# Automated Cart3D Off-Body Pressure Analysis Results

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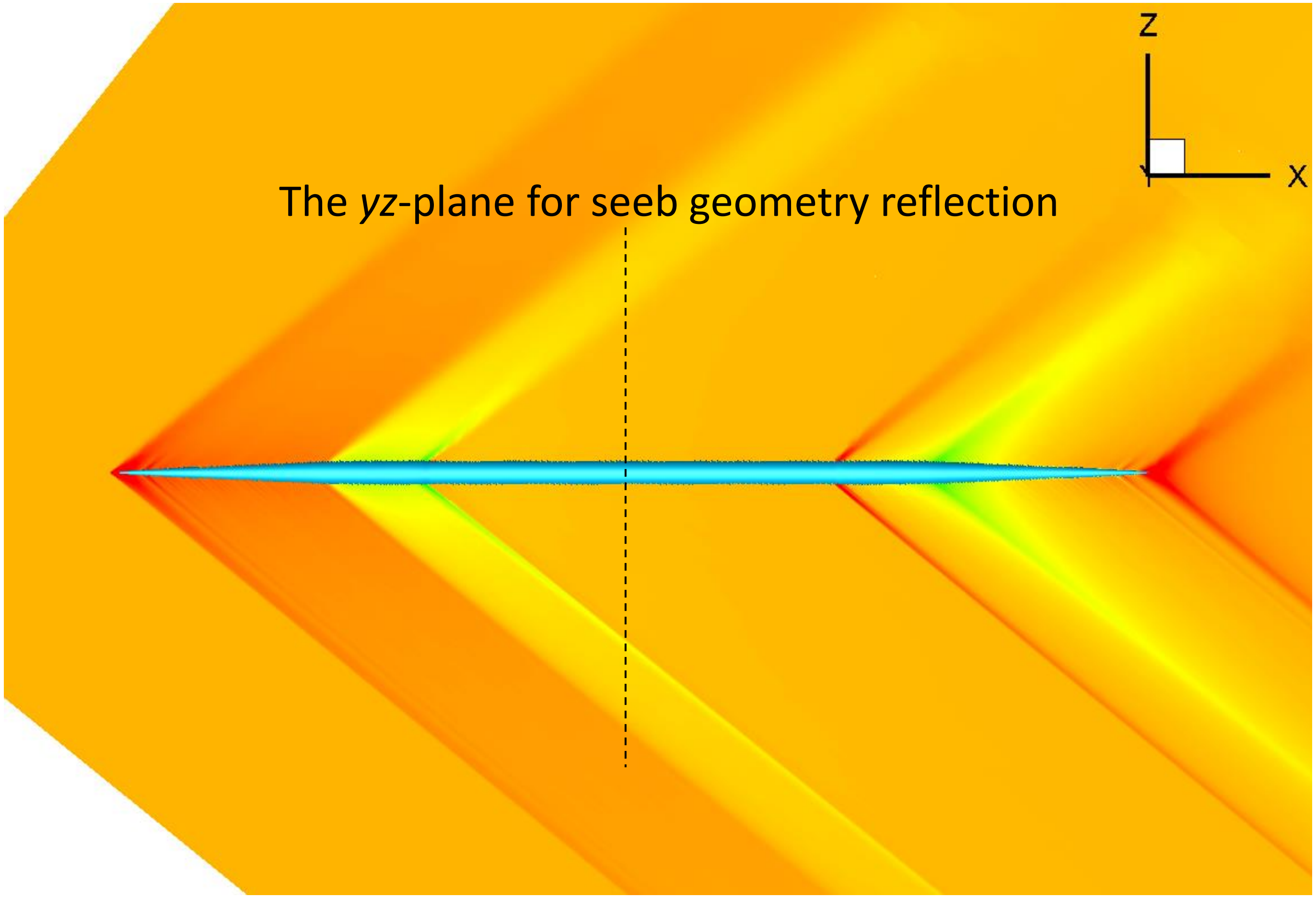
# Introduction

- Cases analyzed, flow solver, and computing platform
  - Cart3D inviscid solutions on shared memory Linux clusters
  - SEEB: Under-track pressure distributions at H = 21.2 and 42.0 inches
  - Delta Wing: All off-body pressure distributions for phi = 0, 30, 60, and 90 deg at H = 0.0127, 0.53848, 0.62992, and 0.80772 inches
- Geometry modifications for automated Cart3D analysis process
- Automated Cart3D sonic boom analysis process
- Analysis results for SEEB body-of-revolution
- Analysis results for Delta Wing
- Conclusions

