Muffler Modeling Options to Simulate Your Exhaust System

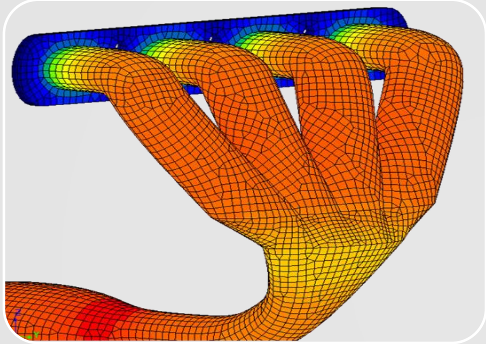
Steven Patterson

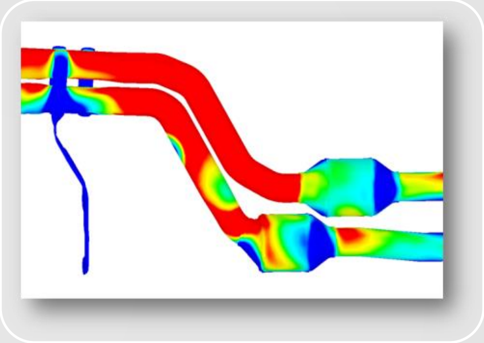
ThermoAnalytics®

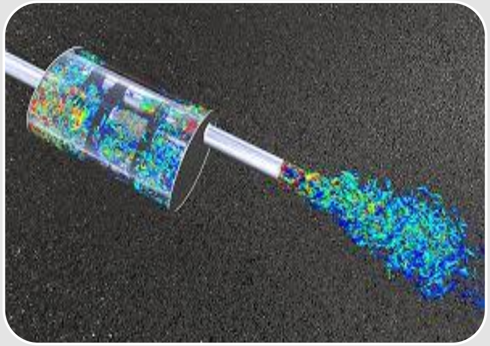
Agenda

- Introduction to Exhaust Streams
- Motivation for Muffler Modeling
- Muffler Chambers in TAITherm
- Comparison of 3 TAITherm muffler models
  - Using only simple chamber type
  - Using advanced chamber types
  - Using interior geometry and custom setup

Exhaust Simulation Methods







Assigned Temperatures

Constant temperature

Interpolated Part from Thermocouples

Typically Low resolution

1D or Fluid Streams

Calculated Temperatures

Higher resolution

General convection calculations

Manual setup of many parts

Exhaust Streams

Calculated Temperatures

Higher resolution

Exhaust specific convection

Easy setup

Run complex geometry or imperfect mesh

3D CFD

Calculated Temperatures

Highest Resolution

Requires fine mesh to resolve heat transfer

Needs detailed geometry for all parts

Requires input of heat sources

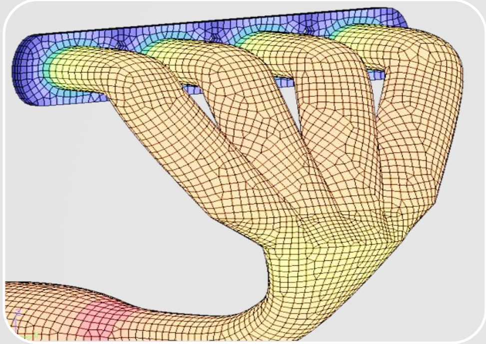
Exhaust Simulation Methods

Assigned Temperatures

Constant temperature

Interpolated Part from Thermocouples

Typically Low resolution



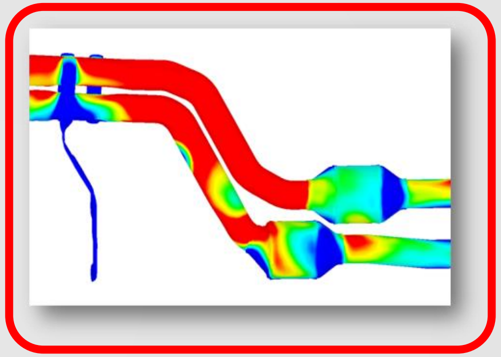
1D or Fluid Streams

Calculated Temperatures

Higher resolution

General convection calculations

Manual setup of many parts



<u>Exhaust Streams</u>

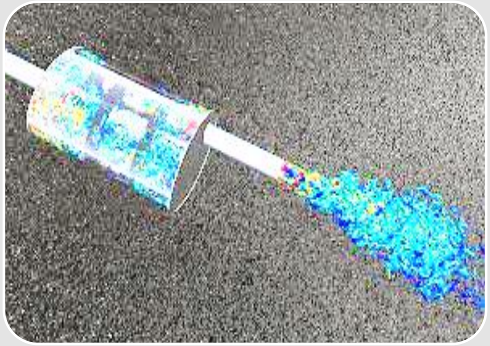
Calculated Temperatures

Higher resolution

Exhaust specific convection

Easy setup

Run complex geometry or imperfect mesh



3D CFD

Calculated Temperatures

Highest Resolution

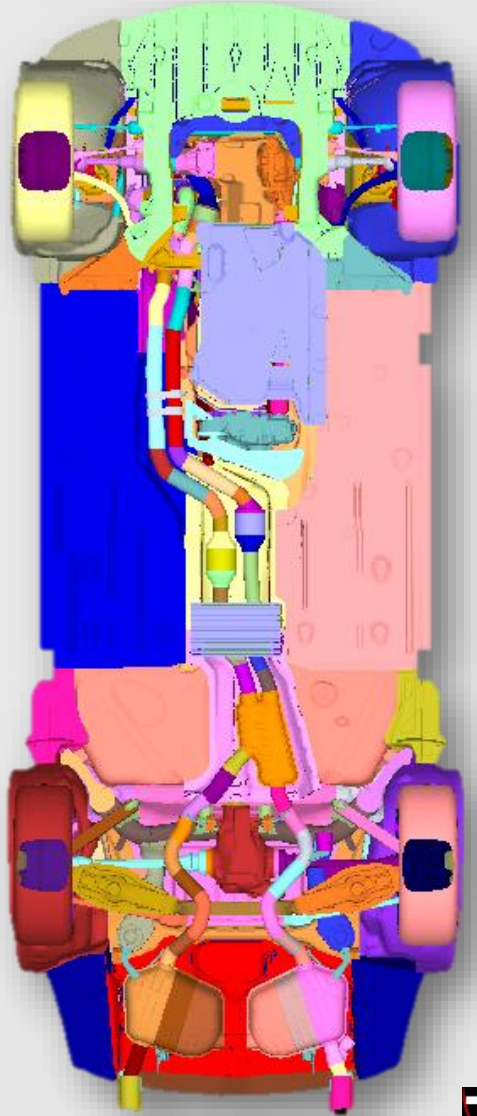
Requires fine mesh to resolve heat transfer

Needs detailed geometry for all parts

Requires input of heat sources

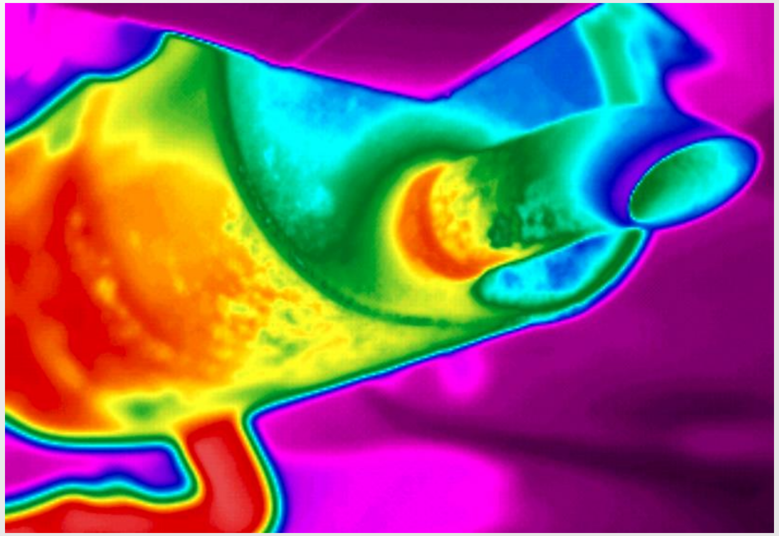
Exhaust Streams

- Thermal prediction of exhaust components is critical
  - Predictions must be fast, accurate & support transient analysis
- Exhaust Streams
  - 1D Convection from 3D Geometry
  - Component Types
    - Catalytic Converters
    - Turbochargers
    - Mufflers
    - Pipes
    - Custom
  - Higher Accuracy
    - Geometric convection effects
    - High resolution 1D networks
    - Increased detail for active components
  - Simplified Setup
    - Engine data integrated with Exhaust Stream
    - Multiple sub-streams for complex exhaust systems
    - Branching & Merging flows



Fast, Simple Muffler Modeling

- There are many types of muffler styles and designs
- Thermal analysts building underbody models have access to different levels of interior detail
- Different modeling methods are needed for different situations

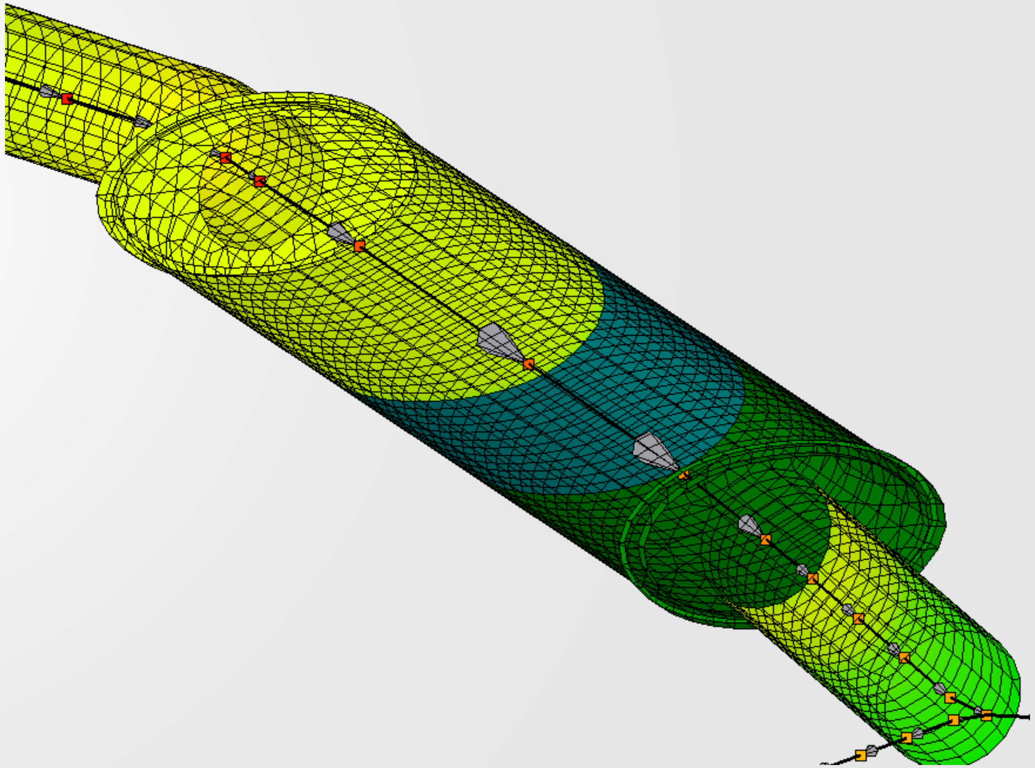


Muffler Chamber Types in TAITherm

- Simple Chamber
- Uninsulated Pipe
- Insulated Pipe
- Open Chamber

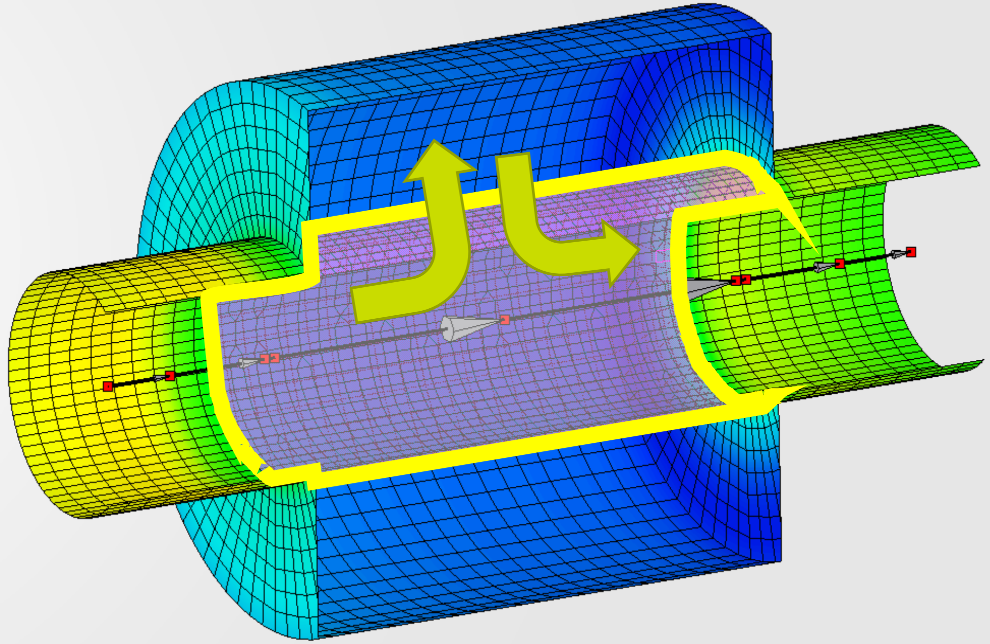
Muffler Chamber Types: Simple Chamber

- Chamber type introduced in version 12.4
- Retained for backward compatibility
- Does not support internal geometry



