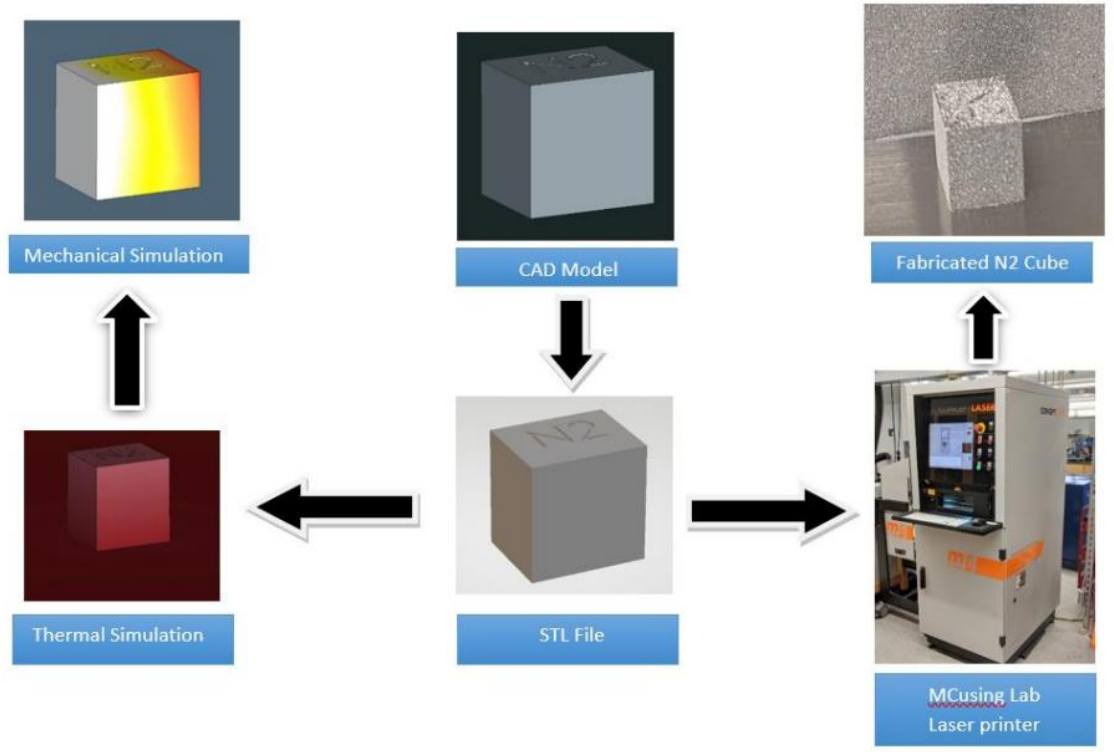
Monitoring Defects in Laser Powder Bed Fusion Using Thermal and Laser Scan Data

- Laser Powder Bed Fusion (LPBF) involves millions of thermal cycles. High geometry sensitivity led to the risk of residual stress and thermal-induced defects.
- The goal is to leverage simulation-based thermal and scan path data to detect defects in-situ.



IMPERIAL

Overview

- Aligning simulated thermal data with laser scan path data.
- Mapping thermal data to spatial laser points.
- Comparing with reference dataset to identify anomalies.
- Developing an initial defect segmentation approach.
- Evaluating pipeline scalability and improvement strategies.

