DOE Office of Science (SC)
Office of High Energy Physics (OHEP)

Report to the
Astronomy and Astrophysics Advisory Committee

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Department of Energy
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DOE SC OHEP Program

http://www.science.doe.gov/hep/index.shtml

The DOE SC OHEP program attempts to understand how our universe works at its most fundamental level by:

- discovering the most elementary constituents of matter and energy
- probing the interactions between them,
- exploring the basic nature of space and time itself.

We are the U.S. Federal Steward of HEP research, providing over 90 % of federal support to:

- **design, construct and operate the research facilities needed to advance our knowledge**
- **support the researchers at universities and laboratories to carry out the research**
- **develop the advanced technologies and next generation scientific/technical workforce**

Input from the Scientific Community:

- **DOE/NSF chartered High Energy Physics Advisory Panel (HEPAP) Reports**
- **Reports from other bodies: AAAC, National Academy (EPP2010, BEPAC, Astro2010), OECD GSF, etc.**
- **Facility Program Advisory Committees, DOE Reviews, etc.**

- **OHEP Mission is to define and oversee the program and maintain the Nation's competency/leadership in HEP research with responsibilities to:**
  - **establish a strategic plan that address the identified scientific opportunities**
  - **formulate, justify and defend Budget Requests to implement that plan**
  - **effectively manage the funding obtained to deliver significant outcomes**

HEP Overview

- **Historically the U.S. has been the leader in HEP research & remained the leader at the beginning of this decade:**
  - **The Fermilab Tevatron was the Energy Frontier facility**
  - **The SLAC B-Factory was an Intensity Frontier facility**
  - **U.S. HEP physicists were playing important roles at the Cosmic Frontier**

The U.S. HEP program's long range strategy was:

- **To participate in the CERN Large Hadron Collider (LHC) program**
- **To start construction of a next-generation lepton collider (ILC) after LHC started operations.**

Over the decade DOE OHEP started to implement this strategy; then the estimated cost of the ILC increased and the schedule was pushed out.

FY 2008 → Challenging Circumstances

FY 2008 Appropriations ($689M → 8.4% reduction compared to FY 2007)

- **Reductions in FY 2008 funding resulted in lessening of**
  - **HEP scientific productivity and workforce**
  - **Momentum on planned activities (NOvA, SRF infrastructure, ILC R&D)**
  - **U.S. credibility as an interagency/international collaborator (BaBar, ILC)**

  There were significant impacts
  - **Staff reductions at SLAC (76+100) and Fermilab (110)**
  - **B-Factory schedule was reduced from 10 months to 4 months**
  - **Work on NOvA stopped**
  - **ILC & SRF R&D supported at a minimal level**

- **Required a new, realistic strategic plan to deal with**
  - **Increased cost and delay in possible start of an ILC**
  - **Movement of energy frontier to Europe in FY 2009**
  - **Closure of B-Factory and imminent closure of Tevatron**
  - **Role of Fermilab in the future**

- **We developed (DOE/NSF with the scientific community) a new strategic plan for U.S. HEP.**
  - **Particle physics at three scientific frontiers**
  - **A U.S. role that will deliver significant outcomes**
  - **Realistic and robust with respect to funding scenarios and scientific discoveries**
    - **See the HEPAP P5 Subpanel report:** www.science.doe.gov/hep/files/pdfs/P5_Report%2006022008.pdf

FY 2008 OHEP Program

- **We dealt with FY 2008 funding reduction**
  - **Most serious impacts were mitigated**
  - **Protected core activities and delivered science**
  - **Supplemental funding at end of year – mitigated impact of 6-month Continuing Resolution**
    - **$32M for HEP ($29.5M for Fermilab, $2.5M for SLAC)**
  - **A productive program**
    - **Tevatron ran well – CDF/D0, MINOS, MiniBooNE**
    - **B-Factory completed a successful four month run**
    - **LHC circulated beam and ATLAS/CMS ready for beam**
    - **FGTS (GLAST) launched and collecting data**
    - **Many projects underway: Minerva, T2K, Daya Bay, EXO, DES, CDMS**
    - **DOE/NASA/NSF planning for joint projects**

