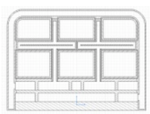
# DCLL Thermal-Hydraulics



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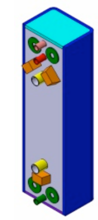


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University of Wisconsin-Madison


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# Outline

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- Goals
- Model Design
- ANSYS CFX
- Preliminary Results
- Simple Channel Simulation
- Future Work

# Goals

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1. Study the Helium flow distribution of the present design and adjust the design geometry to obtain an acceptable flow distribution everywhere. This will be performed with ANSYS CFX[1].

2. Study the simulation of 2-D one-sided heat transfer enhancement of the First Wall and the corresponding increase in pressure drop.

[1] http://www.ansys.com/products/fluid-dynamics/cfx/

# Model Design

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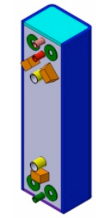
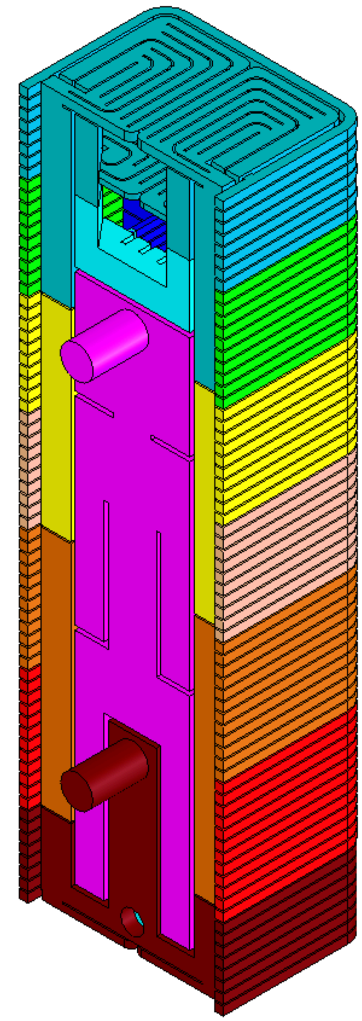
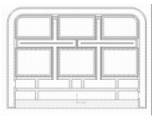


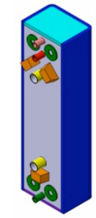
- To analyze the Helium flow in ANSYS CFX it was required to create a solid model of the Helium volume itself.
- This model was created in SolidWorks[2].
- The number of elements is limited in ANSYS so the full Helium volume was broken into sections, each will be analyzed in series.
- For preliminary analysis, no steel structure will be included in the models. The steel structure can be added if necessary.
- The different colors represent different sections of the model. There are 10 sections.



[2] http://www.solidworks.com



# ANSYS CFX



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- ANSYS CFX allows the user to perform a simulation from geometry creation to post-processing without the need for other software.
- Geometry can be created with the integrated ANSYS DesignModeler or geometries can be imported from external CAD programs such as SolidWorks.
- Meshing can be completed using the CFX-Mesh utility within ANSYS CFX.
- When the meshing is completed, then initial and boundary conditions can be established in CFX-Pre. This is the pre-processor portion of the simulation.
- After the simulations have been run, the results can be analyzed in CFX-Post, which is a graphical post-processor.

