Snowmass 2002:
The Fusion Energy Sciences Summer Study

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Fusion Energy Sciences Advisory Committee
Gaithersburg, MD

27-28 February 2002

FESAC BP Report Recommendation 3

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. The U.S. should implement a plan as follows to proceed towards construction of a burning plasma experiment:

- Hold “Snowmass-style” community meeting
- Carry out uniform technical assessment by NSO activity
- Request FESAC “action panel” to select preferred BP option
- National Research Council review of BP plans
- Initiate and outreach effort with broader science community, policy makers, environmental community, and public

FESAC Snowmass Recommendation

Hold a “Snowmass” workshop in the summer 2002 for the critical examination of proposed burning plasma experiments and to provide crucial community input and endorsement to the planning activities undertaken by FESAC.

First, while most of the MFE community has already agreed that we are technically ready to proceed with a burning plasma experiment, there must be a critical mass of fusion energy science community support that confirms that the time to proceed is now and not some undefined time in the future.

Second, the community should carefully examine, on a scientific and technological basis, the viability of each of the burning plasma options presented, particularly ITER-FEAT, FIRE, and IGNITOR. The goal is for the proponents of each option to convince the community that their respective option is sufficiently well advanced that if built, it would have a high probability of success.

Third, the community should agree that under the assumption that every member has had the opportunity to express his or her opinions in a pubic forum, the community as a whole will support whatever decision is ultimately made.

At the workshop there is no need to have extensive discussions of “general” burning plasma science issues (these discussions have already taken place). Also, it should not be a goal of the workshop to select the “best” option, as this will likely not be possible and might lead to counterproductive polarization within the community. The emphasis should be on establishing the credibility of success of each design with respect to its stated scientific mission, cost estimate, and time schedule.

PLAN PRESCRIBED IN HR4

a) PLAN FOR UNITED STATES FUSION EXPERIMENT- The Secretary, on the basis of full consultation with the Fusion Energy Sciences Advisory Committee and the Secretary of Energy Advisory Board, as appropriate, shall develop a plan for United States construction of a magnetic fusion burning plasma experiment for the purpose of accelerating scientific understanding of fusion plasmas. The Secretary shall request a review of the plan by the National Academy of Sciences, and shall transmit the plan and the review to the Congress by July 1, 2004.

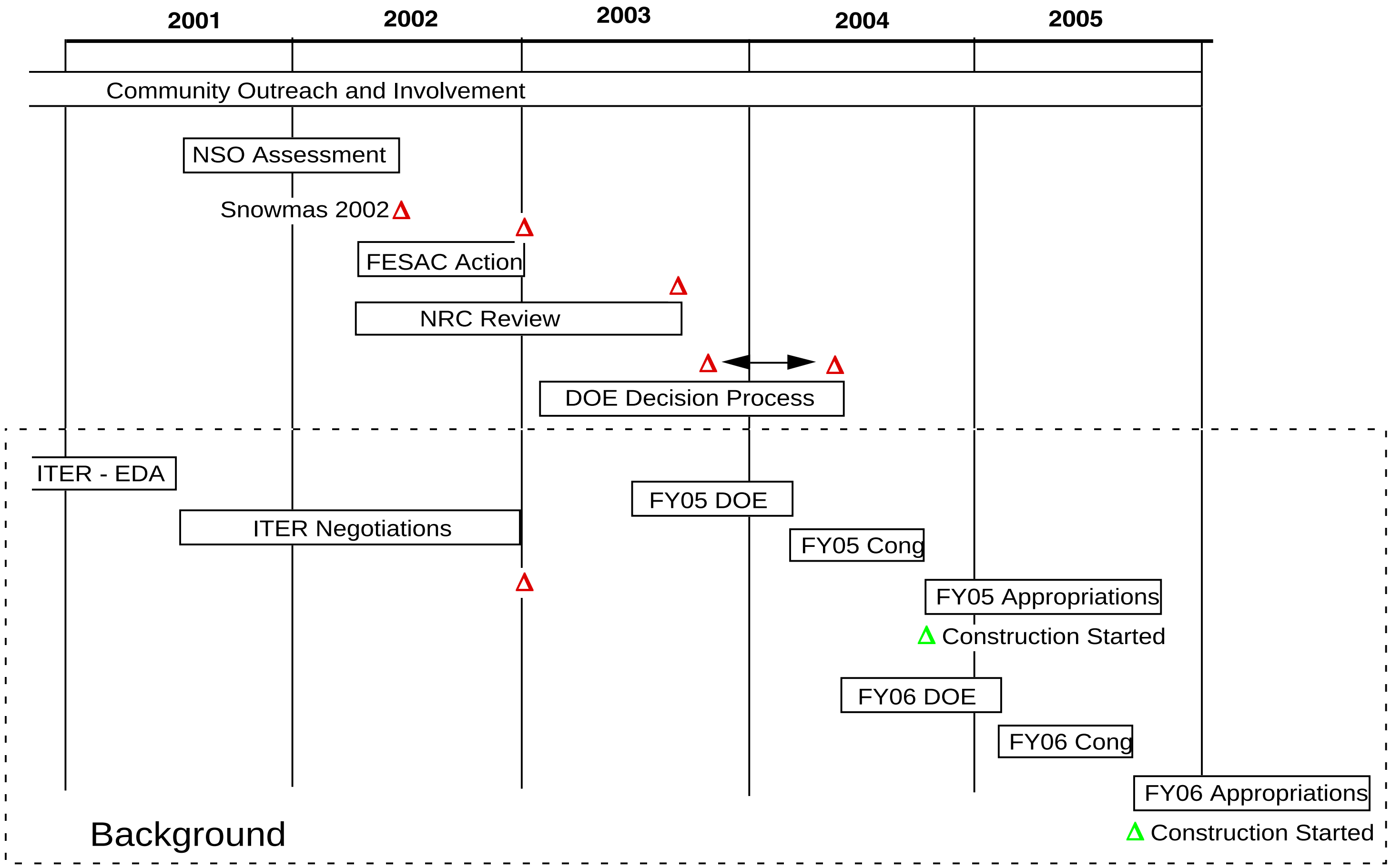
(b) REQUIREMENTS OF PLAN- The plan described in subsection (a) shall--

(1) address key burning plasma physics issues; and

(2) include specific information on the scientific capabilities of the proposed experiment, the relevance of these capabilities to the goal of practical fusion energy, and the overall design of the experiment including its estimated cost and potential construction sites.

(c) UNITED STATES PARTICIPATION IN AN INTERNATIONAL EXPERIMENT- In addition to the plan described in subsection (a), the Secretary, on the basis of full consultation with the Fusion Energy Sciences Advisory Committee and the Secretary of Energy Advisory Board, as appropriate, may also develop a plan for United States participation in an international burning plasma experiment for the same purpose, whose construction is found by the Secretary to be highly likely and where United States participation is cost effective relative to the cost and scientific benefits of a domestic experiment described in subsection (a). If the Secretary elects to develop a plan under this subsection, he shall include the information described in subsection (b), and an estimate of the cost of United States participation in such an international experiment. The Secretary shall request a review by the National Academies of Sciences and Engineering of a plan developed under this subsection, and shall transmit the plan and the review to the Congress not later than July 1, 2004.

