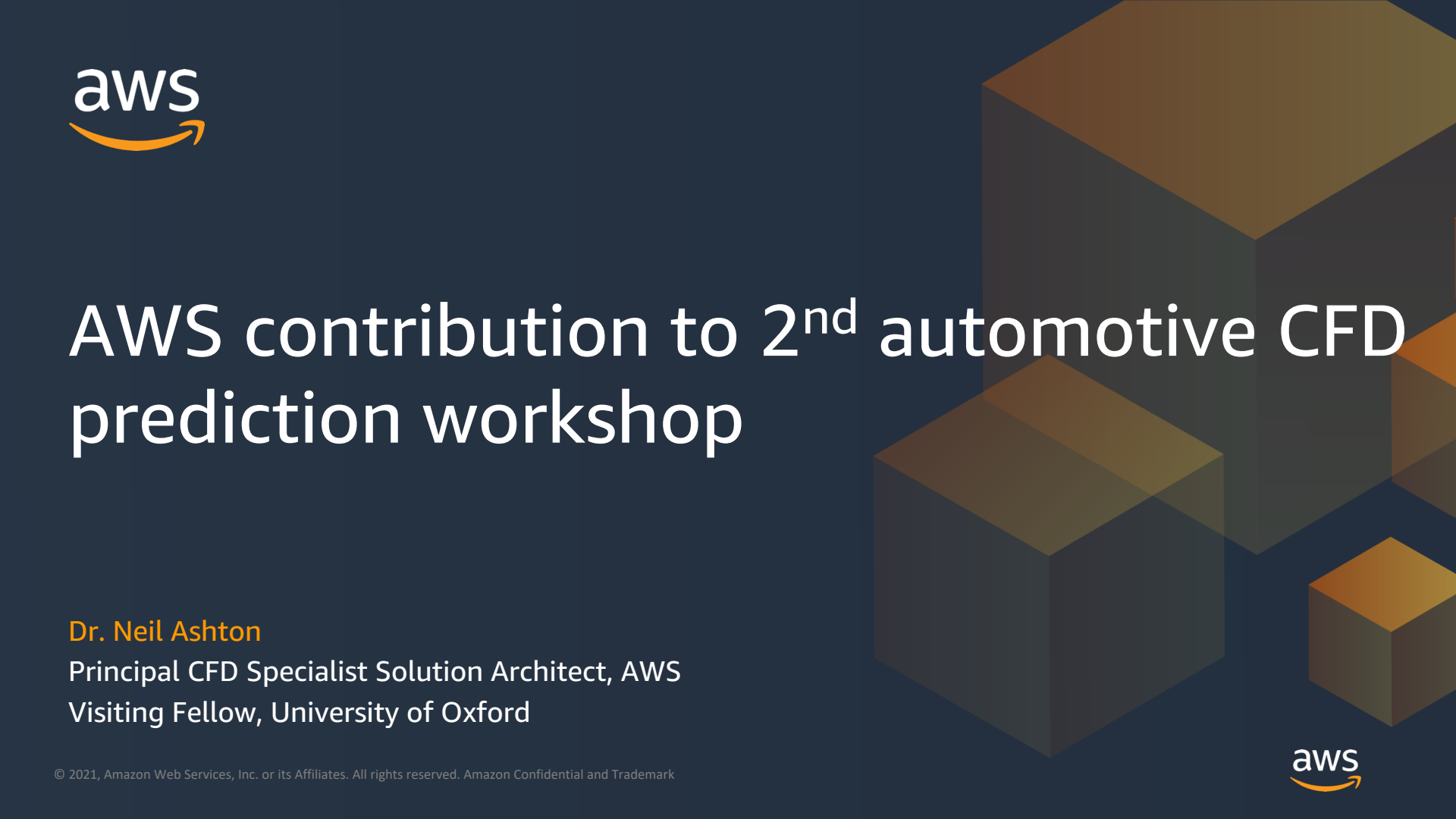


AWS contribution to 2nd automotive CFD prediction workshop

Dr. Neil Ashton
Principal CFD Specialist Solution Architect, AWS
Visiting Fellow, University of Oxford

Motivation

- Keen to see how well we can correlate to the exp. data
- Tried to use identical settings from the 1st automotive workshop
- Looking for sensitivities i.e is it DDES/LES, RANS model, time-step etc
- Keen to explore HPC implications

Simulation setup

- Committee ANSA low y+ & high y + grids
- STAR-CCM+ v16.02 (Mixed Precision unless specified otherwise)
- Segregated pressure-based
- 2nd order temporal (dual-time stepping)
- 2nd order hybrid upwind-central (STAR-CCM+ default ct changed from 1 to 0.1)
- Minmod gradient reconstruction
- Time step default $1e^{-4}$ (unless stated otherwise) CFL<~1 in critical regions
- Range of turbulence models (SA,SST,lag DDES/IDDES)
- All solutions started from a RANS pre-courser simulation
- All simulations run to at least 4s but some run to 7.5s to ensure enough time-averaging

aws

HPC Setup

- Amazon Web Services (AWS)
- Amazon EC2 c5n.18xlarge (Intel Skylake 36 core – 192Gb RAM)
- Elastic Fabric Adapter (EFA) network interconnect IntelMPI 2019.8
- AWS ParallelCluster to create the HPC cluster dynamically
- 20TB Lustre (Amazon Fsx for Lustre) file system for parallel I/O
- NICE DCV to remotely visualize results on a GPU (Amazon EC2 g4dn.16xlarge) – Nvidia T4

aws

What simulations were run?

Case2-high-y+
SA-DDES
SST-DDES
SA-IDDES
SST-IDDES
WALE-LES

Case2-high-y+-SA-DDES
Timestep= $8e^{-4}$
Timestep= $4e^{-4}$
Timestep= $2e^{-4}$
Timestep= $1e^{-4}$ -

