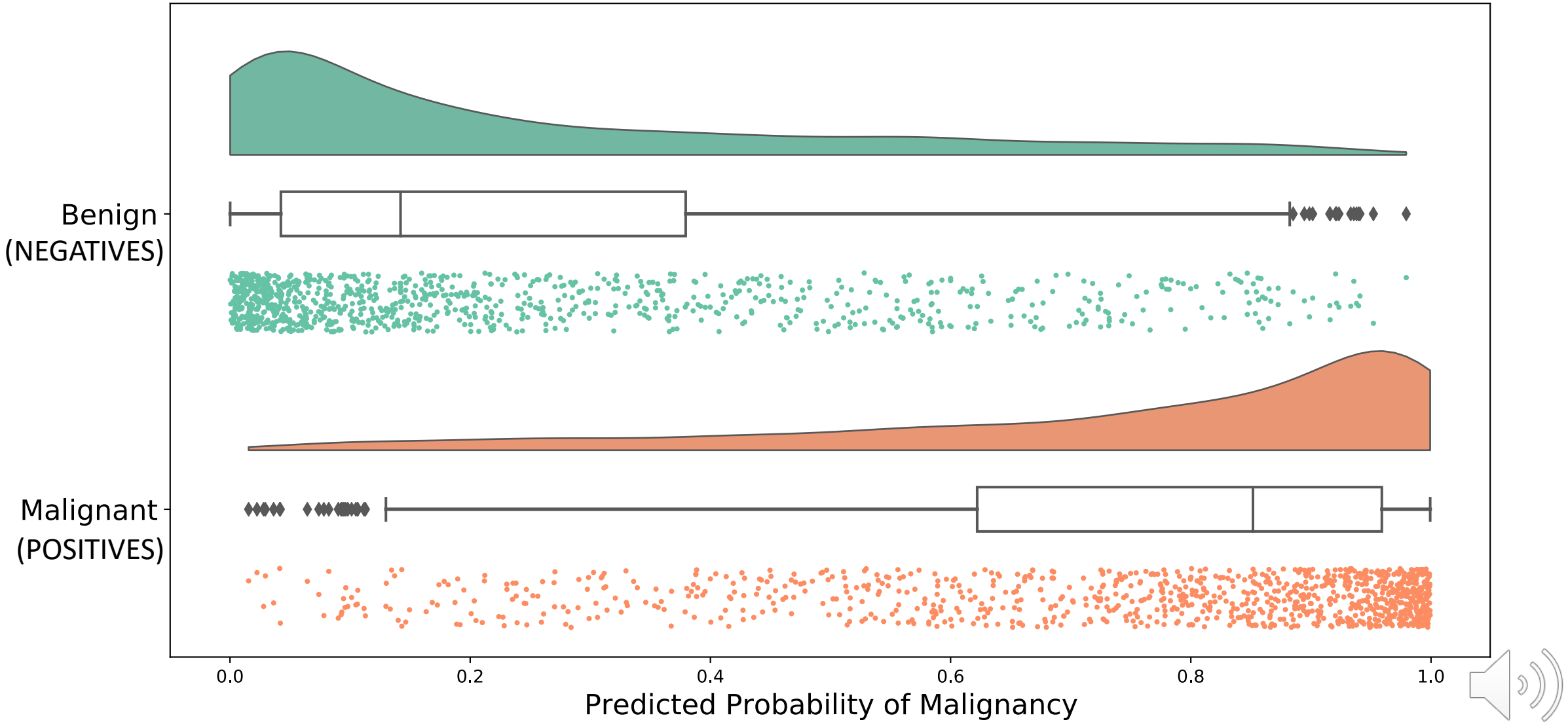
# Performance Measures

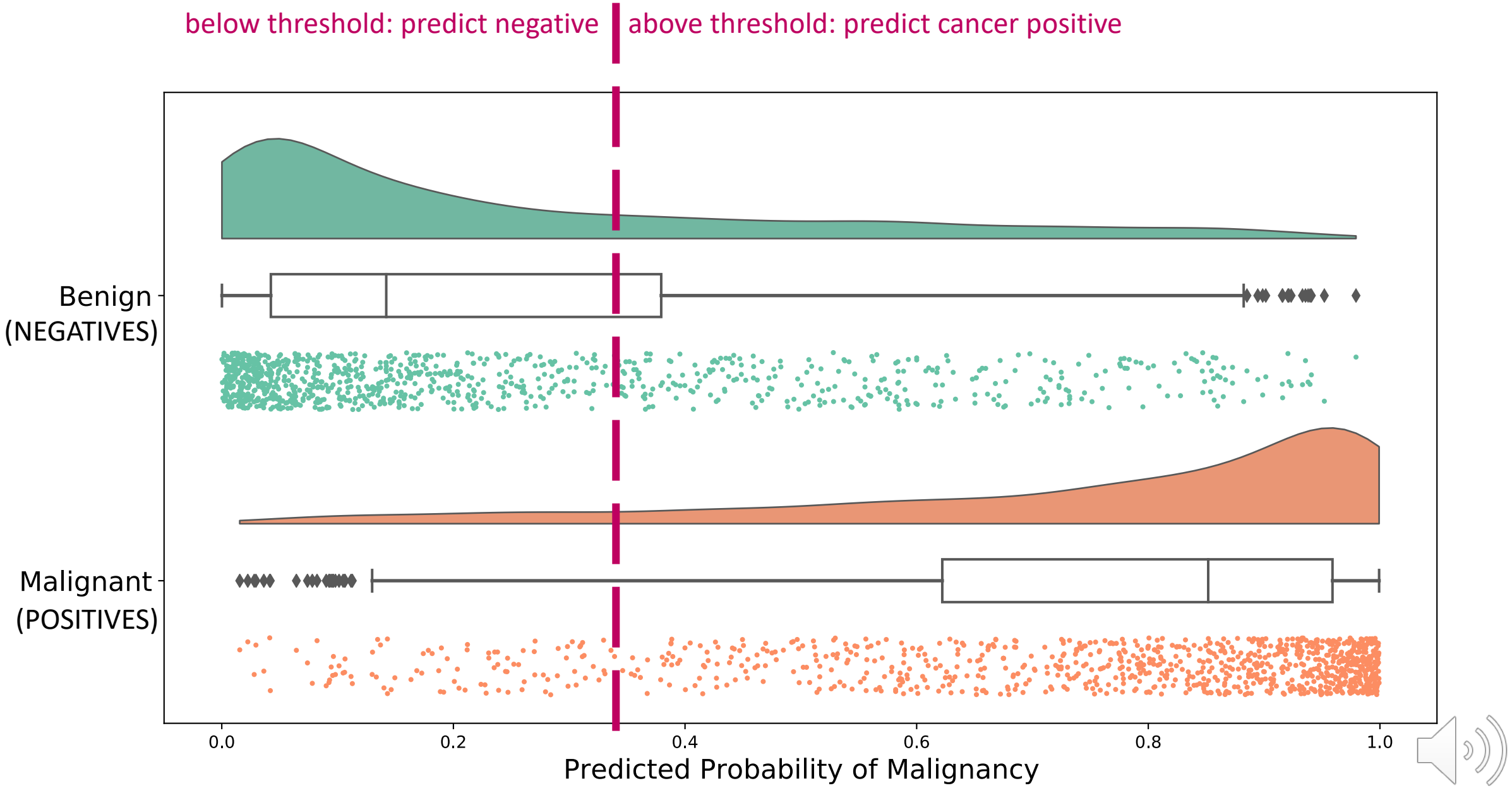
Matthew Engelhard

# Goals

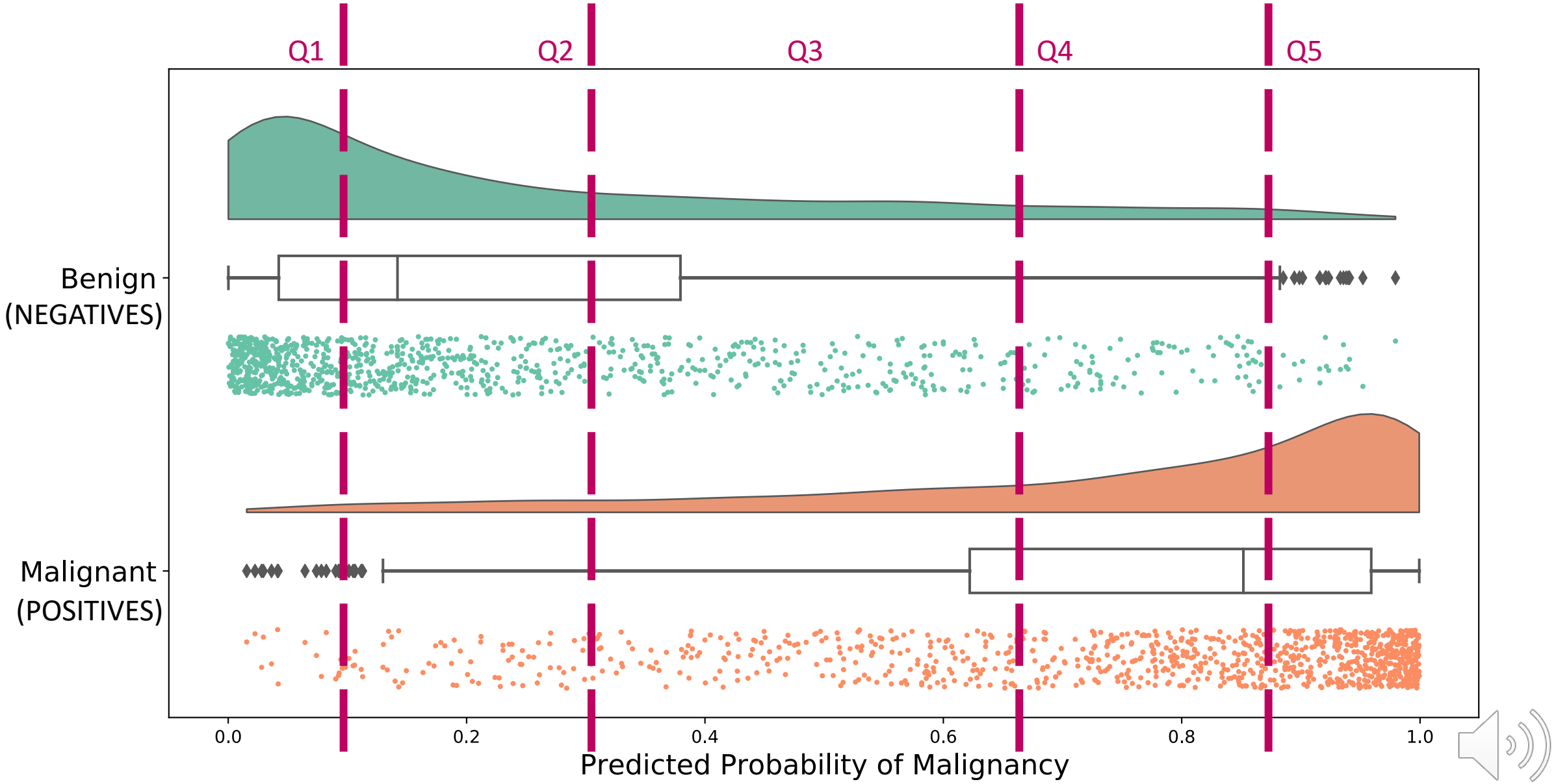
- Understand common performance measures for binary classification
- Recognize that which measure(s) are most appropriate depends on the application
- Run through a few different clinical scenarios
- Touch on metrics for problems other than binary classification

# Let’s go back to cancer prediction




below threshold: predict negative
above threshold: predict cancer positive
Benign
(NEGATIVES)
Malignant
(POSITIVES)
0.0
0.2
0.4
0.6
0.8
1.0
Predicted Probability of Malignancy

# Assess Calibration Graphically



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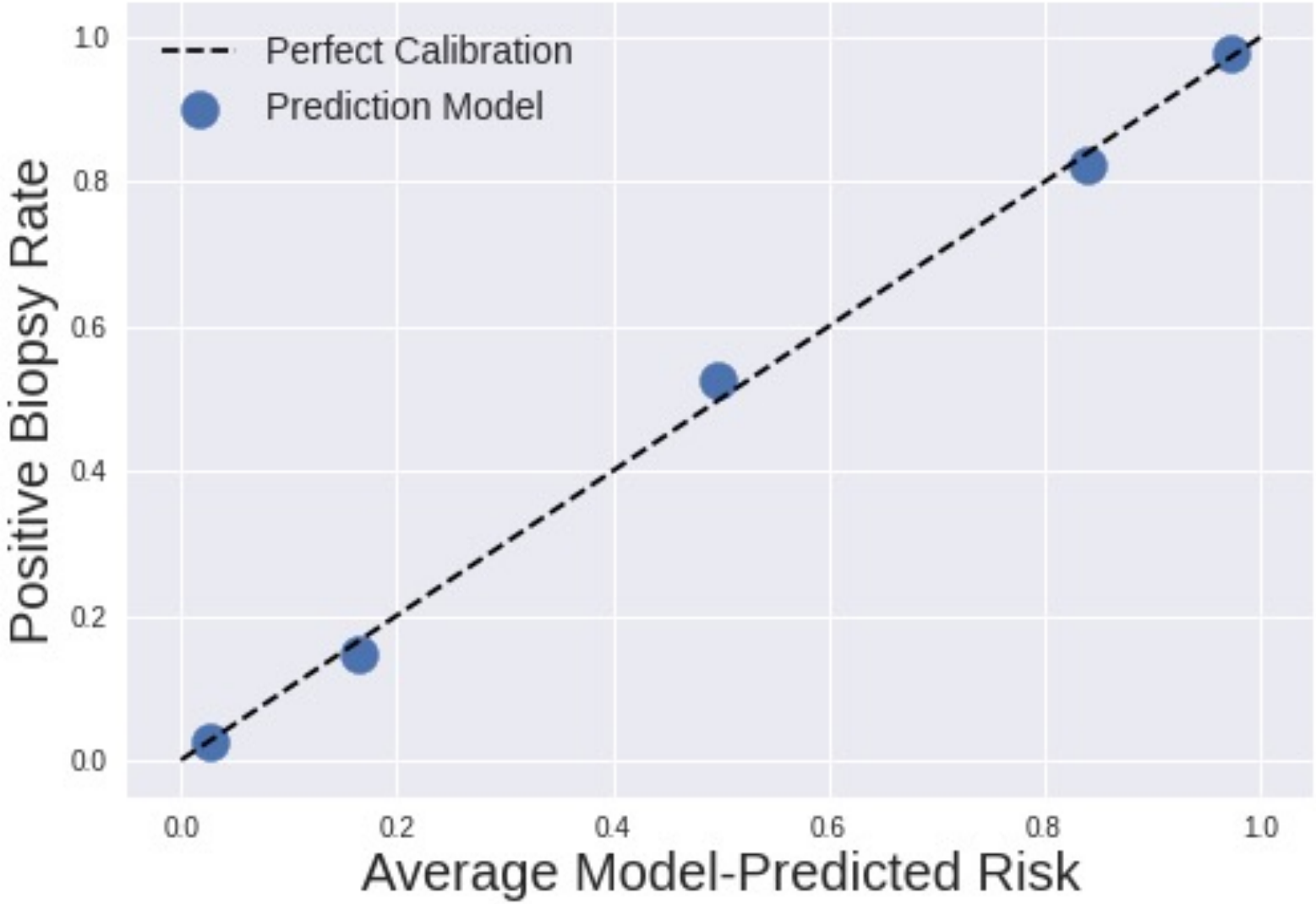

