
Visualization Case Studies



Arterial Blood Flow

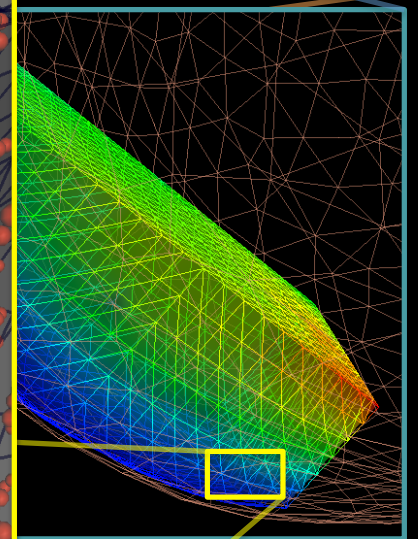
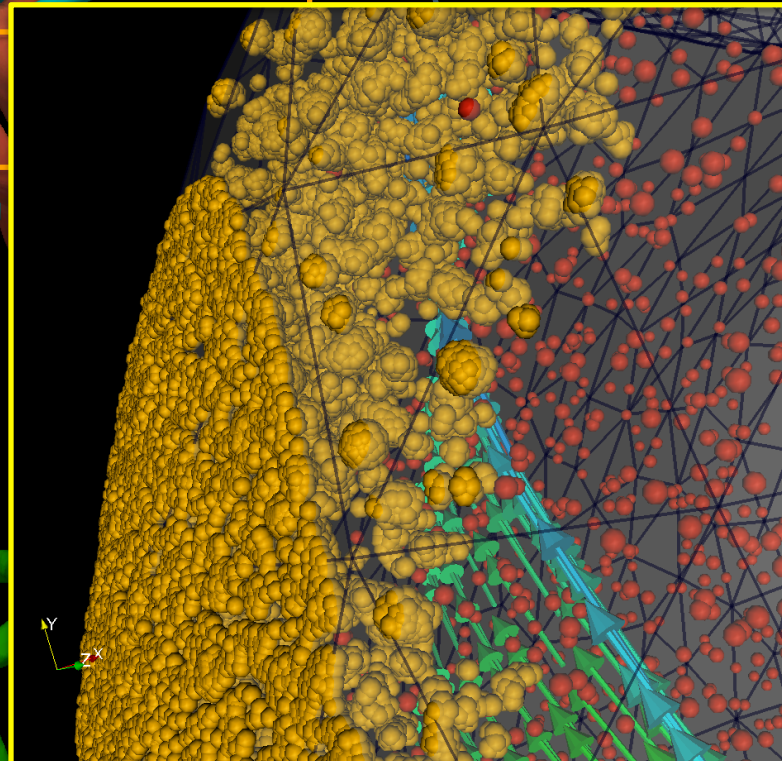
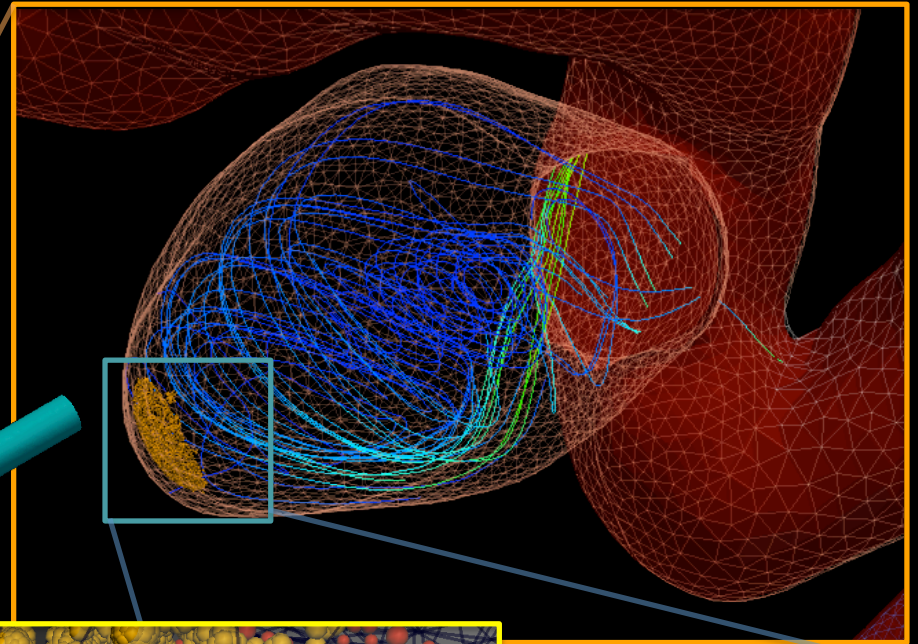
Anterior
Cerebral

Middle
Cerebral

Basilar

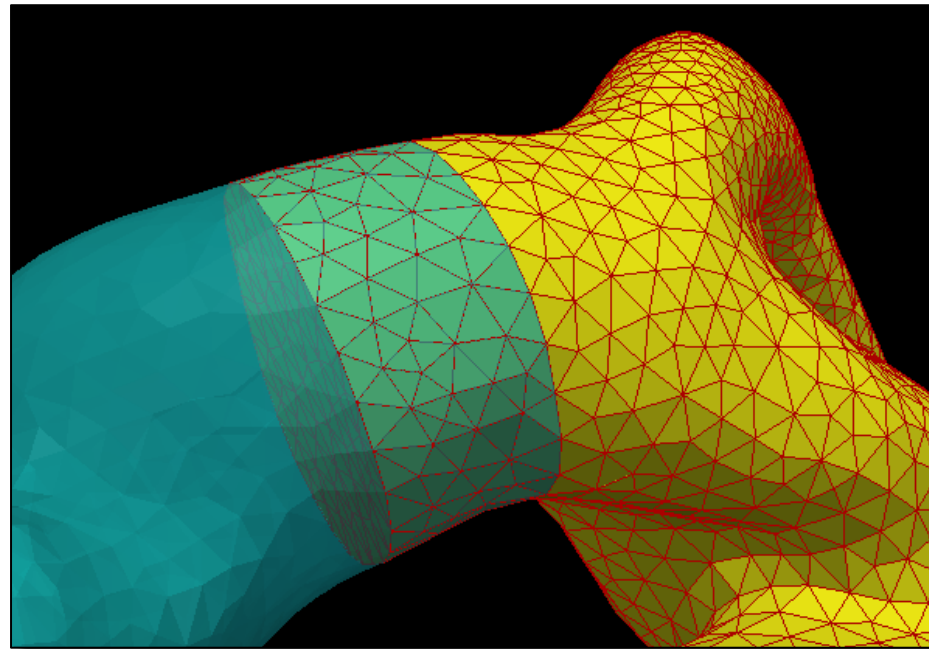
Left Interior
Carotid
Artery

Vertebral

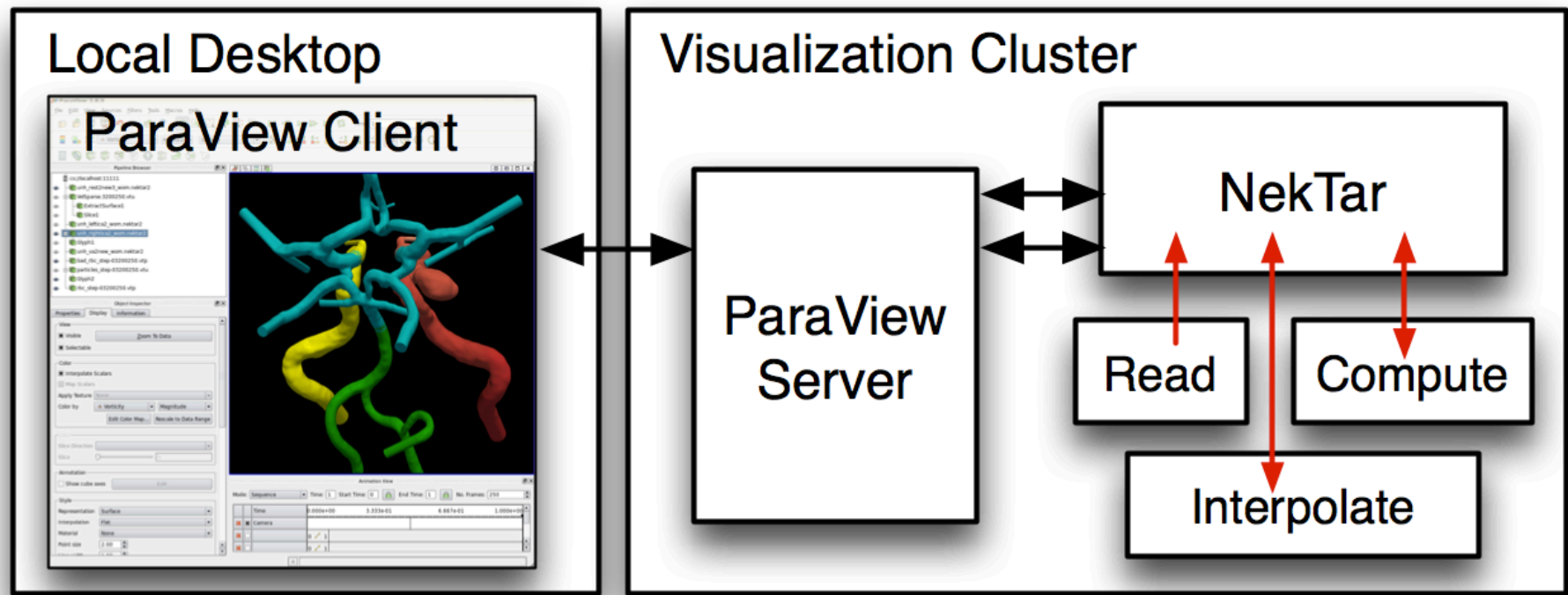


Macroscale Simulation (NekTar)

- ⊙ NekTar: Spectral/hp element method (SEM)
 - ⊙ Non-overlapping elements
 - ⊙ Multi-level approach
 - Domain decomposed into overlapping patches
- ⊙ NekTar Data
 - ⊙ Saved in Modal space
 - ⊙ Mesh (geometry)
 - ⊙ Solution data



