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Resistive Wall Mode Research Plan FY 2004 - 2006

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for the

NSTX Research Team

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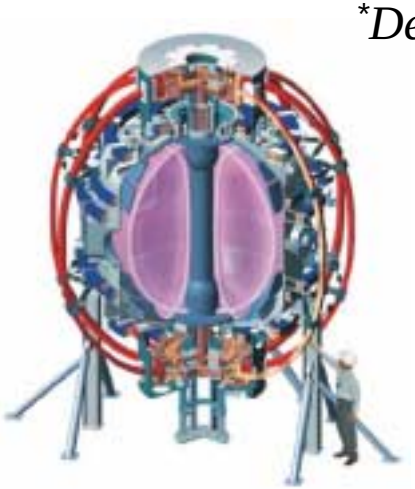

15th NSTX Program Advisory Committee Meeting

January 12 - 14, 2004

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NSTX

NSTX Preparing for Active Stabilization of High β Global MHD Instabilities

- Motivation
  - Resistive wall mode (RWM) identified and associated with global rotation damping
  - Beta collapse can follow rotation damping when $\beta_N > \beta_{N\ no\text{-}wall}$
- Goals
  - Study RWM stability space, rotation damping, dissipation mechanism
  - Determine aspect ratio effects in coordination with other devices
  - Enhance mode detection system
  - Design and implement active feedback stabilization system
  - Use active mode control at low rotation to maintain high β long pulse

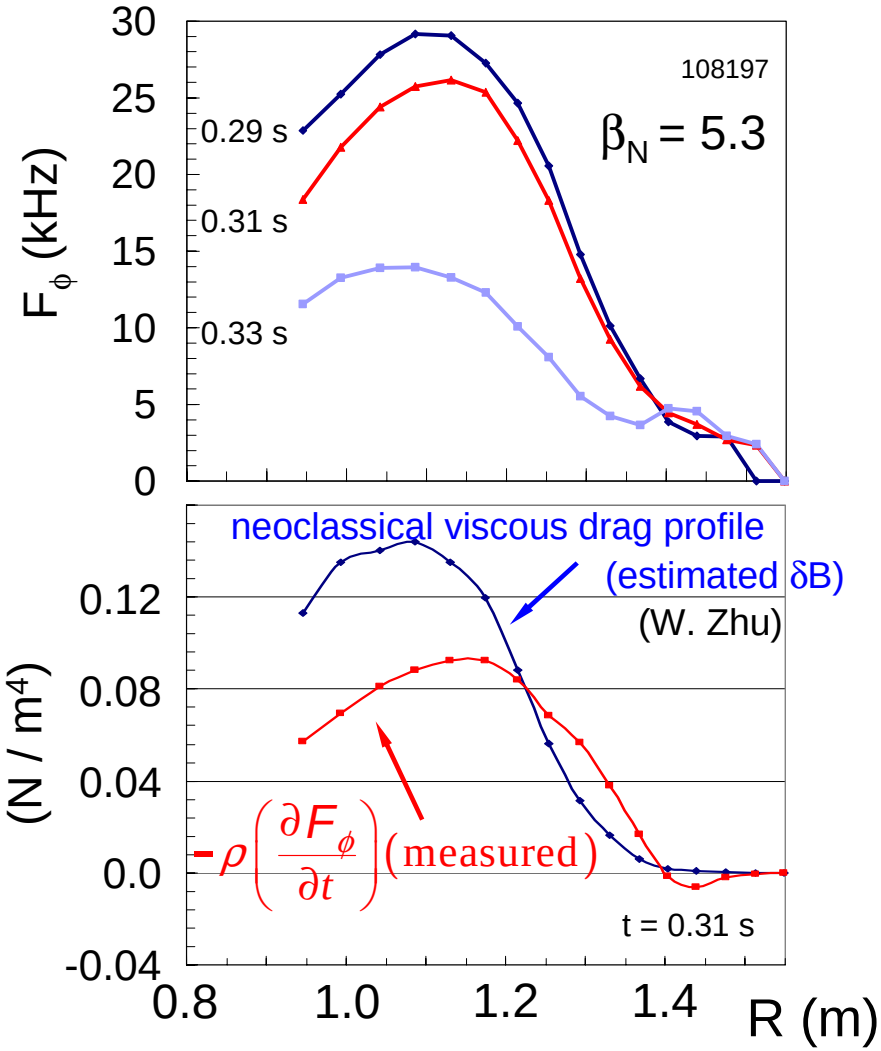
…even with budget related delays, research is largely on schedule

