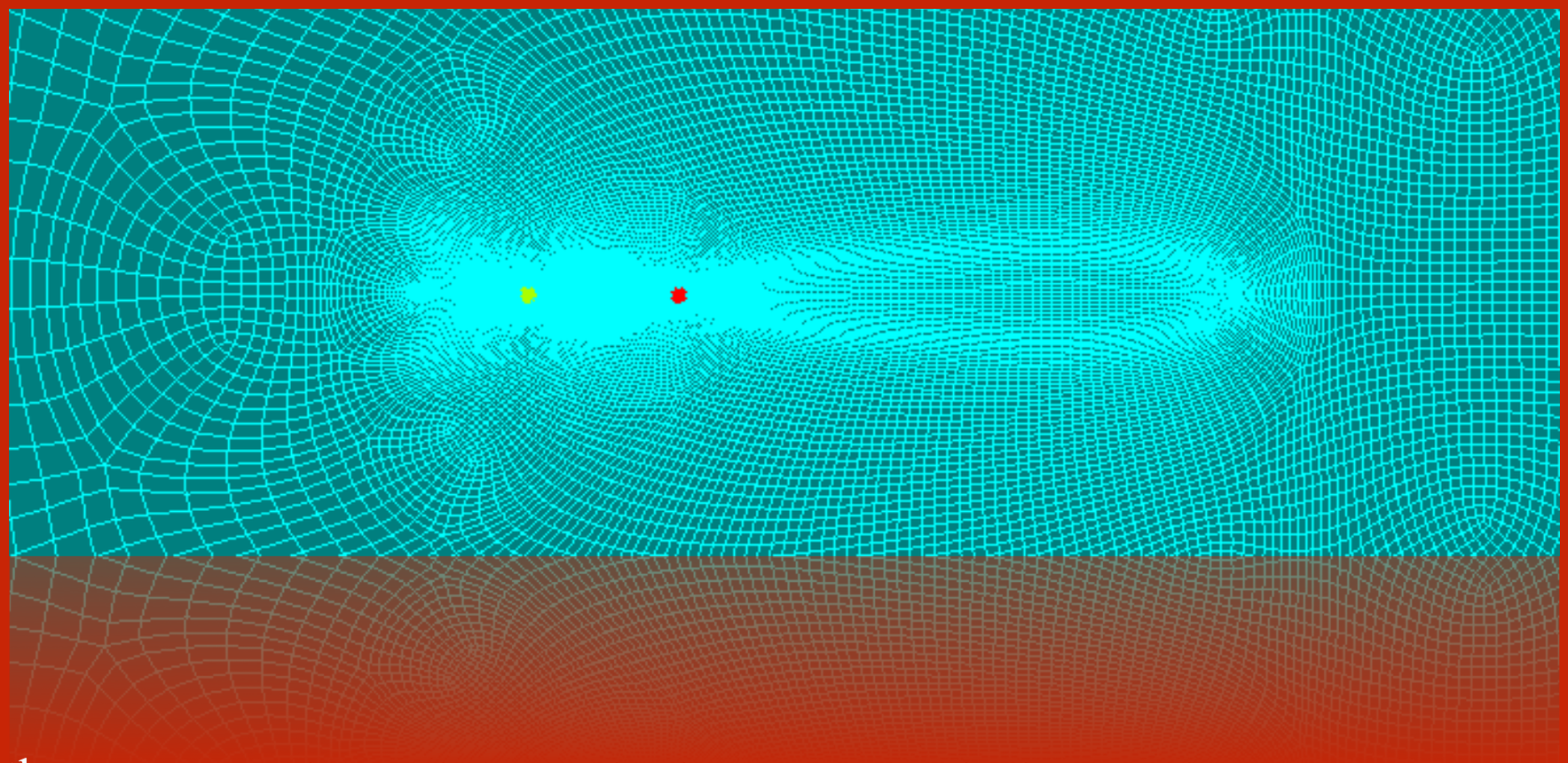
HiOCFD5



5th International Workshop on High-Order CFD Methods

Authors: *Vijay Sudharshanam , Samuel Ebenezer , Peter Eiseman*

GridPro

Overview

- GridPro technology
- Salient features
- Higher order Meshes in GridPro
- Validation cases
- Challenges

Technology

Meshing process in GridPro

Topology

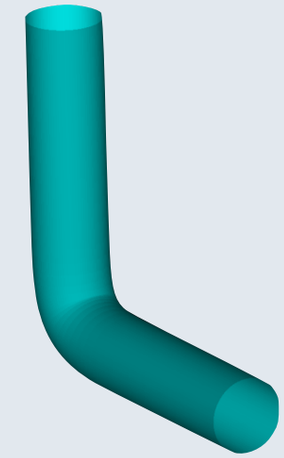
Geometry Import

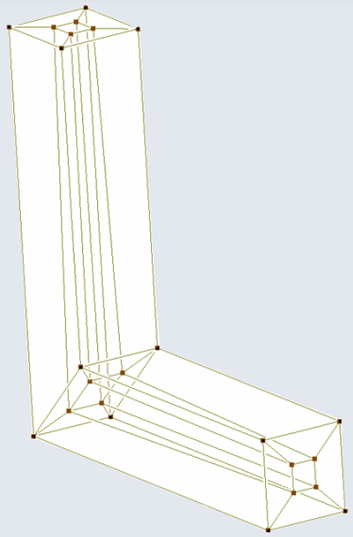
Wireframe

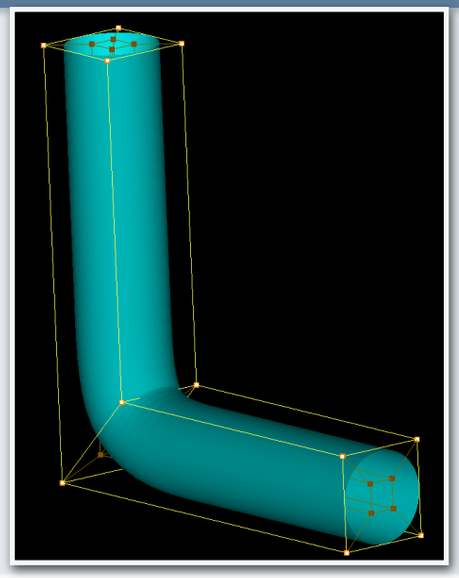
Assignment

Grid generation Engine

Grid







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swp 91 max(r0.351,c{f-12(0.0):e-5(0.0)},s1.34(0.0052),a10.),act(B90,V15,F19)
swp 92 max(r0.253,c{f-8(0.0):e-5(0.0)},s1.37(0.0048),a10.),act(B80,V22,F38)
swp 93 max(r0.191,c{f-9(0.0):e-5(0.0)},s1.40(0.0048),a9.5),act(B80,V17,F14)
swp 94 max(r0.288,c{f-9(0.0):e-5(0.0)},s1.30(0.0045),a9.3),act(B80,V12,F13)
swp 95 max(r0.319,c{f-9(0.0):e-5(0.0)},s1.33(0.0048),a9.2),act(B80,V37,F62)
  surf conn: 0 adjusted, 0 confused and 0 folded.
set static ctrl funcs... (0.4) (0)
swp 96 max(r0.243,c{f-8(0.0):e-5(0.0)},s1.28(0.0046),a9.1),act(B90,V59,F60)
swp 97 max(r0.273,c{f-12(0.0):e-5(0.0)},s1.33(0.0047),a8.9),act(B100,V65,F69)
swp 98 max(r0.224,c{f-11(0.0):e-5(0.0)},s1.32(0.0052),a9.1),act(B100,V56,F54)
swp 99 max(r0.174,c{f-11(0.0):e-5(0.0)},s1.30(0.0044),a8.5),act(B100,V32,F63)
Amount of time taken for 100 sweeps is 0 hours 0 minutes 0 seconds
+action: (~w)  output blocks
st:dep=5/5,dir=1029/2000
st:found 0. too bad.
  all to 'blk.tmp':    block   1/10: snap 13/369...
  all to 'blk.tmp':snap 69/2690      block   1/10...
  all to 'blk.tmp':snap 69/2690      block  10/10...
  all to 'blk.tmp':snap 69/2690

Write action took 0 hours 0 minutes 0 seconds
  all to 'dump.tmp':    block   1/10...
  all to 'dump.tmp':    block  10/10...
  all to 'dump.tmp':

Write action took 0 hours 0 minutes 0 seconds


>::::: Mon Dec 14 10:53:55 2015 :::::
>Scheduling at step 3(swp 100) with 5 actions..
+action: (~c all 1.0 0)  set algebraic cluster parameters.
     3 collected, all reset: ratio=1 growth ratio=0
+action: (~C all 1.0 24)  set surf cluster control parameters.
     3 collected, all reset: ratio=1 radius=24
set static ctrl funcs... (0.4) (0)
+action: (~r)   readjust surf grid
 (0) are reap..ed.
+action: (~S 100)  new sweep interval = 100
swp 100 max(r0.280,c{f26(0.0):e12(0.0)},s1.28(0.0048),a7.7),act(B100,V58,F82)
set static ctrl funcs... (0.4) (0)
swp 101 max(r0.262,c{f26(0.0):e11(0.0)},s1.26(0.0047),a7.5),act(B100,V65,F70)
swp 102 max(r0.210,c{f26(0.0):e11(0.0)},s1.27(0.0046),a7.3),act(B100,V76,F80)
swp 103 max(r0.228,c{f24(0.0):e11(0.0)},s1.27(0.0045),a7.1),act(B100,V79,F82)
swp 104 max(r0.194,c{f24(0.0):e11(0.0)},s1.26(0.0044),a7.3),act(B100,V66,F66)
swp 105 max(r0.268,c{f24(0.0):e11(0.0)},s1.26(0.0042),a6.9),act(B100,V54,F82)
set static ctrl funcs... (0.4) (0)
swp 106 max(r0.257,c{f24(0.0):e11(0.0)},s1.26(0.0043),a6.7),act(B100,V71,F88)
swp 107 max(r0.280,c{f24(0.0):e11(0.0)},s1.26(0.0042),a6.6),act(B100,V74,F83)
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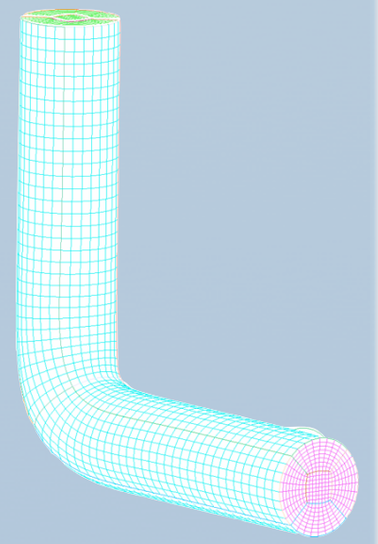
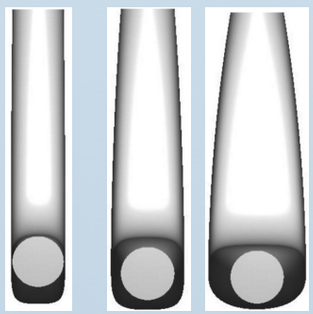




