

Columbia U. group XPs / XMPs on $n = 1$ feedback supporting plasma target and control development

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PPPL

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Three development tasks regarding $n = 1$ feedback control (actually, requiring very little time)

- Development XPs submitted through ASC TSG
 1. RWM PID / state space control to optimize low density startup (SAS)
 - Milestone R(12-3), could combine as part of a larger XP on low density plasma development (D. Mueller submitted XP) piggyback – 0.5 days
 2. RWM PID control optimization based on theory & experiment (SAS)
 - Use present analysis of XP1023 to optimize B_r , B_p sensor gain, B_p feedback phase 0.5 days
 3. RWM state-space control w/6 coils - checkout XMP (SAS)
 - Might be able to do in piggyback (as was done in initial 2010 RWMSC verification) piggyback-0.5 days

- Related RWM and $n = 1$ feedback control physics XPs have been submitted to the Macro-stability TSG

XP Idea 1): Generate reliable low density startup for reduced collisionality (from XP1062 NTV XP experience)

□ Motivation

- Produce reduced collisionality in NSTX (milestone R(12-3))

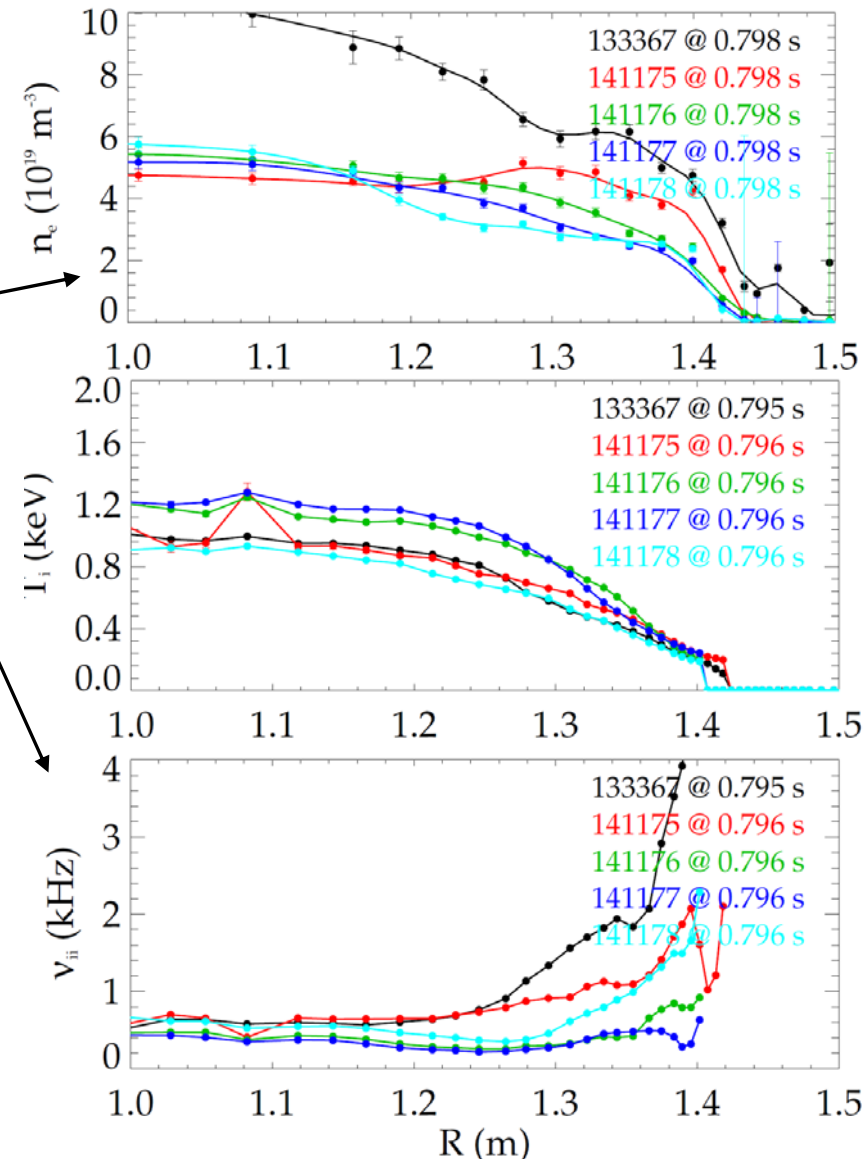
□ XP1062 had success reducing v_i^*

- Errant gas programming (low gas) in the startup – reduced density
- Measured v_i reduced by at least a factor of 4 in max NTV region

□ Idea (for Mueller XP, or new XP)

