1 Title: The VST ATLAS

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1.1 Abstract: (10 lines max)

We propose to make an ATLAS survey with VST. The initial aim is to survey 4500 deg^2 of the Southern Sky at high galactic latitudes to comparable depths to the SDSS in the North. The VST ATLAS will be the first step towards a panoramic digital survey of the Southern Sky in the optical bands. The ATLAS will complement the VISTA IR ATLAS proposed in the South. A prime science driver is to determine the dark energy equation of state by detecting 'baryon wiggles' in the power-spectrum of ≈ 450000 $z \approx 0.6$ Luminous Red Galaxies (LRGs), selected from the VST ATLAS for spectroscopy via the new AAOmega instrument. Other uses include the colour selection of QSO candidates out to $z \approx 7$. Further potential dark energy probes exist including LRG z-space distortion, the Integrated Sachs-Wolfe Effect and the dependence of QSO lensing on redshift. Finally, the VST ATLAS+AAOmega will feed VLT with rare galaxy and QSO targets for high resolution spectroscopy, constituting a new and uniquely powerful tool for survey cosmology.

2 Description of the survey: (Text: 3 pages, Figures: 2 pages)

2.1 Scientific rationale:

The aim here is to make a panoramic 'ATLAS' survey of the Southern sky to the approximate depth of the SDSS imaging survey in the North (e.g. Abazajian et al, 2004, AJ, 128, 502) Initially, we are proposing to make a *ugriz* survey of area 4500 deg^2 during the first three years of VST. This ATLAS survey could be the first step towards a complete S. Hemisphere digital imaging and spectroscopic sky survey - a 'Southern Sloan'.

1. A prime scientific goal for the survey is to measure the dark energy equation of state as a function of redshift. Establishing the nature of the dark energy is perhaps the biggest current question in Physics, far less Astronomy. The suggestion is that the dark energy density may have been different in the past; if the energy density decreased with time, for example, then this would address one of the fine-tuning problems associated with a cosmological constant term, specifically its small present size compared to the energy density in radiation after the inflation epoch. This potential evolution in the equation of state is encoded in the dark energy equation of state $p = w\rho$ where w may be a function of z and $w = -1$ for the case of the cosmological constant.

The powerful combination of VST and AAT AAOmega offers a unique opportunity to make the first determination of the evolution of $w(z)$ over a significant redshift range. The prime route is via a redshift survey of Luminous Red Galaxies (LRGs) based on VST imaging data. The method is based on obtaining precise measurements of the LRG clustering power spectrum or or correlation function to detect the 'baryon wiggles' caused by acoustic oscillation of scales below the baryon Jeans' scale in the pre-recombination Universe. These features can be used as 'standard rods' to measure how the angular diameter distance, d_A, varies with z. The z dependence of d_A can then be used to constrain $w(z)$. Other routes such as the SNIa Hubble Diagram using proposed instruments such as SNAP have the disadvantage that SNIa are susceptible to luminosity evolution with redshift. Baryon wiggles are seen in the power spectrum at large $\approx 100h^{-1}$Mpc scales well into the linear regime where they have the crucial advantage that their scale is immune to evolutionary effects with z.

We then exploit the very high bias of the LRG population to help measure the scale of the baryon wiggles; the strong clustering of LRGs (see Fig. 1) makes it more easy to make accurate measurements of the size and scale of these features. A basic proof of concept is that at lower redshifts ($z \approx 0.35$), 45000 SDSS LRGs have been recently used to detect the baryon wiggles in an LRG correlation function (Eisenstein et al, 2005, astro-ph/0501171, see Fig. 2). The aim here is to improve these constraints by approximately doubling the redshift range out to $z \approx 0.6$ and using an order of magnitude more LRGs (450000) which implies an initial VST ATLAS survey area of 4500deg^2 to a depth of $i < 19.8$. The justification for these parameters are given below. The AAOmega observational set-up will be close to that successfully implemented for the present SDSS-2dF z survey of 10000 LRGs (2SLAQ, Edge et al. 2005 in prep., see Fig. 3).

2. The VST+AAOmega LRG z survey could also be used to track dark energy via redshift space distortions and the Alcock-Pacynzki effect. Essentially, the expected spherical symmetry of galaxy clustering is used to test cosmological models. These methods are already producing results in the current generation of galaxy and QSO surveys where the techniques have evolved to break the degeneracy between the geometric effect of cosmology and dynamical infall to provide interesting constraints on Ω_m and β, which measures the rate of dynamical infall. In an LRG z survey an order of magnitude bigger than those currently available, it may be possible to provide z-space distortion constraints on $w(z)$ via these methods.

