Galaxy completeness in two massive fiber allocation setups

February 18, 2013

1 Introduction

2 Fibers, Surveys and Galaxies

2.1 Fibers

The geometry used for Mohawk allocations was that the spines were based on a hexagonal pitch, with patrol radius equal to this pitch, and an exclusion radius for close pairs of 0.1167 pitches (based on 700μm exclusion radius and $6mm$ pitch). Figure 1 is an illustration for this configuration.

The fibers are placed in an hexagonal tile following a pattern where the inter-fiber distance, the pitch P, is the same for all fibers. The pattern is shown in Figure 1 Each fiber tile is completely described by the patrol radius $r_{\rm p}$ and the exclusion radius $r_{\rm e}$.

2.2 Two survey setups: DESpec and BigBoss

For DESpec the target density was assumed to be twice as large as the spine density, and two 'passes' were made over the field, but with the same spine home positions each time. For the simulated annealing, the targets, spine and assignment distributions were assumed to repeat on a rectangular grid.

For BigBOSS, the differences were that the patrol radius was assumed to 0.5833 times the pitch (7mm on a 12mm pitch, Silber et al SPIE 2012), with exclusion radius for close pairs of 0.15 pitches (crudely measured from the same paper). The target density was assumed to be five times as large as the spine density, with five passes were made over the field, but with the same spine home positions each time. This latter assumption is clearly wrong, and the BigBOSS yields could be improved somewhat by dithering the fields .

2.3 Galaxies

We use two kinds of galaxy distributions: poissonian and clustered.

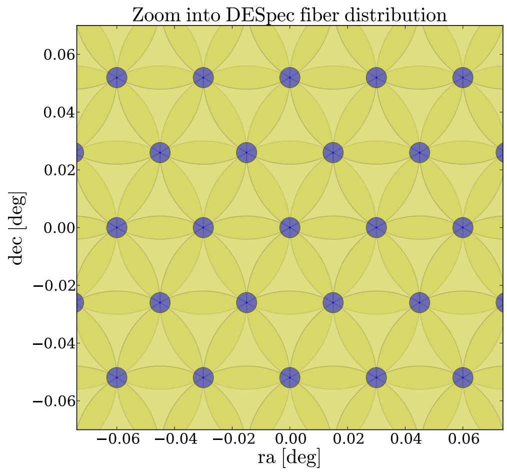

Figure 1: Zoomed in version of the Mohawk fiber distribution for the DESpec configuration. Small circles in blue indicate the fiber size. Large circles illustrate the patrol radius. Regions in light (dark) yellow can be reached by 3 (4) fibers.

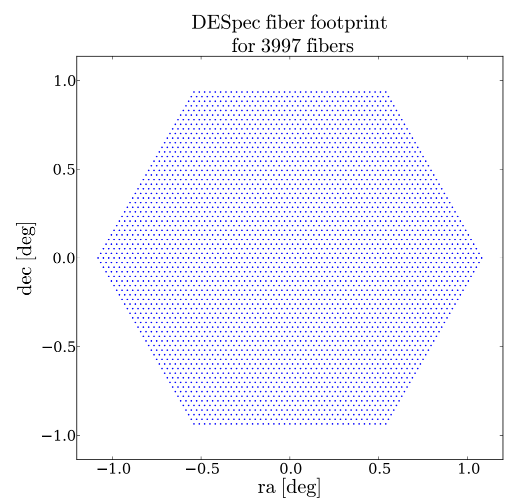

Figure 2: Fiber distribution for a DESpec setup.

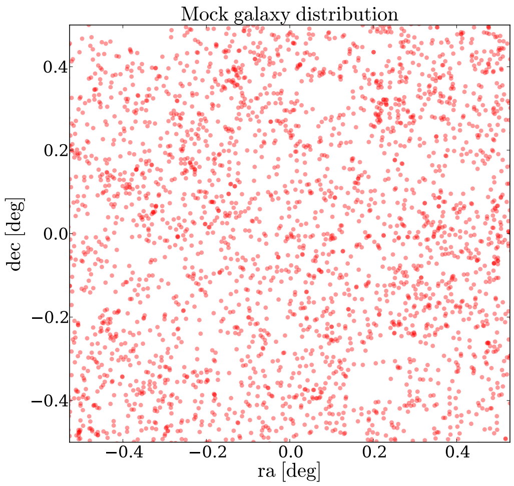

Figure 3: Mock galaxy distribution. The number density is twice the spine number density for the fiducial DESpec setup.

The clustered simulations are built directly from the observed COSMOS catalog of Capak et al. 2008, Ilbert et al. 2009. We refer to this simulation as the COSMOS Mock Catalog (CMC) (Jouvel et al. 2009). The COSMOS photometric-redshift catalog (Ilbert et al. 2009) was computed with 30 bands over 2 deg2 with data from GALEX, Subaru, CFHT, UKIRT, and Spitzer. It achieves very good photo-z accuracy and low catastrophic redshift rates. The CMC is restricted to the area fully covered by HST/ACS imaging, 1.24 deg2 after removal of masked areas. There are a total of 538,000 simulated galaxies at $i < 26.5$, with a density of roughly 120 gal/arcmin2. AGN, stars, and X-ray sources were removed from the input COSMOS catalog. Using the best fit photo-z and template, we first produce simulated magnitudes using DES filter transmission.

