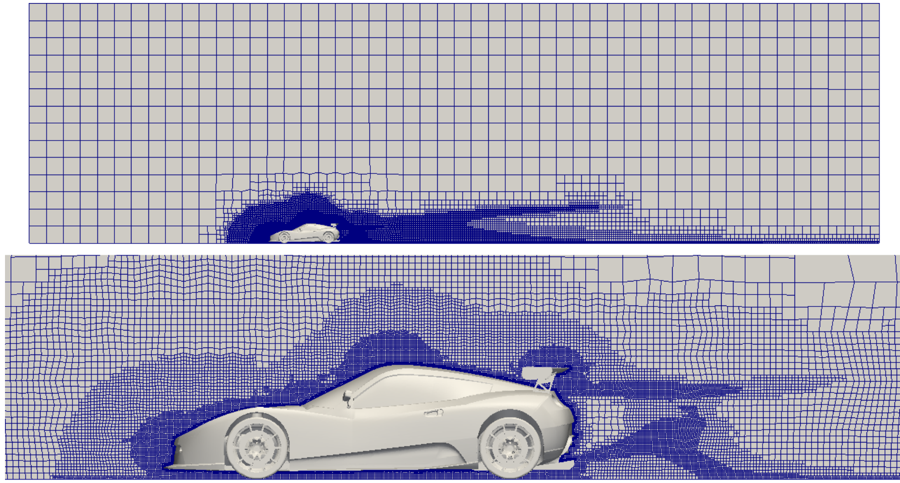
ADAPTIVE MESH REFINEMENT IN AERODYNAMICS



GOFUN 2018

Braunschweig

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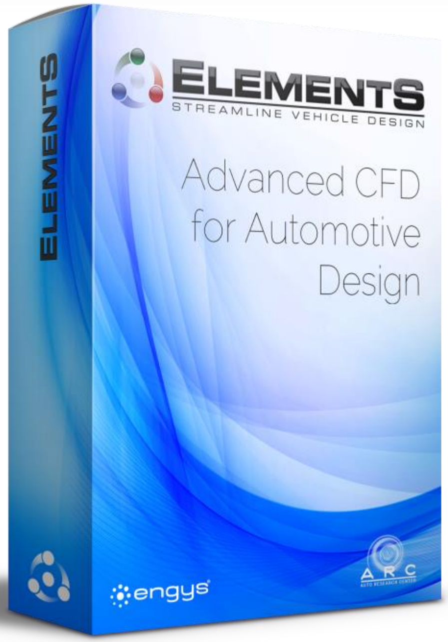
Content

- Introduction to Engys & HELYX
- Adaptive Mesh Refinement (AMR)
  - Motivation & Concept
  - Application to Aerodynamics
- Update on GIB

Introduction Engys

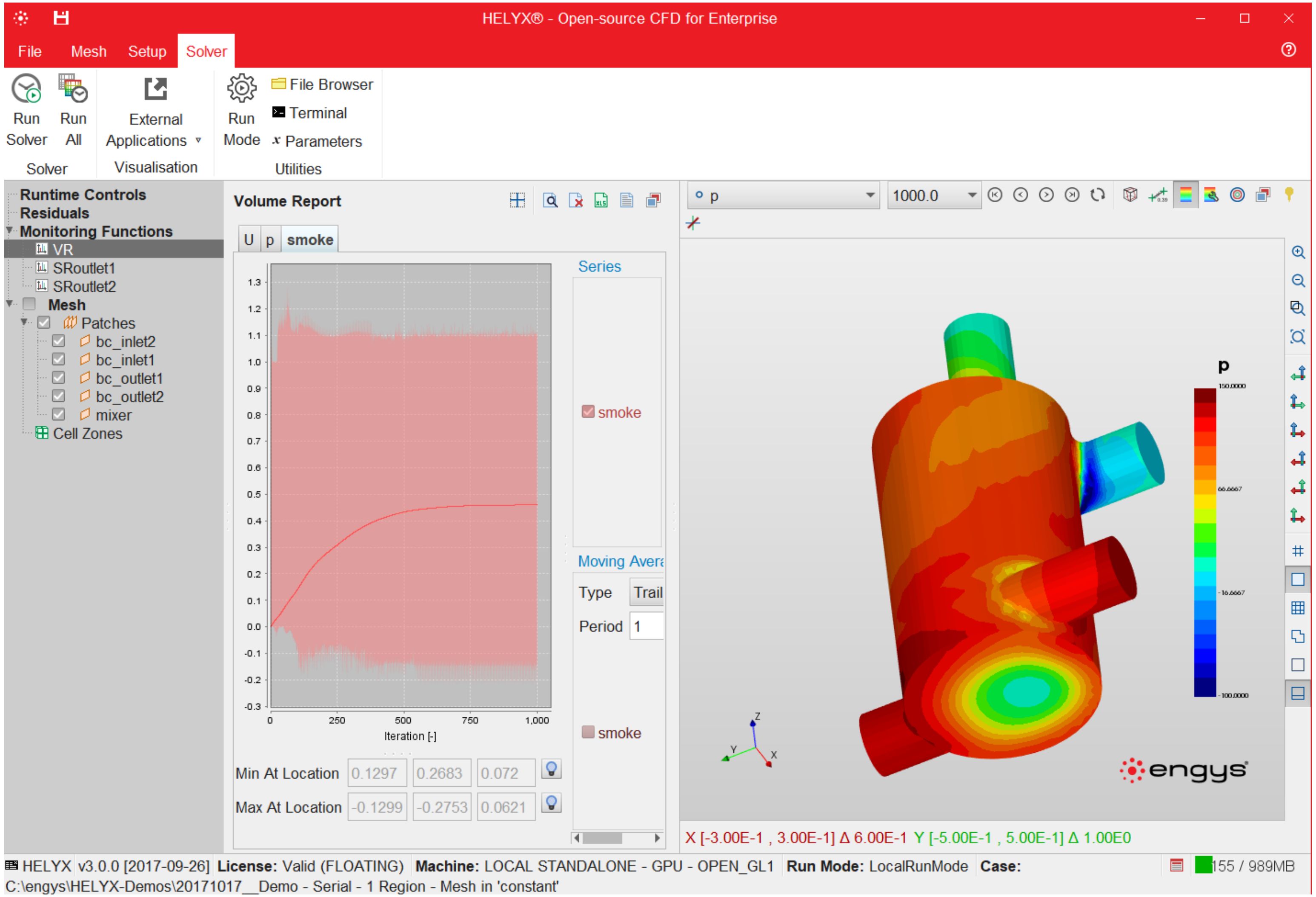
- Founded 2009
- ~20 Developers & Engineers
  - OpenFOAM experience since 1999
- Worldwide Presence

- CFD Consultancy
- Code Development
- CFD Product Provider
  - HELYX®
  - ELEMENTS



Introduction HELYX

- General Purpose CFD Product
  - Open Source Core
  - Modern GUI
  - Comprehensive Documentation
  - Unlimited User Support
  - Code Maintenance

