LSST:UK – Classification of Supernovae with Machine Learning

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LSST DESC Dark Energy Science Collaboration

4MOST

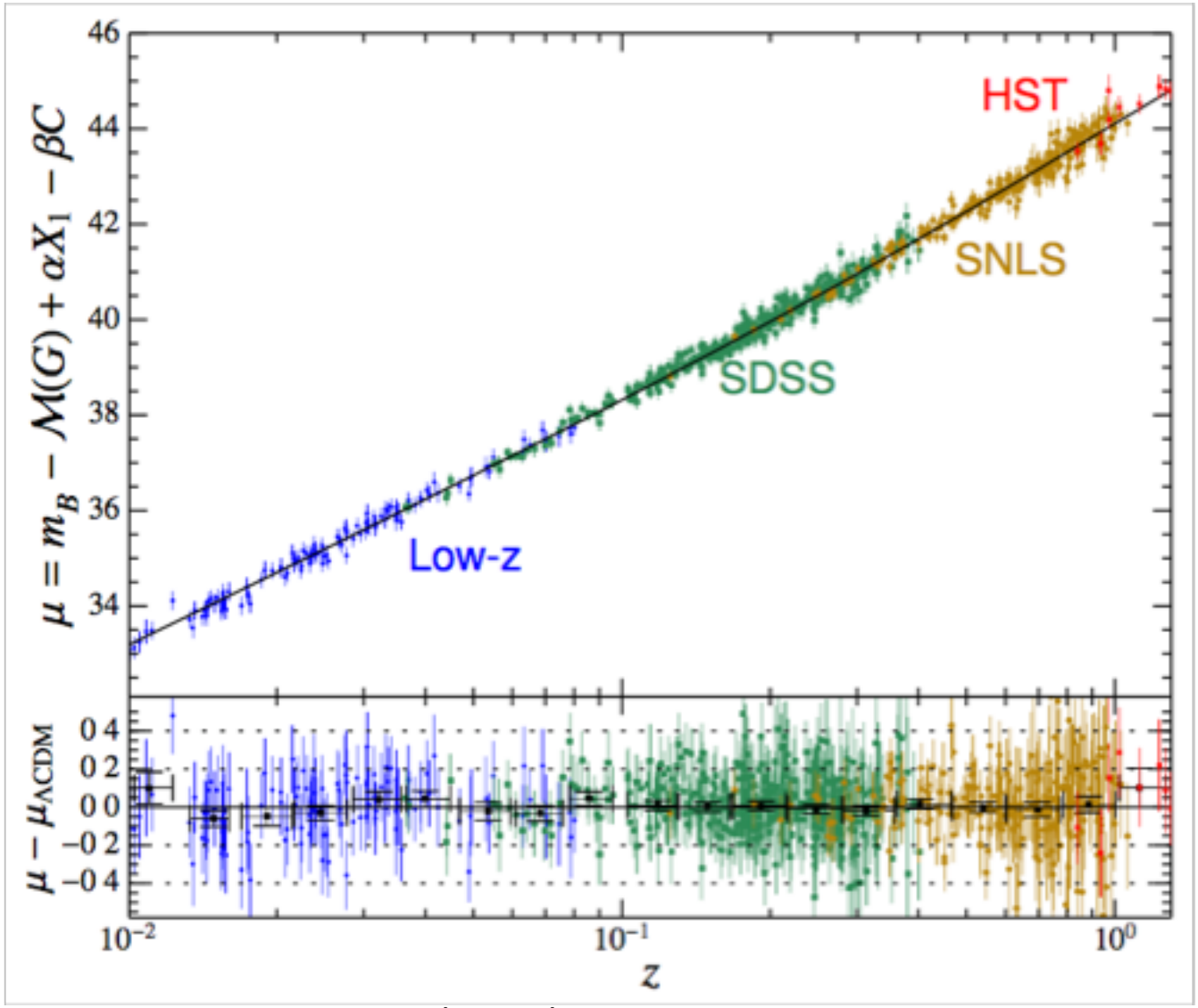
Science & Technology Facilities Council

Lancaster University

Image credit: M. Claro, ESO

Type Ia Supernovae

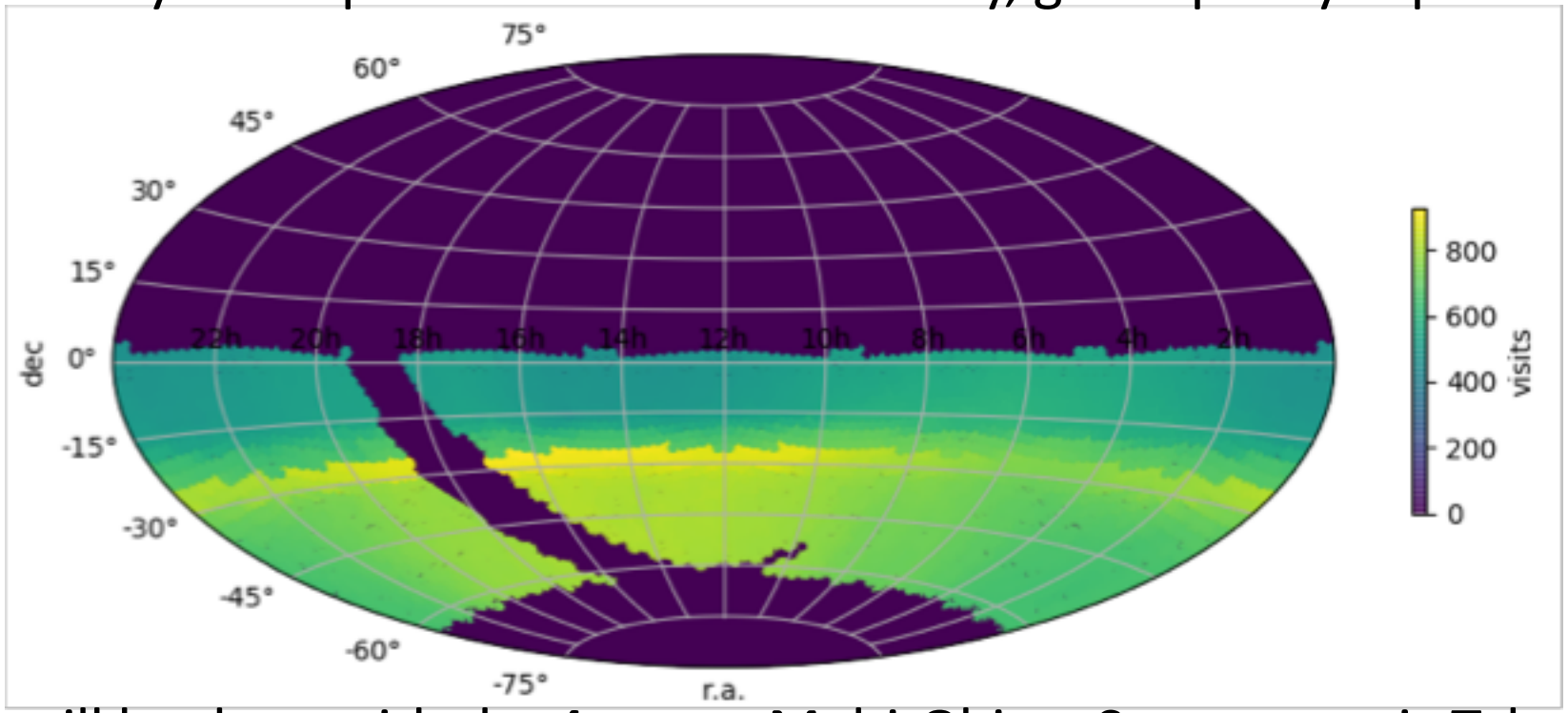
- Standardisable candles
- Cosmological distance indicators - can be used to test models e.g. ΛCDM
- Not possible to spectroscopically follow-up all LSST supernovae – solution: photometric classification with machine learning



Betoule et al. 2014

Creating a training sample – 4MOST

- Rapid spectroscopic follow-up will provide the training sample for machine learning to classify other LSST transient discoveries.
- In the Time-Domain Extragalactic Survey (TiDES) we are working to maximise survey overlap with LSST to obtain many, good quality supernovae.