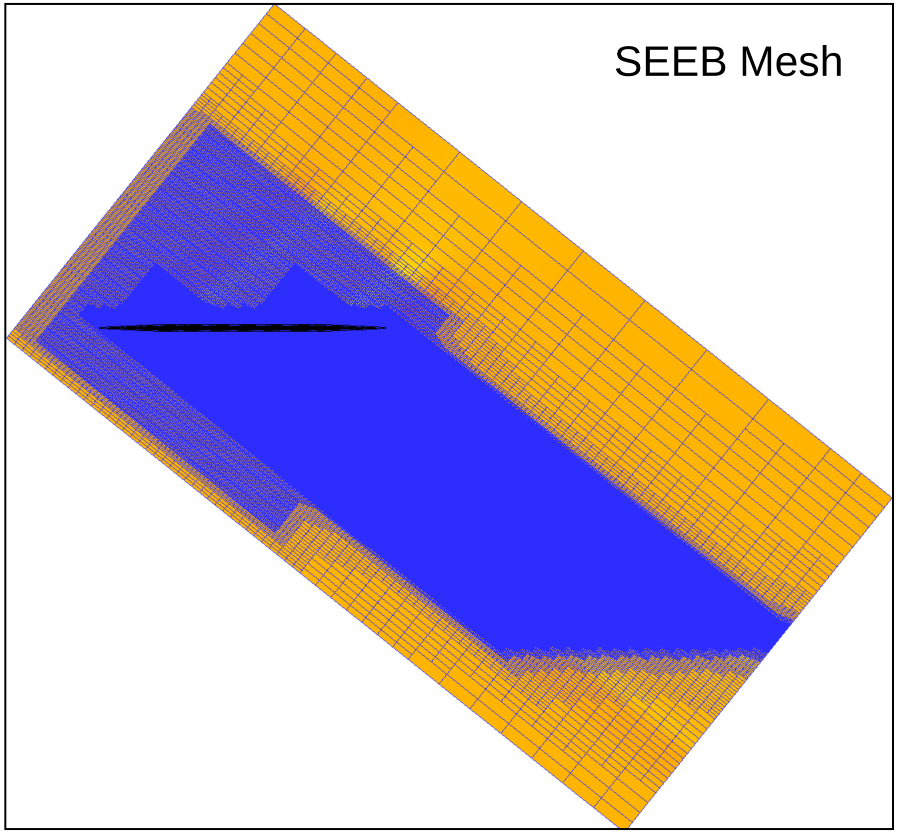
# Modifications of SEEB and Delta Wing

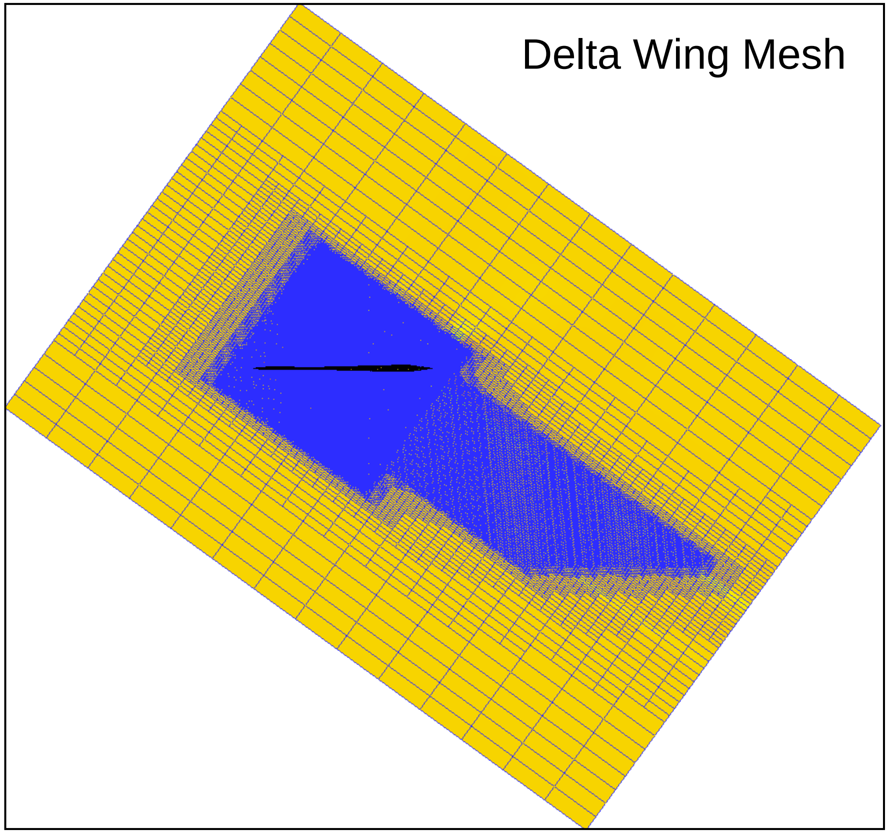
- SEEB-080 geometry is mirrored along the *yz*-plane to form a watertight geometry.
- The watertight SEEB-080 geometry is scaled to 90 ft.
- The delta wing geometry is scaled to 99 ft and a full model is used for analysis.
- The scaling is for easy setup of the automated Cart3D analysis process.



# Automated Cart3D Off-Body Analysis Process

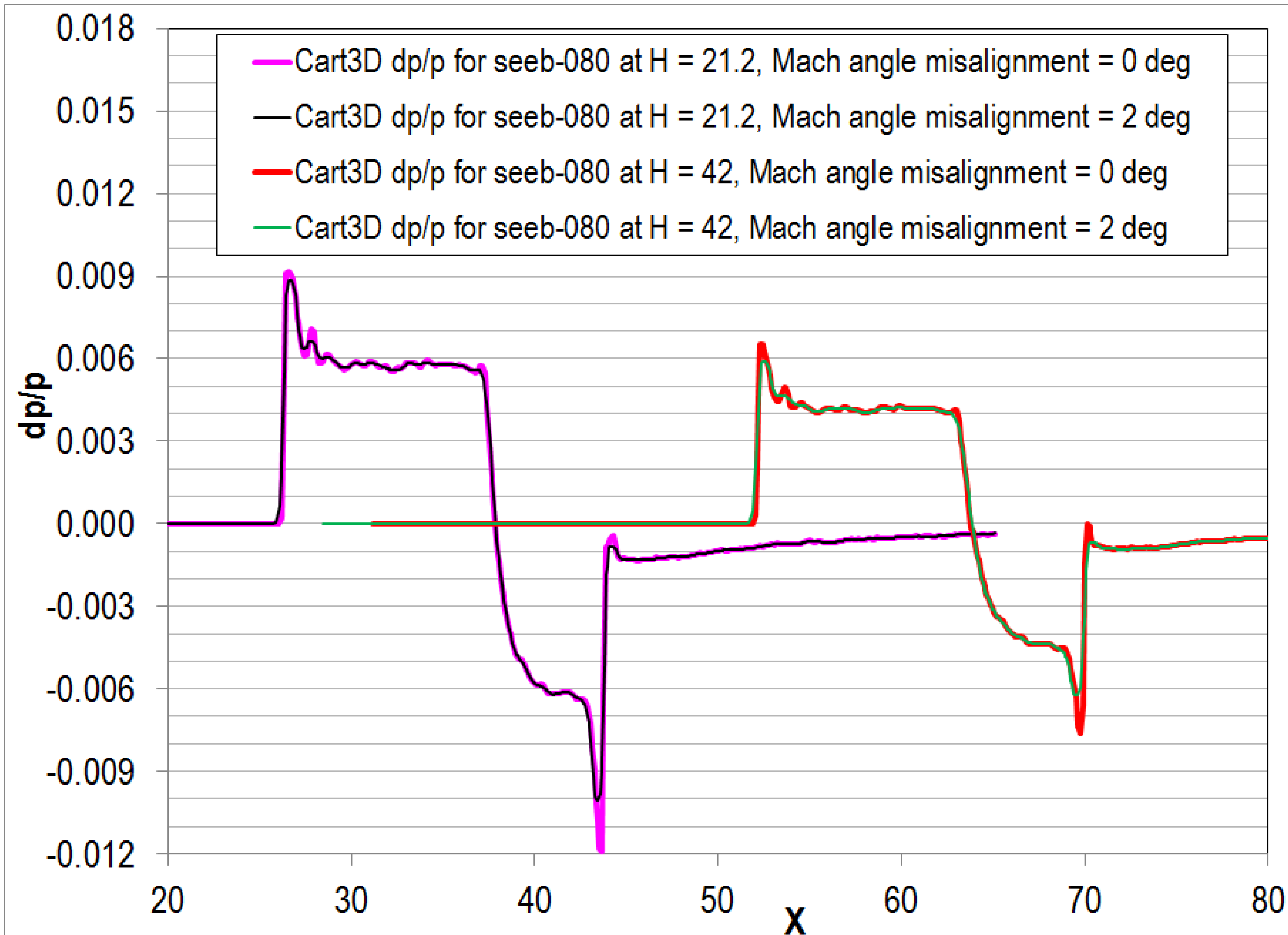
- User inputs: Mach, AoA, off-body location, Xverts (*x*-direction grid density), engine boundary conditions (for powered engine simulation)
- Trial-and-error process: Adjust Xverts until the volume mesh has 20M+ cells.
- Verification: Use the largest Xverts that the computer will generate a volume mesh.

