



Boom Supersonic Contribution to the 3rd AIAA Sonic Boom Prediction Workshop: Nearfield Signatures

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Introduction



- Flow solver, convergence and computational resources
- Test case 1: Biconvex
 - Workshop-provided and BOOM custom grids
- Test case 2: C608
- Conclusions

Flow solver, convergence and computational resources



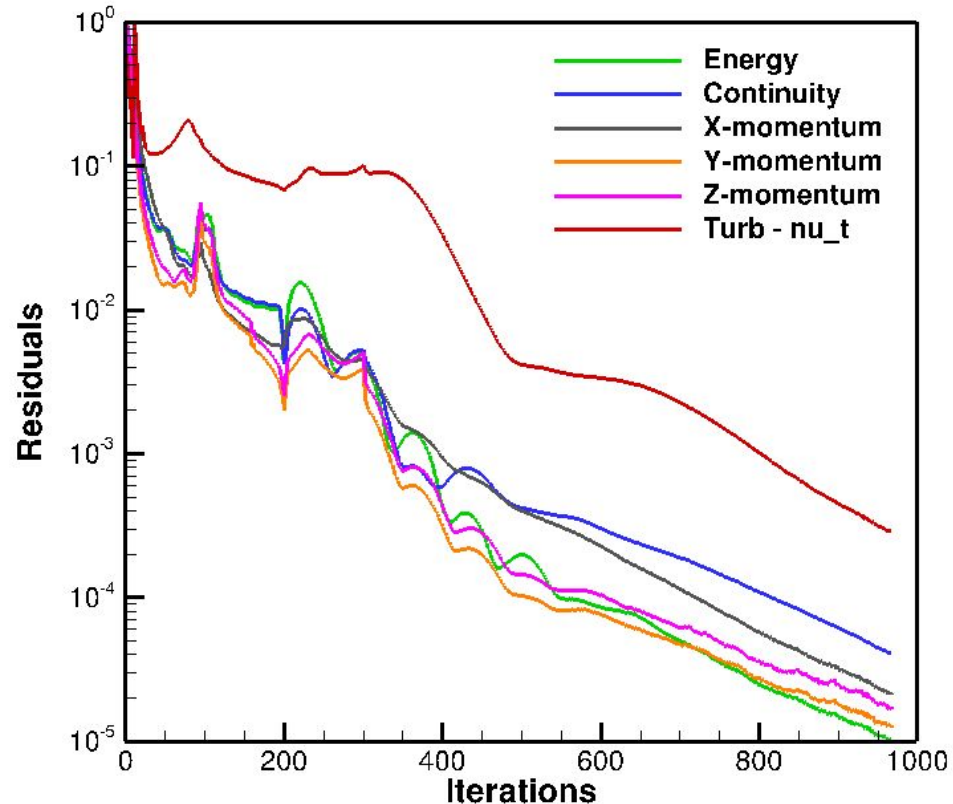
Flow solver

- CFD++ 19.1
 - <http://www.metacomptech.com/>
- 2nd order-accurate, unstructured, finite volume flow solver
- RANS equations, perfect gas
- SA-RC-QCR turbulence model
- Algebraic multigrid

Convergence

- At least 4 order of magnitude residual drop
- All cases exhibited similar convergence

Computational resources: up to 200 Intel® Xeon® Silver 4114 Skylake Processor



Test Case 1: Biconvex

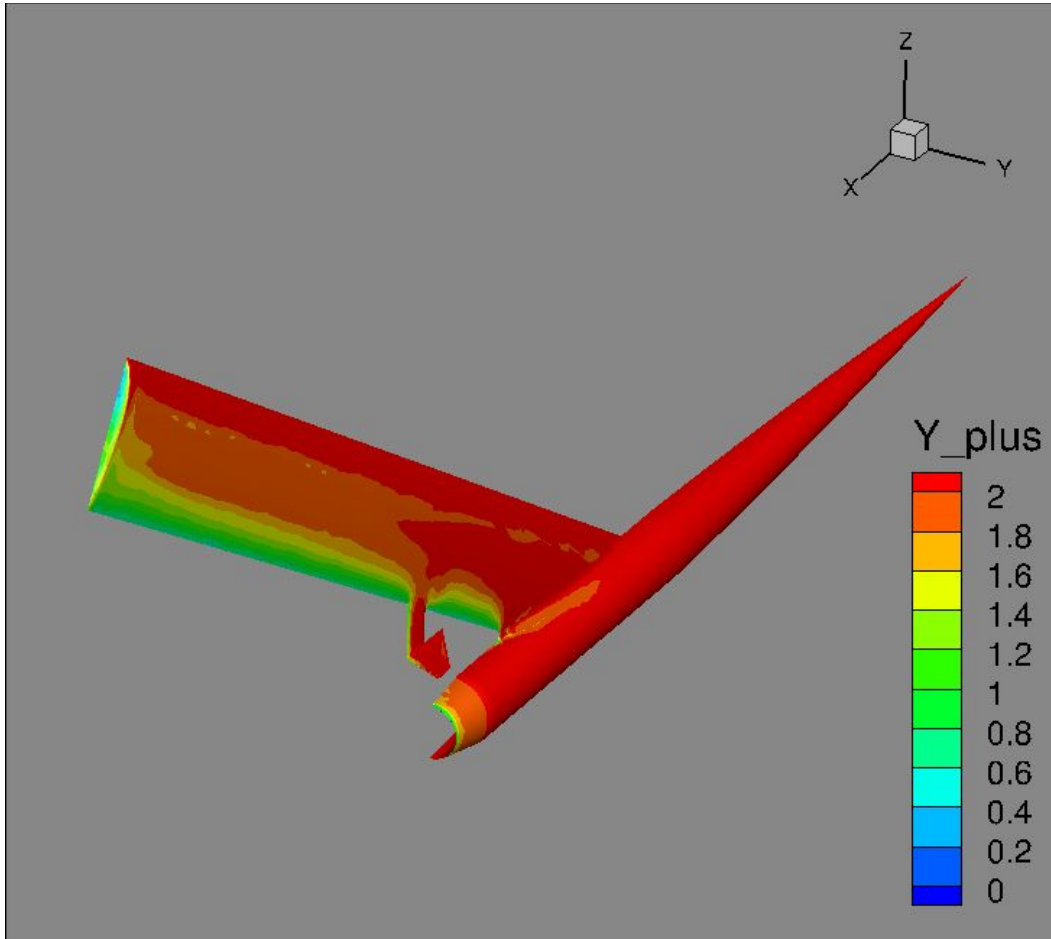


Unstructured, mixed-elements meshes:

- Workshop-provided grids
- BOOM custom grids
 - Geometry modification, Mach-aligned mesh clustering, nozzle plume refinement

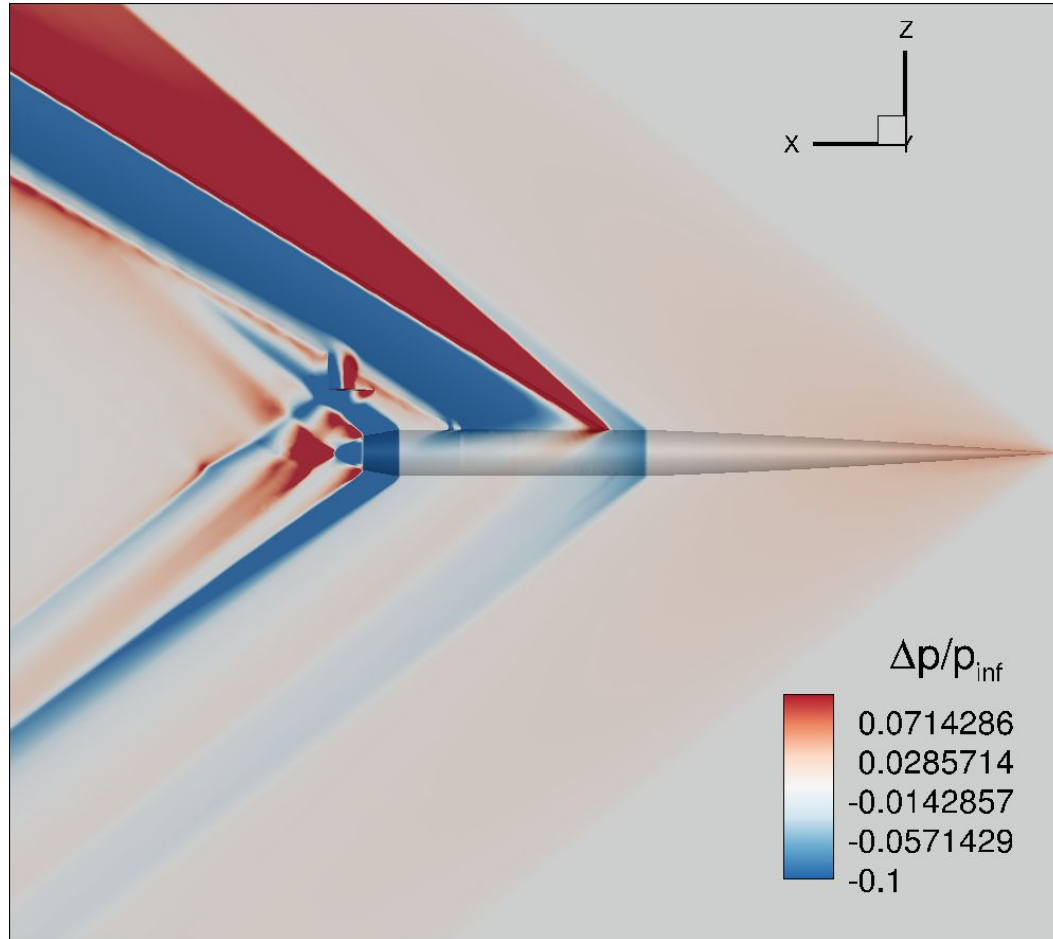
	SBPW - # cells	BOOM - # cells
Coarse	3.4Mln	69.7Mln
Medium	6.9Mln	120.4Mln
Fine	16Mln	187.4Mln

