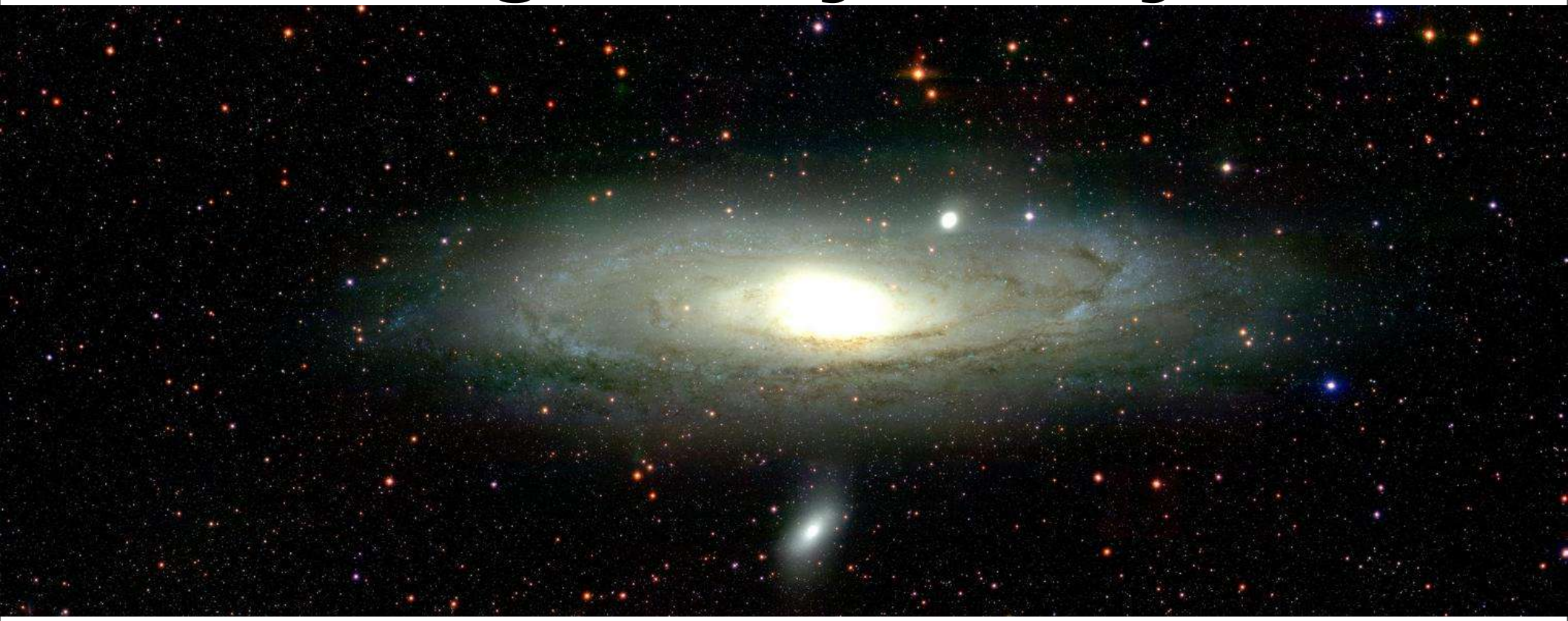
SDSS-II

Sloan Digital Sky Survey Status



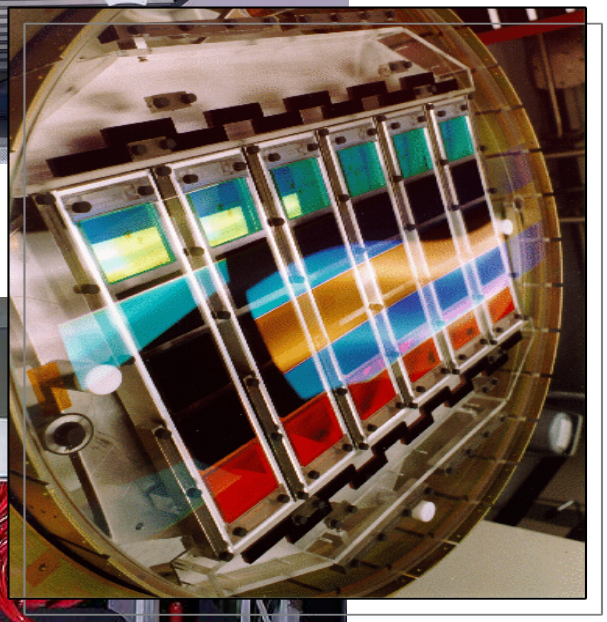
Presentation to the DOE Annual Review
May 17, 2006

Sloan Digital Sky Survey-II (E949) 2005-2008 (underway)

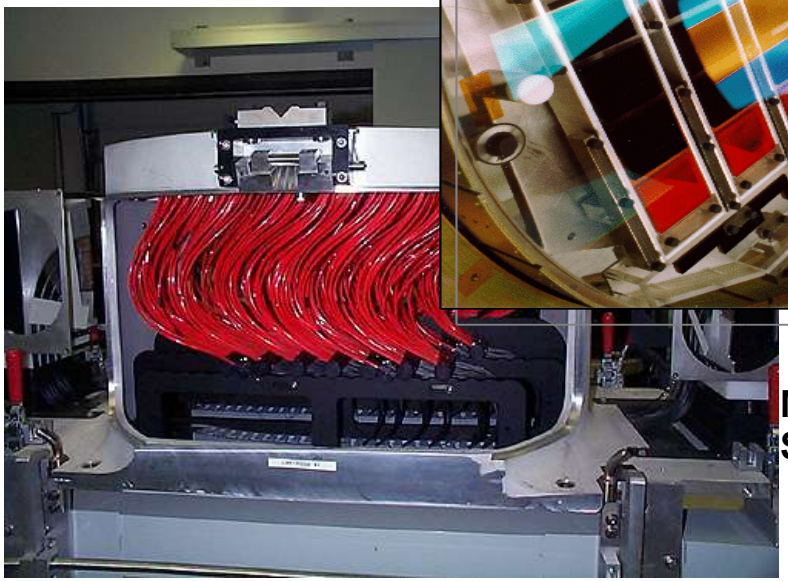
Collaboration: ~150 scientists from

- Am. Museum Nat. History
- Astrophysical Inst. Potsdam
- U. Basel
- Cambridge U.
- Case Western Reserve
- U. Chicago
- Drexel U.
- Fermilab
- Institute for Adv. Studies
- Japanese Participation Grp
- Johns Hopkins U.
- JINA
- Kavli Institute for Part. Astro.
- Korean Scientist Group
- LAMOST (China)
- Los Alamos Nat. Lab
- Max Planck Inst. Astron.
- Max Planck Inst. Astrophy.
- New Mexico State U.
- Ohio State U.
- U. Pittsburgh
- U. Portsmouth
- Princeton U.
- US Naval Obs.
- U. Washington

