# Post-Cooldown August 2018 Assessment

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## Introduction

A cooldown of the Slifer Lab magnet was conducting at the end of August, 2018. Here follow some general thoughts.

## What went right

### 0.1 NLS4 Actuator

Despite being troublesome in the weeks preceding the cooldown, the NLS4 actuator (the one responsible for moving along the vertical z-axis) worked perfectly, going exactly where it was told, and did not cause any problems. Prior to the cooldown, it would behave erratically, not ascending properly, and not keeping track of its absolute step position. It was found out that the set screw for the coupling on the stepper motor was not secured properly, and tightening that resolved the issue.

### 0.2 Gaussmeter Probe

The actual measurements of the magnetic field were also successful; the gaussmeter probe was self-consistent, and gave stable readings while inside the magnet when the magnet was turned on.

# What went wrong

## 0.3 NLE Actuators

In contrast to the NLS4, the NLE actuators (the ones responsible for moving horizontally along the x- and y-axes) often misbehaved, and still do. During a sweep of the magnetic field, the NLE would often drift in one direction, until the gaussmeter probe would be knocking against the inner wall of the magnet, despite the multiple millimeter margin of the sweep inside the magnet. The source of this misbehavior has not been found as of yet, though it seems simply restarting the NLE control box on a regular basis keeps the actuators in line, at least for a while.

## 0.4 Carbon Fiber Tube

A carbon fiber tube had been ordered, from the end of which the gaussmeter would hang. Upon arrival, it was longer than original measurements had required, and was cut. However, original measurements had not taken into account how much higher the scaffold with the actuators needed to be than the magnet, and thus the cut tube was too short to reach the sweet spot. As such, the tube and the cut piece had to be reattached. At first epoxy was tried, but would not work in the time frame needed, so the tube was simply duct taped back together. The tube had already had a slight curve from the beginning, and reassembly did not help matters.

## 0.5 Scaffold for Actuators

The scaffold used to support the NLS4 and NLE actuators was also troublesome. The original wheels ordered were not intended for the type of frame used, and bent fairly easily. Thankfully, there were sturdier wheels available as replacements. However, keeping the scaffold in one spot proved difficult, and even the slightest of jostlings could push it out of alignment. I have no current suggestions to solve this, but if the scaffold is to be used in another cooldown, something needs to be done to keep it firmly in place.

# Achivements

## 0.6 Magnetic Field Map

The magnetic field inside the magnet was mapped (plots will accompany this assessment). The three-axis set of actuators moved the gaussmeter probe in a sweep pattern, creating a cylindrical grid of points, with 2 millimeter separations in each direction. It was found to be quite uniform, most likely to a level conducive to NMR.

There was one hiccup: partway through the sweep, it had looked like the carbon fiber tube had cracked on the webcam being used to monitor the probe during the sweep, and the sweep was halted. However, upon close inspection, it was just a buildup of ice. The sweep was restarted, and completed, but this left a visible delineation on the finished map; the NLE actuators were realigned before the restart, which may have corrected for some possible drift prior to the stop, resulting in the odd look of the finished map.

## 0.7 Magnetic Sweet Spot Found

The sweet spot of the magnet was confirmed to be in almost exactly the spot it was predicted to be, 1225.5 millimeters down from the top of the magnet, or 330.5 millimeters down from the lower, inner lip of the thinnest cylinder inside the magnet, in the center of the column.

## 0.8 Calibration of Magnet Current

Using the gaussmeter, it was discovered that the calibration previously used to tune the current to yield the desired magnetic field was off by about 4%, just enough to potentially prevent an NMR reading. The readings taken were able to refine the calibration, which will hopefully allow for a successful NMR reading in the future.

# Lessons Learned

## 0.9 Don't Modify Unless Certain

The carbon fiber tube should have been checked with the magnet before being cut. While this wasn't necessarily the end of the world in this particular case, we should be more careful in future, double checking before making potentially permanent modifications to instruments or equipment.

