Preliminary Report

FESAC Workforce Development Panel

Presentation to Fusion Energy Sciences Advisory Committee

November 18, 2003

FESAC Workforce Development Panel

Members:

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Mike Brown	Swarthmore	
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Ken Gentle	UT Austin	
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Earl Scime	West Virginia	
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Charge to FESAC

CHARGE: "to address the issue of workforce development in the U.S. fusion program".

The key components of this charge are three-fold:

⇒

- Where are we? Assess the current status of the fusion science, technology, and engineering workforce (e.g., age, skill mix, skill level).

- Where are we going? Determine the workforce that will be needed and when it will be needed in order to ensure that the U.S. is an effective partner in ITER and to enable the U.S. to successfully carry out the fusion program.

- How do we get there? Provide suggestions for ensuring a qualified, diversified, and sufficiently large workforce and a pipeline to maintain that workforce. The suggestions should be things that are reasonable and within the control of the Office of Science.

Panel Process & Progress

• July 31, 2003	Charge to FESAC
• August – September	Formed panel. Developed institutional, organizational, and individual surveys Virtual Meetings (9/8/2003, 9/25/2003, 11/7/03, & 11/12/03)
• Sept. 29 - Oct. 5	Distributed surveys via e-mail
• October 23, 2003	Released on-line “individual” survey **http://www.auburn.edu/cosam/FESAC_survey**
• October 25-26, 2003	Panel meeting at APS-DPP conference; Brief report of findings to UFA at DPP meeting
• November – January	Data collection, analysis and report preparation
• November 18, 2003	Preliminary findings
• March, 2004	Report findings to FESAC

Summary of panel discussions

- Initial e-mail discussions and conference calls focused primarily on the first part of the charge - “Where are we?”

- Objective: attempt to obtain a snapshot of people working in the field
  - Methodology for acquiring data
  - Type of information needed
  - Organizations to be queried

- With the available data, we have begun the process of addressing the second part of the charge - “Where are we going?”

- Working principles:
  - Ensure the **“continuity of intellectual infrastructure”** for the field
  - Ensure sufficient professionals are available to maintain a **vigorous domestic program** that includes a burning plasma experiment
  - Ensure that the **workforce pipeline** is adequate to maintain a healthy, diverse, and flexible base of highly qualified persons capable of continuing the development fusion energy sciences.

Methodology and Comparisons

Two level survey is performed: institutional (survey forms) and individual (online form)

Panel Survey Database (WPS): Faculty - 105
University Researchers - 120
National Laboratories (OFES supported) - 480
[340 PhD's: 192-MFE, 68-IFE, 80-Technology]
National Laboratories (NNSA supported) - 300 (est.)
Total: ~1000 persons

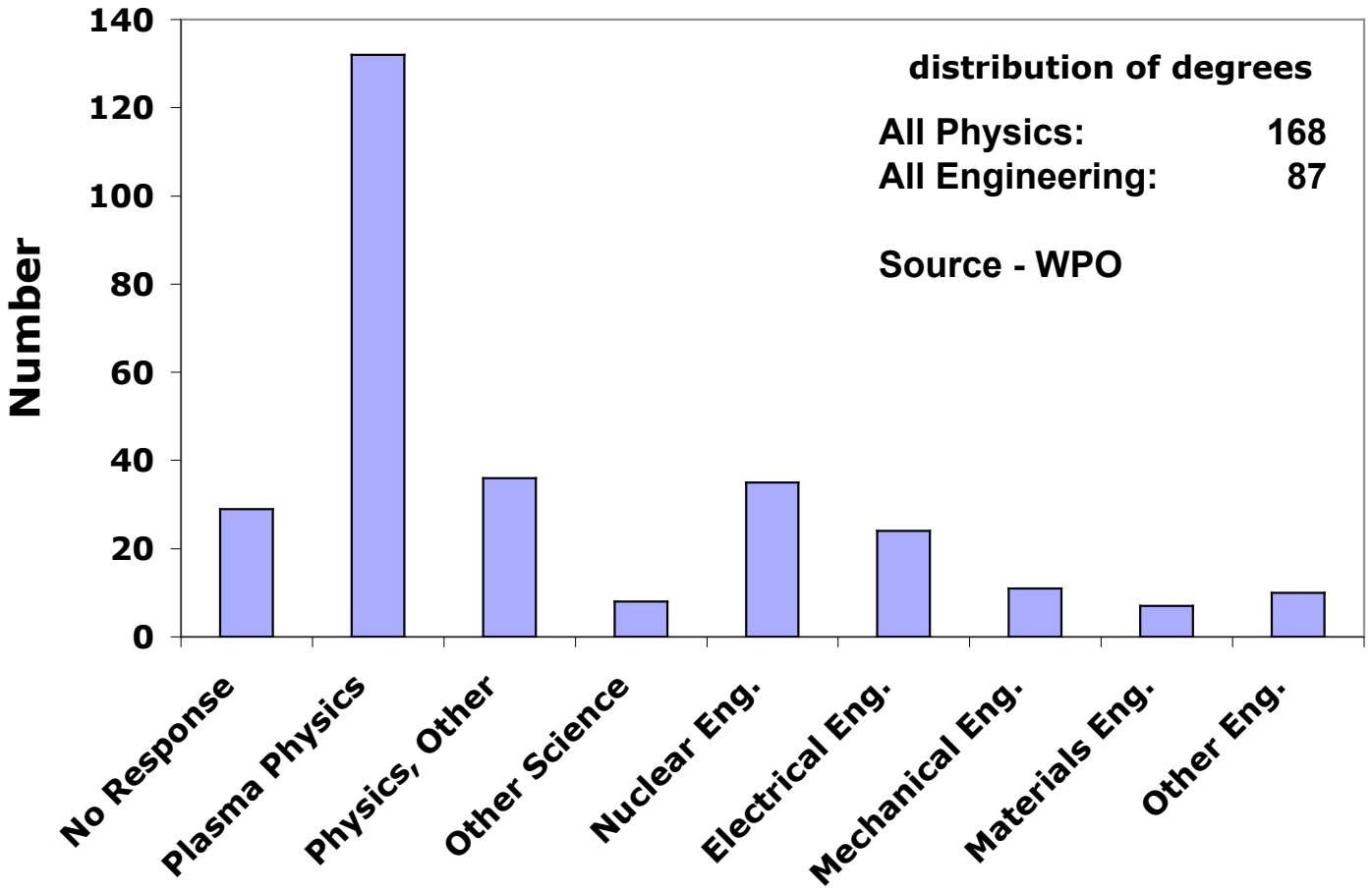
Panel Online Database (WPO): 292 persons (~30% response rate)

