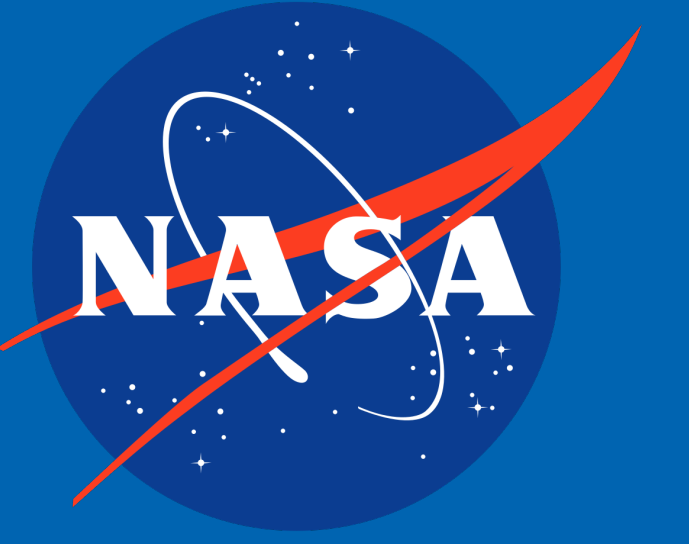




Designing the Imaging and Breadboard System for FBCE-TL Project



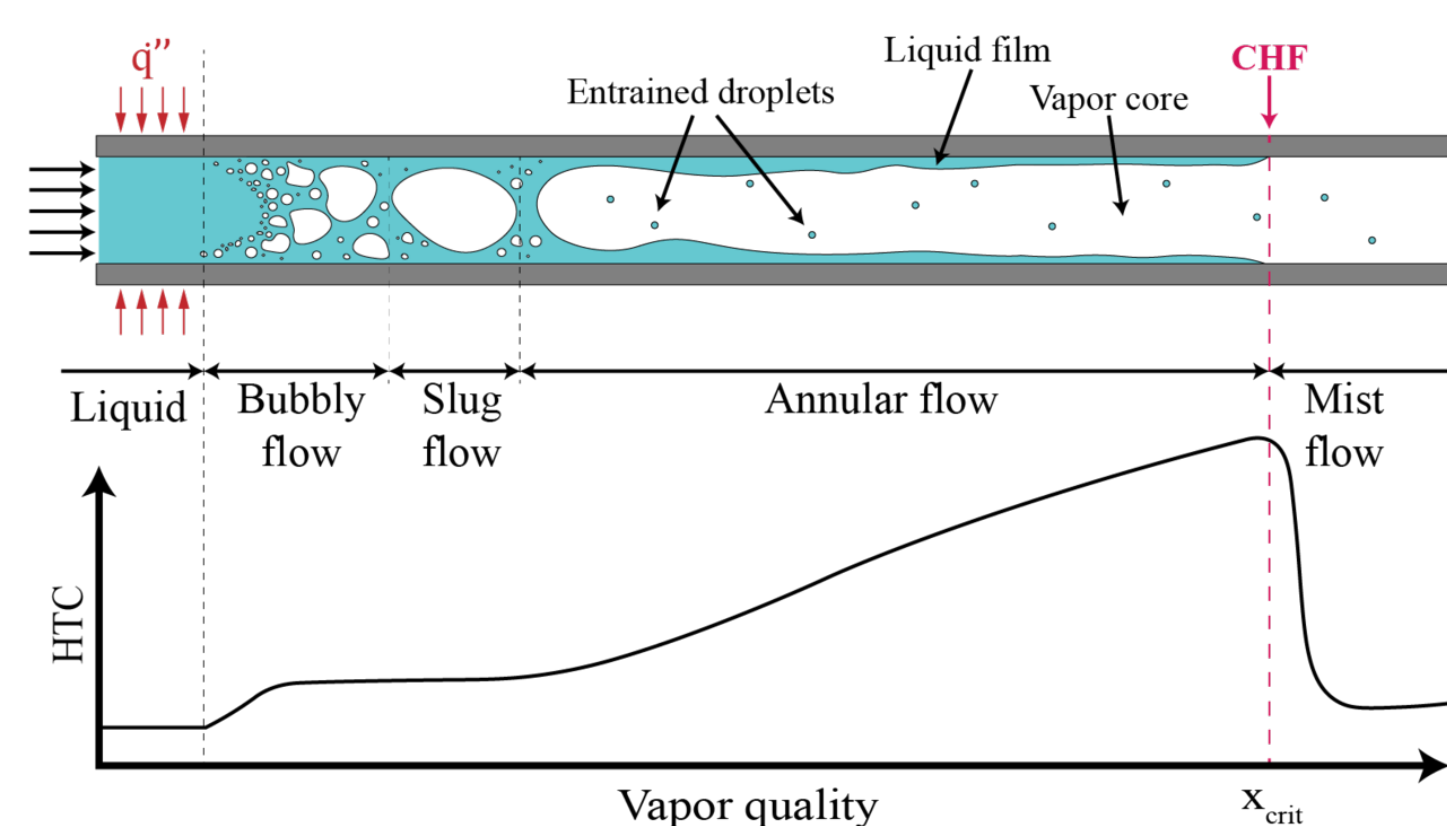
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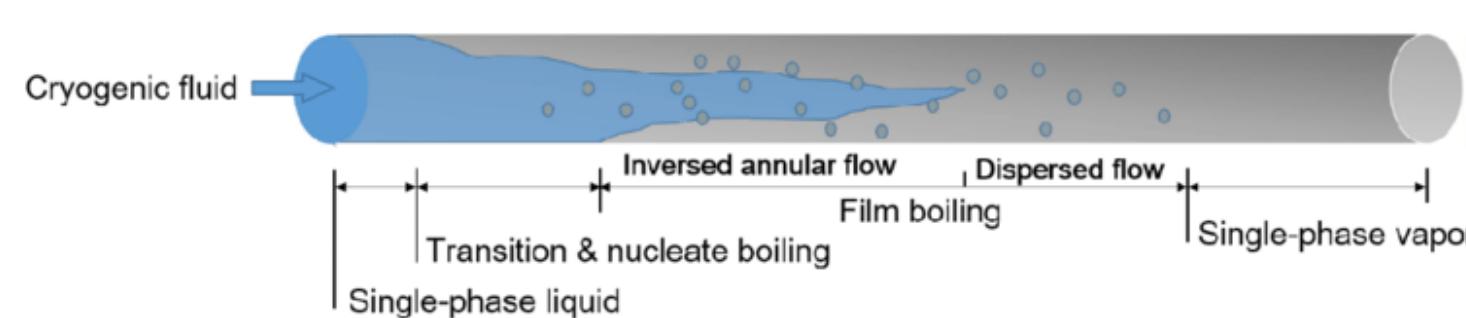
FBCE Overview