Pipeline

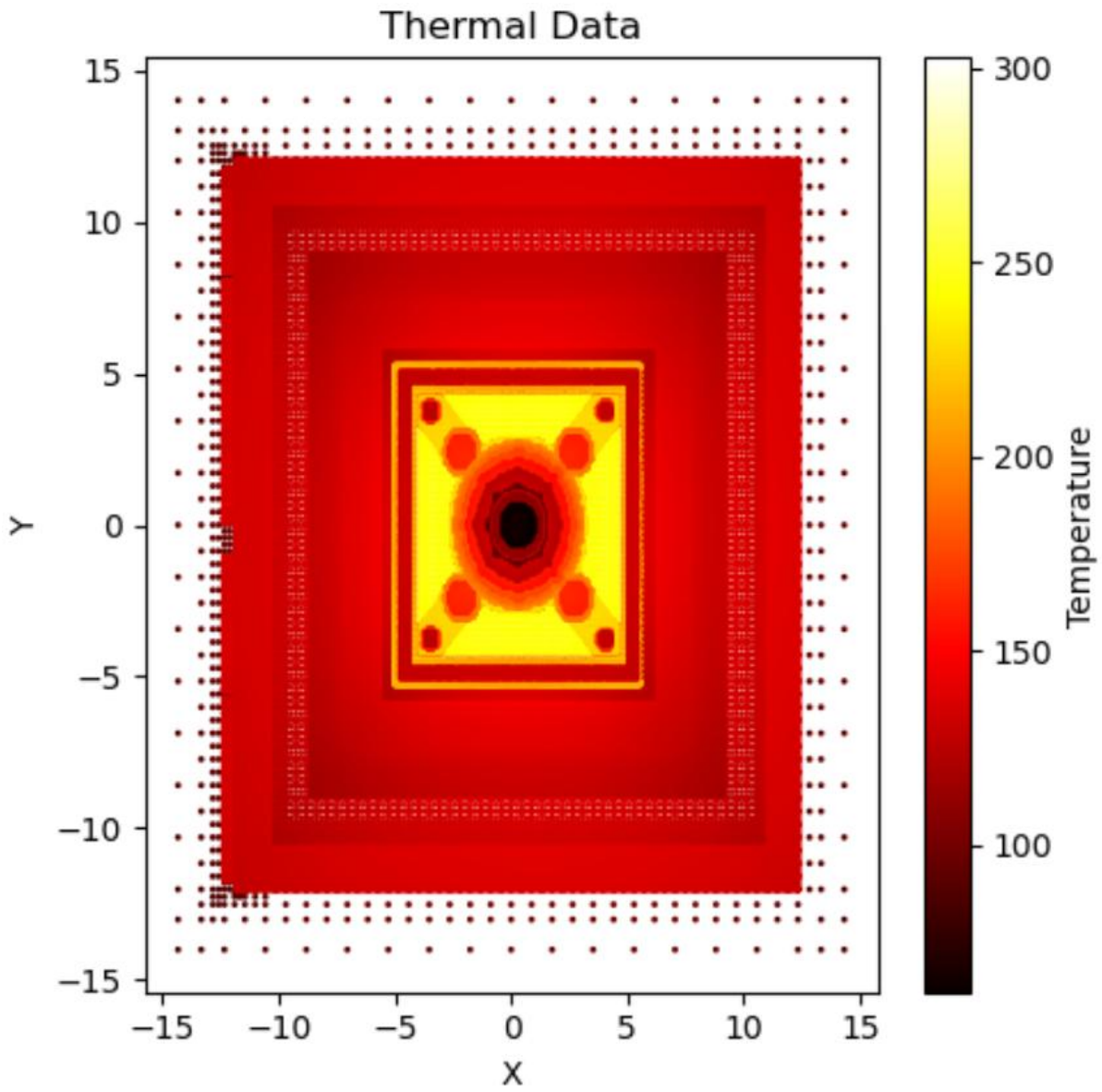
1. Loading Data
2. Aligning Thermal & Laser Points (XY Shift)
3. Mapping Thermal T to Laser Points (KDTree)
4. Comparing to Reference Dataset
5. Segmenting Defective Regions
6. Visualizing and Reporting Defects

