Mentor: Max Bruker — JLab SRGS — June - July 2024

2024

Presentation by
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JLab Portfolio

3D Printing & Testing Corrector Magnet Fixtures for the UITF

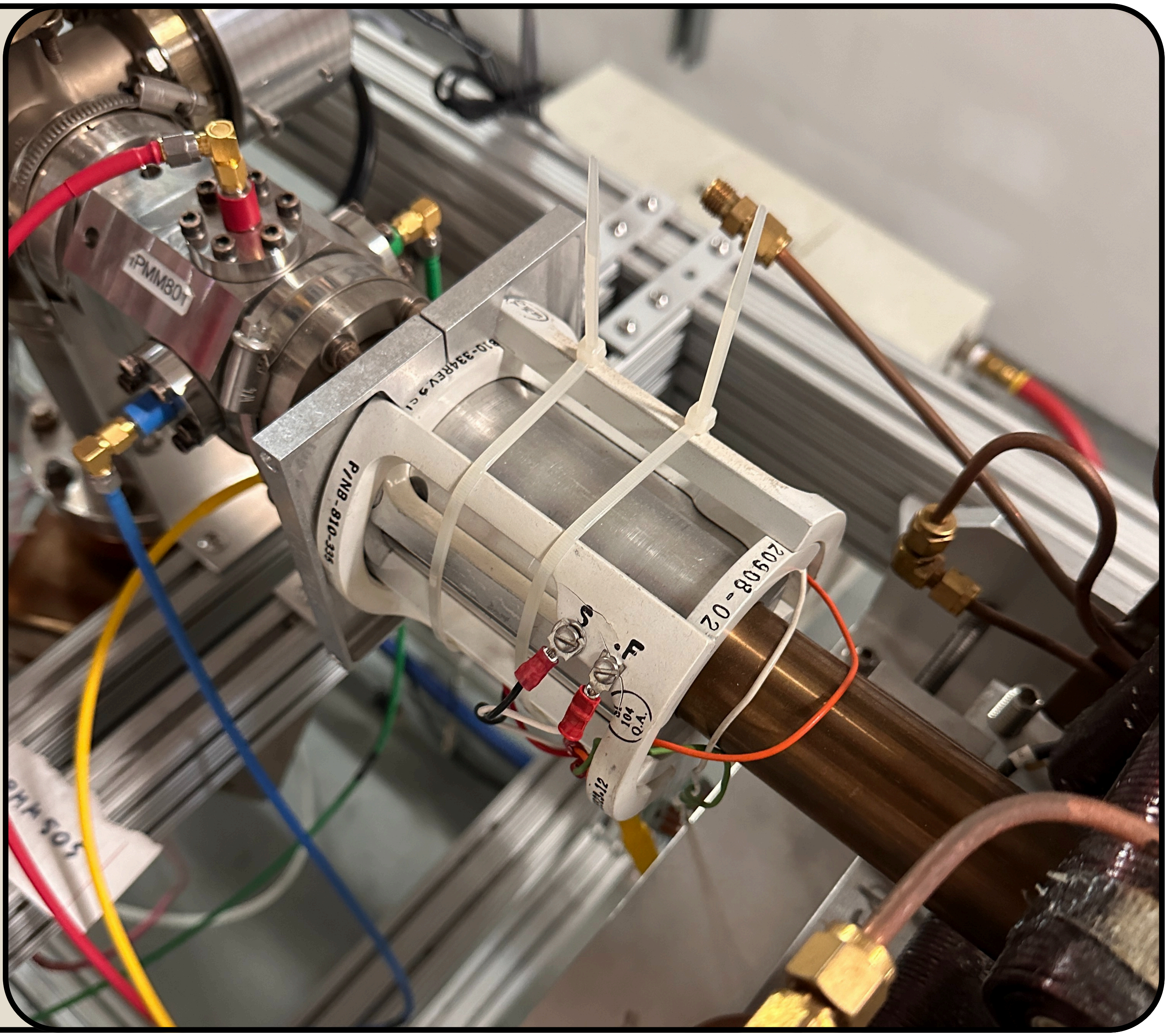
Introduction *

UITF

- **My Project**
- **Why?**
  - **Cost, Time, Accuracy**
- **Magnetic Declination**
  - **JLab –> 37.1° N, 76.5° W**

