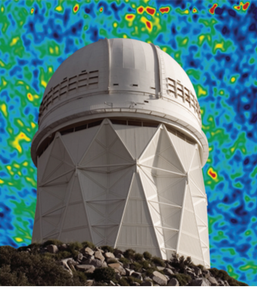

BigBOSS - A Proposed Stage IV Baryon Acoustic Oscillation Experiment at the KPNO Mayall 4-m Telescope

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ABSTRACT

The BigBOSS Key Project is a 14,000 square degree survey that will be carried out using 500 nights over five years. Using data from imaging surveys that are already underway, we will select spectroscopic targets that trace the underlying dark matter distribution. In particular, we will measure the redshifts of luminous red galaxies (LRGs) up to z = 1.0. To probe the universe out to even higher redshift, we will target bright [OII] emission line galaxies (ELGs) up to z = 1.7. In total, approximately 20 million galaxy redshifts will be obtained to measure the BAO feature, trace the matter power spectrum at smaller scales, and detect redshift space distortions. BigBOSS represents at least an order of magnitude improvement over BOSS both in the co-moving volume it probes and the number of galaxies it will map. In addition to the cosmological constraints coming from the galaxy survey, BigBOSS will provide additional constraints on early dark energy and on the curvature of the universe by measuring the Ly-alpha forest in the spectra of over 600,000 2.2 < z < 3.5 quasars.

COLLABORATION

Brookhaven National Laboratory
Carnegie Mellon University
Ewha Womans University, Korea
Fermi National Accelerator Laboratory
French Participation Group
- APC, IAP – Paris
- CPP, CPT, LAP – Marseille
- CEA, IRFU – Saclay

Johns Hopkins University
Lawrence Berkeley National Laboratory
National Optical Astronomy Observatory
New York University
The Ohio State University
Shanghai Astronomical Observatory
SLAC National Accelerator Laboratory
Spanish Participation Group
- IAA, Granada
- IAC, Tenerife

Spanish Participation Group cont'd
- ICC, Barcelona
- IFT, Madrid
- University of Valencia

United Kingdom Participation Group
- Durham University
- University of Edinburgh
- University College London
- University of Portsmouth

University of California, Berkeley
University of California, Santa Cruz/Lick Observatory
University of Kansas
University of Michigan
University of Pittsburgh
University of Science and Technology of China
University of Utah
Yale University

SCIENCE REQUIREMENTS

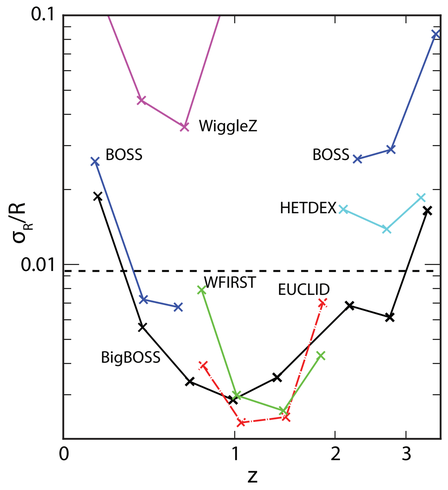
LEVEL 1
Scientific Requirements

- Measure the distance scale error σ_R/R to < 1% for $0.5 < z < 3.0$ (in 6 bins with $\Delta\ln(1+z) = 0.2$)
- Measure H(z) to 1% up to z=2.5 (in 4 bins at <z> = 0.7, 1.1, 1.5, 2.5)
- Constrain growth, $\sigma_8(z)\,f(z)$, with <2% relative error ($\Delta z = 0.1$ bins, $k_{max} = 0.2$, for $0.5 < z < 1.5$)
- Measure galaxy power spectrum to < 1% up to z=1.5 ($\Delta k = 0.02$ Mpc/h bins, $k_{max} = 0.3$)

