

Fermilab Particle Astrophysics Center

Fermilab is home to about 50 astrophysicists. Research focuses on the nature of dark matter and dark energy; the evolution of the universe; and the role of neutrinos in our universe.

Members of the Fermilab Particle Astrophysics Center received funding from the Department of Energy, the National Science Foundation, the National Aeronautics and Space Administration, and The Sloan Foundation at Chicago.

Theoretical
Astrophysics Group

Sloan Digital
Sky Survey

Pierre Auger
Observatory

Cryogenic Dark
Matter Search

Supernova/
Acceleration Probe

Dark Energy Survey

Particle Astrophysics at Fermilab

- The role of Particle Astrophysics at Fermilab
 - The role of Fermilab in Particle Astrophysics
 - A word on procedure
 - Fermilab Particle Astrophysics Projects
 - Theoretical Astrophysics
 - Sloan Digital Sky Survey
 - Pierre Auger Project
 - Cryogenic Dark Matter Search
 - Dark Energy Survey
 - SNAP/JDEM
 - Particle Astrophysics Center
- History
Fermilab science role
Future prospects

Particle Astrophysics at Fermilab

The role of Particle Astrophysics at Fermilab

Fermilab Mission statement:

Fermilab advances the understanding of the fundamental nature of matter and energy by providing leadership and resources for qualified researchers to conduct basic research at the frontiers for high energy physics and related fields.

Fermilab Long Range Plan (May 2004):

Fermilab should substantially expand its leadership role in Particle Astrophysics, which provides probes of fundamental physics that complement accelerator experiments.

Particle Astrophysics at Fermilab

The role of Particle Astrophysics at Fermilab

- Explore Inner Space/Outer Space Connections
- HEP questions are Cosmic Questions
 - Barish/Bagger Report
 - Physics of the Universe
 - Beyond Einstein
 - Quarks to the Cosmos
 - Quantum Universe
- Recognition at the funding agencies
 - interagency committees and task forces
 - jointly funded projects

Fermilab in Particle Astrophysics

The role of Fermilab in Particle Astrophysics

- Participate in projects requiring National Laboratory
- Participate in strength
- Participate with universities and other labs
- Participate where science overlaps with Fermilab mission
- Participate when techniques and talents of staff relevant
- Participate in the science

A word on procedure

- Director → PAC
 - PAC → Director
- }
- URA BOO
 - URA Trustees
- }
- SAGENAP/P5/HEPAP
 - DOE/NSF/NASA
- }
- internal
- management
- agencies

Particle Astrophysics Projects

Theoretical Astrophysics Group (since 1983)

- Lederman and Schramm → Kolb and Turner
- PPD
- Presently 10-15 theoretical astrophysicists
 - 4 FNAL staff (+1 in September)
 - 4 postdocs
 - 1 Schramm fellow
 - students/users/visitors
- Partially (~1/4) funded by a NASA Astrophysics Theory grant
- Since inception, over 1000 papers
- Goals: science, support of Lab projects, world-wide impact

Particle Astrophysics Projects

Theoretical Astrophysics Group (since 1983)

- **Cosmological ν mass constraints**
(Beacom, Bell, & Dodelson 2004; SDSS Abazajian, Dodelson, Frieman, et al. 2004)
- **Dark Energy: Models & Detection**
(Kolb et al. 2005; Battye & Weller 2005)
- **Inflation**
Kolb et al. 2004; Kadota & Stewart 2004
- **Dark Matter**
Beacom, Bell & Bertone 2004; Bertone & Merritt 2005
- **Gravitational Lensing**
Dodelson & Zhang '05; Zhang, Hui, & Stebbins '04
- **Strings**
Greene, Jackson et al. 2004

Particle Astrophysics Projects

Theoretical Astrophysics Group (since 1983)