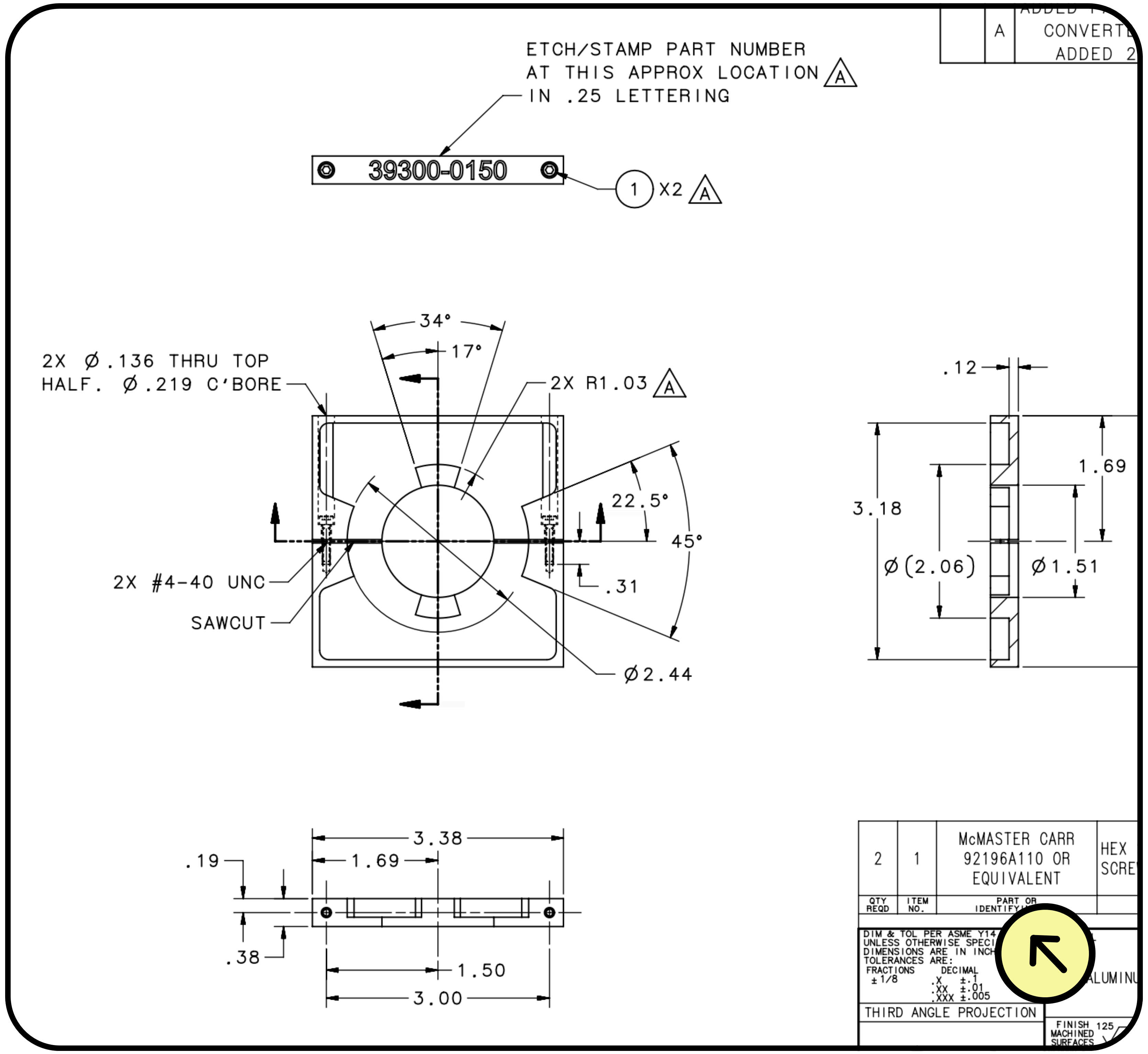
    10.76° W, 49,454.8 nT

    (Nano-Tesla)



