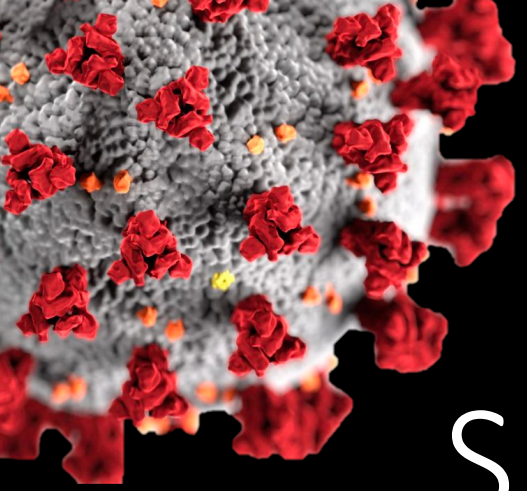

SU2 Analysis in Support of Worldwide Ventilator Effort

Presented by:

Jayant Mukhopadhaya

SU2 foundation

WORLDWIDE VENTILATOR

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Associated Press

Hindustan Times, Raj K Raj

SARS-CoV-2 Pandemic of 2019-2020

SFGate, Douglas Zimmerman

Associated Press

What can we do?

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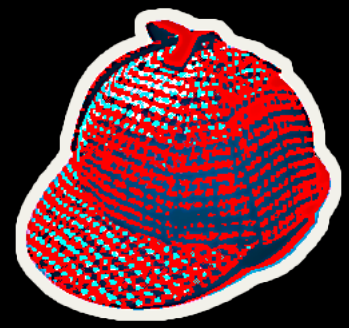
One email… Two hours later



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University of Strathclyde

Imperial College London

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Airflow Sciences Corporation

Stanford MEDICINE

Stanford University

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RAFAEL
SMART AND TO THE POINT

TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

POLITECNICO MILANO 1863

Mechanical Ventilation

- Helps patients breathe in times of respiratory distress
- $25,000 to $50,000
- Highly customizable to patients needs

Can we make them:

- Mass-producable
- Cheap ~$10
- Conserve core functionality

Army Emergency Respirator

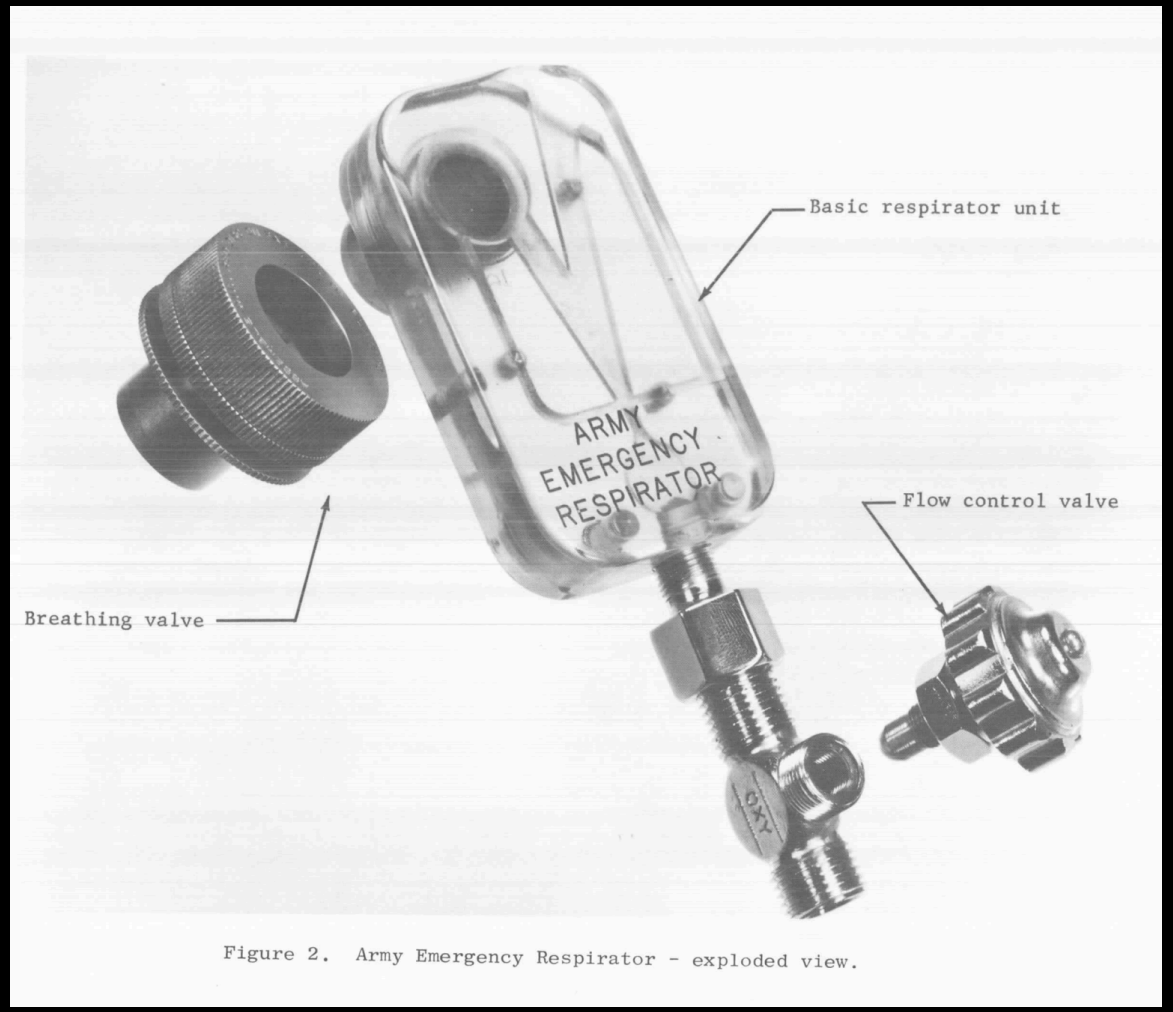


Figure 2. Army Emergency Respirator - exploded view.

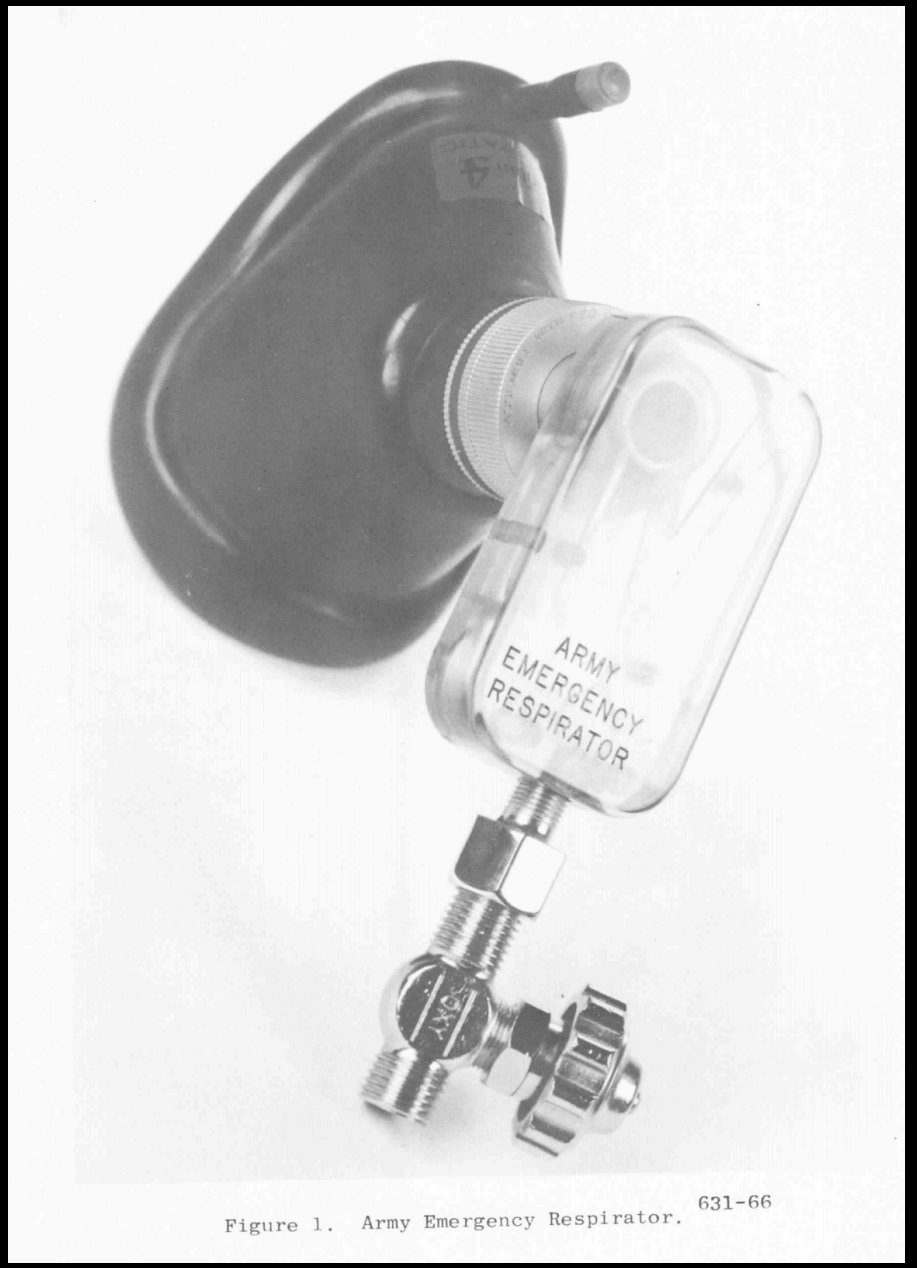
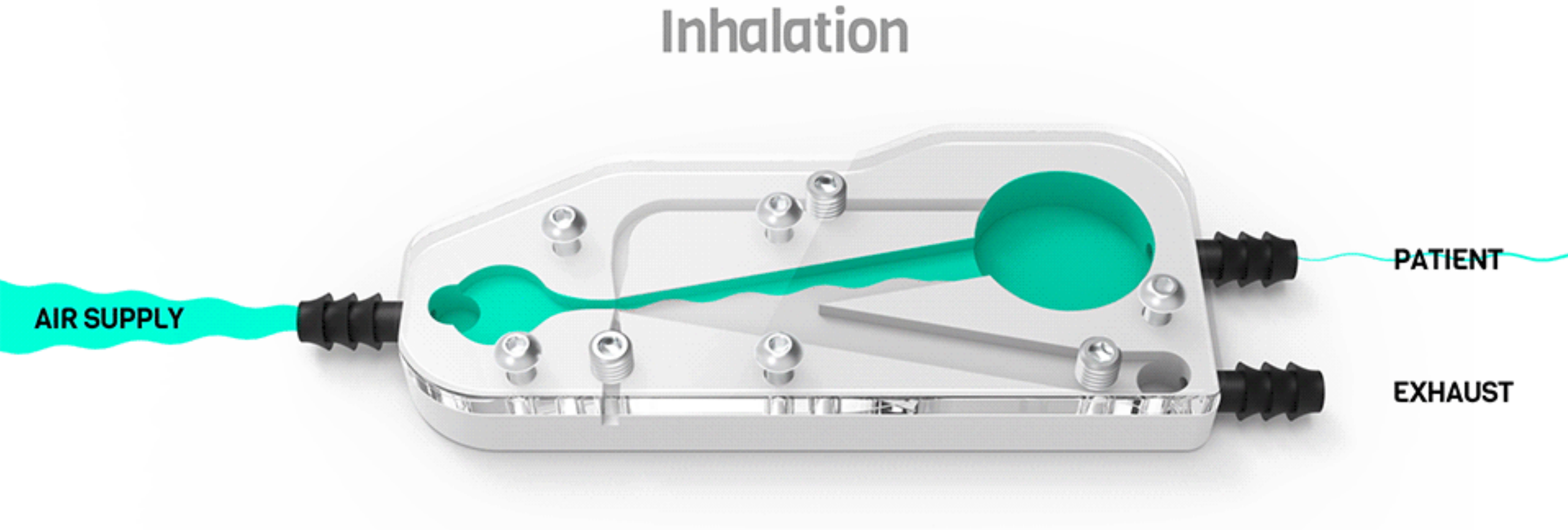


