Effect of Ballast Shoulder Height on a passenger Trains Slipstreams and Wake, A Computational Fluid Dynamics study

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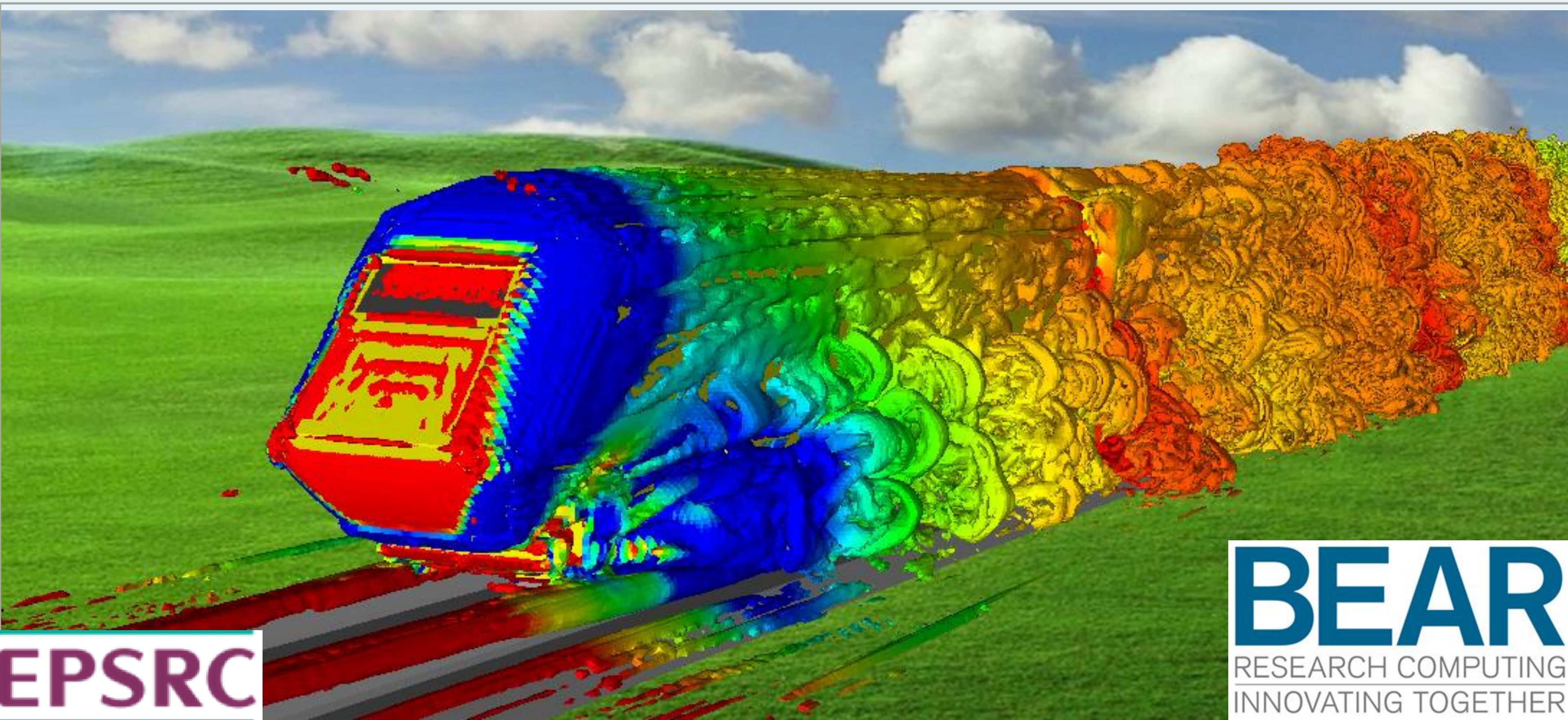

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Introduction to RWTA project

Aim:

To investigate and measure a range of aerodynamic phenomena observed in real train operation, and to compare how such effects match model scale measurements and various types of CFD calculation, and thus to test the validity, or otherwise, of the hypothesis that current methods are highly conservative.

Work split:

- 3 lecturers
  supervision, organisation, research
- 1 Postdoc researcher
  organisation, research
- 2 PHD students
  Myself - CFD
  Martin Gallagher – Experimental measurements

Introduction to presented research

It is hypothesised that velocity and pressure magnitudes within a trains slipstream are affected by ballast shoulder height, and that an increase in ballast shoulder height will lead to a reduction in these flow measurements.

Comparison are made using Pressure coefficients and normalised velocities at three different ballast shoulder heights.

The ballast shoulder heights investigated are flat ground, 0.3m and 0.7m at full scale.

TRAIN rig tests

- Use of a 1/25th scale 4 car model train.
- Train geometry has alterations to account for launching mechanism and working bogies.
- Maximum speed dependent on train up to 80m/s.

