

Computational Fluid Dynamics Analysis of Turbulent Flow in a 2nd-Generation Irradiation Target Holder at HFIR

J. D. D'Arrigo¹, J. D. Freels², A. Elzawawy¹

1. Vaughn College of Aeronautics and Technology, East Elmhurst, NY, USA
2. Oak Ridge National Laboratory, Oak Ridge, TN, USA

Introduction:

- The High Flux Isotope Reactor (HFIR) regularly produces radioactive isotopes
- Current irradiation target holder is difficult to assemble and disassemble
- The new 2nd-generation irradiation target holder (2-GITH) is intended to simplify the process
- Irradiation generates large heat flux, which requires continuous cooling
- 2-GITH requires CFD analysis to ensure the targets receive enough coolant (5 gpm each)

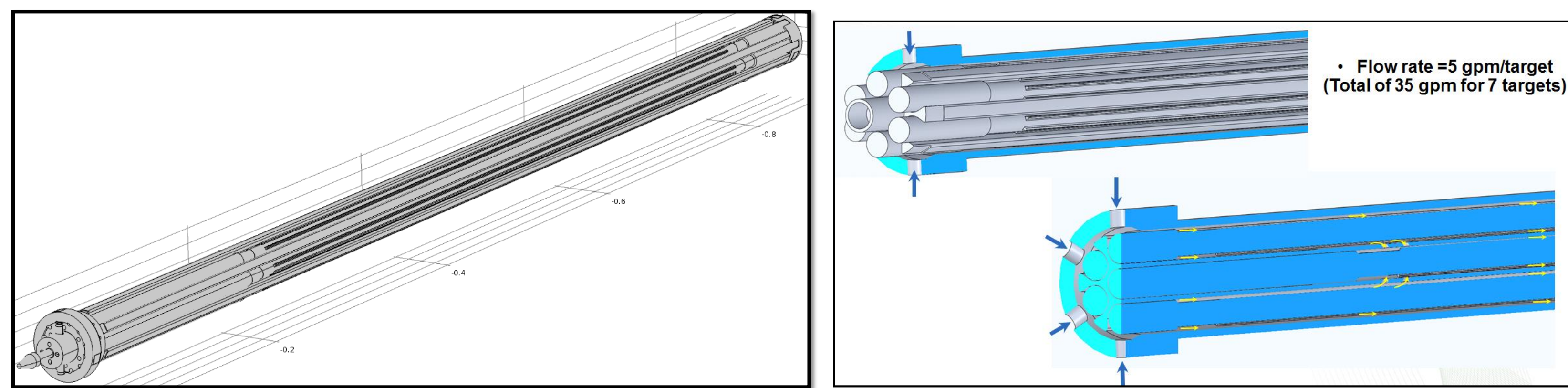


Figure 1. 2-GITH Model

Computational Methods:

- COMSOL is used to simulate flow in 2-GITH using the k- ϵ turbulent flow module and cluster computing
- 2-GITH has six-fold rotational symmetry, so the flow model is reduced to a one-sixth sector to reduce solve time and memory requirements
- Total flow is 5.83 gpm (outer target plus 1/6th of center target)
- Geometry has 3 regions of interest: outer target outer channel (OTOC), outer target inner channel (OTIC), and center target channel (CTC)

