Metrics for Supernova Classification

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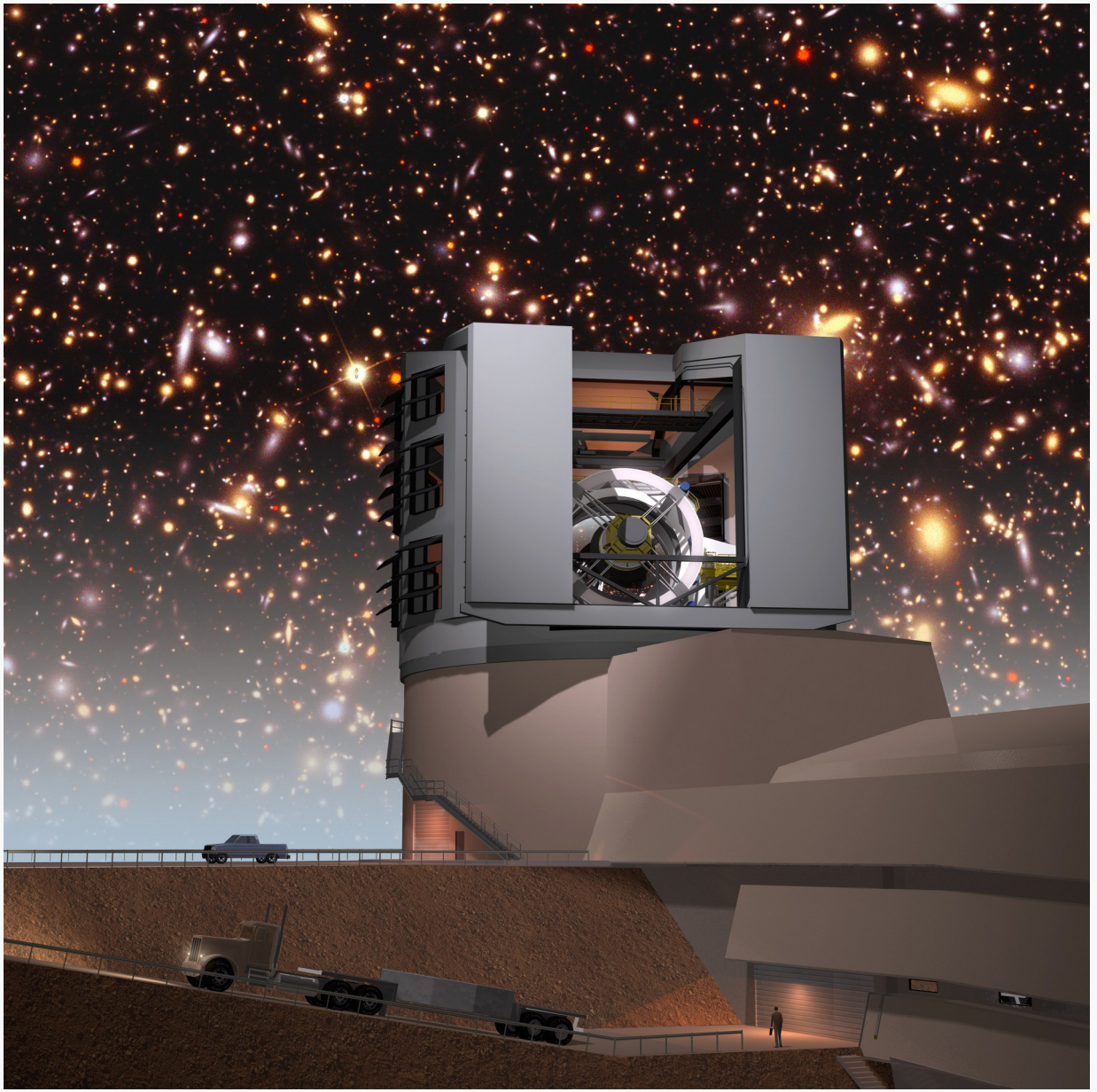
PLASTICC Workshop 2017

