Volumetric Image Analysis for Ultrasonic Inspection Automation

R. David Obenauf

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Lawrence Livermore National Laboratory

Ultrasonic Inspection
An Introduction to Non-Destructive Acoustic Evaluation

- **Traditional Ultrasound Imaging Techniques**
  - Data collection
  - Displaying data and finding indications
  - Limitations
  - How can we use computers to do the hard work for us?

- **UT Inspection Automation and CloudView**
  - Algorithmic process to find relevant data
  - Finding and reporting flaws
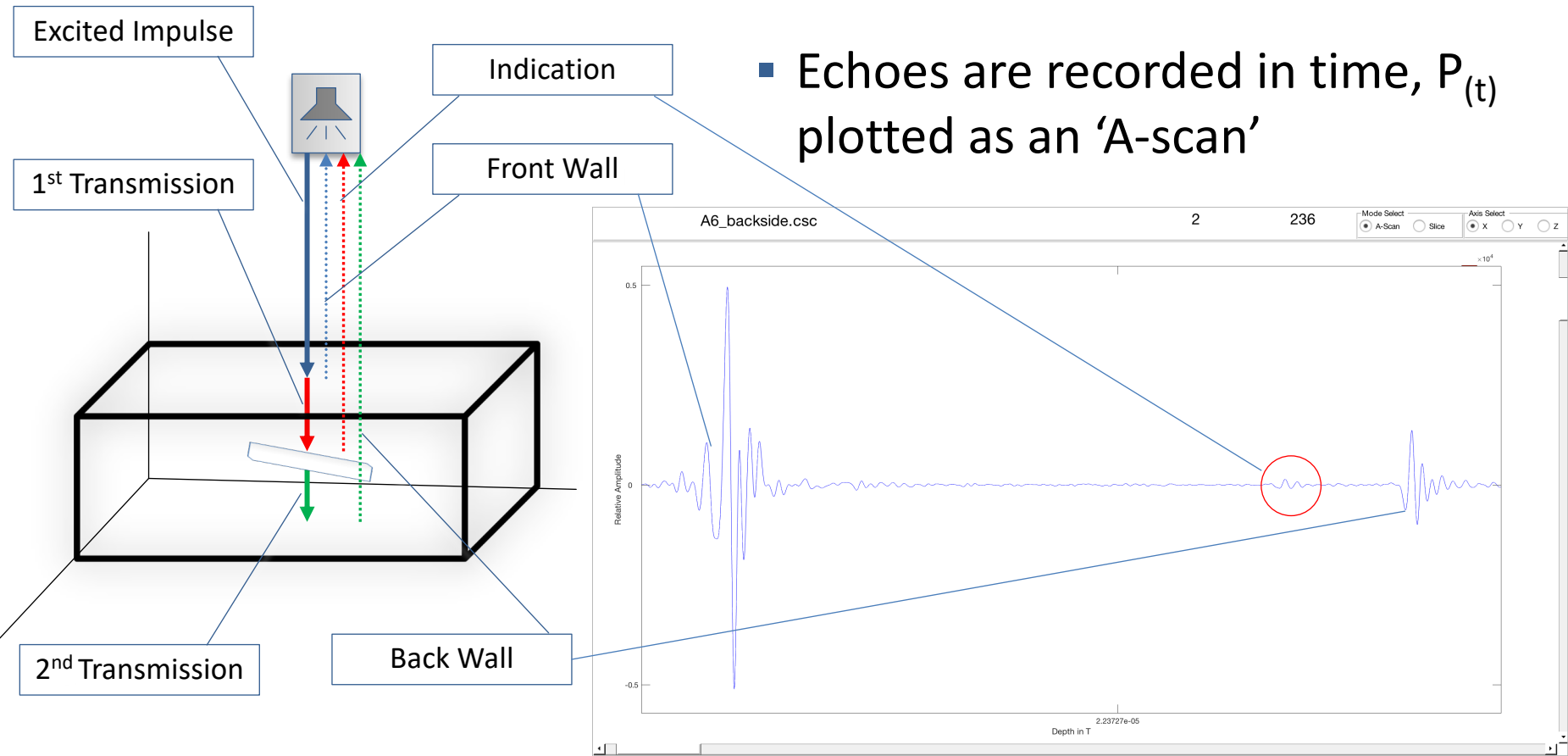 - Limitations and further development

Ultrasonic Inspection Techniques
Finding and Reporting Indications

- **Ultrasonic Transmission**
  - Acoustic waves propagate well through solids
  - Waves reflect on impedance mismatches

- **Indications**
  - Manufacturing defects cause reflections
  - Interior features can be seen as well