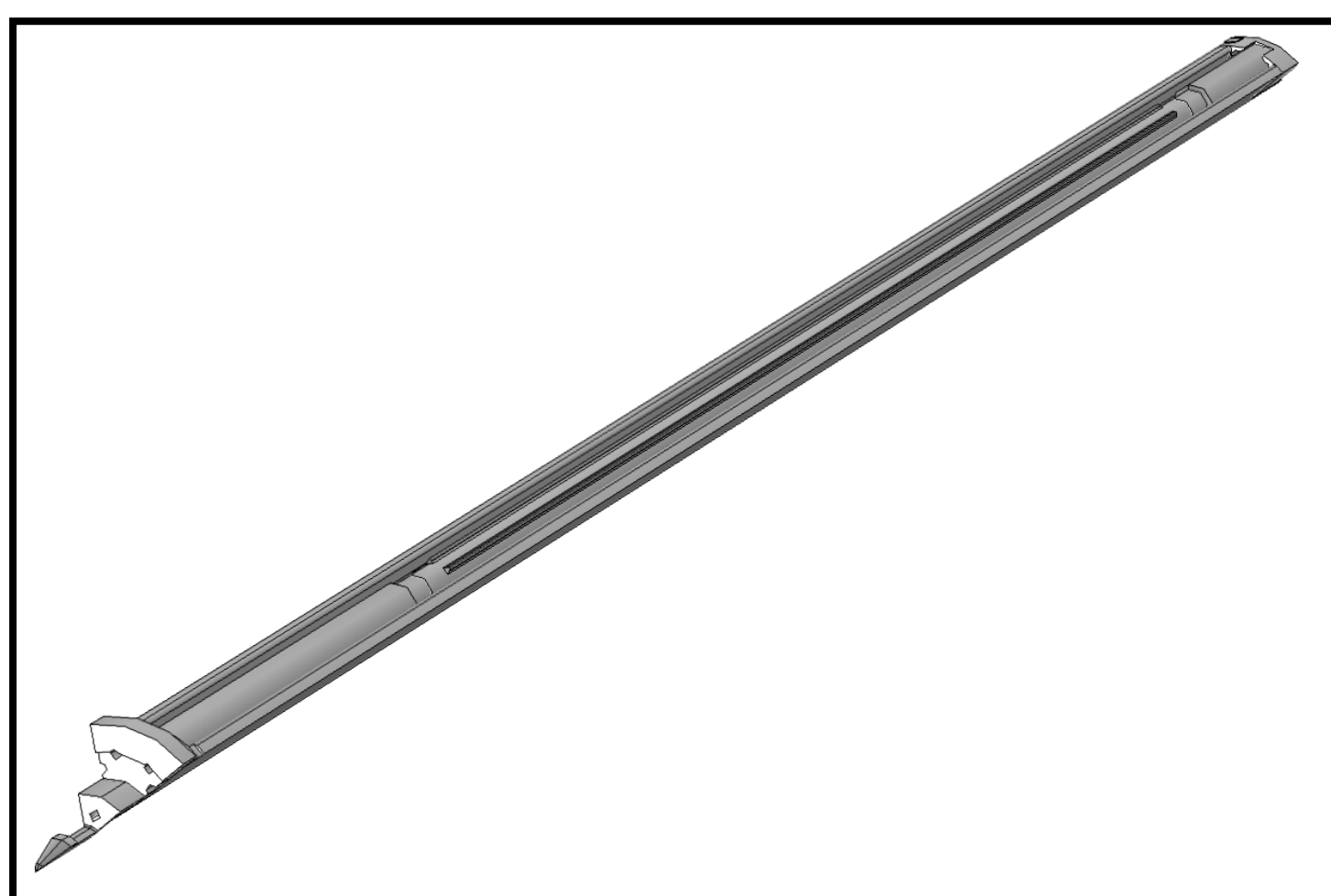


Figure 2. One-sixth slice of 2-GITH

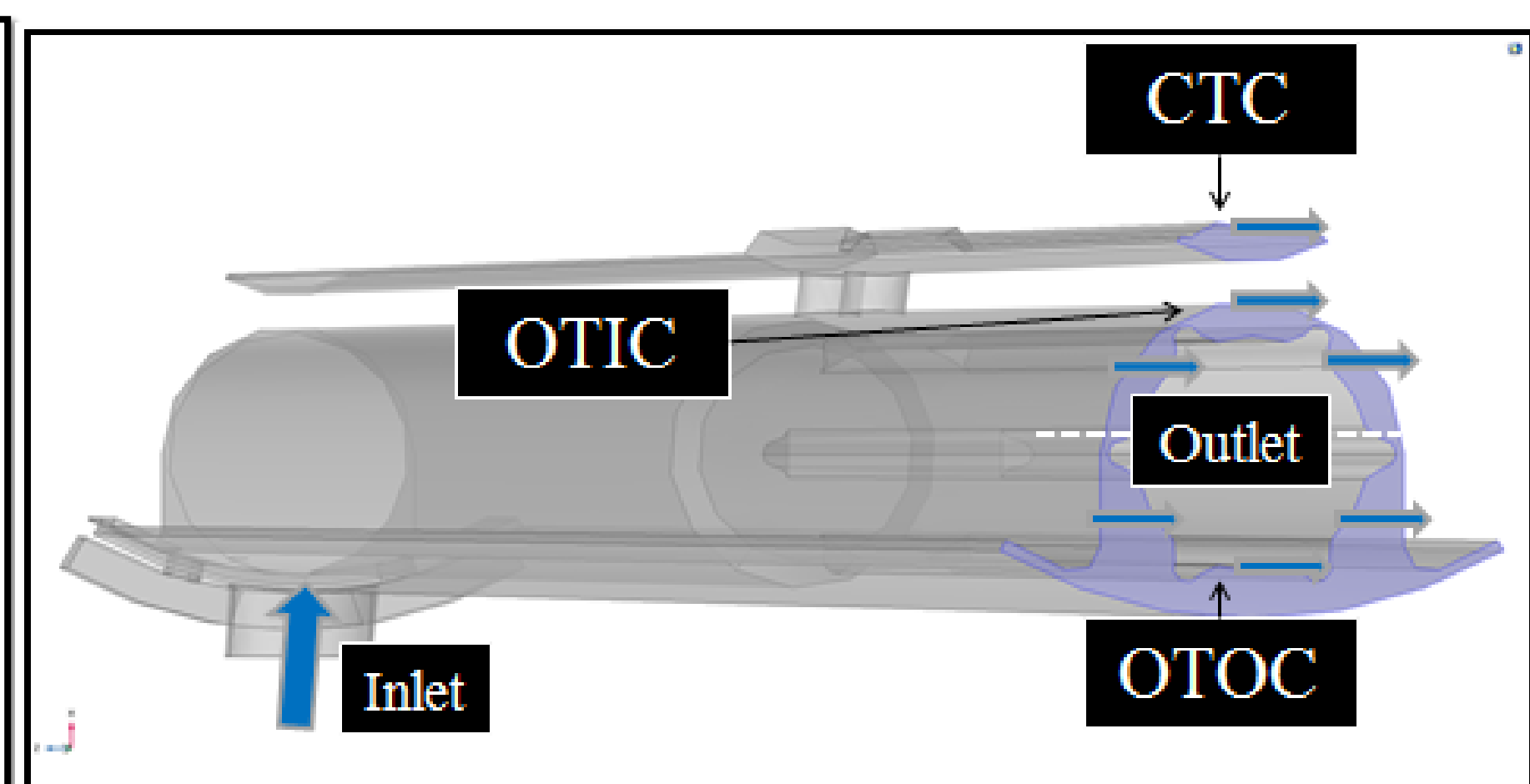


Figure 3. The inverse of the slice is taken to represent the flow volume in 2-GITH

Results:

Preliminary results show severe flow restriction in the CTC and reduced flow in the OTIC

- CTC flow $\cong 0.6 \text{ m/s} \rightarrow 0.269 \text{ gpm}$
- OTIC flow $\cong 2.5 \text{ m/s} \rightarrow 0.68 \text{ gpm}$
- OTOC flow $\cong 10 \text{ m/s} \rightarrow 5.104 \text{ gpm}$

