



U.S. DEPARTMENT OF  
**ENERGY**

OFFICE OF  
**SCIENCE**

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# Office of High Energy Physics (HEP) Program Status

## AAAC Meeting February 12-13, 2013 At NSF

**Kathleen Turner**  
**Office of High Energy Physics**  
**Office of Science, U.S. Department of Energy**

Cosmic Frontier program managers: Michael Salamon, Kathleen Turner

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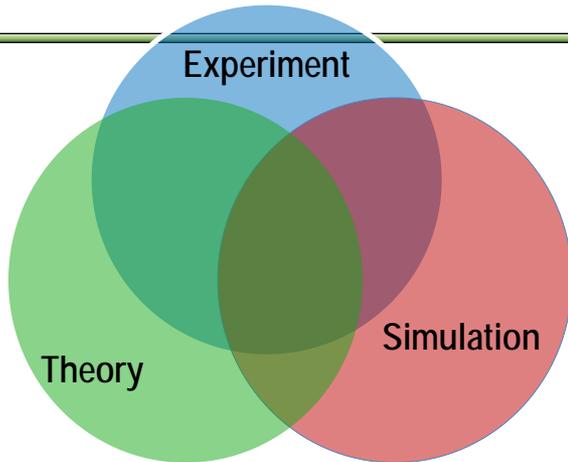
## HEP Program

- Budget
- Guidance & Planning

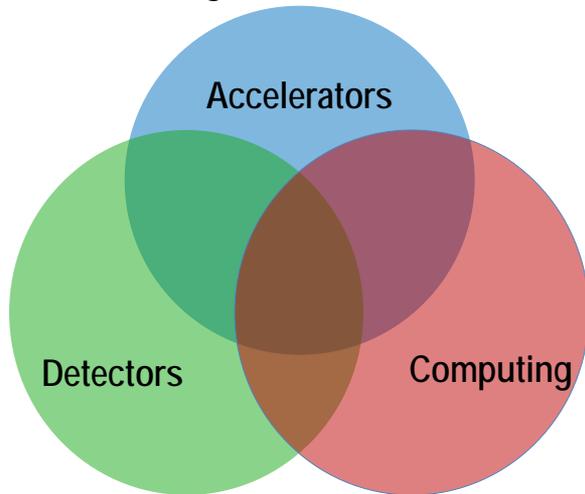
## Cosmic Frontier

- Guidance
- Considerations & Model
- Budget
- Status & Plans
- Going Forward

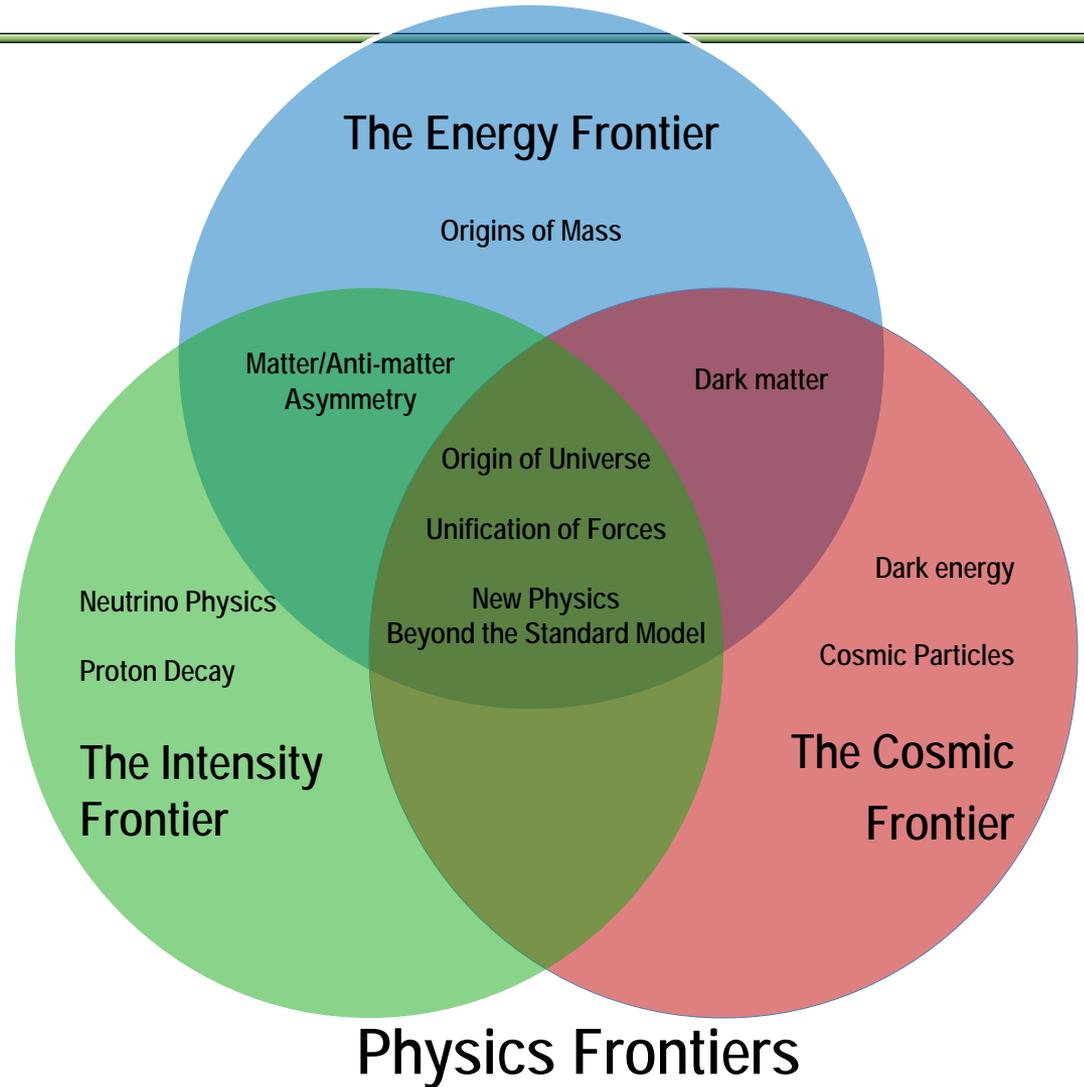
# HEP Program



Along Three Paths



Enabled by  
Advanced Technologies



Physics Frontiers

# High Energy Physics Budget

(dollars in thousands)

