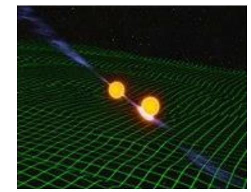
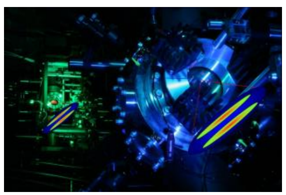
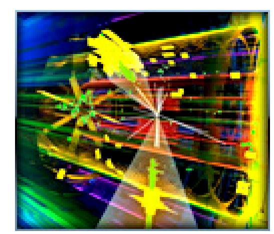
News from NSF MPS & PHY

Denise Caldwell





Division Director
Division of Physics



HEPAP November 2017

First Observation of Binary Neutron Star Merger
LIGO + VIRGO + 60 Observatories

space-time
ripples

matter
distortions

NSF Has a New Home

2415 Eisenhower Avenue
Alexandria, VA 22314

Mathematical and Physical Sciences

New Assistant Director Designated

Welcome (January 2)

Dr. Anne Kinney

BS Degree in Astronomy & Physics; PhD in Astrophysics

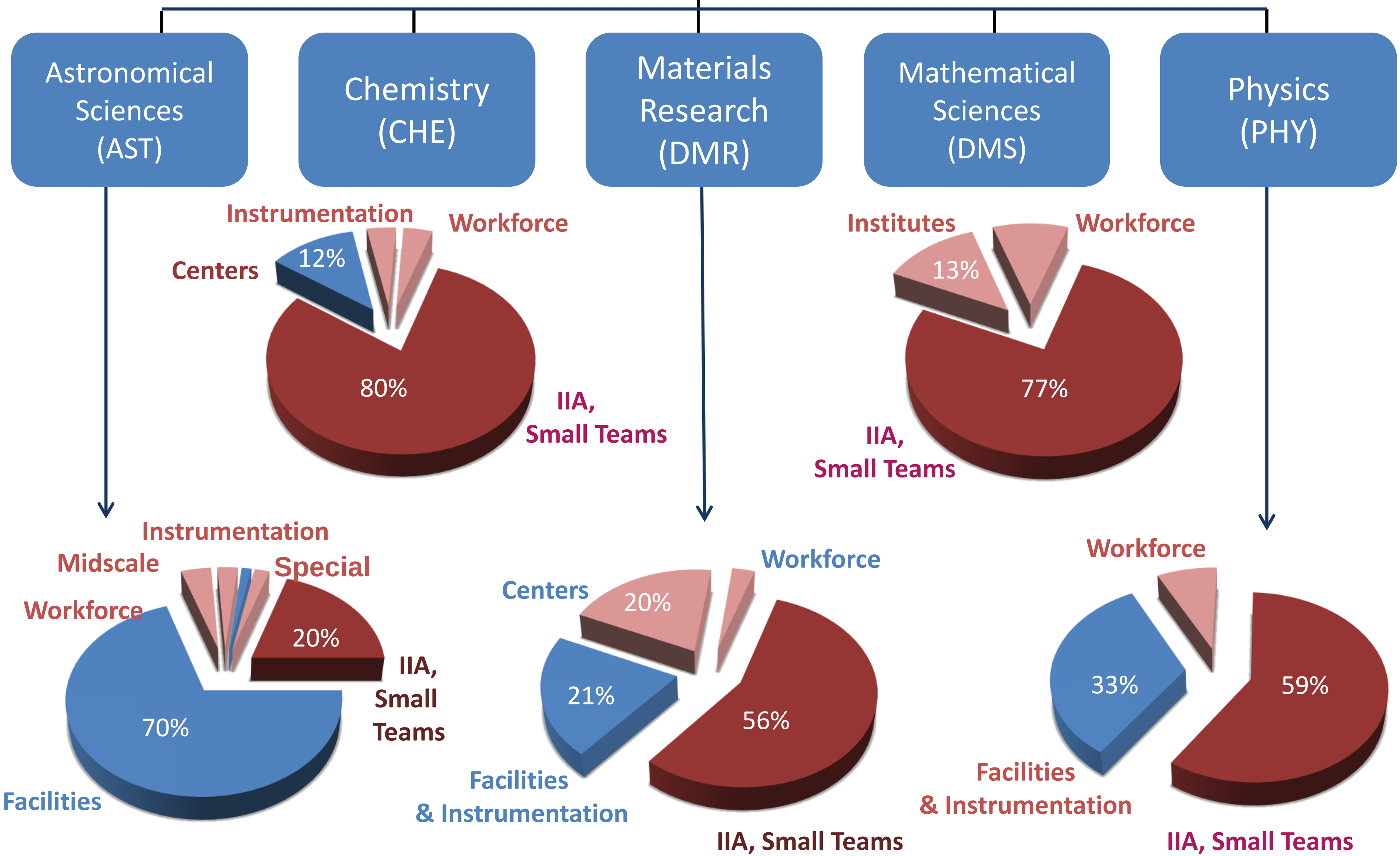
More than 30 years of leadership and management experience in the astronomical community

