NSF Perspective

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Division of Physics

NSAC
March 2, 2006

An Irreducible Set of Strategic Goals

- **Intellectual Frontiers**
- **Broader Impacts**
- **Education**
- **Stewardship**

PHYSICS* FRONTIERS, *circa* 2006

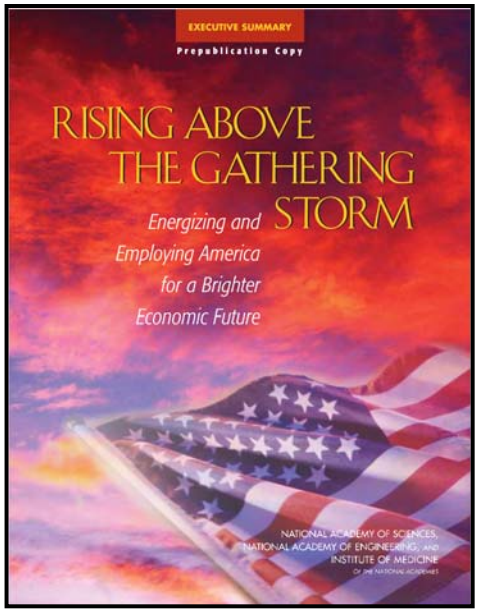
- Bose-Einstein Condensates, Atom "Lasers"
- Dark Matter, Dark Energy, Cosmology
- Gravitational Waves (GW), GW Astronomy
- New Fundamental Particles and Laws > TeV
- ν physics and astrophysics
- String Theory, Branes, Duality, Quantum Gravity
- Quark-Gluon Plasma, Supernova Dynamics
- Ultra-Fast, Ultra-Intense Laser Fields
- Cyberscience, Quantum Information Science
- Biophysics of Single Molecules, Cells, Networks
- Complexity, Emergent Behavior

*** CMP in Division of Materials Research**

INVESTMENT GOALS

- Dramatic scientific advances that alter the course of physics and other fields
- Seeds of major advances in nation's health (Varmus), wealth (Solow), and defense (Hart-Rudman) [Rising Above the Gathering Storm]
- International leadership/cooperation across the intellectual frontiers of science
- Recruitment of exceptional talent into science (education, outreach, and early inspiration)
- Production of highly trained professionals for the nation's workforce
- Significantly increase diversity in science

SUMMARY OF RECOMMENDATIONS: Rising Above the Gathering Storm



RECOMMENDATION A: Increase America's talent pool by vastly improving K–12 science and mathematics education.

RECOMMENDATION B: Sustain and strengthen the nation's traditional commitment to long-term basic research that has the potential to be transformational to maintain the flow of new ideas that fuel the economy, provide security, and enhance the quality of life.

Action B-1: Increase the federal investment in long-term basic research by 10% a year over the next 7 years.

Action B-5: Create in the Department of Energy (DOE) an organization like the Defense Advanced Research Projects Agency (DARPA) called the Advanced Research Projects Agency-Energy (ARPA-E).

RECOMMENDATION C: Make the United States the most attractive setting in which to study and perform research so that we can develop, recruit, and retain the best and brightest students, scientists, and engineers from within the United States and throughout the world.

Action C-1: Increase the number and proportion of US citizens who earn physical-sciences, life-sciences, engineering, and mathematics bachelor's degrees by providing 25,000 new 4-year competitive undergraduate scholarships each year to US citizens attending US institutions.

RECOMMENDATION D: Ensure that the United States is the premier place in the world to innovate; invest in downstream activities such as manufacturing and marketing; and create high-paying jobs that are based on innovation by modernizing the patent system, realigning tax policies to encourage innovation, and ensuring affordable broadband access.

The American Competitiveness Initiative

"Tonight I announce the American Competitiveness Initiative to encourage innovation throughout our economy and to give our nation's children a firm grounding in math and science. First, I propose to double the federal commitment to the most critical basic research programs in the physical sciences over the next 10 years. This funding will support the work of America's most creative minds as they explore promising areas such as nanotechnology, supercomputing and alternative energy sources."

State of the Union Address
Tuesday, January 31, 2006

NSF and the American Competitiveness Initiative

NSF and MPS are Driving Forces Behind American Innovation

- **NSF funds basic research at the frontier – from fundamental discoveries about Nature to breakthroughs that are almost ready for the marketplace**

