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Preliminary Target Selection for the DESI Emission Line Galaxy (ELG) Sample

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ABSTRACT

DESI will precisely constrain cosmic expansion and the growth of structure by collecting ∼35 million redshifts across ∼80% of cosmic history and one third of the sky to study Baryon Acoustic Oscillations (BAO) and Redshift Space Distortions (RSD). We present a preliminary target selection for an Emission Line Galaxy (ELG) sample, which will comprise about half of all DESI tracers. The selection consists of a g-band magnitude cut and a $(g-r)$ vs. $(r-z)$ color box, which we validate using HSC/PDR2 photometric redshifts and DEEP2 spectroscopy. The ELG target density should be ∼2400 deg^{-2}, with ∼65% of ELG redshifts reliably within a redshift range of $0.6 < z < 1.6$. ELG targeting for DESI will be finalized during a 'Survey Validation' phase.

Keywords: Emission line galaxies, Surveys, Large-scale structures

INTRODUCTION

DESI (DESI Collaboration et al. 2016) will measure spectroscopic redshifts for ∼35 million galaxies and quasars over ∼80% of cosmic history and one third of the sky. DESI will target multiple extragalactic tracers optimized for different redshift ranges, supplemented by significant stellar samples for calibration and Galactic science. Relaxed selections

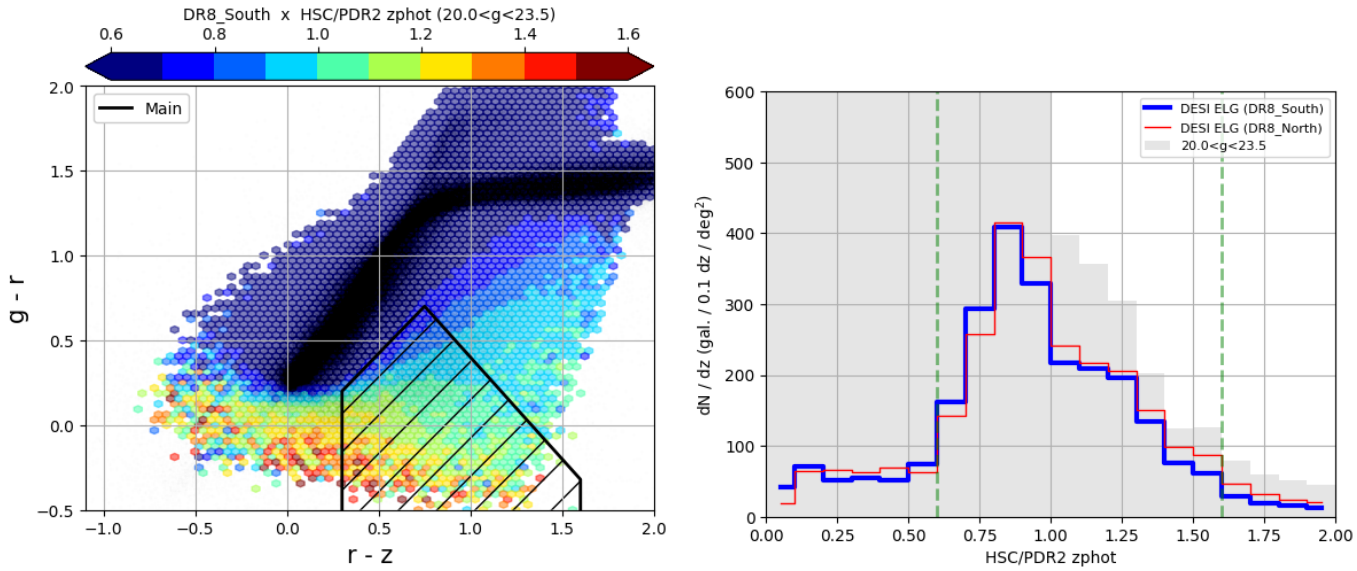

Figure 1. (a): $(g-r)$ vs. $(r-z)$ color-color diagram: the DESI ELG cuts for the 'South' are displayed using black hatched lines. The colored hexagons represent the mean redshift for $20.0 < g < 23.5$ sources using a photometric redshift ($z_{\rm phot}$) from the HSC/PDR2; photometric stars are displayed as black dots. (b): HSC/PDR2 $z_{\rm phot}$ distribution for the DESI ELG targets, in the 'North' (red) and 'South' (blue). The gray shaded histogram shows the $z_{\rm phot}$ distribution of the parent $20.0 < g < 23.5$ sample. Dashed green lines show the desired redshift range.

will be tested during a preliminary 'Survey Validation' phase to validate and optimize targeting for the DESI 'main' survey.

