Public Comments to FESAC
Miklos Porkolab, MIT.
February 28, 2006.

This comment is motivated by the earlier comments of my distinguished colleague, Professor Jeffrey Freidberg of MIT. I beg to disagree with his comment, namely that the "emperor has no tokamak" (ie, clothes).

More importantly, my comment also relates to the new Charge to FESAC in regard to reviewing the future role of the major US plasma confinement facilities.

Let me explain.

The new charge is a very important task, may be the most important in recent years, with significant implications for the future, perhaps for the next decade and possibly beyond. This timely charge deserves a careful study.

However, I am concerned in regard to one of the suggested solutions to the perceived problem of "loss of US leadership" in fusion science unless we transfer our operations to foreign *superconducting* tokamaks in the spirit of a truly international program. This would imply shutting down our existing *copper* magnet facilities and ship our best people (possibly graduate students) and new hardware and operating funds to facilities abroad. Besides being very disruptive, the concern I have is that this goes against the premise that we should be a science driven program, and that the science should determine the facilities on which the experiments should be carried out (to quote Joel Perriott of OMB). Our program is not like high energy physics, where the frontier physics is done at the highest possible energies, imitating those that may have occurred during the big bang.
In fact, when we shut down TFTR we gave away our *fusion* performance pushing research, at least on US facilities. While we lost our own D-T capability, we continued some of this work on JET in a collaborative manner. Nevertheless, this does not mean that we gave away the possibility of achieving record *plasma* performance on US facilities. I remind you that recently we have achieved record values of plasma pressure on Alcator C-Mod at MIT, namely 1.8 atmospheres; we have achieved record beta values on DIII-D at General Atomics and NSTX at PPPL; and have achieved ohmic

current free AT operation on DIII-D at reactor relevant betas and bootstrap current fractions. These are just a few examples to document that we still have the capability to push *plasma performance* that will enable ITER to succeed. Also, let me remind you of the many foreign collaborators who come to our facilities to participate in cutting edge fusion and plasma confinement science research.

Even more important, however, is the understanding of plasma and fusion science that we are developing on our facilities. Let me remind you that the relevant physics time scales that matter in this respect are transport related confinement times, typically a few tenths of a second, and resistive diffusion times, typically one second, and L/R times, typically 3 resistive diffusion times, or 3-5 seconds on the US tokamaks, all within our present tokamak capabilities. In fact, operation on ITER at 600 seconds corresponds to one resistive diffusion time at its projected 30 KeV peak temperature. Therefore I claim that much of the relevant physics that needs to be explored and understood before ITER starts operation, such as stability and transport, can be studied effectively on existing US facilities. What we need is better auxiliary heating/current drive equipment, improved diagnostic capability, and adequate theory/modeling support. We should, of course, collaborate on foreign machines on programmatic elements that require very long pulse, both in well identified physics areas, but probably even more so, in technology oriented areas. And we are already doing some of this on TORE Supra in France. This activity should be expanded as opportunity arises in the future with EAST and K-STAR. However, it is not necessarily true that physics requires a transfer of most of our research activities to these machines. These machines have been built mostly to expand the world's capabilities in reactor relevant technology, and to position individual countries to be ready to push forward with DEMO, the post-ITER fusion demonstration power plant.

The most important asset of a superconducting tokamak is pulse length, and testing technology at reactor relevant time scales. In the past, the US was in the forefront of this activity and we were the first to propose and design modern superconducting tokamaks more than 20 years ago, namely Alcator DCT at MIT, and then TPX, a national effort more than a decade ago, centered at PPPL. Unfortunately, neither project was funded. K-Star is essentially TPX, and a similar machine, EAST has been designed, built and now almost completed in China. I note the existence of TORE-Supra in Europe, a circular cross section superconducting tokamak, which has been in operation for more than a decade. Appropriately, its goals were to test long pulse related technology, namely component testing, rather than plasma science. This machine will likely be shut down in the not too distant future as ITER construction begins in Cadarache. At the same time, Japan is shutting down its TRIAM 1M superconducting tokamak since it does not have shaping capability to carry out modern plasma confinement research.

In sum, in the last half dozen years the US tokamaks (in particular, C-Mod and DIII-D, and in a more general sense, NSTX) have been reoriented to pursue science and advanced tokamak physics research, and arguably, have maintained US scientific competence and perhaps even leadership in plasma confinement and stability research (of course, our European and Japanese colleagues might disagree with this premise). These programs were reviewed very recently by the Dahlberg FESAC Sub-Panel, and found to deliver cutting edge science, the facilities were found to be complementary in scope and furthermore, the study identified much more physics to do, at least for the next 5 years and possibly beyond. The new charge begs the very important question, will the research on our facilities be at the forefront of fusion science 10 years from now when ITER starts its operation? Will our facilities limit our research to obsolescence? Would we be better off to switch all, or at least some of our research activities to foreign superconducting machines, or perhaps should we propose a new medium size machine for the US by the time ITER starts operation? In my opinion to answer these questions will require an in depth study, including a broader US community involvement than just a FESAC Subpanel study. I propose FESAC start from the Dahlberg report, get the new BP Organization involved under the leadership of Ray Fonck, and possibly call for another Snowmass type meeting to flush out new ideas from the fusion community.

Thank you for giving me the opportunity to speak to you today.
End.