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The LEGUE input catalog for dark night observing in the LAMOST pilot survey [*]

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Abstract We outline the design of the dark nights portion of the LAMOST Pilot Survey, which began observations in 2011 October. In particular, we focus on Milky Way stellar candidates that are targeted for the LEGUE (LAMOST Experiment for Galactic Understanding and Exploration) survey. We discuss the regions of sky in which spectroscopic candidates were selected, and the motivations for selecting each of these sky areas. Some limitations due to the unique design of the telescope are discussed, including the requirement that a bright ($V < 8$) star be placed at the center of each plate for wavefront sensing and active optics corrections. The target selection categories and scientific goals motivating them are briefly discussed, followed by a detailed overview of how these selection functions were implemented. We illustrate the difference between the overall input catalog – Sloan Digital Sky Survey (SDSS) photometry – and the final targets selected for LAMOST observations.

Key words: surveys: LAMOST — Galaxy: halo — techniques: spectroscopic

1 INTRODUCTION

The LAMOST survey, slated to begin in late 2012 (see Zhao et al. 2012 for an overview), will obtain spectra of millions of Milky Way stars (in a survey known as LEGUE – LAMOST Experiment for Galactic Understanding and Exploration) in addition to an extragalactic survey of QSOs, galactic redshifts, and stellar populations of galaxies (known as LEGAS – LAMOST ExtraGAlactic Surveys). The LAMOST telescope has a $5°$-diameter field of view, and a focal plane populated with 4000 robotically-positioned optical fibers feeding 16 bench spectrographs. The effective aperture of the telescope varies from 3.6 to 4.9 meters depending on the pointing position (Cui et al. 2012). The combination of a large field of view, ample collecting area, and highly-multiplexed spectroscopy enables surveys of orders of magnitude more targets than was previously feasible, while covering huge contiguous areas of sky. Thus LAMOST (in particular, the LEGUE Galactic structure portion of the survey) will provide unprecedented opportunities for studies of the structure of our Galaxy.

With these new capabilities (and limitations imposed by the unique telescope design that enabled the large-scale spectroscopic survey) come new challenges in selecting input catalogs for observing. We report here on the design of the LAMOST Pilot Survey, a one-year program operated in survey mode, which will provide a set of rich spectroscopic data that allows testing of survey mode operations (in addition to producing science results) before the main LAMOST survey begins. The LAMOST Pilot Survey began on 2011 October 24, and will operate through the end of spring 2012.

In order to more efficiently take advantage of telescope time during all observing conditions, two survey modes were adopted for the Pilot Survey. Separate input target catalogs were generated for observations on bright and dark nights. Bright nights are defined as from five nights before to five nights after the full Moon in each lunation. Dark nights are those from five nights before to five nights after the new Moon, and those between the dark and bright are defined as grey time. During the Pilot Survey, six nights are set aside for test observations and telescope adjustments per lunar month from 5–7 nights and from 20–22 nights after the new Moon. On the bright nights, relatively bright ($r \lesssim 16.5$) stars are observed in the low-latitude regions near the Galactic anticenter (GAC), the Galactic disk area, and a constant-declination stripe at $\delta \sim 29°$. Faint targets are reserved for dark nights, when the LEGUE survey of the Galactic halo and the LEGAS extragalactic surveys are carried out, and portions of the grey nights when moonlight is minimal. In this paper, we discuss the design of the dark nights portion of the LAMOST Pilot Survey; a companion paper (Zhang et al. 2012) will discuss the bright nights observing program.

In this paper we discuss the design of the stellar input catalog for dark nights, including the areas of sky to be observed and special considerations required due to site and telescope limitations and the sharing of plates with the LEGAS survey. Because LEGAS cannot fill all of the fibers on each plate with extragalactic objects, many fibers on a LEGAS plate are available for LEGUE targets. We discuss some details of the selection of individual targets for the dark nights portion of the LAMOST Pilot Survey; details of the target selection algorithm and the bright nights and disk surveys are given elsewhere (Carlin et al. 2012; Zhang et al. 2012; Chen et al. 2012). This paper is organized as follows: In Section 2, we introduce how the observation area for dark nights was selected. Section 3 describes how we selected the targets. Section 4 describes the plate design. We conclude with some brief discussion in Section 5.

