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DOE Office of Science
High Energy Physics Program

Astro2010 Meeting
October 5, 2009
Washington, D.C.

Dennis Kovar
Associate Director of the Office of Science
for High Energy Physics
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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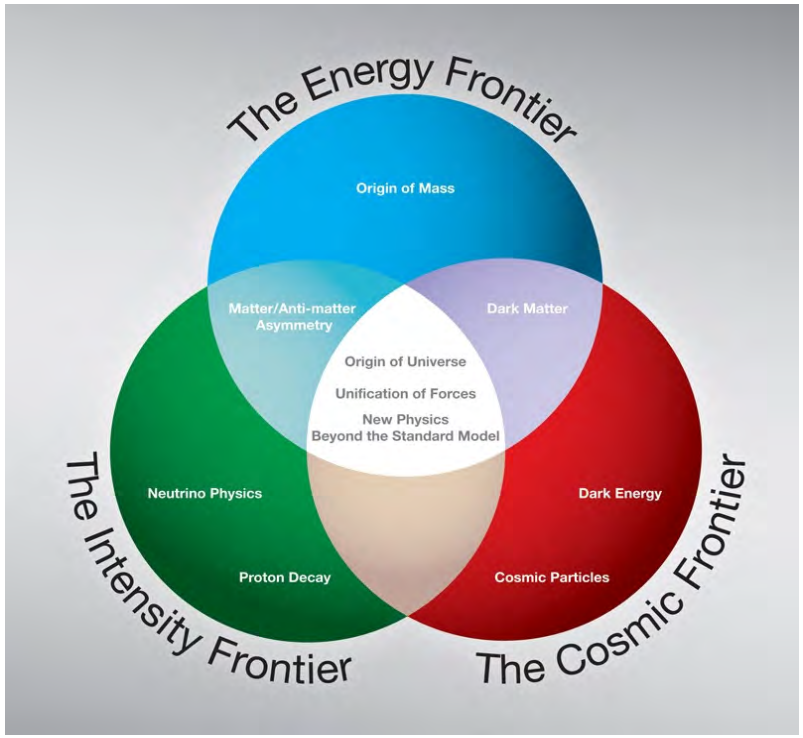
Particle Physics Today
Three Scientific Frontiers

- *The Energy Frontier,* powerful accelerators are used to create new particles, reveal their interactions, and investigate fundamental forces;

- *The Intensity Frontier,* intense particle beams and highly sensitive detectors are used to pursue alternate pathways to investigate fundamental forces and particle interactions by studying events that occur rarely in nature; and

- *The Cosmic Frontier,* ground and space-based experiments and telescopes are used to make measurements that will offer new insight and information about the nature of dark matter and dark energy, to understand fundamental particle properties and discover new phenomena.



The three frontiers have been excellent framework for our discussions of the program with the Office of Science, DOE, OMB, and Congress.

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The HEPAP (P5) Exercise

- Following the reductions in the FY 2008 HEP budget, DOE/NSF requested that HEPAP (P5) develop a new roadmap for HEP.

- HEPAP (Particle Physics Project Prioritization Panel (P5)) seriously addressed the charge given by DOE/NSF:
  - to examine the scientific opportunities and options
  - for mounting a world class particle physics program
  - at different funding levels

- Lays out what the Nation will get with different investments
  - Scenario A (FY 2008 Approp + COL)
    - unable to mount productive, world-class programs at all three frontiers
  - Scenario B (FY 2007 Approp + COL)
    - programs at all three frontiers
  - Scenario C (FY 2007 doubling (+6.5%/yr))
    - leadership programs – partner in TeV-scale facility
  - Scenario D (additional above C)
    - the funding to host next TeV-scale facility

Report submitted 2 June 2008, www.science.doe.gov/hep/files/pdfs/P5_Report%206022008.pdf

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HEPAP (P5) Report
The Guidance

Progress in achieving the goals of particle physics requires advancements at the

- Energy, Intensity and Cosmic Frontiers
- Each provides a unique window for insight about the fundamental forces and particles of nature
- The U.S. should have a strong, integrated research program at all three frontiers

Energy Frontier

- Continued support for the Tevatron Collider program for next 1-2 years
- LHC program has the highest priority, including US involvement in planned upgrades
- Accelerator and detector R&D program for next generation lepton collider

Intensity Frontier

- Recommends a world class neutrino program as core component
- Long term vision includes a large detector at DUSEL and high-intensity neutrino source at Fermilab.
- Program of rare decays (e.g.: muon to electron conversion – Mu2e)

Cosmic Frontier with an emphasis on dark energy and dark matter

- Joint Dark Energy Mission (JDEM) in collaboration with NASA
- Large Synoptic Survey Telescope (LSST) in collaboration with NSF
- Direct dark matter search experiments

HEP at its core is an accelerator based experimental science.

