Theoretical Astrophysics/SDSS at Fermilab

Stephen Kent
March 15, 2003

- Theoretical Astrophysics Group (PPD)
- Experimental Astrophysics Group (CD) and SDSS (Sloan Digital Sky Survey)
- To the future: SNAP

TAG Personnel

Staff:

Scott Dodelson

Josh Frieman

Lam Hui (arrived from Columbia)

Rocky Kolb

Albert Stebbins

Postdocs:

Kev Abazakian (leaving for Los Alamos)

Giovanne Bertone (arriving 9/03 from IAP)

John Beacom (David N. Schramm Fellow, 5 yr)

Nicole Bell

Patrick Greene

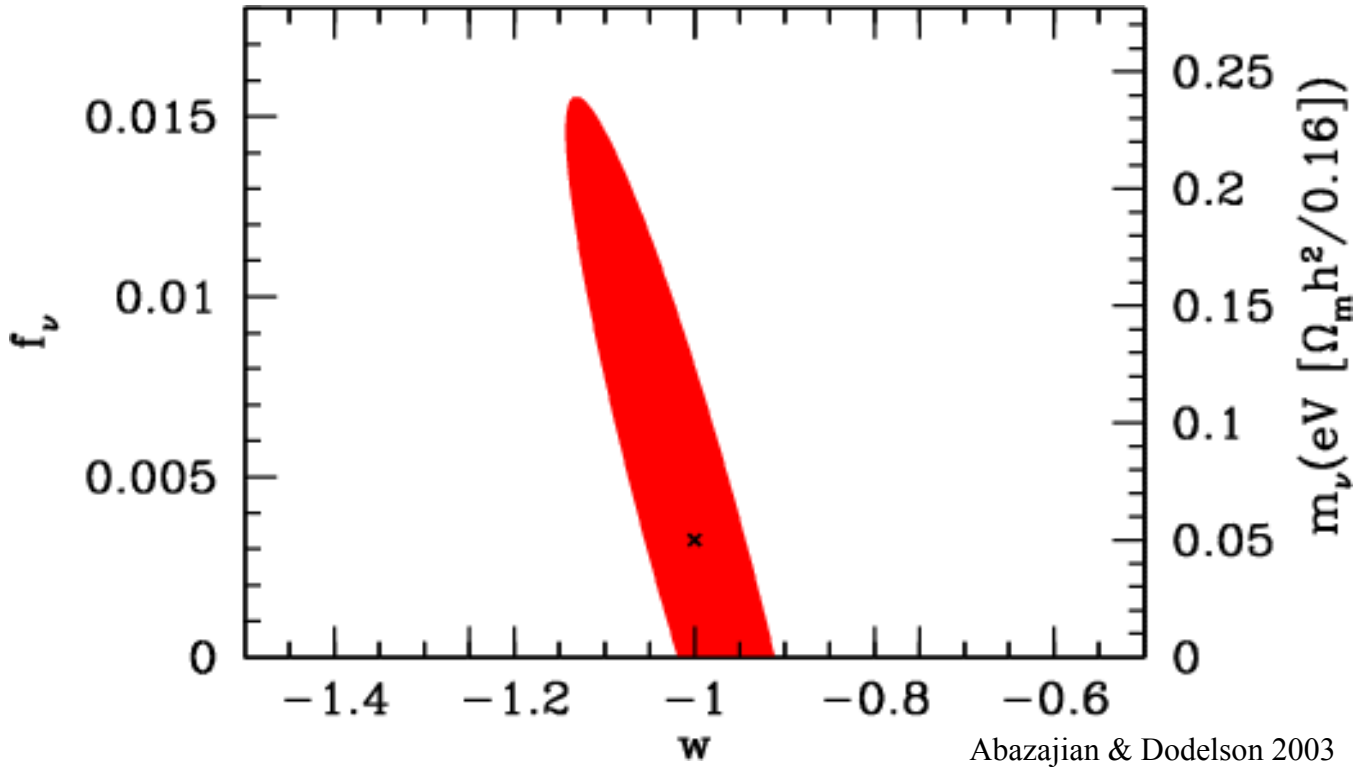
Pengjie Zhang (arrived from CITA)

Students:

Jun Zhang, Adam Lidz (Columbia)

Jim Chisholm, Eduardo Rozo, Dave Johnston (Chicago)

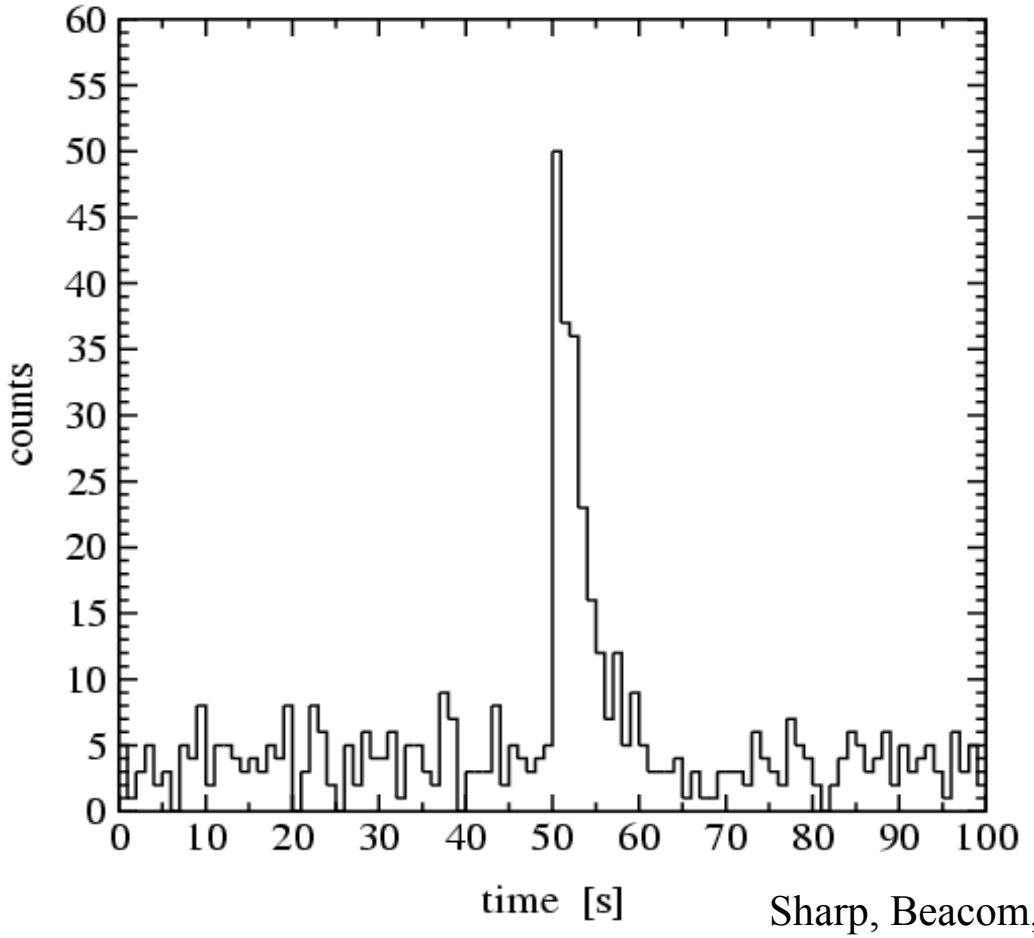
Dark Energy (and Neutrino Mass) with Weak Lensing



