U.S. DEPARTMENT OF ENERGY

OFFICE OF SCIENCE

DOE Office of High Energy Physics (HEP) Status Report to the AAAC November 13, 2013

Kathy Turner
Program Manager, Cosmic Frontier
Office of High Energy Physics
Office of Science, U.S. Department of Energy

Outline

Overview

Program Model & Guidance

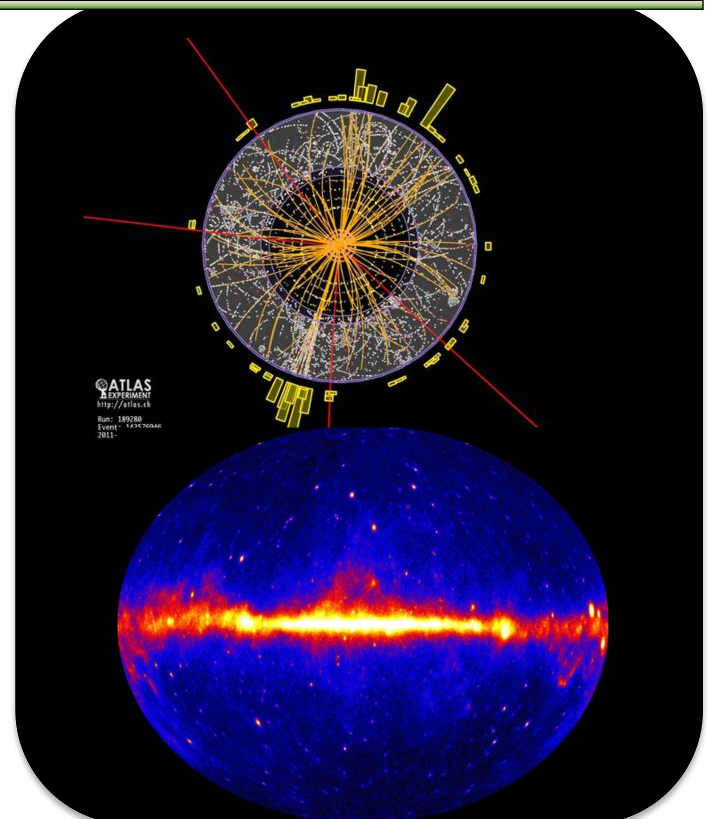
Budget

Strategic Planning

Program Status

Program Model & Guidance

From Deep Underground to the Tops of Mountains, HEP pushes the Frontiers of Research



RESEARCH AT THE ENERGY FRONTIER — HEP supports research where powerful accelerators such as the LHC are used to create new particles, reveal their interactions, and investigate fundamental forces, and where experiments such as ATLAS and CMS explore these phenomena.

RESEARCH AT THE INTENSITY FRONTIER — Reactor and beam-based neutrino physics experiments such as Daya Bay and LBNE may ultimately answer some of the fundamental questions of our time: why does the Universe seem to be composed of matter and not anti-matter?

RESEARCH AT THE COSMIC FRONTIER — **Through ground-based telescopes, space missions, and deep underground detectors, research at the cosmic frontier aims to explore dark energy and dark matter, which together comprise approximately 95% of the universe.**

THEORY AND COMPUTATION — Essential to the lifeblood of High Energy Physics, the interplay between theory, computation, and experiment drive the science forward. Computational sciences and resources enhance both data analysis and model building.

ACCELERATOR SCIENCE — Supports R&D at national labs and universities in beam physics, novel acceleration concepts, beam instrumentation and control, high gradient research, particle and RF sources, superconducting magnets and materials, and superconducting RF technology.

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 selected facilities & projects
- Lab infrastructure, including computing facilities (NERSC, SCiDAC program etc)
- Encourage scientific teams with expertise in required areas to participate in all phases → science results.
- Partnerships as needed to leverage additional science and expertise (e.g. use other agency's facilities)

High Energy Physics
- **We develop and support a specific portfolio of selected facilities & experiments to obtain the science**

-- support a science collaboration in all stages, leading to the best possible science results

Cosmic Frontier:

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.

→ Our model also brings significant new capabilities in terms of instrumentation, and coordinated computing, simulation and analysis efforts that provide impacts & resources to the astronomy community.

Model has been very successful:

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

HEP Program Guidance

FACA panels & subpanels – official advice:

- **High Energy Physics Advisory Panel (HEPAP)**
  – reports to DOE and NSF; provides the primary advice for the program
  - Subpanels for detailed studies (e.g. PASAG, P5)

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

Other:

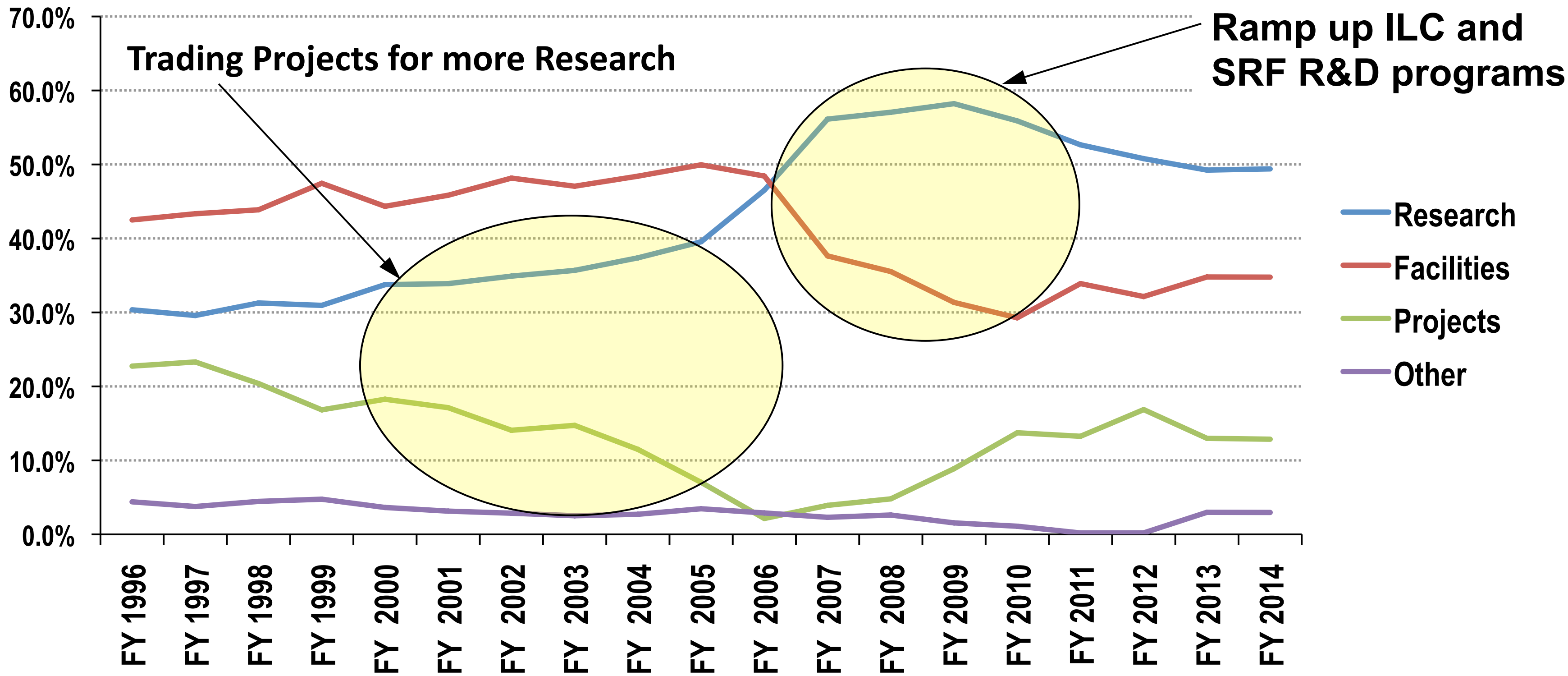
e.g. National Academies of Science studies, community science studies, reviews, etc.

Strategic Program Planning → Have been following the 2008 P5 program plan

→Recently embarked on new strategic planning process:
Snowmass + P5 (May 2014 reports)

Budget

Recent Funding Trends



To maintain healthy and leadership program:

- **Need to fully exploit current research efforts**
- **Progress requires new investments to produce new capabilities**

  → New investments are needed to continue U.S. leadership in well defined areas.

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

FY14 HEP Budget Overview

- FY 2014 President's Request: $776M
- FY 2014 Initial "plan" is based on the House Mark: $772M
- Current FY2014 funding plan based on a Continuing Resolution through 1/15/14 with FY2013 "bottom-line" of $748M.
- FY 2014 original budget philosophy was to enable new world-leading HEP capabilities in the U.S. through investments on all three frontiers
  - We weren't able to start fabrication on new projects.
  - Impact is that several new efforts are delayed and continue in R&D phase:
    - LHC detector upgrades, Long Baseline Neutrino Experiment (LBNE), 2nd Generation Dark Matter detectors (DM-G2), Dark Energy Spectroscopic Instrument (DESI) experiment

Description	FY 2012 Actual	FY 2013 Actual	FY 2014 Request	Explanation of Change [FY14 Request *vs.* FY13]
Total, High Energy Physics:	770,533[a]	727,523[b,c]	776,521	wrt FY13: Up +3.6% after SBIR correction wrt FY12: Down -2% after SBIR correction
Ref: Office of Science (SC):	4,873,634	4,621,075 [c]	5,152,752	

[a] The FY 2012 Actual is reduced by $20,327,000 for SBIR/STTR.

[b] The FY 2013 [Plan] is reduced by $20,791,000 for SBIR/STTR. [c] Reflects sequestration.

