

Classification of Rare Astrophysical Objects: From Galactic to Extragalactic

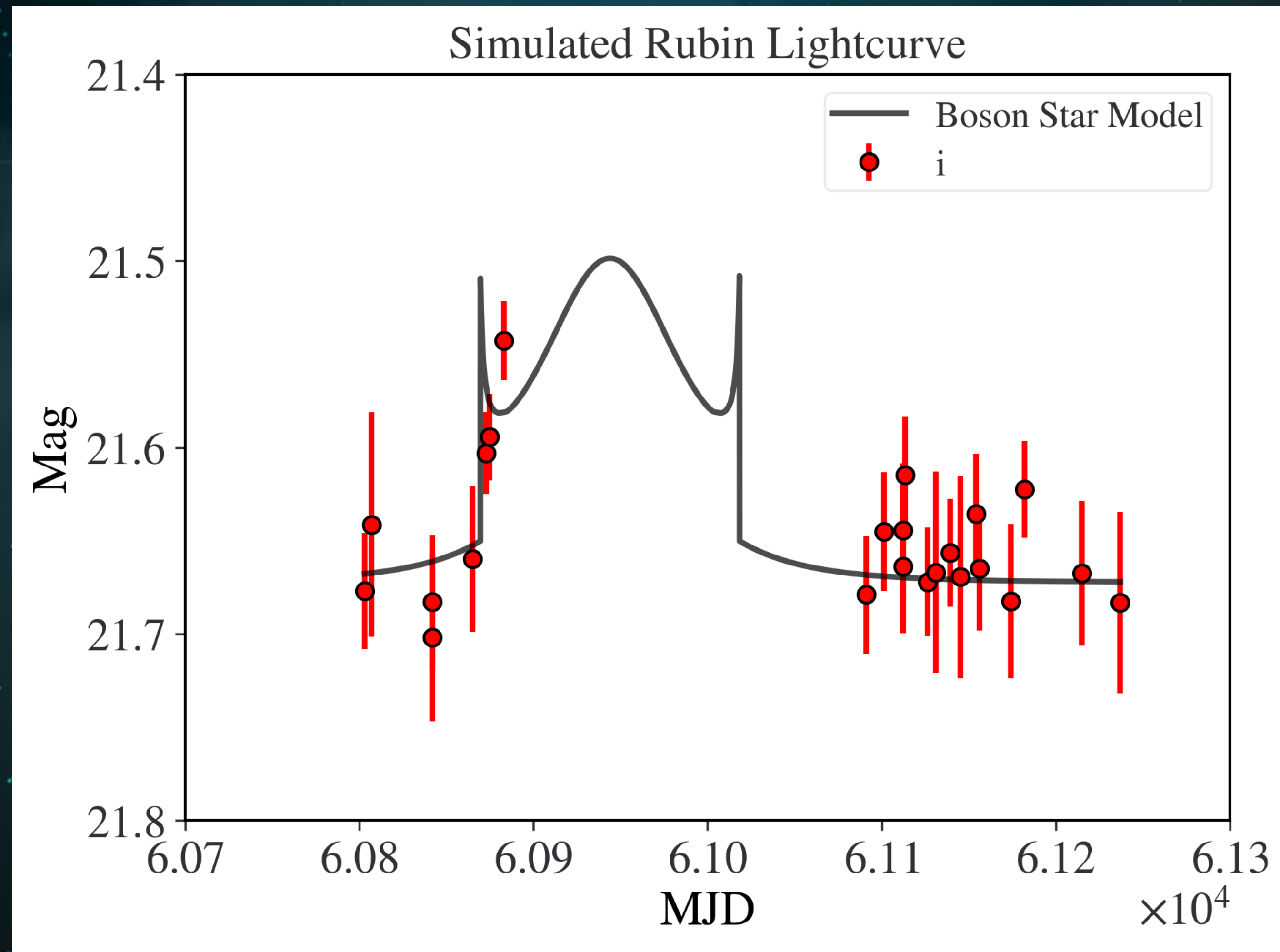
Daniel Godines

PhD Student

New Mexico State University



Low Cadence ($\sim 1-3 d^{-1}$) Makes Transient Classification Difficult



Lightcurve Features

von Neumann et al. (1941) — von Neumann Ratio

Stetson (1996) — Stetson variability indices

Shin et al. (2009) — Statistical measures of variability

**Richards et al. (2011); Wyrzykowski et al. (2015b);
Khakpash et al. (2021)** — Fit-based parameters

Price-Whelan et al. (2014) — Statistical thresholds

Kim & Bailer-Jones (2015) — *UPSILoN* Python Package

Christ et al. (2018) — *tsfresh* Python package

MicroL^A

Godines et al. (2019)



Rachel A. Street



Etienne Bachelet



Gautham Narayan

- **Calculates statistical features from lightcurves**
- **Trains and optimizes tree-based models**
- **Includes functionality to deploy trained models and show model performance & feature visualizations**
- **Implemented as a filter within the ANTARES, FINK, and Pitt-Google brokers**

