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Resonant Field Amplification and Resistive Wall Mode Stability in NSTX

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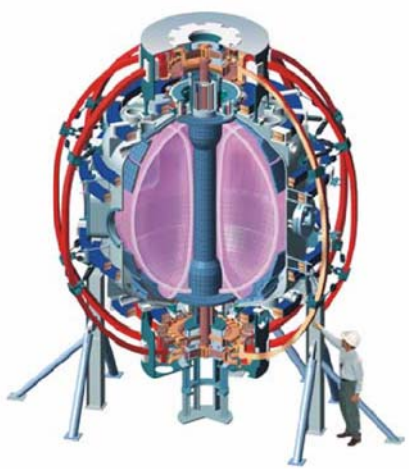

47th Annual Meeting of the Division of Plasma Physics
American Physical Society
October 24 – 28, 2005
Denver, Colorado

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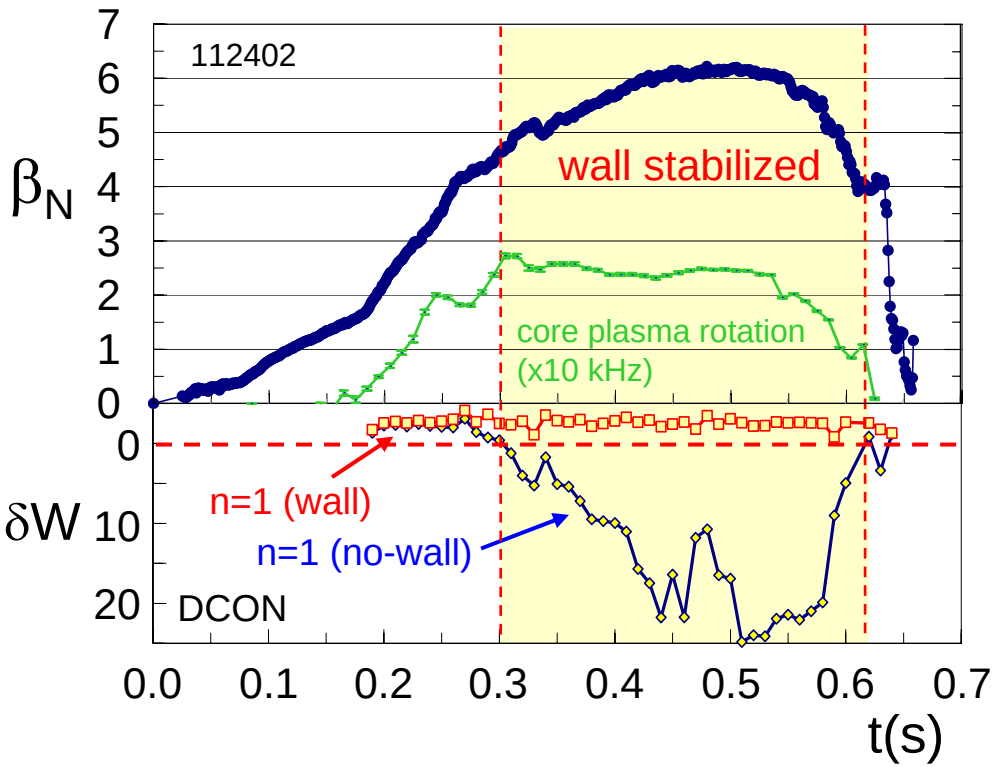
Wall stabilized plasmas allow RWM studies

