Transitional Flow Over an SD7003 Wing

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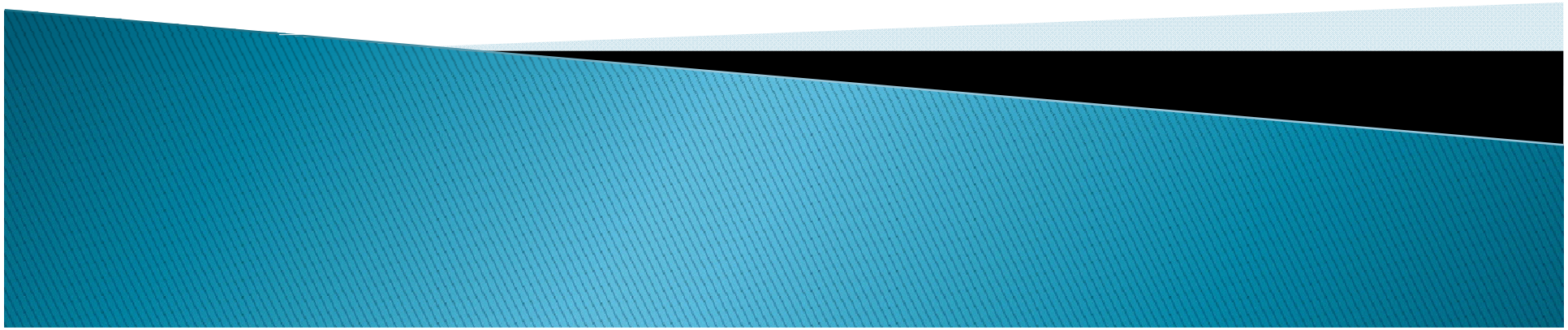
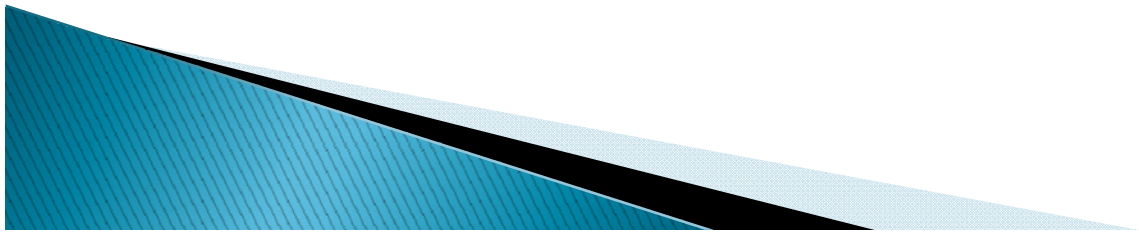


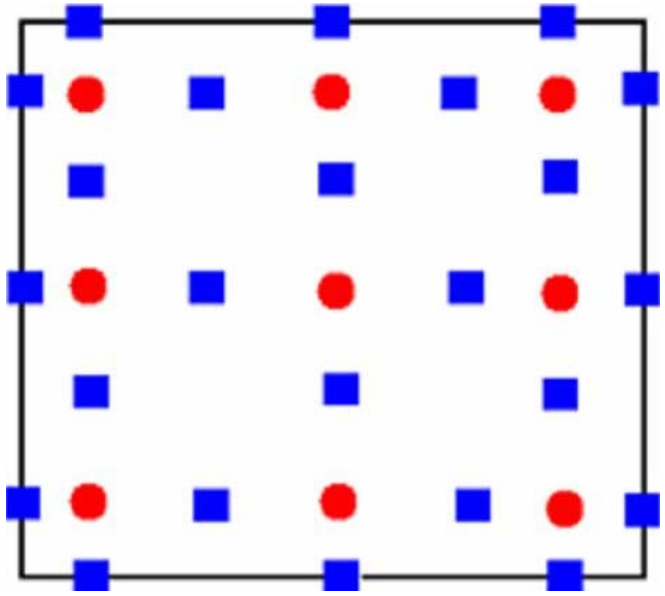
Overview

- Numerical Methods
- Grid
- Computational Cost
- Case overview
- Results
- Conclusions