1. Alex Szalay, Professor Johns Hopkins University
2. Neil Turok, Professor DAMTP, University of Cambridge
3. Andreas Albrecht, Professor University of California, Davis
4. Keith A. Olive, Professor University of Minnesota
5. David Seckel, Associate Professor Bartol Research Institute
6. Lars G. Jensen, Associate Professor North Dakota State
7. Richard F. Holman, Professor Carnegie-Mellon University
8. David P. Bennett, Associate Professor Notre Dame
9. Marcelo Gleiser, Professor Dartmouth College
10. Albert Stebbins, Scientist II Fermilab
11. Edmund J. Copeland, Professor University of Sussex
12. Angela V. Olinto, Associate Professor University of Chicago
13. Dongsu Ryu, Professor Chungnam University, Korea
14. Scott Dodelson, Scientist II Fermilab
15. Ruth A. Gregory, Academic Staff University of Durham
16. David Salopek, Senior Researcher UBC
17. Esteban Roulet, Visiting Professor Valencia, Spain
18. Fay Dowker, Lecturer Queen Mary University of London
19. James Gelb, Assistant Professor UT, Arlington
20. Robert Caldwell, Assistant Professor Dartmouth College
21. Stephane Colombi, Scientist Institut d'Astrophysique, Paris
22. Igor Tkachev, Researcher CERN
23. Andrew Heckler, Assistant Dean, Ohio State University
24. Yun Wang, Assistant Professor University of Oklahoma
25. Istvan Szapudi, Assistant Professor University of Hawaii
26. Antonio Riotto, Professor INFN, Padova
27. Will Kinney, Assistant Professor SUNY Buffalo
28. Lam Hui, Associate Professor, Columbia University
29. Ewan Stewart, Assistant Professor Korea Advanced Inst.
30. Zoltan Haiman, Assistant Professor Columbia University
31. Pasquale Blasi, Faculty Osservatorio Astrofisico di Arcetri
32. Idit Zehavi, Assistant Professor Case Western Reserve
33. Ravi Sheth, Assistant Professor University of Penn
34. Patrick Greene, Assistant Professor UT, San Antonio
35. John Beacom, Assistant Professor Ohio State University

Particle Astrophysics Projects

Sloan Digital Sky Survey – E885 (since 1991)

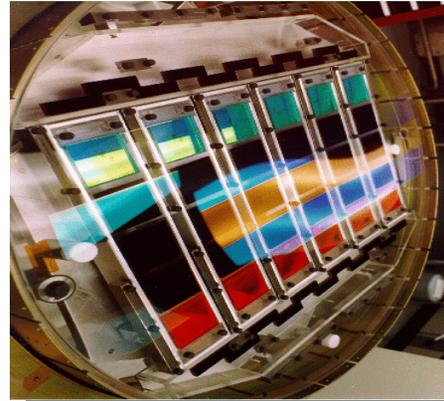
- Presentations to BOO, Trustees, PAC, SAGENAP, etc.

- About 150 scientists

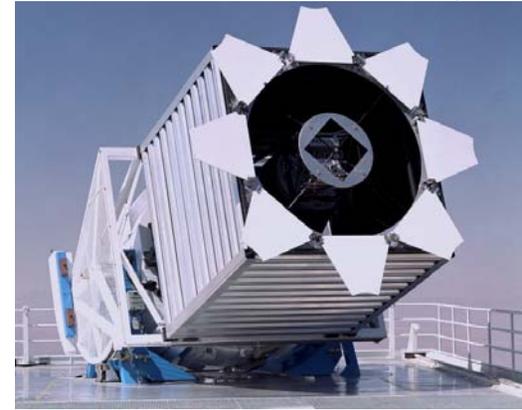
- Participants

University of Chicago
Fermi National Accelerator Laboratory
Institute for Advanced Study
Japan Participation Group
Johns Hopkins University
Korean Scientist Group (KSG)
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, Princeton University
United States Naval Observatory
University of Washington

