U.S. DEPARTMENT OF ENERGY

OFFICE OF SCIENCE

Office of High Energy Physics (HEP) Program Status & Planning

CAA meeting
March 7, 2013

Jim Siegrist
Associate Director for the
Office of High Energy Physics
Office of Science, U.S. Department of Energy

HEP Strategic Plan

HEPAP P5 subpanel 2008 report guides the program

HEP mission is to understand how our universe works at its most fundamental level. To enable discoveries, HEP supports:

–theoretical and experimental research in both elementary particle physics
–and fundamental accelerator science and technology.

Progress in achieving the mission goals requires advancements at the Energy, Intensity and Cosmic Frontiers

–The U.S. should have a strong, integrated research program at all three frontiers.
–At lower funding levels, cannot maintain leadership at all 3 frontiers

Energy: support for the US LHC program, including US involvement in the planned detector and accelerator upgrades. (highest priority)

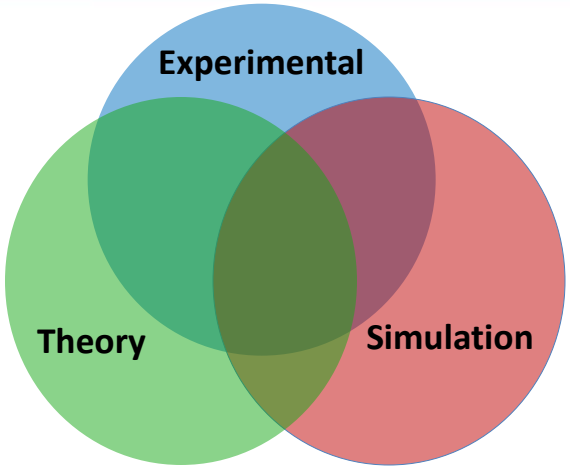
Intensity: world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL and a high-intensity neutrino source at Fermilab.

Cosmic: support for the study of dark matter and dark energy as an integral part of the US particle physics program.

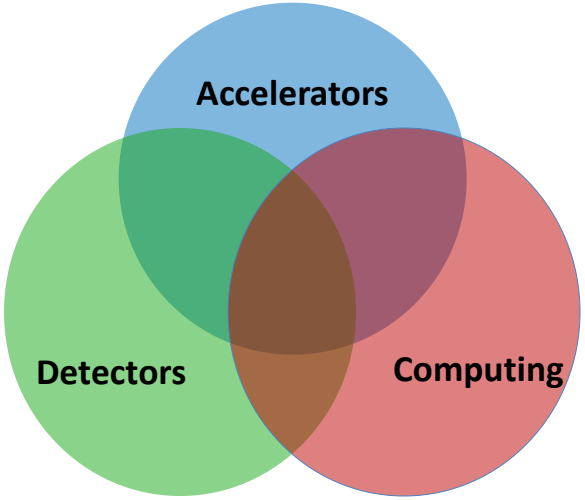
HEP at its core is an accelerator-based experimental science.

–Support accelerator and detector R&D to develop new technologies
- that are needed by the field & that benefit the nation

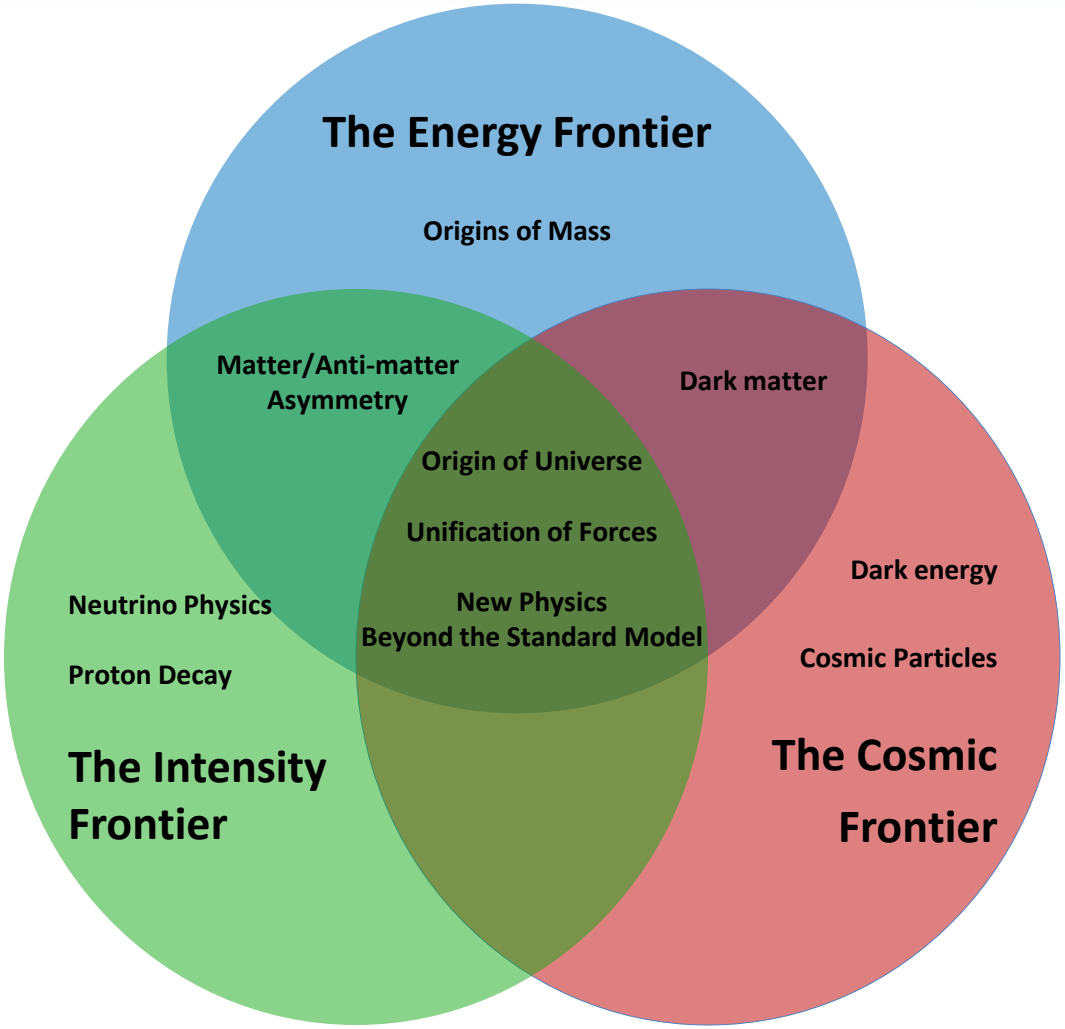
HEP Physics and Technology



Along Three Paths



Enabled by
Advanced Technologies:



Physics Frontiers

HEP Program Model

DOE Office of Science: We are a science mission agency

- Provide science leadership and support to enable significant advances in specific science areas
- Lab environment with a variety of resources needed to design, build, operate facilities/projects selected for the Program
- Lab infrastructure, including computing facilities (NERSC, SCiDAC program etc)
- Encourage scientific teams/collaborations with expertise in required areas to participate in all phases, leading to the science results.
- Partnerships as needed to leverage additional science and expertise
- Include speculative science (e.g. led to dark energy discovery)

Energy & Intensity Frontier:

Design, build, operate facilities to do experiments

Cosmic Frontier: We do experiments!

Design and build instrumentation; led by scientific collaborations; bring other resources (e.g. computing, operations) & use other agency's facilities (e.g. telescopes) when needed.

