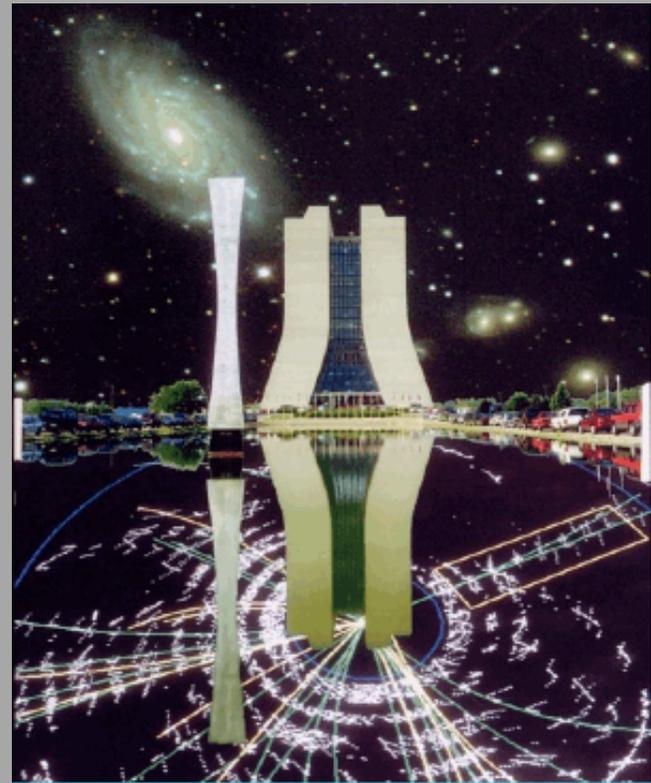


Theoretical Astrophysics Group @ Fermilab

Albert Stebbins
Theoretical Astrophysics Group
Fermi National Laboratory
stebbins@fnal.gov

Annual DOE Review
September 26, 2007



Who We Are

Head:

Albert Stebbins

Deputy Head:

Nick Gnedin

Other Scientists:

Scott Dodelson

Joshua Frieman

Dan Hooper

NEW promoted from Schramm Fellow

Ted Baltz

Darren Croton

Olivier Dore

Dragan Huterer

Patrick McDonald

Jeff Newman

Hiranya Peiris

David Schramm Fellow:

vacant

Hy Trac

lost to Harvard/CfA

Postdoctoral Fellows:

Emiliano Sefussati

Pasquale Serpico

Chris Vale

Mark Jackson

Hee-Jong Seo

NEW shared w/ Particle Theory Group

NEW (Arizona Ph.D.)

Ryan Scranton

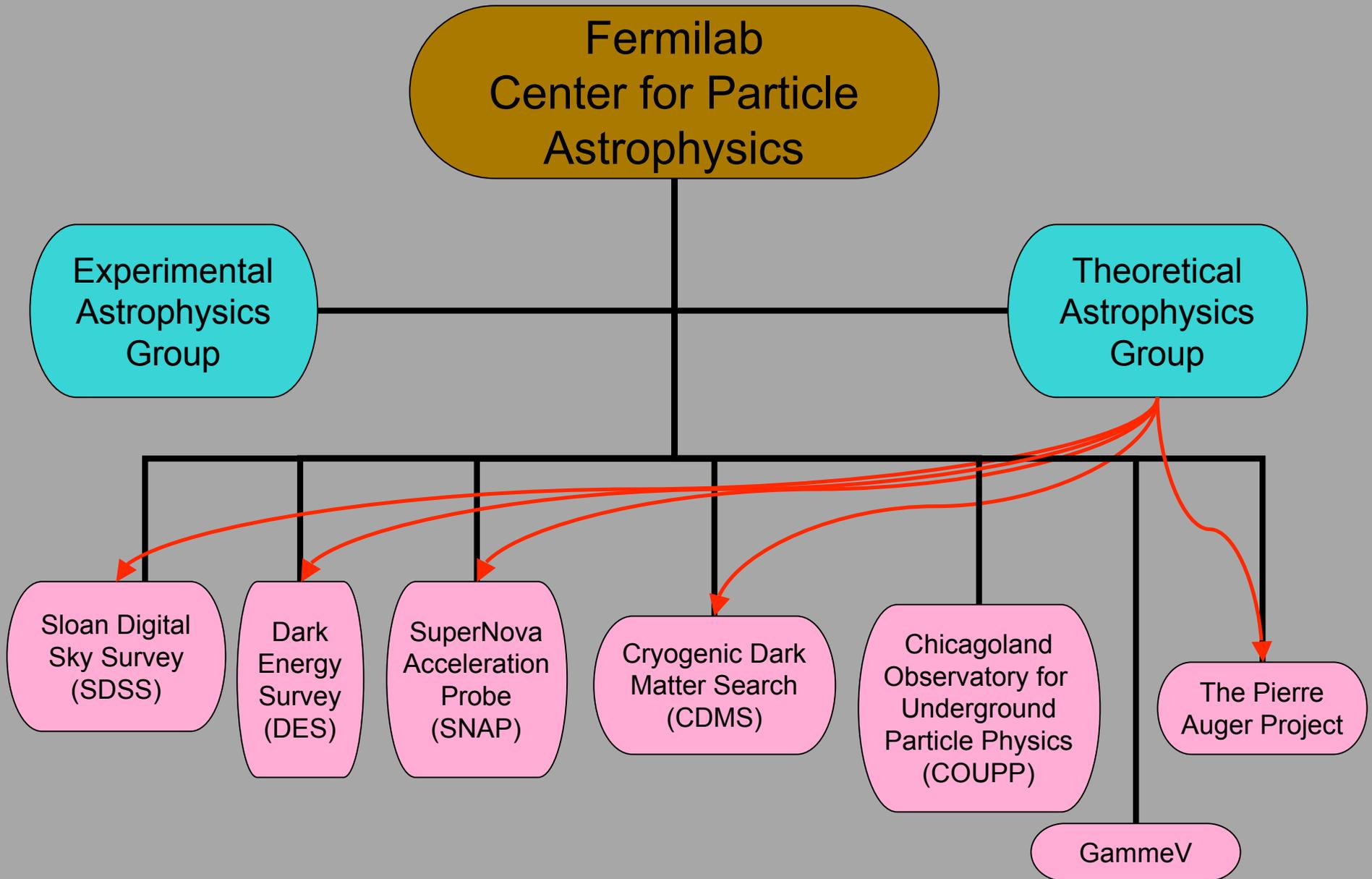
stayed w/ **Google**

What We Do?