3. The VST ATLAS survey will also allow an exploration of the possibility of detecting baryon wiggles using only photometric redshifts. Some authors have suggested this may be a competitive route with > 10000deg^2 sky area (Blake & Bridle, 2004, astro-ph/0411713). Detecting weak wiggle features essentially via semi-projected correlation functions will be challenging, particularly in terms of maintaining photometric consistency to of order ± 0.01 mag in all bands over significant sky areas. But it is a long-term goal to extend the ATLAS to a > 10000deg^2 area and ultimately to address this issue but over a longer period than the initial 3 years.

4. The most interesting highest redshift LRGs will also be targets for further high resolution VLT spectroscopy. There, the equivalent widths of OII emission lines, which are increasingly apparent at higher redshift in the current SDSS-2dF survey, can be precisely measured. Similarly the equivalent widths of Balmer absorption lines will allow accurate characterisation of the E+A population, believed to be post-starburst galaxies and which are also detected with increasing frequency at higher redshifts. In addition, there is also the prospect of using VLT to probe fainter down the luminosity function of high redshift galaxy clusters whose brightest galaxies appear in the LRG surveys.

5. The survey will also provide the base for future QSO surveys. The ATLAS will form the base for *ugr* colour-selected QSO surveys out to $z \approx 3$. One possibility is that AAOmega may also make a new survey of ≈100000 QSOs out to z=2.2 aimed at the Alcock-Pacynzki z-space distortion test and QSO magnification lensing. Z-distortion requires further redshift information whereas QSO magnification lensing studies only require the basic photometry. Candidate wide separation QSO lensed pairs will also be found for further VLT follow-up.

6. The VST ATLAS will also contain ≈ 1000 $z > 4$ QSOs. Colour selected candidates will be spectroscopically confirmed by AAOmega before follow-up at high resolution with VLT UVES to map QSO absorption lines. Further, the data will be able to be used to to search for high redshift QSOs at $5.5 < z < 6.5$ where the SDSS team has found a handful of QSOs. The data will be used further to establish the evolution of the QSO LF in this redshift range, bridging the gap to the VISTA surveys at $z > 7$. These higher redshift QSOs would again be targets for VLT for confirmation in the first instance and then higher resolution spectroscopy.

7. The VST ATLAS will also complement the proposed NIR Atlas with the VISTA telescope which will reach K=18.2 over the 20000deg^2 of the Southern Sky. Null detections in the VST ugriz bands plus detections in the NIR YJHK bands will enable powerful searches for QSOs at $z > 7$. The combination of the VISTA JHK bands and the ugriz bands will also make for more accurate broad band photometric redshifts, improving the chances of detecting baryon wiggles in the imaging data alone. These ultra-high redshift QSOs will again make natural targets for VLT high resolution spectroscopy to probe the ionisation history of the Universe.

8. Via cross-correlation of galaxy surveys with CMB surveys such as Planck, the VST will also be able to search for the ISW effect in the Southern Hmisphere. Independent confirmation of the claimed detections of this effect in the SDSS-WMAP analysis is vital to place further constraints on the nature of dark energy. Cross-correlation with the high resolution Planck data will also further test claims of detections of an extended SZ effect in the cross-correlation of WMAP and galaxy cluster catalogues.

9. The VST ATLAS will therefore be the springboard for a multiplicity of unique astronomical projects. The fundamental prize on offer is an unrivalled new understanding of the equation of state of dark energy via an associated AAT 2dF/AAOmega spectroscopic survey to detect baryon wiggles, with further constraints on dark energy arising from z-distortion, QSO lensing magnification and the ISW effect. But the survey will also provide significant follow-up opportunities for VLT spectroscopy to understand better special objects such as evolved bulge dominated galaxies, high redshift QSOs, wide angle QSO lensed pairs and high redshift galaxy clusters. Indeed, the combination of VST+AAOmega(+VISTA) ATLAS harnessed to the light-grasp of VLT will help set the new standard for the next generation of cosmological surveys.