Comparisons are made with data obtained from the following sources:

REPORTS	DATABASE SIZE	NOTATION
"Characteristics of Doctoral Scientists and Engineers in the United States - 2001", NSF Report NSF-03-310	13000	NSF
"Science and Engineering Doctorate Awards - 2002", NSF Report 04-303	21000	
"2002 Academic Workforce Report" & "2002 Society Membership Profile" - American Institute of Physics	11000	AIP
"Age distribution of fusion science faculty and fusion science PhD production" - University Fusion Assoc., 2003	100	UFA

Because the NSF database contains the most reliable "tracking" of information across many fields of science and engineering, the panel has relied on that data to benchmark its own results.

Distribution of highest degrees - Primarily Physics



- Presently, the fusion workforce is dominated by persons with a plasma physics background, therefore many comparisons of the panel data are with the physics community as a whole.
- In future years,the number of persons with an engineering background is expected to increase .

Workforce: Gender and Diversity

Gender	Males (%)	Females (%)
National / Corporate Labs*	92%	8%
University faculty (tenure-track)*	97%	3%
University research staff*	94%	6%
Physics and Astronomy**	92.5%	7.5%

Diversity	White (%)	Non-White (%)
National / Corporate Labs*	87%	13%
University faculty (tenure-track)*	88%	12%
University research staff*	87%	13%
Physics and Astronomy**	81.5%	18.5%

RESULT: Age and gender distribution similar to physics community

*** WPS**
**** NSF**

University faculty are skewed toward older ages

Group	% under 40	% over 60	Source
Physics PhD's	27% 29%	18% 16%	NSF AIP
Physics faculty	16%	32%	NSF
Fusion faculty	18%	33%	WPS

