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# Mesh Scaling for Solution Verification

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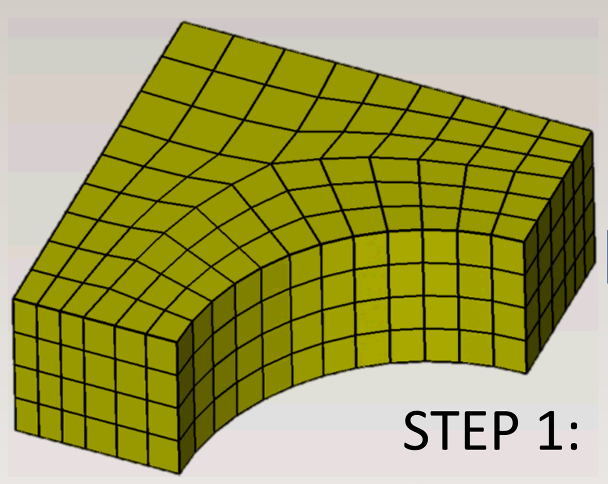
## Problem Statement

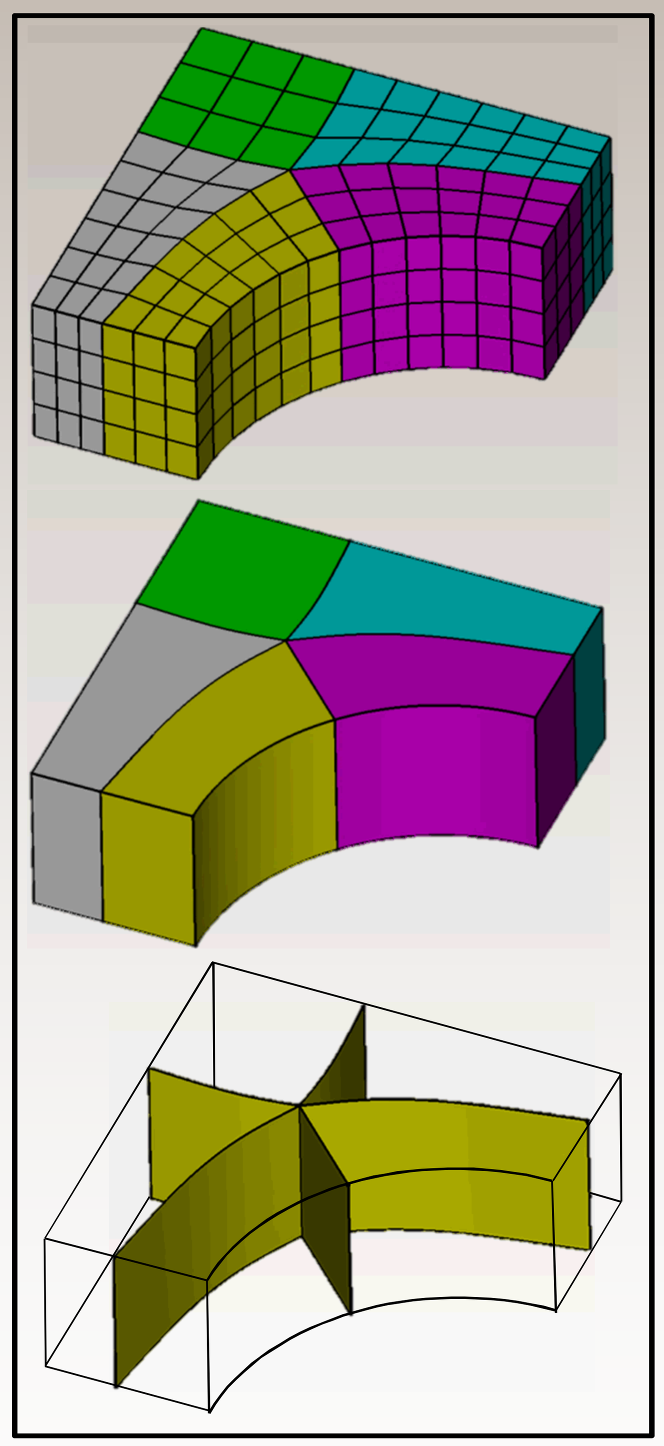
We seek a new mesh adaptivity modification algorithm which will decrease the computational cost of doing solution verification. Solution verification requires a series of meshes, from which the solution is plotted to predict convergence. Currently, the series of meshes are created by mesh doubling, which cuts every edge in half, requiring an 8X increase in element count for each subsequent mesh. This dramatic increase in DOF count quickly exhausts computational resources making solution verification extremely expensive.

## How Mesh Scaling Works

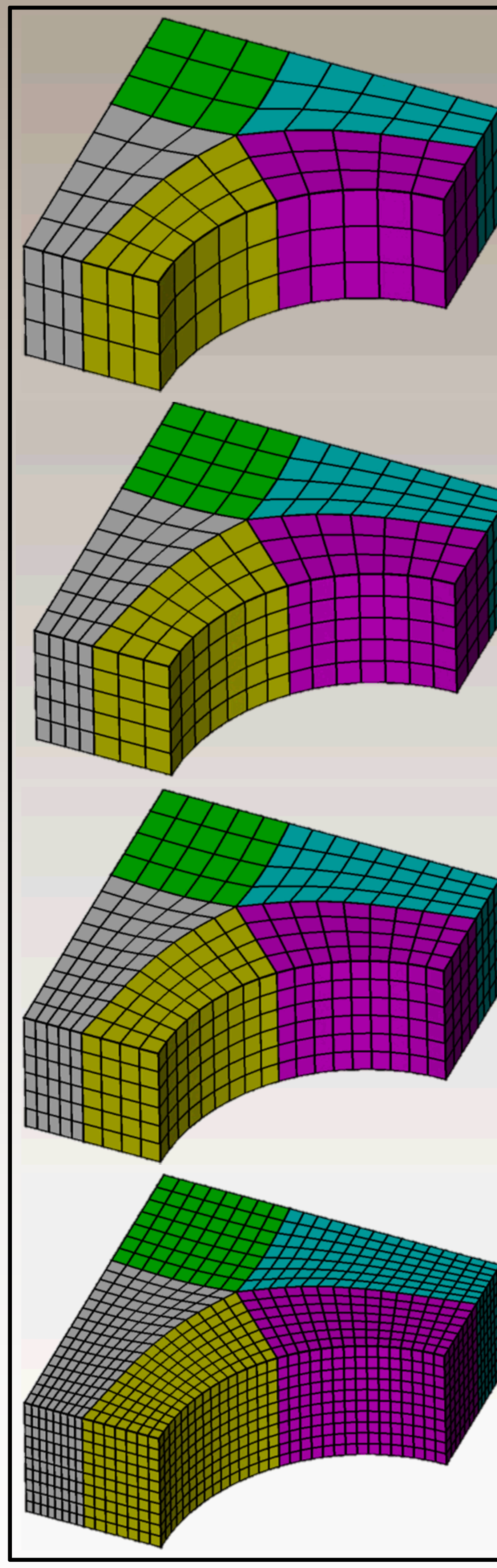
Initial Mesh
324 hexes



STEP 1:
Extract the Block Decomposition



STEP 2:
Remesh each block at a different size.