Key RWM physics studied under passive stabilizatioin

- FY2004 *(red text - experiments delayed from FY03)*
  - Assess dependence of critical rotation frequency for RWM stabilization on beta, q profile, shaping, V_A (started FY02)
  - Investigate RWM dissipation theories and compare to experiment
  - Conduct NSTX / DIII-D RWM similarity XP: investigate aspect ratio dependence of rotation damping, critical rotation frequency, dissipation
  - Compare theoretical / experimental mode structure using internal sensors
    - Measure n=2 RWM presently computed unstable in experiment at $\beta_N > 5.2$
  - Use MSE to assess role of q in RWM stability / rotation damping
  - Benchmark stability codes against experimental plasmas in (β_N, V_ϕ) space
- FY2005-future
  - Analyze RWM physics and stabilization in long-pulse, high-β plasmas
  - Study active feedback stabilization physics in low rotation plasmas

Rapid, global rotation damping observed during RWM

Toroidal rotation profile evolution during RWM

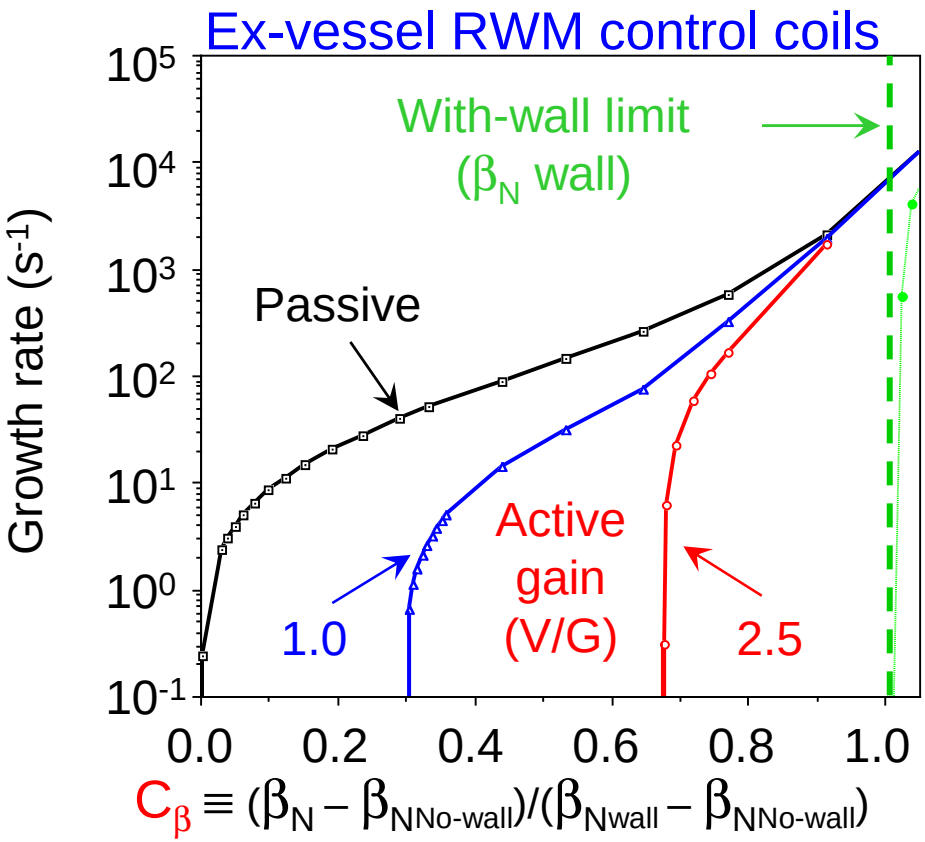


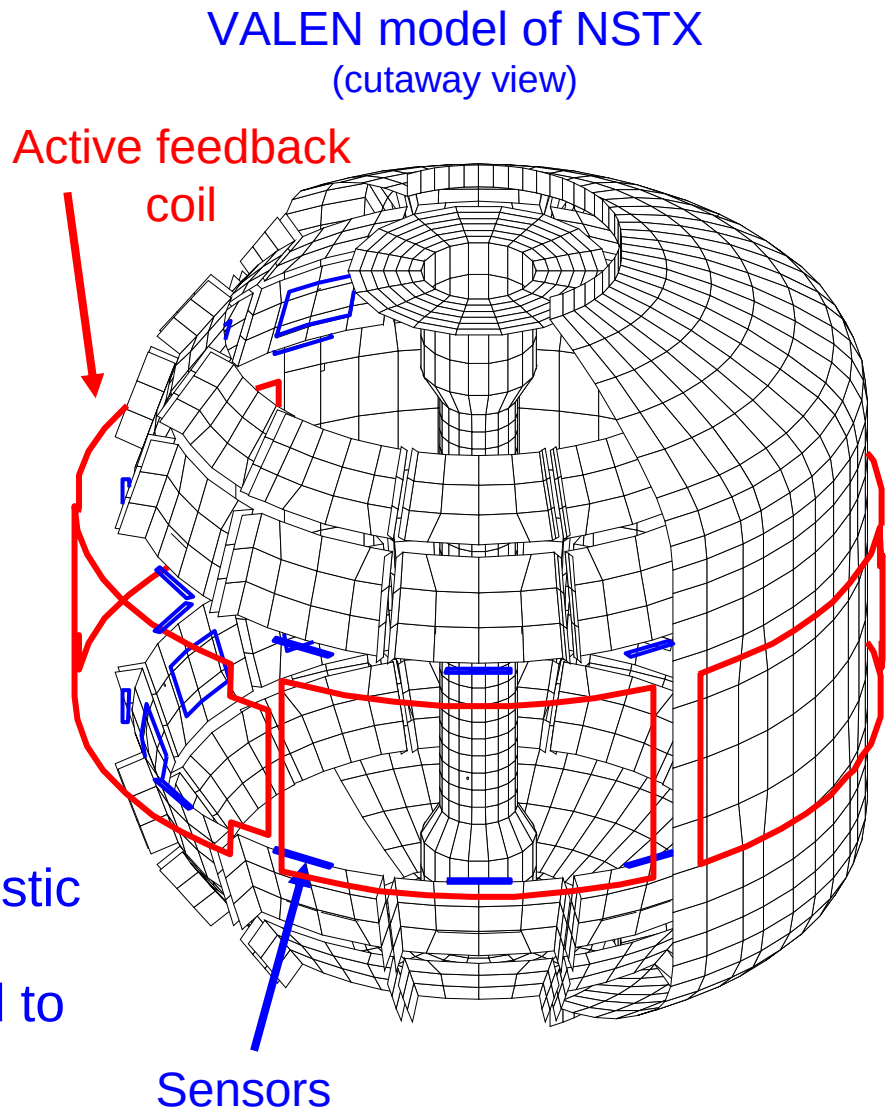
- Rotation damping rate more than 5 times greater than when $\beta_N < \beta_{N\ no\text{-}wall}$
- Occurs most frequently at lower $B_t < 0.4T$
  - Possible q effect on RWM stability
- Unlike localized JxB drag observed due to islands
- Quantitative experimental comparison to neoclassical viscous drag theory
  - initial study: agreement within a factor of 3 over many shots

RWM active feedback plan remains on schedule

- FY2003
  - Finalized physics design of active coil set
  - Decided on external coil set and began engineering design
  - Initiated procurement of power supplies
    - delayed due to budget uncertainty
  - Commission internal RWM/EFA sensor array electronics
    - installed and instrumented; calibration delayed to FY04
- FY2004 *(critical elements: must not slip to maintain schedule)*
  - Procure, install, and commission active coil set and power supplies; purchase and install DAQ for PCS
  - Bandwidth capability sufficient to suppress EFA
- FY2005
  - Optimize control system time delays
  - Active feedback on RWM at full capability of coil, algorithm optimization
- FY2006
  - Maintain high β plasmas with plasma rotation below the critical rotation frequency
  - Determine options required for stabilization at higher β_N (e.g. internal coil)
    - Possibly modify NTM island formation

