VST ATLAS

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Overview

* VST ATLAS Current Plan
* VST ATLAS+VHS → Southern SDSS in ugriz+YJHK
* Competing surveys – DES/PS1/SkyMapper/SCUSS
* ATLAS Science 2005 vs 2010 – NIR → UV
* QSO clustering – example of UV science
* Suggested modification to ATLAS footprint

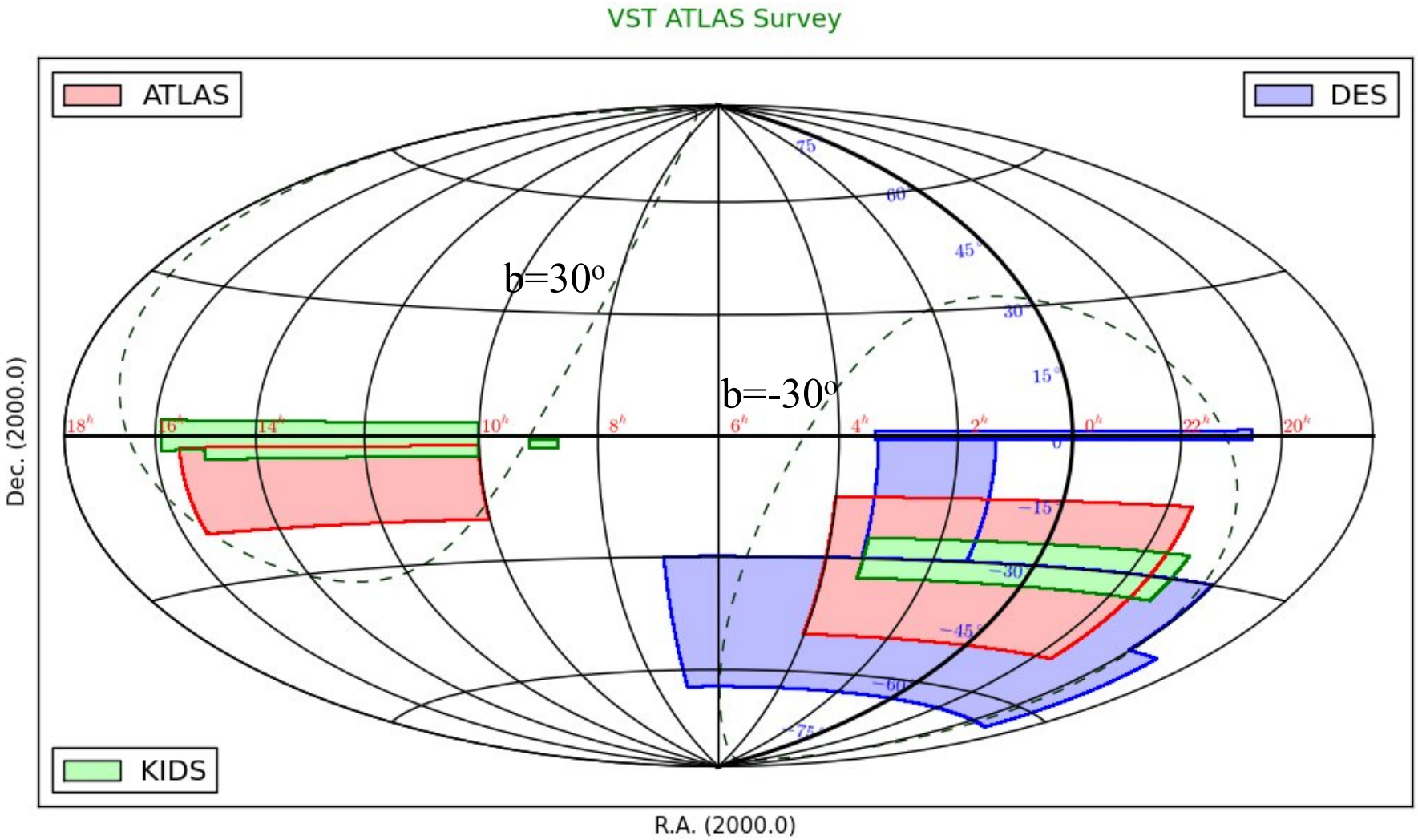
VST ATLAS Survey

- VST ATLAS+VHS → Southern SDSS in ugriz+YJHK!
- 60s exposures in ugriz – better throughput in u, z
- Footprint ~3000 deg^2 in SGC and ~1500deg^2 in NGC
- 1"-1."4 seeing – better than SDSS median at 1."4
- Better seeing used for KiDS
- ~30 nights per year for 3 years

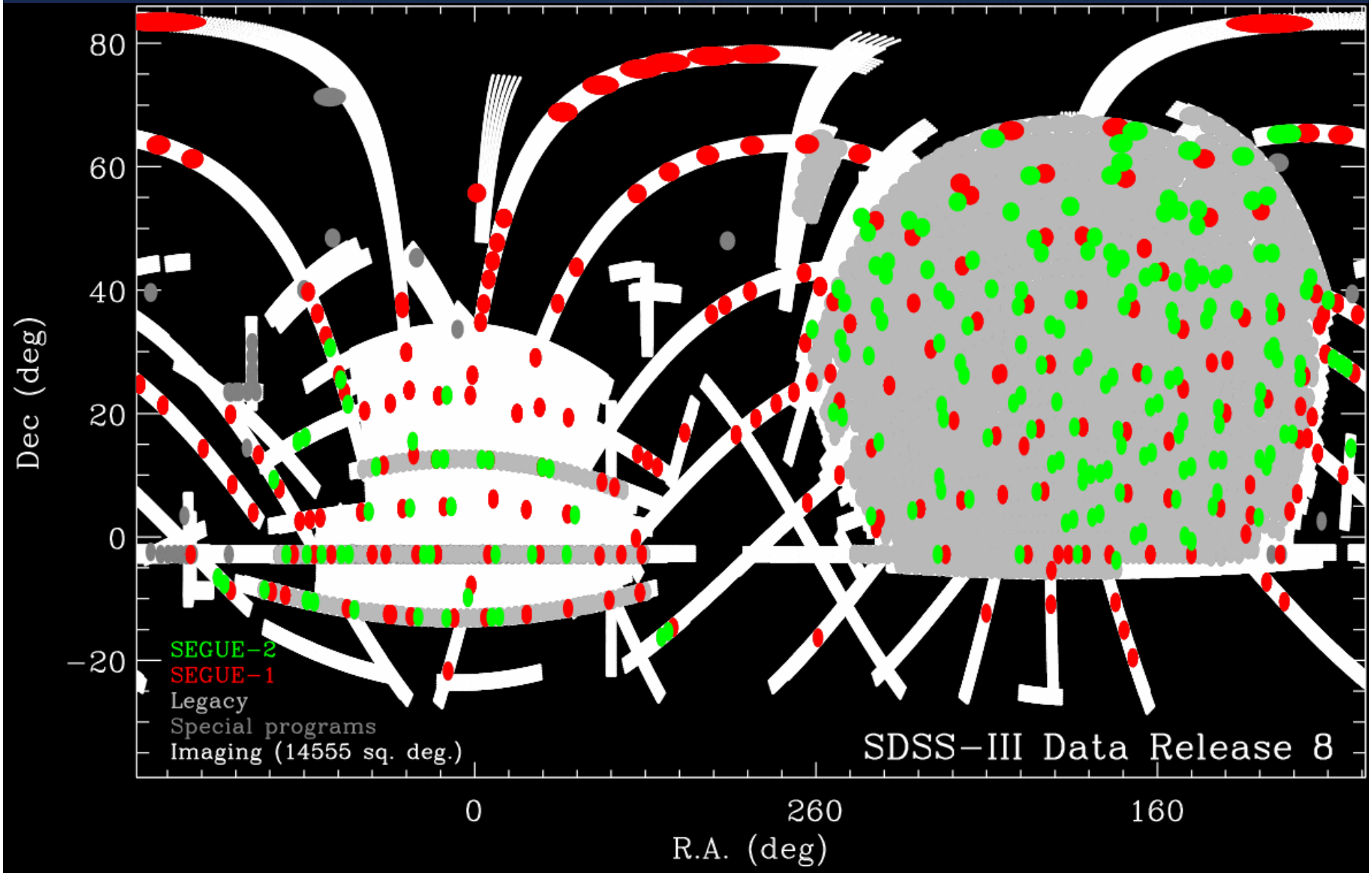
VST ATLAS Core Team

* CASU (Mike Irwin et al, Cambridge) does the basic reduction using the ATLAS Data Flow pipeline
* Steve Maddox (Nottingham) leads the Nottingham-Durham team mosaicing frames
* Nigel Metcalfe+PDRA (Durham) will do QC on the finished products
* WFAU (Bob Mann et al, Edinburgh) to provide archiving facilities, additional to the ESO archive

