

Particle Astrophysics at Fermilab/Computing Division

E881

Pierre Auger Observatory



E891
CDMS-II



DARK ENERGY
Survey

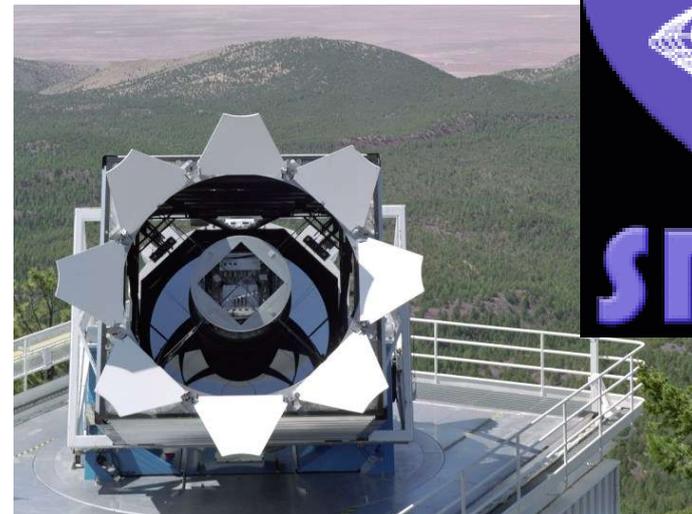
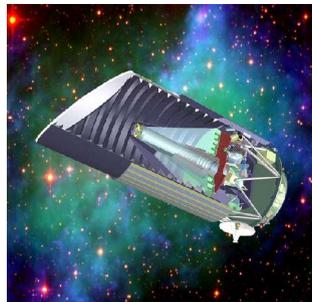
P939
DES



1



R&D
SNAP/JDEM



E949
SDSS-II

Fermilab Center for Particle Astrophysics

Celebrated its first year this past year

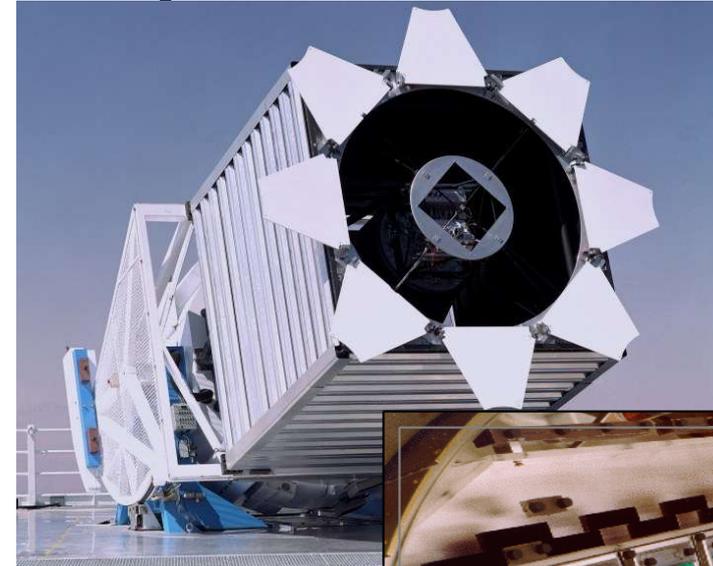
**Unifies 5 astroparticle experiments,
scientists and theorists for exchange
of ideas, results, and people.**



Sloan Digital Sky Survey-II (E949)