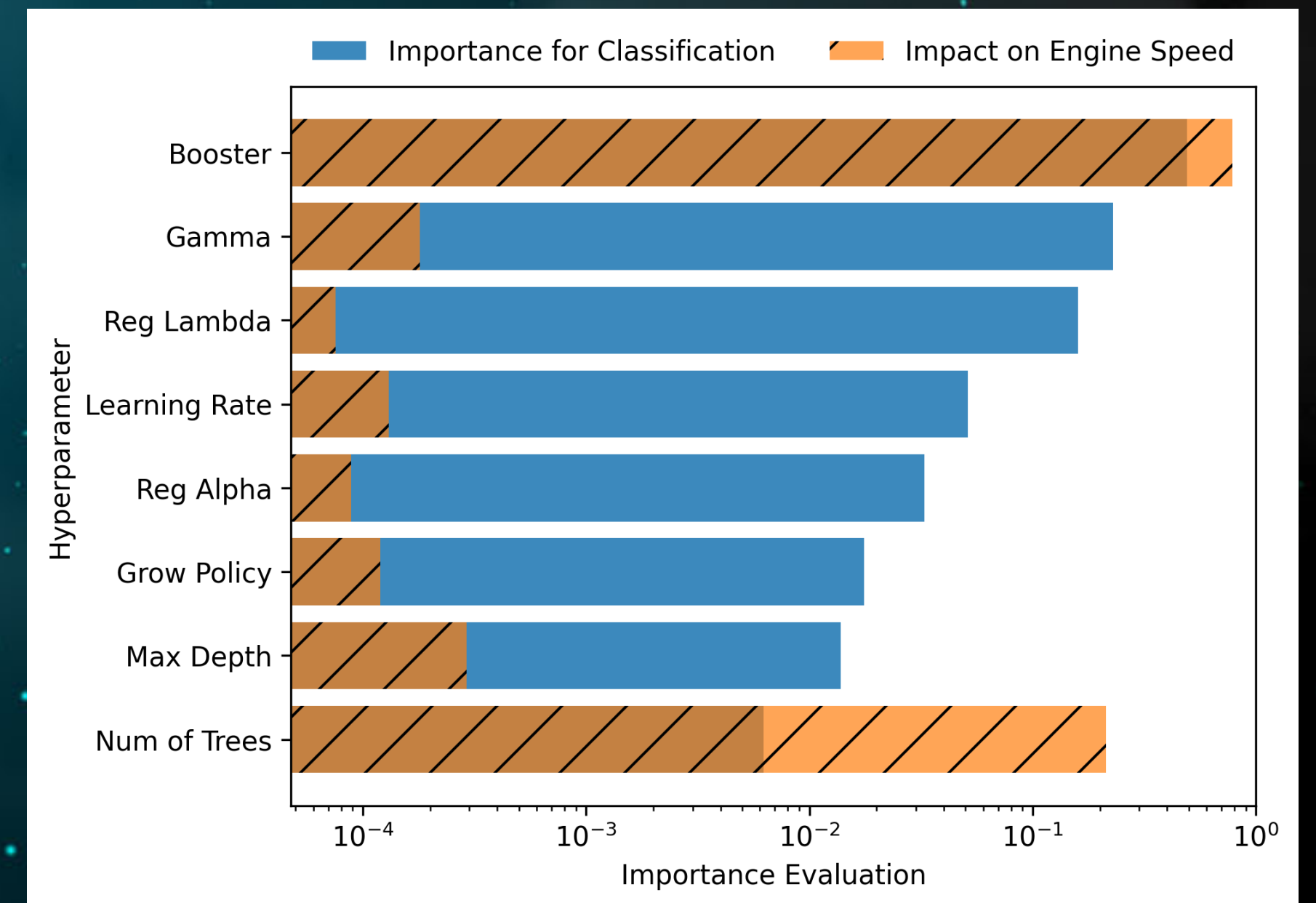
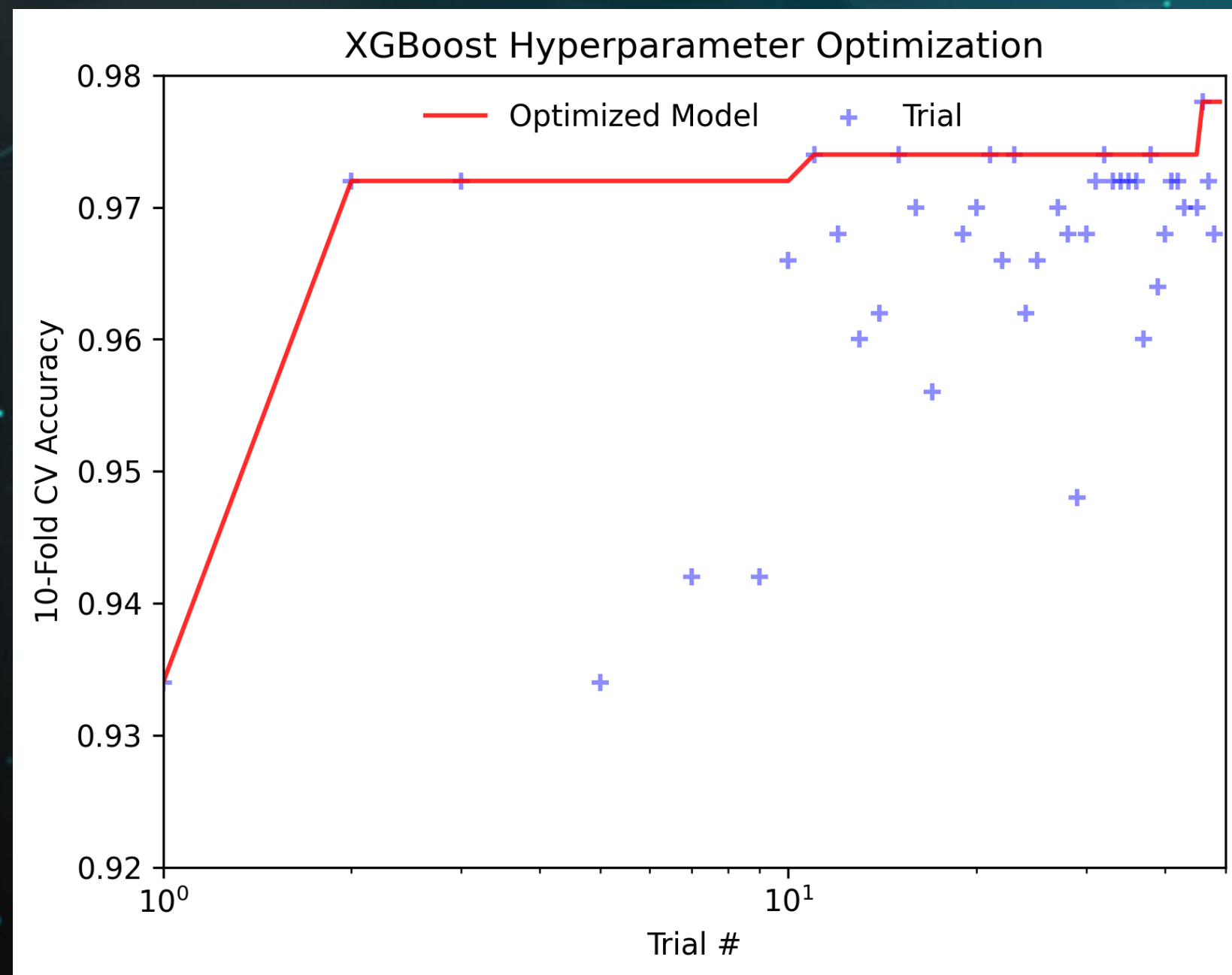
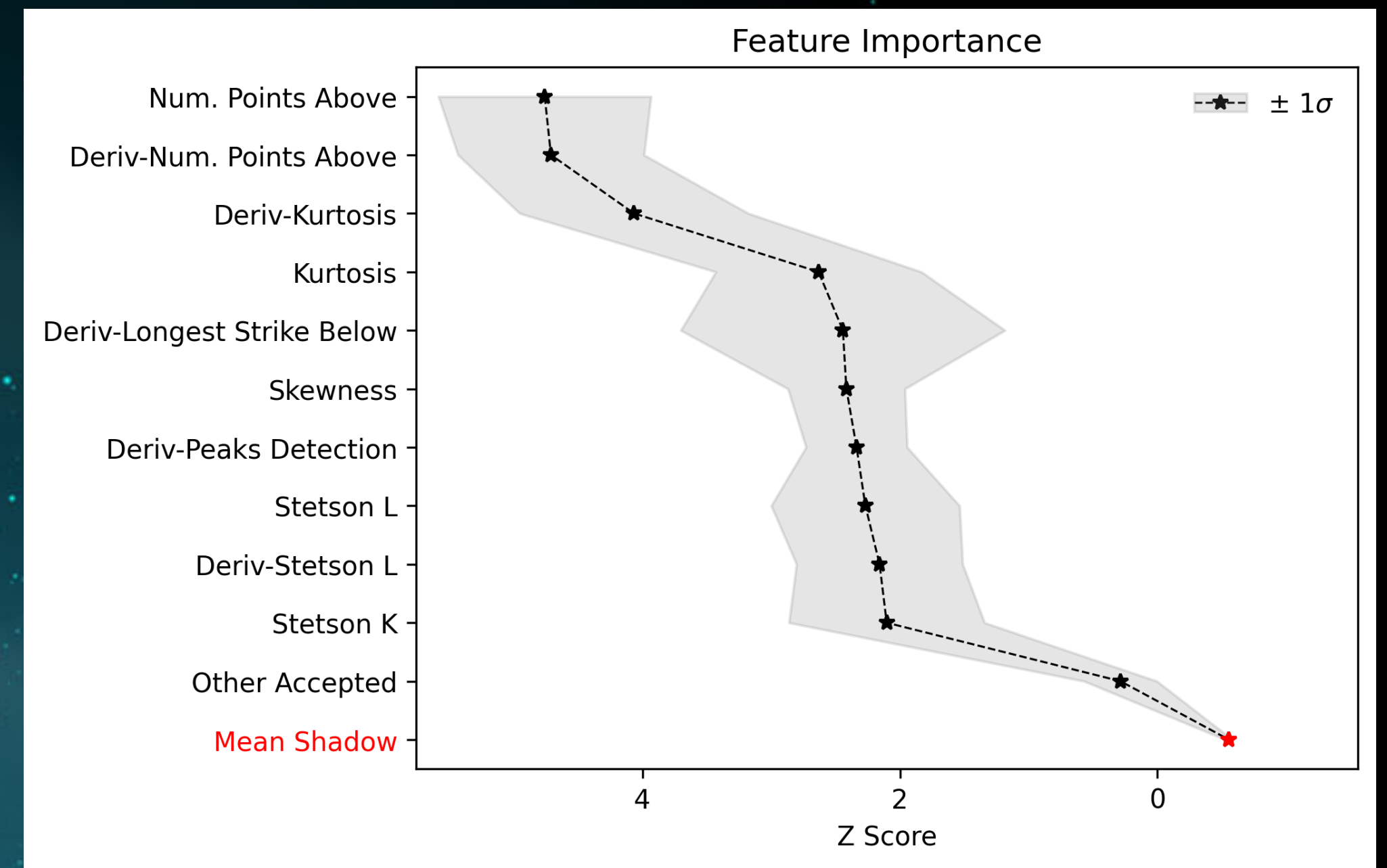
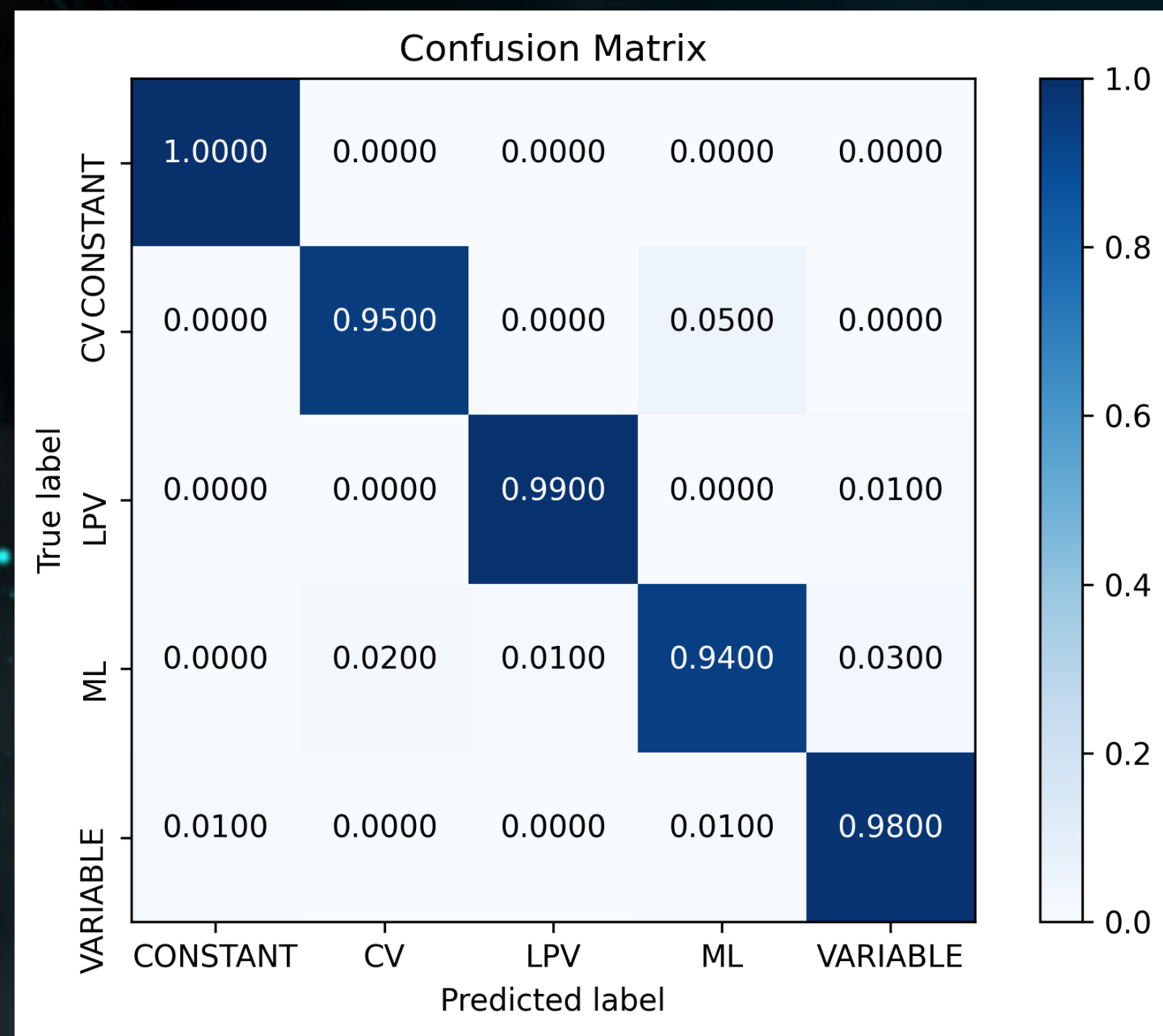
MicroLIA

Godines et al. (2019)

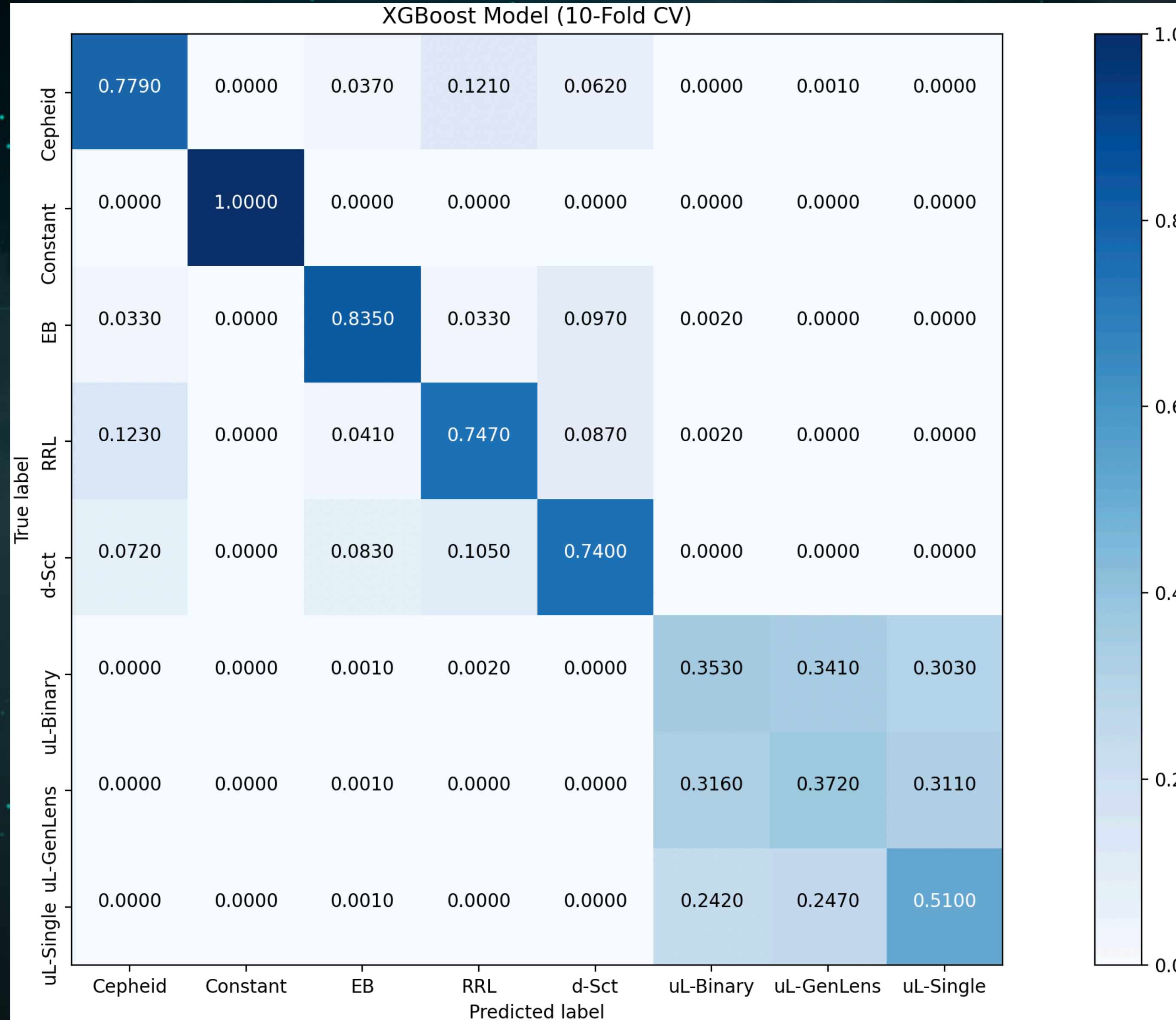
```
from MicroLIA import training_set
data_x, data_y = training_set.load_all(path='/Users/daniel/lightcurves', convert=True, zp=22)

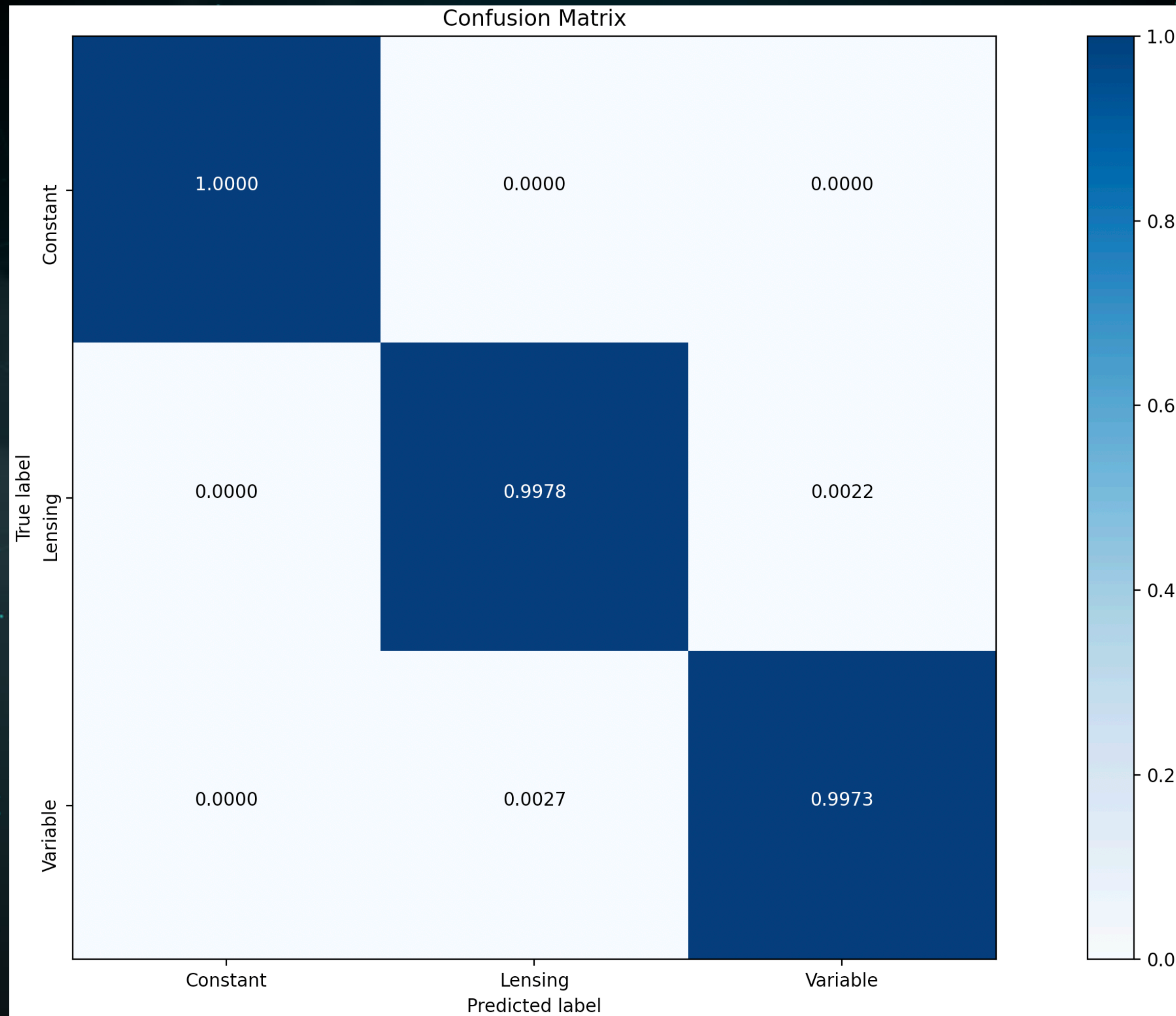
from MicroLIA import ensemble_model

model = ensemble_model.Classifier(data_x, data_y, clf='xgb', impute=True, optimize=True)
model.create()
model.save('Model_1')
```