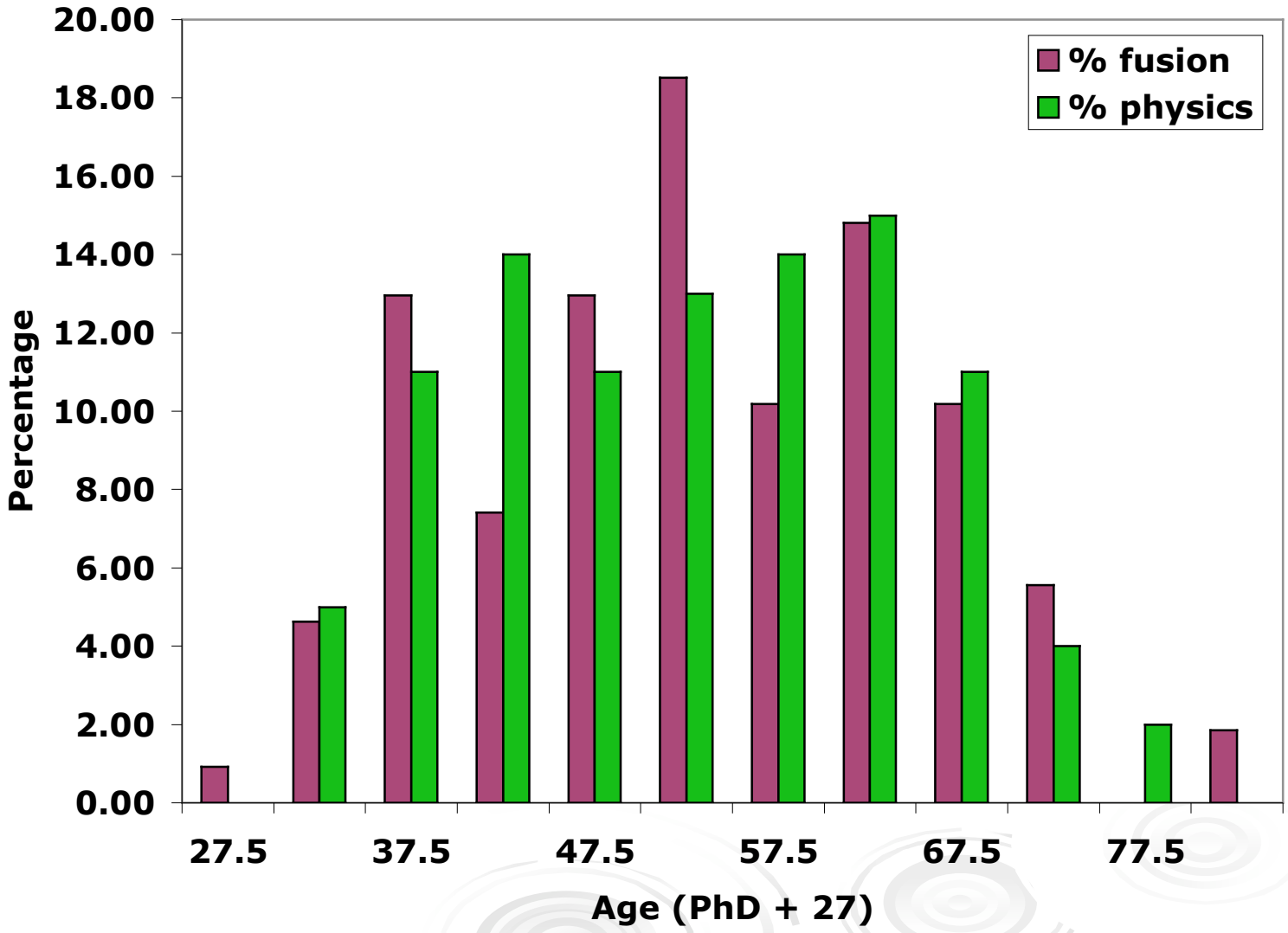
Table above is a summary of the age distribution for three groups:

- All physics PhD's
- All physics faculty
- Fusion faculty

The data shows that the age distribution of physics faculty is older than the population of all physicists.

The age distribution of fusion faculty is generally consistent with the age distribution of the physics faculty.

Age distribution of fusion faculty compared to physics faculty



Recent fusion faculty hires by universities

- Generally, the universities that have hired the most recent fusion PhD's are those that have not previously had large infrastructure or personnel investments in fusion science.

- Furthermore, the data acquired# strongly suggests that many of those institutions that currently have significant investments in fusion science do not plan to fully replace retiring faculty members.

Average hiring rate of 0.8/institution over the next 5 years (WPS)

University	Year of PhD
UC Los Angeles*	2001
Columbia*	2000
UC Irvine*	1999
U. New Mexico	1999
Utah State*	1999
Auburn	1996
UW-Madison*	1995
Maryland	1993
New Mexico Tech*	1993
Auburn	1992
Hampton	1992
Montana*	1992
Nevada-Reno*	1992
Southeast Louisiana	1992
U. Washington	1992
UW-Madison	1992
UW-Madison	1992
West Virginia*	1992
Florida A & M	1991
UC San Diego*	1991

* DOE Junior Faculty award winners (OFES website)