Model has been very successful:

See http://science.energy.gov/about/honors-and-awards/doe-nobel-laureates/

HEP Program Guidance & Input

FACA panels & subpanels – official advice:

- **High Energy Physics Advisory Panel (HEPAP)**
  - reports to DOE and NSF; provides the primary advice for the program

- **Astronomy and Astrophysics Advisory Committee (AAAC)**
  - reports to NASA, NSF and DOE on areas of overlap

Other:

National Academies of Sciences: NWNH (2010), EPP2010

Specific studies:

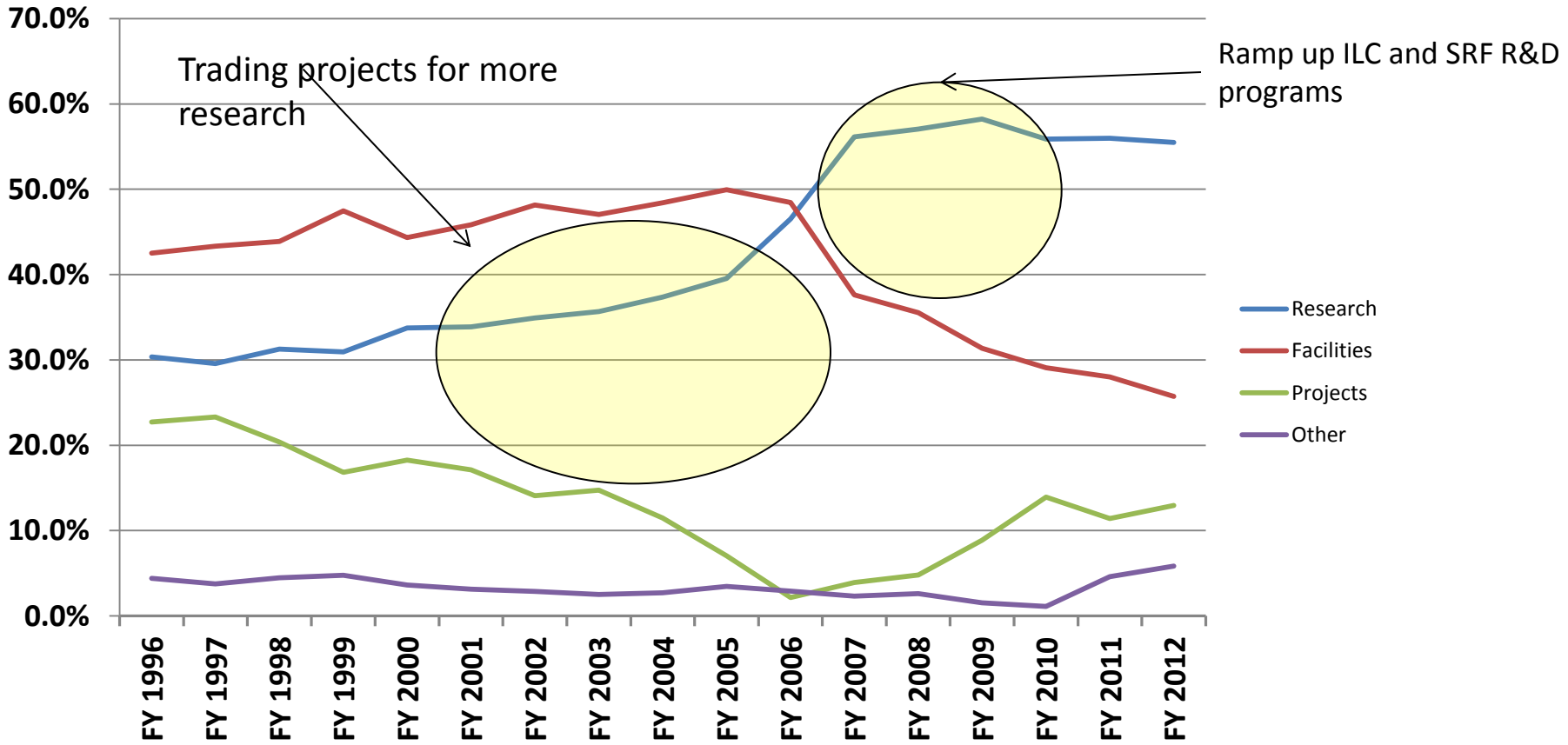
Community task forces & studies provide needed input

High Energy Physics Budget

(dollars in thousands)

Description	FY 2012 actual	FY 2013 Request	FY 2013 - FY 2012	% change
Energy Frontier	159,130	160,736	+1,606	+1.0
Intensity Frontier	284,048	280,743	-3,305	-1.2
Cosmic Frontier	72,390	84,946	+12,556	+17.3
Theoretical and Computational HEP	67,031	65,018	-2,013	-3.0
Advanced Technology R&D	159,934	144,488	-15,446	-9.7
SBIR/STTR	20,327	20,590	+263	+1.3
Construction (Line Item)	28,000	20,000	-8,000	-28.6
Total, High Energy Physics	**790,860**	**776,521**	**-14,339**	**-1.8**
Office of Science	**4,873,634**	**5,001,156**	**+127,522**	**+2.6**

Current Funding Trends



To maintain healthy and leadership program:

- **Need to fully exploit current research efforts**
- **Progress requires new investments to produce new capabilities in well defined areas.**

→ Possibilities for future funding growth are weak. Must make do with what we have.

Budget Status & Directions

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.
- Program priorities and comparative reviews will be used to implement the cuts
- Some frontiers will be more affected than others

Going Forward it is important that we:
- Increase the fraction of the HEP budget for new projects.
- Have a balanced program across the frontiers; with staged implementation and science

FY13:
We are still under a Continuing Resolution (CR); final budget is not known.
→ Cannot approve new project fabrication starts while under a CR.
Sequestration has started; don't know full effects yet…

FY14: President's Request budget – Release in March. Or not.

Making New Investments

- HEP recently finished projects; Critical Decision 4 (CD-4) in FY2012
  Daya Bay, Dark Energy Survey, FACET, BELLA (finished end of 2012)

- New opportunities:
  - LSST camera – FY13 budget requests Major Item of Equipment (MIE) fabrication start
  - Intensity Frontier: NOvA

- Five new "Major Item of Equipment" (MIE) projects received Mission Need (CD-0) approval in September 2012
  - all are in the $20-40 million range.
  - Energy Frontier: ATLAS Detector Upgrade; CMS Detector Upgrade
  - Intensity Frontier: New Muon g−2 Experiment
  - Cosmic Frontier: Second-generation Dark Matter Experiments (DM-G2)
    Midscale Dark Energy Spectroscopic Instrument (MS-DESI)

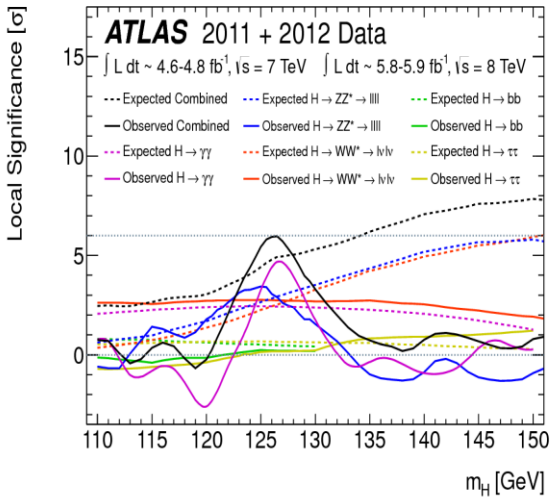
- **Need program plan for new projects to start in 2015-2016 timeframe**