Design Process Pt. 1 *

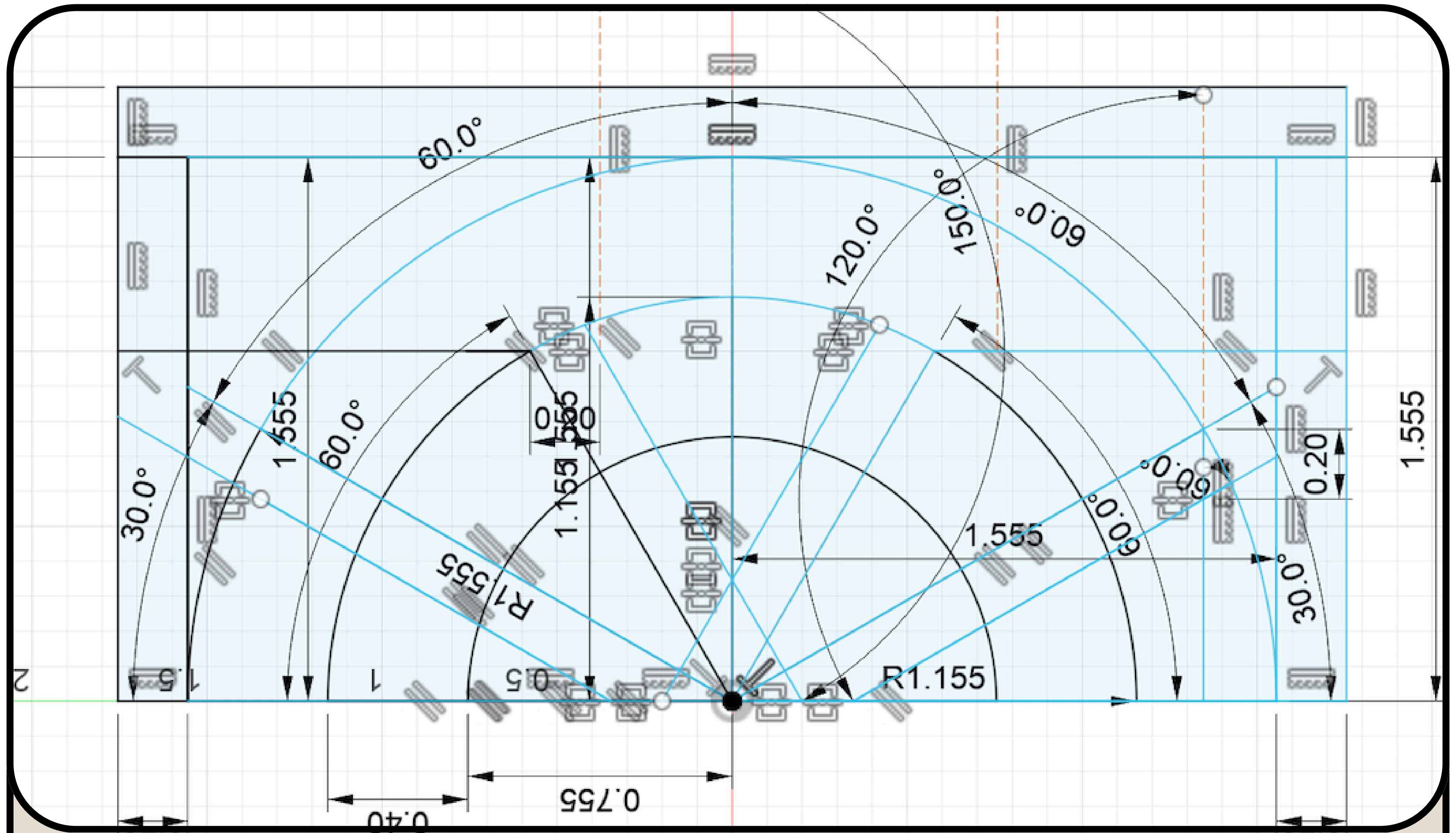
Blueprint



- Old Design
  - 0150 vs. 0151
- Components
- Failures

Design Process Pt. 2

Fusion 360



Initial over constrained model of the 0150 fixture in Fusion 360

- **Modeling**
  - Fusion 360
- **Initial Set-Backs**
  - Over-constrained

Design Process Pt. 3 ✳

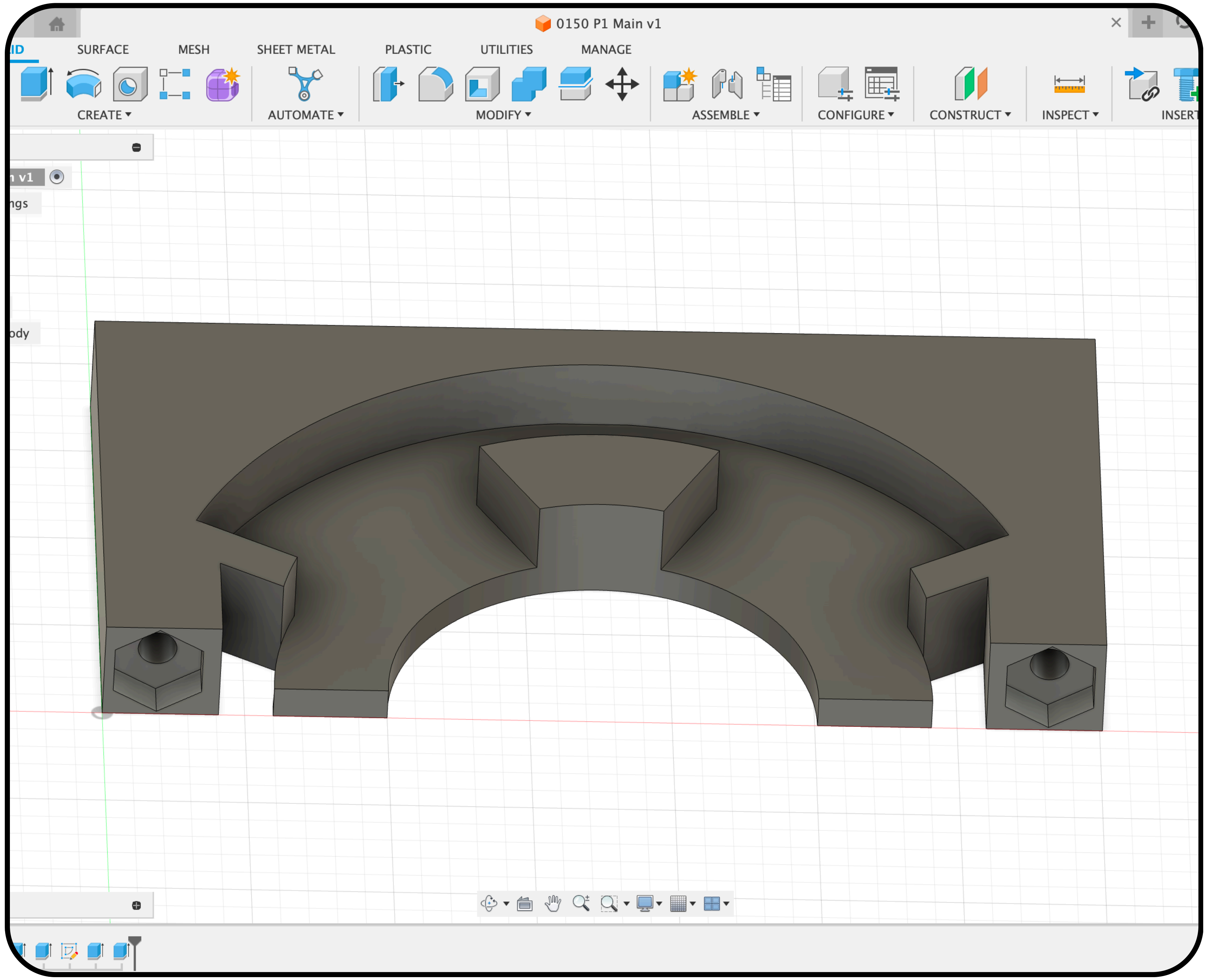
CMM

NOMINAL	+TOL	-TOL
-2.171	0.100	0.100
5.116	0.100	0.100
28.550	0.100	0.100
IM	LOC2 - B-OUTER-CIR	
NOMINAL	+TOL	-TOL
-2.295	0.100	0.100
5.453	0.100	0.100
37.838	0.050	0.050
EG	ANGL1 - LIN1 TO LIN2	
NOMINAL	+TOL	-TOL
59.707	0.100	0.100
IM	LOC3 - A-INNER	
NOMINAL	+TOL	-TOL
-3.495	0.100	0.100
4.304	0.100	0.100
28.610	0.050	0.050
IM	LOC4 - A-OUTER	
NOMINAL	+TOL	-TOL
-3.568	0.100	0.100
4.502	0.100	0.100
37.846	0.050	0.050
EG	ANGL2 - LIN3 TO LIN4	
NOMINAL	+TOL	-TOL
59.645	0.100	0.100