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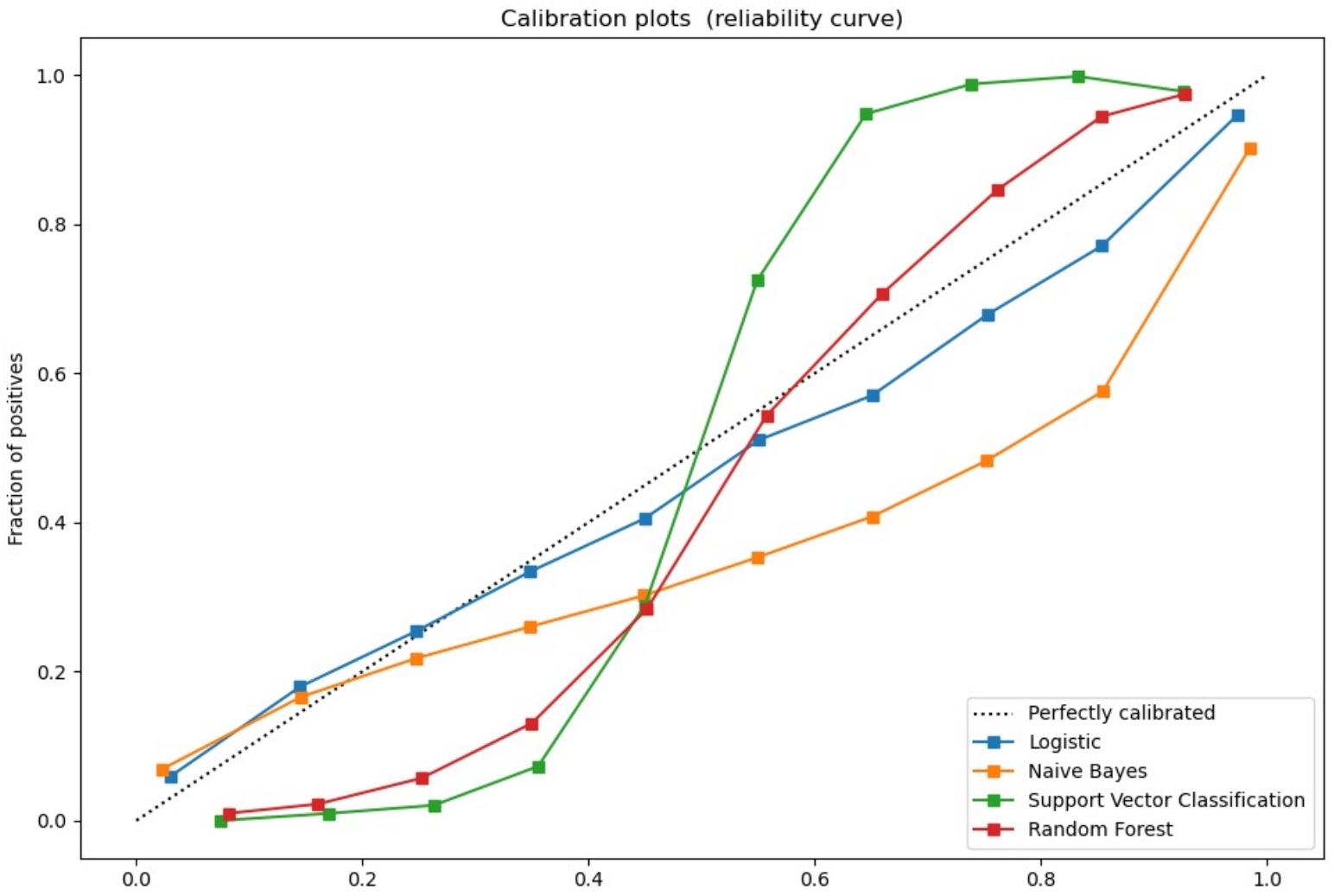
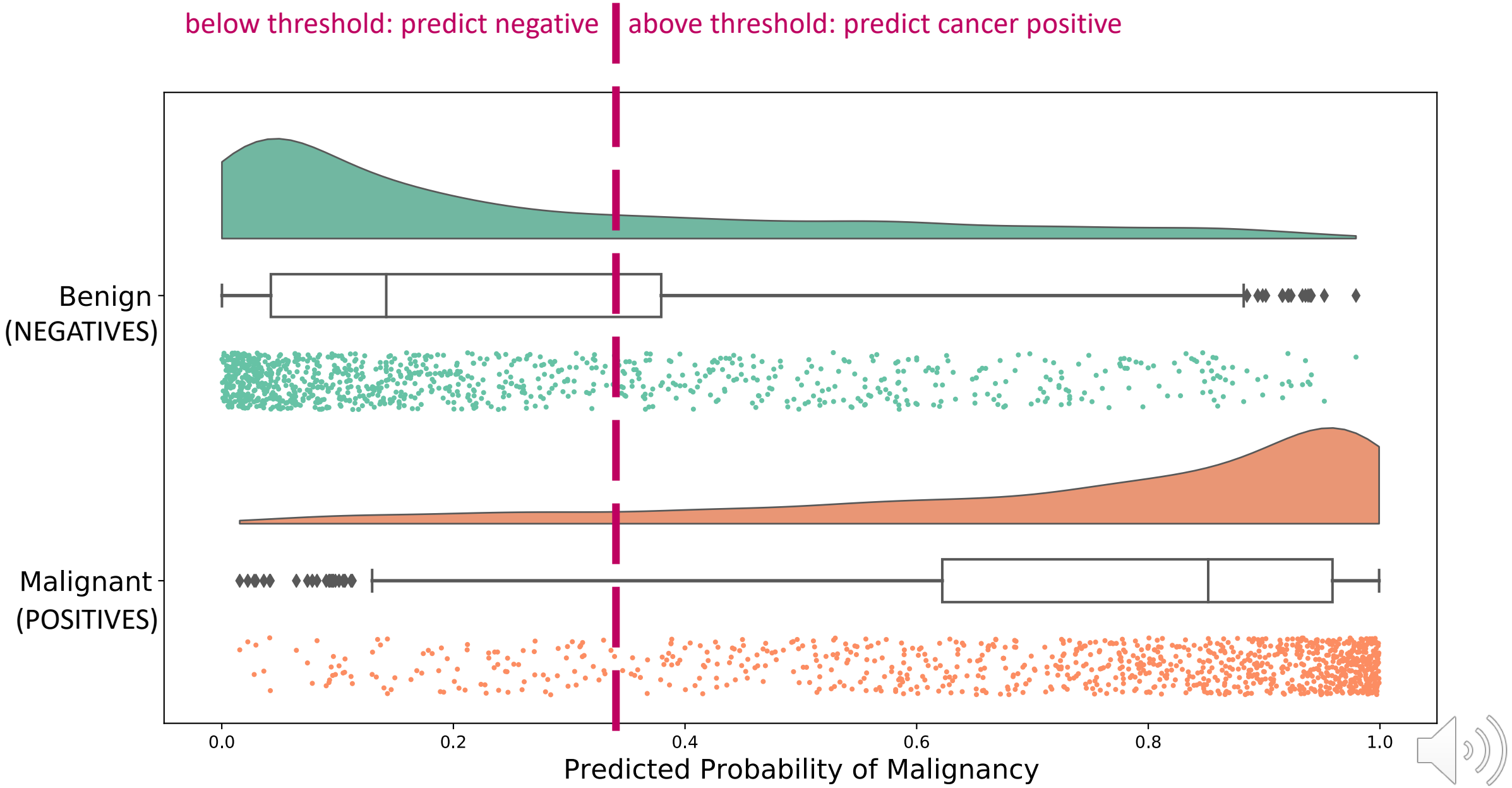



