AAAC-Related Programs in the NSF/Physics Division

AAAC Meeting

June 10, 2014

Jean Cottam & Jim Whitmore

Program Directors for Particle Astrophysics

Marc Sher

Program Director for Particle Astrophysics and Cosmology Theory

Pedro Marronetti & Mark Coles

Program Directors for Gravitational Physics

Division of Physics

Denise Caldwell
Director

Brad Keister
Deputy Director

Facilities

- **Large Hadron Collider** — *Saul Gonzalez*
- **IceCube** — *Jim Whitmore*
- **LIGO** — *Mark Coles*
- **NSCL** — *Gail Dodge*

Experiment

- **Atomic, Molecular, Optical, and Plasma** — *John Gillaspy, Steve Gitomer*
- **Elementary Particle Physics** — *Saul Gonzalez, Randy Ruchti, Jim Shank*
- **Particle Astrophysics** — *Jean Cottam-Allen, Jim Whitmore*
- **Gravitational Physics** — *Mark Coles, Pedro Marronetti*
- **Nuclear Physics** — *Gail Dodge*
- **Physics of Living Systems** — *Krastan Blagoev*
- **Accelerator Science** — *Saul Gonzalez*

Theory

- **Atomic, Molecular, and Optical** — *Ann Orel*
- **Elementary Particle Physics, Astrophysics, and Cosmology** — *Marc Sher*
- **Mathematical Physics** — *Earle Lomon*
- **Gravitational Physics** — *Pedro Marronetti*
- **Nuclear Physics and Nuclear Astrophysics** — *Bogdan Mihalia*
- **Physics of Living Systems** — *Krastan Blagoev*
- **Accelerator Science** — *Saul Gonzalez*

Cross-cutting

- **Physics Frontier Centers** — *Jean Cottam-Allen*
- **Education and Interdisciplinary Research** — *Kathy McCloud*
- **Physics at the Information Frontier** — *Bogdan Mihalia, Ann Orel, Jim Shank*
- **Physics Instrumentation**

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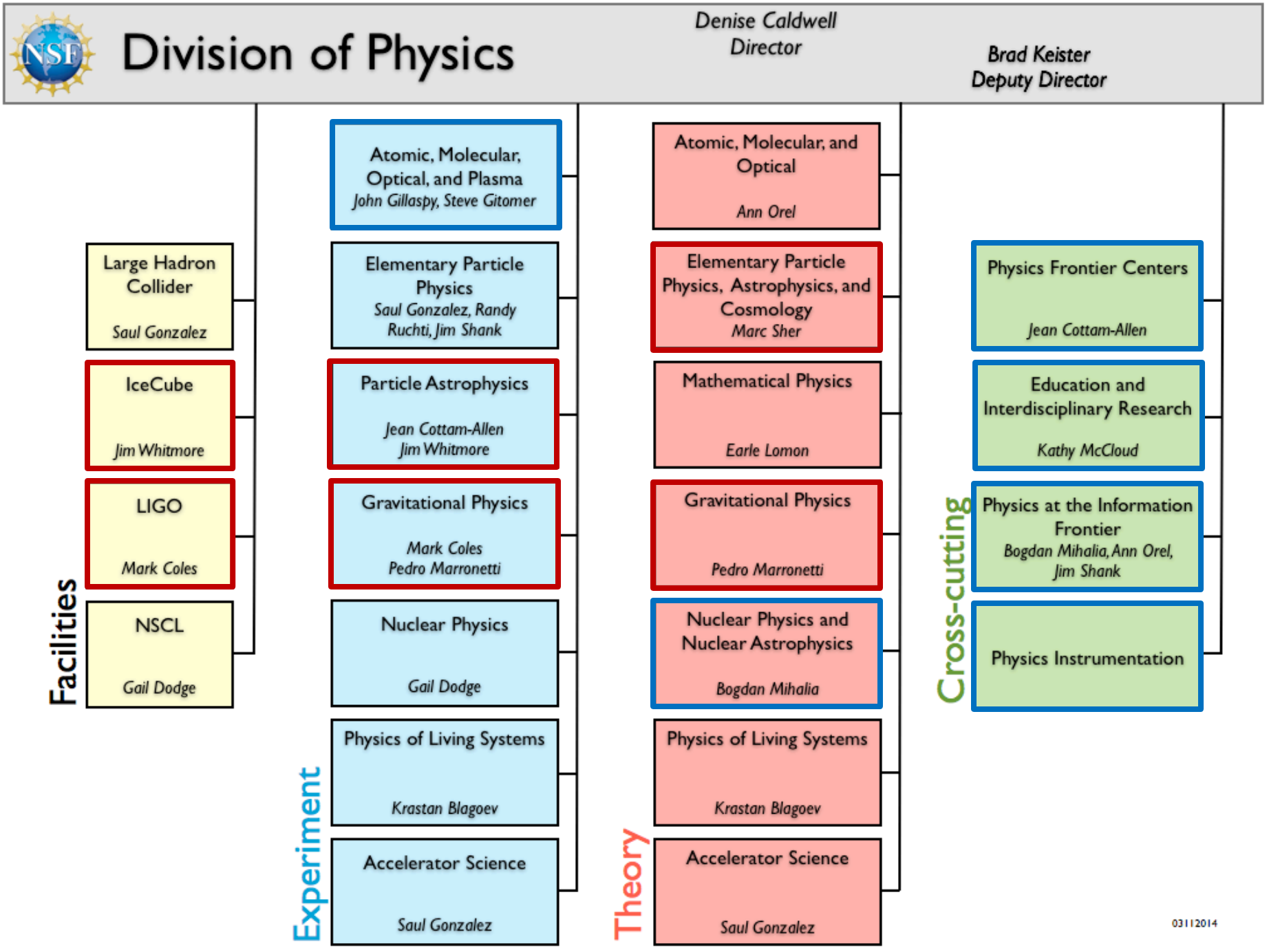
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Particle Astrophysics Programs