VST ATLAS – current footprint



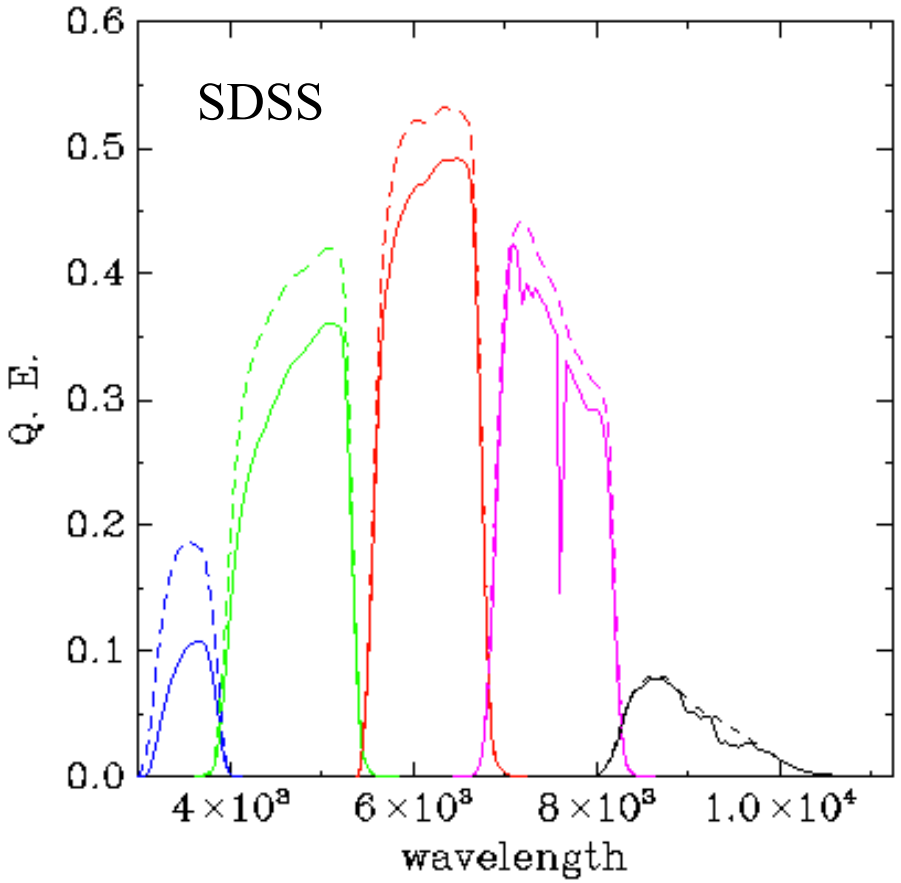
SDSS DR8 footprint

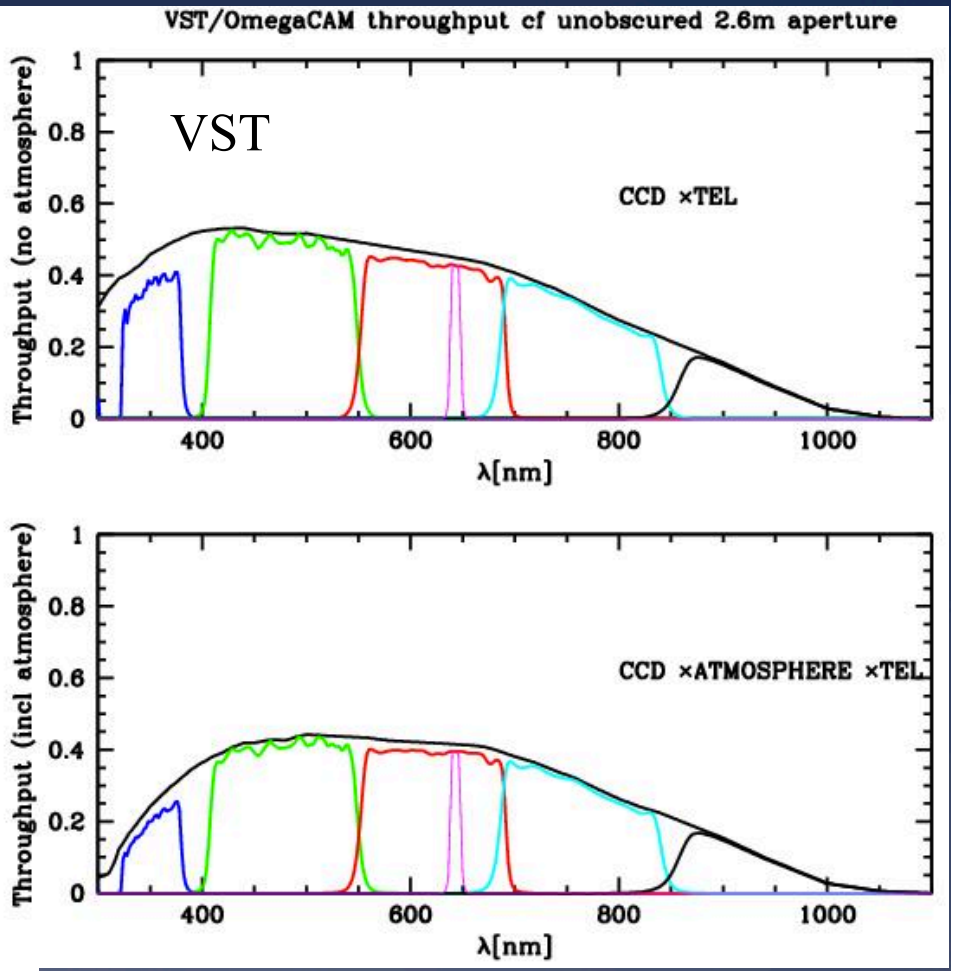


VST UV(+IQ) advantage

* DES/Pan-STARRS only do griz
* SkyMapper - poorer image quality?
* VST does ugriz - like SDSS
* VST u (and z) throughput up to ~2x SDSS
* So here emphasise u science

VST vs SDSS Bands

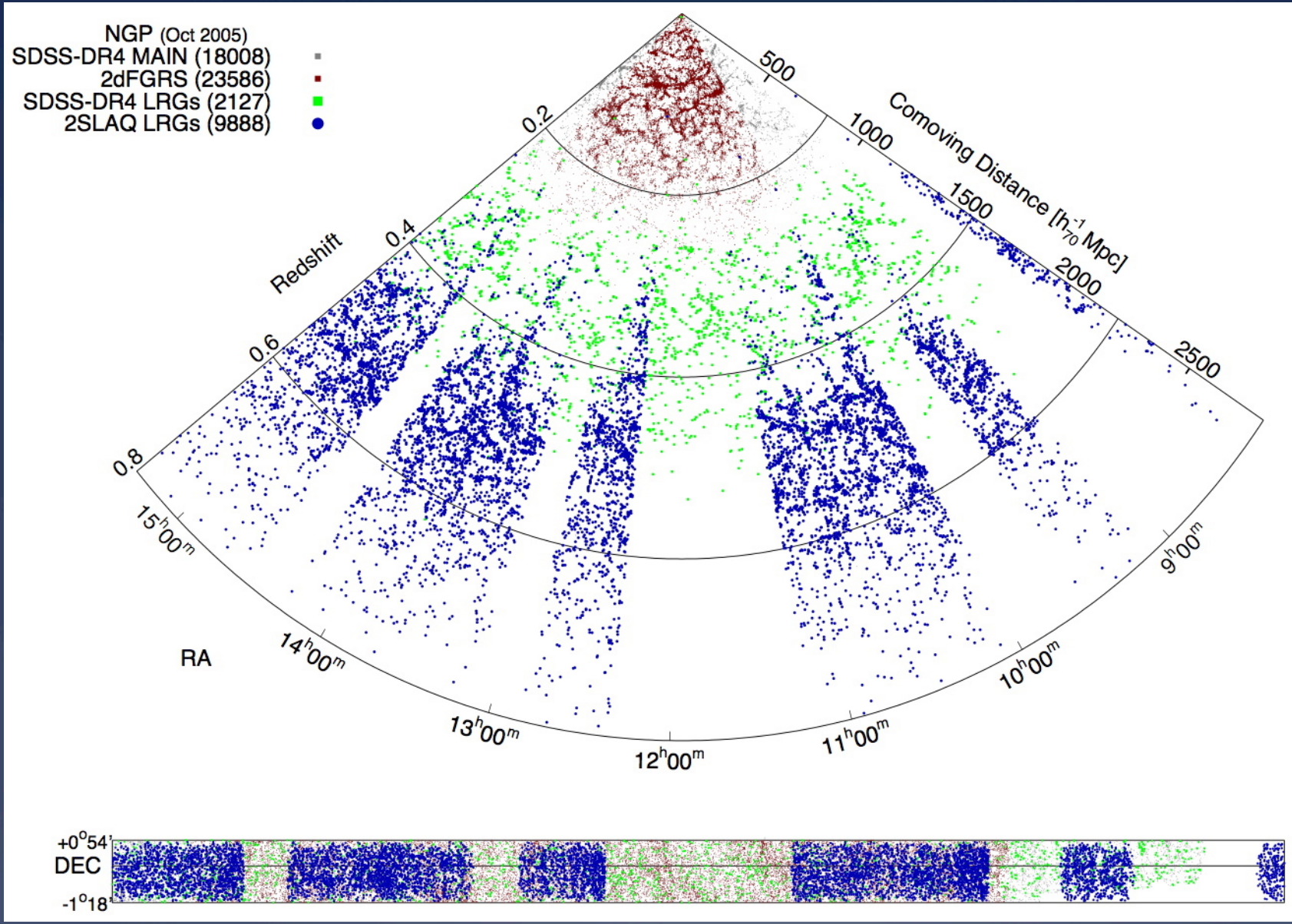




ATLAS Science 2005

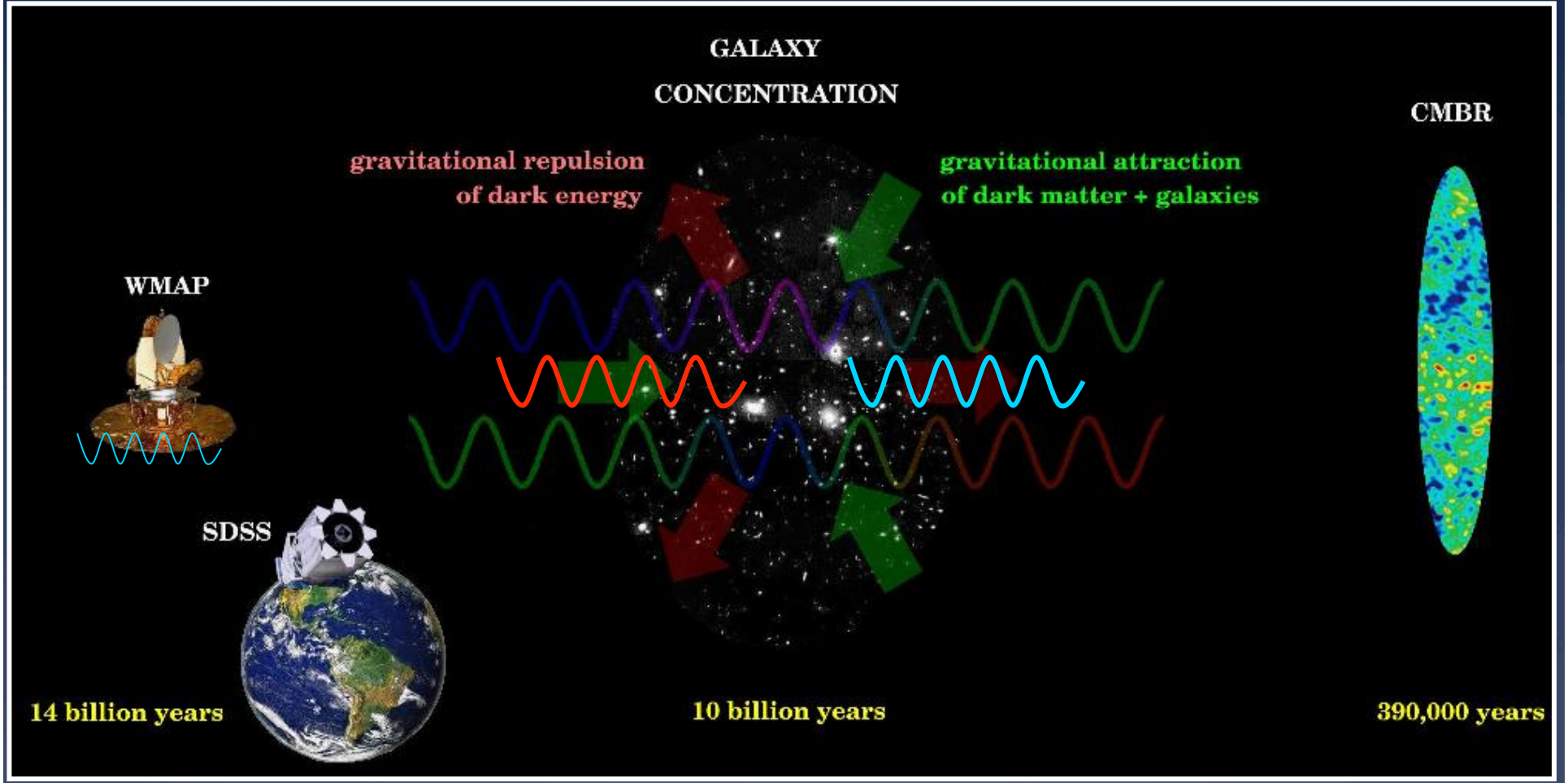
- Focussed on Southern wide area cosmology
- Also on exploiting AAOmega+2dF at AAT for follow-up
- LRG z survey at z~0.7 for BAO - major motivation – still higher than BOSS z~0.5 (WiggleZ has z~0.6)
- BAO via LRG photo-z
- ISW effect in South via LRGs
- QSO clustering via z surveys
- QSO – galaxy/group statistical lensing

