Cosmology and Astrophysics at Brookhaven

Erin Sheldon
Brookhaven National Laboratory

Areas of Focus

- Composition, origin, and history of our universe
  - Properties of dark energy
  - Distribution of matter in the universe
  - Connection between dark and visible matter
- Creation of surveys to facilitate our science goals
  - Software infrastructure
  - Build tools to understand and calibrate the data

Current Surveys

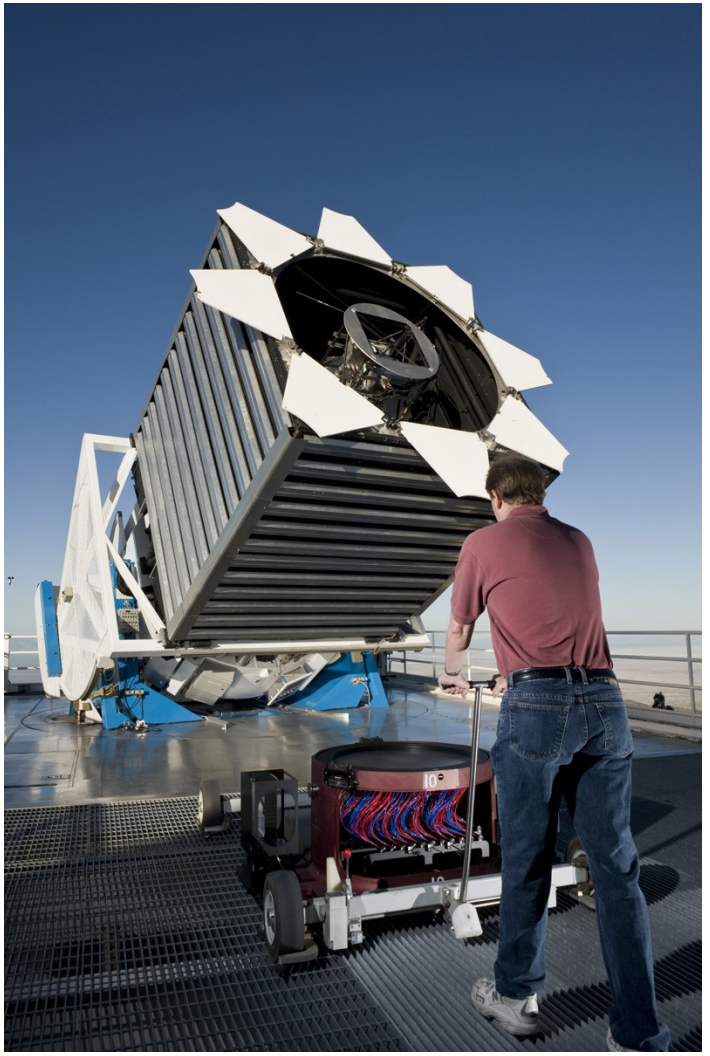
- Baryon Oscillation Spectroscopic Survey (BOSS)
  - BNL is associate member
  - Erin Sheldon, Architect
  - Anze Slosar
  - Tom Throwe
  - Morgan May
- Dark Energy Survey (DES)
  - Erin Sheldon associate member
  - Zhaoming Ma

BOSS

- Part of SDSS III, a 10^4 sq degree imaging survey, 5 bands in the north
- New spectrograph
- Study dark energy using the Baryon Acoustic Feature standard ruler at various redshifts
- Select galaxies and quasars for spectroscopic follow-up: z-distance relation and dark energy
- First light August 2009

