

NSF Elementary Particle Physics and Accelerator Science

Jim Shank, NSF Program Director
(Mark Coles, Brian Meadows, Slava Lukin, Keith
Dienes, Jean Cottam Allen, Jim Whitmore)
DPF Meeting, Ann Arbor
8 August, 2015

Overview

- NSF Organization
- Overall NSF Budget
- Some notes on proposal preparation
- Recent EPP funding
- Mid-Scale Projects
- The MPS/PHY/Accelerator Science Program
- The LHC Phase II Upgrades
- Computing Opportunities



Division of Physics

Denise Caldwell
Director

Brad Keister
Deputy Director

Facilities

Large Hadron Collider
Mark Coles
(Saul Gonzalez)*

IceCube
Jim Whitmore

LIGO
Mark Coles

NSCL
Ken Hicks

Experiment

Atomic, Molecular, Optical,
and Plasma
John Gillaspy, Steve Gitomer

Elementary Particle Physics
(Saul Gonzalez)*, Brian
Meadows, Jim Shank

Particle Astrophysics
*Jean Cottam-Allen
Jim Whitmore*

Gravitational Physics
*Mark Coles
Pedro Marronetti*

Nuclear Physics
*Allena Oppen
Ken Hicks*

Physics of Living Systems
Krstan Blagoev

Accelerator Science
Jim Shank, Slava Lukin
(Saul Gonzalez)*

Theory

Atomic, Molecular, and
Optical
Ann Orel

Elementary Particle Physics,
Astrophysics, and
Cosmology
Keith Dienes

Mathematical Physics
Earle Lomon

Gravitational Physics
Pedro Marronetti

Nuclear Physics and
Nuclear Astrophysics
Bogdan Mihaila

Physics of Living Systems
Krstan Blagoev

Accelerator Science
Jim Shank, Slava Lukin
(Saul Gonzalez)*

Cross-cutting

Physics Frontier Centers
Jean Cottam-Allen

Integrative Activities in
Physics
Kathy McCloud

Computational Physics
Bogdan Mihaila, Ann Orel

Physics Instrumentation

* On Detail at OSTP



NSF Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Expectation
Statistics for Competitive Awards			
Number of Proposals	48,000	50,000	51,700
Number of Awards	11,000	11,700	12,000
Funding Rate	23%	23%	23%
Statistics for Research Grants			
Number of Research Grant Proposals	36,900	39,900	41,100
Number of Research Grant Awards	7,700	8,200	8,500
Funding Rate	21%	21%	21%
Median Annualized Award Size	\$135,900	\$139,800	\$140,900
Average Annualized Award Size	\$167,800	\$174,900	\$177,100
Average Duration (years)	3.0	3.0	3.0



**National Science Foundation
Summary Table
FY 2016 Request to Congress**
(Dollars in Millions)

Physics Division

NSF by Account	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request over:			
				FY 2014 Actual		FY 2015 Estimate	
				Amount	Percent	Amount	Percent
BIO	\$720.84	\$731.03	\$747.92	\$27.08	3.8%	\$16.89	2.3%
CISE	892.60	921.73	954.41	61.81	6.9%	32.68	3.5%
ENG	833.12	892.31	949.22	116.10	13.9%	56.91	6.4%
<i>Eng Programs</i>	673.13	715.20	754.86	81.73	12.1%	39.66	5.5%
<i>SBIR/STTR</i>	159.99	177.11	194.36	34.37	21.5%	17.25	9.7%
GEO	1,321.32	1,304.39	1,365.41	44.09	3.3%	61.02	4.7%
MPS	1,267.86	1,336.72	1,366.23	98.37	7.8%	29.51	2.2%
SBE	256.84	272.20	291.46	34.62	13.5%	19.26	7.1%
OISE ¹	48.31	48.52	51.02	2.71	5.6%	2.50	5.2%
IA ¹	433.12	425.34	459.15	26.03	6.0%	33.81	7.9%
U.S. Arctic Research Commission	1.30	1.41	1.48	0.18	13.5%	0.07	5.0%
Research & Related Activities	\$5,775.32	\$5,933.65	\$6,186.30	\$410.98	7.1%	\$252.66	4.3%
Education & Human Resources	\$832.02	\$866.00	\$962.57	\$130.55	15.7%	\$96.57	11.2%
Major Research Equipment and Facilities Construction	\$200.00	\$200.76	\$200.31	\$0.31	0.2%	-\$0.45	-0.2%
Agency Operations and Award Management	\$305.95	\$325.00	\$354.84	\$48.89	16.0%	\$29.84	9.2%
National Science Board	\$4.25	\$4.37	\$4.37	\$0.12	2.8%	-	-
Office of Inspector General	\$13.84	\$14.43	\$15.16	\$1.32	9.5%	\$0.73	5.1%
Total, NSF	\$7,131.39	\$7,344.21	\$7,723.55	\$592.16	8.3%	\$379.34	5.2%

Totals may not add due to rounding.

