DESI-2 for Photo-z Training and Calibration

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On behalf of the DESI collaboration photo-z topical group

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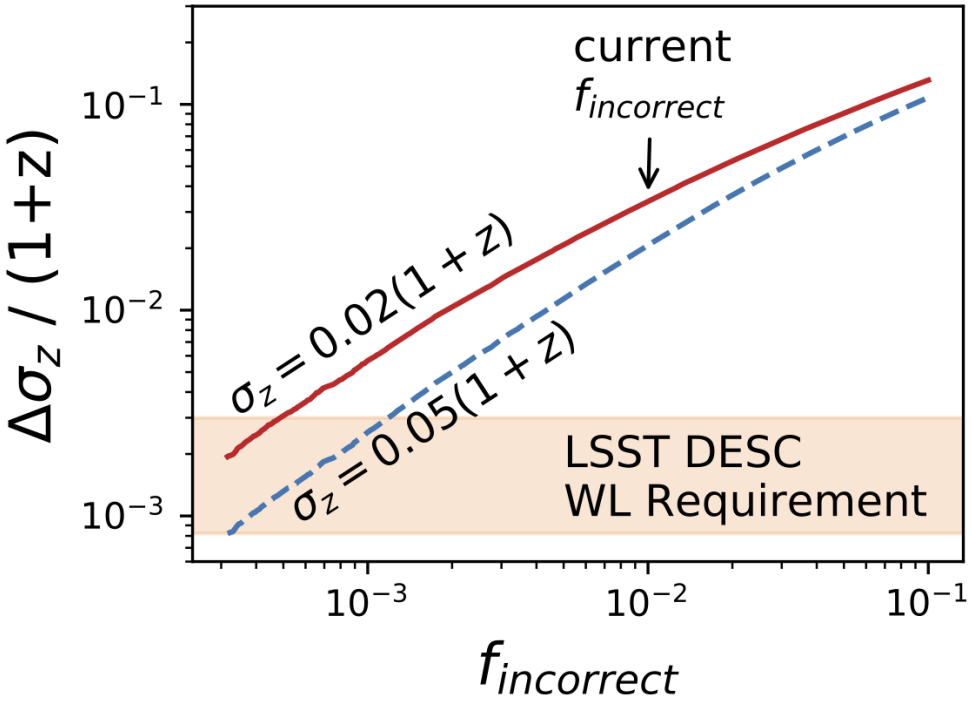
All Rubin Extragalactic Science need Photo-z's

- Mean redshift of each tomographic bin used for 3x2pt must be known to 0.001(1+z) (or 0.002) for the LSST Year 10 (or Year 1) 3x2pt results not to be limited by photo-z systematics (Mandelbaum et al. 2018)

- Galaxy formation and Cluster science, supernova, strong lens studies will also depend critically on photo-z's.

- Spectroscopic samples are needed to train photo-z algorithms and calibrate *z* distributions.



