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AutoCFD3 Case 1 Windsor Body Results

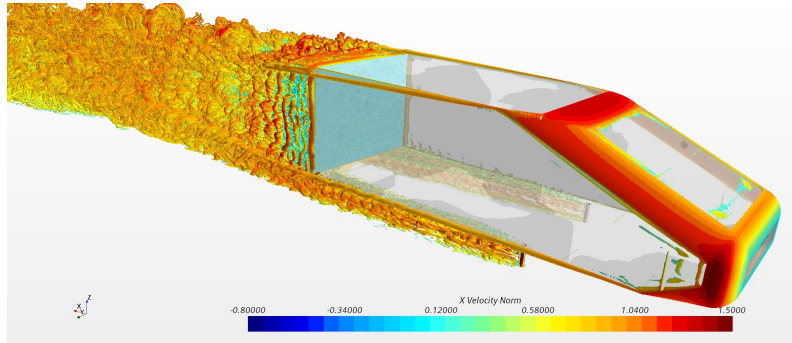
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Third Automotive CFD Workshop

Case 1 Windsor Squareback at Yaw

Introduction and Results Taster

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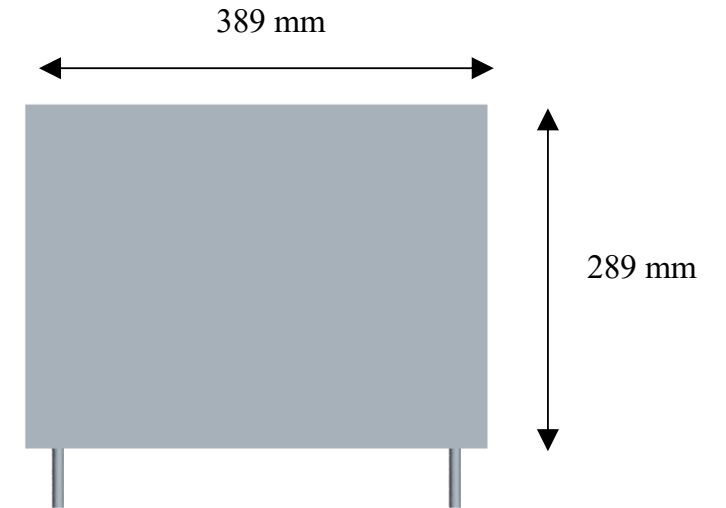
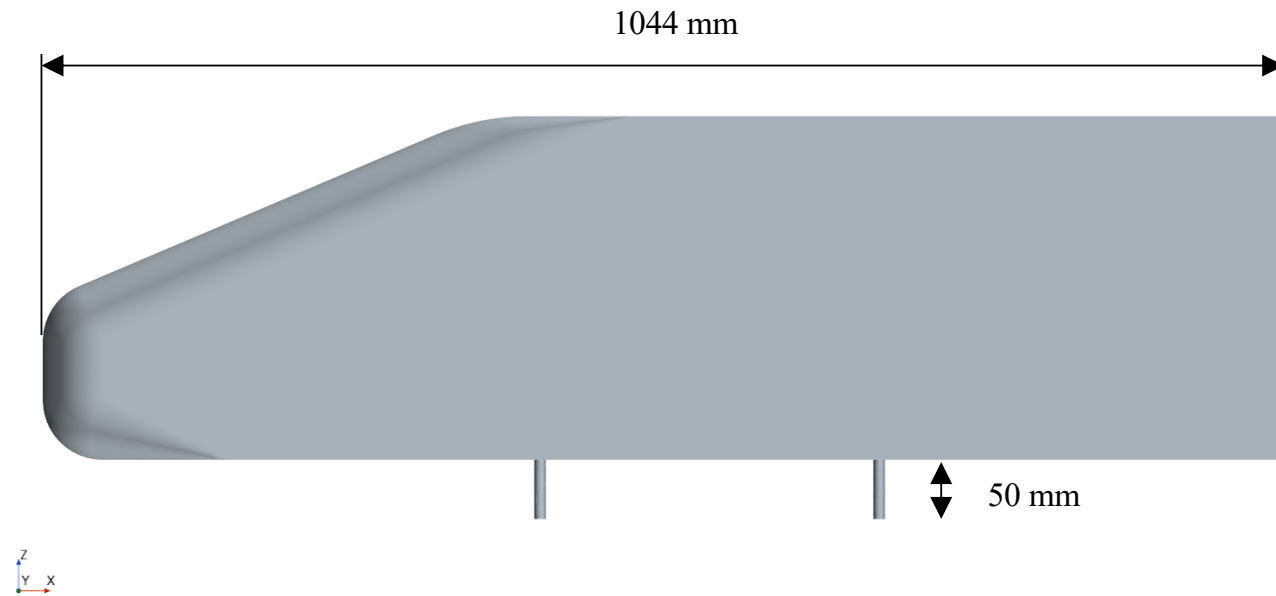
Barcelona, September 2022

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Introduction

- ▶ Previous workshops have used a simplified model for Case I
- ▶ Second workshop Windsor Squareback (with wheels and no wheels)
 - ▶ Duplication of effort for two cases
 - ▶ Bi-stability tended to obscure importance of other features
 - ▶ Little benefit of 'wall resolved' low y^+ grids/models
 - ▶ Criticism that we could not understand grid sensitivity
- ▶ Third workshop:
 - ▶ Single case (no wheels)
 - ▶ Small yaw (2.5 degree) to remove potential bi-stability
 - ▶ Single baseline compulsory (g2) grid for RANS and scale resolving (37M cells)
 - ▶ Coarse g1 doubled cell size (6.7M) and fine g3 almost halved cell size (198M)

