To: FESAC Panel on International Collaboration for Magnetic Fusion Energy

Domestic and International Plasma Fusion Facilities in Education.

Fusion and plasma physics are critical fields of science. They offer the long-term energy production potential of controlled fusion; they address the plasma state that is pervasive throughout the universe; they undergird plasma technologies that are economically important in industry; they study high-energy interactions vital to national security.

Currently, the major facilities in the US are the key places where graduate students carry out fusion research and gain the experience necessary to succeed in fusion science. During the 2006-2011 period the following numbers of graduate students performed their research on the three biggest US magnetic confinement facilities: NSTX 14, DIII-D 22, Alcator C-Mod 56. At MIT, for example, typically more than half of the (currently 66) graduate students at the Plasma Science and Fusion Center work on major domestic facilities. It might be noted that this far exceeds the number of MIT students (currently 15) working at CERN.

Closure of domestic facilities in favor of overseas collaborations would severely curtail the educational opportunities that are currently most productive, and that offer exciting ongoing research prospects. It seems likely that students will find the prospect of carrying out PhD experimental work overseas substantially less attractive than local experiments, and this will affect the numbers and quality of applicants. While this problem is perhaps less severe for theorists, plasma fusion research is highly experimental and the opportunity for theorists and computationalists to interact with in-house experimentalists is a currently very valuable benefit that accrues to domestic facilities. All leading universities require students to be resident on campus for a substantial fraction of their education, which limits their ability to become full-time participants in overseas research teams. (Professors with teaching commitments will have comparable difficulties). Developing the skills to exercise experimental leadership, for example integrated knowledge of the whole device and not just limited diagnostic expertise, is doubly difficult for students in a different culture (and language) with only part-time presence. Such leadership skills will be critical to US exploitation of ITER.

The cultural adventure of researching overseas is a partly compensating factor to these discouragements and difficulties. But, as is clear from the related situations (e.g. students coming to the US for studies) graduate students who succeed in mastering an overseas culture very frequently decide to remain permanently in the new nation. The yield of top-rank professional US scientists from PhDs carried out at overseas facilities may thus be even further attenuated.

Even if the overseas facilities are willing to provide research opportunities to US students at no charge, the costs of PhD education through international facilities will undoubtedly be much higher than domestic because of travel, living, and other logistical expenses. Travel costs will also accrue to Professors from the universities who will have to be involved in the overseas research, and the mentors who must be continuously located at the facilities.

High caliber students are the future science and technology leaders in any nation. Maintaining US expertise and capability in the fusion and plasma physics fields is a vital national interest. Domestic facilities are critical contributors to student education and thereby to US exploitation of opportunities in these fields.

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