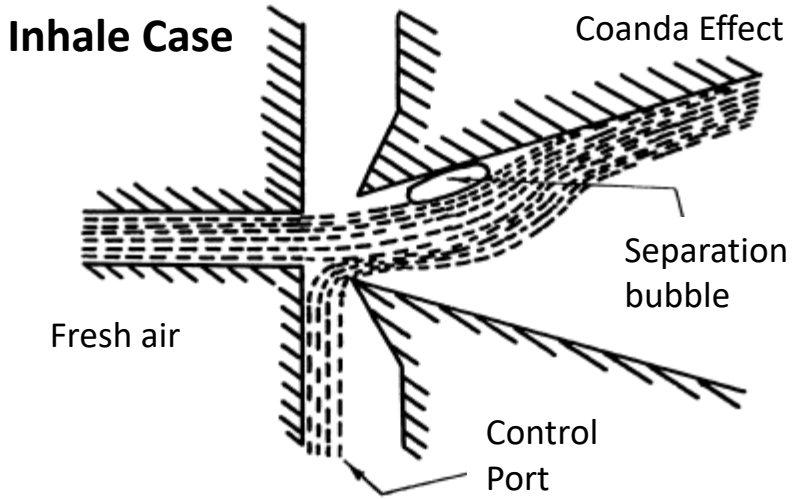
Figure 1. Army Emergency Respirator. 631-66

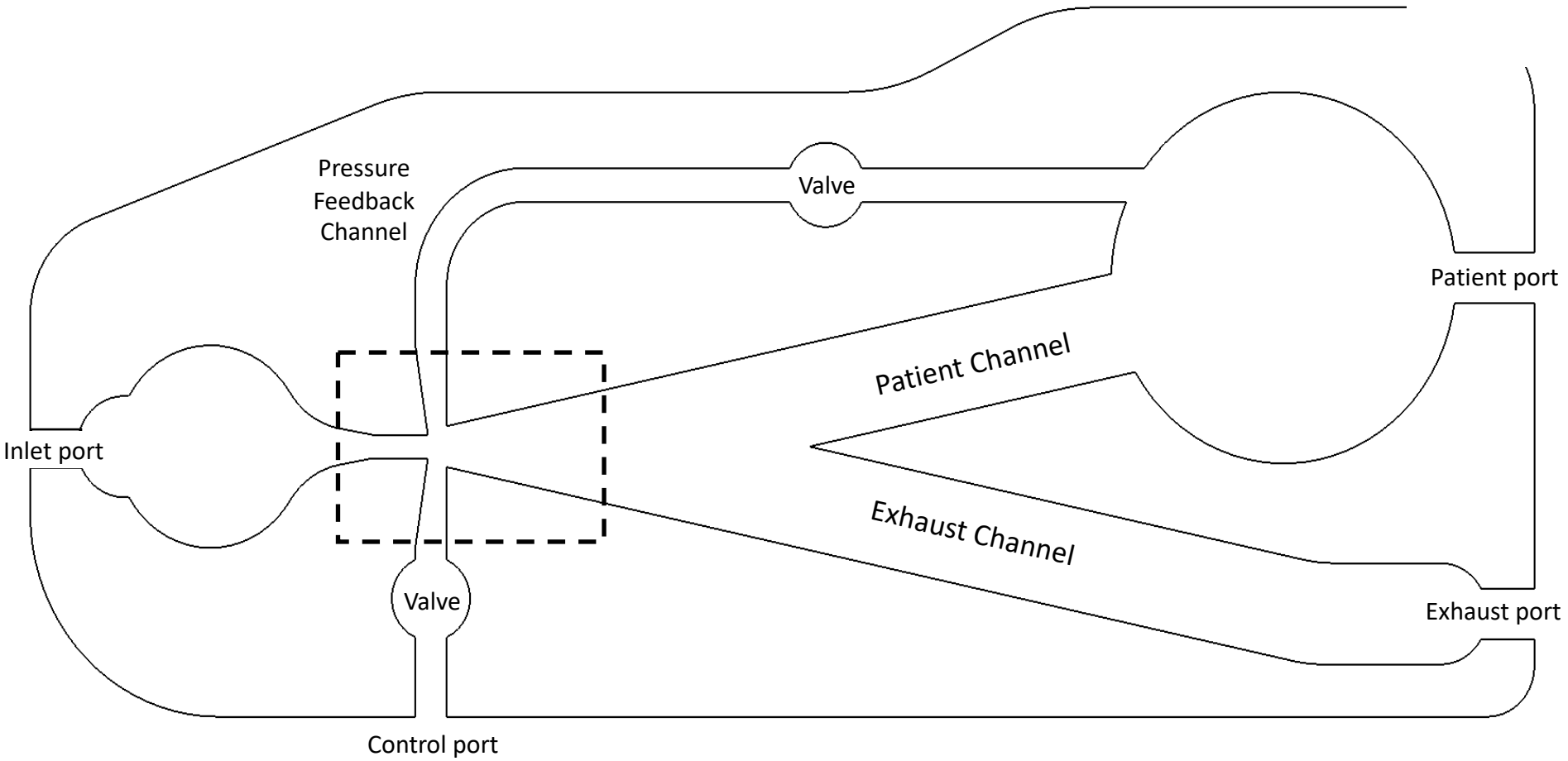
JW Joyce Jr., *The Army Emergency Respirator* published in 1968 by Harry Diamond Laboratories