Director of Universe Division at NASA – Oversaw missions including Hubble Space Telescope, Spitzer Space Telescope, WMAP, Galaxy Evolution Explorer

NASA Goddard Space Flight Center – Most recently
As Director of Solar System Exploration Division

Since 2015, chief scientist at the W. M. Keck Observatory

Mathematical and Physical Sciences Directorate



MPS in FY 2018 Request

MPS Funding

(Dollars in Millions)

	FY 2016 Actual	FY 2017 Estimate	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Astronomical Sciences (AST)	$246.63	246.16	$221.15	-$25.48	-10.3%
Chemistry (CHE)	246.52	245.74	221.05	-25.47	-10.3%
Materials Research (DMR)	309.88	314.31	282.87	-27.01	-8.7%
Mathematical Sciences (DMS)	233.95	233.51	209.78	-24.17	-10.3%
Physics (PHY)	276.91	281.38	253.30	-23.61	-8.5%
Office of Multidisciplinary Activities (OMA)	34.89	34.93	31.28	-3.61	-10.3%
Total	**$1,348.78**	**$1,356.03**	**$1,219.43**	**-$129.35**	**-9.6%**

- Smaller DMR and PHY decreases in FY 2017 caused by hosting of new NSF Science and Technology Centers
- Construction of DKIST and LSST are in a separate budget line, fully funded in request

FY 2018 Appropriation Status

- Congress has passed a Continuing Resolution through December 8, at approximately FY 2017 funding levels
- Note: Budget Control Act (aka "sequester") still in effect
- Appropriations Subcommittee Bills (in $M):

Line	FY16 Actual	FY17 Enacted	FY 18 Request	House	Senate
NSF	7,494	7,472	6,653	7,339	7,311
R&RA	5,998	6,034	5,362	6,034	5,918
EHR	884	880	761	880	862
MREFC	242	209	183	78	183
AOAM	351	330	329	329	329
NSB	4	4	4	4	4
OIG	15	15	15	15	15

Division of Physics

FY 2018 PHY Budget Request

PHY Funding (Dollars in Millions)					
	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
Total	$276.91	-	$253.30	-$23.61	-8.5%
Research	174.12	-	152.09	-22.03	-12.7%
CAREER	8.12	-	7.30	-0.82	-10.1%
STC: Center for Bright Beams (CBB)	-	-	5.00	5.00	N/A
Education	5.40	-	4.80	-0.60	-11.1%
Infrastructure	97.39	-	96.41	-0.98	-1.0%
IceCube	3.48	-	3.50	0.02	0.6%
Large Hadron Collider (LHC)	20.00	-	16.00	-4.00	-20.0%
Laser Interferometer Gravitational Wave Observatory (LIGO)	39.43	-	39.43	-	-
Nat'l Superconducting Cyclotron Lab. (NSCL)	24.00	-	23.00	-1.00	-4.2%
Midscale Research Infrastructure	10.48	-	8.18	-2.30	-21.9%
Pre-construction planning:	-	-	6.30	6.30	N/A
High-Luminosity LHC Upgrade Planning	-	-	6.30	6.30	N/A

Particle Physics in Physics Division

EPP – Experimental Elementary Particle Physics

(Mostly Accelerator-Based users, incl. LHC)

Program Director: Saul Gonzalez

Program Director: Jim Shank (sadly leaving in January ☹)

Program Director: Randy Ruchti (happily joining in January ☺)

PA – Experimental Particle Astrophysics

(Underground Physics, Cosmic Physics, IceCube users)