# Preliminary Results

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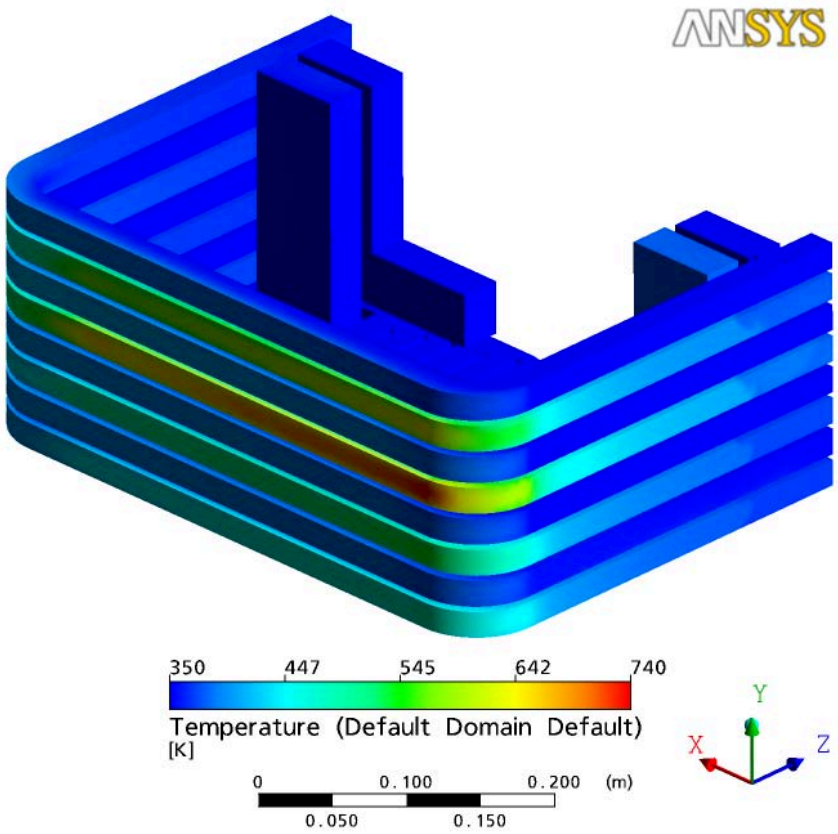
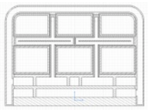
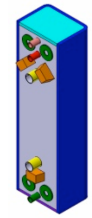
- Preliminary analysis was performed to determine the capability of ANSYS CFX to accurately model the Helium flow.
- Single Channel analysis is currently being performed.
- Stage A (shown on the right) was simulated with an identical mass flow rate going to each "Helium Circuit."
- It can be seen that the flow is anti-symmetric at the first wall, which is a problem that is being worked on.





# Flow non-symmetry is due to non-symmetric First Wall inlet geometry



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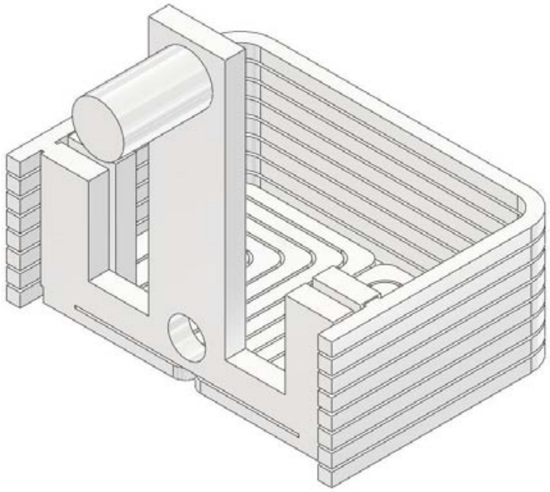