2SLAQ LRG Wedge Plot



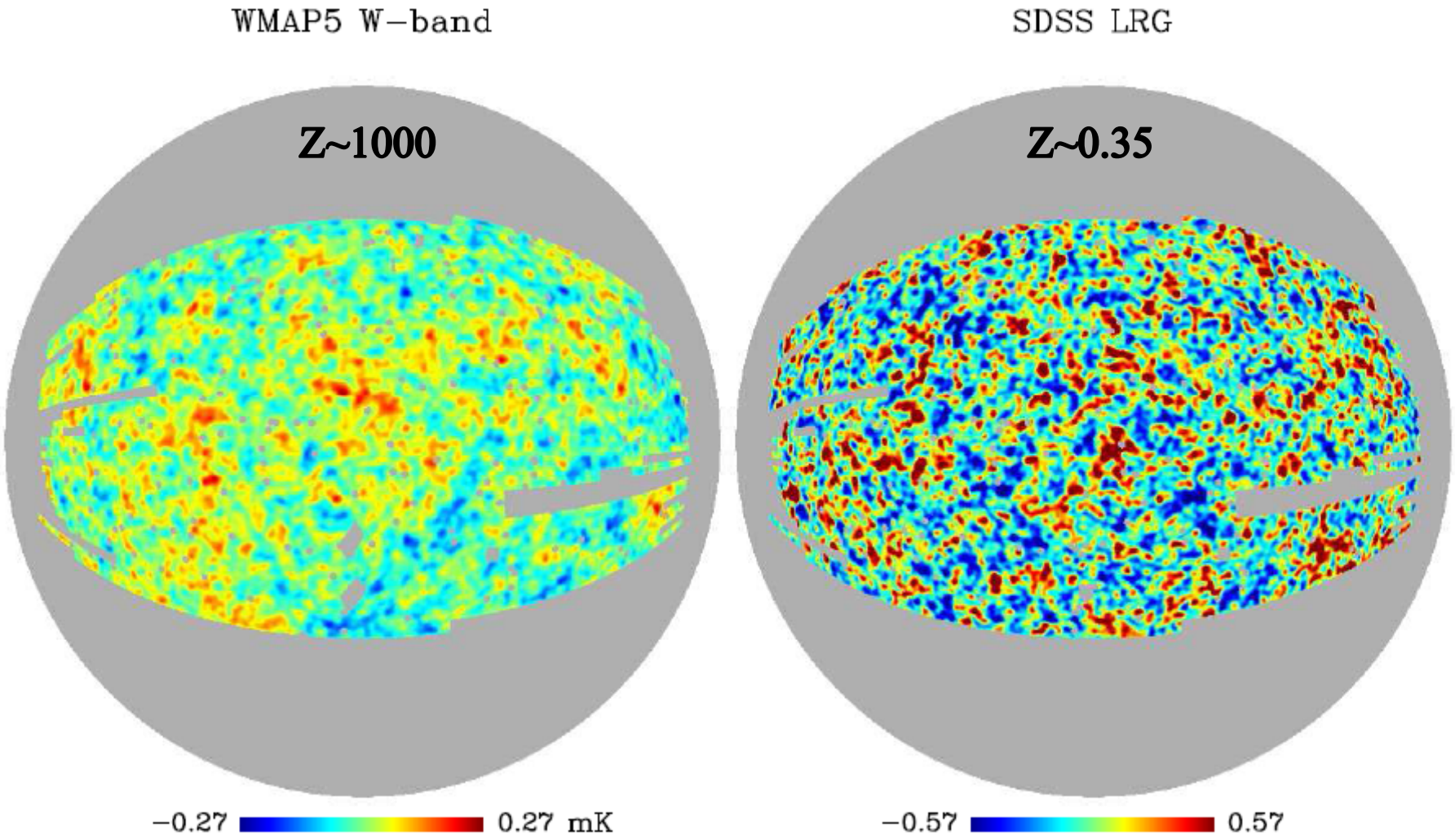
Integrated Sachs Wolfe (ISW)

Physical detection of Dark Energy: Influencing the growth of structure

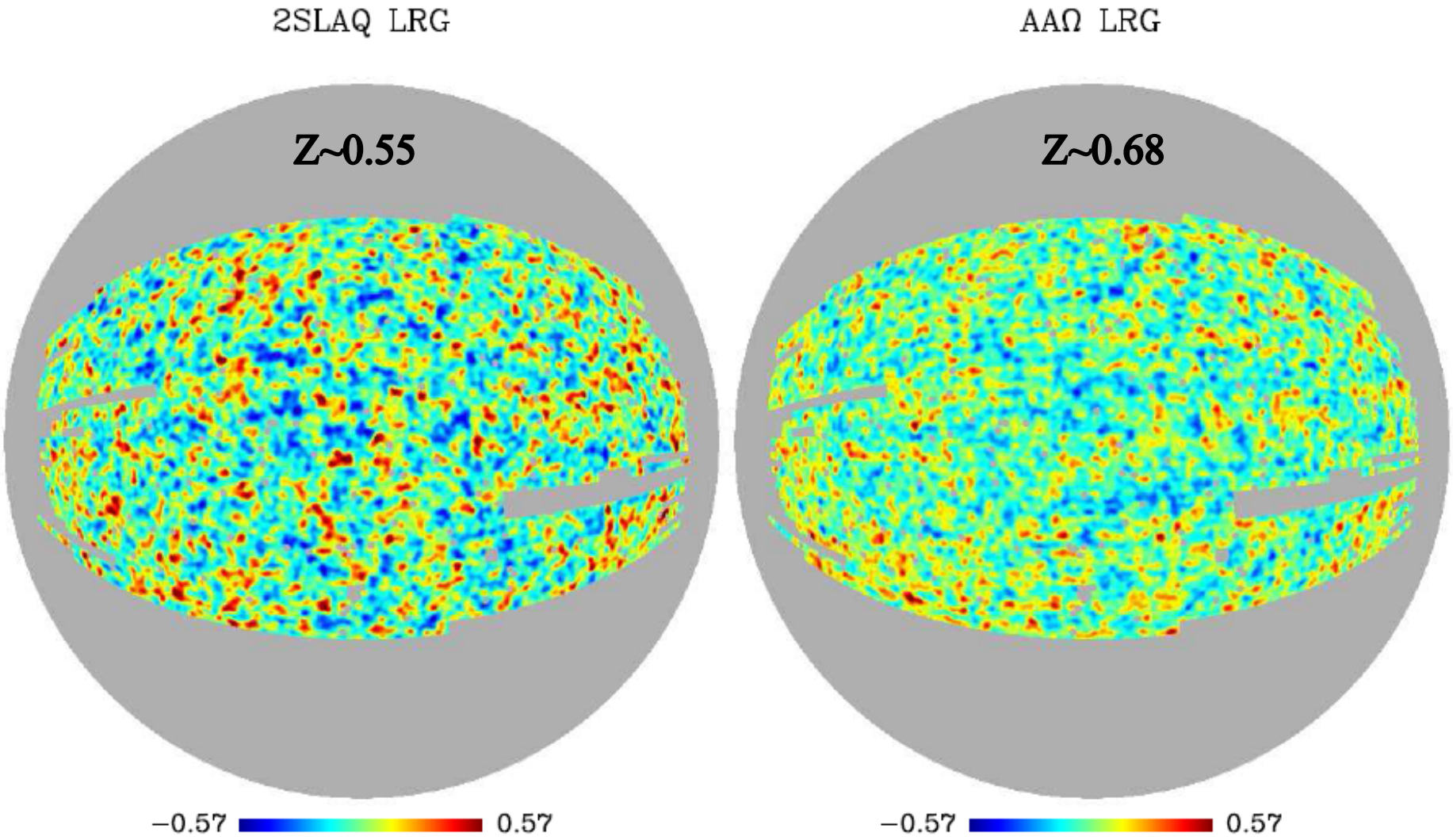


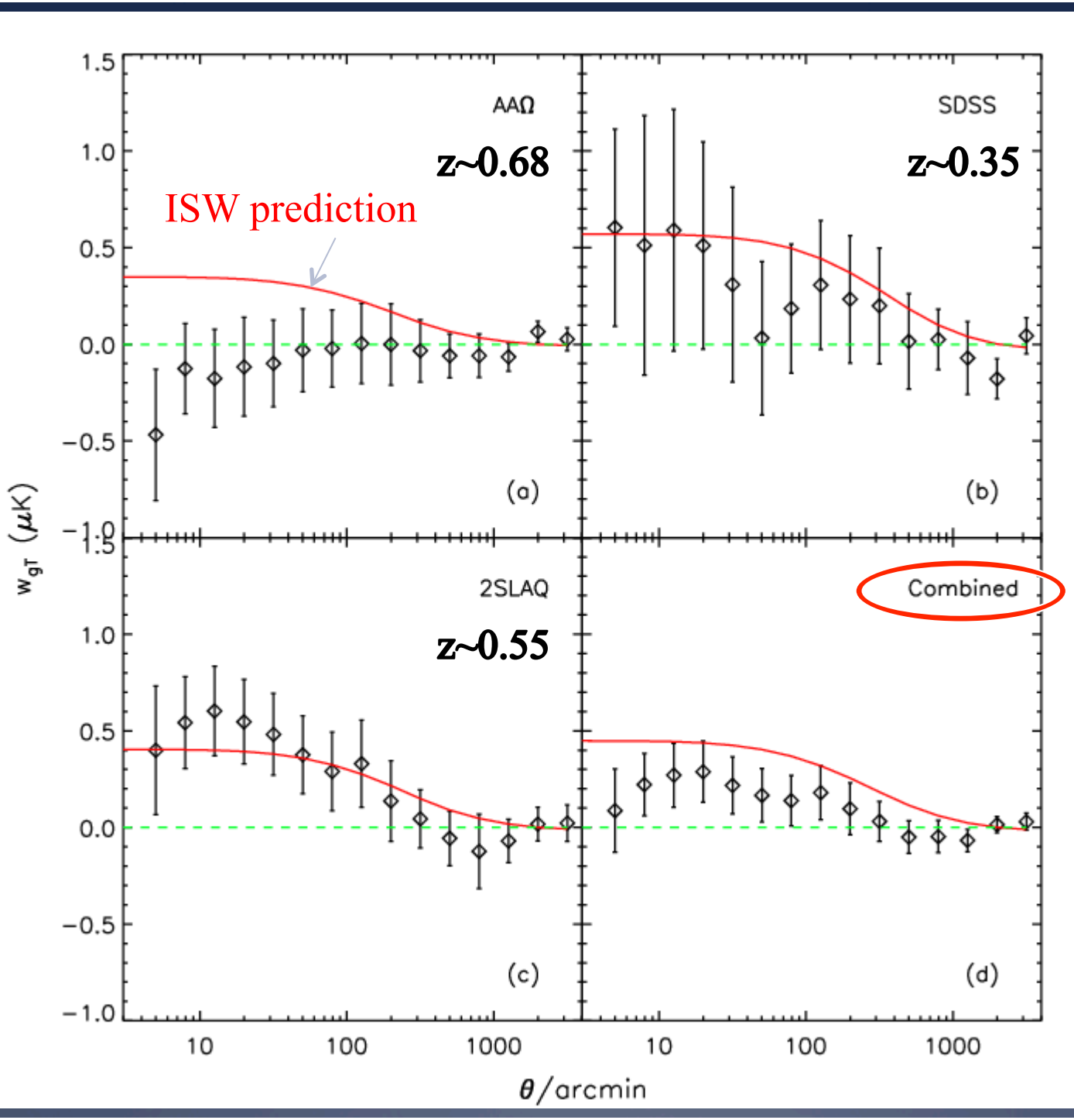
In a flat matter-dominated universe, photon blueshift and redshift on entering and leaving cluster cancels but not if DE acceleration. Results in net higher temperature near overdensity

Temperature and galaxy density maps



More galaxy density maps….




