NSTX-U

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Integrated Scenarios SG Summary

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NSTX-U 2015 Research Forum
2/27/2015

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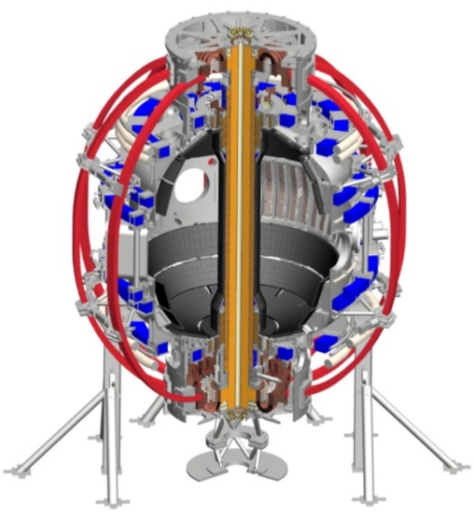

Culham Sci Ctr
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Big Picture For the SG

Topic	Total Allocation
High-Beta Scenario Development	3.5
Low Current Ramp-Up	2
Control	4
CHI	2.5
HHFW in the Flat-Top	3
Total	15
ASC+RF+SFSU	8+3.5+3.5 = 15

Overview

- ASC TSG
- SFSU TSG
- RF H&CD TSG
- Summary comments and issues

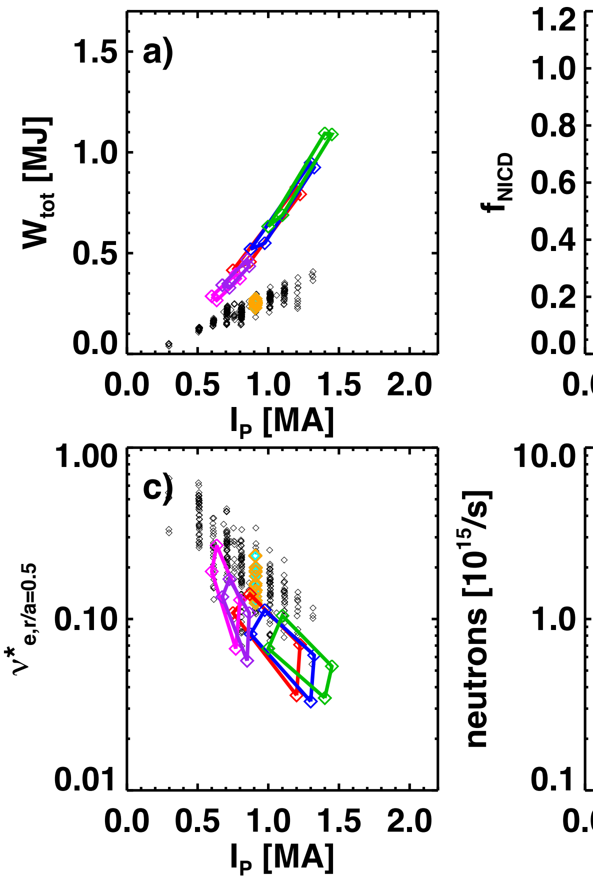
ASC TSG

Author	Title	Tier 1 Time Allocated	Tier 2 Time Allocated	CC&E Recommendation	Notes
Snipes	Actuator Sharing and Integrated Control Demonstration				Premature given our present control capability. But some of this can be done in Boyer's XP.
	Characterizing Type I ELMy H-modes in He plasmas and demonstration of ELM Control				Really is a pedestal physics experiment
Ferron	Compare benefits of off-axis NBI...				Most of the scope can be accomplished in the Mario XP and the other ASC XPs. Be sure to involve Ferron/GA in XP planning
Gerhardt	Maximize the non inductive fraction in H-mode	2			
	Tuning of automated rampdown software			0.5	
	Combining High Non-Inductive Fraction with Advanced Divertors				Reconsider at mid run assessment
Yuh/Gerhardt	Reversed Shear with Relaxed Profiles		0.5		
Poli	Rampdown Studies				No dedicated time this year. Use the fiducial and other XPs to get some data.
	NB Absorption/CD at Low Plasma Current	0.5			Matched with 1/2 day from SFSU, so 1 total day
Levinton	Measurement of NBCD				Combine with Podesta, Gerhardt, Boyer.
Boyer	Beam power and BetaN Control			0.5	
	Combined betaN and l_i control	0.75	0.5		
	Current profile controllability scoping study	0.75			Myers/LaHaye inclusion...
	Optimization of the Vertical Control Algorithm			1	
Schuster	Model Based Optimal Feedforward Current Profile Control				Make sure the Boyer XPs offer some support to this effort
Kolemen	X-Point Control			1	
	3D Coil BetaN Control				Maybe hog some time out of the Boyer XP to provide some run time for this. Handle that during the XP process
	Adaptive ELM Control				Need an EF model to even really do this. Also, is MS scope.
	Radiation Control				Need the PCS capabilities. Consider again at mid run assessment
	Vertical Growth Rate and max. controllable displacement				Combined this scope with the CC&E scope for vertical control by Boyer.
	Controlled Snowflake Studies	1	0.5	0.5	
Soukhanovskii	Snowflake Control Development	w/ Kolemen			
Canik	EPH Access and Long Pulse Development				Push to later years
Battaglia	Development of VERY Long Pulse H-Modes	1			
Battaglie	Closed Loop Density Feedback			0.5	
Group/TBD (Kolemen Lead?)	Rotation Control		0.5		
All	***Group Discussion***				
	Totals:	**6**	**2**	**4**	

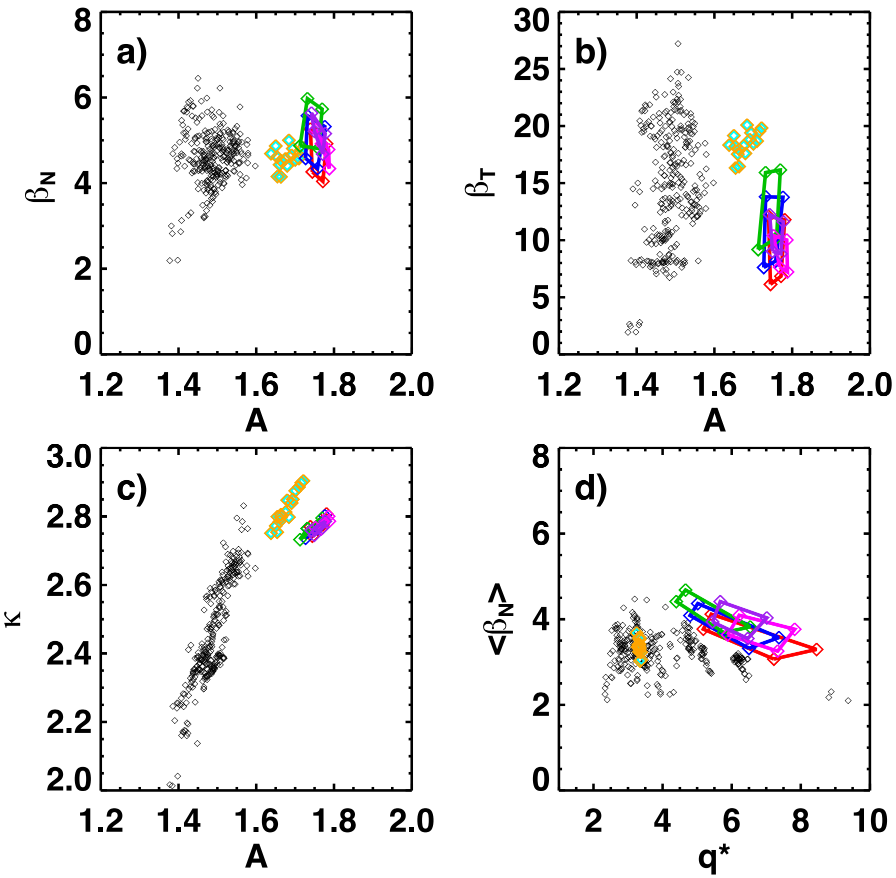
Advanced Scenarios and Control
Does the Allocation Address the Goals?

