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LLNL-TR-468217

Flow Analysis Baseline Heated Flow Turbulence Model Comparison

S. B. Sutton

January 31, 2011

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Flow Analysis

Baseline Heated Flow

Turbulence Model Comparison

Steven Sutton

January 18, 2011

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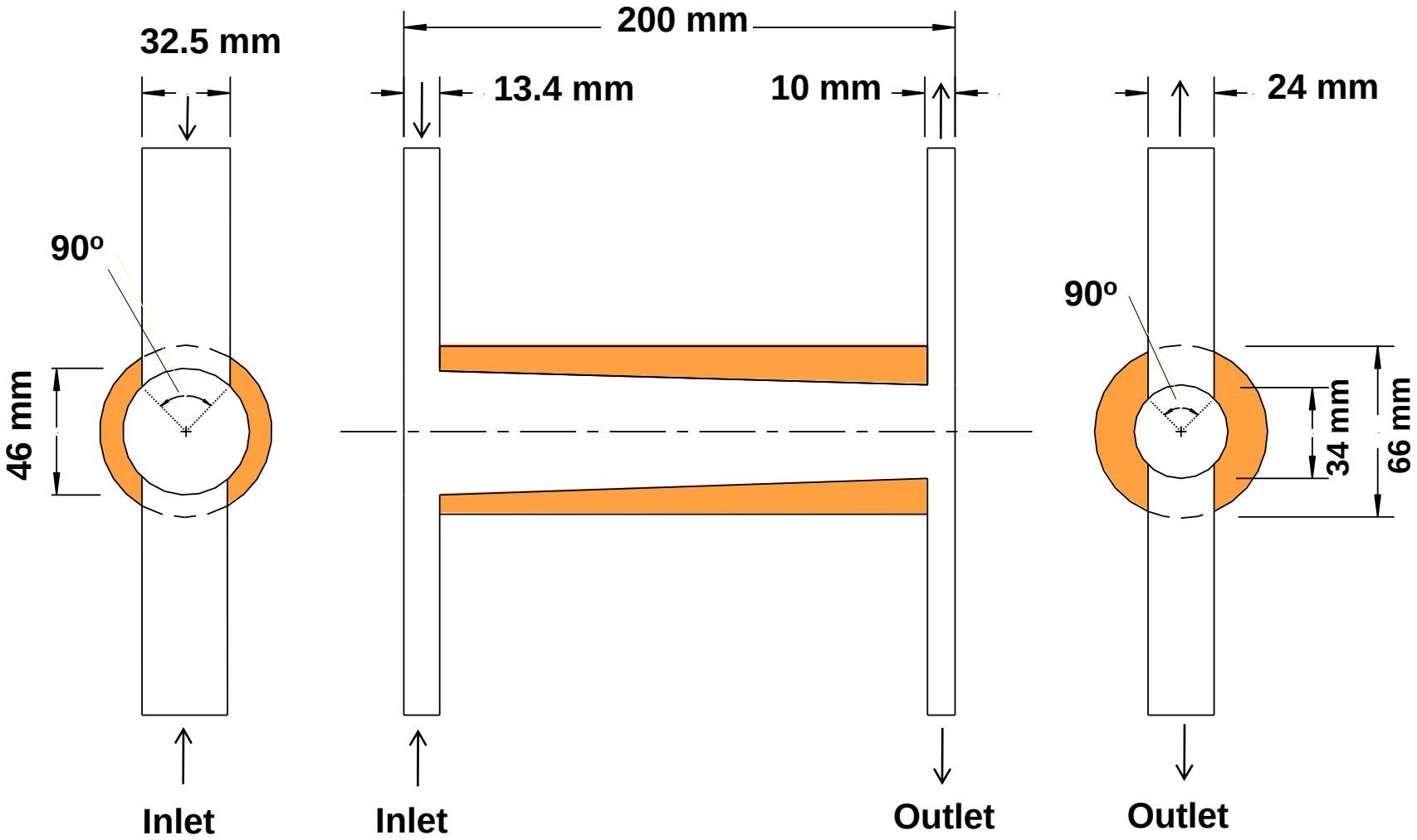
Outline …

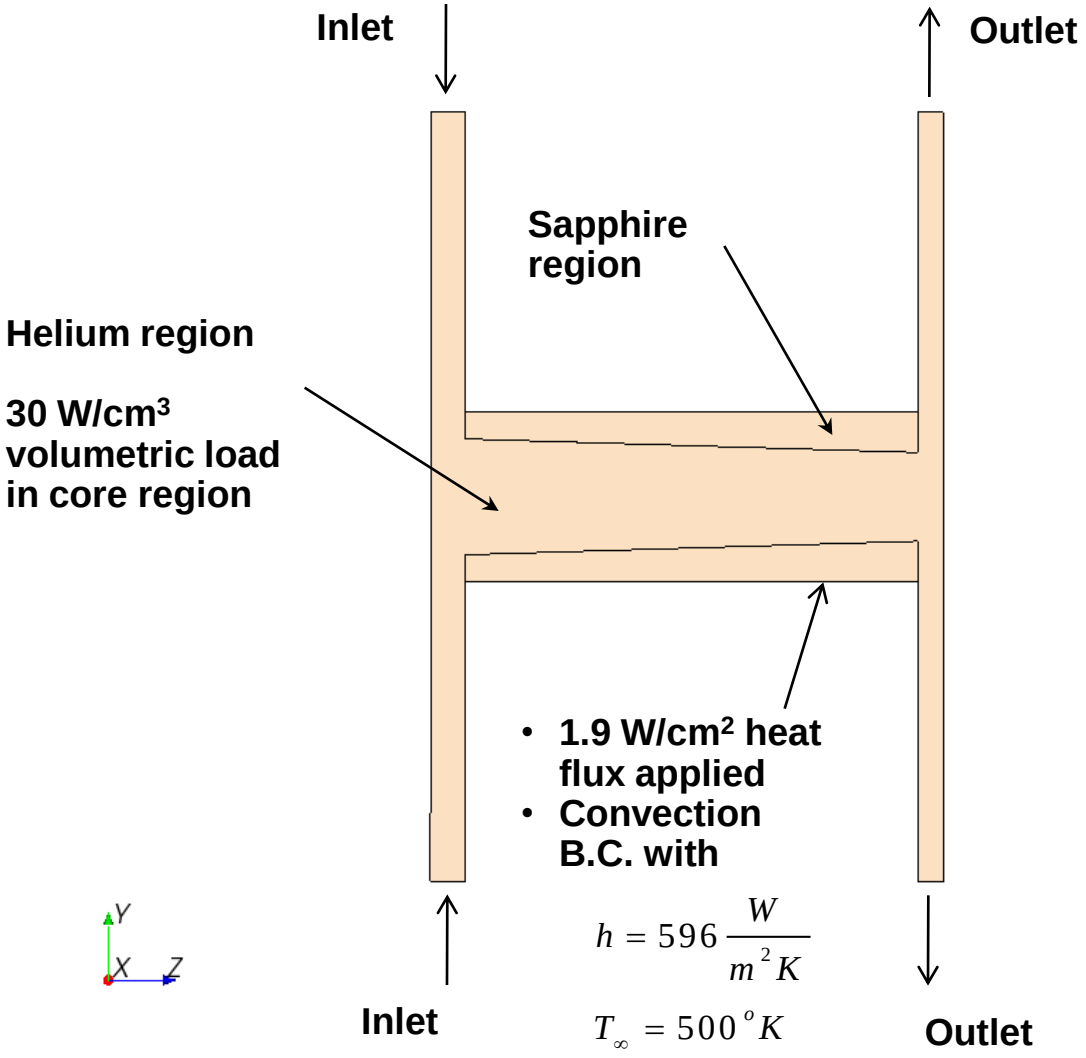
- Calculations were performed using four turbulence models
  - Reynolds-averaged Navier-Stokes (RANS)
    - Standard Spalart-Allmaraz
    - Standard k-ε model
  - Detached Eddy Simulation (DES)
    - Spalart-Allmaraz Detached Eddy
  - Large Eddy Simulation (LES)

- Calculations were run in two stages: steady-state initialization followed by the transient solution
  - The Standard Spalart-Allmaraz steady-state solution was used for the DES and LES transient simulations

Geometry


32.5 mm
200 mm
13.4 mm
10 mm
24 mm
90°
90°
46 mm
34 mm
66 mm
Inlet
Inlet
Outlet
Outlet

