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# ***FIRE***

## **An Opportunity to Explore Burning Plasmas**

**Dale M. Meade  
for the FIRE Study Team**

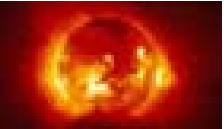
**MFE Final Plenary  
2002 Fusion Summer Study  
Snowmass, CO**

**July 19, 2002**

<http://fire.pppl.gov>

***FIRE***

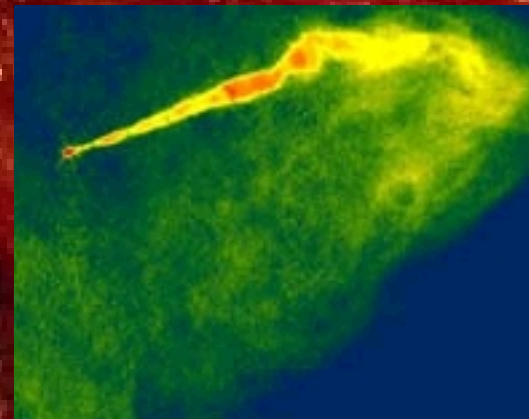
***Lighting the Way to Fusion***



# **Magnetic Fusion needs New Facilities to Explore, and Expand the Frontiers of Fusion Energy Science**



**CHANDRA**



**VLBA**



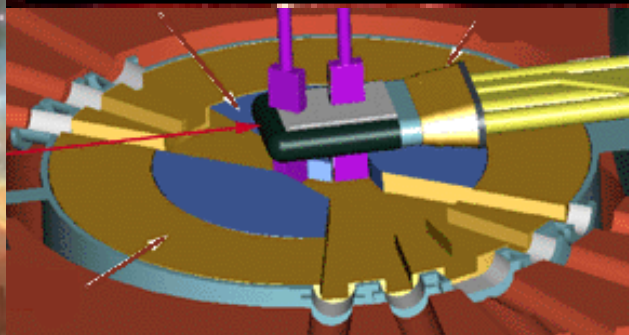
**NIF & LMJ**

**? ?**

**MFES**



**HST (NGST)**



**SNS**

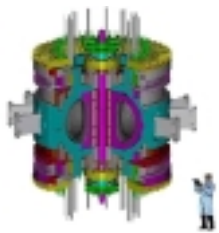


**APS**

# Three Options for a Major Next Step in Magnetic Fusion

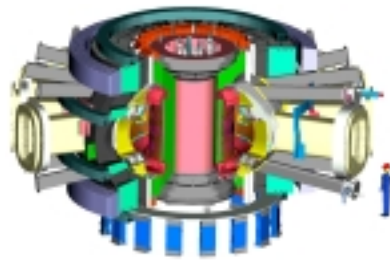
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(same scale)



