EIC – Beryllium Section Thermal Analysis Status

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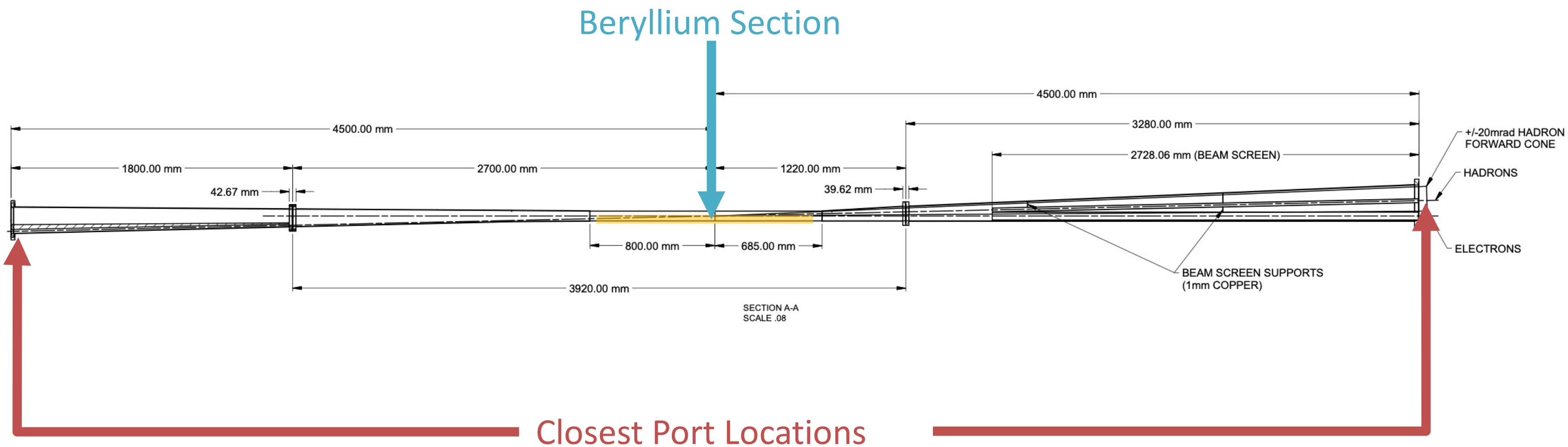
Problem Overview – Beampipe Constraints

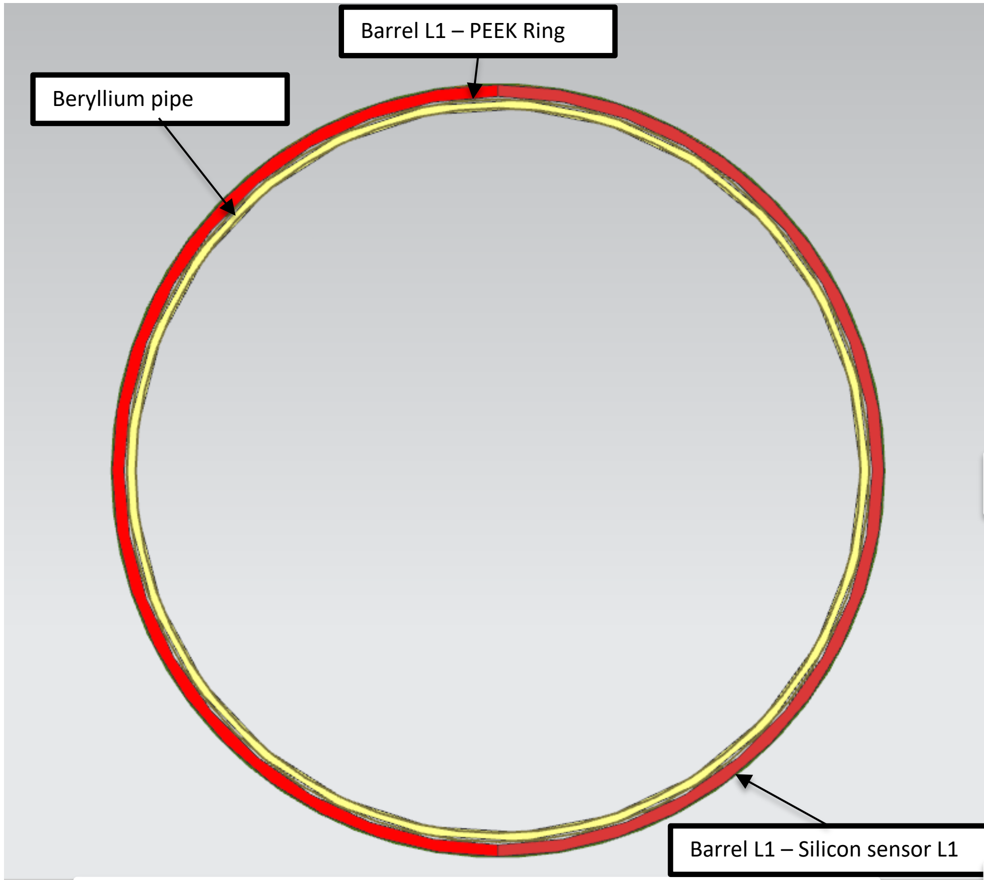
- Unique beampipe
  - No heaters around beampipe due to material/radiation length
  - Pumping ports located ~4.5 m away
    - Ports take lots of space so are outside of the detector volume
    - Needed vacuum (10^{-9} mbar) will be challenging