¹ This table reflects the realignment, expected in FY 2015, of the Office of International Science and Engineering (OISE) and Integrative Activities (IA) as separate budget activities. All data are presented in the FY 2015 structure for comparability.



Physics Division

Mathematical and Physical Sciences (MPS) Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
Astronomical Sciences (AST)	\$238.36	\$244.16	\$246.55	\$2.39	1.0%
Chemistry (CHE)	235.18	243.85	251.20	7.35	3.0%
Materials Research (DMR)	267.09	306.99	315.80	8.81	2.9%
Mathematical Sciences (DMS)	224.97	231.73	235.47	3.74	1.6%
Physics (PHY)	267.09	274.99	277.37	2.38	0.9%
Office of Multidisciplinary Activities (OMA)	35.17	35.00	39.84	4.84	13.8%
Total, MPS	\$1,267.86	\$1,336.72	\$1,366.23	\$29.51	2.2%



Physics (PHY) Funding

(Dollars in Millions)

	Change Over				
	FY 2014	FY 2015	FY 2016	FY 2015	Estimate
	Actual	Estimate	Request	Amount	Percent
Total, PHY	\$267.09	\$274.99	\$277.37	\$2.38	0.9%
Research	163.82	176.05	176.19	0.14	0.1%
CAREER	8.57	7.44	7.45	0.01	0.1%
Centers Funding (total)	0.02	0.02	-	-0.02	-
Nanoscale Science & Engineering Centers	0.02	0.02	-	-0.02	-
Education	5.38	5.56	5.32	-0.24	-4.3%
Infrastructure	97.89	93.38	95.86	2.48	2.7%
IceCube Neutrino Observatory	3.45	3.45	3.45	-	-
Large Hadron Collider (LHC)	17.37	18.00	18.00	-	-
Laser Interferometer Grav. Wave Obs. (LIGO)	36.43	39.43	39.43	-	-
National Superconducting Cyclotron Laboratory (NSCL)	22.50	22.50	22.50	-	-
Research Resources	11.56	-	-	-	N/A
Mid-scale Research Infrastructure	6.58	10.00	12.48	2.48	24.8%



Physics Division

PHY/ Elementary Particle Physics Program

Theory

The NSF Physics Division has two theoretical programs relevant to particle physics:

1. Theoretical High-Energy Physics
2. Theoretical Particle Astrophysics and Cosmology

- Both programs are directed by
 - Keith Dienes, kdienes@nsf.gov.
- Any questions about program emphases, budgets, and proposal submission should be directed to him by email.

Rearrangement of Particle Astrophysics in NSF/PHY

Particle Astrophysics – Cosmic Phenomena:

This area supports university research that uses astrophysical sources and particle physics techniques to study fundamental physics. This includes the study of ultra-high energy particles reaching Earth from beyond our atmosphere (cosmic-rays, gamma-rays, and neutrinos with the exception of IceCube); searches for supernova neutrinos; and studies of the Cosmic Microwave Background (CMB) and Dark Energy.

Particle Astrophysics – Underground Physics :

This area supports university research that generally locates experiments in low background environments. Currently supported activities include: studies of solar, underground and reactor neutrinos; neutrino mass measurements; and searches for the direct detection of Dark Matter.

Particle Astrophysics – IceCube Research Support :

This area supports university research that utilizes the facilities of IceCube at the South Pole. Currently supported activities include: searches for ultra-high energy neutrinos and studies of the properties of neutrinos.

Neutrinoless Double Beta Decay: This has been moved to Nuclear Physics.



PHY division proposal preparation(1)

- As of last year: All proposals now go through a solicitation ([NSF 15-579](#)) Same one for ALL of PHY
 - Not a Dear Colleague Letter
 - There are now multiple deadlines (not target dates)
 - EPP and PA – October 28, 2015
 - THY – December 3, 2015
 - Accelerator Science (AS) – February 3, 2016
 - There are additional requirements to be included in Current & Pending (or the Project Description)
 - If you have multiple sources of support, you must clearly explain how the proposed work is distinct from other funded activities. The proposal review process will include an assessment of the proposers' ability to carry out the proposed research in light of other commitments.
 - Also: collaborators in Bio Sketches
 - Don't just list "ATLAS collaboration"
 - » List a subset that you work with directly
 - » Can be included in supplementary material so as not to fill up the Bio Sketch



PHY division proposal preparation(2)

