Educational Programs at the University of California at Berkeley for Nuclear Engineering

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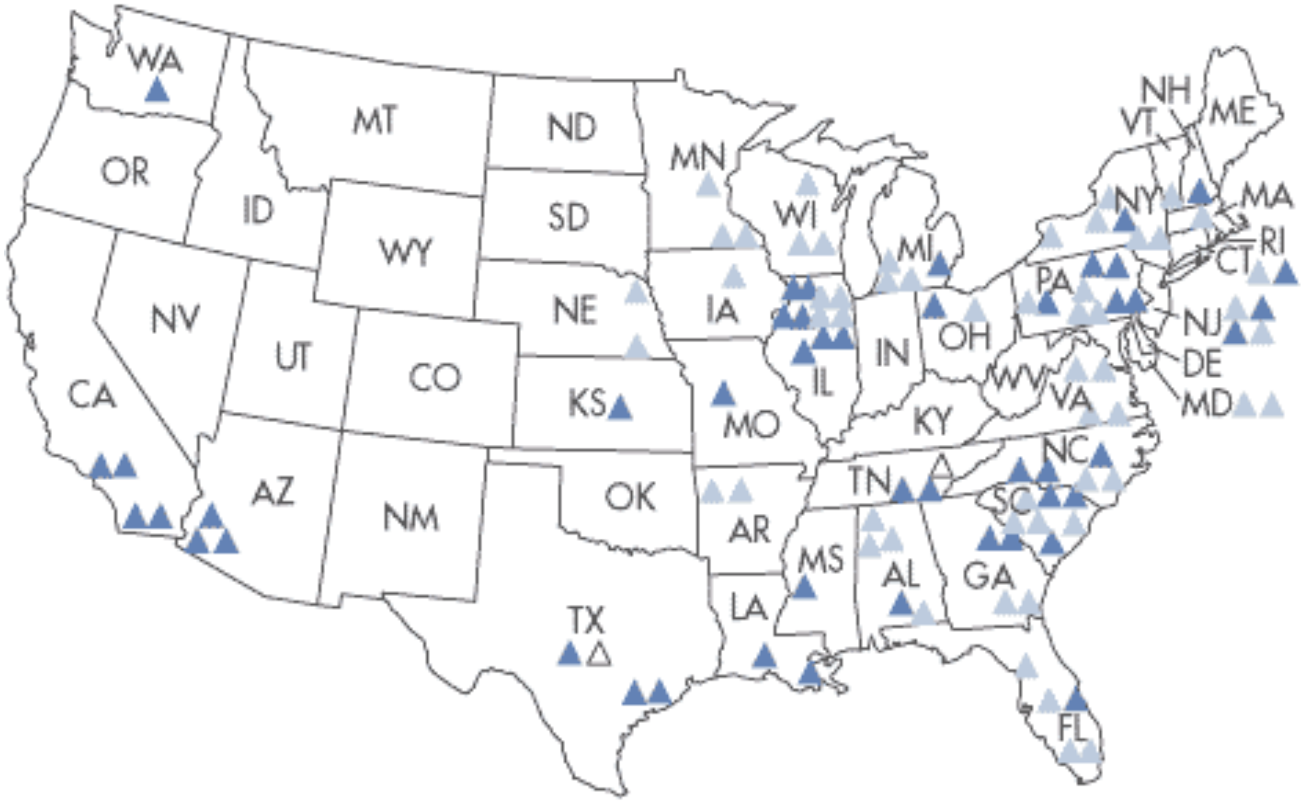
Department of Nuclear Engineering
University of California, Berkeley

International Conference Global 2011
“Toward and Over the Fukushima Daiichi Accident”
Panel III: Fostering of Personnel
8:30 – 10:30 am, December 15, 2011
Makuhari, Chiba

Map of Power Reactor Sites in US



YEARS OF COMMERCIAL OPERATION	NUMBER OF REACTORS	AVERAGE CAPACITY (MDC)
△ 0–9	2	1134
▲ 10–19	47	1092
▲ 20–29	55	779

Note: There are no commercial reactors in Alaska or Hawaii. Calculated data as of 12/00.

US nuclear generating capacity projected in 1999

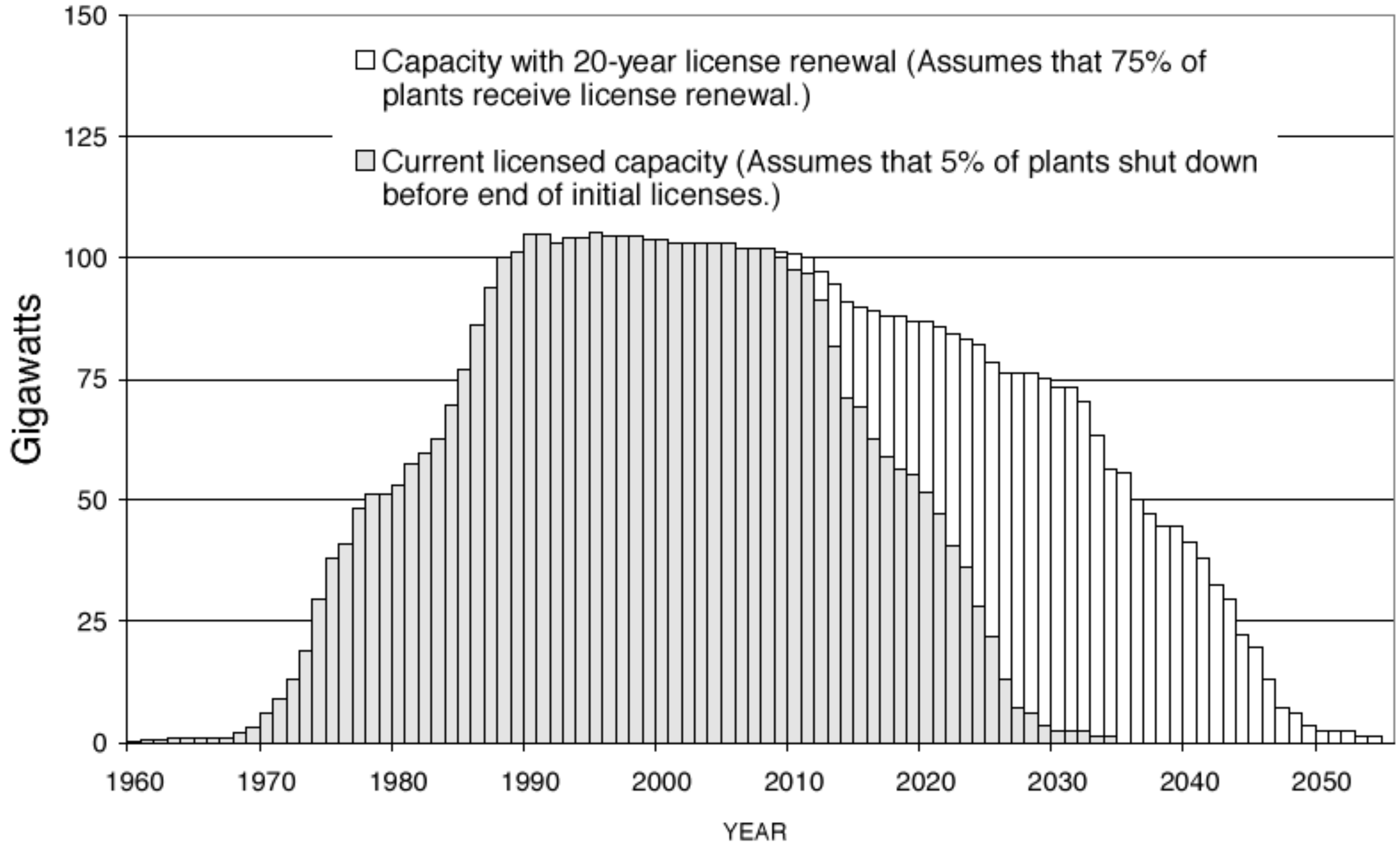
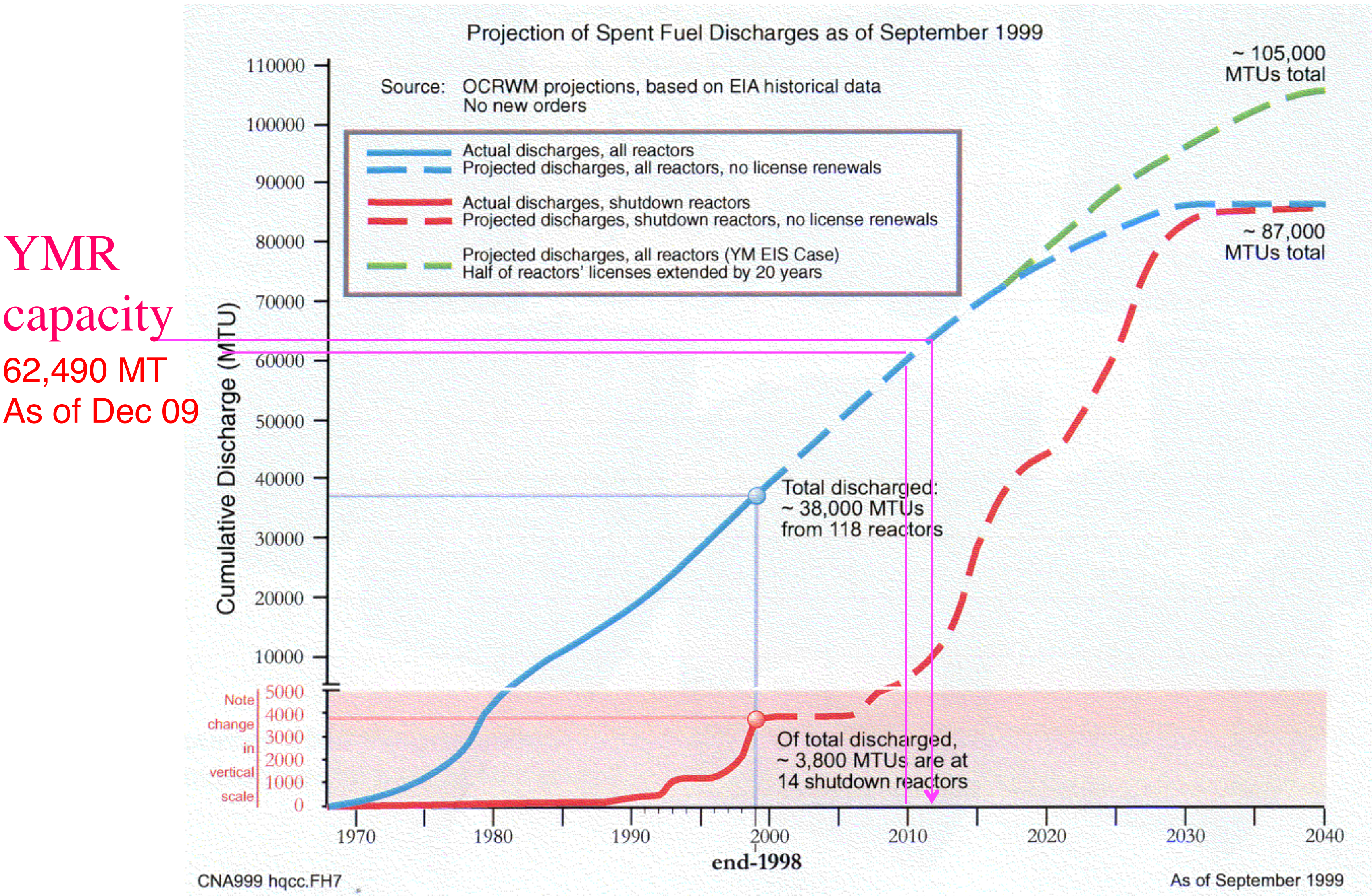


