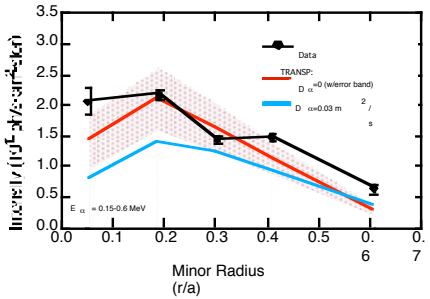
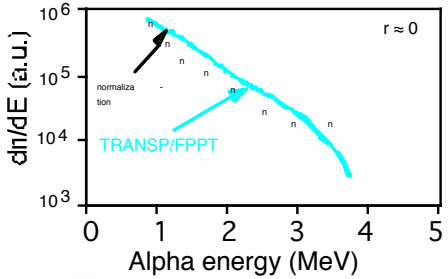
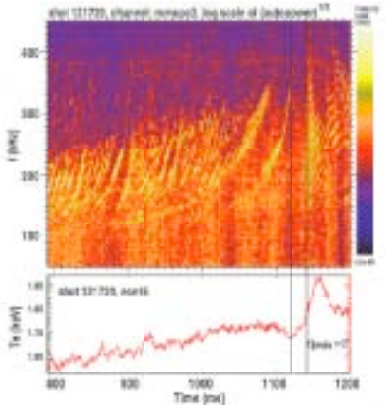
U.S. Burning Plasma Program Development…

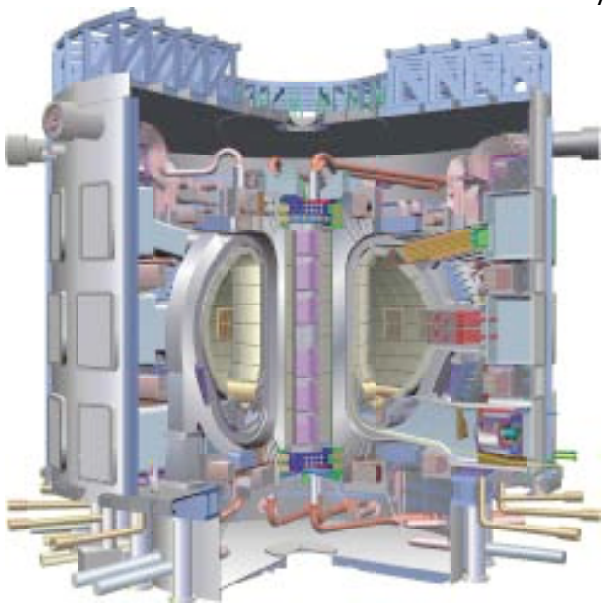
U.S. BURNING PLASMA ORGANIZATION

Science & Technology today…









… for Burning Plasmas to come…

R. J. Fonck

presented to

Fusion Power Associates

Meeting

Washington, DC

Sep. 27, 2006

US Burning Plasma Organization Activities Increasing

U.S. BURNING PLASMA ORGANIZATION

- Building organization
  - USBPO structural elements established
  - Moving to technical activities
- While reacting to immediate needs
  - Identifying ITER Physics and BP research tasks
  - Supporting ITER Design Review Process
  - Starting to develop a BP Research Plan
    - EPAct Task Group assisted in answering Energy Policy Act questions