### 0.10 NLE Can't Be Left On

The control box for the NLE should be restarted at regular intervals, otherwise it starts to act up, including drifting out of alignment, as noted above.

### 0.11 Secure Scaffold Better

As previously mentioned, a better method for securing the scaffold in place should be devised.

## Notes on Terminology

### 0.12 Uniformity

Uniformity is defined as the difference between the magnetic field at a given point and the maximum magnetic field, divided by the magnetic field at the given point: $U = \frac{|B_{max} - B|}{B}$.

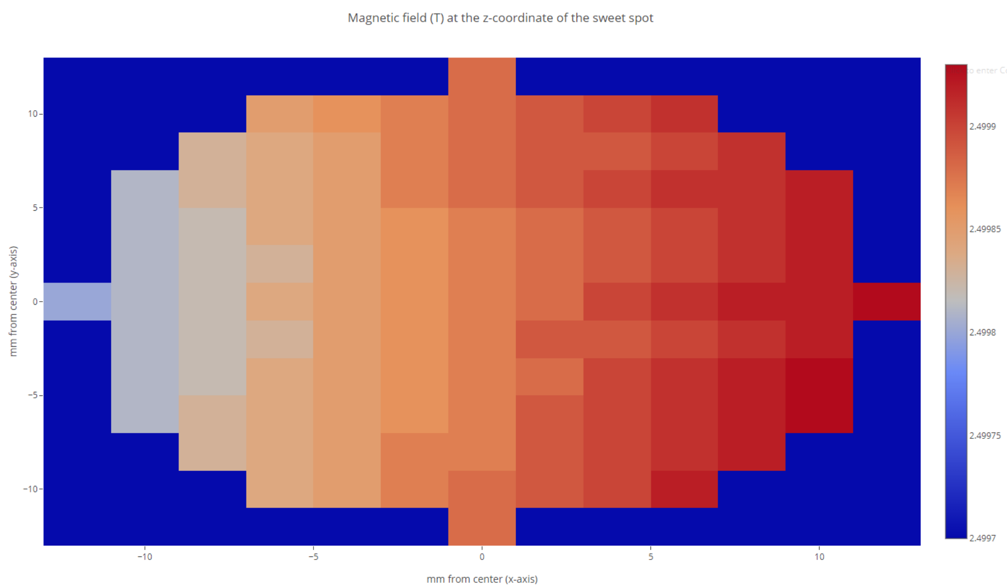


Figure 1: Magnetic field (T) at the z-coordinate of the sweet spot.

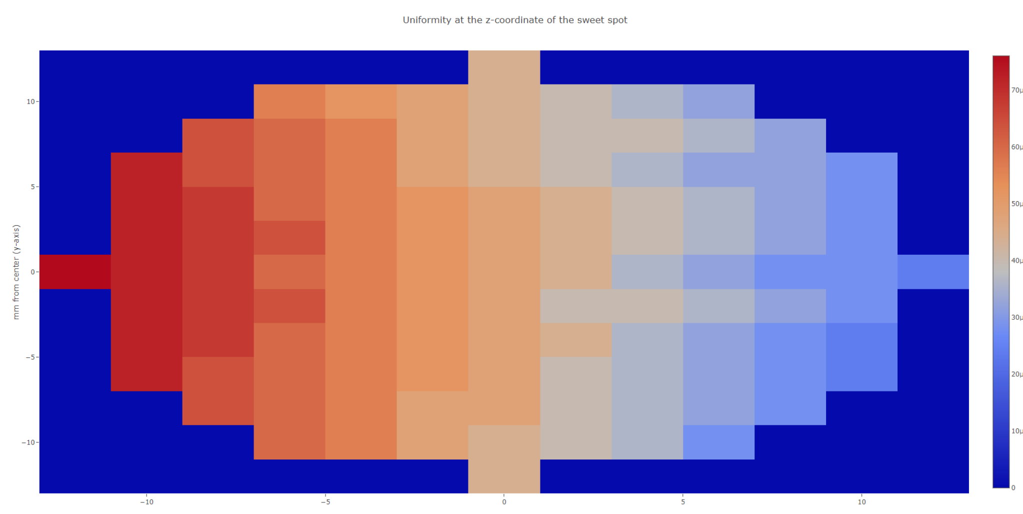


Figure 2: Uniformity at the z-coordinate of the sweet spot.