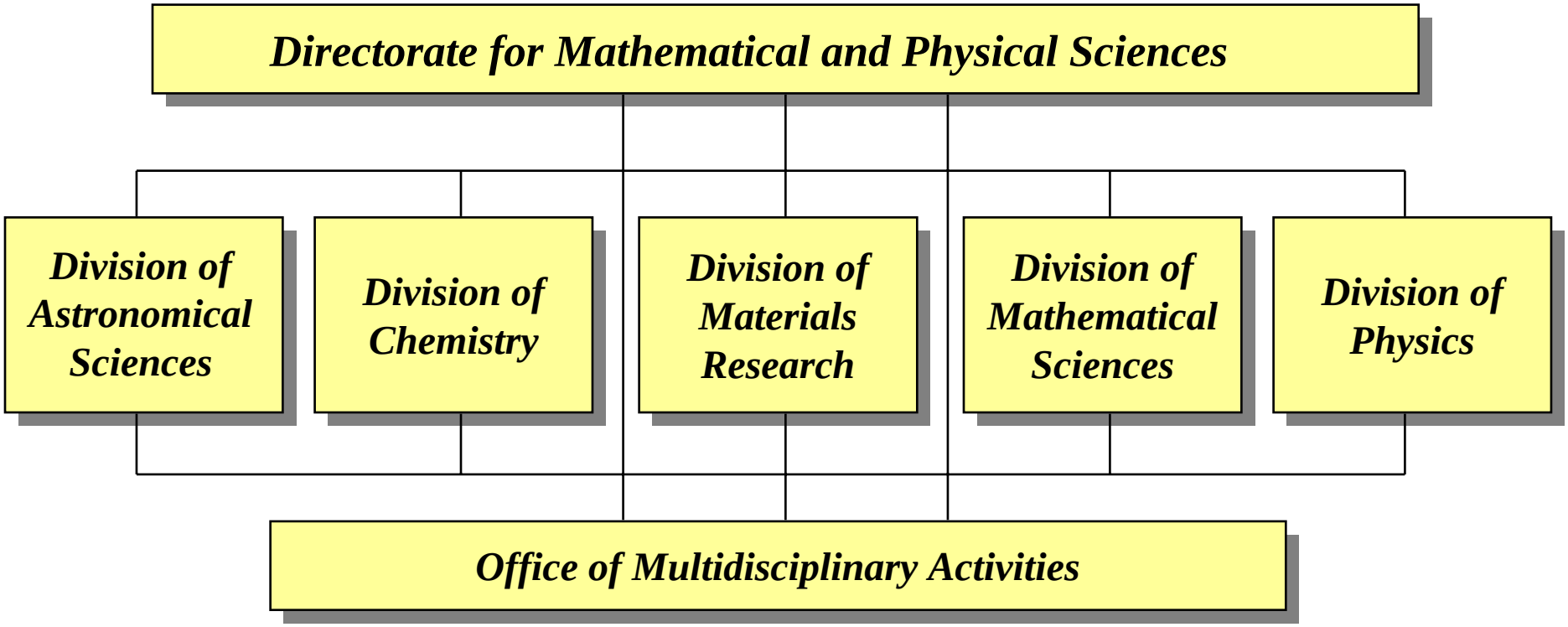
- **NSF-funded research inspires and provides training for the next generation of scientists and engineers**

… this motivates doubling NSF's investment in the Physical Sciences over the next ten years

NSF FY07 Priorities

- **Advancing the Frontier (grant support)**
- **Facility Stewardship, Instrumentation and CyberInfrastructure**
- **Broadening Participation**
- **Education and Workforce Development**

Directorate for Mathematical and Physical Sciences



Advancing the Frontier

Elementary Particle Physics ***(EPP),*** **fundamental research across**

(1) the energy frontier – the attempt to discover new fundamental particles and laws of physics by studying collisions at the highest energies achievable with current and future accelerators;

(2) the neutrino frontier – exploration of the properties of the neutrino, a particle now known to carry mass and believed to be fundamental to understanding the developing universe; and

(3) the cosmic frontier – the study of dark matter and dark energy.

Physics of the Universe ***(POU),*** **a set of activities carried out in partnership with DOE and NASA for exploring**

- **the mysteries of dark matter and dark energy;**
- **the earliest phases in development of the universe;**
- **the fundamental nature of time, matter and space; and**
- **the role of gravitation.**

Advancing the Frontier

Fundamental mathematical and statistical science, **strengthening the core of the Mathematical Sciences Priority Area and enable effective partnering across NSF as well as with NIH and DARPA.**

Physical sciences at the nanoscale, **the foundation for innovative nanoscale technologies in partnership with other NSF organizations and the government-wide National Nanotechnology Initiative.**

Cyberinfrastructure and the cyberscience it enables, **connecting with NSF's high priority activities in this area and the government-wide Networking and Information Technology R&D activities.**

Molecular basis of life processes, **study of complex biological systems in areas such as self-assembly of disordered collections of molecules into the elements of living systems; protein folding; membranes; and emergence of physiological processes such as breathing and thinking out of complex, coupled arrays of individual reactions.**

Sustainability, **areas that link the physical sciences with environmental sustainability, including green chemistry, water chemistry and energy.**

MPS FY07 Budget Highlights

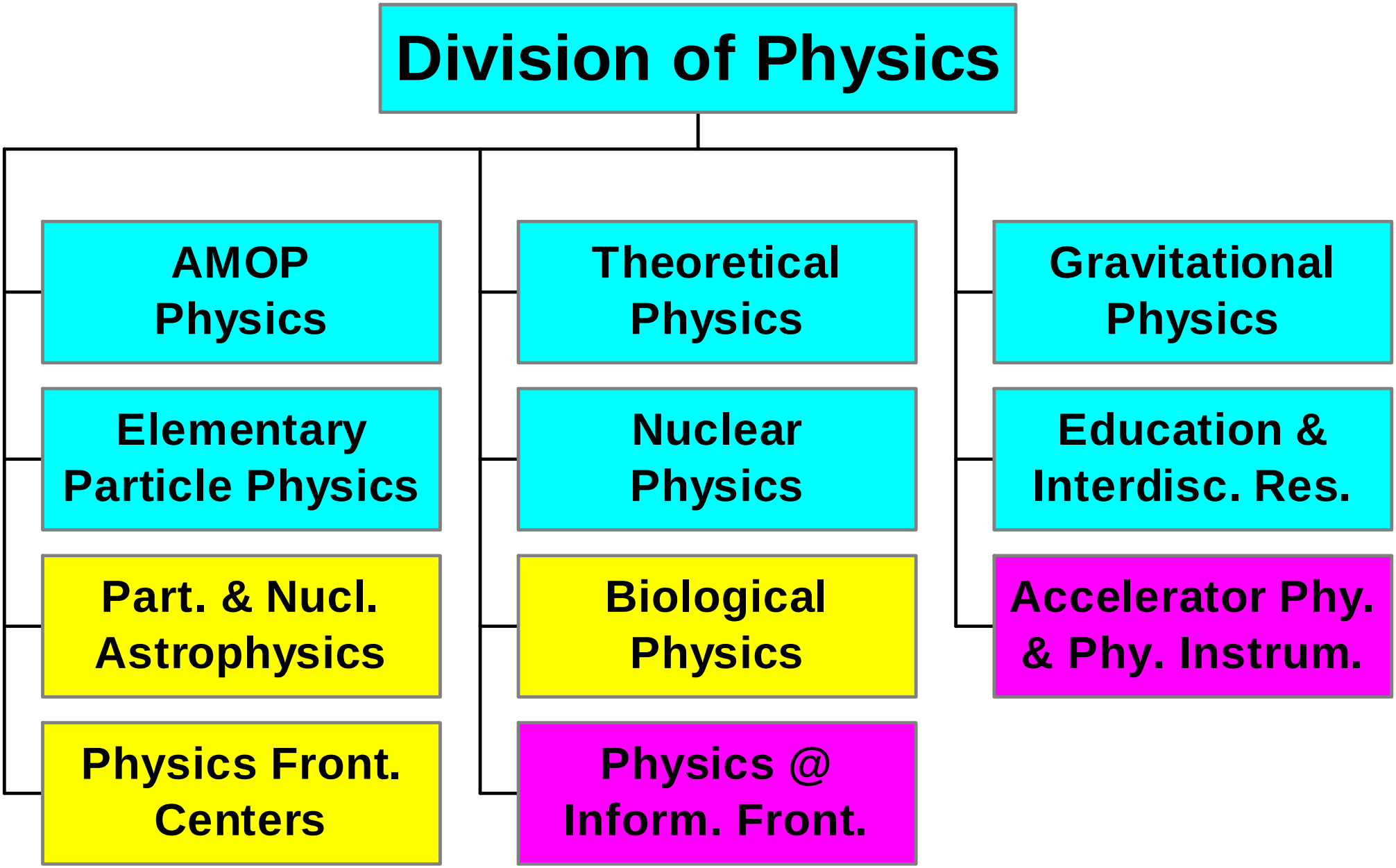
+$65M (6%) Over FY06 Current Plan to $1.15B