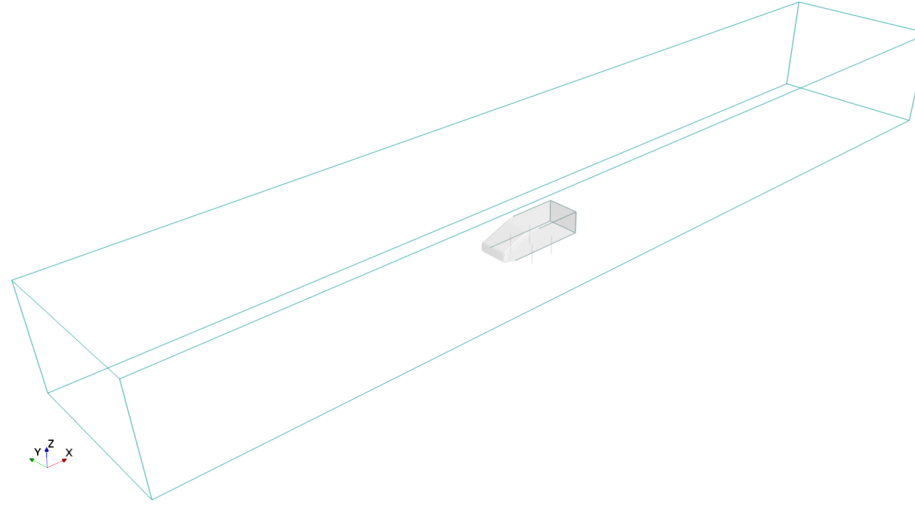
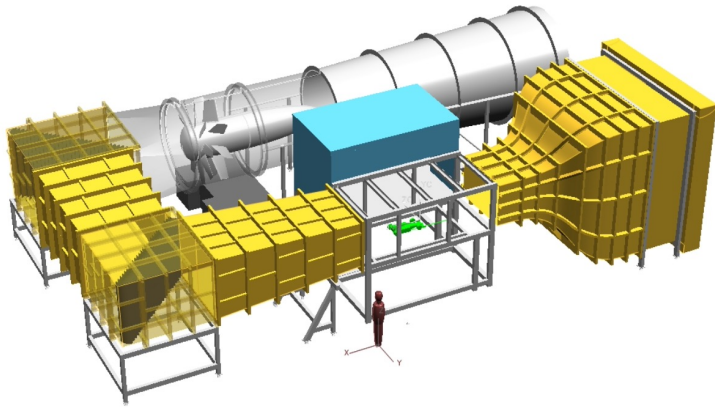
Windsor Squareback Model



Reference area 0.112m^2 , reference length 0.6375m

Origin on centreline, on floor, midway between pins

Wind Tunnel and CFD domain

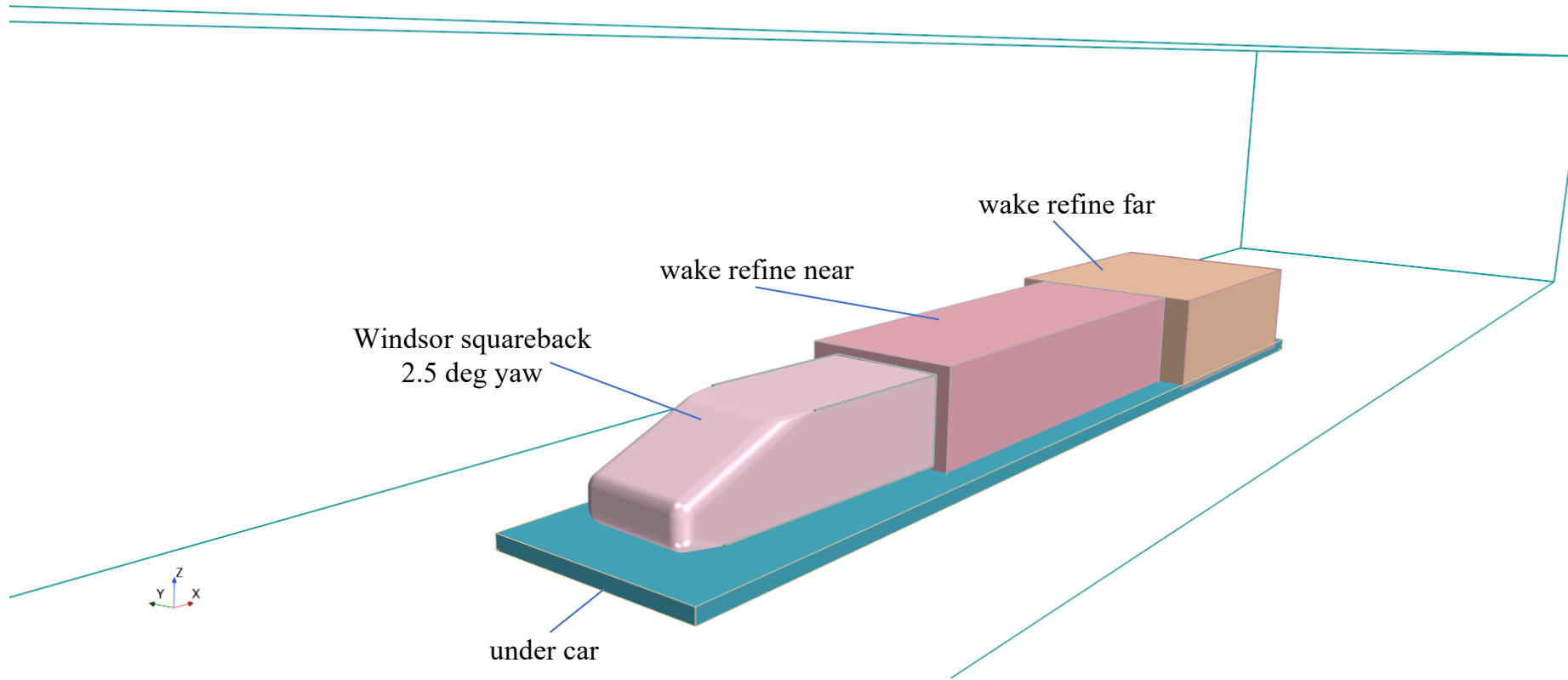


- ▶ Experiment: a 3.2m long working section, 1.92m wide x 1.32m high cross section expanding to 1.94m wide
- ▶ CFD: extend upstream and downstream to 11m long, parallel sidewalls
 - ▶ No slip (or symmetry) for side walls and roof