Device Operation

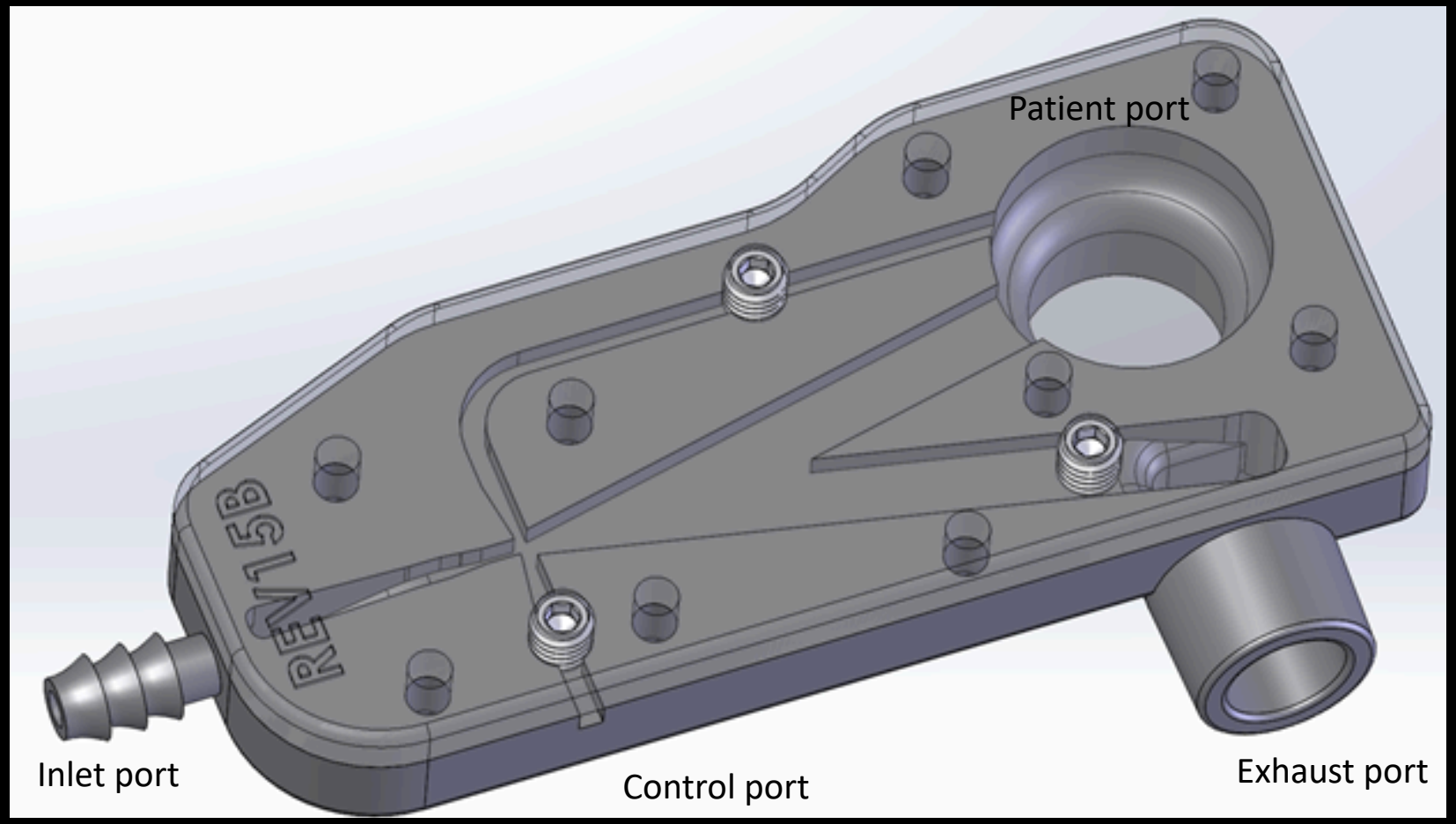


Bi-Stable Jet Oscillator

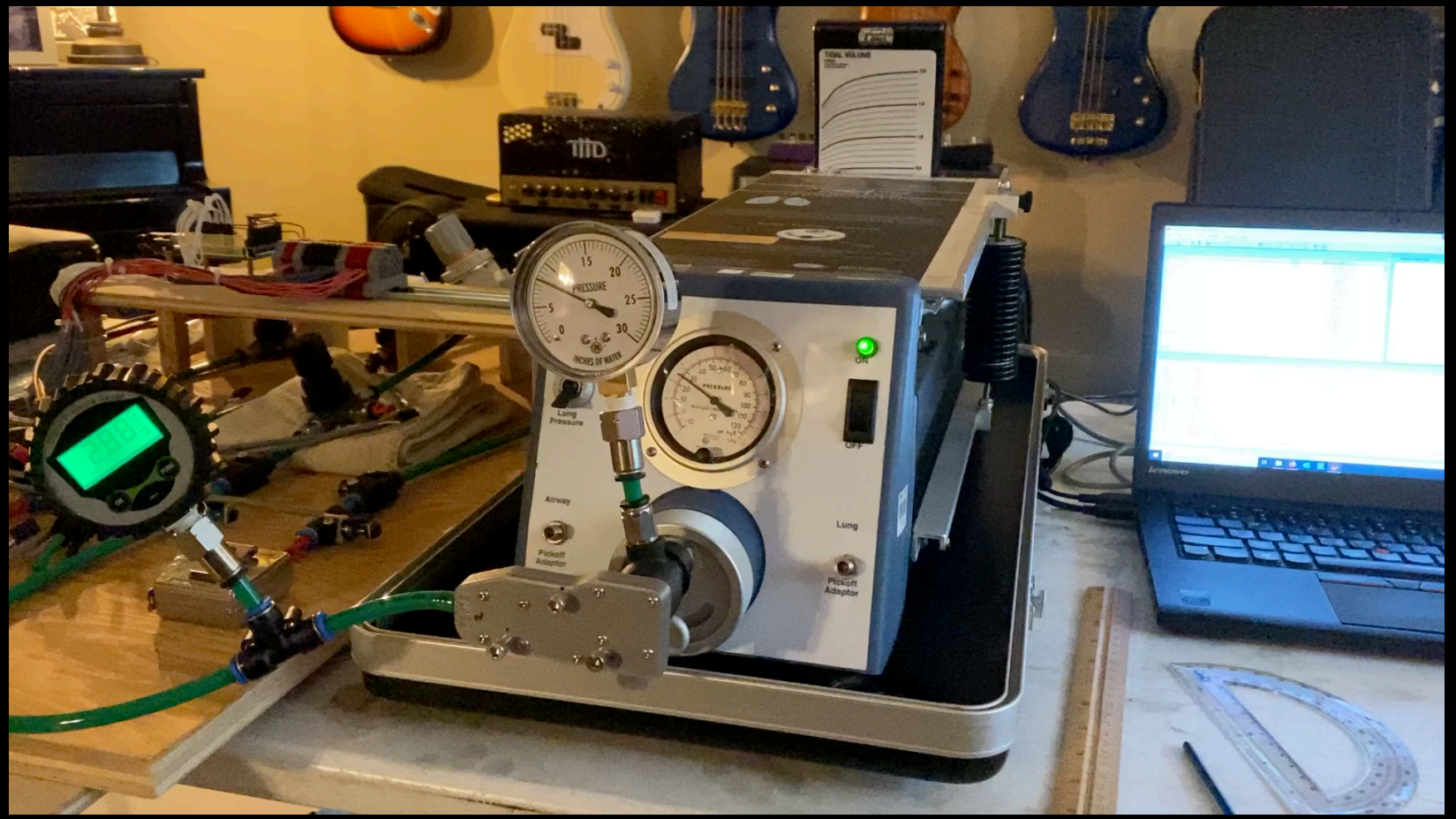


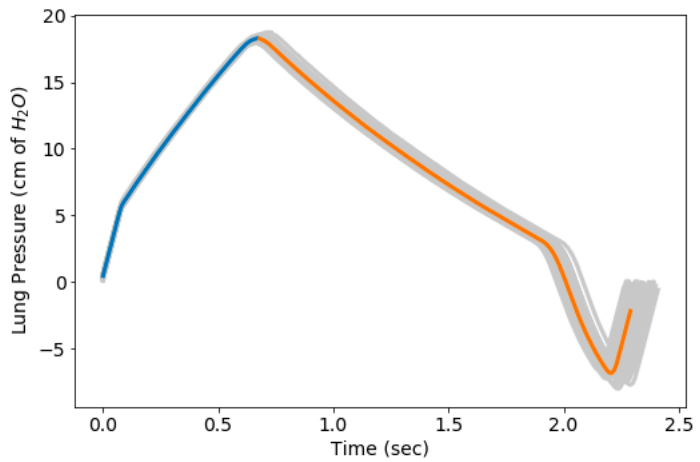


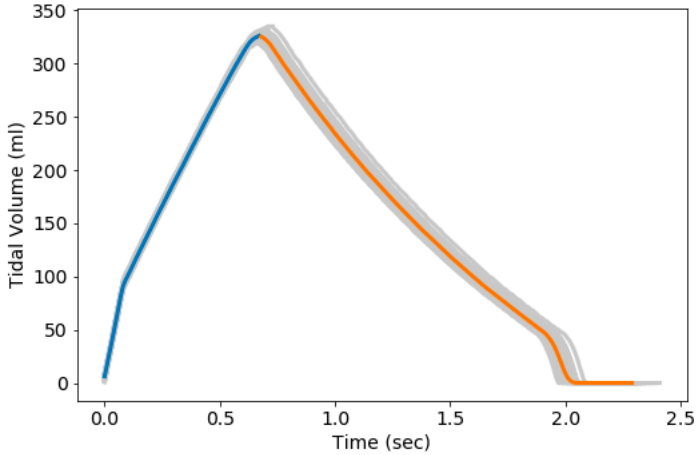
Mass-Production-friendly design

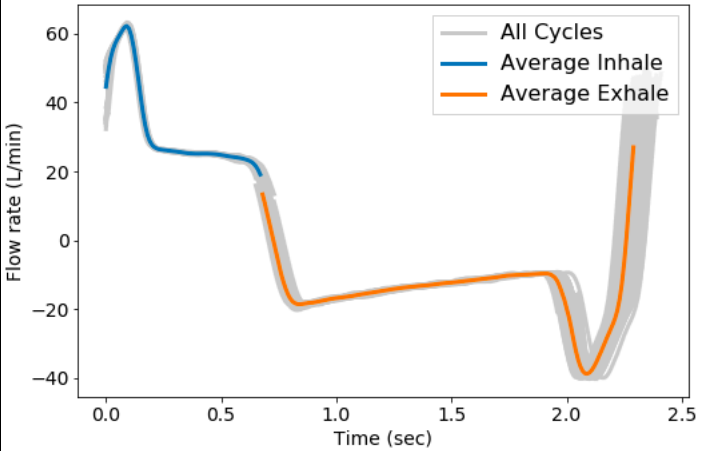


Experimental Setup + Rapid Prototyping









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Objectives for Collaboration