Active control may sustain 68% margin above $\beta_{N\text{no-wall}}$



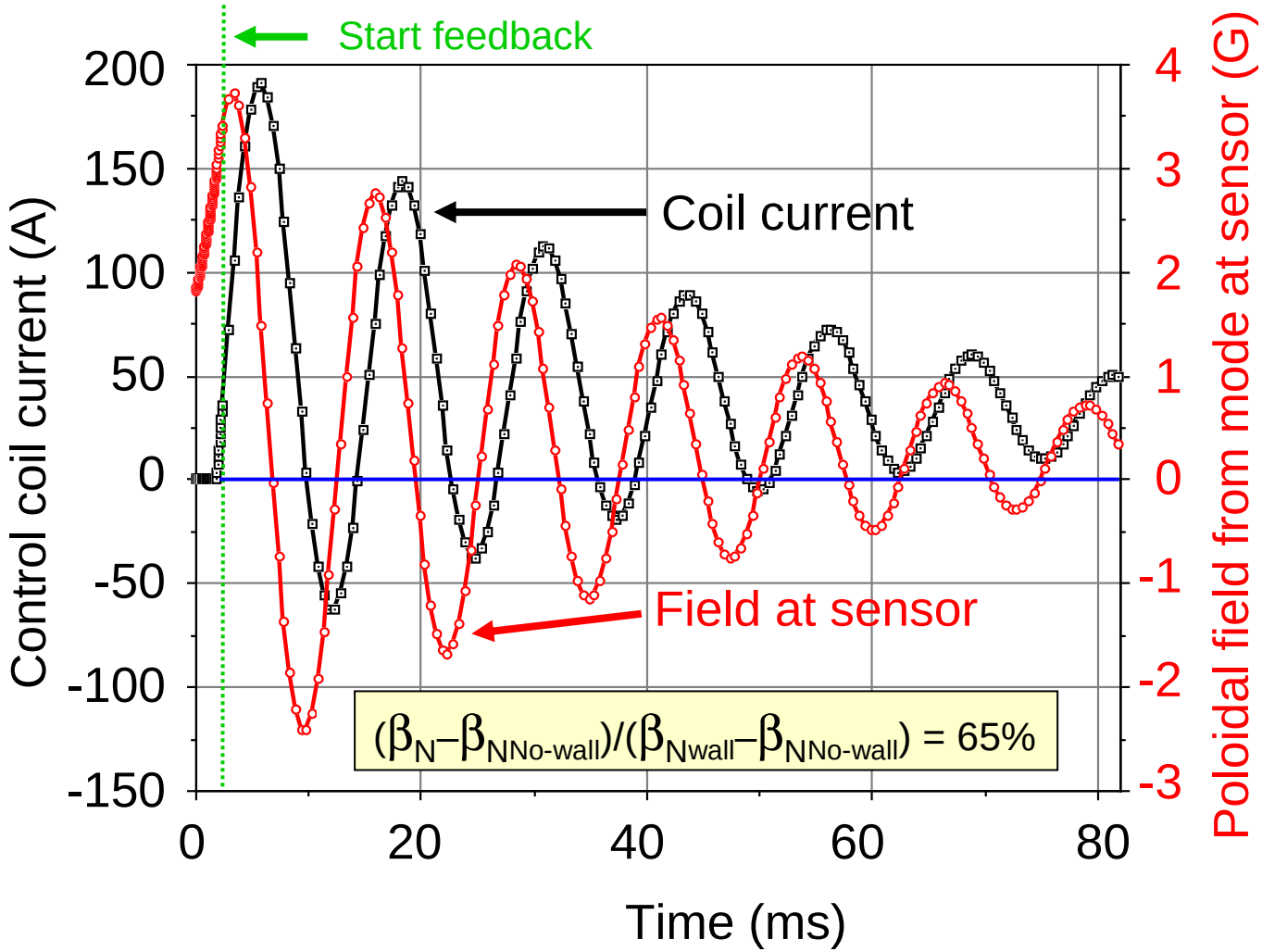


- External control coil design with realistic geometry
- Internal control coil design computed to reach $\Delta\beta_N = 94\%$

(Equilibria used have $\beta_{N\text{no-wall}} = 5.1$; $\beta_{N\text{wall}} = 6.9$)

VALEN (J. Bialek)