Problem Overview

- How to get needed vacuum?
  - Flow hot gas through the length
  - Needs to be at least ~100°C to break H_2O bonds
- Need the first layer of silicon close to beampipe to have a better vertexing resolution
- Placing the Si sensor layer 1 close to the beampipe will increase its temperature
- Assembly of the detector uses adhesives which can only handle ~30°C

Base Geometry Model



Beam view of the Beryllium Pipe, Sensor L1 and PEEK Ring

Part Name	Part Color	ID [mm]	OD [mm]	Thickness [mm]	Length [mm]
Beryllium pipe	Yellow	62.00	63.52	0.76	1470.00
PEEK Support	Red	64.00	66.00	1.00	10.00
Silicon sensor L1	Green	66.00	66.08	0.04	320.50

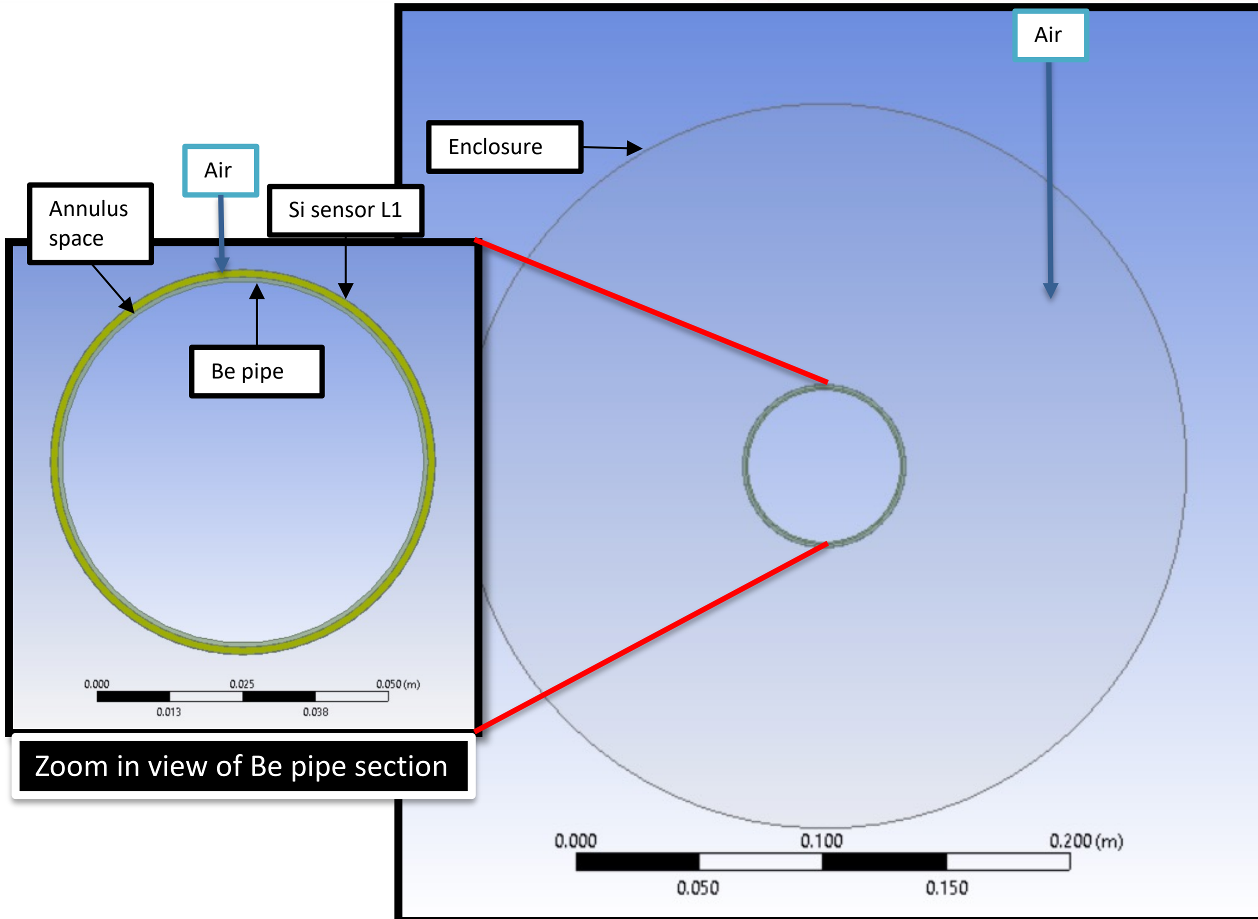
Table 1. Dimensions from imported STEP file

Distance Between	Distance [mm]
Beryllium pipe & PEEK Ring	~0.24
Beryllium pipe & Silicon sensor L1	~1.24

Table 2. Spacing of components

Model Modifications

- Assumed only Be-pipe and Si-sensor L1 parts (both solid domains)
- Created enclosure volume (fluid domain) to control the ambient temperature
- Created annulus space volume (fluid domain) between Be pipe outer face and Si sensor L1 inner face

