NSF Division of Physics

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BPA

April 21, 2006

An Irreducible Set of Strategic Goals

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

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), Gathering Storm, President's ACI
- 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

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.**

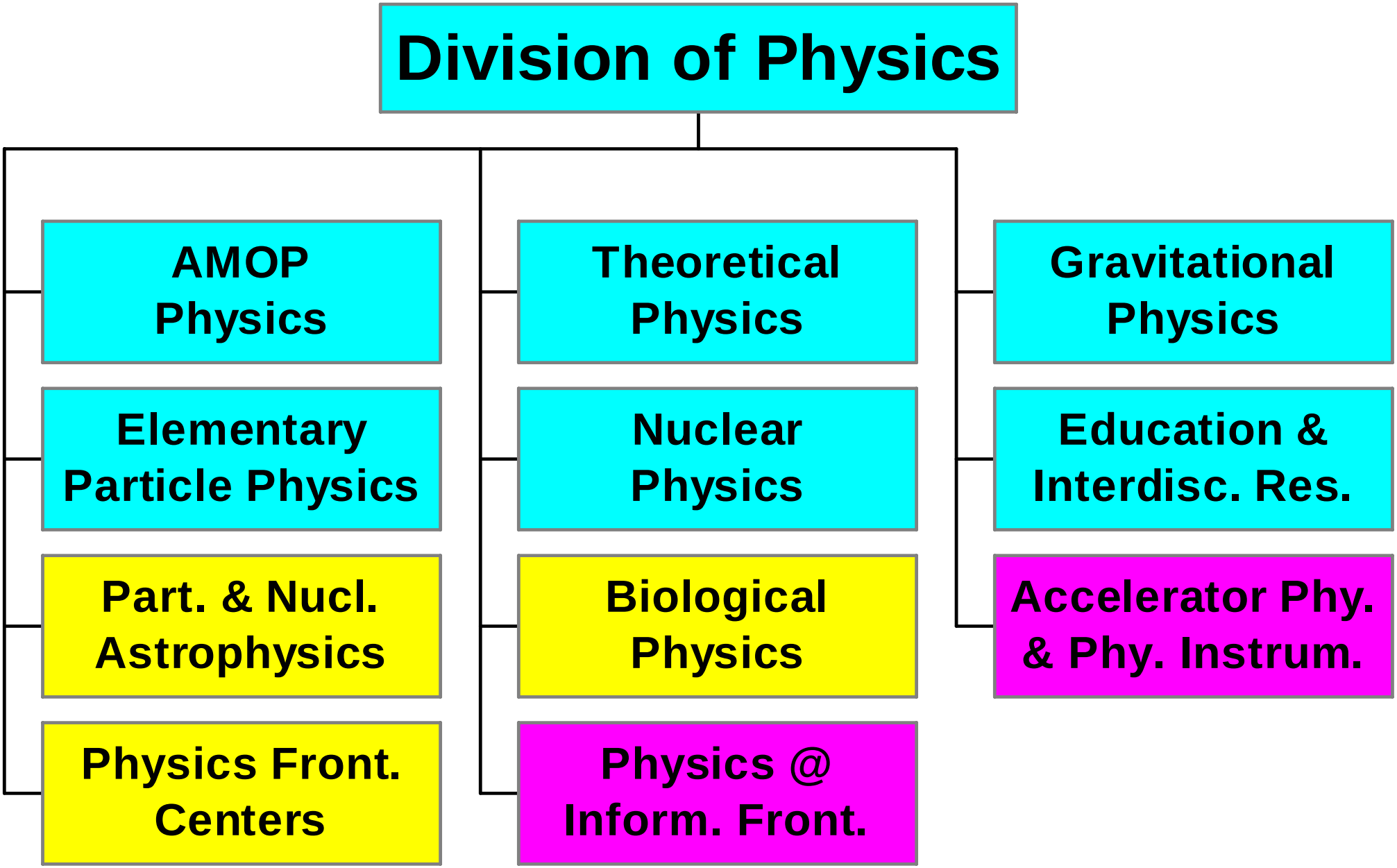
Molecular basis of life processes, **study of complex biological systems in areas such as self-assembly of disordered collections of molecules into the elements of living systems; protein folding; membranes; and emergence of physiological processes such as breathing and thinking out of complex, coupled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