Key features of the model

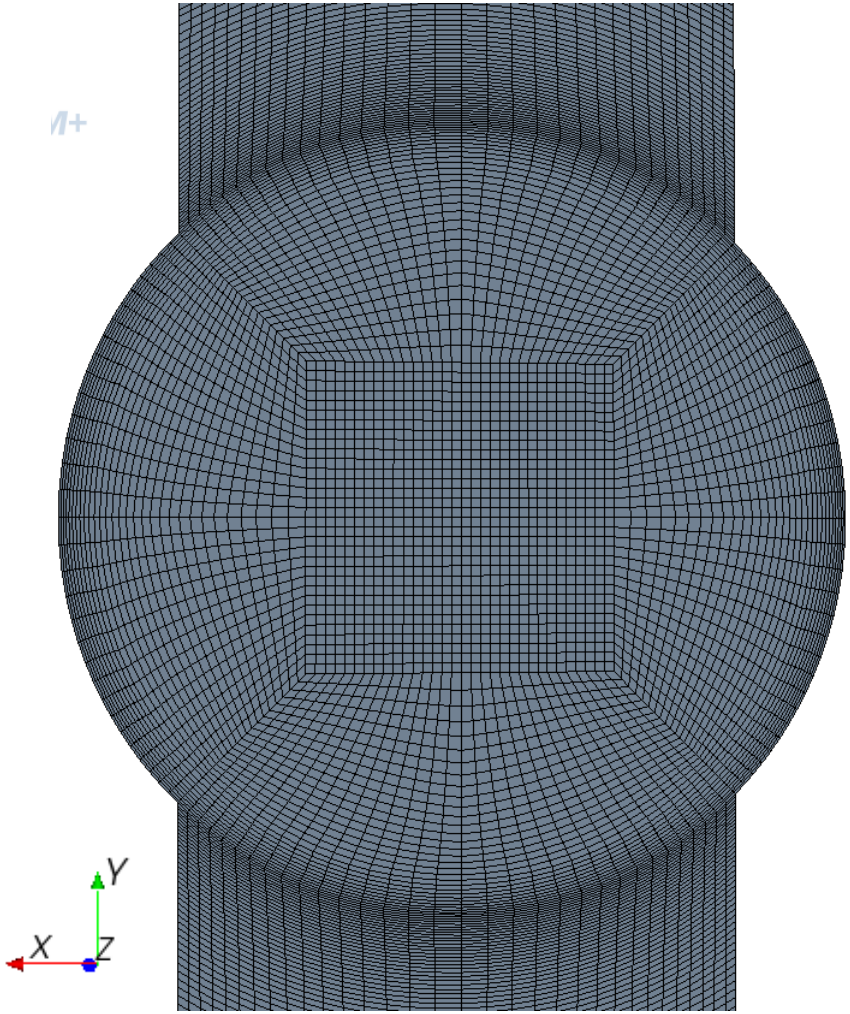


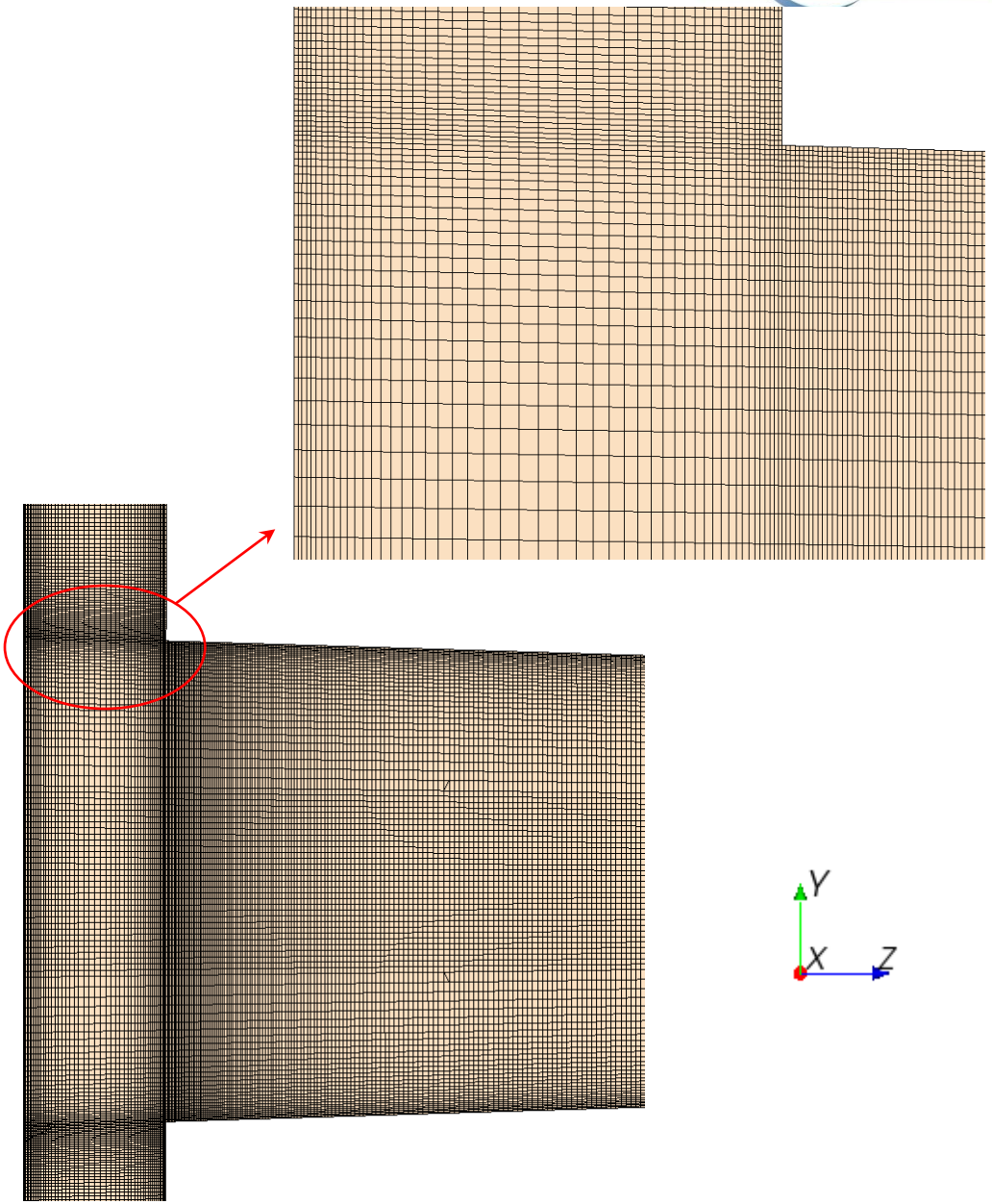
Mesh characteristics

- **Helium region:**
  - **3,481,600 cells**
  - **4864 elements in the truncated cone cross-section**
  - **550 element slices in the core flow direction**

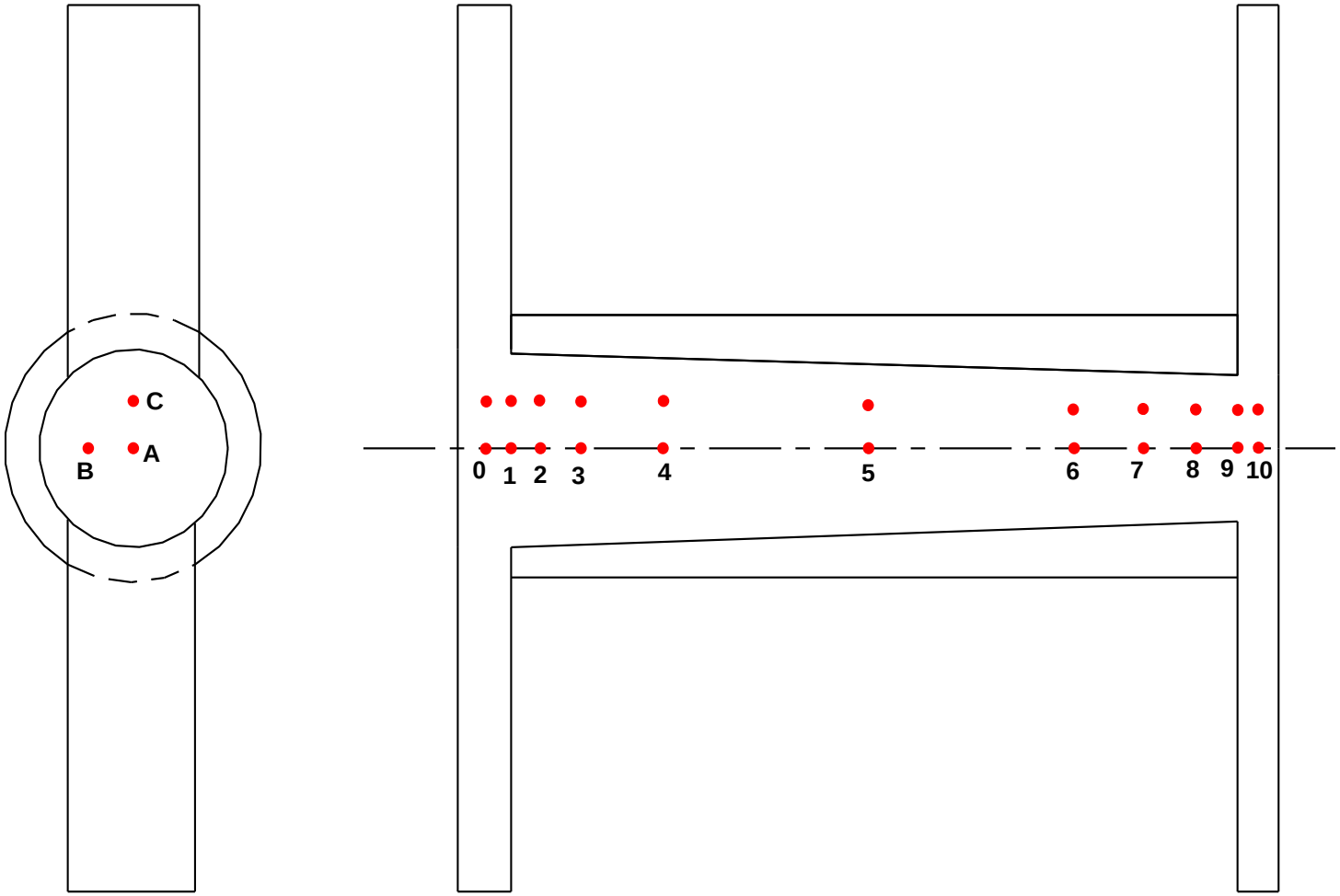
- **Sapphire region:**
  - **199,680 cells**
  - **170 element slices in the core flow direction**
    - **A coarser mesh is allowed in the Sapphire region because the Sapphire thermal conductivity is much greater than the Helium thermal conductivity**