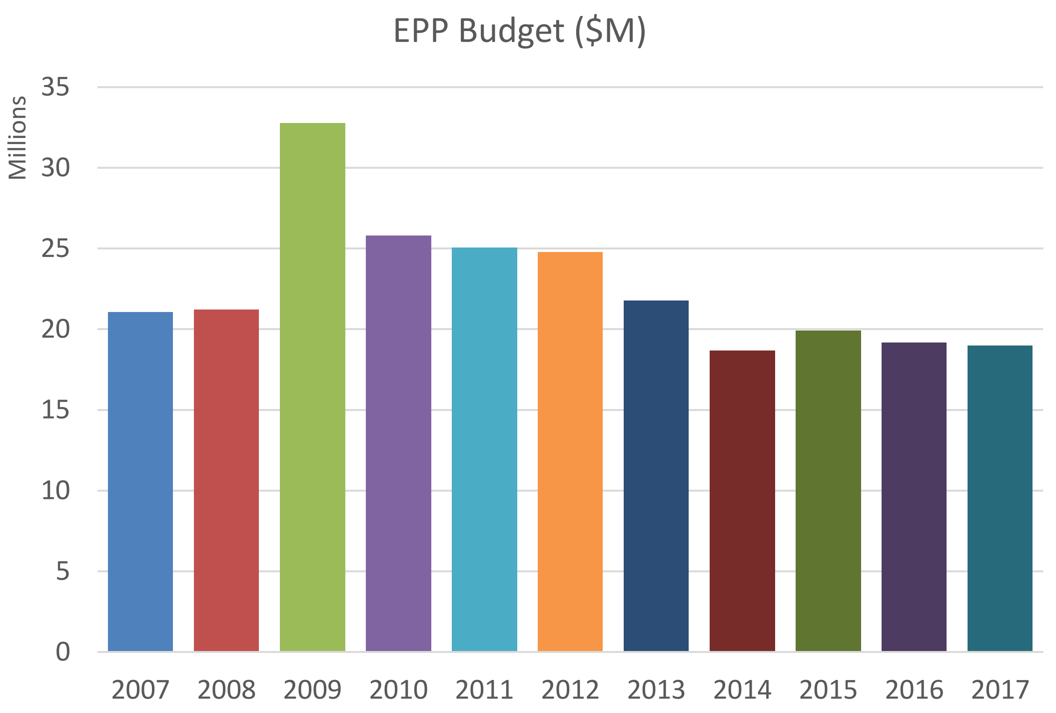
Program Director: Jim Whitmore

Program Director: Jean Cottam-Allen

Theory – Elementary Particle Physics & Astrophysics and Cosmology

Program Director: Keith Dienes

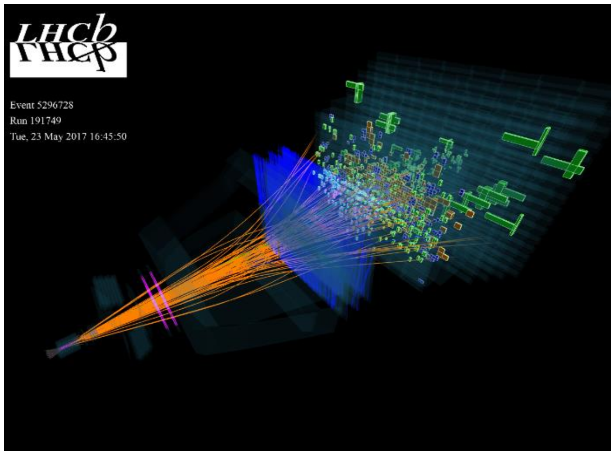
EPP Budget by FY

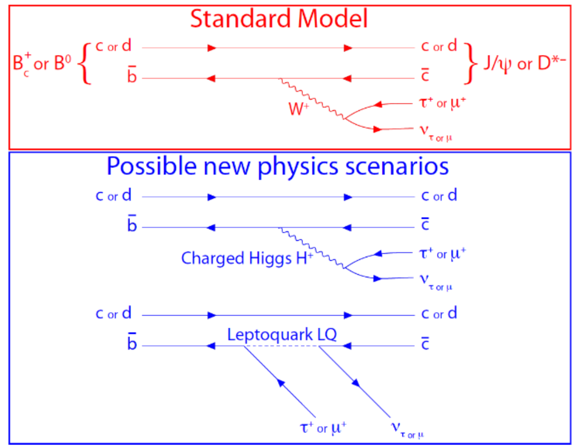


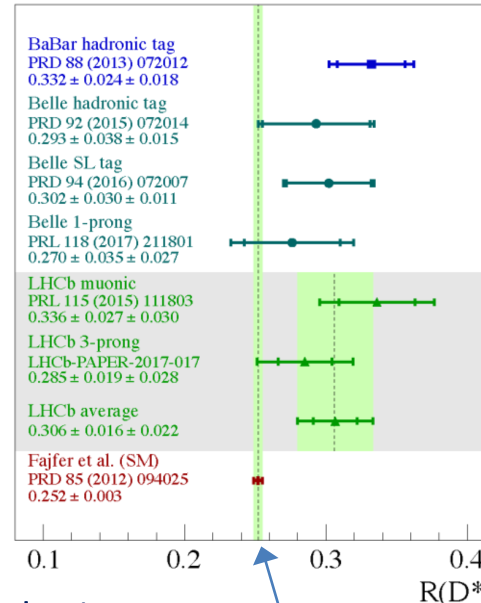
EPP 2017

- Total funding: $18,972,899
- Commitments: $13,308,386
- FY17 Renewals: $5,664,513
- Number of Proposals: 38
- Number funded: 7, All at lower than the requested amount
- 1 new CAREER Award:
  - Verena Martinez Outschoorn, UIUC.