Description	FY 2012 Budget Authority	FY 2013 Request	FY 2013 vs FY 2012
Energy Frontier	159,997	160,736	-739
Intensity Frontier	283,675	280,743	+2,932
<b>Cosmic Frontier</b>	<b>71,940</b>	<b>84,946</b>	<b>-13,006</b>
Theoretical Physics	66,965	65,018	+1,947
Advanced Technology R&D	157,106	141,588	+15,518
Accelerator Stewardship	2,850	2,900	-50
SBIR/STTR	20,327	20,590	-263
Construction (Line Item)	28,000	20,000	-8,000
<b>Total, High Energy Physics</b>	<b>790,860</b>	<b>776,521</b>	<b>-14,339</b>
Office of Science	4,873,634	5,001,156	+127,522

**Budget:**

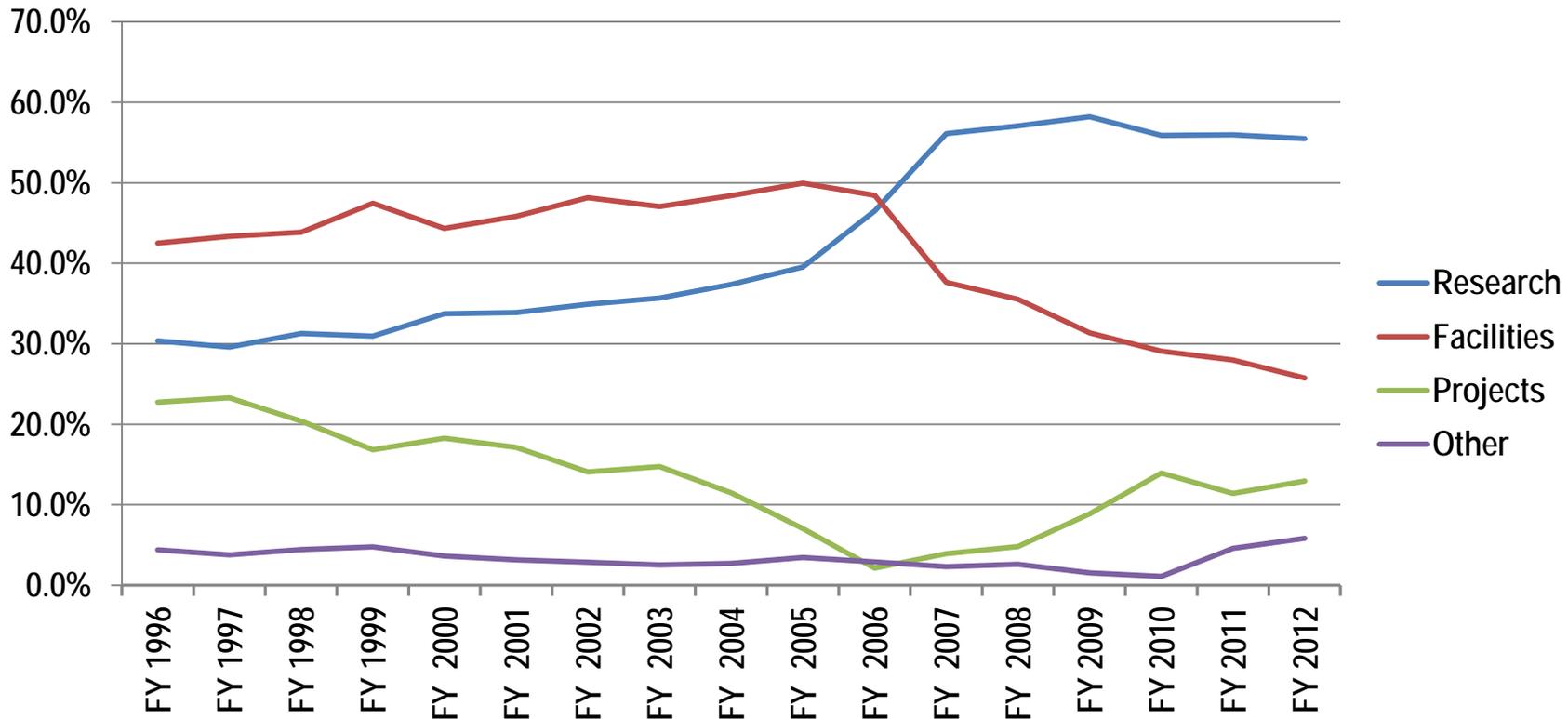
**No changes to report since the last meeting.**

**FY13: We are still under a Continuing Resolution (CR) so the final budget is not known.**

**→ We cannot approve new project “starts” while under a CR!**

**FY14: President’s Request budget – don’t know at this time when it will be released.**

# HEP Budget details



- Lack of new facilities for science threatens the future of the HEP program
- Need to fully exploit current research efforts but also develop new facilities and experiments to maintain a healthy & leadership program.
  - **Overall research funding will decrease at ~2% a year for the next several years** to increase the fraction of the HEP budget for new projects.

# HEP Program Guidance & Input

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## FACA panels – official advice:

- High Energy Physics Advisory Panel (HEPAP)
  - provides the primary advice on the High Energy and Particle Physics programs to DOE and NSF
- Astronomy and Astrophysics Advisory Committee (AAAC)
  - reports to NASA, NSF and DOE on areas of overlap

## Community Input

The APS **Division of Particles and Fields (DPF)** is holding a community-led science planning process to help develop science plans for all the Frontiers in the next year.