Newman & Gruen 2022

Almost all DESC science cases will benefit from spectroscopic redshifts

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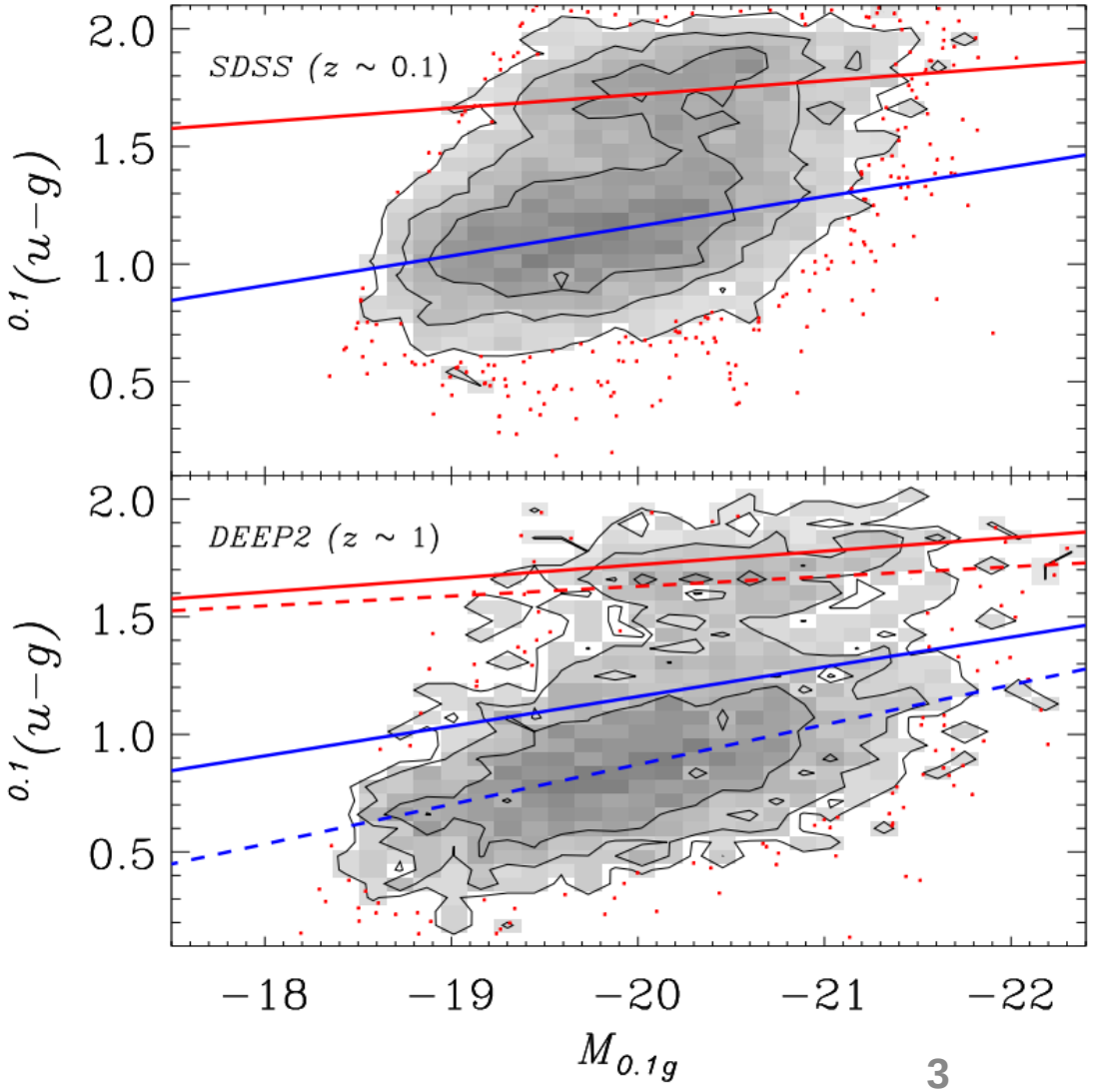
We cannot rely only on redshifts of brighter galaxies: fainter galaxies have a different range of SEDs.

- Both at redshift ~0 and redshift ~1, the range of rest-frame colors of bright objects does not span the range of faint objects
  - i.e., they have a different range of SEDs

- As a result, we can't map out the color-redshift relation fully for LSST samples just using objects that are 1-2 mag brighter
  - Excluding some range of observed colors could work, **if** you can guarantee that they never scatter into your samples due to errors, blending, etc.



Source: Blanton (2006)

