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Target Selection for the Baryon Oscillation Spectroscopic Survey

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Contents

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1. Introduction

2. SDSS Imaging Catalogs

The input catalogs are derived from the imaging released as SDSS III Data Release Eight (SDSS DR8; Aihara et al. 2011). DR8 includes 2500 deg^2 of additional imaging over data release seven, specifically acquired to aid in spectroscopic target selection for `BOSS`.

The creation of the imaging catalogs is mostly well described elsewhere, including the derivation of photometric (Padmanabhan et al. 2008; Smith et al. 2002; Tucker et al. 2006) and astrometric (Pier et al. 2003) calibrations, and calculation of basic quantities such as fluxes and shapes (Lupton et al. 2001). Aihara et al. (2011) also describe some new features in the DR8 dataset.

In the following sub-sections we will add some additional details about the DR8 imaging dataset.

2.1. Ubercal

The catalogs are placed on the same relative photometric system using the "ubercal" technique described in Padmanabhan et al. (2008). The relative calibration is precise at the ∼1% level.

There were small portions of the data used for target selection that were not photometric. We targeted these regions anyway because the tiling algorithm (XXX) cannot find an efficient solution in the presence of holes that are comparable to the tile size. This effectively means that the target selection is not uniform over the entire survey, even in the cases where a uniform algorithm was applied.

We have developed a `mangle` (Swanson et al. 2008) mask to mark these and other regions of sky we wish to ignore in science analyses that depend on a good understanding of the underlying selection function, such as angular correlations. It is recommended that users make use of these masks when performing statistical studies using the `BOSS` spectroscopic samples. See §3 for details of these masks and how to obtain them.

2.2. AB Zero Points

Do we have any knowledge of this? David suggests we know it only vicariously through matching to dr7 and demanding consistency.

Daniel 1152

```
u(AB) = u(SDSS) - 0.036 - 0.009
g(AB) = g(SDSS) + 0.012 - 0.004
r(AB) = r(SDSS) + 0.01 by assumption
i(AB) = i(SDSS) + 0.028 + 0.002
z(AB) = z(SDSS) + 0.04ish + 0.004
```

Marriner 1339

```
u=-0.037
g=+0.024
r=+0.005
i=+0.018
z=+0.016
```

2.3. Cataloged Quantities

In this section we describe the quantities from the imaging catalogs used in target selection. These are all described in the above references, but we will give a few more details here.

2.3.1. Flux Measurements

We use a few different fluxes in our selection. For point sources we always use the flux derived by fitting a model of the local PSF interpolated to the location of the object (Lupton et al. 2001; Sheldon et al. 2004), known as `psfmag`.

For galaxies we use three different magnitudes, one optimized for colors called `modelmag`[1], one designed to be an approximate total magnitudes in each band, called `cmodelmag`, and one designed to mimic the 2 arcsec aperture of the spectroscopic fibers called `fiber2mag`.

We fit each object to elliptical exponential disk and elliptical De Vaucouleurs' models, convolved with a double Gaussian approximate to the PSF model interpolated to the location of the object. The best fit model in the r-band is then used to measure fluxes in the other bands, convolving with the filter-dependent PSF as appropriate. Because the effective aperture is the same for each band, `modelmag` is appropriate for measuring colors.

Note, as part of the De Vaucouleurs' fitting we measure the scale radius r_{deV} which is also used in galaxy target selection.

For approximate total magnitudes, we use "composite model magnitudes", aka `cmodelmag`. In `PHOTO` we do an additional joint fit to a non-negative linear combination of the best-fitting

[1]http://www.sdss3.org/dr8/algorithms/magnitudes.php

exponential and De Vaucouleurs' models. The parameter `frac_deV` (f_{deV}) is then used to construct `cmodelmag` from the individual fits.

$$\mathrm{Flux}_{cmodel} \equiv (1 - f_{dev}) \times \mathrm{Flux}_{exp} + f_{dev} \times \mathrm{Flux}_{dev}, \tag{1}$$

The `fiber2mag` is the flux in a 2 arcecond aparture, convolved with a 2 arcsecond PSF model in order to simulate the expected seeing during spectroscopic observations. The `fiber2mag` is used as a faint end cut for galaxy targets.

2.3.2. Image Processing Flags

The pipelines flag objects based on data quality and processing status, and we use these to help produce a clean sample. The flags used in target selection are `OBJECT`[2] processing flags, `CALIB_STATUS` flags for the photometric calibration, and `RESOLVE_STATUS` to identify unique objects (see also §2.3.3).