- **Reporting Flaws**
  - Inspection of captured data can highlight flaws
  - Data can be reported to customers for further analysis
  - Manufacturing can be improved or changed

Traditional Methods
A-Scans, C-Scans

Excited Impulse

1st Transmission

2nd Transmission

Indication

Front Wall

Back Wall

- Transducers excite a wave in a part

- Echoes are recorded in time, $P_{(t)}$ plotted as an 'A-scan'

A6_backside.csc   2   236

Mode Select   ○ A-Scan ○ Slice
Axis Select   ○ X ○ Y ○ Z

Relative Amplitude

Depth in T

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NNSA
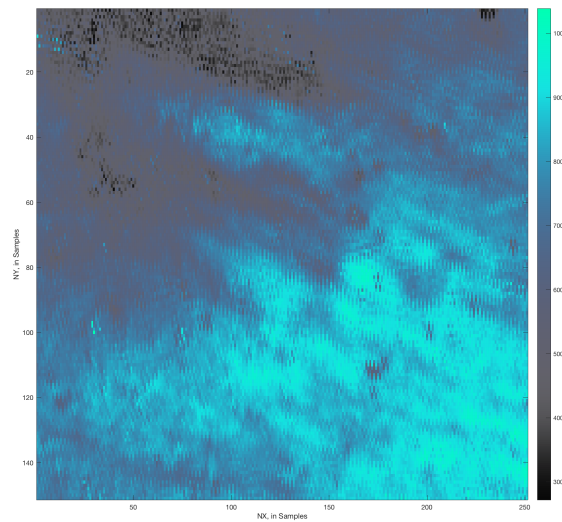National Nuclear Security Administration

Traditional Methods
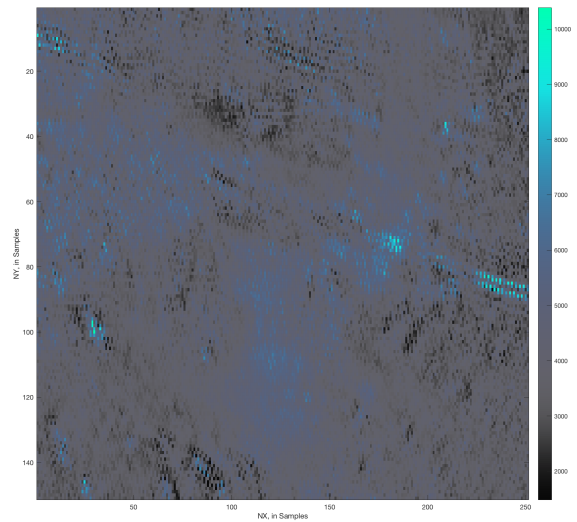## A-Scans, B-Scans, C-Scans

- C-Scans display extrema of an A-scan in a 2D space

- Indications show as $\max(|P_{(x,y,t)}|)$ is relatively large
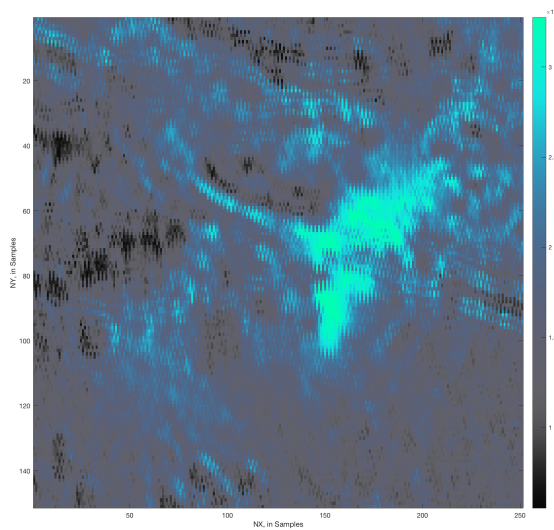
Max(t_s=200 to end)   Max(t_s=2000 to end)   Max(t_s=3500 to end)

Gates must be well-chosen to find indications

Automation and CloudView
Finding and Reporting Indications

- Gating Interior Volume
  — Finding the front and back wall
  — Mitigating 'holes'

