

# Theoretical Astrophysics

URA Visiting Committee

April 22, 2005

# Who We Are

Head: Scott Dodelson  
Deputy Head: Albert Stebbins  
Scientists: Joshua Frieman  
Rocky Kolb

David Schramm Fellow:  
Jochen Weller

Postdoctoral Fellows:  
Gianfranco Bertone  
Pengjie Zhang  
Mark Jackson  
Kenji Kadota

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Lam Hui (>> **Columbia University** faculty)

Nick Gnedin (< **University of Colorado** faculty)

Rachel Bean (< **Princeton** postdoc)

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Jochen Weller (> **University College London** faculty)

Dan Hooper (< **Oxford** postdoc)

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Chris Vale (< **Berkeley** Ph.D.)

Emiliano Sefussati (< **NYU** Ph.D.)

offers

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turned down

**Expect 1 hire next year!**

# Who We Are

## Special Guests

“To enrich and further elevate scientific atmosphere at the Particle-Astrophysics Center”

- **Distinguished Astrophysics Visitor**

Entice an outstanding (and hard to get) astrophysicist to spend about 1 month at the astrophysics center.

September 2004 Craig Hogan

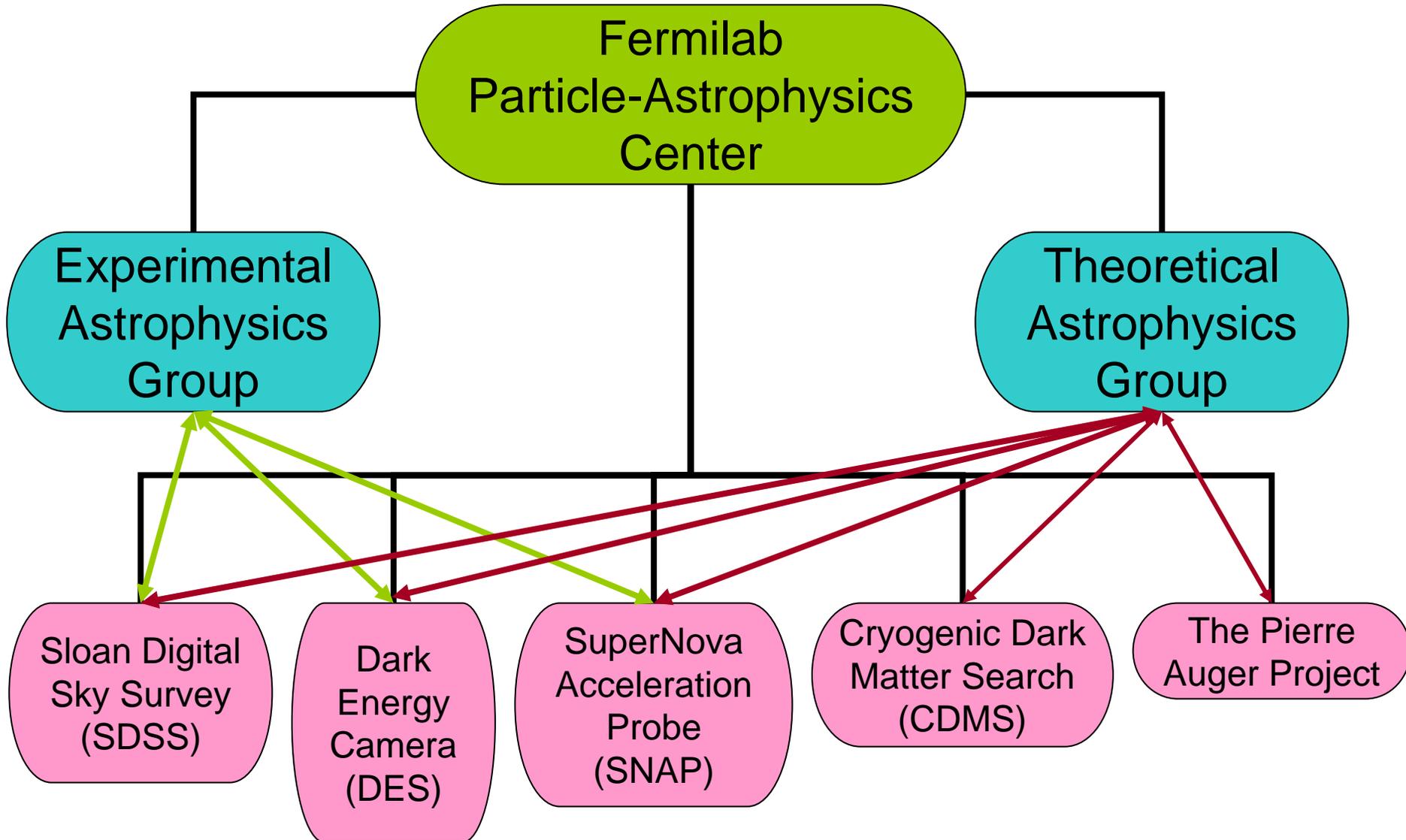
- **Brinson Predoctoral Fellow**

An outstanding Ph.D. student spends final year of study at Astrophysics center.

2004-2005 Michele Liguori

N.B. these positions are really Center not Group Positions.

# Astrophysics @ FNAL



# What do we Do?

Research ) Publications  
sample Fermilab-PUB-...-A 2004@SPIRES

- 01) **SHOWER POWER: ISOLATING THE PROMPT ATMOSPHERIC NEUTRINO FLUX USING ELECTRON NEUTRINOS**
- 02) **THE SECOND DATA RELEASE OF THE SLOAN DIGITAL SKY SURVEY**
- 03) **NEUTRINOS FROM DARK MATTER ANNIHILATIONS AT THE GALACTIC CENTER**
- 04) **MICROLENSING OF THE BROAD EMISSION LINE REGION IN THE QUADRUPLE LENS SDSS J1004+4112**