2.2 Immediate objective:

A prime objective of the ATLAS is to provide targets for a Southern Spectroscopic Redshift Survey of LRGs. This motivates the size of the survey and so some attention should be paid to the justification. The simplest estimate is based on the empirical detection of the wiggles in the SDSS LRG Redshift Survey by Eisenstein et al (2005). This contains $\approx$ 45000 LRGs with an average redshift of $z = 0.35$, a sky density of 12deg^{-2} and a space density of 65000 h^3 Gpc^{-3}. They claim a peak position accuracy of $\pm$4%. Therefore, taking approximate account of a slightly higher LRG space density, an order of magnitude increase in the sample size to 450000 LRGs will provide $\approx \pm$2% accuracy in the peak positions. Our minimum number of 300000 LRGs will provide $\approx \pm$2.4% accuracy. At the current 2SLAQ 2dF-SDSS limits of $i < 19.8$ the sky density of $z \approx 0.55$ LRGs is 53deg^{-2} this rises to $\approx$ 100deg^{-2} if we extend the z range to $0.35 < z < 0.75$ (increasing our average z to $z = 0.65$) while keeping the LRG space density the same. Then we have 300 LRGs per 2dF Field and observing 450000 will take $\approx$ 300 AAOmega nights and observing 300000 will take $\approx$ 200 AAOmega nights. Even our minimum number of 300000 LRGs will provide significantly improved accuracy for the determination of the equation of state at nearly twice the redshift of the SDSS LRGs of Eisenstein et al. (2005). The proposed average redshift of the survey is close to the redshift of maximum sensitivity of standard rod tests for w, at least if w is a constant and close to $w = -1$ (see Fig. 4, after Blake & Glazebrook 2003, ApJ, 594, 665).

Other calculations support this completely empirical estimate. Blake & Glazebrook's simulation results can be corrected for the higher bias of the LRGs as opposed to field galaxies. Assuming a realistic bias of $b = 2$, rather than their assumed bias of $b = 1$, their Figure 3 then suggests that a survey of 250000 LRGs will be enough to detect baryon wiggles to $\pm$2% accuracy. The calculations of Seo & Eisenstein (2003, ApJ, 598, 720) in their Tables 1,3, again suitably corrected to $b = 2$, also suggest that $\approx$300000 $z \approx 0.6$ LRGs will provide $\pm$2% accuracy in peak positions. Blake & Glazebrook indicate that $\pm$2% accuracy in the peak positions will lead to $\pm$10% accuracy in the derived precision of w at $z \approx 0.6$. A redshift survey of 300000-450000 $0.35 < z < 0.75$ LRGs at a sky density of 100deg^{-2} therefore motivates the 3000-4500 deg^2 initial area for the VST ATLAS.

The expected numbers of $5.5 < z < 6.5$ QSOs to be detected are based on the SDSS sky density of 0.003 deg^{-2} from 9 spectroscopically confirmed QSOS with $z > 5.7$ (Fan et al. 2004, AJ, 128, 515). The ATLAS survey would therefore detect 10-15 QSOs in this redshift range more than doubling the currently known numbers for high redshift QSO LF analysis and for VLT follow-up at high resolution.

Similarly, the ATLAS is expected to contain $\approx$1000 $z > 4$ QSOs with $\approx 3 - 10$ candidates per square degree. The brighter QSOs confirmed by AAOmega will be followed up by VLT UVES to provide, for example, a comprehensive picture of the high redshift Lyman-α forest over multiple sightlines.

The VST ATLAS will be capable of selecting $z < 3$ QSOs to a limit $g < 22$, which may also be observed with AAOmega. For a dedicated redshift survey, this would reach sky densities of $\approx$70deg^{-2}, requiring 200 AAOmega fibres, similar to the current 2SLAQ survey. QSO Redshift Surveys simultaneous with an LRG survey may also be possible either by only targetting QSOs to the $g < 21$ limit ($\approx$ 35 deg^{-2}) of the previous 2QZ survey or by reconfiguring fibres at the half-way point of a 2-hour exposure. The VLT ATLAS will therefore contain

210000-350000 QSOs in a 3000-5000deg^2 area and allow an order of magnitude increase in the size of QSO redshift surveys at this faint depth in 200-300 AAT nights.

The area of the survey will be split between the South Galactic Cap and the the Northern Equatorial Zone so that year-round observing will be possible at VST, AAT and VLT. In the latter case we shall target the strip to the south of the current SDSS and SDSS-2dF areas.

