

Summary of NSTX ET1 Experimental Proposals for 2001

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Parallel Session IV
2001 Proposal Summaries

NSTX Research Forum 2001
8 AM(!), Monday, January 16th, 2001
LSB Auditorium, PPPL



Meeting Agenda

- MHD diagnostic overview: J. Menard
- XP summaries, new XP ideas, etc.
 - Identification of Neoclassical Tearing Modes: D. Gates
 - Classical vs. Neoclassical Tearing Modes: A. Pletzer
 - Developing Isoflux Shape Control / RTE reconstruction: J. Ferron
 - Model-Based Multivariable Controllers
for NSTX Shape and Stability : D. Humphreys
 - XP28 - External kink dependence on current profile: J. Manickam
 - XP16 - Experimental test of Troyon scaling - update: J. Menard
 - XP17 - J profile dependence of stability at low A - update: S. Sabbagh
 - XP20 - Characterization of resistive wall modes at low A: S. Sabbagh
 - Effectiveness of configuration on RWM stabilization: F. Paoletti
 - Study of Density and BT Behavior in NSTX: B. H. Deng
 - TAE physics at low A and possible similarity experiments: B. Heidbrink
- Group discussion and XP prioritization

Diagnostic Issues and Concerns

- Diagnostics + analysis vastly improved since last year
 - Mirnov non-linear response removed in software
 - Automated EFITs now routine and reliable
 - High-n and high-f sensors yield:
 - toroidal mode number ID
 - Alfvén activity observations
 - USXR data clearly shows islands and m/n
 - Saddle coil installation largely finished, calibration is next
 - MPTS data fed into TRANSP \Rightarrow lower W_{TOT} than EFIT
 - Obvious cause for concern
 - **Without any actual ion data**, group sentiment was leaning against calling this a “discrepancy”, but
 - time will tell if β is 22% or really 15%

Diagnostic Issues and Concerns

- MHD group eagerly anticipating additional diagnostics:
 - **CHERS:**
 - obtain ion component of thermal pressure for EFIT
 - rotation profile for RWM and other MHD studies
 - **MSE:**
 - q profile observed to influence nearly all NSTX discharges
 - information crucial to future “advanced” MHD XPs
 - **FIReTIP**
 - n_e dl important to entire NSTX team
 - Low fringe count suitable for density feedback control
 - Polarimetry can help constrain EFITs
- Trusted data needs to be written to MDS+ tree
 - MPTS, VB, other

Mirnov Problems

- Small 1D and 2D Mirnovs not surviving in NSTX
 - Sensors used on CS, inner, and outer divertor
 - 50% failure rate (*thermal cycling, vibration, non-zero magnetic moment*)
 - Prototyping new design:
 - Non-magnetic bare copper wire
 - Single layer with physical gap between windings
 - Pot sensors after winding and thermally cycle them to remove weaklings
 - Add electrostatic shielding to reduce Langmuir probe effects
- Why bore you with the details?
 - At least 4 MHD XPs are interested in having a complete poloidal array for mode amplitude vs. poloidal angle studies
- Advocate installation of new sensors not only on CS, but also in the divertor tiles during next outage.

Tearing Mode Theory

- Classical vs. Neoclassical Tearing Modes - A. Pletzer
 - Δ' needed to understand NTM threshold physics
 - $\Delta' > 0 \Rightarrow$ classical, $\Delta' < 0 \Rightarrow$ neoclassical
 - PEST-III can compute Δ' in general 2D geometry
 - Are Δ' formalism and numerical methods still valid at high β ?
- Future:
 - Submit PEST-III to NTCC modules library for general use after DCON/MARS comparisons
 - Implement more realistic wall model?

NSTX Control System Work

- rtEFIT and Isoflux Shape Control - J. Ferron
 - Implementation of rtEFIT:
 - Used routinely on DIII-D
 - Best method for discharge parameter identification (boundary, β , etc.)
 - Requires new NSTX control system hardware with magnetics connected
 - NSTX implementation began August 2000 - First offline test is complete
- Future
 - Need to implement rtEFIT on new PCS
 - followed by real-time testing - piggyback task during normal experiments.
 - Implement isoflux shape control technique
 - basic software same as used on DIII-D
 - Will require some dedicated development time during plasma Ops
- 2001 Goal: Accurate discharge control for all conditions



NSTX Control System Work

- Application of model-based multivariable control design methods to NSTX - D. Humphreys (2002-2005)
 - Derivation of NSTX axisymmetric system models:
 - Includes vessel/conductors, PF coils, power supplies, plasma
 - Validation of system models
 - vacuum response experiments, power supply tests, plasma piggybacks
 - Offline simulations, on-line testing, then controller design
- Goals
 - 2002-2003
 - Development of models and simulations
 - Proof-of-principle control of reference configurations
 - 2003+ Operational use
 - Long term - integrated plasma control: shape + profiles + etc.