LHCb experiment: lepton universality







Standard Model

LHCb is the smallest of 4 experiments at the LHC, focused on finding new physics through precision measurements of *b* quarks. NSF provides support to 5 of 72 research groups in a collaboration of 820 physicists.

- Ongoing Lepton Universality test probes physics beyond the Standard Model
- Ratio of $B_c \rightarrow J/\psi\mu\upsilon_\mu$ rate and $B_c \rightarrow J/\psi\tau\upsilon_\tau$ rate is very sensitive to new physics, such as charged Higgs or leptoquarks
- NSF groups made key contributions to this analysis showing possible deviation from the Standard Model

PA Program Scope - Supported Projects

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

  SuperCDMS at SNOLAB, XENON100/1T, LUX, DArkSide-50, PICO, DRIFT, DM-Ice, SABRE, DAMIC, HAYSTAC (ADMX-HF), ALPS2 and Light mass DM experiments

- Indirect Dark Matter Detection

  VERITAS, HAWC, IceCube

- Cosmic Ray, Gamma Ray, and UHE Neutrino Observatories

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

- Cosmic Microwave Background

  SPT and BICEP

- Neutrino Properties

  Double Chooz, Project 8, IceCube, IsoDAR, CHANDLER

- Solar, SuperNova and Geo-Neutrinos

  Borexino, SNEWS

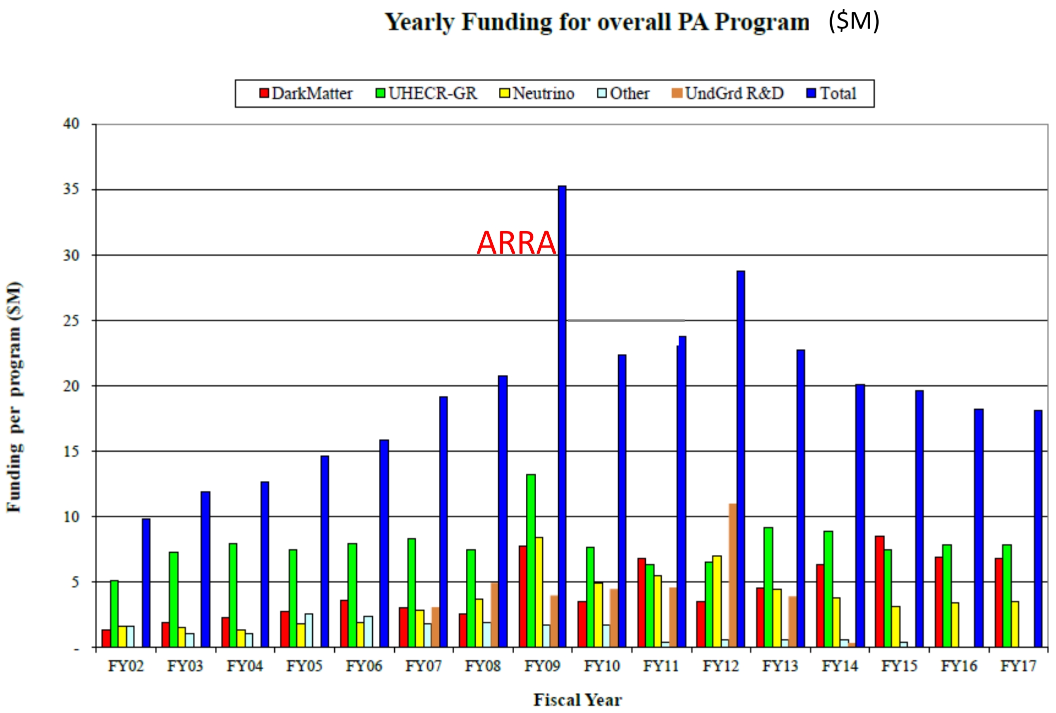
- Detector R&D

  NaI/CsI, LiSc/QuDots

AST

Polar Programs

PA Program Funding FY2002-2017



HAWC Results: Constraints on Origin of Positron Flux

"Extended gamma-ray sources around pulsars constrain the origin of the positron flux at Earth," Science, November 2017

HAWC measured extended high-energy gamma ray emission around two nearby pulsars and constrained the diffusion rates of the accelerated high-energy leptons. The low diffusion rate from pulsars suggests a more exotic origin for the high flux of positron emission observed on Earth.

