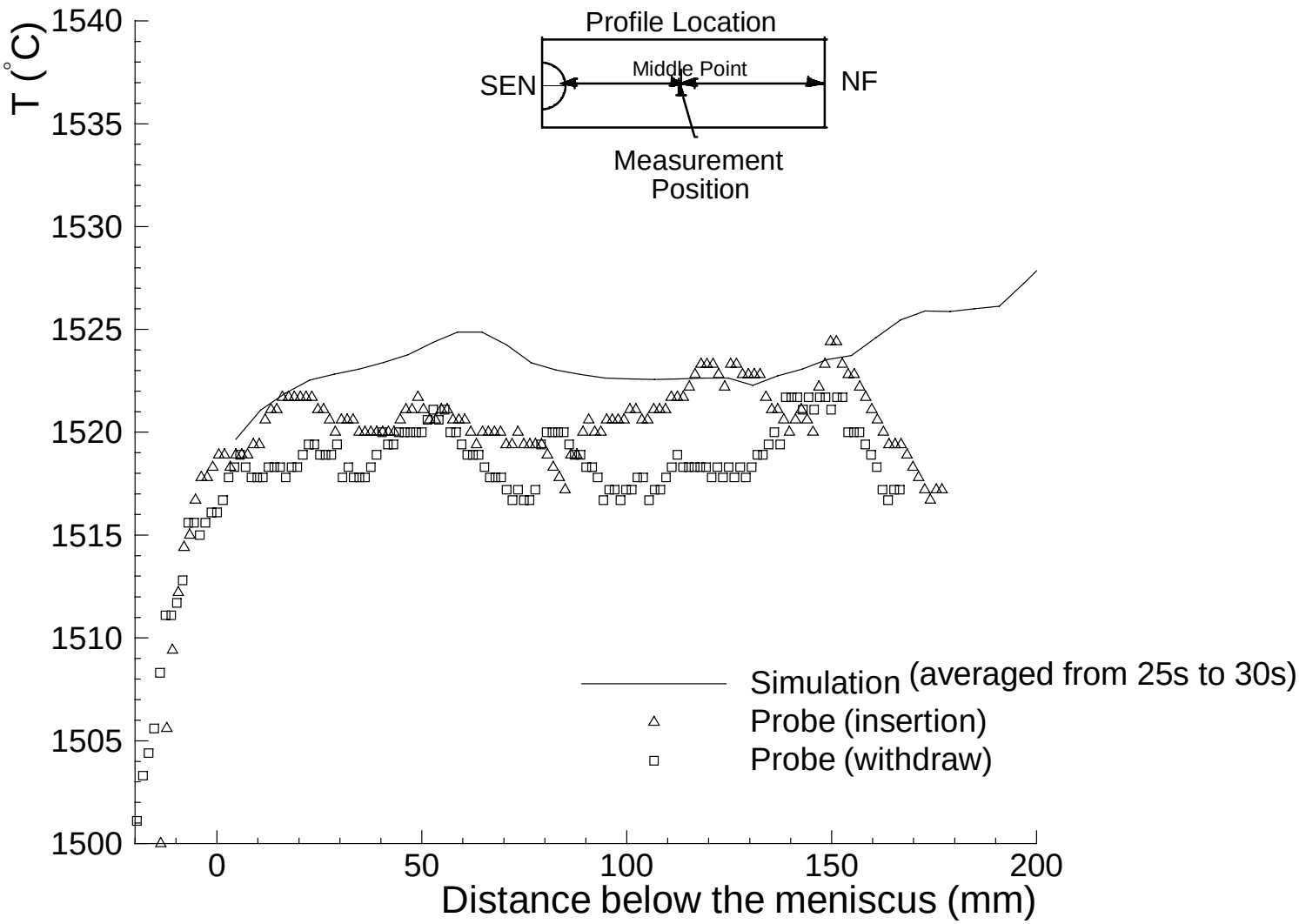
# Temperature profile comparison (I)



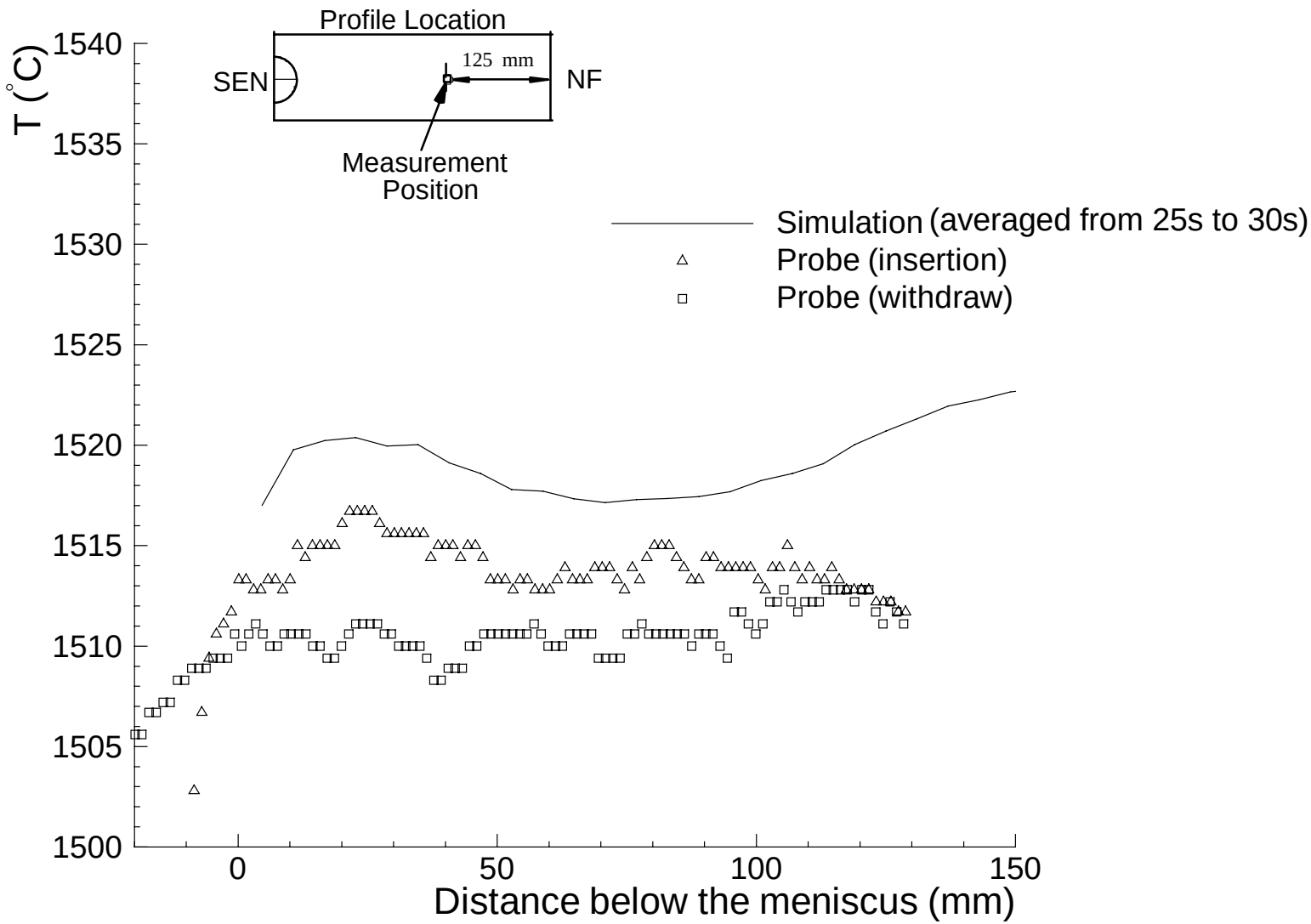