AAΩ
z~0.68
ISW prediction
SDSS
z~0.35
2SLAQ
z~0.55
Combined
(a)
(b)
(c)
(d)
w_{gT} (μK)
θ/arcmin
1.5
1.0
0.5
0.0
−0.5
−1.0
10
100
1000

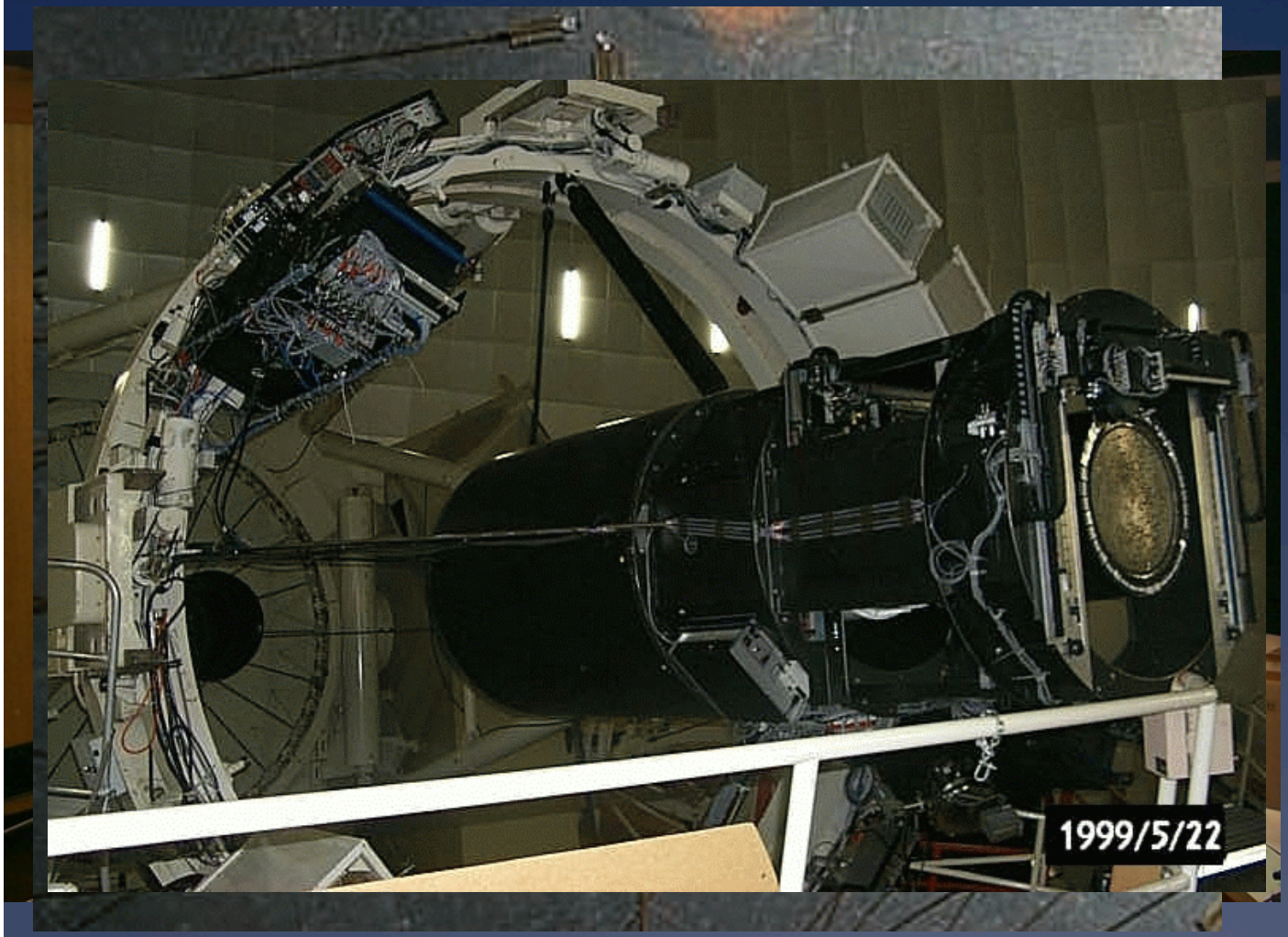
ATLAS Science Plan (2010)

- Focusses on Southern wide area cosmology
- Also on exploiting AAOmega+2dF at AAT for follow-up
- QSO clustering via z surveys
- ISW effect in South via LRGs and ELGs
- QSO – galaxy/group statistical lensing
- BAO via LRG+ELG z and ugrizYJHK photo-z
- Southern Hemisphere – the CMB dipole, the Great Attractor, Shapley supercluster…

BAO QSO Survey

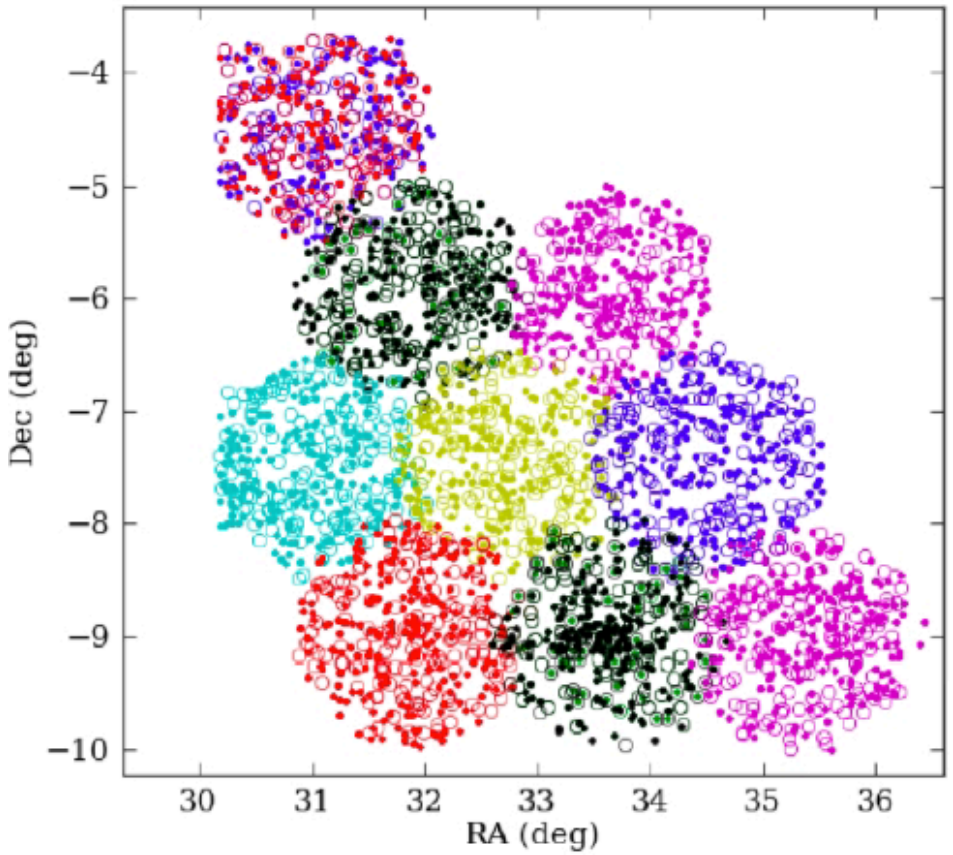
- Example of unique VST ATLAS science
- 2.5<z<3.5 QSO survey using UV dropout
- z<2.2 QSO survey using UV excess
- Exploits 2dF+AAOmega - Needs ~3000deg^2