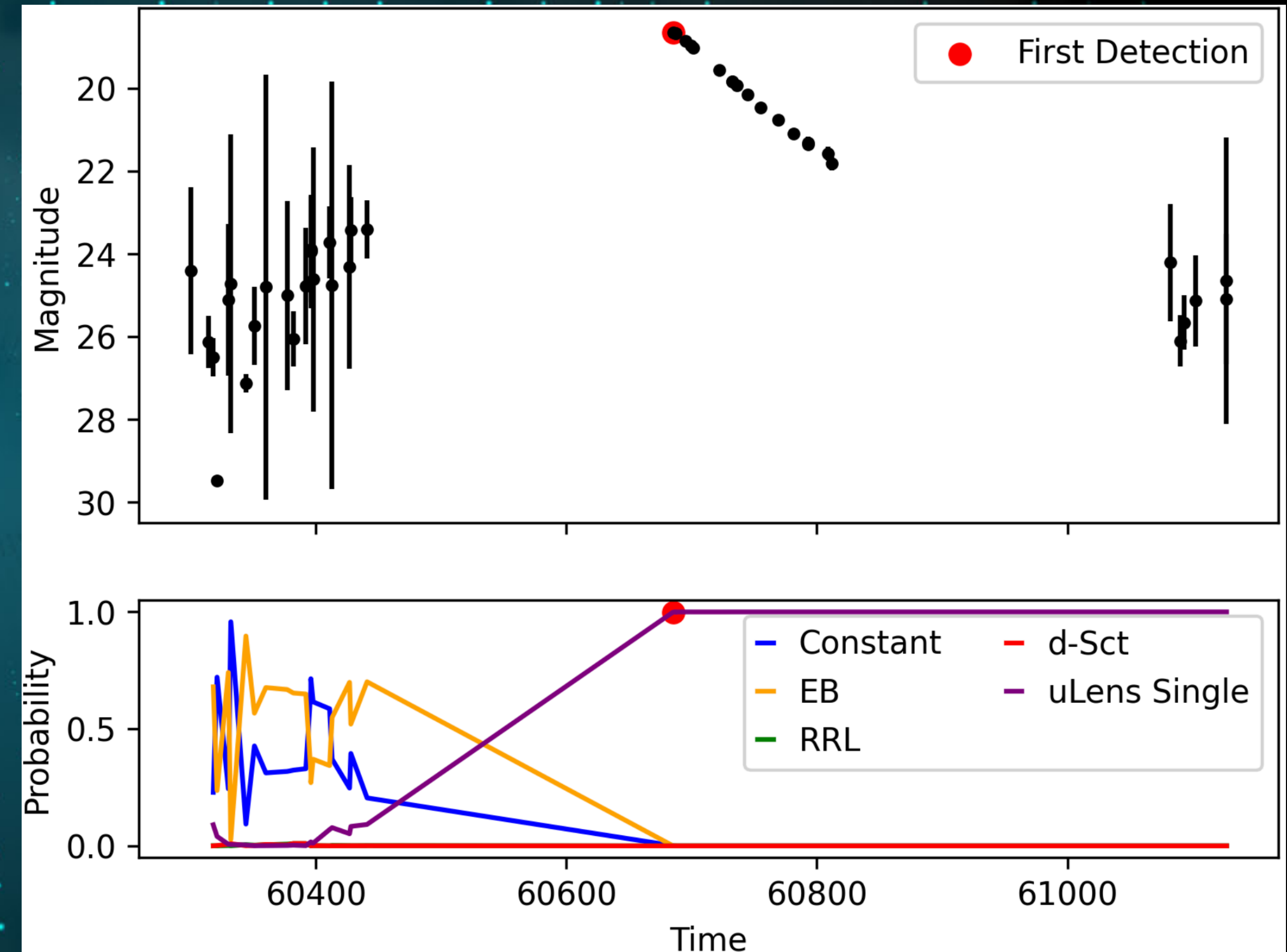
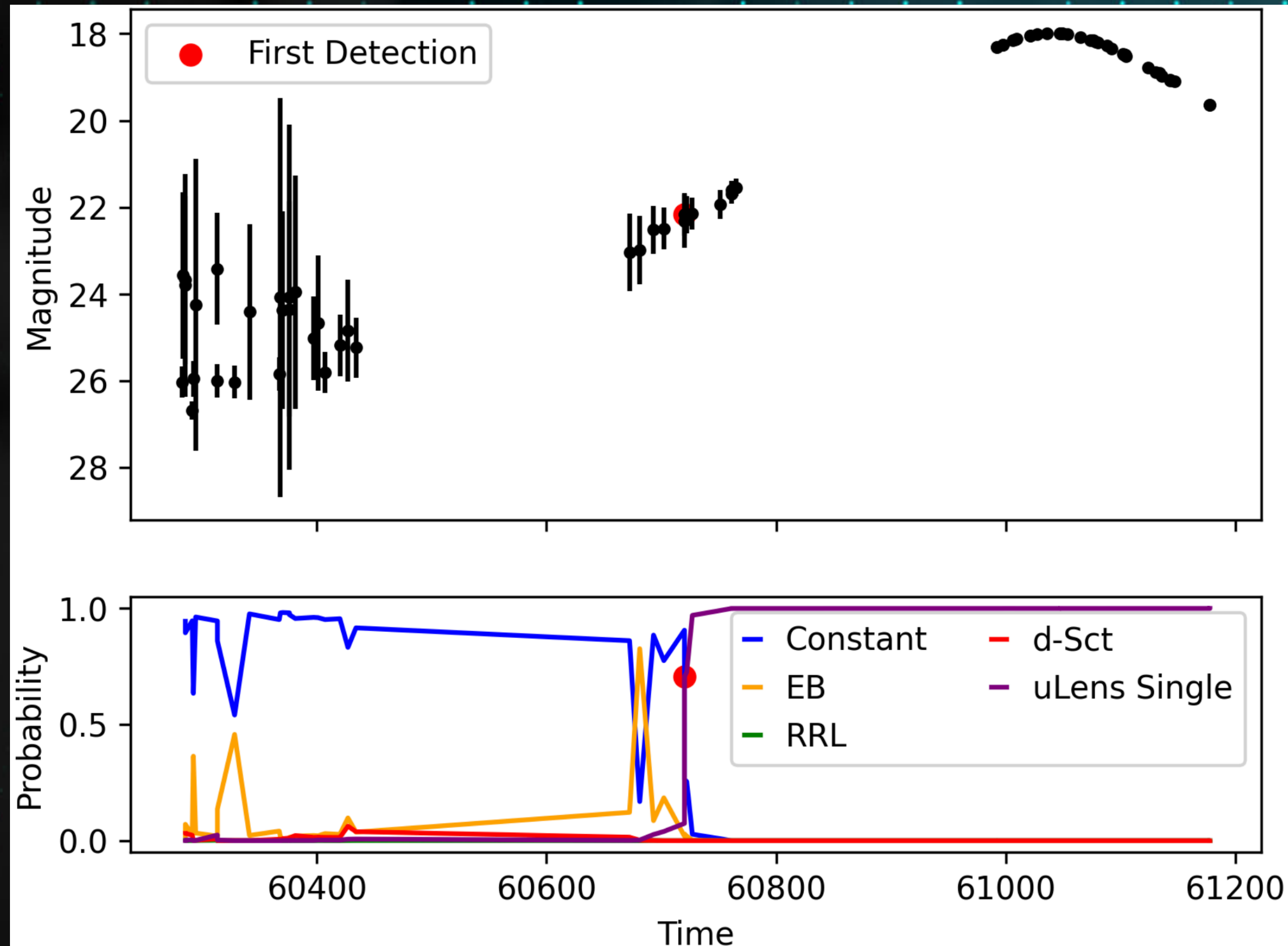