- Letters of Support
 - Letters of support should not be submitted.
 - letters of collaboration, limited to stating the intent to collaborate and not containing endorsements or evaluation of the proposed project, are allowed. Letters of collaboration should follow the single-sentence format:
 - “If the proposal submitted by Dr. [insert the full name of the Principal Investigator] entitled [insert the proposal title] is selected for funding by the NSF, it is my intent to collaborate and/or commit resources as detailed in the Project Description.”
- The Grant Proposal Guide is occasionally updated
 - Old Timers: You need to read it again
 - Follow it to the letter, in particular, read:
 - “Results from Prior NSF Support”, ([II.C.2.d.iii](#))
 - » This section has changed and many people are not following it correctly
 - Proposals could be returned without review
- [PHY Division solicitation](#)



Particle Physics – Budgetary History FY08-FY15

Program Elements	Type	FY 2008 Actuals	FY 2009 Actuals	FY 2009 ARRA	FY 2010 Actuals	FY 2011 Actuals	FY 2012 Actuals	FY 2013 Actuals	FY 2014 Actuals	FY 2015 Actuals
EPP Research	Base	20.5	18.8	14	25.8	25	24.7	21.8	18.7	19.2
LHC Ops	Operations	18	18		18	18	18	18	17.4	18
LHC Upgrades	Midscale								8.2	14.4*
PA Research	Base	15.8	15.9	15.3	17.9	9.7	11.5	12	11.9	
IceCube Ops	Operations	1.5	2.2		2.2	3.5	3.5	3.5	3.5	
Underground Physics	Base					8.4	6.3	6.8	6.8	
THY (EPP/Astro/ Cosmo)	Base	11.7	12	6.8	13.2	14.1	13.6	12.1	12.1	
CESR	CESR	13.7	8.5	1.3						
Accel/ Instrumentation	APPI	4	2.2		3	4.1	11.9	4.5		
DUSEL Planning	DUSEL	2	22		28.9	10.2				
Underground R&D	DUSEL/APPI	5	4	5.6	4.6	6	11	3.9		
Accel Science									8.9	9.3
PFC		6.3	5.9		5.9	6	6	6	6	
Allied Funding		7.2	4.9	0.5	12.7	12.3	24.7	20.8	12.9	
Total - Particle Physics		105.7	114.4	43.5	132.2	117.3	131.2	109.4	106.5	
Total - Physics Division		285	275.5	102.1	307.8	280.3	277.4	247.4	260	

Includes \$6.4M from PHY

Experimental Groupings in EPP (2014)



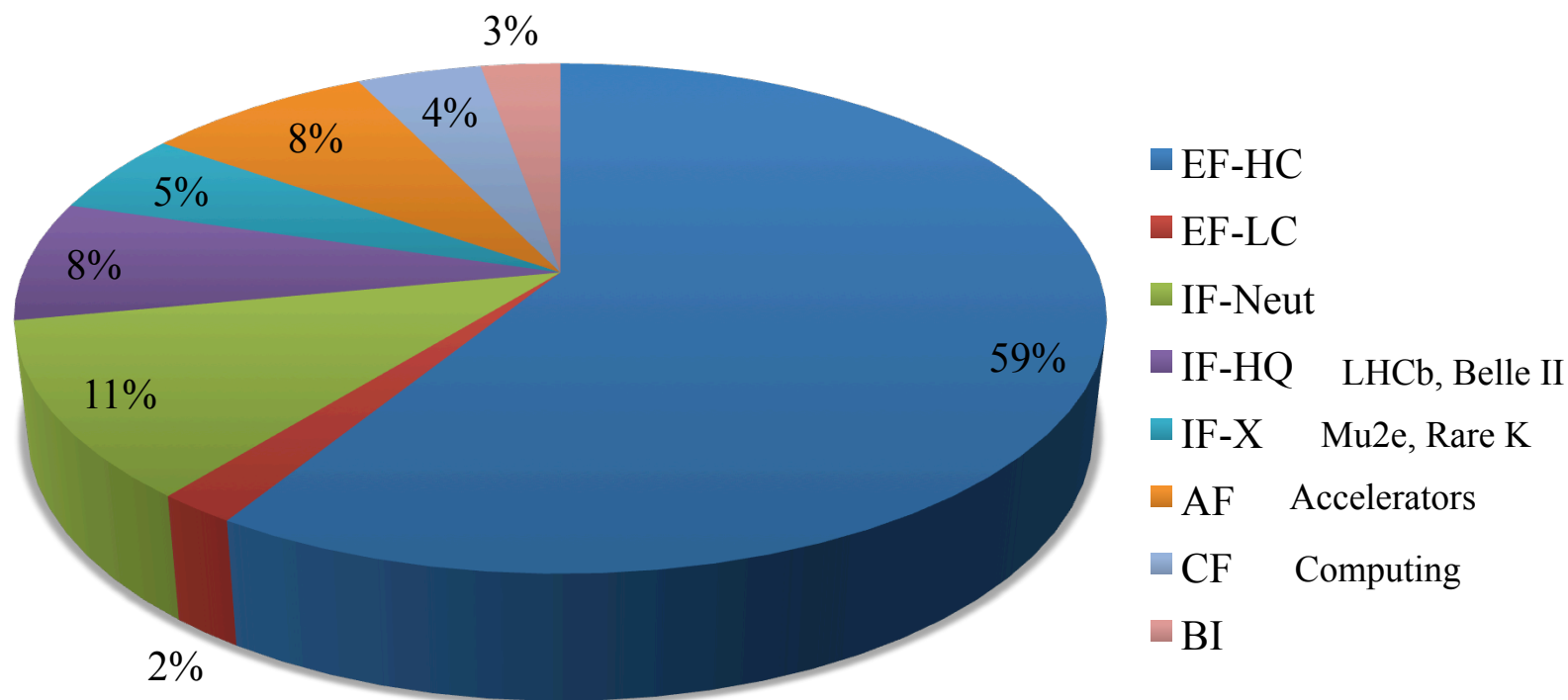
- ATLAS
- CMS
- LHCb
- Tevatron
- ILC
- LArIAT
- LAr1ND
- MicroBOONE
- Minerva
- MINOS, MINOS+
- NOvA
- DarkLight Phase-I (EHR)
- Electron EDM (AMO)
- Mu2e
- Muon g-2 (NP)
- Belle-II
- NA62 ($K^+ \rightarrow \pi^+ \nu \nu$)