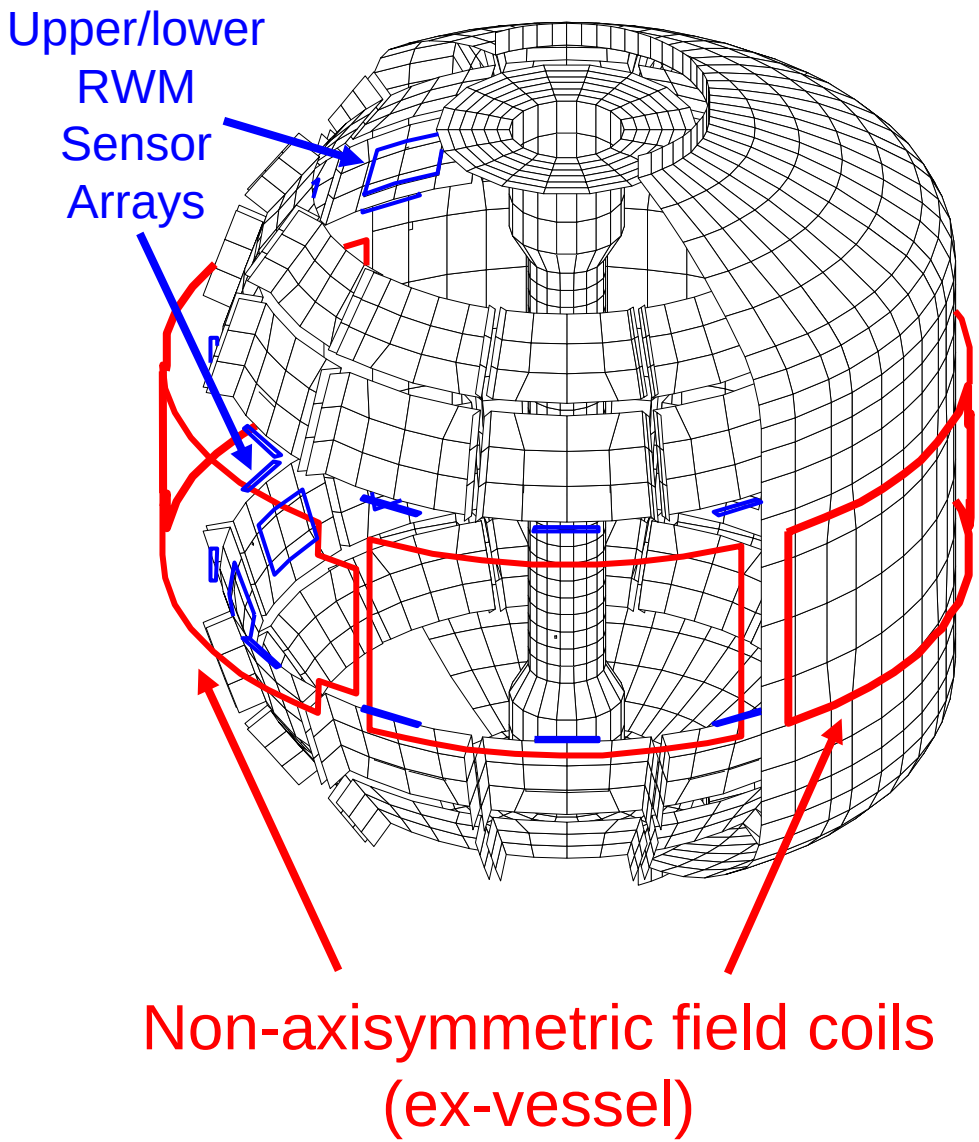


- Operation with $\beta_N/\beta_N^{no\text{-}wall} > 1.5$ at highest β_N for pulse >> τ_{wall}
- Past experiments showed
  - Unstable resistive wall mode (RWM) with toroidal mode number up to 3
  - Critical rotation frequency profile ~ $1/q^2$
  - Resonant field amplification (RFA) increases with increasing β_N

