Importance of University Programs to the FES Mission

A White Paper Submitted to the FESAC Priorities Subcommittee by the

The University Fusion Association

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Introduction

The fusion program now stands at a crossroads, as the collision between budgetary pressures and the mounting costs of constructing ITER threatens to undermine the competitiveness of the domestic research program. It is imperative at this juncture to make the best use of all available resources. The aim of this white paper is to present the arguments for the critical importance of giving the *highest priority to university based research and education*.

We begin by reviewing the contributions of the universities to the fusion program and their cost effectiveness. These contributions include education, high-quality research, leadership, innovation, and advocacy. We then make vigorous arguments for the strong and stable funding of university programs.

Contributions of university programs to the FES mission

Education and training

The best-known contribution of university programs is their *indispensable role in the training of researchers and leaders*. Essentially all scientists presently participating in the fusion program were trained in university graduate programs funded by FES. Both the domestic fusion program's roots in the academic community and the academic training of the next generation of fusion scientists will prove essential to our ability to benefit from the ITER experiment and maintain our position in international fusion science research.

High-quality and cost-effective research

In addition to their role in education, university programs are well known for the *high quality and cost-effectiveness of their scientific contributions*. The quality is reflected, for example, in the list of Maxwell prize recipients, approximately 50% of who are affiliated with universities, compared to 32% for US National Laboratories and 9% for industry (see table below). Comparing the statistics for papers and citations for the period 2002-2011, the decade following the decommissioning of TFTR, shows the cost-effectiveness of university research. As can be seen from the table, the cost per citation to a university-produced paper is a third of that at a National Lab and half of that in industry. Part of this difference is of course due to the high cost of equipment (MIE) and operation for the activities of flagship-class facilities that benefit the entire program. Even after adding these costs to the universities' budget, however, the relative cost per citation to university papers remains only 58% of that for National Lab papers and 80% of that for industry.

Leadership

Another contribution of university programs is the leadership role played by university scientists, which is enabled by the quality of their research. The list of chairpersons of the Division of Plasma Physics offers an example of this (see table below): 58% of DPP chairs in the past 12 years have been university scientists, more than four times as many as National Labs (13%) and twice as many as Industry (29%). Other examples are the two Snowmass meetings, which were organized by university scientists, and the RENEW exercise which was led by a university scientist.

	Universities	National Labs	Industry
Papers	842	583	221
Citations	12,408	9,681	4,449
DPP Chair	7.0	1.5	3.5
Maxwell	18.5	12.0	3.5
Budget (M$)	89	210	66
M$/paper	1.1	3.6	3.0
K$/citation	72	217	148
% DPP Chair	58%	13%	29%
% Maxwell	50%	32%	9%
Statistical methods described in appendix			

Innovation

The independence of universities makes them *uniquely effective incubators for transformational ideas*. Unlike other organizations with deeper hierarchies and larger budgets, university research programs are ideally structured to nurture the maturation of such ideas. The problems that have become apparent in the ITER plans as well as the lack of a well-defined path towards DEMO show that the intellectual ferment provided by universities is more important than ever. A healthy and diverse university fusion research program will be absolutely essential to answer the scientific challenges we will face in the ITER experimental phase and on the path toward DEMO.

Advocacy

Lastly, universities are *indispensable advocates for fusion science in the court of academic and (ultimately) public opinion*. No research program, however strongly promoted by a funding agency, can hope to sustain funding without support from academia. This is evidenced by DOE's regular consultation of institutions, like the National Academy of Sciences, which derive their membership overwhelmingly from academia. Essentially all large research programs, such as High Energy Physics and Astrophysics, support and maintain a strong academic component in university research programs. Fusion energy science must similarly maintain its commitment to its academic program. Note that the advocacy work of fusion faculty is woven into academic life, taking place in faculty review committees and colloquia, in thesis defenses, budget councils, and space committee meetings. If our science is not

supported and promoted in this way the scientific community will dismiss our cause. Our work is reviewed by prominent academics from all walks of science, who hold significant influence on government decisions. The outreach to academia is an essential component of the fusion program, and one that is gravely endangered by the careless way in which FES has terminated university programs in recent budgets.

How does it work? The need for stability

A key feature of the relationship between FES and universities is that it is a *partnership based on trust.* University research programs represent long-term investments. University administrations are thus understandably wary in their commitment to these programs. Tenure awards commit universities to over thirty years, exceeding the lifetime of many experimental devices and representing a considerable financial obligation for the departments. Startup packages, laboratory space and infrastructure generally require further sizable up-front investment and financial commitment. Of course, these university contributions and the fact that FES only pays the summer salaries of faculty are a large part of the explanation for the cost-effectiveness of university research.

For a university, developing a research program thus represents a large, long-term investment. Program planning should permit these programs to evolve, where possible, to maintain relevance to program goals. Over the past twenty years, several abrupt terminations of established programs by OFES have had a devastating effect on the university community. The severe cuts to the domestic fusion program in the past two years have again targeted universities. The manner in which these cuts were implemented conveyed a disturbing disregard for role of universities in the mission of FES. A rarely mentioned, but extremely important point is how difficult it will be to regain the trust of these institutions in the future. *Universities, more than any other institutions, need stable funding*.

Securing the future by correcting the imbalance

In summary, universities constitute an indispensable foundation to the US fusion program. Without a strong and engaged university program, FES will find itself unable to sustain the resources it needs to operate its national laboratories. FES will also find itself unable to deliver the innovations necessary to turn fusion into a viable energy source. Its evident failure to appreciate these facts is imperiling the future of the program. For the above reasons, *we are calling for FES to immediately correct the imbalance it has created between its support for universities and the rest of the program*. If the US fusion program is to emerge from the ITER construction phase with the capacity to participate effectively in the research phase, if it is to succeed in using the resulting knowledge to develop a commercially attractive source of energy, it is essential that DOE dedicate itself immediately to *reversing the historic decline in its support for the university programs and to rebuilding its partnership with universities in sustaining a stable, diverse and broad-based university research program*.

Prepared by the Executive Committee of the University Fusion Association on behalf of the membership.

Executive committee

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Appendix: the methods underlying the statistics

The bibliographic and citation data contained in the table on p. 2 results from the searches on Thomson ISI's Web of Science for Topic=(fusion AND plasma physics), Timespan=(2002-2011), and the following strings in the Address field:

- Universities: USA AND (Univ OR MIT))
- National Labs: "Princeton Plasma Phys Lab" OR "Livermore Natl Lab" OR "Oak Ridge Natl Lab" OR "Los Alamos Natl Lab"
- Industry: "DIII-D OR (Gen Atom Co)"

The budgets for university, national lab and industry are taken from an FES presentation and pertain to 2011. We tacitly assumed that those figures are, for the present purposes, sufficiently close to the average for the past decade.

The adjusted relative costs quoted in the text follow by adding to the university budget of $89M the operation costs for DIII-D and NSTX, as well as the MIE costs for the NSTX upgrade, amounting to an additional $68M.

In the statistics on DPP Chairs, NRL was counted as part of industry, since it describes itself as a "corporate" lab and is not part of the DOE labs. Chairs listed by DPP as having more than one affiliation were apportioned equally between the corresponding categories.

In the statistics on Maxwell prizes, we made an effort to divide the contributions of individuals who changed categories during their careers. Three recipients were thus divided between PPPL and universities, and one between PPPL and industry. All PPPL Faculty was counted in the national lab category. The awards to three foreign scientists are not displayed in the table.