Sloan Digital Sky Survey Extension

Presentation to the Physics Advisory Committee
Stephen Kent
April 2, 2004

• Status of SDSS
• Science Case for a 3 year extension (2005-2008)
• Funding and Resources
Sloan Digital Sky Survey (E885)

Goal:
Conduct fundamental research in cosmology, particularly formation & evolution of galaxies and large scale structure

Approach:
Digital map of ¼ of sky in 5 bands
Spectra of 1 million galaxies, 100,000 quasars

Resources:
2.5 m telescope in New Mexico
Large CCD mosaic camera
640 fiber spectrograph
13 partner institutions

Operations:
2000 to 2005
Current FNAL in SDSS

Role:
- Data acquisition
- Data processing
- Survey Planning
- Data distribution
- Support telescope and instrument systems

Science:
- Galaxy angular correlation functions (Dodelson)
- Weak lensing (Annis, Frieman, Lampeitl)
- Galaxy clusters (Annis, Kent, Tucker)
- Milky Way halo structure (Yanny, Kent)
- Galaxy evolution (Lin)
- QSO luminosity functions (Stoughton, Jester)
- Supernovae (Frieman, Lampeitl DeJongh, Marriner)
- Near Earth Asteroids (Kent)

Participants:
- EAG
  - 8 Scientists
  - 4.5 CP
- TAG
  - 3 Scientists
- PPD
  - 1 Project manager
  - 4 Engr/Tech (APO)
  - 0.5 CP

Funding:
- Primarily FNAL in-kind
- ~2 FTE, some M&S provided by SDSS project
"Integrated Luminosity" vs. 5 Year Baseline
SDSS Current Status (Mar 2004)

Imaging: 82% as of March 11, 2004

Spectroscopy: 55% as of March 11, 2004

Current operations funded thru June, 2005

A proposal is being developed to continue operations for another 3 years (fill the gap)
# Breakthrough of the Year

## The Winner

Illuminating the Dark Universe

A barely unitilizing optimism slowly through the void has captured the very essence of the universe. In February, the Wilkinson Microwave Anisotropy Probe (WMAP) produced an image of the entire sky, all of creation when it was at 400,000 years old. The brightness of these stars marks a living past in the fabric of cosmology. Along with a familial hint of its past, it is about the nature of our cosmic dark energy and the composition of the universe.

The WMAP results are consistent with a flat universe, where the density of dark energy dominates the universe by 70%, dark matter by 25%, and baryons (ordinary matter) by 5%. This result is significant because it confirms the cosmological principle, which states that the universe is homogeneous and isotropic on large scales. The uniformity of the cosmic microwave background (CMB) measured by WMAP supports this principle, providing strong evidence for the flatness of the universe.

The CMB is the afterglow of the Big Bang, the residual heat left over from the Big Bang era. By analyzing the CMB, scientists can infer the properties of the universe, such as its age, composition, and expansion rate. The WMAP observations have significantly improved our understanding of the universe's composition and its history, allowing us to probe the early universe and its evolution.

The WMAP satellite's observations have provided compelling evidence for the dominance of dark energy in the universe. This finding is important because dark energy is responsible for the accelerated expansion of the universe, which has profound implications for our understanding of the universe's evolution and ultimate fate. The WMAP results have also helped refine our understanding of the properties of dark matter and baryonic matter, further constraining the possible nature of dark energy.

In conclusion, the WMAP results are a significant breakthrough in the study of the universe, providing strong evidence for the dominance of dark energy and dark matter. These findings are helping to shape our understanding of the fundamental forces and particles that govern the universe, and they continue to drive ongoing research in cosmology and astrophysics.
The Sloan Digital Sky Survey (see www.sdss.org for general information) will map one-quarter of the entire sky and perform a redshift survey of galaxies, quasars and stars. The DR2 is the second major data release and provides images, imaging catalogs, spectra, and redshifts for download.

**About DR2** explains what is new in DR2.

Please refer to the credits page for our sources of funding, participating institutions, how to acknowledge the use of SDSS data in your publications. Please also note how to refer to SDSS sources in your publications using the proper IAU nomenclature for SDSS sources.