- Increased support for the grants programs (great discovery machine) across the Divisions (AST: 13%; PHY: 6.4%; CHE: 5.5%; DMR: 5%; and DMS: 3%)
- New investment in Elementary-particle Physics frontier activities ($5M in FY06 to $15M in FY07 and beyond)
- Increased support for Nanoscale Science ($14.9M) and Cyber activities ($4.3M), NB: $50M in OCI toward a petascale capability
- Increased support for Physics of the Universe activities ($8.5M) in AST, PHY
- Increased support for Molecular Basis of Life Activities ($9.4M in CHE, DMR, PHY)
- Increased support for facility operations: LHC ($4.6M), Gemini ($1.7M), LIGO ($1.3M), CESR ($0.15M) and early operations for ALMA ($2M)
- Increased support for public/private partnership in optical/IR ($1.1M for AODP, $2M for TSIP)
- Increased support for Materials mid-scale instrumentation ($1M) and Astronomy ATI ($3.7M)
- Design and development funding for GSMT ($5M), continued funding for Energy Recovery Linac (ERL), DUSEL and LSST
- Increased support for Participation and Education/Workforce Activities ($8.5M)

MPS Facilities

(Dollars in Millions)

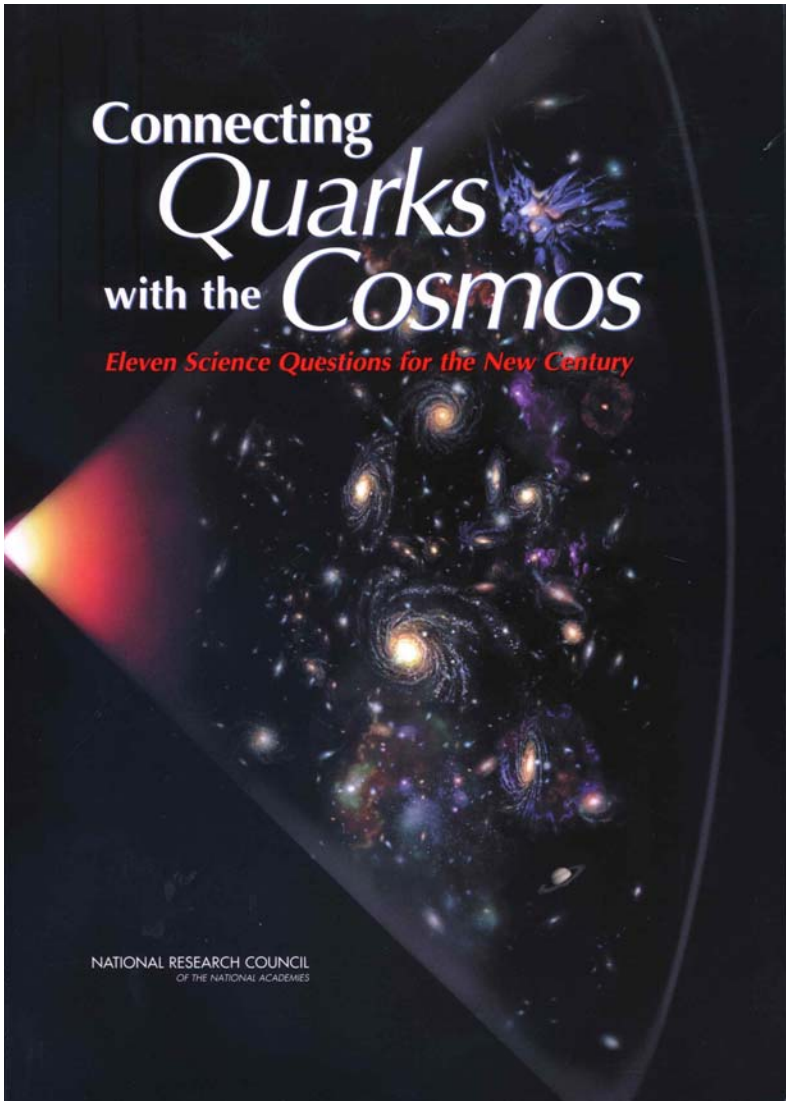
Facilities	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Cornell Electron Storage Ring (CESR)	16.62	14.56	14.71	0.15	1.0%
GEMINI Observatory	15.48	18.26	20.00	1.74	9.5%
Large Hadron Collider (LHC)	10.51	13.36	18.00	4.64	34.7%
Laser Interferometer Gravitational Wave Observatory (LIGO)	32.00	31.68	33.00	1.32	4.2%
MSU Cyclotron	17.50	17.32	17.60	0.28	1.6%
Nanofabrication (NNUN/NNIN)	2.80	2.77	2.80	0.03	1.1%
National High Magnetic Field Laboratory (NHMFL)	25.50	25.74	26.50	0.76	3.0%
Rare Symmetry Violating Processes (RSVP)	2.65	0.99	-	-0.99	-100.0%
National Astronomy and Ionosphere Center (NAIC)	10.52	10.46	10.46	-	-
National Center for Atmospheric Research (NCAR)	1.04	1.12	1.12	-	-
National Optical Astronomy Observatories (NOAO)	37.94	36.91	40.05	3.14	8.5%
National Radio Astronomy Observatory (NRAO)	47.03	50.74	50.74	-	-
Other MPS Facilities	13.49	12.31	12.47	0.16	1.3%
Total, MPS	**$233.08**	**$236.22**	**$247.45**	**$11.23**	**4.8%**