Collaboration: ~150 scientists from

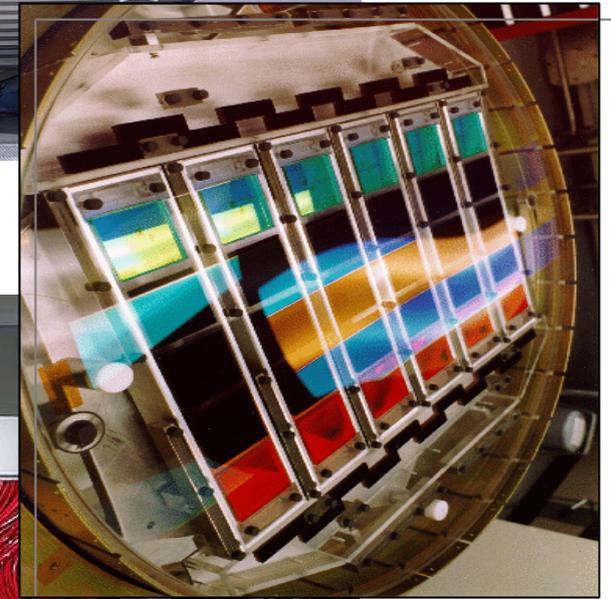
Am. Museum Nat. History
Astrophysical Inst. Potsdam
U. Basel
Cambridge U.
Case Western Reserve
U. Chicago
Drexel U.
Fermilab
Institute for Adv. Studies
Japanese Participation Grp
Johns Hopkins U.
JINA
Kavli Institute for Part. Astro.
Korean Scientist Group
LAMOST (China)
Los Alamos Nat. Lab
Max Planck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



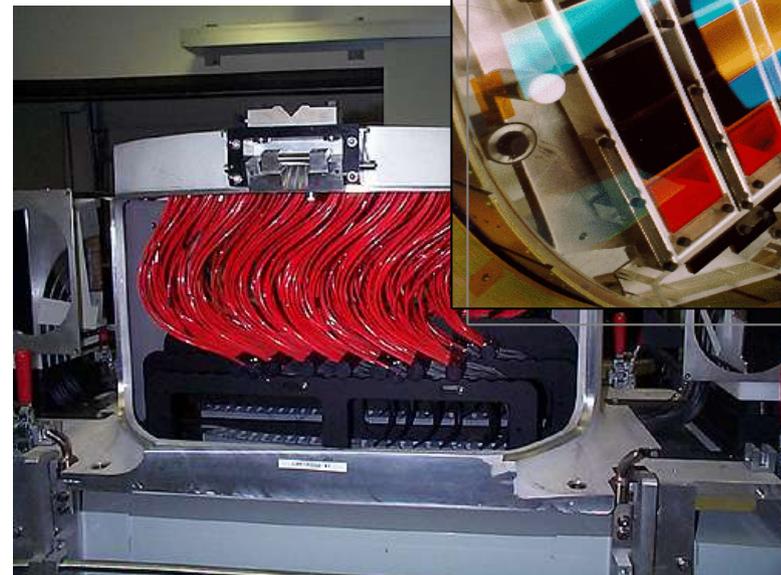
Beamline

3

Calorimeter



Massive Spectrometer





SDSS II - the sequel

3 year mission (2005-2008)

Legacy:

- Complete SDSS program
- Imaging and Redshift survey - Large scale structure

SEGUE:

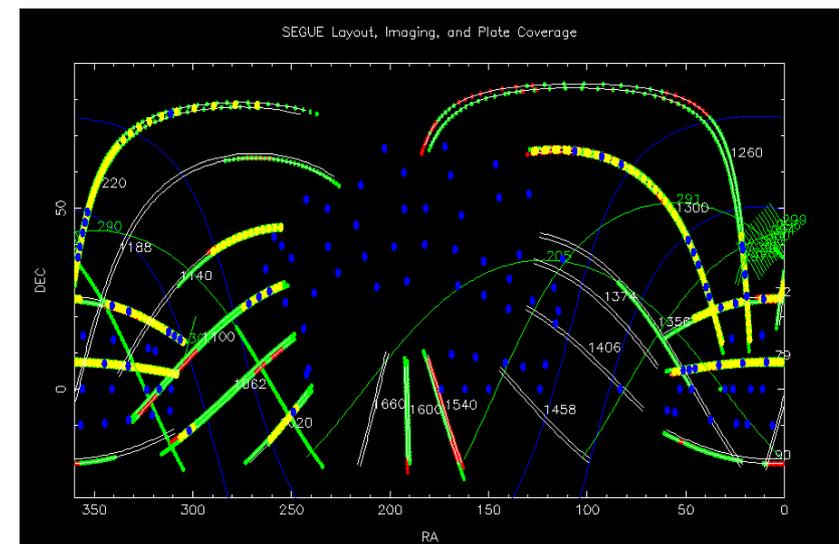
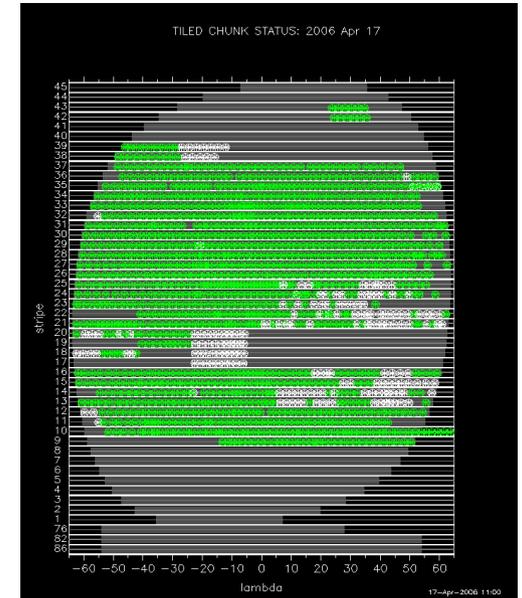
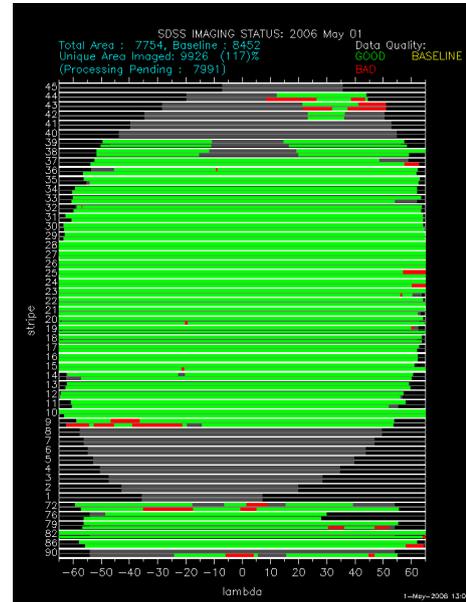
- Milky Way halo – Dark Matter probes

Supernovae

- Low and intermediate redshift, Dark Energy probe

Funding:

- Sloan, DOE, NSF, NASA, Japanese Mongbukagakusho, Max Planck Society, HEFCE





FNAL tasks and resources ***in SDSS-II***

- **Fermilab Interests**

- **13 scientists (3 divisions)**
 - **Kent co-leader of Legacy**
 - **Yanny co-leader of Segue**
 - **Frieman co-leader of Supernova Program**
- **2 current postdocs (including 1 Brinson)**
- **1 joining soon**

Tasks

**DAQ upgrade
Plugplate design**

**Data distribution
APO Engineering/Technical support**

- **Required resources**

- **4 FTE scientist (mainly from CD)**
- **10 FTE CP, admin, tech. (6 from CD)**
- **\$300K M&S/yr**
- **\$300K DAQ upgrade**

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- **Funding**

- **Significant cost sharing with SDSS project (\$1.2 million)**

**Survey planning
Legacy, SEGUE, SNe
data processing
Project Mgmt.**

CD Tasks - Data Processing

- **Defining document - SSP 240**
- **Responsible Organization - FL/CD/EAG**
- **Stakeholders - E949 collaboration**
- **Leader - S. Kent**
- **Responsibilities**
 - **Survey planning**
 - **Observing software maintenance**
 - **SDSS website**
 - **Data Processing Operations (including SNe)**
 - **Pipeline maintenance**
 - **Data Distribution**
 - **DAS**
 - **Data to CAS**
 - **Web pages**

Deliverables -->>

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CD Tasks - DAQ

- **Defining document - SSP261**
- **Responsible organization - FL/CD/CEPA**
- **Stakeholders - E949 collaboration**
- **Leader - G. Guglielmo**
- **Responsibilities**
 - **DAQ hardware maintenance**
 - **DAQ software underpinnings maintenance**

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CD Tasks - Catalog Archive Server

- **Defining document - SSD 268**
- **Responsible organization - FL/CD/CSS**
- **Stakeholders - E949 Collaboration**
- **Leader - J. Trumbo/J. Schmidt**
- **Responsibilities**
 - **Deploy, install, and operate Catalog Archiver Server (hardware and software)**