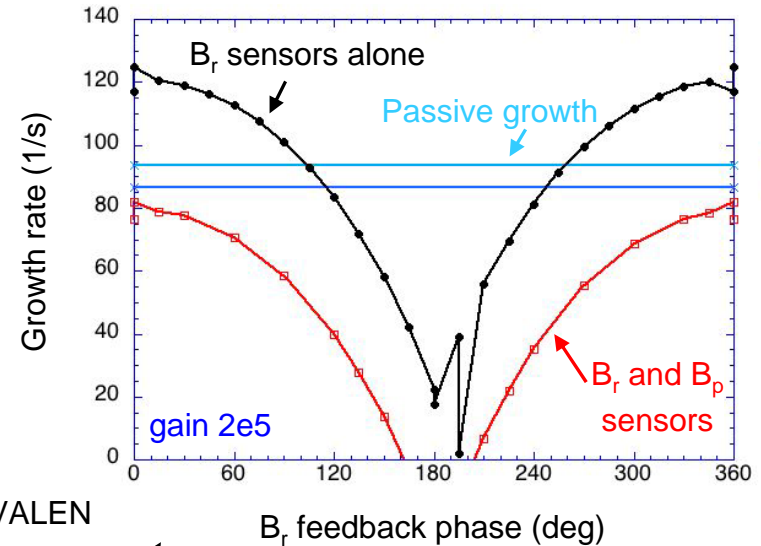
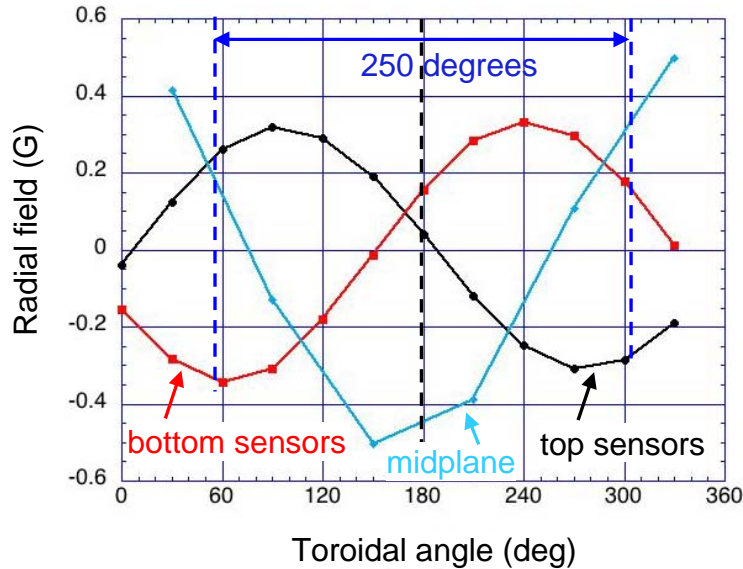
- Alter front-end gas programming – reducing the amount of total gas
- Add $n = 1$ feedback through PID, $n = 1, 2$ with RWM state-space controller early in discharge
 - Reduce mode activity, get data on early feedback, + mode locking vs. n_e (J.-K. Park LM studies)

- Request: piggyback on Mueller XP, or 0.5 days if run separately



XP Idea 2): Optimize $n = 1$ RWM PID feedback settings using theoretical and experimental results

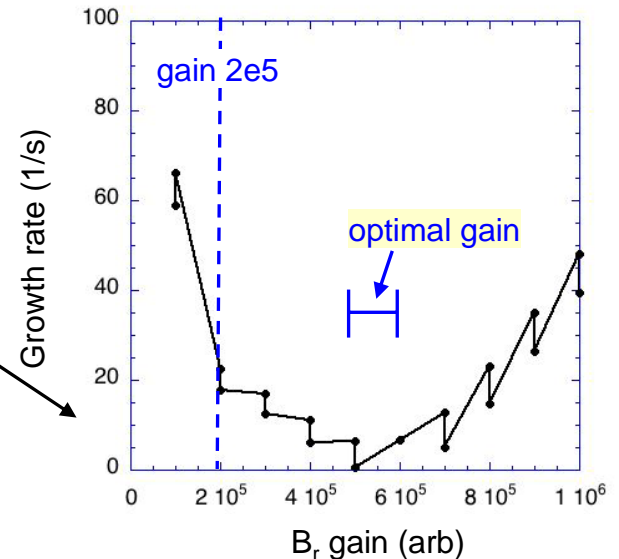
Modeled B_r field at sensors and midplane



DCON, VALEN codes

Combined B_r , B_p feedback (XP1023 + analysis)