Model-Predicted Risk

From: https://scikit-learn.org/stable/modules/calibration.html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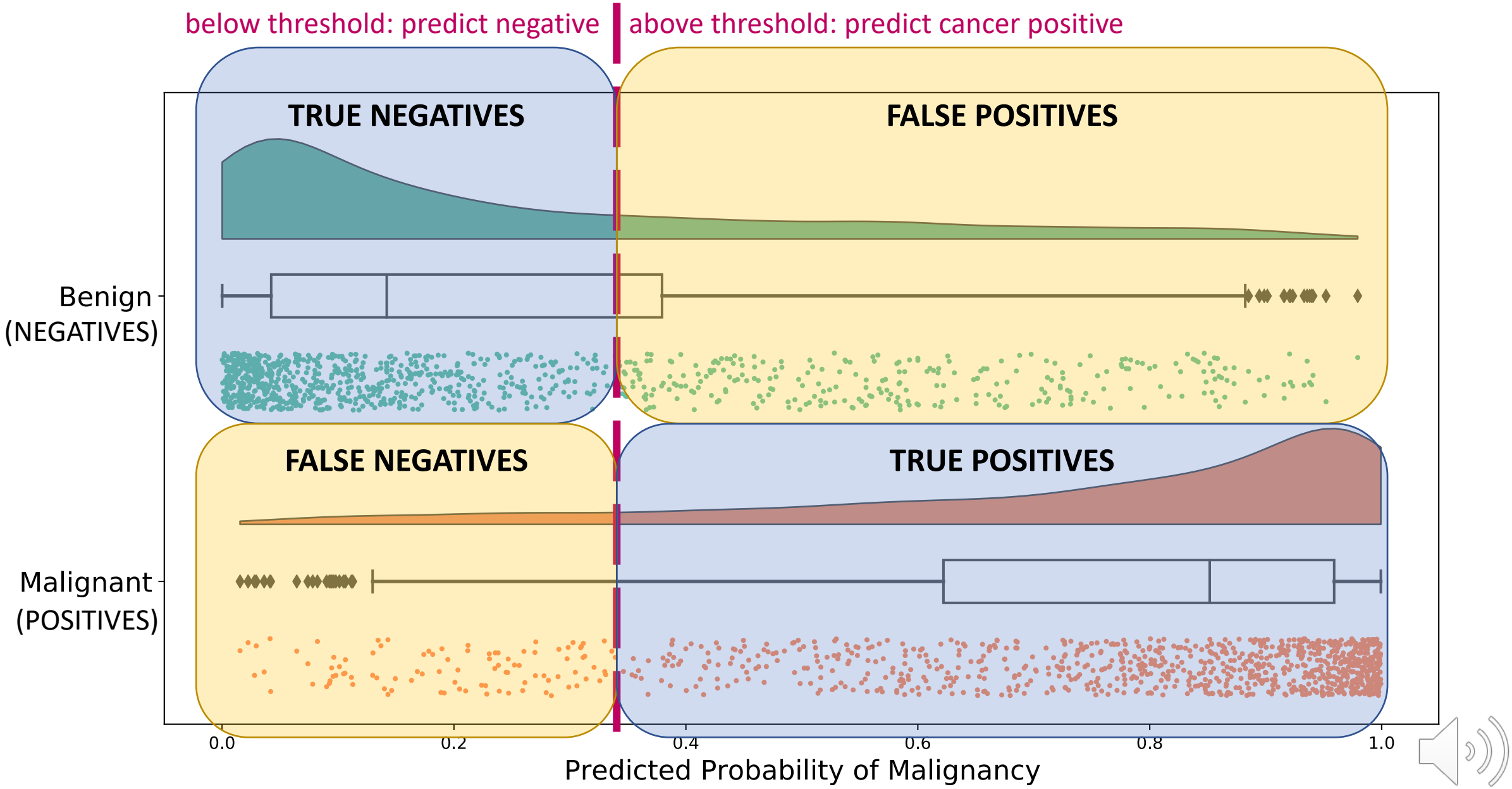
below threshold: predict negative
above threshold: predict cancer positive
TRUE NEGATIVES
FALSE POSITIVES
FALSE NEGATIVES
TRUE POSITIVES
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(NEGATIVES)
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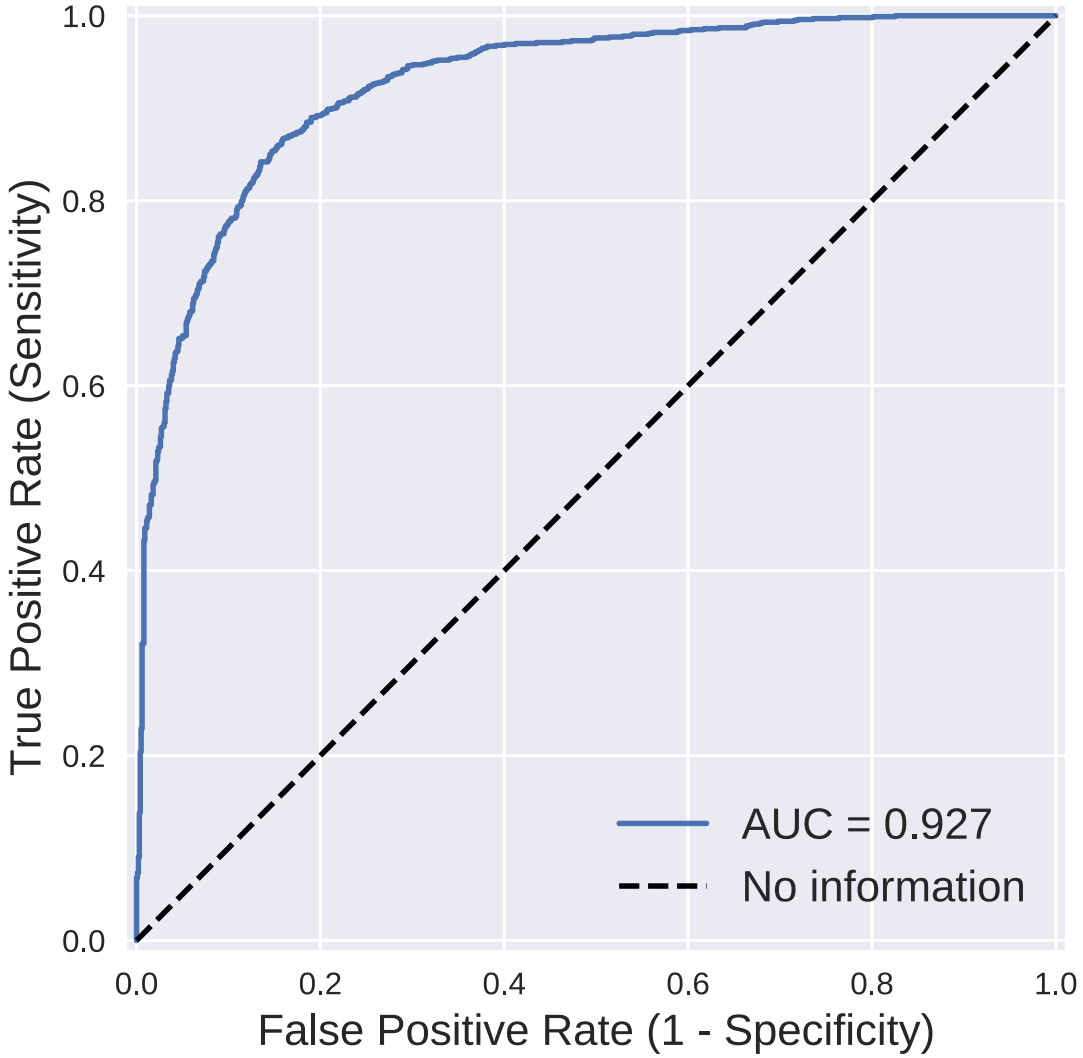
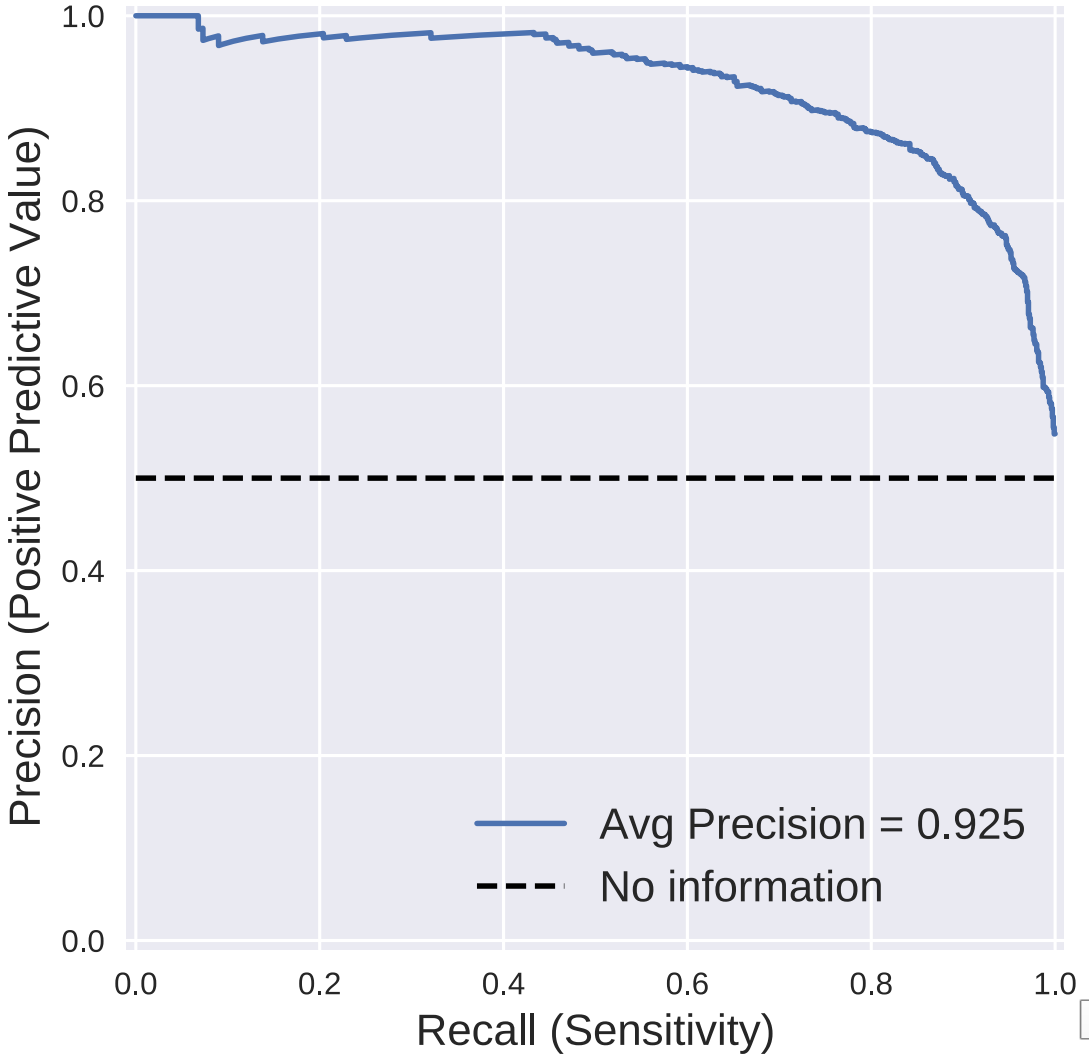
Predicted Probability of Malignancy