- The Flow Boiling and Condensation Experiment (FBCE) serves as a facility to investigate heat transfer with two phase flow in microgravity aboard the ISS
- The goal of the experiment is to characterize flow regimes and investigate heat transfer in the absence of gravity
- The FBCE hardware aboard the ISS is designed to take data and control flow rates, vapor quality, and fluid temperature

Transfer Line Overview



- The Transfer Line experiment (FBCE-TL) aims to study cryogenic chilldown for various inlet mass velocities and fluid temperatures
- Cryogenic chilldown is the initial stage of the transport of cryogenic fluids when the fluid boils into vapor until the transfer pipe and the receiving tank are quenched down to the fluid temperature



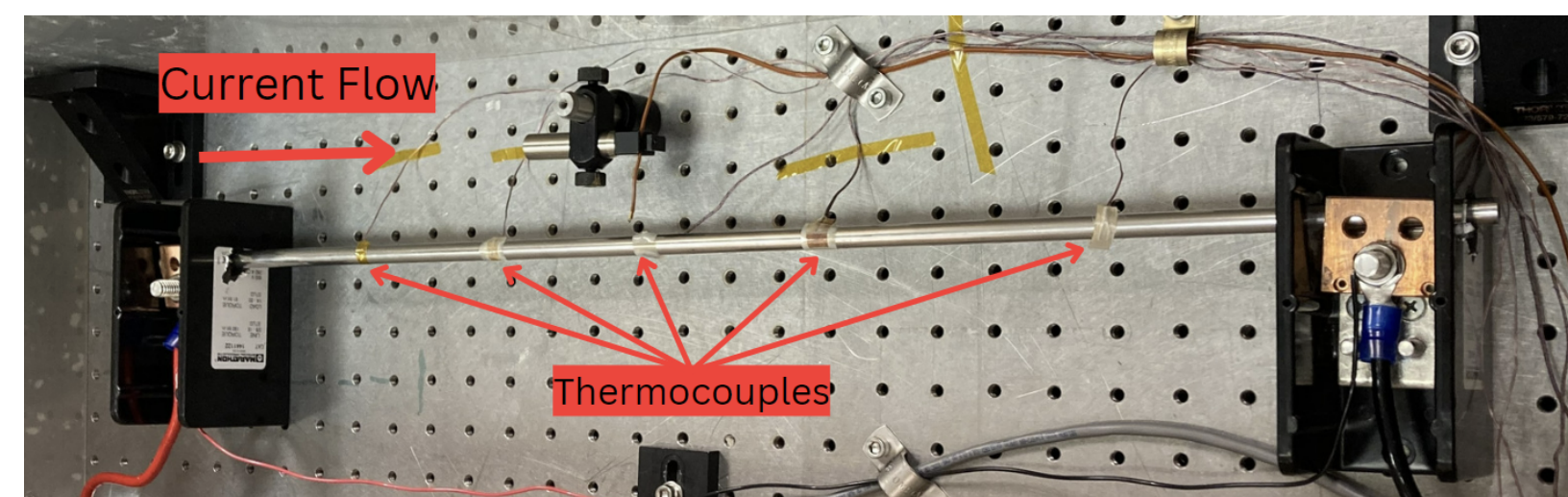