Helium region mesh plots

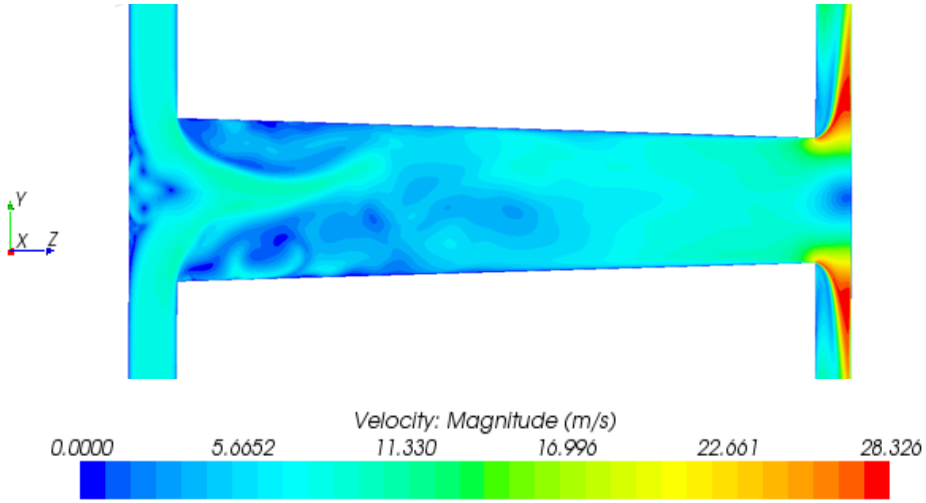


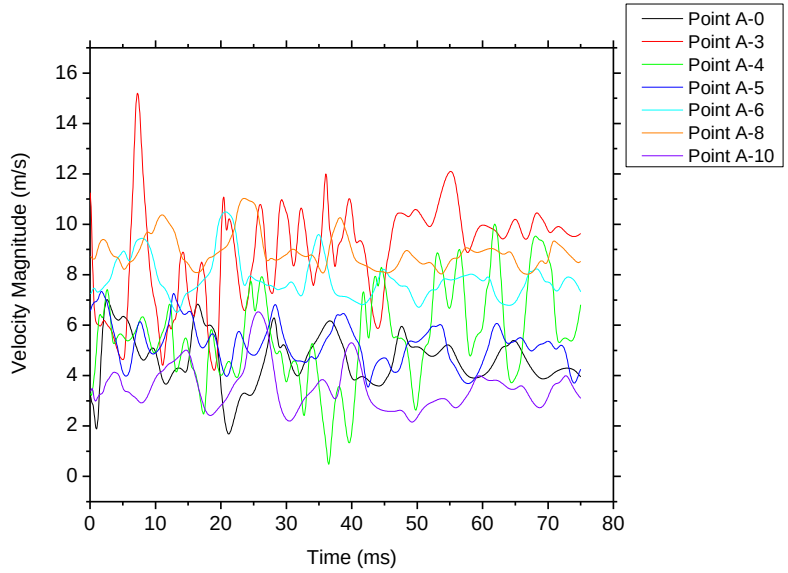


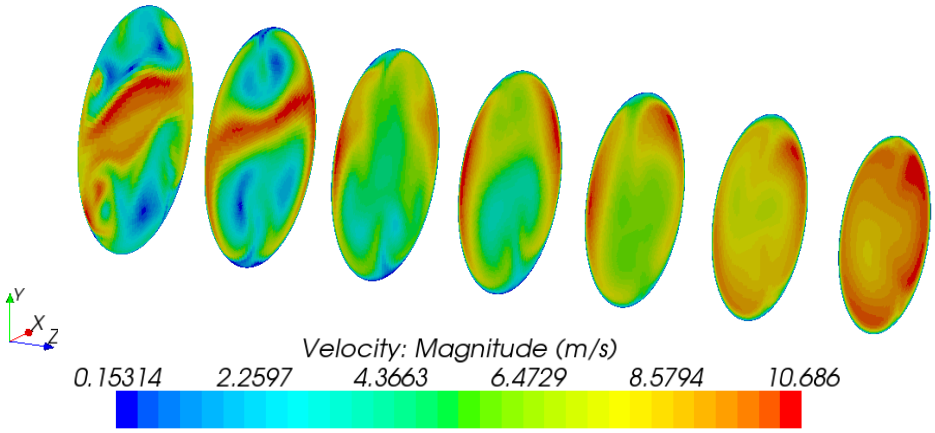
Velocity, temperature and density information was saved at 33 discrete points for time-history plots

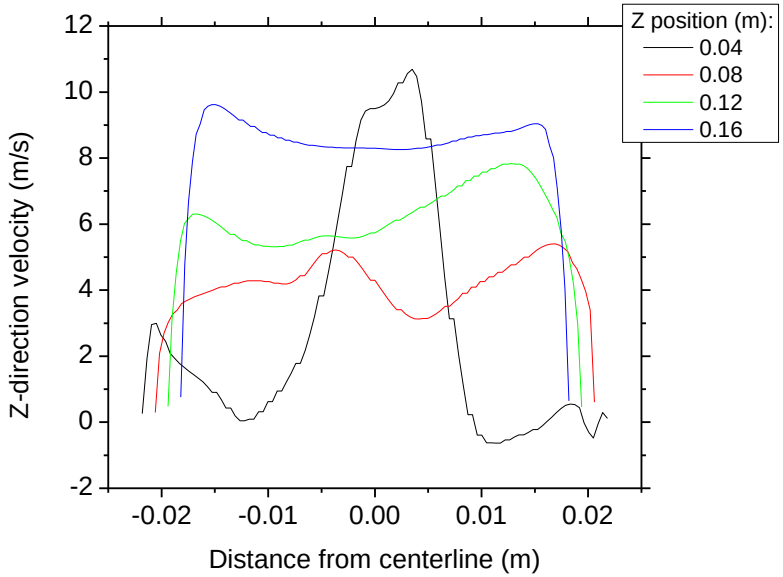


Standard Spalart-Allmaraz Turbulence Model
- *Velocity magnitude*



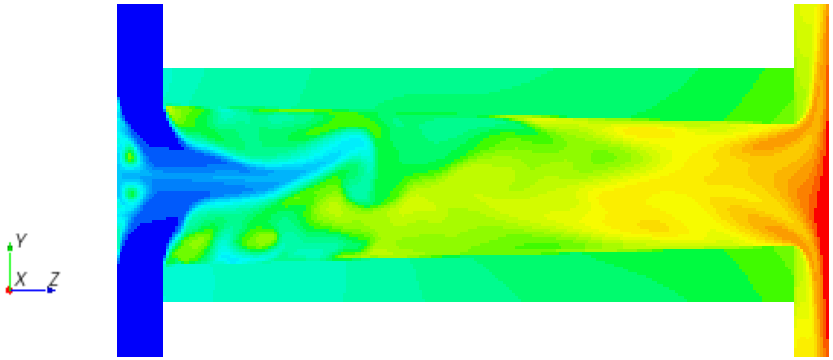


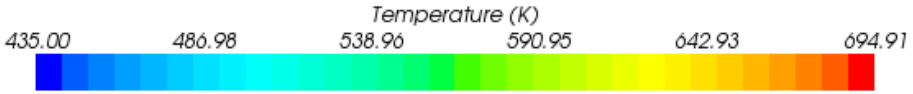


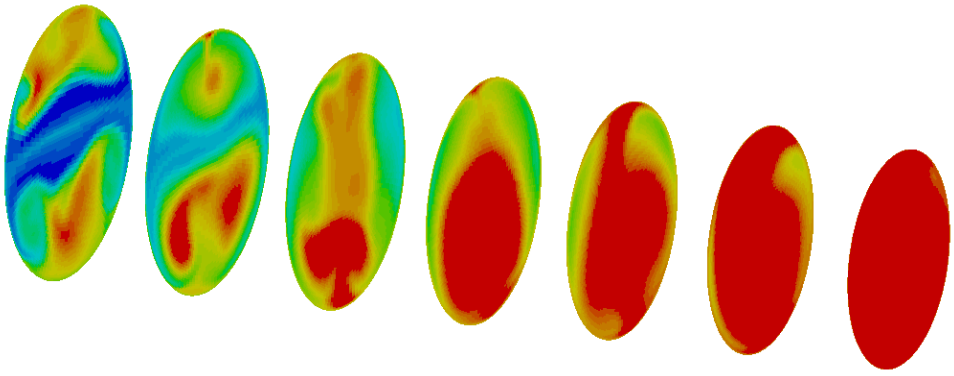


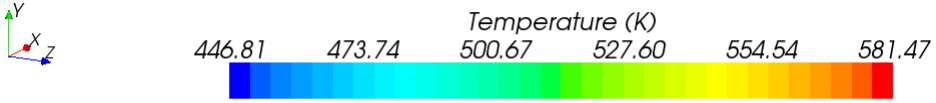
(Case 38.1b)

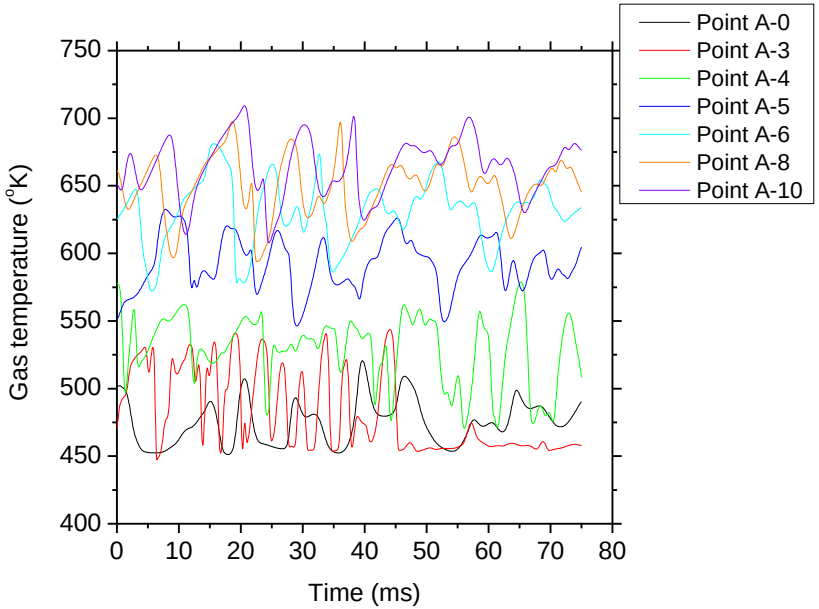
Standard Spalart-Allmaraz Turbulence Model
- *Temperature*





