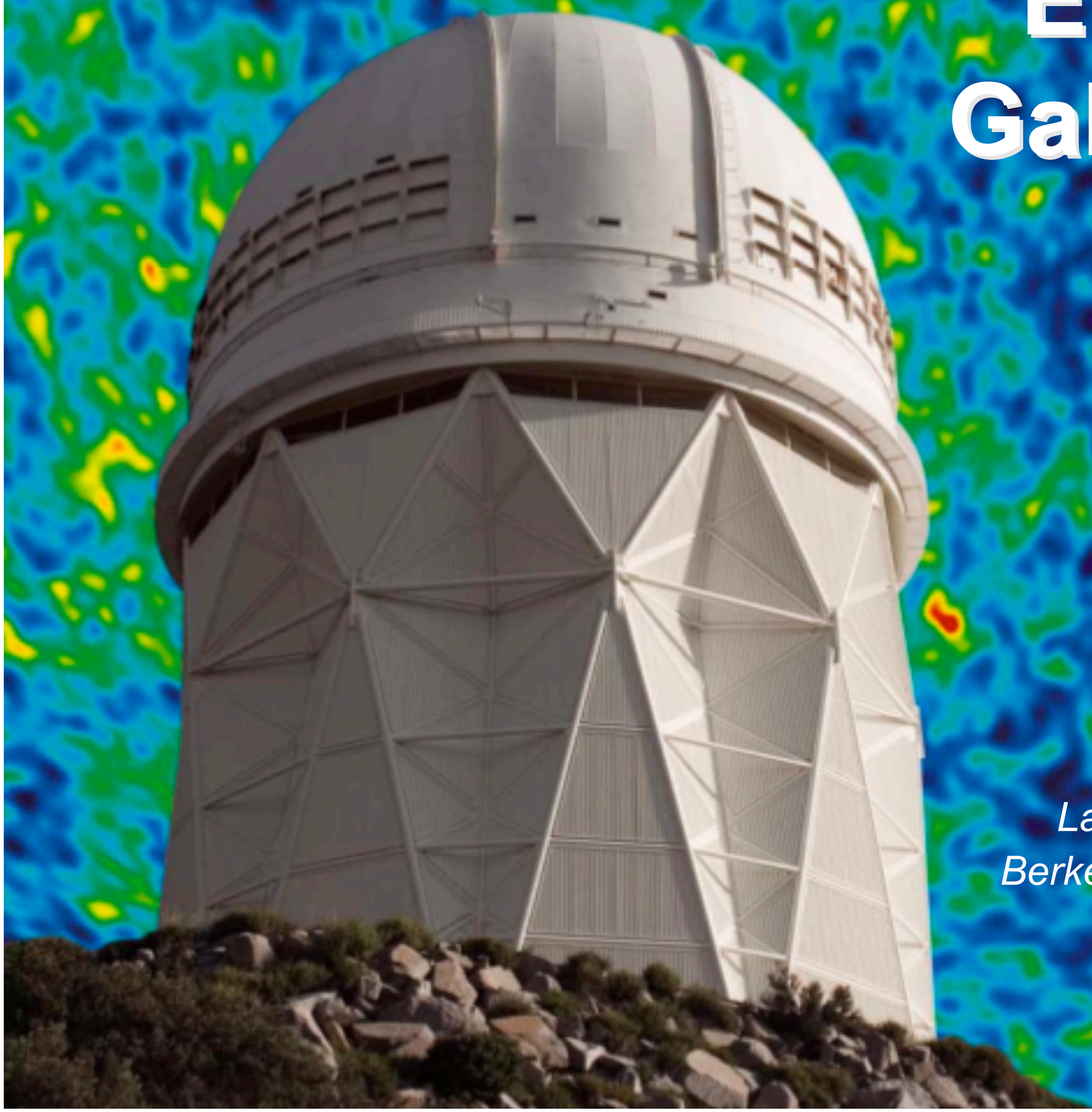

Emission Line Galaxies for BAO

Nick Mostek

Lawrence Berkeley National Lab

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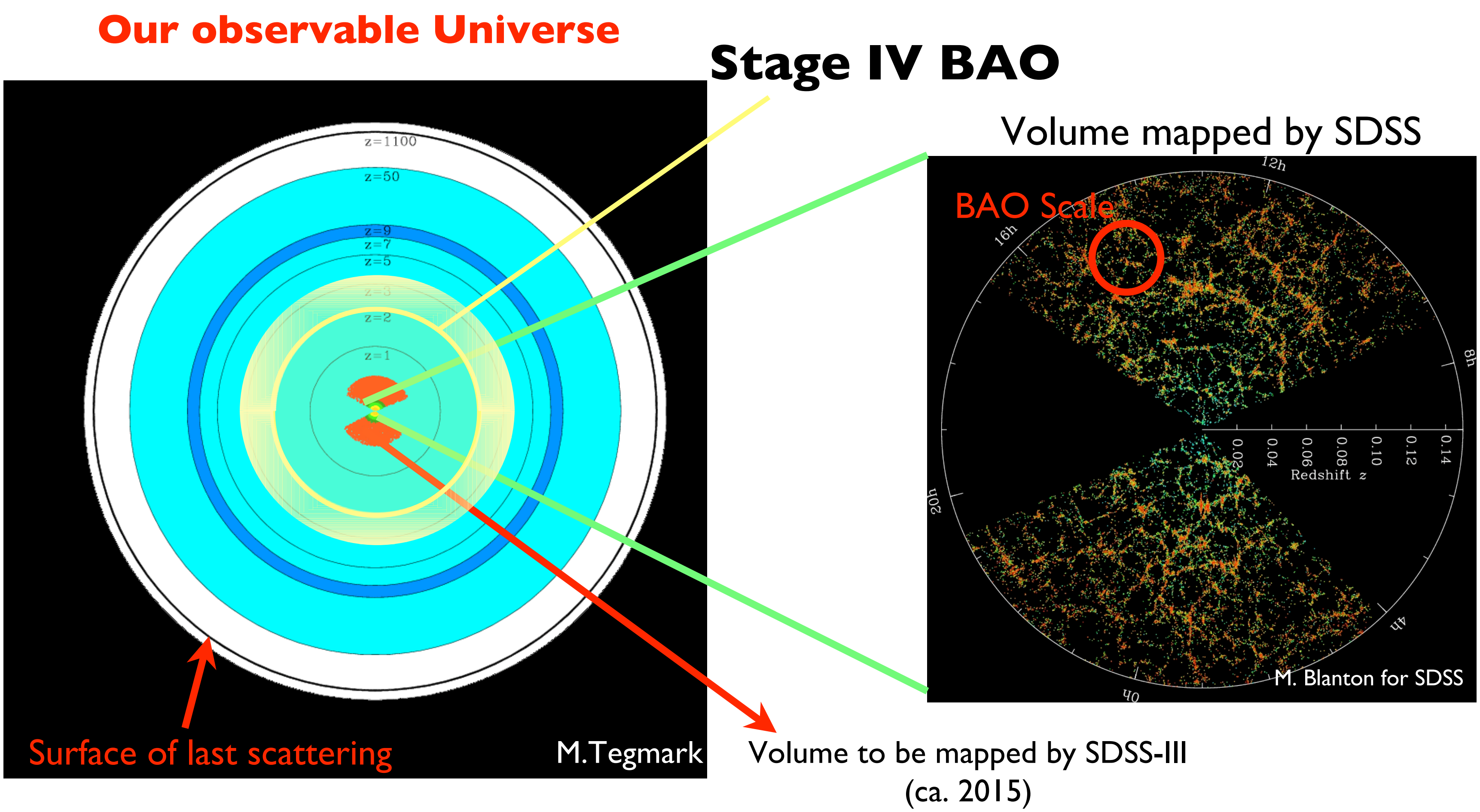
Mapping the Universe



- Measuring distances accurately with BAO scale length is largely limited by the survey volume and redshift accuracy
- Robust against systematic errors, sub-percent accuracies possible
- Stage IV dark energy experiments are considering the use of Emission Line Galaxies (ELGs) as a BAO tracer over the redshift range 1<z<2

Why Emission Line Galaxies?

- Star-forming galaxies excite their ISMs to produce a spectrum with strong emission lines
- Lines fall at specific wavelengths which can be used for accurate redshift measurement