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

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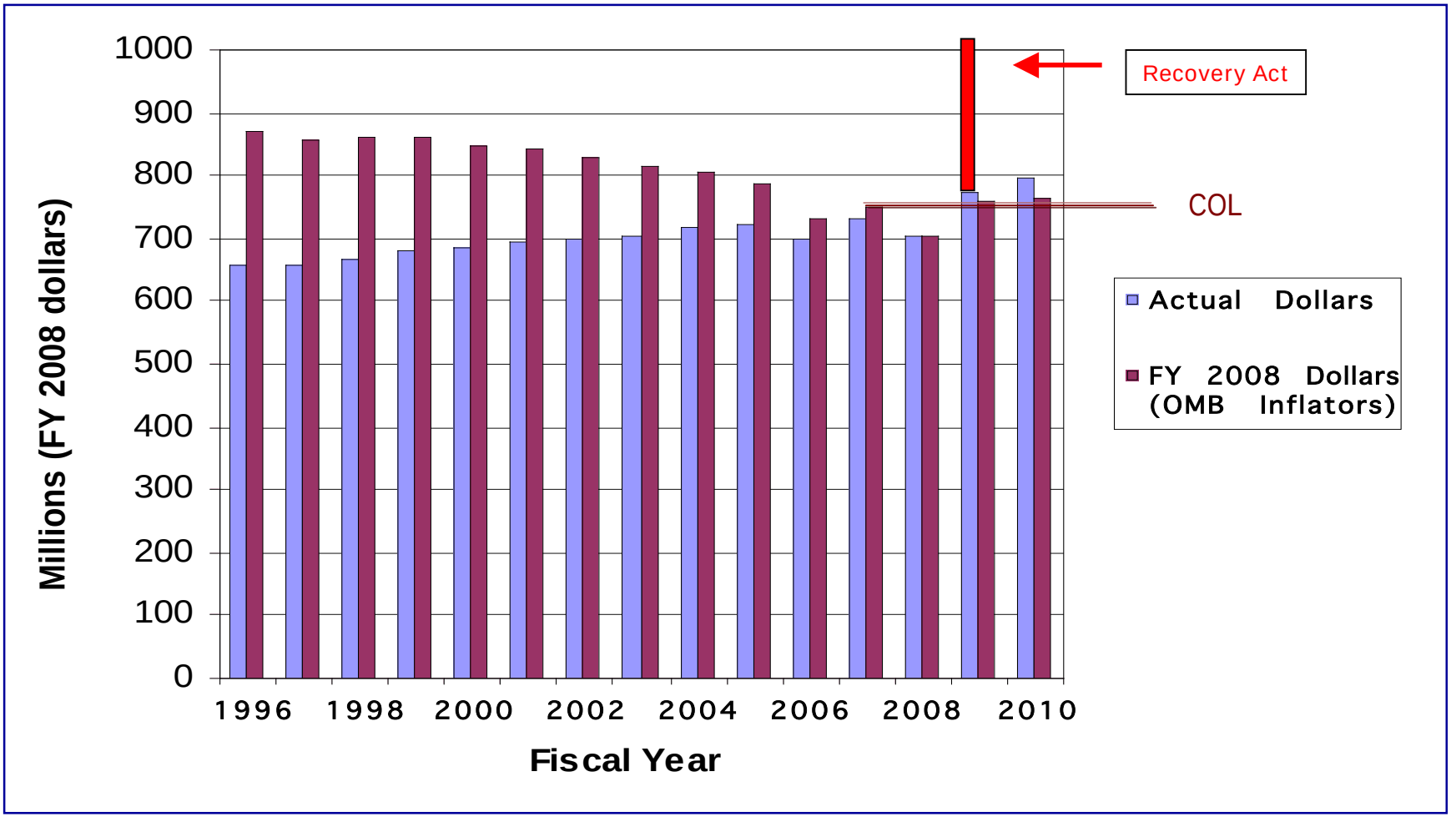
FY 2009 & FY 2010 change the funding trend