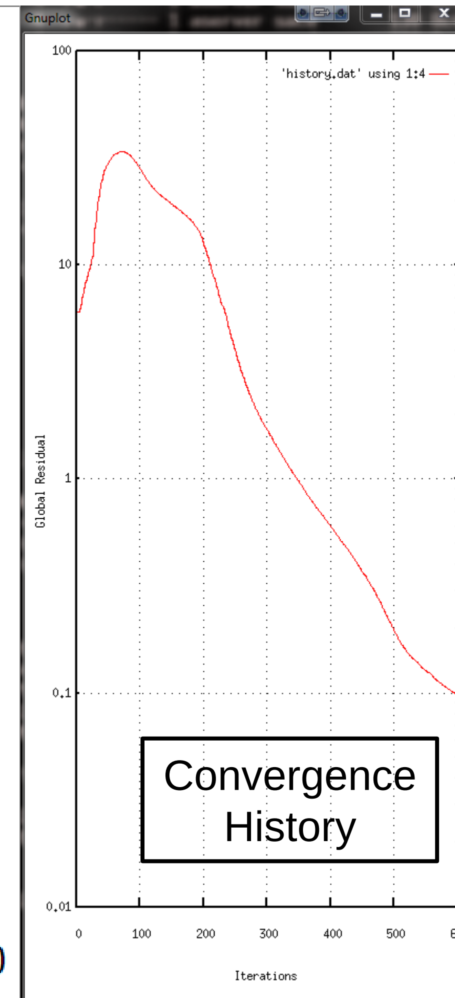


# Cart3D Analysis of SEEB-080

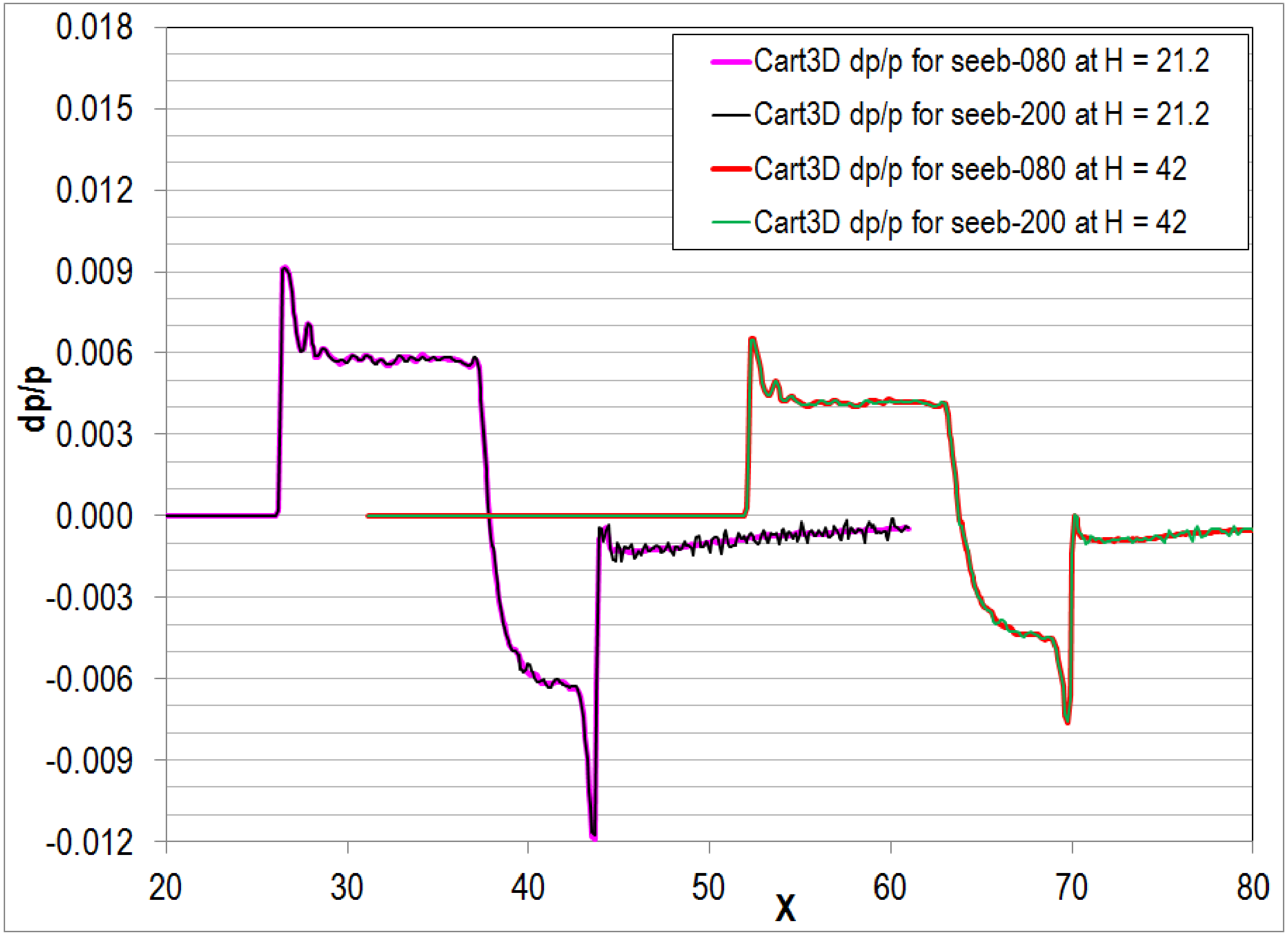
- Mach = 1.6, AoA = 0, mesh size is about 18M cells, convergence error < 0.1, 600 iterations
- Two sets of analysis results for off-body dp/p (d*x* = 0.12): one set uses a grid perfectly aligned with Mach angle and another has a 2 deg off-set between grid line and Mach angle.