Recommended US Plan for Burning Plasmas



BURNING PLASMA PLANNING

July 2001:	FESAC conclusion on technical readiness: we are ready, and the time is now.
July 2002:	“Snowmass” workshop to have a focused discussion of the scientific issues associated with burning plasma physics experiments, including a technical assessment of three options: ITER, FIRE, and Ignitor
August 2002:	FESAC panel to recommend plan for burning plasma physics
Sept 2002:	DOE to prepare a plan based on the FESAC recommendations
Dec 2002:	NRC to complete its review of the Department’s burning plasma physics plan

ITER SCHEDULE

Nov 2001:	Negotiations began on the structure of the ITER legal entity, a preferred site for construction, and division of work for construction
March 2002:	All site offers on the table
June 2002:	Agreement on preferred site and division of work for construction
Dec 2002:	Draft agreement ready for submission to the parties

Organizational Structure of Snowmass Planning

Organizing Committee:

Co-Chairs + Working Group (WG) Heads

Charlie Baker, UCSD
Roger Bangerter, LBNL
Ron Davidson, PPPL
John DeLooper, PPPL
Wayne Meier, LLNL
Bill Nevins, LLNL
Gerald Navratil, Columbia Univ.
Per Peterson, UC-Berkeley
Stewart Prager, Univ. Wisconsin
Ned Sauthoff, PPPL
Max Tabak, LLNL
Tony Taylor, GA

Sub-Group (SG) Conveners:

Normally Two per SG

About 60 people

Introduction to the 2002 Summer Study

- **a forum for the critical uniform technical assessment of major next-steps in the fusion energy sciences program**
  - will provide crucial community input to the long range planning activities undertaken by the DOE and the FESAC
- **an ideal place for a broad community of MFE and IFE scientists to examine goals and proposed initiatives in**
  - burning plasma science (MFE), and
  - integrated research experiments (IFE)
- **open to every member of the fusion energy science community**
  - MFE (tokamaks and other concepts) and IFE
  - significant international participation is encouraged

Background of the Summer Study

- **The 2002 Summer Study builds on**
  - earlier planning activity at the 1999 Snowmass Fusion Summer Study and
  - the scientific assessments at the UFA-sponsored Burning Plasma Science Workshops (Austin, Dec 2000; San Diego, May 2001).
- **The scientific and technological views of the participants will provide critical fusion community inputs**
  - to the decision process of FESAC and DOE in 2002-2003, and
  - to the review of burning plasma science by the National Academy of Sciences called for by FESAC and Energy Legislation which was passed by the House of Representatives [H. R. 4].

Some key MFE issues

- critical burning plasma phenomena and experimental requirements for their study

- scientific basis for proceeding with a burning plasma experiment:
is now the time?

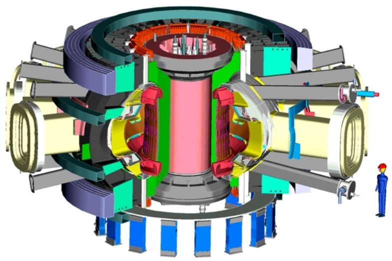
- how generic are burning plasma studies carried out in a tokamak?

- uniform technical assessment of burning plasma experiment options

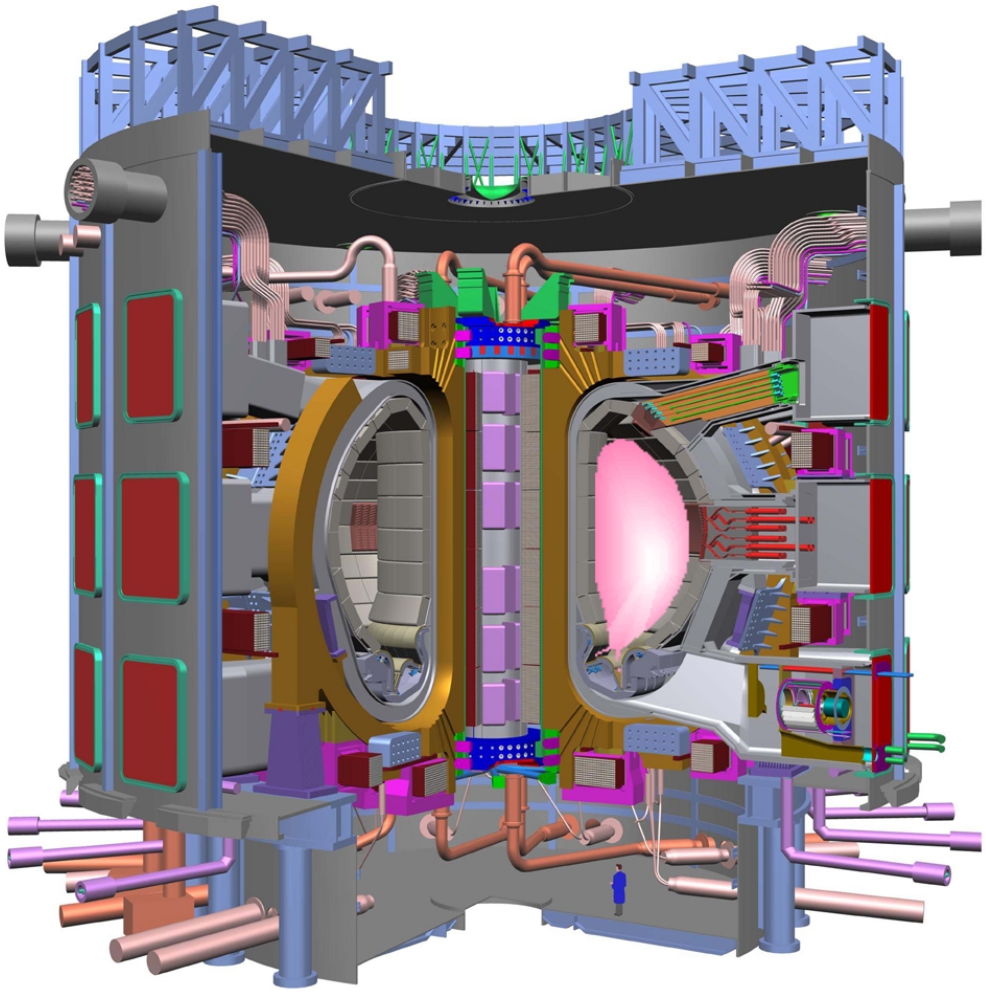
- building consensus for a U.S. plan for burning plasma studies

Burning Plasma Physics - The Next Frontier

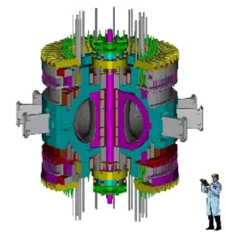
Three Options
(same scale)



FIRE



ITER



IGNITOR

How does the Snowmass MFE Study feed into FESAC and NRC reviews?

- **Providing an expert consensus view on key issues:**
  - clear articulation of the scientific basis for proceeding with a burning plasma experiment.
  - identification of principal new physics phenomena and experimental requirements for their study.
  - uniform technical assessment of approaches to burning plasma research.