Beamline



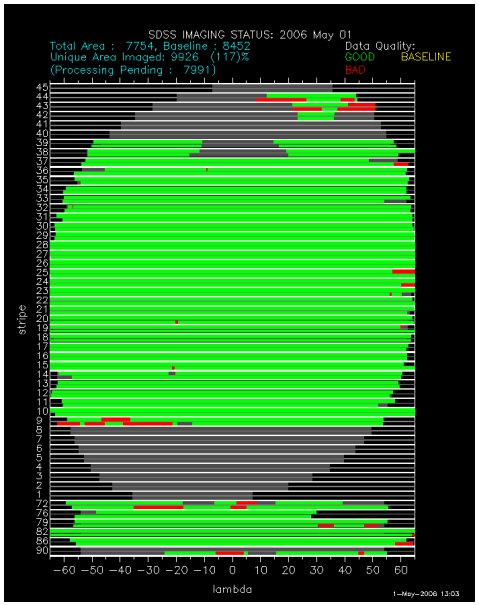
Calorimeter

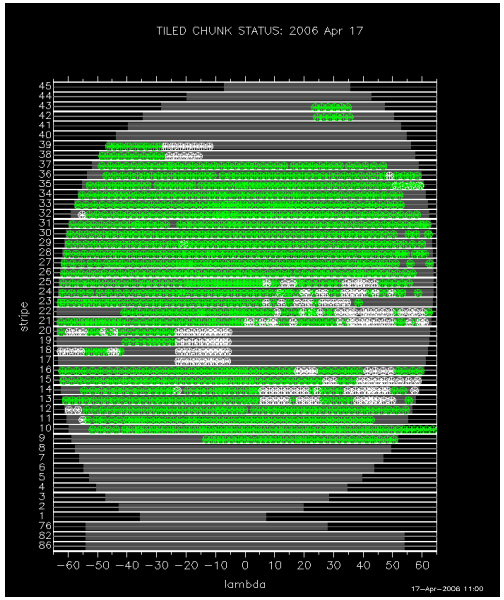


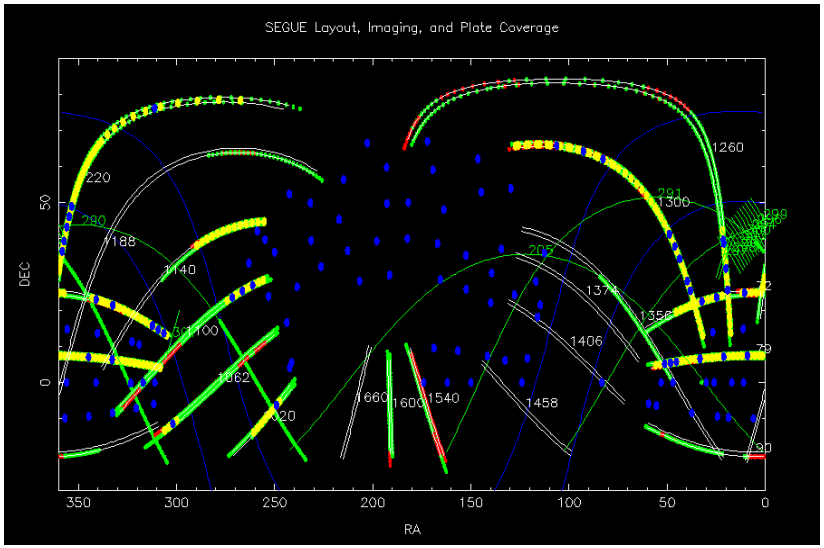
Massive Spectrometer

SDSS-II: The sequel
Its 3 year mission (2005-2008)

- **Legacy:**
  - **Imaging and Redshift survey - Large scale structure**
- **SEGUE:**
  - **Milky Way halo – mergers – Dark Matter probe**
- **Supernovae**
  - **Low and intermediate redshift – Dark Energy probe**
- **Funding:**
  - **NSF, Sloan, DOE, NASA, Max Planck Society, Higher Ed. Fund. Council, UK, Japanese Mongbukagakusho**







FNAL tasks and resources in SDSS-II

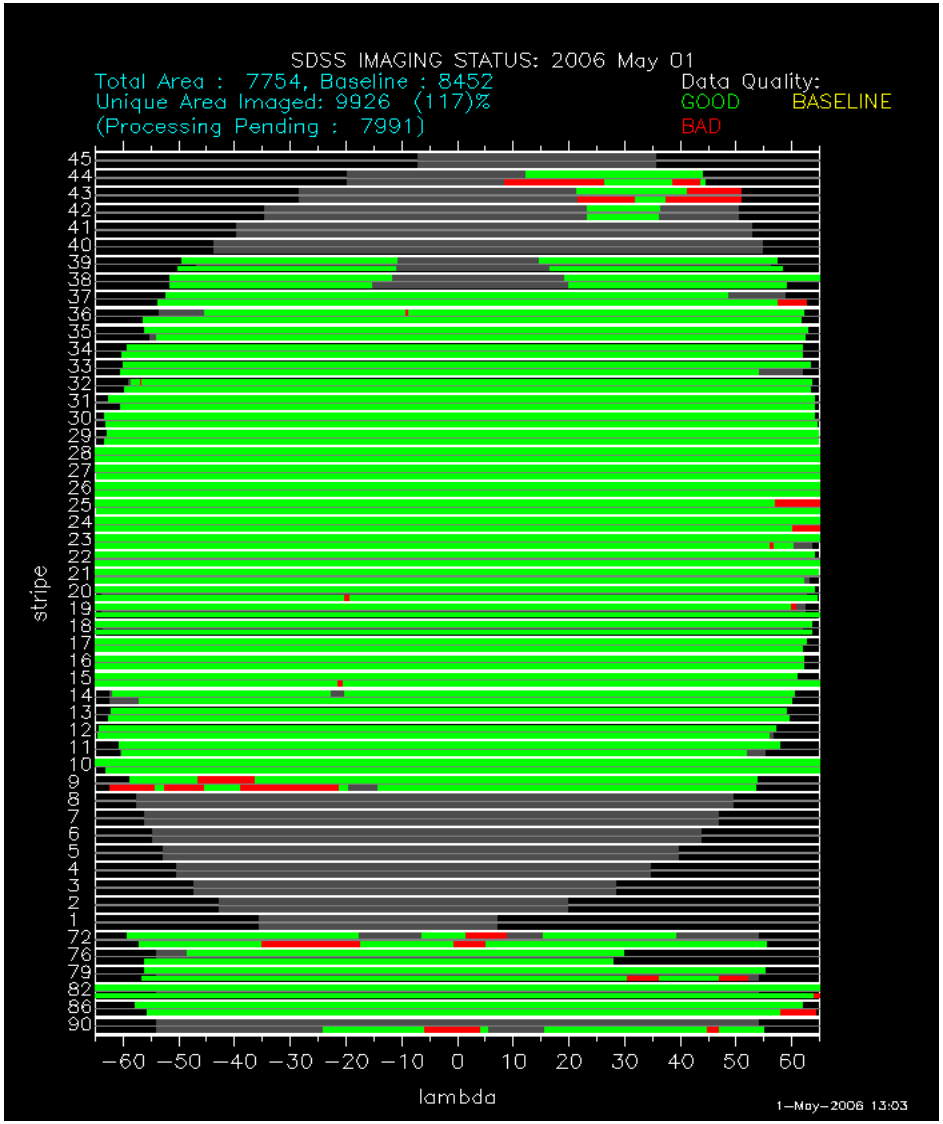
- Fermilab Interests
  - 13 scientists (3 divisions)
    - SEGUE science (streams)
    - Galaxy Clusters
    - Strong Lensing
    - Supernova science
    - Photometric Redshifts
  - 1 current Postdoc
  - 2 arriving soon
- Required resources
  - 4 FTE scientist
  - 10 FTE CP, admin, tech.
  - $300K M&S/yr
  - $300K DAQ upgrade
- Funding
  - Significant cost sharing with SDSS project ($1.2 million)

