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XP1518: RWM PID control optimization based on theory and experiment

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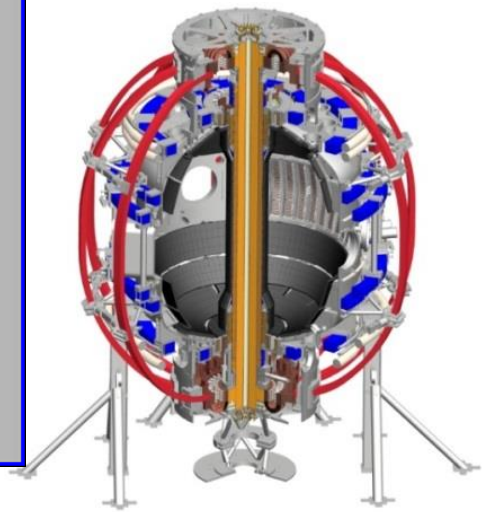
PPPL



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Columbia U. Group 2015 Macrostability TSG XPs (Short Summary)

- XPs (related XPs assigned numbers for "2011 run")
  - RWM stabilization dependence on neutral beam deposition angle (~XP1149) (Berkery)
  - RWM stabilization physics at reduced collisionality (~XP1148) (Berkery)
  - RWM state space active control physics (independent coil control) (~XP1145) (Sabbagh)
  - RWM control physics with partial control coil coverage (JT-60SA) (~XP1147) (Y-S Park)
  - RWM PID control optimization based on theory and experiment (~XP1111) (Sabbagh)
  - RWM state space active control at low plasma rotation (~XP1146) (Y-S Park)
  - Neoclassical toroidal viscosity - reduced ν (independent coil control) (~XP1150) (Sabbagh)
  - NTV steady-state rotation at reduced torque (HHFW) (~XP1062) (Sabbagh)
  - Multi-mode error field correction using the RWMSC (to follow initial EFC XP)
  - NTM Entrainment in NSTX-U (Y.S. Park)
- Piggyback XPs
  - Disruption PAM characterization, measurements, and criteria (Sabbagh, for DPAM WG)

NOTE: - some shot plans already scoped out in web submissions (not repeated here)
- run day requests mostly assume leveraging "2nd NBI XP", "Ip/Bt scaling XP"

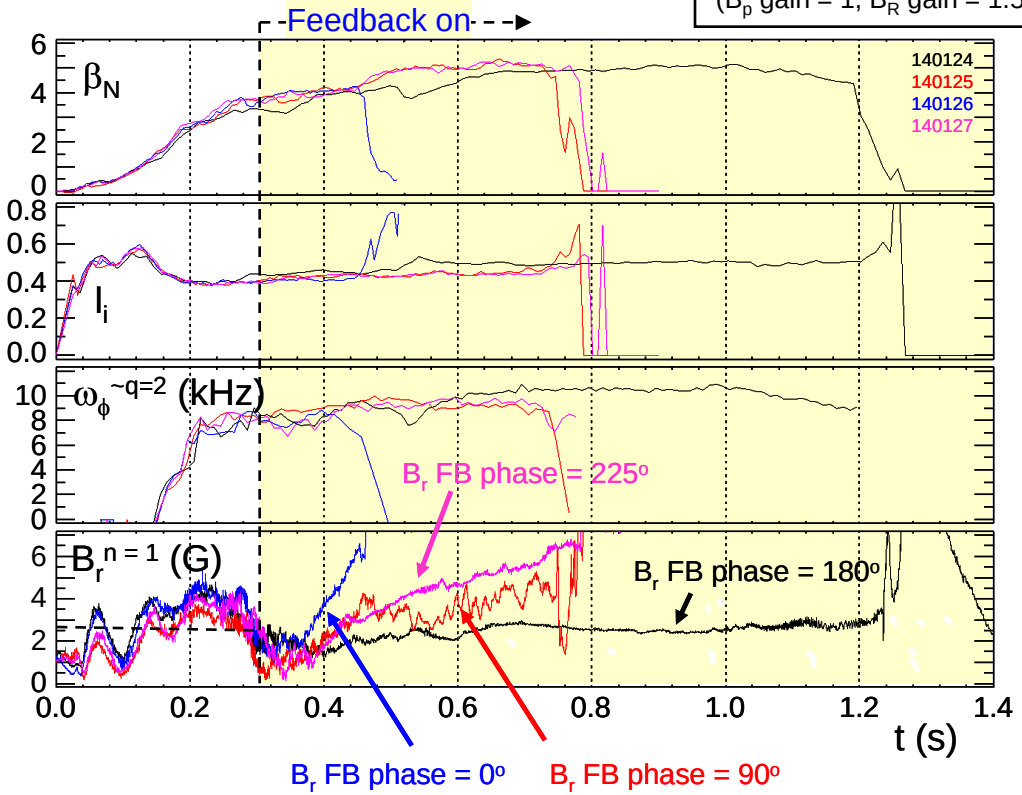
XP1518: RWM PID control optimization based on theory and experiment