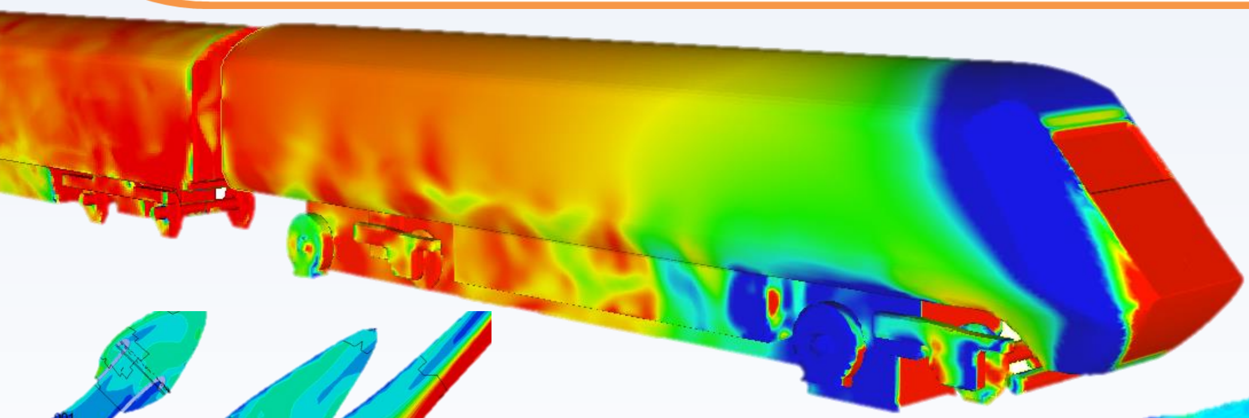
TRAIN Rig

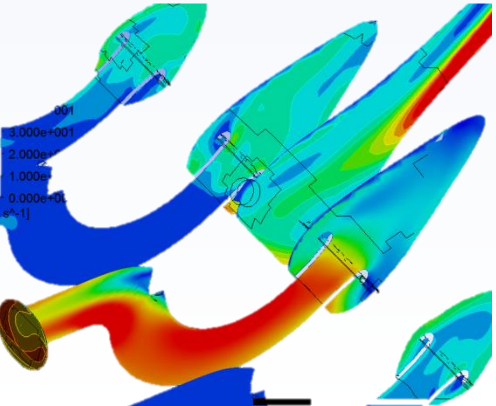
Transient Aerodynamic Investigations

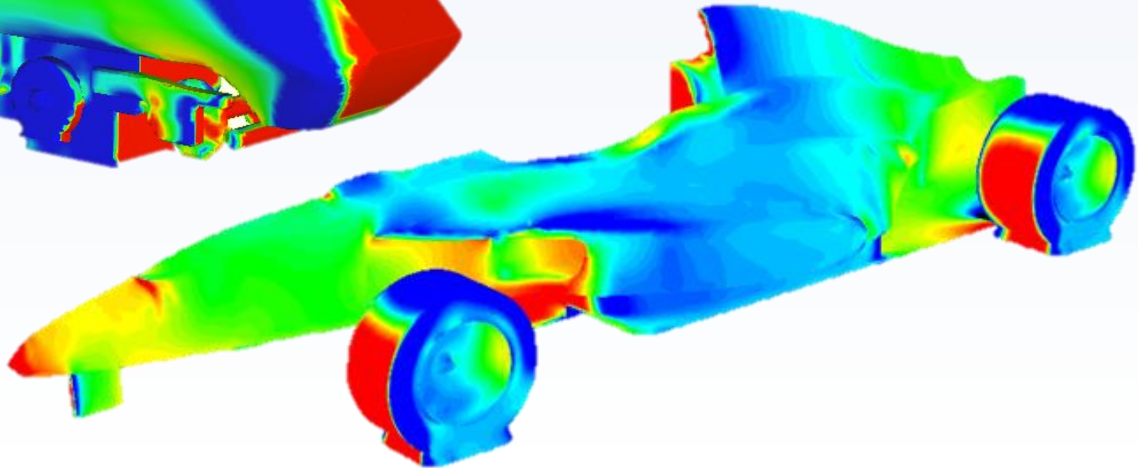
University of Birmingham

CFD

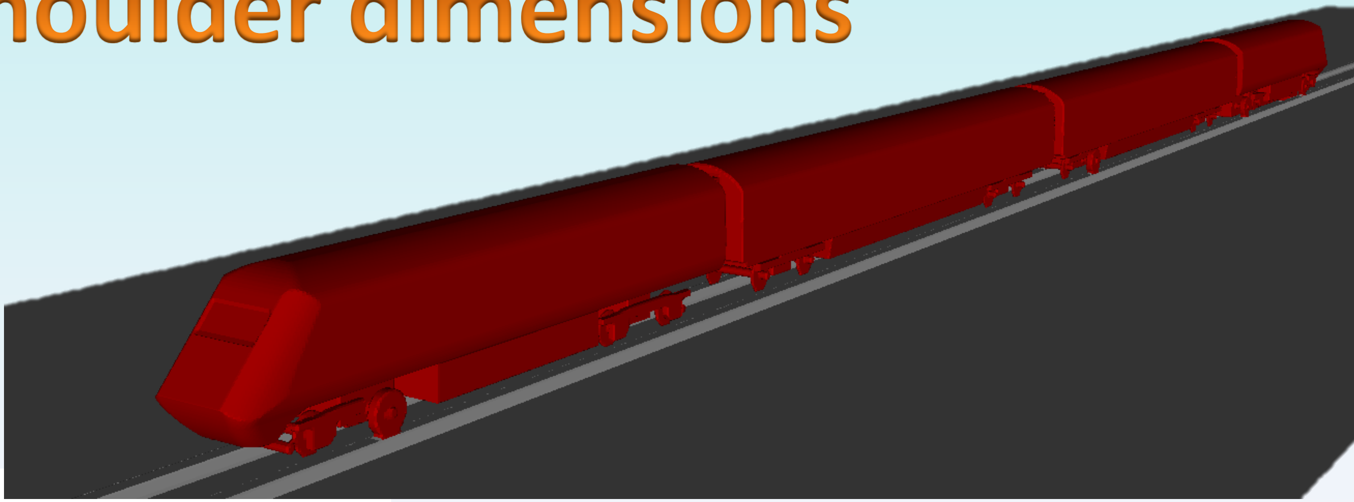
- Use of numerical methods to analyse fluid flows.
- Numerical methods can range from modelling the flow through to resolving the flow depending on requirements and resources.

