FLAMEING: are we able to find SC4K-like LAEs using AI?

Ana Paulino-Afonso

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Unofficial team members, but people always available to discuss and help: Bruno Ribeiro (GBL/Celfocus), David Sobral (BNP Paribas), XGAL team, and CRISP team

This work was supported by Fundação para a Ciência e a Tecnologia (FCT) through the research grants UIDB/04434/2020 and UIDP/04434/2020, the FCT Investigador FCT Contract No. 2020.03946.CEECIND, and in the form of an exploratory project with the EXPL/FIS-AST/1085/2021 reference (PI: Paulino-Afonso).

ia fct Fundação para a Ciência e a Tecnologia

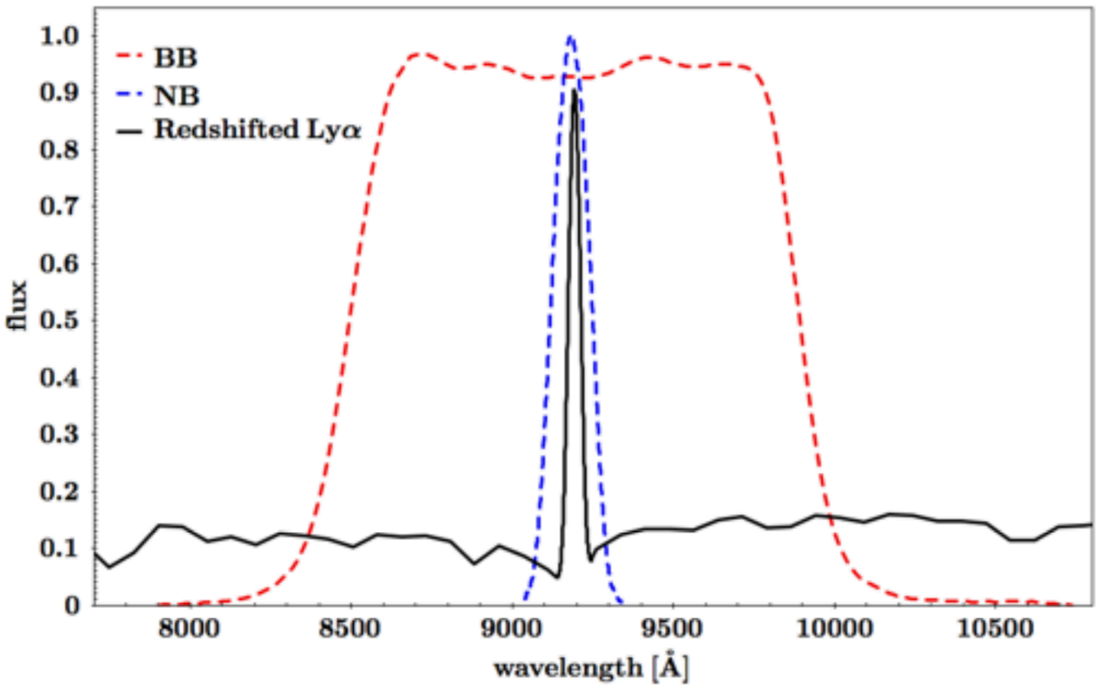
Escape of Lyman radiation from galactic labyrinths @ OAC, Kolymbari, Crete

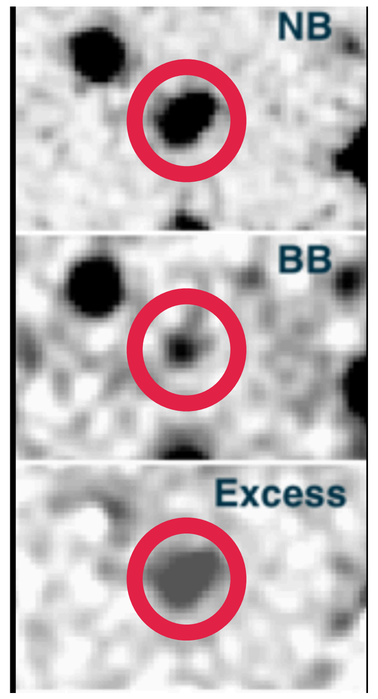
April 21, 2023

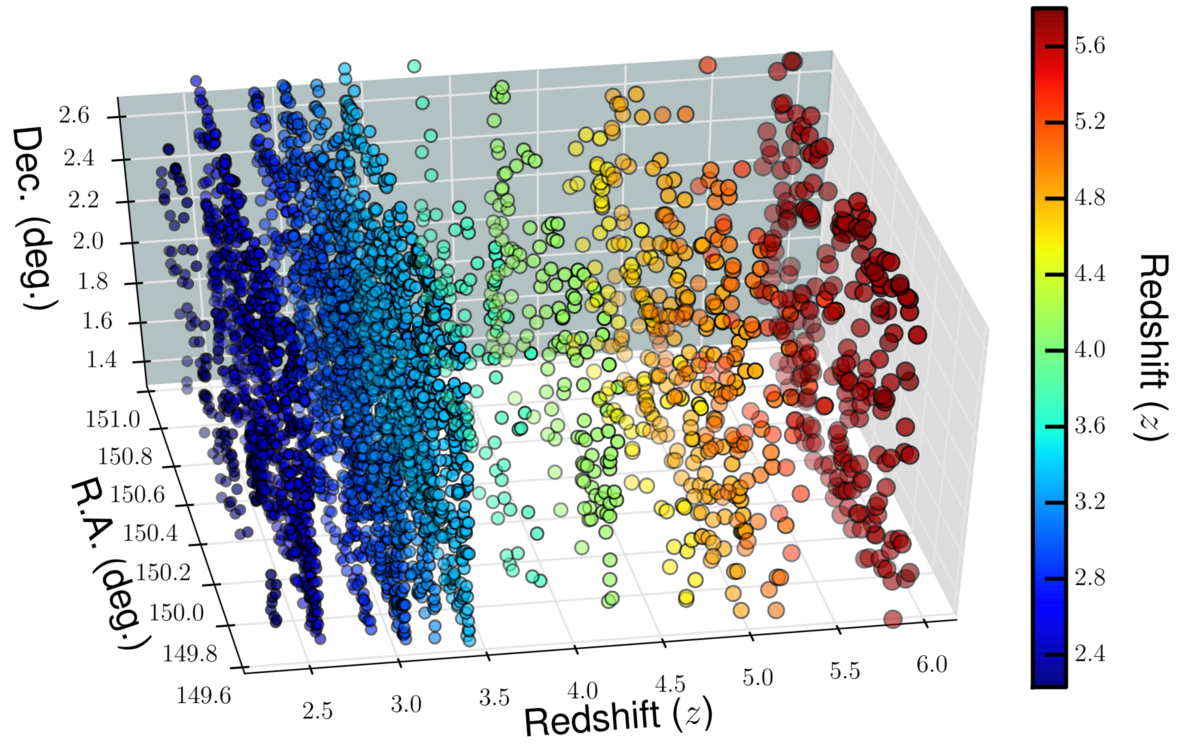
Introducing & Motivation: SC4K

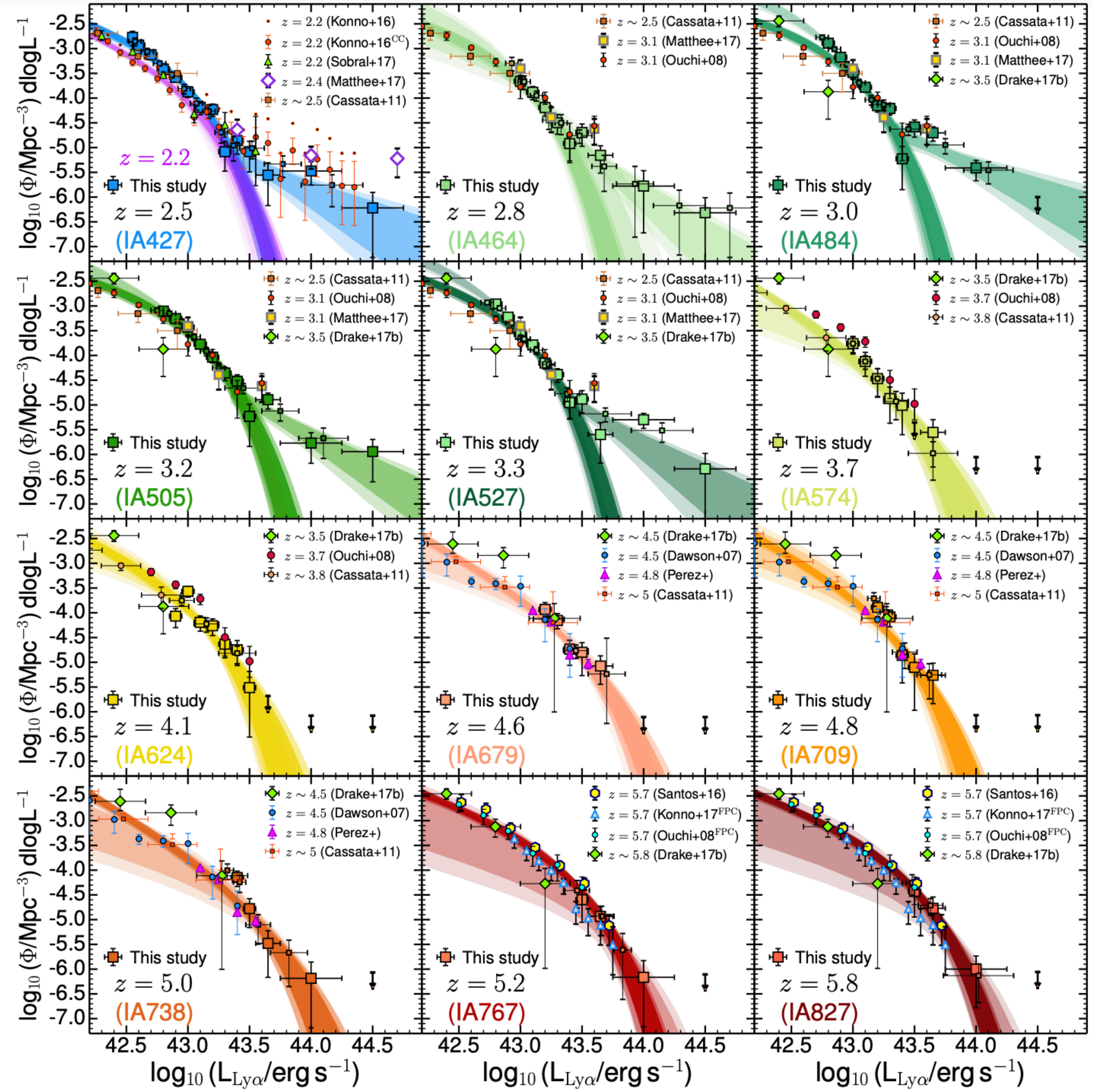
Sobral et al. 2018a

- A **good, well-understood selection** that can be applied with current instrumentation
- Well calibrated + sensitive + resulting in **a representative population of galaxies**
- Able to uniformly select **large samples**
- **Different epochs** + **large areas** + **best-studied fields**









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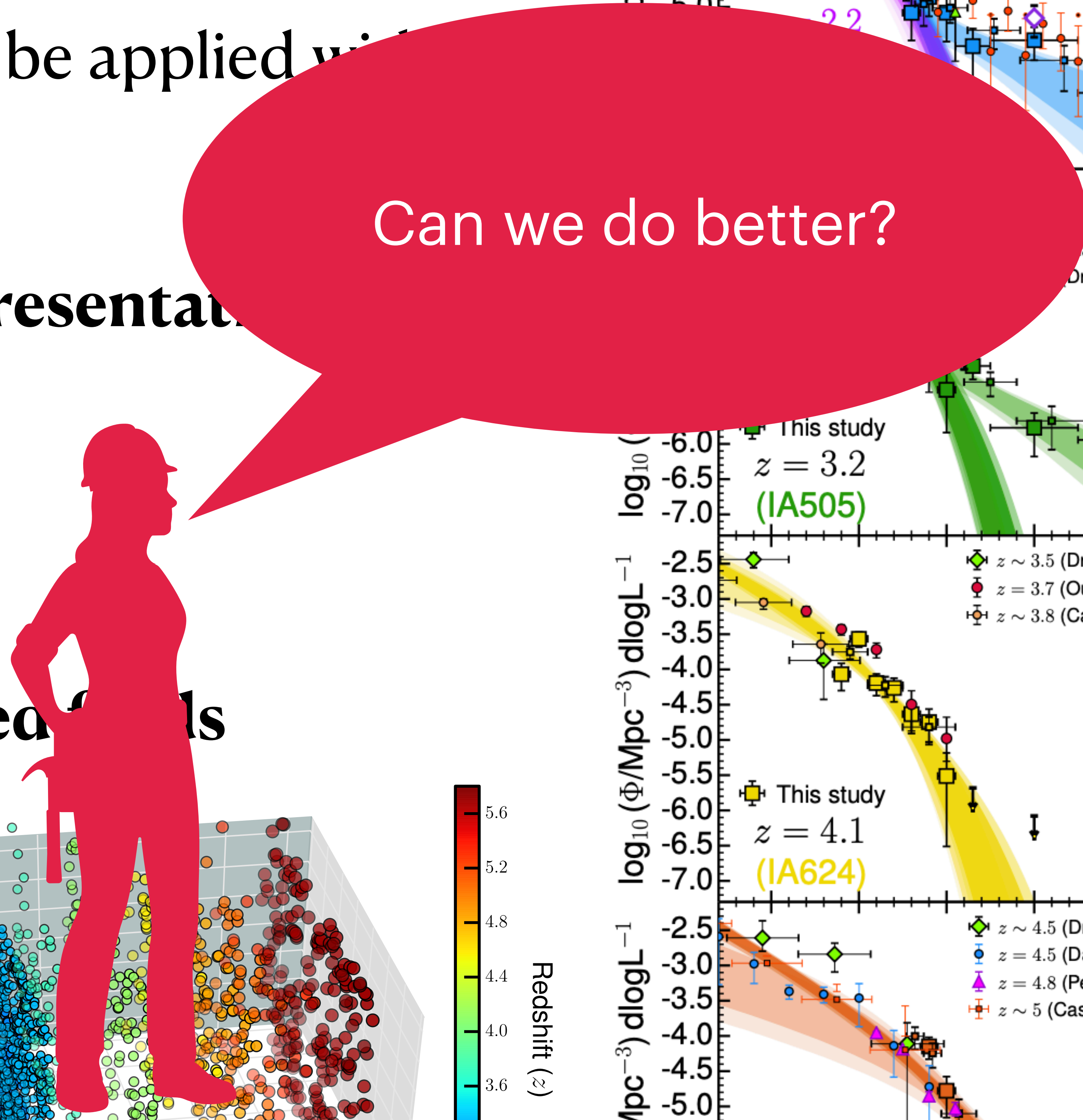

