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PAC-10 Action Items

Martin Peng

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PPPL

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

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

ST MHD & Transport Physics of $\tau_{skin} \gg \tau_{pulse} \gg \tau_E$

Tools, Capabilities

- NBI & HHFW Heating, B/S, EP, Diagnostics
- CHI, HHFWCD, NBCD, SOL, Diagnostics

ST Current Drive & Edge Physics for $\tau_{skin} \gg \tau_{pulse} \gg \tau_E$

Physics of $\tau_{pulse} \geq \tau_{skin}$ ST

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 ~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

NSTX

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

Phase	I	II	III
Rnwks	13	41	40

Exp. Operation Capabilities	Inductive	Non-inductive Assisted	Non-inductive Sustained
Toroidal Beta, β_T		→ 25%	→ 40%
Bootstrap Current		→ 40%	→ 70%
Current	→ 0.5 MA	→ 1 MA	~ 1 MA
Pulse	→ 0.5 s	→ 1 s	→ 5 s
HHFW Power	→ 4 MW	→ 6 MW	~ 6 MW
NBI Power		→ 5 MW	~ 5 MW
EBW Power	→ 30 kW	~ 30 kW	→ 0.4 MW (proposed)
CHI Startup	→ 0.2 MA	→ 0.5 MA	~ 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.*

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*In cooperation with DOE OFES Theory, OFES Technology, Astrophysics, or SBIR programs

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; • Hi-Temp Bake	♦ Long-Pulse Upgrade
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; 8	13(12)	13
MPTS	• 60 Hz, 10 Ch	• 20 Ch	• 90 Hz, 30 Ch
CHERS	• Toroidal 18 Ch	• Toroidal 70 Ch	• Poloidal
MSE (Nova)		• CIF 2 • 10 Ch	• LIF
FIReTIP (UCD)	• 2 Ch	• 4 Ch	• 7 Ch
Locked Mode	• 6 Compensated loops		
USXR (JHU)	• 3 Pol fans • Mirror Array	• Pol fan at 2nd Tor position • Higher density top arrays	
Hi-Freq Mirnov	• 3 ch	• 7 ch	
Particle Detectors	• Fixed sightline NPA • Faraday loss probe • Neutrons	• 2-D Scanning NPA • Scintillator Loss Probe	
Fluctuations	• Core Reflect. (UCLA) • Edge Reflect. (ORNL) • Gas Puff Imaging (LANL)	• Add. Correl. Reflect. (UCLA) • Fast Scan. Edge Probe (UCSD) • MHz Gas Puff Imaging (PSI, LANL)	
Divertor Physics	• Hα 1D CCD (ORNL) • Div. IR Cam. (ORNL)	• 2nd 1D CCD (ORNL) • Divertor Bolometer	
Cameras	• HHFW Antenna IR • 2nd Fast Vis. (LANL)	• Additional IR Camera • Fast Div. Visible (Hiroshima U)	

NSTX Physics Analysis Plans and Tools (FY01-03)

NSTX

	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)

NSTX

	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)