- o **Environment:** Foster exciting, innovative, focused intellectual environment.
 - o Mix of staff scientists, postdocs, and long term visitors/students.
 - o Seminars, workshops, short term visitors.
 - o Individual participation in external collaborations and conferences.
- o **Productivity:** produce new scientific results, support lab programs/projects.
 - o Scientific publications.
 - o New projects (played important role SDSS I&II, SNAP, DES, Auger)
- o **Citizenship:** support of scientific infrastructure (lab/Chicagoland/U.S./world)
 - o Education/Outreach: teaching (U.C., summer schools), students (U.C., Colorado, Howard, IMSA), books, public lectures.
 - o Quality Control: Refereeing/Editing, Grant/Program Reviews
 - o Making the Future: Center for Particle Astrophysics, committees (Dark Energy Task Force).

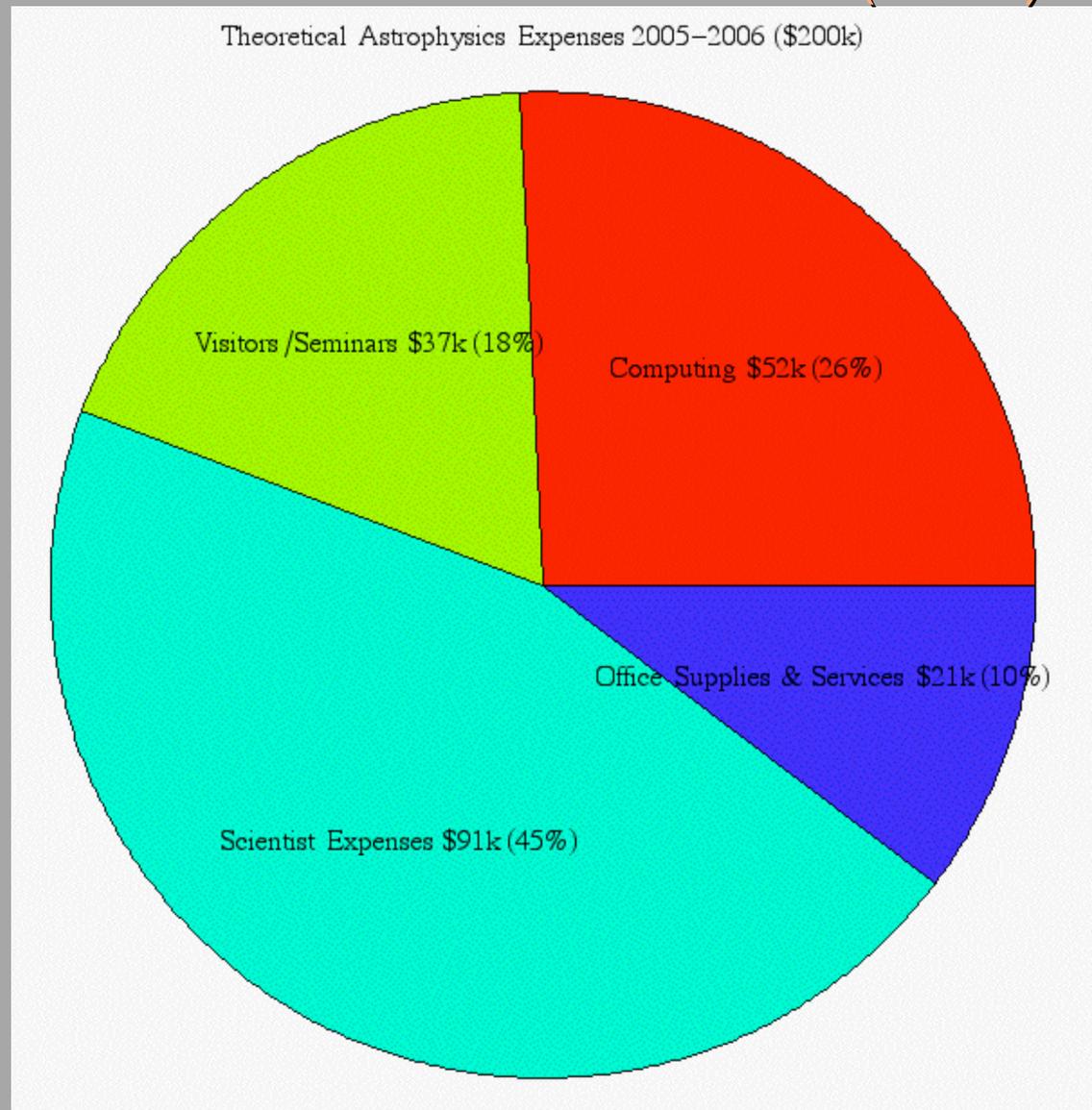
Astrophysics @ FNAL



What We Do?

materials and services (FY06)

4 Scientists
1 Associate Scientist
4.5 Research Associates
FY07 personnel costs
w/o OH “~\$0.9M”
Emerging fCPA
complicates budgetary #s.



External Funding

- Some staff have part in grants @ Uchicago for students, etc.
- Many visitors come with their own money.
- Interest in area Joint Postdocs (ANL, NWU).
- Astro Computing initiative is a collaboration w/ U.C. (growth: ANL, LANL, LBNL, ...?)
 - won FRA grant.
- Trying small focused grant proposals to NASA
 - *Searching for Particle Identity of Dark Matter* - Hooper
 - *Modeling Reionization of Helium* - Gnedin

What We Do?