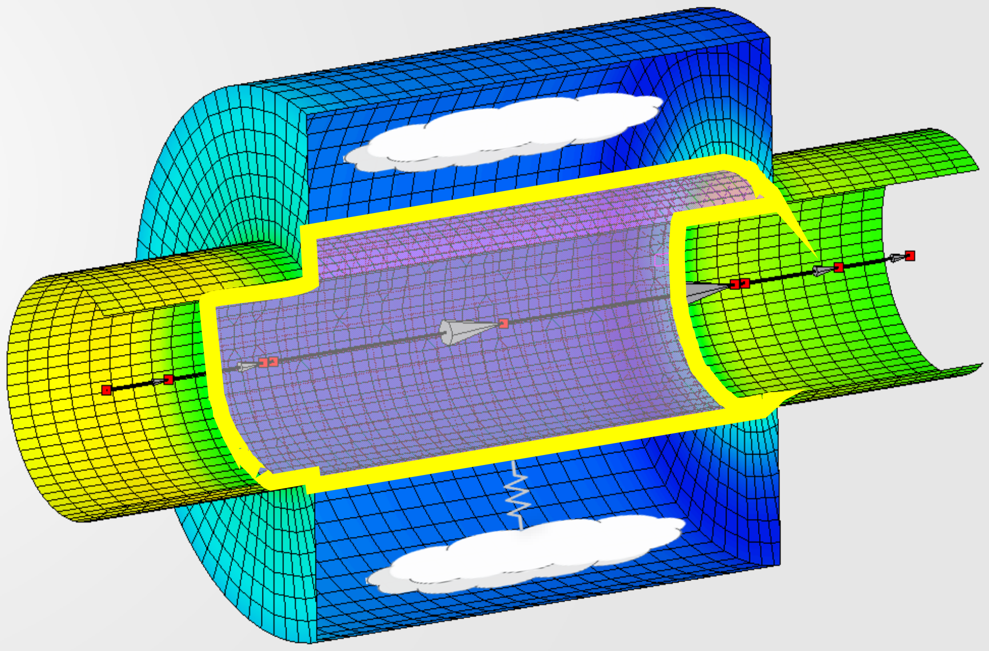
Muffler Chamber Types: Uninsulated Pipe

- No internal geometry
- Implicitly models a perforated pipe passing through the chamber
- User defines fraction of flow exchange between the pipe and the chamber



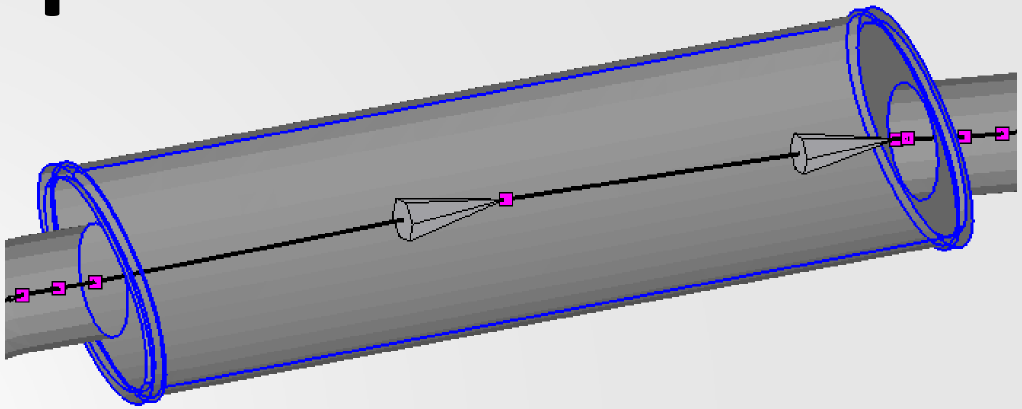
Muffler Chamber Types: Insulated Pipe

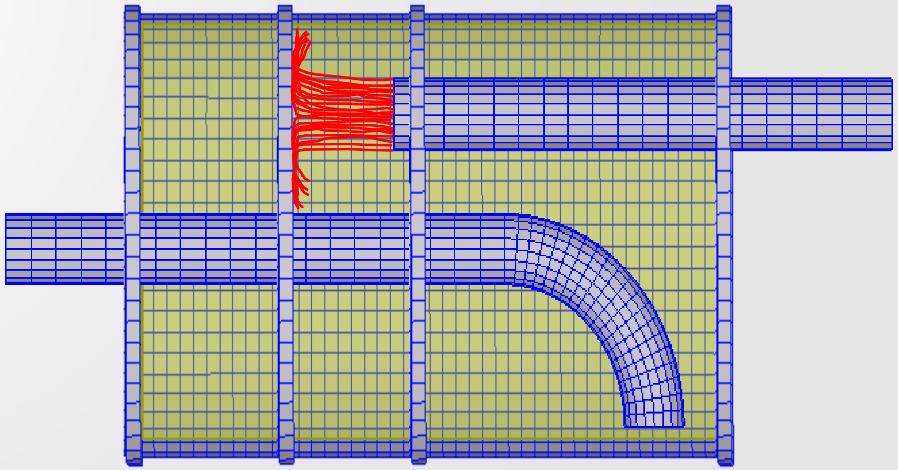
- No internal geometry
- Implicitly models a perforated pipe passing through the chamber and the chamber filled with porous insulation
- User defines fraction of flow exchange between the pipe and the chamber



Muffler Chamber Types: Open

- No internal geometry
- Models flow in a fully open chamber
- Allows convection augmentation for an impingement point

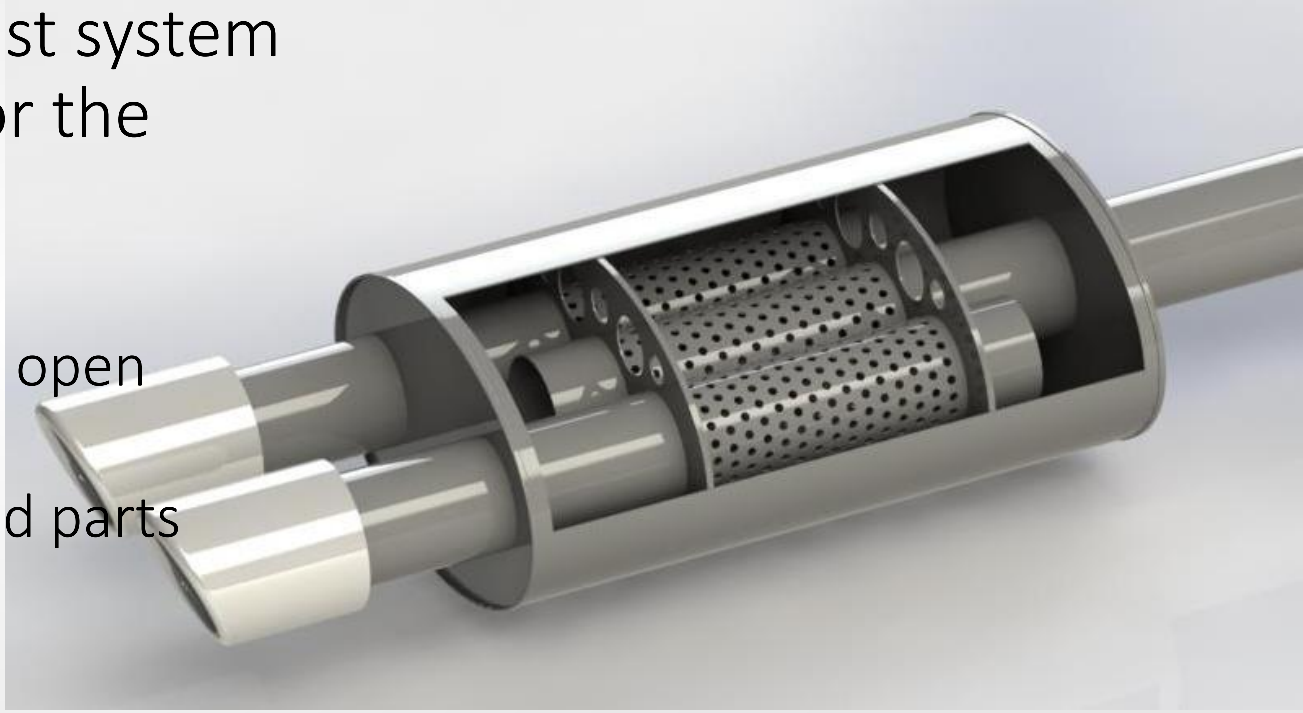




Example Models

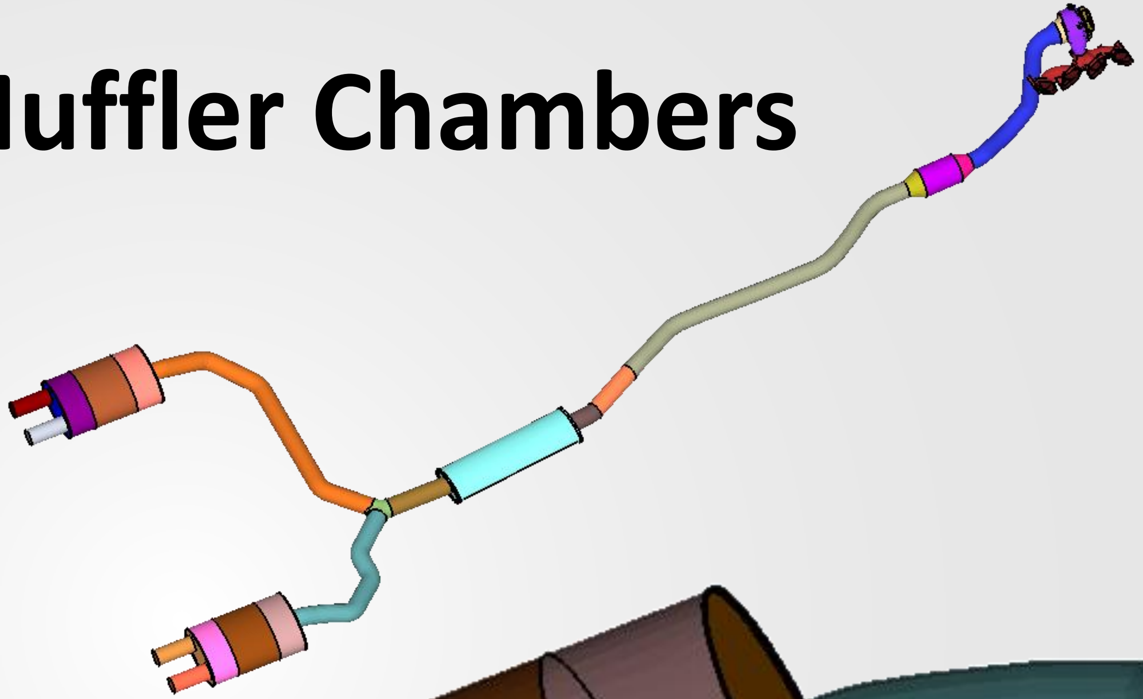
Example Model Variations

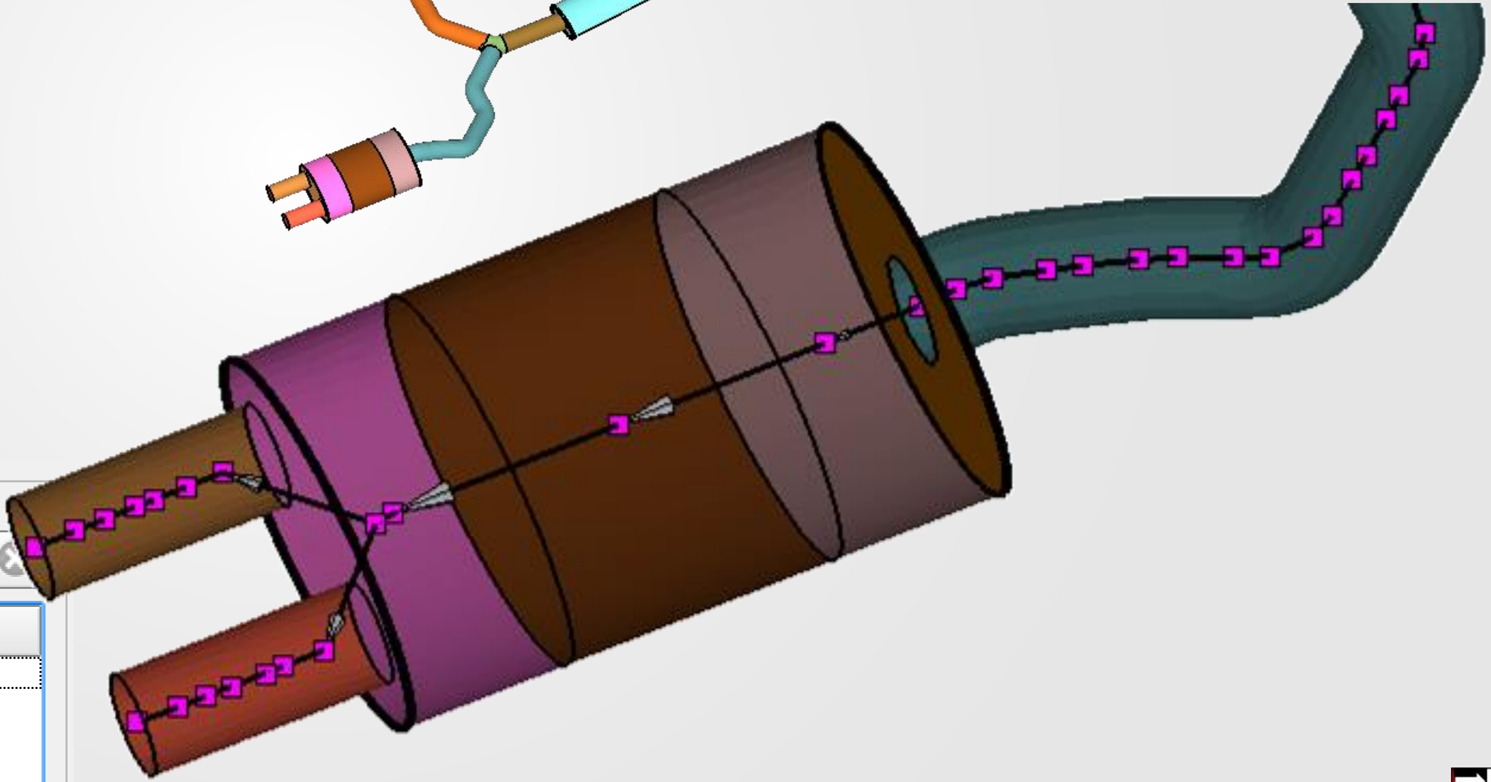
- We will now demonstrate 3 exhaust system models using different methods for the muffler
  - Using 3 simple chambers
  - Using <un>insulated chambers, and open chamber, and impingement
  - Using the interior geometry and fluid parts