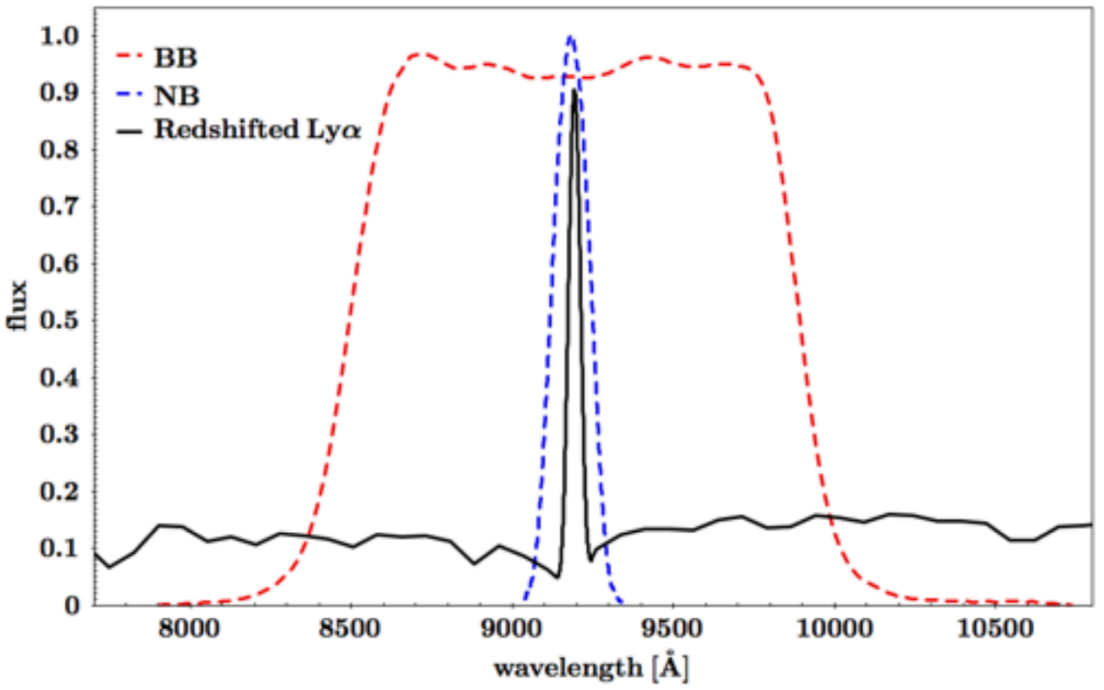

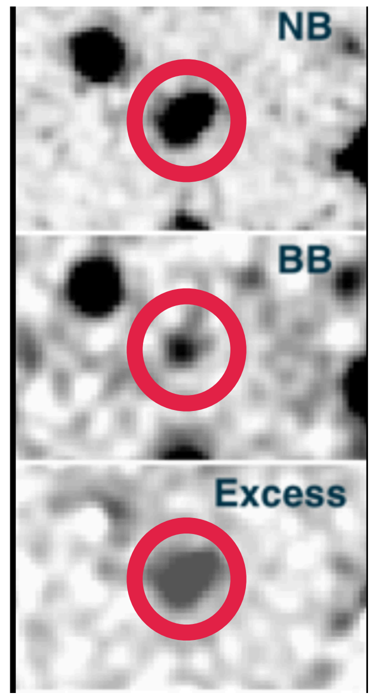

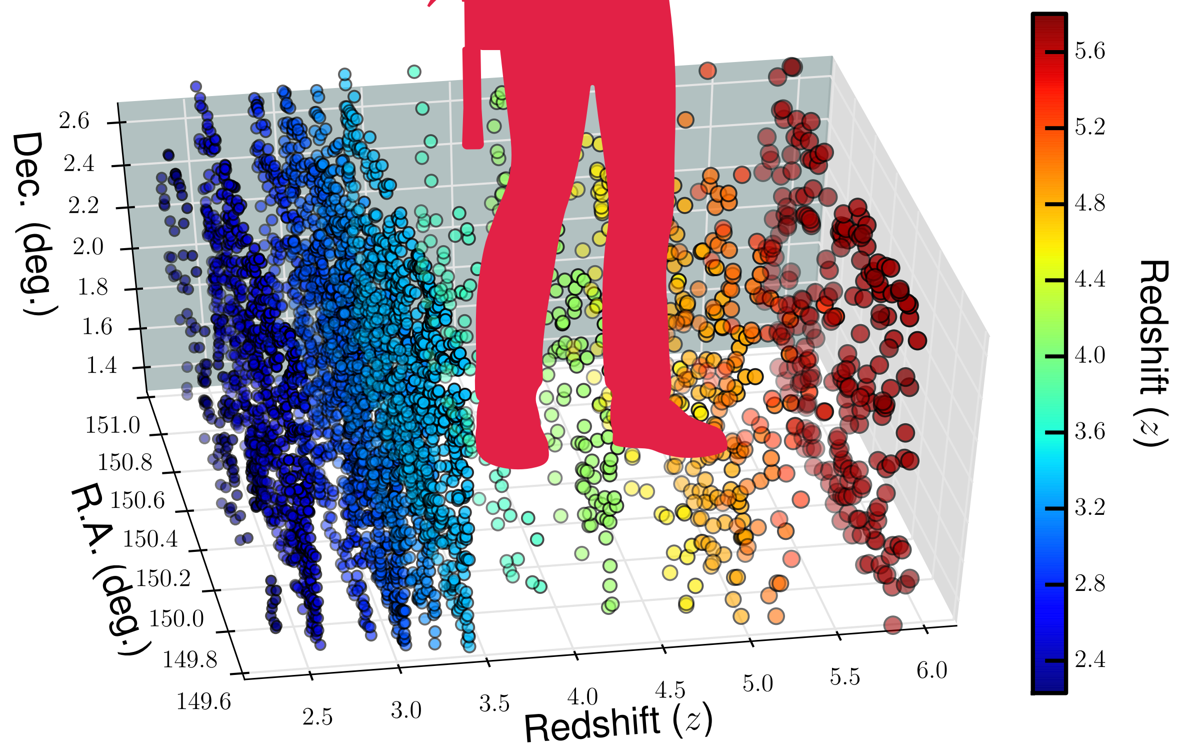

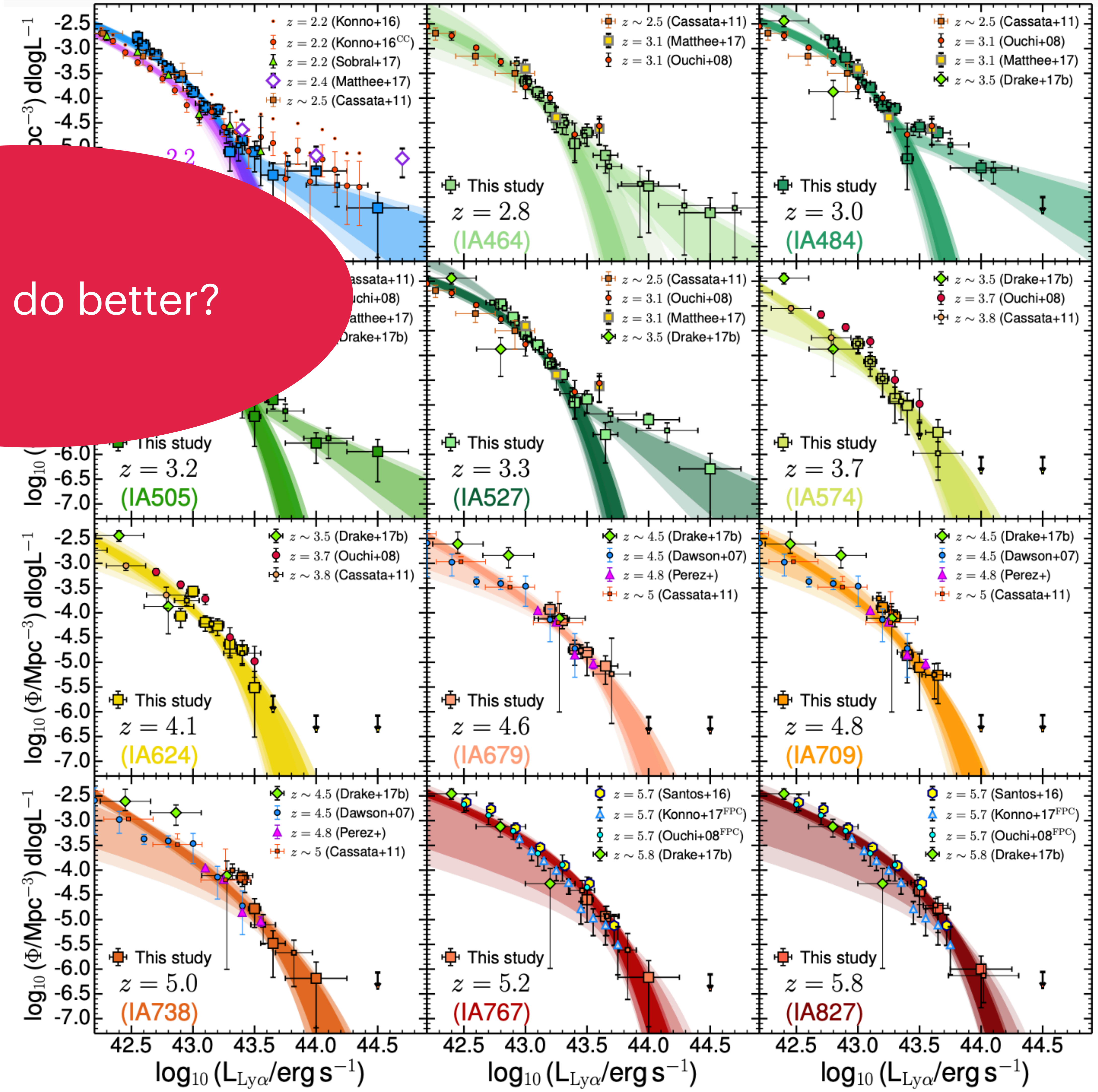

Introducing & Motivation: SILVERRUSH

Ono et al. 2022

ACCEPTED FOR PUBLICATION IN ApJ
Preprint typeset using LaTeX style emulateapj v. 12/16/11

9,318 new LAE candidates @ 2.2 < z < 7.0

177 of them with spectroscopic confirmation

SILVERRUSH X: MACHINE LEARNING-AIDED SELECTION OF 9,318 LAES AT $z = 2.2, 3.3, 4.9, 5.7, 6.6$, AND 7.0 FROM THE HSC SSP AND CHORUS SURVEY DATA

YOSHIAKI ONO[1], RYOHEI ITOH[1,2], TAKATOSHI SHIBUYA[3], MASAMI OUCHI[4,1,5], YUICHI HARIKANE[1,6], SATOSHI YAMANAKA[7,8], AKIO K. INOUE[9,7], TOSHIYUKI AMAGASA[10,11], DAICHI MIURA[10], MAIKI OKURA[10], KAZUHIRO SHIMASAKU[12,13], IKURU IWATA[4], YOSHIAKI TANIGUCHI[14], SEIJI FUJIMOTO[15], MASANORI IYE[4], ANTON T. JAELANI[16,17], NOBUNARI KASHIKAWA[12,13], SHOTARO KIKUCHIHARA[1,12], SATOSHI KIKUTA[11], MASAKAZU A.R. KOBAYASHI[18], HARUKA KUSAKABE[19], CHIEN-HSIU LEE[20], YONGMING LIANG[4], YOSHIKI MATSUOKA[8], RIEKO MOMOSE[12], TOHRU NAGAO[8], KIMIHIKO NAKAJIMA[4], AND KEN-ICHI TADAKI[4]

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ABSTRACT

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Keywords: galaxies: formation — galaxies: evolution — galaxies: high-redshift

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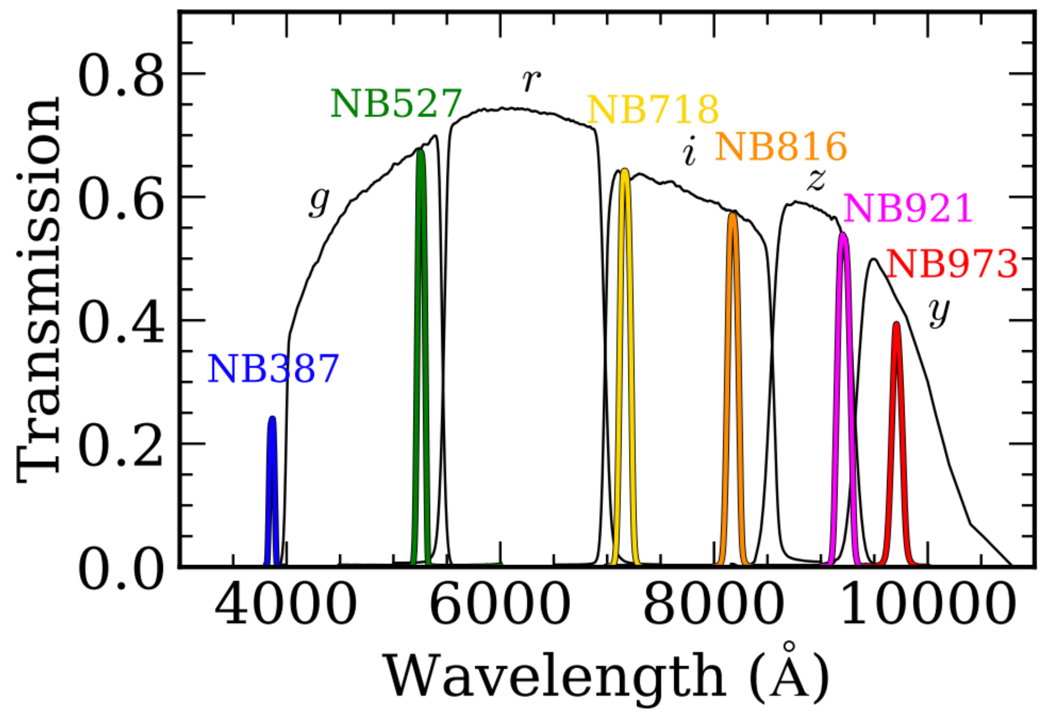