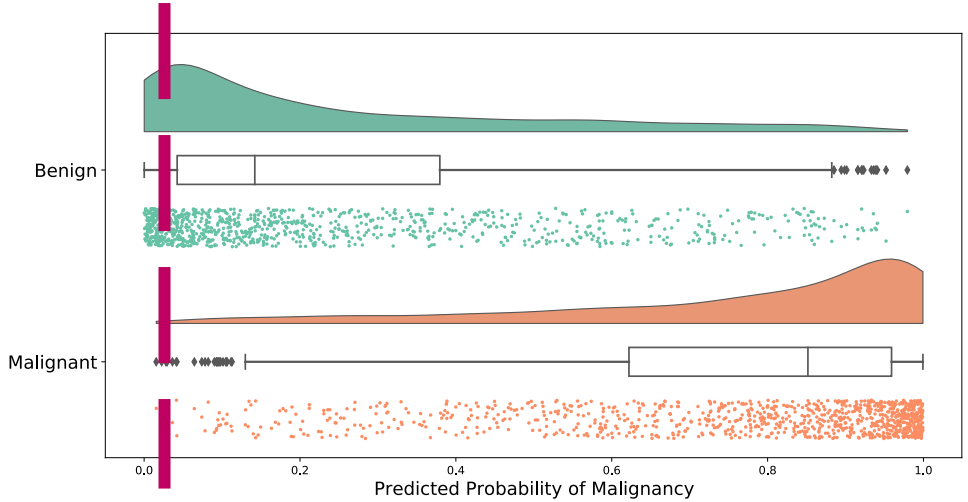
# ROC versus PR curve: two different tradeoffs