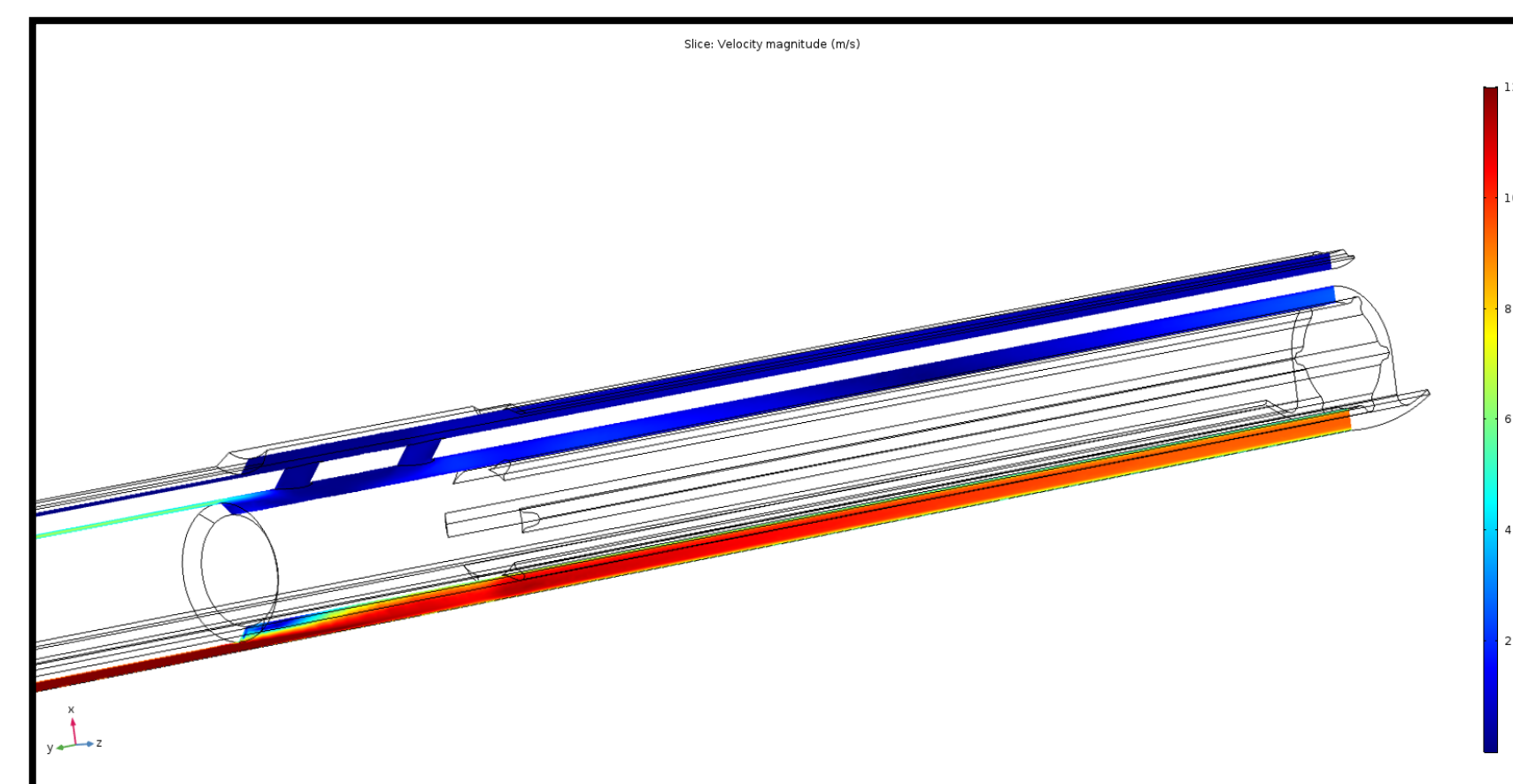


Figure 4. Velocity magnitude surface plot in the CTC, OTIC, and OTOC

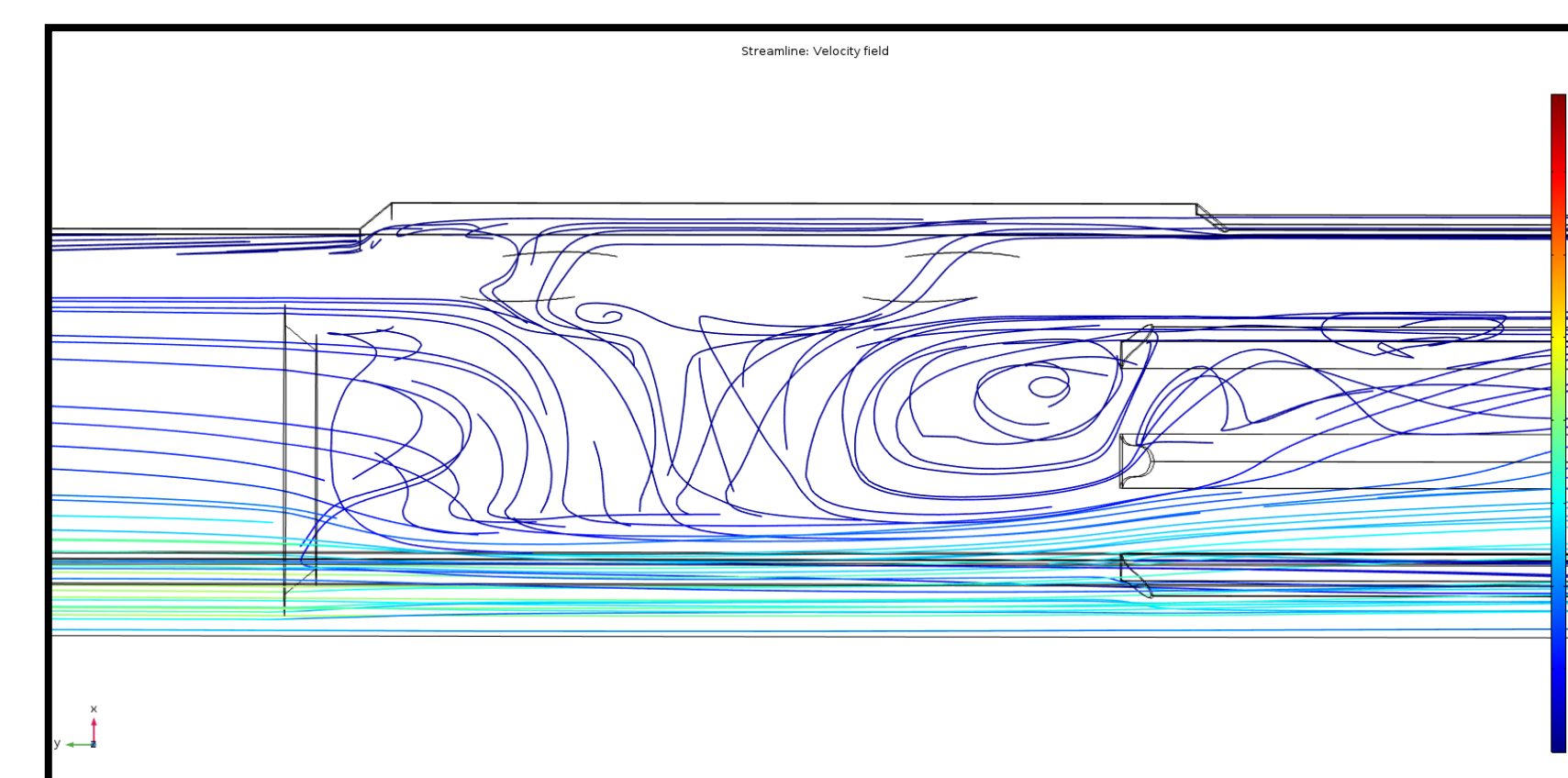


Figure 5. Vortices found in the region upstream of the fins where water flows to the CTC

- Results prompted design change to isolate the center target from the outer targets to give it a 5 gpm flow rate