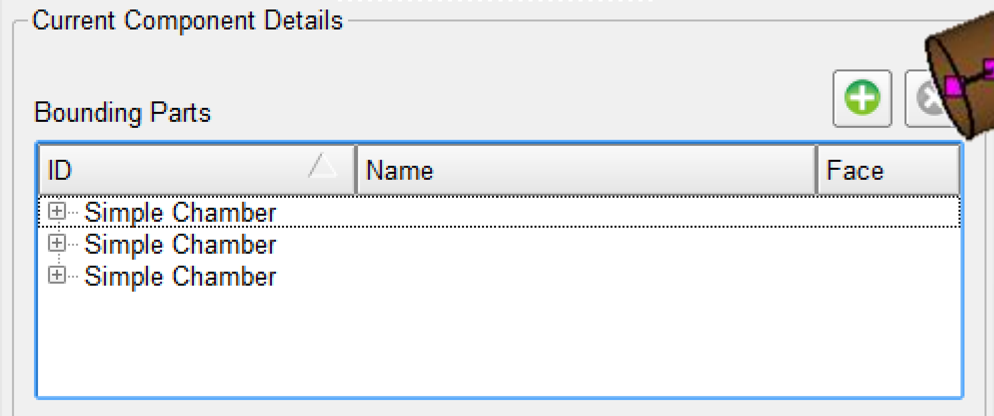


Model 1: Simple Muffler Chambers

- No interior geometry
- 3 Simple Chambers

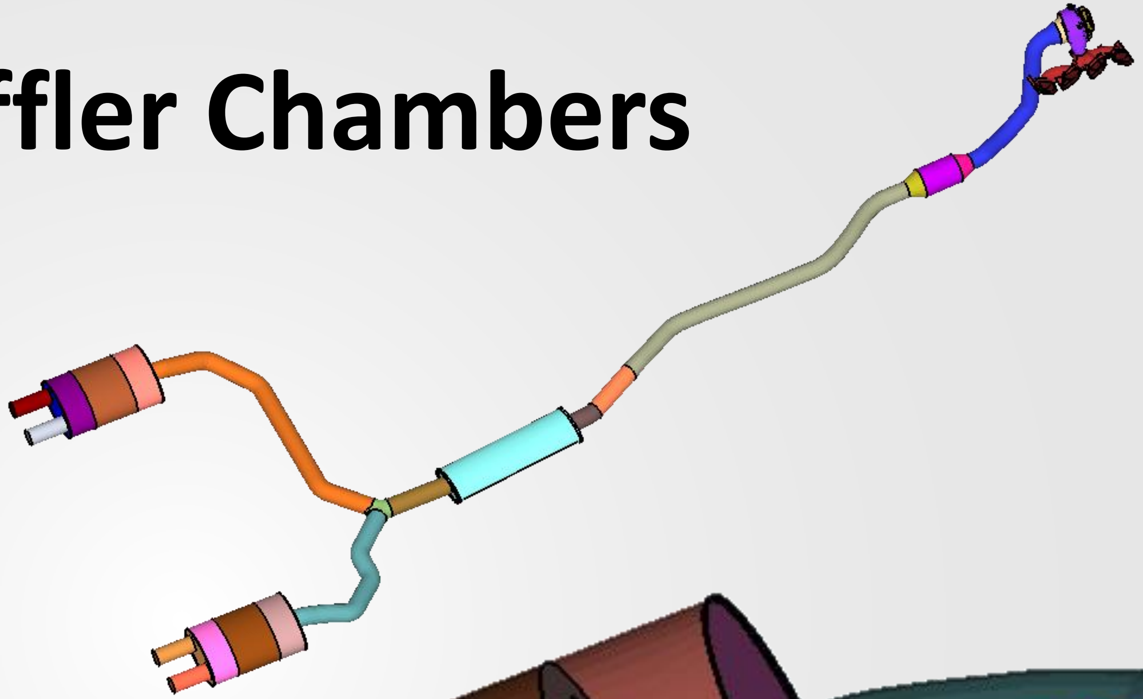


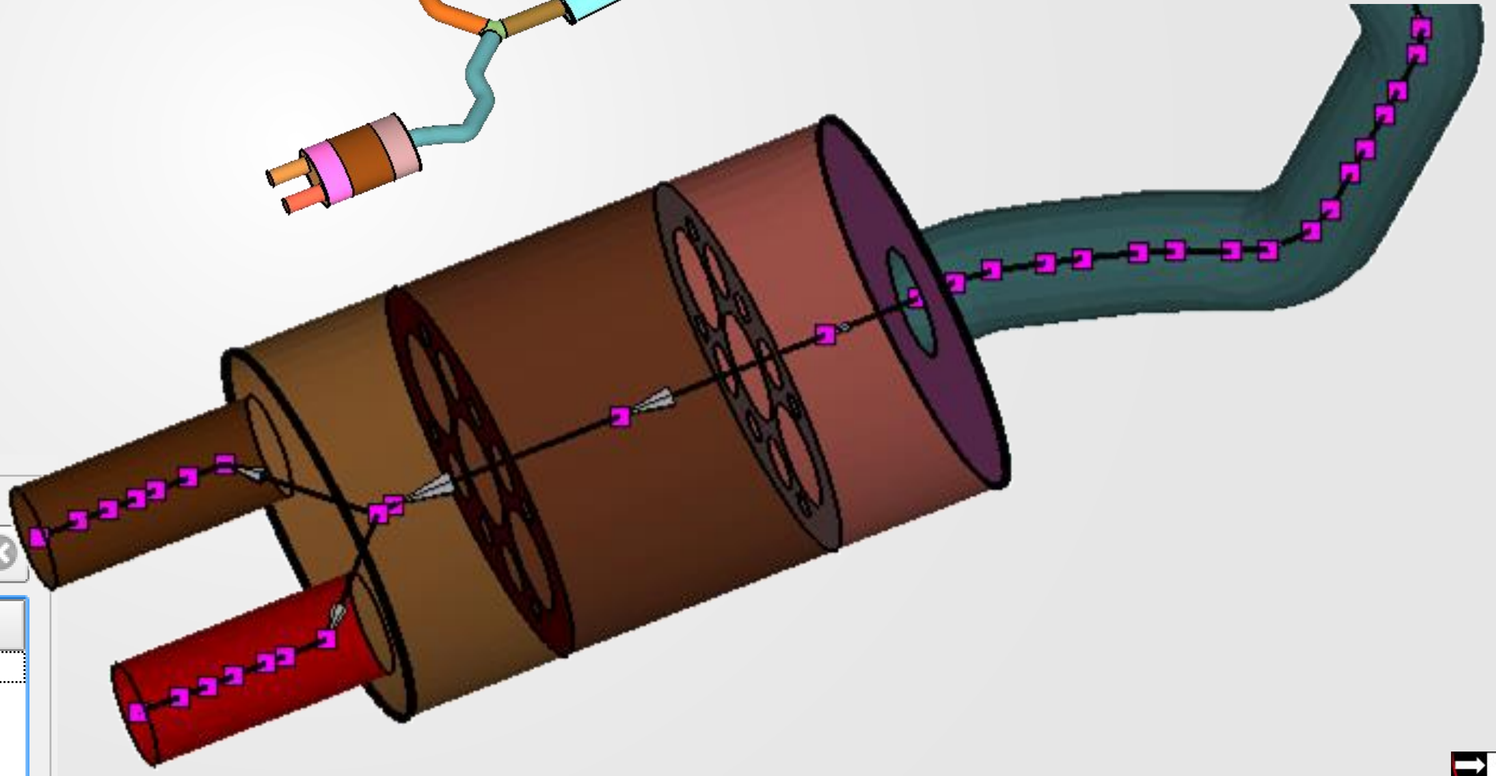


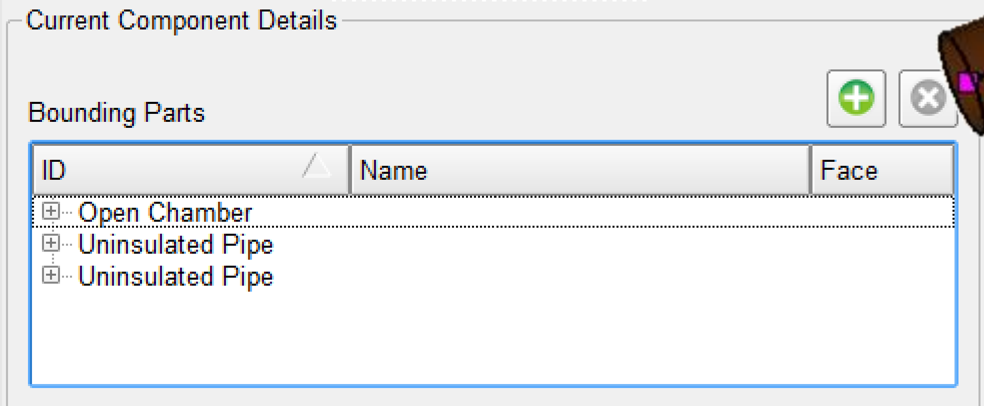


Model 2: New Muffler Chambers

- Include geometry for baffles
- 3 Chambers
- Impingement on back face

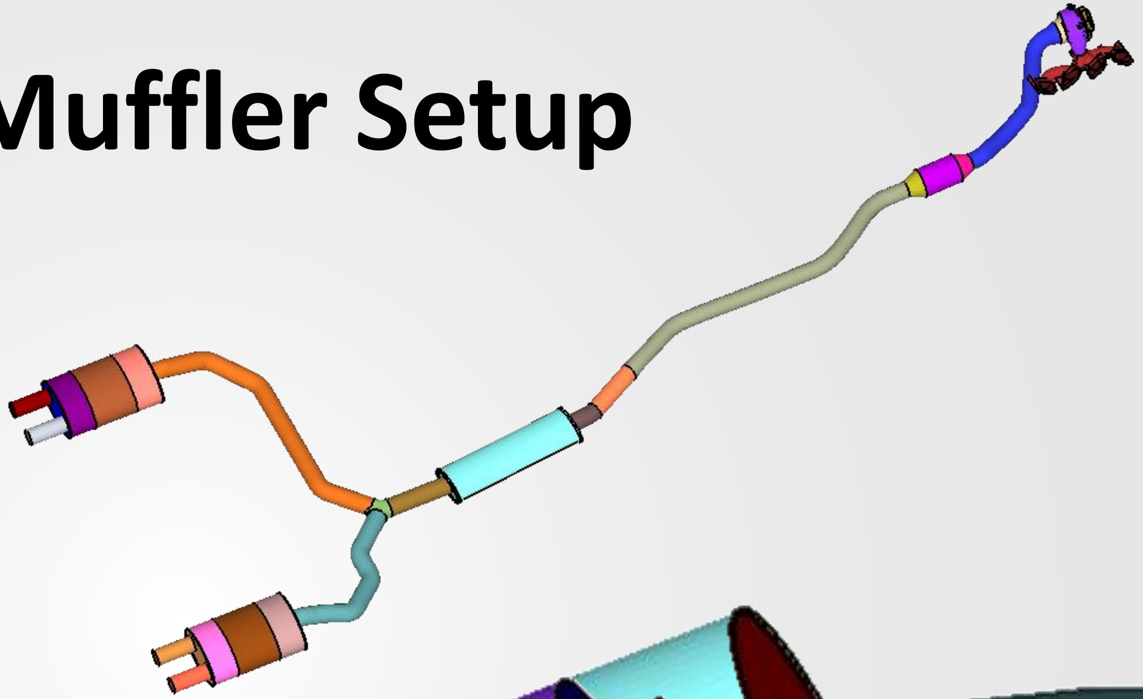


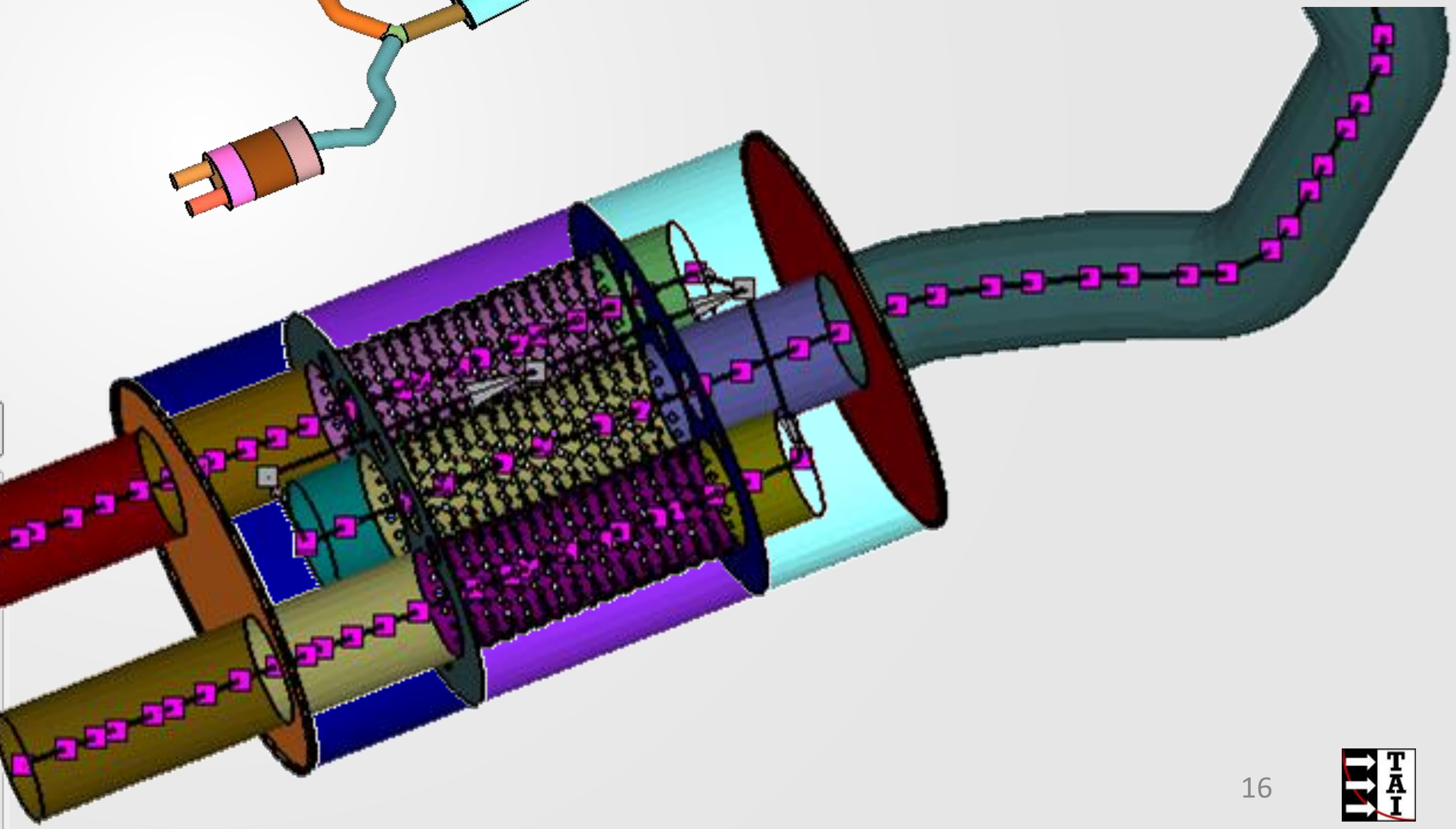




Model 3: Manual Muffler Setup

- Include geometry for baffles
- Includes geometry for interior pipes
- Uses Fluid Parts for convection on muffler walls