Case2-lowy+
SA-DDES
SST-DDES
SST-DDES (DP)
SA-IDDES
SST-IDDES
LAG-EB--DDES

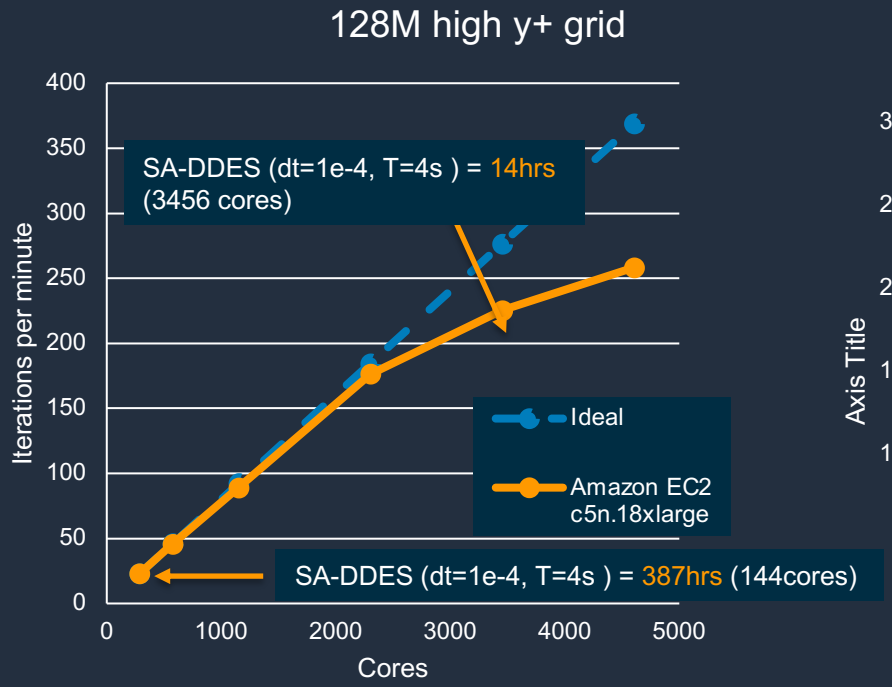
Some were completed after the deadline – they will be shared to committee for transparency but won't be currently shown in the cross-plotting

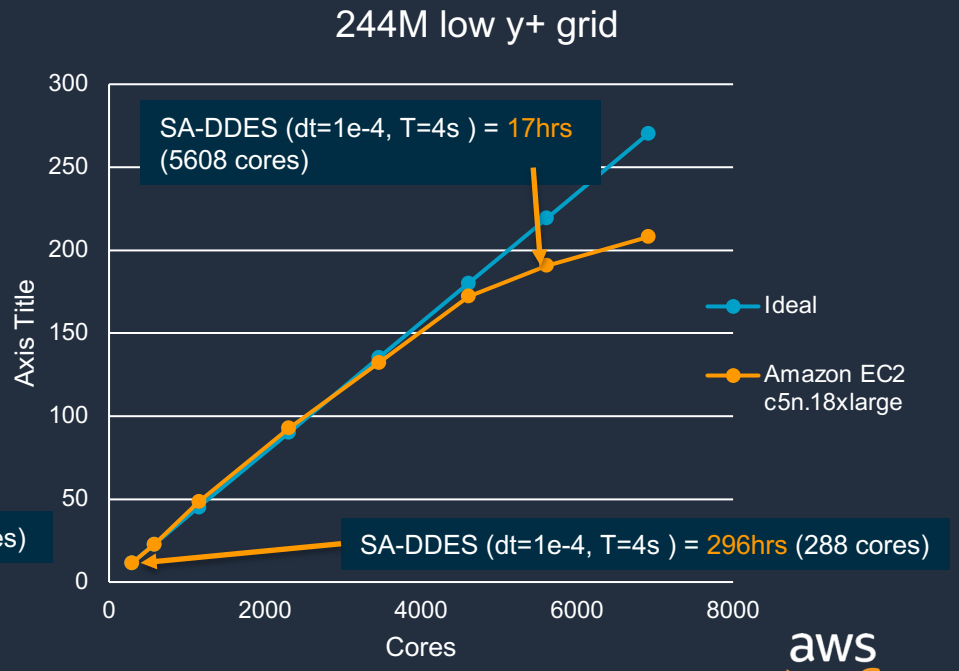
aws

HPC Performance

Feedback from industry is that accuracy has to be balanced against computational time.

Ability to run to the limit of the CFD code means best chance of ‘engineering time-scales’.

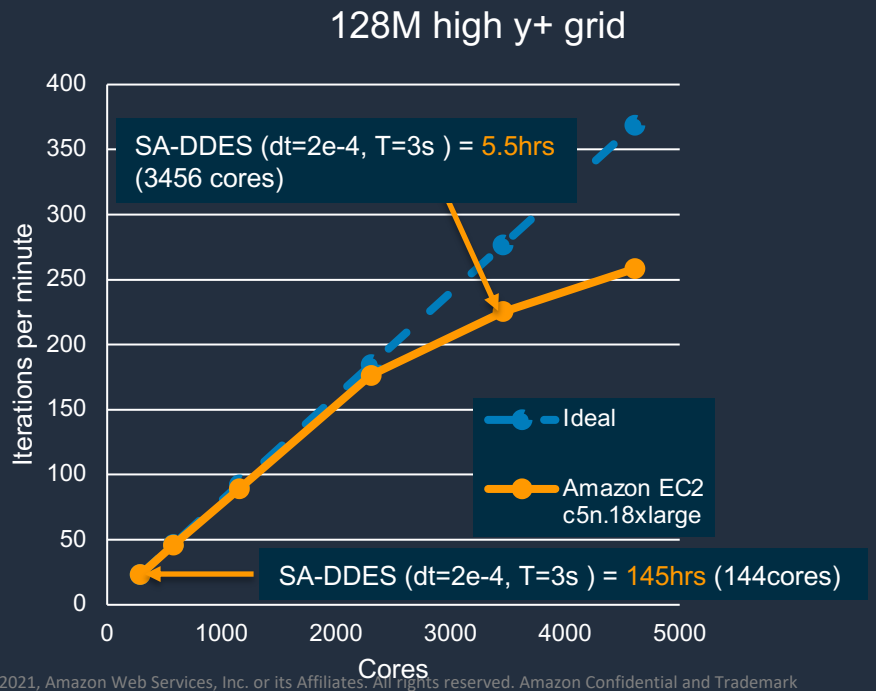


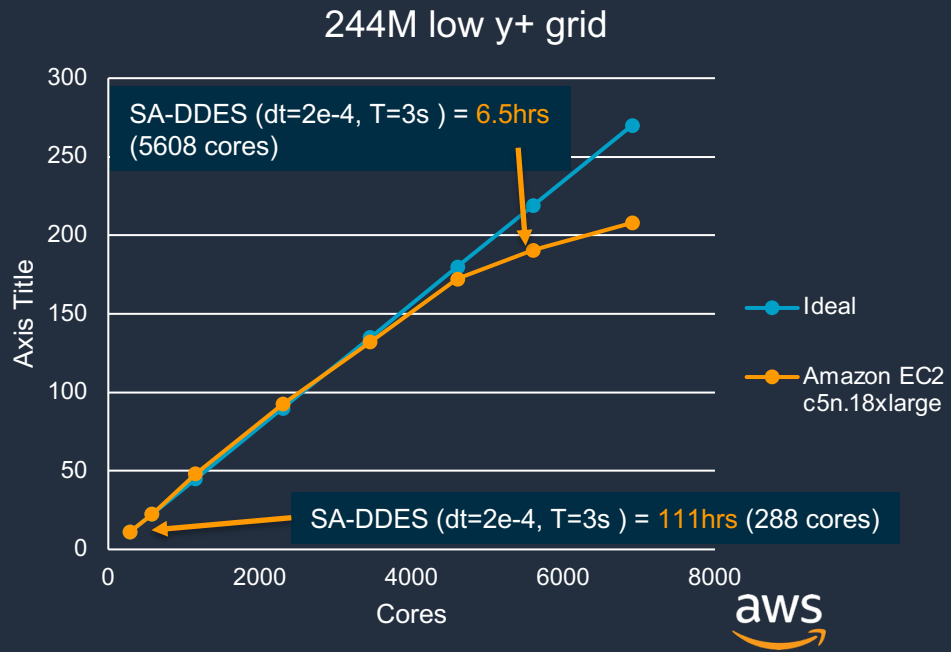


HPC Performance

Larger time-step and less total time (more in line with industry processes) leads to same working day simulation. If company doesn't have access to 3456 cores but only 144 then we see why HRLM methods are too expensive and take too long to run. Middle ground of 24hrs for 500-1000 cores is common.