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- Ability to rapidly prototype
- Experimental setup to characterize device performance
- Connections with medical personnel to provide feedback
- Expertise in manufacturing

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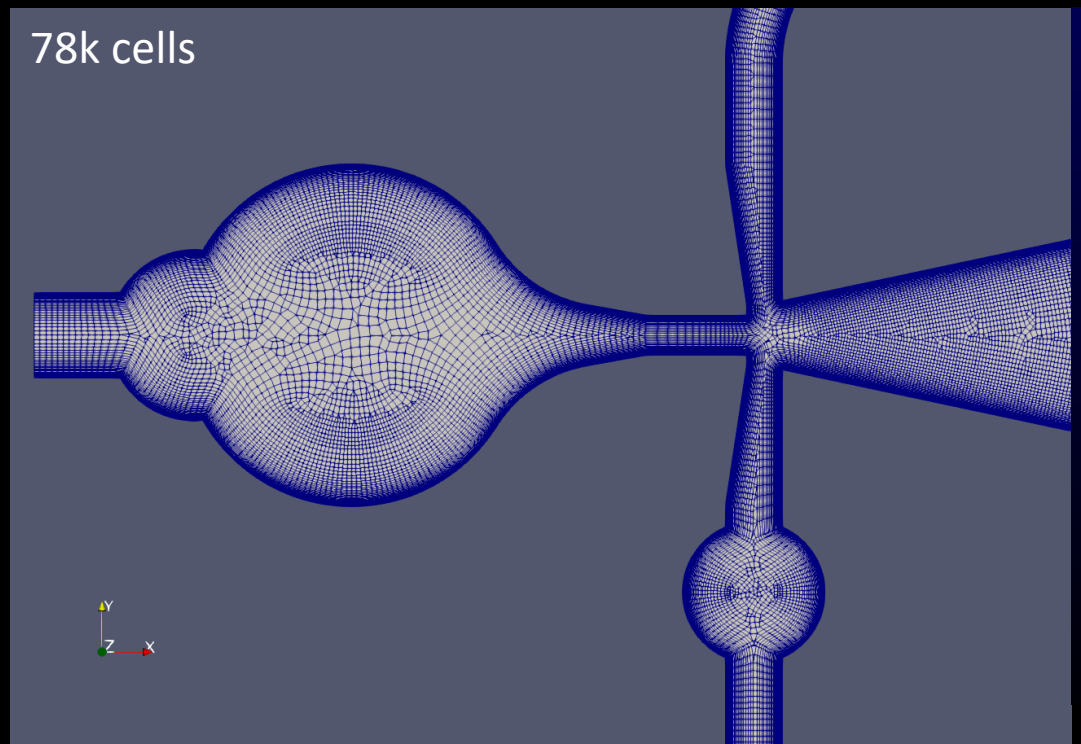
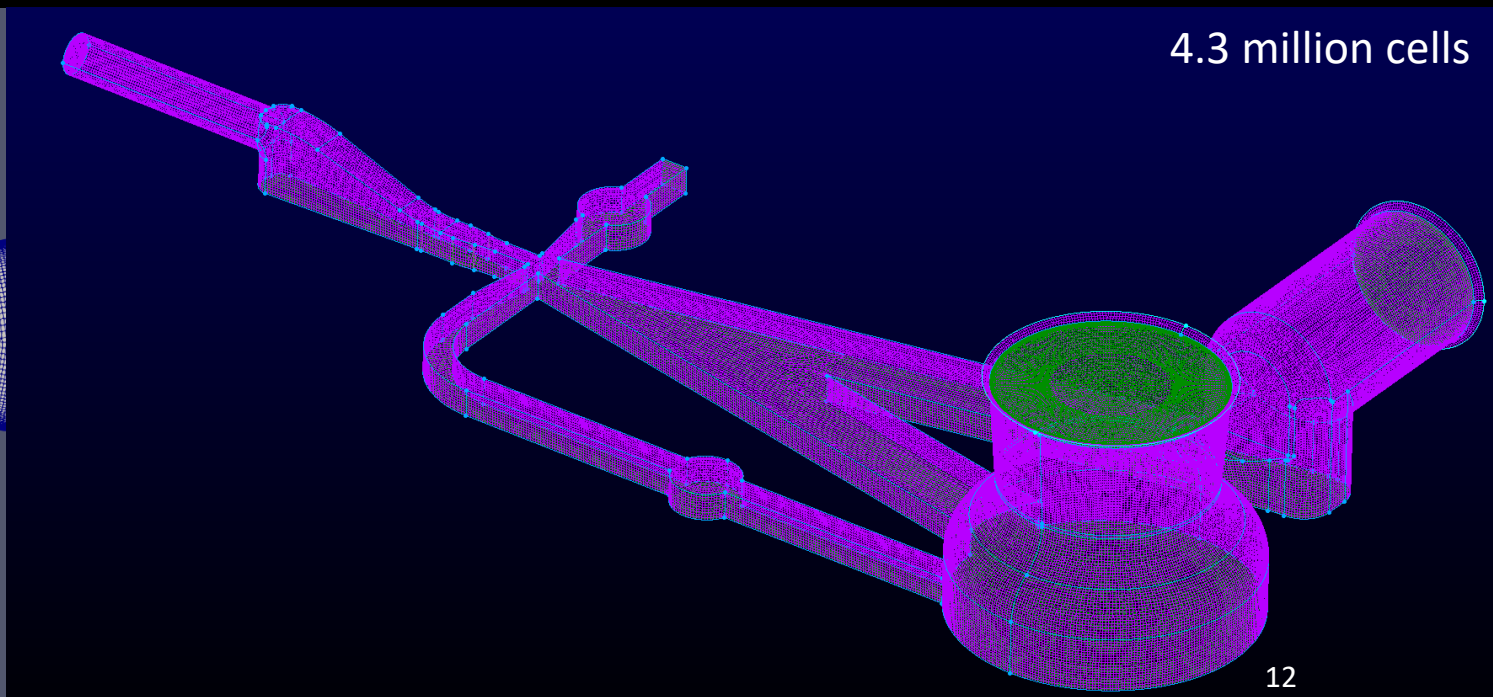
- Provide physics-based background for device operation
- Suggest improvements based on internal flow dynamics
- Characterize effects of valve positions on flow rates

Meshing

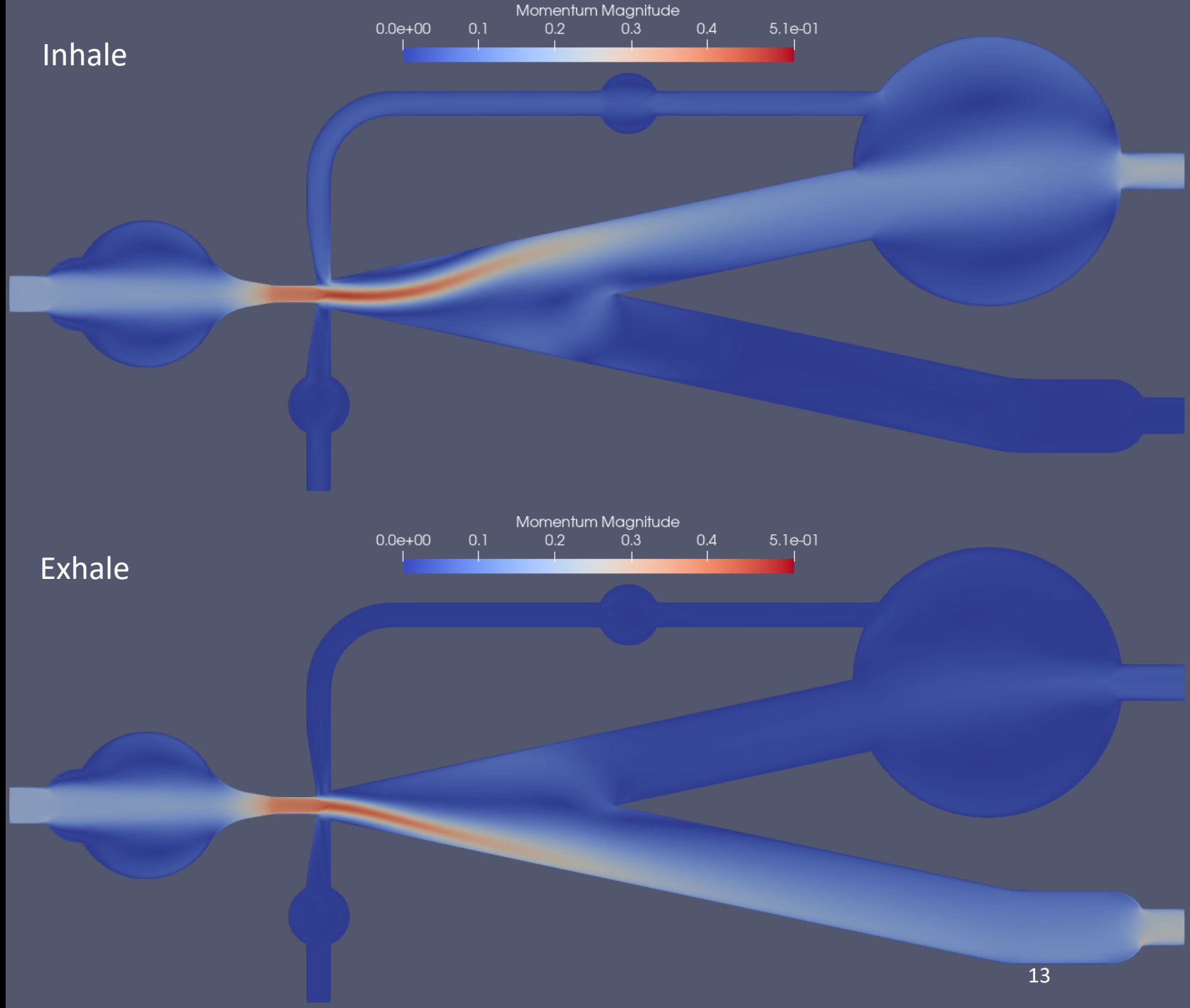
- Used pointwise to automate meshing for multiple valve locations
- Boundary layer mesh created using Trex ($y^+ \approx 1$)