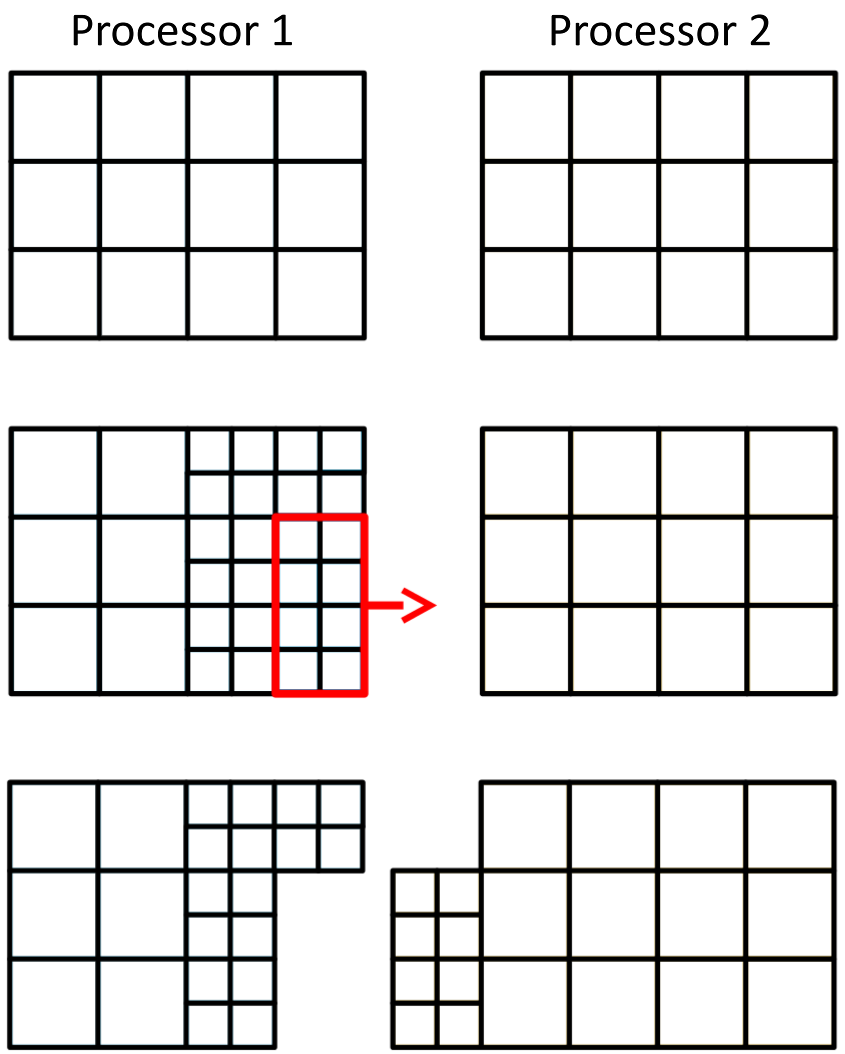


Adaptive Mesh Refinement (AMR)

- Work done by Daniel Deising (TU Darmstadt; Engys)
  PhD Thesis "Direct Numerical Simulation of Mass Transfer in Bubbly Flows"
- Dynamically refine & unrefine mesh based on criterias
- Criterias:
  - Gradients
  - Interfaces
  - Iso-values
- Improves accuracy by putting mesh where it is needed
- Potentially saves run time by creating "unexpected" coarse mesh regions

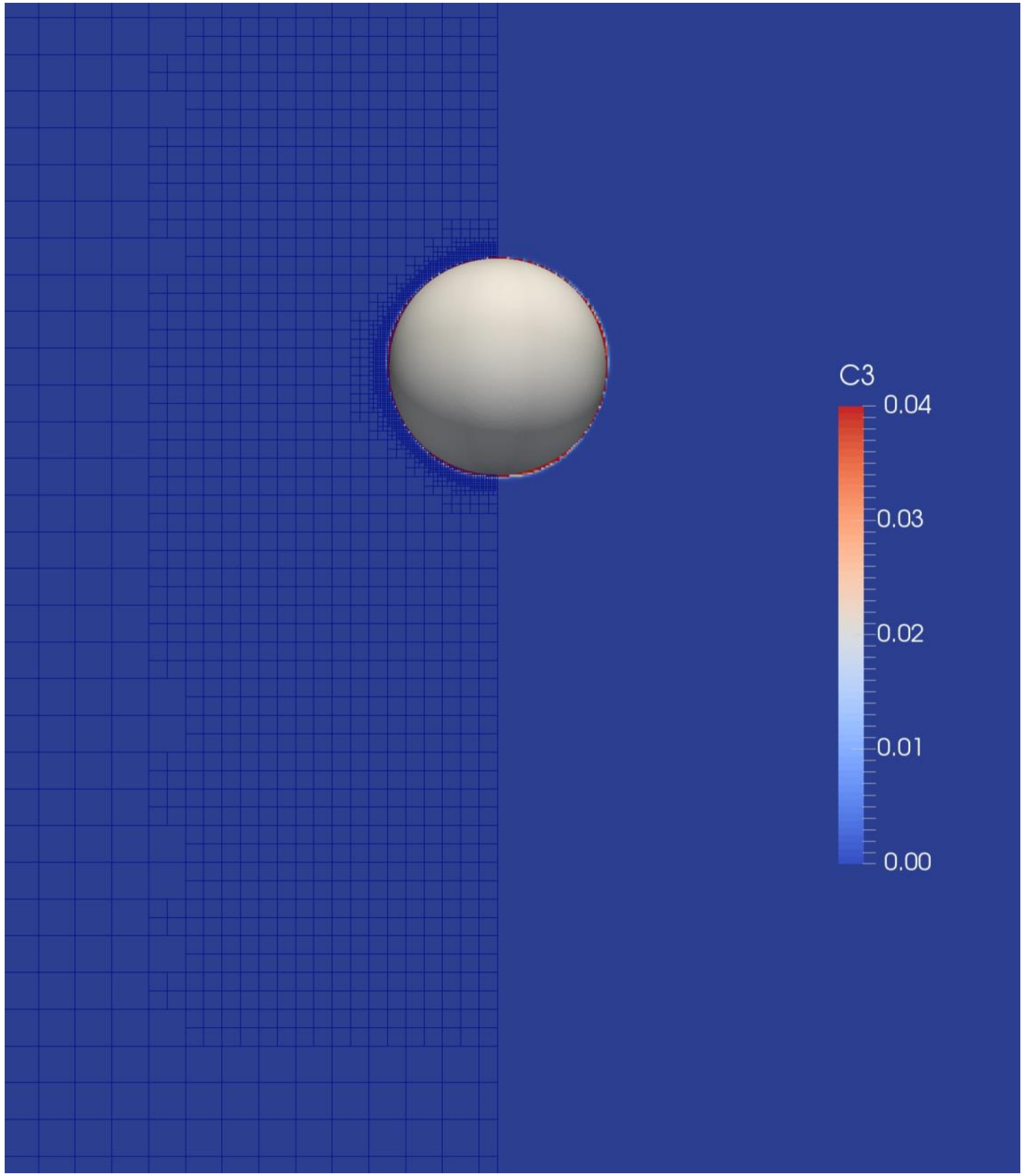
Load Balancing

- Check for parallel processor imbalance w.r.t. cell count
- Redistribute dynamically (for example after every mesh refinement loop)
- Hierarchical decomposition