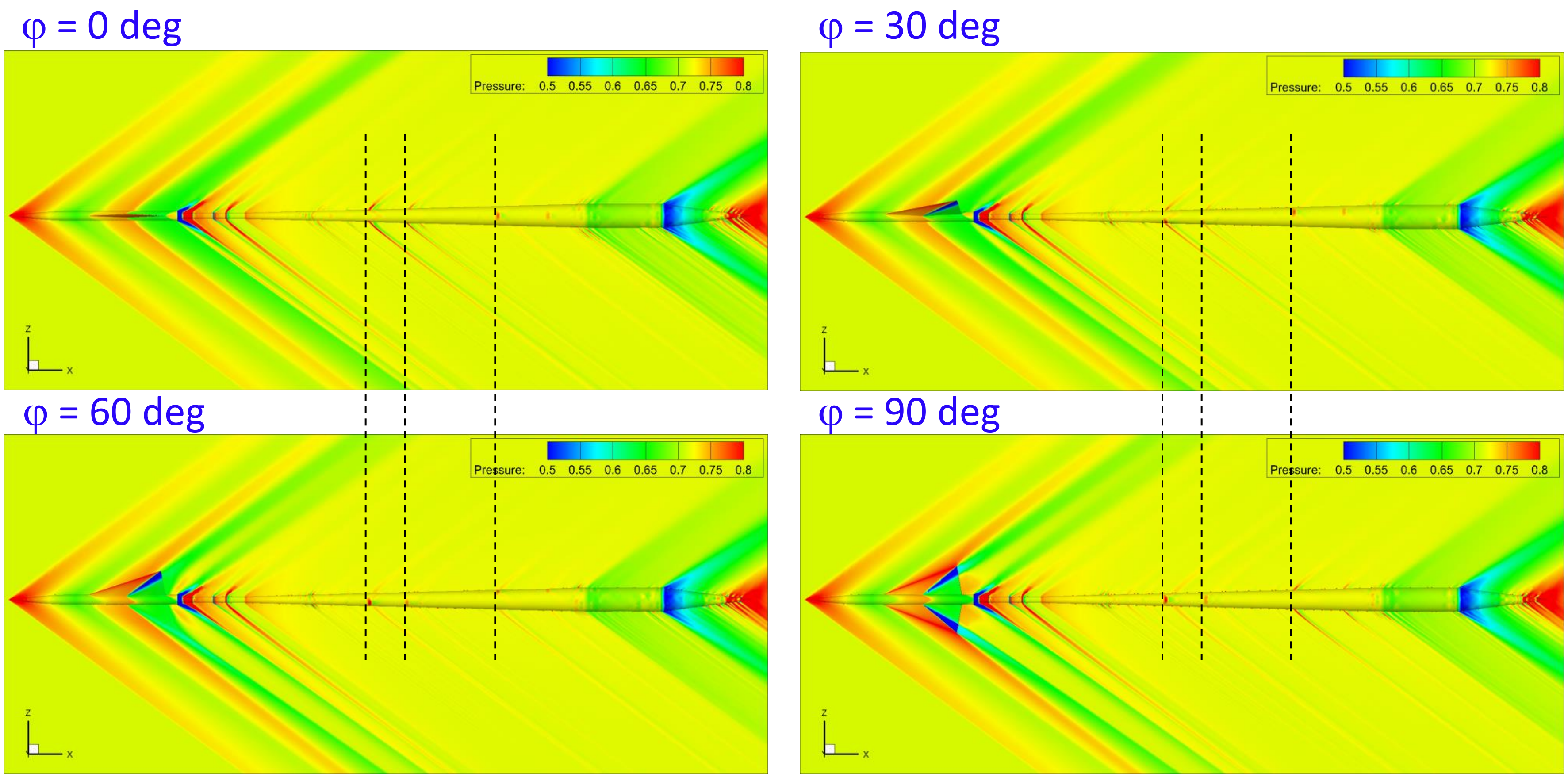
# Cart3D Comparison of SEEB-080 and SEEB-200

- Mach = 1.6, AoA = 0, mesh size is about 18M cells, convergence error < 0.1, 600 iterations
- Two sets of analysis results for off-body dp/p (d*x*=0.12): one set uses SEEB-080 and another uses SEEB-200. No significant difference in dp/p characteristics for the two surface meshes.



