Colombian Contribution to the 2nd AIAA CFD High Lift Prediction Workshop

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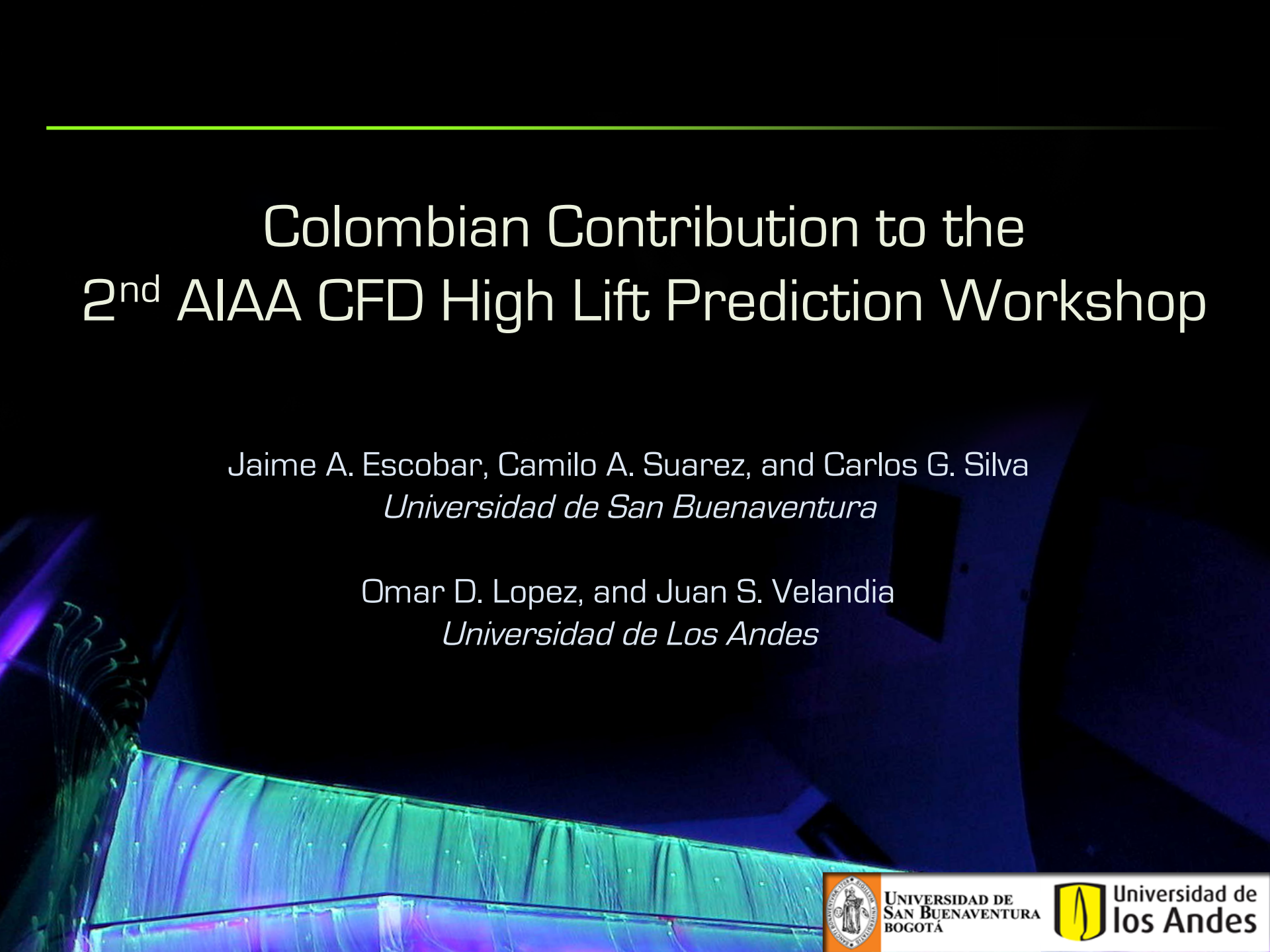

Agenda

1. Who are we?.
2. Motivation
3. Solver and Turbulence Model
4. Bump Case.
5. Grid Type and Main Features.
6. Solver Configuration.
7. Grid Sensitivity Analysis.
8. Results
9. Lessons Learned.
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Who are we?

UNIVERSIDAD DE SAN BUENAVENTURA BOGOTÁ

- Four campuses in Colombia: Bogota, Cali, Medellin, Cartagena.
- 2,800 students in Bogota, 15,000+ in Colombia.
- 16 undergraduate programs and 5 graduate programs.
- First Aerospace Engineering program in Colombia.
- 24 research groups.

Universidad de los Andes

- Located in Bogota
- 12000+ students, 5000+ in engineering
- 9 Engineering undergraduate programs with ABET accreditation, 13 Msc programs in Engineering and 1 PhD program in Engineering.
- 100+ research groups.
- 4th best university in Latin-America according to QS Ranking 2013

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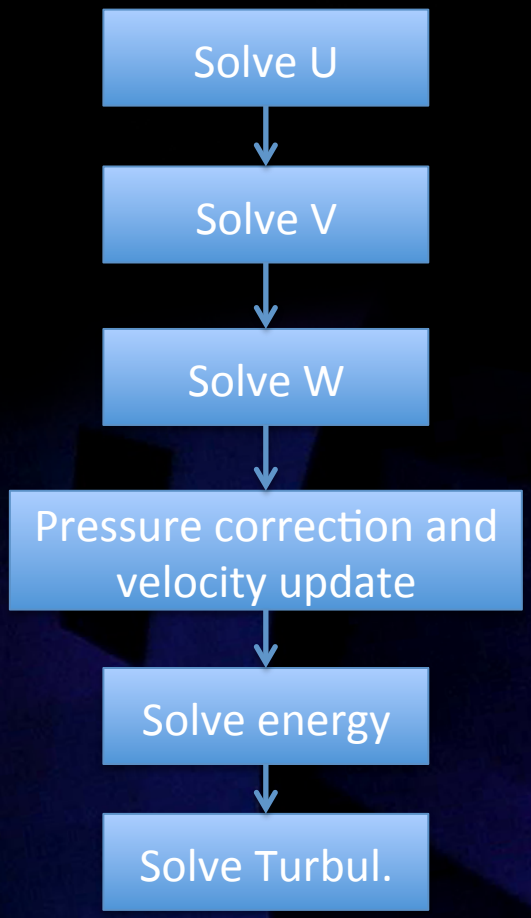
Motivation

- Test our computational capabilities with world class problems.
- Build-up experience in applied computational aerodynamics.
- Determine how well we can predict flowfield variables and aerodynamic forces with limited computational resources.
- Participate in workshops like HiLiftPW-2, were we always learn a lot!