Numerical Methods

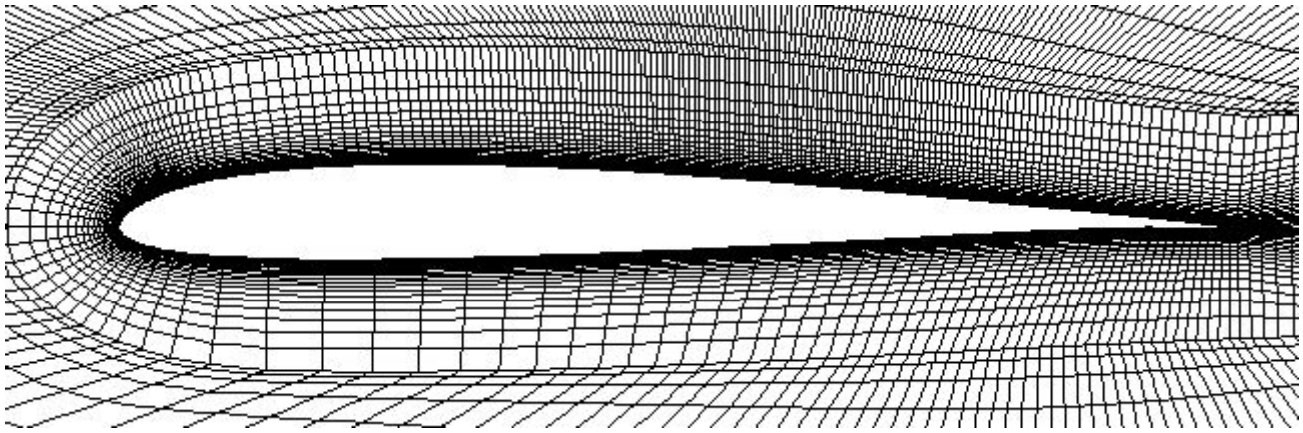
- Spectral Difference
  - Cells consist of solution points and flux points
    - 3rd order scheme used
    - Solution points (red)
    - Flux points (blue)
  - Identical to staggered grid spectral method



- Runge-Kutta
  - 3rd order method
  - Time step of 0.0002

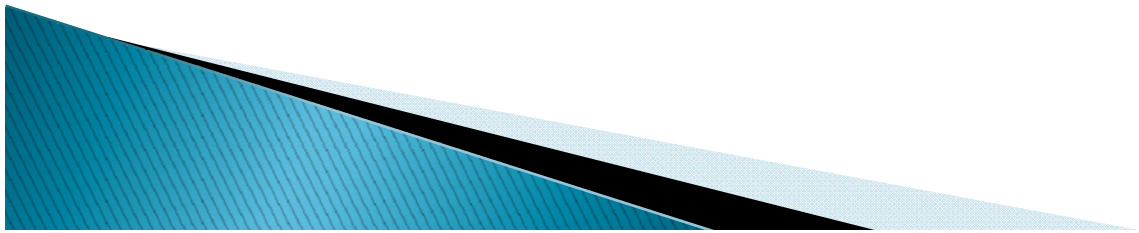
SD7003 Grid

- Hexahedral mesh
  - Maximum upper surface spacing of 0.0101
  - Boundaries set at 100 chords away
  - Total number of cells: 239,590
  - Gives 6,468,930 degree-of-freedoms for 3rd order



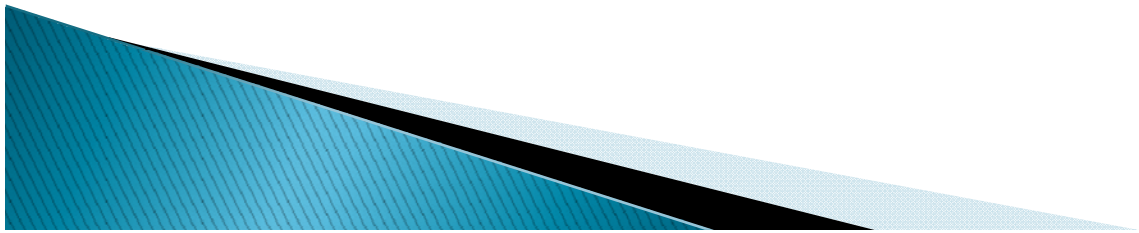
Computational Cost

- NVIDIA CUDA
  - Single precision code
  - Two Tesla C2070 cards
  - Non-dimensional time of 16
    - 66.5 hours
  - Non-dimensional time of 10
    - 41.6 hours
  - Total computational time
    - 108.1 hours
  - Total computational time for one CUDA card
    - 216.2 hours