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SDSS Status

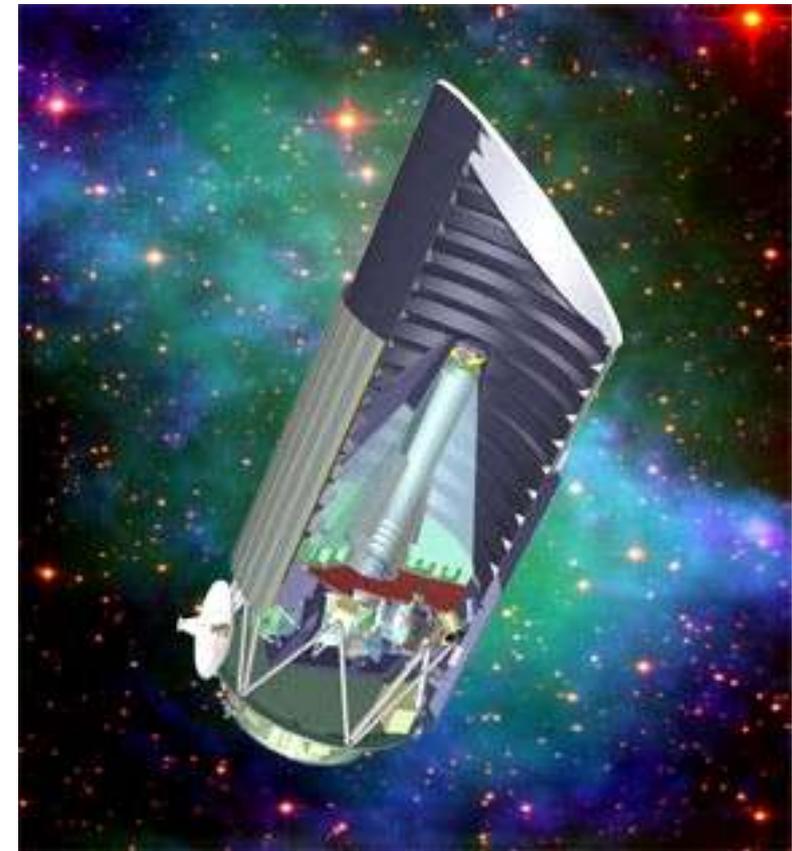
- **We have just begun year 7 of "steady state operations"**
- **Data Releases occur in quantized intervals - DR5, just released to public, includes all data from years 1-5.**
- **> 1000 papers, 30,000 citations in literature**
- **Issues**
 - **Change in data transfer (DLT -> network copy)**
 - **Closure of off-site tape storage**

On the horizon

- **Long-term archiving plans**
 - **Maintain 2 copies of complete archive in tapes robots at separate locations (FCC, GCC)**
 - **Keep public version (a subset of complete archive) "spinning"**
- **SDSS-III ???**

SNAP/JDEM

- **JDEM: Joint DOE/NASA Dark Energy Mission**
- **SNAP: DOE project proposed as the JDEM experiment.**
- **Science: Precision Dark Energy**
- **Techniques:**
 - **Supernovae redshifts out to $z=2$**
 - **Wide area hi-res Weak lensing**
- **Strengths:**
 - **High statistical precision (2000 objects)**
 - **High systematic precision**
- **Timescale: launch beyond 5 year horizon**



11 Stage IV DETF mission, ~\$600M

SNAP - FNAL Tasks and Resources

Tasks

- **Wide angle science**
- **Software & Simulations**
- **Calibrations**
- **Radiation Shield**
- **Electronics**
 - **Mass Memory**
 - **ASICs**
- **CCD testing**

Resources

- **FTEs**
 - **2.25 Scientist (1.1 from CD)**
 - **3.75 Eng/CP/Tech (2 from CD)**
- **M&S**
 - **\$68K per yr**
 - **\$75K from outside (MOUs)**

SNAP - CD tasks

- **Defining document**
 - letter to Mike Witherell
(augmented by MOU's with LBNL)
- **Responsible Organization:**
FL/CD/EAG,
FL/CD/CEPA
- **Stakeholders - SNAP project**
- **Leader - Kent/Diehl**
- **Responsibilities**
 - **Calibrations**
 - **Mass memory electronics R&D**
 - **Simulation software framework**

