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XP1111: RWM PID control optimization based on theory and experiment

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Advanced Scenarios & Control TSG Meeting

Friday June 3rd, 2011

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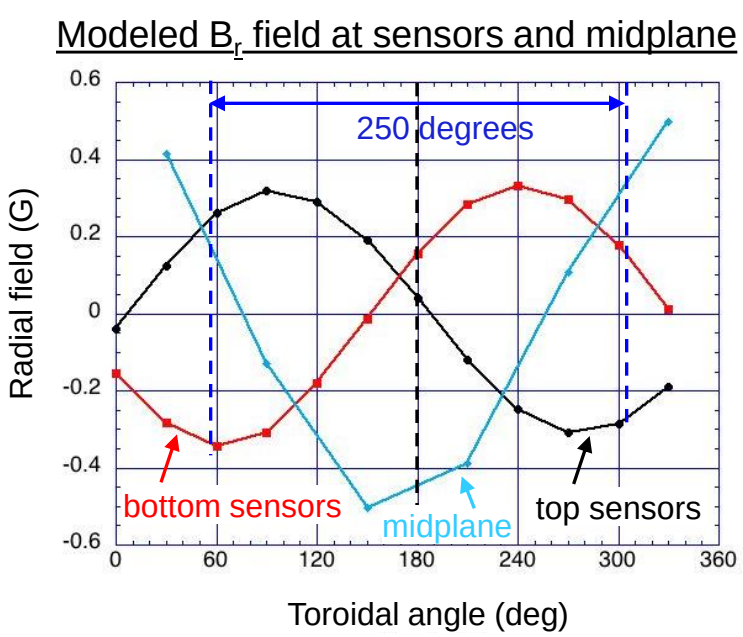
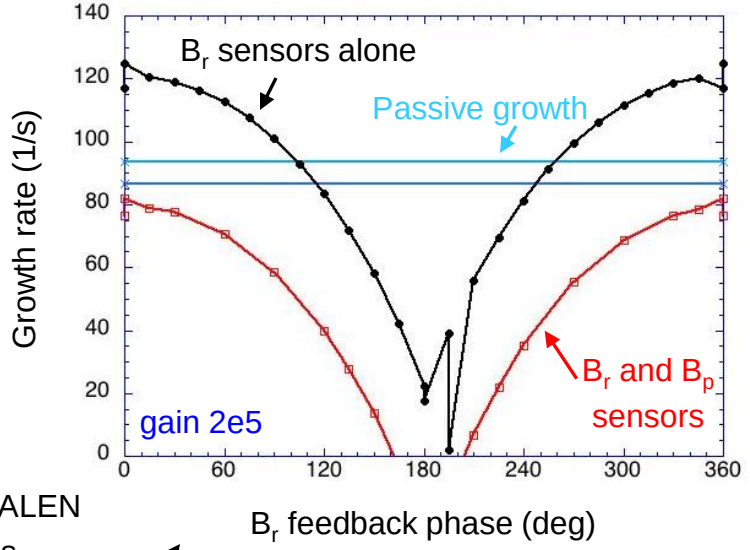
XP1111: Aims to optimize n = 1 RWM PID control for general NSTX experimental use, and comparison to theory

