RWM Feedback of AT plasmas with Audio Amplifiers on the DIII-D Device
- Issues of Robustness of Feedback Performance -

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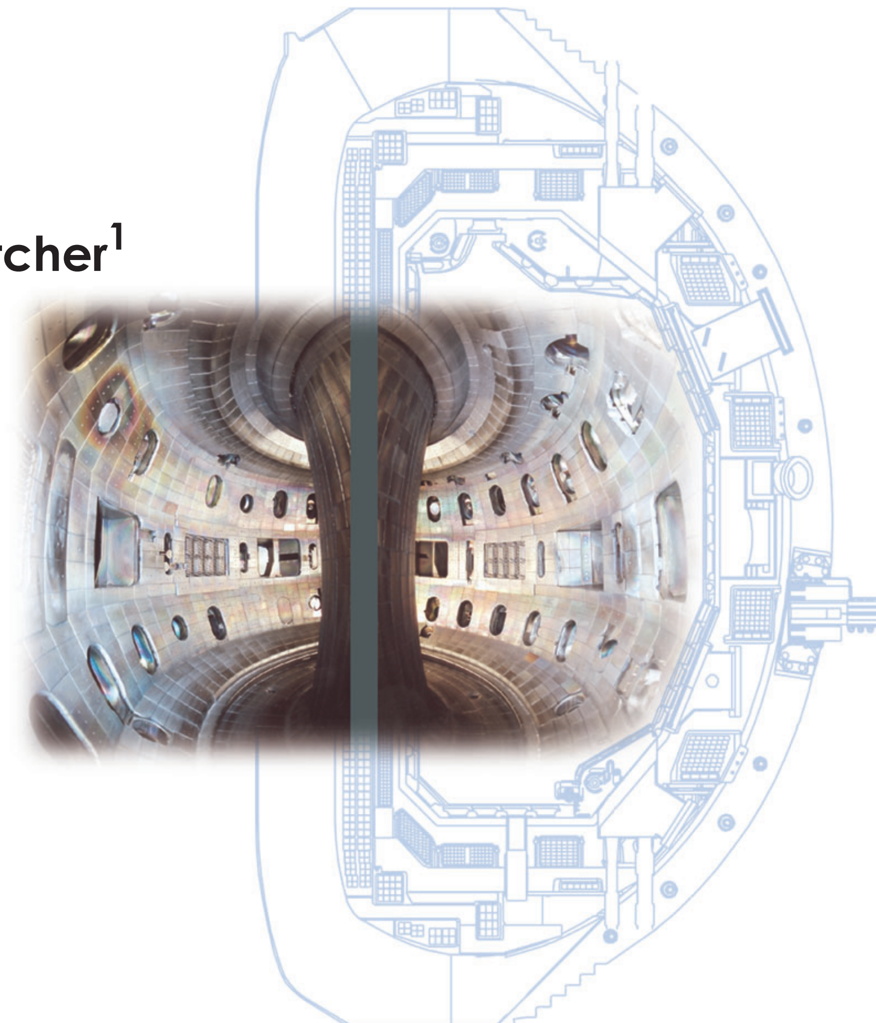

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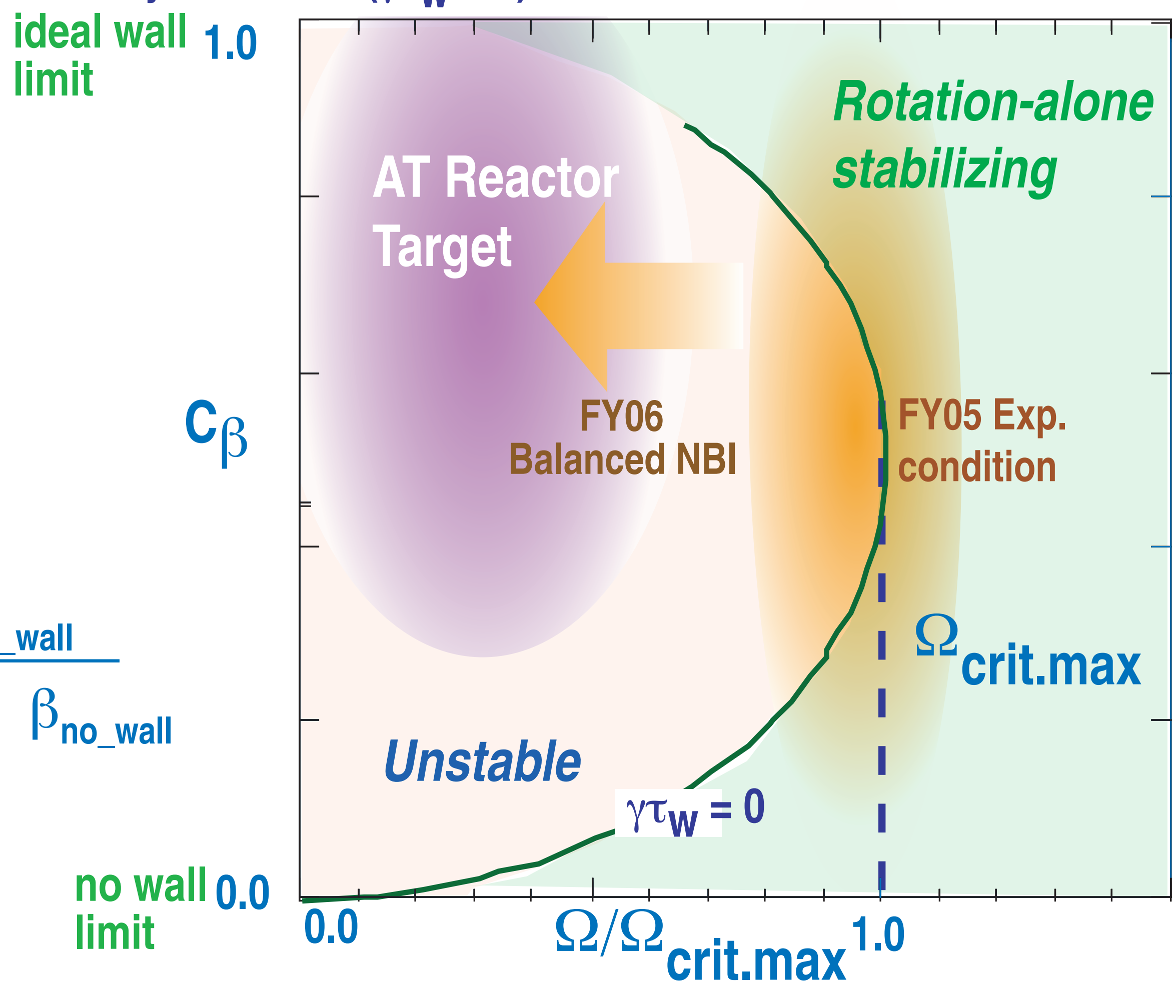
PPPL PRINCETON PLASMA PHYSICS LABORATORY

Synergetic Advantage of Combined RWM Stabilization with Rotation and Feedback Substantially Reduces Both Required Plasma Rotation and Feedback Gain

Marginal stability condition ($\gamma\tau_W = 0$) with Rotational stabilization

$$C_\beta = \frac{\beta - \beta_{no\_wall}}{\beta_{ideal\_wall} - \beta_{no\_wall}}$$



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Marginal stability condition ($\gamma\tau_W = 0$) with Rotational stabilization +Feedback