Research Publications

- 01) Prospects For Detecting Dark Matter With GLAST In Light Of The WMAP Haze.
- 02) Clustering properties of ultrahigh energy cosmic rays and the search for their astrophysical sources.
- 03) Predictions for the Cosmogenic Neutrino Flux in Light of New Data from the Pierre Auger Observatory.
- 04) The Mass Of The Coma Cluster From Weak Lensing In The Sloan Digital Sky Survey.
- 05) The Sloan Digital Sky Survey-II Supernova Survey: Technical Summary.
- 06) The Sloan Digital Sky Survey Quasar Lens Search. 2. Statistical Lens Sample from the Third Data Release.
- 07) The Sloan Digital Sky Survey Quasar Lens Search. 3. Constraints on Dark Energy from the Third Data Release Quasar Lens Catalog.
- 08) A New Constraint on the Escape Fraction in Distant Galaxies Using Gamma-ray Burst Afterglow Spectroscopy.
- 09) Escape of Ionizing Radiation from High Redshift Galaxies.
- 10) High Energy neutrino signals from the Epoch of Reionization.
- 11) Spinless photon dark matter from two universal extra dimensions.
- 12) Detecting Axion-Like Particles With Gamma Ray Telescopes.
- 13) Evidence for nearby universe structures in the ultrahigh energy sky.
- 14) Interactions of cosmic superstrings.
- 15) Evidence Of Dark Matter Annihilations In The WMAP Haze.
- 16) The bispectrum of galaxies from high-redshift galaxy surveys: Primordial non-Gaussianity and non-linear galaxy bias.
- 17) PArthENoPE: Public Algorithm Evaluating the Nucleosynthesis of Primordial Elements.
- 18) Signatures of axion-like particles in the spectra of TeV gamma-ray sources.
- 19) MeV Dark Matter and Small Scale Structure.
- 20) A discriminating probe of gravity at cosmological scales.
- 21) The Sloan Digital Sky Survey Quasar Catalog. 4. Fifth Data Release.
- 22) Modeling the three-point correlation function.
- 23) Cosmological Constraints from SDSS maxBCG Cluster Abundances.
- 24) CMB Spectral Distortions from the Scattering of Temperature Anisotropies.
- 25) Impact of astrophysical processes on the gamma-ray background from dark matter annihilations.
- 26) High-energy neutrinos from astrophysical accelerators of cosmic ray nuclei.
- 27) Weak Lensing of Baryon Acoustic Oscillations.
- 28) Angular Signatures of Dark Matter in the Diffuse Gamma Ray Spectrum.
- 29) The path to metallicity: Synthesis of CNO elements in standard BBN.
- 30) New constraints on neutrino masses from cosmology.
- 31) Cosmological neutrino mass detection: The Best probe of neutrino lifetime.
- 32) The Signature of Large Scale Structures on the Very High Energy Gamma-Ray Sky.
- 33) The Peculiar SN 2005hk: Do Some Type Ia Supernovae Explode as Deflagrations?
- 34) Cosmic microwave background and large-scale structure constraints on a simple quintessential inflation model.
- 35) The 8 O'clock Arc: A Serendipitous Discovery of a Strongly Lensed Lyman Break Galaxy in the SDSS DR4 Imaging Data.
- 36) First hints of large scale structures in the ultrahigh energy sky?
- 37) Star Formation in a Cosmological Simulation of Reionization.
- 38) Scaling Relations of Dwarf Galaxies without Supernova-Driven Winds.

THEORY

TECHNIQUES

DATA

DATA INTERPRETATION

What We Do?

Seminar Series - now shared w/ CPA

Gordon - Isotropy from a Linear Modulation of the Primordial Perturbations
Roszkowski - Solution to the Omega_b - Omega_M Coincidence Puzzle
Dodelson - Dark Matter vs. Modified Gravity
Scoccimarro - Nonlinear Evolution of Baryon Acoustic Oscillations
Calcagni - Tachyon dark energy models: Dynamics and constraints
Abazajian - Dark Matter in the Neutrino Sector: Sterile Neutrinos
Boylan-Kolchin - The Assembly of Massive Galaxies and their Central Black Holes
Poznanski - GW progenitors and rates from low-cost surveys with no spectroscopy
Conroy - Modeling Galaxy Clustering and the Build-up of Stellar Mass Through Cosmic Time
Razoumov - From small to large scales at high redshifts: escape of ionizing photons and absorption properties of young galaxies
Gorodetzky - EUSO: Resurrection then maybe Ascension instead of Cosmic Vision
Klypin - Motion of satellites of galaxies: Newton against MOND
Babich - The Inhomogeneous Nature of Reionization
Oh - New views of the High-Redshift Universe
Evrard - Two Reports on Galaxy Clusters: the Halo Virial Scaling Relation and Red Sequence Cluster Finding
Blondin - Determining the Type, Decline, and Phase of a Supernova Spectrum
Lim - Large Non-gaussianities from Single Field Inflation
Rigopoulos - The evolution of non-linear perturbations in inflation
Stojkovic - Black Hole Formation, Evaporation and the Information Loss Paradox
Wu - First Results from MAXIPOL and Status of AMiBA
Voit - Galaxy Clusters Scaling Relations and Cosmology
Seo - Probing dark energy with baryon acoustic oscillations from future large galaxy redshift surveys
Trac - Radiative transfer simulations of cosmic reionization
Dall'Aglio - The Proximity Effect in high redshift QSOs, Observations and Simulations
Ferrer - Indirect detection of light neutralino dark matter
Weller - Cosmology with Sunyaev-Zeldovich Galaxy Cluster Counts
Stebbins - An Anthropocentric Universe?
Dore - Cosmological Microwave Background: the Next Chapter
Cirelli - Cosmological constraints on light sterile neutrinos (and the ways around them)
Shi - LAMOST (Large Aperture Multiple-Object Survey Telescope) project
Kistler - High-Energy Neutrinos: Spawn of Cosmic Rays
Newman - DEEP2 and Beyond: Testing Fundamental Physics with Surveys
Croton - How to model the Universe in N easy steps (N>>1)
McDonald - Probing inflation, dark matter, dark energy, etc. using the Lyman-alpha forest
Bradac - Shedding Light on Dark Matter: Seeing the Invisible with Gravitational Lensing
Peiris - Understanding Cosmic Acceleration: Connecting Theory and Observation
Siegel - Probing Dark Matter Substructure with Pulsars
Troita - Constraining dark energy - observational status and prospects
Pavlodou - Deciphering the GeV Sky: Gamma-Ray Astronomy in the Era of GLAST
Perez - Warped DGP: self acceleration, ghosts and other beasts
Horan - VERITAS: Current Status and Future Plans
Strigari - Determining the Nature of Dark Matter with Astrometry
Profumo - Probing Supersymmetric Baryogenesis: from Electric Dipole Moments to Neutrino Telescopes
Pocar - The status of the Enriched Xenon Observatory (EXO)
Kuhlen - The Via Lactea simulation -- DM (sub)structure in the Milky Way
Thomson - Observation of the GZK Cutoff by the HiRes Experiment
Donato - New Physics in Cosmic Rays
Friedland - Having fun with neutrinos in cosmology and supernova
Lunardini - The diffuse supernova neutrino background
Pallavicini - Status of the Borexino experiment at the Laboratori Nazionali del Gran Sasso
Vanden Berk - Seeing the Sky Swiftly: Gamma-Ray Bursts and Beyond with the Swift Observatory
Shapiro - The Cosmological Constant Problems and Renormalization Group

