Experimental Characterization of a Cyclist's Wake

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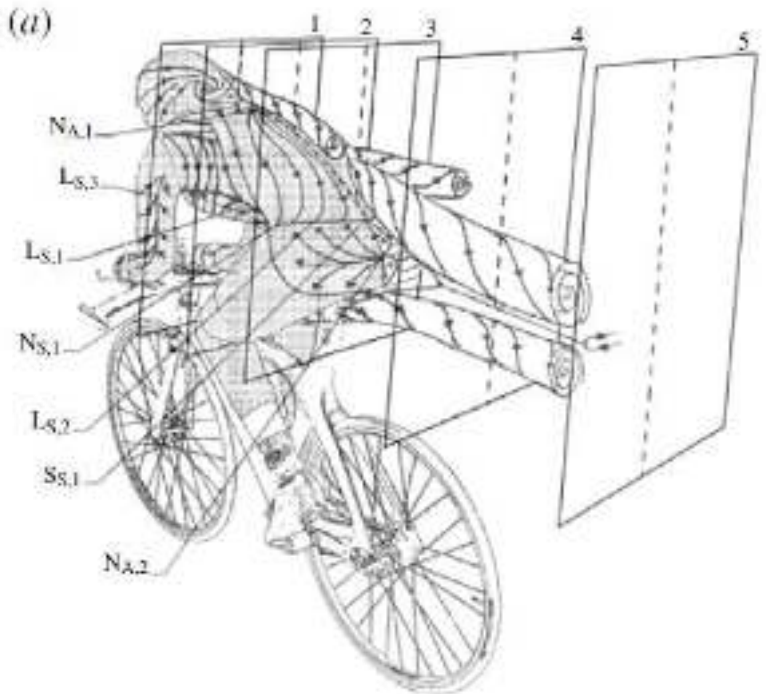
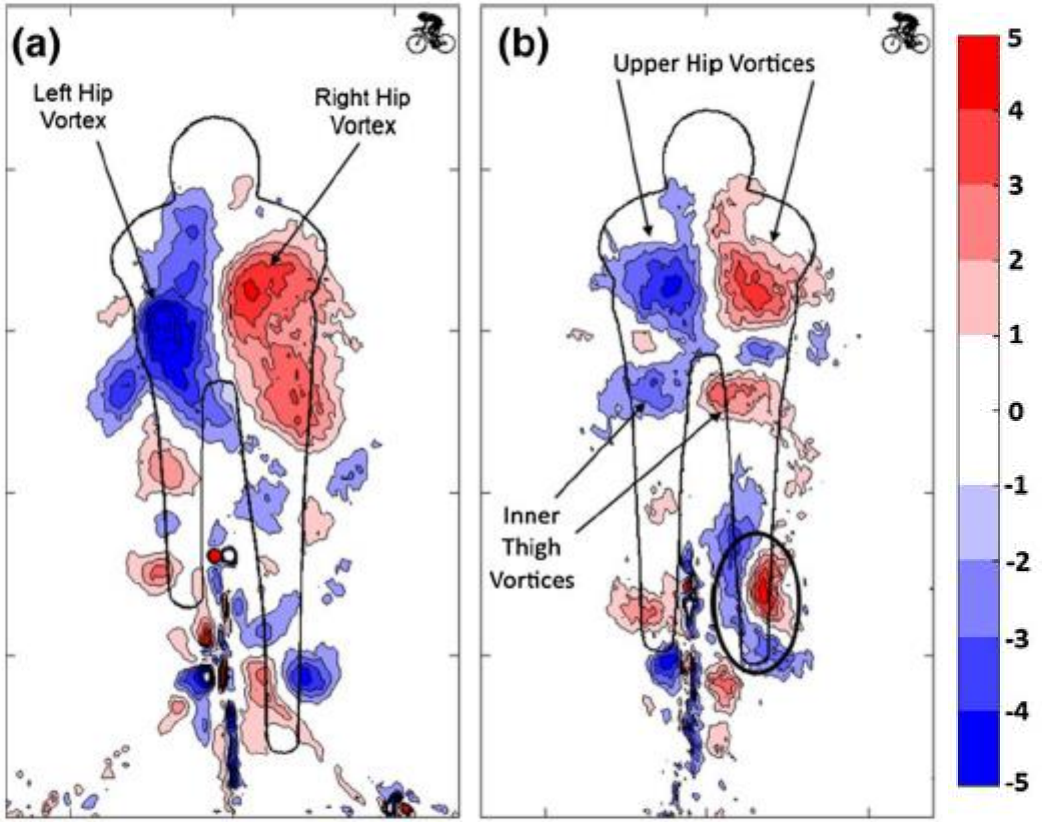
Wake Studies

- Wake measurements with pressure probes



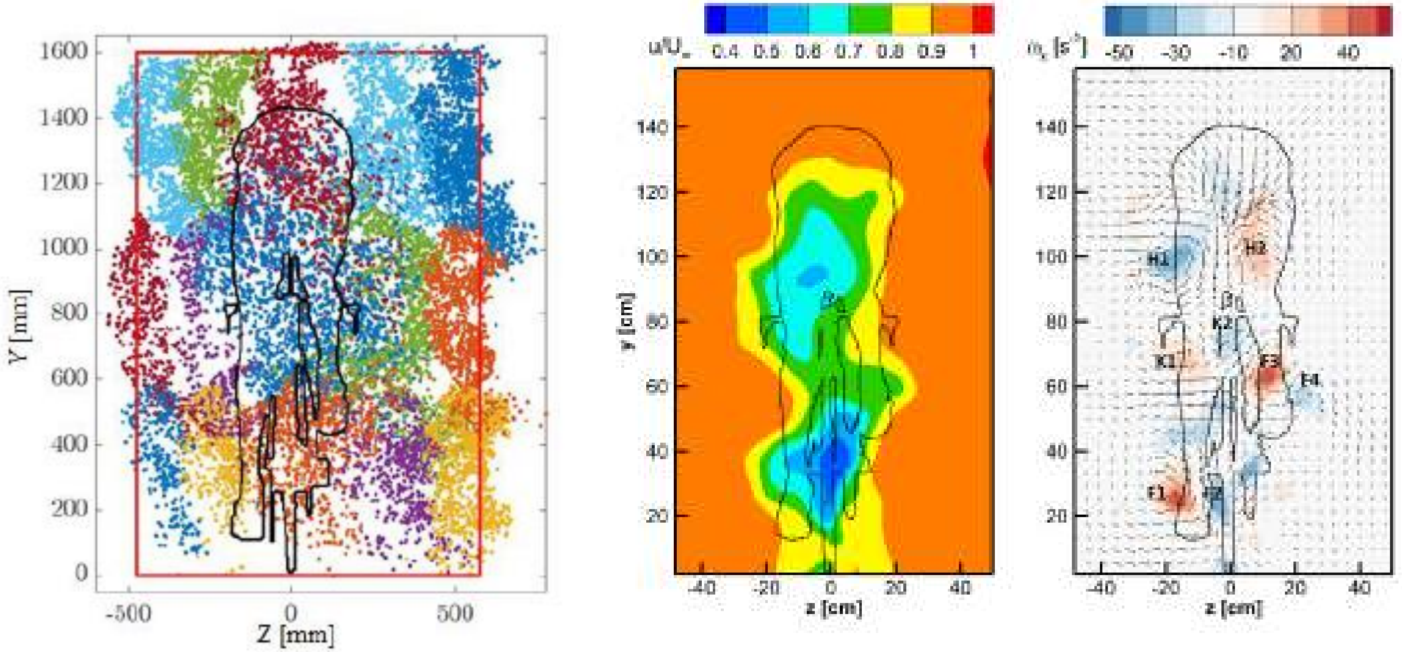


T.N. Crouch et al. - Flow topology in the wake of a cyclist and its effect on aerodynamic drag