- **CMM Process**
- **Output Data**
  - **Old Part's Deviation**
- **Utilization**

Design Process Pt. 4 ✳

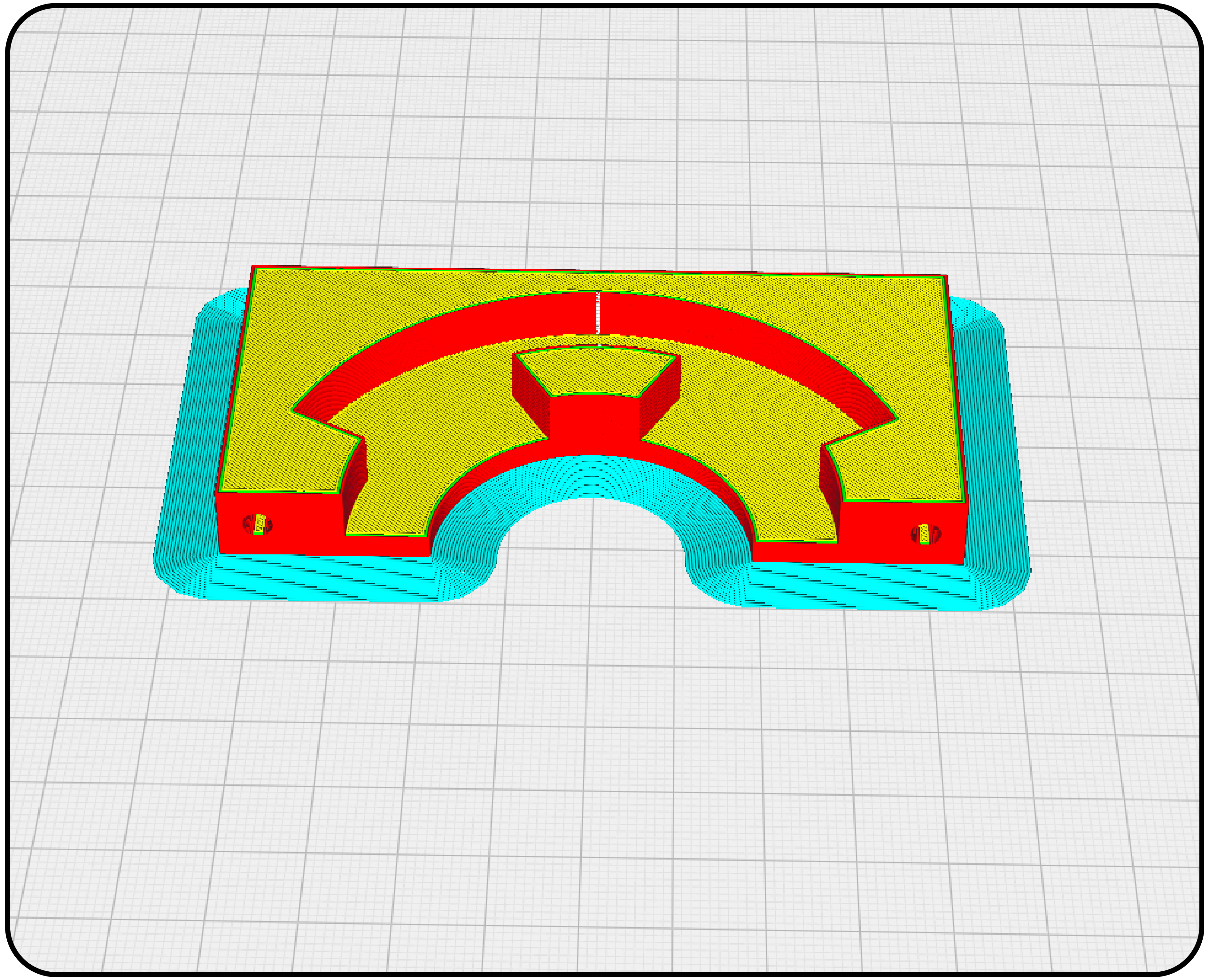
Version-2



- **V1 – V3**
- **Hardware**