Test Case 1: Biconvex - Workshop grids

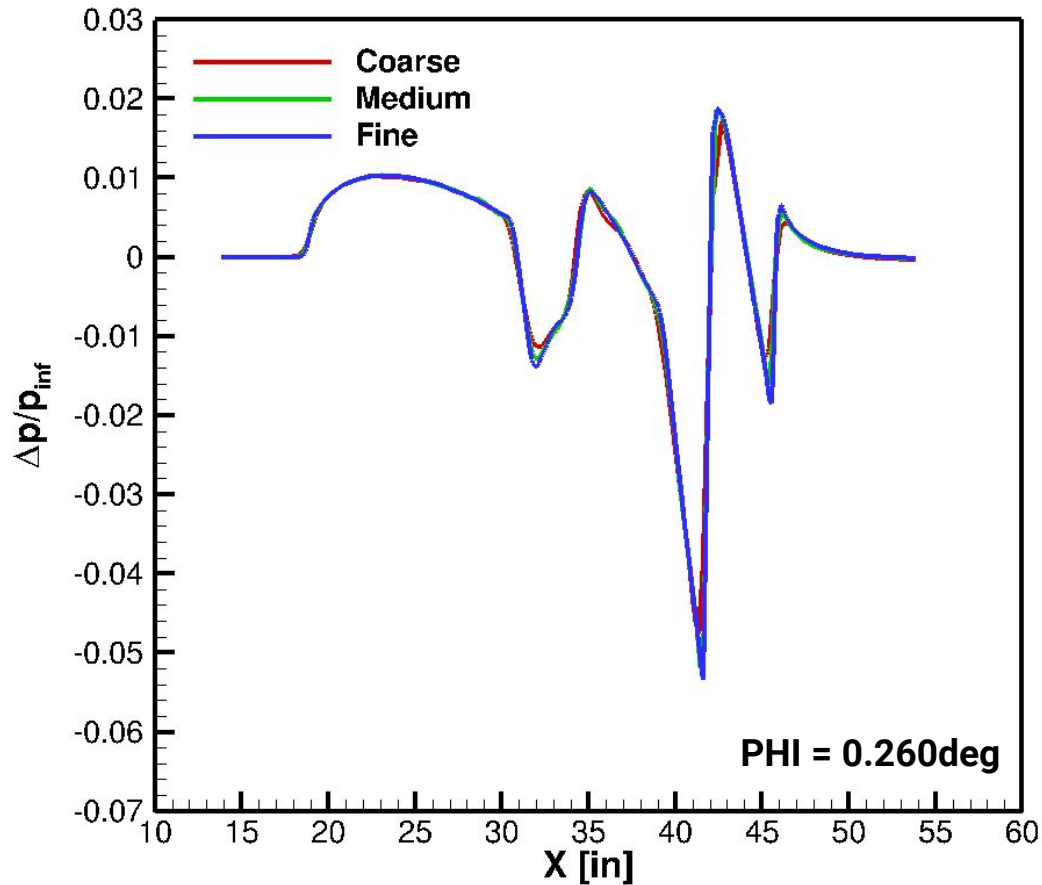


- $Y_+ > 1$ over significant portion of external surface
- Wall function approach

Test Case 1: Biconvex - Workshop grids



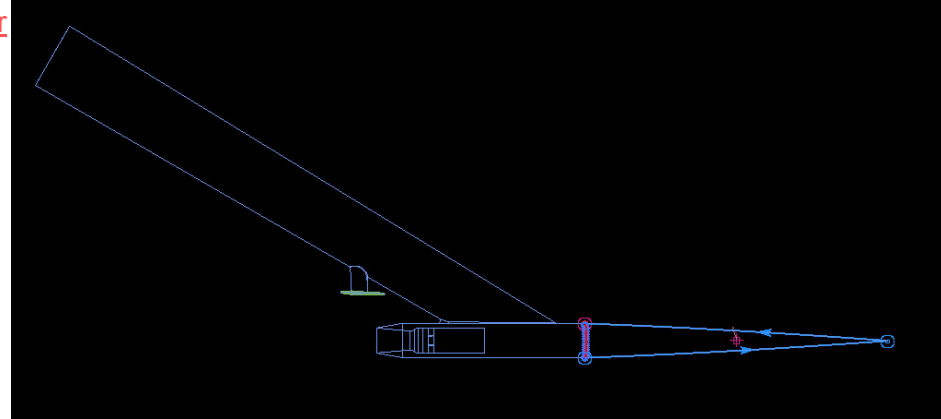
Test Case 1: Biconvex - Workshop grids



Test Case 1: Biconvex - BOOM custom grids



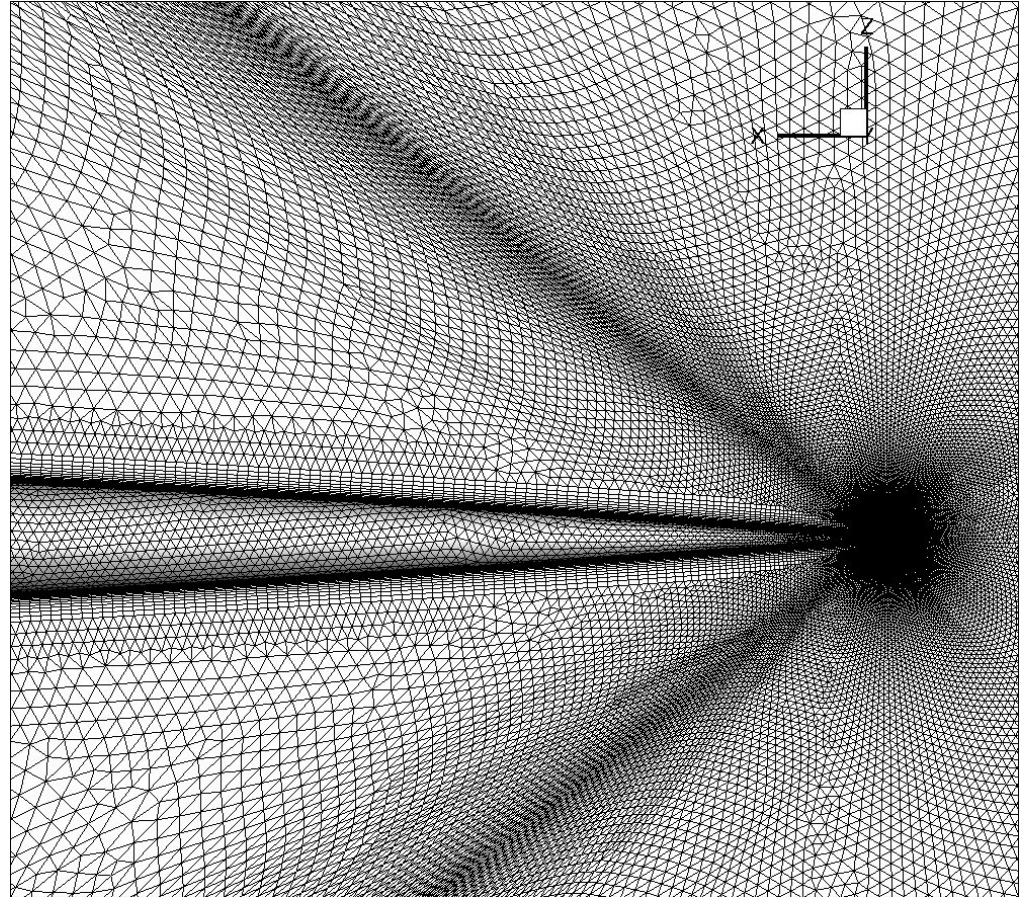
- CAD cleanup with NASA's GTC
 - <https://lbpw-ftp.larc.nasa.gov/sbpw3/biconvex/geometry/biconvex-geometry-assessment.pdf>
 - Enlarged far-field box
- Grids generated with Heldenmesh
 - <https://heldenaero.com/>
- Mixed-element unstructured grids
- $Y^+ \approx 1$
- Mach-aligned mesh refinement
- Nozzle plume refinement



Test Case 1: Biconvex - BOOM custom grids



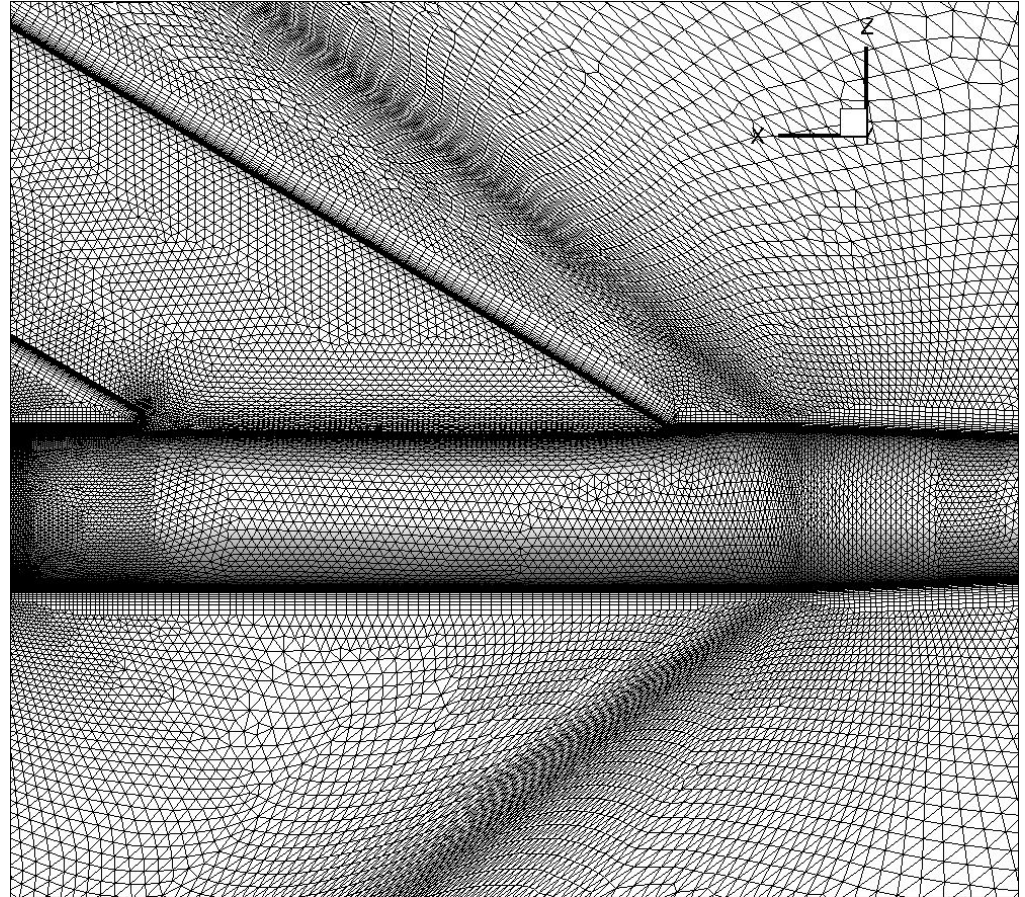
**Mach-aligned
cell clustering at
nose cone**