- HEP FY 2009 funding is + 10% compared to FY 2008 and above OMB Cost-of-Living (COL) from FY 2007
- HEP received $236.5 million in Recovery Act funding
- HEP FY 2010 Request is above OMB COL (+ 1.9%) compared to FY 2009



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FY 2009
American Recovery and Reinvestment Act (ARRA)

	FY 2009 ARRA
Fermilab Accelerator Complex Operations	15.0
Facility Operations	**15.0**
Proton Research	6.6
Electron Based Research	0.3
Non-Accelerator	1.4
Theory	2.9
EPP Research	**11.2**
Accel Science	0.4
General Accel Development	6.0
Superconducting RF	52.7
Advanced Tech SRF R&D	9.0
Detector Development	8.4
Advanced Technology R&D	**76.5**
Core Research	**87.7**
Project - NOvA	55.0
FACET	13.0
BELLA	20.7
Projects	**88.7**
Other (GPP/GPE/SBIR/STTR)	**28.6**
High Energy Physics	**220.0**

	HEP ARRA Projects
15.0	**University Enhancement & Infrastructure**
52.7	**SRF Infrastructure (Fermilab & Industry)**
20.0	**Advanced Technologies (Universities & Labs)**
15.0	**Long Baseline Neutrino Experiment (LBNE) R&D**
55.0	**NOvA (Univ. Minnesota and Fermilab)**
33.7	**Advanced Plasma Accelerator Facilities (LBNL/SLAC)**
25.0	**GPP Fermilab**
3.6	**SBIR/STTR**
220.0	

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FY 2010 HEP Budget

FY 2010 Funding Status
(budget authority in thousands of dollars)

	FY 2009			FY 2010				
	Base Approp.	Recovery	Enacted Approp.[a/]	Request	Req. vs. 09 Base Approp.	Conf.	Conf. vs. Request	
Basic Energy Sciences	1,571,972	+555,406	2,127,378	1,685,500	+113,528	1,636,500	-49,000	4.1%
Advanced Scientific Computing	368,820	+161,795	530,615	409,000	+40,180	394,000	-15,000	6.8%
Biological and Environmental Research	601,540	+165,653	767,193	604,182	+2,642	604,182	—	0.4%
High Energy Physics	795,726	+232,390	1,028,116	819,000	+23,274	810,483	-8,517	1.9%
Nuclear Physics	512,080	+154,800	666,880	552,000	+39,920	535,000	-17,000	4.5%
Fusion Energy Sciences	402,550	+91,023	493,573	421,000	+18,450	426,000	+5,000	5.8%
Science Lab Infrastructure	145,380	+198,114	343,494	133,600	-11,780	127,600	-6,000	-12.2%
Science Program Direction	186,695	+5,600	192,295	213,722	+27,027	189,377	-24,345	1.4%
Workforce Development	13,583	+12,500	26,083	20,678	+7,095	20,678	—	52.2%
Safeguards and Security	80,603	—	80,603	83,000	+2,397	83,000	—	3.0%
Subtotal, Science	4,678,949	+1,577,281	6,256,230	4,941,682	+262,733	4,826,820	-114,862	3.2%
ARPA-E	15,000	—	15,000	—	-15,000	—	—	
Safeguards and Security (reimbursable	—	—	—	—	—	—	—	
Congressionally-directed projects	93,687	—	93,687	—	-93,687	76,890	+76,890	
SBIR/STTR	—	+18,719	18,719	—	—	—	—	
Use of prior year balances	-15,000	—	-15,000	—	+15,000	—	—	
Unallocated	—	+4,000	4,000	—	—	—	—	
Total, Science	4,772,636	+1,600,000	6,372,636	4,941,682	+169,046	4,903,710	-37,972	2.7%

[a/] FY 2009 Enacted Appropriation is prior to the Small Business Innovation Research/Technology Transfer reprogramming and appropriations b/ $15,000,000 appropriated under for Science prior appropriation Acts for the Advanced Research Projects Agency--Energy is to be transferred to

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DOE SC HEP
FY 2010 Budget Overview