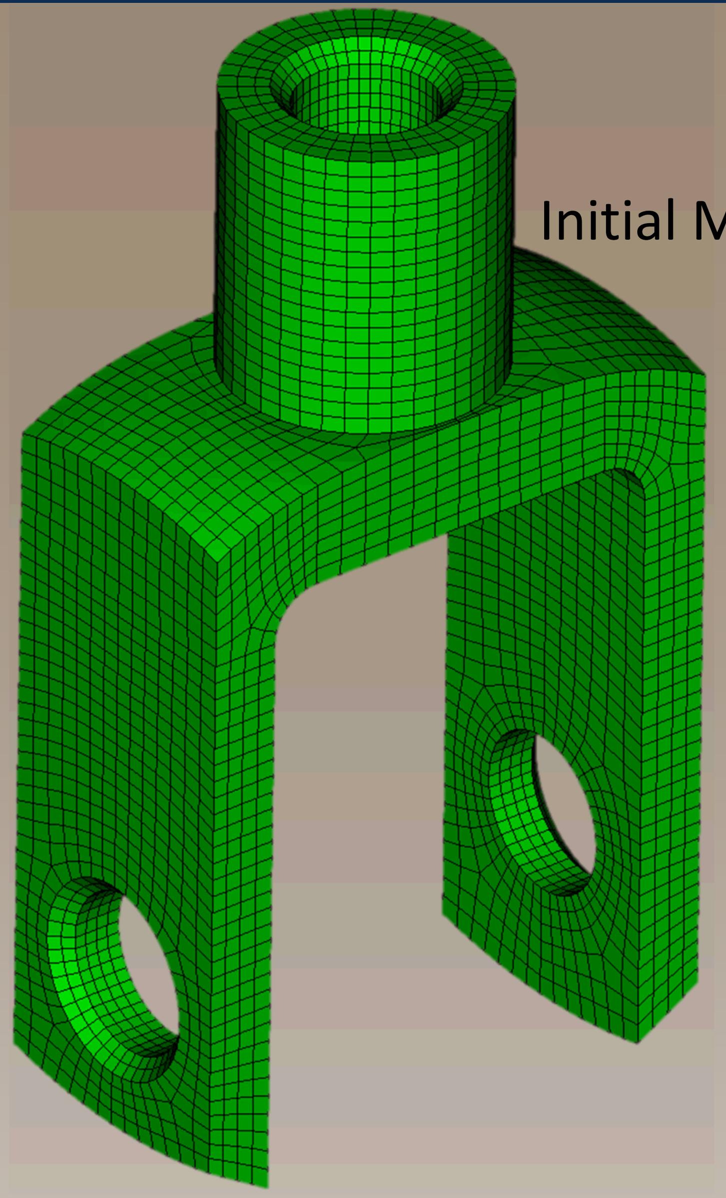
Factor: 0.667
207 hexes

Factor:1.75
570 hexes

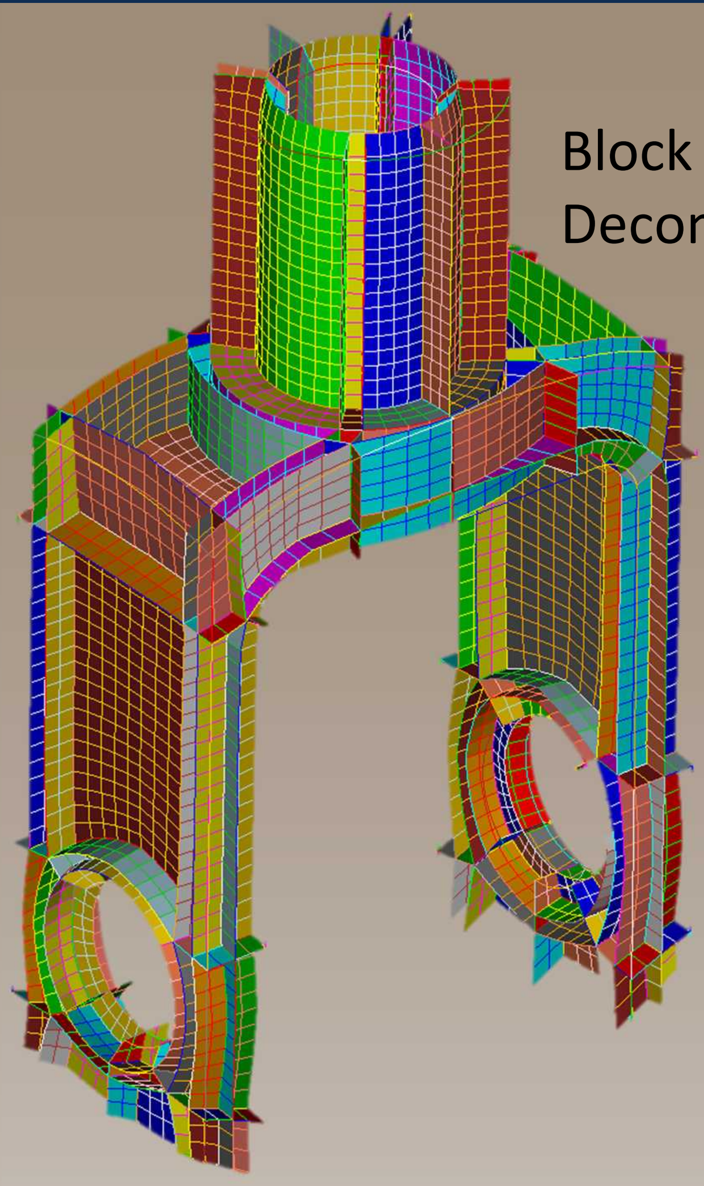
Factor 3.0
1038 hexes

Factor: 15.0
4910 hexes

## Knuckle Example Model

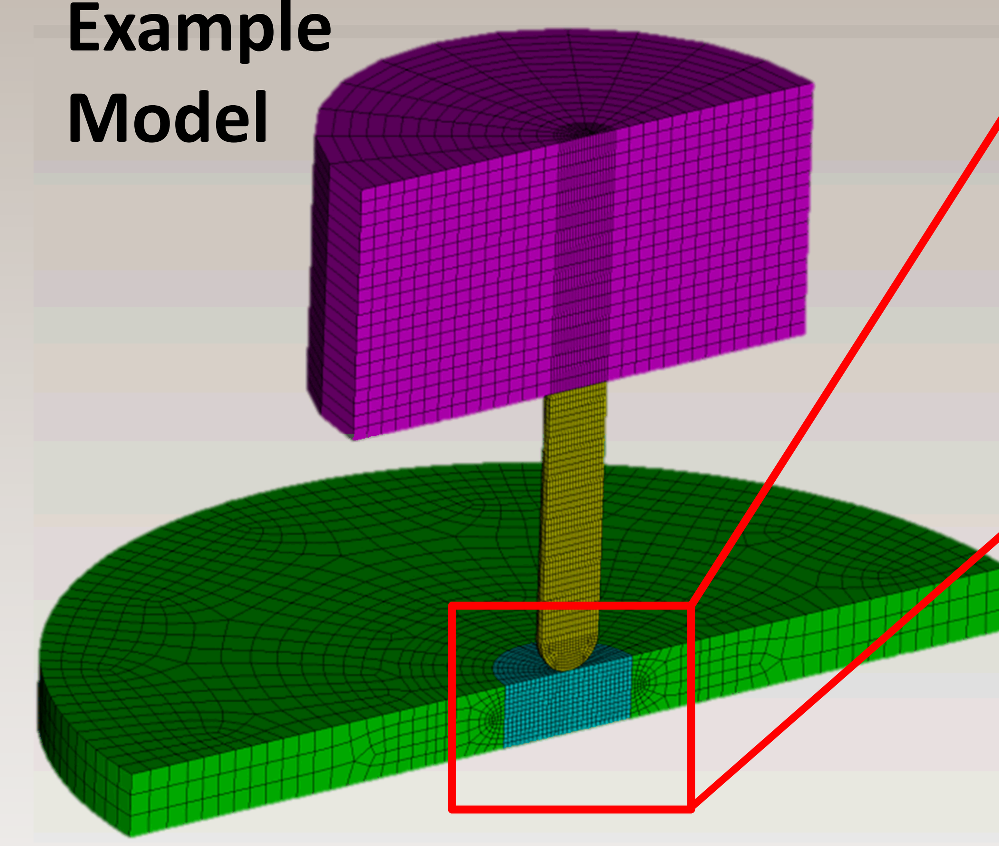


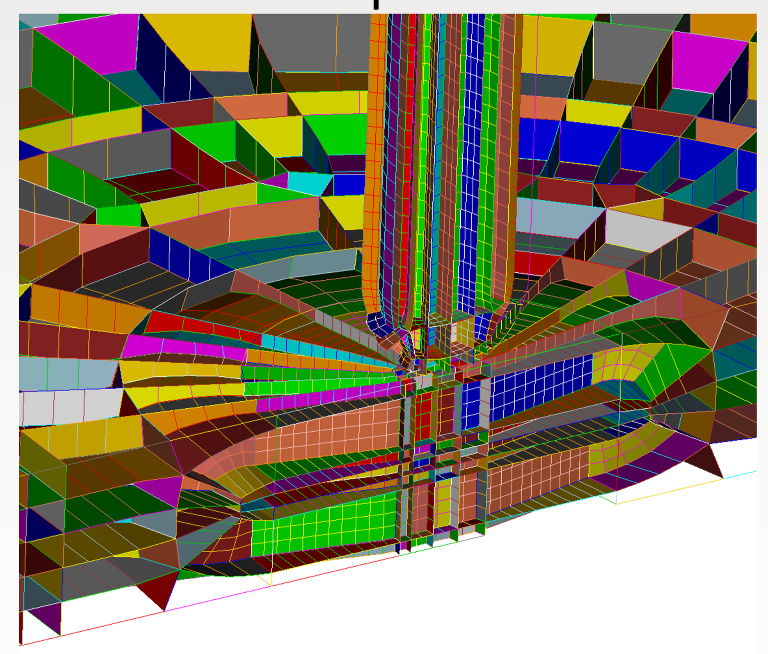
Initial Mesh



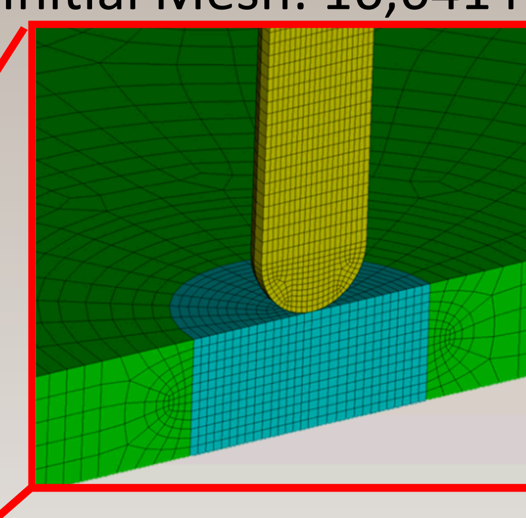