A crucial aspect of the initial ATLAS survey is that it can be done on short enough timescales to feed the AAT when upgraded by AAOmega in 2006. Expressions of interest have been solicited by AAO for large proposals (up to 100 nights per year, extending over several years) to start in semester 06A (February-July 2006). The present 2SLAQ survey at AAT relies on equatorial SDSS imaging photometry and the total that remains in the 3 (sub)-equatorial DR3 stripes after the current target of 10000 LRGs and 10000 QSOs in ≈ 200deg^2 has been met is of ≈ 650deg^2. This is enough to allow a further survey of 35000 LRGs in the current z range or 65000 with the increased z range allowed by AAOmega. At 2 hours AAOmega exposure per field this would require ≈ 60 AAT clear nights. Since AAOmega is scheduled to be implemented in the first half of 2006, this means that SDSS imaging will be available while the VST ATLAS survey is ramping up. To feed AAT at the 100 nights per year level will require 1200deg^2 of VST imaging per year. At 300 deg^2 per night for one band, this means that the VST rate is approximately 20 clear nights per year. To maximise the lead in the spectroscopic follow-up, will also require the VST ATLAS to be in production by late 2006. Clearly the spectroscopic surveys will require their imaging also to be outside areas previously surveyed by SDSS and 2dF. This makes a powerful argument for the VST ATLAS to be run alongside deeper VST imaging programmes; it will take the deeper surveys too long to produce the data required to maintain the spectroscopic initiative at the AAT and ultimately also at VLT.

3 Are there ongoing or planned similar surveys? How will the proposed survey differ from those? (1 page max)

The VST ATLAS will reach at least 2 mag fainter in all bands than the previous photographic Southern Sky surveys. These fainter limits are crucial for almost all of the main science drivers in the VST ATLAS survey.

The crucial difference between the VST ATLAS and the SDSS survey, apart from the Southern Declination, is the link to uniquely powerful spectroscopic follow-up, first at the AAT (2dF+AAOmega) and then at the VLT (VIMOS+UVES). The value of the link to the AAT is demonstrated already by the current use of 2dF by the SDSS team to do spectroscopic follow-up of the higher redshift SDSS LRGs and faint QSOs. There is simply no other spectroscopic follow-up 4-m telescope in the world that can compete with the 3deg^2 field-of-view of 2dF, especially after its AAOmega upgrade.

The VST ATLAS Survey will also perfectly complement the SkyMapper survey being proposed for a 1.3-m telescope at Siding Spring by the Australia National University. The SkyMapper survey will be based on 5 epochs covering 20000 sq. deg and the first epoch will only reach $g = 21.6$, which is not deep enough for the LRG survey. The telescope and camera is also barely started construction, so VST is likely to have at least a 2 year earlier starting time than SkyMapper for any survey that is capable of sustaining the LRG project. Thus a > 3000deg^2 VST ATLAS will be crucial for the timely success of any attempt to measure the cosmic equation of state. The VST ATLAS will form an early first generation deeper epoch for the 5 epochs ultimately to come from SkyMapper and so these surveys can add significant value to each other in terms of nearby supernova searches etc.

The VST ATLAS survey will also complement proposed deeper VST surveys such as KIDS. KIDS is aimed at an area of 1700deg^2 which is too small to provide useful data for AAOmega LRG redshift surveys aimed at baryon wiggles. Total exposure times are proposed to be ≈ 2 hrs per field to cover ugriz. This means a total exposure time of 425 clear VST nights. Effectively, KIDS will cover just over a single AAOmega field per night which is clearly slower than the spectroscopy we are proposing with AAT which will require 4 AAOmega fields per night. This applies even taking into account the higher fraction of clear nights at VST than AAT because of KIDS' requirement for good seeing(< 0.7arcsec FWHM).

Period	Time (h)	Mean RA	Moon	Seeing	Transparency
P77	80+55	10h00-15h30, 21h30-4h00	dark+grey/bright	< 1.4	clear(+ some phot.)
P78	80+55	10h00-15h30, 21h30-4h00	dark+grey/bright	< 1.4	clear(+ some phot.)
P79	80+55	10h00-15h30, 21h30-4h00	dark+grey/bright	< 1.4	clear(+ some phot.)
P80	80+55	10h00-15h30, 21h30-4h00	dark+grey/bright	< 1.4	clear(+ some phot.)
P81	80+55	21h30-4h00	dark+grey/bright	< 1.4	clear(+ some phot.)
P82	80+55	21h30-4h00	dark+grey/bright	< 1.4	clear(+ some phot.)

Table 1: Requested Observing Time for VST ATLAS to cover sky area of 4500deg^2 in $ugriz$.

In addition, KIDS will target the Northern Equatorial strip already observed by 2dF and already imaged by SDSS. This high priority part of KIDS will thus not add to the area of Southern Sky available for spectroscopic follow-up of LRGs. KIDS is also aimed at weak shear galaxy lensing and requires good seeing conditions. VST ATLAS is not aimed at lensing and can use 1-1.4arscec seeing not usable by KIDS and so these surveys complement each other well.

