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Boundary Physics Topical Science Group Plan

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New York U
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U Colorado
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Lawrence Livermore National Laboratory, Livermore, CA

A. Diallo, TSG Deputy

Princeton Plasma Physics Laboratory, Princeton, NJ

D. P. Stotler, Theory & Modeling

Princeton Plasma Physics Laboratory, Princeton, NJ

Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

FY 2011 NSTX Research Forum

18 March 2011

Princeton, NJ

Boundary Physics TSG priorities are defined by

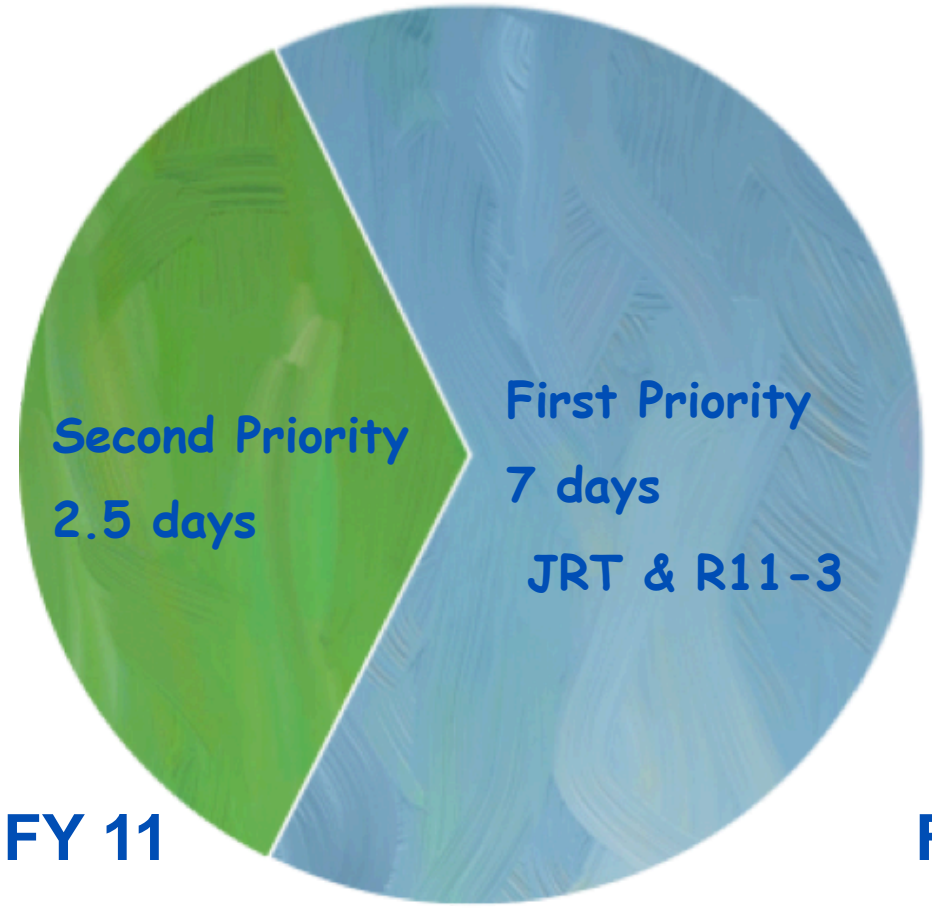
- **DOE and NSTX Milestones**
  - **FY2011 DOE Joint Research Target:** Conduct experiments on major fusion facilities to improve the understanding of the physics mechanisms responsible for the **structure of the pedestal** and compare with the predictive models described in the companion theory milestone.
  - **R(11-3)**: Assess very high flux expansion divertor operation