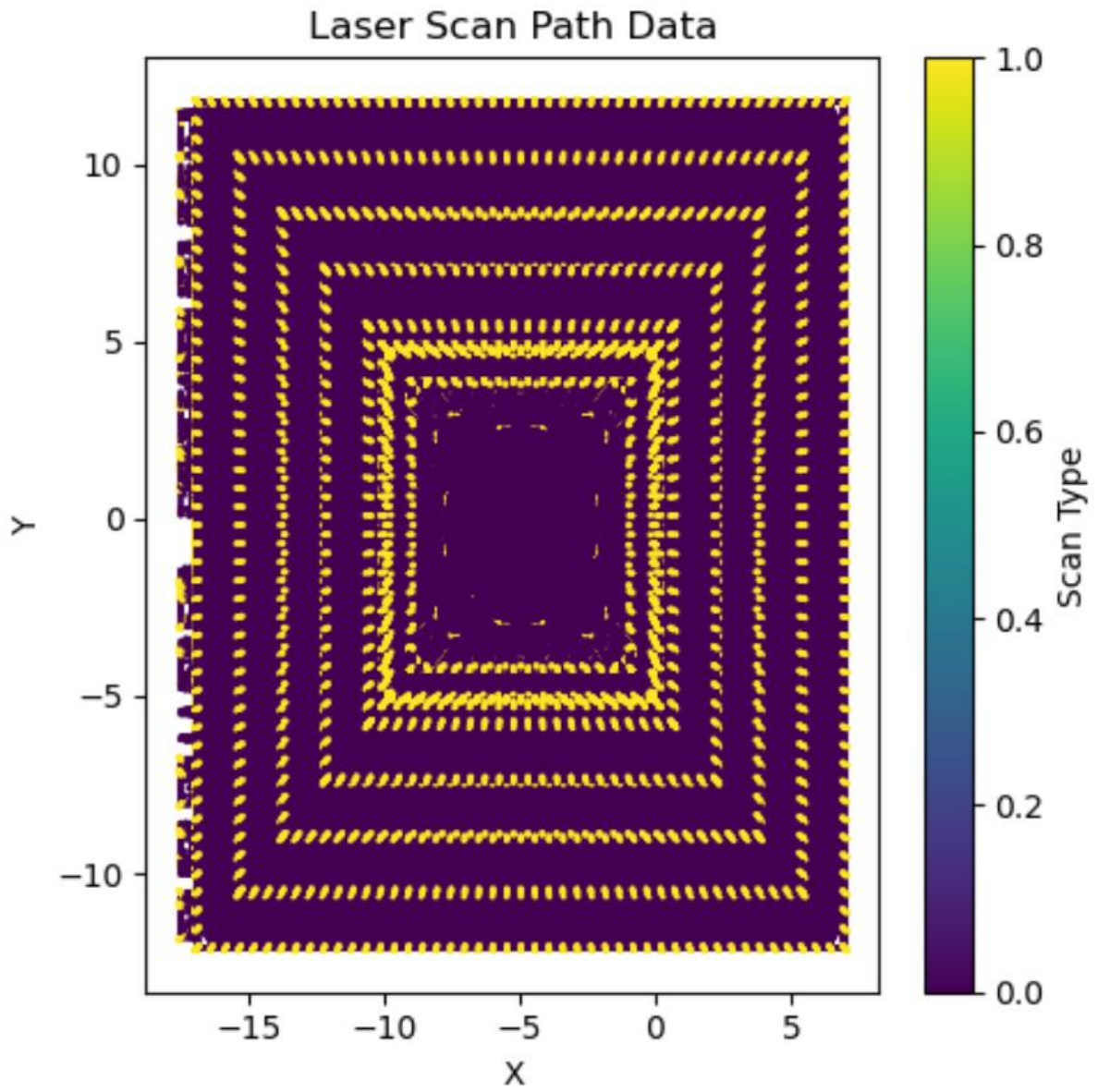
Alignment Strategy

Detecting XY misalignment using nearest neighbor offset (KDTree), and estimating average XY shift vector and translating thermal coordinates.

IMPERIAL

IMPERIAL


Thermal Data
15
10
5
0
−5
−10
−15
Y
−15
−10
−5
0
5
10
15
X
300
250
200
150
100
Temperature


Laser Scan Path Data
10
5
0
−5
−10
Y
−15
−10
−5
0
5
X
1.0
0.8
0.6
0.4
0.2
0.0
Scan Type

