3rd Automotive CFD Prediction Workshop

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Marian Zastawny, Simone Landi, Sylvain Lardeau

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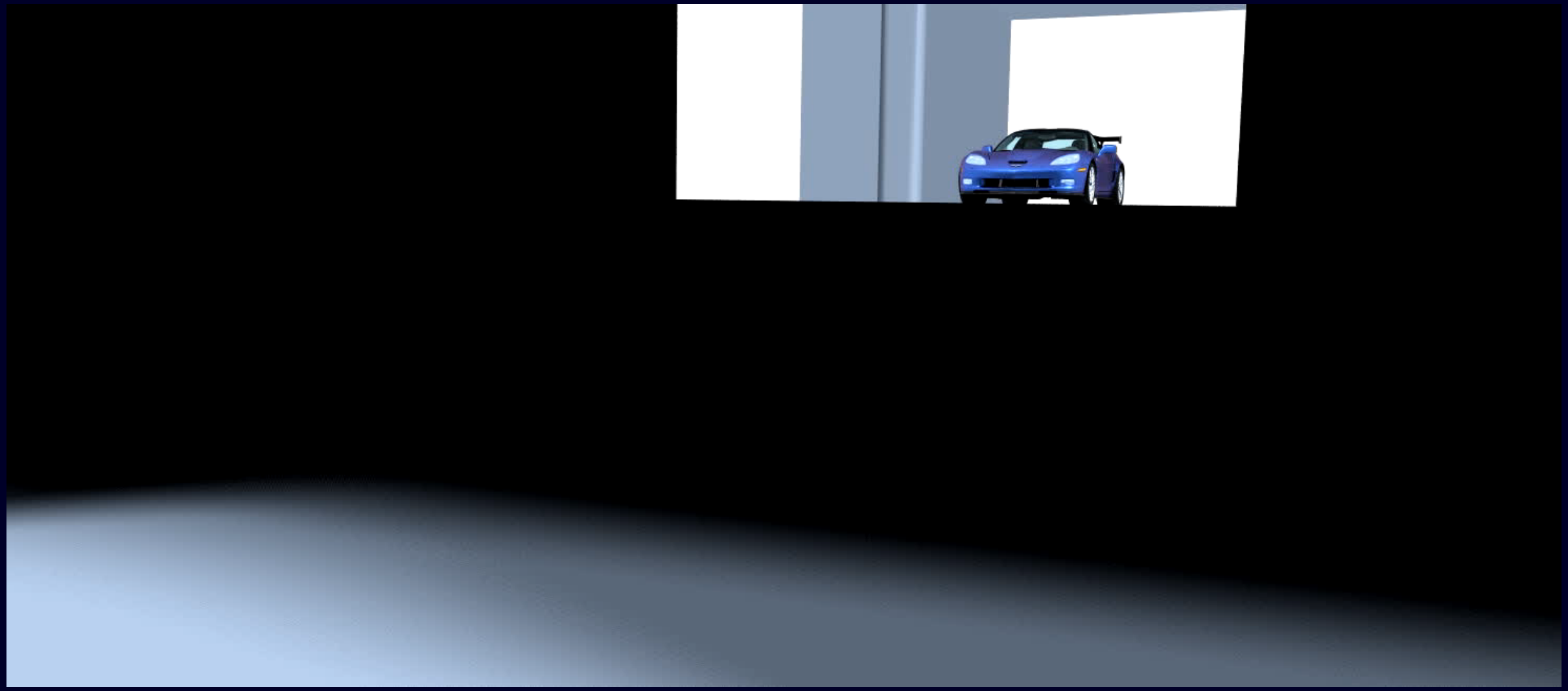
Simcenter STAR-CCM+ development version



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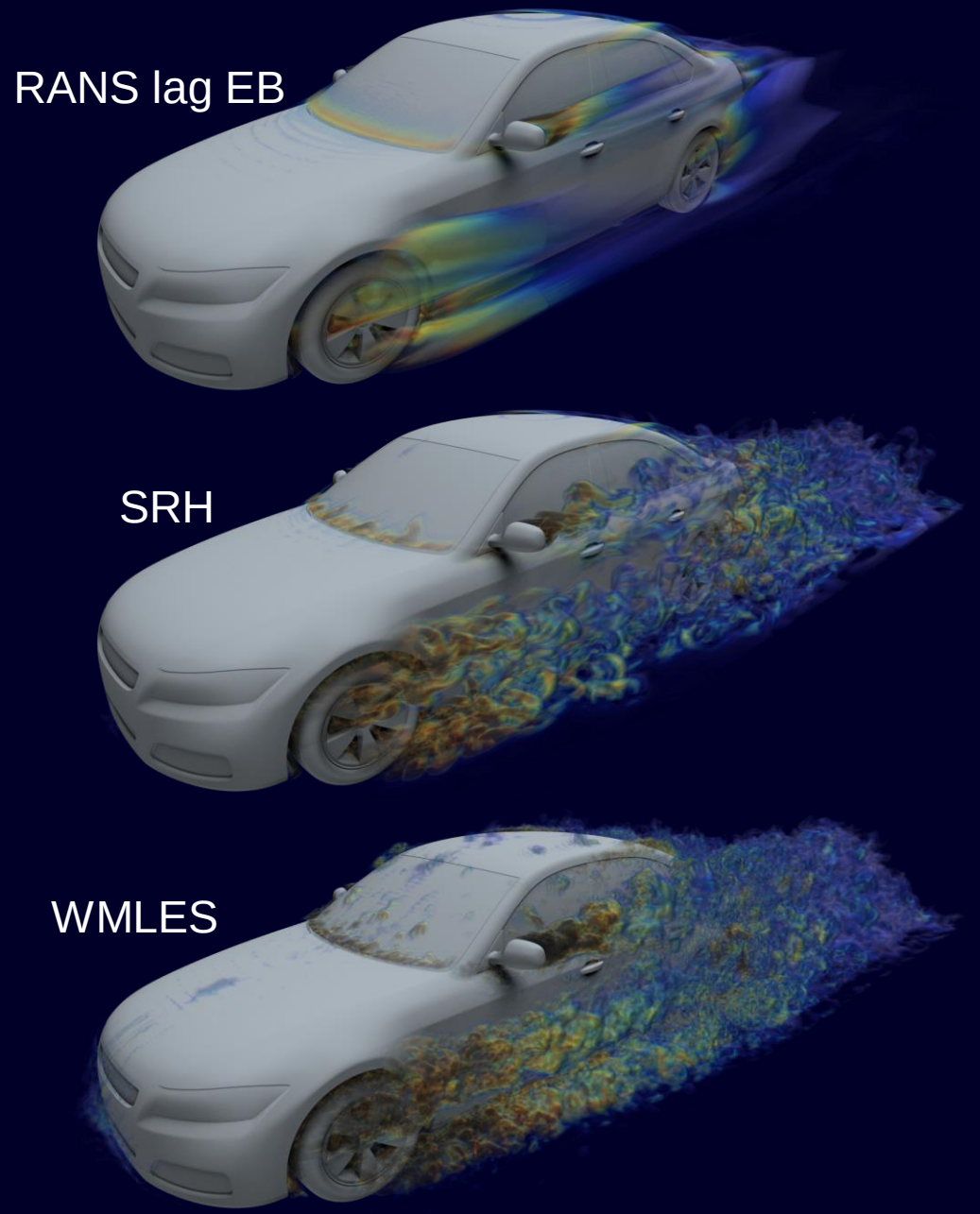
Summary

Focused on DrivAer case (2a and 2b)

Used the provided mesh (ANSA, 130M, hi-y+)

