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DOE Office of Science High Energy Physics Program and Budget Update

AAAC Meeting
February 1-2, 2010
National Science Foundation

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Department of Energy

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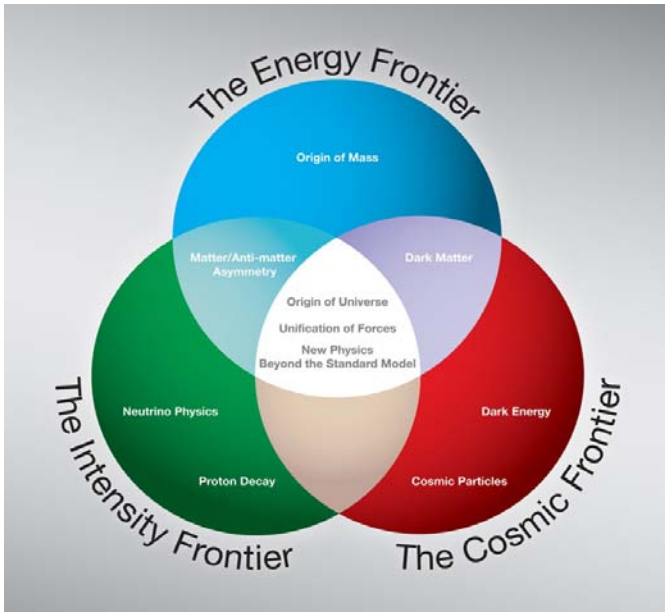
Overview

The HEP program, with input from the scientific community (HEPAP), has developed a long-range plan that maintains a leadership role for the U.S. at the three scientific frontiers that define the field.

The main elements of this plan are to:

- maintain a strong, productive university and laboratory research community
- enable U.S. leadership roles in the Tevatron and LHC programs at the Energy Frontier
- achieve the vision of a world-leading U.S. neutrino and rare decay program at the Intensity Frontier, building on the existing accelerator infrastructure at Fermilab
- deploy selected, high-impact experiments at the Cosmic Frontier
- support accelerator R&D to position the U.S. to be at the forefront of advanced technologies for next-generation facilities.



Need to design and construct new research capabilities, while maintaining a world-leading scientific program and supporting targeted long-range R&D for the future.

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Building the Tools of Discovery Science

- Projects under construction
  - Dark Energy Survey (cosmic)
  - Daya Bay (intensity)
  - NOvA (intensity)
  - MINERvA (intensity)
  - SuperCDMS-Soudan (cosmic)
- Projects in design
  - BELLA (accelerator R&D)
  - FACET (accelerator R&D)
  - Accelerator Project for the Upgrade of the LHC (energy)
- Projects recently receiving Mission Need approval
  - Long Baseline Neutrino Experiment (intensity)
  - MicroBoone (intensity)
  - Muon to Electron Conversion Experiment (intensity)
- Large Projects under consideration for the future
  - Joint Dark Energy Experiment (cosmic)
  - LHC detector upgrades (energy)
  - Large Synoptic Survey Telescope (cosmic)
  - Project X (intensity)
  - + other (cosmic)

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HEP FY 2011 Budget Request

FY 2011 Request is a +2.3% increase compared to FY 2010 Appropriation

FY 2010 Appropriations were a +1.9% increase over FY 2009 Appropriations

(dollars in thousands)

	FY 2009 Current Appropriation	FY 2009 ** Current Recovery Act Appropriations	FY 2010 Current Appropriations	Delta	FY 2011 Request	Percent
High Energy Physics						
Proton Accelerator Based Physics	401,368	107,990	434,167	5,095	439,262	1.2%
Electron Accelerator Based Physics	32,030	1,400	27,427	-2,720	24,707	-9.9%
Non Accelerator Based Physics	101,138	4,445	99,625	-11,086	88,539	-11.1%
Theoretical Physics	66,148	5,975	66,962	2,562	69,524	3.8%
Adavanced Technolgy R&D	195,042 *	112,580	182,302	7,666	189,968	4.2%
Subtotal, High Energy Physics	795,726	232,390	810,483	1,517	812,000	0.2%
Construction	0	0	0	17,000	17,000	
Total, High Energy Physics	795,726 *	232,390	810,483	18,517	829,000	2.3%
			1.90%			

** The Recovery Act Current Appropriation column reflects the allocation of funding as of September 30, 2009.

* Total is reduced by $19,858,000: $17,730,000 of which was transferred to the Small Business Innovation Research (SBIR) program and $2,128,000 of which was transferred to the Small Business Technology Transfer (STTR) program.