Test Case 1: Biconvex - BOOM custom grids



**Mach-aligned
cell clustering at
*expansion***

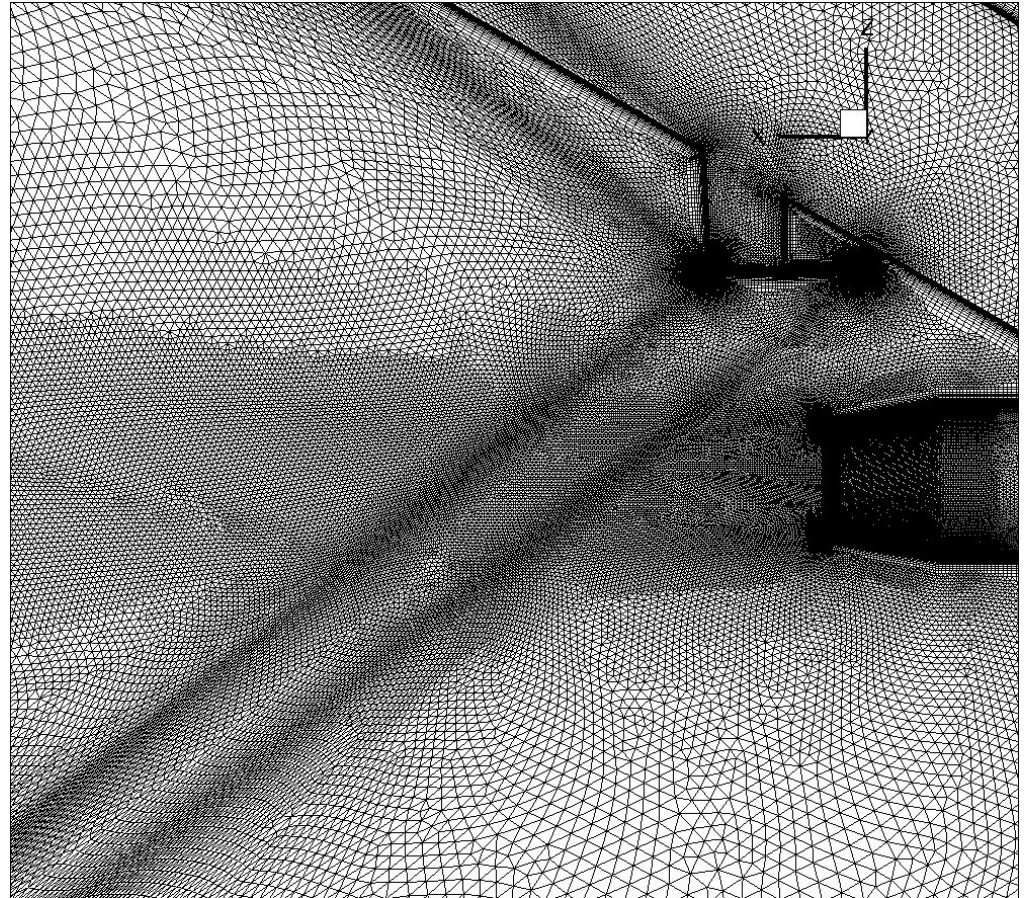


Test Case 1: Biconvex - BOOM custom grids



**Mach-aligned
cell clustering at
fin**

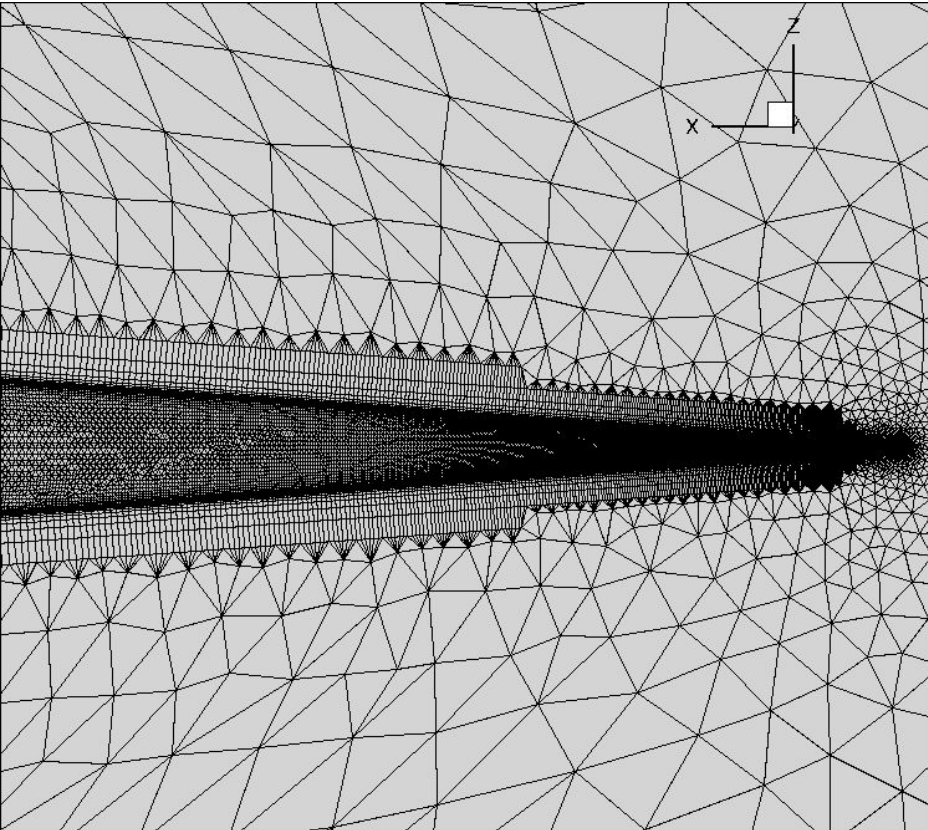
**Nozzle plume
refinement**



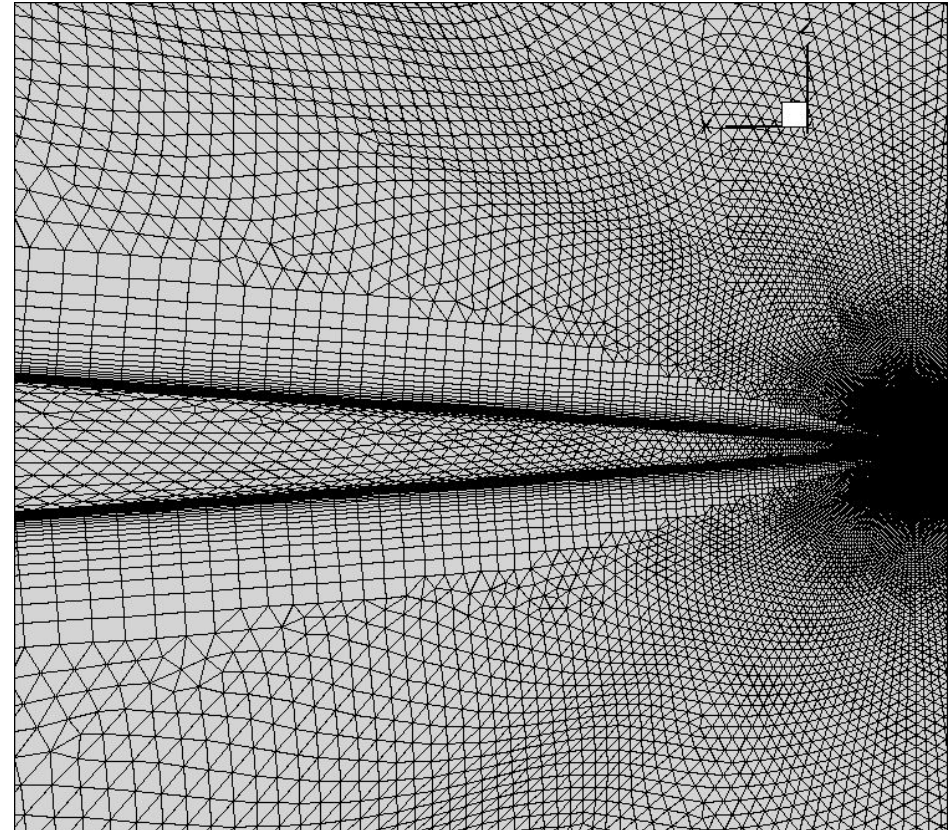
Test Case 1: Biconvex - BOOM custom grids



SBPW - Fine



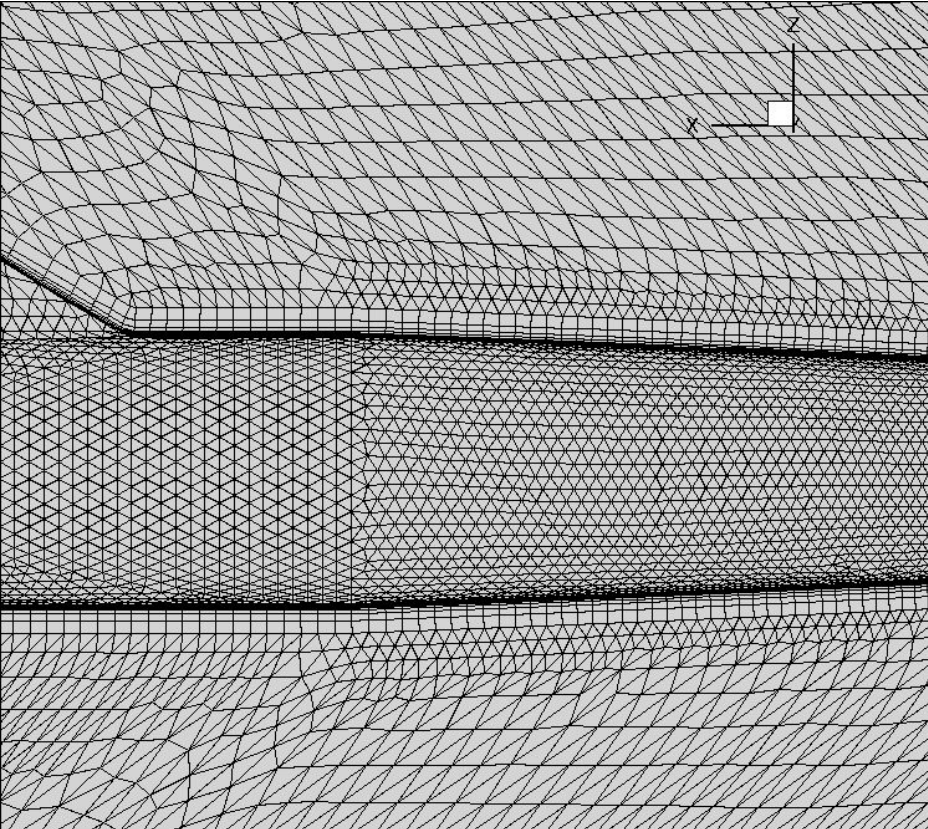
BOOM - Coarse



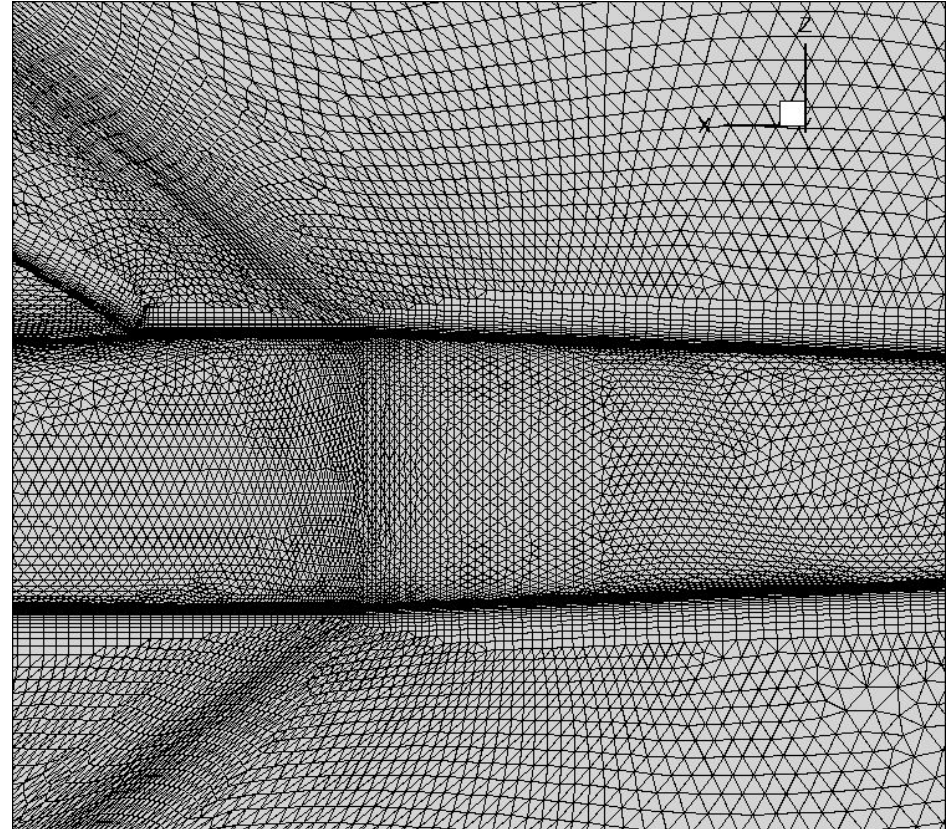
Test Case 1: Biconvex - BOOM custom grids