CAESES

Sculptor

modeFRONTIER

CATIA

SPACECLAIM

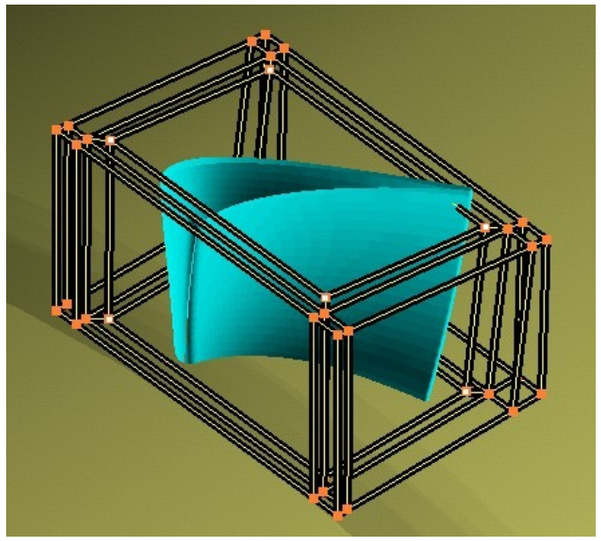
SIMULIA

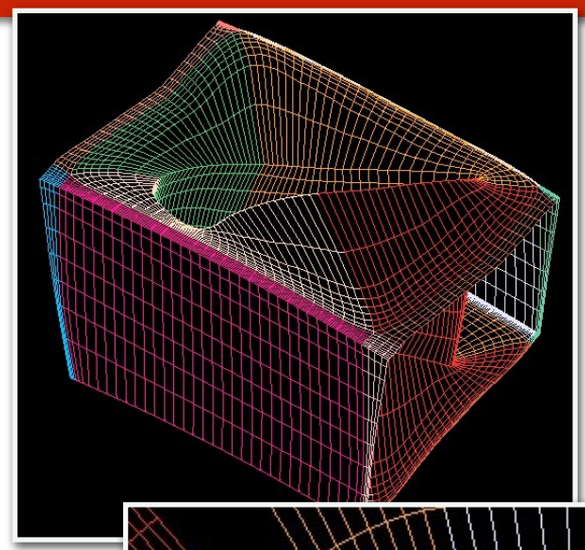
Variable Geometry

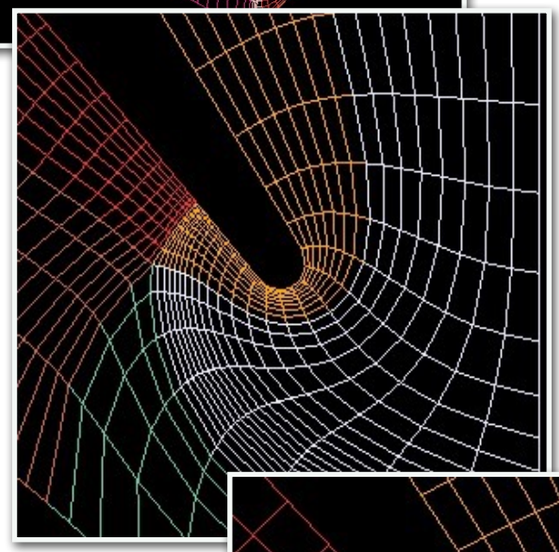
Optimiser

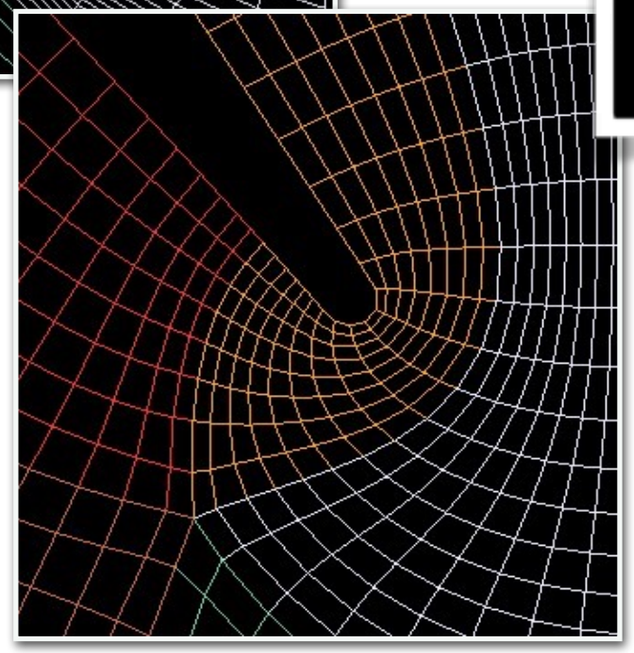
GridPro

Grid Solver



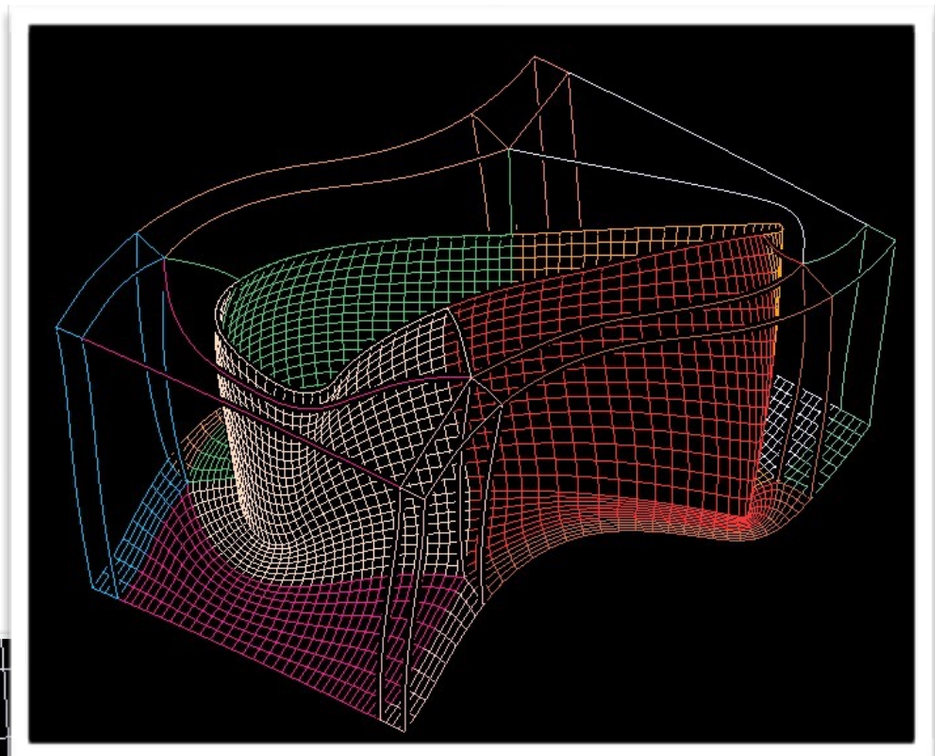






Topology

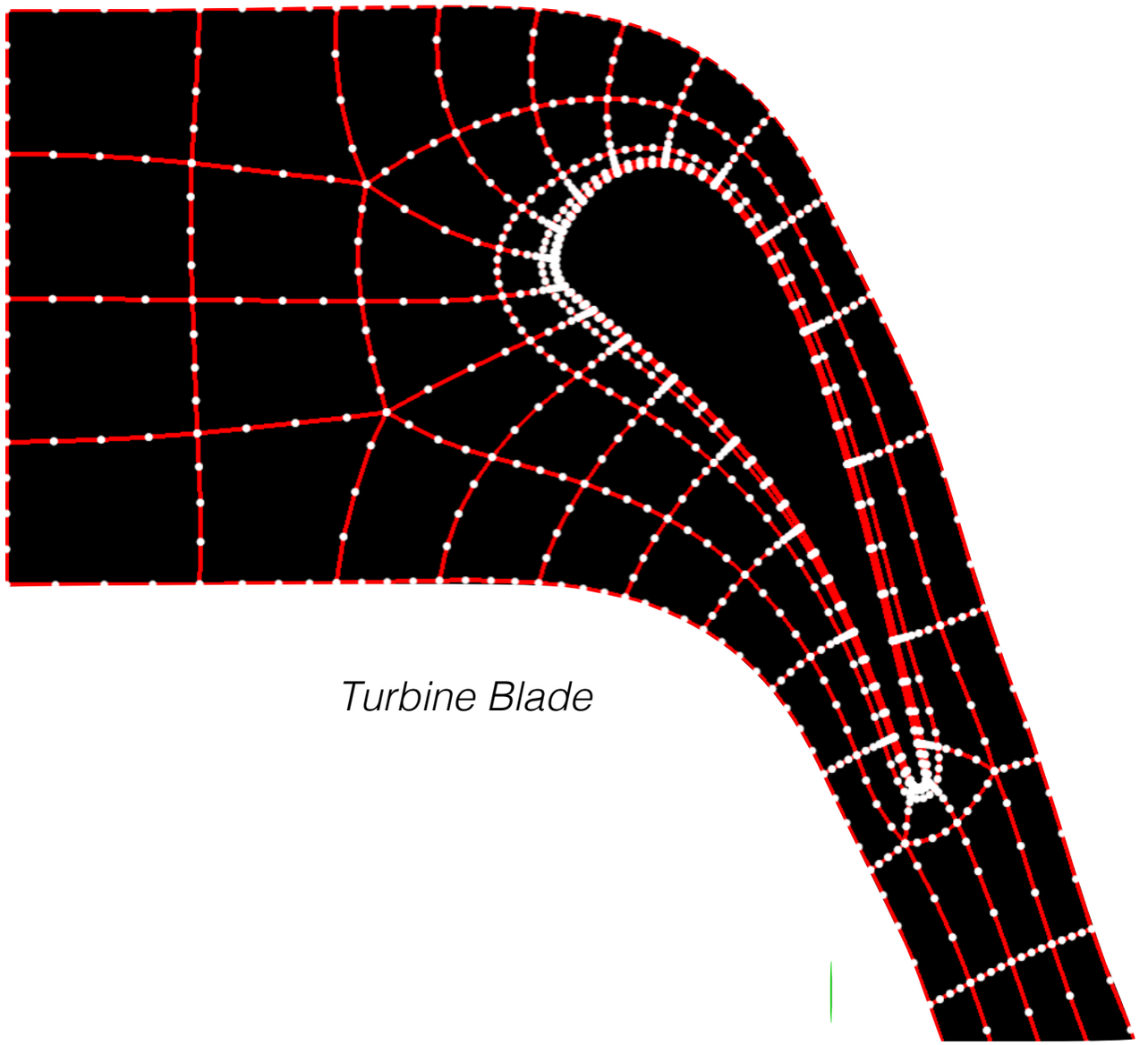
Grid generator automatically projects and moves grid points to optimal locations to create a smooth orthogonal grid.



Grid

Salient features of GridPro

- Topology based approach
- Ability to handle grid adaptations
- Orthogonal and smooth meshes
- Highly complex geometries

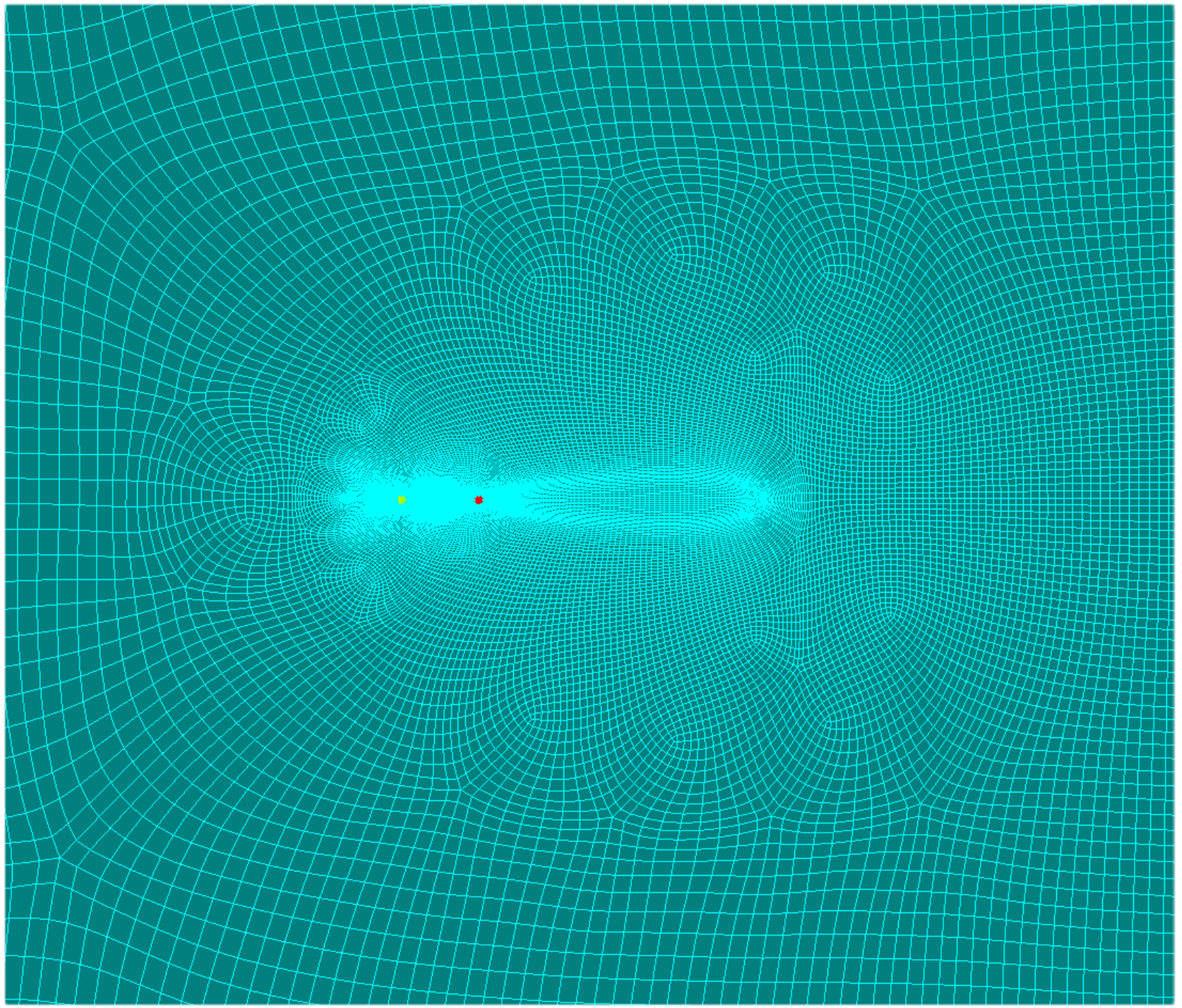


Turbine Blade

Highlights of the Higher order grid generation in GridPro

Higher order grid - created using a dense linear mesh.

No post processing of Grid Required .