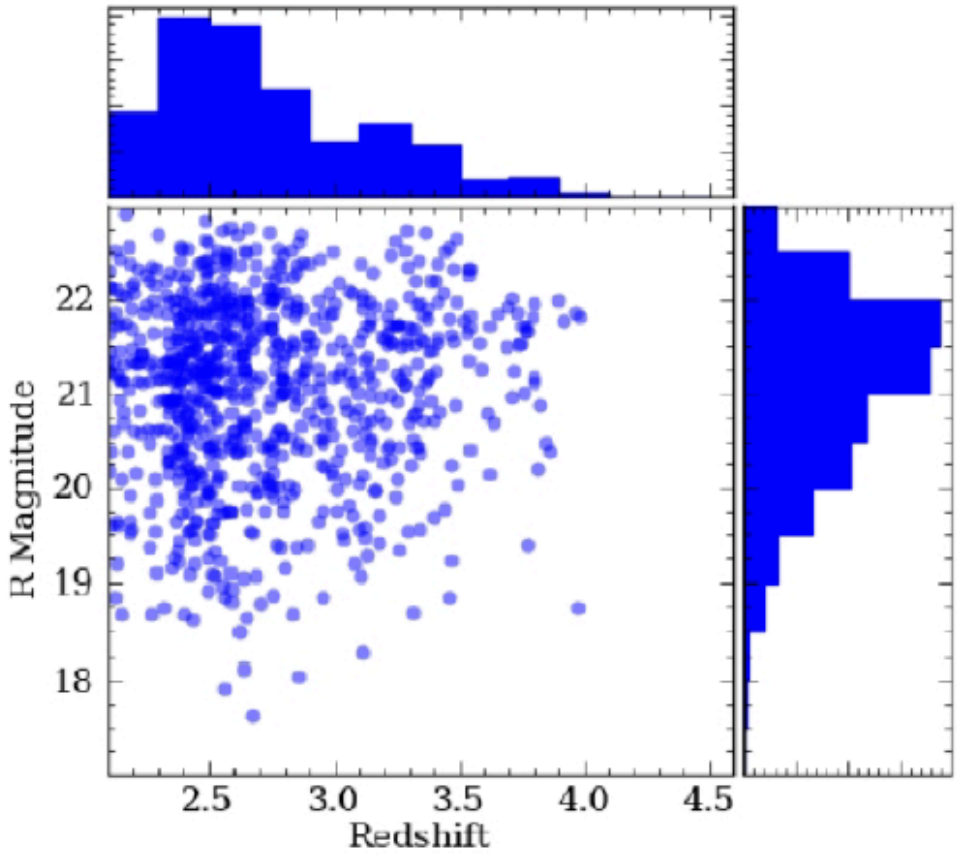
AAT 2dF Redshift Surveys



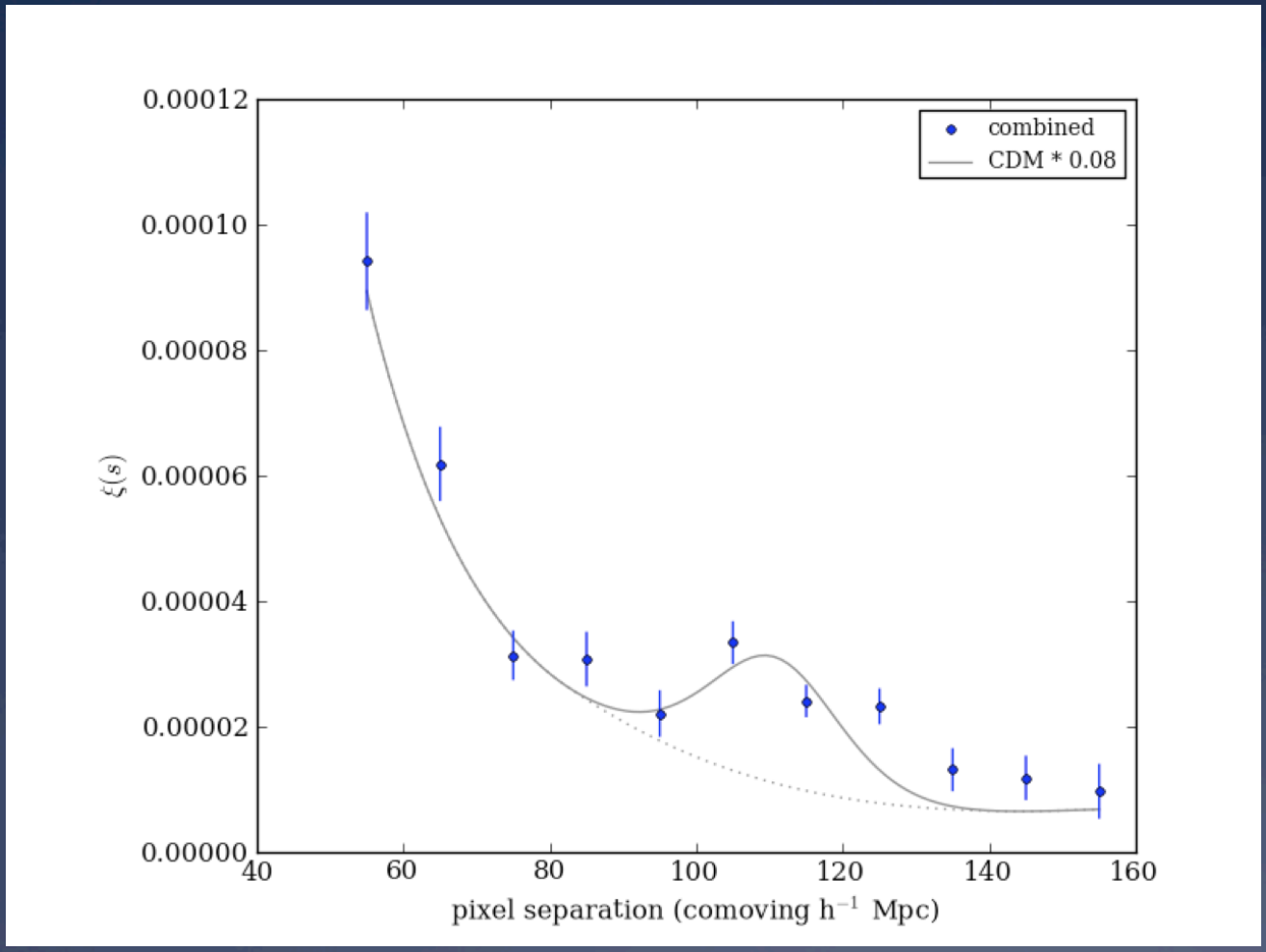
* 2dF ~400 fibres over 3deg^2 -50 x bigger field than VLT vs 4x smaller mirror
* 2dF galaxy and QSO z surveys
* Updated with AAOmega→ WiggleZ