We then apply random errors to the simulated magnitudes based on a simple magnitude-error relation in each filter. The simulated mix of galaxy populations is then, by construction, representative of the COSMOS survey as well as the clustering and additional quantities measured in COSMOS such as galaxy size, UV luminosity, morphology, stellar masses. The CMC is limited to the range of magnitude where the COSMOS imaging is complete $i_{AB} \approx 26.2$ for a 5 σ detection (Capak et al. 2007 and 2008). We associate emission-line fluxes for each galaxy of the CMC.

We used 2 types of targets: Emission-Line Galaxies(ELG) and Lyman Red Galaxies (LRG). These galaxy types give the best probability of having a high spectroscopic success rate. Using the CMC, we use simple criterion to do the target selection: ELG with at least 1 line at 5 sigma and a photoz selection to select highest redshift galaxies. LRGs with $S/N_{\mathrm{continuum}} > 2$ and a $photo-z >$ 0.5. The final number density in this catalog is twice as the spine density for Mowhack in the DESpec configuration ase described in Section 2.2

3 Allocation Algorithms

We use two allocation algorithms

3.1 Local Galaxy Density

The first allocation algorithm gives priority is based on the Local Galaxy Density (LGD). The motivation for this algorithm is give priority to the galaxies in dense regions.

The first step in the algorithm is estimating for each galaxy the number of galaxies to be allocated within a patrol radius, n_p. Then we calculated for each spine a list of galaxies that can be reached, this list is ranked in descending order by n_p. For each spine the galaxy with the highest n_p is allocated. Then the code checks for fiber collisions, in the case of a collision the two fibers are reset and the process iterates until the number of fiber collisions cannot be decreased or the number of collisions is zero.

The code has been implemented in Python. It takes about 25 seconds to run on a 3.8GHz processor for a single field of 8000 targets, observed twice with 4000 spines. Most of the run time is spent in re-setting the fiber collisions.

3.2 Simulated Annealing

The second allocation algorithm used simulated annealing to find the optimum configuration. This has been used in allocation algorithms before, by e.g., [Miszalski et al. (2006)], and the treatment here broadly follows those efforts. An allocation is initially made at random. Assignments and deassignments are then made, also at random, except that deassignments are slowly made less and less likely to be accepted. This is done by assigning a 'temperature' T to the system, and accepting deassignments with probability $\exp(-m_i/T)$, where m_i is the merit of the ith target to be observed. 1/T was slowly increased, linearly, from $1/(1000\ n_s\ n_p)$ to 10, where n_s is the number of spines and n_p is the number of passes. $10^4\ n_p n_s$ trial assignments/deassignments were made in total.

The key to doing these huge numbers of changes in reasonable computation time is in the efficient tabulation of all the possible spine-target assignations, and of all the exclusions that prevent any given spine reassignment. These exclusions may be because (a) the proposed target is already configured, (b) that it is too close to another configured target, or (c) that the spine would cross an existing spine-target assignment, when seen in projection. In actuality, most crossings can be allowed (i.e. the spines do not physically touch), but the penalty from excluding them is very small, and allows great simplification of the reconfiguring process itself. In principle, the algorithm could be more efficient if real reassignments were allowed, i.e. a spine is switched directly from one target to another, without deassignment in between. However, this causes a significant increase in book-keeping complexity and was not pursued at this stage.

The multiple sets of passes are annealed simultaneously, so the exclusions can be circumvented by having them on different passes. The home positions of the spines were kept fixed for the multiple passes, which is not optimal, especially for the BigBOSS geometry with many passes and highly asymmetric overlap between patrol areas.

The annealing source code used to perform the tests presented in this research note is written in FORTRAN77. The code takes about 80 seconds to run on a 3.8GHz processor for a single field of 8000 targets, observed twice with 4000 spines. The run time is about equally divided between setting up the exclusions and doing the annealing.

4 Results

The following table summarizes our results

Fiber Setup	Galaxy Distribution	Allocation Algorithm	% Total Complete.	% ELG Complete.	% LRG Complete.
DESpec	Poisson	SA	95.65	-	-
BB	Poisson	SA	90.77	-	-
DESpec	Mock	SA	90.70	91.09	90.25
BB	Mock	SA	86.27	86.77	85.68
DESpec	Poisson	LGD	93.84	-	-
BB	Poisson	LGD	88.27	-	-
DESpec	Mock	LGD	90.01	93.28	86.23
BB	Mock	LGD	83.69	87.78	78.95

References

[Miszalski et al. (2006)] Multi-Object Spectroscopy Field Configuration by Simulated Annealing, Brent Miszalski, Keith Shortridge, Will Saunders, Quentin A. Parker, Scott M. Croom, MNRAS. 371, 1537-1549 (2006)