BigBOSS
Extra-galactic science

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for

The BigBOSS team

Extragalactic science

- BigBOSS is designed to measure cosmological parameters and constrain dark energy or modified gravity.
- In addition, it will enable a great deal of extra-galactic (and other) science.
  - Legacy extragalactic, spectroscopic database.
  - $O(10^6)$ fibers for "synchronous" observing.
  - PI-led programs (NOAO scheduled).

A few exemplars

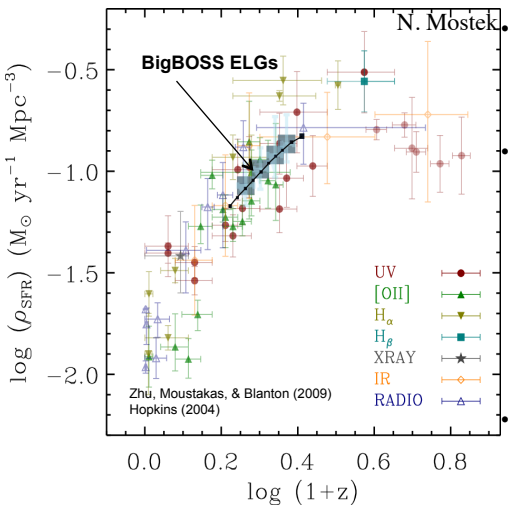
- Galaxy evolution
- Galaxy clusters
- AGN/Quasars
- IGM studies

Drawing from ideas presented in the Tucson workshop on "community science" (and BigBOSS proposal). See also poster by Rudnick et al.

Massive (red) galaxies

- Evolution of luminous ($L>L_*$), massive galaxies has historically been problematic for models of galaxy formation.
  - Silk76, …, Croton++06, Bower++06, DeLucia & Blaizot07, … Skelton++12
- Decoupling of dark matter and stellar mass growth.
  - BigBOSS probes just the redshift range we want for studying this (and the build-up of the ICL).
- Need large volume, and accurate redshifts (for L measurement on steeply falling part of the LF).
  - 880,000 galaxies with $M>3x10^{11}M_{sun}$ at $z<1$

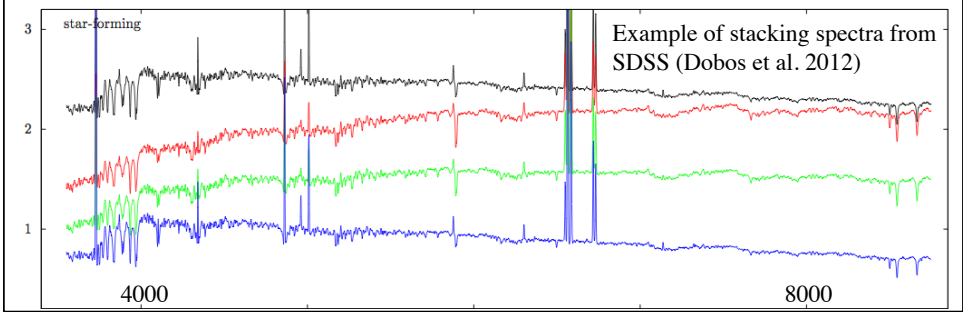
ELGs: Star-formation Rate



- [OII] emission line can be used to estimate the star-formation rate for the main BigBOSS ELG sample
  - 18 million galaxies from 0.6<z<1.6
- Statistical errors will be reduced by ~25x over DEEP2 with Δz=0.1 bins
  - Deep calibration fields will quantify selection effects of main ELG sample at low redshifts
  - SFR dust corrections will be available though emission lines (e.g Hβ at *z*<1) or broad restframe magnitude / color calibration (see Mostek et. al, 2012)
- Evolution of the SFR density from ~4-8 Gyr will be precisely determined

Stacked spectra

- While individual BigBOSS spectra will be relatively low S/N, the large number of spectra lends itself to stacking on photometric properties (plus redshift).
  - Enables measurement of "average" abundances, low-level lines, SFHs, velocity dispersions, …
  - Stacked spectral library has both good wavelength coverage and resolution.
  - 10^6 spectra per Δz=0.1 bin …



Community driven science

- In addition to BigBOSS survey products can use the instrument in “novel” ways:
- Example: A galaxy evolution survey.
  - Understand how stellar mass grows in dark halos.
    - Use group catalogs or HOD methods.
    - Split by central/satellite.
  - Understand how gastrophysical processes (SF, AGN activity, post-starburst signatures, galaxy morphologies) depend on environment (halo mass) and epoch.
  - Connect z=0.8, 0.5, ~0 [SDSS]
    - Focus on $M^*>10^{10}$ solar masses
    - An order of magnitude below “knee” in SMF.

Evolution of $M^*>10^{10}$ galaxies at intermediate z

- M*, SFR, [Fe/H]*, [O/H], AGN diagnostics, velocity dispersion, environment (central/sat + halo mass)
- Want large samples, long wavelength coverage, R~5000, good S/N, dense sampling:
  - z~0.3±0.05 (~3Gyr ago)
    - r<21 (>3e10) (300 per deg^2)
    - r<22 (>1e10) (600 per deg^2)
  - z~0.5±0.05 (~5Gyr ago)
    - r<22 (>3e10) (600 per deg^2)
    - r<23 (>1e10) (1400 per deg^2)
  - Very good ground-based seeing can get useful morphologies…

Moderate GE survey

Example:

- ~10 setups on each of ~6 fields to sample densely enough to get good group catalogs
- Need ~4 hours per setup to reach R~23 at S/N of a few per pixel [need continuum].
- So ~40 [30-60] hours/field.
  - Yields z, emission line diagnostics (SF, AGN, some metallicities)
  - Could have subset with spectra in all setups for ultra-deep stellar population spectroscopy, velocity dispersions and SFH/stellar metallicity.
- ~300 hours (D/G);
- Yields 100k galaxies in each *z* range.
  - Even if split by stellar mass, halo mass and SFR still have thousand(s) objects per bin.

