

## Charge from the Office of Science

October 5, 2000

Professor Richard D. Hazeltine, Chair, FESAC

Dear Professor Hazeltine,

For many years, the U.S. magnetic fusion community has recognized that burning plasma physics is the next frontier of fusion research. In this regard, it is important to note that the September 1990 Fusion Policy Advisory Committee report recommended "...construction as soon as possible of the U.S. Burning Plasma Facility." ...

In the last few years, the U.S. fusion community has reconsidered its priorities and reorganized its efforts. The FESAC Report on Priorities and Balance [1999] ... includes burning plasma physics as a part of a major thrust area, and the IPPA report [2000] includes a section on two aspects of this issue. Therefore, I would like FESAC to address the scientific issues of burning plasma physics, as follows:

1. What scientific issues should be addressed by a burning plasma physics experiment and its major supporting elements? What are the different levels of self-heating that are needed to contribute to our understanding of these issues?
2. Which scientific issues are generic to toroidal magnetic confinement and which ones are concept-specific? What are the relative advantages of using various magnetic confinement concepts in studying burning plasma physics?

As part of your considerations, please address how the NSO program should be used to assist the community in its preparations for an assessment in 2004....

I would like you to provide your report to the Office of Science by the end of July 2001.

Sincerely,  
Mildred S. Dresselhaus  
Director, Office of Science

# **FESAC Burning Plasma Panel**

<b>Herb Berk</b>	<b>U. Texas</b>
<b>Riccardo Betti</b>	<b>U. Rochester</b>
<b>Jill Dahlburg</b>	<b>NRL/GA</b>
<b>Jeff Freidberg (Chair)</b>	<b>MIT</b>
<b>Bick Hooper</b>	<b>LLNL</b>
<b>Dale Meade</b>	<b>PPPL</b>
<b>Jerry Navratil</b>	<b>Columbia U.</b>
<b>Bill Nevins</b>	<b>LLNL</b>
<b>Masa Ono</b>	<b>PPPL</b>
<b>Rip Perkins</b>	<b>PPPL</b>
<b>Stewart Prager</b>	<b>U. Wisconsin</b>
<b>Kurt Schoenburg</b>	<b>LANL</b>
<b>Tony Taylor</b>	<b>GA</b>
<b>Nermin Uckan</b>	<b>ORNL</b>

**This group held 2 public meetings and about 10,000 teleconferences.**

# **Panel Report**

- **80 pages**
- **16 major findings**
- **5 multi-part recommendations**

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# **Main Conclusions**

- **We are scientifically and technically ready to proceed with a burning plasma experiment**
  - **We can expect enormous benefits from such an experiment, regarding both scientific understanding and fusion credibility**
  - **We will realize those benefits if the base program remains strong**
- **We are ready NOW!!**
  - **IGNITOR, FIRE, and ITER-FEAT provide an ample selection of options**
  - **We should devote our efforts toward perfecting and choosing among these designs rather than toward developing additional designs**

## **Representative findings:**

- A BPX is the next step to establish credibility of fusion as an energy option
- The burning plasma regime is the next scientific frontier in fusion research:
  - Alpha particle effects on MHD stability and plasma turbulence
  - Nonlinear coupling between alpha particles, the bootstrap current, turbulent transport, MHD stability, and plasma-boundary interactions
  - Stability and control of the fusion burn
- A new BPX is needed; present experiments cannot achieve strong self heating
- The tokamak is scientifically and technically ready for a burning plasma experiment; no other configuration is ready at this time
- The base program is essential in order to (1) advance our basic knowledge of plasma science and (2) take advantage of a working BPX
- A BPX would contribute to other fields of science, such as space physics, astrophysics, accelerator physics, and computational physics

## Recommendations

***1. NOW is the time for the U.S. Fusion Energy Sciences Program to take the steps leading to the expeditious construction of a burning plasma experiment.***

The critical burning plasma science issues have been recognized for nearly two decades. They have been investigated theoretically and in a limited way experimentally. Substantial scientific progress has been made by exploiting the capabilities of existing facilities. However, the U.S. Fusion Science Program now needs a new facility to move forward. Based on our progress to date, the community has in hand a knowledge base sufficient to design a burning plasma experiment and to move on to a new frontier of vigorous experimental fusion science, inaccessible to present machines. In addition to the strong scientific justification for a new facility there is additional motivation because of the public's increasing awareness of the importance of energy to the general well being of the nation and the fact that the solution involves a long-term investment in research.

## Recommendations (continued)

### *2. Funds for a burning plasma experiment should arise as an addition to the base Fusion Energy Sciences budget.*

A burning plasma experiment, either international or solely within the U.S., will require substantial funding - likely more than \$100M per year. The largest part of this funding should be provided as an addition to the present fusion budget. It is crucial that funding for the project not be generated at the expense of maintaining a balanced base fusion science and technology program. The present program is positioned to develop key insights and develop new understanding into important unresolved science issues, which will ultimately lead to further improvements in the broad spectrum of magnetic fusion concepts. Premature termination of important components of this program would be shortsighted. It would reduce the discovery of important new plasma science phenomena and deplete the fusion science expertise that will be essential when the new facility comes on line.

## Recommendations (continued)

- z *The U.S. Fusion Energy Sciences Program should establish a proactive U.S. plan on burning plasma experiments and should not assume a default position of waiting to see what the international community may or may not do regarding the construction of a burning plasma experiment. If the opportunity for international collaboration occurs, the U.S. should be ready to act and take advantage of it, but should not be dependent upon it.*
  
- z *The U.S. should implement a plan ... to proceed towards construction of a burning plasma experiment...*

## Recommended action plan

- z Hold a “Snowmass” **workshop in the summer 2002**, for the critical scientific and technological examination of proposed burning plasma experimental designs and to provide crucial community input and endorsement to the planning activities undertaken by FESAC... the workshop should determine which of the specific burning plasma options are technically viable but should not select among them. The workshop would further confirm that a critical mass of fusion scientists believe that **the time to proceed is now ...**
  
- z Carry out a uniform **technical assessment** led by the NSO program of each of the burning plasma experimental options for input into the Snowmass summer study.
  
- z Request the Director of the Office of Science to charge FESAC with the mission of **forming a panel ... to select** among the technically viable burning plasma experimental options. The selected option should be communicated to the Director of the Office of Science by January 2003.

## Recommended action plan (continued)

- x Initiate a **review by a National Research Council** panel in Spring 2002, with the goal of determining the desirability as well as the scientific and technological credibility of the burning plasma experiment design by Fall 2003. This is consistent with the submission of a report by DOE to congress no later than July 2004.
  
- x Initiate an **outreach effort** coordinated by FESAC (or an ad-hoc body) to establish an appreciation and support for a burning plasma experiment from science and energy policy makers, the broader scientific community, environmentalists and the general public. This effort should begin now.

## Recommendations (continued)

- z *The NSO program should be expanded both financially and technically in order to organize the preparation of a uniform technical assessment for each of the burning plasma options, ITER-FEAT, IGNITOR, and FIRE, for presentation at the Snowmass summer study.*
  
- z *The U.S. needs to engage the international community in some appropriate capacity with respect to ITER-FEAT and IGNITOR so that these experiments, along with FIRE, can be evaluated on a level playing field.*

# Recommended timeline

## Recommended US Plan for Burning Plasmas