4 Observing strategy: (1 page max)

Our proposed ATLAS survey for VST will assume 60sec exposures in each of the ugriz bands with ≈30s overhead per exposure. Because of the higher efficiency of VST+OmegaCam this will easily reach the Sloan magnitude limits already used in the current SDSS-2dF LRG survey. Our assumption of 30sec overhead is reasonable because in our requested conditions of 1-1.4 arcsec seeing then we shall on-chip bin 2×2 to give 0.42×0.42 arcsec^2 pixels. This will reduce readout time to ≈ 6secs. (Indeed, if in 1-1.4arcsec seeing there is no need to autoguide for a 60sec exposure then the overhead could be significantly less than 30sec.) Thus we estimate that a 3000 sq. deg. survey would take only take 60 clear VST nights for even the full 5 band survey. Grey and even bright time could be used for the i and z bands, although care would have to be taken to ensure survey uniformity. Even seeing of 1-1.4arcsec FWHM could be used, since this is an improvement over the 1.4arcsec FWHM median seeing for the SDSS imaging data used as the base for the current equatorial SDSS-2dF LRG survey.

Our basic targets would be the RA range between RA: 10h30-15h30 at Dec: $-20 < \delta < -2.5$ deg to give ≈ 1500deg^2 in the Northern Galactic Cap and RA: 21h30-04h at Dec: $-50 < \delta < -15$ deg to give ≈ 3000deg^2 in the Southern Galactic Cap for the full 4500deg^2 survey. The third year of the survey would therefore focus mainly on the Southern Galactic Cap.

Experience with processing data from the INT Wide Field Camera is that no CR split is required for EEV CCDs; this would need to be verified with the VST CCDs.

5 Estimated observing time:

Our estimated observing time for the VST ATLAS is given in Table 1.

5.1 Time justification: (1 page max)

Limiting magnitudes for the SDSS survey are given in Table 2. The SDSS telescope has a 2.5-m aperture and uses a 55sec exposure in each band. The limiting magnitudes for VST ATLAS are intended to match SDSS limits. But since CCD throughput is ≈ 10% higher at all wavelengths and also taking into account average seeing of 1.″2 FWHM, our proposed exposure of 60s will make the corresponding VST ATLAS limit ≈ 0.3mag fainter in all bands, although the use of grey/bright time to observe i/z will reduce the VST ATLAS advantage there.

			Limiting	Mag.*
band	λ	$\Delta\lambda$	AB	Vega
u	3550	570	22.0	21.0
g	4750	1390	22.2	22.3
r	6230	1370	22.2	22.0
i	7620	1530	21.3	20.9
z	9130	950	20.5	20.0

Table 2: SDSS limiting magnitudes, defined as the limit for 95% completeness for point sources in $1.''4$ seeing.

We next estimate the time required to survey 1500deg^2 per year to the above depths. This rate is approximately the rate required to feed AAOmega for a variety of projects and in particular the LRG Redshift Survey (2hrs AAT exposure per 3deg^2 field). Over 2 years this rate means we can survey 3000 deg^2 containing 300000 LRGs and in 3 years we can survey 4500 deg^2 containing 450000 LRGs. Deeper VST surveys such as KIDS will only add a small area to this 3 year total; even with 100 VST nights per year such surveys would only cover 350 deg^2 per year, implying a ten year timescale to cover 3000deg^2, a rate which would compromise the competitiveness of the spectroscopic surveys

Our assumptions are as follows:-

- 2×2 binning $\Rightarrow 0.''42 \times 0.''42$ pixels
- 30secs of overheads per exposure
- 10% overlap per pointing $\Rightarrow$ effective area per pointing of 0.78deg^2
- 9hrs per night between astronomical twilights
- Dark time; 60secs in $u, g, r \Rightarrow$ 10.4deg^2 per hour
- $\Rightarrow$ 32 dark nights for 3000 deg^2.
- Grey time; 60secs in $i, z \Rightarrow$ 15.6deg^2 per hour
- $\Rightarrow$ 22 grey/bright nights for 3000 deg^2.[$>|5|$ nights from full moon]

We shall probably need to allow 10% more for calibration observations, implying that the total number of nights that will be needed to cover 1500deg^2 per year is 18 dark nights per year and 12 grey/bright nights per year.