ELaSTiCC Data Challenge





ELaSTiCC: Early Detection



Extended Dark Objects

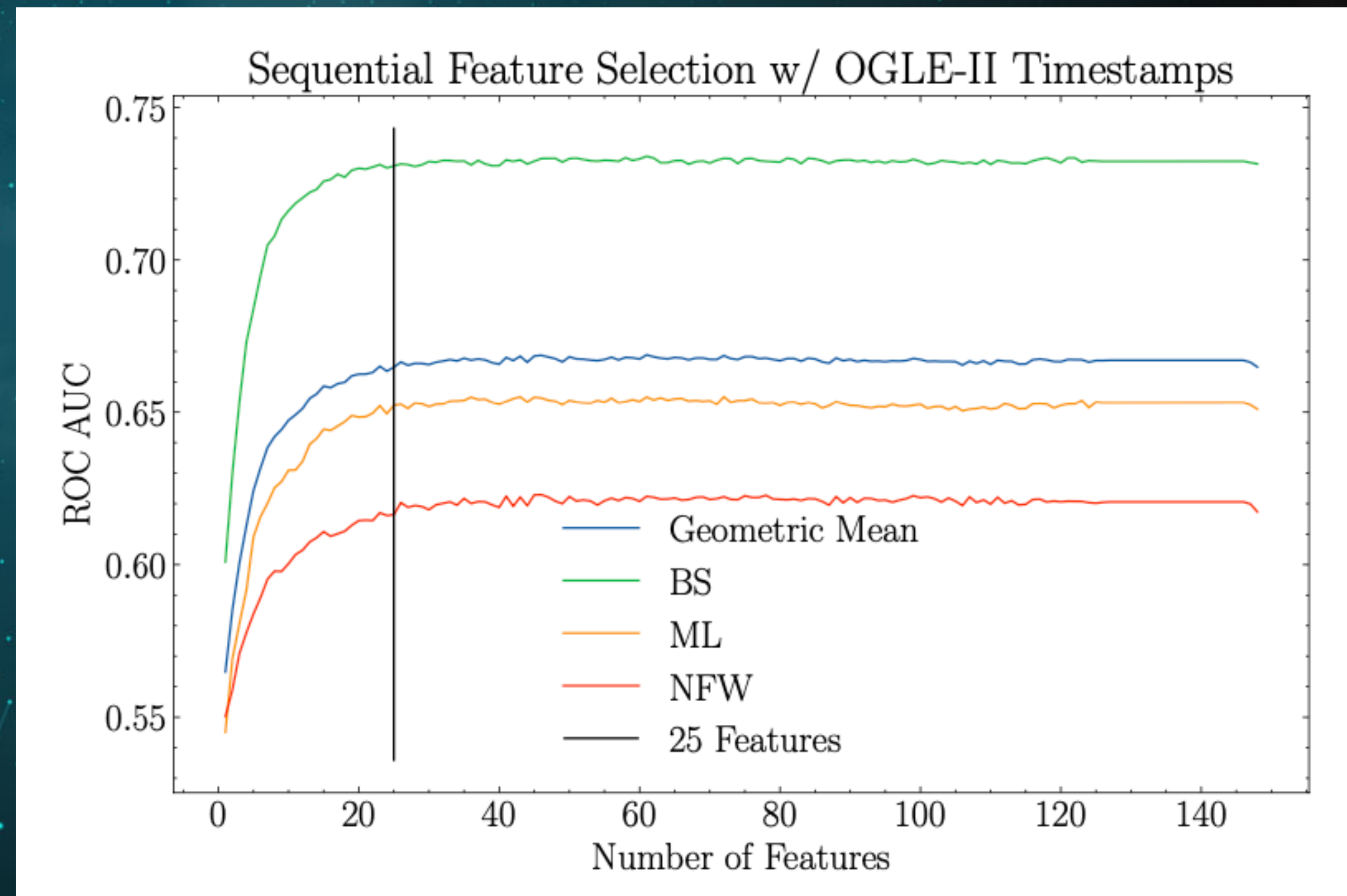
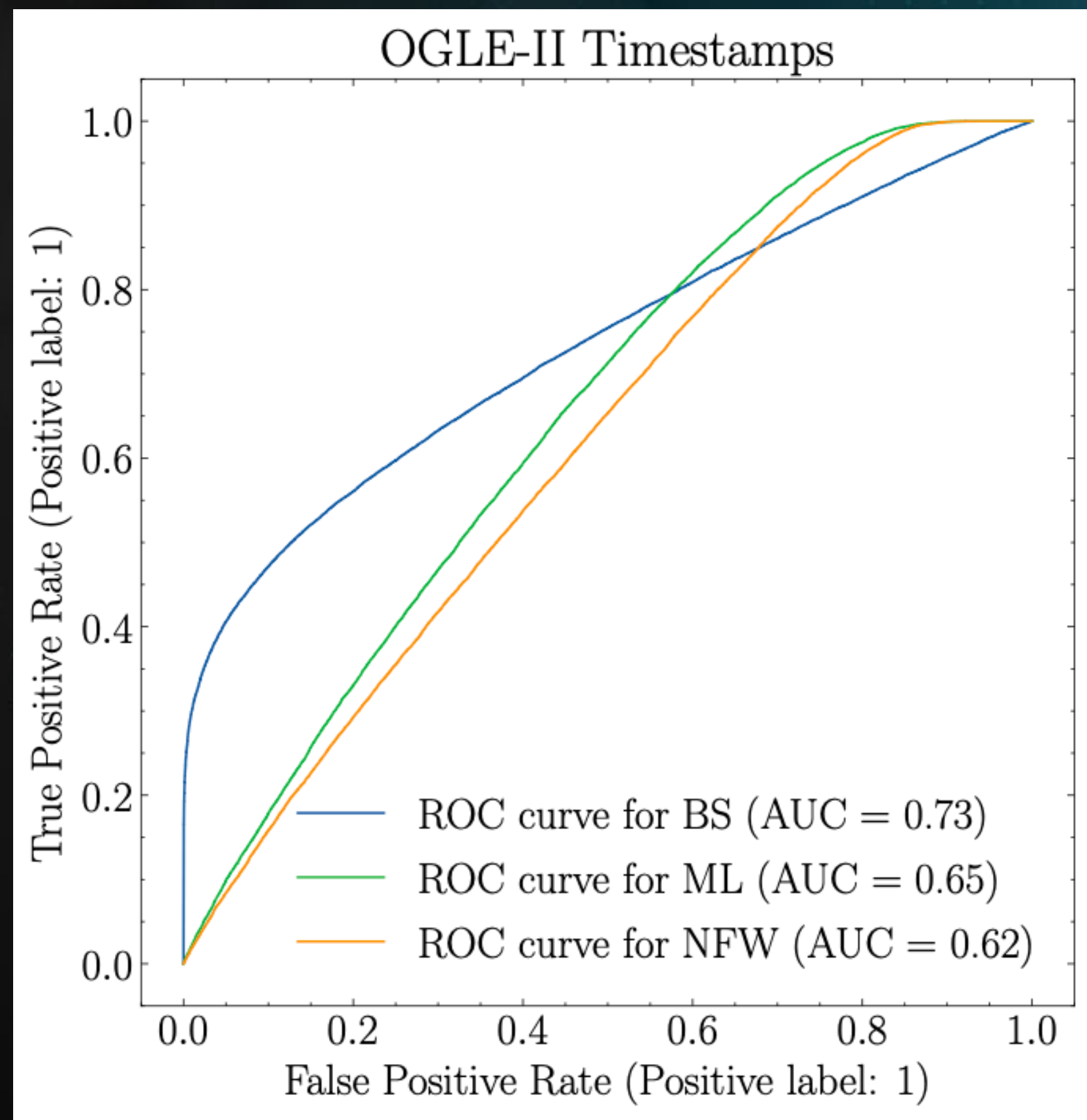
Romão & Croon (2024)



Miguel C. Romão



Djuna Croon



Classification of Extragalactic Sources Using Image Data



Moire Prescott

High-z
Lyman-alpha
Blobs

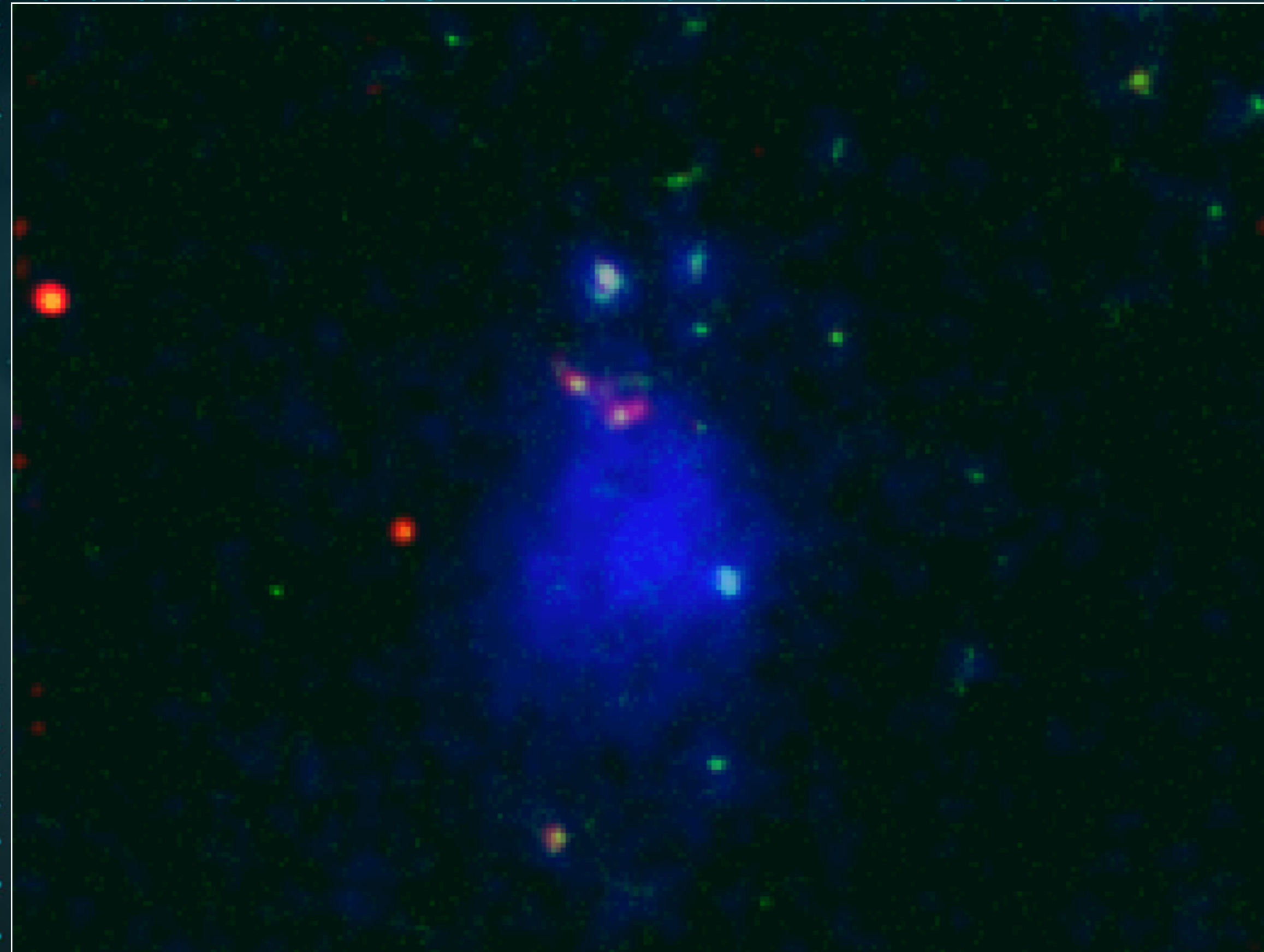
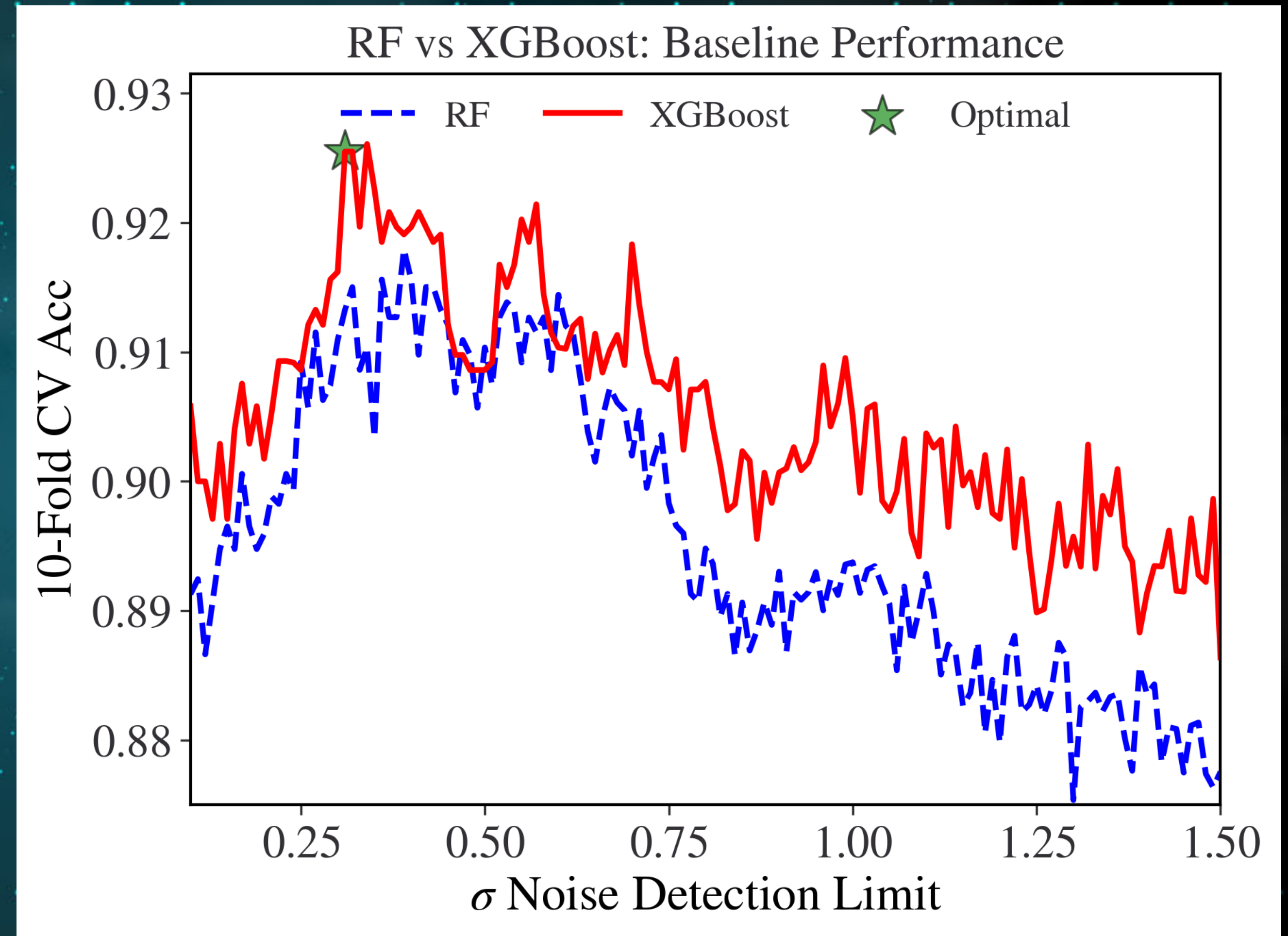
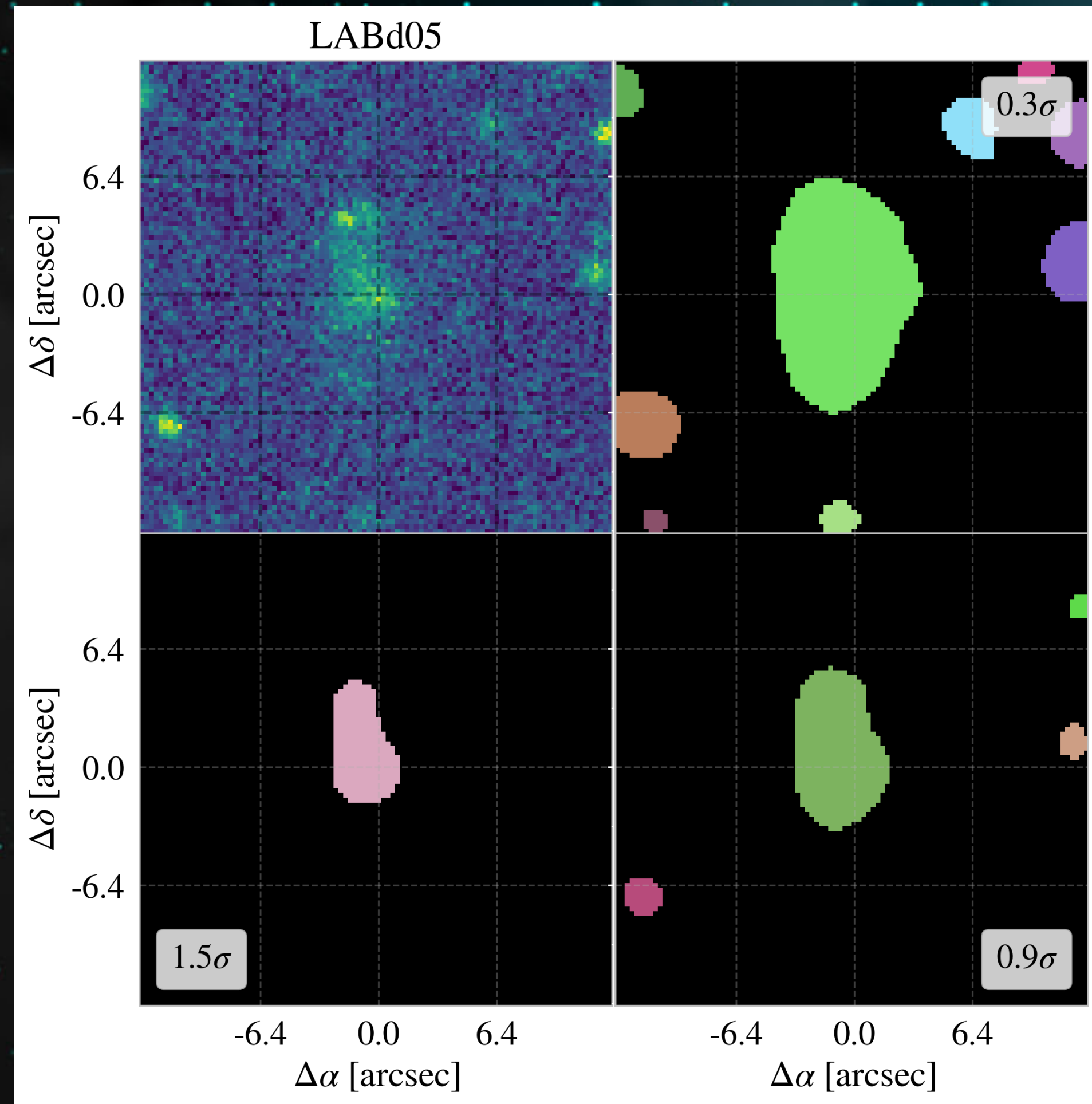