Tested 3 different turbulence modeling approaches



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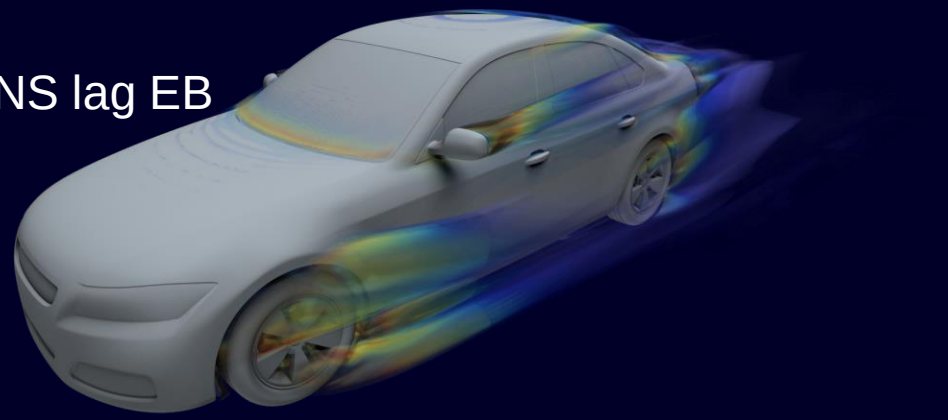
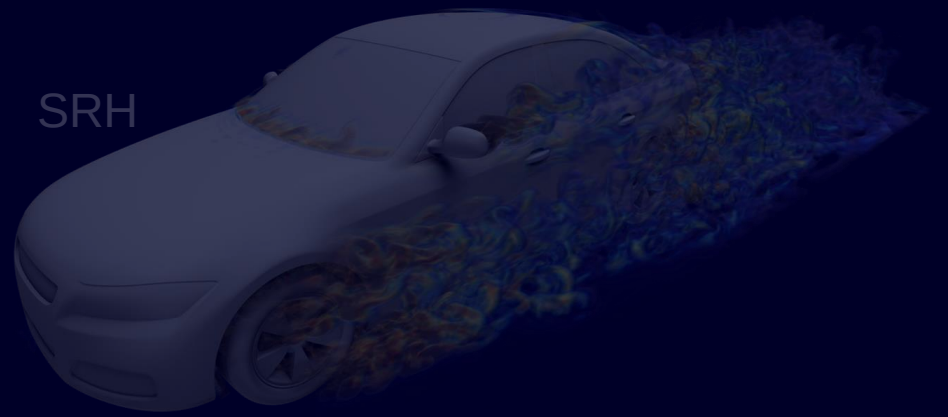
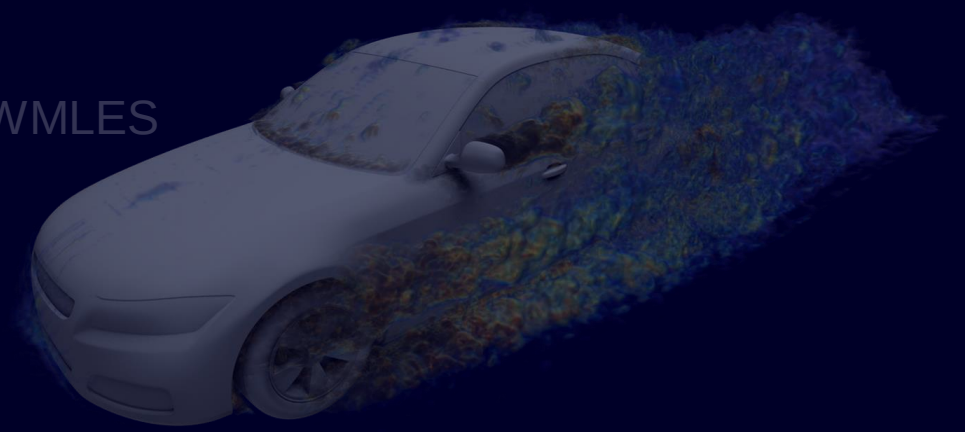
RANS lag EB



SRH



WMLES



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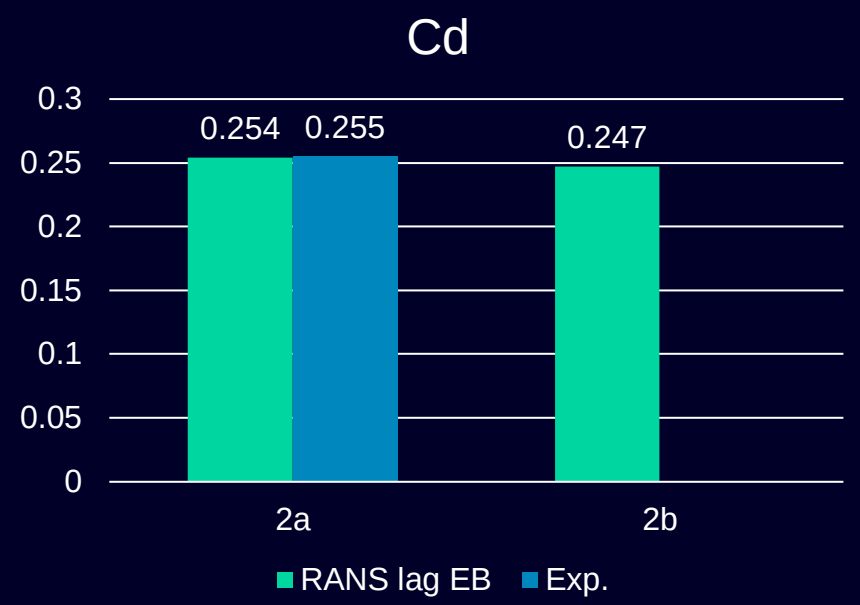
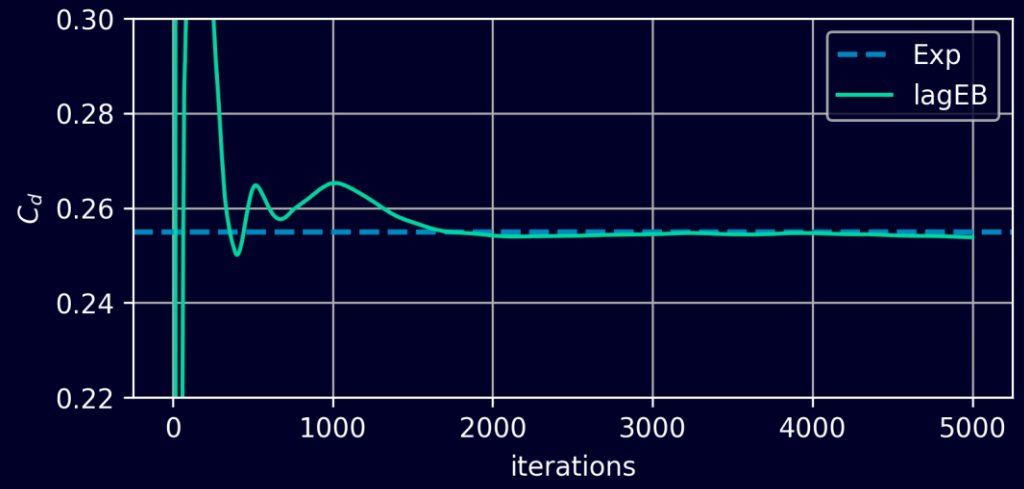
RANS: Lag Elliptic Blending [1]

- Steady
- Coupled Solver
- Grid Sequencing Initialisation
- Fast convergence
- Similar performance for configuration B





[1] Lardeau et al. (2016). Development of an elliptic-blending lag model for industrial applications. AIAA 2016-1600.