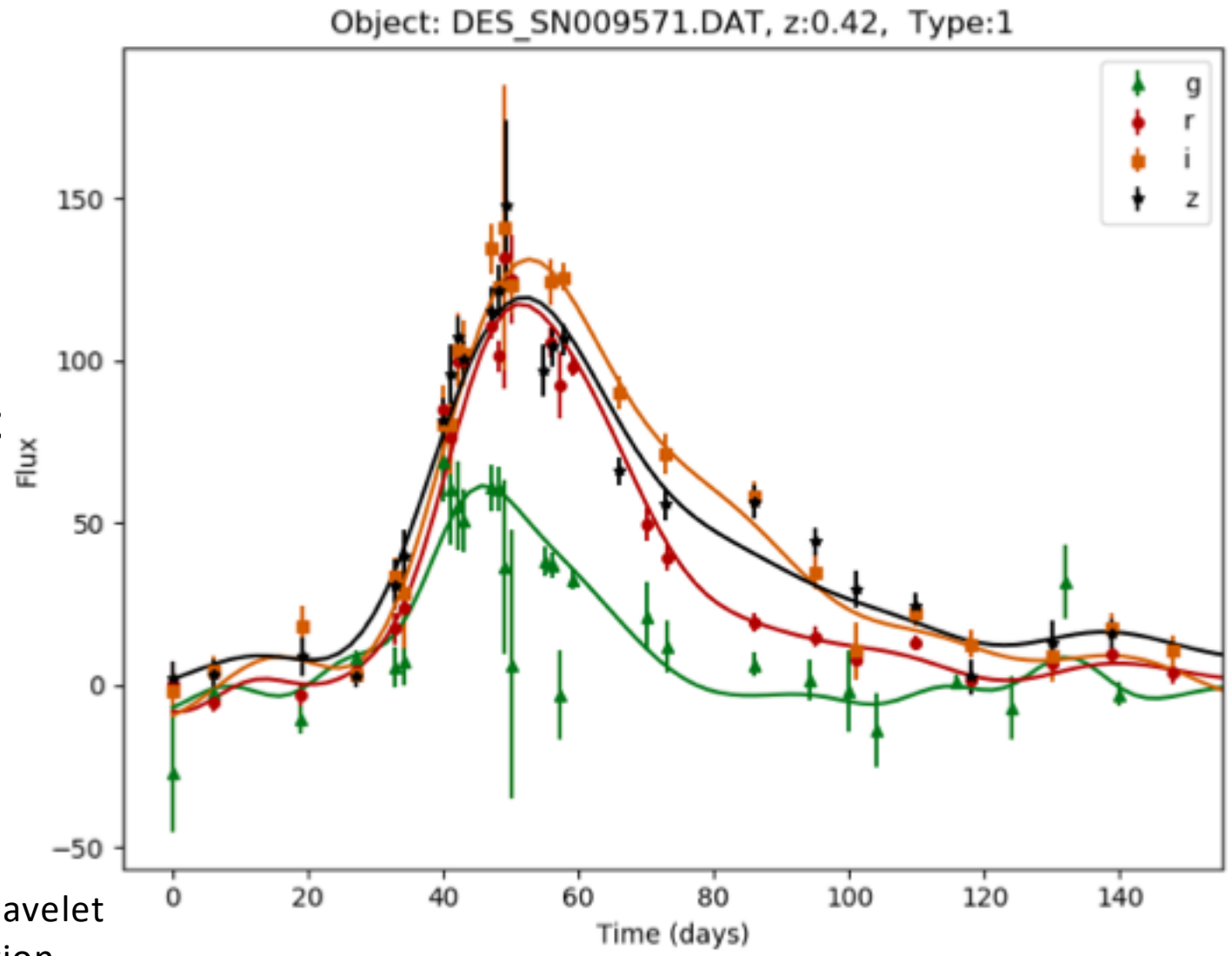


One of LSST's WFD survey proposals (mothra_2045's rolling cadence) over 4MOST's lifetime

This will be done with the 4-metre Multi-Object Spectroscopic Telescope (4MOST) in the first few years of LSST's observations.

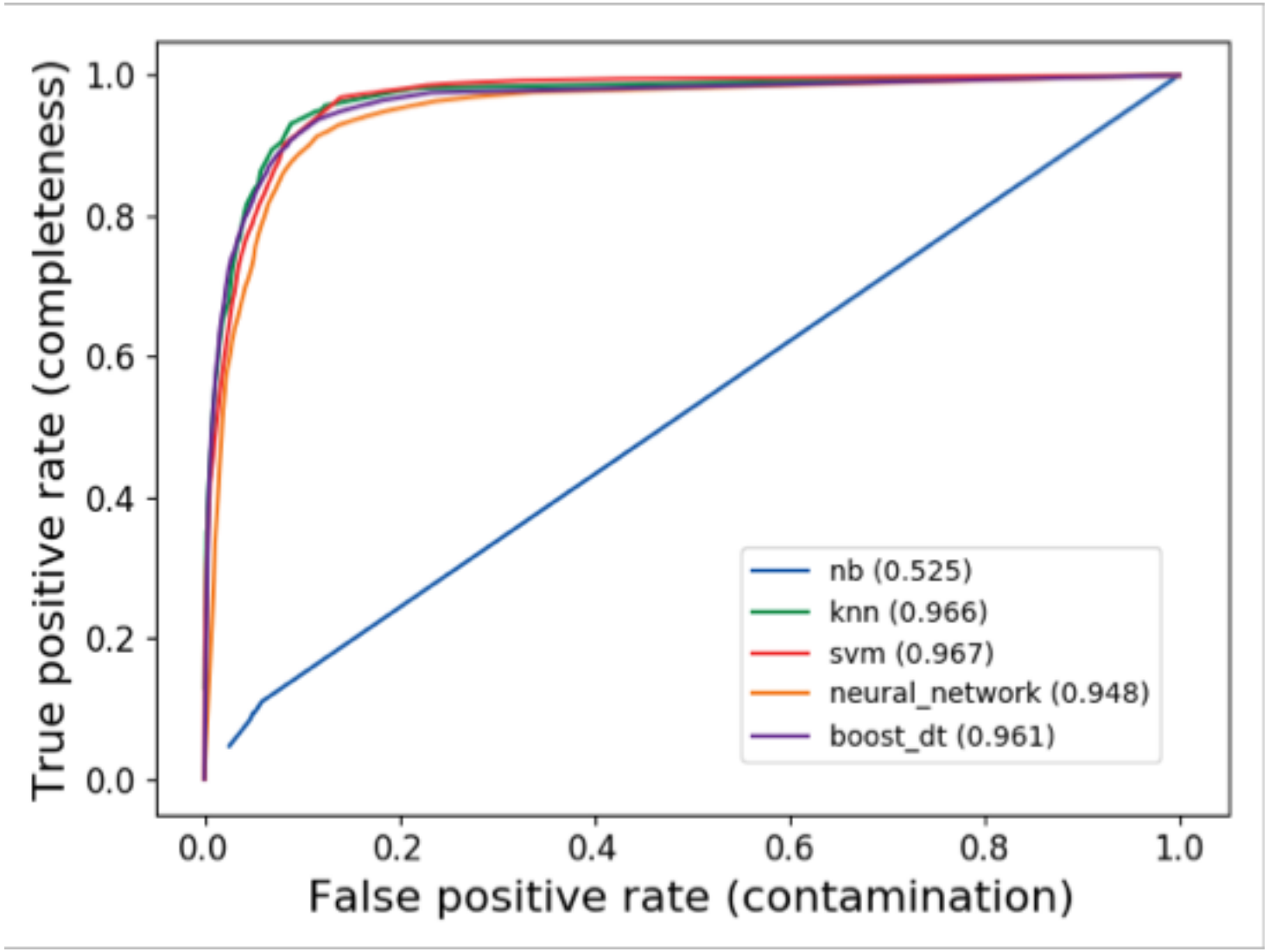
Machine learning on SN light curves

- *snmachine* (Lochner et al. 2016)
- Extract light curve features
- Train algorithms to recognise features belonging to specific classes (i.e. type Ia, Ibc, II)
- Classify new data based on these features