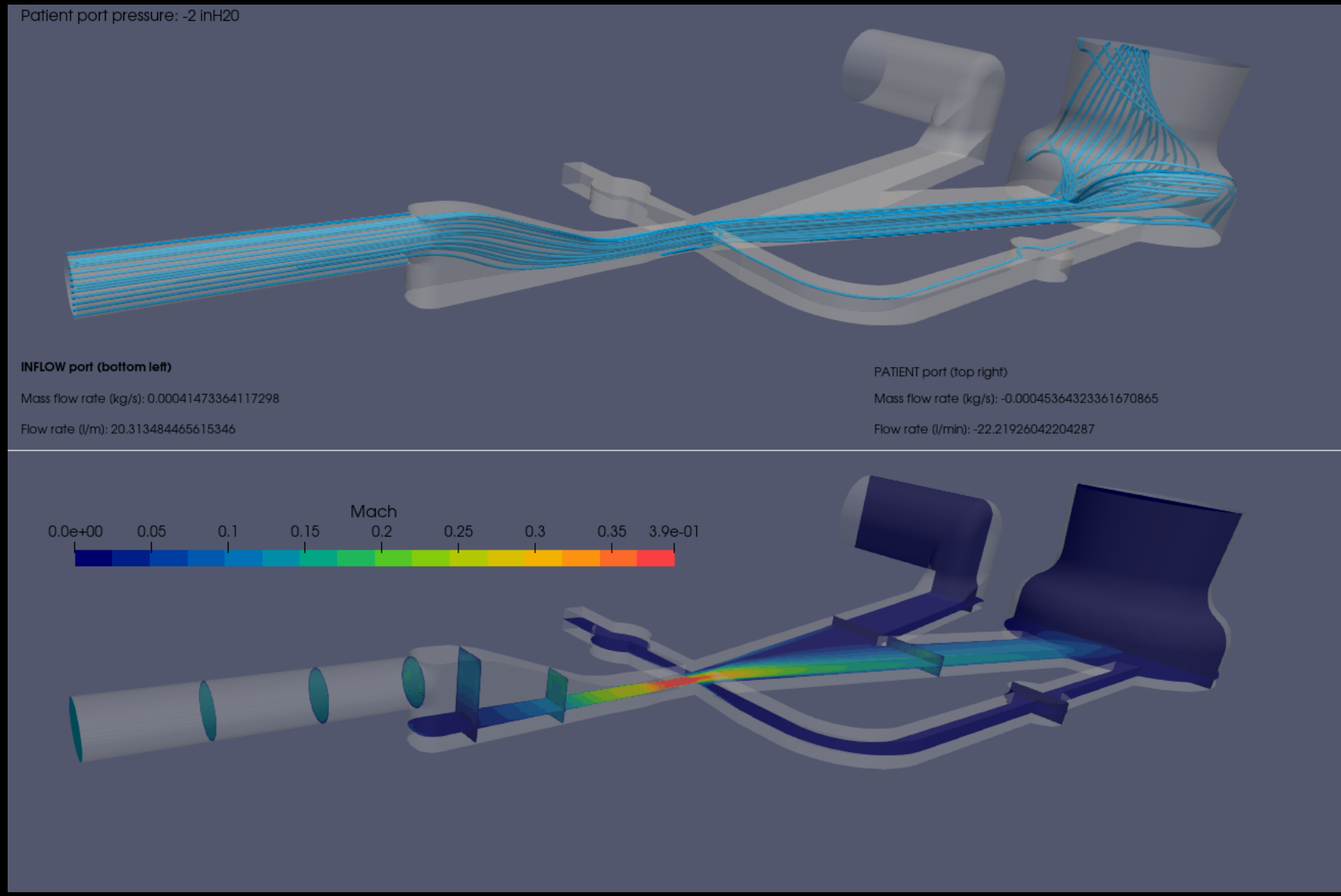
2D Simulations

- Started with a simple 2D model
- Boundary conditions defined by performance requirements
- Separation bubble well defined in the inhale case



3D Inhale Case

- Large area changes cause significant recirculation
- 3 orders of residual reduction
- Average Mass Flow at patient port is converged to 6 orders of magnitude (Cauchy)



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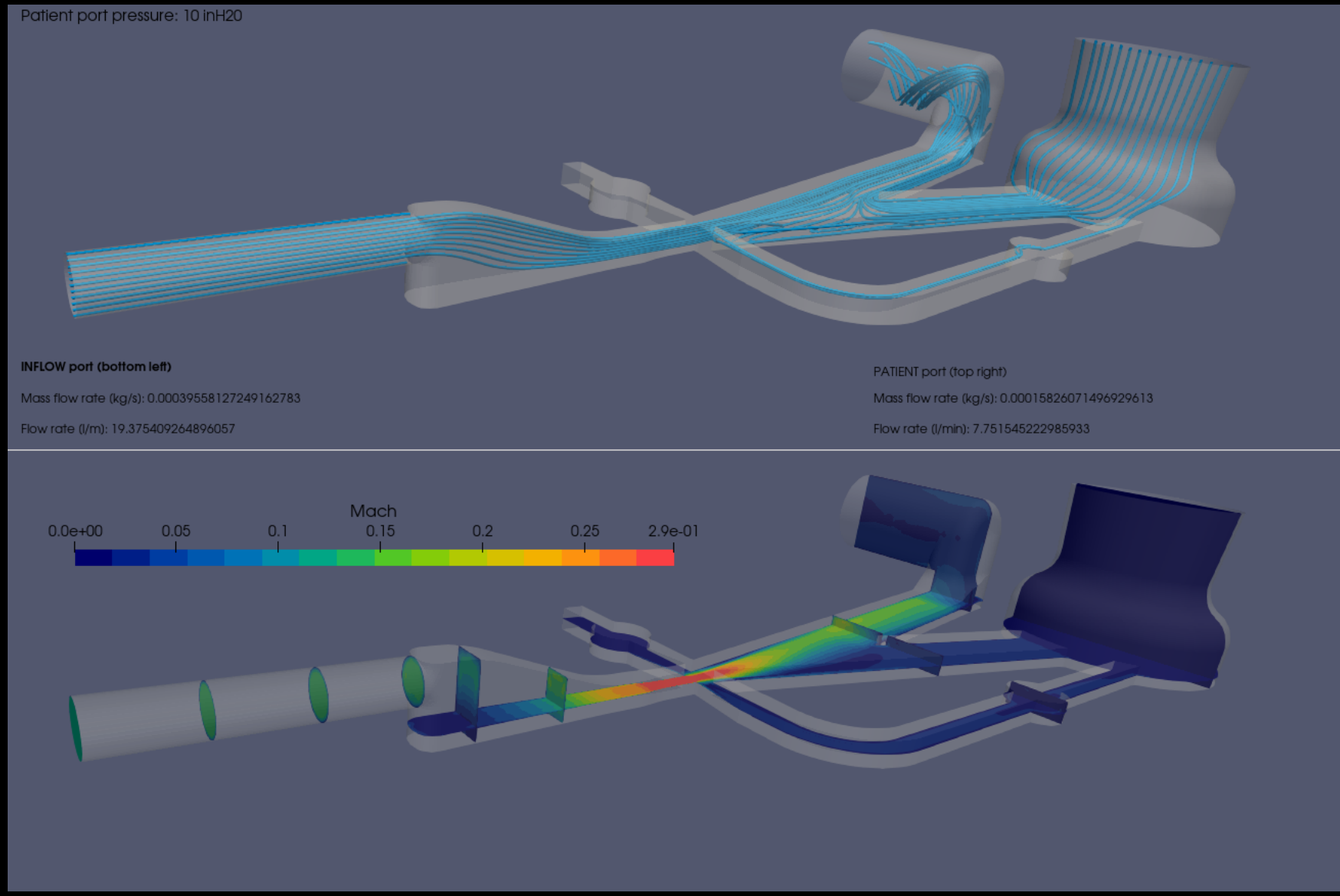
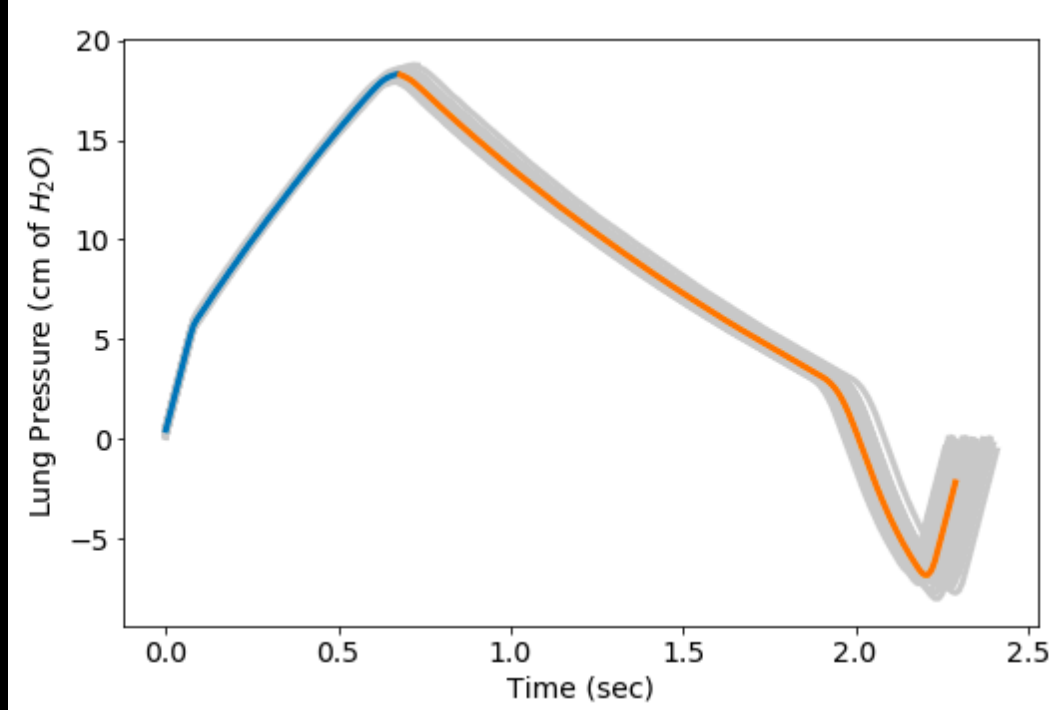
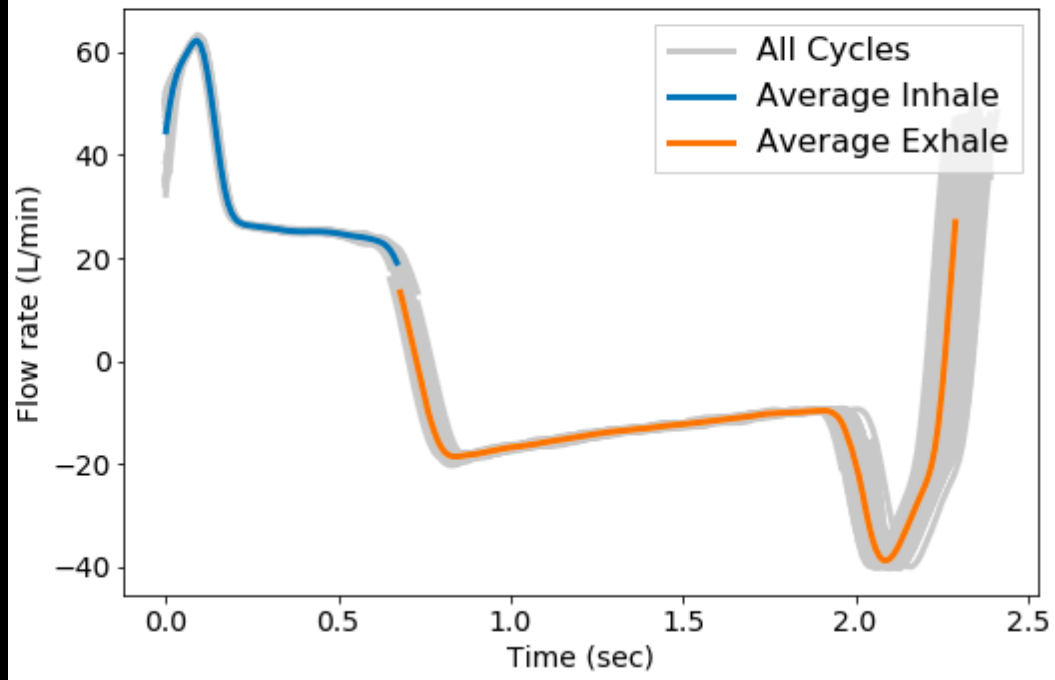


