Report from NSF

Keith R. Dienes

Program Director
Theoretical High-Energy Physics and Cosmology

Also representing…

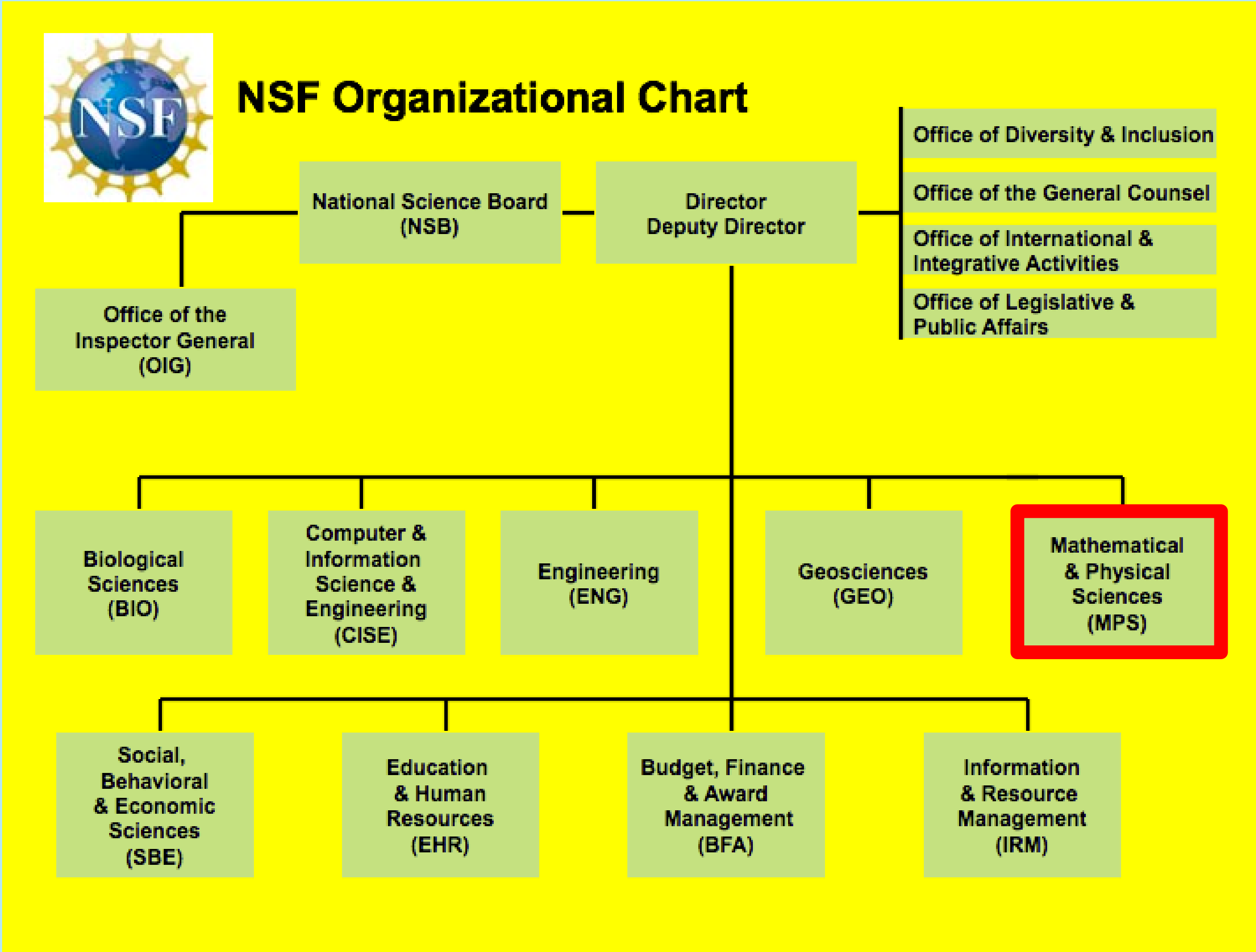
- Marv Goldberg, Saul Gonzalez, Randy Ruchti (Experimental HEP)
- Jean Cottam Allen, Jim Whitmore (Experimental Particle Astro/Cosmo)

Our DNA (just to remind you)

- ***NSF Mission (1950 NSF Act of Congress):*** *"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 do not operate alone
  - Our programs are coordinated with other U.S. and non-U.S. agencies and organizations.
  - We solicit advice concerning scientific issues and strategic directions from advisory committees such as HEPAP, P5, AAAC, NSAC, National Academy of Sciences, etc.
- Our *Modus Operandi*: **We fund grant proposals**, evaluating them through both intrinsic and comparative peer review according to "NSB review criteria"
  - What is the Intellectual Merit?
  - What are the Broader Impacts?
- By and large, we aim to fund the most compelling scientific research and education/outreach activities without preconceived preferences as to direction or scope: "Science for its own sake"

Our Structure

(it's new and improved for 2013 … can you spot the changes?)