Program by PI Headcount (From 2014)

(125 Total PIs)



EPP Research By PI



2015 EPP proposals



2015 EPP Propos		
Science Thru	Sum of FY 15 req	No. Proposals
ATLAS	4,213,852	12
Belle II	185,114	2
CMS	2,058,453	8
Conference	30,649	2
D0	80,007	1
Dark Energy	771,165	1
Dark Matter	1,165,687	1
Detector R&D	251,403	1
LHCb	1,502,087	2
Mu2e	366,598	1
Neutrinos	2,655,722	13
Outreach	133,336	1
Rare K	172,521	1
Grand Total	13,586,594	46

9 actually

24 will be funded at some level.

FY2015 – EPP/PA Proposal Pressures

	Atlas	CMS	LHCb	ν 's	Dark Matter	Other EPP	Total
Number of Proposals	13	8	2	15	1	10	49
Number of PI's	18	9	5	16	1	10	59
Request \$K	4,237	2,058	1,502	3,180	1,165	14,123	
	Cosmic Rays/other	Gamma Rays	Dark Matter	Neutrino	IceCube	PA submit	PA awards
PA-CP Proposals	10.5/1	13		9.5		34	8
PA-CP Request \$K						28,887	
PA-UG Proposals			26	9	14	49	18
PA-UG Request \$K						36,850	



Major Research Instrumentation (MRI)

- The Major Research Instrumentation Program (MRI) serves to increase access to shared scientific and engineering instruments for research and research training in our Nation's institutions of higher education, and not-for-profit museums, science centers and scientific/engineering research organizations.
- This program especially seeks to improve the quality and expand the scope of research and research training in science and engineering, by supporting proposals for shared instrumentation that fosters the integration of research and education in research-intensive learning environments. Two types.
 - Track (1) acquisition of a research instrument
 - Track (2) development of a research instrument.
- Proposals for \$100,000-\$4 million may be accepted from any MRI-eligible organization.
- **Present Solicitation [15-504](#)**
- **Deadline: January 13, 2016**
http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5260
- **Program Contact: Kathleen McCloud or EPP/PA program directors**

MRI Program – Impact in Particle Physics



- MRI Support has been significant to the various programs from FY08 – FY14, totaling \$26.3M
 - EPP related: \$15.9M
 - PA related: \$10M
 - Accelerator Science: \$2.4M
- In FY14 there were 3 MRI awards to Particle Physics totaling ~ \$2M.
 - Projects: LAr1ND, DarkLight Phase 1, Mass Spectrometry(mostly PA & NP)
- 2015 MRI review process just finishing.
 - No awards in EPP or AS (3 submitted)

PHY Mid Scale Program

Mid-Scale Instrumentation and Particle Physics



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: Opportunity to Request Instrumentation Funding for Midscale Level Instrumentation in Physics Division](#)
 - This is not a separate program to which investigators can apply directly. PI's 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.