Particle Astrophysics lies at the intersection of particle physics, astronomy and cosmology. Formerly separate questions in cosmology (the universe on the largest scales) and quantum phenomena (the universe on the smallest scales) become connected through our understanding that the early universe can be explored through the techniques of particle physics.

- The experimental **Particle Astrophysics (PA)** program supports university research in many areas of particle astrophysics, including the study of ultra-high energy particles from cosmic sources, experiments or R&D projects for underground facilities, and non-accelerator-based experiments studying the properties of neutrinos. Currently supported activities include: ultra-high energy cosmic-ray, gamma-ray and neutrino studies; the study of solar, underground and reactor neutrino physics; neutrino mass measurements; searches for the direct and indirect detection of Dark Matter; searches for neutrino-less double beta decay; and studies of Cosmology and Dark Energy.
- The **Theoretical Particle Astrophysics and Cosmology** program supports proposals that primarily are involved with theoretical particle astrophysics and big-bang cosmology as well as more speculative string theory inspired cosmologies. Understanding the quarks to cosmos connection has been a recent focus of the program as well as better understanding the implications of the fluctuation spectra of the cosmic microwave background. The cosmology and astrophysics research supported by the program is usually associated with people with training in particle theory and encompasses dark matter, dark energy, high energy cosmic rays as well as exotic cosmologies arising from Brane-world and String Theory scenarios.

PA Program Scope & Currently Supported Projects

- Direct Dark Matter Detection – WIMP and non-WIMP experiments

  SuperCDMS, XENON, LUX, DArkSide, COUPP, PICASSO, DRIFT, ADMX-HF, DM-Ice

- Indirect Dark Matter Detection

  VERITAS, HAWC, IceCube

- Cosmic Ray, Gamma Ray, and UHE Neutrino Observatories

  IceCube, VERITAS, HAWC, Auger, Telescope Array, ARA, ARIANNA

- Dark Energy

  LSST

- Cosmic Microwave Background

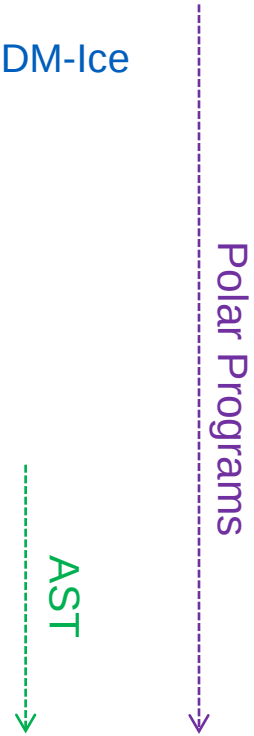
  SPT, ACT-Pol (w/ Gravity)