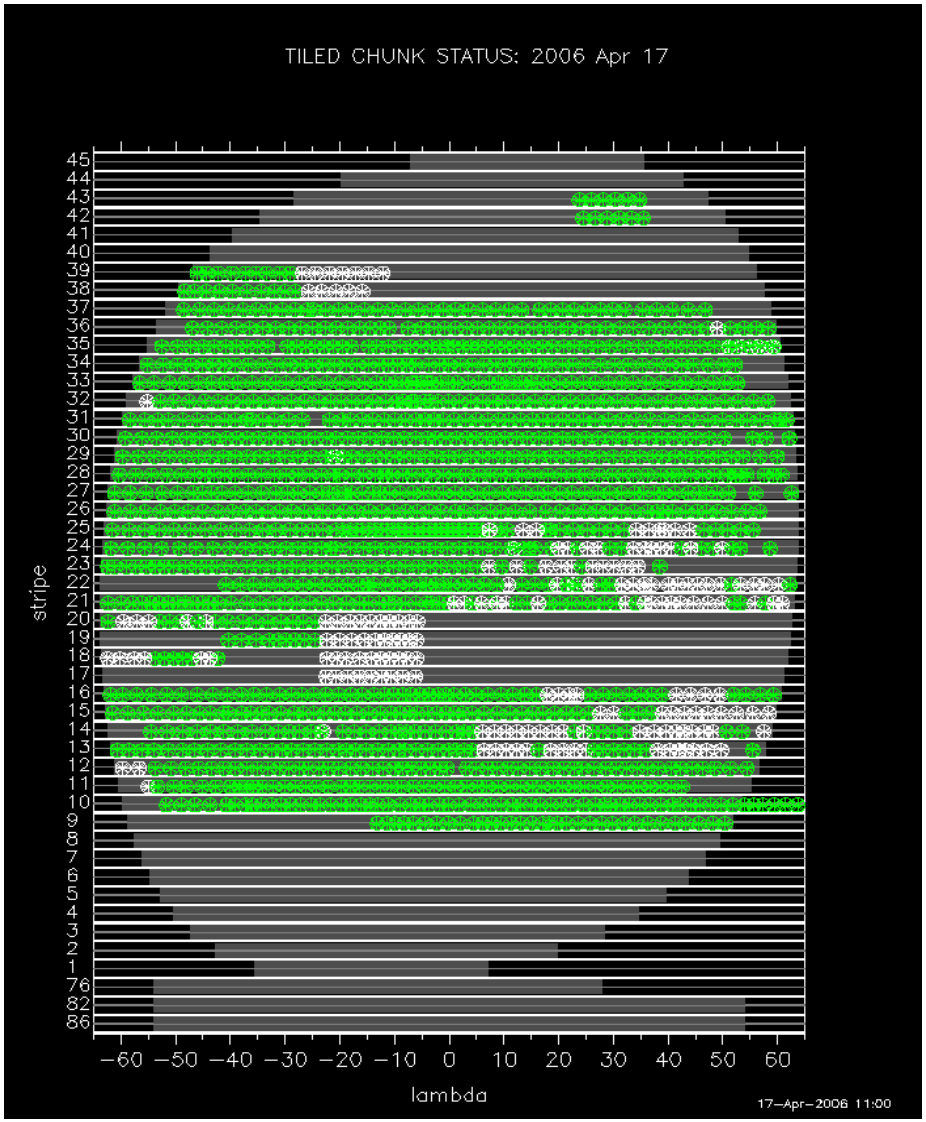
Tasks

DAQ upgrade
Plugplate design
Survey planning
Legacy, SEGUE, SNe data processing
Data distribution
Project Mgmt.
APO Engineering/Technical support

Status - Legacy

Imaging Footprint (8000 sq deg) Spectro footprint: 1700 plates

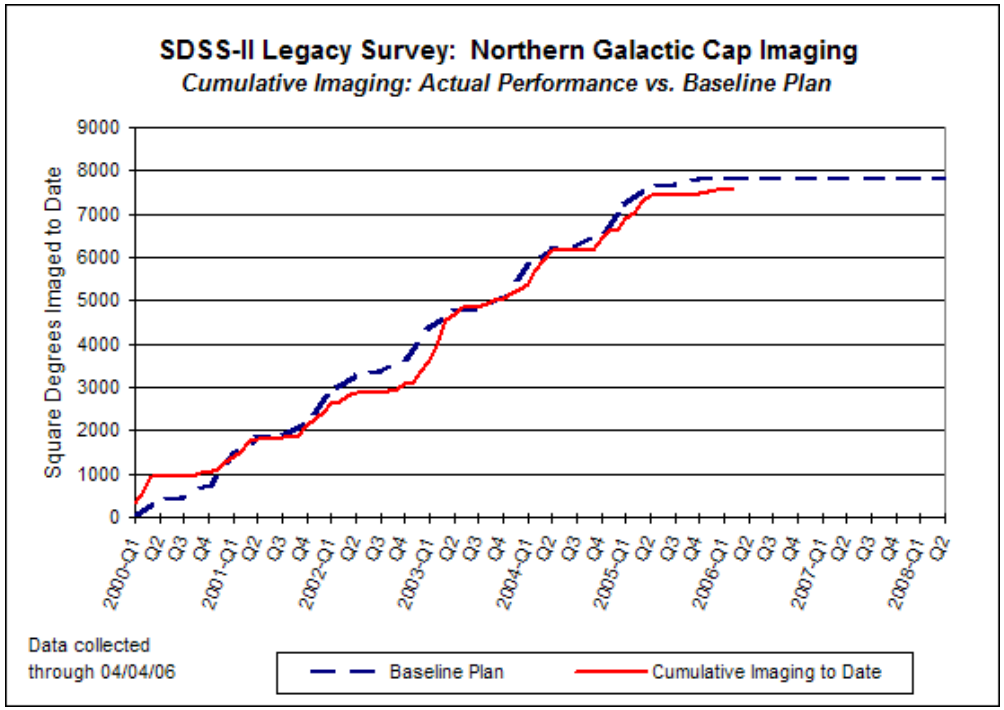


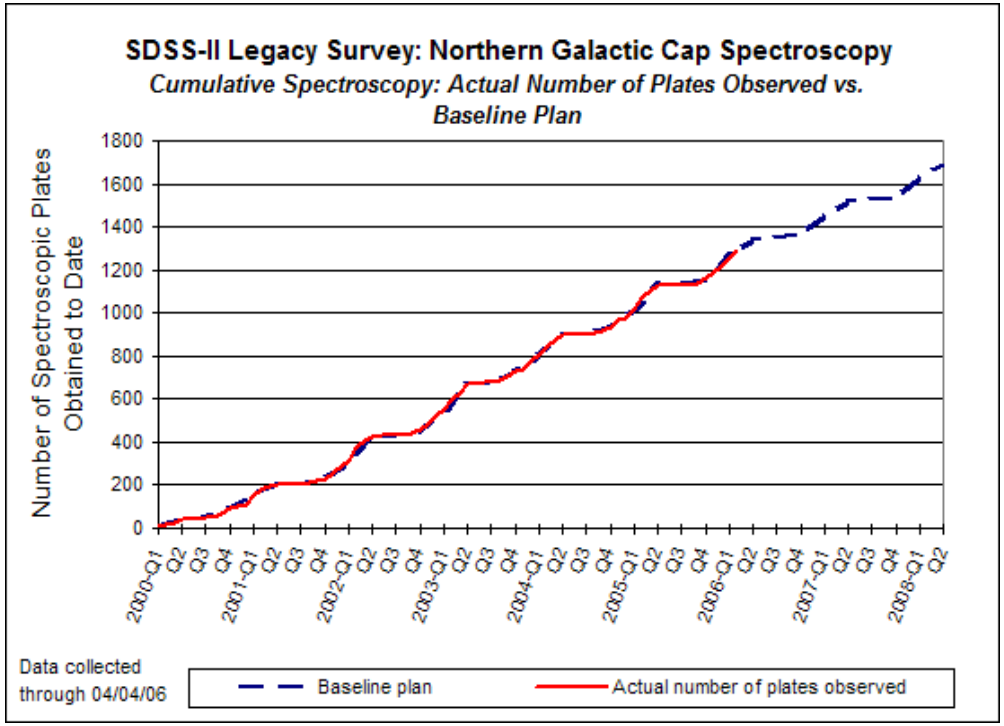


Imaging is complete (gap filled)!

Spectroscopy on track (two years left).

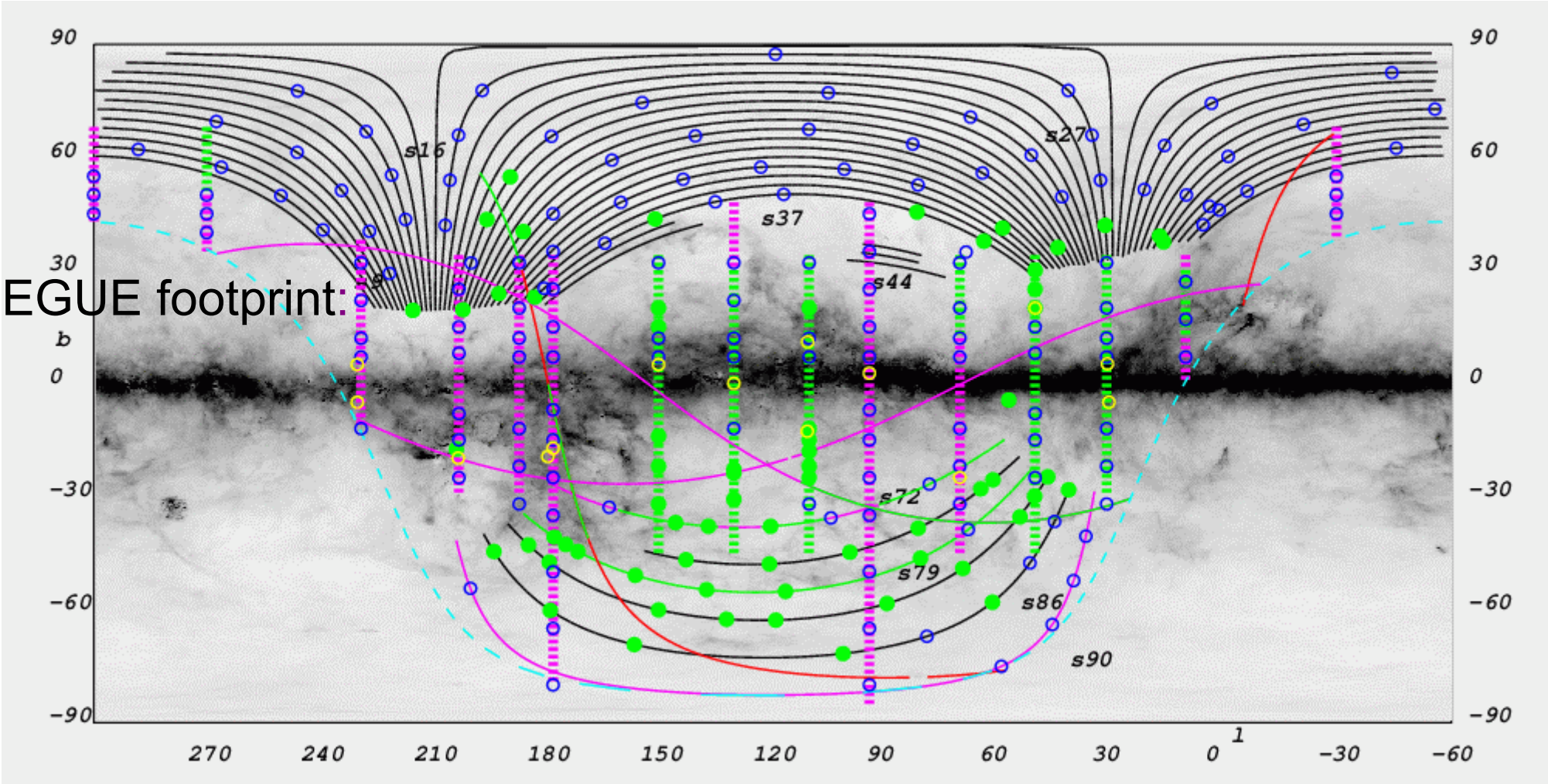
Legacy Survey: delivered "beam" vs. 8 yr. baseline