2.3.3. Resolve Flags

The selection of unique objects from the imaging data, which we call the `resolve`, is described in detail in Aihara et al. (2011) as well as the SDSS3 website[3]. In the following sections, we refer to the use of the `SURVEY_PRIMARY` bit in the `RESOLVE_STATUS`, which marks these unique objects.

2.3.4. Other Quantities

We use the proper motions in the CCD row and column directions (`rowv,colv`) as a flag to remove stars from QSO target selection.

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[2]http://www.sdss3.org/dr8/algorithms/flags_detail.php

[3]http://www.sdss3.org/dr8/algorithms/resolve.php

2.4. Initial Star-Galaxy Separation

Inital star galaxy separation is performed in the photometric pipeline `PHOTO`. The algorithm uses only morphological information. We first define the concentration c as the difference between the `psfmag` and `modelmag`:

$$c \equiv \text{psfmag} - \text{modelmag}\ . \tag{2}$$

The fluxes are summed for all bands. Because the exponential and De Vaucouleurs' models are convolved with the local PSF, the model scale radius approaches a delta function for stars, and c approaches zero. The measured concentration for galaxies should be greater than zero. We define a simple cut $c > 0.145$ for galaxies. For the galaxy `LOZ` sample we add an additional cut in the r-only concentration at 0.3, to be consistent with the Luminous Red Galaxy sample from SDSS I (cite XXX).

We implemented an alternative star galaxy separation scheme for the `CMASS` galaxy target selection using only i-band, which should be more well-measured than bluer bands for our galaxy targets. We did not see significant improvement.

Note the star sample is used as a starting point for quasar target selection. This simple concentration cut is not adequate at the faint magnitudes ($g\sim 22$) used for quasar selection[4]. However, the color based selection reduces the contamination by galaxies and in fact stars are by far the largest contaminant in the quasar target sample (Ross et al. 2012).

3. Masks and Survey Boundaries

3.1. BOSS Survey Boundaries

We define the footprint for `BOSS` as two regions of relatively low galactic extinction in the north and south galactic caps, as shown in figure 1.

We define the footprint in terms of a set of contiguous rectangles in "corrected survey coordinates" (η_c, λ_c). This coordinate system is designed so that the center of SDSS scan lines run along lines of constant longitude η. The center point (η_c, λ_c) = (0,0) maps to equatorial (α, δ) = (185.0,32.5), and the poles map to (95,0) and (275,0). The coordinate is corrected relative to the standard survey coordinates (Stoughton et al. 2002) in that the latitude λ ranges only from -90 to 90 rather than -180 to 180. Software to convert between