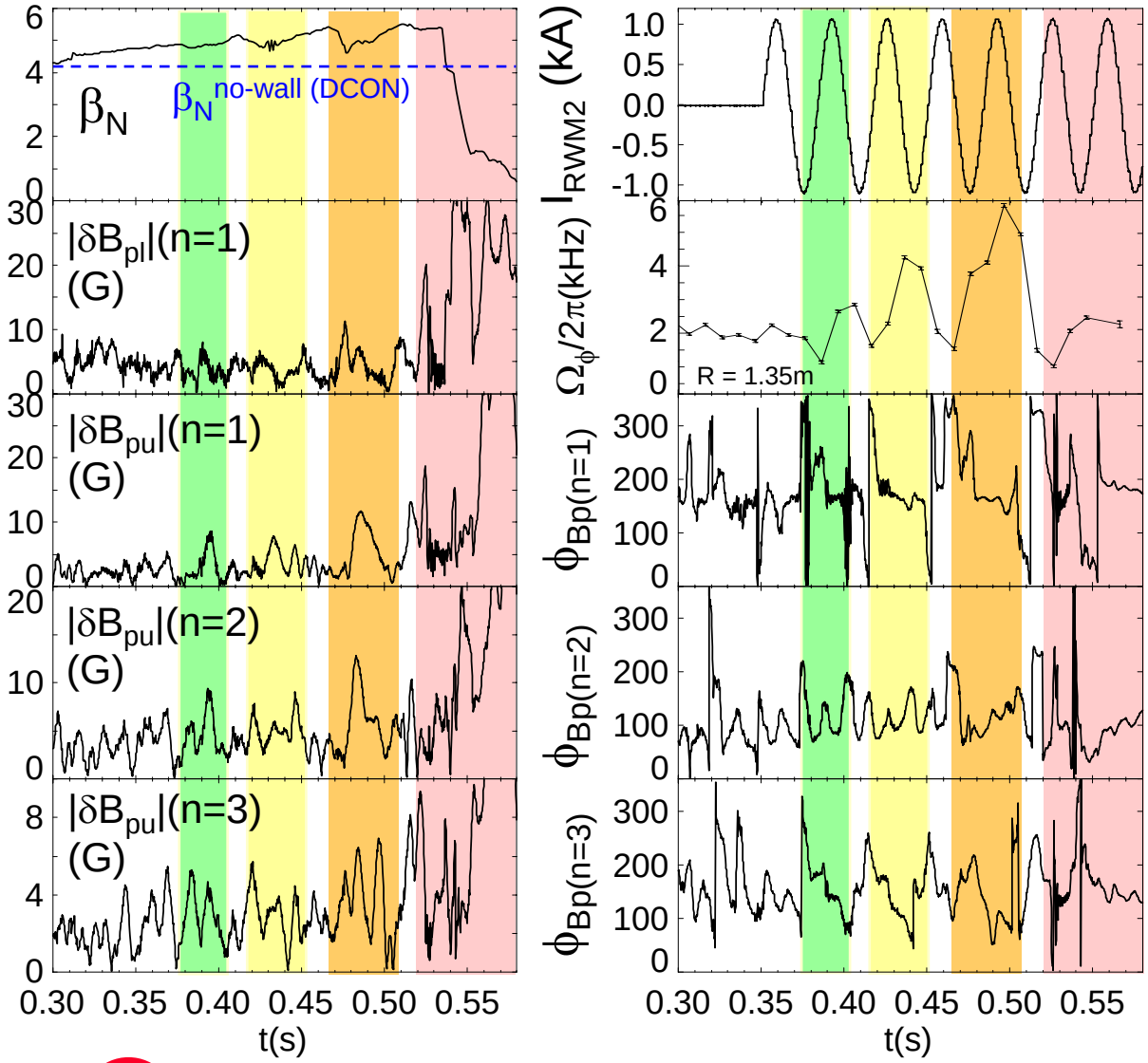
New capabilities continue the study of RFA and RWM stability

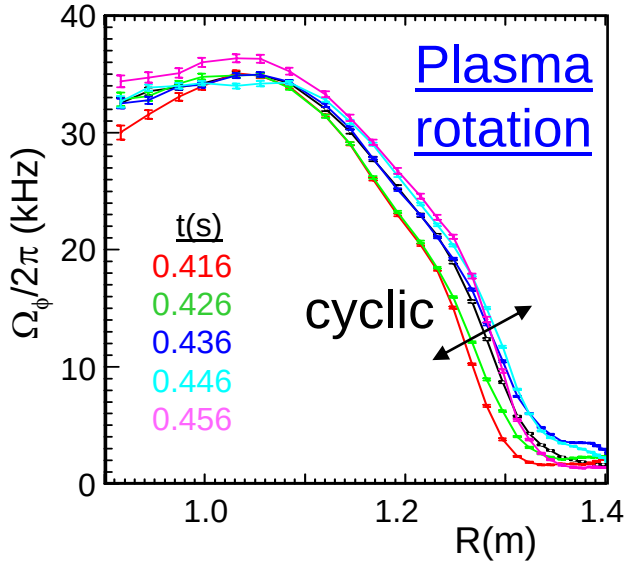
Non-axisymmetric coils for advanced RWM experiments

- Six coils spanning midplane
  - *n* = 1 - 3 DC or AC standing waves
  - Toroidally propagating fields
- Experiments address
  - RWM dynamics at marginal stability
    - using modulated n = 3 standing wave fields
  - Resonant field amplification
    - using toroidally propagating n = 1 fields
  - Triggering of other MHD
    - using co- vs. counter-rotating applied fields with changing frequency



