School of Nuclear Science and Engineering

COLLEGE OF ENGINEERING

Task 2.1 Update

Dr. Brian Woods and Tommy Moore

WORKING GROUP MEETING SPRING 2017
ARGONNE NATIONAL LABORATORY
CHICAGO, IL

Outline

- Task 2.1 Overview
- January Meeting Overview and Outcome
- STAR-CCM+ Modeling
- Preliminary Results
- Conclusions and Future Work

Task 2.1 Description

Task #	Description	Owner
2.1	Sodium Loop	
2.1.1	Survey literature of existing sodium test data	B. Woods
2.1.2	Select two candidate problems	B. Woods
2.1.3	Organize and document data for two candidate problems	B. Woods
2.1.4	Identify and review industry needs for sodium loop data	B. Woods
2.1.5	Down-select to one problem for benchmark evaluation	B. Woods
2.1.6	Preliminary modeling with industry tool Star CCM+	K. Weaver
2.1.7	Preliminary modeling with NEAMS code Nek5000	D. Pointer
2.1.8	Comparison of experimental data & model results for problem	B. Woods
2.1.9	Benchmark level evaluation of problem	B. Woods
2.1.10	Evaluation of uncertainties in selected problem	B. Woods
2.1.11	Submission of benchmark for peer review	B. Woods

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Task 2.1 Schedule

Task ID [#]	Year 1				Year 2				Year 3			
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4
2.												
2.1												
2.1.1												
2.1.2												
2.1.3		=										
2.1.4												
2.1.5			+									
2.1.6												
2.1.7												
2.1.8						+						
2.1.9												
2.1.10												
2.1.11											=	

Two Candidate Problems Selected

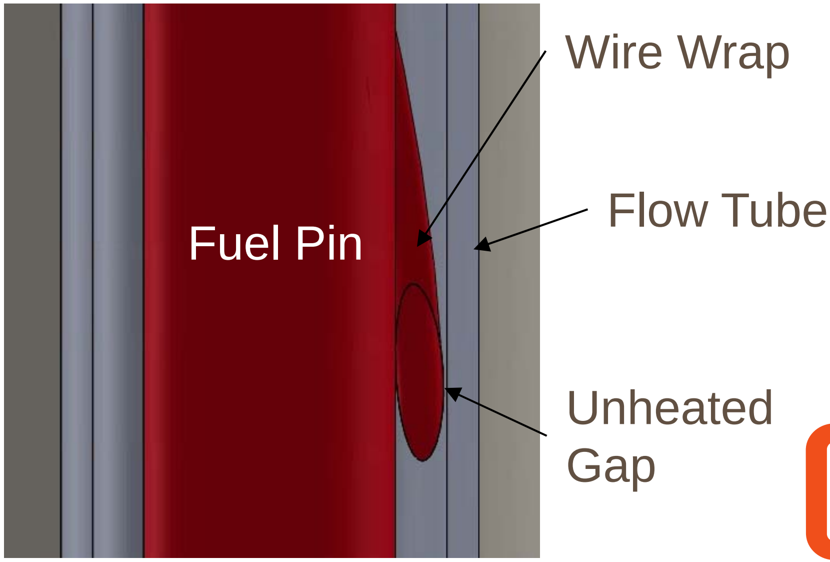
Preliminary Modeling in CFD Codes

Down-selected to a Single Problem

Benchmark Level Evaluation

January Task 2.1 Meeting Overview

- Purpose of meeting
  - Determine the necessary models to create to perform the benchmark
- What is the purpose of the benchmark?
  - Make sure the physics around the pin are well understood
- How to achieve this?
  - Detailed model of the test section
- What challenges might arise from this sort of model?
  - Gap between wire wrap and flow tube is very small, causes test section to essentially become a spiral when heated up.