[4]see, e.g., http://www.sdss.org/DR7/products/general/stargalsep.html

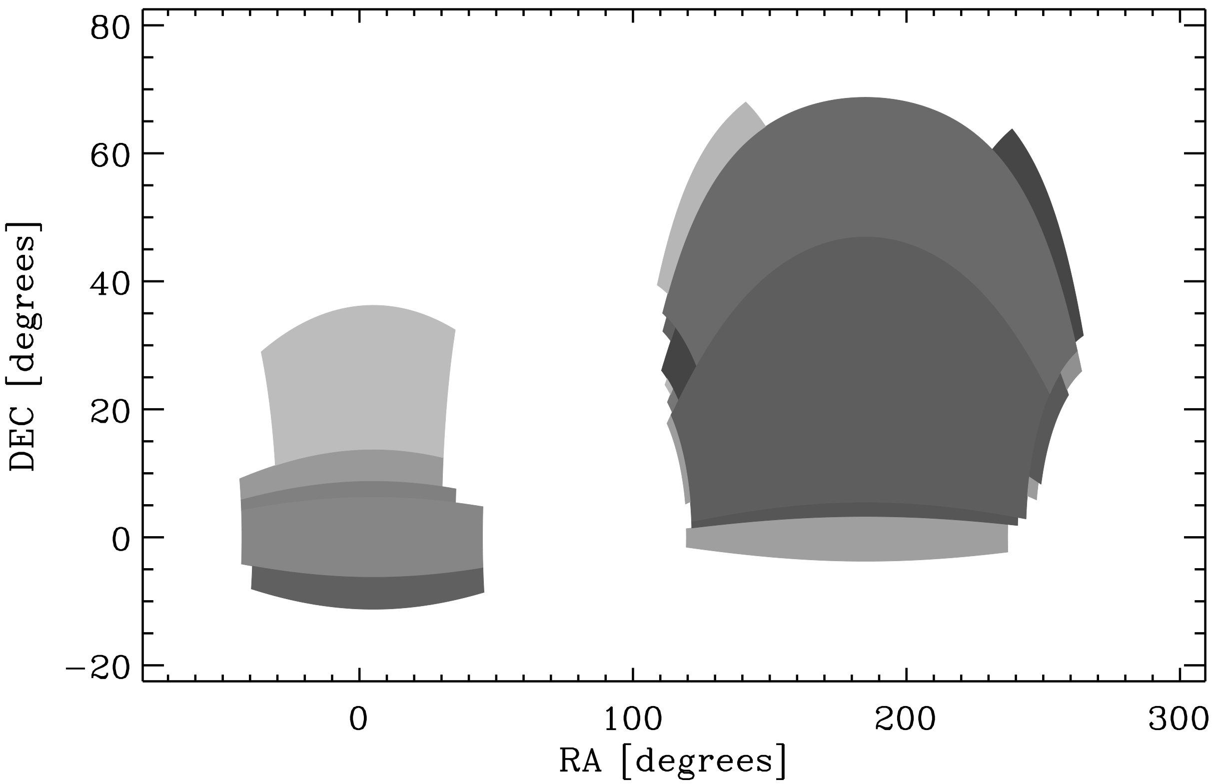

Fig. 1.— BOSS angular window function for the south galactic cap on the left and the north galactic cap on the right. The differently shaded regions represent contiguous rectangular regions in corrected SDSS survey coordinates, used for construction of the window function. Note points with RA $> 300°$ have been wrapped below zero to avoid the $360°$ crossing point.

equatorial and corrected survey coordinates is available on the web[5].

The rectangles as defined in survey coordinates are each assigned a color in figure 1, and appear curved in the equatorial coordinate system. These rectangles are given in table 1.

[5]Python code: http://code.google.com/p/esutil/ IDL code: http://code.google.com/p/sdssidl/

Table 1. Definition of BOSS Survey Footprint

Region	η_c min (deg)	η_c max (deg)	λ_c min (deg)	λ_c max (deg)	Area (sq. deg.)
SGC	111.25	133.75	-25.00	35.00	1284.25
SGC	133.75	138.75	-25.00	48.00	333.97
SGC	138.75	141.25	-30.00	48.00	178.07
SGC	141.25	153.75	-40.00	48.00	992.60
SGC	153.75	158.75	-40.00	44.00	383.15
NGC	-36.25	-29.25	-65.50	52.00	681.01
NGC	-29.25	-27.00	-63.50	55.60	221.74
NGC	-27.00	14.50	-63.50	58.60	4157.50
NGC	-20.00	14.50	-65.30	-63.50	26.83
NGC	-20.00	-14.00	58.60	62.00	10.11
NGC	-14.00	24.00	58.60	63.00	81.55
NGC	14.50	36.25	-52.00	58.60	2045.69
NGC	14.50	29.00	-60.00	-52.00	64.81
NGC	14.50	19.50	-62.80	-60.00	6.70
NGC	19.50	24.50	-61.20	-60.00	2.95
NGC	29.00	34.00	-54.50	-52.00	7.48
NGC	24.00	36.25	58.60	62.00	20.63
NGC	36.25	41.25	-48.60	-15.00	140.74
NGC	36.25	41.25	20.80	57.00	138.53

Note. — Definition of BOSS survey footprint. Rectangles are defined in corrected survey coordinates. Objects found inside these rectangles are considered for target selection. See also figure 1

