



Material Characterization for Millimeter-Wave Passenger Inspection

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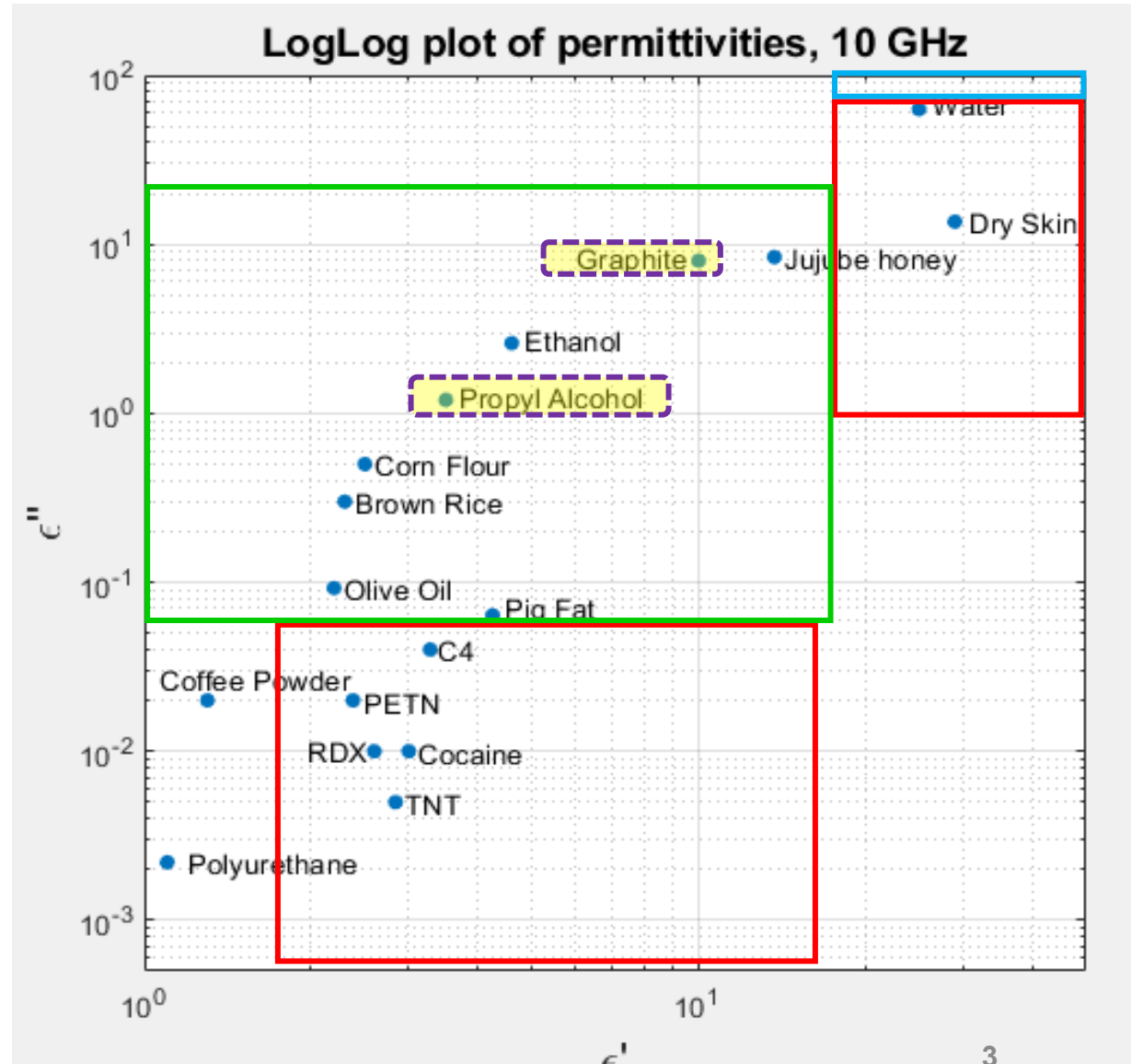
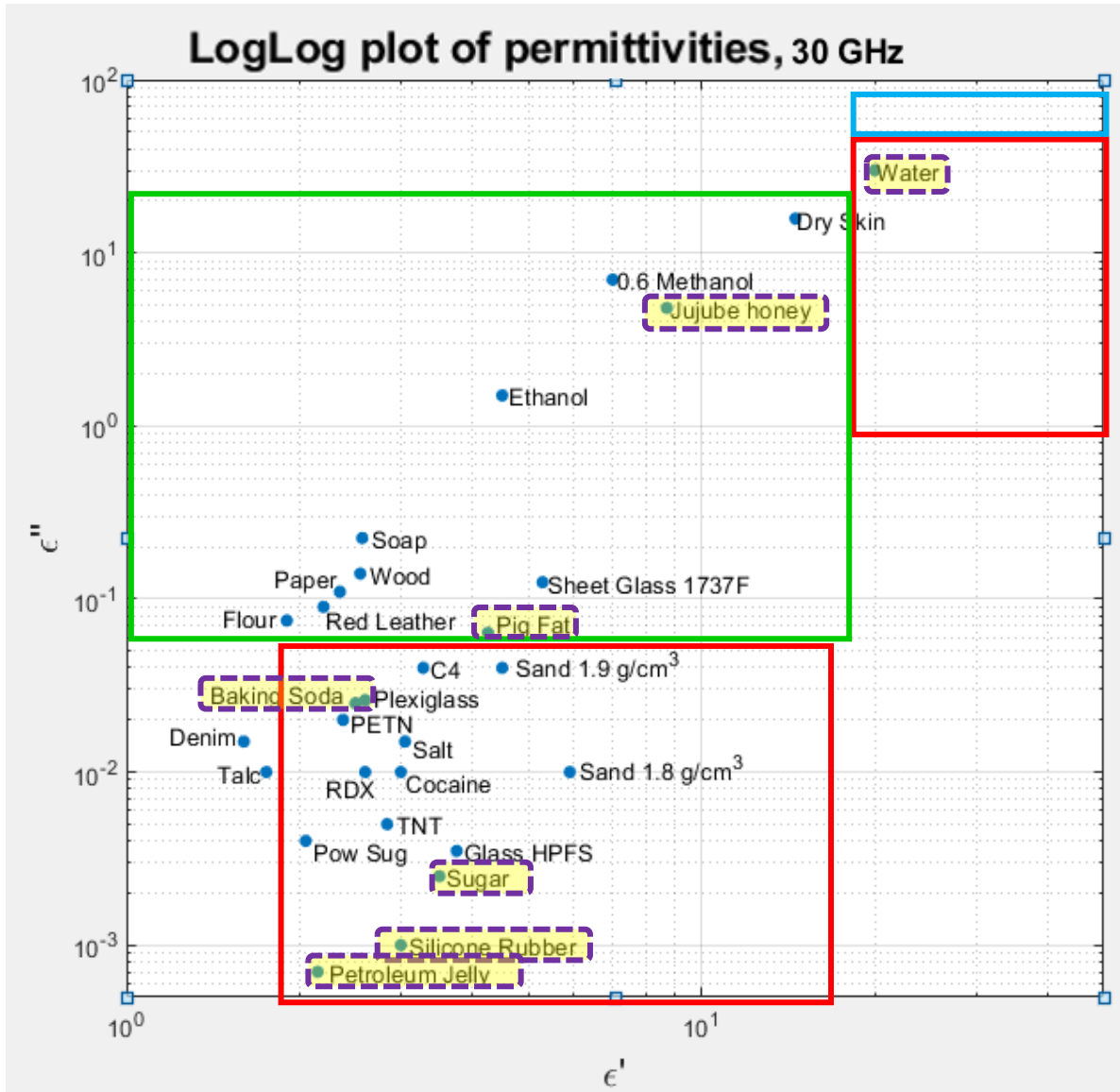