SEGUE

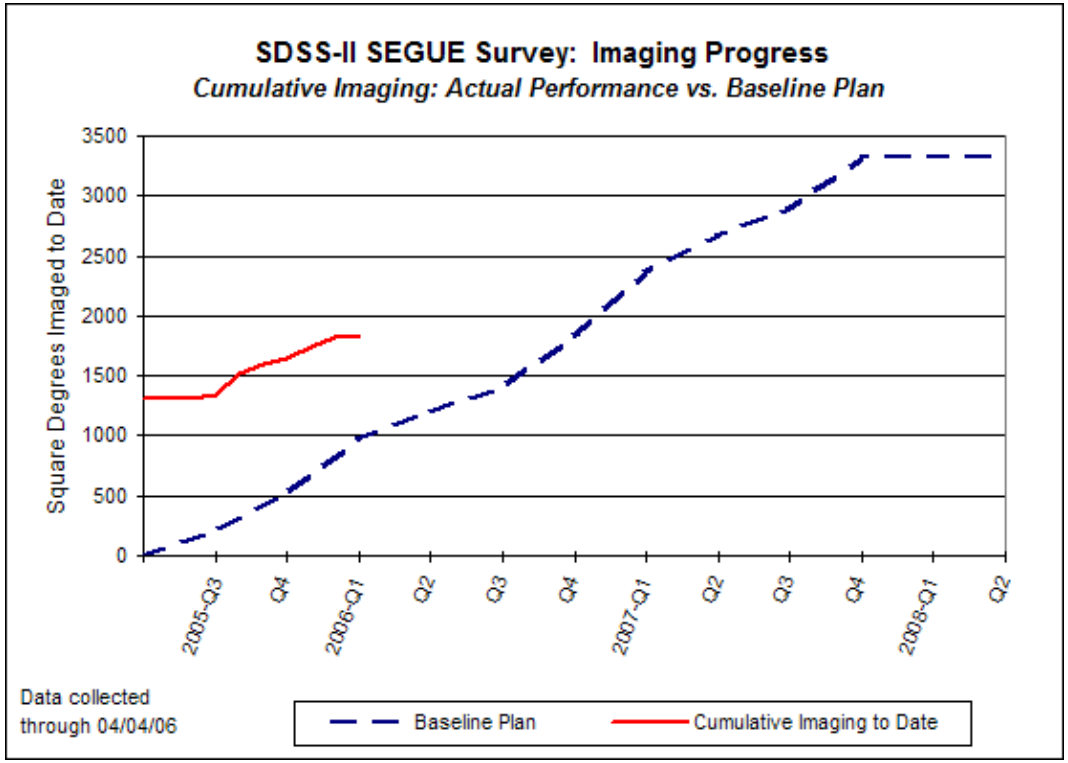
(v.): To proceed to what follows without pause



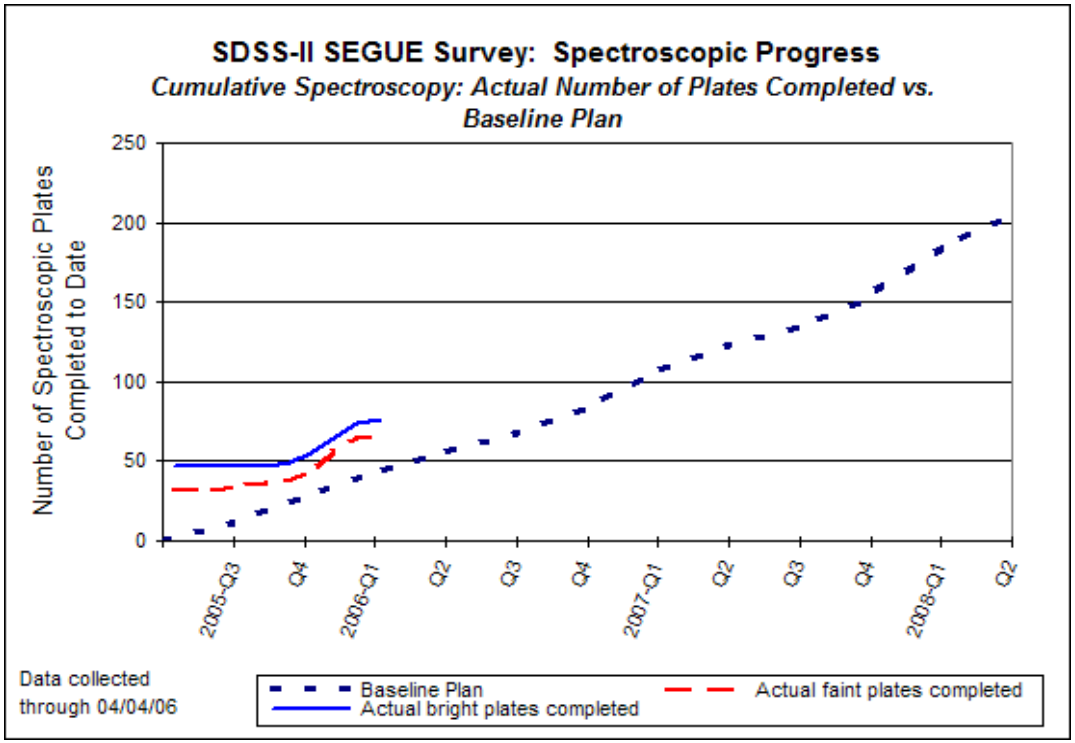
The SEGUE experiment combines accurate low-latitude stellar photometry with radial velocities and chemical abundance information from spectroscopy to answer questions about the global structure of the Milky Way, including its DARK MATTER halo.