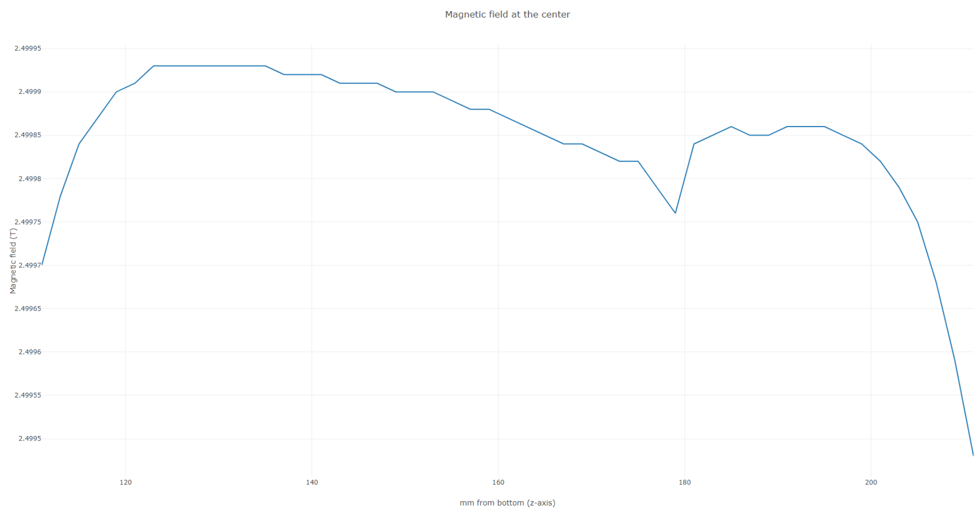


Figure 3: Magnetic field at center, along z-axis

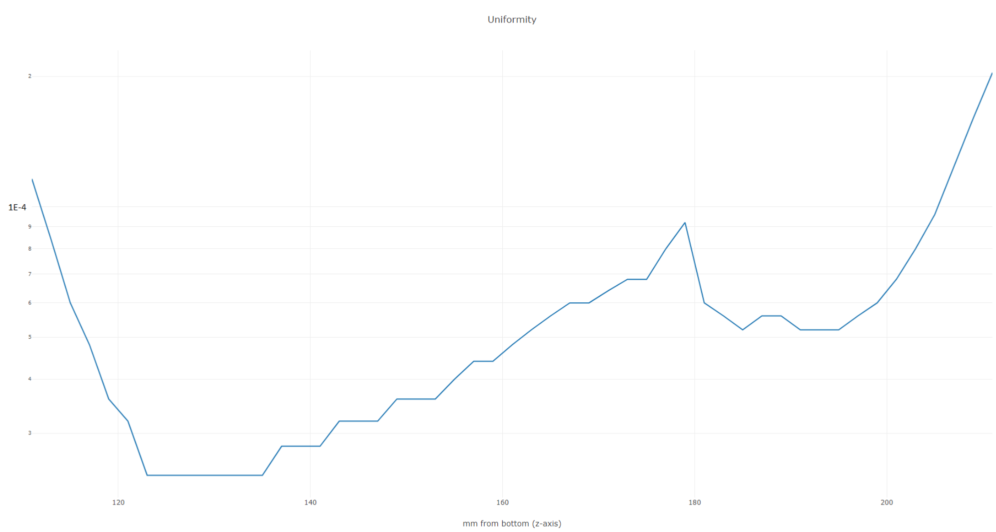