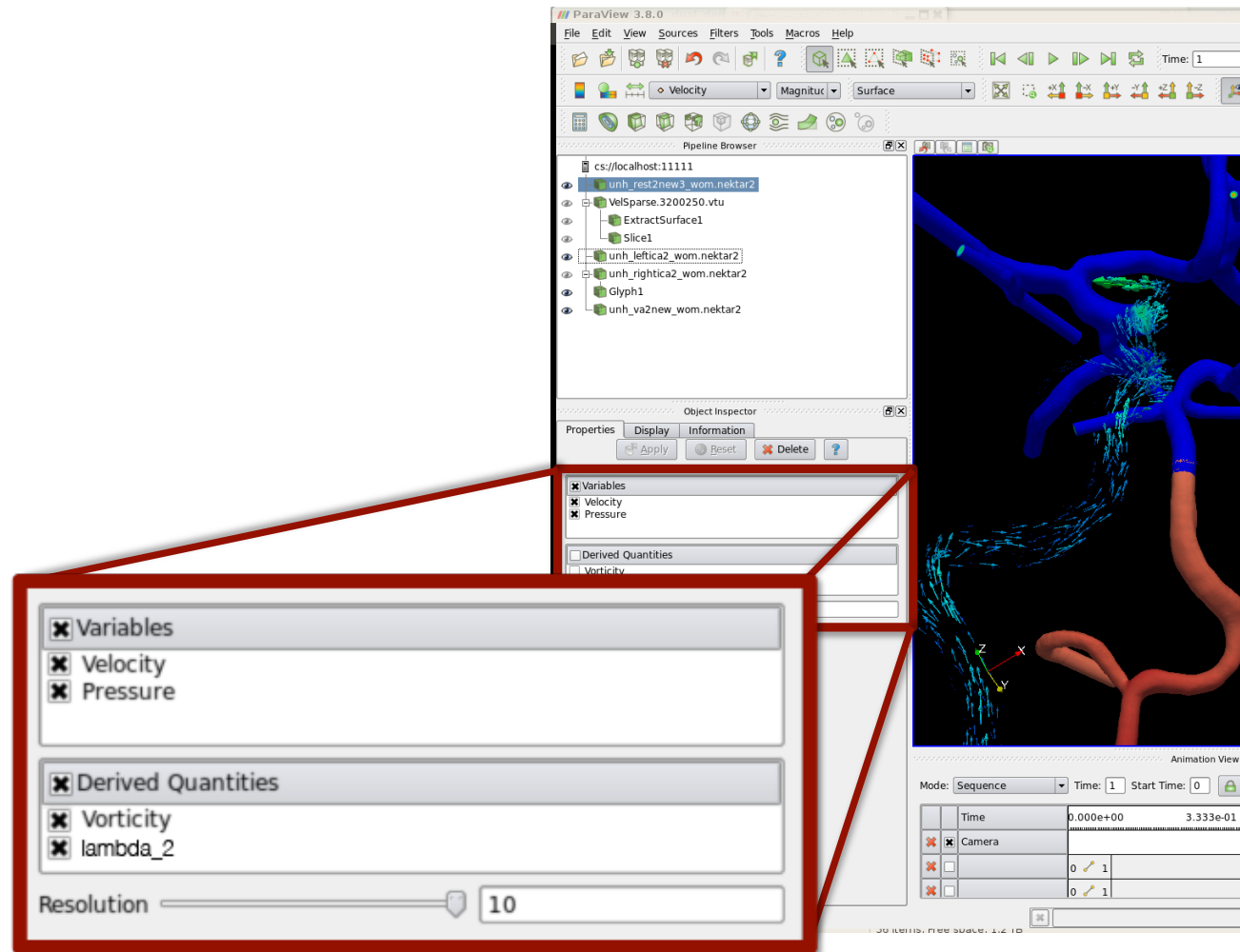
NekTar-ParaView Coupling



- ◉ NekTar for parallel I/O and computation
- ◉ ParaView for parallel visualization and rendering

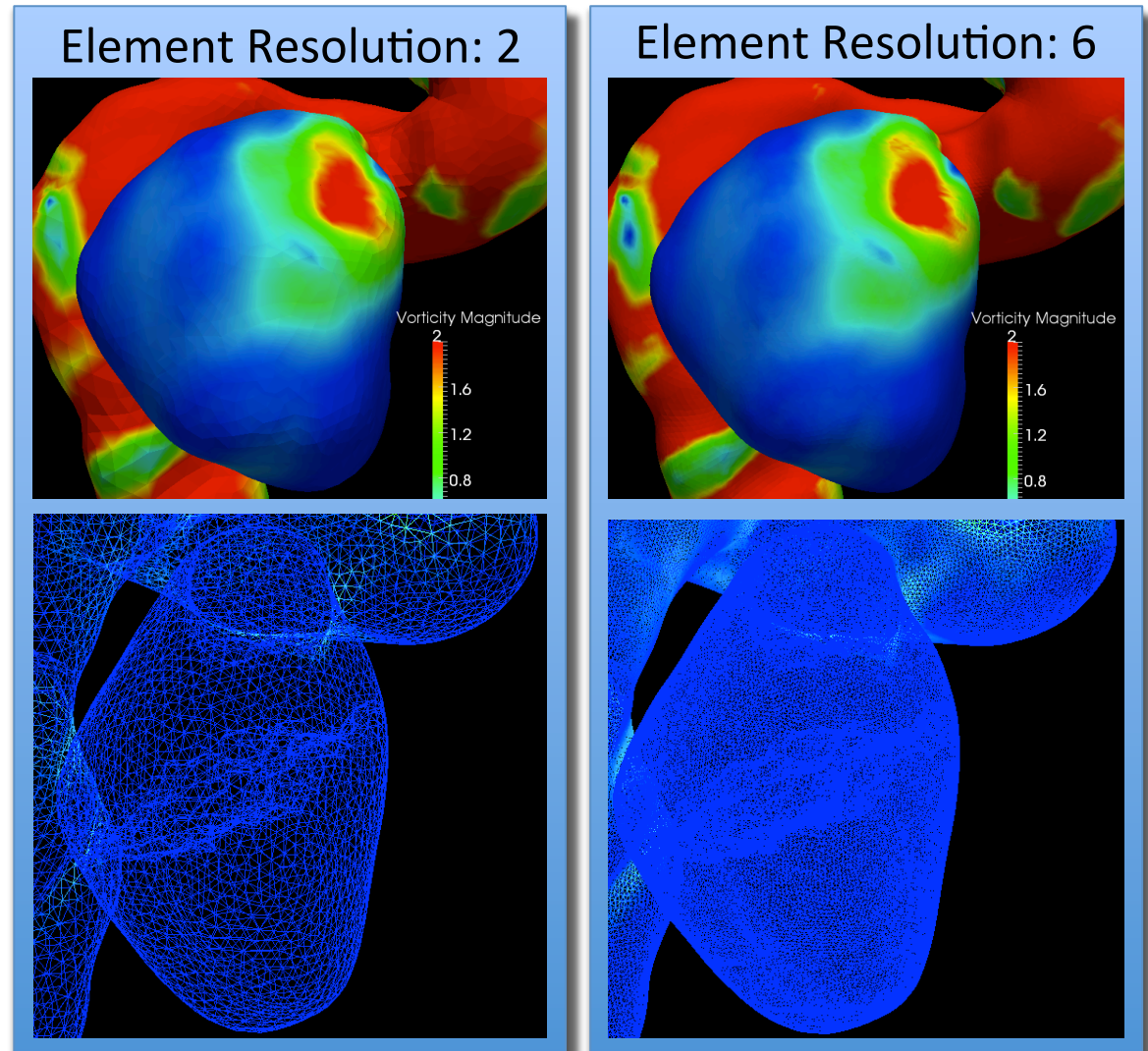
Plug-in Controls

- ◉ Select variables
- ◉ Interactively set data resolution
 - ◉ No need to re-read data from disk
- ◉ Time varying data
 - ◉ Only new data read from disk, not geometry
- ◉ Data caching



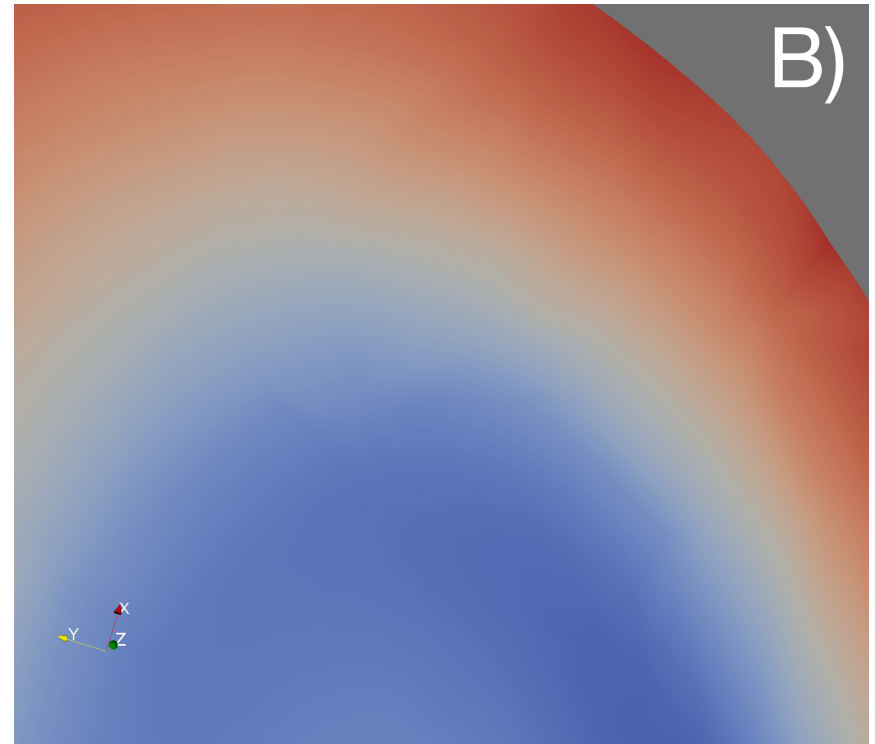
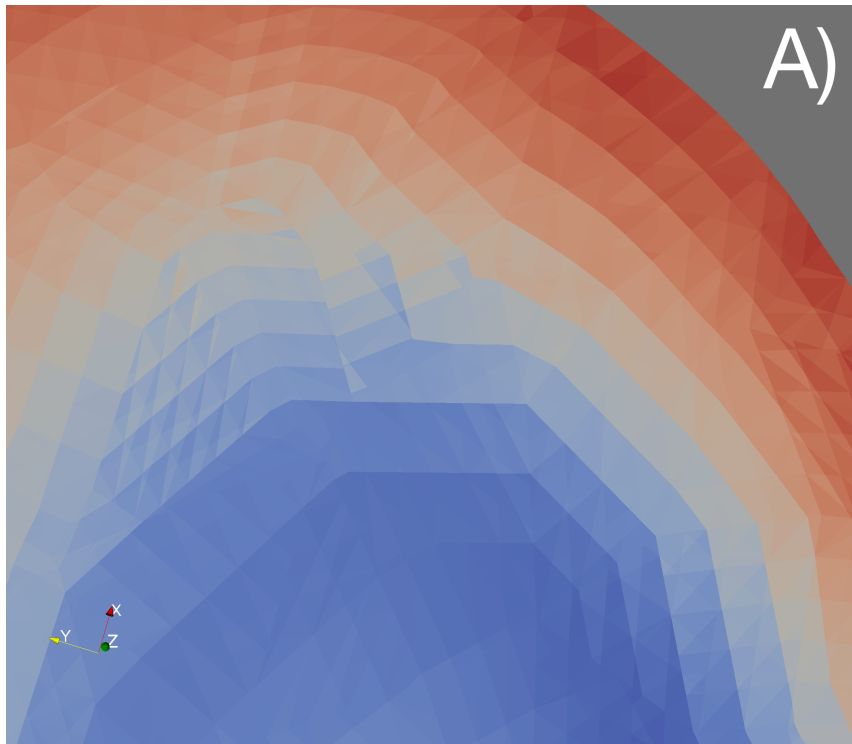
Plug-in Controls

- ⦿ Select variables
- ⦿ Interactively set data resolution
 - ⦿ No need to re-read data from disk
- ⦿ Time varying data
 - ⦿ Only new data read from disk, not geometry
- ⦿ Data caching



