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# EMISSION LINE GALAXIES FOR BigBOSS

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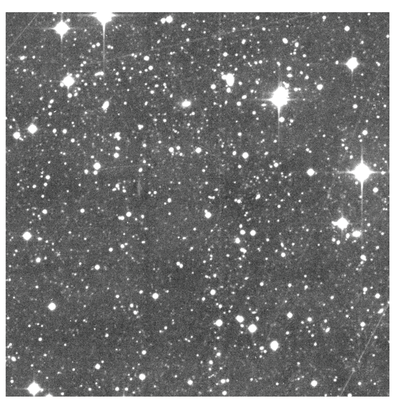
## ABSTRACT

We present a simple optical selection of star-forming emission line galaxies (ELGs) at intermediate redshifts appropriate for BigBOSS. These galaxies exhibit very blue restframe colors and are selected for their bright [OII] doublet emission, ideal for both fast and secure redshift measurements from the ground. The selection is based on (*g*-R) colors generated from co-added Palomar Transient Factory photometry in the COSMOS field. From the selected sample, we generate ~3000 galaxies per deg$^2$ and show that the bulk of the detected redshifts expected from BigBOSS will range from $0.6<z<1.6$. We also detail the general properties of similarly-selected ELGs from DEEP2 and measure the absolute galaxy clustering bias as a function of redshift.

## Photometric DATA

The BigBOSS ELG targets are selected from co-added epoch photometry from the Palomar Transient Factory[a] (PTF) at Palomar Observatory. PTF is a synoptic survey of the Northern Hemisphere using the 1.2m Oschin Schmidt telescope and the CFH12K prime focus camera (Law et al., 2010). Each 60 second exposure covers 7 deg$^2$ in either a Sloan *g* or Mould R filter band. In the Spring of 2011, we obtained 4+ hours of exposure time from PTF in both filter bands within the COSMOS field.



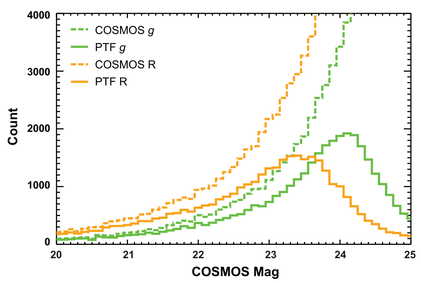



**Figure 1:** (left) A 0.2x0.2 deg$^2$ segment of the *g*+R band co-added detection image constructed from PTF data in the COSMOS field location. The 6.5 hour image stack achieves 50% completeness at *g*=24.2 and R=23.5 using aperture photometry (above).

From the raw data, we select the top 80% of best quality images and construct a *g*+R variance-weighted image stack using SWarp software (Figure 1). The detection image is then used with Source Extractor in dual-image mode to force photometry in each of the individual *g* and R image stacks. Sources with a 5σ detection achieve 50% completeness at *g*=24.2 and R=23.5 using aperture photometry.

### COSMOS Photometry and Mock Spectral Catalog

The detected objects in the co-added PTF data are sphere-matched to the COSMOS catalog (Capak et al., 2007). The COSMOS catalog contains panchromatic photometry complete to I<25 and has highly accurate photometric redshifts (mean error of $\sigma_z$=0.01(1+*z*), see Ilbert et al., 2009).

We also match the PTF sources to the COSMOS Mock Catalog[b] (Jouvel et al., 2009; Zoubian et al., in prep). The catalog contains spectral templates fit to COSMOS photometry and uses additional measures of the star-formation rate, stellar mass, and metallicity to estimate the emission line fluxes (Figure 2). See Poster #335.16 for further details.

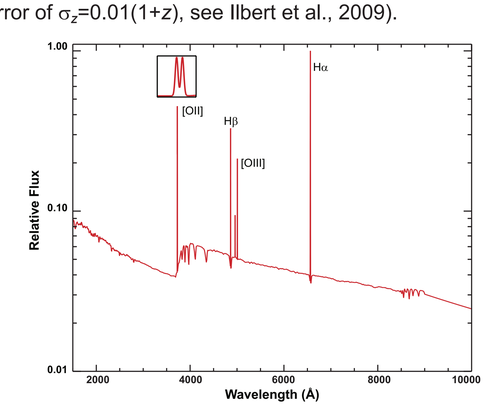



**Figure 2:** Restframe ELG template spectrum generated from fits to 30-band photometry in the COSMOS Mock Catalog. Emission line fluxes are also simulated and calibrated against high redshift spectra from VVDS and DEEP2.