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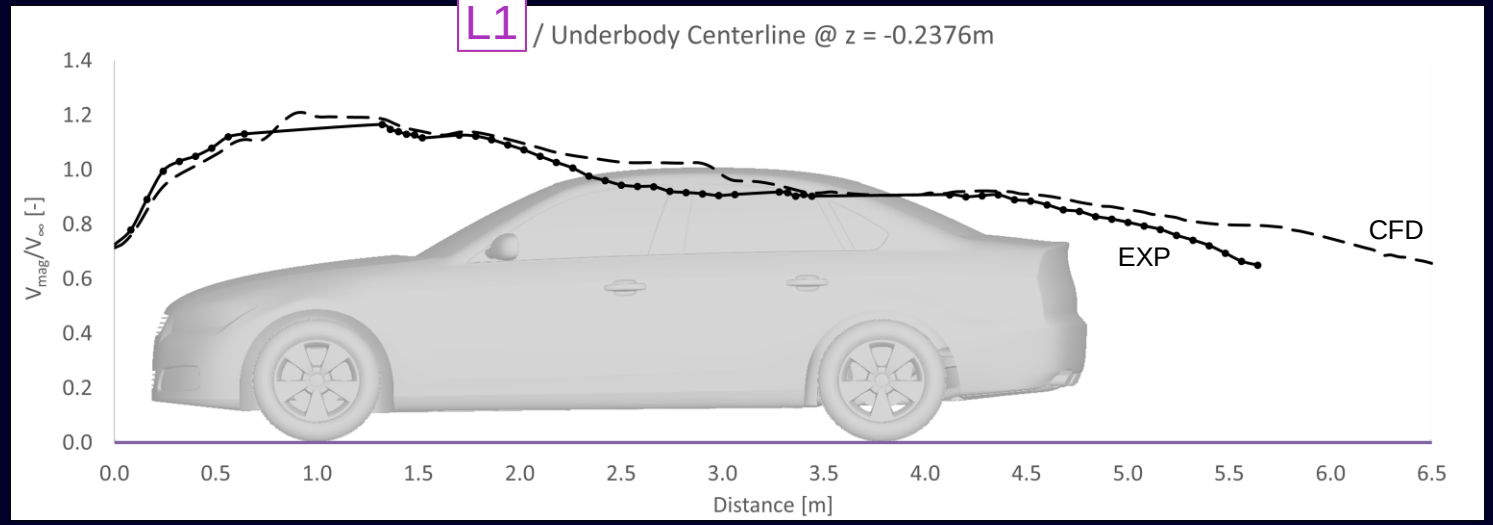
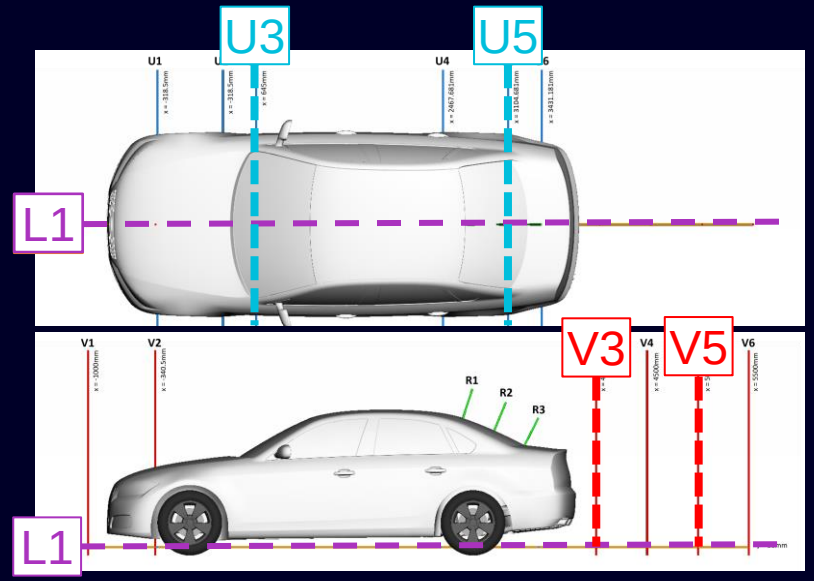
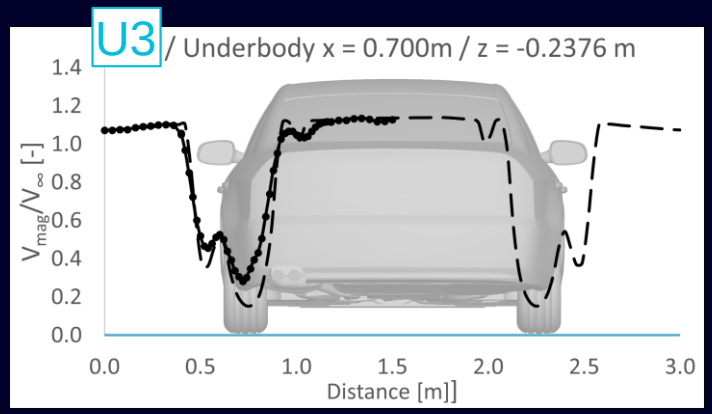
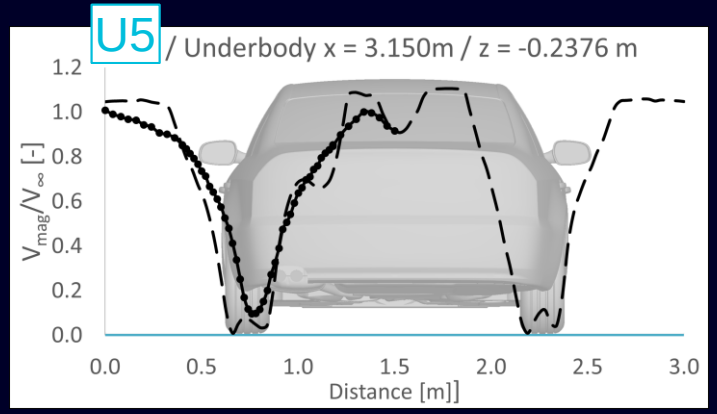
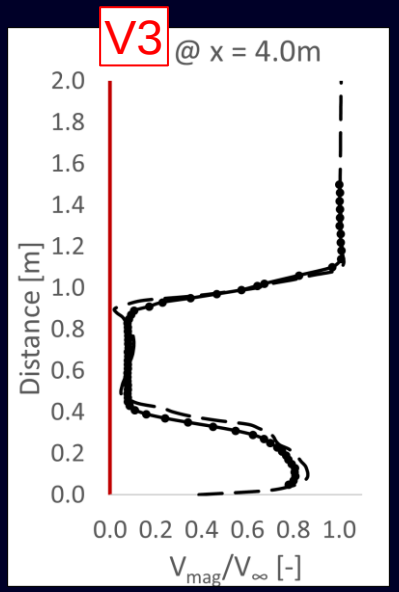
RANS: Lag Elliptic Blending

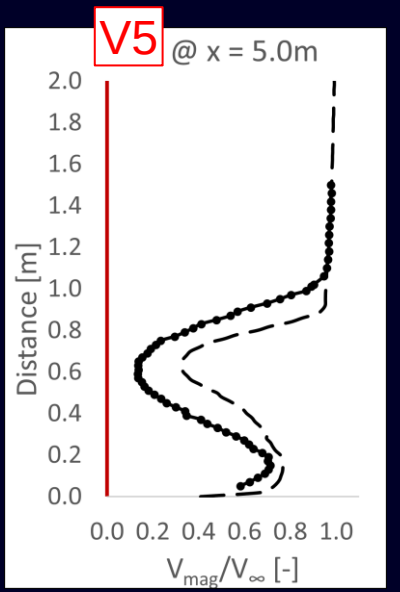












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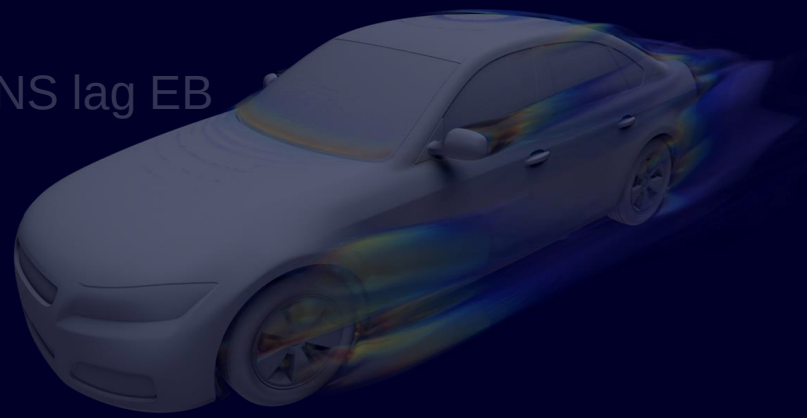
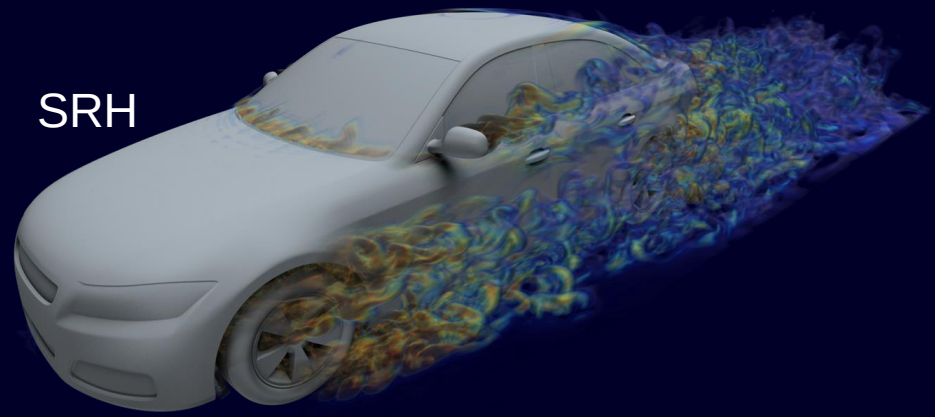
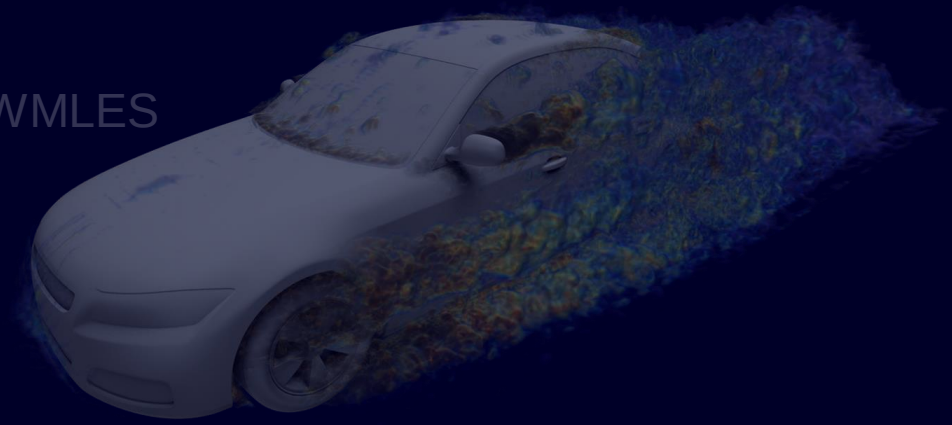
RANS lag EB