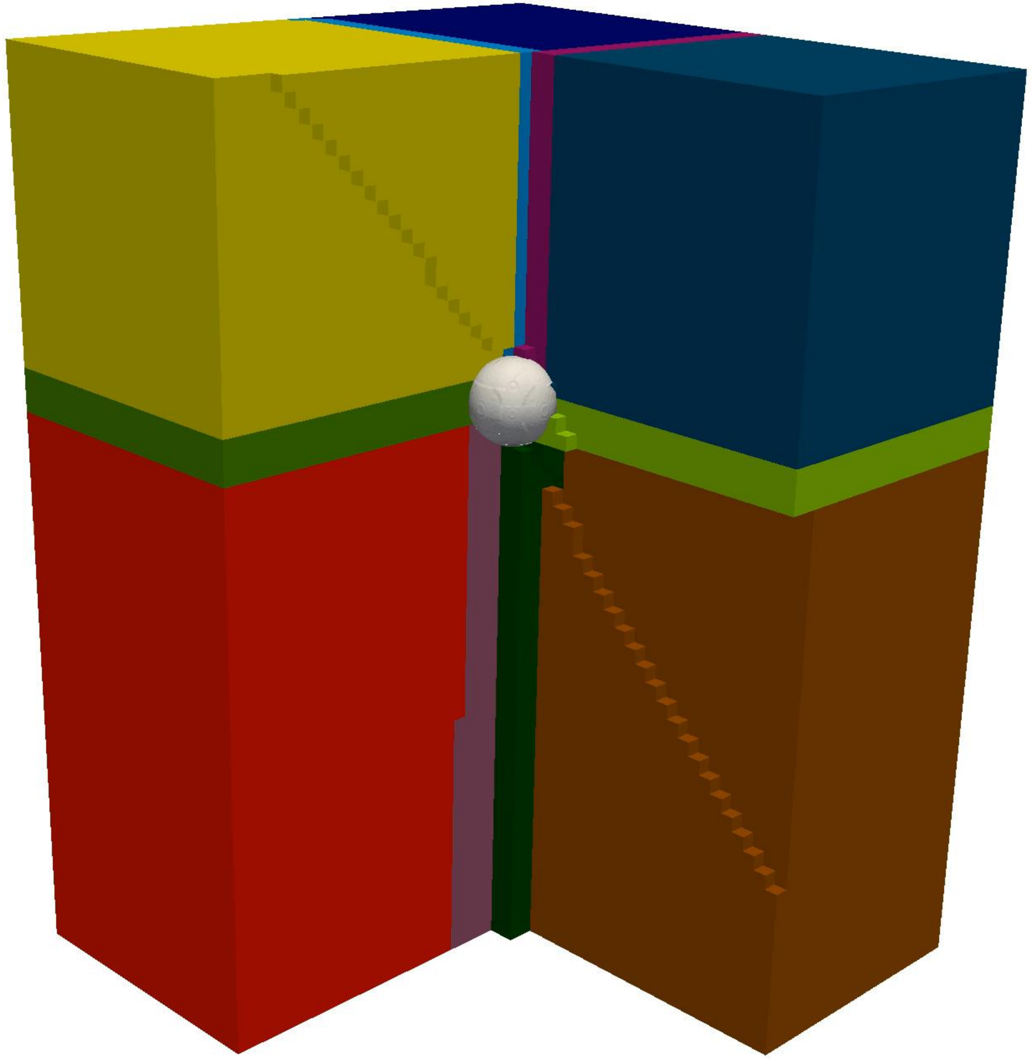
Example AMR

```
dynamicFvMesh dynamicRefineBalancedFvMesh;
refinementControls
{
enableRefinementControl true;
interface
(
alpha1 (2 5)
);
fields
(
alpha1 (0.01 1.1 3)
C1 (0.001 0.05 2)
);
gradients
(
alpha1 (0.01 2 2)
);
curls
(
U (100 1e+05 3)
);
regions
(
cylinderToCell
{
p1 (0.015 0.015 0.015);
p2 (0.015 0.033 0.015);
radius 0.006;
}
);
}
```