Abazajian & Dodelson 2003

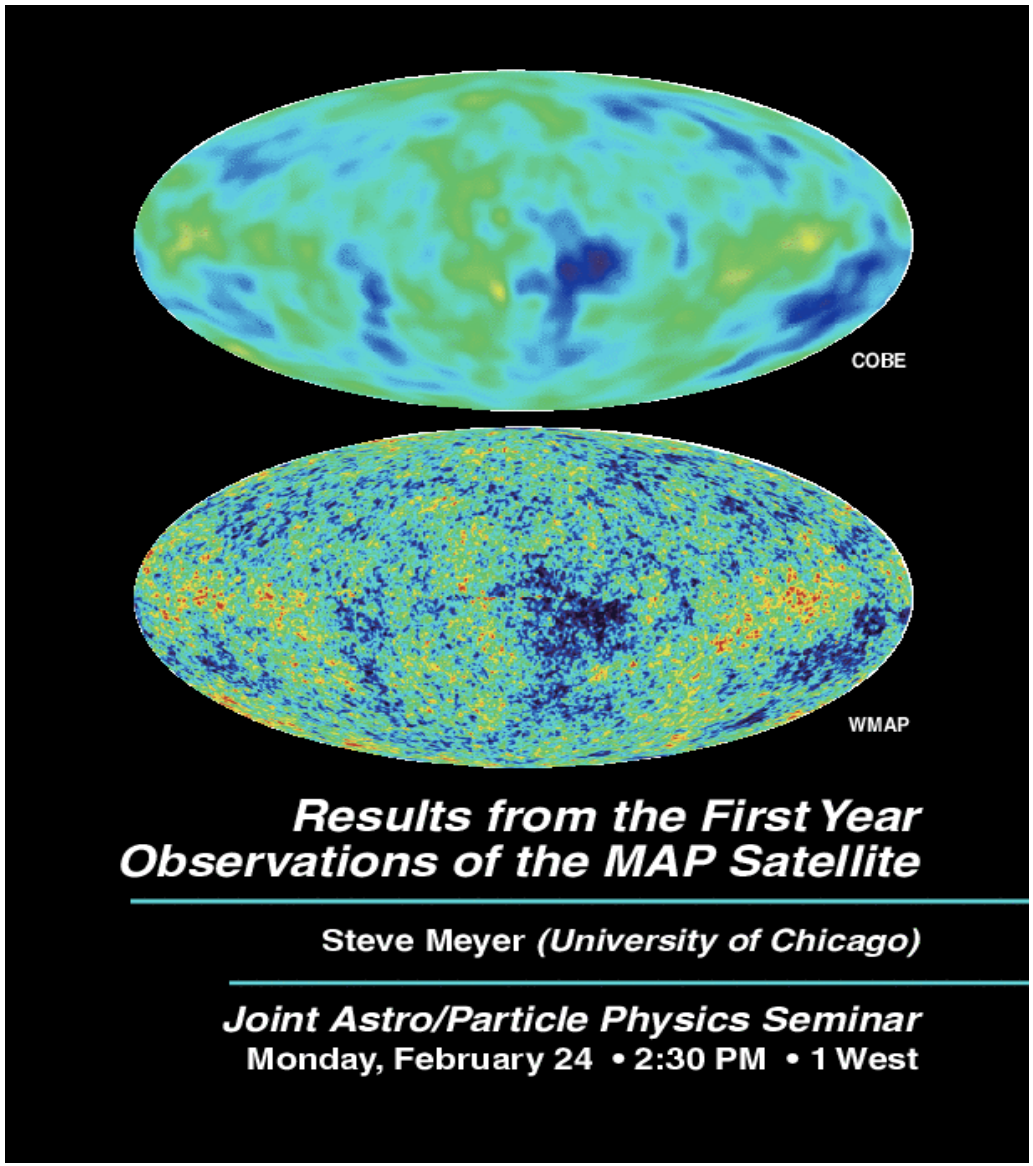
- How rapidly clumping proceeds in the universe depends on Neutrino Mass and Dark Energy
- Projections for deep survey covering 1/10 of the sky

Supernova Neutrinos with MiniBooNE



Sharp, Beacom, & Formaggio

Trigger-level cuts: reduce cosmic-ray muon background, leading to clear signal



Initiated *Joint Astro/Particle Physics Seminar* with Particle Theory Group. Inaugural seminar filled 1 West.

Important Results from WMAP we are studying:

- Structure formed very early. Is this reasonable? (Hui & Haiman, 2003)
- Inflationary models probed (Abazajian, Dodelson, Hui, Kolb, *in preparation*)
- Constraints on Neutrino Mass (Abazajian, Beacom, Bell, Dodelson, *in preparation*)

Neutrino News from the Lab and the Cosmos

Fermilab, 17-19 October 2002

This workshop will focus on cosmological and terrestrial probes of neutrino masses and mixing, highlighting the implications of recent results, and aiming to bring together members of the particle and astrophysics communities. Particular emphasis will be placed on the interplay and complementarity of cosmological and laboratory-based methods of determining neutrino properties, and future directions in both venues.