- Lay out current strengths, capabilities & opportunities for the science program
- Community meetings ongoing, including a Cosmic Frontier workshop at SLAC on March 6-8
- “Snowmass” summer study in Minneapolis July 29 – August 6
- See <http://www.snowmass2013.org> -- participation encouraged!

## HEPAP P5 subpanel

Following the DPF/Snowmass process, the agencies expect to charge HEPAP to establish a new program and project prioritization subpanel (aka P5) to recommend a new strategic plan for the program in various scenarios.

- Will use input from the DPF/Snowmass process, budgetary and other input from the agencies.
- Will then form the basis for planning for the future of the DOE and NSF High Energy & Particle Physics programs

# Office of Science (SC) – Facilities Planning

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SC Director Bill Brinkman issued a charge in December 2012 to the SC advisory committees to get their advice on the scientific impact and technical maturity of planned and proposed SC Facilities, in order to develop a coherent plan for future DOE/SC facilities over the next 10 years.

The HEPAP Chair has been charged with forming a new Facilities subpanel to respond to this request, and its report will be presented for HEPAP's approval at the March 2013 meeting.

- Only facilities with a large projected DOE program contribution (>\$100 million) to fabrication over this time frame will be considered. The subpanel will not rank order projects.
- Since much program planning has already been done, we expect that the panel will summarize the current status of projects and will identify possibilities offered by new ideas not previously considered.
- This SC planning process is not intended to preclude additional ideas that may emerge from the Snowmass and P5 activities to follow.

Feb. 13-14 HEP Facilities Subpanel meeting:

<https://indico.fnal.gov/conferenceOtherViews.py?view=standard&confId=6381>

## **Projects considered:**

Intensity Frontier: Mu2E, LBNE, NuSTORM

Project X: Detectors & Accelerator

Energy Frontier: High Luminosity LHC upgrade – accelerator & detectors; ILC in Japan – accelerator & detectors; Higgs Factory

Cosmic Frontier: LSST, Gen 3 Dark Matter, Next Generation Dark Energy

# HEP – Research Reviews

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## FY2013 HEP Comparative Review of Grants – panels held November 6-15, 2012

- Received 185 proposals requesting \$335.782M in one or more (“umbrella”) of the 6 sub-programs (Intensity, Cosmic, & Energy Frontiers, Theory, Detector R&D, Accelerator R&D)
- 12 declined & 11 withdrawn before review process
- 162 proposals sent out for individual review and then comparatively reviewed, evaluated and discussed by the appropriate panel(s)

## Cosmic Frontier Comparative Grant review – 16 panel members

- 28 proposals with 55 PI’s/Co-PI’s
- ~ \$7.9M requested; ~ \$3.4M in funding available
- We are in the process of making funding decisions and informing the proposers
- Many good proposals → **Hard choices are being made!**

## FY2013 HEP Comparative Review of Early Career proposals (part of SC program)

Jan 17-24, 2013: Early Career comparative review panels

- separate panels for Theory, Accelerator R&D, Experimental-Lab, Experimental-University

## FY2013 HEP Comparative Review of Laboratory Research (rotating reviews every 3 years)

May 2013: Intensity Frontier panel

Sept 2013: Cosmic Frontier panel

# Cosmic Frontier Experimental Program



# Cosmic Frontier – Program Model

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**Science Mission-driven – We develop and support a specific portfolio of projects**

**→ the emphasis is on doing experiments and getting results**

- make significant, coherent contributions to facilities/experiments selected for the program
- support a science collaboration in all stages, leading to the best possible science results
- Form partnerships or use other agency's facilities when needed (e.g. we don't build telescopes)

**Cosmic Frontier Program “thrusts”**

- Discover (or rule out) the particle(s) that make up **Dark Matter**
- Advance understanding of the physics of **Dark Energy**
- Understanding the high energy universe: **Cosmic-rays, Gamma-rays**
- **Other** efforts

# Cosmic Frontier (Experimental) Program - Funding

Cosmic Frontier Funding (in \$K)	FY12 actual	FY13 current plan
<b>Research – university</b>	<b>11,815</b>	<b>11,945</b>
<b>Research – lab</b>	<b>34,937</b>	<b>35,415</b>
Experimental Operations	7,415	7,525
Future project R&D	3,100	2,859
Small project fabrication	2,538	0
<i>MIE – LSST</i>	5,500	10,000
<i>MIE – HAWC</i>	1,500	1,500
<i>DM-G2 R&amp;D</i>	0	7,000
<b>TOTAL</b>	<b>66,805</b>	<b>76,644</b>

MIE = Major Item of Equipment

DM-G2 = Dark Matter Generation 2

## Budgets:

Research – scientists and their expenses

R&D, Fabrication, Operations – covers technical, engineering, computer professional, management, other personnel & expenses, M&S, computers, utilities, common funds, etc.

# Dark Energy

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→ **Balanced, staged program of experiments w/ all methods: supernovae, BAO, galaxy clustering, weak lensing, etc.**

## Current Experiments

**Supernova surveys: Supernova Cosmology Project, Nearby Supernova Factory, Palomar Transient Factory, QUEST – operations continue**

**Baryon Oscillation Spectroscopic Survey (BOSS)**

**Dark Energy Survey (DES)**

**Science effort, but no “project” plans:**

**WFIRST** NASA Science Definition Team – several scientists participating

**Euclid** (ESA/NASA) space mission – several HEP-funded scientists have joined the science collaboration

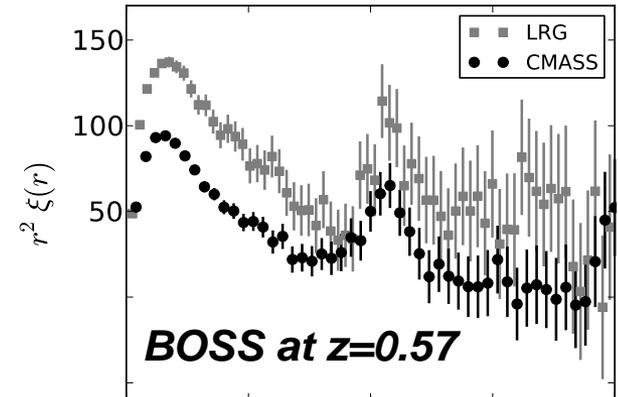
## Coordination of Dark Energy program

Collecting info from experiments about their assets & needs to optimize the dark energy efforts & to create the best dark energy research opportunities for US scientists