SBPW - Fine



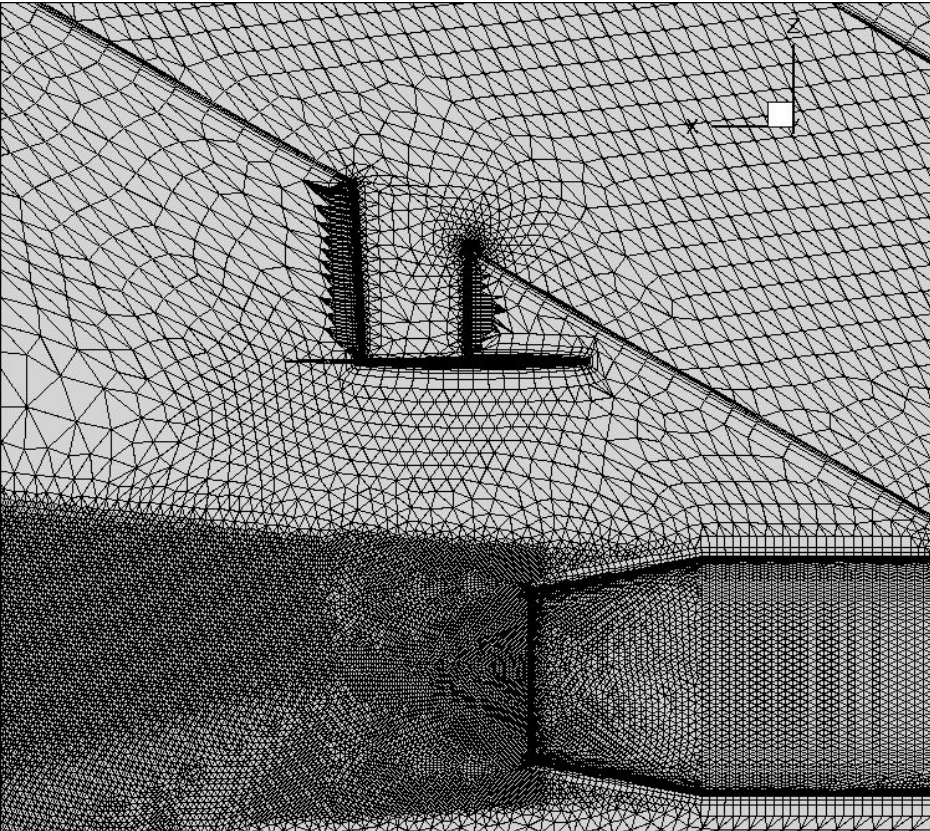
BOOM - Coarse



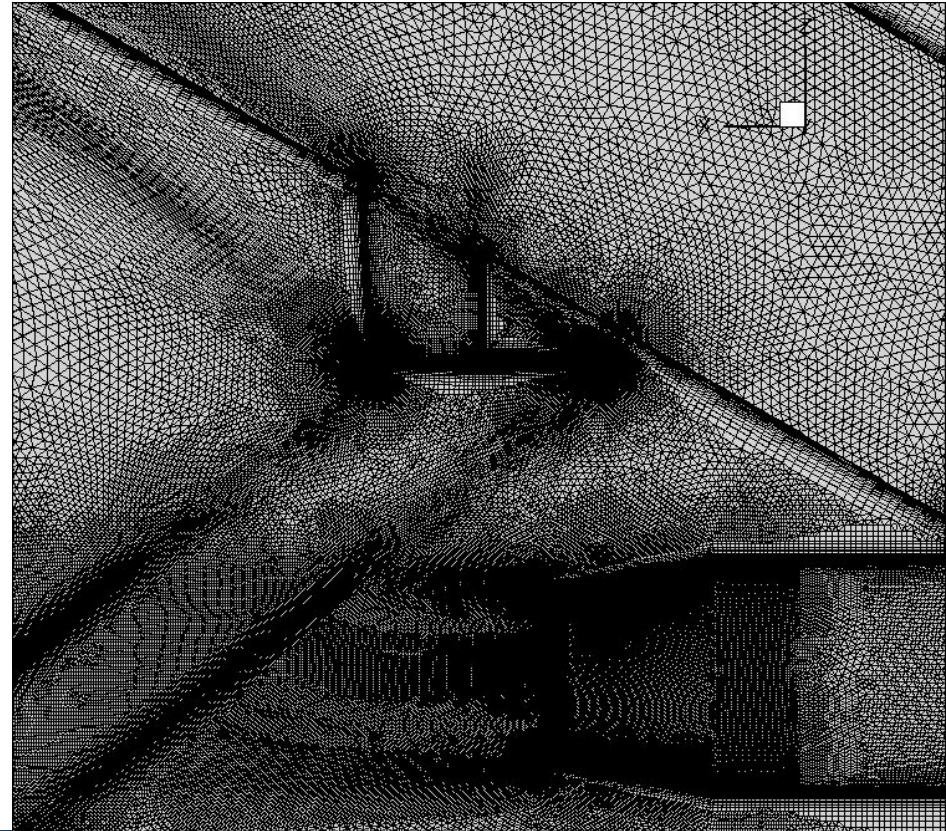
Test Case 1: Biconvex - BOOM custom grids