- **clearing up misconceptions and educating the MFE / IFE community about burning plasma issues and options.**

- **establishing a common technical basis for decision-making**

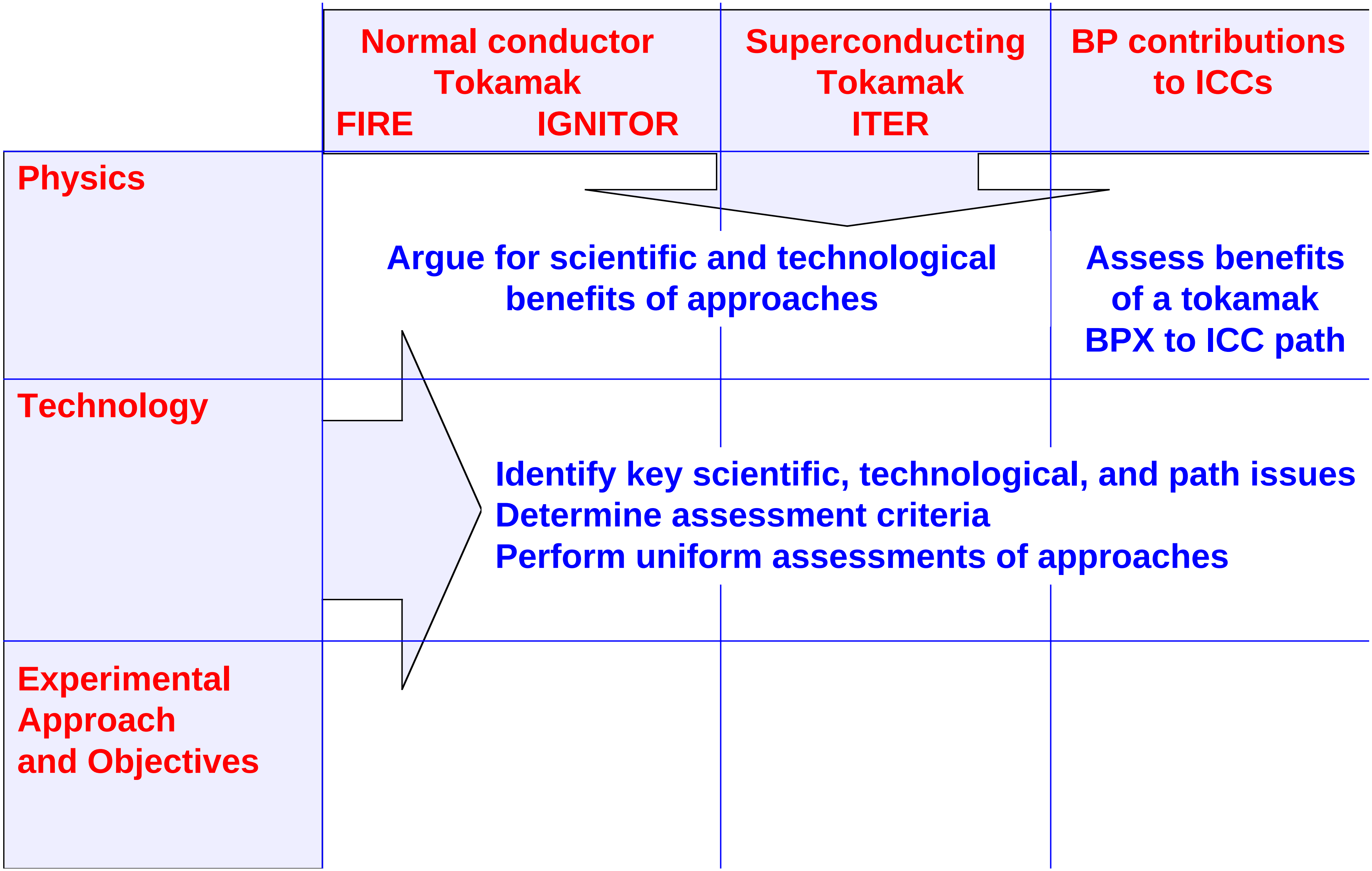
IFE Objectives of the Fusion Summer Study

- **provide a forum to**
  - present plans for prospective integrated research facilities,
  - assess the present status of the technical base for each, and
  - establish a timetable and technical progress necessary to proceed for each.

- **address the relation of ignition in IFE to integrated research facilities**

➢ **Provide the technical basis for decision-makers**

Identifying MFE issues and assessing burning plasma experiments



MFE Topical Groups' roles:
motivating and assessing burning plasma experiments

Physics	Identify key scientific issues Determine criteria for assessment of approaches Perform uniform assessments of approaches	Wave-Particle Interactions MHD Transport Boundary Physics Alpha Physics
Technology	Identify key technological issues and potential benefits Determine criteria for assessment of approaches (feasibility, benefits, cost, …) Perform uniform assessment	Magnets PFC/Heat removal Heating/CD Safety/Tritium/Materials Vacuum Vessel/Remote Cost
Experimental Approach and Objectives	Identify integration, research operations, development path, and "community" issues Determine assessment criteria Perform uniform assessment	Diagnostics Integrated Scenarios/ Ignition Physics/Burn Control Physics Operations Development Path

Roles of MFE approach-advocates and the ICC community

Normal conductor Tokamak FIRE IGNITOR	Superconducting Tokamak ITER	BP contributions to ICCs
Argue for scientific and technological benefits of the approach: - advocate scientific issues - suggest physics “rules” and “guidelines” - suggest assessment criteria - participate in plasma performance simulations and resultant assessments, championing the case for each approach		Assess benefits of a tokamak BPX to ICC path - identify ICC issues (physics, technology, development path) - assess applicability of the tokamak results on the ICC development

MFE Group Leaders

Normal conductor Tokamak		Superconducting Tokamak	BP contributions to ICCs
FIRE	IGNITOR	ITER	
Meade/Thome	Bombarda/Coppi	Perkins/Parker	Hooper/Jarboe

Physics (Prager)	Transport	(Synakowski, Waltz)
	MHD	(Hegna, Strait)
	Energetic Particles/Alpha Physics	(Nazikian, Van Dam)
	Wave-Particle Interactions	(Batchelor, Porkolab)
	Boundary Physics	(Allen, Pitcher)
Technology (Baker)	Magnets	(Martovetski, Minervini)
	PFC/Heat removal	(Mattas, Ulrickson)
	Heating/CD	(Rasmussen, Temkin)
	Safety/Tritium/Materials	(Petti, Zinkel)
	Vacuum Vessel/Remote	(Nelson, Burgess)
	Cost	(Waganer)
Experimental Approach and Objectives (Taylor)	Diagnostics	(Boivin, Young)
	Integrated Scenarios/ Ignition Physics/Burn Control	(Kessel, Politzer)
	Physics Operations	(Wesley, Hill)
	Development Path	(Najmabadi, Schoenberg)