- Neutrino Properties

  Double Chooz, Daya Bay, CUORE, MJD, SuperNEMO, EXO, Project 8

- Solar Neutrinos

  Borexino, HALO, SNEWS



Theory Program Scope & Currently Supported Projects

- Dark Matter - direct detection
  - Limits of direct detection experiments due to neutrino backgrounds
  - Flavor symmetry effects on signatures
  - Studies of DM interactions with various nuclei
  - Computational resources for dark matter density simulations
- Dark Matter - indirect detection (decay or annihilation of DM)
  - Studies of photons and positrons from dwarf galaxies (such as LMC,SMC)
  - Cosmic ray flux predictions as backgrounds for indirect DM signals.
  - Effects of cosmic variance on astrophysical indirect DM signals
  - Effects of resonant DM annihilation and effects from various DM candidates
- Dark Matter - galactic structure
  - Simulations of various DM candidates
  - Search for microstructures due to DM
- Inflation
  - Non-Gaussian perturbations in inflation and effects on CMB and Large Scale Structure
  - Alternative models to inflation
- Cosmic Strings
  - Effects on CMB and Large Scale Structure
  - Observational signatures
  - Theoretical evolution of string networks.

Gravitational Physics Programs

The Gravitational Physics program supports research at the frontiers of science aimed towards answering questions about the nature of space and time, the gravitational attraction at atomically small and cosmological large distances and the use of gravitational waves to explore the universe.

- The **Experimental Gravitational Physics** program supports research that includes tests on the inverse distance square law of gravitational attraction, Lorentz invariance and Equivalence Principle as well as the direct detection of gravitational waves. This program oversees the management of the construction, commissioning, and operation of the Laser Interferometer Gravity Wave Observatory (LIGO), and provides support for LIGO users and other experimental investigations in gravitational physics and related areas. This includes tasks that range from instrument science, data analysis and detector characterization to source population calculations and the connection between the gravitational waves and the electromagnetic and neutrino signatures of astrophysical events.
- The **Theoretical Gravitational Physics** program supports research on classical and quantum gravity theory, including gravitational wave source simulations and other phenomena associated with strong field gravity and the interface between gravitation and quantum mechanics. This includes formulating new approaches for theoretical, computational, and experimental research that explore the fundamental laws of physics and the behavior of physical systems and, in some cases, interpreting the results of experiments. The effort also includes a considerable number of interdisciplinary grants.

Gravitational Physics Scope & Currently Supported Projects

Theory

- Structure of General Relativity (GR)

  Mathematical GR, Classical Field Theory, Properties of horizons and singularities, Stability of Einstein Field Equations (EFE) solutions

- Alternative Theories of Gravity

  Extensions of GR, Scalar-Tensor Theories, Testing of Alternative Theories using current and future Gravitational Wave (GW) detectors

- Unified Theories

  Unification of Quantum Mechanics and Gravity: Loop Quantum Gravity (not String Theory), Approximations to Unified Theories, Semi-classical field theories

- Astrophysics

  Numerical Relativity (NR) as a tool to find solutions of the EFE with astrophysical relevance. Modeling of black holes, neutrons stars, quark stars (in binaries or in isolation). Generation of GW signals for LIGO searches

Experiments

- Short Range Experiments

  Deviations from Inverse Square Law, Weak Equivalence Principle tests, Search for Lorentz Symmetry violations

- Long Range Experiments

  Lunar Laser Ranging, Detection of relic GWs in the Cosmic Microwave Background (Atacama Cosmology Telescope)

- LIGO
  - Instrument Science: Mirror Coatings, Laser Interferometry, Squeezed Light, Noise Isolation
  - Data Analysis: Sky Localization, Connection with EM and Particle observations (Multi-messenger Astronomy), Search Algorithm Development, GW Template Construction. GW Sources Synthesis
  - Outreach: LIGO Science Education Center (Livingston, LA)

New in FY 2014: Dark Matter Solicitation

The current generation of direct dark matter experiments should all achieve their projected sensitivities and complete operations within the next few years. The more sensitive, "second generation" direct detection experiments, will then be required to either search with increased sensitivity or to measure in detail the detected dark matter.