Figure 5.3: Projected U.S. nuclear generating capacity. Source: DOE Office of Nuclear Energy, Science and Technology.

Used Fuel Accumulation in US



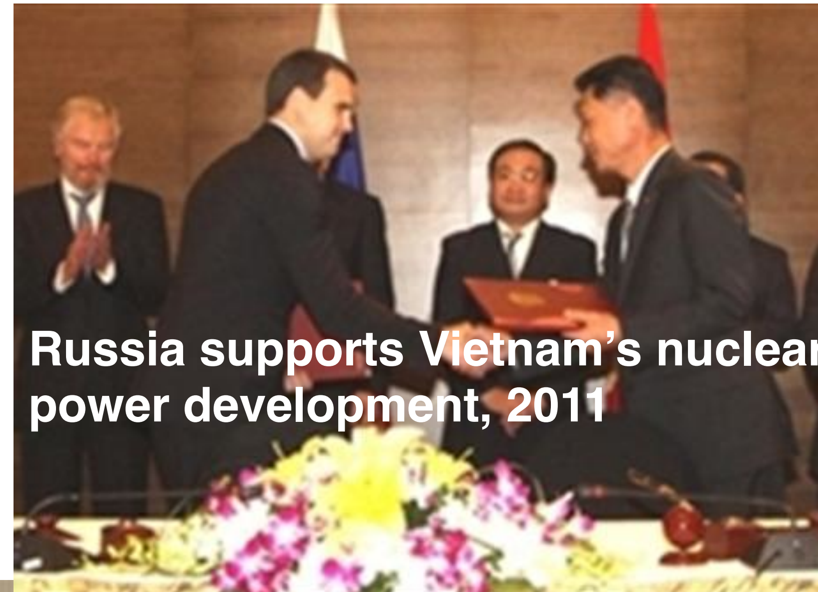
Yucca Mountain Repository Project is stopped, and Blue Ribbon Commission is discussing Future directions

Nuclear Security & Safeguards Issues Emerged

Fukushima Daiichi Accident

Internationalization


UAE, South Korea sign nuclear deal to build plants in the UAE, 2009


Russia supports Vietnam’s nuclear power development, 2011

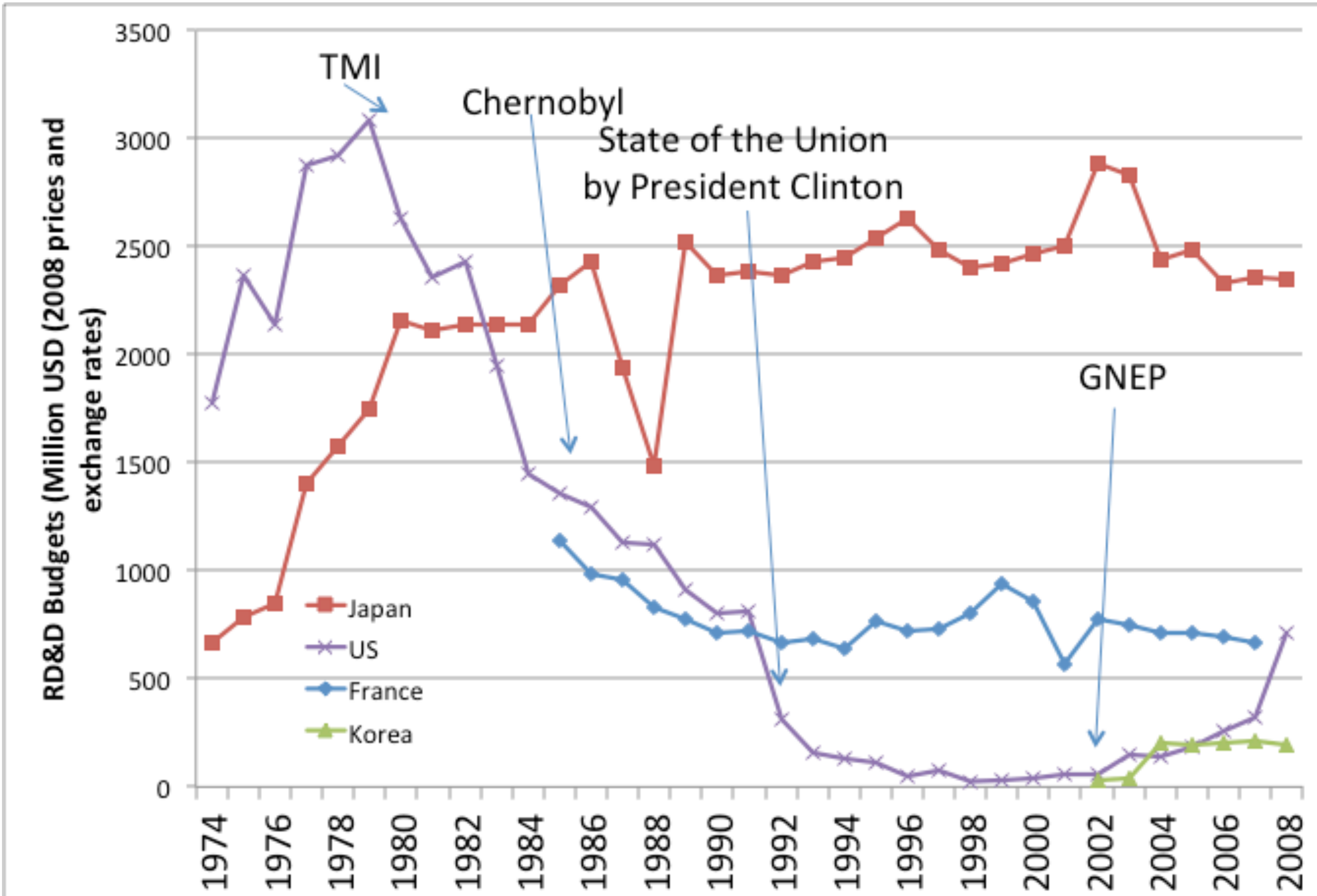
US India Civilian Nuclear Agreement officially signed by President Bush on OCT 8 2008


Japan-Vietnam nuclear cooperation, 2011

New Generation Nuclear Power System Needs to be implemented in the US!