Wake Studies

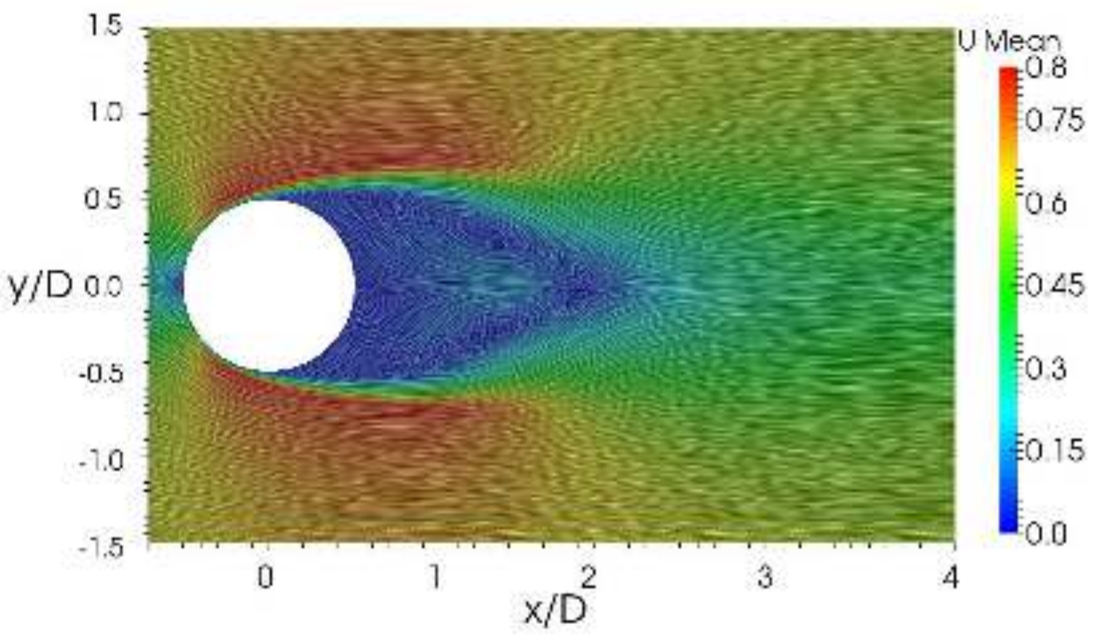
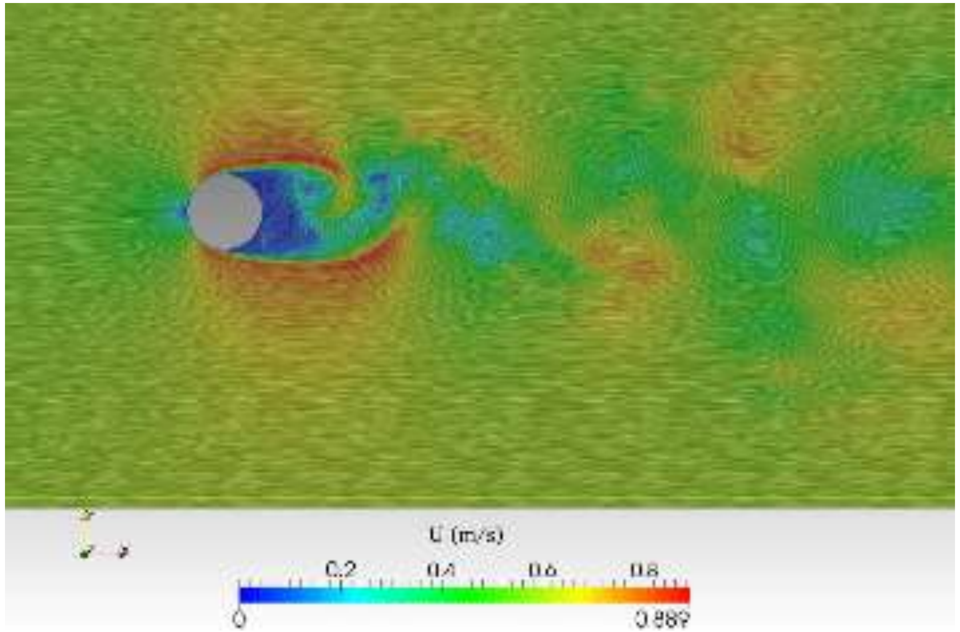
- Characterisation of wake using PIV:
  - Small objects
  - Wake scanning

W. Terra et al. - Aerodynamic drag determination of a full-scale cyclist mannequin from large-scale PTV measurements



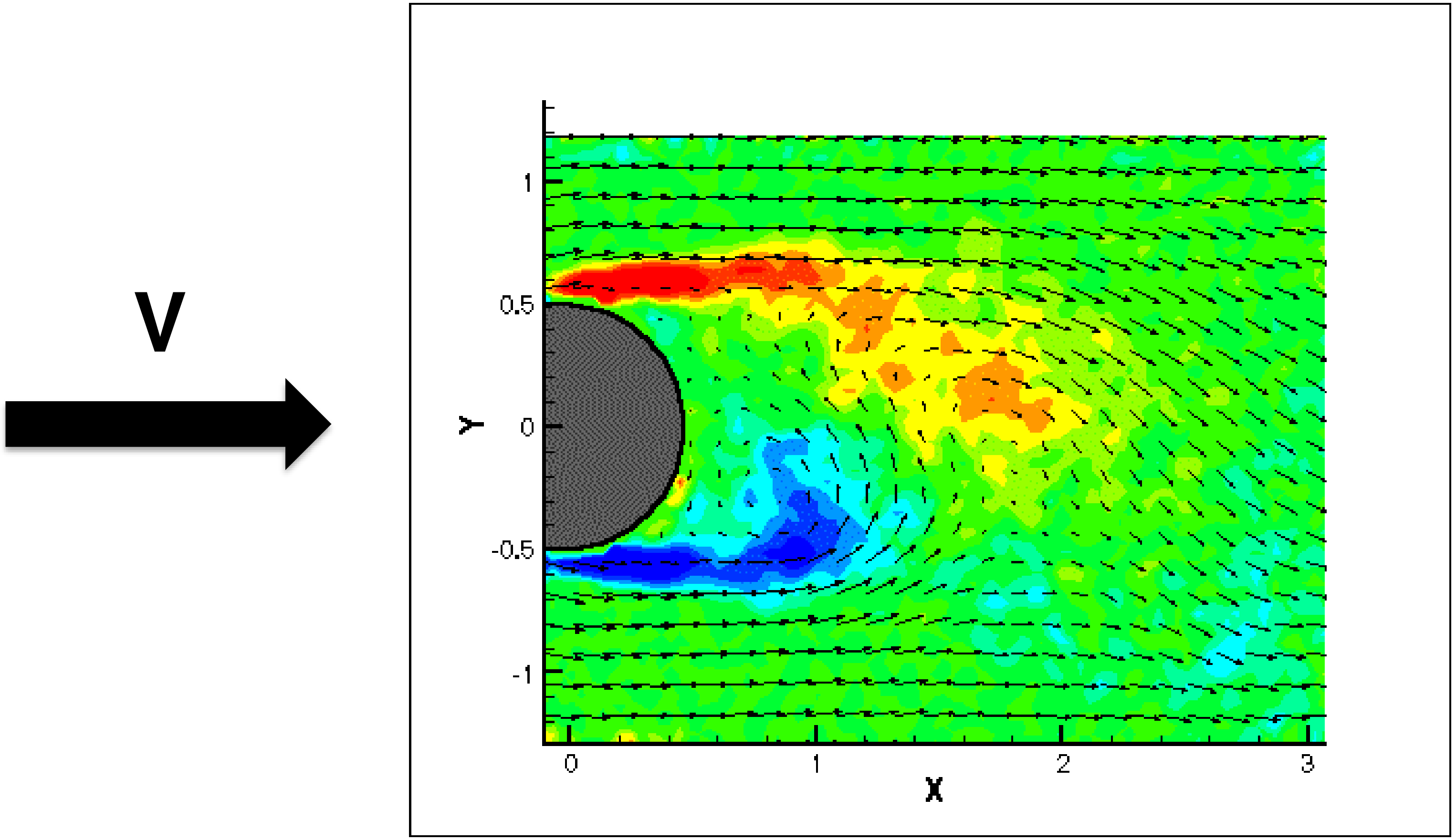
Instantaneous vs. average flow over cylinder

V

Average	Instantaneous
	

https://www.simscale.com/docs/content/validation/FlowOverCylinder-LES/FlowOverCylinder-LES.html

Instantaneous flow over cylinder



http://www.eng.fsu.edu/~shih/succeed/cylinder/cylinder.htm

Goal of Research

- Characterising the wake of a cyclist by:
  - Instantaneous full-field wake measurements
  - Identification of the dynamics of the main wake structures