USBPO Formed to Organize BP Research Activities

U.S. BURNING PLASMA ORGANIZATION

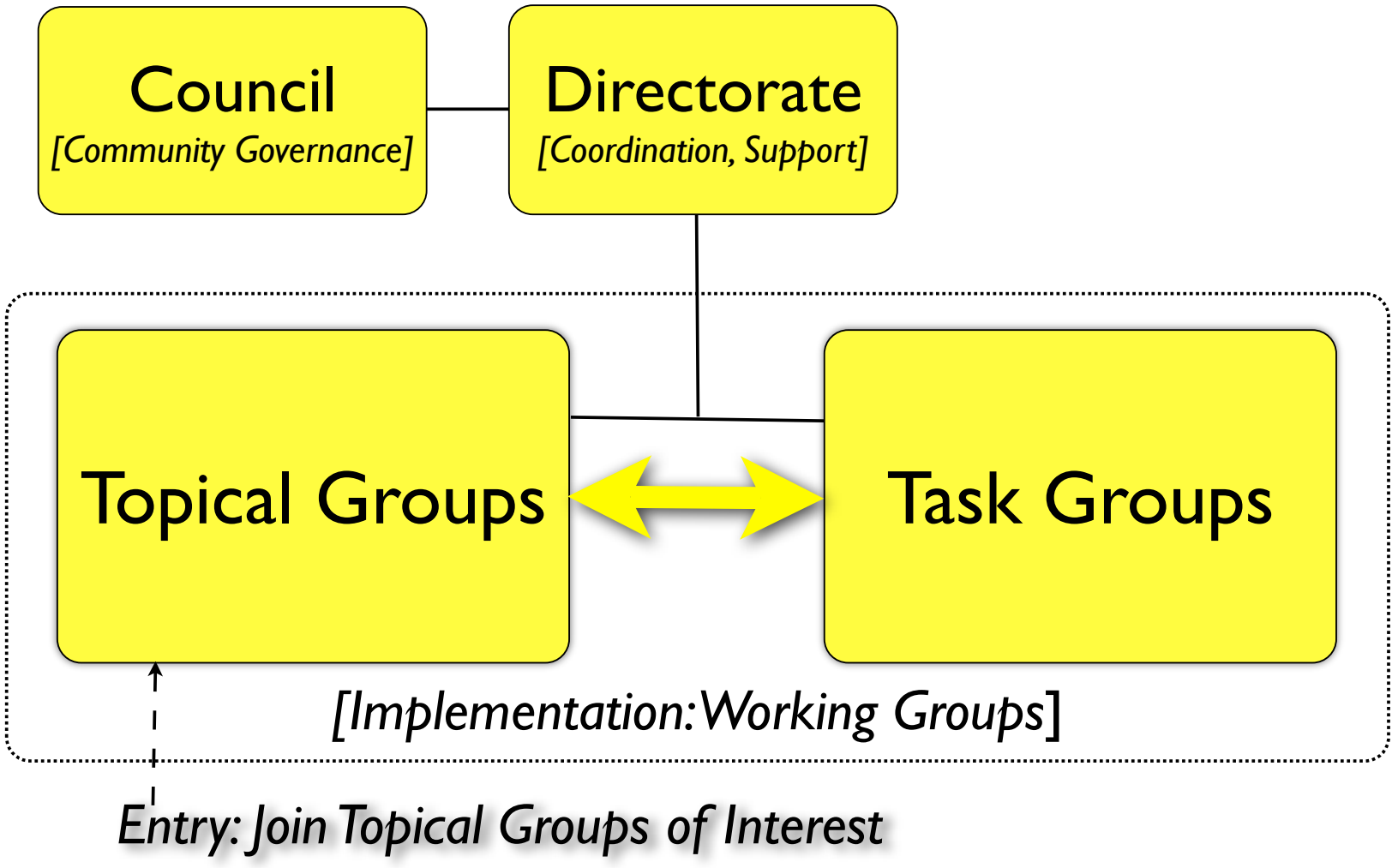
Mission:

Advance the scientific understanding of burning plasmas and ensure the greatest benefit from a burning plasma experiment by coordinating relevant U.S. fusion research with broad community participation.

info: http://www.burningplasma.org

USBPO Comprised of 3 Elements

U.S. BURNING PLASMA ORGANIZATION



Organizational Structure in Place

U.S. BURNING PLASMA ORGANIZATION

- Directorate:

  Director = Ray Fonck (UW)

  Deputy Director = Tony Taylor (GA)

  Research Committee = Topical Group Leaders

  Admin = Joan Welc-Lepain (UW)

  Communications = James Dekock (UW)