SRH



WMLES



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Scale-Resolving Hybrid (SRH) Model

Model Description:

- Increased fidelity and accuracy over URANS-type models
- Aims for improved robustness and mitigation of grey-area effect compared with DES models
- Based formally on temporal filtering

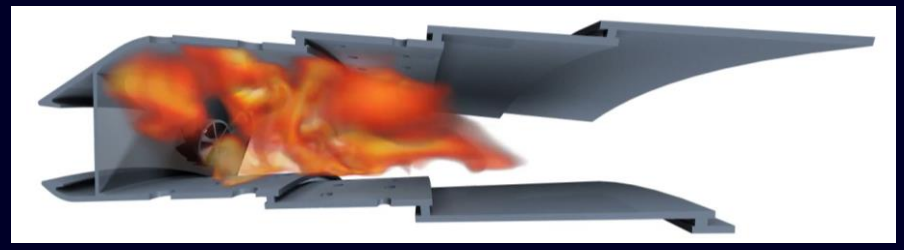
When/Why To Use It:

- Potential improvement to existing URANS and DES simulations
- Minimal additional computational cost
- Minimal effort to switch existing simulations to SRH

Typical Applications:

- Mid-level fidelity unsteady simulations typical of DES applications
- Simulations where fully resolved LES cost is prohibitively high

URANS



SRH

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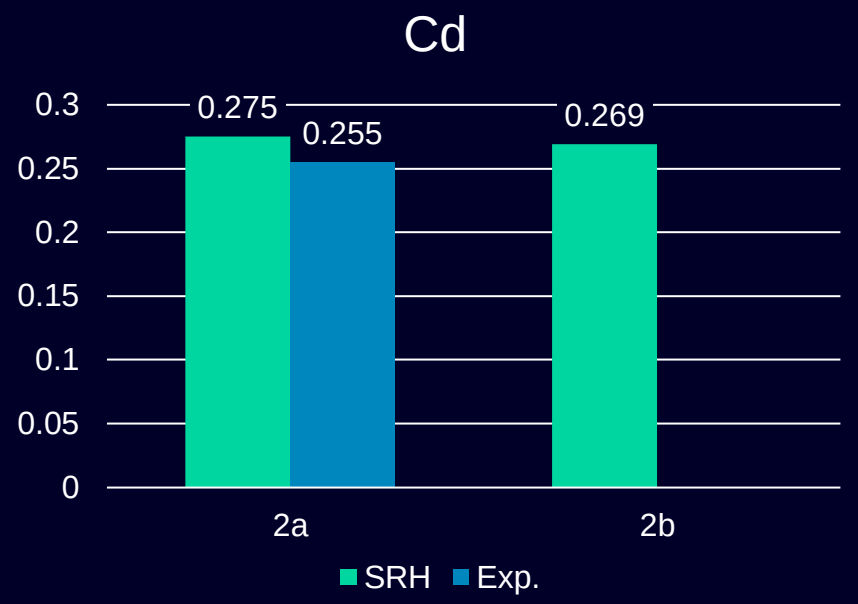
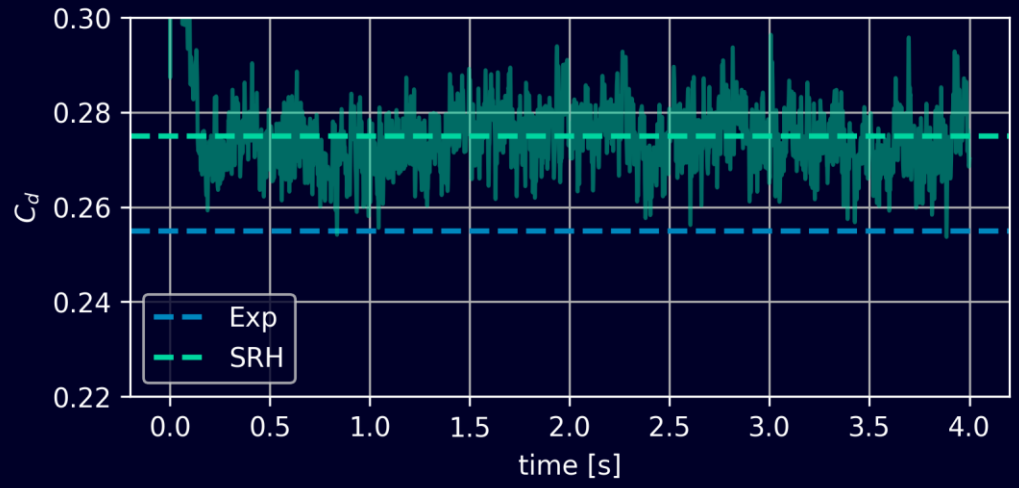
Scale-Resolving Hybrid (SRH) Model [2]

- Time accurate, implicit unsteady
- SST model variant
- Total duration time = 4 s
- Averaging time = 3 s
- Restart from RANS
- Δt = 5e-4 s
- Very similar results for Δt = 2.5e-4 s





[2] Duffal et al. (2021) Development and Validation of a New Formulation of Hybrid Temporal Large Eddy Simulation. Flow Turbulence and Combustion.

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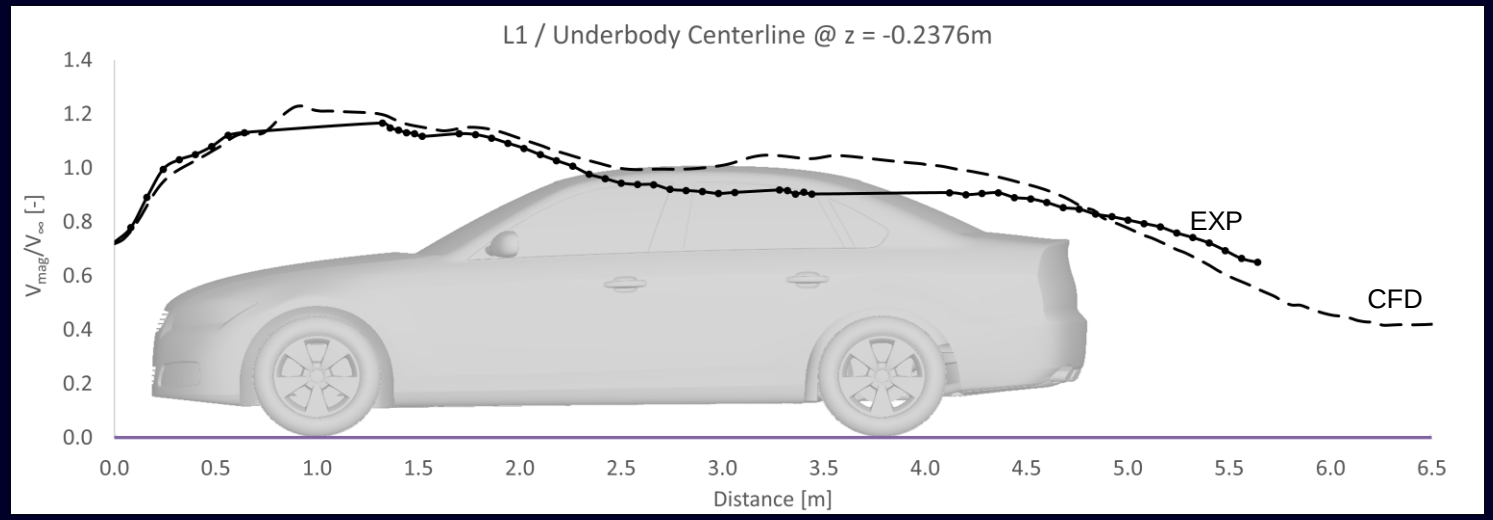
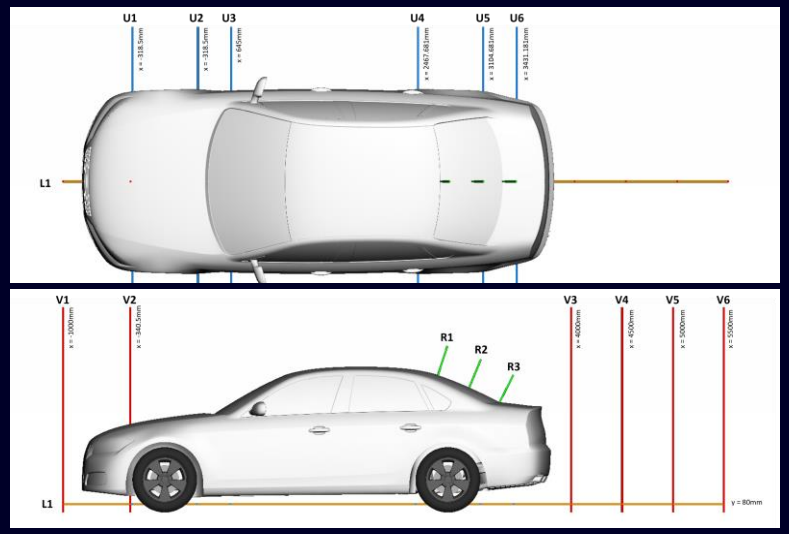
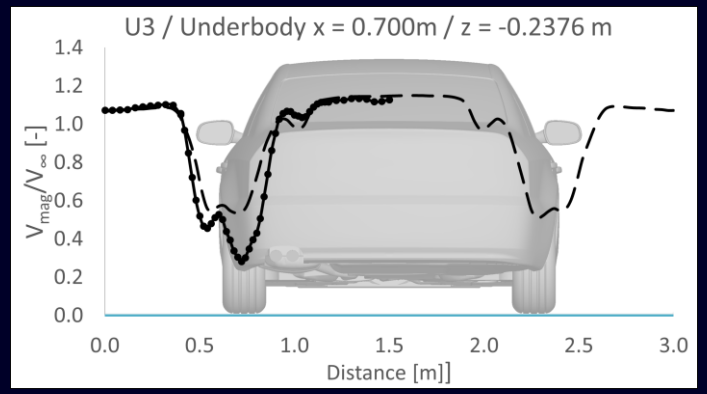
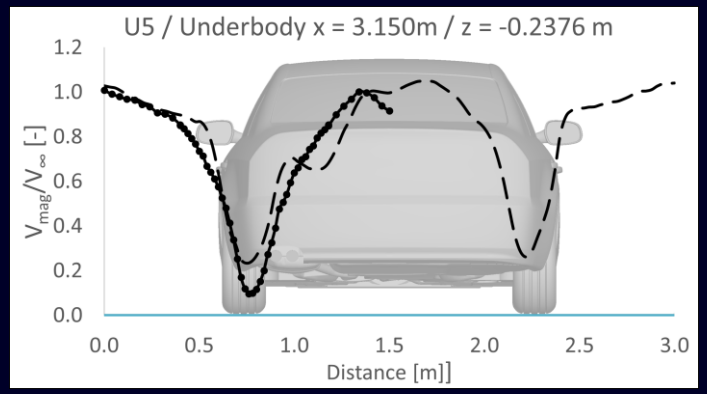
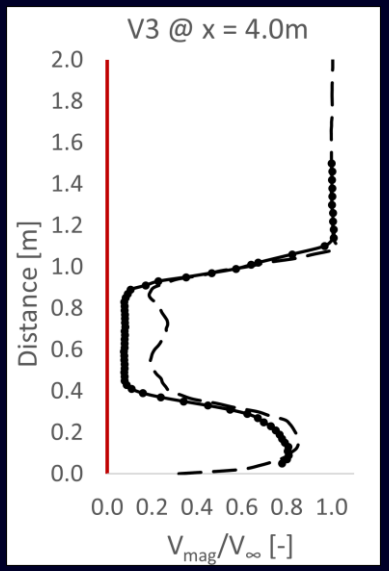
Scale-Resolving Hybrid (SRH) Model