Block Decomposition

## Penetrator Example Model

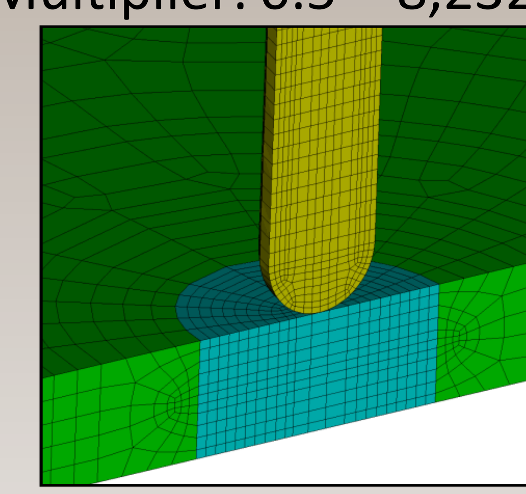




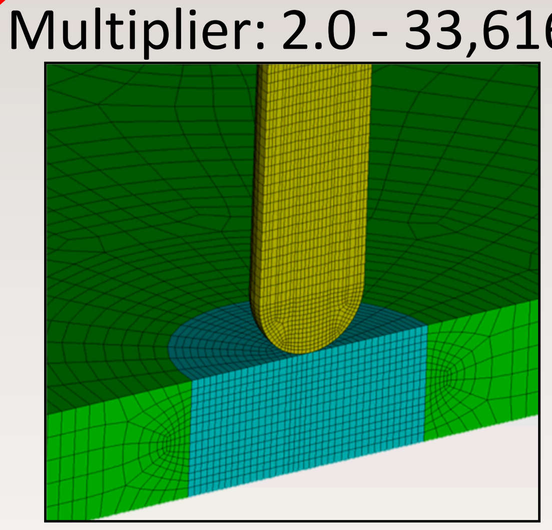
Block Decomposition



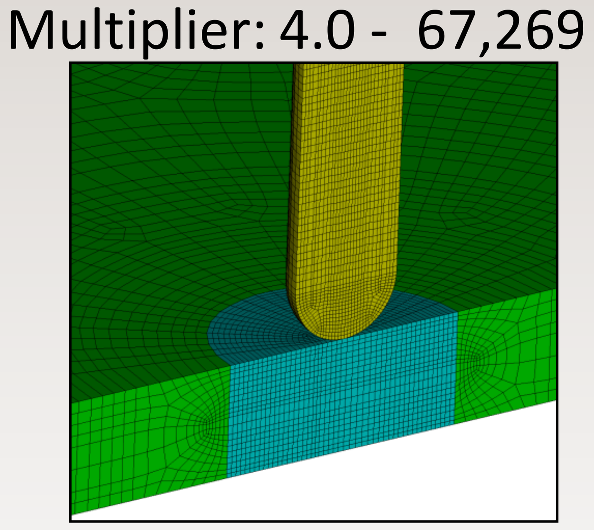
Initial Mesh: 16,641 hex



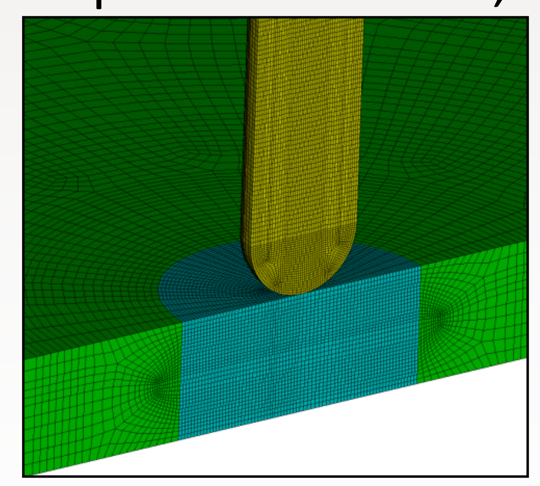
Multiplier: 0.5 - 8,232 hex



