

Supported by



PAC-10 Action Items

Martin Peng

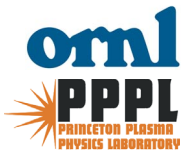
NSTX PAC-11th Meeting

October 4-5, 2001

PPPL



Los Alamos
NATIONAL LABORATORY



Lodestar, NYU, PSI, UC Irvine, UKAEA, Tokyo U, Kyushu-Tokai U, HIST, Hiroshima U, Niigata U, Tsukuba U, Ioffe Inst., TRINITY, KBSI

PAC-10 Action Items

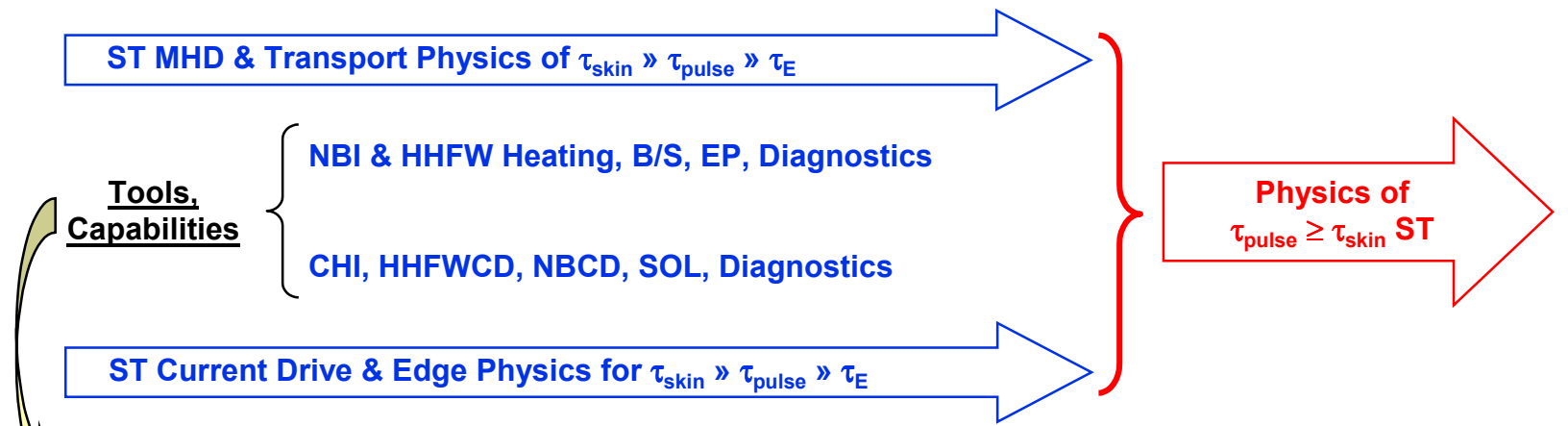


- **Balance between inductive and noninductive research (Peng)**
- **Present status of next step ST assessment (Ono)**
- **Does fast HHFW heat and drive current? (Synakowski)**
- **Obtain reliable HHFW operation and HHFW-alone H-mode (Synakowski)**
- **Reconcile magnetic and kinetic estimates of stored energy (Synakowski)**
- **Plan for control of RWM and NTM (Maingi)**
- **Encourage cost-effective NSTX modifications for CHI (Maingi)**
- **Recommend additional noninductive startup approach to CHI, such as EBW/ECH (Synakowski, Maingi)**
- **Articulate edge physics research plan (Maingi)**
- **Why delay beta-tau milestone to FY03? (Maingi)**

The Research Program Will Investigate the Physics of Special ST Plasma and Magnetic Features



	Noninductive Assisted			Noninductive Sustained
FY	2001	2002	2003	2004 - 2006
Rnwks	15	13(12)	13	40



Research Milestones (Implementation Approaches)

- Study τ_E
- Heat with HHFW
- Study MHD modes (no feedback)
- Assess effects of high β_T & flow on χ
- Demonstrate CHI startup
- Assess HHFW current drive efficiency
- Study SOL fluxes
- Integrate high β_T & high τ_E for $\gg \tau_E$
- Extend startup & sustainment to $\sim 1s$

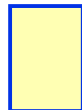
2004 – 2006 Program Areas

- Noninductive startup & sustainment
- Heating, CD, profile control
- MHD mode control
- Turbulence suppression
- Energetic ion effects
- Multi-state interface control

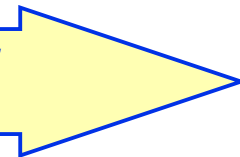
NSTX Plans to Study Physics of Progressively More Non-Inductive ST Plasmas



Present Plan:

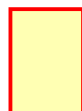


*Decrease reliance on solenoid induction;
Carry out longer-pulse physics studies.*