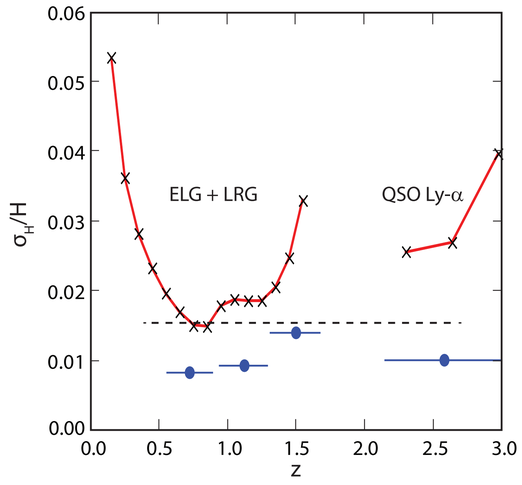
Additional Scientific Goals

- Inflation: constrain spectral index and its running to < 1%
- Measure the sum of neutrino masses $\Sigma\, m_\nu$ with $\sigma < 0.024$ eV

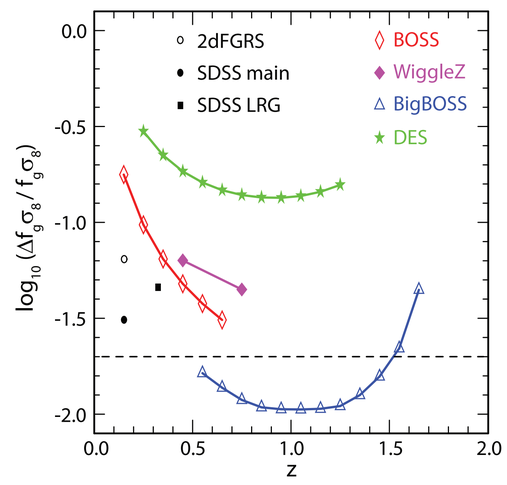
BAO distance scale (isotropic dilation factor) relative error compared with several existing and planned experiments.



Hubble constant relative error determination. Less than 1.5% in four z bins.

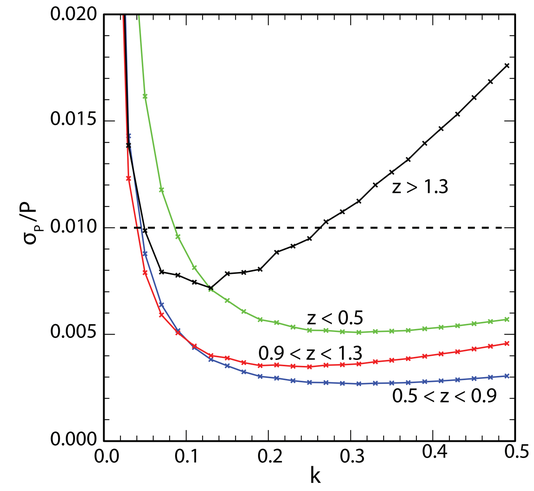


Redshift space distortion constrain on growth of structure <2% relative error ($\Delta z = 0.1$ bins, $k_{max} = 0.2$, for $0.5 < z < 1.5$)



$f(z)\cdot\sigma_8(z)$ quantifies the rate of structure growth using galaxies as test particles.

Two-point galaxy correlation power spectrum measurement to < 1% up to z=1.5. ($\Delta k = 0.02$ Mpc/h bins, $k_{max} = 0.3$)