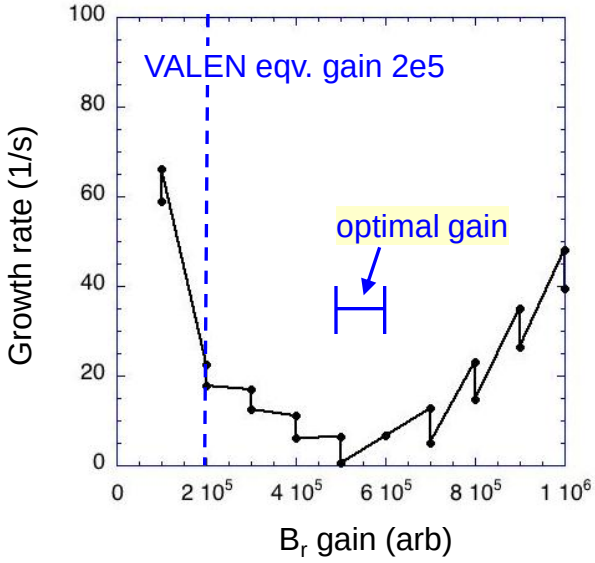
- Motivation
  - Experiments using n = 1 RWM control in 2010, and subsequent analysis using the VALEN code show that some settings for control using B_R and B_p sensors are optimal, while others can be improved
  - Support NSTX experiments in general by optimizing RWM PID control
- Goals / Approach
  - Optimize n = 1 RWM PID control focusing on scans of key parameters not presently optimized in theory
    - Vary B_p feedback phase, B_R feedback gain presently 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).
    - Use two different high performance target plasmas (fiducial; low l_i targets)
- Addresses
  - General support for NSTX high beta experiments
  - ITPA joint experiment MDC-17, MHD Working Group 7

RWM feedback using upper/lower B_p and B_R sensors shows good agreement with B_R feedback phase; gain not optimized





DCON, VALEN codes

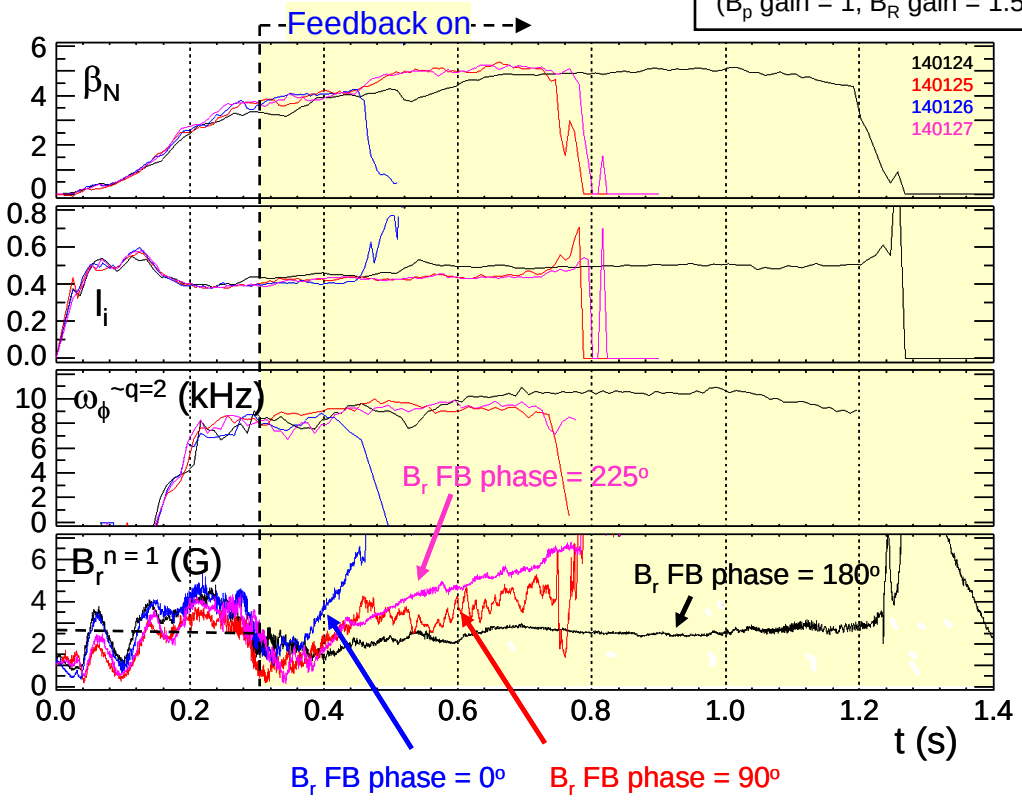


- Both B_r, B_p feedback contribute to active control
  - B_r mode structure and optimal feedback phase agrees with parameters used in experiment
  - B_r feedback alone provides stabilization for growth times down to ~ 10 ms with optimal gain
  - Physics of best feedback phase for B_p sensors in low l_i plasmas under investigation

