

Target Selection in DESI and Survey Validation

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The 5th joint meeting eBOSS-DESI France

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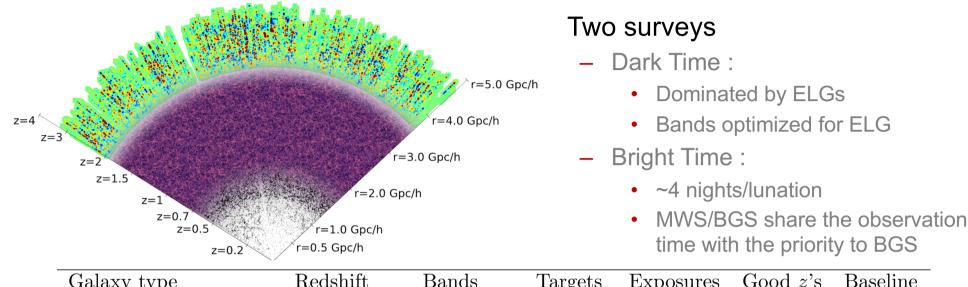
Overview of Target Selection



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Target Selection in DESI



Galaxy type	$\operatorname{Redshift}$	Bands	Targets	Exposures	Good z 's	Baseline
	range	used	$per deg^2$	$per deg^2$	$per deg^2$	sample
LRG	0.4 - 1.0	$g,\!r,\!z,\!W1$	480	610	430	$6.0 \mathrm{M}$
ELG	0.6 - 1.6	g,r,z	2400	1870	1220	17.1 M
QSO (tracers)	< 2.1	g, r, z, W1, W2	170	170	120	$1.7 \mathrm{M}$
QSO (Ly- α)	> 2.1	$g,\!r,\!z,\!W1,\!W2$	90	250	50	$0.7 \mathrm{M}$
Total in dark time			3140	2900	1820	$(25.5 \mathrm{M})$
BGS	0.05 - 0.4	r	800	740	710	9.9 M
BGS-Faint	0.05 - 0.4	r	600	460	430	$6.0 \mathrm{M}$
MWS	0.0	g,r (Gaia μ)	800 +	720	720	10.1 M
Total in bright time			2200+	1920	1860	26.0 M



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Selection of BGS galaxies and MWS stars

BGS mock

BGS

GAMA r<19.5

BGS mock

SDSS MGS

BOSS

0.6

+60°

-60

0.7

+30°

-30°

10000

0.05<z<0.4



- Median z ~0.2 (z~0.1 for MGS)
- 10 times SDSS density at z~0.3

BGS Selection

- Morphology by comparing Gaia G and r band: G-r >0 or G=0
- r<19.5 (priority 1)
- 19.5<r<20 (priority 2)
- BGS Target density
 - BGS-main: 800 deg⁻²
 - BGS-faint: 600 deg⁻²
- Milky Way Stars
 - Extra fibers used for MWS
 - Density: ~700 deg⁻²
 - Selection based on GAIA
 - 8 M of stars in 16<r<19 range, down to r~20 for fainter stars

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4.0

3.5

dN/dz/10³ (deg⁻²) 0.2 (deg⁻²) 0.2 (deg⁻¹) 0.2 (deg⁻¹) 0.1 (deg⁻¹) 0.2 (d

0.5

0.0

 10^{-1}

 $\sum_{l=0}^{\infty} 10^{-2}$ (Wbc/ μ) 10^{-3}

 10^{-4}

10⁻⁵

+30°

0°

-30°

0.1

2000

+60°

0.2

0°

0.3

0.4

redshift

+60°+120°180°-120°

0.5

MWS

8000

6000

Target density deg⁻²

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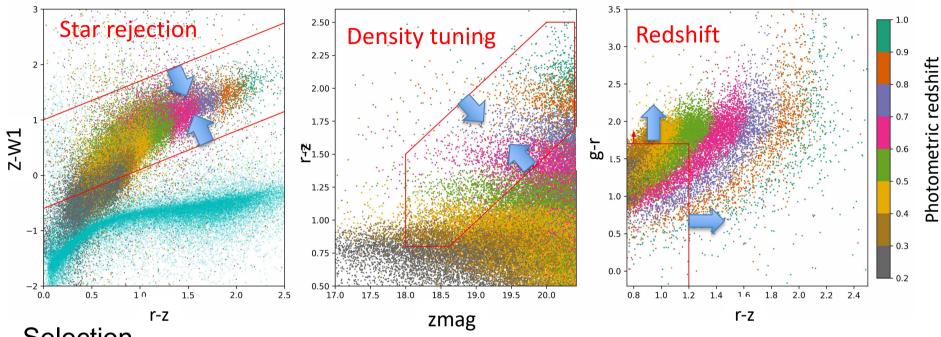
4000