Combined stabilization
Feedback gain

$$G = \left.\frac{\delta\Psi_{FB\_coil}}{\delta\Psi_{mode}}\right|_{sensor}$$

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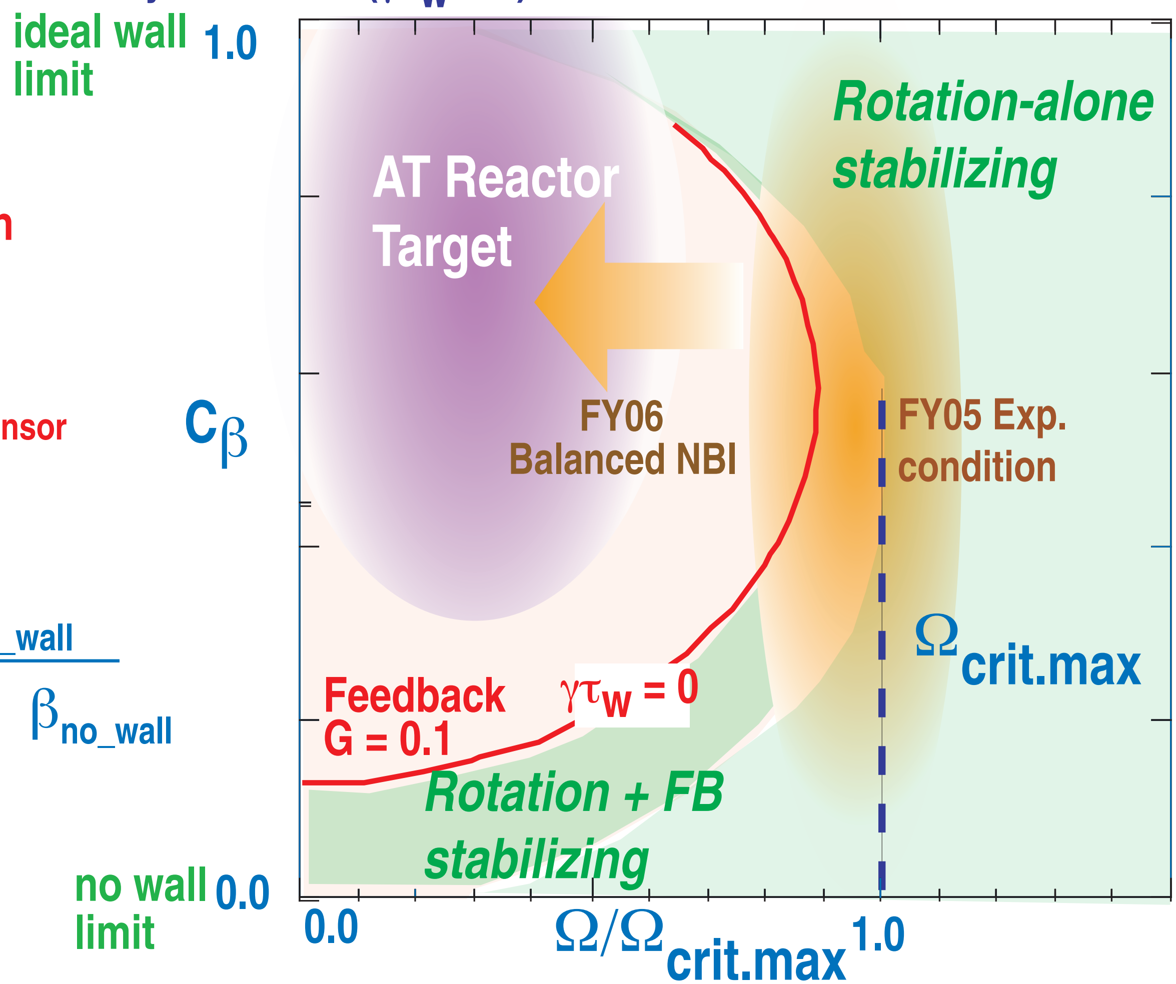

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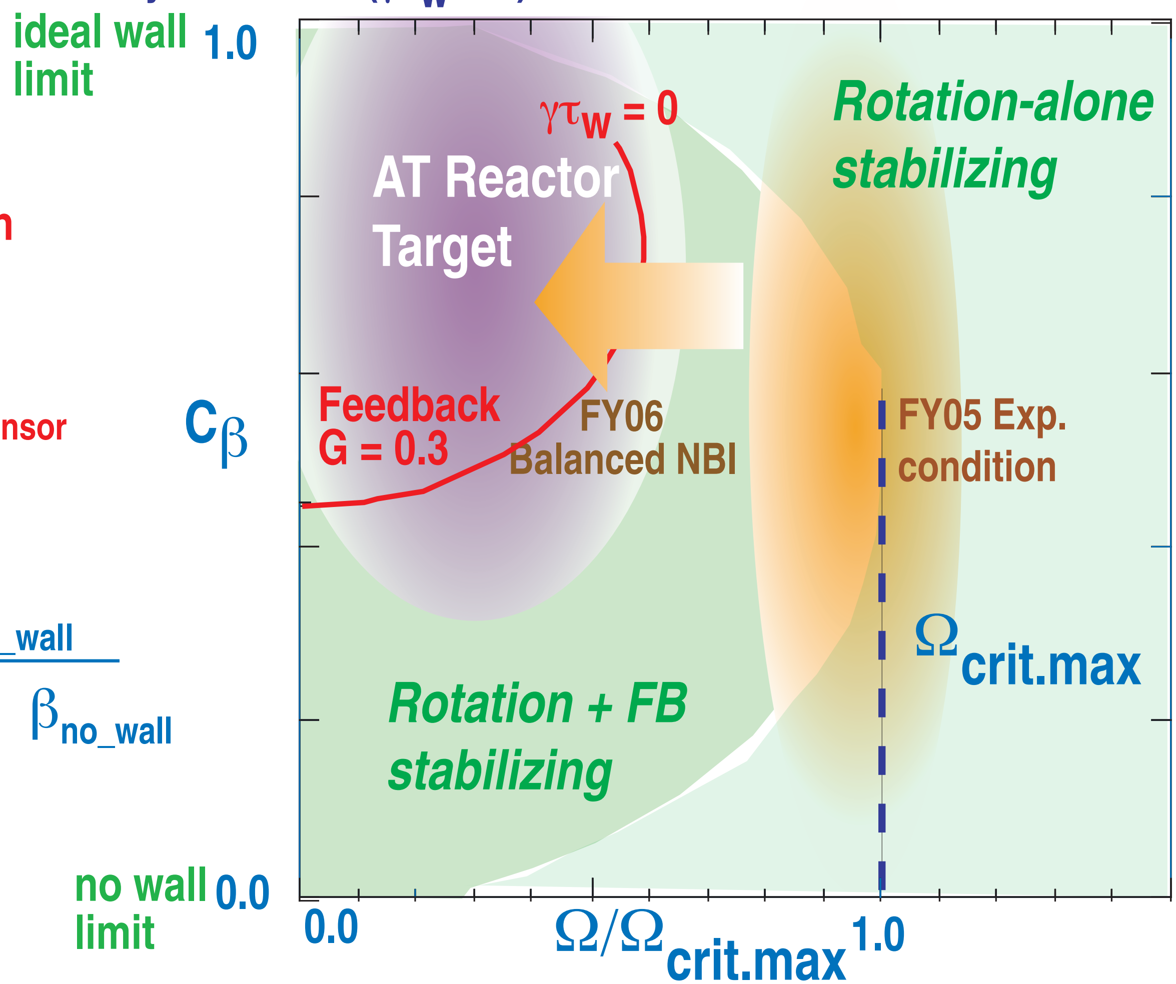