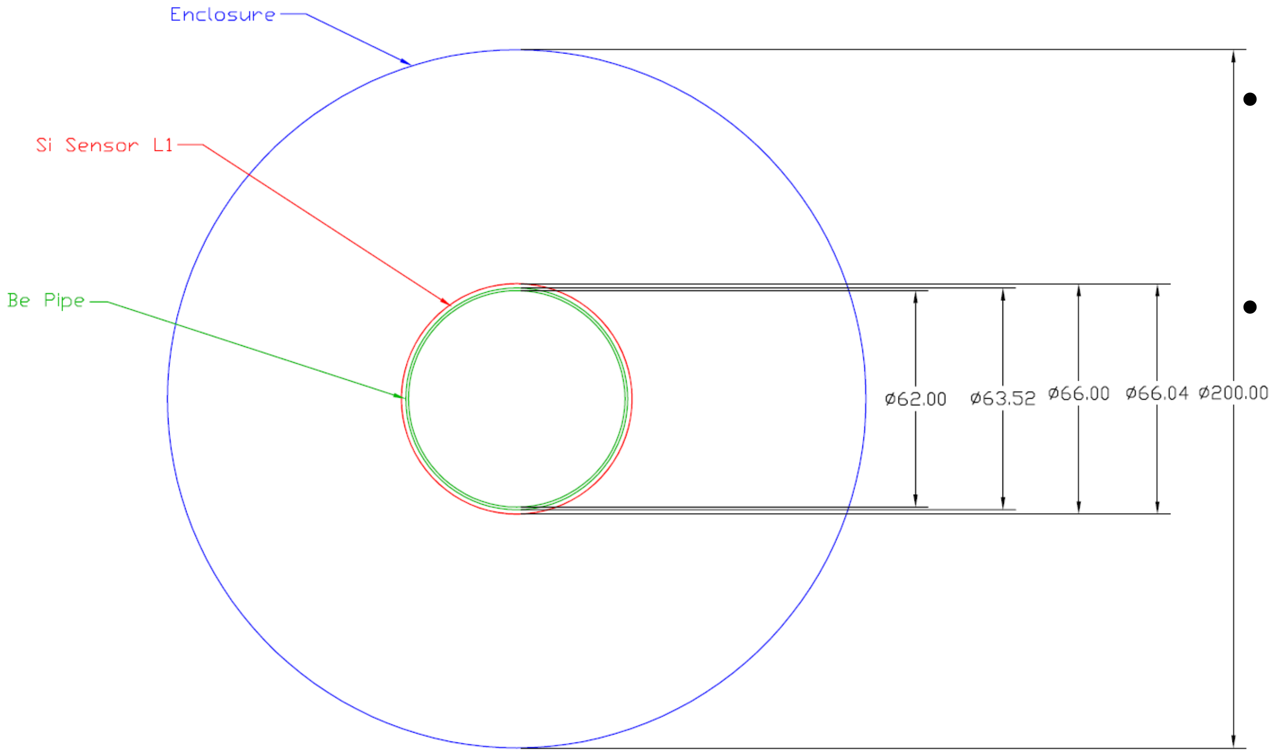


Zoom in view of Be pipe section

Assumed fluids for model – upstream view

Note: Did not consider N2 flow inside Be pipe, only surface temperature provided

Model Modifications

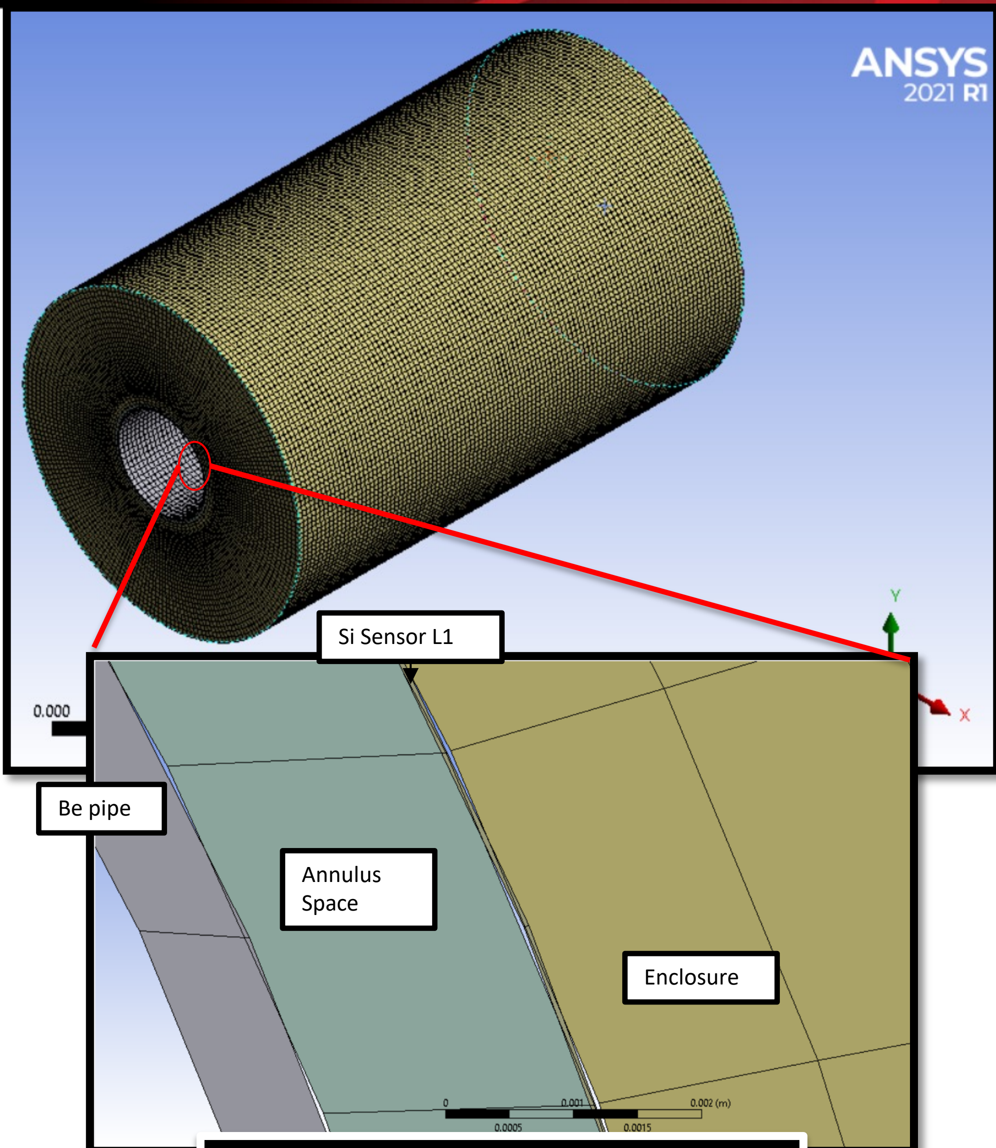


Be-pipe, silicon sensor L1 and enclosure dimensions – upstream view

- Added enclosure with diameter of 200 mm and with length of 320.50 mm
- Shortened length of Be-pipe to 320.50 mm, same as Si sensor L1
- Created various models with different separation between Be pipe and Si sensor L1
  - 1.24 mm (Base model)
  - 2 mm
  - 3 mm
  - 4 mm
  - 5 mm

Ansys Fluid Flow Fluent Analysis – Meshing