- Knowledge of heat transfer through fluids will help for in-space refueling and fluid modeling

Transfer Line Design

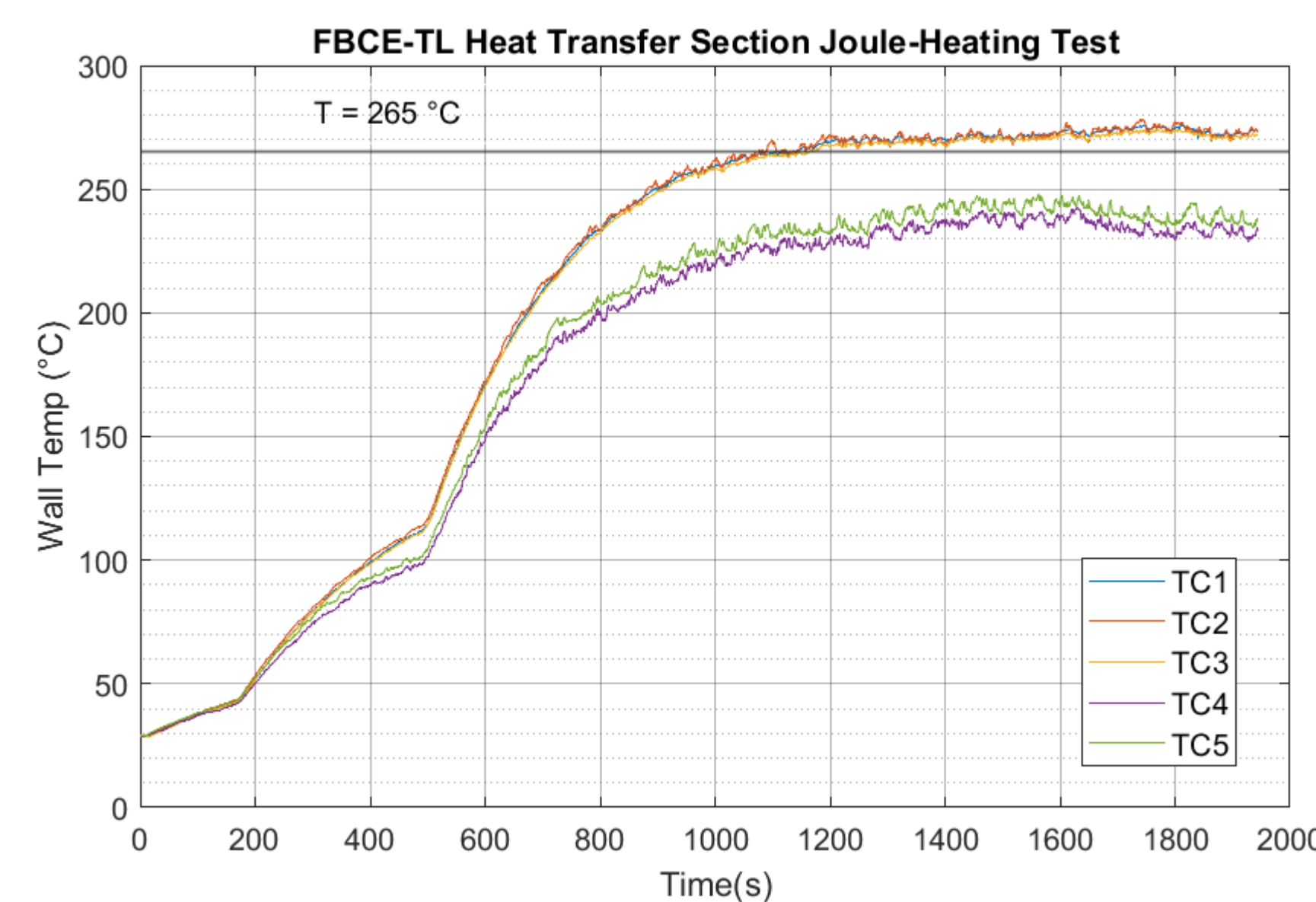
- The Transfer Line module will consist of two separate tubing sections
 1. Heat transfer test section made of stainless steel
 2. Flow visualization test section made of sapphire with an Indium Tin Oxide (ITO) coating
- Thermocouples will be embedded into the heat transfer test section to read temperature data
- Current will flow through the stainless steel tube and ITO coating on the sapphire tube to efficiently and evenly heat the test sections
- TL will gather accurate temperature measurements of the tube walls and fluid during cryogenic chilldown from the stainless steel tube
- TL will collect chilldown image and flow regimes data from the flow visualization test section