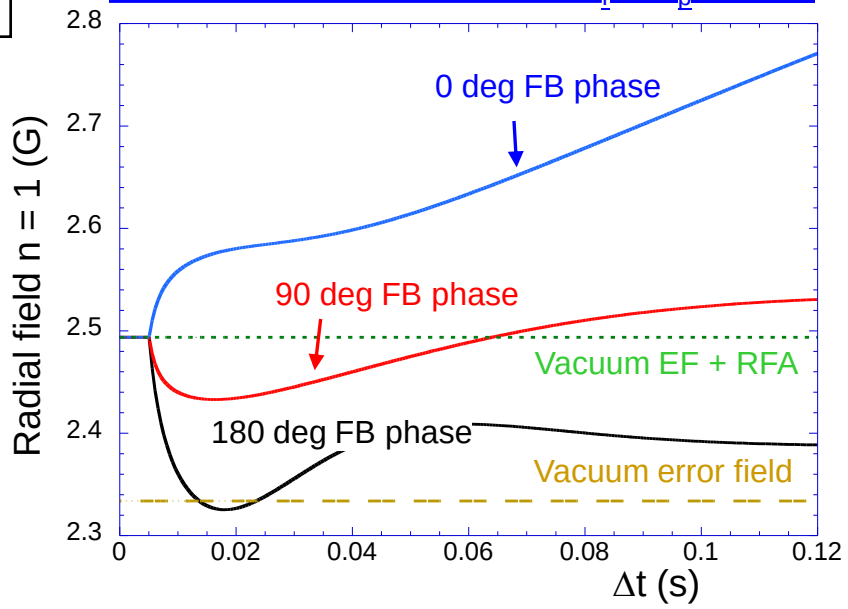
RWM B_r sensor n = 1 feedback phase variation shows superior settings when combined w/B_p sensors; good agreement w/theory so far