- Meshing set up
  - Element size: 3 mm
  - Method: Automatic
  - Nodes: 678,652
  - Elements: 635,790
  - Setup Si sensor L1 component with only one meshing cell layer due to its thickness (0.04 mm)



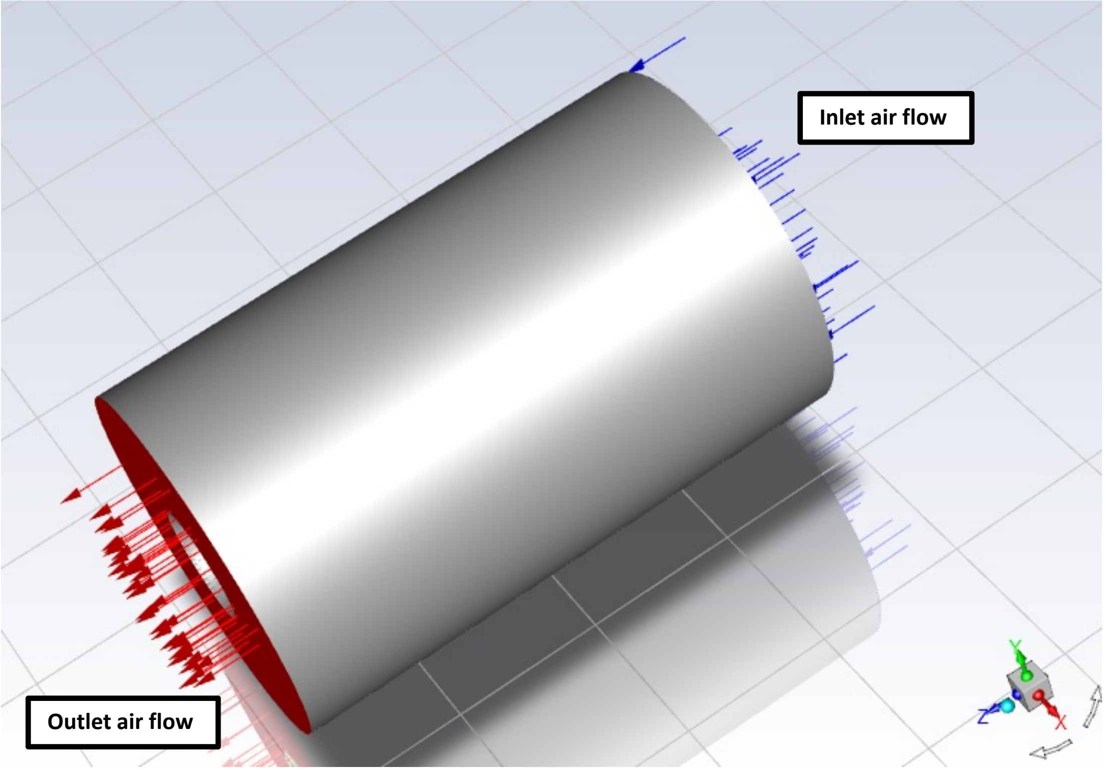
Example of mesh done for analyzed model

Ansys Fluent Analysis – Materials

- Materials
  - Air
    - Density: 1.225 Kg/m3
    - Specific heat: 1006.43 J/Kg*K
    - Thermal conductivity: 0.0242 W/m*K
  - Beryllium
    - Density: 1850 Kg/m3
    - Specific heat: 1825 J/Kg*K
    - Thermal conductivity: 190 W/m*K
  - Silicon
    - Density: 2330 Kg/m3
    - Specific heat: 700 J/Kg*K
    - Thermal conductivity: 148 W/m*K