Top Level Summary

- Autonomous -> Automatic Decision (Screening at Speed: “Seamless and Integrated”)
- Faster thruput, fewer pat downs, increase effectiveness, improve passenger experience
- Characterize foreign objects to rule out benigns
 - Create and process images to highlight differences from nominal body
 - Use quantify differences to derive dielectric constant and conductivity
- Scoring must include “can’t decide” (yellow) declaration
- Explanation of possible failures
- Further work needed



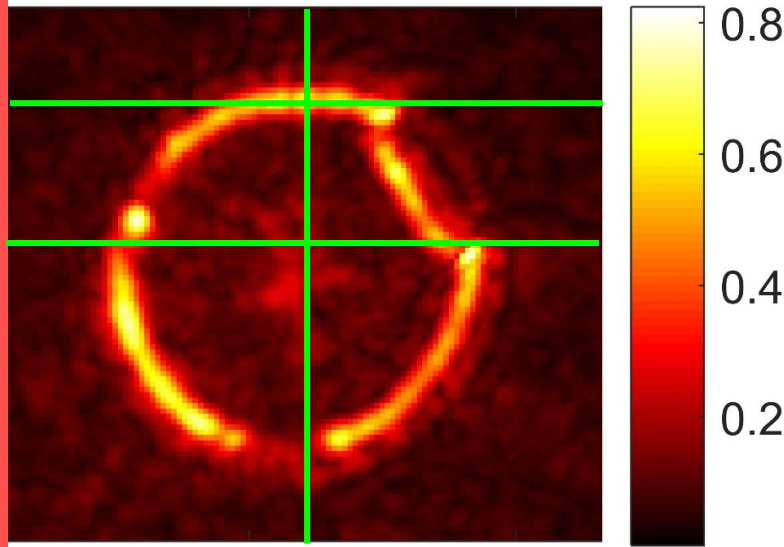
Plots of Permittivities at 10 and 30 GHz