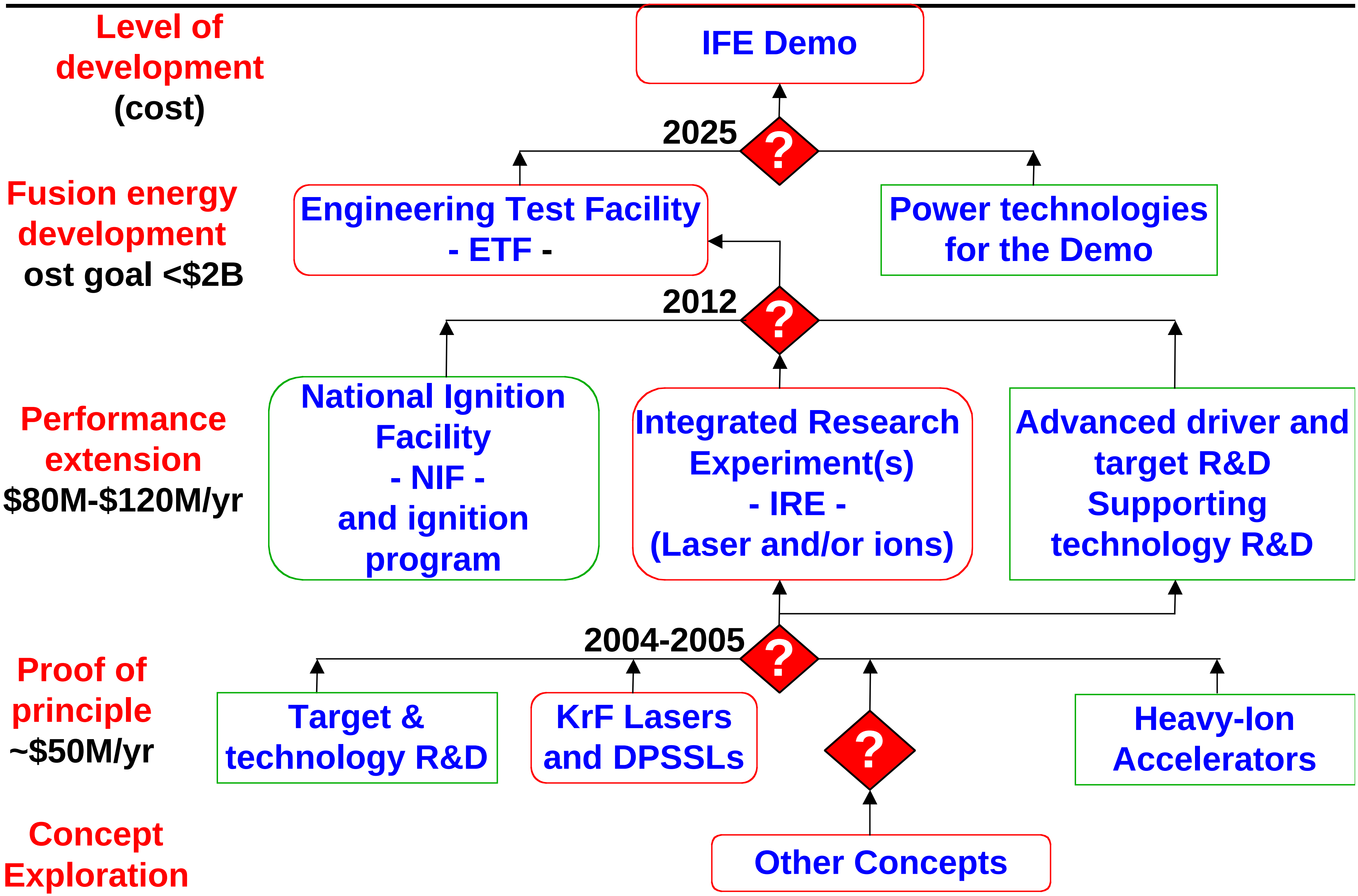
IFE Objectives of the Fusion Summer Study

- **provide a forum to**
  - present plans for prospective integrated research facilities,
  - assess the present status of the technical base for each, and
  - establish a timetable and technical progress necessary to proceed for each.

- **address the relation of ignition in IFE to integrated research facilities**

➢ **Provide the technical basis for decision-makers**

The Inertial Fusion Energy Development Strategy



IFE Group Structure

	Driver Physics and Technology; Next Steps Lasers Accelerators Z Pinch Fast Ignition Drivers
Target Physics	Fast Ignition Gain curves Stability Symmetry Beam-Target Interaction
IFE Chamber/ Target Technology	IFE Chamber Response - Microsecond Phenomena IFE Chamber Clearing/Recovery - Millisecond Phenomena IFE Chamber Safety/Environment/Reliability-Quasi-Steady Phenomena IFE Target Fabrication/Injection IFE Integrated Chamber/Focusing System Design and Modeling

IFE Group Leaders

Driver Physics and Technology; Next Steps
W. Meier

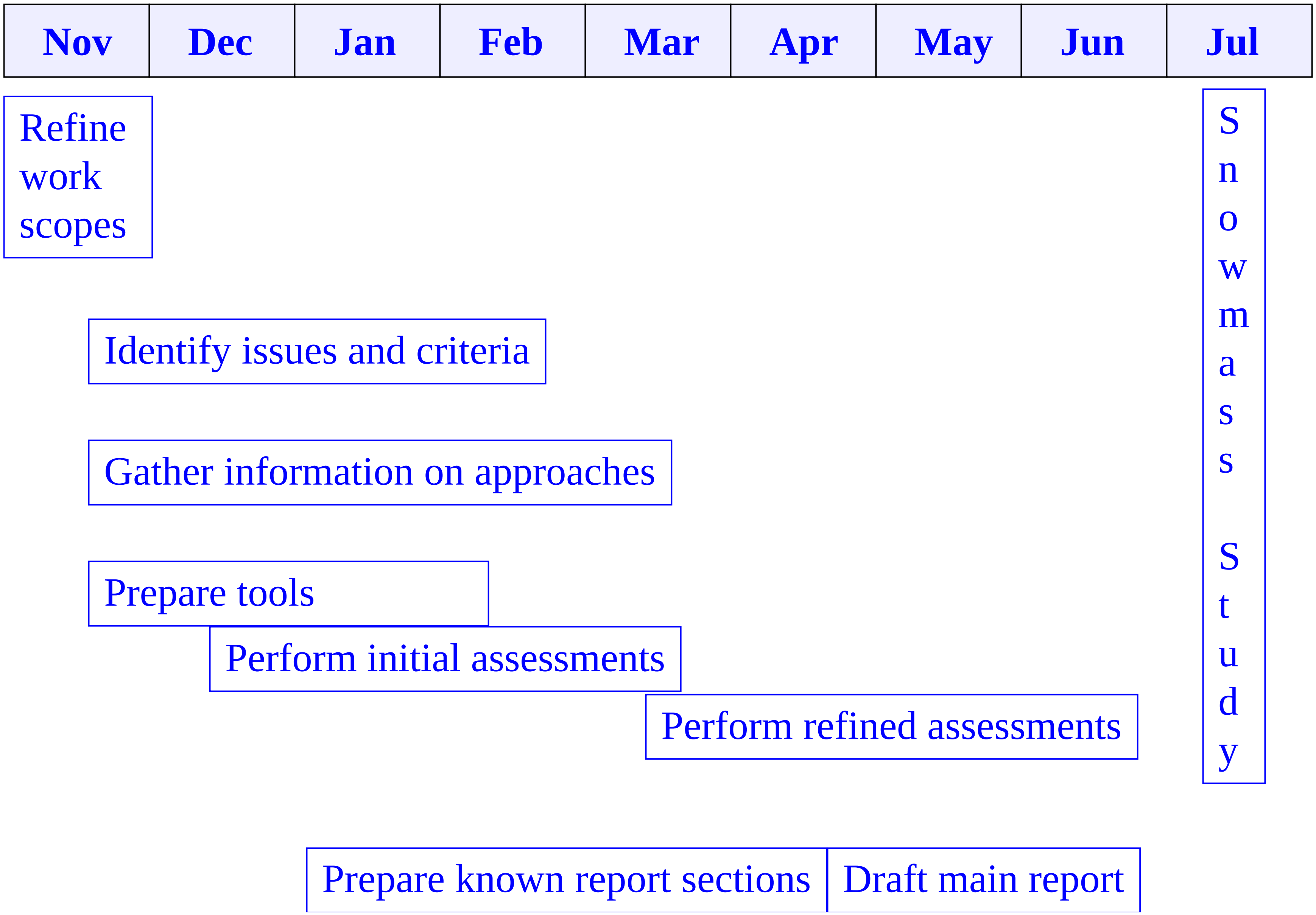
Lasers	Accelerators	Z Pinch	Fast Ignition Drivers
S. Payne	S. Lund	C. Olson	M. Campbell
S. Obenschain	G. Logan	TBD	C. Barty