Our Structure

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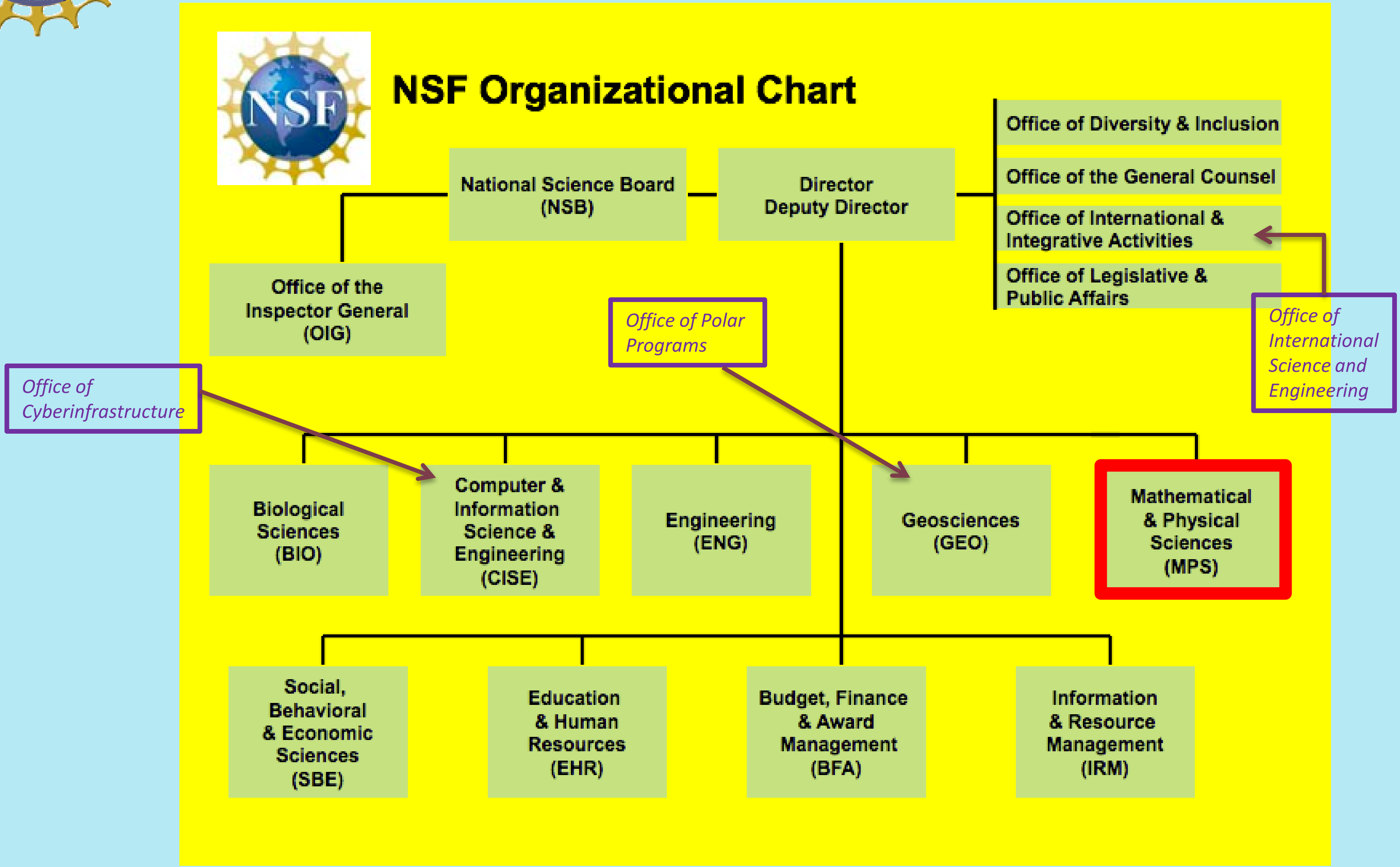