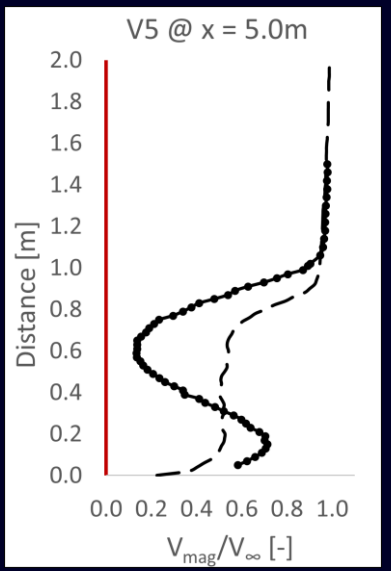












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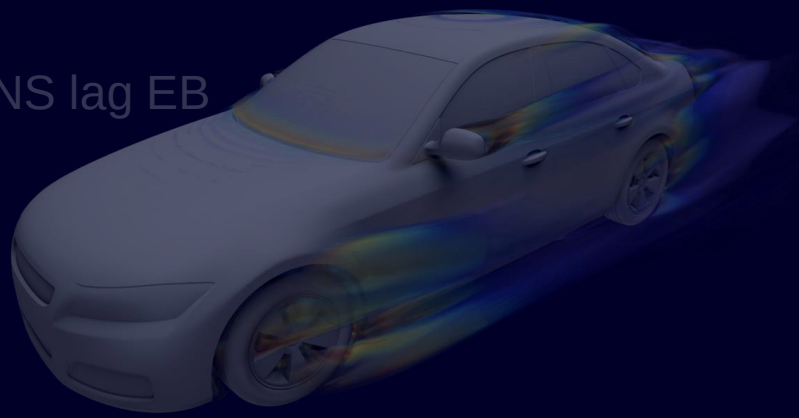
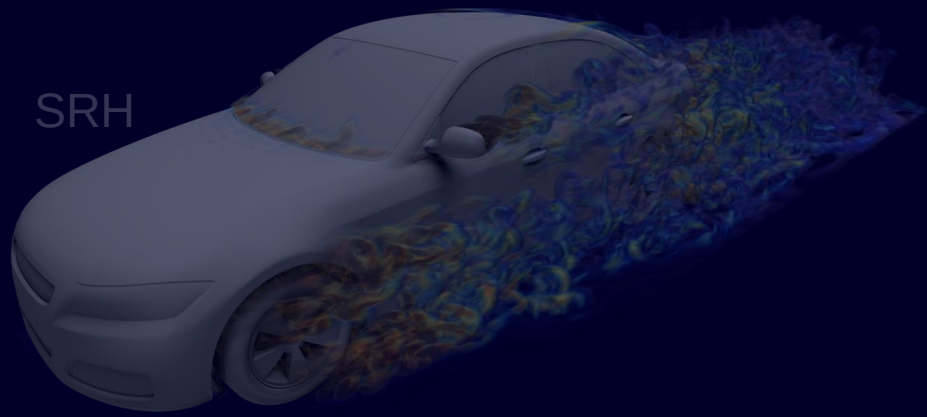
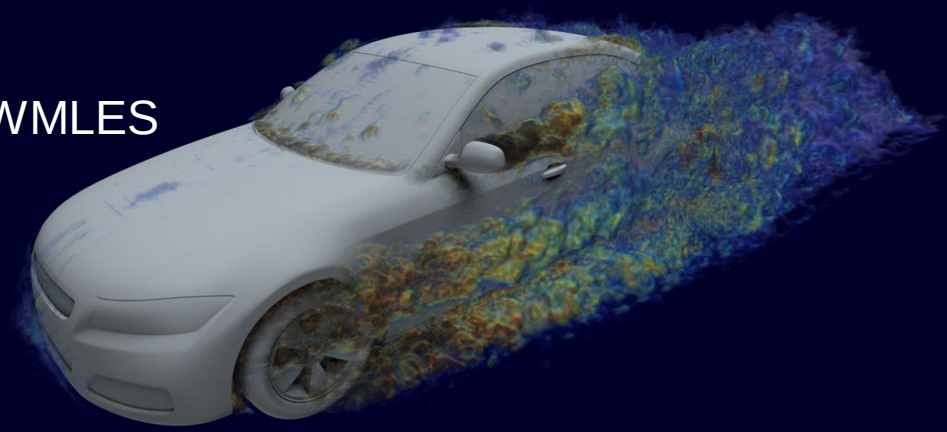
RANS lag EB