SNAP Status

- **Electronics - talk by A. Prosser**
- **Calibrations - July 2006 review**
- **Simulations framework - active development. Used as part of preparation of recent "Advanced Concept Study" proposal to NASA.**
- **Wide angle science - victory! (1000 sq. deg.)**

SNAP - Future

- **House Report 109-474, Energy and Water Appropriations Bill, 2007:**
 - Over the past few years, the Committee has consistently supported the DOE/NASA Joint Dark Energy Mission (JDEM)
 - The Committee strongly believes that this initiative should move forward.
 - DOE has done its part, developing the SuperNova Acceleration Probe (SNAP) as the DOE mission concept for JDEM. Unfortunately, NASA has failed to budget and program for launch services for JDEM.
 - Therefore, the Committee directs the Department to begin planning for a single-agency dark energy mission with a launch in fiscal year 2013.



The Dark Energy Survey (DES)

DARK ENERGY
SURVEY

P939

Program:

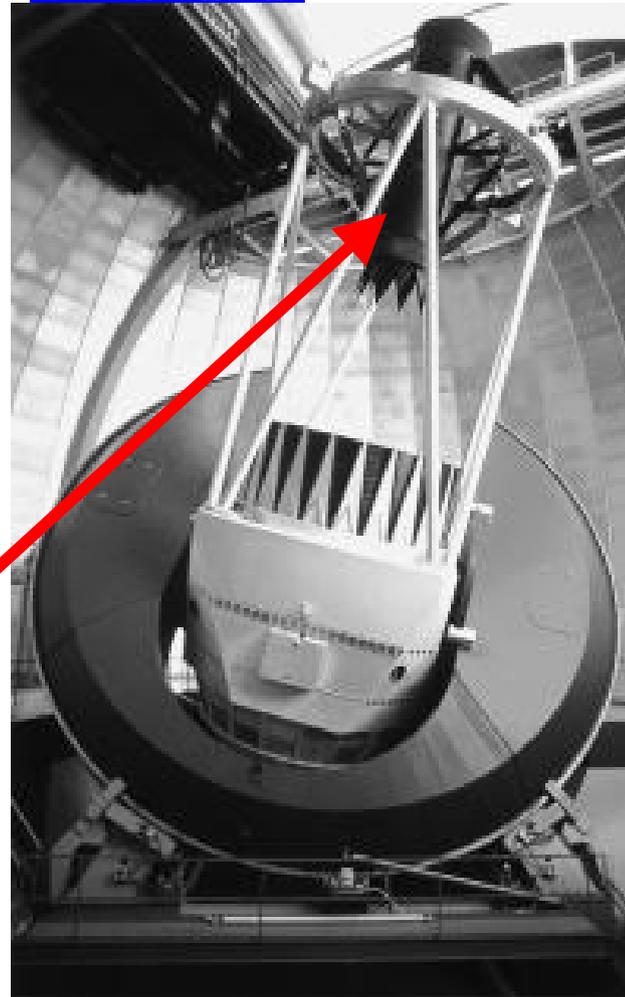
- 5000 sq. deg. survey of the Southern Galactic Cap
- Measure dark energy with 4 complementary techniques:
 - › Clusters
 - › Weak Lensing
 - › Baryon Oscillations
 - › Supernovae
- *Overlap with South Pole Telescope S-Z cluster survey*

New Equipment:

- Fermilab lead: 2.2 Degree field 512 MPixel camera
- UIUC lead: Data Management, public archive

Survey

- 5 year survey: 2010-2015
- Stage III D.E. experiment



Use the Blanco 4M Telescope at the Cerro-Tololo Inter-american Observatory (CTIO)