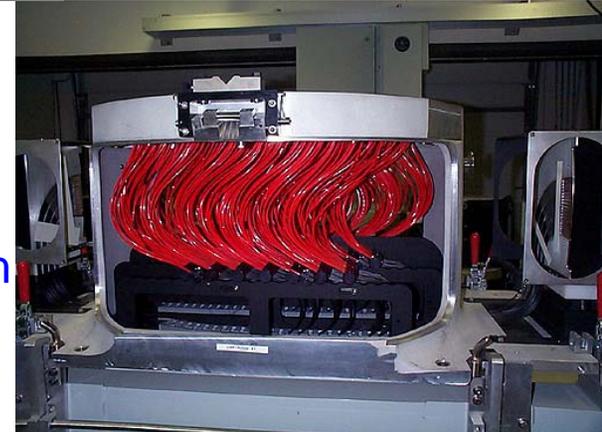
120MPix
camera



2.5m telescope



640 fiber
spectrograph

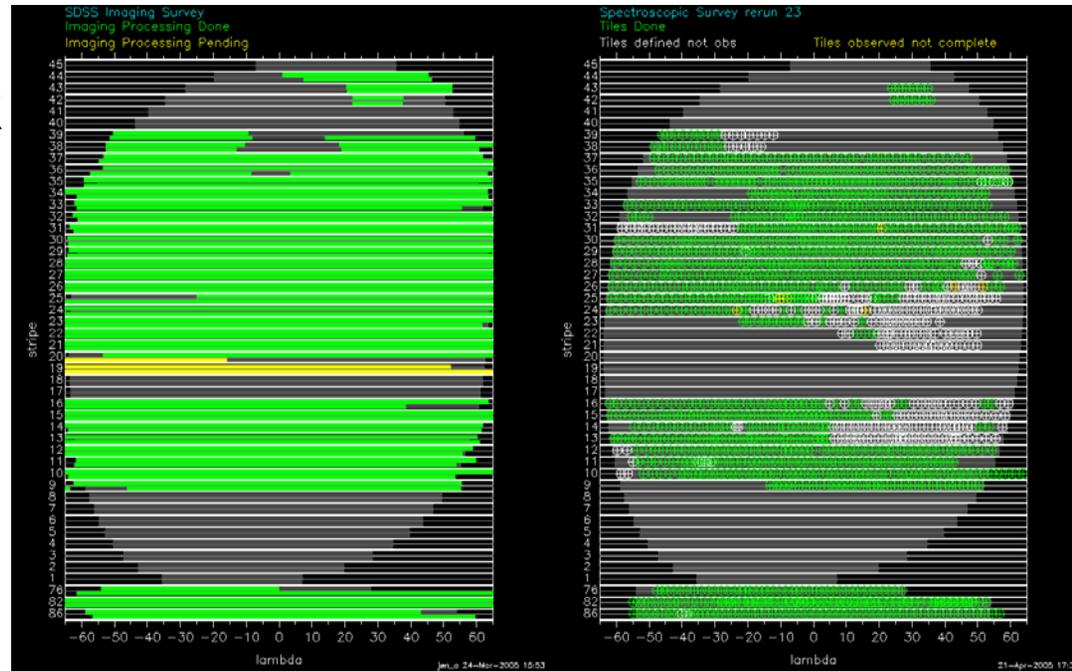


- Funding from Sloan Foundation, DOE, NSF, NASA, USNO, Monbusho, Universities, Max Planck

Particle Astrophysics Projects

Sloan Digital Sky Survey – E885 (since 1991)

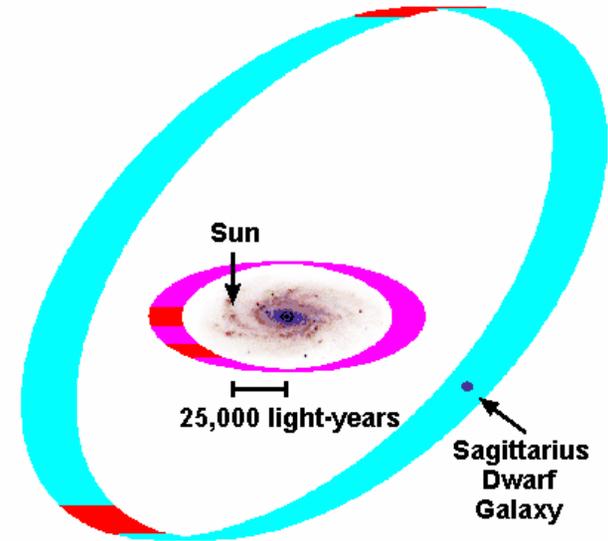
- Its 5-year mission: map $\sim \pi$ steradians in 5 colors, find the redshift of $\sim 10^6$ galaxies and $\sim 200,000$ quasars
- Understand the role of dark matter in shaping structure
- Today: imaging $>100\%$;
spectro $\sim 70\%$
- Metric of success: SDSS-II:
Sloan and NSF (\$5.4M)
 - Legacy (extend SDSS-I)
 - SEGUE (galactic merging)
 - supernovae
(low/intermediate redshift)