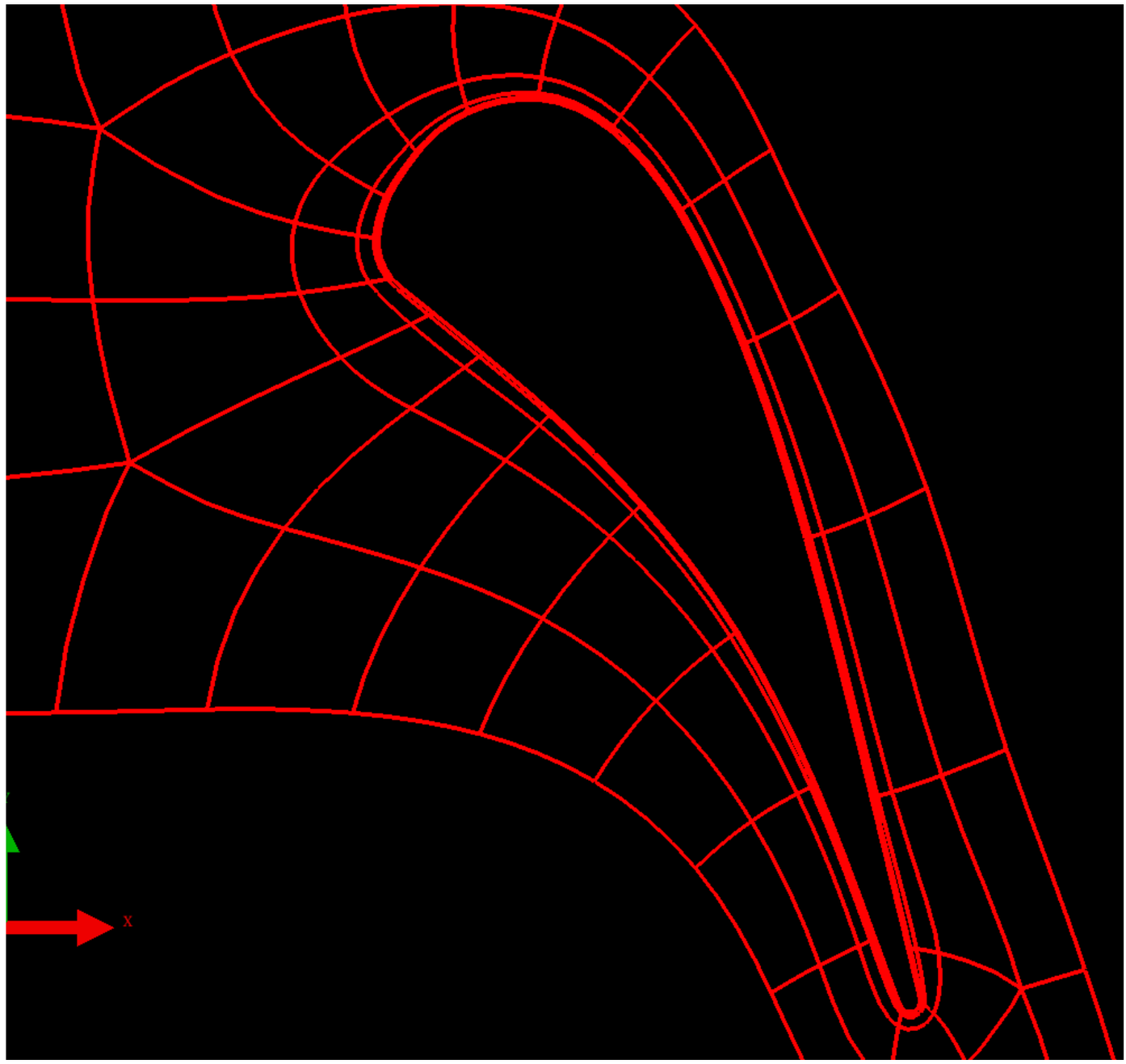


Tandem Spheres

Highlights of the Higher order grid generation in GridPro

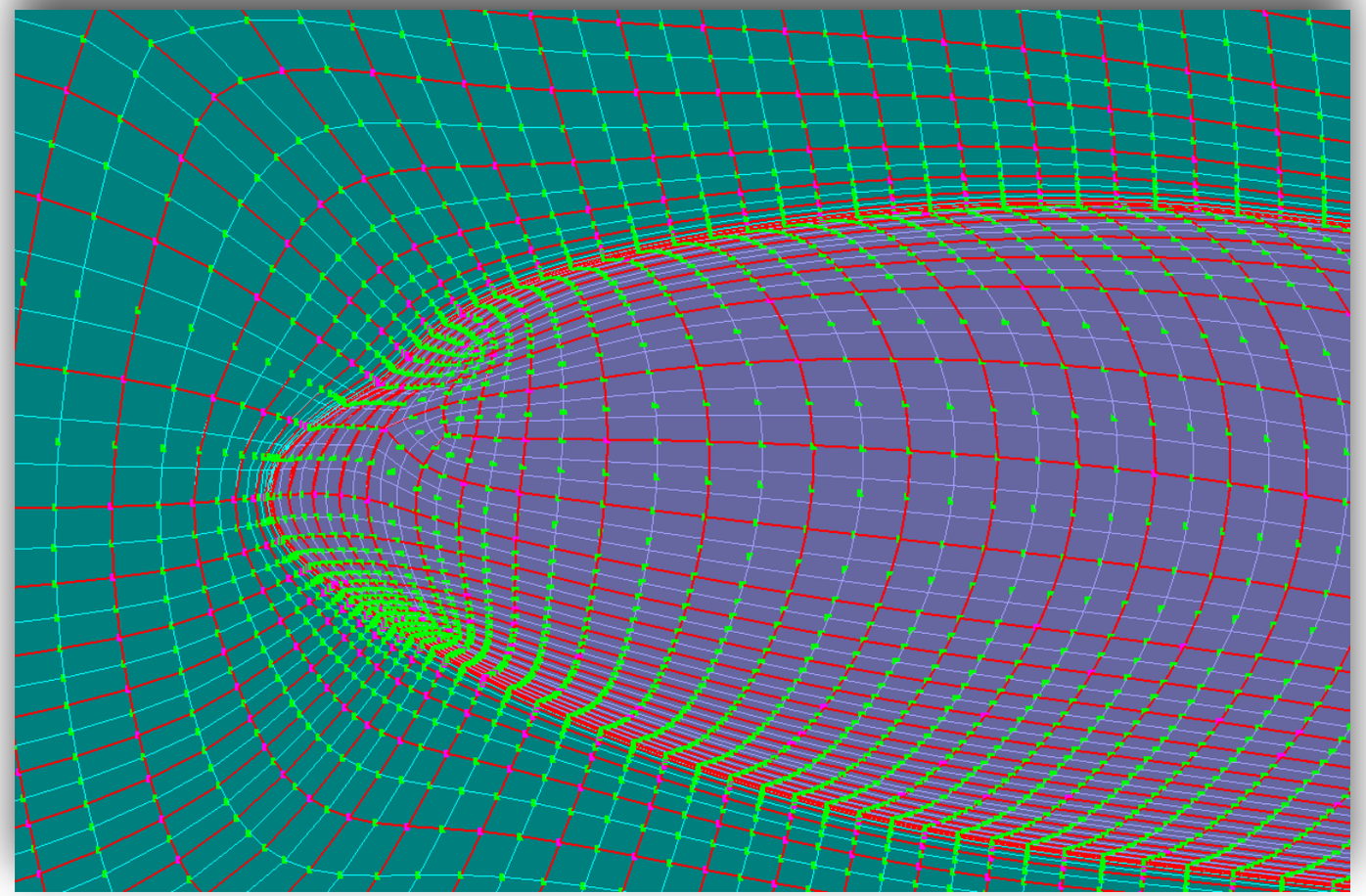
Ggrid generated Grid conforms to the geometry.

Conforms more accurately, compared to a mesh with same number of linear elements.



Highlights of the Higher order grid generation in GridPro

The grid generation engine ensures that the curvature is well captured if the density is large enough.

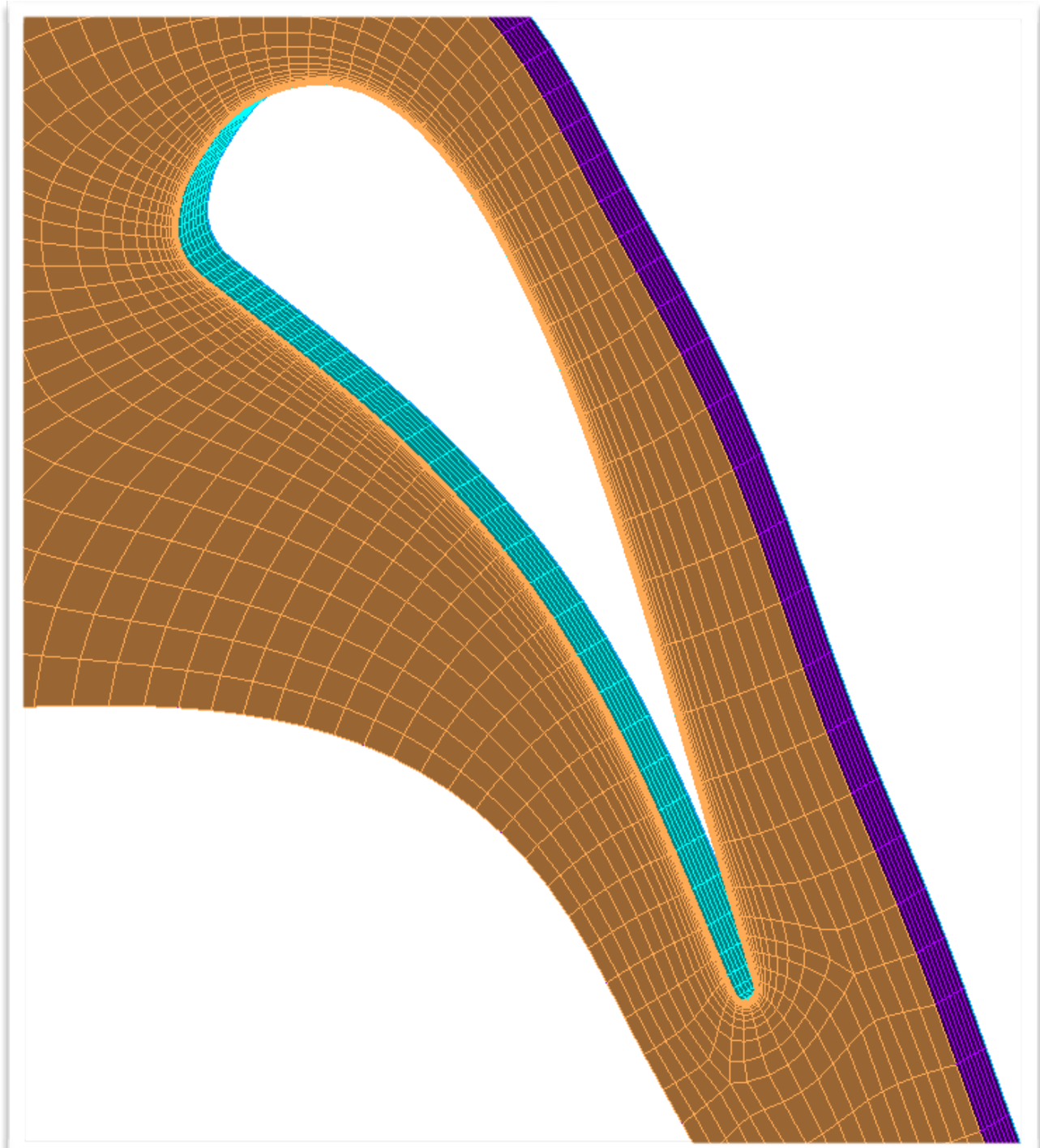


NASA CRM
Fuselage+ Symmetry plane

Highlights of the Higher order grid generation in GridPro

Clustering is specified as apart of grid generation process.

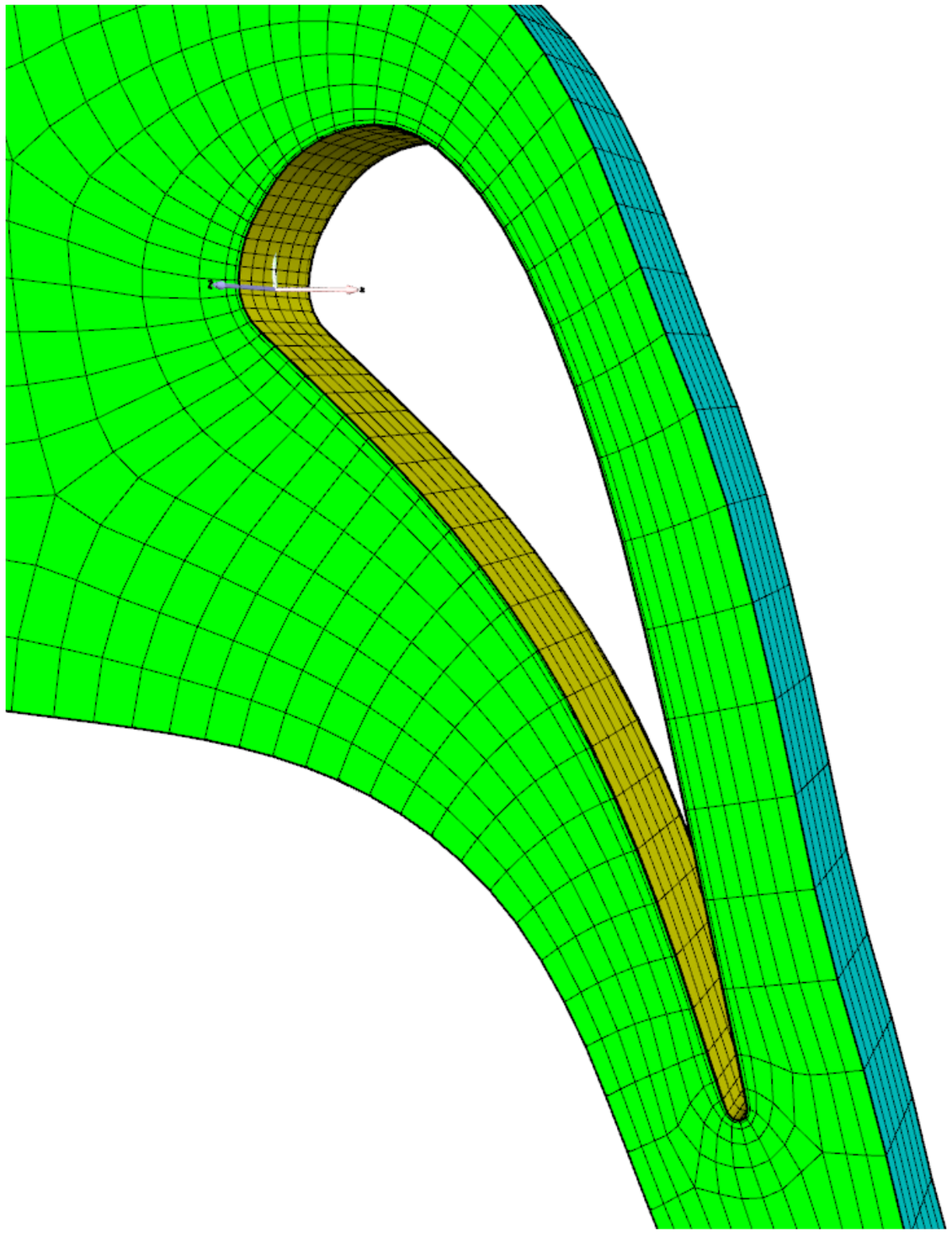
If done as post-processing step, clustering parameters like growth ratio can be modified.



Highlights of the Higher order grid generation in GridPro

Provides flexibility to change edge densities of the grid without losing grid quality.