- These next generation experiments will be selected through a solicitation with funding beginning in FY 2014.
  - Solicitation *NSF 13-597: "Support for Construction of Direct Detection Dark Matter Experiments in Particle Astrophysics"*
- NSF and DOE are closely coordinating the review, selection and funding of the awards and subsequent support for the experiments. The resulting program will be joint NSF/DOE portfolio of investments in the next generation of Dark Matter experiments.
- We expect to announce selections shortly.

New in FY 2014: Mid-Scale Instrumentation

One of the most critical needs of research projects funded through the Physics Division is that of having cutting-edge instrumentation that enables investigators to remain competitive in a rapidly-changing scientific environment.

- The Physics Division has established a Mid-Scale Instrumentation Fund.
  - Dear Colleague Letter *NSF 13-118*: "Announcement of Instrumentation Fund to Provide Mid-Scale Instrumentation for FY2014 Awards in Physics Division"
- This is not a separate program to which investigators can apply directly. PIs should request funding for specialized equipment as part of a regular proposal to a disciplinary program in the Division. The Program Officer can then request funds be provided through the Mid-Scale Instrumentation Fund.
- Resources from the Mid-Scale Instrumentation Fund can be used for off-the-shelf purchases or for construction of specialized equipment.
- Mid-Scale Instrumentation Fund resources are non-renewable and are intended to be one-time investments in the research project.

National Science Foundation Budget

National Science Foundation
Summary Tables
FY 2015 Request to Congress
(Dollars in Millions)

NSF by Account	FY 2013 Actual	FY 2014 Estimate	FY 2015 Request	FY 2015 Request over: FY 2013 Actual Amount	FY 2013 Actual Percent	FY 2014 Estimate Amount	FY 2014 Estimate Percent
BIO	$679.21	$721.27	$708.52	$29.31	4.3%	-$12.75	-1.8%
CISE	858.13	894.00	893.35	35.22	4.1%	-0.65	-0.1%
ENG	820.18	851.07	858.17	37.99	4.6%	7.10	0.8%
Eng Programs	*658.84*	*691.68*	*693.18*	*34.34*	*5.2%*	*1.50*	*0.2%*
SBIR/STTR	*161.34*	*159.39*	*164.99*	*3.65*	*2.3%*	*5.60*	*3.5%*
GEO	1,273.77	1,303.03	1,304.39	30.62	2.4%	1.36	0.1%
MPS	1,249.34	1,299.80	1,295.56	46.22	3.7%	-4.24	-0.3%
SBE	242.62	256.85	272.20	29.58	12.2%	15.35	6.0%
IIA	434.28	481.59	473.86	39.58	9.1%	-7.73	-1.6%
U.S. Arctic Research Commission	1.39	1.30	1.41	0.02	1.4%	0.11	8.1%
Research & Related Activities	**$5,558.88**	**$5,808.92**	**$5,807.46**	**$248.58**	**4.5%**	**-$1.46**	**0.0%**
Education & Human Resources	**$834.62**	**$846.50**	**$889.75**	**$55.13**	**6.6%**	**$43.25**	**5.1%**
Major Research Equipment & Facilities Construction	**$196.49**	**$200.00**	**$200.76**	**$4.27**	**2.2%**	**$0.76**	**0.4%**
Agency Operations & Award Management	**$293.50**	**$298.00**	**$338.23**	**$44.73**	**15.2%**	**$40.23**	**13.5%**
National Science Board	**$4.10**	**$4.30**	**$4.37**	**$0.27**	**6.7%**	**$0.07**	**1.6%**
Office of Inspector General	**$13.17**	**$14.20**	**$14.43**	**$1.26**	**9.5%**	**$0.23**	**1.6%**
OIG FY 2013 ARRA Actual Obligation	$1.16						
Total, NSF	**$6,901.91**	**$7,171.92**	**$7,255.00**	**$353.09**	**5.1%**	**$83.08**	**1.2%**

Totals may not add due to rounding.