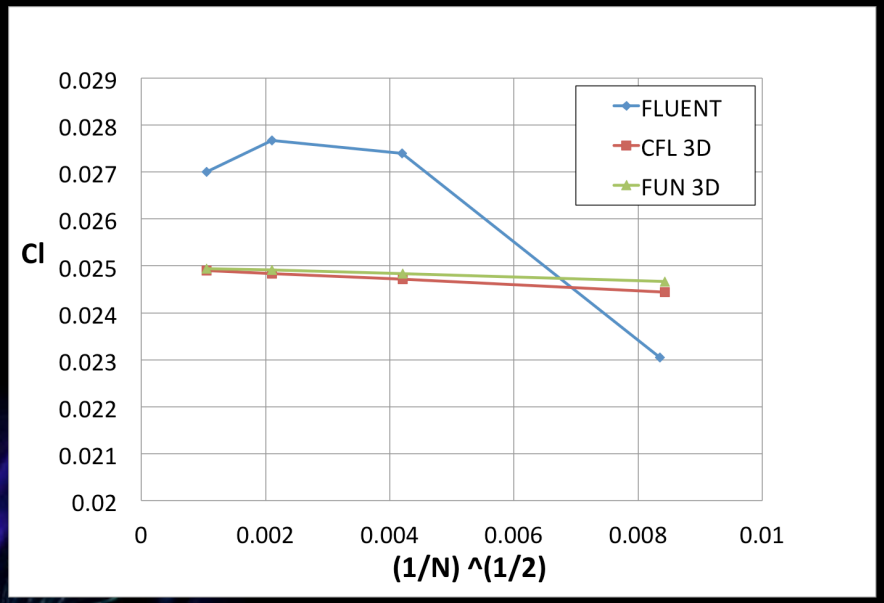
Solver and Turbulence Model

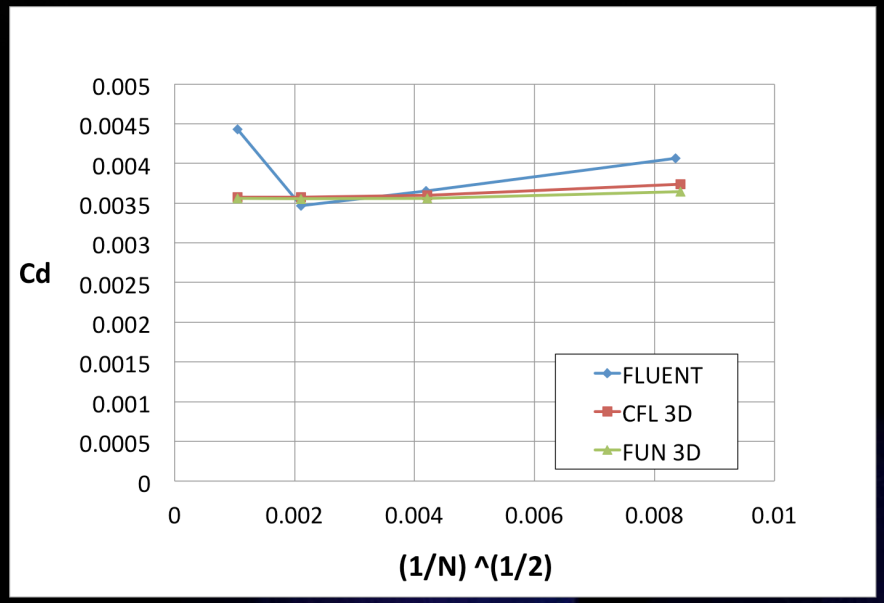
- ANSYS-FLUENT v14
- Two algorithms available:
  - Density based (fully coupled)
  - Segregated (pressure-velocity coupled)
- Segregated solver (SIMPLEC) was used.
  - Solves momentum equations for U, V and W
  - Continuity is enforced through pressure correction equation
  - Velocities are updated
  - Once the pressure and velocity field are known, the energy and turbulence model equations are solved separately.
- Turbulence model used: Spalart-Allmaras-RC
  - One equation model for the modified eddy viscosity (low cost).
  - Designed specifically for aerospace applications involving wall-bounded flows
  - Curvature correction is applied to the production term of the SA equation.



Bump Case

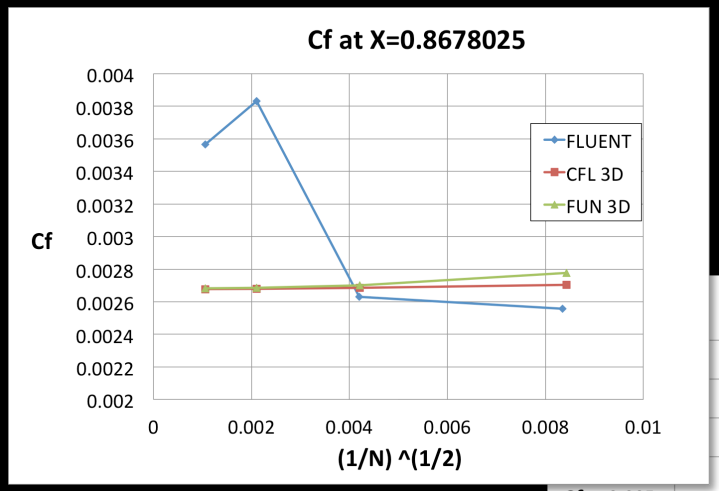
Force Coefficients

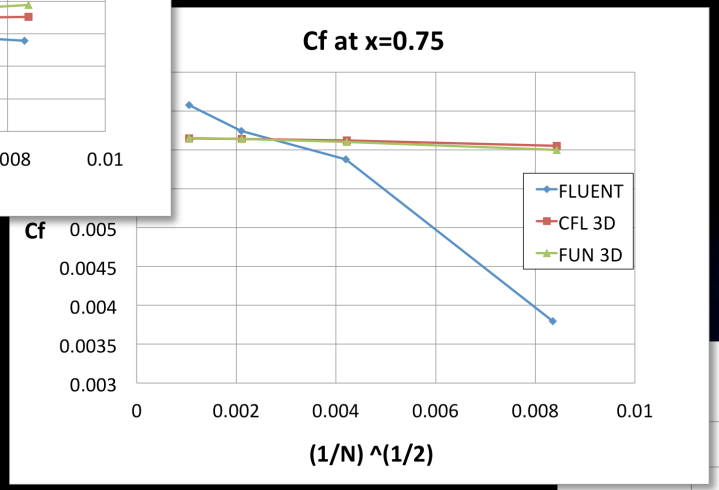


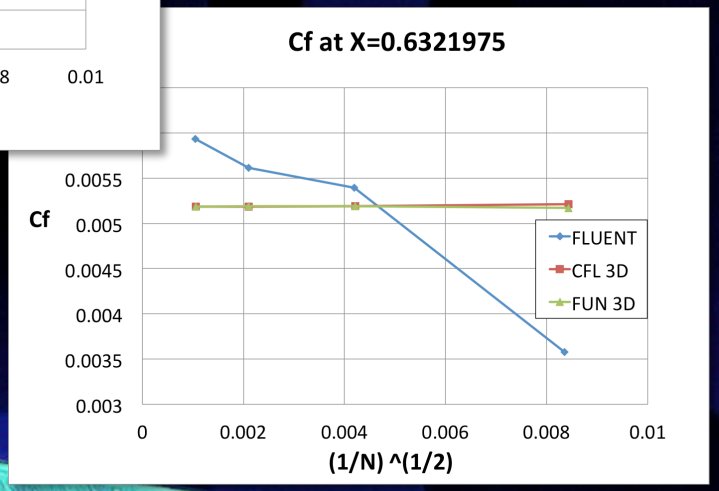


Bump Case (Cont'd)