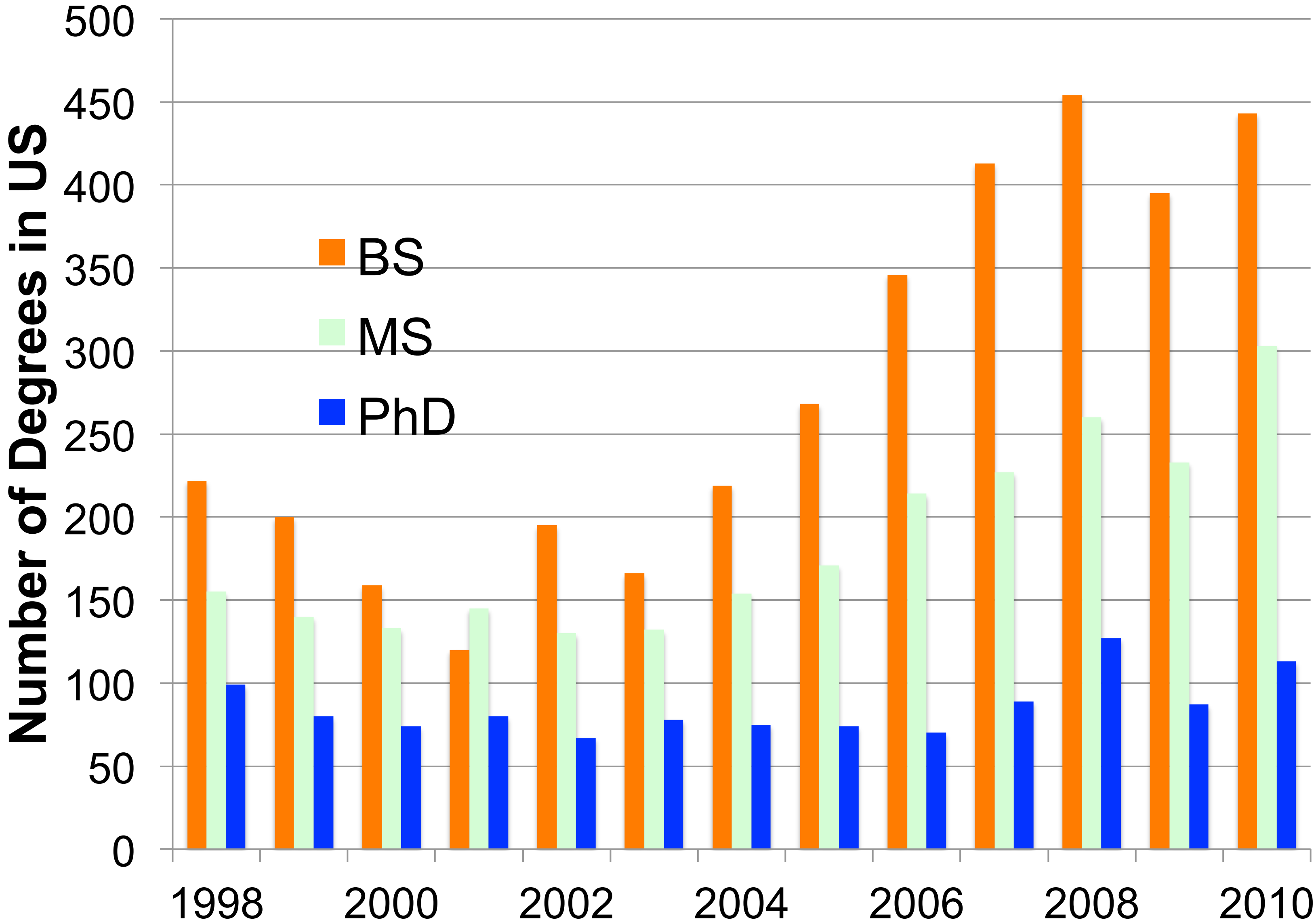
- For future nuclear power, we need to make efforts to improve technologies, because ….
  - Safety
  - Security (Proliferation and Terrorism)
  - Radioactive Waste Disposal
  - Economical competitiveness
  - Sustainability

Governmental funding for fission R&D



Department of Nuclear Engineering, University of California, Berkeley

Growth in 2000's



Support for Universities

- Department of Energy
  - Nuclear Energy University Program (NEUP)
- Nuclear Regulatory Commission
  - Curricula development
  - Scholarship and fellowship
  - Faculty development

Nuclear Energy University Program (NEUP) by US DOE

Awards	FY 2009 NEUP	FY 2010 NEUP	FY 2011 NEUP
University Research & Development (R&D) Awards (from 20% of the NE R&D budget)	$44 million. 71 awards to 31 schools in 20 states.	$38 million. 42 awards to 23 schools in 17 states.	$39 million 51 awards to 31 schools in 21 states.
Integrated Research Projects(from 20% of the NE R&D budget)	N/A	N/A	TBA
University Infrastructure Awards (from 20% of the NE R&D Budget)	$6 million 29 schools in 23 states for scientific equipment	$13.2 million 39 schools in 27 states for research reactor upgrades and scientific equipment	TBA
University Student Fellowship and Scholarship Awards	$3.1 million 76 scholarships and 18 fellowships	$5.0 million (IUP) 85 scholarships and 32 fellowships	TBA (IUP)
Total	$53,000,000	$56,200,000	About $60M

Programs at UC Berkeley

NE Faculty

PROFESSORS

- Joonhong Ahn, radioactive waste management; mathematical safety assessment of deep geologic repository; transport of radionuclides in geologic formations
- Edward C. Morse, applied plasma physics; fusion technology; microwaves
- Eric B. Norman, homeland security, neutrino physics and nuclear astrophysics (LLNL)
- Per F. Peterson, heat and mass transfer; multispecies; thermal hydraulics; nuclear reactor design and safety; radioactive waste and materials management
- Jasmina L. Vujic, advanced deterministic and stochastic numerical methods in radiation transport; biomedical application of radiation; nuclear reactor core analysis and design

ASSISTANT PROFESSORS

- Peter Hosemann, experimental nuclear material science and technology, liquid metal corrosion, radiation effects in structural materials, characterization of ODS alloys, low activation steels and radiation tolerant materials for use in extreme environments

PROFESSORS in Residence

- Kai Vetter, applied nuclear physics: radiation detection, biomedical research, nuclear security (LLNL)
- Ehud Greenspan, advanced reactor conception, design and analysis; advanced nuclear fuel cycles; transmutation of nuclear waste; reactor physics; criticality safety; boron neutron capture therapy; optimization of radiation shields; fusion neutronics
- Ka-Ngo Leung, plasma source and ion beam development for fusion; neutron production; microelectronic fabrication; particle accelerators (LBNL)

NE Faculty - Emeritus

- Professors in Graduate School
- Stanley G. Prussin, low-energy nuclear physics and chemistry and applications
- William E. Kastenberg, risk assessment; risk management; ethics and the development of technology; conflict resolution (Ret. 12/31/07)
- Donald R. Olander, nuclear materials; reactor fuel behavior; hydriding of zirconium and uranium (Ret. 06/30/08)

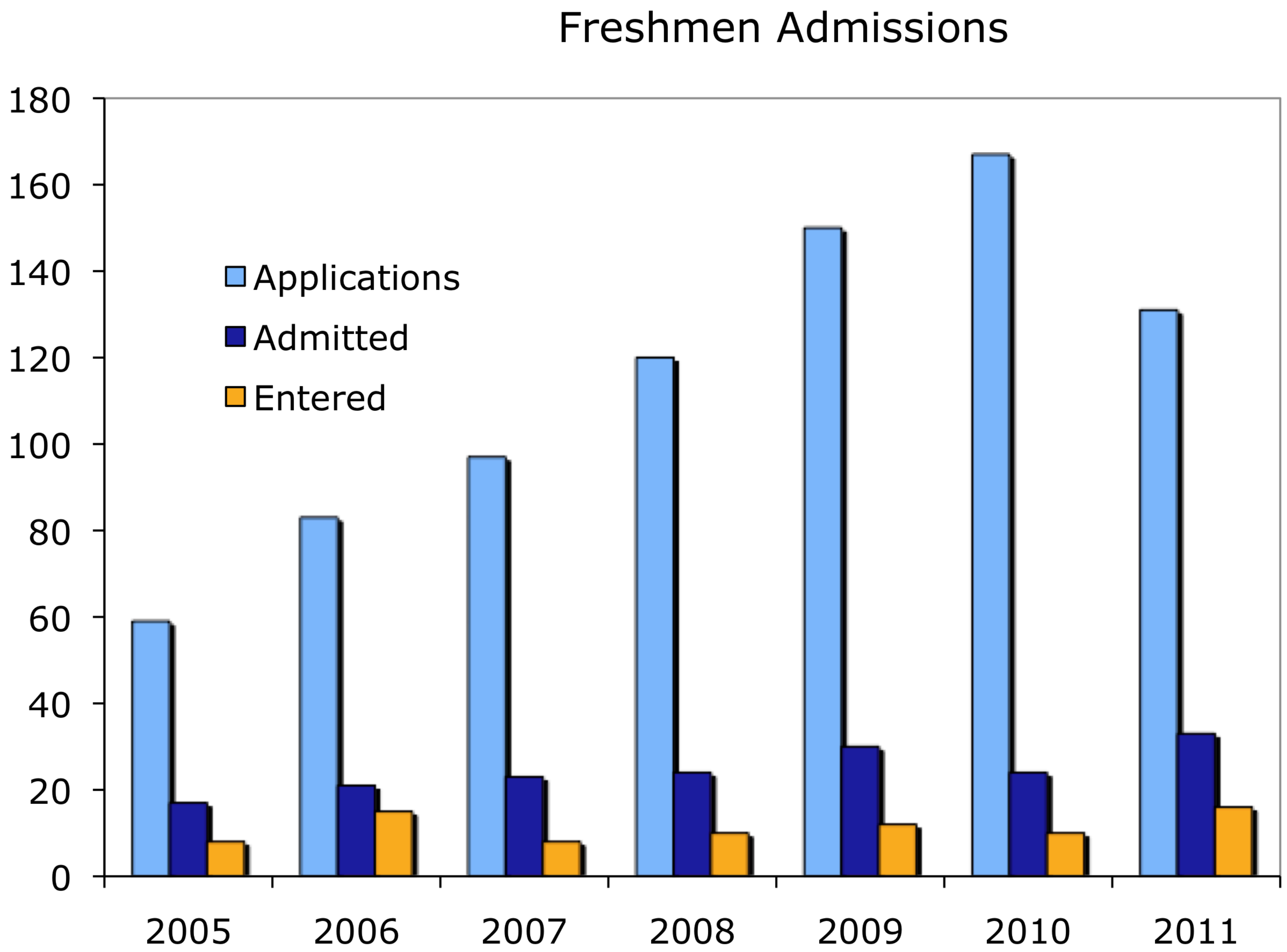
Student Data 2011

- NE Majors – increase in number of undergrad (76) & grad majors (70)
- Drop in # of freshman applications but higher acceptance rate:
  - 59 for Fall ’05 120 for Fall ’08 131 for Fall ‘11
  - 83 for Fall ’06 150 for Fall ’09
  - 97 for Fall ’07 167 for Fall ’10
- Rise in # of graduate applications
- Rise in # of international students
  - Further drop in % of undergrad women after severe drop in 2008
- 100% funding for graduate students - research, labs, fellowship
- Do not have immediate employment for 100% MS/Ph.D. grads (one MS, one Ph.D. student without jobs)