UCL
AIMS African Institute for Mathematical Sciences SOUTH AFRICA
SKA AFRICA SQUARE KILOMETRE ARRAY

LSST Supernova Survey



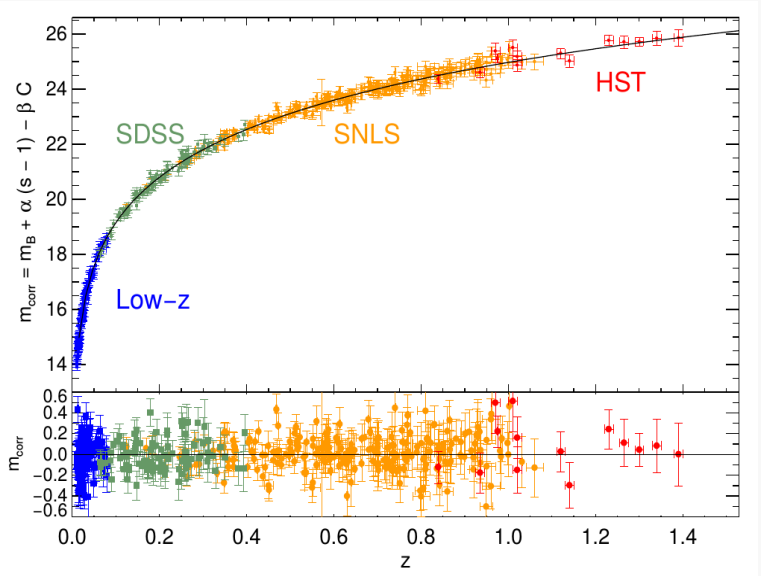
Over 10 years, LSST will detect ~100 000 well-characterised supernovae over the entire southern sky