Energy Frontier Status

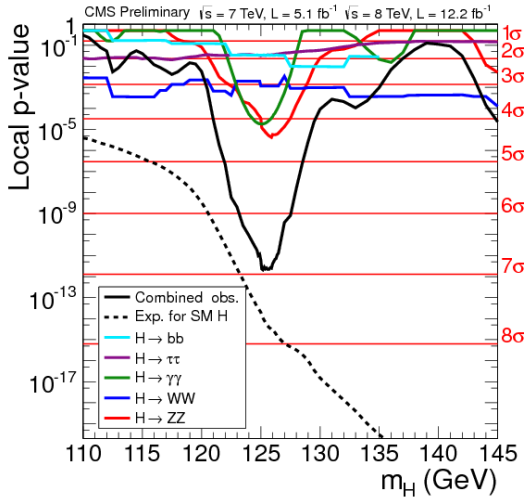
Fermilab Tevatron - operations ended FY2011

Large Hadron Collider (LHC) at CERN: DOE made significant contributions to the accelerator and detectors (ATLAS and CMS)

2012 Major Result: A Higgs Boson-like particle has been observed by both experiments in several decay modes



ATLAS Observed Result (July 2012)



CMS Observed Result (as of HCP 2012)

Energy Frontier Plan & Issues

Plan:

- **Science goals going forward:**
  - Fully explore the TeV scale.
  - Is there anything there but a SM Higgs?
  - Is it really a “SM Higgs”?
  - Do we have a complete picture of EWSB?

- **Planned program of major projects:**
  - LHC Detector Upgrades: (2017-8) to cope with increased data rates
  - Participate in LHC-High Luminosity upgrade; installation ~ 2022.

Issues:

- **No new facilities under construction at this time**
  - Everything in the foreseeable future is off-shore
  - US has a leading role in LHC physics collaborations but is not the **driver**

Intensity Frontier Status

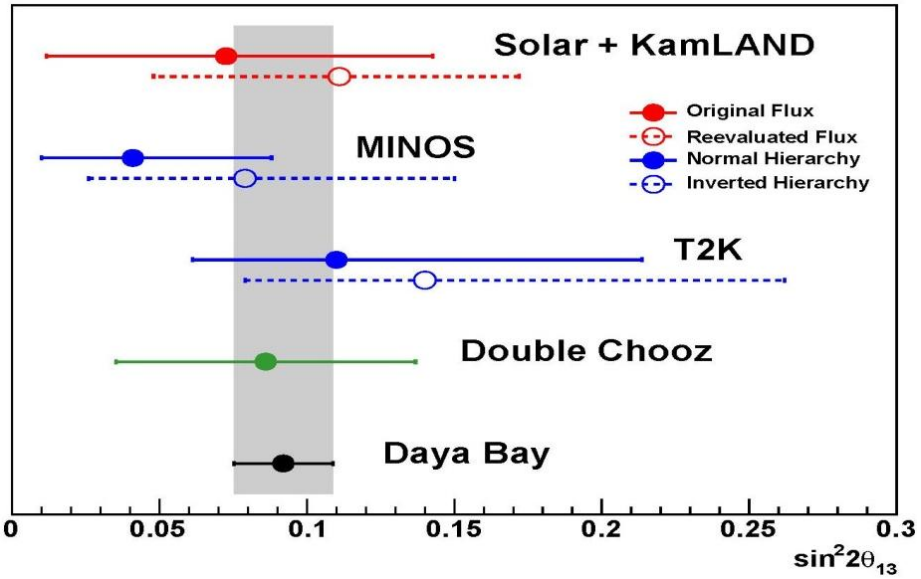
Current program in neutrino physics: Minerva, NOvA, T2K, MicroBoone, Daya Bay, EXO-200

- **NOvA** and **MicroBoone** will complete construction in FY 2014
- Others taking data

Planned program: projects in design/R&D phase; fabrication not approved yet: Belle-II, Mu2e, LBNE, Muon g-2

Physics Status

- Daya Bay, T2K, NOvA, et al. will usher in the era of precision neutrino physics with few % measurements



Intensity Frontier – Plans & Issues

Future Directions:

We must have long-term goals for the precision needed to measure the neutrino mixing matrix elements.

→ This is an essential element that will guide the development of the neutrino program.

Issues:

US is a (the?) world leader and needs new facilities and/or upgrades of existing facilities to maintain its position

- Need to get the program going to attract partners
- Portfolio of experiments and science case is diverse; makes explaining it to stakeholders difficult
- The scale of the projected investments is a big challenge

Cosmic Frontier Program

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** – small efforts in CMB, holographic interferometry

Cosmic Frontier - model

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 at a level commensurate with expected science return on HEP physics goals

- support an HEP-style science collaboration in all stages, including coordinated data analysis to get the best possible science results

- Form partnerships or use other agency's facilities when needed (e.g. telescopes)

- For facilities with broader science program, we make project contributions at an appropriate level and support research efforts for our interests

Cosmic Frontier – Guidance

FACA subpanels provide targeted advice

→ We are following HEPAP's Particle Astrophysics Science Assessment Group (**PASAG**) 2009 report:

- Recommended an optimized program over the next 10 years in 4 funding scenarios
- Dark matter & dark energy remain highest priorities; don't zero out everything else

Prioritization Criteria - Make contributions to select, high impact experiments:
– That directly address HEP science goals
– That will make a visible or leadership contribution
– With HEP community contributions: instrumentation, collaborations, analysis techniques etc.

Other input:

National Academies: Decadal Survey of Astronomy & Astrophysics – NWNH 2010 report

We consider NWNH recommendations to DOE for their scientific value & options for our program --

- Large projects - LSST was recommended as priority for DOE because role is critical
- 2nd priority ground based - contributions to NSF mid-scale experiments
- 4th priority ground based - contribute (w/NSF) as a minor partner to European-led CTA

Specific studies:

Dark Energy task force: Science case for a HEP dark energy program developed at HEP request (Rocky Kolb, chair) – August 2012.

Cosmic Frontier (Experimental) budget

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

MIE = Major Item of Equipment

DM-G2 = Dark Matter Generation 2

Cosmic Frontier Status

High-energy cosmic and gamma rays

- Fermi/GLAST, Veritas, Auger, AMS operating

Dark Matter:

1st generation dark matter (DM-G1) direct detection experiments commissioning or operating with variety of technologies: **ADMX, COUPP, DarkSide, LUX, SuperCDMS**

Dark energy:

Experiments using existing facilities & instruments**:**

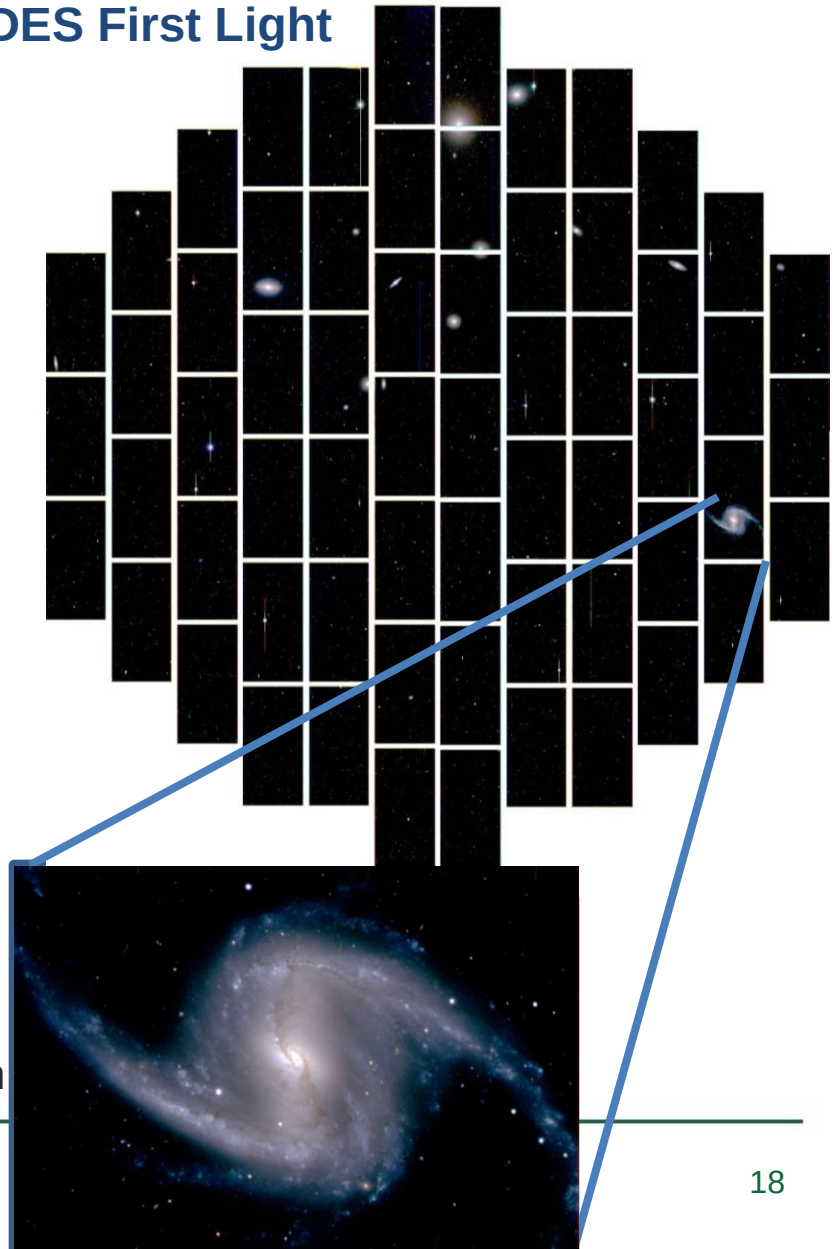
• **Supernova surveys** and **BOSS** operating

• **Dark Energy Survey** commissioning

• Science effort, but no "project" plans:

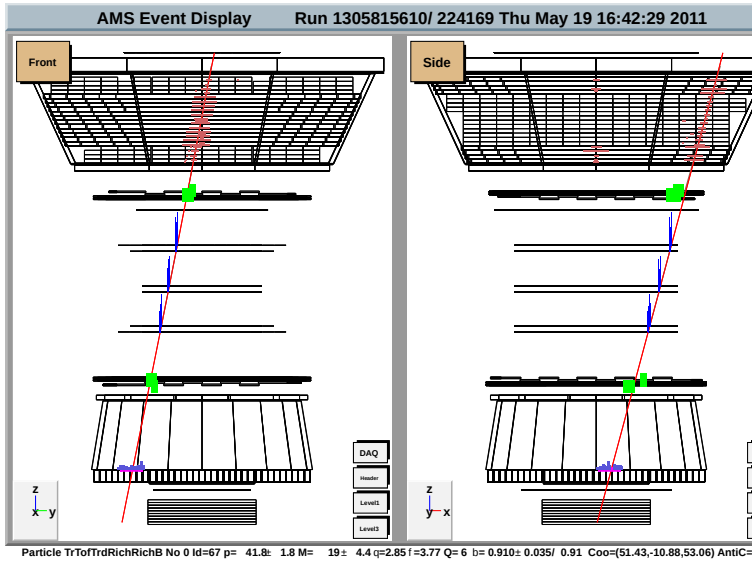
- WFIRST NASA Science Definition Team – several scientists participating

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

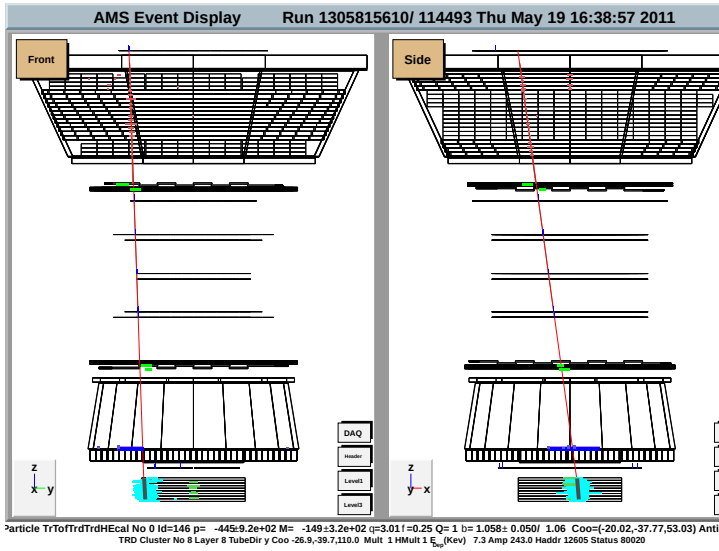


AMS – Alpha Magnetic Spectrometer

- Launched on May 16, 2011, (Endeavor, STS-134) and installed on Space Station
- AMS is performing as expected and has collected many billions of cosmic ray events since installation; operations and analysis continues



42 GeV carbon



20 GeV Electron

Fermi Gamma-ray Space Telescope (FGST) - status

- 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, depending on NASA plan

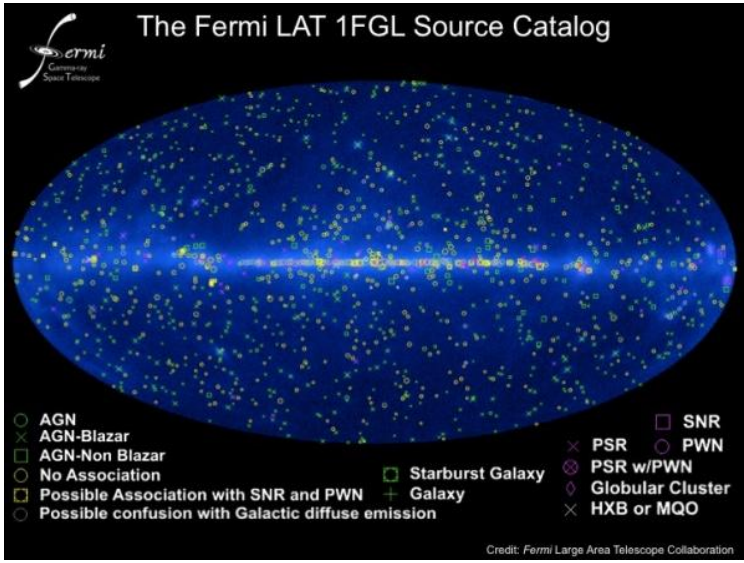
→ International Finance Board meets twice a year

Recent highlights include:

• Collaboration update at Fermi Symposium (October 2012) on the ~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