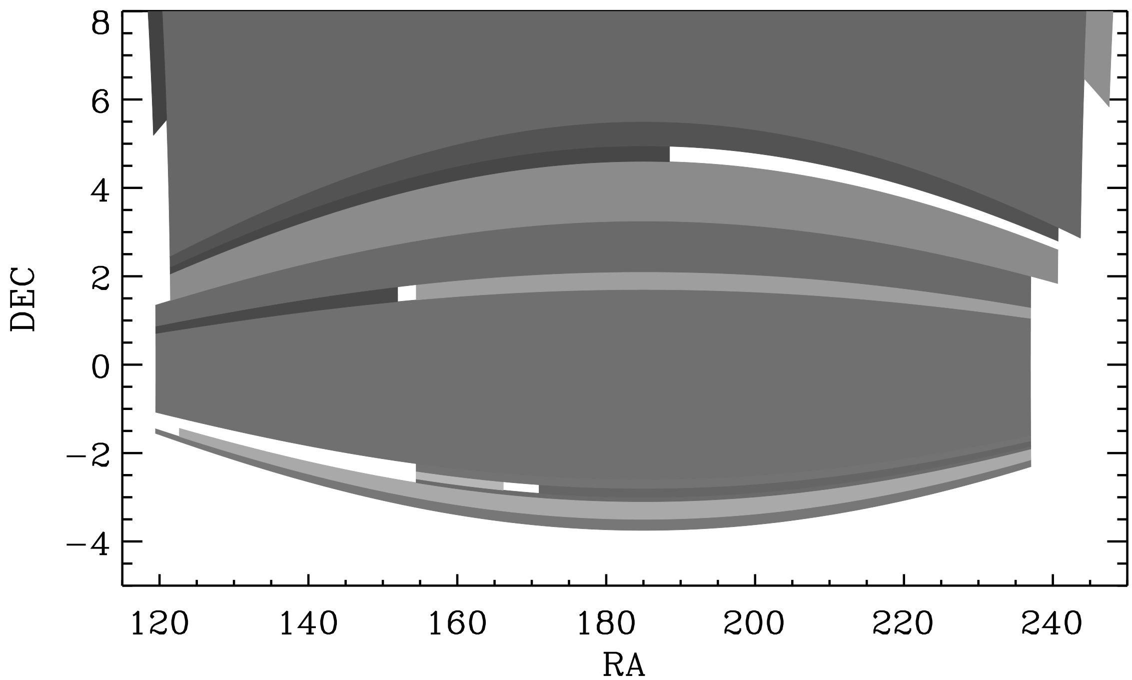

Fig. 2.— A zoomed view of the BOSS footprint, now excluding regions where an amplifier attached to a CCD behind one of the u-band filters was not working. We use this mask during quasar target selection.

3.2. Masked Regions for Quasar Target Selection

For quasar target selection, which uses the u-band, we mask a few regions from the survey footprint where the only available imaging was taken during a failure of an amplifier attached to a CCD behind one of the u filters[6]. These are again defined as rectangles in (η_c, λ_c). The definition of these mask rectangles are given in table 2 and shown in figure 2.

3.3. Bright Star Masking For Galaxy Target Selection

We define a simple mask around bright stars from the tycho catalog (Høg et al. 2000). The radius is magnitude dependent, and is given by

$$r = (0.0802 \times B_T^2 - 1.860 \times B_T + 11.625)/60.0, \tag{3}$$

[6]http://www.sdss.org/dr7.1/start/aboutdr7.1.html#imcaveat

where B_T is the Tycho magnitude and r is in degrees.

3.4. Trimming During Tiling

Note during the tiling process XXX, this full BOSS footprint is not used. Details of that further trimming are given in XXX.

3.5. Mangle Representation of Footprint and Masks

We have developed mangle (Swanson et al. 2008) representations of the survey footprint with and without the masked regions. should we give URLs into the svn repo?

4. Pre-selection

4.1. Unique Objects

For the main target selection, we only consider unique objects labeled as SURVEY_PRIMARY in the RESOLVE_STATUS flags as described in §2.3.3.

4.2. Angular Masking

Using the definitions in §3, we trim these catalogs to the survey footprint and, for quasars, we further mask out some bad imaging regions.

4.3. Basic Photometric Cuts

We use as the starting point for our selection the calibObj or "datasweep" files. These files contain only objects that meet certain basic criteria. First, basic star-galaxy separation is performed as described in §2.4. For objects marked as stars, we only retain those objects with extinction-corrected psfmag less than [22.5, 22.5, 22.5, 22, 21.5] in the u, g, r, i, z bands, respectively. For galaxies, we retain objects with extinction-corrected modelmag less than [21, 22, 22, 20.5, 20.1].

Objects with the following OBJECT flags set (see §2.3.2) are not considered for spectroscopic follow-up.

- Objects labeled as BRIGHT.
- Objects labeled as SATUR.
- For quasars and standard stars, objects labeled as INTERP_CENTER, PSF_FLUX_INTERP
- For galaxies and quasars, objects labeled as NOTCHECKED, for standards labeled as NOTCHECKED_CENTER.
- For galaxies and quasars, objects labeled as PEAKCENTER.
- For galaxies and standard stars, objects labeled as NOPROFILE.
- For galaxies and standard stars, objects labeled as DEBLEND_TOO_MANY_PEAKS.
- For quasars and standard stars, objects that have a cosmic ray in an associated pixel CR.
- For quasars and standards, objects labeled as BLENDED, for galaxies objects labeled as BLENDED but also NODEBLEND.
- For quasars, objects not labeled as BINNED1 in some band, for galaxies not labeled as BINNED1, BINNED2 or BINNED4 either the r- or i-band.