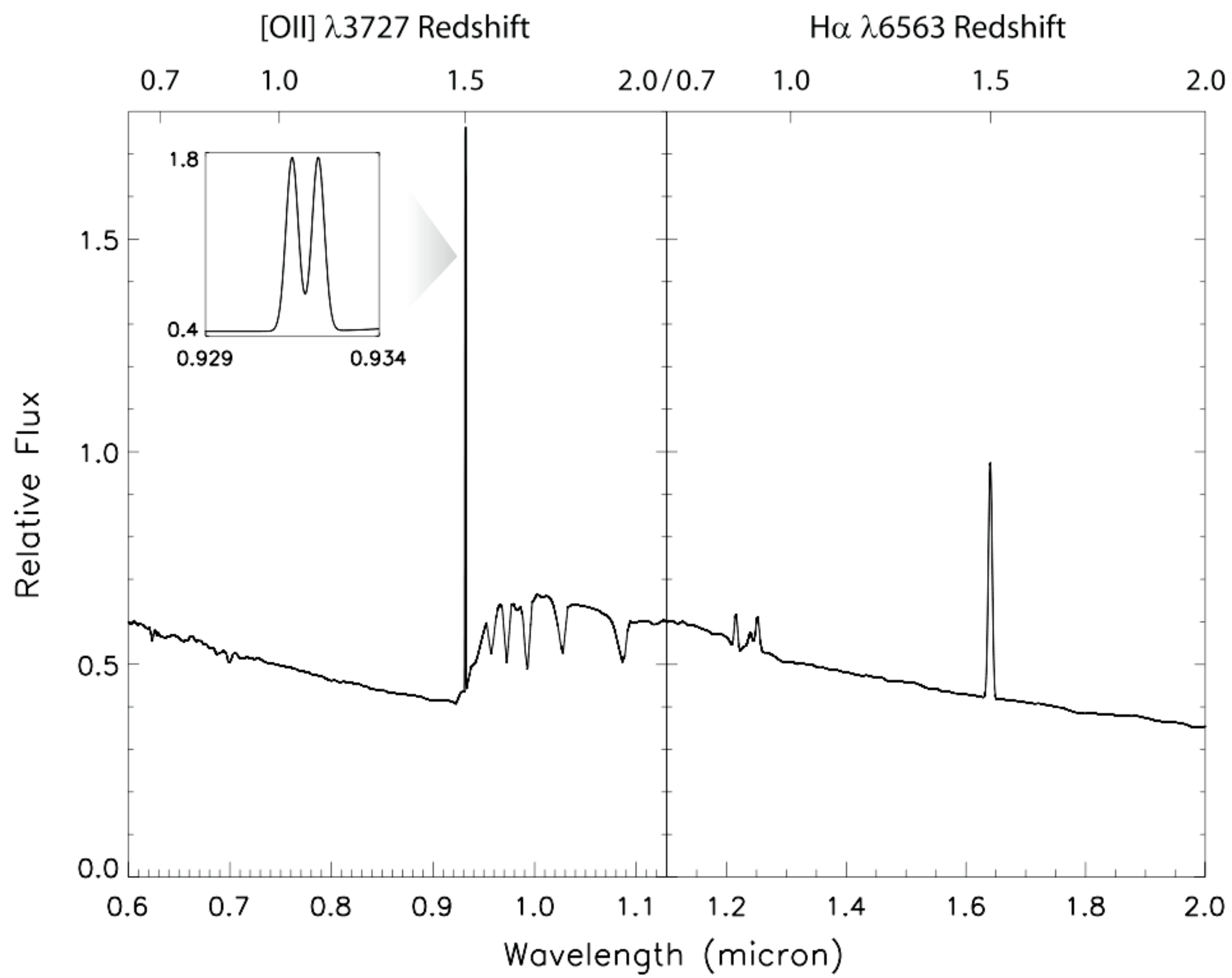
Advantages:

- ELGs are numerous in the range of $1<z<2$ as they do not require hierarchical structure formation
- Emission lines can be bright, unique identifiers - ideal for measuring redshifts efficiently
- In the case of the [OII] λ3727 line, evolution in the luminosity function is observed. Therefore, the [OII] luminosity in distant ELGs is brighter than the present day ($z=0$) ELGs

Disadvantages:

- Accurate luminosity functions are rarely measured beyond $z>1.5$
- Single emission line detections can be ambiguous
- Must have sufficient spectroscopic resolution to achieve $\Delta z<0.001(1+z)$ **AND** efficiently detect the line over background noise