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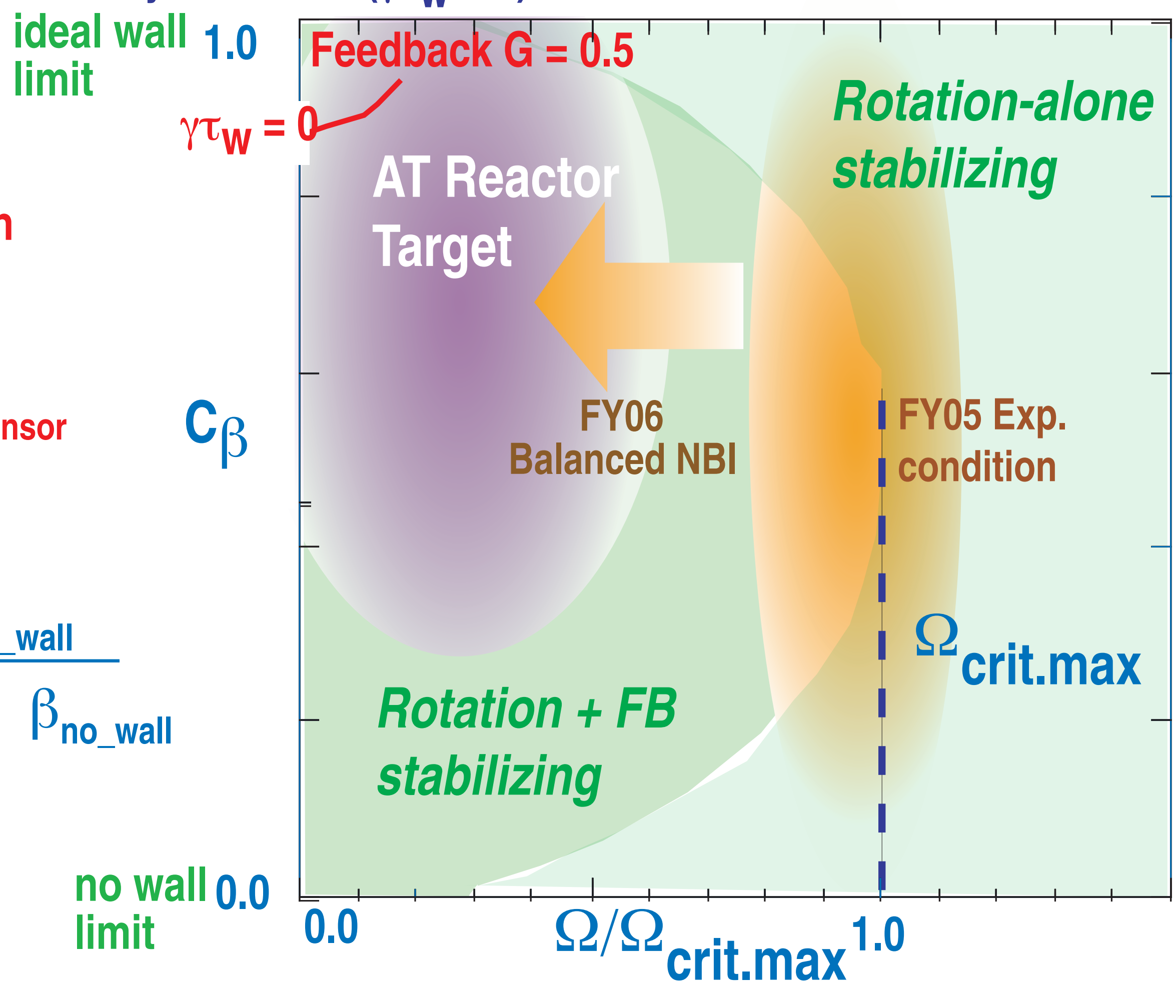