LSST

Supernova types

Type Ia supernovae

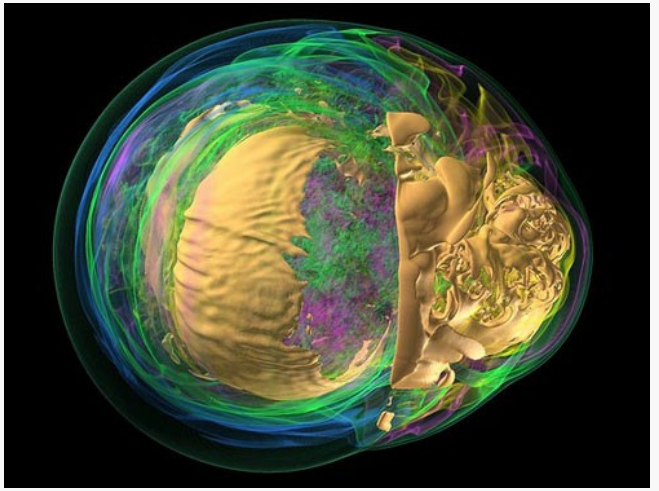
Cosmology



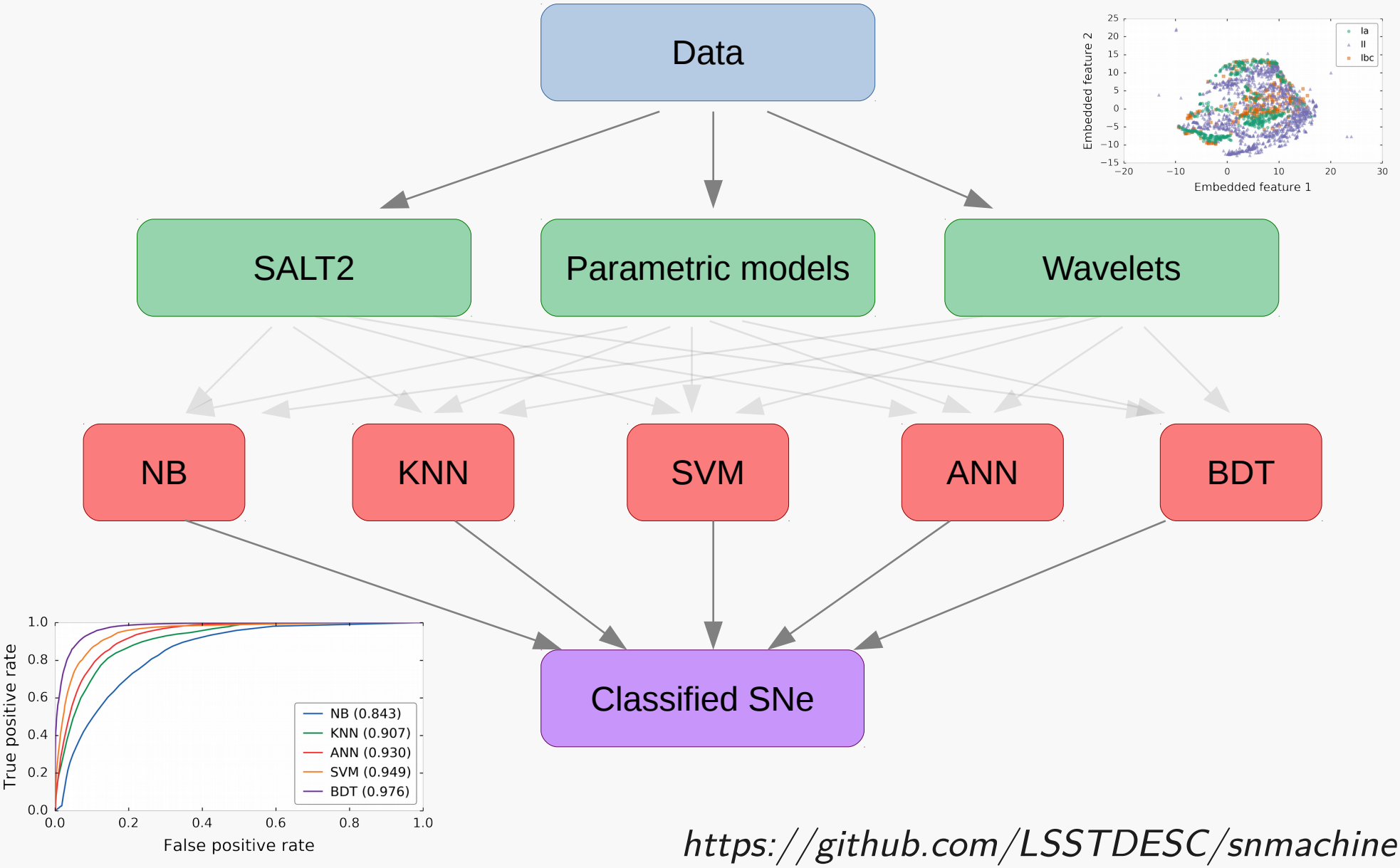
Conley et al. 2011

Core collapse supernovae

Supernova astrophysics

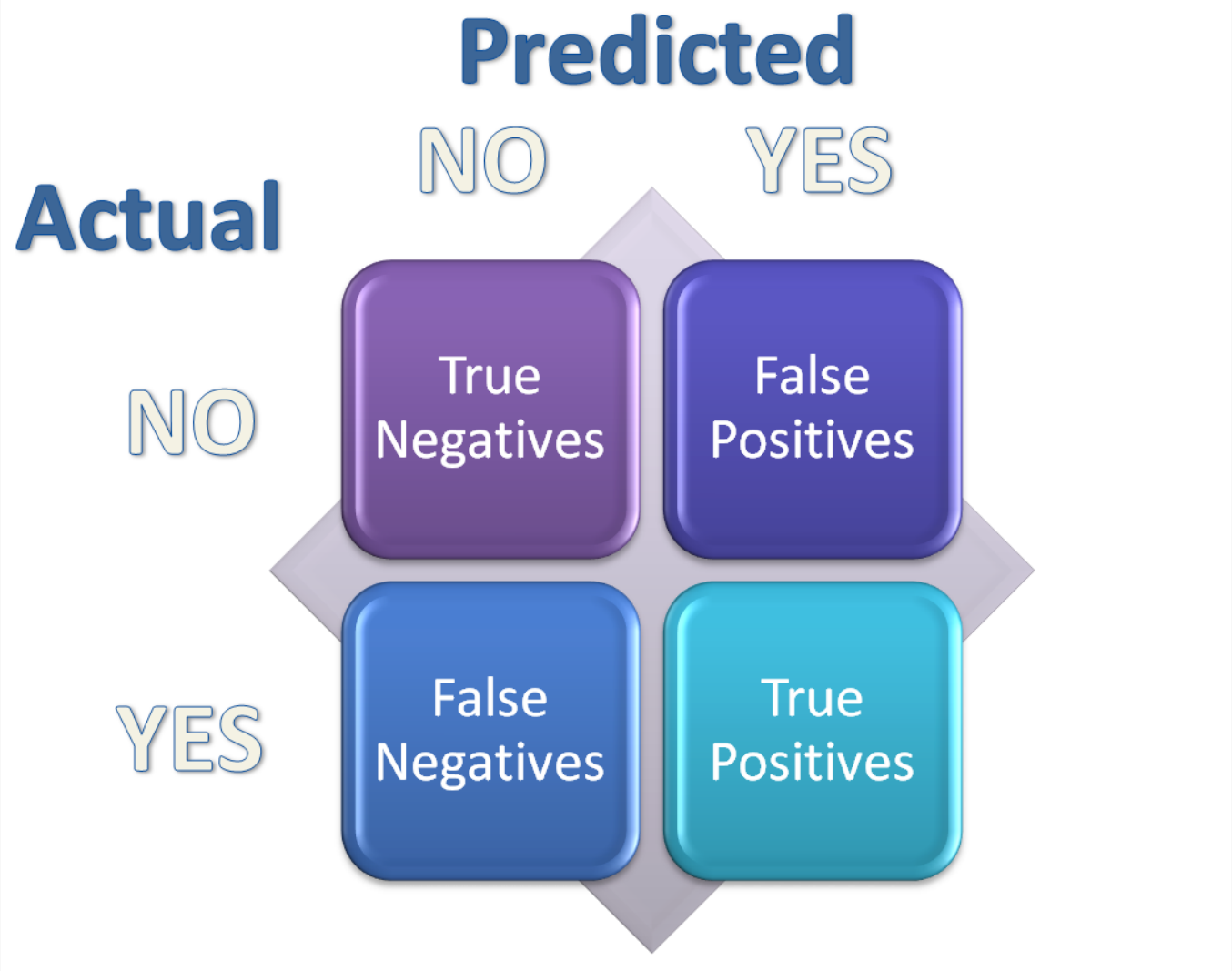


Pipeline



https://github.com/LSSTDESC/snmachine

Evaluating algorithms



Machine Learning Metrics

- Precision $\rightarrow$ TP/(TP + FP)
- Recall $\rightarrow$ TP/(TP + FN)
- Accuracy $\rightarrow$ (TP + TF) / N
- ...

Supernova Photometric Challenge

Kessler et al. (2010)