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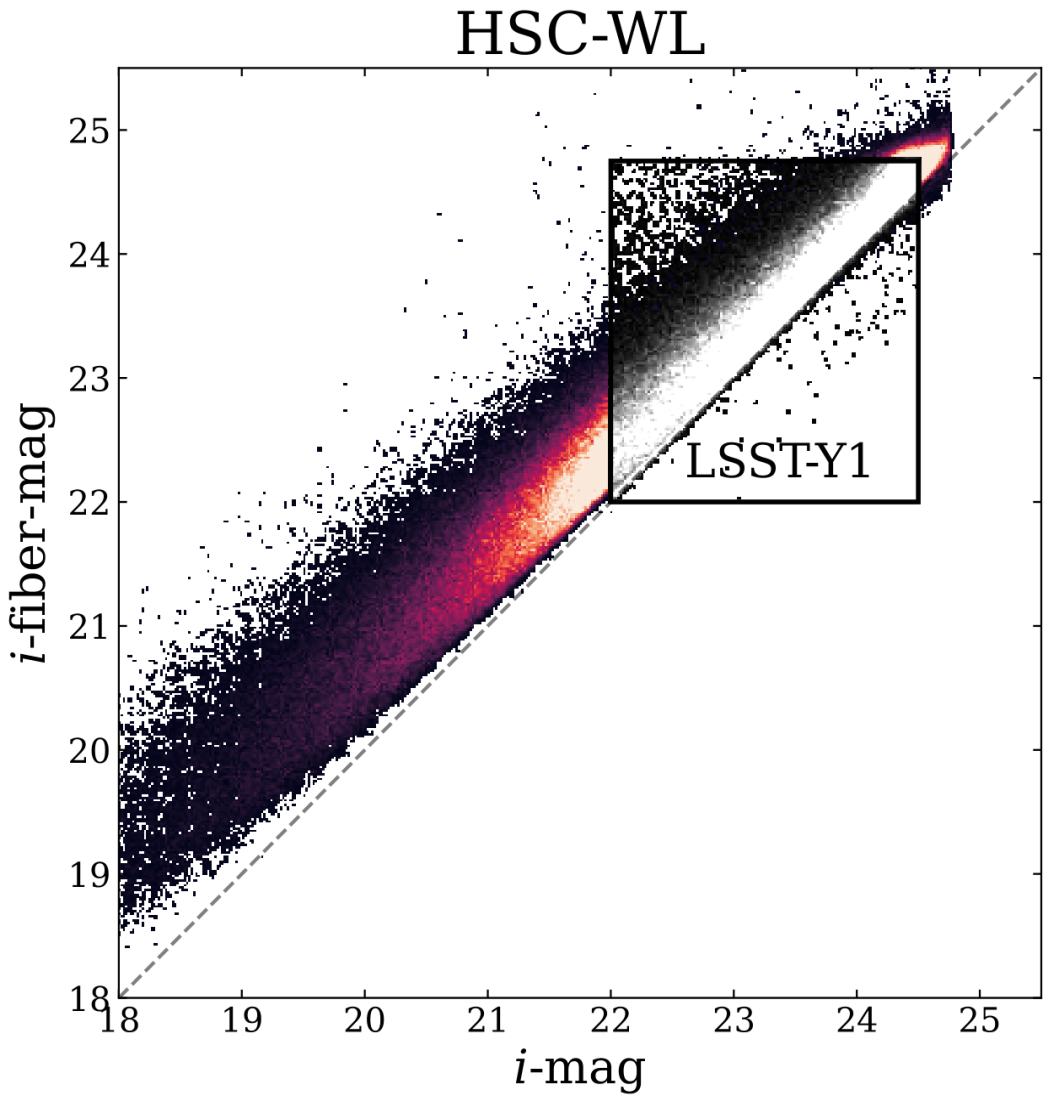
DESI Performance for faint galaxies



- As a secondary program we observed magnitude-limited samples of objects fainter than typical DESI targets ($22 < i < 24.5$)
- Samples constructed to be uniformly distributed in *i* magnitude
- Spectra were visually inspected to determine redshift measurement success