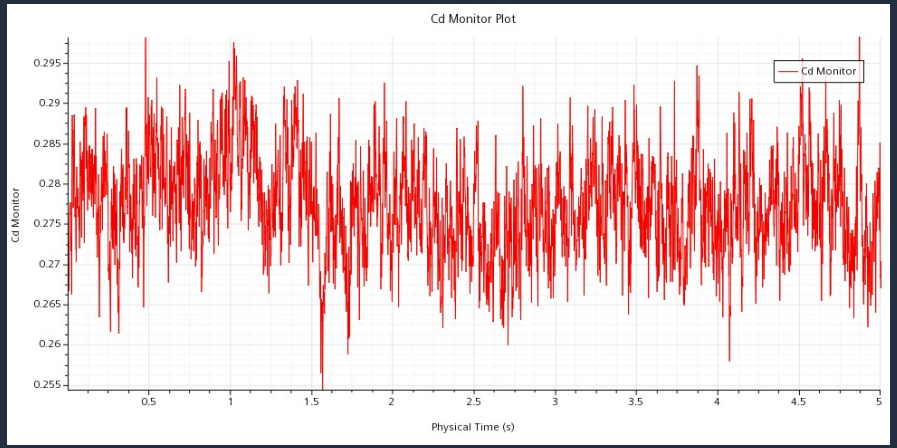
Alternative is to run much coarser time-step and coarser grid. Need to consider run-time/hpc. **GPU's may help.**

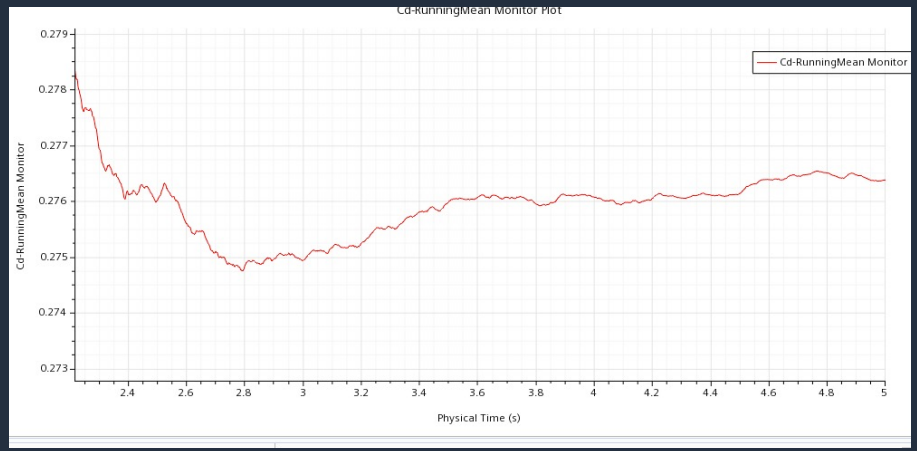




Running averages

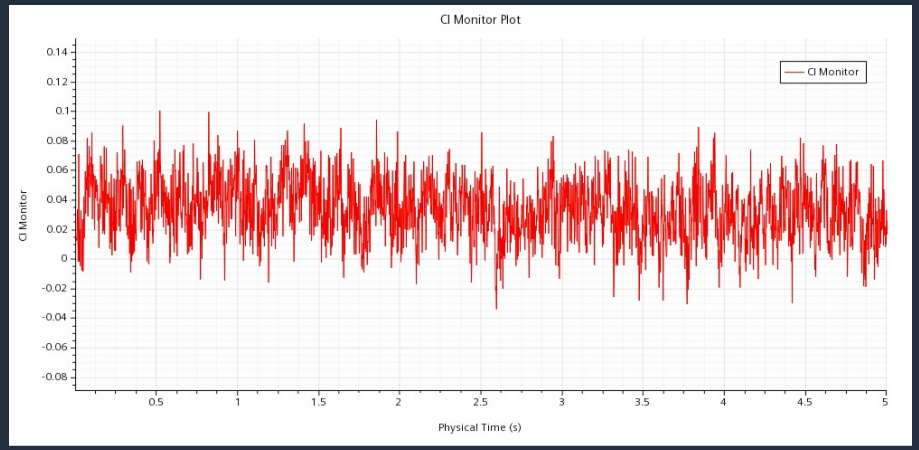
Focus on ensuring every single simulation was run longer enough. Largely 4s (starting averaging at 2s) but sometimes ran out to 7s to be extra sure.