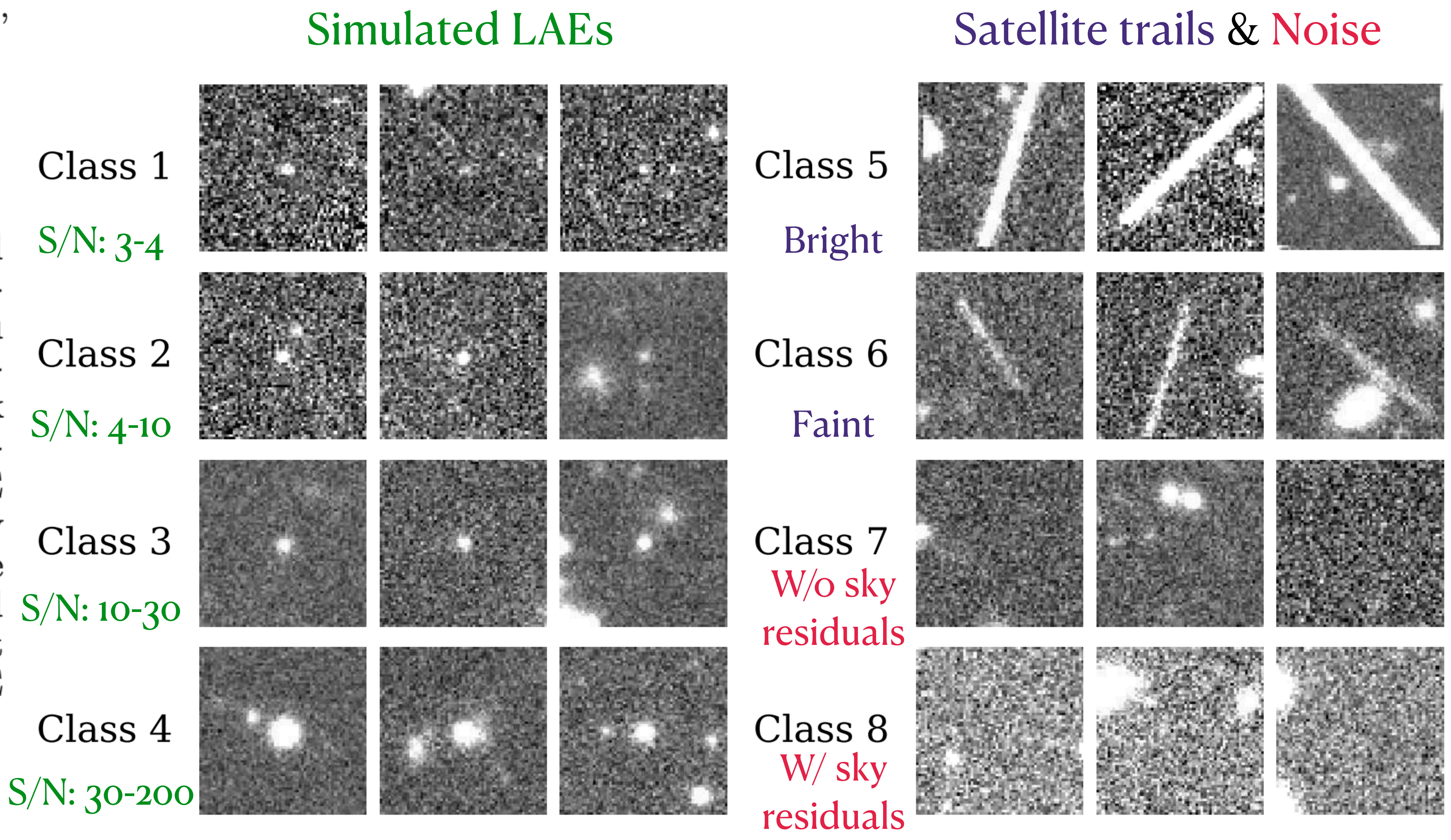

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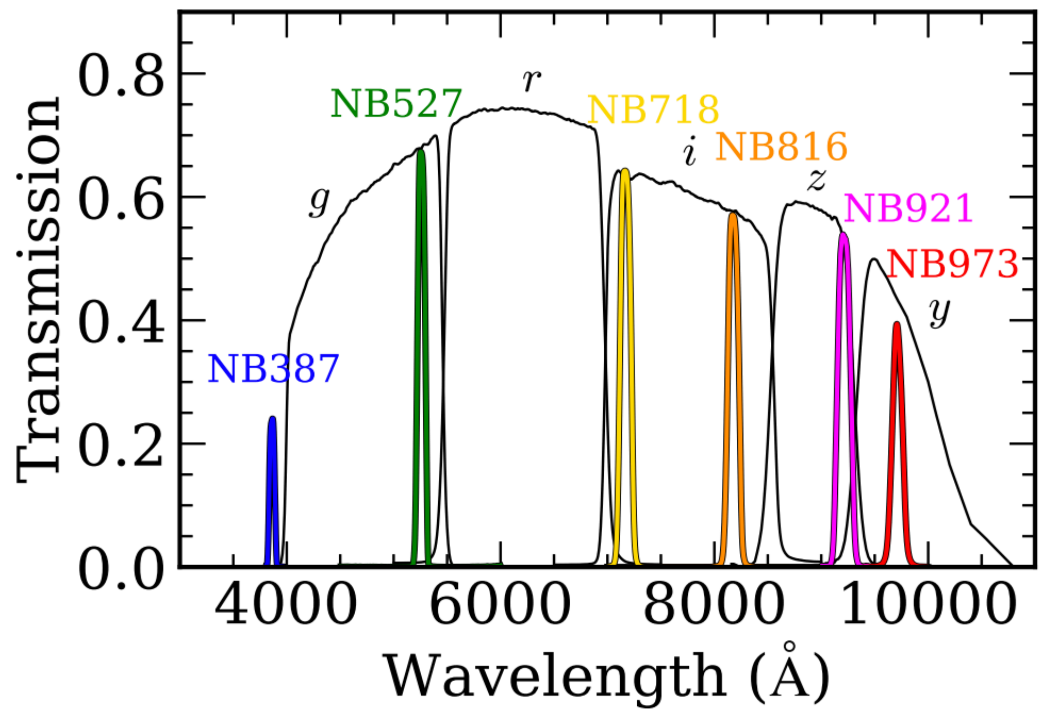
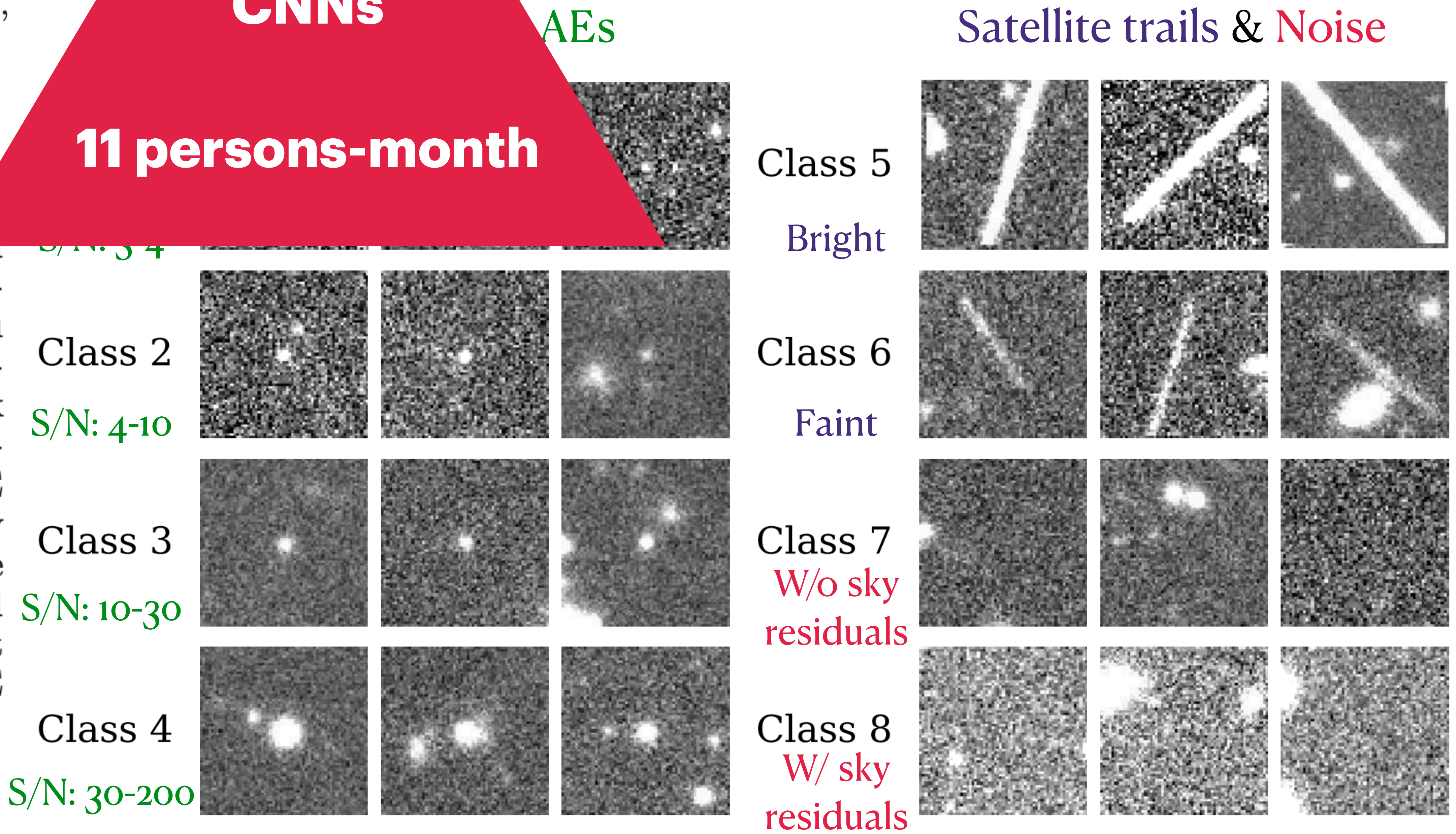
!!!

CNNs

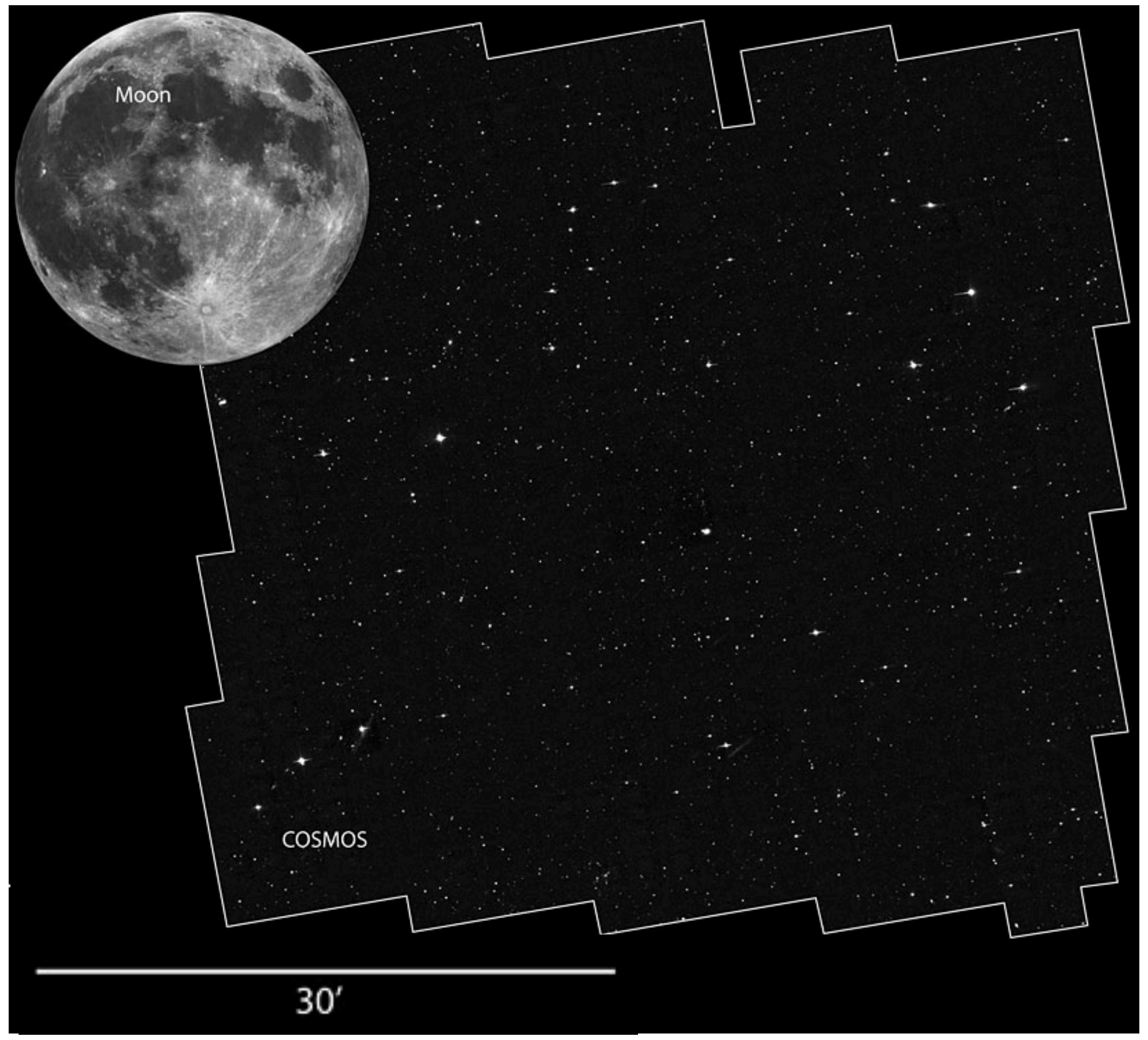
11 persons-month





Data & Feature Engineering

- COSMOS 2020 (Weaver et al. 2022a)
- SC4K 2018 (Sobral et al. 2018a)

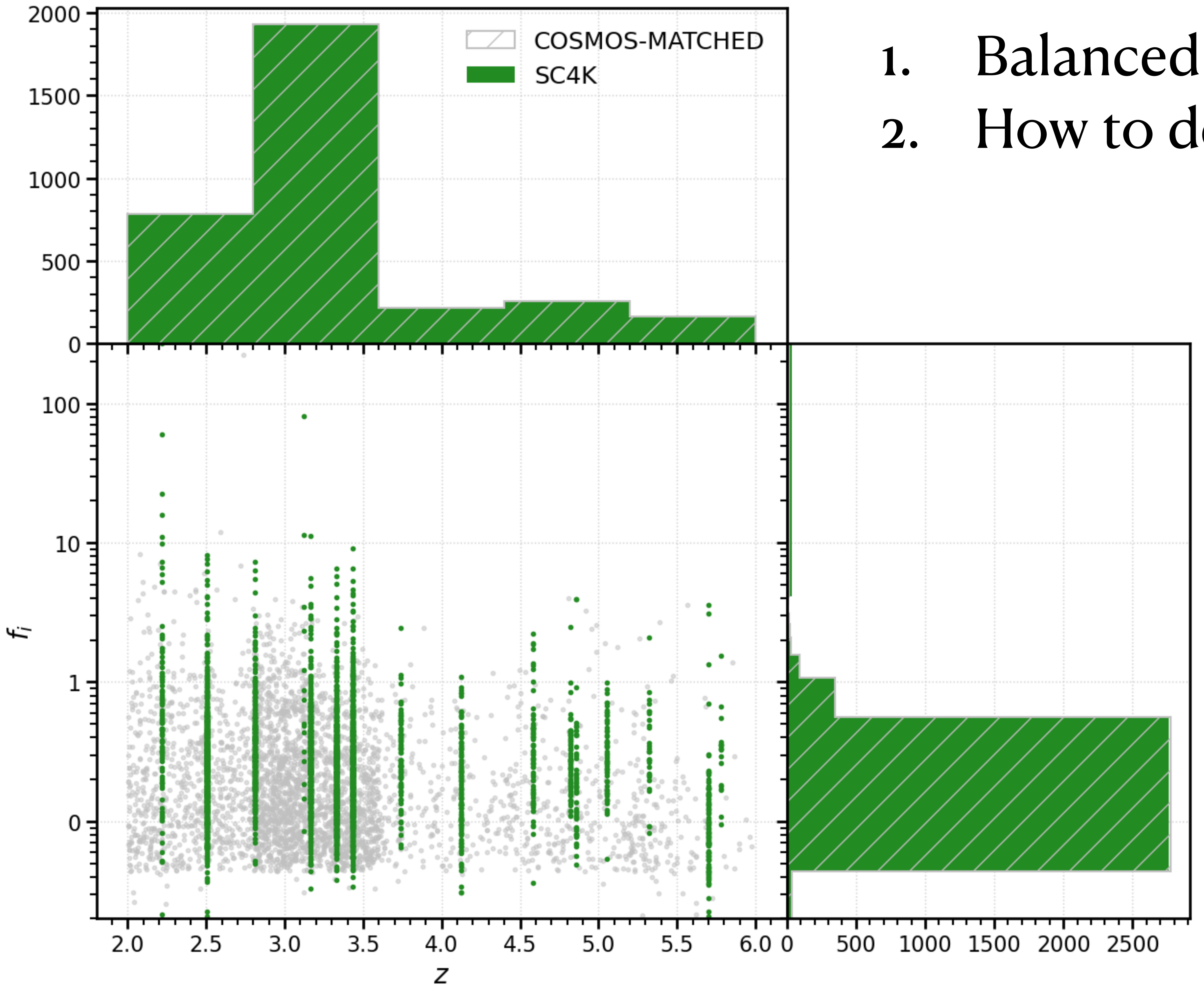


COSMOS field
Credit: NASA, ESA, and Z. Levay (STScI)