Topics Include:

Large Scale Structure	Direct Mass Limits
Small Scale Structure	Solar & Atmospheric Neutrinos
Cosmic Microwave Background	Reactor Neutrinos
Big Bang Nucleosynthesis	Short & Long Baselines

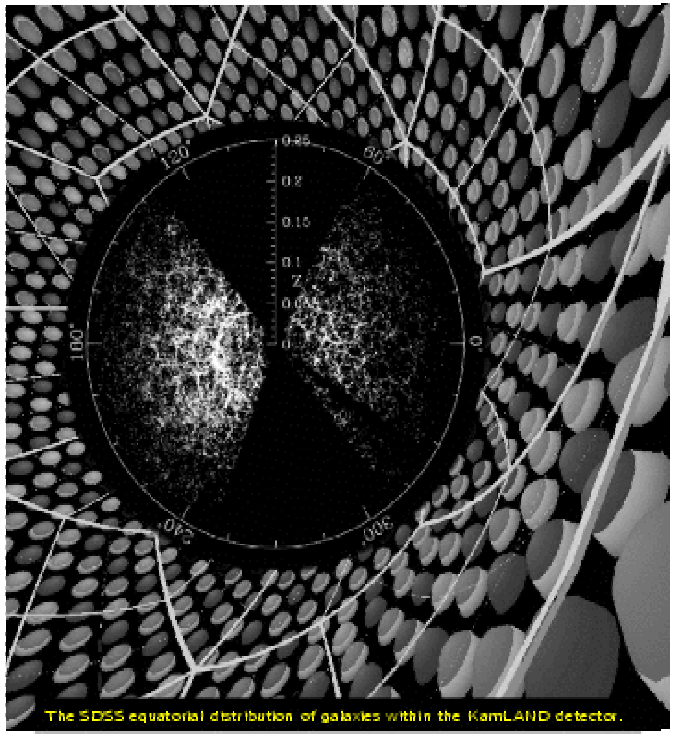
Local Organizing Committee:

Kev Abazajian & Nicole Bell

John Beacom, Janet Conrad, Scott Dodelson, Josh Frieman & Boris Kayser

Registration and schedule available at:

http://www-astro-theory.fnal.gov/Conferences/NuCosmo/



- Organized Neutrino workshop: > 130 people
- Organized Cosmo02 about Particle Physics and Cosmolgy: 260 attendees

Experimental Astrophysics Group

- **Staff Scientists**
  - **Chris Stoughton**
  - **Stephen Kent**
  - **Jim Annis**
  - **Rich Kron**
  - **Huan Lin**
  - **(John Peoples)**
  - **Douglas Tucker**
  - **Brian Yanny**
- **Postdocs**
  - **Hubert Lampeitl (Hamburg)**
  - **Sebastian Jester (Heidelberg)**
  - **Brian Lee ==> Postdoc (Berkeley)**
  - **Dan vanden Berk ==> Res. Prof. (Pittsburgh)**
- **Computing Professionals**
  - **Jen Adelman**
  - **Nikolai Kuropatkine**
  - **Dan Yocum**
  - **John Inkmann**
  - **John Hendry**
  - **Vijay Sekhri (NVO/iVDGL)**
- **Students**
  - **Brian Wilhite (UC)**
- **Visitors/Guests**
  - **Christobal Lara (Spain)**
  - **Rob Sparks ==> HS (Racine)**
  - **Susan Kayser**
  - **Sahar Allam ==> Postdoc (NMSU)**

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

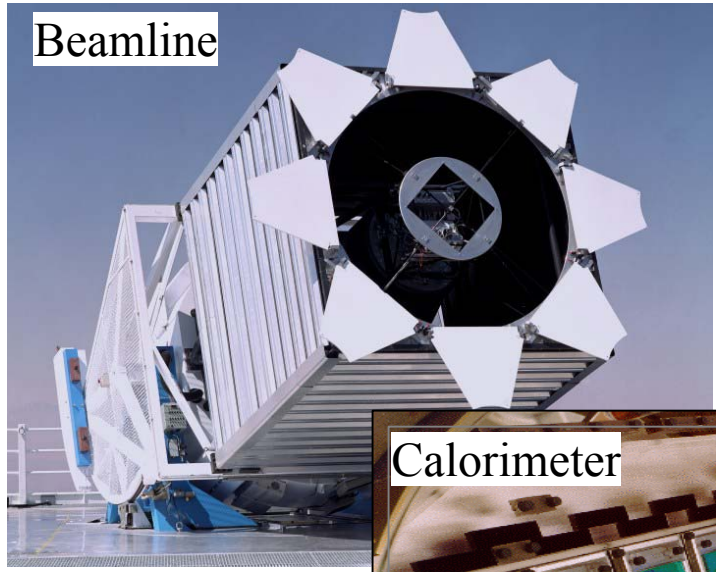
Resources:

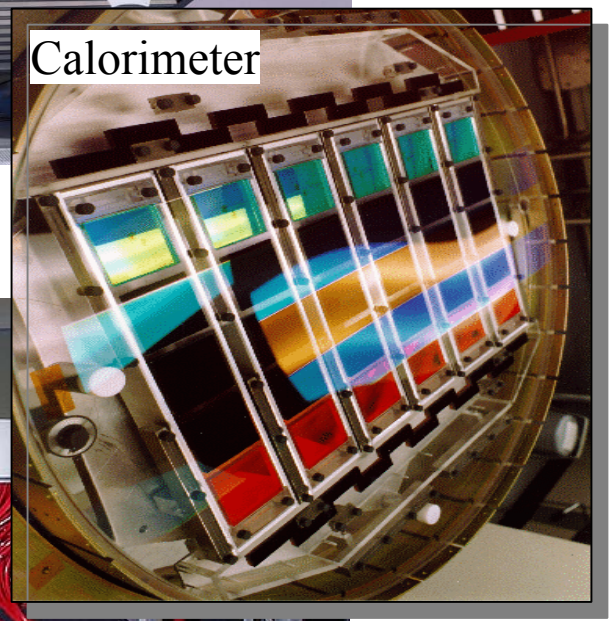
2.5 m telescope in New Mexico

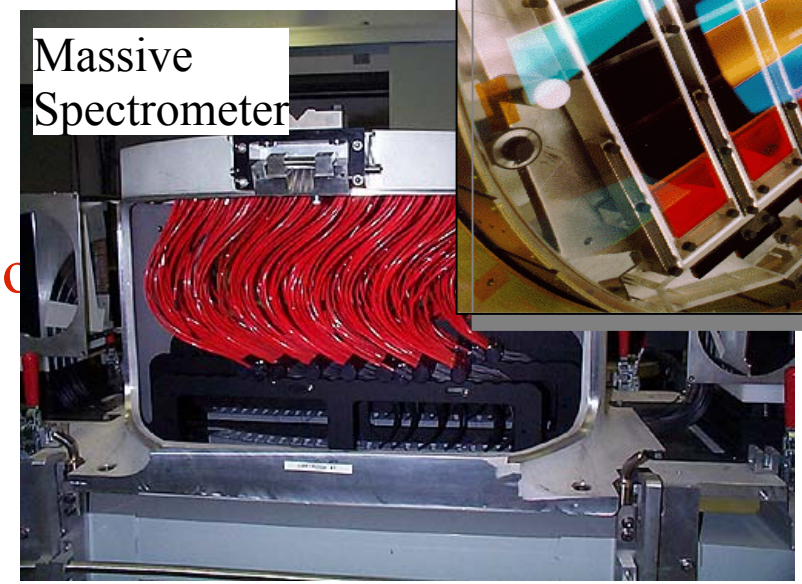
Large CCD camera

640 fiber spectrograph

11 partner institutions







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)
- Galaxy clusters (Annis, Kent, Tucker)
- Milky Way halo structure (Yanny, Kent)
- Galaxy evolution (Lin)
- QSO luminosity functions (Stoughton)
- Near Earth Asteroids (Kent)

Of 103 refereed papers, 17 have current or former FNAL scientist or student supervised by FNAL as lead author

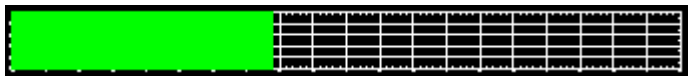
Particpants

- **EAG**
- TAG
- PPD
  - Bill Boroski
  - French Leger
  - Carlos Gonzalez
  - Steve Bastian
- Comp. Comm. Fabric (CD)
  - Don Holmgren
  - Eric Neilsen
  - Ron Rechenmacher
  - Valery Sergeev

SDSS Current Status (Mar 2003)

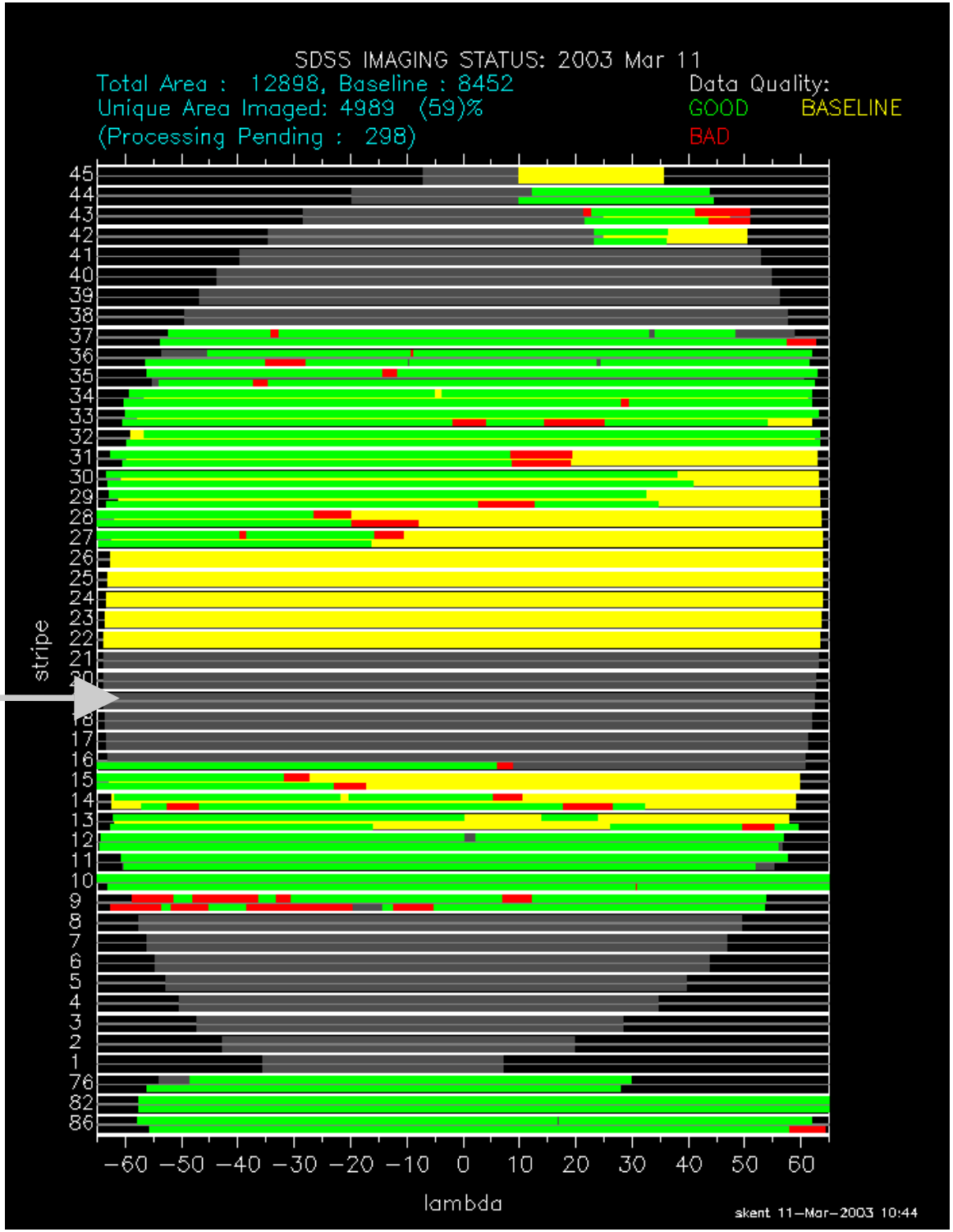
Imaging: 59% as of March 11, 2003

Spectroscopy: 41% as of March 11, 2003



Current operations funded thru June, 2005

A proposal is being developed to continue operations for another 2 or more years (fill the gap).