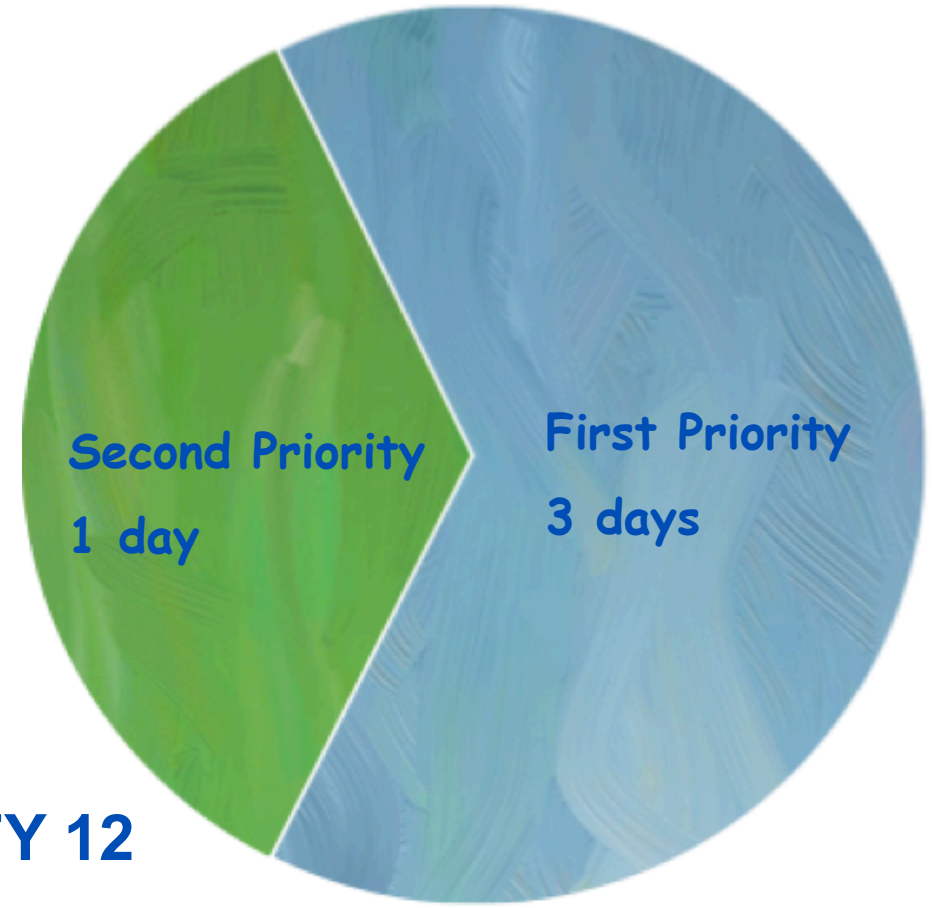
- **NSTX-U design needs**
- **ITPA participation, ITER design and physics needs**
- **Career development: post-doctoral research**

Boundary Physics TSG is actively involved in a number of ITPA PEP and DSOL experiments

- **DSOL (= Divertor and Scrape-off layer)**
  - DSOL-21 Introduction of pre-characterized dust for dust transport studies in divertor and SOL
- **PEP (= Pedestal and Edge)**
  - PEP-19 Basic mechanisms of edge transport with RMP
  - PEP-23 Quantification of the requirements for ELM suppression by magnetic perturbations from off-midplane coils
  - PEP-25 Inter-machine comparison of ELM control by magnetic field perturbations from midplane RMP coils
  - PEP-26 Critical parameters for achieving L-H transitions
  - PEP-27 Pedestal profile evolution following L-H/H-L transition
  - PEP-28 Physics of H-mode access with different X-point height
  - PEP-29 Vertical jolts/kicks for ELM triggering and control
  - PEP-31 Pedestal structure and edge relaxation mechanisms in I-mode
  - PEP-33 Effects of current ramps on the L-H transition and on the stability and confinement of H-modes at low power above the threshold
  - PEP-34 Non-resonant magnetic field driven QH-mode

Boundary Physics TSG run time guidance << number of received proposals





Received 28 Proposals, ~ 30 Run days requested

Submitted proposals grouped by topic

[T. Gray] Achieving I-mode on NSTX
[A. Diallo] Aspect Ratio Effects on the Pedestal Structure in ELMy discharges
[D. Smith] Assess pedestal_SOL fluctuations and poloidal flow fluctuations across LH transitions and ELMs
[R. Maingi] Dependence of density profile modification, and pedestal_core performance on amount of lithium evaporated between discharges
[A. Diallo] Effects of Triangularity and Toroidal field on the Pedestal Structure in ELMy H-mode
[A. Diallo] Elongation Effects on the Pedestal Structure in ELMy H-mode
[D. Battaglia] LH power threshold and H-mode pedestal height versus X-point height
[R. Maingi] Reproduce medium triangularity Enhanced Pedestal H-mode Discharge
[D. Smith] Searching for EHOs in low triangularity plasmas with early RMP
[K. C. Lee] Turbulence and transport measurement on Enhanced Pedestal H-mode triggered by 3-D field