2 REGIONS OF SKY FOR DARK NIGHT OBSERVING

The LAMOST Pilot Survey began in 2011 October and is planned to continue through the end of spring 2012; this places some limitations on the accessible range of right ascension (RA). Of course, it is important that targets are available on every night with clear weather. Two ranges in RA that bracket the Galactic plane were selected for the input catalogs: one between $-45° < \alpha < 60°$ and the other between $120° < \alpha < 240°$. To enable studies of Galactic halo stellar populations, the high stellar density regions at low ($b \lesssim 30°$) Galactic latitudes were not included (note that low-latitude
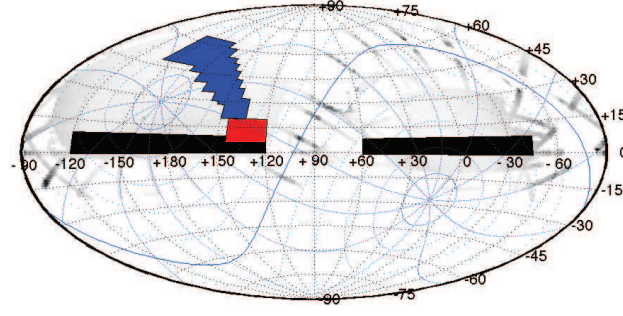
Fig. 1 Sky areas targeted on dark nights during the LAMOST Pilot Survey, shown in equatorial coordinates. The figure is centered at $(RA, Dec)_{J2000}=(90°, 0°)$. Black dots show the RA, Dec coordinate grid, while blue dots show Galactic longitude and latitude. The thick blue line shows the Galactic plane. The grey background is a stellar density map of stars with $-0.5 < (g - r)_0 < 0.4$ and $20 < r_0 < 22$ from SDSS DR8 photometry. The LEGAS area (*filled black rectangles*) has two stripes, one is RA between $-45°$ and $60°$ and Dec between $-1.5°$ and $8.5°$, the other is $120° < RA < 240°$, $-0.5° < Dec < 9.5°$. The Anticenter box (*filled red box*) was selected by $120° < RA < 145°$, $6° < Dec < 20°$, where the Sagittarius stream and "Monoceros Ring" substructures overlap. The GD-1 area (*filled blue region*) follows the position of the GD-1 stream as fit by Willett et al. 2009 (see Eq. (1)).

stars are included either in the anticenter portion of the survey or the disk portion of the survey, both of which focus predominantly on brighter stars near the disk; see Chen et al. 2012). Due to the telescope site and the unique optical design of LAMOST, the optimal observable sky area is restricted to an area between declinations of $-10° < \delta < 60°$ (Zhao et al. 2012).

Three regions of sky were selected for dark night observations during the Pilot Survey (see the map in Fig. 1). We will denote these the "GD-1 area" (shown in blue in Fig. 1), the low Galactic latitude "Anticenter Box" (red), and the "LEGAS area" (black). These regions are defined as follows:

(1) The GD-1 area (blue region in Fig. 1) was selected to cover the GD-1 tidal stream (Grillmair & Dionatos 2006) as much as possible. To do so, a region of $\sim 5°$ width was selected surrounding the stream as traced by Willett et al. (2009)

$$\delta = -864.5161 + 13.22518\alpha - 0.06325544\alpha^2 + 0.0001009792\alpha^3. \qquad (1)$$

(2) The Anticenter Box is defined by $120° < \alpha < 145°$ and $6° < \delta < 20°$. It was selected to overlap some known Milky Way substructures, including the Sagittarius stream, the Anticenter Stream (and/or the "Monoceros Ring"; see Li et al. 2012), and the Eastern Banded Structure (Grillmair 2011).

(3) The LEGAS area was selected by the LEGAS group for the study of galaxies and QSOs using LAMOST. Because the surface density of galaxies and QSOs in the observable magnitude range is much smaller than 200 deg^{-2} (the fiber density of LAMOST), we fill the remaining fibers (typically about half of them) with stars selected in the same way as those for the rest of the LEGUE survey. The LEGAS area consists of fields near the celestial equator, and is split into two regions (again, to avoid the Galactic plane). One is the South Galactic Cap region (SGC), ranging from $-45° < \alpha < 60°$ and $-1.5° < \delta < 8.5°$, and the other region is in the North Galactic Cap (NGC), ranging from $120° < \alpha < 240°$ and $-0.5° < \delta < 9.5°$.