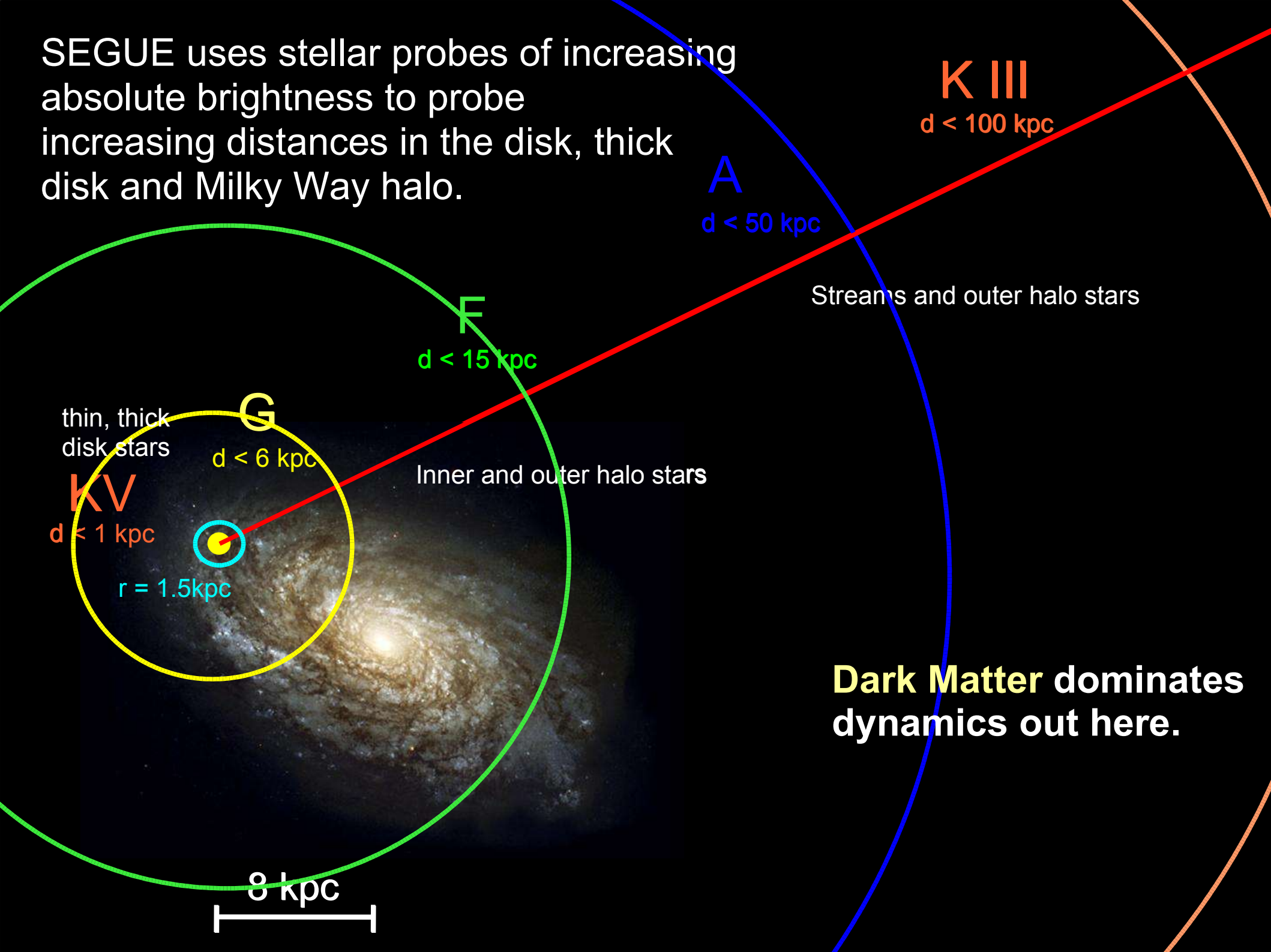
Ahead of Imaging baseline:

Segue Survey: delivered "beam" vs. 3yr. baseline

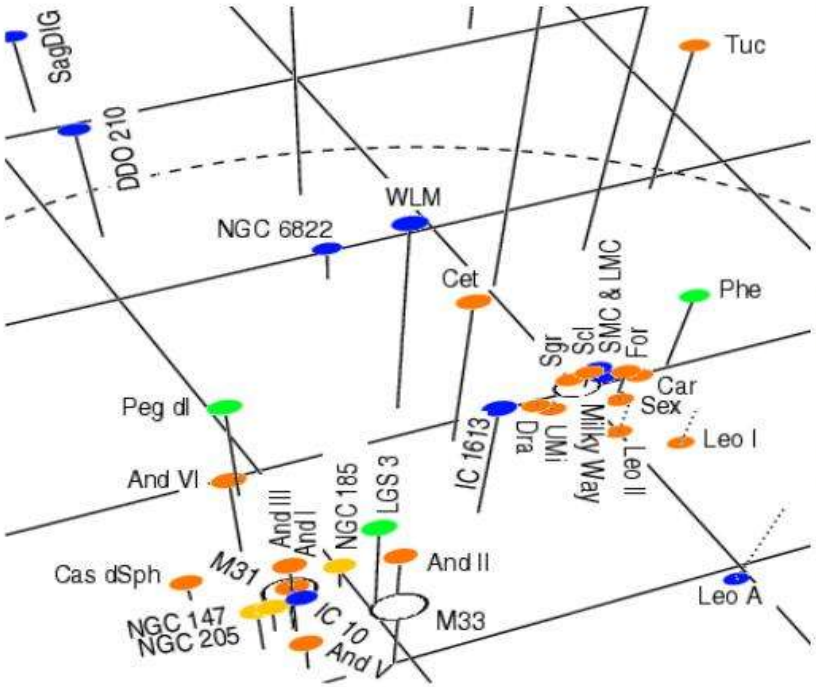


In-line with Spectro baseline:

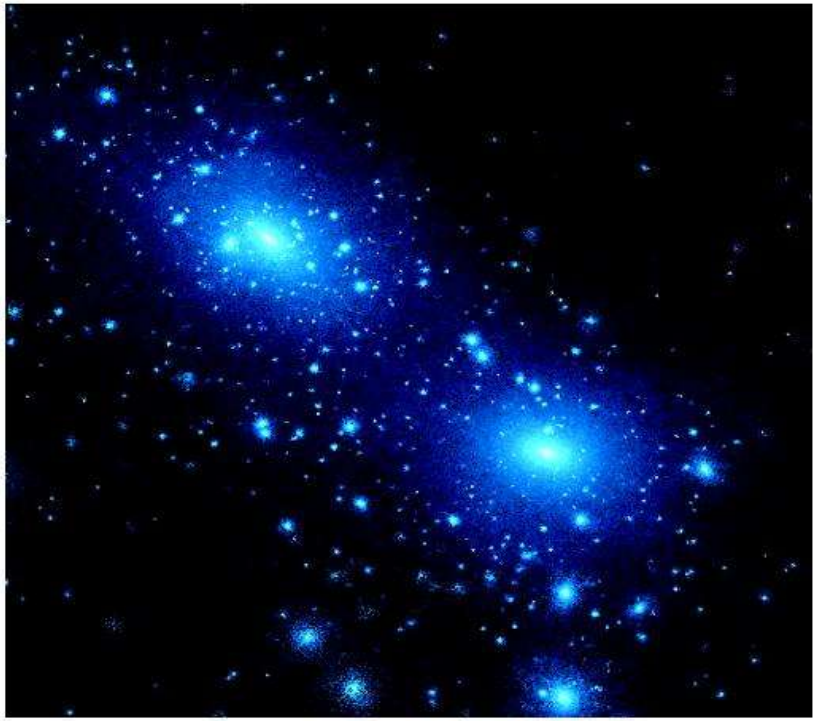



SEGUE uses stellar probes of increasing absolute brightness to probe increasing distances in the disk, thick disk and Milky Way halo.
K III
d < 100 kpc
A
d < 50 kpc
Streams and outer halo stars
F
d < 15 kpc
G
d < 6 kpc
thin, thick disk stars
Inner and outer halo stars
KV
d < 1 kpc
r = 1.5kpc
8 kpc
Dark Matter dominates dynamics out here.

