
**ITER
and
the US Burning Plasma Program**

What is the US Burning Plasma Program?

- **An integrated set of US experimental, theoretical, modeling and technological activities aimed at study of self-heated plasmas**

What does the US Burning Plasma Program involve?

- **Present-day research activities aimed at strengthening the basis for**
 - Understanding burning plasmas
 - Design of a burning plasma facility
 - Research operations of a burning plasma facility
- **Design and fabrication of burning plasma facility(ies)**
 - Engineering design
 - Physics design
 - Fabrication, assembly/installation/test/...
- **Development of enabling tools for the study of burning plasmas**
 - Experimental: diagnostics, plasma control, ...
 - Theoretical/Modeling: integrated predictive model, topical models, ...
 - Technological: magnets, PFC's, heating/current-drive/fueling, tritium-processing, safety, tritium-breeding blanket, materials, engineering, ...
 - Cultural: remote participation tools, prototypes, team-building, ...

How might the US Burning Plasma program get started?

- **Workshop to define US burning plasma scopes and refine directions**
 - Topics/issues
 - Activities to address these topics/issues
- **Establishment of integrated teams of researchers and designers**
 - NTMs
 - RWMs
 - ELMs, Disruptions, ...
 - Integrated/predictive modeling for scenario development (for design and for experimental operations)
 - Burning plasma diagnostics
 - Remote participation tools
- **Workshops to discuss the results of the focus groups and refine future directions (iterate...)**

Physics R&D and Physics Design

- **Physics R&D**

- Focuses on understanding and tool-building
- Output typically consists of papers and tools...
- ITPA is an international forum for topical experts to share results and facilitate coordination
- IEA-** Agreements foster and enable joint experiments in key research areas

- **Physics Design**

- Focuses on problem-solving/design by application of understandings and tools
- Output typically consists of specifications for the performance of engineering systems
- Typically involves a focused team of experts in a range of topical areas

- **Physics R&D and Physics Design are synergistic and interactive**

ITPA Topical Physics Groups

	US Leader	US Co-Leader	OFES Contact		
Transport Physics	Ed Doyle (UCLA)	Ed Synakowski (PPPL)	Curt Bolton		
Confinement DB & Modeling	Wayne Houlberg (ORNL)	Jim DeBoo (GA)	Steve Eckstrand		
Pedestal & Edge Physics	Tony Leonard (GA)	Amanda Hubbard (MIT)	Arnold Kritz		
Divertor & Scrape-Off Layer	Bruce Lipschultz (MIT)	Peter Stangeby (GA/LLNL)	Chuck Finfgeld		
Steady State & Energetic Part.	Cynthia Phillips (PPPL)	Ron Prater (GA)	Erol Oktay		
MHD, Disruption & Control	Ted Strait (GA)	Steve Jardin (PPPL)	Rostom Dagazian		
Diagnostics	Dave Johnson (PPPL)	Rejean Boivin (GA)	Darlene Markevich		

ITPA: MHD, Disruption and Control

- MHD stability analyses of H-mode edge transport barriers under Type-I and tolerable ELM conditions.
- NTMs: island-onset threshold, stabilization of (3,2) and (2,1) NTM islands at high- β and β -recovery, possible operation with benign NTMs, identification of requirements for reactor plasmas.
- RWMs: analyses, experimental verification of RWM-control, roles of plasma rotation and error fields, control system requirements for diagnostics.
- Construction of a new disruption data base including conventional and advanced scenarios and heat loads on walls/targets.
- Development of disruption mitigation techniques, particularly noble gas injection.

ITPA: Steady State Operation and Energetic Particles

- **Steady state plasma operation: Investigations of hybrid scenarios and full current-drive plasmas with significant bootstrap current; assessment of beta limits**
- **Use of Heating & CD actuators for real-time current-profile control: assessment of predictability, in particular for off-axis CD**
- **Studies of fast-particles collective modes in low- and reversed-magnetic shear configurations: Identification of key parameters. Benchmarking of theories and codes for damping and stability, including nonlinear mode dynamics and fast-particle transport.**

IT-Leader-Requested 2004 Physics Tasks (2/27/04)

- 1) NTM control in Inductive and Hybrid Scenario in ITER**
- 2) RWM in Steady State Scenario in ITER**
- 3) VDE, Disruptions and their mitigation in ITER**
- 4) Plasma position and shape control with 3D model of vacuum vessel**
- 5) Error Field Control in ITER**
- 6) ITER Plasma Integrated Model for ITER**
- 7) Development of Steady State Scenarios in ITER**
- 8) Evaluation of Fast Particle Confinement of ITER**
- 9) Assessment of Edge Pedestal and ELMs of ITER**

Example of Physics R&D and Physics Design: Specification of the systems for stabilizing NTMs

- **Physics R&D**

- MHD:

- understanding NTM behavior
 - predictive codes and models

- EC:

- understanding current drive behavior, including localization
 - predictive codes

- **Physics Design**

- MHD:

- analyze NTM-stability of a range of ITER scenarios, and characterize the modes,
 - derive the locations and magnitudes of internal plasma currents required for NTM-stabilization

- EC:

- specify needed EC-power and launcher capability/performance

Example of Physics R&D and Physics Design: Specification of the systems for stabilizing RWMs

- **Physics R&D**
 - MHD:
 - understanding of RWM behavior
 - understanding of interactions of finite-extent coils with RWMs
 - understanding of rotation-effects on RWMs
 - predictive codes and models
- **Physics Design: Working with engineers**
 - analyze scenarios for RWM-stability characteristics
 - analyze rotation of the ITER plasma and effects on ITER's RWMs
 - analyze options for RWM-stabilization coils in port-plugs
 - derive the necessary performance specifications for control and power systems to drive the coils

Bottom Line...

- **Physics research focuses on increasing understanding and building tools**
 - The ITPA offers facilitation/coordination of physics research in high-priority areas
 - Presently emphasizing focus on design issues
 - Should extend focus to research operations issues
 - We are considering improvement of topical coordination in the US
- **Physics design activity applies the understanding and tools to the integrated design of facilities**
- **It is time for the US to establish a burning plasma program**
 - Present-day research activities aimed at strengthening the basis
 - Design and fabrication of burning plasma facility(ies)
 - Development of enabling tools for the study of burning plasmas