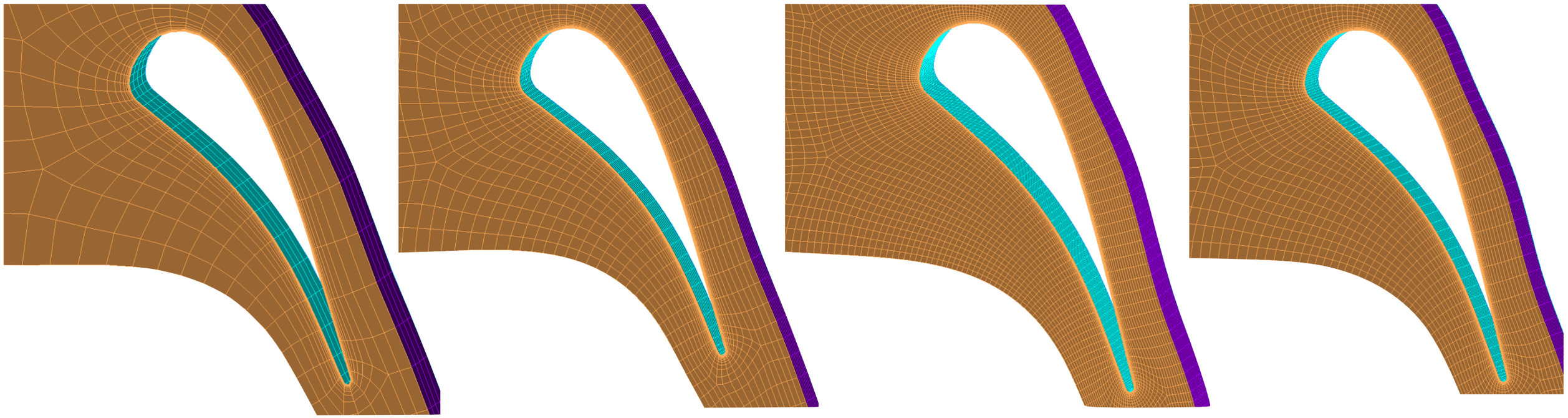
Ideal for higher order elements



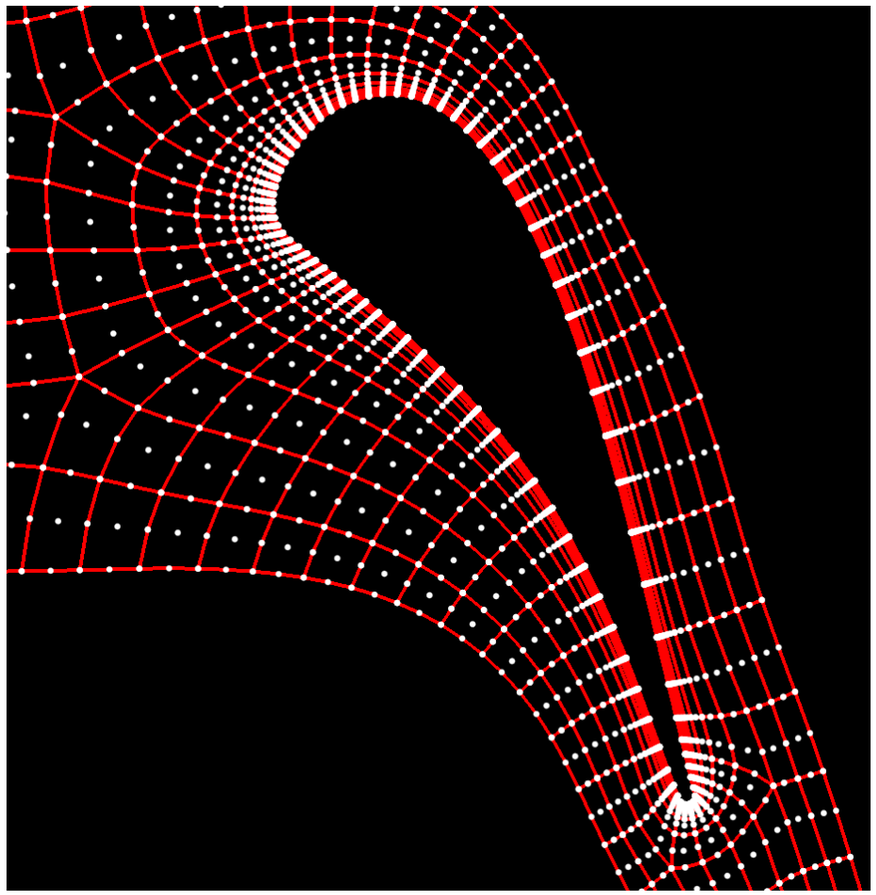
GridPro

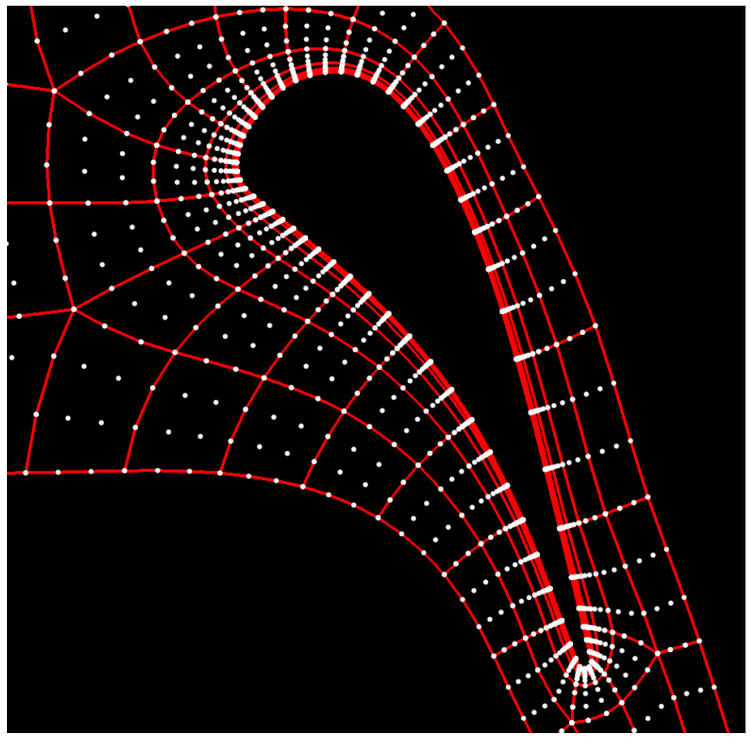
Highlights of the Higher order grid generation in GridPro

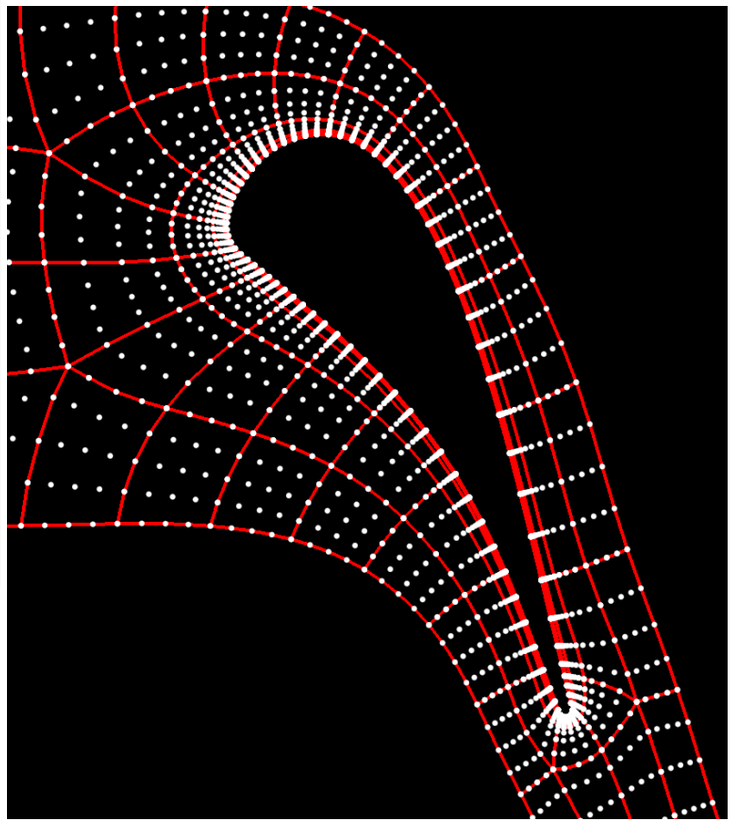
Flexibility to change edge densities while grid generation (using schedule file) can be readily used to generate different higher order elements.



- Supports P2, P3, P4





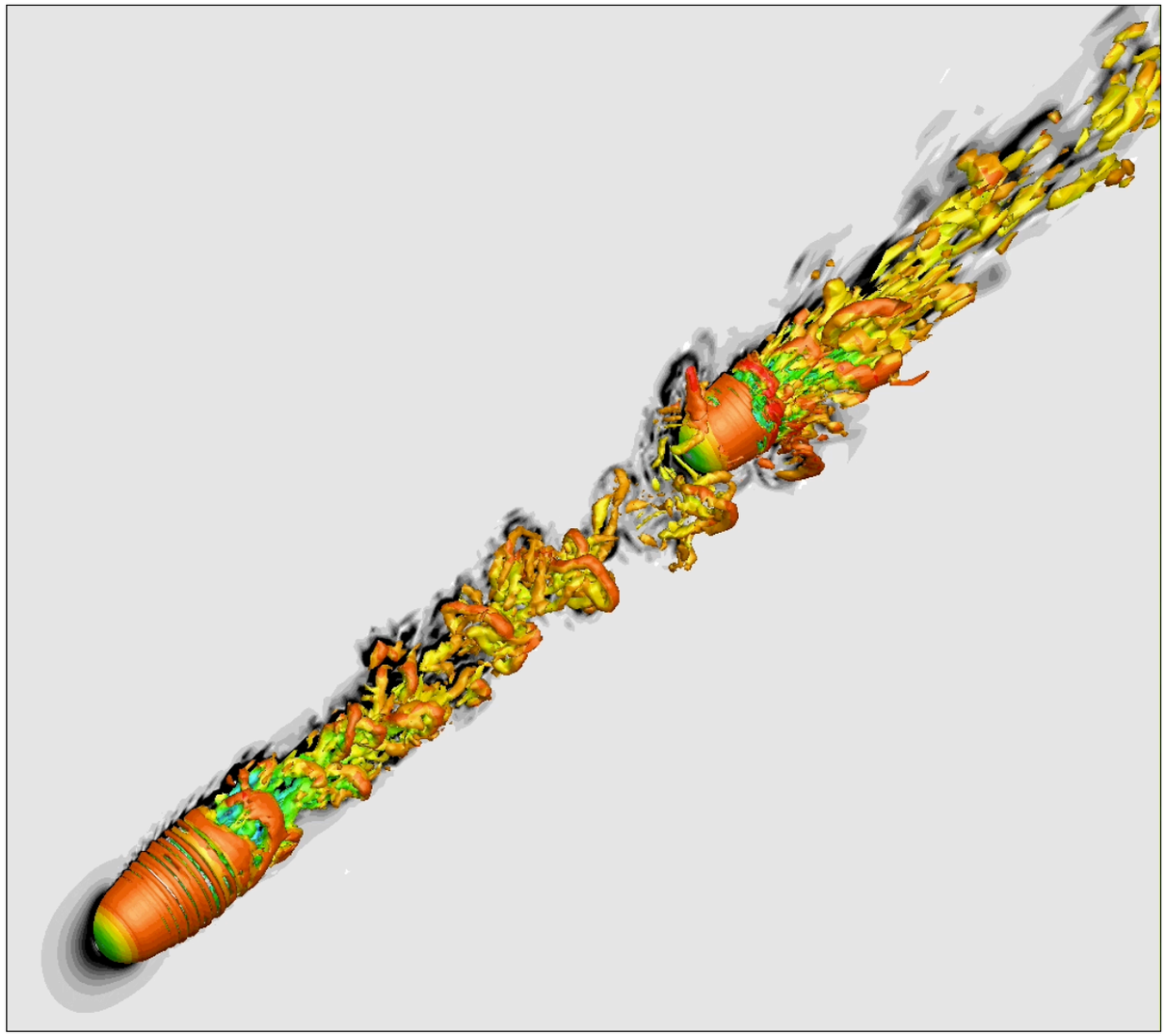


GridPro

VALIDATION CASES

CS 1 - Tandem Spheres

- Sphere diameter: 1 unit
- Distance between the spheres center: 10units
- Far field dimension: 100*100*100
- Family of grids: 7 (Mesh 1 - 7)
    i. Each grid is generated based on the no. of edge nodes derived for the family.
    ii. Grid resolution → 1.5x in each direction
    iii. Normal spacing → 1.5x for each grid starting from 0.010125

