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# **NSTX RWM Active Feedback System** **Implementation Plan Discussion**

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**NSTX Global Mode Stabilization Meeting**

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PPPL

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# Active RWM Stabilization Meeting Agenda

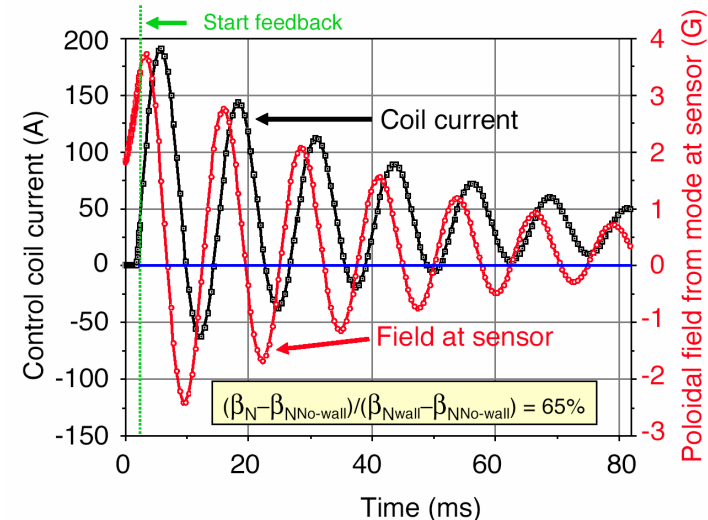
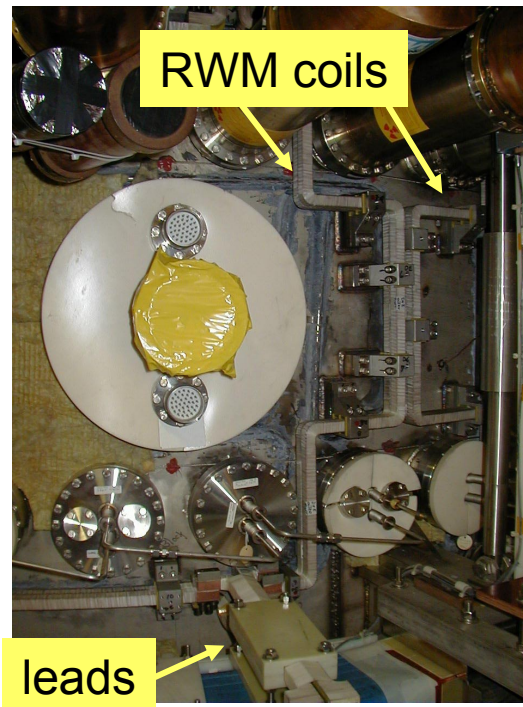
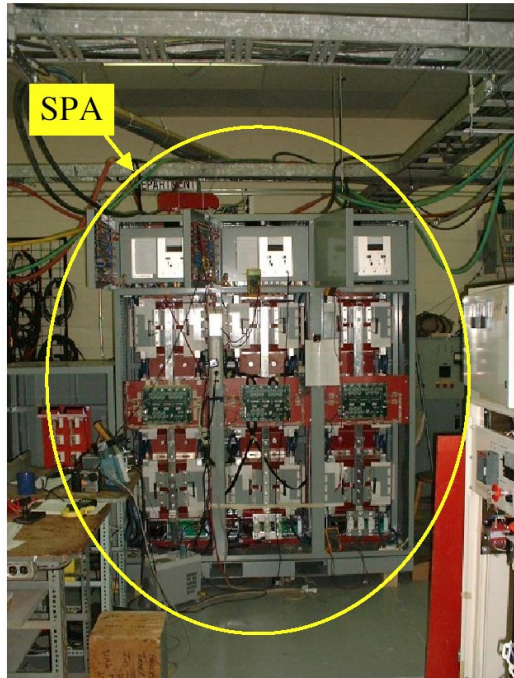
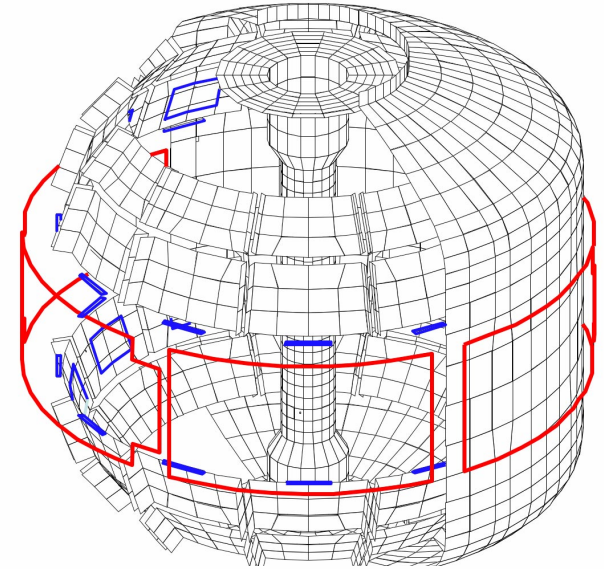
- Brief intro: applicable physics results
- Engineering update: Coil and power systems status
- Control System plan / tasks discussion