HEP Functional Categories	FY 2007	FY 2008	FY 2009	Diff vs FY09	FY 2010 Conference	Diff vs FY09
Fermilab Accelerator Complex Operations	145.1	151.0	162.8	-4.3	158.5	-2.6%
LHC Detector Support/Operations	56.8	65.6	69.4	1.1	70.5	1.6%
SLAC Accelerator Complex Operations	79.0	36.5	15.3	-3.3	12.1	-21.3%
Facility Operations	**280.9**	**253.1**	**247.5**	-6.4	**241.1**	-2.6%
EPP Research	249.1	264.5	284.7	2.4	287.0	0.8%
Advanced Technology R&D	167.7	138.1	167.2	-4.7	162.5	-2.8%
Core Research	**416.8**	**402.6**	**451.9**	-2.3	**449.6**	-0.5%
Project - NOvA	12.5	12.0	27.8	31.2	59.0	
Project - Minerva	4.0	7.2	4.9	-4.1	0.8	
Project - T2K	0.6	2.5	1.0	-1.0	0.0	
Daya Bay	1.0	6.9	14.0	-3.0	11.0	
LHC Detectors	3.2	0.0	0.0	0.0	0.0	
LHC Accelerator Upgrade Phase I	0.0	0.0	2.5	5.5	8.0	
DES	1.4	5.5	9.7	-1.1	8.6	
Super CDMS	0.0	0.0	1.0	0.5	1.5	
FACET	0.0	0.0	0.0	0.0	0.0	
BELLA	0.0	0.0	8.0	-8.0	**0.0**	
Projects	**22.6**	**34.1**	**68.9**	20.0	**88.9**	29.1%
Other (GPP/GPE/SBIR/STTR)	**31.5**	**31.5**	**27.5**	3.4	**30.9**	12.4%
High Energy Physics	**751.8**	**721.3**	**795.7**	14.8	**810.5**	1.9%

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Building the tools to deliver the science

- Projects under construction
  - Dark Energy Survey (cosmic)
  - Daya Bay (intensity)
  - NOvA (intensity)
  - MINERvA (intensity)
  - SuperCDMS-Soudan (cosmic)
- Projects where we are working on Mission Need
  - Long Baseline Neutrino Experiment (intensity)
  - Muon to Electron Conversion Experiment (intensity)
  - MicroBoone (intensity)
- Projects in design
  - BELLA (accelerator R&D)
  - FACET (accelerator R&D)
  - Accelerator Project for the Upgrade of the LHC (energy)
- Large Projects that are being considered for the future
  - Joint Dark Energy Experiment (cosmic)
  - LHC detector upgrades (energy)
  - Large Synoptic Survey Telescope (cosmic)
  - Project X (intensity)

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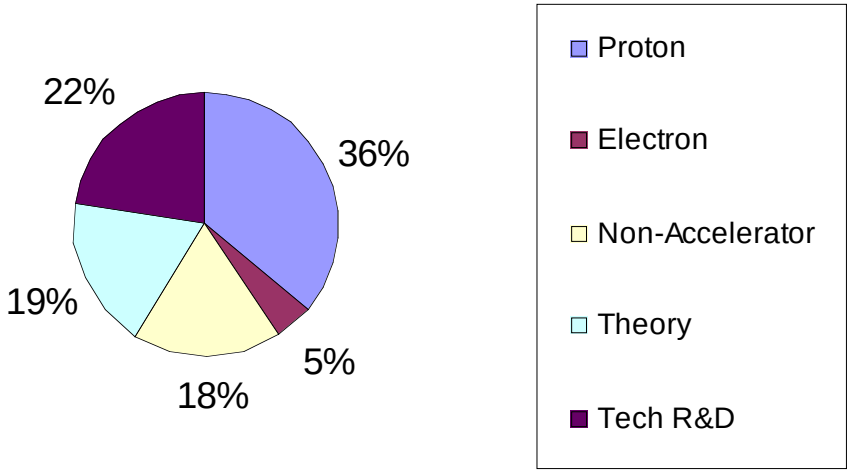
HEP Funding by Budget Categories

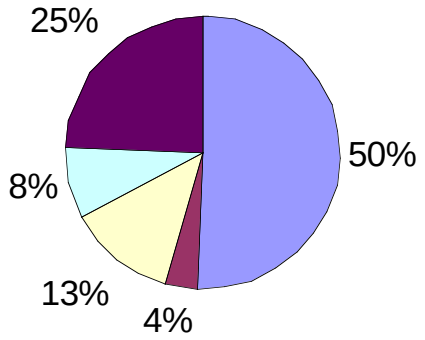
(millions)