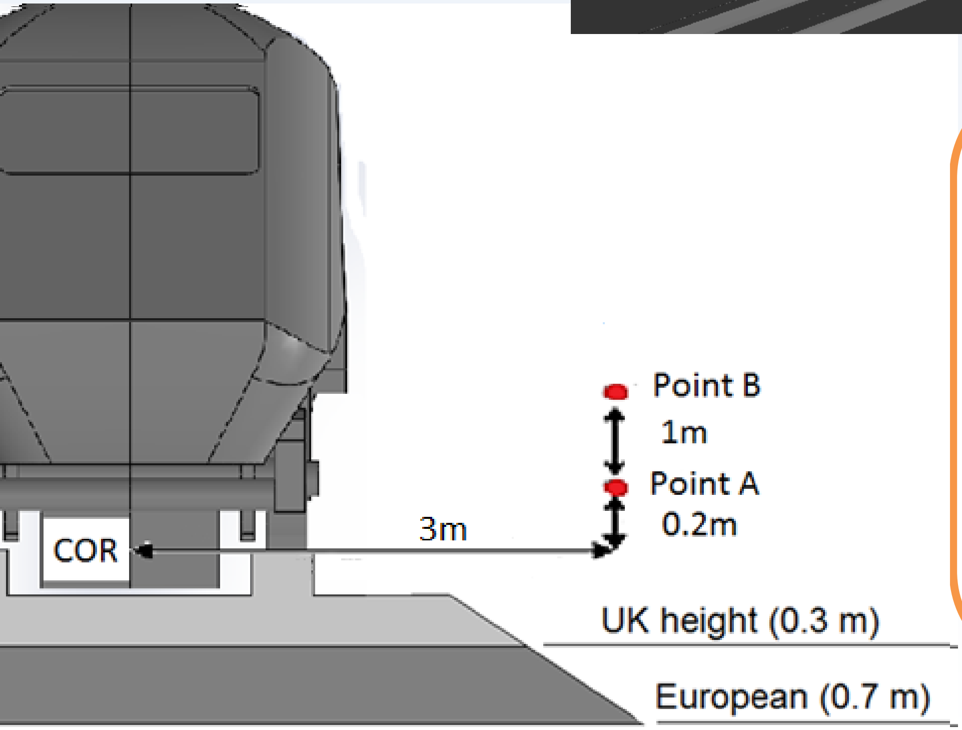






Computational domain + ballast shoulder dimensions





- Computational domain measured 1.5m wide, 1m high and 10m long.
- Domain featured a blockage ratio of ≈ 3%
- Computational mesh of 46 million cells was used

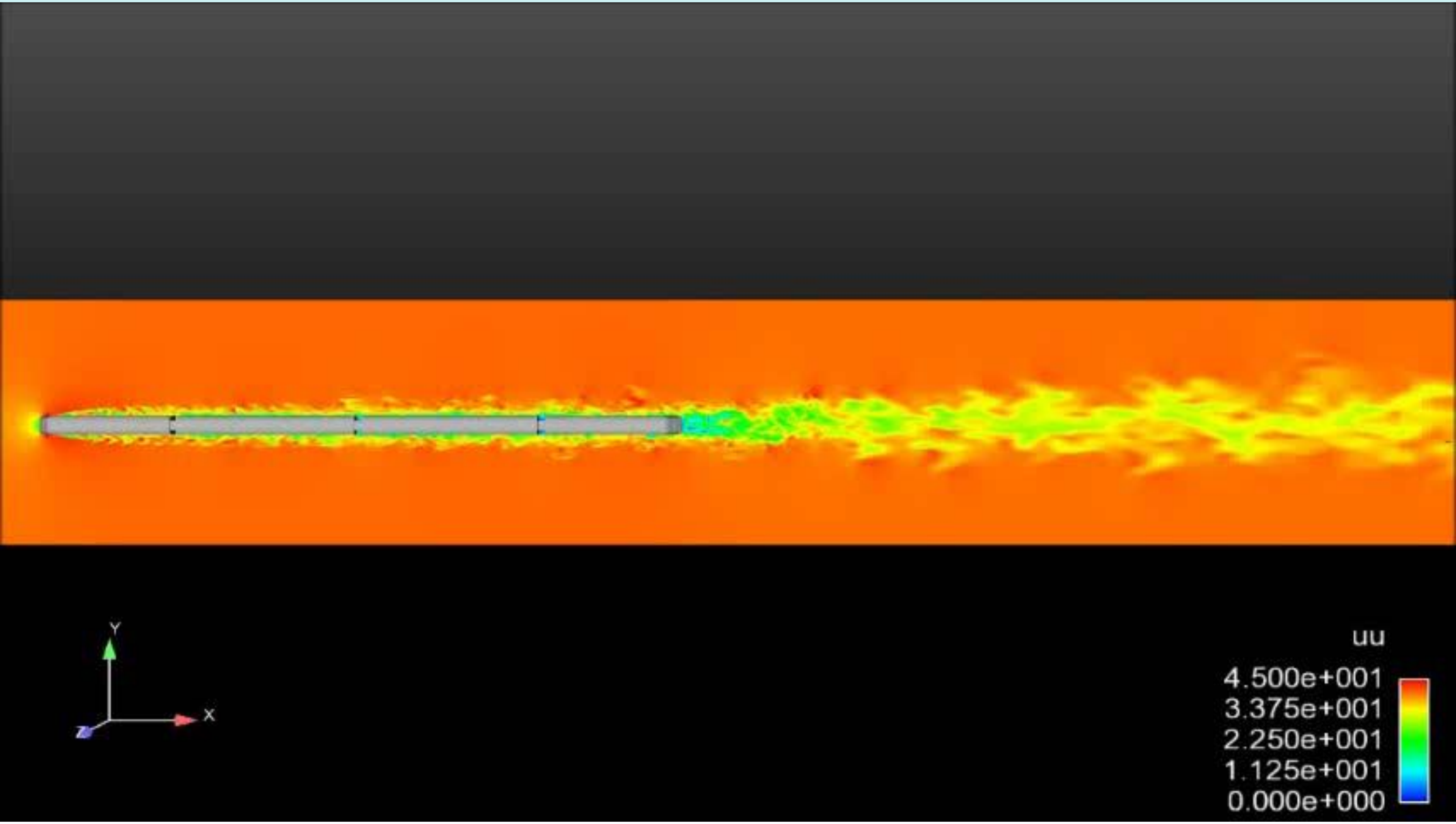
Numerical methods

- A Detached Eddy Simulation (DES) approach was chosen.