- Identify mechanisms limiting vertical stability and what additional capabilities are required for achieving vertical stability at high κ.
  - No explicit ASC time…assuming 1 day of CC&E as per discussion with RC (Boyer, Kolemen)
- Evaluate access and scalability of three scenarios:
  - High non-inductive fraction
    - 2 days ASC (Gerhardt)
  - High(est) current and field
    - No explicit ASC time…assumed CC&E
  - Long(est) pulse
    - 1 day ASC (Battaglia)
- Advance capabilities of tokamak/ST control and disruption avoidance.
  - 1.5 days ASC for SFD control (Kolemen)
  - 2.0 days ASC for current profile and β control topics (Boyer, Lehigh,…)
  - 0.5 day ASC for rotation control (leader TBD)
- Achieve scenarios that optimize the verification and validation of transport and confinement modeling and predictive tools.
  - 0.5 days ASC for reversed shear studies
- Achieve steady-state density and radiation at a fixed fraction (0.5-0.8) of n_{GR}.
  - No explicit ASC time, but longest pulse XP will challenge it

100% Non-Inductive (I)
(2 Days, Gerhardt)



All: f_{GW}=0.7, f_{NI}=100%, 15 cm outer gap
6x80 kV, B_T=1 T
6x90 kV, B_T=1 T
6x100 kV, B_T=1 T
4x80 kV, B_T=0.75 T
4x90 kV, B_T=0.75 T



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6x90 kV, B_T=1 T
6x100 kV, B_T=1 T
4x80 kV, B_T=0.75 T
4x90 kV, B_T=0.75 T

100% Non-Inductive (I)
(2 Days, Gerhardt)

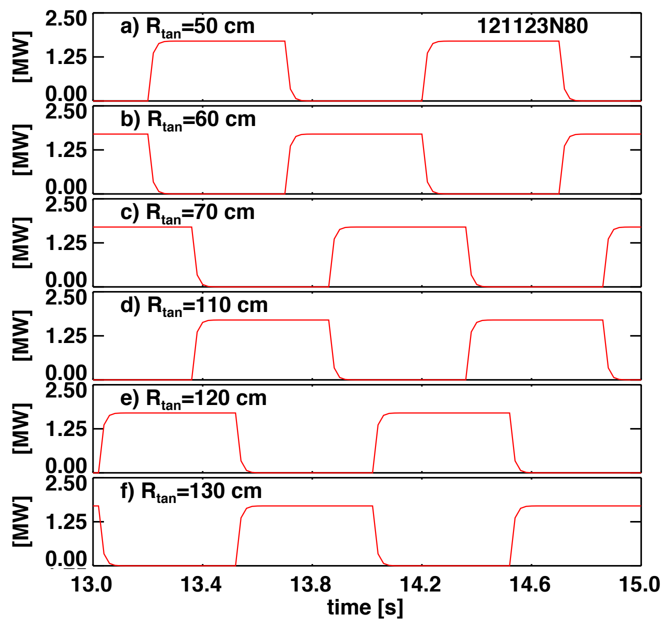
- From modeling, determine a likely operating point.
  - Right now, I think 0.65 T, 600 kA, 6-8 MW made up of [60,70,130] + other sources.
- Establish baseline at this field and current, ~65-75% of the baseline power.
  - Reduced power to avoid hard beta limits.
- Increase the power towards the non-inductive value, until either fully non-inductive, or reaching beta limit.
- If it becomes clear that non-inductivity is not possible at this current, then reduce the plasma current and power, and repeat the power scan.
- Once a near non-inductive point is found, then:
  - Scan the beam sources around that operating point.
  - For different beam sources, make small modifications to the plasma current request around that operating point, to account for different beam current drive efficiencies.

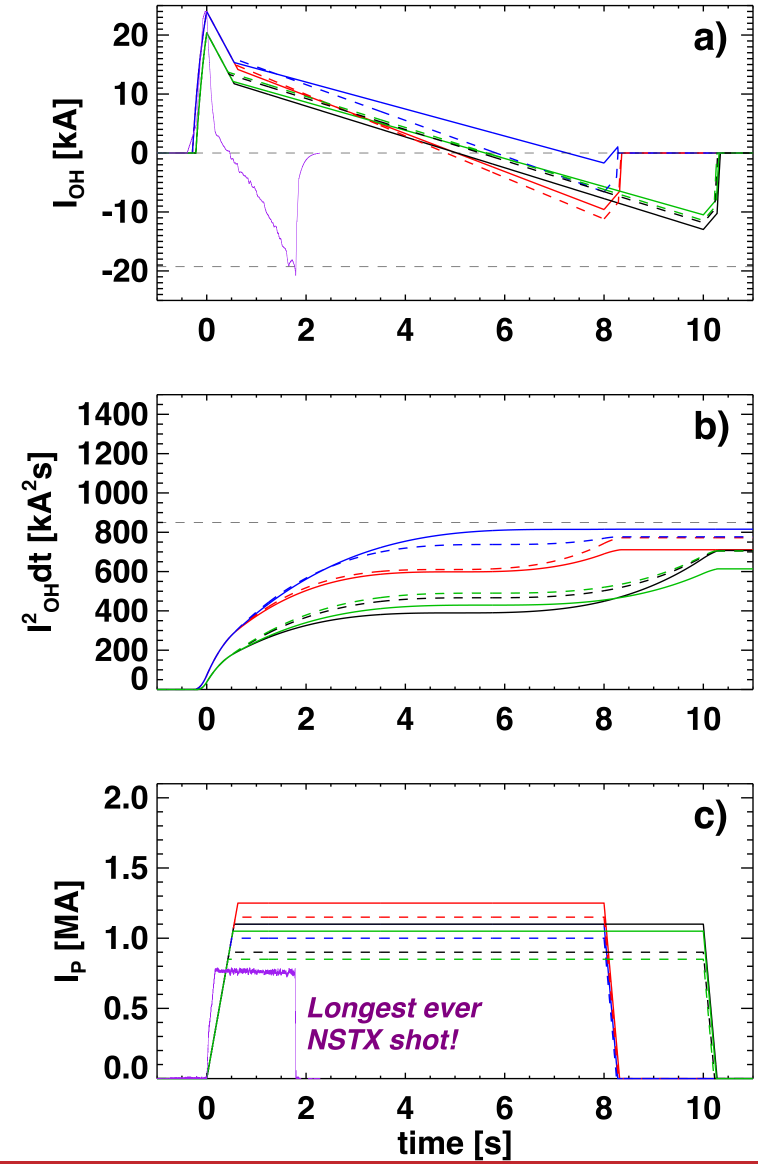
This XP also picks up the control requests from Ferron, maybe Poli

VERY Long Pulse H-mode (I) (Battaglia, 1 Day)

Consider the ultimate potential for long pulse in NSTX-U

- Highest current consistent with q_{min}>1.0 and solenoid flux limit.
  - B_T=0.75 T.
- Two configurations of beams:
  - 6 x 60 kV: 8 seconds total
  - 3 x 80 kV, staggered: 10 seconds total
- Note: full pre-charge may not be available in the first year.