Exhaust Components

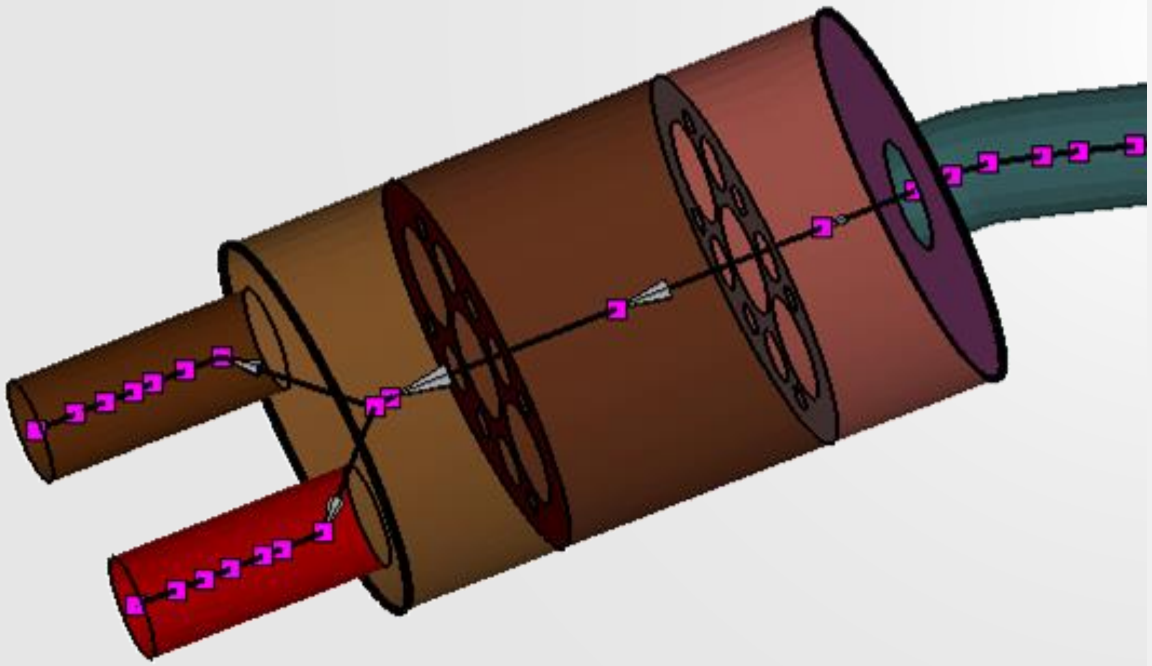
Name	Type
manifold	Pipe
turbo	Turbocharger
pipesToSilencer	Pipe
cat	Catalytic Converter
silencer	Muffler
pipes_silencerIntoMufflers	Pipe
pipes_lhs_tail1	Pipe
pipes_lhs_tail2	Pipe
pipes_rhs_tail1	Pipe
pipes_rhs_tail2	Pipe