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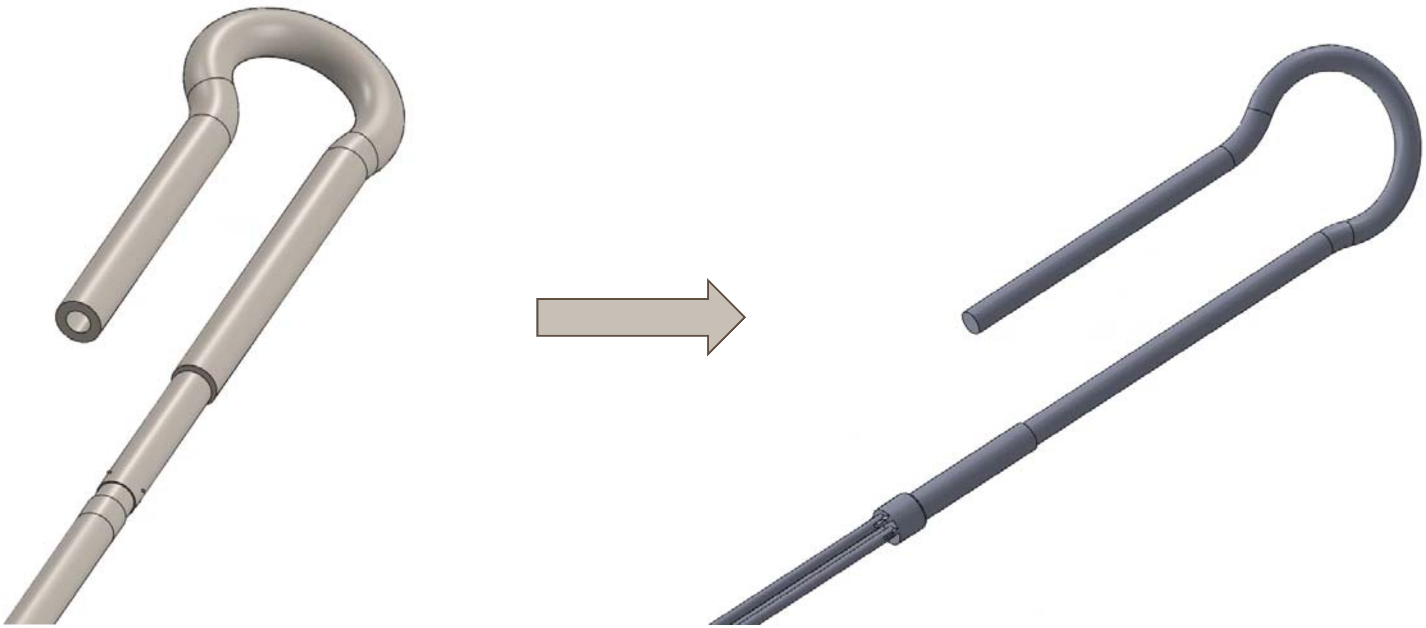
January Task 2.1 Meeting Outcome

- Mike Steer, David Pointer, and Tommy Moore in attendance with appearances by Wade Marcum and Brian Woods
- Path Forward
  - Begin with a commercial code as a scoping study to see if a single pin model will be sufficient for Nek5000 model
  - Need to determine the flow splits through each flow tube as a boundary condition for the Nek5000 model
  - Use a porous body model for the flow tubes to model the fuel pins and wire spacers
  - Simpler and quicker than explicit modeling of these features
  - Also provides a good baseline of knowledge for future Nek5000 modeling

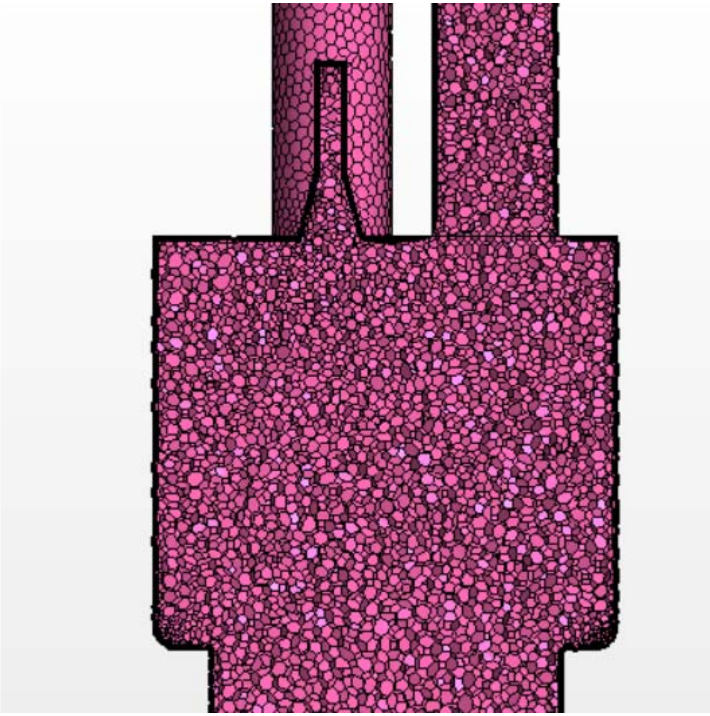
STAR-CMM+ Modeling - Geometry

- HOP 1-6A Geometry imported from SolidWorks model
  - Had to create a fluid model in SolidWorks to be imported
- Parts from this geometry can be imported in future Nek5000 model