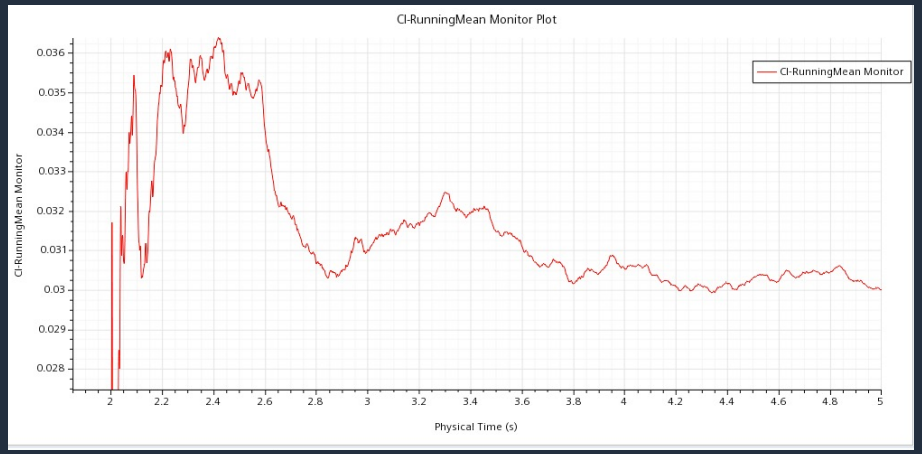




Running averages

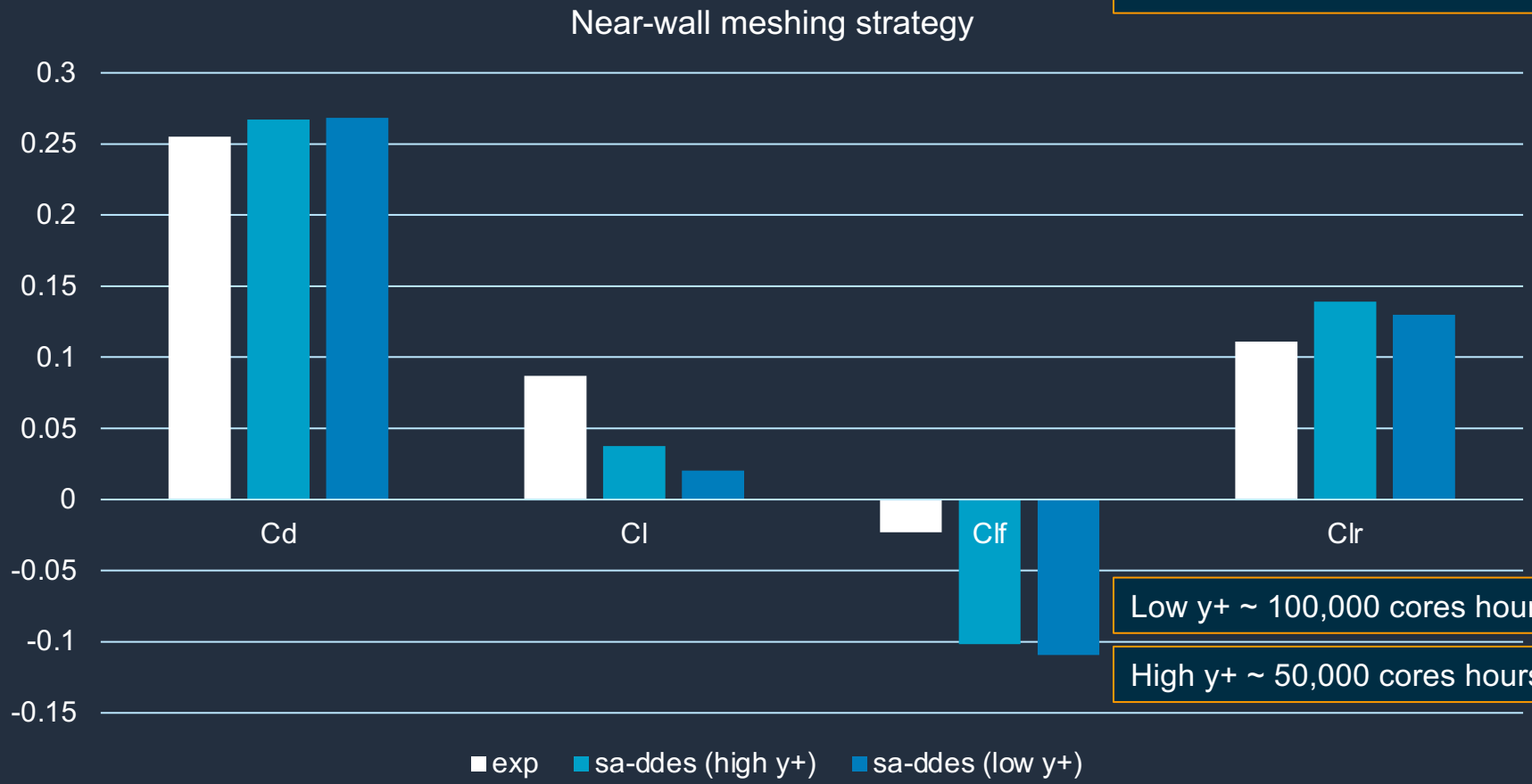
Focus on ensuring every single simulation was run longer enough. Largely 4s (starting averaging at 2s) but sometimes ran out to 7s to be extra sure.





Overview of results

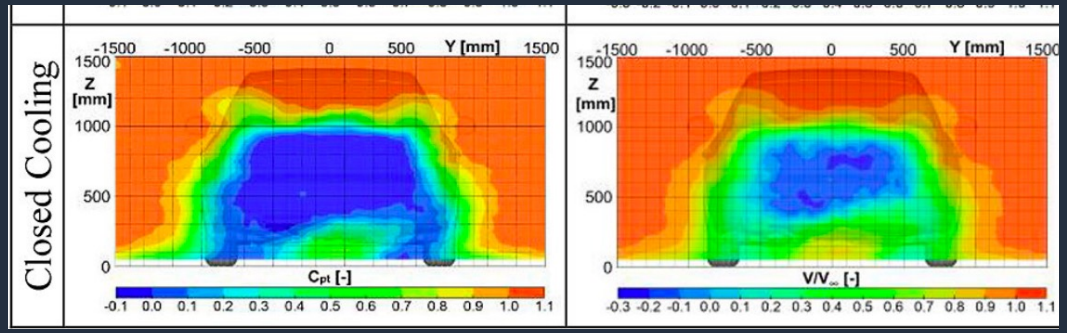
Small overall difference

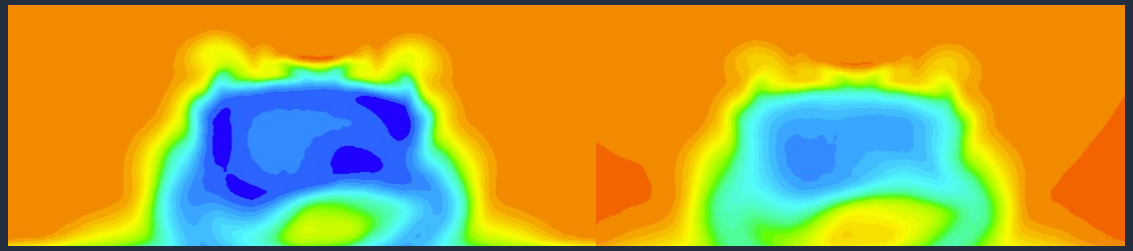


Low y+ ~ 100,000 cores hours

High y+ ~ 50,000 cores hours

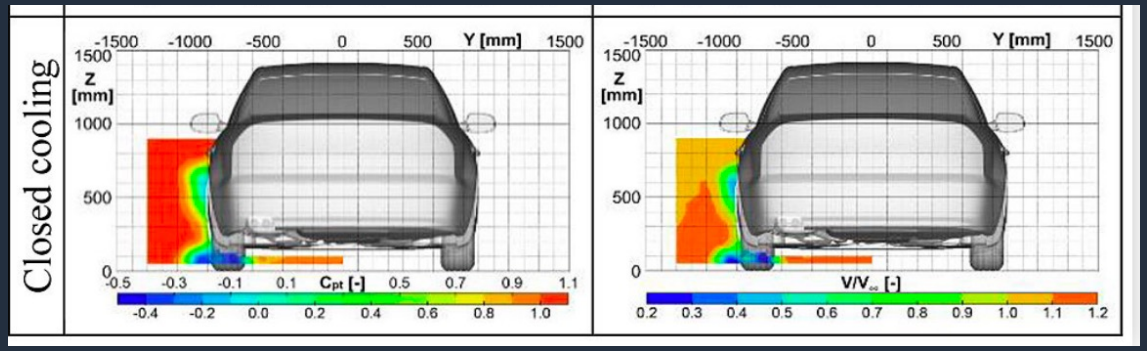
Overview of results – SA-DDES – low y+ - 4m