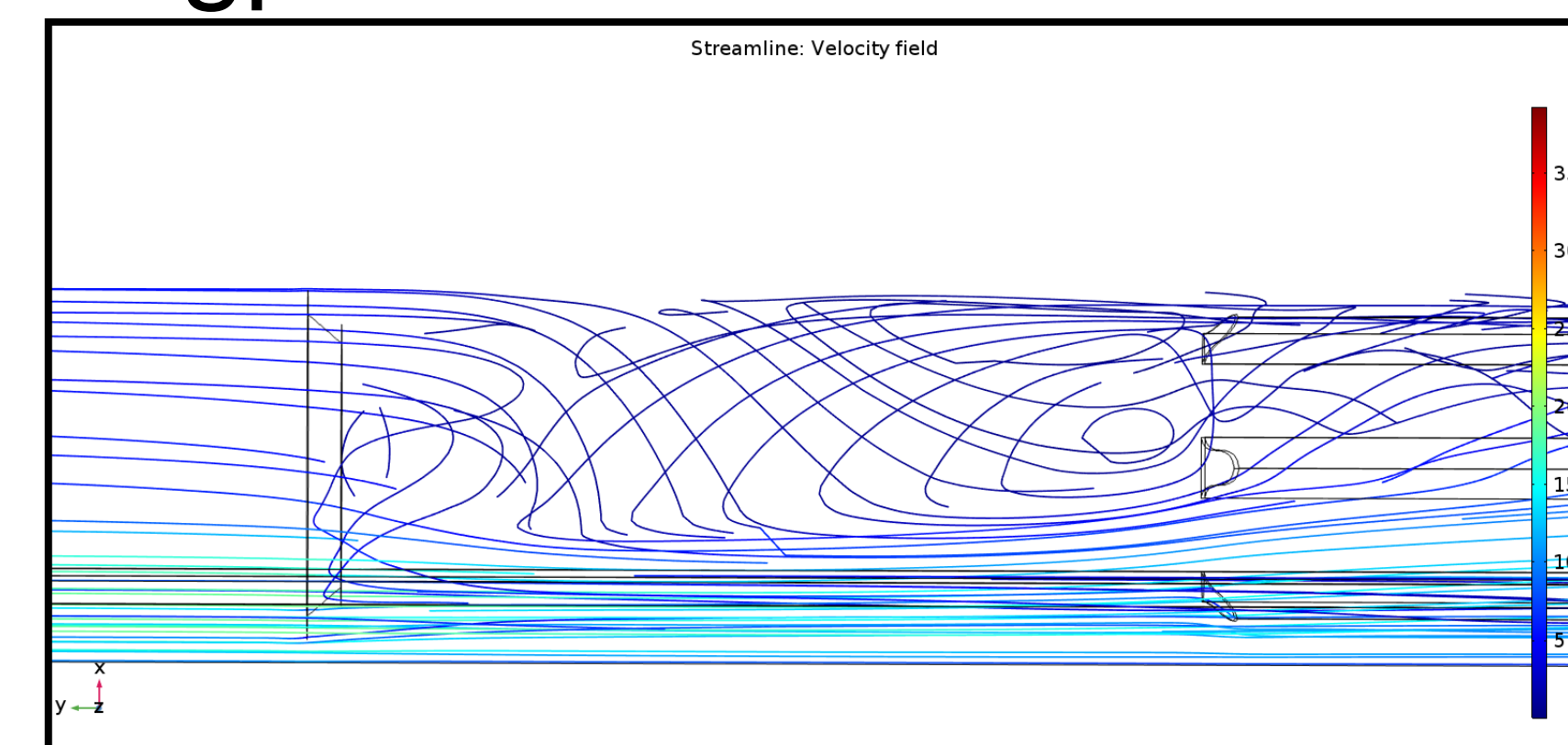


Figure 6. Velocity streamlines of the modified 2-GITH show the vortices remain

- Results of modified model show slight velocity increase in OTIC (to 3.1 m/s $\rightarrow 0.8 \text{ gpm}$) but negligible change in vortex development

Conclusions:

- Insufficient flow prompted design change to make the CTC independent of outer targets.
- Isolation of the center target will be implemented in the next 2-GITH production.
- Vortices and low-flow rate in the OTIC are still present in the modified model.
- Heat transfer analysis and more CFD simulation are needed to determine adequacy of the proposed cooling process.

Acknowledgements:

This work was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Visiting Faculty Program (VFP), and the National Science Foundation under Grant No. 1154000..