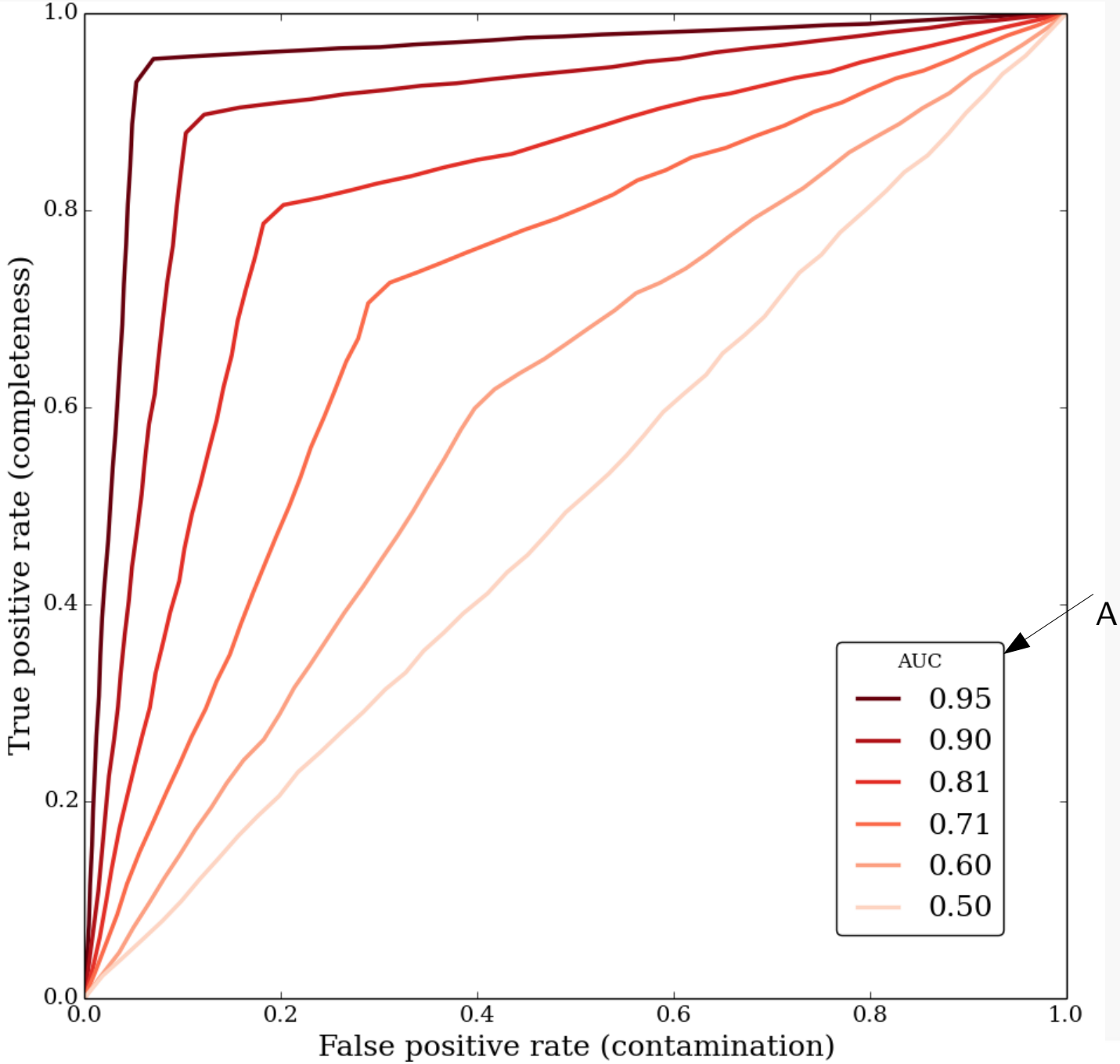
$$\mathcal{C}_{\mathrm{FoM-Ia}} \equiv \frac{1}{\mathcal{N}_{\mathrm{Ia}}^{\mathrm{TOT}}} \times \frac{(N_{\mathrm{Ia}}^{\mathrm{true}})^2}{N_{\mathrm{Ia}}^{\mathrm{true}} + W_{\mathrm{Ia}}^{\mathrm{false}} N_{\mathrm{Ia}}^{\mathrm{false}}}$$

$$= \epsilon_{\mathrm{Ia}} \times [N_{\mathrm{Ia}}^{\mathrm{true}} / (N_{\mathrm{Ia}}^{\mathrm{true}} + W_{\mathrm{Ia}}^{\mathrm{false}} N_{\mathrm{Ia}}^{\mathrm{false}})]$$