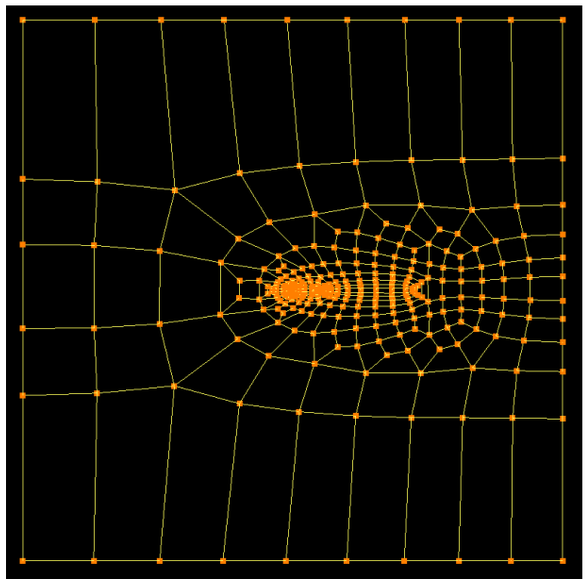


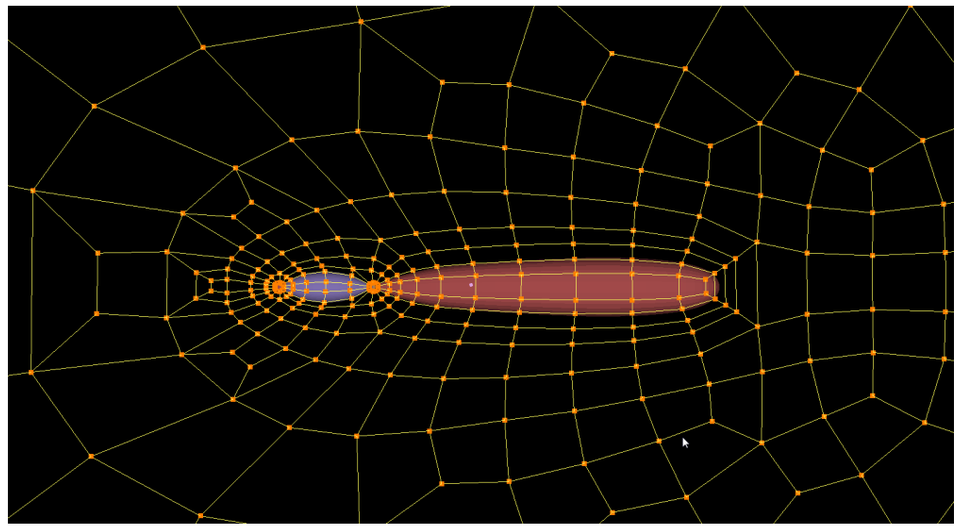
Courtesy ZJ.Wang

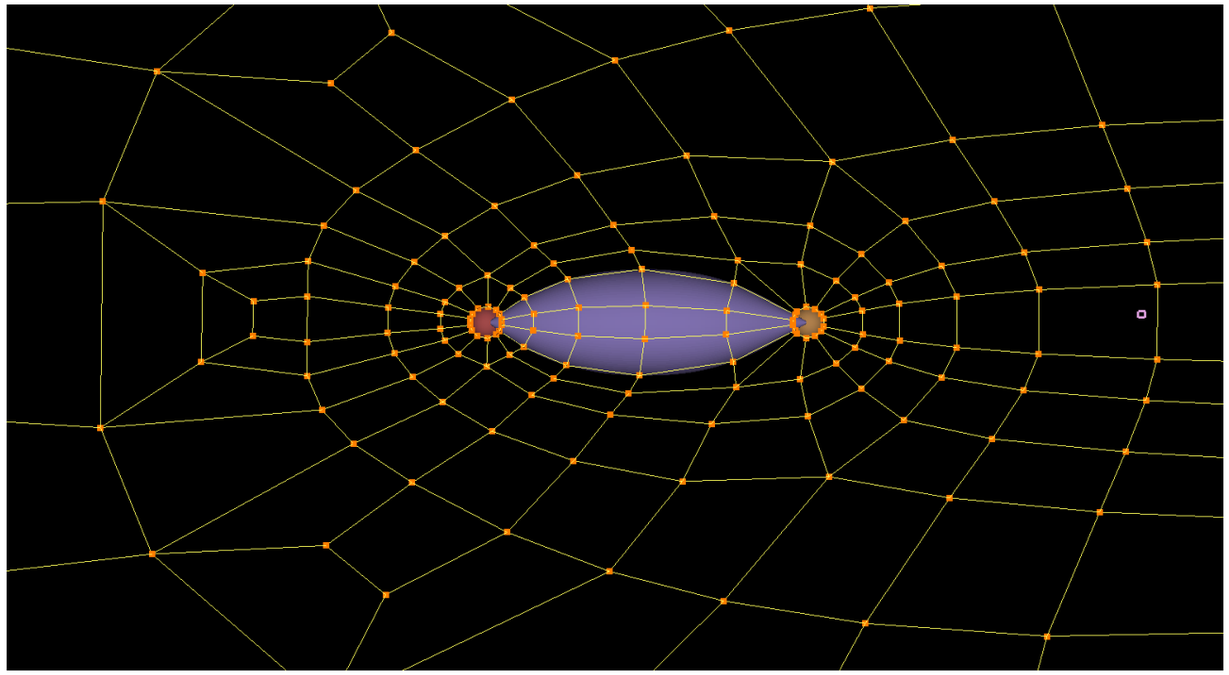
Tandem Spheres-Topology

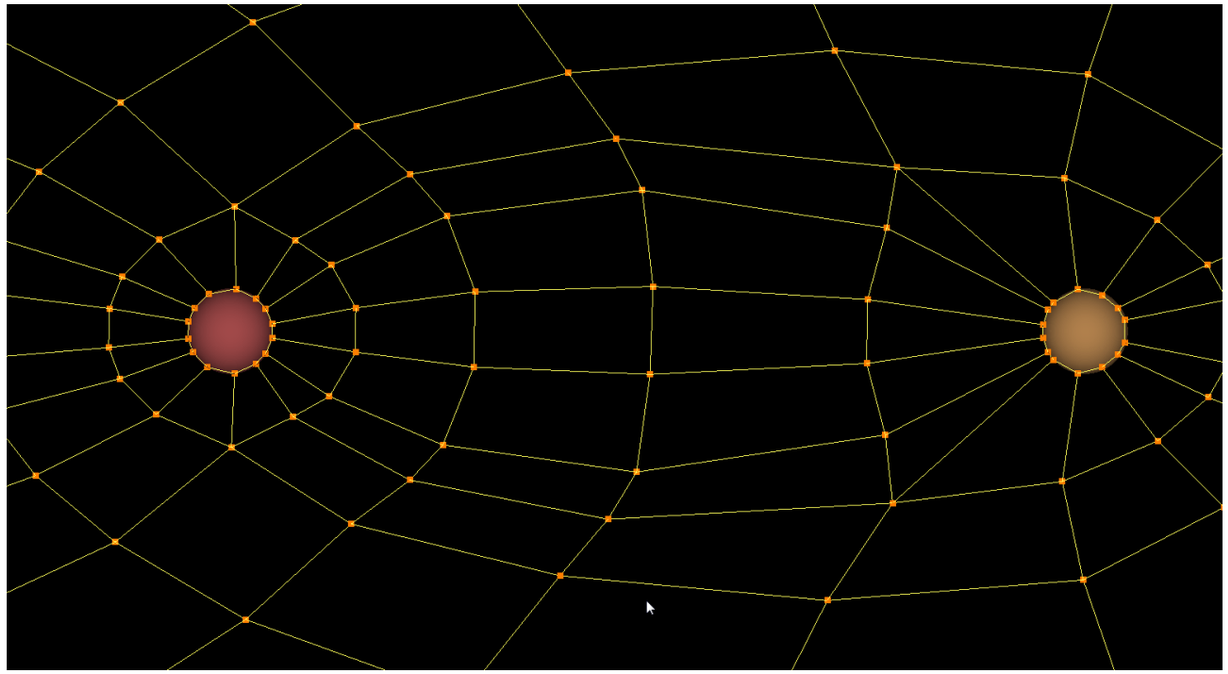
Local refinement

- Around the spheres
- Between the spheres
- Along the downstream
- On the upstream