Particle Astrophysics Projects

Sloan Digital Sky Survey – E885 (since 1991)

- Computing Division (EAG)
- Science: 7 staff + 2 postdocs
+ visitors + students
- Staff has ~ 50% for science
(also involved in other projects)
- Impact:
 - Yanny co-leader of SEGUE
 - Stream around Sagittarius
 - Ring around galaxy
 - Galaxy clusters (with theory group)
 - Weak lensing (with theory group)
 - Quasars



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Particle Astrophysics Projects

Pierre Auger Project – E881 (since 1995)

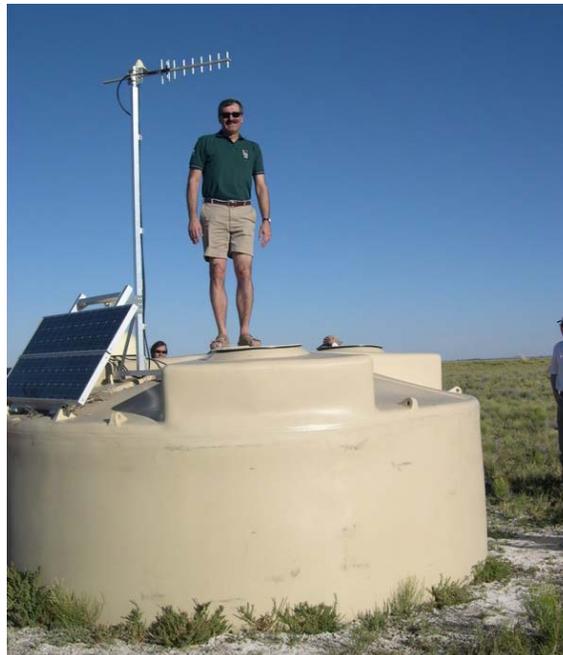
- Presentations to BOO, Trustees, PAC, SAGENAP, etc.

- About 250 scientists

- Participants

Argentina	UCLA
Italy	Michigan Tech
Australia	Case Wester
Mexico	Minnesota
Bolivia	Chicago
Poland	Nebraska
Brazil	Colorado
Slovenia	New Mexico
Czech Republic	Colorado State
Spain	Northeastern
France	Columbia
United Kingdom	Ohio State
Germany	Fermilab
USA	Argonne
Greece	Utah
Vietnam	Louisiana State

1600 surface detectors



Hybrid scheme



24 fluorescence detectors

- Funding from DOE & NSF
US ~ 25% & 13 agencies abroad
- URA manages

Particle Astrophysics Projects

Pierre Auger Project – E881 (since 1995)

- Its mission: spectrum, source, and composition of highest energy cosmic rays
- Already world's largest array
- 30,000 km² of pampas in Argentina
- Build, calibrate, data, interpret
- 38 papers at ICRC

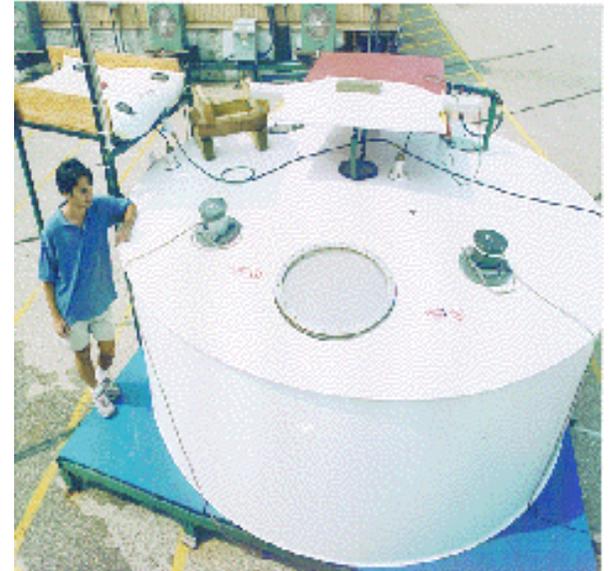
Still bugs



Particle Astrophysics Projects

Pierre Auger Project – E881 (since 1995)

- Technical Division
- Science: 5 staff + 2 postdoc
(4 staff full time 1 @25-50%)
FNAL one of larger groups
- Science
FNAL sponsored design study
Paul Mantsch project manager
Lead role in hybrid analysis
Mantsch highlight talk at ICRC
- Future:
Complete southern site
Northern site??