- Council:
  - Policy, advice, long-range directions, etc.
  - Whole Council meetings so far: teleconference; videoconference
  - Chair and Vice-Chair meet bi-weekly with Directorate and OFES

Council Provides Policy and Advice

U.S. BURNING PLASMA ORGANIZATION

- Council: Chair = James VanDam (U. Texas)

  Vice-Chair = Amanda Hubbard (MIT)

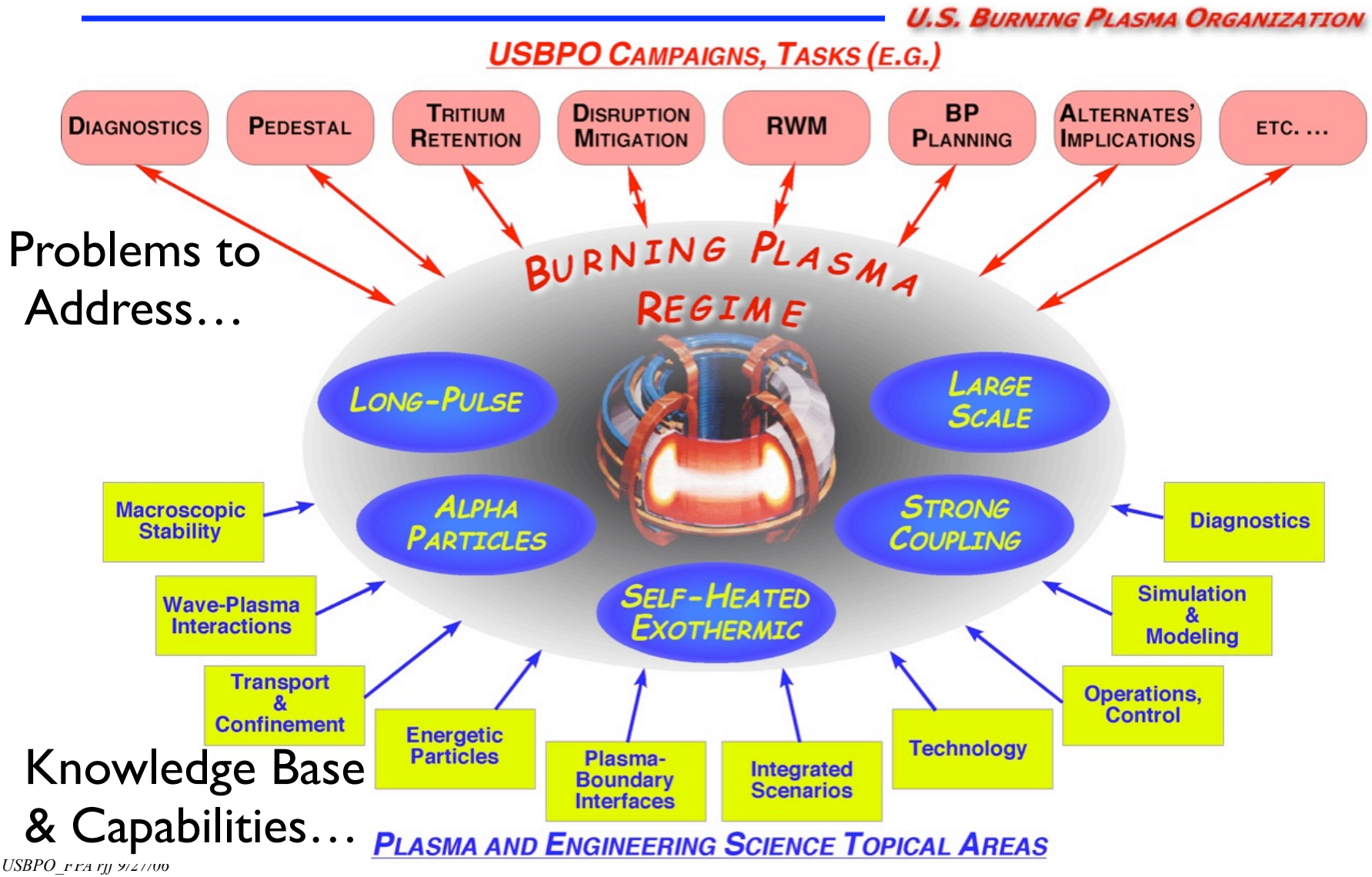
Steven Cowley (UCLA)
Richard Hawryluk (PPPL)
Gerald Navratil (Col. U.)
Craig Petty (GA)
William Nevins (LLNL)
George Tynan (UCSD)

