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NSTX Program Update:

BPM meeting summary
5 year plan schedule

College W&M
Colorado Sch Mines
Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
Princeton U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Maryland
U Rochester
U Washington
U Wisconsin

J. Menard, PPPL

March 21, 2008
NSTX Team Meeting
Princeton Plasma Physics Laboratory

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
JAERI
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

Prioritization of understanding and performance gaps

Based on input from NSTX team (5yr plan), STCC discussions, PAC-23

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Next-step ST's will have ν^* 1–2 orders of magnitude lower than present ST's
→ Impacts many topical science areas: transport, MHD, boundary physics, fast-ion modes, etc.

1. Increase and understand beam-driven current at lower n_e, ν^*
   – Next-step STs ***require*** full NICD to achieve missions, NBI-CD is largest gap
   – Need to test if decreasing n_e increases NBI-CD & non-inductive fraction as assumed
      • Test if high H_{98}, β_N, f_{BS}, and sufficient fast-ion confinement are achievable at reduced n_e

2. Increase and understand H-mode confinement at low ν^*
   – Electron energy transport (to a lesser extent ion energy transport) not sufficiently well understood to make extrapolation to next-steps with high confidence
   – Need to better understand underlying physics of scalings

3. Demonstrate and understand non-inductive start-up and ramp-up
   – Non-inductive ramp-up essential to ST-CTF and ST-DEMO, benefits AT-DEMO
   – Non-inductive start-up also beneficial

4. Sustain β_N and understand MHD near and above no-wall limit
   – Operation at no-wall limit assumed as baseline for all next-step ST designs
   – Operation near ideal-wall limit is NHTX goal, enhances NCT, required for ST-DEMO

Priorities cut across FESAC-05 topical science questions and campaigns

Reduced normalized density/collisionality represents the largest gap between present and next-step ST operating scenarios

Reduced density / collisionality impacts all topical science areas:

- Transport & Turbulence
  - Underlying instabilities (micro-tearing, TEM, and ETG) scale differently versus ν^*
  - If $T_e(r)$ is determined by critical ∇T_e, H-mode confinement may be reduced at reduced n_e
- Macroscopic Stability
  - RWM critical rotation and viscous torques may increase at lower ν_i
- Boundary Physics
  - ELM ΔW increases with reduced ν^*_e - could impact confinement, plasma purity, divertor
  - Detachment schemes for heat flux reduction more challenging with reduced SOL ν
- Wave-Particle Interaction
  - AE avalanches more easily triggered at reduced n_e – possible fast-ion redistribution/loss
- Start-up, Ramp-up, Sustainment
  - NBI-CD and RF-CD efficiency for ramp-up are increased at reduced n_e, increased T_e
- Scenario Integration and Control
  - Steady-state scenarios rely on reduced n_e to increase NBI-CD to achieve 100% NI-CD

- We are counting on LLD to pump D to access reduced collisionality
  - Need to understand LLD operation, Li transport in SOL and to core, etc.
- Separate dependence on collisionality vs. Lithium

Near-term impact of priorities & emphasis on ν^* and Li

- We need to deliver on progress on the priorities

- Alignment of research with 4 priorities (in addition to milestones) will be assessed at mid-run assessment
  – Will consider new experiments, and/or de-emphasis of existing proposed experiments

- Consider new research “thrust” or TSG that leads research on cross-cutting impact of reduced collisionality and impact of Li (both LITER and LLD)
  – Needed for FY09 Joule milestone on pumping characterization and H retention

Baseline FY2008-10 research and "Joule" milestones

(15 run weeks in FY2009/10 would enable more in-depth research of milestone topical areas)

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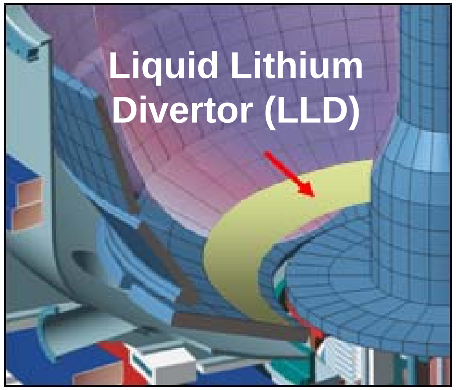
	FY2008	FY2009	FY2010
Expt. Run Weeks:	15	11 (15)	11 (15)
1) Transport & Turbulence	Measure poloidal rotation at low A and compare w/ theory		Study turbulence regimes responsible for ion and electron energy transport
2) Macroscopic Stability		Understand physics of RWM stabilization & control as a function of rotation	
3) Boundary Physics	Study variation and control of heat flux in SOL		Assess H-mode characteristics as a function of collisionality and lithium conditioning
4) Wave-Particle Interaction		Study how j(r) is modified by super-Alfvénic ion-driven modes	Characterize HHFW heating, CD, and ramp-up in deuterium H-mode
5) Start-up, Ramp-up, Sustainment	Couple inductive ramp-up to CHI plasma		
6) Scenario Integration & Control		Perform high-elongation wall-stabilized operation at lower n_e	
"JOULE" Milestones:	Rotation and momentum transport & stability physics	Particle control and hydrogenic fuel retention	TBD