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FY 2011 Program Highlights

Energy Frontier

- Tevatron will operate in FY 2011 (possibility of discovery or ruling out over a significant fraction of the allowed mass region for the Higgs boson in the Standard Model at the 95% confidence level).
- U.S. LHC program is supported (at a level that will allow U.S. researchers to play an leading role in extracting physics from the data obtained and in planned upgrades).

Intensity Frontier

- On-going MIE projects (NOvA and Daya Bay) are supported on planned schedules
- First investments (MicroBooNE, Mu2e and LBNE) for next generation U.S. leadership program

Cosmic Frontier

- Support ongoing programs (e.g.; Fermi, AMS, VERITAS, Pierre Auger, BOSS, CDMS, COUPP, LUX, ADMX)
- On-going MIE project (DES) is supported on planned schedule
- R&D for possible future experiments

Core Research

- EPP Research supported at a level that will maintain scientific workforce and the ability to be productive
- Advanced Technology R&D supports high risk, high impact initiatives , development of infrastructure and core competencies important for the U.S.

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FY 2011 Budget Overview

Facility Operations remain about the same

Core Research and Projects grow

HEP Functional Categories	FY 2009	FY 2010	Delta	FY 2011 Request	vs FY10
Fermilab Accelerator Complex Operations	162.8	156.5	-1.4	155.1	-0.9%
LHC Detector Support/Operations	69.4	71.2	3.6	74.8	5.1%
SLAC Accelerator Complex Operations	15.3	12.1	-2.3	9.8	-19.0%
Facility Operations	**247.5**	**239.7**	-0.1	**239.6**	0.0%
EPP Research	284.5	286.3	10.9	297.1	3.8%
Advanced Technology R&D	167.2	162.6	4.1	166.7	2.5%
Core Research	**451.7**	**448.9**	15.0	**463.9**	3.3%
Intensity Frontier Projects	47.7	72.8	5.4	78.3	
Energy Frontier Projects	2.5	9.0	0.3	9.3	
Cosmic Frontier Projects	10.9	10.1	-6.1	4.0	
Technology Projects	8.0	0.0	3.2	3.2	
Projects	**69.1**	**92.0**	2.8	**94.7**	3.0%
Other (GPP/GPE/SBIR/STTR)	**27.5**	**29.9**	0.9	**30.8**	2.9%
High Energy Physics	**795.7**	**810.5**	18.5	**829.0**	2.3%

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FY 2011 Program Projects

Projects:

- Energy Frontier:
  - Planned funding is provided for APUL (LHC Phase I Accelerator Upgrade MIE) project to be completed in FY 2014

- Intensity Frontier:
  - The on-going Daya Bay and NOvA MIEs are supported at planned funding levels
  - One new MIEs integral to the planned U.S. Intensity Frontier program is started in FY 2011
    - MicroBooNE
  - Two new construction projects started in FY 2011
    - Mu2e (Muon to electron conversion experiment)
    - LBNE (Long Baseline Neutrino Experiment)

- Cosmic Frontier:
  - The on-going DES MIE project will be completed and start operation in FY 2012.
  - Decisions on proposed Cosmic Frontier projects (JDEM, LSST, etc.) await ASTRO2010 Report
    - Funding in FY 2011 available for R&D on selected projects