Each of these regions was chosen in part to maximize the potential scientific yield of the Pilot Survey data, and in part to provide valuable test data for assessment of LAMOST's performance.

The stellar tidal stream of Grillmair & Dionatos (2006), which has come to be known as "GD-1," is one of the nearest known halo substructures. This stream is a narrow feature sweeping across much of the NGC region of the sky. Distances derived from F-type main sequence turnoff stars (at g magnitudes of ~ 18.5) place GD-1 at 7–10 kpc from the Sun (Willett et al. 2009). With kinematics and distances over a large angular extent, one can fit an orbit to the stream and use this to trace the gravitational potential of the dark halo of the Milky Way (e.g., Koposov et al. 2010, Willett et al. 2009). Another benefit of the GD-1 region for the Pilot Survey is that it spans a large range in declination. As mentioned previously, the telescope's performance varies with declination; data from the GD-1 area will provide valuable test data to assess the data quality over a large range of declinations.

The Anticenter Box (red box in Fig. 1) was selected for the study of known stellar tidal streams. Obtaining thousands of spectra covering this complicated region of sky is essential for disentangling these numerous features that overlap on the sky. Additionally, these data will probe the Milky Way at moderate latitudes ($20° \lesssim b \lesssim 45°$) near the Galactic anticenter, providing a valuable data set for studies of thin/thick disk structure in addition to the substructures that will be present in the data.

Finally, the LEGAS regions, while selected by the extragalactic group to optimize their science, will provide a valuable data set for Galactic structure studies as well. These two regions (the filled black rectangles in Fig. 1) probe a large volume of the high-latitude Milky Way in both the southern and northern Galactic caps. The stellar spectra from these regions can be used to study the overall density structure of the Galactic halo; in particular, these data will provide a means of comparing the stellar density profile in the NGC to that of the SGC. Recent evidence has shown that the Milky Way stellar halo is asymmetric (Newberg et al. 2007; Newberg & Yanny 2006; Xu et al. 2006, 2007), with excess stars in the north relative to the southern Galactic cap. At least some of this asymmetry is due to the large, cloud-like Virgo substructure (see Newberg et al. 2007; Jurić et al. 2008), a $\sim 1000 \text{ deg}^{-2}$ stellar overdensity in the northern Galactic hemisphere, centered at $\alpha \sim 180°$ (Vivas & Zinn 2006). The LEGAS stripe will yield a large number of spectra of candidate Virgo substructure members. Overall, the LEGAS stripes, while effectively "bonus" data for the LEGUE survey, will be an important resource for Galactic structure studies.

3 TARGET SELECTION

The fixed-meridian design of the telescope restricts observations to objects within ~ 2 hours on either side of the meridian plane. The observational magnitude limit in the r band for the Pilot Survey is $r \lesssim 19.5$, which can be achieved by summing three exposures of 1800 s each. This 1.5-hour exposure time is the standard for the faint plates in the Pilot Survey.

In order to generate the input catalog for the dark nights portion of the LAMOST Pilot Survey, we need to find a proper source of high-quality, homogeneous photometry. It must be photometrically complete to the LAMOST magnitude limit ($r \sim 19.5$), and must cover much of the northern hemisphere sky accessible from the Xinglong Station (the LAMOST site). An ideal source for this is the publicly available Sloan Digital Sky Survey (SDSS) Eighth Data Release (DR8; Aihara et al. 2011), which covers 14 555 square degrees in sky area, mostly in two large contiguous areas near the north and south Galactic caps. SDSS DR8 contains more than 260 million stars, and is 95% complete to magnitudes of $r \sim 22$. For the Galactic halo portion of the LEGUE survey, the five photometric bands (u, g, r, i and z) provided by SDSS offer the possibility of selecting different types of stars of particular interest based on their colors. We thus chose to use SDSS DR8 photometry to create input target catalogs for the relatively high-latitude LEGUE survey.