- **Process**

3D-Printing Pt. 1

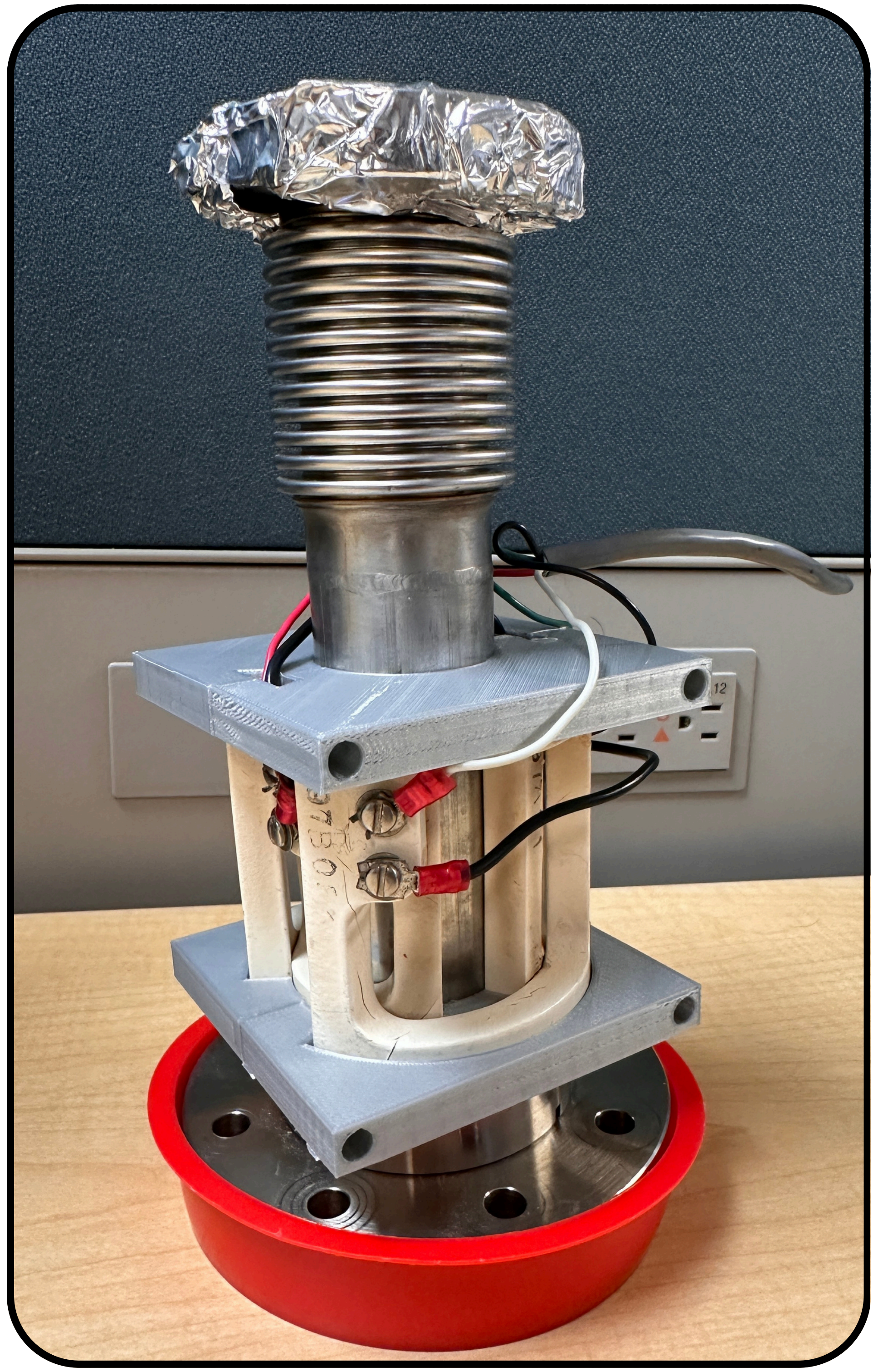
Cura



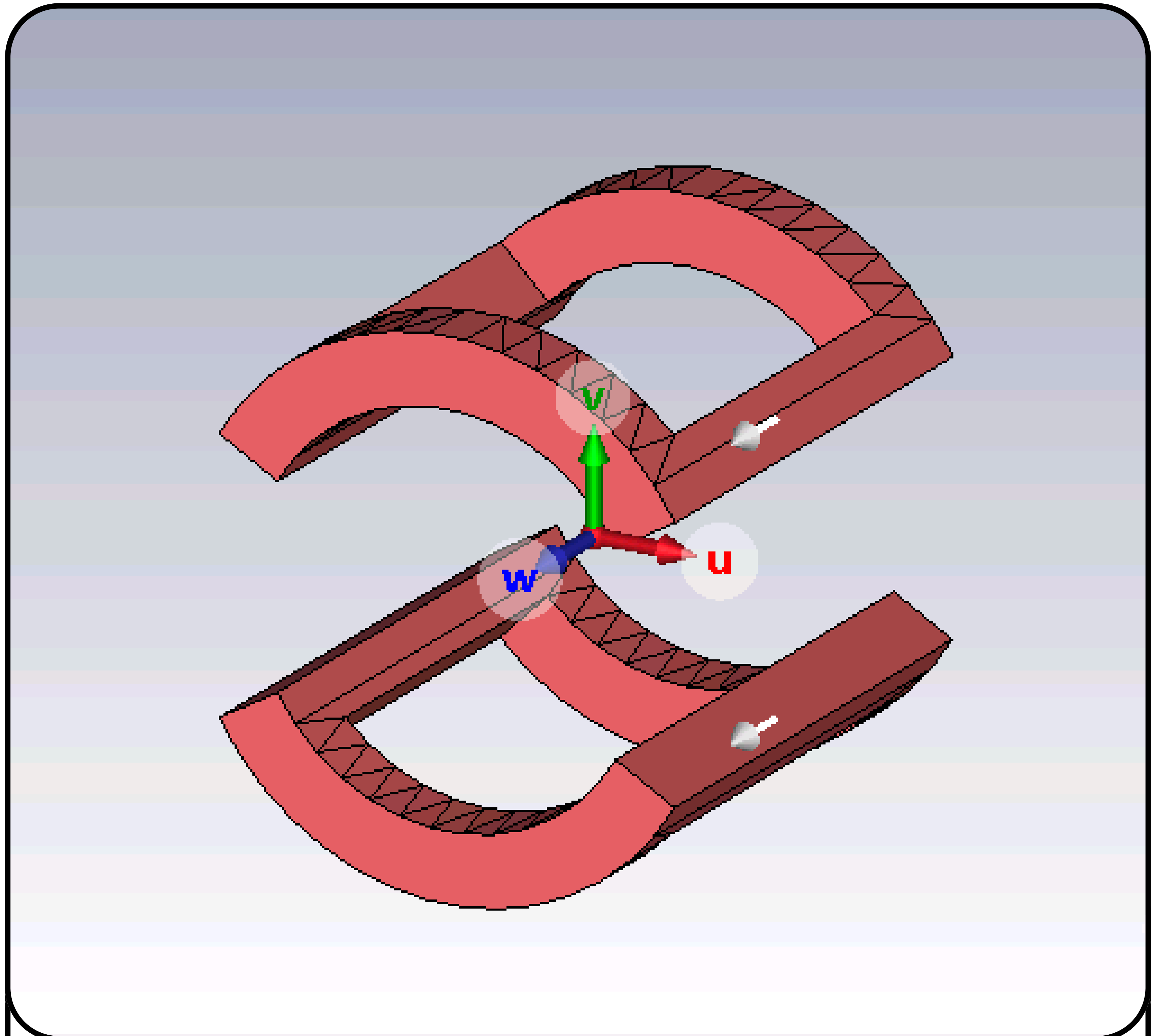
- **Printer**
- **Platform**
- **Settings**
  - Temp, Precision, Speed, Infill