The Missing Satellites Problem



The Local Group

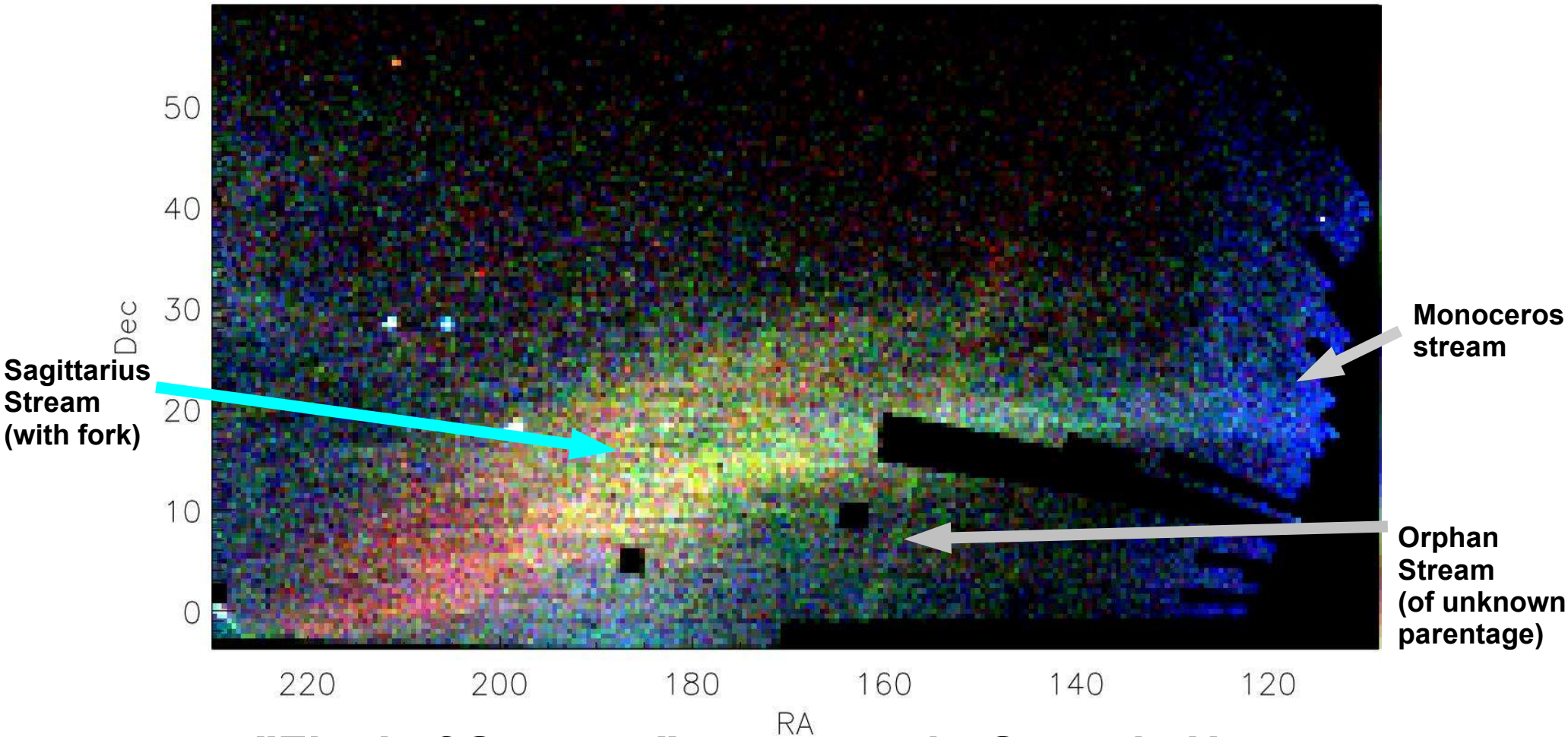


LCDM simulation

Kauffman, White & Guiderdoni 1993
Klypin, Kravtsov, Valenzuela & Prada 1999; Moore et al. 1999

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.

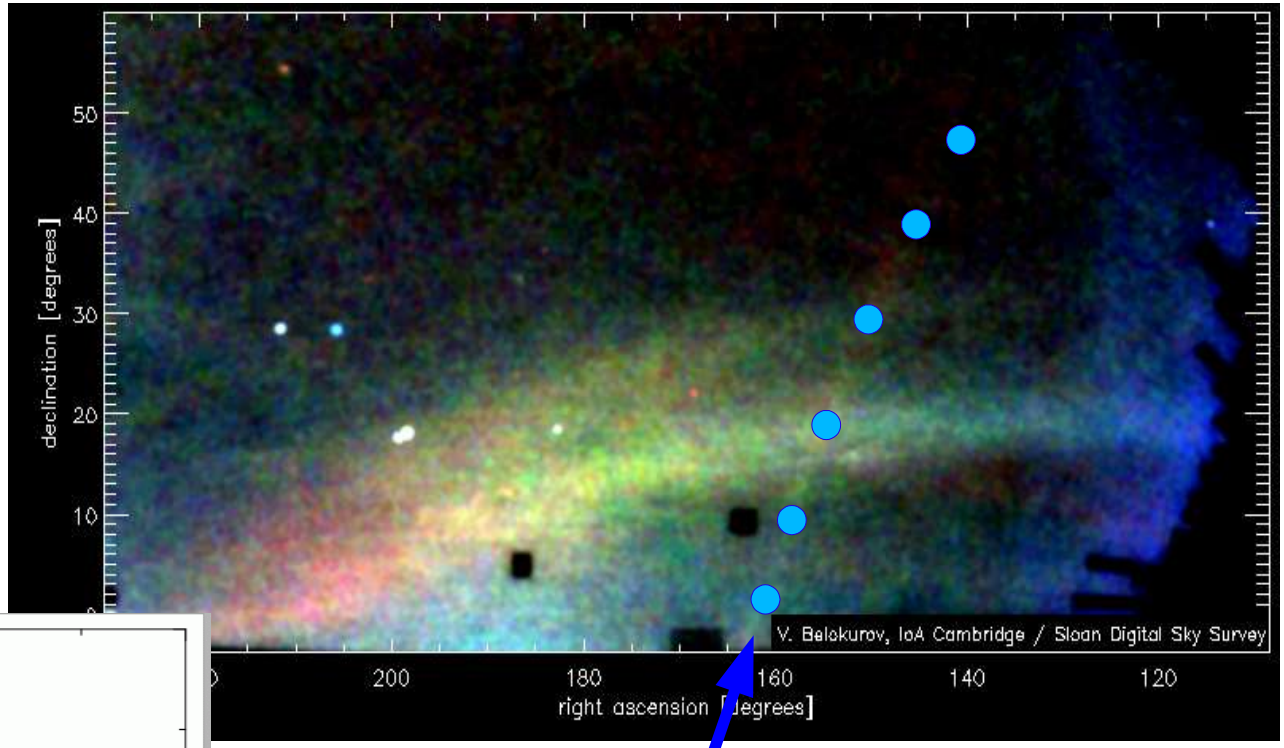
SDSS-II/SEGUE Hot result:

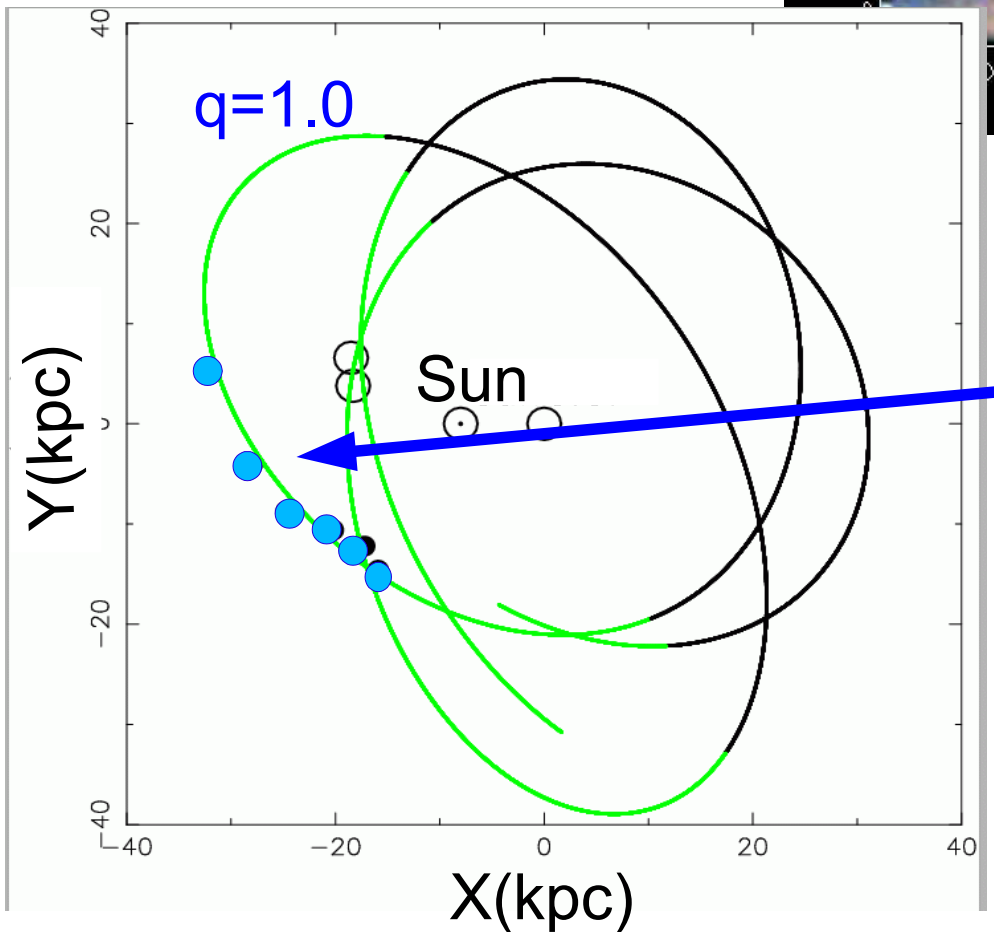


"Field of Streams" - mergers in Galactic Halo (Beam to CDMS II)

Star streams as probes of Dark Matter!