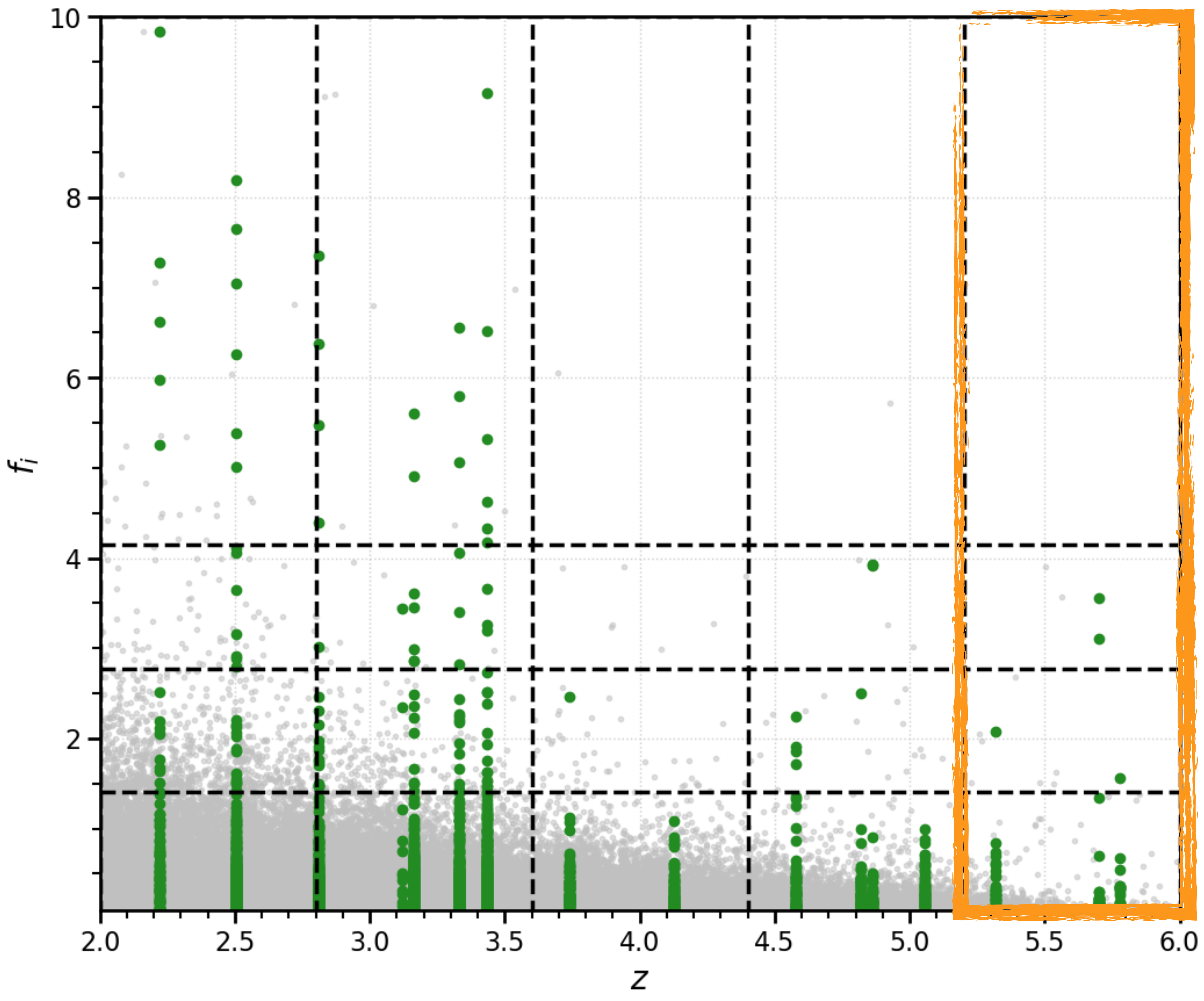
Optical to Near-Infrared

Fluxes + Uncertainties & Normalisation (unit-norm)

Data & Feature Engineering

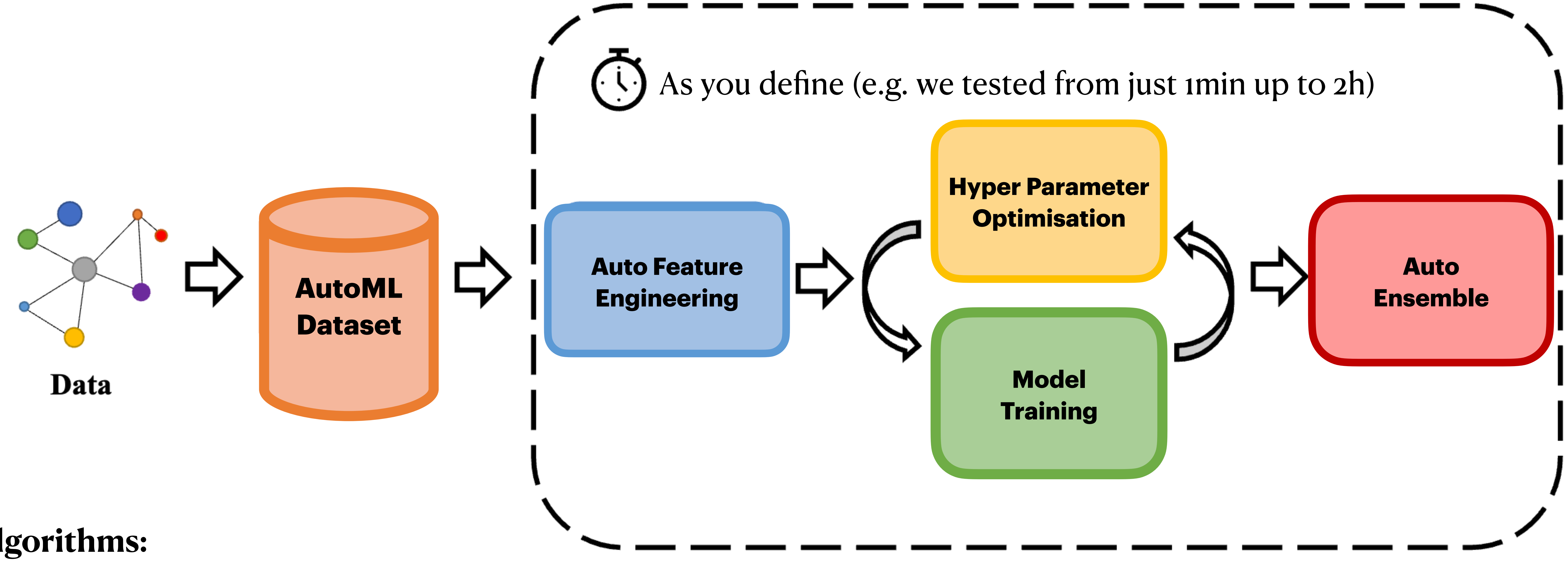


1. Balanced or unbalanced data?
2. How to define a proper sample of non-LAEs?



Methods: H20 AutoML

LeDell & Poirier 2020



Algorithms:

- Distributed Random Forest (DRF, including both Random Forest and Extremely Randomised Trees (XRT) models)
- Generalised Linear Model (GLM)
- XGBoost
- ***Gradient Boosting Machines (GBM)***
- DeepLearning
- ~~Stacked Ensemble~~

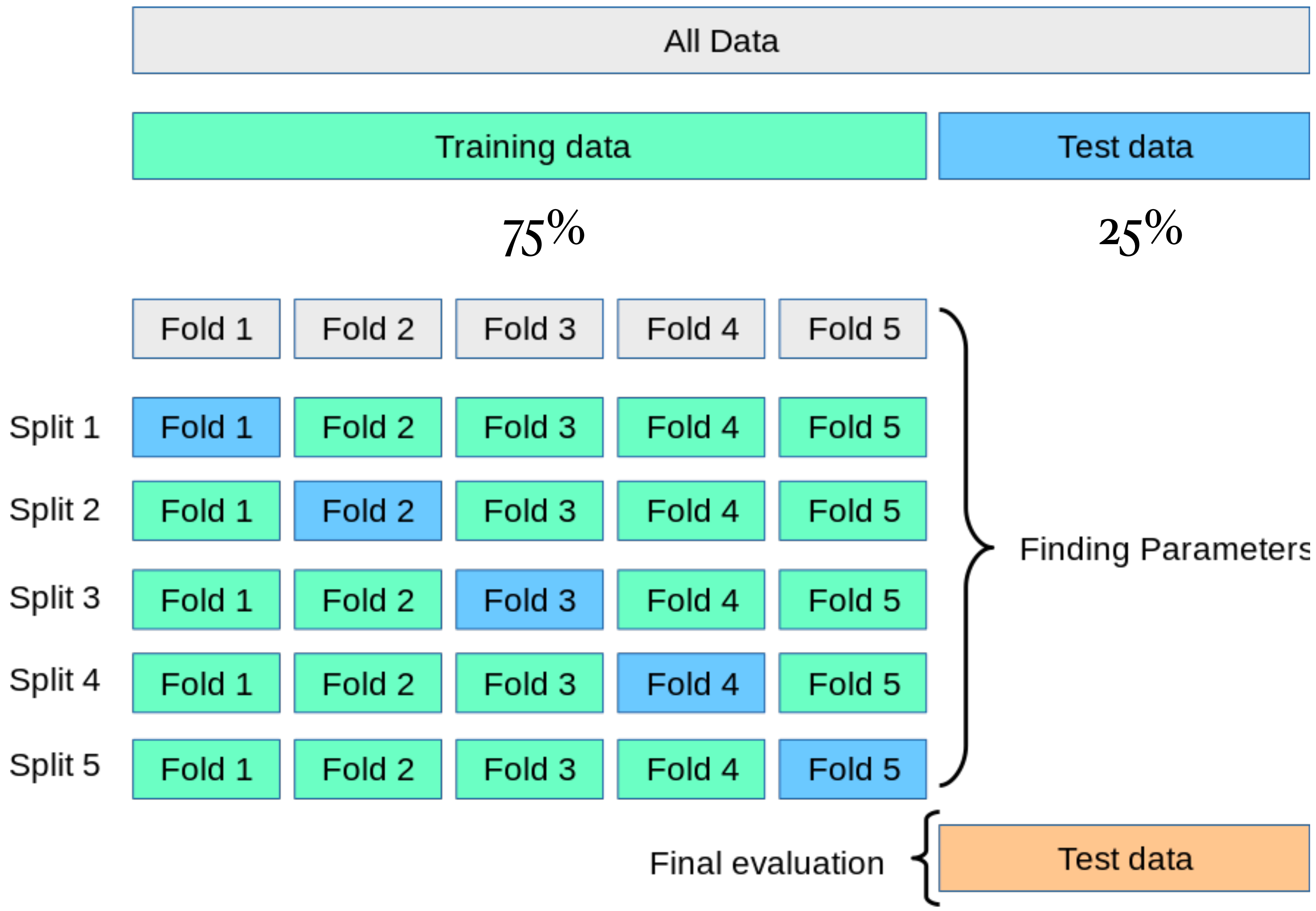
Classification
Regression

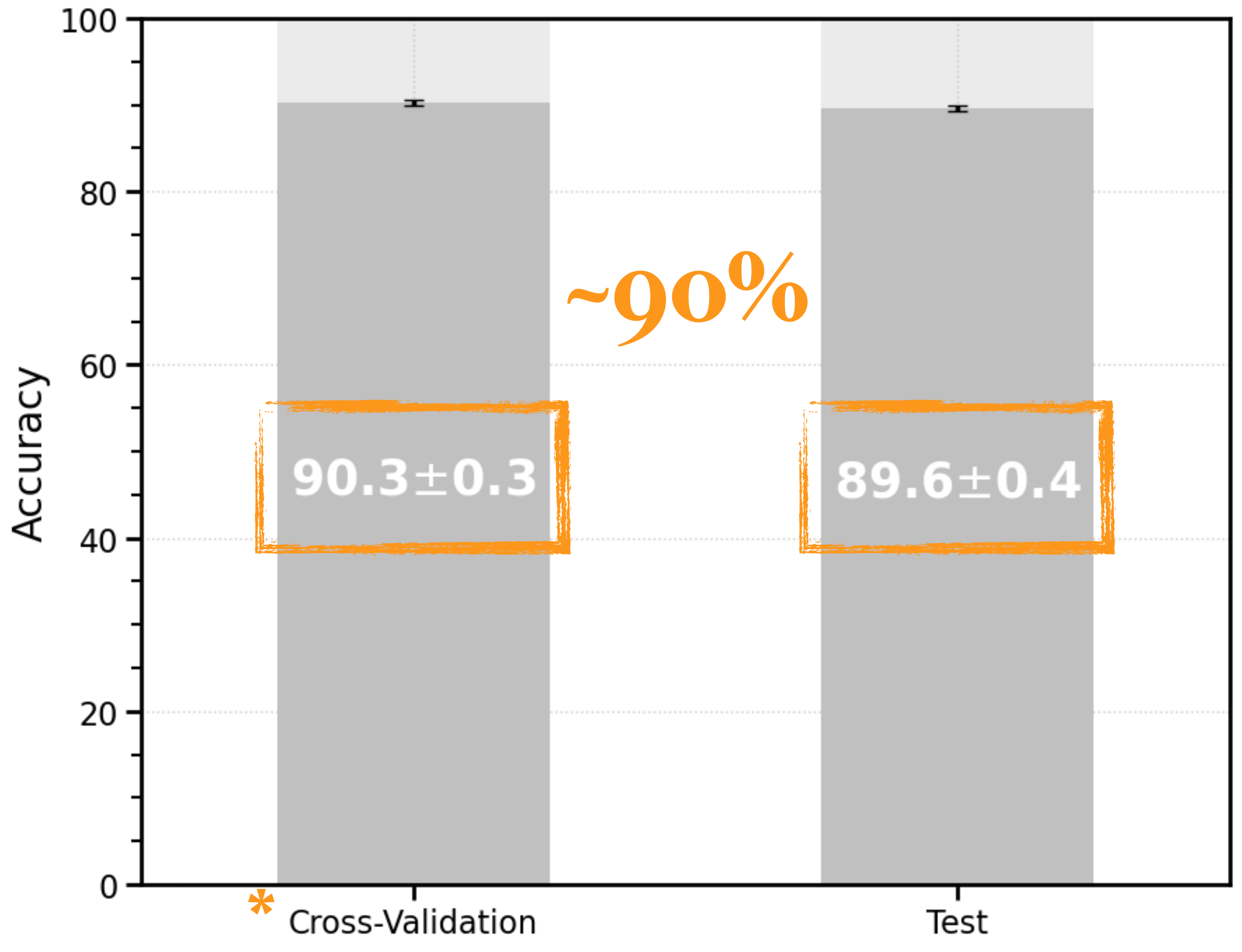
Supervised
Unsupervised

Tabular (**see Afonso's talk!**)
Image (**see Bruno's talk!**)
...