Steven Allen (LLNL)
Earl Marmar (MIT)
Martin Peng (ORNL)
David Petti (INEEL)
John Sarff (U. Wisc.)
Michael Zarnstorff (PPPL)

ex-officio: Stanley Milora (IPO Chief Technologist, ORNL)
Raymond Fonck (USBPO Dir.; IPO Chief Scientist)

OFES Program Managers: Erol Oktay (Science)
Gene Nardella (Technology)

Address BP-Relevant Issues by Combining Community Expertise



Topical Groups Formed: Focus of BP Research Activities

U.S. BURNING PLASMA ORGANIZATION

Topical Group	Leader	Deputy Leader
MHD, Macroscopic Plasma Physics	Jon Menard (PPPL)	Chris Hegna (UW)
Confinement and Transport	Paul Terry (UW)	Ed Doyle (UCLA)
Boundary	Dennis Whyte (MIT)	Tom Rognlien (LLNL)
Plasma-Wave Interactions	Cynthia Phillips (PPPL)	Steve Wukitch (MIT)
Energetic Particles	Raffi Nazikian (PPPL)	Bill Heidbrink (UCI)
Fusion Engineering Science	Nermin Uckan (ORNL)	Rich Nygren (SNL)
Modeling and Simulation	Don Batchelor (ORNL)	Jon Kinsey (Lehigh)
Operation and Control	Dave Humphreys (GA)	Dave Gates (PPPL)
Diagnostics	Rejean Boivin (GA)	Jim Terry (MIT), Steve Allen (LLNL)
Integrated Scenarios	Chuck Greenfield (GA)	Chuck Kessel (PPPL)

Research Committee Organizing Research Tasks

U.S. Burning Plasma Organization

- Bi-weekly videoconference
  - Chaired by Deputy Director - T. Taylor
- Various Tasks underway in USBPO
  - ITER CODAC
  - Communications standards and tools
  - Burning Plasma issues identification
  - ITER Physics Tasks for 2006-2007
  - ITER Issue Card contributions
  - EPAct BP Planning activity
  - Charter and policies development (Council sub-panel)
  - USBPO and ITPA coordination (Council)

Research Committee has Proposed U.S. ITER Physics Tasks for 2007

U.S. Burning Plasma Organization

- Used existing info to start
  - ITPA priorities; 2005-2006 ITER tasks; USIPO WBS needs; USBPO Workshop; etc.
- Topical Group leaders engaged community for ideas
  - Ongoing discussions on BPO forums
- 76 discrete tasks identified
- High-priority list of 14 advanced to USIPO
  - Used well-defined metrics for evaluation
- Work with USIPO to refine & discuss with ITER team
  - Identifying participants and work plans
  - Topical/Task groups will perform the chosen Tasks

Metrics for ITER Physics Tasks Suggested

U.S. Burning Plasma Organization

- **Impact on ITER design (machine construction) – Urgency**
  - Clearly impacts ITER design 5
  - May impact ITER design 3
  - Does not impact ITER design 1
- **How well-defined are task and deliverables**
  - Clearly defined 5
  - Sufficiently defined to execute 3
  - Poorly defined 1
- **Addresses an ITPA high priority item**
  - Clearly addresses ITPA high priority 5
  - Contributes to ITPA high priority 3
  - Minimally contributes to ITPA high priority 1

Metrics for ITER Physics Tasks Suggested (continued)