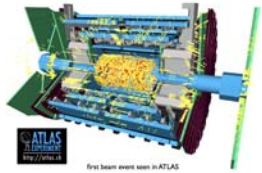
DOE SC HEP
FY 2008 Science Highlights

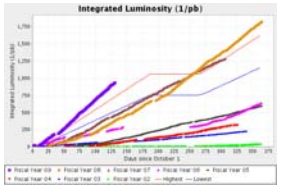
office of high energy physics

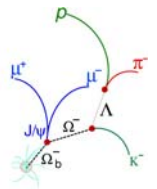
Department of Energy
Office of Science

Energy Frontier

- **Operation of LHC**
  (AIP Top Ten Story)
- **Tevatron (Performance/Experimental Results)**
  (AIP Top Ten Story)

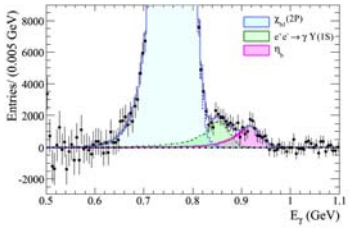


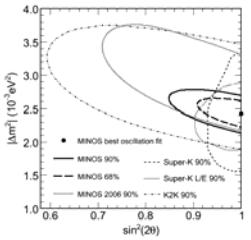


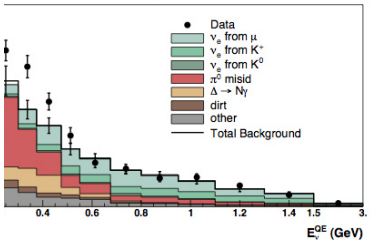


Intensity Frontier

- **BaBar discovery of bottomonium ground state**
  (AIP Top Ten Story)
- **Results from MiniBooNE and MINOS**

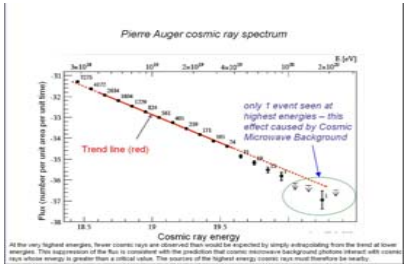


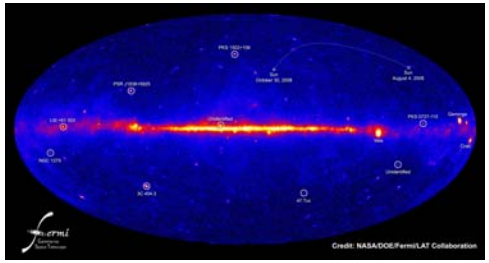




Cosmic Frontier

- **Pierre Auger**
  (AIP Top Ten Story)
- **Fermi (GLAST) launch and first all-sky map**