Target Physics M. Tabak	**Fast Ignition**	Jill Dahlburg; M. Key
	Gain curves	R. Town; M. Herrmann
	Stability	Ricardo Betti; A. Schmitt
	Symmetry	D. Callahan-Miller; John Porter
	Beam-Target Interaction	J. Fernandez; T. Mehlhorn
IFE Chamber/ Target Technology P. Peterson	**IFE Chamber Response - Microsecond Phenomena**	R. Peterson; M. Ulrickson
	IFE Chamber Clearing/Recovery - Millisecond Phenomena	N. Morley; R. Raffray
	IFE Chamber Safety/Environment/Reliability-Quasi-Steady Phenomena	J. Latkowski; D. Petti
	IFE Target Fabrication/Injection	D. Goodin; A. Nobile
	IFE Integrated Systems	M. Tillack; W. Meier

Community Issues Working Group

- **Mission & Goal: Foster Communication on non-technical issues**
  - Many feel that non-technical issues are at least as important as the technical ones
  - For the whole fusion community
- **Discuss our direction as a community**
  - Our visions of the nature of the science we do, and how it fits with possible BP experiments
- **Group:** S. Allen, R. Betti, J. Dahlburg, R. Fonck, S. Pitcher, P. Politzer, E. Synakowski, G. Tynan
- **Activities now**
  - Reaching out to a broad audience to obtain feedback (this meeting is an example)
  - Moderated web site for “position papers” at http://web.gat.com/snowmass/working/ci/
    - Some have already been invited; contributed essays more than welcome
  - A *carefully done* survey being discussed
  - Invite speakers with differing points of view to Snowmass
- **Activities during Snowmass**
  - Moderated discussions (need strong facilitators!)
  - Webcsat for those not at Snowmass (High Energy does this) being considered
- **Product**
  - Develop a contribution for the Snowmass report based on broad community input
  - Consider a statement of consensus, depending on input and discussion

Upcoming activities



Snowmass 2002 Fusion Summer Study

Outline of the Final Report

**[Executive Summary 9 pages,
Introduction 3 pages,
MFE 91 pages,
IFE 37 pages]**

draft 5.0 [NRS 2/22/02]

I. Executive Summary [9 pages] {co-chairs, based on report}

- **A. Science, technology, and energy development path benefits of MFE burning plasma experiments and IFE integrated research experiments and assessment of scientific and technological readiness [3 pages]**
  - **1. roles of burning plasmas in fusion science and in the fusion development path, and relations to the base program**
    - a) MFE
    - b) IFE
  - **2. scientific readiness and scientific questions/issues to be addressed/resolved in the major next step approaches**
    - a) MFE burning plasma experiments
    - b) IFE integrated research facilities
  - **3. technology readiness and technology benefits of major next steps, including development path benefits**
    - a) MFE burning plasma experiments
    - b) IFE integrated research facilities
  - **4. relationship between tokamak's and ICCs' burning plasmas' science, technology, and development paths**
- **B. uniform assessment of proposed major next steps [NOT a selection of "the best"] [6 pages]**
  - **1. MFE burning plasma experiments [3 pages]**
    - a) Scope and description of each approach/next-step-option for burning plasma experiments
    - b) brief description of assessment methodology
    - c) overview of uniform technical assessment of benefits (physics, technology and development path), credibility, and cost of each approach/option
  - **2. IFE integrated research facilities [3 pages]**
    - a) scope of each approach/ next-step-option for integrated research facilities
    - b) brief description of assessment methodology
    - c) overview of uniform technical assessment of benefits (physics, technology and development path), credibility, and cost of each approach/option

II. Introduction for both MFE and IFE next steps [3 pages] {co-chairs}

A. Background of the study in both MFE and IFE [1 page]

B. Goals of the study in both MFE and IFE [1 page]

C. Brief description of the study's products and processes [1 page]

III. MFE next steps [91 pages] {MFE.*}

A. Overviews of MFE burning plasmas science, technology, and experimental approaches/objectives [16 pages] {MFE.*}

1. Physics issues of MFE burning plasmas [6 pages]

a) wave-particle interactions [1 page] {MFE.P1}

b) energetic particles/alpha-physics [1 page] {MFE.P2}

c) MHD [1 page] {MFE.P3}

d) transport [1 page] {MFE.P4}

e) boundary physics [1 page] {MFE.P5}

f) integration [1 page] {MFE.P*}

2. Technology issues of MFE burning plasma next steps [6 pages]

a) magnets [1 page] {MFE.T1}

b) PFC/heat removal [1 page] {MFE.T2}

c) heating/current drive [1 page] {MFE.T3}

d) vacuum vessel/remote handling [1 page] {MFE.T4}

e) safety/tritium/materials [1 page] {MFE.T5}

f) costing [1 page] {MFE.T6}

3. Experimental approach and objectives [4 pages]

a) diagnostics [1 page] {MFE.E1}

b) integrated scenarios/ignition physics/burn control [1 page] {MFE.E2}

c) physics operations [1 page] {MFE.E3}

d) development path [1 page] {MFE.E4}

B. Approaches to MFE burning plasma studies: development paths and next step options [24 pages] {MFE.*}

1. MFE development paths (including US strategy, integrated/supporting paths for burning plasmas and concept optimization) [7 pages]

a) Modular approach (including ICCs) [2 pages] {MFE.E4 and MFE.B4}

b) Integrated physics/technology approach (including ICCs) [2 pages] {MFE.E4 and MFE.B4}

c) Relationship between MFE innovative confinement concepts (ICCs) and tokamak burning plasmas (science and technology) [3 pages] {MFE.B4}

2. Visions of the future program [4 pages]

a) Visions of the program 10-15 years in the future with and without a burning plasma experiment [2 pages] [2 pages] {Community Issues}

b) Roles of the "base program" and "curiosity-driven science" in the future program [2 pages] {Community Issues}

3. Pro's and con's of domestic and international programs and of facilities inside and outside the US [4 pages] {Community Issues}

4. MFE next step options addressed in this study [9 pages] {MFE.B1-3}

a) FIRE [3 pages] {MFE/B1}

b) Ignitor [3 pages] {MFE/B2}

c) ITER [3 pages] {MFE/B3}

C. Uniform assessments of tokamak approaches to MFE burning plasmas, including explicit sub-outline sections on
(i) key issues and associated assessment criteria,
(ii) methods for projecting plasmas in future devices,
(iii) assessment tools and methods, and
(iv) uniform assessments of approaches to burning plasmas (FIRE, IGNITOR, and ITER) [51 pages]

1. Physics issues of MFE burning plasmas [18 pages]

a) wave-particle interactions [3 page] {MFE.P1}

b) energetic particles/alpha-physics [3 page] {MFE.P2}

c) MHD [3 page] {MFE.P3}

d) transport [3 page] {MFE.P4}

e) boundary physics [3 page] {MFE.P5}

f) integration [3 pages] {MFE.P*}

2. Technology issues of MFE burning plasma next steps [18 pages]

a) magnets [3 page] {MFE.T1}

b) PFC/heat removal [3 page] {MFE.T2}

c) heating/current drive [3 page] {MFE.T3}

d) vacuum vessel/remote handling [3 page] {MFE.T4}

e) safety/tritium/materials [3 page] {MFE.T5}

f) costing [3 pages] {MFE.T6}

3. Experimental approach and objectives [12 pages]

a) diagnostics [3 page] {MFE.E1}

b) integrated scenarios/ignition physics/burn control [3 page] {MFE.E2}

c) physics operations [3 page] {MFE.E3}

d) development path [3 page] {MFE.E4}

4. Contributions to the ICC development paths [3 page] {MFE.B4}

IV. IFE next steps [37 pages] {IFE.*}

A. Overview of IFE (5 pages)

1. Generic description of IFE concept – pulsed, modular

2. Separability of driver, targets, and chamber – allows modular cost-effective research on key issues with synergy between integrated concepts. Discuss table showing spatial and time separation of systems and phenomena; discuss implications for scaled studies of system behavior.