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

PHYSICS* FRONTIERS, *circa* 2006

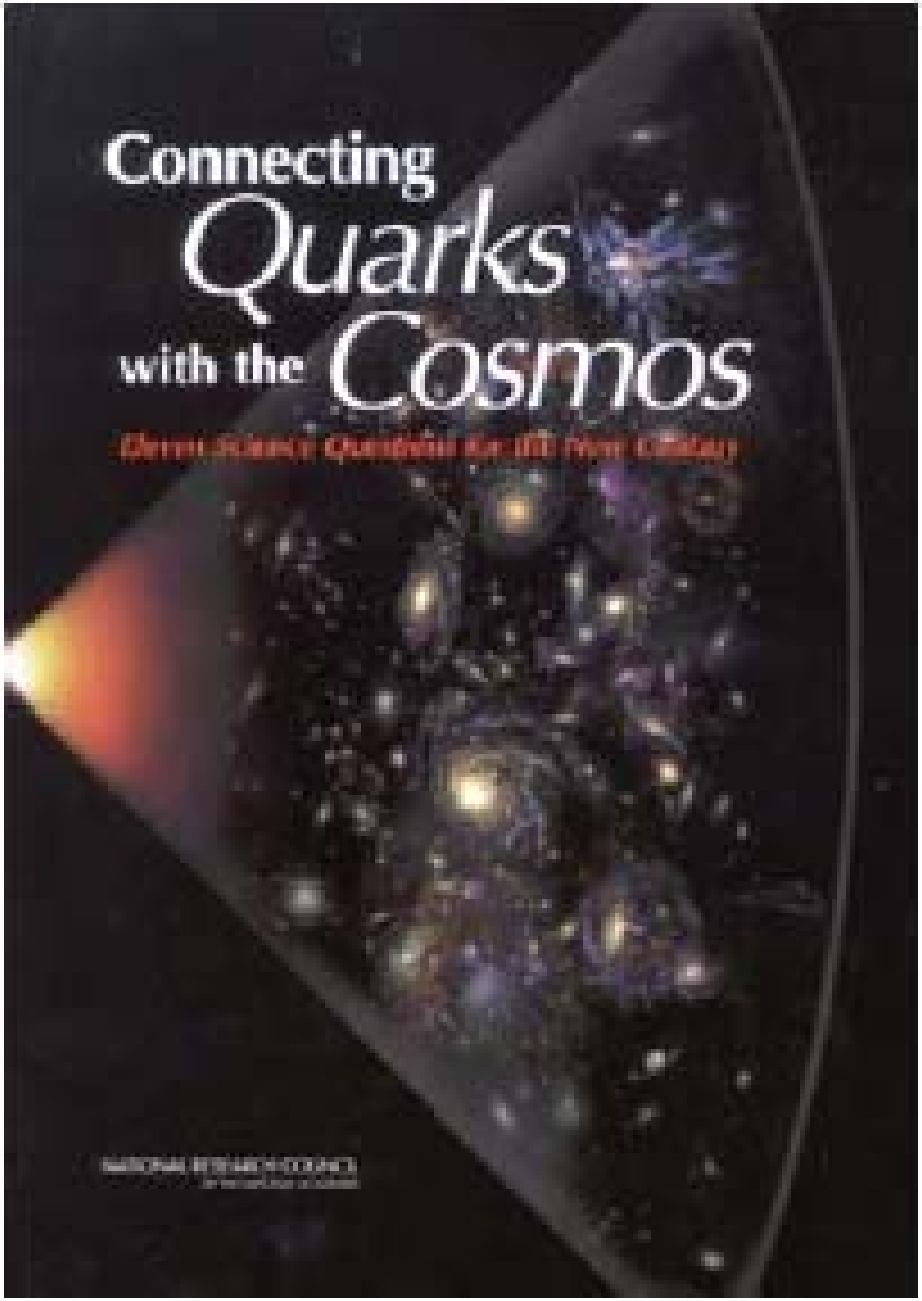
- Bose-Einstein Condensates, Atom "Lasers"
- Dark Matter, Dark Energy, Cosmology
- Gravitational Waves (GW), GW Astronomy
- New Fundamental Particles and Laws > TeV
- ν physics and astrophysics
- String Theory, Branes, Duality, Quantum Gravity
- Quark-Gluon Plasma, Supernova Dynamics
- Ultra-Fast, Ultra-Intense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