Projected tenure-track faculty hiring at major fusion institutions

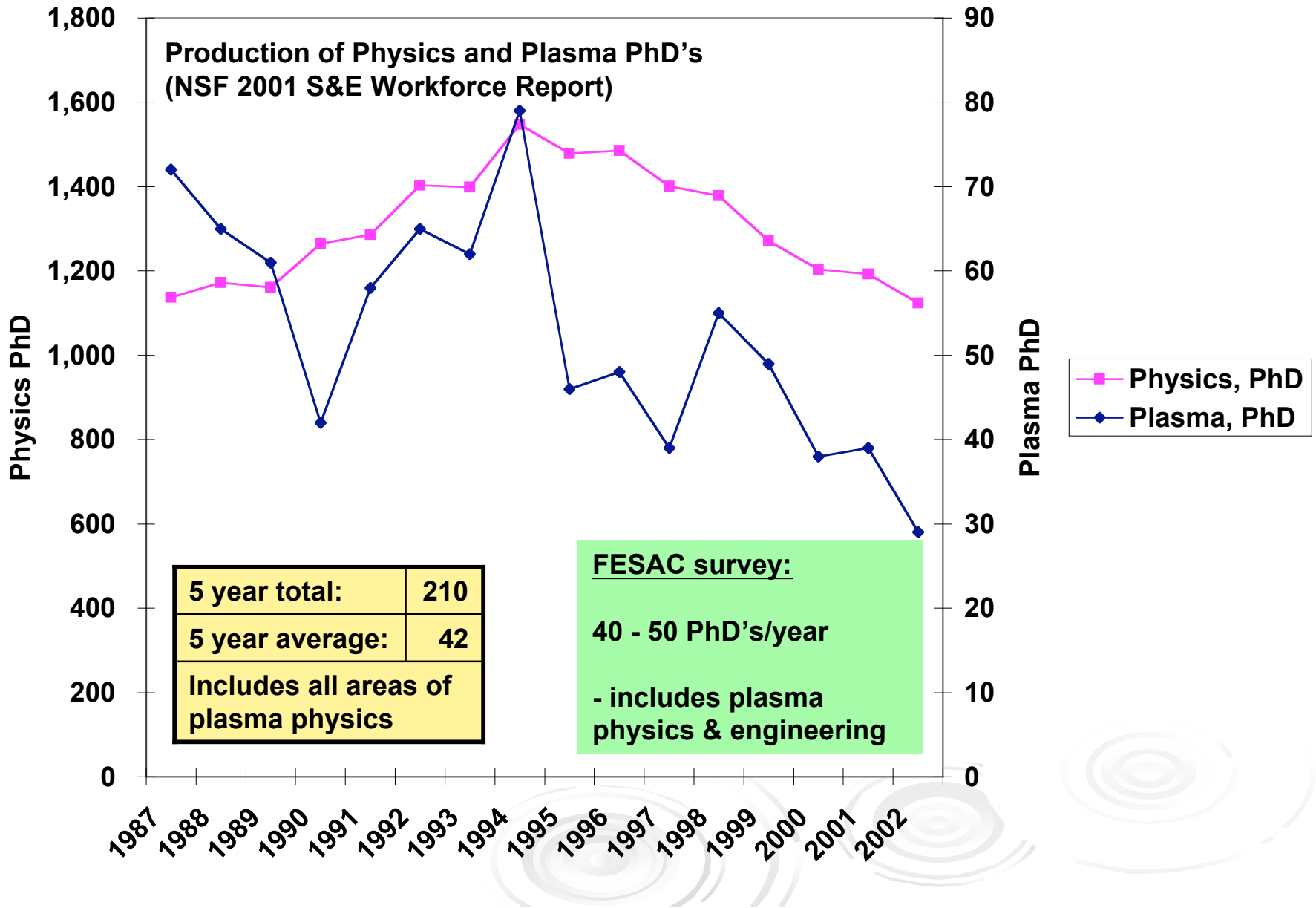
University	Current number of fusion faculty	Age distribution of current fusion faculty (PhD+27)	Projected new hires (+5 years)
Columbia	5	30, 47, 54, 60, 67	0
MIT	6	54, 44, 63, 63, 66, 71	2
Maryland	7	37, 52, 53, 55, 57, 60, 62	0
Princeton	3	52, 53, 64	1
UCLA	9	29, 43, 45, 52, 53, 57, 57, 58, 67	2
UCSD	8	39, 46, 48, 50, 51, 54, 62, 65	2

Source: WPS - Data is presented for all departments involved in fusion research at each institution.

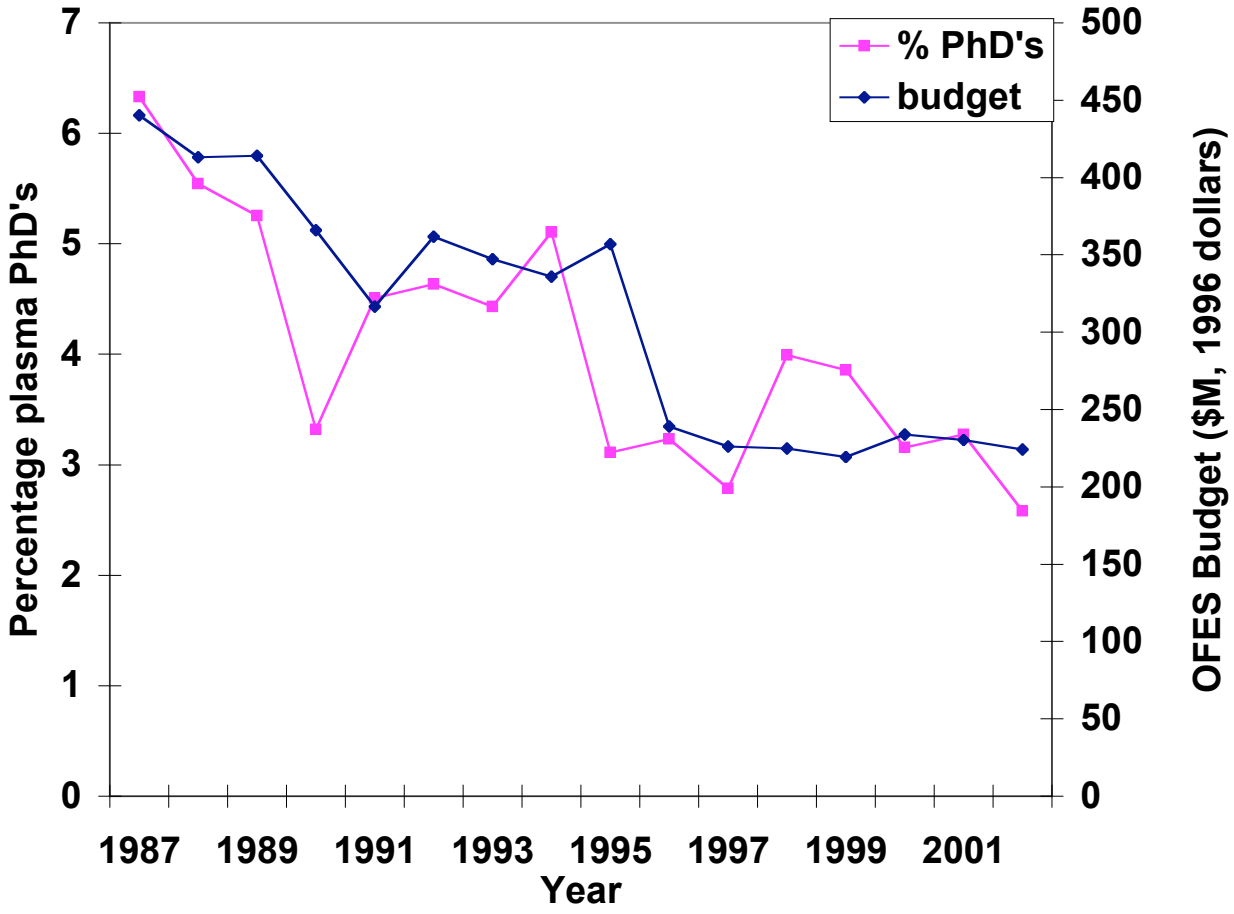
Plasma Science and Engineering PhD production - Survey data (WPS)