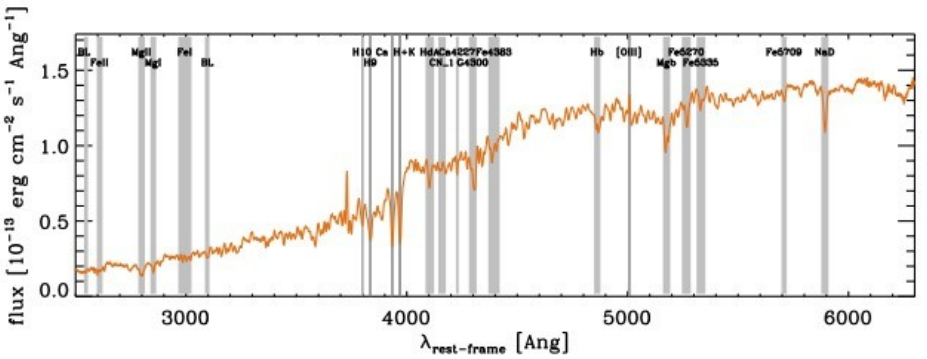
BOSS: BNL Participation

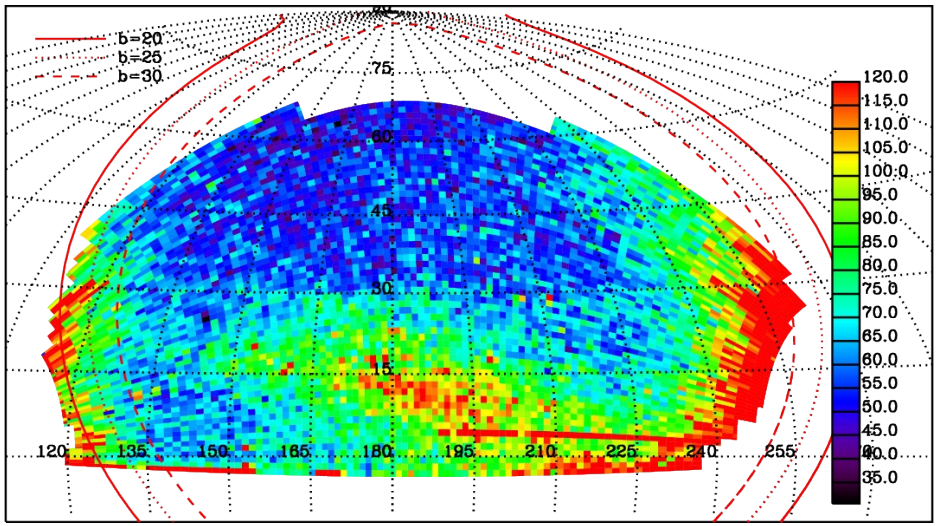
- BNL is an associate member
- BNL membership is based on infrastructure contributions ES,TT
- ES target selection, Architect
- Tom Throwe software support
- Anze Slosar leads LyA forest effort