7 Local Talent

31 Inside N. America

14 Outside N. America

Theory

Numerical Experiment

Observational Techniques

Observations: present/future

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 II** 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 one 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
- o **Cosmological Computing Initiative** 2006-
 - o **Gnedin, Dodelson** and Kravtsov started this nascent project.
 - o Comparatively small \$, but may have real impact on U.S. cosmology.
- o **Future Projects ...**

Varying amount of service work for projects once established

- o **Frieman** has done an lot of this.

What We Do

Organize/Host **Workshops/Conferences/Schools**

- 05/07 Searching for Strong Lenses in Large Imaging Surveys*
- 05/07 The Hunt for Dark Matter*
- 05/06 External Correlations of the Cosmic Microwave Background and Cosmology
- 07/05 TeV Particle Astrophysics*
- 12/04 Fundamental Physics from Clusters of Galaxies
- 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
- ...
- 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

* Recent workshops collaboration w/ other groups in the laboratory.

What We Do

Imitation is sincerest form of flattery:

TeV Particle Astrophysics III, Istituto Veneto, Venice, Italy 27-31 August 2007

TeV Particle Astrophysics II

2nd Workshop On TeV Particle Astrophysics

28-31 August 2006

Madison, WI, USA

Welcome

The Second Edition of the TeV Particle Astrophysics Workshop was held at the University of Wisconsin's Physics Department from August 28 to 31, 2006.

The goals of the Workshops were:

- to cover a variety of topics in Astroparticle Physics, focusing on the energy region of the TeV and above
- to salute the increasing involvement of women in this field
- to initiate new contacts and cooperation among different branches of the international astroparticle physics community

This event brought together 145 scientists and students from around the world working in diverse fields of Astroparticle Physics, including Gamma and Neutrino Astronomy, Cosmic Ray studies, Dark Matter, TeV Particle Physics, Physics beyond the Standard Model, and Gravitational Wave Searches. Roughly 20% of the plenary speakers, the work group leaders, and the work group speakers and poster submitters, as well as of the participants at large, were women.

The workshop provided an occasion for theorists and experimentalists to discuss the latest results in these fields, and to consider new strategies, technologies and collaborative efforts to address some of the most pressing questions in physics today, including:

- What is the dark matter?

First Circular
Second Circular
Third Circular
Committees
Conference Poster (PDF)
Important Deadlines
Participants
Previous Conference
Speakers and WG Leaders
Contact
Program
Poster Sessions
Abstracts
Presentations
Proceedings
Lodging
Travel
About Madison
UW Campus
Printable ATM & Detailed Area Map



TOPICS

- **New Physics at LHC**
 - TeV Particle Physics
 - Connections with Cosmology
- **TeV Gamma-ray Astrophysics**
 - Theoretical aspects
 - Ground-Based Experiments (*ARGO-YBJ*, *CANGAROO*, *HESS*, *MAGIC*, *Milagro*, *STACEE*, *TACTIC*, *Tibet*, *VERITAS*): latest results and future plans
 - Upcoming Space Telescope *GLAST*
- **Direct and Indirect Dark Matter Searches**
 - Update on direct searches
 - New strategies of indirect detection
 - First *PAMELA* results
- **Neutrino Telescopes**
 - *Amanda*, *Antares*, *Baikal*, *IceCube*, *Nemo*, *Nestor*, *KM3NeT*
- **Ultra-High Energy Cosmic Rays**
 - Latest *AUGER* results
 - Acceleration and propagation