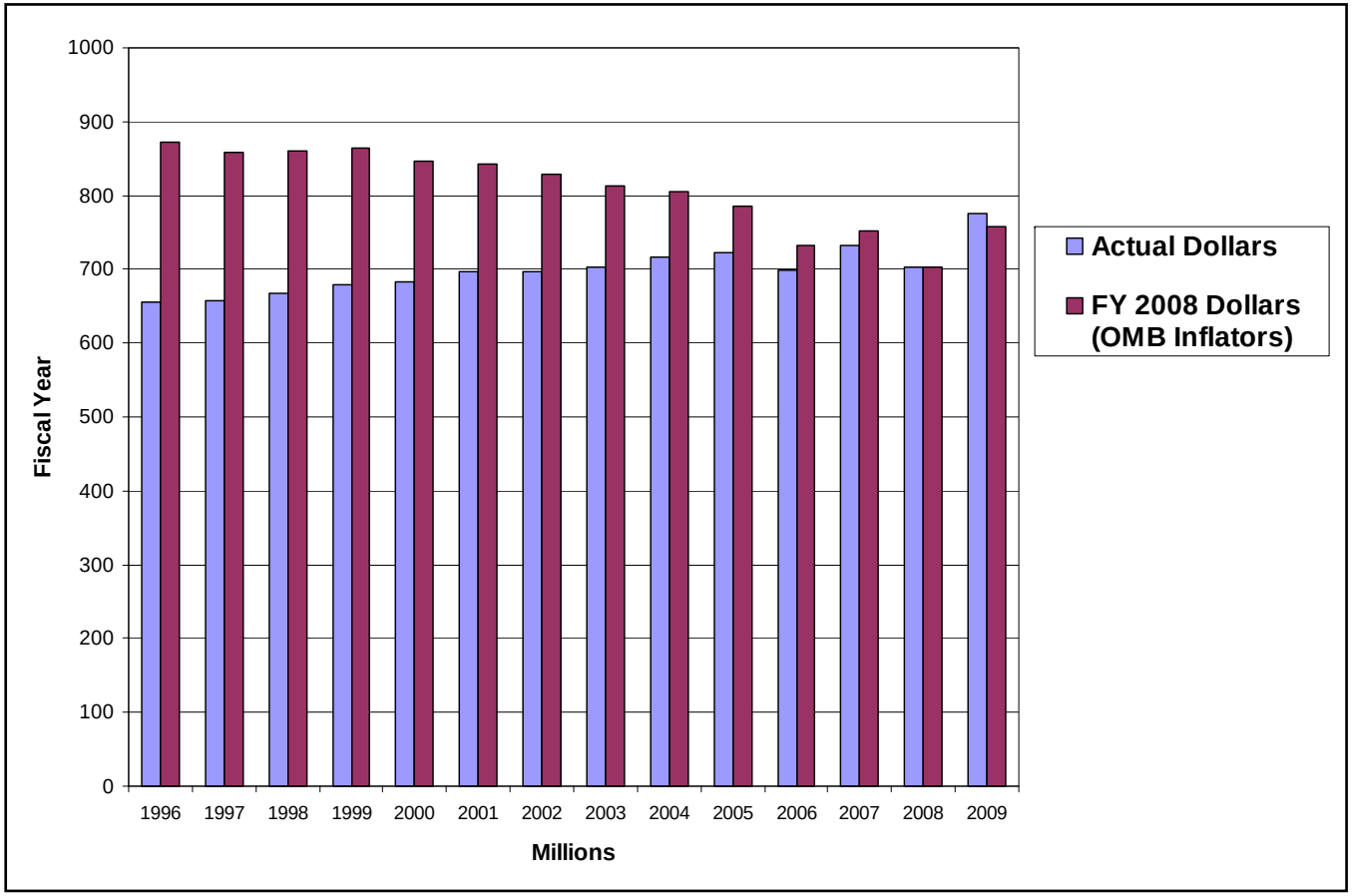
FY 2009 Path Forward

- **DOE HEP funding in FY 2009 supports the implementation of the P5 plan**
  - **FY 2009 Appropriation of $795.7M restores program to FY 2007 level**
  - **Recovery Act funding of > $200M accelerates / enhances research / infrastructure projects**

FY 2009 funding is (hopefully) a reversal of recent DOE HEP funding trend

- **HEP funding has been eroded by inflation: FY 2008 / FY 1996 ~ 20 % (OMB COL)**
- **HEP FY 2008 funding of $689M was a -8.4 % reduction from FY 2007 (mitigated by supplement of $32M)**

- **HEP FY 2009 funding of $795.7M is +10 % compared to FY 2008 and above Cost-of-Living (COL) from FY 2007**
- **HEP to receive >$200 million in 2009 Recovery Act funding**



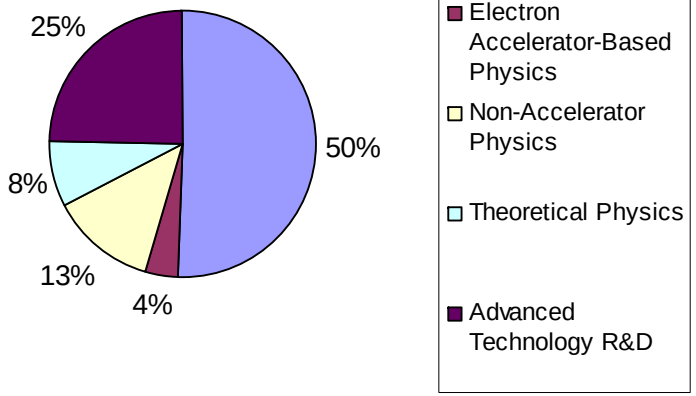
U.S. DOE OHEP
FY 2009 Program Overview

office of high energy physics

Department of Energy
Office of Science

FIVE Subprograms

Budget Categories	(millions) FY 2009
Proton Accelerator-Based Physics	402.5
Electron Accelerator-Based Physics	31.0
Non-Accelerator Physics	100.9
Theoretical Physics	64.8
Advanced Technology R&D	196.6
High Energy Physics Total	795.7