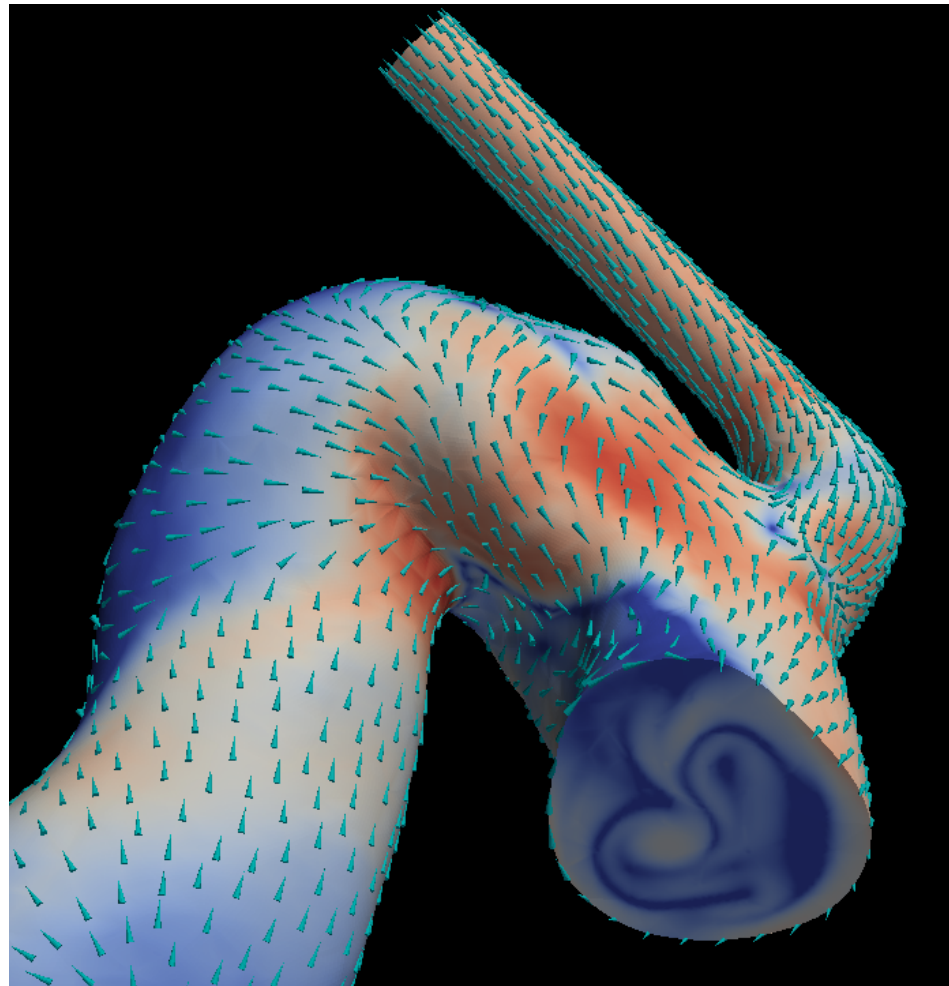
Derived Quantities: Vorticity

- ⊙ Data computed with high-order spectral accuracy
- ⊙ Grid consistent with simulation resolution