MPS/PHY Budget

MPS Funding
(Dollars in Millions)

	FY 2013 Actual	FY 2014 Estimate	FY 2015 Request	Change Over FY 2014 Estimate Amount	Change Over FY 2014 Estimate Percent
Astronomical Sciences (AST)	$232.17	$239.06	$236.24	-$2.82	-1.2%
Chemistry (CHE)	229.39	235.79	237.23	1.44	0.6%
Materials Research (DMR)	291.09	298.01	298.99	0.98	0.3%
Mathematical Sciences (DMS)	219.02	225.64	224.40	-1.24	-0.5%
Physics (PHY)	250.45	266.30	263.70	-2.60	-1.0%
Office of Multidisciplinary Activities (OMA)	27.22	35.00	35.00	-	-
Total, MPS	**$1,249.34**	**$1,299.80**	**$1,295.56**	**-$4.24**	**-0.3%**

Totals may not add due to rounding.

PHY Funding
(Dollars in Millions)

	FY 2013 Actual	FY 2014 Estimate	FY 2015 Request	Change Over FY 2014 Estimate Amount	Change Over FY 2014 Estimate Percent
Total, PHY	**$250.45**	**$266.30**	**$263.70**	**-$2.60**	**-1.0%**
Research	**164.72**	**165.99**	**159.35**	**-6.64**	**-4.0%**
CAREER	7.68	7.34	7.34	-	-
Centers Funding (total)	1.16	0.02	0.02	-	-
Nanoscale Science & Engineering	1.16	0.02	0.02	-	-
Education	**5.31**	**6.98**	**5.97**	**-1.01**	**-14.5%**
Infrastructure	**80.42**	**93.33**	**98.38**	**5.05**	5.4%
IceCube	3.45	3.45	3.45	-	-
Large Hadron Collider (LHC)	18.00	17.37	18.00	0.63	3.6%
Laser Interferometer Grav. Wave Obs.	30.50	36.43	39.43	3.00	8.2%
Nat'l Superconducting Cyclotron Lab.	21.50	22.50	22.50	-	-
Research Resources	6.97	13.58	15.00	1.42	10.5%

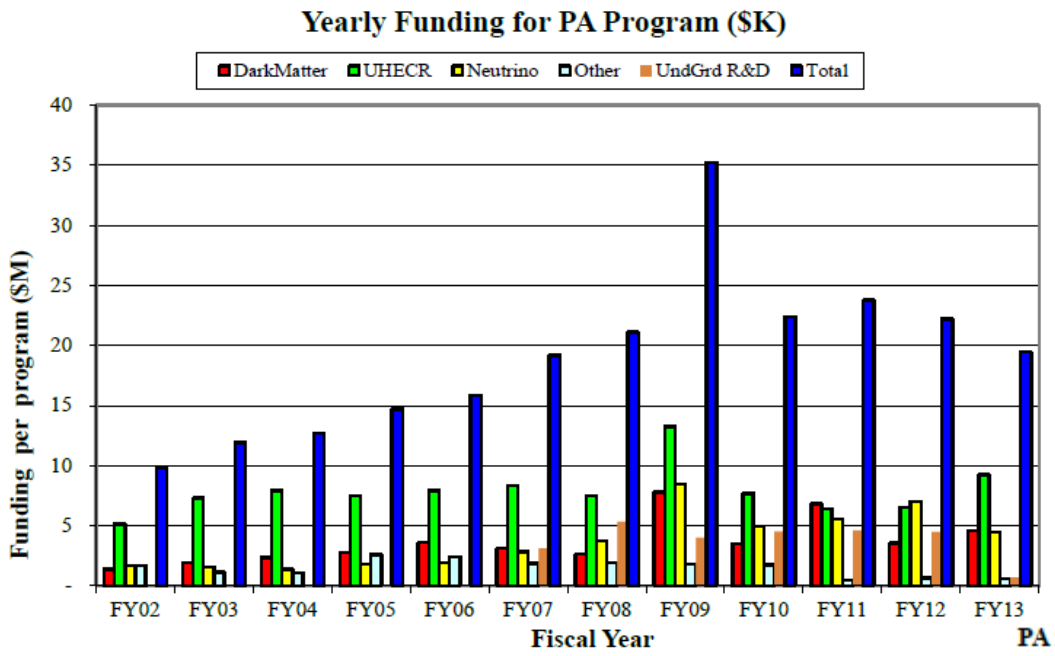
Totals may not add due to rounding.