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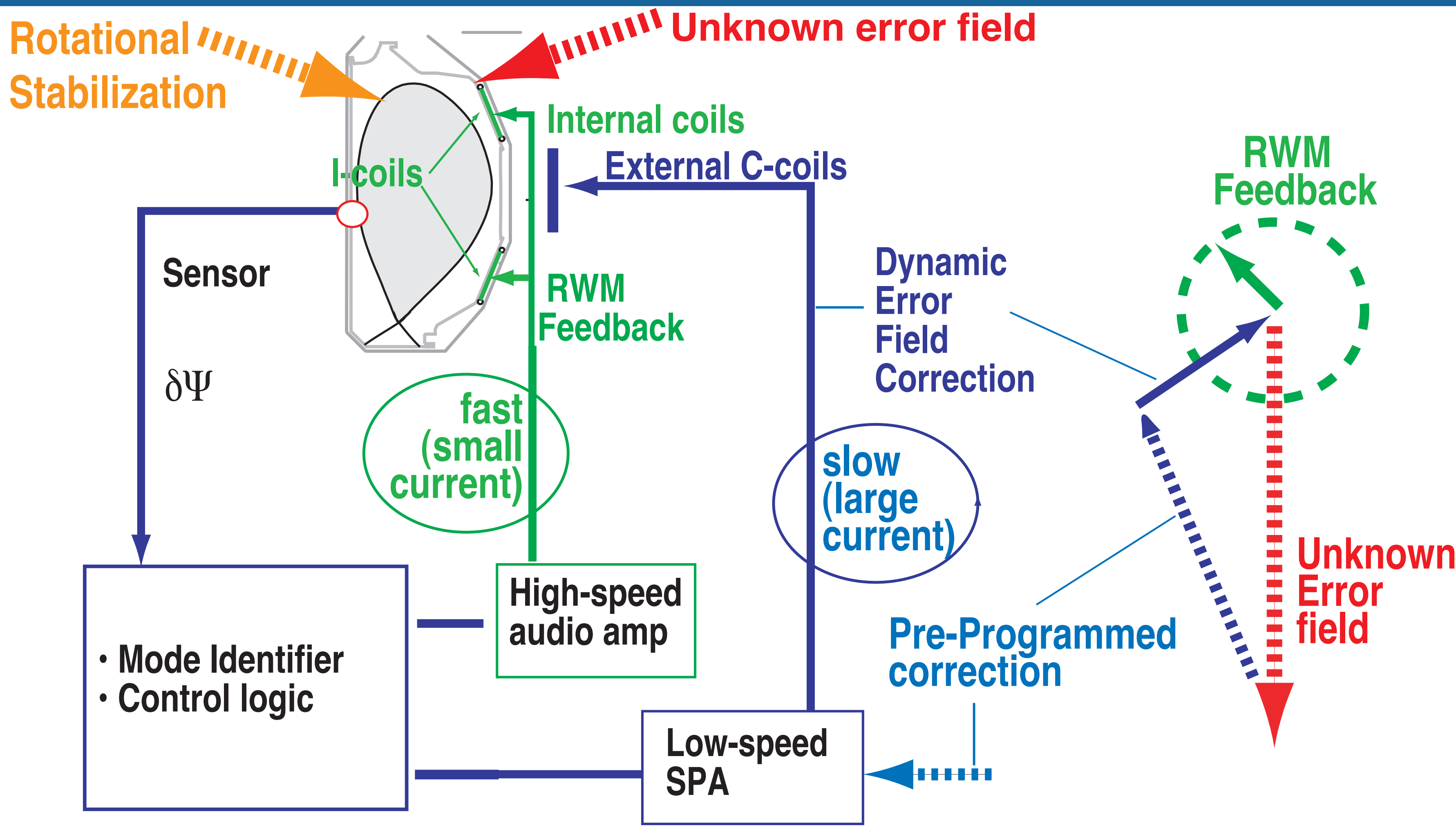
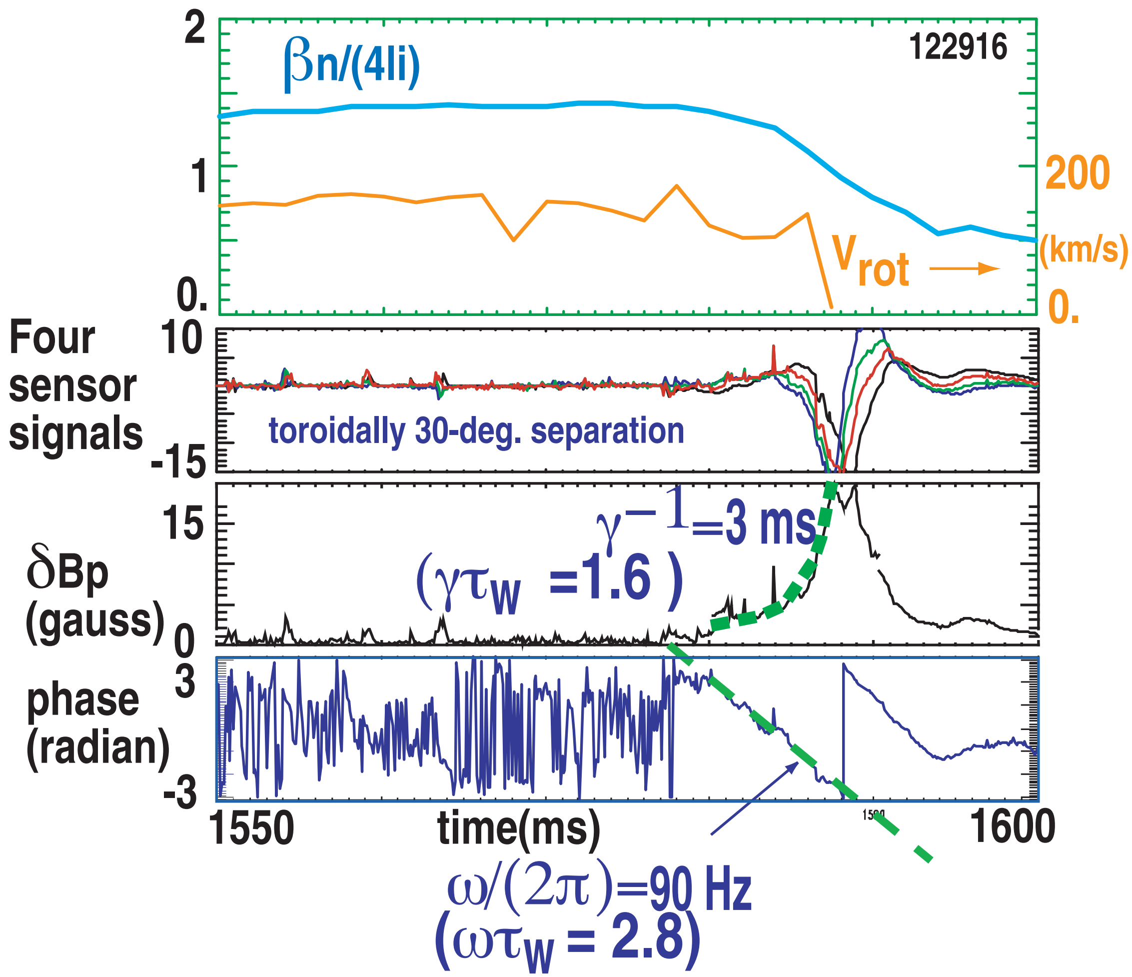
OUTLINE

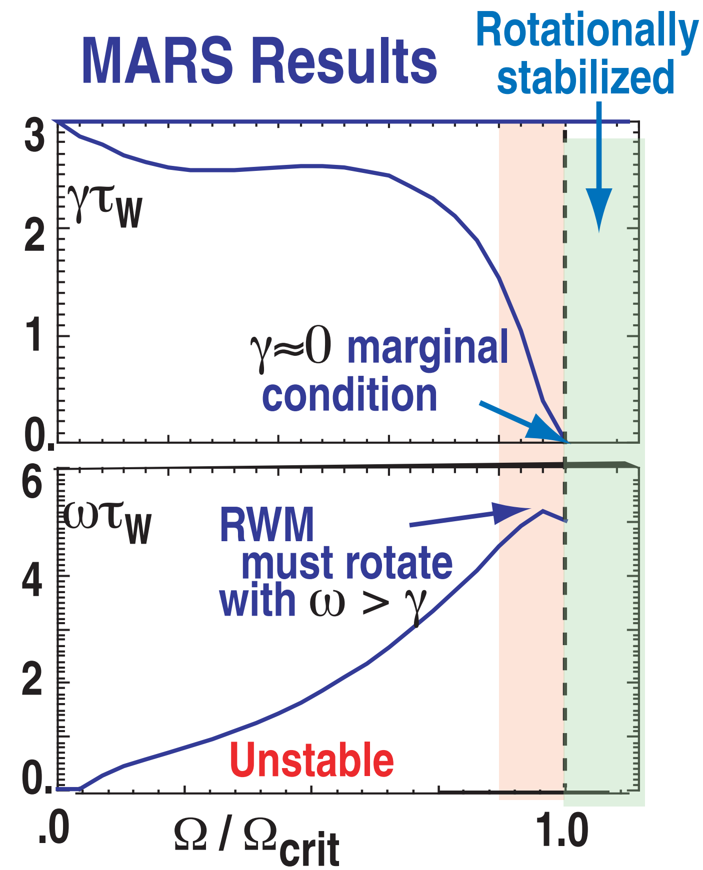
- Two independent power supply system for non-axisymmetric magnetic field is effective and efficient
  - Existing Slow Switching Power Amplifiers (SPA) ⟶ Dynamic Error Field Correction
  - New Audio Amplifiers (AA): DC- 40 kHz ⟶ Direct RWM feedback
- With better error field correction, RWM behaves as predicted by theory (without feedback)
  - Together with commonality of RWM in other devices (JET/NSTX)
    -> added the confidence on RWM physics understanding
- RWM feedback assisted the performance in q>2 AT plasmas
- Without feedback abrupt events (like ELMs) cause bursting RWMs
  - Large ELM event can lead to a major collapse by exciting RWM
- With Feedback feedback reduces the n=1 RWM bursting activity
  - A possible hidden parameter for robust feedback operation can be "ELM event"

Two Independent Power Supply Combination is Effective and Efficient for Improving the n=1 RWM Stabilization