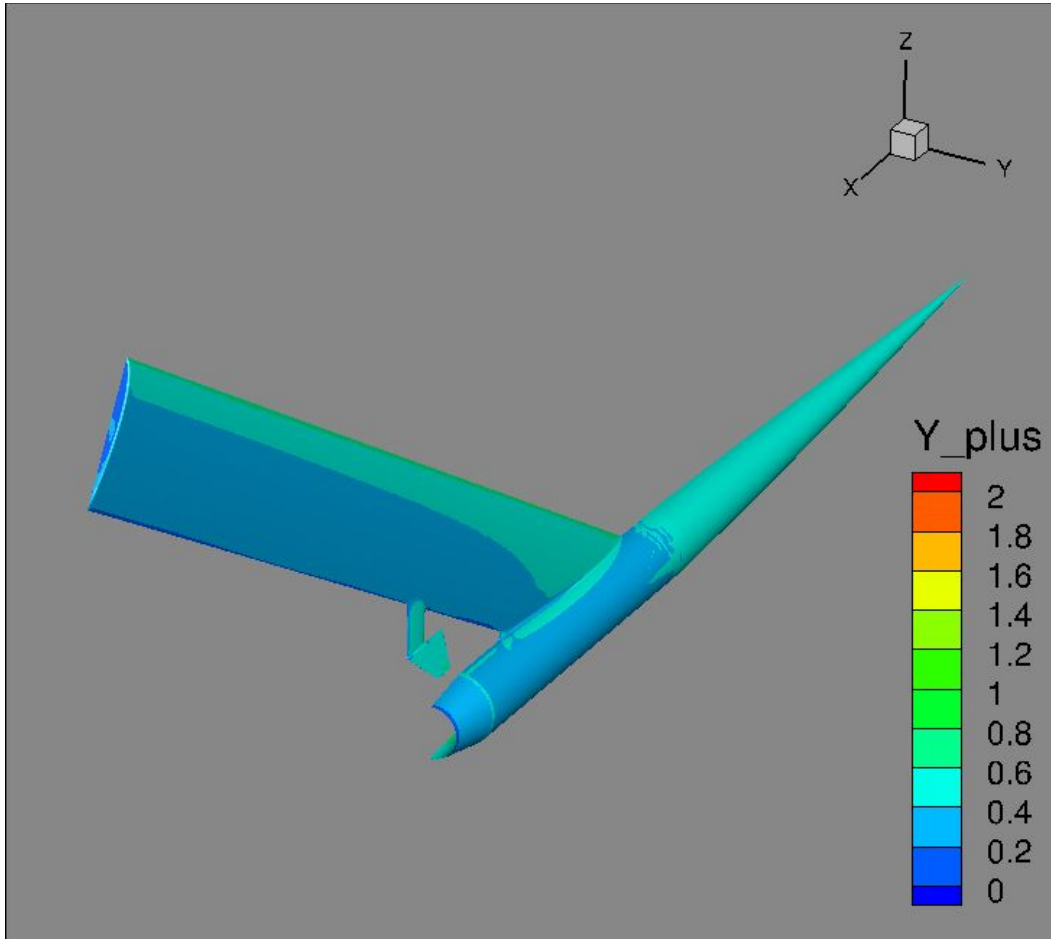
SBPW - Fine



BOOM - Coarse

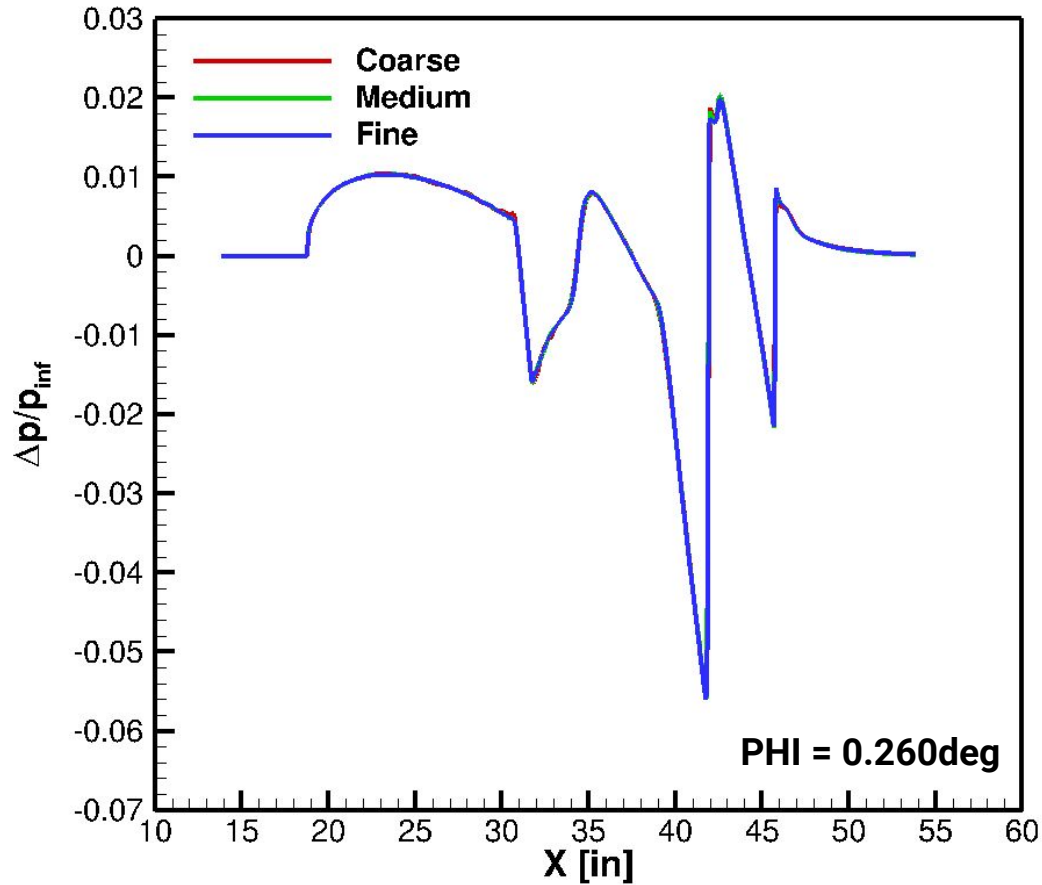


Test Case 1: Biconvex - BOOM custom grids

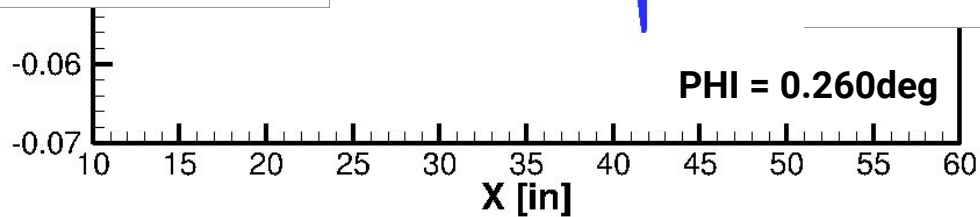
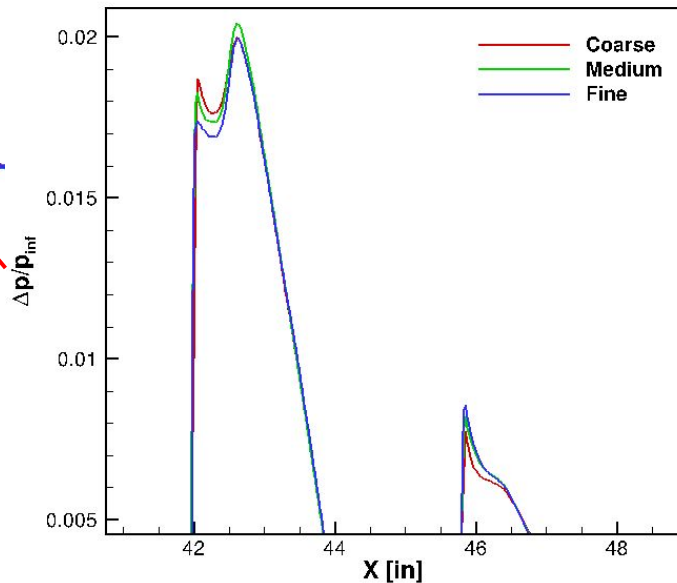
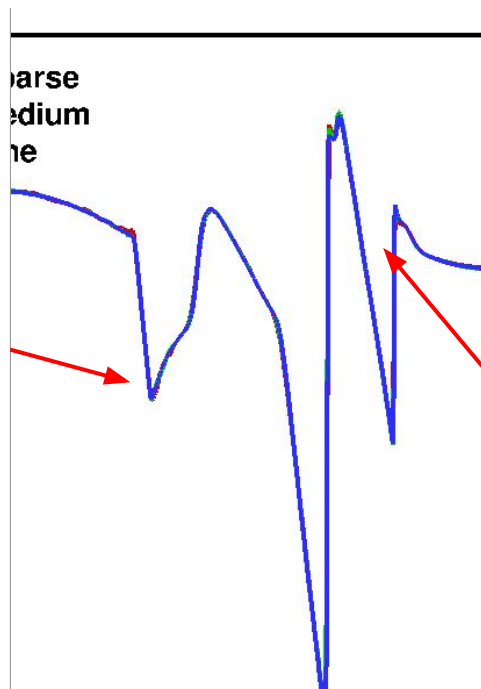
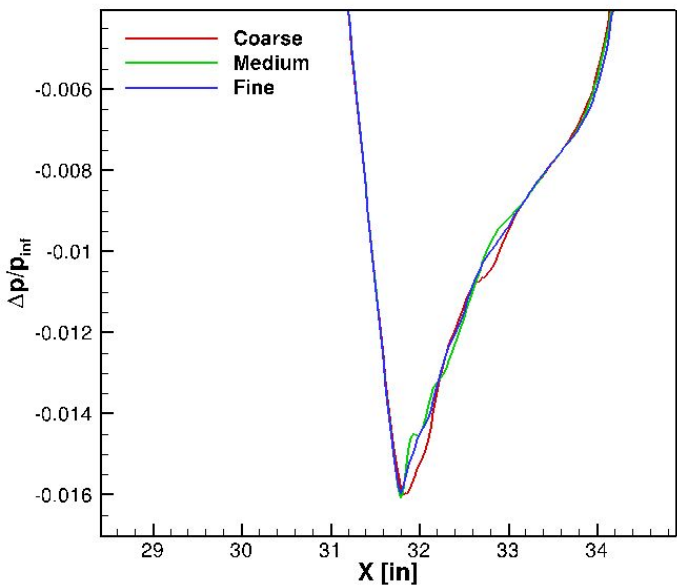


- $Y^+ < 1$ over external surface
- Low-Re viscous integration

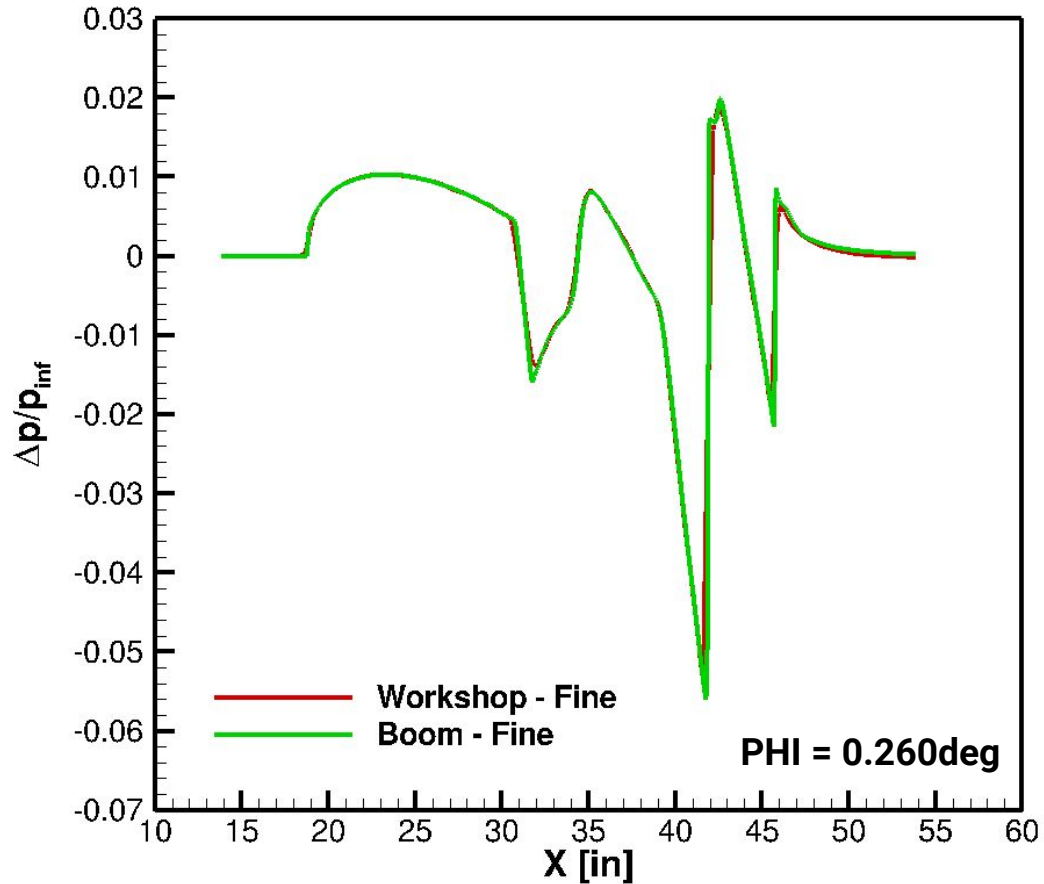
Test Case 1: Biconvex - BOOM custom grids



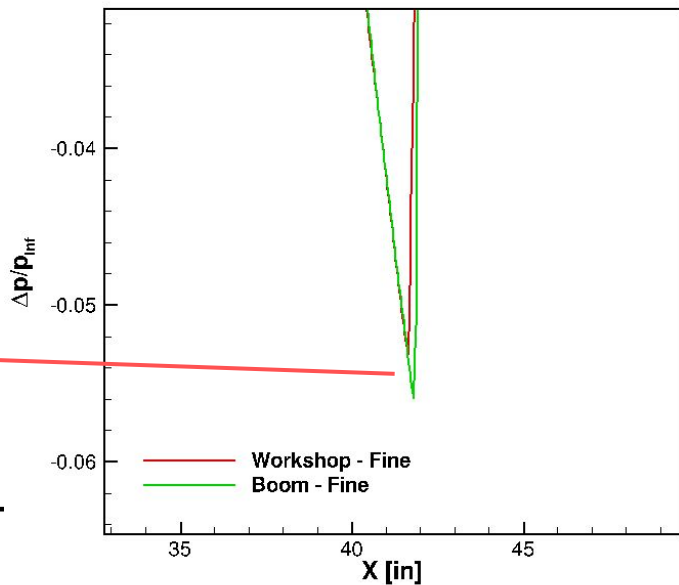
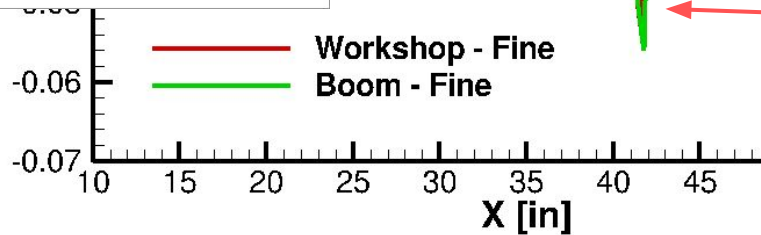
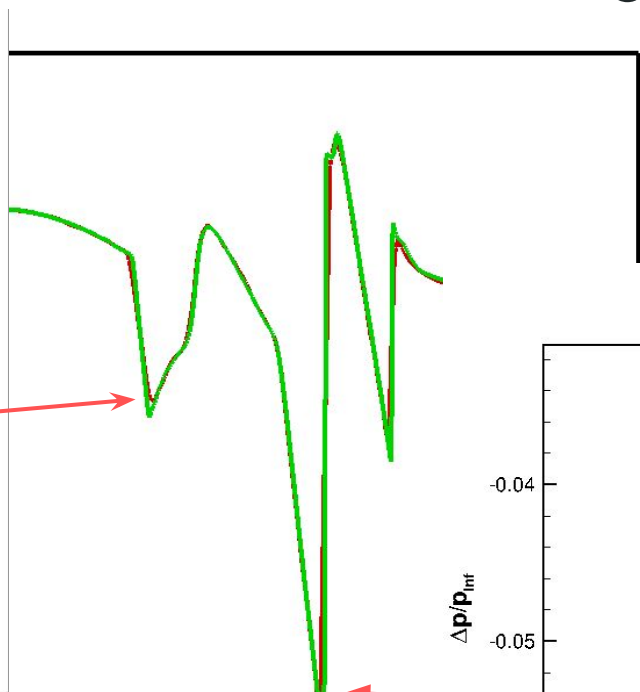
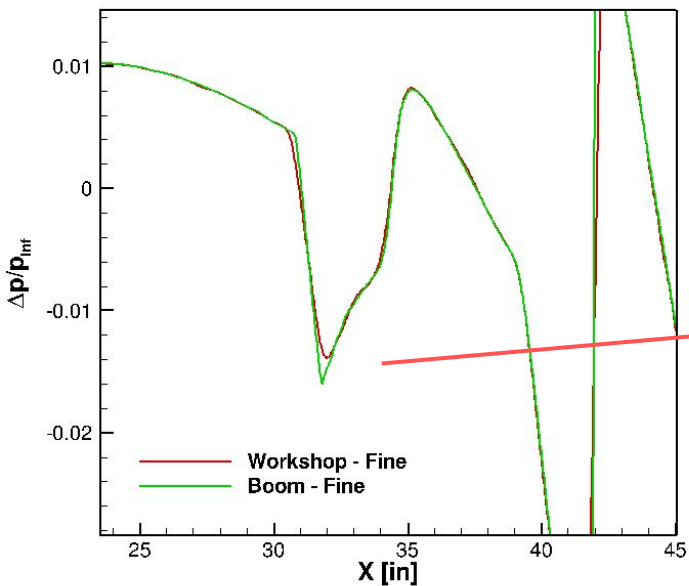
Test Case 1: Biconvex - BOOM custom grids