Budget Categories	FY 2009 HEP Research	FY 2009 HEP Research, Projects and Operations
Proton Accelerator-Based Physics	125.7	401.4
Electron Accelerator-Based Physics	16.5	32.0
Non-Accelerator Physics	62.4	101.1
Theoretical Physics	64.8	66.1
Advanced Technology R&D	77.7	195.1
High Energy Physics	347.1	795.7

Research Funding



Total Funding



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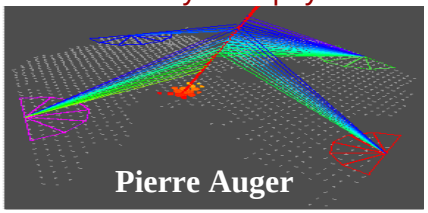
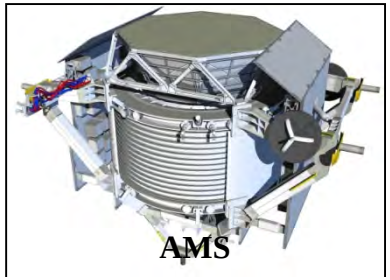
OHEP has on-going, planned and proposed Particle Astrophysics experiments

Gamma-ray Astrophysics

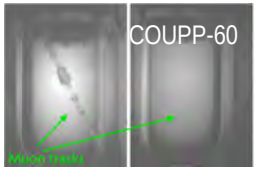
Cosmic Ray Astrophysics

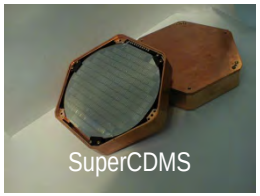


Anti-matter, Dark Matter



Dark Matter (WIMPs)





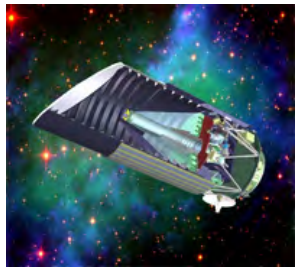
LUX

Dark Matter (axions)

Dark Energy (ground-based)

LSST - proposed

Dark Energy (space-based)



JDEM - proposed

HEPAP PASAG
(Particle Astrophysics Scientific Assessment Group)

DOE/NSF has charged to HEPAP to review the scientific opportunities in Particle Astrophysics

- In response to recommendations in the May 2008 P5 report
- To identify the scientific opportunities that should be pursued by the U.S. program at various funding levels in the out-years.
  - Similar to the P5 charge.
- To better clarify what constitutes “particle astrophysics” and what this contributes to the mission of particle physics and to the fields of astrophysics and astronomy and what our role should be in experiments that overlap areas
- Report is to be submitted to HEPAP for their meeting on October 22, 2009.

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PASAG charge

DOE/NSF requests that HEPAP

- examine current and proposed U.S. research capabilities in particle astrophysics
- assess their role and potential for scientific advancement
- determine the time and resources needed to achieve an optimum program
- in the context of various budgetary scenarios indicated below.

PASAG should identify and evaluate the scientific opportunities and options

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

The scientific scope of this review should be 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 consider 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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PASAG charge (continued)

Your report should 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:

- Constant effort at the FY 2008 funding level
- Constant effort at the FY 2009 President's Request level
- Doubling of funding over a ten year period starting in FY 2009
- Additional funding above funding scenario 3, in priority order

The report should articulate:

- the scientific opportunities that can and cannot be pursued and
- the impacts on training of physicists
- as well as the broader scientific community under each of the funding profile scenarios.
- For example, continued operations of existing facilities will have to be balanced against the opportunities to develop new or upgraded facilities with advanced capabilities.
- The report should also provide a detailed perspective on how the pursuit of possible major initiatives would complement the program you recommend in each of the scenarios.