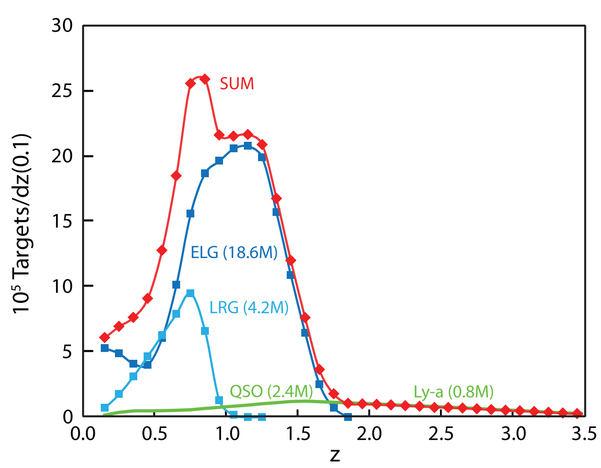


DATA REQUIREMENTS

LEVEL 2
Data Set Requirements

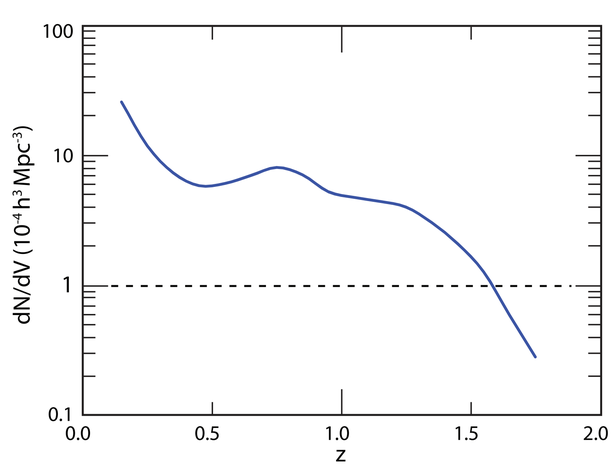
- Survey Area: 14,000 sq deg
- Redshift range:
  - LRGs $0.5 < z < 1.0$
  - ELGs $0.5 < z < 1.6$
  - Tracer QSOs $0.5 < z < 3.5$
  - Ly-α QSOs $2.2 < z < 3.5$
- Galaxy dN/dV > 1×10^{-4} (h/Mpc)^3
- Number of redshifts: 20M
- Redshift accuracy:
  - $\sigma_z < 0.001(1+z)$ rms
  - <5% catastrophic failures
  - resolve [O II] doublet for $0.76 < z < 1.6$

Target galaxy redshift distribution for the BigBOSS 20M galaxy, 14,000 sq deg survey (depth of 23.5 mag).

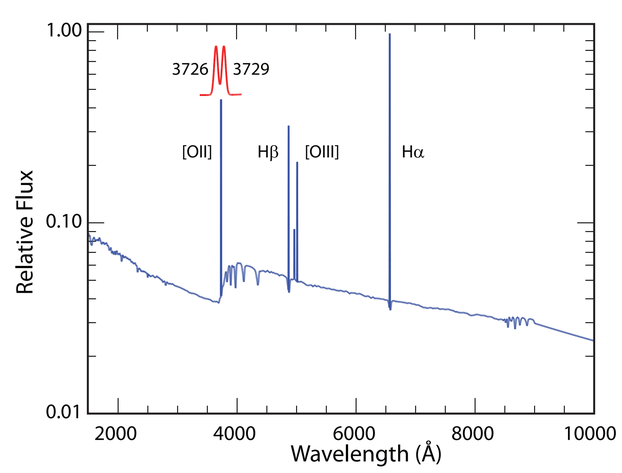


Numbers in parentheses are total targets for each galaxy type.

Target galaxy volume density versus redshift >1×10^{-4} (h/Mpc)^3 for z < 1.6.



Emission Line Galaxies are the vast majority of the survey targets. The [O II] doublet for $0.7 < z < 1.6$ is used for positive identification and redshift determination to 0.001(1+z) rms.



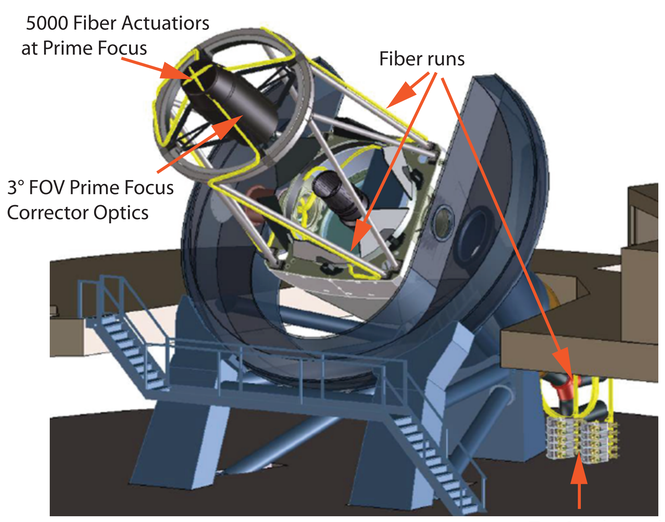
Shown is a restframe ELG spectrum.