AutoML: evaluating the classification model

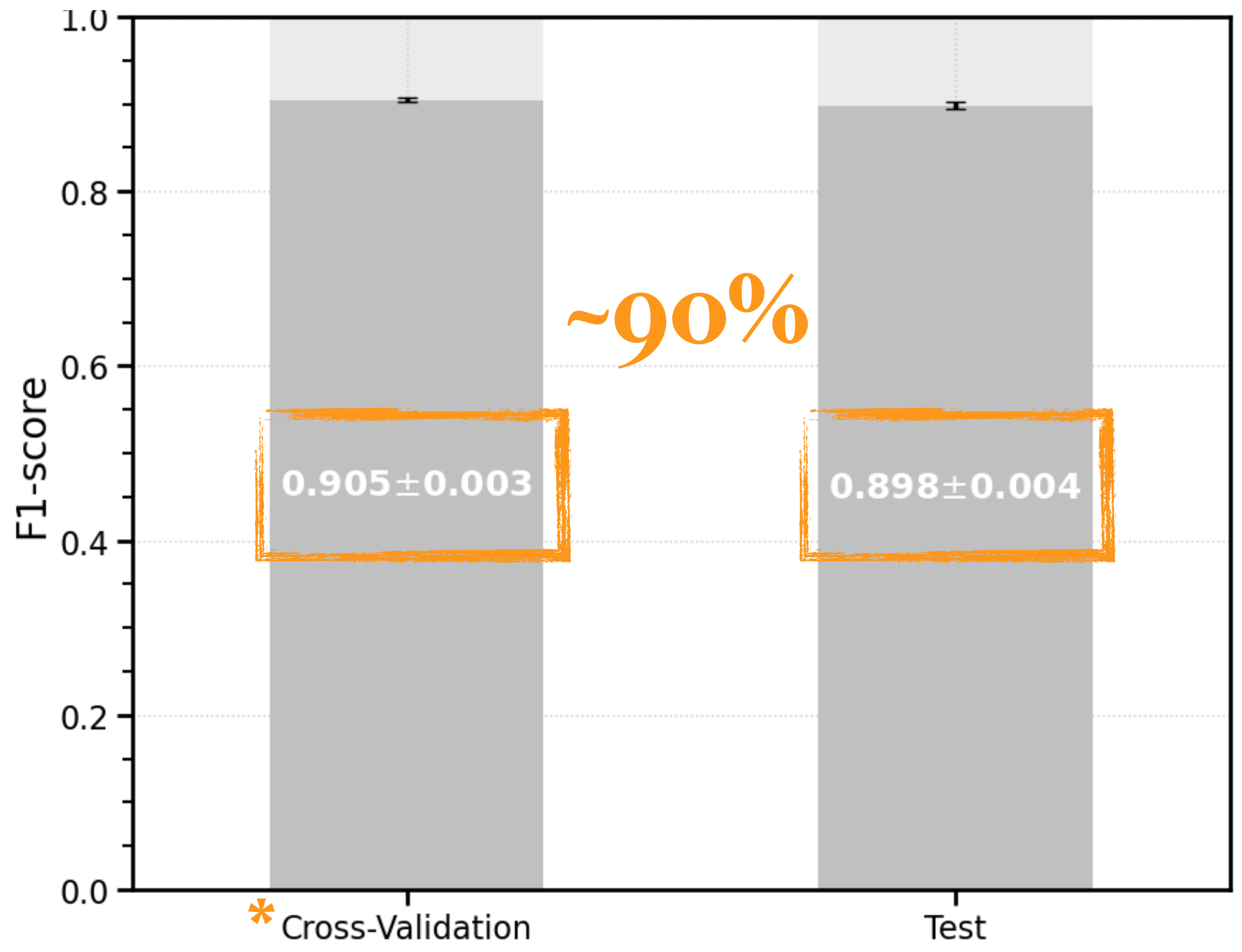
* ***Cross-validation***: a resampling method that uses different portions of the data to test and train a model on different iterations. **Important** to protect against overfitting, particularly when the amount of data is limited.





Accuracy is the ratio of predictions that exactly math the true class labels.

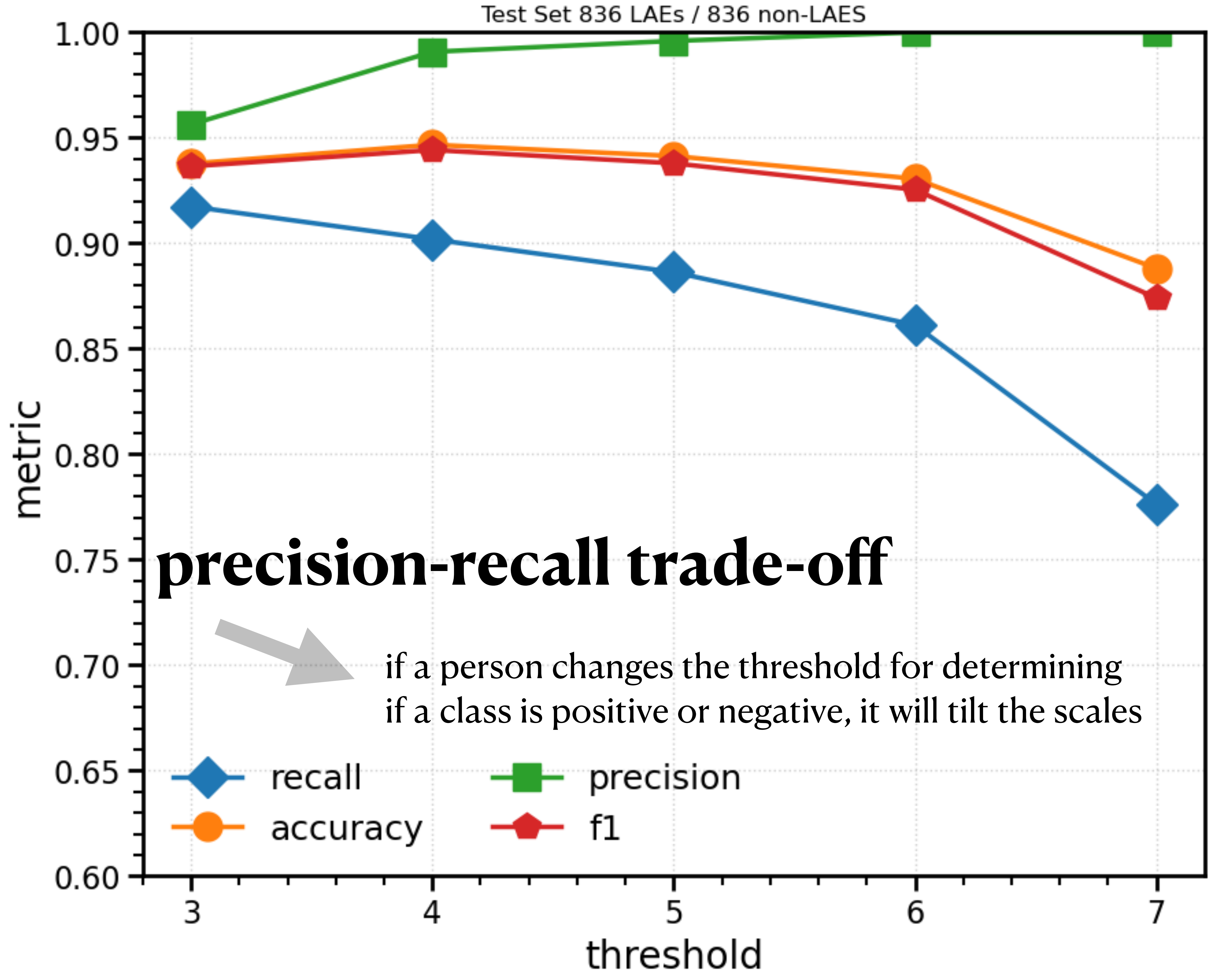
$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

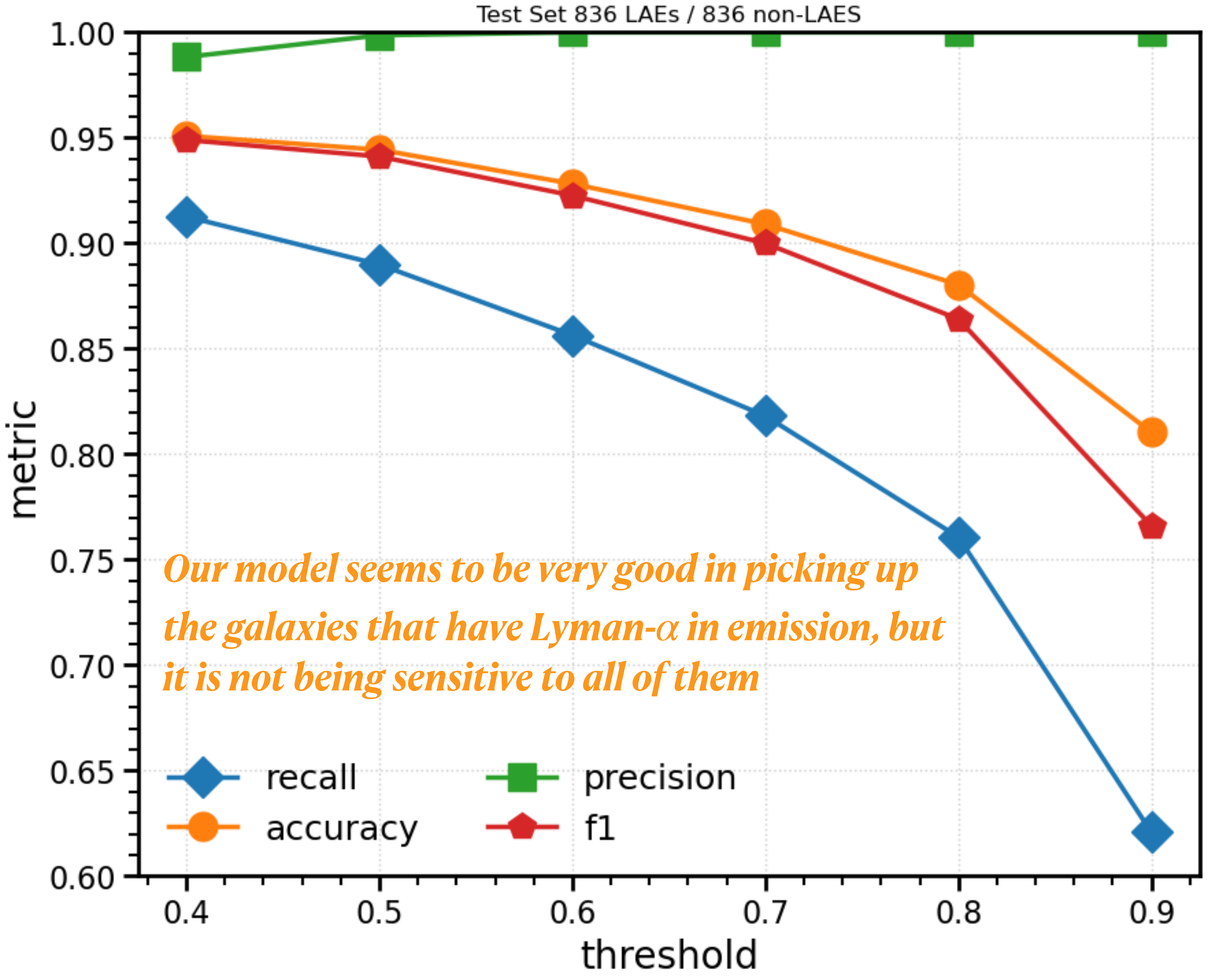


F1-score is a good balanced measure of both false positives and false negatives.

$$F1\ \ Score = \frac{2TP}{2TP + FP + FN}$$

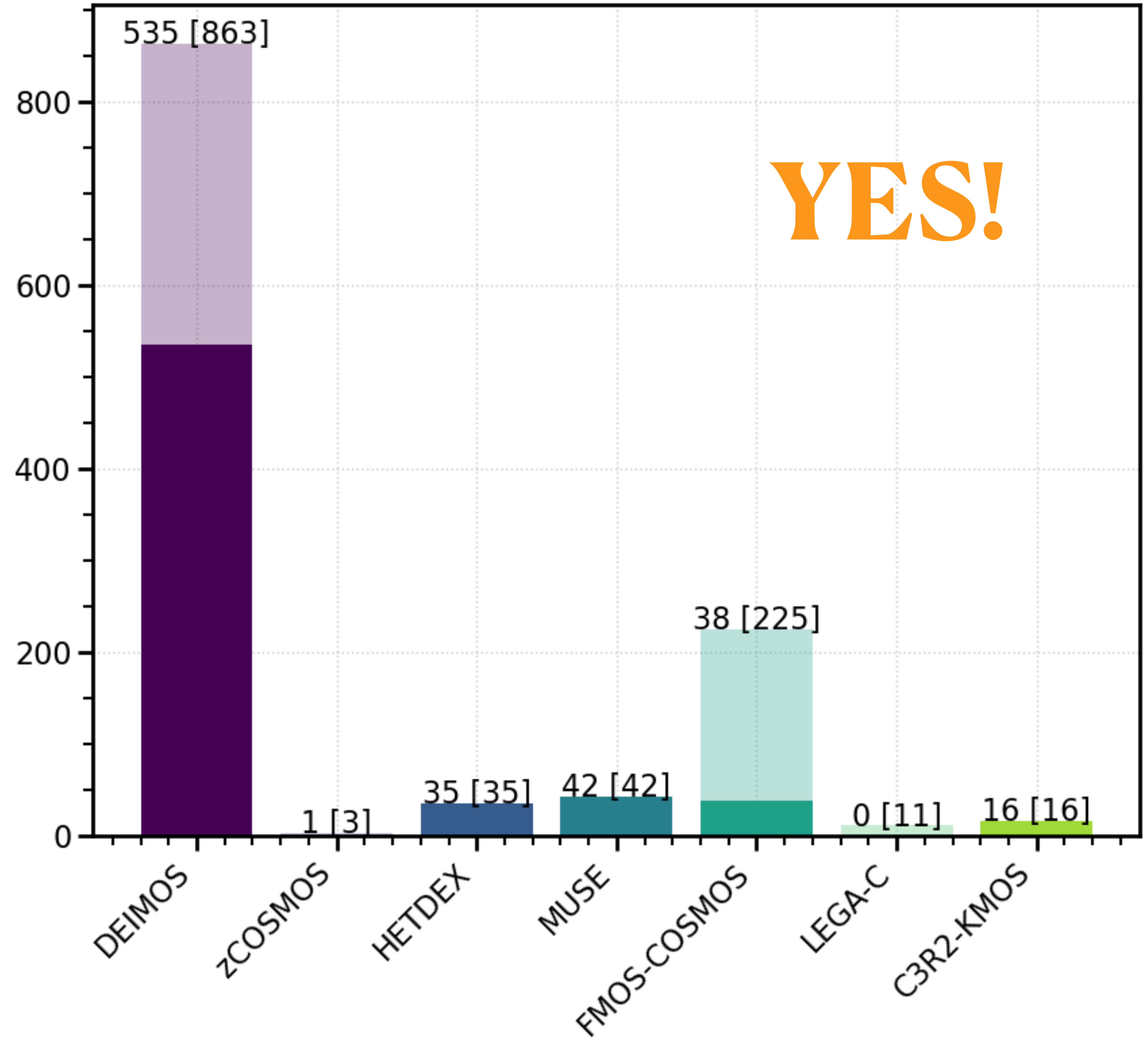
AutoML: evaluating the classification model



