Status Report
FESAC Panel on Priorities

Charles C. Baker, Panel Chair

DOE FESAC Meeting
30 March 2004

For further information, please access FESAC Priorities Panel website at:

http://www.mfescience.org/fesac/index.html

FESAC Charge on Priorities
from Dr. Ray Orbach

- It is now time to focus the program in a more complete and fundamental way than we have done before.
- I would like FESAC to identify the major science and technology issues that need to be addressed, recommend how to organize campaigns to address those issues, and recommend the priority order for these campaigns.
- You will need to assemble a balanced domestic program that takes account of fusion programs abroad and that includes ITER as an integrated part of the whole. In each case, please recommend the relative priority of activities to pursue at any given time.
- It should be assumed that funding for ITER construction is provided in addition to (base program) funds.
- I would like FESAC to include Inertial Fusion and relevant aspects of High Energy Density Physics…
- Please look at the program through 2014, the year ITER operation is expected to begin.

FESAC Program Priorities Panel

Chair: **Charles Baker, *University of California, San Diego***
Vice-Chair: **Stewart Prager, *University of Wisconsin at Madison***

Mohamed Abdou
University of California, Los Angeles

Lee Berry
Oak Ridge National Laboratory

Riccardo Betti
University of Rochester

Vincent Chan
General Atomics

Darren Craig
University of Wisconsin at Madison

Jill Dahlburg
Naval Research Laboratory

Ronald Davidson
Princeton Plasma Physics Laboratory

James Drake
University of Maryland

Rich Hawryluk
Princeton Plasma Physics Laboratory

David Hill
Lawrence Livermore National Laboratory

Amanda Hubbard
Massachusetts Institute of Technology

Grant Logan
Lawrence Berkeley National Laboratory

Earl Marmar
Massachusetts Institute of Technology

Michael Mauel
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Kathryn McCarthy
Idaho Nat'l Eng. & Environmental Laboratory

Scott Parker
University of Colorado at Boulder

Ned Sauthoff
Princeton Plasma Physics Laboratory

Ronald Stambaugh
General Atomics

Michael Ulrickson
Sandia National Laboratories

James Van Dam
University of Texas at Austin

Glen Wurden
Los Alamos National Laboratory

Michael Zarnstorff
Princeton Plasma Physics Laboratory

Steven Zinkle
Oak Ridge National Laboratory

Lessons from Prioritization of Scientific Programs

- **Examples from other areas of science have been examined.**
  - **"Connecting Quarks with the Cosmos:
    Eleven Science Questions for the New Century"**
  - **Astronomy's and astrophysics' decadal surveys**
    - **The Decade of Discovery in Astronomy and Astrophysics (1991)**
    - **Astronomy and Astrophysics in the New Millennium (2001)**
  - **High energy physics' "The Science Ahead, The Way to Discovery"**
  - **NASA Astrobiology's roadmaps**

- **In recent years, several areas of physical sciences have emphasized deep scientific questions as the basis for their planning and prioritizations.**
  - **Focus on questions leads to topical research programs.**
  - **Facilities are to be treated as means to address questions,
    rather than ends in themselves**.

- **FESAC has been charged by DOE/SC to prioritize all of our activities (i.e., not just the new scopes) for the next 10 years on the basis of questions and campaigns to address the questions.**
  - **There seem to be no models for this bottoms-up prioritization of entire programs.**
  - **OMB and OSTP strongly support DOE/SC's charge.**

Panel Work Plan

- **Step 1 -** **Develop overarching themes, topical scientific and technical questions, and decision criteria.**
  → ***Initial step completed—now seeking community feedback.***
- **Step 2 -** **Develop process working with the community to define research thrusts and campaigns.**
  → ***Underway. Developing a strawman case and guidelines for community groups. Defining groups along lines of theme areas and possible chairs/participants.***

  → ***Next meetings of the panel: April 13-14, June 17-19***

Interim Report—July, 2004

- **Step 3 -** **Develop priorities and interact with the community.**
  → ***Panel discussing basic process.***

Final Report—December, 2004

Overarching Themes

01. Understand the dynamics of matter and fields in the high-temperature plasma state.

02. Create and understand a controlled, self-heated, burning starfire on earth.

03. Make fusion power practical.

Topical Questions

Theme: Macroscopic Plasma Behavior

T1. How does magnetic field structure affect plasma confinement?
T2. What limits the maximum pressure that can be achieved in laboratory plasmas?
T3. How much external control versus self-organization will a fusion plasma require?