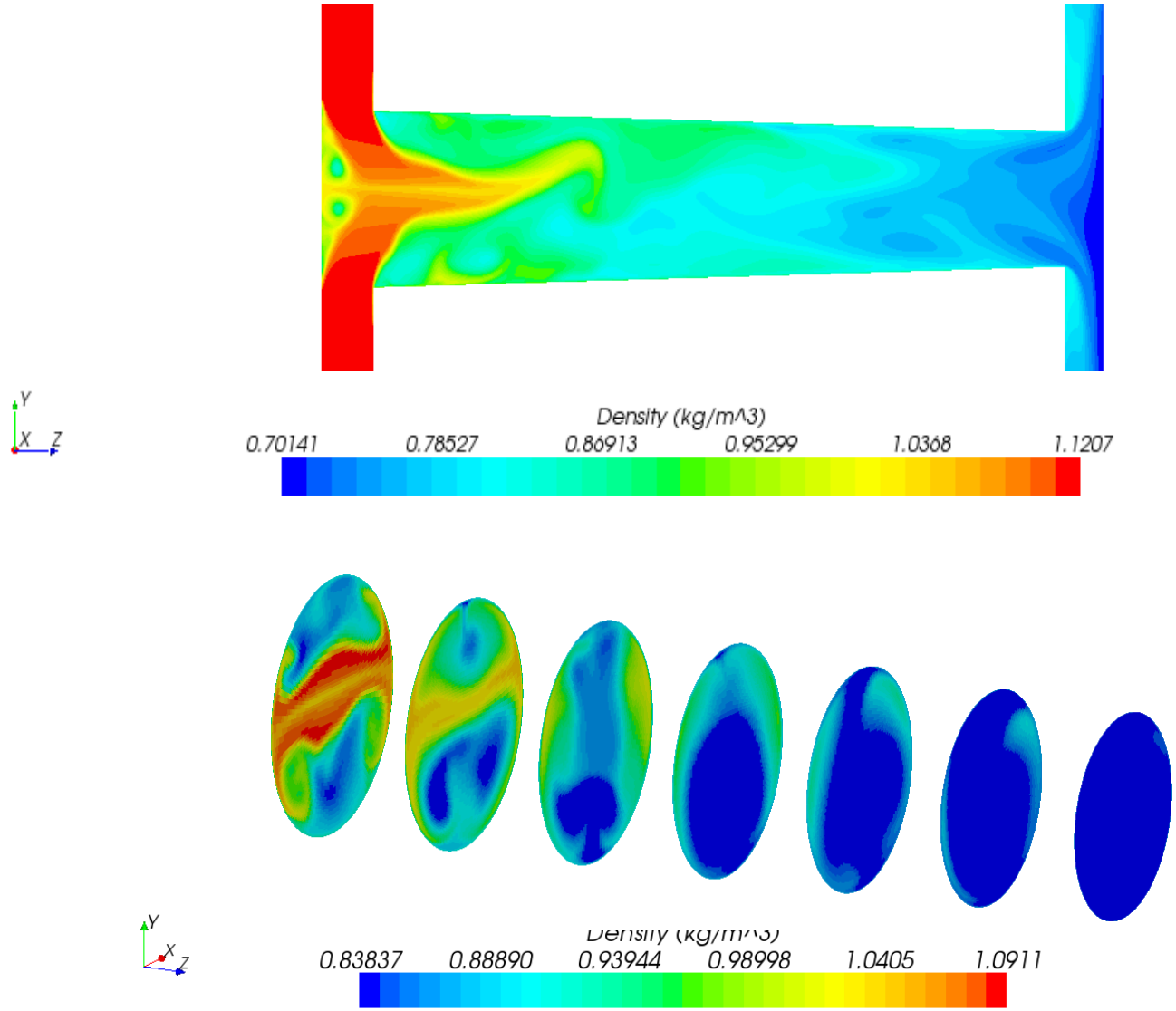






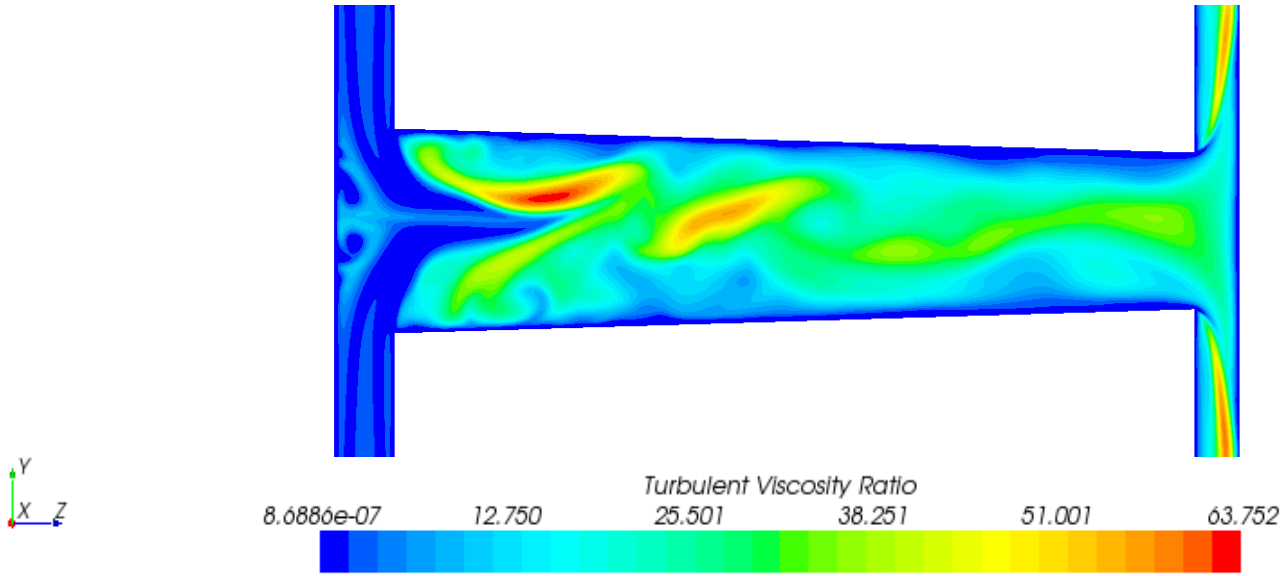
(Case 38.1b)

Standard Spalart-Allmaraz Turbulence Model
- *Density*



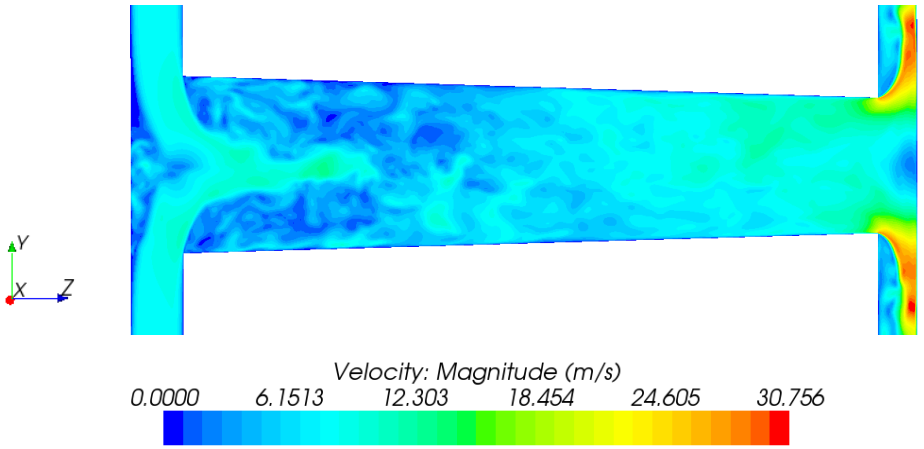
(Case 38.1b)

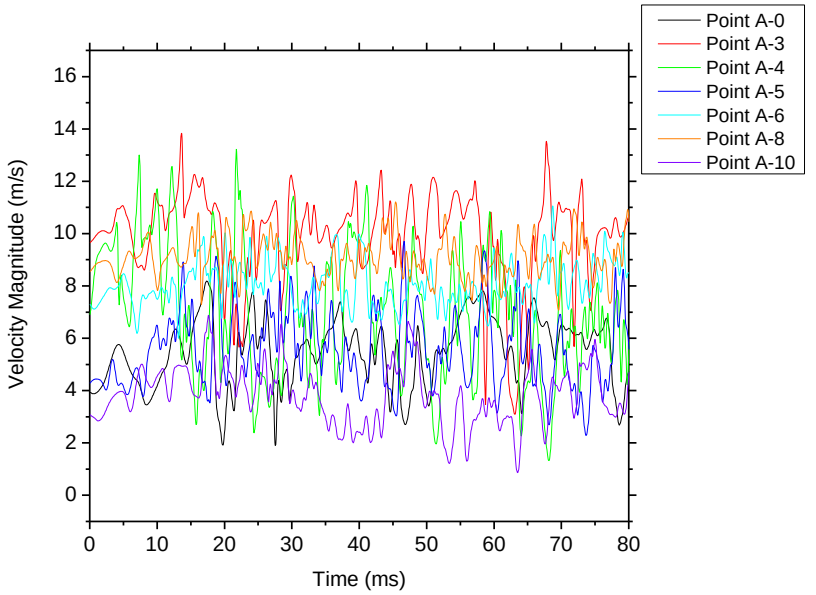
Standard Spalart-Allmaraz Turbulence Model
- *Turbulent Viscosity Ratio*

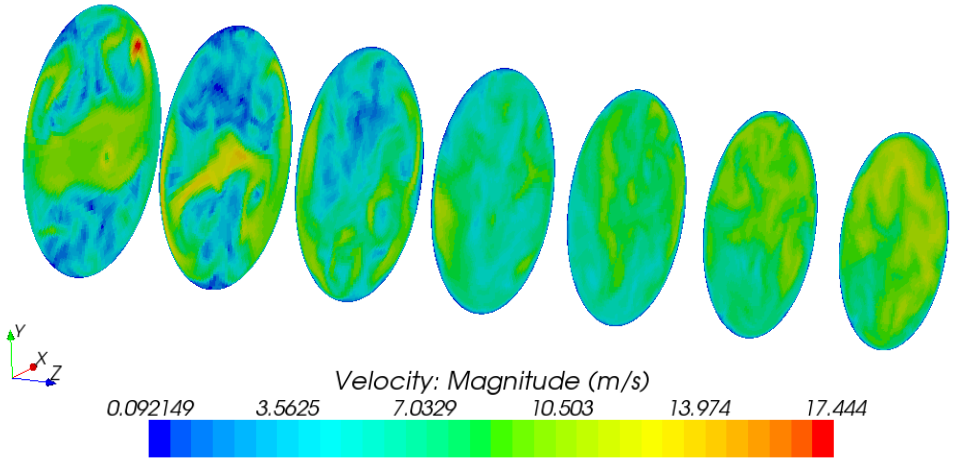


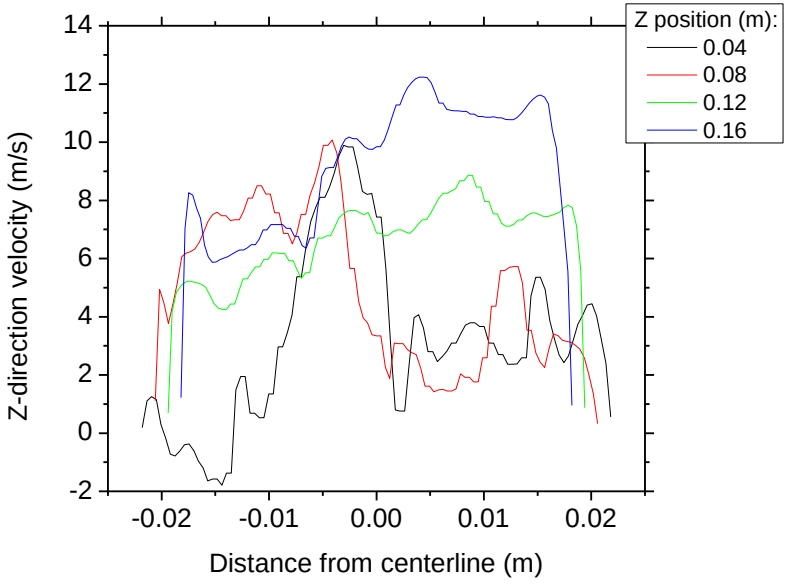
(Case 38.1b)