Research Statistics	FY 2009 estimate
# University Grants	200
# Laboratory Groups	45
# Permanent Ph.D.'s (FTEs)	1,135
# Postdoctoral Associates (FTEs)	550
# Graduate Students (FTEs)	595
# Ph.D.'s awarded	110

OHEP
Non-Accelerator Physics Budget

(In $M)	FY07	FY08	FY09
Research – science, operations, small projects			
-- Universities	**20.4**	**20.4**	**20.5**
-- Labs	**31.5**	**36.9**	**40.5**
Projects – R&D + Fabrication	**8.8**	**18.5**	**39.8**
-- includes DES, Daya Bay, JDEM, LSST, etc.			
TOTAL	**60.7**	**75.8**	**100.9**

Total Project Cost - R&D + Fabrication

Dark Energy Survey (FY06 – FY011) $35.15M

Daya Bay reactor neutrino (FY07 – FY011) $34.0M

Proton Accelerator Based Physics

The Proton Accelerator Based Physics subprogram supports research / facility operations at the Energy and Intensity Frontiers that utilize / provide proton beams

- **Research program supports:**
  - **Groups at 75 universities and 5 national labs**
  - **Approximately 940 FTEs (= 700 university + 240 lab) at Energy Frontier (775) and Intensity Frontier (165)**

- **Facility Operations supports:**
  - **Fermilab Accelerator Complex Operations and Development**
  - **LHC Experimental Operations and Support (Phase I accelerator upgrade MIE)**
  - **Ongoing Facility Projects (Minerva and NOvA)**
  - **Future Projects R&D (MicroBooNE, Mu2e, LBNE, Project X)**

- **Priorities:**
  - **Discover evidence of physics beyond the Standard Model at Tevatron (D0/CDF) and/or LHC (ATLAS/CMS)**
  - **Improve knowledge about neutrino properties (Minerva, MINOS and NOvA)**
  - **Implement capabilities to measure CP violation and proton decay (LBNE)**
    - **positions US with infrastructure to regain Energy Frontier (muon collider)**

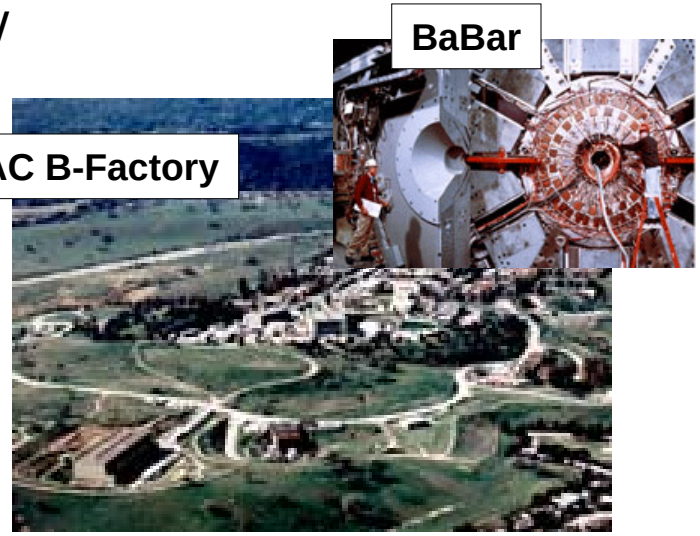
Electron Accelerator Based Physics

The Electron Accelerator Based Physics subprogram supports research/ facility operations at the Intensity Frontier that utilize / provide electron beams

- **Research program supports:**
  - **Groups at 34 universities and 3 national labs**
  - **Approximately 105 FTEs (= 75 university + 30 lab), focused on Intensity Frontier**

- **Facility Operations supports:**
  - **Computing infrastructure to complete analysis of BaBAR data**
  - **Decommissioning and Decontamination (D&D) of the BaBAR and PEP II ring**

- **Priorities:**
  - **Discover evidence of physics beyond the Standard Model in the BaBAR data**
  - **Complete D&D of BaBAR and PEP II in a timely and cost-effective manner**
  - **If Italians pursue "SuperB" project – the transfer of PEP II components to SuperB will**
    - **Save D&D costs for US DOE HEP programs**
    - **Science opportunity with ~100 greater intensity than B-Factory**



Neutrino Physics – at the Intensity Frontier

- **Goals for the next phases of the experimental program in neutrino oscillations:**
  - **The mixing angles**
  - **The ordering of the neutrino mass states.**
  - **The extent of CP violation in neutrino sector.**