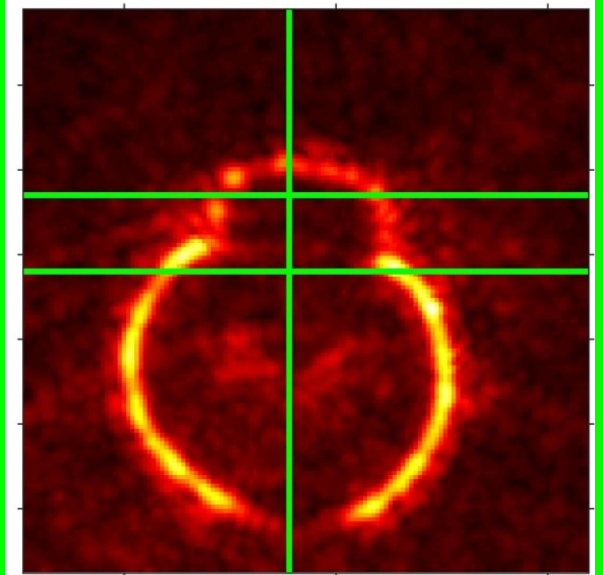


Characteristic Cross Section Images for Various Materials

20x5x2 cm
Petroleum Jelly
rectangle
on right calf

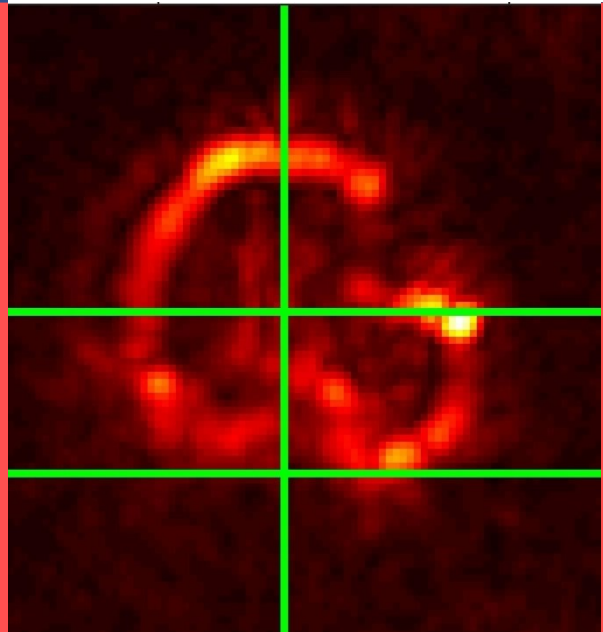


20x10x4 cm
Honey rectangle
on knee

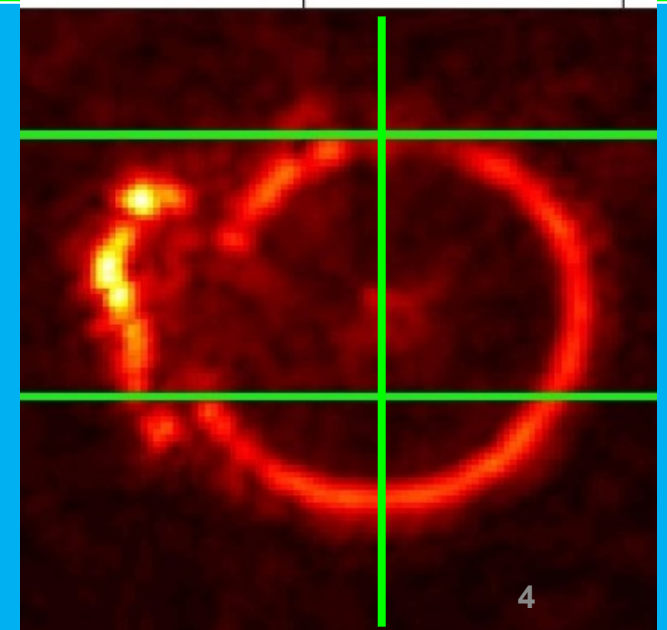


Facing Front

20x3.5x3.5 cm
cylinder Dish Soap
on right forearm

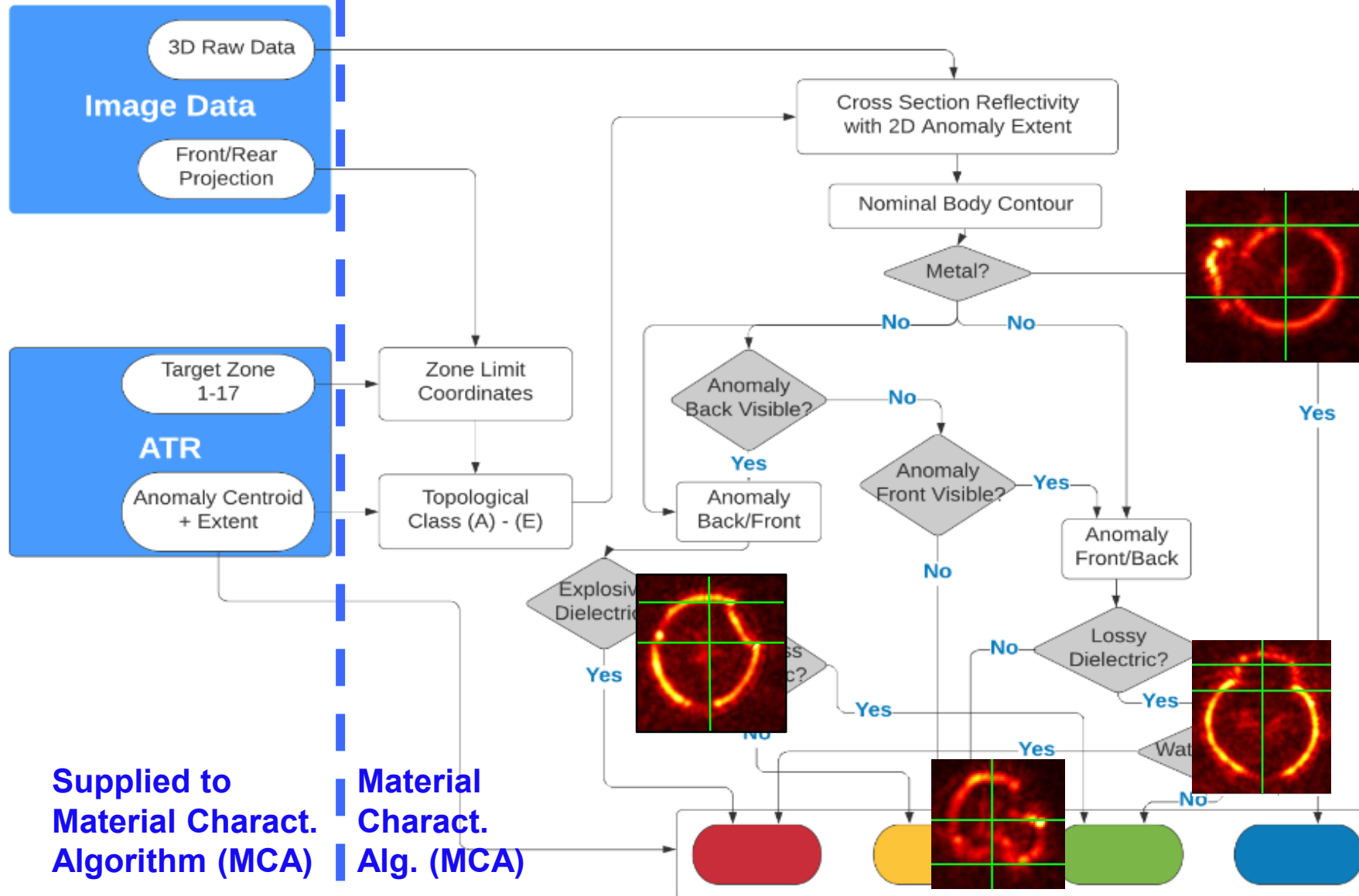


18x12x3 cm Gun
on left calf





Interface and Process Flow Chart



Supplied to
Material Charact.
Algorithm (MCA)

Material
Charact.
Alg. (MCA)



Scoring Description

- Report ground truth and declaration
 - True Positive (TP): Explosive/Metal/Water-Based Actual and Declared
(red/blue) -> (red/blue)
 - Miss (M): Explosive/Metal/Water-Based Actual, Declared Benign
(red/blue) -> (green)
 - False Alarm (FA): Benign Actual, Declared Explosive/Metal/Water-Based
(green) -> (red/blue)
 - True Negative (TN): Benign Actual, Declared Benign
(green) -> (green)
- Weighting applied to enhance penalty for Misses (w_M) and False Alarm (w_{FA})