* CMP in Division of Materials Research

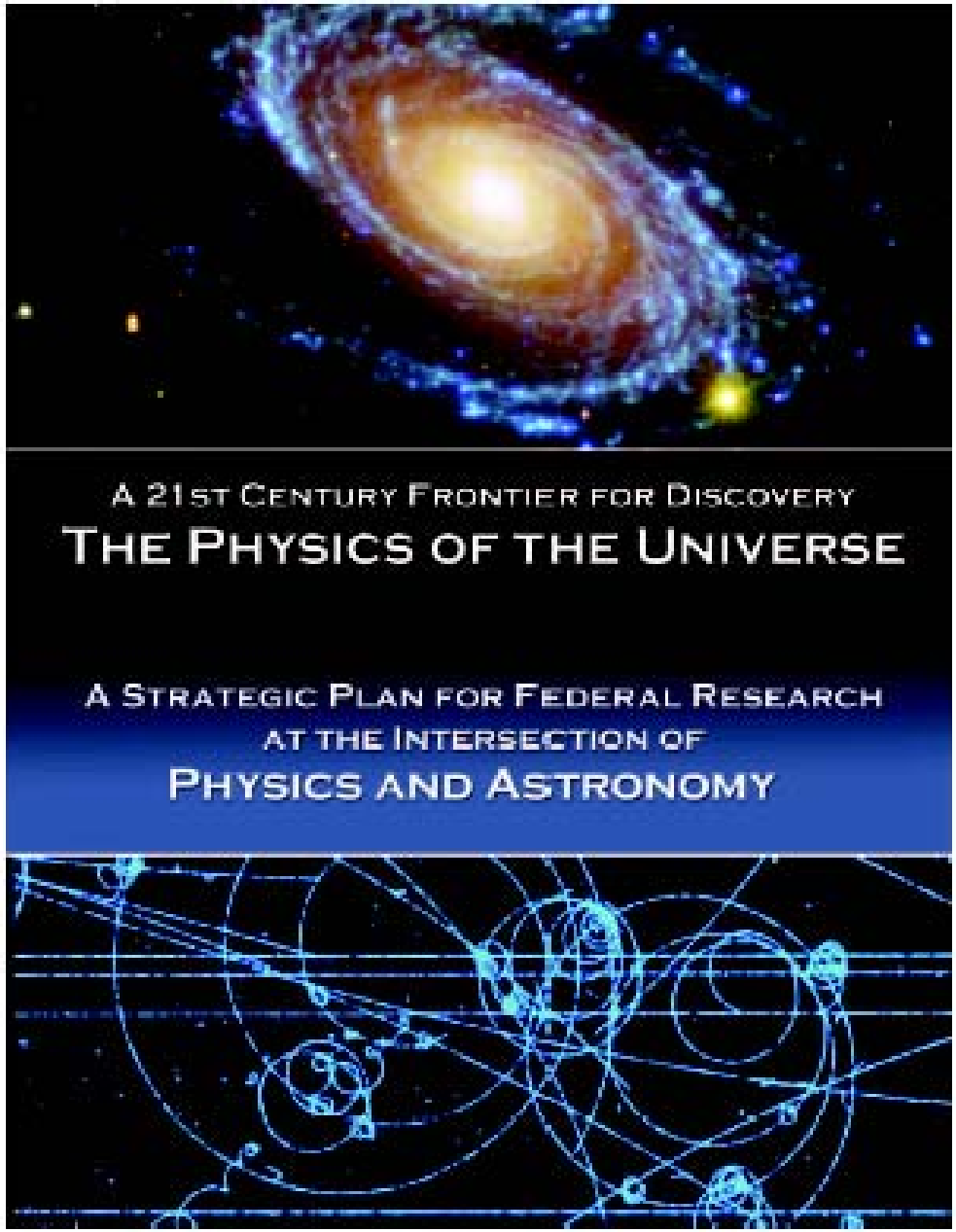

Division of Physics
AMOP Physics
Elementary Particle Physics
Part. & Nucl. Astrophysics
Physics Front. Centers
Theoretical Physics
Nuclear Physics
Biological Physics
Physics @ Inform. Front.
Gravitational Physics
Education & Interdisc. Res.
Accelerator Phy. & Phy. Instrum.

PRIORITIES for FY 2006+

- Strong, flexible core programs (GDM, >50% of PHY budget)
- EPP + POU (10%/yr)
- Increase diversity (10%/yr)
- Strengthen theory (5%/yr)
- Stewardship of facilities, e.g., (Adv)LIGO, LHC, NSCL, IceCube, CESR
- Addressing future opportunities, e.g., DUSEL, ILC