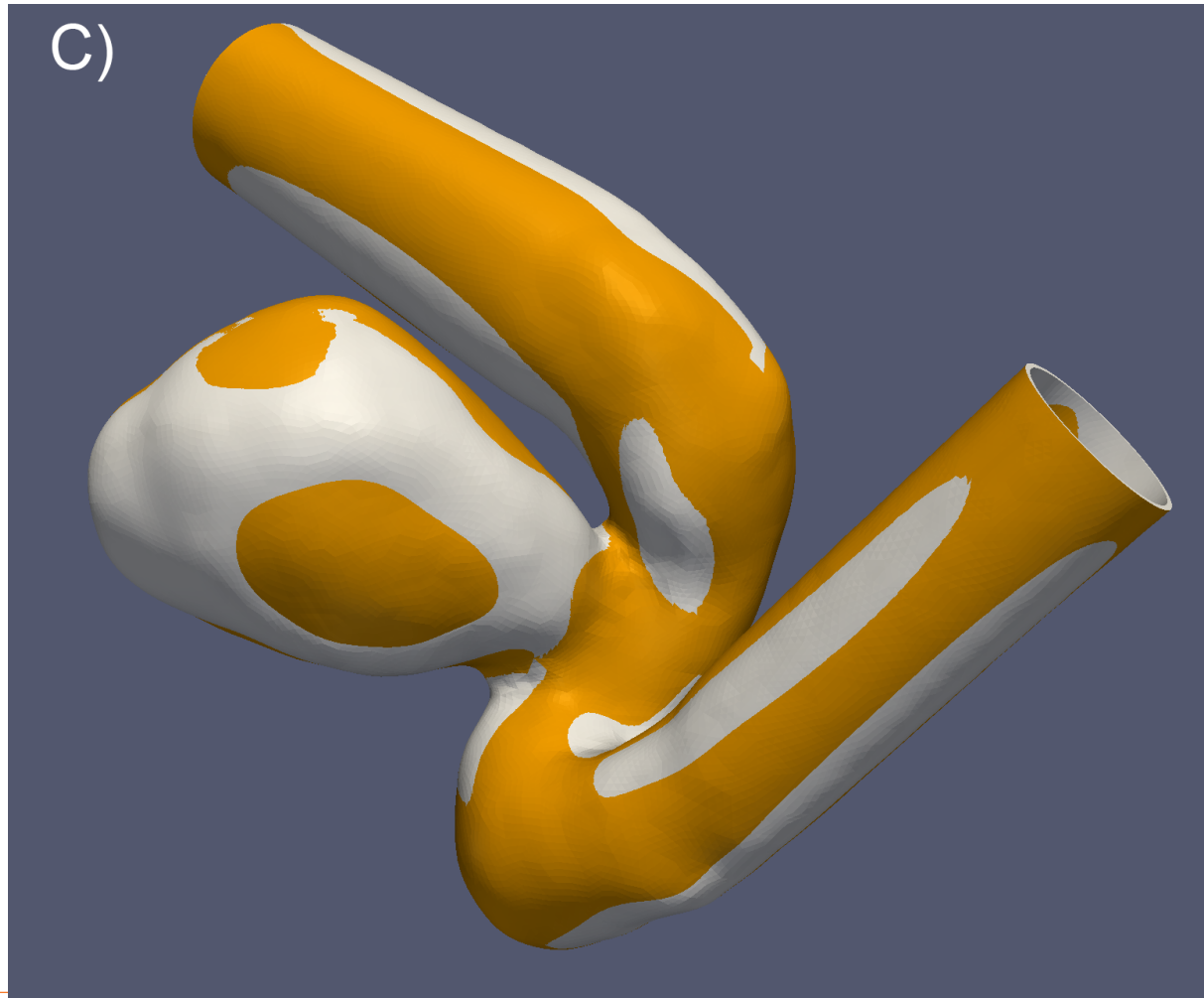
Derived Quantities: Wall Shear Stress

- ◉ Extract boundary mesh



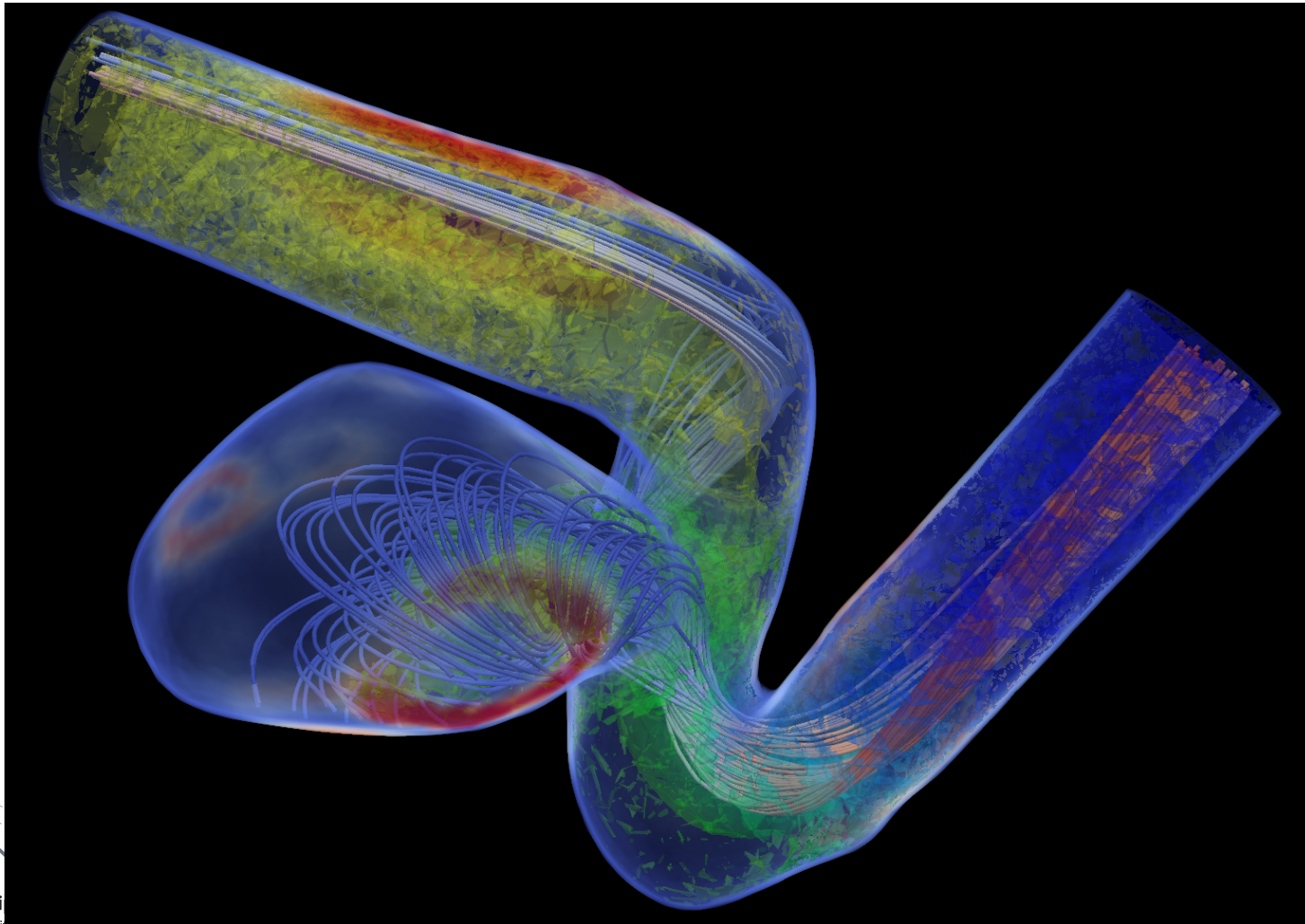
Fluid-Structure Interaction

- ⦿ Dynamic mesh
- ⦿ Stress Tensor

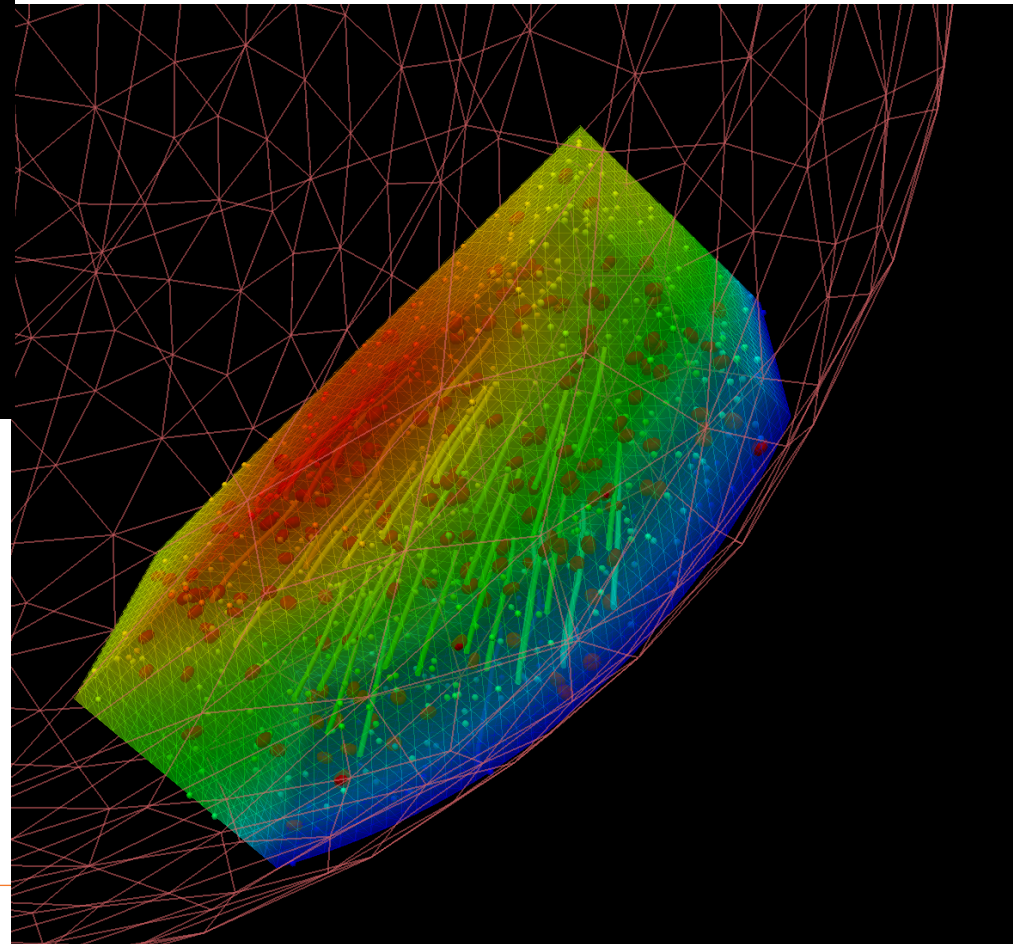
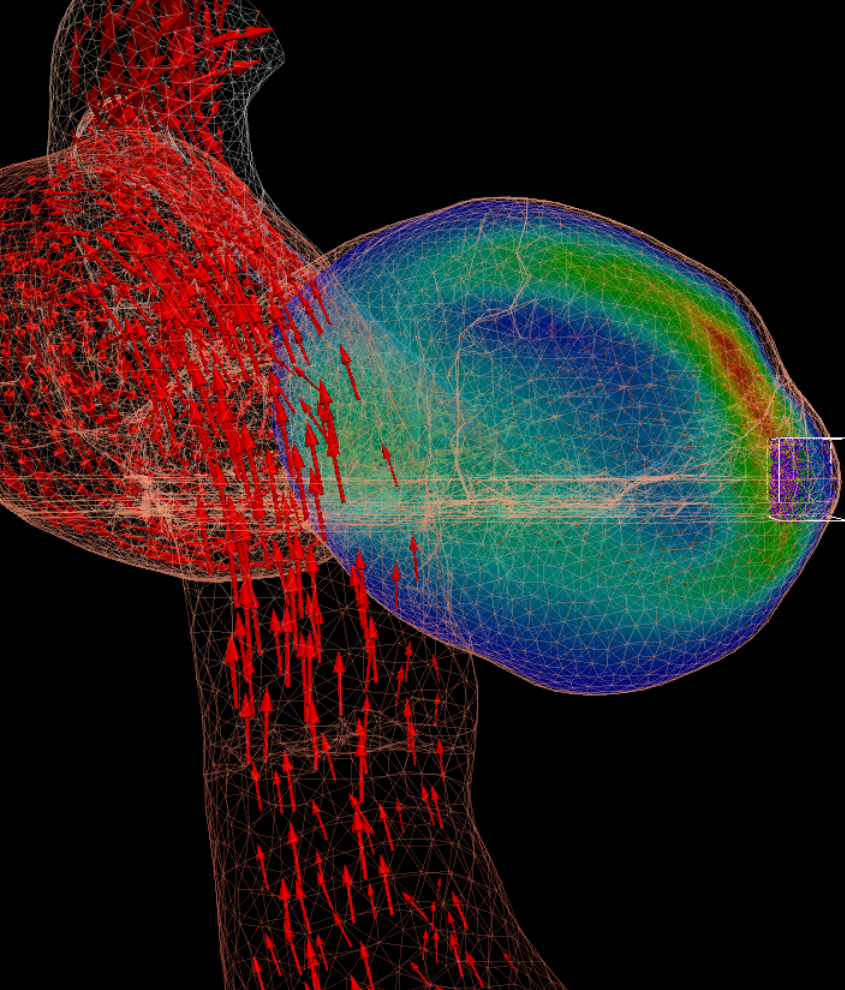


Fluid-Structure Interaction

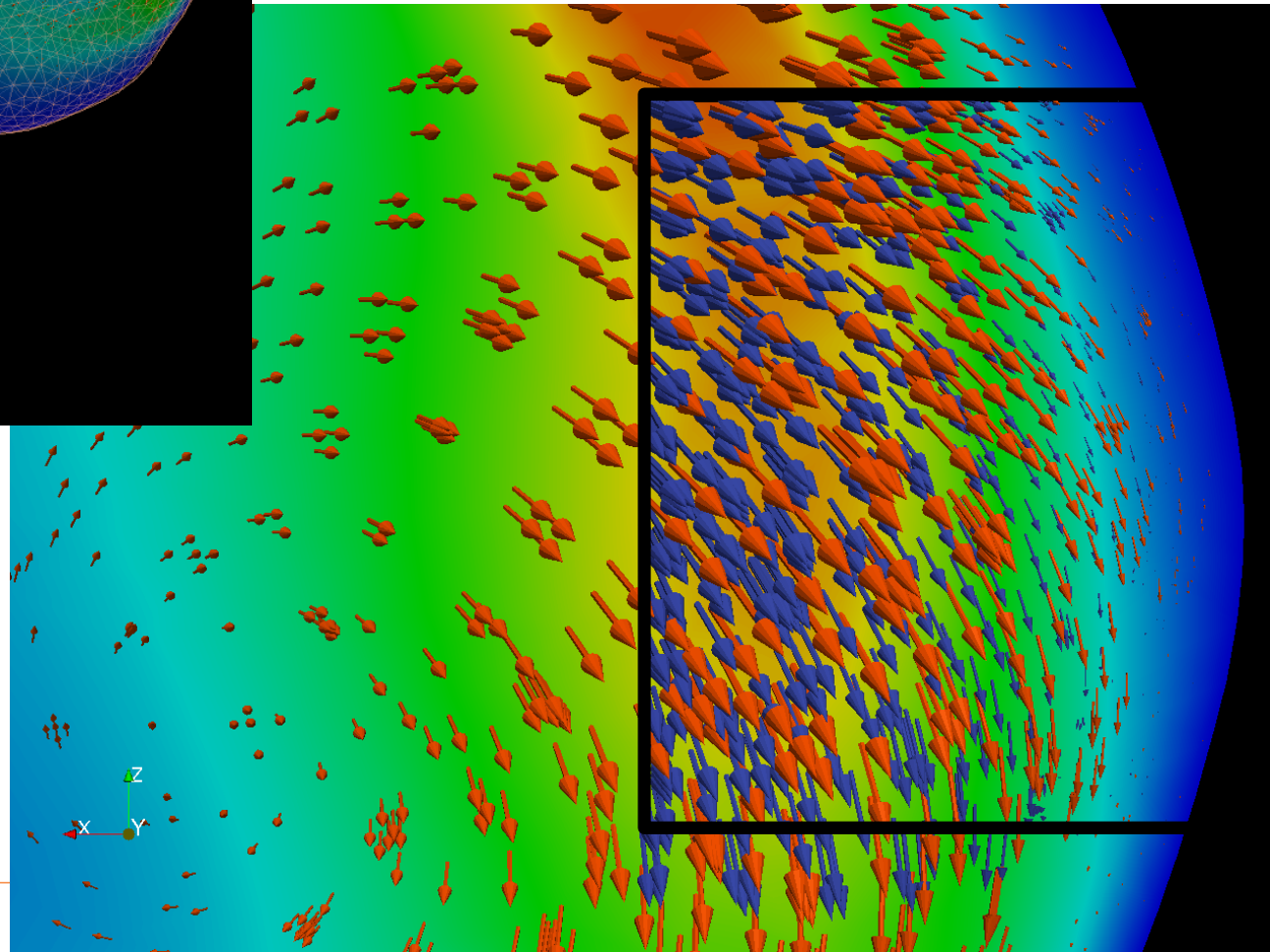
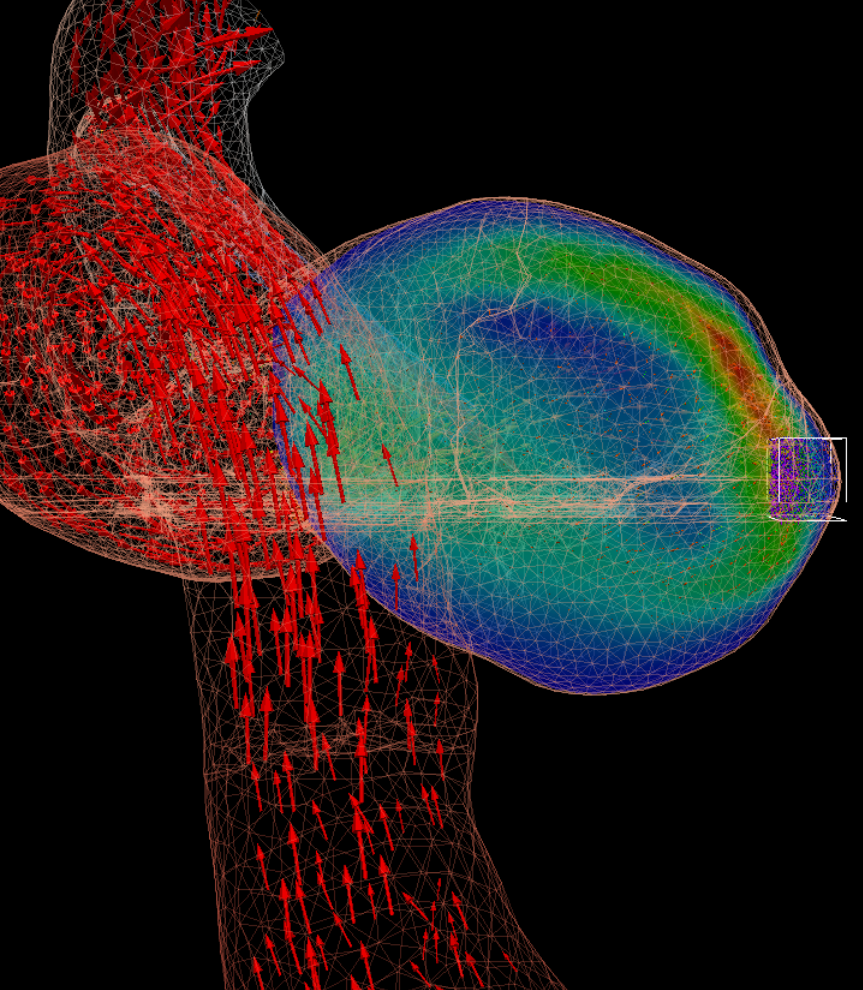
- ⊙ Dynamic mesh
- ⊙ Stress Tensor