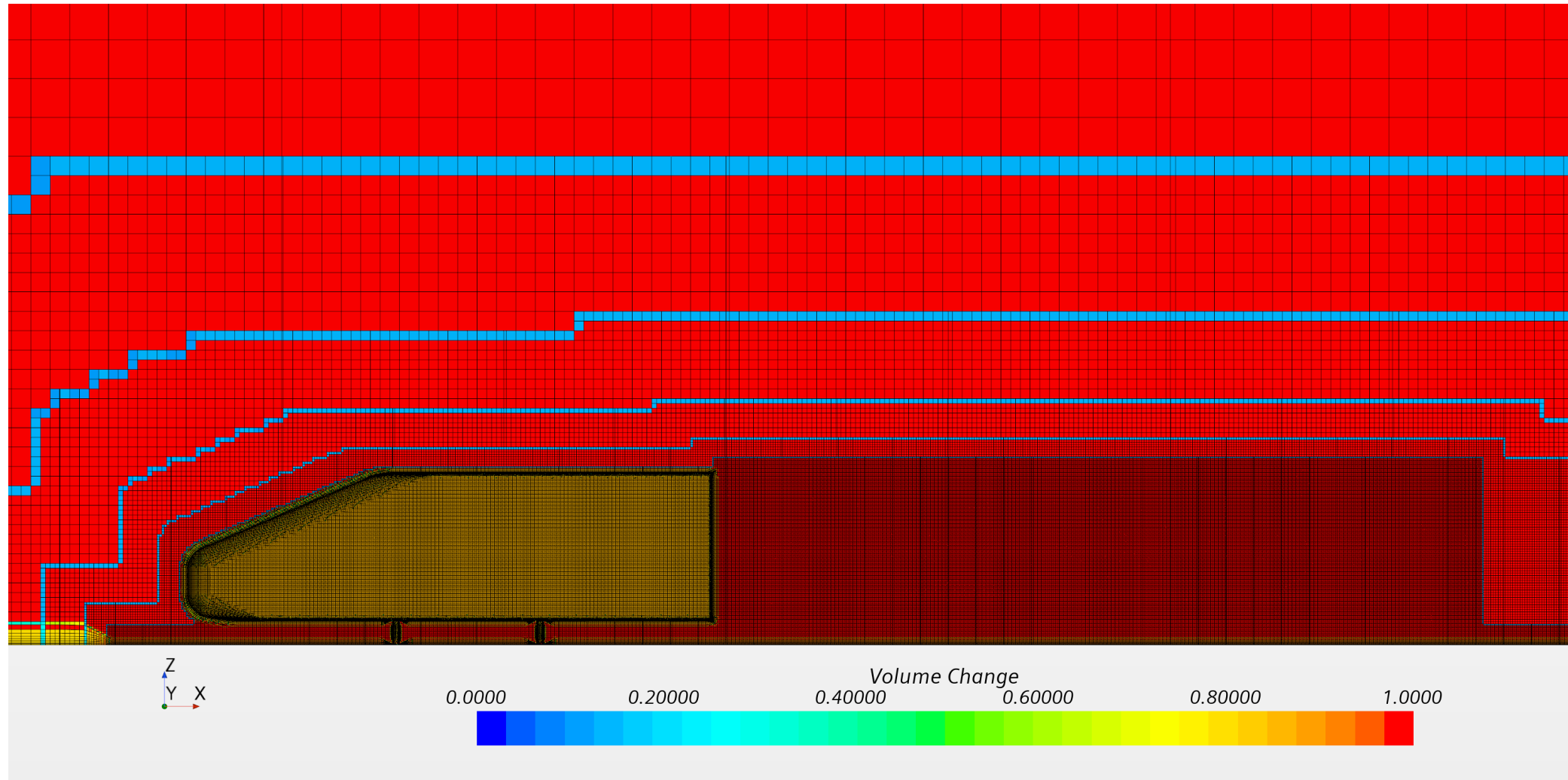
Grids

- ▶ STAR-CCM+ trimmer + prism layer
- ▶ Baseline (compulsory) **g2** has smallest cubical cells 2.4×10^{-3} m
 - ▶ g1 x2 4.8×10^{-3} m, g3 1.32×10^{-3} m
 - ▶ 6.7M, **37M** and 197M
- ▶ All three grids have same prism layer near wall cell height, number of layers, and thickness
- ▶ Same grid for RANS/DES/LES
 - ▶ *Should* be suitable for WMLES
 - ▶ DES/RANS would normally have higher aspect ratios
- ▶ Aiming for near wall cell centre y^+ of 40 on model and 50-75 on ground plane