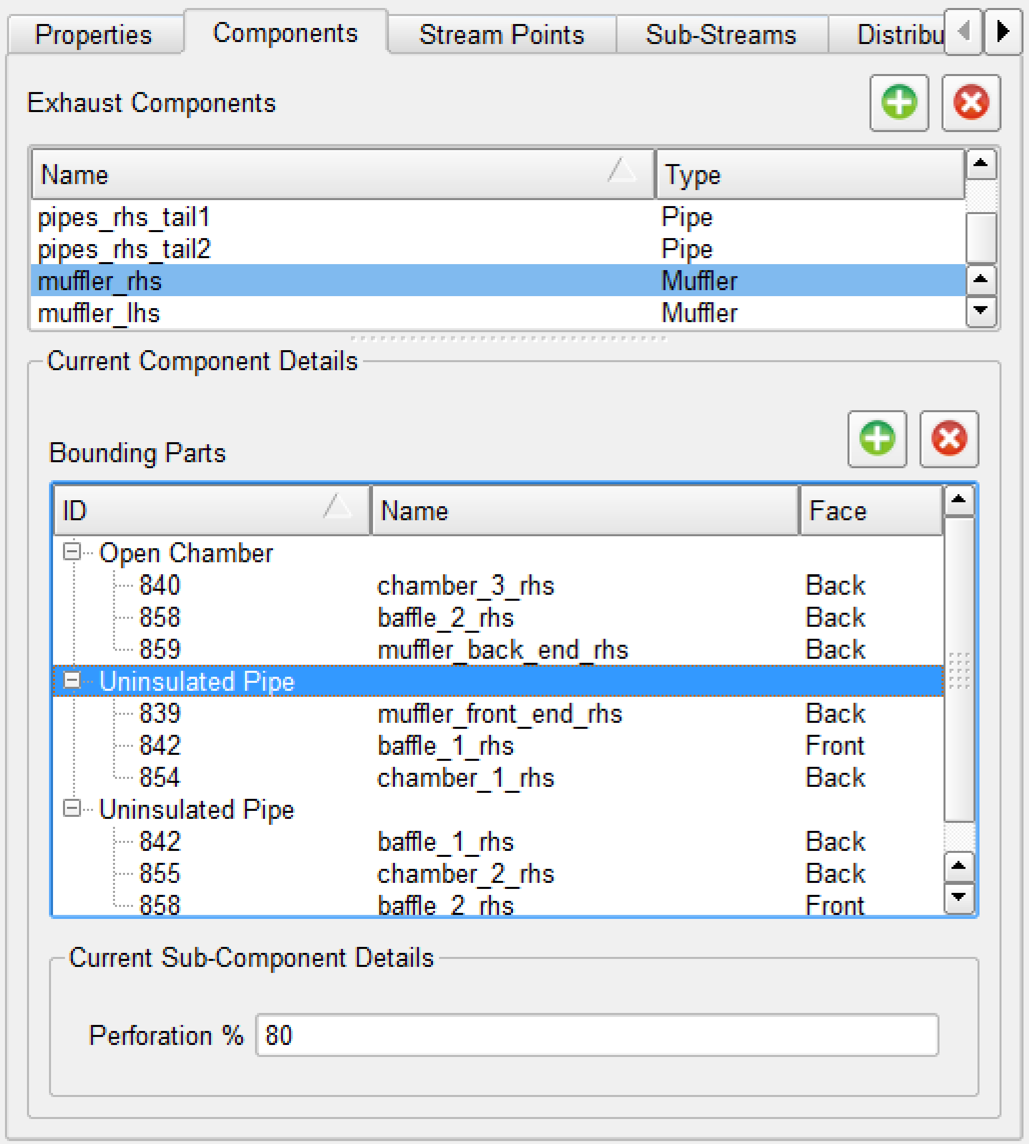
Model 2: Muffler Chambers

Model Setup

Model 2: Muffler Chambers

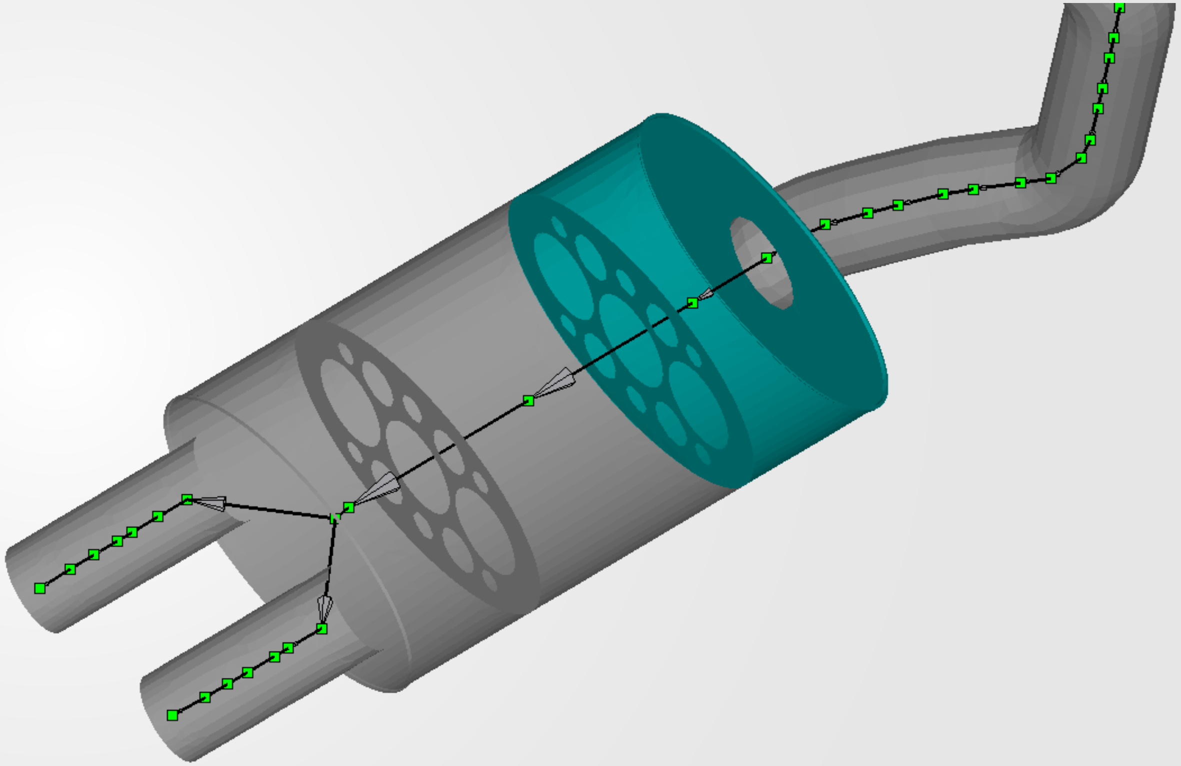
- Defined 3 Chambers





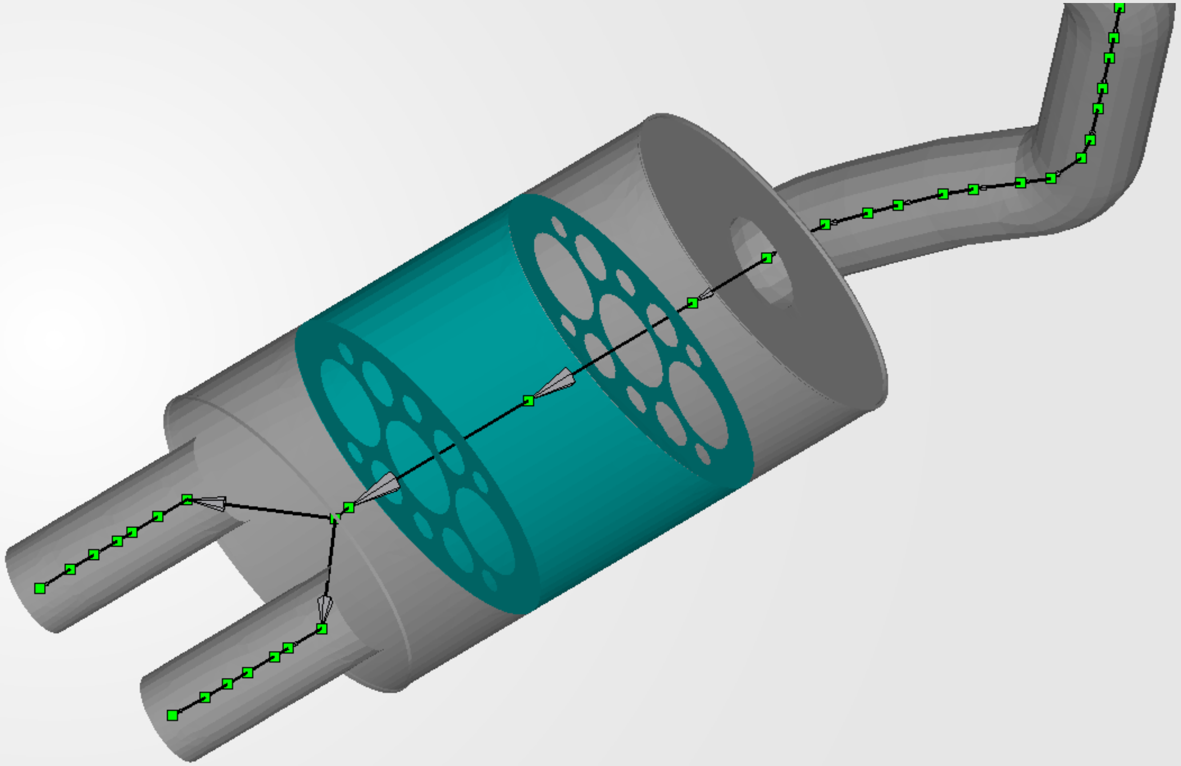
Model 2: Muffler Chambers

- Chamber 1
- Uninsulated Pipe



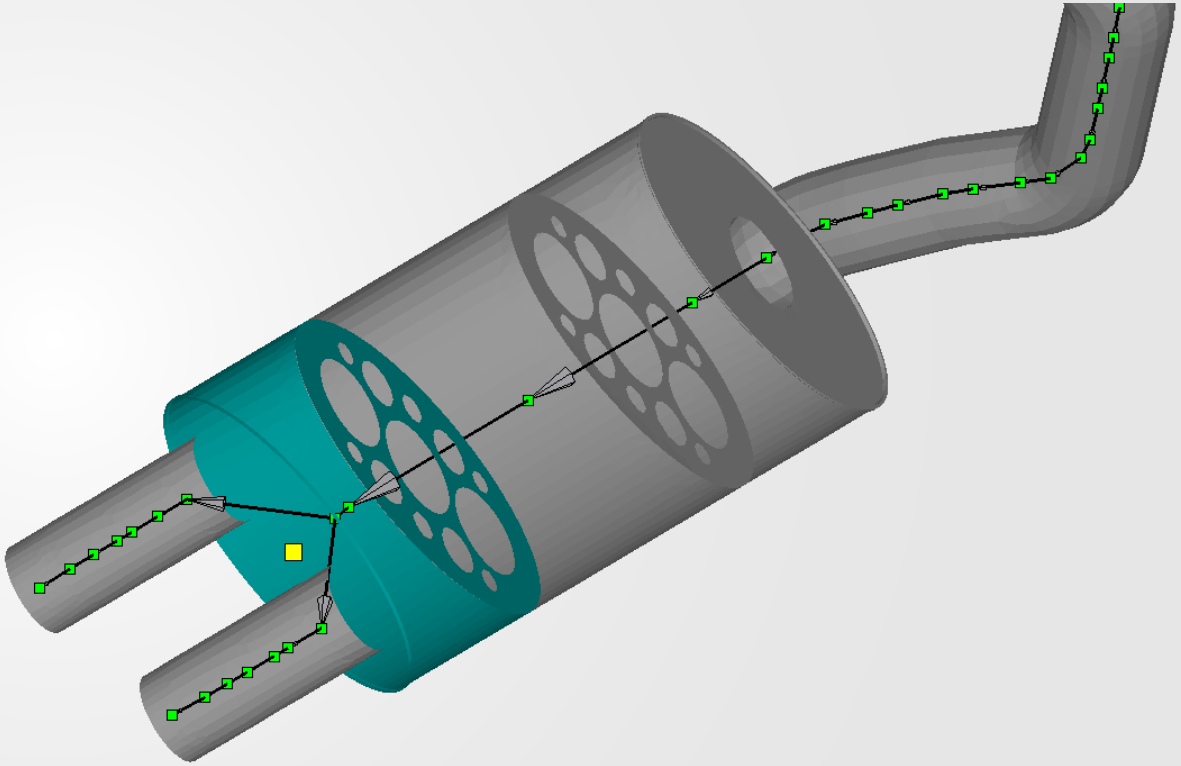
Model 2: Muffler Chambers

- Chamber 2
- Uninsulated Pipe



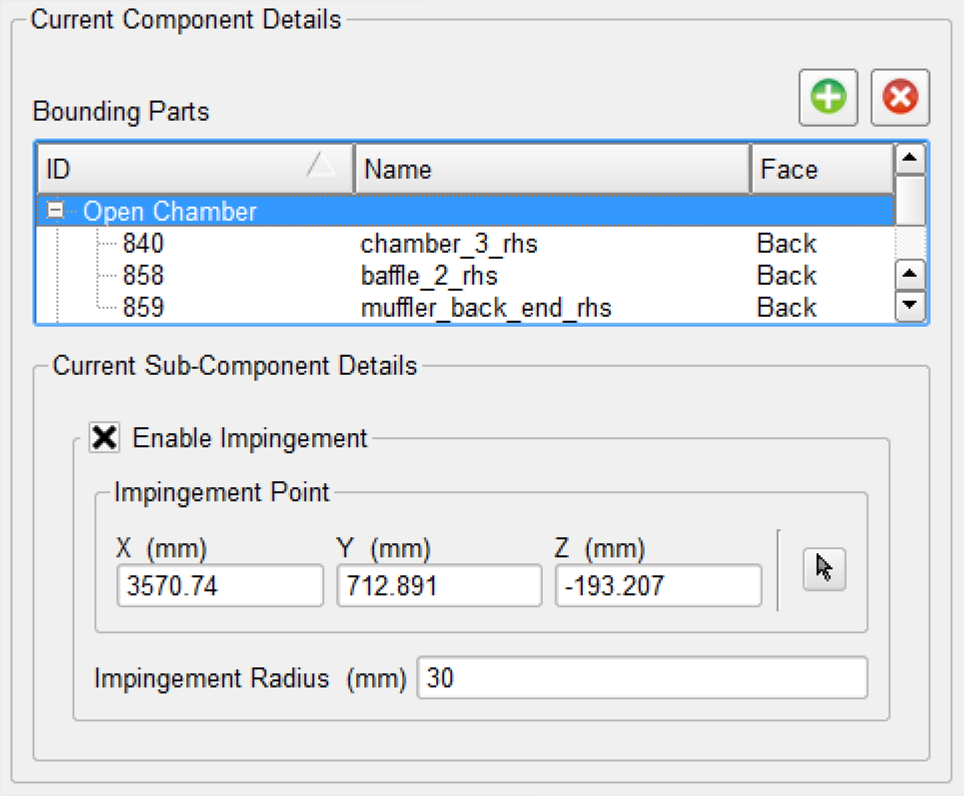
Model 2: Muffler Chambers

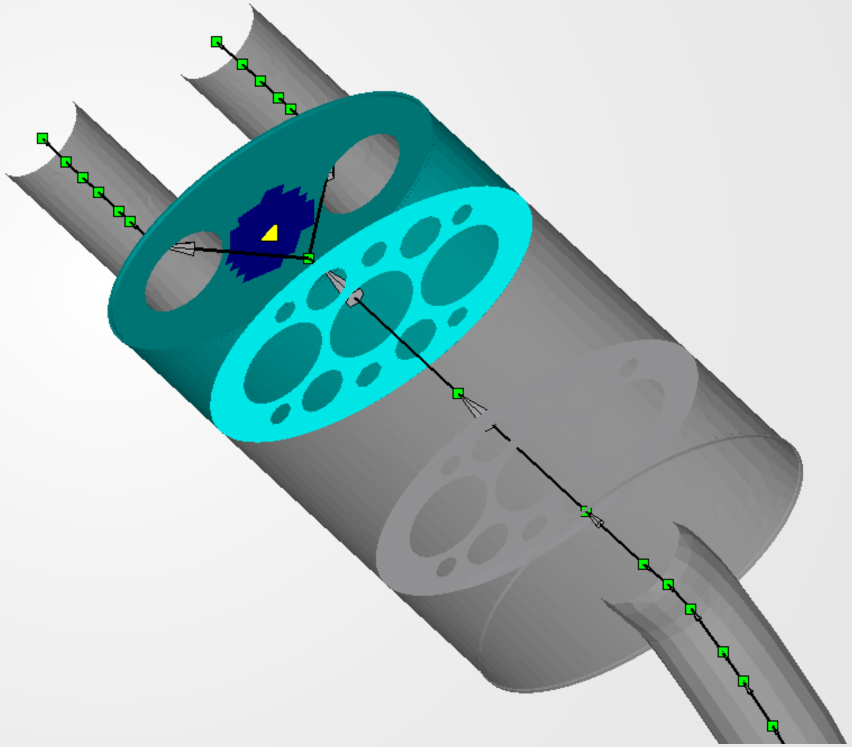
- Chamber 3