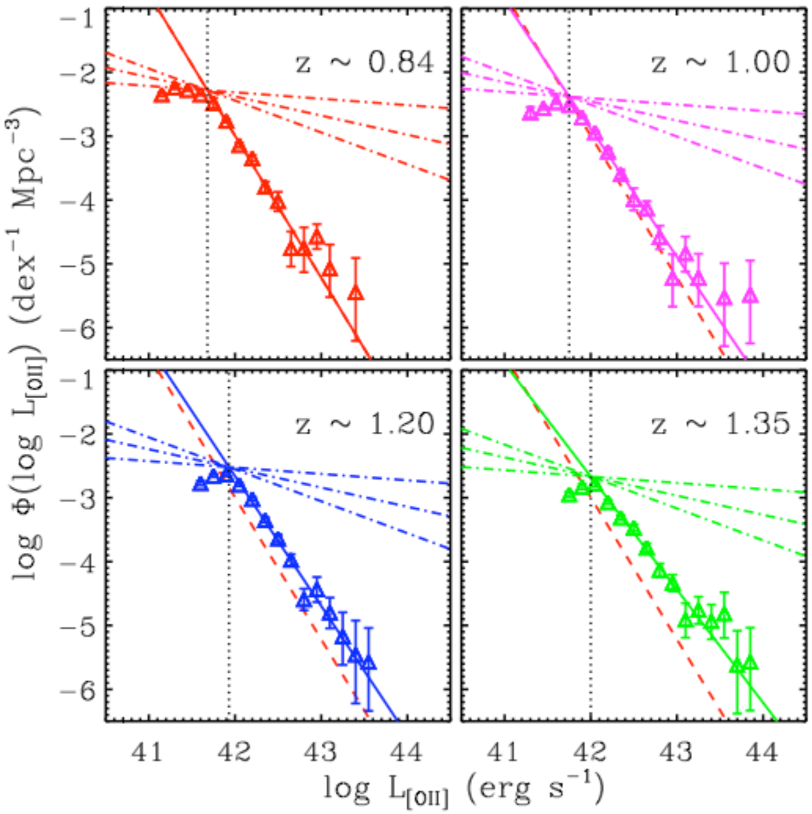
Spectroscopic Targets



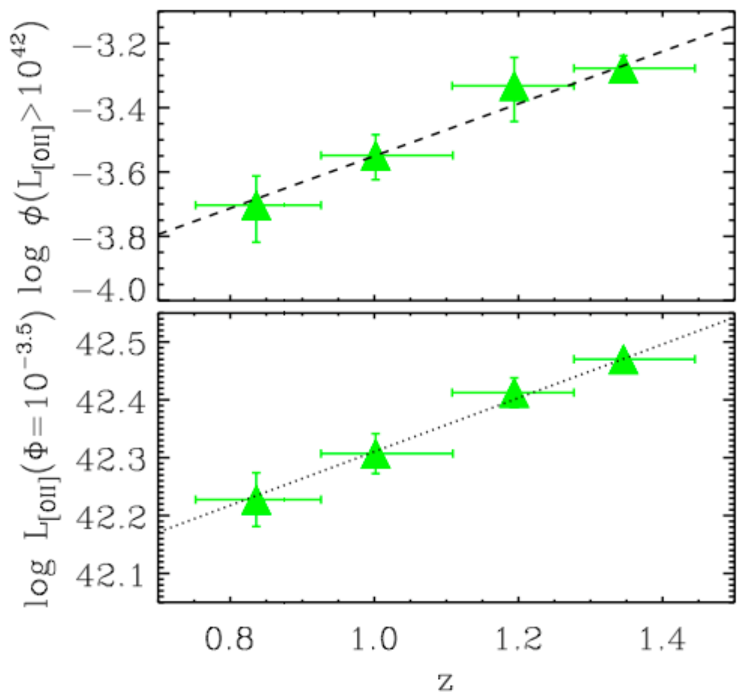
- Shown above is the relative flux for a z=1.5 template emission line galaxy.
- Left panel shows the [OII] doublet and spectrum at R=5000 resolution
- Right panel shows Hα and spectrum at R=200