SRH



WMLES



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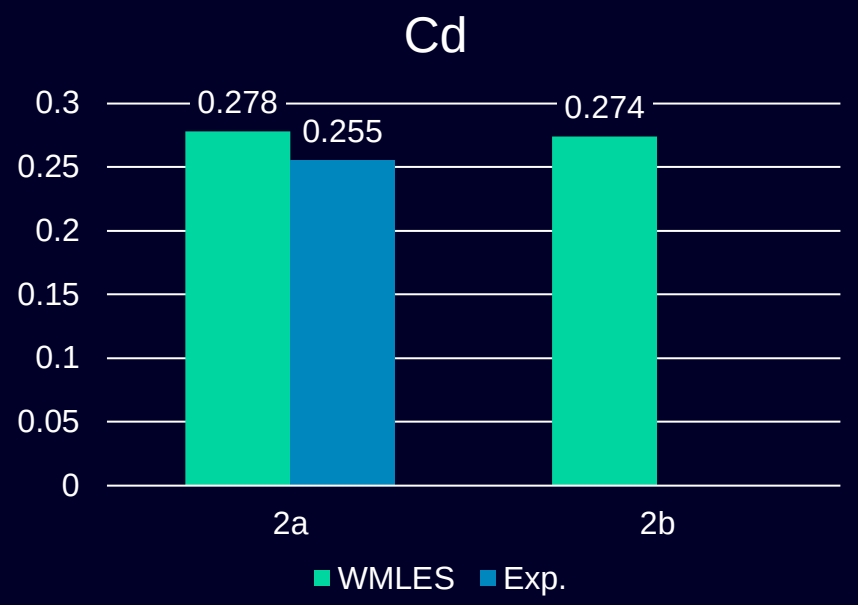
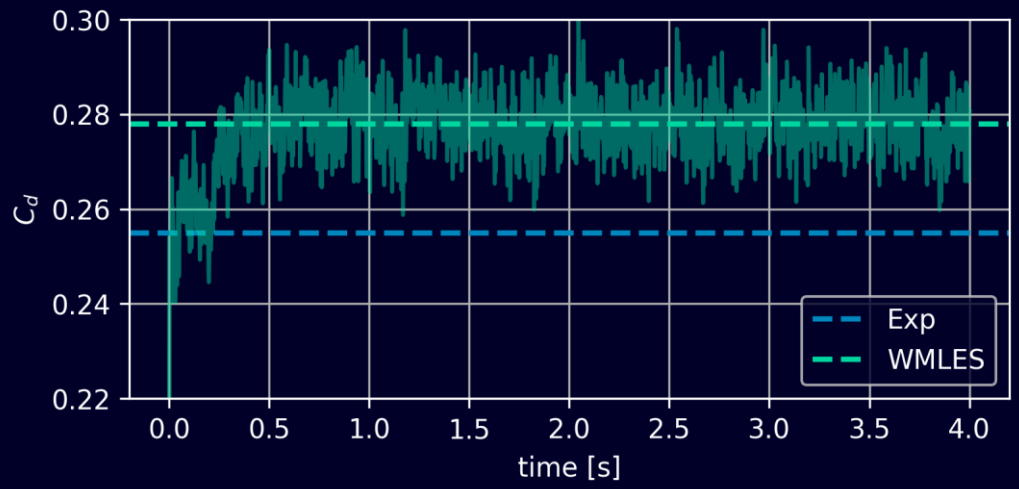
WMLES

- Time accurate, implicit unsteady
- WALE model
- Total duration time = 4 s
- Averaging time = 3 s
- Restart from RANS
- Δt = 2.5e-4s





EXP

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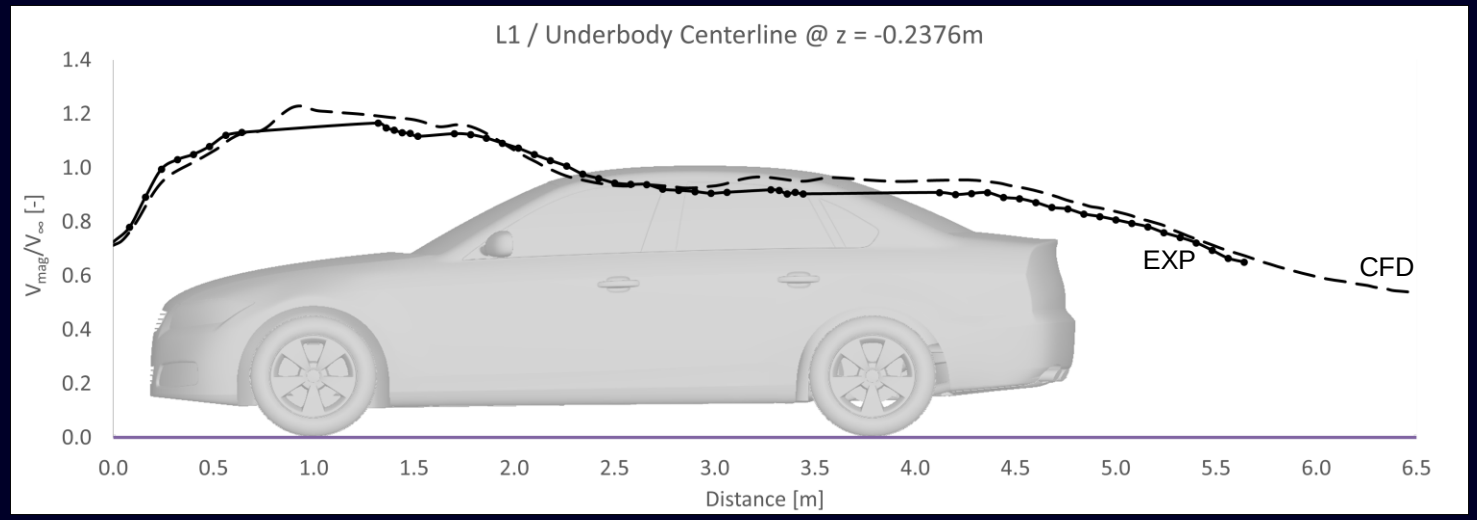
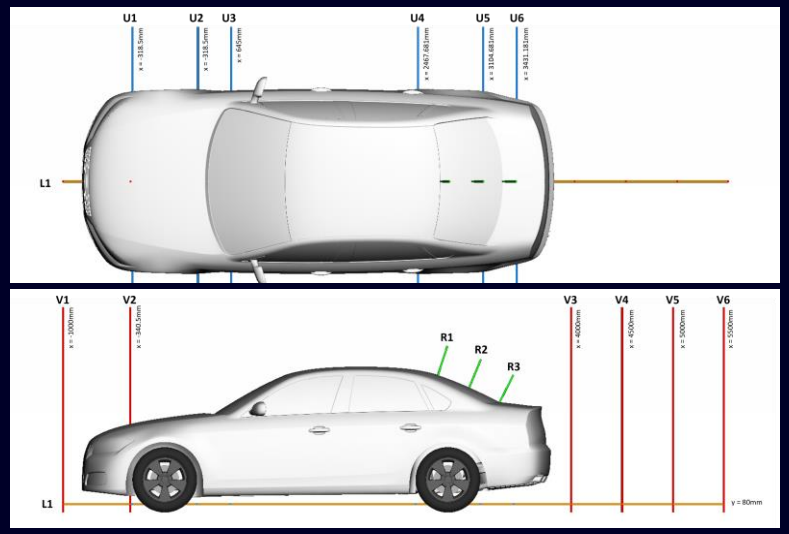
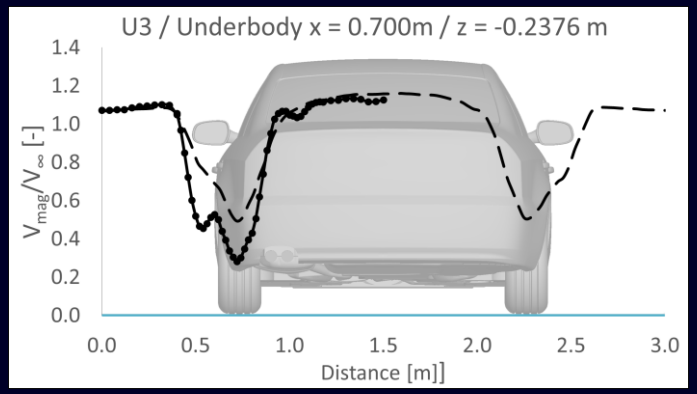
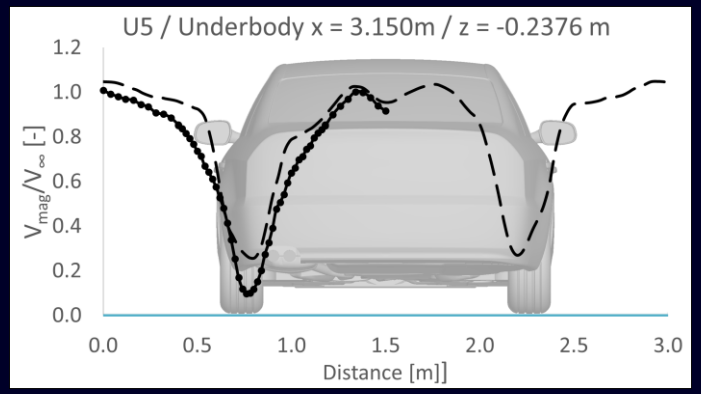
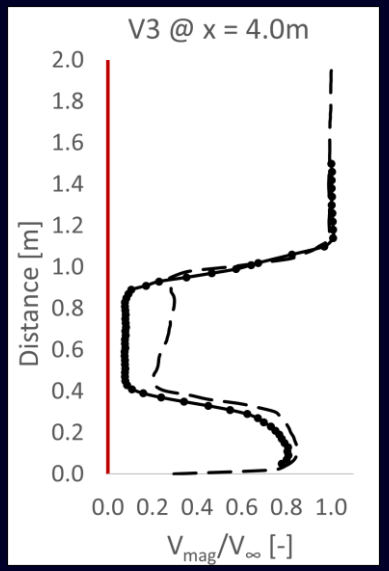
WMLES