- **There is worldwide effort to address these questions**


NuMI Horn

DOE Program:

- **Fermilab: Accelerator-based Neutrino Oscillations**
  - **Running: MiniBooNe, Minos**
  - **Under construction: Minerva, Nova**
  - **In planning stages: Long Baseline Neutrino Exp. (LBNE)**
  - **Supported by a series of phased beam upgrades**

- **Elsewhere:**
  - **Daya Bay Reactor Neutrino Detector (China)** - **reactor neutrino oscillation**
  - **Double Chooz (France)** - **reactor neutrino oscillation**
  - **Tokai-to-Kamioka (T2K/Japan)** - **accelerator neutrino oscillation**
  - **Enriched Xenon experiment (EXO/U.S.)** - **double beta decay**

Non-Accelerator Physics – at the Cosmic Frontier

The Non Accelerator Physics subprogram supports research/ facility operations at the Cosmic and Intensity Frontiers using measurements of radiation or particles from non-particle accelerator sources (e.g.; reactors, naturally occurring (beta decay, proton decay), and astrophysical phenomena)

- **Research program supports:**
  - **Groups at 35 universities and 5 national labs**
  - **Approximately 300 FTEs (= 180 university + 120 lab) at Cosmic (200) and Intensity (100) Frontiers**
  - **Operations & Commissioning of ongoing experiments (Fermi/GLAST, VERITAS, Pierre Auger, BOSS, LUX, ADMX, CDMS, EXO, AMS etc.)**
  - **Ongoing Project Fabrication (DES, and Daya Bay) and future projects R&D (JDEM, LSST, dark matter, double beta decay)**

- **Priorities:**
  - **To obtain insight into nature of Dark Energy from Stage III & planned Stage IV Dark Energy searches**
  - **To measure "small" neutrino mixing angle (Θ_{13}) in the Daya Bay Reactor Experiment**
  - **To push the sensitivity of direct Dark Matter measurements by a factor 1000**
  - **To gather support for an international effort for a proton decay measurement as part of a Long Baseline Neutrino Experiment**

News:

Baryon Oscillation Spectroscopic Survey (BOSS) – dark energy on SDSS-III

DOE HEP provided R&D and instrumentation upgrade funds in FY07 & FY08

DOE HEP recently approved operations funding starting in FY09.

NSF and Sloan Foundation are also providing funds.

Alpha Magnetic Spectrometer (AMS)

Now on the Shuttle manifest for 2010

Cosmic Frontier Projects

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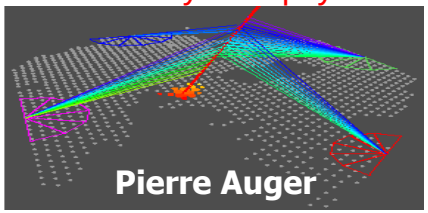
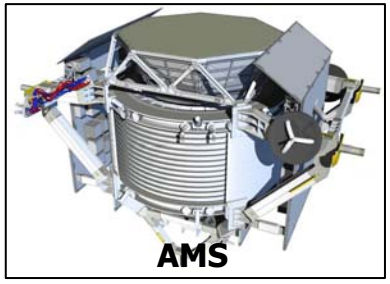
Department of Energy
Office of Science

Gamma-ray Astrophysics

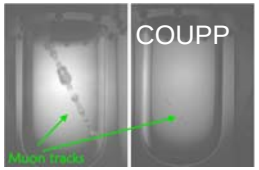
Cosmic Ray Astrophysics



Anti-matter, Dark Matter



Dark Matter (WIMPs)



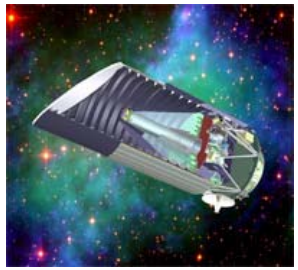
LUX

Dark Matter (axions)

Dark Energy (ground-based)

LSST - proposed

Dark Energy (space-based)



JDEM - proposed

Planning Activities

In Feb. '09, we requested that HEPAP initiate a Particle Astrophysics Scientific Assessment Group (PASAG) to explore in further detail the opportunities and scientific challenges available at the Cosmic Frontier. Steve Ritz is the chair.