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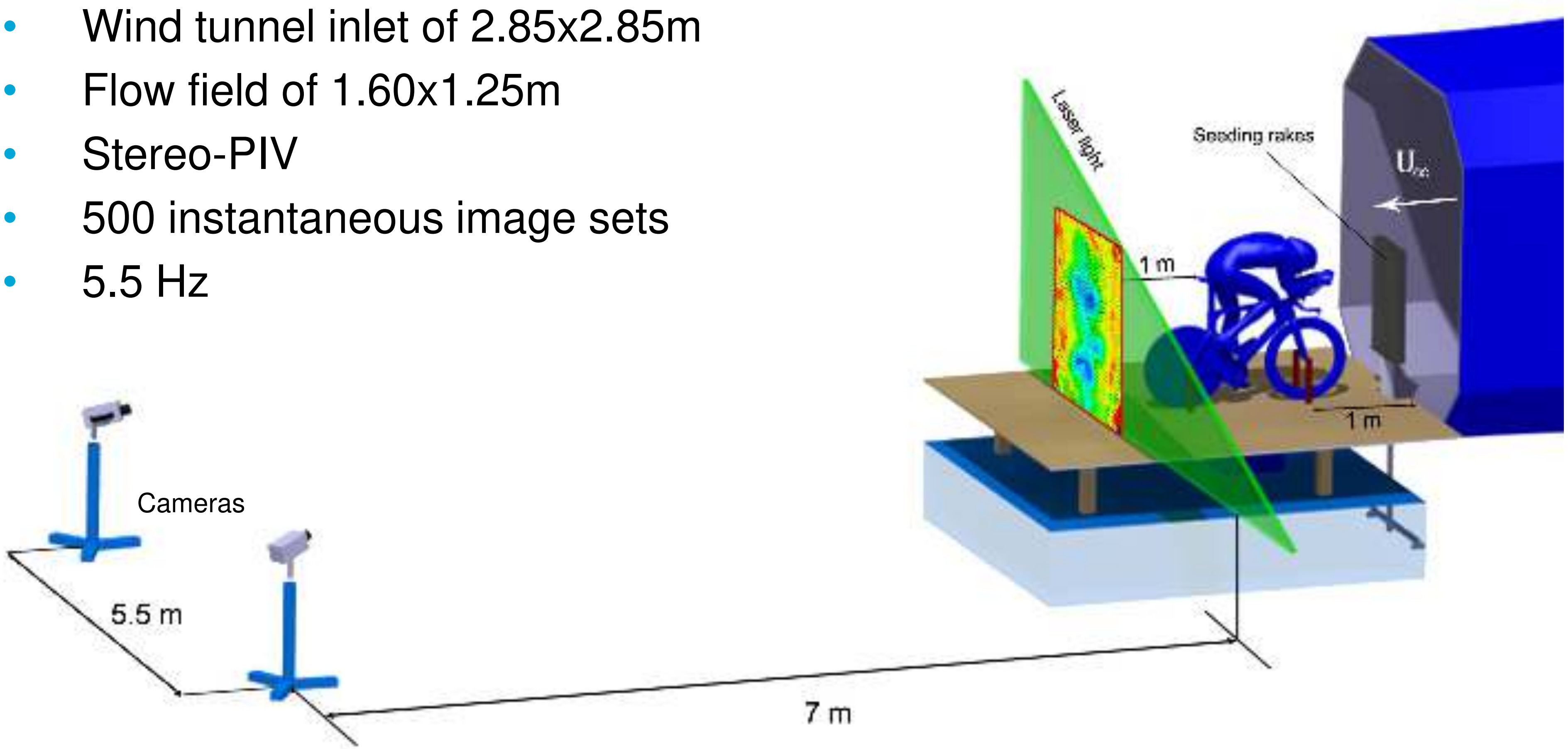
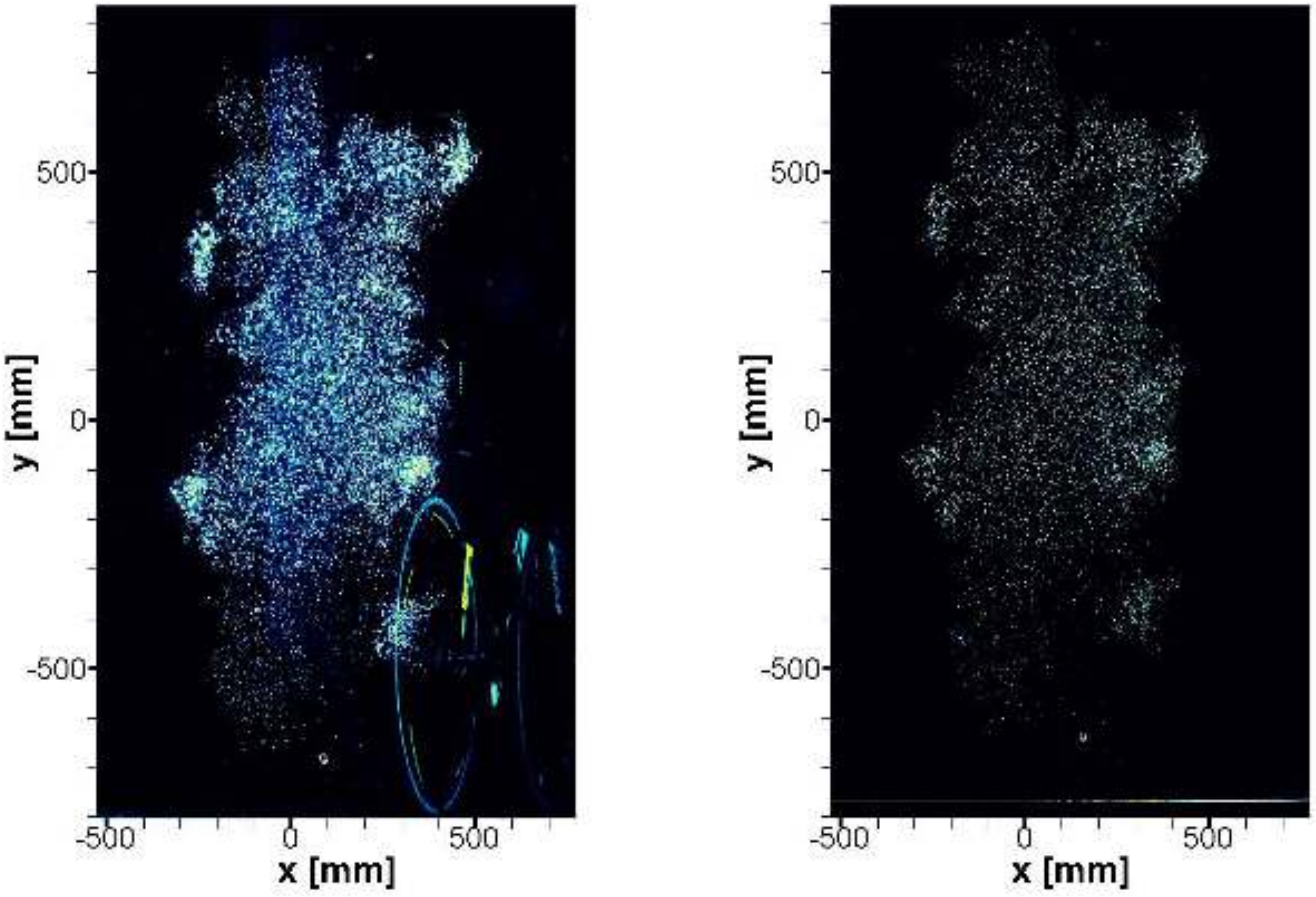
Wind Tunnel Experiment

Wind Tunnel Experiment

- Wind tunnel inlet of 2.85x2.85m
- Flow field of 1.60x1.25m
- Stereo-PIV
- 500 instantaneous image sets
- 5.5 Hz