Spalart-Allmaraz Detached Eddy Turbulence Model
- *Velocity Magnitude*



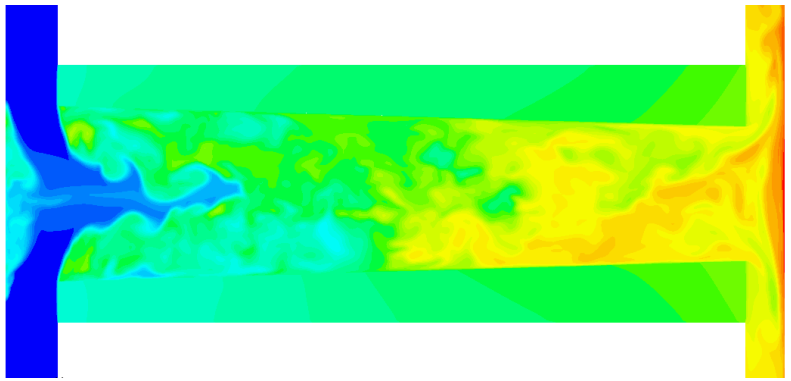


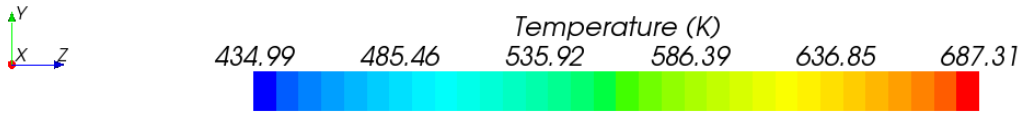


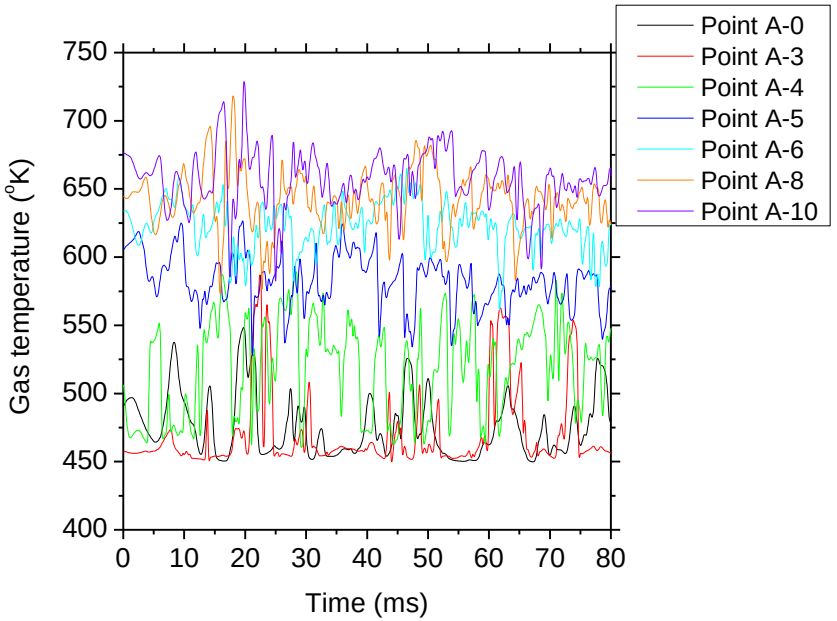


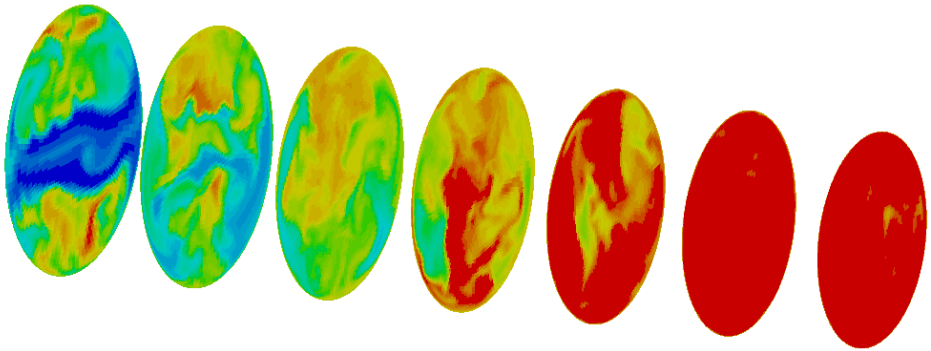
(Case 38.2b)

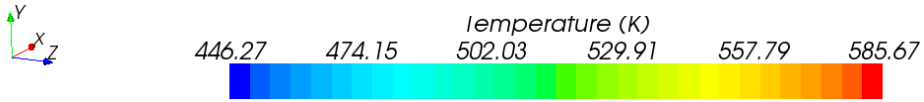
Spalart-Allmaraz Detached Eddy Turbulence Model
- *Temperature*





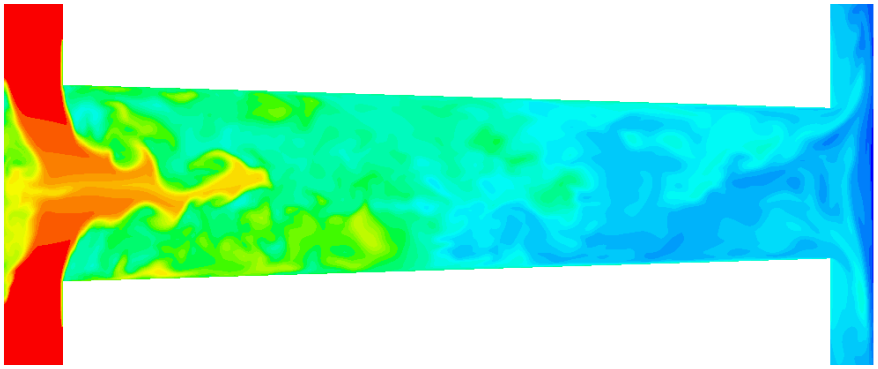


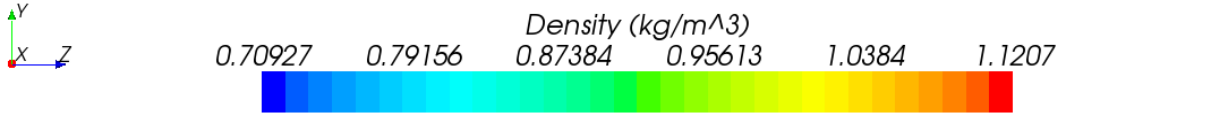


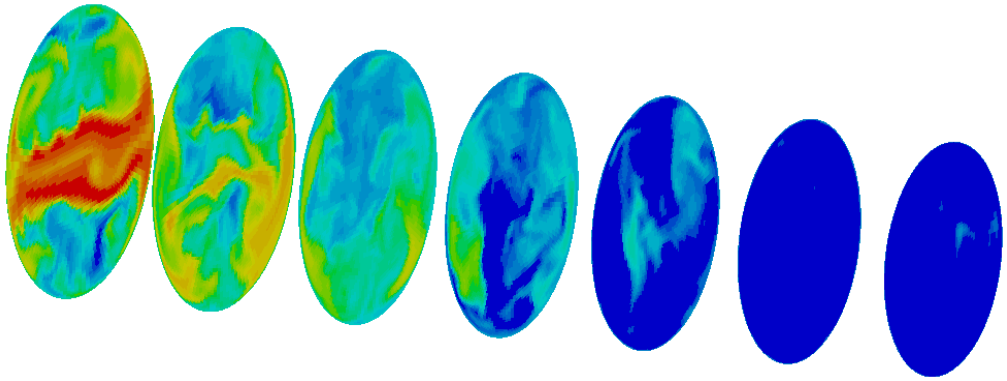


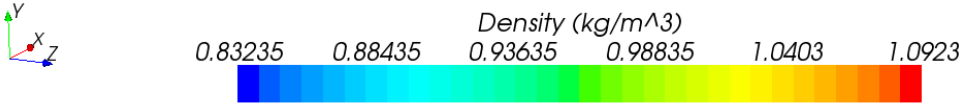
(Case 38.2b)

Spalart-Allmaraz Detached Eddy Turbulence Model
- *Temperature*



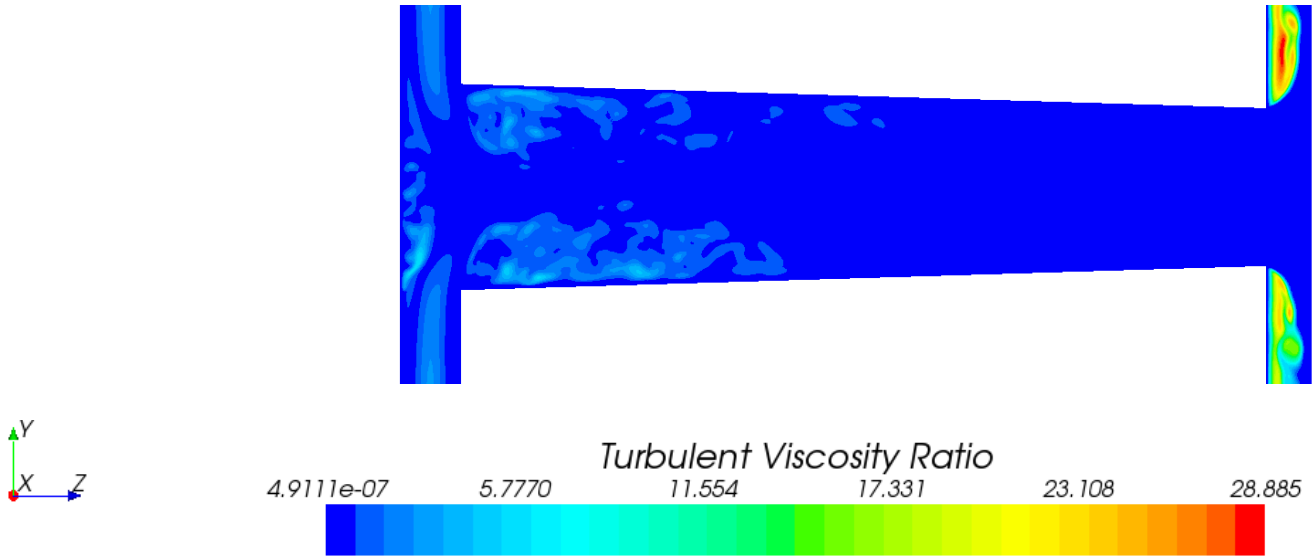






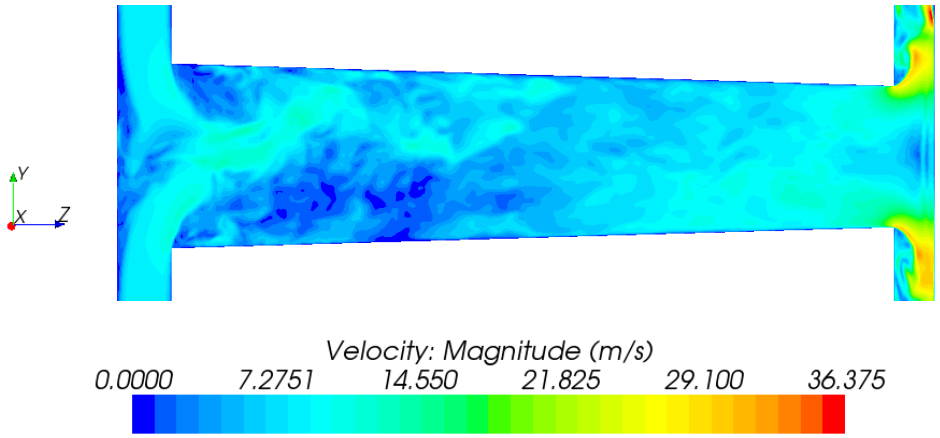
(Case 38.2b)

