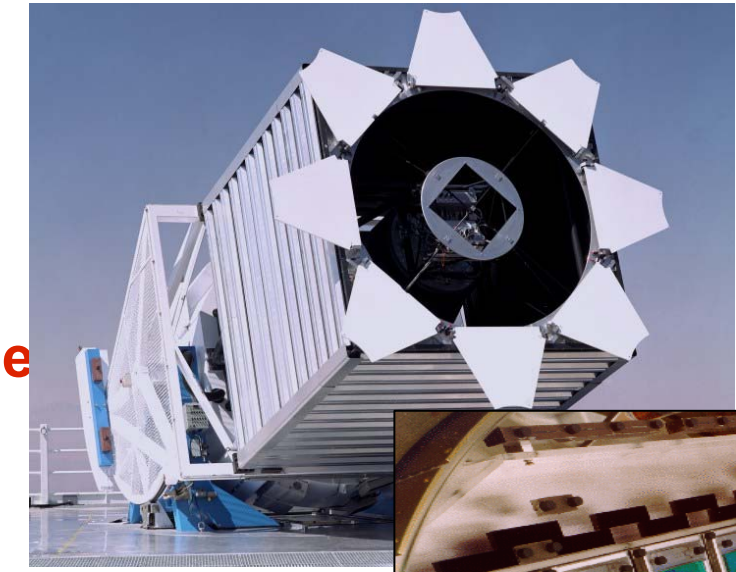
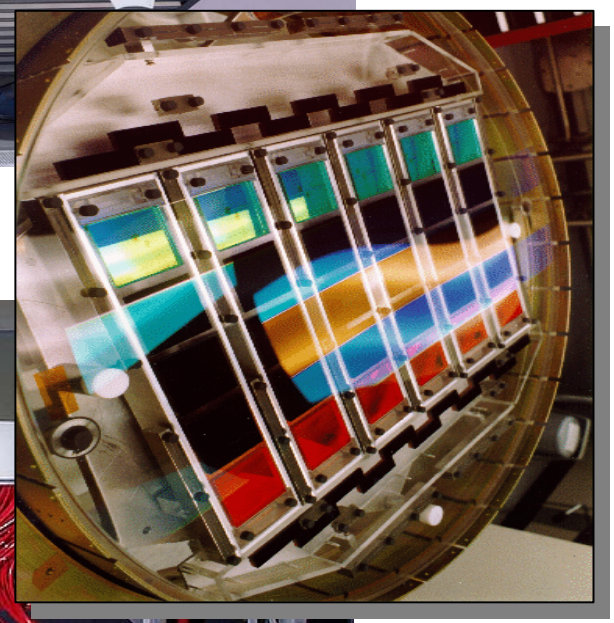
Sloan Digital Sky Survey Status

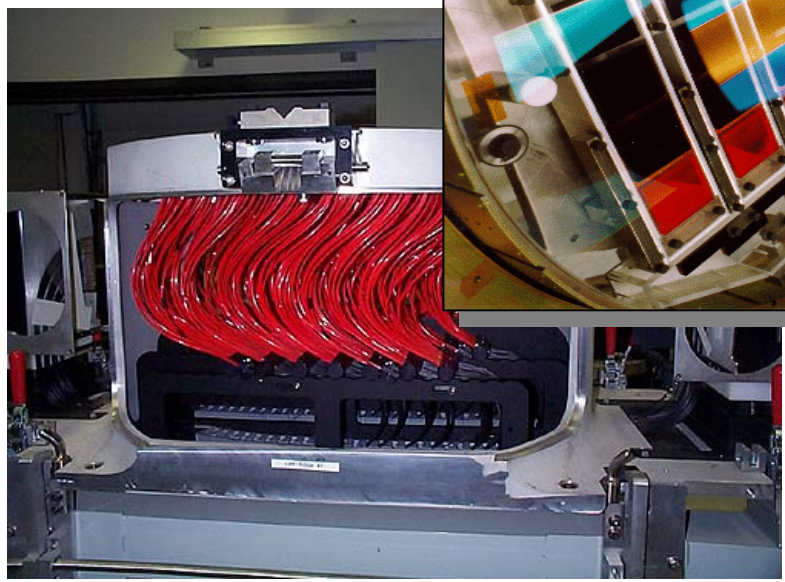
Presentation to the
Physics Advisory Committee
April 8, 2005

Brian Yanny, reporting for the
Experimental Astrophysics Group
Fermilab

Sloan Digital Sky Survey (E885)







Goal:

Conduct fundamental research in cosmology, particularly formation and 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 camera
640 fiber spectrograph
15 partner institutions

Operations:

2000-2005

Participating Institutions

University of Chicago
Fermi National Accelerator Laboratory
Institute for Advanced Study
Japan Participation Group
Johns Hopkins University
Korean Scientist Group
Los Alamos National Laboratory
Max Planck Institute for Astronomy, Heidelberg
Max Planck Institute for Astrophysics, Garching
New Mexico State University
University of Pittsburgh
University of Portsmouth, UK
Princeton University
US Naval Observatory
University of Washington

FNAL in SDSS

Role:

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

Science:

- Large-scale structure
- Weak lensing and strong lensing
- Galaxy clusters
- Milky Way halo structure
- Dark energy
- Galaxy evolution
- QSO luminosity functions
- Supernovae
- Near Earth Asteroids

Participants:

- EAG
- TAG
- PPD
- CD (outside EAG)

Status (April 2005)
(North survey only)

IMAGING

Baseline:
8452 sq. deg.