Division of Physics
AMOP Physics
Elementary Particle Physics
Part. & Nucl. Astrophysics
Physics Front. Centers
Theoretical Physics
Nuclear Physics
Biological Physics
Physics @ Inform. Front.
Gravitational Physics
Education & Interdisc. Res.
Accelerator Phy. & Phy. Instrum.

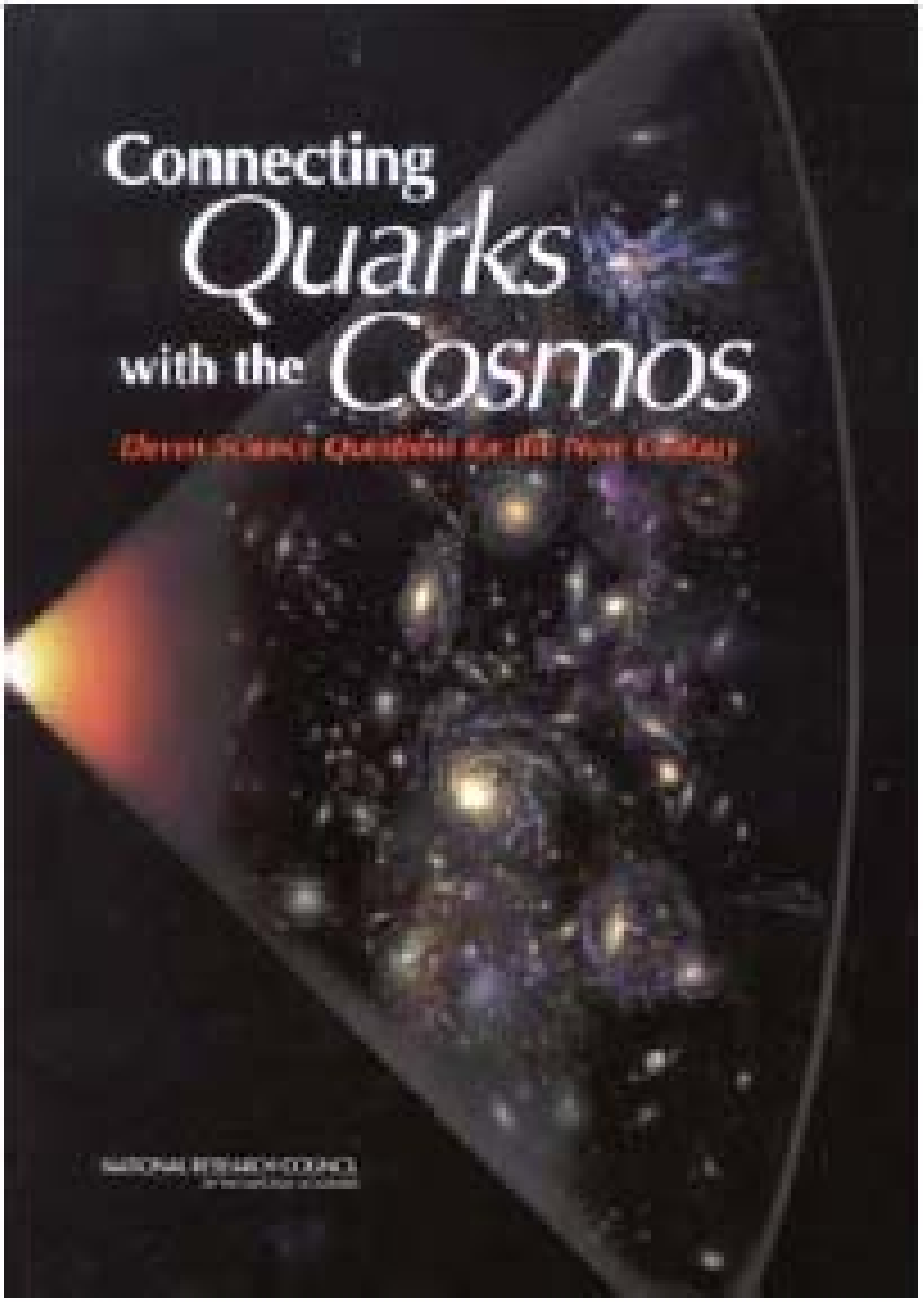
PRIORITIES for FY 2006+

- Strong, flexible core programs (GDM, >50% of PHY budget)
- Physics of the Universe (10%/yr)
- Increase diversity (10%/yr)
- Strengthen theory (5%/yr)
- Stewardship of facilities
- Cultivate new opportunities, e.g., Biological Physics, Physics at the Information Frontier, DUSEL…