A type Ia light curve fit after wavelet decomposition feature extraction

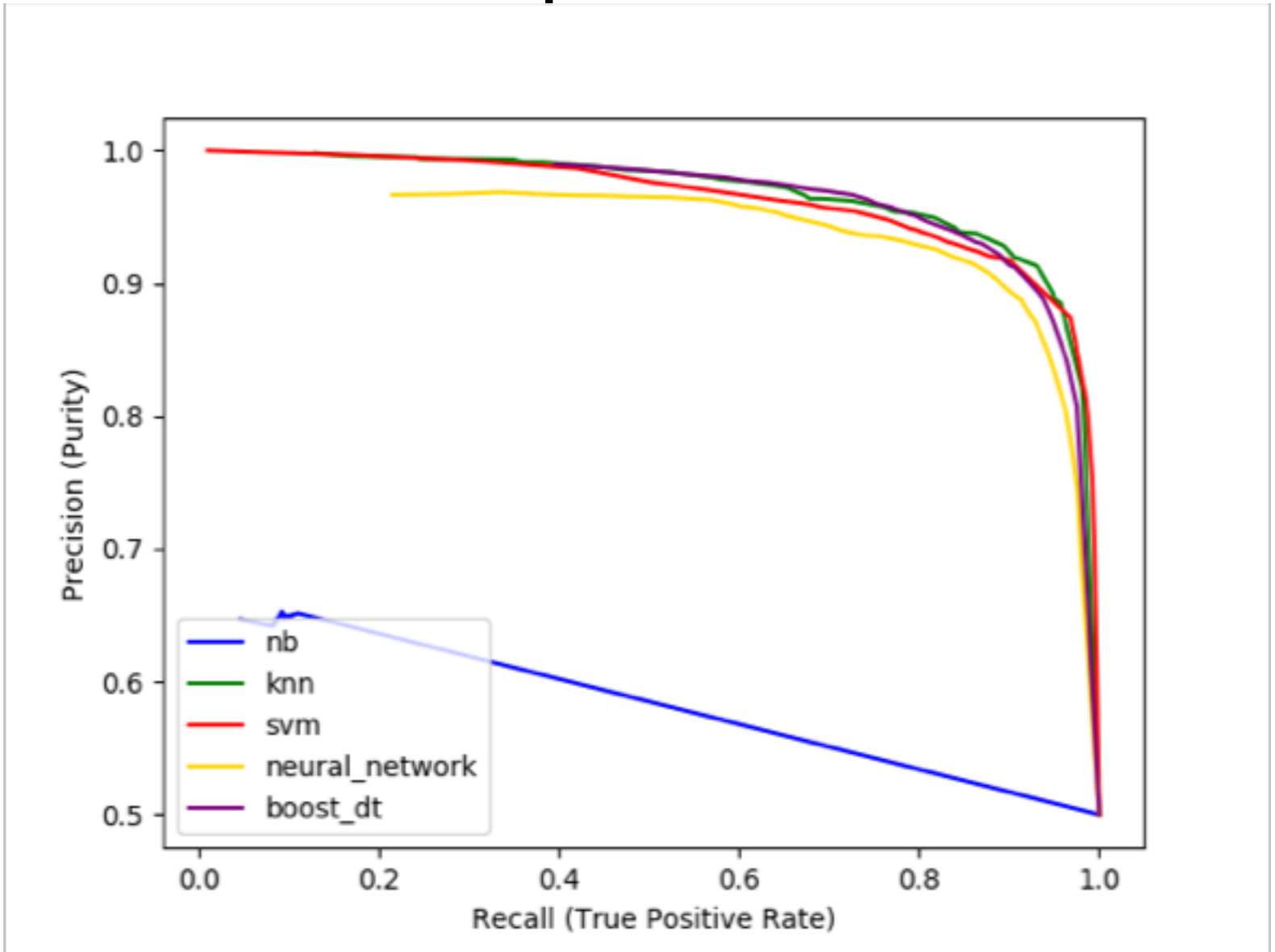
Classification performance



ROC Curves:

- Classification performance over a range of probability thresholds

Classification performance



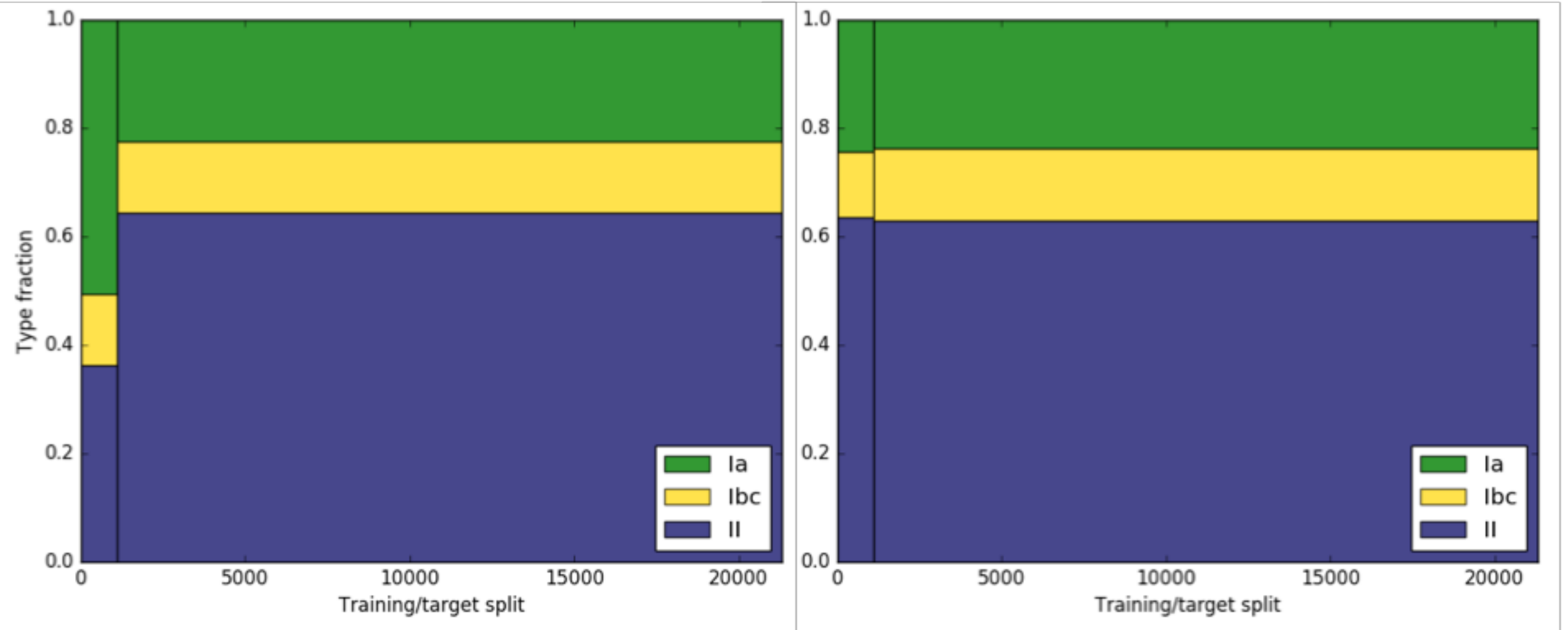
Precision-Recall Curves:

- Purity of classified sample

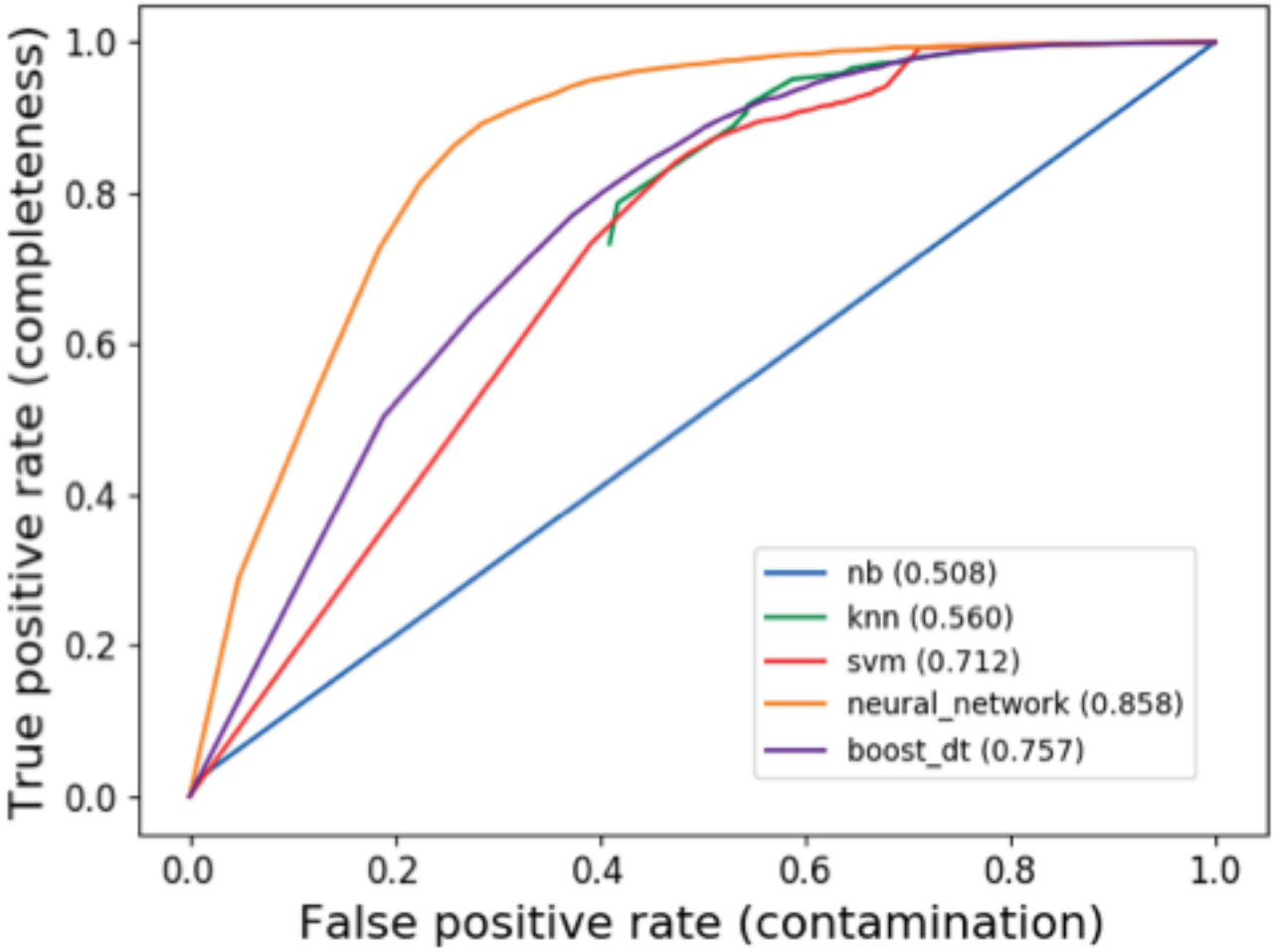
$$\text{Purity} = \frac{TP}{TP+FP}$$

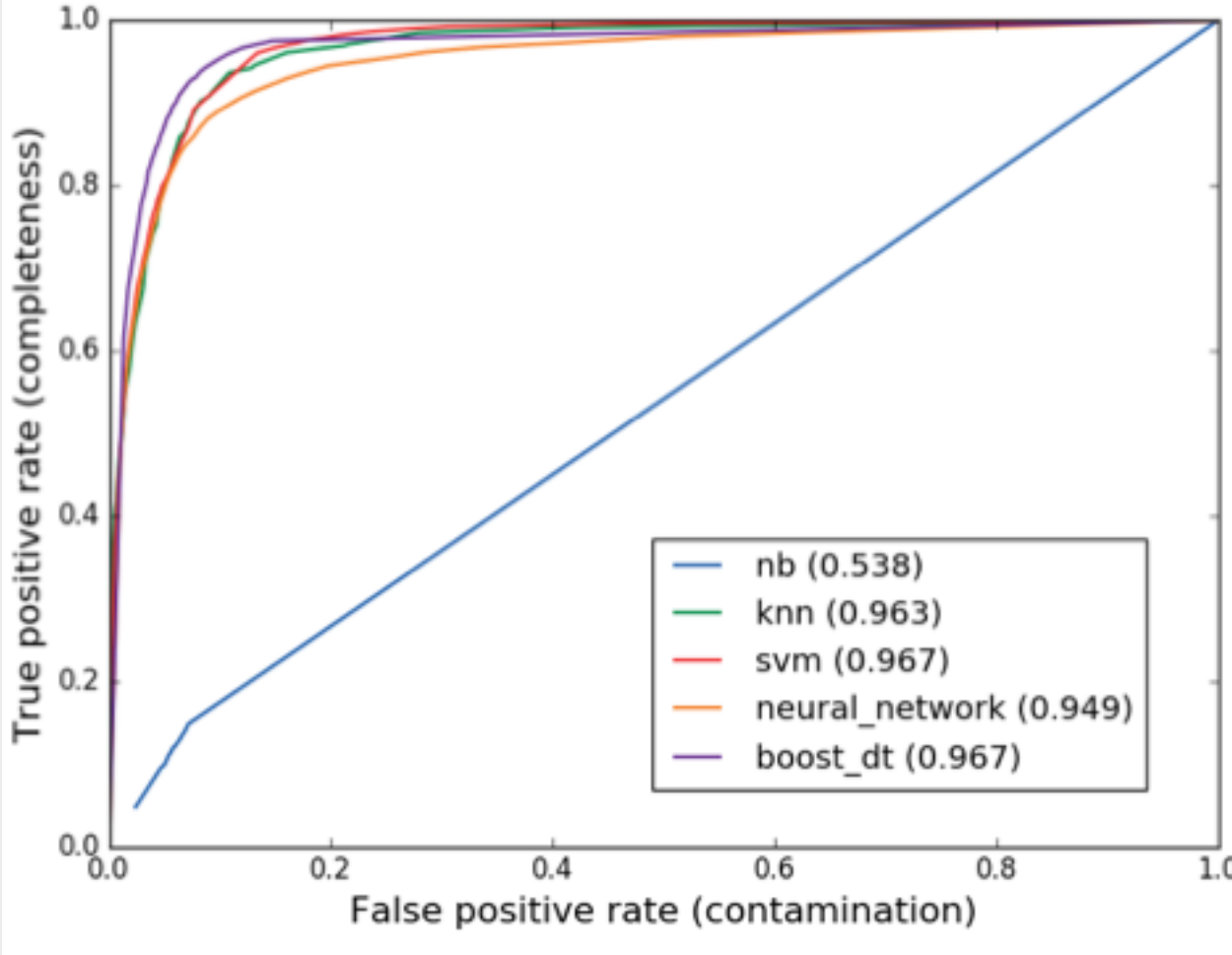
Class balance

Comparing original training (non-representative) against same size but class-representative