Rewards completeness

Penalises contamination

Receiver Operator Characteristic (ROC) curves

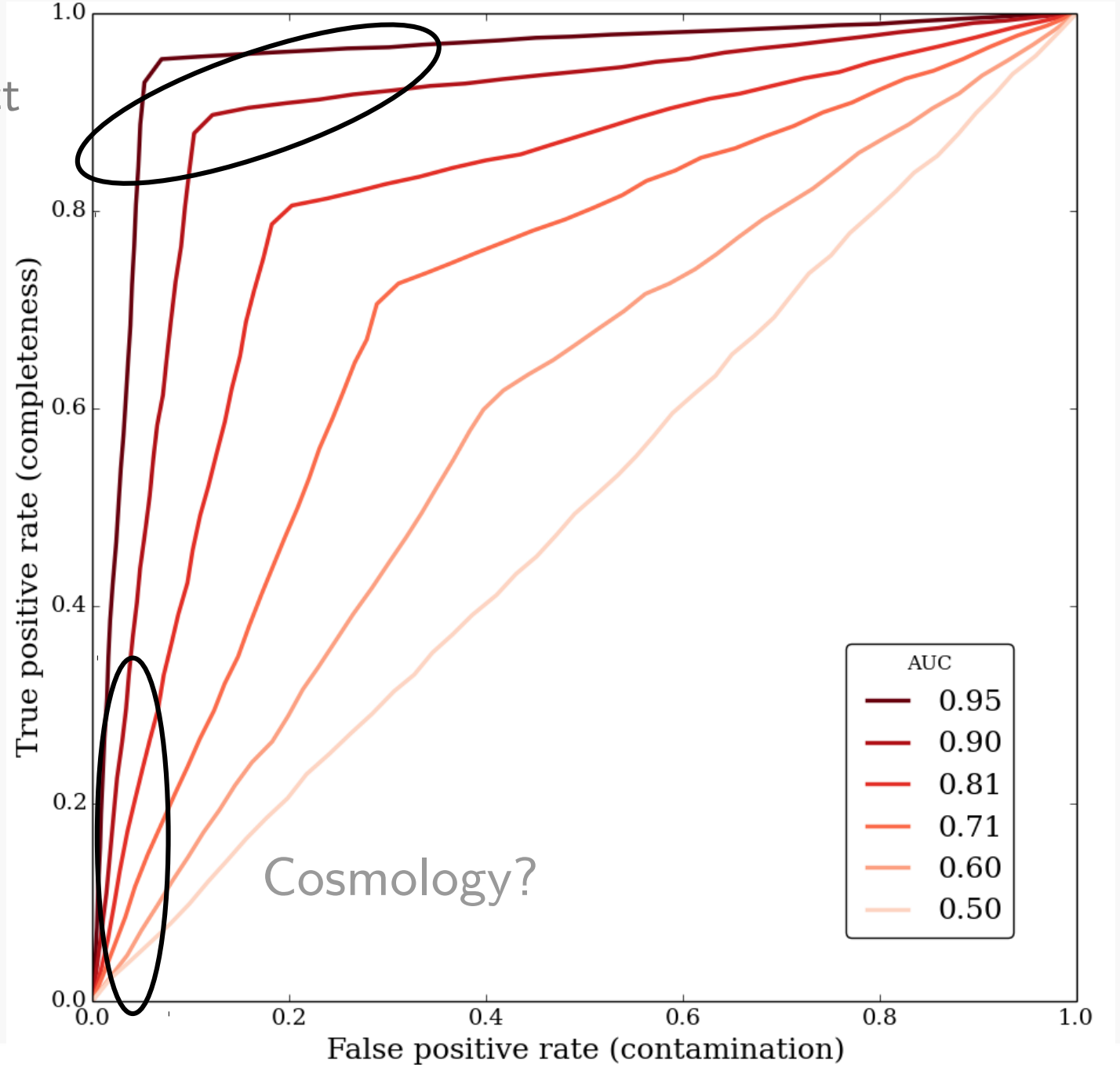


AUC =

Area Under Curve

Where does your science live?