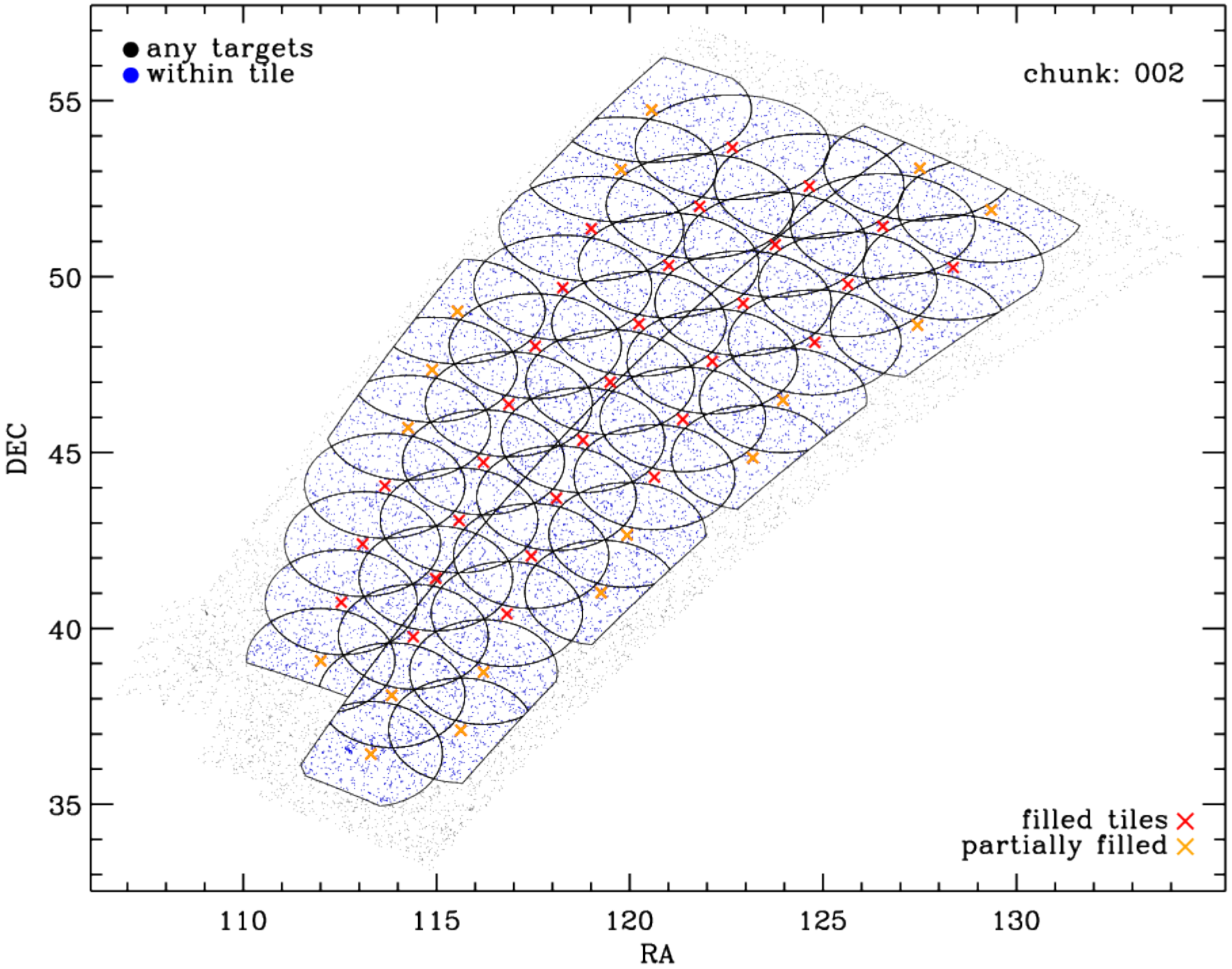


BOSS: BNL Participation

- Erin Sheldon built the software framework for selecting spectroscopic targets from the imaging data (galaxies, quasars, standard stars).
- ES coordinates and balances the 8 selection algorithms, produces target lists, which are used to tile the sky and design plates.
- ES has Architect status in recognition of his core infrastructure contributions.






any targets
within tile
chunk: 002
filled tiles
partially filled
DEC
RA
55
50
45
40
35
110
115
120
125
130

BOSS: BNL Participation

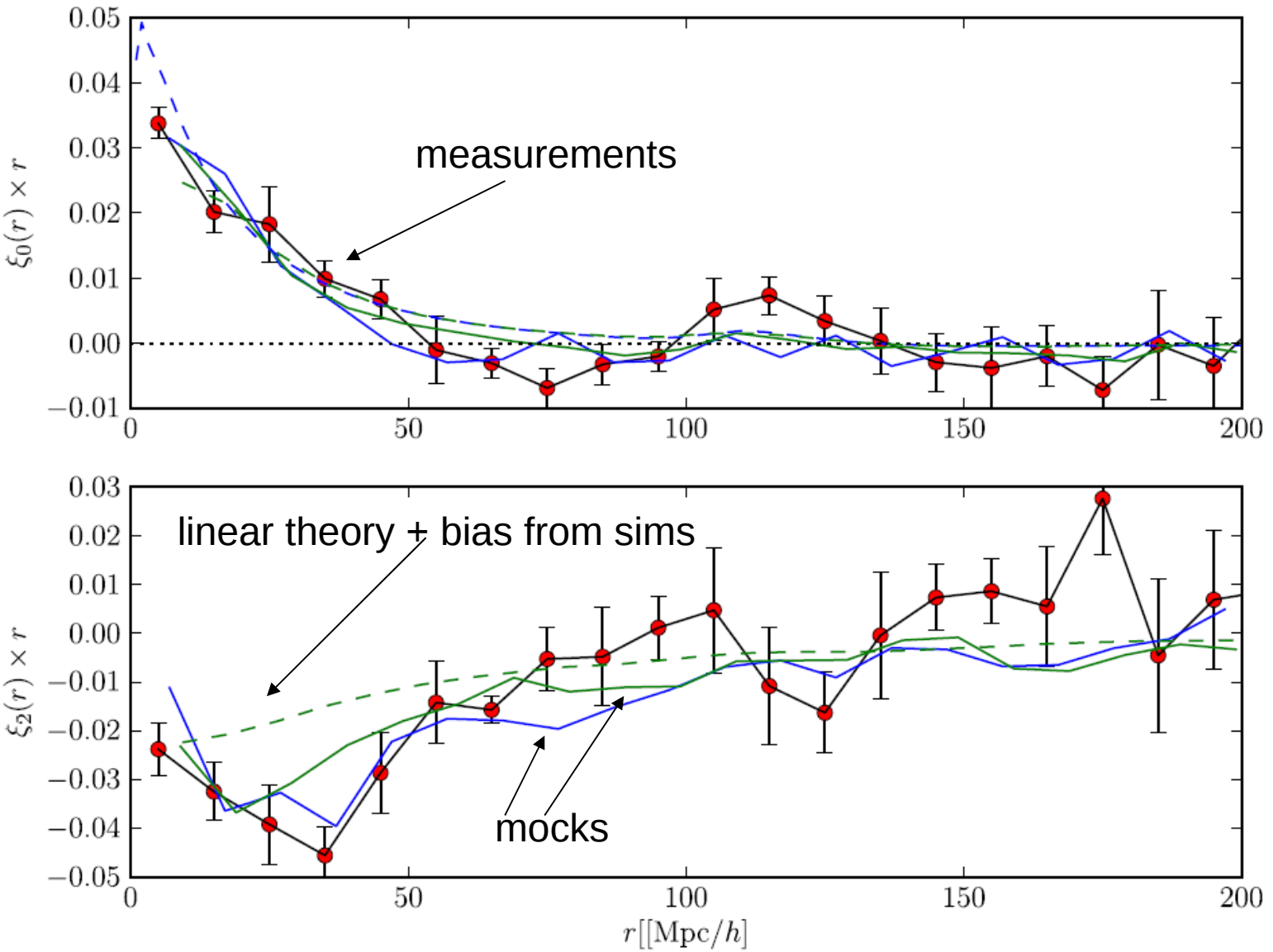
- Anže Slosar:
  - Convening the LyA cosmology working group
  - Inspecting the quasar data as they come in.
  - Understanding of noise-properties of instrument at the pixel level, crucial for LyA part of the project to succeed
  - Uncovered/tested a number of issues in the pipeline:
    - Spectro-photometric errors
    - Fiber-fiber correlated errors
    - Galactic Ca II absorption
    - Sky-fiber tests of beam and pixelization effects
  - Fed back into the pipeline group to improve processing