Skin Friction Coefficients

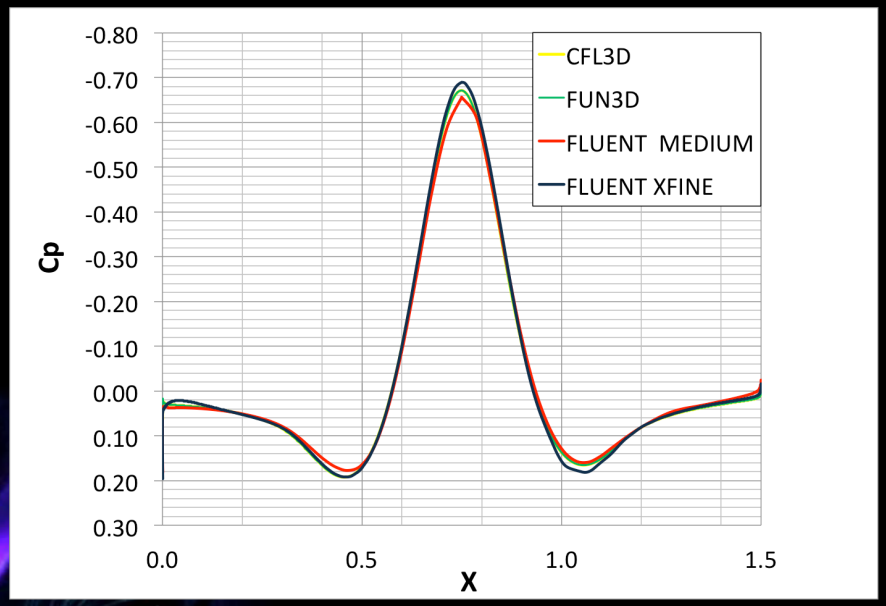


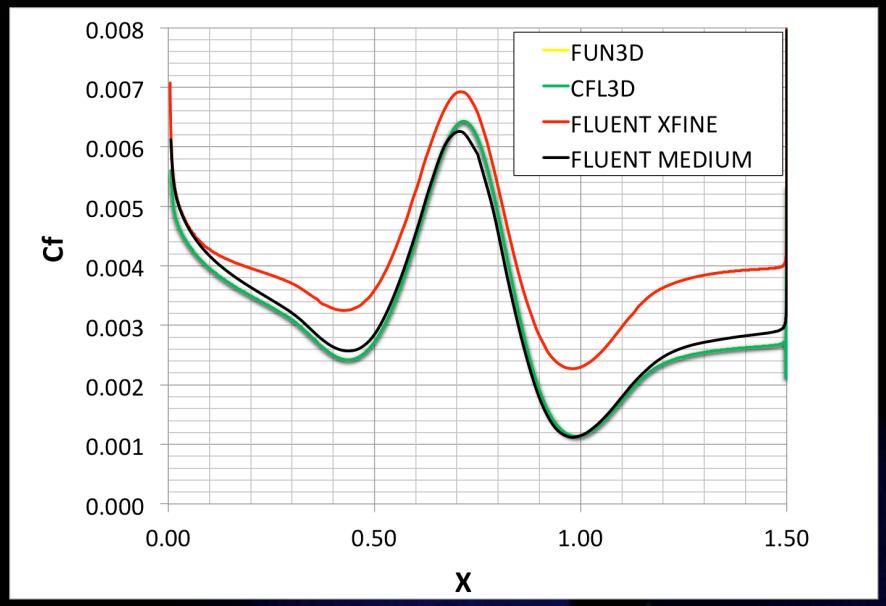




Bump Case (Cont'd)

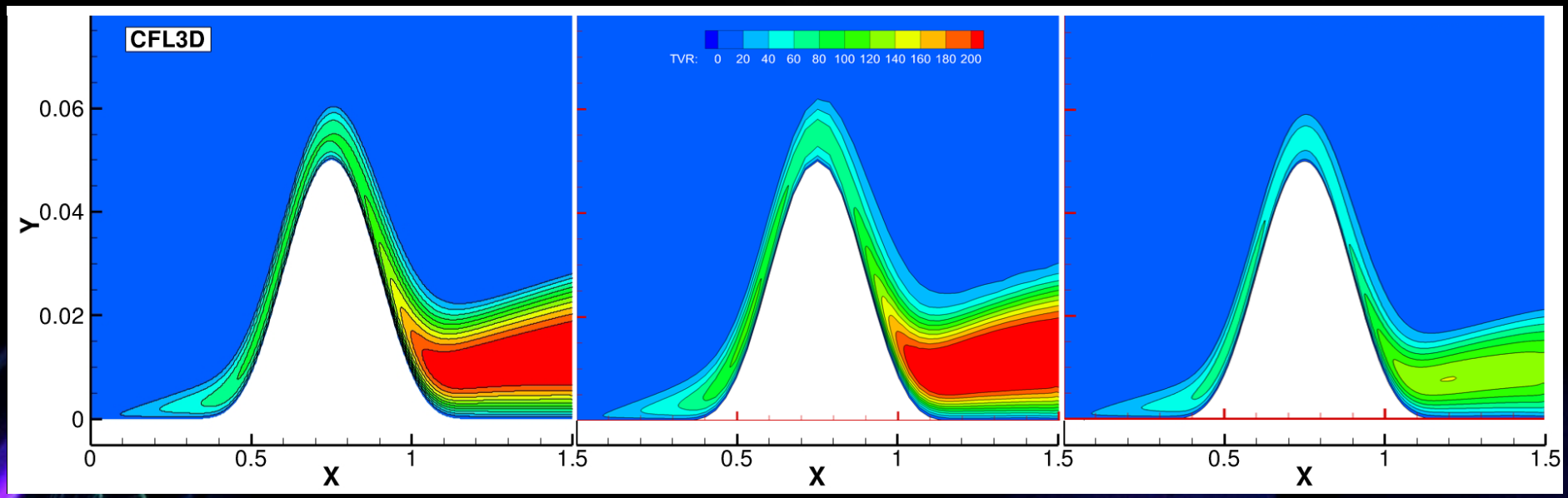
Pressure and Skin Friction Coefficient Distributions





Bump Case (Cont'd)

Turbulence Viscosity Ratio



Grid Type and Main Features

Grid:	A_str_1to1_Case1Config2_v2	Boeing – Huntinton Beach
Type:	Multi-zone one-to-one	
Software:	Ansys ICEM CFD	

Grid:	A_uns_1to1_Case1Config2_v2	C. Rumsey - NASA
Type:	Unstructured version of Boeing's Grids	
Software:	Unknown	

Work done:	882 grid surfaces grouped by main geometry surfaces.	U. San Buenaventura / U. de Los Andes
Software:	Ansys ICEM CFD	

Work done:	Mesh generation for Ansys FLUENT	U. San Buenaventura / U. de Los Andes
Software:	Ansys ICEM CFD	

Grid Type and Main Features (Cont'd)

Grid:	Coarse
Free-stream boundaries	Pressure Farfield
Symmetry plane	Symmetry
Airplane surfaces	Wall