# Baryon Oscillation Spectroscopic Survey (BOSS)

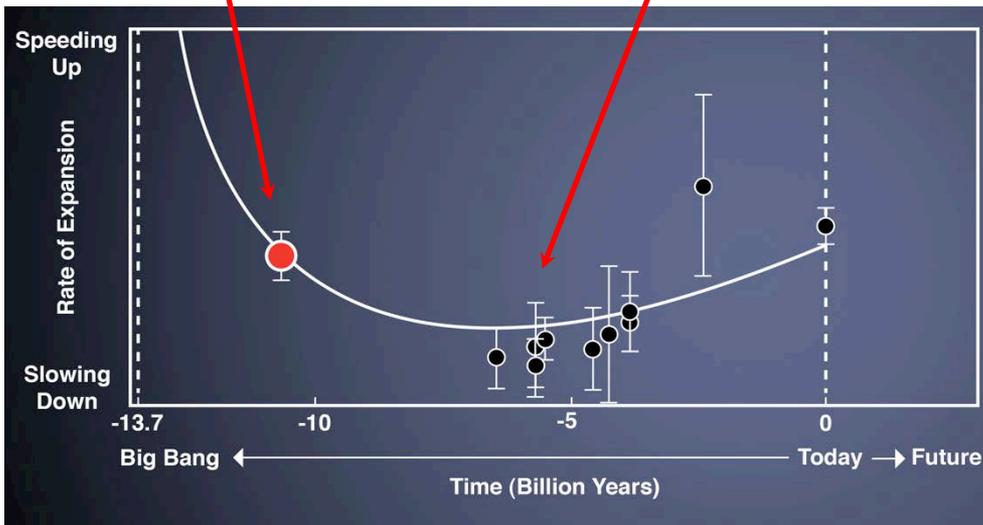
- BOSS mapping 3-D positions of 1.5 million galaxies and line-of-sight to 160,000 quasars using the Lyman-alpha forest.
- 5-year survey of 10,000 deg<sup>2</sup> completes in 2014
- Funded by DOE, NSF, the Sloan Foundation, and contributions private and foreign institutions; Primary survey on SDSS-III
- All data made public in a freely-available, user-friendly database.

SDSS-II at z=0.35



*BAO from BOSS Lyman-alpha forest*

*BAO from BOSS galaxies*

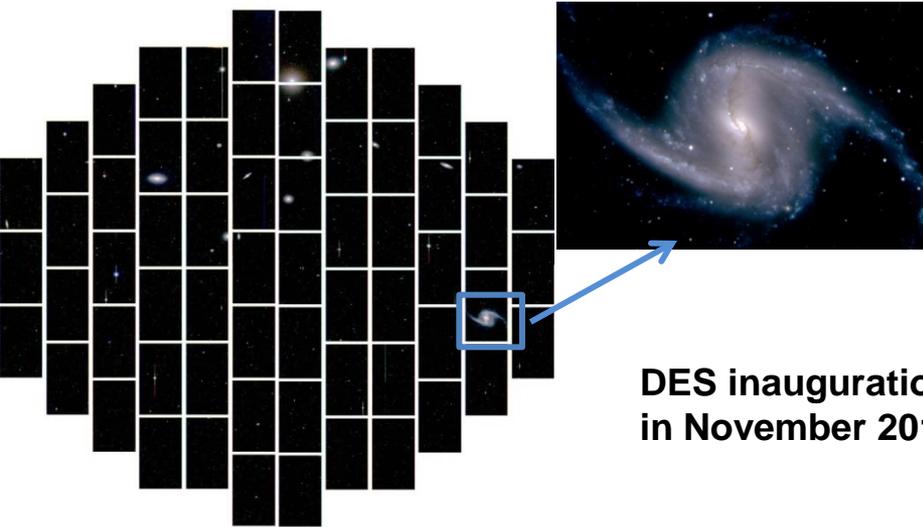


**April 2012:** 1.7% distance measure at z=0.55 consistent with Einstein's  $\Lambda$ CDM  
- Supersedes all previous BAO results combined

**Nov 2012:** 3% distance measure at z=2.3 from newly-demonstrated Lyman-alpha technique from distant quasars

# Dark Energy Survey (DES)

Fornax cluster with close-up of the galaxy NGC 1365



DES inauguration  
in November 2012

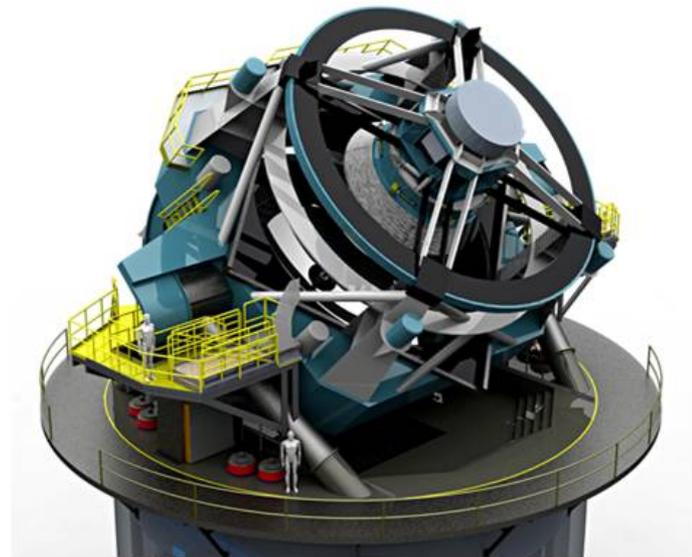


DES – first light on 9/2/12

- DOE/NSF partnership with private and foreign contributions
- DOE/NSF Joint Oversight Group (JOG) meets monthly
- HEP supported fabrication of the Dark Energy camera (DECam), managed by Fermilab, which was installed on Blanco telescope in Chile
- NSF supporting the telescope operations and the data management system
- Status: engineering studies & commissioning; working on telescope efficiency and overall operations; plan to start the 5 year science survey in Sept. 2013
- April 2013: Panel review of DES pre-operations status and planning