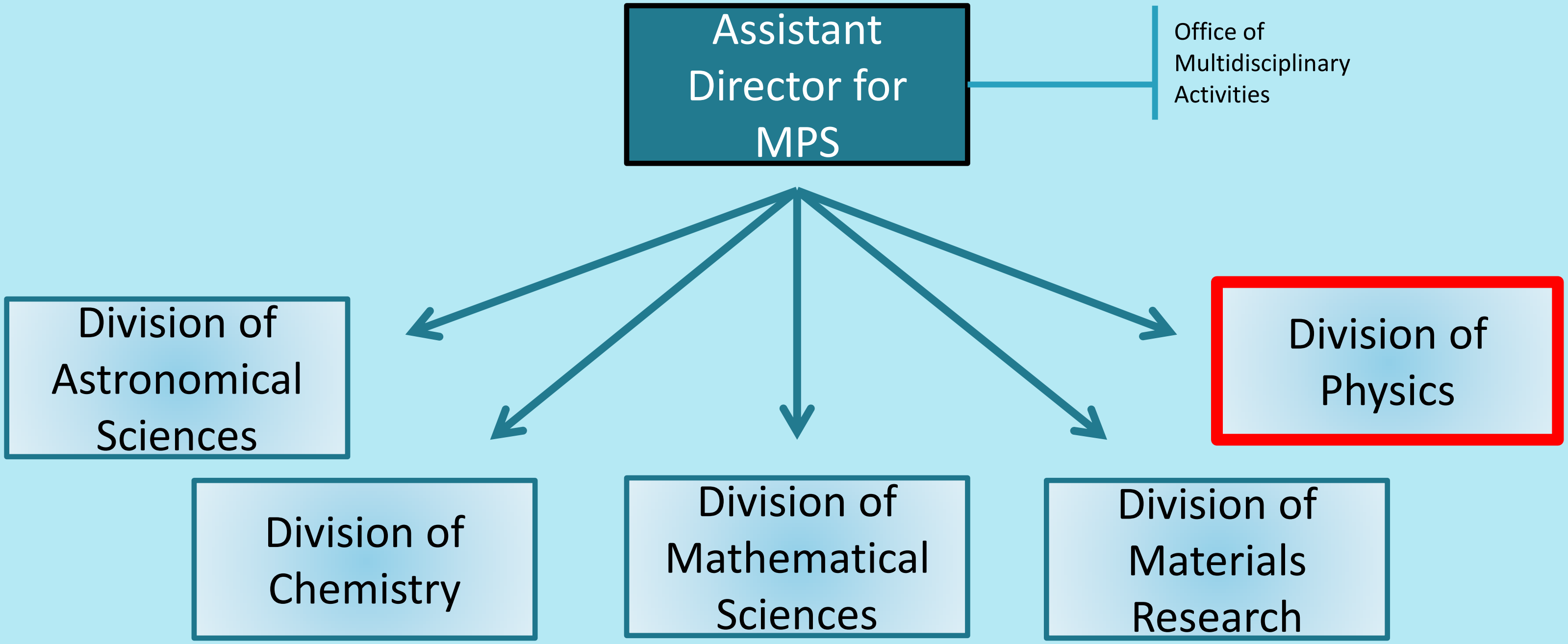
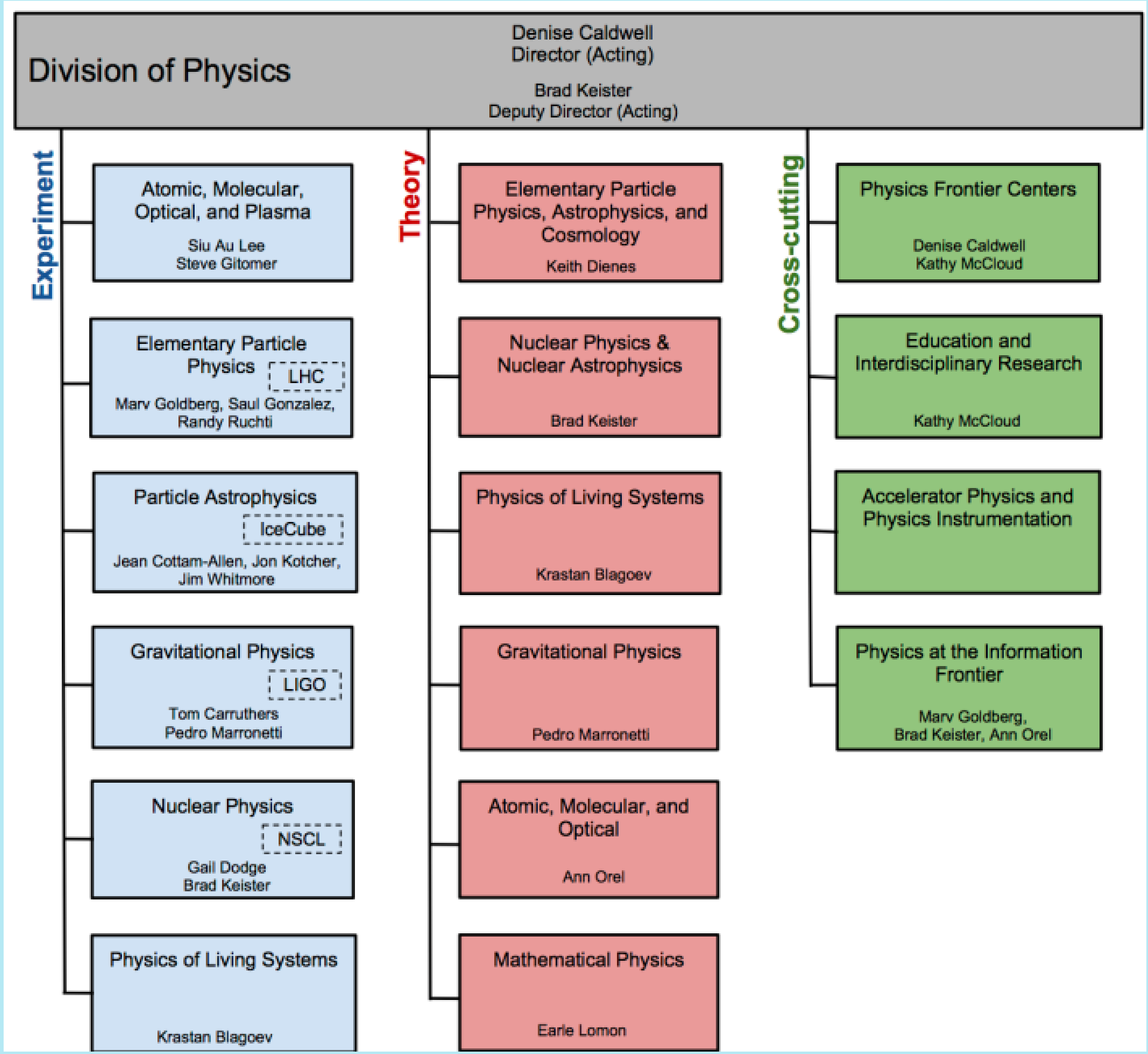