Goal: Demonstrate NSTX RWM active stabilization in 2005 !

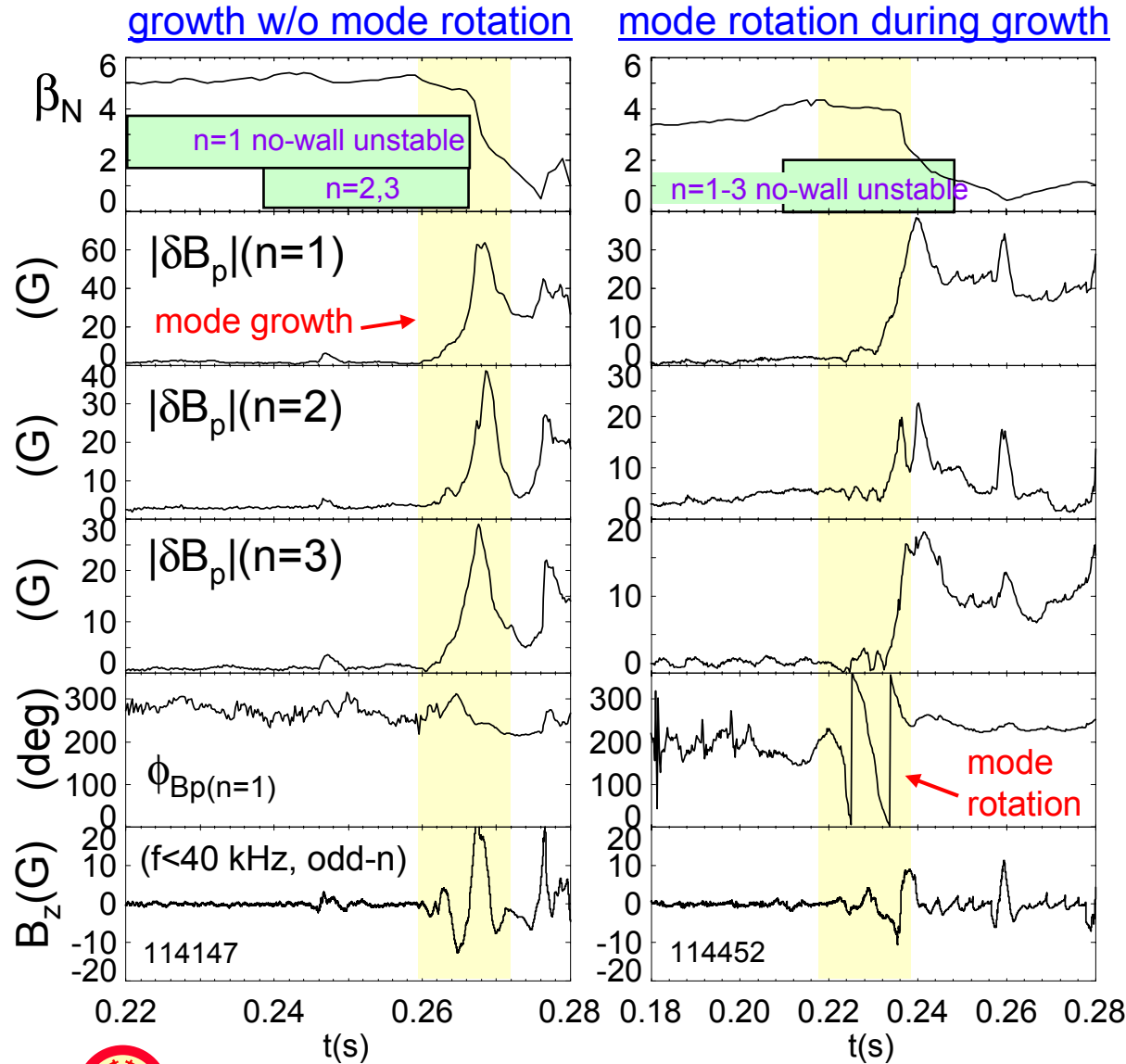
# RWM stabilization system being installed for 2005 run