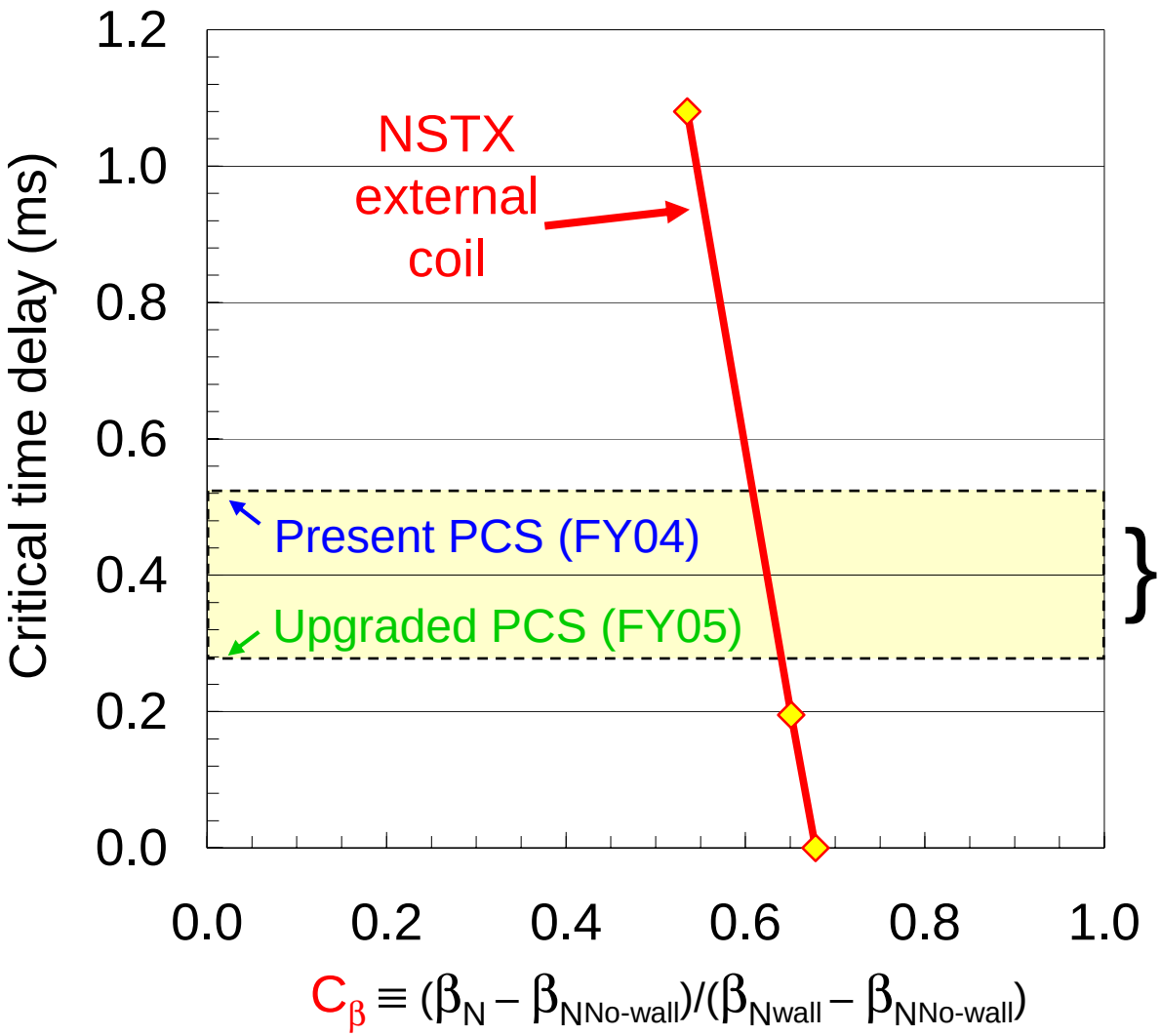
Active mode control modeling shows mode stabilization



- "Mode control" feedback algorithm simulation
- Ideal system response (no time delay between mode detection and feedback)

VALEN (J. Bialek)

