AAΩ LRG Redshift Survey - Report on Pilot Observations

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Introduction The AAΩ LRG pilot run was held on the 3-7 March, 2006. The observers were R.D. Cannon, N.P Ross, T. Shanks, R.G. Sharp and D.A. Wake, with TO J. Stevenson. Weather conditions were average on this run; although 70% of the time was clear, seeing was frequently poor, with a range of $1.''5 - 3.''0$ and a mean/median of $2.''0$. The AAΩ setup used the 5700A dichroic with the 385R grating in the red arm and the 580V grating in the blue arm. There were a few teething problems with AAΩ - fringing, spatially dependent redshift completeness etc. We discuss below the different samples targetted in the pilot observations and then recommend the best approach for the main survey. All magnitudes quoted are in the SDSS AB system.

***gri* selected (2SLAQ) $i < 19.8$ LRGs** We first aimed at establishing the exposure time needed for obtaining redshifts for $i < 19.8$ LRGs selected using the same *gri* 'sample 8' cuts as the 2SLAQ survey. 2SLAQ LRGs have average $z \approx 0.55$. The main field here was a 2SLAQ field (delta05) at $1322 - 00$ but LRGs with $i < 19.8$ were also observed on the COSMOS field at $1000 + 02$ and the COMBO-17 S11 field at $1142 - 02$, albeit in poorer seeing. Reductions of 1,1.5,2,3 hr subexposures have been made on these fields. It quickly became clear that at this $i < 19.8$ limit an ≈1hr exposure was enough to obtain redshifts, reduced from the 4hrs used for 2SLAQ due to the $3 - 4\times$ higher AAΩ throughput. 112 LRG redshifts were measured in 3 fields and the $n(z)$ is shown in Fig. 1. Redshift completeness in 1.5hr is ≈ 90% in $1.''6$ seeing, similar to 2SLAQ (see Table 1). A comparison with 2SLAQ redshifts is shown in Fig. 2 and typical LRG (1.5hr) spectra in Figs. 3(a,b).

***riz* selected $19.8 < i < 20.5$ LRGs** We also looked at *riz* selections of LRGs to the fainter limit of $i < 20.5$ in order to test if we could increase the average redshift from $z \approx 0.55$ to $z \approx 0.75$. We found that the redshift completeness rates for these targets as estimated from fibres with no technical problems (i.e. fringing etc) were 90% in 3hr, 84% in 1.5 hr and 46% in 1hr in $1.''6$ seeing. The redshift histogram from 3 fields is shown in Fig. 1. A significant fraction (22%) of M stars was detected. We have now checked that it is easy to reject these stars using a star-galaxy separation in the $i-$ (or $z-$) band rather than the standard SDSS separation in r. Our *riz* selection with the i/z s-g separation produces an average $z = 0.69 \pm 0.09$ (r.m.s) with $84 \pm 13\%$ z completeness in a 1.5hr exposure in reasonable ($1.''6$ seeing) conditions. As expected, in poorer conditions ($\approx 2''$ seeing), completeness drops as is also found for 2SLAQ (see Table 1). Typical (1.5hr) spectra are shown in Figs. 3(c,d). A candidate galaxy cluster surrounding a $z = 0.84$ LRG is shown in Fig. 4.

***riz* selected $19.5 < z < 20.2$ LRGs** We then pushed fainter using a $19.5 < z < 20.2$ LRG sample to see if the z-band selection would advantage high redshift LRGs enough to increase the average redshift still further (see Fig. 5 of proposal). The z completeness rates were 64% (3hr) 57% (2hr), 35% (1hr). Again, star-galaxy separating in the i/z bands will reduce the fraction of M stars to acceptable levels. The average redshift was $z \approx 0.7$ from 53 LRGs. We conclude that a longer > 2hr exposure would be needed here.

$i < 20.5$ Emission line galaxies and $g < 22$ QSOs We also explored another strategy where we used SDSS data to select high redshift spirals with a sky density of ≈ 90deg^{-2}. 1hr exposures were made in S11 and COSMOS fields. The completeness was ≈ 60% and the average redshift was $z \approx 0.7 \pm 0.1$. Although the AAΩ QSO reductions are still incomplete, we are confident we can choose $0.5 < z < 0.9$ QSOs with ≈ 12deg^{-2} from the photo-z sample of Richards et al (2004).