- 05) **CMB - CLUSTER LENSING**
- 06) **PROBING THE EVOLUTION OF THE DARK ENERGY DENSITY WITH FUTURE SUPERNOVA SURVEYS**
- 07) **HALO MODEL ANALYSIS OF CLUSTER STATISTICS**
- 08) **ANGULAR CORRELATIONS OF THE MEV COSMIC GAMMA RAY BACKGROUND**
- 09) **COSMOLOGICAL PARAMETERS FROM EIGENMODE ANALYSIS OF SLOAN DIGITAL SKY SURVEY GALAXY REDSHIFTS**
- 10) **OBSERVATIONS AND THEORETICAL IMPLICATIONS OF THE LARGE SEPARATION LENSED QUASAR SDSS J1004+4112**
- 11) **SDSS J115517.35+634622.0: A NEWLY DISCOVERED GRAVITATIONALLY LENSED QUASAR**
- 12) **THE GALAXY - MASS CORRELATION FUNCTION MEASURED FROM WEAK LENSING IN THE SDSS**
- 13) **SDSS J1335+0118: A NEW TWO - IMAGE GRAVITATIONAL LENS**
- 14) **INFLATIONARY POTENTIALS YIELDING CONSTANT SCALAR PERTURBATION SPECTRAL INDICES**
- 15) **THE 3-D POWER SPECTRUM OF GALAXIES FROM THE SDSS**
- 16) **COSMOLOGICAL PARAMETERS FROM SDSS AND WMAP**
- 17) **GADZOOKS! ANTI-NEUTRINO SPECTROSCOPY WITH LARGE WATER CHERENKOV DETECTORS**
- 18) **SENSITIVITY TO  $\theta_{13}$  AND  $\Delta$  IN THE DECAYING ASTROPHYSICAL NEUTRINO SCENARIO**
- 19) **CLUSTER MASSES ACCOUNTING FOR STRUCTURE ALONG THE LINE OF SIGHT**
- 20) **THE EFFECT OF CLUSTER MAGNETIC FIELD ON THE SUNYAEV ZELDOVICH POWER SPECTRUM**
- 21) **PSEUDODIRAC NEUTRINOS: A CHALLENGE FOR NEUTRINO TELESCOPES**
- 22) **LORENTZ INVARIANCE VIOLATION IN TOP - DOWN SCENARIOS OF ULTRAHIGH-ENERGY COSMIC RAY CREATION**
- 23) **IS COSMIC SPEED-UP DUE TO NEW GRAVITATIONAL PHYSICS?**
- 24) **BEYOND LYMAN  $\alpha$ : CONSTRAINTS AND CONSISTENCY TESTS FROM THE LYMAN  $\beta$  FOREST**
- 25) **WMAPPING INFLATIONARY PHYSICS**
- 26) **PRECISION ERA OF THE KINETIC SUNYAEV-ZELDOVICH EFFECT: SIMULATIONS, ANALYTICAL MODELS ...**
- 27) **ON DEPARTURES FROM A POWER LAW IN THE GALAXY CORRELATION FUNCTION**
- 28) **EVERPRESENT LAMBDA**