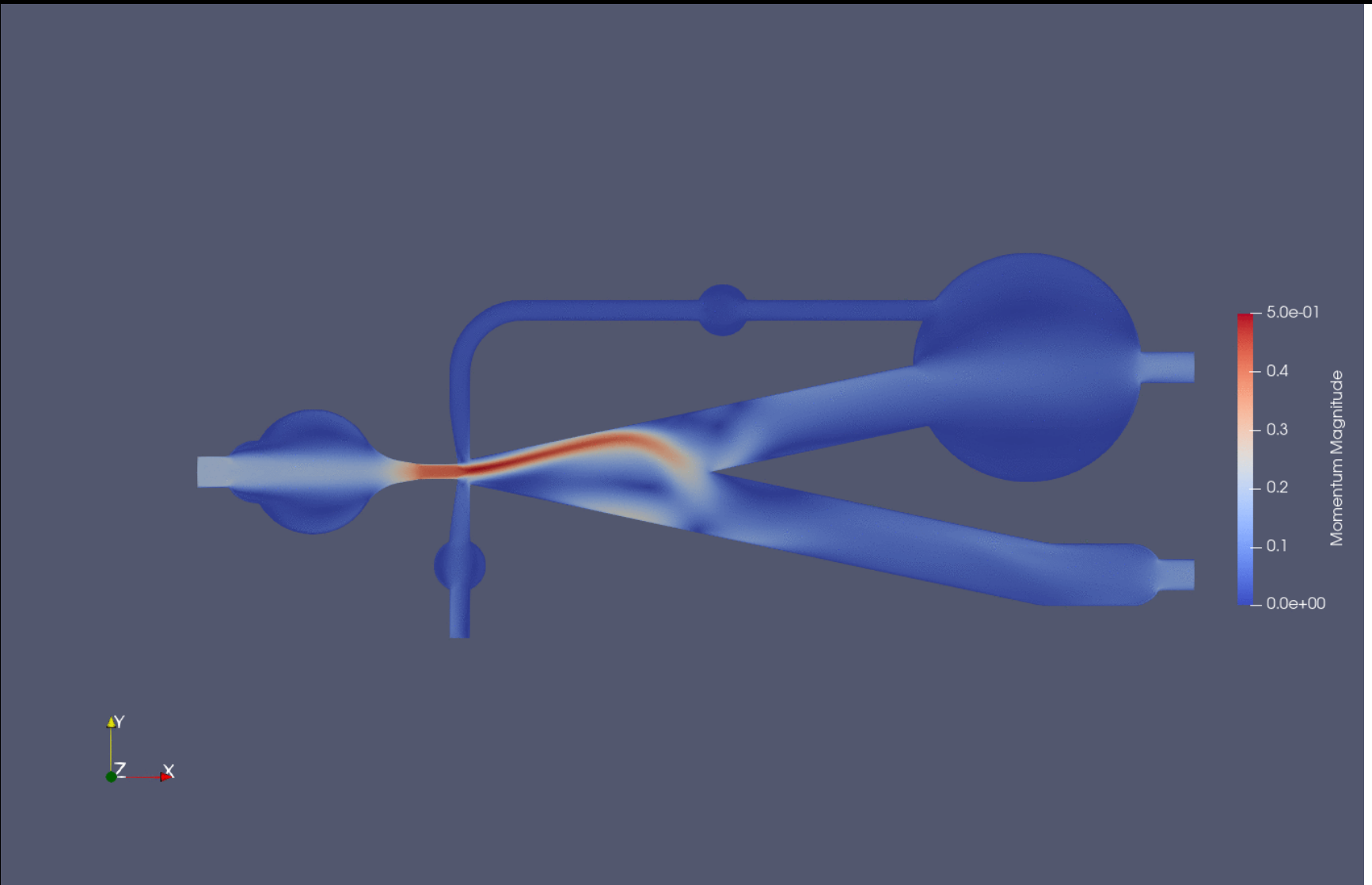
SU2 Development

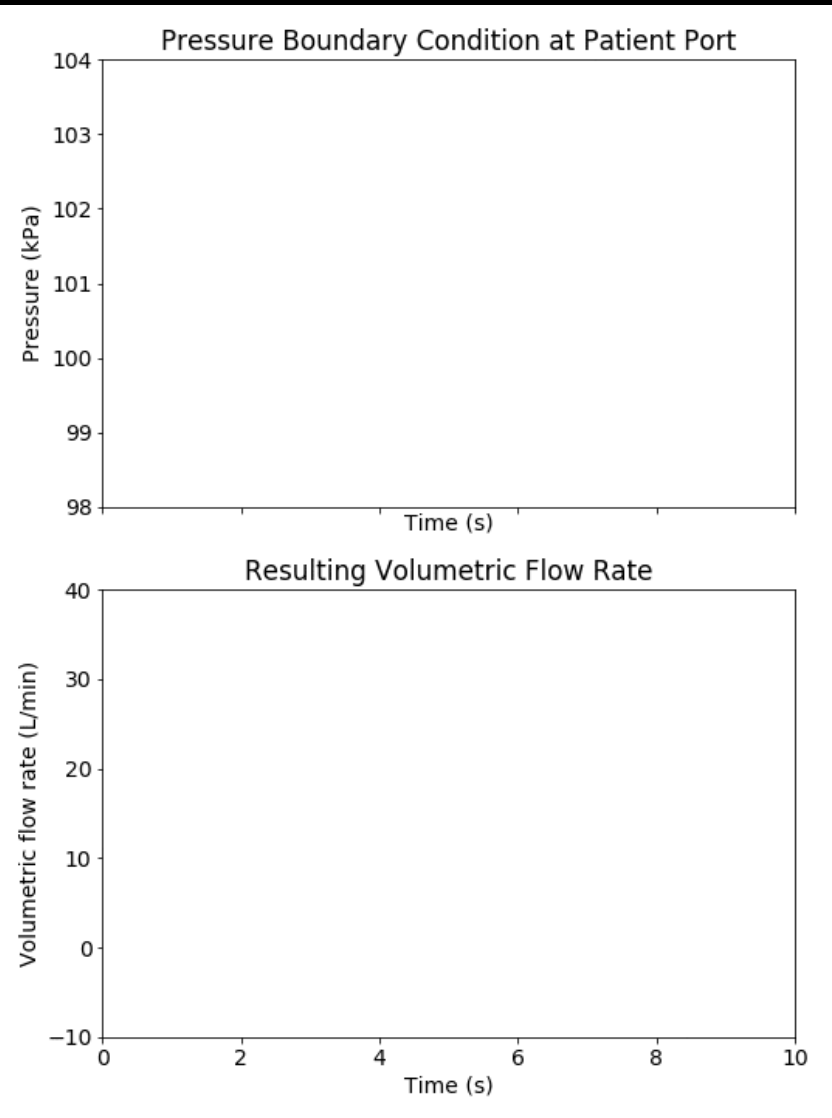
- Boundary conditions are unsteady!
- Make use of expression language (#913)
- Able to define a time varying boundary conditions
- Can switch types of BC (inlet ↔ outlet)