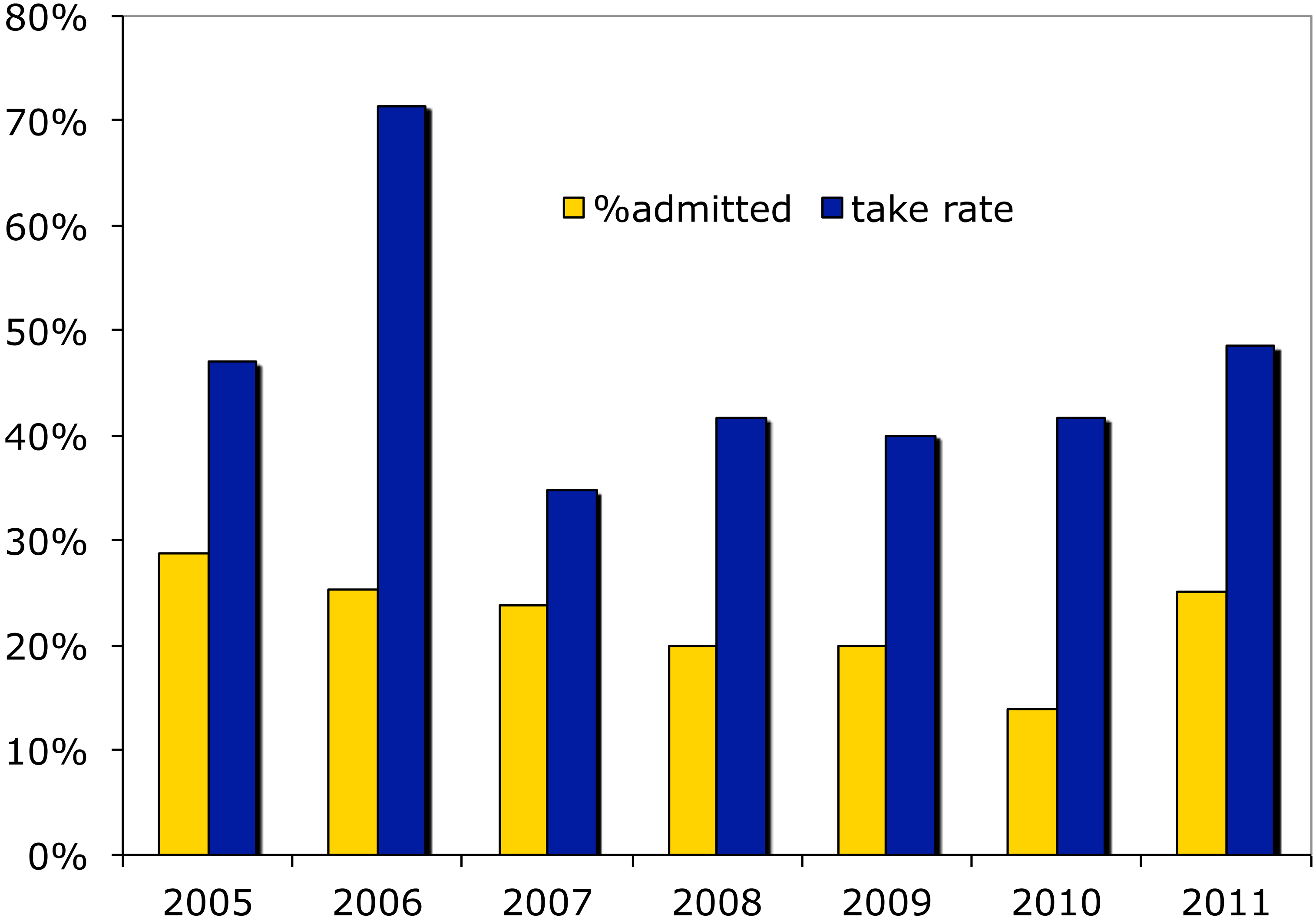
UCB-NE Department Productivity

	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Faculty FTE	7.5	7	7.5	6.5	6	6	6
Research $*	$4,070,000	$5,278,366	$6,821,525	$8,864,158	$9,283,614	$9,769,725	$11,259,125
$/FTE*	$542,667	$754,052	$909,537	$1,363,717	$1,547,269	$1,628,288	$1,876,520
Undergrads	58	56	66	62	58	65	66
Grads	55	56	57	63	58	65	66
BS Degrees	10	8	17	17	12	13	13
MS Degrees	6	8	10	12	12	13	7
PhD Degrees	4	6	6	8	8	5	9
Total Degrees	20	22	33	37	32	31	29

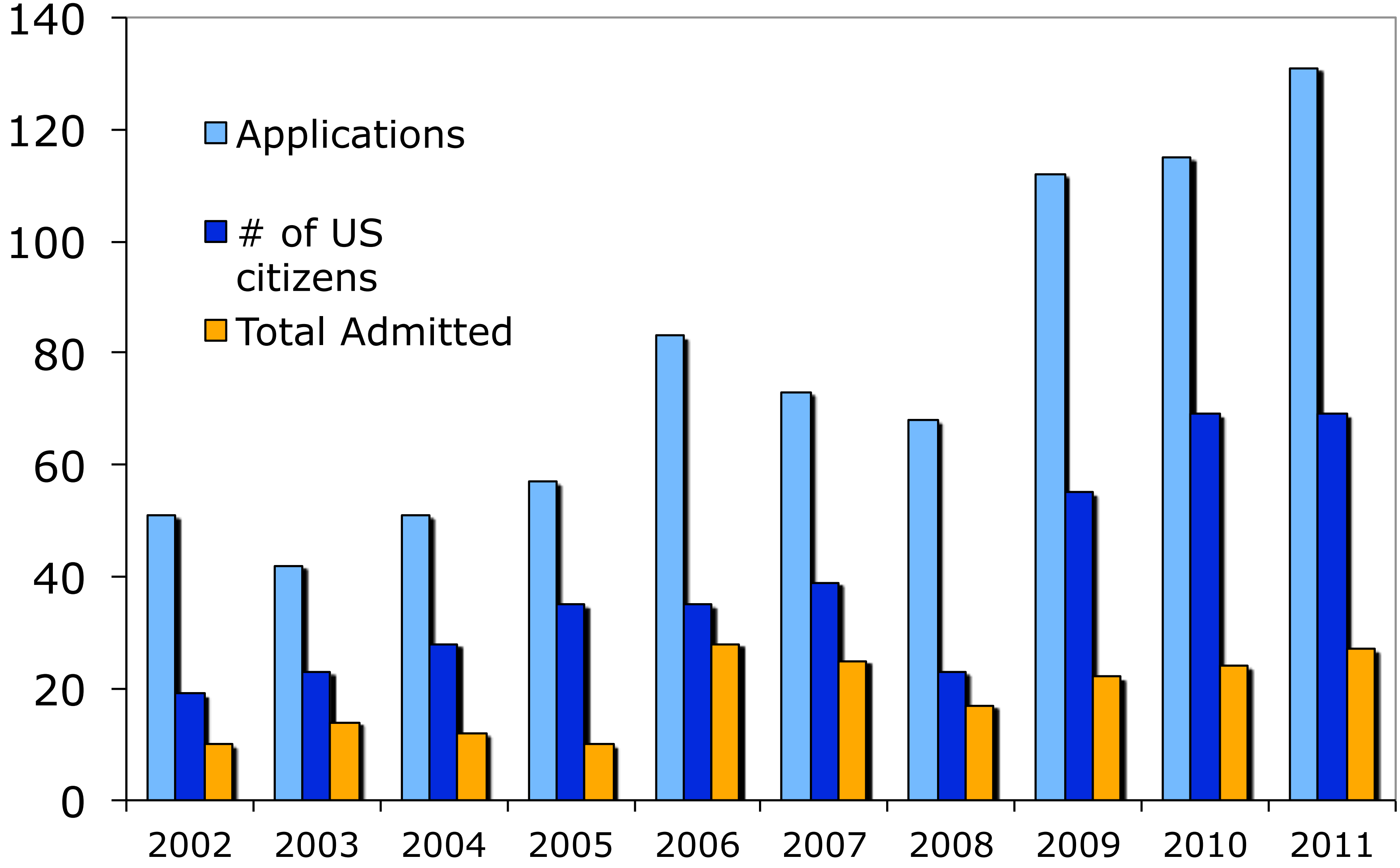
*includes national lab support


Freshmen Admissions
180
160
140
120
100
80
60
40
20
0
Applications
Admitted
Entered
2005
2006
2007
2008
2009
2010
2011