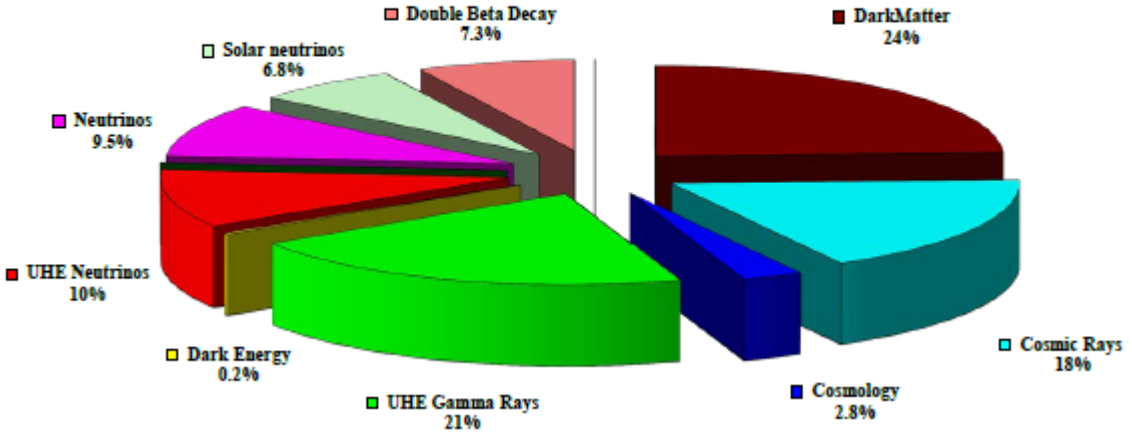
“Physics of the Universe” Funding Details

	(in M$)	FY 2008 Actuals	FY 2009 Actuals	FY 2010 Actuals	FY 2011 Actuals	FY 2012 Actuals	FY 2013 Actuals
Experimental Particle Astro	Particle Astrophysics	15.8	31.2	17.9	9.7	11.5	12.0
	IceCube Ops	1.5	2.2	2.2	3.5	3.5	3.5
	DUSEL Planning	2.0	22.0	28.9	10.2		
	Underground R&D	5.0	9.6	4.6	6.0	11.0	3.9
	Underground Physics				8.4	6.3	6.8
	THY - Astro/Cosmo	~1.2	~1.9	~1.3	~1.4	1.1	0.9
	THY - Gravitational Phys	3.8	6.9	4.7	3.9	4.0	4.1
Experimental Gravitational Phys	Exp. Gravitational Phys	2.3	3.3	2.2	2.4	2.4	2.2
	LIGO Research Support	7.4	12.7	8.4	8.7	8.6	7.5
	LIGO M&O	29.5	30.3	28.5	30.3	30.4	30.5
	Physics Frontier Centers	6.3	5.9	5.9	6.0	6.0	6.0
	Total	73.8	126.0	104.6	90.5	84.8	77.4
	Total Physics Division	285.0	377.6	307.8	280.3	277.4	247.4
	% of Physics Division	25.9%	33.4%	34.0%	32.3%	30.6%	31.3
	Adv LIGO MREFC	32.8	51.4	46.4	23.6	21.0	15.2

** FY2009 includes ARRA funding

Particle Astrophysics Program Funding





NSF/PHY Comments on P5

- NSF sincerely appreciates the work of P5 and the Particle Physics Community over the last two years.
- The P5 Process and Report are very important to the NSF, especially for articulating clear Science Drivers and for identifying the experimental and theoretical opportunities.
- The P5 Report recommendations represent critical input to ongoing strategy for NSF investments, aligned with the agency's mission, both for the short and longer term.