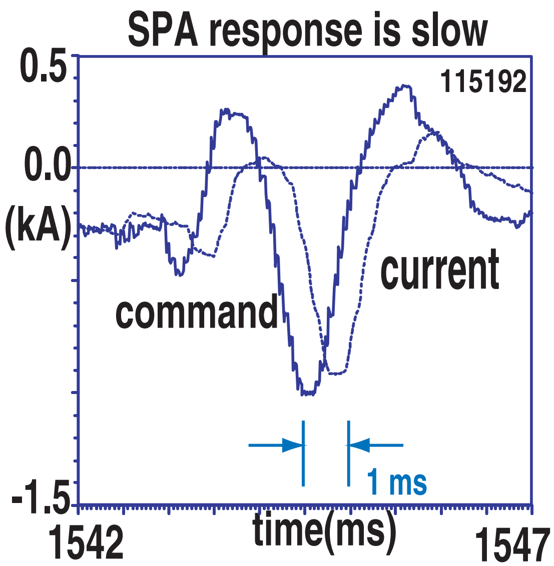


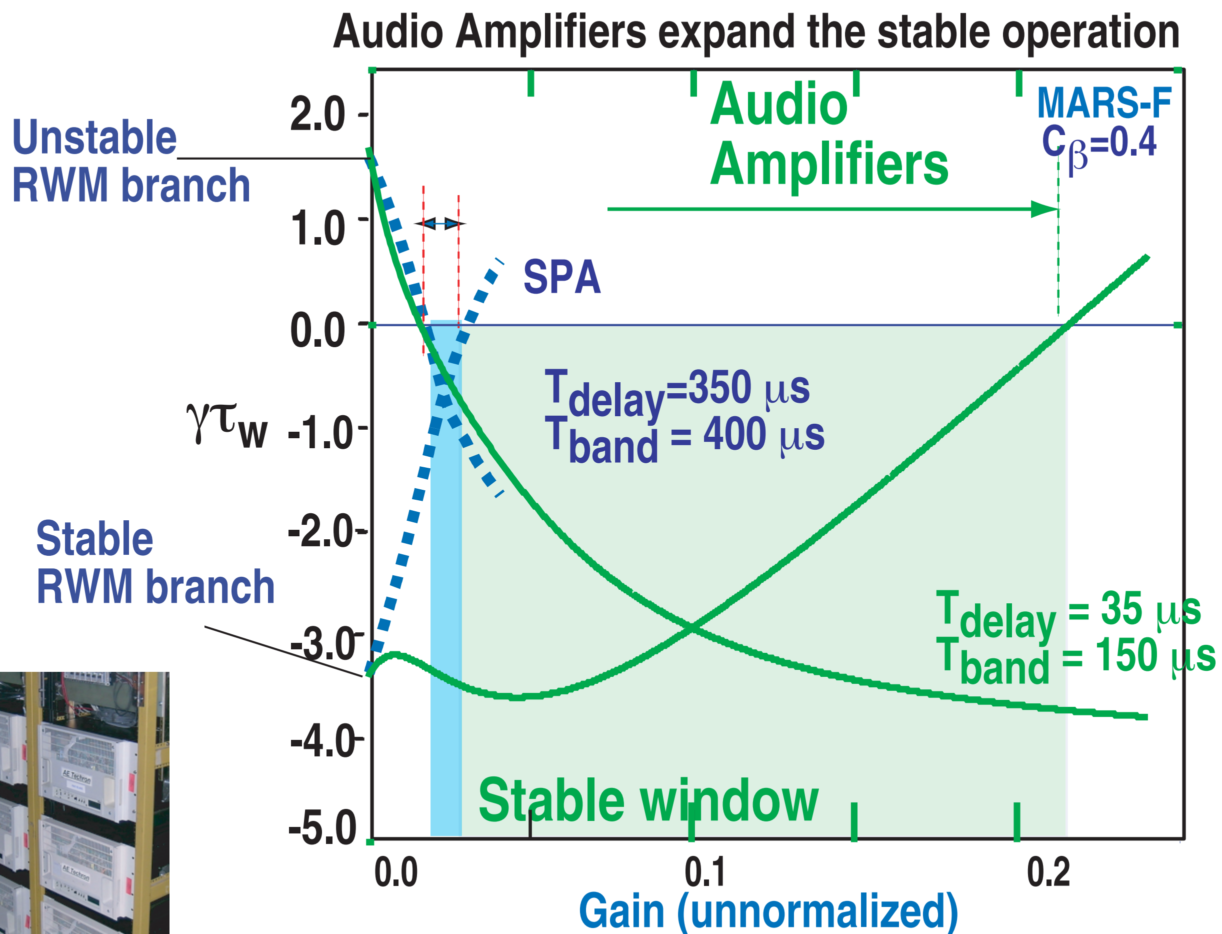
Observed Relation: Real Frequency $\omega\tau_W$ > Growth Rate $\gamma\tau_W$ are Consistent with RWM Theory (Without Feedback)