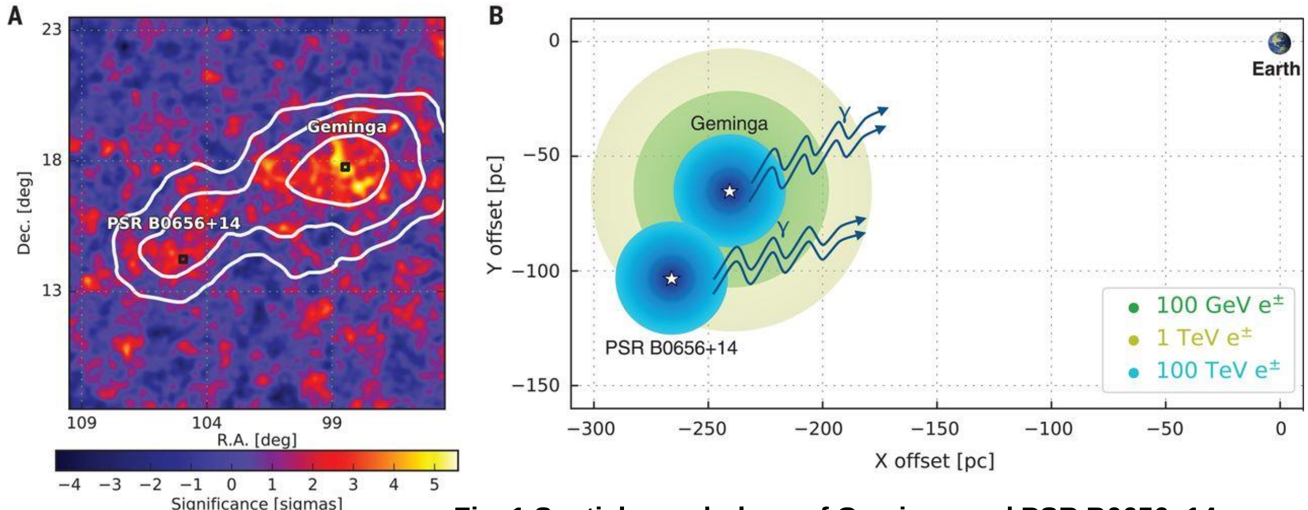


Fig. 1 Spatial morphology of Geminga and PSR B0656+14.

IceCube Results:
Measurement of Neutrino interaction Cross-Sections

"Measurement of the multi-TeV neutrino interaction cross-section with IceCube using Earth absorption," Nature, November 2017

IceCube reports measurements of neutrino absorption by the Earth using observations of upward-moving neutrino-induced muons. They determined the neutrino–nucleon interaction cross-section for neutrinos at energies of 6.3–980 TeV, which is more than an order of magnitude higher than previous measurements.

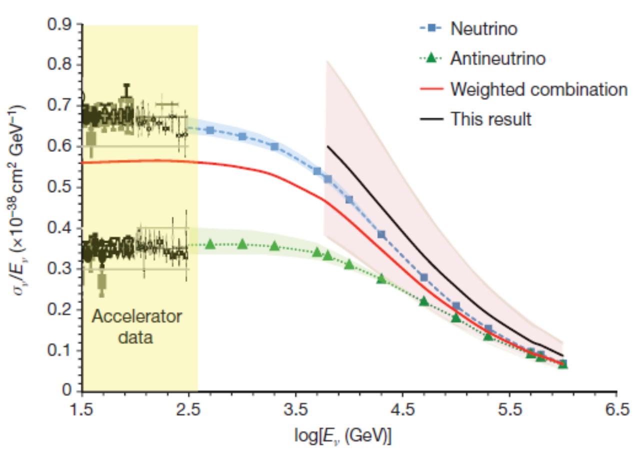


Fig. 1 Neutrino Cross Section Measurement

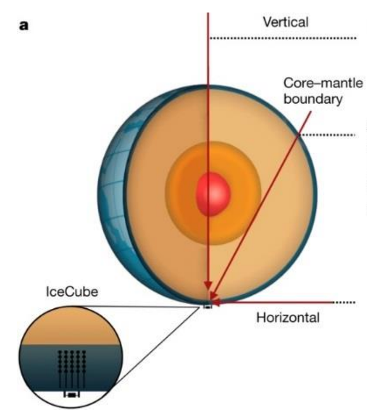


Fig. 2a Neutrino Absorption in the Earth

Theory

A vibrant, intellectually diverse Theory program is vital to the success of the entire Particle Physics mission. We capitalize on the talents and creativity of the Theory community by supporting the best, most cutting-edge investigator-driven research in two programs:

- Theoretical High-Energy Physics
- Theoretical Particle Astrophysics and Cosmology

These two theory programs interface regularly with many other programs at NSF (EPP, PA, Gravity Theory, Nuclear Theory, Astronomy, Materials Research, Mathematical Sciences, etc.) We also coordinate, as needed, with DOE.

Approximately 110 separate active grants supporting ~180 PIs; ~30 large university groups.

Supporting individuals, RUI's, and special facilities or initiatives (Aspen Center for Physics, TASI summer school, LHC Theory Initiative, etc.)