3.1 Color and Magnitude Target Selection Criteria

All stars between $14 < r < 19.5$ were selected from SDSS DR8 as the source of the input catalog for dark nights. Candidates were selected from the SDSS "Star" database (i.e., objects identified as point sources by the SDSS pipelines) using the "clean" photometry flag to ensure that we obtain only well-measured stars. Unlike brighter magnitude-limited spectroscopic surveys such as RAVE (Steinmetz et al. 2006) or HERMES (Freeman & Bland-Hawthorn 2008), the number of available sources for the faint plates in the LEGUE survey is much larger than the number of objects that can be observed. To deal with this problem, we adopt the Target Selection (TS) algorithm described in Carlin et al. (2012), which implements a way to preferentially select targets of particular types based on any observable quantity (or combinations of observables), while retaining a smoothly-varying, well-understood selection function that samples stars from all regions of parameter space. For LEGUE, we are specifically interested in biasing the target selection to include as many horizontal-branch (and/or blue straggler) stars as possible, as well as over-selection of blue F-type turnoff stars. These categories of intrinsically bright stars of relatively unambiguous luminosity classification are extremely useful for studies of the Galactic halo to large distances. In addition, the selection is biased toward bluish bright stars at brighter magnitudes, from which we hope to identify candidates of extremely metal poor stars at bright enough magnitudes for high-resolution spectroscopic follow-up. (Note that these and other LEGUE science goals are outlined in Deng et al. 2012.) We would like to de-emphasize M dwarf disk stars, which would otherwise dominate the sample, but still observe a large sample of M stars. The rough overall targeting goals are the following (note that these actually pertain to the full LAMOST survey; these goals can only be partly accomplished during the Pilot Survey):

(1) Select nearly all stars with $0.1 < (g - r) < 1.0$ and $r < 17$ at high Galactic latitudes, and subsample at $b < 40°$.
(2) Select nearly all stars with $g - r < 0.0$ and $u - g$ colors that suggest they are not quasars.
(3) Select a significant fraction of the stars with $0.0 < (g - r) < 1.0$, $17 < r < 19.5$ and $u - g$ colors that suggest they are not quasars. The bluer side of the color range should be selected with a probability about twice the redder side of the range. The stars should be somewhat evenly distributed in magnitude.
(4) Select a large number of M dwarfs at all magnitudes.

As outlined in Carlin et al. (2012), each star from an input catalog can be assigned a probability of being selected for targeting using a function of the form

$$P_{j,\mathrm{D}} = \frac{K_{\mathrm{D}}}{[\Psi_0(\lambda_i)]_j^\alpha} f_i(\lambda_i), \qquad (2)$$

where λ_i are any observables that are known for all stars in the input catalog (i.e., photometry, astrometry, or any combination of observed quantities). The $\Psi_0(\lambda_i)$ term is the statistical distribution function of the observable λ_i, and K_{D} is a normalization constant to ensure that the probabilities sum to one. The function $f_i(\lambda_i)$ can be any smooth function of the observables, and can be used to add emphasis to certain regions of parameter space. The "local density," Ψ_0, was determined for each star in the input catalog by counting the number of stars j whose observables satisfy the condition

$$\sqrt{\sum_i (\lambda_i - [\lambda_i]_j)^2} < \Delta\lambda, \qquad (3)$$

where λ_i were chosen to be r magnitude and $g - r$, $r - i$ colors. The $\Delta\lambda$ defines the size of the volume in the three dimensional (magnitude, color, color) space over which the density of stars is

being counted, and can be thought of as the "resolution" of the function $\Psi_0 = \Psi_0(r, g-r, r-i)$. We chose $\Delta\lambda = 0.1$, defining the local density as the number of objects found within 0.1 magnitudes of the location of each star in the $(r, g-r, r-i)$ parameter space.