- Classifying Indications
  — Pulse nature
  — Signal Techniques

- Presentation of Data
  — Validation of Results
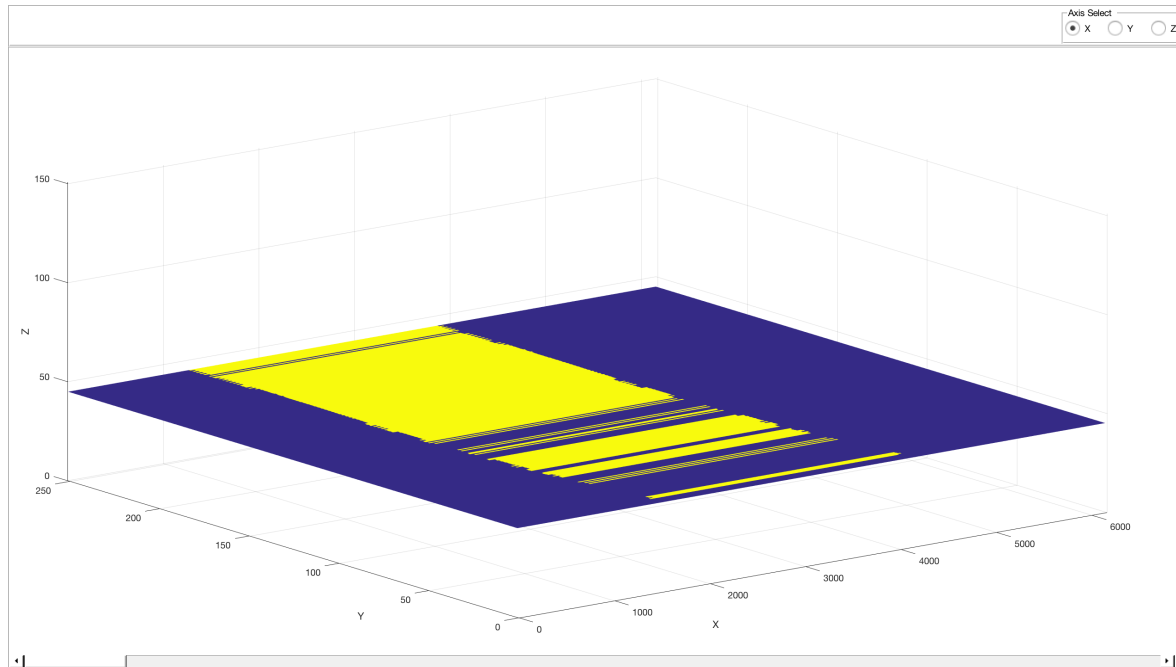 — Sorting and Reporting

- Further Considerations

Gating
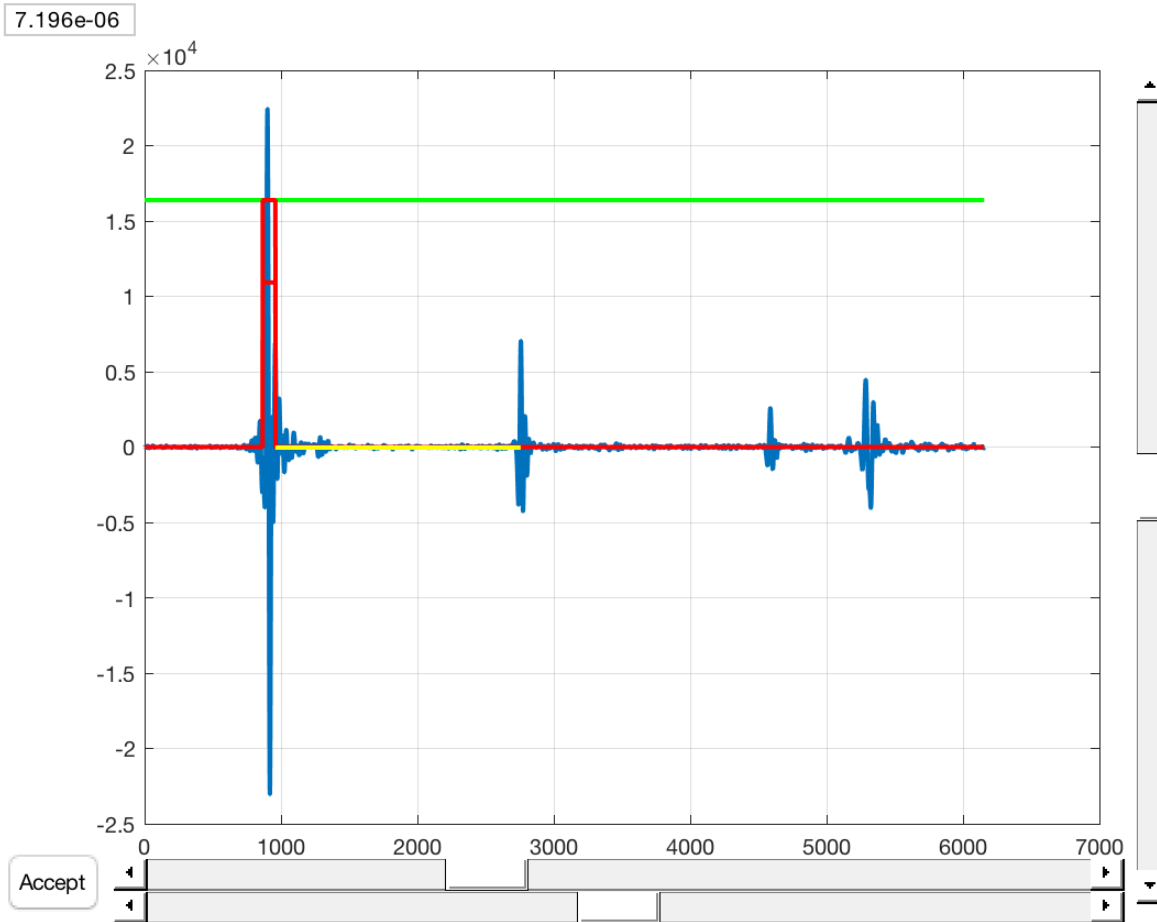
- Variable thresholds allow for tuning based on the acquired data