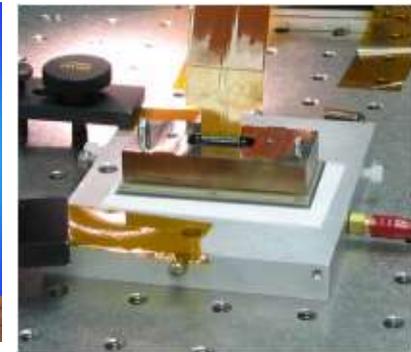
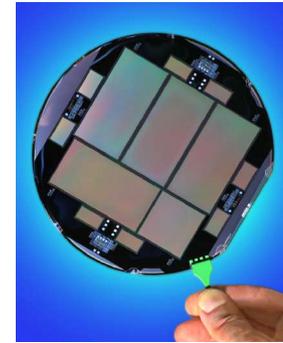
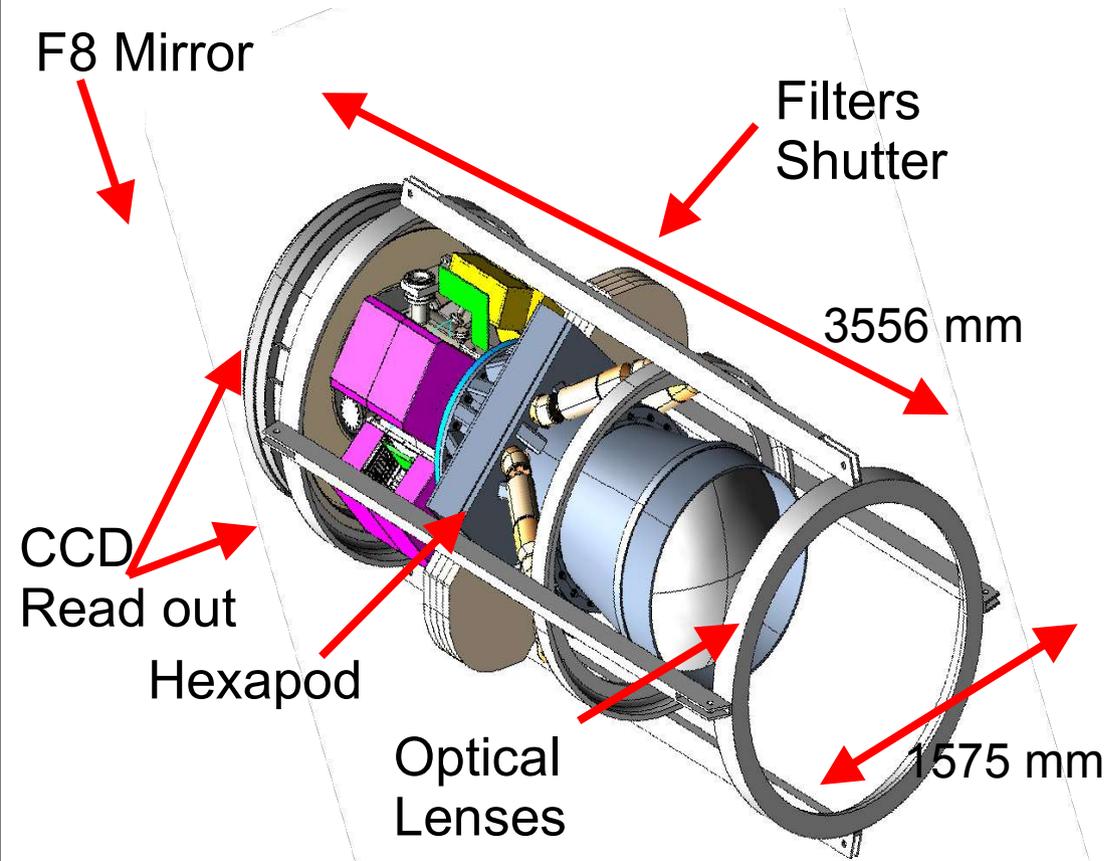


DARK ENERGY SURVEY

The DES Instrument: DECam

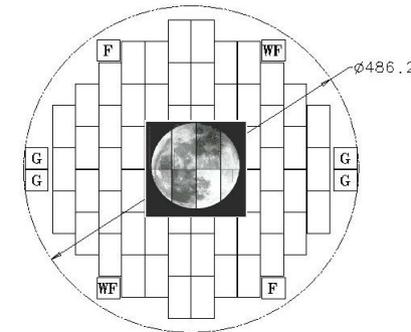
DECam will be larger than any existing CCD camera