Dark Matter Future

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

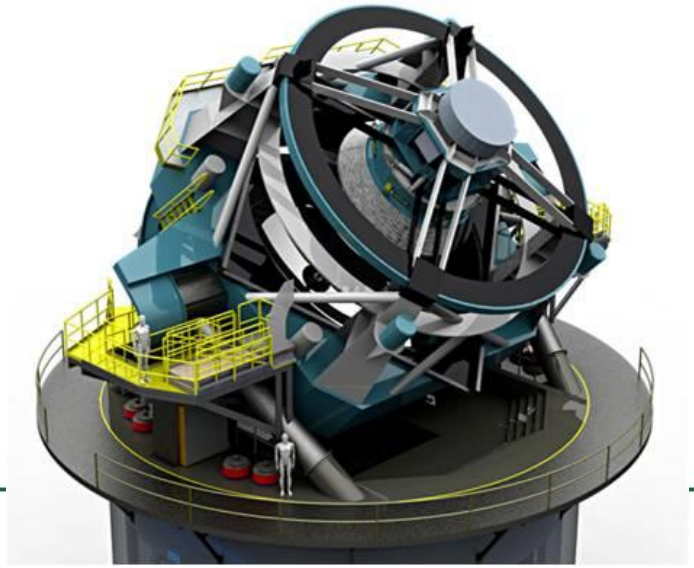
Direct Detection Dark Matter Generation 2 (DM-G2) experiments
• September 2012: CD-0 for DM-G2 experiment(s) approved
• September 2012: comparative review of proposals for FY13 R&D funding
• March 2013: FY13 R&D review and funding results presented at HEPAP meeting
• Downselection for experiments to move into fabrication phase 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.

DM-G3 experiments

- G3 R&D and planning continues at a low level

Dark Energy 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) → <u>can't approve until CR is lifted!</u>
- 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



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

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 using 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.

January 2013: HEP and NSF-AST signed a statement of agency principles
- **HEP goal is to do the survey in 3-5 years with 70-100% of the dark time and is willing to pay operating costs; HEP would like to make the site selection asap to meet the envisioned schedule.**
- **NSF is interested in identifying a suitable telescope to support MS-DESI; Mayall is likely to be available for usage and a decision could be made ~ April 2013; Blanco not known yet to be available and decision is not likely possible in the April 2013 time frame.**

February 2013: HEP has charged the MS-DESI project office at LBNL to conduct a science alternatives analysis in the near-term to support HEP's decision-making process in selecting a preferred telescope facility. DOE will then work with NSF to determine if the preferred site can be made available for MS-DESI.

Cosmic Frontier Status – Next Steps & Issues

Dark Matter:

• Have plan for DM-G2 experiments that will probe most of preferred phase space
• Will have to make technology choices going forward.

Dark Energy

• Have ground-based plan to reach Stage-IV measurements using multiple methods:
BOSS, DES → MS-DESI, LSST
• What other measurements or instrumentation will be needed to fully exploit these experiments?

High Energy Gamma Rays

DOE/HEP recently guidance to the US CTA collaboration:

▪ Following Astro2010 recommendations, we consider NSF to be the lead for considering the project.

▪ We have no funding identified for a contribution to CTA in the foreseeable future and therefore don't plan to fund R&D towards it.

Issues & Path forward

–US HEP has a leading role in a competitive, multidisciplinary environment
–Technologies are diverse but HEP physics case is simple and compelling.

- **How far do we need to go in precision/setting limits in each area?**
- **Dark Matter & Dark Energy – have path forward; need to further develop & optimize**
- **Other particle astrophysics areas: science case and role needs to be better articulated**

Strategic Planning

The HEP budget puts in place a comprehensive program across the three frontiers.

- In five years,
  - Intensity Frontier: NOvA,Mu2e, g-2 will be taking data
  - Energy Frontier: The CMS and ATLAS detector upgrades will be installed at CERN.
  - Cosmic Frontier: DES near the end of its survey; MS-DESI beginning operations
  - The two big initiatives, LSST and LBNE, will be well underway.

Need to start planning now for what comes next.

- Identify scientific opportunities and directions
- Develop prioritized plan of projects to carry out science goals
- Start the agency process to propose new initiatives as the current initiatives finish.

Strategic Planning Goals

Need a realistic, coherent, shared plan for US HEP

- Enabling world-leading facilities/experiments in the US while recognizing the global context and the priorities of other regions
- Recognizing the centrality of Fermilab while maintaining a healthy US research ecosystem that has essential roles for both universities and multipurpose labs
- Articulating both the value of basic research & the broader impacts of HEP
- Maintaining a balanced and diverse program that can deliver research results consistently

- Need a realistic, coherent science plan for each of the Frontiers, plus accelerator research, theory, etc.
- This will need to be integrated into 1 overall, coherent, coordinated plan, and prioritized.

Planning & Prioritization Process

DPF Community Science Study (CSS2013, aka "Snowmass") will identify compelling HEP science opportunities over an ~ 20 year time frame. The plan:

- doesn't need to be a consensus; rather it can show the range of options available.
- should show the current science reach and potential future science reach that can be achieved by experiments in the HEP program to make significant advances in the coming years.
- can make scientific judgments, but is not a prioritization process
- should exhibit timescale, technical and fiscal realism

Particle Physics Project Prioritization Panel (P5)

- After CSS2013 process completes, we plan to re-establish a HEPAP-P5 subpanel to take the CSS2013 output as input to the next round of prioritization, including budget projections.
- We expect to have an updated plan sometime in calendar 2014 that will shape the program going forward.
- Note that we need more projects in the pipeline than we have budget to support, since we need to move construction money continuously from one project to the next.

In Parallel: Office of Science (SC) Facilities Planning

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 HEP 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. The subpanel can add or subtract from the initial list.

Some of the Projects being 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, DM-G3

Summary

Physics results continue to come out.

Have plan for next 5 years.

Have embarked on strategic planning process to lay out longer term plans and priorities.

BACKUPS

Dark Energy

➔**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

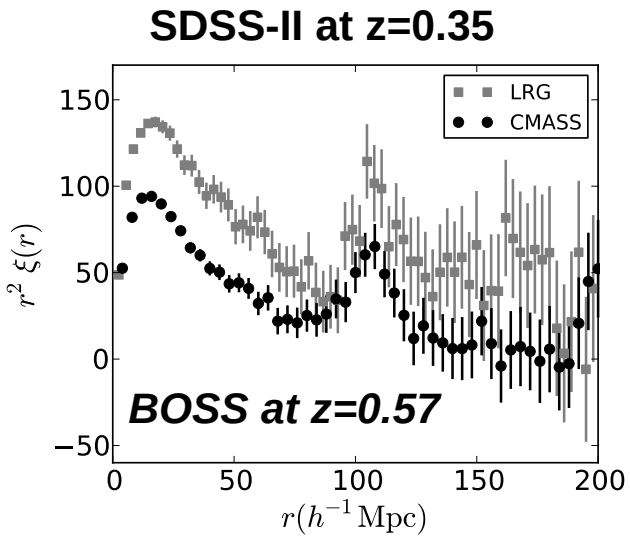
Euclid (ESA/NASA) space mission – several HEP-funded scientists have joined the science collaboration