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FY 2011 Budget Projects

HEP Projects (MIEs and Construction)	FY 2009	FY 2010	Delta	FY 2011 Request	vs FY10
Project - NOvA - MIE	27.8	59.0	-12.8	46.2	
Project - Minerva - MIE	4.9	0.8	-0.8	0.0	
Project - MicroBooNE - MIE	0.0	2.0	6.0	8.0	
Project - Mu2e - Construction (Ops & TEC)	0.0	0.0	10.0	10.0	
Project - T2K - MIE	1.0	0.0	0.0	0.0	
Daya Bay - MIE	14.0	11.0	-8.9	2.1	
Project - LBNE - Construction (Ops & TEC)	0.0	0.0	12.0	12.0	
Intensity Frontier Projects	**47.7**	**72.8**	5.4	**78.3**	7.5%
LHC Accelerator Upgrade - APUL - MIE	2.5	9.0	0.3	9.3	
Energy Frontier Projects	**2.5**	**9.0**	0.3	**9.3**	2.8%
Project - DES - MIE	9.9	8.6	-4.6	4.0	
Project - Super CDMS - MIE	1.0	1.5	-1.5	0.0	
Cosmic Frontier Projects	**10.9**	**10.1**	-6.1	**4.0**	-60.4%
FACET	0.0	0.0	0.0	0.0	
Project - SRF Electron Beam Welder - MIE	0.0	0.0	3.2	3.2	
Project - BELLA - MIE	8.0	**0.0**	0.0	0.0	
Technology Projects	**8.0**	**0.0**	3.2	3.2	
Total, HEP Projects	**69.1**	**92.0**	2.8	**94.7**	3.0%

Subprograms Activities: Science for Discovery

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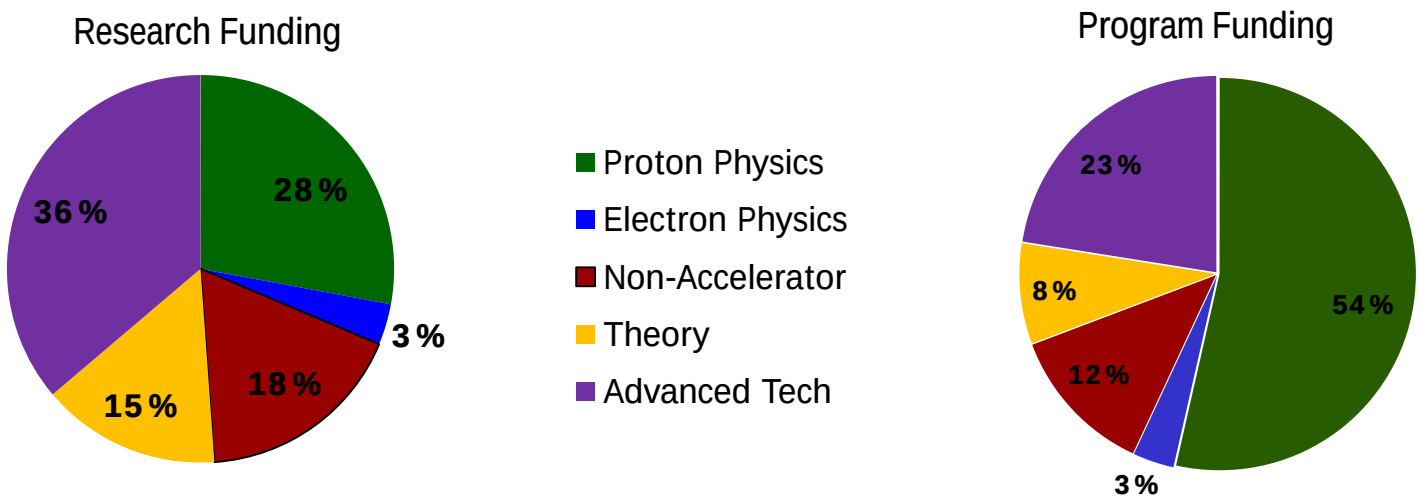
HEP FY2010 Funding by Budget Categories