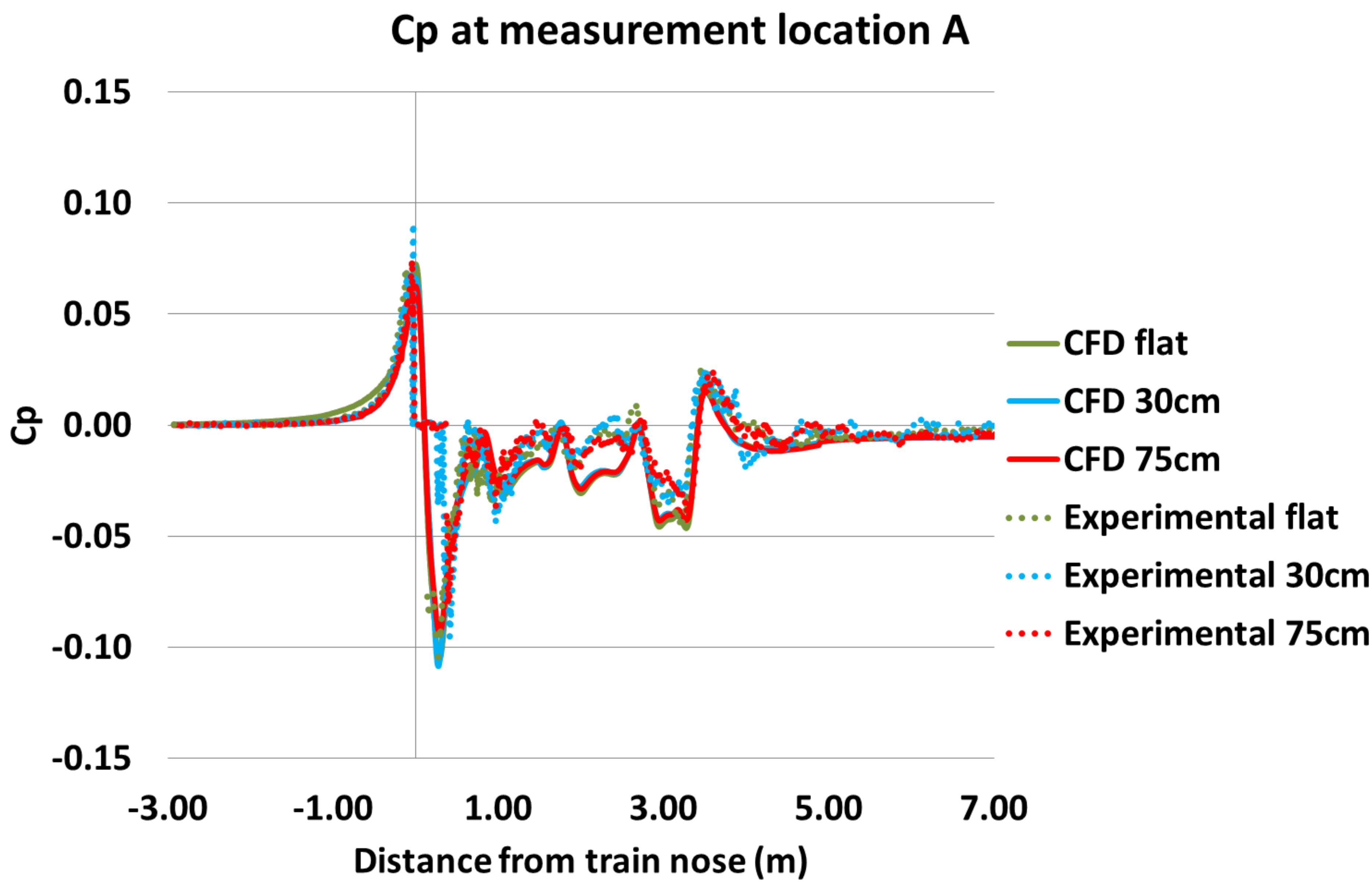
  - Resolves the larger turbulence scales, models the smaller scales.

- Modelling achieved with the Spalart-Allmaras turbulence model.