Major Item of Equipment (MIE) Issues

- **We were not able to implement [most] new MIE-fabrication starts in the FY14 request**
  - **Muon g-2 experiment is the only new start in HEP that was not requested in FY13**
  - **LSST-Camera and Belle-II, which didn't receive approval in FY13, are requested again in FY14**

- **This upsets at least 2 major features of our budget strategy:**
  - **Strategic plan: "Trading Research for Projects"**
  - **Implementation of facilities balanced across Frontiers**

Strategic Planning

Strategic Plan & Budget

- **The U.S. HEP program is following the strategic plan laid out by the previous HEPAP/P5 studies (2008)**
  - Recent results provide compelling evidence that the science focus is shifting "Beyond the Standard Model."
  - We are adapting the program to the science opportunities.
- **Though some of the boundary conditions have changed, we are still trying to implement the 2008 strategic plan within the current constraints**

- **We are currently actively engaged with community in developing new strategic plan through Snowmass/P5 process (2013-2014)**
- **Increased emphasis on broader impacts via accelerator stewardship**
- **Maintain leadership**
  - Focus on areas where US can have leadership
  - High impact science as opposed to incremental advances

Snowmass – community scientific input

- **Snowmass 2013 process – community input on science directions:**
  - ✓ What are the most compelling science questions in HEP that can be addressed in the next 10 to 20 years and why?
  - ✓ What are the primary experimental approaches that can be used to address them?
    - are they likely to answer the question(s) in a "definitive" manner *or* will follow-on experiments be needed?
  - ✓ What are the "hard questions" (science, technical) that a given experiment or facility needs to answer to respond to perceived limitations in its proposal?

These topics are covered in the Snowmass reports and White Papers

- P5 will use these reports and white papers as its starting point.
- Draft Summary Working Group Reports available on the P5 webpage: *http://www.usparticlephysics.org/p5*

P5 Strategic Planning Process

http://www.usparticlephysics.org/p5/

- **P5 will assess and prioritize HEP projects over a 20-year timeframe within reasonable budget assumptions and position the U.S. to a be a leader in some (but not all) areas of HEP.**
  - **Identify priorities with 10-year budget profiles but may well extend past the next decade**
    - **consider technical feasibility as well as fiscal plausibility of future projects that can be executed in a 20-year timescale.**
  - **Scenario A: FY 2013 budget baseline: flat for 3 years, then +2% per year.**
  - **Scenario B: FY 2014 President's budget request baseline: flat for 3 years, then +3% per year.**
    - **difference between Scenarios A and B integrated over the 10-year period: ~$540M**
  - **Scenario C: Unconstrained budget scenario. Beyond A and B, prioritize *"… specific activities … … needed to mount a leadership program addressing the scientific opportunities identified by the research community."***
  - **This will include an explicit discussion of the necessity (or not) of domestic HEP facilities in order to maintain such a world leadership position.**
  - **Consideration of possible international partnerships will be required.**

  - ***Charge: "[P5] report should articulate the scientific opportunities which can and cannot be pursued and the approximate overall level of support that is needed in the HEP core research and advanced technology R&D programs to achieve these opportunities in the various scenarios."***

P5 Reports: Final P5 report due by May 1, 2014 (interim March 1)

Program Status

Recent News

HEP supports about 1100 researchers at 65 universities and 5 labs on ATLAS and CMS.

- 2013 Nobel Prize in Physics awarded for work on the Higgs boson jointly to:
  - François Englert (Université Libre de Bruxelles, Belgium) and Peter W. Higgs (University of Edinburgh, UK)
    - *"For the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider."*

Energy Frontier Program Status

Fermilab Tevatron (DØ and CDF)

- Working with DØ and CDF collaborations on completion of **legacy** analyses as part of its ramp-down research program
  - **most effort completed in FY13 and FY14**
  - **final papers (*e.g.,* $M_W^{Tevatron}$): FY15**

Large Hadron Collider (LHC) at CERN

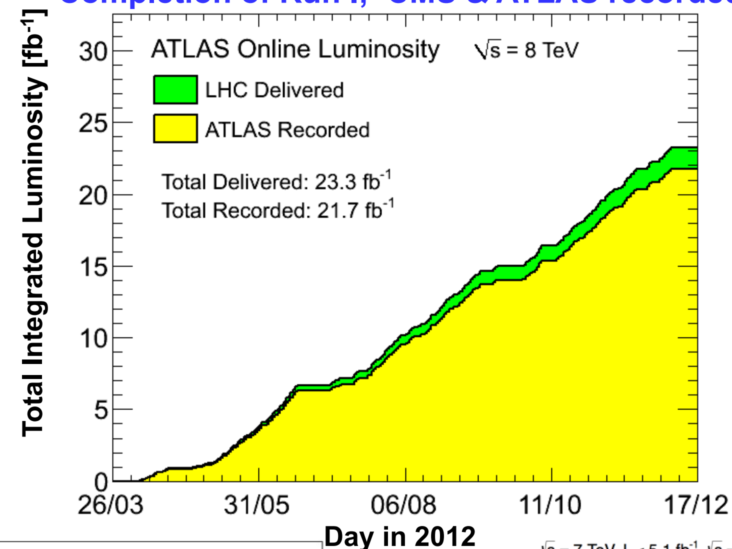
- **Run 1 (proton) completed in Dec. 2012**
- Working with experiments to **execute** plan for U.S. contributions to "Phase-1" [2018**]** upgrades
- CD-0 (Critical Decision 0) approval: Sept. 2012
- CD-1 approval: Oct. 17, 2013

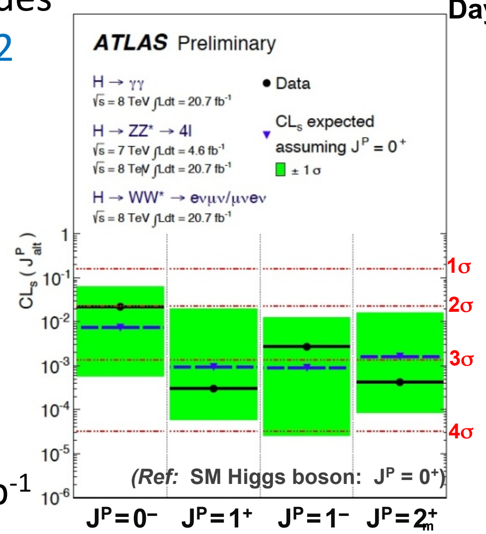
  (CMS: \$29.2M – 35.9M; ATLAS: \$32.2M – 34.5M)

Current program

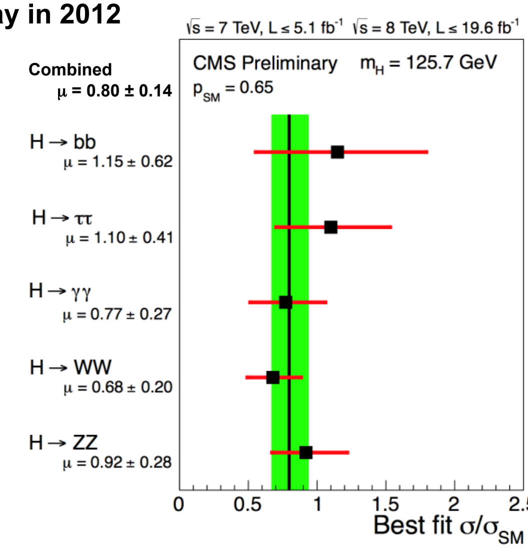
- Analyze and publish results from LHC Run 1
- 2013-2014 shutdown: repair splices in LHC magnets; detector maintenance and consolidation, upgrades and repairs
- In 2015: resume [**Run 2]** at 13~14 TeV**:** 100 fb^{-1}
  - **Continue precision Higgs measurements**
  - **Focus on new physics**

Completion of Run I; CMS & ATLAS recorded: ~22 fb^{-1}





ATLAS Spin-Parity
[Lepton-Photon 2013]



CMS Signal Strength
[Lepton-Photon 2013]

Energy Frontier Plan & Issues

Plan:

- **Science goals going forward:**
  - Fully explore the TeV scale.
  - Is there anything there but a Standard Model (SM) Higgs?
  - Is it really a “SM Higgs”?
  - Do we have a complete picture of electroweak symmetry breaking

- **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

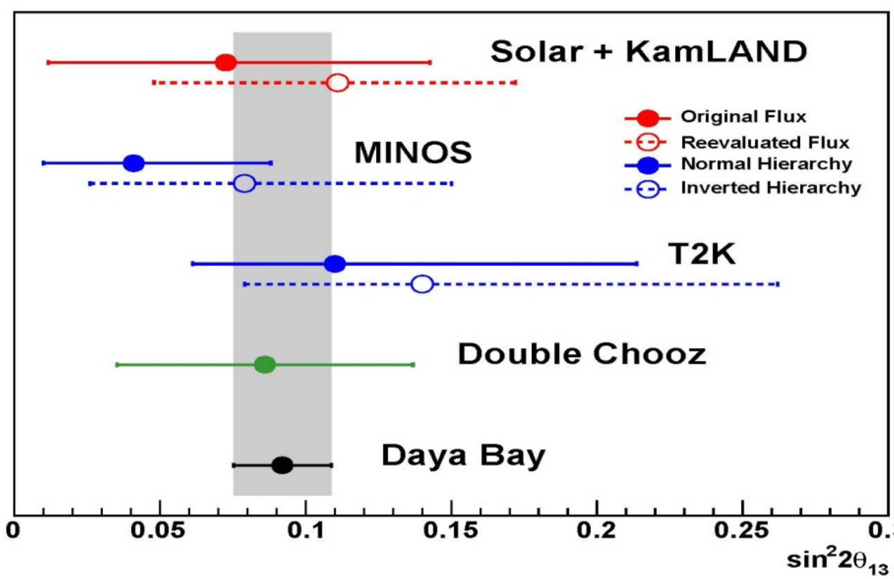
Current program in neutrino physics: Minerva, NOvA, T2K, MicroBoone, Daya Bay, EXO-200

- **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

Program Status
→Cosmic Frontier

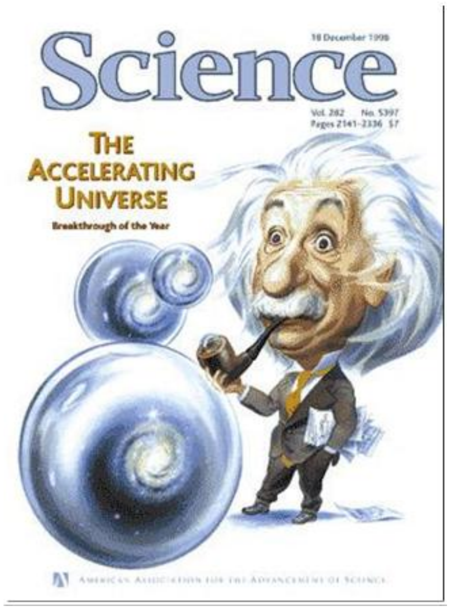
Cosmic Frontier - Experimental Program

<u>COSMIC FRONTIER</u> — Through ground-based telescopes, space missions, and deep underground detectors, research at the cosmic frontier aims to explore dark energy and dark matter, which together comprise approximately 95% of the universe.