PASAG is charged to:

- **identify and evaluate the scientific opportunities and options**
- **that can be pursued at different funding levels (provided)**
- **for mounting a world-class program**
- **that addresses the highest priority science in particle astrophysics.**

See http://www.science.doe.gov/hep/panels/subpanel_list.shtml

The National Academies of Science Astronomy and Astrophysics Decadal Survey (Astro2010) is well underway. This study is mainly to inform NASA and NSF, but is of interest to DOE HEP because of overlapping scientific opportunities.

A Global Science Forum study on Astroparticle Physics was established in Oct. 2008. The study will last 2 years (2009-2010) with 2 phases.

Phase 1 is devoted to laying out the world-wide scope of astroparticle physics.

Phase 2 is devoted to developing a plan for a coordinated path forward with a consensus global roadmap for astroparticle physics, if it is seen to be needed.

Summary

FY 2009 – things are looking up for the OHEP program

FY 2010 President's Request budget to be released May 6th

Backups

DOE SC HEP Budget Overview

HEP Functional Categories	FY 2007	FY 2008	vs FY08	FY 2009	vs FY08	vs FY07
Fermilab Accelerator Complex Operations	145.1	151.0	6.6	157.7	4.4%	8.7%
LHC Detector Support/Operations	56.8	65.6	6.4	71.9	9.7%	26.6%
SLAC Accelerator Complex Operations	79.0	36.5	-22.0	14.5	-60.3%	-81.7%
Facility Operations	**280.9**	**253.1**	-9.0	**244.1**	-3.6%	-13.1%
EPP Research	249.1	264.5	19.7	284.2	7.5%	14.1%
Advanced Technology R&D	167.7	138.1	30.1	168.2	21.8%	0.3%
Core Research	**416.8**	**402.6**	49.8	**452.4**	12.4%	8.5%
Project - NOvA	12.5	12.0	15.7	27.8		
Project - Minerva	4.0	7.2	-2.3	4.9		
Project - T2K	0.6	2.5	-1.5	1.0		
Daya Bay	1.0	6.9	6.1	13.0		
LHC Detectors	3.2	0.0	0.0	0.0		
LHC Accelerator Upgrade Phase I	0.0	0.0	2.5	2.5		
DES	1.4	5.5	3.2	8.7		
CDMS 25 MIE	0.0	0.0	1.0	1.0		
FACET	0.0	0.0	0.0	0.0		
BELLA	0.0	0.0	8.0	8.0		
Projects	**22.6**	**34.1**	32.7	**66.9**	96.0%	195.5%
Other (GPP/GPE/SBIR/STTR)	**31.5**	**31.5**	0.9	**32.4**	2.7%	2.9%
High Energy Physics	**751.8**	**721.3**	74.4	**795.7**	10.3%	5.8%

OHEP
Budget Overview

HEP Budget Categories	FY 2007	FY 2008	vs FY08	FY 2009	vs FY08	vs FY07
Proton Accelerator-Based Research	110.0	122.9	2.9	125.7	2.3%	14.3%
Proton Accelerator-Based Facilities	233.6	248.8	27.9	276.7	11.2%	18.5%
Proton Accelerator-Based Physics	**343.6**	**371.7**	30.8	**402.5**	8.3%	17.1%
Electron Accelerator-Based Research	22.3	20.7	-4.2	16.5	-20.3%	-26.0%
Electron Accelerator-Based Facilities	79.0	36.5	-22.0	14.5	-60.3%	-81.7%
Electron Accelerator-Based Physics	**101.3**	**57.2**	-26.2	**31.0**	-45.8%	-69.4%
Non-Accelerator Physics	**60.7**	**75.8**	25.1	**100.9**	33.1%	66.3%
Theoretical Physics	**59.1**	**60.0**	4.8	**64.8**	7.9%	9.6%
Accel Science	37.4	45.1	8.1	53.2	18.1%	42.2%
Accelerator Development	98.6	70.2	28.3	98.5	40.4%	0.0%
Detector Development	31.7	22.9	1.6	24.5	6.8%	-22.9%
Advanced Technology R&D	**167.7**	**138.1**	38.1	**176.2**	27.5%	5.1%
SBIR/STTR (2.8% of ops)	19.4	18.5	1.9	20.4	10.3%	5.4%
Advanced Technology R&D	**187.1**	**156.6**	40.0	**196.6**	25.5%	5.1%
High Energy Physics Total	**751.8**	**721.3**	74.4	**795.7**	10.3%	5.8%