Recommended AAΩ BAO Strategy Our recommended set-up for each AAΩ field is a 1.5hr exposure with:

- ≈ 100 *gri* selected $i < 19.8$ LRGs with average $z \approx 0.55$
- ≈ 260 *riz* selected $19.8 < i < 20.5$ LRGs with average $z \approx 0.7$

There is clearly a possible alternative combination of ≈ 100 2SLAQ $0.45 < z < 0.65$ LRGs and ≈ 260 higher redshift $0.5 < z < 0.9$ spirals and QSOs with an exposure time of ≈ 1hr. However, we regard the unknown spiral clustering strength as a major drawback. We also suggest that the longer > 2hr exposure time to achieve ≈ 60% completeness of the $z < 20.2$ selected sample makes this LRG selection less viable.

For the optimal set-up above, the recommended exposure time of 1.5hr is close to the current AAΩ configuration time. With 50% longer exposures we shall have no extra fibres to target QSOs as previously envisaged. So now with 360 rather than 300 LRGs per field this means that in the same number of nights as before we shall observe ≈360000 LRGs in ≈ 3000deg^2 to give ≈ $4\times$ the effective volume (see Fig. 5) and ≈ $2\times$ the S/N of the best previous result at low redshift (Eisenstein et al. 2005). The sample also guarantees strong LRG clustering and measures the power spectrum at $1.6\times$ and $2\times$ higher z than the $z = 0.35$ LRG sample of Eisenstein et al.

LRG Sample/ Field (Seeing)	delta05 (1.″6)	S11 (1.″8)	COSMOS (2.″1)
gri $i < 19.8$ (2SLAQ)	88 ± 19	70 ± 22	64 ± 24
riz $19.8 < i < 20.5$	84 ± 13	60 ± 11	50 ± 9

Table 1: LRG percentage redshift completeness rates (Quality=3-5) as estimated for $\approx$ 80 unfringed fibres between fibres 200-299 in a 1.5hr exposure (stars excluded). Better observing conditions (delta05) yield completenesses consistent with 2SLAQ. Poorer observing conditions (S11 and COSMOS) yield lower completeness. The COSMOS data had average airmass 1.4 plus some cloud, as well as poorer seeing.

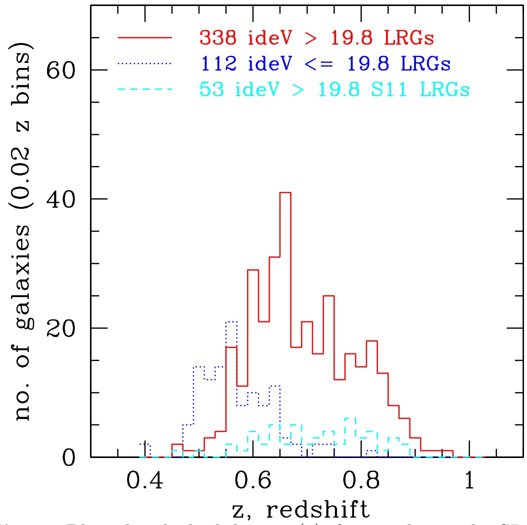

Fig. 1 Blue dot-dashed line, n(z) for re-observed 2SLAQ galaxies cut in gri with $i < 19.8$. Red solid line, n(z) for galaxies cut in riz with $19.8 < i < 20.5$. Light blue dashed line, n(z) for galaxies cut in riz with $z < 20.2$.

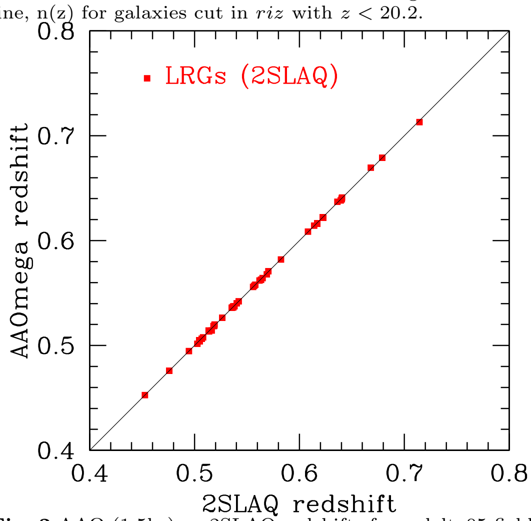

Fig. 2 AAΩ (1.5hr) vs 2SLAQ redshifts from delta05 field.