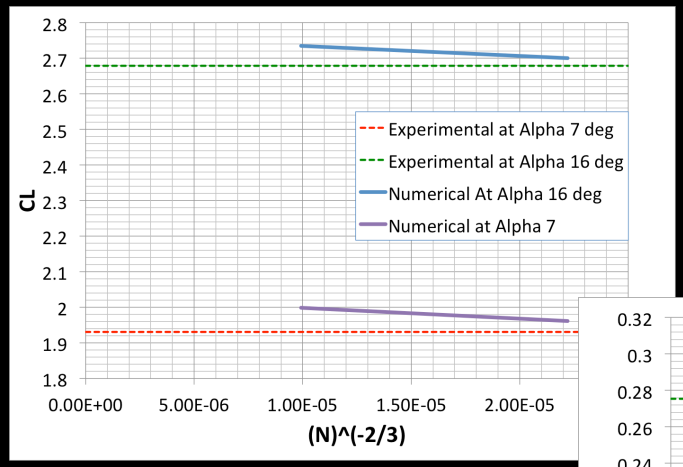
Grid:	Coarse	
Number of cells:	9,556,725	
y+ statistics:	0 – 1	94.06 %
	1 – 2	5.33 %
	> 2	0.61 %

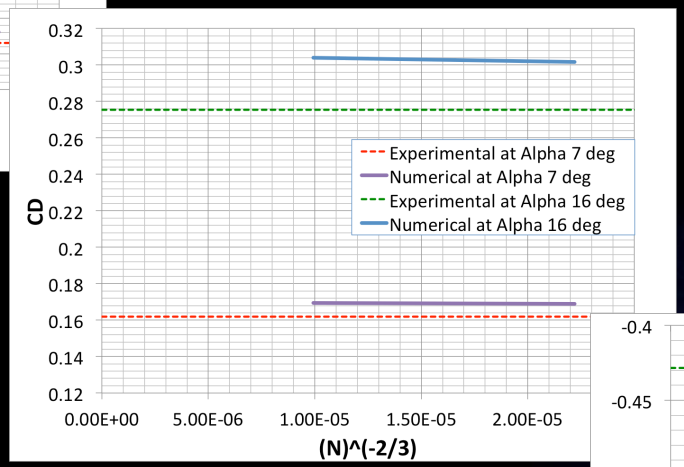
Grid:	Medium	
Number of cells:	31,998,440	
y+ statistics:	0 – 2/3	93.52 %
	2/3 – 4/3	5.58 %
	> 4/3	0.9 %

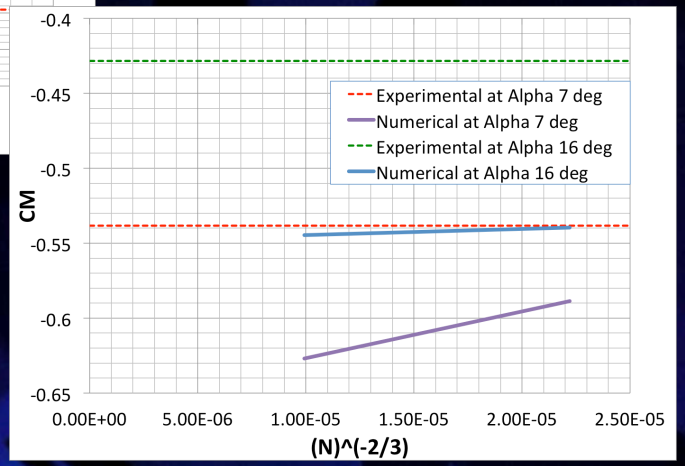
Solver Configuration

Solver:	Pressure-Based Segregated Algorithm	
P-V Coupling Algorithm:	SIMPLEC	
Spatial Discretization:	Pressure:	Standard (First iterations)
		Second-Order Upwind Scheme
	Modified Turbulent Viscosity:	First-Order Upwind Scheme (First iterations)
		Second-Order Upwind Scheme
	Density:	Second-Order Upwind Scheme
	Momentum:	Second-Order Upwind Scheme
	Energy:	Second-Order Upwind Scheme
Gradients of the Scalar Quantities	Green-Gauss Node Based Theorem	

