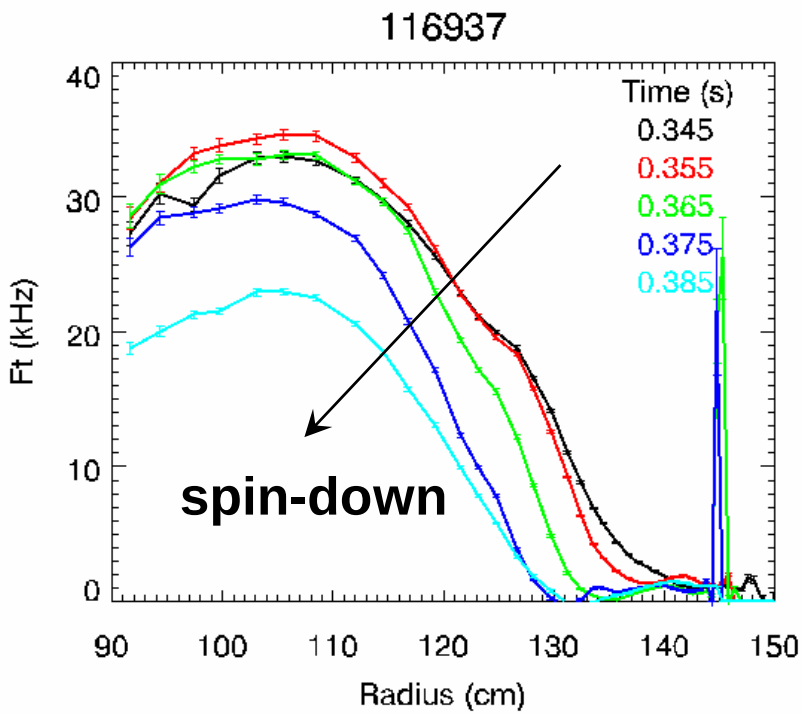
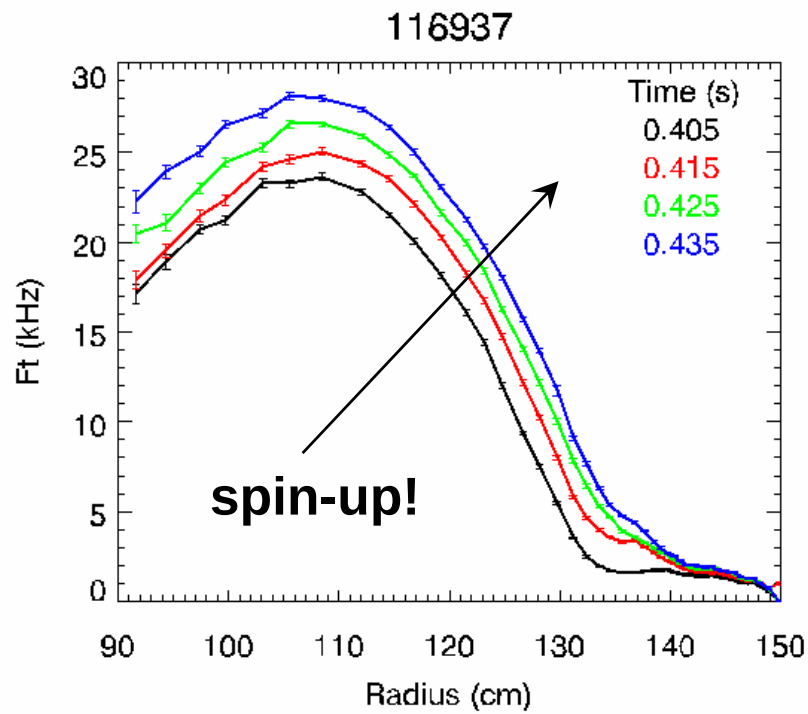
XP535: Active Stabilization of the Resistive Wall Mode at Low Aspect Ratio

- Motivation
  - Demonstrate and study active stabilization of the RWM in plasmas rotating slower than the critical RWM rotation frequency
    - Addresses RWM stabilization in ITER-relevant rotation regimes
  - Examine the impact on plasma rotation
    - Anticipate that NTV damping model (XP524) will explain the data
  - First attempt at active RWM stabilization at low aspect ratio
- Goals
  - Actively stabilize the RWM in plasmas above the no-wall beta limit and at the highest β_N values possible
  - Investigate variations of feedback gain and phase
    - Use n=1 AC applied field for stabilization; n=3 DC field for braking
  - Compare to theory (single mode model, VALEN, MARS-F)