Above view of a trains slipstream

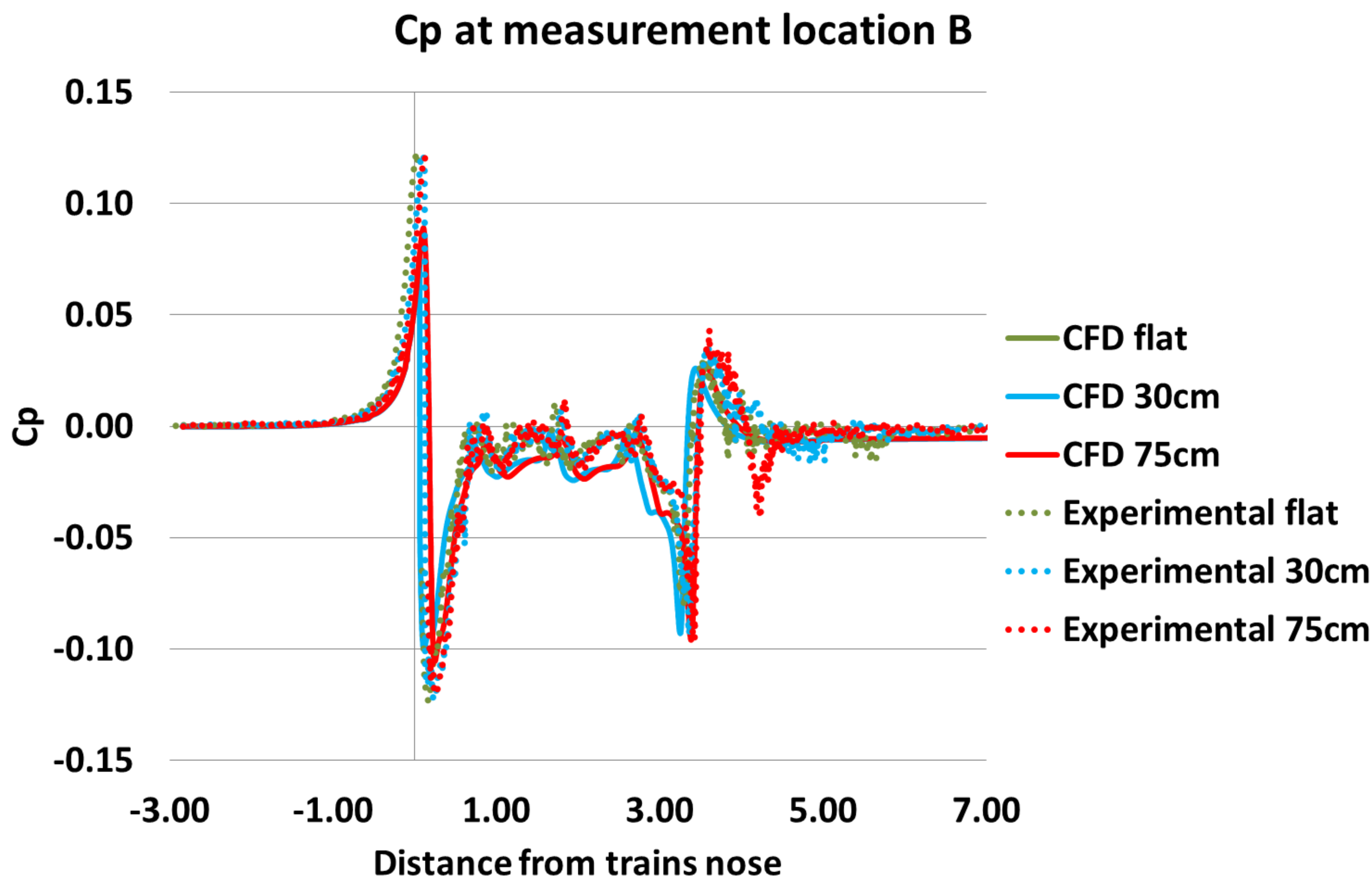


Results

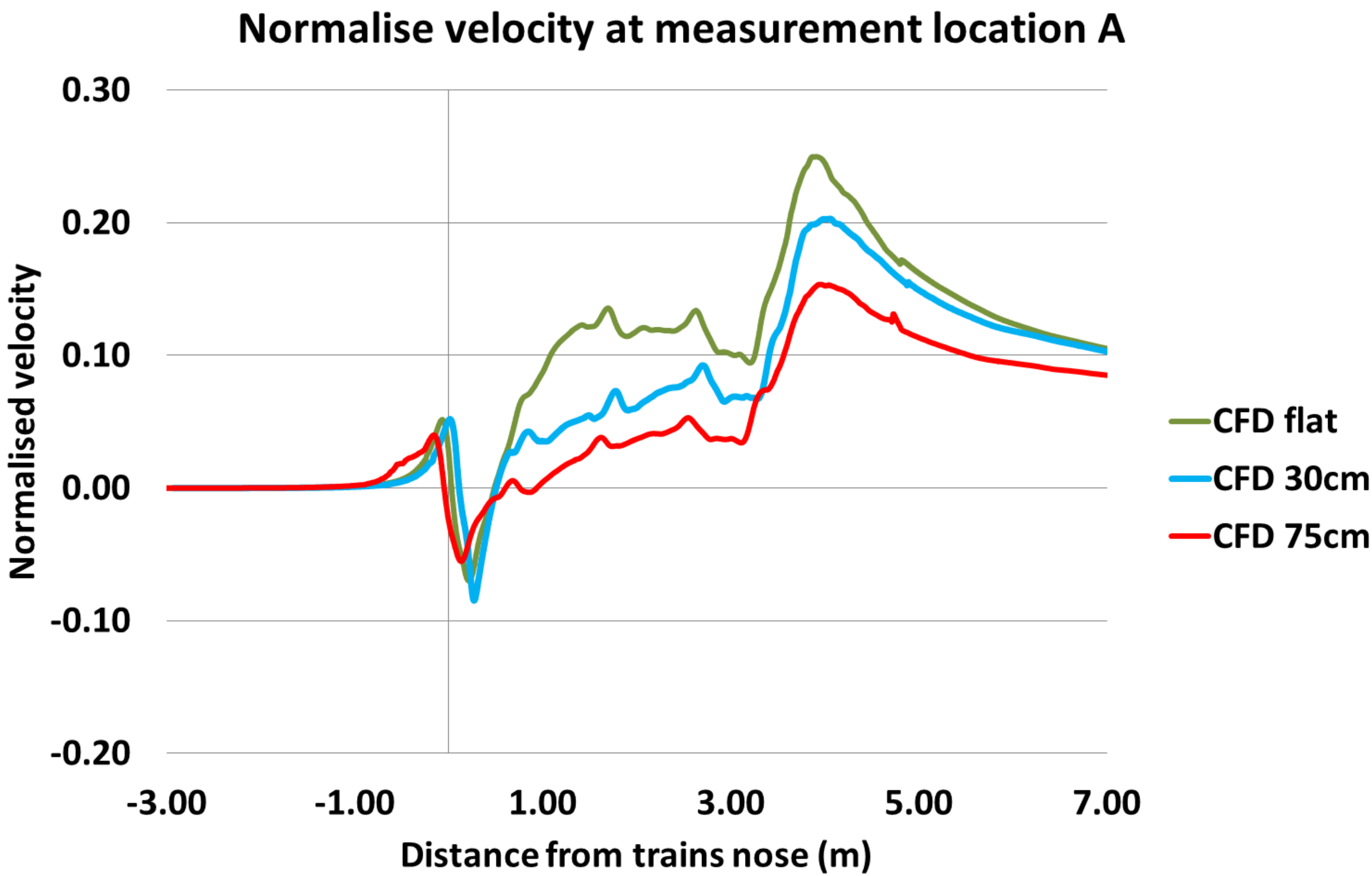


Cp at measurement location A
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
Cp
-3.00
-1.00
1.00
3.00
5.00
7.00
Distance from train nose (m)
CFD flat
CFD 30cm
CFD 75cm
Experimental flat
Experimental 30cm
Experimental 75cm