- RWM sensor array used in 2004 experiments
- 6 B<sub>r</sub> coils now installed on NSTX
- 3-channel switching power amplifier (SPA) on-site
- Real-time mode detection and control algorithm development in 2005 for feedback experiments

Physics design (VALEN code)

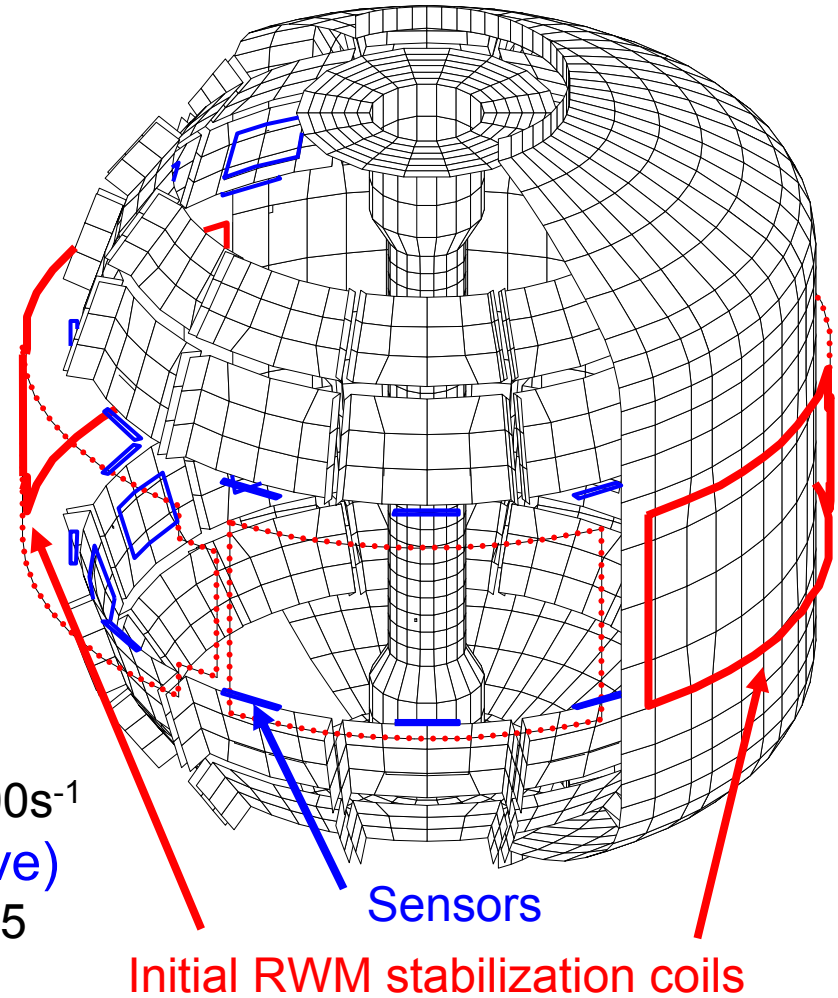
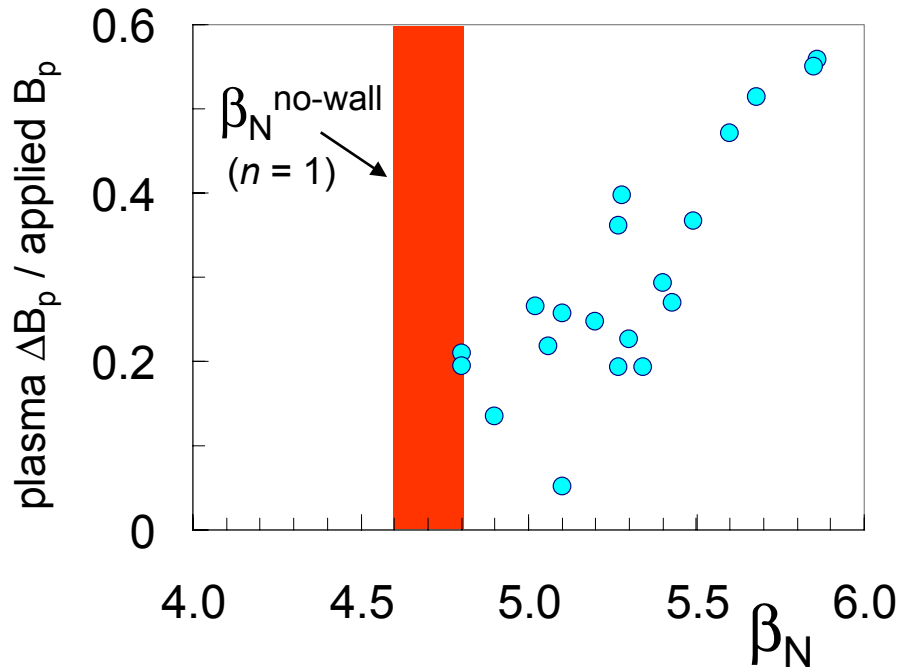