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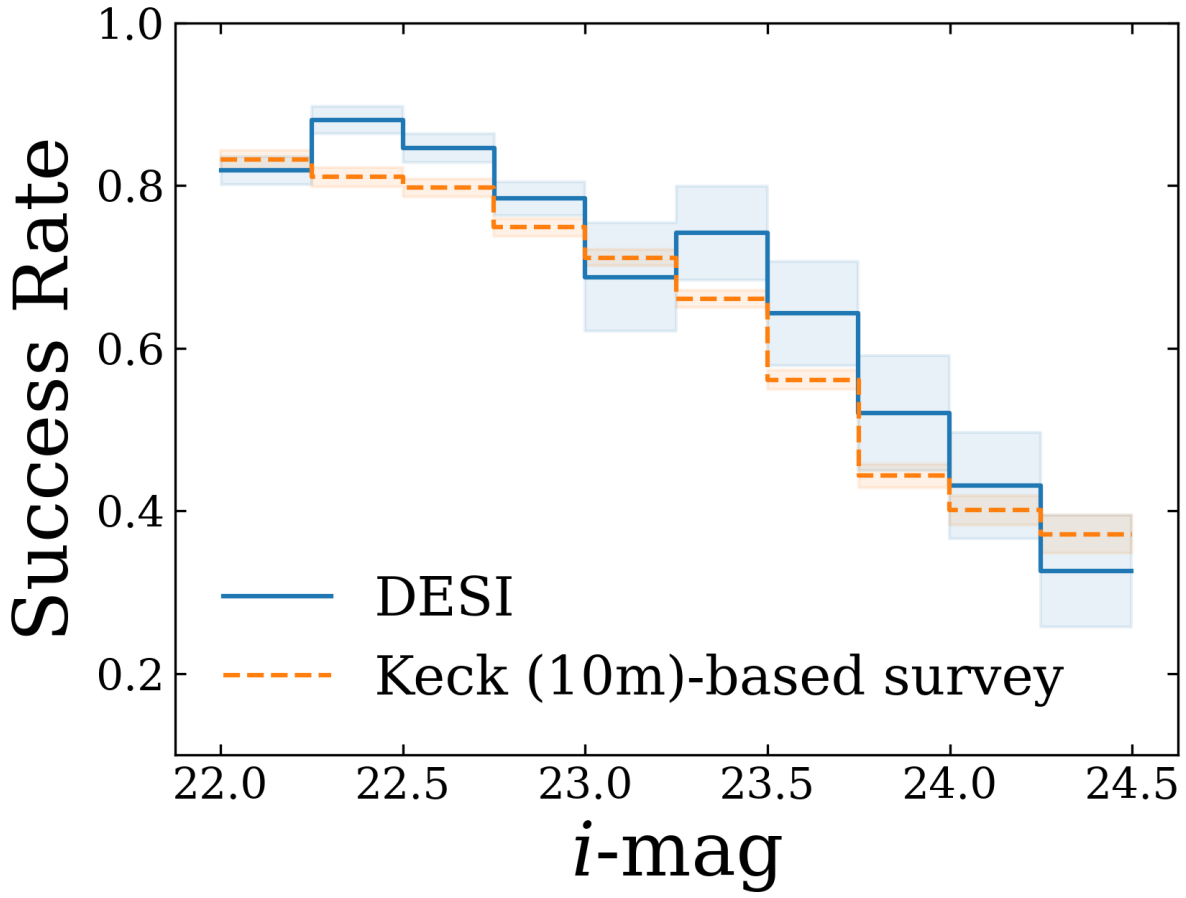
DESI Performance for faint galaxies



~1.5 hours of DESI dark time exposure yields results comparable to one hour on Keck/ DEIMOS but reaches z≈1.65 instead of 1.45 (Dey et al., In prep)