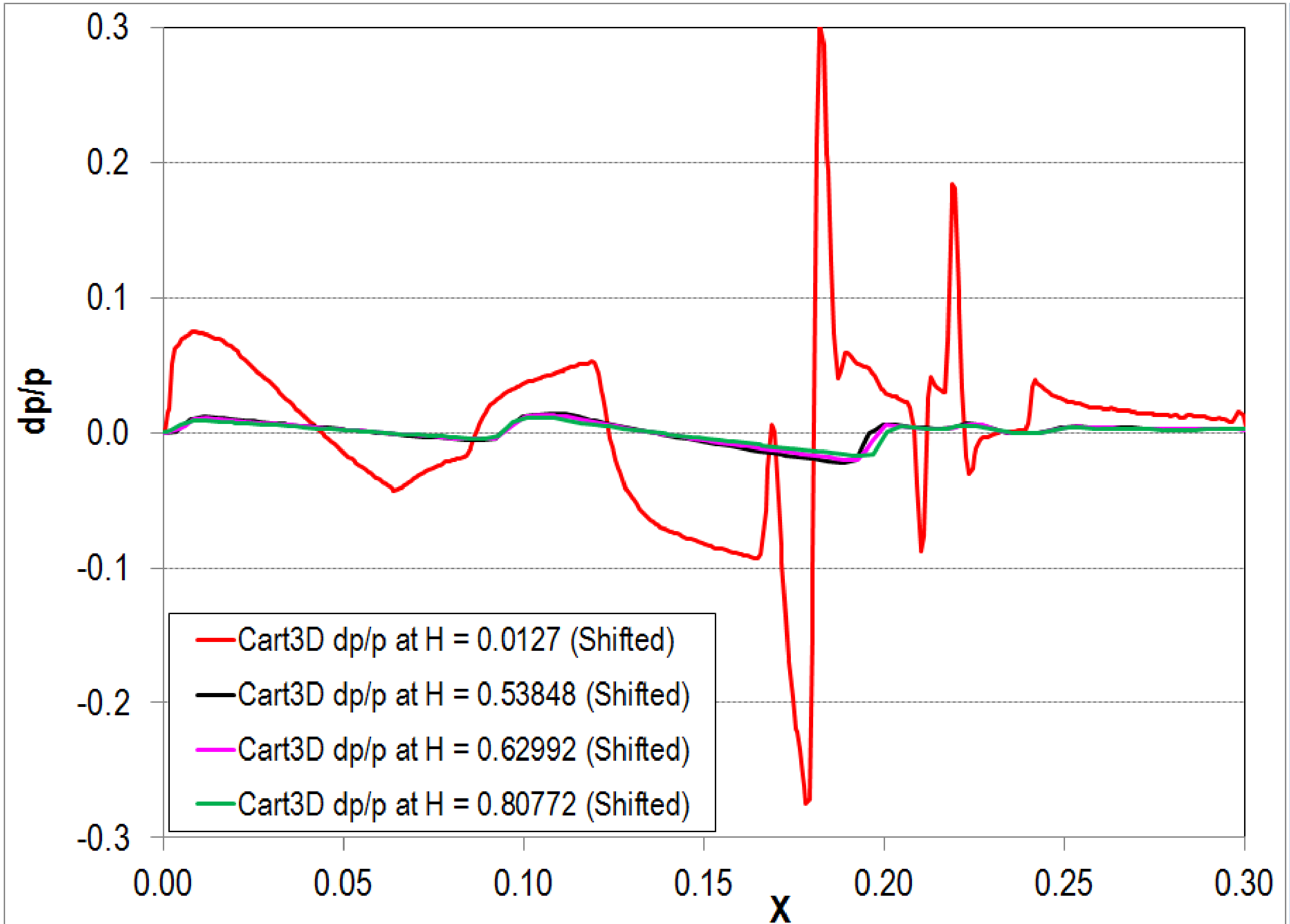
# Cart3D Analysis of Delta Wing at Off-Track Locations

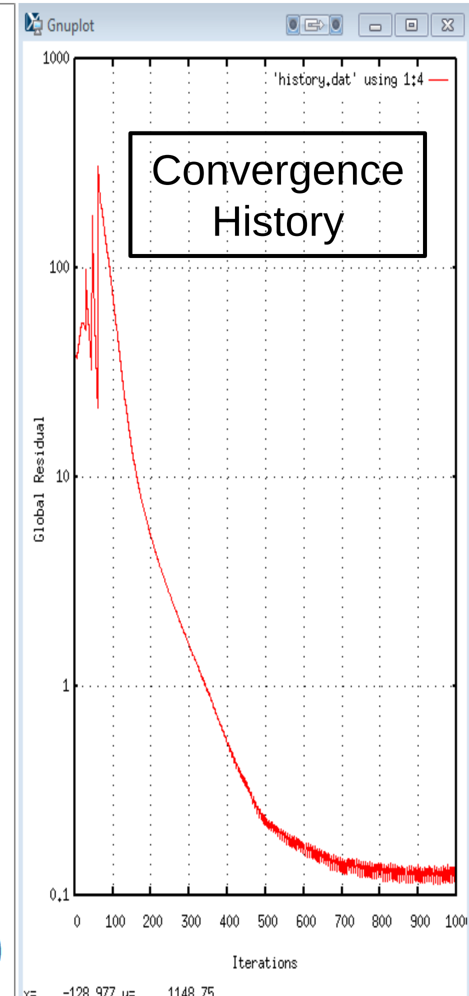
- Mach = 1.7, AoA = 0, mesh size is about 26M for under-track and 54M cells for off-track, the linear cut-cell option of Cart3D is required for convergence error < 0.2, 1000 iterations
- For each off-track location, the configuration is rotated by the off-track angle along the *y*-axis to convert the off-track analysis into the under-track one (with a configuration non-symmetric with respect to the *xz*-plane).
- The front fuselage behaves like a body of revolution but the sting part does not.