Square degrees at baseline as of Apr 1, 2005

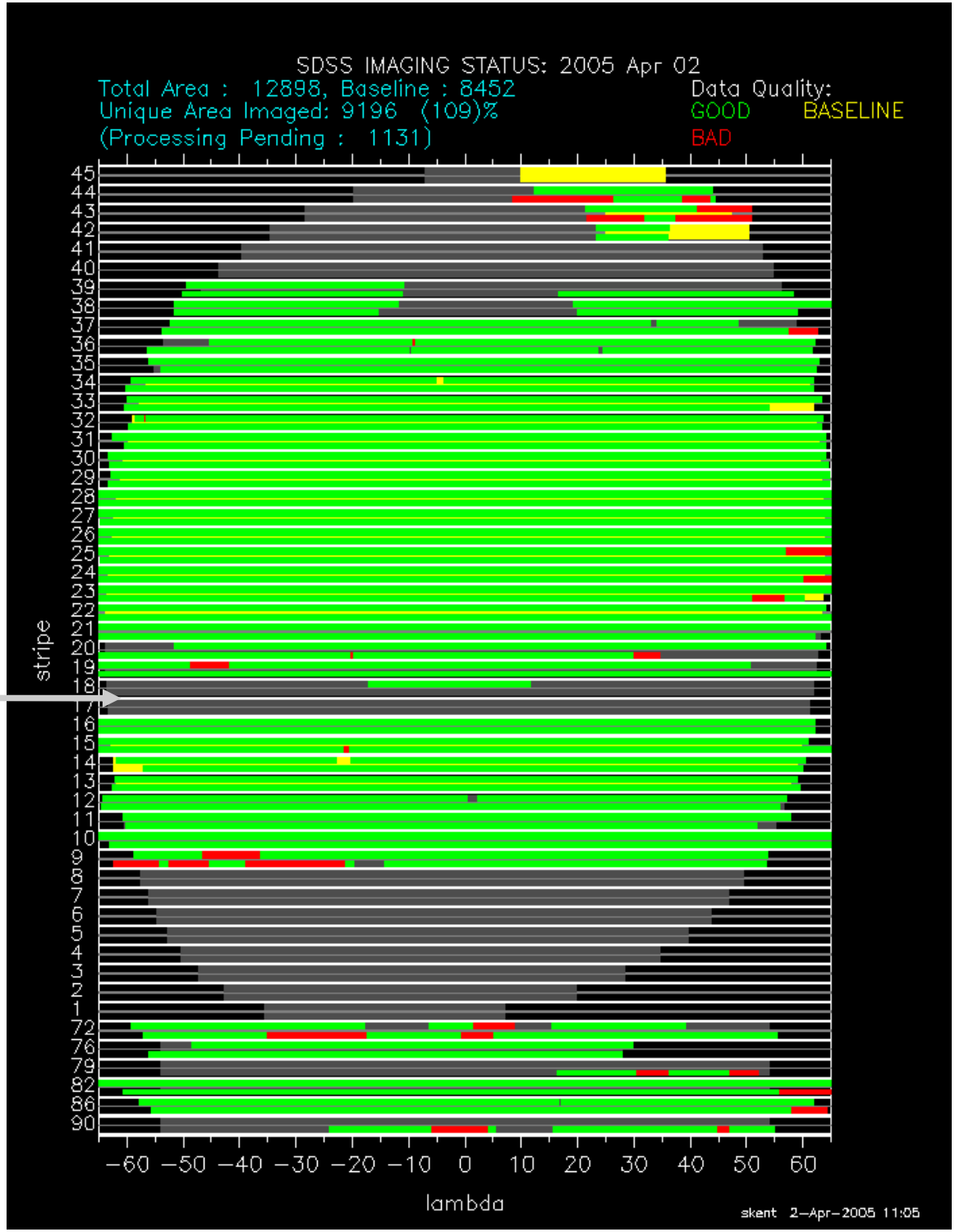
SPECTROSCOPY

Baseline:
1688 tiles

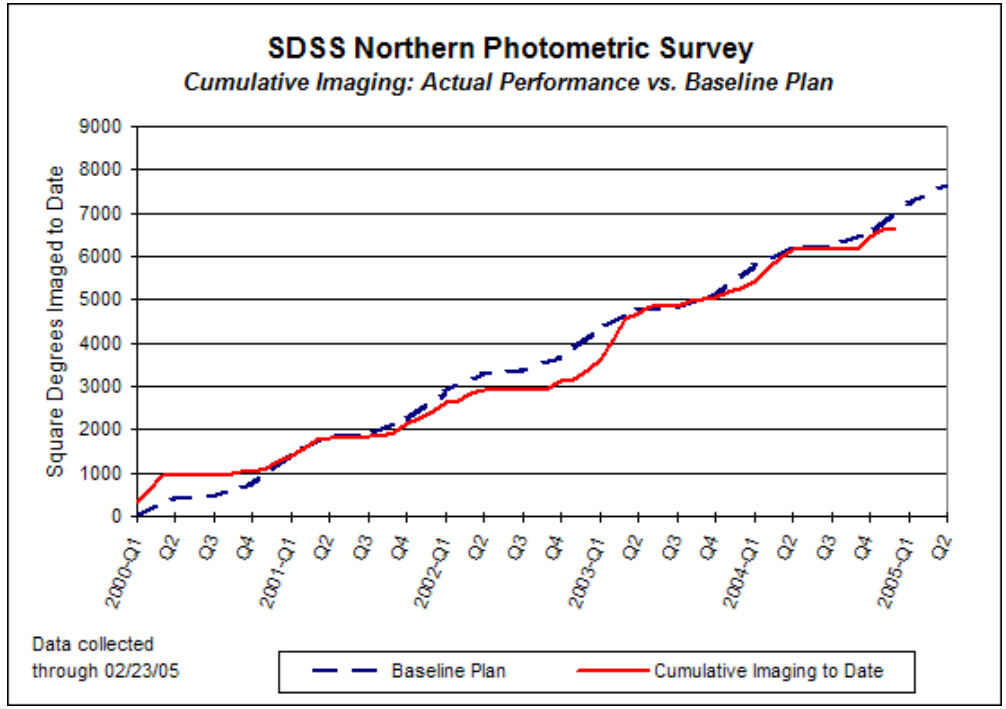
68% as of Apr 1, 2005

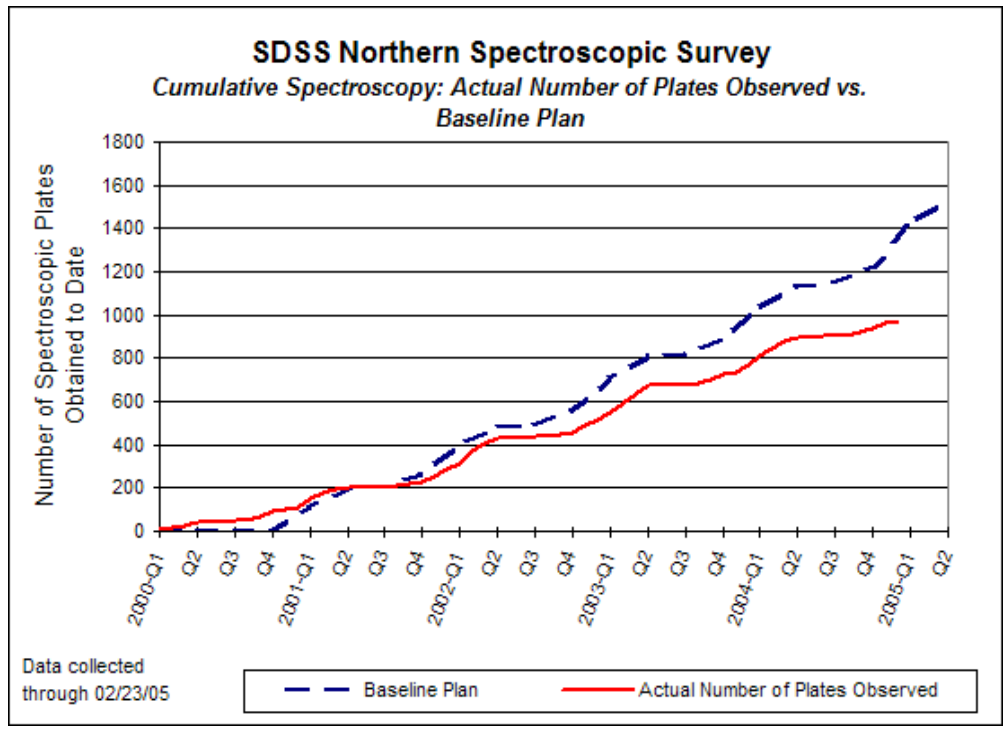
Current SDSS-I operations funded through June, 2005

SDSS-II proposes to continue operations for another 3 years (fill the gap and finish spectroscopy).