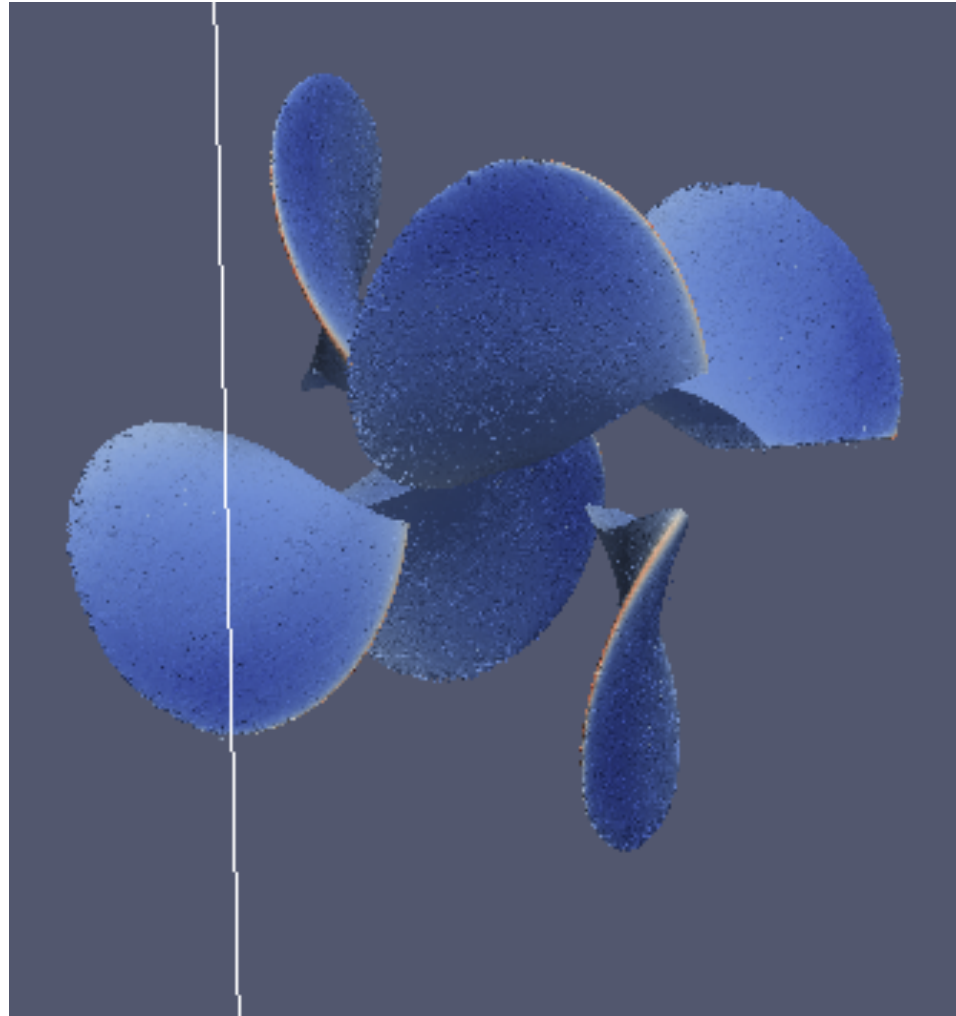
Visualization for Verification



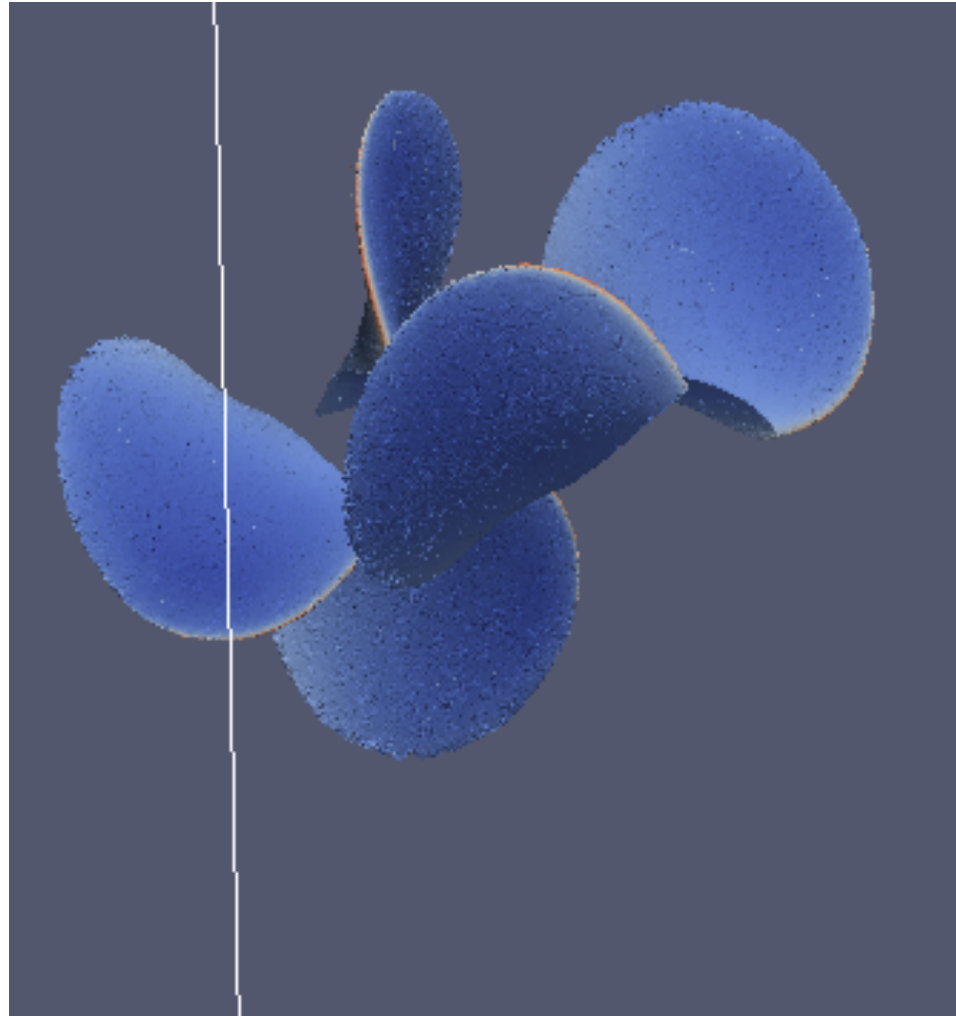
Visualization for Verification



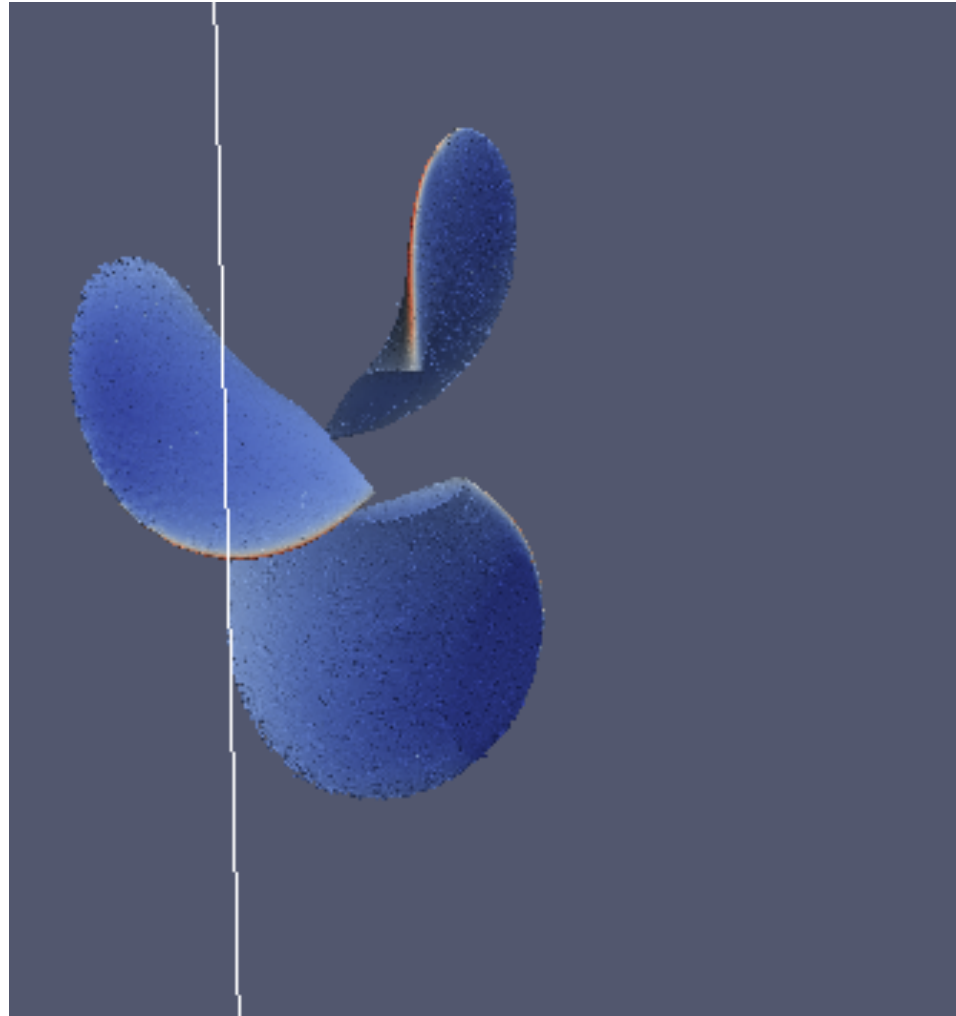
Visualization for Debugging



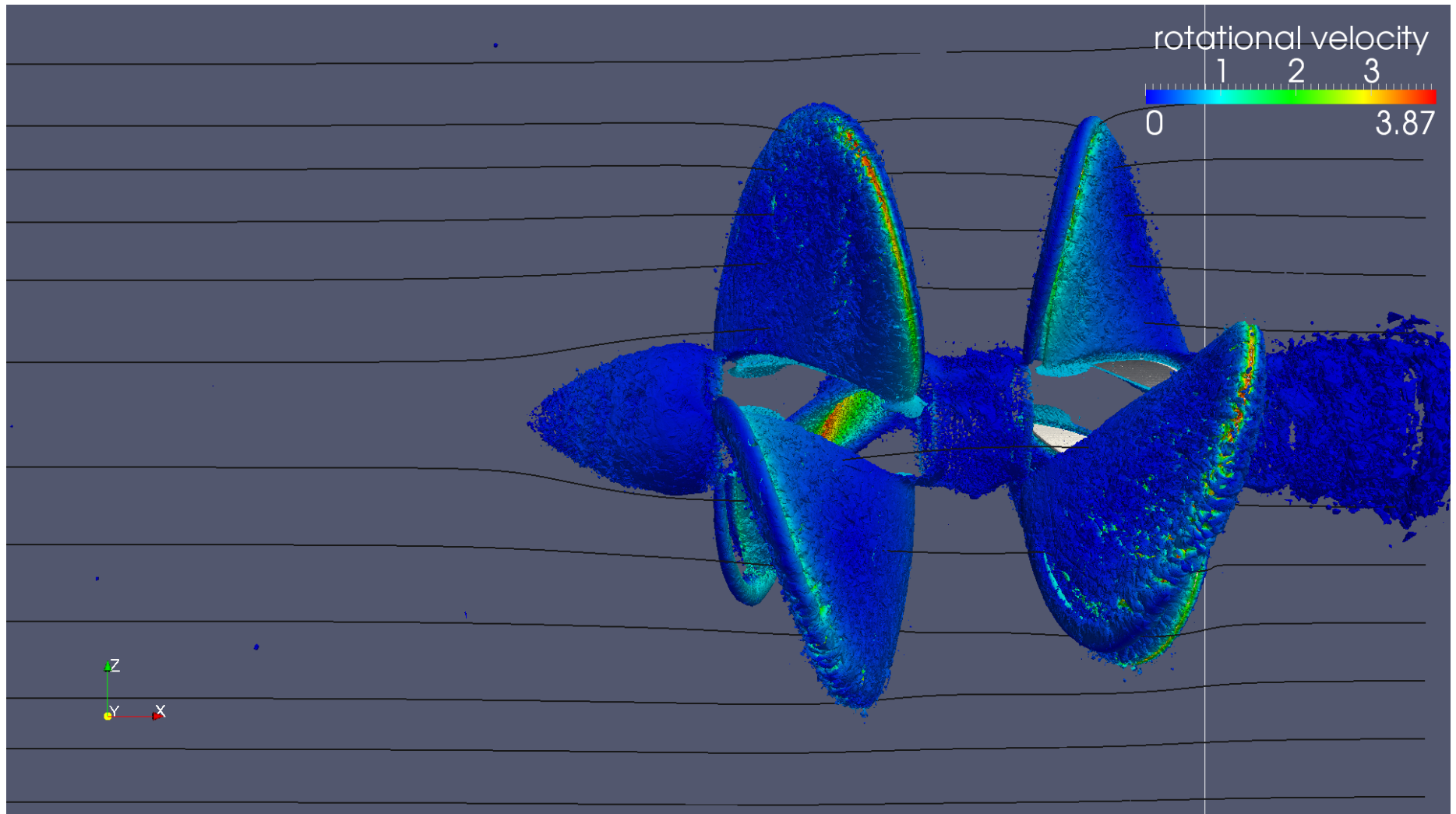
Visualization for Debugging



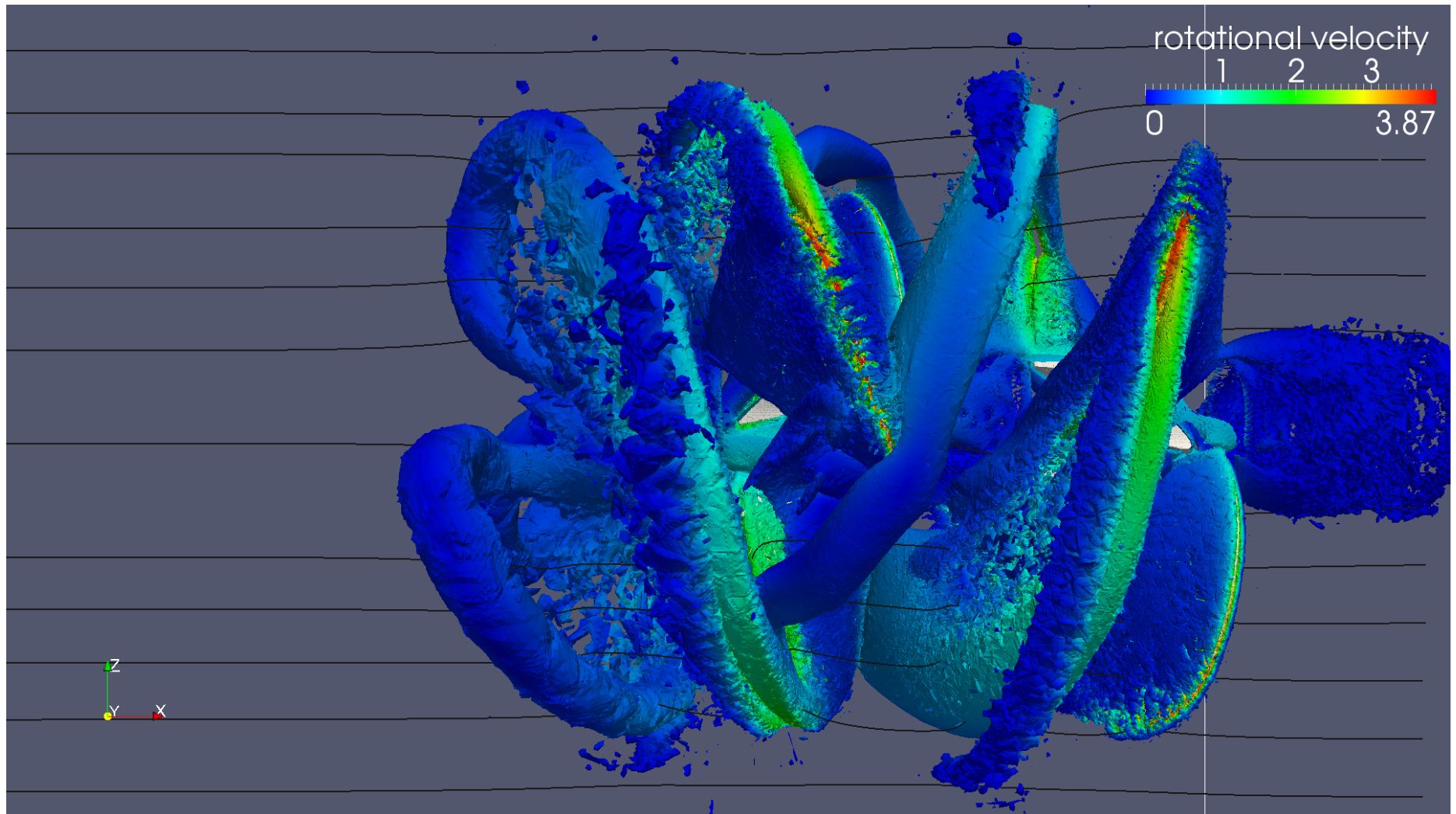
Visualization for Debugging