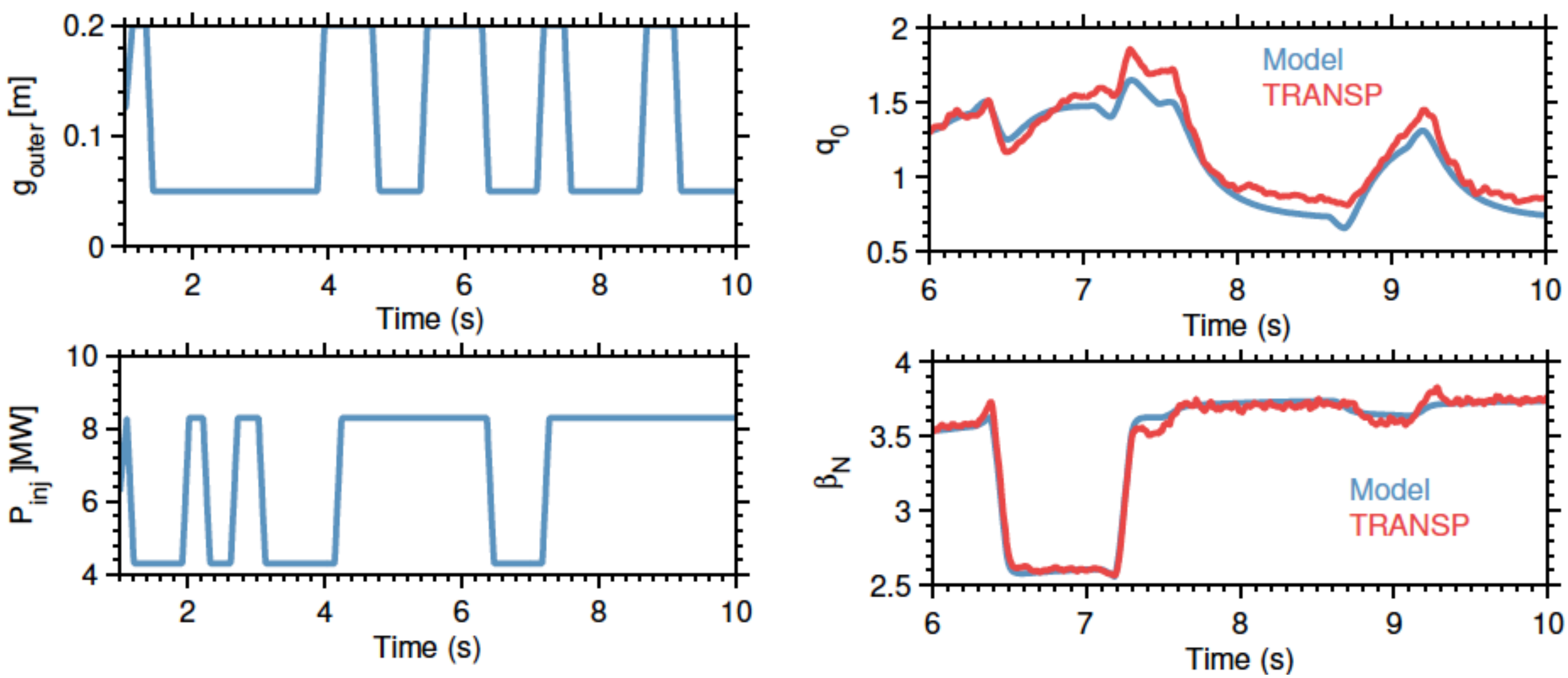


VERY Long Pulse H-mode (II)
(Battaglia, 1 Day)

- Configure for 0.75 T, 80 kV beams
  - Warn beams well ahead of time that they will be asked for long pulse
- Using four 80 kV beams (50, 60, 70, 130), optimize shape, fuelling, pre-charge around 1 MA.
  - Don't strive for non-inductive, but hopefully use the inductive current to stabilize things, raise betaT.
  - Attempt to minimize front-end fuelling.
  - If q_{min} dropping to/beneath 1 is problem, then reduce I_P and continue.
- Once longest pulse is achieved at 1.0 MA, then repeat at 1.2 MA.
- Other considerations:
  - Lithium vs. Boron:
    - May actually control the electron inventory better with boron.
    - But flux consumption and MHD triggering from ELMs will be undesirable?
  - Diagnostics:
    - All profile diagnostics required.
    - Would be nice to have the full complement of impurity monitors, as particle accumulation may be the biggest problem.

Current Profile Controllability Study (I) (Boyer, 0.75 Days)

- Example: modulation data used to identify a linearized model of the response of q_0 and β_N to changes in outer gap and total injected power
  - Resulting model is in a form that can be used with a variety of model-based control design tools



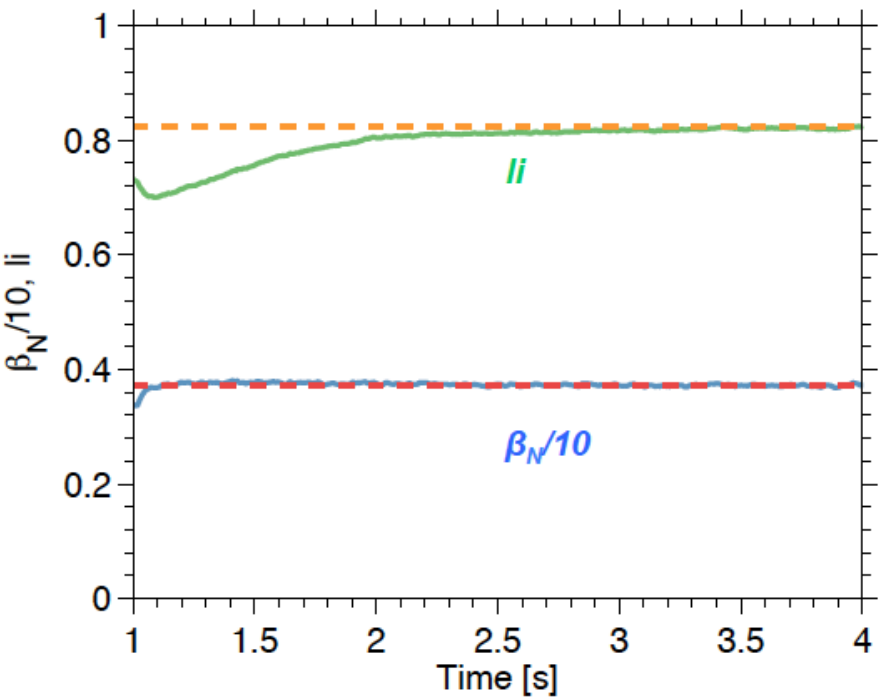
Current Profile Controllability Study (II) (Boyer, 0.75 Days)

- Scan $B_T/I_p/f_{GW}$/outer gap to identify scenarios [0.5 days]
  - Guided by TRANSP scans, considering restrictions on beams for diagnostics
  - Ties in with broader 2nd NBI characterization efforts
    - Will be a refinement of the broader scan in promising regions
- Modulation for control-oriented modeling [0.5 days]
  - Modulate actuators (individually and/or simultaneously) during flat-top
    - Individual beams
    - Plasma current
    - Density
    - Outer gap
  - Repeat during ramp-up
    - Model and control approach may differ in ramp-up phase

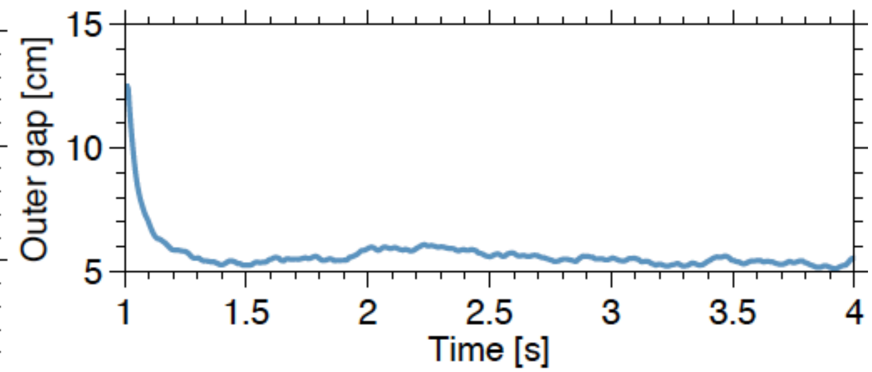
This XP also picks up requests from Schuster

