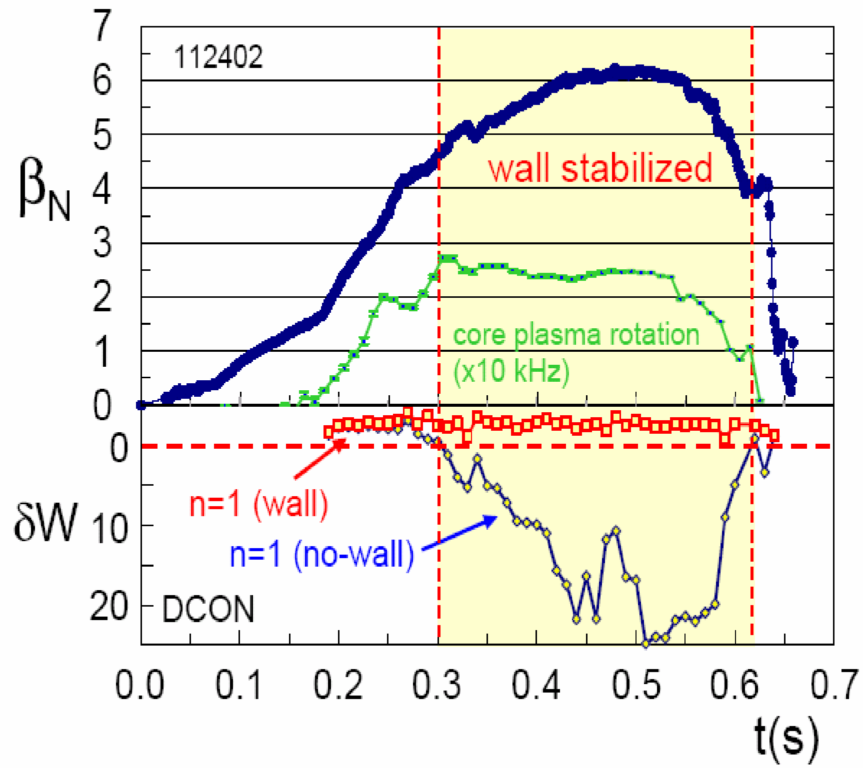
XP524:Active control of rotation damping in RWM plasmas

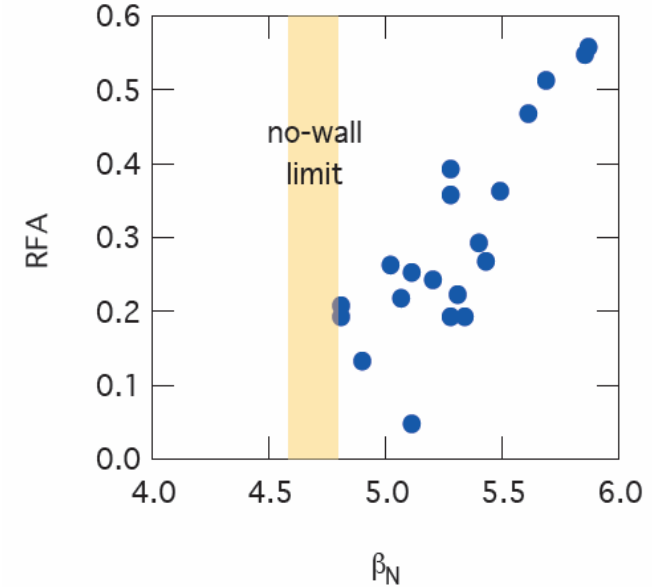
- Overall Goal
  - Use new resistive wall mode (RWM) stabilization coils for a broader study of the physics of plasma and mode rotation damping

- Specific Studies
  - Rotation damping physics due to applied field (plasma rotation alteration)
    - Apply n=1 - 3 DC field perturbation below / above $\beta_{N\ nowall}$
    - Damp plasma rotation in a controlled approach to Ω_{crit}
    - Test
      - neoclassical toroidal viscosity (NTV) theory
      - rotation damping due to resonant field amplification (RFA)
  - Rotation damping during RWM activity (RWM rotation alteration)
    - Apply n=1 - 3 rotating field f_{field} ~ f_{RWM}
    - Unlock and rotate RWM, suppress RWM growth, and allow a greater duration to study the rotation damping during RWM