[OII] Luminosity Function

Zhu et al., 2008

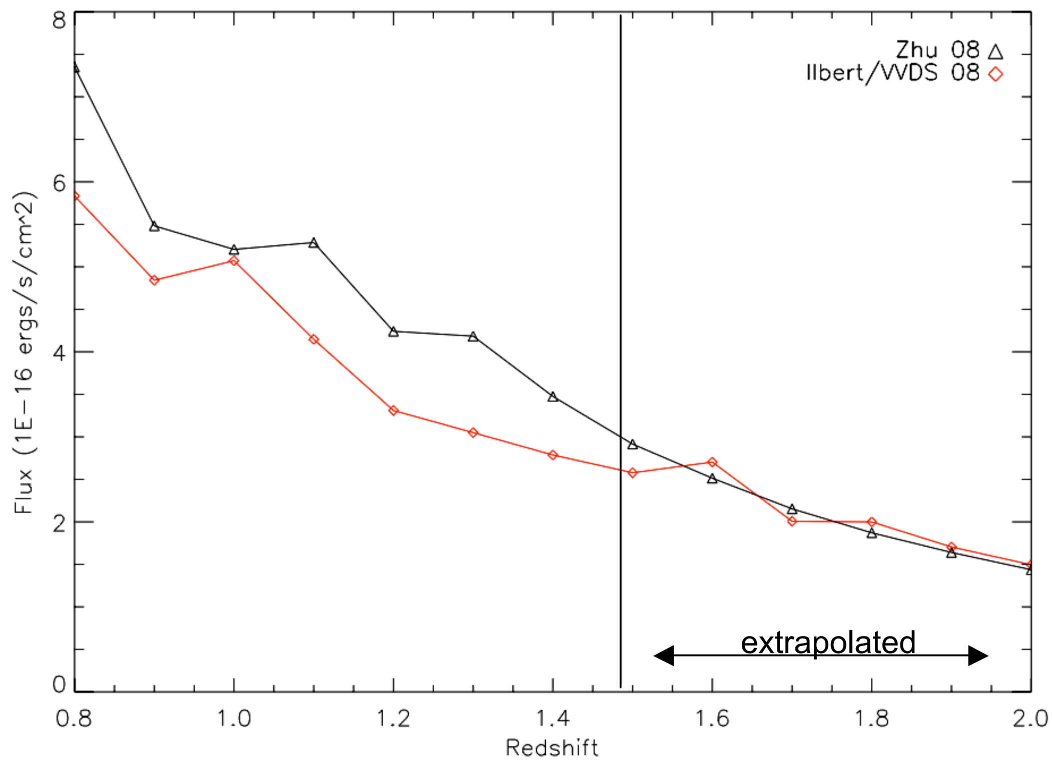


Zhu et. al, 2008



- Left figure shows the measured luminosity function of DEEP2 [OII]-emitting galaxies for 4 redshift bins. 14,000 [OII] emission line galaxies were used in this sample.
- Right figure shows the [OII] luminosity at a fixed space density. The increase in luminosity is likely due to evolution in the ISMs of these galaxies (decreased metallicity and/or increased abundance of oxygen)
- Stage IV BAO experiments are considering densities in the 10^{-3} -10^{-4} (Mpc/h)$^{-3}$ range
- Ha luminosity is roughly 2x that of [OII] at these densities. (Sumiyoshi, 2009)