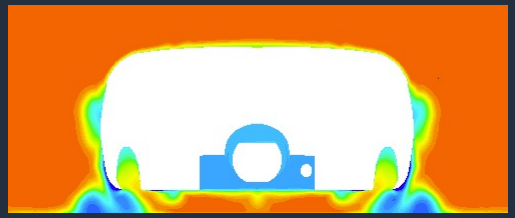


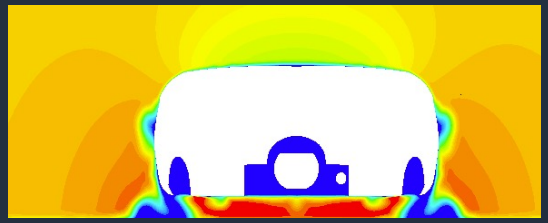


Will do a proper analysis once receive exp. data from organisers. Rear-flow looks reasonable (hence Clr agreement)

Overview of results – SA-DDES – low y+ - 0.4m

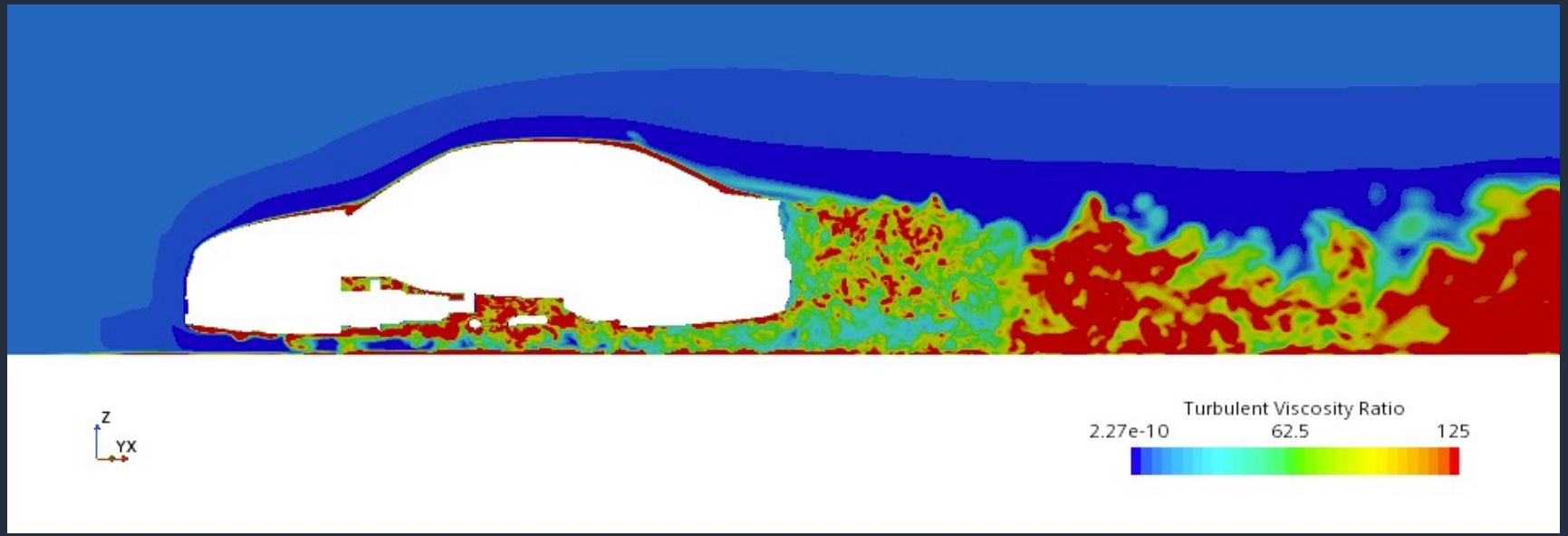






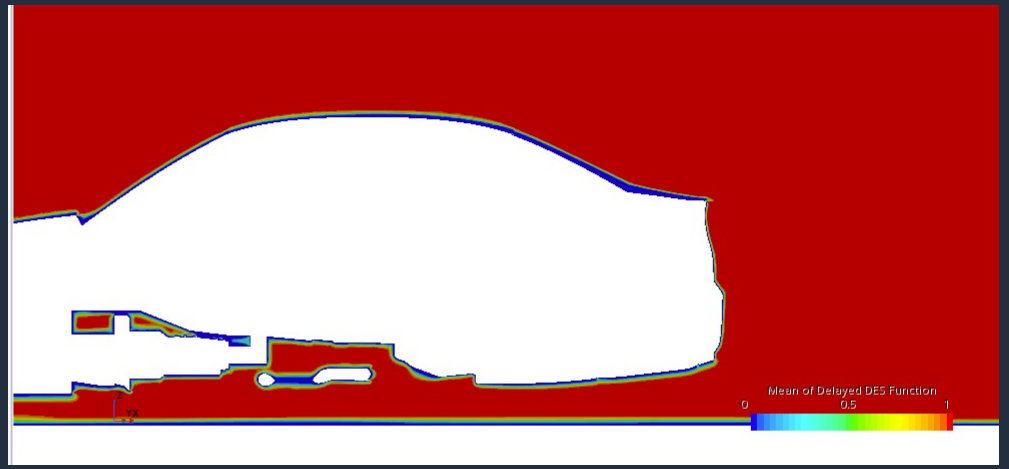
Will do a proper analysis once receive exp. data from organisers. Front-wheel flow looks worse correlation. May explain poor Clf prediction.