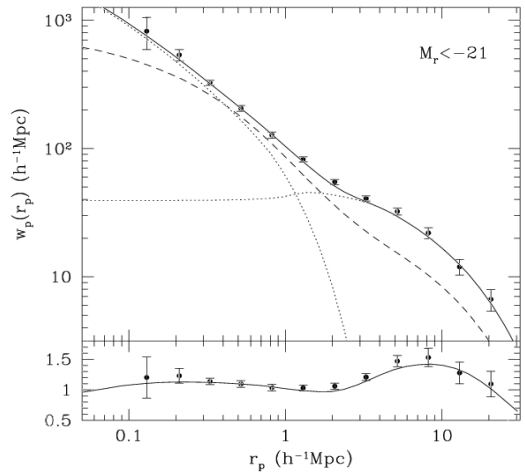


Research Highlights

- 31 papers submitted by collaboration in past year.
- 20 papers submitted by noncollaboration based on publicly released data (EDR)

Yet another speed record for QSOs (z=6.4)

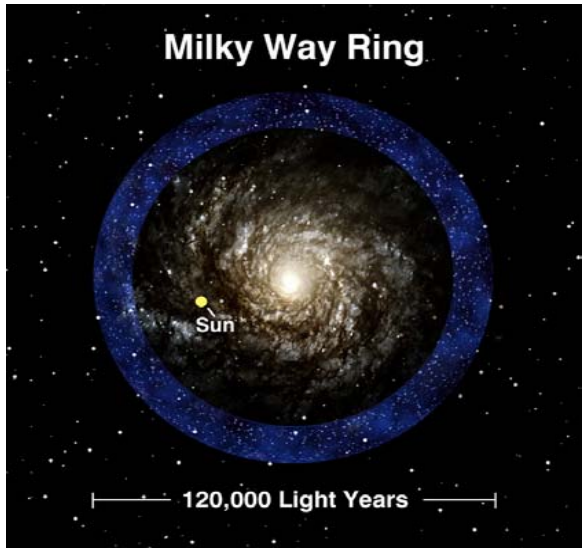
Improved galaxy 2 point correlation function