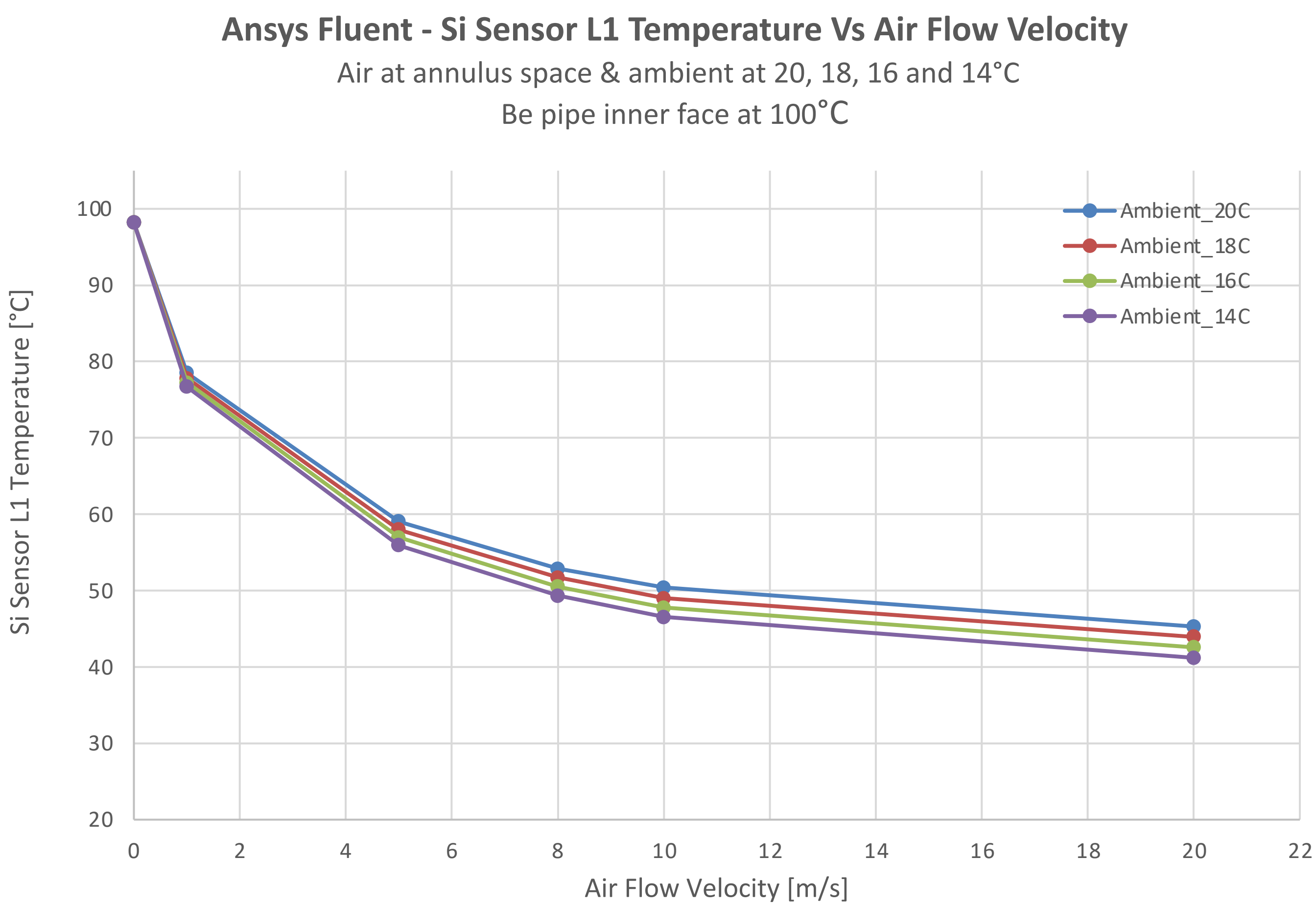
Ansys Fluid Flow Fluent Analysis – Conditions

- Solver: CFD Fluid Flow Fluent
- Viscous model: k-omega, Shear Stress Transport (SST)
- Simulation Iterations: 50
- Precision option: Double
- Be pipe inner face temp: 100°C
- Air temperature:20 to 14°C
- Air flow velocity: 0 to 20 m/s
- Thermal heat transfer: forced convection



