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Preliminary Target Selection for the DESI Bright Galaxy Survey (BGS)

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ABSTRACT

The Dark Energy Spectroscopic Instrument (DESI) will execute a nearly magnitude-limited survey of low redshift galaxies ($0.05 \leq z \leq 0.4$, median $z \approx 0.2$). Clustering analyses of this Bright Galaxy Survey (BGS) will yield the most precise measurements to date of baryon acoustic oscillations and redshift-space distortions at low redshift. DESI BGS will comprise two target classes: (i) BRIGHT ($r < 19.5$ mag), and (ii) FAINT ($19.5 < r < 20$ mag). Here we present a summary of the star-galaxy separation, and different photometric and geometrical masks, used in BGS to reduce the number of spurious targets. The selection results in a total density of ~ 800 objects/deg^2 for the BRIGHT and ~ 600 objects/deg^2 for the FAINT selections. A full characterization of the BGS selection can be found in Ruiz-Macias et al. (2020).

Keywords: BGS, surveys, large-scale structure, star-galaxy separation

INTRODUCTION

The DESI BGS (DESI Collaboration et al. 2016) will be a flux-limited r-band selected sample of 10 million galaxies to $z = 0.4$. The DESI target selection will be done on the Legacy Surveys (LS) imaging (Dey et al. 2019). Results presented here are based on the DR8 release[1]. The DESI BGS is expected to have a target density of about 800 galaxies/deg^2 in a primary selection with a magnitude limit in the r-band of 19.5 and 600 galaxies/deg^2 in an additional sample defined by the magnitude range $19.5 < r < 20$ (Smith et al. 2017). Henceforth, we will refer to these BGS samples as BRIGHT and FAINT respectively.

BGS TARGET SELECTION

The BGS targets are selected using the three optical fluxes in the Legacy Surveys (Ruiz-Macias et al. 2020):

$$r < 19.5 \text{ for BRIGHT}, \qquad 19.5 < r < 20 \text{ for FAINT} \tag{1}$$
$$(-1 < g - r < 4) \tag{2}$$
$$(-1 < r - z < 4) \tag{3}$$
$$\text{rfibmag} < \begin{cases} 22.9 + (r - 17.8) & \text{for } r < 17.8 \\ 22.9 & \text{for } 17.8 < r < 20 \end{cases} \tag{4}$$

where g, r, and z indicate the extinction-corrected AB magnitudes in the corresponding band (using LS extinction corrections). In addition, we require all targets to be covered by at least one image in each optical band. We remove sources near bright stars, large galaxies, or globular clusters by requiring that LS MASKBITS 1, 12 and 13 are not set as defined in the LS data model. The bright star mask (defined by `bit=1`) combines stars from *Gaia* DR2 (Gaia Collaboration et al. 2018) and the Tycho2 (Høg et al. 2000) catalog, corrected for epoch and proper motions. This mask consists of a circular exclusion region with a radius that depends on the magnitude of the star, m. The magnitude is either the Tycho2 MAG_VT or *Gaia* G-mag with *Gaia* G-mag taking precedence. Stars fainter than $m = 13$ are not masked. The large galaxies mask (`bit=12`) was defined by the Siena Galaxy Atlas – 2020 (Moustakas, J. in prep), an angular diameter-limited sample of galaxies with mostly HyperLeda objects(Makarov et al. 2014). To mask around large galaxies and elliptical mask is used defined by the diameter at the 25 mag/arcsec^2 (optical) surface brightness, the ratio of the semi-minor axis to the to semi-major axis and the position angle. The globular cluster (GC) mask (`bit=13`) consists of a circular exclusion zone around known GCs from the OpenNGC catalog[2].

BGS star-galaxy separation is based on *Gaia* DR2. *Gaia* is highly complete for BGS and has a better point spread function (PSF) than ground-based surveys. A galaxy in BGS is defined by $(G - rr > 0.6)$ `or` $(G = 0)$ where G is *Gaia* G-mag and rr is LS r-band magnitude (without any extinction correction). We apply Equation 2 and 3 to remove sources that are beyond the color range of BGS galaxies. To remove spurious large and low-surface-brightness galaxies, we implement a cut that compares the r-band magnitude (r) to the predicted r-band *fiber* magnitude (rfibmag), as in Equation 4. Finally, we impose a minimum quality for the data reduced by *The Tractor*[3] (Lang et al. 2016), in $\texttt{FRACMASKED\_}i < 0.4$, $\texttt{FRACIN\_}i > 0.3$, $\texttt{FRACFLUX\_}i < 5$, where $i \equiv g, r$ or z. `FRACIN` is used to select sources for which a large fraction of the model flux lies within the contiguous pixels to which the model was fitted, `FRACFLUX` is used to reject objects that are swamped by flux from adjacent sources, and `FRACMASKED` is used to veto objects with a high fraction of masked pixels.