Audio Amplifiers have been installed to Improve the Time Response





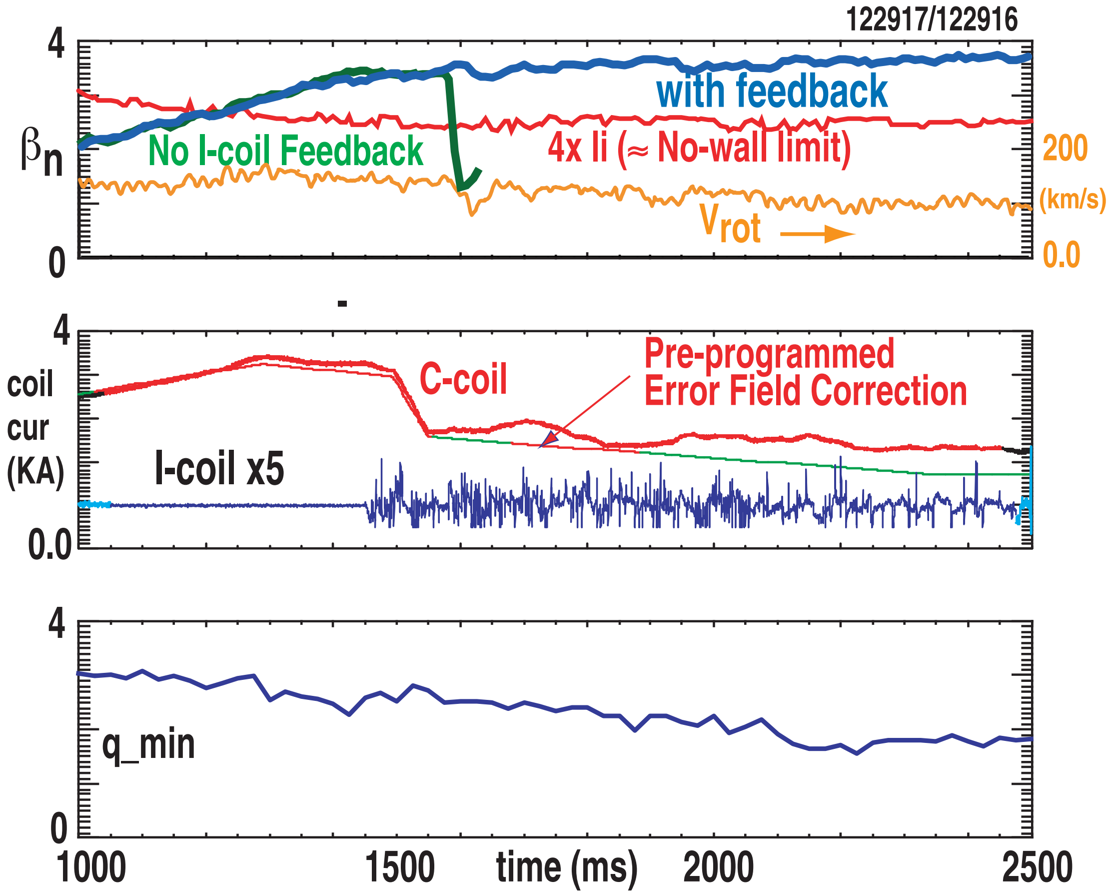
Audio Amplifiers

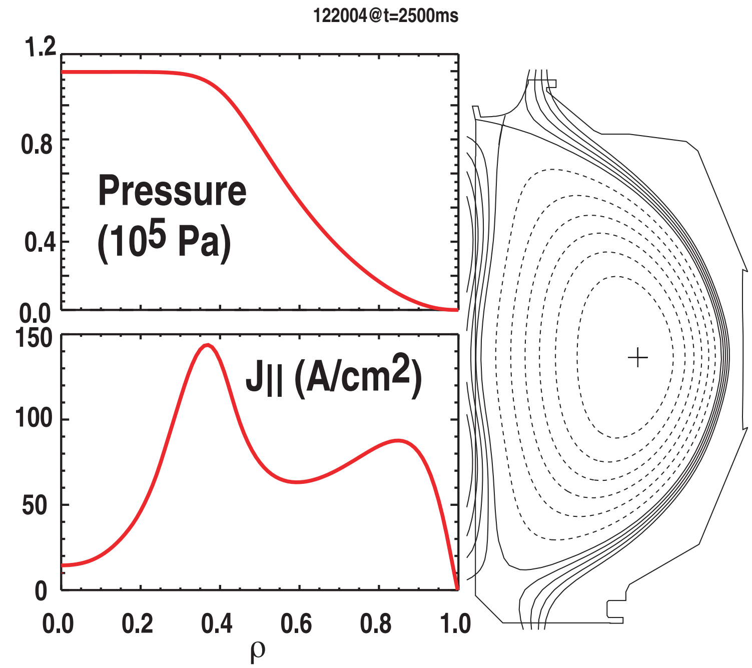
- 200A 100V
(6 units in FY05)
- parallel connection capability
- DC-40 kHz

-> G. Jackson CP1.
Monday afternoon

RWM Stabilization Has Opened Path to New High Performance Regimes

- Simultaneous dynamic error field correction and RWM feedback control assists AT operation (β_N ~ 4 with q_min > 2)