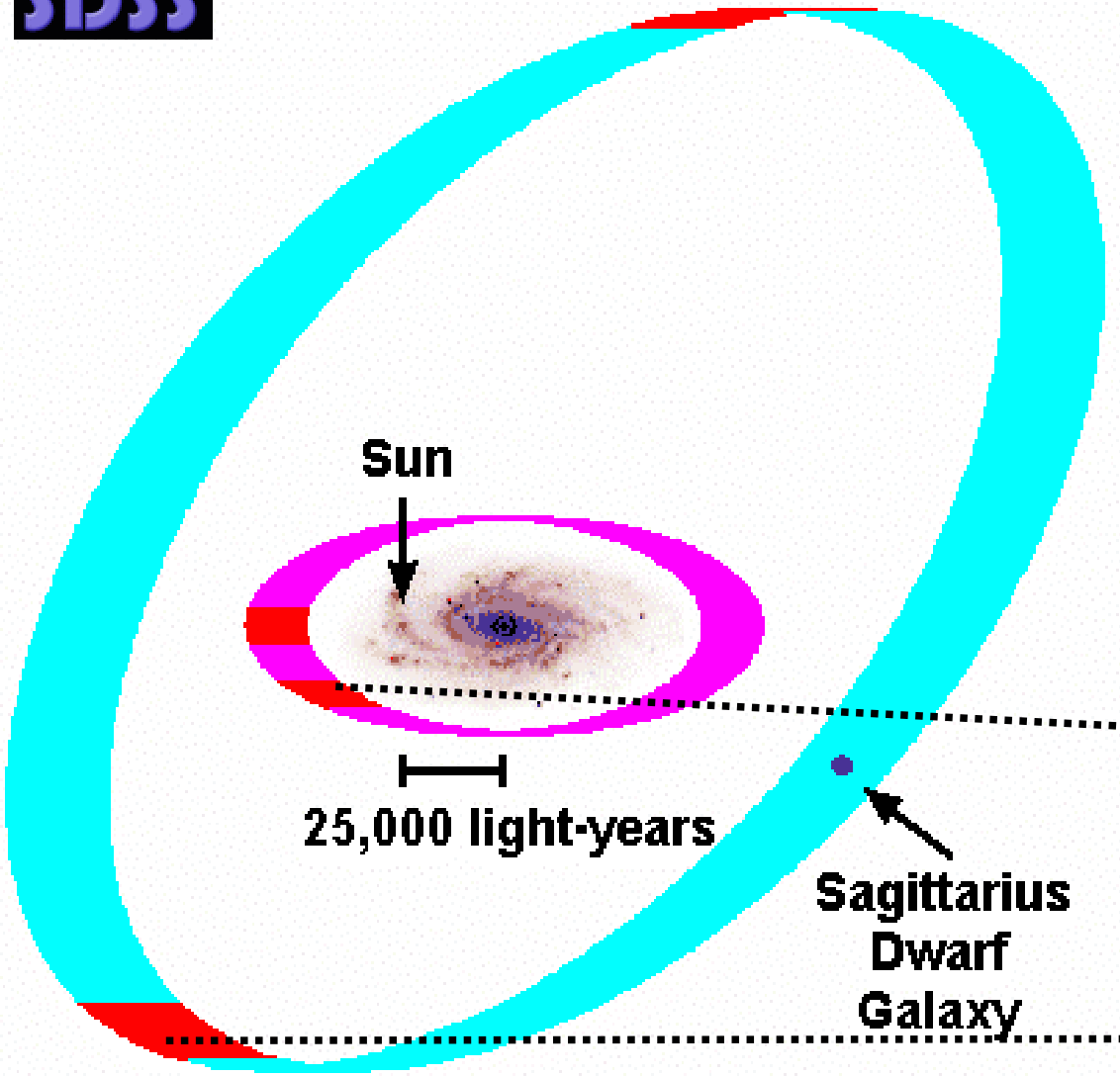


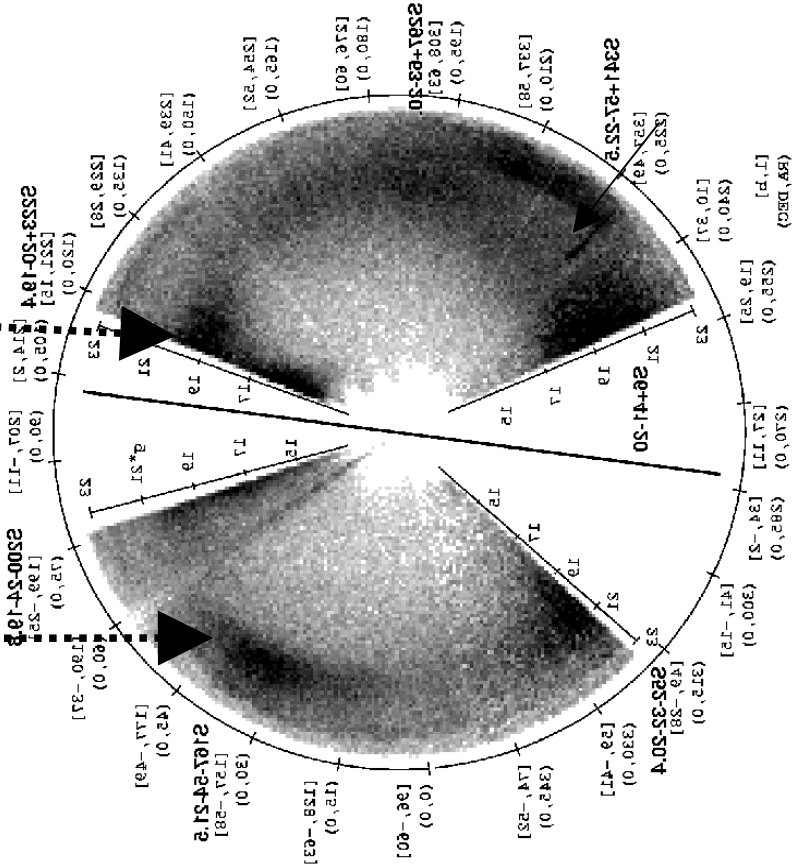
Ring around the Milky Way (see next slide)

Rings around the Galaxy

(Yanny & Newberg)







Data Release 1 to public imminent

All data through June 30, 2001

SDSS Data Release 1

Sloan Digital Sky Survey

- Where to Start
- News and Updates
- Data Products
- Data Access
- Sky Coverage
- Instruments
- Data Flow
- Algorithms
- Glossary
- Help and Feedback
- Search

The Sloan Digital Sky Survey (see www.sdss.org for general information) will map in detail one-quarter of the entire sky and perform a redshift survey of galaxies, quasars and stars. The data are released to the astronomical community in increments of 1-2 years. After last year's Early Data Release (EDR), the DR1 is the first major data release. It contains

- Imaging of a footprint of 2067 square degrees, and a photometric catalogue of 53 million unique objects
- Spectra of 186240 objects from 1556 square degrees of sky, comprising 134015 galaxies, 17705 quasars, 17623 stars, 9684 sky spectra, 4491 stars dominated by molecular bands (M or later), 1738 spectra with unknown classification, and 984 quasars at redshift $z > 2.3$.

We will provide news and updates of immediate relevance through this web page. If you are new to the SDSS, read "Where to start" first. Learn what SDSS provides on the Data products page, and how to obtain the data on the Data access page.

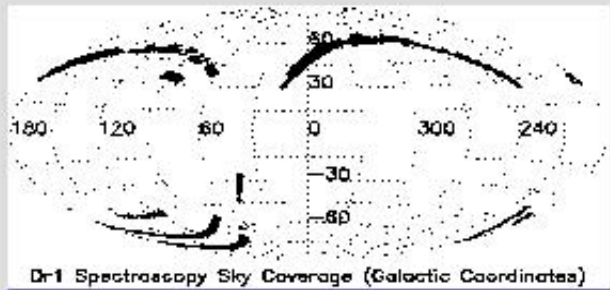
Please refer to the credits page for our sources of funding, participating institutions, and how to acknowledge the use of SDSS data in your publications.

This is version v0_30_30 .
Last modified: Fri Mar 7 15:06:12 CST 2003

If you are using Netscape 4.x and see oversized fonts, please look at the workaround on the Credits page.

Dr1 Best Imaging Sky Coverage (Galactic Coordinates)

Aitoff projection in Galactic coordinates of SDSS DR1 "Best" Imaging Sky Coverage



Dr1 Spectroscopy Sky Coverage (Galactic Coordinates)

Aitoff projection in Galactic coordinates of SDSS DR1 Spectral Sky Coverage

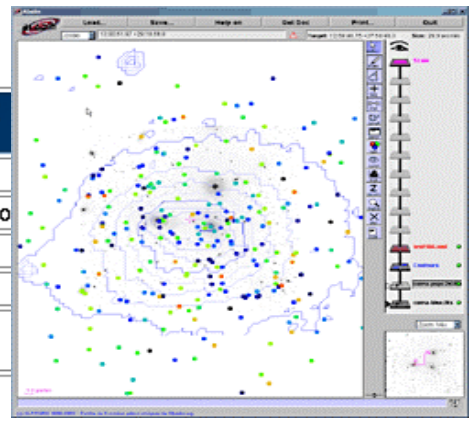
Send your questions to sdss-webmaster@sdss.org

Computational Projects

- Griphyn and iVDGL
- National Virtual Observatory (NVO)
  - Apply grid toolkits to problems in astrophysics
  - Provide testbed, develop grid-enabled applications using SDSS data for challenge problems
  - Create standards for astronomical data collections that will make data easier to use and facilitate joining multiple data collection

Galaxy Morphology Science Prototype: A Case Study in Grid Computing

Data Resources	Computing Resources
Chandra X-ray image (SAO/CXC)	USC/ISI
ROSAT image (GSFC/HEASARC)	UW-Madiso
DSS image (STScI/MAST)	Fermilab
Galaxy cluster catalogs (NED)	
CNOC1 cluster images and catalogs (CADC)	