Background

- PHY midscale program was new in FY 2014
- Evolved from Accelerator Physics and Physics Instrumentation (APPI) program to meet community demand for midscale project funding
 - Total Project Cost > \$4M MRI cap and \$ < MREFC threshold (~\$140M)
 - New program includes well-defined budgetary and competitive selection process

Features

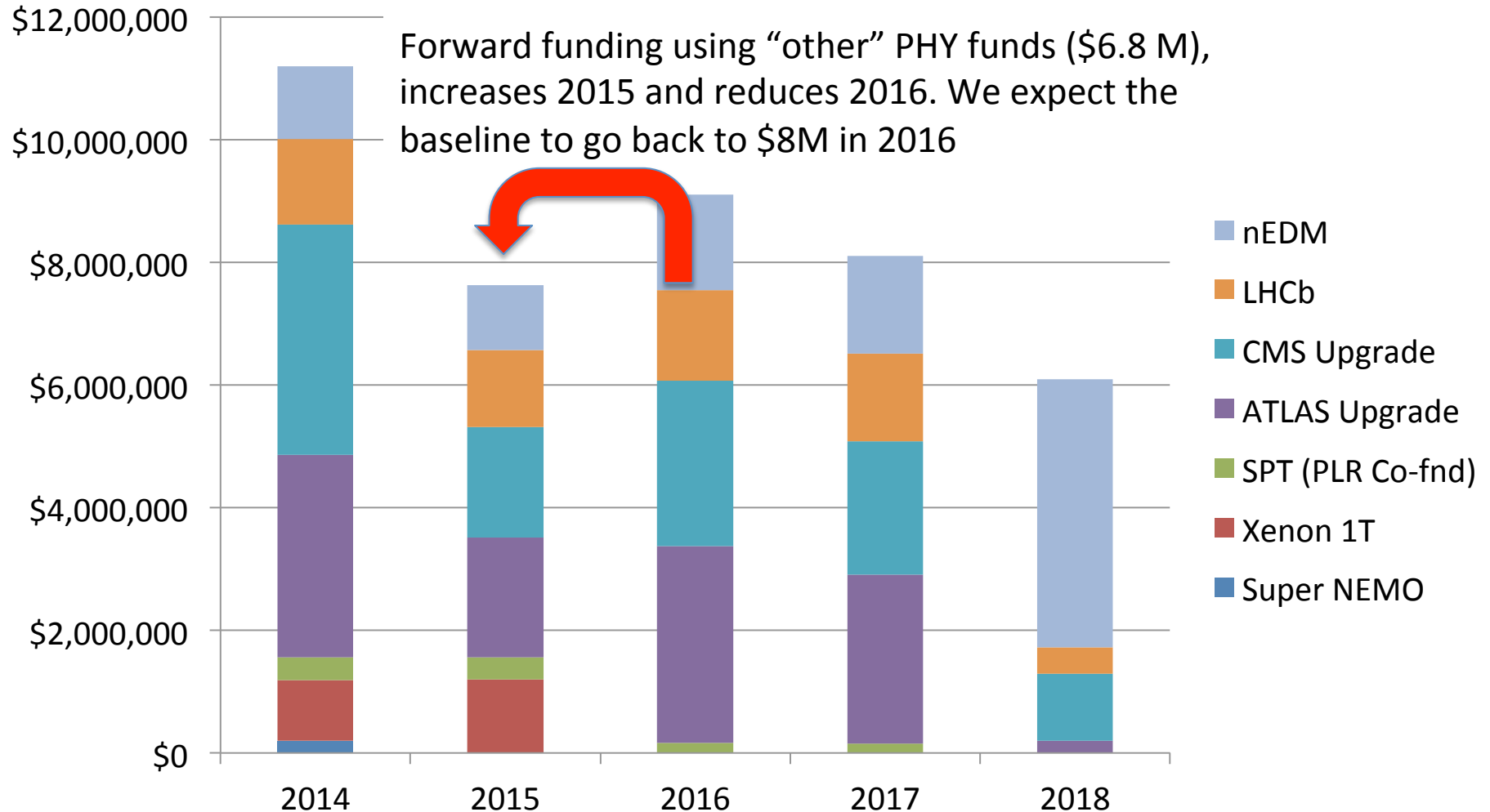
- Selection based on merit review of unsolicited proposals representing exceptional opportunity and of high priority to research community
- Excludes:
 - planning and development funding for future midscale and MREFC candidates
 - O&M for facilities and funds for utilization of constructed/acquired infrastructure
 - educational outreach

Status

- \$7.3M awarded in FY14
- ~\$8M awarded in FY15
- Demand is much higher
 - Additional ~\$10M/yr over next 3 years, just for projects we already know about
 - Possibly +\$20M/yr looking out 5-10 years

Funding profile of **current** PHY Mid Scale projects.

