BOSS Calibration
A Step Towards BigBOSS

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BAO

- Baryon Acoustic Oscillation
  - Shells of high density
  - Standard ruler
  - 100 Mpc scale
  - Map galaxies and quasars
  - DE information

One source
BAO

- Baryon Acoustic Oscillation
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Astronomical Spectroscopy

Targets

Telescope

Focal Plane

Optical Fibers

CCD - Raw data

BOSS

- Baryon Oscillation Spectroscopic Survey
- Sloan Digital Sky Survey (SDSS) 2.5m telescope
- Room for Improvement
  - Plug plates
  - Too slow
  - Depth of field
  - Unstable

http://blog.galaxyzoo.org/2009/04/01/a-visit-to-apache-point/
BigBOSS

- Mayall 4m Telescope
- Robotics
- More fibers
  - 5000 spectra/12 minutes
- Stable
- 5 years
  - 10 million spectra
Calibration Goals

- Fiber Variations
- Response of each pixel to each wavelength
  - 340 nm to 1060 nm
  - 0.01 nm bandwidth
  - 0.01 nm increments
  - Absolute wavelengths to 0.1 pixel error
- Fast
- Current methods
  - Dome and sky flats
  - Arclamp

http://www.astro.wisc.edu/~morscher/index.html
Calibration Method

• KiloArc
  – 1000 W Xe lamp
  – Lines
  – Fireball

• Monochromator
  – Broadband input
  – 0.01 nm band output
  – High speed
Calibration Method

- Monochromator Input optics
Calibration Method

http://www.sdss3.org/instruments/telescope.php
Calibration Method

- Projector
  - Hexagon frame
  - Fills primary mirror
  - Parallel

Fiber from monochromator

Light to primary mirror

29" parabolic mirror
Calibration Method

- **Projector**
  - Hexagon frame
  - Fills primary mirror
  - Parallel
  - Semi-diffuse
  - 3° spread

- Fiber from monochromator
- Triplet lens
- Holographic diffuser
- 29” parabolic mirror
- Photodiode
- Light to primary mirror
Calibration Method

• Photodiode
  – Pixels illuminated at different times
  – Normalize power input
  – Light source varies
  – Fibers move
Near Future

• Assemble input optics and projector
  – Alignment
  – Apache Point, NM
  – Calibrate BOSS!

• Distant Future
  – Replace KiloArc with OPO
  – Add mirrors to projector
  – Calibrate BigBOSS!

• Questions
Neutrinos

- Uniform background mass
- Measure $\Sigma m_\nu$ to 0.024 eV
- Resolve Hierarchy degeneracy?