**THEORY**

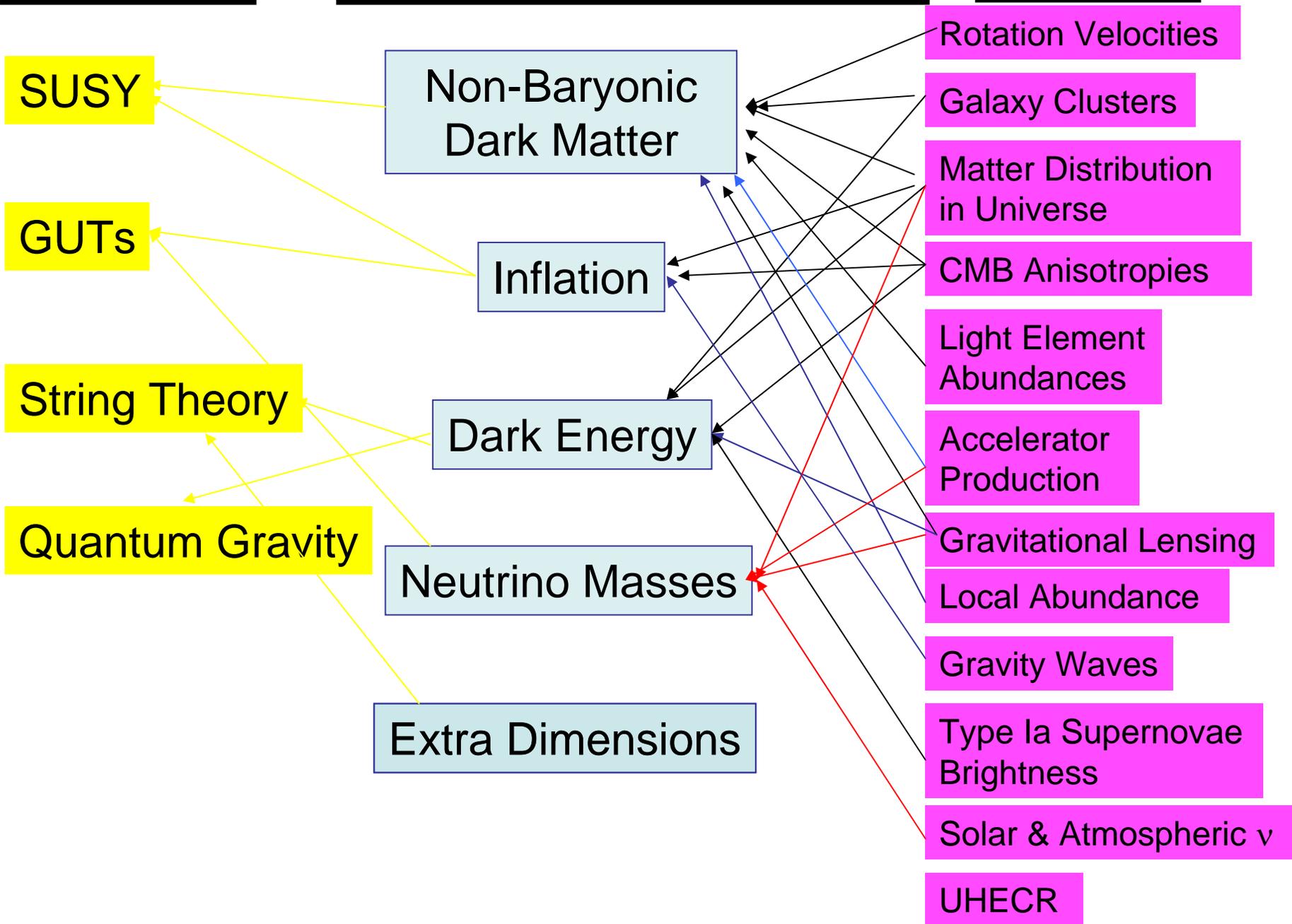
**TECHNIQUES**

**DATA INTERPRETATION**

*Fundamentals*

*Physics Beyond the Standard Model*

*Phenomena*



# Re-Ionization of Universe *a la* Nick Gnedin

QuickTime™ and a  
YUV420 codec decompressor  
are needed to see this picture.