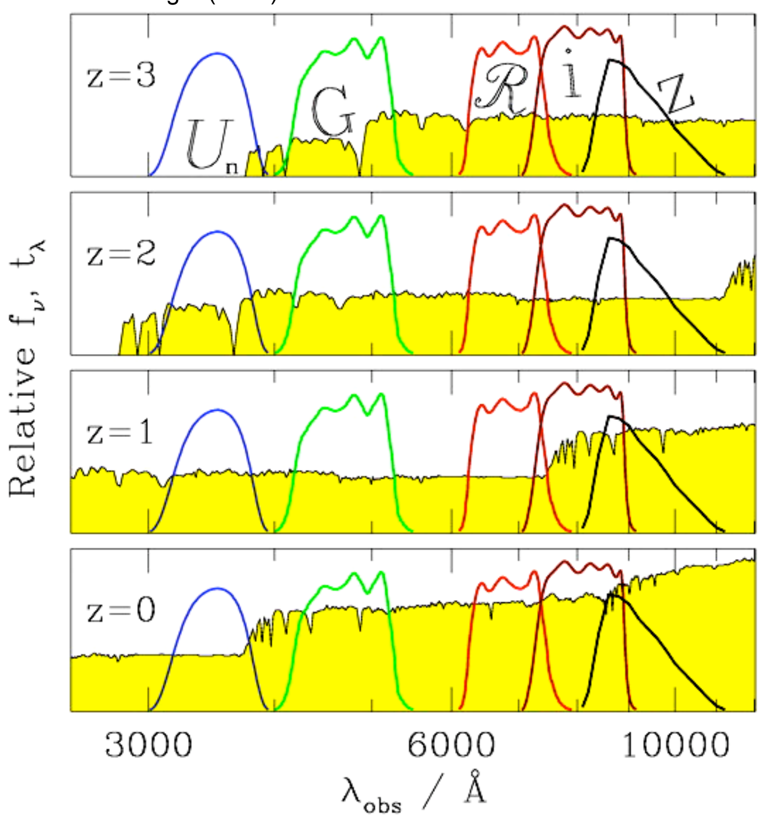
[OII] Line Flux Sensitivity

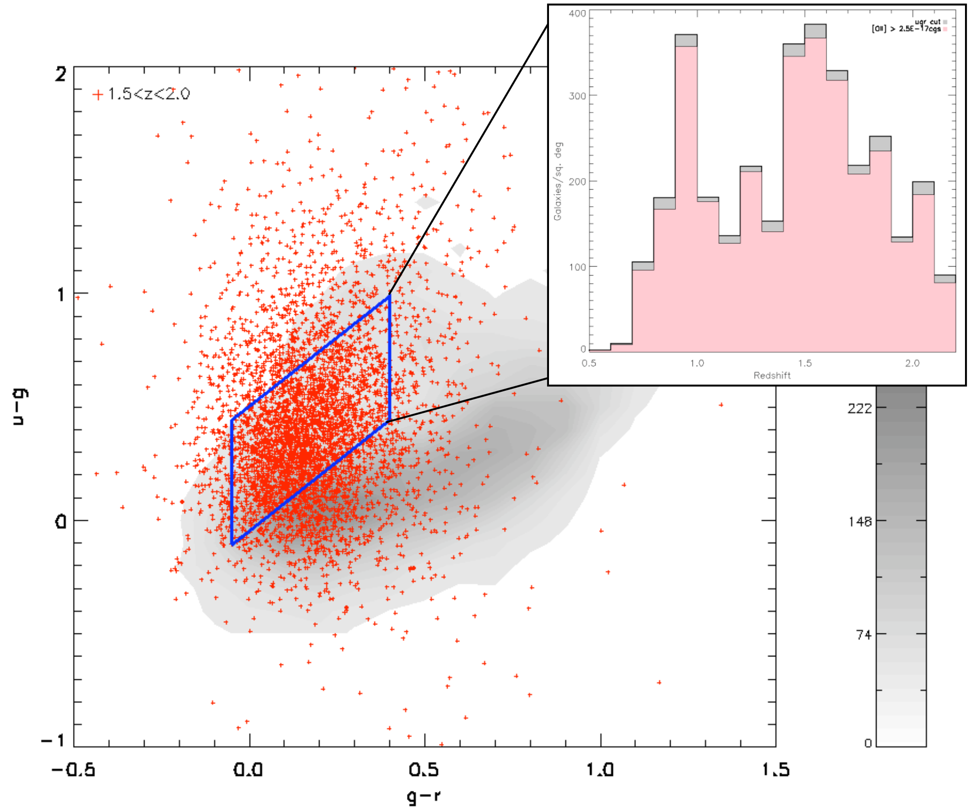


- Above graph shows the [OII] line flux limit for a sky source density ~3E-4 $(Mpc/h)^{-3}$
- Both Zhu and Ilbert/VVDS are in reasonable agreement from $0.8<z<2$, particularly considering that such luminosity functions can easily vary by a factor of 2 or more
- Additional data is needed beyond $z>1.5$ to confirm the predicted [OII] fluxes for the brightest members of the sample

Target Selection