Delivered "beam" vs. 5 yr. baseline





Data Distribution

- Data Release 3 to public in Oct 2004
  - www.sdss.org
  - 5300 sq. deg. of sky
  - 20 terabytes downloaded by public so far (includes DR1+2+3) from servers based at FNAL.
  - Science publications:
    - 55/yr SDSS collab
    - 50/yr by public
- Data release 4
  - Scheduled for July 2005
  - 6700 sq. deg (+30%)

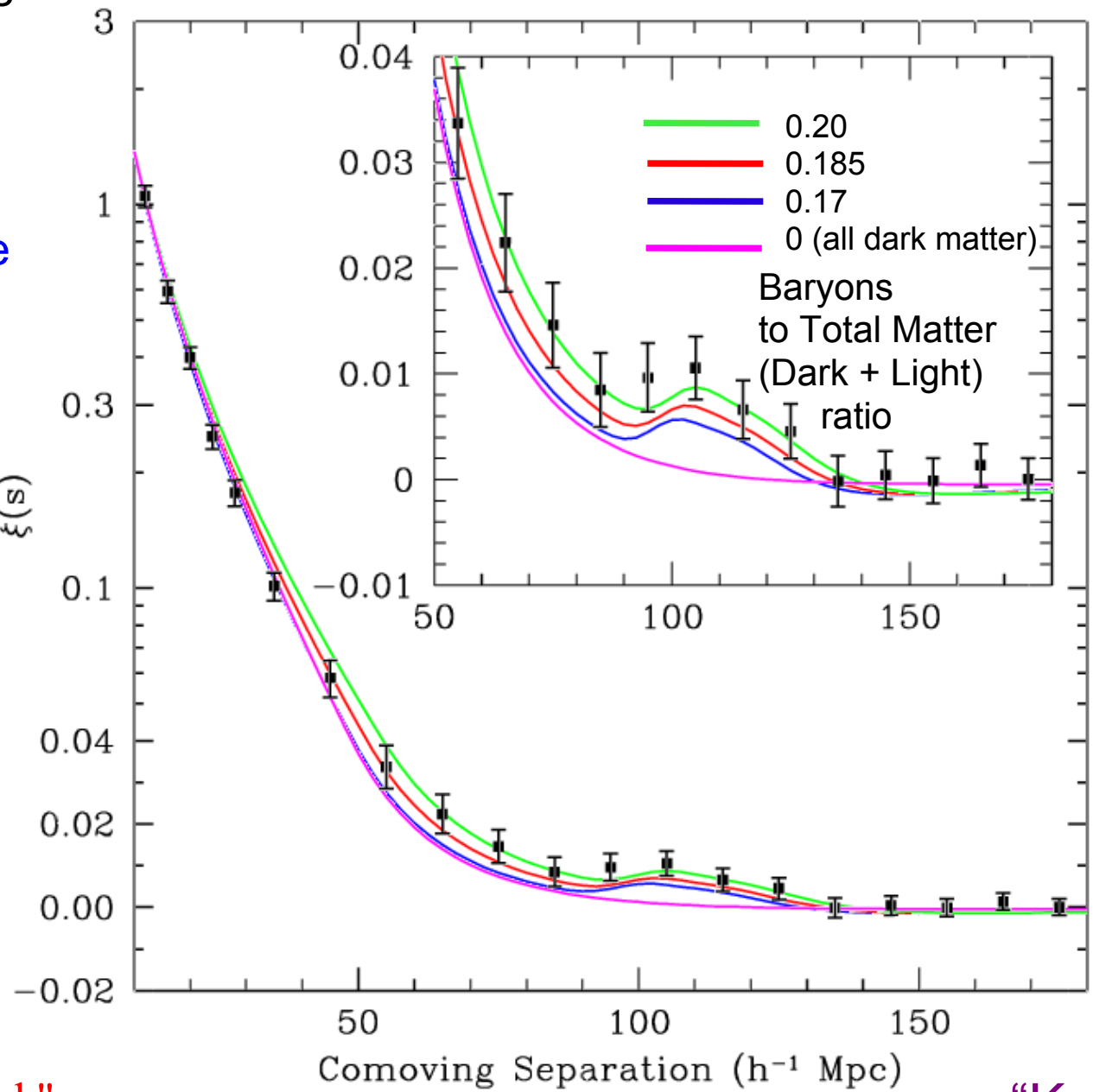
Detection of the 'Baryon Acoustic Peak' in the clustering of Galaxies on Large Scales with SDSS:

PHYSICS

Demonstrates:

1. There is some 'thing' which behaves like dark matter (not all baryons) at redshift 1000 (just like at z=0).

2. There are baryons which interact with photon plasma and evolve gravitationally.



3.Ratio of these two 'types of matter', light and dark, is determined.

4. Combined with CMB results: Curvature ~0, i.e. we live in a Euclidean 'Flat Universe'.

"Result of the week"

Eisenstein et al. 2005 ApJ in press

"Key Project" goal of SDSS

Adapted from B. Boroski & M. Strauss

Our Impact

As of March 2005:

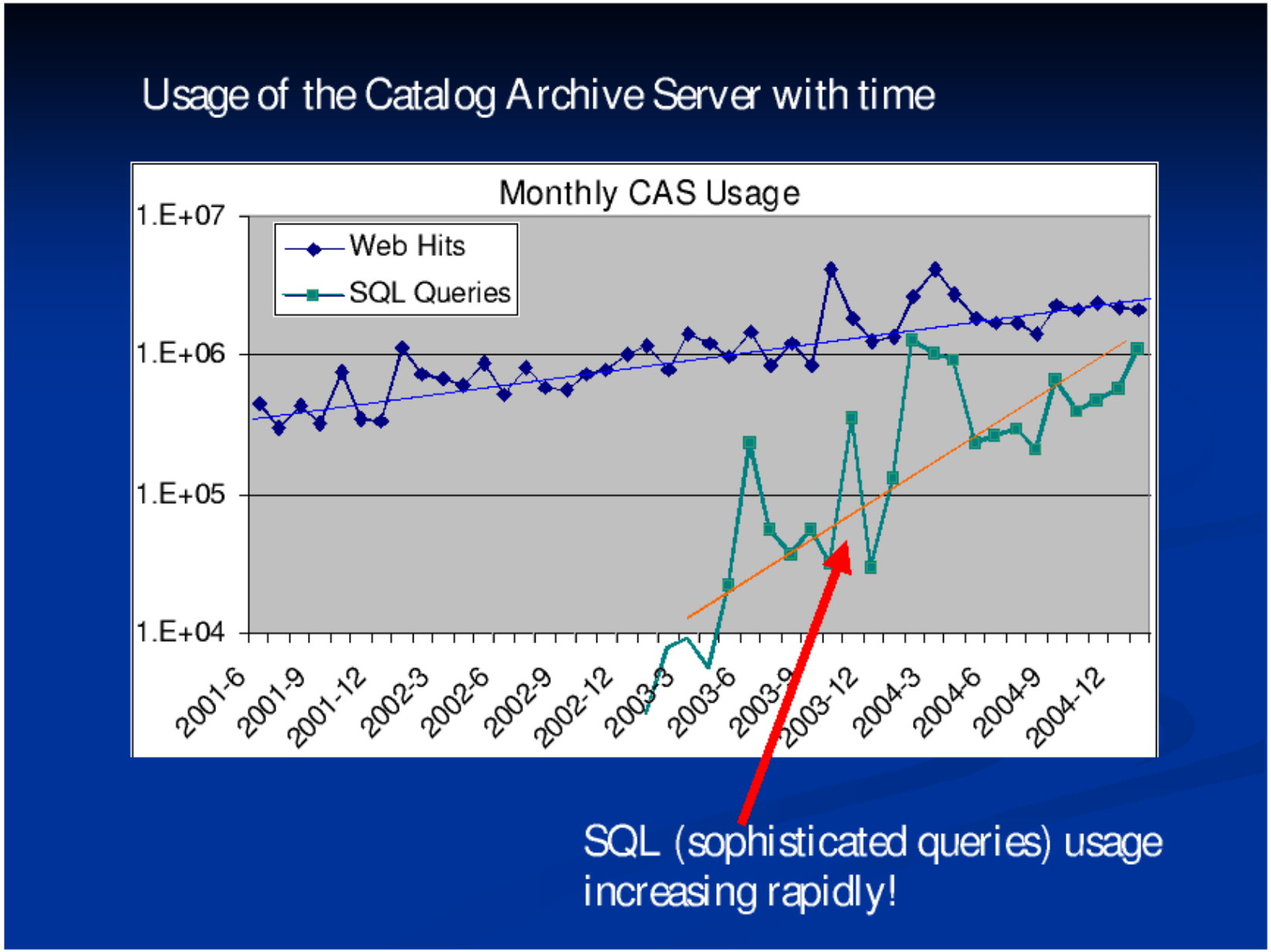
660 published refereed papers that include 'SDSS' or 'Sloan' in their title and/or abstract.