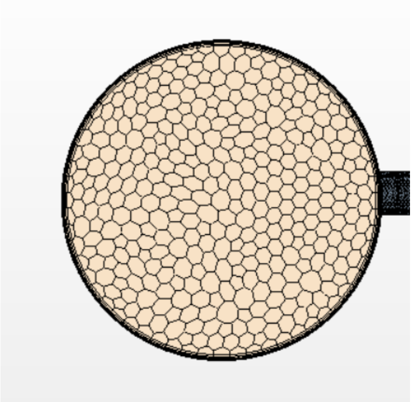
STAR-CMM+ Modeling - Mesh

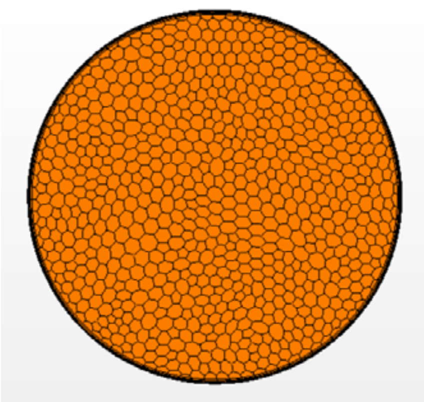
- Polyhedral and Prism Layer Mesher
  - 7 cells in the prism layer
  - Base cell size of 1 mm
- Lower Bend - 612741 Cells
- Lower Plenum - 206580 Cells
- Flow Tube A - 542657 Cells
- Flow Tube B - 538936 Cells
- Flow Tube C - 535602 Cells
- Upper Flow Region - 724013 Cells
- Total - 3160529 Cells



Inlet to Test Section

Inlet to Lower Bend





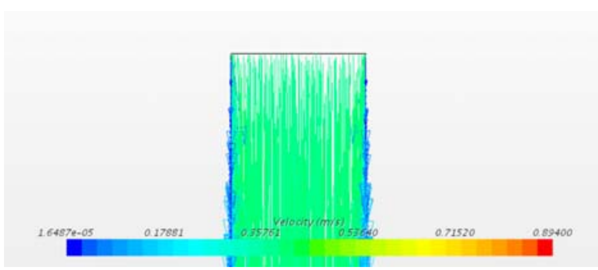
Loop Outlet

STAR-CCM+ Modeling – Physics Values, Initial and Boundary Conditions

Physics Values

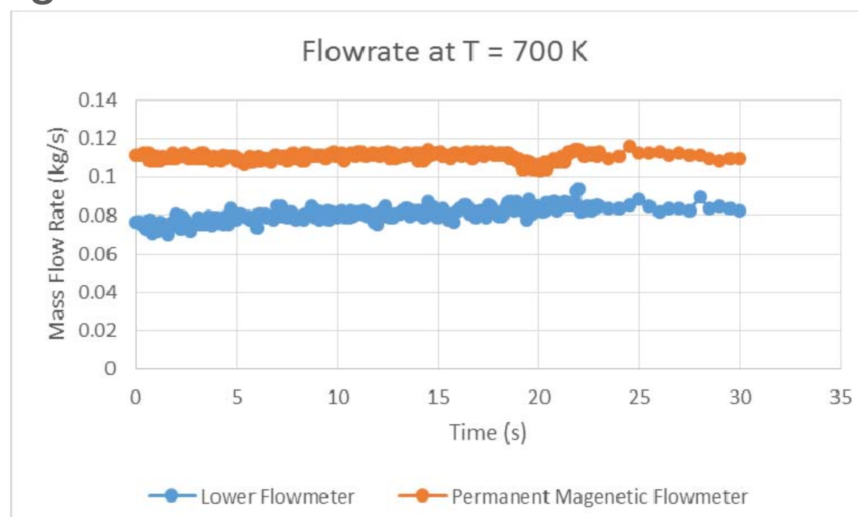
- Steady State
- Reynolds Averaged Navier Stokes (RANS) with k-epsilon model for turbulence modeling
- Segregated Flow model
  - Best used for incompressible flow
- Constant density and dynamic viscosity for sodium properties

Inlet Velocity Vector



Initial and Boundary Conditions

- Initial velocity set to zero throughout the loop
- Approximate average value of inlet mass flow rate set to 0.1 kg/s