# Recent RWM sensor capability essential for feedback



- $B_p$  sensors measure
  - unstable  $n=1-3$  RWM
  - mode rotation can occur during growth
  - growth rate, rotation frequency  $\sim 1/\tau_{wall}$ 
    - $\ll$  edge  $\Omega_\phi > 1$  kHz
  - what will be needed / desired in real time?
- Control system
  - threshold / peak  $|B_p|$  for feedback
  - ability to track / alter mode phase evolution
  - focus on  $n=1$  for initial system (?)

# Pre-programmed current control of initial RWM stabilization coil pair adequate for CY2004 XPs



- Resonant field amplification increase at high  $\beta_N$  consistent with DIII-D
  - Measured stable RWM damping rate  $300s^{-1}$
- AC and pulsed  $n = 1$  field (standing wave)
  - Require traveling wave capability in 2005
- Ripple on applied pulse to be greatly reduced by new SPA supply

# MHD XP Prioritization: NSTX Forum 9/22/2004 (mod2)

- MHD XP Presentations requesting run time (RWM coil XPs highlighted)
  - Troyon Scaling at high  $I_N$ , high  $\delta$ , modified PF1A (Gates) 1.5 days(+1.5)
  - Error field/locked-mode studies using RWM coils (Menard) 1.5 days(+.5)
  - MHD spectroscopy of wall stabilized high  $\beta$  plasmas (Sabbagh) 1.0 days
  - Suppression of resonant field amplification at high  $\beta_N$  (Sabbagh) 1.5 days
  - Active stabilization of the resistive wall mode (Sabbagh) 1.5 days(+.5)
  - XP453: DIII-D/NSTX RWM similarity experiment (Sontag) 1.0 days
  - XP428: Dissipation physics of the RWM (Sontag) 0.5 days(+.5)
  - Onset and saturation characteristics of the 1/1 mode (Menard) 0.5 days
  - Active control of rotation damping in RWM plasmas (Zhu) 1.0 days
    - External kink and control of RWM (Okabayashi) (combined)
  - XP414: Aspect ratio effects near the high  $\beta_p$  equilibrium limit (Sabbagh) 0.5 days
  - Fishbone mode and the beam ion distribution function (Heidbrink) 0.5 days
  - DIII-D/NSTX CAE similarity experiment ( $B_t = 6$  kG) (Fredrickson) 0.5 days(+.5)
  - Neoclassical tearing modes (Fredrickson) 0.5 days
    - Piggy back
  - Kinetic Instabilities – TAE/central shear/q(0) – L-mode (Fredrickson) 0.0 days
    - Piggy back