6 Data management plan: (3 pages max)

We shall use the VISTA Data Flow System (VDFS; Emerson et al. 2004, Irwin et al. 2004, Hambly et al. 2004) for all aspects of data management, including:

- pipeline processing and management
- database ingestion of pipeline products
- production of enhanced database-driven products, including federation of VST survey products with UKIDSS surey products
- dissemination via a purpose-built science archive with Virtual Observatory services using IVOA standards
- delivery of survey products to the ESO/STECF Science Archive Facility(SAF)

The VDFS is a systems-engineered project that is being employed for the UKIRT WFCAM and VISTA infrared surveys that are complementary to VST public surveys in the optical, and is sufficiently flexible as to be applicable to any imaging survey project requiring an end-to-end (instrument to end-user) data management system.

The pipeline processing component of the VDFS has been scientifically verified by processing wide field mosaic imaging data using a range of existing CCD mosaic camera e.g. ESO WFI, CFHT 12K and MegaCam, CTIO Mosaic, KPNO Mosaic AAO WFI, INT WFC and WHT PFC. It has also been used to process ESO ISAAC data e.g. the FIRES survey data, and recent commissioning data from UKIRT WFCAM.

6.1 Team members:

Name	Function	Affiliation	Country
J. Emerson(VDFS and VISTA PI)	Chair of Oversight Commitee	Queen Mary University of London	UK
R. McMahon(VDFS co-I)	Data Quality Control Manager	University of Cambridge	UK
M. Irwin(VDFS team)	Pipeline Manager	University of Cambridge	UK
S. Hodgkin(VDFS team)	Photometry	University of Cambridge	UK
D. Evans(VDFS team)	Astrometry	University of Cambridge	UK
P. Williams(VDFS team)	Local Manager	University of Edinburgh	UK
N. Hambly(VDFS team)	Science archive architect	University of Edinburgh	UK
M. Read(VDFS team)	User interface design	University of Edinburgh	UK
E. Sutorius(VDFS team)	Archive operations	University of Edinburgh	UK

6.2 Detailed responsibilities of the team:

see Table above

6.3 Data reduction plan:

Following VDFS, we divide the plan into two distinct but intimately related parts: pipeline processing and science archiving. Much greater detail can be found in the SPIE papers cited previously, and we emphasise the track record over the last decade of both the Cambridge and Edinburgh survey units in processing and delivering large-scale imaging datasets to the community.

6.3.1 Pipeline processing

The VDFS pipeline shall be used for all processing. This includes the following processing steps but is a modular design so that extra steps are easily added. All the steps have been tested on a range of input datasets.

- instrumental signature removal – bias, non-linearity, dark, flat, fringe, cross-talk
- sky background tracking and removal during image stacking – possible need to also remove other 2D background variations from imperfect multi-sector operation of detectors
- define and produce a strategy for dealing with image persistence from preceding exposures
- combine frames if part of an observed dither sequence or tile pattern
- consistent internal photometric calibration to put observations on an approximately uniform system
- basic catalogue generation including astrometric, photometric, shape and Data Quality Control(DQC) information

- final astrometric calibration from the catalogue with an appropriate and World Coordinate System (WCS) in all FITS headers
- basic photometric calibration from catalogue using suitable pre-selected standard areas covering entire field-of-view to monitor and control systematics
- each frame and catalogue supplied with provisional calibration information and overall morphological classification embedded in FITS files
- propagation of error arrays and use of confidence maps
- realistic errors on selected derived parameters
- nightly extinction measurements in relevant passbands
- pipeline software version control – version used recorded in FITS header
- processing history including calibration files recorded in FITS header

6.3.2 Science archiving

The concept of the science archive (Hambly et al. 2004 and references therein) is key to the successful exploitation of wide field imaging survey datasets. The science archive ingests the products of pipeline processing (instrumentally corrected images, derived source catalogues, and all associated metadata) into a database. Furthermore - and this is the critical point - the science archive system then goes on to curate them to produce enhanced database-driven products. In the VDFS science archive, the curation process includes, but is not limited to, the following: individual passband frame association; source association to provide multi-colour, multi-epoch source lists; global photometric calibration; enhanced astrometry including derivation of stellar proper motions; consistent list-driven photometry across sets of frames in the same area; cross-association with external catalogues; and generation of new image products, e.g. stacks, mosaics and difference images etc., all according to prescriptions set up for a given survey programme. All these features are available in the context of a continually updating survey dataset from which periodic releases (as required by the community) can be made.

Moreover, end-user interfaces were catered for from the beginning in the VDFS design process, and the philosophy has always been to provide both simple and sophisticated interfaces for the data. The former is achieved via simple point-and-click web forms, while the latter is achieved via exposing the full power of the DBMS back-end to the user. To that end, full access to Structure Query Language and the relational organisation of all data are given to the user.