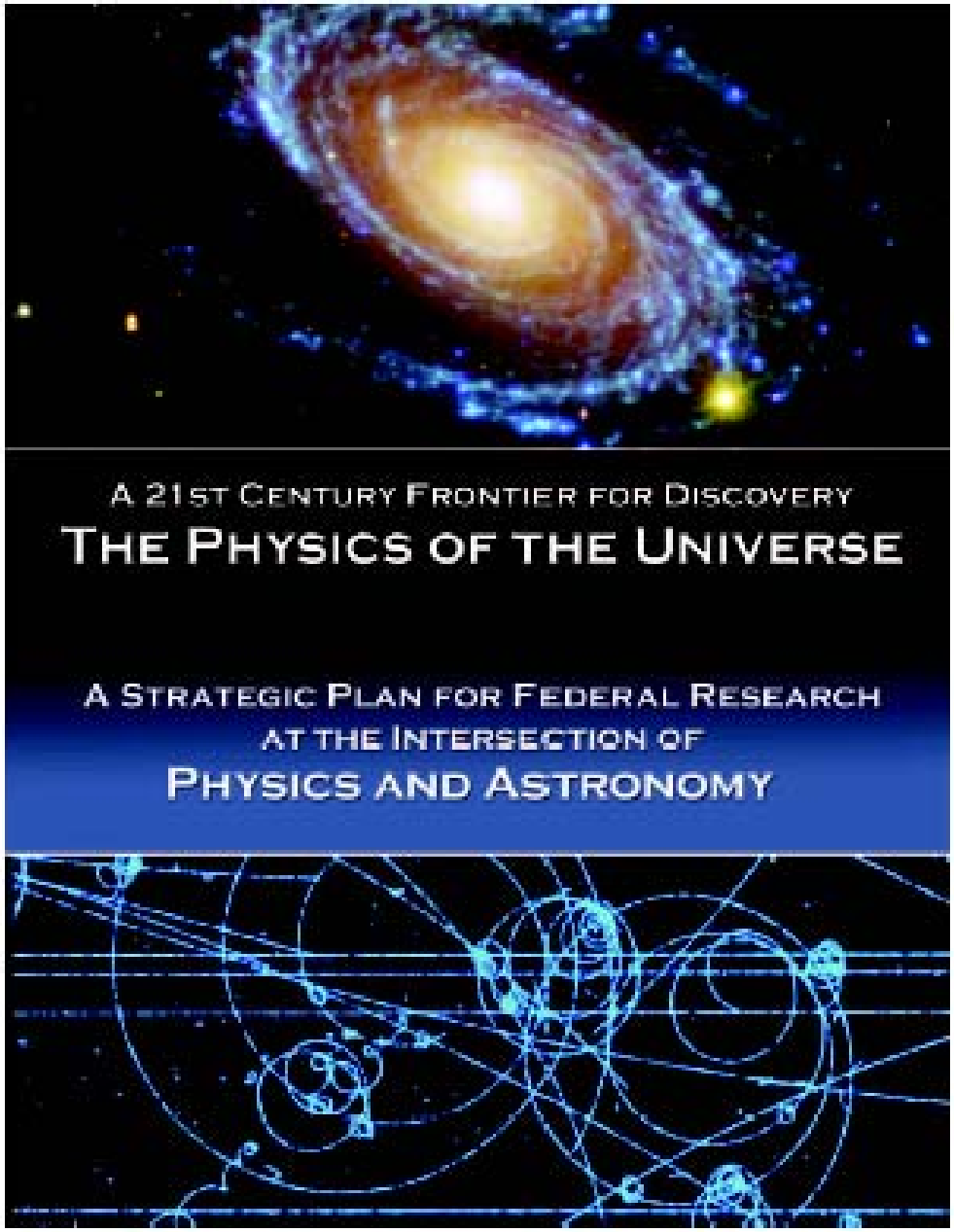
Connecting quarks with the Cosmos—11 Questions For The 21st Century



- What is dark matter?
- What is dark energy?
- How did the universe begin?
- Was Einstein right about gravity?
- How have ν shaped the universe?
- What are nature's most energetic particles?
- Are protons stable?
- Are there new states of matter at exceedingly high density/energy?
- Are there additional dimensions?
- How were elements Fe to U made?
- Is a new theory needed at the highest energies and EM Fields?