These papers have been cited a total over 12,000 times, including 14 papers cited more than 100 times, and 36 additional papers cited between 50 and 100 times. 40% of the citations have been in the last year.

In the last year, over half of the 213 SDSS papers were by astronomers outside the collaboration.

20 PhD. theses based on SDSS data completed within the collaboration in the last year.

The on-line database gets a million queries a month



SDSS-II (2005-2008)

- **Legacy Survey**
  - Fill the gap in the North Galactic Cap: ~few hundred sq. deg. imaging and ~500 spectroscopic plates
  - Unique, high photometric precision, homogeneous legacy data set for future science
  - Filled volume to improve large-scale structure studies
- **SEGUE**
  - Imaging and spectroscopy into the Milky Way: 3500 sq. deg. imaging and 400 spectroscopic plates
  - Goals to study the structure and evolution of our galaxy and to probe the dark matter halo of the Milky Way
- **Supernova Survey**
  - 200 Type Ia supernovae with high-quality light curves, in the redshift gap z=0.05-0.35, to probe dark energy

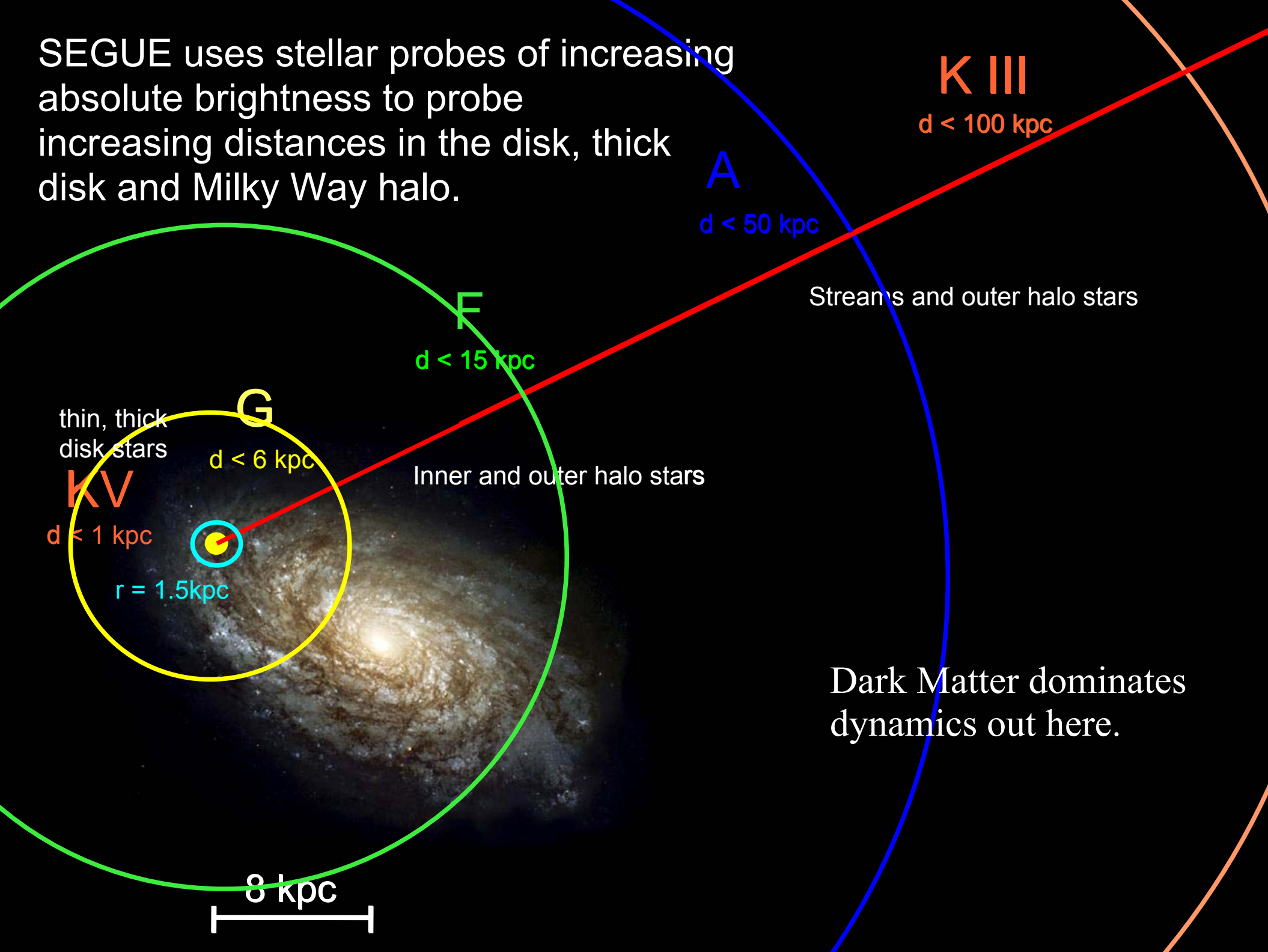
SDSS-II Funding in place

$ 5.4 M	Sloan Foundation
$ 5.4 M	NSF (note recvd. by SDSS Dir. 3/31/05*)
$ 2.5 M	Partner Institutions (nearly 20)
$ 1.6 M (1.35 FNAL)	In-Kind

$ 14.9 M	Total (July 1, 2005 thru Jun 30, 2008)

*Official Public Announcement of SDSS-II awaits official letter from NSF.