Breadboard Setup

- A breadboard is a pre-engineering model used to prototype design solutions for science requirements
- Constructed a setup with a power source, stainless steel tube, and thermocouples



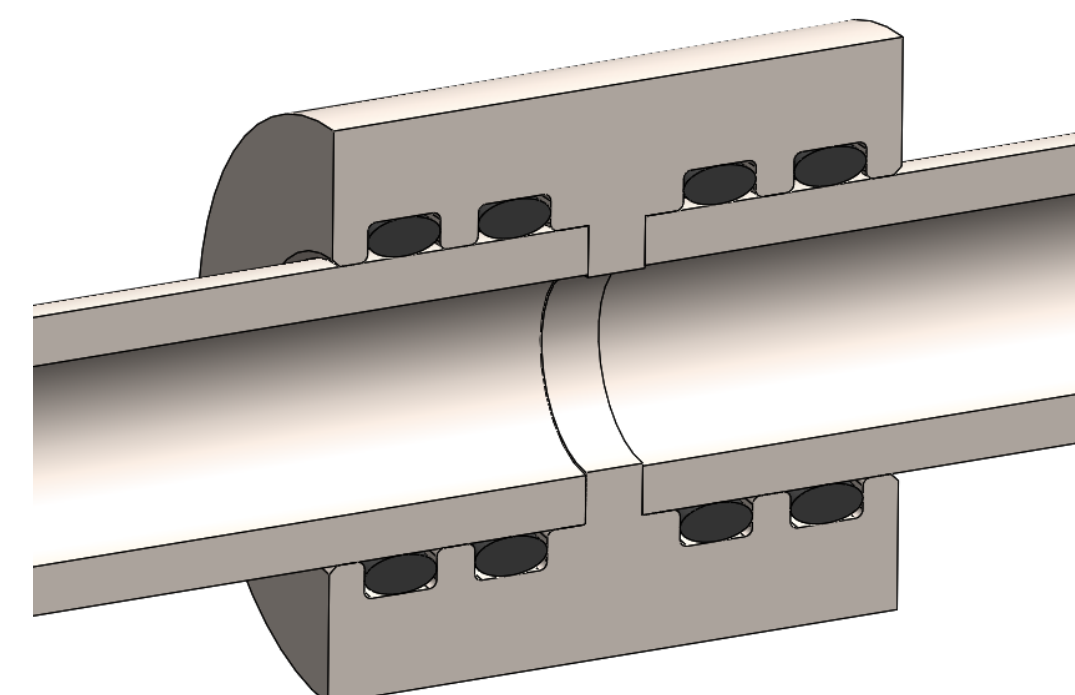
- A trial was conducted to verify the heater in the heat transfer test section is able to increase the outer wall temperature of the heat transfer test section to 250 °C