www.nap.edu



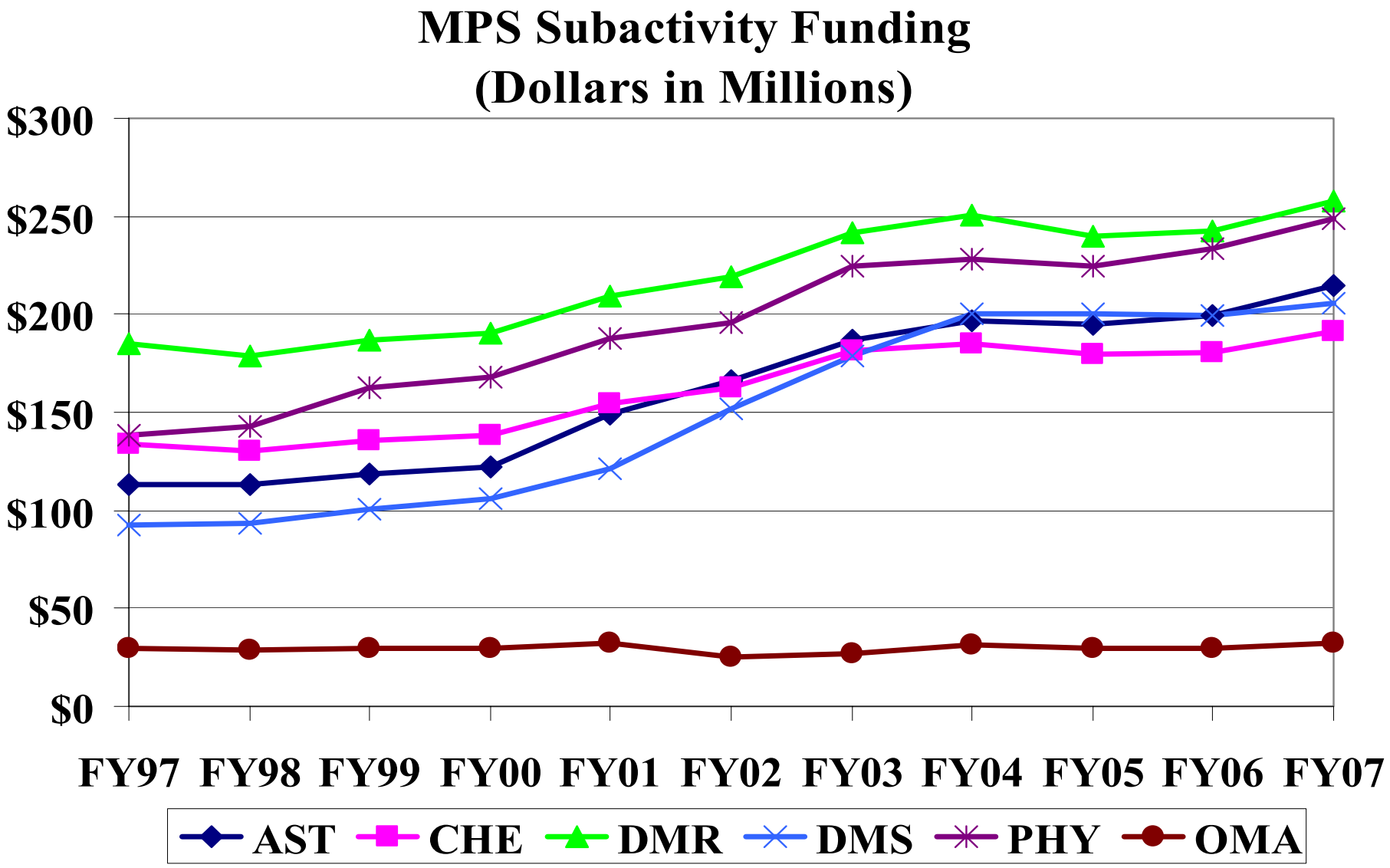
http://www.ostp.gov/nstc/html/NSTC_Home.html

Budget Request for FY 2007

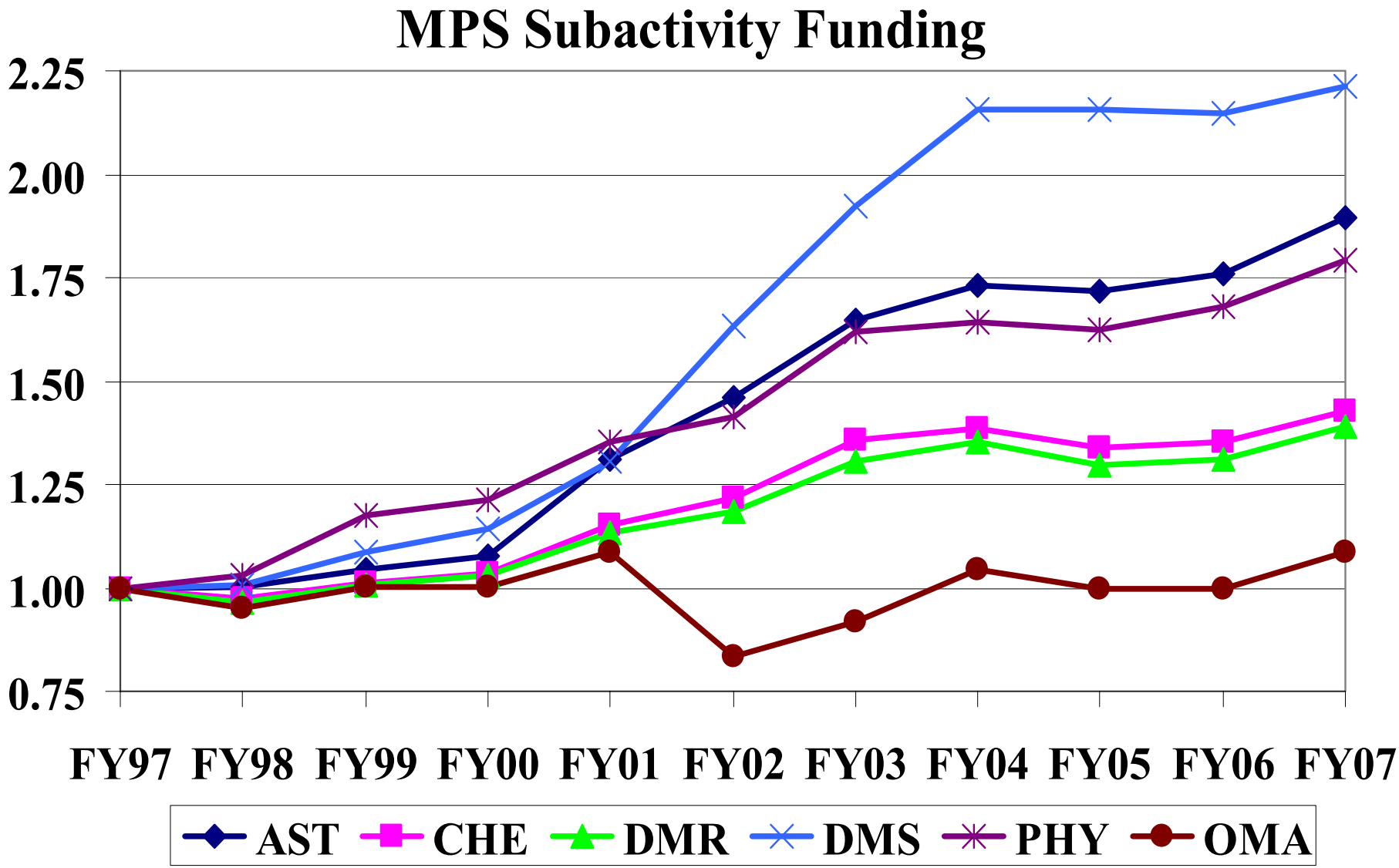
(Dollars in Millions)