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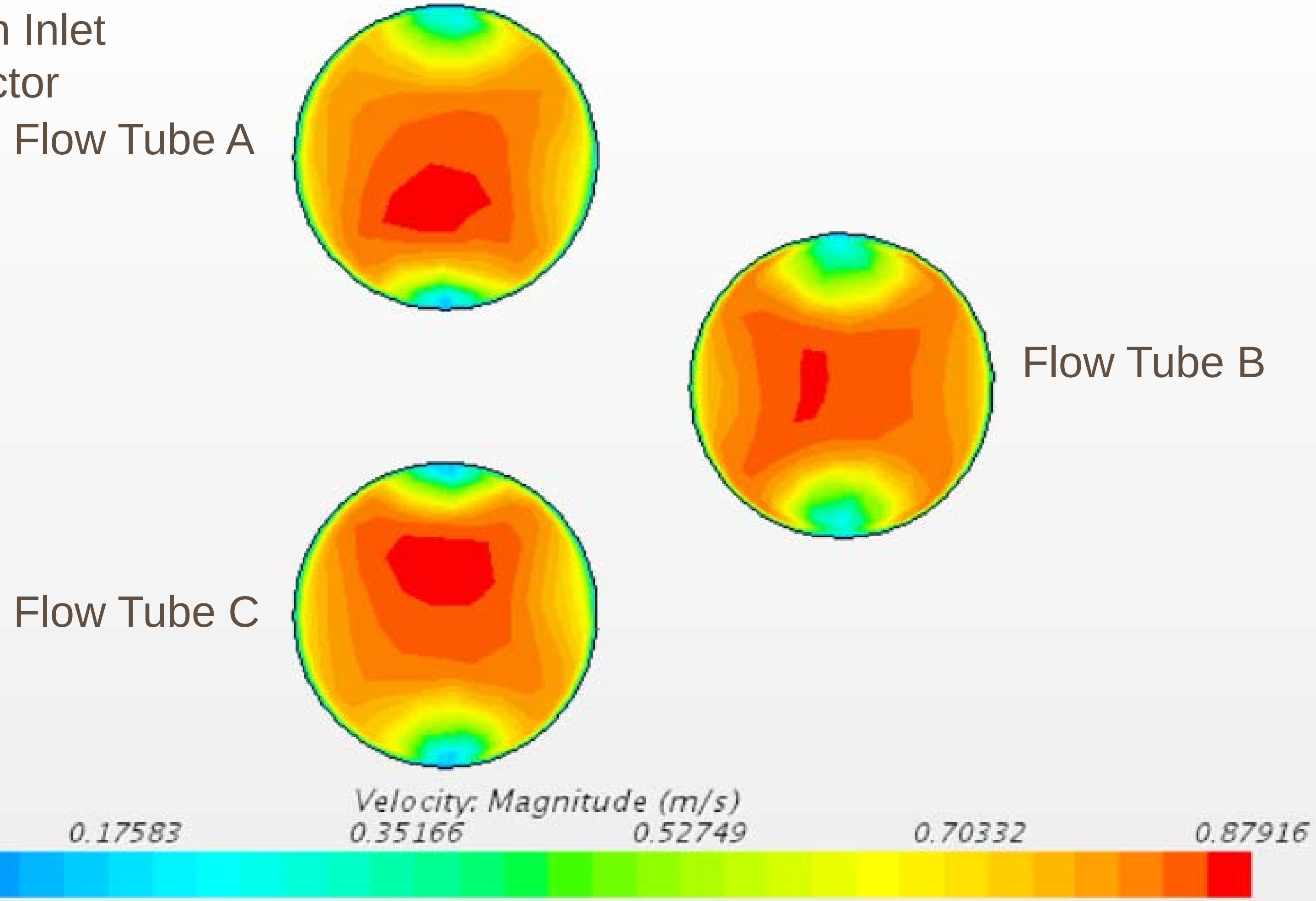