# Future – Large Synoptic Survey Telescope (LSST)

- NSF is lead-agency, responsible for telescope & data management; DOE responsible for the camera
- DOE/NSF Joint Oversight Group (JOG) meets biweekly
- DOE Critical Decision 1 (CD-1) approved for LSST-camera in Feb. 2012
- FY 2013 Budget Request has MIE funding for LSST-camera project (long lead items in FY2013) → can't approve until CR is lifted!
- DOE-HEP planning assumes FY2014 Budget Request for NSF will include construction funding
- April 30 – May 2, 2013: Panel review of LSST-camera status & planning
- LSST-DESC – got going in 2012 & will continue to grow; collaboration with mix of expertise needed to plan for data analysis to get precision dark energy results



# Future – Mid-scale Dark Energy Spectroscopic Instrument (MS-DESI)

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HEP community dark energy science plan (August 2012) identified a wide-field spectroscopic survey, that would enable using the Baryon Acoustic Oscillations and Redshift Space Distortions methods, as an important next step in going forward to a Stage IV dark energy program a variety of methods.

9/18/12 -- Critical Decision 0 (CD-0) for MS-DESI experiment approved

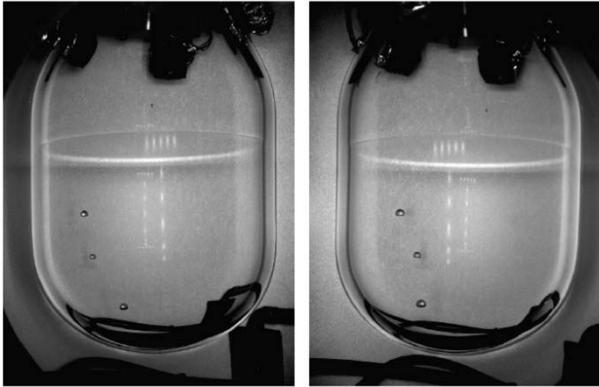
The CD-0 statement calls for the development of new instrumentation to be operated in the time gap between other dark energy experiments (i.e. DES & LSST).

DOE & NSF having regular talks (at least biweekly) about possible opportunities, constraints and models for the experiment and use of a telescope facility.

December 2012 – appointed LBNL to manage the project design, fabrication & operations (Michael Levi appointed as Project Director)

HEP is preparing a Charge letter to request that the MS-DESI project office conduct a science alternatives analysis in the near-term to support HEP's decision-making process in selecting a preferred telescope facility. To support DOE's plan to hold a CD-1 review in late FY 2013, it is expected that DOE will need to make this selection in spring 2013. This would then feed in to the discussions with NSF.

# Direct-Detection Dark Matter – Current “Generation 1” (DM-G1)



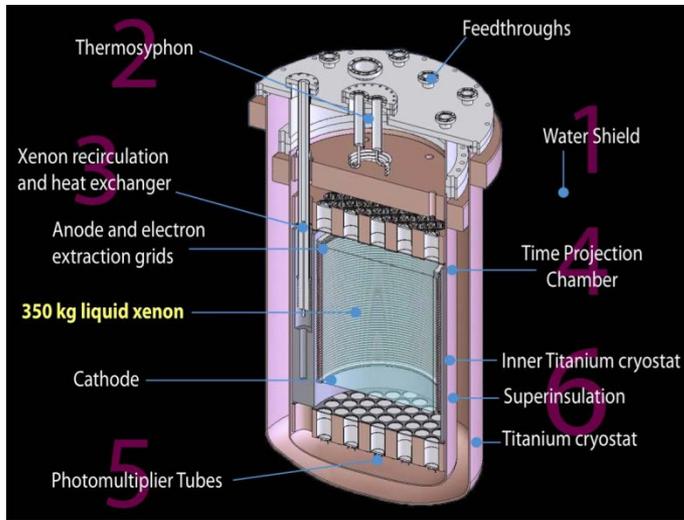
COUPP Bubble Chamber – Fermilab, SNOLab - commissioning



Axion Dark Matter eXperiment (ADMX) Phase-2a at U.Washington -commissioning; start science run in summer



Cryogenic Dark Matter Search (CDMS) at Soudan mine - germanium detectors - operating



Large Underground Xenon (LUX) detector – Sanford Lab, Homestake mine – now underground & in commissioning



FIG. 5: (a) The DARKSIDE-50 internal detector. (b) The DARKSIDE-50 detector within the active liquid scintillator neutron veto and the passive shield.

DarkSide-50 – Dual-Phase liquid argon TPC at LNGS Gran Sasso; commissioning

# Next Steps : Cosmic Frontier – Dark Matter

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→ **Balanced, staged program of experiments w/multiple technologies in the near term.**

- Continue to coordinate with NSF-PHY
- Have a path forward for next phase of direct detection dark matter experiments

## Direct Detection Dark Matter Generation 2 (DM-G2) experiments

- Critical Decision 0 (CD-0) for DM-G2 experiment(s) was signed 9/18/12.
- September 2012 – held comparative panel review of proposals for FY13 R&D funding
- Funding decisions made & will be discussed in detail at the next HEPAP meeting in March
- Downselection expected to occur near beginning of FY14.
- Technology choices will need to be made at time of G2 downselect; will only be able to fund ~2 of the DM-G2 groups for continuation into project phase.