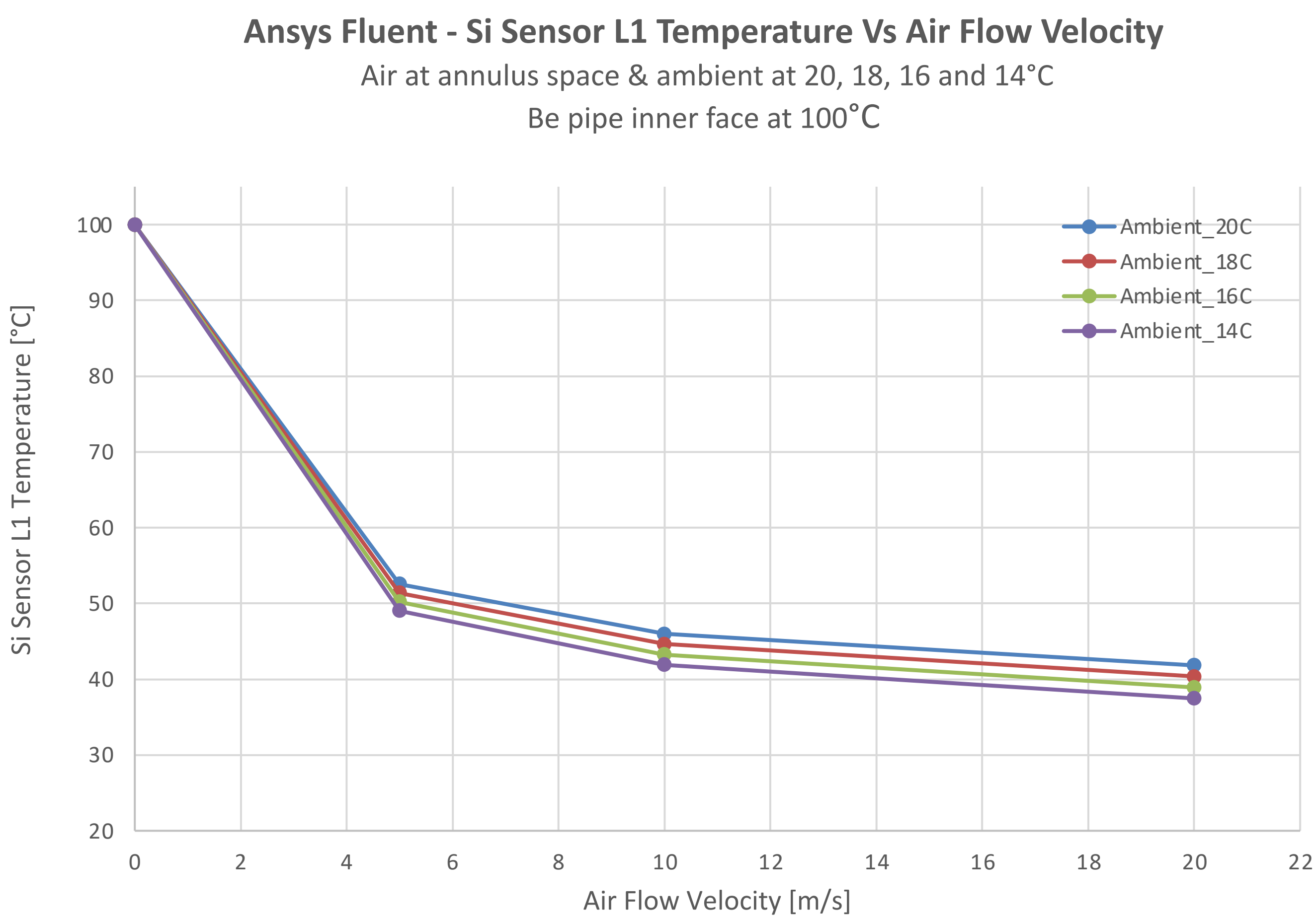
Boundary conditions setup - Red Arrows represents the output air flow and blue arrows the input air flow

Ansys Fluent Analysis – 1.24mm Results



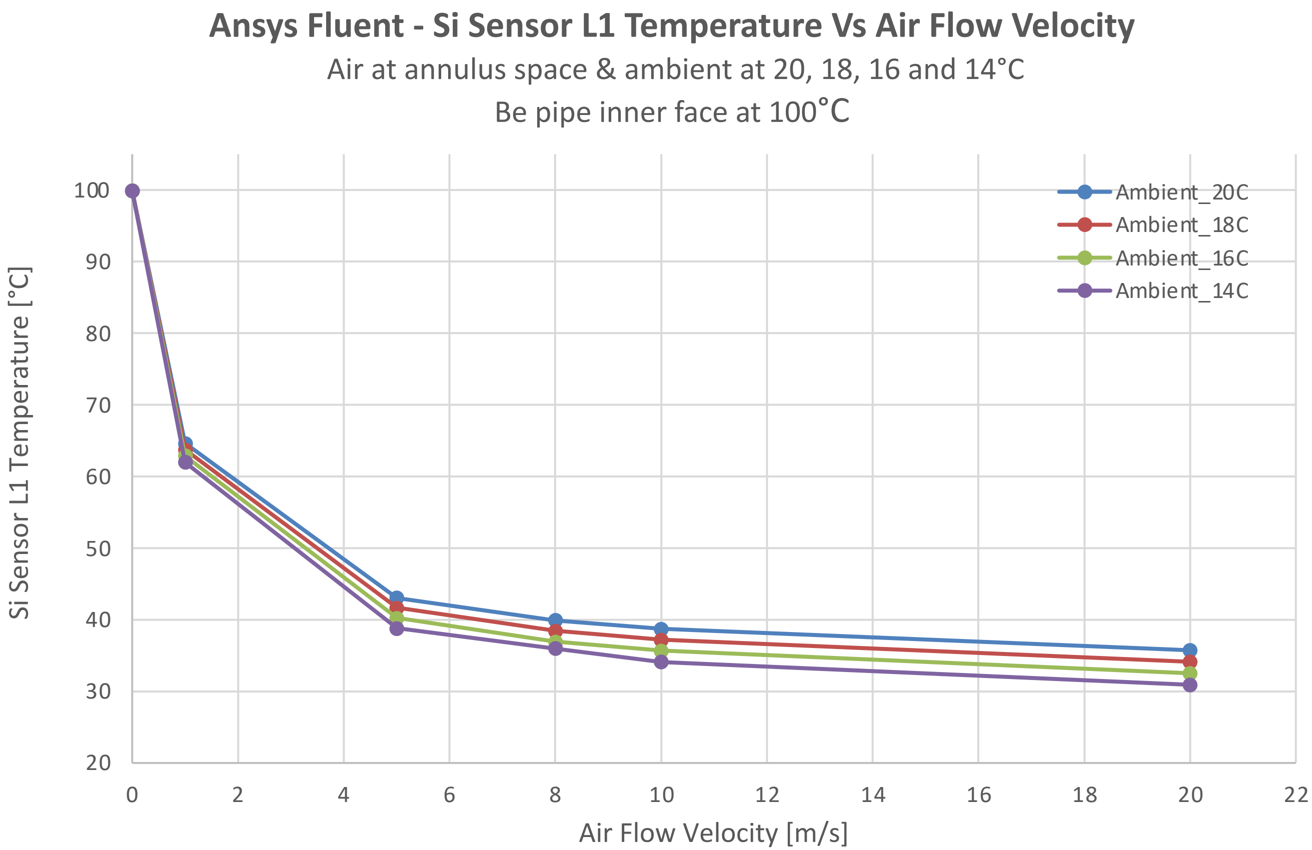
Maximum temperature for Si sensor L1 for model with 1.24 mm of separation