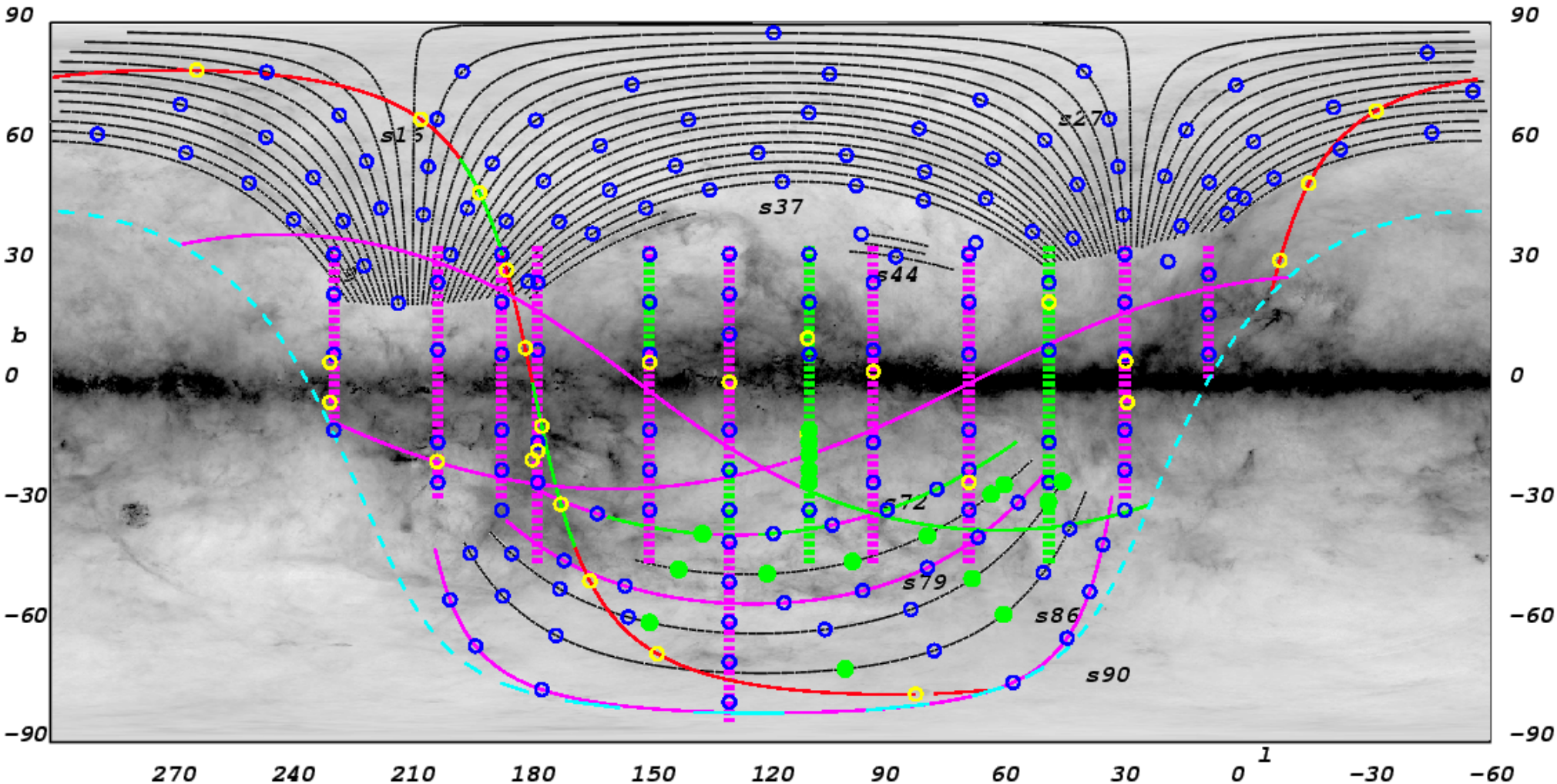
SEGUE uses stellar probes of increasing absolute brightness to probe increasing distances in the disk, thick disk and Milky Way halo.



Dark Matter dominates dynamics out here.

SEGUE

(v.): To proceed to what follows without pause



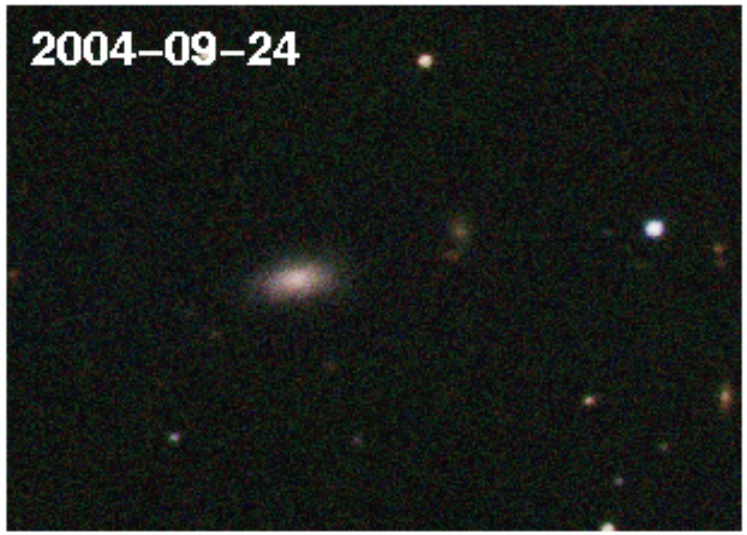
The SEGUE experiment combines accurate low-latitude stellar photometry with radial velocities and chemical abundance information from spectroscopy to answer questions about the global structure of the Milky Way, including its DARK MATTER halo.

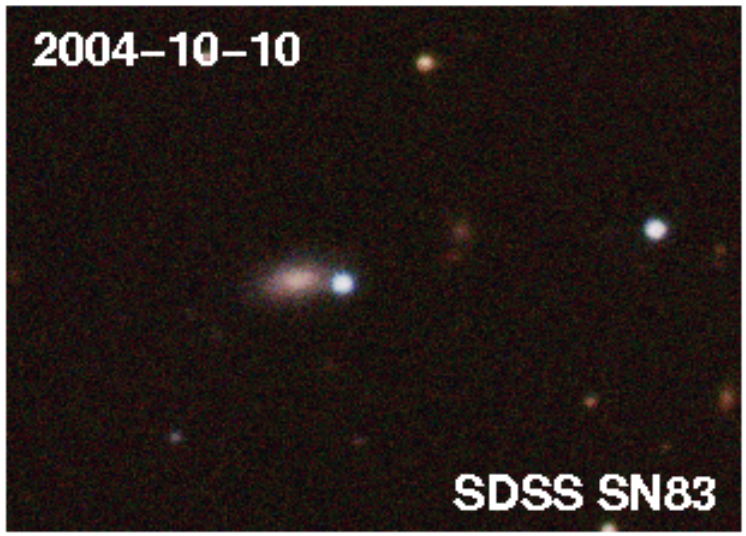
SDSS Supernova Survey

- **Science Goals**
  - **Probe dark energy in redshift regime less sensitive to evolution than deeper surveys: sigma□(w) ~ 0.1-0.15**
  - **Study SN Ia systematics (critical for SN cosmology) with high photometric accuracy**
- **Program**
  - **Repeat scans of equatorial stripe 82 for three 3-month runs (Sep-Nov, 2005-7) as weather permits**
  - **Frame subtraction in multiple bands for SN selection**
  - **Follow-up spectroscopy for SN typing, redshifts, and k-corrections**
  - **Obtain ~200 high-quality, densely sampled SN Ia ugriz light curves in the redshift desert z=0.05-0.35**