www.infn.it/TeV/index.html



What We Do

Train Postdocs

Theoretical Astrophysics

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THEORETICAL ASTROPHYSICS

HOME
PEOPLE
ALUMNI
VISITORS
PROJECTS
EVENTS
INTERNAL

NAME:	PRESENT POSITION / OCCUPATION:	INSTITUTION / LOCATION:	PERIOD AT FERMILAB:
SCIENTISTS:			
Alex Szalay	Professor	Johns Hopkins University	09/84--09/85
Neil Turok	Professor	DAMTP, University of Cambridge	09/87--09/88
Andreas Albrecht	Professor	University of California, Davis	09/87--09/92
POSTDOCS:			
Keith A. Olive	Professor	University of Minnesota	07/83--08/85
David Seckel	Associate Professor	Bartol Research Institute	09/83--09/85
David Lindley	Author/Editor	Science/Nature/Science News	10/83--02/86
Lars G. Jensen	Associate Professor	North Dakota State University	09/84--08/86
Richard F. Holman	Professor	Carnegie-Mellon University	09/85--06/87
Jaime A. Stein-Schabes	Physicist	Shell Oil	09/85--09/88
David P. Bennett	Associate Professor	Notre Dame University	09/86--08/88
Marcelo Gleiser	Professor	Dartmouth College	09/86--09/88
Albert Stebbins	Scientist II	Fermilab	11/86--11/88
Edmund J. Copeland	Professor	University of Sussex	09/87--09/89
Angela V. Olinto	Associate Professor & Department Chairman	University of Chicago	09/87--09/90
Dongsu Ryu	Professor	Chungnam National University, Korea	09/88--09/90
Ruth A. Gregory	Academic Staff	University of Durham, England	09/88--10/91
David R. Haws	Computing	London	10/88--05/90
David Salopek	Senior Researcher	University of British Columbia	09/89--09/91
Ben-Ami Gradwohl	Managing Director	J. & W. Seligman & Co. New York	09/90--09/92
Esteban Roulet	Visiting Professor	Valencia, Spain	10/90--10/92
Fay Dowker	Lecturer	Queen Mary, University of London	10/90--10/93
Scott Dodelson	Scientist II	Fermilab	10/91--03/94
James Gelb	Assistant Professor	University of Texas, Arlington	12/91--03/93
Robert Caldwell	Assistant Professor	Dartmouth College	10/92--09/94
Stephane Colombi	Scientist	Institut d'Astrophysique, Paris	10/93--10/95
Igor Tkachev	Researcher	CERN	10/92--10/95
Andrew Heckler	Assistant Dean, College of Mathematical and Physical Sciences	Ohio State University	10/94--10/96

Theoretical Astrophysics

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Yun Wang	Assistant Professor	University of Oklahoma	10/93--10/96
Istvan Szapudi	Assistant Professor	University of Hawaii	10/94--08/97
Antonio Riotto	Professor	Istituto Nazionale di Fisica Nucleare, Padova	11/95--09/97
Will Kinney	Assistant Professor	SUNY Buffalo	10/96--09/98
Chris Metzler	Postdoc	Harvard Smithsonian Center for Astrophysics	10/95--09/98
Lam Hui	Professor	Columbia	09/96--09/99
Andrew Sornborger	Faculty	University of Georgia	10/97--08/99
Ewan Stewart	Assistant Professor	Korea Advanced Institute of Science & Technology	08/97--07/99
Zoltan Haiman	Assistant Professor	Columbia University	09/98--09/99
Pasquale Blasi	Faculty	Osservatorio Astrofisico di Arcetri	10/99--05/01
Michael Blanton	Research Scientist	New York University	11/99--07/01
Idit Zehavi	Assistant Professor	Case Western	09/98--10/01
Ravi Sheth	Assistant Professor	University of Pennsylvania	10/99--12/01
Kev Abazajian	Assistant Professor	University of Maryland	08/01--09/03
Patrick Greene	Assistant Professor	University of Texas, San Antonio	08/01--07/04
John Beacom	Assistant Professor	Ohio State University, Physics/ Astronomy	08/00--07/04
Nicole Bell	Lecturer	Melbourne	09/01--08/04
Gianfranco Bertone	Postdoctoral Fellow	INFN, Padova	09/03--08/05
Pengjie Zhang	Assistant Professor	Shanghai Astronomical Observatory	09/03--08/05
Jochen Weller	Faculty	UCL	09/04--08/05
Kenji Kadota	Post-doc	Minnesota	09/04--08/06

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Batavia, IL 60510, USA

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Fax (630) 840-8231

Security, Privacy, Legal

Ph.D. Students

What We Do

While we don't really support students - this is the natural fallout of the vibrant research environment and our close connection with the University of Chicago.

Dodelson

Kimberly Coble - professor Chicago State University

Eduardo Rozo - postdoc OSU

Ryan Scranton - [Google](#)

Frieman

Andrew Jaffe - professor Imperial College, London

Michael Joffre - lawyer

David Johnston - postdoc CalTech

Roman Scoccimarro - professor NYU

Craig Wiegert - adjunct professor, University of Georgia, Athens

Gnedin

Robyn Levine - student University of Colorado, resident at Fermilab

Hui

Adam Lidz - postdoc Harvard University

Jun Zhang - postdoc University of California, Berkeley

Kolb

Eun-Joo Sein Ahn - postdoc Bartol Research Institute

James Chisholm - postdoc University of Florida, Gainesville

Daniel Chung - professor University of Wisconsin, Madison

Patrick Crotty - postdoc LAPP Annecy, France

Lloyd Knox - professor University of California, Davis

Alberto Vallinotto - postdoc Institut d'Astrophysique, Paris

Terry Walker - professor OSU

Turner...

What We Do

Art/Outreach



“Arguably the best image in Google Sky!”

Google
Earth

Explore, Search and Discover

[Home](#)

[Downloads](#)

[Products](#)

[Product Tour](#)

[Help](#)



New! [Explore the sky in Google Earth 4.2](#)