Program is divided into THRUSTS:

- **Discover (or rule out) the particle(s) that make up <u>Dark Matter</u>**
- **Advance understanding of the physics of <u>Dark Energy</u>**
- **Understanding the high energy universe: <u>Cosmic-rays, Gamma-rays</u>**
- **<u>Other</u> efforts, including small CMB contributions, other experiments, etc.**

2011 Nobel Prize !!



Cosmic Frontier – Guidance

FACA subpanels provide targeted advice

- High Energy Physics Advisory Panel (**HEPAP**) & subpanels – primary advice
- Astronomy and Astrophysics Advisory Committee (**AAAC**)
  - – reports to NASA, NSF and DOE on areas of overlap

→ 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.

Future planning: Snowmass/P5 process

23

Cosmic Frontier – Program Model, Considerations…

Science Mission-driven: **We develop and support a specific portfolio of projects and need to ensure results are obtained.**

Program needs to have:

- Staged implementation & results
- mix of smaller, larger projects
- balance between thrusts
- some room for high risk, high yield experiments.

Considerations for including Project in Program: **Use PASAG Criteria!**

- Science goals and how it will address DOE-HEP goals?
- Is all or part of experiment directly-aligned with HEP goals?
- What does our community bring to the experiment? Visible, leadership contributions?
- Are our contributions in line with % of the project relevant to our science goals?
- Partnering with other agencies has plusses & minuses.

Details of Building Program

- 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

→ **Our model also brings significant new capabilities in terms of instrumentation, and coordinated computing, simulation and analysis efforts that provide impacts & resources to the astronomy community.**

HEP Budget - Cosmic Frontier

Cosmic Frontier Funding (in $K)	**FY12 actual**	**FY13 actual**	**FY14 REQUEST**	**FY14 comments**
Research			**48040**	R&D for G2 Dark Matter and other concepts
Research – university	**12881**	**12233**		
Research – lab	**34962**	**36448**		
Experimental Operations	8505	10111	7500	
Future project R&D		9659	1494	Dark energy and dark matter projects move to conceptual design
Small project fabrication	5891		1200	
MIE – LSST	5500	8000	22000	LSSTcam fabrication starts
MIE – HAWC	1500	1500		
TOTAL	**69,239**	**77951**	**91034**	

MIE = Major Item of Equipment
DM-G2 = Dark Matter Generation 2

Cosmic Frontier – Research Model & Opportunities

Considerations for Research Support

➔can use same PASAG criteria and considerations in program model

- Priority is to support efforts in our program, where we have responsibility for experiment
- People working in HEP collaboration model – long term commitments, responsibilities, % effort
- Increasing university involvement in dark energy, dark matter
- Change distribution between thrusts as we go forward to support changing program

Reviews - for Research Funding Opportunities

Sept. 2013 – Cosmic Frontier comparative review of Lab research programs (held every 3 years)
Nov. 2013 – Cosmic Frontier comparative review of Grant Proposals (were due 9/9/13)
Jan. 2014 – Comparative review of Early Career lab & university proposals (due 11/9/13)

Cosmic Frontier: Research Grant Statistics

Statistics on FUNDED grants

	FY10		FY11		FY12		FY13	
	Amt $K	# grants	Amt $K	# grants	Amt $K	# grants	Amt $K	# grants
Research - Bridge renewals					669	6	691	9
Research - conference	3	1	3	1	20	4	9	2
Research - NEW			258	3	1,605	5	3410	18
Research - Renewal	3,415	16	5,919	7				
Research - Continuations	7,705	19	5,726	24	10,137	28	7510	17
Early Career FY10 (ARRA funds)	0	2	0	2	0	2	0	2
Early Career FY11			150	1	150	1	150	1
Early Career FY12					300	2	300	2
Early Career FY13							150	1
TOTALS	**11,123**	**38**	**12,056**	**38**	**12,881**	**48**	**12,200**	**52**

Statistics on Received/Funded grants

	FY12	FY12	FY12	FY13	FY13	FY13
	Amount $K	#proposals	# PI's	Amount $K	#proposals	# PI's
Received	3319	11	21	7731	28	53
Funded	1605	5	12	3410	20	28
Success rate	**48%**	**50%**	**60%**	**44%**	**71%**	**53%**

Dark Energy

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

Current Experiments - operating
Supernova surveys: Supernova Cosmology Project, Nearby Supernova Factory, Palomar Transient Factory, QUEST

Baryon Oscillation Spectroscopic Survey (BOSS)

Dark Energy Survey (DES)

Future Planning:
Large Synoptic Survey Telescope (LSST)

Dark Energy Spectroscopic Instrument (DESI)

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

Baryon Oscillation Spectroscopic Survey (BOSS)

BOSS is the flagship survey on the Sloan Digital Sky Survey (SDSS) Phase III at Apache Point Observatory in New Mexico; DOE funded the SDSS spectrograph upgrade needed for BOSS

Science: Dark Energy using Baryon Acoustic Oscillation (BAO) method.

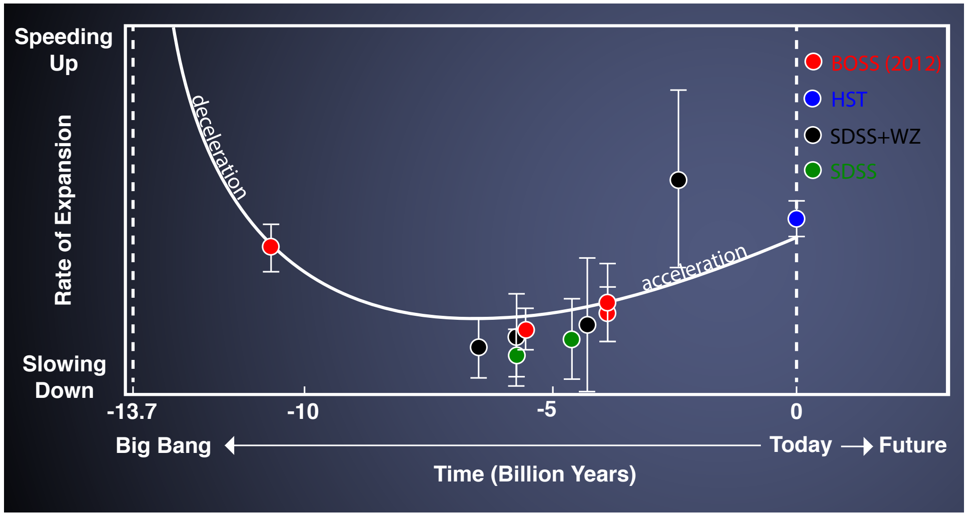
- **Mapping 3-D positions of 1.5 million galaxies & line-of-sight to 160,000 quasars using Lyman-alpha forest.**
- **All data made public in a freely-available, user-friendly database.**

Partnership: DOE, NSF, the Sloan Foundation, and contributions private and foreign institutions
Collaboration: ~ 160 scientists from ~ 15 US institutions and UK, Brazil, Germany, France, Japan
HEP funding: LBNL (project office), BNL, Utah, Yale, OSU, Michigan, UC-Irvine
Status:

- **5-year survey of 10,000 sq-degrees will complete in 2014**
- **Some members of collaboration are planning to propose an extended-BOSS (eBOSS) survey**

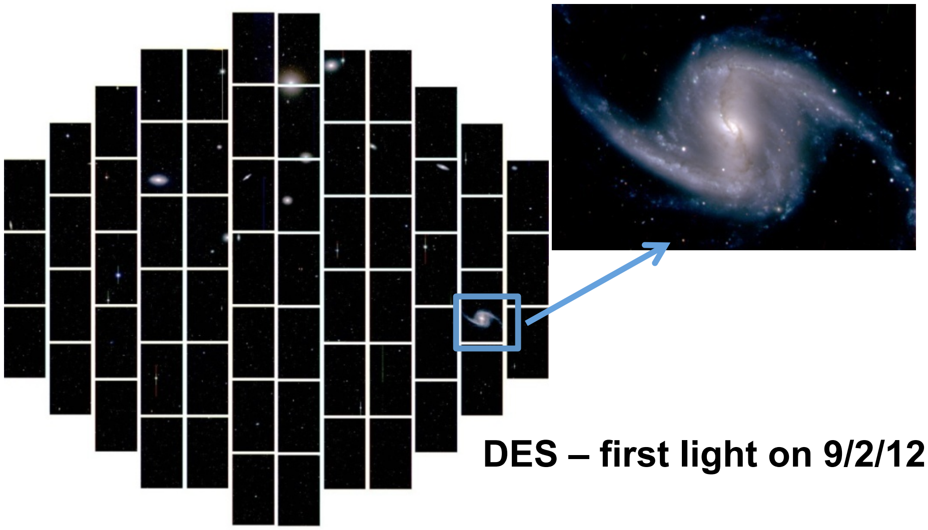
Results:

- **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**

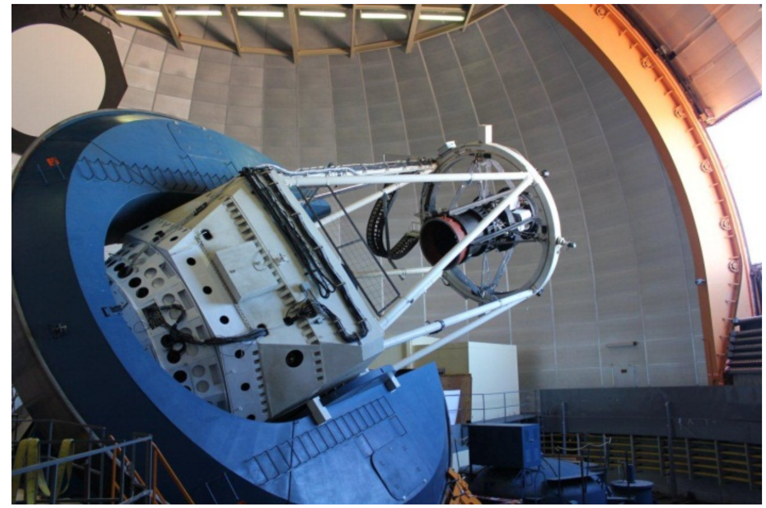


Dark Energy Survey (DES)

Fornax cluster with close-up of the galaxy NGC 1365



DES – first light on 9/2/12



Science: Stage-III dark energy experiment using imaging survey
- **HEP supported fabrication of the Dark Energy camera (DECam), managed by Fermilab, which was installed on Blanco telescope at CTIO in Chile**
- **NSF supporting telescope and camera operations, and the data management system**

Partnership: DOE/NSF partnership + private & foreign contributions
- DOE/NSF Joint Oversight Group (JOG) meets monthly

Status:
- **first light 9/12/12; commissioning now complete**
- **started 5 year science survey in Sept. 2013**

Status – Nov. 2013

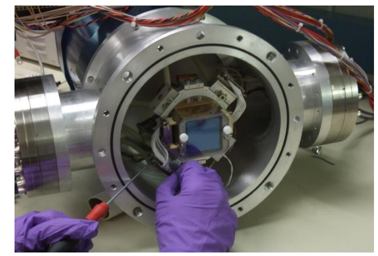
Future Planning → Large Synoptic Survey Telescope (LSST)

Science:

- DOE's interest is the nature of Dark Energy, causing the expansion of the universe to accelerate.
- The data will also be used by the wider community for a variety of astronomical measurements.
- The optical/NIR imaging survey will be used for a variety of dark energy methods, especially weak lensing.

Project:

- New 8.4 m telescope facility and associated instrumentation on Cerro Pachon (8,800 ft) in Chile.
- NSF is the lead-agency, responsible for telescope & data management;
- DOE is responsible for the 3-billion pixel imaging camera (LSSTcam), managed by SLAC.

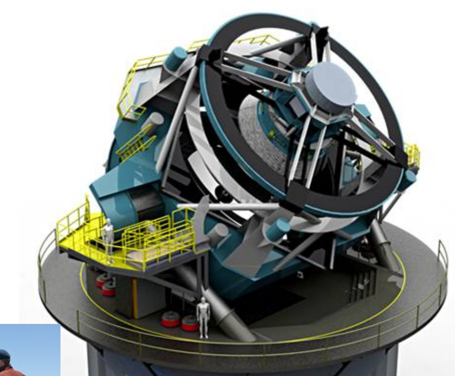


Partnership: DOE & NSF (MOU July 2012), with contributions from private and foreign institutions
-DOE/NSF Joint Oversight Group (JOG) meets weekly

Science Planning: Dark Energy Science Collaboration (DESC) formed to start preparations for precision analyses.
- Started in 2012 and will continue to grow; collaboration with mix of expertise needed to plan for data analysis to get precision dark energy results

Status (LSST Project)

- Critical Decision 1 (CD-1) approved for LSST-camera in Feb. 2012
- FY 2013 – DOE wasn't able to get a fabrication-start approved for LSSTcam
- FY 2014 President's Request budget for DOE includes fabrication start for **LSSTcam**
- FY 2014 President's Request budget for NSF includes MREFC funds for LSST construction
- NSF Final Design Review in December to support going to the NSB in 2014



On Cerro Pachon

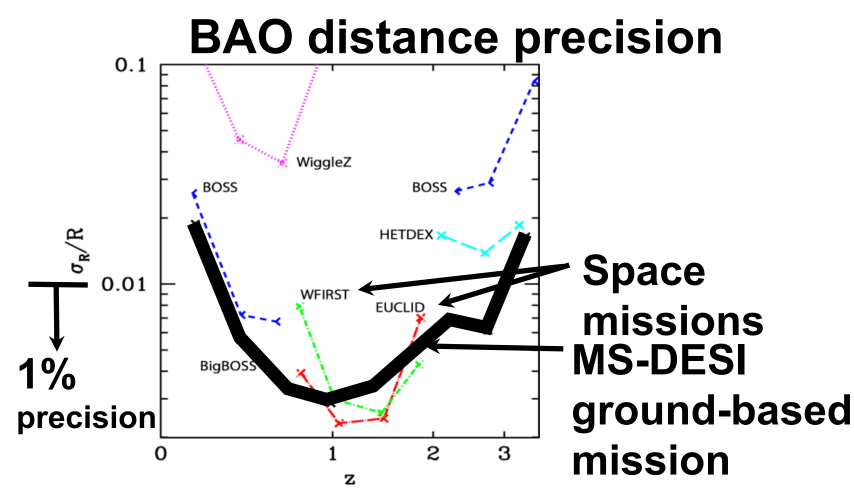
Future Planning → Dark Energy Spectroscopic Instrument (MS-DESI)

Status – Nov. 2013

Science:
HEP community dark energy science plan (August 2012) identified a wide-field spectroscopic survey to carry out a Stage IV dark energy program using the Baryon Acoustic Oscillations and Redshift Space Distortions methods as a high priority medium-scale project to maintain US leadership in this area.
- DESI will follow BOSS & will complement the DES → LSST imaging surveys

Description:
- Fabricate new spectrograph to mount on existing telescope (plan the Mayall at Kitt Peak)
- HEP would provide operations support for use of the telescope facility

Status:
Sept. 2012 -- Critical Decision 0 (CD-0) for DESI experiment approved
December 2012 – appointed LBNL to manage the project design, fabrication & operations (Michael Levi appointed as Project Director)
Jan. 2013 – DOE and NSF signed a joint statement of agency principles; continue to talk regularly about possible opportunities, constraints and models for the experiment and use of a telescope facility.
As of Nov. 2013 - R&D support continuing; Review for CD-1 being planned for ~ Feb. 2014 (moved from January due to concerns about travel and effort right at end of the CR)



Dark Matter – Direct Detection

→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

"Generation 1" – currently commissioning/operating direct detection search experiments
→ADMX-2a, COUPP-60, DarkSide-50, LUX, SuperCDMS-Soudan

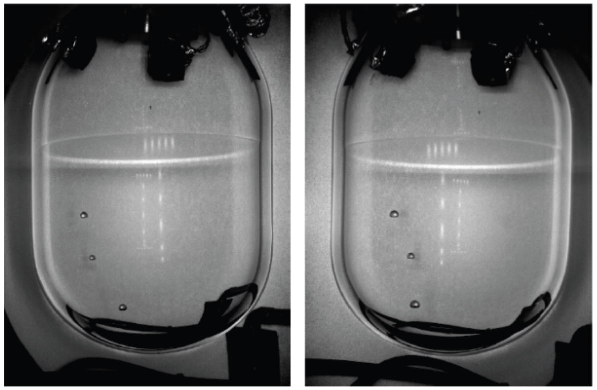
Dark Matter Generation 2 (DM-G2) experiments

- September 2012 – approved Critical Decision 0 (CD-0) for DM-G2 experiment(s)
- September 2012 – held comparative panel review of proposals for FY13 R&D funding – results announced March 2013
- January 2014 – down-select review for 1 or more DM-G2 experiments to move to the fabrication phase planned for January 2014.

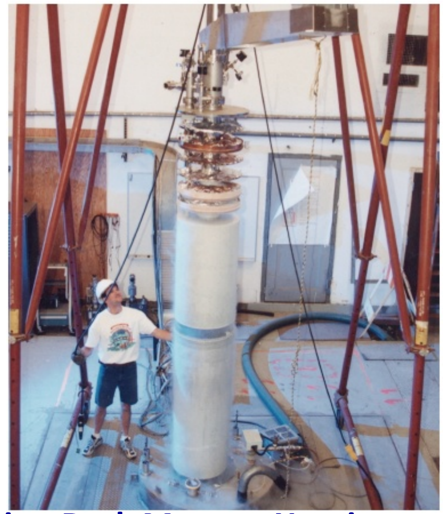
DM-G3 experiments

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

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

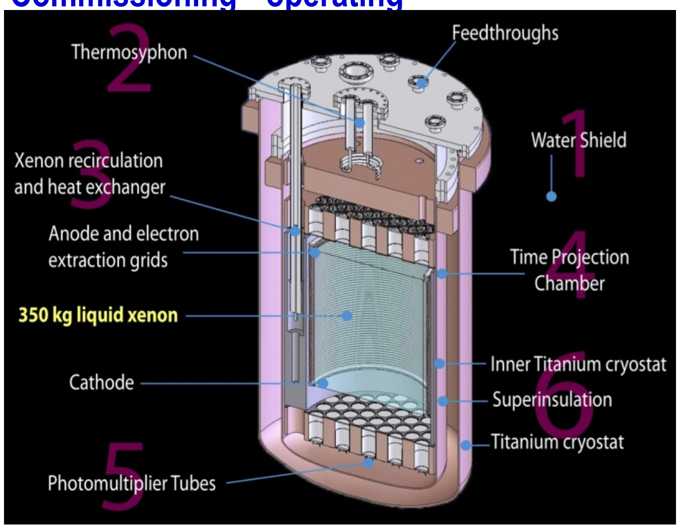


COUPP --PICO Bubble Chambers–SNOLAB
- Commissioning --operating



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 operating, currently the world's most sensitive direct-detection DM detector.