[a]http://www.astro.caltech.edu/ptf

[b]http://lamwws.oamp.fr/cosmowiki/RealisticSpectroPhotCat

## Target SELECTION

Using PTF photometry and photometric redshifts matched from the COSMOS catalog, Figure 3 shows the PTF (*g*-R) color vs *g*-band magnitude. A simple selection of ELGs with *z*~1 is made using a color cut of (*g*-R)<0.2 and a bright limit of *g*>22.5. The selection produces ~3000 candidate ELGs per deg$^2$ with a target redshift distribution (see right side of Figure 5).

### Sample Properties

- $N_{targets}$~3000 per deg$^2$
- Redshifts from $0<z<2.5$ (right side of Figure 5)
- Blue restframe color, indicating strong star formation
- High emission line luminosity
- Low stellar contamination (<3% of all targets)

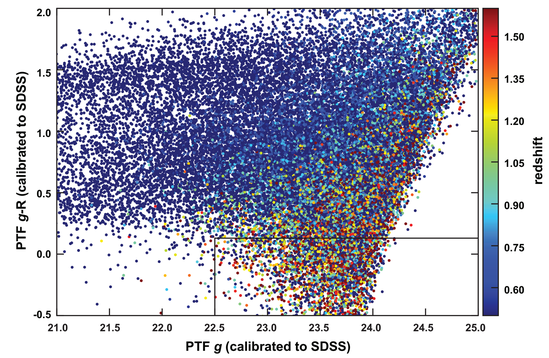



**Figure 3:** The color-magnitude diagram for PTF sources matched to COSMOS photo-*z*s. The PTF magnitudes have been zeropoint calibrated to SDSS magnitudes to remove color terms between the PTF detectors.

## Simulated DETECTIONS

To understand the detected sample of BigBOSS ELGs, we have developed a software package (*bbspecsim*) to simulate BigBOSS observations. The simulation incorporates many factors of a BigBOSS exposure including galaxy size, sky conditions, seeing effects, instrument throughputs, spectral extraction, and sky subtraction. We also use a SDSS redshift fitting routine (*zfind*) to measure redshifts from known emission lines.

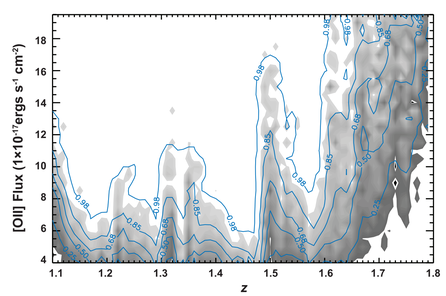



**Figure 4:** Redshift success rates for 10k simulated [OII] emission line spectra in the BigBOSS red spectrograph.

Using *bbspecsim* and *zfind*, we simulate and detect 10,000 ELG spectra with random [OII] line fluxes and redshifts under mean observing conditions. Figure 4 shows the redshift success rates for [OII] in the red spectrograph arm (7600-10600Å). Bright OH sky emission lines and continuum limit the spectrograph sensitivity, while the LBNL detector response drops off at $z>1.65$ for the [OII] doublet.

We then project the simulated redshift success rates onto the target sample (Figure 5). We find that under typical observing conditions, BigBOSS will deliver successful redshifts for ~65% of the ELG targets that are allocated to a fiber. Further improvements to the target selection efficiency will be studied in the upcoming year, including optimized spectrograph resolution, instrument throughputs, exposure times, and additional photometric criteria.

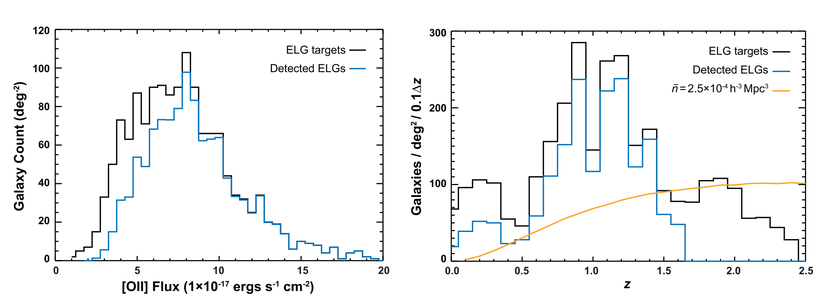



**Figure 5:** The histogram of BigBOSS ELG [OII] line fluxes (left) and the equivalent redshift distribution from associated COSMOS photo-*z*s (right). The black lines show the entire ELG target sample and the blue lines represent the detected sample after applying the simulated redshift success rates.

## Clustering PROPERTIES

To project how effective the BigBOSS ELG sample will be in measuring the BAO feature, we measure the large-scale clustering amplitude (bias) of the galaxy sample relative to dark matter halos. We opt to use the DEEP2 dataset (Davis et. al, 2007) which has ~3.5 deg$^2$ of sky coverage and precisely measured spectroscopic redshifts from line emission over $0.7<z<1.4$.