JRT

[V. Soukhanoskii] Development and assessment of X-divertor configuration on NSTX
[M. Jaworski] Divertor electron temperature and EEDF modification due to connection length modification
[V. Soukhanoskii] Divertor heat flux mitigation with impurity seeding in high-performance discharges
[V. Soukhanoskii] Snowflake divertor configuration studies in support of R11-3 and NSTX-U divertor options
[R. Maingi] Triggered ELMs in the snowflake configuration – do they burn through
[V. Soukhanovskii] Development of early snowflake-minus configuration for impurity control
[A. Loarte] Compatibility of Radiative Divertor Operation with High Confinement H-mode Plasmas

R11-3,

Divertor Physics

[D. Battaglia] LH power threshold and H-mode pedestal height versus X-point height {Note Overlap above}
[S. Kaye] L-H Threshold Power Study_ Ramp-Up vs Steady Ip Phase

[A. Loarte] Access and sustainment of H-mode confinement in ramped phases of ITER scenarios
[J. Clementson] Development of Spectroscopic ITER Divertor Diagnostics

ITER & ITPA

[T. Gray] Scrape-off Layer Particle and Energy Transport with varying SOL Collisionality
[T. Munsat] Dynamics of Zonal Flow-Drift Wave System Preceding L-H Transition
[R. Raman] Steady state discharges with LFS fueling
[H. Takahashi] Optimal Positioning of ELM Triggering Electrodes
[H. Takahashi] Validation of SOLC-based ELM-triggering Model
[H. Takahashi] Distinguishing between Two SOLC-Based ELM-Models Inter-Divertor Flux Tube and Homoclinic Tangle
[A. Sontag] Edge oscillations during Type-V and ELM-free H-mode
[A. Sontag] Effect of toroidal flow shear on edge stability

ELMs,Zonal Flows,

Stability, transport

Boundary Physics proposed research plan for FY 2011

n	Author	Affiliation	Title	Milestone/ITPA	Boundary Group conclusion
1	A. Diallo	PPPL	Effects of Triangularity and Toroidal field on the Pedestal Structure in ELMy H-mode	JRT	1 day
2	Rajesh Maingi	ORNL	Dependence of density profile modification, and pedestal/core performance on amount of lithium evaporated between discharges	JRT	0.5 day
3	Rajesh Maingi	ORNL	Reproduce medium triangularity Enhanced Pedestal H-mode Discharge	JRT	Combine with 4 for 1 day
4	K. C. Lee	UCD	Turbulence and transport measurements on Enhanced Pedestal H-mode triggered by 3-D field	JRT	Combine with 3 for 1 day
5	Travis Gray	ORNL	Achieving I-mode on NSTX	JRT	0.5 day
6	A. Diallo	PPPL	Elongation Effects on the Pedestal Structure in ELMy H-mode	JRT	0.5 day
7	Devon Battaglia, Rajesh Maingi	ORNL	H-mode pedestal height versus X-point height	JRT, ITPA PEP-28	0.5 day
8	Vlad Soukhanovskii	LLNL	Snowflake divertor configuration studies in support of R11-3 milestone and NSTX-U divertor options	R11-3, NSTX-U	3 days
9	Vlad Soukhanovskii	LLNL	Development and assessment of X-divertor configuration on NSTX	R11-3, NSTX-U	Combine with 8
10	D. Smith	UW	Searching for EHOs in low triangularity plasmas with early RMP	R11-4, JRT	Combine with 11 for 1 day
11	Aaron Sontag	ORNL	Edge oscillations during Type-V and ELM-free H-mode		Combine with 10 for 1 day
12	Michael Jaworski	PPPL	Divertor electron temperature and EEDF modification due to connection length modification	R11-3	Combine with 13 for 1 day
13	Travis Gray	ORNL	Scrape-off Layer Particle and Energy Transport with varying SOL Collisionality	N/A	Combine with 12 for 1 day
14	Hiro Takahashi	PPPL	Optimal Positioning of ELM Triggering Electrodes	NA	0.5 day