Results

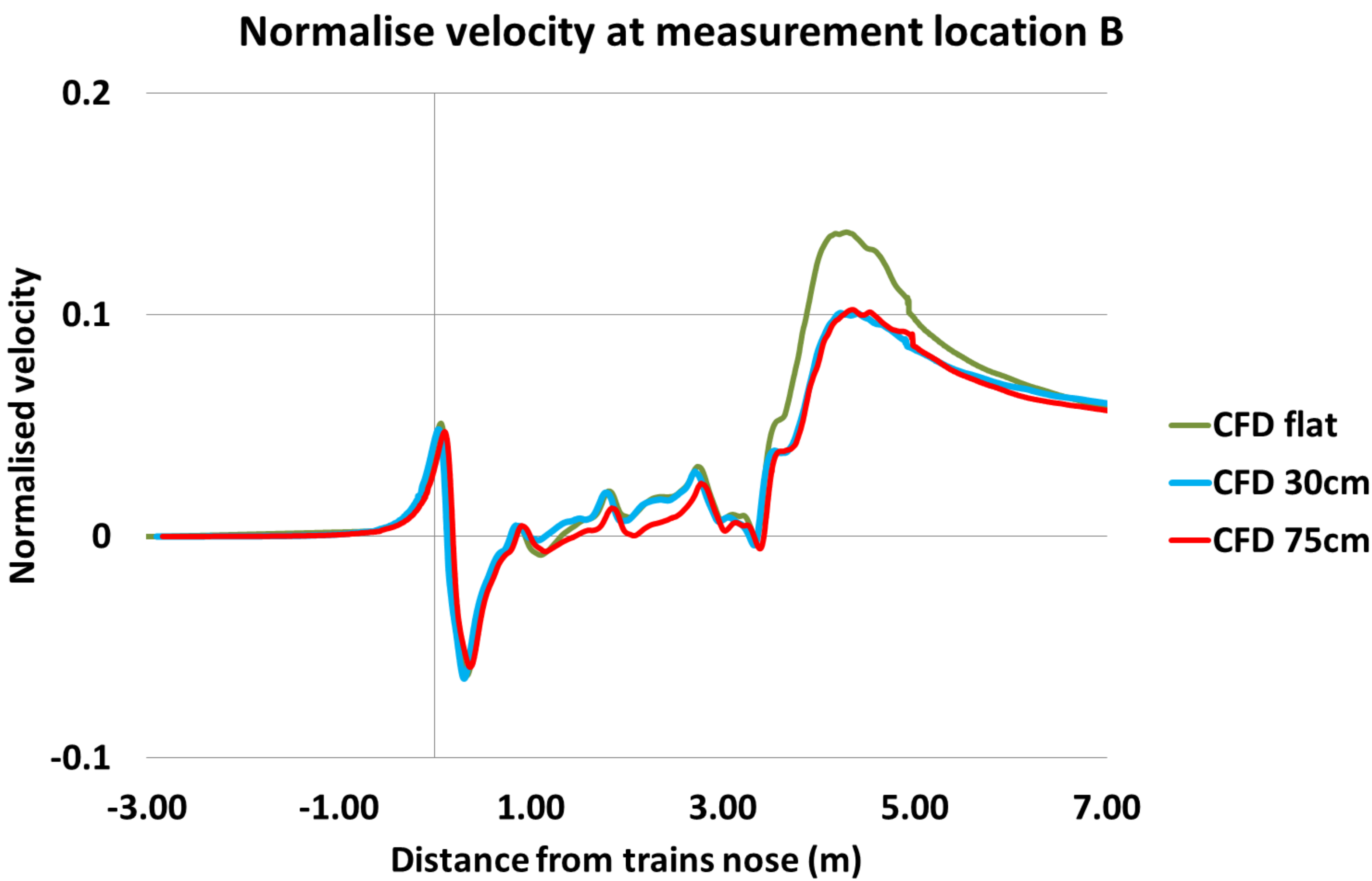

Cp at measurement location B
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
Cp
-3.00
-1.00
1.00
3.00
5.00
7.00
Distance from trains nose
CFD flat
CFD 30cm
CFD 75cm
Experimental flat
Experimental 30cm
Experimental 75cm

Results



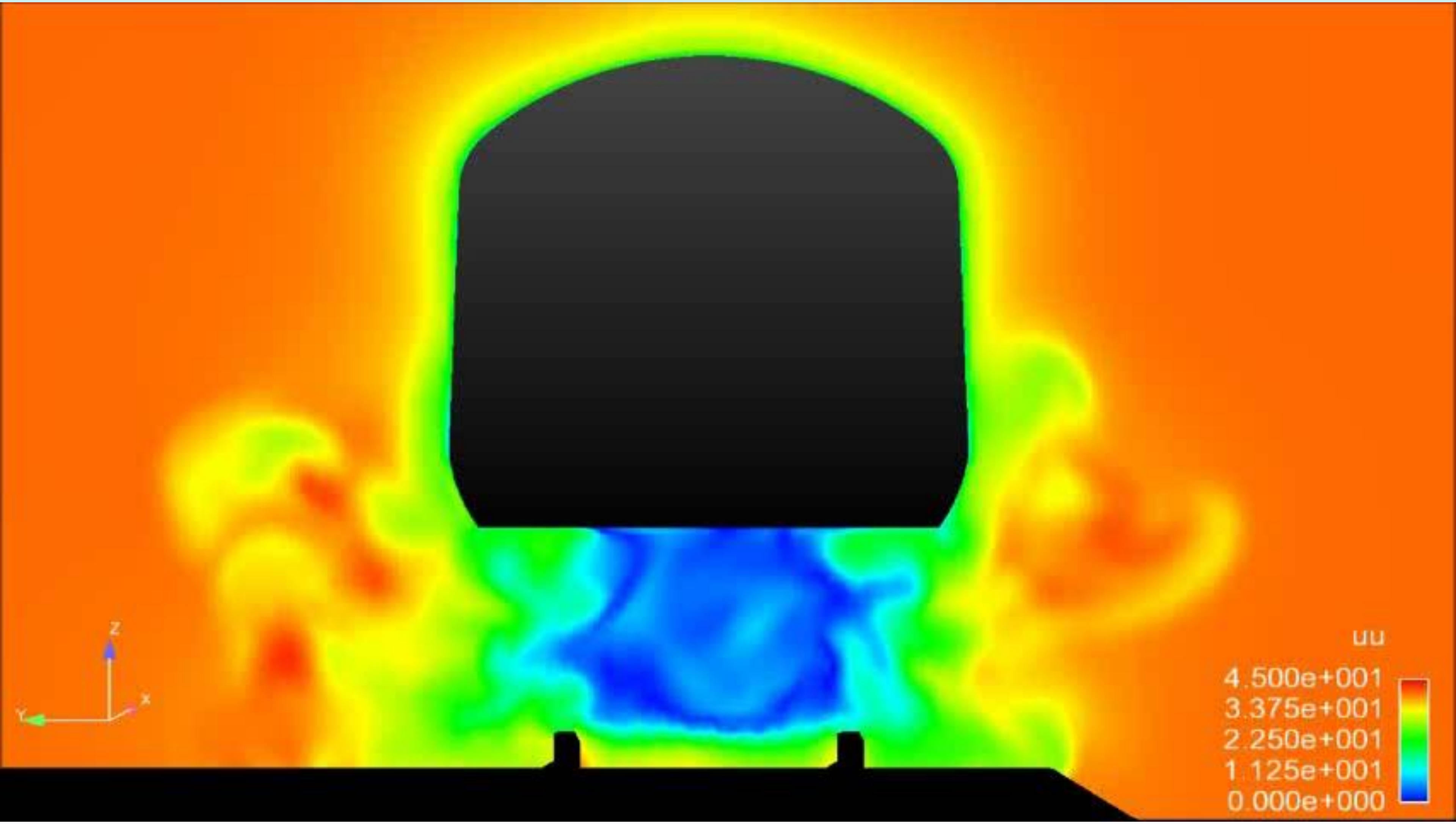
Normalise velocity at measurement location A
0.30
0.20
0.10
0.00
-0.10
-0.20
Normalised velocity
-3.00
-1.00
1.00
3.00
5.00
7.00
Distance from trains nose (m)
CFD flat
CFD 30cm
CFD 75cm