- Motivation
  - Experiments using n = 1 RWM control in 2010, and subsequent analysis using the VALEN code show that some settings for control using dual B_R and B_p sensor feedback were optimal, others could have been improved
  - Active RWM PID control settings need to be re-optimized for NSTX-U
  - Support general NSTX-U experiments by optimizing RWM PID control
- Goals / Approach
  - Optimize n = 1 RWM PID control focusing on scans of key parameters
    - Vary B_p feedback phase, B_R feedback gain – which differ in the most in the analysis from the experimental settings
    - B_p sensor gain will also be examined in this experiment (never scanned with r/t AC compensation).
    - Perform on high performance target plasmas (fiducial; low l_i; snowflake)
- Addresses
  - General support for NSTX-U high beta experiments, R(15-3)
  - ITPA joint experiment MDC-17

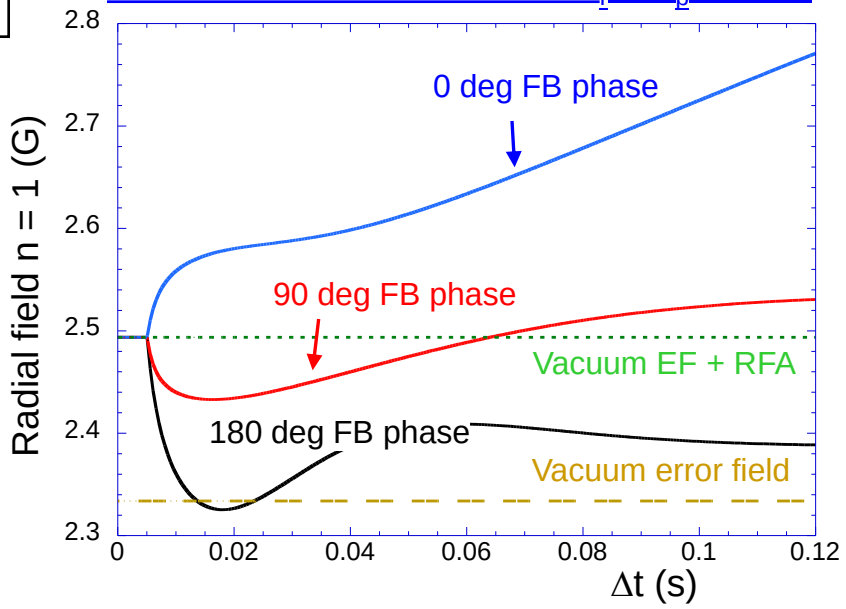
RWM B_r sensor n = 1 feedback phase variation shows superior settings when combined w/B_p sensors; good agreement w/theory

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



- Favorable (experimental) B_p feedback settings, varied B_R settings
  - Positive/negative feedback produced at theoretically expected phase values

- VALEN calculation of B_r+B_p feedback follows XP
  - stable plasma (negative "s")
  - Now examining plasma response model variation
    - impact of "s", and diff. rotation ("α") on results

XP1518: RWM PID control optimization based on theory and experiment – basic shot scans / run time allocation

- Primary scans (number of data points/shot will depend on high beta steady-state duration)
  - Vary B_p sensor feedback phase, no B_r feedback (4 shots) – (at 4 phases/shot)
    - Extra shot added here in case gain increase needed
  - Vary B_p sensor feedback gain, no B_r feedback (2 shots)
  - Vary B_r sensor feedback gain, with "best" B_p feedback settings (2 shots)
    - B_r sensor feedback phase of 180 degrees
  - Vary B_r sensor feedback phase, with "best" B_p feedback settings (2 shots)
  - Vary B_p sensor feedback phase to check with "best" B_r feedback (4 shots)
- Additional details/scans
  - Add an interval of pre-programmed n = 1 field to determine that feedback is being effective – change gain if needed on early shots (no extra shots needed)
  - Use fiducial, or generally high performance low l_i target plasma
  - May wish to redo all/part of these scans on significantly different NSTX-U plasma conditions (e.g. standard DND vs. snowflake)
- Run time
  - 0.5 priority run days allocated for XP1518 (~14 shots?)

XP1518: RWM PID control optimization based on theory and experiment – Diagnostics, etc.

- Required diagnostics / capabilities
  - RWM B_p and B_r sensors
  - RWM n = 1 PID feedback using B_p and B_r sensors
  - RWM coils generating n = 3 or n = 2 applied field configurations
  - CHERS toroidal rotation measurement
  - Thomson scattering
  - MSE
  - Toroidal Mirnov array / between-shots spectrogram with toroidal mode number analysis
- Desired diagnostics / capabilities
  - Real-time rotation measurement
  - USXR and ME-SXR
  - Fast camera