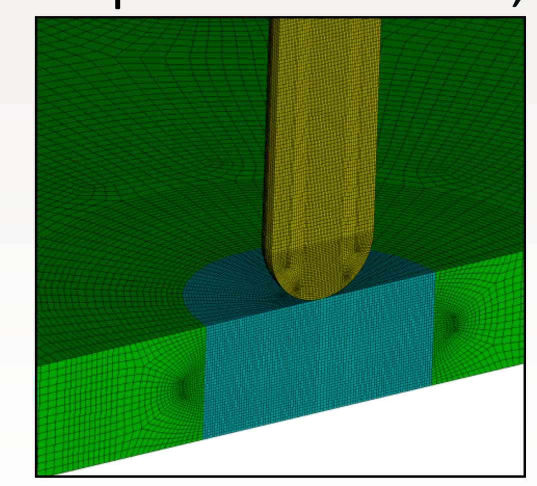
Multiplier: 2.0 - 33,616 hex



Multiplier: 4.0 - 67,269 hex

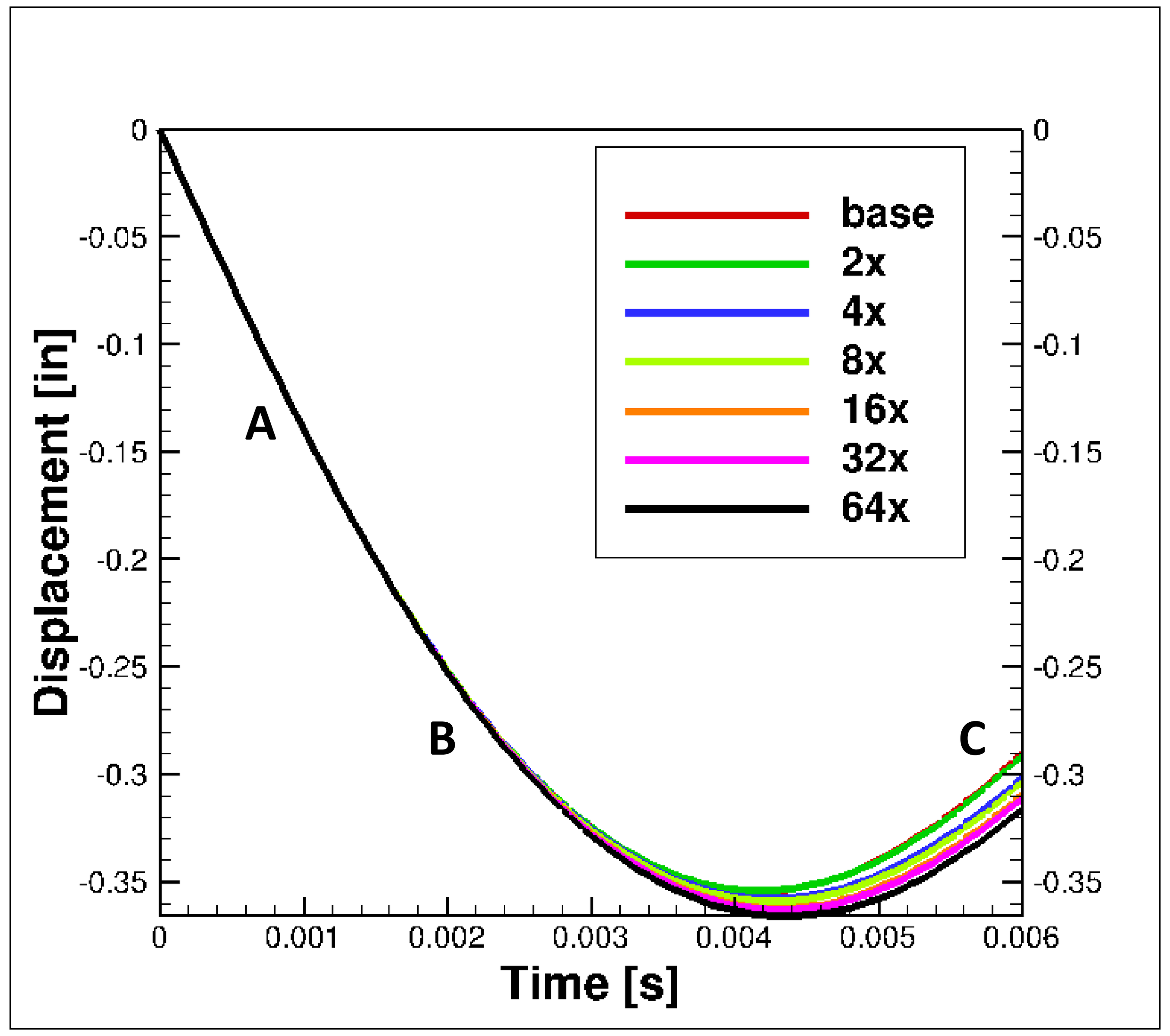


Multiplier: 16.0 - 266,507 hex



Multiplier: 32.0 - 533,042 hex

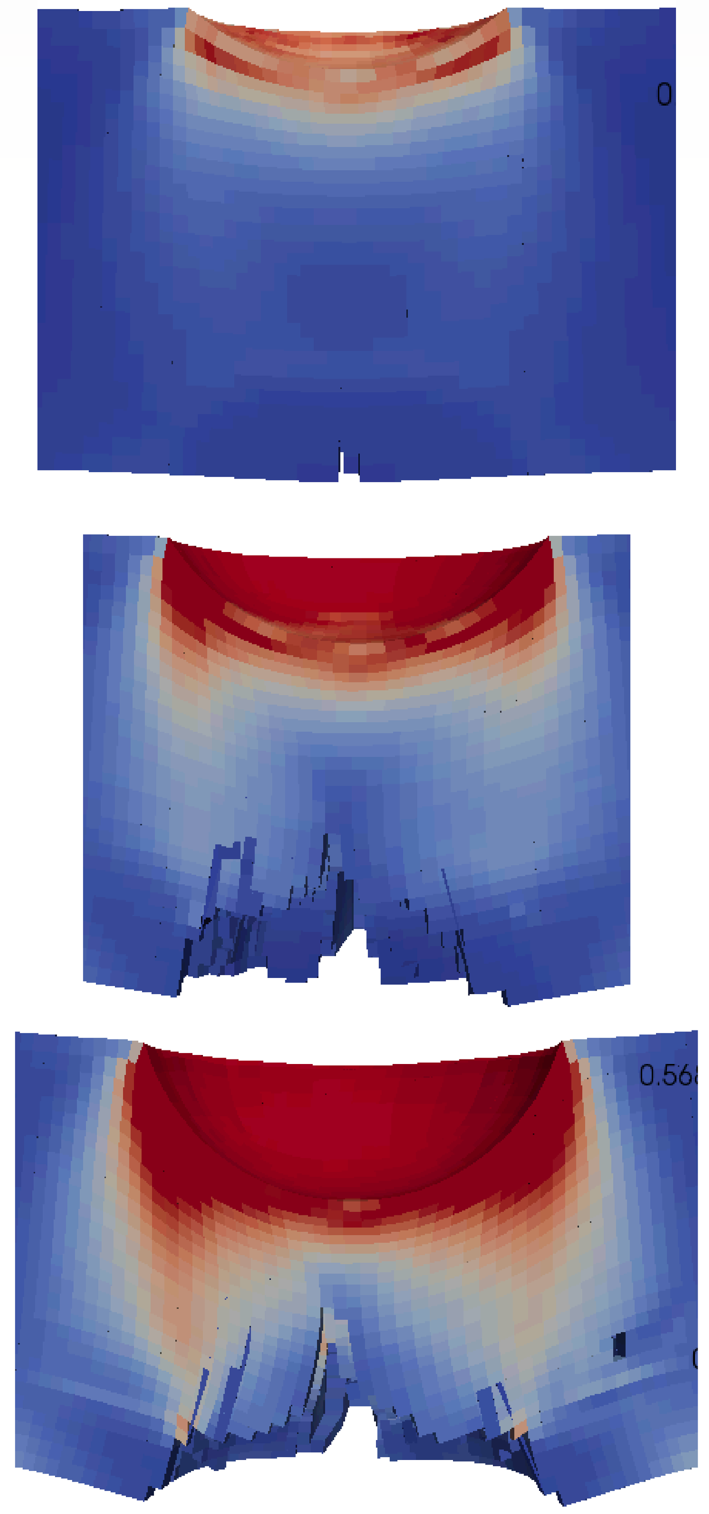
## Puncture Failure Case: Displacement History and Equivalent Plastic Strain