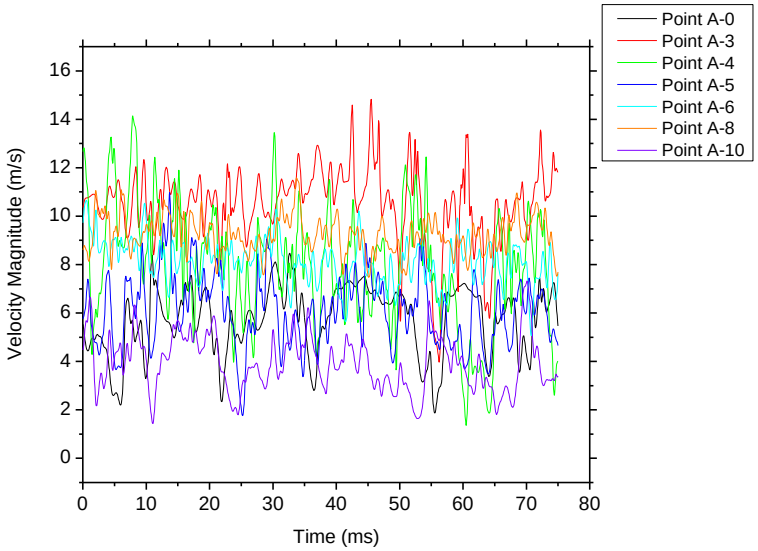
Spalart-Allmaraz Detached Eddy Turbulence Model
- *Turbulent Viscosity Ratio*

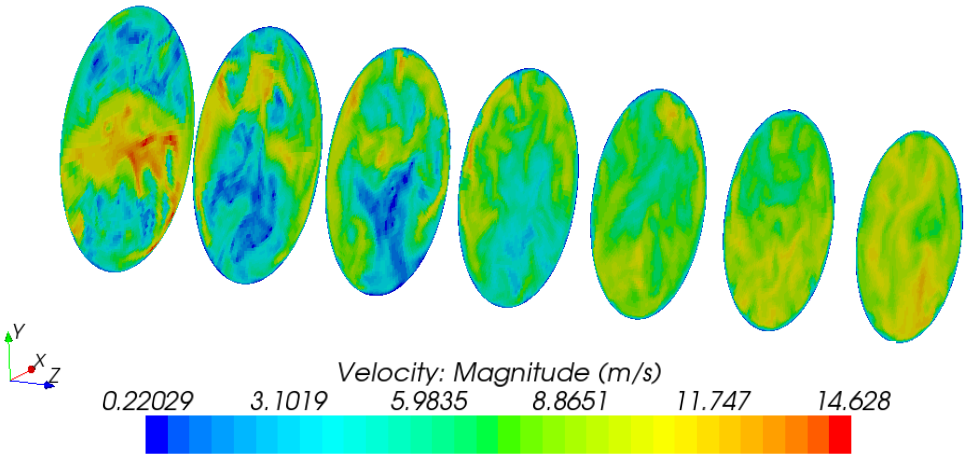


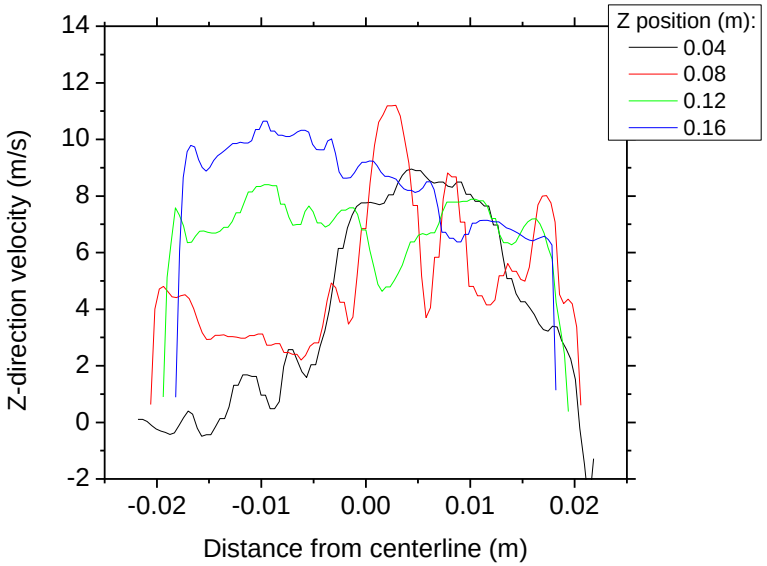
(Case 38.2b)

Large Eddy Simulation Turbulence Model
- *Velocity Magnitude*



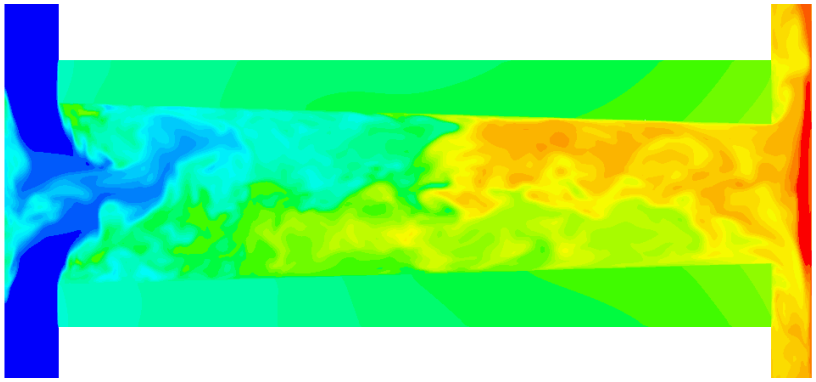


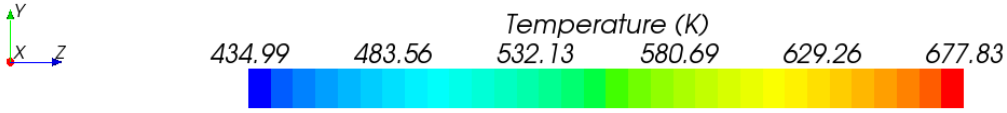


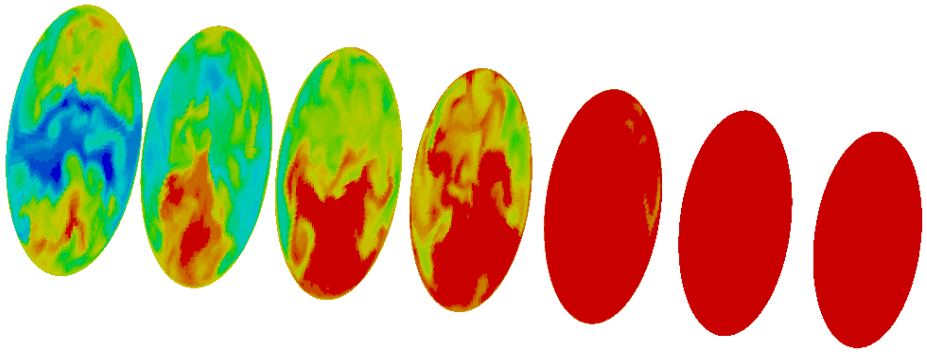


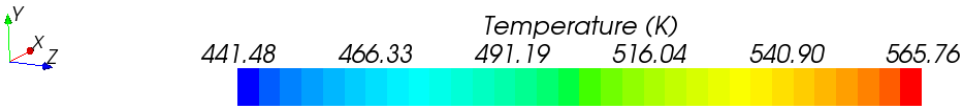
(Case 38.3b)

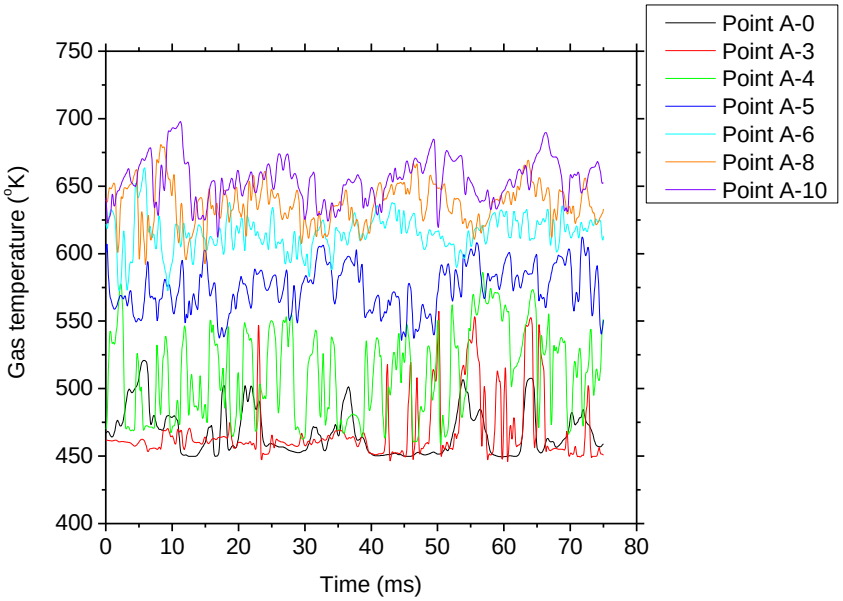
Large Eddy Simulation Turbulence Model
- *Temperature*





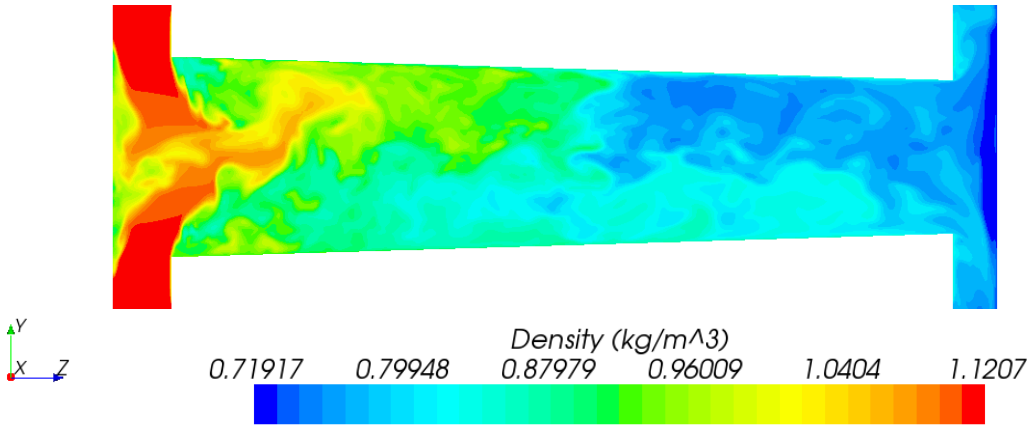


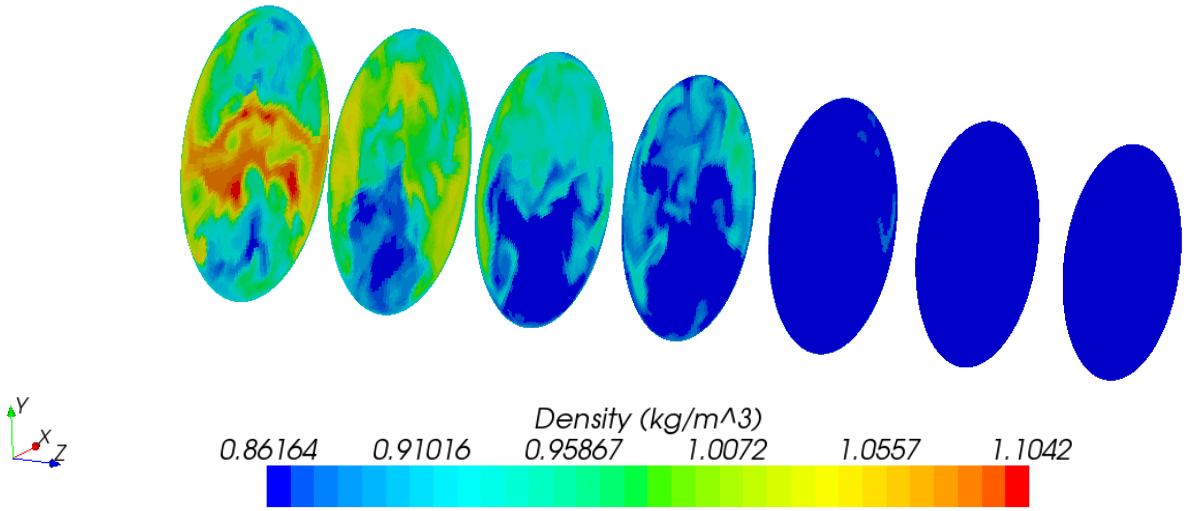




(Case 38.3b)