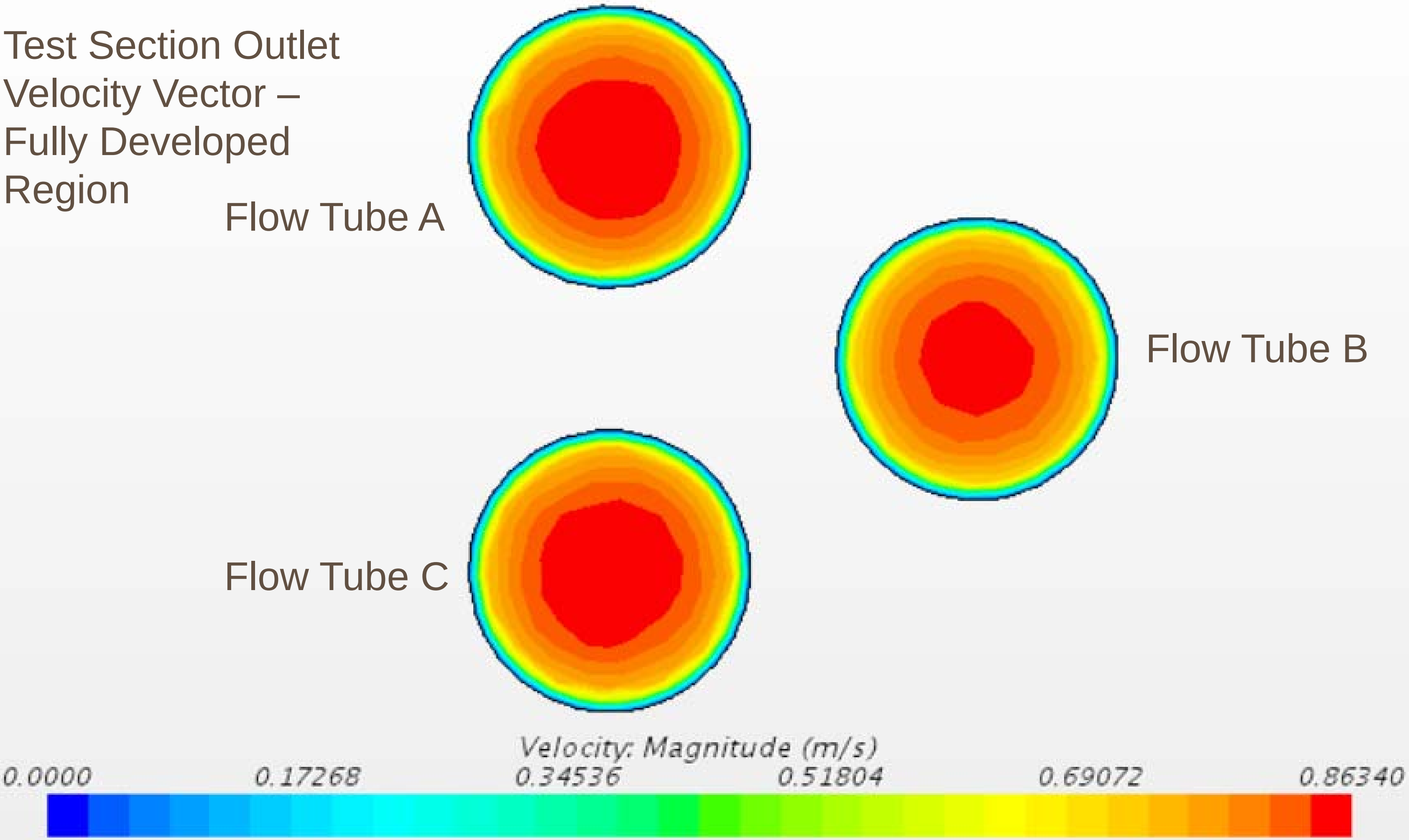
Preliminary Results