# Cart3D Under-Track Analysis Results for Delta Wing

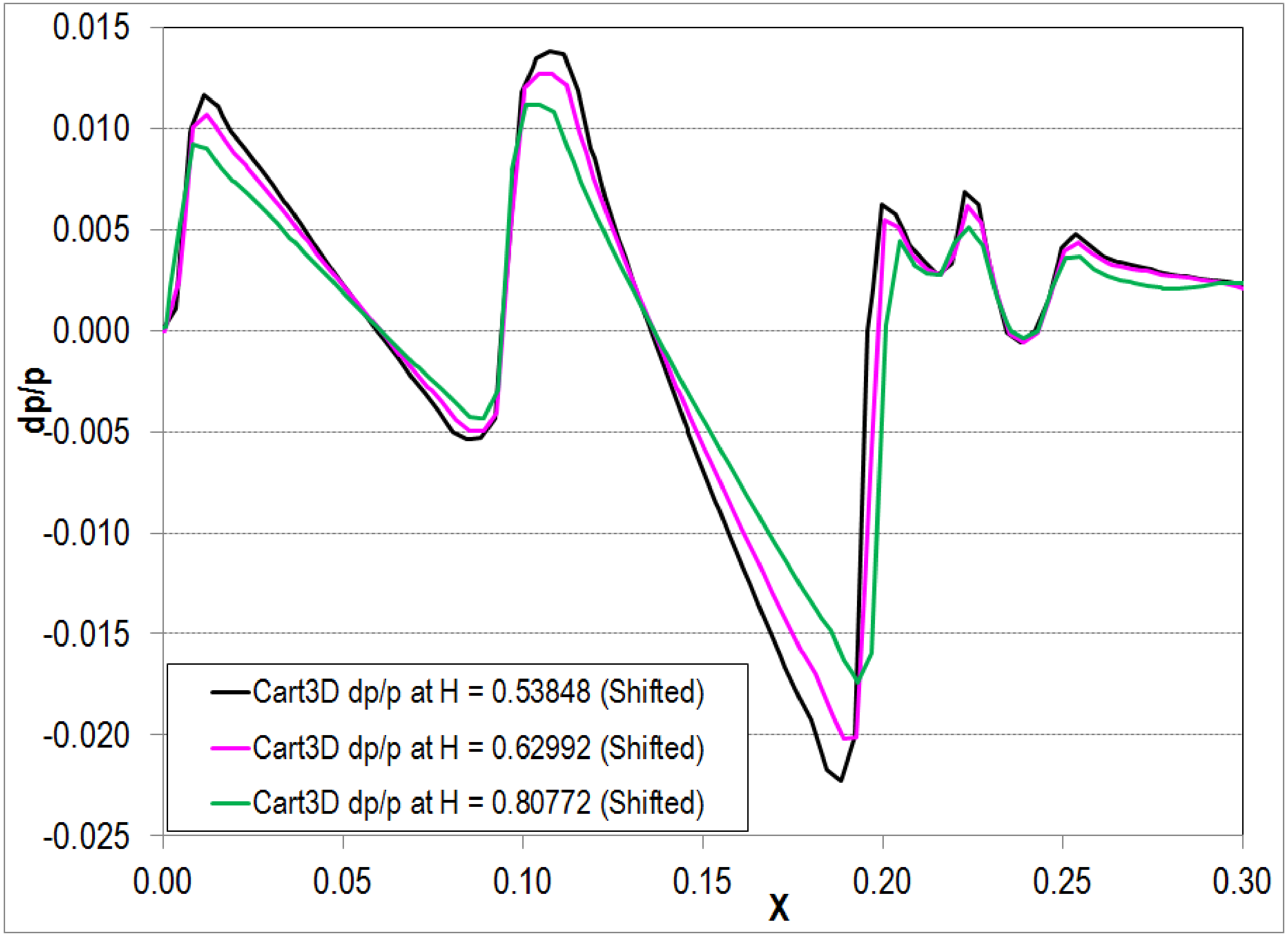
- Mach = 1.7, AoA = 0, mesh size is about 26M for under-track and 54M cells for off-track, the linear cut-cell option of Cart3D is used for convergence error < 0.2, 1000 iterations
- More than ¾ of dp/p points are not relevant to the delta wing model.



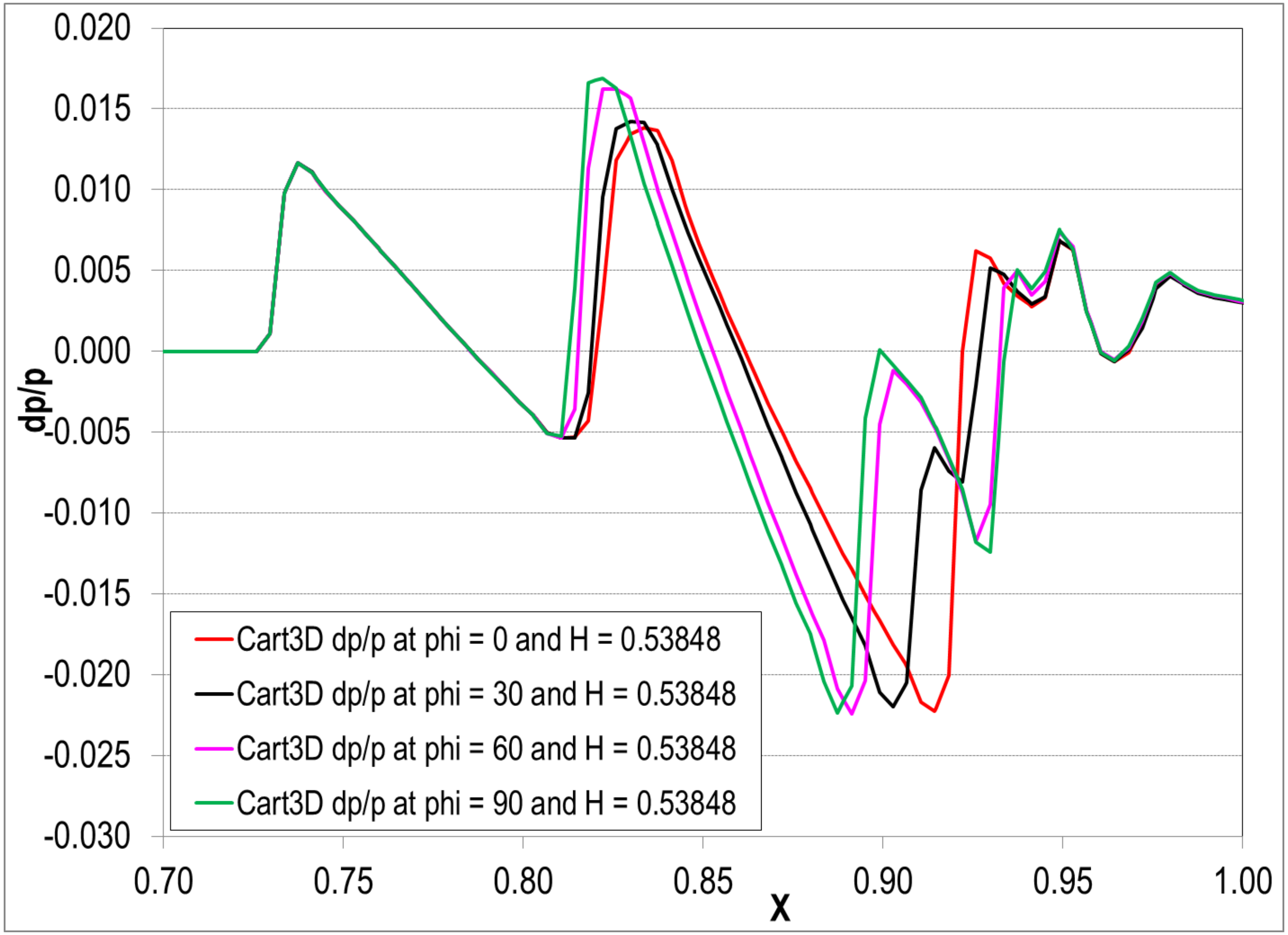
# Cart3D Under-Track Analysis Results for Delta Wing (II)