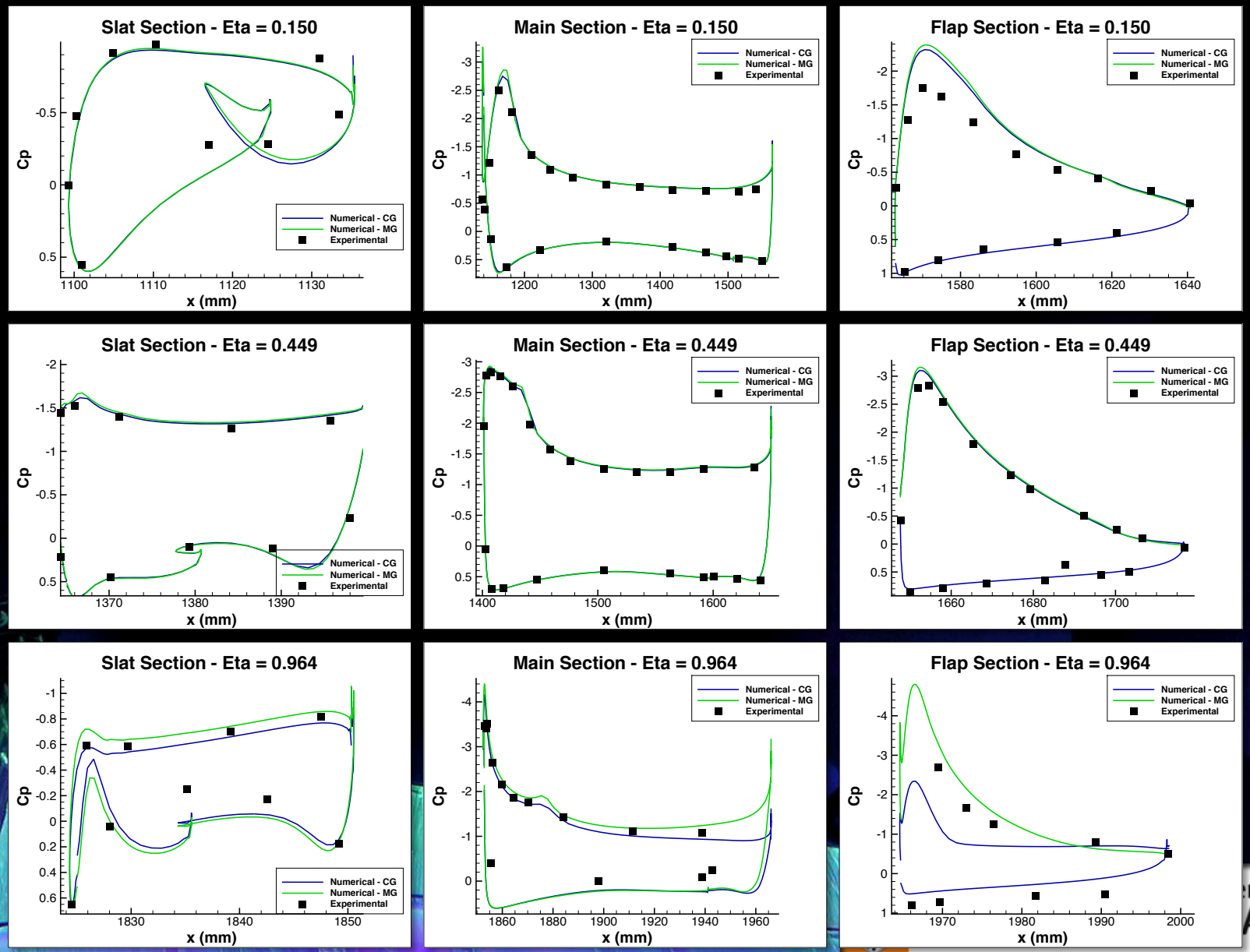
Results - Grid Sensitivity Analysis



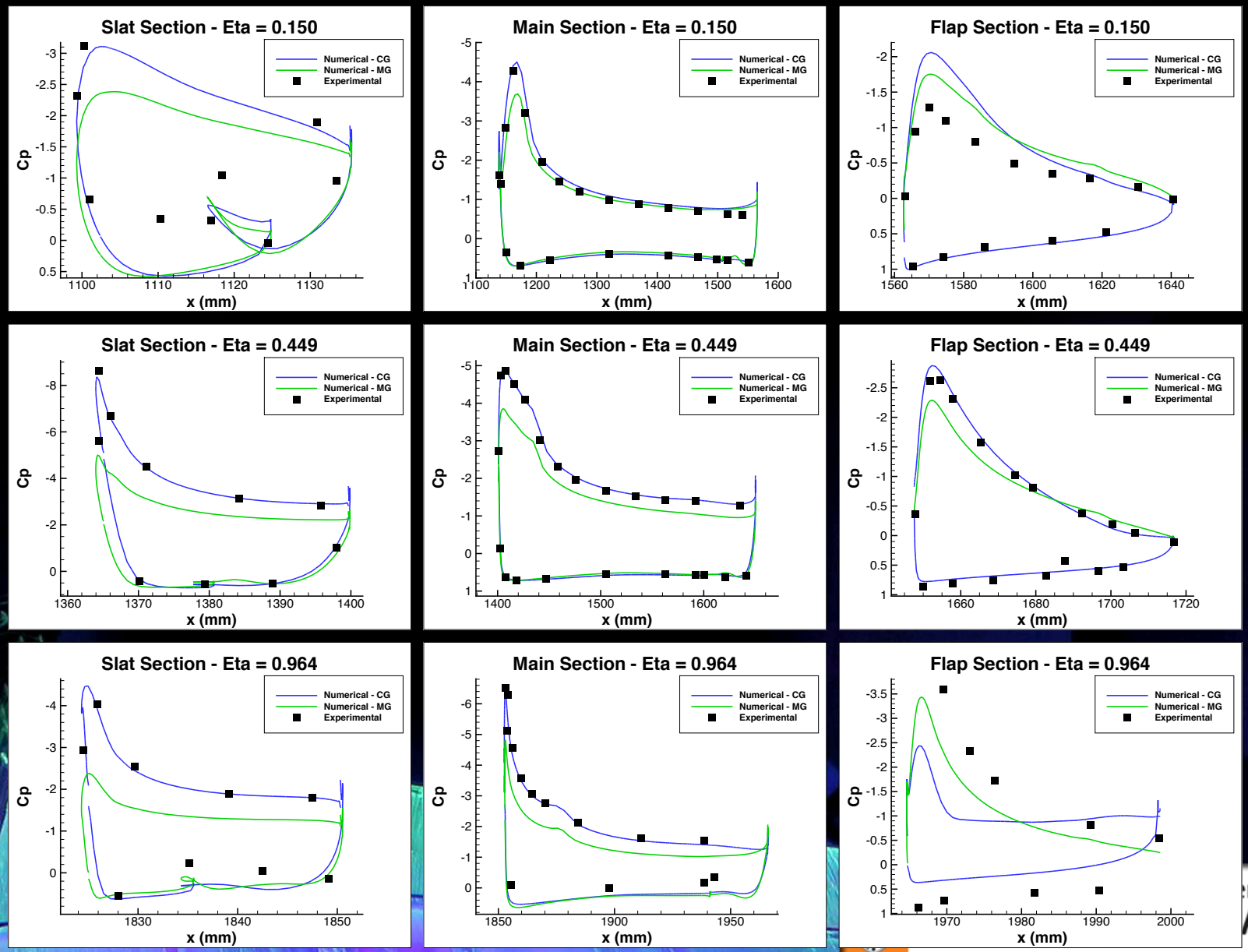




Results - Cp Distribution (Alpha 7)

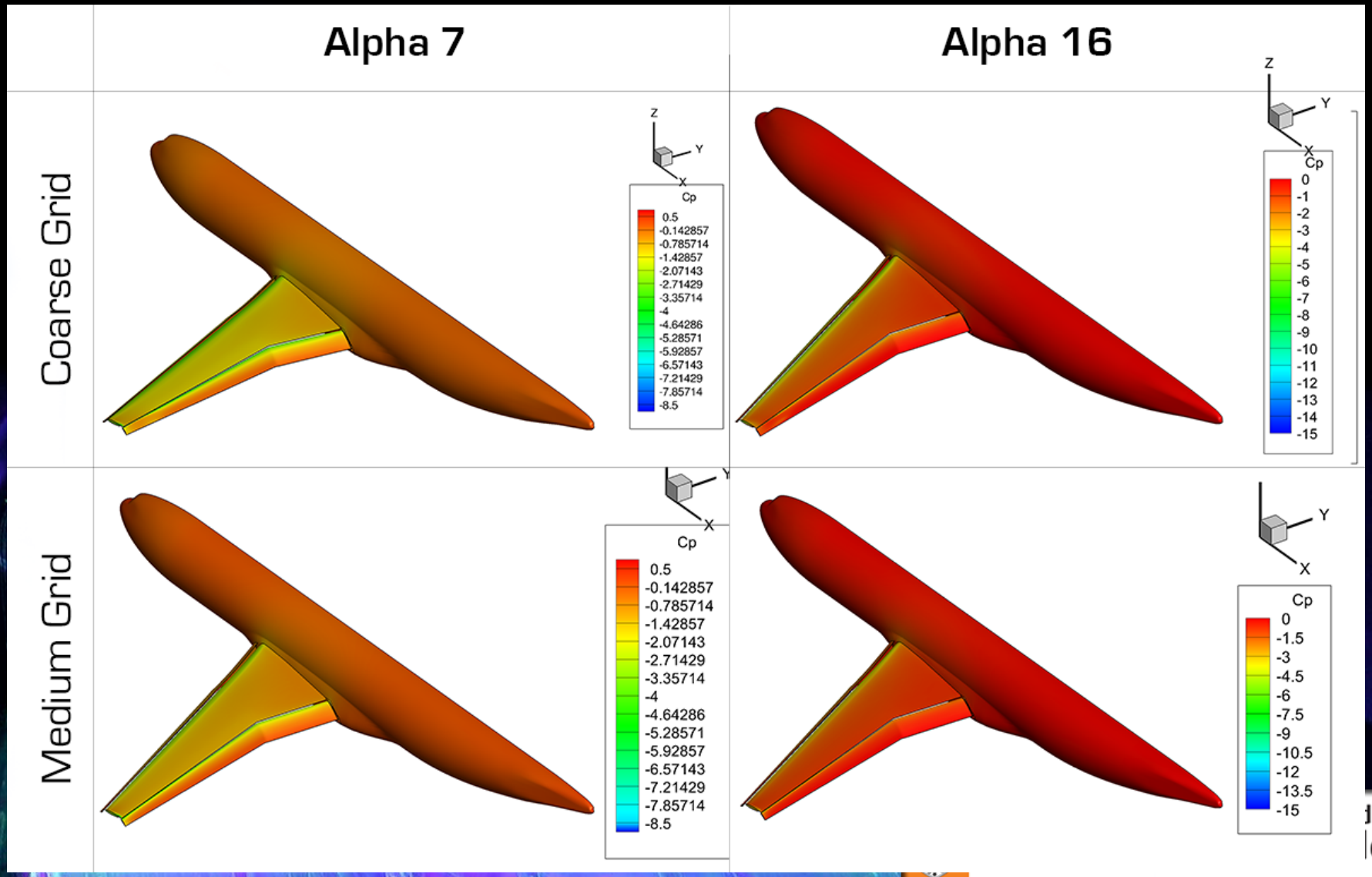


Results - Cp Distribution (Alpha 16)