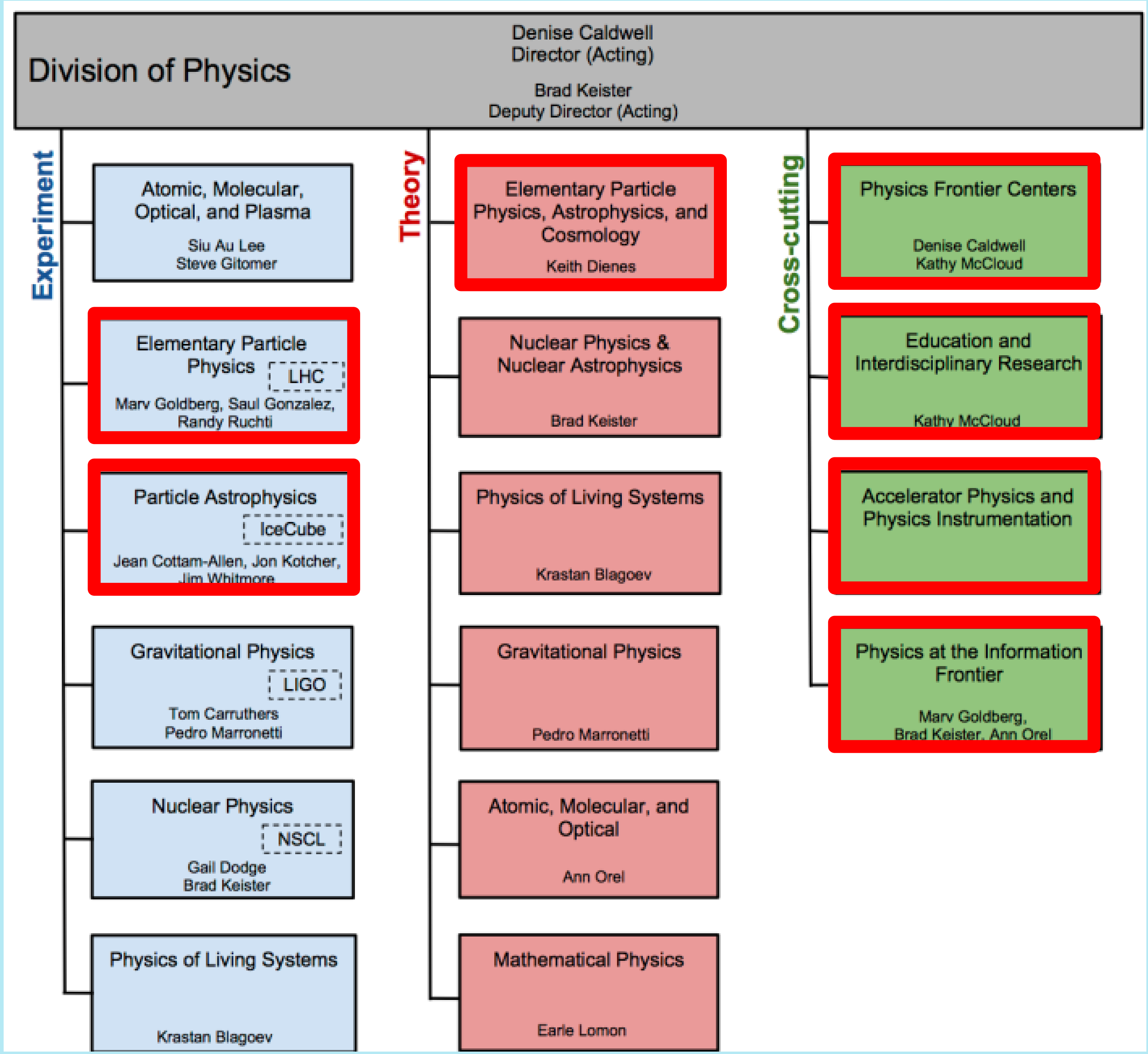
MPS has its own substructure…

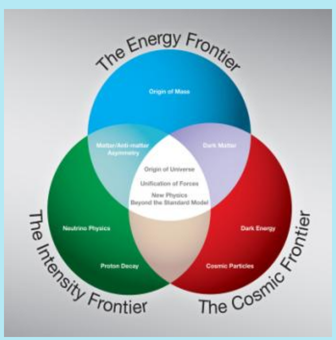




Division of Physics
Denise Caldwell
Director (Acting)
Brad Keister
Deputy Director (Acting)
Experiment
Atomic, Molecular, Optical, and Plasma
Siu Au Lee
Steve Gitomer
Elementary Particle Physics
LHC
Marv Goldberg, Saul Gonzalez, Randy Ruchti
Particle Astrophysics
IceCube
Jean Cottam-Allen, Jon Kotcher, Jim Whitmore
Gravitational Physics
LIGO
Tom Carruthers
Pedro Marronetti
Nuclear Physics
NSCL
Gail Dodge
Brad Keister
Physics of Living Systems
Krastan Blagoev
Theory
Elementary Particle Physics, Astrophysics, and Cosmology
Keith Dienes
Nuclear Physics & Nuclear Astrophysics
Brad Keister
Physics of Living Systems
Krastan Blagoev
Gravitational Physics
Pedro Marronetti
Atomic, Molecular, and Optical
Ann Orel
Mathematical Physics
Earle Lomon
Cross-cutting
Physics Frontier Centers
Denise Caldwell
Kathy McCloud
Education and Interdisciplinary Research
Kathy McCloud
Accelerator Physics and Physics Instrumentation
Physics at the Information Frontier
Marv Goldberg,
Brad Keister, Ann Orel

Particle Physics at NSF





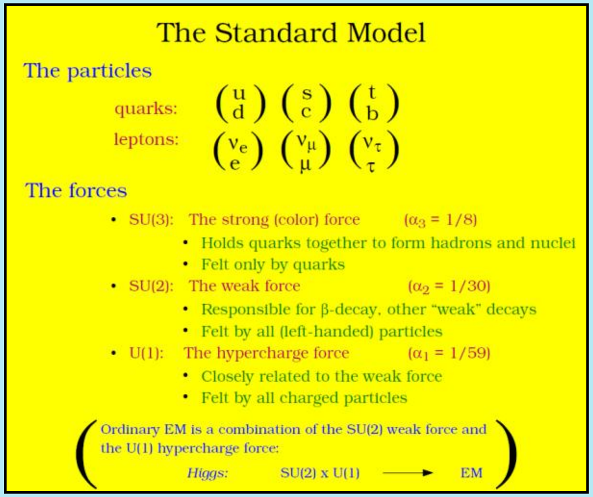
Particle physics is one of several dominant components within the Physics Division portfolio.

We at NSF are very proud of this, as there are excellent reasons why this should be so!

To be blunt:

Several undeniable facts worth repeating:

(my 30-second "elevator speech")

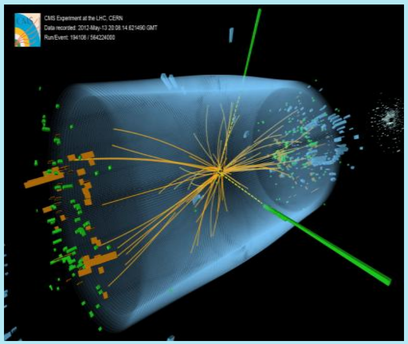


?

- The Standard Model is nothing less than an encapsulation of all of humanity's current knowledge of the fundamental laws of physics. It successfully and compactly describes literally all relevant accelerator data which has ever been collected. Its development is therefore one of the triumphs of 20th-century physics.
- However, for approximately 35 years, our understanding of what might lie ***beyond*** the Standard Model has awaited the development of a new accelerator with sufficient energy to probe more deeply into the structure of matter and its interactions.
- Finally, that wait is over. Nature is "talking" again! This is therefore truly a special time for our field.

The 2010's will be the Decade of the LHC!

Data from the LHC will be truly *transformational.*



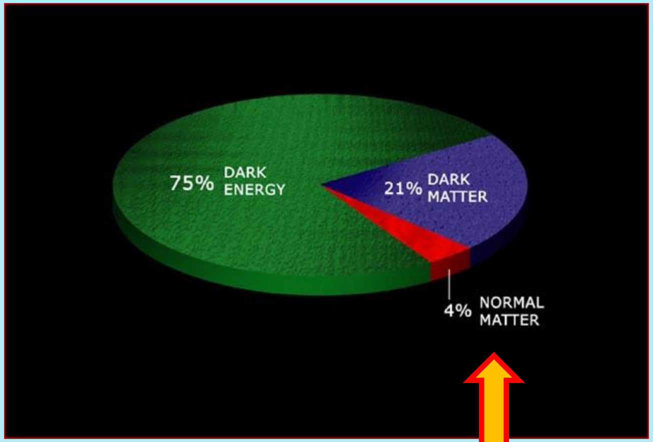
Coming soon to NSF: MPS Distinguished Lecture by Joe Incandela (3/25/2013)

- ***Discovery of the Higgs***: First step towards unravelling the mechanism behind electroweak symmetry breaking and the origins of mass
- ***Direct confrontation with the hierarchy problem***: SUSY, extra dimensions, new kinds of strong interactions… a deeper understanding of *naturalness*

The consequences of these efforts have the potential to reach from present-day energy scales all the way to the highest fundamental energy scales --- namely those associated with grand unification, quantum gravity, and even string theory.

The end result will be nothing less than the establishment of the *next* Standard Model, appropriate for the new energy frontier that the LHC will be exploring.

- Of course, higher energies are not the only way to probe for new physics --- higher *intensities* can also provide an independent window into fundamental physics.
  - Likewise, the Standard Model and the “normal” matter it describes are not all there is. Dark matter and dark energy also transcend the SM, and are dominant slices of the cosmic pie.
  - Finally, particle physics also has increasing synergistic connections to “neighboring” fields
    - e.g., Nuclear physics … strong-interaction physics, heavy ions, quark-gluon plasma, RHIC…
    - Astrophysics and Cosmology … history of the universe and its present-day phenomena



Stars, planets, and ***us***

Many exciting developments await!

As a result, a "golden age" for particle physics has begun and NSF is playing an active role in supporting these efforts.