Phase	I	II	III
Rnwks	13	41	40
<u>Exp. Operation Capabilities</u>	<u>Inductive</u>	<u>Non-inductive Assisted</u>	<u>Non-inductive Sustained</u>
• Toroidal Beta, β_T		• \rightarrow 25%	• \rightarrow 40%
• Bootstrap Current		• \rightarrow 40%	• \rightarrow 70%
• Current	• \rightarrow 0.5 MA	• \rightarrow 1 MA	• \sim 1 MA
• Pulse	• \rightarrow 0.5 s	• \rightarrow 1 s	• \rightarrow 5 s
• HHFW Power	• \rightarrow 4 MW	• \rightarrow 6 MW	• \sim 6 MW
• NBI Power		• \rightarrow 5 MW	• \sim 5 MW
• EBW Power	• \rightarrow 30 kW	• \sim 30 kW	• \rightarrow 0.4 MW (proposed)
• CHI Startup	• \rightarrow 0.2 MA	• \rightarrow 0.5 MA	• \sim 0.5 MA
• Control	• current, R, shape	• heating, density	• flows, profiles, modes
• Measure	• $T_e(r)$, $n_e(r)$	• $j(r)$, $T_i(r)$, flow, edge, modes	• turbulence

Future Prospect:



*Decrease next-step device complexity & size;
Carry out longer-pulse technology R&D.*



U.S. National NSTX Research Team Collaboration and International Research Cooperation



Princeton Plasma Physics Laboratory: M. Ono, E. Synakowski, S. Kaye, M. Bell, R. E. Bell, S. Bernabei, M. Bitter,* C. Bourdelle, R. Budny, D. Darrow, P. Efthimion, D. Ernst, G. Fu, D. Gates, L. Grisham, N. Gorelenkov, R. Kaita, H. Kugel, K. Hill, J. Hosea, H. Ji, S. Jardin, D. Johnson, B. LeBlanc, Z. Lin, R. Majeski, J. Manickam, E. Mazzucato, S. Medley, J. Menard, D. Mueller, M. Okabayashi, H. Park, S. Paul, C.K. Phillips, N. Pomphrey, M. Redi, G. Rewoldt, A. Rosenberg, C. Skinner, V. Soukhanovskii, D. Stotler, B. Stratton, H. Takahashi, G. Taylor, R. White, J. Wilson, M. Yamada, S. Zweben

Oak Ridge National Laboratory: M. Peng, R. Maingi, C. Bush, T. Bigelow, S. Hirshman,* W. Houlberg, M. Menon,* D. Rasmussen,* P. Mioduszewski, P. Ryan, P. Strand, D. Swain, J. Wilgen

University of Washington: R. Raman, T. Jarboe, B. A. Nelson, A. Redd, D. Orvis, E. Ewig

Columbia University: S. Sabbagh, F. Paoletti, J. Bialek, G. Navratil, W. Zhu

General Atomics: J. Ferron, R. Pinsker, M. Schaffer, L. Lao, B. Penaflor, D. Piglowski

Johns Hopkins University: D. Stutman, M. Finkenthal, B. Blagojevic, R. Vero

Los Alamos National Laboratory: G. Wurden, R. Maqueda, A. Glasser*

Lawrence Livermore National Laboratory: G. Porter, M. Rensink, X. Xu, P. Beiersdorfer,* G. Brown*

UC San Diego: T. Mau, J. Boedo, S. Luckhardt, A. Pigarov,* S. Krasheninnikov*

UC Davis: N. Luhmann, K. Lee, B. Deng, B. Nathan, H. Lu

UC Los Angeles: S. Kubota, T. Peebles, M. Gilmore

Nova Photonics: F. Levinton, J. Foley

Massachusetts Institute of Technology: A. Bers, P. Bonoli, A. Ram, J. Egedal*

UC Irvine: W. Heidbrink

Sandia National Laboratory: M. Ulrickson,* R. Nygren,* W. Wampler*

Princeton Scientific Instruments: J. Lowrance,* S. von Goeler*

Lodestar: J. Myra, D. D'Ippolito

NYU: C. Cheng*

University of Maryland: W. Dorland*

Dartmouth University: B. Rogers*

U.K., EURATOM UKAEA Culham: A. Sykes, R. Akers, S. Fielding, B. Lloyd, M. Nightingale, G. Voss, H. Wilson

JAPAN, Univ. Tokyo: Y. Takase, H. Hayashiya, Y. Ono, S. Shiraiwa; **Kyushu Tokai Univ.:** O. Mitarai; **Himeji Inst of Science & Technology:** M. Nagata; **Hiroshima Univ.:** N. Nishino; **Niigata Univ.:** A. Ishida; **Tsukuba Univ.:** T. Tamano,

Russian Federation, Ioffe Inst.: V. Gusev, A. Detch, E. Mukhin, M. Petrov, Y. Petrov, N. Sakharov, S. Tolstyakov, Dyachenko, A. Alexeev; **TRINITY:** S. Mirnov, I. Semenov,

Korea, KBSI: N. Na

NSTX Facility Plan (●) and Program Decision Points (◆)