We have developed a generalised relational model for survey catalogue data in the VDFS. The key features to note are the normalised design with merged multi-waveband catalogue data (the table of most use for scientific queries) being part of a related set of tables that allow the user to track right back to the individual source images if they require to do so; and also that the merged source tables (as derived either from individually analysed images, or consistently across the full passband set available in any one field) are seamless, and present the user with a generally applicable science-ready dataset. Similar relational models describe the organisation of all data in the science archive (image, catalogue, calibration metadata, etc.) - see Hambly et al. (2004) and references therein.

The relational model is applicable to any imaging survey project, and provides an easy-to-use science-ready data resource for the community scientist in the form of a seamless, merged multi-colour multi-epoch source catalogue.

6.4 Expected data products:

6.4.1 Pipeline products

- Instrumentally corrected frames along with header descriptors propagated from the instrument and processing steps (science frames and calibration frames)
- stacked data for dithered observations
- derived catalogues (source detections from science frames with standard isophotal parameters, model profile fitted parameters, image classification, etc.)
- Data Quality Control database

6.4.2 Archive

- Database-driven image products (stacks, mosaics, difference images, image cut-outs)
- frame associations yielding a survey field system; seamless, merged, multi-colour, multi-epoch source catalogues with global photometric calibration, proper motions (where appropriate)
- source remeasurement parameters from consistent list-driven photometry across all available bands in any one field

6.5 General schedule of the project:

- T0: Start of observations
- T0+4months; Public release of science products from first month of survey observations
- T0+8month; Public release of science products from first 6 months of survey observations
- Thereafter we would hope that science products can be released to the ESO community within 1-2 months of raw data arriving in the UK.
- Optional reprocessing of data based on improved knowledge of instrument would also be considered.

References:

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7 Envisaged follow-up: (1 page max)

The follow-up that will be required from ESO VLT will be mainly spectroscopic. Medium resolution spectroscopy from FORS1/2 spectroscopy will be required to obtain higher signal-to-noise spectra of high redshift emission line and E+A LRGs than are obtainable from 4-m class telescopes such as the AAT. The VIMOS IFU may also provide spatially resolved spectra which may be useful in these cases. FORS1/2 will be required to obtain higher signal-to-noise spectra of candidate wide-angle lensed QSO pairs and also to obtain confirming spectra for high redshift $4 < z < 7$ QSO candidates. VLT UVES would also be needed to provide high resolution spectra the brighter $z > 4$ QSOs and also occasionally for LRGs with anomalous spectra from AAOmega.

We estimate that 6 dark nights per year will be required for follow-up. These will be split mainly between the VLT UVES, FORS1, FORS2 and VIMOS spectrographs. We understand that these 6 dark nights and our data release schedule may be the subject of negotiation between our team and ESO if this ATLAS proposal is accepted. More details of the specific justification for our requested VLT follow-up will be made available at that point.

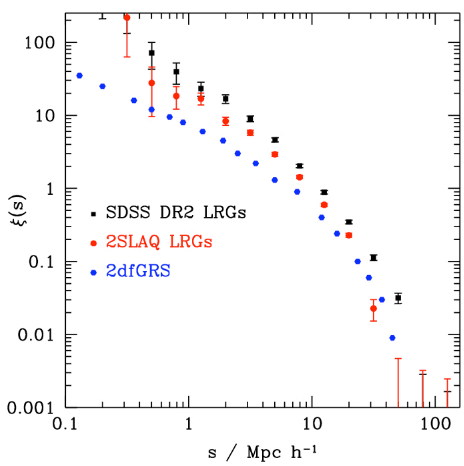

Figure 1: The redshift-space correlation functions for $z \approx 0.35$ SDSS DR2(filled squares) and $z \approx 0.6$ 2SLAQ LRGs(open circles) are significantly higher than for the 2dFGRS galaxy survey(filled circles).

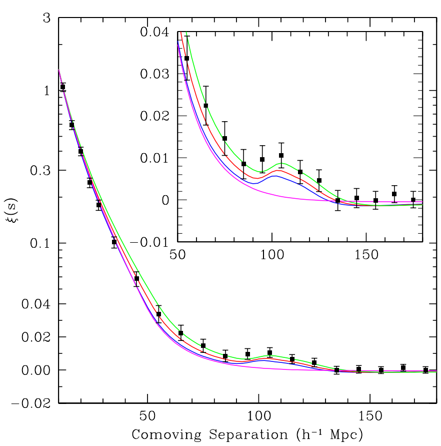

Figure 2: The redshift-space correlation function of 45000 SDSS LRGs (filled squares) from Eisenstein et al (2005) showing the detection of a baryon wiggle at a separation of $\approx 100\mathrm{h}^{-1}$ Mpc compared to ΛCDM model predictions with and without baryons (lines).