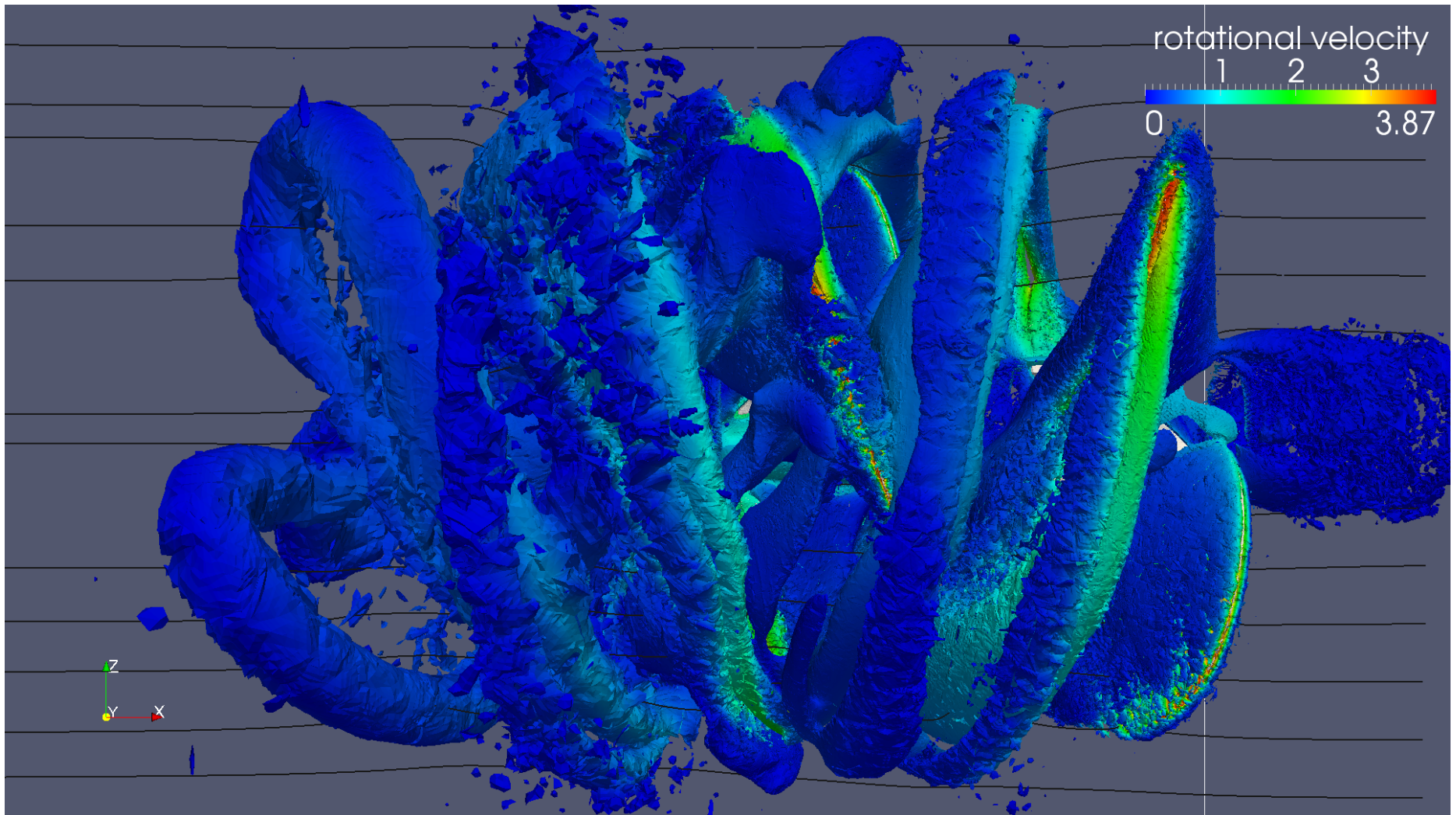
Visualization for Debugging



Visualization for Debugging

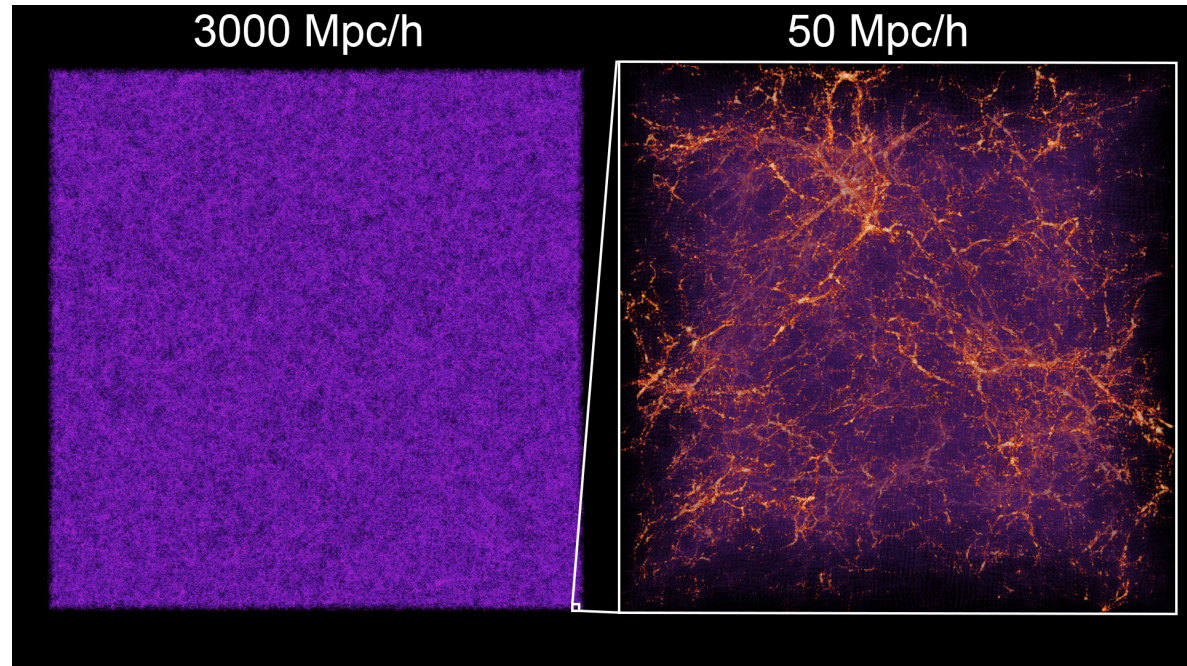


Visualization for Debugging



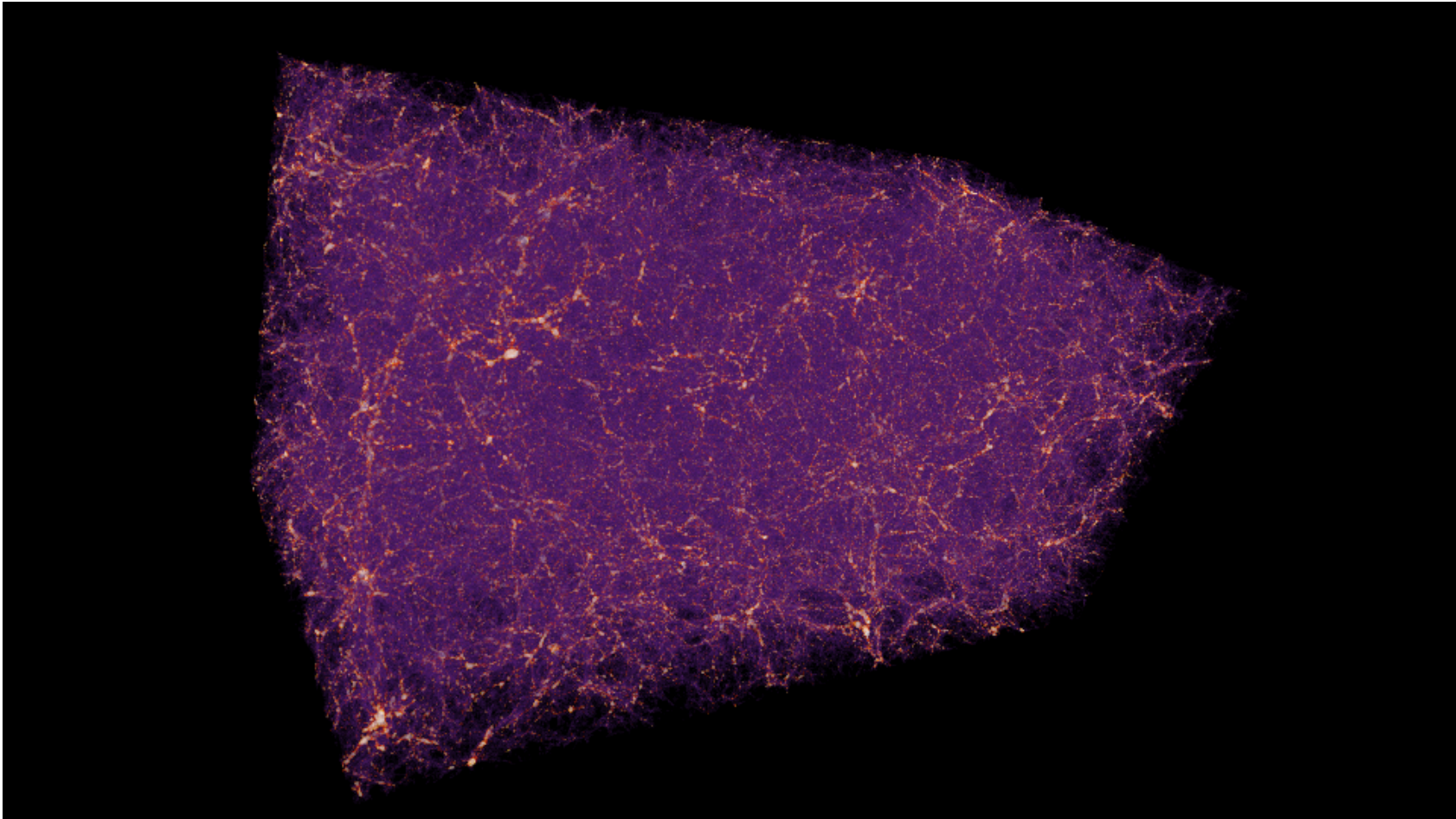
HACC: Cosmology Simulation

- ⊙ 1.1 trillion particles
- ⊙ Projected onto a regular grid currently ($10K^3$), post-processed ($\sim 4TB$ per time step)