www.nap.edu



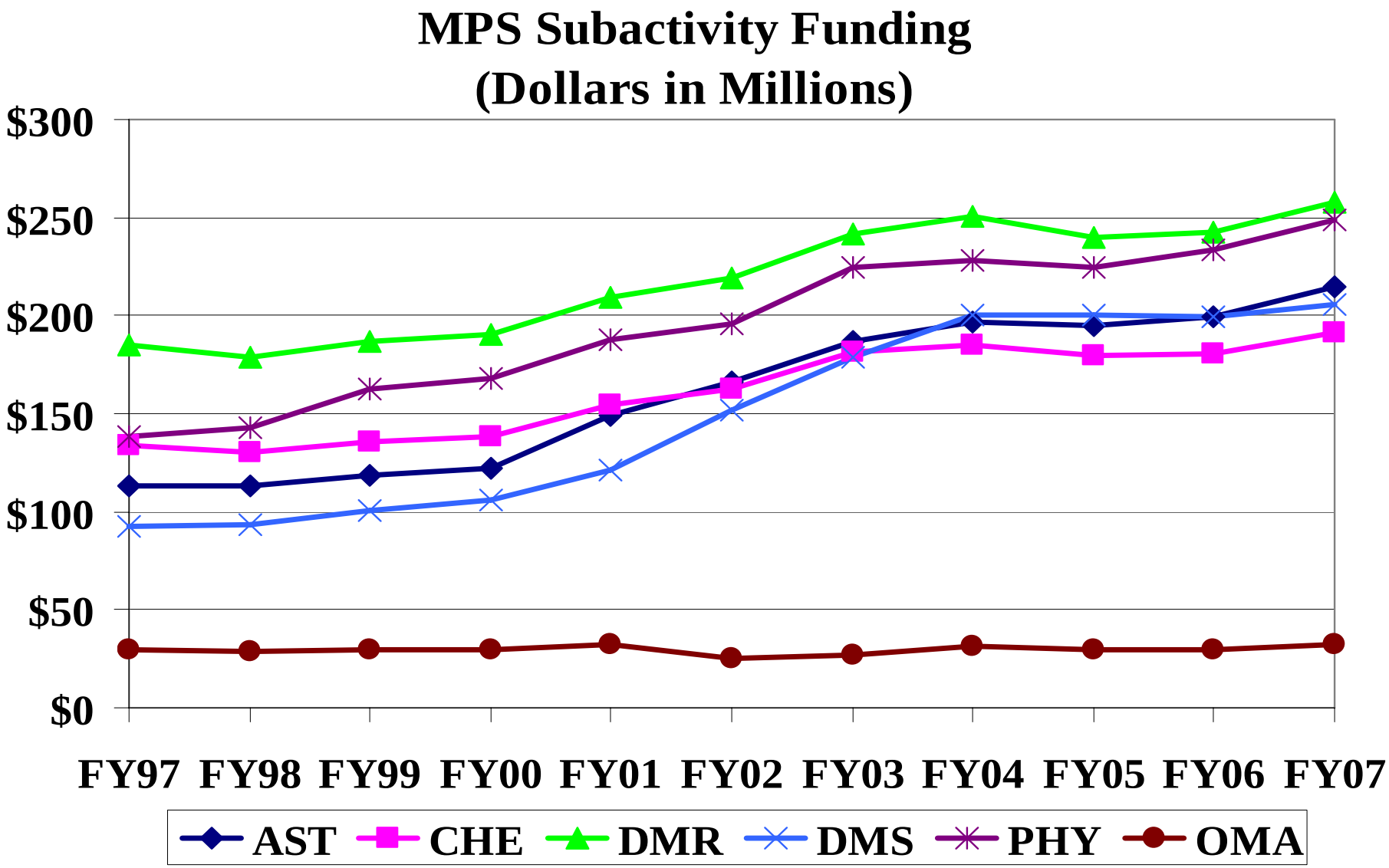
http://www.ostp.gov/nstc/html/NSTC_Home.html