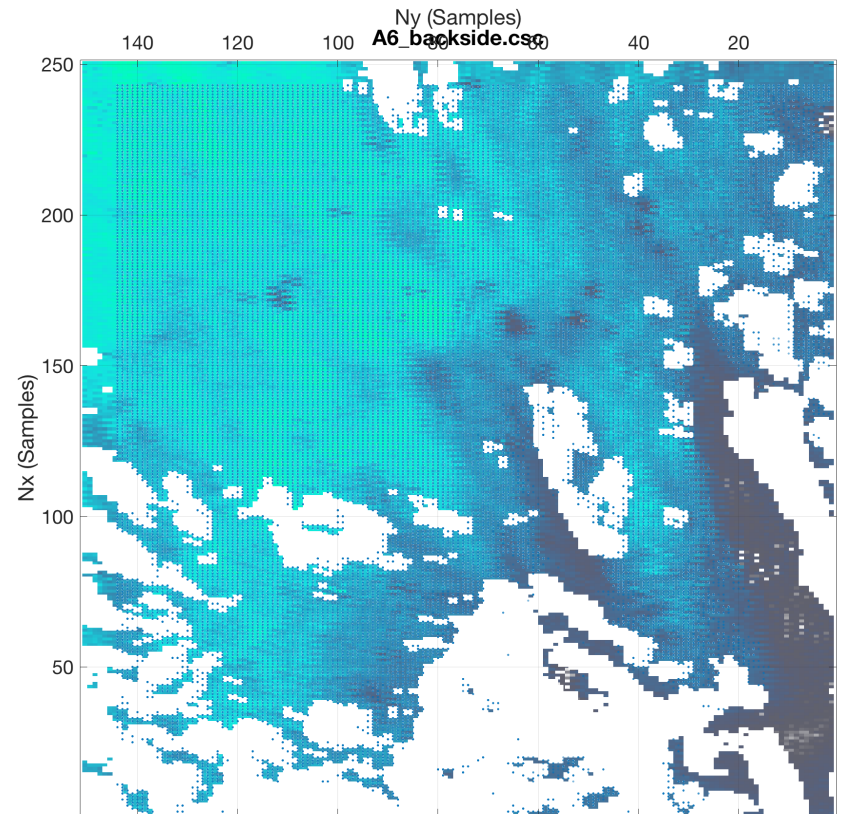- Visual presentation gives user feedback
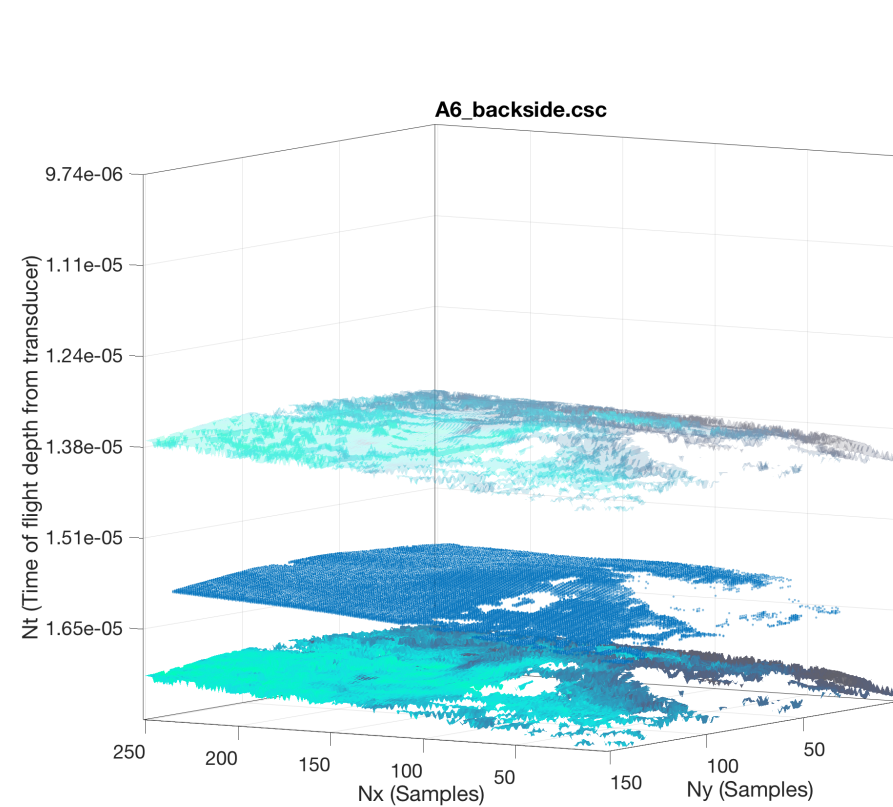
Incorrect Gating
Holes in the data