Google Earth Front Page News: earth.google.com

Fundamentals

Physics Beyond the Standard Model

Phenomena

SUSY

GUTs

String Theory

Quantum Gravity

Non-Baryonic Dark Matter

Inflation

Dark Energy

Neutrino Masses

Extra Dimensions

Rotation Velocities

Galaxy Clusters

Matter Distribution in Universe

CMB Anisotropies

Light Element Abundances

Accelerator Production

Gravitational Lensing

Local Abundance

Gravity Waves

Type Ia Supernovae Brightness

Solar & Atmospheric ν

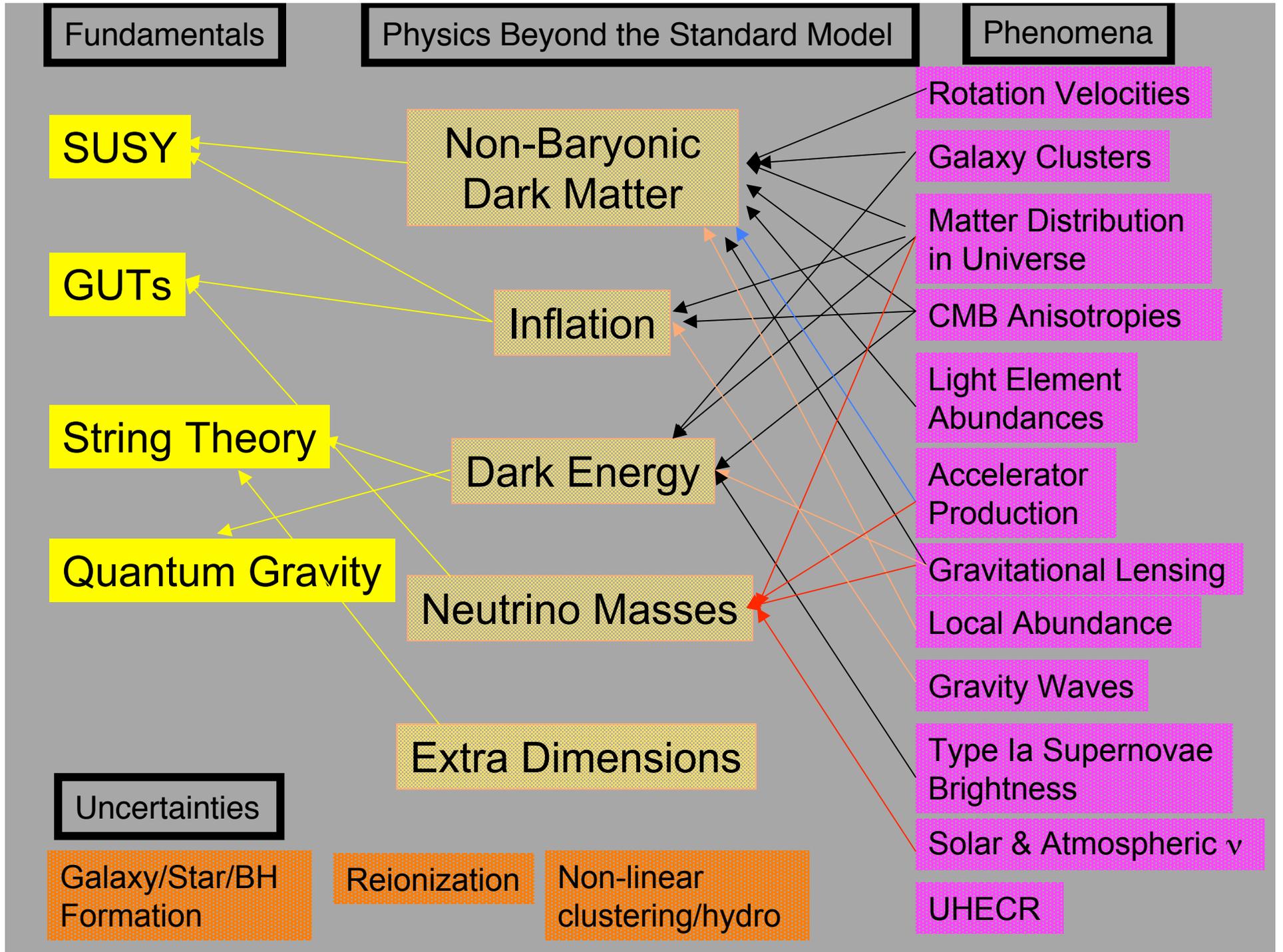
UHECR

Uncertainties

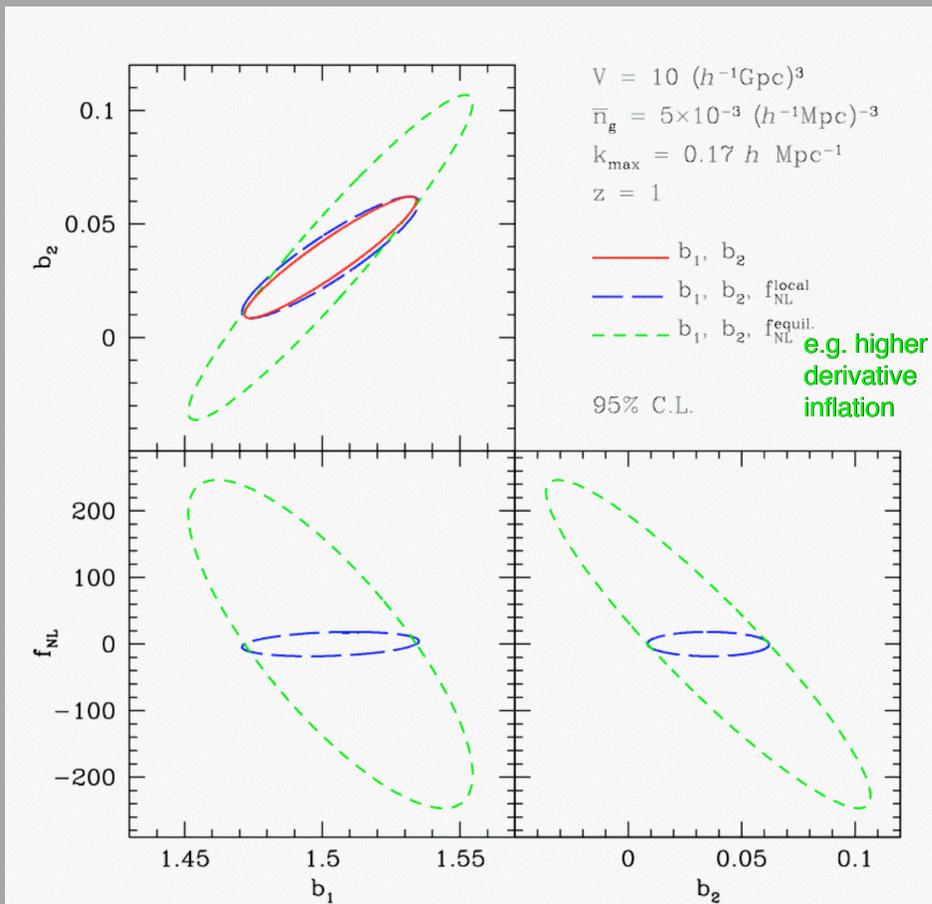
Galaxy/Star/BH Formation

Reionization

Non-linear clustering/hydro



Understand Inflation:
Disentangling bias, non-linear
clustering, and primordial
non-Gaussianity.



Sefusatti & Komatsu '07

Understand Reionization: escape
of ionizing radiation from Milky
Way like galaxy @ hi z.