Test Section Inlet
Velocity Vector



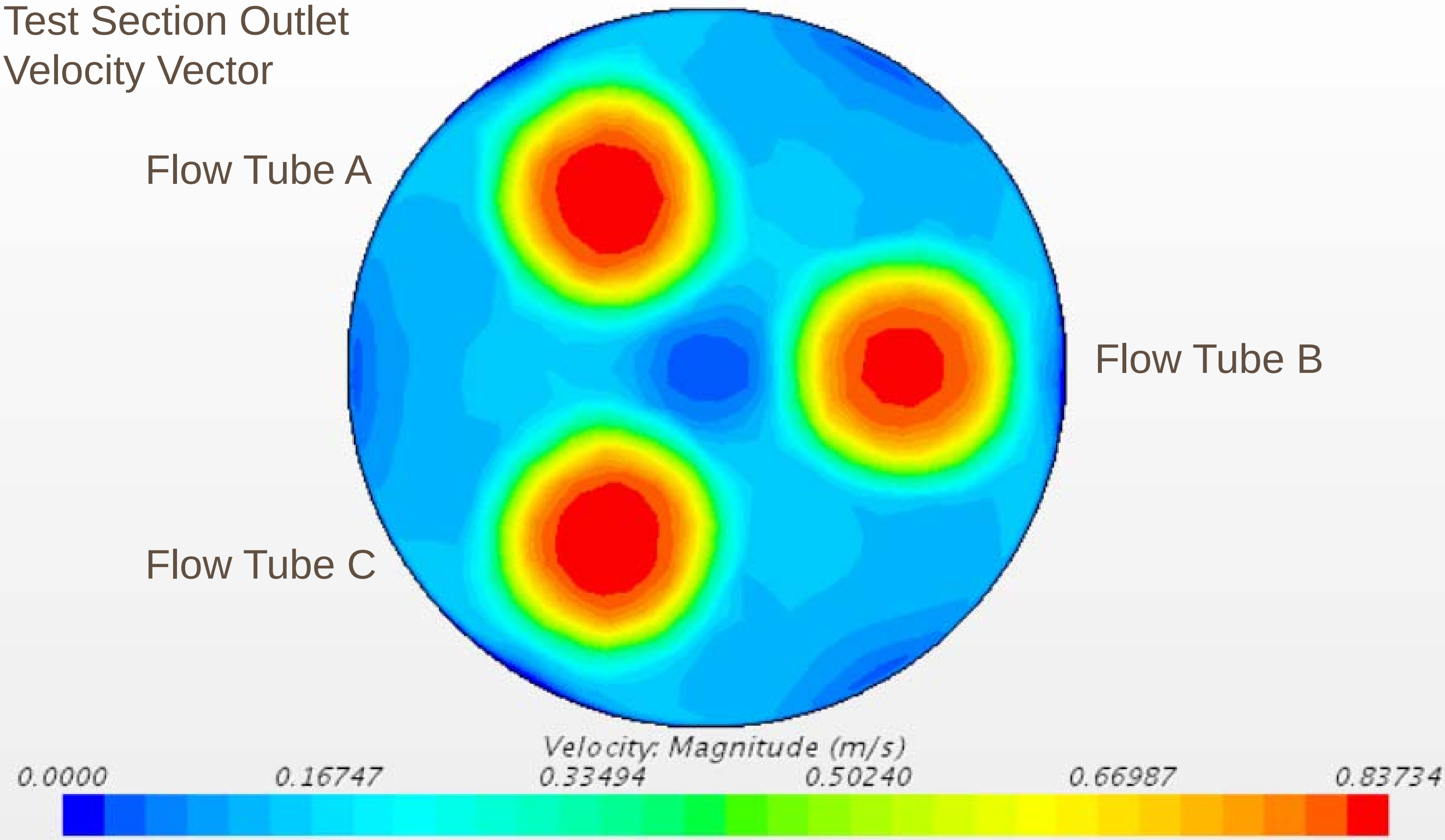
Preliminary Results

Test Section Outlet Velocity Vector – Fully Developed Region

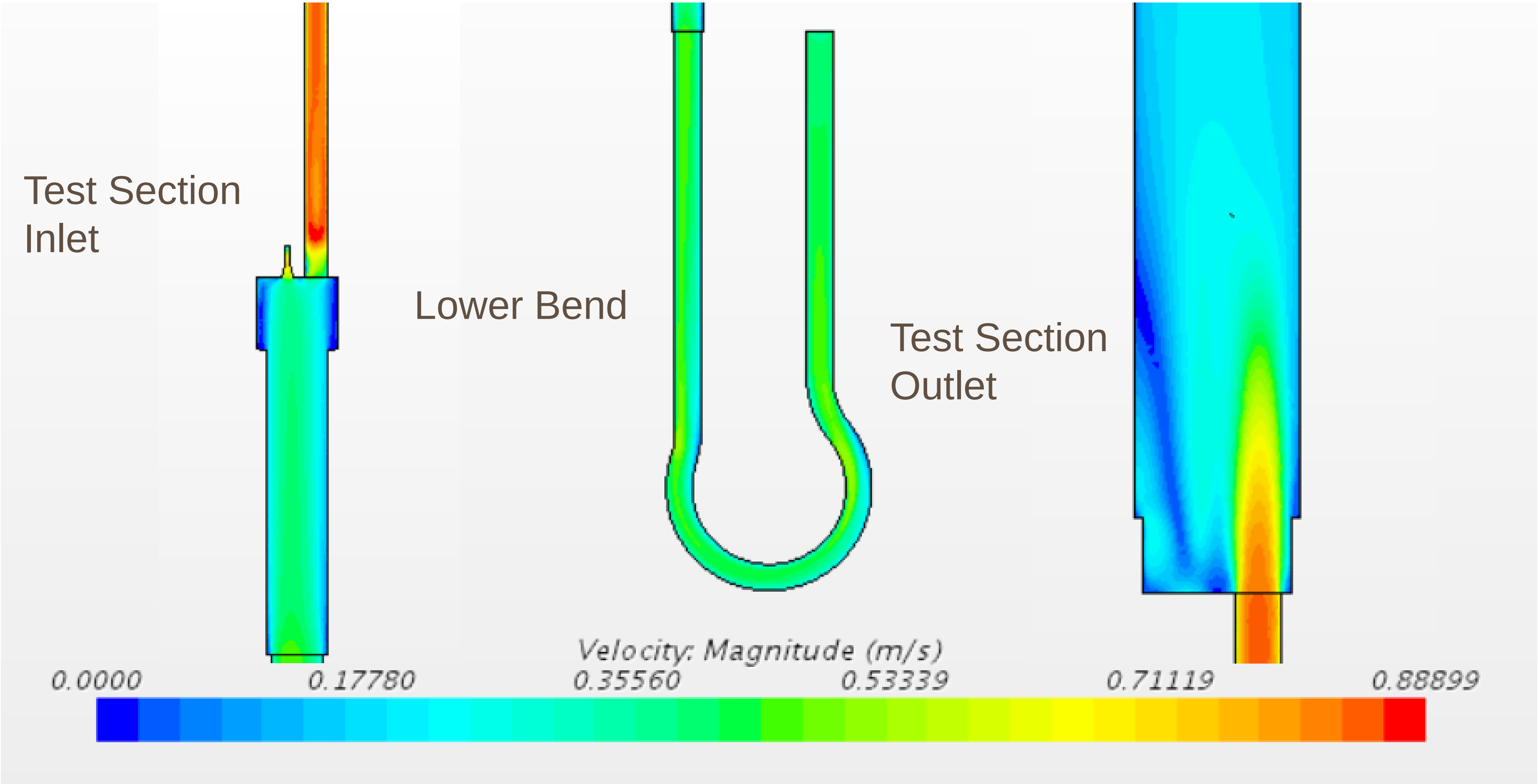


Preliminary Results

Test Section Outlet
Velocity Vector