Mesh considerations



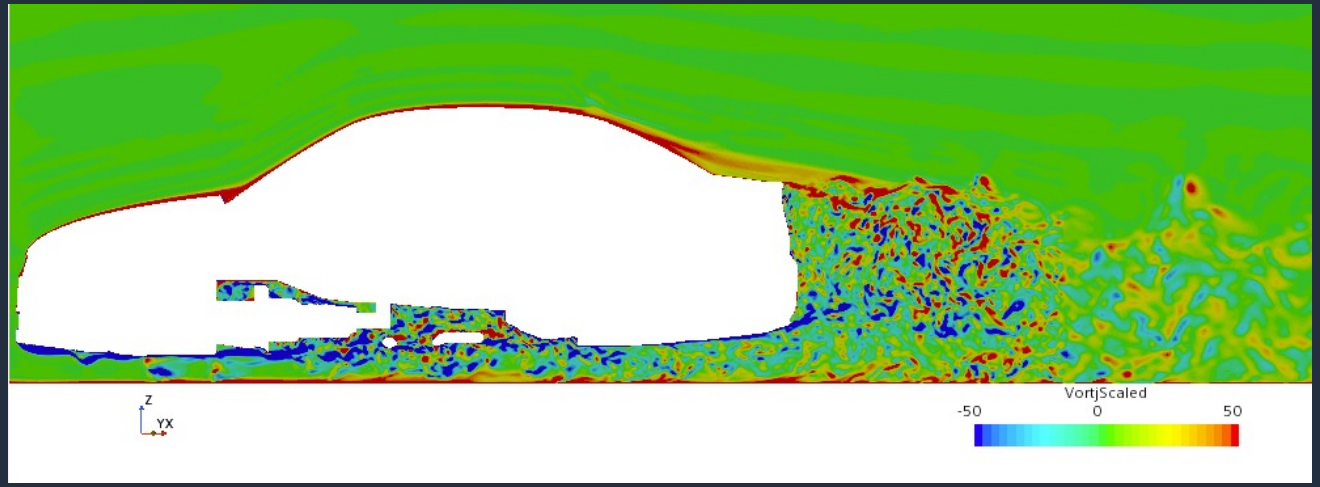
Reasonably large turbulent viscosity ratio (compared to best-practices) in the front wheel/under-floor. Often we would want ~50 for this Re number. Suggests even finer mesh may be required.

Mesh



Shielding function is robust with no drop-outs.

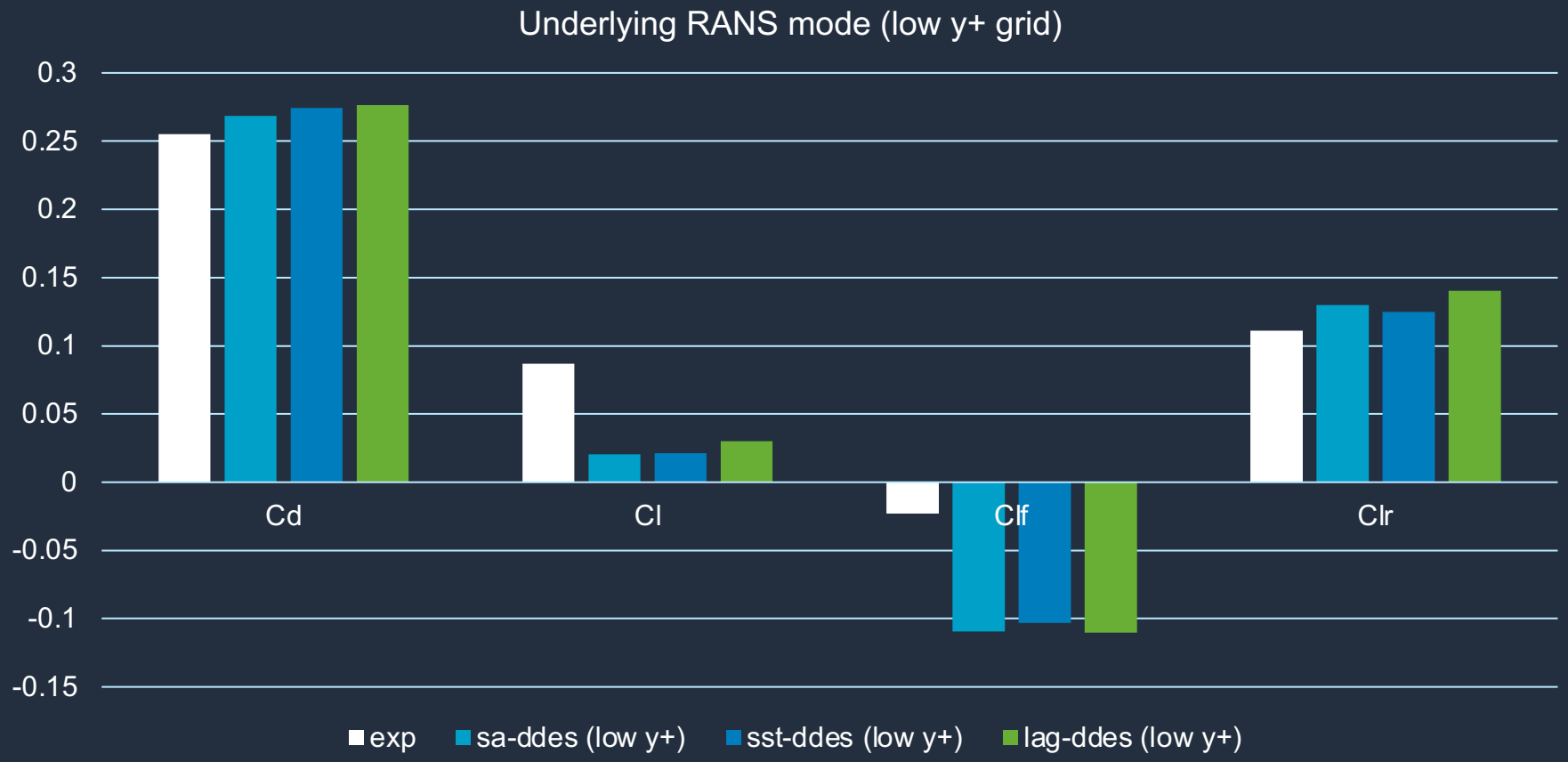
Mesh



Spanwise vorticity suggests resolved content but maybe slow transition in certain areas.