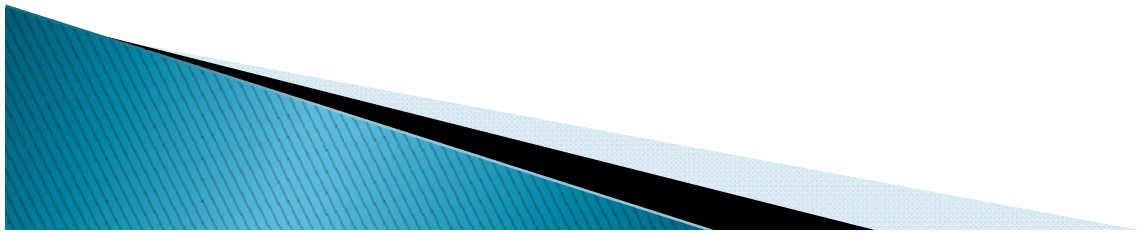
Computational Cost

- CPU cluster with 64 processors
  - TauBench of 9.77
  - 1000 steps took 890 seconds
  - Require non-dimensional time of 26
    - 421.0622 hours



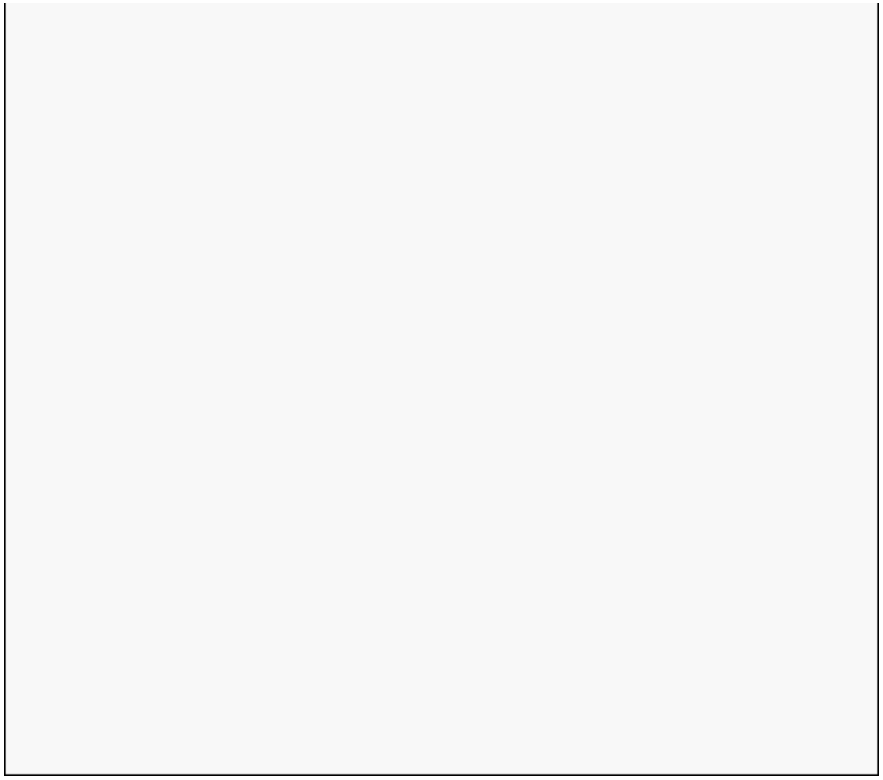
Case Overview

- SD7003 wing ran at following conditions:
  - Reynolds number 60,000
  - Mach number 0.1
  - Angle of attack 8°
  - Ratio of wall to free-stream temperature 1.002
  - Span set at 0.2
    - Periodic span-wise conditions