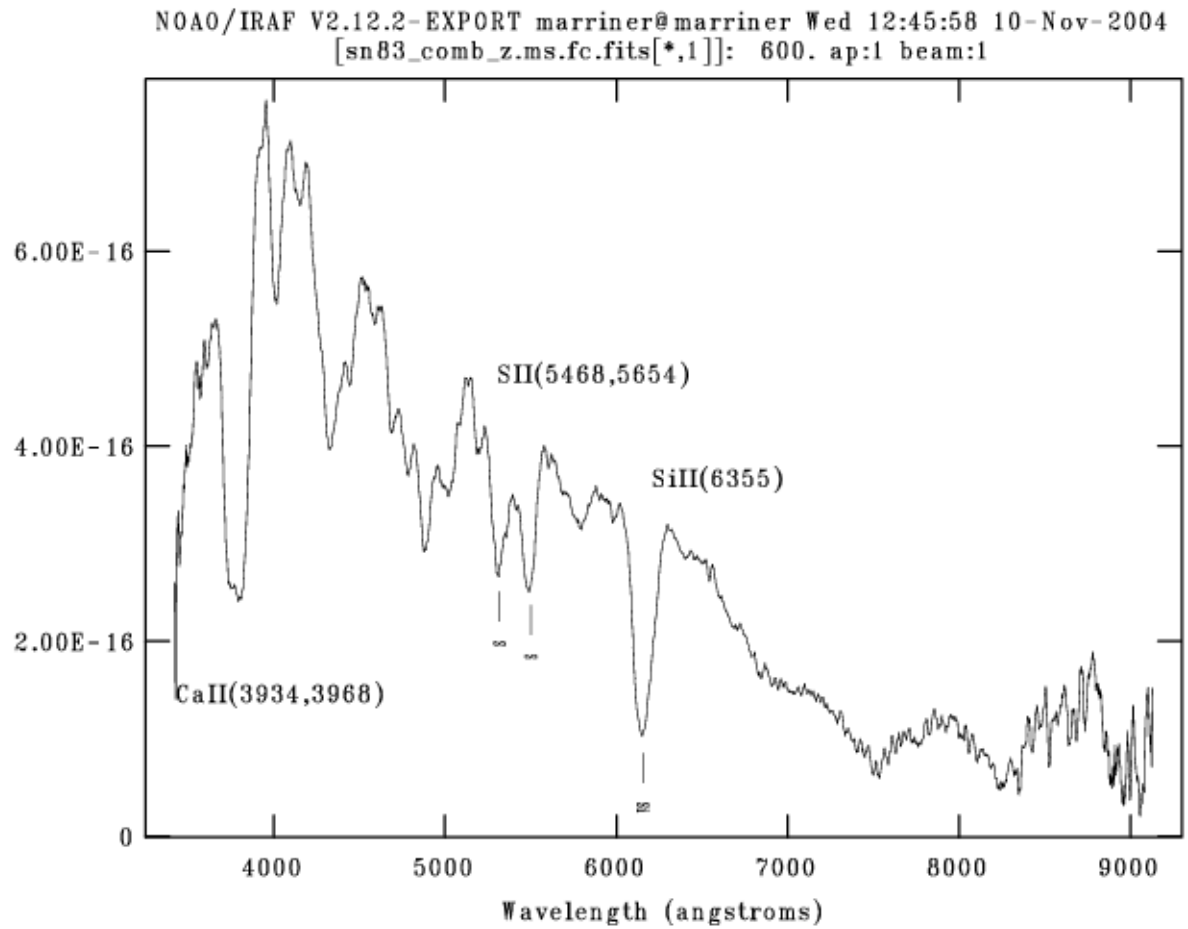
SDSS SN83: Type Ia at redshift z=0.05

SDSS 2.5m imaging





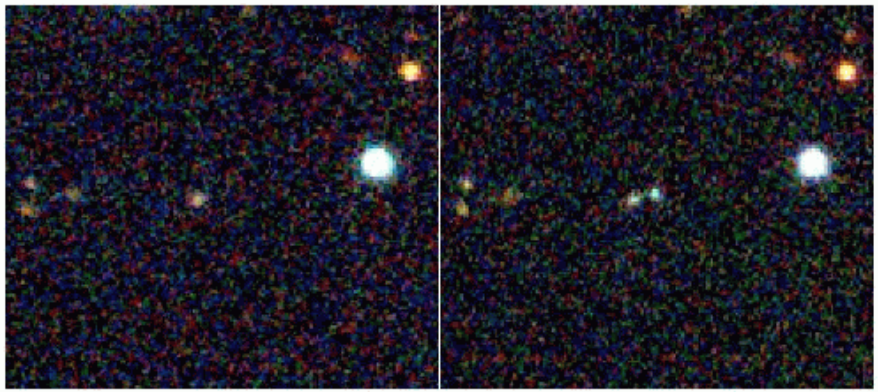
Follow-up spectrum from APO 3.5m

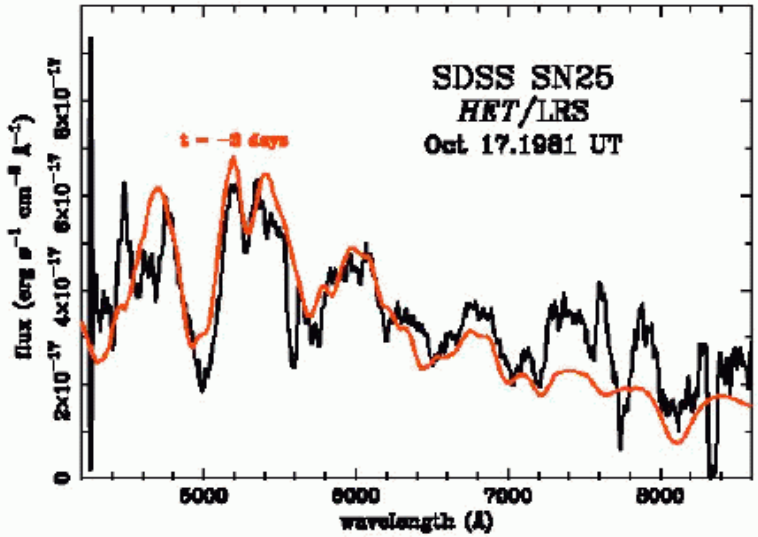


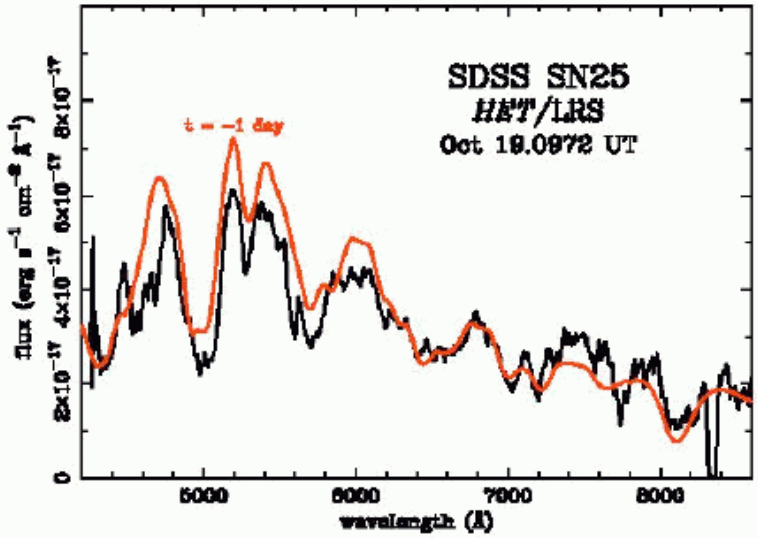
SN25

sn2004if

- Highest redshift Ia from this sample: z=0.32
- Luminous Ia: $M_r \sim -20$
- Cross-correlation analysis yields best-fit Ia spectral templates separated by 2 days, in excellent agreement with data