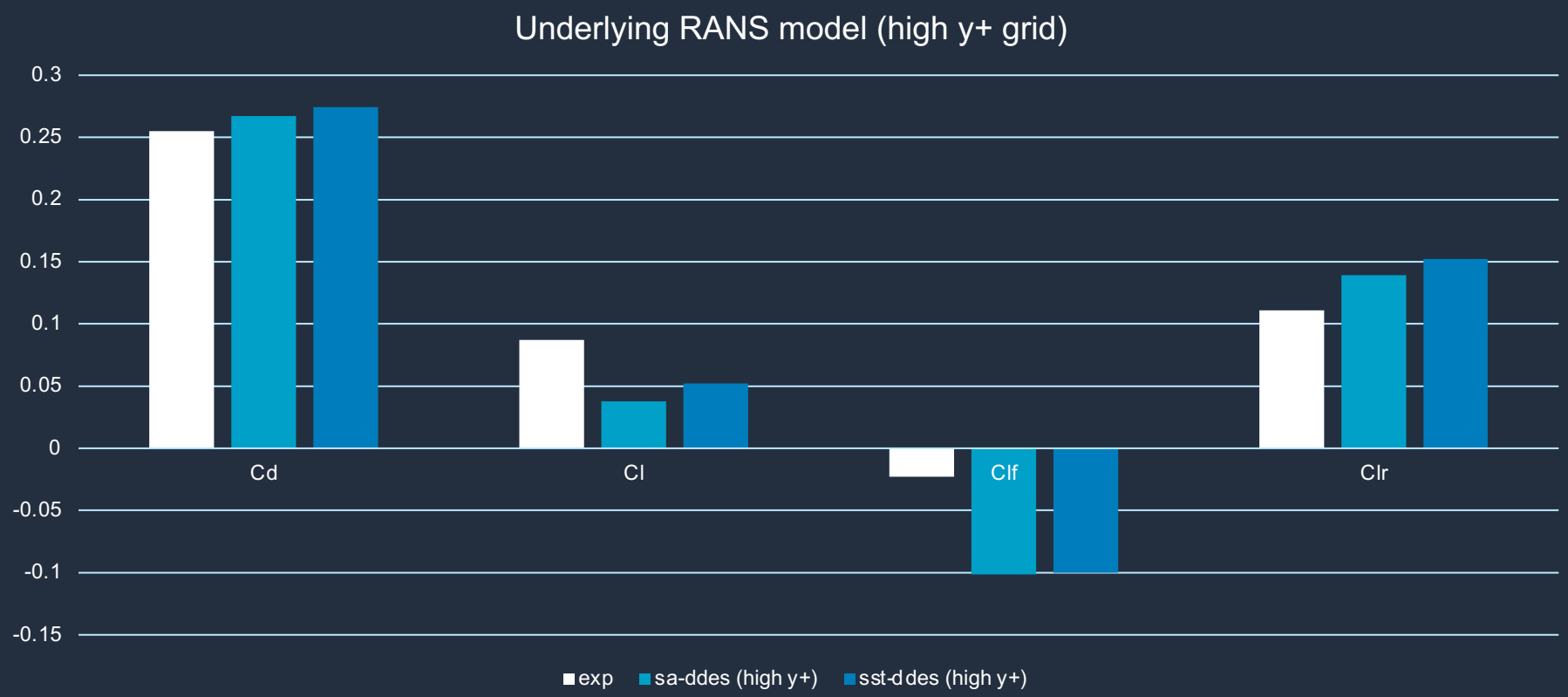
Overview of results

Some sensitivity but doesn't solve Clf issue



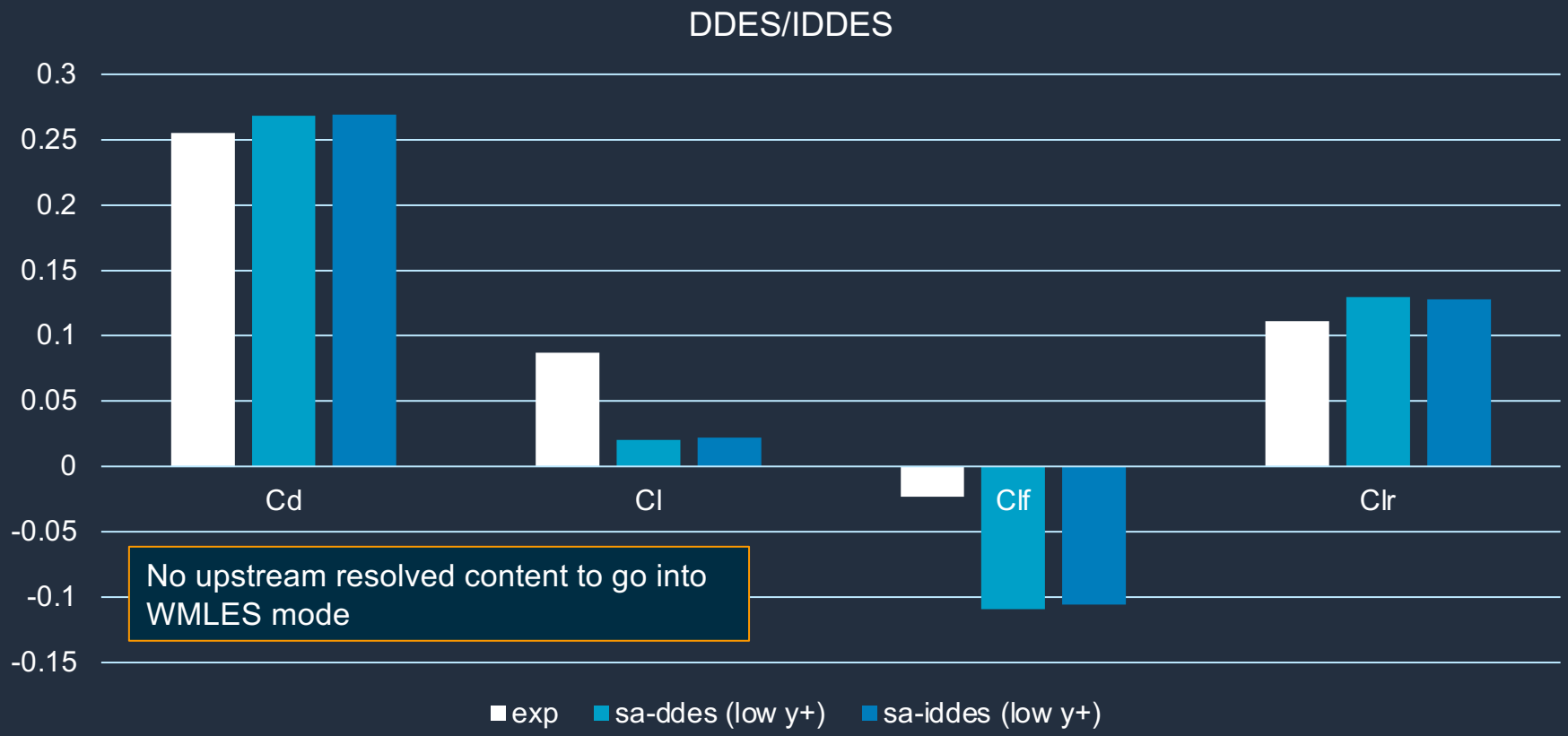
Overview of results

Similar change between high y+ and low y+



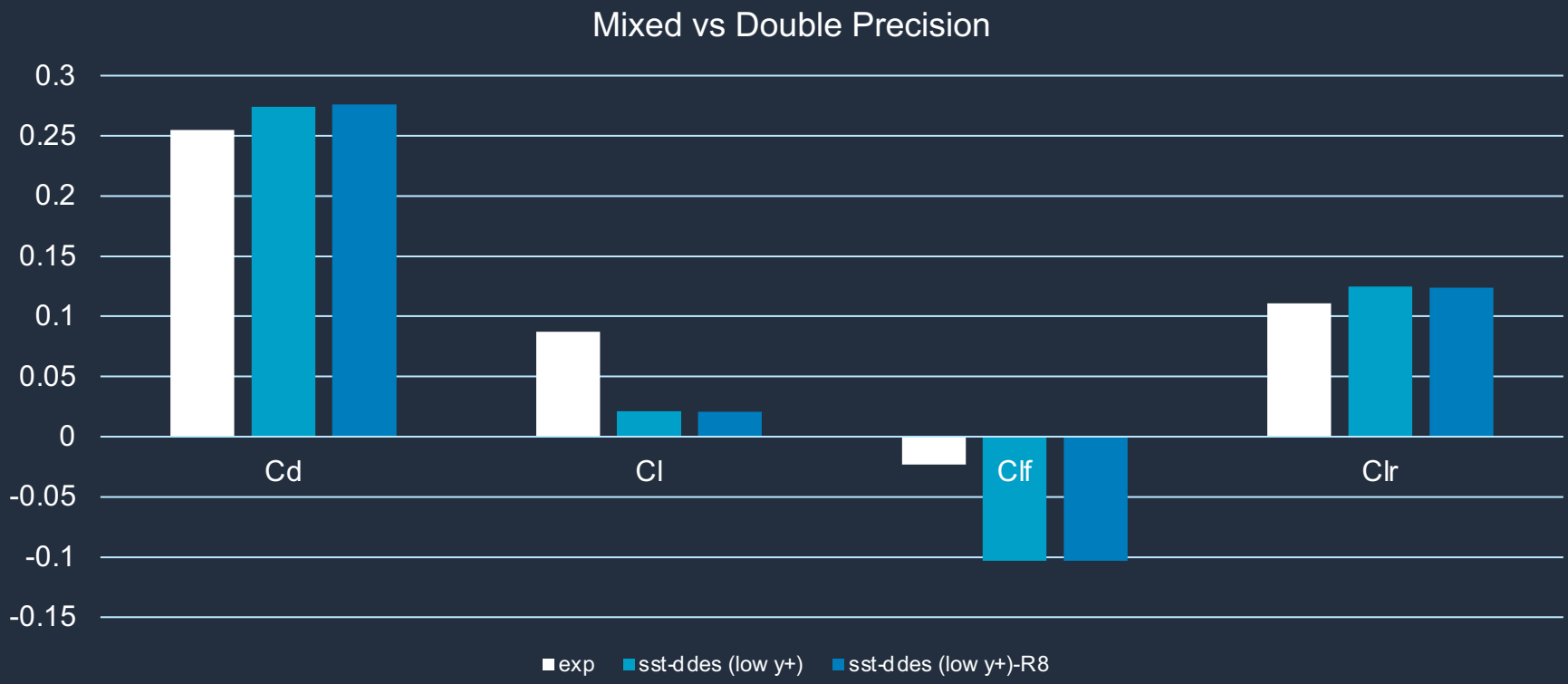
Overview of results

Minimal change between DDES & IDDES



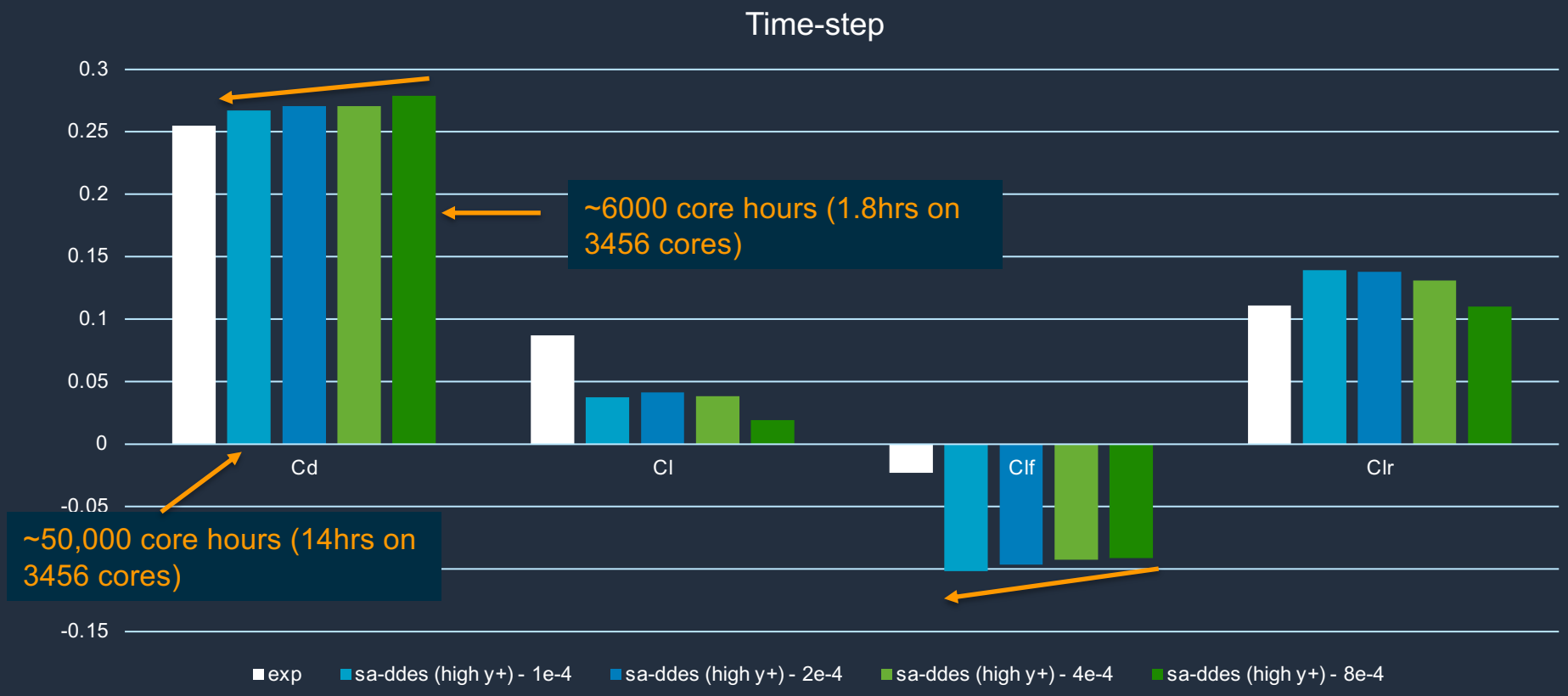
Overview of results

30% increase in computational cost for DP



Overview of results

Clear trend suggesting time-step hasn't converged.
Trend doesn't suggest Clf would be fixed by time-step reduction. Goes wrong direction.



Summary

- Correlation is poorer than hoped. No variation in DDES-style approach (DDES/IDDES),underlying model (SA,SST,lag), time-step influenced this significantly towards the right range.

- Clearly mesh has not been assessed other than high y+ /low y+ however mesh follows similar design to 1st auto workshop that showed better correlation.

- Need to look into the detail experimental data before jumping to many more conclusions.