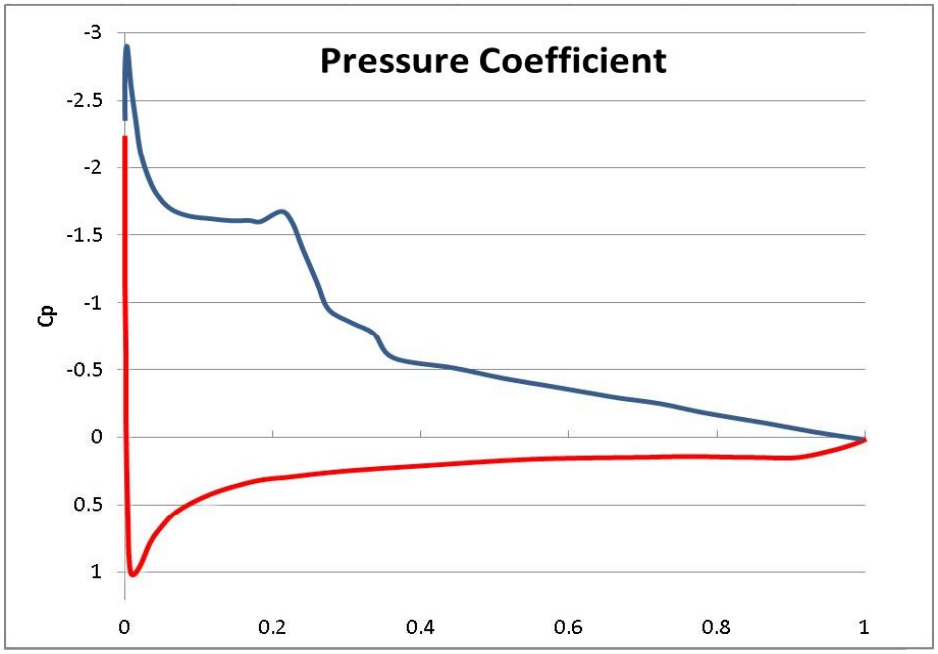


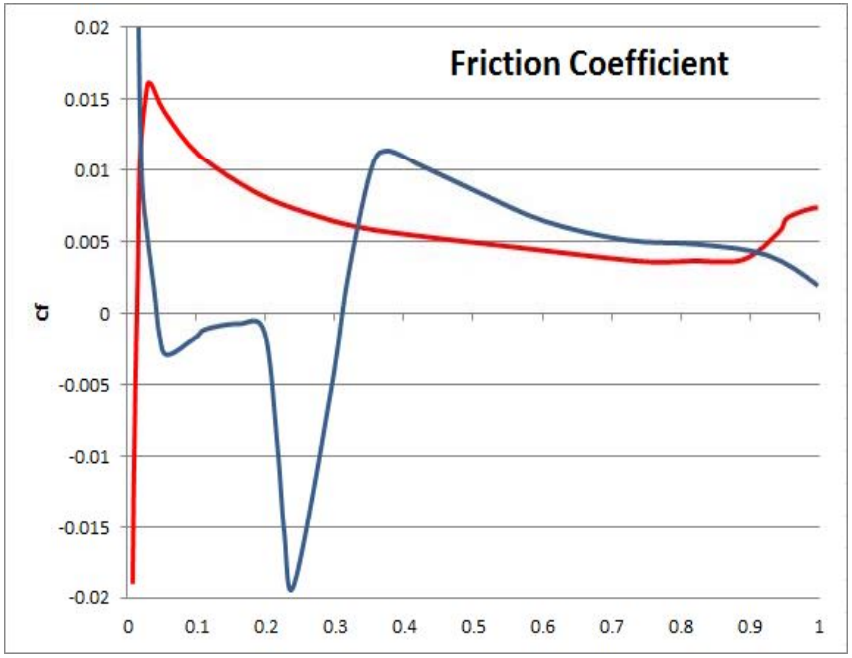
Results – Q Criterion

- Laminar separation bubble
  - Starting point
    - x/c = 0.18
  - Ending point
    - x/c = 0.29
  - Maximum height
    - 0.0235