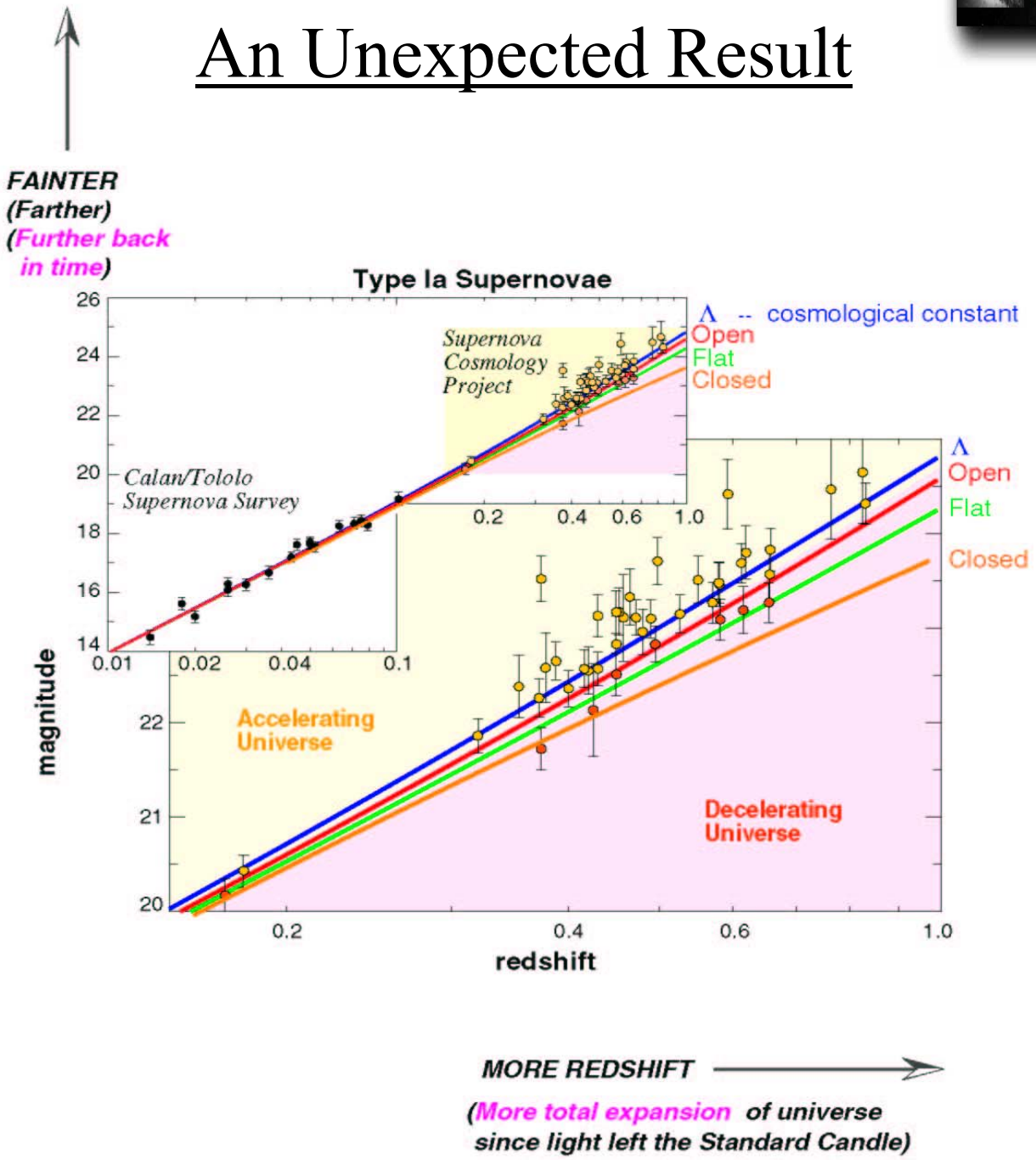


To the future ...What is SNAP?

- SNAP is a proposed space-based mission to probe the nature of dark energy and the accelerating universe.
  - ***A deep survey of Type Ia SNe, which are thought to be standard candles***
  - ***Expect to see ~2000 SNe Ia in 2-3 yrs***
  - ***Also has a 300 sq. deg. wide-field survey***
  - ***Launch ~2010, operate for 4 years***

- http://snap.lbl.gov
- SNAP is an important goal for DOE in this decade. It has CD-0 approval.
  - ***Centered at and managed from LBNL***
- A dark-energy mission is on the NASA roadmap, and an AO has been released for preliminary work.
  - **http://research.hq.nasa.gov/code_s/nra/current/nra-03-oss-01/appendA1_9.html**