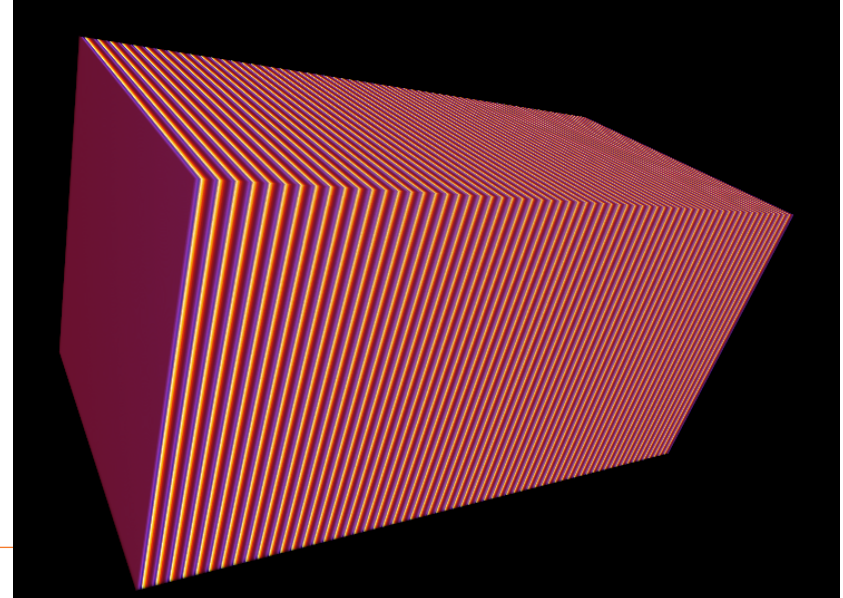
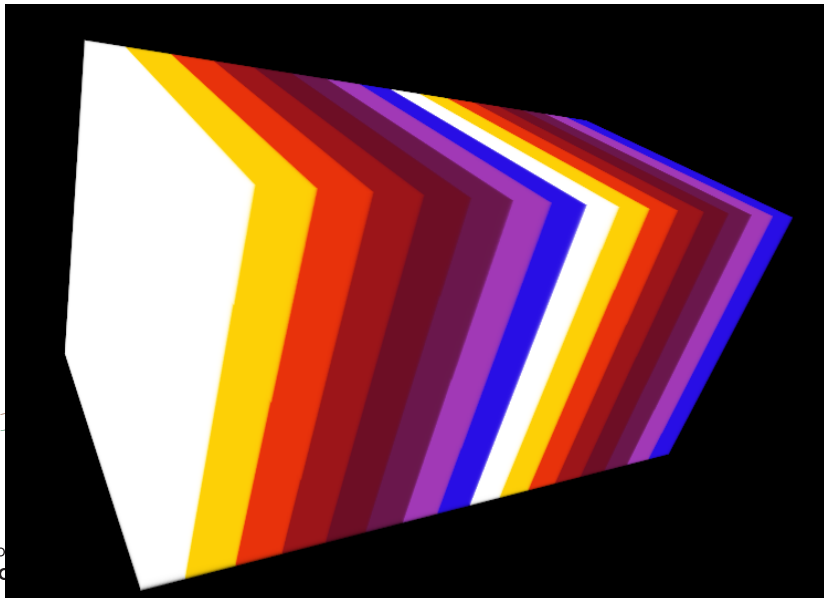
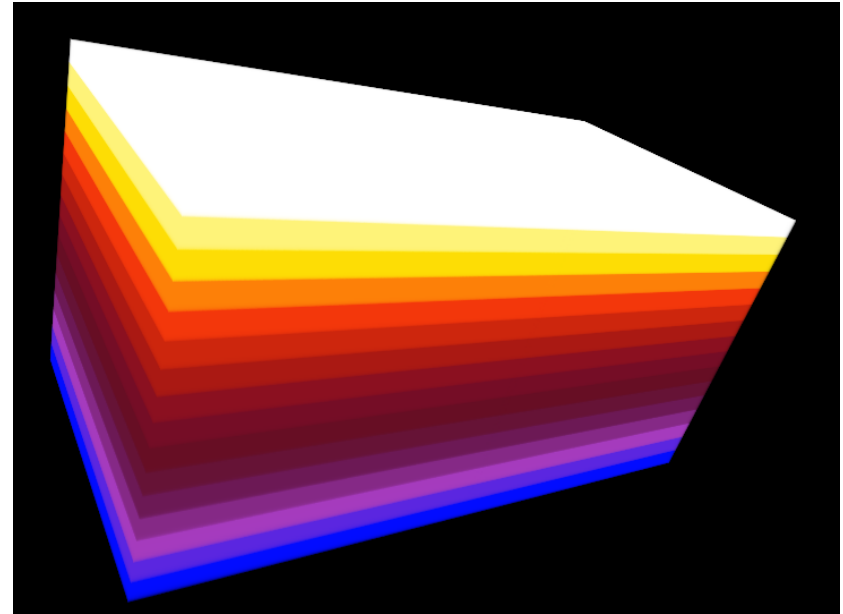
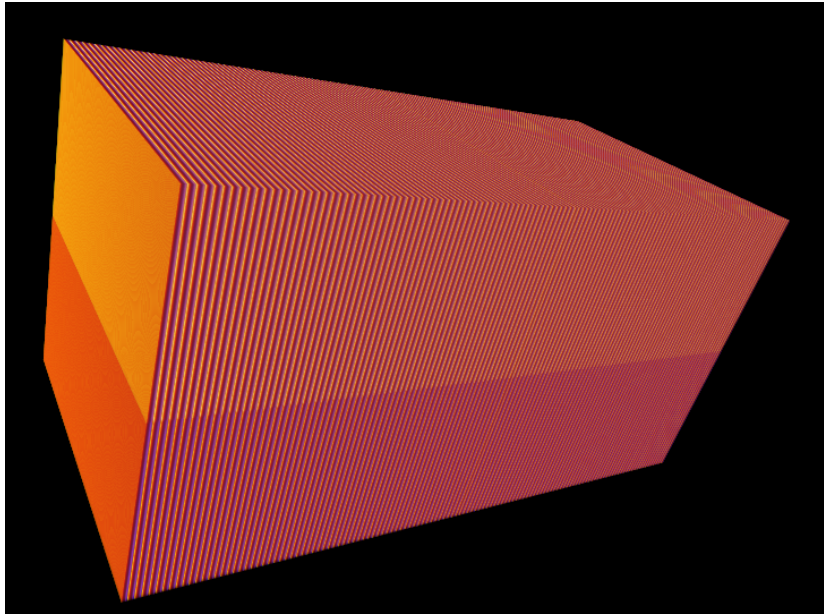


- ⊙ $10K \times 10K \times 800$ ($\sim 9,000$ light-years on a side) from a single I/O node (left image)
- ⊙ 512^3 (~ 150 light-years on a side) from a single process (right image)