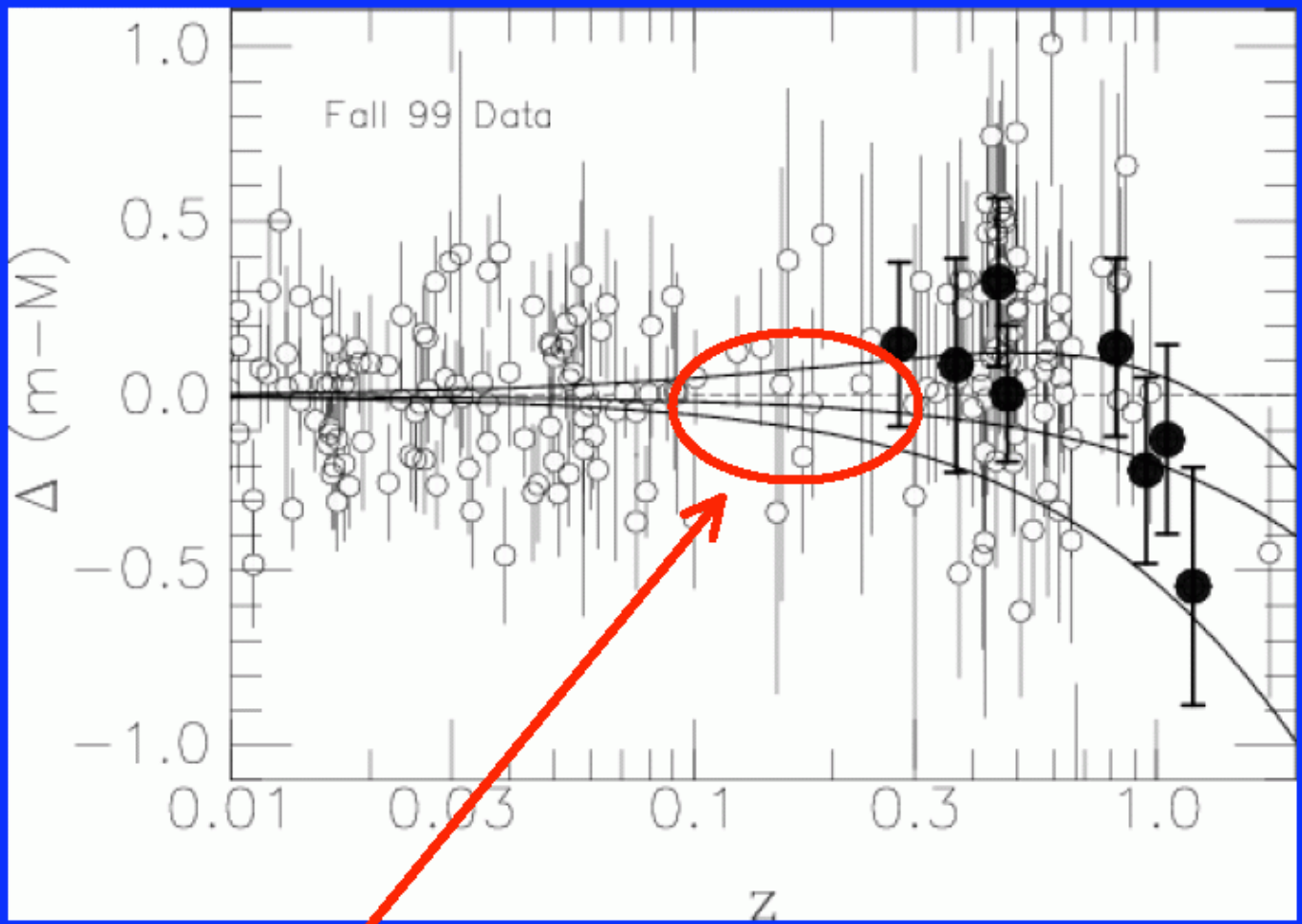






Compiled Supernovae Ia Sample

Brightness relative to empty Universe: ($\Omega_m = \Omega_\Lambda = 0$)



Ω_m Ω_Λ

0.3, 0.7

0.3, 0.0

1.0, 0.0

`Gold' sample of 157 SNe included only 6 between z = 0.1-0.3; SDSS naturally fills this gap

Tonry etal '03
Riess etal '04

The SDSS COADD: repeated scans of the same piece of sky summed.

One Scan

Nine Scans summed

H. Lin
J. Annis
H. Lampeitl

IMAGING

Baseline:
8452 sq. deg.