Does not include unapproved proposals which could start in this period.





PHY Accelerator Science Program



NSF Perspective on Accelerator Science

- NSF Mission: *“to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes”*
 - Empowering university-based investigators
 - Educating and training an exceptional and diverse scientific workforce
 - Adding value through partnerships and broadening participation
- We fund grant proposals, evaluating them through intrinsic and comparative peer review according to the criteria:
 - What is the Intellectual Merit?
 - What are the Broader Impacts?
- We aim to fund the most compelling scientific research, education through research, and outreach activities – without preconceived preferences on direction
 - Programs evolve organically as scientific fields evolve and as new scientific opportunities emerge

New in FY 2014: Accelerator Science



The acceleration and control of charged particle beams are essential tools for discovery science within the Physics Division: from high to low energy beams, high intensity sources for secondary or tertiary beams (e.g., neutrinos), nuclear physics, nuclear astrophysics.

- We have started an accelerator science program with the goal of enabling fundamental discoveries and train students and postdocs across disciplinary boundaries
 - Current Program Solicitation **NSF 15-579** : “*Accelerator Science*”
 - http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504937&org=PHY&from=home
 - Program Contact: Jim Shank (jshank@nsf.edu), Slava Lukin (vlukin@nsf.gov)
- Broader impacts are significant: industrial applications, medical applications, homeland security, light sources
- Program focuses on transformational developments that are likely to come from curiosity-driven research with strong interdisciplinary link.
- Program will evolve with the community as new challenges are identified

In FY2014, a total of 60 proposals were received requesting ~ \$70M in funding. A dozen awards were made totaling \$8.9M.

2015: 50 Proposals received. Total request: \$34 M. Budget: \$9.3M, but \$4.5 M already committed from last year.

Review process complete: awards decisions made, not all awards are through budget div. yet



Key Features of NSF Accelerator Science

- Focus on fundamental science best done at universities
 - High risk, transformational, academic discipline
 - Cross-cutting with other disciplines
 - Can take place on campus or off campus (national lab, etc.)
- Workforce
 - Attract the best students/postdocs by tackling hard and interesting problems
- This program is NOT intended to be
 - Directed R&D towards a foreseen project or facility
 - Incremental improvement to an existing facility (unless it is proof of concept of a new idea)
 - “Supplement” to an existing DOE award or program (does not mean that NSF award will not be issued to DOE award recipient; scope must be different than DOE’s)
- [Accelerator Science NSF web page](#)
- Next solicitation deadline: Feb. 3, 2016
- Special thanks to LK Len, Department of Energy for help in getting this program started.

Accelerator Science Program

- FY2014 Portfolio.

- 60 proposals, 52 projects (some proposals were collaborative)

- Request total

- \$70M

- 12 awards

- \$9M

	Amount	
	\$	No. awards
Beam Dynamics	520,397	2
Plasma	1,469,900	3
Sources	1,006,910	2
SRF	4,522,786	2
Education	700,000	1
Other	720,000	2
Total	8,939,993	12