Adelberger (2004)

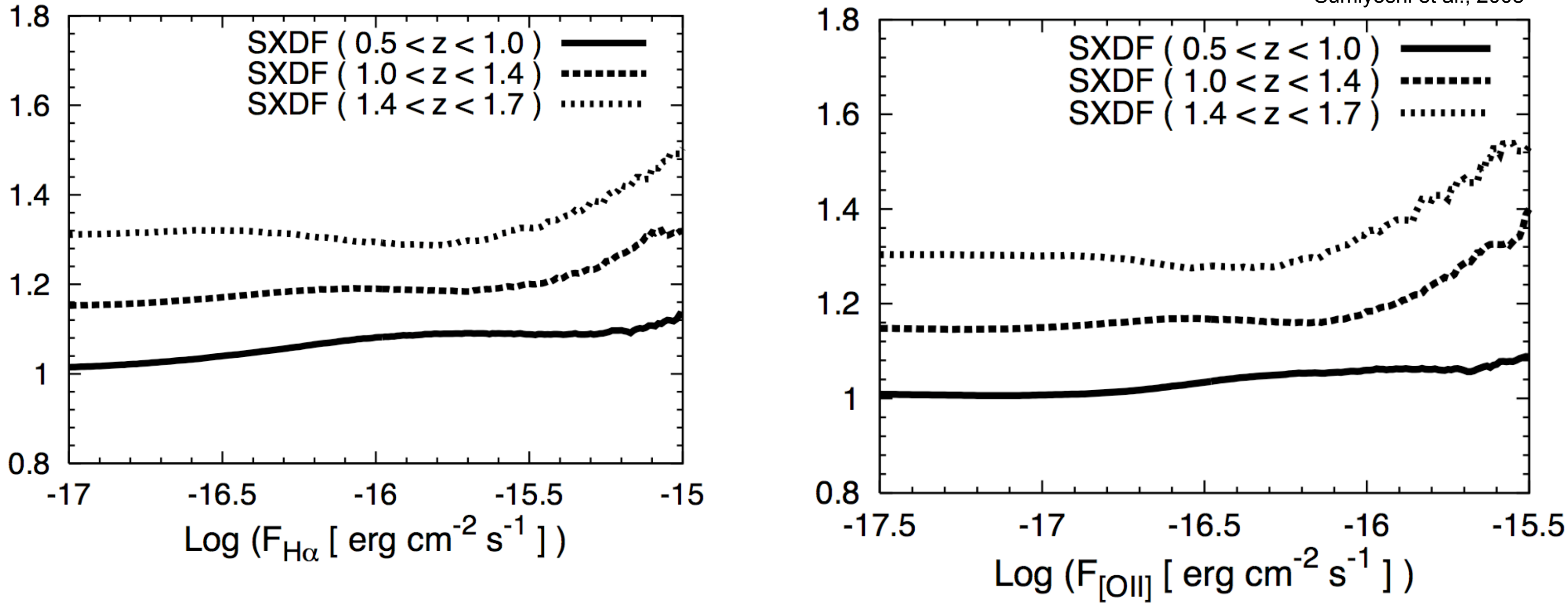




- Large slit/fiber spectroscopic surveys require efficient target selection
- Multiband targeting has been used in the literature, including *BRI* for 0.7<z<1.4, *Biz'K* for 0.5<z<1.7, typically to R<24 depths
- Emission Line galaxies with bright [OII] can be selected to z=2 with *ugr* or with a dual selection of *gri* (0.7<z<1.5) and *grz* (1.5<z<2.0)
- Targeting efficiencies are >70%, possibly better with optimization studies