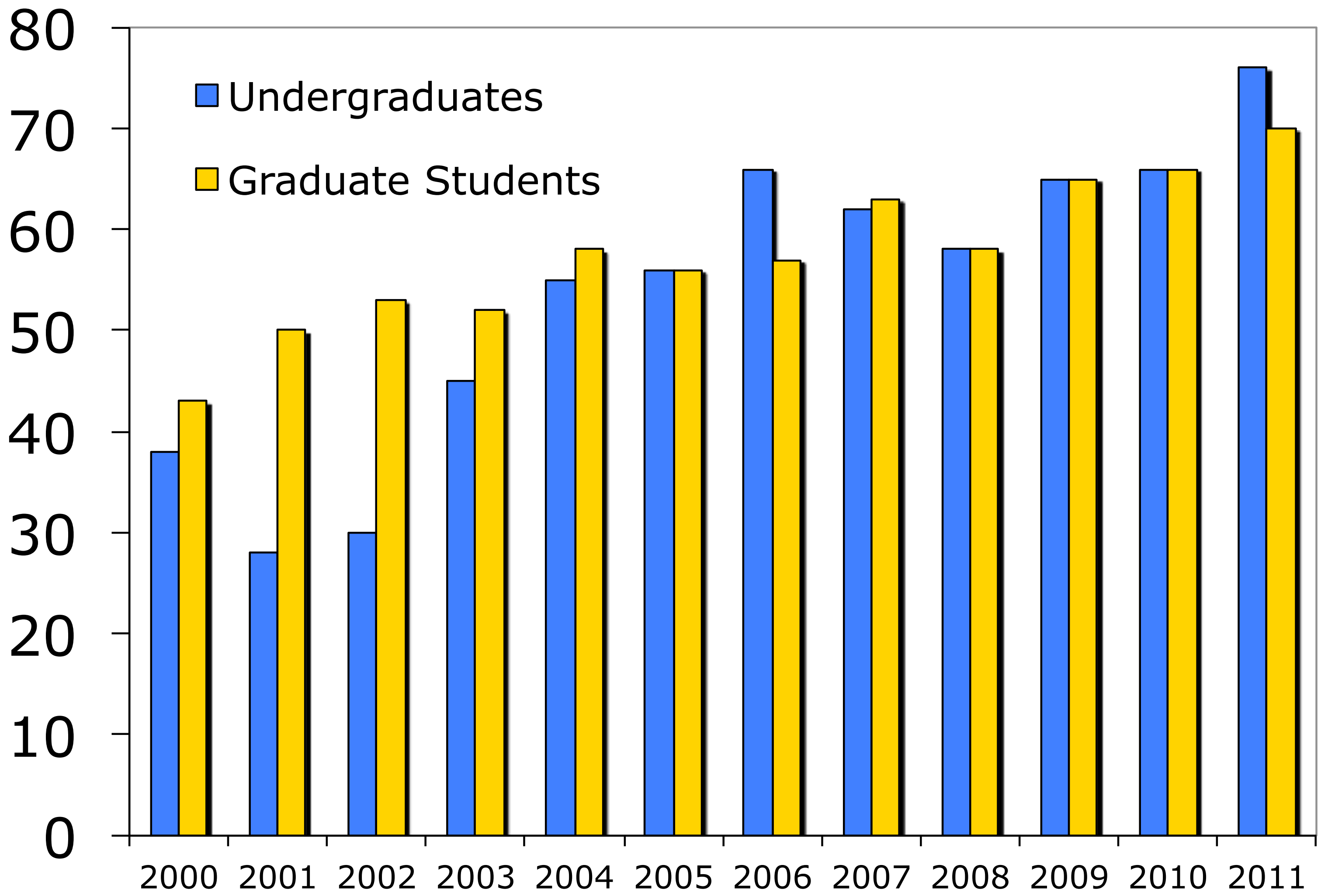
Freshmen Admissions Take rate

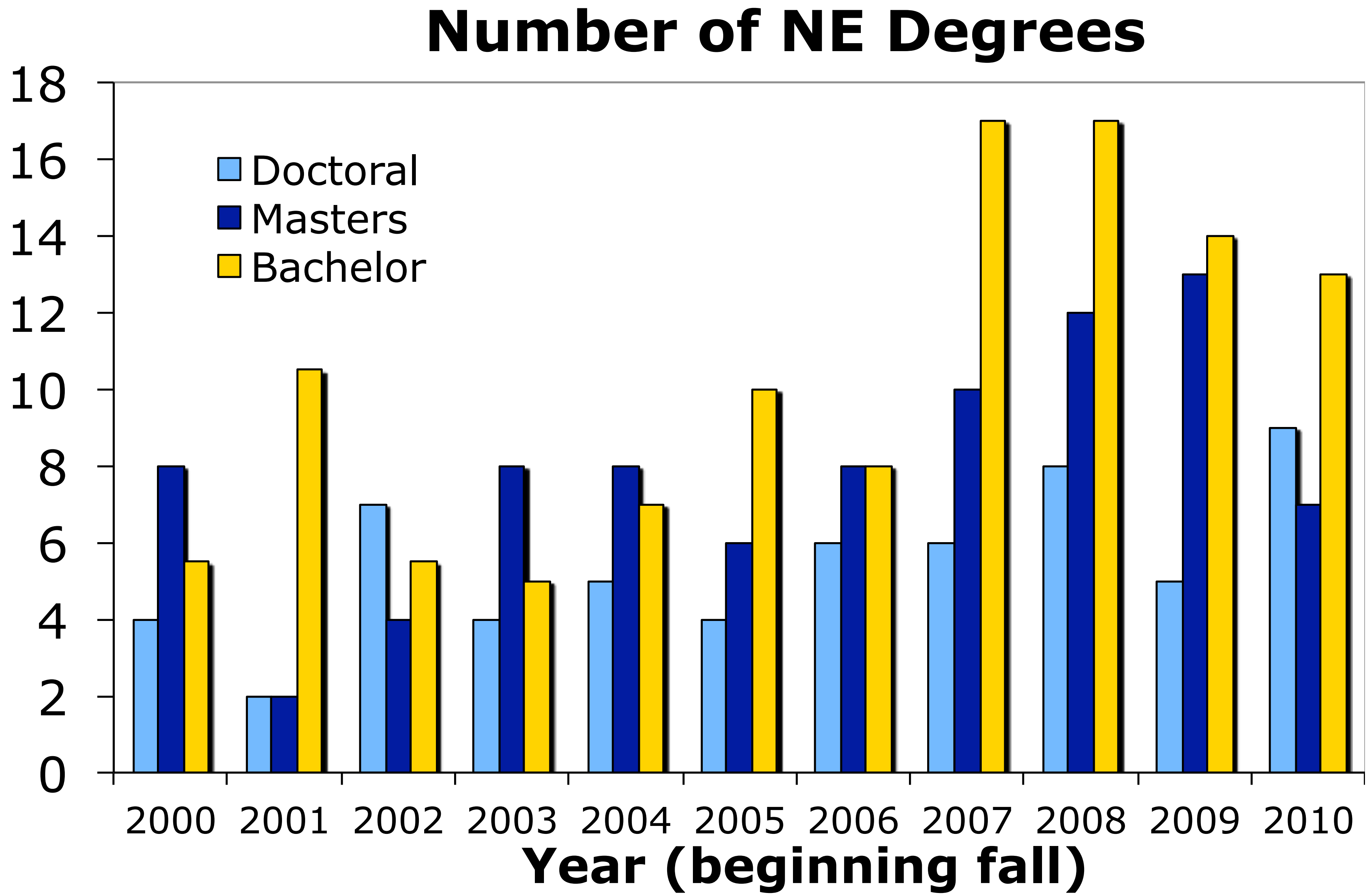


Graduate Admissions

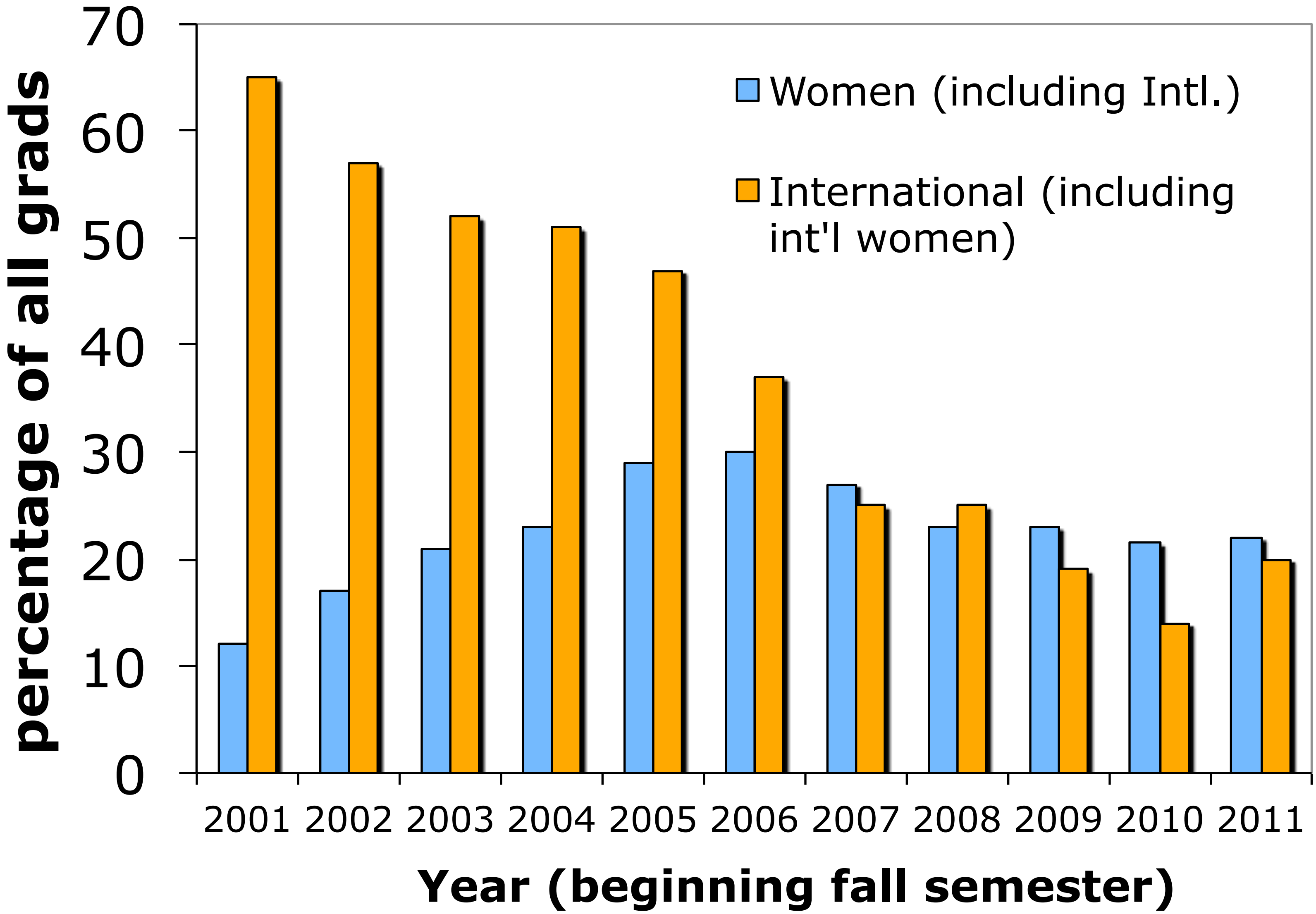


Number of Students in NE Majors