Theory Trends

- FY15-17: three-year absorption of string-theoretic portion of former Mathematical Physics program. Now nearly complete.
- FY16: NSF renews Aspen Center for Physics grant for next five years, expands support and scope into Atomic Physics
- Numbers of proposals received is currently twice what it was only 3-4 years ago.
- Increasing numbers of RUI proposals, particularly in FY17.
- One major challenge affecting Theory is the entrance of non-traditional (private philanthropic) funding sources. NSF has developed new procedures for evaluating overlapping sources of funding and introducing such evaluations into the proposal review process. (See NSF 17-561)

	FY 2015	FY 2016	FY 2017
THY Budget	$13.7 million	$13.2 million	$13.4 million
Proposals receiving awards	28	30	26
CAREER	2	1	2

NSF Beyond the Disciplinary Programs

Centers and Institutes

Physics Frontiers Centers – FY 2017 Competition Concluded

Kavli Institute for Cosmological Physics – U Chicago
Center for Ultracold Atoms – MIT/Harvard
PFC@JILA – UC Boulder
Kavli Institute for Theoretical Physics – UCSB
Center for Theoretical Biological Physics – Rice
Joint Institute for Nuclear Astrophysics – Michigan State
PFC@Joint Quantum Institute – U Maryland
Center for the Physics of Living Cells – UIUC
Institute for Quantum Information and Matter – CalTech
North America Nanohertz Observatory for Gravitational Waves – UW Milwaukee
Center for the Physics of Biological Function – Princeton/CUNY (New in FY 2017)

Centers and Institutes (Science and Technology Center)

Center for Bright Beams – Cornell

Instrumentation

Major Research Instrumentation (MRI) – up to $4M – NSF 18-513

Mid-Scale (PHY Only) - $4M - Realistically $10-15M TPC; Apply to PHY program

ATLAS and CMS Phase-One Upgrades
LHCb Upgrade
NSF Support for SuperCDMS

MREFC - $70M TPC and higher (new!)

Alert!!: This is only Construction Costs; All Planning Costs must come from program

High-Luminosity ATLAS and CMS detector upgrades

Input Needed !! Deadline December 8, 2017!!

NSF 18-013

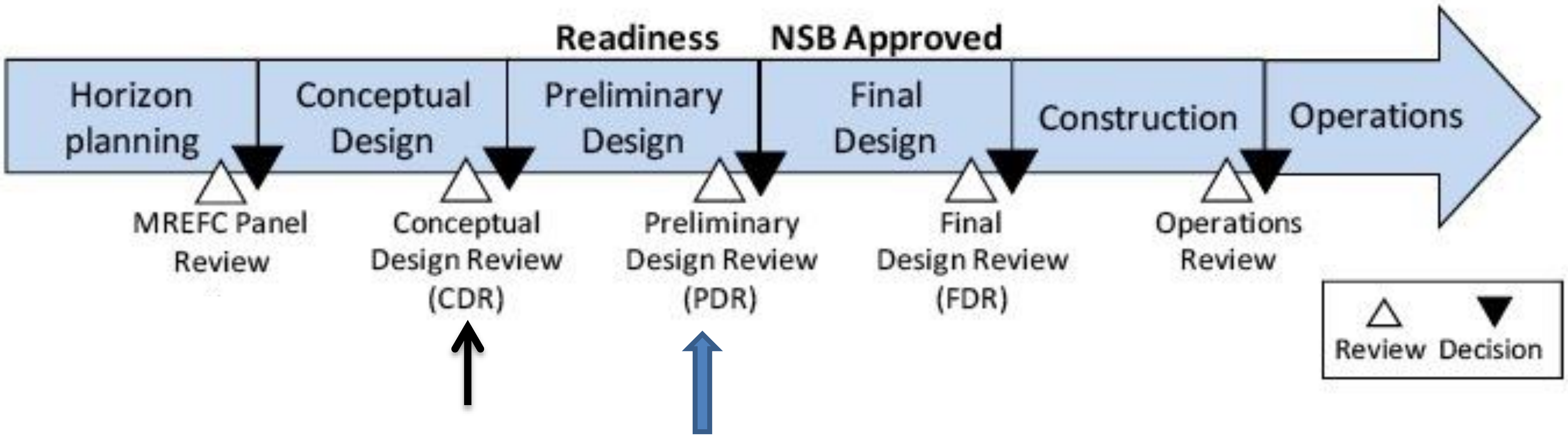
Dear Colleague Letter: Request for Information on Mid-scale Research Infrastructure

NSF seeks information on existing and future needs for mid-scale research infrastructure projects from the US-based NSF science and engineering community.