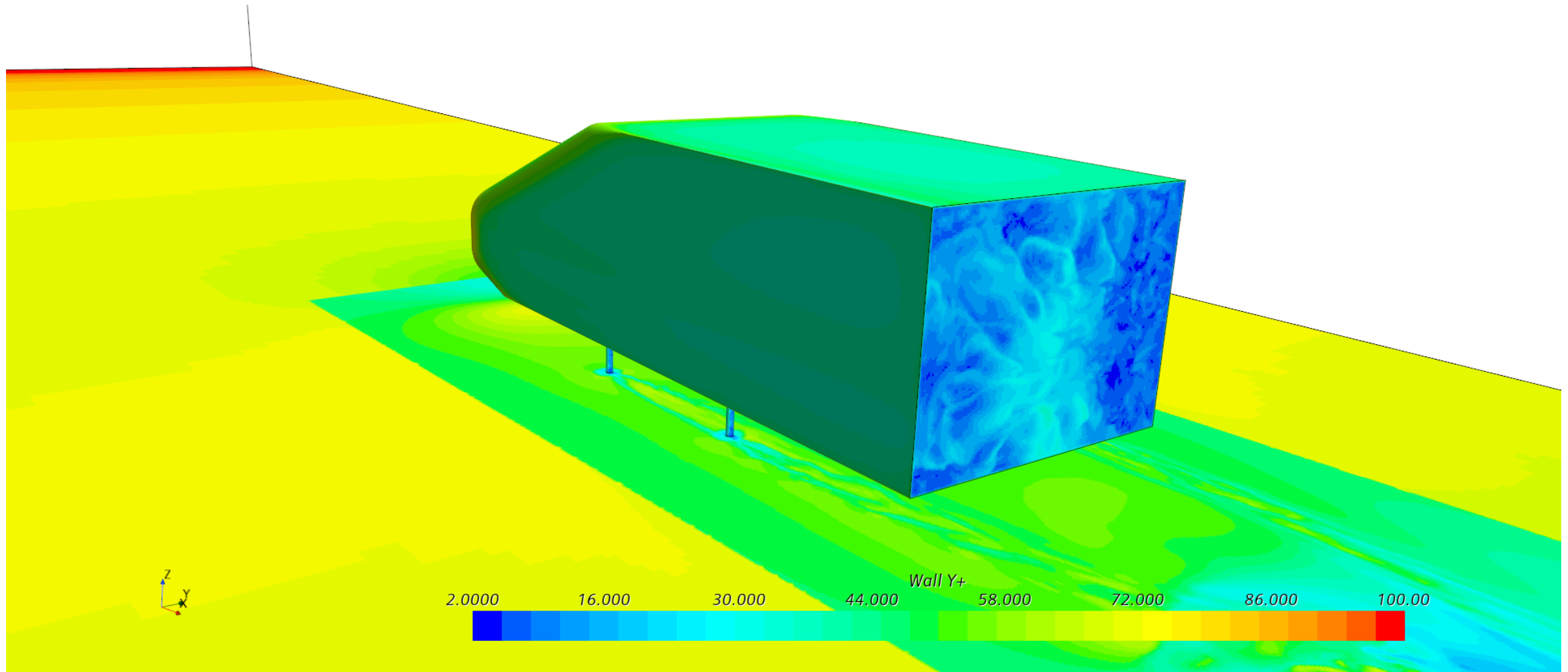
Grid Refinement Zones



Grid Side View



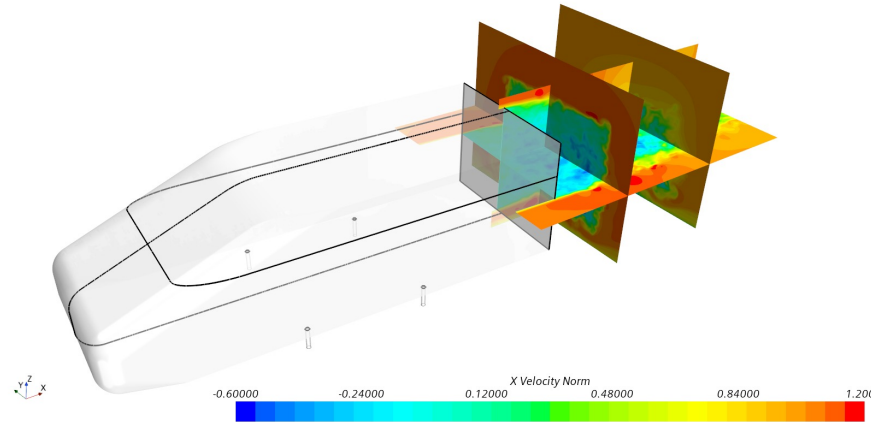
Near Wall Cell Centre y^+



Test Case

- ▶ 2.5 degree yaw (rotated –ve around z axis)
- ▶ 40 m/s , gives $Re\ 3 \times 10^6$ (based on vehicle length)
- ▶ Use a virtual probe ahead of model on roof [2.0,0.0,1.3]m to determine
 - ▶ Reference pressure
 - ▶ Reference velocity
 - ▶ Use for all force and pressure coefficients
- ▶ No wind tunnel corrections
- ▶ All force coefficients are in the yawed vehicle coordinate system (VCS)
- ▶ Symmetry and glasshouse pressure in VCS
- ▶ Base pressure and PIV slices in Wind Tunnel Coordinate System (WTCS)

Experimental Data



- ▶ Pressure tappings along symmetry plane and glasshouse plane
- ▶ Pressure tappings on base
- ▶ PIV slice horizontal plane (red)
- ▶ Tomographic PIV (30m/s) for volume – used to generate other experimental slices (blue, green, light blue)

https://repository.lboro.ac.uk/articles/dataset/Windsor_Body_Experimental_Aerodynamic_Dataset/13161284

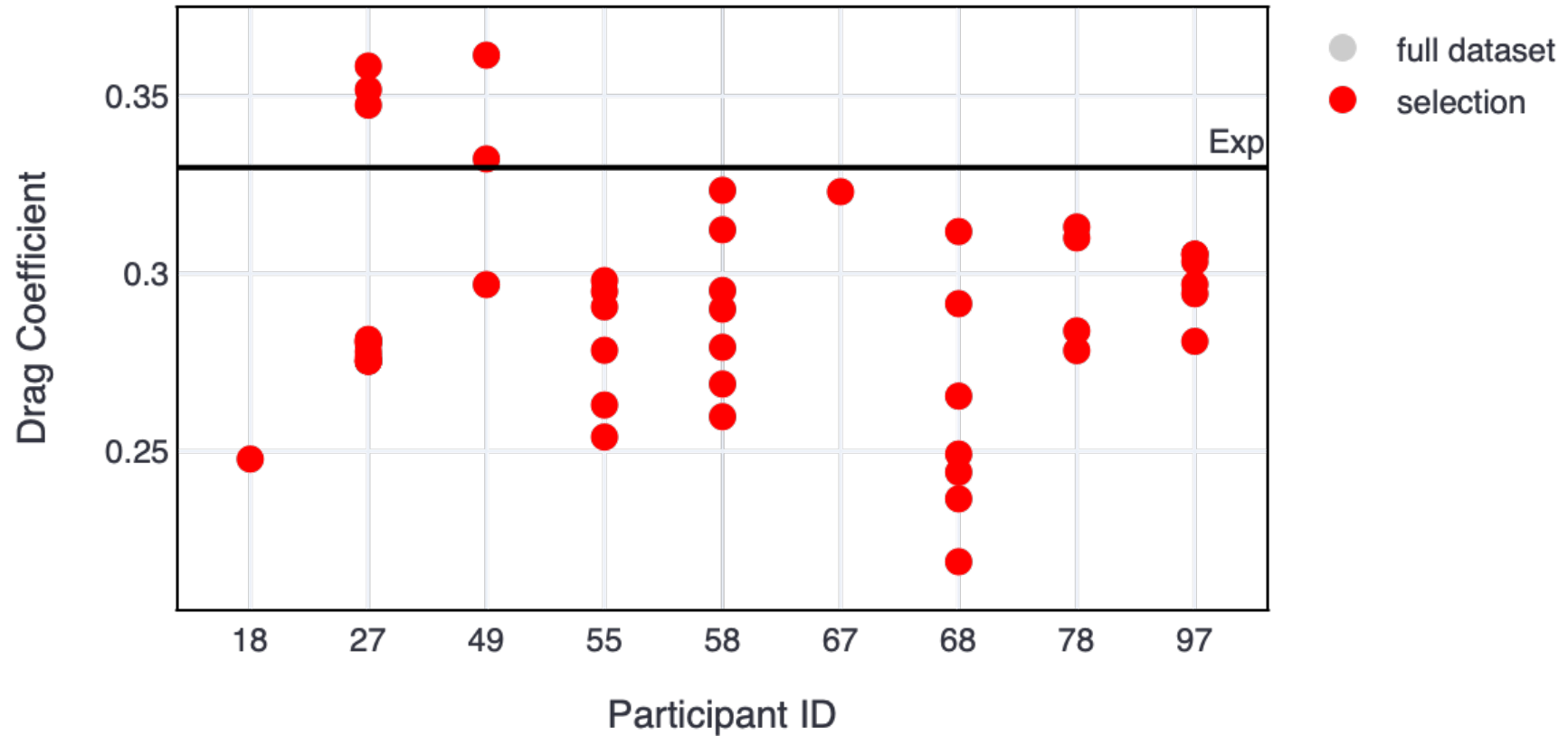
Results Taster...