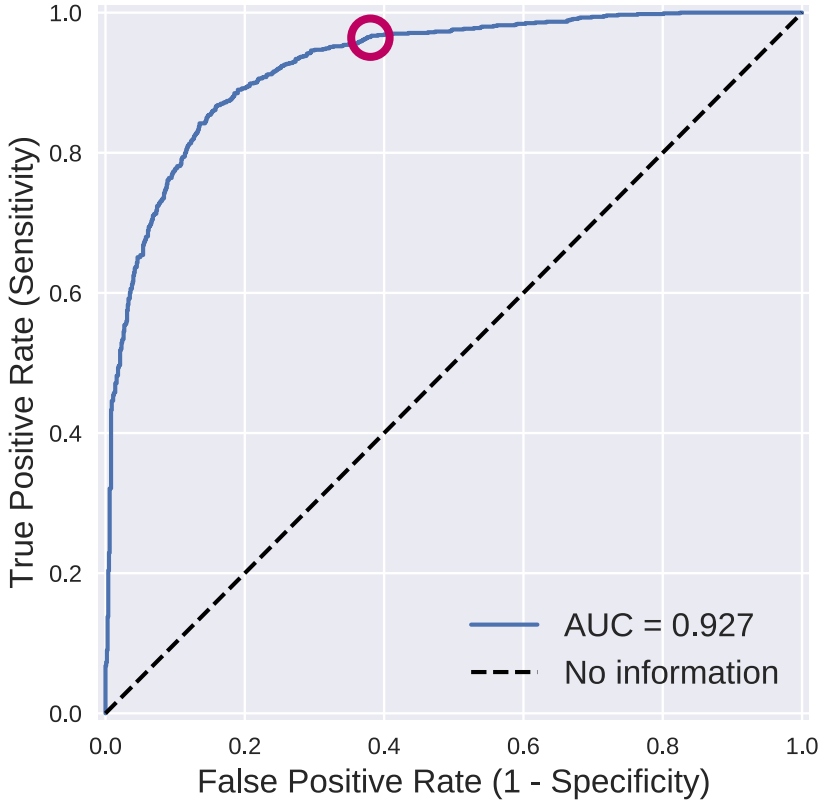


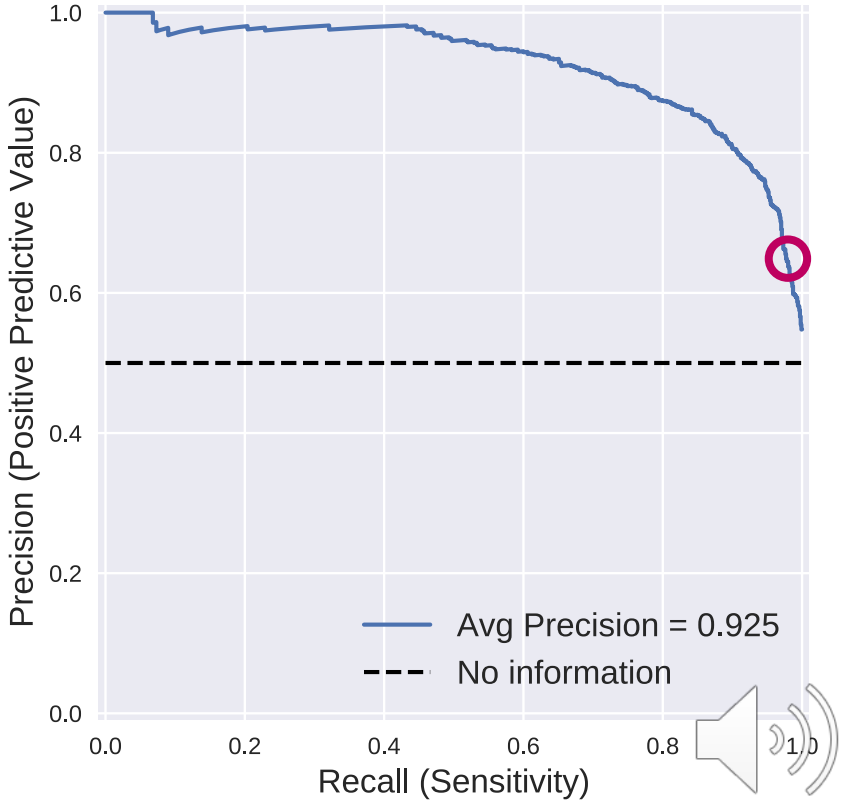



# Operating Point:

*high sensitivity*

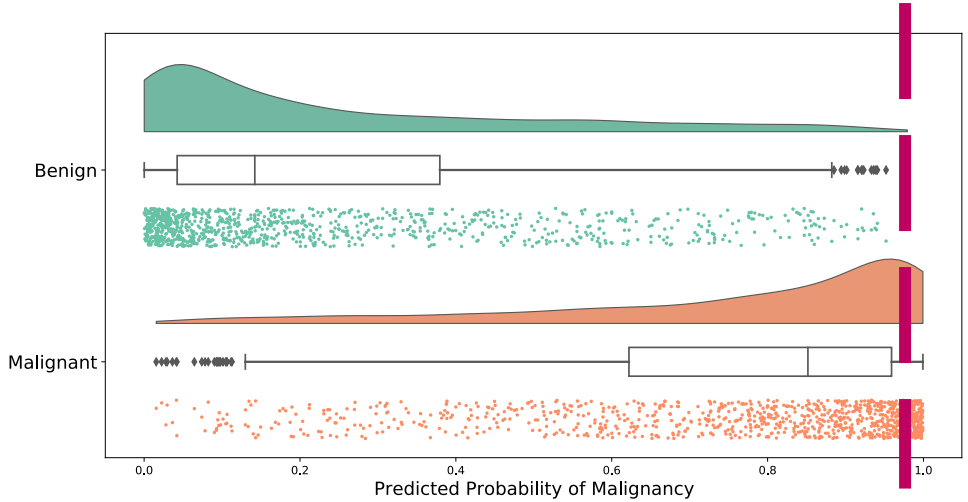


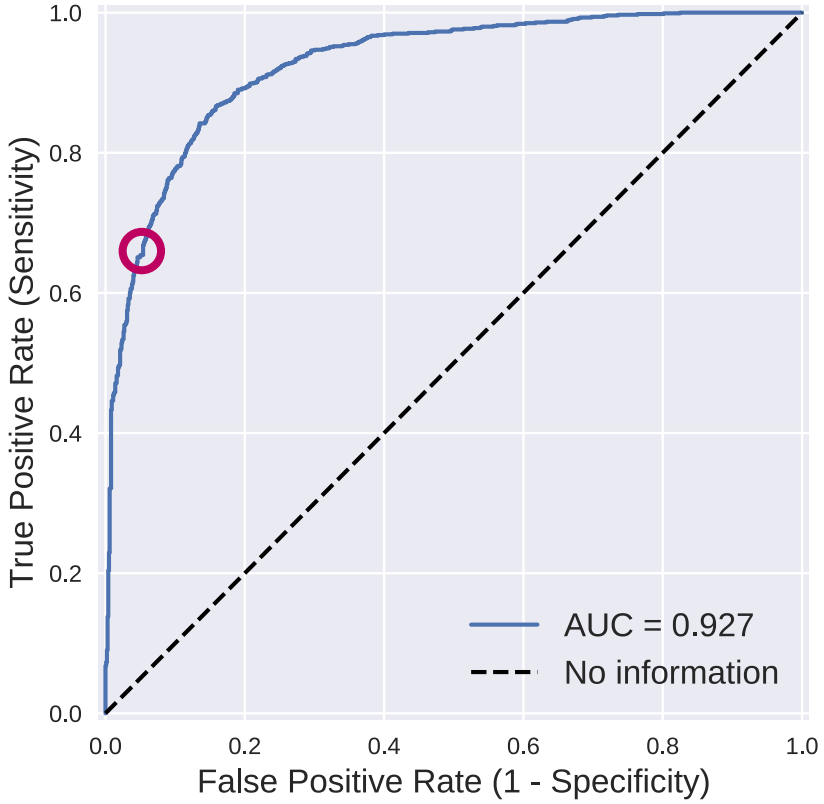



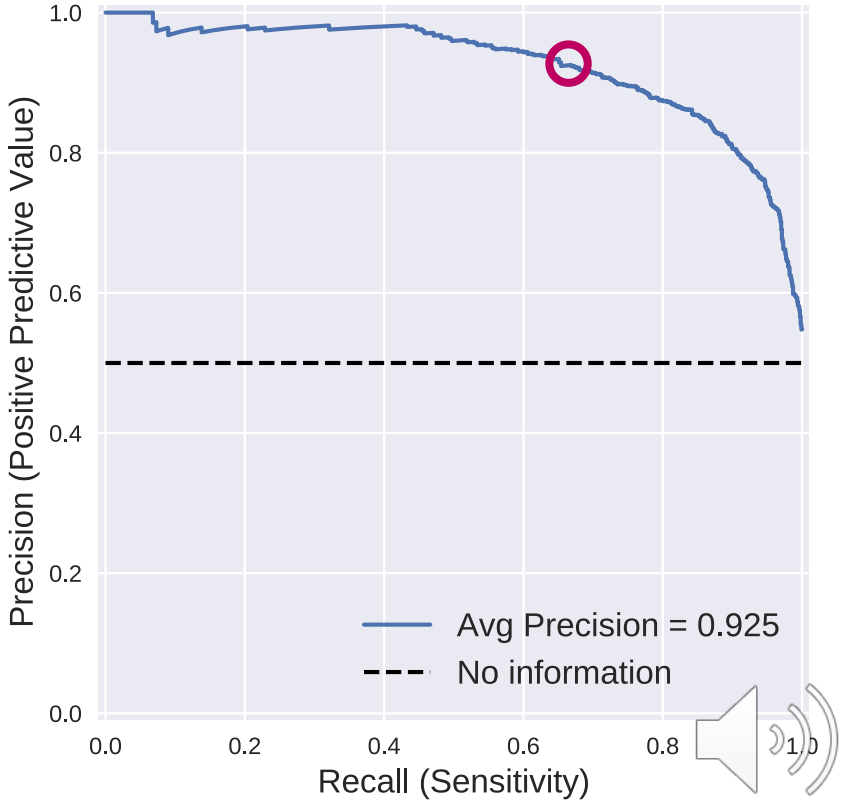



# Operating Point:

*high specificity*

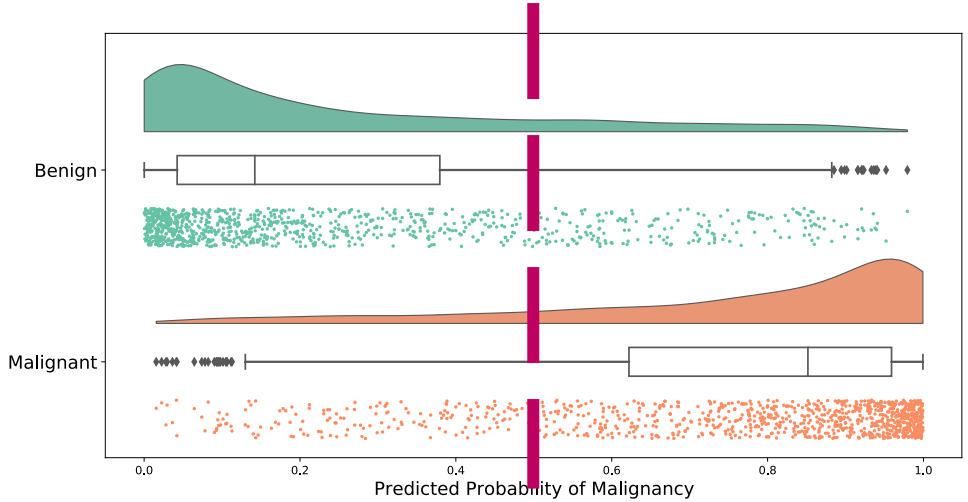