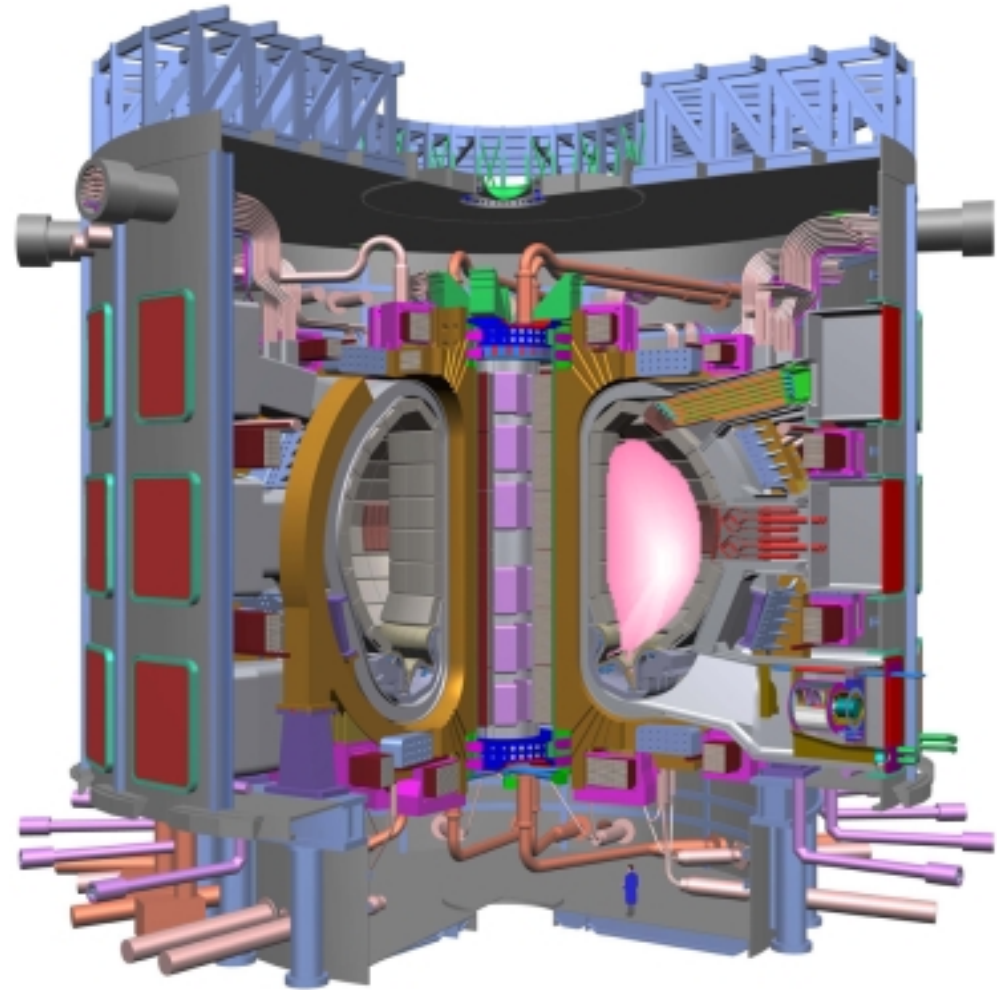
**IGNITOR**

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**

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## **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**

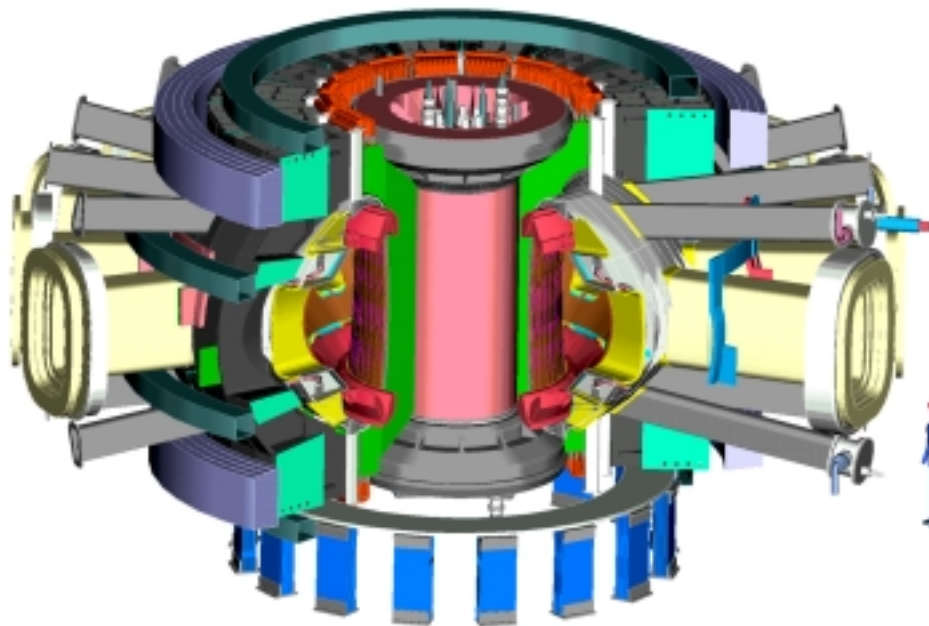
- 15 members from the U.S. and abroad.
- Extensive PAC Reports provide detailed recommendations for the FIRE activity to address. NSO-PAC reports are on FIRE (<http://fire.pppl.gov>).