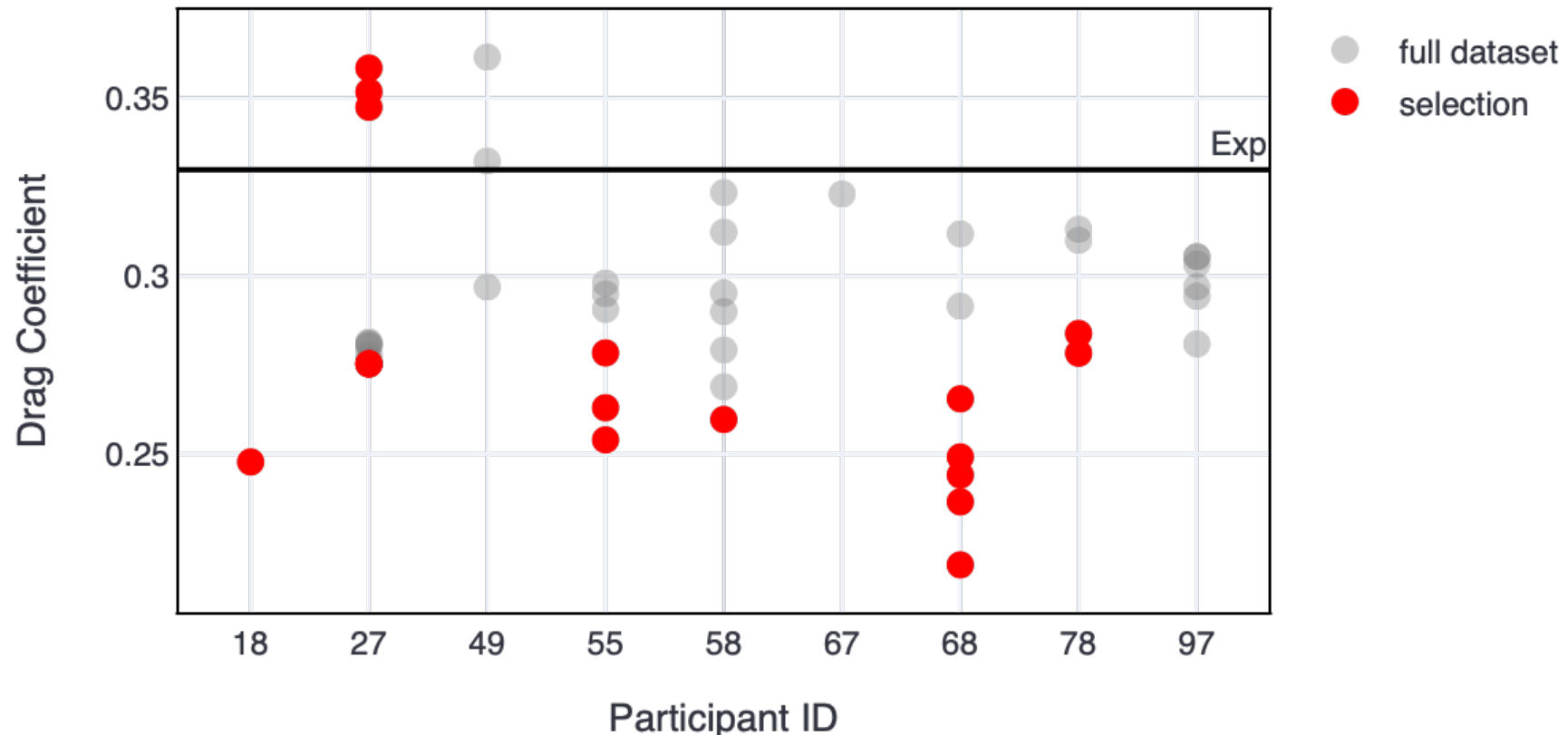
Contributions

- ▶ 47 calculations submitted
- ▶ 9 organisations
 - ▶ 3 Universities / Research Institutes
 - ▶ 1 large CFD vendor
 - ▶ 5 small/medium CFD vendors/consultancies
- ▶ 22 on standard grids, 25 on 'own' grids
- ▶ 20 RANS/URANS solutions, 27 DES/LES/LBMDES