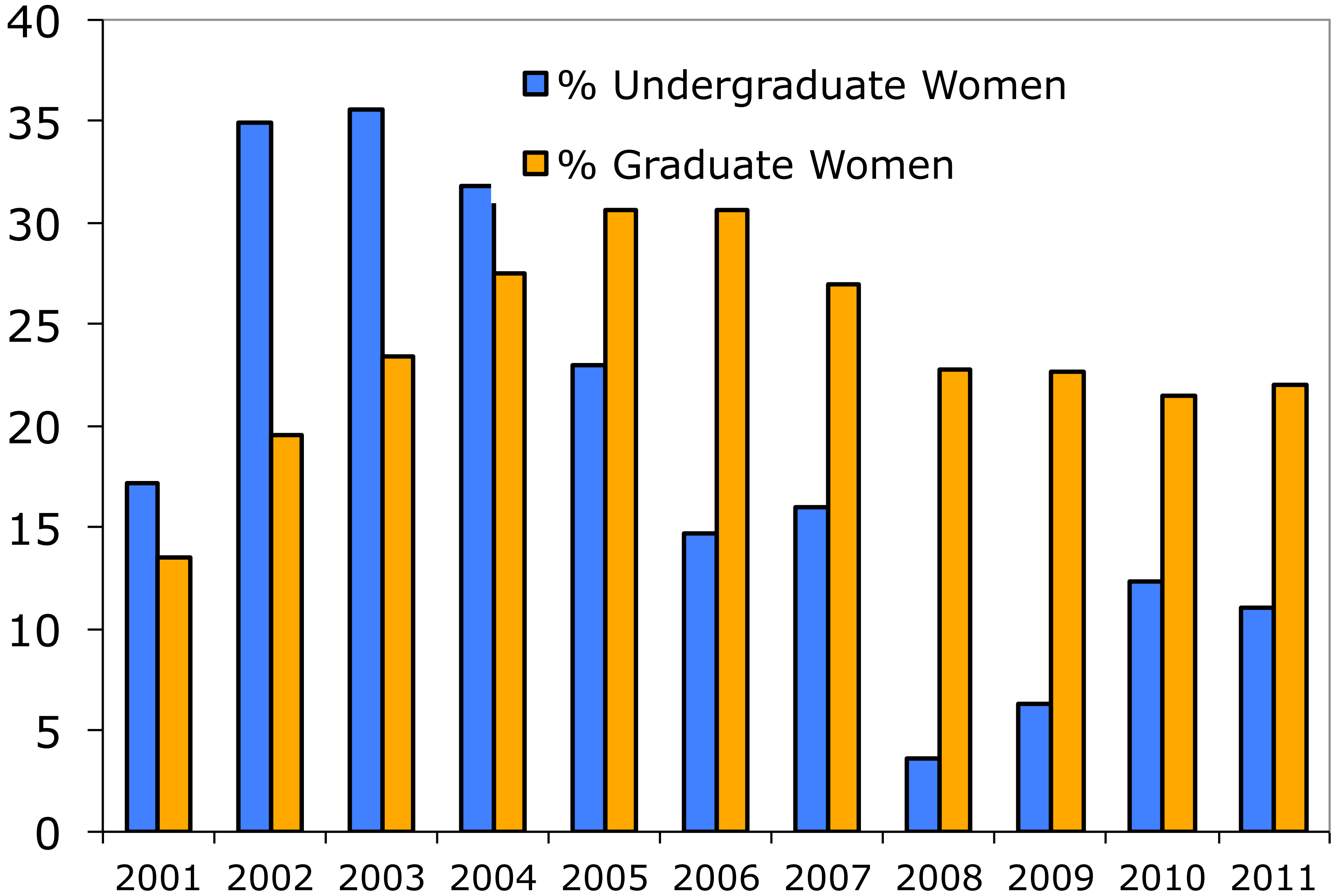


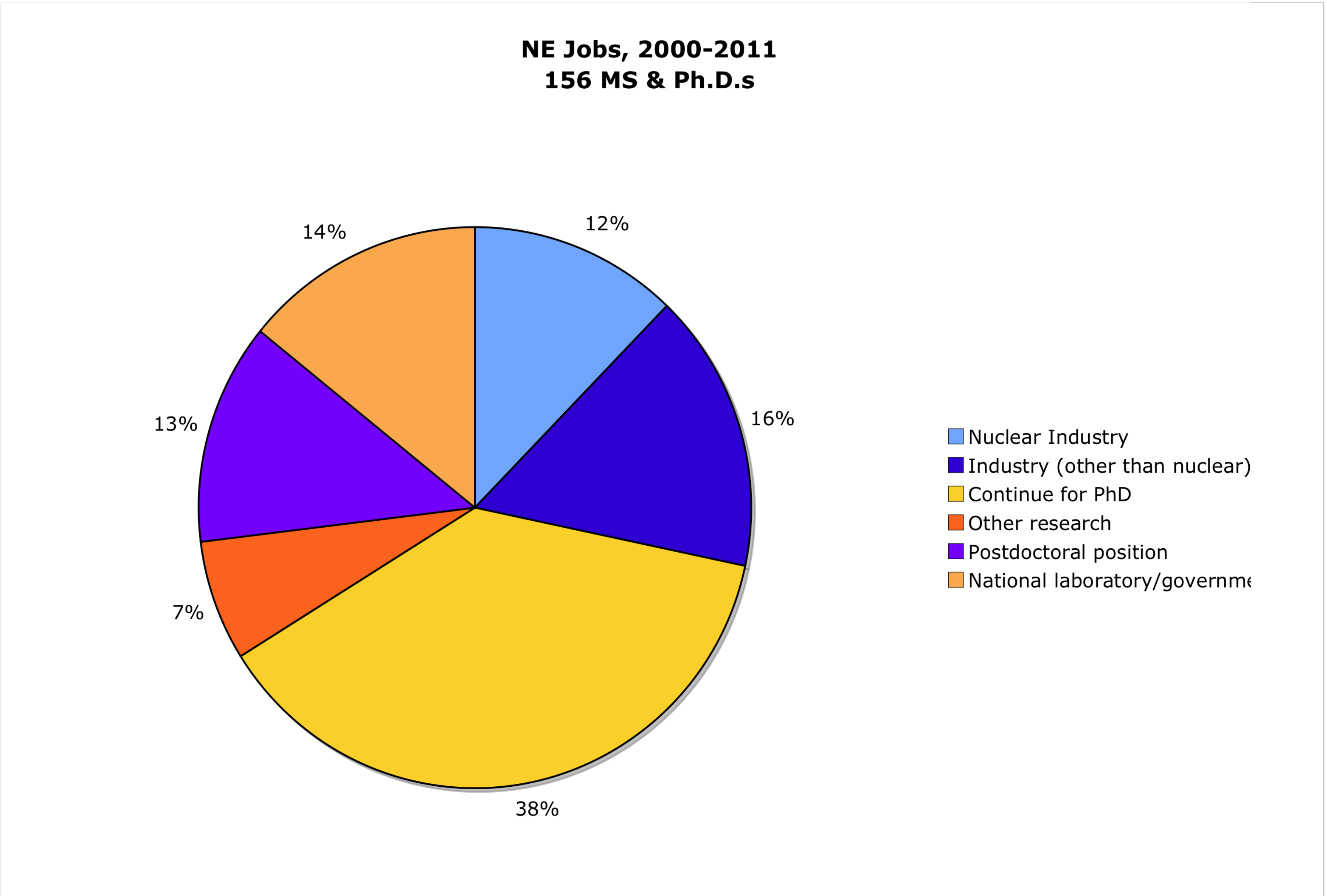

Number of NE Degrees
18
16
14
12
10
8
6
4
2
0
Doctoral
Masters
Bachelor
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year (beginning fall)