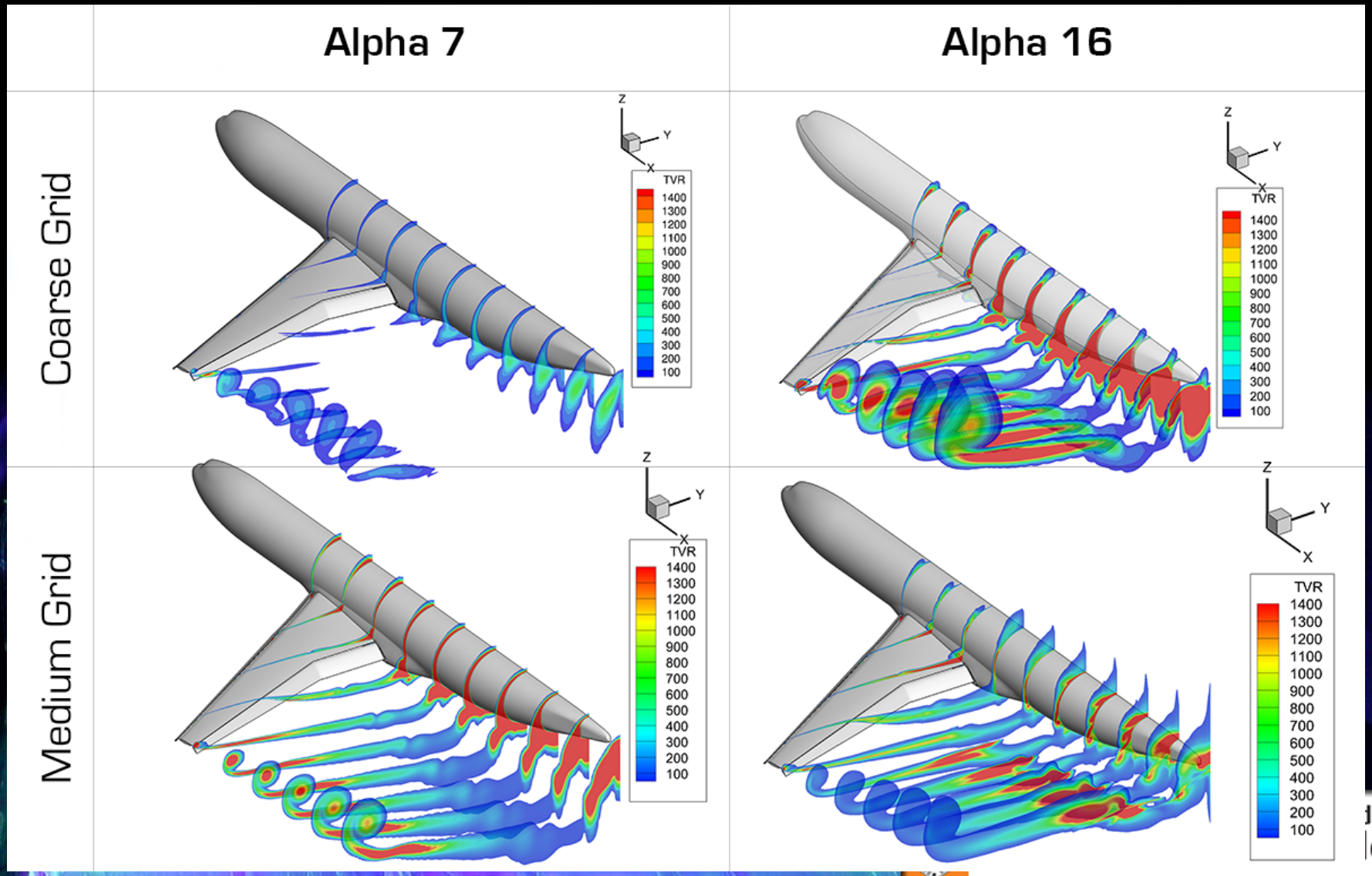
Results - Flow Visualization (Cont'd)

Contours of Cp



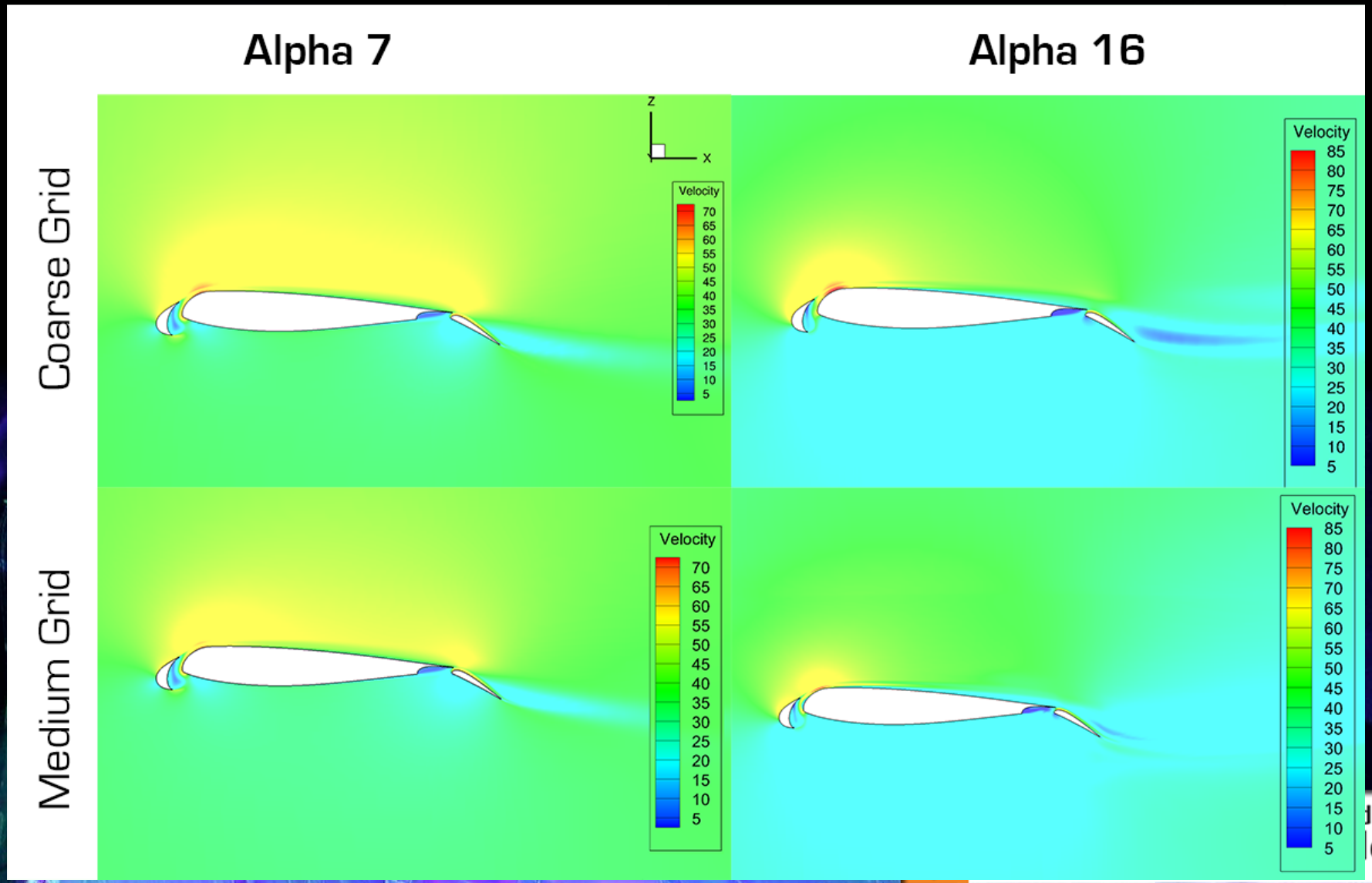
Results - Flow Visualization (Cont'd)