Full utilization in FY2009-10 would enable critical research on fast-ion redistribution, start-up and ramp-up, HHFW, and high β

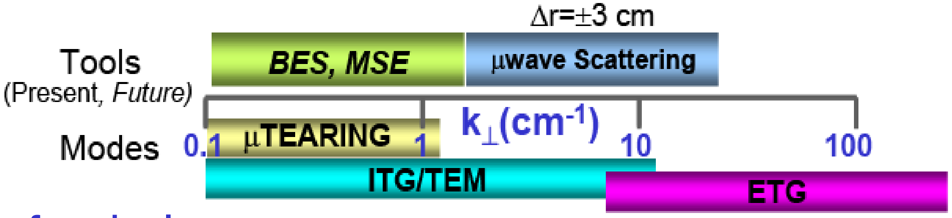
	FY2008	FY2009	FY2010
Expt. Run Weeks:	15	25	25
1) Transport & Turbulence	Measure poloidal rotation at low A and compare w/ theory		Study turbulence regimes responsible for ion and electron energy transport
2) Macroscopic Stability		Understand physics of RWM stabilization & control as a function of rotation	Assess sustained operation above the no-wall limit at reduced collisionality
3) Boundary Physics	Study variation and control of heat flux in SOL		Assess H-mode characteristics as a function of collisionality and lithium conditioning
4) Wave-Particle Interaction		Study how j(r) is modified by super-Alfvénic ion-driven modes Accelerate high-power HHFW 1yr Integrate MHD mode modification of j(r) into optimized operation	Characterize HHFW heating, CD, and ramp-up in deuterium H-mode Test predictive capability of mode-induced fast-ion redistribution/loss
5) Start-up, Ramp-up, Sustainment	Couple inductive ramp-up to CHI plasma	Investigate methods for solenoid-free current initiation using induction from the outer poloidal field coils	Test non-inductive current generation using plasma guns
6) Scenario Integration & Control		Perform high-elongation wall-stabilized operation at lower n_e	
"JOULE" Milestones:	Rotation and momentum transport & stability physics	Particle control and hydrogenic fuel retention	TBD

Near-term upgrades support highest priorities for FY08-10 and enable key research thrusts:

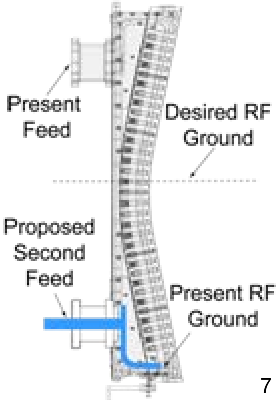
1. Implement liquid lithium divertor for pumping, and investigate other potential benefits:
   - Improved confinement
   - Reduction/elimination of ELMs
   - Compatibility of LLD with high flux expansion
   - Longer-term: steady-state high-heat-flux handling



2. Implement BES to complement existing high-k scattering diagnostic
   - Measure full wavenumber spectrum of turbulence
   - Determine modes responsible for anomalous transport of energy & momentum



3. Upgrade HHFW system for higher P_{RF} + ELM resilience
   - Determine if HHFW can ramp-up I_P in H-mode (BS+RF overdrive)
   - Determine if HHFW can heat high-β_N advanced H-mode scenarios
   - HHFW/ICRF also important for NHTX/CTF/ITER



5 year plan completion schedule

- NSTX 5 year plan **review** will be week of June 23, 2008
  - Provide clear/clean separation of FY09-10 and FY11-13 plans
  - Provide strong scientific justification for FY11-13 upgrades/operation
    - Focus on *new understanding* gained from additional capabilities/run-time

We are here →

• **March, 2008**	**Revise chapters to separate FY09-10 and FY11-13 plans**
• **April 4, 2008**	**Completed draft chapters**
• **April 21, 2008**	**Complete draft plan edits complete**
• **May 5, 2008**	**5 year plan text complete**
• **Week of June 2**	**Dry runs of presentations**
• **June 9-13**	**EPS**
• **Week of June 16**	**Final presentation material ready**
• **Week of June 23**	**2009-13 Five year plan review meeting**