Theme: Multi-scale Transport Behavior

T4. How does turbulence cause heat, particles, and momentum to escape from plasmas?
T5. How are large-scale electromagnetic fields and mass flows generated in plasmas?
T6. How do magnetic fields in plasmas rearrange and dissipate their energy?

Theme: High-energy Density Implosion Physics

T7. How can high energy density fusion plasmas be assembled and ignited in the laboratory?
T8. How do hydrodynamic plasma instabilities affect implosions to high energy density?

Topical Questions (cont'd)

Theme: Plasma Boundary Interfaces

T9. **How can we interface a 100 million degree burning plasma to its room temperature surroundings?**

Theme: Waves and Energetic Particles

T10. **How can heavy ion beams be compressed to the high intensities required for creating high energy density matter?**

T11. **How do electromagnetic waves interact with plasma?**

T12. **How do high energy particles interact with plasma?**

Theme: Fusion Engineering Science

T13. **How does the challenging fusion environment affect plasma chamber systems?**

T14. **What are the ultimate limits for materials in the harsh fusion environment?**

T15. **How can systems be engineered to heat, fuel, pump and confine steady-state or repetitively pulsed burning plasmas?**

Example Text

T1. How does magnetic field structure impact fusion plasma confinement?

For fusion to be self-sustaining, plasma hot enough for fusion must be confined long enough to allow sufficient fusion reactions to take place…Both astrophysical and laboratory plasmas can be confined by magnetic field. The properties of the confined plasma depend sensitively on the structure of the magnetic field—curvature twist, spatial symmetries, strength, and topology. These characteristics of the field determine the existence of plasma equilibria, their stability (tendency to grow large scale structures from noise) and turbulent transport. Understanding their influence provides the basis to design configurations most favorable to fusion energy; for example, topological symmetries have been shown to beneficially improve many aspects of confinement. Many astrophysical phenomena such as plasma confined in solar magnetic arcades, in jets emanating from plasma surrounding black holes, and in extra-galactic plasma confined in radio lobes, are critically influenced by magnetic field structures. These share common physics principles that can be productively studied in magnetically confined fusion plasmas.

Decision Criteria for Prioritizing Activities Within the Fusion Program

Category A: ***Criteria to be applied to campaigns, or to activities within a campaign, across all topical questions.***

Importance to Overarching Themes of the Fusion Program

What is the importance and benefit of the campaign or activity to addressing each of the three key overarching themes expressed in 01-03; i.e.

1. ***Understanding the physics and dynamics of the plasma state,***
2. ***Creating, exploiting and understanding a controlled burning plasma, and***
3. ***Making fusion power practical.***

It is recognized that the relative contributions will vary for each campaign.

Portfolio Strength

Does the prioritized *set* of campaigns meet the strategic needs of the OFES fusion research program, including the required breadth of activities and development of the fusion workforce?

Decision Criteria for Prioritizing Activities Within the Fusion Program (cont'd)

Category B: *Criteria to be applied to individual campaigns or activities, to help determine priorities within each question or topical area.*

Quality of Research

Is the research of high quality; does it have scientific and technical credibility?

Issue Resolution

Does the activity address a clearly defined science/technology issue? Does it provide reasonable expectation to develop the knowledge base required to resolve the issue?

Role in World Program

Is the research at the leading edge, or an important and timely contributor, in the context of the national and international fusion programs?

Present Capabilities and Results

Do present capabilities and results justify proceeding with this activity?

Education and Workforce

How strongly does the activity contribute to the training of junior fusion scientists?

Breadth of Impact

Are the results important for a range of fusion concepts? Is there cross-cutting application to other fields of science and technology?

Milestones

Are key milestones suitably identified for evaluation of progress? Are they achievable, and appropriate to campaign objectives?

Resources

Are necessary infrastructure resources at an adequate level of technological readiness?

Cost Effectiveness

Is the proposed activity a cost-effective way to address the defined issue?