U.S. Burning Plasma Organization

- **Unique capabilities within in the US community**
  - Capability only within the US 5
  - Superior capability within the US 3
  - Capabilities shared amongst ITER parties 1
- **Impact on US Positioning (supports US program long term goals/interests)**
  - Advances US ITER goals 5
  - Supports US ITER goals 3
  - Minimal contribution to US ITER goals 1
- **Complementarity/Synergy with ITER Parties**

  (Significant added value provided by multiple parties addressing jointly an issue vs being addressed by parties separately (or singly))
  - o Strong synergy with other parties 5
  - o Moderate 3
  - o Weak 1

Final List of Recommended ITER Physics Tasks

U.S. BURNING PLASMA ORGANIZATION

- Active coil system for ELM suppression and RWM stabilization
- ITER disruption mitigation system design and physics understanding
- Tritium retention and H/D/T control
- Requirements for stabilization of (3,2) and (2,1) NTMs
- Limitations to startup flexibility for advanced scenarios
- ELM mitigation
- ICRF antenna performance and coupling studies
- Critical assessment of heating and current drive mix on ITER and impact on achievable scenarios
- Review measurement requirements related to US diagnostic packages
- Evaluate the feasibility of lost and confined fast ion diagnostic systems for ITER
- ITER CODAC architecture design
- ICRF heating and current drive scenarios (time-independent)
- Development of improved pedestal and L-H transition predictive capabilities and impact on ITER design and performance.
- Locked-modes and error field correction specification

Engaging the ITER Issue Card Process

U.S. BURNING PLASMA ORGANIZATION

- Identification of Issues in ITER reference design
  - On-going ITER design review process
- Sub-comm extracted 1st set from 14 priority tasks
  - Some additions from Res Comm and sifting for design impact
  - Initial list of 11 forwarded to USIPO for discussion
  - More under consideration and refinement
- Topical Groups engaged to ID more as needed
  - Reaching out to community membership
- Initial group to be advanced forward by USIPO
  - Refine and expand as feedback obtained

ITER Issue Card Titles - I

U.S. Burning Plasma Organization

- Active coil system for ELM suppression and RWM stabilization
- Limitations to startup flexibility for advanced scenarios
- ELM mitigation scenario
- ITER disruption mitigation system design and physics understanding
- Requirements for stabilization of (3,2) and (2,1) NTMs
- ICRF antenna performance and coupling

ITER Issue Card Titles - II

U.S. Burning Plasma Organization

- Heating and current drive mix on ITER and impact on achievable scenarios
- A review of measurement requirements and performance expectations of planned ITER diagnostics
- Tritium retention and H/D/T control
- Pedestal and L-H transition
- Locked-modes and error field correction specification
- + others …

Address a BP/ITER Research Plan

U.S. BURNING PLASMA ORGANIZATION

- Energy Policy Act of July, 2005 called for a Plan for US Participation in ITER
- DoE/OFES asked USBPO to help develop this Plan
  - Consultation with FESAC
- EPAct Task Group formed to produce this
  - Short timescale ~ 2 months
  - Via teleconferences and e-mail
  - Draft commented on by FESAC
  - Sent to OFES in early June 2006

Overview

U.S. Burning Plasma Organization

- Introduction
  - Uniqueness = *strong-coupling* in burning plasma
  - Focus of U.S. program = *predictive understanding* of the fusion plasma system
  - Organize plan around previously identified priority campaigns
  - Always recognize tight coupling to international community planning
- Research community structure is evolving to adapt to anticipated modes of participation
  - Participation in USIPO
  - Members of international ITER Organization
  - Visiting participant scientists
  - ITPA
  - USBPO
  - Multilateral IEA and U.S. bilateral agreements