Figure 4: Uniformity at center, along z-axis

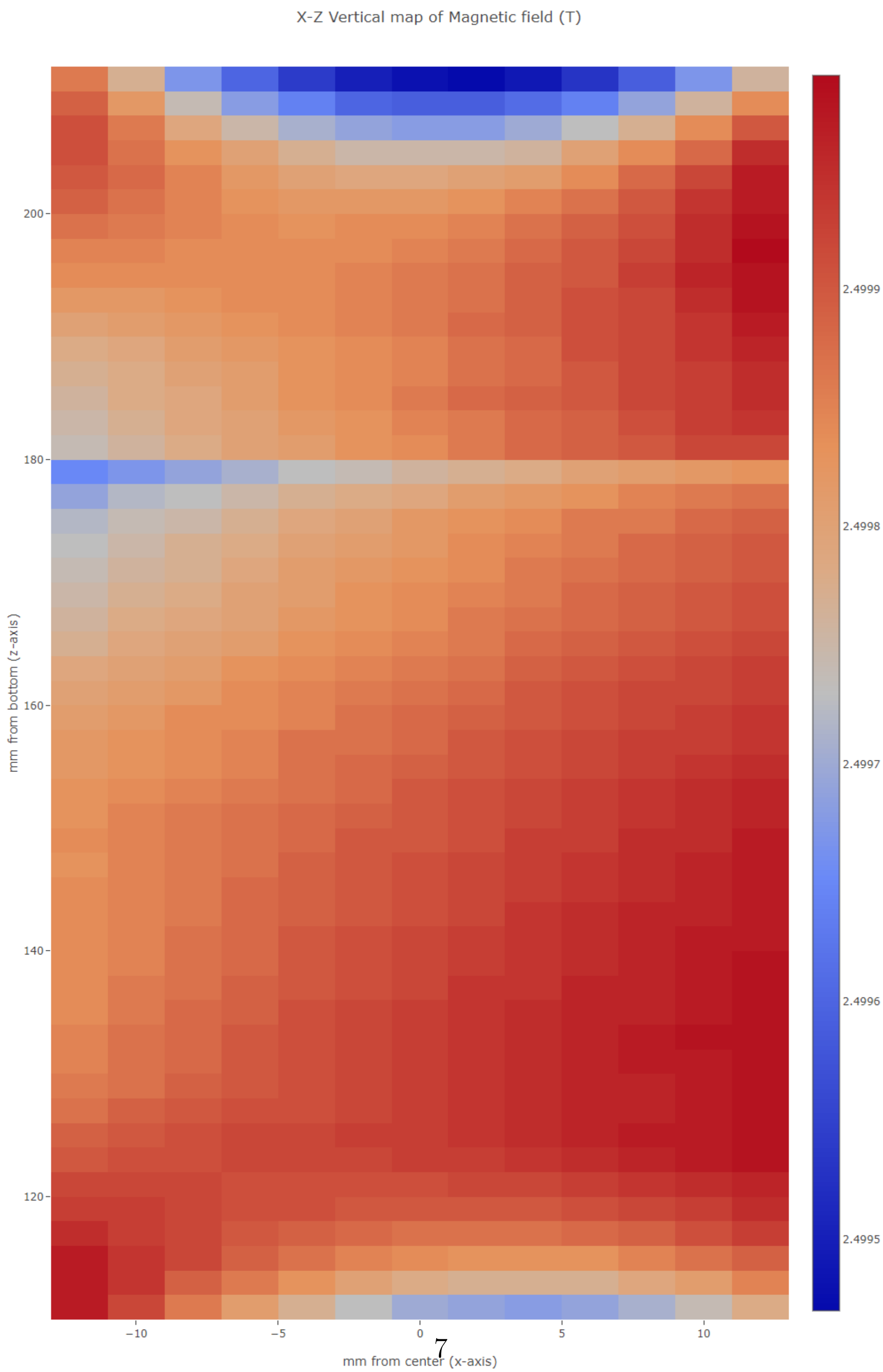


Figure 5: X-Z vertical map of magnetic field.