CONCLUSION

We have presented the BGS target selection from LS DR8 divided into two samples, the BRIGHT and FAINT samples. The BRIGHT sample, which will have a higher fiber-allocation priority, comprises ~800 targets/deg^2. The FAINT sample, which will be assigned at lower priority, comprises ~600 objects/deg^2. Both samples undergo the spatial and photometric cuts outlined by the MASKBITS and the number of observations required, and by Equations 2-4 respectively, passed the *Gaia* based star-galaxy classification and our quality cuts. Fig. 1 shows the BGS target density as a function of r-band magnitude and the $N(z)$ of BGS targets cross-matched to GAMA DR4 (Driver et al. 2012; Liske et al. 2015; Baldry et al. 2017). The preliminary selection described in this note is public[4].

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

[2] https://github.com/mattiaverga/OpenNGC

[3] https://github.com/dstndstn/tractor

[4] Available at https://data.desi.lbl.gov/public/ets/target/catalogs/ and detailed at https://desidatamodel.readthedocs.io

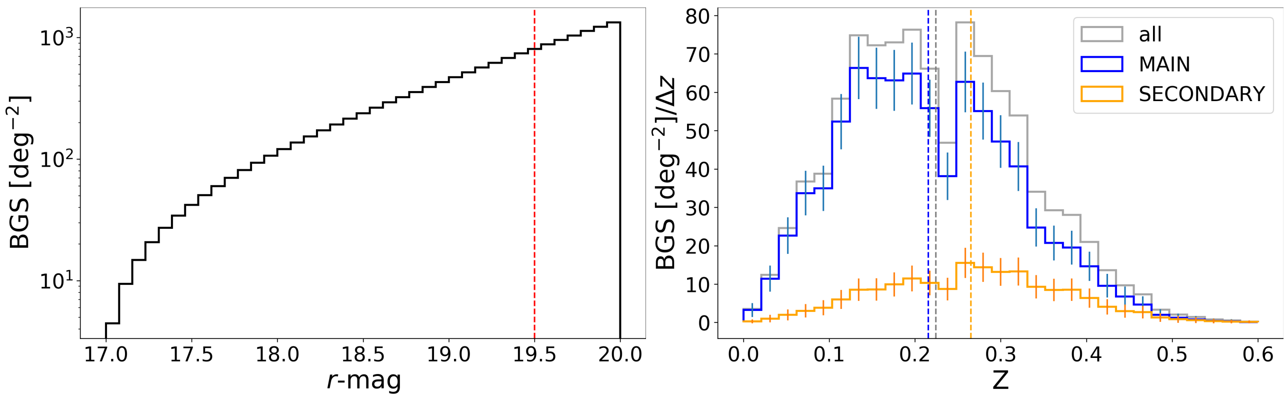

Figure 1. **Left:** Target density of BGS as a function of r-band magnitude in DECaLS DR8. The red dashed line at 19.5 marks the boundary between the BRIGHT and FAINT selections. **Right:** Redshift distribution of DECaLS DR8 BGS targets cross-matched with GAMA DR4 in redshift bins of $\Delta z = 0.02$. The solid blue, orange and gray lines show the BRIGHT, FAINT and combined samples respectively. The dashed lines show the means of the samples at 0.21 (BRIGHT), 0.26 (FAINT) and 0.22 (combined). Error bars for BRIGHT and FAINT distributions are Poisson. Because GAMA has a magnitude limit of approximately $r = 19.8$ in (SDSS DR7) r-petrosian (Abazajian et al. 2009; Driver et al. 2012), only 30 per cent of the FAINT sample appears in GAMA and the mean redshift is expected to be somewhat higher. While for the BRIGHT sample, the GAMA completeness is as high as 95 per cent.

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