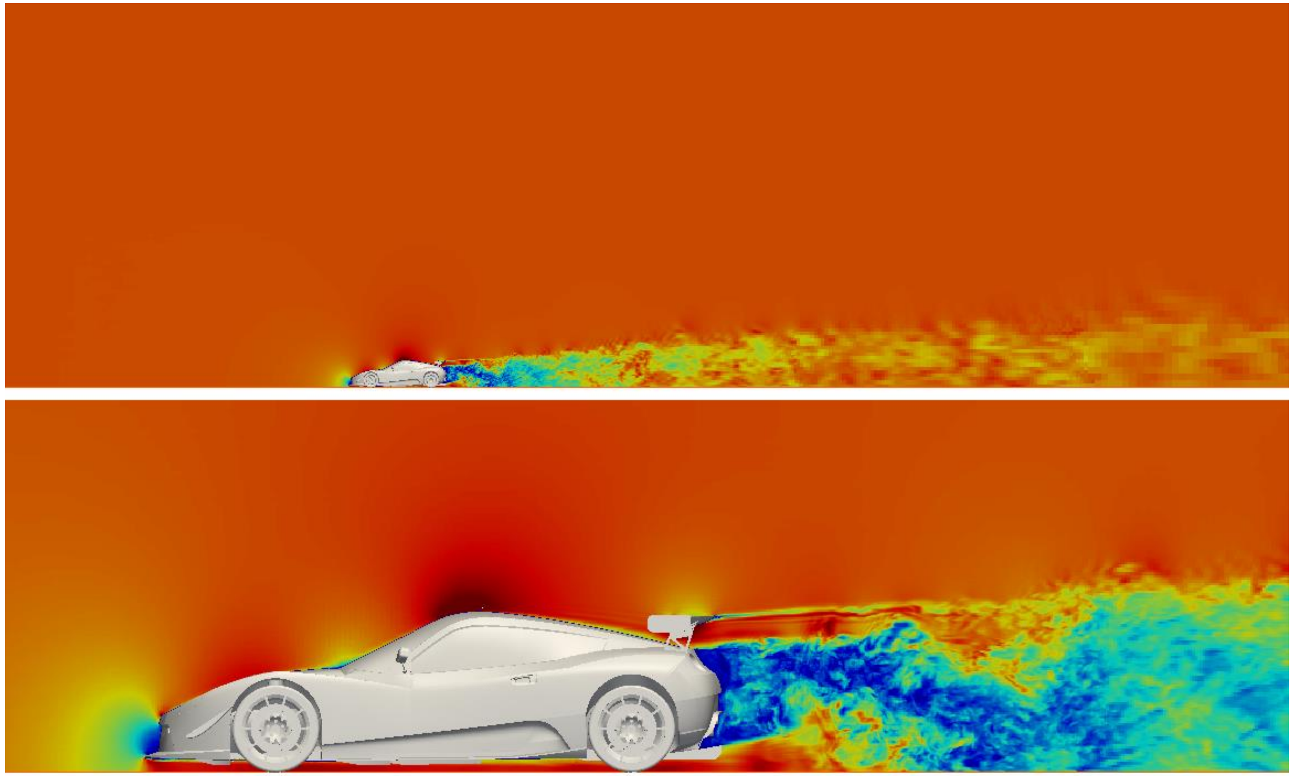
engys

Example Load Balancing

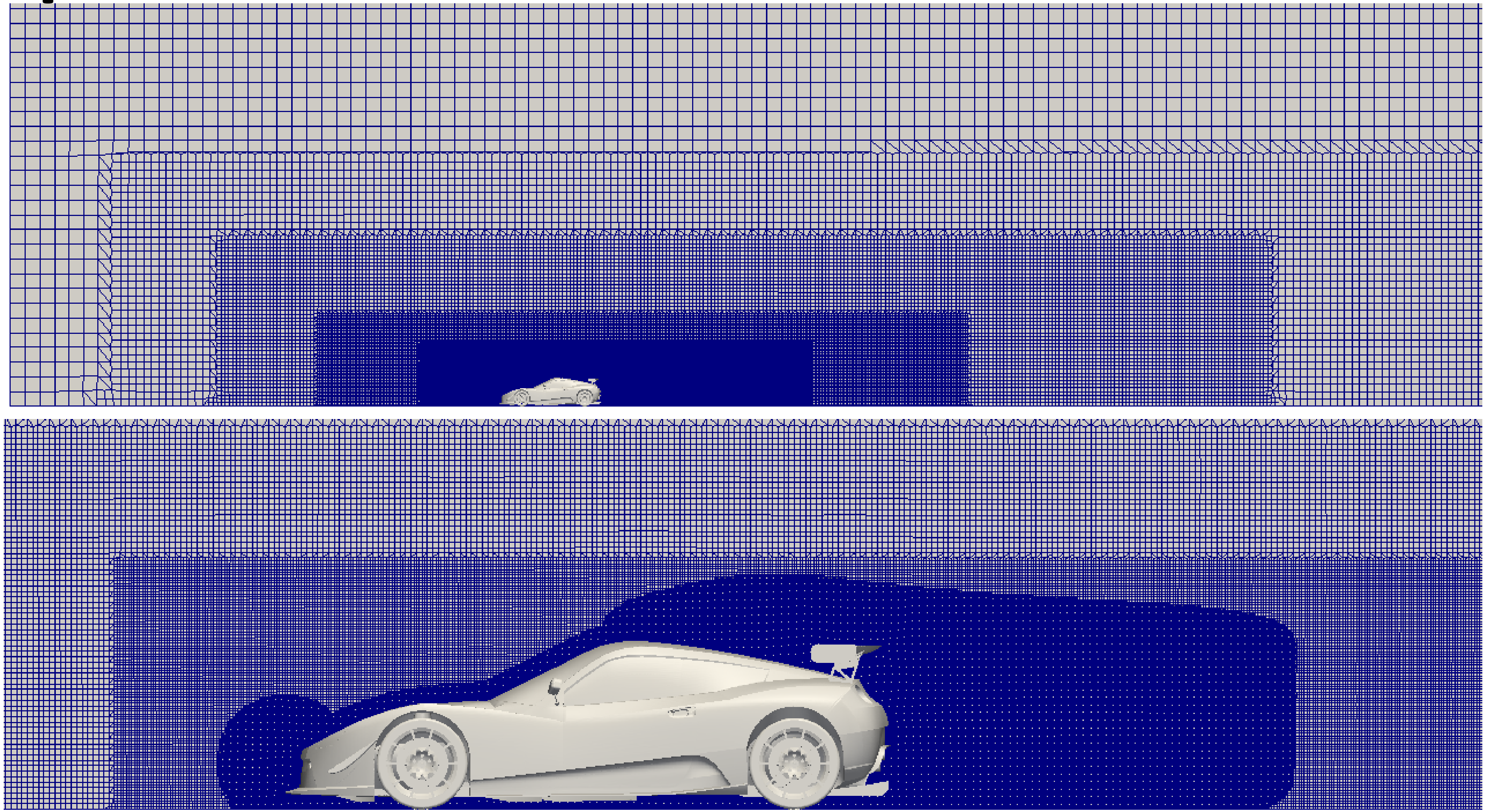


Automotive Aerodynamics

- Transient DDES simulation ~1-4seconds
- Detailed car geometries
- Typical mesh sizes up to 200M cells
- Typical 100-1000 parallel processors
- Turnaround times ~12-36hours



Example Mesh



Test Setup

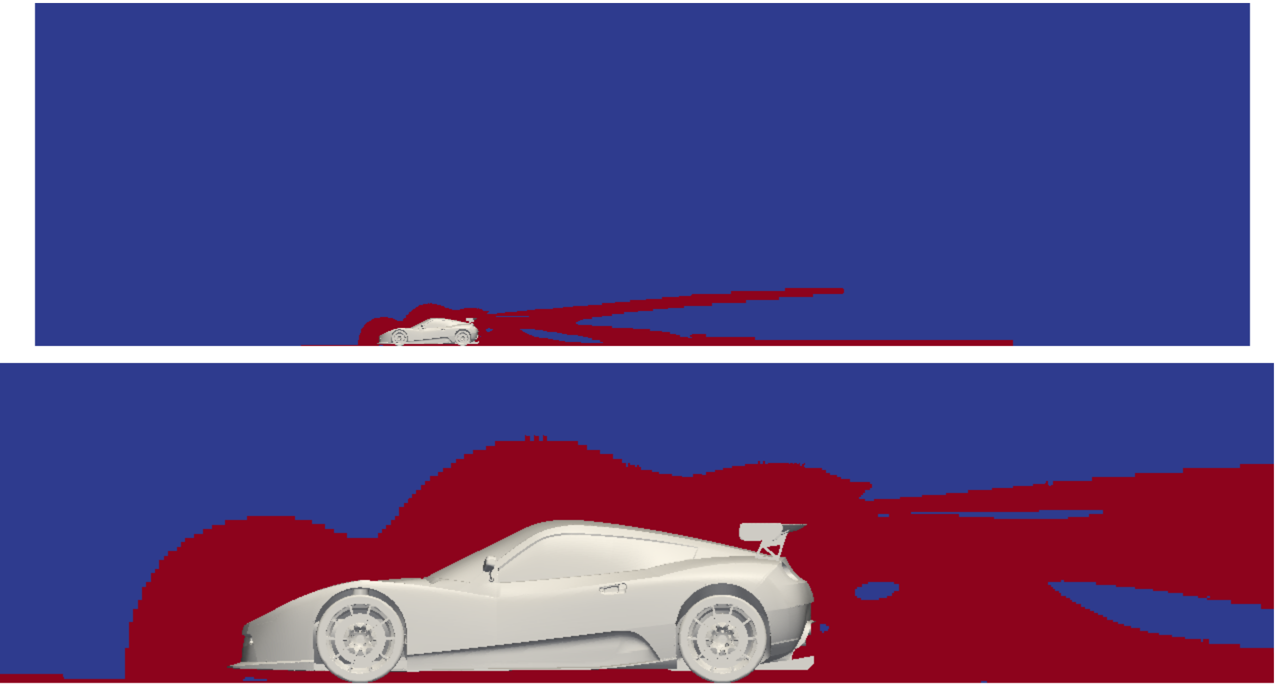
- ERA electric car in Nürburgring record configuration
- Steady state RANS
- 8mm surface cells (coarser than production cases, which are typically ~1-2mm) for faster turn around and testing
- Symmetrical half model
- 48 processors

Refinement Criteria

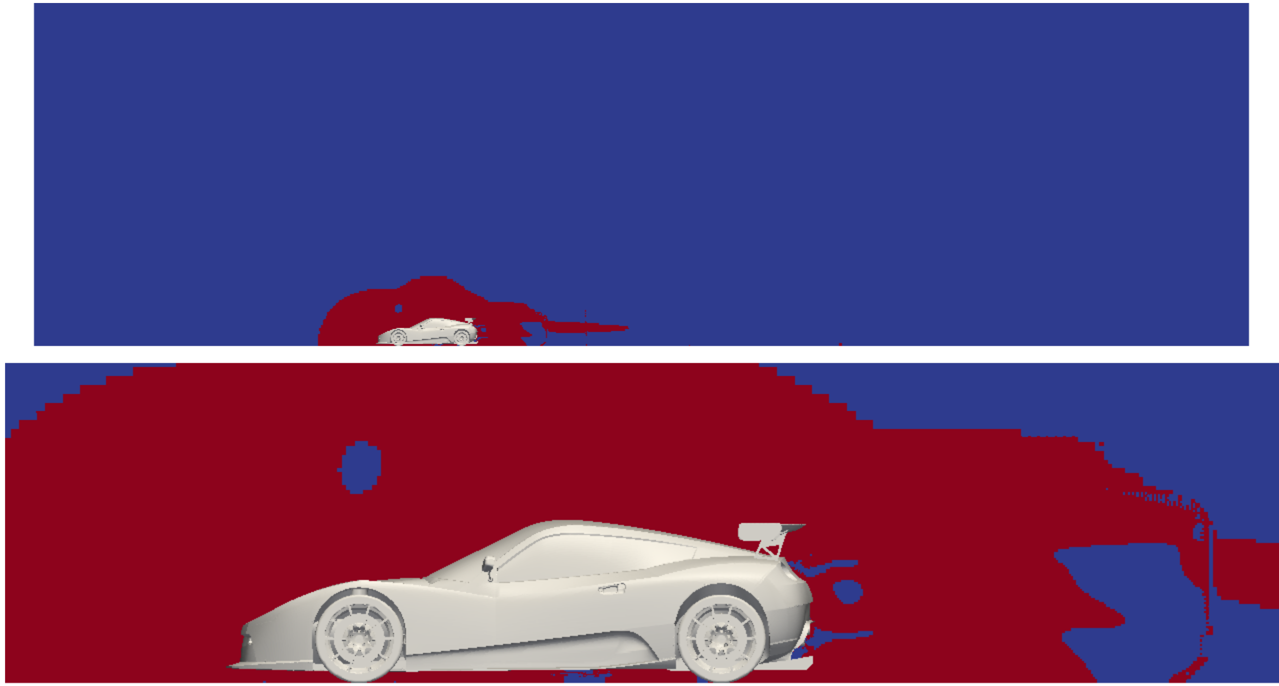
- Start refinement at iteration 300
- Refine every 20 iterations
- Velocity gradient
  - 10, 50, 100 [1/s]
- Pressure gradient
  - 30, 150, 600 [m/s^2]
- Values are chose “arbitrary” / engineering guess

