

## Goal: Apply unsupervised machine learning to upstream detection of capping defects

**Example Pre-Cap Defects**

Genesis RW Westcapper®

Pre-Cap Inspection    Post-Cap Inspection

\* = simulated defect

**Example Post-Cap Defects**

## Method: Anomaly detection based on Boon Logic AVIS technology



**Step 1. Create training set:** Collect ~500 images of compliant units from RW machine's pre- and post-capping cameras

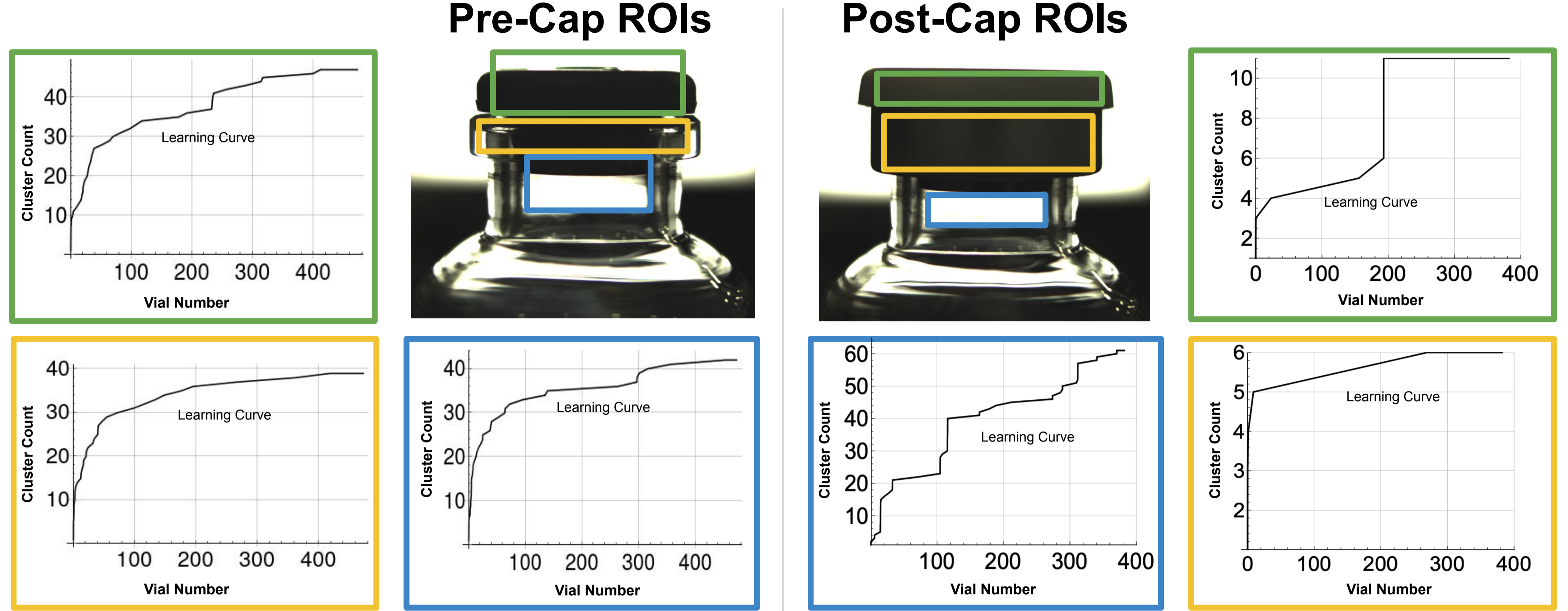
**Examples:** 7 out of 629 Compliant Pre-capped Vials  
Note the normal variation of compliant units

**Examples:** 7 out of 509 Compliant Post-capped Vials  
Note the normal variation of compliant units

**Step 2. Define Regions of Interest; AVIS generates a unique model of "normal variation" for each ROI**

### Advantages

- Easy to create the training set since >99% of produced vials are compliant
- **No image labeling required**
- **No hand-crafted computer vision rules to implement**
- A "defect" is any unit that has low (or no) representation in the trained recipe
- High-dimensional ML models create high detection accuracy (low false accept rate combined with low false reject rate)



**Learning curves for each ROI:** The number of clusters (vertical axis) increases as new variations are found in the training set vials (horizontal axis)

**Step 3. Combine ROI models into two recipes: one for pre-cap inspection and one for post-cap inspection**

## Results: AVIS marks non-compliant areas of defective vials

<p><b>Pre-Cap Recipe</b> 472 training images 157 holdback images 36 defect images</p> <p>100% True Positive 0% False Positive</p>	<p><b>Post-Cap Recipe</b> 382 training images 127 holdback images 16 defect images</p> <p>93% True Positive 1% False Positive</p> <p><b>Processing speed (single-core COTS)</b> <b>90 milliseconds per image</b> <b>Equivalent to &gt; 600 vials per minute</b></p>	
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