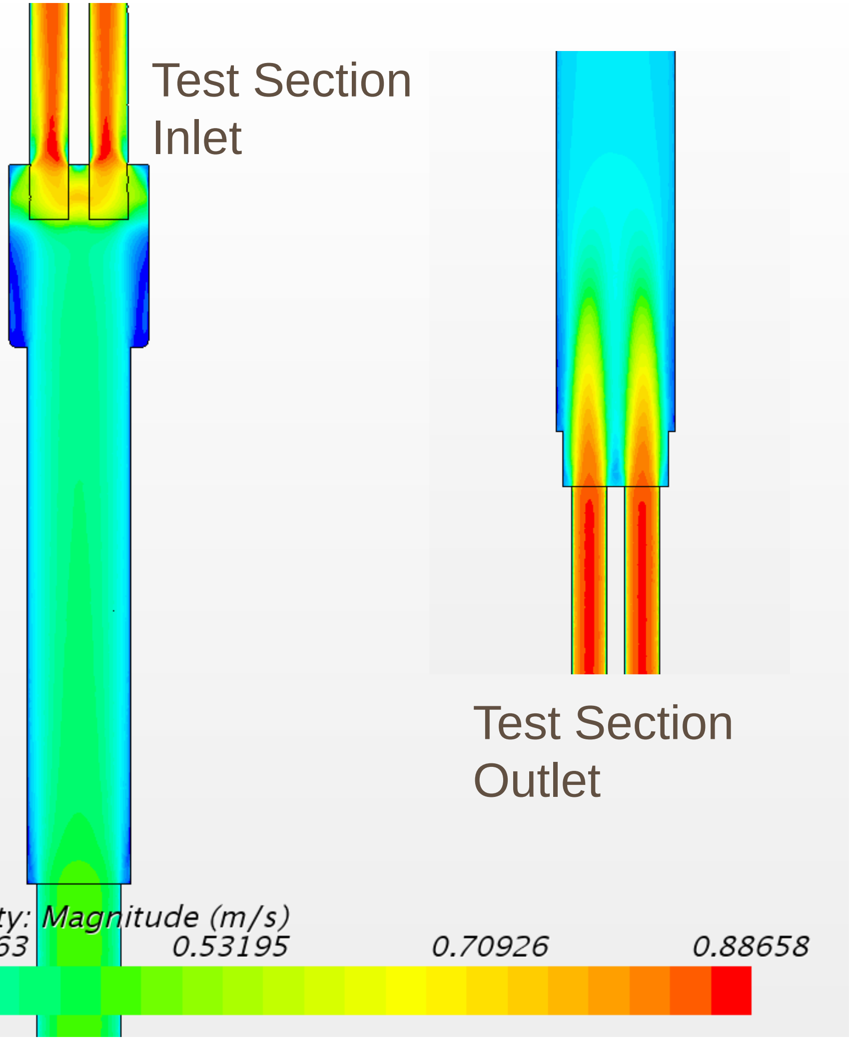


Preliminary Results



Preliminary Results

- Mass Flow Rate
  - Inlet Boundary Condition - .01 kg/s
  - Flow Tube A – 0.03346 (33.46 %)
  - Flow Tube B – 0.03295 (32.95 %)
  - Flow Tube C – 0.03356 (33.56 %)