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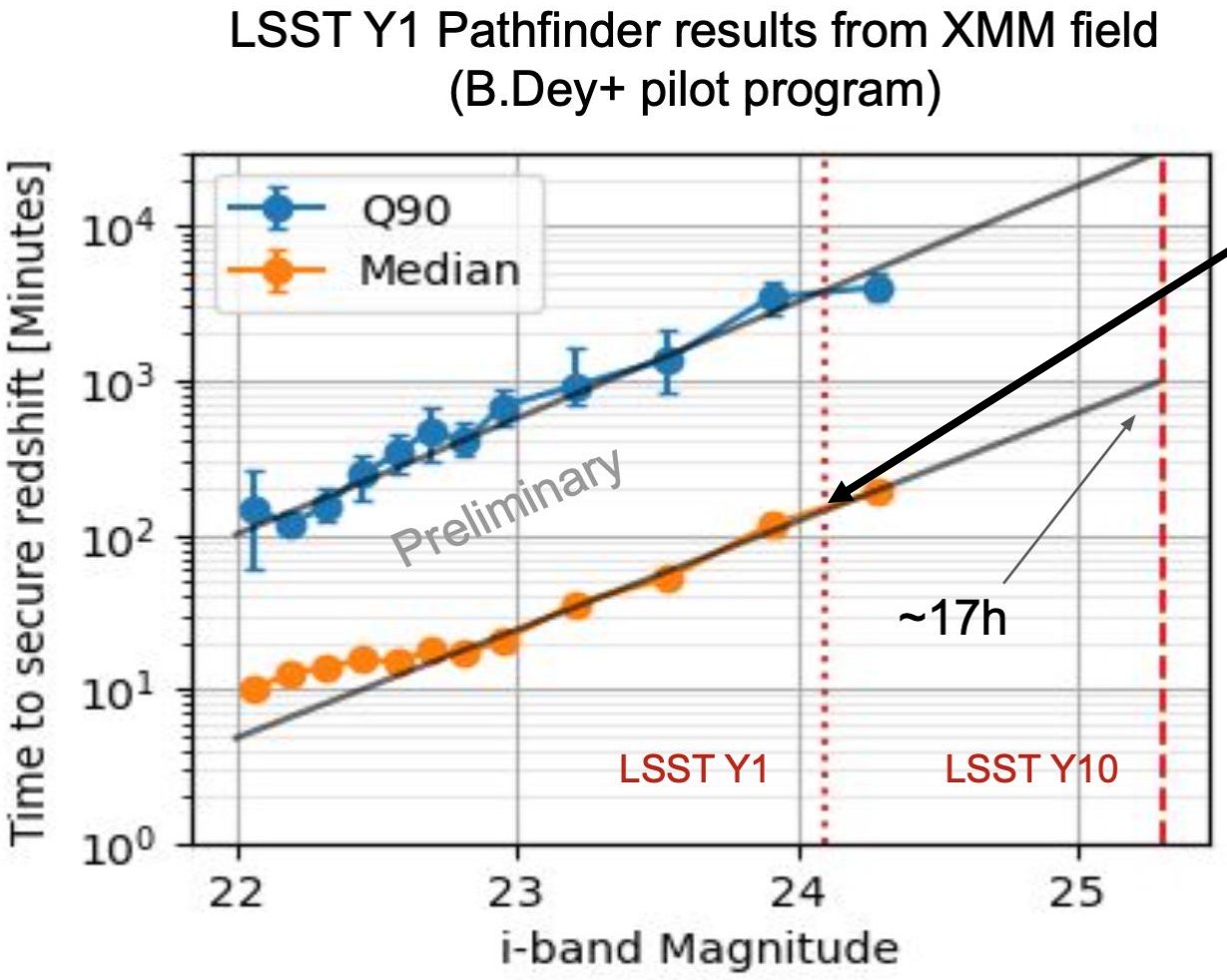
Current DESI-2 planning for photo-z samples



- DESI-2 team's current plan includes a spare-fiber program targeting the LSST objects which would be easiest to get redshifts for
- Maximum exposure times ~2 hours: could get redshifts for easiest ~50% of objects down to Y1 depth
- Would likely give large numbers of spectra, but only over part of color space (selected in more bands than just *riz*)

Weaverdyck et al., In prep)