Number of graduate students in any type of plasma science or engineering research	286
Number of graduate students in fusion-related research	145
Graduation rate in plasma science and engineering (over past 5 years) *added 15/year for "missing" university data	175 (35/year) **250 (50/year)***
Number of graduate students obtaining permanent positions in fusion	26
Number of graduate students obtaining post-doctoral research positions in fusion	26
Number remaining in plasma science	~30
"Loss" rate	~90 persons 50% - don't pursue plasma science or engineering professions

Plasma science PhD production - NSF data



Relative production of plasma PhD's is in decline

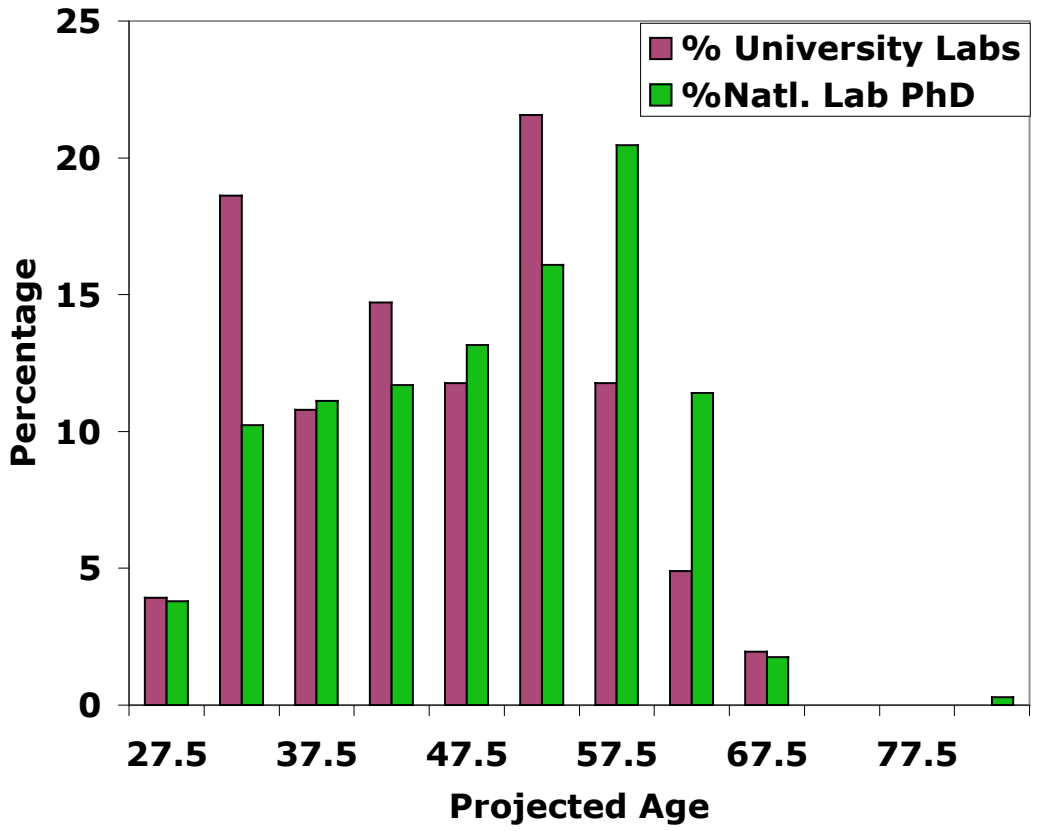


- A clear result from the analysis of the plasma physics PhD production rate is that the RELATIVE NUMBER of new plasma PhD's is in a steady decline.
- This trend appears in BOTH years of increasing numbers of physics PhD's (1987-1995) and decreasing numbers of PhD's (1996-present)
- The data shows a strong correlation between PhD production and the funding levels of the OFES.