- The heat transfer section was able to reach greater than 250 °C in three of the thermocouples which means that the method joule-heating works for the Transfer Line module

Flow Visualization Design

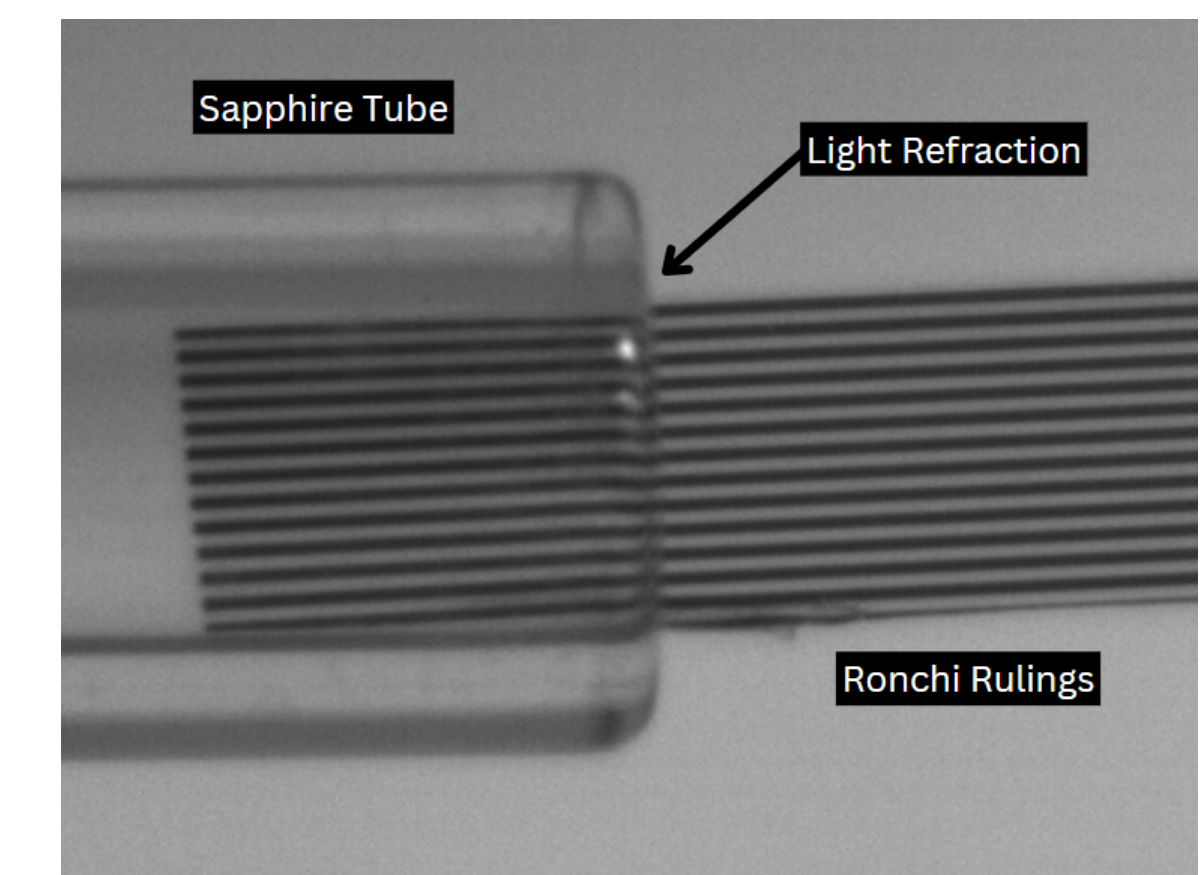
- The sapphire tubes are manufactured in short sections and must be chained together