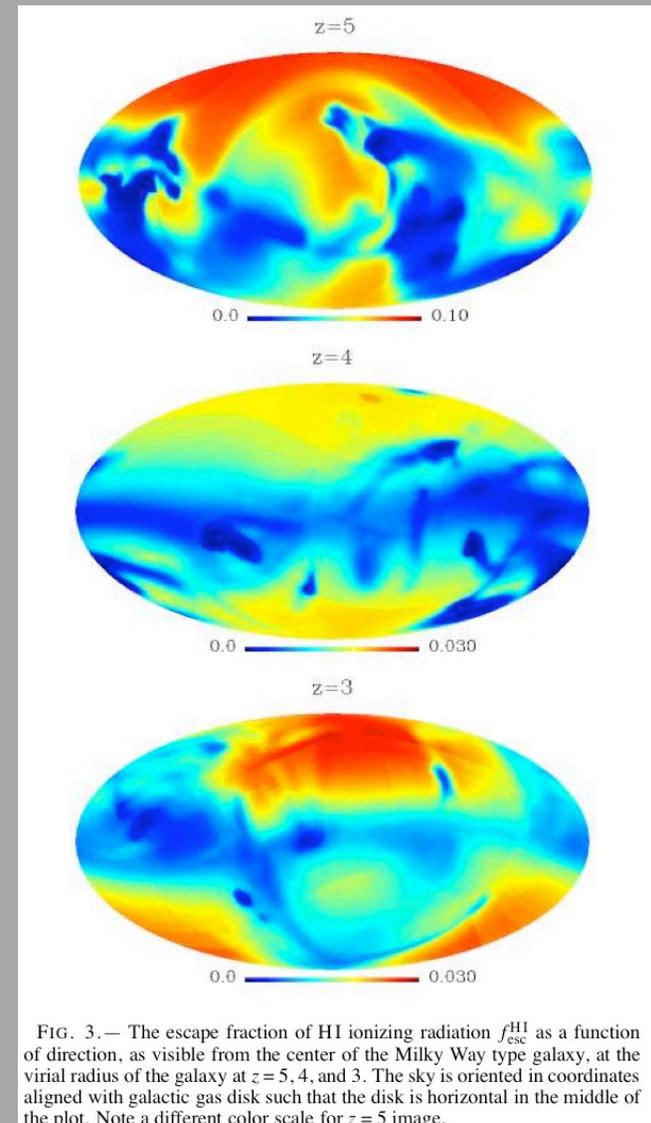


FIG. 3.— The escape fraction of HI ionizing radiation $f_{\text{esc}}^{\text{HI}}$ as a function of direction, as visible from the center of the Milky Way type galaxy, at the virial radius of the galaxy at $z = 5, 4$, and 3 . The sky is oriented in coordinates aligned with galactic gas disk such that the disk is horizontal in the middle of the plot. Note a different color scale for $z = 5$ image.