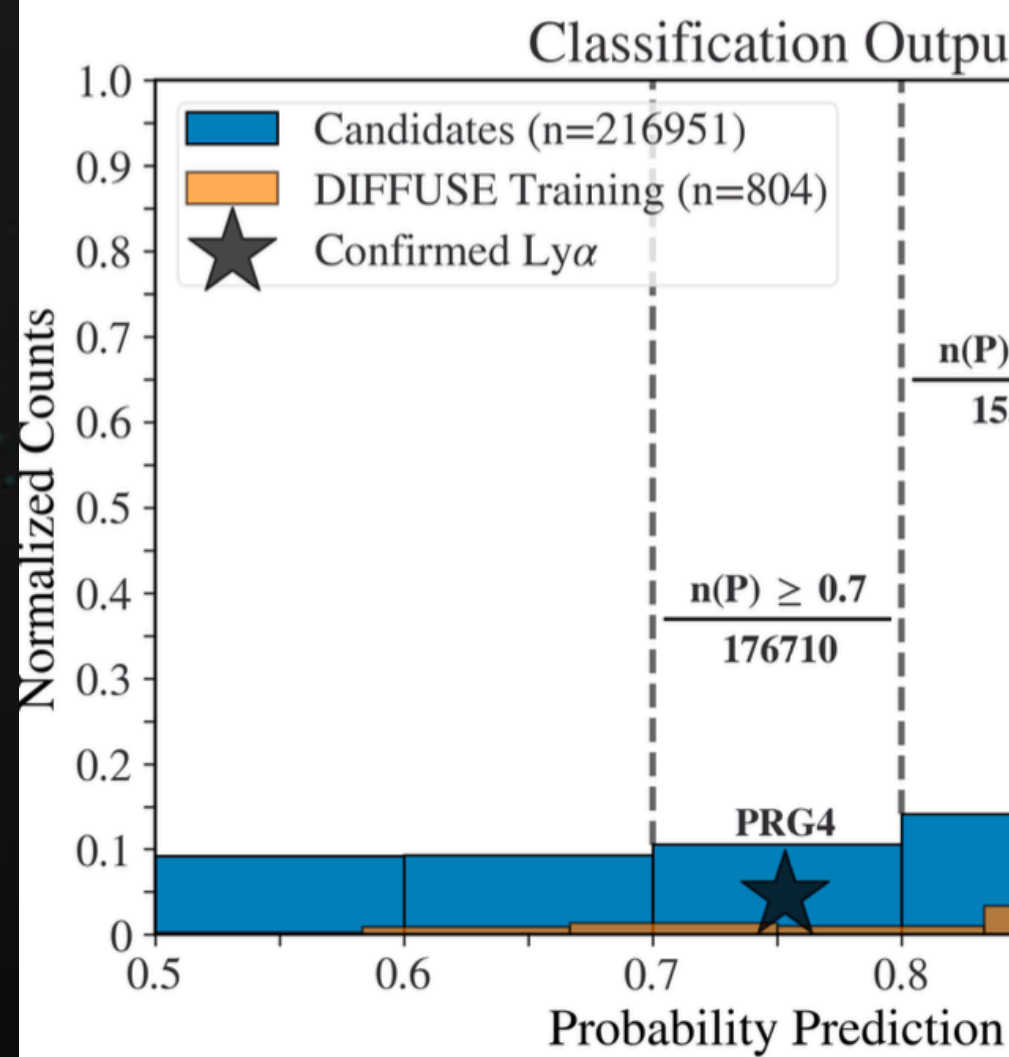
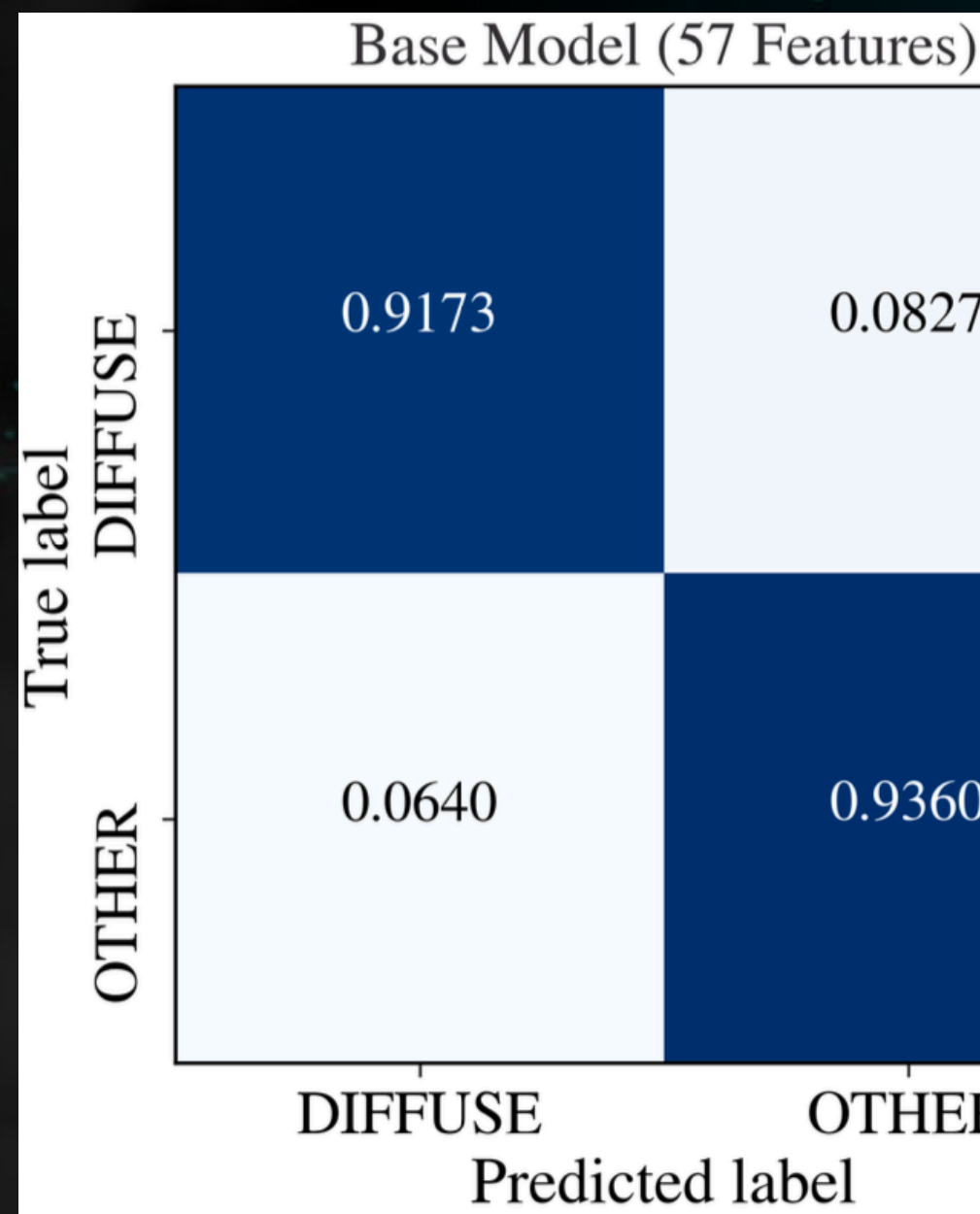
Image Credit: M. Prescott and A. Dey, 2010