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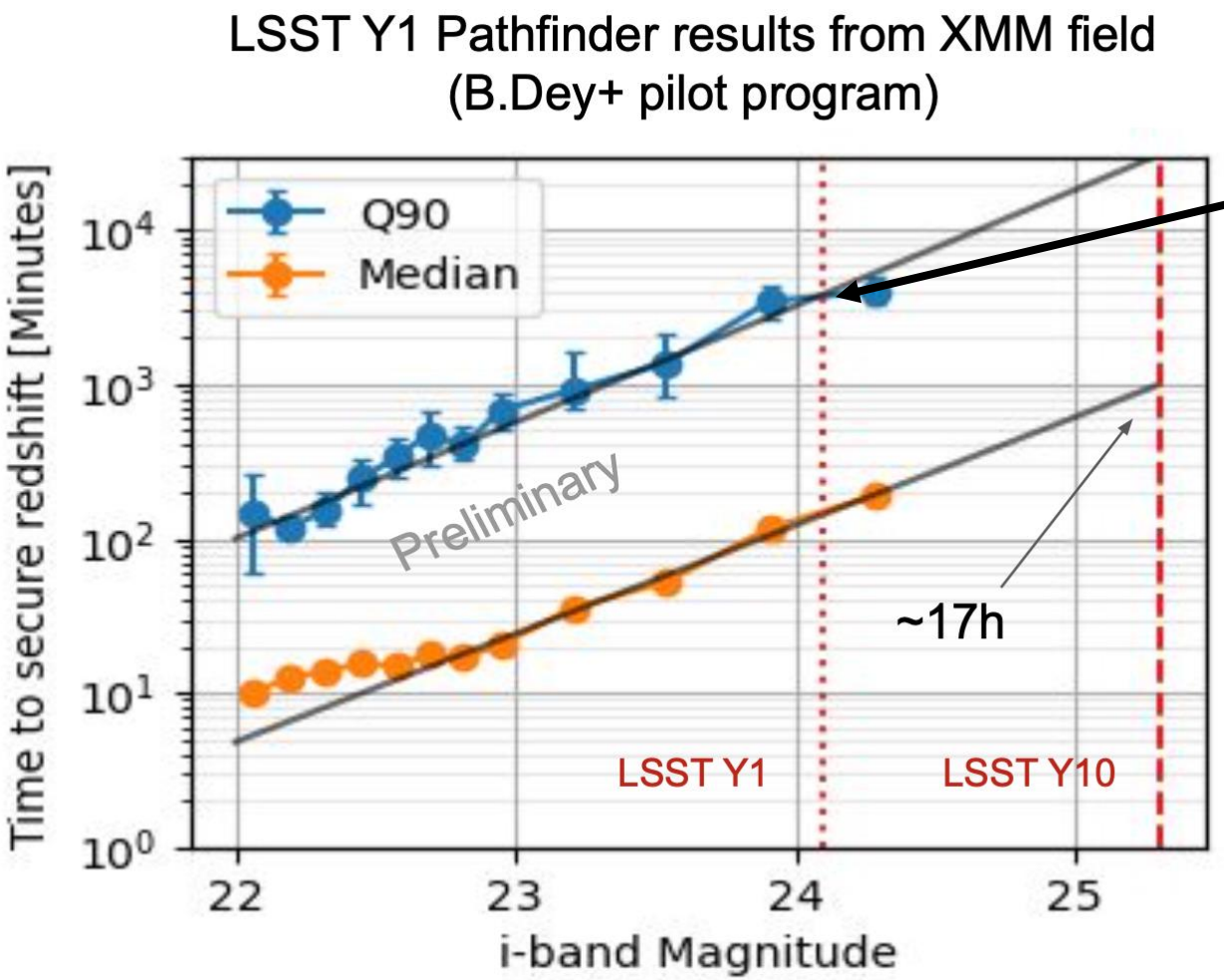
Alternative strategy: DESC photo-z training baseline



- To reach point of diminishing returns for training, want spectra of 20,000-30,000 objects spanning full LSST color space down to Y1 (or Y10) limit
  - Requires 29 (290) hours exposure time for faintest objects to achieve ~90% redshift success rates (likely much higher where z<1.65); 5-8 DESI pointings total
  - Full campaign requires 15-25 dark nights (Y1 depth) or 150-250 (Y10)

Weaverdyck et al., In prep)