# High Energy Cosmic-ray, Gamma-ray experiments

→ Experiments measuring properties of high energy cosmic-rays & gamma rays; can also explore acceleration mechanisms and do indirect searches for dark matter candidates.

**Pierre Auger** - cosmic ray observatory  
**VERITAS** – gamma-ray array  
**Fermi Gamma-ray Space Telescope**  
**HAWC** – gamma ray array

Cherenkov Telescope Array (CTA):

Astro2010 recommended US contribution to CTA in higher budget scenarios (4th on list of ground-based experiments) and that funding be split approximately 2/3 NSF and 1/3 DOE.

DOE/HEP recently gave guidance to the US collaboration:

- Following the Astro2010, we consider NSF to be in the lead for considering the project.
- We have no funding identified for a contribution to CTA in the foreseeable future and therefore aren't funding R&D for it (science studies okay)



**Alpha Magnetic Spectrometer (AMS)** on the International Space Station – launched May 2011  
- Operations & analysis continues  
- Summer 2013 – planning operations review

# Pierre Auger Observatory

Science: observe, understand and characterize the Ultra High Energy (UHE) cosmic rays and probe particle interactions at UHE.

Observatory: installed over a 3000 km<sup>2</sup> site in Argentina with 24 fluorescence telescopes & 1600 surface Cherenkov detectors

Enhancements: 3 high elevation fluorescence telescopes, 60 infill detectors, muon counter array, + more

Collaboration & Partnership: Large international collaboration of 18 countries, 463 collaborators

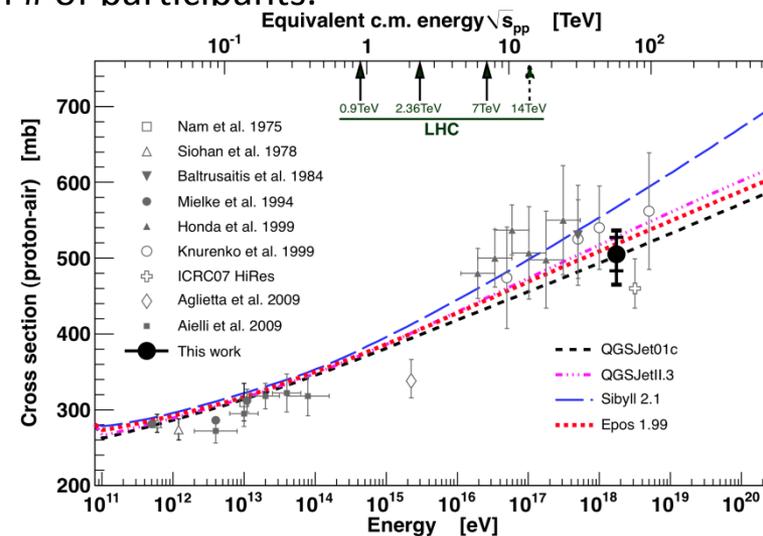
-- Fermilab hosts the Project Office – Project Office will transition to Argentina ~ 2014. After that, DOE's commitment will still be to provide common funds based on # of participants.

→ International Finance Board meets annually

Publications: As of end 2012: 36 full-authored papers,

Operations Status: Data taking started in 2004. Full array completed in 2008; Collaboration plans to run through to at least 2015.

Future: Collaboration is doing R&D for enhancements and future detection techniques which may extend the lifetime of the Observatory → proposal is being prepared to submit later in 2013.



Proton-air cross section measured at center-of-mass 57 TeV (2012).

# VERITAS

(Very Energetic Radiation Imaging Telescope Array System)

Four 12-meter Cherenkov telescope high energy (100 GeV to 30 TeV) gamma-ray array at Whipple observatory in Arizona

Collaboration/Partnership: ~100 scientists from US (DOE,NSF,SAO), Canada, Ireland, UK.

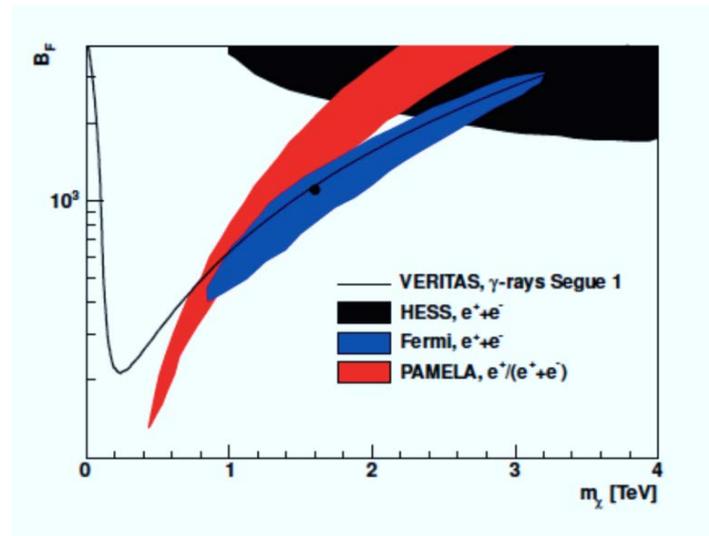
→DOE, NSF, SAO Joint Oversight Group meets quarterly

Current Status of experiment:

- Operating since Fall 2007
- Recently started 6<sup>th</sup> season of operations & 1<sup>st</sup> with upgrade, which was completed summer 2013
- Collaboration requesting to continue operations through FY17
- November 2012: DOE told VERITAS that we expect to fund DOE part of their operations for 3 more years and consider this to complete the experiment; this plan depends on getting the funding shares from other agencies

Recent Highlights:

- Discovery of new, unexpected VHE emission from the Crab Pulsar
- VERITAS DM limits from dwarf galaxy Segue 1