Rare object discovery?
Cosmic census?



Advantages of ROC Curves

- Gives you the full picture without arbitrary thresholding
- Allows the fair comparison of different algorithms for different possible science cases
- Rewards completeness while penalising false positives
- Robust to class imbalances

Connecting Metrics to Science

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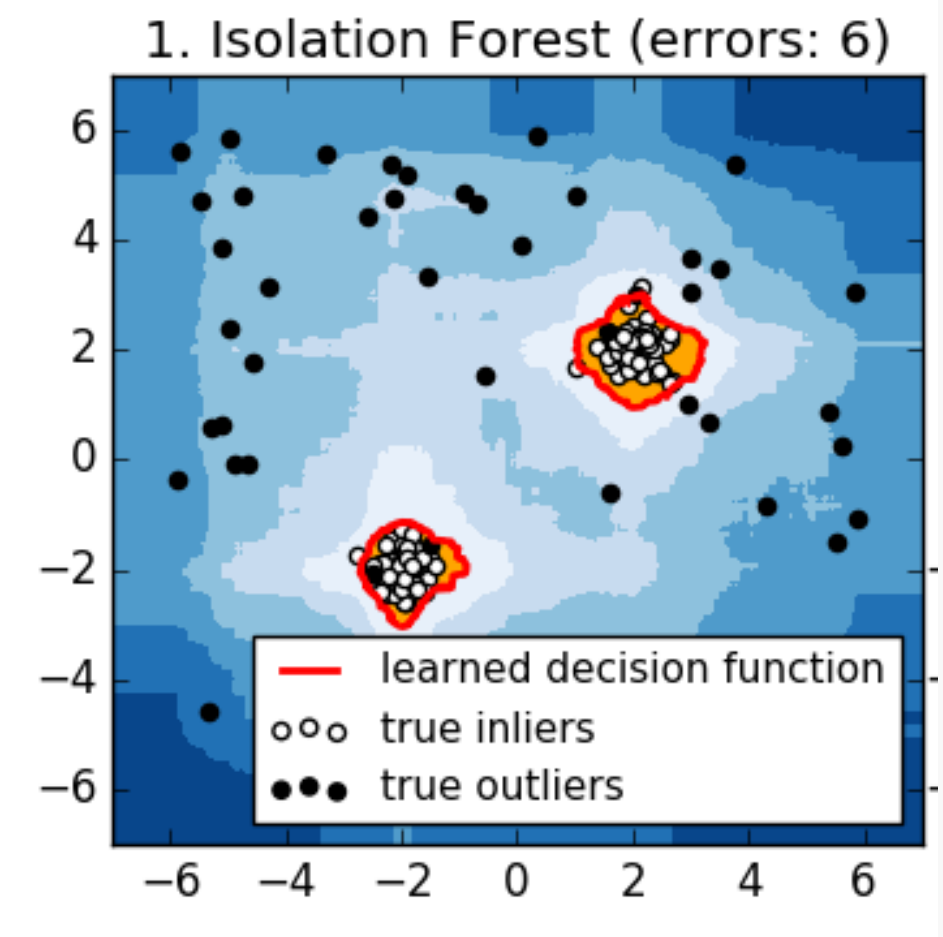
- Different science cases may need different metrics
- Simple metric: for a given purity, how many supernovae do I find?
- Still some subtleties connecting to science

Anomaly detection

- The exciting prospect of discovering new objects with LSST!
- Most algorithms are supervised, anomaly detection is technically an unsupervised problem
- May need a unique metric
- Worth running an anomaly detection component of the challenge?



Discussion points

- How do we connect metrics to science?
- Is it even possible to find "one metric to rule them all"?
- Should there be multiple metrics for different science cases/ different challenges?
- How do we (easily) test that the metrics we come up with are reasonable?