	FY 2004 Actuals	FY 2005 Actuals	Change from 04 to 05	FY 2006 Current Plan	Change from 05 to 06	FY 2007 Request	Change from 06 to 07
AST	196.63	195.11	-0.8%	199.65	2.3%	215.11	7.7%
CHE	185.12	179.26	-3.2%	180.78	0.8%	191.10	5.7%
DMR	250.65	240.09	-4.2%	242.91	1.2%	257.45	6.0%
DMS	200.35	200.24	-0.1%	199.30	-0.5%	205.74	3.2%
PHY	227.77	224.86	-1.3%	233.13	3.7%	248.50	6.6%
OMA	31.07	29.80	-4.1%	29.68	-0.4%	32.40	9.2%
Total, MPS	1,091.59	1,069.36	-2.0%	1085.45	1.5%	1150.30	6.0%
R&RA	4293.34	4234.82	-1.4%	4,331.48	2.3%	4,665.95	7.7%
NSF	5652.01	5480.78	-3.0%	5,581.17	1.8%	6,020.21	7.9%

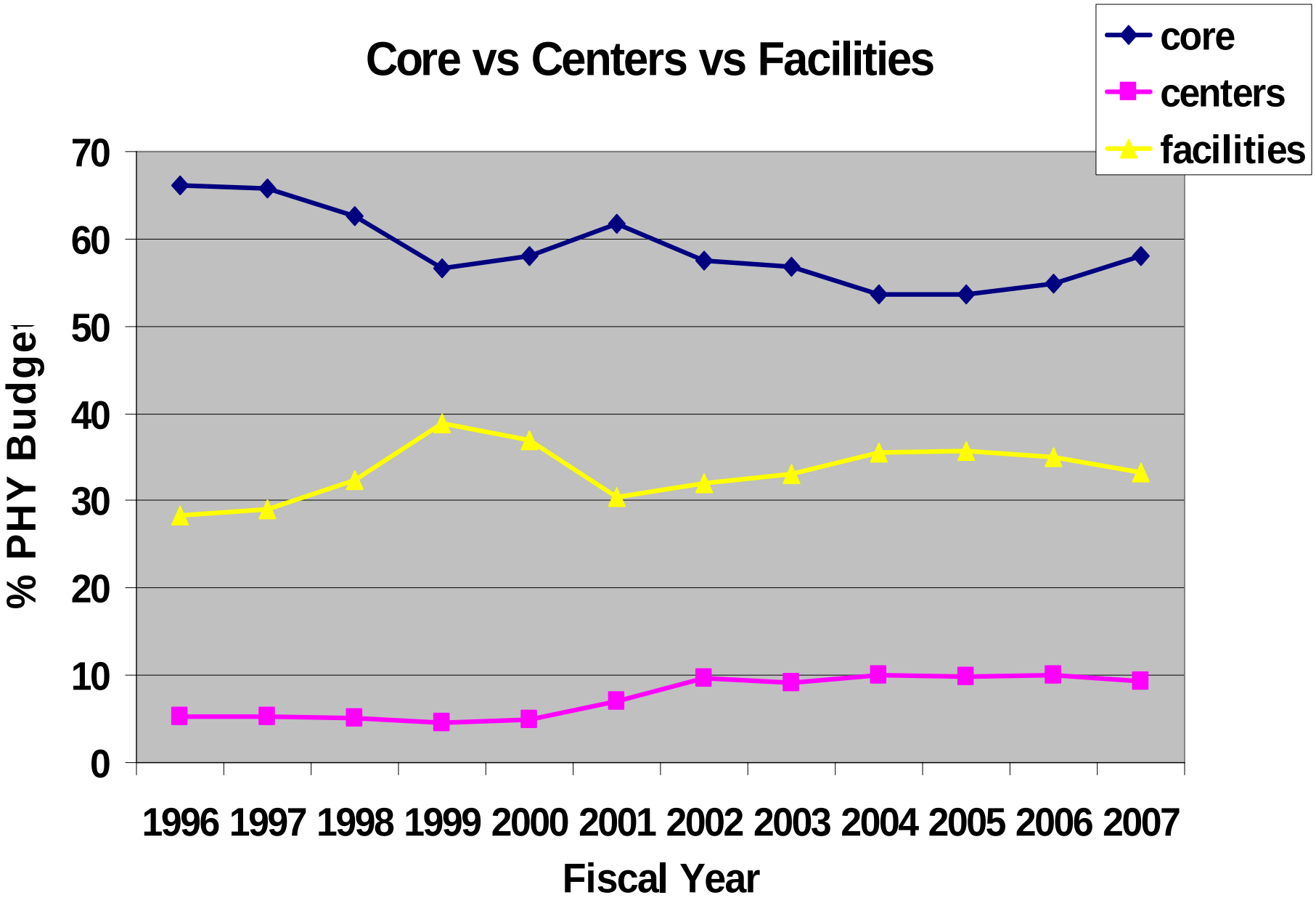
Ten-Year Funding History



Ten-Year Funding History



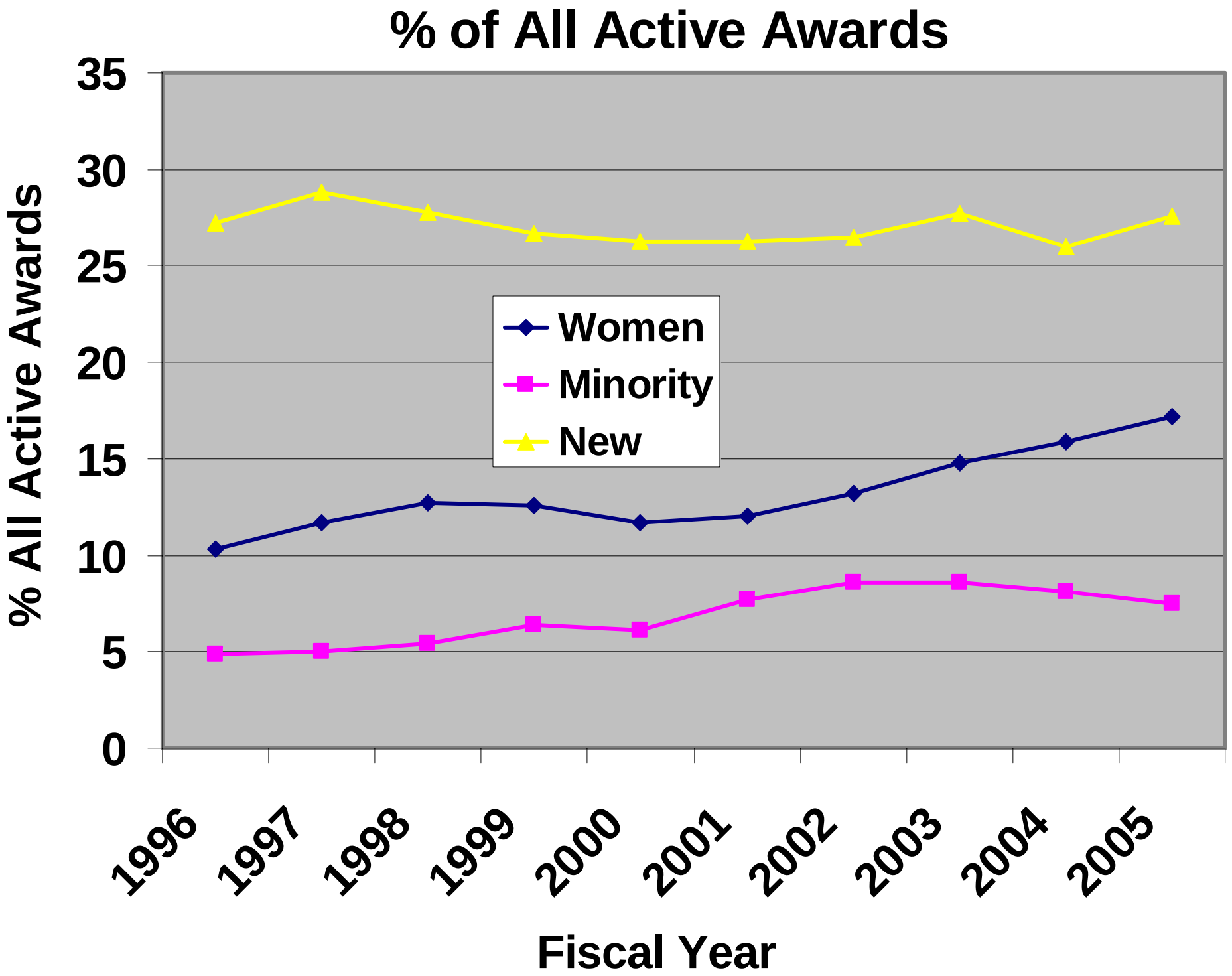
Budget sectors over time



Personnel on Awards (FY 05)

- **Senior Personnel** **969**
- **Active awards** **664**
- **Postdocs** **536**
- **Other Professionals** **370**
- **Graduate Students** **997**
- **Undergraduate Students** **419***

***Plus about 500 at REU Sites**


% of All Active Awards
% All Active Awards
35
30
25
20
15
10
5
0
Women
Minority
New
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Fiscal Year

DUSEL

- **DUSEL = Deep Underground Science and Engineering Lab**
- **Interdisciplinary Scope: particle physics, nuclear physics, astrophysics, geosciences, engineering, biosciences, industry, defense**
- **Physics would benefit from lowest cosmic ray flux possible anywhere**
- **Proton decay, neutrinoless double beta decay, dark matter detection, long-baseline neutrino experiments, solar and supersovae neutrinos, low-energy nuclear cross sections for nucleosynthesis research, etc.**

Community Planning Activities

Bahcall report (2001): NSF-DOE sponsored ad hoc committee of scientists strongly recommended that Homestake Mine