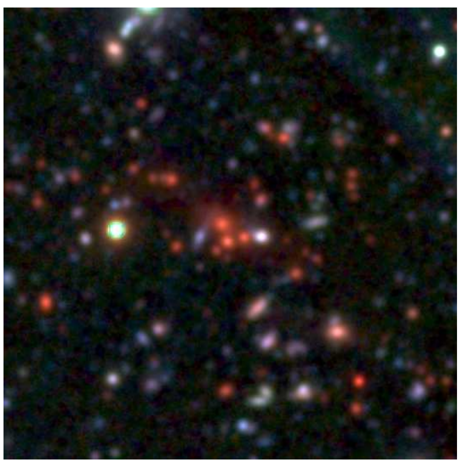

Fig. 4 A candidate cluster at $z = 0.84$ showing the $1.'3 \times 1.'3$ area surrounding the LRG from true-colour Subaru imaging in the COSMOS field. Many candidate cluster members as red as the central LRG are seen in this $\approx 1\mathrm{h}^{-1}$ Mpc field.

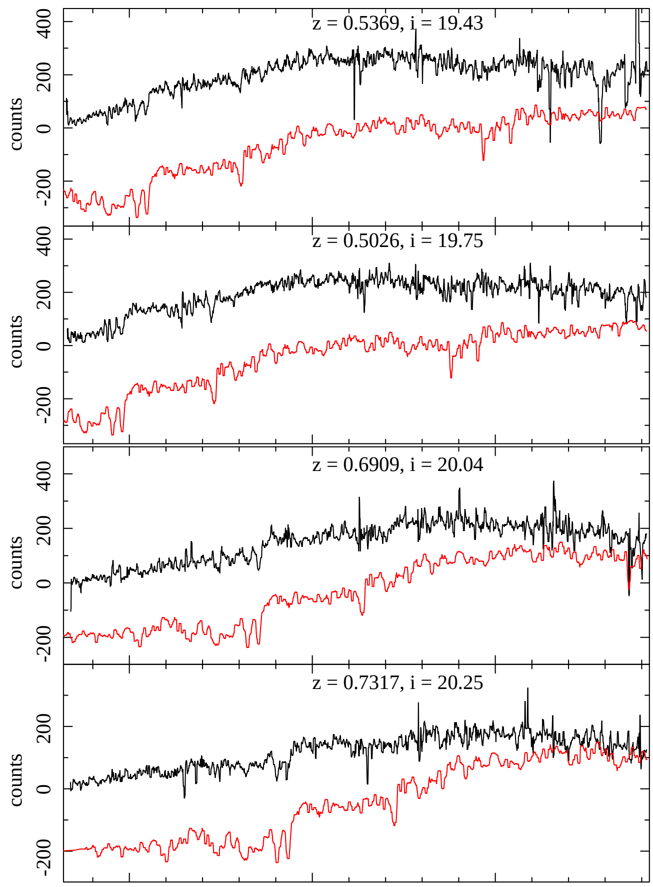

Fig. 3 Typical spectra in 1.5hr exposure from: (a, b) gri, $i < 19.8$ LRG sample (upper), (c,d) riz, $19.8 < i < 20.5$ LRG sample (lower). Red (light) spectrum is template.

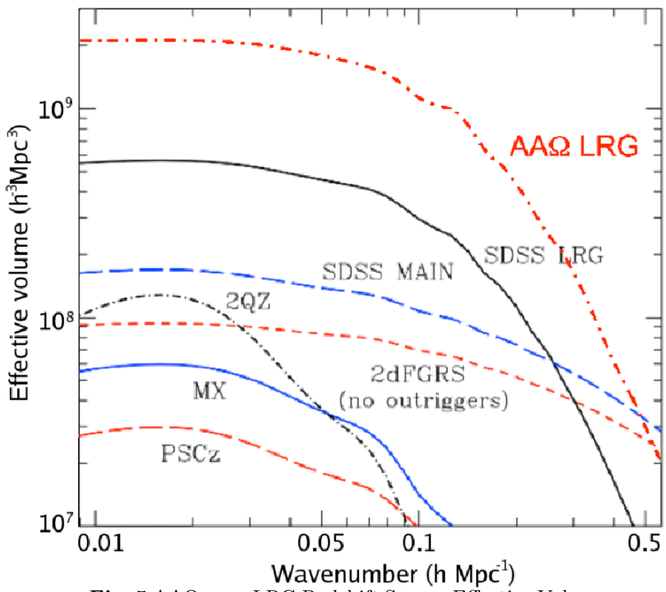

Fig. 5 AAOmega LRG Redshift Survey Effective Volume comparison. We have added $V_{eff}(k)$ for the AAOmega LRG survey (light red dot-dashed line) calculated from equation (1) of Eisenstein et al (2005) assuming 3000deg^2 and the form of the n(z) distributions for the $i < 19.8$ gri and $19.8 < i < 20.5$ riz selected LRG samples given in Fig. 1. Adapted from Fig. 1 of Eisenstein et al.