- Open Chamber



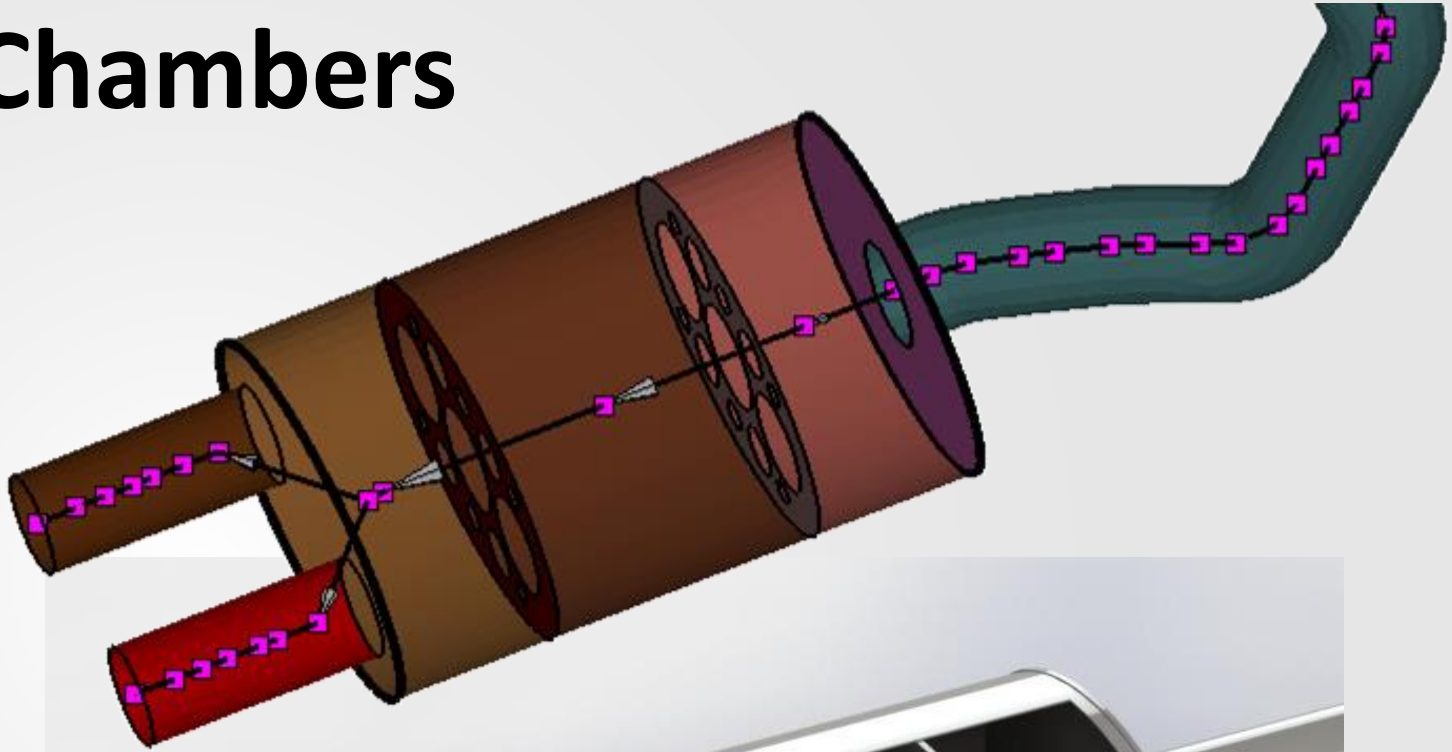
Model 2: Muffler Chambers

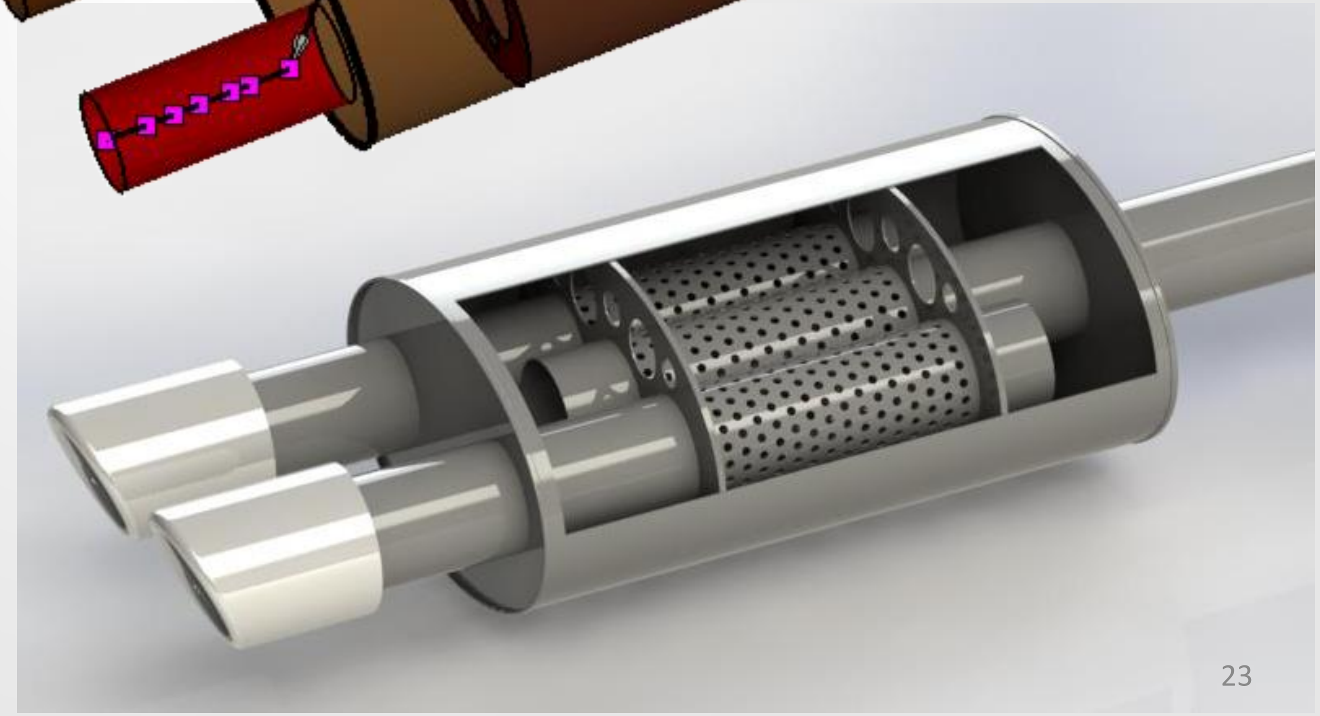
- Chamber 3
- Impingement





Model 2: Muffler Chambers



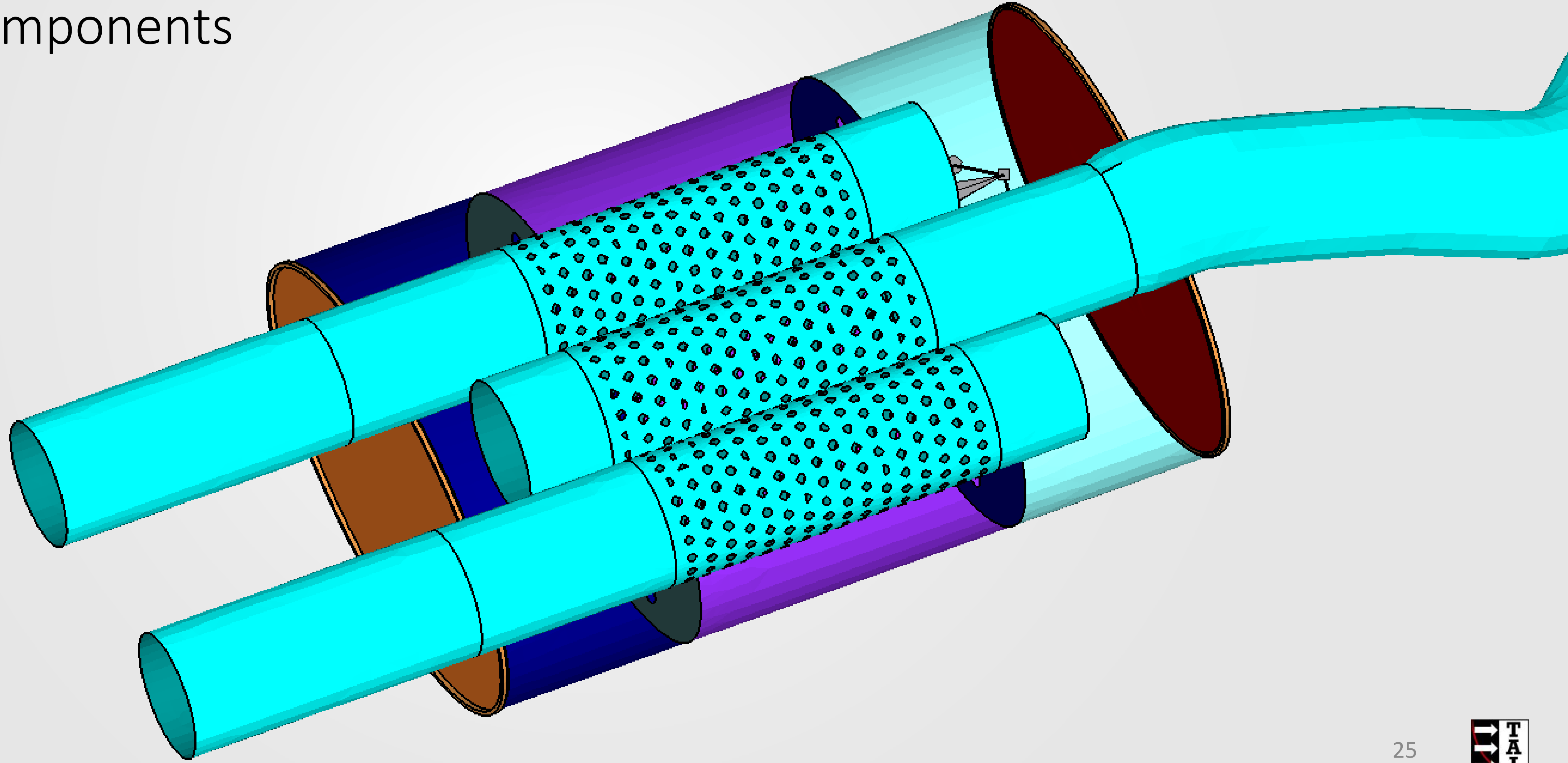


Model 3: Full Interior

Model Setup

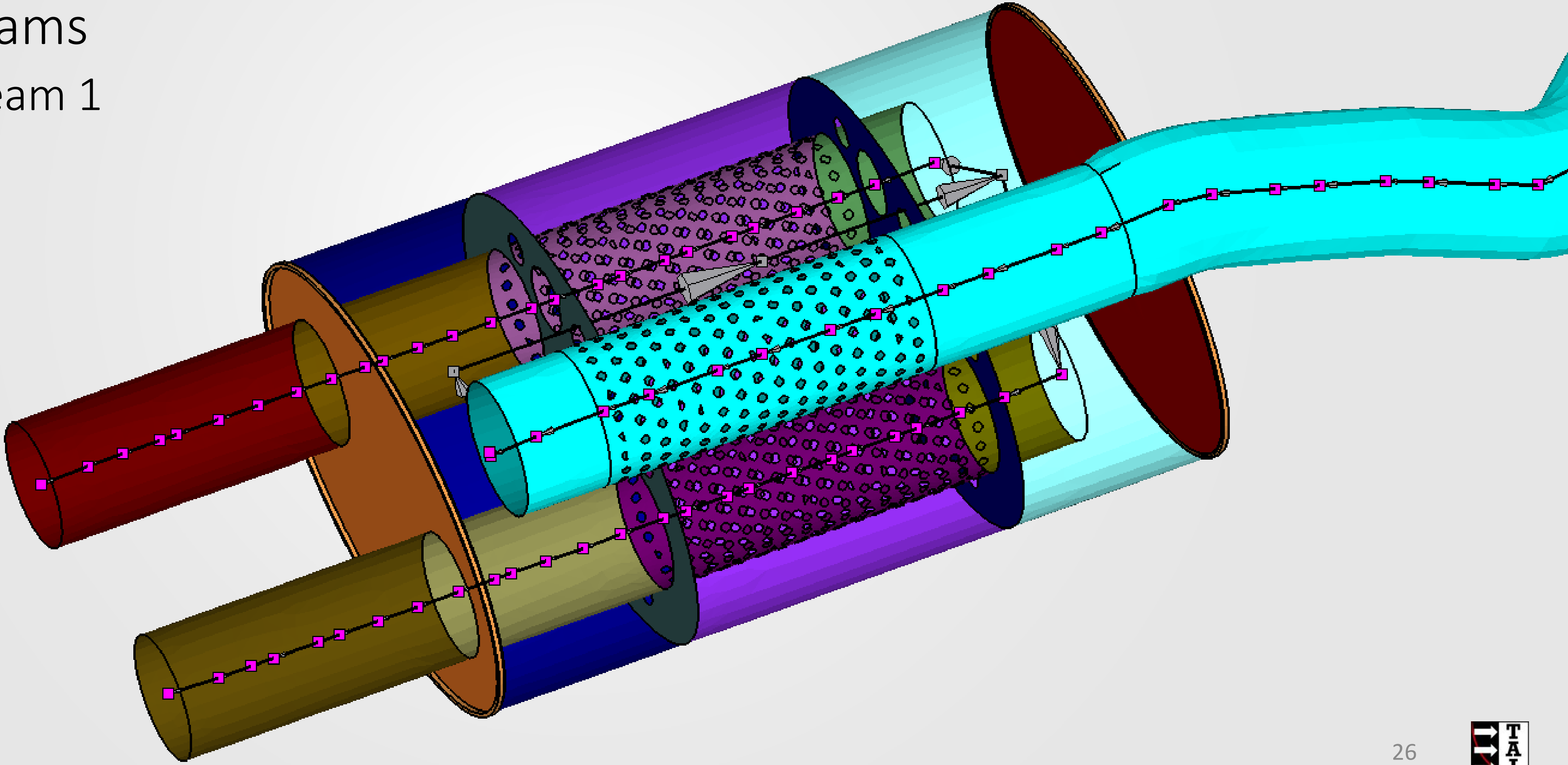
Model 3: Manual Muffler Setup

- 3 Pipe Components



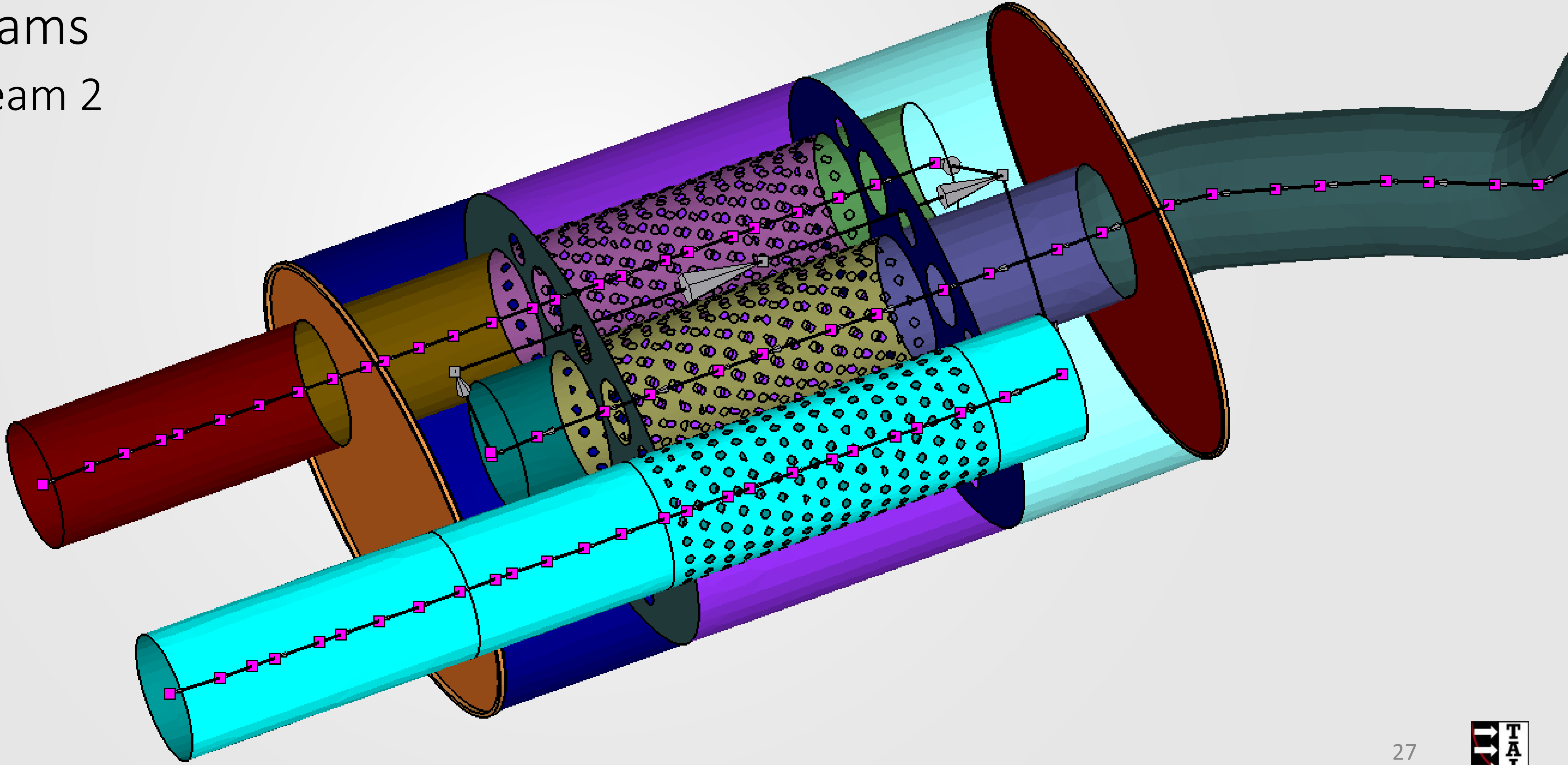
Model 3: Manual Muffler Setup

- 3 Substreams
  - Substream 1



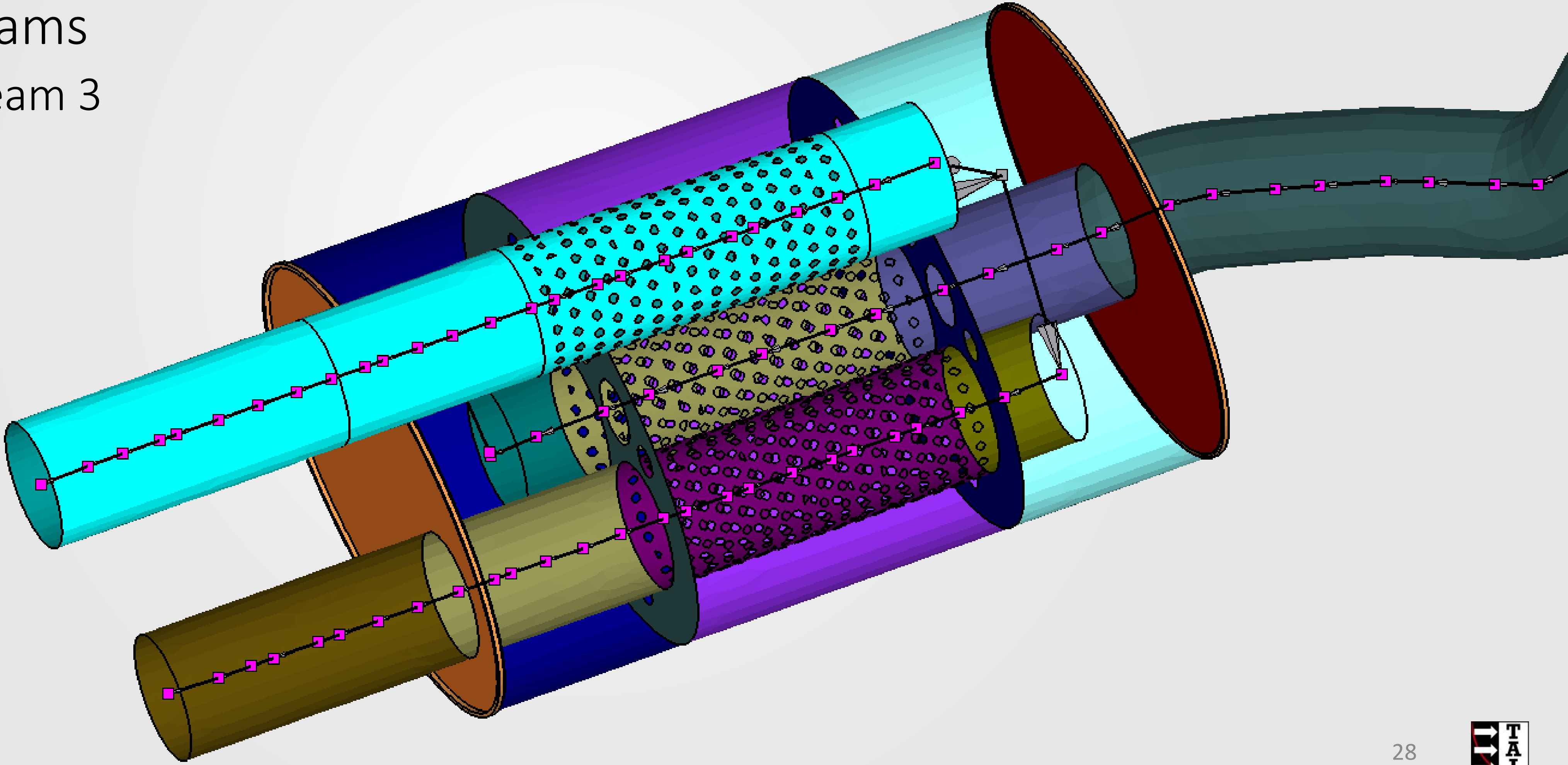