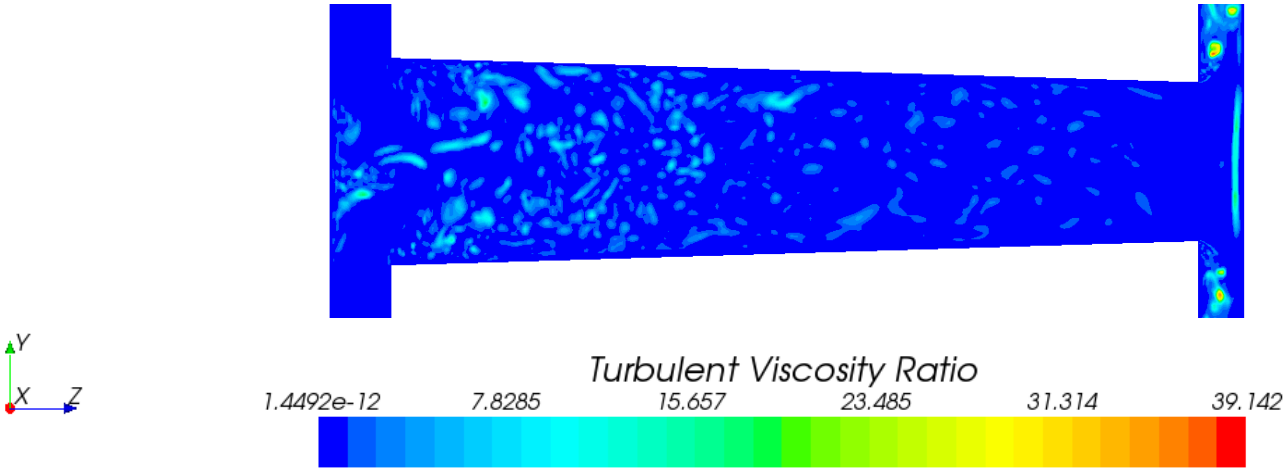
Large Eddy Simulation Turbulence Model
- *Density*





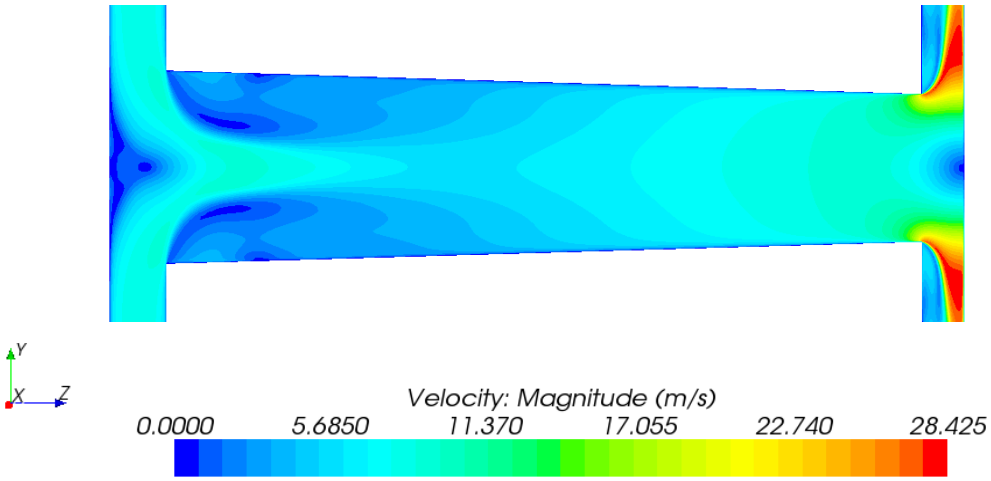
(Case 38.3b)

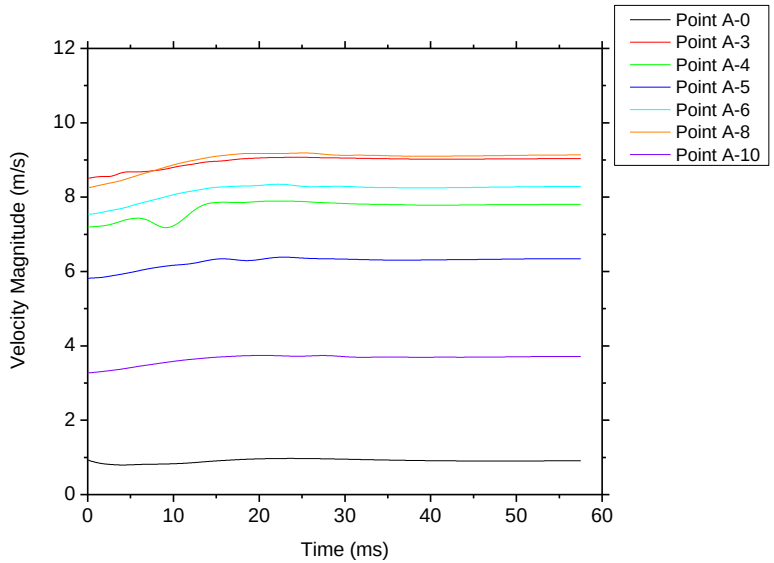
Large Eddy Simulation Turbulence Model
- *Turbulent Viscosity Ratio*

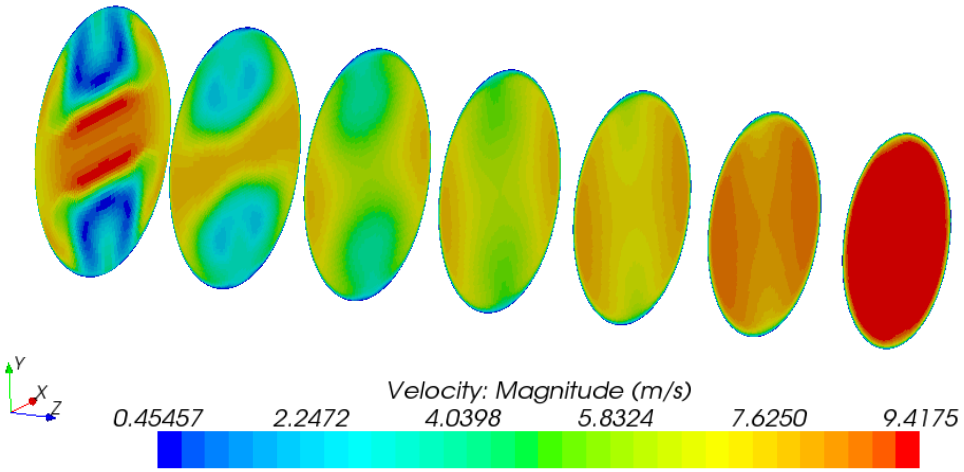


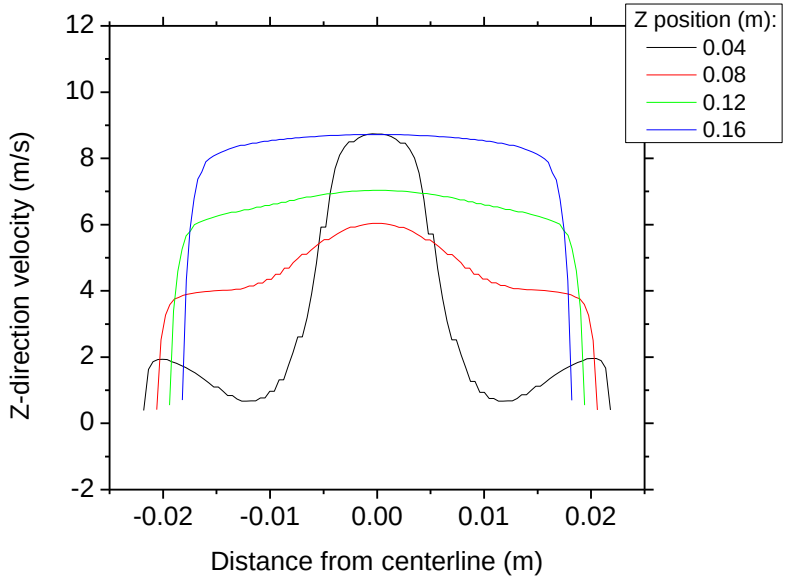
(Case 38.3b)