Sources:
Production of Physics and Plasma PhD's
(NSF 2001 S&E Workforce Report)

Fusion Power Associates - OFES budget history

Laboratory workforce is similar to physics workforce



PhD's only	Average Age	Median Age
National labs	53.8	50
University labs	45.1	45.5

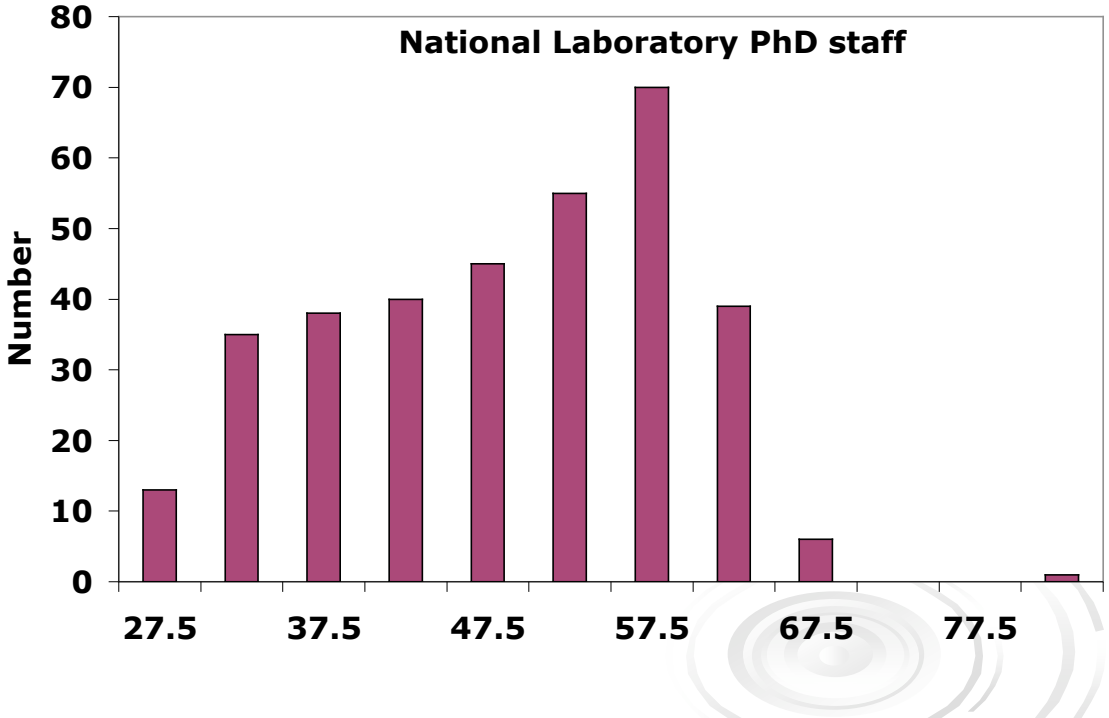
Group	% under 40	% over 60	Source
Physics PhD's	27%	18%	NSF
University Labs	33%	7%	WPS
National Labs	25%	13%	WPS

Overproduction or Underproduction?

With a “loss rate” of > 50%, it appears as if the fusion community is in an overproduction mode - i.e., more PhD’s produced than positions available.