Realistic time delay yields near-maximum stabilized β_N

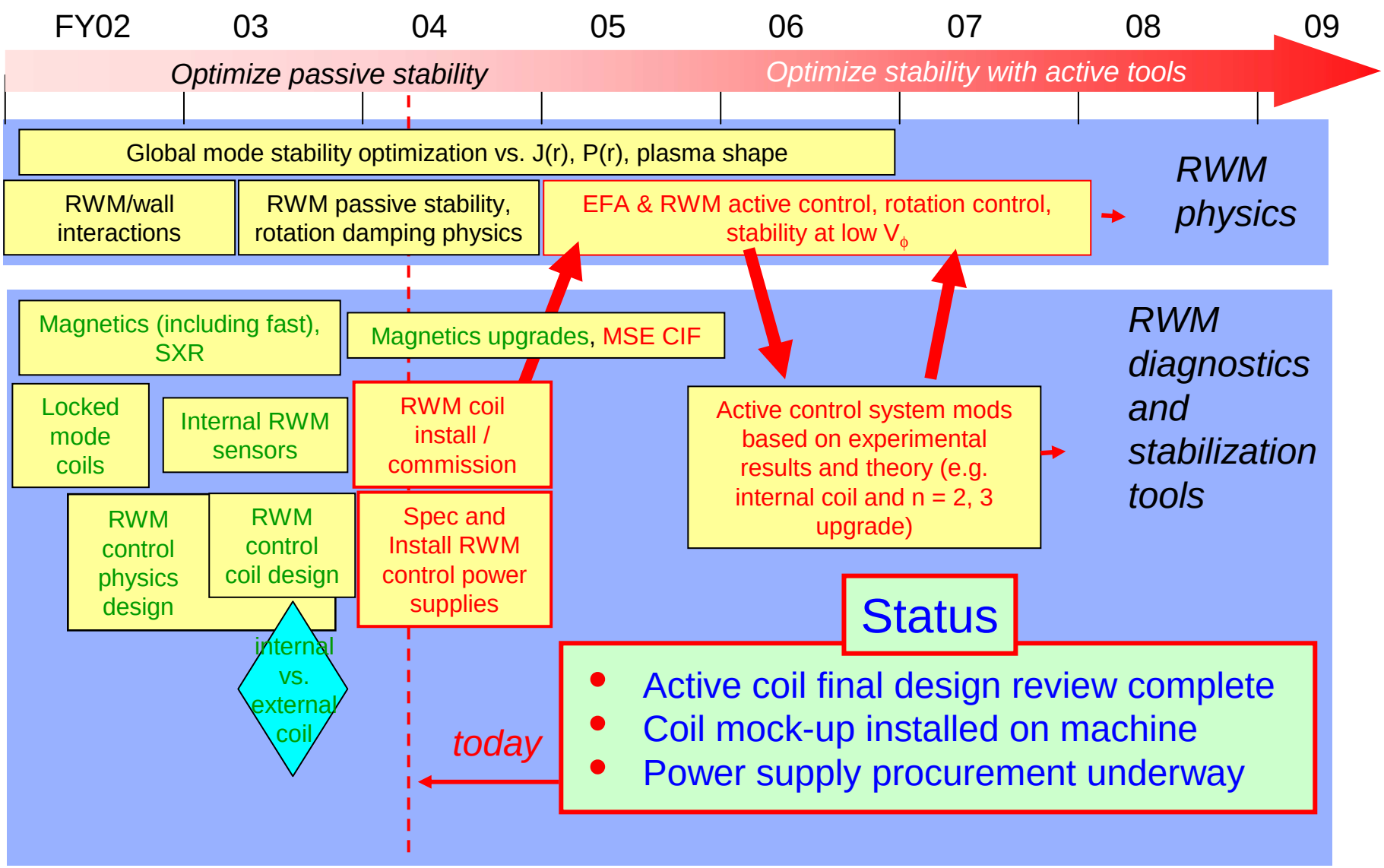


- Insignificant change of maximum stabilized β_N over range of planned stabilization system time delay

Planned NSTX system time delay range

VALEN (J. Bialek)

RWM stabilization plan following 5-Year Plan timeline



FY04 RWM XPs properly address 5-Year Plan

- Proper emphasis on RWM in 2004 NSTX Forum XPs
- Flexible program with greater priority to XPs using active feedback coil when available
  - RWM experiments under passive stabilization
    - Passive stabilization physics of the RWM
    - Rotation damping physics in high β_N ST plasmas
    - Dissipation physics of the RWM
    - DIII-D/NSTX RWM physics similarity XP
  - RWM experiments using active feedback coil
    - Active RWM control physics
    - DIII-D/NSTX RWM physics similarity XP
    - External kink and control of RWM
    - Error field amplification joint experiment

RWM research schedule is following the 5-Year Plan

- Despite overall reduction of facility upgrade budget, support for RWM stabilization system has been maintained
- Delay in budget guidance delayed power supply procurement process
  - Total system implementation schedule tighter, not delayed
- Completion of difficult FY04 tasks needed for maintaining schedule
  - Procurement / installation of active stabilization system power supply
  - Active stabilization coil construction during FY04 run
  - Integration of power supply, coil, and control system