- Gate Thresholding fails on weak signals, leaving holes in the results

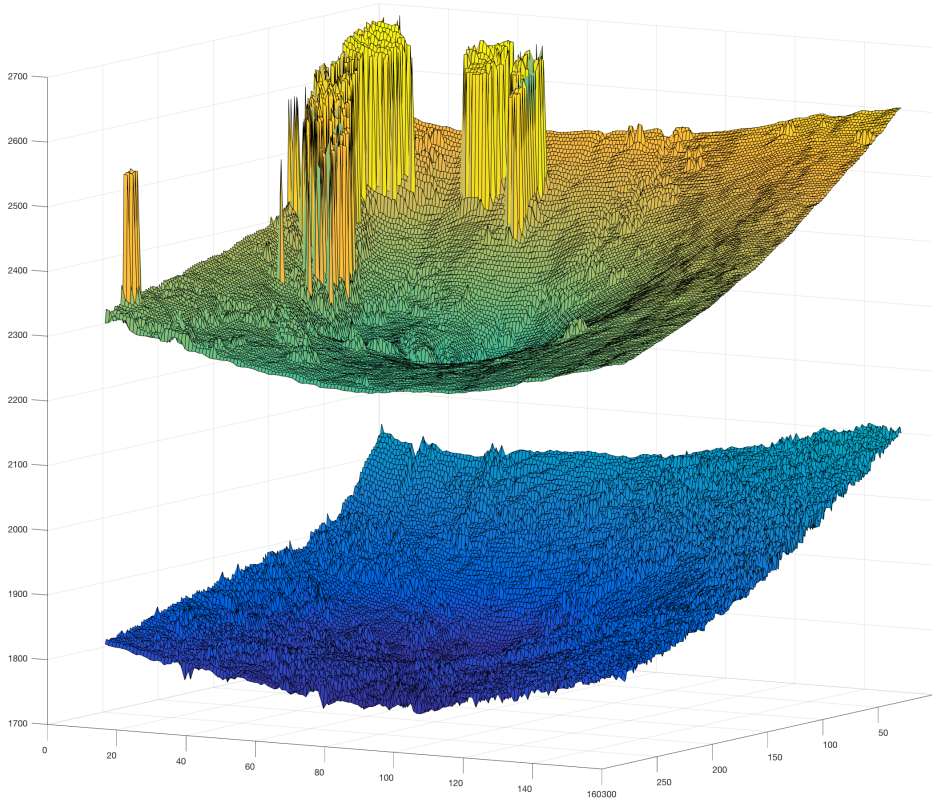- Data can be interpolated to fill in the gaps