Plasma rotation control demonstrated using n=3 applied field

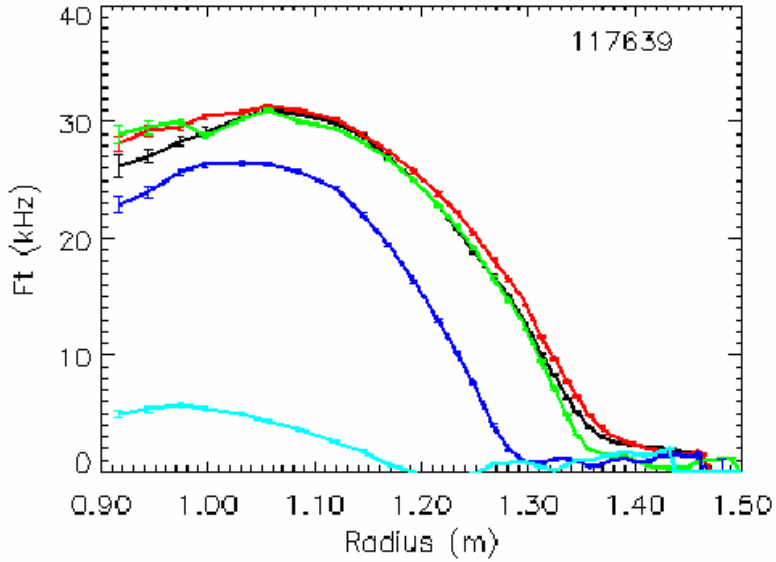


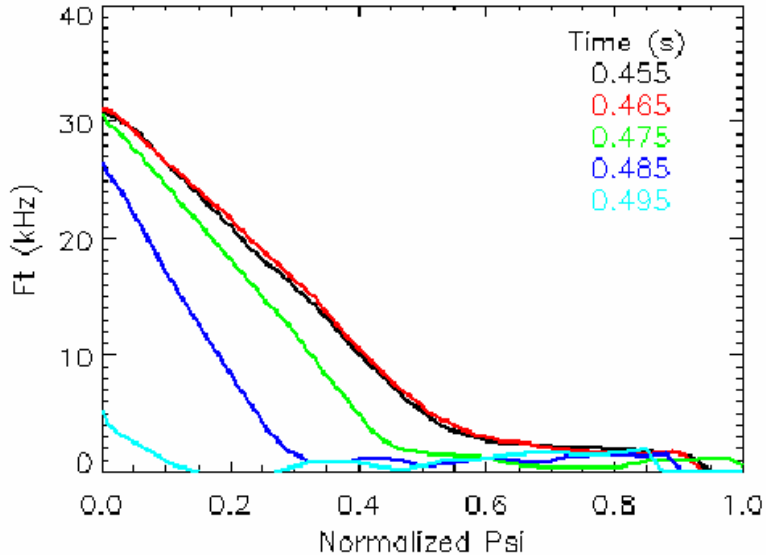
n=3 DC (1.1kA) external field applied

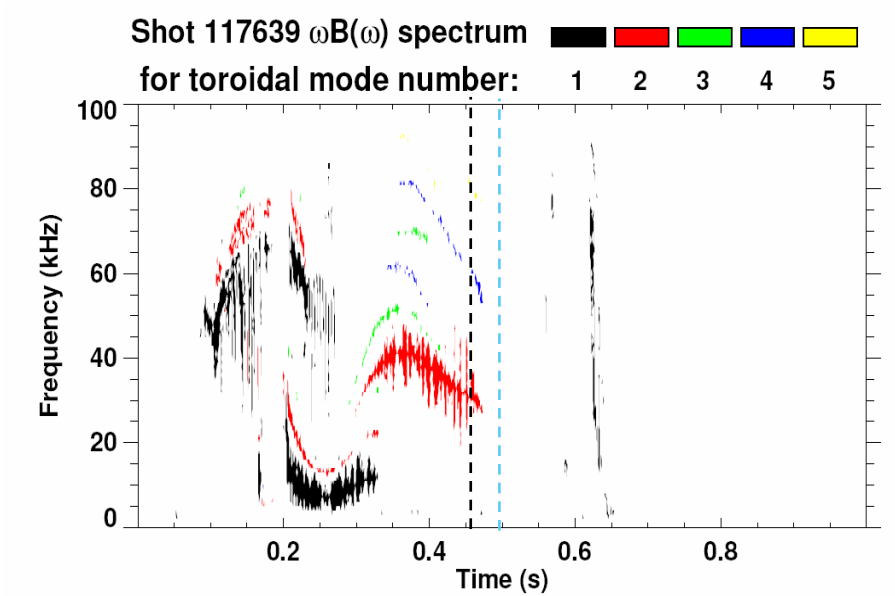


n=3 external field turned off

Low rotation target created in a controlled manner

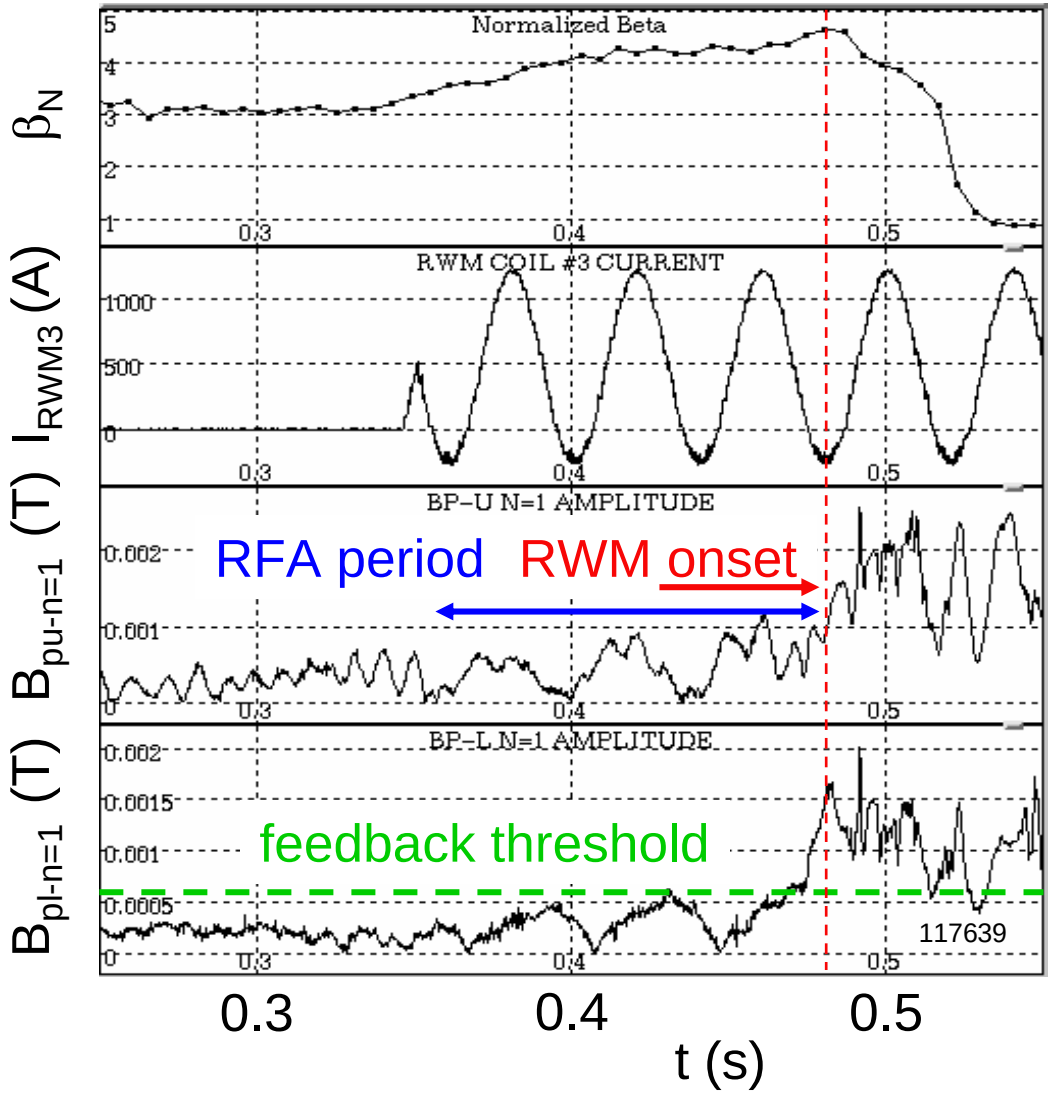






- Plasma rotation damping by n=3 DC field and applied n=1 AC field
- Plasma is a good candidate for first attempt at active RWM feedback

A key goal - sustain plasmas limited by growing RWM



- RWM destabilization
  - 25Hz *n*=1 1.6kA (peak-to-peak) traveling wave in the plasma rotation direction with 500A *n*=3 DC offset applied
- Active feedback stabilization
  - Use B_p sensors
  - Set threshold n=1 amplitude for active feedback stabilization at $|B_{p-n=1}| <= 10G$
  - Note: n=1 RWM was destabilized by n=3 field alone in other shots

XP535: Active Stabilization of RWM at low A - Run plan

Task	Number of Shots
1) Create target plasma with high margin over the ideal no-wall beta limit (control shot)	
(use 116861 as setup shot)	
A) Produce at least a 0.2s period free of n=1 tearing mode activity	2
2) Drive control shot over the RWM marginal stability boundary	
A) Apply pre-programmed n=3 helical field to reduce plasma rotation below the RWM critical rotation frequency	
(i) Vary n=3 current to produce unstable RWM during n=1 tearing mode-free period	3
3) Observe effect of RWM active stabilization system on plasma rotation and performance	
A) Vary n=1 AC feedback gain for a given phase shift between measured/applied field (set threshold of measured mode amplitude for feedback based on (2) above)	3
B) Vary n=1 AC feedback relative phase between measured/applied field	10
C) Vary n=1 AC feedback gain for most favorable phases	6
	Total: 24

Duration and Required / Desired Diagnostics: XP535

- XP could be completed in 1 run day
- Required
  - Internal RWM sensors
  - Initial PCS active RWM stabilization system
  - CHERS toroidal rotation measurement
  - Thomson scattering
  - Diamagnetic loop
- Desired (highly)
  - MSE
  - Toroidal Mirnov array