Women & International Graduate



Women in Nuclear Engineering

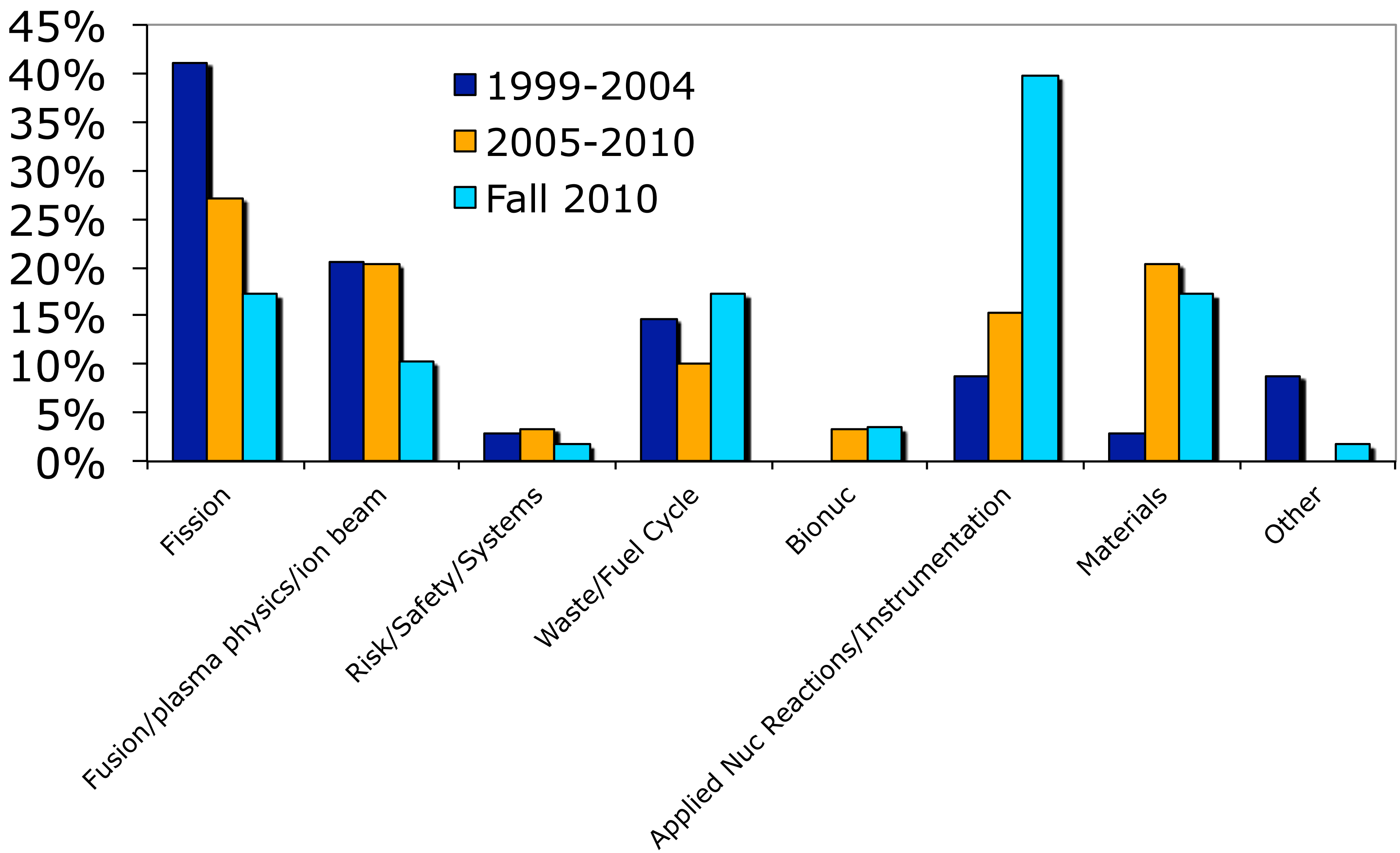



NE Jobs, 2000-2011
156 MS & Ph.D.s
12%
16%
38%
7%
13%
14%
Nuclear Industry
Industry (other than nuclear)
Continue for PhD
Other research
Postdoctoral position
National laboratory/governme

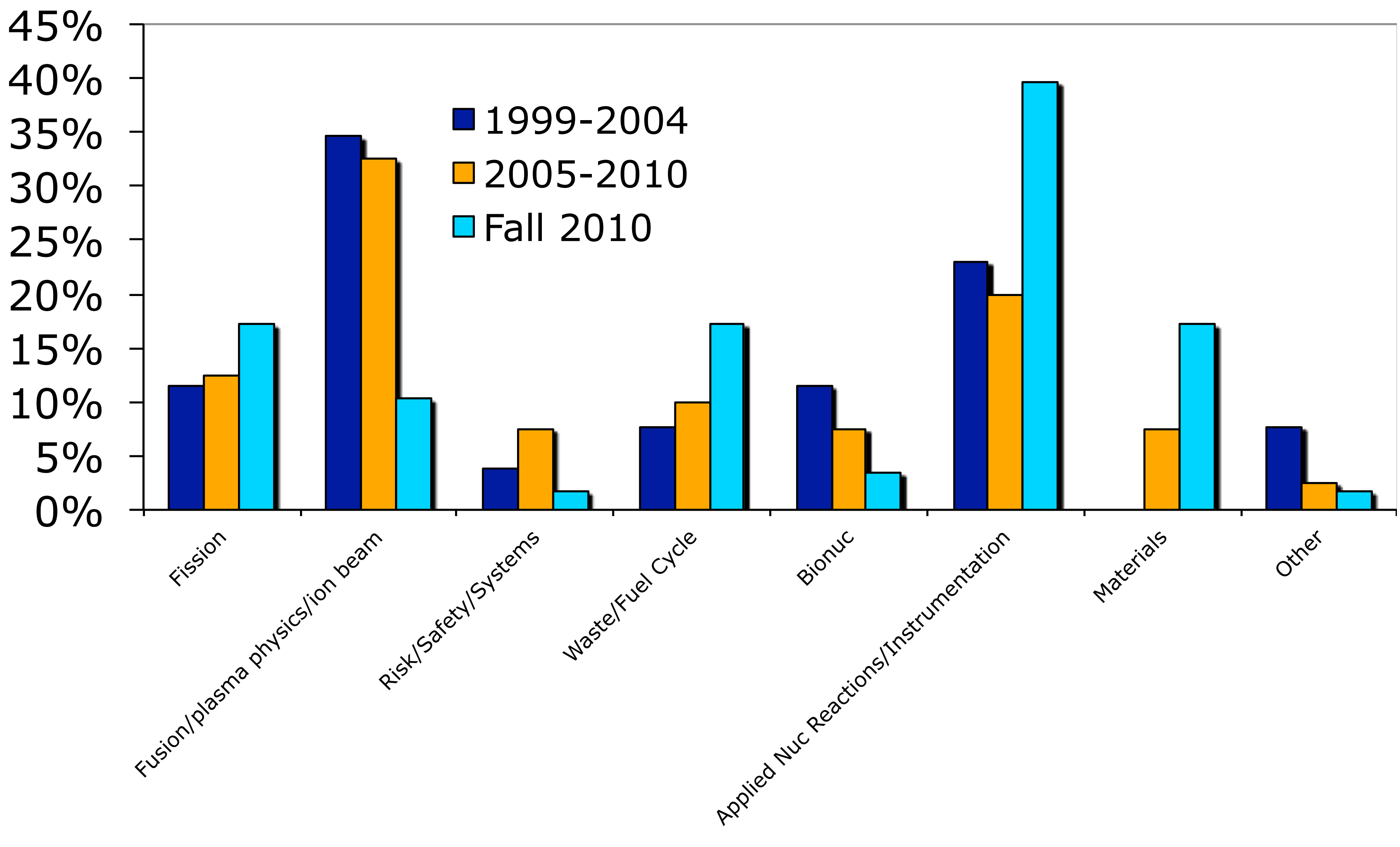
Areas of Graduate Study

Applied Nuclear Reactions & Instrumentation
Bionuclear and Radiological Physics
Energy Systems and the Environment
Ethics and the Impact of Technology on Society
Fission Reactor Analysis
Fuel Cycles and Radioactive Waste
Fusion Science and Technology
Laser, Particle Beam, and Plasma Technologies
Nuclear Materials and Chemistry
Nuclear Thermal Hydraulics
Risk, Safety and Large-Scale Systems Analysis

NE MS Subject Areas



NE Ph.D. Subject Areas



Objectives of Undergraduate Curriculum

- to produce graduates who as practicing engineers and researchers:
  - 1) Apply solid knowledge of the fundamental mathematics and natural (both physical and biological) sciences that provide the foundation for engineering applications.
  - 2) Demonstrate an understanding of nuclear processes, and the application of general natural science and engineering principles to the analysis and design of nuclear and related systems of current and/or future importance to society.
  - 3) Have exhibited strong, independent learning, analytical and problem-solving skills, with special emphasis on design, communication, and an ability to work in teams.
  - 4) Demonstrate an understanding of the broad social, ethical, safety and environmental context within which nuclear engineering is practiced.
  - 5) Display an awareness of the importance of, and opportunities for, life-long learning.

Our graduating students achieve nine key outcomes.