Incorrect Gating
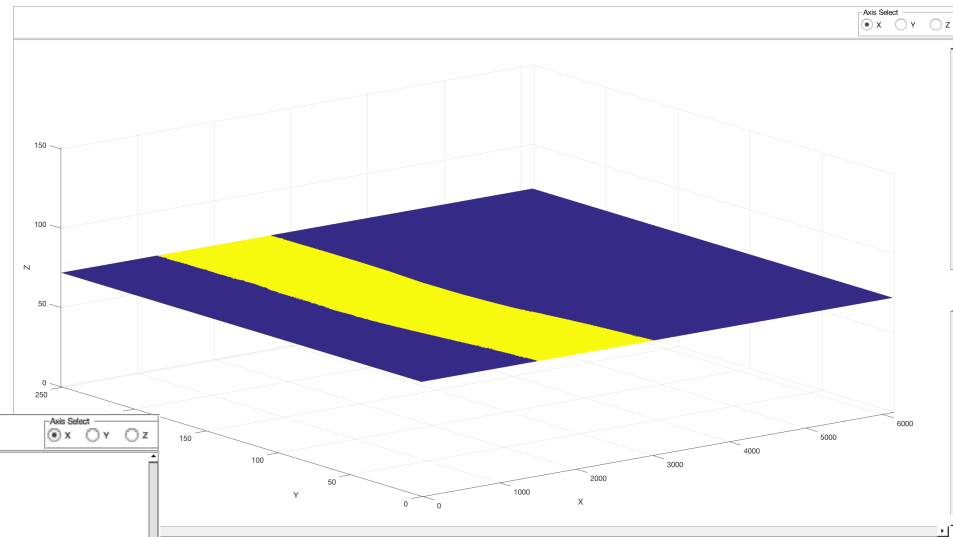## Holes in the data

Incorrect Gating
Filling in the Holes

- Gate start and stop yield two 'images'

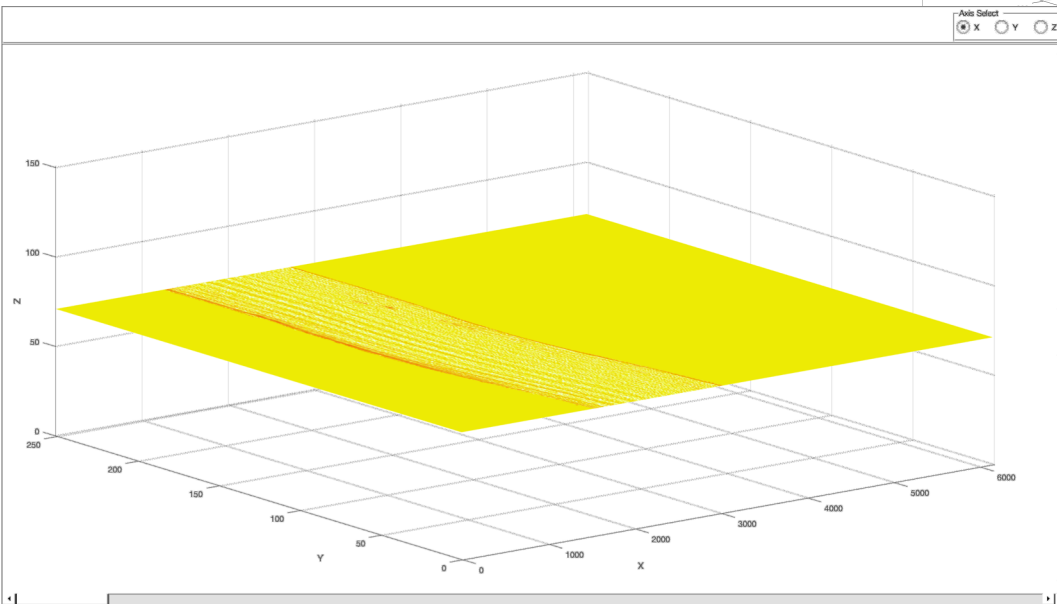- Interpolation, smoothing, and comparison with an anticipated shape corrects the gate