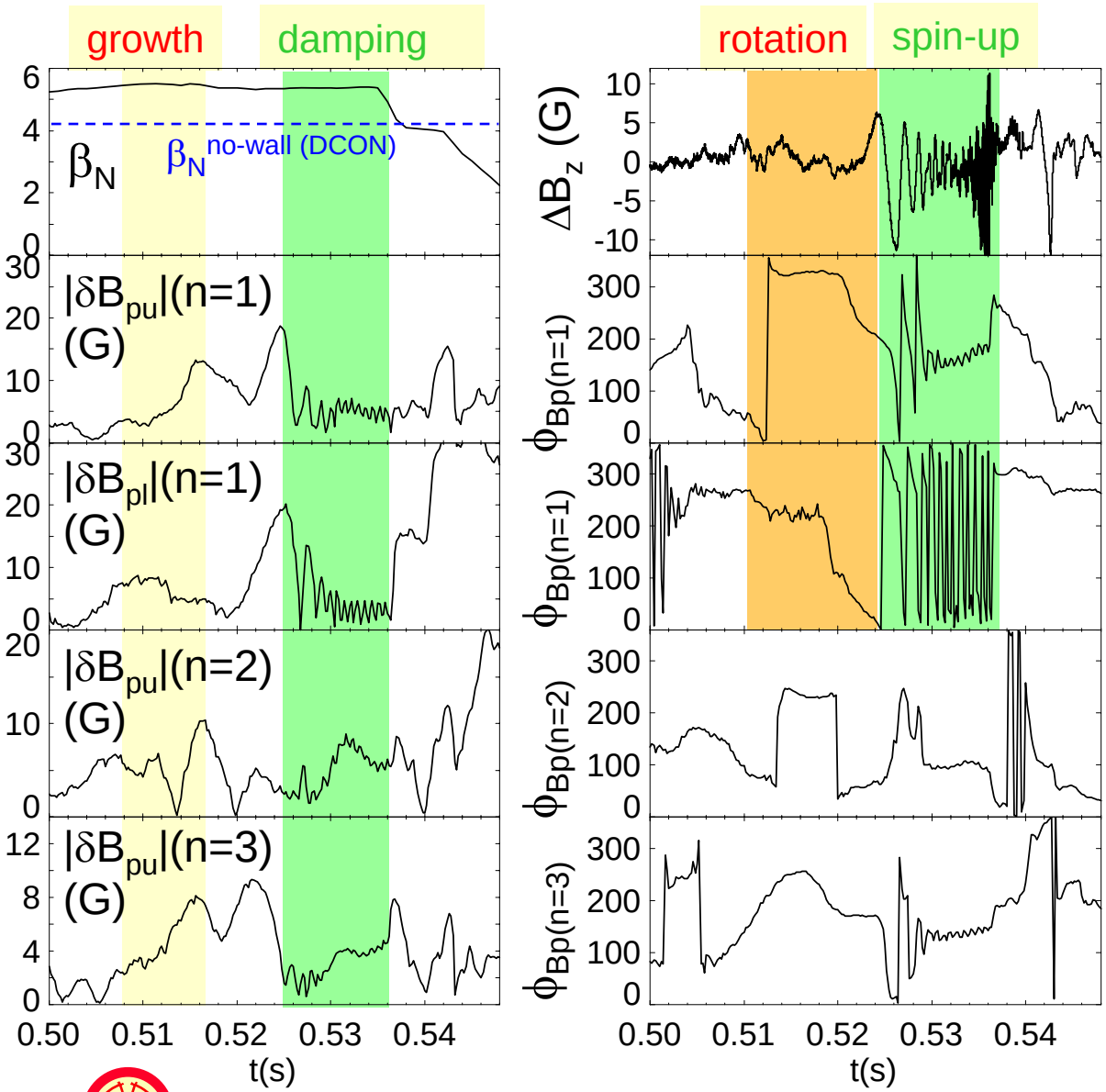
n=3 standing wave field probes RWM marginal stability