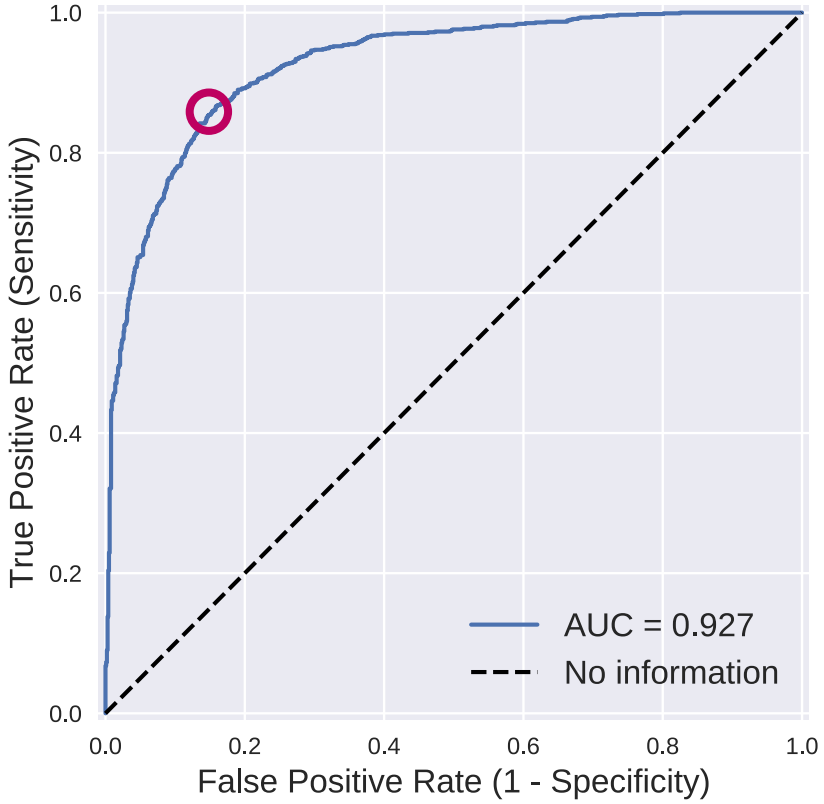



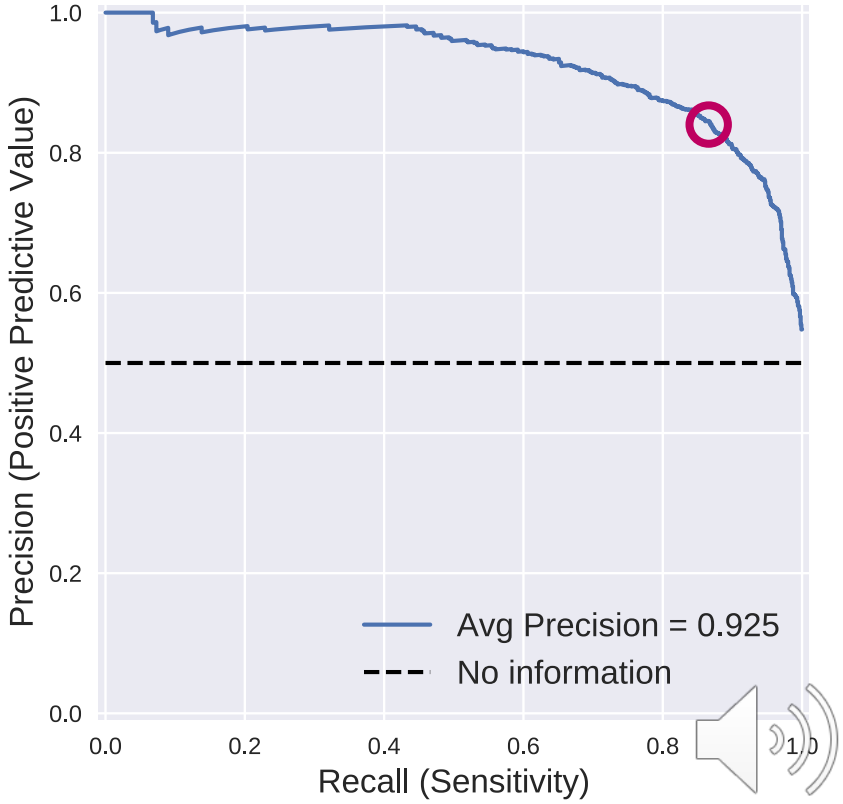



# Operating Point:

*balanced*



# Healthcare Scenarios

1. A computer vision model that detects carcinoma

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2. An EHR-based model that surveils autism risk

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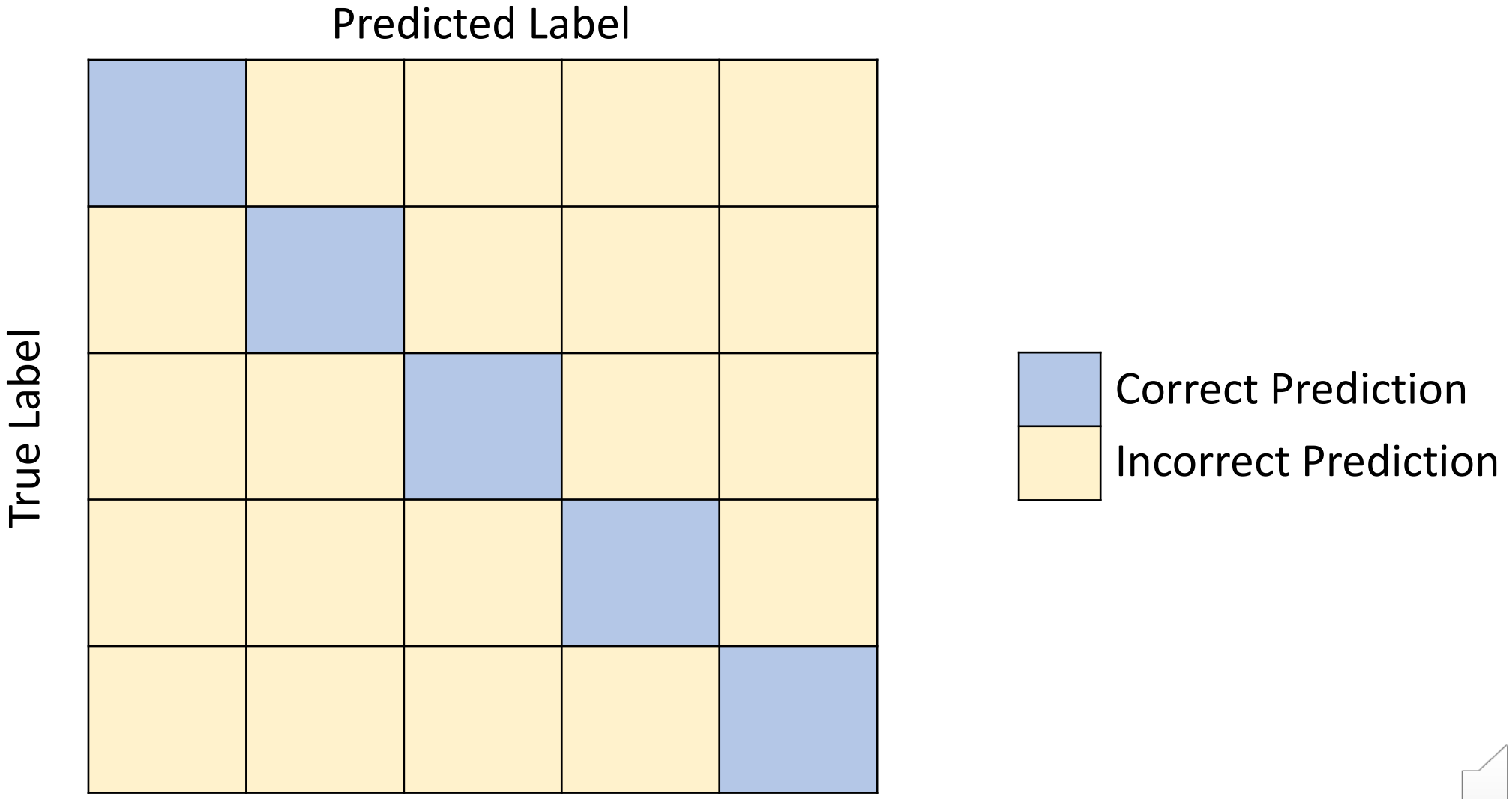