Prototype tank at FNAL

Particle Astrophysics Projects

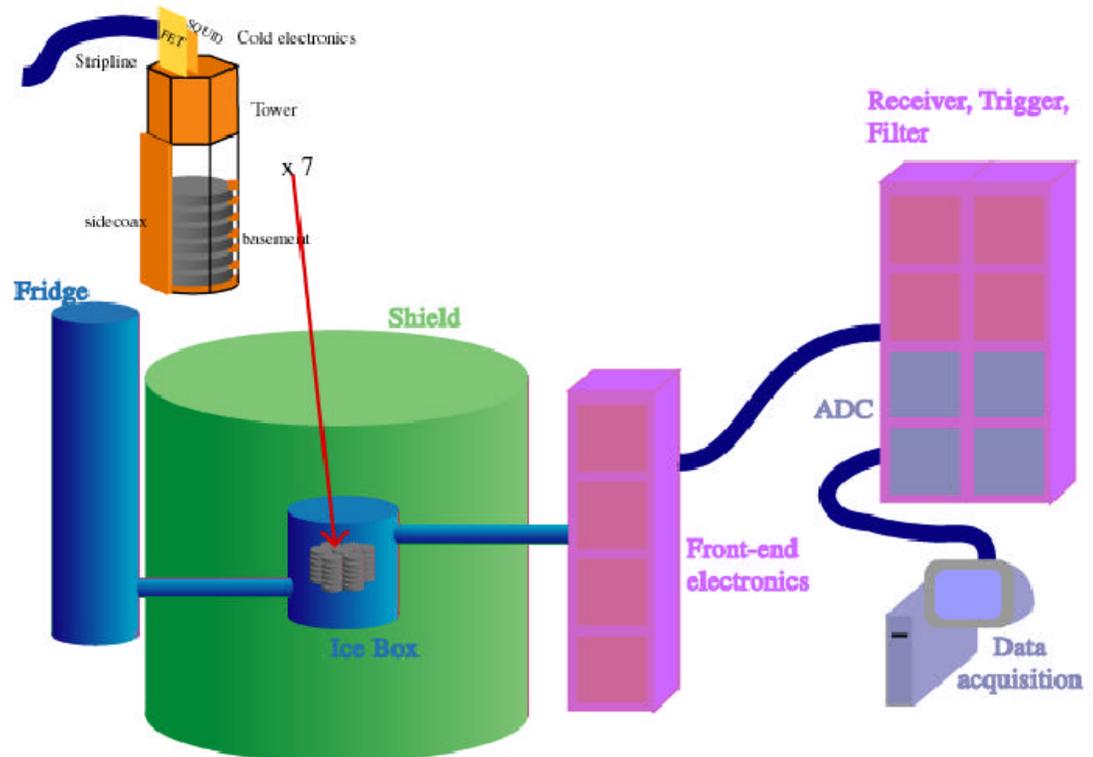
Cryogenic Dark Matter Search – E891 (since 1996)

- Presentations to BOO, Trustees, PAC, SAGENAP, etc.

- About 50 scientists

- Participants

Fermilab
LBNL
Brown
Minnesota
Stanford
UC Santa Barbara
Case Western Reserve
Colorado (Denver)
Santa Clara
UC Berkeley
Caltech
Florida