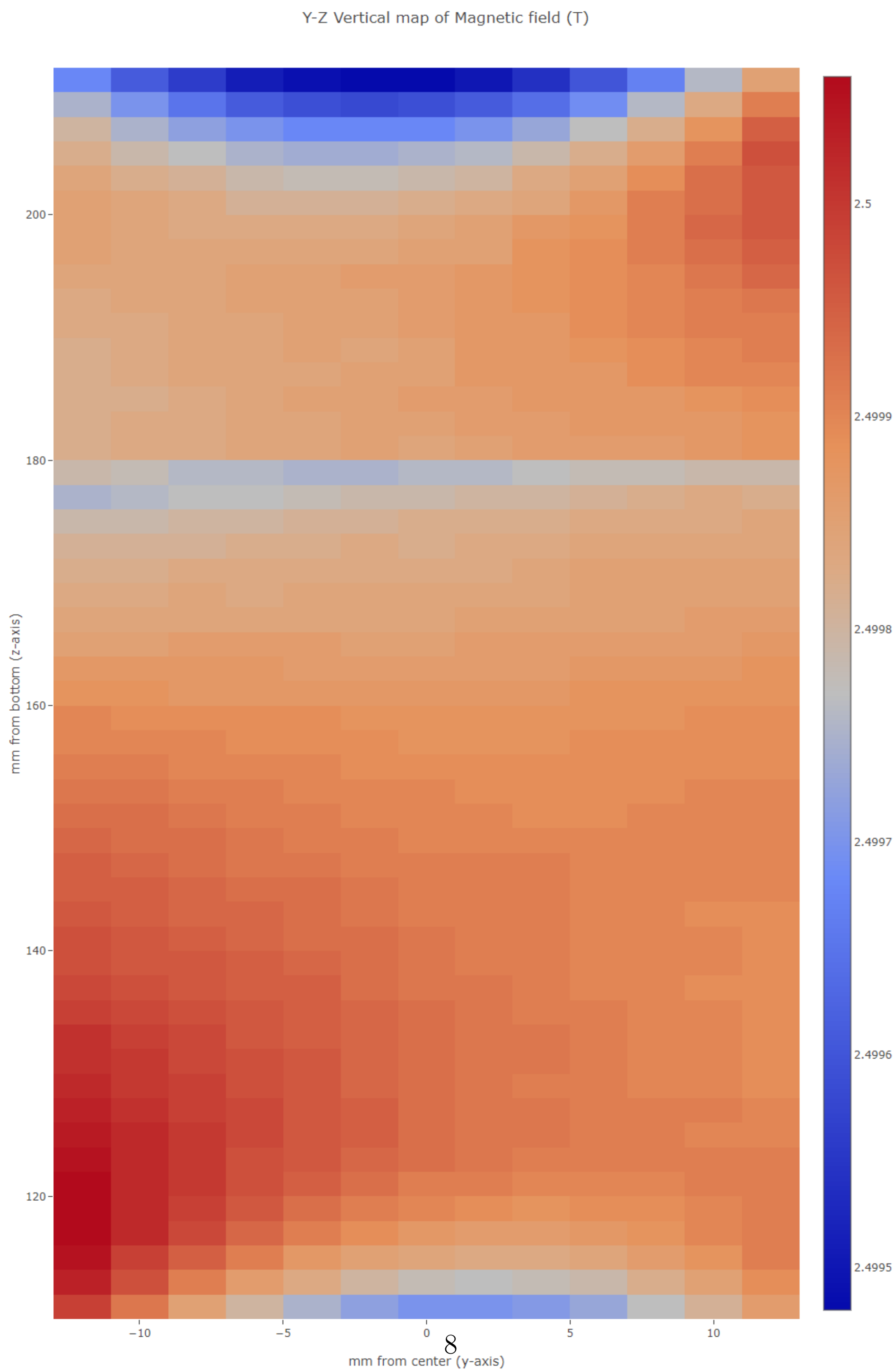




Figure 6: Y-Z vertical map of magnetic field.