BOSS Science – Lyman-alpha forest

- Anže Slosar is leading the effort to measure the BAO feature using the LyA forest signal in quasar spectra.
- LyA used to measure BAO signal at high redshift. Good lever-arm for measuring the expansion history.
- Coordinating the WG to ensure everything is getting done and that there is minimal duplication (some duplication useful as cross-check)
- Creation of synthetic data for testing progressing steadily with increasing fidelity
- Continuum fitting not yet production level, but improving
- Metal contamination, etc. in progress

SDSSIII

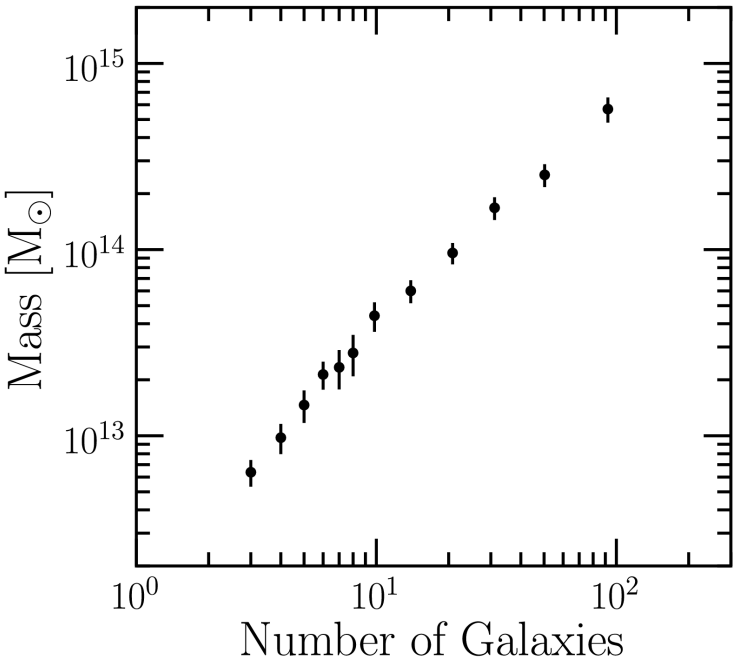
3D Lyman-α flux correlation function

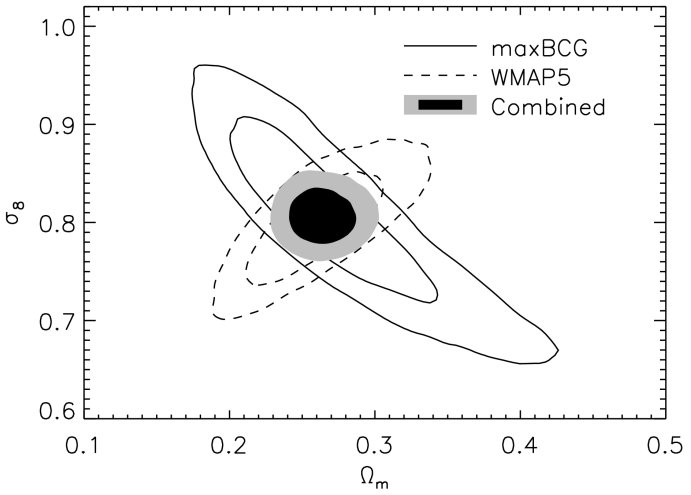


- flux correlation and redshift-space distortions detected to 50 Mpc/h.
- error-bars expected to decrease by order of magnitude through more data and better reduction