Feature Extraction & Model Selection

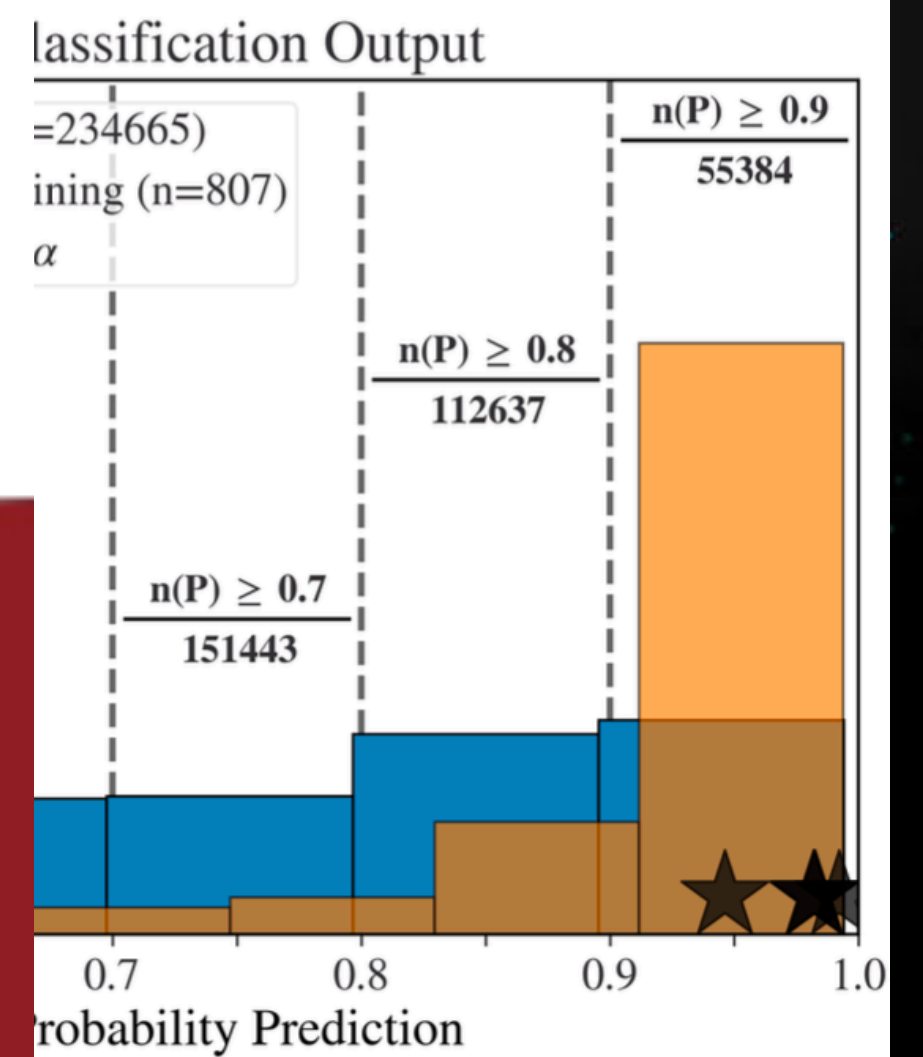
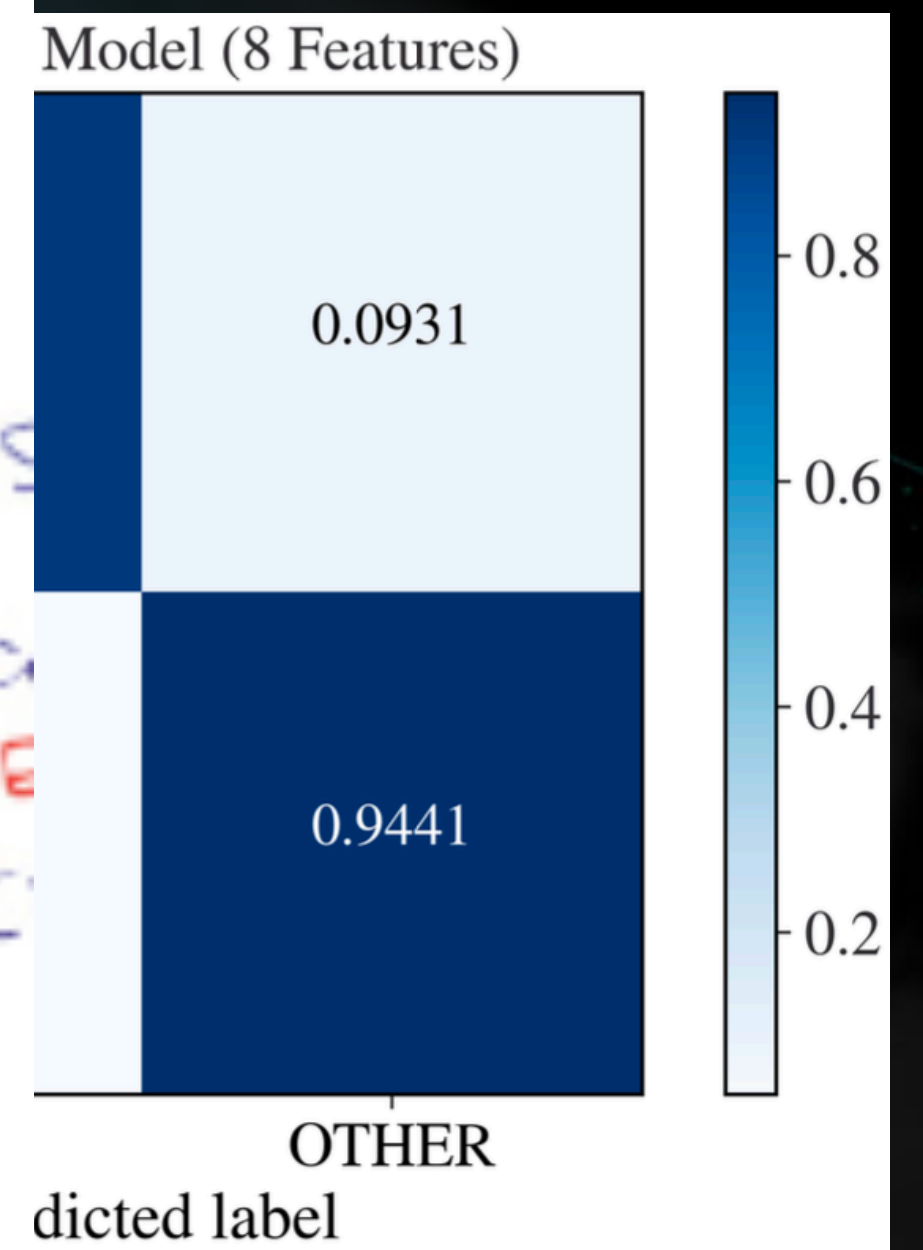


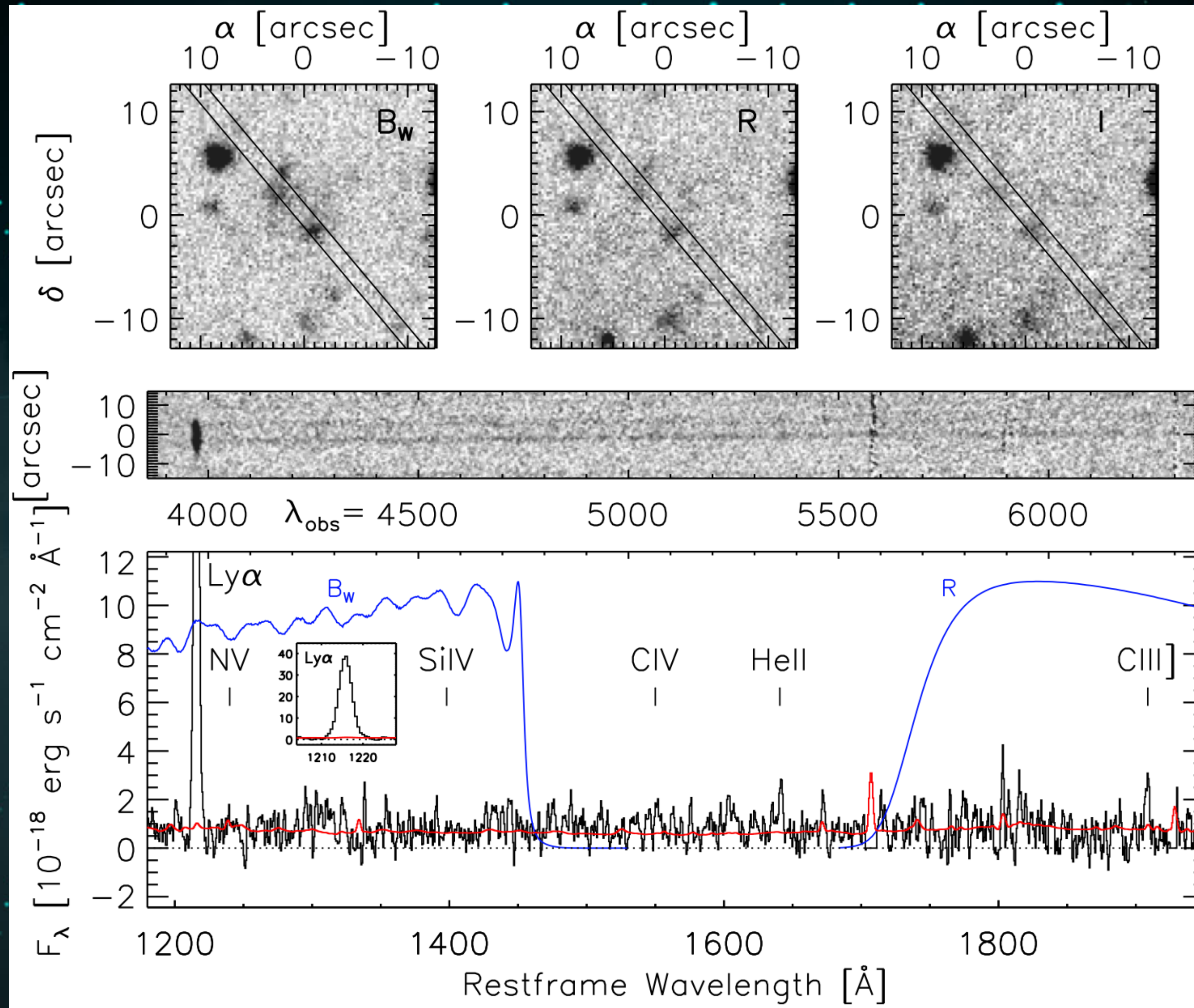
Godines & Prescott (in prep.)

