FIRE
An Opportunity to Explore Burning Plasmas

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http://fire.pppl.gov
Magnetic Fusion needs New Facilities to Explore, and Expand the Frontiers of Fusion Energy Science
Three Options for a Major Next Step in Magnetic Fusion

(same scale)

IGNITOR
Italian Based
Int’l Collaboration

FIRE
US Based
International Portfolio

ITER
EU, JA or CA Based
International Partnership
FIRE, the U.S. National Activity on a Next Step Option

Organization

• National activity managed by the Virtual Laboratory for Technology with participation by more than 15 institutions.

• Benefited from prior participation in ITER, and earlier BPX design activities.

Purpose:

• to investigate and assess various opportunities for advancing the scientific understanding of fusion energy, with emphasis on plasma behavior at high energy gain and for long duration.

• tasks to be pursued include investigation of a multi-machine pathway, with initial emphasis on the burning plasma experiment (e.g., FIRE).

Program Advisory Committee

• 15 members from the U.S. and abroad.

• Extensive PAC Reports provide detailed recommendations for the FIRE activity to address. NSO-PAC reports are on FIRE (http://fire.pppl.gov).
FIRE, A Laboratory to Explore Burning Plasmas

http://fire.pppl.gov

Design Features

- $R = 2.14 \text{ m}, \quad a = 0.595 \text{ m}$
- $B = 10 \text{ T}$
- $W_{\text{mag}} = 5.2 \text{ GJ}$
- $I_p = 7.7 \text{ MA}$
- $P_{\text{aux}} \leq 20 \text{ MW}$
- $Q \approx 10, \quad P_{\text{fusion}} \sim 150 \text{ MW}$
- Burn Time $\approx 20 \text{ s (2 \text{ tau}\_cr)}$
- Tokamak Cost $\approx$ $351\text{M (FY02)}$
- Total Project Cost $\approx$ $1.2\text{B(FY02)}$

Mission: Attain, explore, understand and optimize magnetically-confined fusion-dominated plasmas.

FIRE has adopted the Advanced Tokamak features identified by the Advanced Reactor Studies (ARIES)
Quasi-Stationary Burning Plasma in FIRE

- ITER98(y, 2) with \( H(y, 2) = 1.1, \frac{n(0)}{\langle n \rangle} = 1.2, \) and \( n/n_{GW} = 0.67 \)
- Burn Time \( \approx 20 \text{ s} \approx 21\tau_E \approx 4\tau_{He} \approx 2\tau_{CR} \)
- \( Q = \frac{P_{fusion}}{P_{aux} + P_{oh}} \)
Advanced Burning Plasma Physics could be Explored in FIRE

Self-Heating Dominant

\[ Q = 5.7, \quad f_\alpha = 53\% \]

Alpha

ICRF + LHCD

LHCD

Cyclotron

bremsstrahlung

Self-Current Drive Dominant

Fully Non-Inductive for \( > 1 \tau_{CR} \)

\[ 8.5 \text{ T}, 5.4 \text{ MA}, \]

\[ f_{BS} = 65\% \]

Tokamak simulation code results for \( H(y, 2) = 1.4, \beta_N = 3.5 \), would require RW mode stabilization. \( q(0) = 2.9, q_{\text{min}} = 2.2 \) @ \( r/a = 0.8, 8.5 \text{ T}, 5.5 \text{ MA} \)
Diversified International Portfolio for Magnetic Fusion

**Second Phase**
Scientific Feasibility
- Three Large Tokamaks
  - JT-60 U
  - JET
  - TFTR

**Third Phase**
Fusion Science and Technology Feasibility
- Several Large Facilities
  - FIRE
  - KSTAR, JT-60 SC
  - Nuclear Tech Dev

**Fourth Phase**
Electric Power Feasibility
- Choice of Configuration
  - Advanced Test Reactor
  - Advanced DEMO

**Commercialization Phase**
Economic Feasibility
- Technology Demonstration
  (the overall portfolio approach includes IFE)

**Base Program**
- Plasma Science
- Scientific Simulation Initiatives
- Fusion Technology

**Non-Tokamak Configurations**
- Long Pulse Adv. Stellarator
- Spherical Torus, RFP
- Spheromak, FRC, MTF

**Reduced Technical Risk**
- Streamlined Management Structure
- Better Product/Lower Overall Cost
- Faster Implementation

**Increased Technical Flexibility**

Is this the lowest cost most efficient path to fusion? Modular Strategy9a
A challenging process that required hard work by many

• Thanks to the Working Groups and Snowmass participants for their outstanding effort and constructive criticism.

• Thanks to the FIRE Team for their tireless efforts in rising to the occasion.

FIRE’s Plan – Use the results to make FIRE the best it can be.

• Let us build on all this hard work and continue Community participation in FIRE.

• FIRE will review advice, update design goals, improve design as appropriate

• Review with the Community, Program Advisory Committee and DOE.

• Be ready to move ahead to Conceptual Design and initiate R&D if we are asked
The U.S. Fusion Program is at a Fork in the Road

There is an opportunity to expand the frontier of fusion science while moving toward the fusion energy goal by initiating a burning plasma program.

Let’s Take It.

• Let’s explore the international opportunity with ITER.
  • We must do our cost/benefit homework prior to negotiations.
  • We should set a date certain for completion of negotiations.

• Let’s continue to develop FIRE as a U.S. based experiment in the context of an international portfolio.
  • We will incorporate the advice from this assessment.
  • We should continue to advance the FIRE design and initiate critical R&D.

Consistent with HR-4: Energy Policy Act of 2002
“I want you to develop fusion energy for the world”

Let’s Do It !