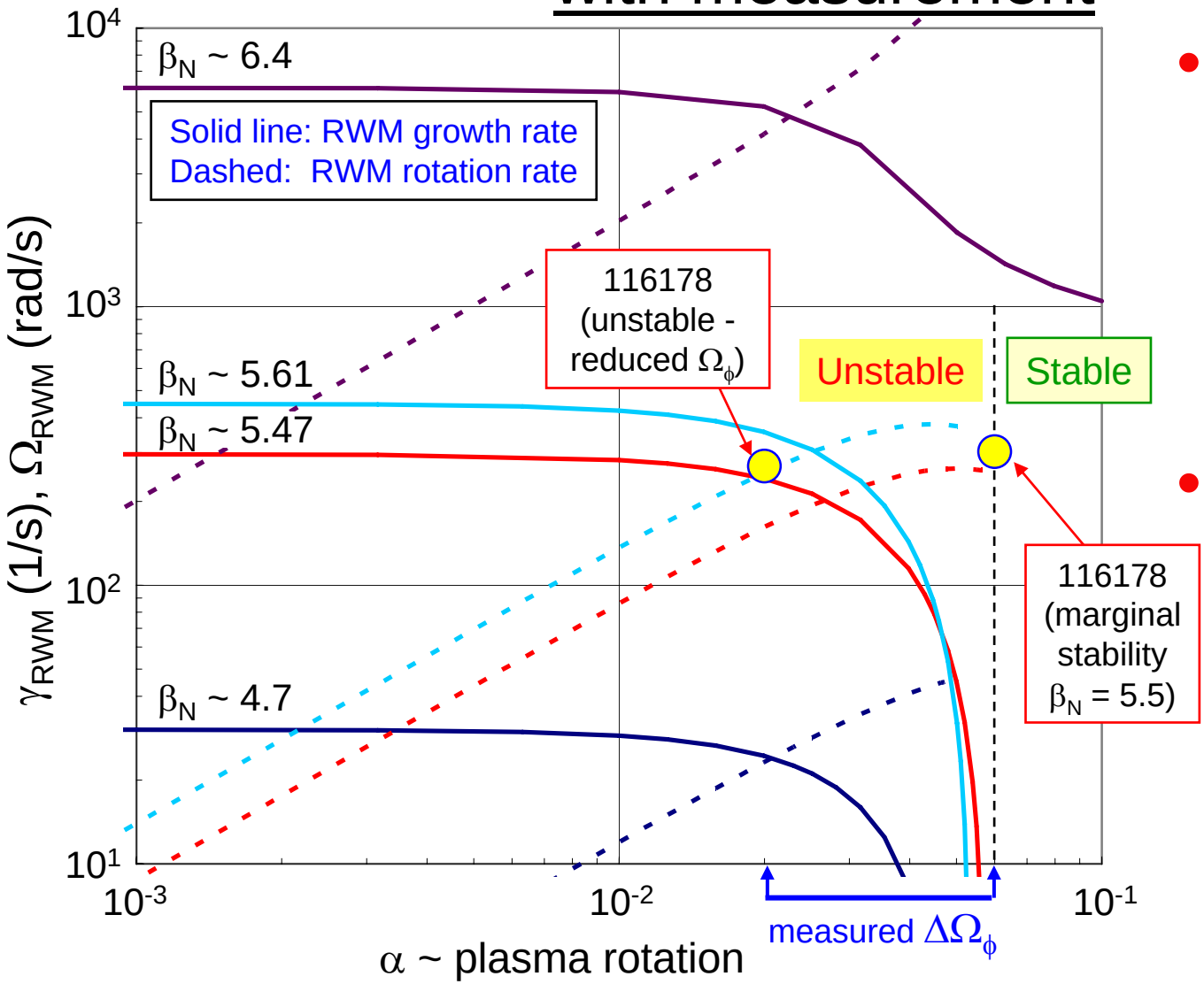
- Modulated rotation cycles stability
  - "anti-lock" braking of plasma rotation
  - n = 1 rotates in direction of flow
  - n = 2 not rotating with plasma flow