A

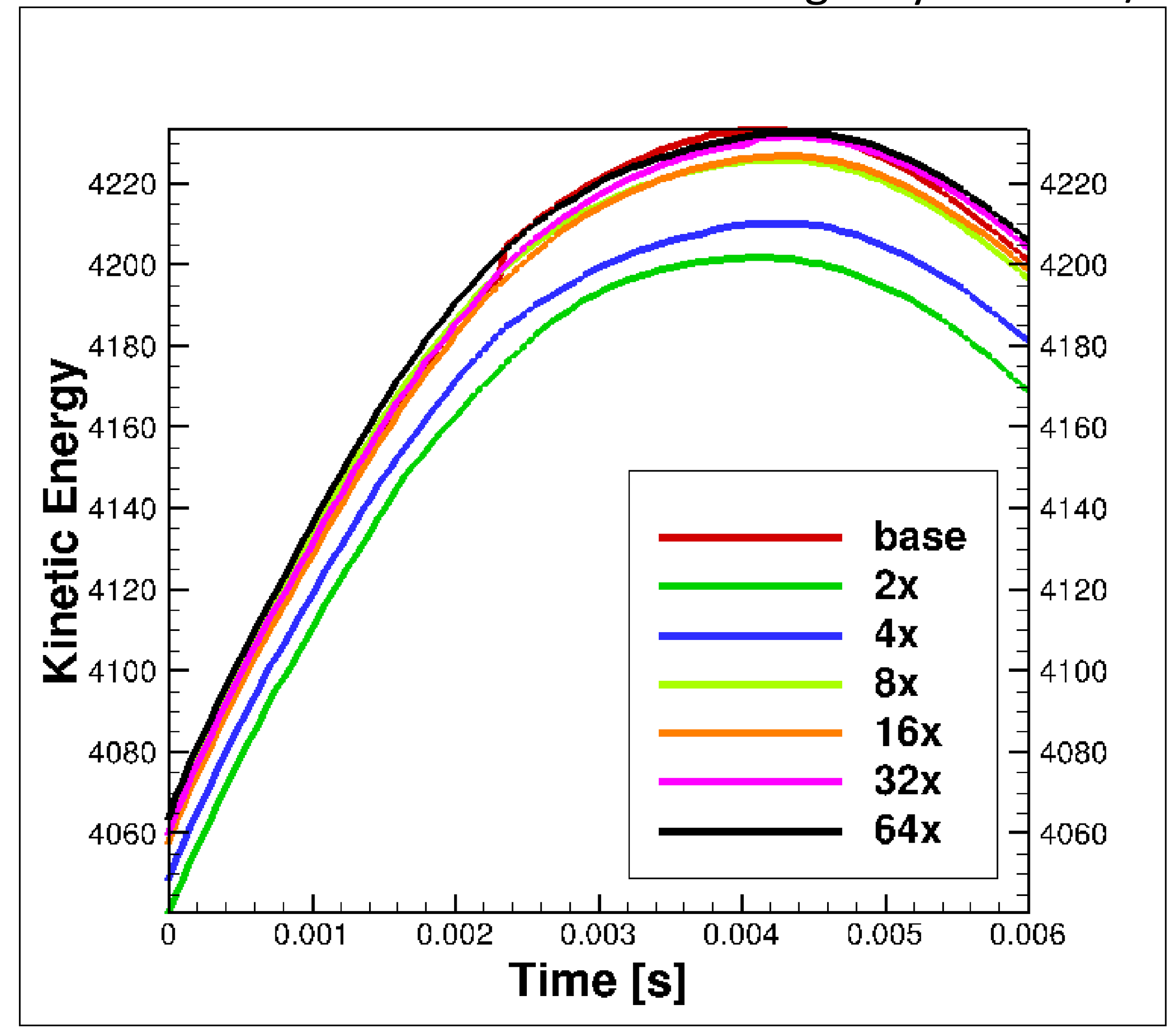
B

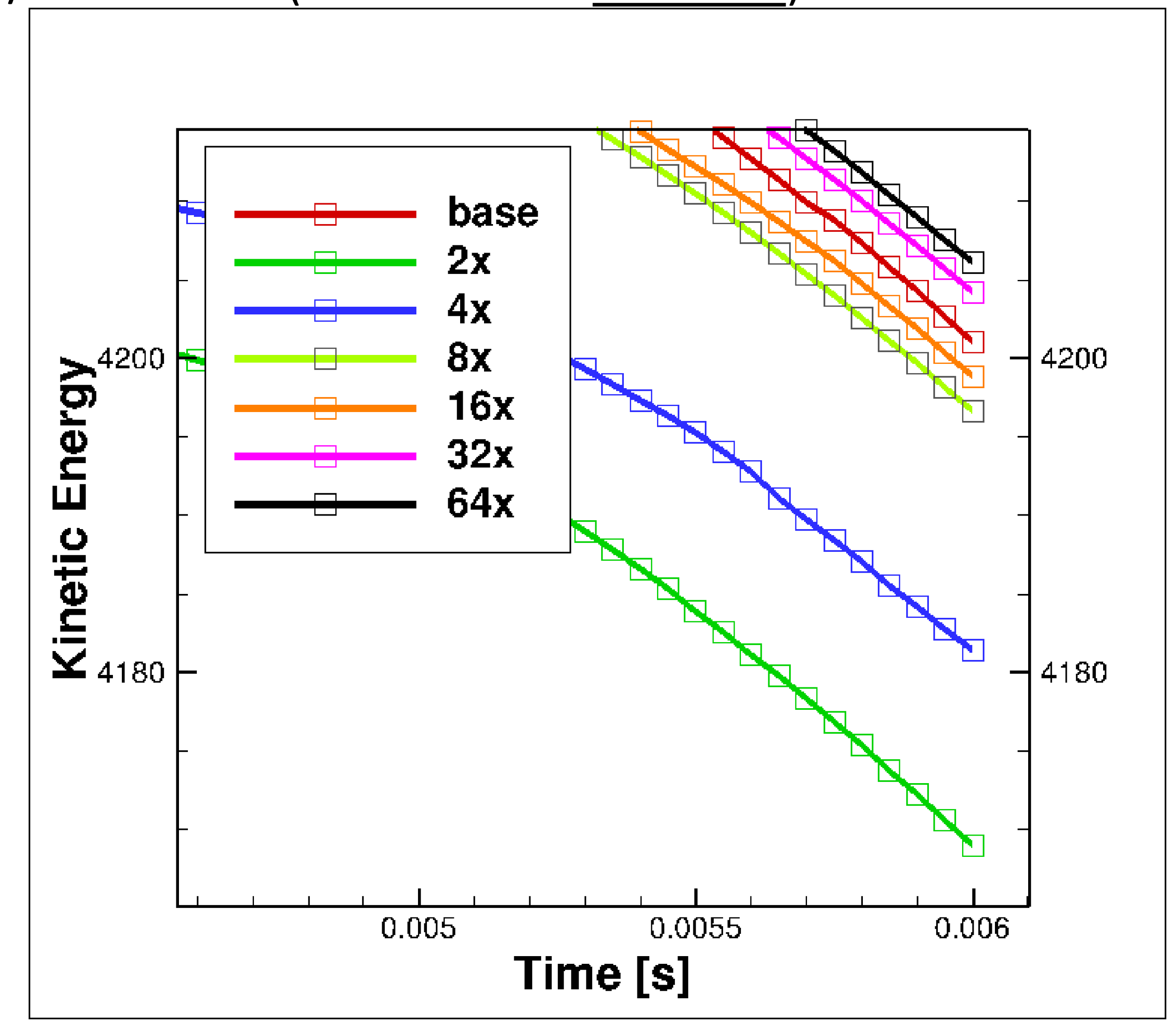
C



## Puncture Failure Case: Kinetic Energy

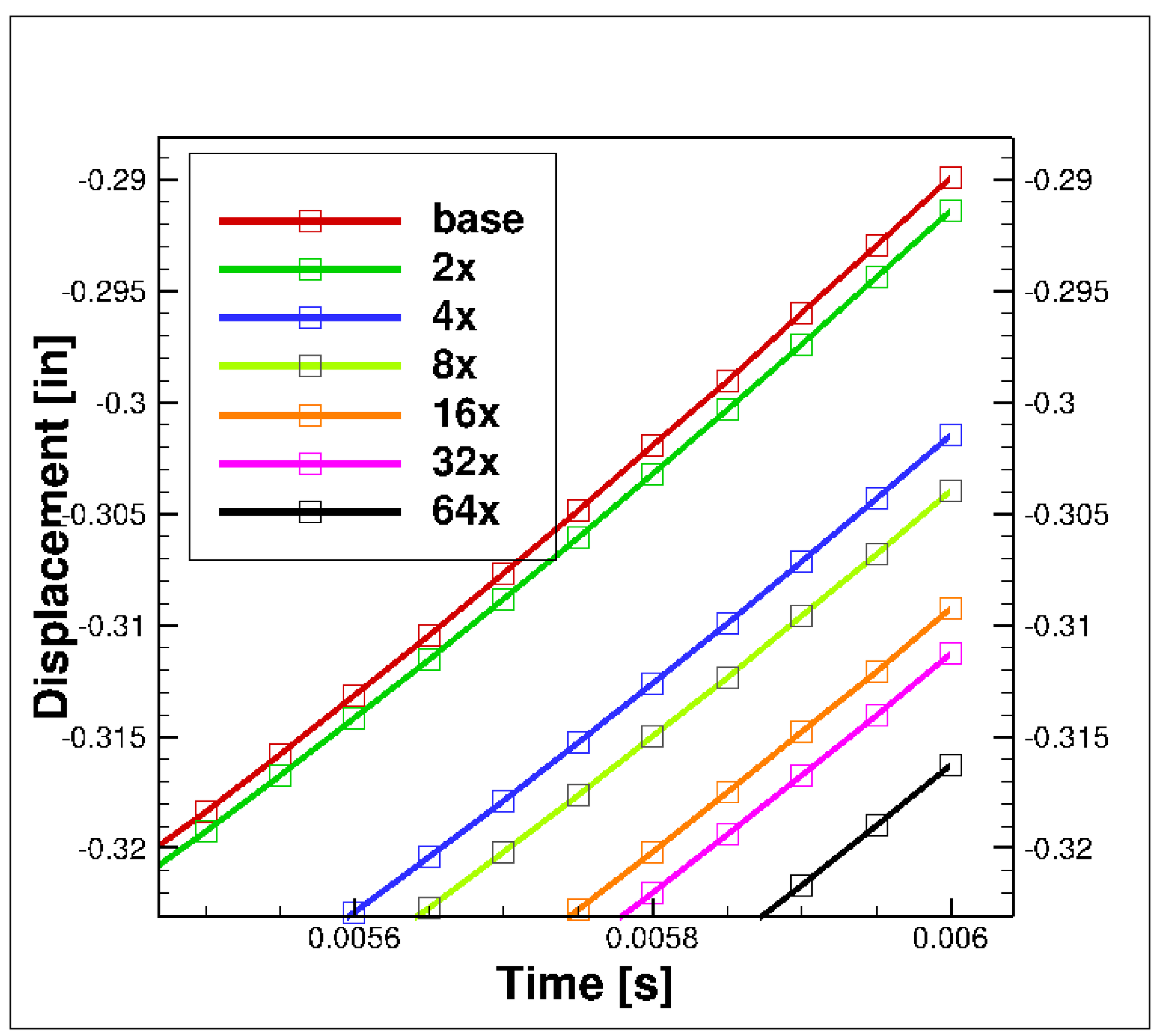
- Integral quantities generally are more well behaved
- We see convergence in kinetic energy (KE) on the finest three meshes (16x/32x/64x)
- This would be missed using only the base/8x/64x meshes (where the KE oscillates).