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Specific Questions from Astro2010

Questions:

- How do you see the HEP physics support of astrophysics evolving in the next decade? Are there any additional, new, parts of astrophysics that DOE is likely to get engaged in?
- You asked the committee not to make recommendations on direct detection of dark matter. What do you anticipate will be the nature and scale of this program?
- Much has happened on JDEM since the committee last met and given the upcoming ESA review of M-class missions plus the studies currently underway much is likely to happen still. Could you clarify what the committee should assume now?
- What is the level of commitment is now anticipated for DES, LSST and (Big)-BOSS over the next decade and what are the contingencies?
- Could you explain how DOE distinguishes base and project funding?
- What is the best guidance you can give this committee concerning a baseline planning budget for the Cosmic Frontier program (minus dark matter detections and the commitments that have already been made) that the committee can use for its recommendations over the next decade?
- How do you view the relationship between internal advisory committees such as HEPAP, P5 and PASAG and NRC committees such as EPP2010 and Astro2010?
- Have HEP in general and Particle Astrophysics in particular received any benefit from ARRA funds?
- DOE/NNSA are discussing initiatives in High Energy Density Physics. Much of that overlaps strongly with astrophysics (e.g. planetary interiors, opacities), and takes advantage of DOE facilities, such as ZR/Sandia and NIF. What's your perspective on whether this activity fits within DOE's intrinsic interest in astrophysics?

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Questions from Astro2010

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Questions from Astro2010

Question 1: How do you see the HEP physics support of astrophysics evolving in the next decade? Are there any additional, new, parts of astrophysics that DOE is likely to get engaged in?

HEP's strategic plan incorporates the major findings/ recommendations of HEPAP P5 report

- Namely, that progress in achieving the goals of particle physics requires advancements at all three frontiers of particle physics and the U.S. should try to play a major role in all three
- Funding in the out years has been tentatively allocated for the support of initiatives based upon guidance of P5 report. Decisions on whether to pursue these initiatives depend upon updated scientific/technical/cost information – as well as the funding levels for HEP in the out years.

For the Cosmic Frontier we are awaiting the input of the findings and recommendations of the HEPAP PASAP and your Academy Decadal Survey assessments.

- The near term scientific opportunities at the Energy Frontier and longer term scientific opportunities and importance of developing a U.S. leadership program at the Intensity Frontier have been identified as priorities for the HEP program.
- Compelling scientific opportunities for particle astrophysics (and commitments of the partners needed to implement the capabilities to addresses these) will be needed
  - to compete with the other priorities within HEP
  - and, especially under conditions of constrained funding, to retain the funding that has been allocated for the initiatives at the Cosmic Frontier.

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Questions from Astro2010

Questions 2: You asked the committee not to make recommendations on direct detection of dark matter. What do you anticipate will be the nature and scale of this program?

The direct-detection dark matter experiments are funded by DOE-OHEP and NSF-PHY and we get advice from HEPAP and its subpanels on these.

- Currently, DOE is funding a number of experiments in different stages and using different techniques: LUX, SuperCDMS-Soudan, ADMX, COUPP. We are also funding R&D for future near-term and next-generation mega-ton scale experiments.
- Currently funding for dark matter experiments is approximately $11M (FY09) and is planned to be about the same for FY10.
- We expect guidance from PASAG on the opportunities, options and scale for the program in the future. We anticipated that there will be a strong case for increasing the investments in this scientific thrust.

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Questions from Astro2010

Question 3: Much has happened on JDEM since the committee last met and given the upcoming ESA review of M-class missions plus the studies currently underway much is likely to happen still. Could you clarify what the committee should assume now?

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

- Two concepts (IDECS and OMEGA) have been presented to Astro2010. The cost of both of these missions is large and our current budget projections show that large-class missions may not be possible.
- We have notified you that NASA and DOE have agreed that examination of a "probe class" $650-capped mission concept is important and that we are asking the Project Offices at GSFC and LBNL to develop to develop these concepts.
- We are looking for guidance from Astro2010 on the relative importance of a JDEM to the overall portfolio and what the science return needs to be to justify going to space.

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Questions from Astro2010

Question 4: What is the level of commitment is now anticipated for DES, LSST and (Big)-BOSS over the next decade and what are the contingencies?

We have allocated in our plans over the next decade about $430M for fabrication and operations of particle astrophysics initiatives (Dark Matter, Dark Energy, High Energy gamma-rays, cosmic rays, and neutrinos, CMB, etc.).

- The findings and recommendations on scientific opportunities and priorities of HEPAP PASAG and the Decadal Survey will be used as input to our decisions on:
  - Whether the allocated funding level is justified (or adequate)
  - What scientific opportunities should be pursued

- Advice on an optimized dark energy program with ground and space based observatories would be greatly appreciated.

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Questions from Astro2010

Question 5: Could you explain how DOE distinguishes base and project funding?

DOE OHEP provides peer-reviewed "base" scientific support to the laboratories and university groups to participate in experiments and analyze the resulting data.