1. The ability to apply knowledge of mathematics, natural science and engineering to the analysis of nuclear and other systems.
2. The ability to identify, formulate and solve nuclear engineering problems.
3. The ability to design integrated systems involving nuclear and other physical processes.
4. The ability to design and perform laboratory experiments to gather data, test theories, and solve problems.
5. The ability to learn and work independently, and to practice leadership and teamwork in and across disciplines.
6. The ability for effective oral, graphic and written communication.
7. A broad education necessary to understand the social, safety and environmental consequences of engineering decisions, and to engage thoughtfully in public debate on technological issues.
8. An understanding of professional and ethical responsibility.
9. Knowledge of the importance of, and opportunities for, life-long learning.

Undergrad Curriculum

Freshman Year [Common First Year]	***Fall***	***Spring***
Math 1A, 1B, Calculus	4	4
Chemistry 1A (or 4A), General Chemistry	4	
Physics 7A, Physics for Scientists and Engineers		4
Engin 10, Engineering Design and Analysis	3	
Engin 7, Introduction to Applied Computing		4
Nuc Eng 39, Issues in Nuclear Engineering (Optional)	2	
Reading and Composition course from List A	4	
Reading and Composition course from List B		4
Sophomore Year	***Fall***	***Spring***
Math 53-54, Multivariable Calculus, Linear Algebra, Diff. Eqns.	4	4
Physics 7B, 7C, Physics for Scientists and Engineers	4	4
EE 40, Introduction to Microelectronic Circuits or EE 100, Electronic Techniquies for Engineering		4
Engin 45, Properties of Materials	3	
First and Second additional Humanities / Social Studies courses	4	3
Junior Year	***Fall***	***Spring***
Engin 115, Engineering Thermodynamics	4	
Engin 117, Methods of Materials Analysis	3	
Nuc Eng 101, Nuclear Reactions and Radiation	4	
Nuc Eng 104, Radiation Detection Lab		3
Nuc Eng 150, Nuclear Reactor Theory		3
Third Additional Humanities / Social Studies course (ethics content)	4	
Technical Electives #		9
Senior Year	***Fall***	***Spring***
Nuc Eng 170, Nuclear Design		3
Fourth Additional Humanities / Social Studies course		3
Technical Electives #	14	9

Beam and Accelerator Applications: Physics 110A/B (or EE 117), 129 A/B, 139, 142; NE 155, 180;
Bionuclear Engineering: BioE C165; EE 120 (EE 20N is a prerequisite for this course), 145B; NE 107, 162;
Fission Power Engineering: ME 106, 109 (ChemE 150A may be substituted for ME 106 and 109); NE 120, 124, 155, 161, 167, 175;
Fusion Power Engineering: Physics 110A/B, 142; NE 120, 180, 155;
Homeland Security and Nonproliferation: Chem 143, Physics 110A/B, 111, NE 107, 130, 155, 175;
Materials in Nuclear Technology: MSE 102, 104, 112, 113; NE 120, 124, 155, 161;
Nuclear Fuel Cycles and Waste Management: ChemE 150A/B; E 120; Energy Resources Group 151; MSE 112; NE 120, 124, 155, 161, 175;
Radiation and Health Physics: NE 120, 155, 162, 180; Risk, Safety and Systems Analysis: CE 193; Chem E 150A; E 120; IEOR 166; NE 120, 124, 155, 161, 167, 175.

ABET Requirements and NE Courses

Course	NE Program Outcomes								
	1	2	3	4	5	6	7	8	9
Math 1A, 1B, 53, 54	X								
Chemistry 1A	X			X					
Physics 7A, 7B, 7C	X			X					
EE 40 (or 100)	X								
Engin 45	X								
Engin 7	X	X							
Engin 117	X								
Engin 115	X		X						
Nuc Eng 101	X	X							
Nuc Eng 150	X	X	X						
Nuc Eng 104	X			X	X	X			
Nuc Eng 170	X	X	X		X	X	X	X	X
Technical Electives including courses required for selected area of specialization #	X	X	X						
Ethics course requirement							X	X	
Humanities and Social Science Electives						X	X		

Courses Offered

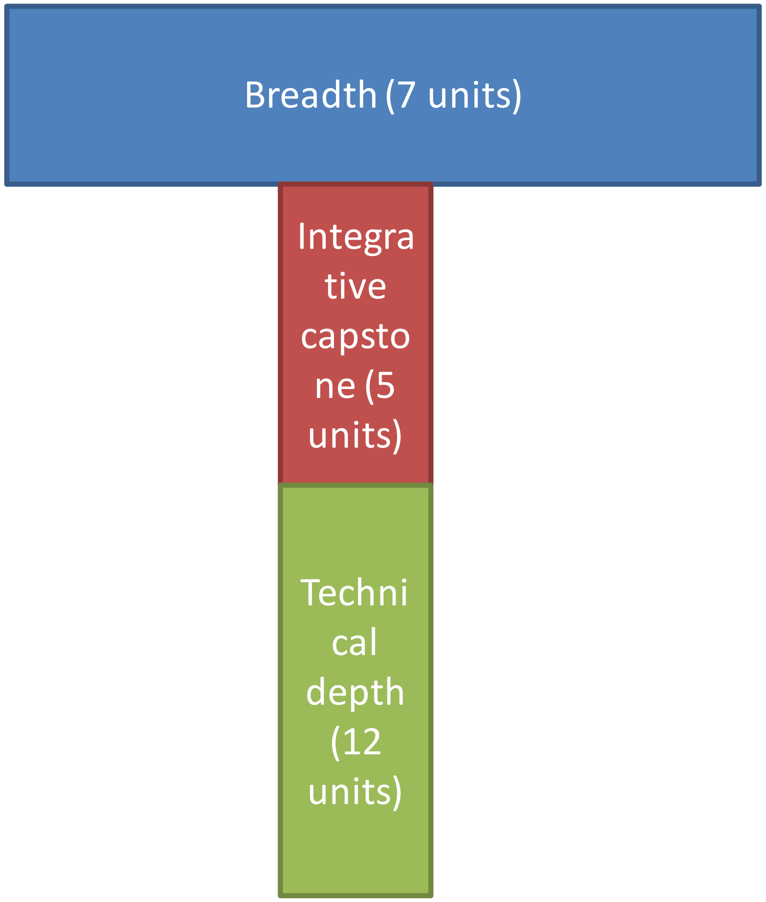
NE	Undergraduate Level		
24	Freshman Seminar	1	
39	Issues in Nuclear Science and Engineering	2	Peterson
101	Nuclear Reactions and Radiation	4	Norman
104	Radiation Detection and Nuclear Instrumentation Laboratory	3	Vetter
107	Introduction to Imaging	3	Vetter
120	Nuclear Materials	4	Hoseman
124	Radioactive Waste Management	3	Ahn
130	Analytical Methods for Non Proliferation	3	Morse
150	Introduction to Nuclear Reactor Theory	4	Vujic
155	Introduction to Numerical Simulations in Radiation Transport	3	
161	Nuclear Power Engineering	3	Peterson
162	Radiation Biophysics and Dosimetry	3	Vujic
167	Nuclear Reactor Safety	3	Peterson
170	Nuclear Design	3	Peterson
175	Methods of Risk Analysis	3	Peterson
180	Introduction to Controlled Fusion	3	Morse
198	Group Studies for Advanced Undergraduates	1-4	
199	Supervised Independent Study	1-4	

Graduate Level			
201	Nuclear Reactions and Interactions of Radiation with Matter	4	Norman
220	Irradiation Effects in Nuclear Materials	3	Hoseman
221	Corrosion in Nuclear Power Systems	3	Hoseman
224	Safety Assessment for Geological Disposal of Radioactive Wastes	3	Ahn
225	Nuclear Fuel Cycle	3	Ahn
230	Analytical Methods for Non-Proliferation	3	Morse
250	Nuclear Reactor Theory	4	Vujic
255	Numerical Methods of Reactor Analysis	3	Vujic
260	Thermal Aspects of Nuclear Reactors	4	Peterson
265	Design Analysis of Nuclear Reactors	3	Greenspan
267	Nuclear Reactor Safety	3	Peterson
275	Principles and Methods of Risk Analysis	4	Peterson
280	Fusion Reactor Engineering	3	Morse
281	Fully Ionized Plasmas	3	Morse
282	Ion Source and Beam Technology	3	Leung
282L	Ion Source and Beam Technology Lab	1	Leung
290G	Scientific and Regulatory Basis for Environmental Protection in Nuclear Fuel Cycle	3	Ahn
295	Nuclear Engineering Colloquium	0	
298	Group Research Seminar	1	
299	Individual Research	1-10	

Professional Master of Engineering Degree (NEW in 2011)

- The objective is to develop professional engineering leaders who understand the technical, environmental, economic, and social issues involved in the design and operation of nuclear engineering devices, systems, and organizations.
- Prospective students are engineers, typically with industrial experience, who aspire to substantially advance in their careers and ultimately to lead large, complex organizations, including governments.

M.Eng. Curriculum



Summary

- After decades of negative feedback and declines, the nuclear industry, federal government policies, and university enrollment turned around.
- We now need to develop innovative solutions for complicated, coupled problems of energy resources, environmental impact reduction, nuclear security and safety, and economics, especially in post-Fukushima situation.
- To respond to such needs and situation, university needs to develop educational programs with innovative approaches. Cross-disciplinary training is critical in the energy field. The nuclear energy power sector should be more integrated into energy planning and evaluation across a wide range of energy technologies and systems.
- Nuclear Engineering programs at UC Berkeley have been continuously revised to meet such needs both at undergraduate and graduate levels.