AAT Lyman-α BAO Pilot





Lyman-α BAO Simulation

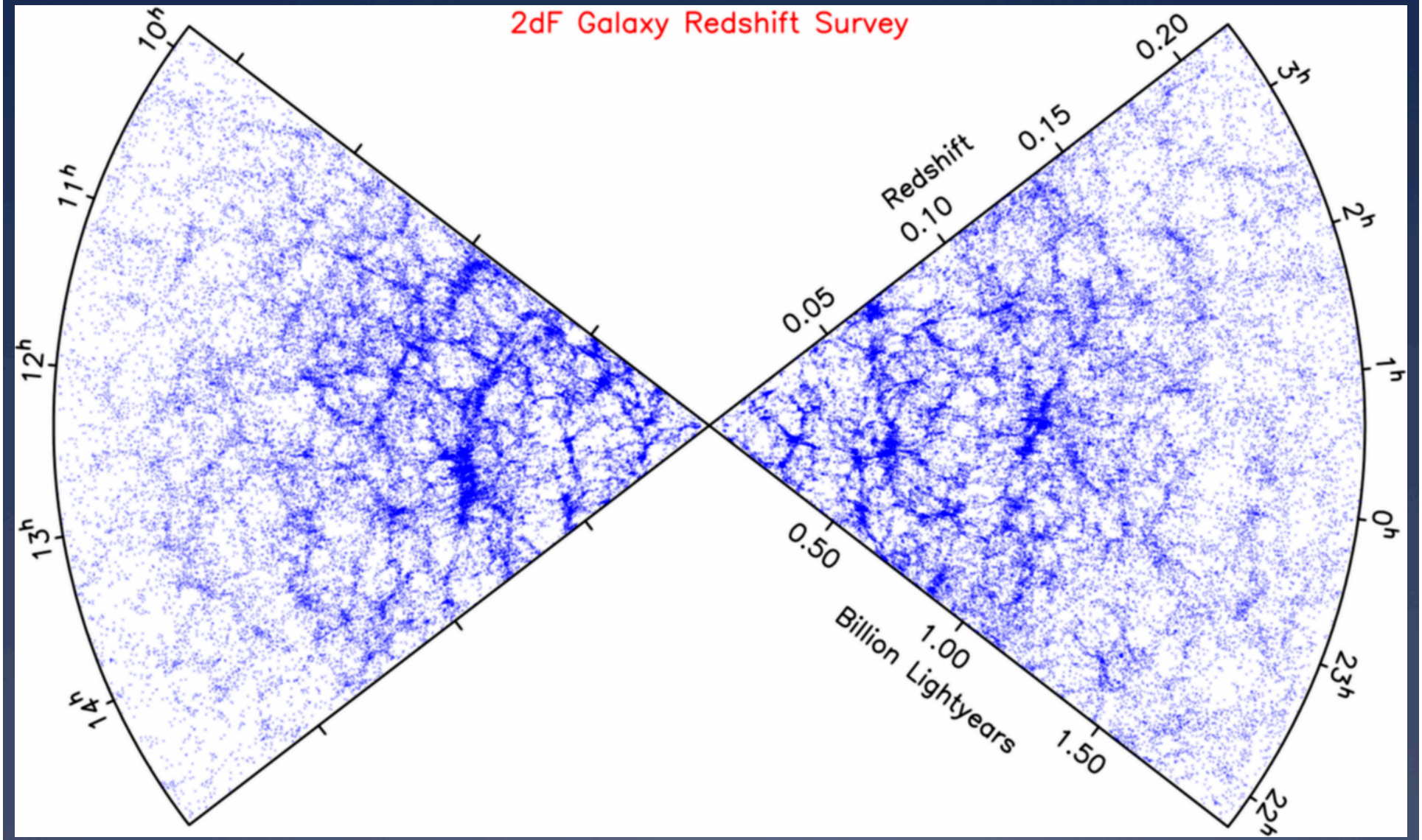


Area 3000deg^2

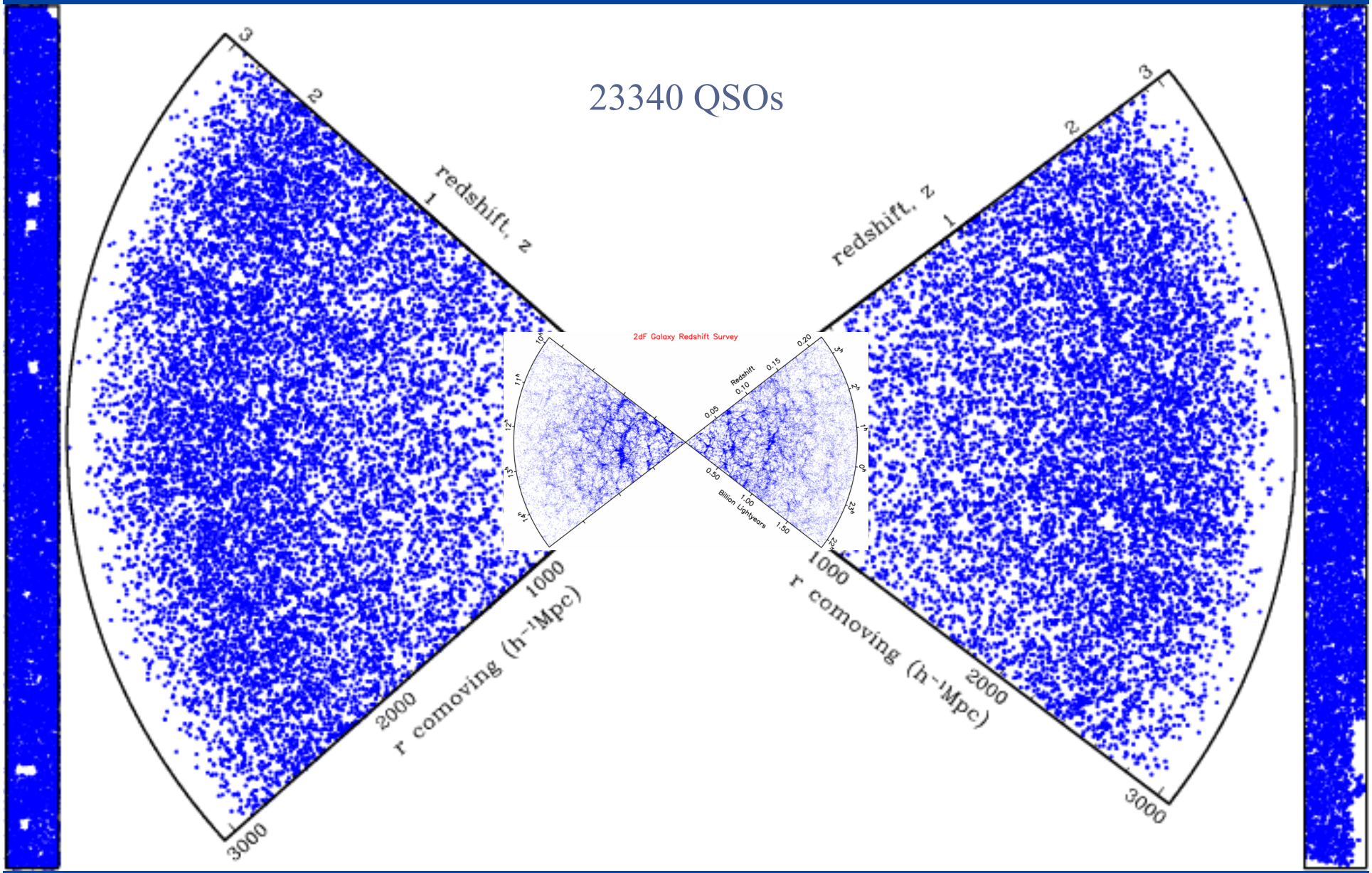
QSO density15deg^{-2}

45000 QSOs

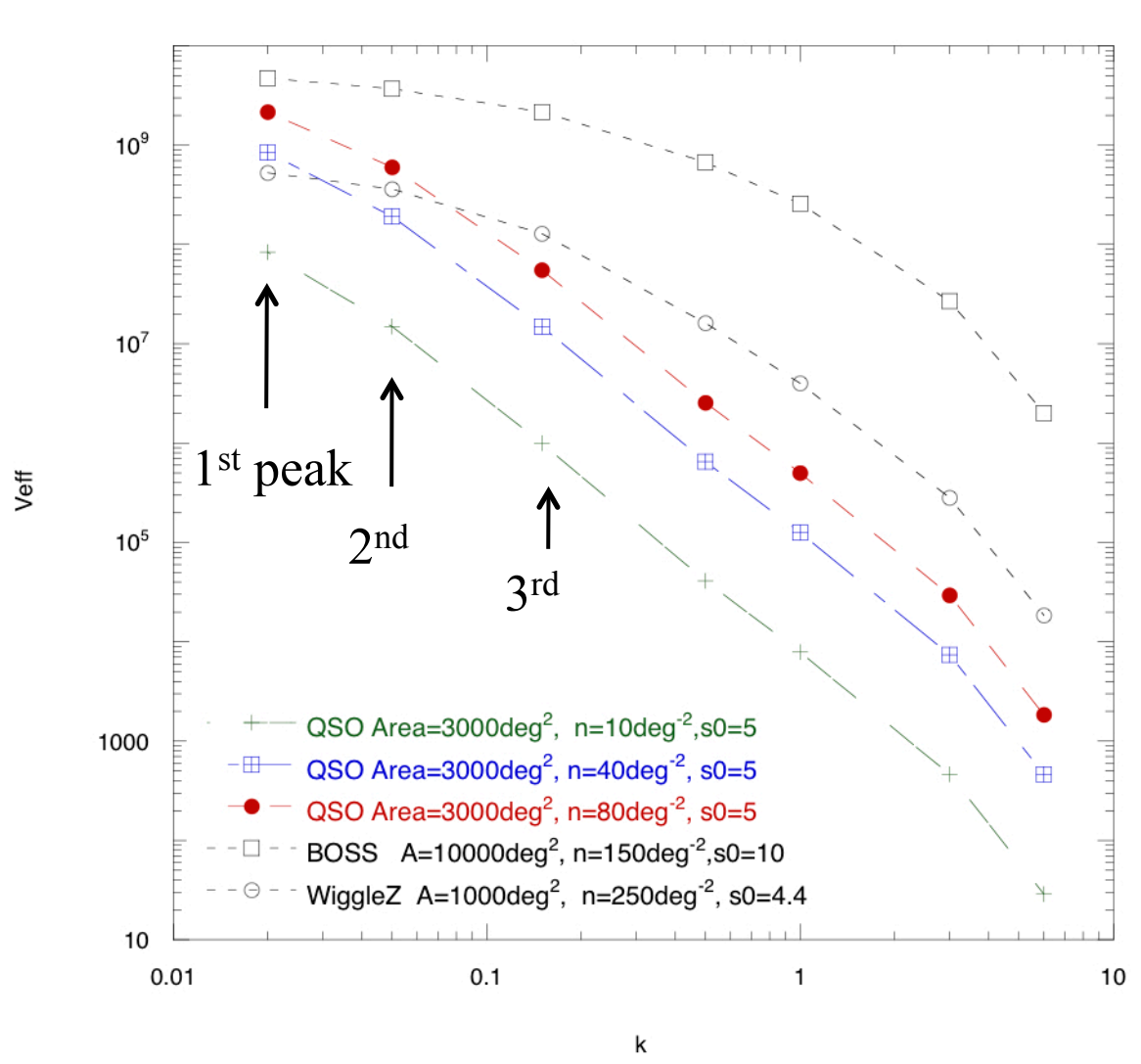
2dF Galaxy Redshift Survey



The 2dF QSO Redshift Survey

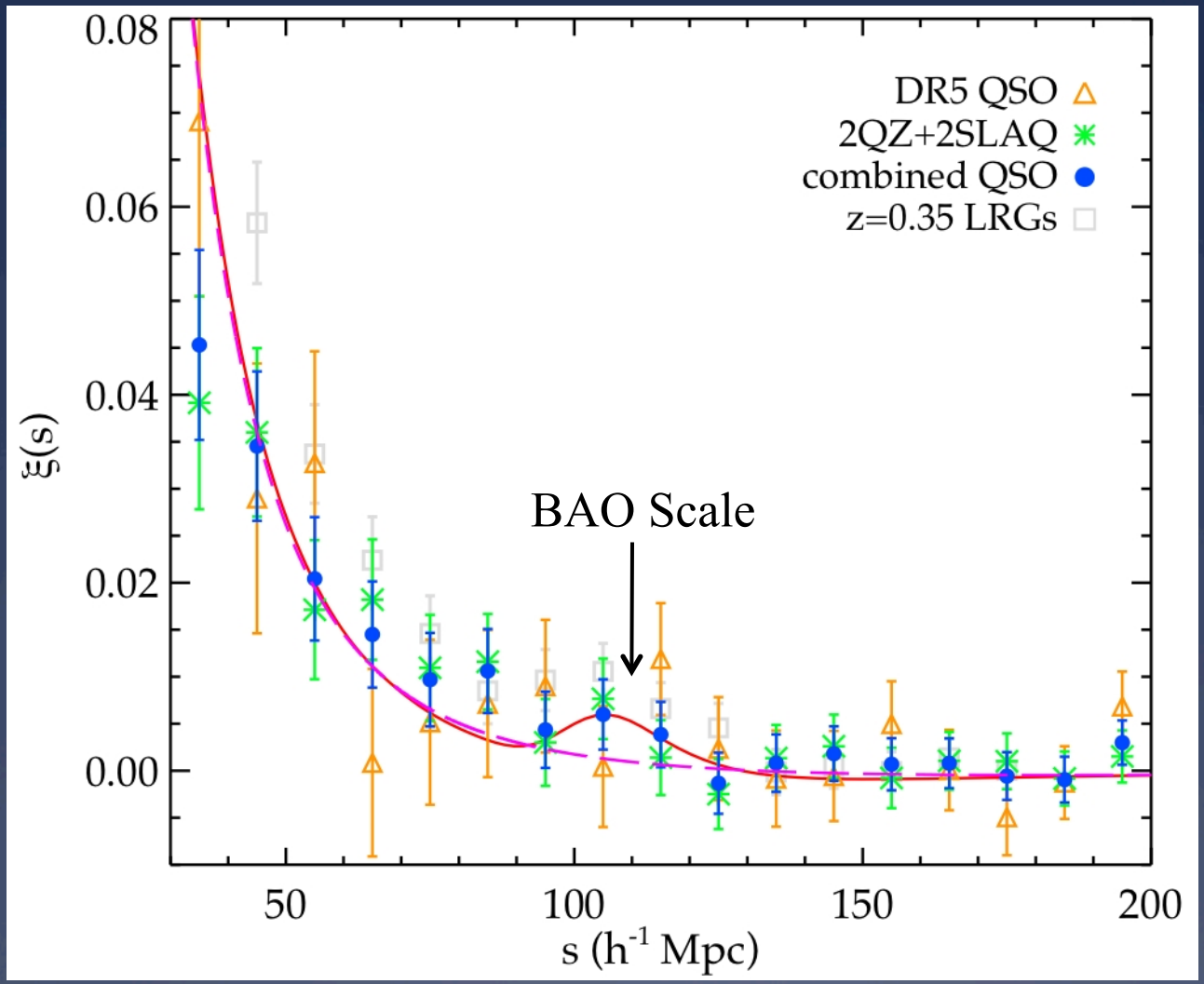


QSO Effective Volume



- Despite low sky density…
- QSOs can win at BAO scales
- → z~1.5 BAO measurement

2QZ+2SLAQ ξ(s)


0.08
0.06
0.04
0.02
0.00
ξ(s)
DR5 QSO
2QZ+2SLAQ
combined QSO
z=0.35 LRGs
BAO Scale
50
100
150
200
s (h-1 Mpc)

AAT LoI

Letter of Intent for a new large program on the AAT:

Determining dark energy evolution to z~3

In this letter our consortium (see end for list) expresses its interest in starting a new Large Programme in 2011B. We propose to use the Ly-α forest in z~3 QSOs to measure the BAO scale in the range 2.5<z<3.5, while simultaneously measuring the BAO scale at z~1.5 directly via QSO clustering. The programme will build on the success of the WiggleZ BAO measurement at z~0.6 and determine the evolution of the dark energy equation of state over a large fraction of the age of the Universe. Given the lack of a convincing physical model for dark energy, it is critical to measure the equation of state over a wide range of redshifts and thus provide the best possible constraints on evolving dark energy models.

In the pilot project of Croom et al. (AAT/09B/10), we observed ~1000 2<z<4 QSOs in 14 2dF pointings covering ~42deg^2. The magnitude limit was r<22 and the QSOs were selected in the W1, W2, W4 fields of CFHTLS. We have used both pilot data and simulated surveys to estimate the likely BAO S/N. A ~3000 deg^2 survey will achieve a ~5σ BAO detection based on the simulations (see Fig 1). Current uncertainties from the pilot project are ~2.6 times the expectation from the simulations (i.e. a 2σ BAO detection in the full survey). However, there is significant scope for reducing the errors in the measurement. This work is ongoing and we will update these predictions for the full 2011B proposal.