Last cycle before β collapse shows RWM dynamics



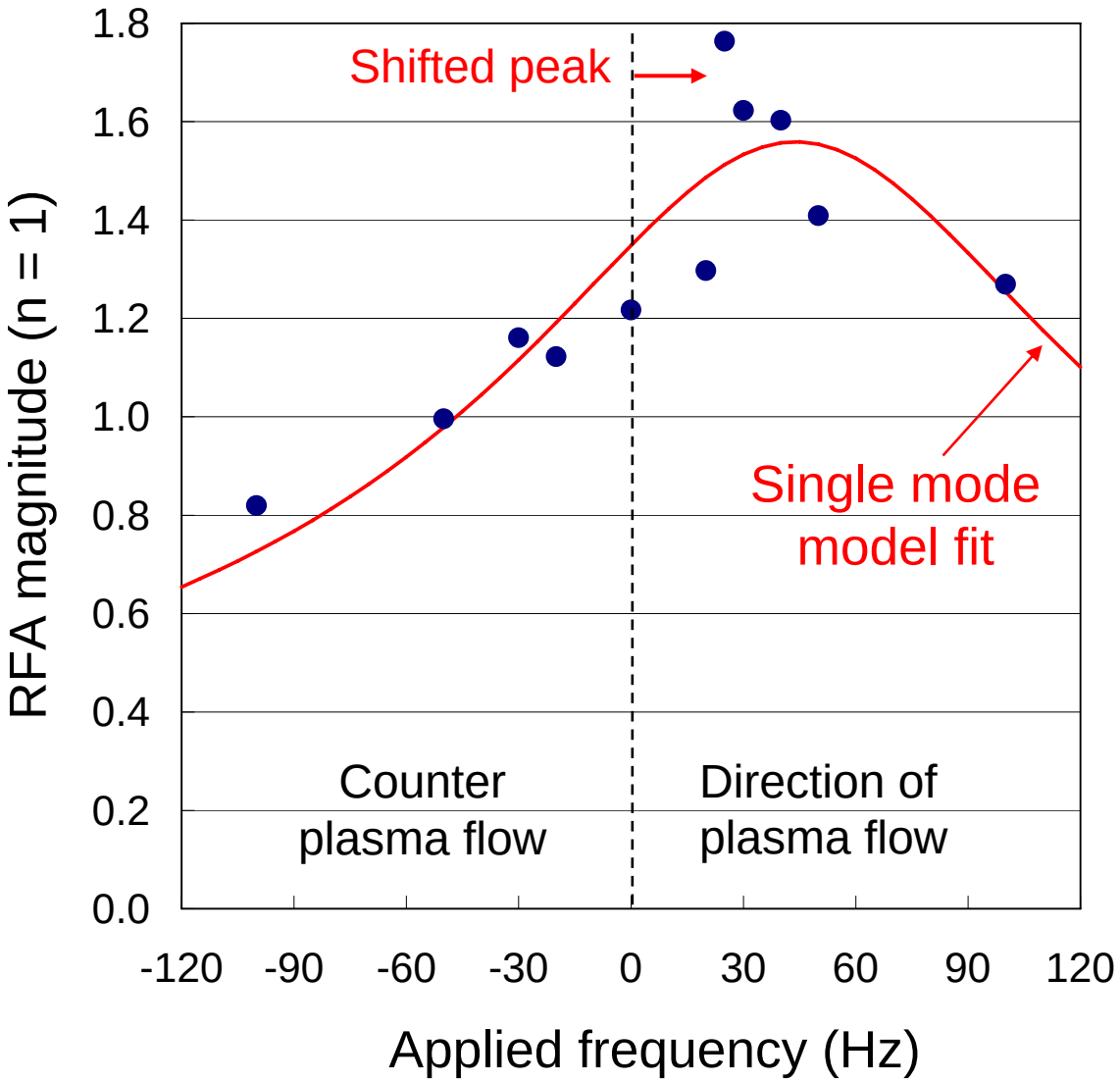
- RWM n=1 component shows growth and rotation
  - Growth rate: 268 s^{-1}
  - Rotation rate (avg. one cycle): 48Hz
  - RWM possibly triggers rapidly rotating mode
- n=2 growth / phase change during n=1 damping / spin-up

RWM growth/rotation modeled with VALEN consistent with measurement



- Boozer RWM model in VALEN code
  - Plasma rotation
    - Normalized plasma torque $\alpha \Leftrightarrow \Omega_\phi$
  - RWM rotation
- Calibrate code using NSTX data
  - RWM rotation measured near marginal stability
  - RWM growth rate measured when edge Ω_ϕ reduced