Fermilab Role:
DECam project management
CCD packaging
CCD readout (lead)
CCD Focal plane and vessel
Optical Corrector barrel
Cage and hexapod/alignment
Simulations, Calibrations



UK will provide optical elements
Spain will provide production electronics

62 2kx4k Image
CCDs: **520 MPix**
8 2kx2k Guide,
focus, alignment



DES - CD Tasks and Resources

- **Tasks**

- **Simulations**
- **Science planning**
- **Pipeline software (calibrations)**
- **Optical design (requirements)**
- **Support CCD testing**
- **Web site, document management**
- **DAQ (Monsoon) - evaluation**

- **Resources**

- **1.7 FTE - scientist**
- **.75 FTE - CP (some shows up under Grid)**
- **\$57K M&S**
 - **File servers**
 - **Travel**

DES - Status

- **Tasks**

- **Simulations & pipeline software - delivered for data challenges 0 and 1**
- **Science planning (photo-z's, filter selection) ongoing**
- **Web site, etc - going OK**
- **Optics - PDR in Feb 2006**
- **CCD testing - limping along**
- **DAQ evaluation - other collaborators (UIUC, Ohio State, FNAL/PPD Barcelona) are picking up some of the pieces**

DES - Future

- **P5, FY 2008 roadmap: "We recommend the start of construction on ...**
 - **The Dark Energy Survey, which combined measurements on baryon oscillations, cluster surveys, supernovae studies, and weak lensing to significantly improve our understanding of dark energy"**

NVO - National Virtual Observatory

- **Defining document - NVO subaward**
- **Stakeholders - NVO project/NSF**
- **Responsible Organization - FL/CD/EAG**
- **Leader - Kent/Annis**
- **Status - Ends Sept. 2006**
- **Resources - 0.25 FTE**
- **Accomplishments**
 - **Integrated grid-based application with NVO interfaces (cluster finding demo)**
 - **Development of SDSS CAS (one of main data archives used by NVO)**
 - **Testing of numerous NVO software packages and web interfaces**

International Virtual Data Grid **Laboratory (iVDGL)**

- **Defining document - subaward (IVDGL)**
- **Stakeholders - EAG(SDSS), iVDGL collaboration, NSF**
- **Responsible organization: FL/CD/EAG**
- **Leader - S. Kent**
- **Responsibilities:**
 - **Build and operate "tier 1" data center in conjunction with JHU**
 - **Deploy SDSS applications to use iVDGL facilities**
- **Resources**
 - **1.5 FTE**

iVDGL Status

- **Current project ends Aug 2006**
- **iVDGL has "morphed" into OSG**
- **TAM cluster was created and serves as the "tier 1" center; collaboration with JHU largely ineffective. TAM is part of FermiGrid.**
- **Contributed to numerous software projects (development and testing)**
- **Several SDSS (and now DES) analysis applications deployed**
 - **Cluster finder**
 - **Southern Coadd**
 - **Quasar spectrum template fitting**
 - **DES simulations for data challenge 1**
 - **NEO search**
- **SDSS data processing runs on FermiGrid**



The Pierre Auger Project (E881)

A new cosmic ray observatory to study

The Highest Energy Cosmic Rays

$>10^{19}$ eV

Energy Spectrum - Direction - Composition

Two Large Air Shower Detectors

Mendoza, Argentina (construction underway)

Colorado, USA (in planning)