Budget Categories	FY 2010 HEP Research		FY 2010 HEP Research, Projects and Operations	
Proton Accelerator-Based Physics	125.4	28%	434.2	54%
Electron Accelerator-Based Physics	15.4	3%	27.4	3%
Non-Accelerator Physics	78.5	17%	99.6	12%
Theoretical Physics	67.0	15%	67.0	8%
Advanced Technology R&D	162.6	36%	182.3	22%
High Energy Physics	448.9		810.5	
	55.4%			



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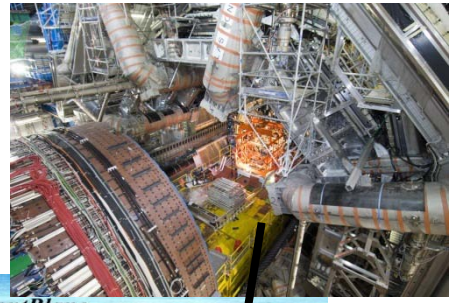
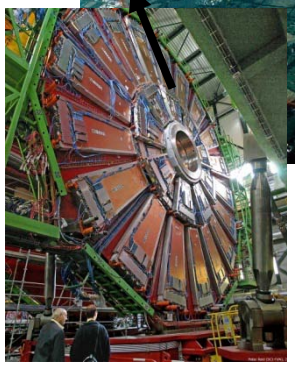
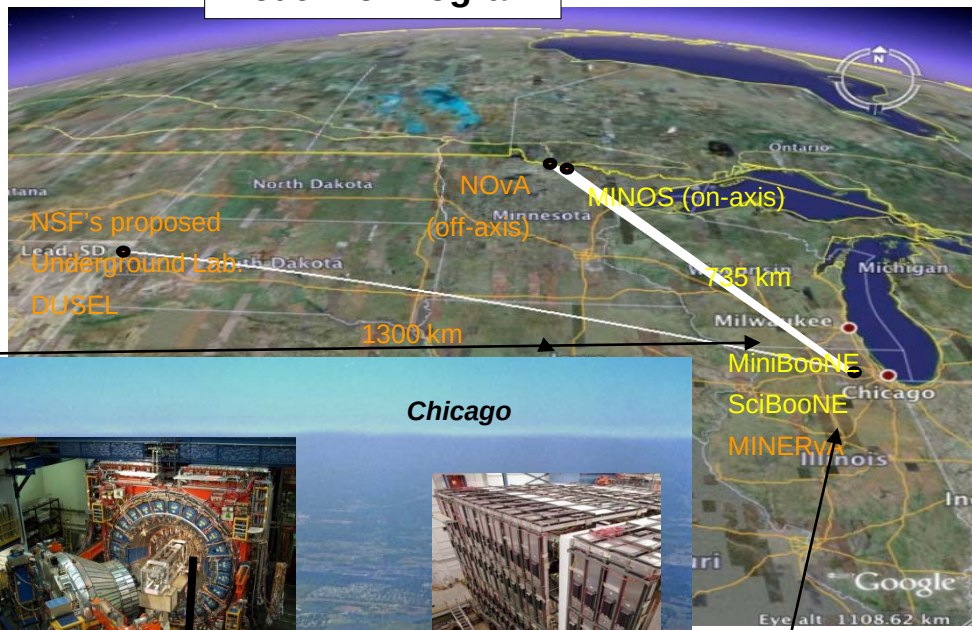
Energy Frontier: Facilities