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

Status - November 2013

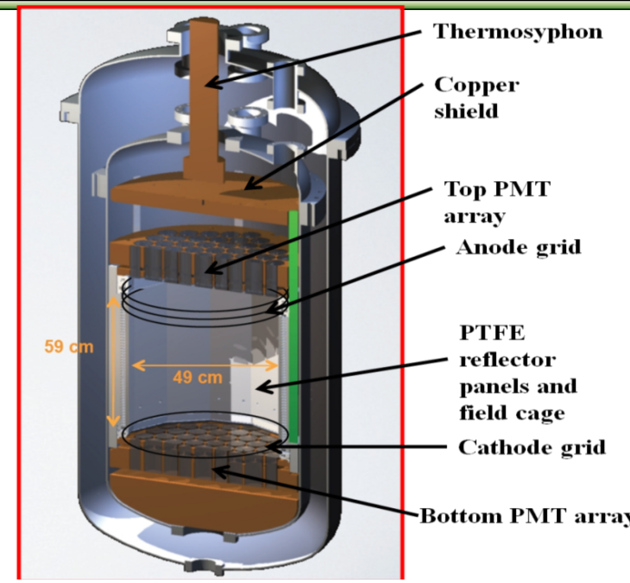
Large Underground Xenon (LUX) + ZEPLIN → LZ

LUX (operating): Liquid xenon time projection chamber (TPC) detector with 370 kg of xenon within a shielding water tank. Installed at the Sanford Underground Research Facility (SURF) in the Davis cavern, 4850' underground. Prompt scintillation and drifted ionized electron measurement following interaction provide discrimination and 3D event location within fiducial target volume.

LZ (proposed): 7-ton version, with added liquid scintillator shield.

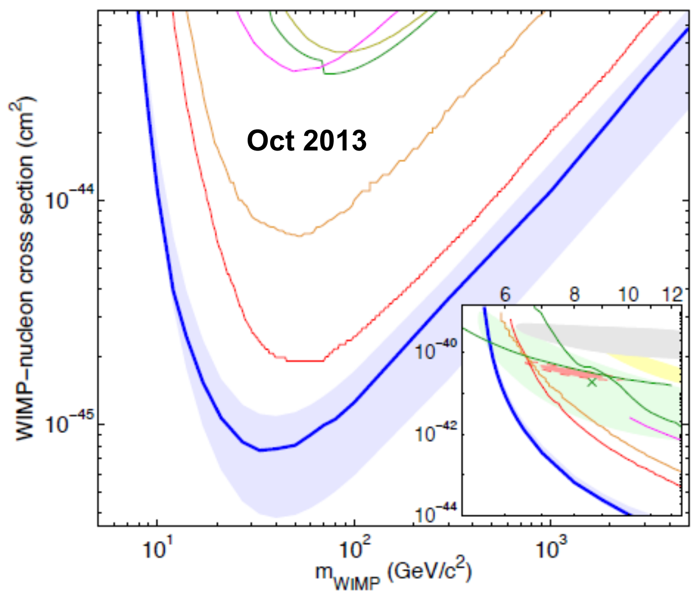
- explore discovery space down to the astrophysical neutrino floor

Partnership: DOE & NSF partnership + foreign contributions



Science Results – October 31, 2013

LUX: Recent 85 live-day run, 118 kg fiducial target → lowest spin-independent WIMP-nucleon cross section, 7.6×10^{-46} cm^2 at 33 GeV mass (90% CL). Sensitivity down to ~6 GeV mass → results do not support hypotheses of low mass WIMPs that come from earlier experiments' potential hints of signal.



New York Times → "Dark Matter Experiment Has Detected Nothing, Researchers Say Proudly"

http://www.nytimes.com/2013/10/31/science/space/dark-matter-experiment-has-found-nothing-scientists-say-proudly.html

Status

LUX: A final 300 live-day run is planned for 2014.

LZ: Awarded FY13 DM-G2 R&D funding; down-selection review in Jan 2014.

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.

Alpha Magnetic Spectrometer – cosmic ray observatory in space
Pierre Auger - cosmic ray observatory
Fermi Gamma-ray Space Telescope
VERITAS – gamma-ray array
HAWC – gamma ray array

Future Planning:

- community planning on Cherenkov Telescope Array (CTA)

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 (2008);

-- Has since been enhanced with 3 high elevation fluorescence telescopes, 60 infill detectors, muon counter array, Auger Engineering Radio Array (AERA), Microwave (AMBER, MIDAS, EASIER)

Collaboration: Large international collaboration of 18 countries, 463 collaborators
Project leadership transitioning from Fermilab to Germany in 2013.

→ International Finance Board meets annually

Operations Status: Data taking started in 2004. Full array completed in 2008; Collaboration has commitments to run through 2015; planning another 10 years.

Future Plans: Working on proposal for upgrade to submit in 2014 → to determine if the features of the spectrum at high energy are dominated by energy-limited heavy primaries or by a dramatic change in hadronic interactions of light particles at these energies.

Energy Spectra multiplied by E^3 (ICRC 2013)

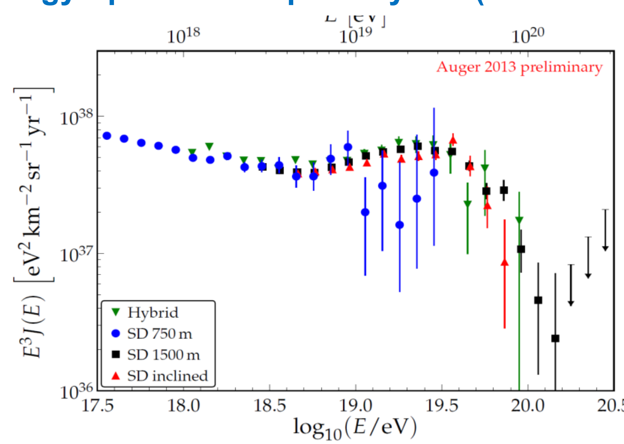


Figure 4: Energy spectra, corrected for energy resolution, derived from SD and from hybrid data.

VERITAS

Status – Nov. 2013

(Very Energetic Radiation Imaging Telescope Array System)

Science:

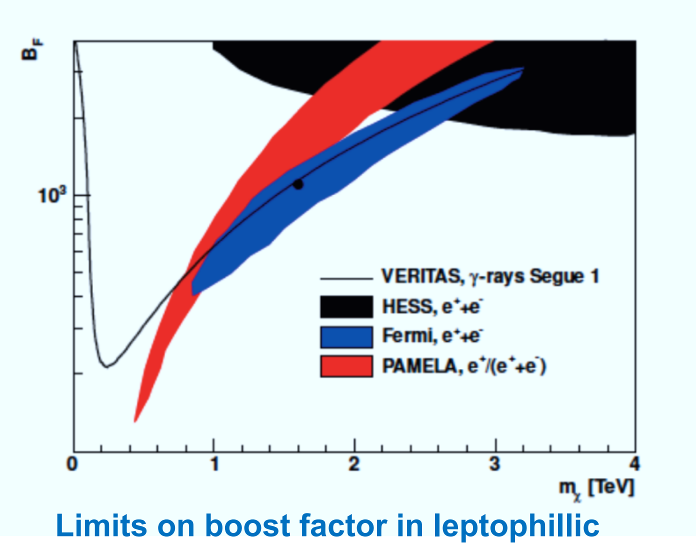
Four 12-meter Cherenkov telescope high energy (~ 100 GeV to 30 TeV) gamma-ray array at Whipple observatory in Arizona

Collaboration/Partnership: ~100 scientists from US (DOE, NSF, SAO), Canada, Ireland, UK, Germany; SAO is managing agency

→DOE, NSF, SAO Joint Oversight Group meets quarterly

Status:

- **Operating since Fall 2007**
- **Emphasizing dark matter searches for a large fraction of time**
- **Recently started 6th season of operations & 1st with NSF-funded upgrade, which was completed summer 2013**
- **Collaboration requesting to continue operations through FY17**
- **NSF and DOE funded 3-year grants for operations starting FY13; DOE not making further commitments**



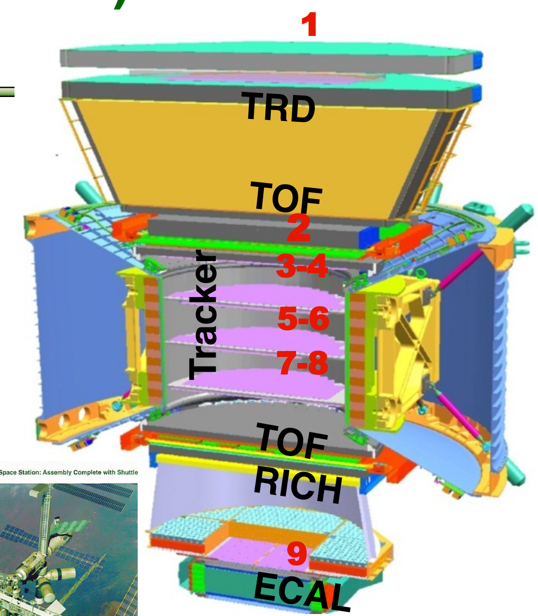
Limits on boost factor in leptophillic DM models (region above line excluded); arXiv:1202.2144, Phys. Rev. D 85, 062001 (2012)

Recent Highlights:

- VERITAS Dark Matter limits from dwarf galaxy Segue 1
- Discovery of most distant VHE emitting galaxy (with cosmological implications)
- Discovery of TeV gamma-ray emission towards the supernova remnant SNR G78.2+2.1, Astrophysical Journal, in press, 2013
- Discovery of unexpected VHE emission from the Crab Pulsar

Status – Nov. 2013

Alpha Magnetic Spectrometer (AMS)



Science: Search for antimatter, dark matter, missing matter in space.