Tip Vortex Visualization



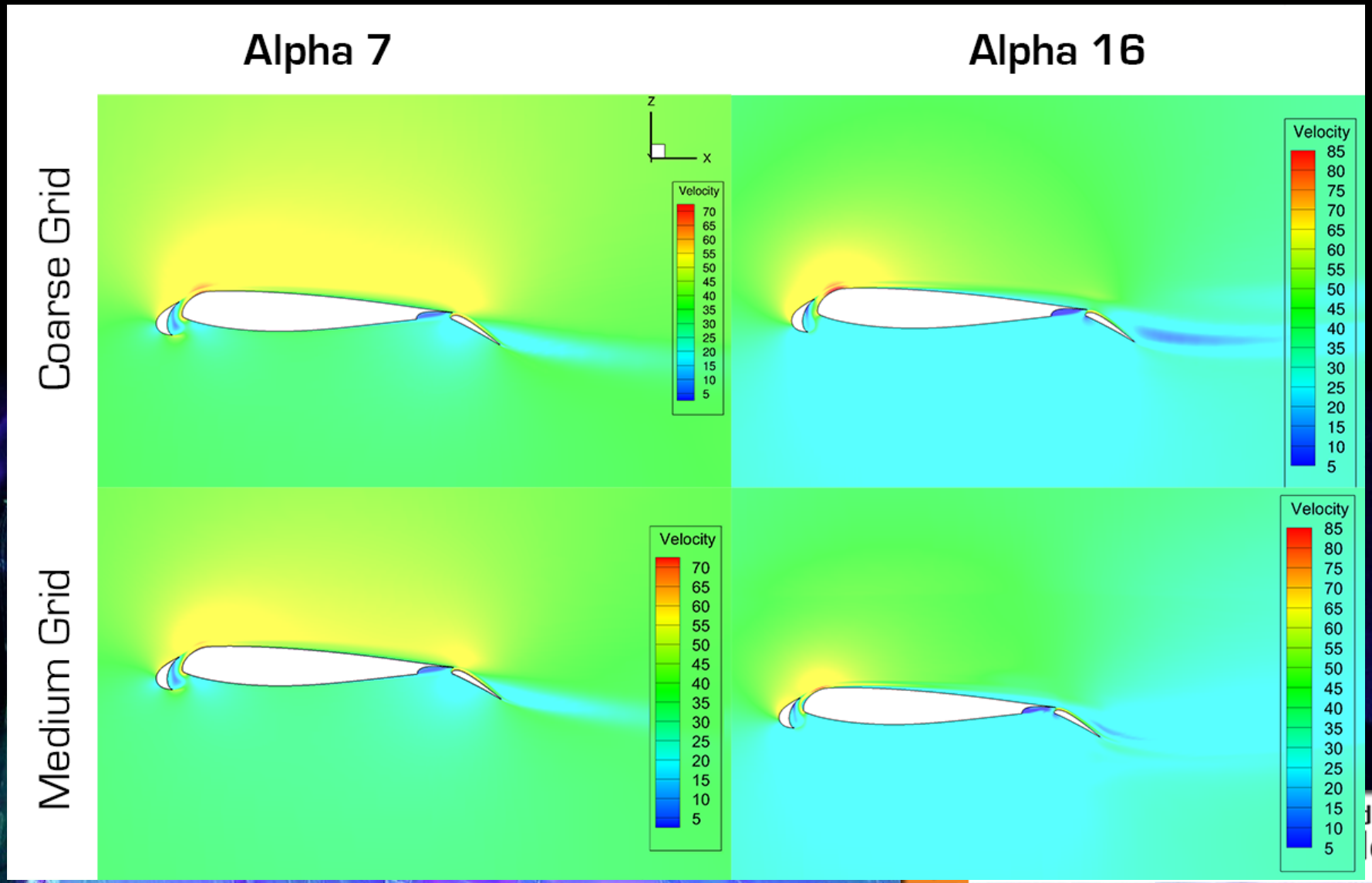
Results - Flow Visualization (Cont'd)