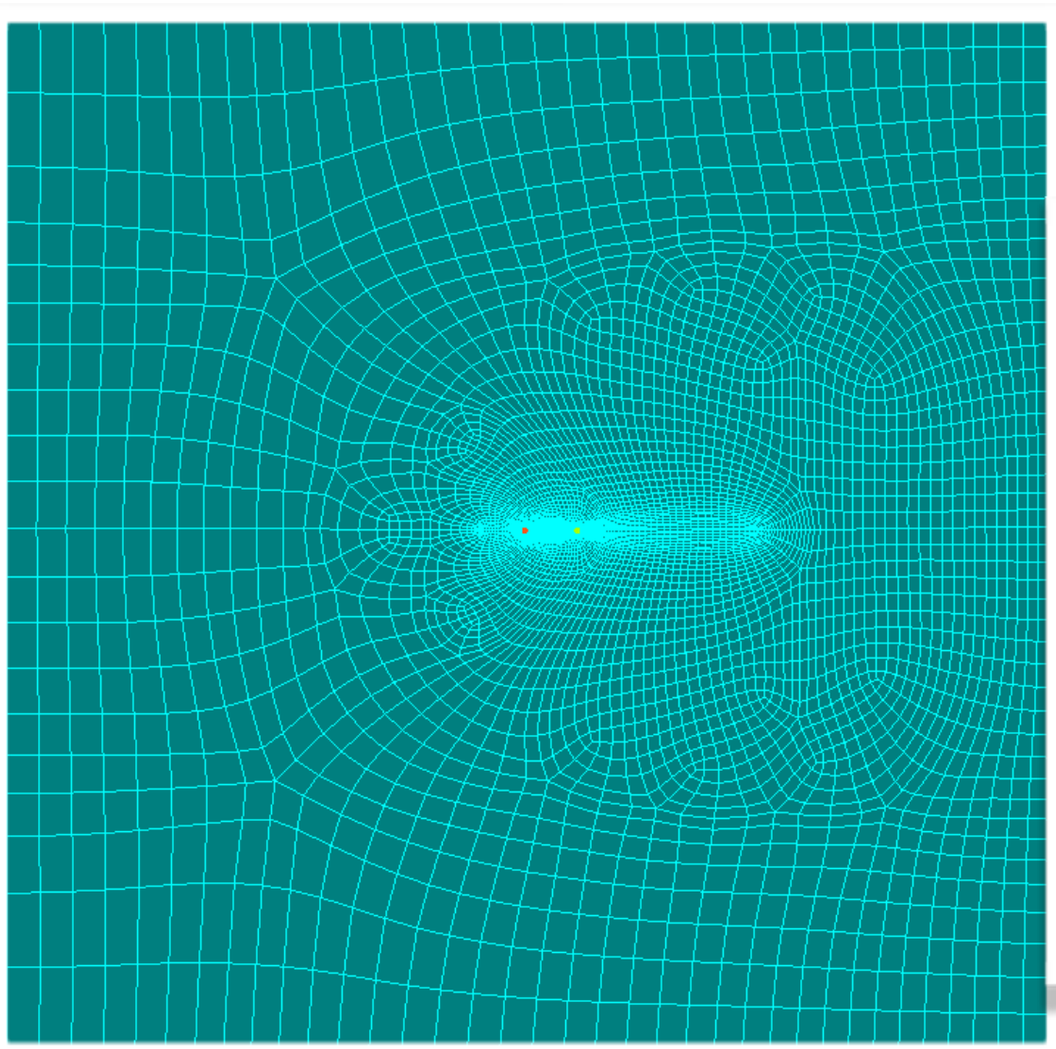


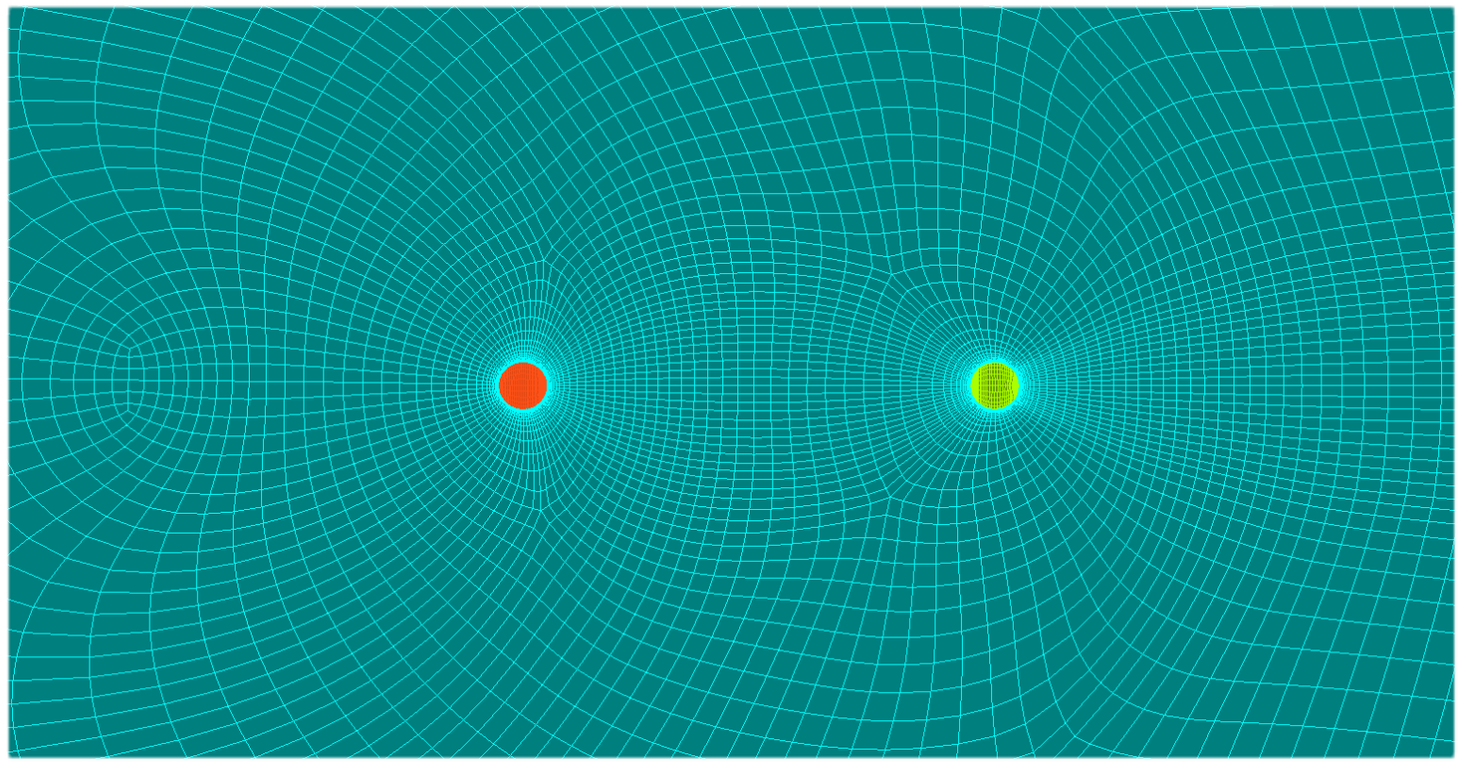




GridPro

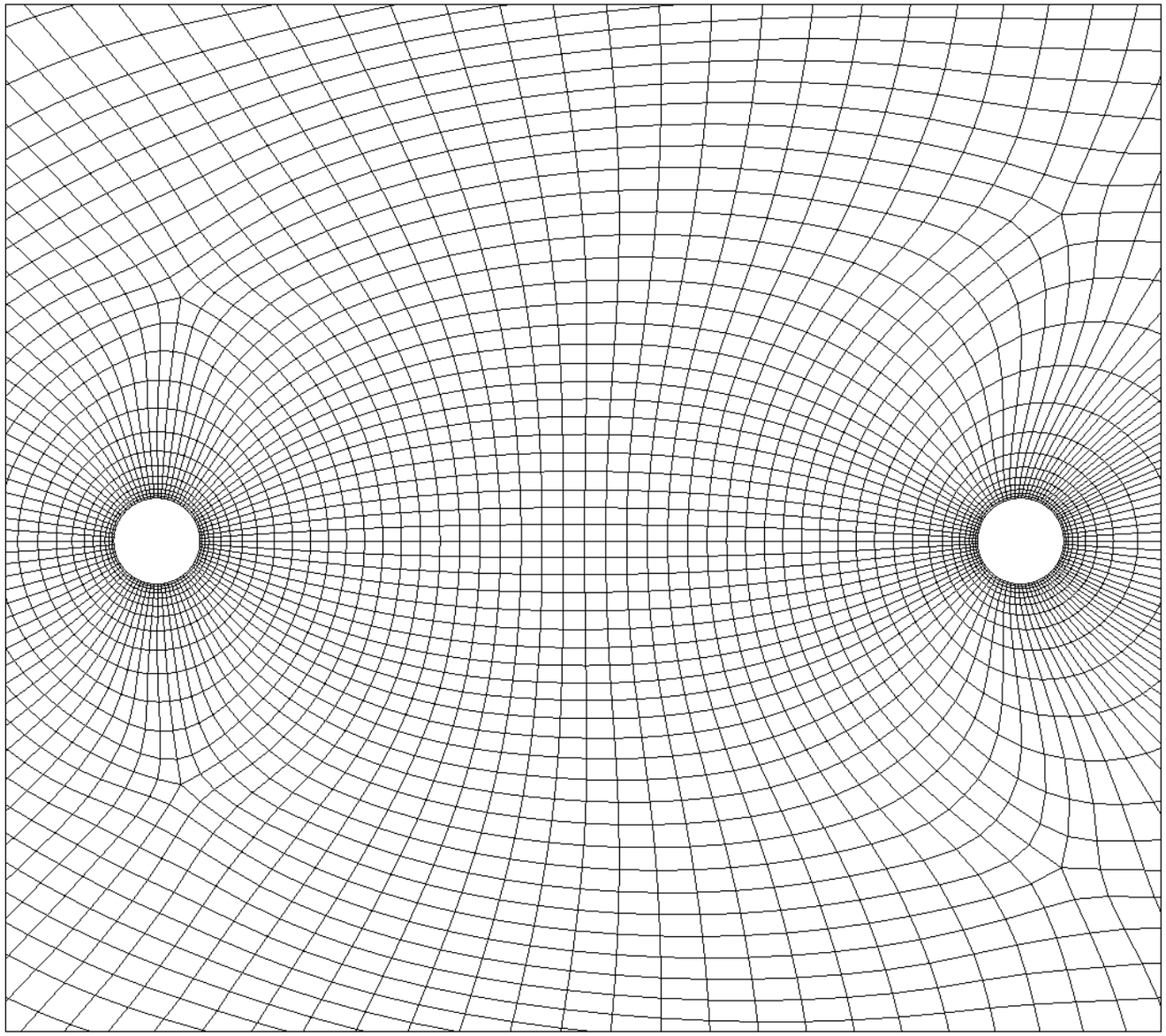
Tandem Spheres-Grid





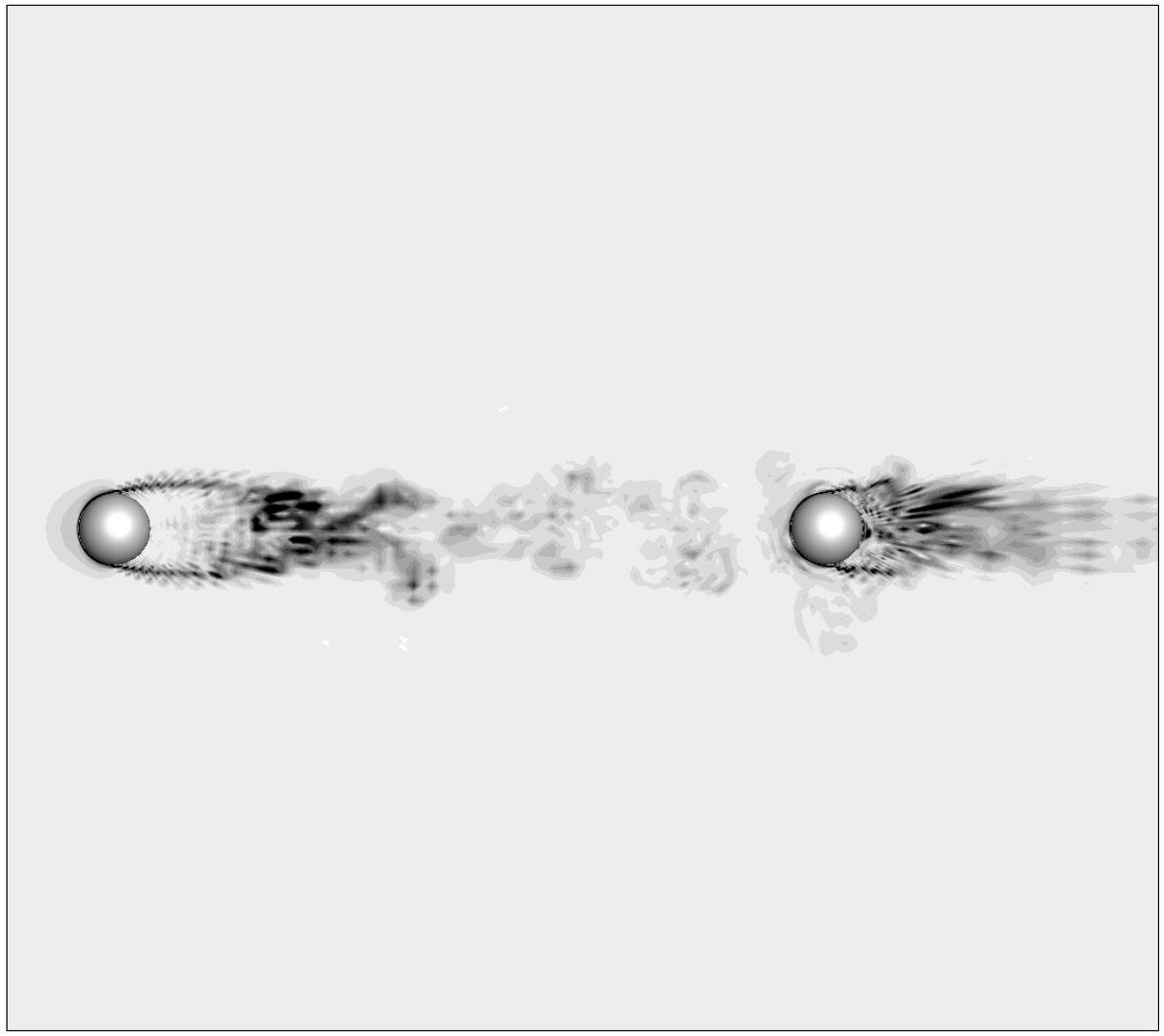
Test Case – Tandem Spheres

- P2 mesh generated by GridPro used
  - 192,640 elements
  - Δy = 0.024 (y+ ~ 7.4, based on element height)
  - Similar to Mesh 5, but not exactly the same