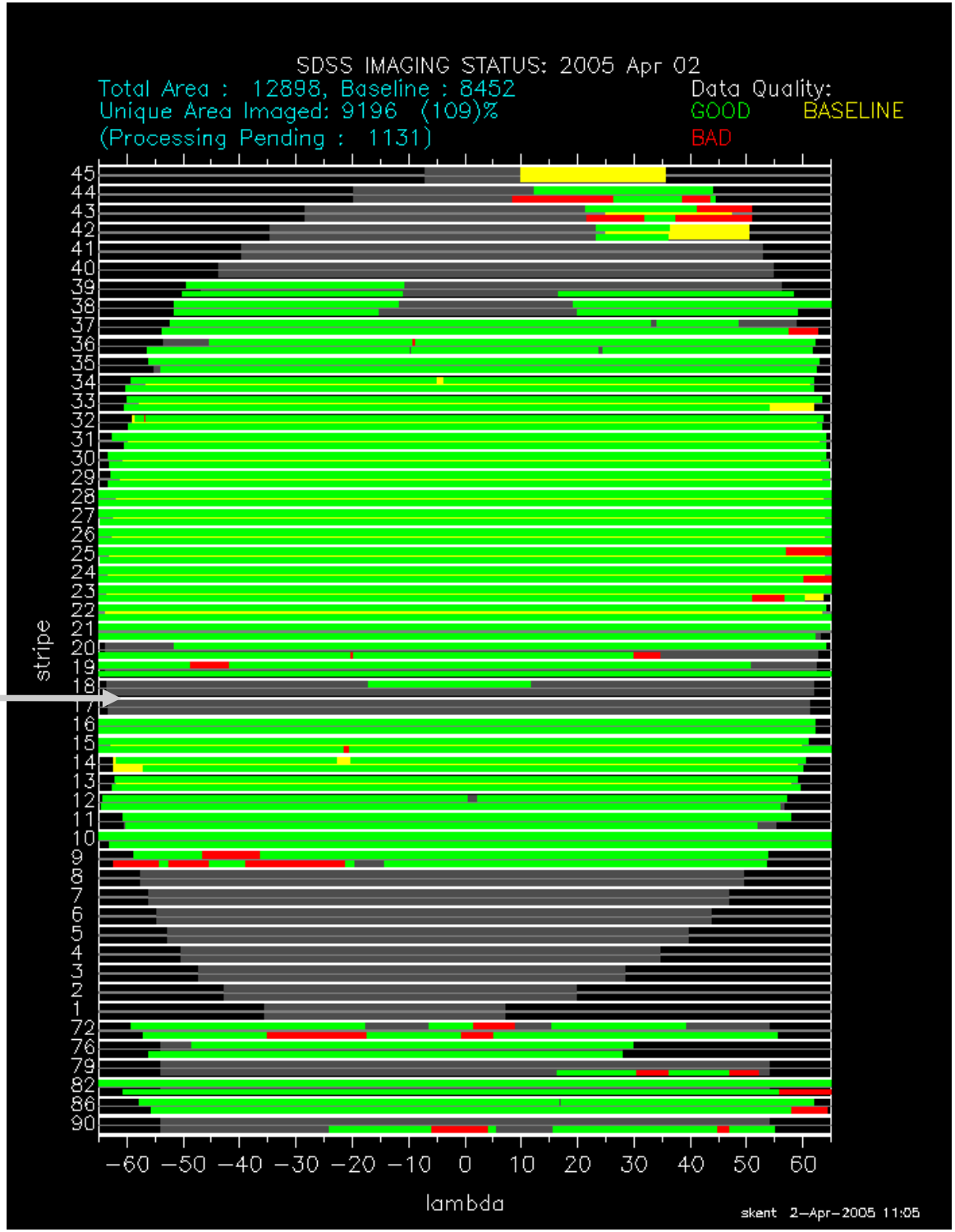
as of Apr 1, 2005

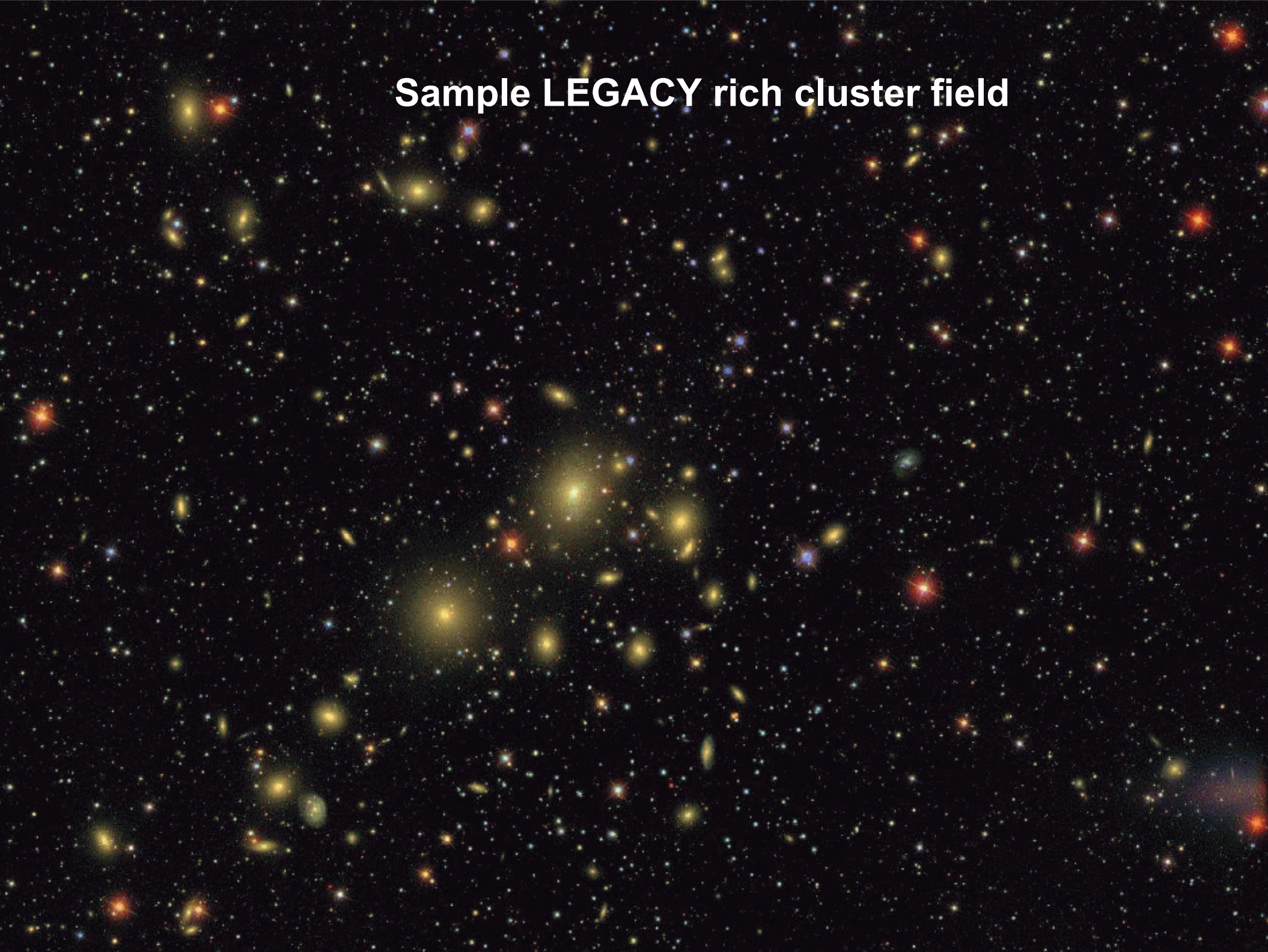
SPECTROSCOPY

Baseline:
1688 tiles

68% as of Apr 1, 2005

LEGACY Survey will fill the gap, a key piece of sky.




Sample LEGACY rich cluster field

from S. Kent

EAG Balancing Act

- EAG currently has 9 scientists, 3.5 CP FNAL funded and working on astrophysics.
- Next few years
  - SDSS: 4.2 Scientists, 3 CPs
  - SNAP: 1.25 Scientists, 0.5 CP
  - DES: 1.85 Scientists, 0 CP
  - Research: 1.7 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

- SDSS-I is wrapping up, meeting its baseline imaging goals.
  - Public release of DR3 was on schedule and SDSS data is being widely used by the astronomy community.
  - SDSS results and papers numerous, diverse, and exciting.
  - Archive an unmatched resource for at least a decade.

- SDSS-II has funding in place from Sloan Foundation, NSF and institutional partners. Legacy, SEGUE and Supernova Survey programs had successful initial observations and test runs during the Fall '04 observing season, they are ready to begin full operations in Fall '05.