Description:

• A TeV, precision multi-purpose spectrometer; the most precise cosmic-ray detector ever flown in space.

• A major challenge of operating on the International Space Station (ISS) is the extreme thermal environment – has to be continually monitored and adjusted.

Partnership & Collaboration:

AMS is a U.S.-DOE-led international collaboration (led by Prof. Sam Ting, MIT) of 16 Countries, ~600 Physicists.

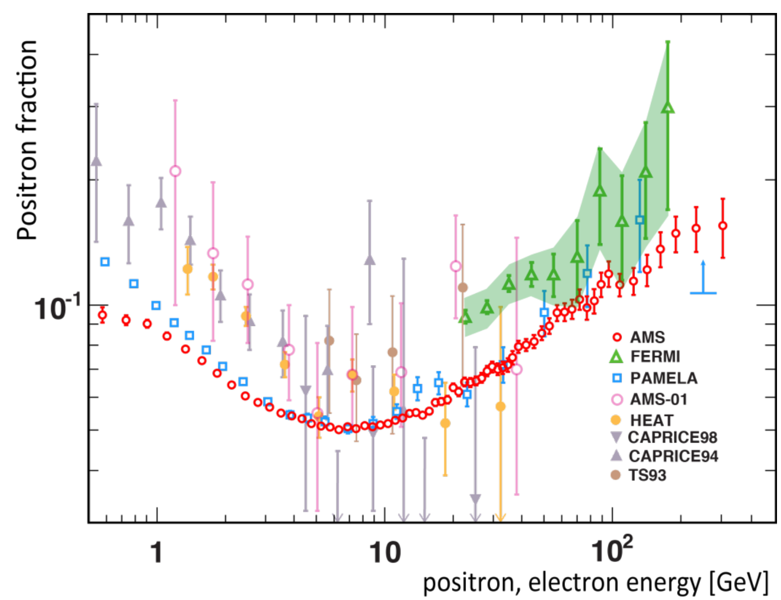
- 95% of ~$2B construction costs from Europe and Asia .
- NASA provided dedicated Space Shuttle flight, use of the ISS resources (power, data, …) and mission management.
- CERN hosts the AMS Payload Operations Control Center (POCC).

Status:

Launched on May 16, 2011, (STS-134); installed on ISS

- Has collected over 25 billion events in first 18 months of operations, including 6.8 million electrons or positrons.
- Operations continuing

April 3, 2013: First Results announced! The data show that the positron fraction is steadily increasing from 10 to ~ 250 GeV, but from 20 to 250 GeV the slope decreases by an order of magnitude.



Fermi Gamma-ray Space Telescope (FGST)

Science :

- study high-energy (~20 MeV->300 GeV) gamma rays using particle physics detector technology in space
- Indirect dark matter detection; high energy acceleration mechanisms, etc

Partnership:

- DOE, NASA and 4 international agencies partnered on Large Area Telescope (LAT); NASA leads the mission.
- DOE supports SLAC's Instrument Science Operations Center (ISOC)

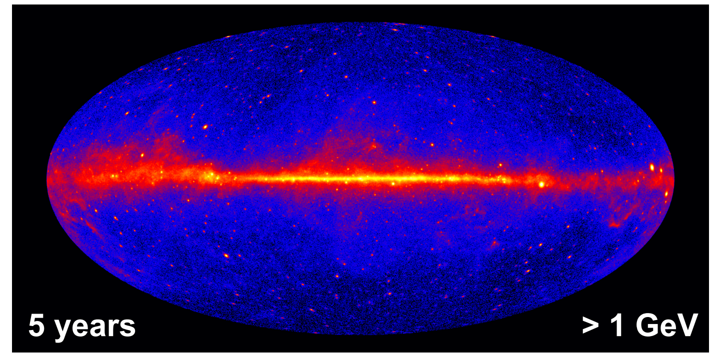
→ International Finance Board meets twice a year

Recent highlights include:

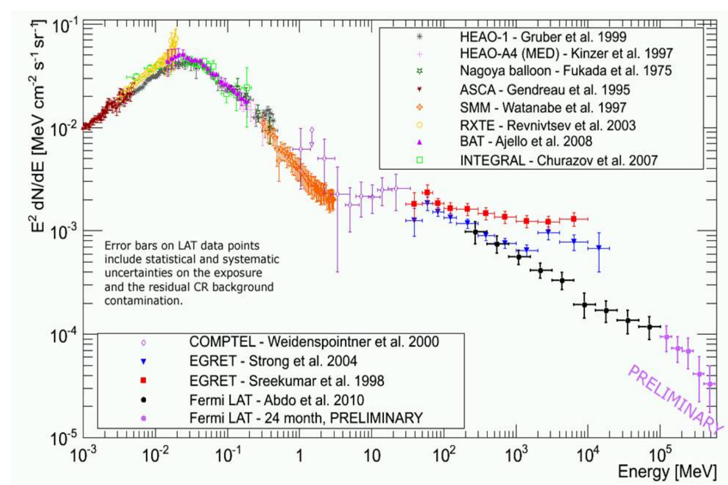
- ~1300 papers since 2008 , >160 PhD
- Brightest gamma ray burst in 20 years on 27 April 2013.
- Search for dark matter in gamma-ray spectrum, ~ 135 GeV bump
- -- systematics under careful investigation; more statistics will answer the question

Status:

- Launched June 2008 with 5 year prime mission, currently recommended for extension through FY2016, want to run through at least 2018 (NASA senior review in spring 2014)
- Upgrade of event reconstruction and analysis ("Pass 8") to be released in 2014; will further improve instrument performance



Gamma-ray sky
More than 2500 sources, ~30% unidentified



Status – Nov. 2013

High Altitude Water Cherenkov (HAWC) Gamma Ray Observatory

Science:

Sky survey 100 GeV to> 100 TeV gamma-rays

- indirect dark matter search using gamma-ray annihilation
- quantum gravity effects on propagation of gamma-rays
- particle acceleration in extreme magnetic and gravitational fields; transient objects, GRBs, supermassive black holes in AGNs

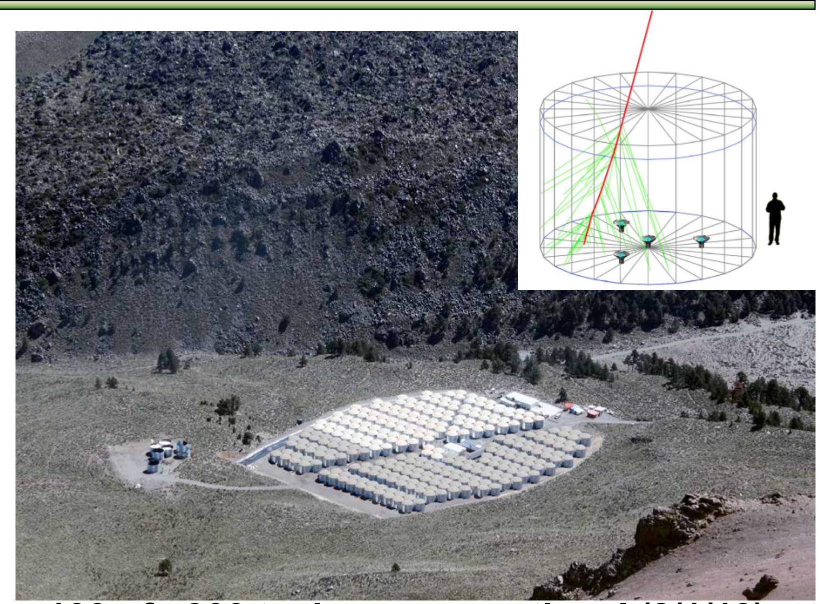
Project:

- Air Shower Detector with ~300 Water Cherenkov Detector tanks covering 20,000 m^2 at 4100 m in Sierra Negra Volcano, Mexico. Exposure to half of the sky during a 24-hour period.

Partnership:

NSF (lead), DOE, Mexico (CONACyT)

→Joint Oversight Group meets quarterly



100 of ~300 tanks are operational (8/1/13)

Status:

- **2011-2014: fabrication**
- **Aug 2013: started operations with 100 tank array**
- **Aug 2014: projected start of operations with full array**

Status – Nov. 2013

CTA
The Cherenkov Telescope Array

Science:

- CTA is a next-generation ground-based Ultra-High Energy telescope array with plans for northern & southern sites
- 2010 Astronomy & Astrophysics Decadal Survey recommended US contribution in higher budget scenarios (4^{th} on list of ground-based experiments) and that funding be split approximately 2/3 NSF and 1/3 DOE; total US contribution ~ $100M

Observatory:

- Variety of telescopes with different apertures and field-of-views:
  23 12m medium size telescopes (MST), 4 23m telescopes (LST), 32 5-6m telescopes (SST)
- US collaboration proposing to add 28 2-mirror MST's for enhanced resolution & wide field of view, and 2-3X sensitivity gain