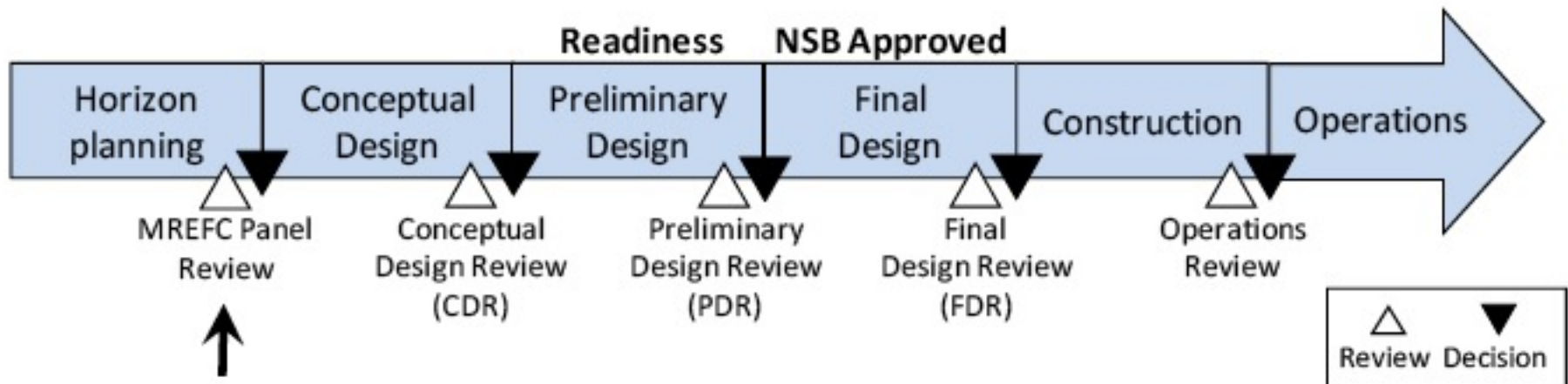
2015 AS Awards

AS 2015 Awards		
Science Area	No. of Awards	Award total
AdvAccel	1	\$450,000
Beam Dynamics	4	\$1,572,259
Instrumentation	1	\$600,000
Plasma	4	\$1,619,999
Simulation	3	\$1,093,899
Sources	3	\$1,369,781
Grand Total	16	\$6,705,939

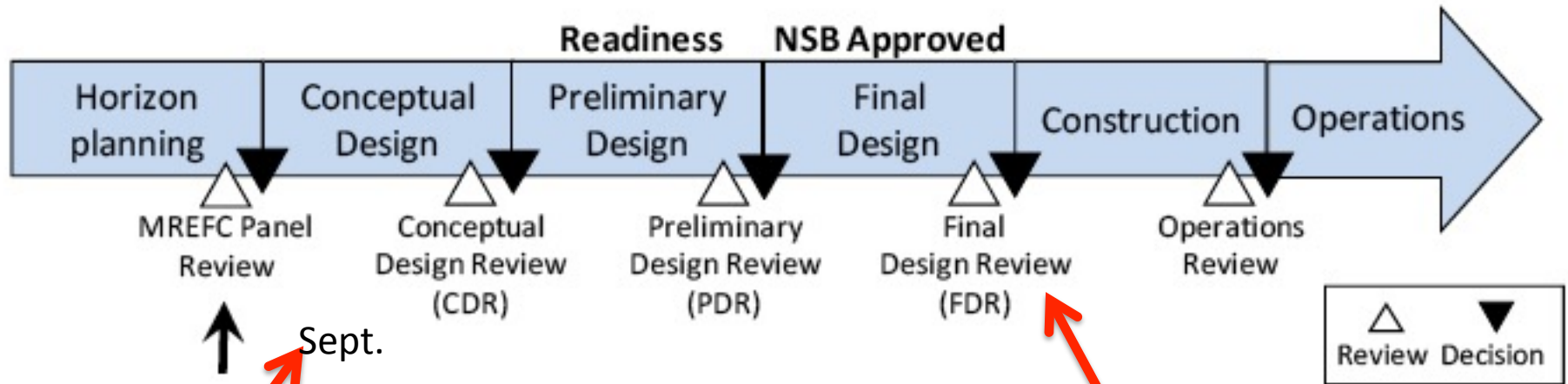
LHC Phase II Upgrade

LHC Phase II Upgrade

- The NSF MPSAC subcommittee recommended:
 - “Based on the above considerations, the proper funding mechanism for the NSF investment in the LHC Phase-2 upgrades is through the MREFC process”



The NSF MREFC Process



Perhaps July, 2015

PHY Division (& MPS Directorate) is preparing a “case” for the Panel review:

- Science case prepared by ATLAS & CMS
- Other documentation as mentioned in the NSF

Large Facility Manual

Panel members are the AD’s of all of NSF.