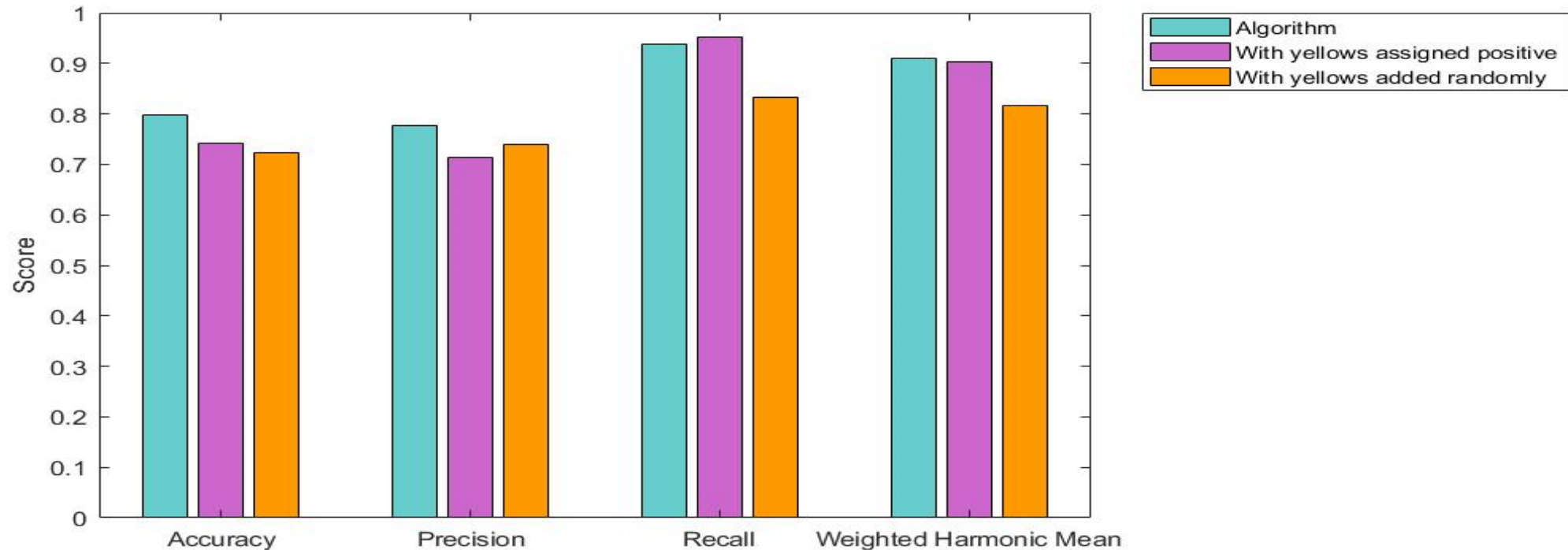
What Does Yellow Mean?

1. Bad data was delivered to MCA by Sensor/ATR
 - a) Sensor unable to detect accurately entire anomaly (bad imaging)
 - b) Incorrect anomaly declaration (confusion with body surface, challenging anomaly configuration)
 - c) Bad position information (anomaly position hard to determine)
2. Algorithm produces non-physical results
3. Algorithm produces conflicting results
 - a) Second opinion for conservative declarations disagree with primary
 - b) Associated features of particular cases not prominent enough
4. Thresholds for benign declaration set too high



Algorithm Scoring for Three Yellow Scenarios

	No yellows (N = 79)	Yellows assigned red- positive (N = 105)	Yellows assigned randomly (N = 105)
Accuracy	0.80	0.74	0.72
Precision	0.78	0.71	0.74
Recall	0.94	0.95	0.83
Weighted Harmonic Mean	0.91	0.90	0.82





Explanation of Possible Failures

- Benign cases not fully representative
 - Limited cases of benign materials tested
- Human ATR is imperfect
 - Identifying anomaly targets from reconstructed images is hard (even for human)
- Advanced Imaging Technology (AIT) sensor is good but not perfect
 - Image gaps
 - Inclined body surfaces have weaker reconstructed images
- Body Zone mapping is hard to generalize
- Conservative declaration avoids misses, but leads to more yellows



Further work

- Identify functional problems, repair deficiencies
- Examine misses and false alarms to understand their causes
- Wish list of new material scans
 - Consider cases once they are measured
 - Adapt algorithm/software to optimally declare for new cases
- Incorporate AI in threshold specification