Model 3: Manual Muffler Setup

- 3 Substreams
  - Substream 2



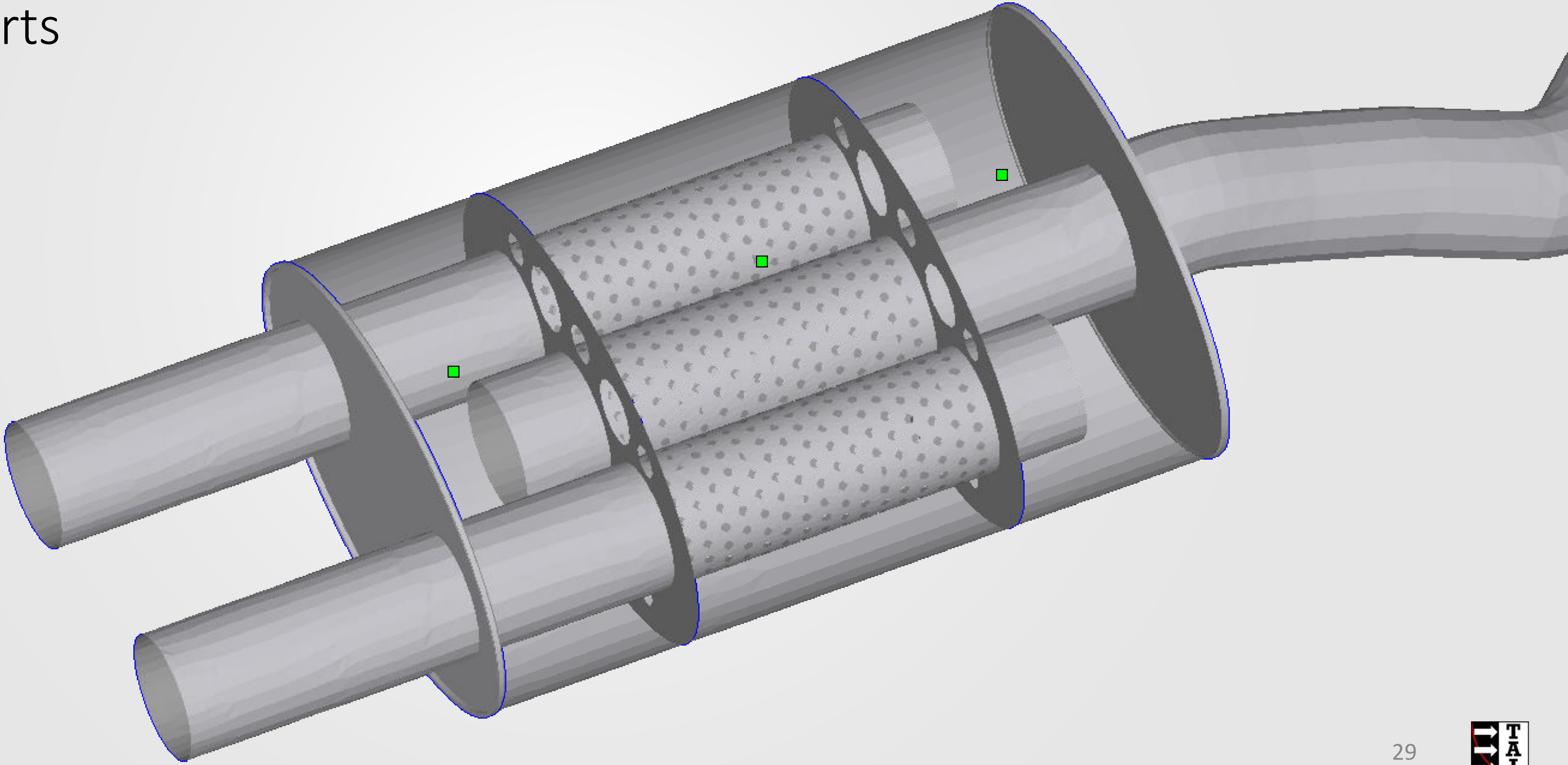
Model 3: Manual Muffler Setup

- 3 Substreams
  - Substream 3



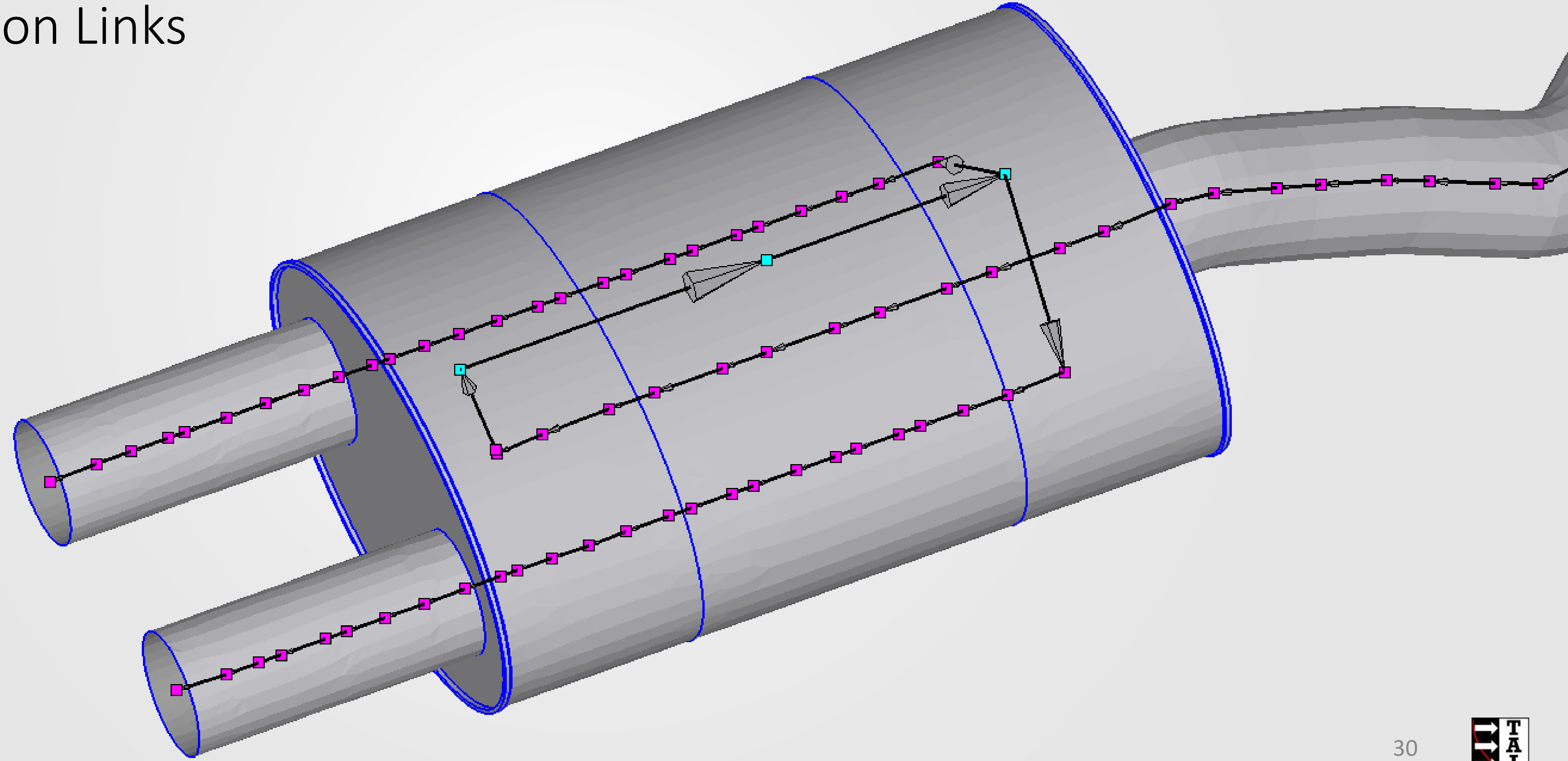
Model 3: Manual Muffler Setup

- 3 Fluid Parts



Model 3: Manual Muffler Setup

- 5 Advection Links



Model 3: Manual Muffler Setup

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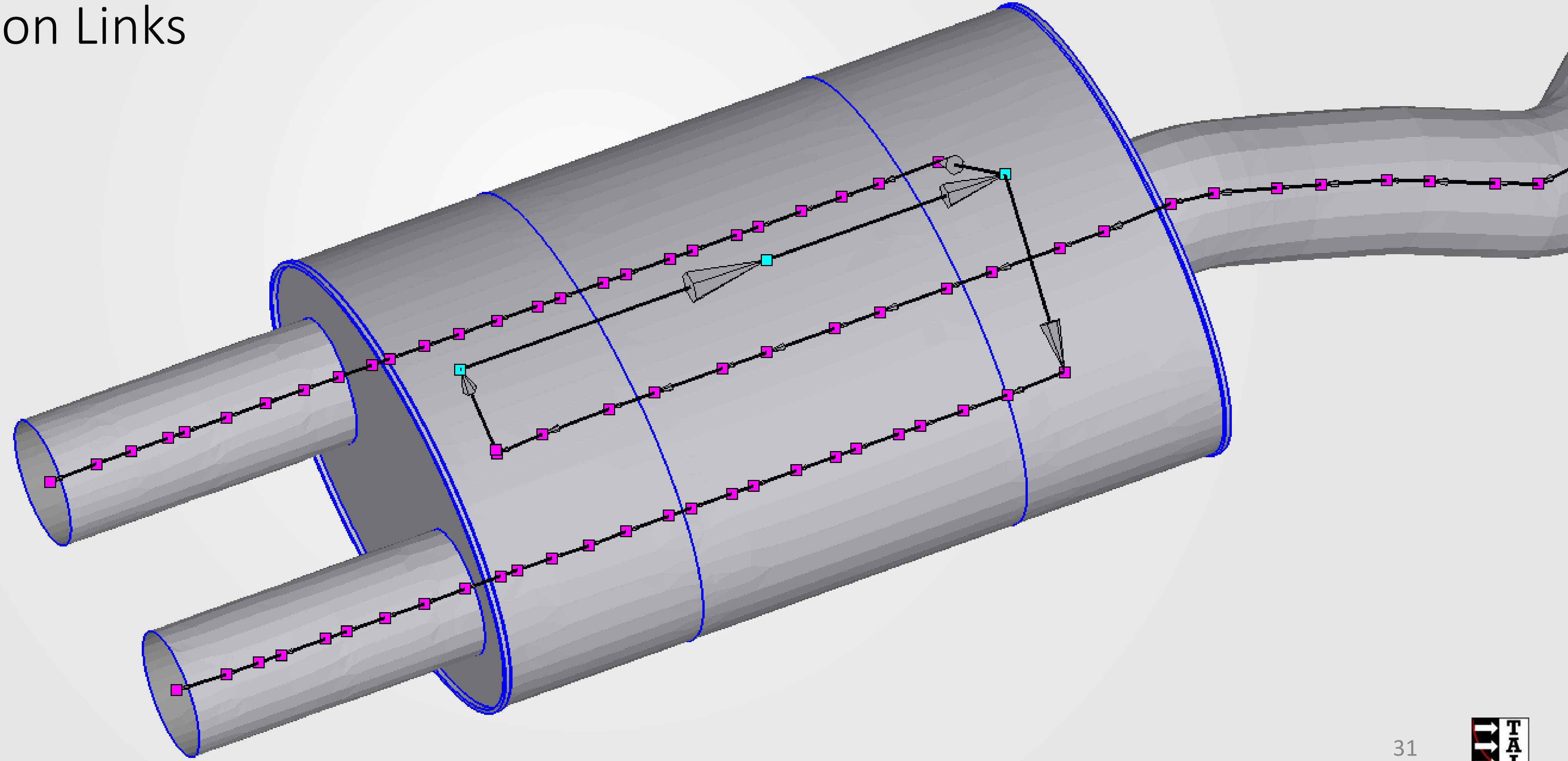
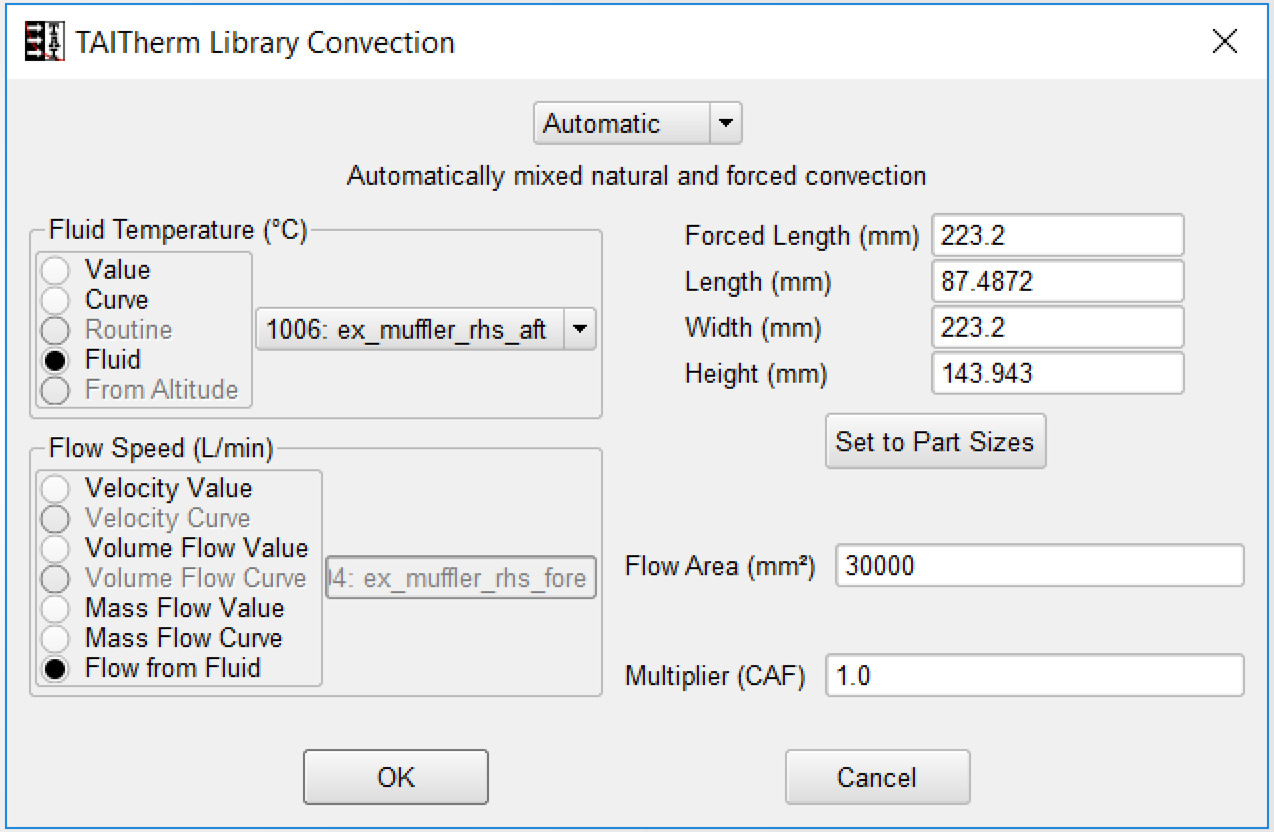