BOSS Science

- Erin Sheldon is expanding earlier SDSS work on galaxy cluster lensing, galaxy lensing, photometric redshifts.
- Factor of two more data, better understanding of systematics
- Extracting cosmological parameters from these.
- Same techniques can be used in DES, LSST





Dark Energy Survey

- Imaging survey of 5000 sq degrees in 5 bands.
- New camera for 4-meter Blanco at CTIO
- Will cover the footprint of the South Pole Telescope survey
- Probe Dark Energy
  - weak lensing (WL)
  - WL+galaxy cluster counts
  - WL+galaxy distribution
  - Supernovae

DES: BNL Participation

- Erin Sheldon is an associate member. Has been working on DES infrastructure since 2004, has data rights for himself, postdoc, students
- Sheldon+Jarvis (UPenn) are building the primary pipeline for galaxy shape measurement. Considered core infrastructure that facilitates all weak lensing studies. Pipeline is incorporated into data management system.
- Will process DES data in real time as it arrives, feed back into QA and development. Improvements will make it downstream for yearly data releases.

DES: BNL Participation

- The point spread function of the system (PSF) is the dominant source of error in lensing measurements, correction is required to calibrate lensing measurements and the inferred cosmological parameters.
- The information on a single image is insufficient to correct at the precision needed for DES science.
- Zhaoming Ma is building a code to characterize the global principal components of the PSF.

DES Science

- The counts of clusters as a function of mass is a key DES project and sensitive to dark energy properties. Weak lensing is the primary method for determining these masses.
- ES and ZM will measure these masses, straightforward extension of work in SDSS/BOSS.
- ES and ZM will participate in other WL studies, such as cosmic shear.
- ES, ZM technical papers 2011
- Science papers on first year data begin to appear 2012

Large Synoptic Survey Telescope (LSST)

- Essentially a much larger, deeper DES with a time-domain component.
- Dark energy probes: Weak lensing, supernovae, BAO, galaxy clusters, galaxy and mass power spectrum ...
- ~4-5 times the statistical power of DES for studies like lensing, with better control of systematic effects.
- Vastly better for finding supernovae due to expanded time-domain

LSST

- BNL Instrumentation Division responsible for design and construction of key focal plane modules: sensors and electronics: See talk by Paul O'Connor to follow
- ES infrastructure work on pipelines, etc in DES/BOSS will lead naturally to LSST.
- ES science interests fit nicely with LSST.
- Transition to work on LSST as current surveys wind down.

LSST

- Morgan May: Institutional representative to the board of directors since Brookhaven joined the project
- Working on methods to constrain dark energy using LSST weak lensing data, investigating statistics beyond shear power spectrum: shear peaks in the weak lensing map.
- Co-author of weak lensing chapter of the LSST science book.
- Jim Frank of the Physics Department works with the instrumentation group on CCD characterization.

LSST

- Anže Slosar: Member of the large scale structure collaboration
- Will work on constraining neutrino masses and inflation using LSST data. This work will flow naturally from his work on BOSS data.

Hardware-Science Synergy

- Interaction between subtle hardware effects and science
- Naturally studied at an institution with a a major hardware role and a science/software role
- Hardware role since 2003, software/science recently established
- Two-way interaction between the hardware design/properties and the analysis and science is developing

Transition to LSST

- We have important infrastructure roles in current surveys
  - BOSS: Target selection, data QA and processing.
  - DES: Pipeline development, PSF characterization
- In order to ensure early transition to work on LSST while still fulfilling our responsibilities in BOSS and DES, we propose to hire an additional young scientist and postdoc with strengths and interests coherent with the present group effort.

Dark Energy Center

- Proposed to support LSST Science
- Layer of computing beyond data management
- Funding to begin outside of the 3-year period, but planning must occur soon
- Brookhaven will participate in planning of the Dark Energy Center and is interested in being considered for hosting it.
- Existing infrastructure for the Tier I Atlas computing center makes this extremely cost effective.