Focuses on mid-scale research infrastructure projects with an anticipated NSF contribution of between $20 million and $100 million towards construction and/or acquisition

High-Luminosity LHC Upgrade

Planning for a possible MREFC in support of the high-luminosity upgrades of the ATLAS and CMS detectors at CERN now in Preliminary Design Phase



Coordinating with the DOE in support of the US-CMS and US-ATLAS Teams

PDR sets baseline scope and Total Project Cost for future MREFC request

Computing

- NSF issued a Software Institute Conceptualization award: “Conceptualization of an S2I2 Software Institute for High Energy Physics” Award 1558216 (Elmer, Princeton) / 1558233 (Sokoloff, Cincinnati) / 1558233 (Neubauer, UIUC)
- Sponsors community workshops and conceptual work to take advantage of the significant data and computing requirements of the Large Hadron Collider as a science driver for next generation high-performance software and sustainability developments. Working together with the HEP Software Foundation to produce a Community White Paper.
- This effort will inform the future of computing and various software development needs for the HL-LHC era
- We are partnering with NSF’s Office of Advanced Cyberinfrastructure*
- Working with ATLAS, CMS, and OSG to minimize disruption to U.S. LHC
- On-going activities and drafts of Community White Paper can be found at: http://s2i2-hep.org/

*Will be important for Harnessing Data (see Big Idea later)

Major Thrust – Fostering Connections

Focus on Science Question, not Discipline or Subarea

Partner with Others whenever Possible to Promote Science

Partnering within Division – AMO-Nuclear, AMO-Particle, AMO-Gravity

Partnering with other NSF divisions on specific topics –
MPS/AST,CHE,DMR,DMS; BIO/MCB,IOS,DBI; GEO/PLR,AGS;
ENG/ECCS,CBET; CISE/CCF,OAC

Participation in NSF priority areas jointly with other Directorates/Divisions -
Understanding the Brain, CIF21, Big Ideas

Partnering with DOE in Particle Physics, Nuclear Physics, Plasma Physics

Partnering with NASA in Gravitational Physics and Plasma Physics

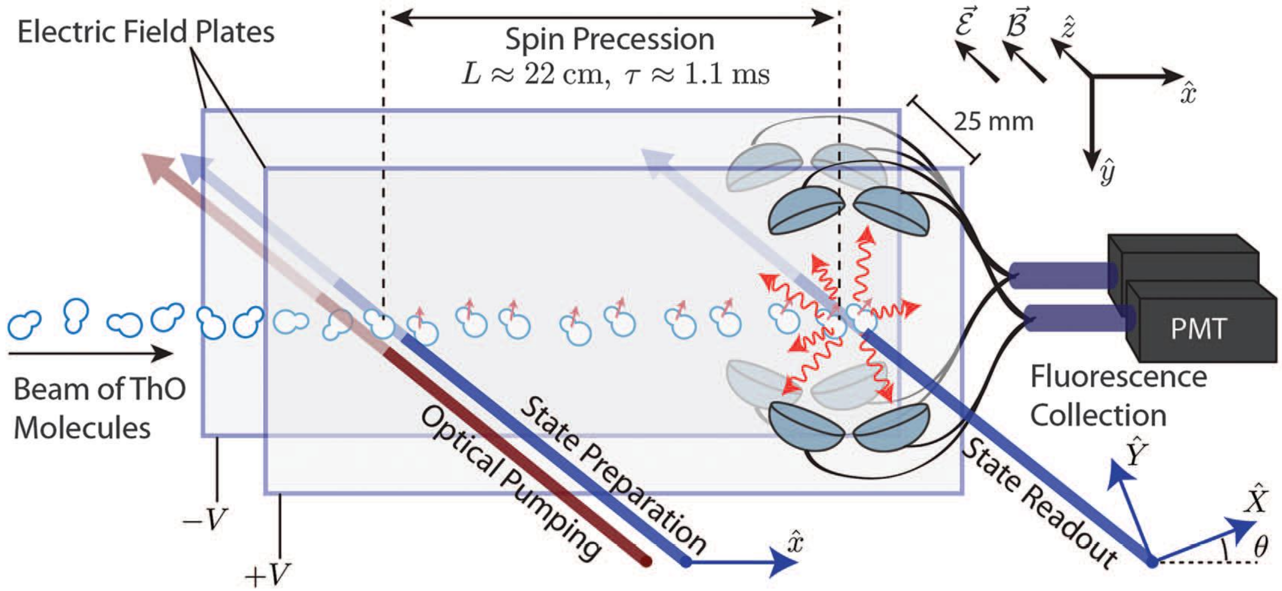
AMO Coupled with PA and Gravitational Physics
Very-Low Mass Dark Matter & Gravity at Small Distances

Blewitt and Derevianko, PHY-1506424; "Search of Topological Dark Matter with Atomic Clocks and GPS Constellation": Analyze clock data from the 30 GPS satellites, which use atomic clocks for everyday navigation. Topological defect dark matter would cause initially synchronized clocks to become desynchronized, causing time discrepancies between spatially separated clocks to exhibit a distinct signature.