FIReTIP Development

- Study of n_e and B_t behavior in NSTX - B.H. Deng
 - Discussed status of FIReTIP
 - Hardware installation largely complete
 - System debugging:
 - Strong OH/PF pickup causing laser cavity vibration
 - High-f pickup through power lines
 - 60Hz noise - probably related to diagnostic grounding problem
 - Better shielding, filters, and removal of ground loops \Rightarrow
2 channel operation is expected soon.
- 2001 Research Goals
 - Make density measurement
 - Make magnetic field measurement
- As stated previously, this diagnostic is our only near-term means of implementing density feedback control.

Possible DIII-D Similarity Experiments

- Beam induced MHD in NSTX and DIII-D- B. Heidbrink
 - Bill performed experiments on DIII-D in 1991 which studied beam-driven MHD at 0.6T \Rightarrow directly relevant to similarity experiments on NSTX
 - Beam loss was $> 50\%$
 - Long beam pulses + loss \Rightarrow coated windows \Rightarrow unhappy researchers
 - Clearly, confinement studies would need to take this into account
- Also possibly interested in collaboration/experiments studying low-A geometrical effects on continuum gaps and impact on BAE, TAE, and EAE modes

XP Summaries and Ideas

- XP 24: Identification of NTMs - D. Gates
 - Tearing activity limits β in high-power NBI shots
 - Modes impose $\beta_p < 0.4$ limit for standard discharges
 - Using beam turn-off experiments to see if mode amplitude decreases - no “smoking gun” yet
- Future:
 - Repeat beam turn-off experiments with kinetic EFITs
 - Local pressure gradient, collisionality, etc. determine physics
 - Implement analysis using cylindrical model and full toroidal model (PEST-III + NIMROD + IDL)

XP Summaries and Ideas

- XP28: External kink dependence on current profile - J. Manickam
 - Develop comprehensive experimental data for current driven external kink mode - *NSTX has not yet done this*
 - Establish fiduciary discharges for future RWM studies
 - Kink mode physics
 - Edge-q dependence
 - Poloidal mode structure
 - Poloidal mode coupling
 - Current drive parameterization
 - J(edge) dependence
 - H-mode pedestal
 - Influence of shear, q, and shape
 - Experiment should draw on lessons from XP-16 and 17

XP Summaries and Ideas

- XP16: Experimental Test of Troyon Scaling - J. Menard
 - Determine κ and B_T (q^*) scaling of ideal stability limit
 - Work in regime with $q(0) > 1$ (Use early HHFW injection)
 - Eliminate sawteeth, 1/1 activity, NTM
 - Observed rapid β -drop near beginning of flat-top at $\beta_N \approx 3$
 - Mode character largely external
 - EFITs indicate large $J(\text{edge})$
 - Edge J critical to instability: $J(\text{edge}) = 0 \Rightarrow n=1 \beta_N \text{ limit} = 5.5 \text{ w/o wall}$
- Future
 - Try lowering $J(\text{edge})$ with gas puff (or ramp-down ala XP-17?)
 - HHFW in Helium may heat rather than create density- better J ?
 - With more modest $J(\text{edge})$ but $q(0) > 1$,
perform κ , B_t , and gap scan to complete XP

XP Summaries and Ideas

- XP17: Influence of J Profile on Stability at Low A - S. Sabbagh
 - Generated plasmas with $0.5 < l_i < 1.1$ as prescribed in XP
 - Stability limits reached in both low and high l_i plasmas
 - low $l_i \Rightarrow$ fast β collapses observed as in XP-16
 - high l_i limit \Rightarrow slow rollover in $\beta \Rightarrow$ tearing activity
 - Increase of β_N limit at low A established (*Dale Meade might disagree*)
 - TFTR and DIII-D limits exceeded for fixed l_i
- Future work
 - Reach the gross plasma stability limit at $l_i \sim 0.8$ while avoiding sawteeth
 - Determine effect of passive plates with gap scan - document β_N increases
 - Reduce uncertainty in stability calculations
 - Utilize internal kinetic profiles
 - Utilize divertor and passive plate magnetics
 - This mode should be a resistive wall mode \Rightarrow start XP-20