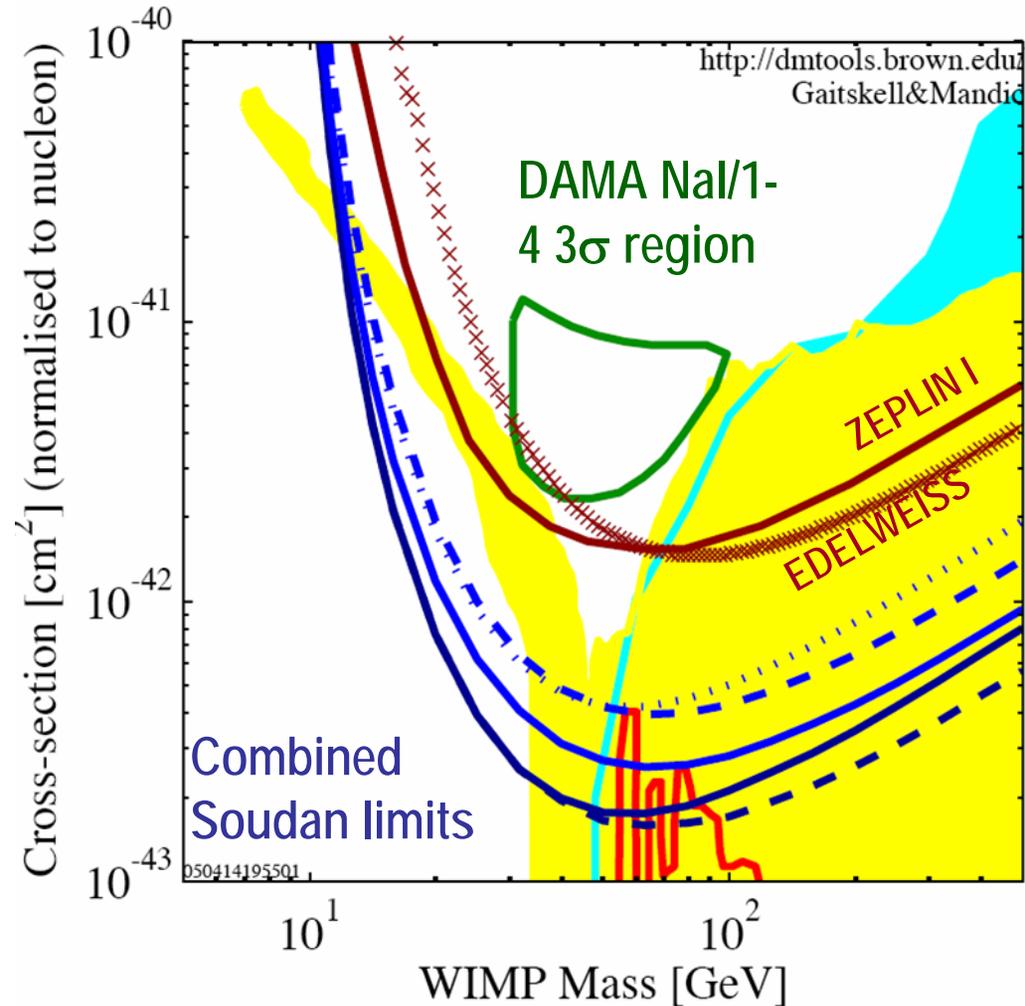
- Funding from DOE & NSF

Located in Soudan mine
(co-located w/ MINOS)

Particle Astrophysics Projects

Cryogenic Dark Matter Search – E891 (since 1996)

- Its mission: direct detection of dark matter
- Best limit in the world by a factor of 4
- Probing significant regions of MSSM model space
- Light-mass region largely ruled out
- Another factor of 3-4 at hand in Soudan



Particle Astrophysics Projects

Cryogenic Dark Matter Search – E891 (since 1996)

- Particle Physics Division (EPP)
- Science: 6 staff + 1 postdoc
(2 staff full time 4 @ 25-50%)
(not largest: Berkeley and CWRU)
- Science
Dan Bauer project manager
Lead in developing new way
of fitting pulses (impact?)
- Future:
SuperCDMS at SNOLAB?