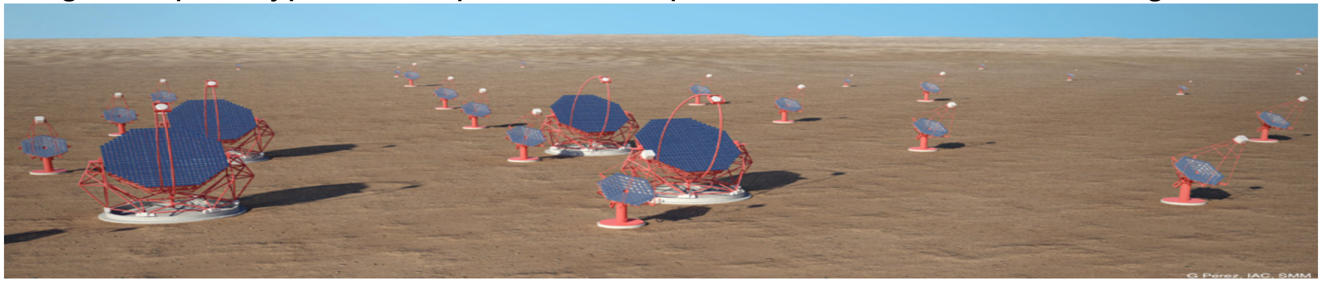
HEP Guidance: to US collaboration from Jim Siegrist's August 2012 HEPAP talk

- Following the Astro2010 recommendation, we consider NSF to be in the lead for considering the project
- HEP has no funding identified for CTA contribution in the foreseeable future; therefore don't plan to fund R&D for prototypes or the project but is supporting science simulations and design studies effort

→**Further consideration awaiting Snowmass/P5 process**

Status – R&D

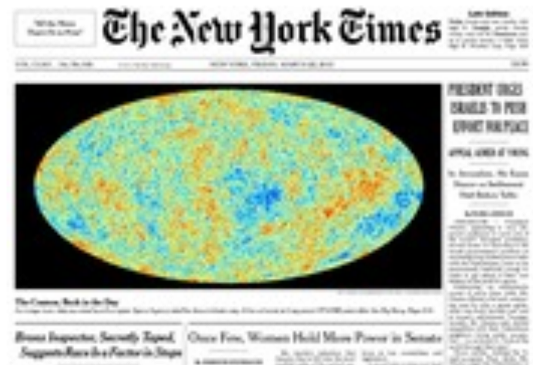
NSF MRI funding for a prototype telescope to be completed in 2014; commissioning with VERITAS in 2015



Cosmic Frontier – Cosmic Microwave Background (CMB)

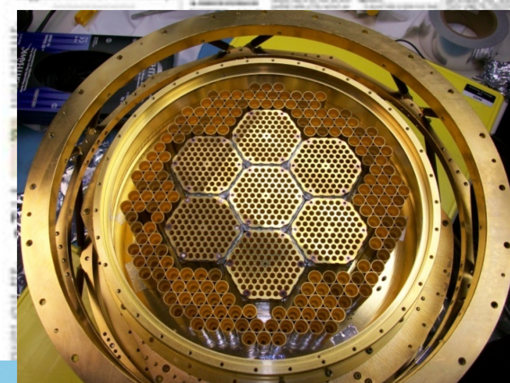
CMB experiments: HEP currently has small contributions to:

- South Pole Telescope polarization (SPTpol)
- Planck – DOE signed an MOU with NASA for interagency cooperation on providing supercomputing resources for data analysis at NERSC; also supports small science effort



SPTpol

- NSF-led experiment
- HEP provided outer-ring detectors, fabricated at Argonne National Lab (ANL) and is currently supporting operations and research for ANL activities
- Experiment is currently in operations phase which lasts through 2015.
- **Recent results: first ever detection of lensing B-mode polarization!**



SPTpol-3G

- Collaboration is starting major upgrade to replace the camera with a larger focal plane with 2539 multi-chroic pixels (total of 15,234 detectors) to greatly increase sensitivity
- NSF funded; have requested DOE project participation (in consideration)

CMB Future: Community is developing science case and concept for a Stage-IV CMB experiment (Snowmass); will be considered by P5

Cosmic Frontier – Next Steps & Issues

→ US HEP has a leading role in a competitive, multidisciplinary environment

→ **Follow PASAG criteria: Make contributions to select, high impact experiments:**

- That directly address HEP science goals
- That will make a significant, visible or leadership contribution
- For which the HEP community contributions or expertise is needed – instrumentation, collaborations, analysis techniques etc.

Path Forward

Dark Matter - working with NSF-PHY on planning direct detection generation 2 experiments (DM-G2)
Dark Energy – planning LSST (partnership NSF-AST) & DESI (in coordination w/NSF-AST); considering eBOSS
Cosmic-ray, Gamma-ray, CMB: - HAWC (w/NSF-PHY), Considering SPT-3G (w/NSF)

➢ Other possibilities awaiting guidance from Snowmass/P5, e.g.

- CTA contributions
- 4th generation ground-based CMB experiment

→ **Will further develop and optimize program following the Snowmass/P5 process.**

Issues going forward:
What other measurements, theoretical studies or technology/instrumentation will be needed to fully exploit the science? How far do we need to go in precision/setting limits in each area?

HEP Cosmic Frontier Experiments

Experiment	Location	Description	Current Status	# Collaborators (# US, HEP)	# Institutions (# US, HEP)	# Countries
Baryon Oscillation Spectrosopic Survey (BOSS)	APO in New Mexico	dark energy stage III (spectroscopic)	operating through FY14	230 (150 US, 40 HEP)	(22 US, 8 HEP)	7
Dark Energy Survey (DES)	CTIO in Chile	dark energy stage III (imaging)	operations started Sept. 2013	300	25 (13 US, 9 HEP)	6
Large Synoptic Survey Telescope (LSST) - Dark Energy Science Collaboration (DESC)	Cerro Pachon in Chile	dark energy stage IV (imaging)	science studies	232 (200 US, 134 HEP)	53 (41 US, 16 HEP)	3
Large Synoptic Survey Telescope (LSST) - LSSTcam Project	Cerro Pachon in Chile	dark energy stage IV (imaging)	CD1 for LSSTcam approved; FY14 Fabrication start requested	142 (111 US, 111 HEP)	17 (11 US, 11 HEP)	2
Dark Energy Spectroscopic Instrument (DESI)	expected to be at KPNO in AZ	dark energy stage IV (spectroscopic)	CD0 approved Sept 2012; planning CD1 in FY14	180 (95 US, 72 HEP)	42 (23 US, 18 HEP)	13
Axion Dark Matter eXperiment (ADMX-IIa)	Univ Washington	dark matter - axion search	Operating	24 (20 US, 17 HEP)	7 (6 US, 3 HEP)	2
Chicagoland Observatory for Underground Particle Physics (COUPP-60) → PICO	SNOLab in Canada	dark matter - WIMP search	Operating	60 (26 US, 8 HEP)	14 (6 US, 1 HEP)	5
DarkSide-50	LNGS in Italy	dark matter - WIMP search	Operating	122 (66 US, 12 HEP)	26 (12 US, 3 HEP)	7
Large Underground Xenon (LUX)	SURF in South Dakota	dark matter - WIMP search	Operating	102 (86 US, 56 HEP)	17 (13 US, 9 HEP)	3
Super Cryogenic Dark Matter Search (SuperCDMS-Soudan)	Soudan in Minnesota	dark matter - WIMP search	Operating	83 (70 US, 38 HEP)	19 (16 US, 6 HEP)	3
Very Energetic Radiation Imaging Telescope Array System (VERITAS)	FLWO in AZ	gamma-ray survey	Operating	92 (74 US, 32 HEP)	20 (15 US, 5 HEP)	4
Pierre Auger Observatory	Argentina	cosmic-ray	Operating	463 (51 US, 12 HEP)	100 (20 US, 5 HEP)	18
Fermi Gamma-ray Space Telescope (FGST) Large Area Telescope (LAT)	space-based	gamma-ray survey	June 2008 launch; operating	319 (157 US, 73 HEP)	49 (14 US, 3 HEP)	9
Alpha Magnetic Spectrometer (AMS-02)	space-based (on ISS)	cosmic-ray	May 2011 launch; operating	600	60 (6 US, 2 HEP)	16
High Altitude Water Cherenkov (HAWC)	Mexico	gamma-ray survey	Fabrication; Operations starts summer 2014 in Mexico	111 (54 US, 8 HEP)	31 (16 US, 2 HEP)	2

AAAC 2013 recommendations - response

Ensure Coordination of Funding for Partnerships
- Have Joint Oversight Groups (JOG) and/or frequent discussions for DES, DESI, LSST (w/NSF-AST), on dark matter experiments, Auger, VERITAS, HAWC (NSF-PHY), FGST (NASA), etc.
- Meet with NSF, OMB, OSTP several times per year and as needed on LSST.

Prioritization of NWNH projects and existing projects should include merit review process
- Cosmic Frontier planning follows PASAG report (2009); HEP has embarked on Snowmass/P5 process.
- Review of all Cosmic Frontier operating experiments held Sept 2012; planning to do every 2 years

Continue LSST development as highest priority ground-based large astronomy facility
- LSST is the highest priority new project for the Cosmic Frontier

Flexible open-skies policy & partnerships to maximize science return
- See separate multi-agency presentation

Interagency coordination should occur early in process – Yes, this is being done!

Balance among small, medium, and large projects & facilities
- Planning a balanced, staged program for the Cosmic Frontier

AAAC 2013 recommendations - response

Take prompt action and coordination between DOE, NASA and other agencies to support Pu-238 production and sufficient availability of He-3 and He-4.

~ April 2013: NASA will pay for cost of plutonium-238 production, which resumed a few months ago by DOE

He-3:

DOE Office of Science is participating in a governmental interagency ^{3}He Integrated Product Team (IPT) composed of DOE, National Nuclear Security Administration, Department of Homeland Security, Department of Defense, and other government agencies. This group has been formed to address the decreasing supply of ^{3}He. See **http://science.energy.gov/np/research/idpra/he3-fact-sheet/**

He-4:

Federal government had been funding to keep this going but it was planned to stop this year. There is legislation in Congress to keep the program going.

Summary

Cosmic Frontier:
Lots of results coming out or expected soon in all areas.
Future is looking bright for science!!