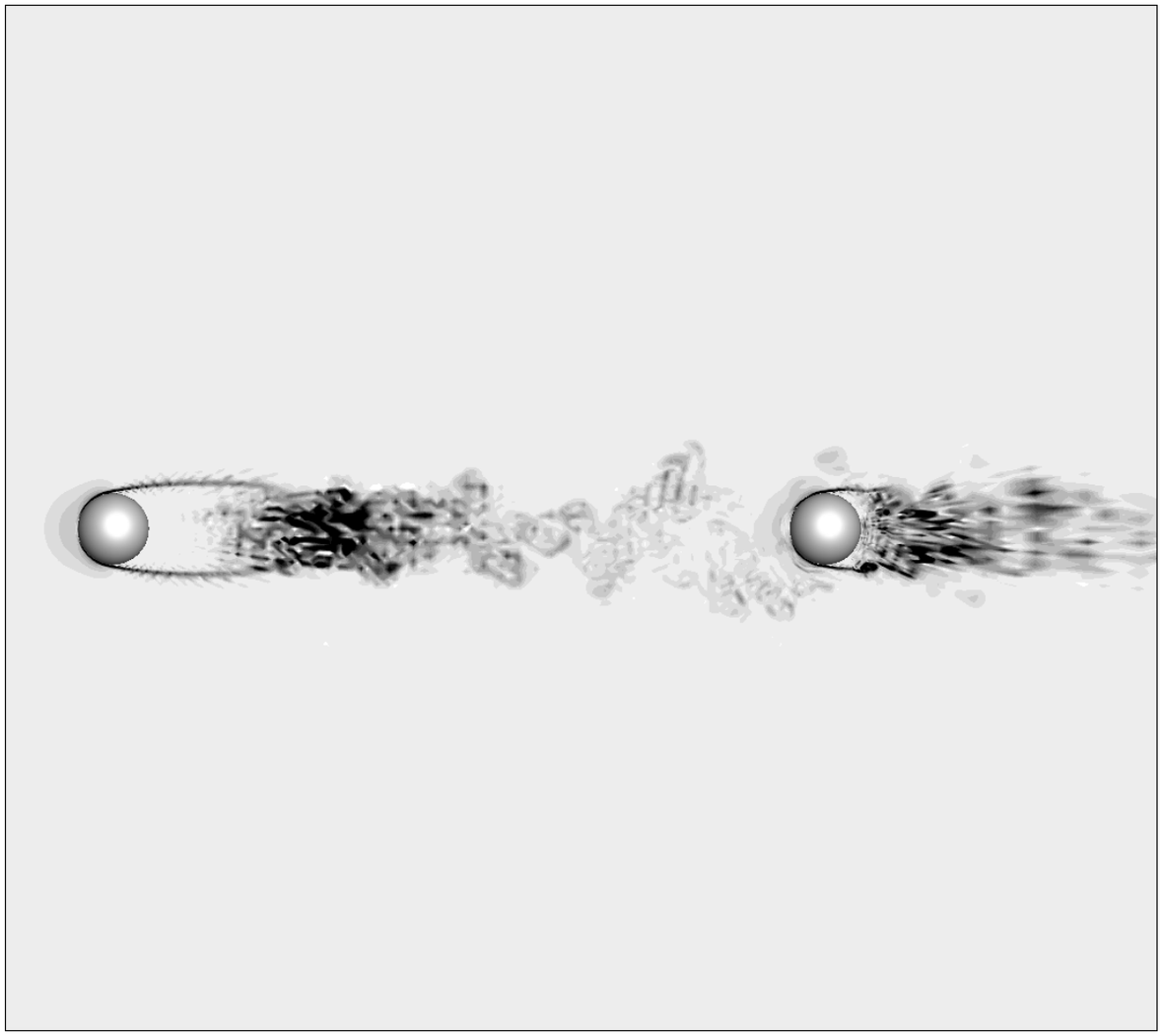


Courtesy ZJ.Wang

Schlieren



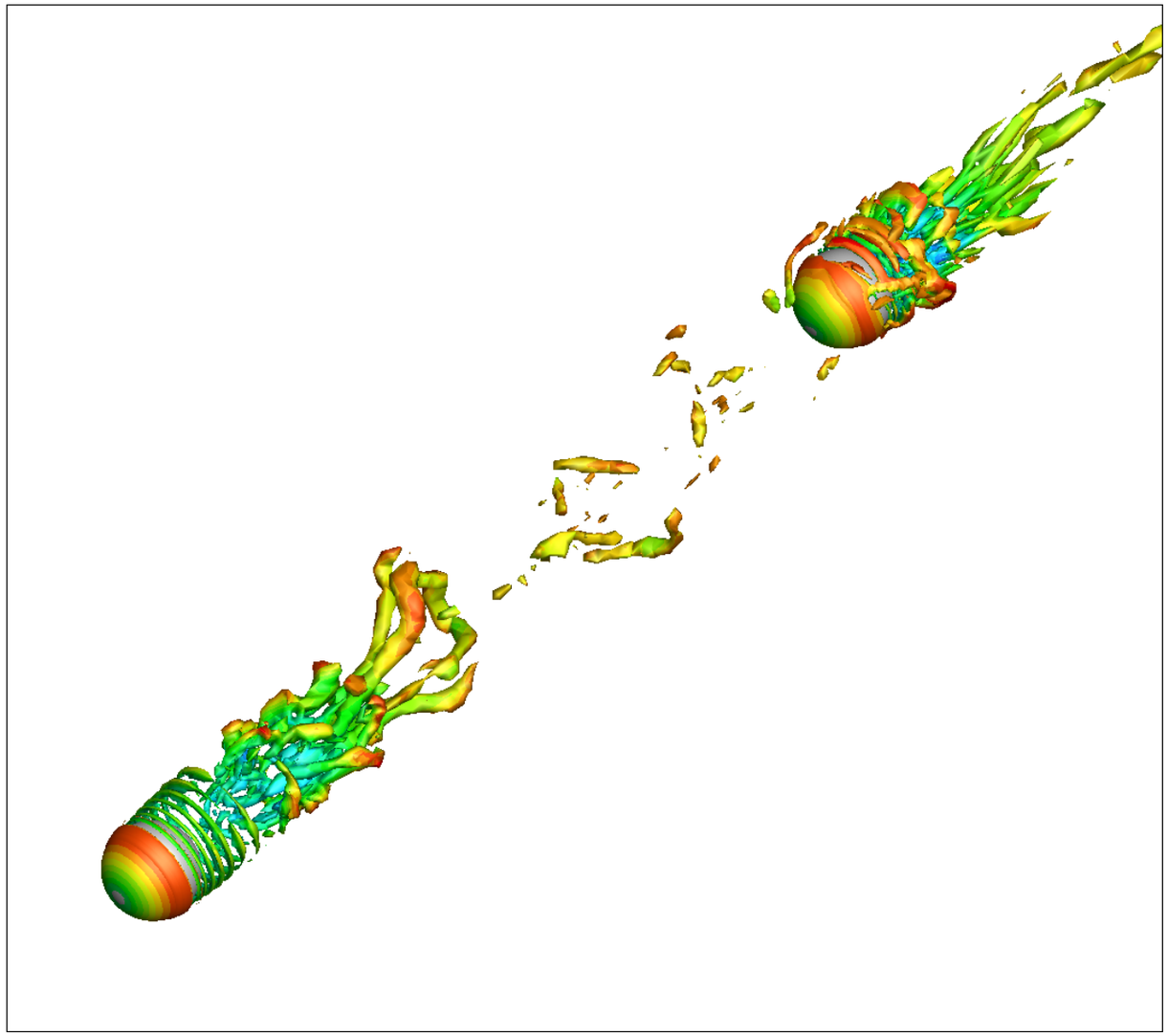
P2



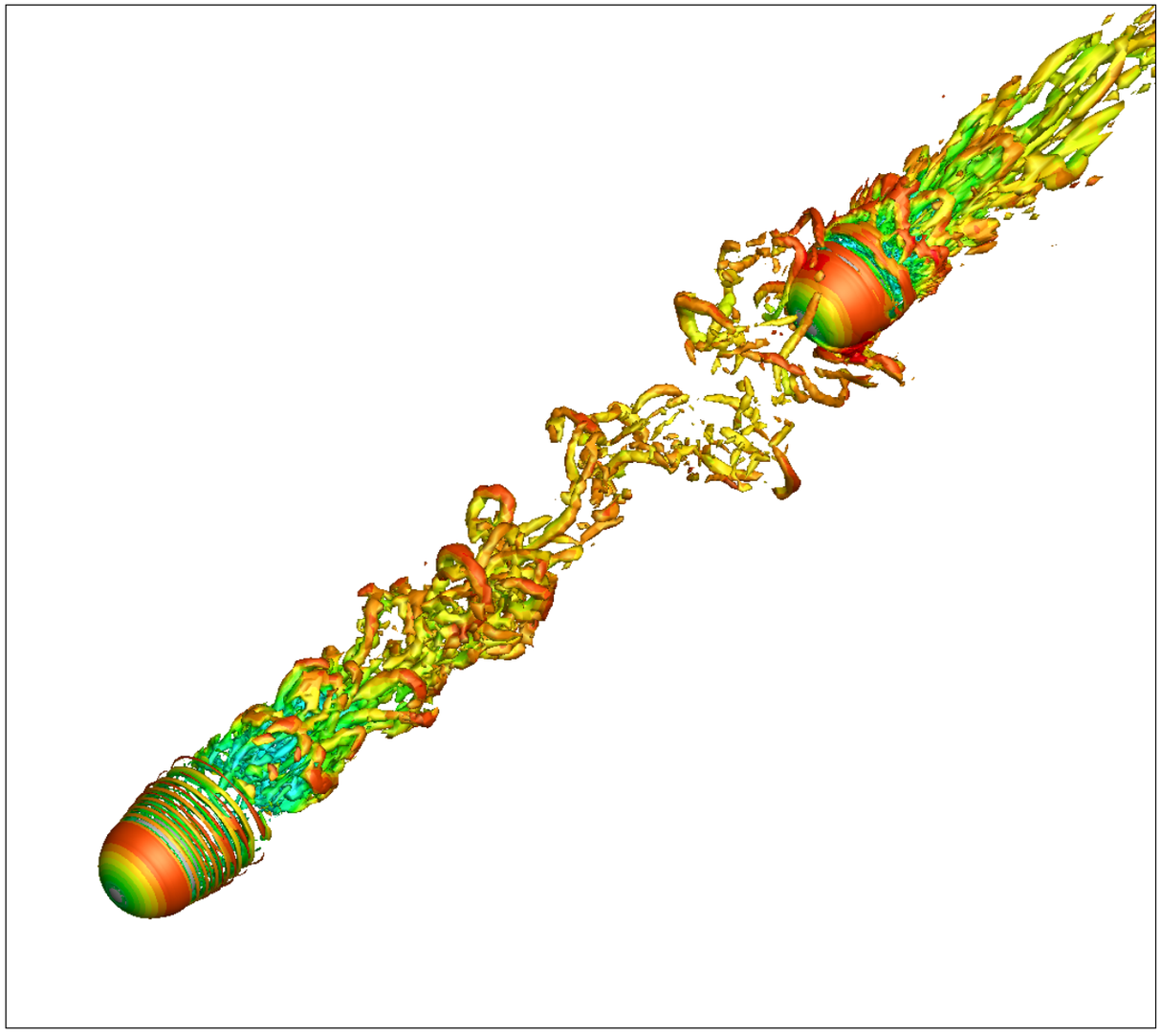
P3

Courtesy ZJ.Wang

Q-criterion



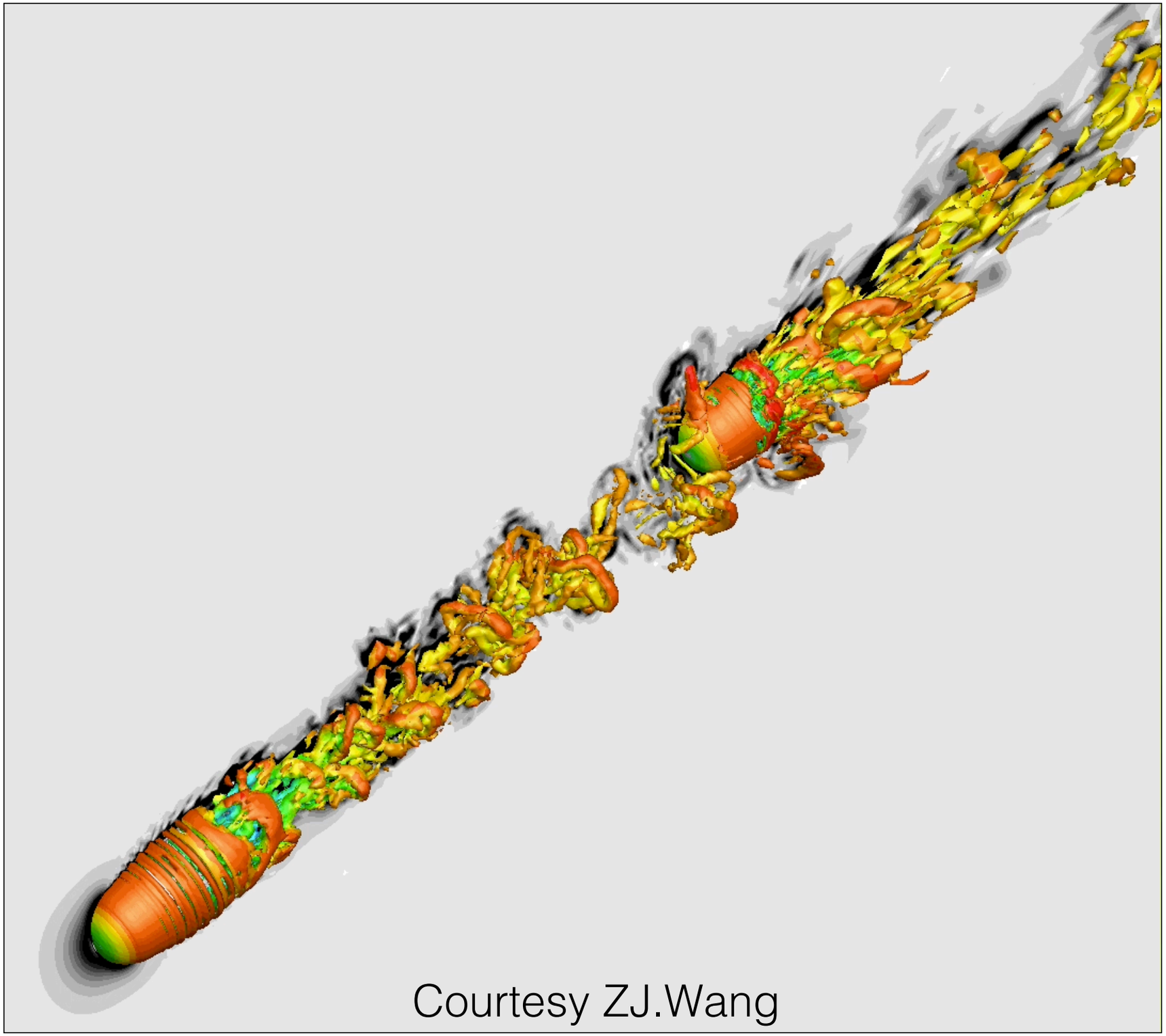
P2



P3

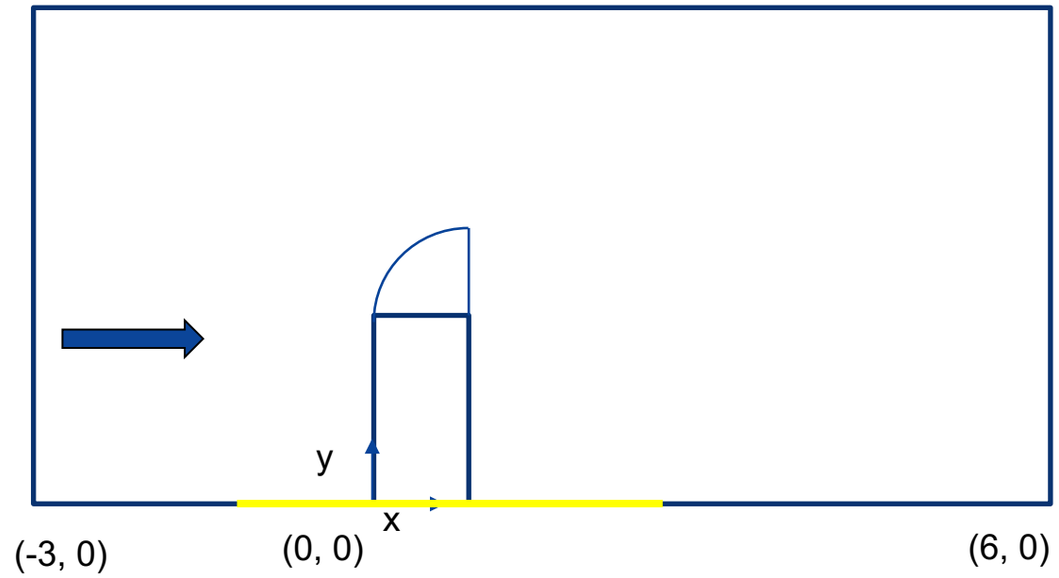
Courtesy ZJ.Wang

Q-criterion + Schlieren Movie

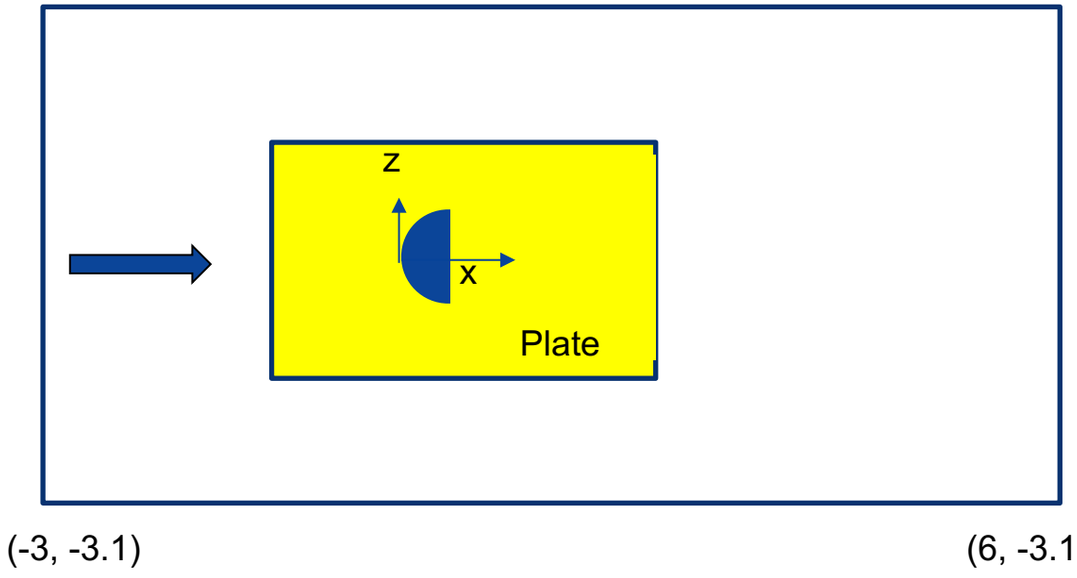


Demonstration Problem– Generic Car Mirror (CAA)

Side View



Top View

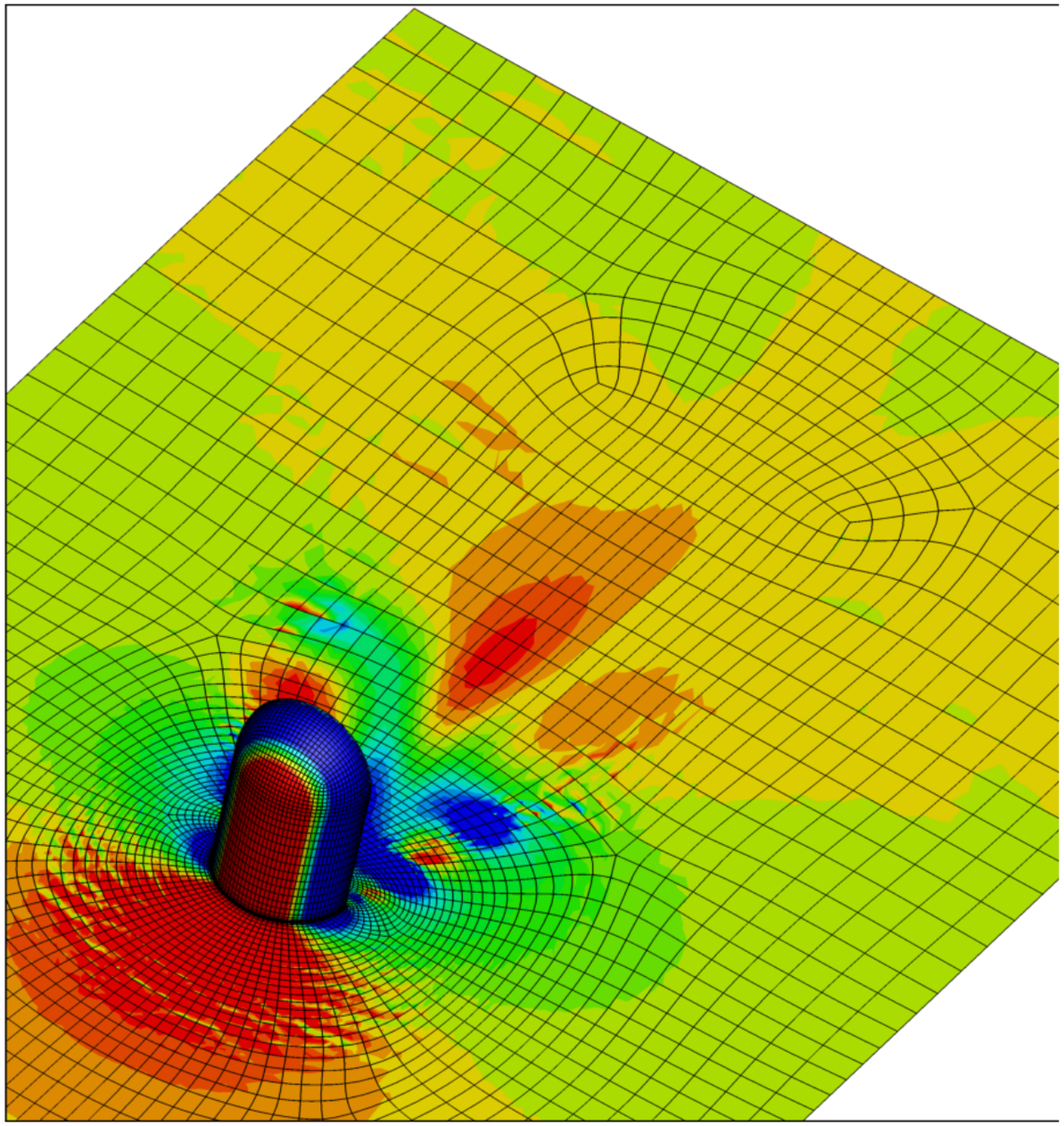


Diameter of the cylinder and sphere D = 0.2

Courtesy ZJ.Wang

Generic Car Mirror (cont.)

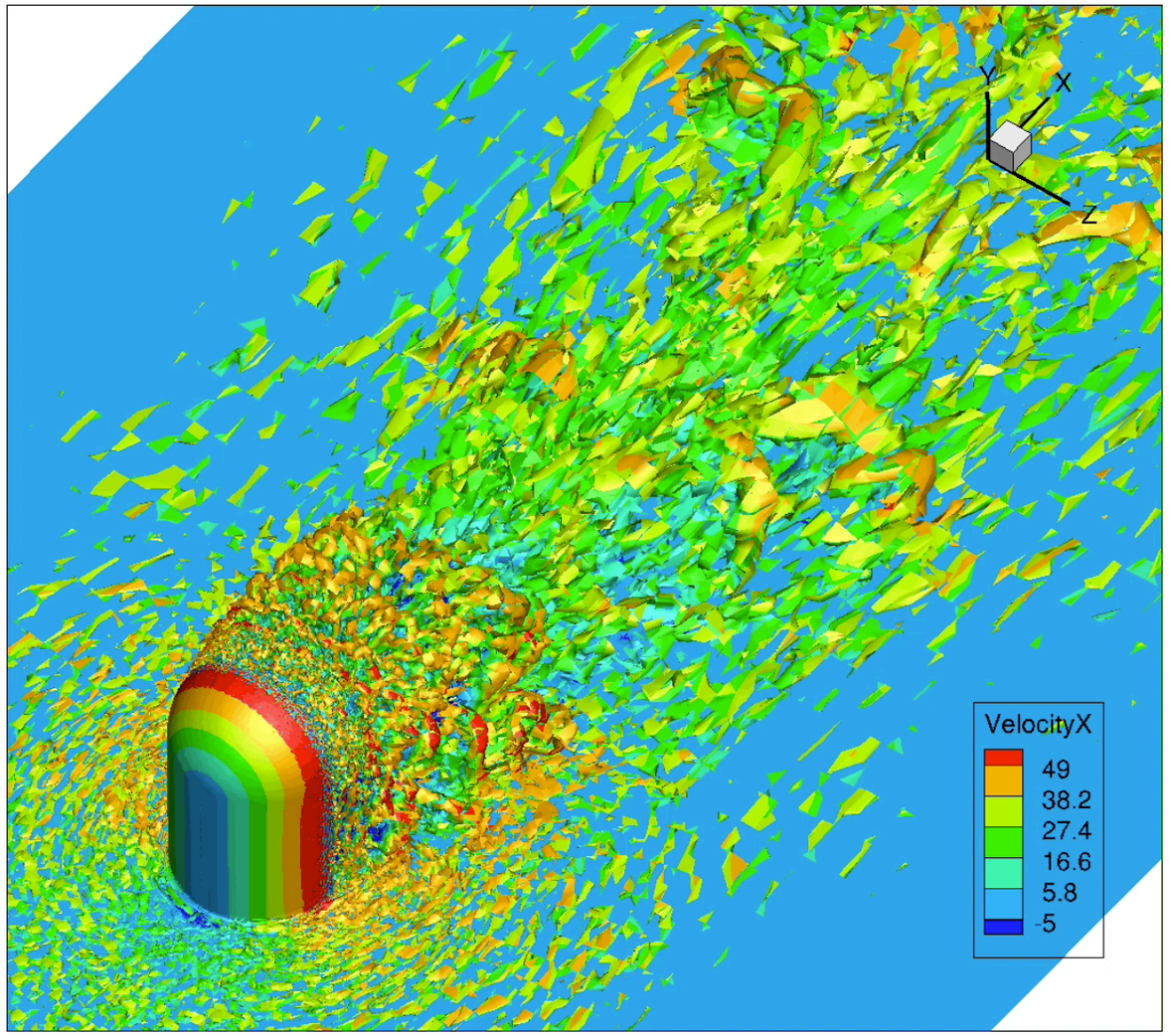
- A well known benchmark
  - M = 0.11, Re_D = 5.2x10^5
  - Experimental data available for comparison
- A high-order P2 mesh was successfully generated by GridPro
  - All hex mesh with 284,224 cells
- Simulation details
  - FR/CPR p1 and p2 simulations carried out with GMRES-BDF2
  - Wall-resolved ILES performed
  - ~710 cells/core (400 cores)