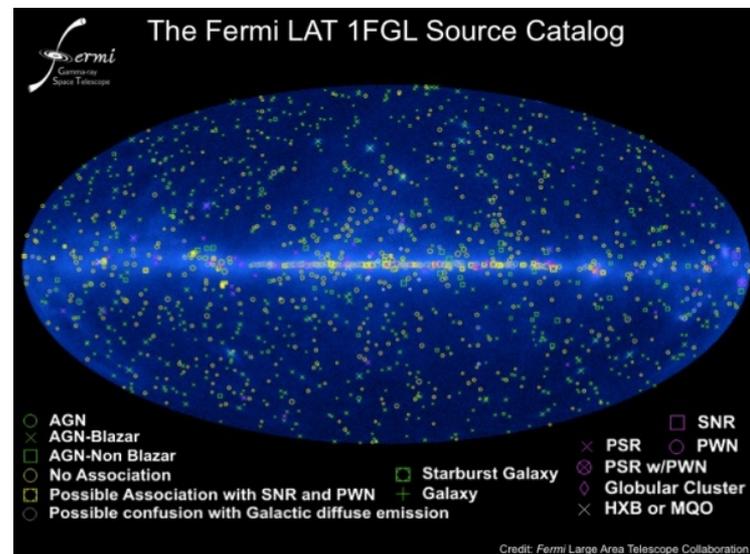
Limits on boost factor in leptophilic DM models (region above line excluded); arXiv:1202.2144, accepted in PRD.

# Fermi Gamma-ray Space Telescope (FGST)

- DOE, NASA and 4 international partners on Large Area Telescope; NASA leads the mission
  - HEP plans continued support for the Instrument Science Operations Center (ISOC) at SLAC through at least FY 2014 – will revisit extending to FY2016
- International Finance Board meets twice a year

## Recent highlights include:

- Collaboration update at Fermi Symposium (October 2012) on the  $\sim 135$  GeV bump in the spectrum from the Galactic Center region and elsewhere:
  - systematics under careful investigation; more statistics will answer the question
  - upgrade of event reconstruction and analysis (“Pass 8”) in 2013 will further improve instrument performance
- first blind search detection of a millisecond pulsar
  - Science Express 1229054 online 25 October 2012
- measurement of cosmic extragalactic background light
  - Science 30 November 2012: 1190-1192
- search for dark matter in gamma-ray lines
  - Phys Rev D 86, id. 022002, July 2012



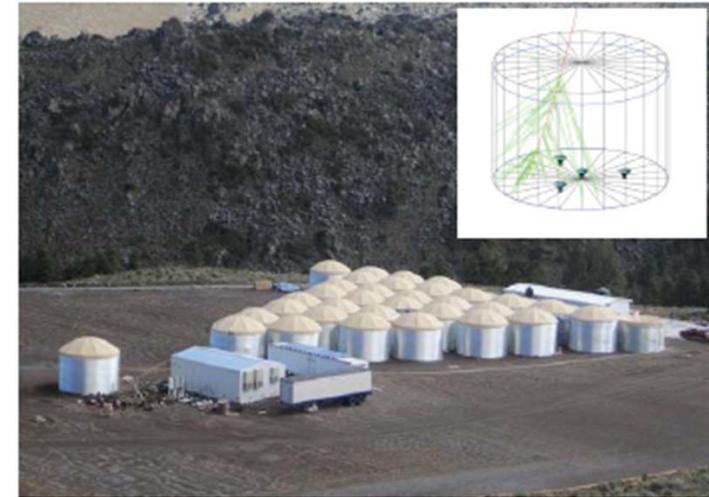
# High Altitude Water Cherenkov (HAWC) Gamma Ray Observatory

Extensive Air Shower Detector with 250-300 Water Cherenkov Detector tanks located at 13500' in Mexico

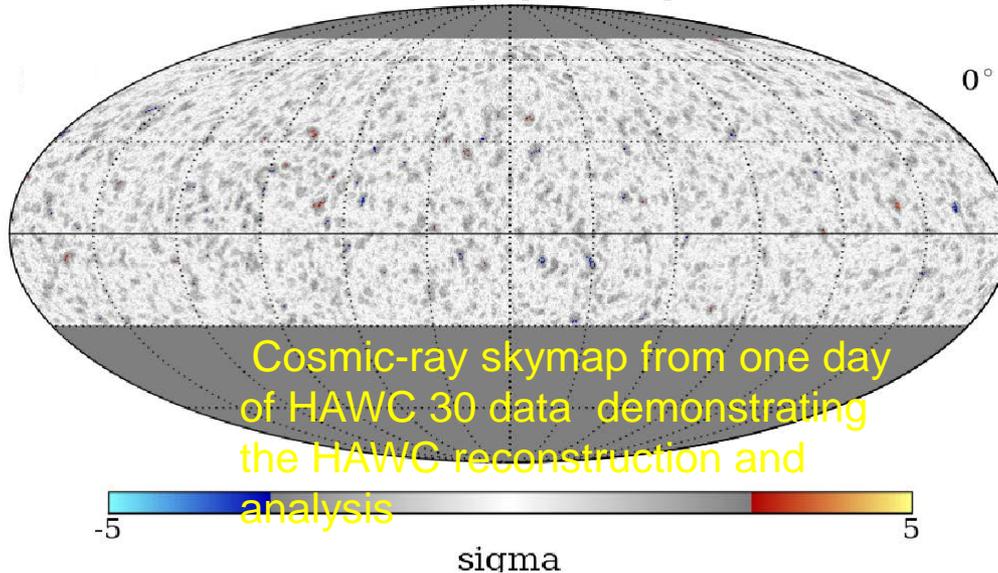
Collaboration: 150 scientists from US and Mexico

Partnership: US (DOE, NSF) and Mexico (CONACyT)