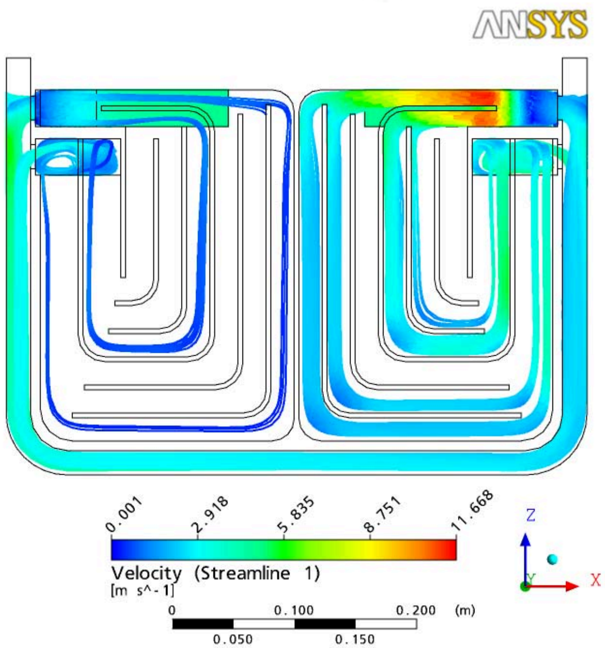


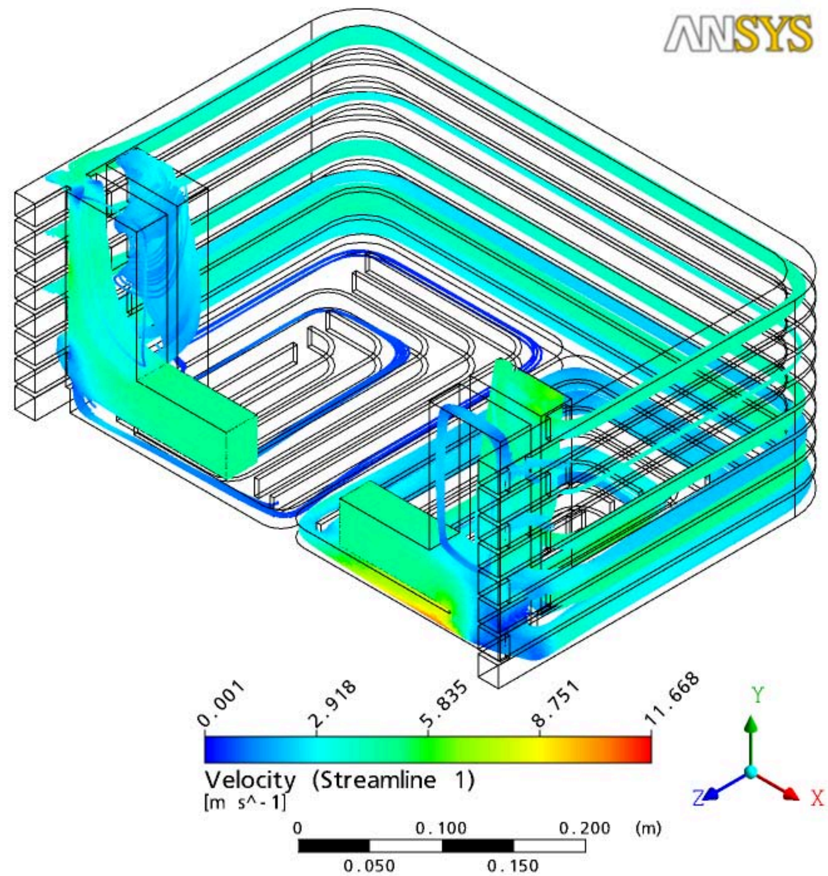

# Simple Channel Simulation of Surface Roughening

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- In the interest of applying ANSYS-CFX to simulate heat transfer coefficient enhancement a simple channel simulation is being performed.

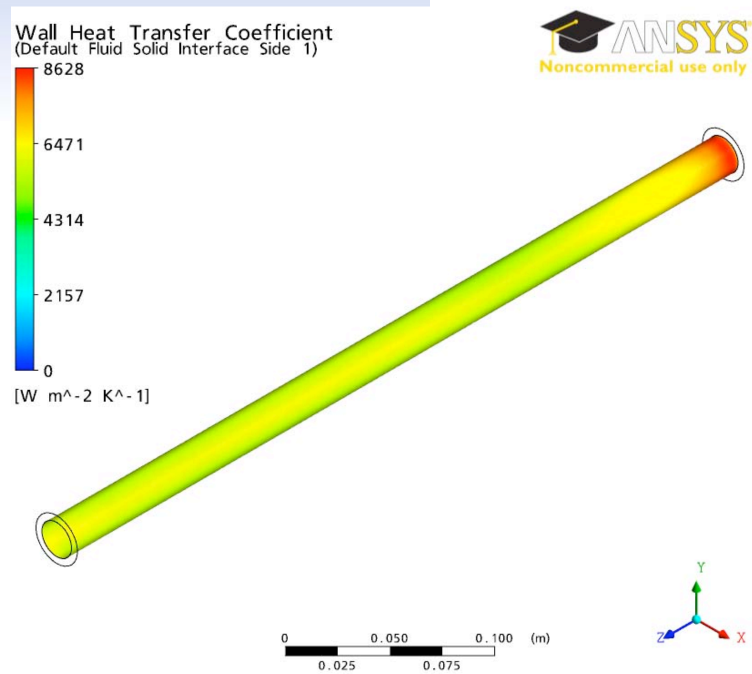
- One effect being studied is the change in heat transfer coefficient due to the application of roughness in the simulation.

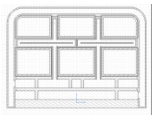
- The goal is to accurately create a result that gives at least

  $h = 2*h_{smooth}$

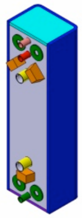
  - where $h_{smooth}$ is the heat transfer coefficient from a smooth-walled simulation.