3D-Printing Pt. 2

Initial Test



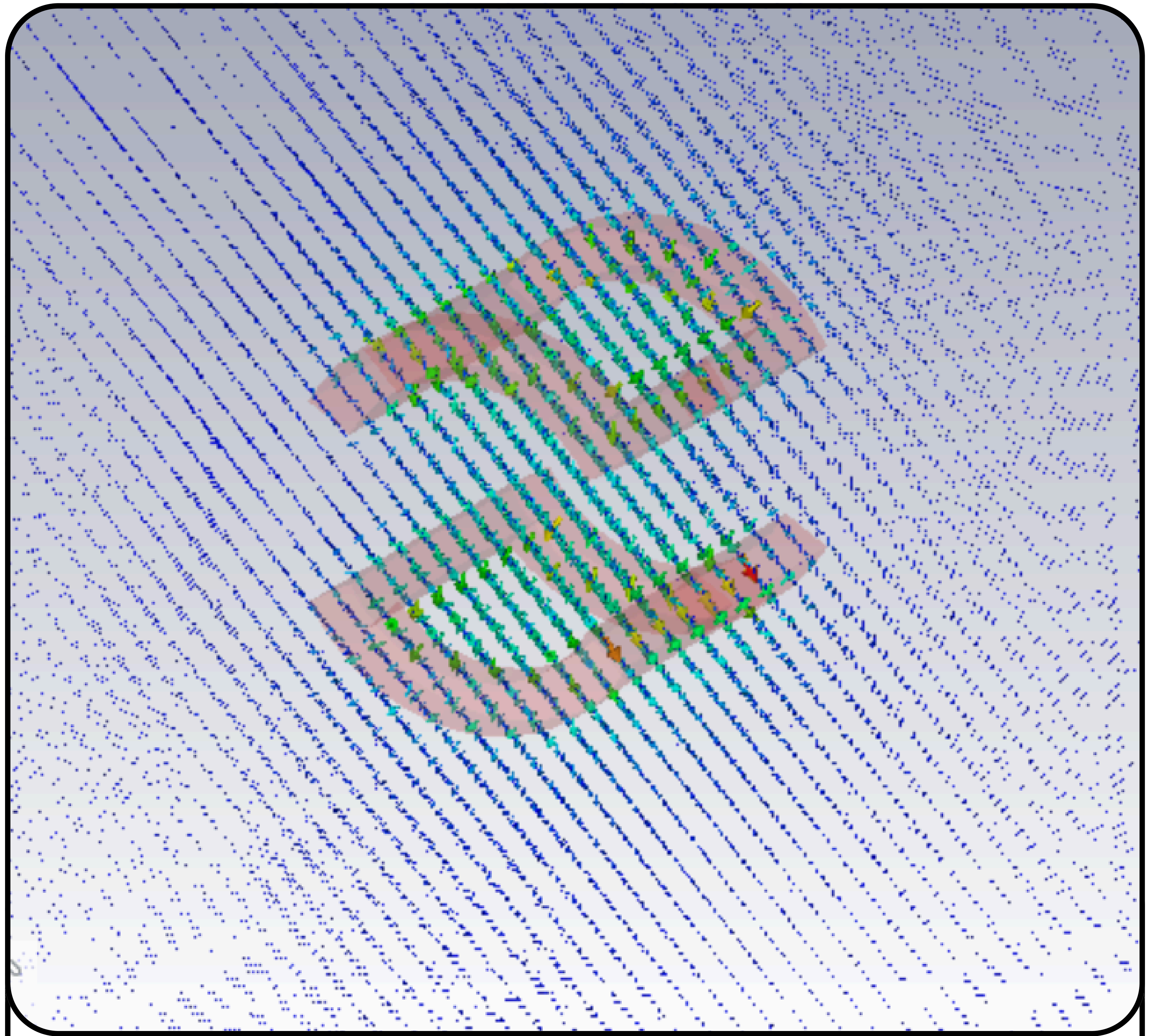
- Initial Test
- Successes
- Failures



0150 corrector magnet model with corresponding coils and current

CST Setup

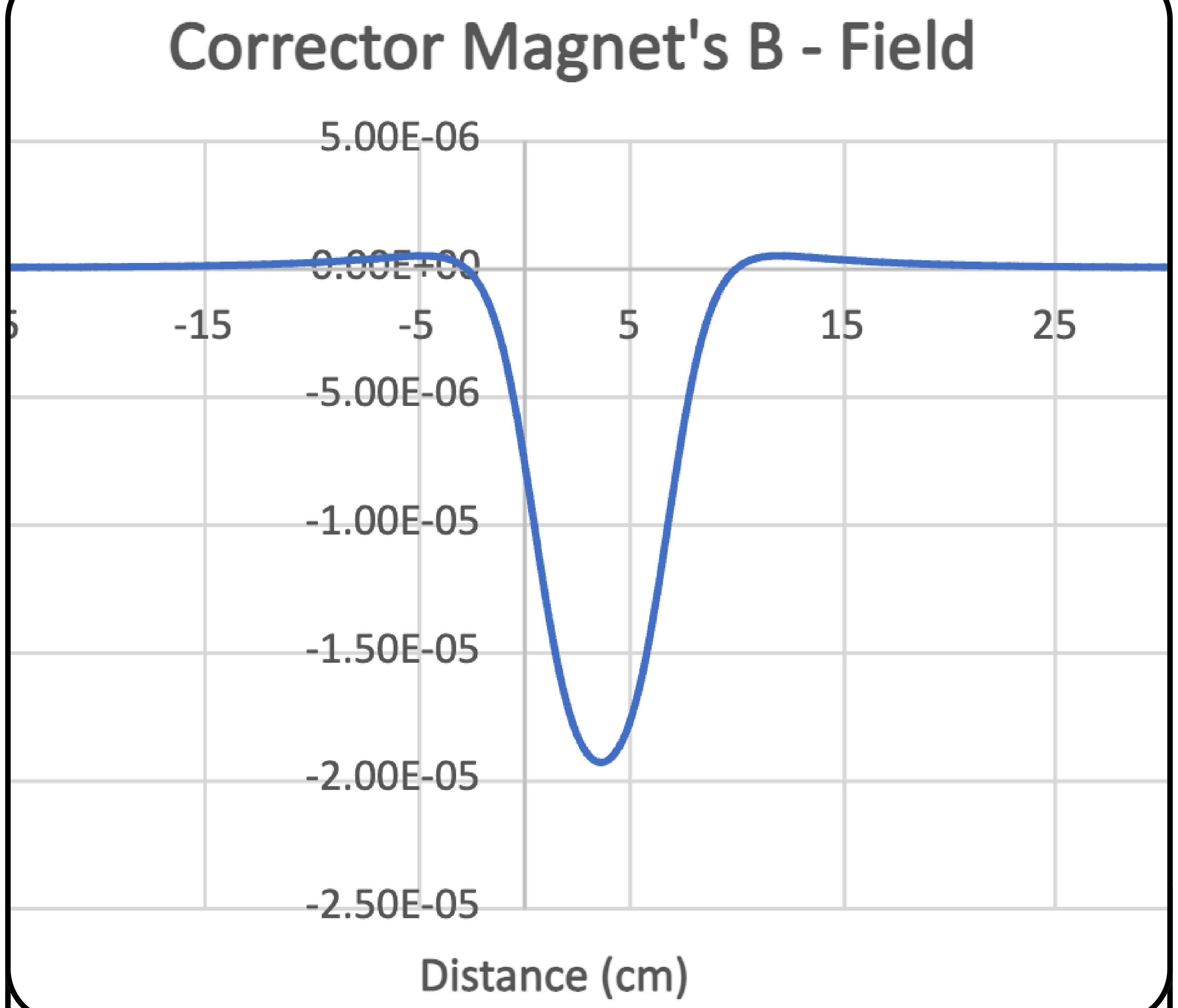
- **Model**
- **Coil Conversion**
  - WCS Plane
- **Parameters**
  - 1 amp, 1 turn, direction