Incorrect Gating
Filling in the Holes

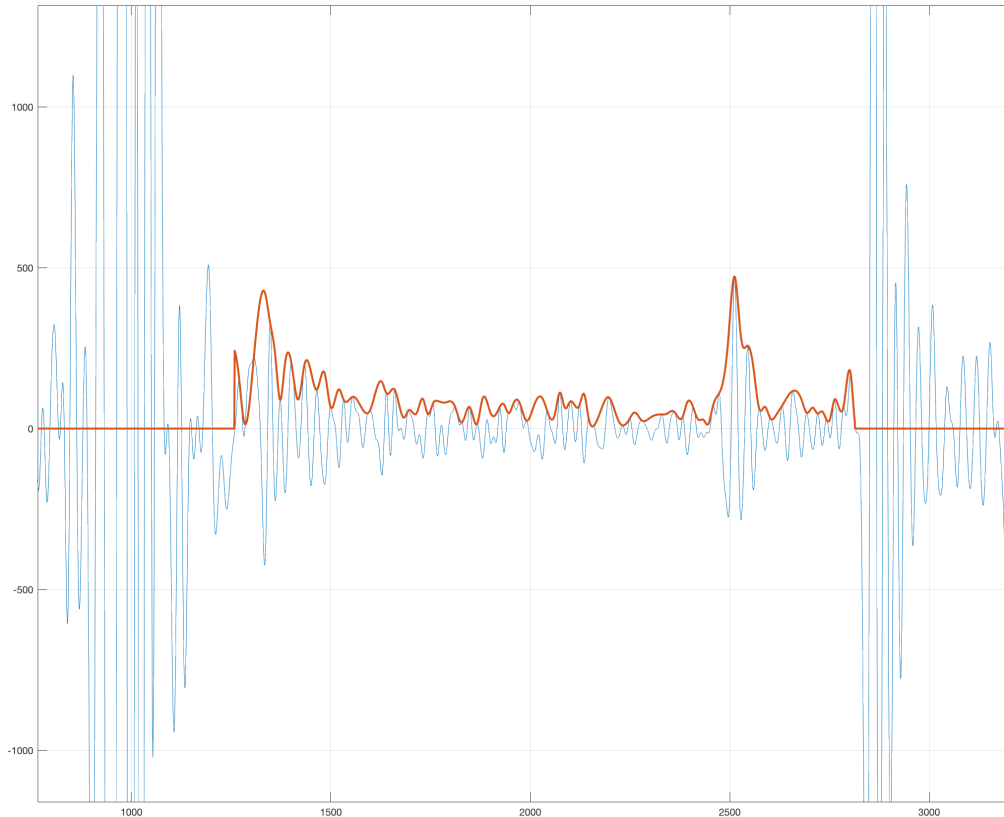- Fixing the Gate allows us to 'see' inside the part

- Maxima within the new region can be examined

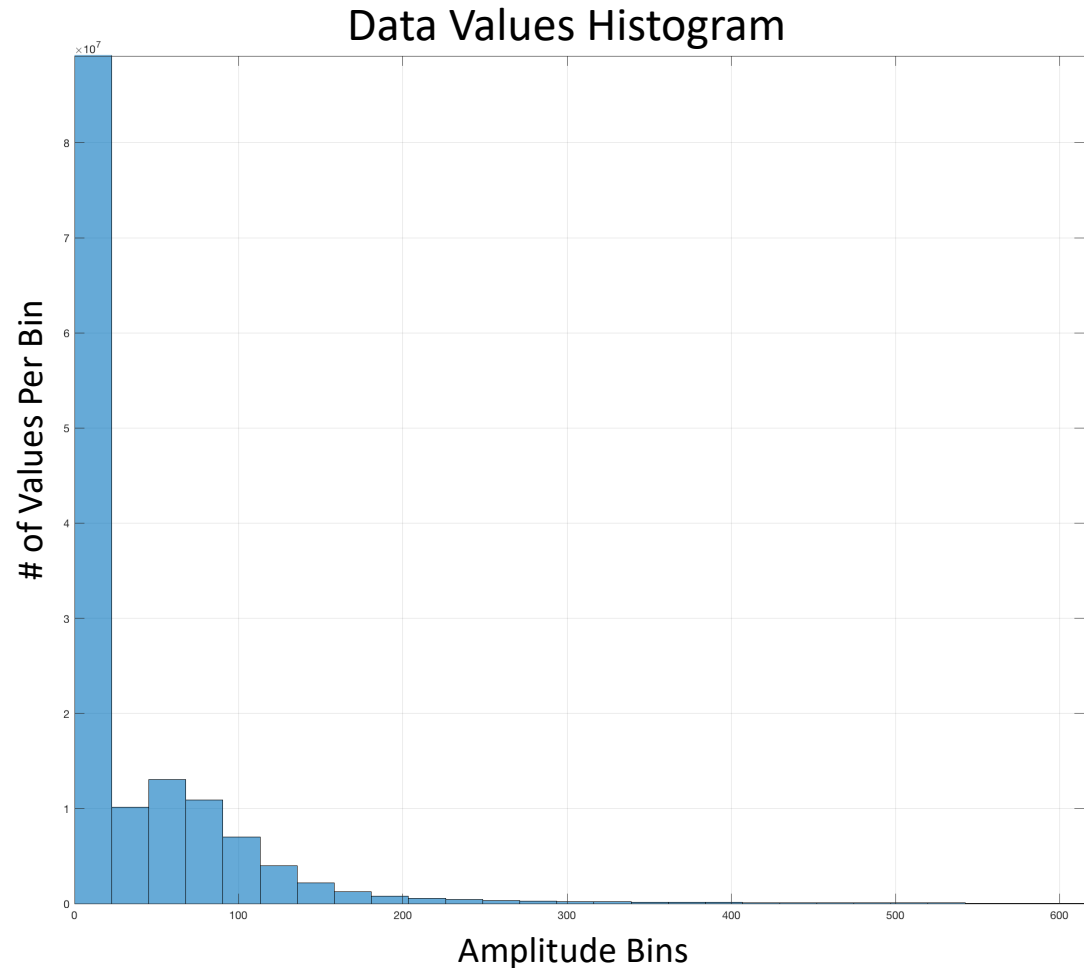# Finding Significant Features
Amplitude Analysis