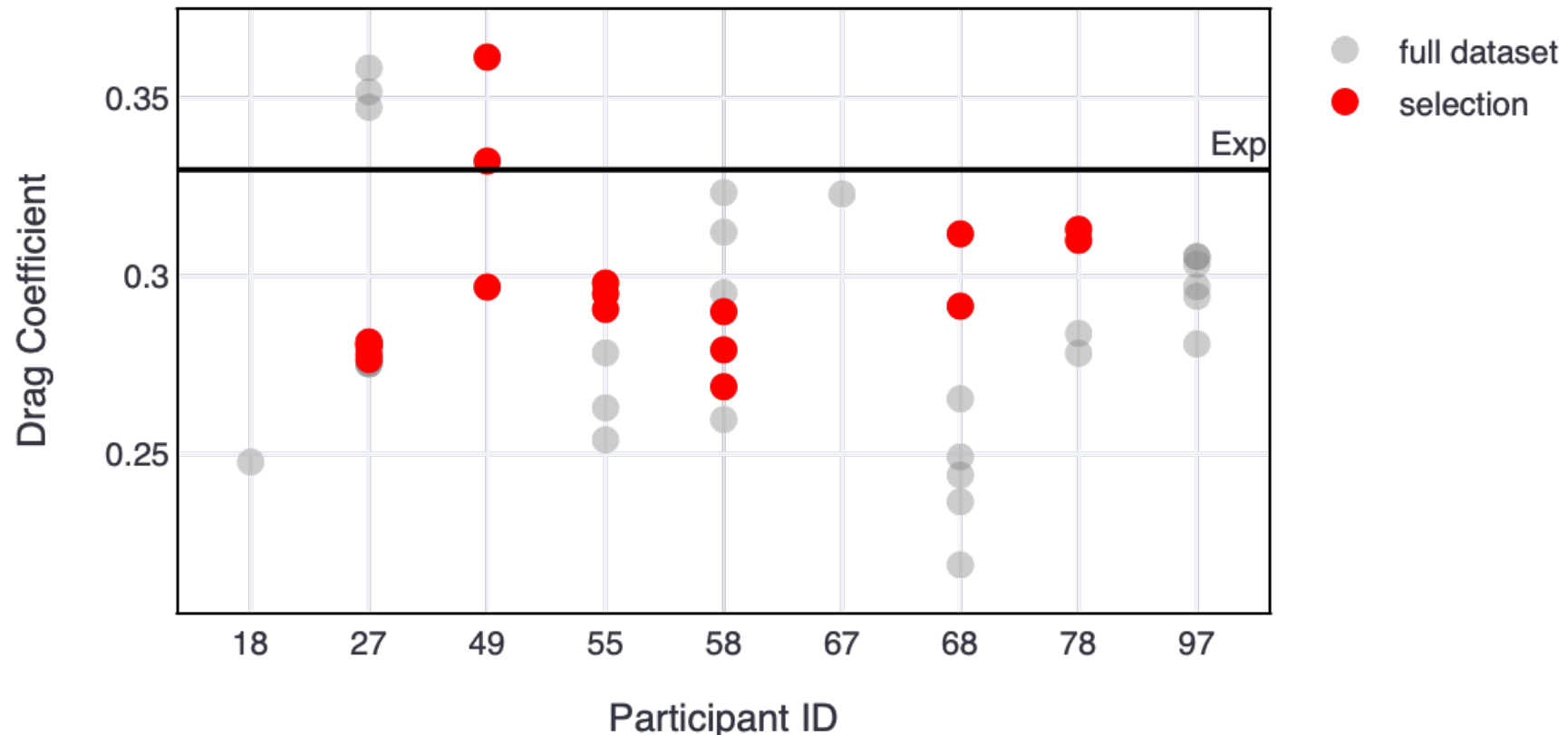
Drag Coefficient: All



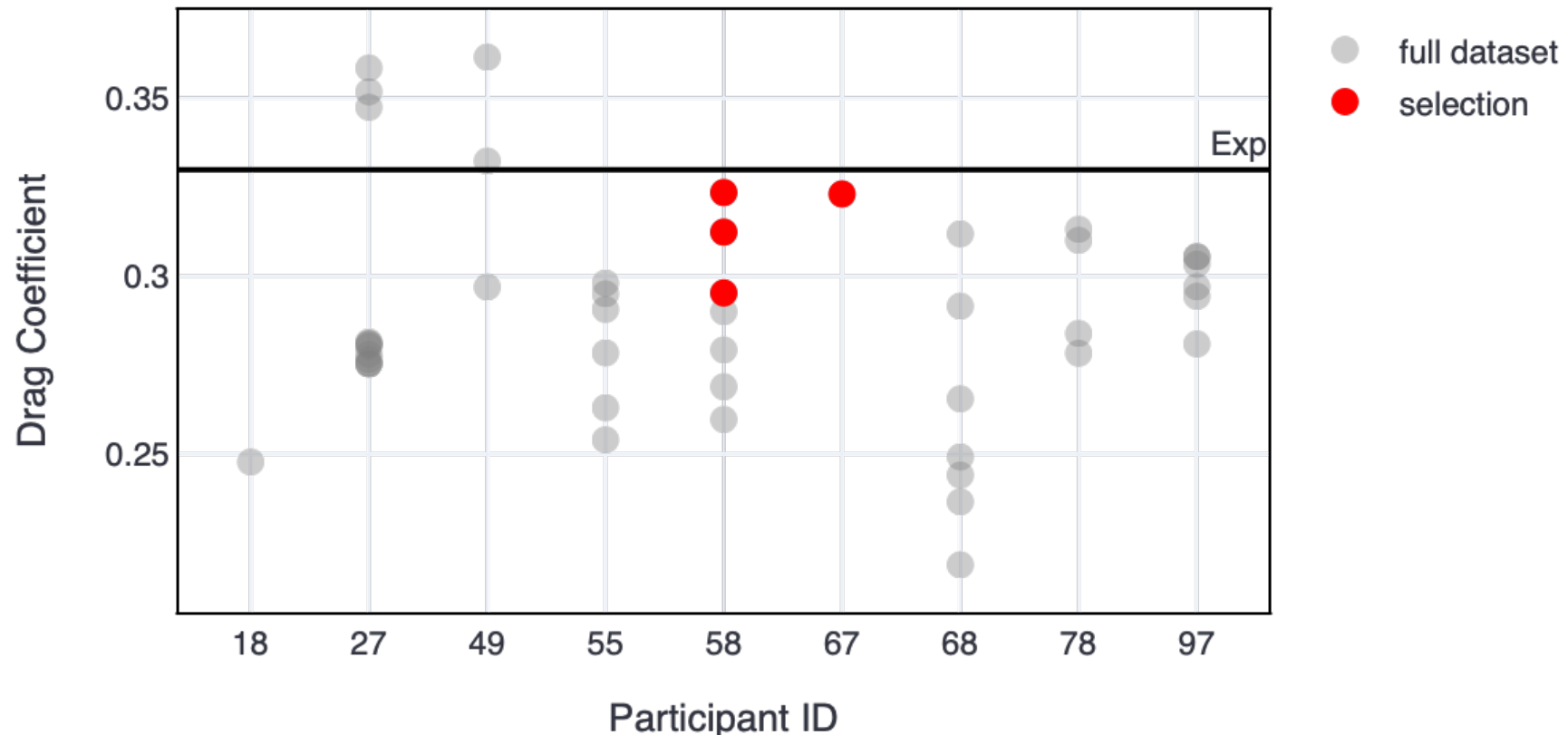
Drag Coefficient: RANS and URANS, all grids