The only exceptions to the above criteria are certain known quasar objects, which are subjected to less restrictive criteria (see §**??**), and quasars selected from coadded data during commissioning (XXX need Christophe's criteria).

4.3.1. Galaxy-specific Cuts

In addition to those cuts listed in 4.3, the following are not considered for follow-up as galaxies:

- Objects in close proximity to a known Tycho star as described in §3.3.
- Galaxies that already have known redshifts from the SDSS.
- The object matches a known quasar or star within 1 arcsecond. how was known-quasarstar.060910.fits generated?

4.3.2. Quasar Specific Cuts

In addition to those cuts listed in §4.3, the following are not considered for follow-up as quasars:

- Objects labeled as `BAD_COUNTS_ERROR`.
- Objects labeled as `DEBLEND_NOPEAK`.
- Objects labeled as `EDGE`.
- Objects labeled as `DEBLENDED_AS_MOVING`.

Standard Star Specific Cuts

In addition to those cuts listed in 4.3 the following are not considered for follow-up as standard stars:

- Objects that have bad sky measurements `BADSKY`.
- Objects labeled to have `PEAKS_TOO_CLOSE`.
- Objects not labeled as `STATIONARY`.
- Known quasars.

5. Coadds

6. Galaxy Selection

The full description of the evolution of the galaxy target selection algorithms is given in Padmanabhan et al. (2013). Here we will give an overview of the final selection and the simple diagnostics used to tune the algorithms to produce the nominal target density.

6.1. Galaxy Selection Algorithms

Show formulas and some status, heat maps, etc.