Calculated magnetic mesh field with over 7,000,000 tetrahedrons

CST Testing

- **Setup**
  - **Box + Mesh Density**
- **Calculations**
- **Outcome**

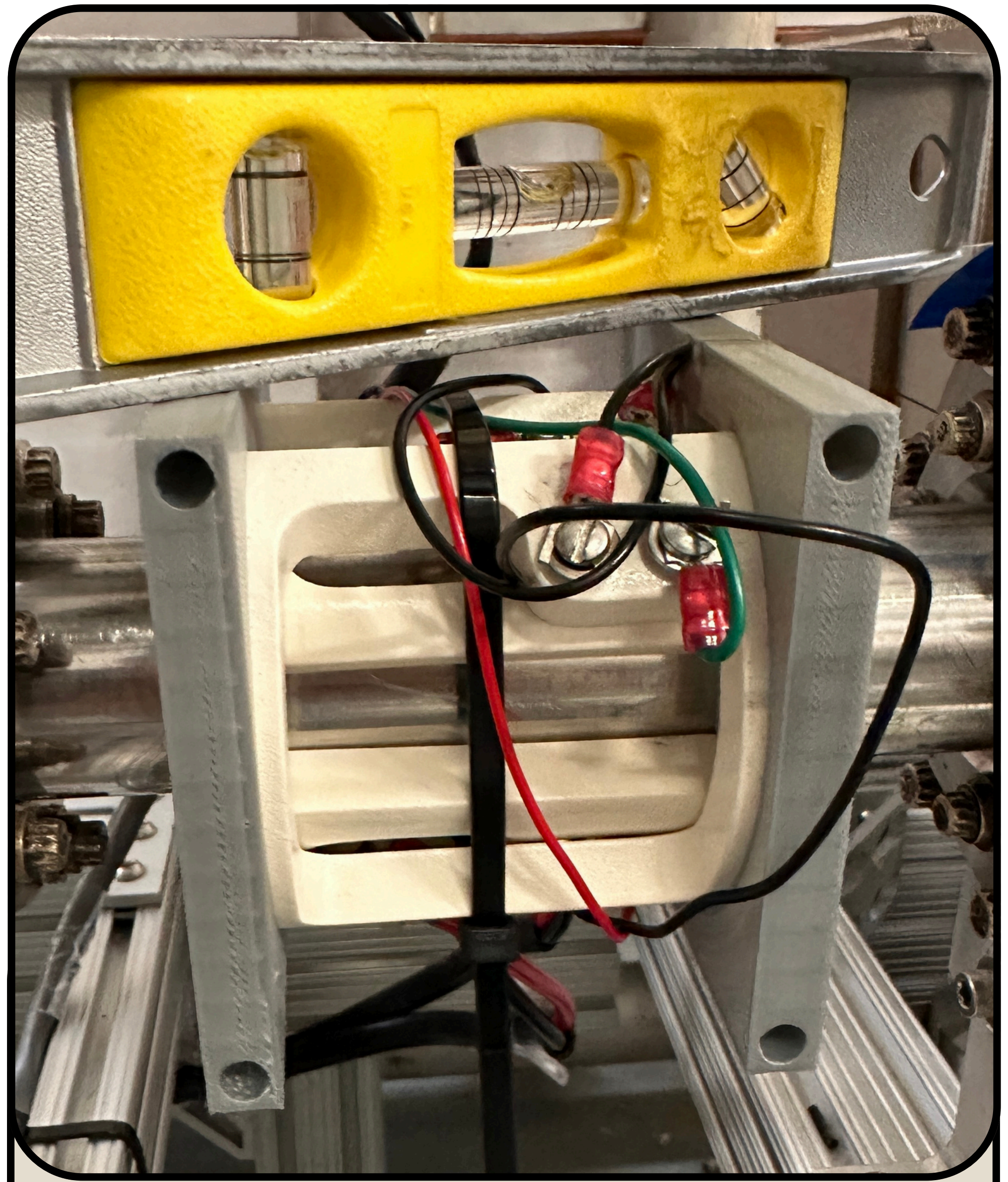


Graphed B-field curve correlating magnetic flux in “tesla” to distance in “cm”

CST Results

- Parameters
- Graph
- Calculations
- Total Field @ 1 Turn
  - 1.17 µT m

Installation



Levelling the installed 0150 fixture on UITF

- Tools
- Procedure
- Wiring
- Initial Testing
  - Hall Probe + Bubble Level

Testing

- UITF Lockdown Procedure
- Beam Visualization (View Screen)
- Corrector Magnet Test
  - Vertical/Horizontal Shifts

Tech Notes

Overview

UITF Corrector Magnets 3D-Printed Alignment Fixture Workflow: Design, Fabrication, and Testing

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Abstract

The UITF (Upgraded Injector Test Facility) at Jefferson Lab, demonstrated the need for a well-designed and documented fixture to accurately, efficiently, and precisely align the corrector magnets running along the beam line. Such optimization of the UITF is prohibitively complex when the fabricated parts, machined out of aluminum due to their paramagnetic properties, fail to clamp the corrector magnets reliably. We aim to introduce how 3D modeling, geometric calculations, schematic design, and CST magnetic visualizations can be combined toward this goal, describing the basics of their use and some caveats to be aware of.

1 Introduction

Along the UITF, the corrector magnets aim to counteract the Earth's respective magnetic field. Located at 37.0966° N, 76.4867° W, Jefferson Lab experiences a magnetic declination of approximately 10.76° W ± 0.36° (changing by 0.01° W per year) and a field strength of 49454.8 nT. The alignment of the corrector magnet allows for a predictable beam path throughout the process, inducing reliable beam results. For optimal performance, two corrector magnets are required for each segment upstream of a solenoid lens, with one magnet to alter the orientation of the beam and another to return the beam to a perfectly horizontal position. Often, only one correct magnet is used which makes for a zigzag-type trajectory, adequate but not ideal. Achieving said result with accuracy and precision is instrumental to the holistic process. The alignment mounts must position the corrector magnets such that they experience no angular deformation off their set horizontal position. Such an angle induces a varying magnetic field throughout the beam pipe, allowing for variability within results.

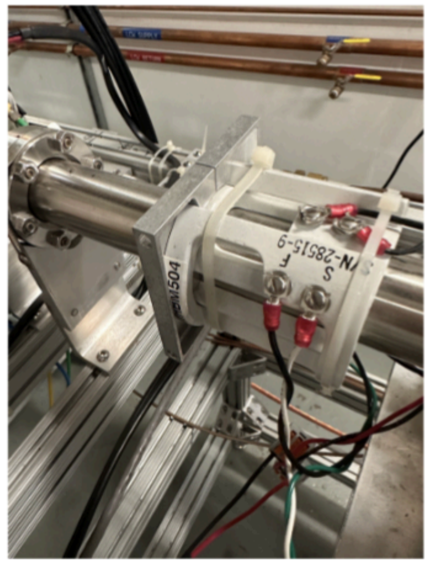

Figure 1: An image of the alignment fixture and corrector magnets

- Learning LaTeX
- Writing Process
- Importance/Goals

Acknowledgments

Summary

- Special Thanks!
- Reflection
- Take Away's
- Questions