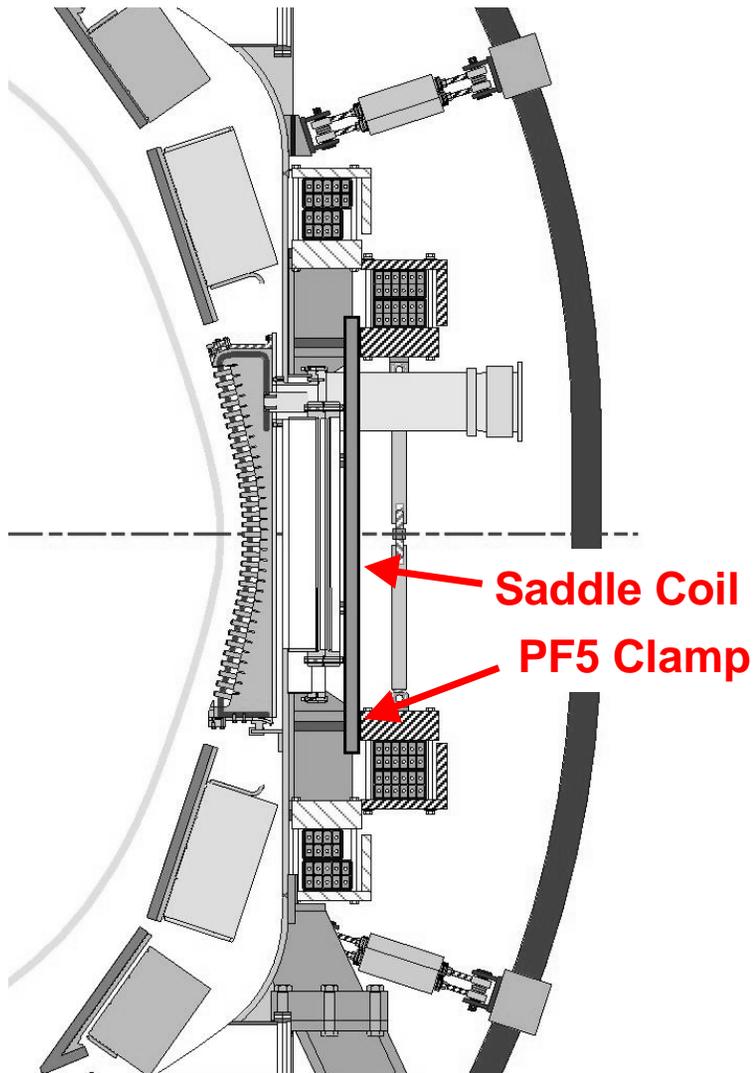
XP Summaries and Ideas

- XP 20: Characterization of RWM at Low A - S. Sabbagh
 - Exceed the no-wall ideal MHD limit in NSTX as determined by ideal MHD stability analysis of experimental plasmas
 - Document characteristics of the resistive wall mode in low aspect ratio plasmas exceeding the no-wall ideal MHD limit
 - Compare to similar experiments on DIII-D to document differences and similarities of the mode at low and moderate aspect ratio.
 - Compare expectations of mode structure, dynamics, and stability between theory and experiment
- Status
 - ET1 group review completed, full review pending
 - Execution contingent on diagnostic readiness

XP Summaries and Ideas

- Effectiveness of Configuration on RWM Stabilization - F. Paoletti
 - Reproduce RWM target (see results of XP #20)
 - Compare growth rate results with modeling
 - Verify and calibrate VALEN for low aspect ratio RWM
 - Reconstruct with VALEN full set of magnetic measurements and compare to data to start active mode control design
 - Study toroidal rotation stabilizing effect
 - Quantify effect on growth rate and attempt modification of rotation using different NBI setups (*may be difficult with NSTX beams*)
 - Quantify extension of discharge length vs. plasma-wall gap
 - Quantify any increase in maximum β_N reached
- Execution again contingent on diagnostic readiness

NSTX Saddle Coils Essential for Locked Mode and RWM Physics



(E. Fredrickson)

- 6 coils centered at mid-plane each with 2 B_R and 2 B_Z pickup subtraction loops
- Will be connected in “n=1” configuration $\Rightarrow \Delta B_{\text{RADIAL}}$ from 3 pairs of opposing coils
- *Calibration will take time*
- Poloidal Mirnov array complements the saddle coil set

Preliminary ET1 2001 Run-time Suggestions

(Assumes 12 run days)

Experimental Proposal	Leader	Run Days
– XP?? Operation at $I_p = 1.5$ MA	D. Gates	1
– XP24 Observation of NTMs in NSTX	D. Gates	1
– XP22 Survey of modes in Alfvén/ICE frequency range	E. Fredrickson	1
– XP23 NBI Heating with small $q=1$ radius in NSTX	M. Bell	0.5
– XP16 Investigation of Troyon Scaling in NSTX	J. Menard	2
– XP17 Influence of J profile on MHD stability at low A	S. Sabbagh	2
– XP28 Current driven kink modes in NSTX	J. Manickam	1.5
– XP20 Characterization of resistive wall modes at low A	S. Sabbagh	1
– XP?? Effectiveness of Configuration on RWM Stabilization	F. Paoletti	1
– XP?? TAE physics at low A and possible similarity experiments	B. Heidbrink	1



Green XPs could be run now

Red XPs require additional diagnostics

Summary

- Sensors+analysis vastly improved since last year
 - Some repairs are needed
- NSTX is already obtaining exciting MHD results, future looks even more enticing.
- As requested, a preliminary list and prioritization has been established for ET1 XPs for 2001.
- Any new XP or diagnostic ideas are welcome!