ELG Bias

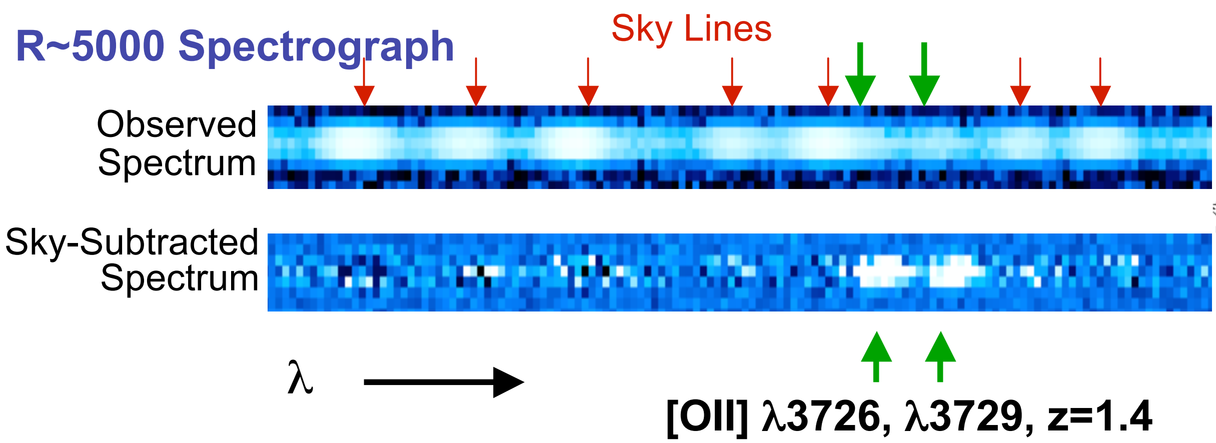
Sumiyoshi et al., 2008

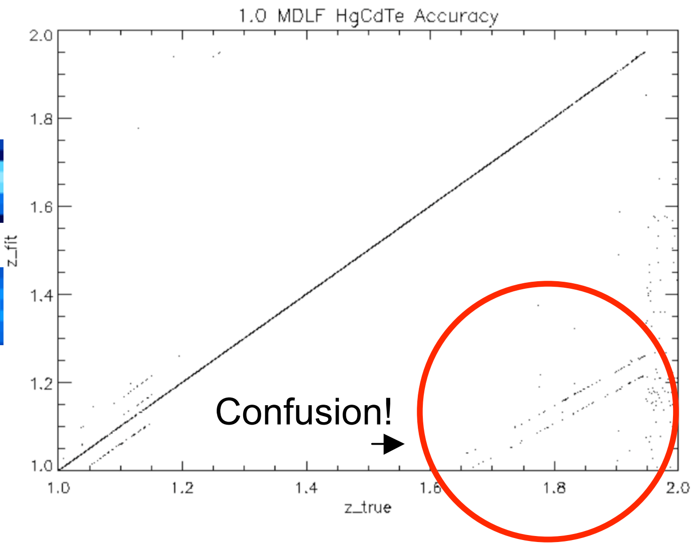


- Sumiyoshi et. Al (2009) performed a measurement of the mass bias with the Subaru XMM-Newton Deep Field (SXDF)
- Found $b(0) \sim 0.8$ and that the clustering amplitude was roughly constant with redshift in this redshift range.
- Agrees with other studies performed in small redshift windows (Blake et al., 2009, Geach et al., 2008)
- Clustering bias *could* be affected by AGN in the emission line sample