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

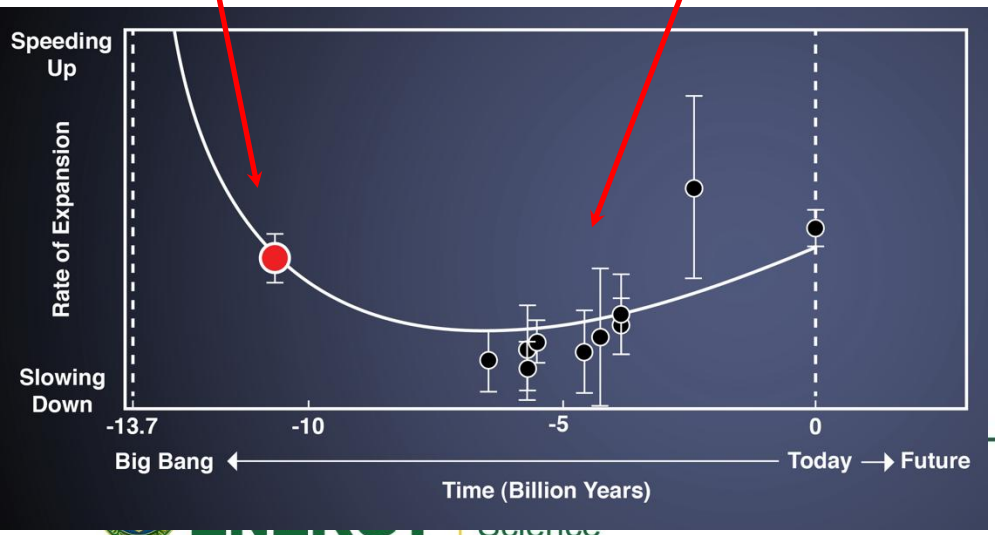
Baryon Oscillation Spectroscopic Survey (BOSS)

- **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 deg2 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.**



BAO from BOSS Lyman-alpha forest

BAO from BOSS galaxies

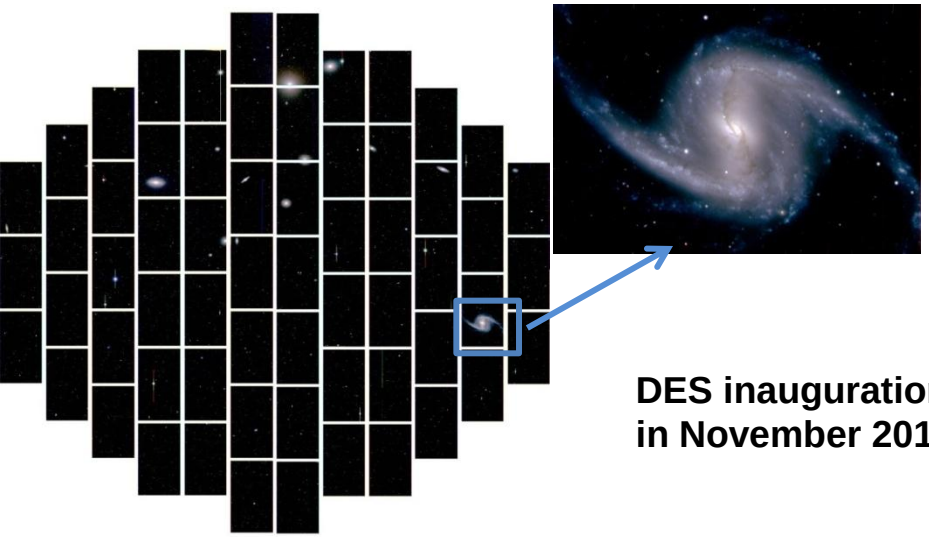


April 2012: 1.7% distance measure at z=0.55 consistent with Einstein's Λ
- Supersedes all previous BAO results combined

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



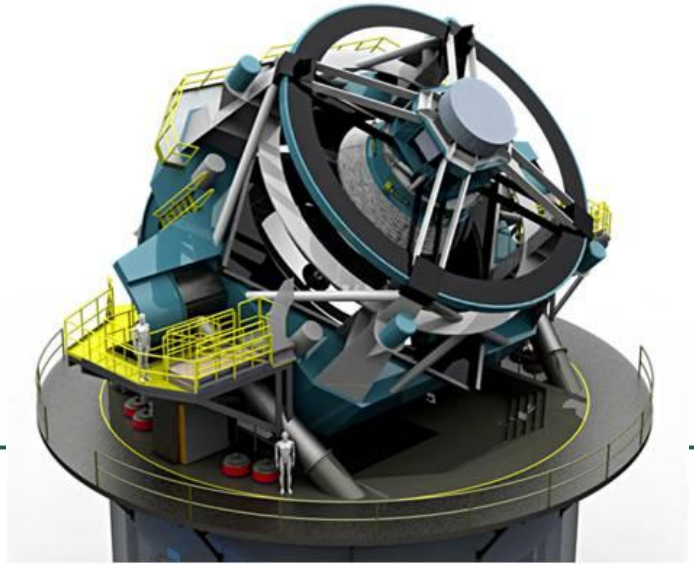
DES – first light on 9/2/12

DES inauguration in November 2012

- 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) → <u>can't approve until CR is lifted!</u>
- 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



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

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).

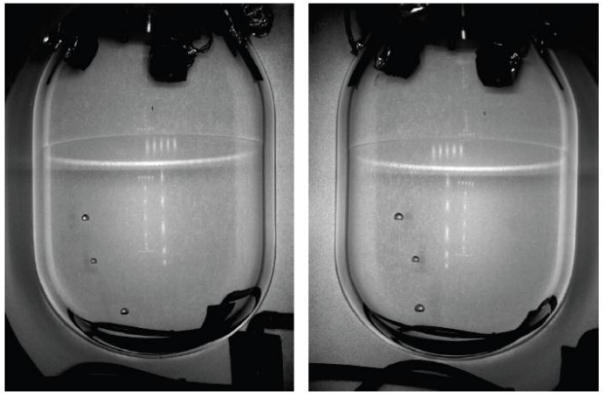
DOE & NSF having regular talks (at least biweekly) about possible opportunities, constraints and models for the experiment and use of a telescope facility.

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

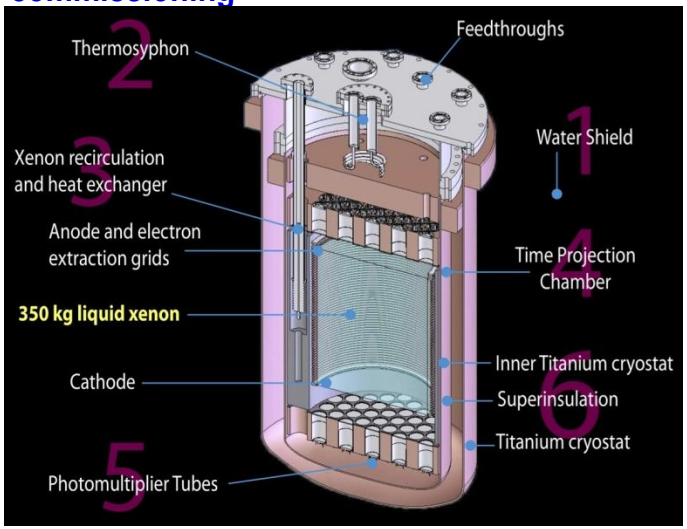
January 2013: HEP and NSF-AST signed a joint Statement of Principles for basics of project layout.

February 2013: HEP has charged the MS-DESI project office to conduct a science alternatives analysis in the near-term to support HEP's decision-making process in selecting a preferred telescope facility.

