Priorities for the US Fusion Program

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Introduction: Below I would like to provide input to the FESAC Fusion Priorities Panel. This input reflects only my own views which are critical of DoE and probably will be unpopular in some parts of the fusion community. So be it. Someone needs to get up and say "the Emperor of Fusion has no clothes". I will discuss three topics: (1) ITER, (2) PPPL, and (3) the US tokamak program. After raising each issue I will then make a recommendation towards a path forward.

ITER: At $5B ITER is a good idea. At $25B+ ITER is a bad idea. The huge cost increases from ITER's initial to present value are leading to a savaging of the base fusion program which puts the US on the fast track to disaster for the future of fusion research. More important, even if ITER works as expected, but does indeed cost $25B, this is essentially a proof of principle that tokamak fusion will never be an economical source of electricity. Now, I recognize that as far as the Panel is concerned ITER is off the table. However, this is a constraint that deserves to be ignored since it is an absolutely absurd one to impose on a Panel whose job it is to recommend priorities for the US fusion program.

Recommendation: The US and the world fusion community have to take a step back and come up with a convincing, and I mean convincing, argument that future costs will be much lower. Assuming such arguments are forthcoming we should implement any applicable ideas to the present ITER program. My own belief is that there are two main problems that have led to the large cost increases: (1) the ridiculously inefficient management system that the world's fusion scientists are forced to work under, and (2) the fact that while ITER represents a justifiable next step in plasma physics, it may be too ambitious with respect to the engineering and technology. If a convincing case cannot be made for reducing the cost of a future tokamak fusion reactor the US should consider pulling out of the project and go back to the drawing board.

PPPL: PPPL is the national laboratory for fusion in the US. As such it is essential that it have a strong program and play a major role in defining the future direction of the US fusion research. My concern here is that PPPL's present research program focuses on the spherical tokamak (ST) which I do not believe is a good option. While I have strong confidence that PPPL will carry out exceptional quality research, when I look ahead the ST does not hold, at least for me, much hope of turning into a low cost compact component test facility, which is its ultimate mission. My problems largely have to do with plasma physics – MHD stability, heating, current drive, and transport are each more difficult in an ST than in a standard tokamak which has enough problems of its own. I just do not believe that these plasma physics problems can be satisfactorily resolved. My own preference would be for PPPL to switch from the spherical tokamak to the compact stellarator, which is partially built and currently in mothballs at PPPL. In my opinion this is a very clever idea that has the potential to solve two of the major problems facing

tokamaks – steady state and major disruptions. Here too I recognize that the compact stellarator is a real sore point in DoE. My only advice is to "get over it" and not let politics and management issues override the best scientific path.

Recommendation: Although I favor the stellarator it is clear to me that there are also strong advocates for the spherical tokamak. I would like to see a panel of high level fusion scientists hear competing presentations from PPPL describing the pros and cons of each concept – effectively "gunfight at the PPPL corral". This review could be carried out within three months and whichever way the results came out members of the fusion community would feel more confident about the program at PPPL since it will have been decided on the basis of science.

The US tokamak program: At every high level DoE review one always hears about the US leadership in fusion research and how we must maintain this role in the world's program. Wake up! You're dreaming! I believe that while US scientists are outstanding, we are being forced to rest on our laurels since we haven't built a new state of the art tokamak in many years. The current plan is for many US scientists to move to Asia and collaborate on the new tokamaks that have recently been built there. This is a polite way of saying that we are outsourcing our fusion expertise because it will save us money. This major outsourcing plan borders on the ludicrous – the US has to have its own facilities if we are going to learn how to build and operate large fusion experiments, a near impossible task to do on someone else's facility.

Recommendation: I would like the major US fusion laboratories, GA, PPPL, and MIT, to develop a doable design for a next generation device. Resources would obviously have to be shared and reprogrammed. Given the budget constraints facing the US fusion program for the foreseeable future, it seems probable to me that a new device would focus on the steady state mission in order to save the large costs associated with a radioactive tritium experiment. I am not sure what the final device might look like but continuing to do paper studies on $2 – 4B dollar experiments to be built with the ITER roll-off seems like pie in the sky. We need a sharply defined mission that leads to a device that can actually be built under budget constraints – it is essential that it be a real machine so it is not relegated to the warehouse of paper studies.

Discussion: Knowing the way that DoE operates I am doubtful that any of the above recommendations will be implemented. It seems likely to me that the US-DoE will, for all the wrong reasons, continue along its current path of supporting ITER as it barrels ahead towards bankruptcy. The rationale for continuing would be along the lines of "the US strongly supports ITER, views it to be the world's first burning plasma experiment, and considers it to be a major milestone on the path to fusion energy" - a well intentioned and logical rationale. The problem, however, is the implementation. The present US Fusion Program set by DoE contradicts the very rationale that it purports to be supporting. In effect the current US program is one in which we demonstrate our strong support for ITER by (1) never paying the full share of our commitment, (2) strangling the base program, and (3) shutting down and seriously curtailing operation of precisely those two US tokamaks that could actually directly support ITER.