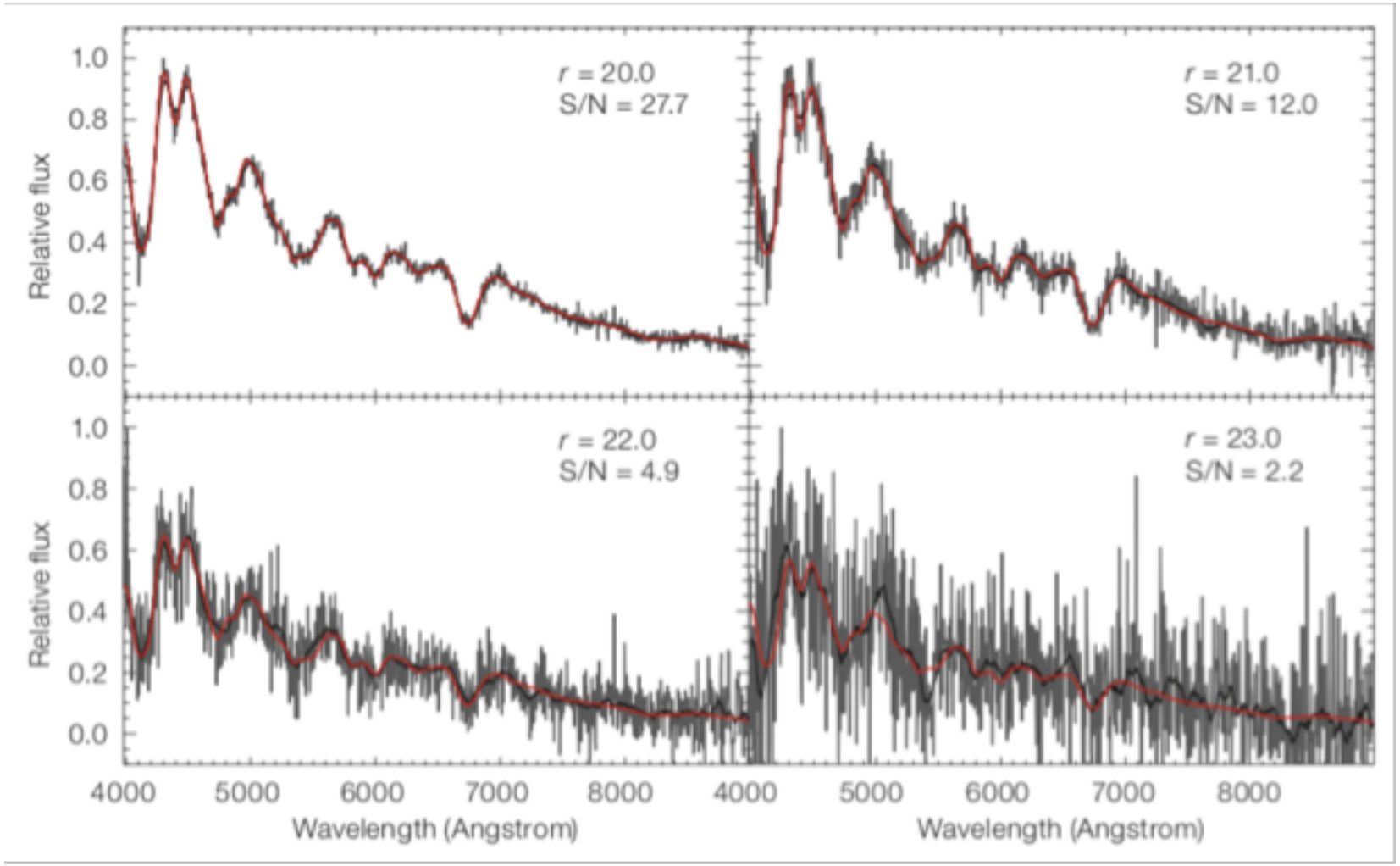


Class balance





Magnitude cut

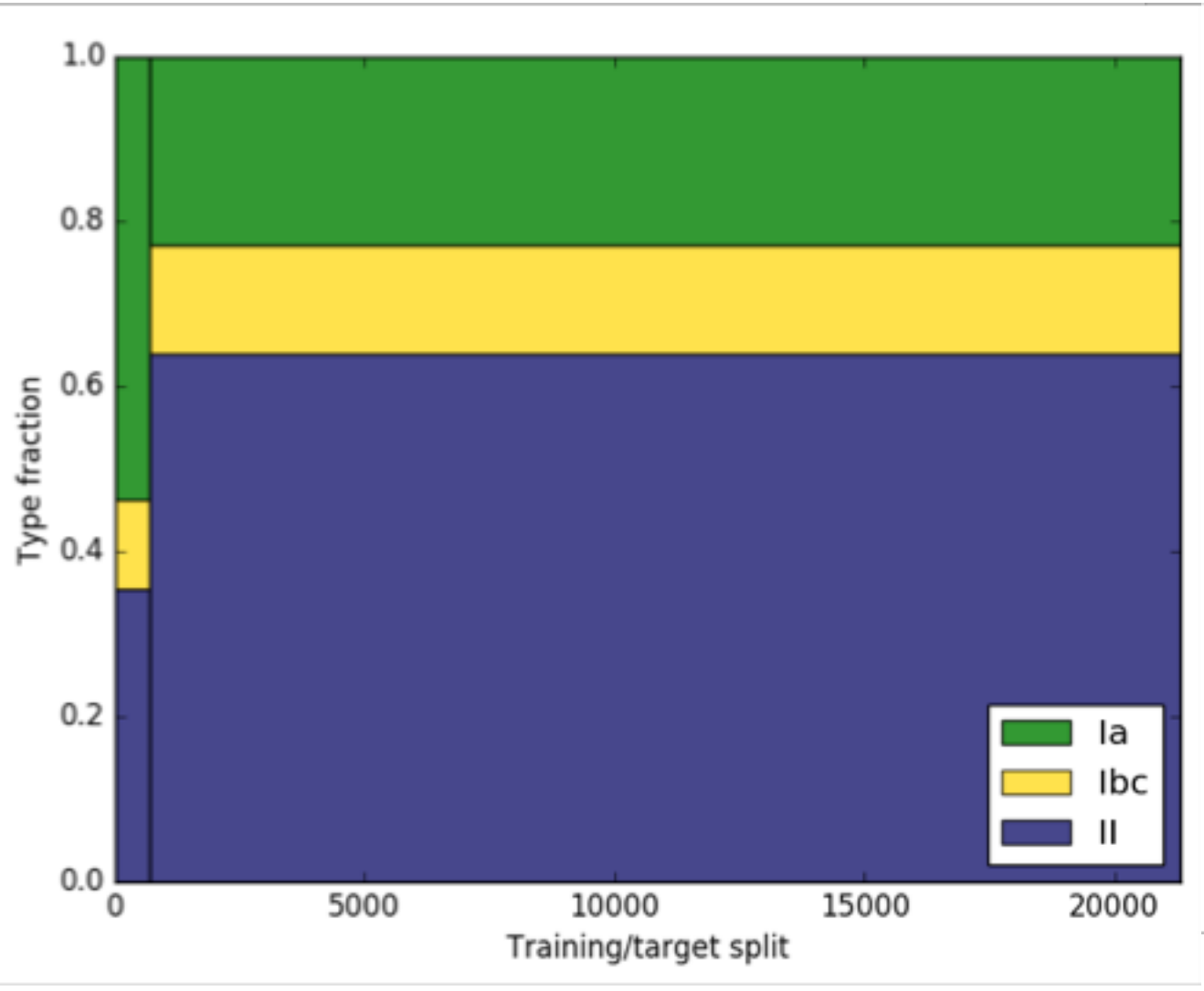


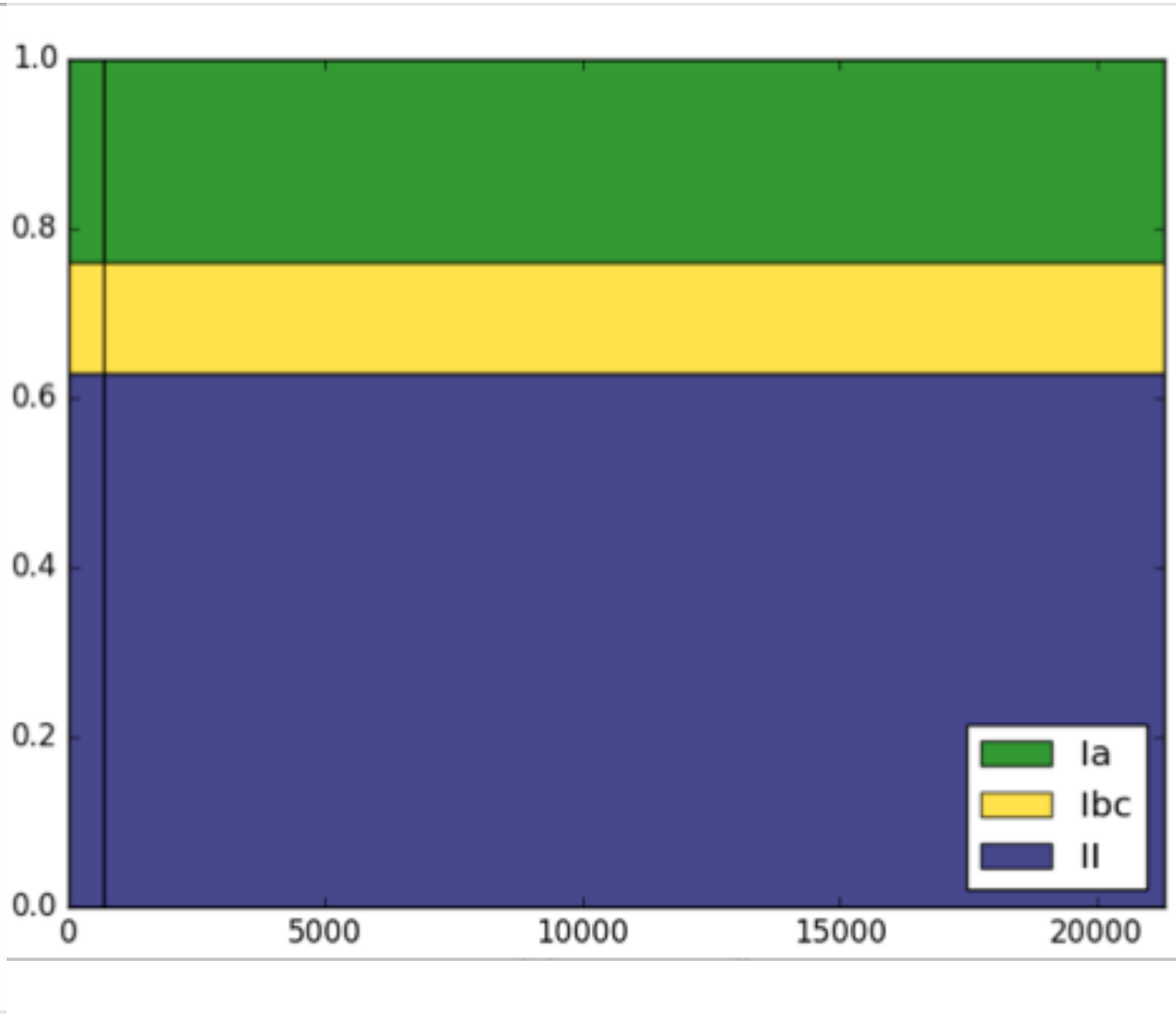
Mock spectra, created with 4MOST's exposure time calculator