Ansys Fluent Analysis – 2mm Results



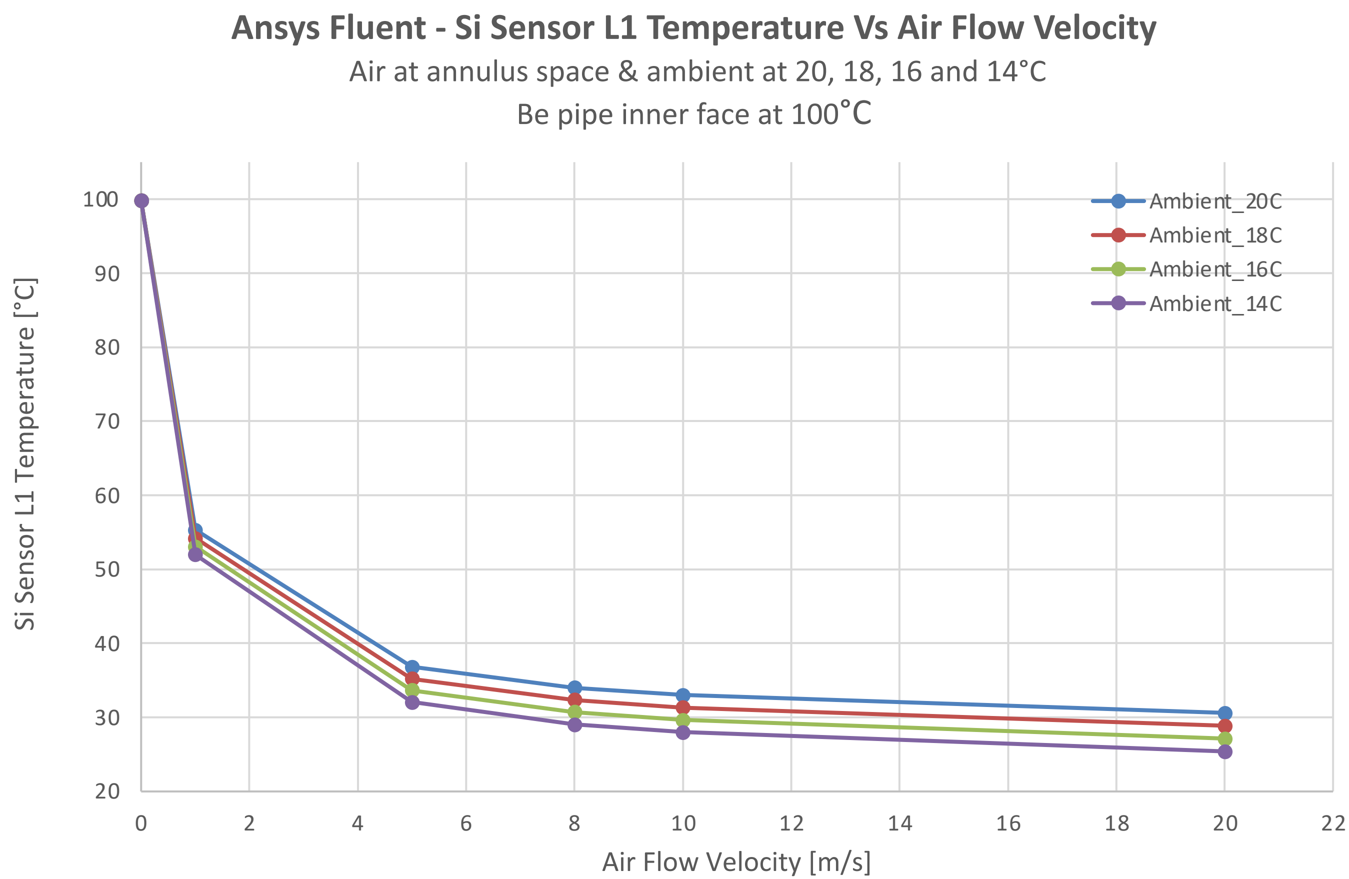
Maximum temperature for Si sensor L1 for model with 2 mm of separation