NSAC Long-Range Plan (2002): Strongly supported development of an underground laboratory to enable some aspects of nuclear research, e.g., double beta decay.

NESS 2002: An NSF sponsored conference on Underground Science showcases the wide variety of science that would be enabled with an underground laboratory.

Connecting Quarks to the Cosmos (2003): Known as Turner Report, NRC panel recommended development of an underground laboratory to enable a number of fundamental science experiments.

HEPAP Long-Range Plan (2003): Supported development of an underground laboratory to enable some aspects of high energy research, e.g., long baseline neutrino detector and proton decay

Neutrinos and Beyond (2003): Known as Barish Report, OSTP charged NRC panel emphasized neutrino physics, much of which requires an underground laboratory; placed in international context.

EarthLab 2003: An NSF sponsored report of the GeoSciences and GeoEngineering opportunities that would be enabled by an underground laboratory.

Physics of the Universe—A Strategic Plan for Federal Research at the Intersection of Physics and Astronomy (NSTC) 2004: Strongly supported development of an underground laboratory for science and engineering

Quantum Universe—The Revolution in 21st Century Particle Physics, 2004: NSF-DOE HEPAP Sub Panel report identifies key science drivers and indicates need for DUSEL to address key questions

A lot more activity in 2005: NuSAG (HEPAP, NSAC, AAAS sub panel), Dark Matter sub panel…

Process, from March 2004

- Prehistory from ~ 1960s (Ray Davis Nobel Prize)
- Town Meeting at NSF, March 2004
- Solicitation (S1) to define site-independent science scope, infrastructure needs, and unify the community
- Solicitation (S2) to develop conceptual designs for specific sites
- Solicitation (S3) to do full technical design
- Could lead to MREFC candidate for FY 09