# Temperature profile comparison (II)



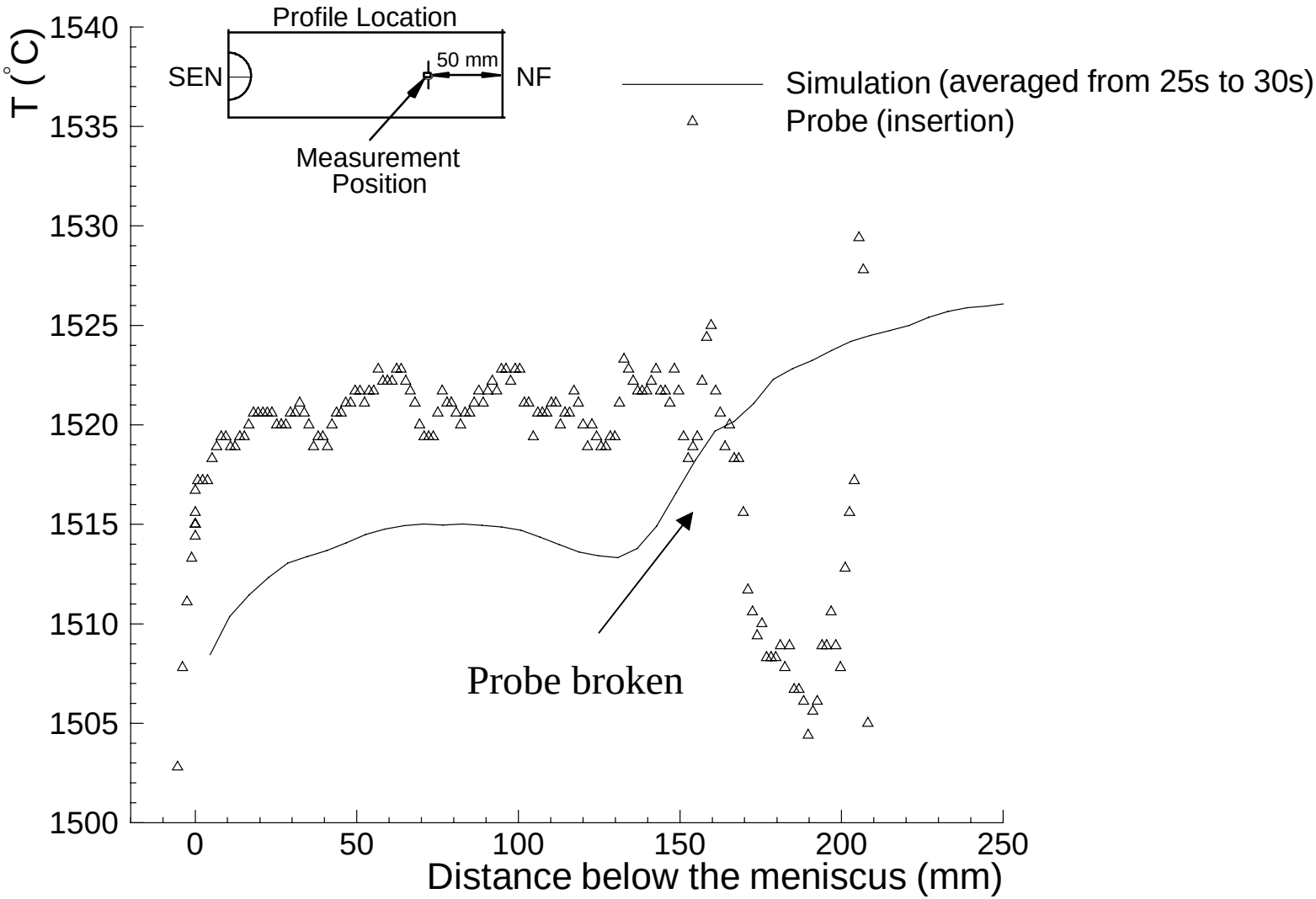