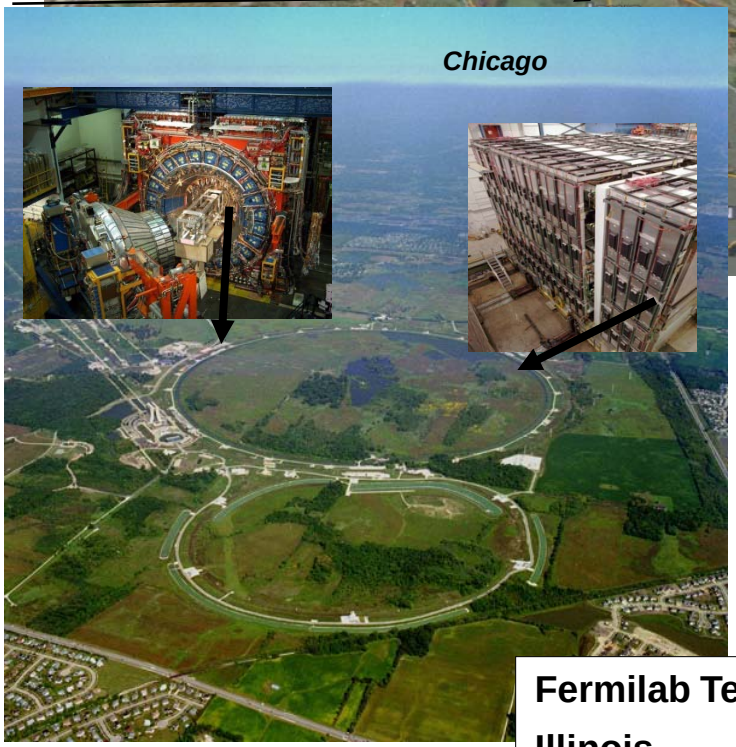




Large Hadron Collider
Geneva

Neutrino Program





Fermilab Tevatron
Illinois

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Energy Frontier: Recent Activities

Tevatron Program

- There is a strong case for running the Tevatron in FY 2011 as the machine/detectors have competitive advantages over the LHC for first Standard Model Higgs exclusion or observation
- OHEP has requested funding in FY 2011 to run the Tevatron

LHC Program

- In December, 2009, successfully collided beam at 900 GeV and ramped to 1.2 TeV center of mass energy
  - 7 TeV center of mass energy is a main objective for 2010
- U.S. will participate in the LHC program until end of US-CERN MOU in 2017
  - Participation includes detector / accelerator "modest upgrades" (Phase I LHC upgrades)

Next generation TeV Facility

- An international "ILC decision" awaits results from LHC and commitments of interested participants
- This had been envisioned to happen ~ FY 2012, but most now believe it will happen later

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Intensity Frontier Facilities: Fermilab Neutrino Program

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Proton Accelerator Based Intensity Frontier: Recent Activities

HEPAP envisioned "world-class" intensity frontier program entails evolution of Fermilab program

- MINOS/Minerva → NOvA (700kW) → LBNE (700kW) → SLBNE (2000 kW) --> Energy Frontier ?
- The accelerator infrastructure allow: SLBNE → neutrino factory → muon collidier

Envisioned "world-class" intensity frontier program entails development of an underground detector

- LBNE needs a large underground detector (~100-300 ktons)
- A large detector (~300 kton) at the right depth (~5000 ft) detector can also do proton decay
- Physics goals: searches for CP violation and proton decay at factors of 10-100 greater sensitivity

Goals are ambitious and will take significant combined (DOE, NSF, other countries) resources

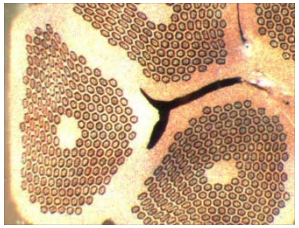
- NSF is proposing a Deep Underground Science and Engineering Laboratory (DUSEL) with a suite of experiments that includes a large detector (for neutrino oscillations and proton decay)
- Europeans have a large underground detector in their strategic planning
- Japanese are also interested in the science

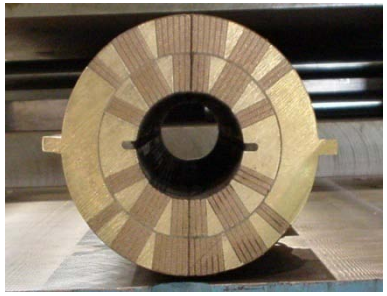
DOE and NSF are coordinating planning

- NSF is supporting the conceptual design of the DUSEL facility and a suite of experiments
- DOE HEP has received Mission Need (CD-0) approval for the Long Baseline Neutrino Experiment (LBNE) that includes the neutrino beam and a large underground detector
- DOE and NSF are working to coordinate their efforts, avoid duplication, and optimize their investments