	FY01		FY02		FY03
Experimental Run-Weeks	7	8	13(12)		13
NBI	● 5 MW	● Modulation			● β Feedback
HHFW		● 6 MW (k = 14/m)	● 6 MW (k = 7/m)	● Real-Time ϕ Control	
CHI	● $I_{inj} = 50$ kA		● Absorber Design	● Installation	
EBW		● Emission/Conversion	● System Design (0.4 MW)	◆ System Decision	◆ FDR
Wall Conditioning Pwr & Part. Cntrl.	● Gas B-zation	● Plasma B-zation	● Li/B Pellet Injector		◆ Long-Pulse Upgrade
		● Hi-Temp Bake			
Fueling	● Gas Puff, NBI		● Inboard Gas Fueling		
RWM Control		● Mode ID		◆ System Decision	◆ FDR
NTM Control		● Mode ID	● Mode Avoidance	◆ EBW & Profile Requirements	
Locked Mode Coil	● Installation	● Mode ID	● PF5 Corrections		
Plasma Control	● Sky-II On-line		● 150 Inputs, GIS Control, n_e Feedback		

NSTX Diagnostics Implementation Plan (FY01-03)



	FY01	FY02	FY03
Experimental Run-Weeks	7	13(12)	13
MPTS			
CHERS	<ul style="list-style-type: none"> • Toroidal 18 Ch 	<ul style="list-style-type: none"> • 20 Ch • Toroidal 70 Ch 	<ul style="list-style-type: none"> • 90 Hz, 30 Ch • Poloidal
MSE (Nova)			
FIReTIP (UCD)	<ul style="list-style-type: none"> • 60 Hz, 10 Ch • 2 Ch 	<ul style="list-style-type: none"> • CIF 2 • 10 Ch • 4 Ch 	<ul style="list-style-type: none"> • LIF • 7 Ch
Locked Mode	<ul style="list-style-type: none"> • 6 Compensated loops 		
USXR (JHU)	<ul style="list-style-type: none"> • 3 Pol fans • Mirror Array 	<ul style="list-style-type: none"> • Pol fan at 2nd Tor position • Higher density top arrays 	
Hi-Freq Mirnov	<ul style="list-style-type: none"> • 3 ch 	<ul style="list-style-type: none"> • 7 ch 	
Particle Detectors	<ul style="list-style-type: none"> • Fixed sightline NPA • Faraday loss probe • Neutrons 	<ul style="list-style-type: none"> • 2-D Scanning NPA • Scintillator Loss Probe 	
Fluctuations	<ul style="list-style-type: none"> • Core Reflect. (UCLA) • Edge Reflect. (ORNL) • Gas Puff Imaging (LANL) 	<ul style="list-style-type: none"> • Add. Correl. Reflect. (UCLA) • Fast Scan. Edge Probe (UCSD) • MHz Gas Puff Imaging (PSI, LANL) 	
Divertor Physics	<ul style="list-style-type: none"> • Hα 1D CCD (ORNL) • Div. IR Cam. (ORNL) 	<ul style="list-style-type: none"> • 2nd 1D CCD (ORNL) • Divertor Bolometer 	
Cameras	<ul style="list-style-type: none"> • HHFW Antenna IR • 2nd Fast Vis. (LANL) 	<ul style="list-style-type: none"> • Additional IR Camera • Fast Div. Visible (Hiroshima U) 	

NSTX Physics Analysis Plans and Tools (FY01-03)



	FY01	FY02	FY03
Core Transport	Characterize Global Confinement EFIT/TRANSP →		
	Resolve Power Balance Issues/Assess Local Transport Properties TRANSP/TSC →		
	Determine Physics Basis for Transport Linear GS2/FULL →		
		Non-linear GS2, NCLASS upgrade →	
		Neo theory w/ FLR →	
		Gyro-kinetic treatment →	
		Develop anomalous htg models →	
	Predictive Transport Modeling (Physics Studies/Scenario Development) TRANSP, NTCC, TSC, BALDUR →		
MHD	Study Ideal Stability Properties PEST-I, II/DCON →		
	Study Resistive/Neoclassical MHD PEST-III, M3D, NIMROD(?) →		
		Implement full 3D equil/stability →	
	Characterize RWM Response/Asses Req. for Active Mode Control VALEN (3D) →		
Fast Particles	Implement Full Orbit Codes EIGOL, Glasser code →	LOCUST (w/atomic physics) →	
	Rapid Determination of Fast Ion Loss Boundaries Egedal code →		
	Treat Non-Adiabatic Behavior of Fast Ions Yavorskij (theory) →		
	Fast Particle Driven Instabilities CAEs linear →		CAEs Non-linear, TAEs, EPMs →

NSTX Physics Analysis Plans and Tools (FY01-03)



	FY01	FY02	FY03
RF/CHI	Determine HHFW Heating/Current Drive Profiles Ray tracing (CURRAY, HPRT) → Integrate into TRANSP → Full wave (TORIC, AORSA)		
	Study Effect of HHFW on Electron and Fast Ion Distributions Develop self-consistent model →		
	EBW Current Drive Ram (theory) →		
	Determine Flux Closure During CHI Startup MFIT/ TSC →	EFIT, Develop theory/model for underlying physics →	
Boundary and Divertor	Determine Particle Transport Properties Inside Plasma DEGAS →		
	Characterize Particle and Power Flux in SOL UEDGE/DEGAS →		
	Understand Edge Fluctuation Properties BAL (linear), BOUT (non-linear) →		

Process to Enhance NSTX National Team & Research (FY01-02)