Budget Request for FY 2007

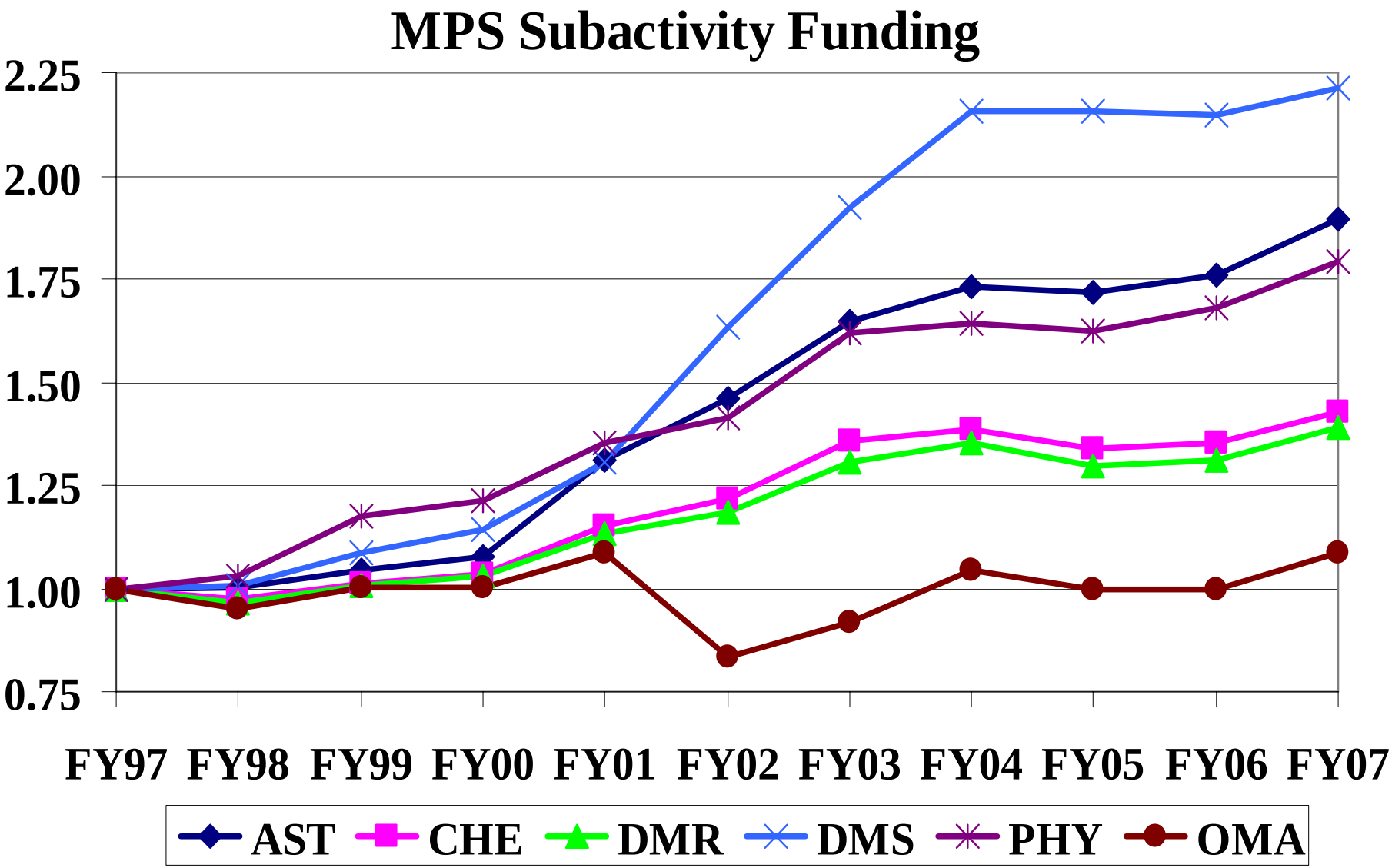
(Dollars in Millions)