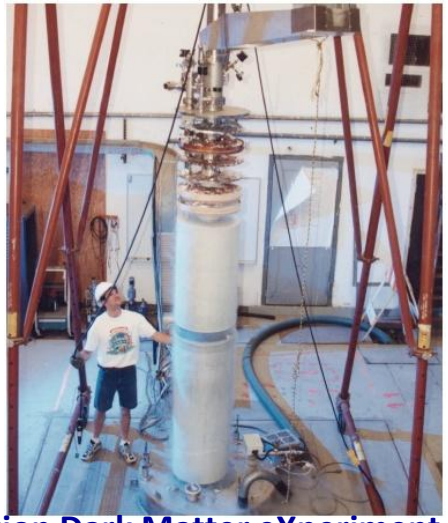
Direct-Detection Dark Matter – Current "Generation 1" (DM-G1)



COUPP Bubble Chamber – Fermilab, SNOLab
- commissioning



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

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

→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.

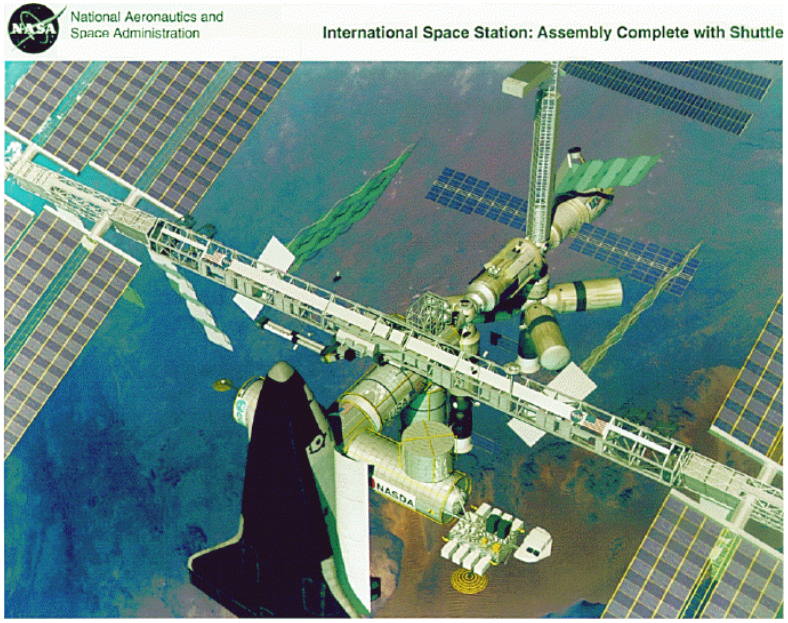
High Energy Cosmic-ray, Gamma-ray experiments

➔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

<u>Cherenkov Telescope Array (CTA):</u>
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.

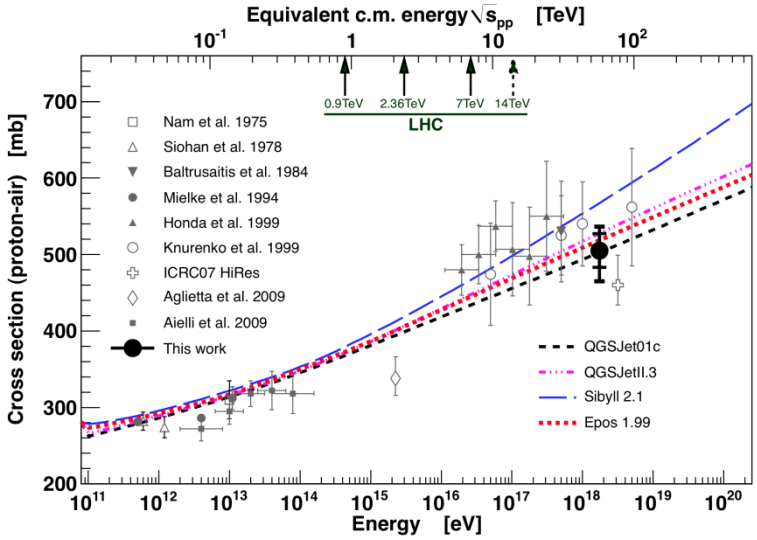
Observatory: installed over a 3000 km^2 site in Argentina with 24 fluorescence telescopes & 1600 surface Cherenkov detectors
Enhancements: 3 high elevation fluorescence telescopes, 60 infill detectors, muon counter array, + more

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).

U.S. DEPARTMENT OF ENERGY | Office of Science

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.

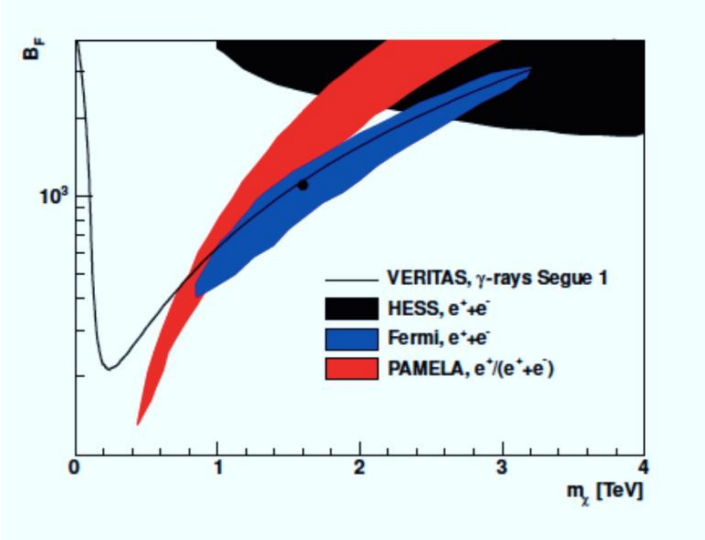
→DOE, NSF, SAO Joint Oversight Group meets quarterly

Current Status of experiment:

- Operating since Fall 2007
- Recently started 6th season of operations & 1st 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 leptophillic DM models (region above line excluded); arVix: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, depending on NASA plan

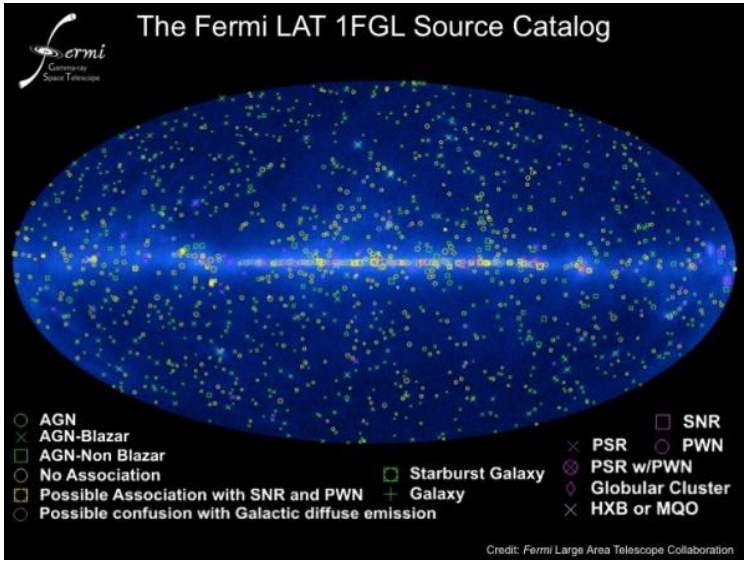
→ International Finance Board meets twice a year

Recent highlights include:

• Collaboration update at Fermi Symposium (October 2012) on the ~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