Example: Fit with q=1.0 model implies consistency with Spherical halo.





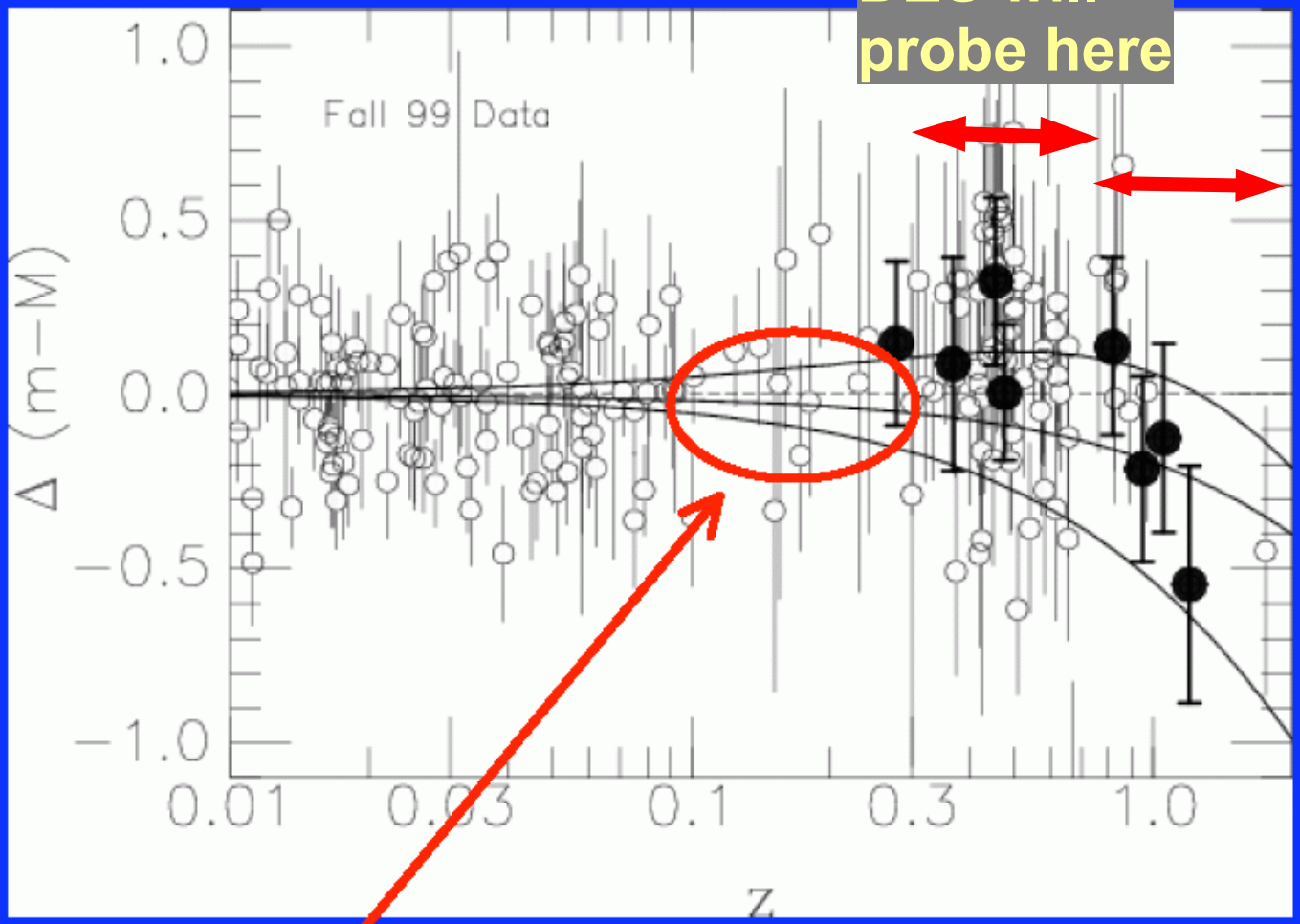
Fitting the orbit of the 'Orphan stream' in 3-D can constrain the flattening of the Dark Matter Halo surrounding our Milky Way Galaxy.

SDSS-II Supernova Survey

- Science Goals
  - Probe dark energy in redshift regime less sensitive to evolution than deeper surveys: $\sigma(w) \sim 0.1\text{-}0.15$
  - 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

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

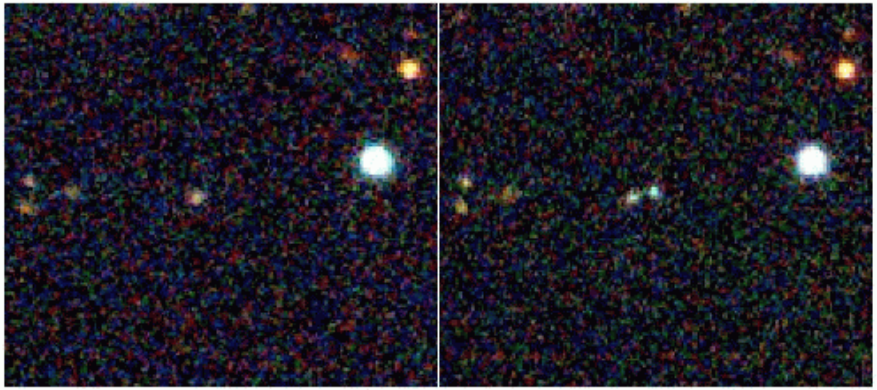
Tonry etal '03
Riess etal '04

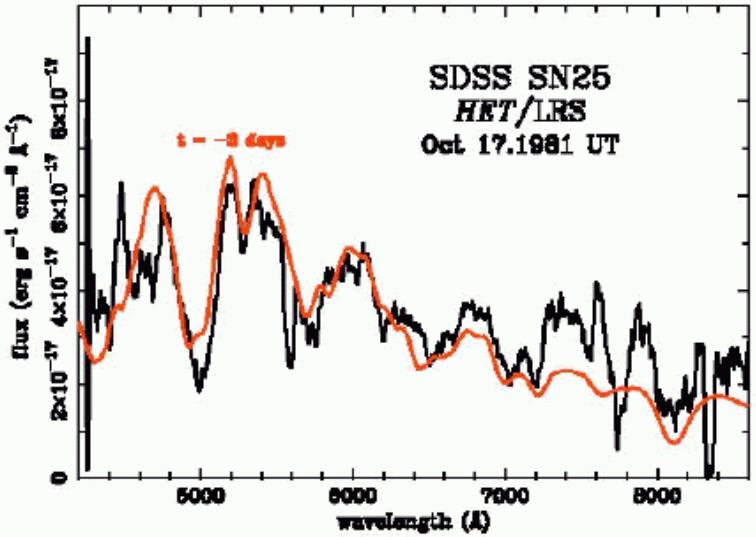
130 Confirmed Type Ia SN collected in first year! Two more still to come!

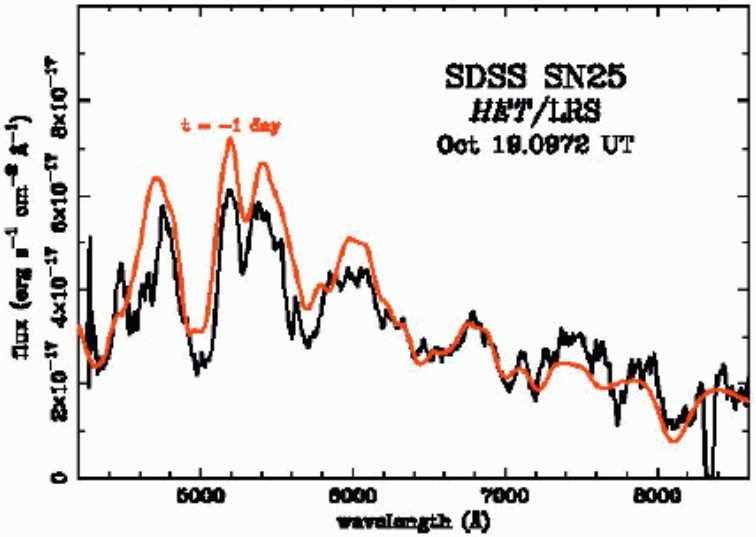
SN25

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







Status - Supernovae

Fall 2005:

130 spectroscopically confirmed Type Ia's

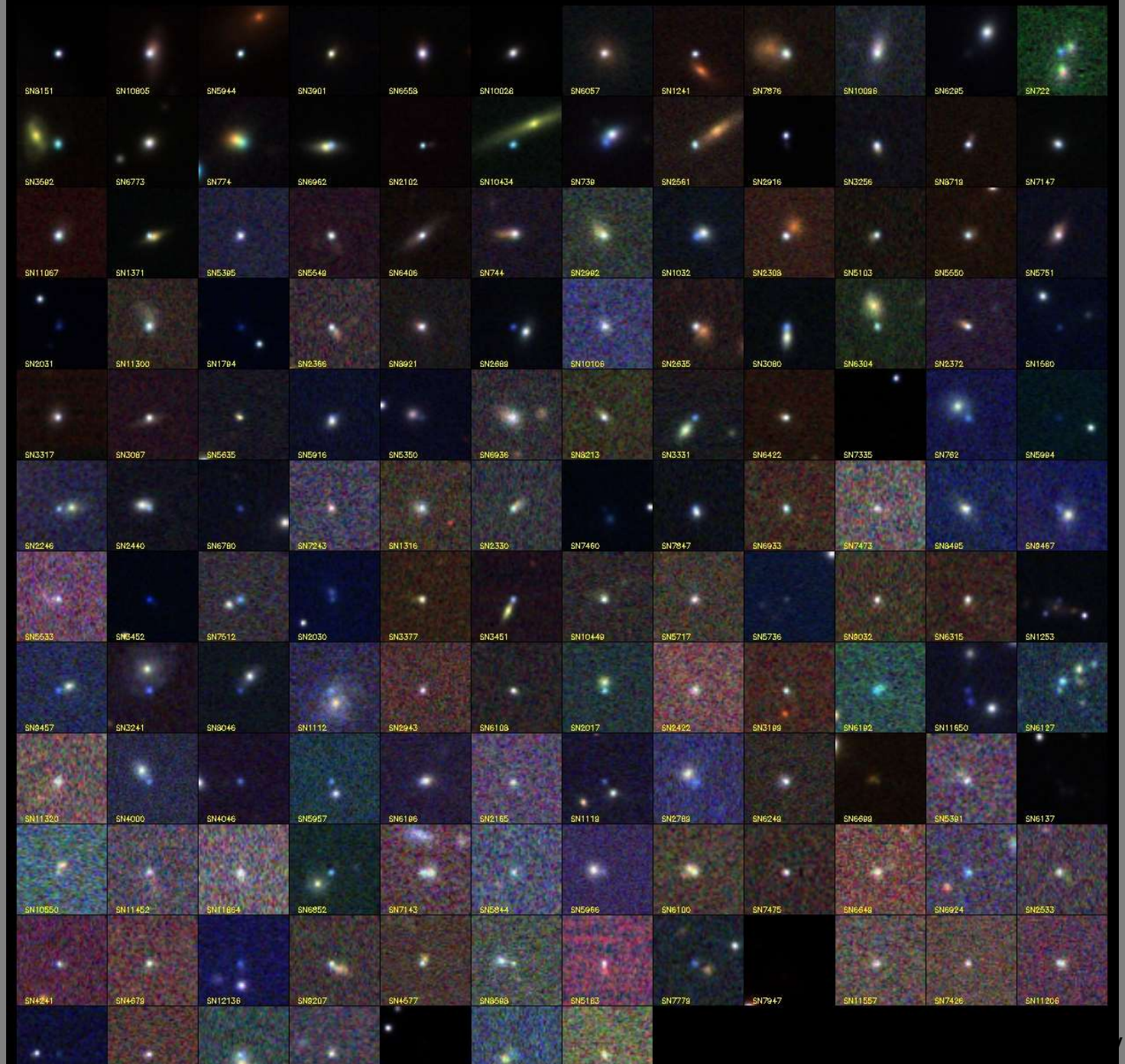
14 spectroscopically likely/possible Ia

11 confirmed SN II

6 confirmed Ib/c

~100's of unconfirmed Ia's based on light curves

Full results coming this summer



Data Distribution

- Data release 5 scheduled for July 2006 release.
- 8000 sq. deg of sky.
- Over 1,000,000 spectra
- CAS SQL database: over 8,000,000 queries in '04 and '05.
- 1061 refereed papers related to SDSS.
- 30,000 citations of these papers.

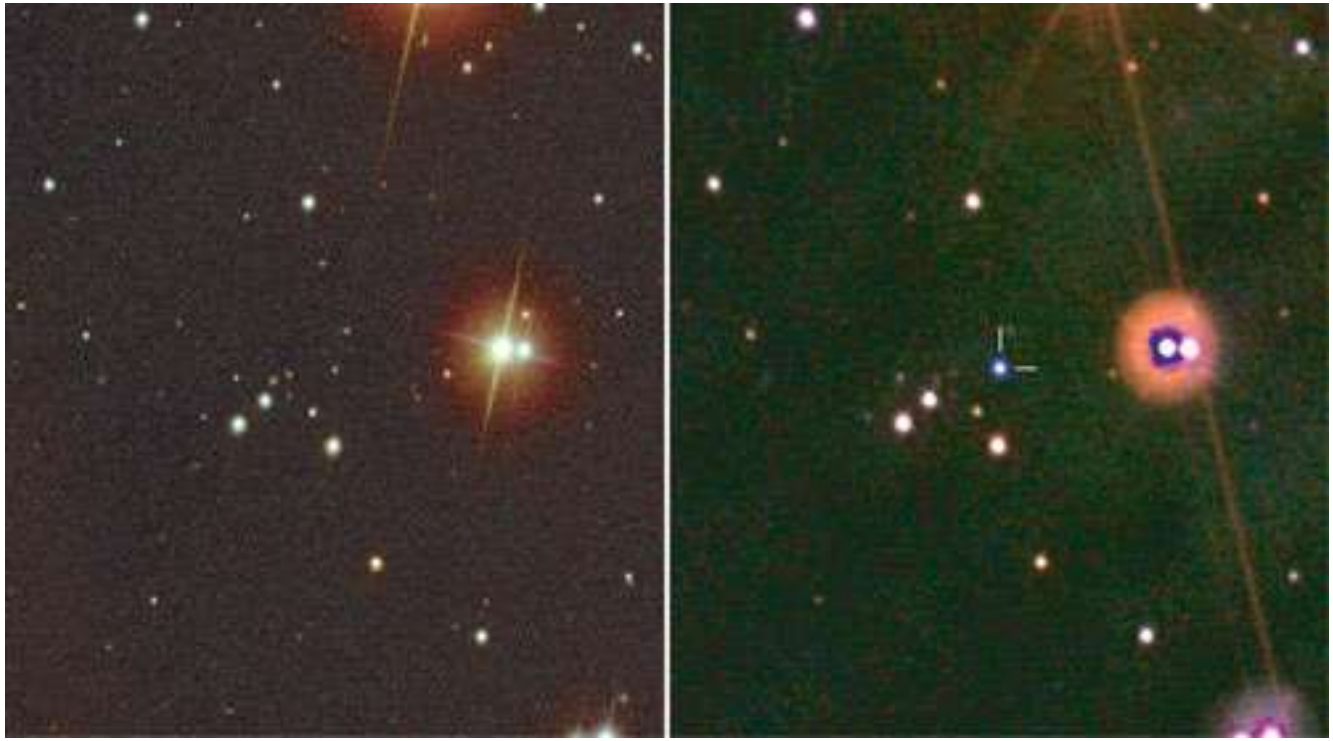
- Over 60 Terabytes served over the internet.
- Over half of all publications by users of the data NOT affiliated with SDSS.

Our Impact

Example:

Oddball Gamma Ray Burst

Left: SDSS image
Right: NASA/SWIFT UV image



SDSS provides archive catalog of sky to compare when transient objects appear.

SDSS-II Funding

$ 5.4 M	Sloan Foundation
$ 5.4 M	NSF
$ 2.5 M	Partner Institutions (nearly 20)
$ 1.6 M	In-Kind

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

SDSS-II Collaboration

All of original SDSS plus several new institutions

- SDSS-II has completed its first of three years of operations and is meeting its baseline imaging and spectroscopic goals.
  - Public release of DR5 is on schedule and SDSS data is being widely used by the astronomy community.
  - SDSS results and papers are numerous, diverse, and exciting.
  - Database Archive is an unmatched resource for Astrophysics community world-wide.
  - SDSS-II is exploring Dark Matter and Dark Energy with its SEGUE and Supernovae programs.