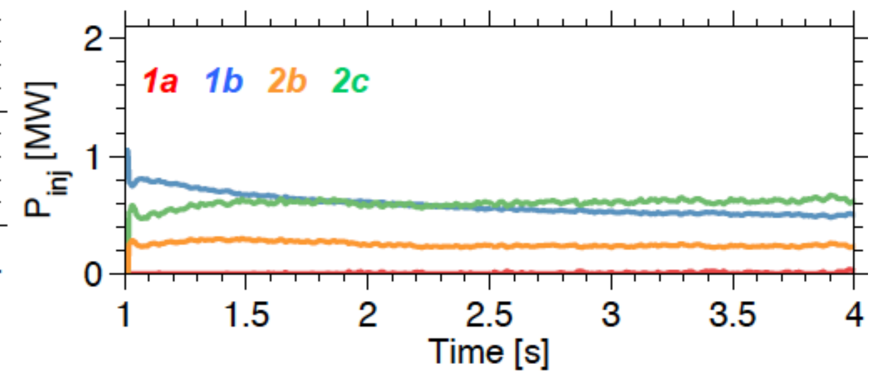
BetaN + l_i Control (I) (Boyer, 1.25 Days)

Example: Outer gap and individual beams used for feedback



f_{GW}=0.6
B_T=1T
I_p=600kA





1c and 2a fixed at 2.1MW

BetaN + l_i Control (II)
(Boyer, 1.25 Days)

- Initial test
  - Establish a reference shot
  - Modify pre-programmed heating during ramp-up/flat-top, turn on feedback to correct for change
  - Modify pre-programmed plasma current ramp-rate, turn on feedback to correct for change
- Further testing
  - Change target li for fixed β_N
  - Change target β_N for fixed li
- Several potential feedback actuator combinations to explore
  - 2 beams (or groups of beams)
  - Individual beams
  - Total beam power + outer-gap size
  - Total beam power + plasma current (during ramp-up)

Part of the long allocation is that this is the first XP that will really stress the PCS control of NB modulations

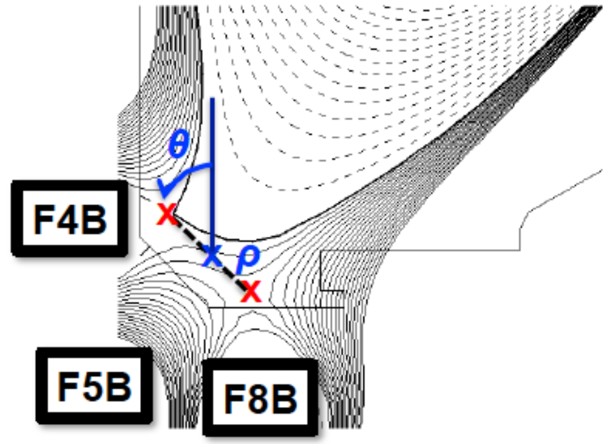
This XP can maybe support a request from Kolemen as well

Reversed Shear With Sustained Profiles (1/2 day from ASC + ½ from T&T, Yuh)

- NSTX had many examples of ITBs formed by reverse magnetic shear.
  - But the reversed shear was typically generated during the ramp, and was typically very transient.
- Might we be able to generate that reversed shear in a more steady state fashion with off-axis NBCD?
- What could we learn:
  - Might be an extreme test of OANBCD.
  - Might allow us to study better the dependence of core transport of the safety factor.
  - Might allow us to generate ITBs with an H-mode edge.
    - And study all kinds of fun MHD.
- Ideas
  - Use the 130 cm source to drive current off axis
  - Adjust the other sources, ramp-rate, outer gap, to achieve reversed shear.

Snowflake Control (1.5 Days, Kolemen)

- First SFD development likely done with the the S.P controllers.
  - XMP by Kolemen & Soukhanovskii
- Control Scheme (Roughly):
  - Local expansion of G.-S. equation to find nulls
  - Green's function approach to determine the changes in the required PF coil currents.
  - Need to incorporate those requested changes in the coil currents with the rest if the shape controller
- First focus on controlling a single divertor, then move to double snowflake.



Location of the X-points and Centroid

$$\begin{bmatrix} \delta I_{F4B} \\ \delta I_{F5B} \\ \delta I_{F8B} \end{bmatrix} = (A^T A)^{-1} A^T W \begin{bmatrix} \delta\theta \\ \delta\rho \\ \delta r_c \\ \delta z_c \end{bmatrix}$$

This XP also picks up the control requests from Soukhanovskii

Rotation Control
(TBD, ½ Day)

- We have some risk that a rtVPhi diagnostic will work by the end of the run.
  - Better be ready to use it!!!
- Has been considerable work in modeling for rotation control.
  - Ege and Sam about 4-5 years ago.
  - I. Goumiri, Gates, Sabbagh, Gerhardt,… over the past few years.
- Will hold a meeting in a few weeks (when Imene returns) to discuss:
  - What kind of control should be attempted this year if the diagnostic is available.
  - Who should work with SW engineers to get it implemented & tested
  - How the XP will be brought through the review process.

With Official Approval, We Shifted a Number of XPs to CC&E

- Vertical Control Study (Boyer, Kolemen, 1 Day)
  - Optimize sensors for the derivative control term.
  - Determine if the gains are correct or need modifications.
  - Assess if more sophisticated control laws are required.
  - Determine maximum stable κ vs l_i.
- X-Point/Strike Point Control (Kolemen, 1 Day)
  - Redevelop the divertor coil feedback that we had on NSTX.
- Automated plasma current rampdowns (Gerhardt, ½ day)
  - Need to protect facility from large PF coil current oscillations and forces.
- Beam and betaN control checkout (Boyer, ½ day)
  - First time we control beams from PCS in NSTX-U
- SFD development (Soukhanovskii, Kolemen ½ day)
  - Simple SFD, no 2^{nd} null detection or control
  - Should be done after X-point/SP control XMP
- Density feedback (Battaglia, ½ day)
  - If we can get a realtime FIReTIP signal that we can use, then we should try feedback with it.

Some Proposals Didn't Get Explicit Run Time at the Moment (I)

- Radiation Control (Kolemen)
  - Need to get measurements into PCS.
  - Need measurements from DivSOL on the effects of various gas injectors.
  - Will revisit at the mid-run assessment
- Adaptive ELM control (Kolemen)
  - Don't have enough physics basis for this at the moment.
  - Hard to do feedback if you don't have any model for how ELMs respond to 3D fields
- 3D coil betaN control (Kolemen)
  - Not yet a strong basis for pedestal control w/ 3D fields in NSTX-U
  - Might consider adding to betaN+l_i control XP
- Model Based Optimal Feedforward Current Profile Control (Schuster)
  - Will try to incorporate some ideas into the current profile control XPs.
- Shared Actuator Control (Snipes)
  - Need to establish more of the individual actuator control first.
- Helium H-modes (Snipes)
  - Largely an XP on ELM & pedestal characterization in He vs D_2.
  - Maybe get some piggyback data?

Some Proposals Didn't Get Explicit Run Time at the Moment (II)

- EPH mode development (Canik, 1 day)
  - Piggyback at first, may revisit request at mid-run assessment
- High Non-Inductive Fraction with Advanced Divertors (Gerhardt, 1 day)
  - Is premature to allocate run time to this.
- Comparing benefits of off-axis NBI for advanced scenarios in low and medium aspect ratio plasmas (Ferron, 3 days).
  - Excellent summary of things we should be doing, looking out for, aware of…
  - Will combine elements of this into "Mario XP", scenario XPs in ASC.
  - Involve GA experts in our experiment planning and execution
- Measurement of NBCD (Levinton, 1 Day).
  - Combine this with the H-mode parts of the Boyer, Podesta XP.
  - Get L-mode parts out of the reversed shear XP (Yuh)?