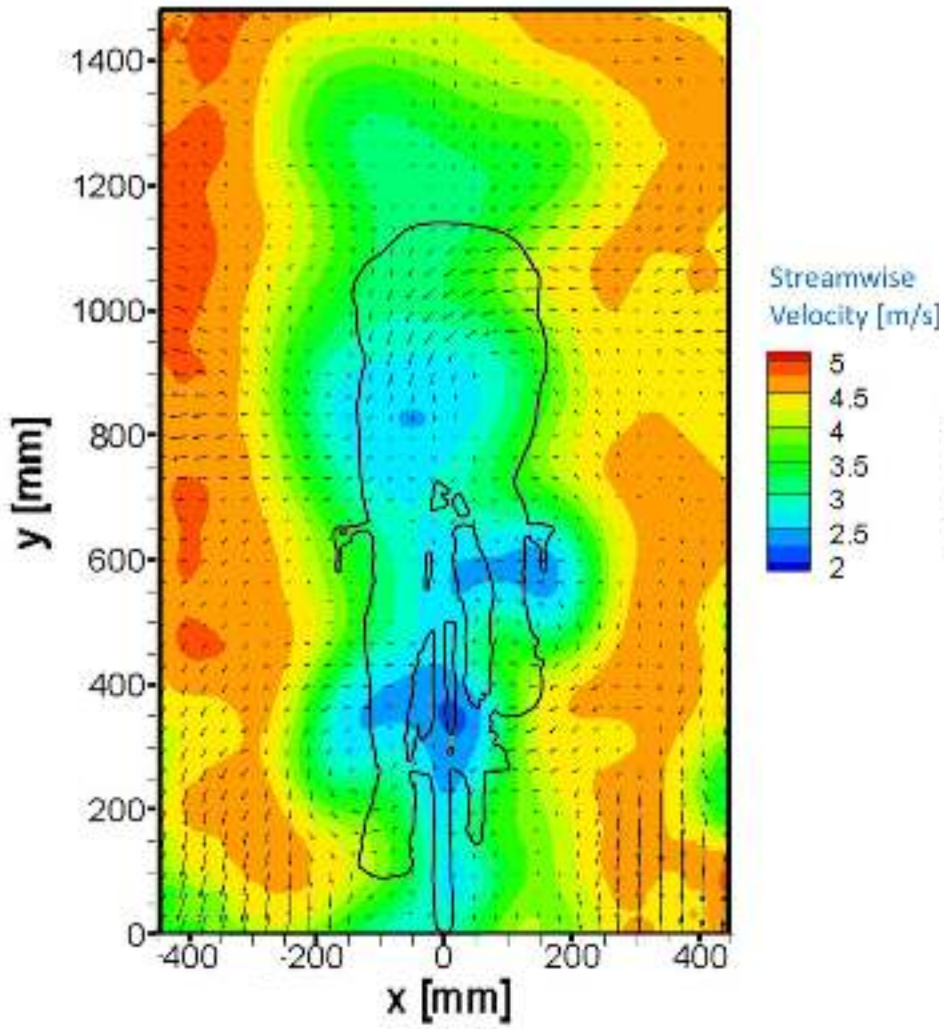


Raw data from both angles

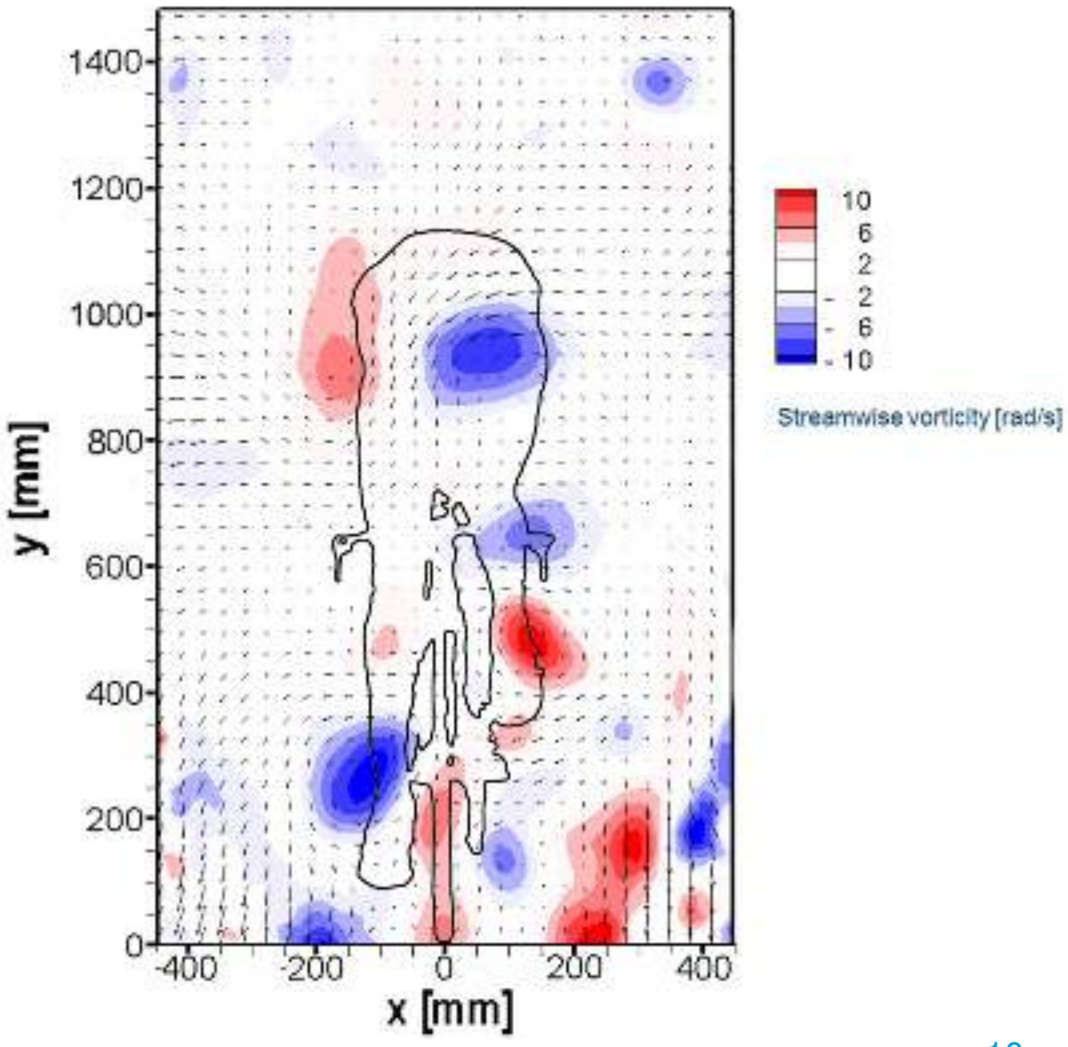


Averaged Flow Fields

Streamwise Velocity



Streamwise Vorticity



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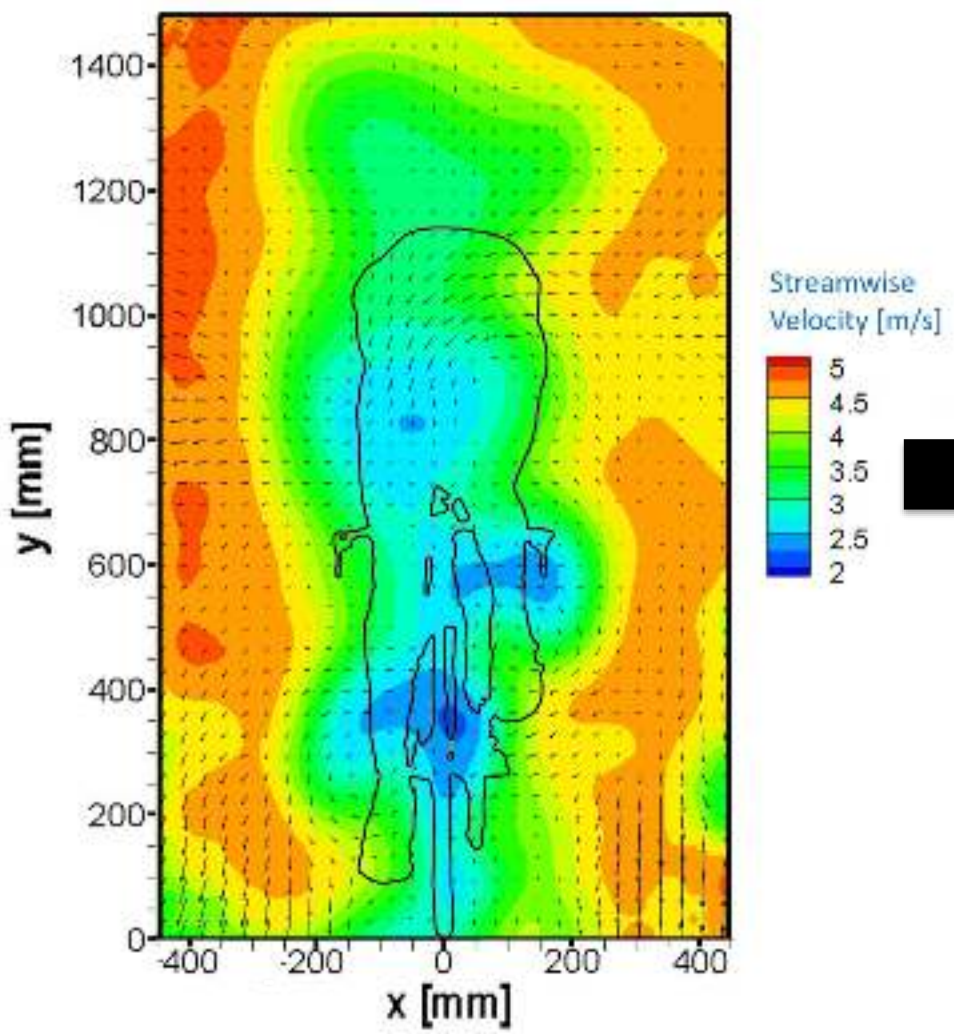
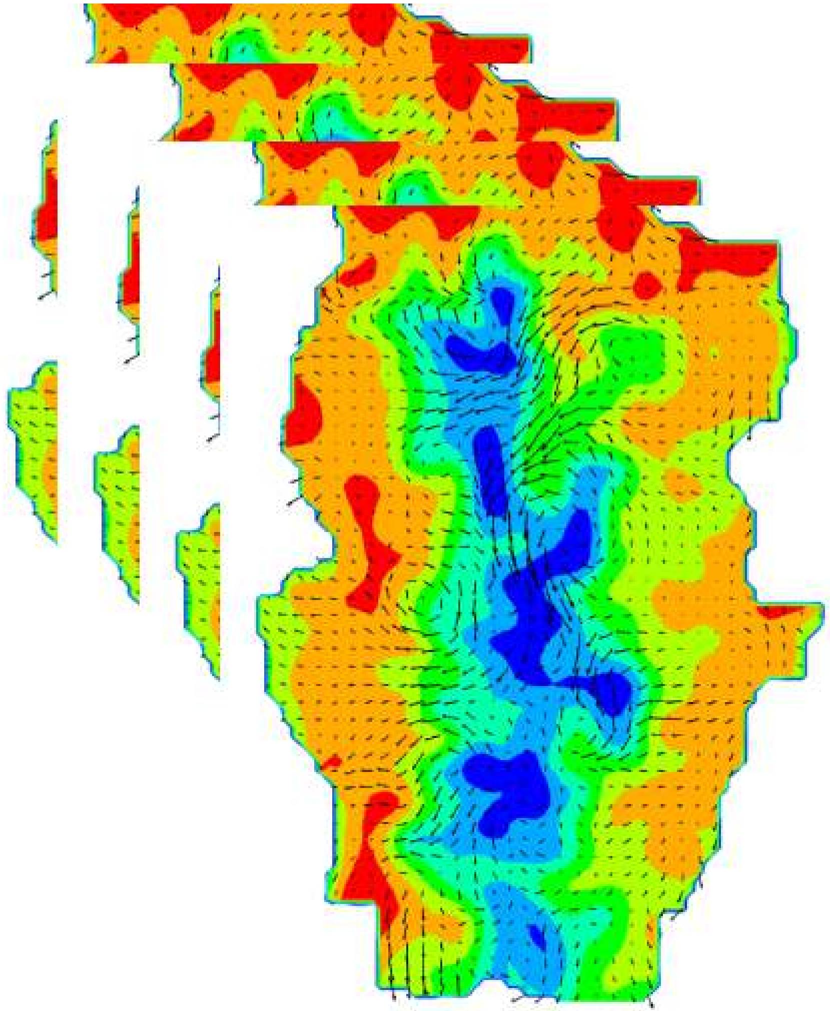
Averaged Flow Fields