The exponent α in Equation (2) weights candidates by some power of the local density, and is typically between 0 and 1. When $\alpha = 0$, all targets have the same probability of being selected (it is a random selection), so the selected sample will have the same distribution in the observables used to define the local density as that of the input sample. To produce a selection that is evenly distributed across the observable space, one can weight the probability for selection by the inverse of the local density, i.e., $\alpha = 1$. This type of sample will over-emphasize rare objects in relatively sparsely-populated regions of parameter space. We examined the actual targets "observed" in many simulations of plate selection at different latitudes, and based on the distribution of targets selected we determined that an intermediate case of $\alpha = 1/2$ (weighting by the inverse square root of the local density) best produced our desired overemphasis of rare objects while retaining many stars from higher-density regions. To accomplish the extra weighting of brighter, $r < 17$ stars, desired from point (1) above, we include a linear "ramp" function $f(r) = 1 - 1.0 * (17.5 - r)$ in r magnitude beginning at $r = 17.5$ and increasing toward brighter stars with a slope of 1.0. Likewise, a ramp in $g - r$ color was applied to overemphasize blue stars as desired in criteria 1–3 above: $f(g - r) = 1 - 2.5 * [1.1 - (g - r)]$. Some examples of the effects of these criteria on the color and magnitude distributions of targets will be seen later in this work.

4 PLATE DESIGN

An important consideration in the design of the LAMOST survey is the requirement that each plate must have a bright star at its center, which is fed to the Shack-Hartmann (SH) wavefront sensor to control active optics corrections. Without the active corrections, the images of stars will be wildly out of focus in the focal plane. SH stars must be brighter than 8th magnitude in the V-band in order to provide sufficient flux for high-frequency active mirror distortions. One goal of the Pilot Survey is to cover as much sky area as possible, with each plate observed only one time. This theoretically requires the SH stars to be separated by roughly $5°$ (the diameter of a LAMOST plate) from each other. The distribution of all potential SH stars in the dark nights survey region from the Hipparcos (Perryman et al. 1997) catalog is shown in Figure 2 as yellow dots, with red circles of $5°$ diameter around each SH star representing possible LAMOST plates. Most of the desired regions on the sky can be easily covered with available SH stars, but there are a few small high-latitude areas that will be inaccessible to the survey. Based on the calculation of the site conditions and the available dark time during the period of the Pilot Survey (see, e.g., Deng et al. 2012; Yao et al. 2012), around 30 dark night plates will be observed; Approximately 15 of these will be in the Anticenter Box (the red area in Fig. 1), and 15 in the GD-1 area.

Figure 3 shows a sample tiling of 15 plates in each of these regions, centered on known $V < 8$ SH stars. The additional yellow asterisk symbols are unused SH-star candidates; these show that contiguous coverage of these sky areas can be easily achieved in the main LAMOST survey. The design of the plates for dark nights in the LEGUE area will be described below.

For the Pilot Survey, we extracted all photometry from SDSS DR8 in each of the four regions (Anticenter Box, GD-1 Area, LEGAS SGC, and LEGAS NGC; i.e., the filled regions in Fig. 1) to be observed during dark nights. We then applied our general target selection algorithm to these large catalogs, assigning selection probabilities to stars using the TS algorithm from Carlin et al. (2012), with the parameters given in Section 3.1, until a density of 600 stars deg^{-2} was reached. This input catalog density was used to satisfy the requirement of the LAMOST fiber assignment software of a catalog containing three times the number of stars to be assigned; LAMOST has 200 fibers deg^{-2} in the focal plane, so 600 stars deg^{-2} is required for fiber assignment. This means that each plate
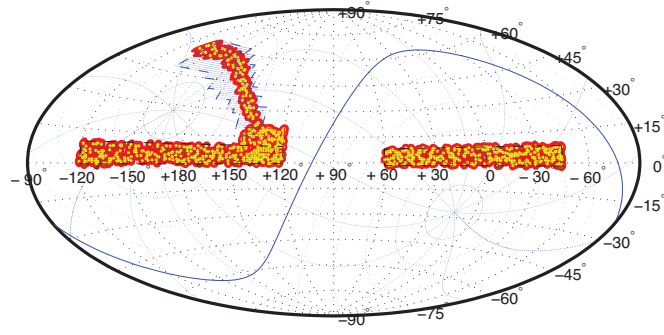
Fig. 2 Sky coverage for all possible plates for dark nights: As shown in Figure 1, blue is the GD-1 area, red is the Anticenter Box, and two black rectangles are SGC and NGC areas, respectively. The red circles show all the possible plates while the SH star is selected to be the center for each plate, seen as yellow dots.
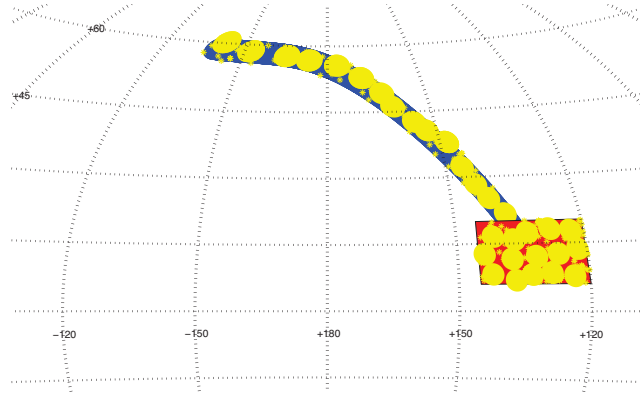