### Selection Criteria

We select a BigBOSS-like ELG sample from DEEP2 using the following criteria:

- R<23.5 and (*g*-R)<0.3
- F([OII])>9x10$^{-17}$ ergs s$^{-1}$ cm$^{-2}$
- Redshift bins at <z>=0.87, 1.0, and 1.2

Figure 6 shows the color-M/L stellar mass distributions of the selected samples are very similar between redshift bins with <Log(M$_*$)>=10.0-10.2 M$_\odot$.

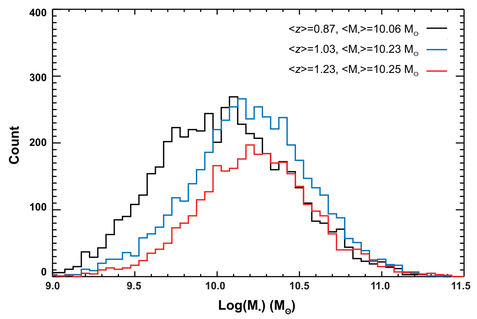



**Figure 6:** DEEP2 color-M/L stellar masses in 3 redshift bins for a galaxy sample selected similarly to BigBOSS ELGs.

### Correlation Function

Following the techniques developed for DEEP2 data in Coil et al. (2008), we compute the real-space two-point correlation function $\xi(r_p,\pi)$ using the Landy & Szalay (1993) estimator both along ($\pi$) and across ($r_p$) the line of sight. The estimator compares to random galaxy pairs to account for missing survey volume (slit masks, field geometry, etc.) We then integrate to $\pi_{max}<20\ h^{-1}$ Mpc to obtain the projected correlation function $\omega_p(r_p)$ (Figure 7).

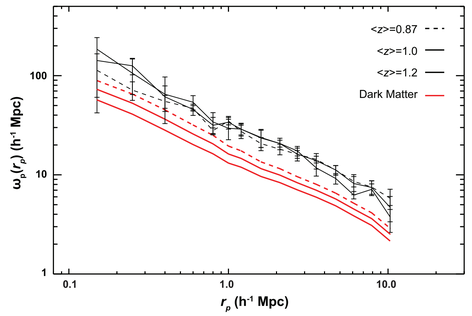



**Figure 7:** The projected two-point correlation function of BigBOSS-like ELGs. The dark matter clustering is generated for each mean redshift using publically available code from Smith et al. (2003).

### Linear Bias and Galaxy Sample Correlation Length

We measure the absolute bias by computing $b^2=[\omega_p]_{gal}/[\omega_p]_{matter}$ over linear scales of 1-10 $h^{-1}$ Mpc in a ΛCDM universe. We also fit the real-space correlation function with a power law $\xi(r)=(r/r_0)^{-\gamma}$ to retrieve the galaxy sample correlation length $r_0$ (Figure 8). The correlation function amplitude is generally constant with redshift and is fit with $r_0$=3.4 $h^{-1}$ Mpc and $\gamma$=1.7 from $0.7<z<1.4$. Appropriately, the galaxy bias increases linearly with the growth factor assuming a current epoch bias of $b(z=0)$=0.84. The measured bias behavior is consistent with other studies of ELGs in redshift windows spanning *z*=0.5-2.2 (Blake et al., 2009; Geach et al., 2008; Sumiyoshi et al., 2009).

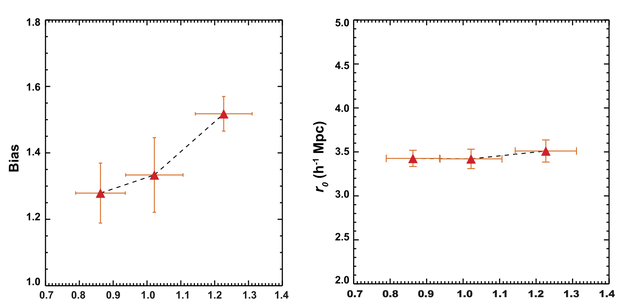



**Figure 8:** The absolute linear bias (left) and power-law fit correlation length (right) of BigBOSS-like ELGs. The clustering amplitude is constant with redshift over the range of $0.7<z<1.4$.

For more information, contact Nick Mostek (njmostek@lbl.gov) or refer to the BigBOSS experiment white paper (arXiv:1106.1706) for a general description of the survey. This work is supported by the Director, Office of Science, High Energy Physics, of the U.S. Department of Energy, under contract number DE-AC03-76SF00098.