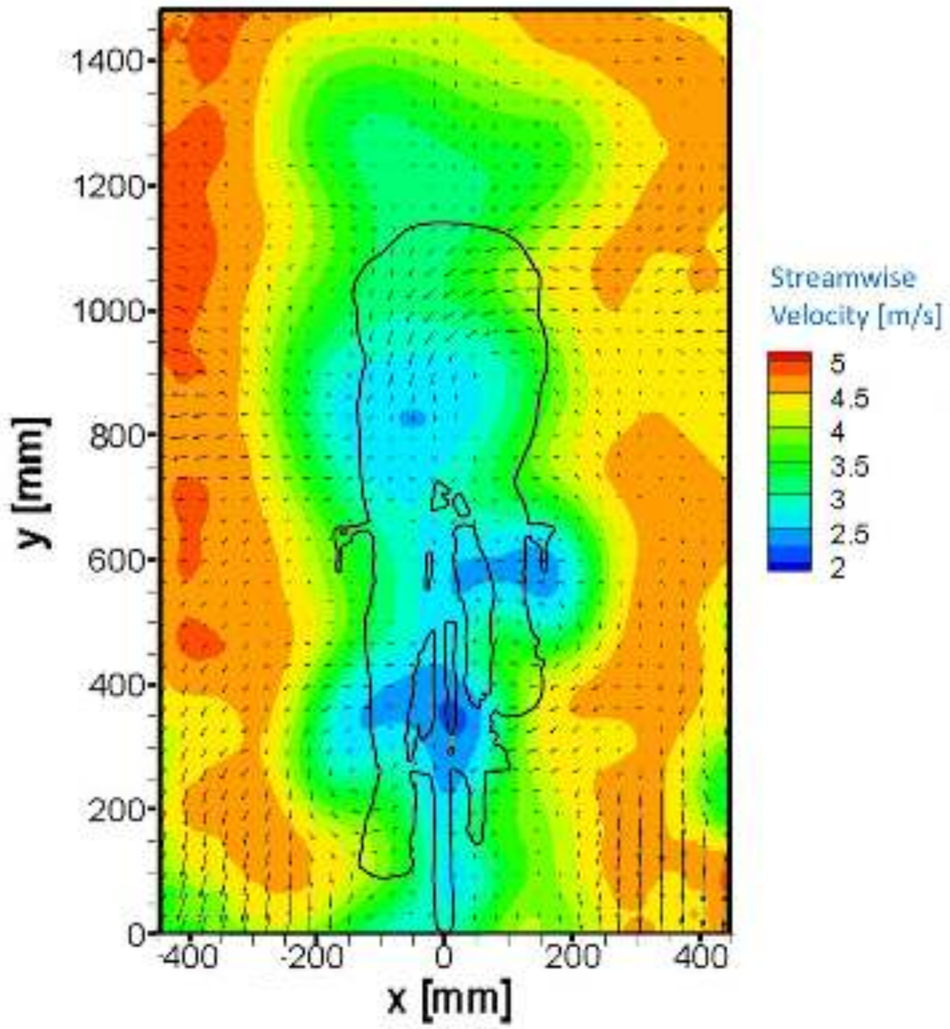
Streamwise Velocity



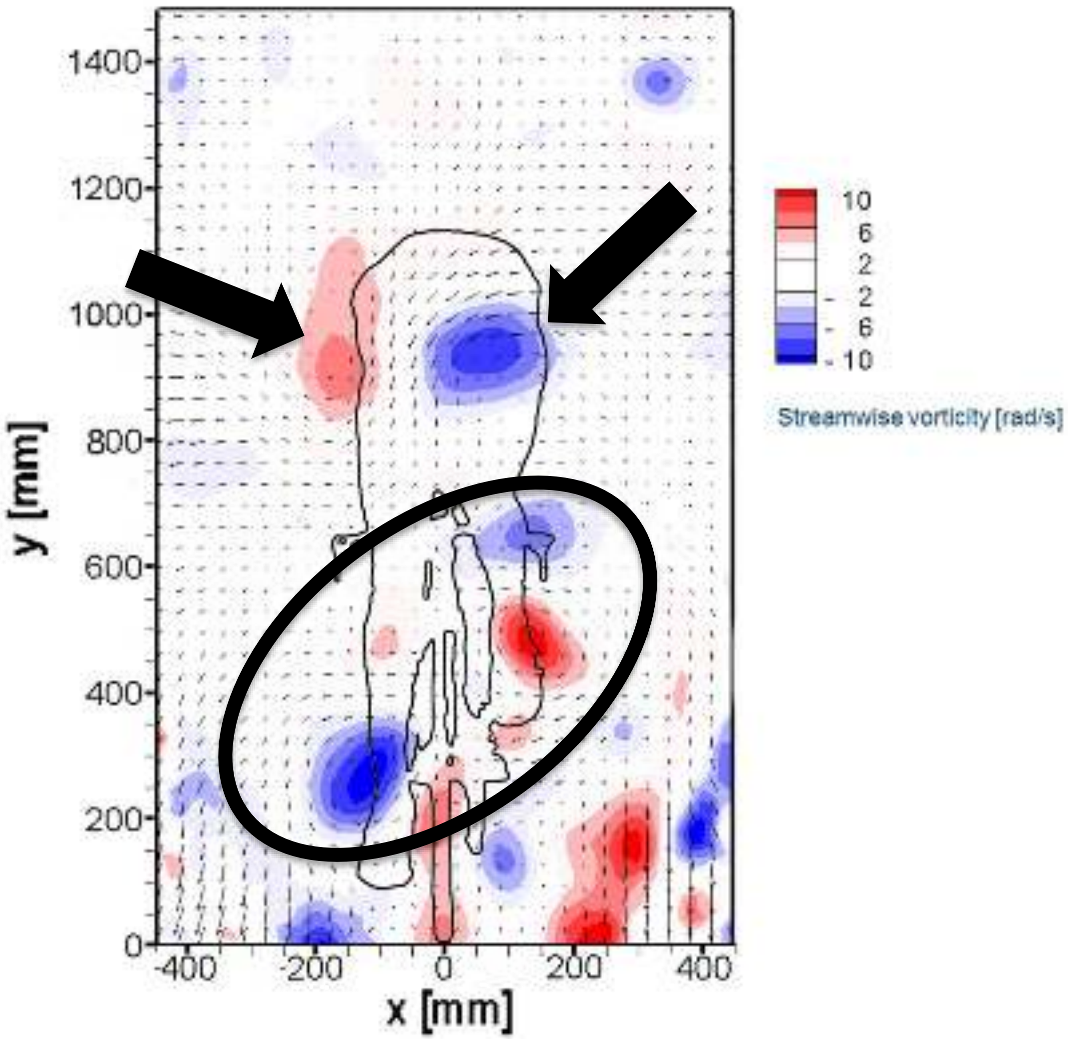


Averaged Flow Fields

Streamwise Velocity



Streamwise Vorticity



Proper Orthogonal Decomposition

- Instantaneous data
- Decomposing velocity fluctuations

$$\left\langle \overline{u'(x_i, t)\, u'(x_j, t)} \right\rangle = \sum_{n=1}^{N} \lambda_n$$