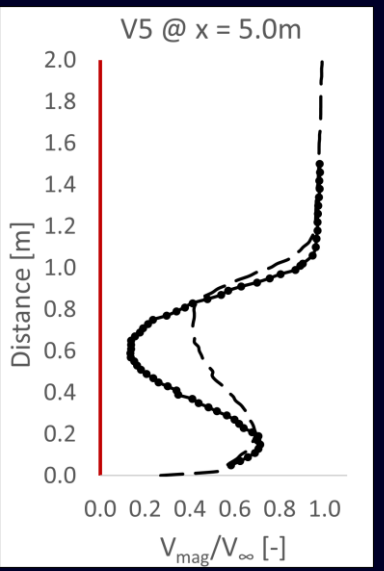












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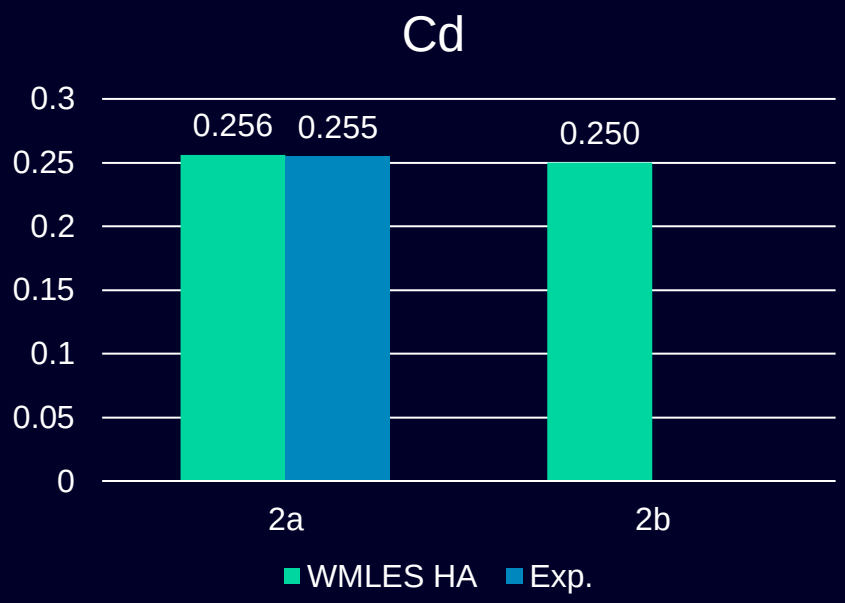
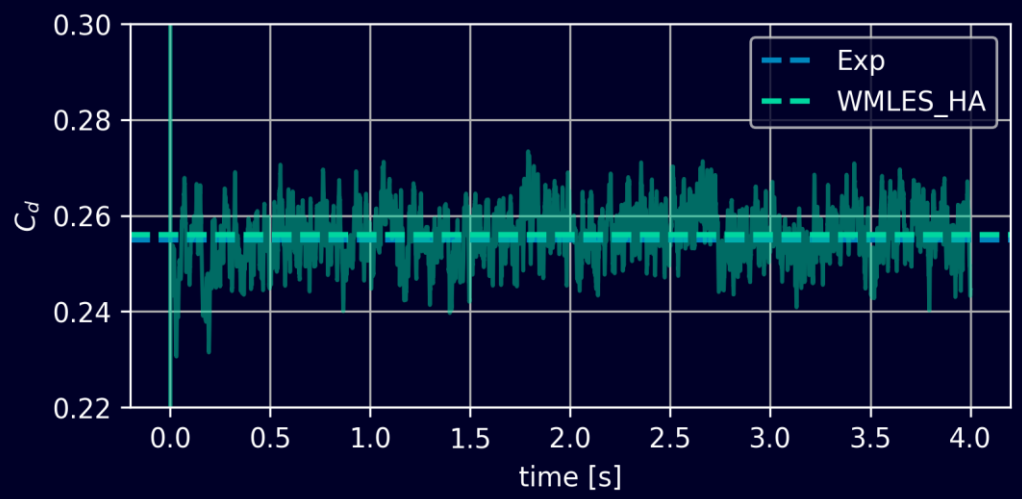
WMLES High Accuracy (HA)

- Time accurate, implicit unsteady
- WALE model
- Total duration time = 4 s
- Averaging time = 3 s
- Restart from RANS

- MUSCL/CD scheme
- High accuracy temporal scheme
- Δt = 1e-4 s





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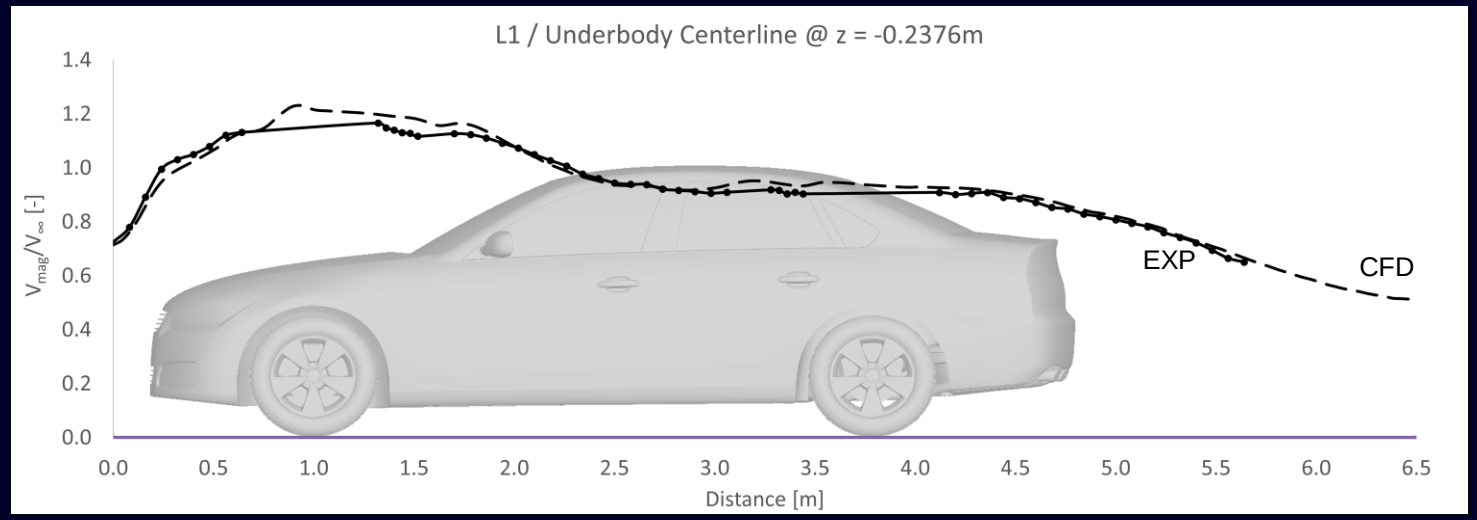
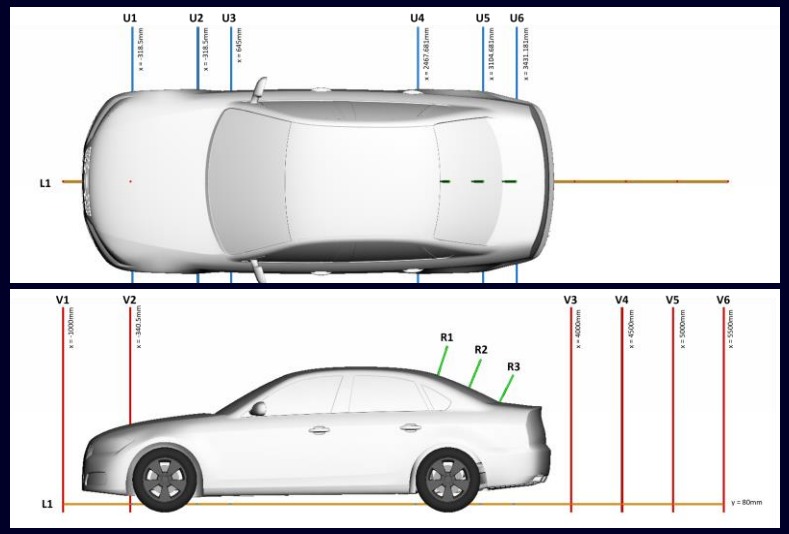
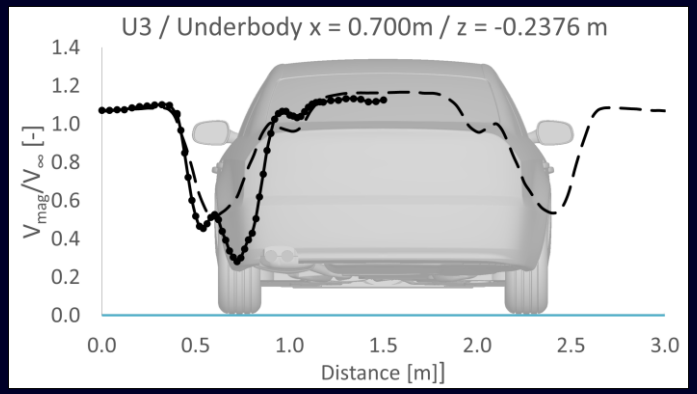
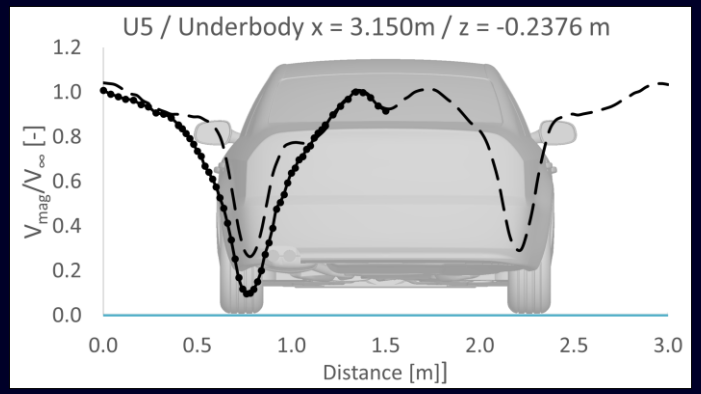
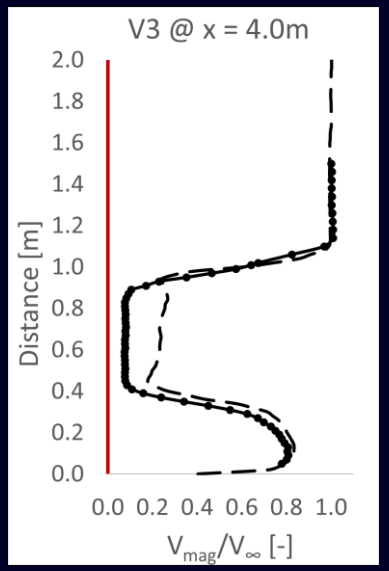
WMLES HA

