EIC Beryllium Pipe Section - CFD Thermal Analysis

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I continued with the thermal analysis of the Electron Ion Collider (EIC) beam pipe central section, which is to be made of beryllium and will be heated to 100°C to ensure that the molecules of water are broken on its inner surface.

I used Computational Fluid Dynamics (CFD) tools such as *Ansys Fluid Flow Fluent* software. I imported the simplified model of the beryllium pipe (Be pipe), the silicon sensor layer 1 (Si sensor L1) and the ambient enclosure. The model dimensions were showed on previous monthly memo.

I created two models with different separation between Be pipe and Si sensor L1 with 4 mm and 5 mm. Models with these separation allows mechanical stability. The selected meshing option, materials and the boundary conditions for the imported model in *Ansys Fluid Flow Fluent* software were the same as the models described in previous monthly memo. I selected a viscous model K-omega, shear stress transport model, recommended for turbulent flows.

I ran simulations for each model at different temperatures for the air in the annulus space and enclosure, 20, 18, 16, and 14°C; see Fig.1 with the results for 5 mm separation. Table 2 below includes the results for all simulation done from 1.24 mm to 5 mm.

I plotted the maximum temperature in the Si sensor L1 vs the separation and found the best fit for the trend, which turns out to be a polynomial of second order given as $y = 1.0272x^2 - 13.688x + 73.81$. Where x is the separation in mm and y is the maximum temperature in °C. See Fig.2.

- **Used *Ansys Fluid Flow Fluent* software to to find the temperature of the silicon layer.**
- **Ran simulation with different separation between Be pipe and Si sensor L1 at different temperatures and velocities for the air in the annulus space and enclosure. From the results the model with 5 mm separation with air at 18°C and 5 m/s keeps the Si sensor L1 at ~31°C**

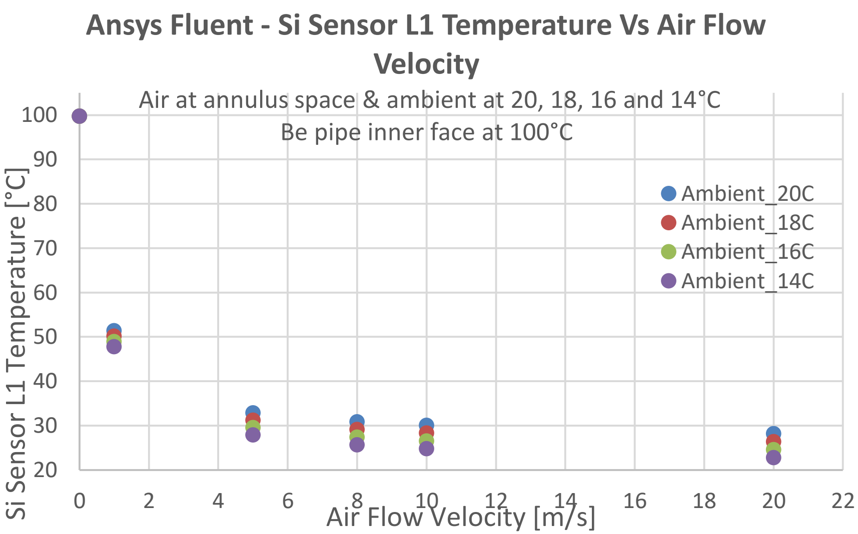

Fig.1. Maximum temperature for Si sensor L1 for model with 5 mm of separation between Be pipe and Si Sensor L1

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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

Table 2. Maximum temperature for Si sensor L1 for model for various separation between Be pipe and Si sensor L1. Air temperature in the annulus space and in the enclosure (ambient) at 18°C and 5 m/s.

Observed about 10°C difference between models from 1 to 3 mm of separation and also noticed that the temperature between models with 4 and 5 mm gap only drops about 4°C The results for simulation at the other temperatures followed the same trend. The results shows that 5 mm is the separation required to keep the temperature at lower 30°C, which was expected.

To improve the thermal simulation, the meshing method can be changed, add more details and components from the original model with a selected separation. However, I assume that this additions or modifications will not impact significantly to the obtained maximum temperature for the Si sensor L1. I plan to continue with the thermal analysis using the more of the post processing options on Fluent to visualize the data and provide detailed results.

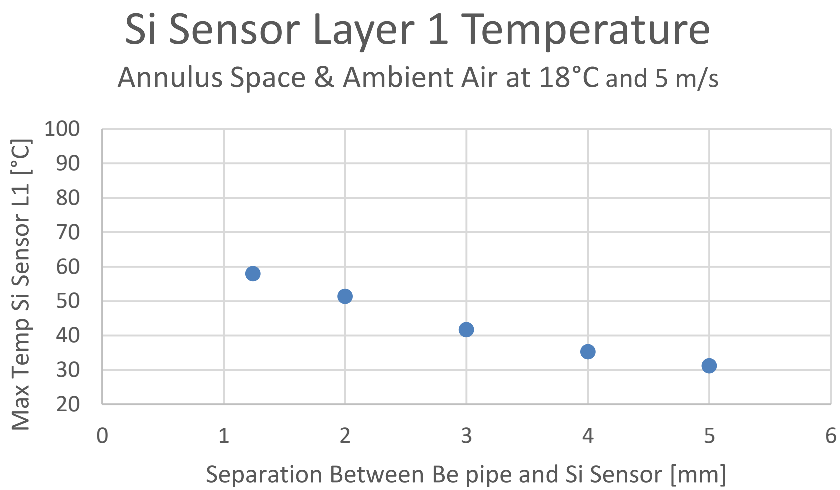

Fig.2. Maximum temperature for Si sensor L1 vs separation between Be pipe and Si Sensor L1