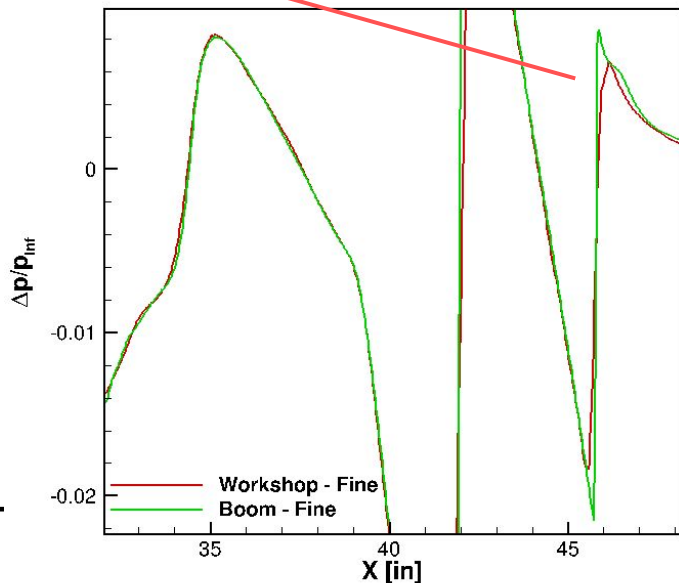
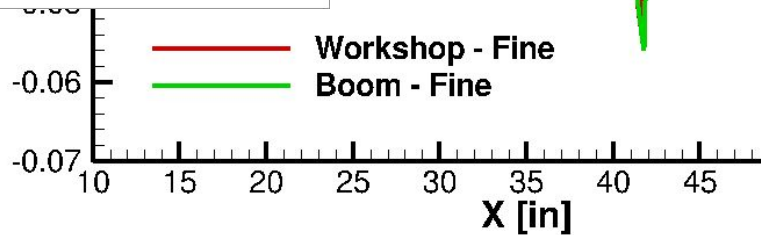
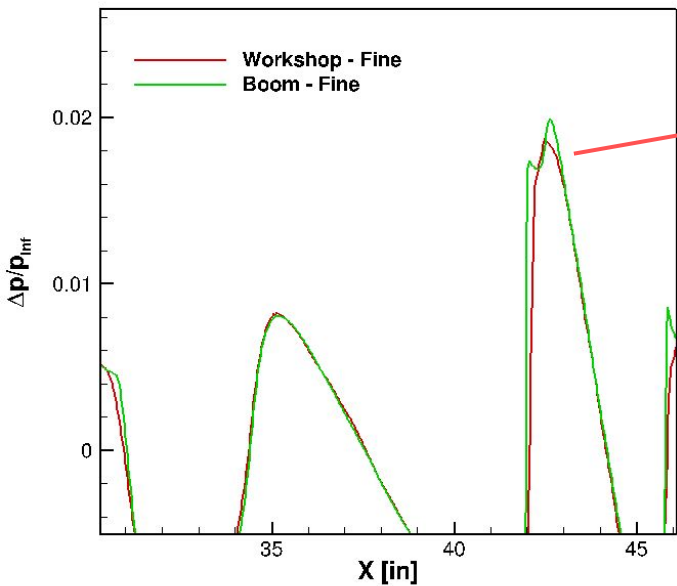
Test Case 1: Biconvex - BOOM custom grids



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Test Case 1: Biconvex - BOOM custom grids



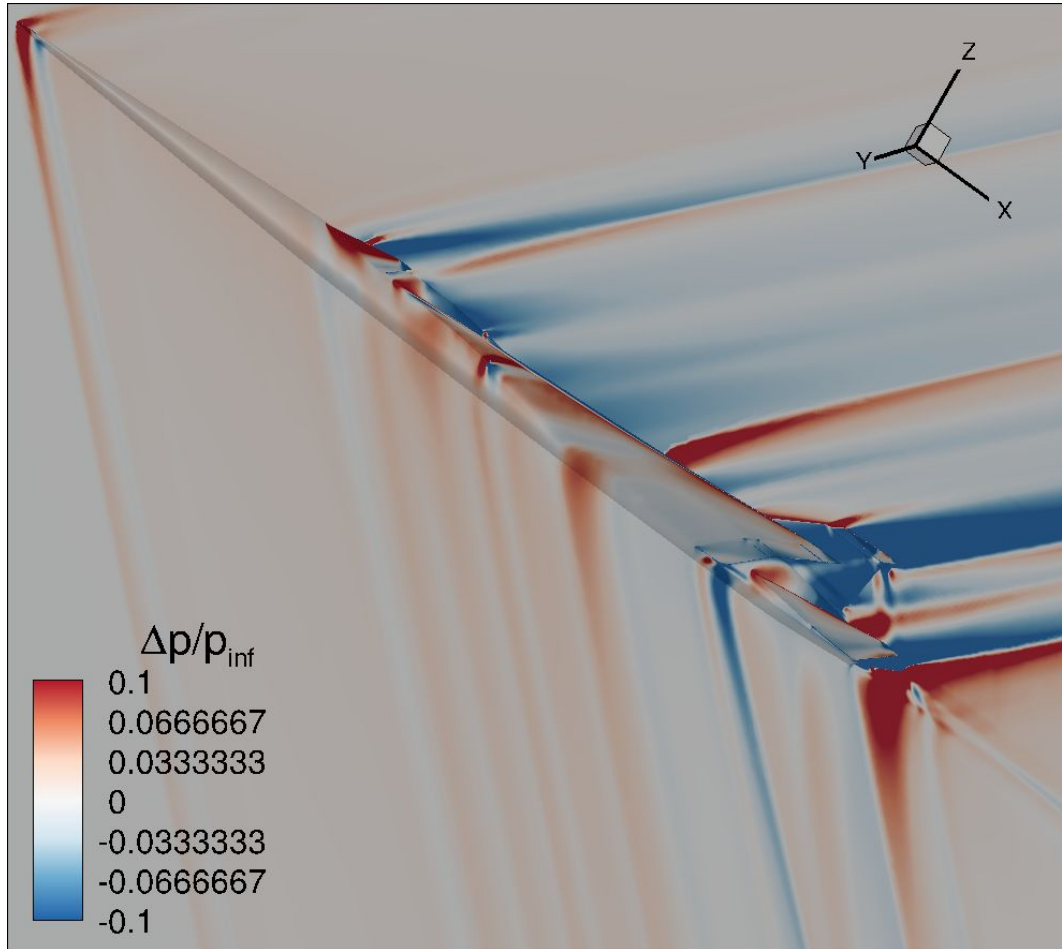


Test Case 2: C608

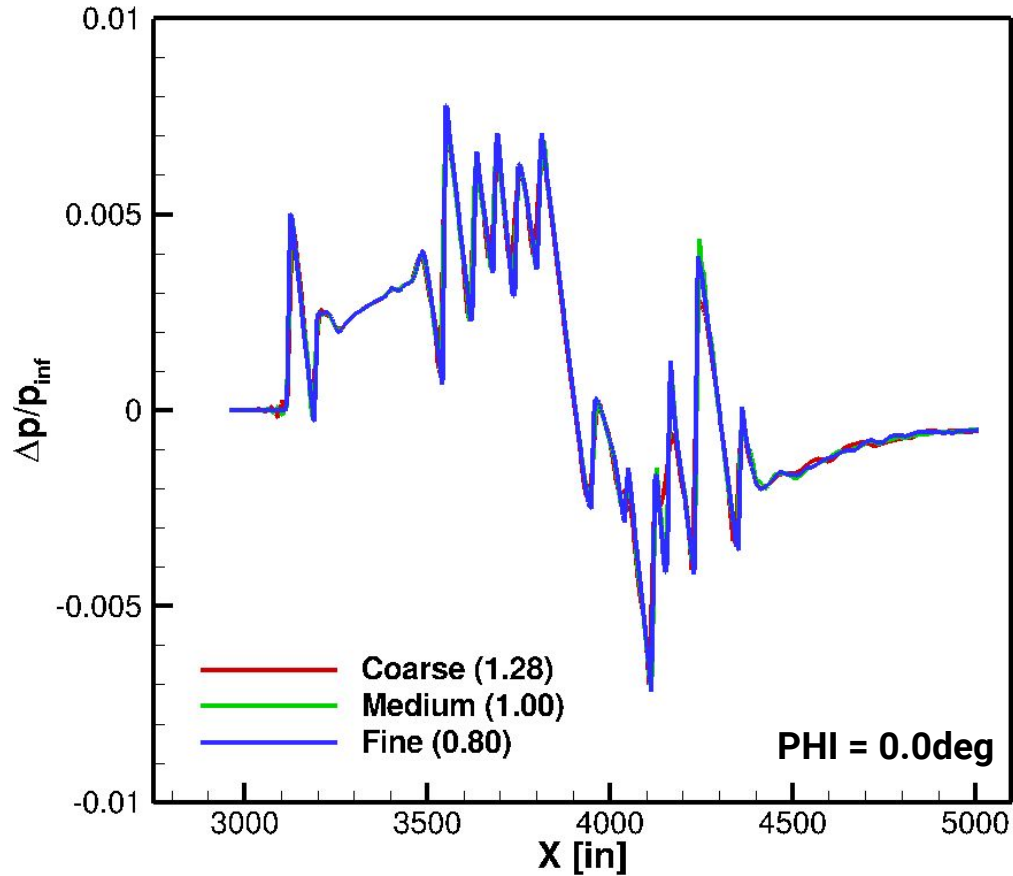
- Mixed-elements, workshop-provided grids
- Mach Outflow BC at Engine intake, ECS
- Near-field signatures recomputed after committee inquiry
 - Incorrect specification of thermal conductivity