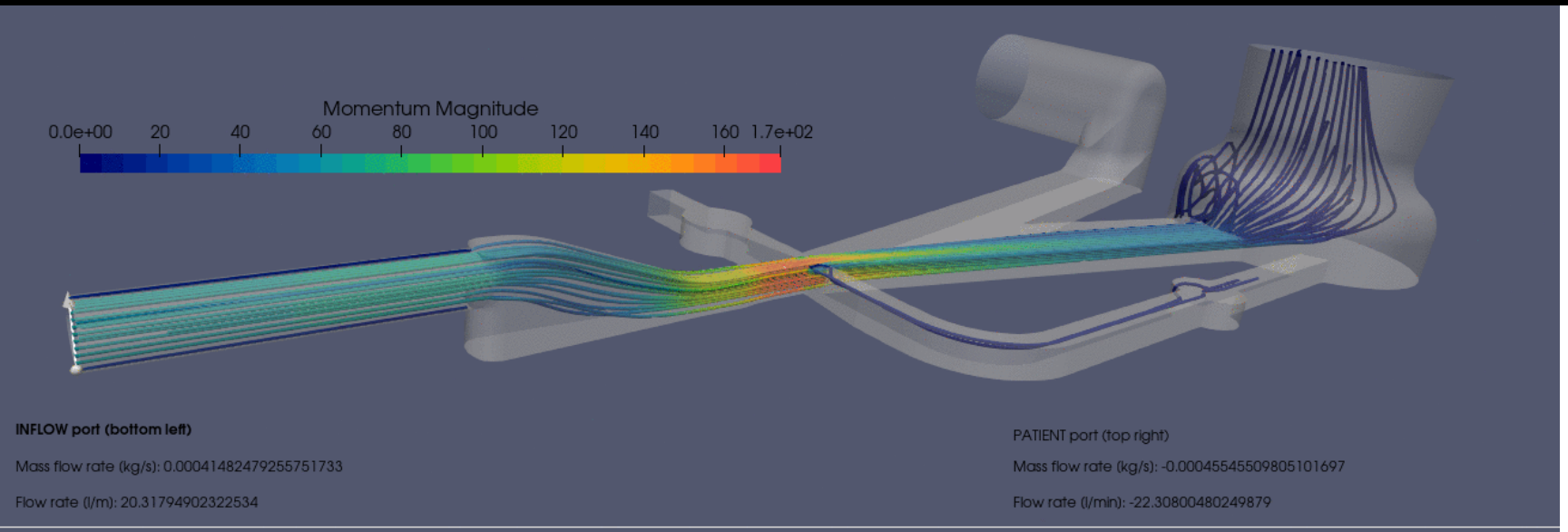


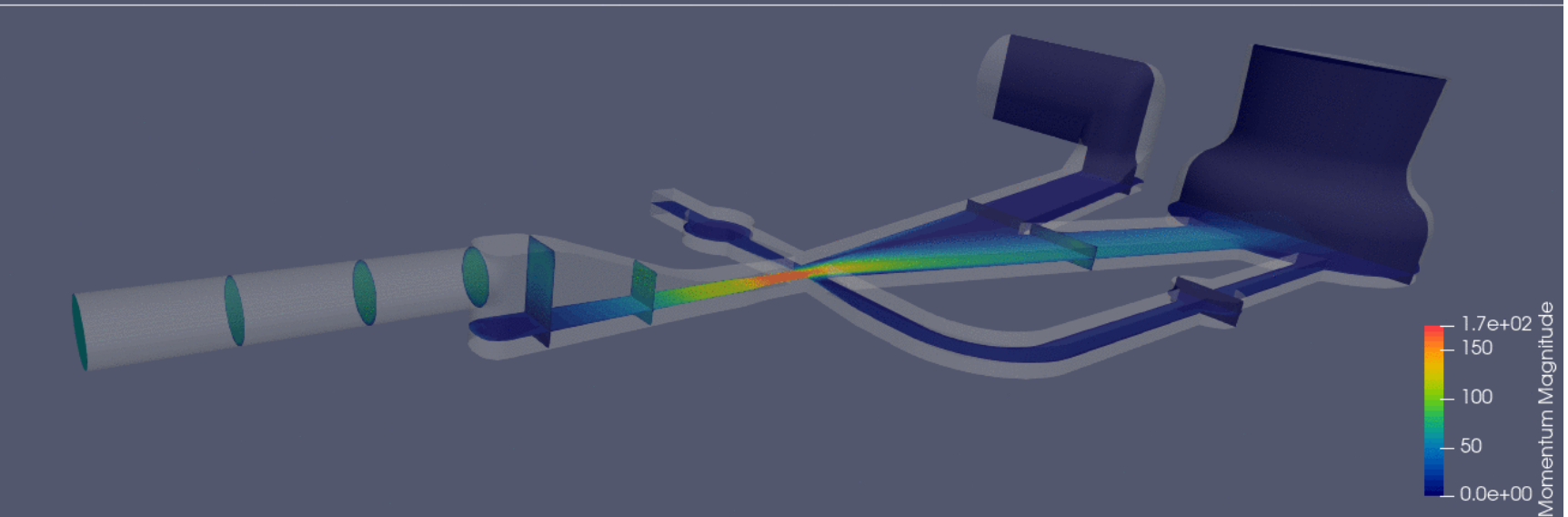
URANS 2D Simulation with Pressure Switch