- Mach = 1.7, AoA = 0, mesh size is about 26M for under-track and 54M cells for off-track, the linear cut-cell option of Cart3D is used for convergence error < 0.2, 1000 iterations
- The resolution in *x*-axis (d*x* = 0.003) is not desirable due to loss of ¾ of dp/p points.



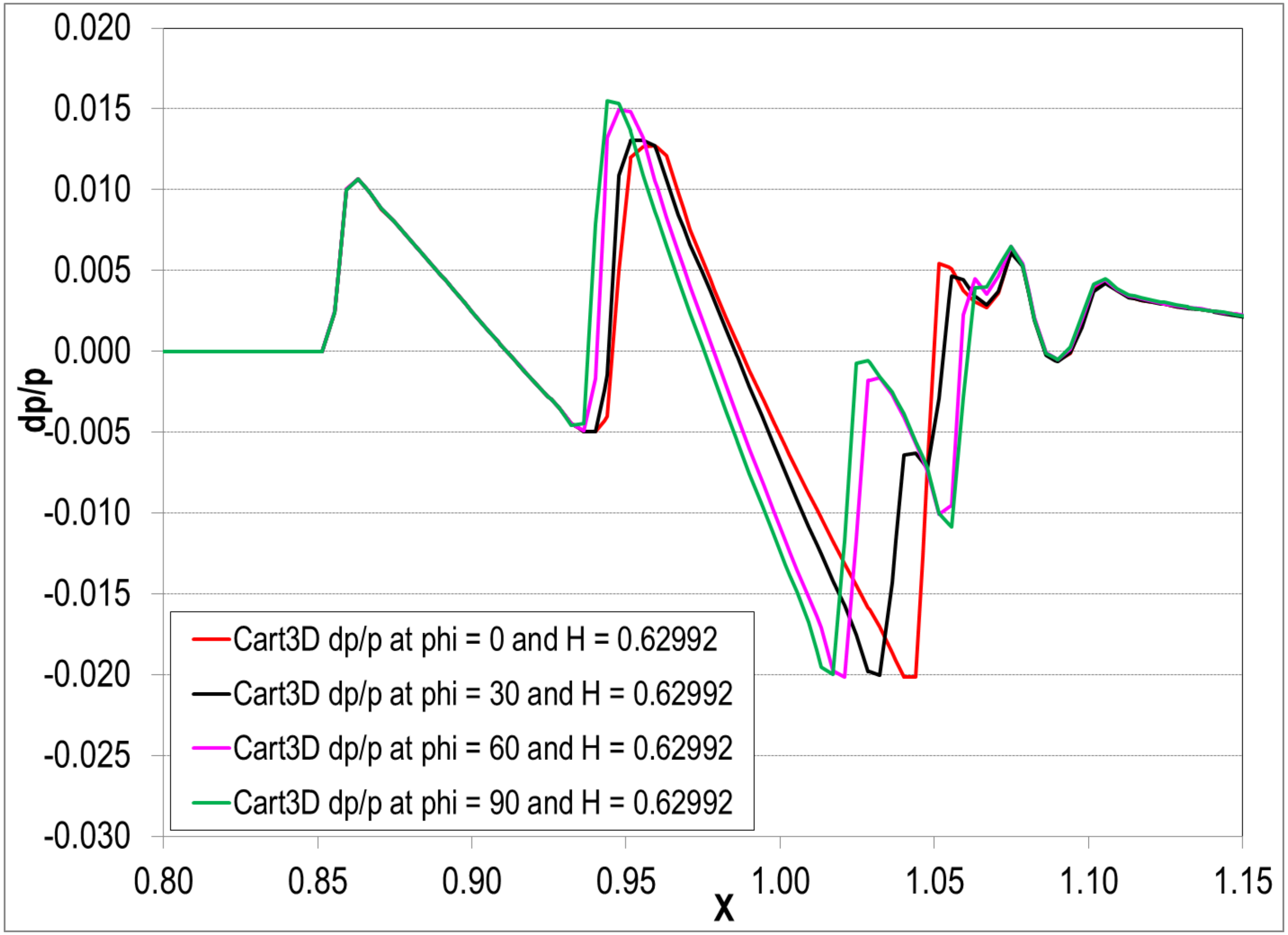
# Cart3D Comparison of dp/p at H = 0.53848 for Delta Wing