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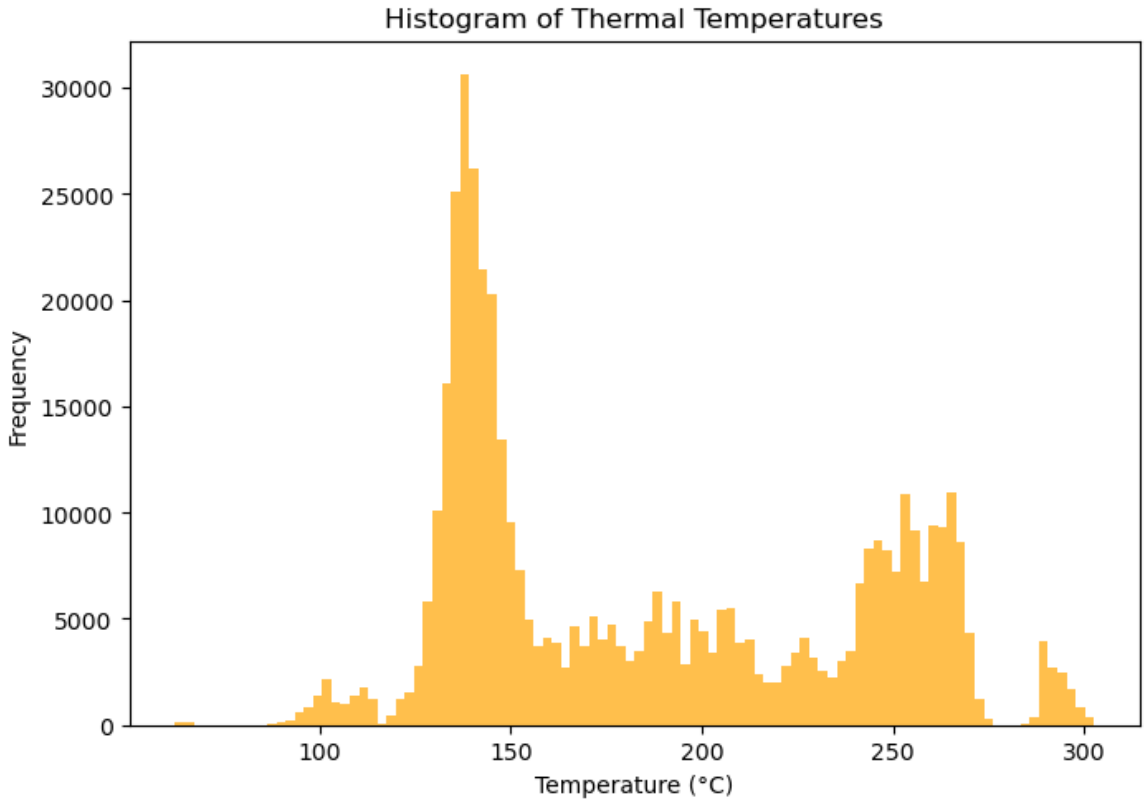
Histogram of Thermal Temperatures
Frequency
30000
25000
20000
15000
10000
5000
0
100
150
200
250
300
Temperature (°C)