**Imaging**

<table>
<thead>
<tr>
<th>Footprint area</th>
<th>3324 sq. deg.</th>
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<tbody>
<tr>
<td>Imaging catalog</td>
<td>88 million unique objects</td>
</tr>
</tbody>
</table>

**Data volume**

- images: 5.0 TB
- catalogs (DAS fits format): 0.7 TB
- catalogs (CAS, SQL database): 1.4 TB

**Average wavelengths and magnitude limits (95% detection repeatability for point sources)**

<table>
<thead>
<tr>
<th>$u$</th>
<th>$g$</th>
<th>$r$</th>
<th>$i$</th>
<th>$z$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3551Å</td>
<td>4606Å</td>
<td>6165Å</td>
<td>7481Å</td>
<td>8831Å</td>
</tr>
<tr>
<td>22.0</td>
<td>22.2</td>
<td>22.2</td>
<td>21.3</td>
<td>20.5</td>
</tr>
</tbody>
</table>

**PSF width**

1.4" median in $r$

**Photometric calibration**

$\centering r - u-g \centering p-r \centering r-i \centering r-z$

2% 3% 2% 2% 3%

**Astrometry**

< 0.1" rms absolute per coordinate

**Spectroscopy**

| Spectroscopic area | 9227 sq. deg. |
To the Future: SDSS Extension (2005-2008)

• Why?
  – Will be short of goal of a FILLED survey after 5 years
  – Unexpected discoveries offer opportunity for new science in Galactic Structure
  – Realization that SDSS telescope provides unique capability for supernova detection.

• How long?
  – The above programs can be accomplished with minimal conflict in a period of 3 years
Collaboration

- Astrophysical Research Consortium is legal "umbrella" for existing collaboration
  - Fermilab
  - Princeton
  - U. of Washington
  - JHU
  - Max-Planck Institute for Astronomy
  - Max-Planck Institute for Astrophysics
  - U. of Pittsburgh
  - IAS

- Many current partners are interested in extension; some new partners have expressed interest
Fermilab Scientists

- CD
  - J. Annis (L, S)
  - S. Kent (L, G)
  - R. Kron (L, G)
  - H. Lin (L)
  - J. Marriner (S)
  - J. Peoples (L)
  - C. Stoughton (L)
  - B. Yanny (G)

- PPD
  - F. DeJongh (S)
  - S. Dodelson (L)
  - J. Frieman (S, L)
  - A. Stebbins (L, S)
  - L: Legacy
  - G: Galactic Structure
  - S: Supernovae
Budget

• Cost
  – $14.9 M over 3 years

• Funding
  – Proposal to Sloan Foundation ($5.4 M)
  – Proposal to NSF ($5.4 M)
  – Member Institutions ($4 M)
    • Cash
    • In-Kind
Data Collection Goals

- **Legacy**
  - Imaging: 762 sq deg
  - Spectroscopy: 495 plates

- **Galactic Structure (SEGUE)**
  - Imaging: 3600 sq deg
  - Imaging: 520 plates

- **Supernovae**
  - Imaging: 10 months dedicated
Legacy Survey

- SDSS data are unique
  - High precision
  - Joint imaging/spectroscopy
  - Large area
- Filled volume
  - Improve resolution of galaxy power spectrum by factor 3 (search for "baryon wiggles")
  - Measure higher order clustering with 45% improved accuracy (non-Gaussian initial conditions?)
Numerical simulations of galaxy halo formation from cold, dark matter are now sufficiently accurate to make quantitative predictions for satellite galaxy populations around the Milky Way Galaxy.
Rings around the Galaxy
(Yanny & Newberg)

SDSS + CDMS (Soudan)

Sagittarius Dwarf Galaxy

25,000 light-years
"Sloan Extension for Galactic Underpinnings and Evolution"
Supernova Program

Detection of supernova 2001eu from SDSS data

Goals:
200 supernovae with light curves $0.05 < z < 0.3$
Fill gap in redshift coverage of other SN surveys:
SN Factory: $Z < 0.1$
CFHT Legacy survey: $z > 0.3$
FNAL tasks and resources

- Fermilab Interests
  - 13 scientists (EAG, PPD, AD)

- Tasks
  - DAQ upgrade
  - Survey planning
  - Plugplate design
  - Legacy, SEGUE, SNe data processing
  - Data distribution
  - Project Mgmt.
  - APO Technical Support

- Required resources
  - 4 FTE scientist
  - 10.5 FTE CP, admin, tech.
  - $200K M&S/yr
  - $300K DAQ upgrade (one time only) labor, M&S

- Funding
  - Expect significant cost sharing with SDSS project
EAG Balancing Act

- EAG currently has 8 scientists, 3.5 CP FNAL funded and working on astrophysics.
- Next few years
  - SDSS: 3 Scientists, 2.5 CPs
  - SNAP: 1.25 Scientists, 1 CP
  - DES: 1.5 Scientists, 0 CP
  - Research: 2.25 Scientists
- Remaining people for SDSS are either existing non-EAG scientists, existing CD people not in EAG or existing or planned CPs in EAG funded by ARC
Summary

• SDSS extension will deliver
  – Unique, high precision, homogeneous survey that delivers key science on large scale structure and a complete legacy dataset for future science
  – New insights into structure of Milky Way halo (a laboratory for dark matter physics)
  – Supernovae at low/intermediate redshifts to make a measurement of dark energy density and to serve as anchor for future high redshift SNe surveys such as SNAP/JDEM.