k-ε Turbulence Model
- *Velocity Magni*tude



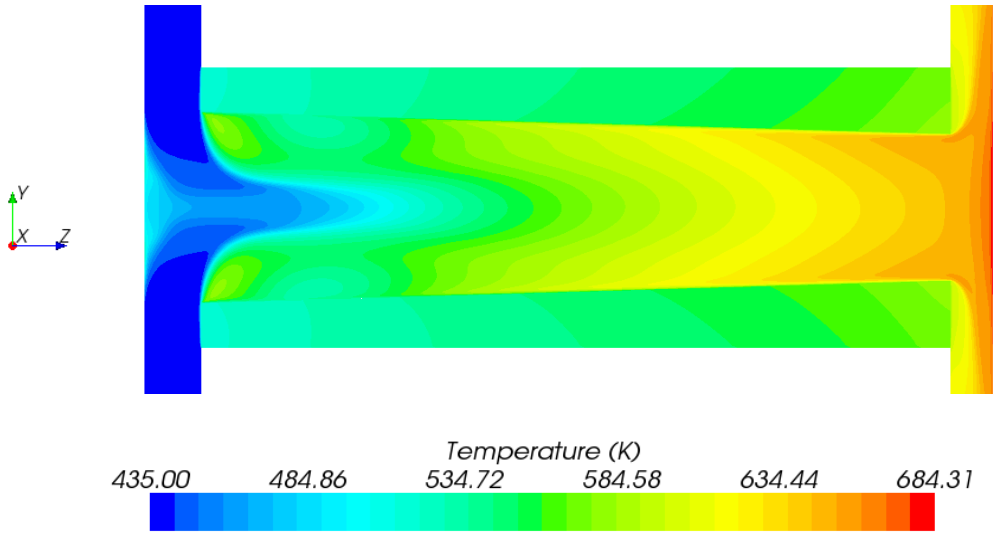


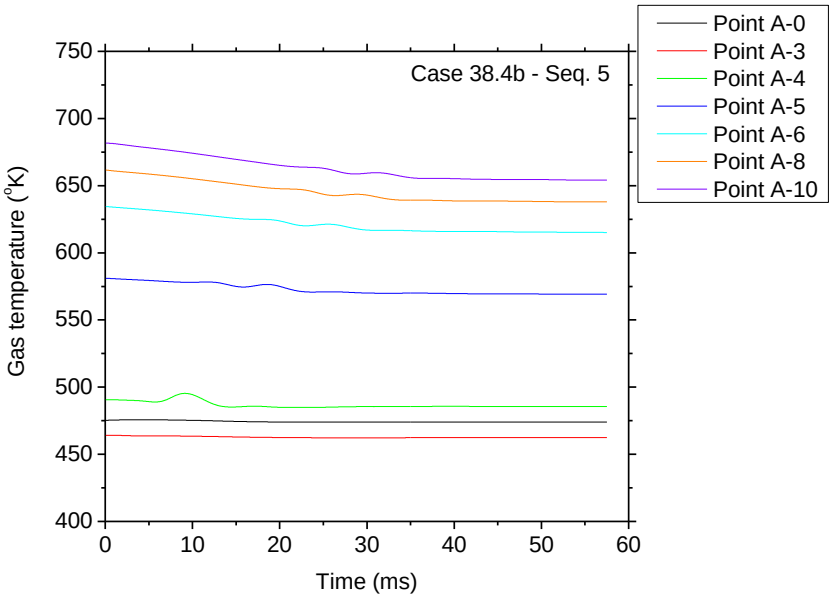


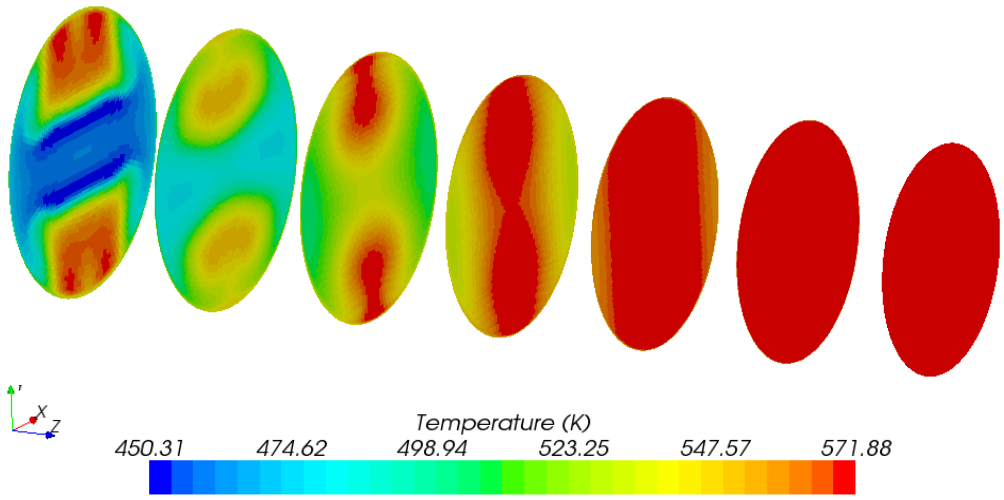


(Case 38.4b)

k-ε Turbulence Model
- *Temperature*

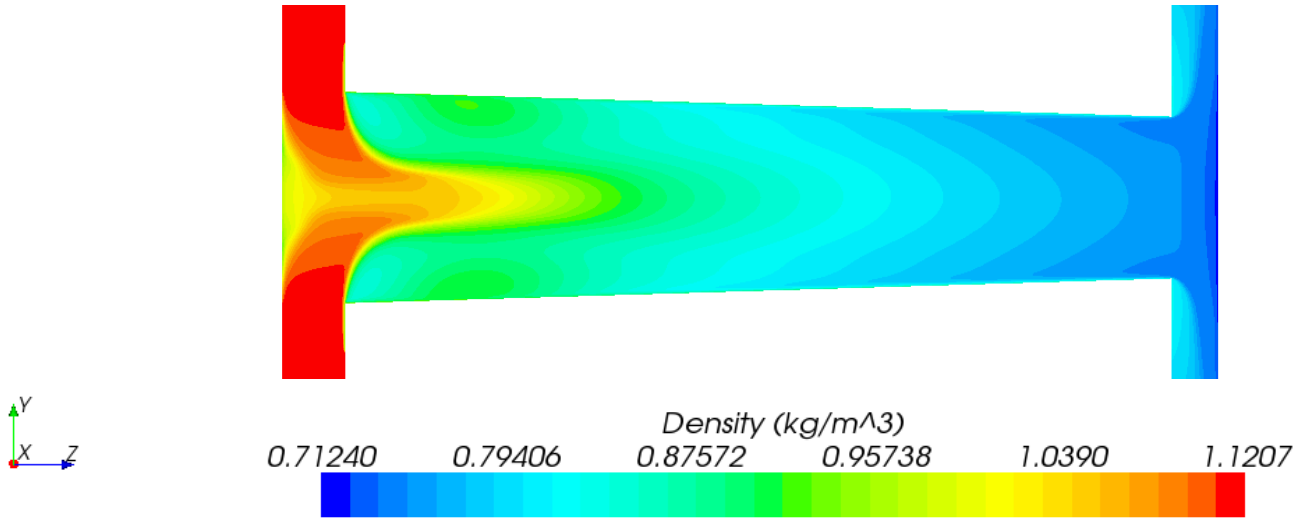


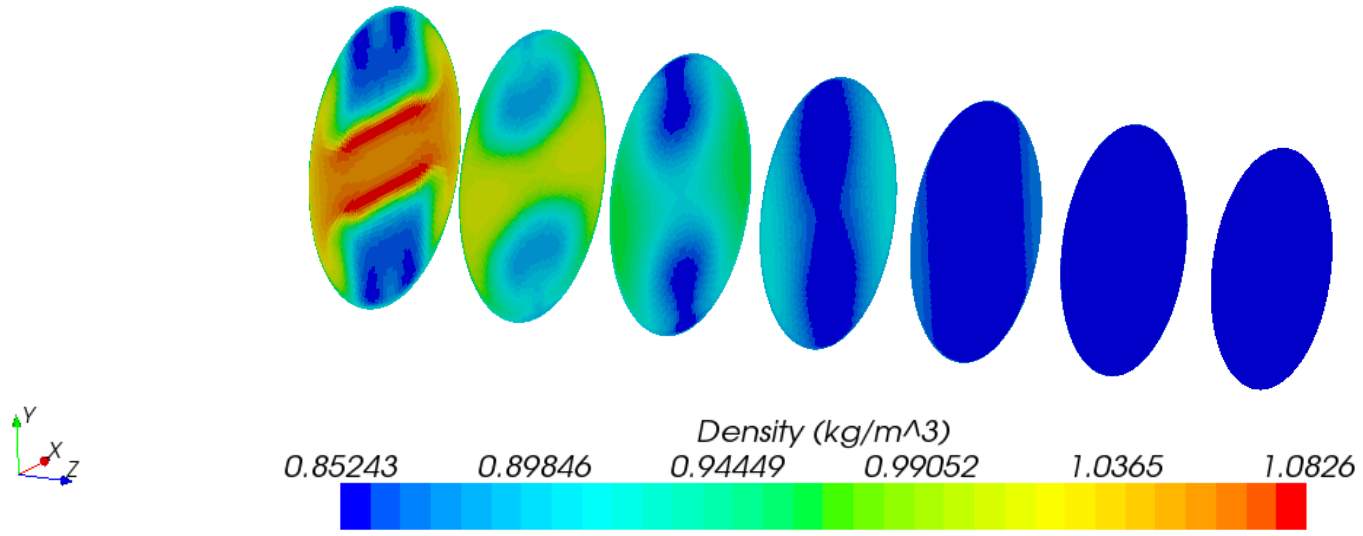




(Case 38.4b)

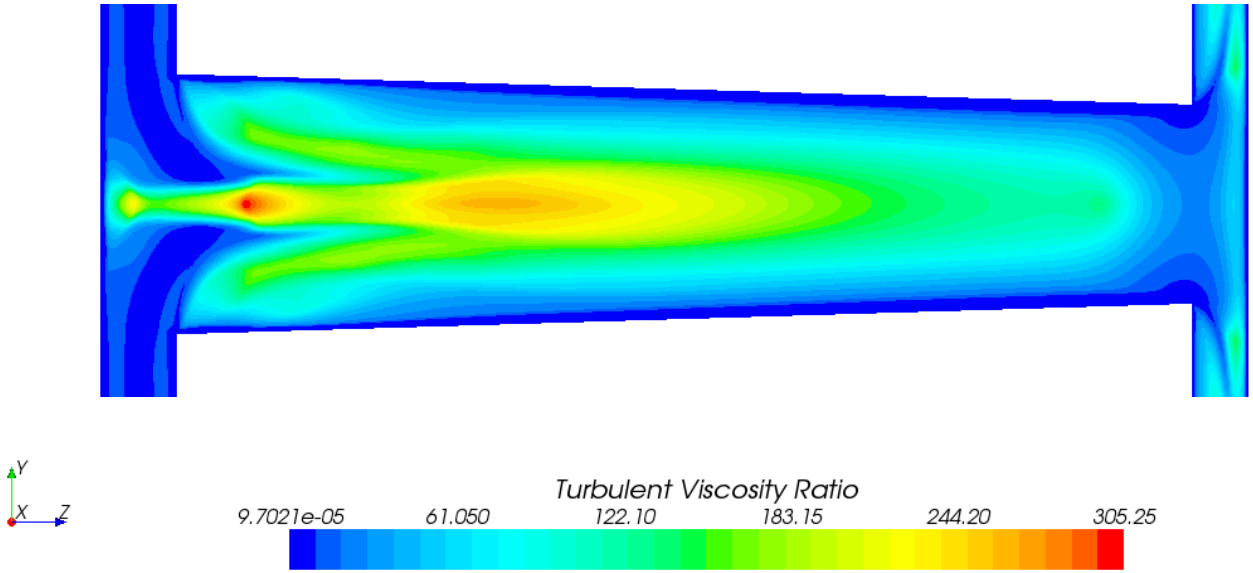
k-ε Turbulence Model
- *Density*





(Case 38.4b)

k-ε Turbulence Model
- *Turbulent Viscosity Ratio*



(Case 38.4b)