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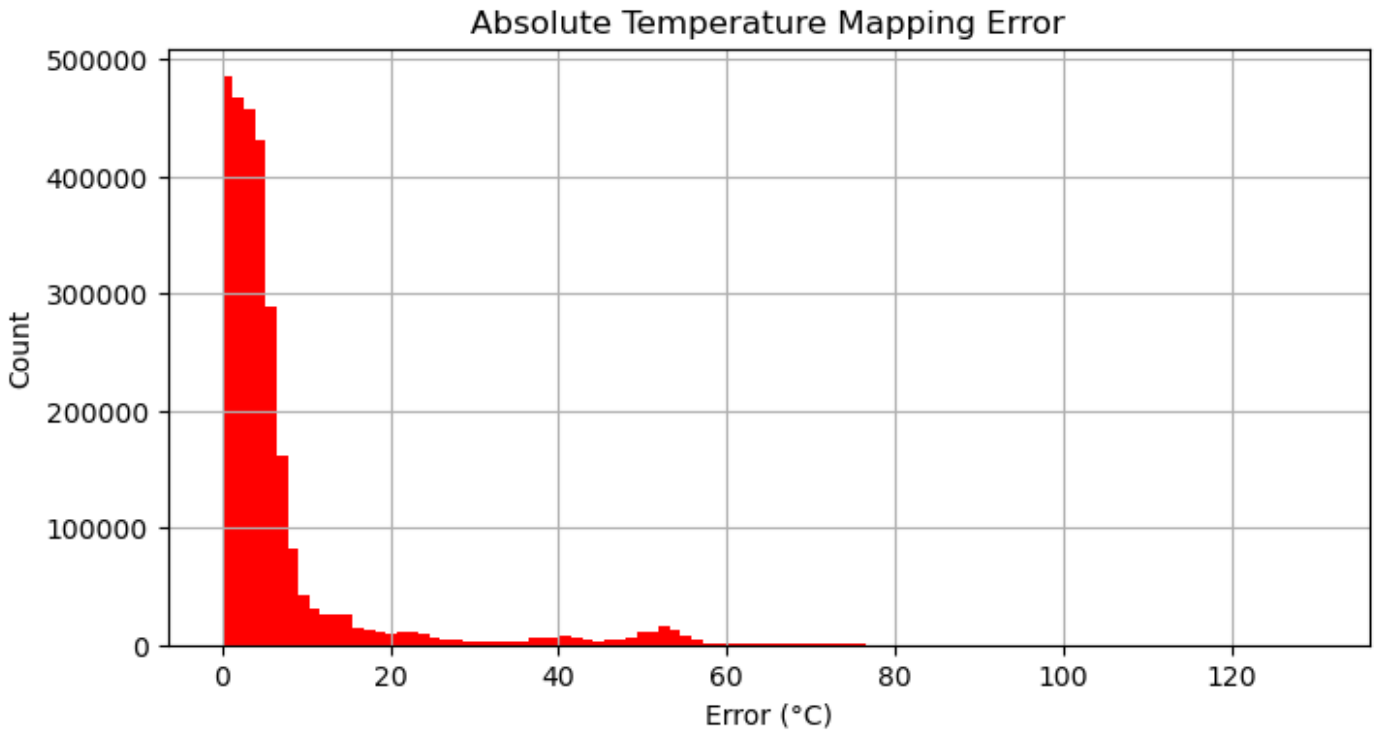
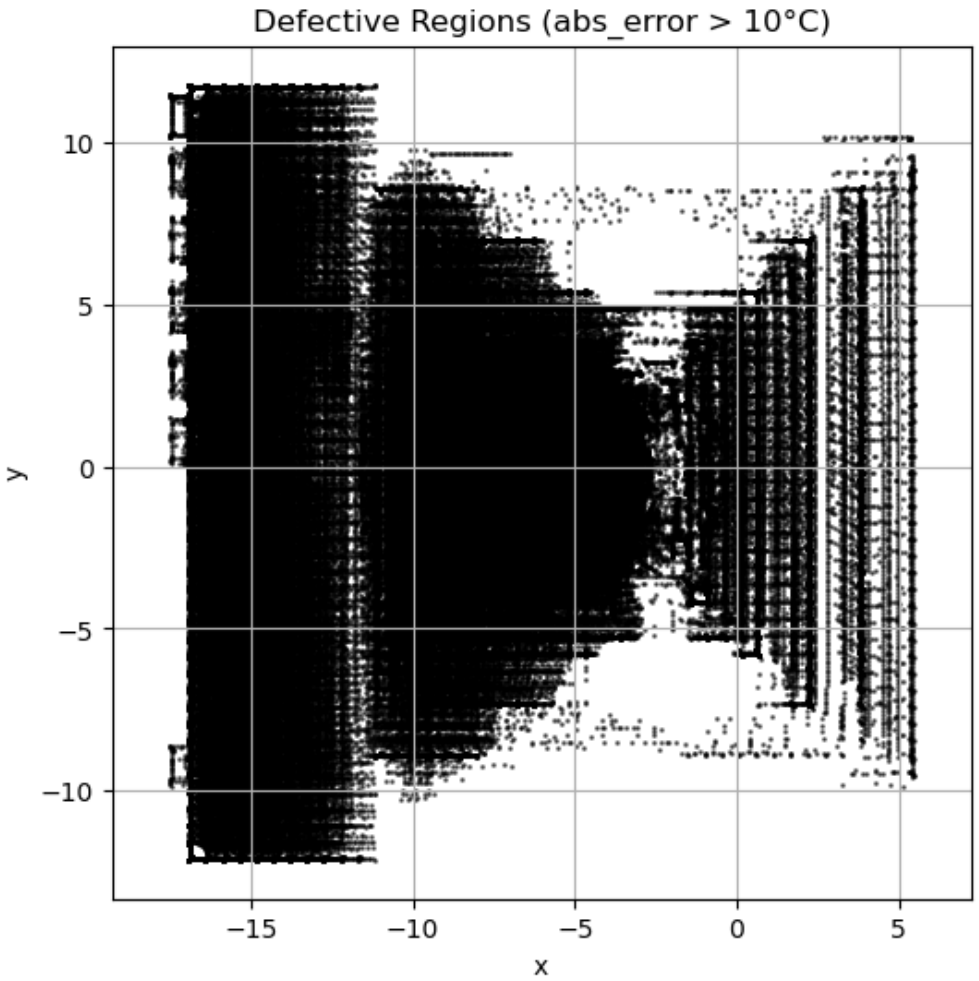