3. Builds upon ICF program (NNSA-funded) but energy application requires expanded scope of research to achieve high repetition rates, and to produce economic energy with safety and reliability.

4. Overall IFE Program Roadmap – Introduce the integrated research experiments (IREs). Also introduce the ETF and the Demo steps that follow NIF ignition (e.g. scaled demonstrations of all aspects of IFE power plant functions including the generation of fusion electricity).

B. Integrated IFE Concepts (Current Point Design Descriptions) [5 pages = 1 page intro plus 1 page each driver type]

These are specific present-day manifestations of an IFE system, for each driver. Also present the primary ETF parameters (driver energy, target yield and rep-rate, chamber geometric scaling and basis for selection (primary phenomena to be preserved)), possibly in a table format that covers all of the driver concepts)

1. Lasers

a) KrF

b) DPSSL

2. Ions

a) Induction linacs

b) Other accelerators

3. Z-pinches

4. Fast ignitor options

C. Near-term R&D plans to address critical issues [27 pages = 1 page introduction plus 26 pages on specific topics]
First list critical issues for each IFE concept in Section B generated by the working groups and subgroups (separate into generic and driver-specific discussions for each working group area). Next describe a 3-5 year research program that addresses the critical issues in a prioritized, cost-effective fashion For items 2-5, specifically present goals of near-term development plan that would provide basis for IRE construction decision.

1. Summary of Critical Issues (10 pp.)

a) Target Physics (2 pp.)

b) IFE Chamber and Target Technology (2 pp)

c) Driver Physics and Technology (4 pp.)

d) Interface Issues (2 pp.)

2. Target Physics Plan (3 pp. = 1 p. direct drive, 1 p. indirect drive, 1 pp. fast ignitor)

3. IFE Chamber and Target Technology Plans (3 pp. = 1 p. liquid chambers, 1 p. dry chambers, 1 p. targets)

4. Driver Physics and Technology Plan (4 pp. = 1 p. each driver type)

5. Other pre-IREs R&D (integration/interface items not covered in 2-4 above) (2 pp.)

6. IREs (including supporting technology activities with goals that would provide basis for ETF construction decision) (4 pp. = 1 p. each driver type)

V. Appendices {MFE.*, IFE.*}

A. 2002 Snowmass organization, process, etc. {co-chairs]

B. Integrated MFE and IFE matters {?}

C. MFE working group reports {MFE.*}

1. Physics issues of MFE burning plasmas

a) wave-particle interactions {MFE.P1}

b) energetic particles/alpha-physics {MFE.P2}
c) MHD {MFE.P3}
d) transport {MFE.P4}
e) boundary physics {MFE.P5}

2. Technology issues of MFE burning plasma next steps

a) magnets {MFE.T1}
b) PFC/heat removal {MFE.T2}
c) heating/current drive {MFE.T3}
d) vacuum vessel/remote handling {MFE.T4}
e) safety/tritium/materials {MFE.T5}
f) costing {MFE.T6}

3. Experimental approach and objectives

a) diagnostics {MFE.E1}
b) integrated scenarios/ignition physics/burn control {MFE.E2}
c) physics operations {MFE.E3}
d) development path {MFE.E4}

4. Relation between Innovative Confinement Concepts and Tokamak Burning Plasmas {MFE.B4}

5. Approaches

a) FIRE {MFE.B1}
b) Ignitor {MFE.B2}
c) ITER {MFE.B3}

D. IFE working group reports {IFE.*}

VI. Attachments [unlimited pages] {all participants}

Issues Involving Foreign Participation in Snowmass

>>> Two different aspects of participation in US discussions (e.g.Snowmass) on
>>> ITER should be considered:
>>>
>>> 1) Formal presentations of the project.
>>>
>>> On this point we have already agreed with the other ITER parties that an
>>> ITER dedicated presentation by the CTA, possibly in the frame of a US
>>> domestic assessment of ITER, would be appropriate, while comparative
>>> assessments with less advanced and less reactor-relevant concepts should
>>> be avoided.
>>>
>>> 2) Participation of European scientists in US discussions on ITER.
>>>
>>> This should not be discouraged. On the contrary it should contribute to
>>> explain to our US colleagues the rationale of ITER. Moreover there is an
>>> important message which should be delivered with a maximum of clarity:
>>> it is about the high priority given to ITER construction in the European
>>> programme and about the state of progress of decision making about ITER at
>>> the European and world level.

Strawman Snowmass Schedule Week 1

<table>
<tr><th></th><th>Monday</th><th colspan="2">Tuesday</th><th colspan="2">Wednesday</th><th colspan="2">Thursday</th><th colspan="2">Friday</th></tr>
<tr><td>A</td><td>General Plenary Session

Keynote Speakers
MFE Overview
IFE Overview
FESAC
NRC</td><td>MFE Plenary

P
T
E</td><td>IFE

Group and Subgroup Breakouts</td><td>MFE

B/T Joint ITER

B/E Joint ITER</td><td>IFE

D1,4/IP
D2/IT1-3
D3/IT4,5

D1,4/IT4,5
D2/IP
D3/IT1-3</td><td>MFE

B/T Joint FIRE

B/E Joint FIRE</td><td>IFE Plenary

D1
D3</td><td>MFE

B/T Joint IGNITOR

B/E Joint IGNITOR</td><td>IFE

Breakouts and Work on Interim Reports</td></tr>
<tr><td rowspan="2">B</td><td rowspan="2">IFE/MFE Joint Plenary

B1
IP (Targets)
B2
IT (IFE technonolgy)
B3
D (Drivers)
B4</td><td>MFE

B/P Joint ITER</td><td>B4/P

IFE

Group and Subgroup Breakouts</td><td>MFE

B/P Joint FIRE</td><td rowspan="2">IFE

D1,4/IT1-3
D2/IT4,5
D3/IP</td><td>MFE

B/P Joint IGNITOR</td><td rowspan="2">IFE Plenary

D2
D4</td><td>MFE

Breakouts and Work on Interim Reports</td><td>IFE

Breakouts and Work on Interim Reports</td></tr>
<tr><td colspan="2">Community Issues Group Discussion</td><td>B/P ICCs</td><td>B/T/E ICCs</td><td colspan="2">Community Issues Group Discussion</td></tr>
<tr><td>C</td><td rowspan="3">Welcome Reception</td><td colspan="2">Social Hour</td><td colspan="2">Social Hour</td><td colspan="2">Social Hour</td><td colspan="2" rowspan="3">Reception and Party</td></tr>
<tr><td>D</td><td colspan="2">DINNER BREAK</td><td colspan="2">DINNER BREAK</td><td colspan="2">DINNER BREAK</td></tr>
<tr><td>E</td><td colspan="2">Open</td><td colspan="2">FESAC Open House</td><td colspan="2">Community Issues Group Discussion</td></tr>
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Strawman Snowmass Schedule Week 2