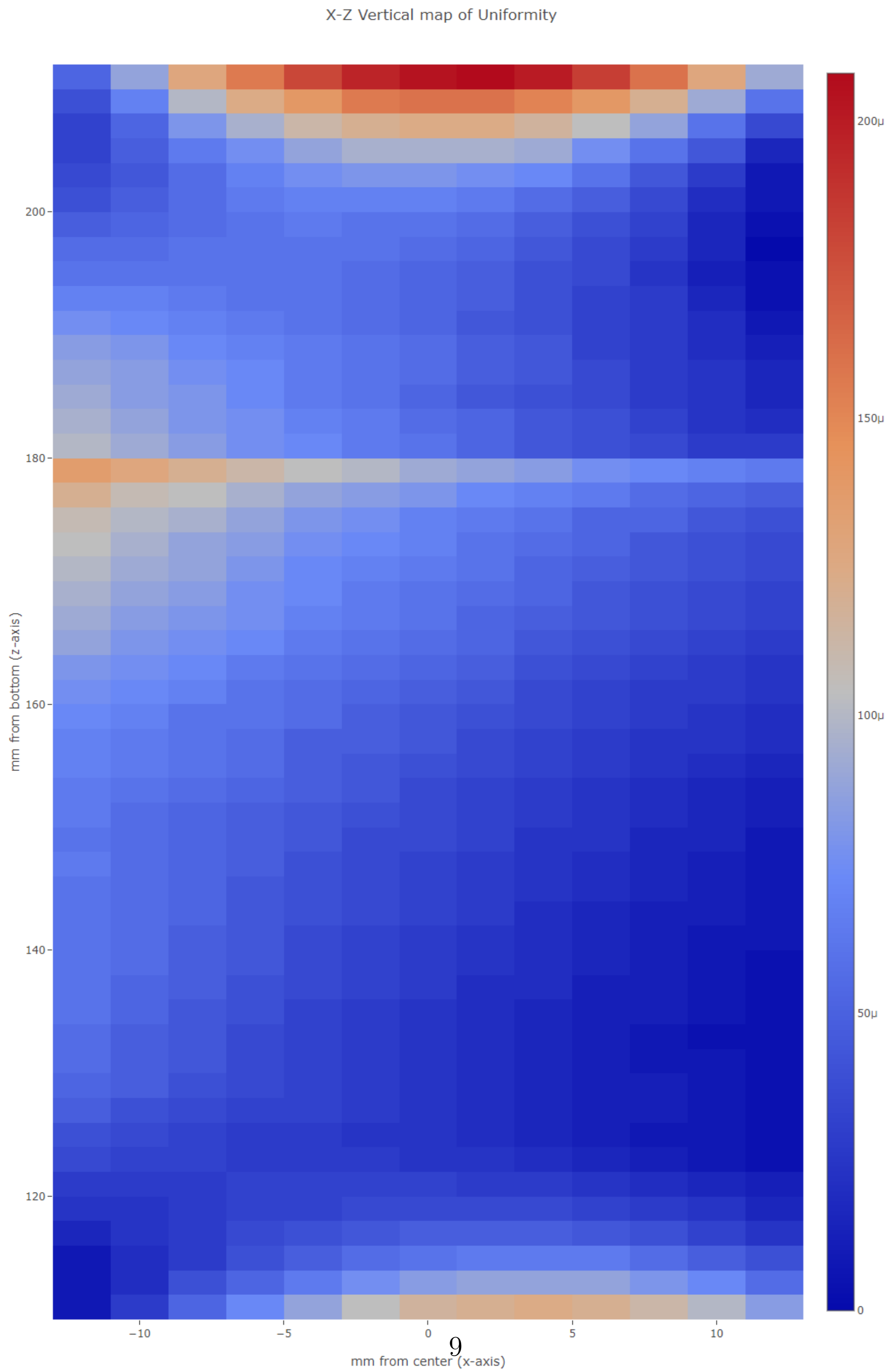




Figure 7: X-Z vertical map of uniformity.