Importance of Optimization



WE NEED TO FIND A BETTER WAY TO FILTER

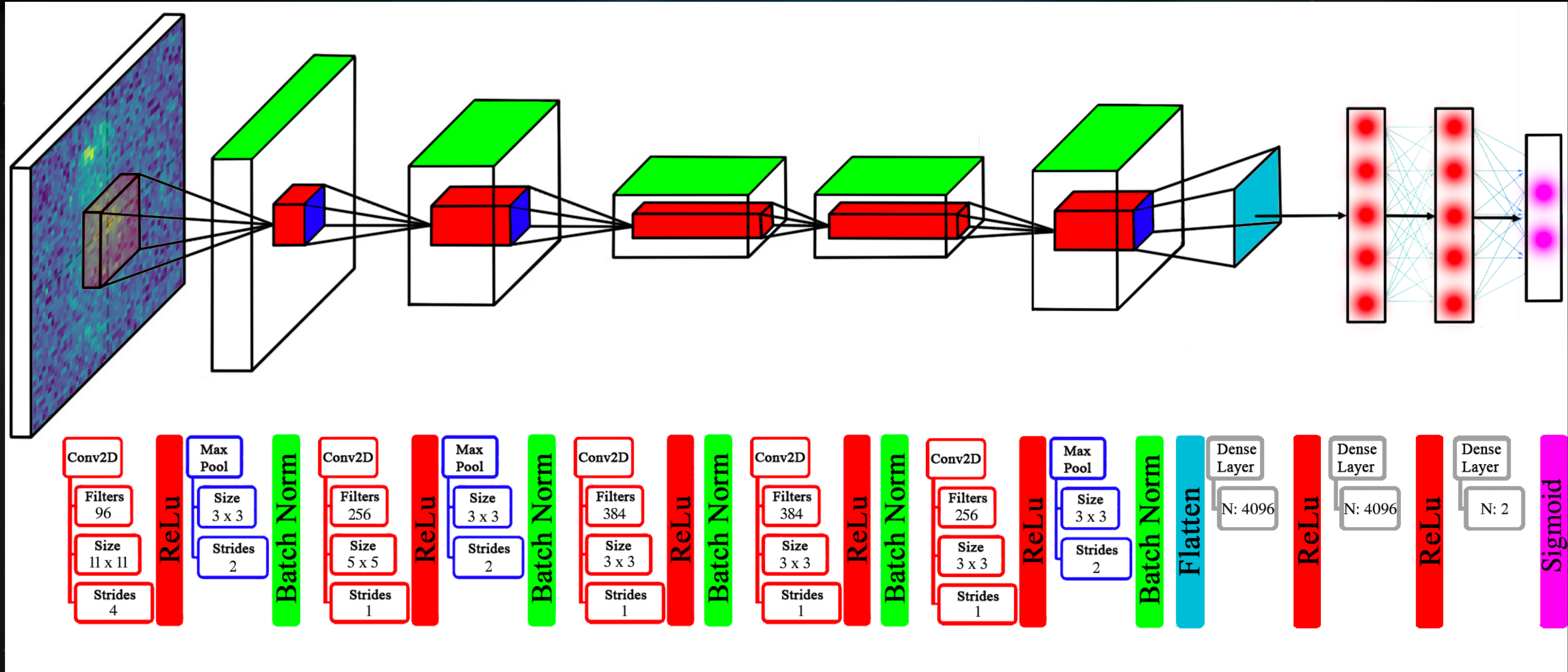




Prescott et al. (2013)

Daniel Godines Rare Gems 2024

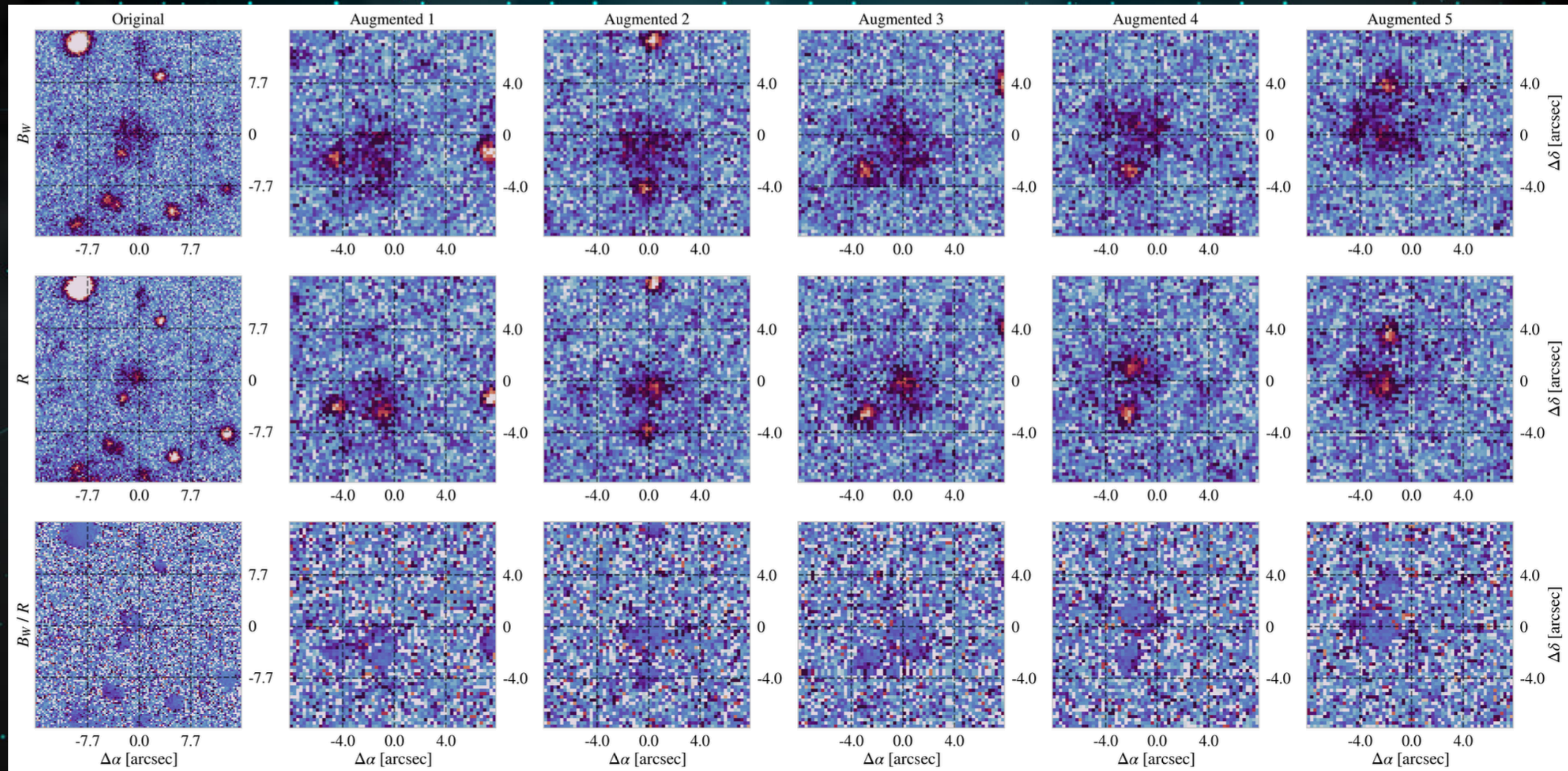
CNN Architecture: AlexNet (Krizhevsky et al. (2012))