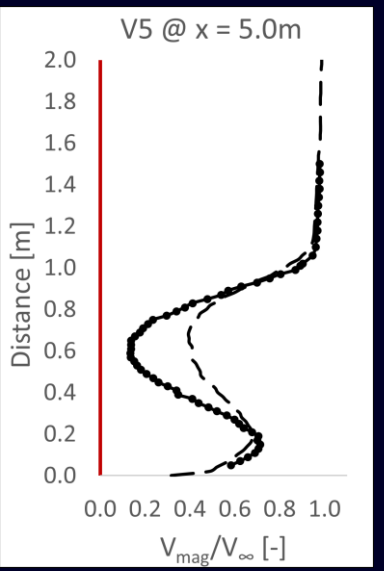












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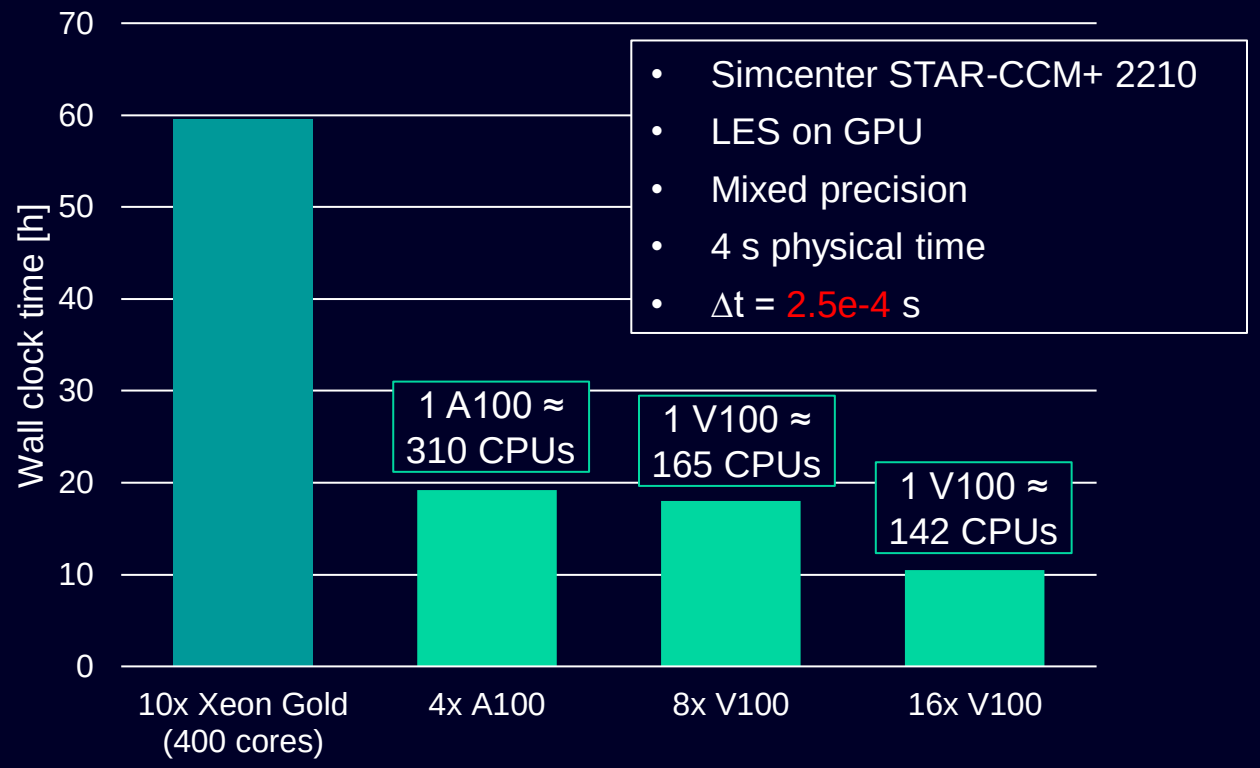
WMLES: performance

	Drag Coeff.	Δt (s)	Wall clock time
Experiments (2a)	0.255		
WMLES	0.278	2.5e-4	10 hours on 16 NVIDIA V100
WMLES high. acc.	0.256	1.0e-4	25 hours on 16 NVIDIA V100



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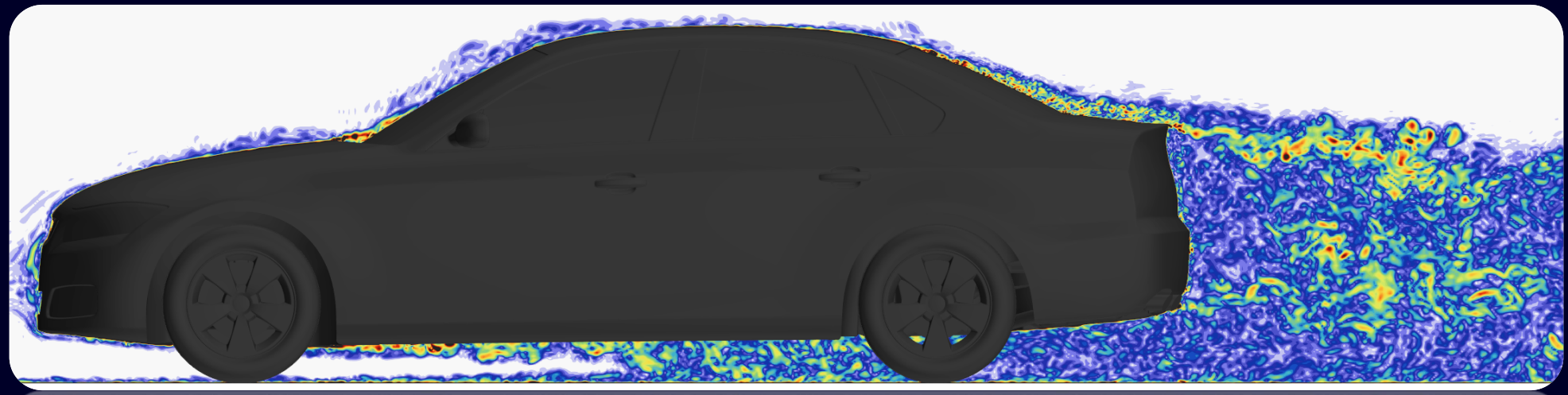
Conclusions

- Tested 3 different turbulence modelling approaches: RANS lagEB, SRH and WMLES
- LagEB is in very good agreement with experiments
- WMLES require appropriate numerical set-up
- SRH less dependent on Δt than WMLES
- Delta between the A and B configurations is consistent between the 3 approaches
- GPU acceleration is a key enabler for scale-resolving simulations in an industrial environment



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