Library Convection

- Muffler is not part of "Exhaust Stream" in this model
- Use Library Convection with flow from the Fluid Parts

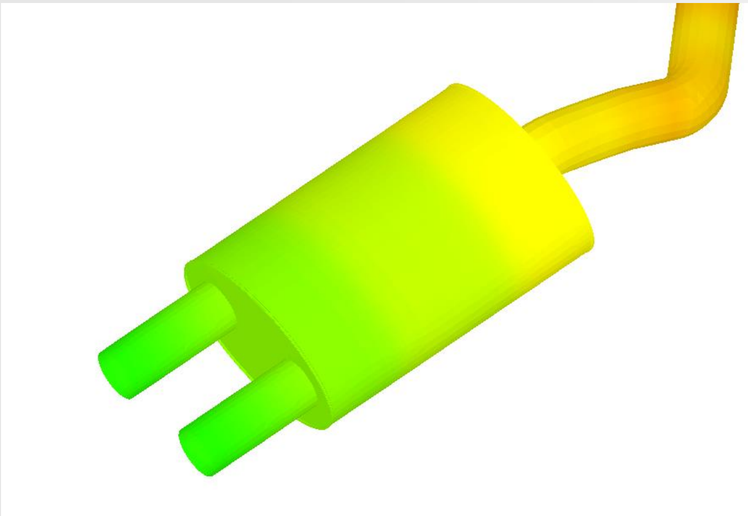


Results

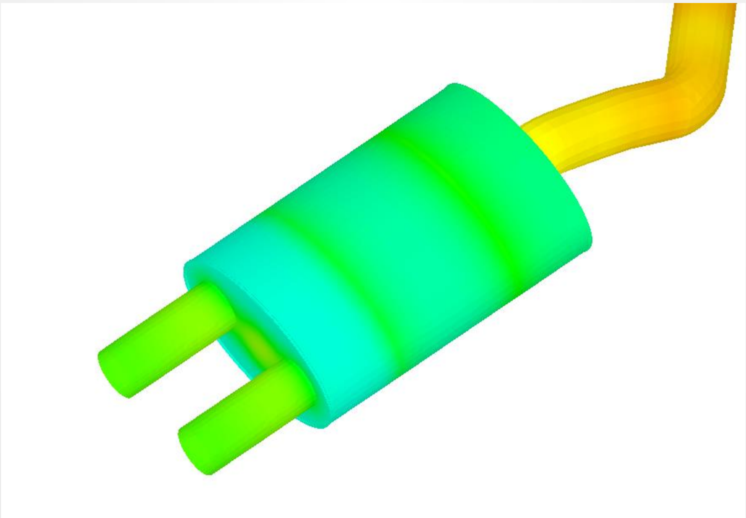
Muffler Comparison

- Temperatures are different when baffles are included

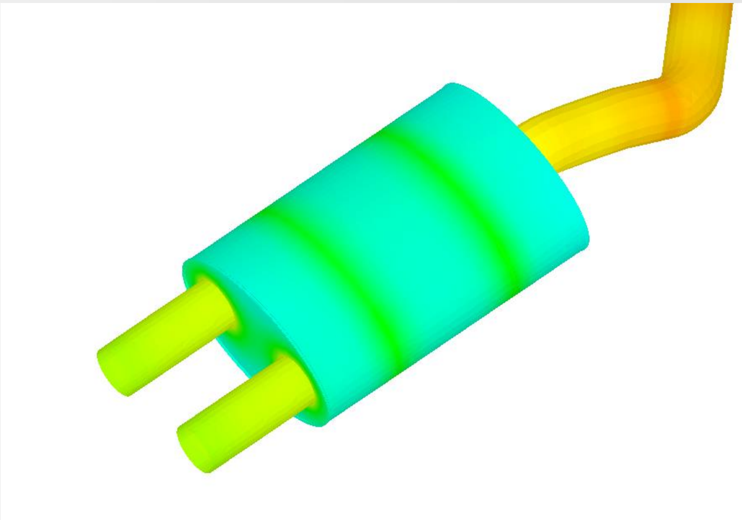
Simple Chambers

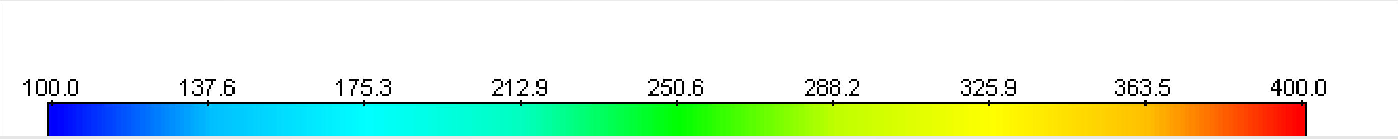


Open Chamber with Impingement



Custom with Interior Pipes





Muffler Comparison

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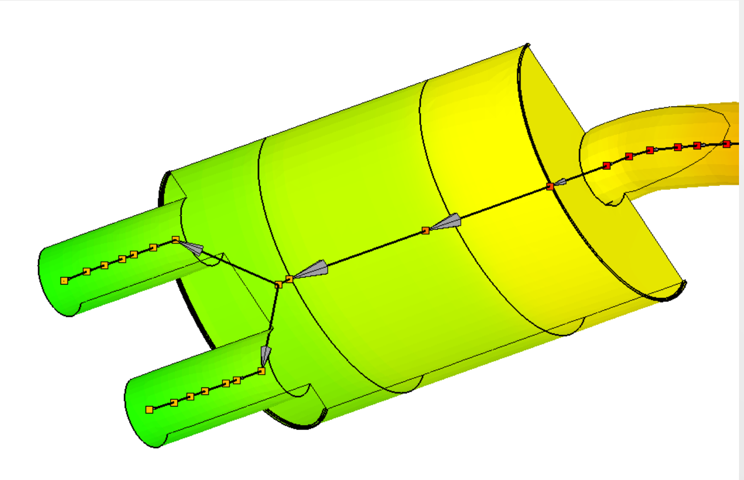
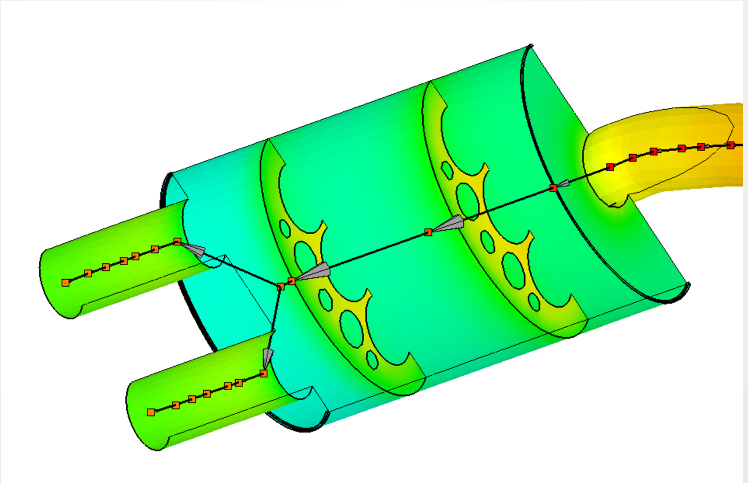
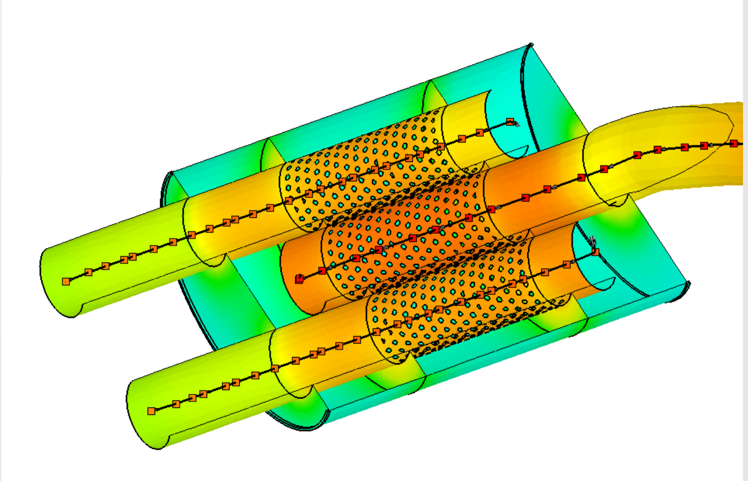
Simple Chambers

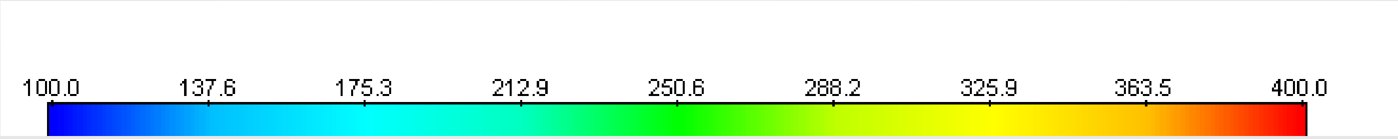


Open Chamber with Impingement



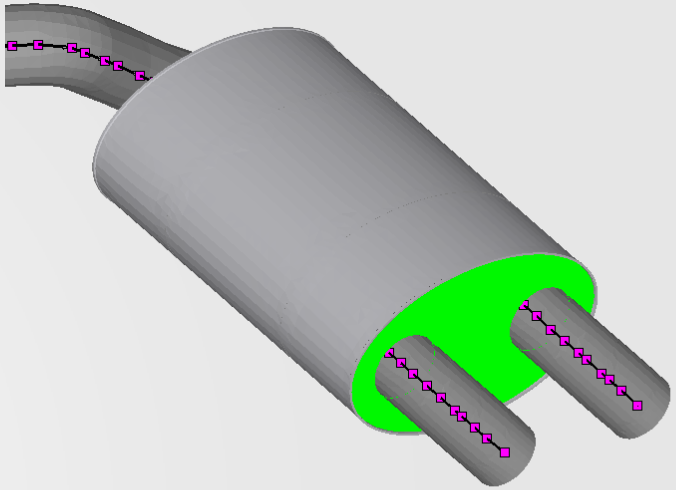
Custom with Interior Pipes



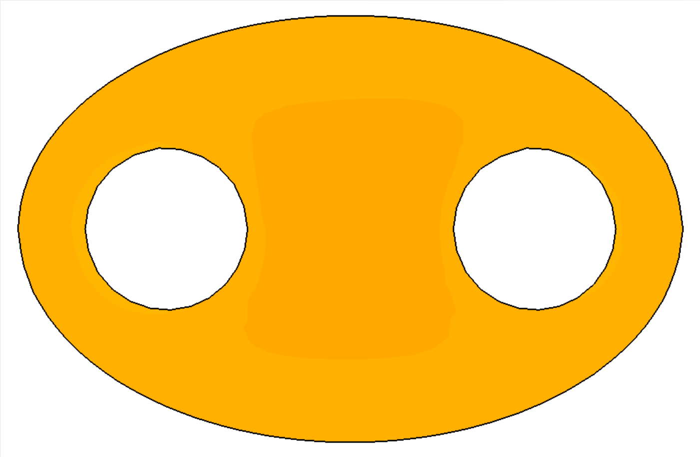


Muffler Back

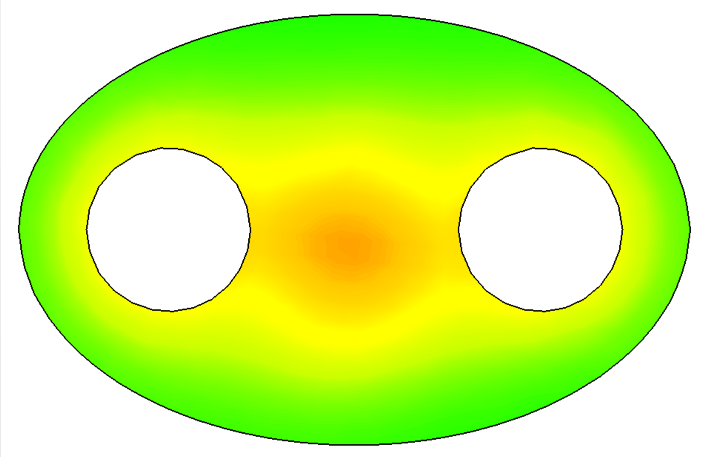
	Part 864 muffler_end_back (front max)	Part 864 muffler_end_back (front avg)
Simple Chamber	275.3	274.7
Open Chamber with Impingement	276.3	224.5
Custom with Interior Pipes	279.1	228.9



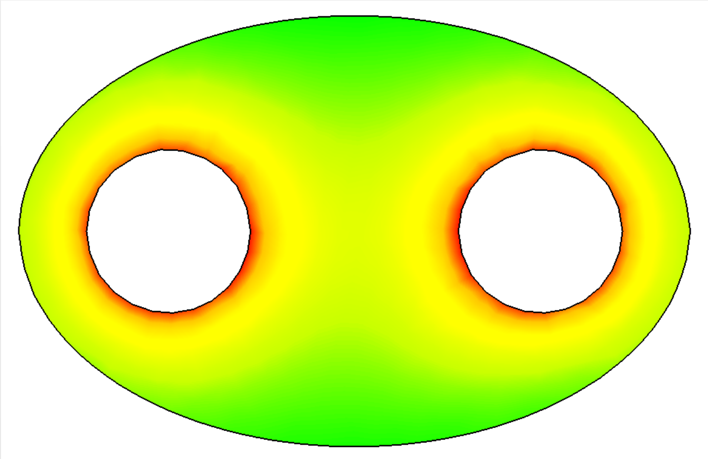
Simple Chambers



Open Chamber with Impingement



Custom with Interior Pipes



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