Since the Ly-α projects will take up <40% of the 2dF fibres with z>2.2 QSO candidates, we also propose to make a companion survey of z<2.2 QSOs in the same ~3000 deg^2 area. Fig. 2 shows the correlation function at the BAO scale from 2QZ and 2SLAQ QSOs over ~750deg^2. The S/N in this measurement is such that a marginal BAO peak may be visible. Scaling the results of Fig. 2 to higher density (double the density of 2QZ) and larger area suggests that 3000 deg^2 will provide a BAO peak detection at 3-4σ. This agrees with the predictions of Wang et al (2009, MNRAS, 394, 1775). The z<2.2 QSO survey will therefore fill in the dark energy evolutionary history between the WiggleZ result at z~0.6 and the Ly-α result at z~3.

The Large Programme will enable a host of other projects. From the z>2.2 QSOs, we shall compare the Ly-α correlations in the redshift and angular directions to determine the gravitational growth rate and apply the Alcock-Pacynzski cosmological test. We shall also make a sensitive measurement of the "transverse proximity effect" using QSO pairs that lie close on the sky. Redshift-distortions in the small-scale clustering of the z<2.2 QSOs will similarly allow the gravitational growth rate and AP tests at z~1.5. This survey will test inflation via the QSO power-spectrum turn-over and also make possible a sensitive search for early-Universe non-Gaussianity.

At the current stage of pilot survey analysis, we therefore envisage a strawman project as follows. The exposure time per field will be ~1.5 hrs so that ~3000deg^2 can be surveyed in ~200 clear nights. The project will measure spectra for ~25000 z>2.2 QSOs to r=22 and ~150000 z<2.2 QSOs to approximately the same limit. These numbers assume a tiling overlap of 25-30%, and efficiencies of selection of ~15% for the high redshift QSOs and ~60% for the lower redshift QSOs. These efficiencies are conservative in that they assume SDSS imaging quality and more than half our survey area will be covered by *ugr* imaging significantly deeper than SDSS, from VST KiDS+ATLAS and CFHTLS.

The light-grasp and field of AAT 2dF, coupled with the powerful combination of Ly-α forest clustering at z~3 and direct QSO clustering at z~1.5 make this programme unique. The Ly-α aspect can compete with BOSS and the z<2.2 QSO survey could pre-empt stage-3 dark energy probes such as BigBOSS and WFIRST in this redshift range.

Consortium: Scott Croom (PI), Ben Jelliffe (Sydney), Chris Blake, Karl Glazebrook(Swinburne), James Bolton, Bradley Greig, Stuart Wyithe (Melbourne), Matthew Colless (AAO), Neil Crighton, Tom Shanks (Durham), Brian Schmidt, Ragini Singh, Rob Sharp (RSAA), Henry McCracken, Yannick Mellier (IAP).

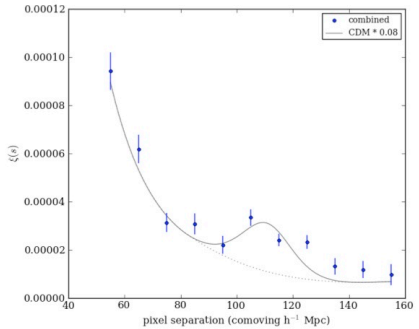


Fig. 1. The simulated Ly-α forest correlation function compared to an LCDM simulation from Slosar et al (2009, JCAP, 10, 19). The model was run for a 3000deg^2 area and a QSO density of ~15deg^{-2}, similar to the survey parameters proposed here.

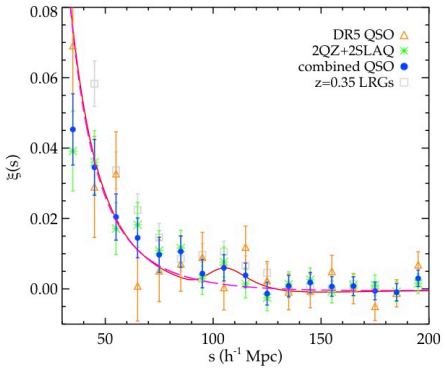


Fig. 2. The green crosses show the correlation function from 35000 z<2.2 QSOs in the ~750deg^2 2QZ+2SLAQ surveys compared to the z=0.35 LRGs and the LCDM model, with and without an acoustic peak at ~100Mpc. The 1σ BAO "detection" here will convert into a 3-4σ detection in a 4x bigger area with a QSO density of 80deg^{-2}. The 35000 DR5 SDSS QSOs have a 4-8x lower sky density than 2QZ/2SLAQ and hence produce correspondingly larger errors.

BAO QSO Survey

- Example of unique VST ATLAS science
- 2.5<z<3.5 QSO survey using UV dropout
- z<2.2 QSO survey using UV excess
- Exploits 2dF+AAOmega - Needs ~3000deg^2
- AAT LOI submitted to start in August 2011
- BAO + Early-universe non-Gaussianity + P(k) turnover

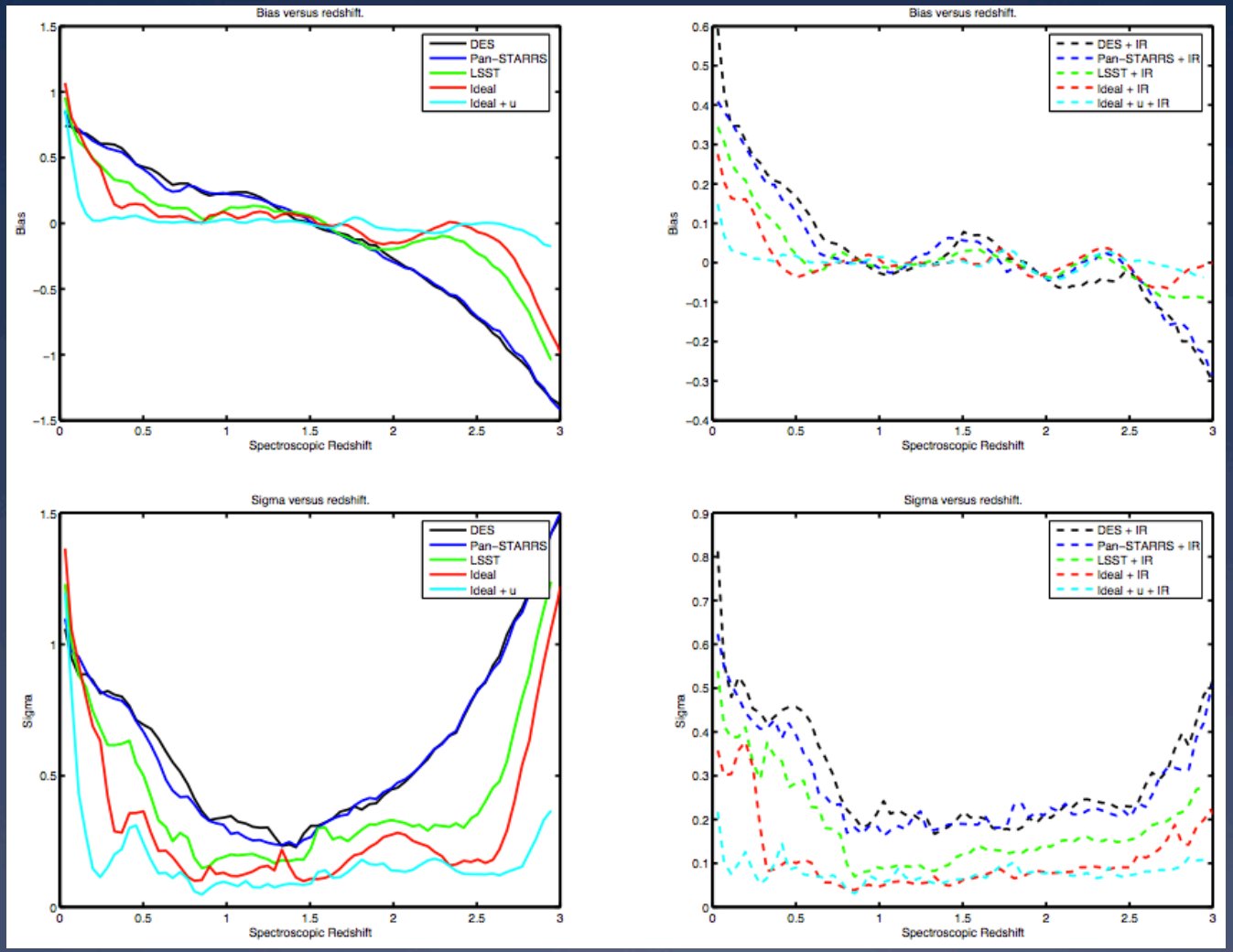
Other ATLAS Science

- Gravitational growth rate at z=1-3 via QSO z-distortion
- ATLAS+VHS optical dropout → z~7 QSOs
- QSO Lensing
- Galaxy Photometric Redshifts
- Stellar Streams+Galactic Archaeology
- Beyond the Great Attractor

u improves z_{photo} as much as JHK!