	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%

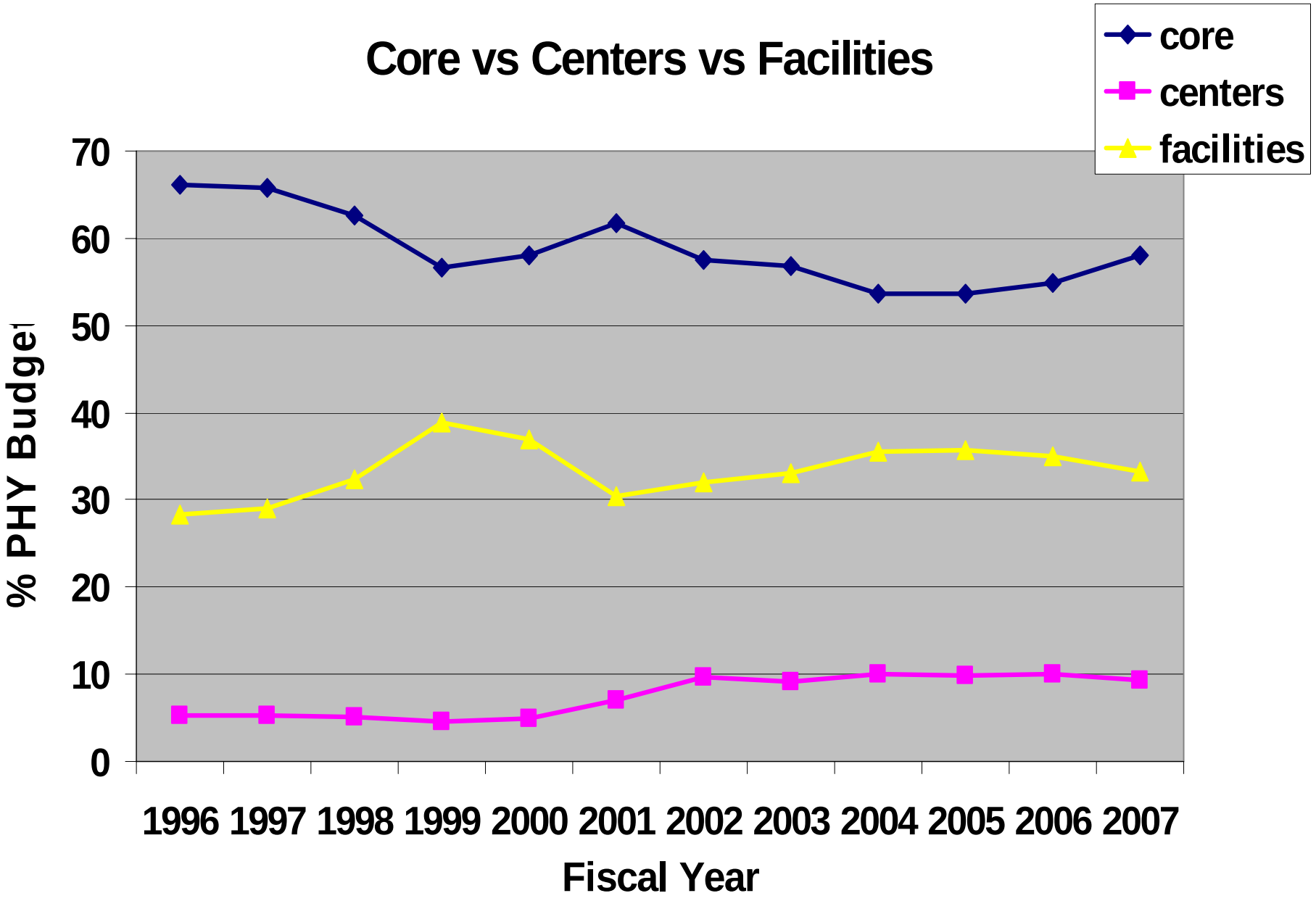
Ten-Year Funding History



Ten-Year Funding History



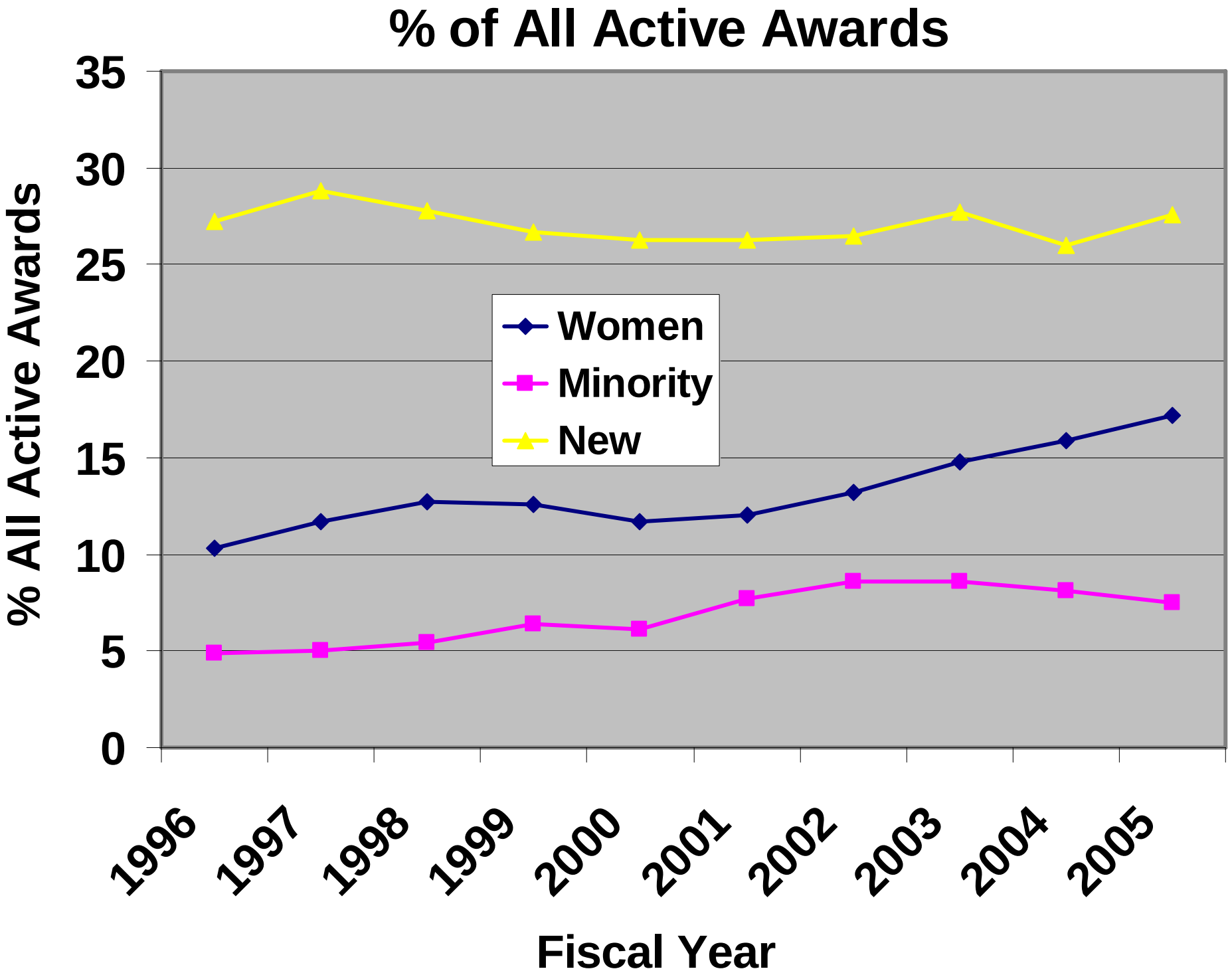
Budget sectors over time



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

Facilities

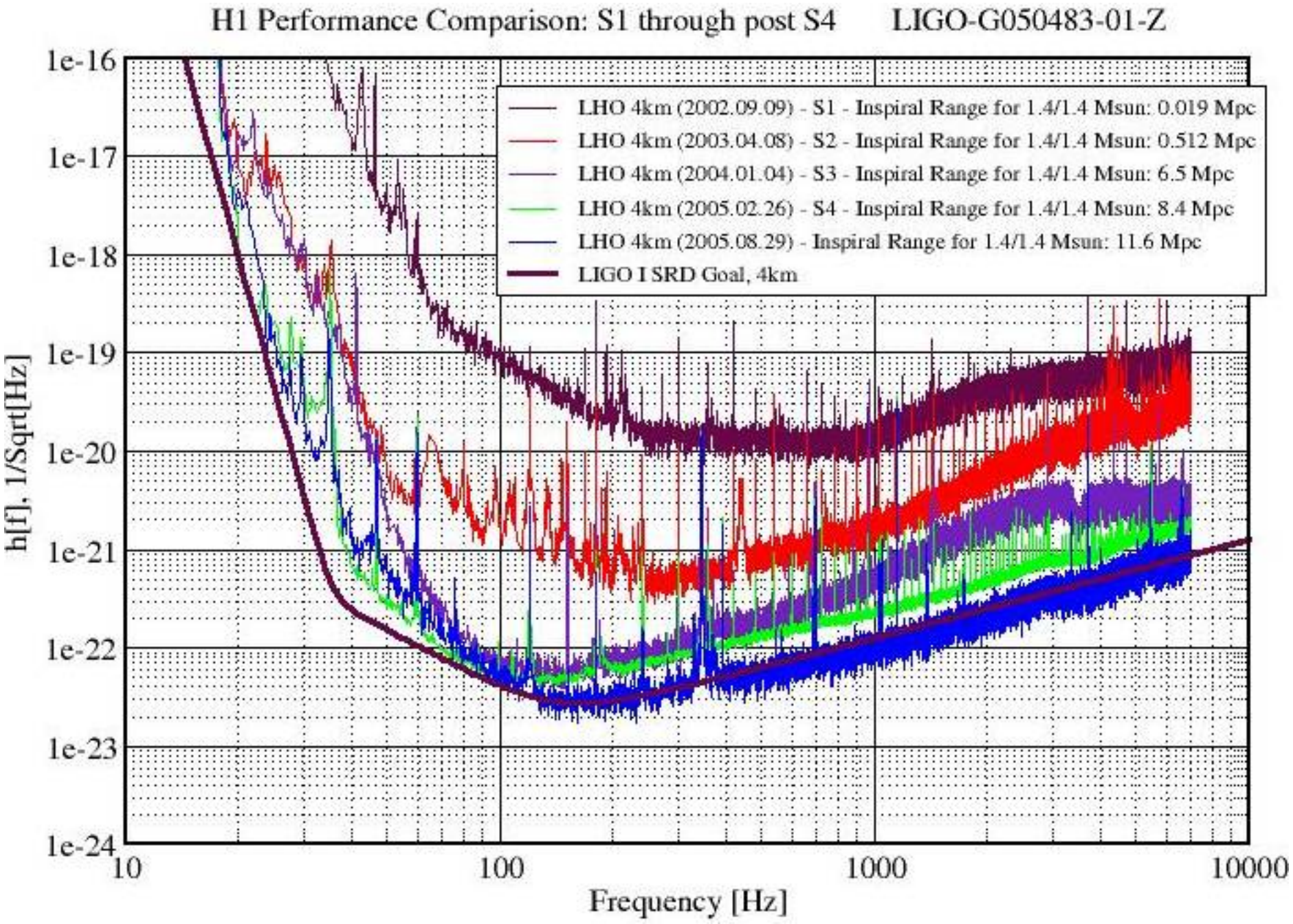
- LIGO/AdvLIGO
- LHC (with DOE)
- IceCube (with OPP)
- RSVP (cancelled in 2005)
- DUSEL (priority for future)
- ILC (DOE lead, NSF: university participation)
- NSCL, CESR
- Midscale (many with DOE and/or AST): ACT, Auger, CDMS, Borexino, HiRES, Milagro, Stacey, Veritas, MiniBoone, Numi/MINOS, RHIC end-cap calorimeter, university based NP accelerators, etc.