Results

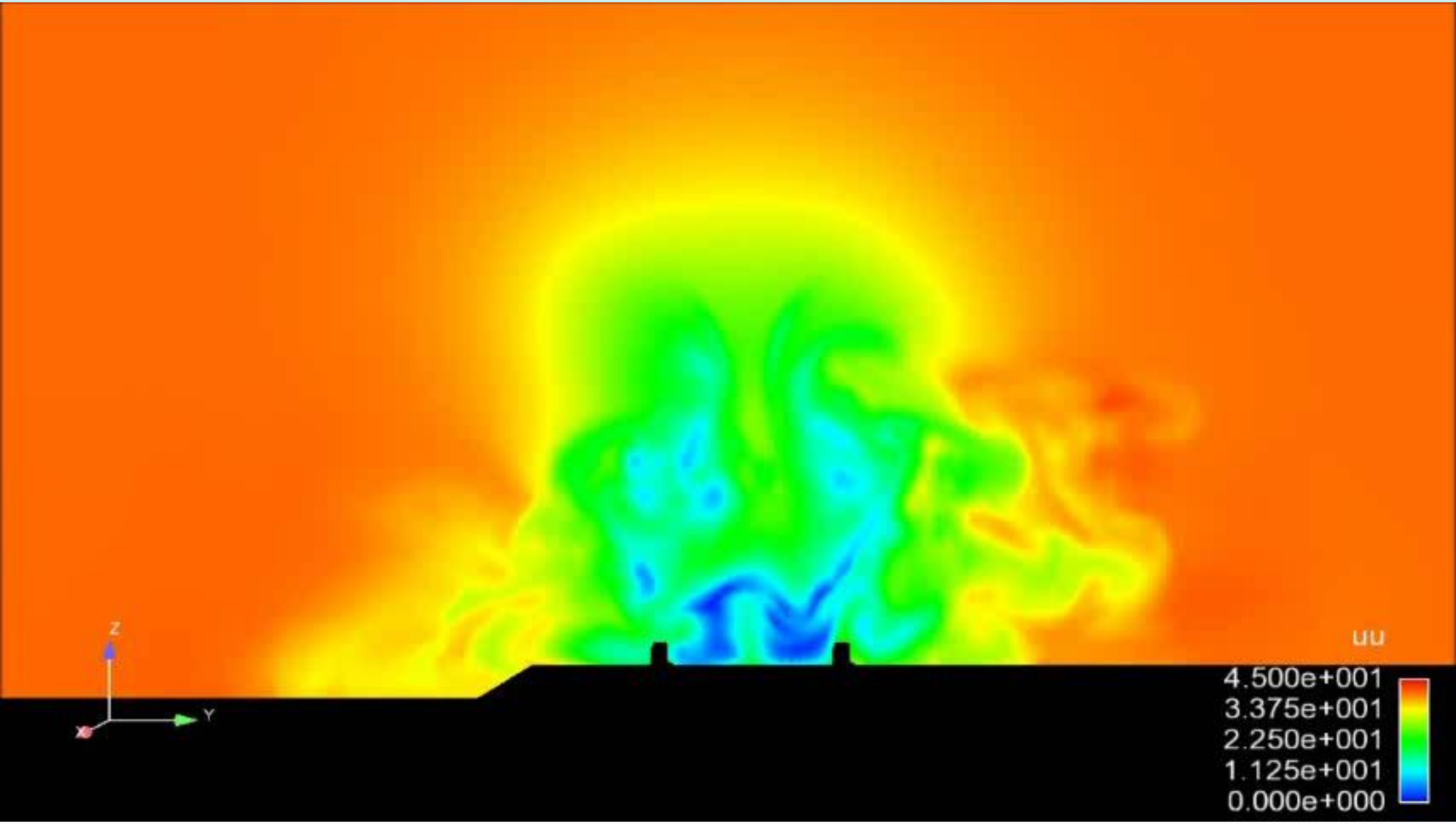


Normalise velocity at measurement location B
0.2
0.1
0
-0.1
Normalised velocity
-3.00
-1.00
1.00
3.00
5.00
7.00
Distance from trains nose (m)
CFD flat
CFD 30cm
CFD 75cm