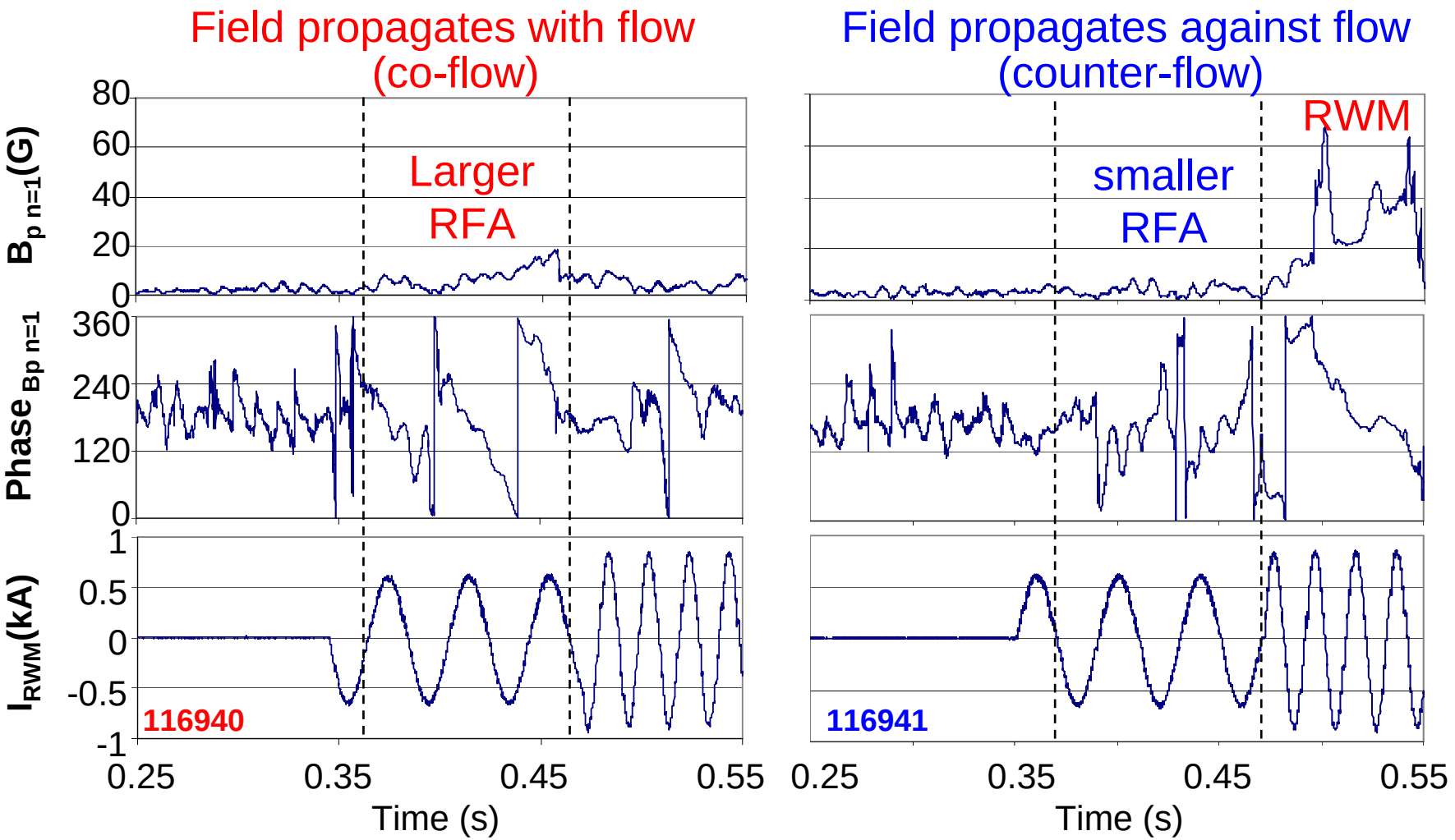
RFA magnitude dependent on applied field frequency



$$RFA = \frac{B_{plasma}}{B_{applied}}$$

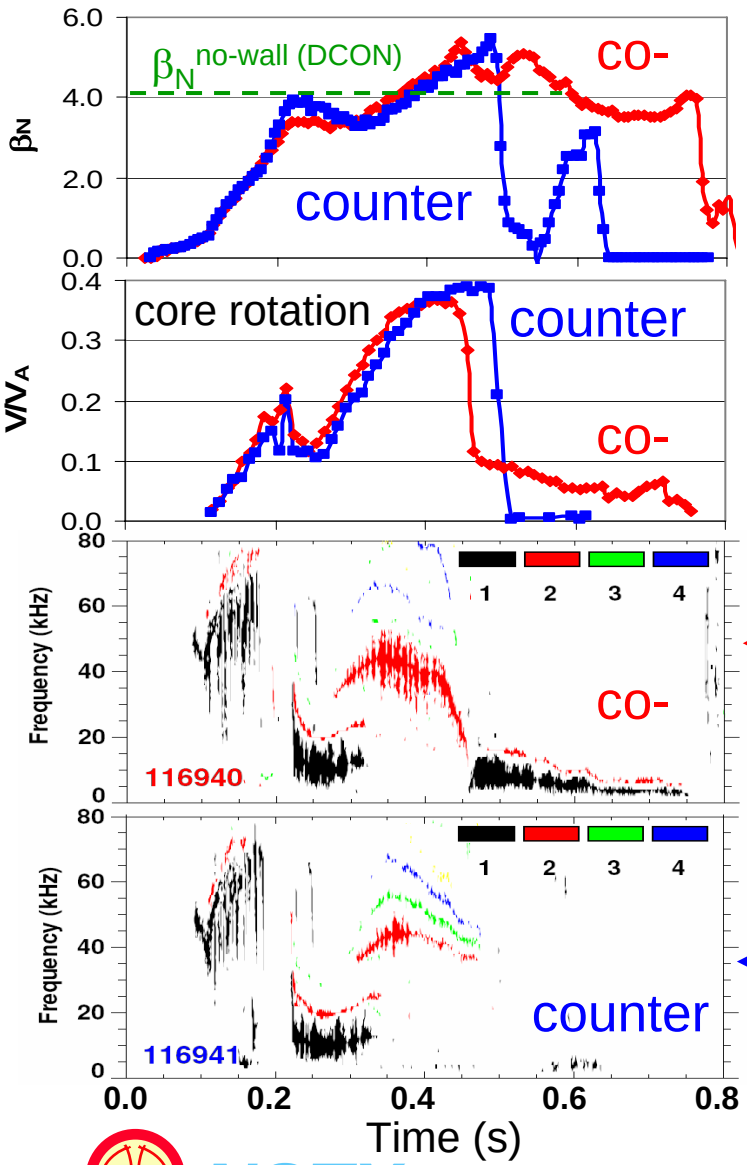
- Applied field phased to create traveling wave in toroidal direction
- Peak in RFA shifted in the direction of plasma flow
  - Peak near 30 Hz
  - Expected by RWM theory / experiment
    - Observed in DIII-D (H. Reimerdes, NF 45 (2005) 368.)