# FIRE, A Laboratory to Explore Burning Plasmas

<http://fire.pppl.gov>

## Design Features

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

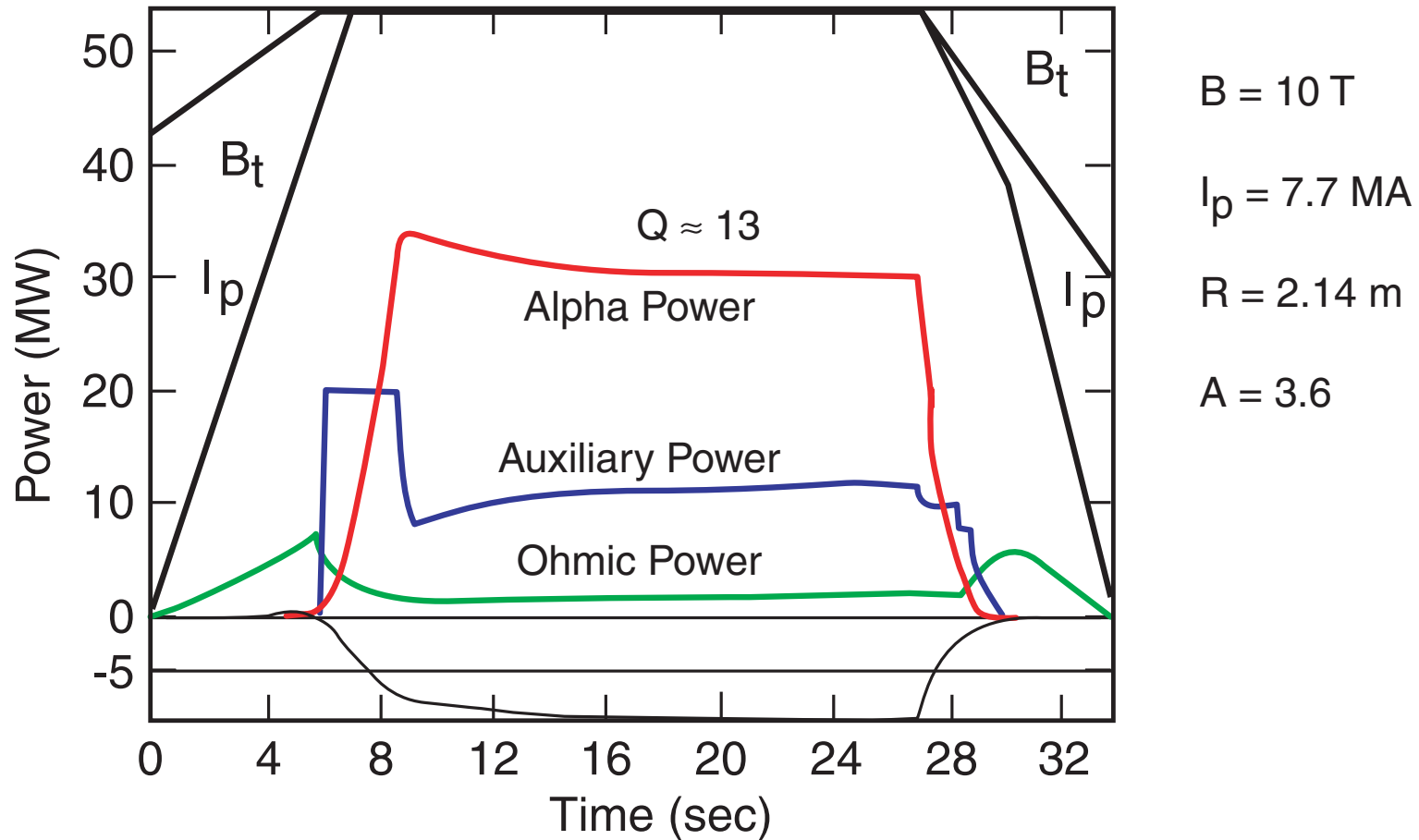


1,400 tonne

**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

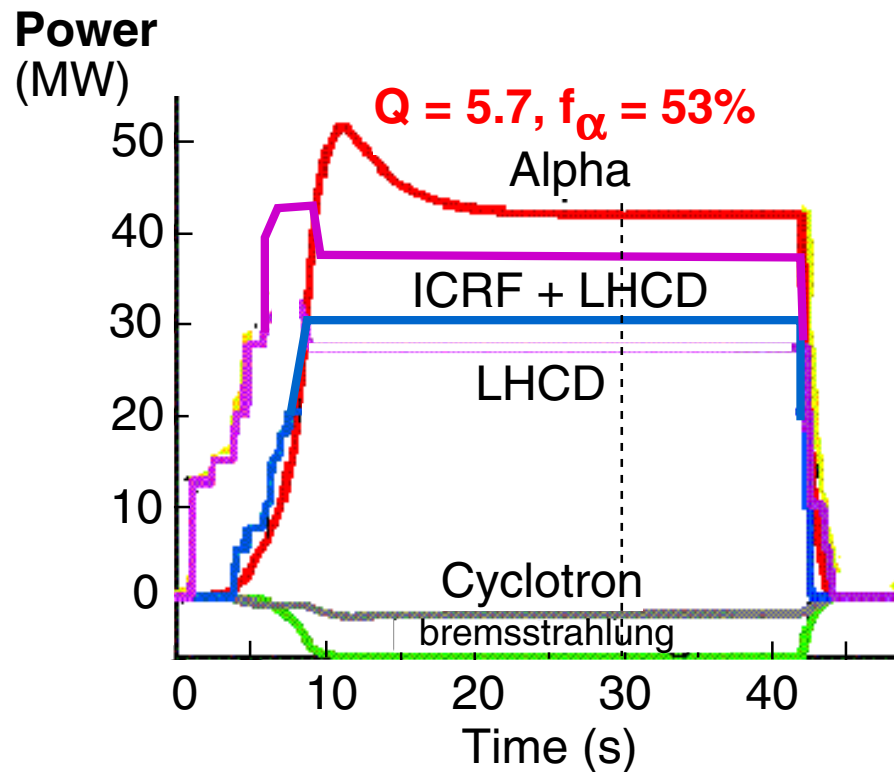