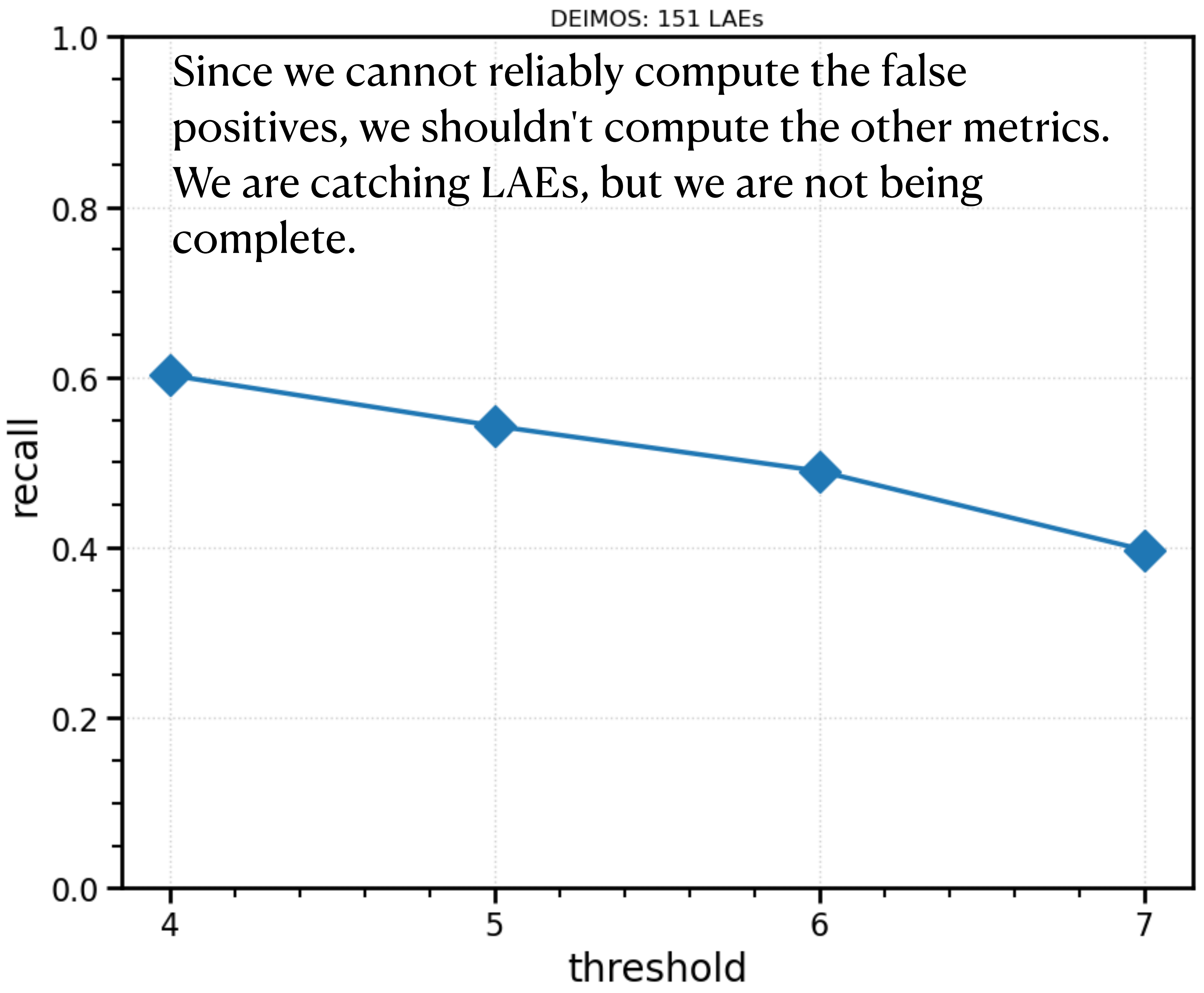


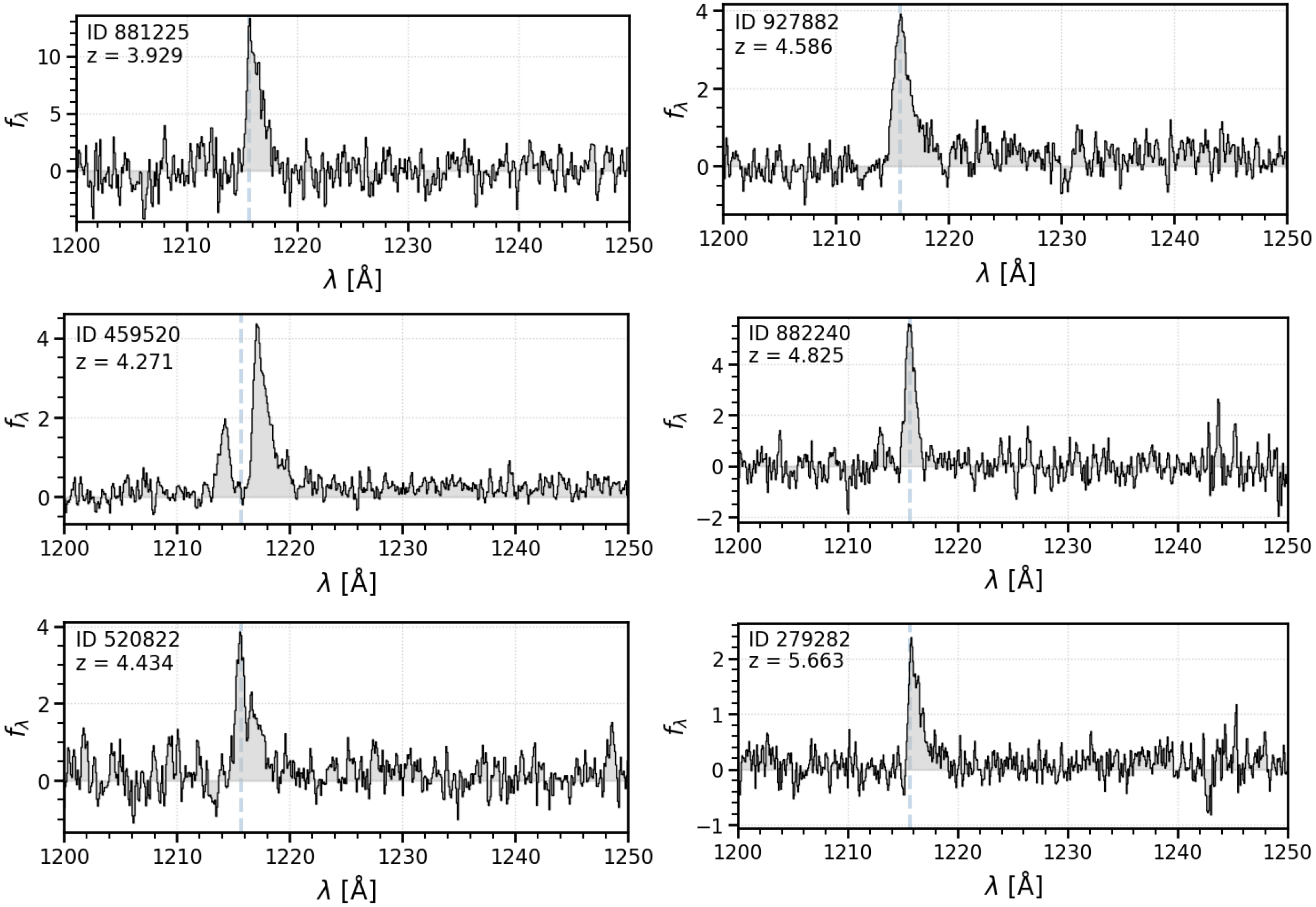
Results: how many LAEs are probably escaping us?

Results: can we spectroscopically confirm some of them?



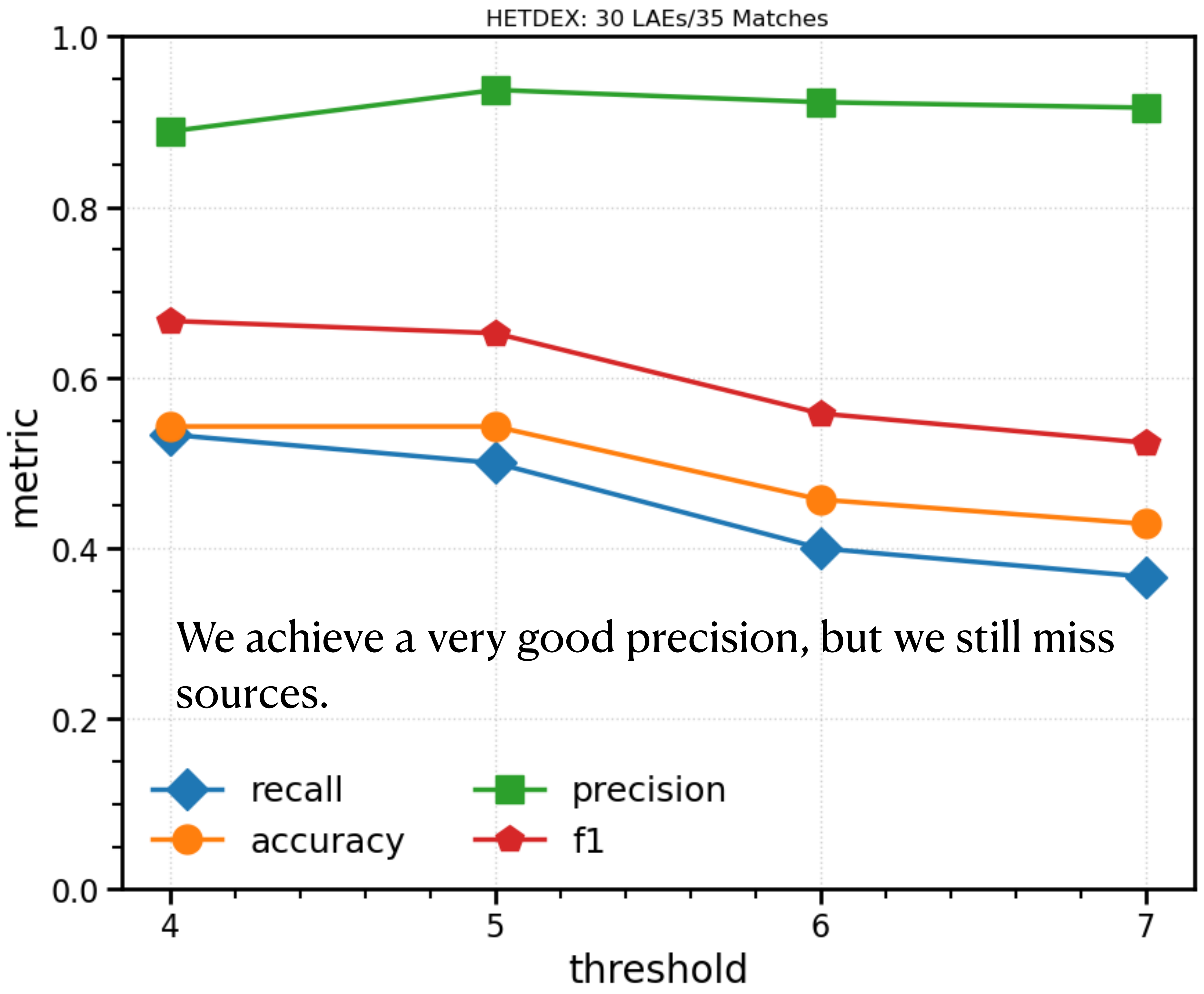
Results: DEIMOS spectroscopic confirmations