# What We Do

Theoretical Astrophysics' key role in **creating** new projects @ FNAL

- o **SDSS** circa 1990-2005
  - o **Kolb, Turner, Schramm** played a important role in starting SDSS
- o **SDSS extension** 2005-
  - o The SDSS extension seems likely to go ahead and contains 3 main projects
    - o Legacy - fill in the gap in original SDSS survey area
    - o Supernova search - find intermediate redshift Type Ia SNe
    - o SEGUE - Galactic structure
  - o The 1st 2 (new) science products crucial in justifying extension
  - o the originator and prime mover behind the SNe search was **Frieman!**
- o **Dark Energy Survey** (DES) 2004-
  - o **Frieman** one of the prime movers behind DES (1st on VISTA then Blanco)
  - o **Frieman, Dodelson, and Stebbins** among “authors” of project proposal

Theoretical Astrophysics' **service work** for new projects @FNAL

- o **Frieman** head of SDSS large-scale structure working group
- o **Frieman** oversaw development of SDSS spectroscopic software
- o About third of group very active participants in SDSS working groups
- o SNAP and DES white papers
- o N.B. postdoc job description **is not** service work oriented!

# What We Do

Organize/Host Workshops/Conferences/Schools

07/05 TeV Particle-Astrophysics

12/04 Fundamental Physics from Clusters of Galaxies (>150 participants!)

05/04 From Zero to Z0: A Workshop on Precision Electroweak Physics

11/03 de Sitter Days

10/02 Neutrino News From the Lab and the Cosmos

09/02 COSMO-02: International Workshop on Particle Physics and the Early Universe

05/01 Workshop on Structure Formation and Dark Matter Halos

05/99 Inner Space/Outer Space II

01/99 Pritzker Symposium & Workshop

09/98 Young Scholars Institute in Astroparticle Physics

12/96 18th Texas Symposium on Relativistic Astrophysics

12/96 Weak Lensing Workshop

04/96 Solar Neutrino Workshop

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05/87 Quantum Cosmology Workshop

12/86 13th Texas Symposium on Relativistic Astrophysics

12/86 Workshop on Cosmic Strings

05/84 Inner Space/Outer Space I

# How Are We Doing?

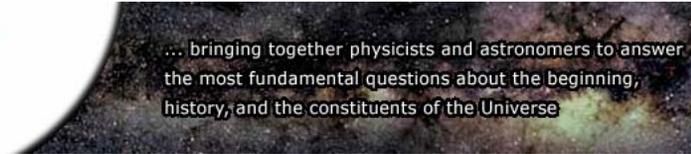
- 32/133 (24%) NASA ATP proposals funded
- Grant for \$245k/year, ~5 times higher than average grant
- Evaluation: “There is no weakness in the group of permanent astro-staff” and “... they arguably constitute the best collection of theoretical cosmologists in the world.” and “The group consistently attracts and trains very good postdocs, and places them in faculty jobs at elite institutions.”
- N.B. present grant quite exceptional and budgets may be decreasing ...

# We've company ...

KIPAC: The Kavli Institute for Particle Astrophysics and Cosmology



Theoretical Cosmology  
Research Description



Center for Education and Research in Cosmology and Astrophysics



# Established Collaborations with many groups

- Dodelson, Frieman, & Kolb part-time faculty at **University of Chicago (UC)**
- ~60% of 2004 non-SDSS paper w/ external  co-authors
- SDSS (UC, **Princeton**, **JHU**, ... )
- DES (UIUC, UC, **LBNL**, **NCSA**, **NOAO**, UCL, Barcelona)
- SNAP (**LBNL**, **UCB**, Caltech, Michigan, UPenn, **Yale**, **Indiana**, **JHU**, **INSU**, **UStockholm**, **LAM**)
- Parallel Computing (**LANL**)
- Summer Workshops (**LANL**) Frieman, Dodelson, co-organizers.
- Frieman is Orson Anderson Scholar @ **LANL** 02/05-07/05

# Conclusion

## PROGRESS:

- Gnedin hire should fill gap in computational astrophysics
  - N.B. CD (hardware) support may be needed

## GOALS:

- Keep high level/productivity in theory research
  - One more “faculty” hire next year
- Support nascent projects (DES, SNAP/JDEM)
- Strengthen Ties to Fundamental Physics
  - in particular the FNAL particle theory group
- Support nascent Particle-Astrophysics Center
- On lookout for new project opportunities for FNAL

## OUTLOOK

- One can **see** a vibrant future for at least a 10-15 years:
  - SDSS/DES/SNAP data provides fuel if needed