Fig. 3 Plates designed for the GD-1 area and the Anticenter Box in equatorial coordinates. The red area is the anticenter red box while the blue area is the GD-1 area. The yellow circles are plates designed to cover as much sky area as possible with a limited number of plates. It could be different in the real observation due to other factors such as weather conditions, observing time window and so on. The yellow asterisks are unused SH-star candidates; these show that contiguous coverage of these sky areas can be easily achieved in the main LAMOST survey with an SH limiting magnitude of $V = 8$.

selected in these areas will consist of an input catalog of $\sim 12\,000$ stars, from which ~ 4000 will be selected for observation.

One complication that arises is that during the pilot survey, the LAMOST fiber assignment program (Survey Strategy System; SSS) is not able to deal directly with the selection probabilities as calculated. Instead, SSS uses an integer priority value (currently constrained to values 0–99), with lower numbers equaling higher priority for assignment. When assigning fibers, SSS considers all stars available to each fiber, and if possible assigns the one with the highest priority among those available. If all stars in an input catalog have equal priority, then the resulting plate will have targets with a roughly uniform spatial distribution, because SSS will simply assign the target to the nearest

"home" position for each fiber. Thus to ensure that our assignment probabilities have the desired effect, we must assign each star in the input catalog a priority flag according to the process outlined in Section 2 of Carlin et al. (2012). For the dark nights survey we chose to assign priorities 1–80, reserving the remaining values in case they were needed for other purposes. For each square degree of sky, the 600 targets deg^{-2} were divided into 80 bins with 600/80 stars in each. We loop over the priority bins, selecting stars using the selection probabilities until each priority bin has the desired number of stars. In this way, the high probability stars are most likely to have high priority for assignment (i.e., low integer priority value) because they have a higher likelihood of being selected near the beginning of the process.

The large input catalogs with a target density of 600 stars deg^{-2} were given to the LAMOST observing specialists together with the list of possible SH stars in these regions. The observing group can then decide for each night which SH stars the plates will be centered on, and use SSS to allocate stars to fibers for observation. Operating in this mode is preferable to designing each plate in advance because it provides the observers some flexibility in scheduling observations. Because LAMOST is limited to observing near the meridian, only limited regions (in right ascension) are available at any given time, making contingency plans essential for efficient survey operations. Also, the effects of atmospheric refraction can slightly change the objects available to each fiber.