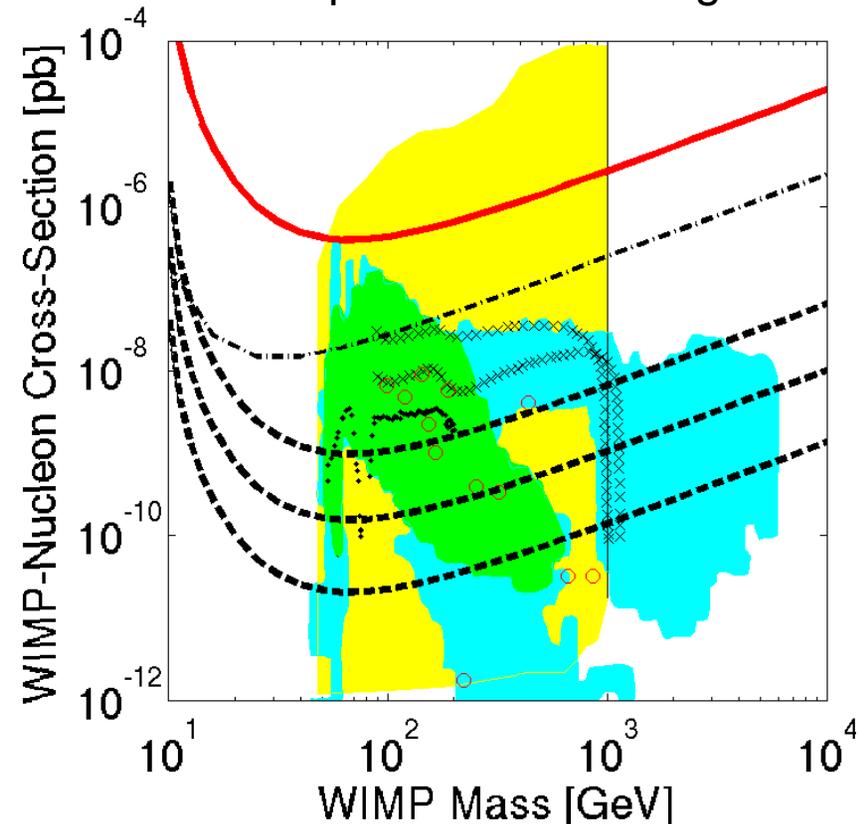
Published limit

CDMS II goal (end 2005)

SuperCDMS 25 kg

SuperCDMS150 kg

SuperCDMS 1000 kg



Particle Astrophysics Projects

New Initiatives

SDSS II:

- presented to PAC April '04
- approved by PAC pending funding from other sources
- funding secured from NSF, Sloan, universities



Dark Energy Survey (DES):

- Started Fall of 2003, PAC presentation April '04
- Director gave stage-1 approval pending funding
- Fermilab leading construction of the camera and optics
- UIUC is leading Data Management
- Goal is to be on the telescope in 2009



DARK ENERGY
SURVEY

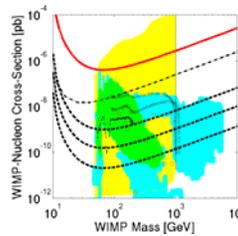
SNAP (JDEM):

- R&D lead by LBNL
- Fermilab admitted to SNAP in 2004



On the horizon:

- Auger North
- SuperCDMS



Particle Astrophysics Projects

DES

- Proposal:
 - 5000 sq. deg. survey of the southern galactic cap
 - constrain w to $\sim 5\%$ with 4 complementary techniques
 - begin to constrain dw/dz
- Equipment:
 - 2.2 deg. FOV camera \$22.5M
 - CCD detectors @ SiDET
- Time scale:
 - 2005-2009 Construction
 - 2009-2014 Operations
- FNAL Role:
 - 12 people (3-4 FTEs)
 - Lead building
 - Largest group (but $< 1/2$)