Advanced Technology

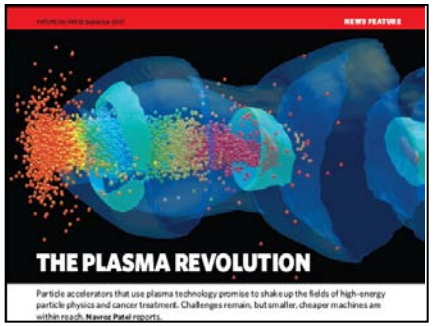
Superconducting Cable & High Field Magnets

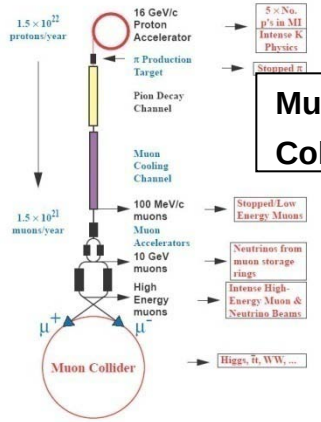




Superconducting Cavity Technology

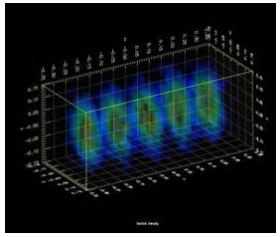
Accelerators

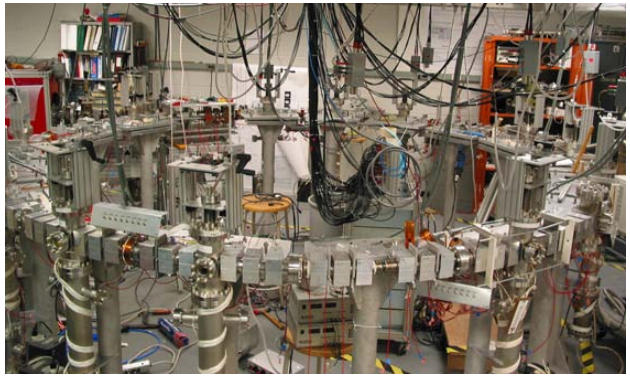




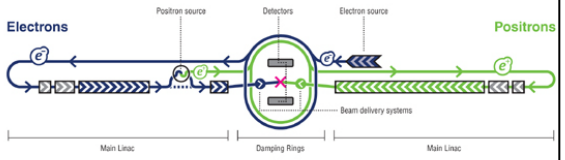
Muon Collider

Accelerator Science





International Linear Collider



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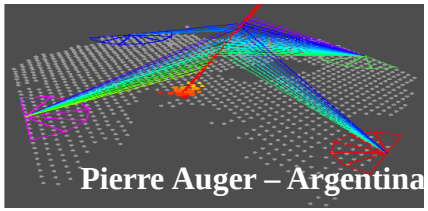
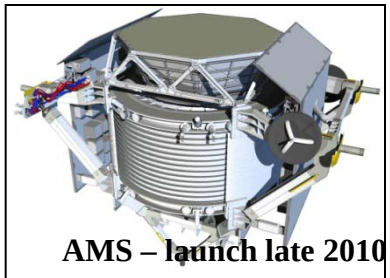
Cosmic Frontier Experiments
Operating, Fabrication and Possibilities for the Future

Gamma-ray Astrophysics

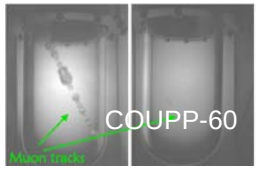
Cosmic Ray Astrophysics



Anti-matter, Dark Matter



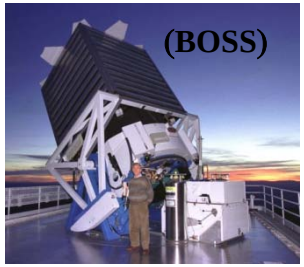
Dark Matter (WIMPs)