Figures 4–7 show examples of the color and magnitude distributions of the input data and selected stars in two plates at high and low Galactic latitudes. At high Galactic latitude, we present a sample plate designated F5593003, centered at $(l, b) = (132.6°, 60.2°)$. In Figure 4 we show a comparison of the r-magnitude and $g - r$ distributions (left and middle panels, respectively) between the source (DR8) photometry (blue histograms), the input catalog (candidates given to the fiber assignment algorithm; red lines), and the stars selected for observation (in black). The histograms have been normalized by the total number of stars in each set to produce something equivalent to a probability distribution (i.e., the probability of any randomly selected star falling within one of the bins is equal to the bin height). The right panel shows the fraction of available DR8 (source) stars in each color bin that were selected for the input catalog. This clearly illustrates the overemphasis of blue objects – nearly all of the stars bluer than $(g - r) = 0.0$ are selected by the target selection algorithm for input to the SSS fiber assignment code. Hess diagrams for the same three datasets
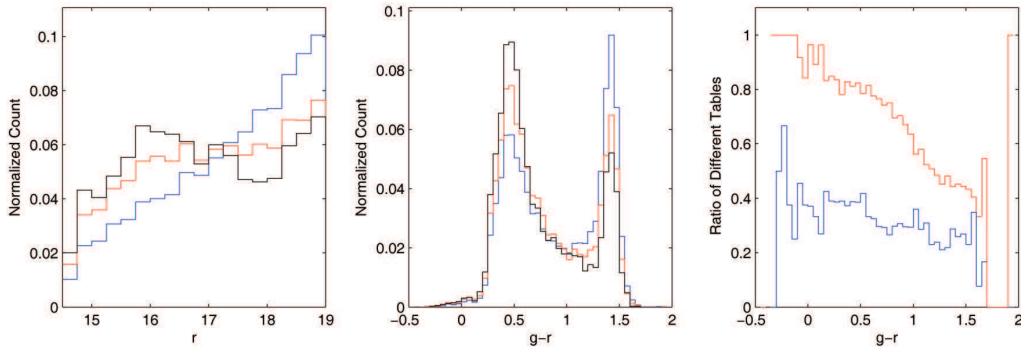

Fig. 4 Distribution in r magnitude (*left panel*), $g - r$ (*middle panel*) and proportion of input catalog to source (DR8) catalog for stars selected in the field of F5593003 centered at (RA, Dec)$_{J2000}$ =(184.21°, 56.28°). For the left and middle figures, the blue line shows the distribution for all stars (20 406 stars) in the field of view (*color online*), the red histogram shows the 12 512 stars selected using the TS algorithm and the black line is the histogram of 3744 stars selected by SSS and will be put into real observations. In the right panel, the red line shows the proportion of input catalog to source (DR8) catalog versus color, and the blue, SSS selected catalog to input catalog.
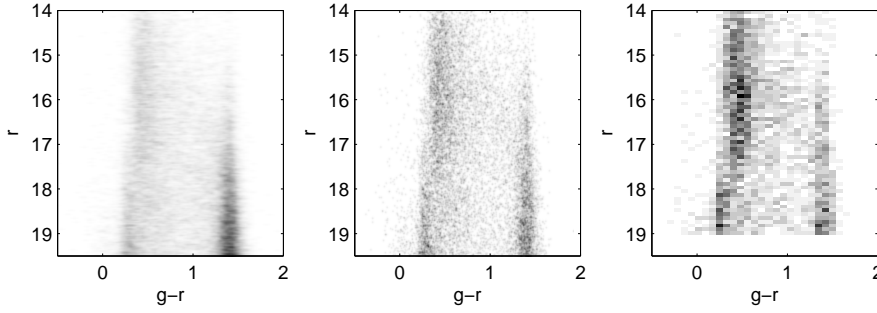
Fig. 5 Color-magnitude Hess diagram of stars in the plate F5593003. *Left panel:* All stars in the field of view. *Middle panel:* Stars selected applying the TS algorithm. *Right panel:* Stars selected by SSS.
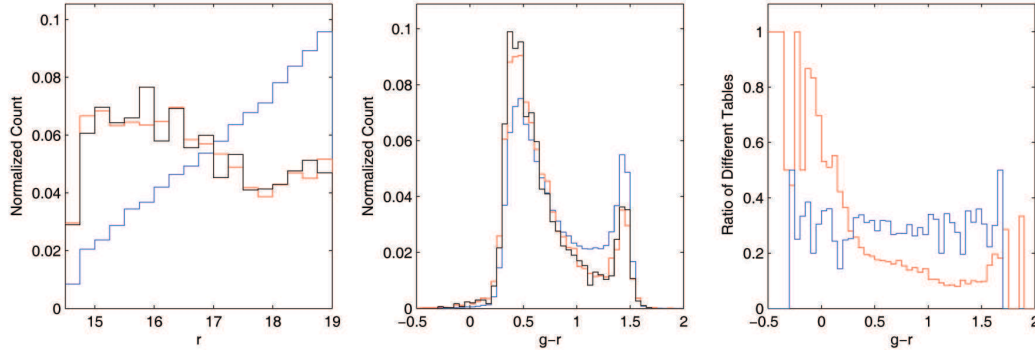