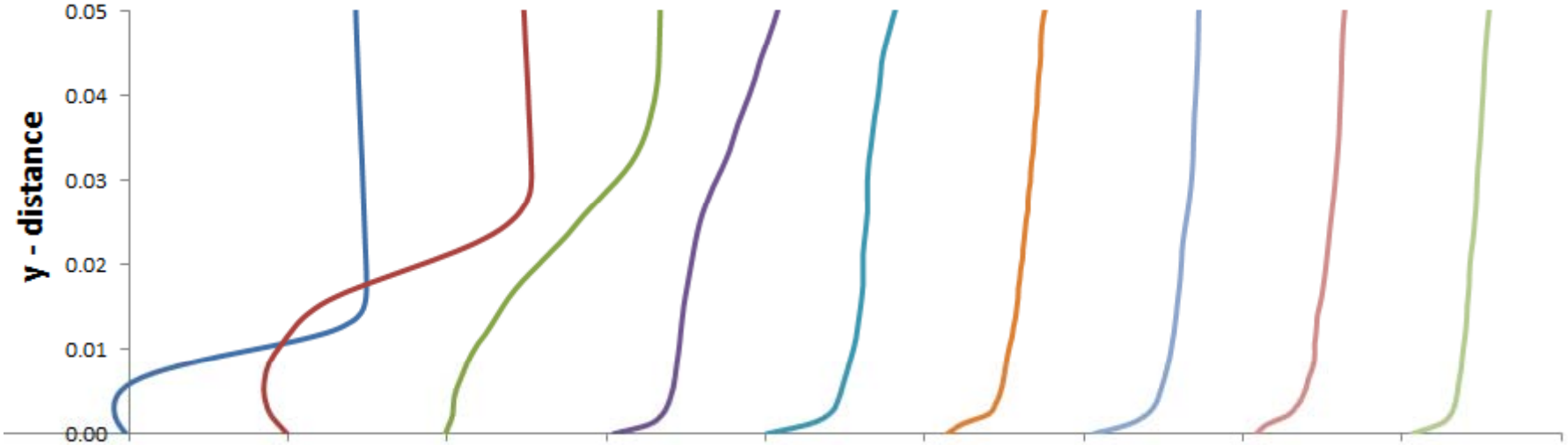
Results – Friction and Pressure





- Airfoil top (blue) and bottom (red)

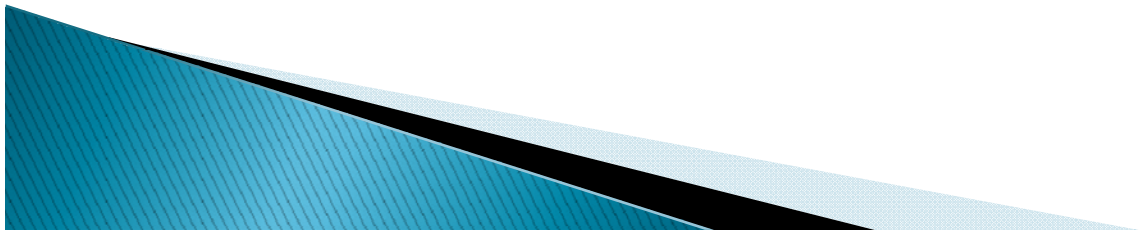
Results – Velocity Profile



- Mean u-velocity profile
  - Time and span-wise averaged
  - Data taken at chord locations 0.1, 0.2, 0.3, … , 0.9

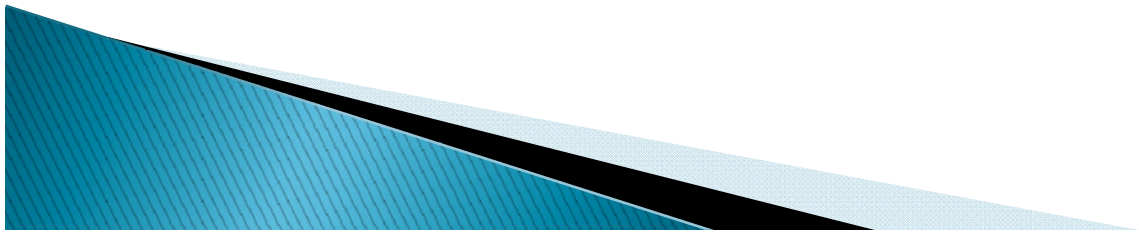
Results – Lift, Drag, and Moment

- Time averaged forces for 10 non-dimensional time
  - Lift coefficient
    - 0.916397
  - Drag coefficient
    - 0.049397
  - Moment coefficient about the quarter chord
    - 0.002324



Conclusions

- High order methods can capture complicated unsteady flow structures
  - Turbulent region captured very well
  - Less dissipation compared with lower order schemes
- CUDA speeds
  - Two CUDA cards out-preform 64 processors
    - Speed-up of roughly 4x



Questions