- ITER98(y, 2) with  $H(y, 2) = 1.1$ ,  $n(0)/\langle n \rangle = 1.2$ , and  $n/n_{GW} = 0.67$
- Burn Time  $\approx 20$  s  $\approx 21\tau_E \approx 4\tau_{He} \approx 2\tau_{CR}$

$$Q = P_{\text{fusion}} / (P_{\text{aux}} + P_{\text{oh}})$$

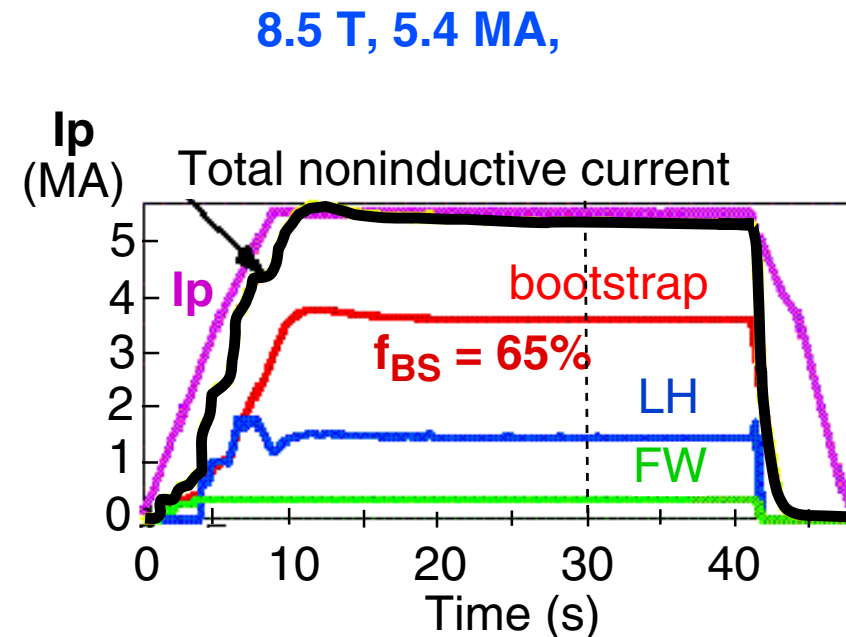
# Advanced Burning Plasma Physics could be Explored in FIRE