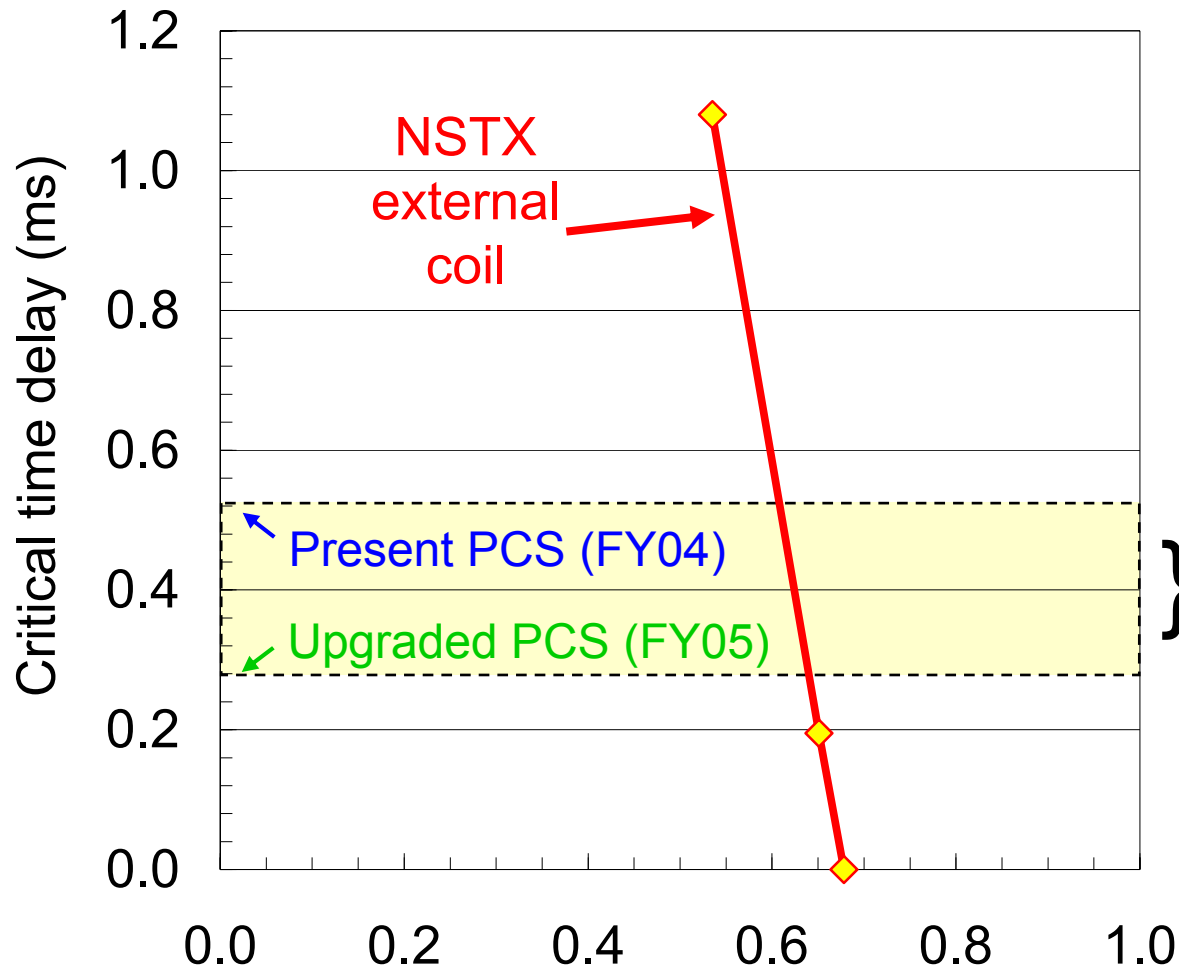
**Run days: 19.5-20.5; (guidance: 8 days for 14 week run, 12 days for longer)**



# Active RWM Stabilization – Discussion Topics

- Engineering update: Coil and power systems status
  - Circuit flexibility for odd/even parity, single turn coil capability?
- Control System plan / tasks discussion
  - Pre-programmed RWM coil capabilities
    - capability for DC and AC pulses, AC frequency range, time-dependent phase
    - capability of  $n > 1$  field generation for plasma rotation damping
  - RWM sensor input
    - real-time implementation, decision of sensors to use, mode discrimination, noise filtering
  - Controller
    - desired capabilities, software needs
    - control algorithm, flexibility for algorithm development, mode control vs. suppression
    - noise rejection,  $n > 1$  capability
    - PCS or alternate standalone controller ?
  - Output to SPA
    - voltage / current feedback control options, ability to switch
  - Feedback system analysis tasks
    - VALEN using present RWM coil, SPA specs, system latency,  $B_p$  sensors; other analyses

# Realistic time delay yields near-maximum stabilized $\beta_N$



- Insignificant change of maximum stabilized  $\beta_N$  over range of planned stabilization system time delay

$$C_\beta \equiv (\beta_N - \beta_{N\text{No-wall}}) / (\beta_{N\text{wall}} - \beta_{N\text{No-wall}})$$