(i) The U.S. research agenda for ITER: Goals: Posed as 4 Questions to Answer

U.S. BURNING PLASMA ORGANIZATION

- Large-Confinement-Scale Physics:
  - *How does the large size required for a fusion power plant affect its confinement, stability, and energy dissipation properties?*
- The Burning Plasma State:
  - *Can a self-heated fusion plasma be created, controlled, and sustained?*
- Toward Steady-state Burning Plasma Operation:
  - *Can the tokamak confinement concept be extended to the continuous, self-sustaining regime required for future power plants?*
- Fusion Technology:
  - *What materials and components are compatible with the nuclear and plasma environment of a fusion power plant?*

(i) The U.S. research agenda for ITER: Aligned with Science Campaigns

U.S. BURNING PLASMA ORGANIZATION

- Specific long-term goals require near-term preparatory research
  - Determines the near-term agenda for U.S. program over next decade or so
  - A range of topics identified
  - Plan backwards from goals…
- Examples:
  - Macroscopic Plasma Physics:

Goal on ITER:	***Stabilize pressure-limiting instabilities***
ITER Time Frame:	***Modest gain Non-inductive Phase***
Preparatory Research:	***Define suitable control coil systems for ITER***

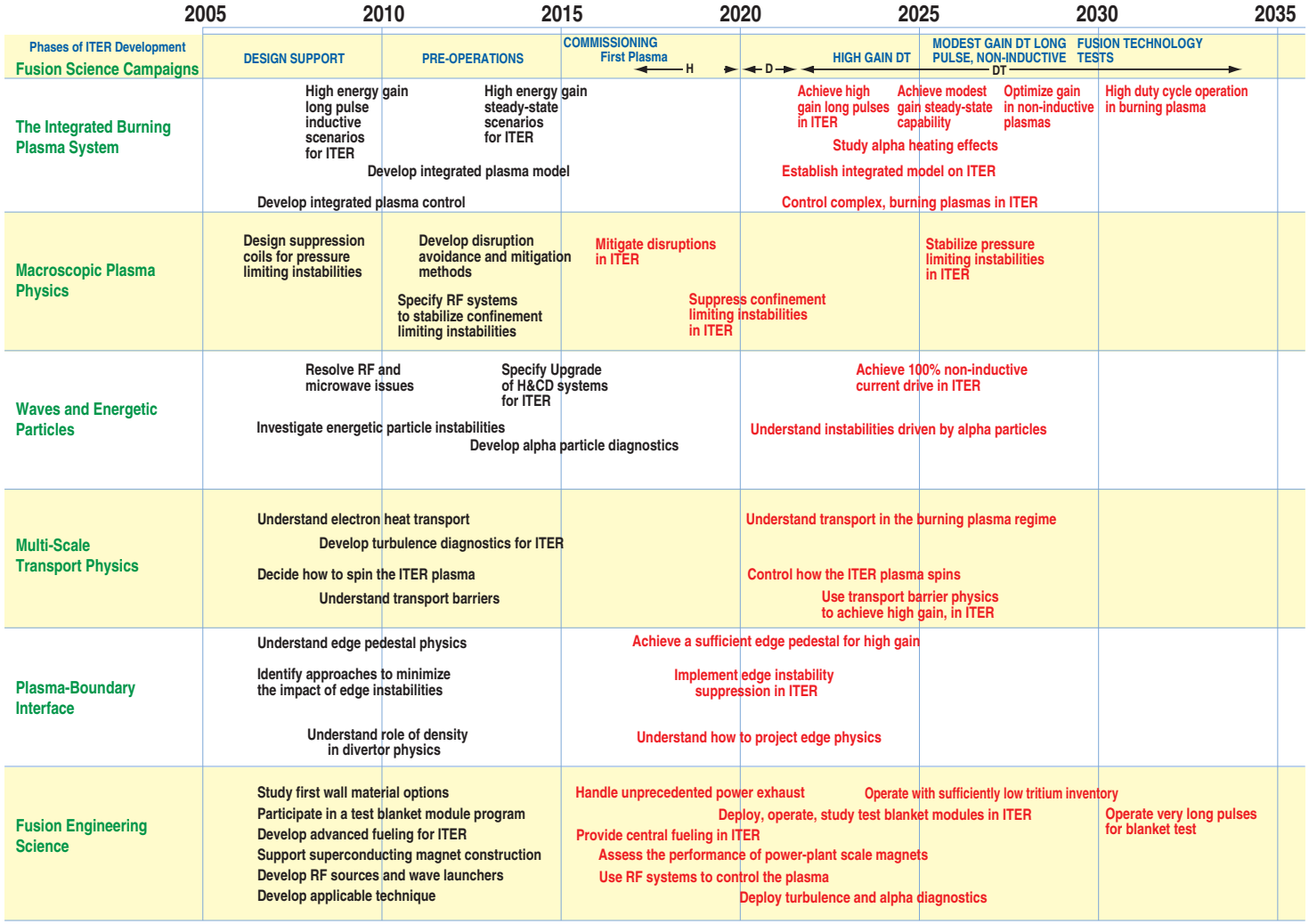
  - Waves and Energetic Particles:

Goal on ITER:	***Understand instabilities driven by alpha-particles***
ITER Time Frame:	***High gain DT Phase***
	Modest gain Non-inductive Phase
Preparatory Research:	***Investigate energetic particle instabilities***
	Develop alpha particle diagnostics

(i) The U.S. research agenda for ITER: Specific Tasks for Each Campaign

U.S. BURNING PLASMA ORGANIZATION

Research Agenda for ITER



(ii) Methods to evaluate whether ITER is promoting progress toward making fusion a reliable and affordable source of power

- Metric Class 1: Scientific Progress
  - Focus of U.S. program = development of underlying science and a *predictive understanding* of the fusion plasma system
  - Comparison of predicted and measured properties of plasma
    - Experimental validation of theory and simulations
    - e.g., explore predicted stability limits once in BP regime
  - Use of knowledge for controlling and extending plasma performance
- Metric Class II: Energy and Technology Progress
  - Performance goals: e.g. fusion power, gain, pulse length, etc.
  - Secondary to scientific metrics, but easier to define - need to be careful!

(iii) Description of how work at ITER will relate to other elements of the U.S. fusion program.

- Follow NRC BPAC report: goals for attractive fusion energy
  - *Maximize the plasma pressure*
  - *Maximize the plasma energy confinement*
  - *Minimize the power needed for sustainment*
  - *Simplify and increase reliability*
- A portfolio approach used to develop the predictive understanding of magnetic confinement to achieve these goals
  - Experiment in four leading categories
  - Theory and simulation
  - Fusion engineering science and tools
  - Tests of emerging concepts
- Relation to ITER and burning plasma research in an integrated fusion program
  - Support
  - Complement
  - Benefit from

This is Just a Beginning: What We Did Not Do

U.S. BURNING PLASMA ORGANIZATION

- Produce a finalized plan for burning-plasma activities in the U.S. program
  - Needs further development and input from the wider research community
- Set clear priorities among the tasks
  - Some prioritization explicit in tasks chosen for inclusion
  - Some inferred from schedule estimates
  - Not at point to suggest BP priorities in near-term domestic research (but closer!)
- Interface with international environment and partners

Moving to the Future

U.S. Burning Plasma Organization

- Further develop tasks and timescales
  - Long-term BP Planning Activity in USBPO - Council activity
  - Continue refining tasks and specific goals as science issues
  - Work with partners through ITPA, USIPO, and ITER for U.S. roles
- Set clear priorities among the tasks
  - As tasks are defined, confront prioritization
  - Lead to suggest BP priorities in near-term domestic research
- Work with FESAC planning activity
  - Address the ITER/BP participation part of the U.S. program

Summary

U.S. Burning Plasma Organization

- USBPO organization is defined
- Several Tasks ongoing
  - Working to kick off technical research activities
- Responding to USIPO needs
  - Physics Tasks proposed; Issues Card process underway
- EPAct study Task Group produced a first-level cut at a plan for BP research in the U.S.
  - Need to develop further