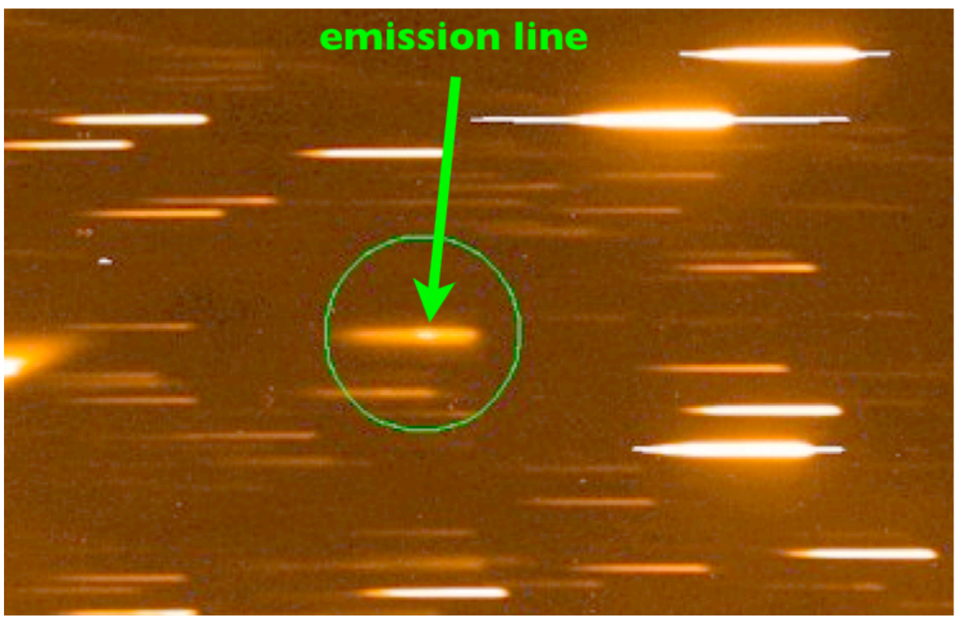
Redshift Confusion

R~5000 Spectrograph





R~200 Grism



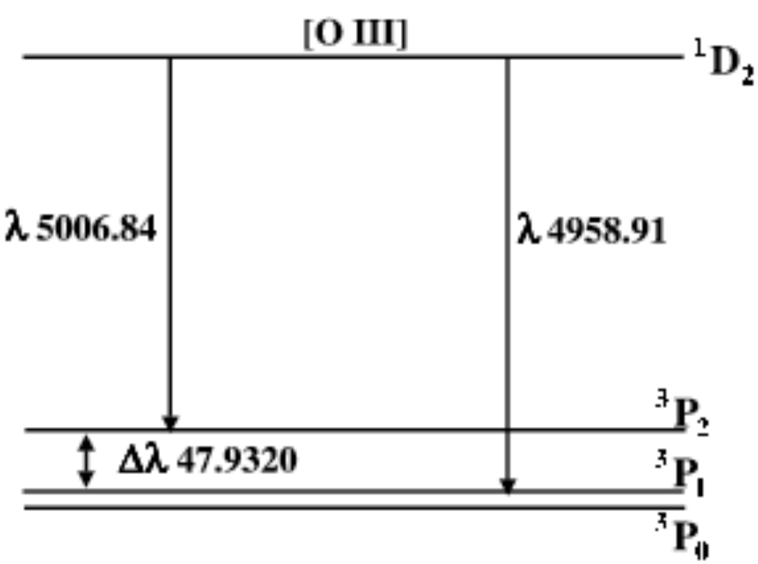
- Single emission line detections from different individual lines can lead to incorrect redshifts
- Mitigate by assuming luminosity functions for lines or additional data (continuum, photo-zs, higher resolution, wider wavelength range)

Fine Structure Constant

$$\alpha = \frac{e^2}{\hbar c}$$

$$\alpha^2 \propto \frac{\lambda_2 - \lambda_1}{\lambda_2 + \lambda_1}$$

- Parameter that describes the strength of electromagnetic interaction between atomic ionization levels
- Past claims have been made that α evolves with redshift, indicating the influence of dark energy on physical laws
- Measuring α is typically systematic limited due to required wavelength precisions and source densities



- Measuring [OIII] doublet (λ4959, λ5007) provides a simple, robust measurement of ionized atomic levels
- Jeff Newman (DEEP2) performed this measurement on ~800 from $0.3<z<0.8$ and found no evolution in α at the Poisson error limit of the data.
- Requires minimum resolution (R~200) AND high sensitivity into the NIR

Fine Structure Constant

- The high resolution of BigBOSS would definitively measure α from 0.7<z<1.3.
    - $\Delta\lambda$ < 0.07Å for fiber spectra emission line centroids
    - 20 million [OIII] measurements over 24k deg^2, so for 0.1 redshift bins, sqrt(N) = 2200.
    - $\Delta\alpha$=3e-7 per 0.1 zbin at z=1, 100x precision of DEEP2 measurement.

- Bench spectrographs provide stability and local, resolved OH sky lines provide wavelength calibration sources

- Measurement could also test for spatial variation of α

Best of all….Measurement come for free with the standard BigBOSS survey!

Summary

- Star-forming galaxies are the ideal BAO target due to their high densities at $z>1$ and bright emission lines generated at identifiable wavelengths such as $H\alpha$ and the [OII] doublet

- Disadvantages to using ELGs for BAO include their relatively low clustering bias (lower mass halos) and lack of direct data beyond $z>1.5$

- Single emission line detection can create ambiguous line identifications and incorrect redshifts

- Higher resolution spectra of [OII] doublet can provide both unambiguous identification and measurements to $z<2$ for $\lambda<11000$Å

- Photometric targeting of these galaxies has been done in the past and requires large area photometry to $R<24$

- Splitting [OIII] doublet and measuring the $\lambda 4963$ line will provide a measurement of the fine structure constant of unprecedented accuracy and possibly a detection of change in a fundamental universal constant