	# Cells
Coarse (Grid factor 1.28)	29.9Mln
Medium (Grid factor 1.00)	50.0Mln
Fine (Grid factor 0.80)	82.4Mln

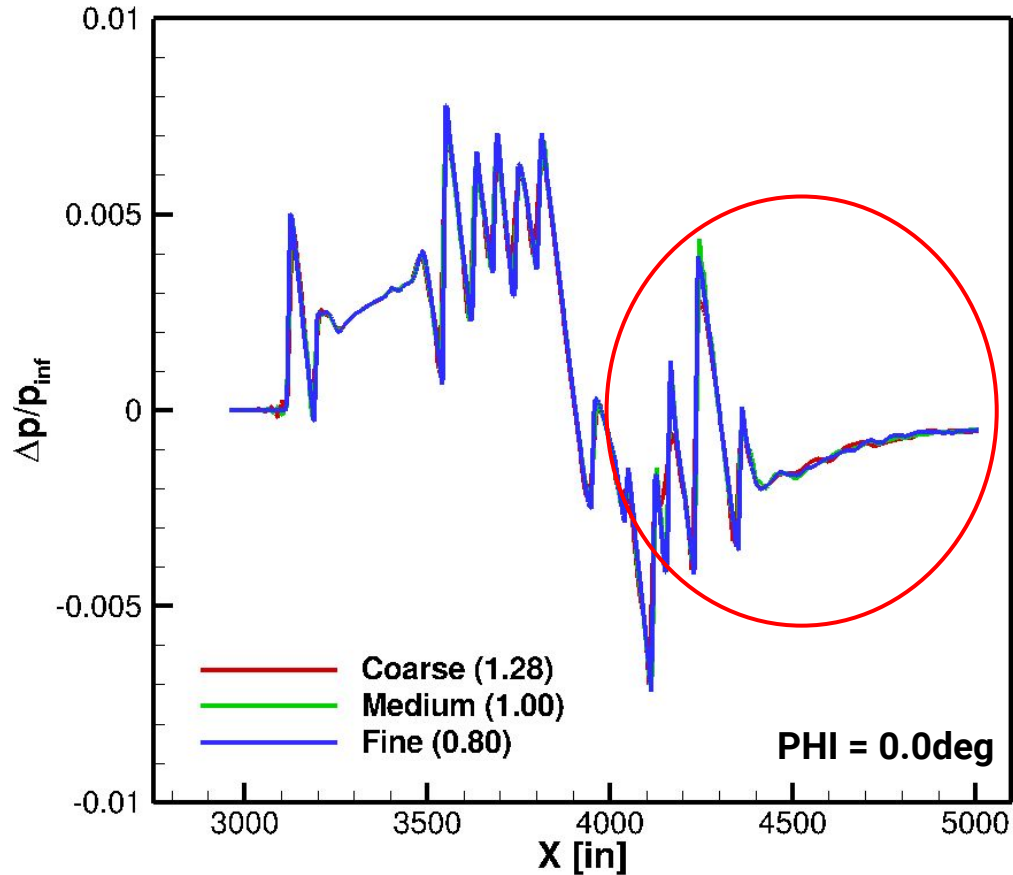
Test Case 2: C608 - Nearfield contours



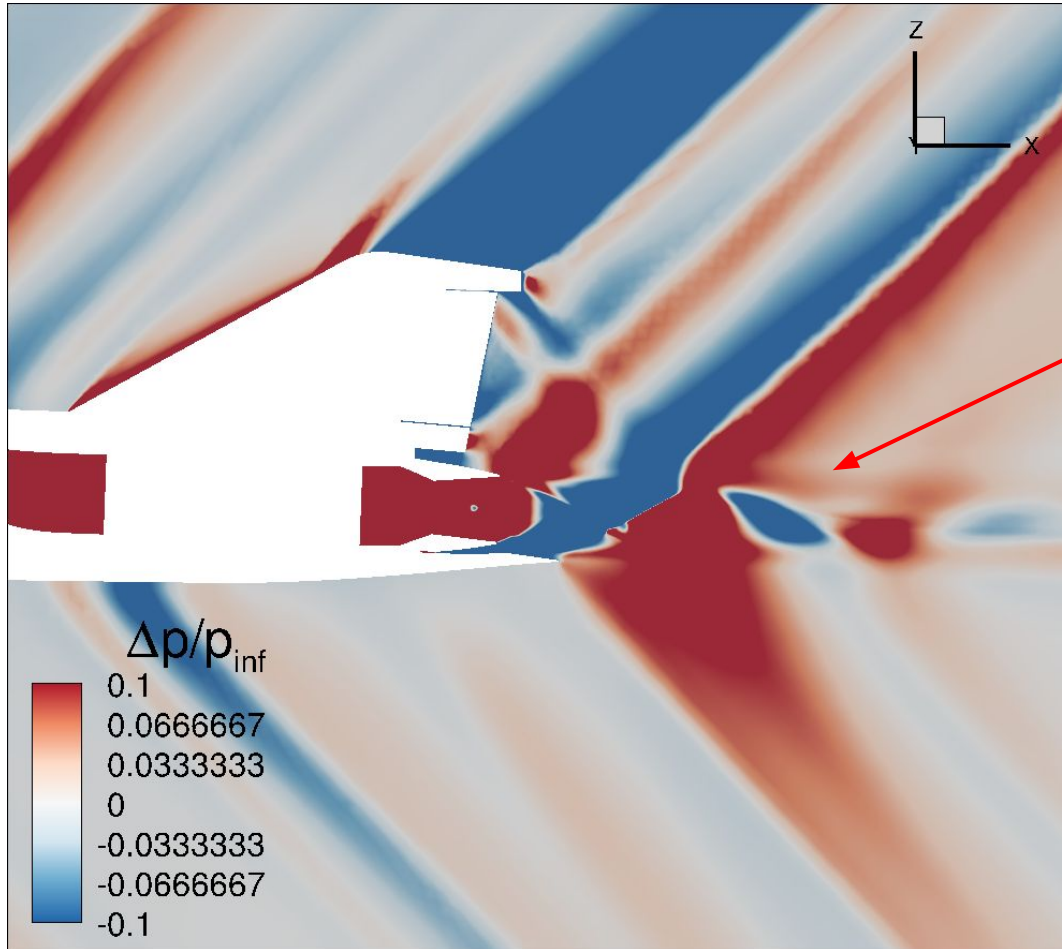
Test Case 2: C608 - Submitted signatures



Test Case 2: C608 - Submitted signatures

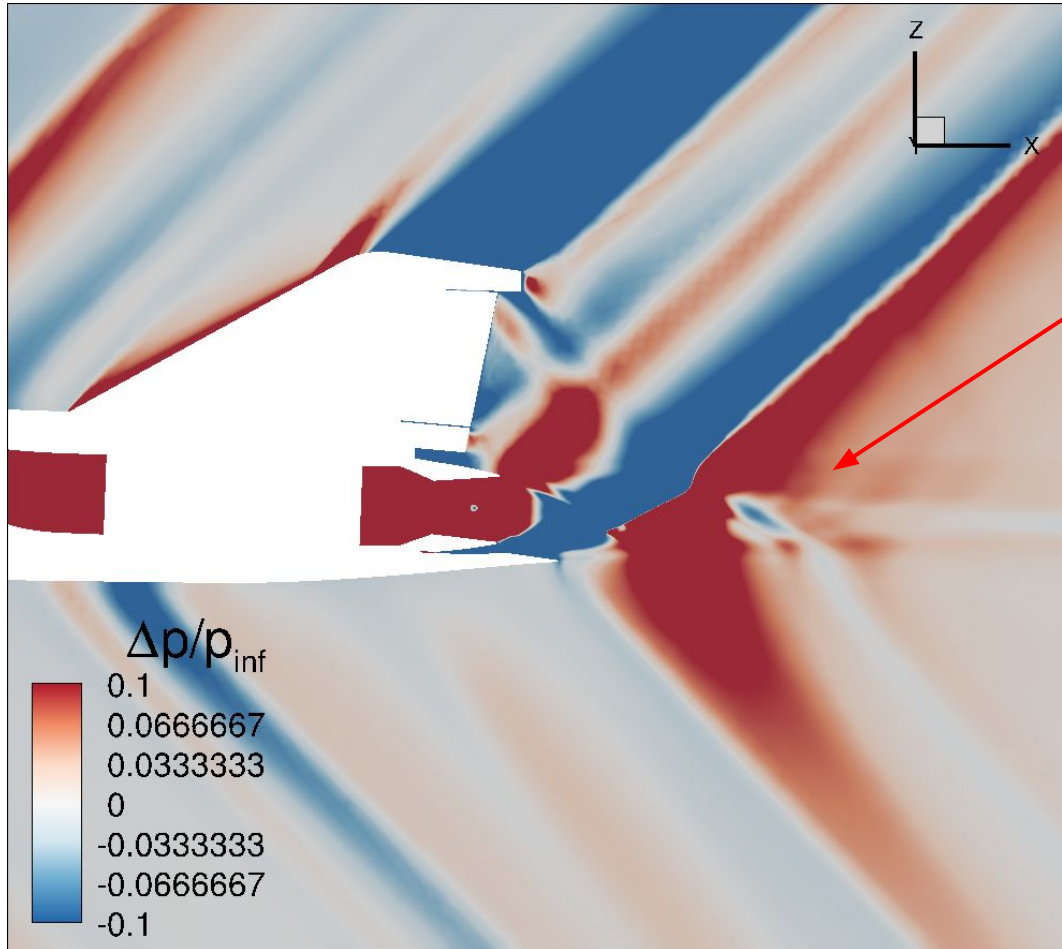


Test Case 2: C608 - Corrected signatures



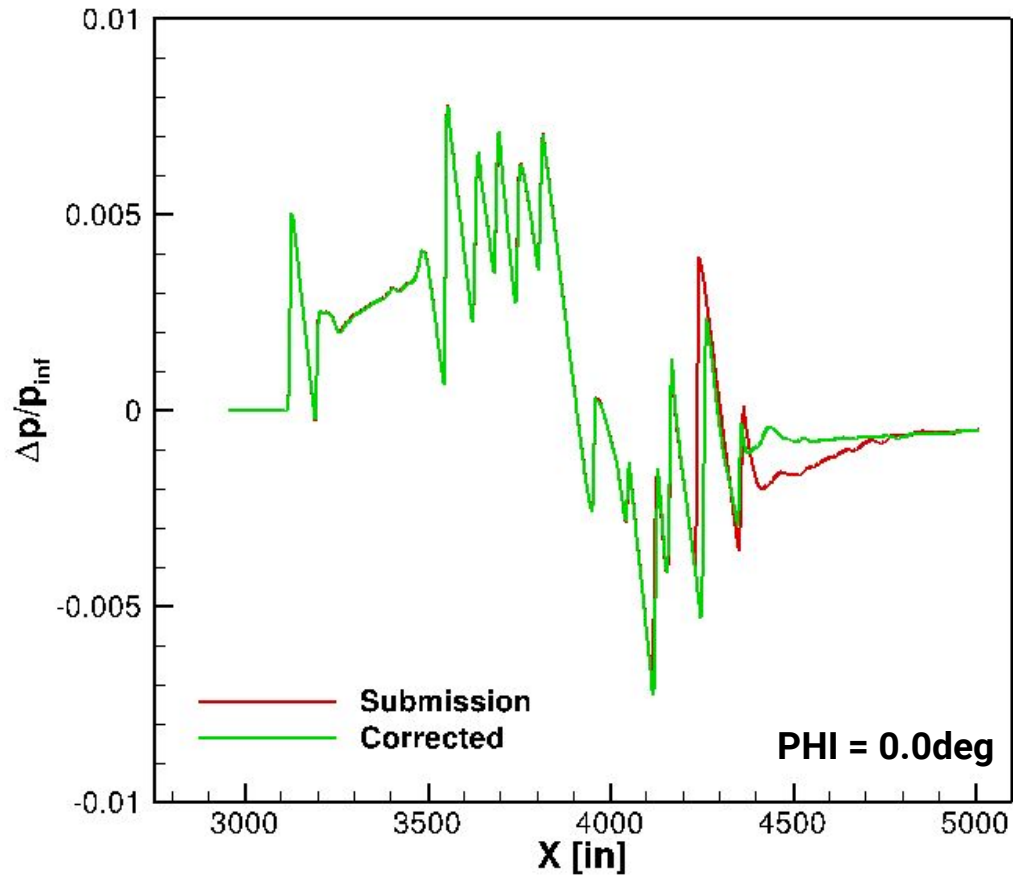
Wrong thermal conductivity affects jet plume region