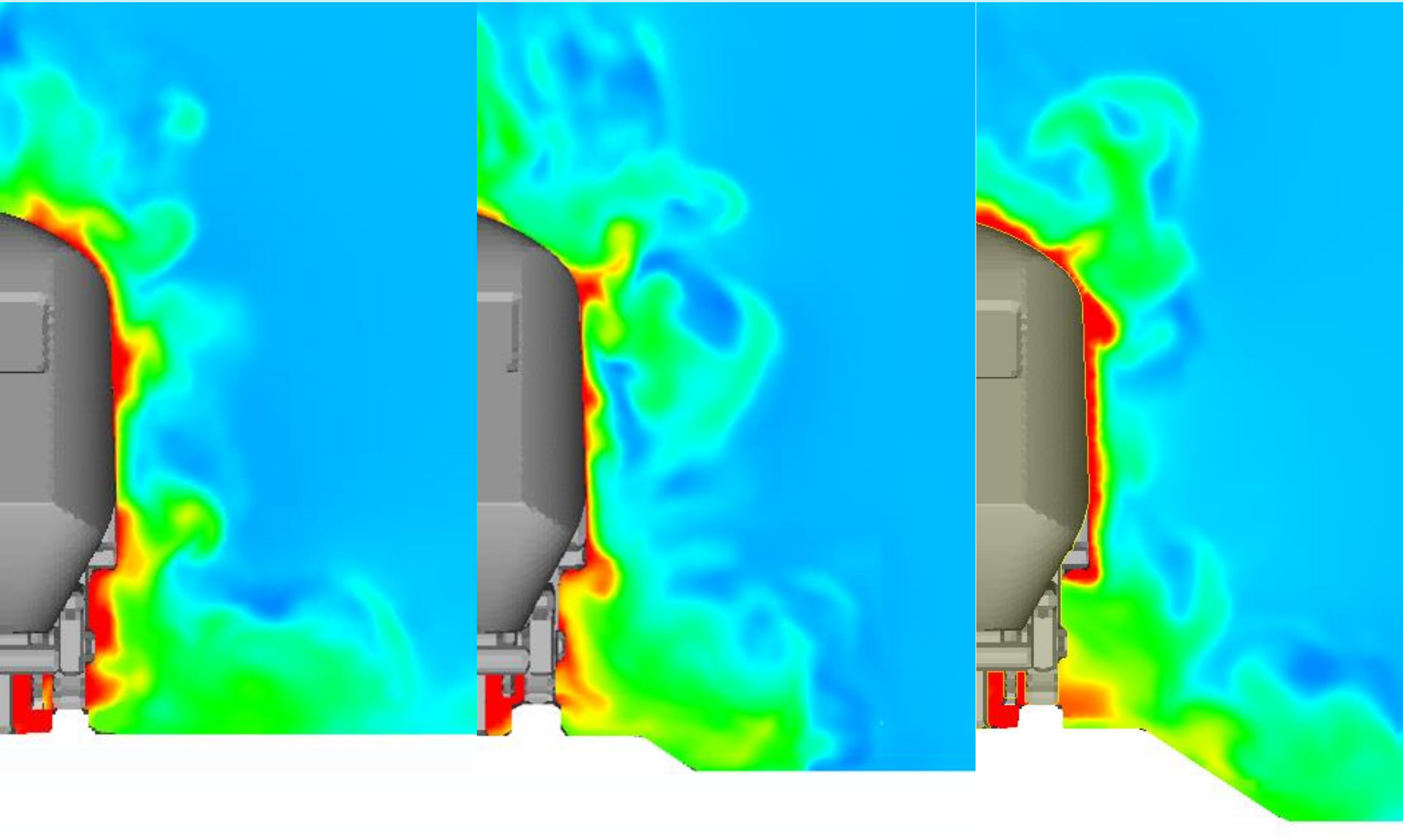
Instantaneous vortices shedding



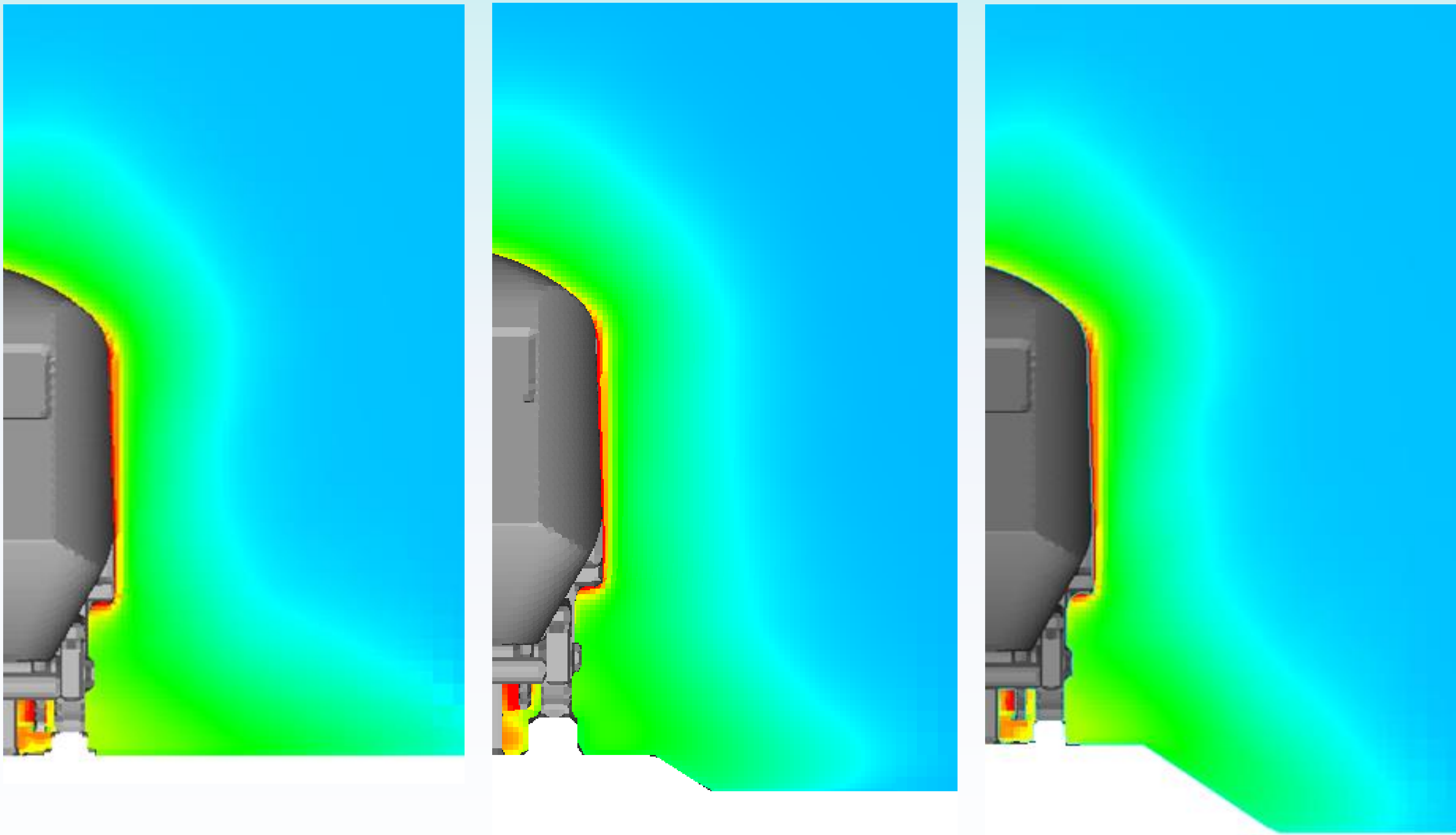
Instantaneous tail wake



Instantaneous results



Time averaged results



Conclusion

- The CFD results show good agreement with the experimental data for the Cp.
- It can be seen that the CFD results predict little difference between the 30cm and 75cm ballast shoulders due to the slipstream in both cases moving a similar distance away from the train.
- The CFD results show that the trains slipstream is affected by the ballast shoulder.

Thank you

Any questions