	Monday	Tuesday		Wednesday		Thursday		Friday
A	**Plenary Interim Reports** **Diagnostic Report from APS-HTPD** **B Reports** **D Reports**	**MFE** Breakout Discuss and draft reports **P,T,E,B**	**IFE** Breakout Discuss and draft reports	**MFE** **B/T Joint** **B2/T** **B3/T** **B4/T** **B1/T**	**IFE** Group and Subgroup Breakouts Discuss and draft reports	**MFE** Draft final reports **P,T,E, B1-4**	**IFE** Breakout Discuss and draft reports	**Plenary Final Report** **P** **T** **E** **B** **For IFE TBD if IP,IT,D or D1,D2,D3,D4**
		Community Issues Group Discussion				**Community Issues Group Discussion**		
B	**Plenary Interim Reports** **P** **IP** **T** **IT** **E**	**MFE** **B/P Joint** **B1/P** **B2/P** **B3/P** **B4/P**	**IFE** Group and Subgroup Breakouts Discuss and draft reports	**MFE** **B/E Joint** **B3/E** **B4/E** **B1/E** **B2/E**	**IFE** Group and Subgroup Breakouts Discuss and draft reports	**MFE** Final Report Work Sessions	**IFE** Group and Subgroup Breakouts Discuss and draft reports	**Press Conference** **FESAC Action Panel**
C	**Social Hour**	**Social Hour**		**Social Hour**		**Social Hour**		
D	**Dinner Break**	**Dinner Break**		**Rodeo**		**Dinner Break**		
E	**NASA Session**	**NRC Review Open House**						

Organization

Working Groups

Draft Final Report Outline

Letter from Anne Davies

Maps

Lodging

Registration

Presentations

Snowmass 1999

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Guidelines for Snowmass 2002 site contributors

Template for Snowmass 2002 site contributors

Related Sites

Disclaimers

Snowmass 2002 Fusion Energy Sciences Summer Study

8-19 July 2002
Snowmass Village, Colorado, USA

The **2002 Fusion Energy Sciences Summer Study** will be a forum for the critical assessment of major next-steps in the fusion energy sciences program, and will provide crucial community input to the long-range planning activities undertaken by the DOE and the FESAC. It will be an ideal place for a broad community of scientists to examine goals and proposed initiatives in burning plasma science in magnetic fusion energy and integrated research experiments in inertial fusion energy.

This meeting is open to every member of the fusion energy science community and significant international participation is encouraged.

Objectives of the Fusion Summer Study

1. Review scientific issues in burning plasmas to establish the basis for the following two objectives. Address the relation of burning plasma in tokamaks to innovative MFE confinement concepts and of ignition in IFE to integrated research facilities.

2. Provide a forum for critical discussion and review of proposed MFE burning plasma experiments (e.g., FIRE, IGNITOR and ITER) and assess the scientific and technological research opportunities and prospective benefits of these approaches to the study of burning plasmas.

3. Provide a forum for the IFE community to present plans for prospective integrated research facilities, assess present status of the technical base for each, and establish a timetable and technical progress necessary to proceed for each.

Background

The 2002 Summer Study will build on earlier planning activity at the 1999 Fusion Summer Study and the scientific assessments at the UFA-sponsored Burning Plasma Science Workshops (Austin, December 2000 and San Diego, May 2001). The scientific views of the participants developed during the 2002 Summer Study preparation activities and during the 2002 Summer Study itself, will provide critical fusion community input to the decision process of FESAC and DOE in 2002-2003, and to the review of burning plasma science by the National Academy of Sciences called for by FESAC and Energy Legislation which was passed by the House of Representatives [H. R. 4].

Output of the Fusion Summer Study

An executive summary based on summary reports from each of the working groups will be prepared as well as a comprehensive proceedings of plenary and contributed presentations.

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Snowmass 2002 Fusion Energy Sciences Summer Study

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Snowmass 2002 Fusion Energy Sciences Summer Study

Working Groups

- ## MFE Working Groups
  - **Physics Working Group - S. Prager, University of Wisconsin**
    - P1: Wave-Particle Interactions - D. Batchelor, ORNL; M. Porkolab, MIT
    - P2: Energetic Particles/Alpha-Physics - R. Nazikian, PPPL; J. Van Dam, University of Texas
    - P3: MHD - C. Hegna, University of Wisconsin; E. Strait, GA
    - P4: Transport - E. Synakowski, PPPL; R. Waltz, GA
    - P5: Boundary Physics - S. Allen, LLNL; S. Pitcher; MIT
  - **Technology Working Group - C. Baker, UCSD**
    - T1: Magnets - N. Martovetsky, LLNL; J. Minervini, MIT
    - T2: PFC/Heat Removal - R. Mattas, ANL; M. Ulrickson, Sandia
    - T3: Heating/Current Drive - D. Rasmussen, ORNL; R. Temkin, MIT
    - T4: Vacuum Vessel/Remote Handling - B. Nelson, ORNL; T. Burgess, ORNL
    - T5: Safety/Tritium/Materials - D. Petti, INEEL; S. Zinkle, ORNL
    - T6: Cost - L. Waganer, Boeing
  - **Experimental Approach and Objectives Working Group - T. Taylor, GA**
    - E1: Diagnostics - R. Boivin, GA; R. Fonck, University of Wisconsin; K. Young, PPPL
    - E2: Integrated Scenarios/Ignition Physics/Burn Control - C. Kessel, PPPL; P. Politzer, GA
    - E3: Physics Operations - J. Wesley, GA; R. Parker, MIT
    - E4: Development Path - F. Najmabadi, UCSD; K. Schoenberg, LANL
  - **Burning Plasma Experiments Working Group - W. Nevins, LLNL**
    - B1: FIRE - D. Meade, PPPL; R. Thome, GA
    - B2: IGNITOR - F. Bombarda, MIT; B. Coppi, MIT
    - B3: ITER - F. (Rip) Perkins, PPPL
    - B4: ICCs - B. Hooper, LLNL; T. Jarboe, University of Washington
-

IFE Working Groups

- **Target Physics Working Group - M. Tabak, LLNL**
  - IP1: Fast Ignitor - J. Dahlburg, GA; M. Key, LLNL
  - IP2: Gain Curves - R. Town, LLE; M. Herrmann, LLNL
  - IP3: Stability - R. Betti, Rochester; A. Schmitt, NRL
  - IP4: Symmetry - D. Callahan-Miller, LLNL; J. Porter, SNLA
  - IP5: Beam-Target Interaction - J. Fernandez, LANL; T. Mehlhorn, SNLA
- **IFE Chamber/Target Technology Working Group - P. Peterson, UCB**
  - IT1: IFE Chamber Response - Microsecond Phenomena - R. Peterson, University of Wisconsin; M. Ulrickson, Sandia
  - IT2: IFE Chamber Clearing/Recovery - Millisecond Phenomena - N. Morley, UCLA; R. Raffray, UCSD
  - IT3: IFE Chamber Safety/Environment/Reliability - Quasi-Steady Phenomena - J. Latkowski, LLNL; D. Petti, INEEL
  - IT4: IFE Target Fabrication/Injection - D. Goodin, GA; A. Nobile, LANL
  - IT5: IFE Integrated Chamber/Focusing System Design and Modeling - M. Tillack, UCSD, W. Meier, LLNL
- **Driver Physics and Technology Working Group - W. Meier, LLNL**
  - D1: Lasers - S. Payne, LLNL; S. Obenschain, NRL
  - D2: Accelerators - S. Lund, HIF VNL; G. Logan, HIF VNL
  - D3: Z Pinch - C. Olson, SNL; TBD
  - D4: Fast Ignition Drivers - M. Campbell, GA; C. Barty, LLNL

Community Issues Working Group

- C1: About the Community Issues Working Group
- C2: Commentaries
- C3: TBD
- C4: TBD

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Snowmass 2002 Fusion Energy Sciences Summer Study

Physics Working Group

Physics Working Group - S. Prager, University of Wisconsin

Charter of physics working groups: The five physics working groups will prepare a uniform technical assessment of the three burning plasma experimental options. Specifically, each group will evaluate each option with regard to (1) the new physics to learn (the device's capability to contribute), (2) the readiness to proceed (will a particular physics phenomenon impede the goals of the device?), (3) the relation or contributions of the device to other fusion concepts, and (4) the impact of the different options on the fusion development path in this particular physics area.