SFSU TSG

Solenoid-free Plasma Start-up is an essential high-priority requirement for the viability of the ST concept

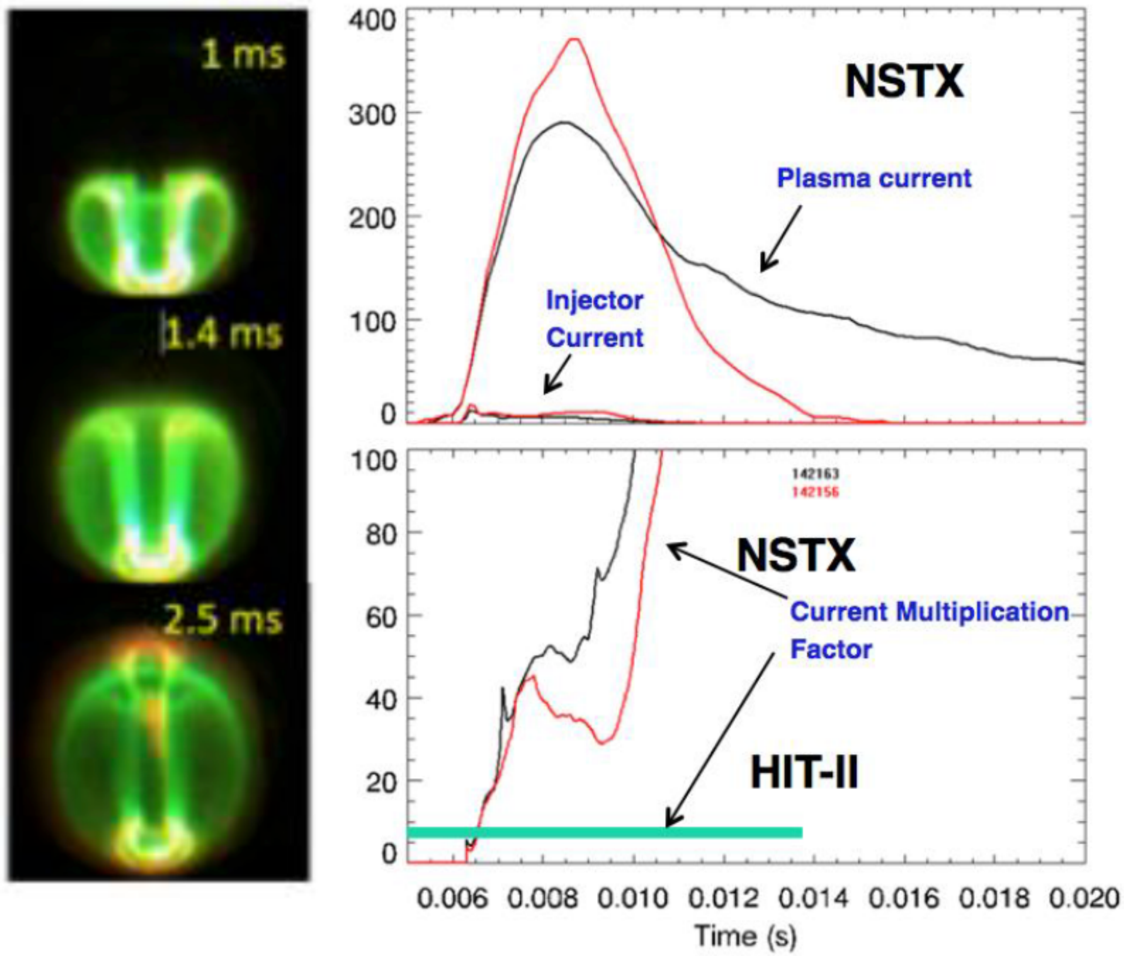
Rundown on XPs

	Author	Title	Tier 1 Time Allocated	Tier 2 Time Allocated	Comment
1	Raman	Transient CHI Plasma Startu-up	1.5	0.5	
2	Nelson	Inductive flux saving of Inductively ...	0.5		
3	Ebrahimi	Plasmoid instability during CHI			this can be done in piggyback, needs improved diagnostics for best results
4	Poli	NBI Overdrive / RF			
	Poli	NBI Overdrive w/0 RF		0.5	1/2 day from ASC for 1 total day
5	Taylor	HHFW Heating of CHI Discharges			
6	Taylor	HHFW Ramp-up of Inductively Initiated...			
7	Taylor	Low Plasma Current, Fully Non-Inductive HHFW H-modes	0.5		1/2 day from RF for 1 total day
8	Reusch	Characterization of the scrape off layer density and...			Piggyback. Can benefit from MPTS measurements of Ohmic and CHI plasmas
9	Nelson	Impact of controlled fluctuations on edge current drive			Can be applied to the Transient CHI startup XP to begin with (so piggyback)
	Diallo	Effect of the edge current produced by CHI on the edge pedestal in H-mode plasmas			Consider for 2016
10		**Group Discussion**			
		Totals:	**2.5**	**1**	
			2.5	**1**	

Solenoid Free Start-up and Ramp-up Does the Allocation Address the Goals?

- Commission the CHI Hardware
  - XMP, no explicit SFSU run time
- Recover CHI plasma initiation
  - 2 days SFSU (Raman)
- Inductive ramp-up of the CHI plasma
  - 0.5 days SFSU (Nelson)
- HHFW heating and CD of low I_P plasmas
  - 0.5 SFSU + 0.5 RF for low current studies (Taylor/Poli,…)
- HHFW heating of CHI formed plasmas
  - 0 run days
- NBI overdrive of low and moderate I_P plasmas
  - 0.5 ASC days + 0.5 SFSU days (Poli)
- Sustainment of NBI overdriven cases with NBI and pressure driven currents
  - No explicit run time beyond Poli and Gerhardt in ASC
- Supporting activities for Point Source Helicity Injection
  - Piggyback
- Impact of controlled fluctuations on edge current drive (MHD)
  - Piggyback

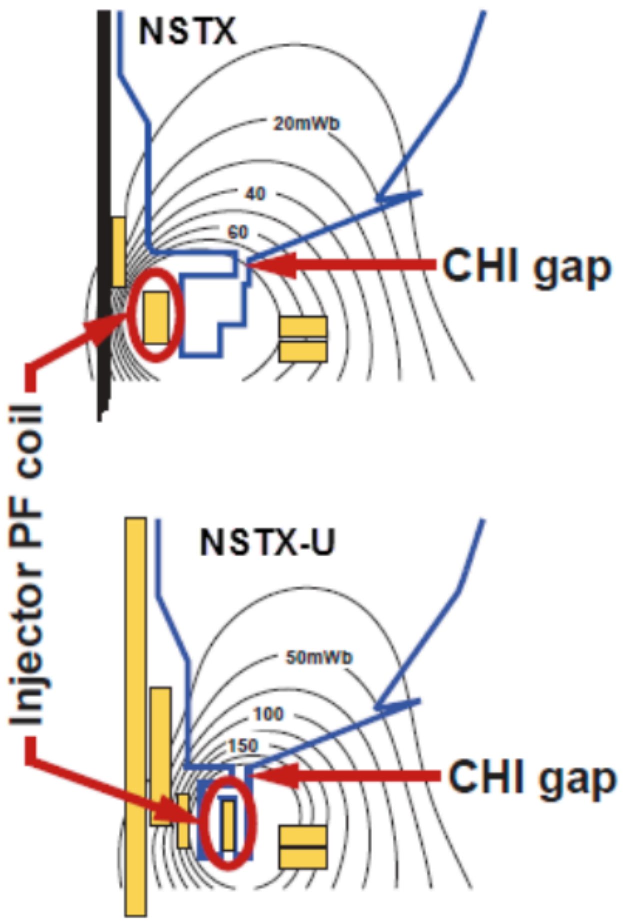
Transient CHI Plasma Start-up
Raman (2 days)



- CHI form a closed flux plasma without induction.
- Transient CHI is planned as the front end of a full non-inductive start-up and current ramp-up in NSTX-U

CHI is Cool!