Hopeful Outcome: The NSF Director gives permission to proceed to a CDR

Perhaps Jan, 2020

NSF Computing

NSF Computing Opportunities

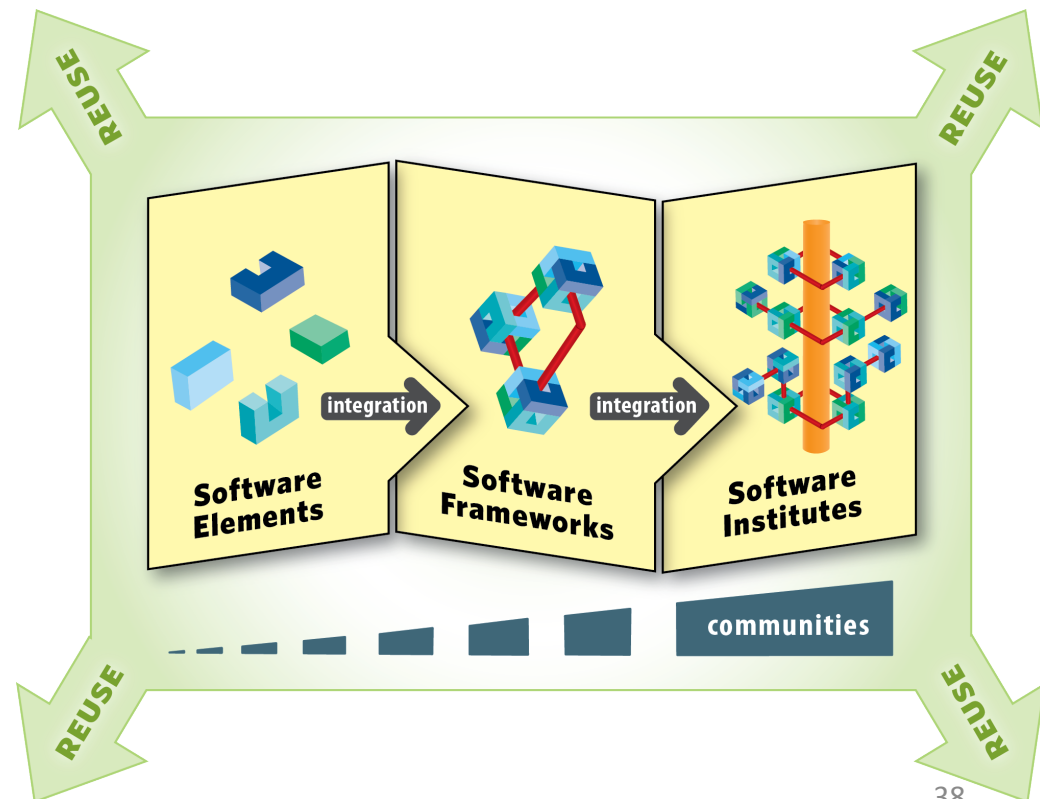
- In MPS/PHY
 - [Computational Physics](#)
 - Physics at the Information Frontier is gone.
 - CP is the program through which the Physics Division participates in the CDS&E program.
 - Next deadline December 3rd
- CDS&E,
[Computational and Data-Enabled Science and Engineering](#)
 - **Physics:** ideas at the interface between scientific frameworks and computing capability that enable advances well beyond the expected natural progress of either activity, including development of science-driven algorithms to address pivotal problems in physics and efficient methods to access and mine large data sets.

CISE/ACI, Advanced Cyberinfrastructure

- CIF21, Cyberinfrastructure Framework for the 21st Century
 - [A Vision and Strategy for Software for Science, Engineering, and Education](#) (NSF 12-113)
 - [Implementation of NSF Software Vision](#)
- In CISE/ACI (Advanced Cyber Infrastructure)
 - Co-funded with MPS (PHY, OMA)
 - SI2, Software Infrastructure for Sustained Innovation
 - SSE, Scientific Software Elements -- TBA
 - SSI, Scientific Software Integration -- TBA
 - S2I2: Scientific Software Innovation Institutes
 - Conceptualization Proposals (accepted anytime)
 - Reuse
 - DIBBs, Data Infrastructure Building Blocks
 - Now part of Campus Cyberinfrastructure - Data, Networking, and Innovation Program (CC*DNI) program. Solicitation: [15-534](#)

Recent successful Co-Funding with CISE

- Data and Software Preservation for Open Science: DASPOS [ATLAS, CMS, TeVatron, ...]
- SSI: Data-Intensive Analysis for HEP: DIANA/HEP [CMS, ATLAS, LHCb]
~ \$4M/4 years



Extras

NSF Statistics



Physics Division

- Research and Related Activities

	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015
	Actual	Actual	Actual	Actual	Estimate	Request
NSF Total	\$6,926	\$6,860	\$7,033	\$6,902	\$7,172	\$7,255
R&RA (req)	\$5,733	\$6,019	\$6,254	\$5,983	\$6,213	\$5,807
R&RA	\$5,615	\$5,564	\$5,719	\$5,559	\$5,809	TBD

Total includes agency operations
Administration: ~2100 staff in Arlington, VA

- FY 2013:
 - Proposals received: 49,013
 - Proposals awarded: 10,844 (22%)



Adding Value/Allied Funding

- MRI
 - ATLAS (IBL, FTK, T3 Consortium, High Speed Datalinks)
 - LAr1ND, DarkLight-Phase 1, Plasma Mass Spectrometer, Muon g-2
 - LHCb/LIGO (High Throughput Computing)
 - LHCb/UT
- Scientific Computing
 - OSG
 - CONDOR
 - DASPOS
 - GPU/Multicore Architectures
- International (PIRE)
 - CMS Pixels
 - Data Intensive Computing
- Multidisciplinary Activity
 - AGEP
 - INSPIRE
- Education (Formal and Informal)
 - QuarkNet
 - Planetarium Show
 - IMAX Movie
 - Soudan Visitor Center