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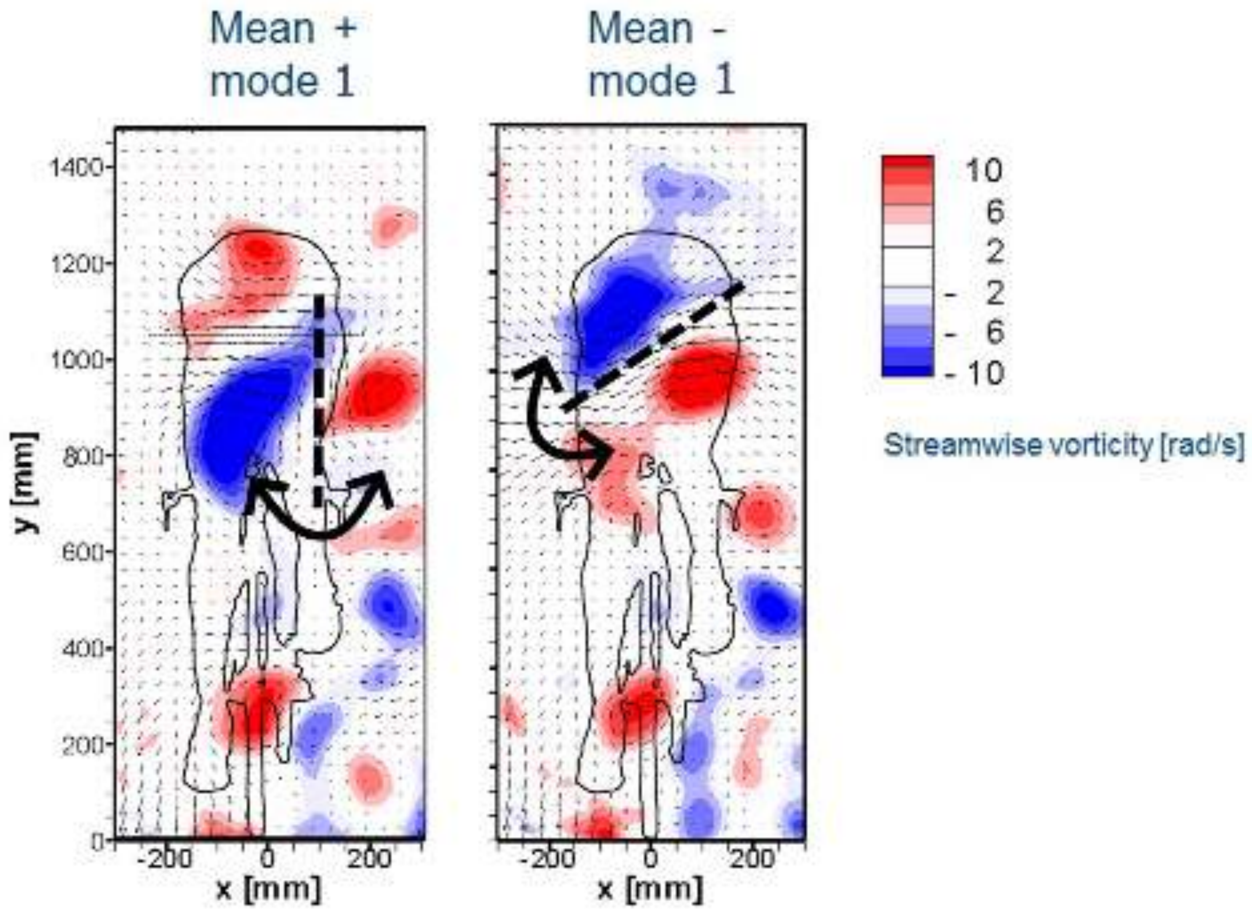
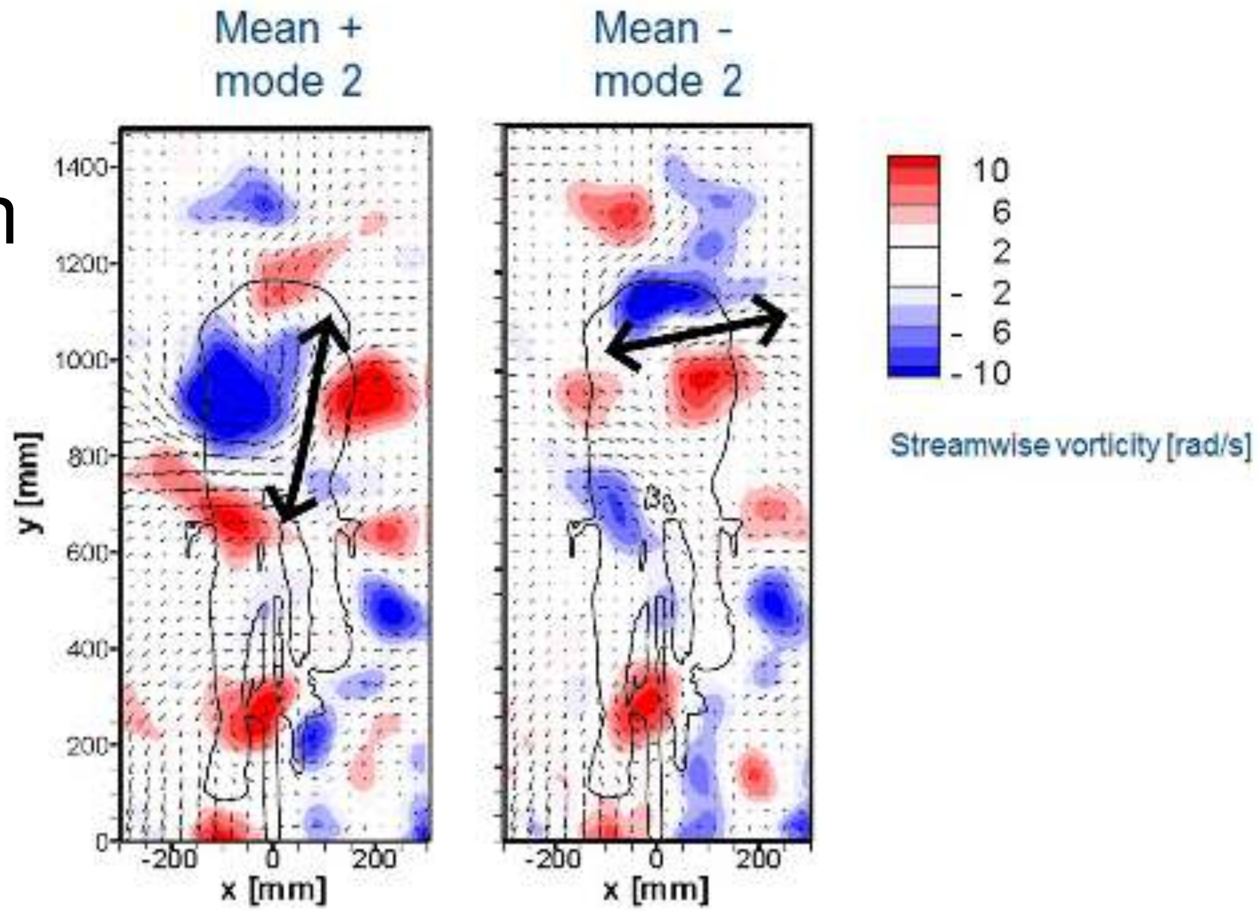
POD Mode 1