On the theoretical side, our PI's are developing and investigating most of the theoretical possibilities that will soon be tested…

Program Director
- Keith Dienes

- Alternative Higgs structures (little Higgs, twin Higgs, inert doublet models, etc.)
- New models of dark matter (to explain existing results and interpret upcoming data)
- Studies of metastability (opens up whole new classes of SUSY theories to potential phenomenological relevance)
- AdS/CFT, AdS/QCD, AdS/CondMat (new mathematical techniques for studying theories that were previously beyond calculational accessibility)
- New software codes and refinements for studying collider processes (Pythia, MadGraph, … new emphasis on correctly modeling hadronization and fragmentation, *essential for precision calculations*!) and for studying strong interactions (improved techniques in lattice gauge theory)
- New kinds of gravity theories (DGP, Horava-Lifshitz, …)
- New kinds of particles ("unparticles": scale-invariant even though massive – a new type of matter!)
- New approaches to explaining flavor hierarchies (flavor symmetries, "warped flavor", etc.)
- New kinds of spacetime structures (non-commutativity, M2 branes, Bagger-Lambert theory, …)
- New connections between string theory and inflation (deriving de Sitter vacua from strings, …)
- Neutrino oscillations and implications for various GUT scenarios
- Novel cosmologies (non-thermal histories, new inflationary scenarios, quintessence, alternate theories of structure formation, brane worlds, …)
- Even new approaches to the fundamental "why?" questions (Why three generations? Why four kinds of forces? … Alternative universes, string landscape studies, the cosmological-constant problem…)

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Program Statistics

- 104 grants, including
  - 13 CAREER awards
- 186 PI's and co-PI's
- approx. 50 postdocs
- approx. 50 graduate students
- 29 theory groups of 3 or more PI's
- Program also funds (in whole or in part): Aspen Center for Physics, LHC Theory Initiative, CTEQ collaboration and summer school, String Vacuum Project, TASI summer school

Program Director
- Keith Dienes

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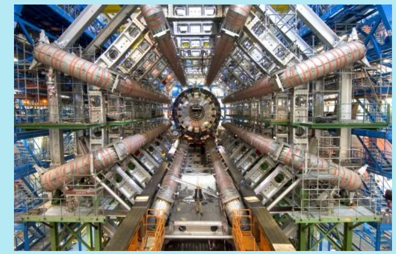
University Theory Groups funded

- UC Berkeley (partial)
- Buffalo
- U. Chicago (partial)
- Cornell
- CUNY City College/Lehman
- Dartmouth
- Harvard
- Institute for Advanced Study (partial)
- UC Irvine
- Johns Hopkins
- U. Kentucky
- U. Maryland
- U. Mass.-Amherst
- U. Miami
- Michigan State (partial)
- Northeastern
- Notre Dame
- NYU
- Penn State (partial)
- U. Pittsburgh (partial)
- Princeton
- UC Santa Barbara
- Stanford
- Stony Brook
- Texas A&M
- UT Austin
- Tufts
- UCLA (partial)
- University of the Pacific

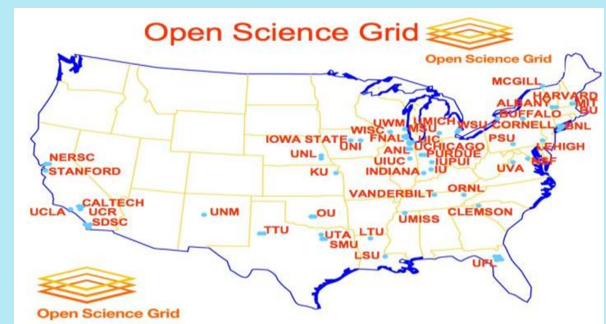
<u>On the experimental HEP side</u>, NSF also funds a rich program which spans all three particle-physics frontiers and transcends international boundaries…

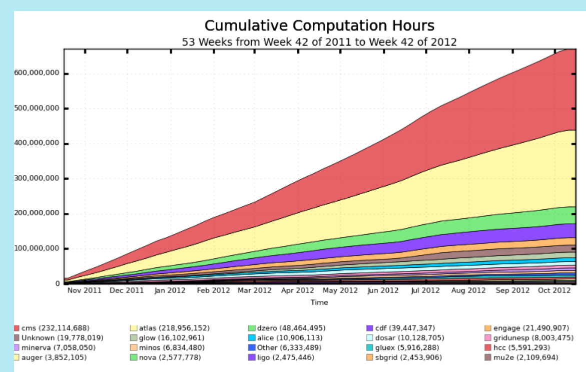
Program Directors
- Marv Goldberg
- Saul Gonzalez
- Randy Ruchti

- LHC (Switzerland/France)
  - Energy frontier (ATLAS, CMS)
  - Intensity/precision frontier (LHCb)
- Neutrino experiments (US, Japan)
  - Neutrino oscillations (MINOS, MINOS+, NOvA, MINERvA, LBNE, SuperK, Mini/MicroBOONE, ARGONeut, …)
- Precision measurements
  - Muon g-2, mu2e (US)
  - Belle-II (Japan), BES-III (China)
- Detector/instrumentation R&D
  - LHC upgrades, ILC, diamond detectors, Large Optical Array, etc.
- Accelerator research
  - CESR TA, muon colliders, plasma acceleration, SRF, etc.
- HEP Computing (Big Data), Data Preservation, Open Access …
  - Open Science Grid
  - Tier II Centers
- Legacy Experiments (US)
  - Tevatron @ Fermilab (CDF, D0)
  - BaBar @ SLAC
  - CLEO-c



ATLAS detector at CERN





On the experimental HEP side, NSF also funds a rich program which spans all three particle-physics frontiers and trans

Program Directors

- Marv Goldberg
- Saul Gonzalez
- Randy Ruchti

Program Statistics

- 49 regular base grants
- 11 CAREER awards
- 181 senior researchers (PI’s and others)
- 104 postdocs
- 176 graduate students

- LHC (Swit
  - Energ
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- Precision r
  - Muon
  - Belle-
- Detector/i
  - LHC upgrade
- Accelerator resea
  - CESR TA, muon colliders, plasma acceleration, SRF, etc.
- HEP Computing (Big Data), Data Preservation, Open Access …
  - Open Science Grid
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  - BaBar @ SLAC
  - CLEO-c