- Enveloping the magnitude of the function shows us peaks

- Reduces ripple in results, Blobs are contiguous

# Finding Significant Indications
Blob Analysis

- Indications are 'louder' than their surroundings

- Statistical thresholding picks out significant features

Data Values Histogram

y-axis: # of Values Per Bin ($\times 10^7$)

x-axis: Amplitude Bins

Finding Significant Indications
Automation with CloudView

- Points are found by thresholding above a chosen bin amplitude

- Points can then be sorted into blobs and highlighted as indications for further analysis

A6_backside.csc
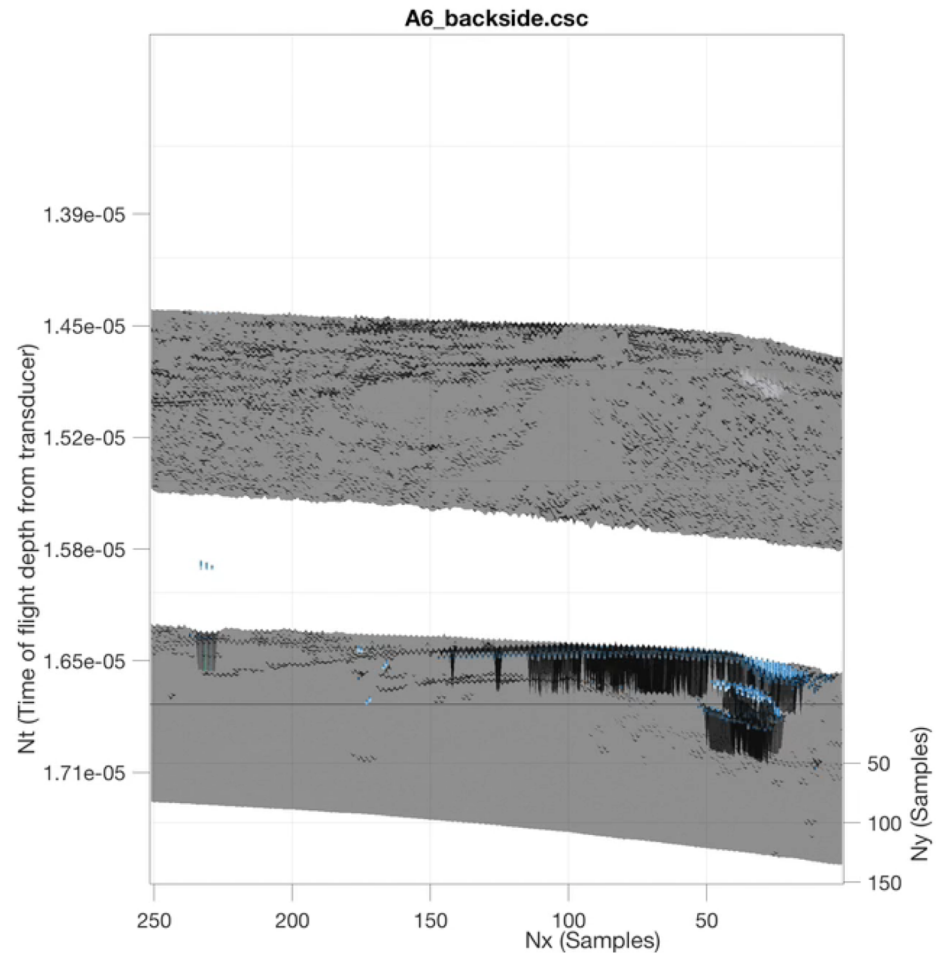
Automation and CloudView
Further Development

- Blob Analysis
  - Sort points into groups
  - Capture the data within a group

- Reporting
  - Automate report generation
  - Getting and presenting data snippets

- Further Selection Criteria
  - Cleaning signals
  - Finding obfuscated reflections
  - Characterizing type of indication

- Porting to other languages

Volumetric Ultrasonic Analysis
In Conclusion

- Traditional Ultrasonic Data Interpretation
  — Robust
  — Time consuming, error prone

- Proposed Solution
  — Signal Analysis techniques can automate indication-hunting process
  — Image Analysis can be used on the resulting data to automate reporting and characterization, saving inspectors and customers time

- Further Development
  — Implement Blob sorting algorithm
  — Generate automatic reports with data voxels
  — Hone the indication segmentation process, characterize flaws in-place

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