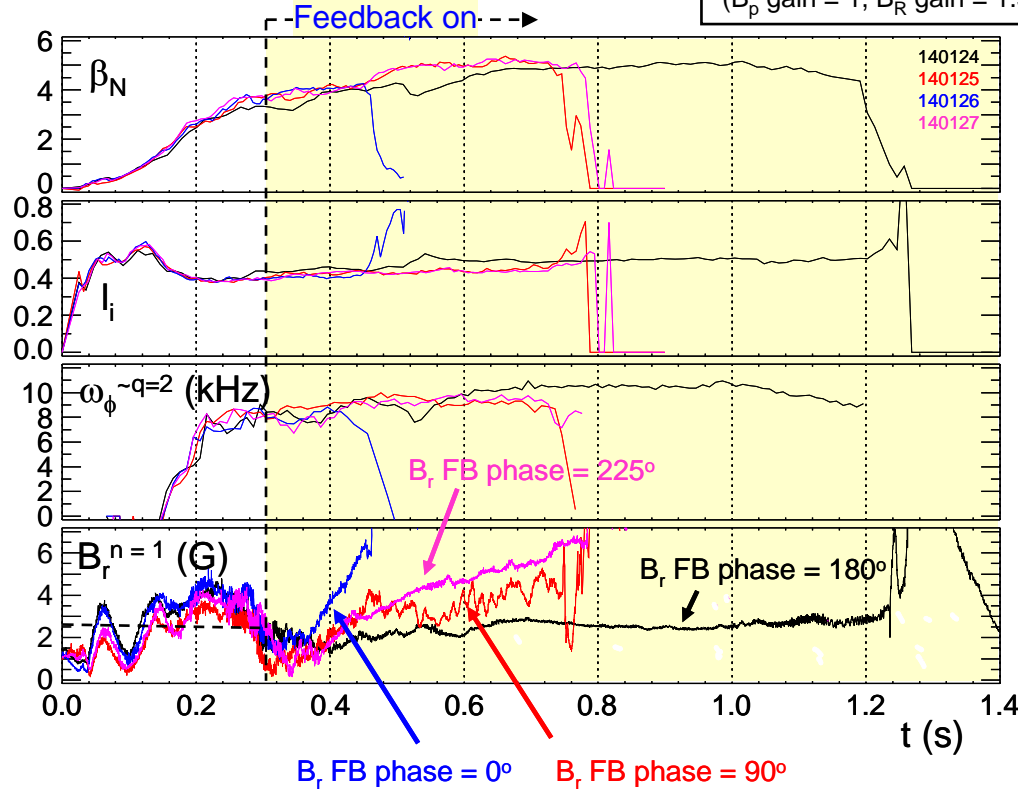
- Modeled B_r mode structure and optimal feedback phase agrees with parameters used in experiment
- B_r feedback alone provides stabilization for growth times down to ~ 10 ms with optimal gain
- Physics of best feedback phase for B_p sensors in low I_i plasmas under investigation
 - Present analysis: B_p feedback phase mismatches experiment – 3D structure model, plasma response model, equilibria/eigenfunctions being investigated



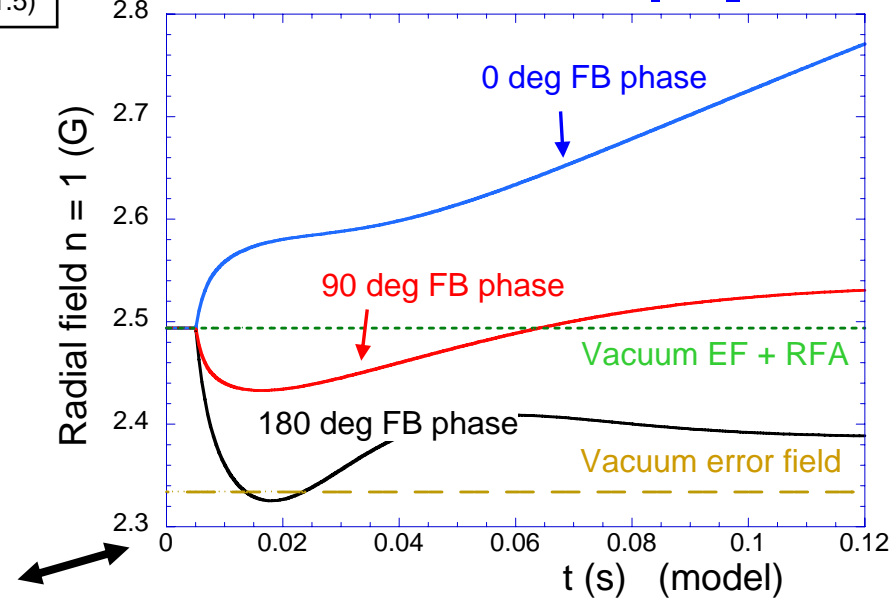
XP Idea 2): Run focused variations of $n = 1$ RWM PID control parameters showing least agreement w/theory – akin to “system calibration”

NSTX Experiments: $B_p + B_R$ feedback

$n = 1$ $B_R + B_p$ feedback
(B_p gain = 1, B_R gain = 1.5)



VALEN calculation of NSTX $B_r + B_p$ control



- B_R FB dynamics reproduced in theory
 - Positive/negative feedback produced at theoretically expected phase values
 - Amplitude dynamics similar (theory/XP)

□ XP needs

- Request: 0.5 days in plasma over $n = 1$ no-wall limit
- Focused variation of B_r gain, B_p FB phase and gain
- Run more than one target if time allows (low I_i , higher A ,...)

XMP Idea 3): Test upgrades of new RWM state space controller to leverage new 2nd SPA power supply

Targeted Improvements

- Independent control of the 6 RWM coils using 2nd SPA power supply
- Addition of $n > 1$ eigenfunction will then yield $n = 1, 2$ feedback, and higher n based on observer match to wall states
 - Note: inclusion of $n > 1$ eigenfunction may improve mismatched 90 deg difference signals even without PCS code upgrade

XMP needs

- Request: should be able to test in piggyback (as done with initial controller). If not possible, dedicate a few hours run time for tests