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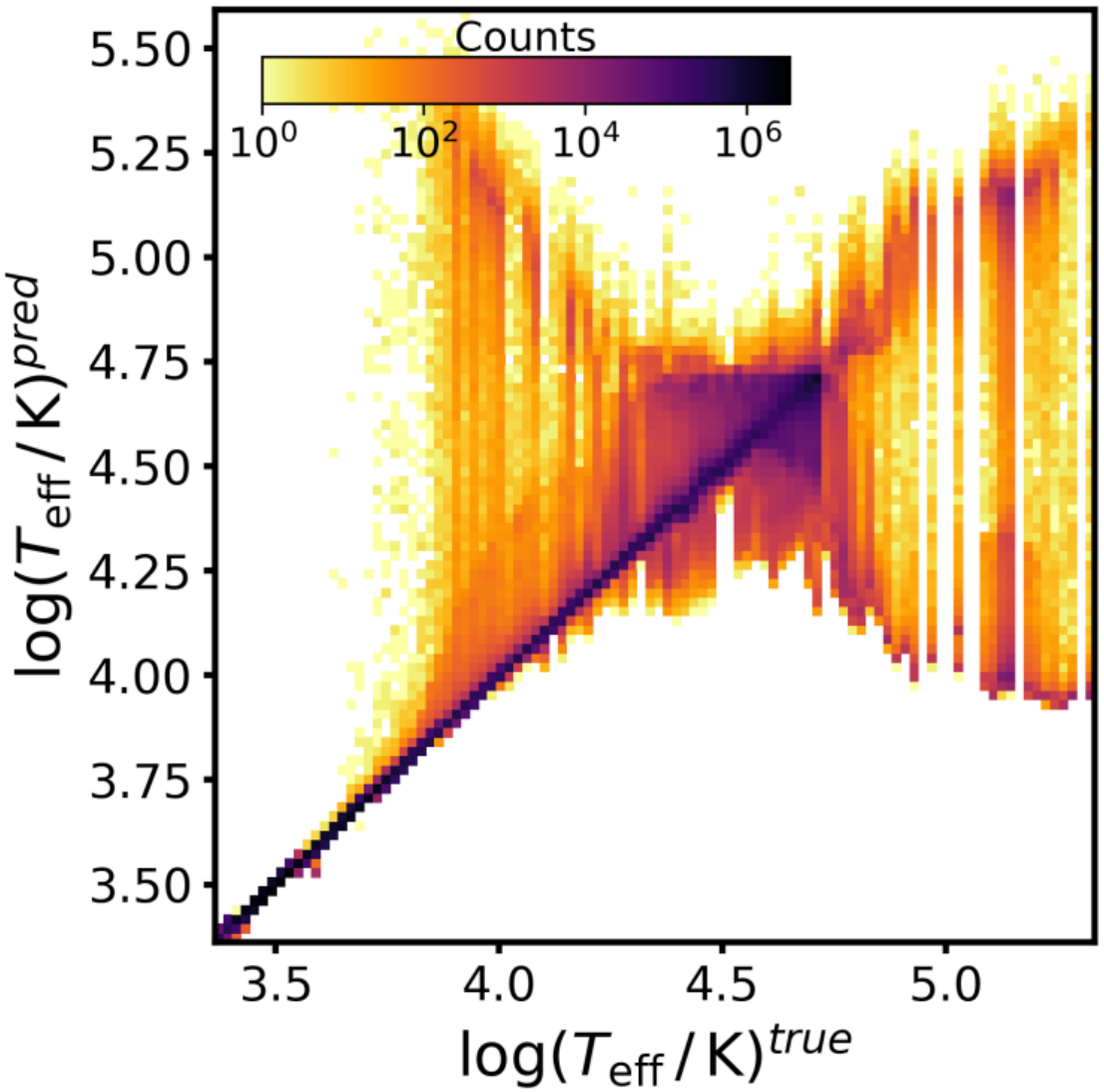
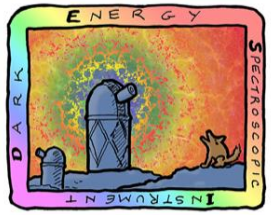
We can emulate the same recipe for LSST Stellar astrophysics too

- Obtain spectra for a representative training sample of stars observed by Rubin.
- Use the training set to predict stellar properties like T_{eff} , log *g,* [Fe/H], [α]/H, etc. using template/Ml methods just like we do for photo-*z*'s
  - e.g., Apellaniz (2005), Miller (2015), Blancato (2019), Ksoll (2020).



Ref: Ksoll (2020)



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Key questions

- How feasible is it to use Rubin Commissioning/SV fields for an early DESI-2 photo-z program?
  - It may be easiest to obtain DESI time before large imaging datasets from LSST are available for targeting.

- How can DESI and Rubin best work together to maximize the science from both?
  - e.g., early access to 2-year depth *u*-band photometry can enable target selection for the DESI z>2 survey; photo-*z* training spectroscopy would benefit a broad range of LSST science.

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