Transient CHI Plasma Start-up
Raman (2 days)



Injector flux in NSTX-U is ~ 2.5 times higher than in NSTX → supports increased CHI current

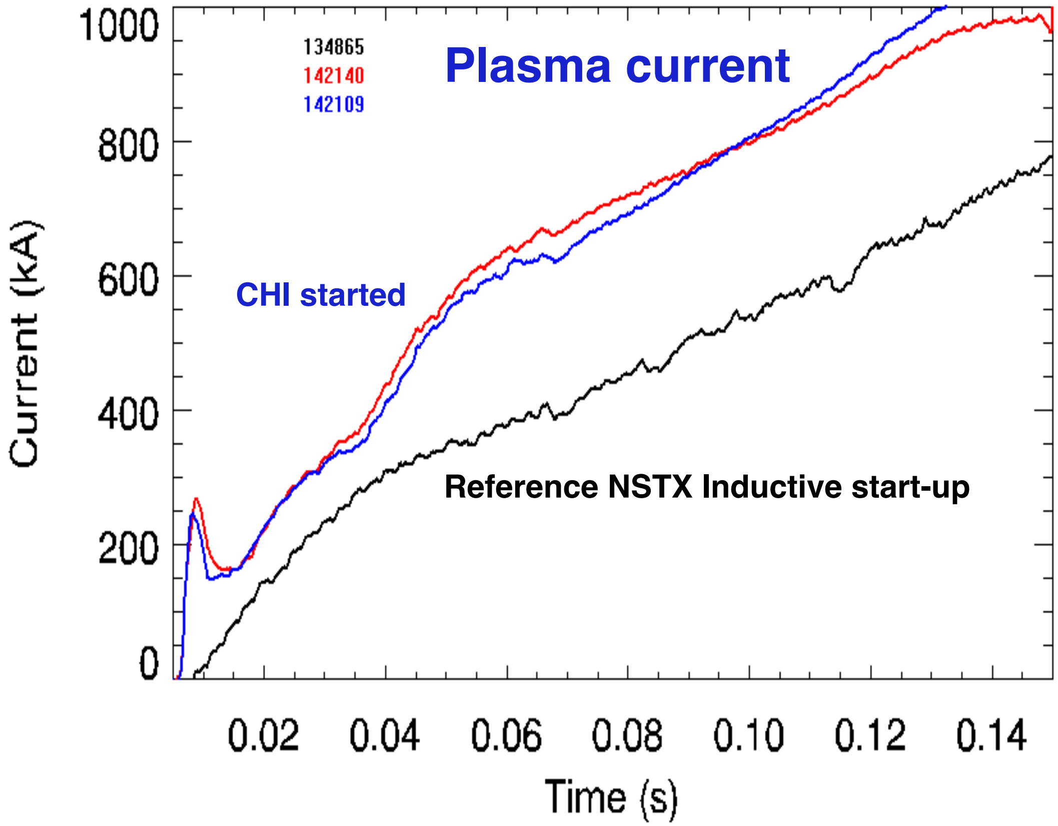
This XP will support requests from Nelson, Ebrahimi, Reusch

- Upgrades to NSTX-U should enable very high plasma current start-up using Transient CHI

<u>Plans:</u>

- Step 1: Establish a transient CHI discharge on NSTX
  - XMP
- Step 2: generate significant amounts of high-quality closed flux current on NSTX-U, <u>*which is the goals of this XP*</u>.
- Elements:
  - Optimizing the voltage waveform and gas injection.
  - Adjusting the flux footprints.
  - Providing buffer flux in the absorber.
  - PF fields to keep the plasma off the walls.

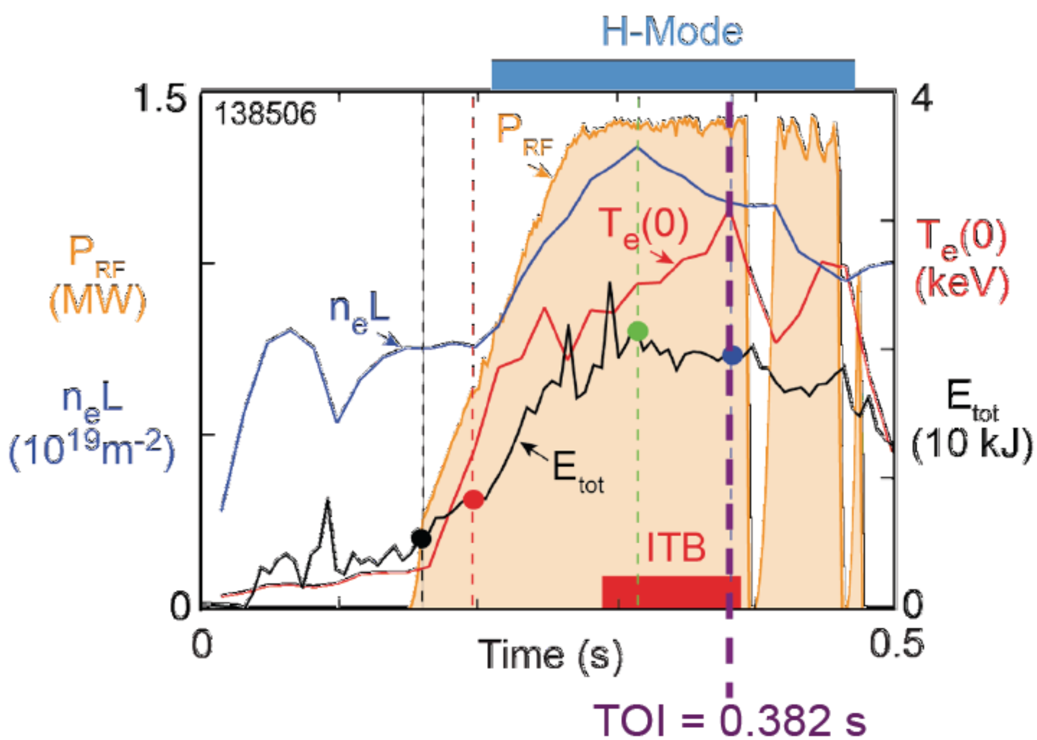
Inductive flux savings in CHI started plasmas
Nelson (0.5 days)



- **Reference Inductive discharge**
  - **Uses 396mWb to get to 1MA**
- **CHI started discharge**
  - **Uses 258 mWb to get to 1MA (138 mWb less flux to get to 1MA)**

- Prior to coupling to NBI and RF, it is necessary to asses the quality of a CHI discharge by coupling it to induction,
  - verifies that the equilibrium and current profiles generated by a CHI target are compatible with standard operations
- Also helps assess if the CHI plasmas in NSTX-U are better than those in NSTX
- Transitioning from the CHI phase to a standard operating condition requires additional needed equilibrium control development, which will be covered by this XP.

Low I_P with HHFW, high NI fraction (Taylor/Poli - 0.5 days SFSU + 0.5 days RF H&CD)