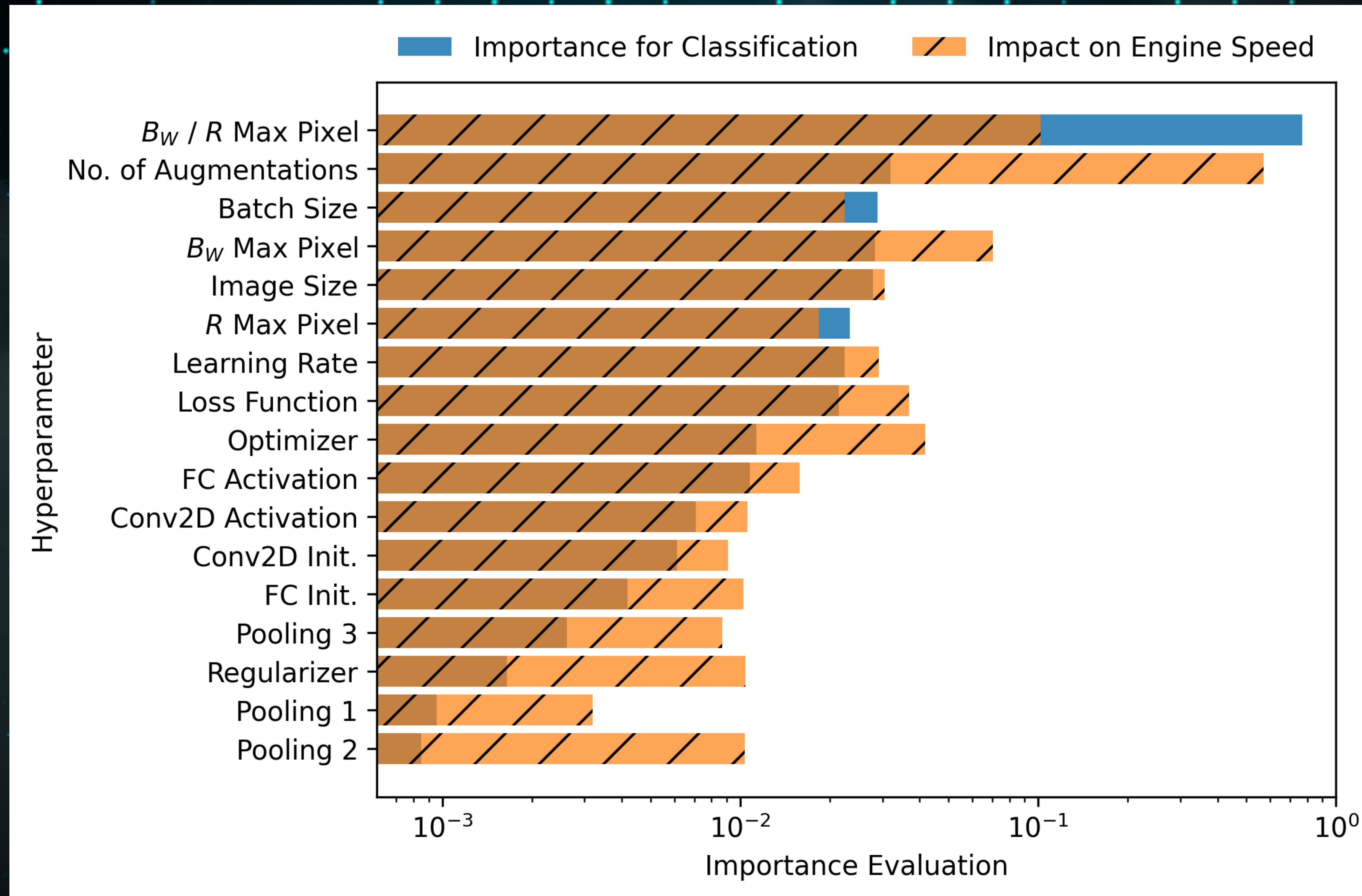
Ghosh et al. (2020) — *GaMorNet*

Aniyan & Thora (2017) — *Toothless*

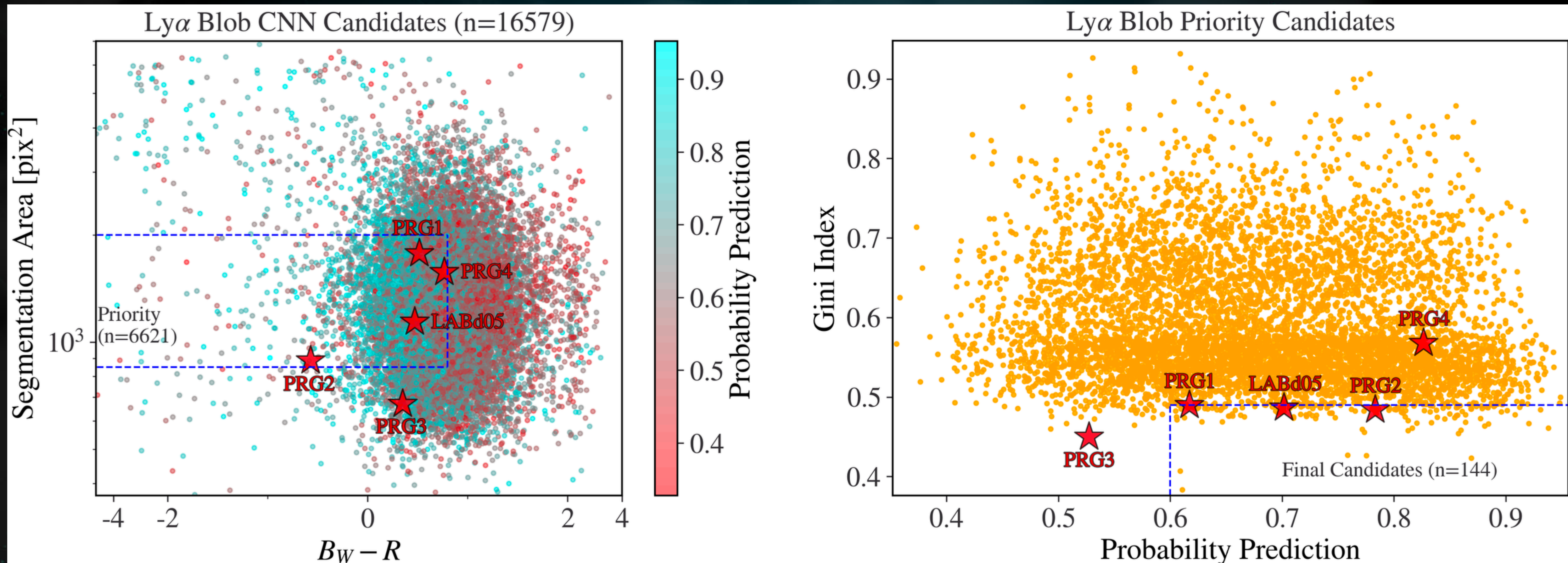
Data Augmentation



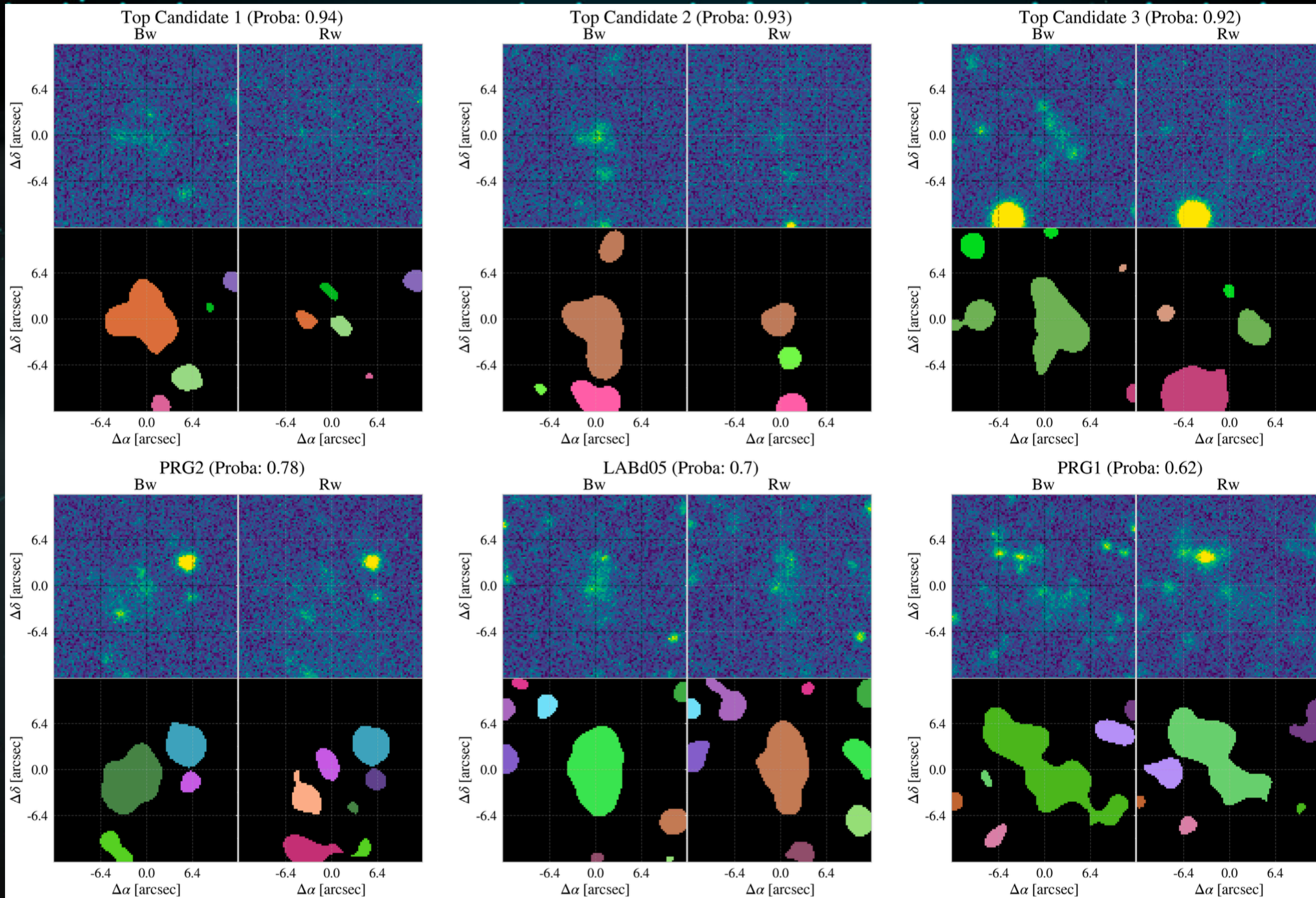
Akiba et al. (2019) — Optuna Optimizer



Godines & Prescott (in prep.)

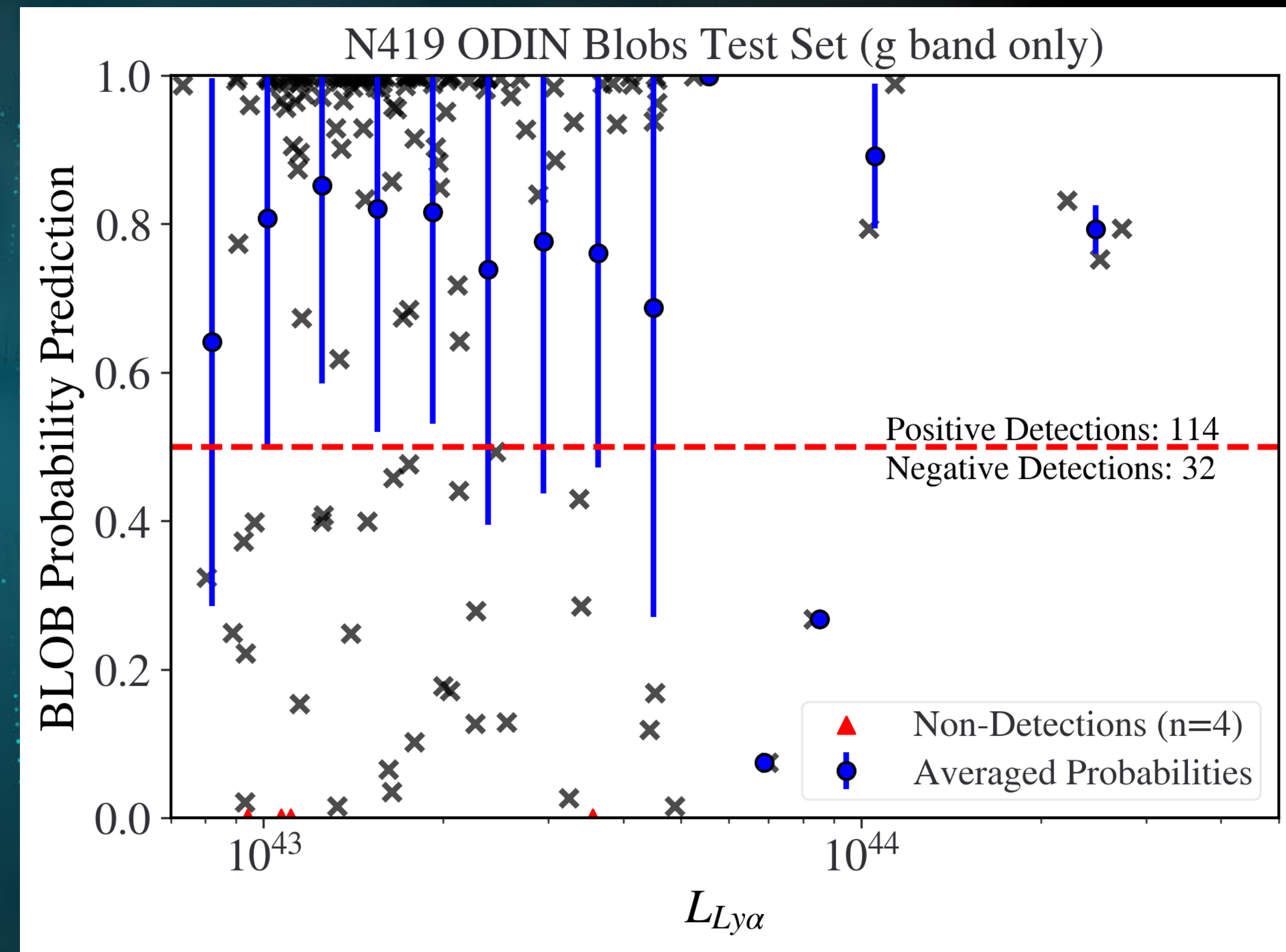
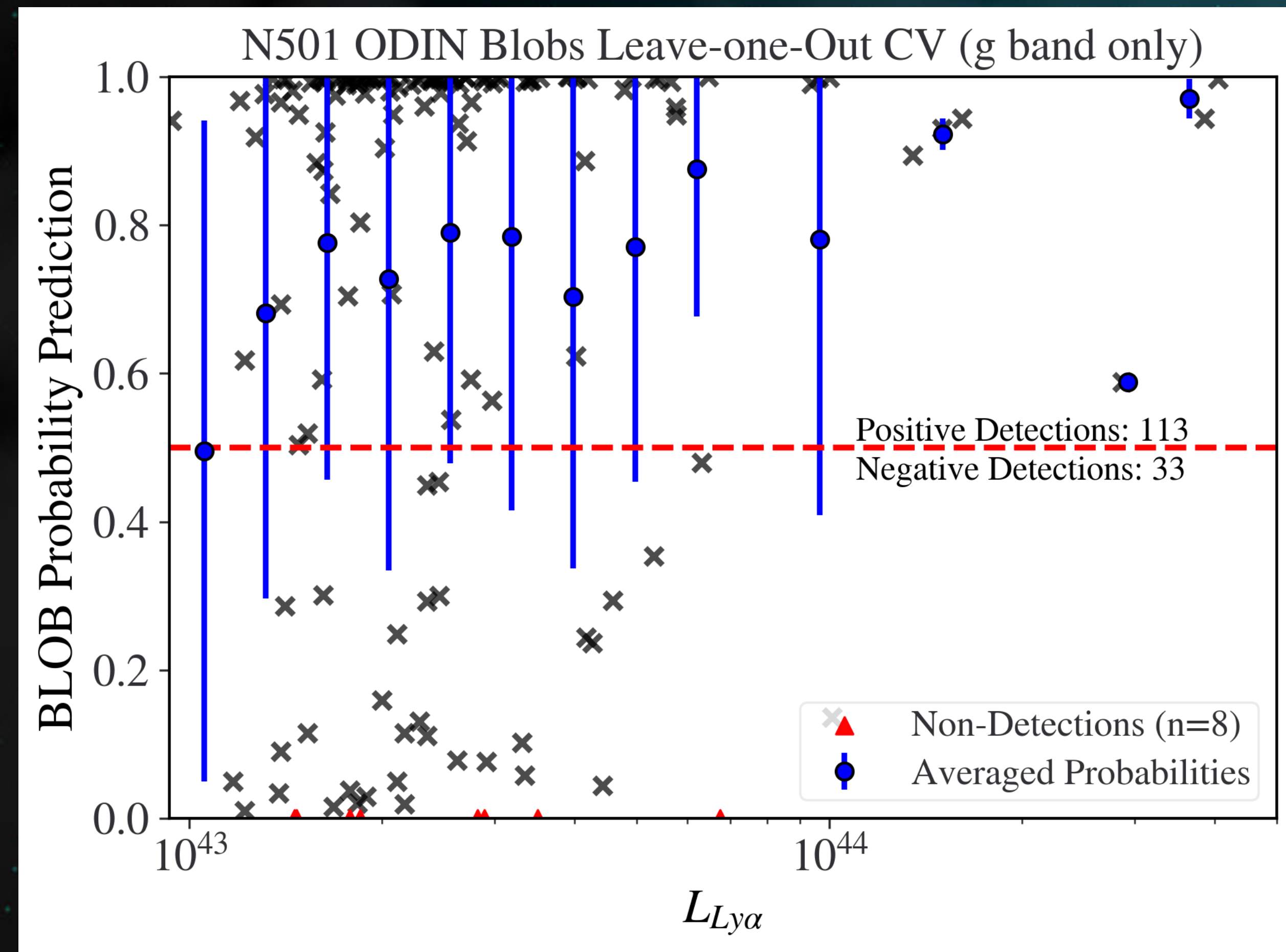


Godines & Prescott (in prep.)



Ramakrishnan et al. (2023)

One-hundred-deg² DECam Imaging in Narrowbands (ODIN) survey



Preliminary Baseline Classification Tests (Godines et al. (in prep.))

Summary

- Lensing events can be detected in sparsely sampled wide-field data using single-band lightcurve statistics
- Image segmentation yields object characteristics that can be used to train interpretable tree-based models
- Multi-band CNNs can be trained with limited training sets (~2000 instances) if tuned and optimized

Questions?

- For lightcurve classification:

`pip install MicroLIA`



- For image classification:

`pip install pyBIA`