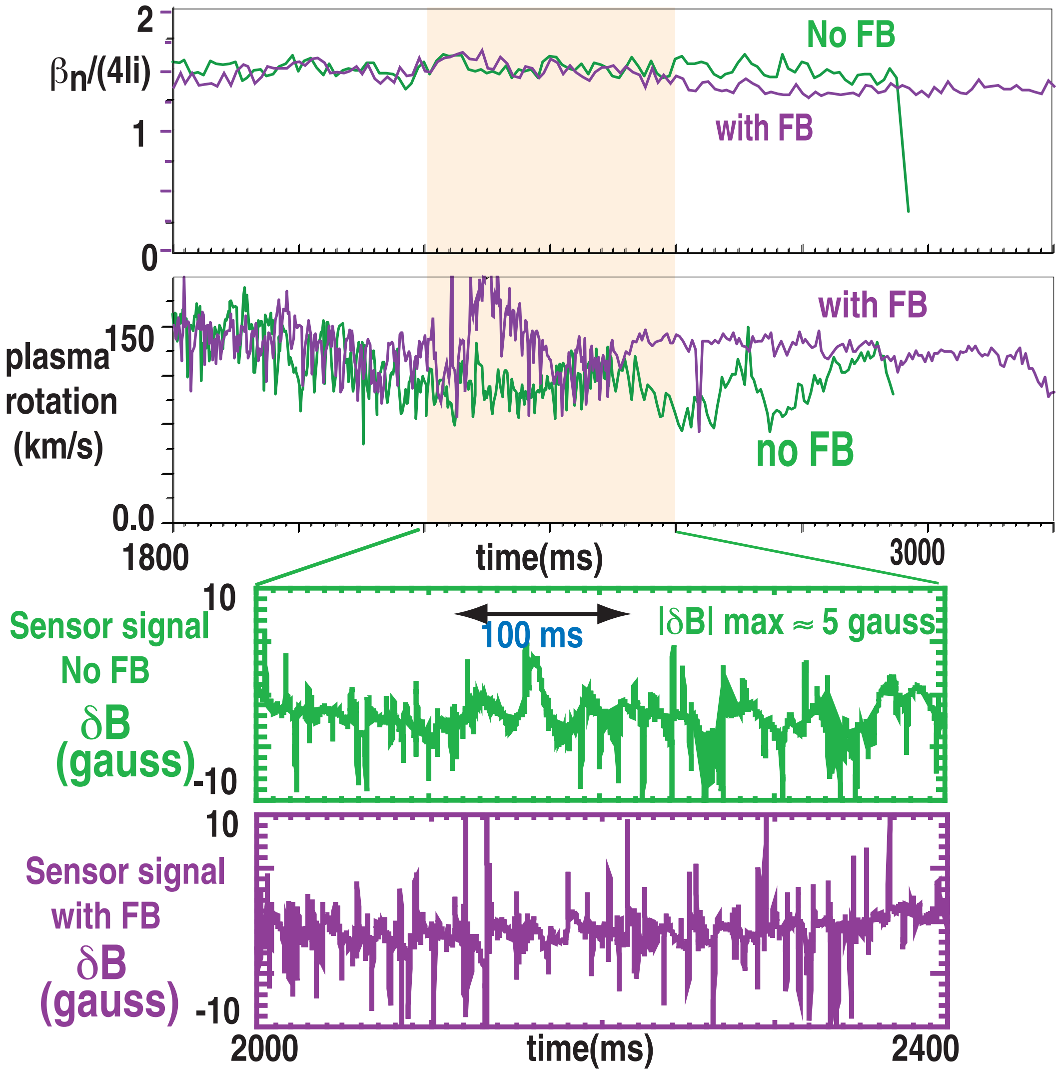


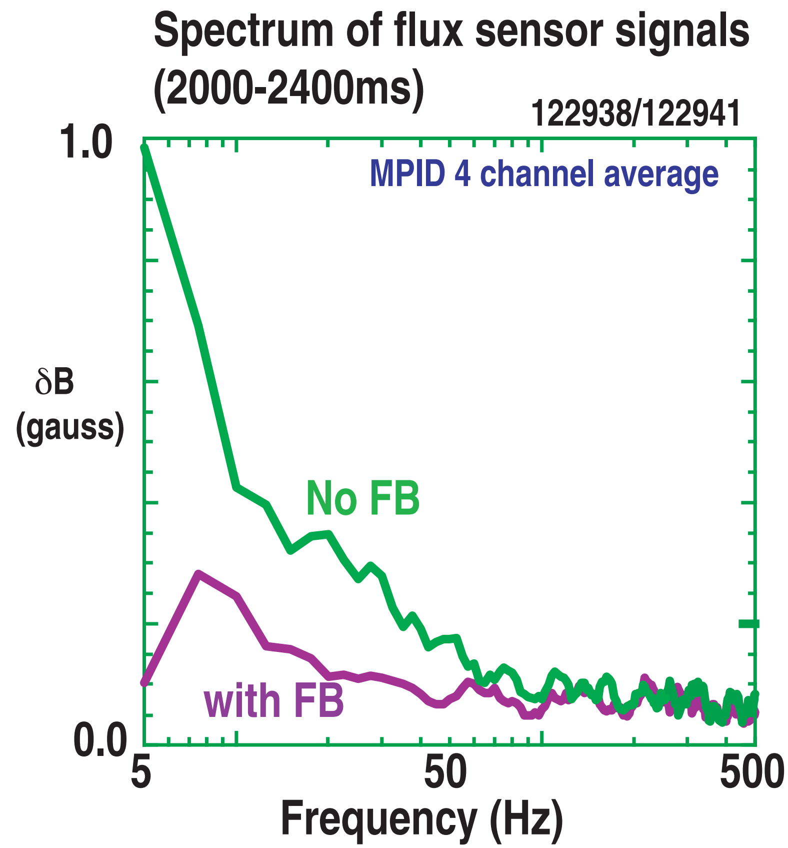


-> A.Garofalo U12.03 Friday Morning

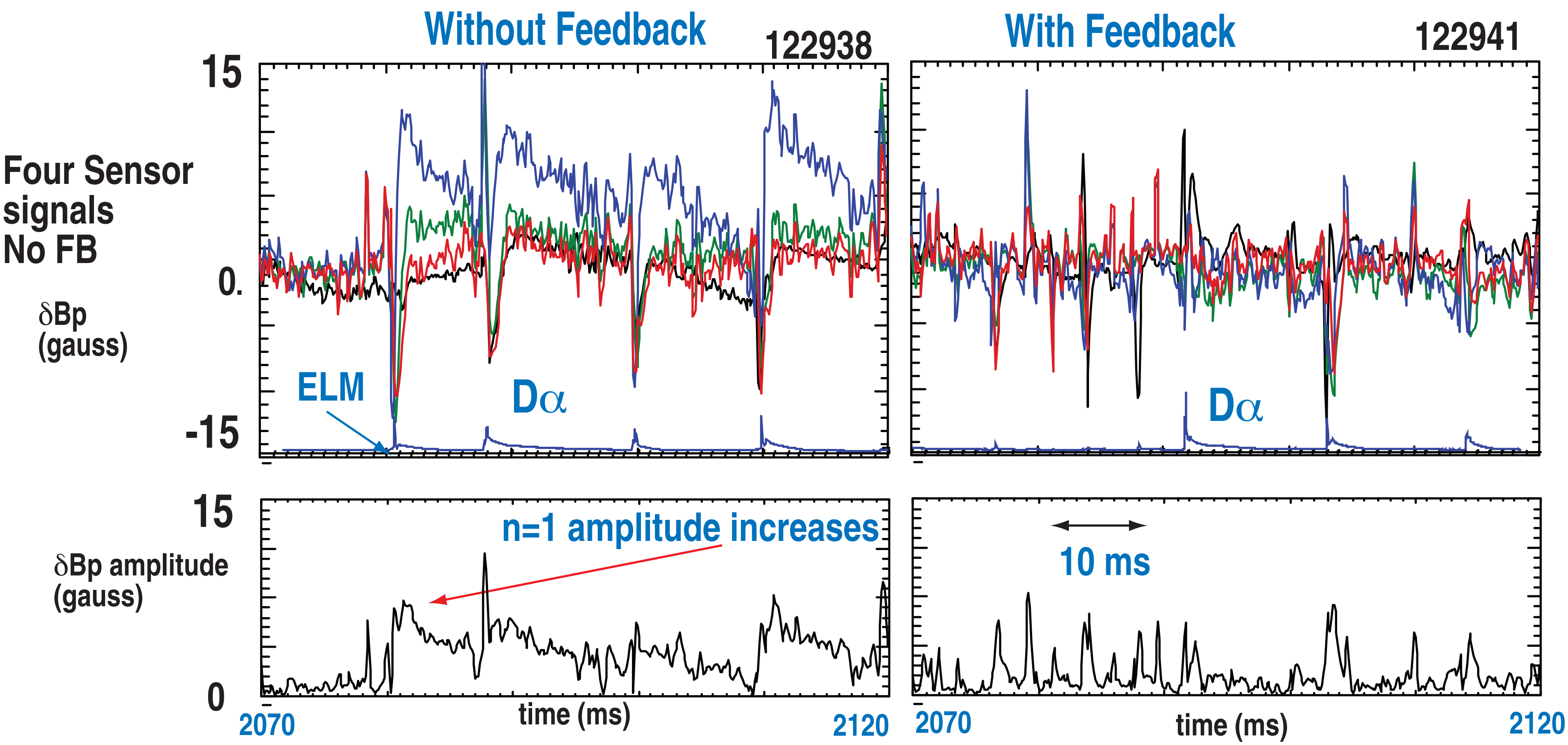
Feedback with Audio Amplifiers Reduces the Bursting n=1 Activity

- δB-max ≈ 5 gauss RWM is repetitively excited





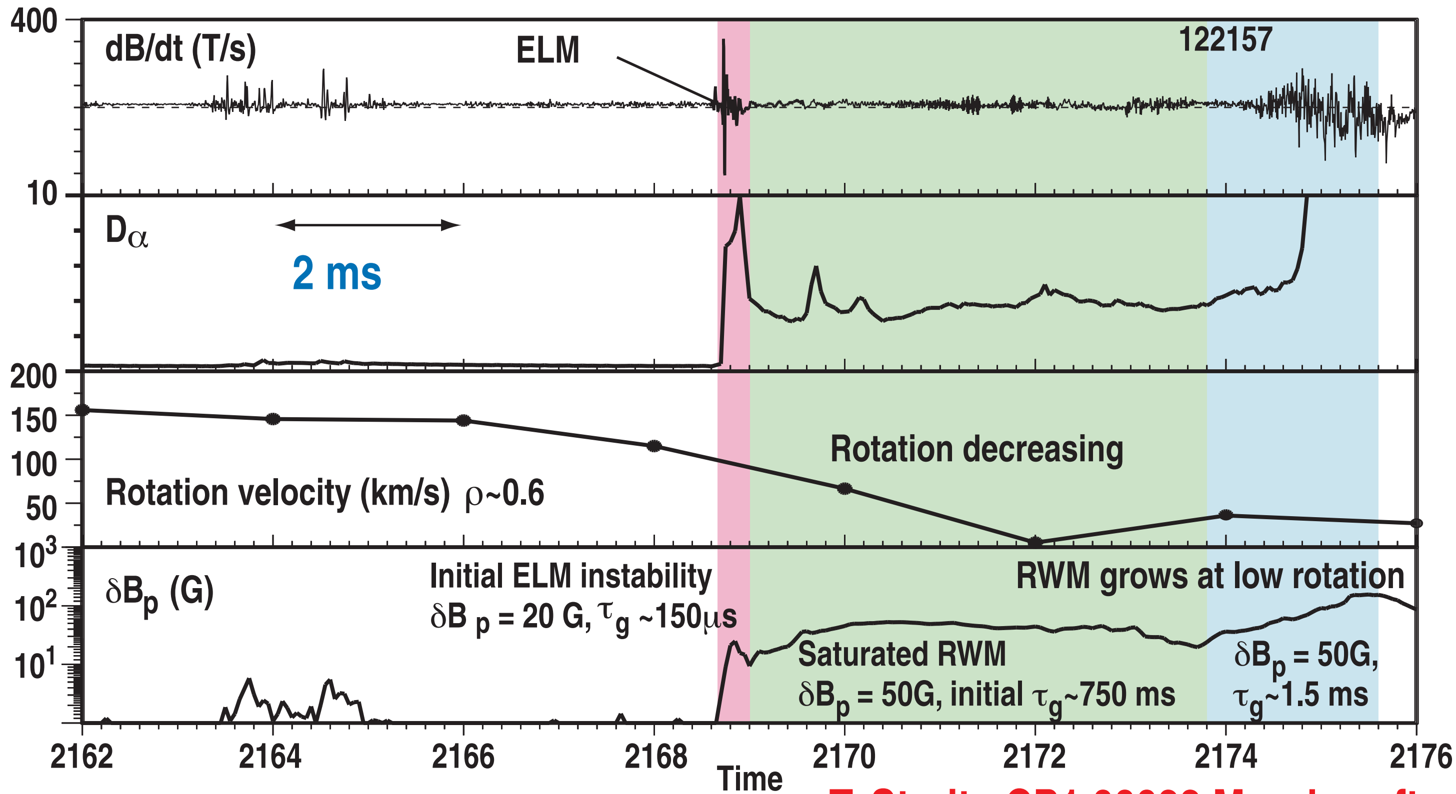
Feedback Also Reduces the n=1 RWM Activity at ELM Aftermath