- P1: Wave-Particle Interactions - D. Batchelor, ORNL; M. Porkolab, MIT
- P2: Energetic Particles/Alpha-Physics - R. Nazikian, PPPL; J. Van Dam, University of Texas
- P3: MHD - C. Hegna, University of Wisconsin; E. Strait, GA
- P4: Transport - E. Synakowski, PPPL; R. Waltz, GA
- P5: Boundary Physics - S. Allen, LLNL; S. Pitcher; MIT

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Snowmass 2002 Fusion Energy Sciences Summer Study

E1: Diagnostics

Charge Template

Recent Burning Plasma workshops focused on the plasma science that can be learned. In fact, the success and the legacy of a Burning Plasma Science Experiment resides in large part in the ability to properly measure the plasma properties, which will define the knowledge to be gotten from the undertaking. Is the present state-of-the-art in diagnostics and current progress in diagnostic development sufficient to support the studies of Burning Plasma Experiments? Are the plans for diagnostics tie in with a global road map, which would lead to a fusion reactor? Is there a global/national diagnostic development and integration that would lead to successful and productive experiment.

DIAGNOSTIC APPROACH

Specifically, in assessing the various proposals for BP experiments, such as ITER, FIRE and IGNITOR, is there a proper balance between the physics requirements and the technology and scientific capability of the diagnostics? Consequently, does it appear from the plans for diagnostics that:

a. they can support the mission of the experiment through providing necessary measurement capability?
b. they are sufficiently flexible and redundant to optimize physics information and to allow an objective assertion of the device performance?
c. they are scheduled for installation and commissioning in a timely fashion in order to support the physics program appropriately?
d. there are areas of research and development necessary for achieving measurements of some key parameters?
e. Are there opportunities for new measurements/techniques, and unique challenges for diagnostics?

PHYSICS REQUIREMENTS

In parallel, are the physics requirements for these experiments:

1. sufficiently well defined for setting the measurement requirements and associated diagnostic techniques?
2. consistent with measurement capability, including but not limited to sufficient resolution and coverage, and an ability to maintain proper calibration?
3. consistent with the availability and survivability of these diagnostics in the environment expected in the various proposals?

WORK OUTLINE

Deliverables/schedule (draft):

Fall 2001:

- List of conveners for diagnostics subgroup.
- Charter/charge to the group.
- Assessors identified, promoters identified.

January 2002:

- Information gathered about diagnostics, requirements and issues.
- Review measurement requirements versus mission by January 15th.

December 2001 - January 2002:

- Disseminate "open" letter from the diagnostic subgroup to other.
- Subgroups to identify/refine physics requirements.
- Distinguish between control and science/physics quantities.

- Use the fact that many ITPA meetings are in the US!
- Invite people to have a discussion/agenda item at their own meeting.
- Reach out to diagnostic community, junior staff and university.

January 2002 - February 2002:

- Establish "grid" of requirements versus plan/design.
- Establish criteria.
- Assess the well-established diagnostics aspects versus the problematic or unknown.
- Identify technological versus "political" aspects.

March 2002:

- ITPA (GA), review inputs from all subgroups, participants, and perform initial written assessment of options.

April 2002:

- Distribute initial assessment for review, completeness and comments.

July 2002 (HTPD-Wisconsin):

- Reach out to diagnostic community and present next to final version.

Conveners

- R. Boivin (GA)
- R. Fonck (University of Wisconsin)

The resources for the BPSX experiments are

- K. Young - FIRE
- F. Bombarda - IGNITOR
- Others?

Participants (others are welcome and encouraged to join):

- G. McKee (University of Wisconsin)
- D. Den Hartog (University of Wisconsin)
- T. Peebles (UCLA)
- D. Johnson (PPPL)
- J. Terry (MIT)
- G. Wurden (LANL)

We strongly support the interaction with young scientists, either students or early in their career. Please, encourage them to participate.

Relevant documents

BPX (general)

- FESAC - Review of Burning Plasma Physics, Sep 2001
- BPS2 summary workshop / diagnostics - A. Costley, May 2001
- BPX diagnostics, requirements and issues - A. Costley, Varenna, Sep 2001
- Minutes of the 1st Meeting
  of the ITPA Topical Group on Diagnostics held in St. Petersburg, Russia from 14-16 November 2001

ITER

- Measurement Requirements and Diagnostic System Designs for ITER - FEAT A. J. H. Donné, Oct 2000
- ITER divertor diagnostics requirements discussion - R. Pitts, ITPA, Nov 2001
- ITER divertor diagnostics requirements discussion - G. Vayakis, ITPA, Nov 2001
- ITER diagnostics - A. Costley, EPS, Jun 2001
- ITER diagnostics status - A. Costley, ITPA, Nov 2001
- ITER diagnostics integration - C. Walker, ITPA, Nov 2001
- ITER plant description (FDR) diagnostics - 2001
- ITER diagnostic requirements update - ITPA, Nov 2001
- ITER research priorities - ITPA, Nov 2001

FIRE

- FIRE Measurements Specifications, K. Young, Feb 2002
- FIRE diagnostics issues - K. Young, Wisconsin, Jul 2001
- FIRE diagnostics layout - K. Young, Jan 2002
- FIRE diagnostics - K. Young, Princeton Workshop, May 2000
- FIRE diagnostics - K. Young, ITPA, Nov 2001
- FIRE engineering report (DRAFT) diagnostics - K. Young, Jan 2002
- Paper FIRE Diagnostics SOFE conference, K. Young, Jan 2002
- Poster FIRE Diagnostics SOFE conference, K. Young, Jan 2002

IGNITOR

- Ignitor Diagnostic set description (1996)

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Every Part of the Fusion Community Will Play a Key Role at Snowmass 2002

MFE: Whether to take BP Step, and if taken, in what form will profoundly affect Fusion Energy Sciences Program:

- **ALL** of us are major stakeholders in this decision – our input into the planning and decision process is essential.

IFE: Advances in IFE ICCs and rethinking of integrated research experiment (IRE) goals and needs:

- IFE Community must update 1999 Snowmass/Knoxville IFE Roadmap

MFE/IFE: Relative timing of major steps?

We invite [& urge] you to GET INVOLVED!

Decisions made based on Snowmass activity will affect ALL of us.

How well we carry out the assessments of major next steps in our program will affect how our program credibility is viewed by broader scientific community through NRC Review & by DOE and Congressional Decision Makers

Please check out Snowmass 2002 Web-site
http://web.gat.com/snowmass/