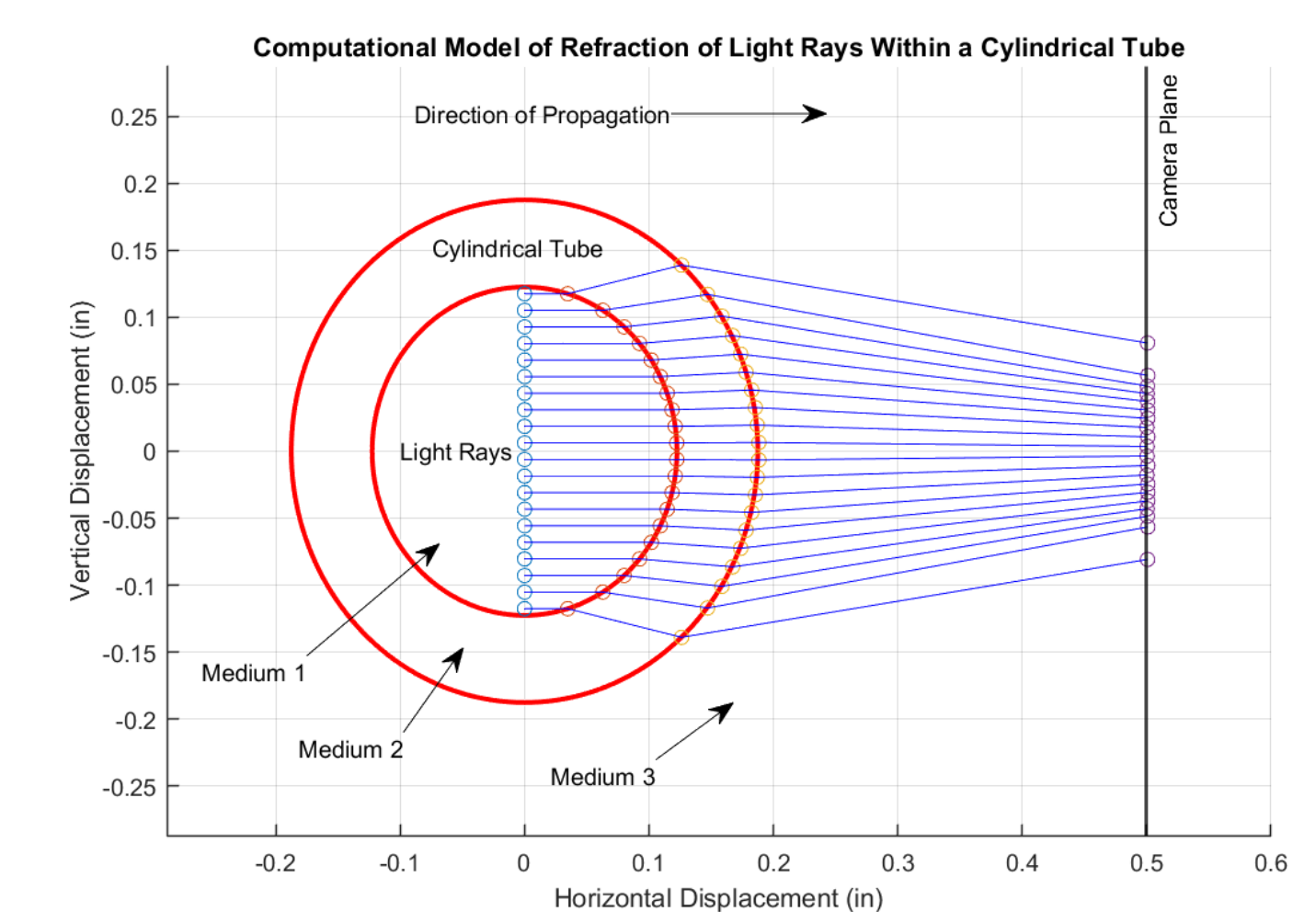
- Stainless steel couplers for ITO coated sapphire tubes
- Double O-ring channels to prevent leaks
- Stainless steel conducts across ITO surfaces to provide uniform current density

Image Remapping

- Light refracts as it propagates through the cylindrical tubes and must be accounted for



- Computational model built to simulate light rays propagating from the center of a cylindrical tube towards a camera plane



- The refraction is affected by the indexes of refraction of the fluid and tube
- Parameters such as camera distance and indexes of refraction can be changed to show how an image is distorted
- This can be used to produce a remapping algorithm that distorts images to account for light refraction

Future Work

- Perform joule-heating tests with the ITO coated sapphire tubes
- Manufacture and test stainless steel tube junctions up to high temperatures.
- Tubes with Ronchi rulings should be filled with test fluid and imaged in flight conditions to obtain necessary preliminary data for a remapping algorithm.

Acknowledgments

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