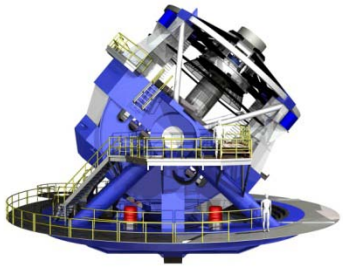
LUX

Dark Matter (axions)

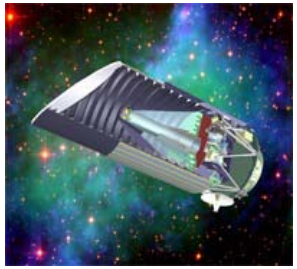
Dark Energy (ground-based)



LSST - proposed



Dark Energy (space-based)



JDEM - proposed

Possible Future:

- QUIET-II
- BigBOSS
- AGIS
- Auger-North
- Dark Matter experiments – next step

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Non-Accelerator Physics
Recent Activities

DOE and NASA have been working on identifying the path forward on a JDEM

- Two concepts (IDECS and OMEGA) were presented to Astro2010 in June 2009.
- Costs are not compatible with current budget projections.
- Project Offices (GSFC and LBNL) have been asked to develop a "probe class" $650M-capped mission concept
- Scientific advice is being provided by the Interim Science Working Group (since December 2009).

We have received guidance from HEPAP (PASAG)

- The findings and recommendations are important:
  - they will help define the HEP "particle astrophysics" program
  - they will be used in setting priorities and articulating the scientific deliverables
  - we thank them for their hard work

We are looking for guidance from Astro2010.

- The findings and recommendations are important:
  - they will influence the opportunities for HEP participation
  - they will inform OHEP on scientific/technical aspects of particle astrophysics
    (e.g.; optimum dark energy strategy with available resources)

OECD Global Science Forum Astroparticle Physics Working Group

- A 2-year study of global coordination and planning of astro-particle physics experiments.
- The study report will be completed in Oct. 2010.

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HEPAP (PASAG) Charge

DOE/NSF requested that HEPAP

- examine current and proposed U.S. research capabilities in particle astrophysics
- assess their role and potential for scientific advancement
- determine the resources needed

PASAG was asked to identify and evaluate the scientific opportunities and options

- that can be pursued at different funding levels for mounting a world-class program
- that addresses the highest priority science in particle astrophysics

The scientific scope of this review was limited to opportunities that will advance our understanding of the fundamental properties of particles and forces using observations of phenomena from astrophysical sources.

To be specific, we considered the following scientific areas to be within the scope of this study

- exploring the particle nature of dark matter
- understanding the fundamental properties of dark energy, and
- measuring the properties of astrophysically generated particles (including cosmic rays, gamma rays, and neutrinos)

These evaluations should be done in the context of the increasing internationalization of particle astrophysics,

- while recognizing the need to maintain a healthy, flexible, domestic research infrastructure
- and respecting the funding agencies' different but complementary scientific missions and the varied ways they intersect with this research.

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HEPAP PASAG
Funding Levels Considered

PASAG charged to provide recommendations on the priorities for an optimized particle astrophysics program over the next ten years (FY 2010-2019), under the following four funding profile scenarios:

Scenario A ~ $266M DOE + NSF

- Constant effort (3.5% inflation) at the FY 2008 funding level

Scenario B ~ $389M

- Constant effort (3.5% inflation) at the FY 2009 President's Request level

Scenario C ~ $640M

- Doubling of funding (inflate by 6.5%) over a 10-year period starting in FY 2009

Scenario D:

- Additional funding above funding scenario 3, in priority order

PASAG Report

Report approved by HEPAP at their October 23, 2009 meeting

See report and Steve Ritz' presentation to HEPAP at:
http://www.science.doe.gov/hep/files/pdfs/PASAG_Report.pdf
http://www.science.doe.gov/hep/files/pdfs/HEPAP_2009_10_Ritz_PASAG.pdf

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PASAG Developed Prioritization Criteria

The science addressed by the project is necessary

- Addresses fundamental physics (matter, energy, space, time).
- Anticipated results: either at least one compelling result or a preponderance of solid, important results. Check that anticipated results would not be marginal, either in statistics or in systematic uncertainties, relative to the needed precision for clear science results.
- Discovery space: large leap in key capabilities, significant new discovery space, and possibility of important surprises.