HEP Program

- **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.**
- **Concerns about budget**

BACKUPS

FY14 HEP Budget Overview

- **FY 2014 President's Request: $776M**
- **Original FY14 budget philosophy was to enable new world-leading HEP capabilities in the U.S. through investments on all three frontiers**

  - Accomplished through ramp-down Research (~ -6%) and operations of existing Projects

  - When we were not able to fully implement this approach (*i.e.,* start new projects), converted planned project funds to R&D: Research → ~~Projects~~ → Research

•Hence, the FY14 Request shows *increases* for Research that are due to this added R&D "bump", while Construction/MIE funding is only slightly increased

- **Impact of these actions:**
  - **Several new efforts are delayed:**
    - **LHC detector upgrades, Long Baseline Neutrino Experiment (LBNE), 2nd Generation Dark Matter detectors, Dark Energy Spectroscopic Instrument (DESI) experiment**
  - **US leadership/partnership capabilities will be challenged by others; Workforce reductions**
- **Key areas in FY14 Request**
  - **Maintaining forward progress on new projects via Construction and Research (incl. R&D for projects) funding lines**
- **Congressional response for FY14**
  - **House and Senate Marks add $$$ for SURF Ops and LBNE (both houses) and accelerator stewardship (Senate). Senate adds $$$, House re-allocates within reduced bottom-line.**
- **Current FY2014 funding based on a Continuing Resolution through 1/15/14 with FY2013 "bottom-line"**

– To accommodate FY13 "sequestration" level ($748M), initial FY14 "plan" based on FY14 House Mark ($772M)

DOE OHEP Organization

Office of High Energy Physics

James Siegrist (IPA)
Sherry Pepper-Roby

Eric Colby (IPA)

HEP Budget and Planning

Donna Gilbert
Dean Oyler
John Boger
Larry Price (Detailee)

HEP Operations

Kathy Yarmas

Research & Technology Division

Glen Crawford
Michael Cooke (AAAS Fellow)
Janice Hannan
Kristi Naehr
Christie Ashton
Wanda Morris

Physics Research

Energy Frontier
Abid Patwa
David Boehnlein (IPA)
James Stone (IPA)

Intensity Frontier
Alan Stone
Tim Bolton (IPA)

Cosmic Frontier
Kathy Turner
Michael Salamon
Anwar Bhatti (IPA)

Theoretical Physics
Simona Rolli

Research Technology

General Accelerator R&D
L.K. Len
John Boger
Eric Colby (IPA)
Ken Marken
Michael Zisman (Detailee)

Detector R&D
Glen Crawford (Acting)
Peter Kim (Detailee)

Computational HEP
Lali Chatterjee
Larry Price (Detailee)

SBIR/STTR
Ken Marken

Facilities Division

Mike Procario
Vera Bibbs

Facility Operations

Fermilab Complex
John Kogut

LHC Operations
Simona Rolli
James Stone (IPA)

Other Operations
(SLAC/Other Labs)
John Kogut

Facilities Development

LARP
Bruce Strauss

Muon Accelerator (MAP)
Bruce Strauss

Instrumentation & Major Systems

NOvA – Ted Lavine
MicroBooNE – Ted Lavine
Mu2e – Ted Lavine
LSSTcam – Helmut Marsiske
APUL – Bruce Strauss
LBNE – Mike Procario
Belle-II – Helmut Marsiske
CMS Upgrade – Simona Rolli
ATLAS Upgrade – Simona Rolli
DESI – Kathy Turner
Muon g-2 – Ted Lavine
Dark Matter G2 – Helmut Marsiske

FY 2014 High Energy Physics Budget
(dollars in thousands)

Description	FY 2012 Actual	FY 2013 Plan	FY 2014 Request	Explanation of Change [FY14 Request *vs.* FY13]
Energy Frontier Exp. Physics	159,997	148,164	154,687	Ramp-down of Tevatron Research
Intensity Frontier Exp. Physics	283,675	287,220	271,043	Completion of NOνA (MIE), partially offset by Fermi Ops
Cosmic Frontier Exp. Physics	71,940	78,943	99,080	Ramp-up of LSST-Camera
Theoretical and Computational Physics	66,965	66,398	62,870	Continuing reductions in Research
Advanced Technology R&D	157,106	131,885	122,453	Completion of ILC R&D
Accelerator Stewardship	2,850	3,132	9,931	FY14 includes Stewardship-related Research
SBIR/STTR	0	0	21,457	FY12 and FY13 to SBIR/STTR office.
Construction (Line-Item)	28,000	11,781	35,000	Mostly Mu2e; no LBNE ramp-up
Total, High Energy Physics:	**770,533**[a]	**727,523**[b,c]	**776,521**	**wrt FY13: Up +3.6% after SBIR correction** **wrt FY12: Down -2% after SBIR correction**
***Ref:* Office of Science (SC):**	**4,873,634**	**4,621,075**[c]	**5,152,752**	

SBIR = Small Business Innovation Research
STTR = Small Business Technology Transfer

[a] The FY 2012 Actual is reduced by $20,327,000 for SBIR/STTR.

[b] The FY 2013 [Plan] is reduced by $20,791,000 for SBIR/STTR.

[c] Reflects sequestration.

Cosmic Frontier Program Execution - FY12 Comparative Review of Research Grants

Grant Award Decisions – Considerations by Panel → Program Managers

- **In Cosmic, there are many new proposals coming in from non-HEP-trained people that don't necessarily work in the "HEP model" of collaboration and contribution to the experiment. The PASAG criteria can be applied to research activities too.**

Other considerations included:

- **Priority is to support experiments in our program, where we have responsibilities**
- **Distribution of efforts across thrusts will necessarily change to support changing priorities**
- **What are the experience, responsibilities and commitment (% time) of the researcher? Will they have time to make significant contribution?**
- **Funding isn't optimized by funding small fractions of lots of different people.**
- **Will they work in the "HEP model" by making significant, continuous contributions to the experiment, in addition to their own data analysis?**
- **For experiments with a broad science program, need to ensure that we are concentrating on the most important efforts for HEP program (e.g. dark energy on multi-use facility).**

Cosmic Frontier – Program Model & Vision

Build Program with:
- Staged implementation & results
- mix of smaller, larger projects
- balance between thrusts
- some room for high risk, high yield experiments.

Considerations: PASAG Criteria!
- Science goals and how it will address DOE-HEP goals
- Is all or part of experiment directly-aligned with HEP goals?
- What does our community bring to the experiment? Visible, leadership contributions?
- Are our contributions in line with % of the project relevant to our science goals.
- Partnering with other agencies has plusses & minuses.

Research funding
- Priority is to support efforts in our program, where we have responsibility for experiment
- People working in HEP collaboration model
- Increasing university involvement in dark energy, dark matter
- Change distribution between thrusts as we go forward to support changing program

Overall
- Higher threshold for efforts not directly related to HEP science goals
- Higher threshold for new efforts at labs, labs where we don't have an HEP program/responsibility

Cosmic Frontier – PASAG guidance

In planning the program, we are following guidance from the Particle Astrophysics Science Advisory Group (**PASAG**) HEPAP Subpanel (Oct. 2009) ➔

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

Defined Prioritization Criteria - make contributions to select, high impact experiments:

- That directly address HEP science goals
- That will make a visible or leadership contribution
- For which the HEP community makes contributions – instrumentation, collaborations, analysis techniques etc.

PASAG Criteria can also be applied to research efforts on projects in the program:

- **will the effort will significantly advance HEP science goals?**
- **will the researcher(s) make significant/visible/leadership impact & contributions**

Cosmic Frontier – Research Model

➔**Additional Considerations**

PASAG Criteria can also be applied to research efforts on projects in the program:
- **will the effort will significantly advance HEP science goals?**
- **will the researcher(s) make significant/visible/leadership impact & contributions**

In practice, we typically support teams/collaborations of scientists with the necessary expertise and responsibilities to take experiments through all phases, from R&D, Fabrication, Operations, and Data Analysis

-- Science planning is expected throughout all phases to end up with coordinated data analysis by a collaboration (1 precision result rather than 100 independent results)

-- Understand that people have different strengths & are involved in different aspects.

-- Support theory/simulations/phenomenology/computational efforts in direct support of our experiments (otherwise should be proposed to the Theory program).

Priority is to support efforts in our program, where we have responsibility for experiment.
- Need to make sure that our experiments are adequately supported before supporting or adding to research efforts for other programs.

Cosmic Frontier – Early Career

Statistics on Received & Funded grants →

	FY10	FY11	FY12
# received – Univ	11	8	12
# received – Labs	10	4	7
# funded – Univ	2	1	2
# funded - Lab	0	2	1

Awards:

FY10
Newman (Pitt)
Mahapatra (TAMU)

FY11
Chou (FNAL)
Slosar (BNL)
Hall (Maryland)

FY12
Mandelbaum (CMU)
Padmanabhan (Yale)
Carosi (LLNL)

AAAC 2013 recommendations - response

- Funding Coordination
  - Frequent NSF/DOE discussions on LSST & DESI, plus semi-annual LSST meetings with OMB and OSTP
  - TCAN, VAO funding coordinated with NASA
- Merit review process for decadal priorities in diminished funding environment
  - Next stage in portfolio review response in December 2013
  - MSIP program: will consider proposals from NWNH recommendations that cannot be supported as strategic activities
- Continue LSST development as highest priority (see earlier charts)
- Support Mid-Scale Innovations Program
  - Funding requested in FY 2014, solicitation released, total funds available dependent on budget outcome
- Flexible open-skies policy
  - Multi-agency principles to be discussed in later agenda item
- Agencies coordinate early in development process
  - Occurring for DESI, ongoing for LSST
- Balance among small, medium, and large programs, facilities and individual investigator awards
  - Depends on ability to implement response to portfolio review recommendations
- Request CAA study on OIR system
  - Recent convergence with CAA and NRC; proposal under review
- Mid-decadal survey and ongoing review/advisory committees
  - Not yet ready to commission mid-decadal survey
  - Met with CAA last week, continued AAAC activitie