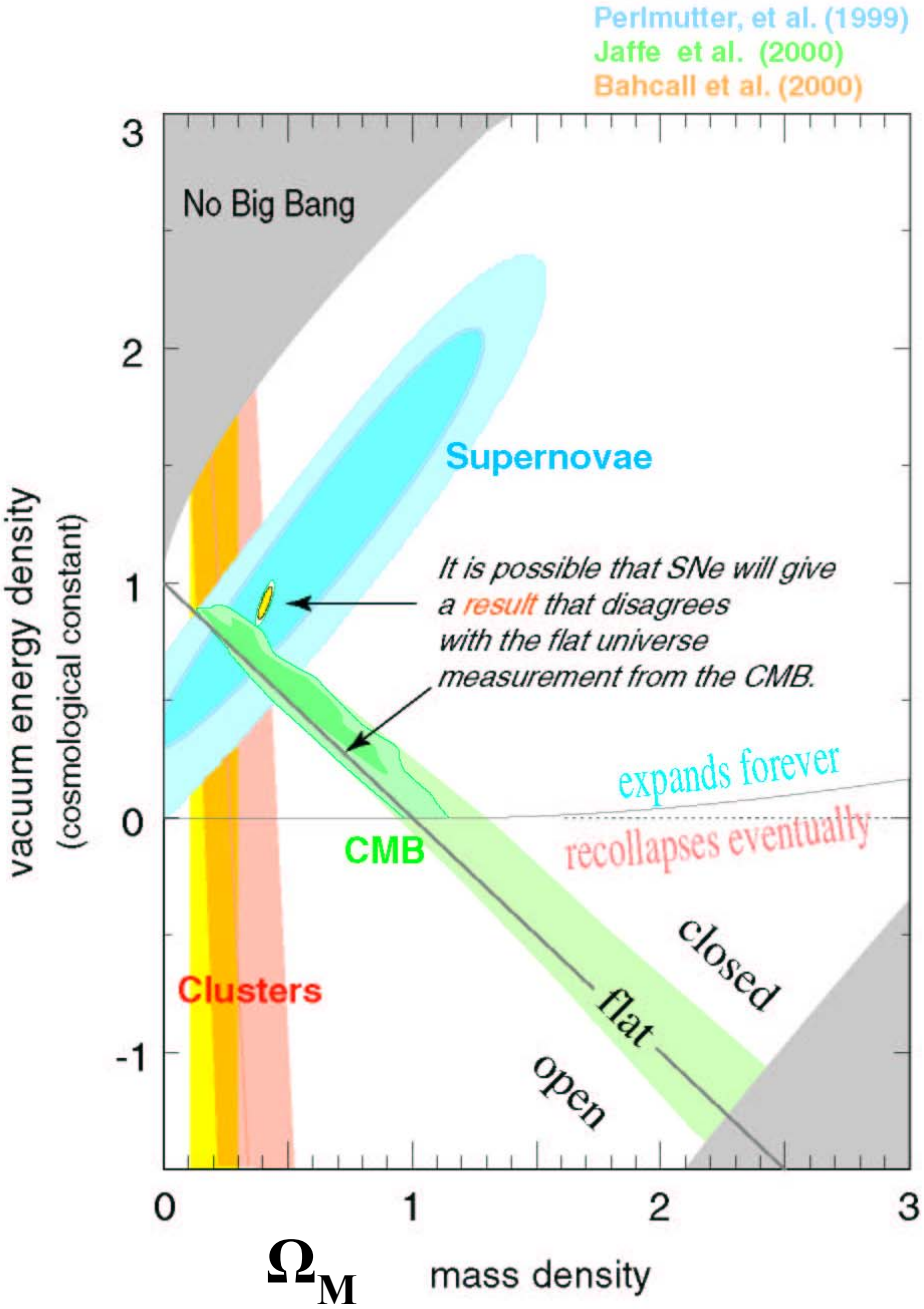
An Unexpected Result

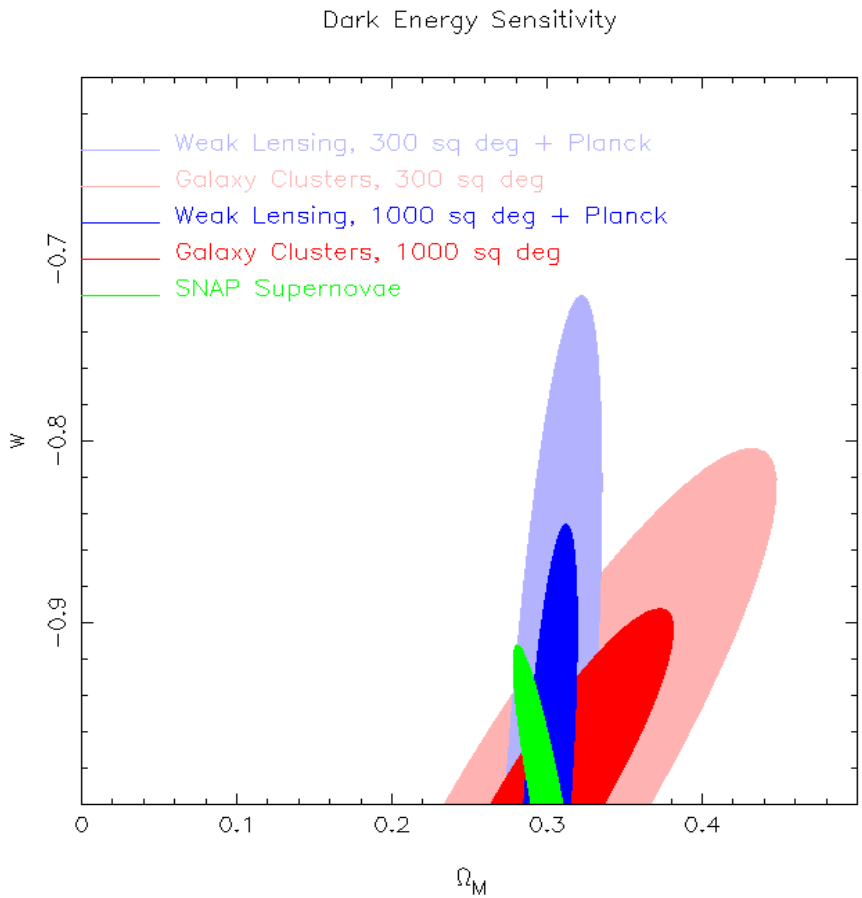


Dark Energy Eqn. of State

$$P = -w\rho$$

***w* = -1 Cosmological Constant**
***w* < -1 Quintessence**





Science Interests

- Many Fermilab scientists are interested in SNe deep survey because of its apparent straight-forward connection to dark energy.
- Some are also pushing an enlarged wide-field survey as a different look at dark energy and dark matter via galaxy clustering and weak lensing.
  - *It will provide results with different systematics*
  - *A 1000 sq. deg. survey may require some minor mission modifications*
- Some are also interested in the ancillary science on galaxies and quasars that will come from mining the enormous dataset.

Current Status

- Instigators: Peter Limon and Steve Kent
- Michael Witherell has encouraged us to "investigate" involvement in SNAP.
- ~30 Fermilab scientists have expressed interest.
- We have submitted a letter to the SNAP Collaboration asking for admission.

Proposed Contributions

- Science & Simulations
- Photometric Calibration
  - *Expertise due to SDSS work*
- Scientific Software & Archiving
  - *Expertise due to SDSS work*
- Electronics
  - *Solid-state recorder*
  - *Data compression hardware*
    - Both of above could help wide-field survey
  - *Electronics associated with IR detector (maybe)*
  - *Microwave systems for telemetry (maybe)*
    - Fermilab expertise in microwave & electronics
- Radiation Shields
  - *Cosmic-ray, light baffle, thermal*
  - *Involved in all three; concentrate on cosmic-ray shield and integration*
    - Uses GEANT & MARS design tools
    - Serious mechanical & thermal engineering requires solid modeling and sophisticated FEA