Refinement Level 4 Gradients

gradU

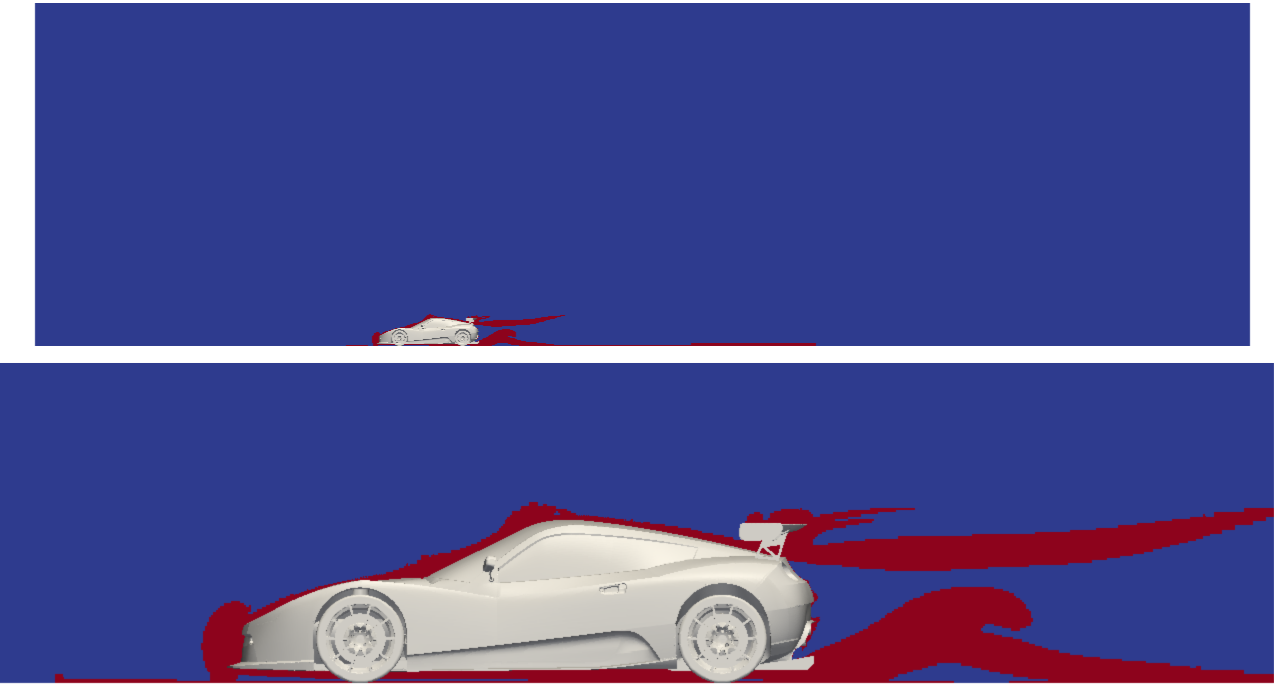


gradp

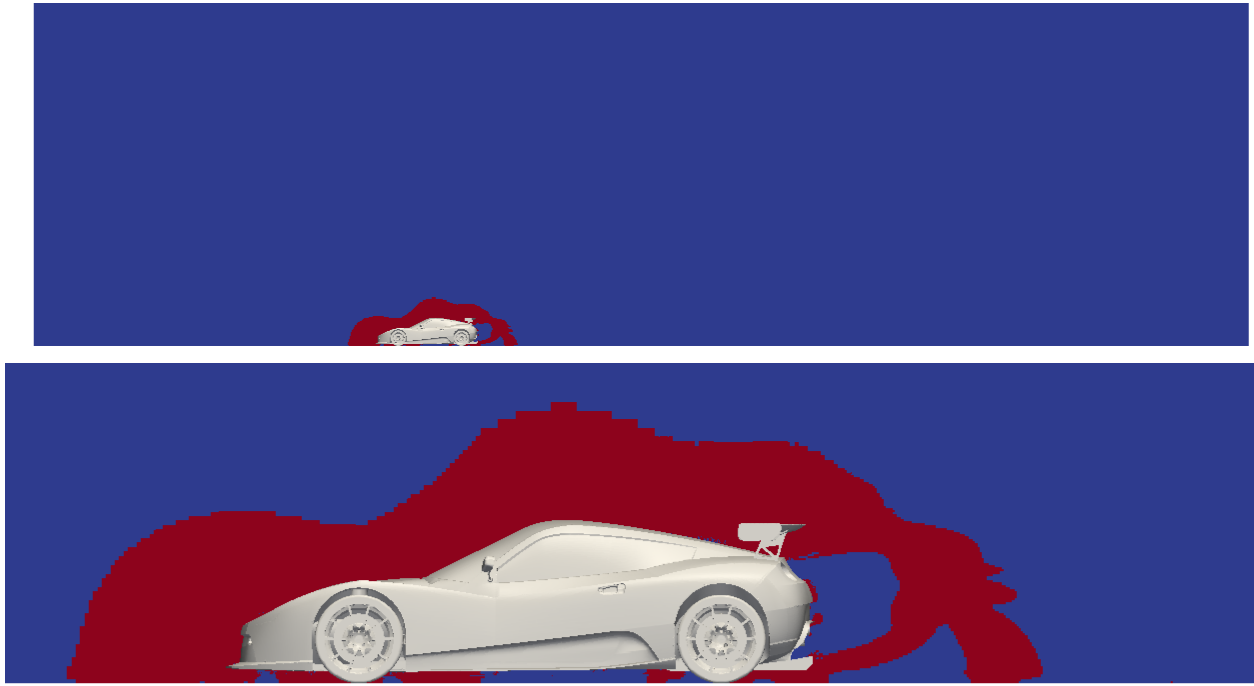


Refinement Level 5 Gradients

gradU

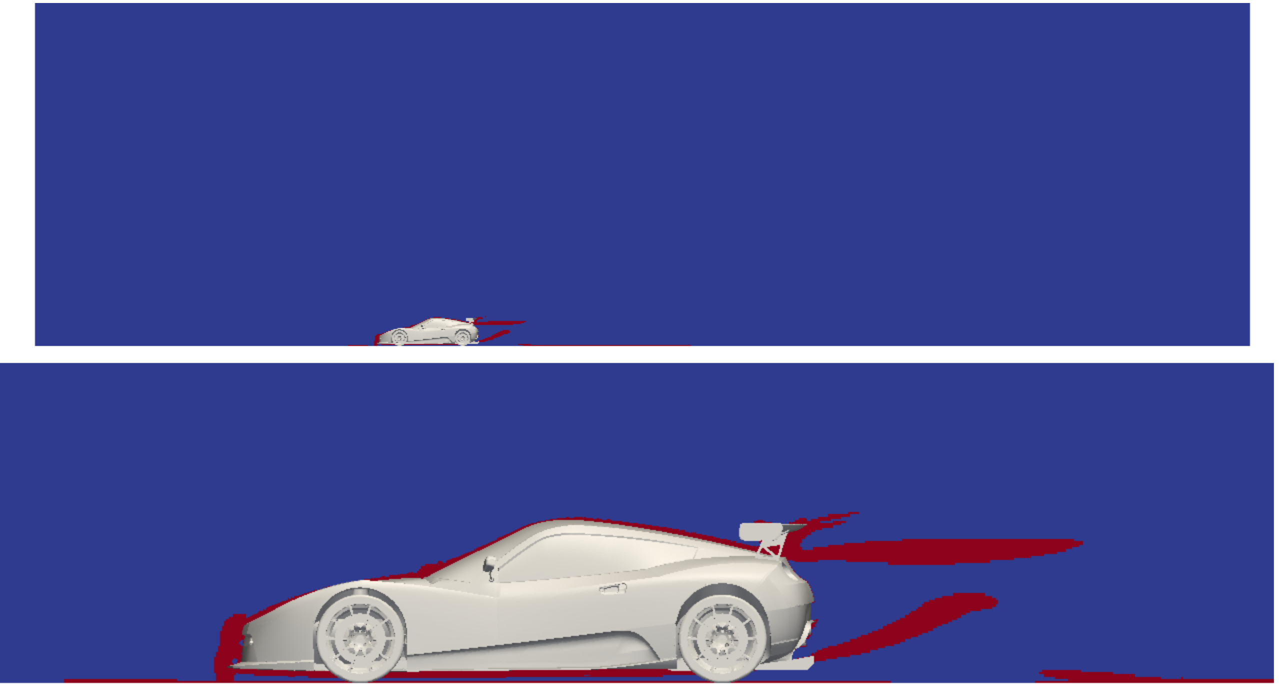


gradp