# Temperature profile comparison (III)



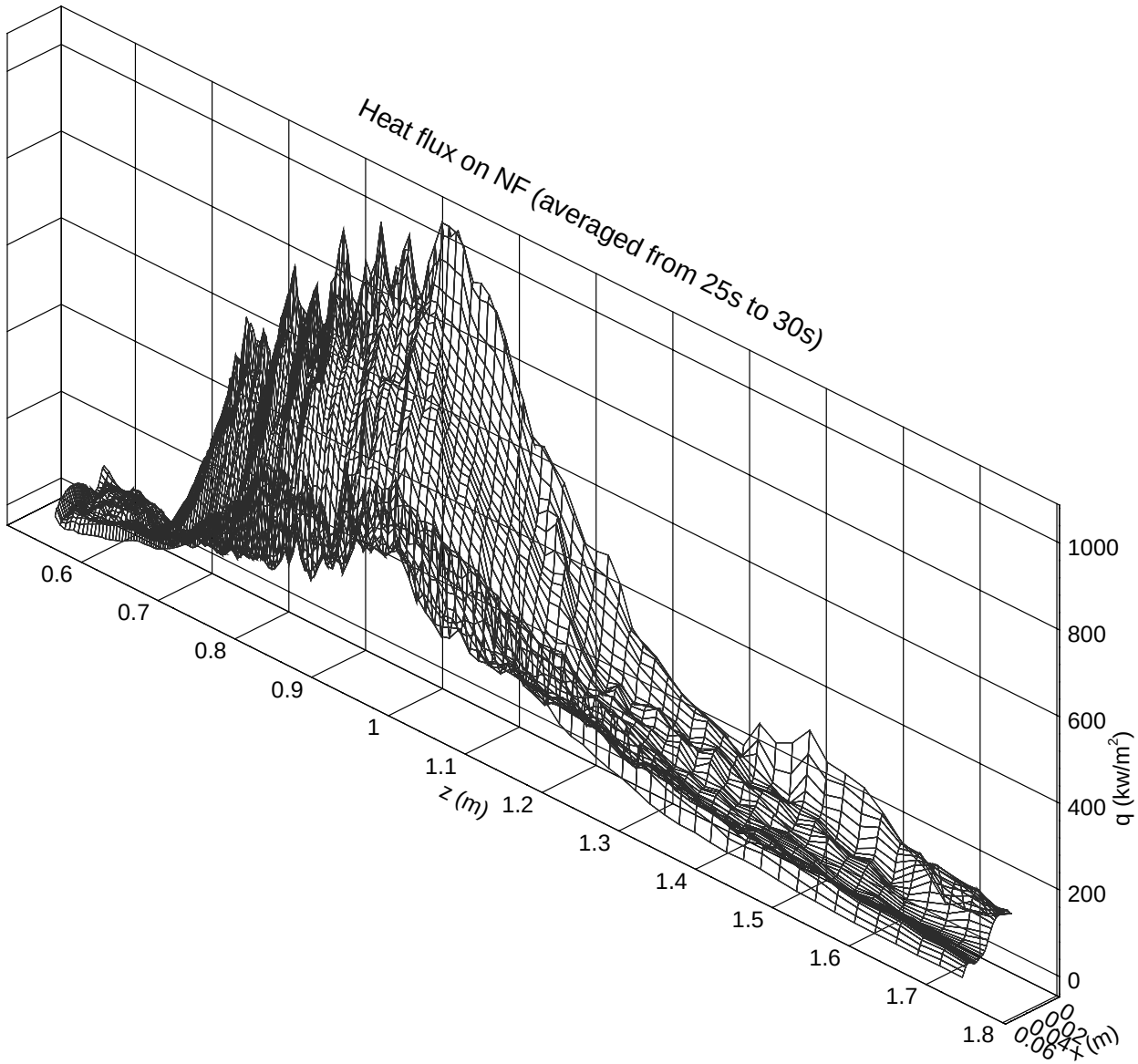
# Temperature profile comparison (IV)



# Temperature profile comparison (V)



# Heat flux on narrow face



# Heat flux on wide face