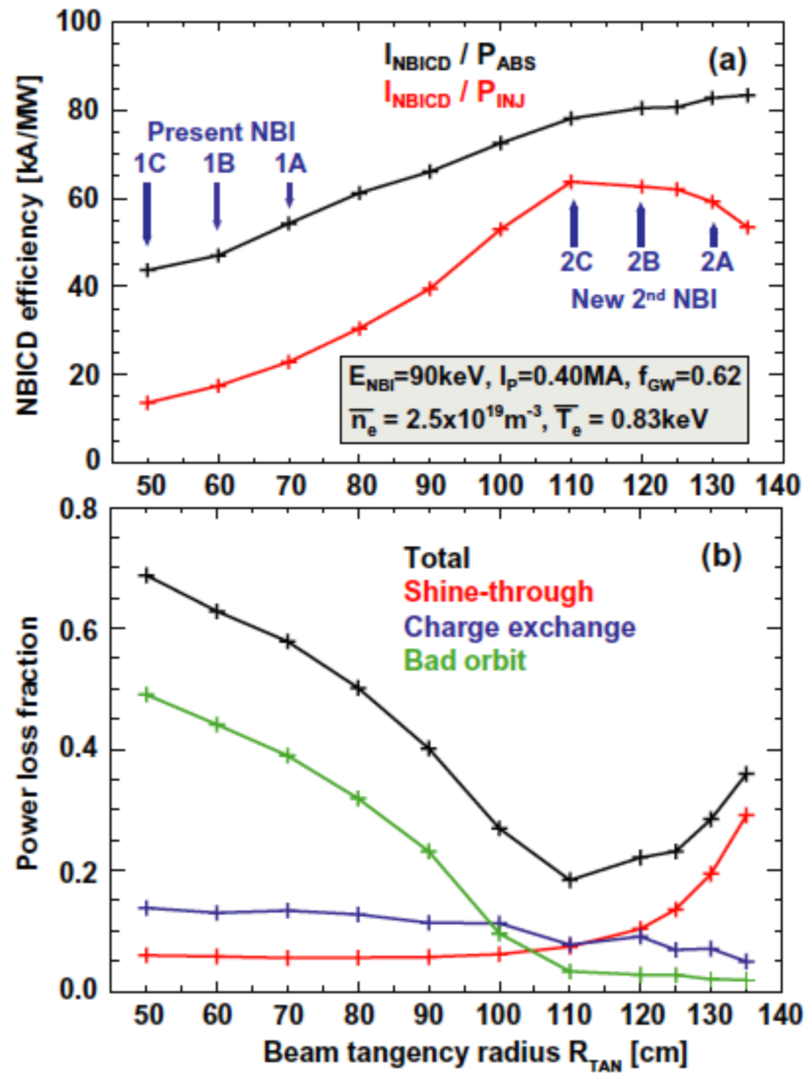


300 kA inductive target heated to 3keV using 1 MW HHFW

- In this experiment, the very efficient heating of a low current plasma demonstrated on NSTX will be re-established,
  - this capability is needed for increasing the T_e to the levels needed for NBI CD.
- In addition this will also develop a configuration with very high levels of bootstrap CD.
- Issues:
  - Shape control and ELMs impact on the RF coupling.
  - ITB formation
- Start at ~300 kA, may go lower or higher, or even try some small ramp-up if wildly successful

NB Coupling in Lower I_P Plasmas (1/2 day SFSU + ½ day ASC, Poli)

- Goal:
  - Assess lowest I_P (or T_e) for NB coupling.
  - Absorption of beamline #2 at lower current
- Issues:
  - Shine through losses
  - FI pressure peaking
  - Confinement & plasma control at low I_P
- Techniques
  - FI diagnostics and comparison to TRANSP predictions
  - HHFW may be used to increase T_e
  - Make very first assessment on the feasibility of NB overdrive.



A Few XPs Didn't Get Explicit Time

- Heating of CHI plasmas (Taylor)
  - Deemed to have insufficient likelihood of success for runtime this year.
- Plasmoid Instability during CHI (Ebrahimi)
  - Needs best possible diagnostics for CHI dynamics (cameras, for instance).
  - Will piggyback on the primary CHI XP.
- NBI overdrive w/ RF (Poli)
  - Some ideas may be captured in the new low-I_P w/ NBI XP.
- Impact of controlled fluctuations on edge current drive (Nelson).
  - Will piggyback on primary CHI XP.
- Characterization of scrape off layer density and temperature of point source helicity injection (Reusch)
  - Need plasma characteristics in order to properly design plasma guns.
  - Appears that CHI and low-current Ohmic cases are most appropriate plasmas.
  - Will help get the needed data in piggyback mode.

RF TSG

Rundown on XPs

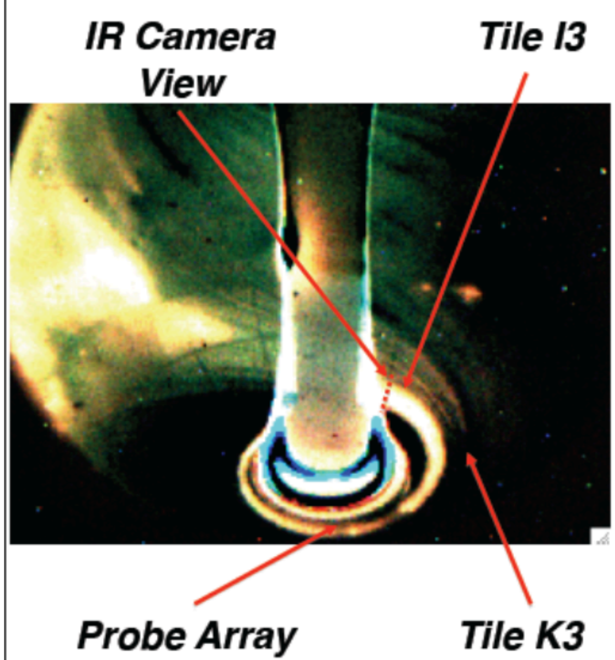
	Author	Title	Tier 1 Time Allocated	Tier 2 Time Allocated	Notes
1	Perkins/Lau/Menard	Characterizing SOL Losses in H-Mode, SOL Reflectometer & Antenna Model validation, Scoping Study for Impurity Reduction	1.25	0.5	
2	Bertelli	HHFW Absorption in NB Heated Plasmas	1	0	
3	Perkins	Plasma-Antenna Interactions	Combine with the Perkins XP.		Piggyback on all other H-mode RF XPs.
4	Menard	Scoping Study for Impurity Reduction...			Piggyback on all other H-mode RF XPs.
5	Lau	SOL Reflectometer & Validating models...			Piggyback on all other H-mode RF XPs.
6	Bertelli	HHFW CD measurements and validation	0	0	review status at mid run assessment
7	Bertelli	HHFW Effect on Toroidal Rotation	0	0	Important, but just no time.
8	Smith	BES to measure HHFW wavefield	0.25		XP designed to test capability, then use technique for many other cases
	Taylor	Low Plasma Current, fully non-inductive HHFW H-modes		0.5	Matching with 1/2 day from SFSU, for 1 total day.
9	Golfinopoulos	Coupling to Plasma Fluctuations Using Amp...	0	0	Particle Control TF is a better home
10		**Group Discussion**			
		Totals:	**2.5**	**1**	
			2.5	**1**	

RF Heating and Current Drive
Does the Allocation Address the Goals?

- Establish reliable coupling in L- and H-mode plasmas, w/ and w/o NBI.
  - 1.75 RF days (Perkins)
- Characterize HHFW absorption in NBI-heated plasmas
  - 1.0 RF days (Bertelli)
- Generate non-inductive low current (I_P~300 kA) H-modes with HHFW alone.
  - 0.5 RF days + 0.5 days SFSU for low-current ramp-up studies (Taylor/Poli).
- Measure O-X-B coupling with synthetic aperture microwave imaging (SAMI).
  - No explicit run time.

Characterize SOL Losses in H-Mode (I) (1.75 Days, Perkins)

- Heating typically improves with increasing B_T and decreasing SOL density
  - Suggests that poor heating efficiency occurs when the fast wave cutoff is near the antenna.



- New diagnostics to help understand this physics
  - RF Langmuir probes
  - IR camera with wide angle view
  - Upgraded ORNL reflectometer

Characterize SOL Losses in H-Mode (II) (1.75 Days, Perkins)

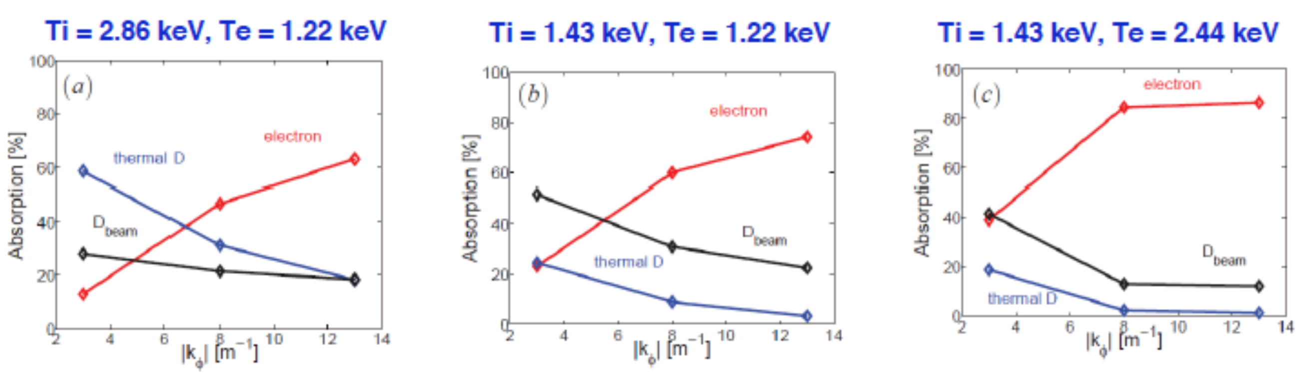
- Operate in both RF-only and RF+NBI H-modes
- RF-only H-modes were He discharges in past
  - Lower recycling -> better RF coupling
  - Good option for pre-lithium operation
- RF + NBI discharges may be feasible w/o Li conditioning
  - However, if XP is execute after LI conditioning, we may use it to lower edge density
- Scan antenna phase (six values)
- Perform a power scan at one or two phases
- Scan magnetic field to highest value allowed at time