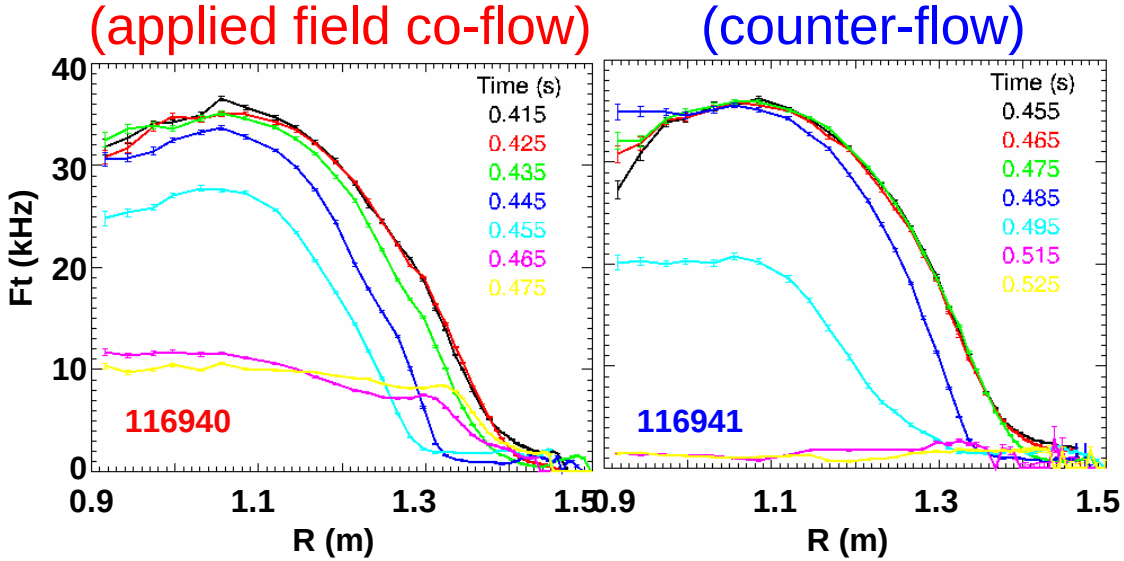
Direction of applied n=1 traveling wave alters RWM stability



- Stronger RFA with co-flow field
- RWM not destabilized
- Weaker RFA with counter-flow field
- Unstable RWM

Unstable RWM avoided when rotation maintained





- Applied field in the direction of plasma flow:
  - RFA increases and rotation damps
  - n=1 internal mode triggered
  - Rigid rotor rotation profile; beta recovers
- Applied field against the plasma flow:
  - RWM grows
  - Rapid, complete rotation and beta collapse

New non-axisymmetric coils have enabled advanced RWM experiments

- Precise modification of the plasma rotation profile allows control of RWM near marginal stability
- RWM rotation near marginal stability allows comparison to theory (Boozer model)
- Resonant field amplification depends on applied field frequency and propagation with respect to plasma flow
- Direction of applied field propagation can modify RWM evolution; triggering of other MHD modes
- Plasma rotation profile control / rotation damping physics (Zhu GO3.00005 – next talk)
- Critical rotation profile for RWM stability (Sontag RP1.00021 Thurs.)
  - Rotation on higher order rational surfaces not required for stability