Test Case 2: C608 - Corrected signatures

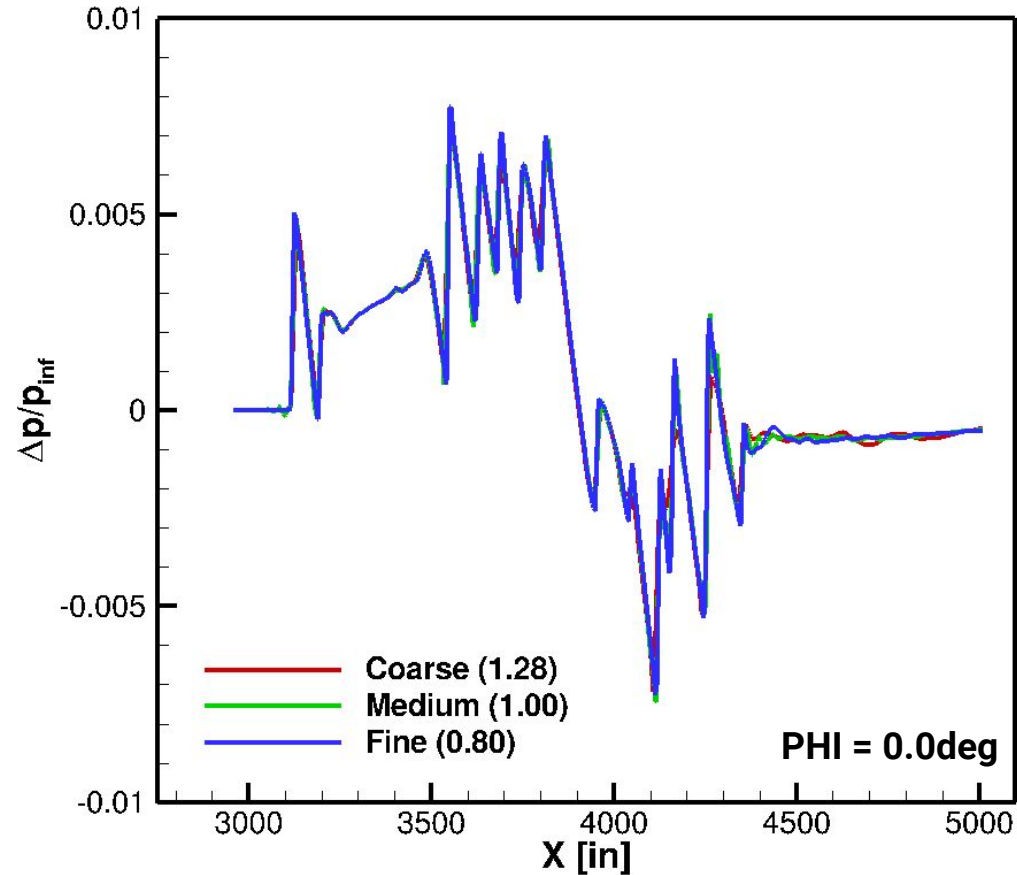


Correct thermal conductivity

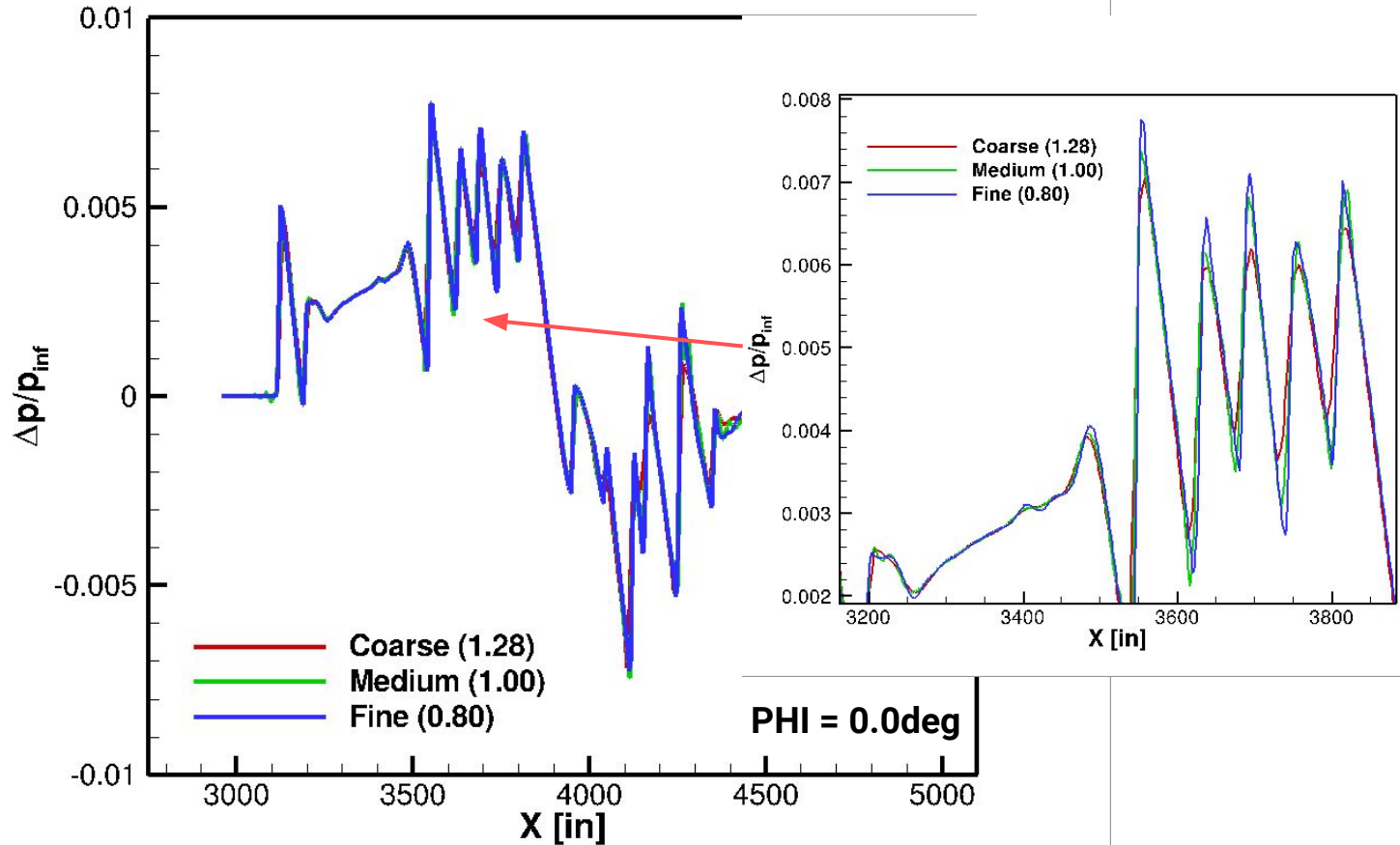
Test Case 2: C608 - Corrected signatures



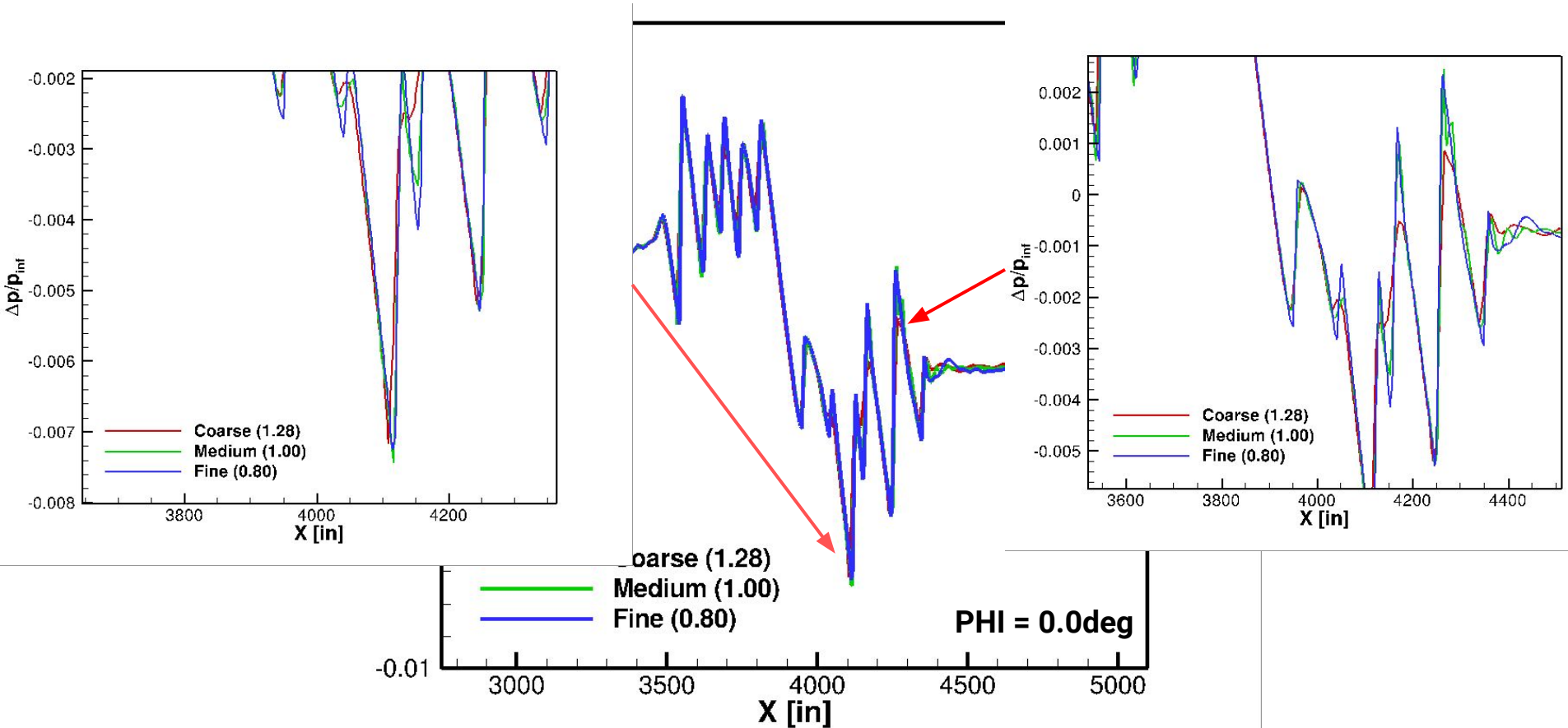
Test Case 2: C608 - Corrected signatures



Test Case 2: C608 - Corrected signatures



Test Case 2: C608 - Corrected signatures



Conclusions and Future Work



- All near-field signatures exhibit reasonable grid convergence behavior
 - Sharper pressure peaks, more flow features on BOOM's custom meshes, higher computational cost
 - Grid convergence of ground signatures?
- C608 initial submission with *wrong* plume's signature
 - Submitted signatures corrected after committee inquiry
 - Wrong thermal conductivity caused wrong signature
 - Bug/User's error
- Compare signatures from BOOM custom grids with **Refine** grids (underway)
- Propagation of computed signatures?

Acknowledgements



- Sonic Boom Prediction Workshop Organizing Committee
- BOOM Aero Team



BOOM