## Self-Heating Dominant



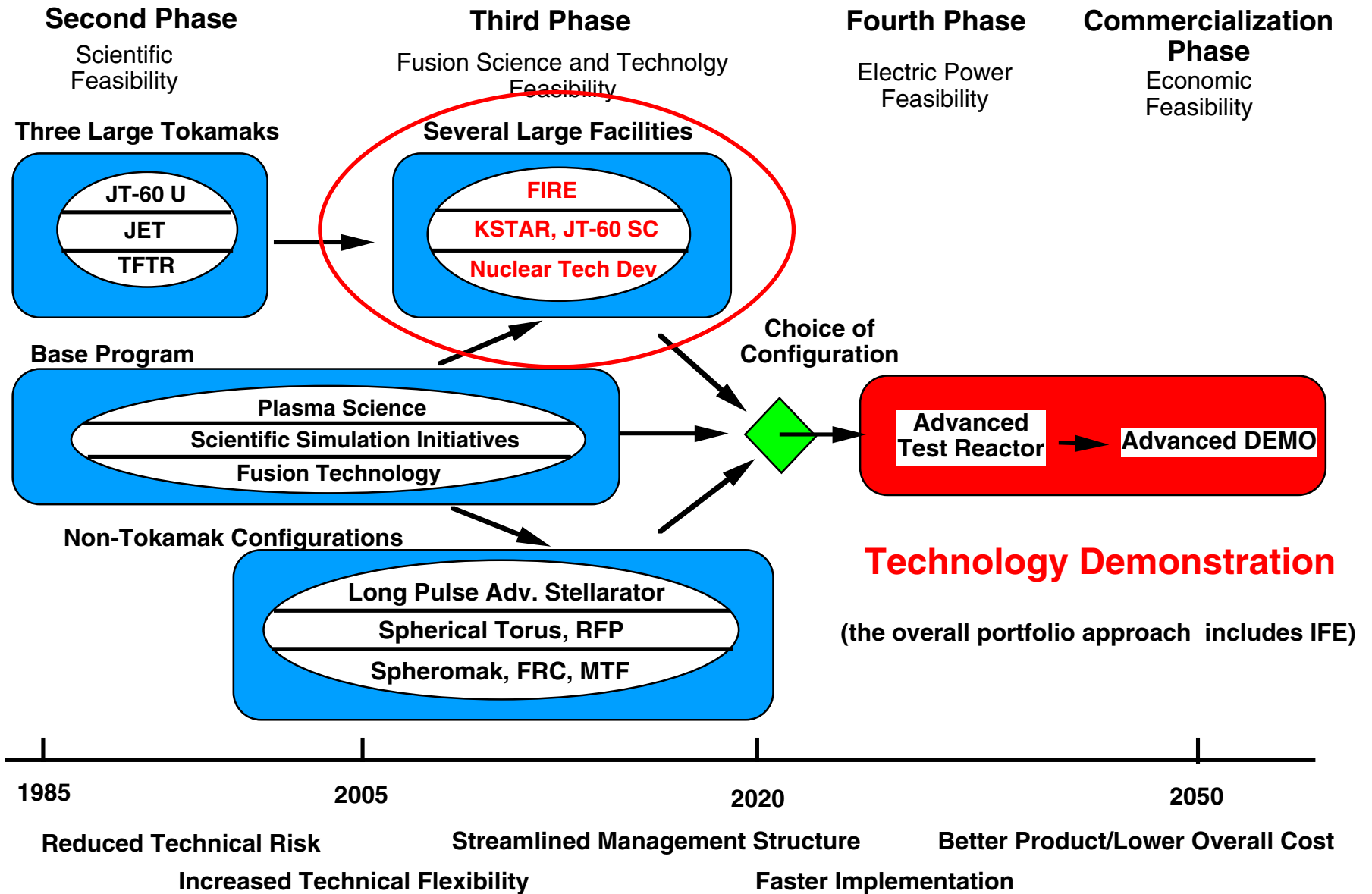
## Self-Current Drive Dominant

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



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

# Diversified International Portfolio for Magnetic Fusion



**Is this the lowest cost most efficient path to fusion?**



# **Snowmass Assessment - FIRE's Response**

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## **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**

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**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.**

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- 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 !**

Fusion Snowmass 2002