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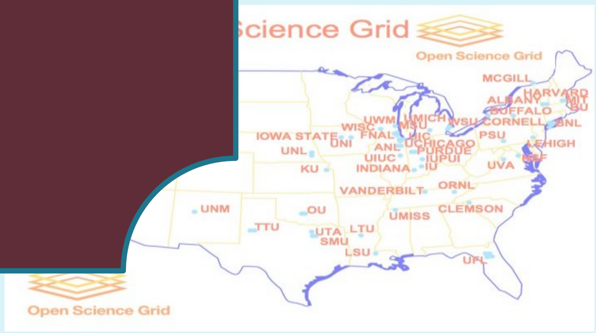
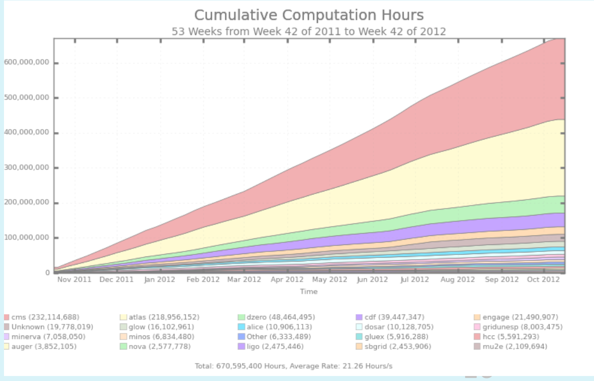
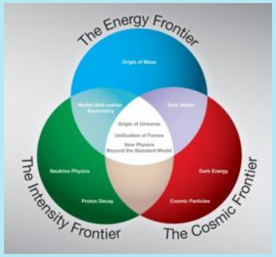




On the experimental PA/Cosmo side, NSF also funds a rich program at both the Cosmic and Intensity Frontiers…



Program Directors

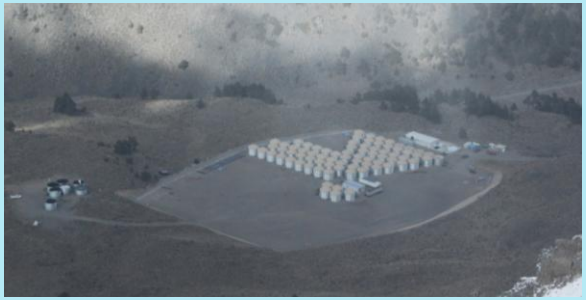
- Jean Cottam Allen
- Jim Whitmore

At the Cosmic Frontier…

- Dark matter
  - Direct detection (underground experiments)
  - Indirect detection (VERITAS, IceCube)
- Dark energy --- Experimental efforts on LSST (NSF/AST–led)
- Cosmology
- High-energy particles (cosmic rays, γ-rays, neutrinos)

At the Intensity Frontier…

- Neutrino mass
- Neutrinoless double beta decay
- Non-accelerator (and solar) neutrinos



HAWC: γ-rays

All to address very fundamental questions…

- What are the origins of the Universe? How did it evolve to its present state?
- What is the particle nature of Dark Matter (and Dark Energy)?
- How can cosmic messengers (cosmic rays, γ-rays, neutrinos) be used to probe the high-energy phenomena of the universe, both nearby and distant (i.e., hot)?
- What are the energy mechanisms at work inside extreme objects (Sun, Earth, supernovae)?
- Complementary methods to address particle-physics questions: Masses and properties of neutrinos? Leptogenesis as origin of CP violation? etc.

On the experimental PA/Cosmo side, NSF also funds a rich program at both the Cosmic and Intensity Frontiers…

Program Directors

…n Cottam Allen Whitmore

At the Cosmic Fr…

- Dark matt…
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  - Indire…
- Dark ener…
- Cosmolog…
- High-ener…

At the Intens…

- Neutrino…
- Neutrino…
- Non-accelera…

Program Statistics

- 134 regular base grants, including
  - 35 under-represented PI's
  - 14 PI's with Ph.D. after 2001
- 8 CAREER awards, including 6 under-represented PI's
- 63.3 postdoc FTE's
- 127 graduate students

HAWC: γ-rays

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- What are the energy mechanisms at work inside extreme objects (Sun, Earth, supernovae)?
- Complementary methods to address particle-physics questions: Masses and properties of neutrinos? Leptogenesis as origin of CP violation? etc.

Moreover, all of our research activities operate in parallel with major community-organized **education/outreach activities**:

- QuarkNet, TheoryNet, Aspen Center for Physics, I2U2 and C3PO, CHEPREO, LHC Theory Initiative, Annual TASI program (grad summer institute), CTEQ summer school, etc..

e.g., QuarkNet in 2012

- LHC Data: to teachers and students through e-Labs and Masterclasses
- Research Experiences and Professional Development
  - *Per year*: 450 teachers, 100 student researchers, 100 physicists

So how do we actually fund all this great stuff?

NSF gets its money from the taxpayers, via annual Congressional allocations…

National Science Foundation
Summary Table
FY 2013 Request to Congress

(Dollars in Millions)