NSTX Experiments: B_p + B_R feedback

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



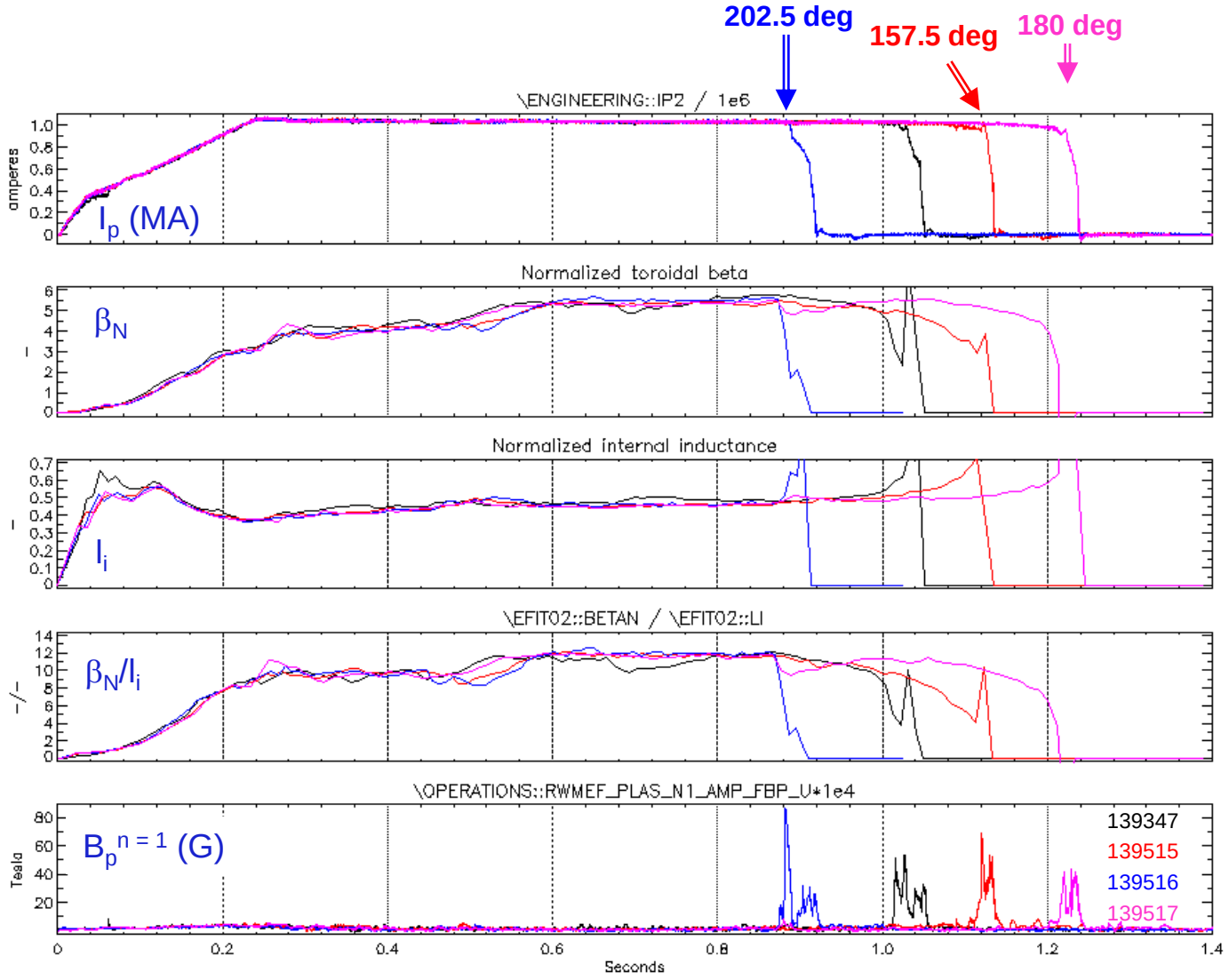
VALEN calculation of NSTX B_r + B_p control



- 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

Tweaking B_p sensor feedback phase around 180 degrees led to long-pulse, low l_i, high β_N/l_i



- Steady, high β_N/l_i
  - Between 12 – 12.5
- Not in agreement with theory
  - VALEN indicates a value near 270 deg is optimal
  - Analysis ongoing

XP1111: RWM PID control optimization based on theory and experiment – shot plan

Task	Number of Shots
0) Control shots	
A) Generate Fidicial target (long pulse ~ 1s, I_p ~ 0.9 MA)	1
B) Generate low l_i target (long pulse ~ 1s, I_p ~ 0.9 MA) - NOTE: run this AFTER fiducial scans done	1
C) Generate RWM using n > 1 magnetic braking if RWM is not generated	2
1) RWM n = 1 PID feedback control variable scans (at optimal B_R feedback phase)	
A) Vary RWM B_p sensor feedback phase for first target plasma	6
B) Vary RWM B_R sensor feedback gain for first target plasma	3
C) Repeat scans (A) for second target plasma	6
D) Vary RWM B_p sensor feedback gain for one of the two plasma targets	3
Total: 22	

½ run day originally slated for RWM state space controller XMP would be used for this XP (RWM state space controller work can be run in transparent piggyback)

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XP1111: RWM PID control optimization based on theory and experiment – Diagnostics, etc.

- Required diagnostics / capabilities
  - n = 1 RWM PID feedback control using B_p and B_r sensors
  - CHERS toroidal rotation measurement
  - Thomson scattering
  - MSE
  - Toroidal Mirnov array / between-shots spectrogram with toroidal mode number analysis
  - Diamagnetic loop
- Desired diagnostics
  - USXR, ME-SXR, BES
  - FIDA variants
  - FIReTip
  - Fast camera