Ansys Fluent Analysis – 3mm Results



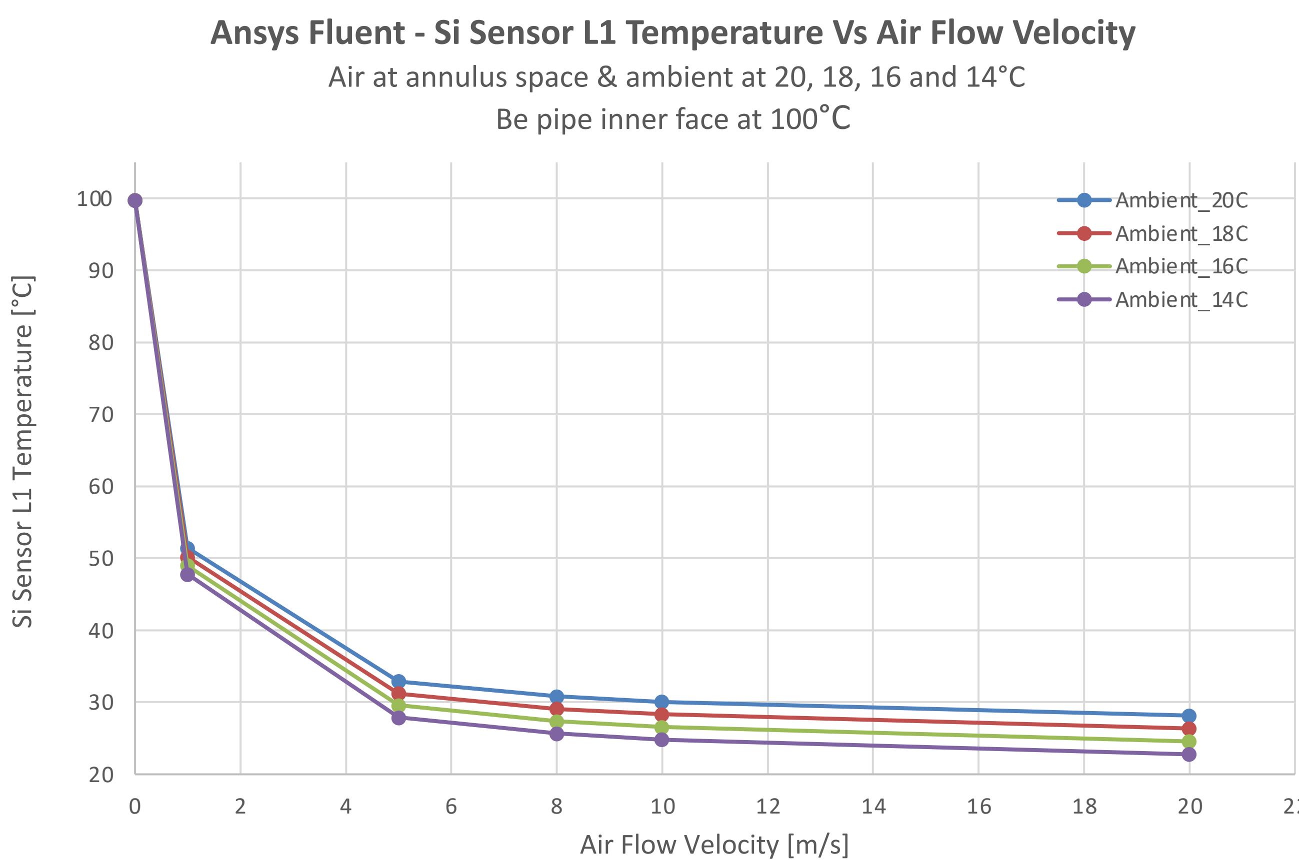
Maximum temperature for Si sensor L1 for model with 3 mm of separation

Ansys Fluent Analysis – 4mm Results



Maximum temperature for Si sensor L1 for model with 4 mm of separation

Ansys Fluent Analysis – 5mm Results

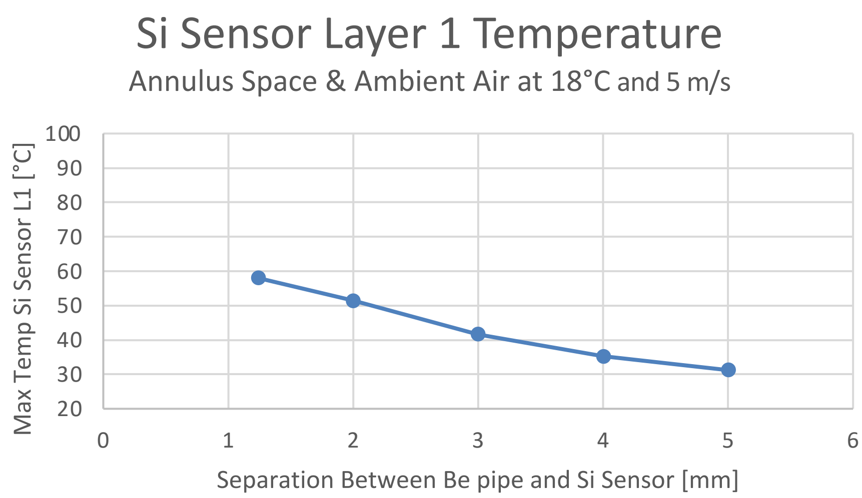


Maximum temperature for Si sensor L1 for model with 5 mm of separation

Ansys Fluent Analysis – Results

Ambient Temp [°C]	Annulus Temp [°C]	Separation between Be pipe and Si sensor L1 [mm]	Air flow Velocity [m/s]	Si sensor L1 Max Temp [°C]
18	18	1.24	5	57.99
		2	5	51.39
		3	5	41.64
		4	5	35.23
		5	5	31.23

Maximum temperature for Si sensor L1 for model for various separation between Be pipe and Si sensor L1



- Observed about 10°C difference between models from 1 to 3 mm of separation
- Noticed that temperature between models with 4 and 5 mm gap only drops about 4°C
- Results for simulation at the other temperatures followed the same trend