Particle physicist participation is necessary

- Transformative techniques and know-how to have a major, visible impact; project would not otherwise happen.
- Leadership is higher priority than participation

Scale matters, particularly for projects at the boundary between particle physics and astrophysics.

- Relatively small projects with high science per dollar help ensure scientific breadth while maintaining program focus on the highest priorities.

Programmatic issues:

- International context: cooperation vs. duplication/competition.

PASAG Experiments Considered

Current Experiments – operating or in fabrication

Projects Considered for PASAG funding scenarios

Dark Matter

- SuperCDMS-Soudan, ADMX-I, LUX, miniCLEAN, COUPP + R&D for others.
- G2 experiments have masses of ~ 1 ton and cost ~ $15-20M
- G3 experiments are many tons and cost ~ $50M

Dark Energy:

- Supernova Cosmology Project, Supernova Factory, DES, BOSS,
- DEM, LSST, BigBOSS

Cosmic Particles:

- AMS, Auger in Argentina, VERITAS
- Auger-North, TALE, AGIS, HAWC, VERITAS-upgrade

Cosmic Microwave Background (CMB):

- Fermilab participation QUIET-II

PASAG Scenario A - Recommendations

Dark Matter – direct detection

- Maintain world-leading program by supporting 2 next-generation (G2) experiments and SuperCDMS-SNOLab
- Not able to do a third-generation (G3) experiment this decade which may mean loss of world leadership

Dark Energy

- Not possible to have major hardware and science contributions to any large project -- participation supported only in very limited areas

High Energy Cosmic Particles:

- Effort is severely curtailed in order to preserve viable program in dark matter & energy
- VERITAS upgrade & HAWC should be a priority.
- Auger-North & AGIS are not possible

Cosmic Microwave Background:

- QUIET-II should be supported along with other small investments that meet prioritization criteria.

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PASAG Scenario B - Recommendations

Dark Matter – direct detection

- Maintain world-leading program by supporting 2 G2 experiments and SuperCDMS-SNOLab
- Start a G3 experiment this decade.
- A broad G2 program is higher priority than a 2nd G3 experiment

Dark Energy

- May have just enough funding for significant participation in 1 large project but there are risks since costs are uncertain; fast start may not be possible

High Energy Cosmic Particles:

- VERITAS upgrade, HAWC and a reduced but leading role in an AGIS that is merged with CTA
- Auger-North is not possible

Cosmic Microwave Background:

- QUIET-II should be supported along with other small investments that meet prioritization criteria.

PASAG Scenario C & D - Recommendations

Dark Matter – direct detection

- World-leading program with support of 2 G2 experiments and SuperCDMS-SNOLab, followed by 2 G3 experiments.

Dark Energy

- A world-leading program is enabled, with coordinated experiments in space and on the ground
- Significant HEP role in 1 large experiment plus a moderate-scale project and/or substantial role in 2nd large project. Project start may need to be pushed out due to funding profile

→Scenario D would allow major roles in 2 large experiments

High Energy Cosmic Particles:

- A world-leading program is enabled. VERITAS upgrade, HAWC and a reduced but leading role in an AGIS that is merged with CTA, along with leadership of Auger-North

Cosmic Microwave Background:

- QUIET-II should be supported along with other small investments that meet prioritization criteria

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PASAG - Summary

- Priorities are generally aligned with recommendations for Cosmic Frontier in the 2008 HEPAP (P5 Report)
- Dark matter & dark energy remain high priorities.
- Dark energy funding, which receives the largest budget portion, should not significantly compromise US leadership in dark matter, where a discovery could be imminent.
- Dark energy and dark matter together should not completely zero out other important activities (except in the lowest funding scenario, but even then a limited CMB is recommended)

BACKUP