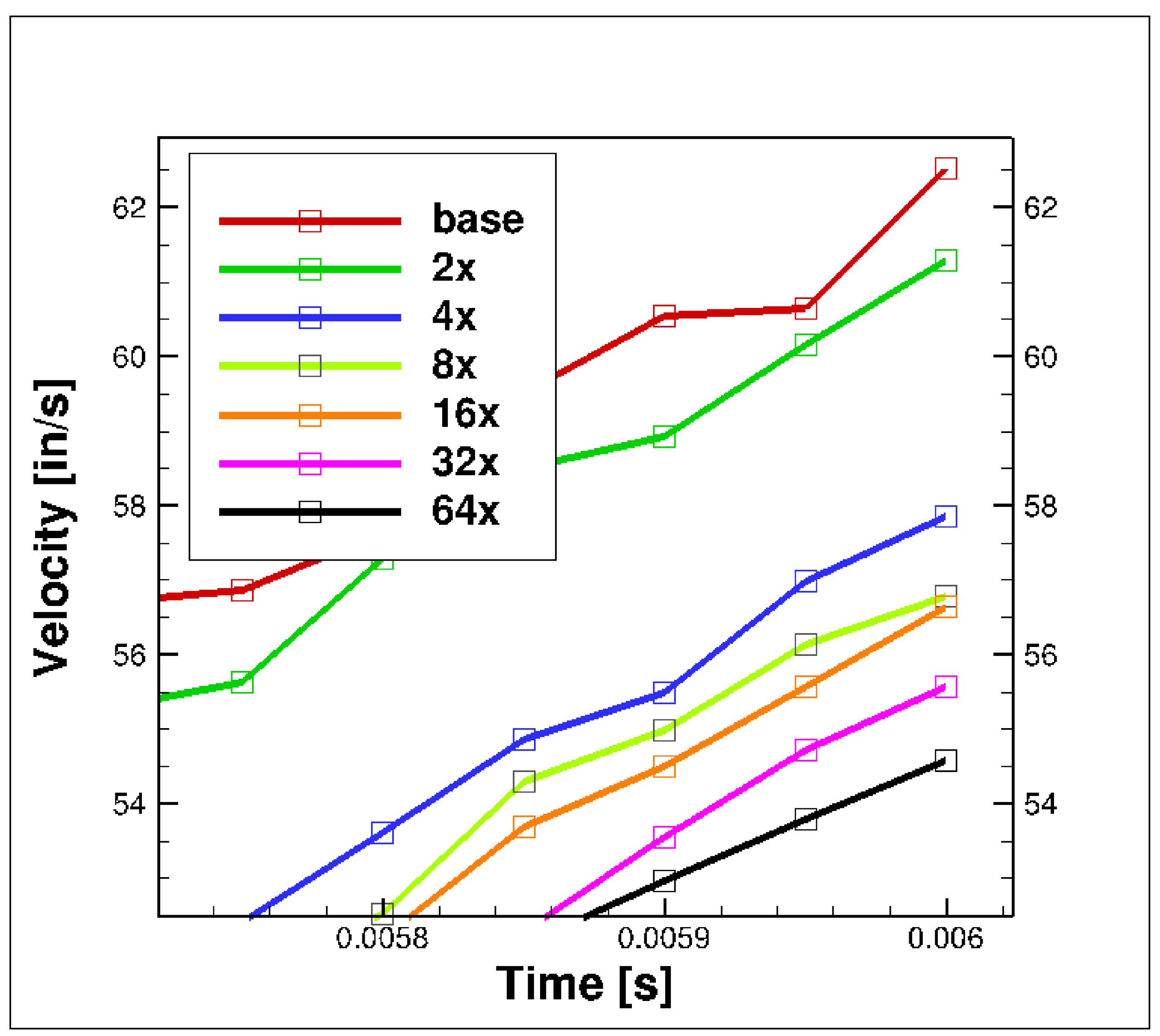



## Puncture Failure Case: Displacement and Velocity at Final Time

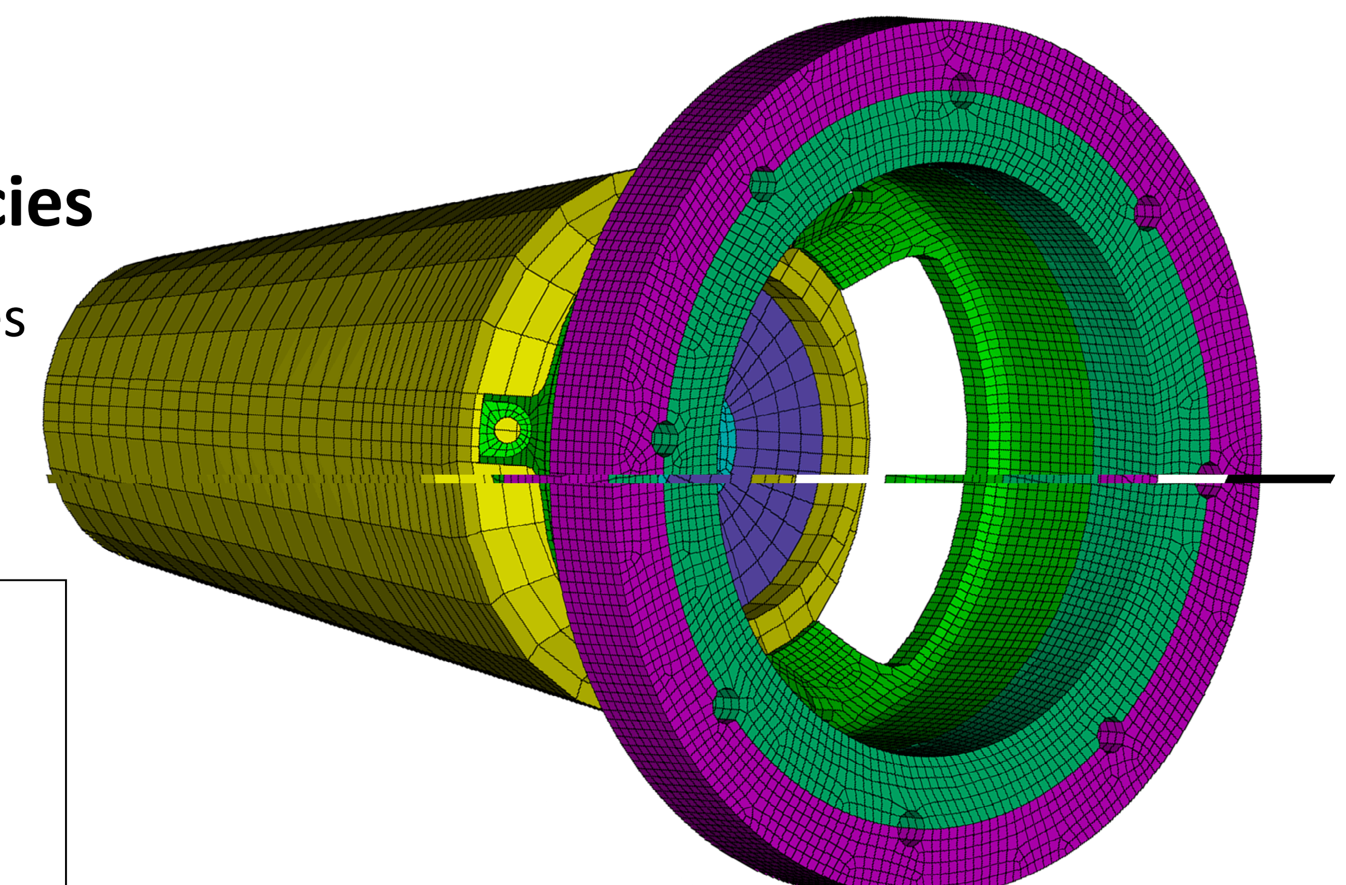
- Displacement/velocity convergence and rates of convergence are uncertain
- We do have more data for assessment (7 meshes instead of just 3)

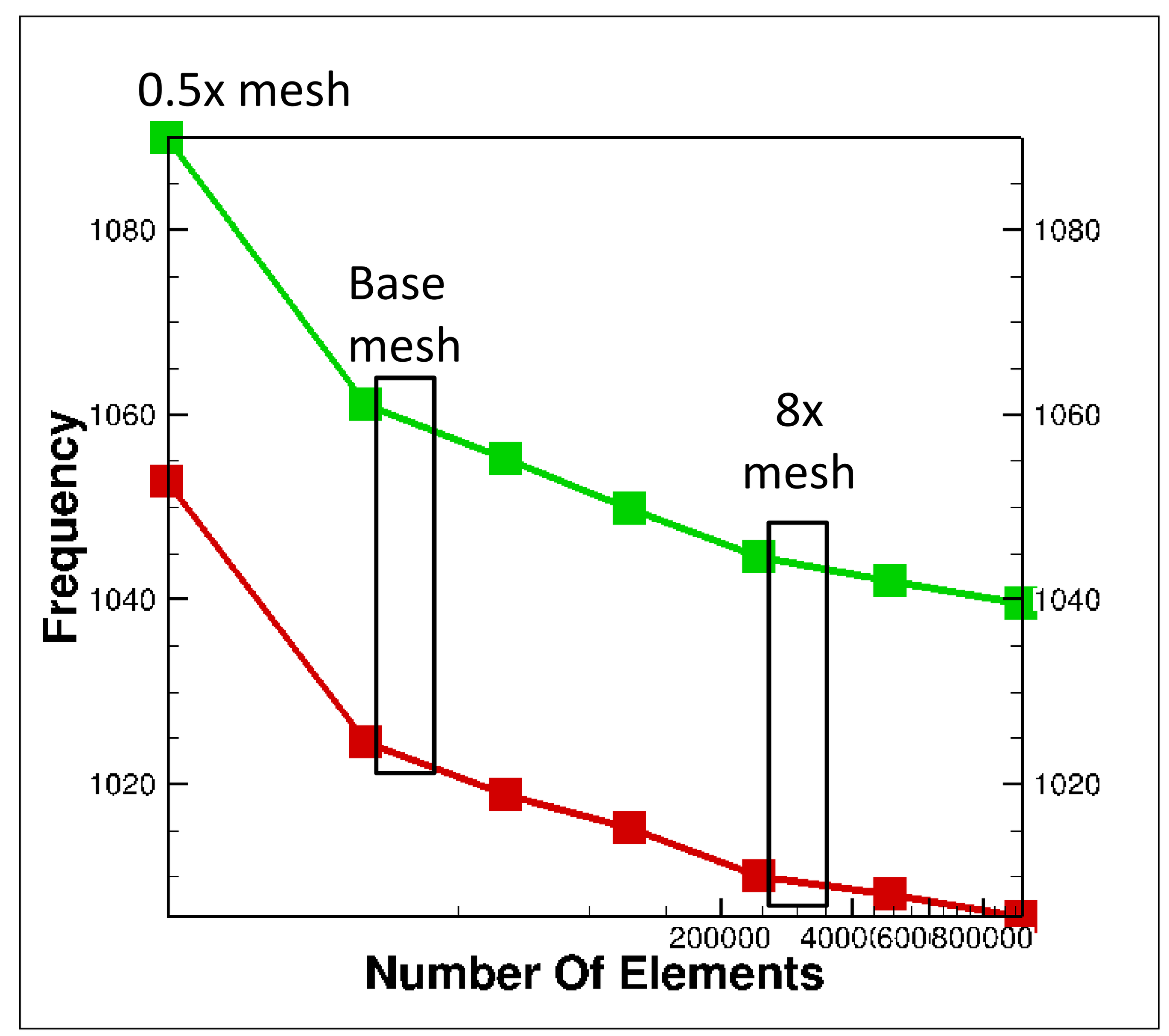



## Cone Model: First Two Frequencies

- We are able to generate a wider range of meshes
- Scaled at multipliers of 0.5x, 2x, 4x, 8x, 16x and 32 x providing 7 incrementally finer meshes






- We are computing a number of frequencies and mode shapes
- The model contains elastic materials and tied joint models
- Convergence rate assessment may not always be possible
- Data indicates likely convergence of frequencies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