Mean Absolute Error: 6.94 °C

Max Error: 129.81 °C

Defective Points: 362911



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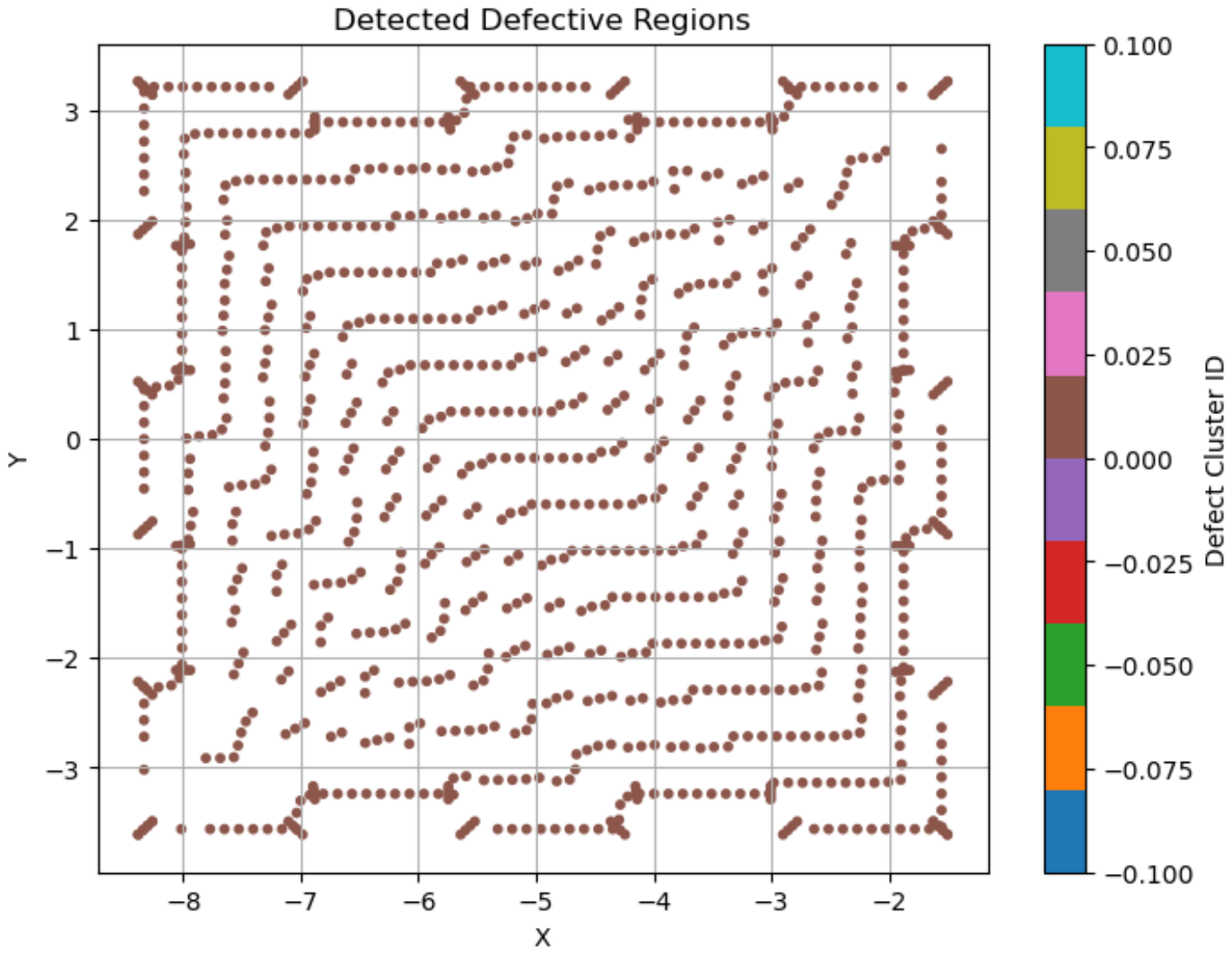
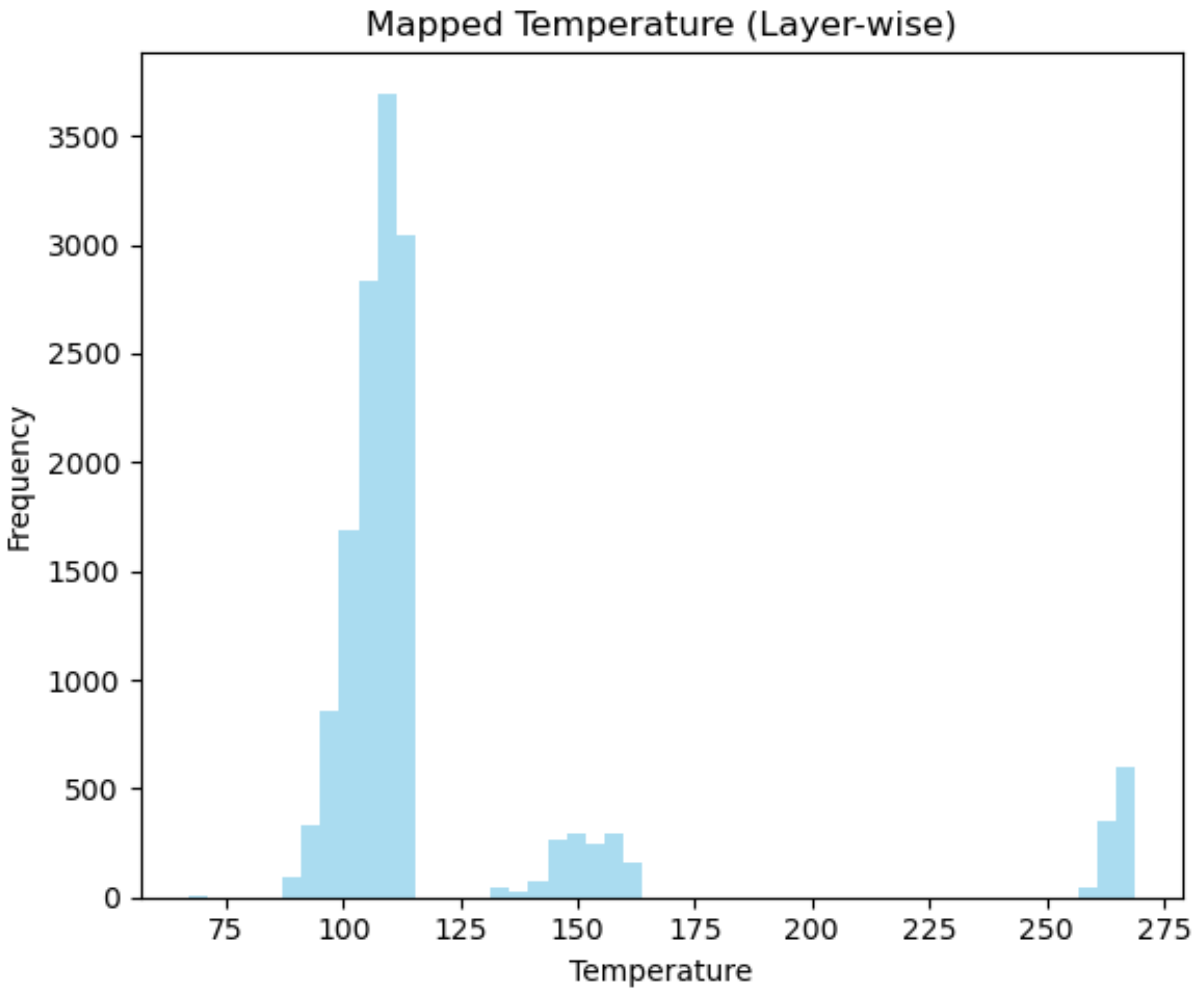