Z_{photo} Bias

Z_{photo} Error



0 1 2 3 0 1 2 3

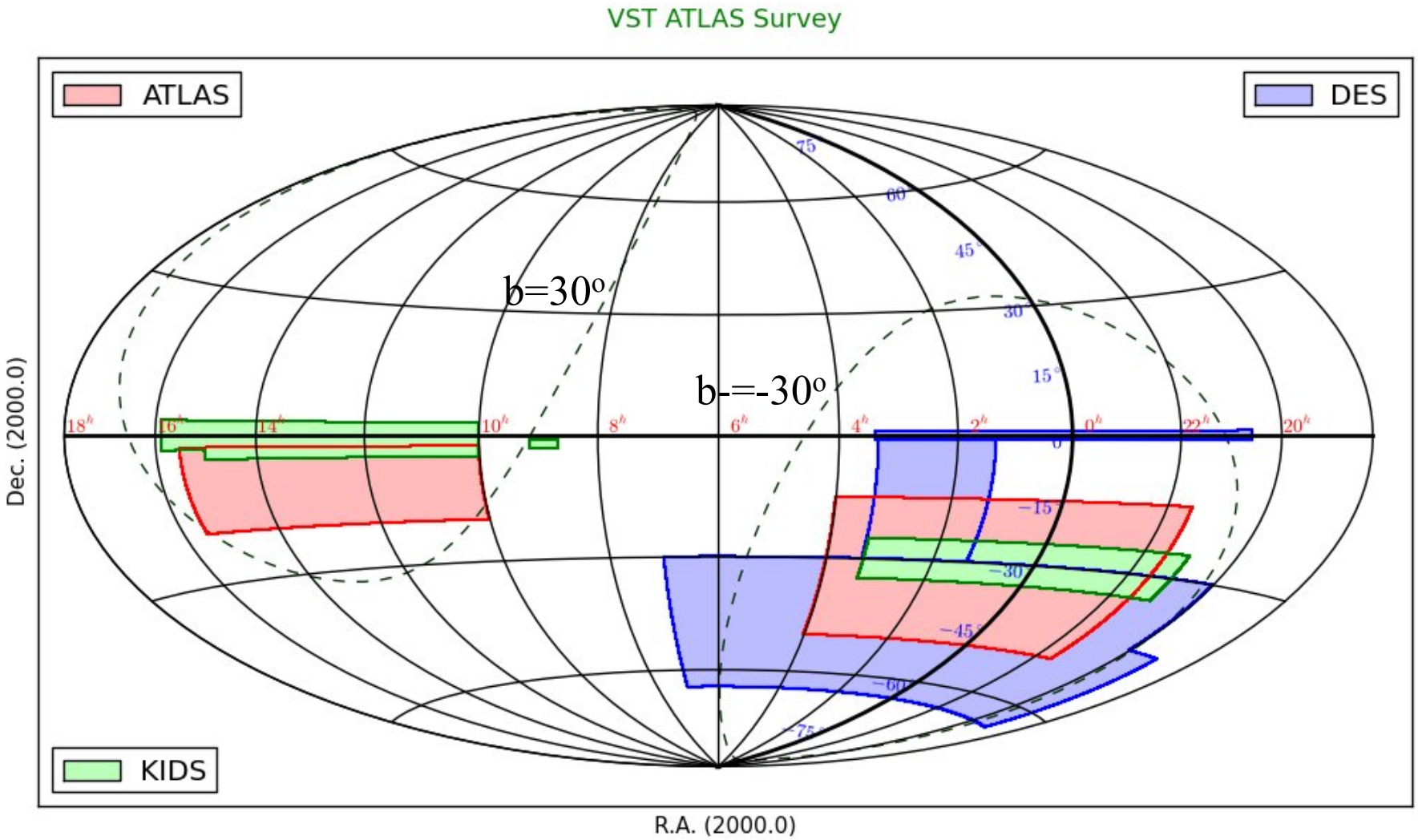
Spectroscopic Redshift

Abdalla et al 2008

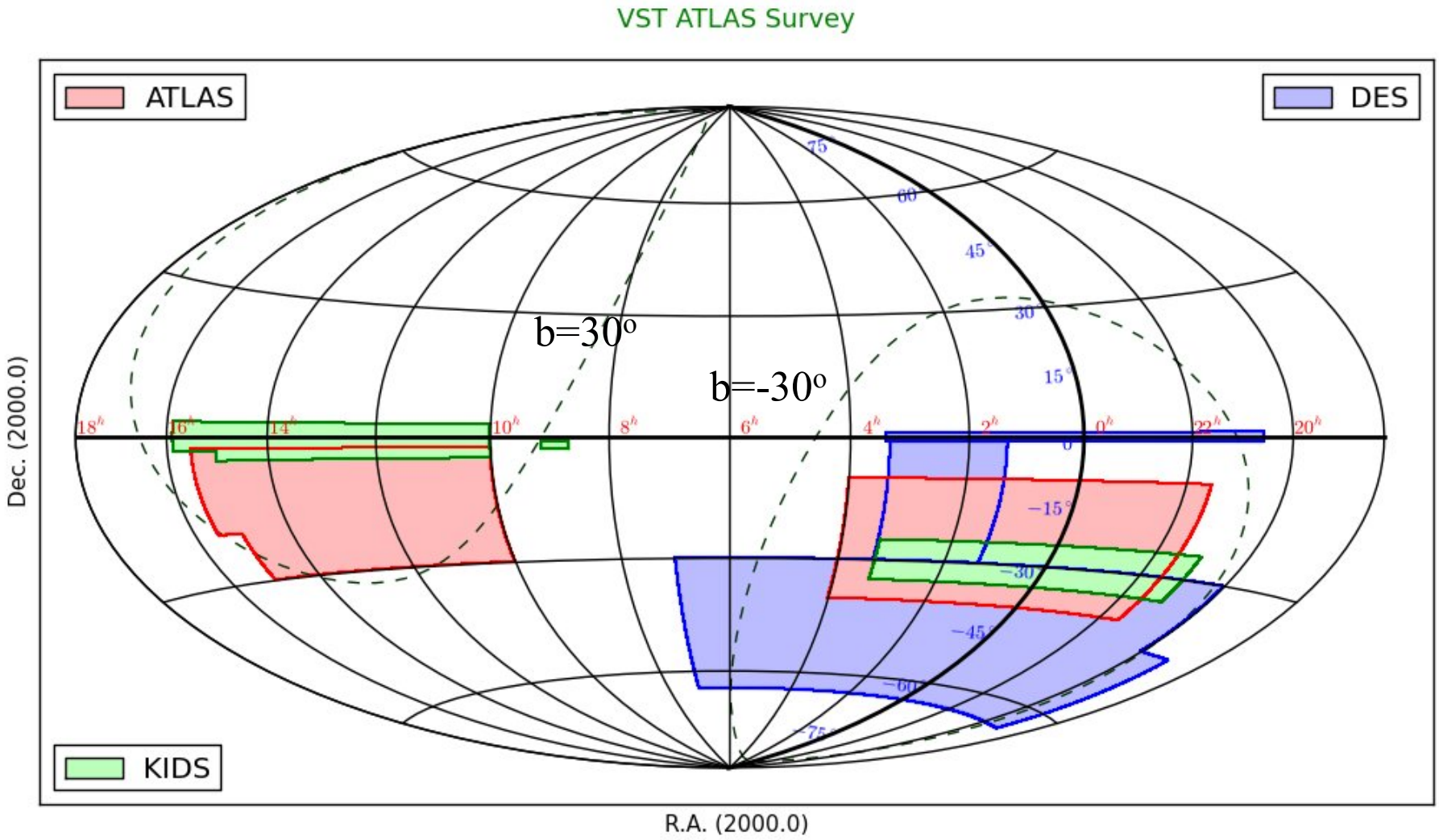
Possible ATLAS Changes

- Double u exposure time relative to griz?
  - Slows survey – more time – u already deep
- Wholly focus on u band?
  - But then reliant on other surveys for griz
- Transients – split r exposures?
  - Depends on binning/readout time
- Accelerate ATLAS – it only takes 90 nights?
  - Could go to 60 nights/year without affecting KiDS!
- Change footprint?
  - Decrease DES overlap

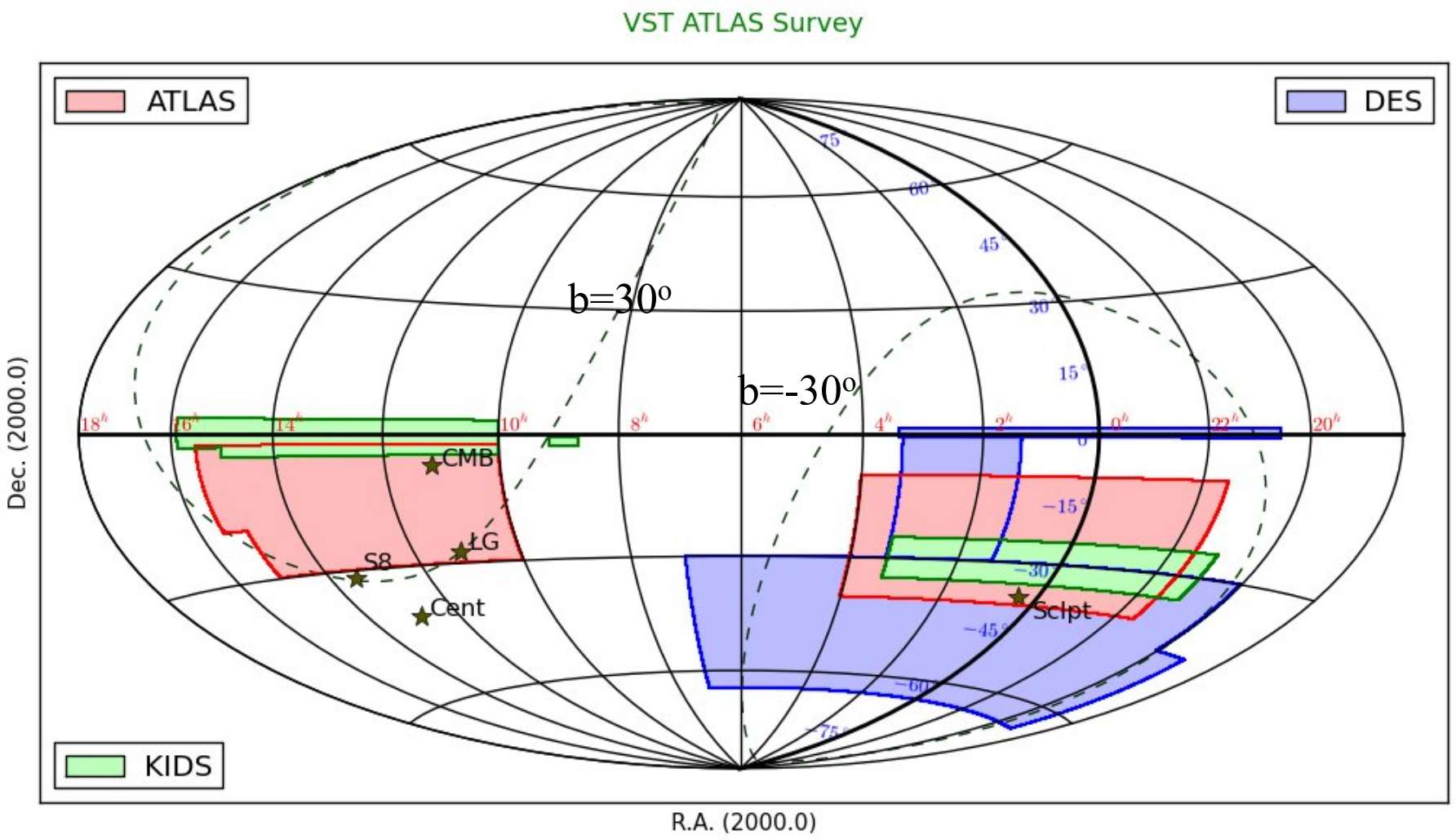
VST ATLAS – current footprint



VST ATLAS – new footprint?



VST ATLAS – new footprint?



Possible changes

- ATLAS footprint moves 5-10° N in SGC and 10° S in NGC
  - Reduces overlap with DES
  - Proceed to make ugriz survey for 3 years
  - Then as DES griz data becomes public, option to move to u survey over remaining DES area?
- Or - accelerate ATLAS to original+extended area
  - Do both – with no effect on KiDS!

Summary

- VST ATLAS offers high quality science at low cost
- Cosmology Package to rival WFIRST!
  - BAO at z~1.5 via QSO clustering
  - BAO at z~3 via QSO Lyman α forest
  - Gravitational Growth rate at z=1-3 via QSOs
  - ISW via LRGs
  - QSO Lensing vs galaxy ugrizYJHK photo-z
  - Other Science
    - Stellar Streams + Galactic Archaeology
    - Z~7 QSOs via ATLAS+VHS z dropouts
    - Beyond the Great Attractor....