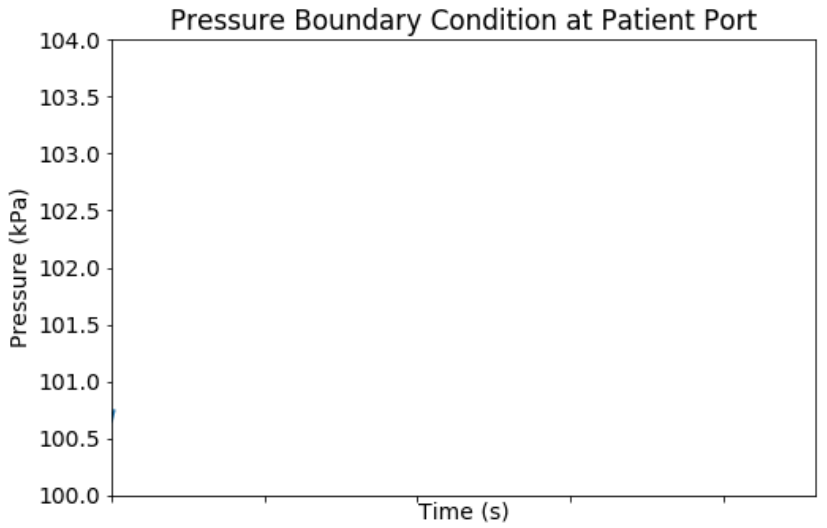


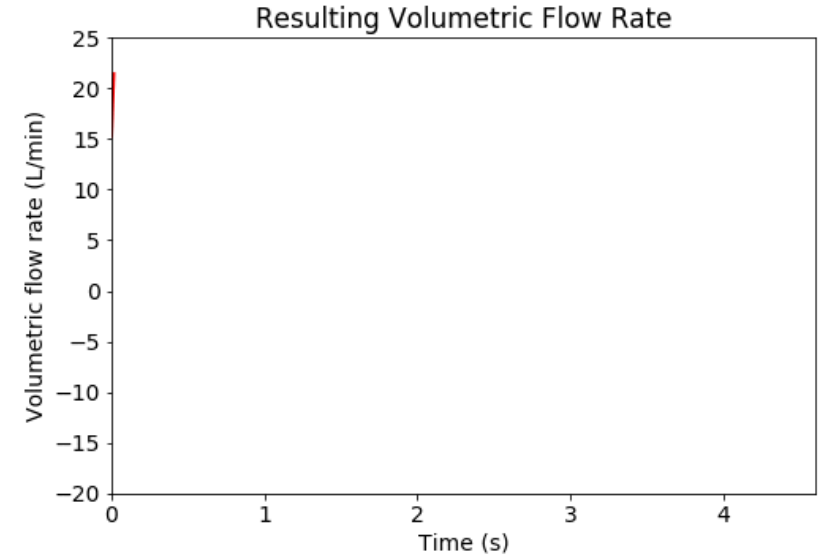


URANS 3D Simulation based on Experiments

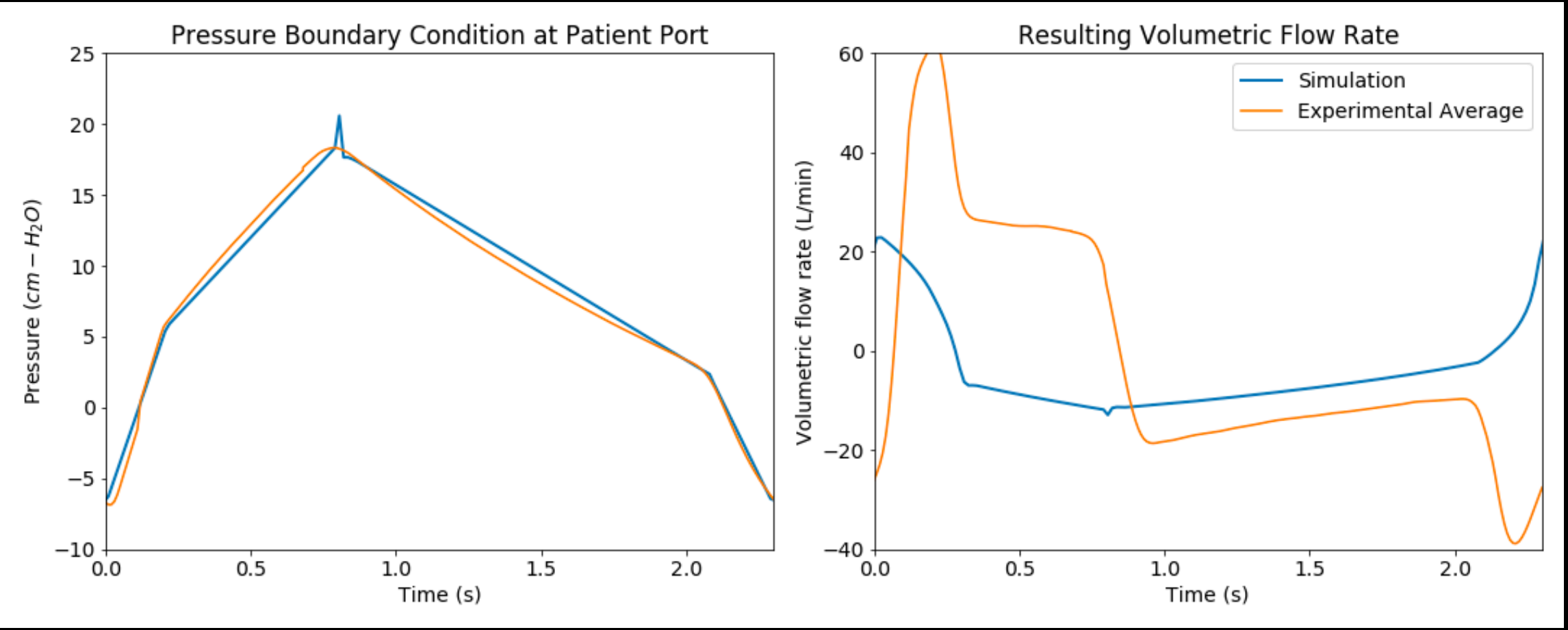




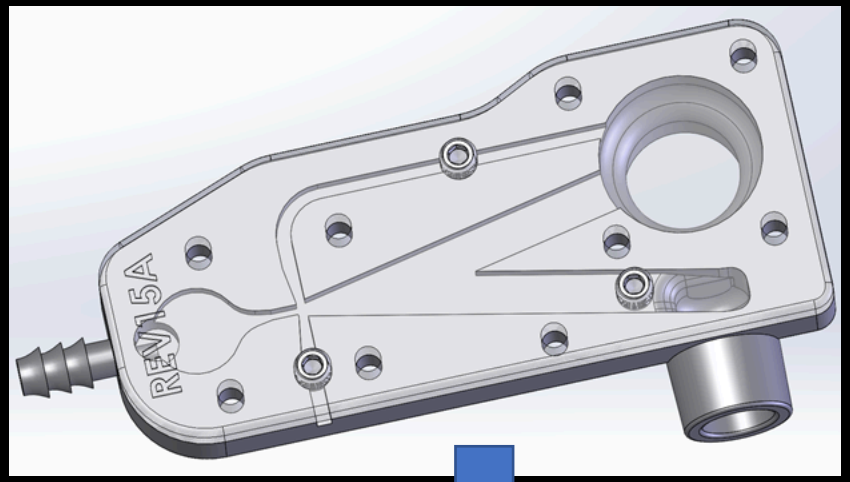




Comparing Simulation to Experiment

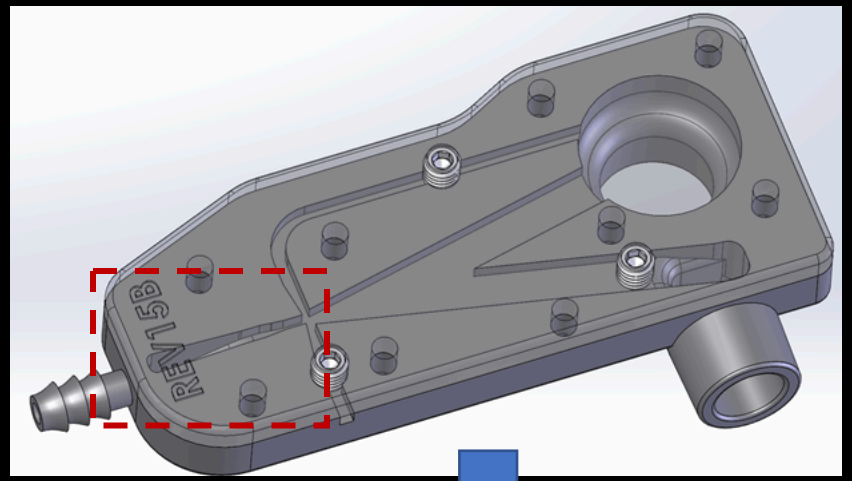


Improvements to the design



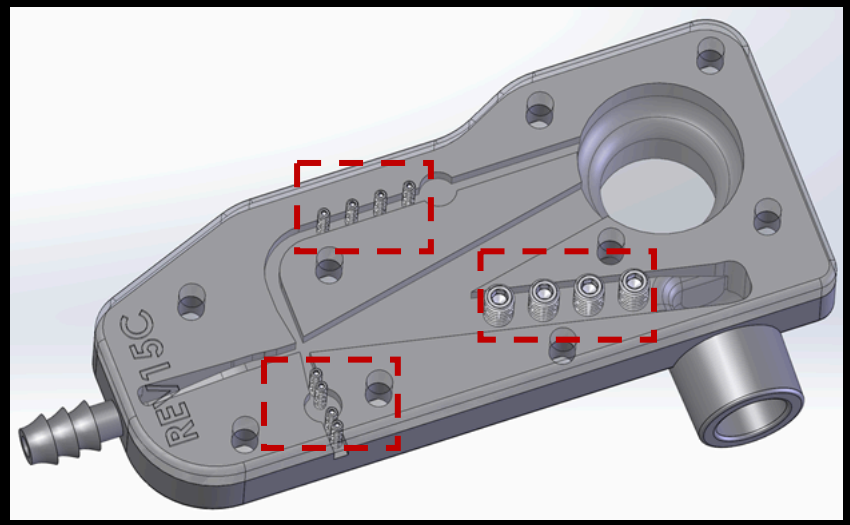
Remove inlet plenum

Stabilize flow response to pressure changes

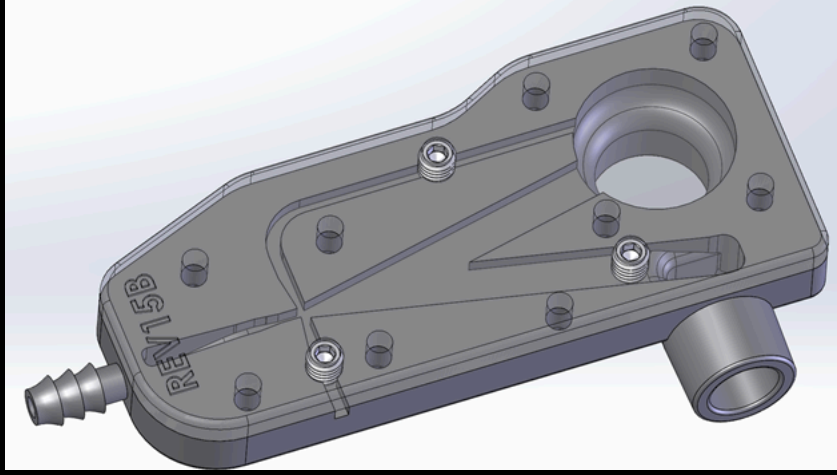


Increase number of set screws

Better control of ventilation properties



Takeaways



- The SU2 Community can mobilize very quickly.
- Rapid prototyping allows for quick experimentation-based design
- Numerical analyses provide background physics for phenomenon
- Unsteady boundary conditions need further validation

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Acknowledgements

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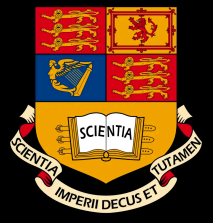

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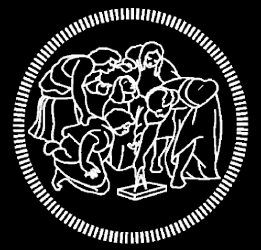
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