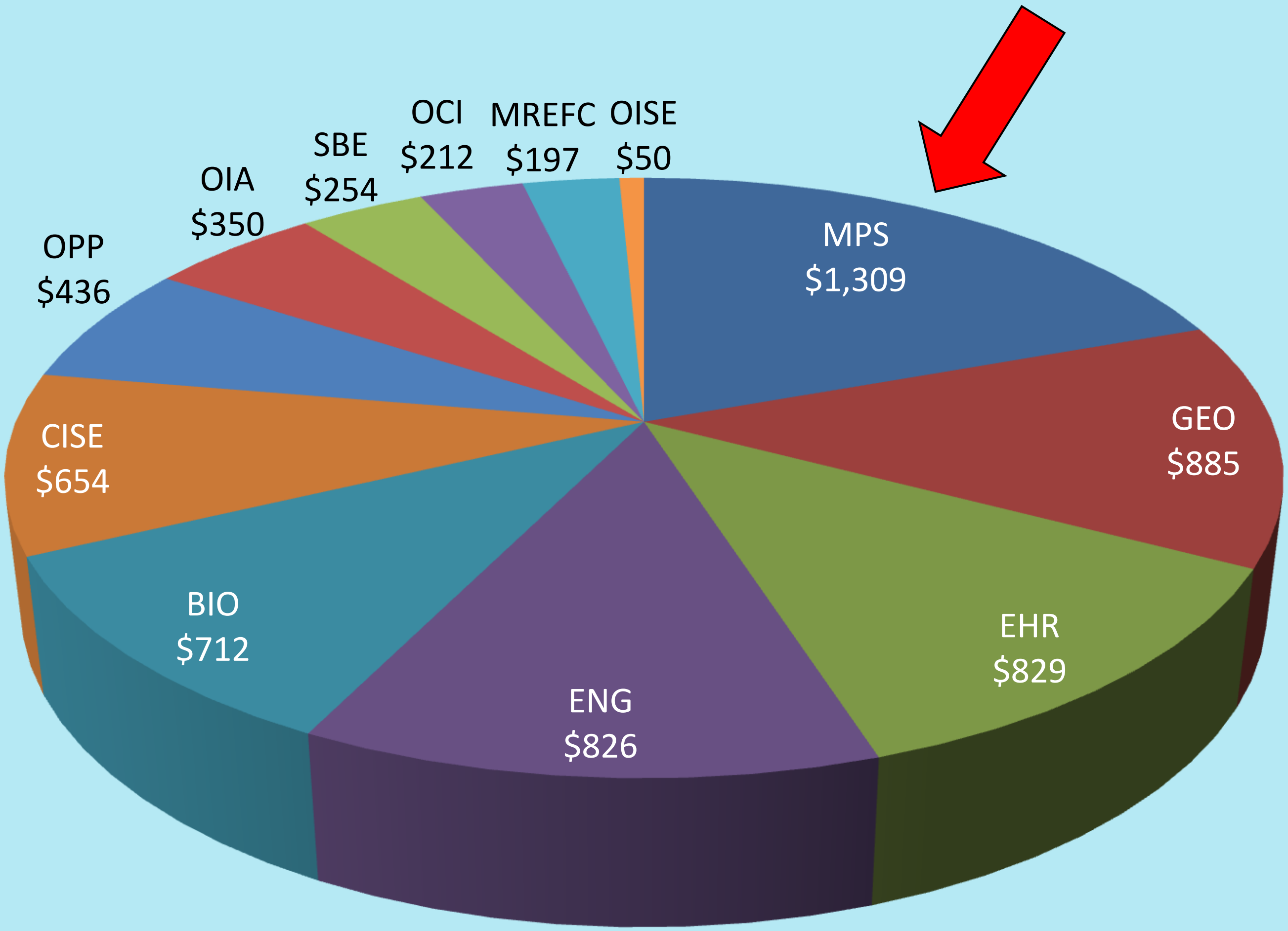
NSF by Account	FY 2011 Actual	FY 2012 Estimate	FY 2013 Request	FY 2013 Request over: FY 2011 Actual Amount	FY 2011 Actual Percent	FY 2012 Estimate Amount	FY 2012 Estimate Percent
BIO	$712.27	$712.38	$733.86	$21.59	3.0%	$21.48	3.0%
CISE	636.06	653.59	709.72	73.66	11.6%	56.13	8.6%
ENG	763.33	826.17	876.33	113.00	14.8%	50.16	6.1%
ENG Programs	*636.86*	*673.41*	*711.13*	*74.27*	*11.7%*	*37.72*	*5.6%*
SBIR/STTR	*126.47*	*152.76*	*165.20*	*38.73*	*30.6%*	*12.44*	*8.1%*
GEO	885.32	885.27	906.44	21.12	2.4%	21.17	2.4%
MPS	1,312.42	1,308.94	1,345.18	32.76	2.5%	36.24	2.8%
SBE	247.33	254.25	259.55	12.22	4.9%	5.30	2.1%
OCI[1]	300.75	211.64	218.27	-82.48	-27.4%	6.63	3.1%
OISE	49.03	49.85	51.28	2.25	4.6%	1.43	2.9%
OPP[2]	440.70	435.87	449.74	9.04	2.1%	13.87	3.2%
IA	259.60	349.59	431.52	171.92	66.2%	81.93	23.4%
U.S. Arctic Research Commission	1.58	1.45	1.39	-0.19	-11.8%	-0.06	-4.1%
Research & Related Activities	**$5,608.38**	**$5,689.00**	**$5,983.28**	**$374.90**	**6.7%**	**$294.28**	**5.2%**
Education & Human Resources	**$861.04**	**$829.00**	**$875.61**	**$14.57**	**1.7%**	**$46.61**	**5.6%**
Major Research Equipment & Facilities Construction	**$125.37**	**$197.06**	**$196.17**	**$70.80**	**56.5%**	**-$0.89**	**-0.4%**
Agency Operations & Award Management	**$299.29**	**$299.40**	**$299.40**	**$0.11**	**0.0%**	-	-
National Science Board	**$4.47**	**$4.44**	**$4.44**	**-$0.03**	**-0.7%**	-	-
Office of Inspector General	**$13.92**	**$14.20**	**$14.20**	**$0.28**	**2.0%**	-	-
OIG FY 2011 ARRA Obligations	$0.08	-	-	-	-	-	-
Total, NSF	**$6,912.55**	**$7,033.10**	**$7,373.10**	**$460.55**	**6.7%**	**$340.00**	**4.8%**

Totals may not add due to rounding.

[1] FY 2011 Actual for OCI includes $90.50 million in funds that were obligated in FY 2010, deobligated in FY 2011, and then obligated in FY 2011 to other projects in the OCI portfolio.

[2] Funding for OPP for FY 2011 excludes a one-time appropriation transfer of $53.892 million, $54.0 million less the 0.2% rescission, to U.S. Coast Guard per P.L. 112-10.

NSF 2012 Budget ($7.034 M)