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Selection of LRGs





- Selection
 - z-W1 Vs r-z to veto stars
 - No morphology criterion
 - r-z>1.2 or g-r>1.7 for redshift range
 - Sliding color magnitude cut to tune the density: (z-17.18)/2 < r-z < (z-15.11)/2
 - Slightly different selections for DECaLS and MzLS+BASS

Density

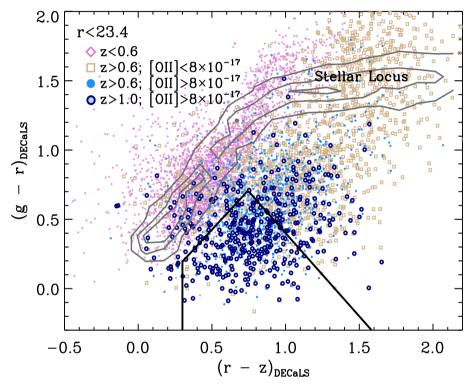
- One pass (z<20) : 350 deg⁻²
- Two passes (20<z<20.4): 130 deg⁻²
- Good redshifts: 90% ~430 deg⁻²



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Selection of ELGs





From DEEP2, validated with COSMOS

- Redshift distribution
 - Median z ~ 1.0
 - nP(k)>1 up to z~1.3
- Selection
 - g,r,z optical bands
 - g<~23.5 to reach density goal
 - No morphology criterion
- Different selection in North/South
 - g<23.6 \rightarrow g<23.4 and color box
- Target density goal
 - 2400 deg⁻²
- 2nd generation selection
 - Ongoing work to develop 2nd generation selections (Number Density Modeling and Random Forest)
 - Pilot surveys with MMT

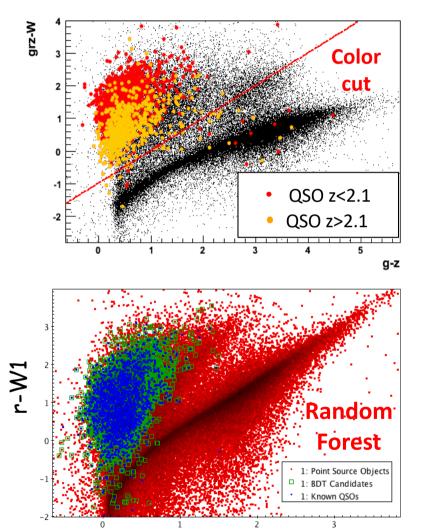


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Selection of QSOs

z < 2.1 (mean z ~ 1.5) → QSO clustering z > 2.1 (mean z ~ 2.5) → Lyα clustering



r-Z



- Point source morphology
- grz optical bands and W_1W_2 NIR bands

– r<22.7

Two approaches

- 1st generation: Color cut selection
- 2nd generation: Machine learning approach with Random Forest

Target density goal

- 260 deg⁻²
- Up to 4 passes for SNR of Ly- α QSO
- Success rate
 - z<2.1: 120 deg⁻²
 - z>2.1: 50 deg⁻²

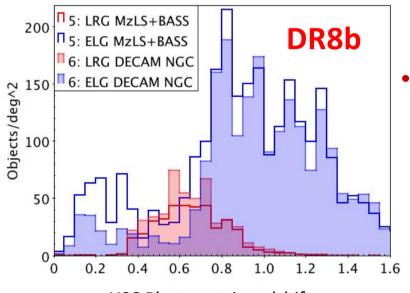


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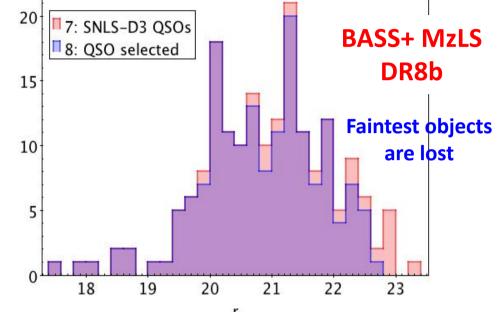
Validations with DECaLS and BASS+MzLS

Validation of QSOs

- Use SLNS D3 field (1 deg²) with QSOs selected by their variability (210 deg⁻²)
- Achieve FDR goals : ~170 QSOs deg⁻² with (>50) with z>2.1 but with a density a very low statistic...