Velocity Field (Magnitude) – Eta = 0.150



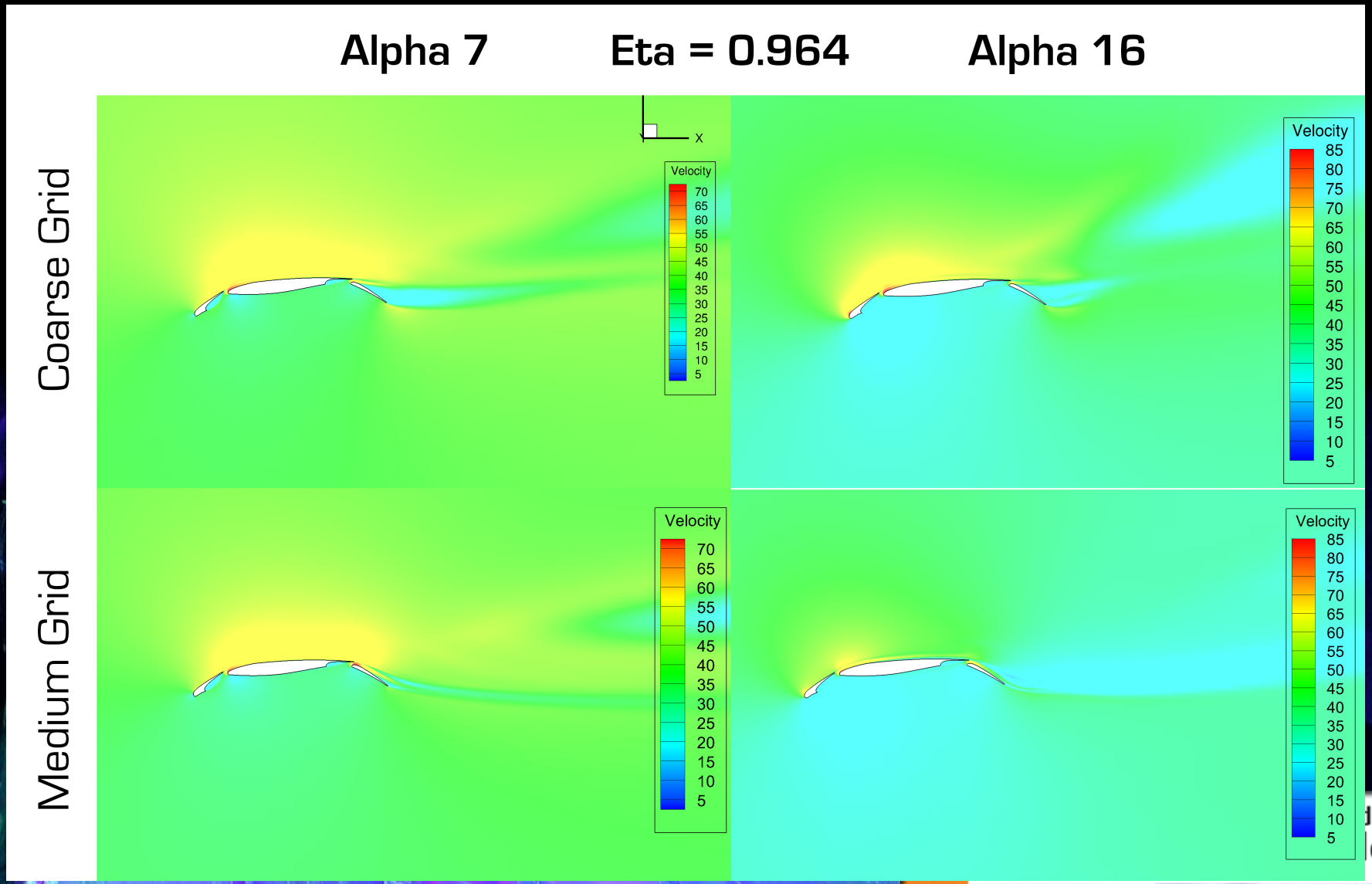
Results - Flow Visualization (Cont'd)

Velocity Field (Magnitude) – Eta = 0.449



Results - Flow Visualization (Cont'd)

Velocity Field (Magnitude) – Eta = 0.964



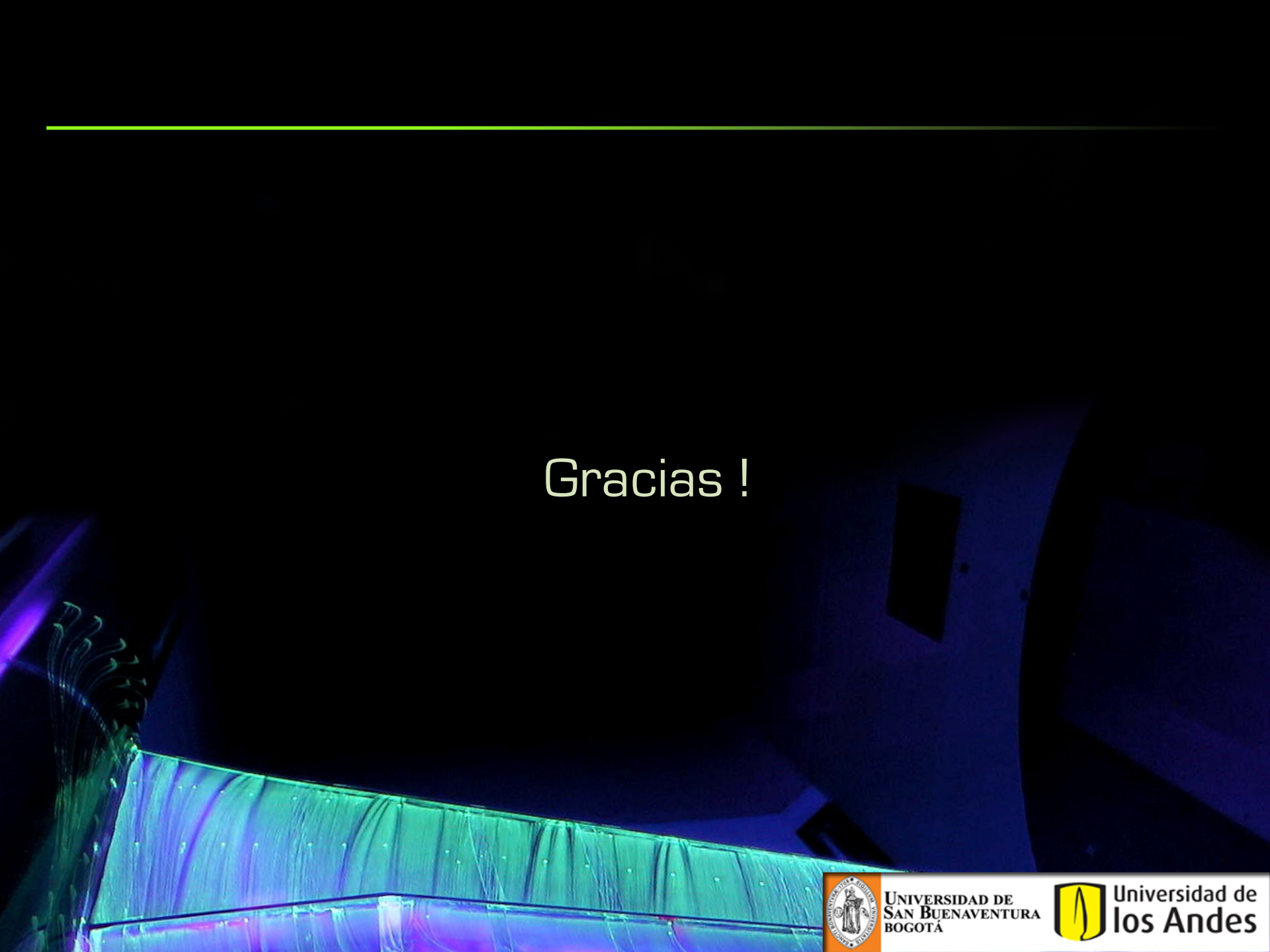
Lessons Learned

- Fully coupled solver in FLUENT requires at least four times more RAM memory than segregated solver.
- SA-RC implemented in FLUENT is more computationally expensive that SA model.
- Cp prediction near the wing tip had a significant improvement over the results obtained for the HiLiftPW-1 cases ran without CR.
- Need to generate our own grid sets based on the workshop gridding guidelines hopefully to prevent compatibility issues when reading into the solver or to modify the mesh if errors (i.e. negative volumes, left handed faces) are detected by the solver.
- Post-processing requires more time and hardware resources than expected, specially if cases with large number of cells are analyzed (i.e. > 50M).

Future Work

- Grid generation: possible commercial software: ICEM, Gridgen (Pointwise)
- Alpha Sweep and Low Reynolds number study.
- Increase RAM memory in available hardware in order to run the fine grid for the grid convergence study.
- Increase RAM memory in available hardware in order to run Case 3.
- Evaluate local mesh adaptation based on flowfield variables and use hybrid turbulence models in continuation to work done for the HiLiftPW-1.
- Evaluate the effects of the Curvature Correction in the prediction of the pressure distribution.
- Participation in AIAA summer conference 2014.

Gracias !



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