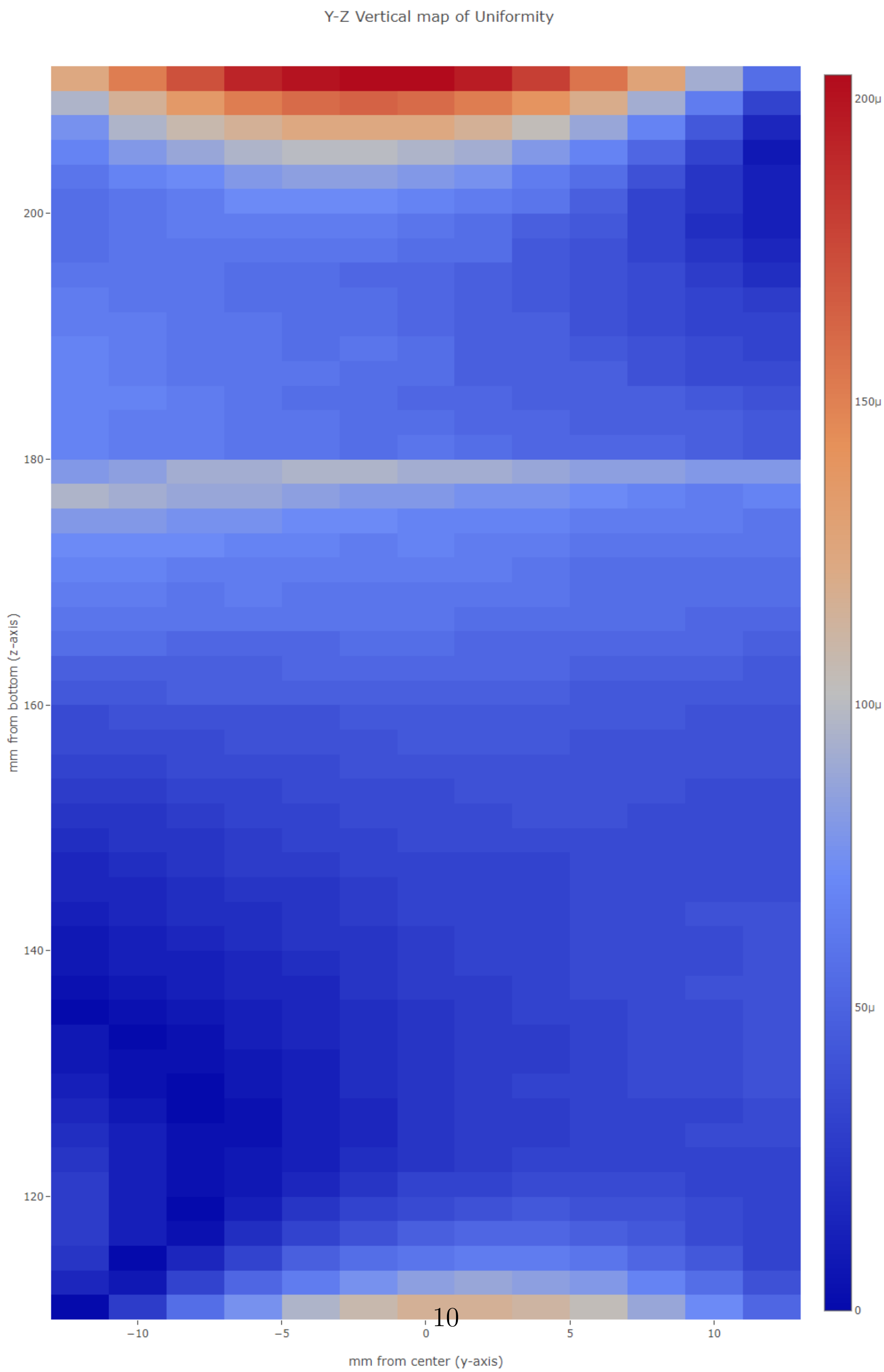




Figure 8: Y-Z vertical map of uniformity.