Boundary Physics proposed research plan for FY 2012 and remaining XPs

n	Author	Affiliation	Title	Milestone/ITPA	Boundary Group conclusion
15	Vlad Soukhanovskii	LLNL	Radiative divertor with impurity seeding in high-performance discharges	DSOL, ITER, NSTX-U	Combine with 16 for 1 day
16	A. Loarte	ITER	Compatibility of Radiative Divertor Operation with High Confinement H-mode Plasmas	Joint ITPA IOS experiment	Combine with 15 for 1 day
17	Vlad Soukhanovskii	LLNL	Snowflake divertor configuration studies in support of NSTX-U divertor options	R11-3, NSTX-U	1 days
18	D. Smith	UW	Assess pedestal/SOL fluctuations and poloidal flow fluctuations across LH transitions and ELMs	R11-4, JRT	Combine with 19, 20 for 1 day and 0.5 P.2 day
19	Devon Battaglia	ORNL	L-H power threshold for D and He plasmas using RF current drive with symmetric phasing	TC-4	Combine with 18, 20 for 1 day and 0.5 P.2 day
20	Tobin Munsat	U Colorado	Dynamics of Zonal Flow-Drift Wave System Preceding L-H Transition	PEP-26	Combine with 18, 19 for 1 day and 0.5 P.2 day
21	Hiro Takahashi	PPPL	Validation of SOLC-based ELM-triggering Model	NA	Combine with 22 for 0.5 day
22	Hiro Takahashi	PPPL	Distinguishing between Two SOLC-Based ELM-Models - Inter-Divertor Flux Tube and Homoclinic Tangle	NA	Combine with 21 for 0.5 day
23	A. Diallo	PPPL	Aspect Ratio Effects on the Pedestal Structure in ELMy discharges	JRT	Piggiback
24	Stan Kaye	PPPL	L-H Threshold Power Study: Ramp-Up vs Steady Ip Phase	PEP-33	Moved to T&T TSG
25	A. Loarte	ITER	Access and sustainment of H-mode confinement in ramped phases of ITER scenarios	Joint ITPA IOS experiment	Moved to T&T TSG
26	R. Raman, et al.	U Washington	Steady state discharges with LFS fueling	PAC Request	Combine with XPs in ASC TSG for R12-3 milestone
27	Aaron Sontag	ORNL	Effect of toroidal flow shear on edge stability		Piggiback
28	J. Clementson	LLNL	Development of Spectroscopic ITER Divertor Diagnostics	ITER	Not presented, may piggiback on 15, 16

FY 2011JRT on Pedestal Structure

- **Conduct experiments on major fusion facilities to improve the understanding of the physics mechanisms responsible for the structure of the pedestal and compare with the predictive models described in the companion theory milestone. Proposed description: The goal of the joint theory-experiment milestones (or replace with research campaigns depending on what OFES prefers) is to understand the physics mechanisms responsible for the structure of the pedestal and develop a predictive capability. The edge of high performance tokamaks is characterized by very steep pressure gradients forming a pedestal in the pressure profile. Core confinement is strongly correlated with the value of the pressure at the top of the pedestal, which is predicted to significantly impact the fusion power in ITER.**

- ***Experiment:*** *Improve the understanding of the physics mechanisms responsible for the structure of the pedestal and compare with the predictive models described in the companion theory milestone. Perform experiments to test theoretical physics models in the pedestal region on multiple devices over a broad range of plasma parameters (e.g., collisionality, beta, and aspect ratio). Detailed measurements of the height and width of the pedestal will be performed augmented by measurements of the radial electric field. The evolution of these parameters during the discharge will be studied. Initial measurements of the turbulence in the pedestal region will also be performed to improve understanding of the relationship between edge turbulent transport and pedestal structure.*
- ***Theory:*** *A focused analytic theory and computational effort, including large-scale simulations, will be used to identify and quantify relevant physics mechanisms controlling the structure of the pedestal. The performance of future burning plasmas is strongly correlated with the pressure at the top of the edge transport barrier (or pedestal height). Predicting the pedestal height has proved challenging due to a wide and overlapping range of relevant spatiotemporal scales, geometrical complexity, and a variety of potentially important physics mechanisms. Predictive models will be developed and key features of each model will be tested against observations, to clarify the relative importance of various physics mechanisms, and to make progress in developing a validated physics model for the pedestal height.*

R(11-3): Assess very high flux expansion divertor operation

The exploration of high flux expansion divertors for mitigation of high power exhaust is important for NSTX-Upgrade, proposed ST and AT-based fusion nuclear science facilities and for Demo. In this milestone, high flux expansion divertor concepts, e.g. the “snowflake”, will be assessed. The magnetic control, divertor heat flux handling and power accountability, pumping with lithium coatings, impurity production, and their trends with engineering parameters will be studied in this configuration. Potential benefits of combining high flux expansion divertors with gas-seeded radiative techniques and ion pumping by lithium will be explored. Two dimensional fluid codes, e.g. UEDGE, will be employed to study divertor heat and particle transport and impurity radiation distribution. Further, H-mode pedestal stability, ELM characterization, as well as edge transport will also be studied in the experiment and modeled with pedestal MHD stability codes, e.g., ELITE, and transport codes, e.g. TRANSP and MIST. This research will provide the foundation for assessing the extrapolability of high flux expansion divertors for heat-flux mitigation in next-step devices.