- Two hip vortices
- Rotating
- Low noise

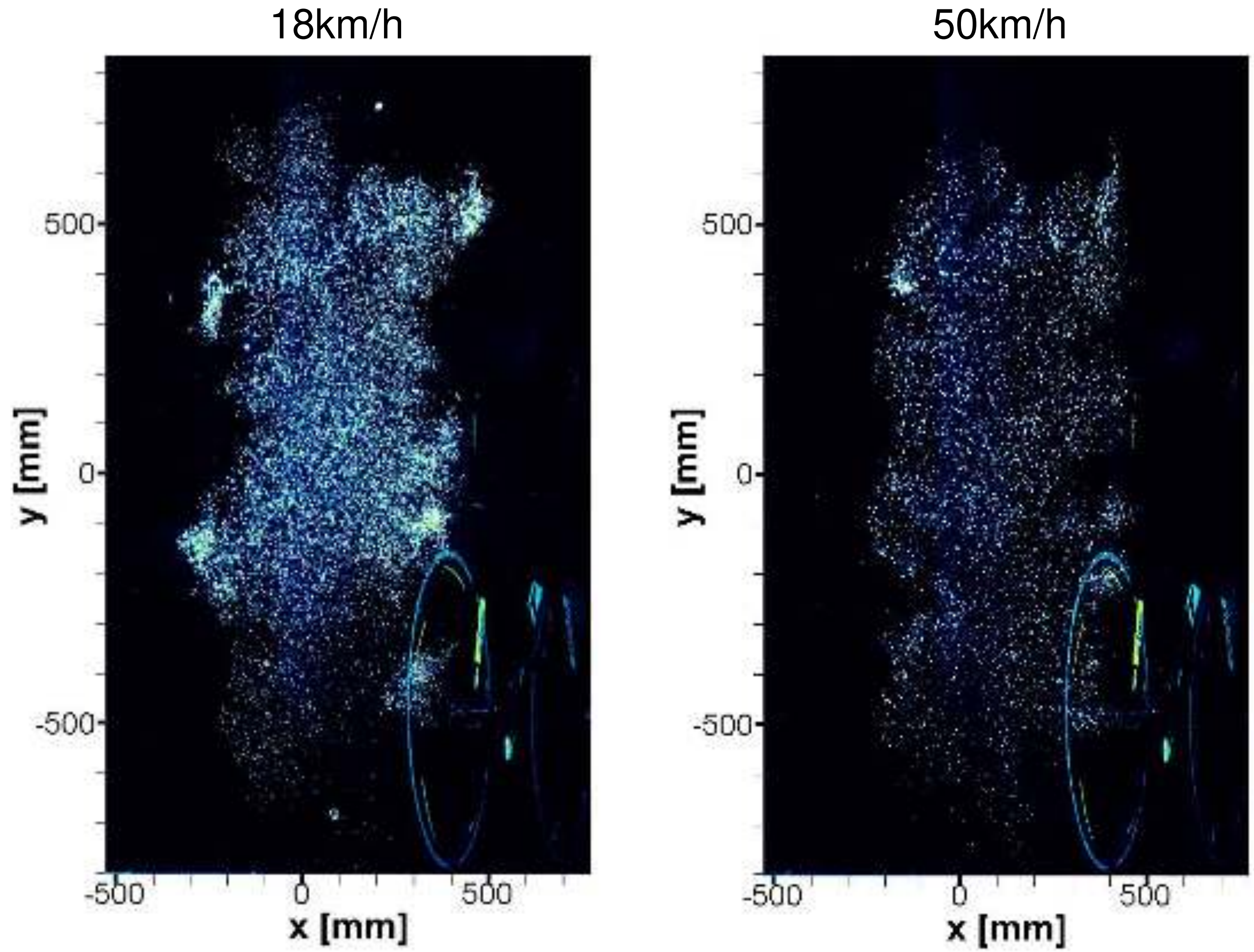


POD Mode 2

- Two hip vortices
- Changing strength
- Rotating

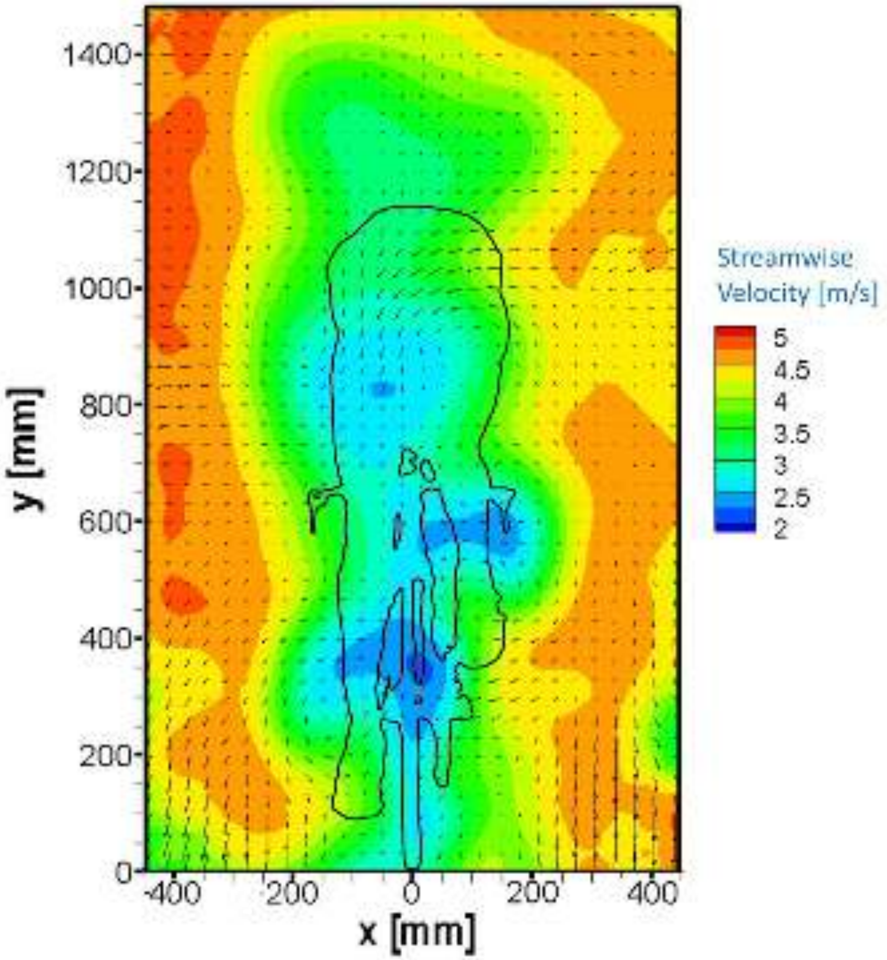


Increasing Velocity

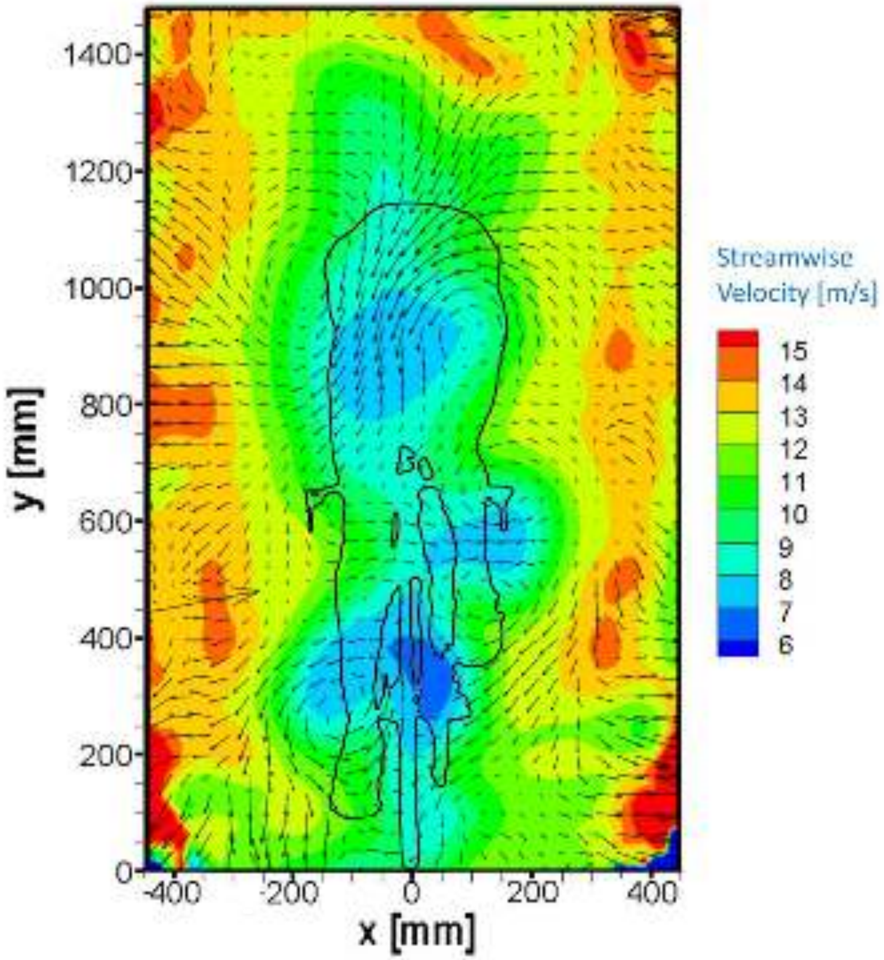


Wake Similarity – 18km/h vs. 50km/h

18km/h



50km/h



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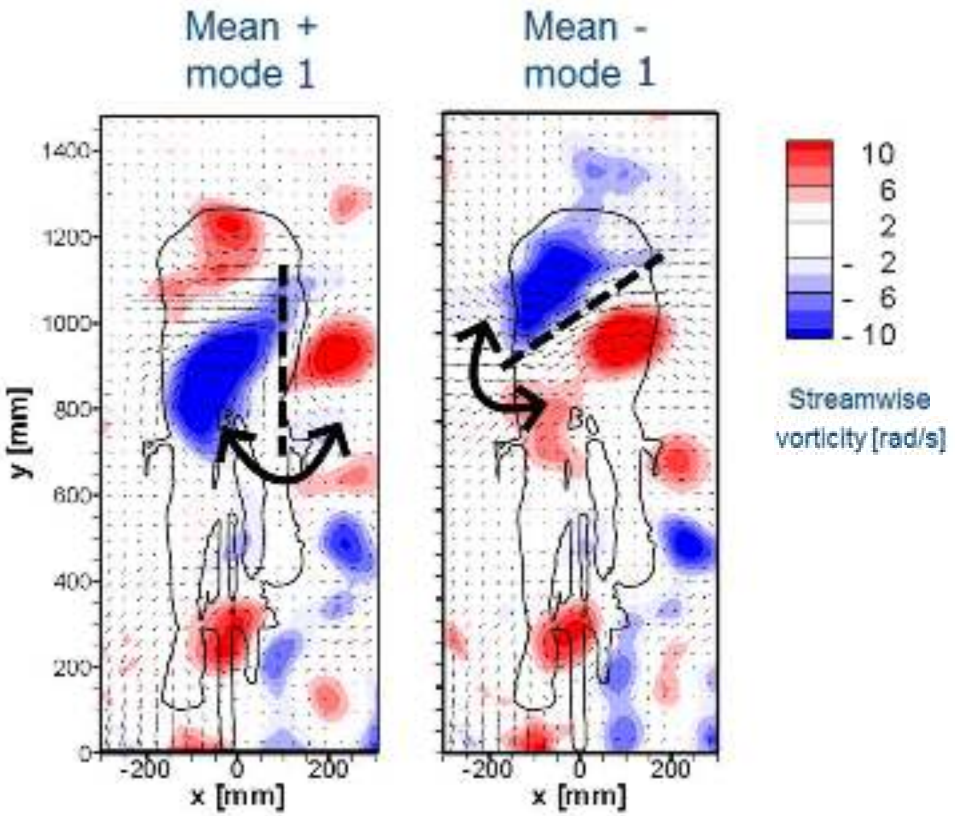
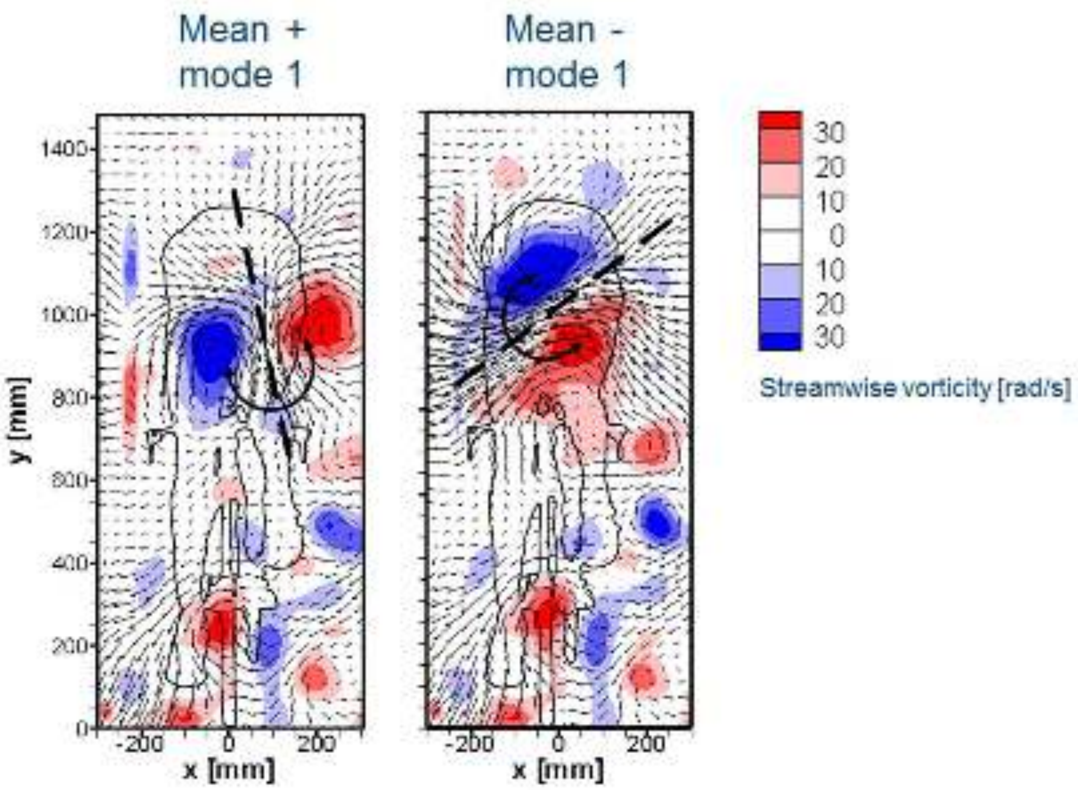
Wake Similarity - 18km/h vs. 50km/h

18km/h



50km/h



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Changing Helmet Position

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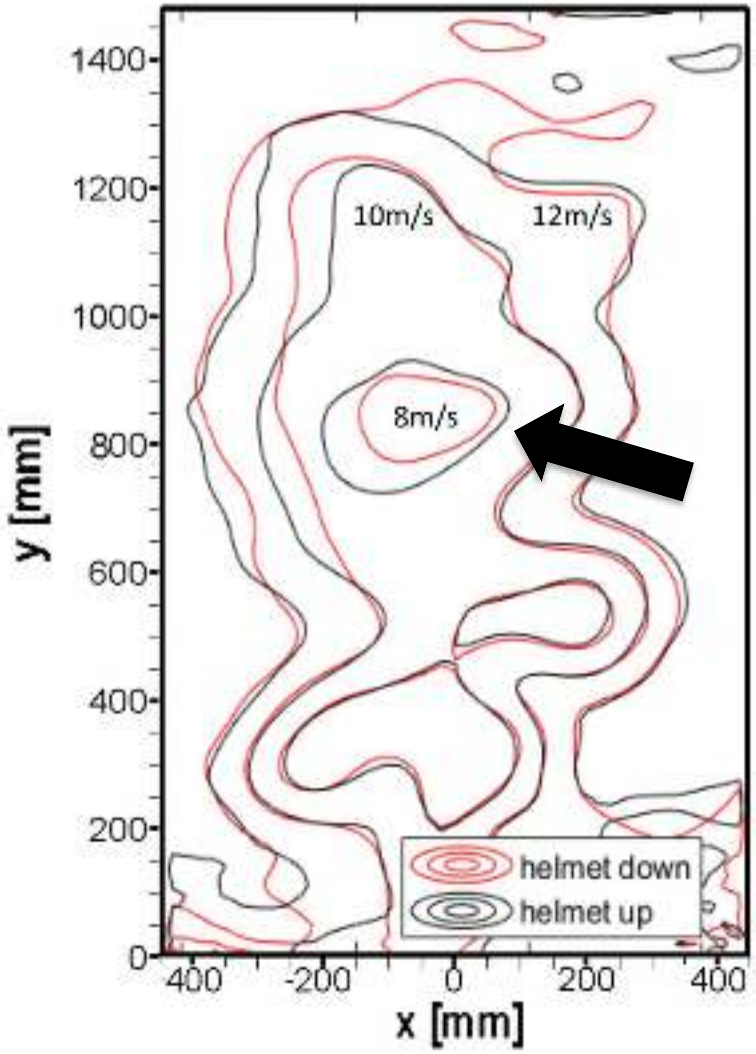
Detection of Position Changes

- Lower half, negligible difference
- Visible difference in centre and at top
- Balance Drag
  - Helmet Down: 21.2N
  - Helmet Up: 22.2N



Conclusion

- First instantaneous, full-field cyclist wake measurement
- Most energetic wake structures identified
- Effect of small position changes on wake investigated

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Future Consideration

- Investigation of pedalling model
- Modification of seeding system to reduce PIV noise
- Moving seeding system further upstream

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