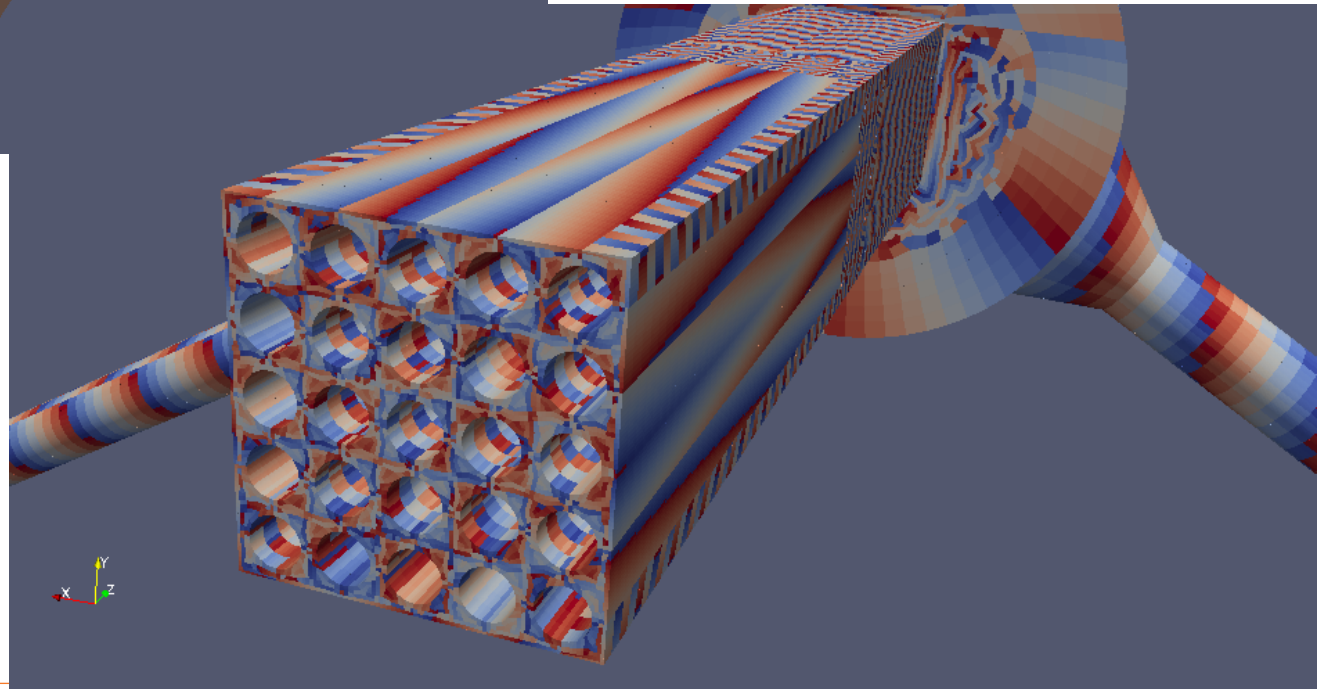
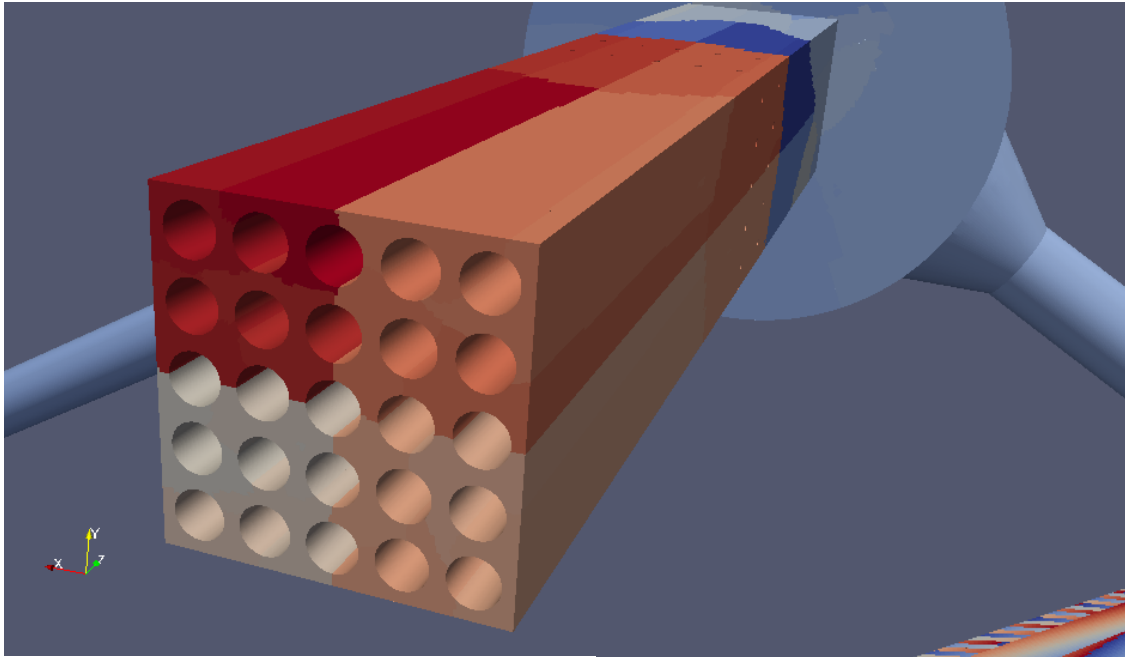
Visualization as Diagnostics: Color by Thread ID



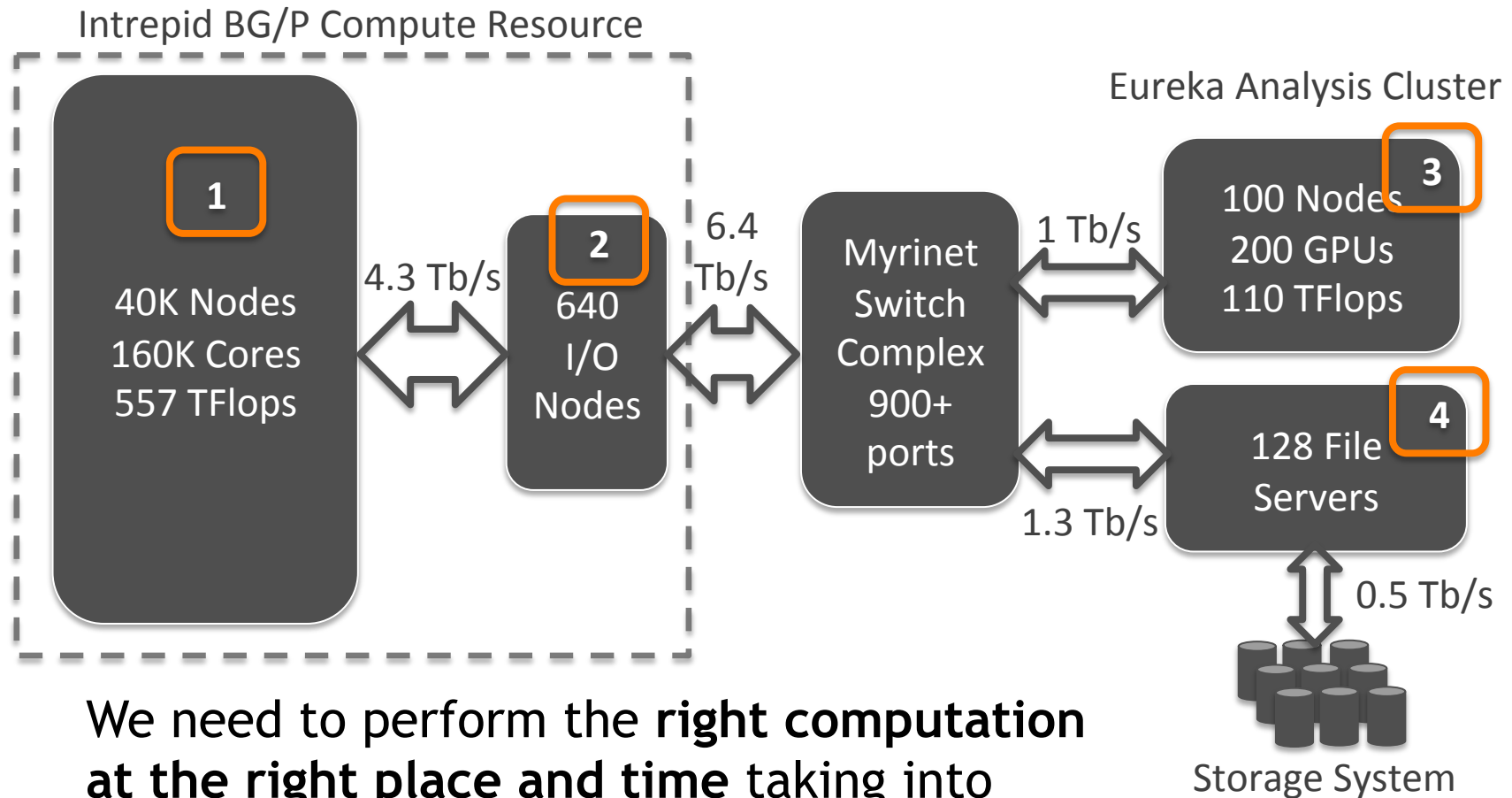
Visualization as Diagnostics: Color by Thread ID



Visualization as Diagnostics: Color by Process ID

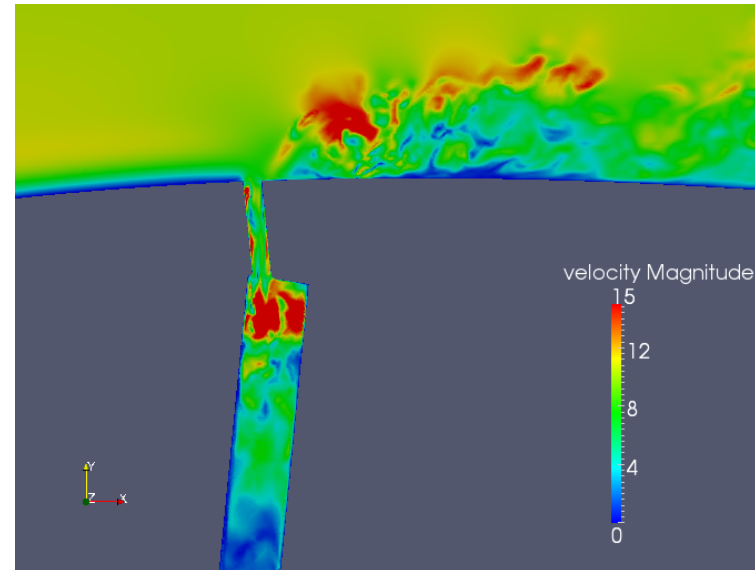
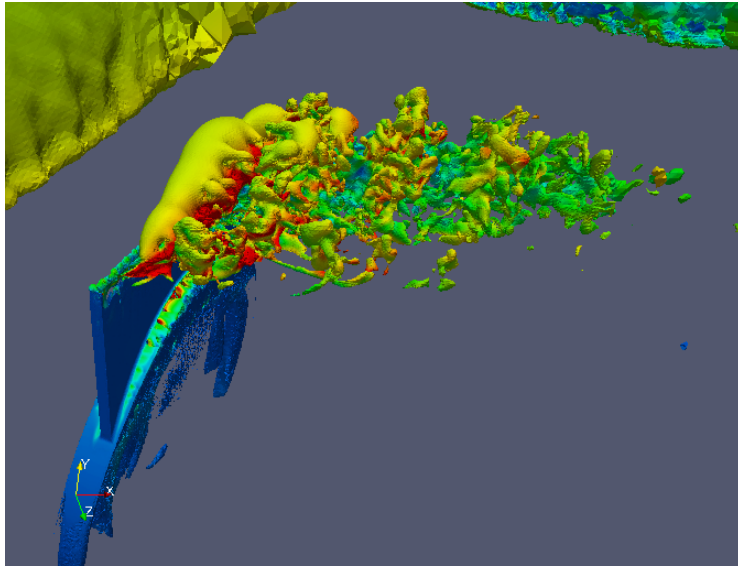


Simulation-time Analysis Opportunities on the Argonne Leadership Computing Facility



We need to perform the **right computation at the right place and time** taking into account the characteristics of the simulation, resources and analysis

Simulation-time analysis of PHASTA on 160K Intrepid BG/P cores



Isosurface of vertical velocity colored by velocity and cut plane through the synthetic jet (both on 3.3 Billion element mesh). *Image Courtesy: Ken Jansen*

- ⦿ Visualization of a PHASTA simulation running on **160K cores** of Intrepid using ParaView on 100 Eureka nodes **enabled by GLEAN**
- ⦿ Enabled scientists to better understand evolution of the simulation
- ⦿ GLEAN achieves **48 GBps** sustained throughput for data movement for simulation-time analysis