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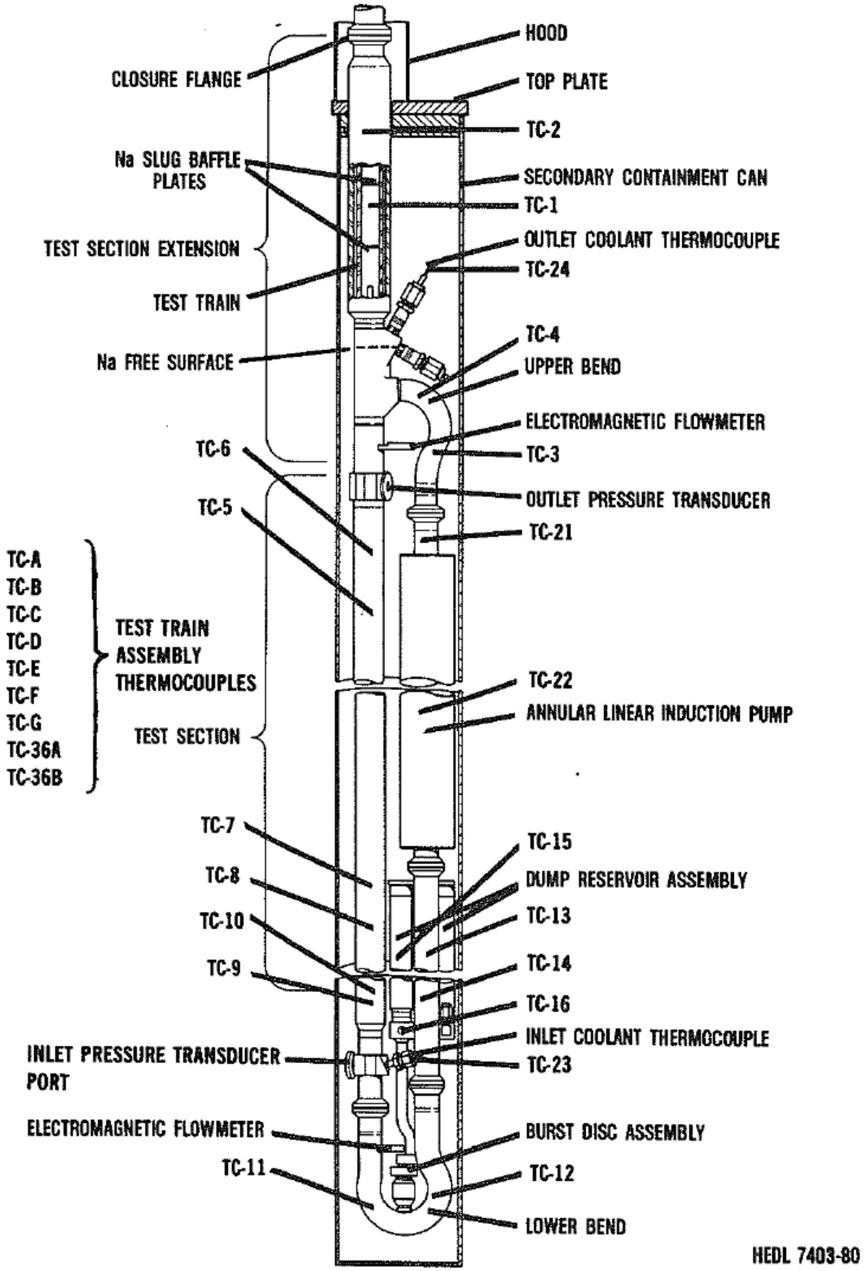
Conclusions and Future Work

- Flow through each flow tube is similar for steady state
- A transient case with a heat flux could provide more information about differences in flow tubes
- More meshing studies will provide confidence in results
- Additional inputs for porous body regions will provide better results
- Preliminary modeling overextending schedule one quarter, but have room to catch up this summer with Nek5000 modeling taking place at ORNL during a ten week internship


HOOD
CLOSURE FLANGE
TOP PLATE
TC-2
Na SLUG BAFFLE PLATES
SECONDARY CONTAINMENT CAN
TC-1
TEST SECTION EXTENSION
OUTLET COOLANT THERMOCOUPLE
TC-24
TEST TRAIN
TC-4
Na FREE SURFACE
UPPER BEND
ELECTROMAGNETIC FLOWMETER
TC-6
TC-3
TC-5
OUTLET PRESSURE TRANSDUCER
TC-21
TC-A
TC-B
TC-C
TC-D
TC-E
TC-F
TC-G
TC-36A
TC-36B
TEST TRAIN ASSEMBLY THERMOCOUPLES
TC-22
ANNULAR LINEAR INDUCTION PUMP
TEST SECTION
TC-7
TC-15
TC-8
DUMP RESERVOIR ASSEMBLY
TC-10
TC-13
TC-9
TC-14
TC-16
INLET COOLANT THERMOCOUPLE
INLET PRESSURE TRANSDUCER PORT
TC-23
ELECTROMAGNETIC FLOWMETER
BURST DISC ASSEMBLY
TC-11
TC-12
LOWER BEND
HEDL 7403-80