Fig. 6 Distribution in r magnitude (*left panel*) and $g - r$ (*middle panel*) for stars selected in the field of F5591504 centered at (RA, Dec)$_{J2000}$=(121.54°, 15.35°). The lines are defined as in Figure 4 (78 629 stars in the field of view, 11 758 selected from TS and 3902 from SSS). In the right panel, same as Figure 4, the red line shows the proportion of the input catalog to source (DR8) catalog versus color while the blue line shows the proportion of the SSS selected catalog to the input catalog (*color online*).
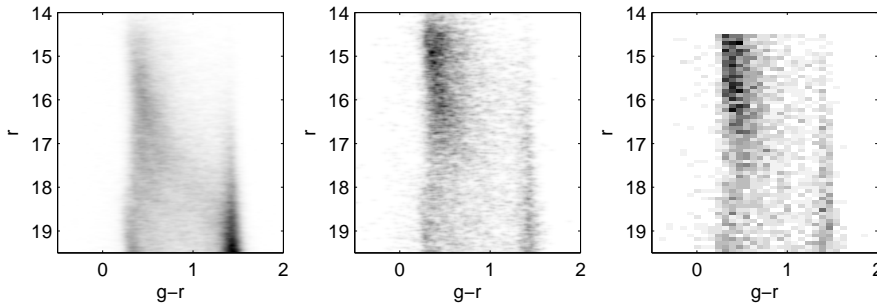

Fig. 7 Hess diagram of F5591504 selected using SSS. *Left panel*: All stars in the field of view. *Middle panel*: Stars selected applying the TS algorithm. *Right panel*: Stars selected by SSS.

(source, input, and observed) in F5593003 are seen in Figure 5. From these figures, one can see that the selected targets contain more bright, blue stars than the input catalogs, having de-emphasized the faint, red (predominantly M-dwarf) stars. However, because the stellar density at high ($b \sim 60°$) latitudes is rather low, a large fraction of available stars are actually assigned to fibers in F5593003. This is not the case at lower latitudes – as an example, we show the plate F5591504, centered at $(l, b) = (207.0°, 23.3°)$, in Figures 6 and 7. Note that in this low-latitude field with much higher stellar density, the difference between the overall input distributions and the observed targets is more dramatic. This is simply a reflection of our target selection scheme and our desired overemphasis on bright, blue targets.

5 SUMMARY

We have presented details about the design of the LEGUE dark nights portion of the recently completed LAMOST Pilot Survey. The survey of faint stellar targets designed for clear, dark nights consists of three regions of sky. The "Anticenter Box" region, spanning $120° < \mathrm{RA} < 145°$ and $6° < \mathrm{Dec} < 20°$, was chosen because a number of known Galactic halo substructures are present in this region. The "GD-1 Area" is a region of $\sim 5°$ width centered on the narrow tidal stream traced across the northern SDSS footprint by Grillmair & Dionatos (2006). Finally, the LEGAS areas consist of two strips near the celestial equator that share targets with the extragalactic survey. These regions were selected to maximize the science impact of the Pilot Survey while providing data on survey performance, including a range of declinations and Galactic latitudes.

The targets for the dark nights survey were selected from SDSS DR8 photometry using the algorithm outlined by Carlin et al. (2012). In particular, objects in relatively sparsely-populated regions of $(r, g - r, r - i)$ phase space were overemphasized, and additional emphasis was placed on objects toward blue colors and bright magnitudes. Each of these choices is motivated by scientific goals of the LEGUE collaboration. The effects of our target selection process were illustrated for a low and high latitude field by comparing the magnitude and color distributions of stars in the input (SDSS) catalog to those selected for observation.

In total, the dark nights portion of the LAMOST Pilot Survey should yield $\sim 10^6$ stellar spectra. These data will provide a valuable science resource as well as serving as test data for refinement of the targeting and fiber assignment process in the main LAMOST/LEGUE survey.

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