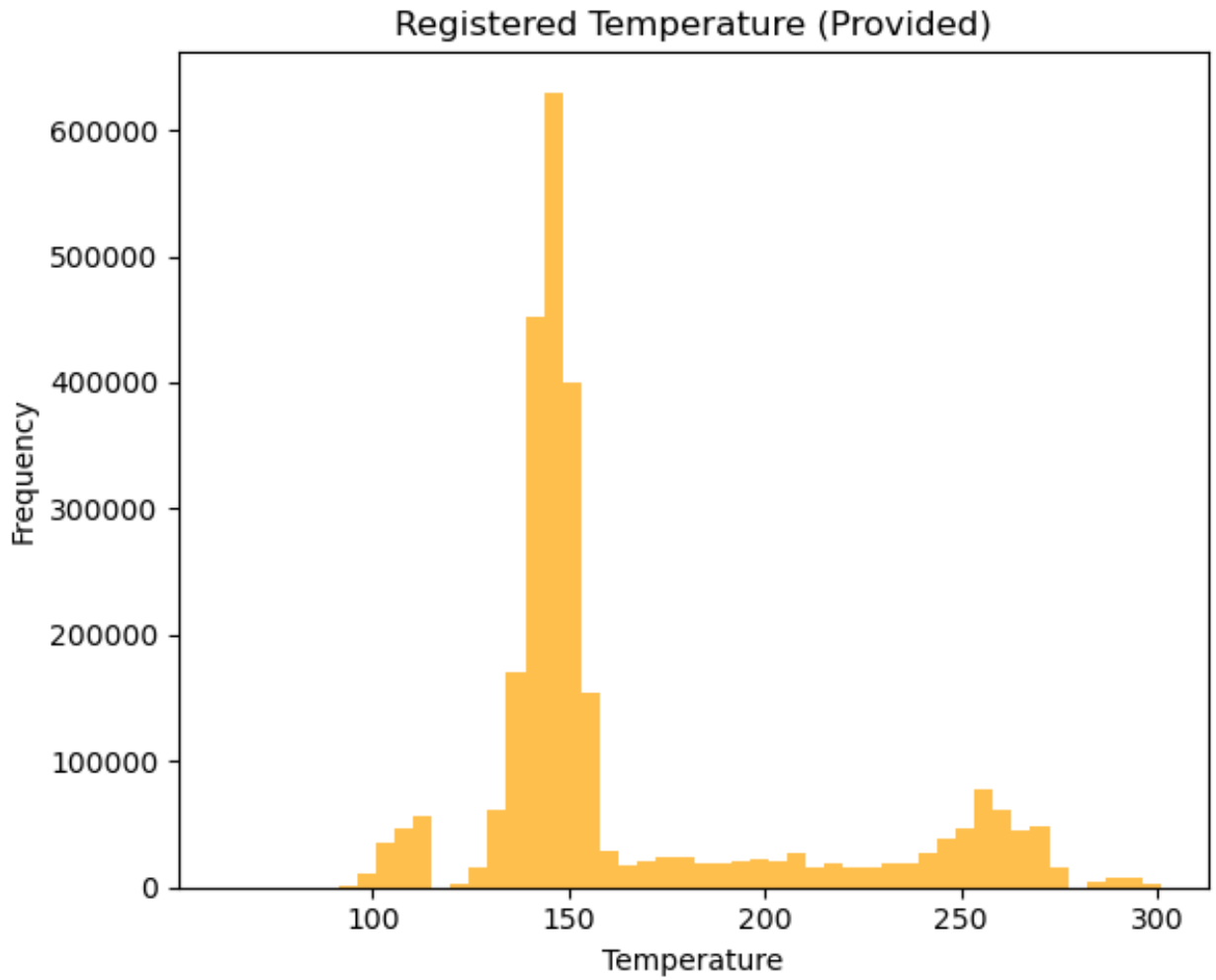

Detected Defective Regions
Y
X
3
2
1
0
−1
−2
−3
−8
−7
−6
−5
−4
−3
−2
Defect Cluster ID
0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.100

IMPERIAL


Mapped Temperature (Layer-wise)
Frequency
Temperature
0
500
1000
1500
2000
2500
3000
3500
75
100
125
150
175
200
225
250
275


Registered Temperature (Provided)
Frequency
Temperature
0
100000
200000
300000
400000
500000
600000
100
150
200
250
300