Drag Coefficient: DDES and IDDES, all grids

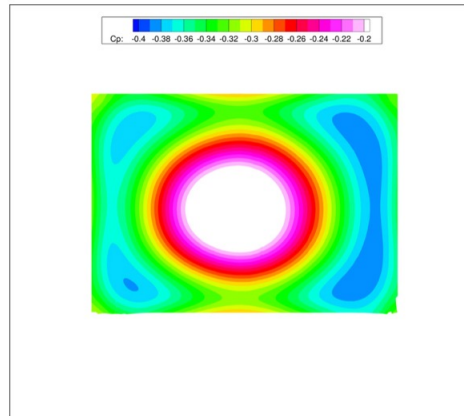


Drag Coefficient: LES, all grids

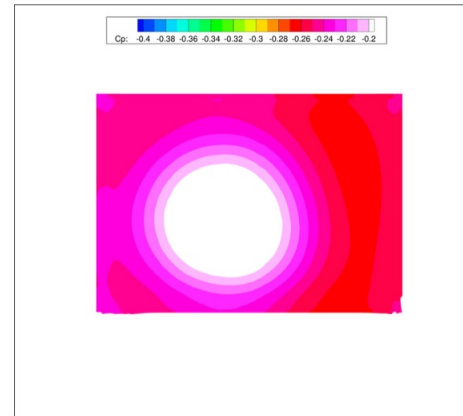


Typical RANS Base Pressure, g2

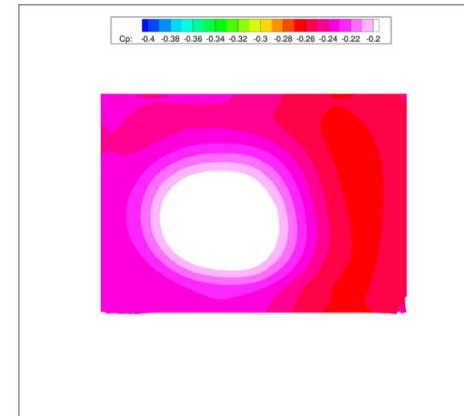
27_owng2_RANS_SA-RC_v2



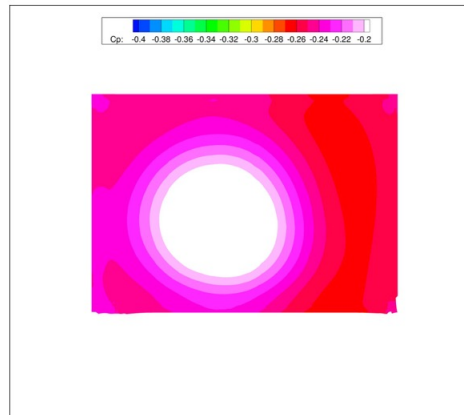
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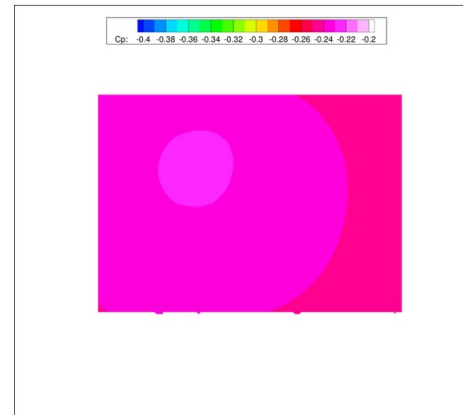
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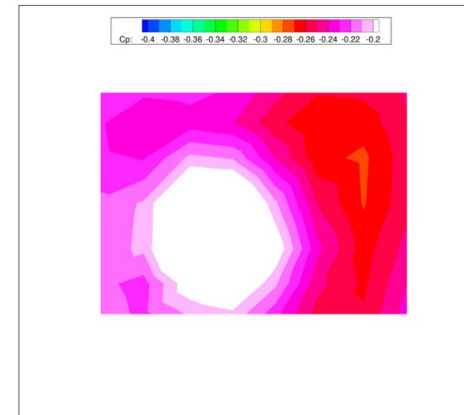
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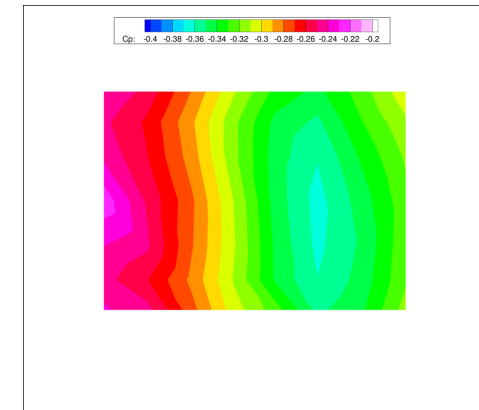
55_owng2_RANS_RSM_v1



78_g2_RANS_SST_v1

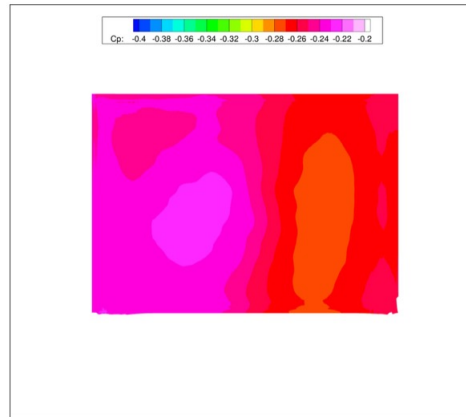


Experiment

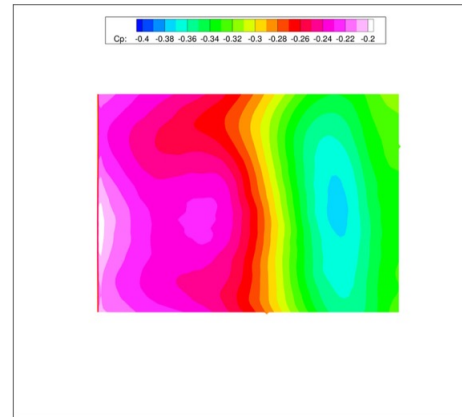


Typical DDES, IDDES Base Pressure, g2

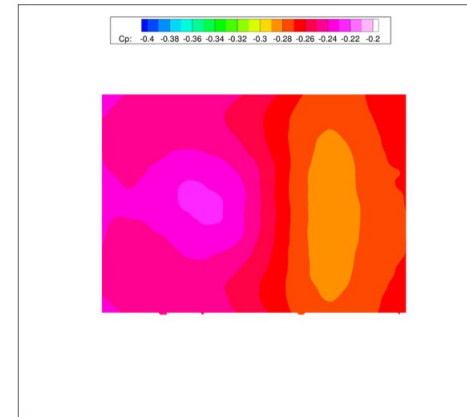
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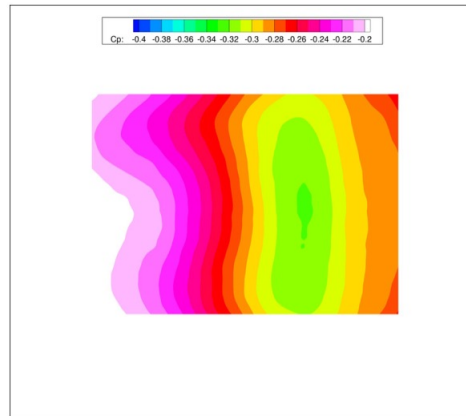
49_g2_DDES_SA_v1