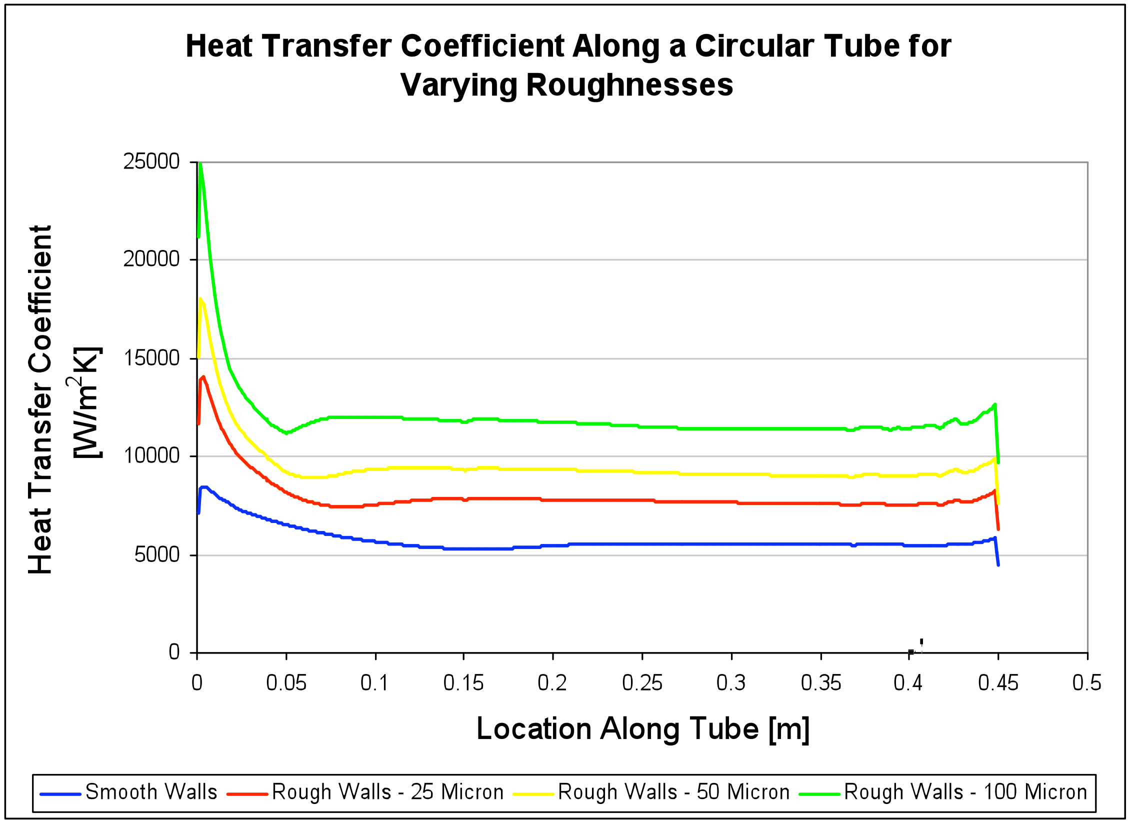
- These results will be compared to 2-D roughened results with well defined geometry; increase of the friction factor will also be compared.



# Simple Channel Simulation




- It is seen that an increase in wall roughness causes an increase in the heat transfer coefficient.
- These results were compared to a calculation done with EES[3] to examine the trend exhibited by the change in heat transfer coefficient.

**h [W/m²K] at x=0.3m**

| | ANSYS | EES | Ratio of EES/ANSYS |
|---|---|---|---|
| **Smooth Walls** | 5555 | 4772 | 0.859 |
| **Rough - 25 μm** | 7661 | 7149 | 0.933 |
| **Rough - 50 μm** | 9091 | 8518 | 0.937 |
| **Rough - 100 μm** | 11435 | 10494 | 0.918 |

[3] http://www.fchart.com/ees/ees.shtml

# ANSYS Wall Roughness



- ANSYS CFX treats rough walls similar to smooth walls with the exception being that the logarithmic profile is moved closer to the wall.

- Roughness effects are accounted for by modifying the expression for $u^+$ as follows:

$$u^{+} = \frac{1}{\kappa}\ln\left(\frac{y^{*}}{1+0.3k^{+}}\right)+C$$

where

$$k^{+} = y_R \frac{\rho}{\mu} u^{*}$$

$y_R$ is the equivalent sand grain roughness.

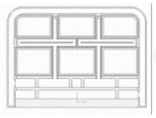
- We will learn if ANSYS CFX can be used or modified to approximate wall defined geometry roughening for both *h* and *f*.

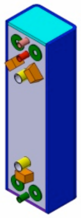
# Future Work

1. Continue assessment of the Helium flow distribution and extend its assessment to the other sections of the Helium volume. Compare these results to those from CRADLE.

2. Continue to investigate the possibility of ANSYS CFX to simulate 2-D roughening and 2-D one-sided roughening of the first wall channel. It is likely that other methods of approximation will be needed.

# Questions?





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