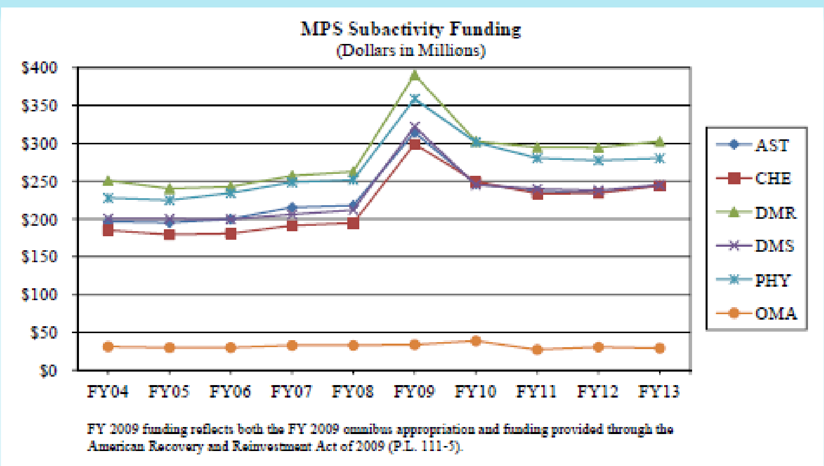


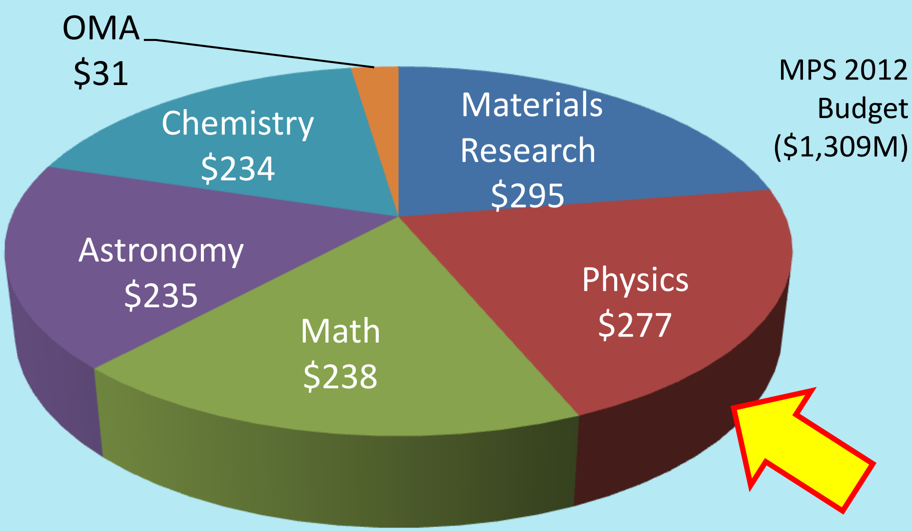
And then that money flows through MPS….

MPS Funding
(Dollars in Millions)

	FY 2011 Actual	FY 2012 Estimate	FY 2013 Request	Change Over FY 2012 Estimate Amount	Change Over FY 2012 Estimate Percent
Division of Astronomical Sciences (AST)	$236.78	$234.55	$244.55	$10.00	4.3%
Division of Chemistry (CHE)	233.55	234.06	243.85	9.79	4.2%
Division of Materials Research (DMR)	294.91	294.55	302.63	8.08	2.7%
Division of Mathematical Sciences (DMS)	239.79	237.77	245.00	7.23	3.0%
Division of Physics (PHY)	280.34	277.37	280.08	2.71	1.0%
Office of Multidisciplinary Activities (OMA)	27.06	30.64	29.07	-1.57	-5.1%
Total, MPS	**$1,312.42**	**$1,308.94**	**$1,345.18**	**$36.24**	**2.8%**

Totals may not add due to rounding.





And finally through the Physics Division to particle physics…

EPP/PA/THY Budgets FY08-12 ($M)

		FY08 Actuals	FY09 Omnibus Actuals	FY09 ARRA Actuals	FY10 Actuals	FY11 Actuals	FY12 Actuals
Experimental EPP	EPP Base Program	20.45	18.79	13.99	25.79	25.03	24.7
	LHC Ops	18	18		18	18	18
	CESR	13.71	8.5	1.29			
	Accel/Instrumentation	4	2.2		2.98	4.05	
Experimental Particle Astro	PA Base Program	15.83	15.93	15.31	17.88	19.19	11.47
	IceCube Ops	1.5	2.15		2.15	3.45	3.45
	DUSEL Planning	2	22		28.91	10.19	
	DUSEL R&D	4.96	4	5.57	4.59		
	Underground Physics					4.59	17.29
Combined Theory	THY: EPP+Astro/Cosmo	11.68	11.99	6.8	13.2	14.12	13.59
	Physics Frontier Centers	6.26	5.93		5.93	6.03	6.04
Total Particle Physics Programs	**EPP/PA/THY Sum**	**98.39**	**109.49**	**42.96**	**119.43**	**104.65**	**94.54**
	Ref: NSF PHY Division	285.03	275.5	102.13	307.83	280.34	277.37
	% of PHY to EPP/PA/THY	34.5%	39.7%	42.1%	38.8%	37.3%	34.1%
	Allied Funding	7.15	4.91	0.54	12.68	7.54	30.3
Total Particle Physics	**EPP/PA/THY Total**	**105.54**	**114.4**	**43.5**	**132.11**	**112.19**	**124.84**

Allied Funding:

Adding Value to our Particle-Physics Investment through Outside Partnerships

- Education & Interdisciplinary Research
  - QuarkNet
  - CHEPREO
  - Planetarium Show
  - Feature-length Video Documentary (“Particle Fever”)
  - REU programs

– Physics Division
  - BP - Broadening Participation
  - EIR - Education & Interdisciplinary Research
  - PIF - Physics at the Information Frontier

– OMA – Multidisciplinary Activities

– OCI – Cyberinfrastructure

– OISE – International

– EHR -- Education and Human Resources

– Other agencies (e.g., DOE)

- OMA -- Broadening Participation
  - AGEP Graduate Supplements

- Cyber Infrastructure
  - Open Science Grid
  - DASPOS
  - ISGTW

- International
  - Partnerships in International Science and Engineering
  - Particle Physics School
  - Grid School
  - Accelerator School

Despite our best efforts, there is never enough funding to support all that we would like to see happen.

Moreover, we are likely to be facing some very challenging funding years and a rather austere future fiscal climate.

Protecting our core scientific program and keeping it healthy must therefore remain our primary concern…

Theory Program: Financial Stresses and Goals

- As always, these programs are under severe financial stress.
  - E.g., new faculty start at $40-$50K/year for top people (others, nothing):   Barely covers summer salary. No grads, no postdocs. While startup funds exist, they are rapidly depleted within first 2-3 years, yet "ramp-up" time has become increasingly long (often a full decade or more!).
- Emerging "systemic" problems
  - University TA cutbacks are stranding HEP theory grads! Unlike other fields, HEP theory grads especially vulnerable to local TA budgets.   ***Must reinforce this talent supply.***
  - NSF versus DOE:
    - » **Need clear policies/expectations regarding overlapping funding situations,** CAREER/Early CAREER awards versus "regular" grants, while avoiding "double dipping"
    - » Funding levels are not always commensurate across agencies. ***CAREER awards, in particular, are becoming deeply problematic for NSF.***
- Goals for short and long terms…
  - Establish and deploy "emergency" fund for grad-student support, **slowly build appropriate levels of grad-student support into long-term grant profiles.**
  - **Establish a higher minimum floor for starting grant sizes and increase grant sizes for mid-career physicists whose funding levels have been frozen since their junior-faculty days.**
  - Possible new initiatives:
    - » **Theory Initiative for Underground Science/ Intensity Frontier** (analogue of LHC-TI)
    - » **International "Network" (LHC?) Collaborations** --- partner with NSF's SAVI (Science Across Virtual Institutes) program?