Gnedin, Kravtsov & Chen '07

Cosmological Computing Initiative

Local Talent
needs

Computing
Resources

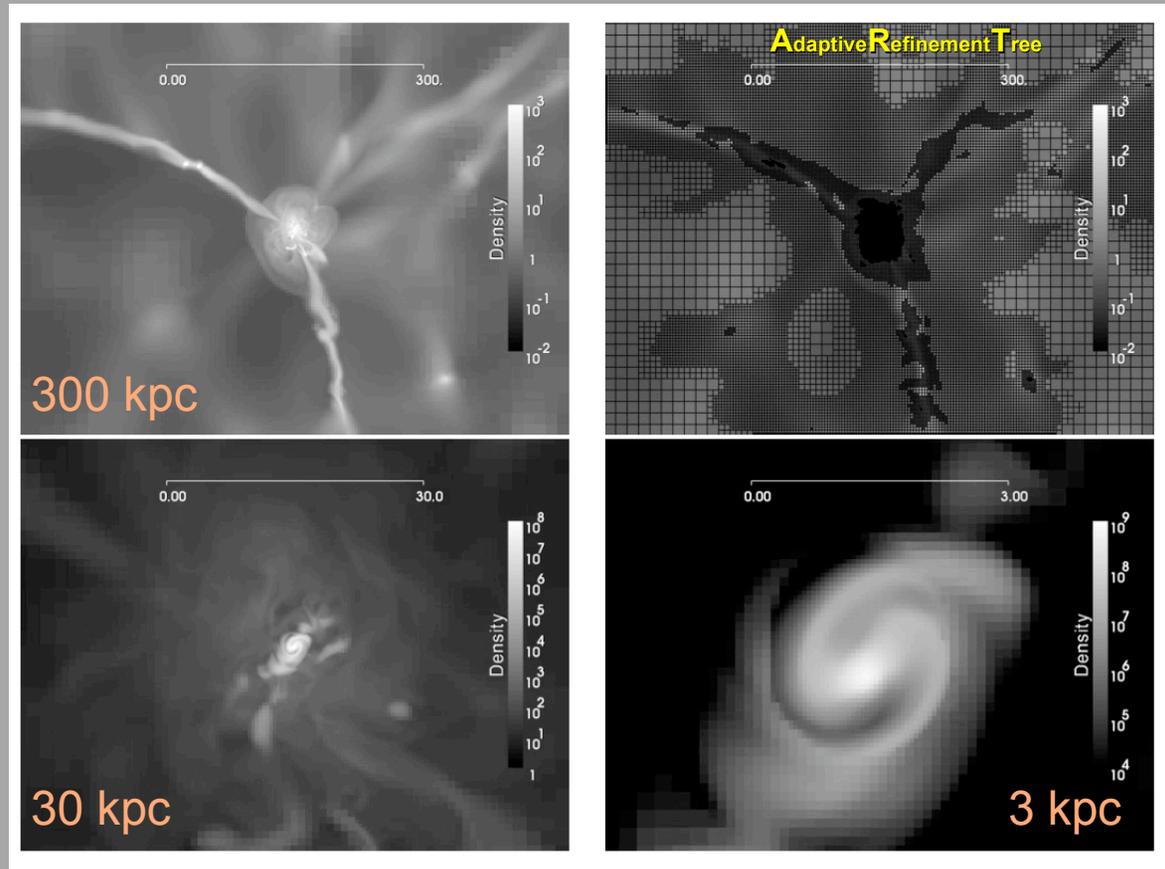
Gnedin & Kravtsov

Kuhlmann ANL

Modeling, Simulation
& Visualization Group

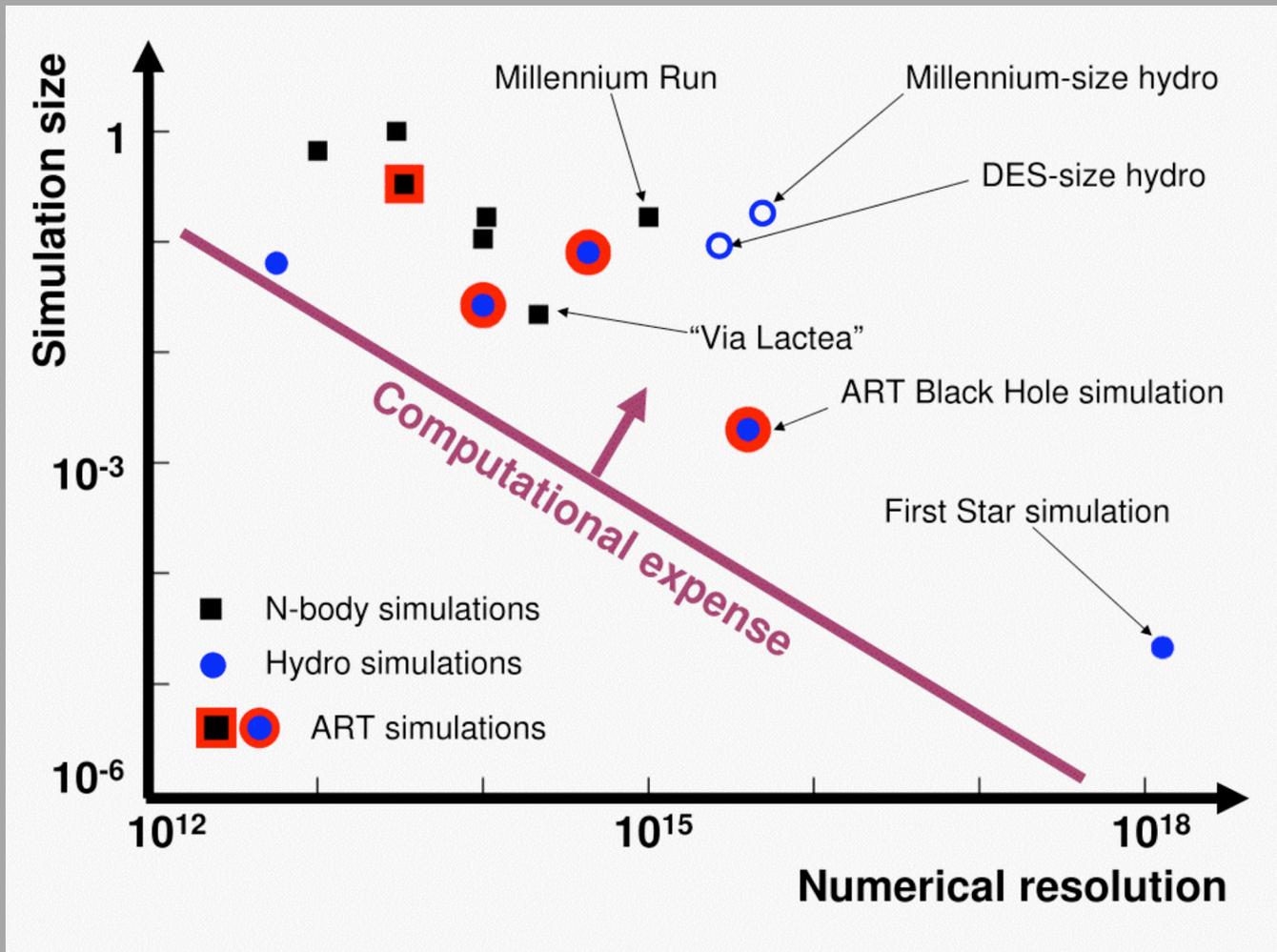
Topic of Opportunity

- o Baryon Acoustic Oscillations
- o Galaxy Cluster Counts
- o Weak Gravitational Lensing
- o Galaxy Formation and Evolution
- o First Star and Reionization of the Universe
- o Supermassive Black Holes At Centers of Galaxies



Rudd & Kravtsov

Cosmological Computing Initiative



Other groups, in particular Virgo Consortium (U.K./Germany) CITA (Canada) have better resources.

o We have natural allies in U.S., Spain, ...

Cosmological Computing Initiative

Science	Single DES-size hydro					
	Multiple Millennium N-body			Millennium-size hydro		
	Multiple DES-size hydro					
Hardware	300 processors		1,000 processors		10,000 processors	
	500 processors		3,000 processors			
Software	ART (core only)		4D parallel ART			
	Enzo		ART (full)			
Funding	KICP, FNAL, FRA		NSF (postdocs)			
	Argonne LDRD		SciDAC (software)			
	DOE Office of Science (hardware)					
Collaboration	FNAL, UC	SLAC	UCLA, NMSU, UIUC,			
	Argonne	LANL	Washington, Princeton,			
		LBL	Harvard, Michigan, ...			
	2007	2008	2009	2010	2011	2012

think big / think global!

Summary and Conclusions

PROGRESS:

- **Hooper** has added need breadth in permanent staff.
- Real progress in computational astrophysics/hardware
- Closer ties with
 - Particle Theory
 - Experiments in Center
 - Fundamental physics & collider program.

GOALS:

- Keep high level/productivity in theory research
- Support nascent projects (DES, SNAP, Computing)
 - In particular push SNAP for JDEM decision.
- Be on lookout for new project opportunities for FNAL

OUTLOOK

- Choice of CPA Director will effect staffing.
- One can **see** a vibrant future for at least a10 years.