→ DOE, NSF, Mexico Joint Oversight Group meets quarterly



HAWC 30 Skymap - 2012 Sept 5



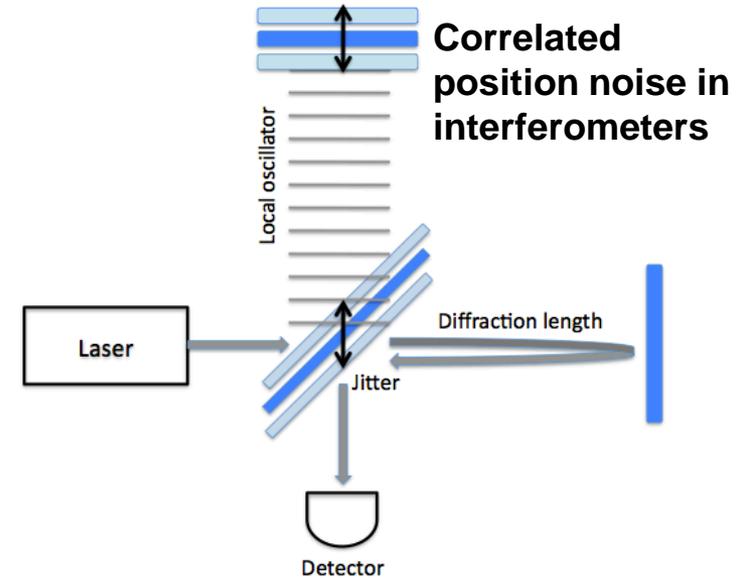
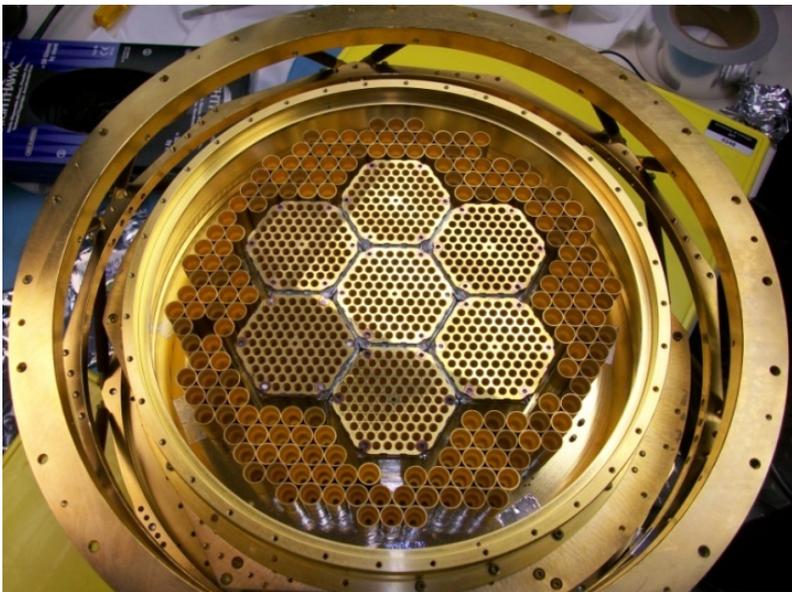
## Status:

- Project fabrication 2011-2014
- Sept 2012: 30 tank array completed
- May 2013: 100 tank array will be completed and start operations in August 2013
- June 2013: panel review of their operations plan
- August 2014: operations with full array starts

# Cosmic Frontier – Other experiments

## South Pole Telescope polarization (SPTpol)

- CMB polarization experiment
- HEP provided support for outer-ring detector fabrication and is supporting operations for ANL activities.
- Collaboration proposing SPTpol-3G as next step



### Holometer status:

- Full vacuum system in place & finishing mechanical installation
- Will go into full commissioning in the next few months

# Cosmic Frontier – Related efforts

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## Computational Cosmology

SciDAC-3 (Scientific Discovery through Advanced Computing) DOE award to Cosmic Frontier Computational Collaboration at DOE Labs (2012 for 3 Years): Computation-Driven Discovery for the Dark Universe PI: S. Habib

ESA/NASA Planck mission: First comprehensive simulations run at DOE NERSC Computing Facility generating 35TB of data – used to validate ongoing analysis of the real Planck data in preparation for their release in January 2013. POC: J. Borrill, LBNL

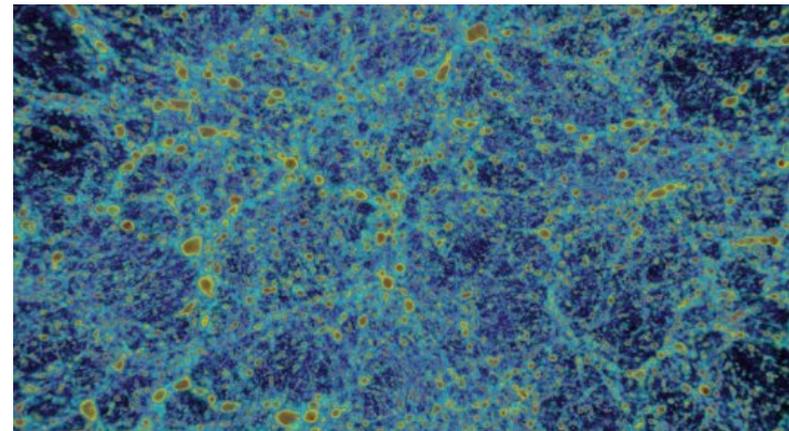
Allocations at NERSC: Both DES and LSST planning on using NERSC for simulations and analysis

## HEP Theory Program

- funds Cosmic Frontier related theory efforts; typically not directly in support of experiments in the program

## Detector R&D

- Funds generic detector R&D; some efforts related to Cosmic Frontier needs



# Cosmic Frontier – Summary

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## **Dark Matter & Dark Energy:**

Have path forward for next steps

Will further develop and optimize program starting with input from the DPF/Snowmass process.

## **Other areas:**

-- Science case and role of other particle astrophysics areas needs to be better articulated through DPF/Snowmass process

**Lots of results coming out or expected soon in all areas. Future is looking bright!!**