This XP will support requests from Lau, Menard, Bertelli

HHFW Absorption in Beam Heated Plasmas (I) (1 Day, Bertelli)

- Combine RF and NBI has been challenging
- Little data available on how much RF power is absorbed by fast vs. thermal ions
- For NSTX-U:
  - ion acceleration to loss orbits can constitute a loss of FW and fast-ion power, and can cause detrimental heat loads on PFCs (i.e. the HHFW antenna limiter)
  - the increased magnetic field will reduce the harmonic number of the FW system and potentially enhance ion absorption

- RF simulations show significant RF power absorption by fast ions in many cases and also large thermal ion absorption when $T_i \geq T_e$
  - additional absorption dependence on the HHFW antenna phase



AORSA results on NSTX-U [Bertelli et al, AIP Conf. Proc. 2014]

HHFW Absorption in Beam Heated Plasmas (II) (1 Day, Bertelli)

- Benchmark RF codes such as GENRAY, TORIC, AORSA, AORSA+CQL3D, and ORBIT-RF
- Scans of:
  - Toroidal field
  - RF power
  - Antenna phase
  - Different NB tangency radius
- Needs all fast ion diagnostics, all profile diagnostics
- Proposers like L-mode plasmas for providing the best benchmarking.

This XP will have strong collaboration with the EP group.

Use BES to Measure the RF Density Perturbations (Smith, 0.25 days)

- Use an amplitude modulation of the RF power.
  - Maybe 5 kHz or so.
  - Much easier to do than to tune different sources to different frequencies.
- 2D images of the resulting fluctuations with BES, in order to resolve the RF fields.
- Needs beam blips into RF plasmas (or RF+NBI H-modes).
- Short XP to study how the measurement works.
  - Can be added to all other RF XPs if found to be useful.

Not all Proposals Got Explicit Run Time

- Plasma Antenna Interactions (Perkins)
  - RF effects on the sheath heat flux transmission
  - Runs piggyback on primary XP by Perkins.
- Scoping study for impurity reduction with RF (Menard)
  - Runs piggyback on primary XP by Perkins.
- SOL Reflectometer and Validating RF Models (Lau).
  - Physics side goals include incorporating full EM models of the antenna with plasma physics RF codes.
  - Data can be collected piggyback with primary H-mode XP.
- HHFW effect on toroidal rotation (Bertelli)
  - Interesting XP, but couldn't find the time for it.
  - Try to get some piggyback data if it is possible
- HHFW CD measurements and validation (Bertelli)
  - Revisit this at the mid-run assessment if there is any evidence (for instance, from V_{loop}) that current has been driven in the cases that are run.

Summary and Comments

CC&E for SFSU and RF H&CD

- SFSU expects to do a 1-2 day commissioning XMP for transient CHI.
  - This was NOT counted again the runtime tally provided here.
- RF H&CD group expects to do a conditioning XMP.
  - This was also NOT counted against the runtime tally provided here.
  - 3-4 days of plasma conditioning may be required.
  - Can probably get some physics out of that as well.

Which XPs are Most "Cross Cutting"? Some examples…

- Two XPs on ramp-up are cross cutting within the SG.
  - All three TSGs dedicate some time.
  - And have significant aspects of transport and current drive modeling in non-standard, low-I_P scenarios.
  - Lots of FI physics in the low-I_P NBCD experiment.
- The 100% non-inductive XP has significant run time.
  - Has significant transport and current drive modeling.
  - Will start with the TRANSP predicted operating points.
  - Will entertain requests for shots to be included, within the goals of the XP, since understanding these scenarios is so critical across the program.
- Very long pulse H-mode XP is by design cross-cutting.
  - Strongest overlap with MHD, PCTF
- SFD control serves many needs in the boundary physics SG.
- Rotation control, if we get it done, will facilitate many XPs in the core SG.
- RF+NBI experiments have strong connection to EP group.

Distribution of First Authors (not including CC&E, XMPs) ~12 First Authors

Author	XP	Run Days	Area
Gerhardt	100% non-inductive	2 (ASC)	Scenario Development (3.5 Days)
Battaglia	Longest Possible Pulse	1 (ASC)	
Yuh	Reversed Shear	0.5 (ASC+0.5 T&T)	
Kolemen	SFD Control	1.5 (ASC)	Control Development (4 Days)
TBD	Rotation Control	0.5 (ASC)	
Boyer	Current profile control, β_N + l_i control	2.0 (ASC)	
Bertelli	Absorption in NB plasmas	1.0 (RF)	HHFW at Higher Current (3 Days)
Perkins	SOL Losses in H-mode	1.75 (RF)	
D. Smith	Measure Density Perturbation with BES	0.25 (RF)	
Poli	NBI Coupling to Low-Current Plasmas	1 (0.5 ASC+ 0.5 SFSU)	Ramp-Up (2.0 Days)
Taylor/Poli	Low Current, high f_{NI}, HHFW	1 (0.5 RF+ 0.5 SFSU)	
Raman	Transient CHI startup	2.0 (SFSU)	CHI (2.5 Days)
Nelson	Inductive Rampup	0.5 (SFSU)	

The RF and SFSU run time is severely constrained.

- HHFW could use more time
  - Considerable interest from MANY TSGs in developing HHFW H-modes
  - Issues
    - Shot development of RF needs to be accomplished.
    - Totally dropped the HHFW impact on rotation study.
    - No time allocated for explicitly studying the impact of RF on impurities.
  - Mitigation strategy
    - Need to use the commissioning XMP to get some data.
    - Will learn from XPs that use RF in other groups.
- CHI is likely the more critically impacted.
  - Totally new geometry in the injector/absorber.
    - It is not clear how long it will take to get ~200 kA.
  - Previous 10 minute shot cycle may not be achievable.
    - Cannot compare the future rate of progress with the NSTX experience.
    - To get 10 minutes it will require numerous tricks with the coil protection system.
  - 2 total days likely severely limits the progress that can be made.
    - Significant risk that a CHI closed-flux discharge may not form.
    - Will not fully optimize the scenario under this guidance, even under optimistic assumptions on progress.

Backup

2 Days Of Cross-Cutting XPs to Study Ramp-Up Physics

- Day 1: HHFW heating of low current high f_{BS} current fraction
  - (SFSU + RF) 1 day.
  - Scenario: ~250-350 kA, high B_T, P_{NBI}~0.
  - Goals:
    - Stationary FW H&CD, high NI at low current
    - FW H&CD assessment at low Te,ne (on inductive)=> more SFSU oriented [2nd part of the day]. Step-up power.
  - Lead author: Gary Tayor, F. Poli to support
- Day 2: NB coupling to low(er) current/density/temperature plasmas
  - (ASC+SFSU) 1 day
  - Goal:
    - Assess lowest Ip/Te for NB coupling?
    - Absorption of beamline #2 at lower current?
  - Issues:
    - Shine through losses
    - FI pressure peaking
    - Confinement
    - FI diagnostics
    - HHFW may be used to increase T_e (to broaden FW profiles)
    - Pick the optimal initial current from simulation