Swann et al 2019

Magnitude cut

Training objects < 22.5 r-mag





Magnitude cut

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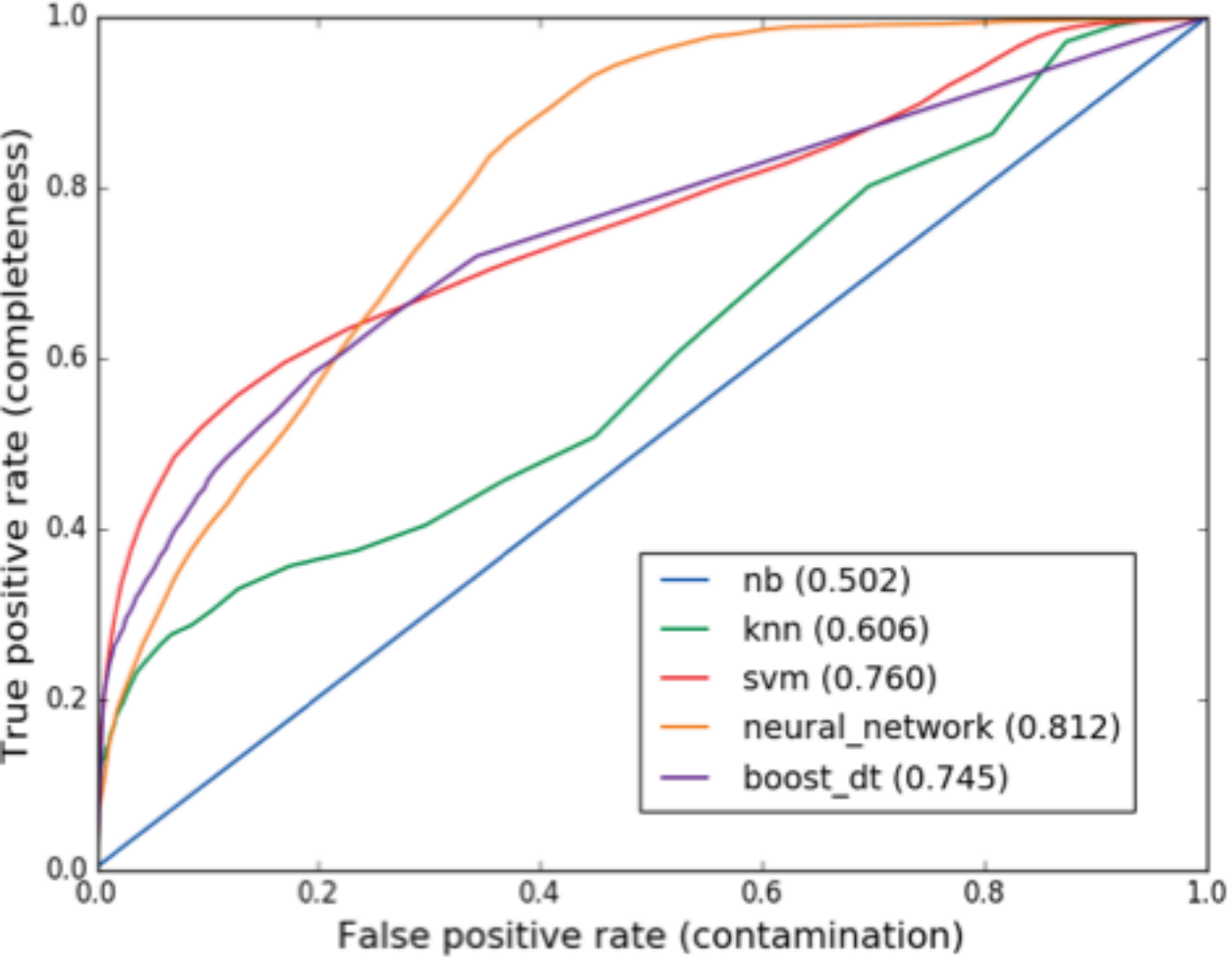