HSC Photometric redshift



Validation of LRGs and ELGs

- Photometric redshifts from Hyper Suprime-Cam Subaru (HSC)
- Encouraging results with color cut selection for DECaLS
- More low-z galaxies for BASS+MzLS

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Preparation of Survey Validation



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Goals of Survey Validation (SV)

• Quality of the spectra

- Exposure times: achieve expected S/N
- Calibration: test that calibration satisfies spectrophotometry requirements
- Pipeline performances: Achieve redshift accuracy

• Validation of Target Selection (discussed in next slides)

- Final target efficiency \rightarrow Target densities
- Final n(z) for each tracer
- Finalization of the TS

Observation constraints

- 3-4 months at 50% efficiency
- 100 / 60 fields per month for (LRG,ELG,QSO) / BGS
- 4x times the nominal exposure time



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Preparation of Target Selection for SV

• Definition of the supersets

- Relax the cuts
- Alternative selections (LRGs: Optical/IR or QSO Color cuts/Random Forest)
- Tune the redshift distributions
- Optimize the redshift overlap: BGS/LRG, LRG/ELG
- ~Double fiber budget compared to nominal selection

Subsampling

- If the density of superset too high \rightarrow Subsampling according categories
- Mandatory for LRGs, possible for ELGs, not required for QSOs
- Subsampling managed by MTL (Merged Target List)





10

0.9

0.8

07

0.6

0.5

0.4

0.3

02

number of targets

1.0

- 0.9

0.8

0.7

- 0.6

0.5

- 0.4

- 0.3

Adding

IR selection

19.5 20.0 20.5 21.0

19.0



- Optical/IR selection
 - Sliding mag. cut :
 - (W1 17.74)/0.4 < r-W1
- + Low-z extension
 - Bright LRGs (or z<19.4)
- + High-z extension
 - Faint LRGs (or z<20.8)
- + Relaxed
 - Stellar rejection + Sliding cuts
 + g-r <1.45
- + more relaxed cuts
 - No g-r cut and r-z>0.65
- Final budget
 - Five bits are defined
 - Optical+IR: 600 deg⁻²
 - All bits: 2300 deg⁻²



2.50

2.25

2.00

1.75

1.25

1.00

0.75

3.5

3.0

2.5

2.0

1.0 -

0.5

0.0

0.8

1.0 1.2 1.4

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0.50

∾ ∟ 1.50

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2.0 2.2 2.4

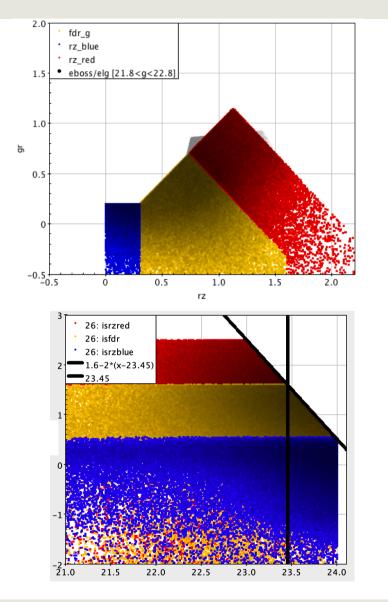
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1.6 1.8

r - 7

SV supersets for ELGs

0.6<z<1.6



- Faint objects
 - Magnitude limit: 23.45<g<23.65
- Red region
 - ELGs with similar redshift
 - But lower OII flux...
- Blue region
 - ELGs with very high redshift and reasonable OII flux
 - But close to stellar locus and low-z galaxy region
- Three bits