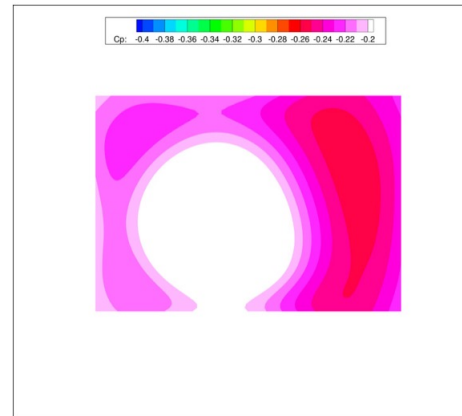
55_owng2_DDES_OTHER_v1



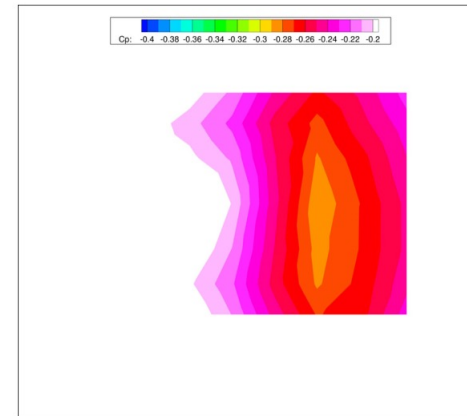
58_g2_DDES_SST_v1



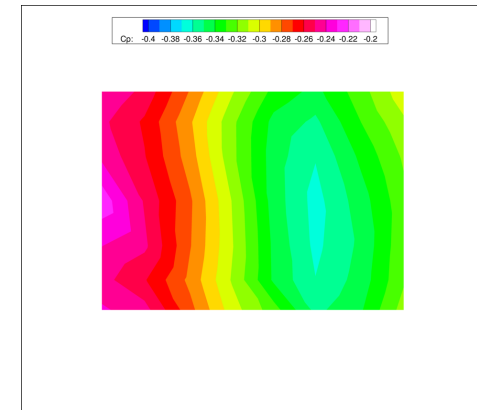
68_g2_DDES_SST_v2



78_g2_IDDES_SA_v1

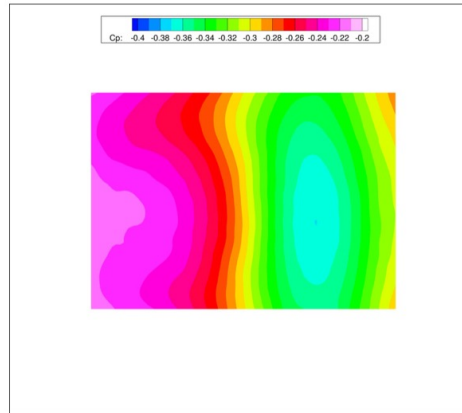


Experiment

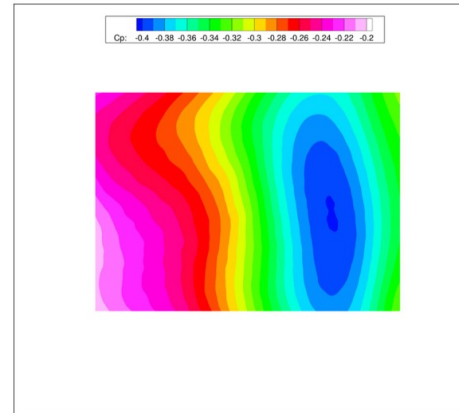


Typical LES Base Pressure, g2, g3

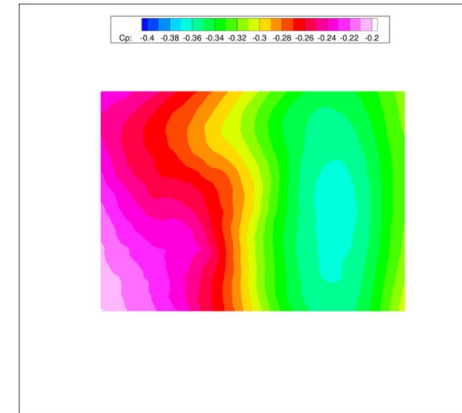
58_g1_LES_WALE_v1



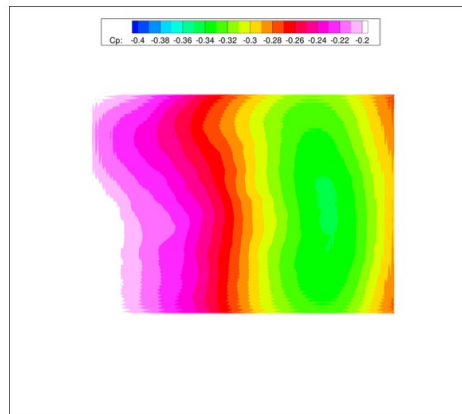
58_g2_LES_WALE_v1



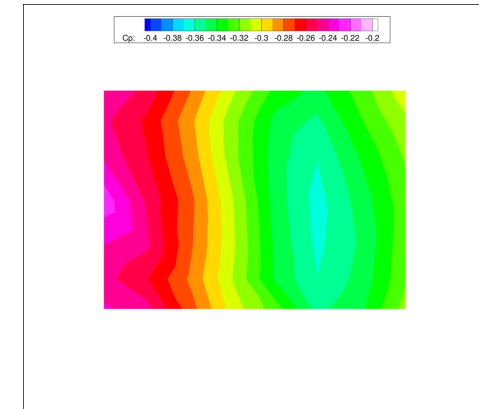
58_g3_LES_WALE_v1



67_owng3_LES_VREMAN_v1



Experiment



More Tomorrow Questions?