INSTRUMENT REQUIREMENTS

LEVEL 3
Instrument Requirements

- Operational Constraints
  - < 500 nights
  - Instrument compatible with Mayall telescope
  - Preserve use of f/8 secondary
  - Typical seeing, weather for site used in forecasts
- Field of View: 3 deg diameter
- Number of Fibers: 5000
- Operational overheads: total < 60 s/exposure
- Spectral Range and Resolution
  - 360 nm < λ <660 nm: R > 1500
  - 620 nm < λ <840 nm: R > 3000
  - 800 nm < λ <980 nm: R > 4000
- Optical Throughput vs λ
- Fiber Positioning Error < 0.35 asec (rms, includes actuators, guiding, tracking, target astrometry)

Mayall 4-m with BigBOSS Instrument Components



STATUS

BigBOSS has been successfully reviewed and accepted in principle by NOAO to be hosted at the Kitt Peak Mayall 4-m. We have completed a successful Department of Energy High Energy Physics review for the science case, an 18 month instrument R&D period and for pilot surveys for galaxy target selection.

SCIENCE OBJECTIVE

Perform a Stage IV BAO Spectroscopic Survey

DETF Stage II FoM (BAO + SN + CMB) is 10.
Stage III experiments will approach 50.
BigBOSS plus Stage III experiments is 160-180.

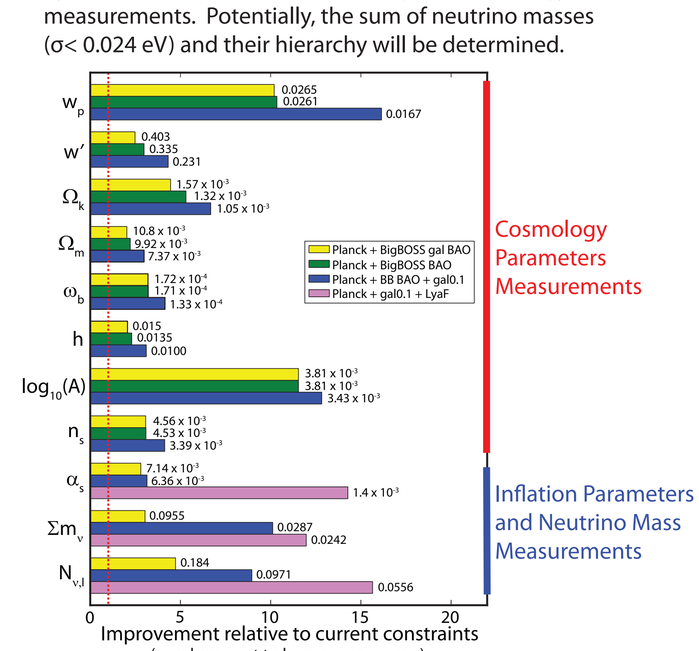
	BOSS	BigBOSS
no Ly-α	11	125
+ BAO III	34	132
+ SN III	49	163
Ly-α forest	23	150
+ BAO III	39	155
+ SN III	56	186

BigBOSS is competitive with space missions.

	WFIRST +BOSS	EUCLID +BOSS	BigBOSS
-	122	140	125
+ BAO III	126	145	132
+ SN III	163	183	163

For BAO only, assuming Planck prior and H0.
Assumes 14K sq.deg.

Cosmology and inflation parameters will be improved by multiple factors compared to Stage III dark energy measurements. Potentially, the sum of neutrino masses (σ< 0.024 eV) and their hierarchy will be determined.



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