- Within this support are modest resources for R&D and pre-conceptual development and design efforts for future initiatives.
- This base support is considered to be relatively stable (with COL) in our program as people move from experiment to experiment
- This base funding is managed by the Program Manager for Non Accelerator Physics.

The decision to pursue a project is made at the HEP Office level

- All projects are managed according to DOE Project management practices (Order 413.3), must be approved at Office of Science, DOE and OMB levels, and must be identified in Budget Request to Congress.
- Projects have funding profiles that start and end, as do the operating costs. Hence funding in a specific subprogram for projects may shift to another HEP subprogram after any specific project is completed.
- Projects need be an integral part of the HEP strategic plan.

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Questions from Astro2010

Question 6: What is the best guidance you can give this committee concerning a baseline planning budget for the Cosmic Frontier program (minus dark matter detections and the commitments that have already been made) that the committee can use for its recommendations over the next decade?

We have already provided to you (as we have to HEPAP PASAG) the funding in our planning for particle astrophysics initiatives.

- If I have not made it clear – these planning numbers are subject to change and have indeed have already changed.

For the purposes of your exercise I would suggest that you consider three cases:

Case 1: $500M over ten years ($50M/year)

Case 2: $400M over ten years ($40M/year)

Case 3: $300M over ten years ($30M/year)

NOTE: These cases include direct detection of dark matter!

OHEP would be interested in what science would be enabled with OHEP investments at these different levels.

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Questions from Astro2010

Question 7: How do you view the relationship between internal advisory committees such as HEPAP, P5 and PASAG and NRC committees such as EPP2010 and Astro2010?

HEPAP is a Federal Advisory Committee Act (FACA) panel chartered specifically to give advice to DOE and NSF on the High Energy/Particle Physics program.

- This is our main advisory panel. HEPAP establishes and tasks subpanels (such as P5 and PASAG) for specific studies that it has been charged by the agencies to do.

The NRC EPP2010 Report provided an independent assessment of the scientific opportunities of particle physics and the role the United States could and should play in the future.

- The findings and recommendations of this report were valuable input to HEPAP P5 exercise to develop a strategic plan for the U.S. program that dealt with changing circumstances and fiscal realities.

AAAC is a FACA panel chartered to give advice to DOE, NSF and NASA on areas of astronomy and astrophysics where our programs overlap.

- There have been several subpanels of both HEPAP and AAAC that were convened: DMSAG, TFCR, DETF

We view Astro2010 as providing guidance to the stewards of astronomy and astrophysics (NASA and NSF)

- We do not aspire to set up competing programs – we look to leverage investments - to advance particle physics
- Your finding and recommendations are important to us
  - they will influence whether there are opportunities for us to participate
  - they will inform us on scientific/technical aspects of particle astrophysics (e.g.; optimum dark energy strategy)
- We do not look to Astro2010 to make recommendations on priorities in particle physics

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Questions from Astro2010

Question 8: Have HEP in general and Particle Astrophysics in particular received any benefit from ARRA funds?

As I showed in my presentation, the DOE OHEP program received $220M in ARRA funding plus $16.5M as part of the Early Career Award program. There were many provisions on how these funds could be spent. Funds were provided for:

15.0	university enhancement and infrastructure (non-accelerator received $1.4M of this)
52.7	SRF infrastructure (Fermilab and industry)
20.0	advanced technology (universities and labs)
15.0	Long Baseline Neutrino Experiment (LBNL) R&D
55.0	NOvA experiment (Univ of Minnesota and Fermilab)
33.7	Advanced Plasma Accelerator Facilities (LBNL/SLAC)
25.0	GPP Fermilab
3.6	SBIR/STTR

Total = $220.0M

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Questions from Astro2010

Question 9: DOE/NNSA are discussing initiatives in High Energy Density Physics. Much of that overlaps strongly with astrophysics (e.g. planetary interiors, opacities), and takes advantage of DOE facilities, such as ZR/Sandia and NIF. What's your perspective on whether this activity fits within DOE's intrinsic interest in astrophysics?

The DOE Office of High Energy Physics program studies fundamental matter, energy, space and time. We are interested in areas of astrophysics that can shed light on these areas.

- High Energy Density Physics (HEDP) does not have a strong overlap with the particle astrophysics identified by our community and is not being considered by our program.
- There are other offices in DOE and labs that have programs/interests in high energy density physics that may overlap with other areas of astrophysics.