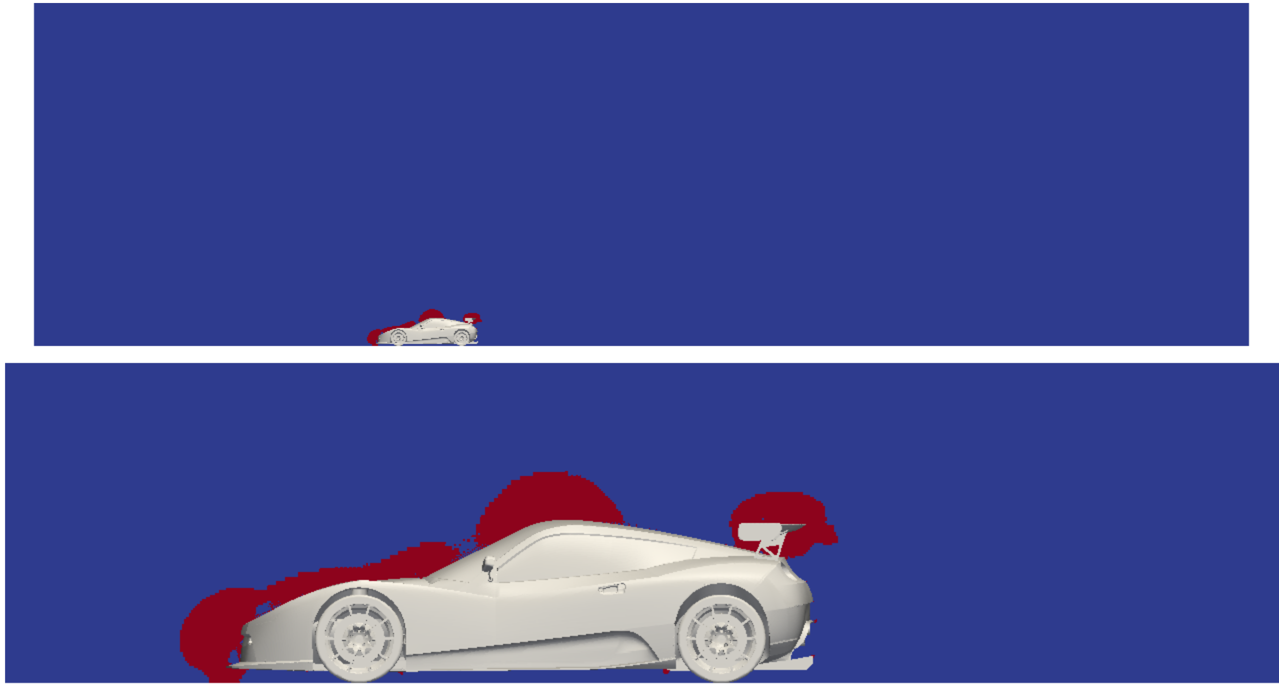


Refinement Level 6 Gradients

gradU

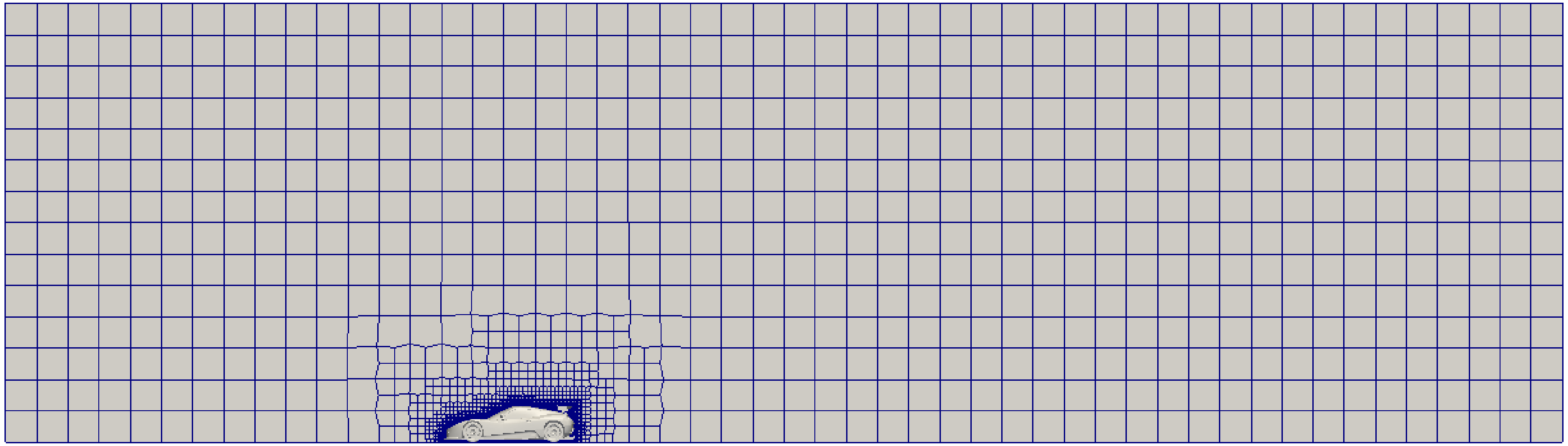


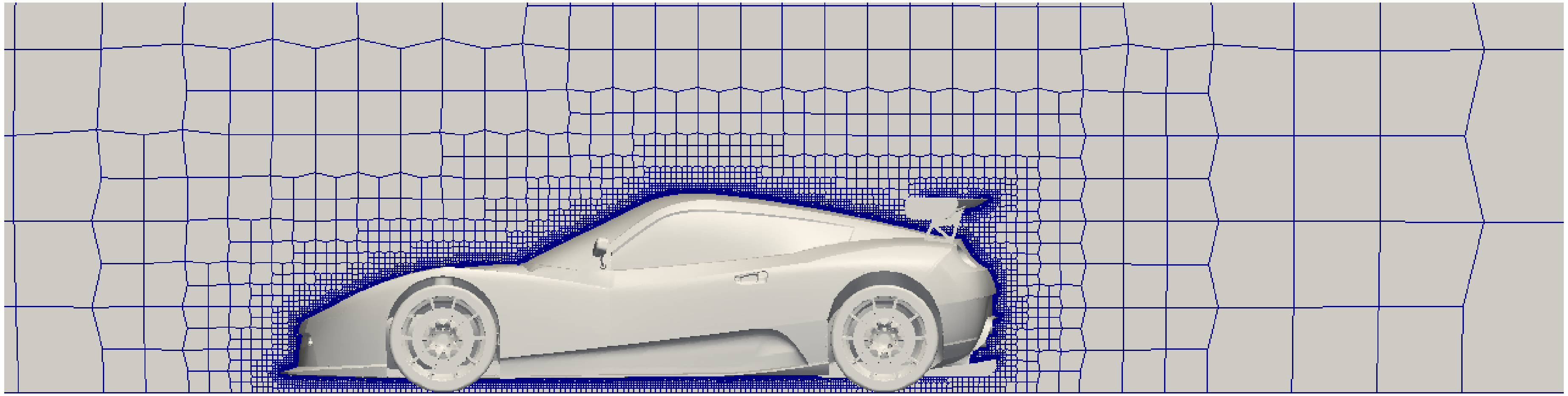
gradp



Initial Mesh (Surface Refinement Only)