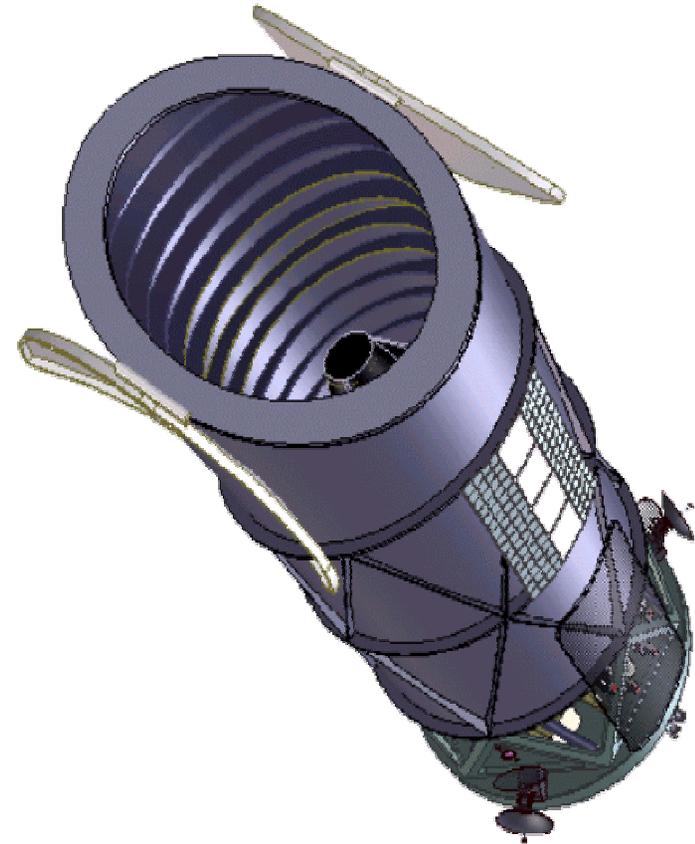


Blanco 4m @ CTIO

Particle Astrophysics Projects

SNAP/JDEM

- Science:
 - Explore dark energy
 - NASA/DOE Science Definition Team (Frieman member)
- Equipment:
 - Optical/NIR satellite
 - Instrument Cost: ?
- Time scale:
 - “Beyond the budget horizon”
- FNAL Role:
 - 13-15 people (~4 FTEs) [2nd-largest?]
 - Theory
 - Calibrations & standards
 - Electronics (minor role)
 - Wide-angle stuff



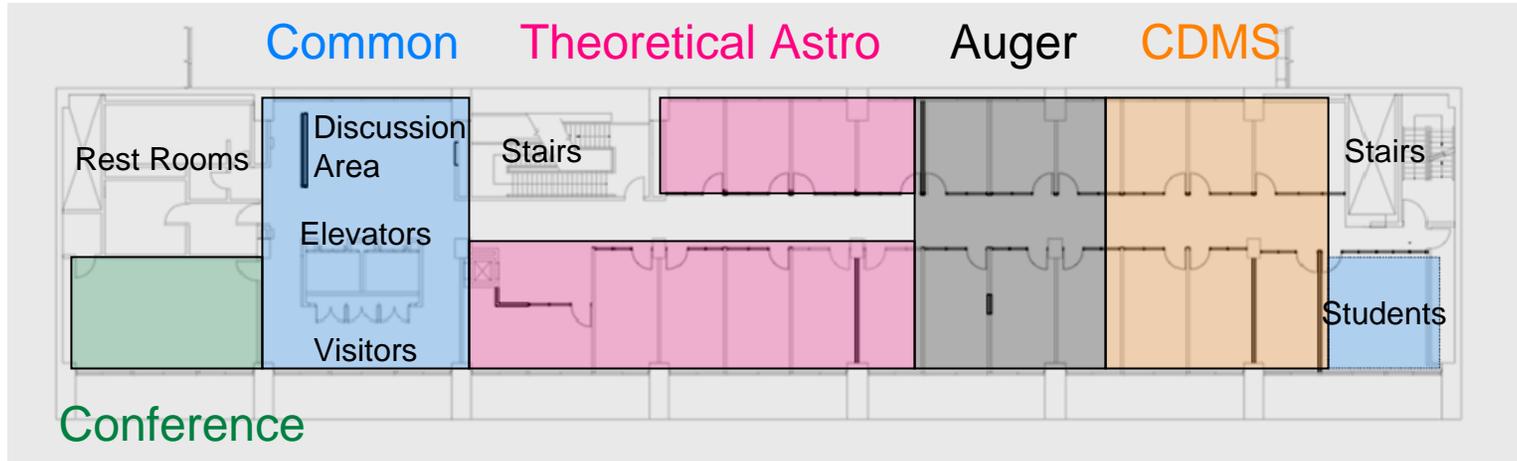
Particle Astrophysics Center

Goals

- Intellectual center to unify and focus the astrophysics program, enhance effectiveness and recruiting power
- Framework to germinate, develop, advance future efforts
- Internationally recognized center for Particle Astrophysics
- Interdivisional
- Membership open to all Fermilab employees working on existing astrophysics projects and new initiatives
- Assist Users community involved in Center programs

Particle Astrophysics Center

Location, location, location: WH6W+WH7W



Proximity will facilitate discussions and use of common resources



Fermilab Particle Astrophysics Center

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