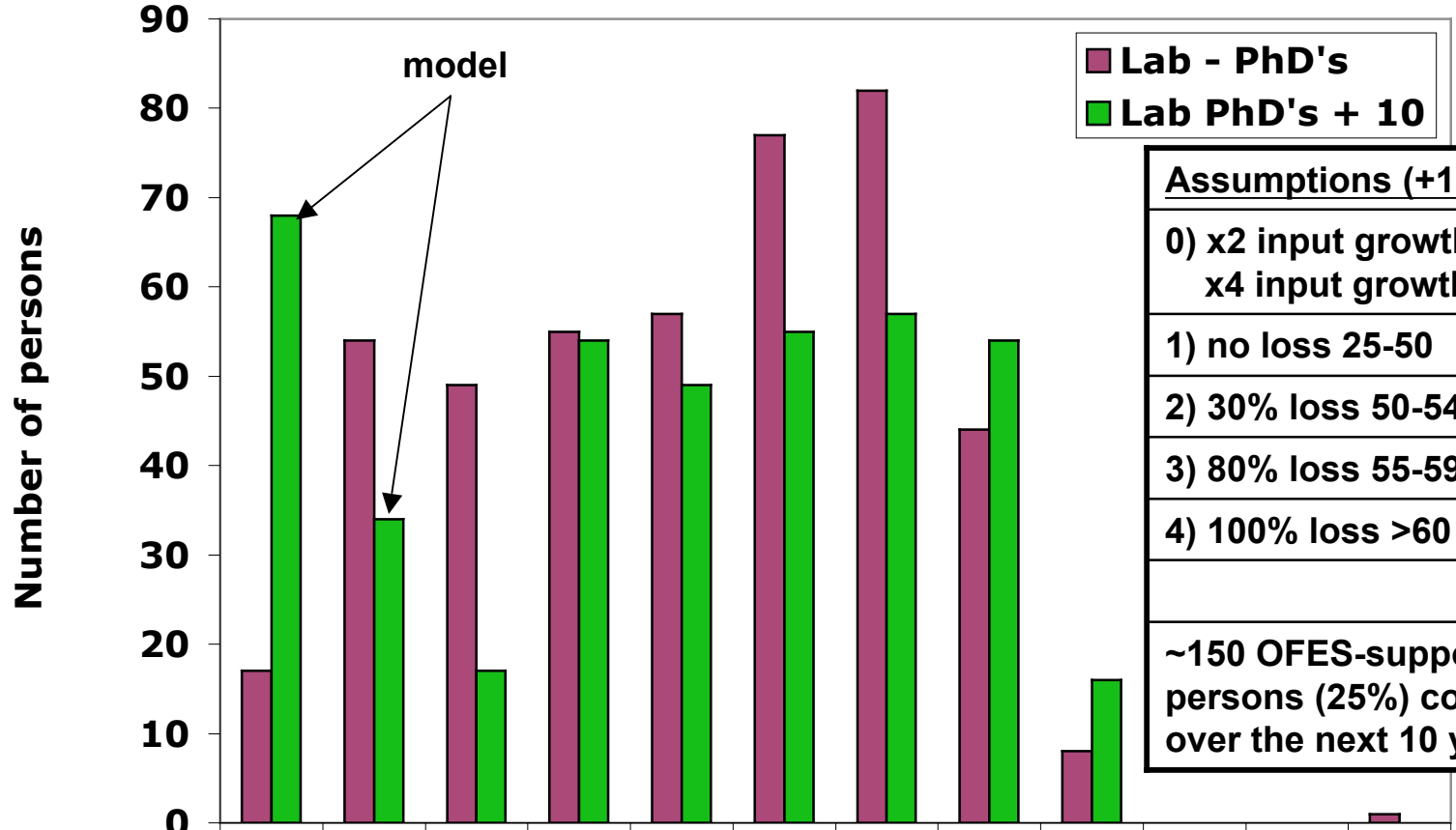
BUT -

We are also facing a “**demographic logjam**”!



- In each successive 5 year category from age 25 - 60 there is an increasing number of persons.
- After 60-65, retirements effects determine the fall-off.

Lab future workforce: significant growth is required to maintain "steady-state"



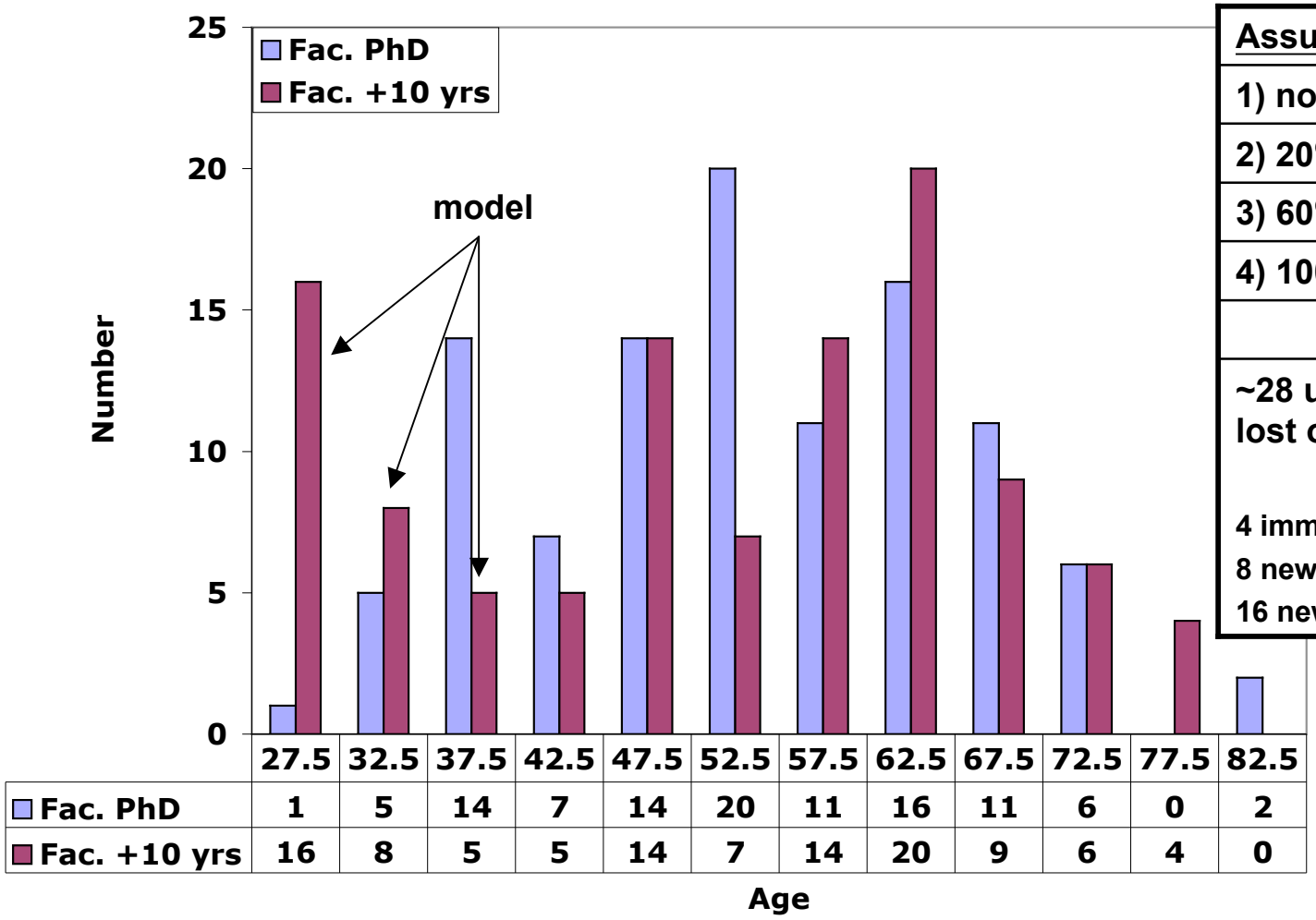
Assumptions (+10 years)
0) x2 input growth (+5 yrs) x4 input growth (5-10 yrs)
1) no loss 25-50
2) 30% loss 50-54 (40%)
3) 80% loss 55-59 (90%)
4) 100% loss >60
~150 OFES-supported persons (25%) could be lost over the next 10 years.