This note outlines preliminary targeting for an Emission Line Galaxy (ELG) sample in the redshift range $0.6 < z < 1.6$, which will constitute approximately half of DESI extragalactic tracers. DESI exploits the abundance of star forming galaxies at $z \sim 1$–2 to target ELG tracers with a spectroscopic redshift that can be measured reasonably quickly. The high star formation rate at these redshifts produces identifiable emission lines without the need to detect a strong continuum. A key spectroscopic diagnostic is the [O II] doublet at $\lambda\lambda$ 3726,3729: the DESI spectrographs are designed to resolve this feature over the targeted ELG redshift range. ELGs, which have been used as tracers in previous surveys (e.g., WiggleZ and eBOSS), will also underpin future BAO surveys, such as PFS (Takada et al. 2014) and *Euclid* (Laureijs et al. 2011).

ELG TARGET SELECTION

The target selection will use grz imaging from the Legacy Surveys (Dey et al. 2019). Results presented here are based on Data Release 8 of the Legacy Surveys[1]. The DESI footprint is split into two regions; 'North' (Galactic $b > 0°$ and Dec. $> 32.375°$) and 'South'; the 'North' has a slightly different photometric system and is shallower (0.5 magnitudes) in the g- and r-bands. We therefore define slightly different cuts for the 'North' and 'South'.

First, we require a minimum photometric quality by enforcing at least one observation and a positive signal-to-noise ratio in each of g-, r-, and z-band. We also require that targets are not in corrupted pixels, nor near bright or medium-bright stars, globular clusters, or large galaxies (`MASKBITS` is not set for bits 1, 5, 6, 7, 11, 12 or 13).

[1] http://legacysurvey.org/dr8/

Next, we apply the following cuts in grz (see Figure 1):

$$20.0 < g < g_{\rm max} \tag{1a}$$
$$0.3 < (r-z) < 1.6 \tag{1b}$$
$$(g-r) < 1.15 \times (r-z) + {\rm zpt} \tag{1c}$$
$$(g-r) < -1.20 \times (r-z) + 1.6, \tag{1d}$$

with ($g_{\rm max}$, zpt) = (23.6, -0.35) for the 'North' and ($g_{\rm max}$, zpt) = (23.5, -0.15) for the 'South'. All magnitudes are corrected for Galactic extinction using the Schlegel et al. (1998) maps. Eqs. (1b) and (1c) select targets in the desired redshift range and Eq. (1d) favors star-forming galaxies. As the photometry is noisier in the 'North', our selection box is farther from the low-redshift locus to avoid significant contamination from $z < 0.6$ galaxies. Eq. (1a) targets the requisite [O II] flux (see e.g., Comparat et al. 2015) and also sets the density to $\sim$2400 deg^{-2}.

As no spectroscopic truth table exists for a complete sample with $g \lesssim 23.5$, we assess our selection using HSC/PDR2 `DEmP` photometric redshifts ($z_{\rm phot}$; Aihara et al. 2019) for the redshift distribution, and DEEP2 spectroscopic data over $0.8 < z < 1.4$ for the [O II] flux (Newman et al. 2013). The HSC/PDR2 $z_{\rm phot}$ cover $\sim$100 deg^2 in the 'North' and $\sim$200 deg^2 in the 'South'. The $z_{\rm phot}$ are estimated from deep $grizy$-photometry and are of exquisite quality for $z < 1.6$ ELGs when compared to spectroscopy from eBOSS and from DESI Pilot Observations with the MMT (Raichoor et al. 2020; Karim et al. 2020). Figure 1 shows the $z_{\rm phot}$ distribution of our ELG targets, demonstrating that $z_{\rm phot} > 1.0$ objects are efficiently selected; overall, $\sim$80% of the selection has $0.6 < z_{\rm phot} < 1.6$ for both 'North' and 'South'.

Finally, we characterize [O II] flux for our selection using measurements from Comparat et al. (2015) in DEEP2 over $0.8 < z < 1.4$, where DEEP2 is complete over all fields for our $g < 23.5$–23.6 ELG sample. We find that 76% ('North') and 83% ('South') of our targets have sufficient [O II] flux for a secure spectroscopic redshift measurement given the expected DESI specifications.

CONCLUSION

This note outlines a preliminary DESI ELG selection based on a g-band cut and a $(g-r)$ vs. $(r-z)$ color-color box that produces $\sim$2400 deg^{-2} targets. Analyses using HSC/PDR2 $z_{\rm phot}$ and DEEP2 [O II] flux show that $\sim$65% of resulting ELGs will provide a reliable spectroscopic redshift within $0.6 < z < 1.6$, in accord with DESI Collaboration et al. (2016). Preliminary ELG targeting will be tested during DESI 'Survey Validation' to inform a final selection for the DESI 'main' survey. Target catalogs that use the selection described in this note are public[2].

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