Geraci, PHY-1506431, "Measuring Gravity at the Micron Scale with Laser-Cooled Trapped Microspheres": Uses levitated spheres of silica to search for hidden forces - sensitivities of a few zeptonewtons. Distinguishes between whether gravity will be much weaker than expected at short range, or stronger.

ACME: Advanced Cold Molecule Electron Electric Dipole Moment Search

Figure source:
Science **343**, 269 (2014)



In 2014 the ACME Collaboration placed a limit of 8.7x10^{-29} e-cm on the size of the electron EDM. This measurement is a sensitive probe of new physics at the TeV scale, and complements accelerator-based searches (such as the LHC) for new particles and interactions.

NSF Award 1404146 supports 8 PhD students and 2 postdocs working with 3 PIs to improve this experiments sensitivity to an EDM by a factor of 10.

Looking Ahead: Ten Big Ideas

RESEARCH IDEAS

Navigating the New Arctic

Harnessing Data for 21st Century Science and Engineering

Work at the Human-Technology Frontier: Shaping the Future

Understanding the Rules of Life: Predicting Phenotype

The Quantum Leap: Leading the Next Quantum Revolution

Windows on the Universe: The Era of Multi-messenger Astrophysics

PROCESS IDEAS

Growing Convergent Research at NSF

NSF-Includes: Enhancing Science and Engineering through Diversity

Mid-scale Research Infrastructure

NSF 2050: Seeding Innovation

10 Big Ideas for Future NSF Investments

- Bold questions that will drive NSF’s long-term research agenda
- Catalyze investment in fundamental research
- Collaborations with industry, private foundations, other agencies, universities
- Solve pressing problems and lead to new discoveries

Windows on the Universe

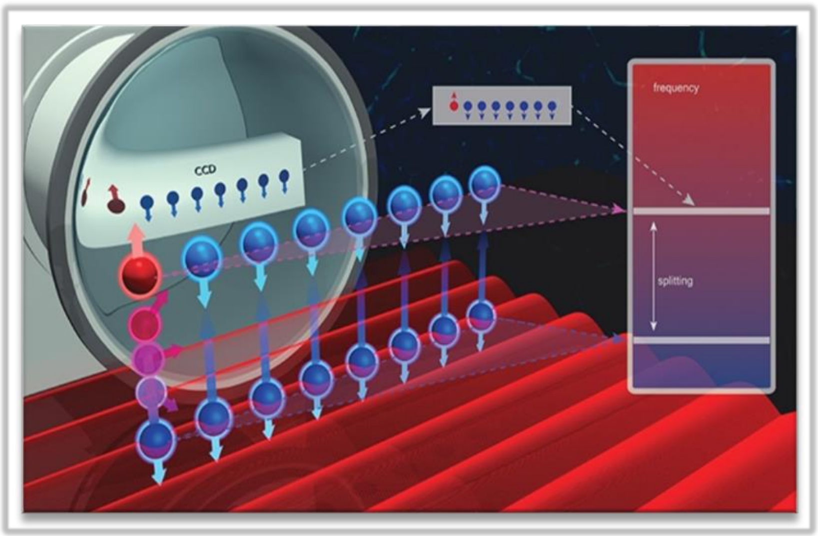
The goal of “Windows on the Universe” is to bring electromagnetic waves, high-energy particles, and gravitational waves together to study the universe and probe events in real time in a way that was previously impossible.

Credit: LIGO Laboratory

Credit: IceCube

Credit: AURA

Quantum Leap



Trapped ion computation
(JQI – University of Maryland)

Today:

- lasers, atomic clocks, GPS, semiconductors, storage media

Tomorrow:

- Ultra-secure communication
- Ultra-precise sensing, measurement
- Quantum simulators
- Computing beyond the scale of supercomputing

Builds on 20-Year NSF Investment in

Quantum Information Science

"Advancing Quantum Information Science: National Challenges and Opportunities", NSTC, July 2016

Quantum Leap is an NSF-Wide Activity Involving Multiple Directorates that extends QIS into new regimes of materials science and engineering

NSF/DOE Quantum Science Summer School, JHU, 5-16 June 2017
Three more to follow: Cornell (2018); Penn State (2019); UC (2020)

Triplets: Quantum Information Science and Engineering Network, PI Awschalom

NSF 17-053 Funding Opportunity – A "Quantum Leap" Demonstration of Topological Quantum Computing

Ideas Lab: Practical Fully-Connected Quantum Computer Challenge (PFCQC)
Ideas Lab in August; Proposals due November 30

Harnessing Data

Domain Science ↔ Computation and Data Challenges

Connecting domain scientists with computer scientists

Essential for Handling Large Data Sets from LIGO, LHC, LSST

Efforts closely coordinated with OAC in CISE Directorate