rz

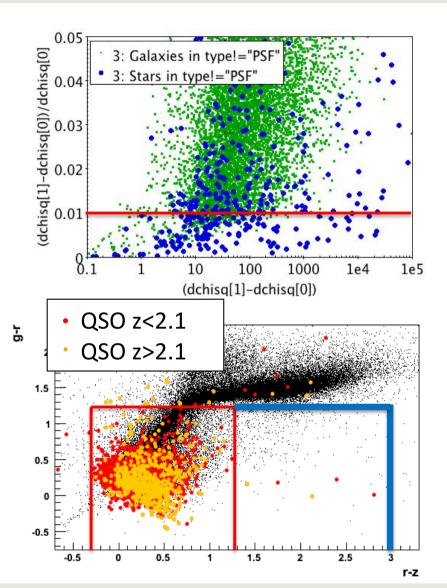
- Combination of faint / red / blue bits
- **b** Density: With sliding color cut on mag. to reject faint objects in red region $\rightarrow ~4500 \text{ deg}^{-2}$



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SV supersets for QSOs

z < 2.1 (mean z ~ 1.5) → QSO clustering z > 2.1 (mean z ~ 2.5) → Lyα clustering



- Relax PSF definition
 - Recover objects with
 (dchisq[1]-dchisq[0])/dchisq[0]<0.01
- Select fainter objects
 - Magnitude limit r<22.7 \rightarrow r<23.0
- Relax color cut selection
 - Enlarge grz and WISE color boxes
 - Reduce star stripe
- Relax random forest
 - Tune RF probability
- Add High-z faint QSOs
 - 22.7<r<23.5 (optimization of f_{NL})
- Three bits
 - Color Cut / RF / high-z faint QSO
 - Density: $400/400/70 \rightarrow 600 \text{ deg}^{-2}$
 - Completeness: ~95%



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Observation in SV

LRG and QSO observations

- 10 fields (with 8x exposure time): faint LRGs and high-z QSOs
- 10 fields (with 4x exposure time): bright LRGs and low-z QSOs
- 10 fields (with 4x exposure time): all QSOs

ELG observations

- 25 isolated fields with 4x exposure time
- Density: ~4000 deg⁻²
- Schedule
 - From Feb./March 2020 to June 2020
 - 55 specific fields with increased exposure time (2-3 months)
 - Final TS selection \rightarrow 1% survey (1 month)

SV and science is starting at DESI in less than one year!



Extra Slides



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Science Requirements

SCIENTIFIC OBJECTIVE: PERFORM A STAGE-IV BAO SPECTROSCOPIC SURVEY

LEVEL 1

SCIENTIFIC REQUIREMENTS

- Survey area > 9000 deg² with volume density nP ~ 1 (galaxies)
- Measure the distance scale R to < 0.28% for 0.0 < z < 1.1 and < 0.39% for 1.1 < z < 1.9
- Measure the Hubble parameter H to < 1% for 1.9 < z < 3.7
- Systematic error < 0.16% for D_n and < 0.26% for H

ADDITIONAL SCIENTIFIC GOALS

- Constrain growth factor at few percent level up to 0.5 < z < 1.6
- Constrain inflation spectral index and running to < 0.4%
- Measure the sum of neutrino masses to σ < 0.02 eV

LEVEL 2

DATA SET REQUIREMENTS

- Redshift range:
 - LRGs 0.4 < z < 1.0
 ELGs 0.6 < z < 1.6
 - OSOs z < 2.1
 - Ly-α z>2.1
- BG5 0.0 < z < 0.4
- Successful z object density/deg²
 - LRGs > 285
- ELGs > 1220
- QSO > 120
- Ly-α >50
- BGS > 700
- Number of redshifts: ≈O(34M)
- ELG redshift accuracy
 Δz < 0.0005 (1+z) rms with < 5% catastrophic failures
- ELG completeness
 > 90% for object fluxes > ~8x10⁻¹⁷ erg/s/cm²

LEVEL 3 TECHNICAL REQUIREMENTS Operational constraints ≤ 5 Years Median seeing 1.1" with Moffat $\beta = 3.5$ profile Astrometric error of target catalog ≤ 100 mas rms Field of view > 7 deg² Fiber density < 700/deg² Operational overheads • < 10% deadtime</p> Spectral range and resolution 360 nm < λ < 555 nm; R > 1500 555 nm < λ < 656 nm; R > 3000 656 nm < λ < 980 nm; R > 4000

DESI-0844v4

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