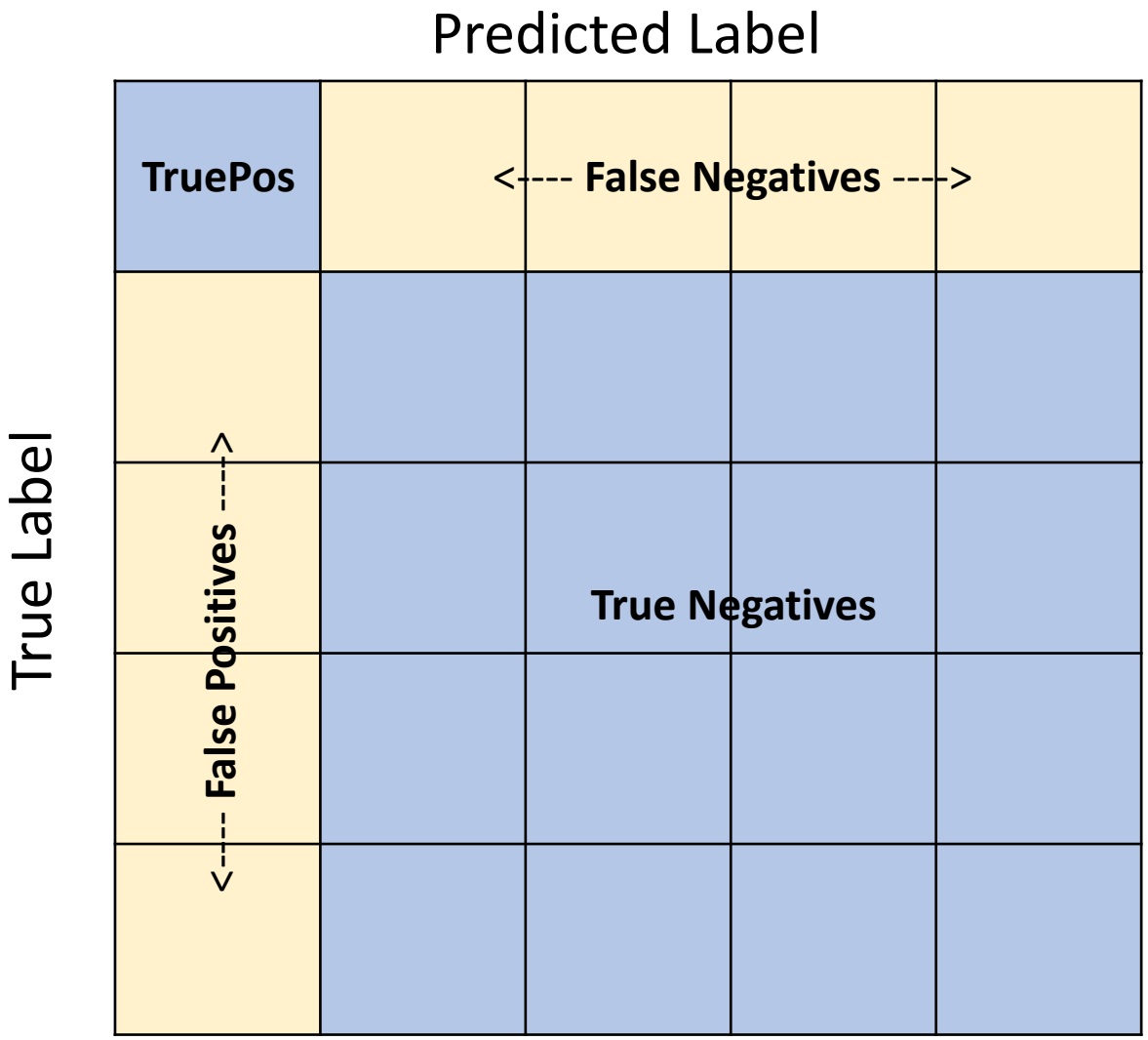
1. A computer vision model that detects carcinoma
2. An EHR-based model that surveils autism risk
3. An algorithm that detects COVID in Apple watch users
4. An NLP model that identifies urgent text messages received through a maternal health platform with 2 million users