LIGO

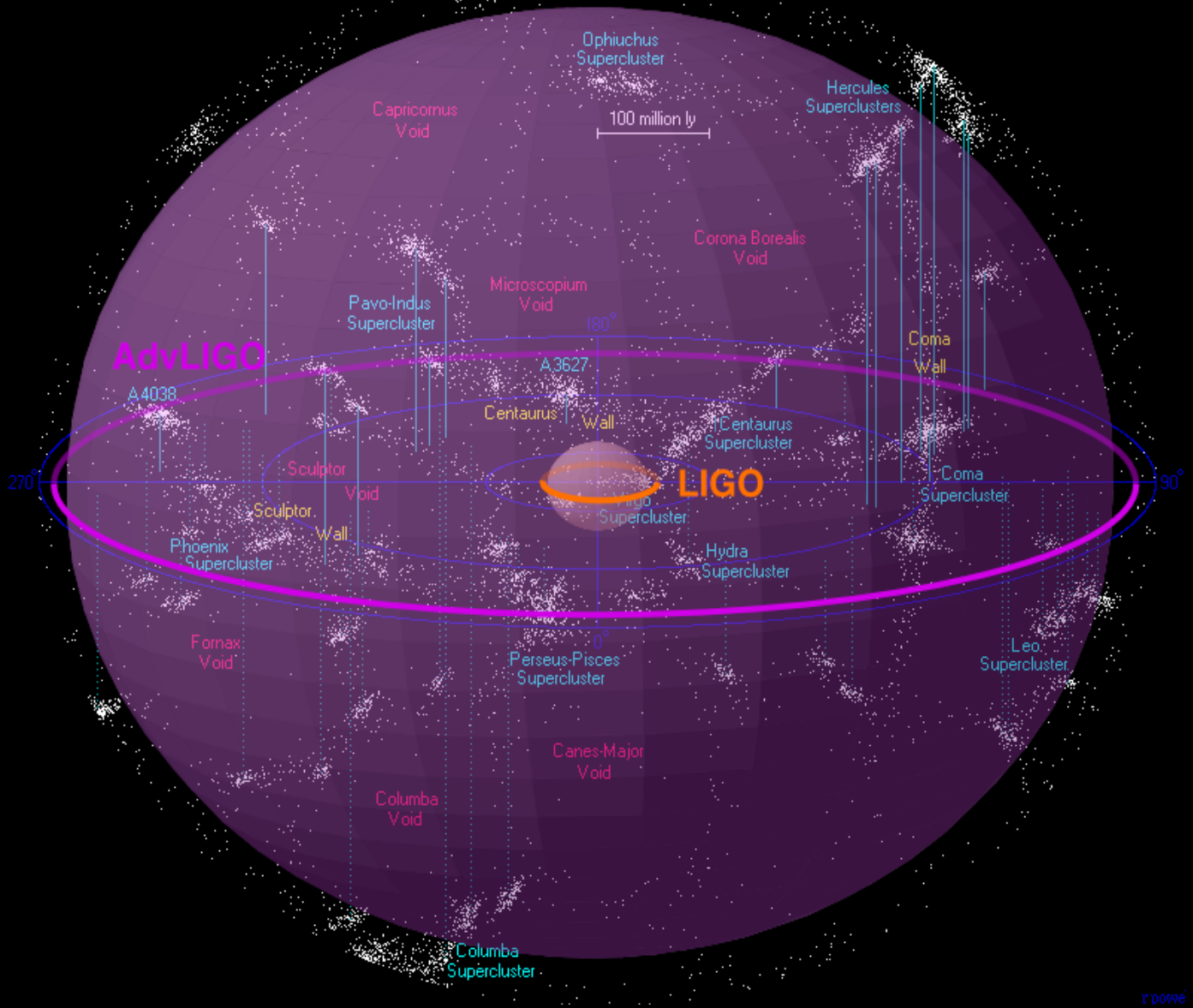
Science Goals of LIGO

- First direct detection of gravitational waves
- Open a new window on the Universe
- Explore the strong-gravity régime of Einstein's General Theory of Relativity
- Explore space and time back through the inflationary epoch, all the way to the Big Bang, when all four fundamental forces of nature were unified.

LIGO performance



AdvLIGO is LIGO's 2nd phase:
10x in Sensitivity Extends "Listening" Volume
By Factor of >1000 (!)



AdvLIGO in FY 06 Pres. Request for FY 08 start

Estimated event rates for LIGO and AdvLIGO:

	LIGO	AdvLIGO
Neutron Star / Neutron Star Inspiral	**0.004 to 1.5/yr**	**20 to 1000/yr**
Neutron Star / Black Hole Inspiral	**0.0003 to 0.3/yr**	**1.5 to 1500/yr**
Tidal Disruption of the Neutron Star in Inspiral	**< 0.001/yr**	**0.01 to 15/yr**
Black Hole / Black Hole Inspiral & Merger	**0.004 to 2/yr**	**15 to 10,000/yr**
Gamma Ray Bursts, Triggered by Merger	**Not detectable**	**Several per yr**

9 hours of AdvLIGO

=

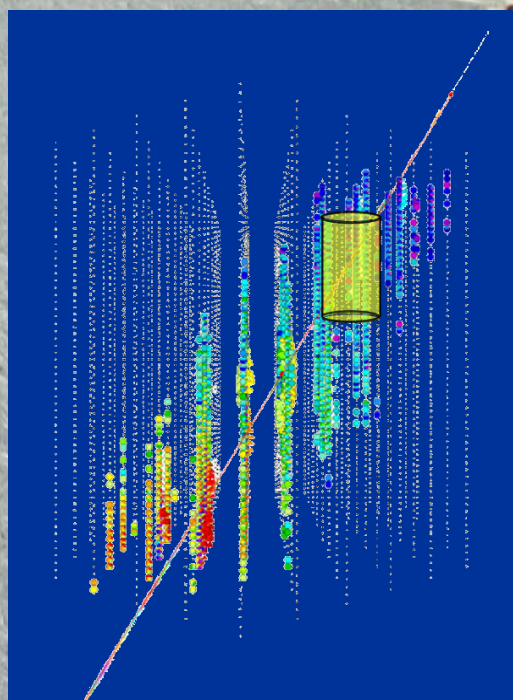
1 year of LIGO

From the possibility of detection (LIGO) to the near certainty of detection and gravitational wave astronomy (AdvLIGO).

IceCube Neutrino Observatory

South Pole Station

1450m
to
2450m ↓



- International project (272M$ TPC); joint OPP/MPS within NSF
- 1 km^3 of ice instrumented with 4800 optical sensors detect h.e. neutrinos from galactic/extra-galactic sources
- neutrinos interact in ice creating h.e. muons, which carry away original momentum, pointing precision of ½ degree
- 'Neutrino Astronomy': point sources, origins of h.e. cosmic rays, astrophysics of quasars, pulsars, gamma-ray bursters, ...

Eight Strings Installed at IceCube

DUSEL

- **DUSEL = Deep Underground Science and Engineering Lab**
- **Interdisciplinary Scope: particle physics, nuclear physics, astrophysics, geosciences, engineering, biosciences, industry, defense**
- **Physics (NSF & DOE) 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.**