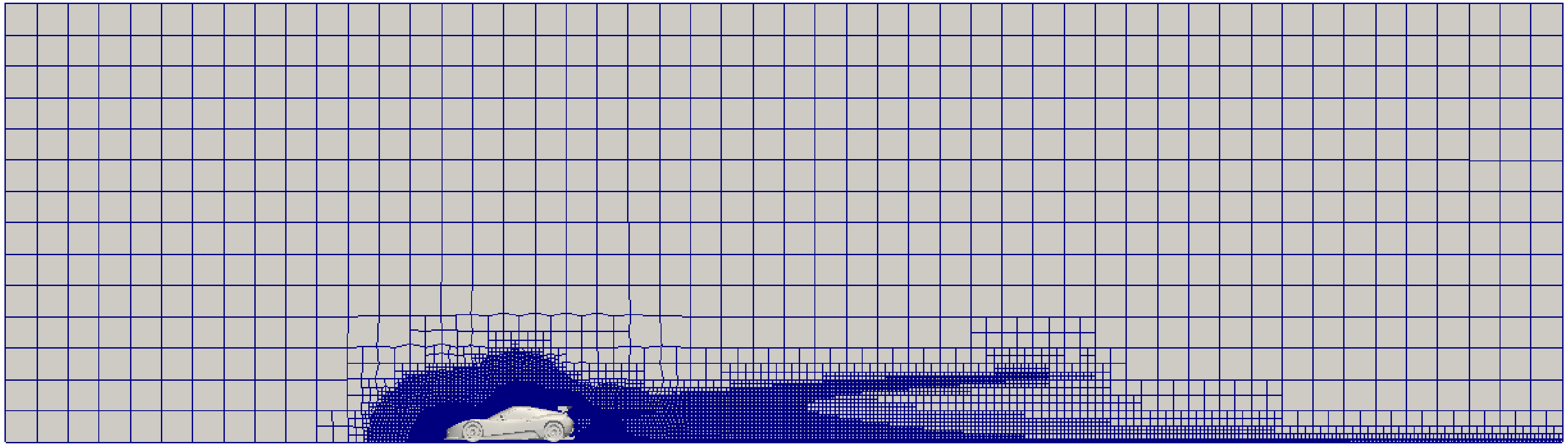
1.72M cells

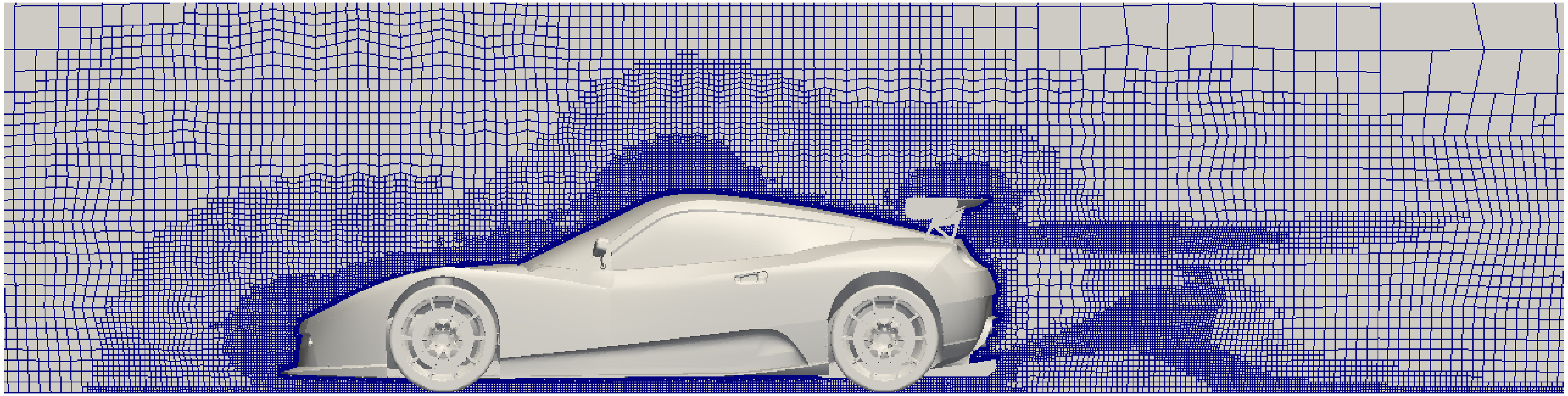




Final AMR mesh

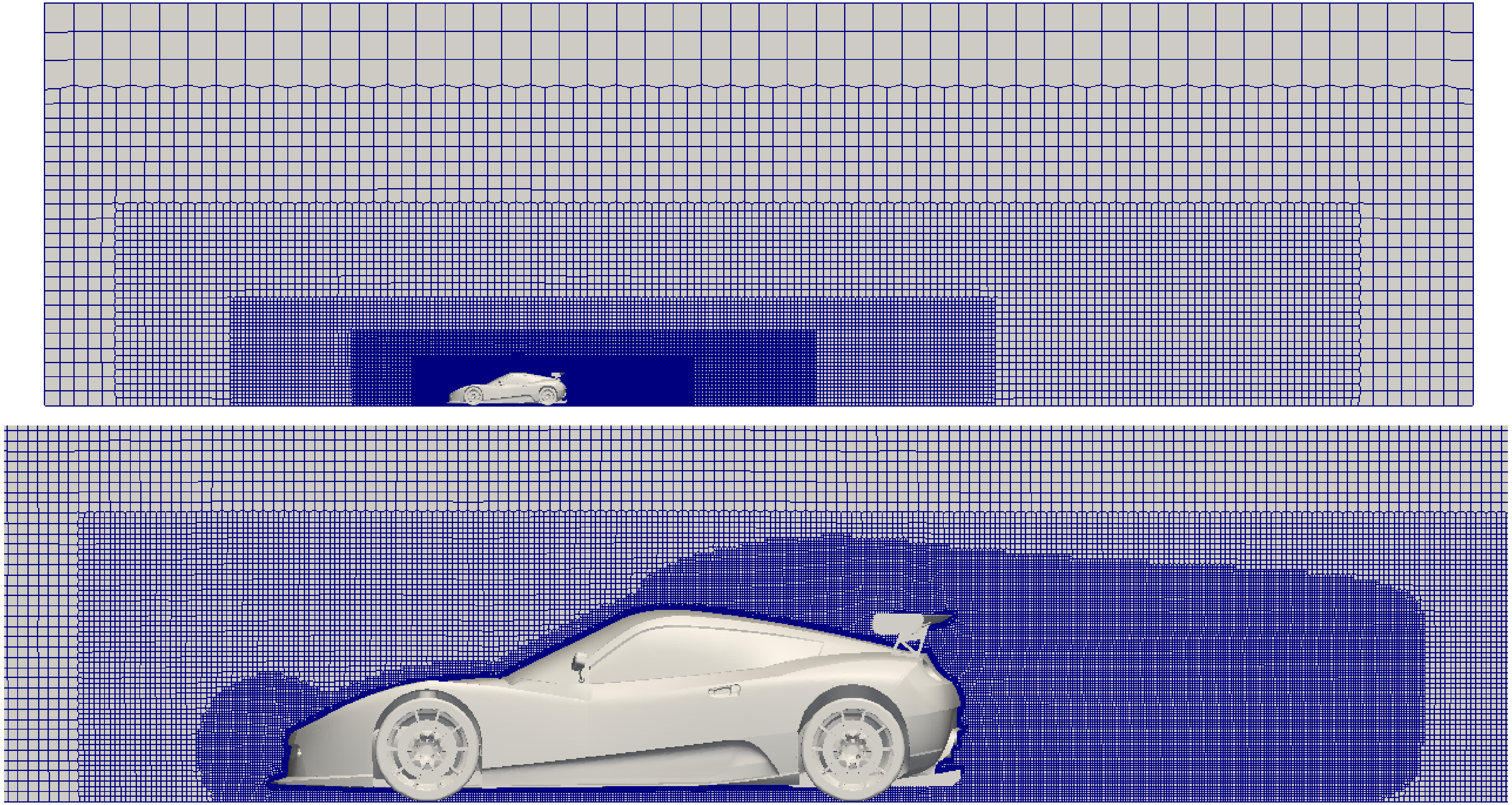
2.63M cells





Conventional Mesh

5.65M cells



Results

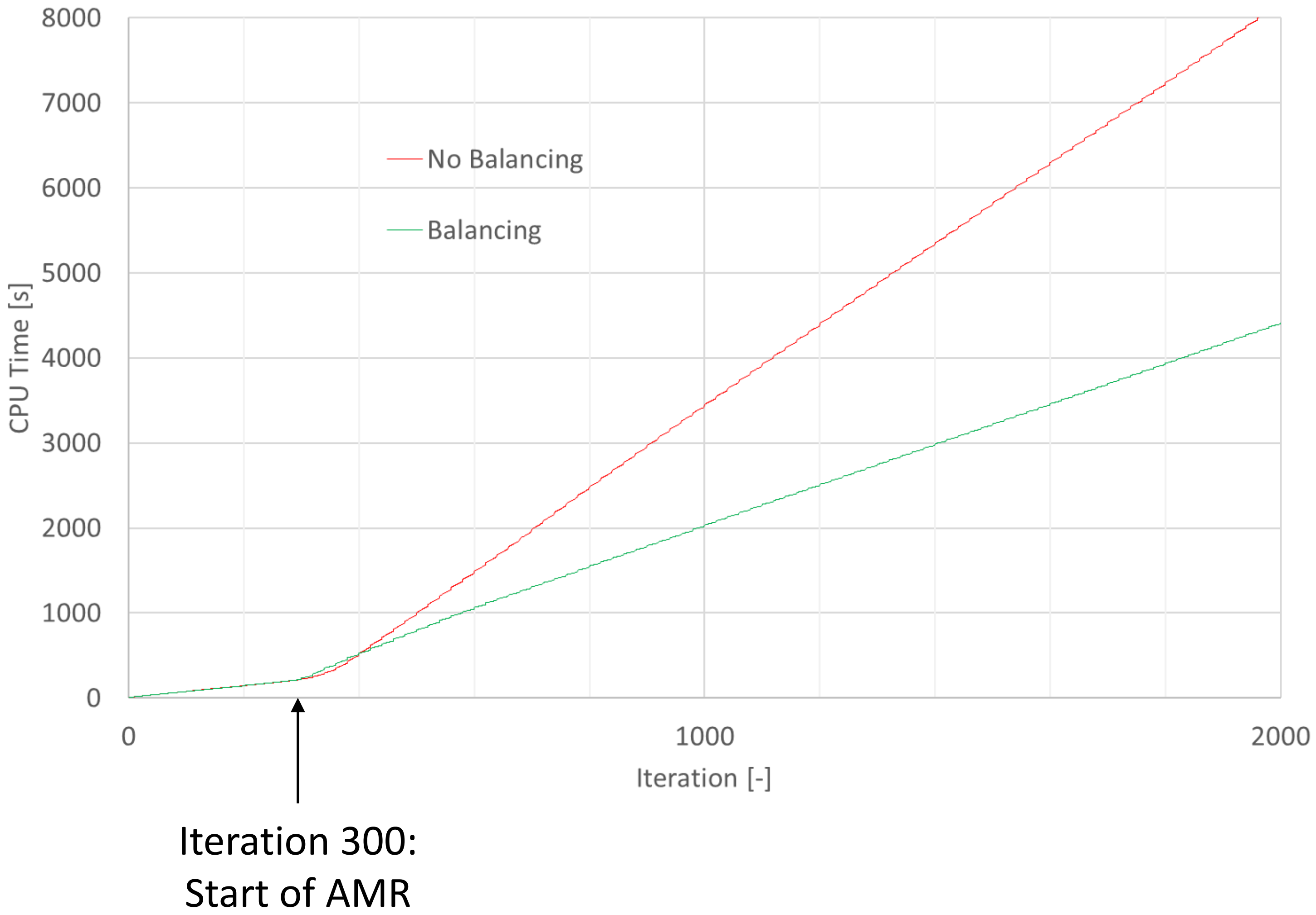
- Difference between final AMR mesh & conventional mesh

	Convential Mesh	AMR	Δ/c_{DconvM}
Drag	0.382	0.395	3.4%
Front lift	-0.070	-0.092	5.8%
Rear lift	-0.375	-0.335	10.5%

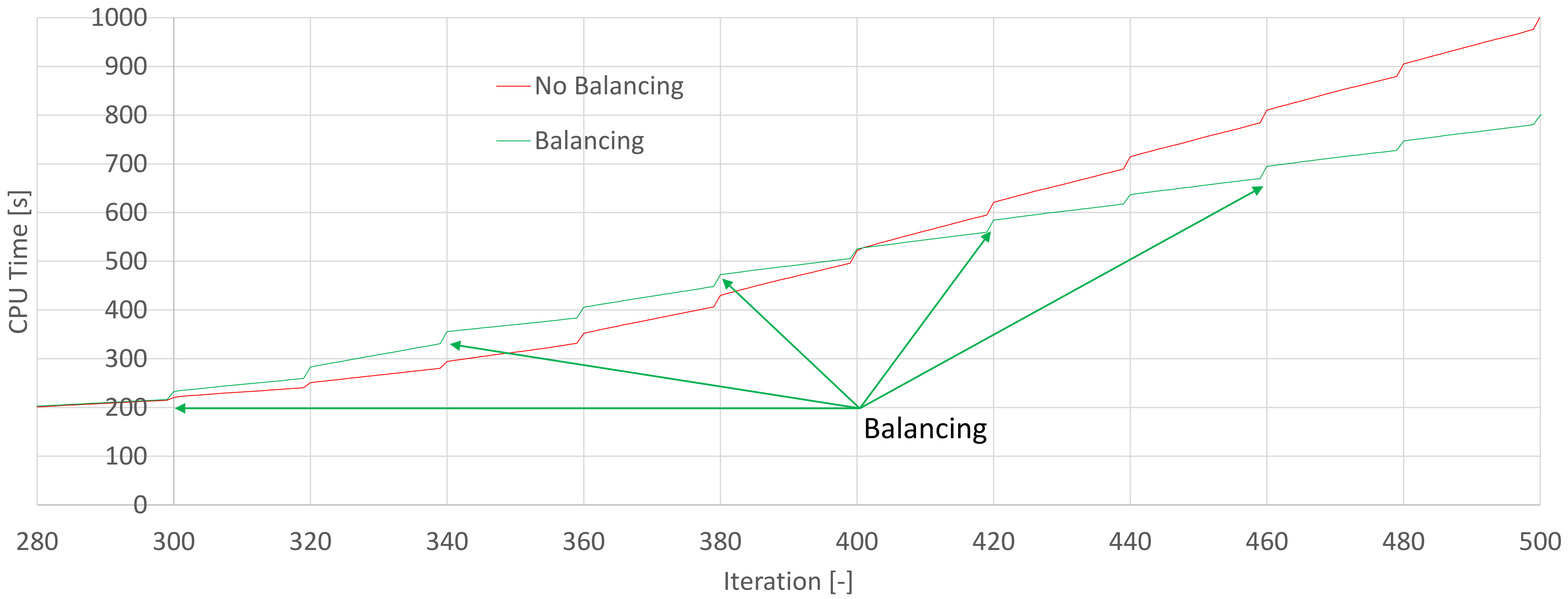
- Unclear yet, which mesh is more accurate
- Test with production cars where windtunnel data is available

Load Balancing

- Test Setup
- Run same AMR run with and without load balancing → compare run times
- Rebalance every 2 refinement loops
- ~50% speed up in this example



Load Balancing Zoom In



Next Steps

- Investigate which meshing strategy is more accurate
- Come up with DES AMR strategy (refinement criterias)

Thank You

- Contact us for more information
  info@engys.com

- Try HELYX-OS – freely available GUI for OpenFOAM
  http://engys.github.io/HELYX-OS/

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