# Multi-class problems: “Confusion Matrix”



# Multi-class problems: Binary for Label 1

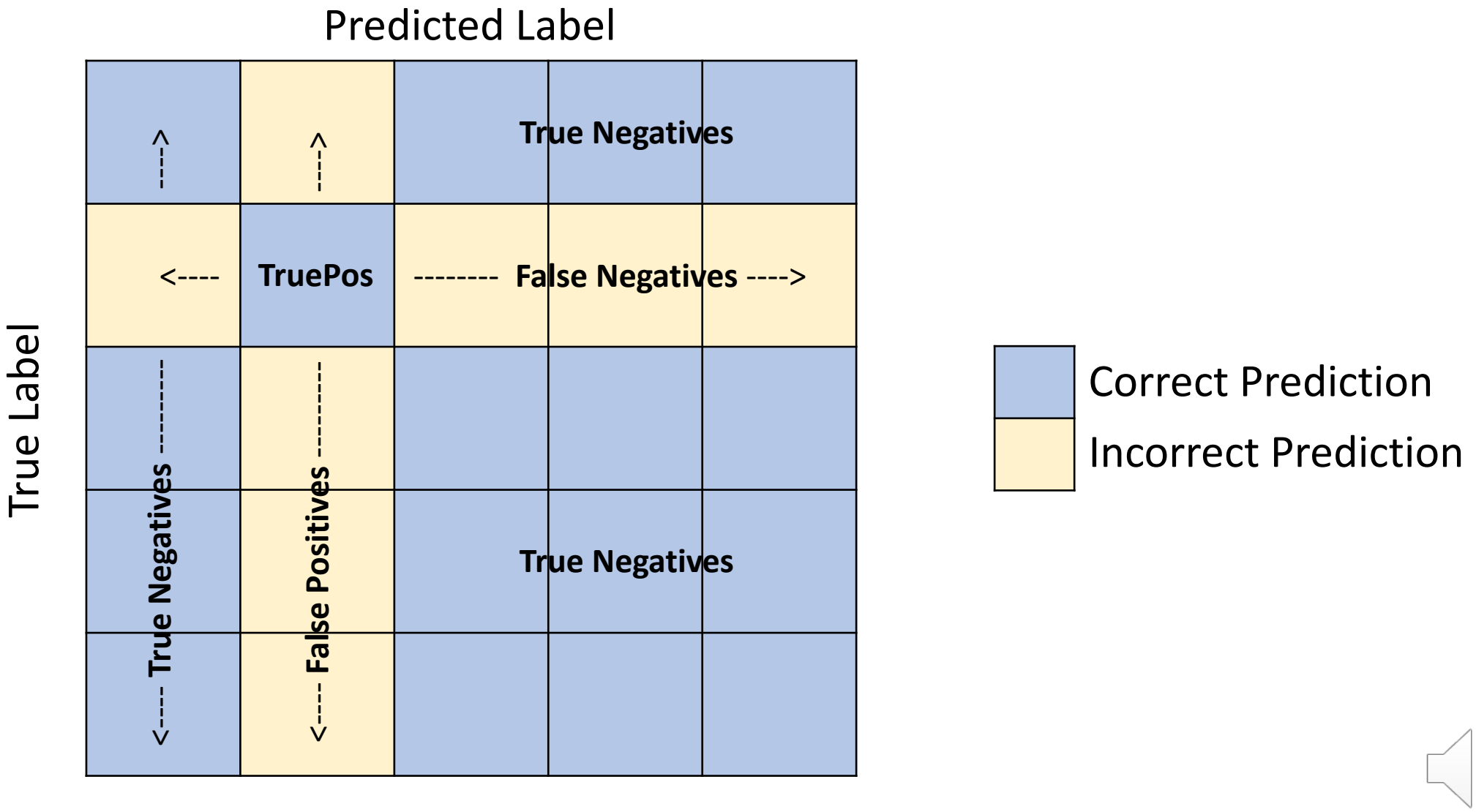



False Pos

Correct Prediction

Incorrect Prediction

# Multi-class problems: Binary for Label 2



# There are many more, of course, but classification metrics go a long way.

- Regression
  - Mean squared error (MSE)
  - Mean absolute error (MAE)
  - $R^2$
- Survival Analysis (i.e. failure time)
  - Concordance index
  - MSE, MAE
  - Brier Score
  - $AUC_t$

# Summary

- Understanding performance measures is critical to make sure we're using models effectively, and when developing our own models

- Some performance measures for classification models measure the model's ability to discriminate positive from negative cases, whereas others measure whether model-predicted probabilities are *calibrated* to true event rates.

- The receiver operating characteristic curve and precision-recall curve describe two different but related tradeoffs that are important when selecting a decision threshold, or operating point.