Surface detector station

1600 total

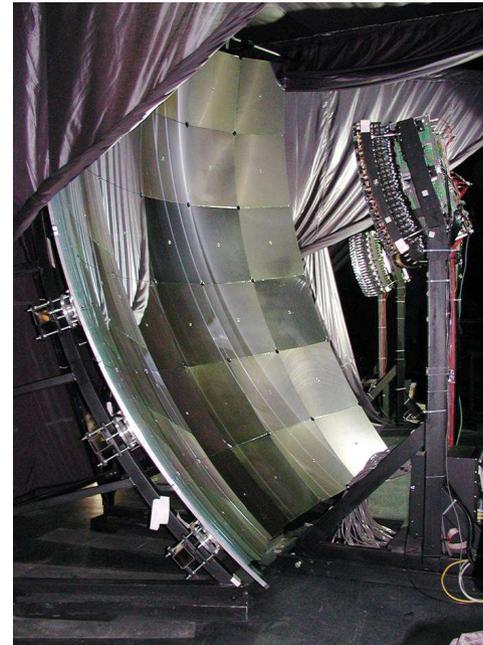
Status

Construction

Commissioning

Data taking

First Results in 2005



Fluorescence telescope

24 total



The Auger Collaboration

Participating Countries - 63 Institutions, ~269 Scientists

Argentina

Australia

Bolivia*

Brazil

Czech Republic

France

Germany

Italy

Mexico

Netherlands**

Poland

Portugal**

Slovenia

Spain

United Kingdom

USA

Vietnam*

****Associate countries***

*****New countries***

Support

DOE, NSF – Funding agencies in 15 other countries. US support about 25%.



Fermilab Participation

- **Fermilab Participation**
 - **Scientists – 5 full time + 2 Part time+1 postdoc**
 - **+ 1 Brinson Pre-doctoral Fellow**
 - **Staff – 2 full time**
 - **Activities**
 - **Project Management**
 - **Construction**
 - **Commissioning**
 - **Data analysis**
 - **Group size – approximately constant; may grow slightly as Auger North evolves.**
- **Funding**
 - **~\$250K M&S/yr – mostly travel and project office support**

Software infrastructure

- **Support of augerd1 by Merina Albert**
- **Installation of the Auger Offline on augerd1 node. Helped with one or two ROOT feature (i..e, not quite able to read data written less then two years ago. but it fixed!)**
- **MySQL server on augerd²⁷1, by Chi-Hao Huang**
 - **It runs smoothly, and used in analysis.**
 - **and is kept up to date via ssh tunnel to expert sites (with help from Security people)**
 - **Next step: boost security, x.509 based access.**

Analysis of Surface Detector Calibration Rates.

- Photo-multiplier gains are constantly adjusted to keep track of the Vertical Muon Equivalent (VEM) peak, and a given cosmic rate fixed...
- This is cross-checked with a single station rate at ~ 2.5 VEM. This T2 rate is indeed “constant”, to a precision of a fraction of one percent.
 - Is this so for all stations? (not quite)
 - Can we improve the stability? Is the rate on which we calibrate stable, and to which accuracy?
 - Impact on the UHE rate and large scale anisotropy measurement, if we are looking after small (%) effects at moderate energies (we will have large statistics at $\sim 10^{18}$ EV.

CDMS - Direct Detection of Dark Matter (E891)

CDMS Collaboration at Soudan



CDMS Institutions

DOE Laboratory

Fermilab

LBNL

DOE University

Brown

Minnesota

Stanford

UC Santa Barbara

NSF

Case Western Reserve

Colorado (Denver)

Santa Clara

UC Berkeley

Other

Caltech

Florida

Fermilab role in CDMS

- **Scientific (3 FTE → 4 FTE)**
 - 3 Scientist + 1 postdoc
 - Project Manager, Soudan operations and infrastructure, cryogenics, electronics, analysis, electronics, analysis
 - Need another scientist/postdoc
 - Cryogenics/detector/electronics interface + analysis
- **Technical and Administrative (4 FTE → 7 FTE)**
 - Engineering/Technicians -> New cryogenics, electronics
 - 0.25 FTE administrative (need more project management help)
- **Budget (2006)**
 - \$0.5M M&S
 - \$1.3M Labor

CD participation in CDMS

- **Minimal (D. Holgrem)**
- **Tasks**
 - **DAQ support**
 - **Some support for compute clusters at Soudan, FNAL**
 - **CDMS currently uses Fermigrid for data analysis**

CDMS - Future

- **P5, FY 2008 roadmap: "We recommend the start of construction on ...**
 - **The next phase of the Cryogenic Dark Matter Search experiment, using a 25 kg detector deep underground to significantly extend our sensitivity for direct detection of dark matter.**

Summary

Fermilab Experimental Particle Astrophysics Program is vibrant, with multiple operating and planned experiments

Each operating experiment is a world-leader in its particular field

Vision for the future: precision experiments to investigate what the universe can tell us about dark matter, dark energy, and the most energetic particles