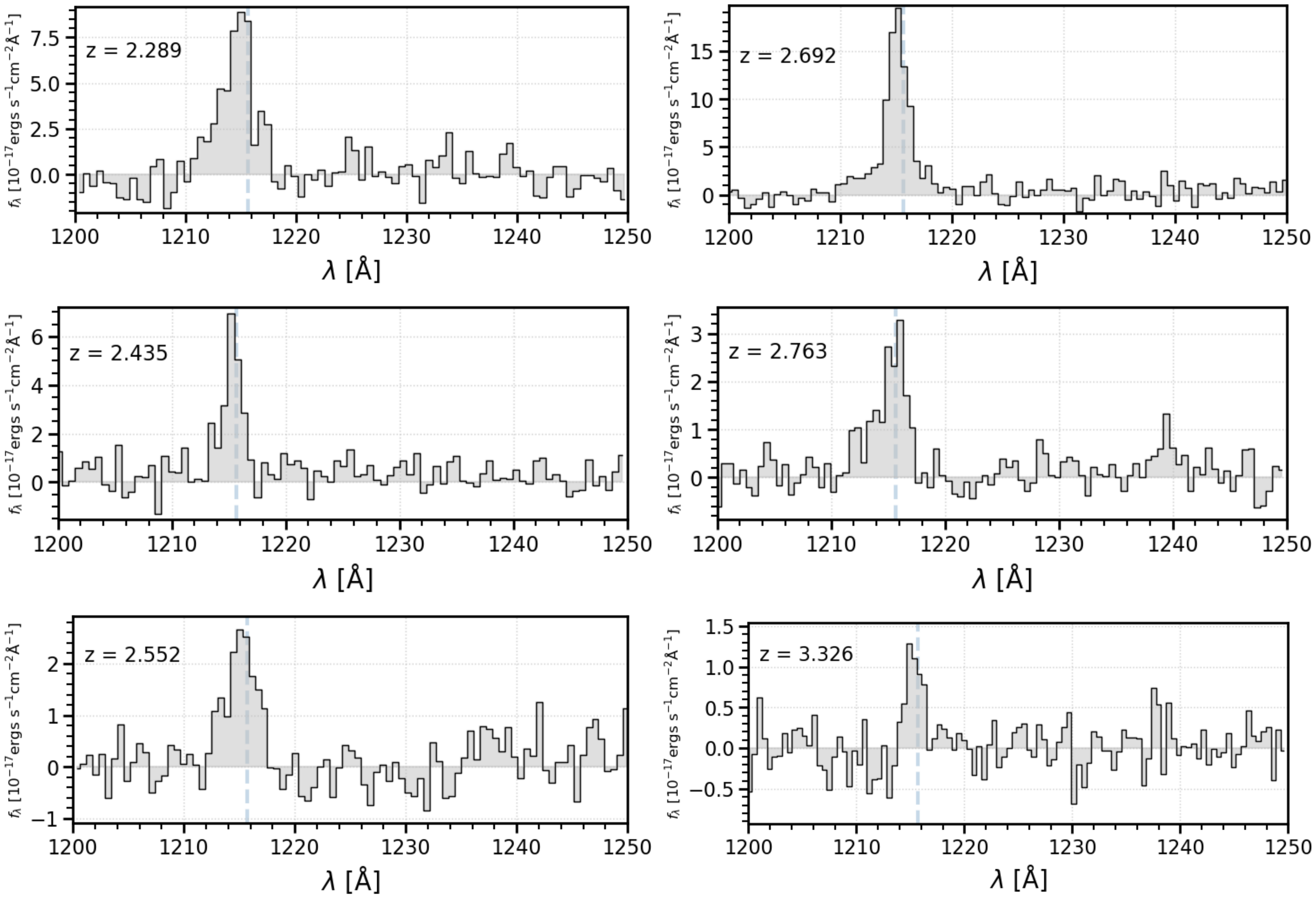


Hasinger et al. 2018

Results: HETDEX spectroscopic confirmations

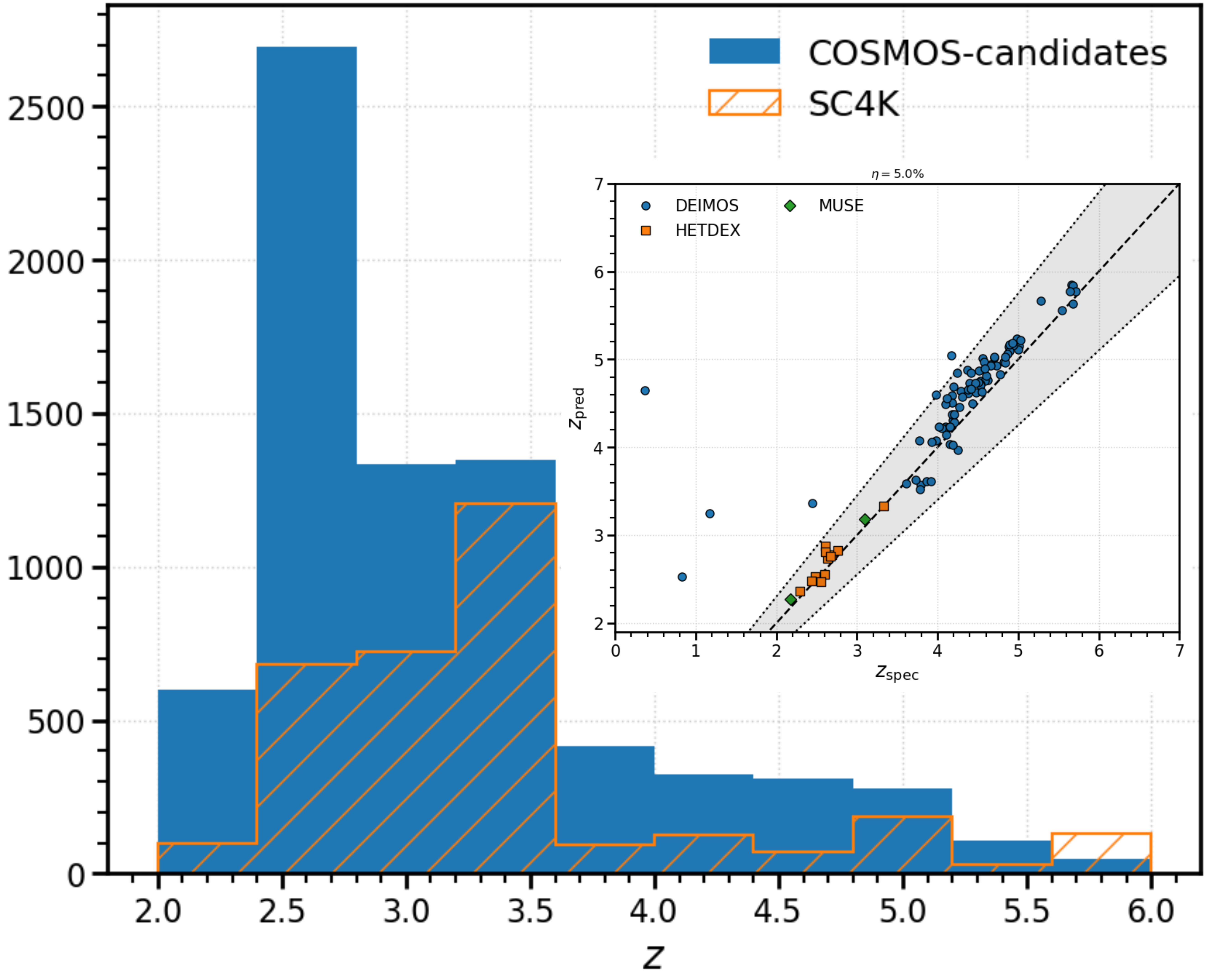


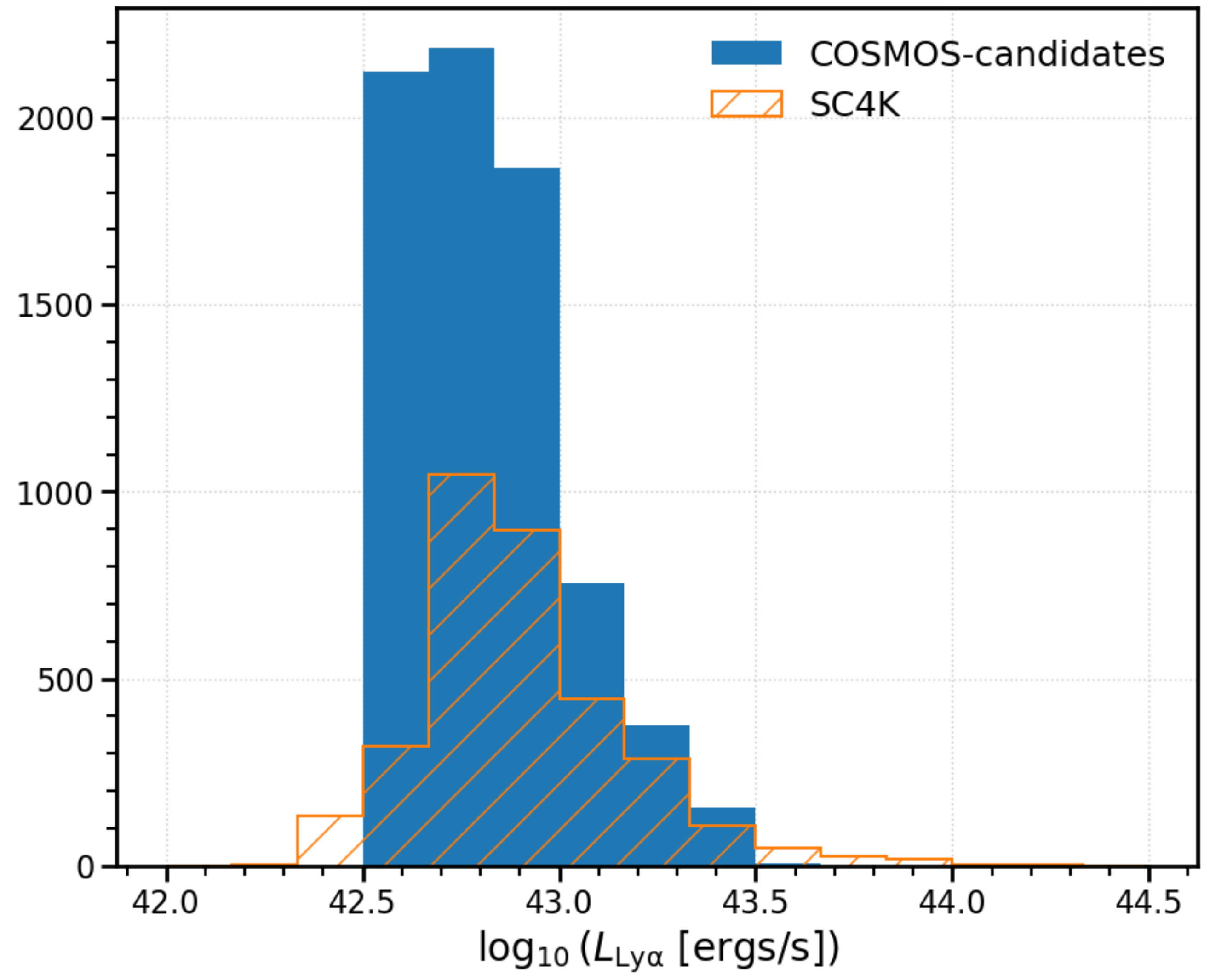
We achieve a very good precision, but we still miss sources.

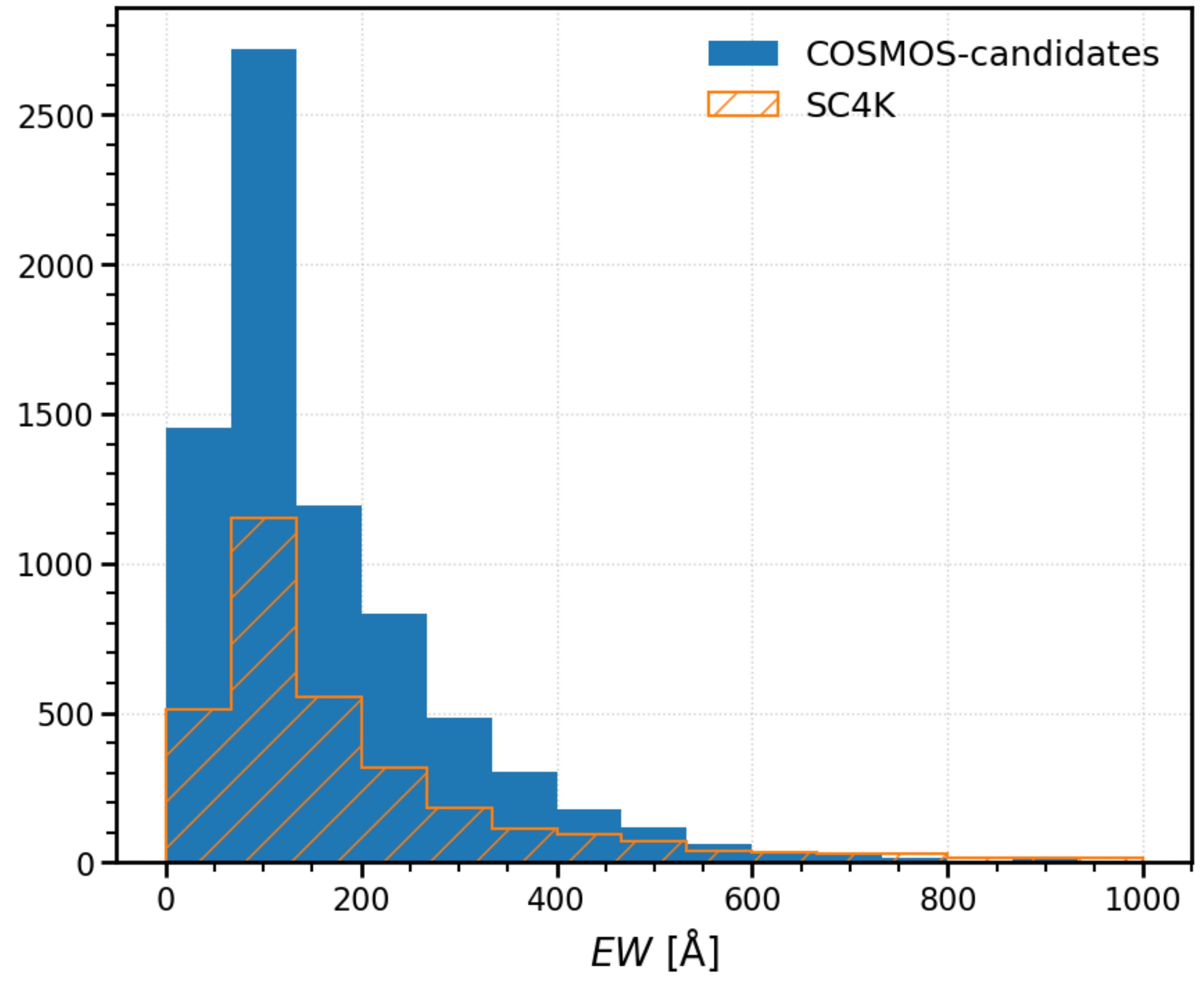


Cooper et al. 2023

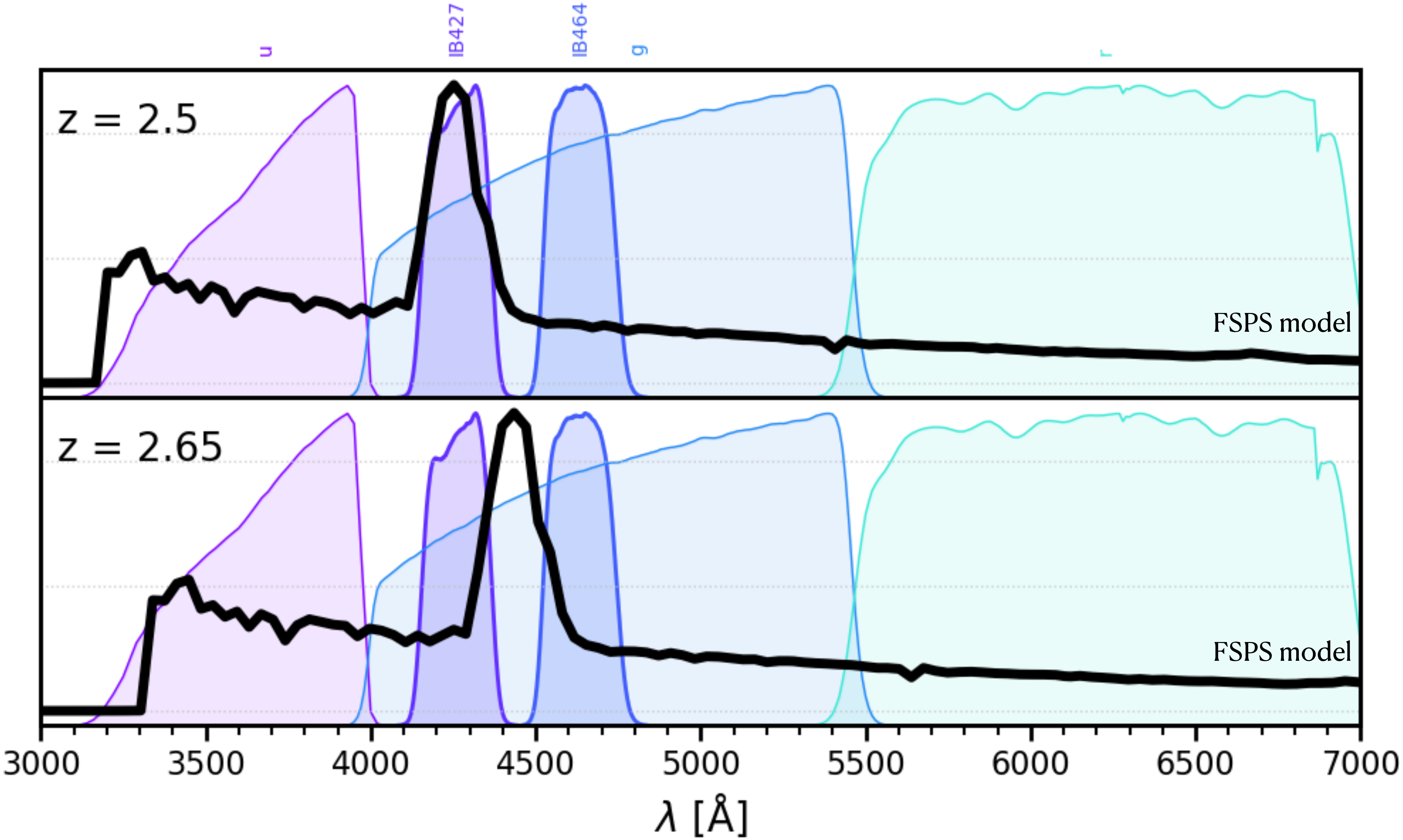
Results: predicting their zs, $L_{Ly\alpha}$, and EWs







Discussion: why are we missing them?