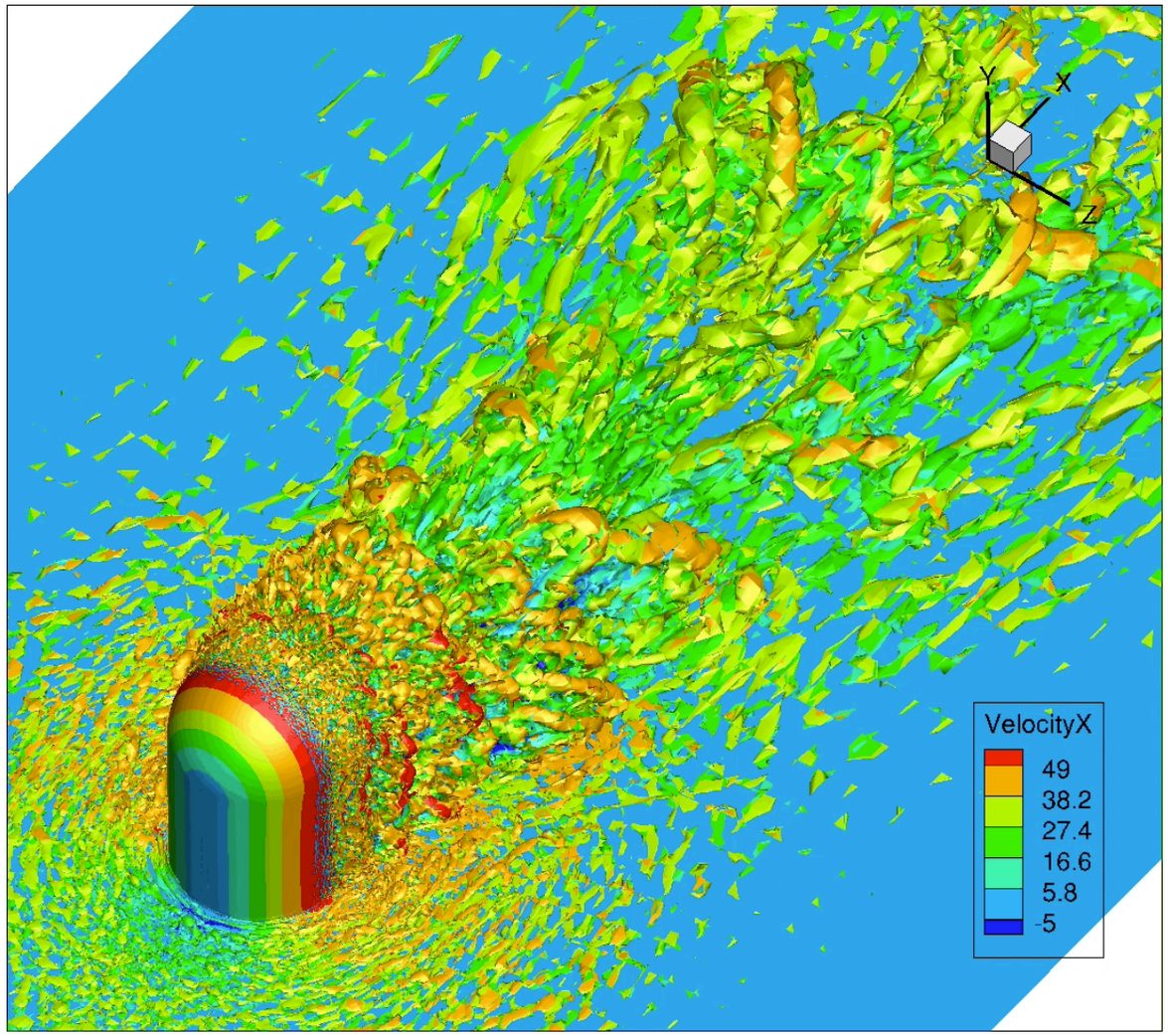


Courtesy ZJ.Wang

Q-Criteria Colored by Stream-wise Velocity

Hair-pin vortices clearly visible





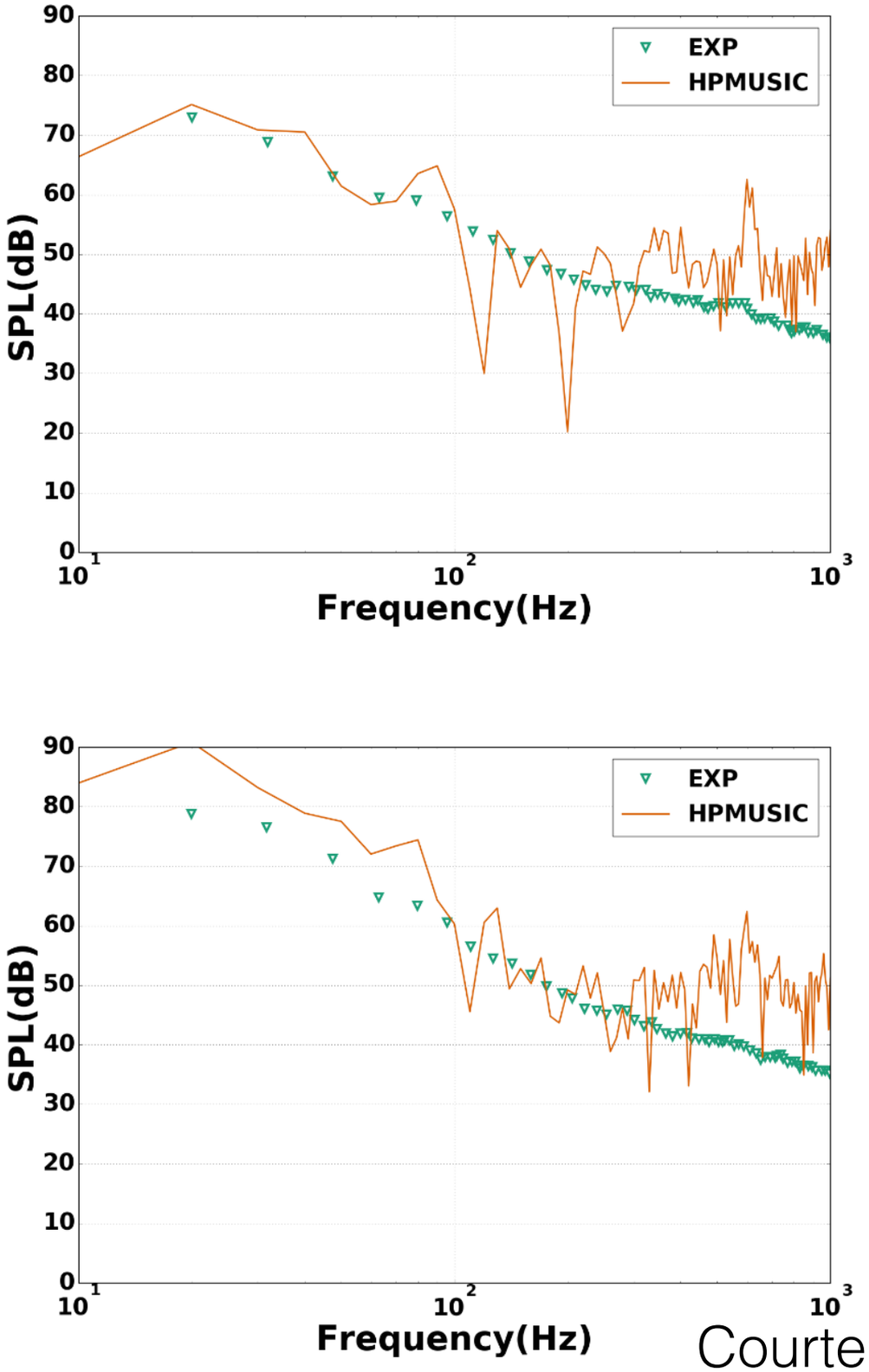
P2 – 3rd order
7.67M DOFs/equation

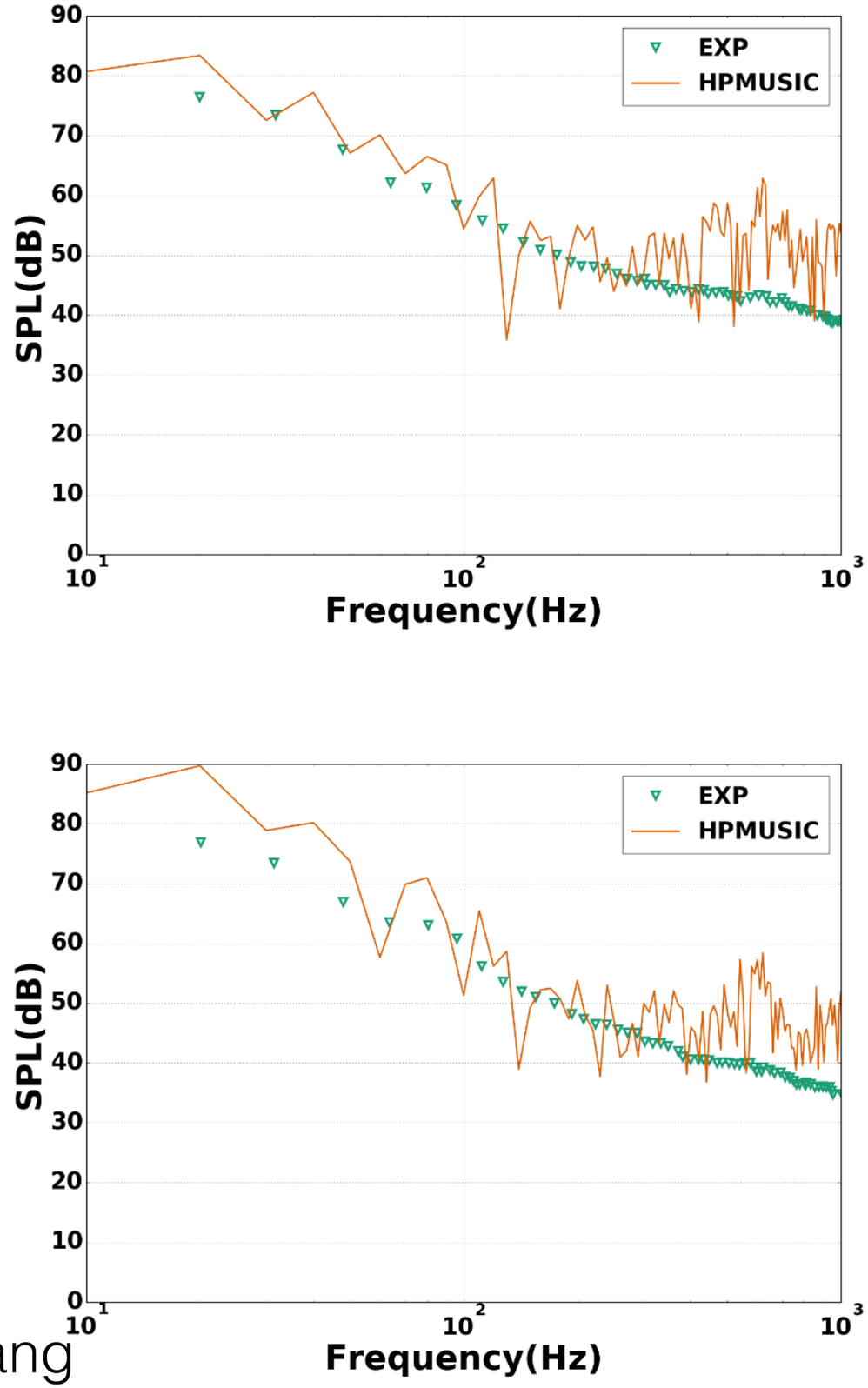
P3 – 4th order
18.2M DOFs/equation

Courtesy ZJ.Wang

GridPro

Comparison with Experimental Data

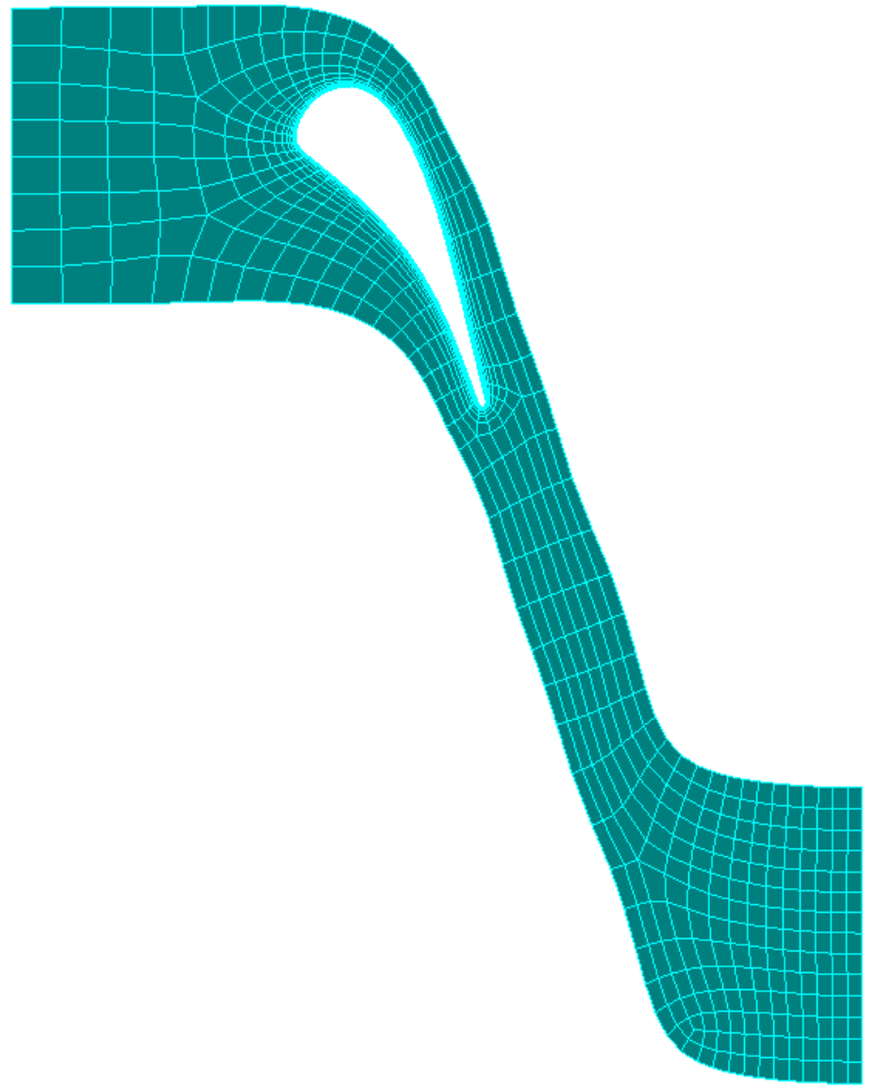




Courtesy ZJ.Wang

GridPro

- Challenges:
- Tension between Cell Thickness, Curvature, and Foot Print



Thank you!

Questions?