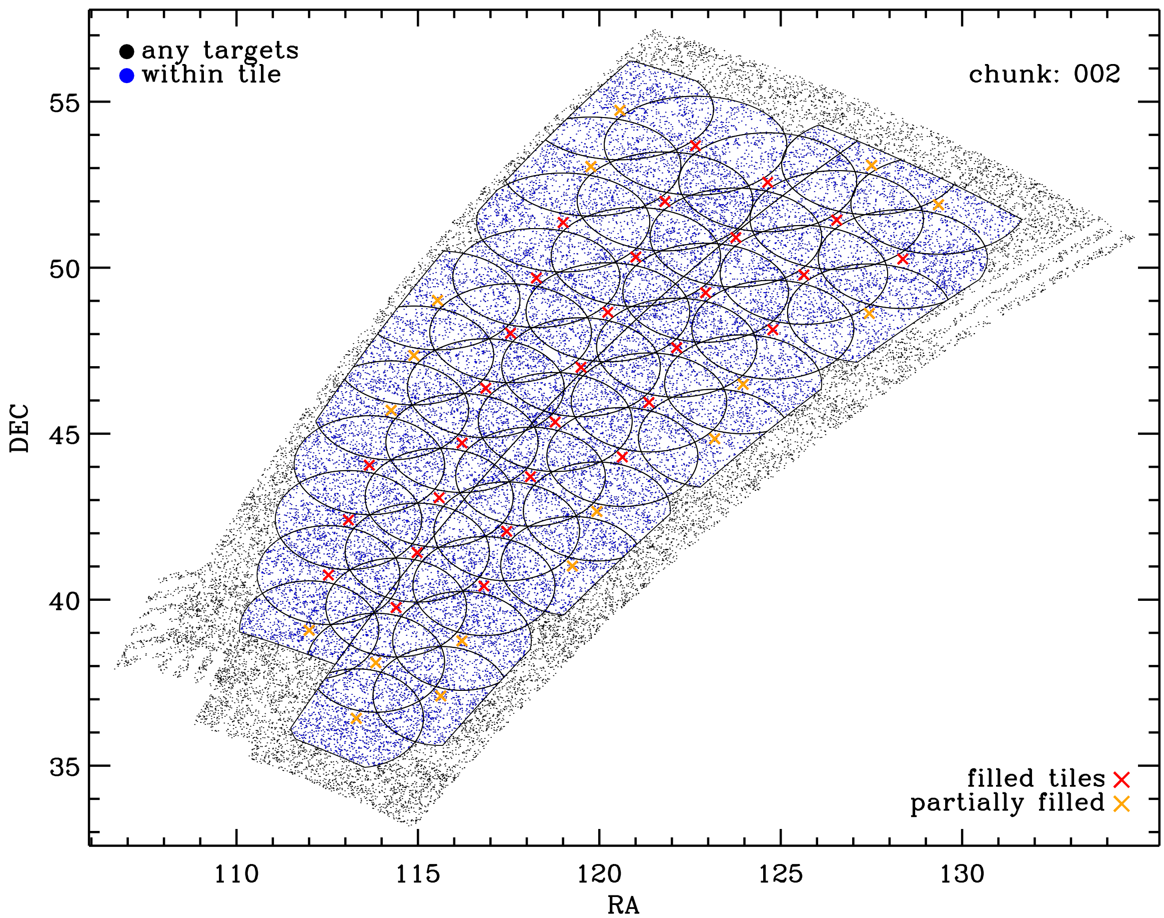

Fig. 3.— blah

6.2. Tuning the Density

7. Quasar Selection

This is all in Ross et al now

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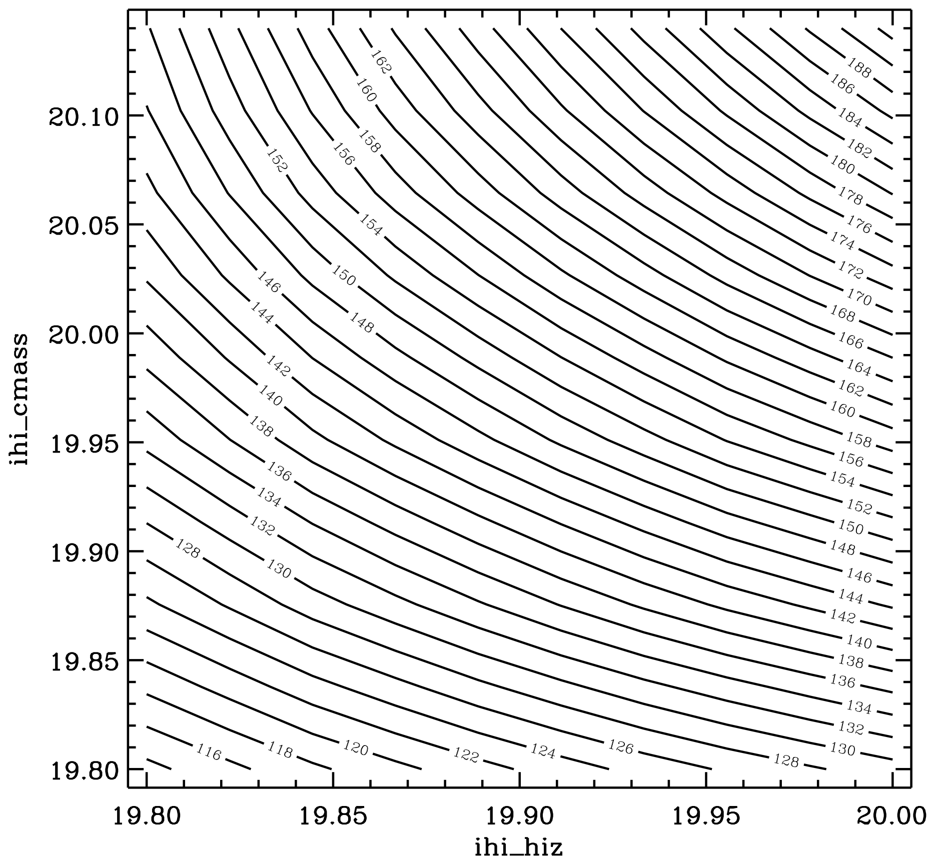

Fig. 4.— blah

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Table 2. Masked Areas

Region	η_c min (deg)	η_c max (deg)	λ_c min (deg)	λ_c max (deg)	Area (sq. deg.)
NGC	-36.00	-35.60	-65.50	-62.30	0.56
NGC	-35.60	-35.10	-65.50	-30.50	11.53
NGC	-35.50	-35.30	-18.80	-14.00	0.92
NGC	-30.80	-30.40	-33.00	-30.50	0.85
NGC	-27.90	-27.55	3.50	55.60	15.32

Note. — Regions excluded from the quasar target selection due to malfunctioning amplifier attached to a CCD behind a u-band filter. See also 2