• Sometimes, n=1 RWM amplitude remains finite at the following ELM event

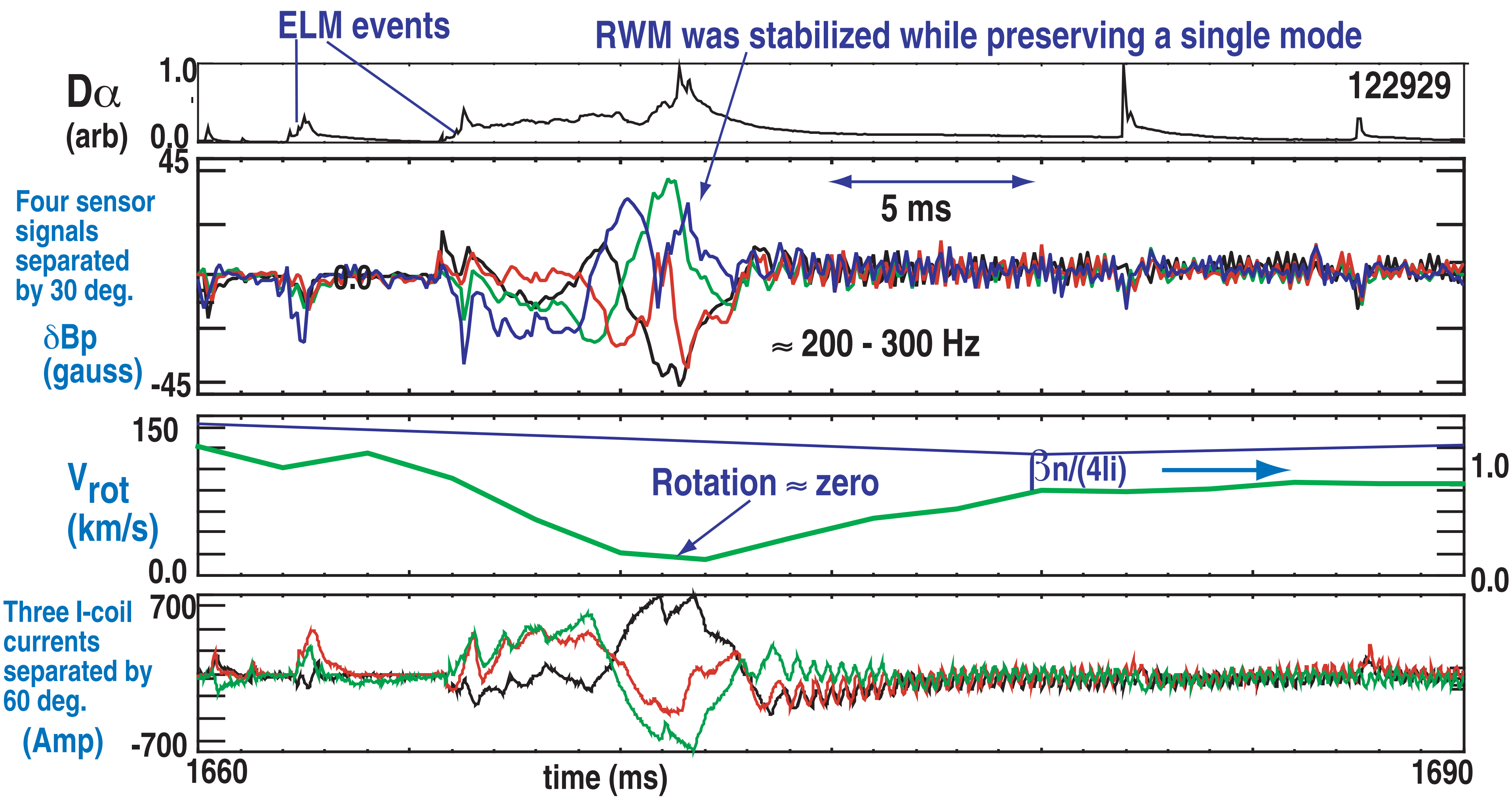
Possible Excitation of Unstable RWM by ELMs (without feedback)

- Hypothesis: Near marginal stability for the RWM ...
  - Sometimes, ELM excites a weakly damped RWM at a large amplitude (≈ 10 Gauss)
  - Magnetic braking by the RWM causes plasma rotation to decrease
  - If sufficient braking occurs during the damping time, the RWM becomes unstable



-> T. Strait : CP1.00022 Monday afternoon

Feedback Suppressed Large Amplitude RWM Buildup and Allows the Plasma to Survive Transient Intervals of Low Rotation



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SUMMARY

- Two independent power supply system is effective and efficient for RWM control,
  - SPA : slow, high current with External Coils --> Dynamic Error field correction
  - New AA : fast, small current with Internal Coils --> RWM feedback

  -> G. Jackson CP1.19 Monday afternoon

- RWM (no feedback) is excited as predicted by RWM theory
  - Universality of RWM in other devices - added confidence on RWM physics understanding

  -> H. Reimerdes GI1.05 Tuesday afternoon (Invited paper)

- RWM feedback assisted the performance in q_{min} >2 AT plasmas -> A.Garofalo U12.03 Friday Morning (Invited paper)

- Without feedback, bursting n=1 RWMs are excited during high beta
  - Possibility of fatal RWM: ELM induces large amplitude RWM leading to rotation collapse

  -> T. Strait : CP1.22 Monday afternoon

- Feedback reduced these n=1 bursting activities
  - Feedback can avoid the beta collapse even though rapid rotational collapse takes place
  - Need of precise mode identification near ELM event -> Y. In: CP1.00021 Monday afternoon

- A possible hidden parameter of robustness for RWM control is "ELM events"
  - will be studied in FY06 with AA currents up to 1200A in balanced NBI low rotation plasmas

  -> G. Jackson CP1.19 Monday afternoon

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