- Mach = 1.7, AoA = 0, mesh size is about 26M for under-track and 54M cells for off-track, the linear cut-cell option of Cart3D is used for convergence error < 0.2, 1000 iterations



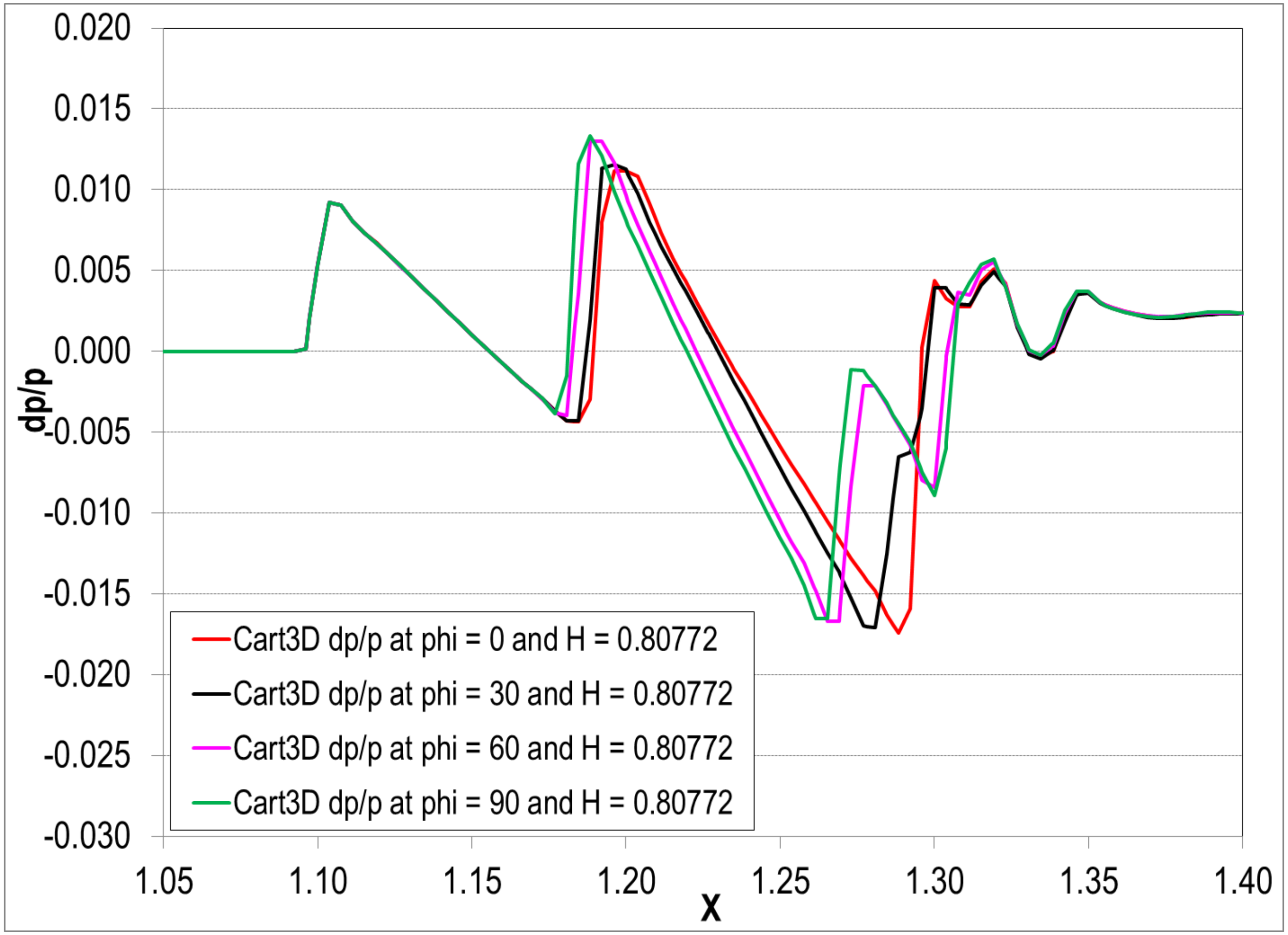
# Cart3D Comparison of dp/p at H = 0.62992 for Delta Wing

- Mach = 1.7, AoA = 0, mesh size is about 26M for under-track and 54M cells for off-track, the linear cut-cell option of Cart3D is used for convergence error < 0.2, 1000 iterations



# Cart3D Comparison of dp/p at H = 0.80772 for Delta Wing

- Mach = 1.7, AoA = 0, mesh size is about 26M for under-track and 54M cells for off-track, the linear cut-cell option of Cart3D is used for convergence error < 0.2, 1000 iterations



# Lessons Learned

- The most time-consuming aspect of the automated Cart3D off-body dp/p analysis is to use a trial-and-error approach for generating a mesh resolution of the desirable quality.
- Lack of easy-to-understand error messages about failed CFD runs for Delta Wing (Cart3D without using the linear cut-cell option or USM3D without using a special boundary flag) led to several days of delay for completing the runs. (Thanks to Mathias Wintzer and Richard Campbell for resolving the convergence issues!)
- The current automated Cart3D analysis process for off-body dp/p is very robust and extremely easy to use for both in-house and external geometry models!!
- The automated analysis process shifts the geometry to place the fuselage “nose” at (0,0,0). This might lead to some marginal (about 0.2%) errors in *x*-location of *dp/p* distribution. (Only realized the importance of *x*-location for *dp/p* after seeing Mike Park’s preview of his summary slides.)
- Reduction of manual steps is critical for quality assurance in any complex engineering analysis process.
- Need some definitive criterion about the accuracy of dp/p calculation. (Is a solution with sharper peaks/valleys more representative of the actual dp/p?)

**Questions?**

# Backup (Errors in dp/p due to configuration shift)