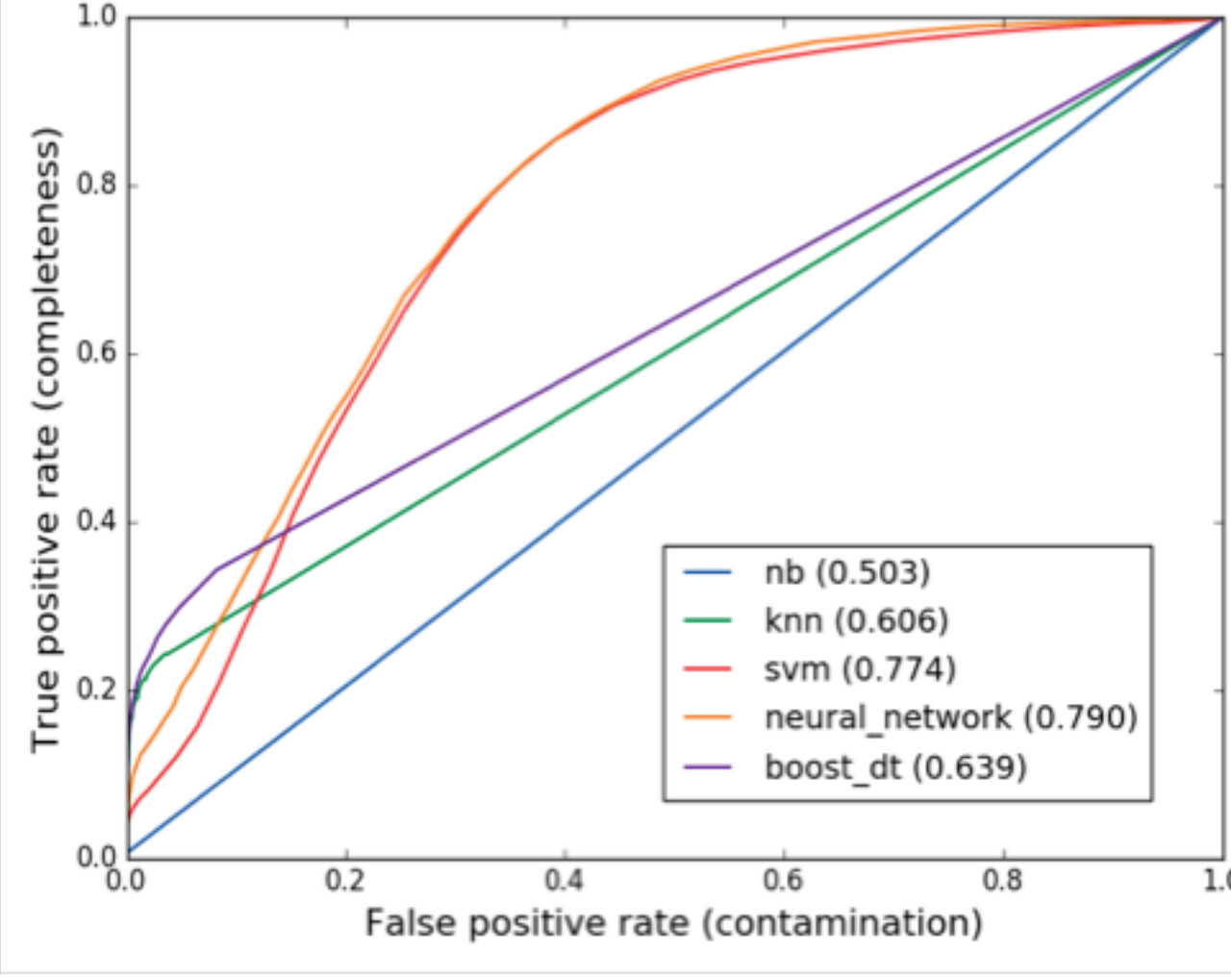

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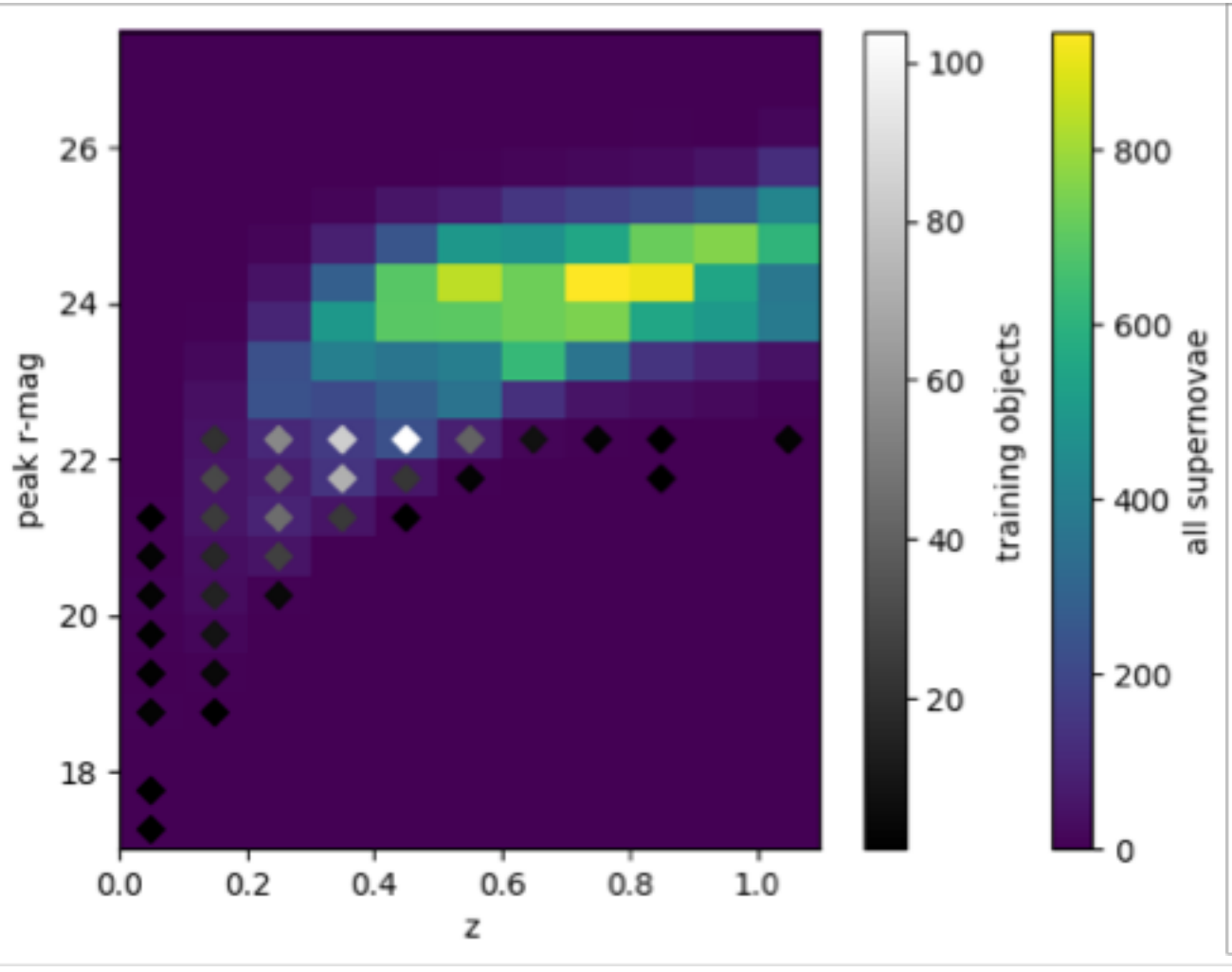
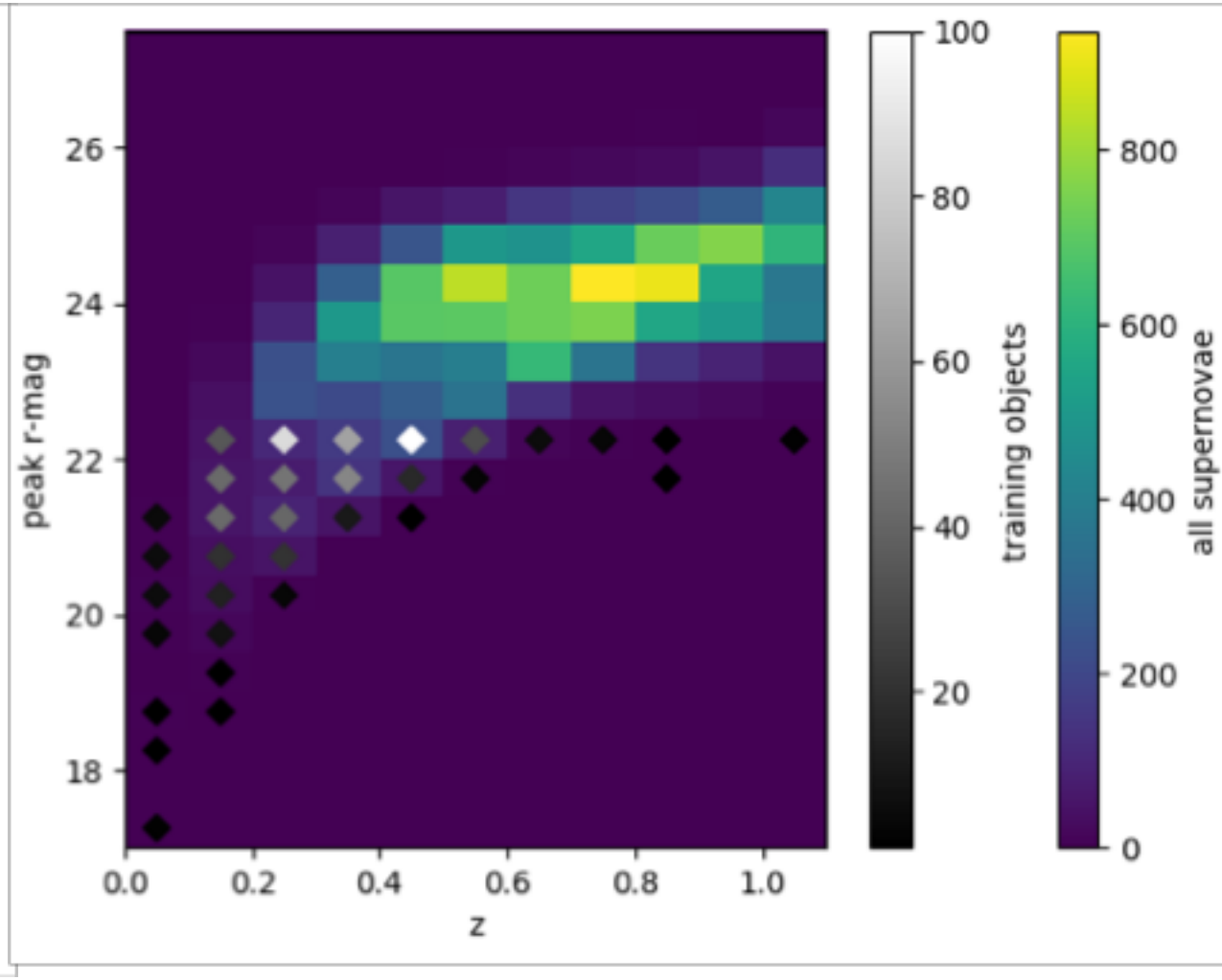
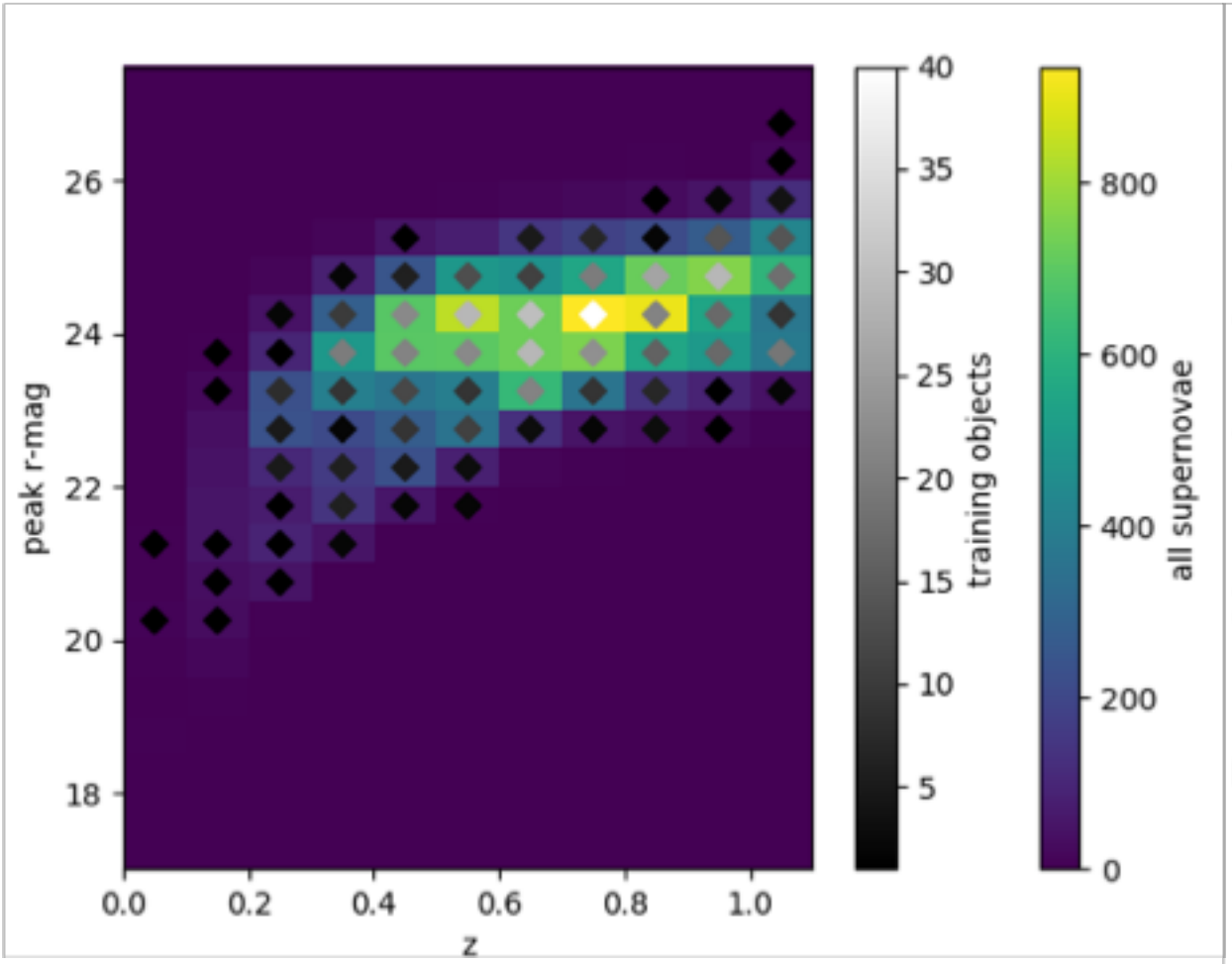
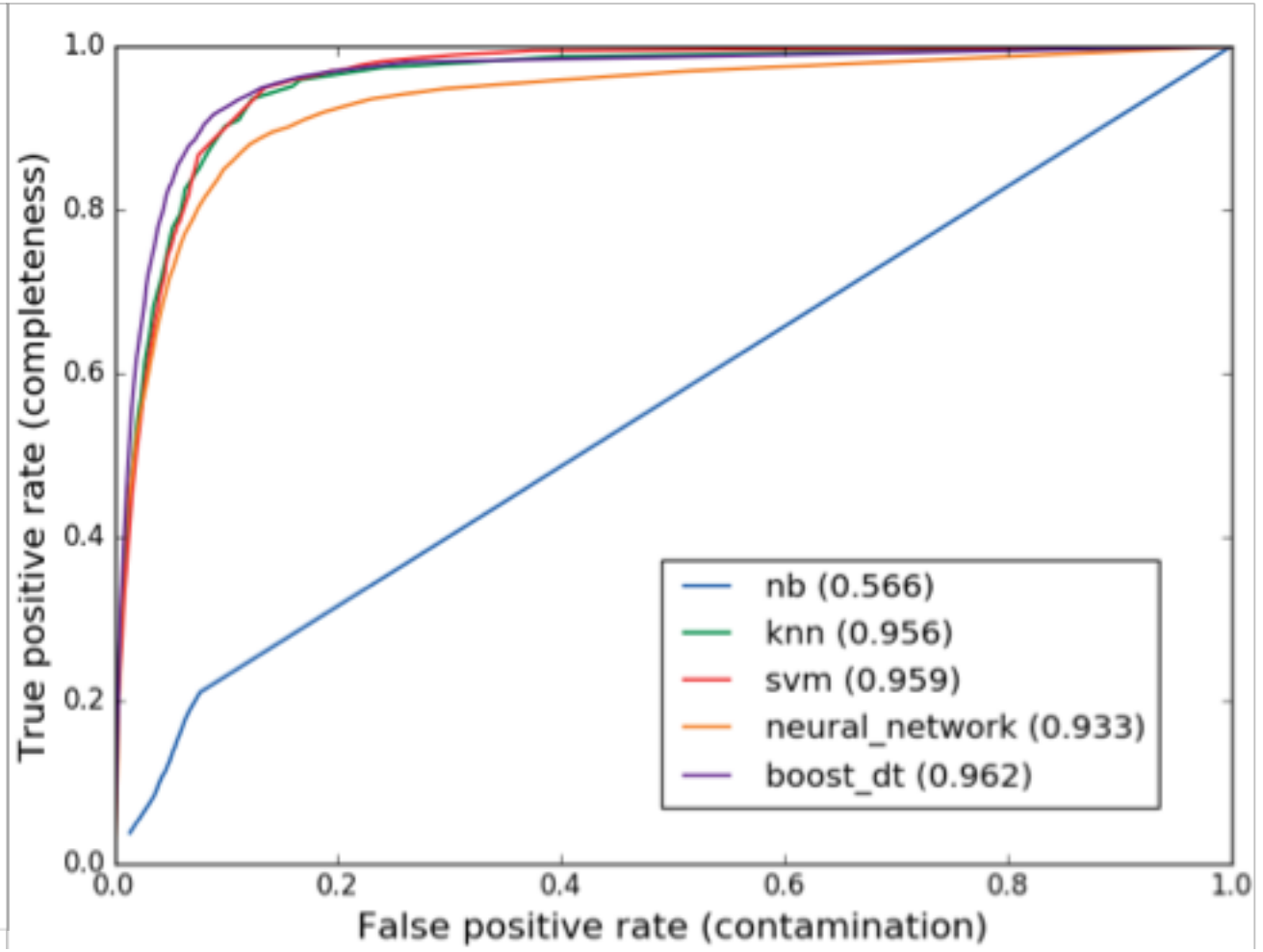




Class- and magnitude-representative

i.e. what we need for good photometric classification





Summary

- 4MOST will provide us with the largest spectroscopically confirmed sample of supernovae to date.
- To create a fully-representative training set for photometrically classifying LSST transients, we will need to either: apply data-augmentation methods; reallocate exposure times; make use of other spectroscopic facilities.

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LSST-DESC project: https://confluence.slac.stanford.edu/pages/viewpage.action?pageId=241349134

Image Credit: NASA/JPL-Caltech