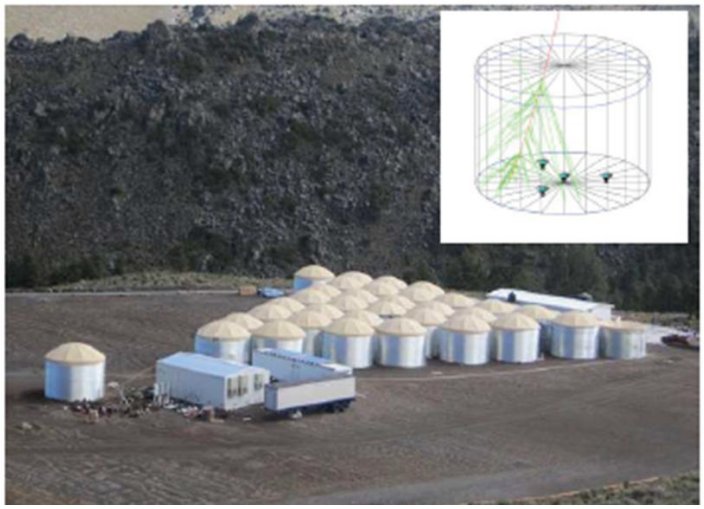
• first blind search detection of a millisecond pulsar
- Science Express 1229054 online 25 October 2012

• measurement of cosmic extragalactic background light
- Science 30 November 2012: 1190-1192

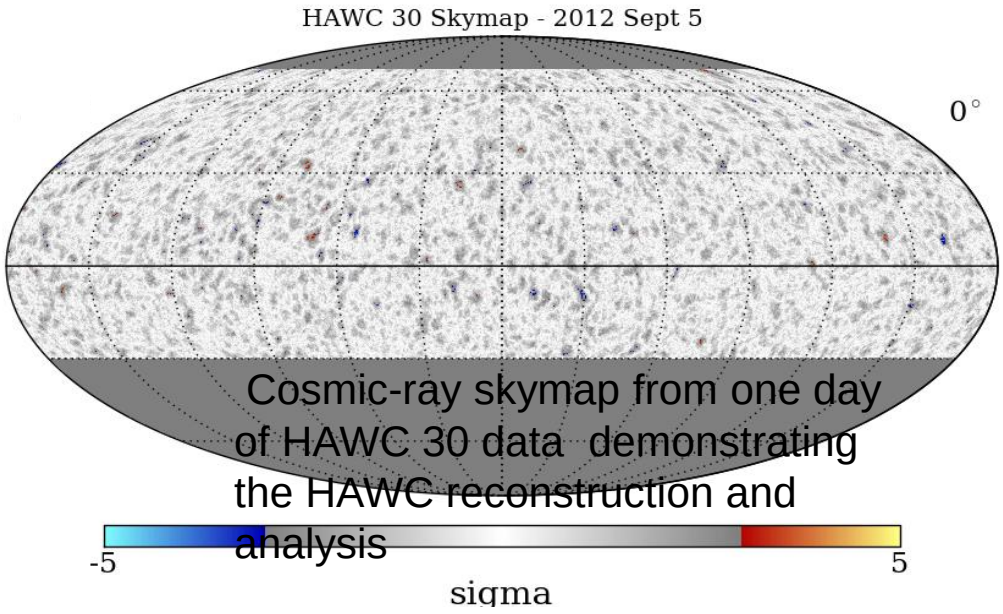
•search for dark matter in gamma-ray lines
- Phys Rev D 86, id. 022002, July 2012

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

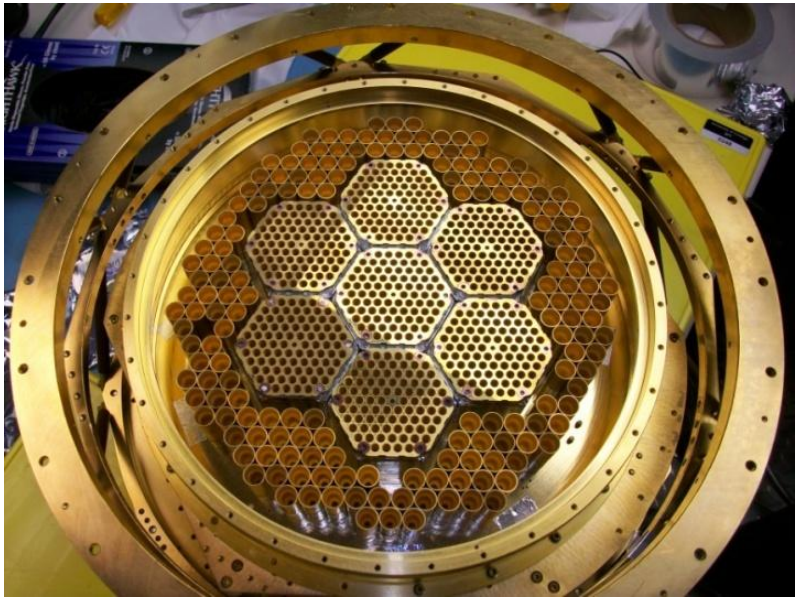


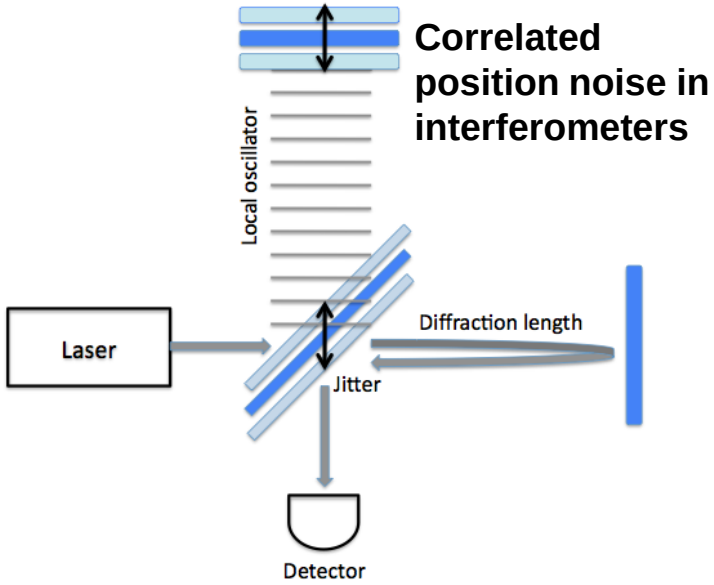
Cosmic-ray skymap from one day of HAWC 30 data demonstrating the HAWC reconstruction and analysis

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

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

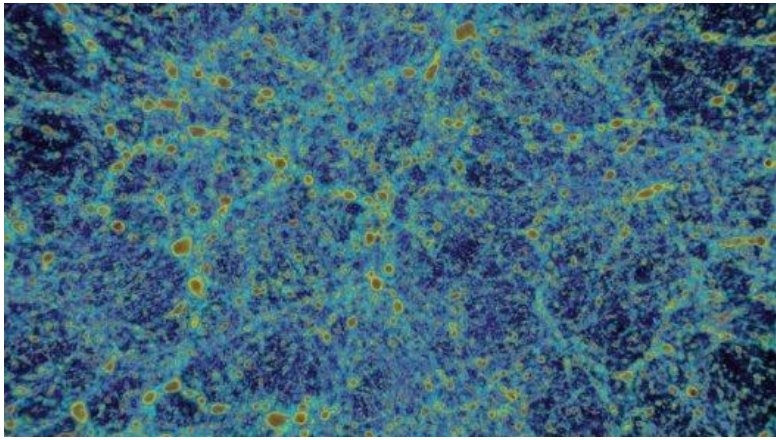
Computational Cosmology
SciDAC-3 (Scientific Discovery through Advanced Computing) DOE award to Cosmic Frontier Computational Collaboration at DOE Labs (2012 for 3 Years): Computation-Driven Discovery for the Dark Universe PI: S. Habib

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

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!!