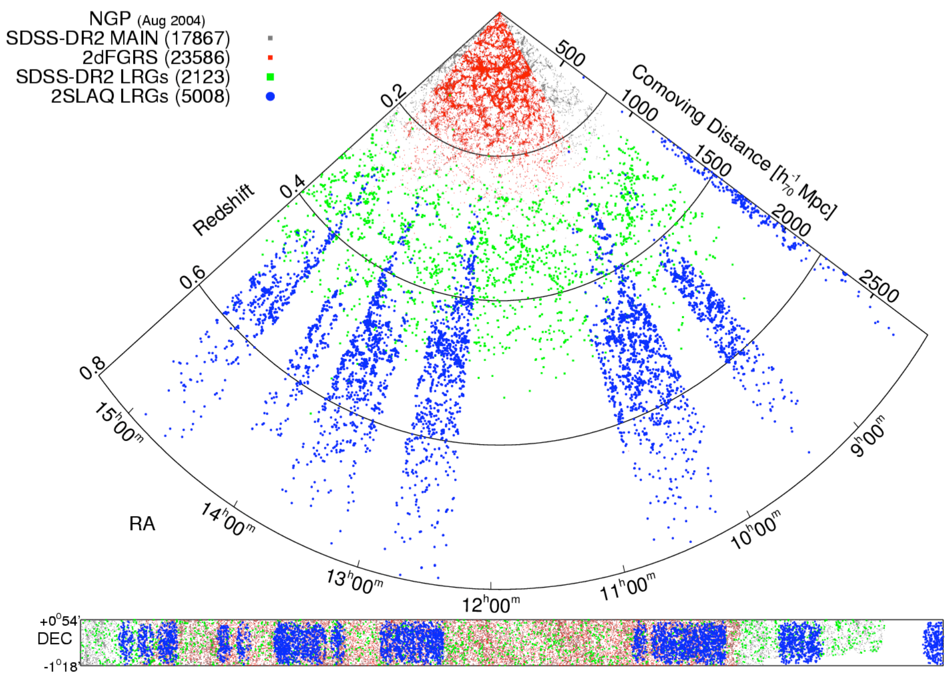

Figure 3: The Northern Equatorial strip containing 2dFGRS galaxies (red), SDSS LRGs (green) and 2SLAQ LRGs (blue). Note the significantly higher redshift of the 2SLAQ LRGs ($z \approx 0.6$) compared to the SDSS LRGs ($z \approx 0.35$).

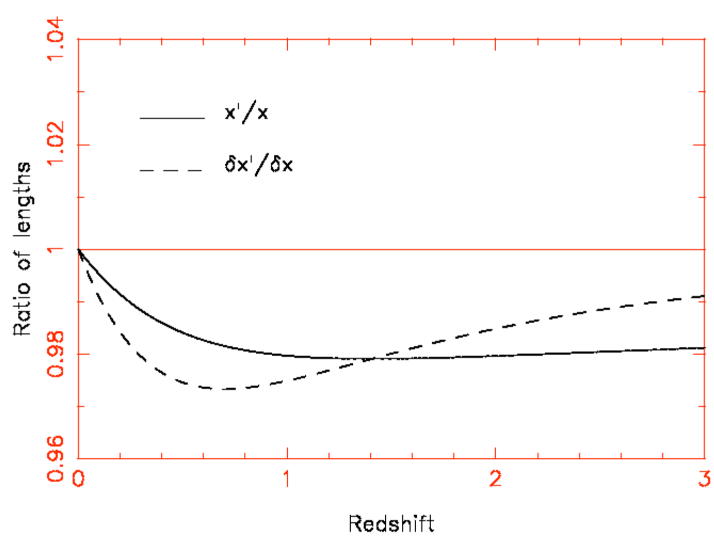

Figure 4: The length distortion of a rod as a function of redshift in the radial (dashed) and angular (solid) directions. The ratio of lengths represents the difference measured in $w = -1$ and $w = -0.9$ (constant) models assuming an $\Omega_m = 0.3, k = 0$ cosmology. The difference maximises at $z \approx 0.65$, our average LRG redshift.