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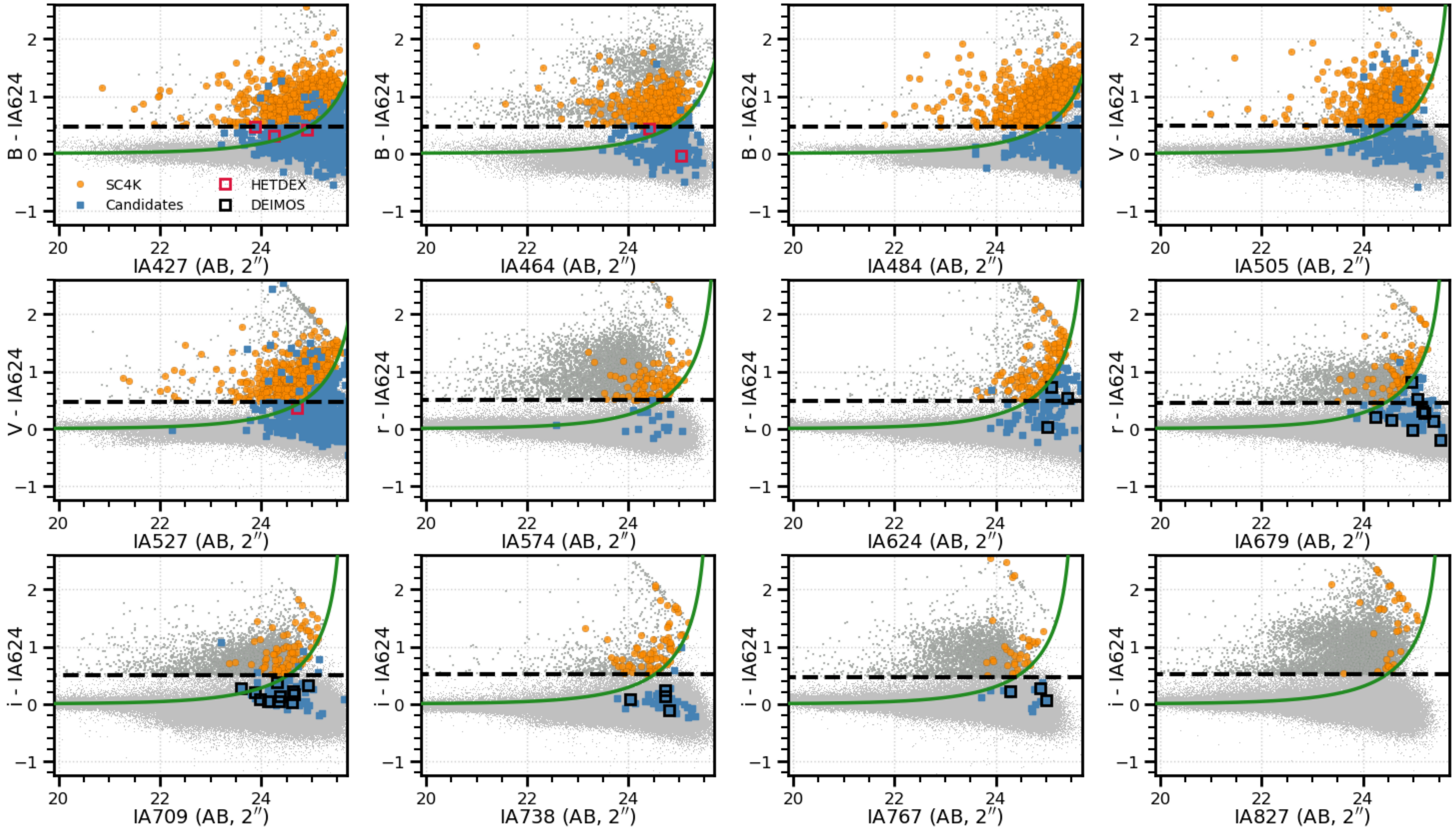
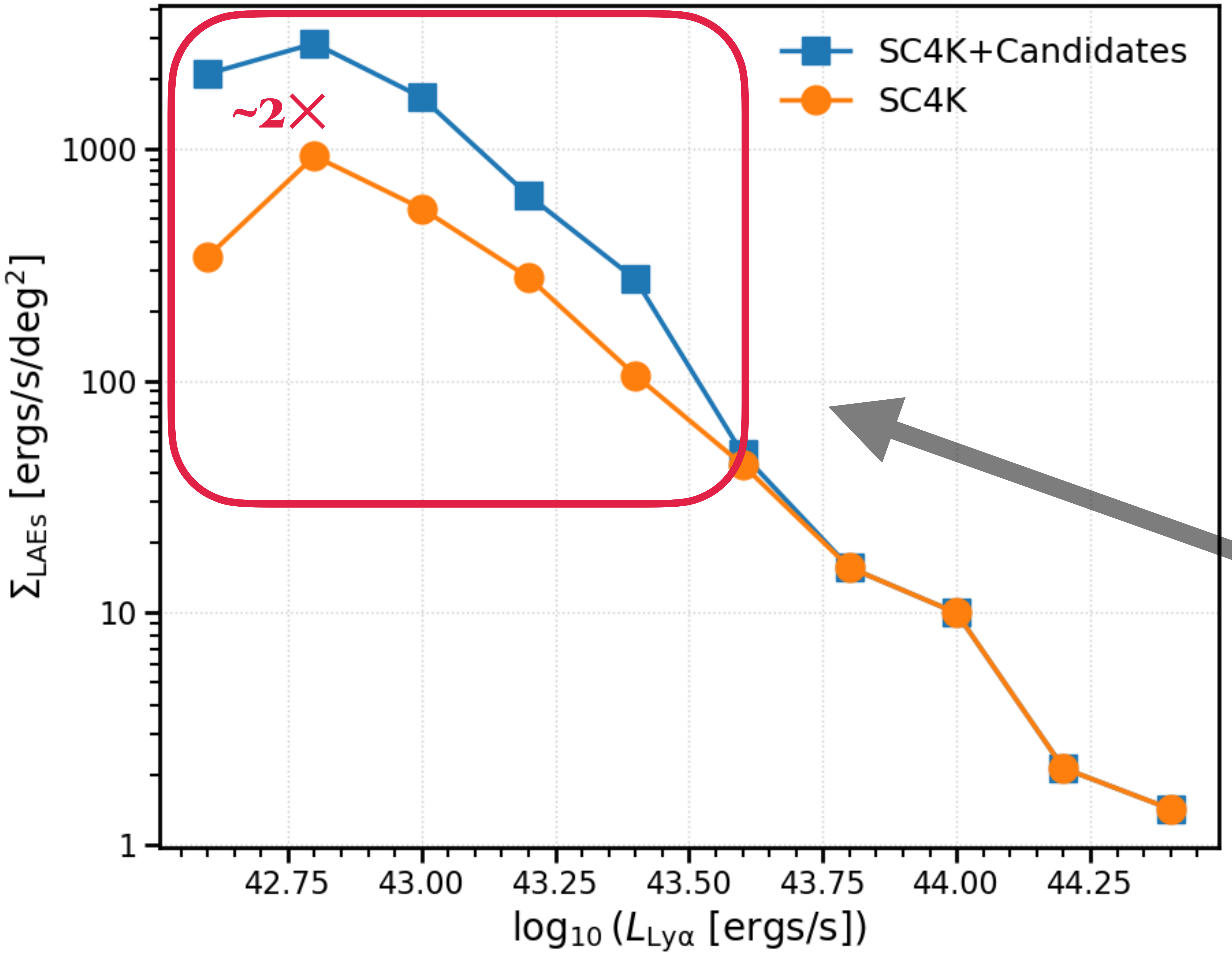
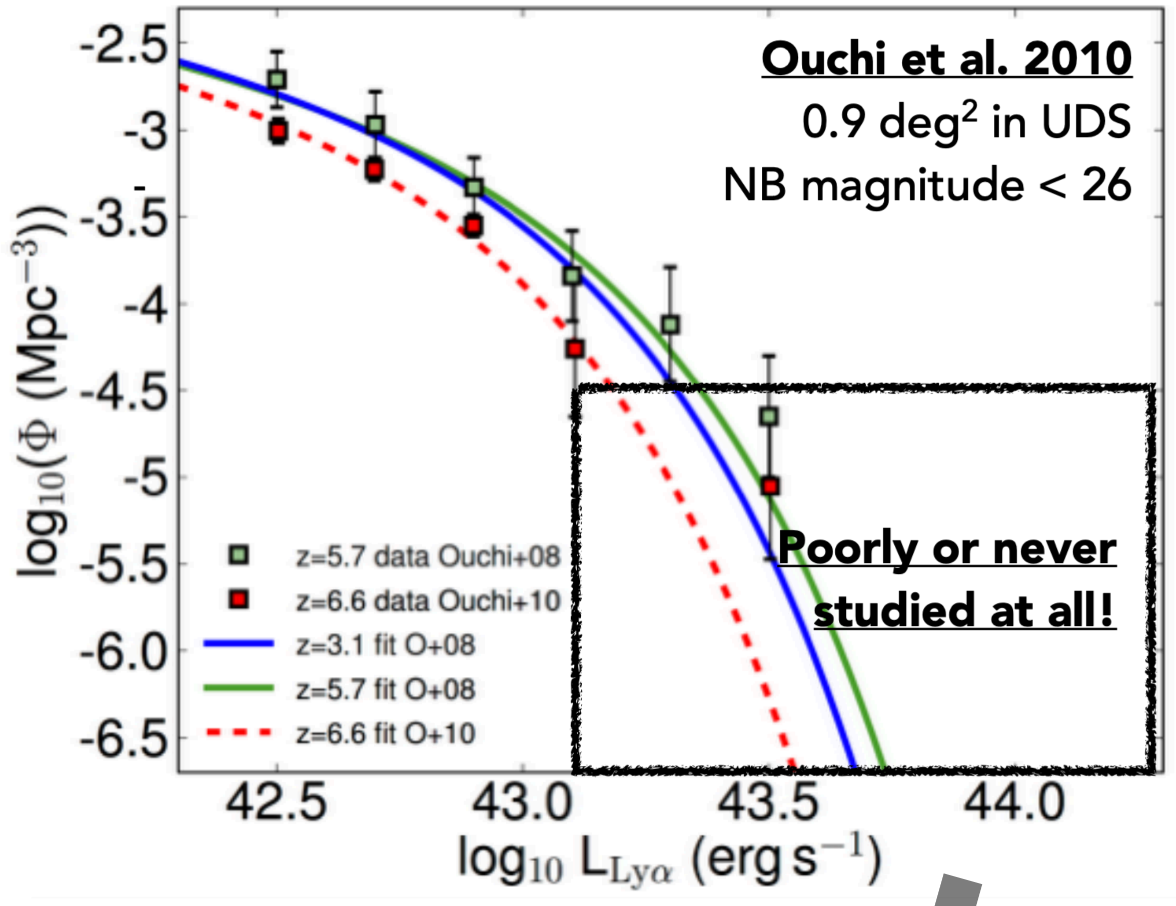
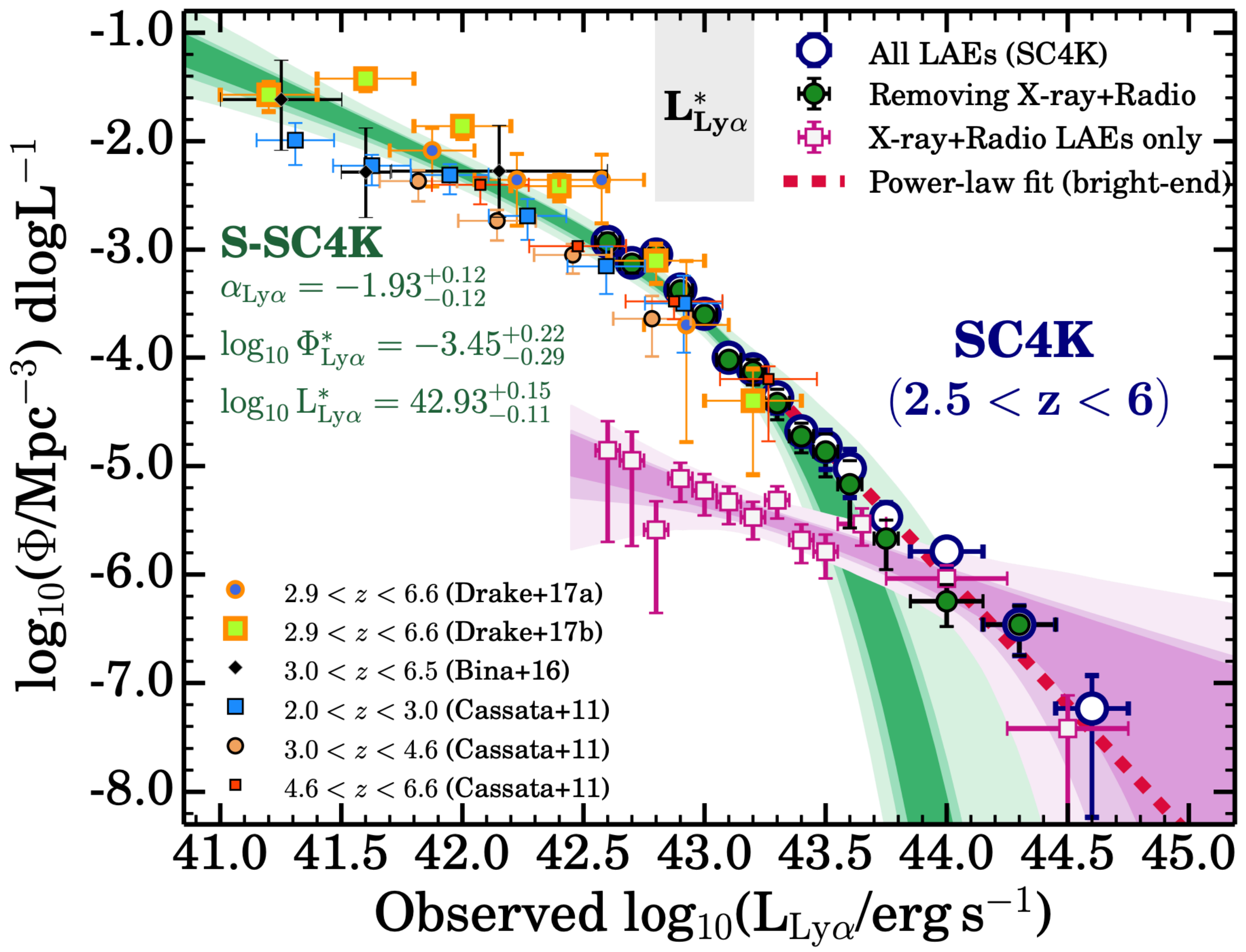


Discussion: what are the implications?







Take-home messages

- AI can be used to increase samples of LAEs.
- We are getting pure sample, but we are still far from having complete samples.
- We can also predict basic properties of LAEs which is useful for effective target selection.
- We still need to prove generalisation capabilities and discuss uncertainties.

Future directions

FLAEMING: Finding Lyman-α emitters through machine learning

T-FLAEMING: Transcoding the way of finding LAEs in the era of large surveys and AI