	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	82.5	Totals:
Lab - PhD's	17	54	49	55	57	77	82	44	8	0	0	1	442
Lab PhD's + 10	68	34	17	54	49	55	57	54	16	0	0	0	404

Age

RESULT: Even with optimistic growth projections, there remains a potential for a drop in total number of lab fusion personnel available over the next 10 years

Faculty future workforce: A potential problem?



	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	82.5	Totals:
Fac. PhD	1	5	14	7	14	20	11	16	11	6	0	2	105
Fac. +10 yrs	16	8	5	5	14	7	14	20	9	6	4	0	105

Assumptions (+10 years)
1) no loss 25-55
2) 20% loss 55-59 (20%)
3) 60% loss 60-69 (70%)
4) 100% loss >70
~28 university faculty (25%) lost over the next 10 years.
4 immediate hires + 8 new hires in next 5 yrs + 16 new hires in following 5 yrs

PROBLEM: Universities have generally not indicated a commitment to maintaining fusion faculty. With university programs potentially reducing and new faculty based at institutions that do not have a substantial fusion infrastructure, fewer fusion-trained students will be graduating.

Summary: Where are we?

- The fusion workforce is largely a white, male population with an average age between 48 - 52.
- Currently, the production of fusion PhD's exceeds demands.
- Most of the growth of new faculty is occurring at universities that have not previously had a large investment in fusion energy.
- Over the next 5 to 10 years, the fusion community may undergo a SIGNIFICANT loss of its most experienced and highly trained personnel.
  - This loss is essentially UNAVOIDABLE due to retirements.
  - Not only is this a loss of personnel, but it represents a major loss of the intellectual capacity of the entire field.
  - Furthermore, by the time the construction of the burning plasma experiment is projected to be completed (10 - 12 years from now) much of the current leadership of the burning plasma community will be approaching retirement age.

Workforce Panel tasks

- **Where are we?**
  - Work is almost completed here
  - Gather data from a few remaining institutions

- **Where are we going?**
  - The panel believes that the fusion program may have to take active steps to ensure that adequate manpower is available under virtually any projection of future needs.
  - The panel will develop models for future workforce needs based upon different funding / program scenarios.
  - Key question: How many persons will be required to maintain a vigorous national program in fusion science while maintaining a commitment to aggressive participation in a burning plasma experiment?

- **How do we get there?**
  - Ensure a continuity of intellectual capacity for the fusion program.
  - Ensure that the production rate (even with reasonable “losses”) of new PhD’s remains sufficient to maintain the vitality of the program.
  - Ensure that universities maintain their commitments to fusion science.

Panel directions

- OFES must provide the leadership to preserve the knowledge gained from 40+ years of fusion research.
- Increased employment opportunities for new fusion energy / technology PhD's is needed to preserve the "corporate knowledge" for fusion energy research.
- Faculty at non-traditional fusion institutions should have expanded opportunities to actively compete and participate in fusion projects.
- OFES should actively provide opportunities to encourage a younger and more diverse population of fusion scientists to begin taking on a more active role in the fusion community.