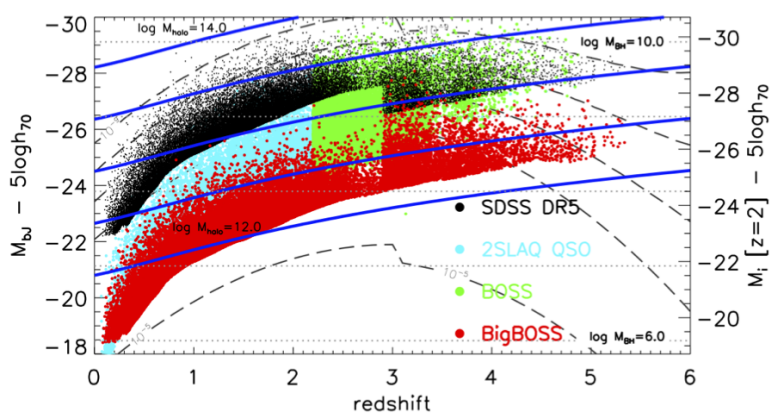
Other ideas

- What powers very IR luminous systems?
  - WISE has identified large sample of IR bright galaxies in the field.
  - A systematic survey of intermediate z galaxies would take ~10^2 fibers per setup.
  - What physical processes trigger obscured SF and AGN activity?
- Clusters of galaxies.
  - Get spectro-zs for BCGs of $O(10^4)$ optically or SZ selected cluster candidates.
  - Can be used to bootstrap calibration to a larger sample of red galaxy photo-zs.
  - Deeper calibration fields could get several redshifts per cluster for up to 10^3 clusters at 70km/s spectral resolution.
  - Studies of cluster+background, infall regions, superclusters, quenching, pre-processing, ...

Quasars

- BigBOSS will observe an order of magnitude more spectroscopically confirmed quasars than currently exist.
  - 2dF + SDSS + BOSS = $O(10^5)$.
  - BigBOSS = $O(10^6)$ out to z~6.
- Will fill in the L-*z* plane with dynamic range in L of ~5 magnitudes at any z!
  - Effectively "breaks" the L-*z* degeneracy.

Filling the L-*z* plane



Quasars/AGN

- Test models of quasar growth, fueling and connection with galaxy evolution.
- Will be like the leap from early galaxy surveys to 2dF and SDSS.
- Can look for rare objects, e.g. dual AGN.
  - Double peaked, narrow AGN emission lines in spectra.
- AGN can be identified from presence of high ionization lines
  - (e.g. [NeV], MgII, …)
- Can correlate AGN activity with
  - Color, SFR, M_*, …
- to study role of AGN in SF quenching.

Intergalactic Medium

- BigBOSS will observe over 600,000 high-z quasar sightlines.
- Tomographic studies of the IGM.
  - Imaging the IGM at high z in 3D.
  - Cross-correlating absorption line systems with galaxies at z<1.
  - Cross-correlating high-z objects with LyαF to get large-scale bias, host halo properties, etc.
- Large catalog(s) of DLAs and BALs.
  - Intrinsically rare objects, so large parent sample essential.
  - Expect 33,000 DLAs and 100,000 BAL QSOs.

Blind survey/Rare objects

- A small fraction of BigBOSS survey fibers can be devoted to a blind survey of the sky.
  - 0.4-1 deg^2 spread over BigBOSS area.
    - Not limited by sample variance
    - Large wavelength coverage
    - Complements HETDEX
  - Different census than targeted observations.
    - e.g. very high EW emission line galaxies.
- Identification of rare objects.
  - Use 100 fibers (each) to look for:
    - Very bright LBGs (lensed & unlensed)
    - Very IR-luminous starbursts/obscured QSOs
    - High mass galaxies at $1<z<1.5$

Calibration fields

- There will be 4-6 “calibration” fields which the survey observes at least once per run.
  - 30-40 deg^2 at survey end.
- These fields will have denser spectroscopy and/or multiple exposures per object.
- Possibilities
    - NDWFS Bootes field
    - COSMOS field
    - SXDF, UDS,
    - …

Magnitude limited sub-survey

- The calibration fields could be used to construct a magnitude limited survey, with no color cuts, potentially as deep as *i*~22 to 22.5.
- Of use for galaxy evolution but also
  - LF to fainter magnitudes.
  - Redshift distribution of fainter, blue objects for lensing.
  - Used for x-correlation studies.
  - <Other good idea here>.

Conclusions

- The BigBOSS spectrograph is a powerful, next-generation instrument which enables a wide-range of astronomical investigation.
- It will, in particular, enable a great deal of extra-galactic (and other) science.
  - Legacy extragalactic, spectroscopic database.
  - $O(10^6)$ fibers for "synchronous" observing.
  - PI-led programs (NOAO scheduled).
- Examples:
  - Galaxy evolution.
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