NTV torque dependence on δB and n to be investigated

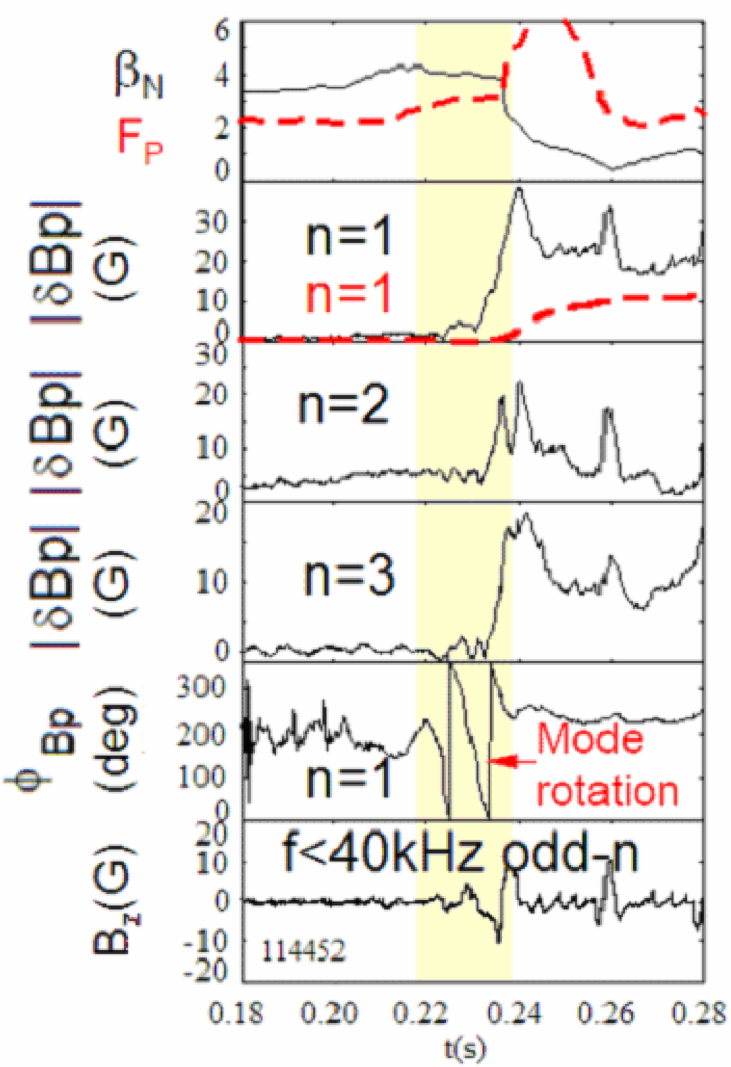


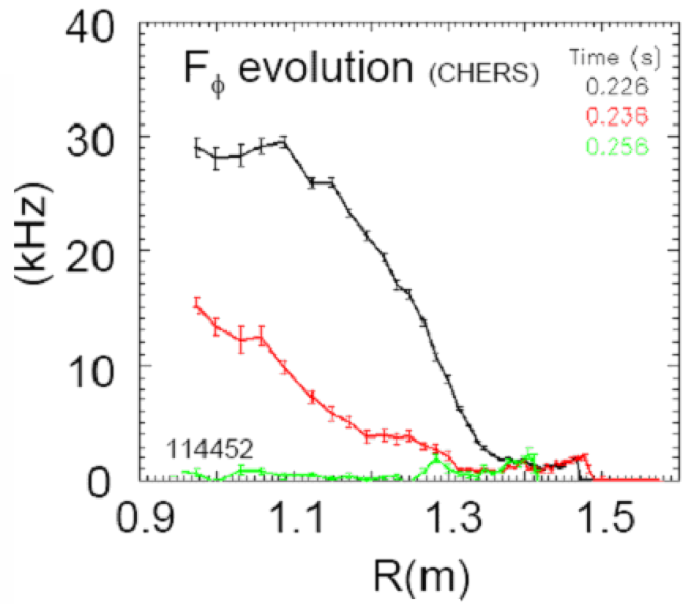
$$T_{NTV} = R\frac{\pi^{1/2} p_{\mathrm{i}}}{v_{t_{\mathrm{i}}}}\left(\Omega_{\phi} - \Omega_{\mathrm{mode}}\right)\varepsilon^{2} n^{2} q\left(\frac{\delta B_r^{mn}}{B_{\varphi}}\right)^{2}$$



- RWM passively stabilized most of the time without error field correction
  - Applied δB from RWM coil used for rotation braking alone
- Vary the applied field to create a controlled scan of δB
- δB is dependent on RFA (a function of β_N)
  - β_N scan
- Scan n number
  - n=1, 3 can be run on same day
  - n=2 best run on second day

Apply rotating field to unlock and rotate RWM





- RWM growth suppressed during mode rotation
- f_{RWM} ~ 100Hz observed in CY2004 experiments

- Apply n=1 - 3 rotating field at f_{field} ~ f_{RWM} to unlock RWM
- Study the rotation damping dynamics due to RWM in greater detail
- RFA is a function of applied field frequency
  - Frequency scan

XP524 could be completed in 1.5 days (1)

***n*=1, 3**

1) Rotation damping physics due to applied field (plasma rotation alteration)	**16**
vary applied current, zero rotation of applied field, attempt to avoid NTM to clearly distinguish RWM, $\beta_N/\beta_{N\ \text{no-wall}} < 1$ and $\beta_N/\beta_{N\ \text{no-wall}} > 1$	
A. 1-1.5 NBI sources ($\beta_N/\beta_{N\ \text{no-wall}} < 1$)	
i. Control shot without tearing mode (no applied field)	1
ii. Apply *n*=1 constant DC current to alter plasma rotation 3(or more)-step current scan, 50ms each step, anti-phase with static error field	2
iii. Apply *n*=3 constant DC current to alter plasma rotation 3(or more)-step current scan, 50ms each step, in/anti-phase with static error field	2
B. 2-3 NBI sources ($\beta_N/\beta_{N\ \text{no-wall}} > 1$)	
i. Longest possible pulse (reference target in XP501) no applied field	1
ii. Apply *n*=1 DC current to alter plasma rotation 3(or more)-step current scan, 50ms each step, up to the field causing RWM growth, anti-phase with static error field	2
iii. Apply *n*=3 DC current to alter plasma rotation 3(or more)-step current scan, 50ms each step, up to the field causing RWM growth, in/anti-phase with static error field	2
iv. Apply *n*=1 DC field in pulses at different β_N to study plasma rotation damping due to RFA pre-programmed 100ms pulses at β_N values not acquired in above step ii)	3
v. Apply *n*=3 DC field in pulses at different β_N to study plasma rotation damping due to RFA pre-programmed 100ms pulses at β_N values not acquired in above step iii)	3

XP524 could be completed in 1.5 days (2)

***n*=1, 3**

2) Rotation damping during RWM activity (RWM rotation alteration) 14

Preprogrammed rotating applied field, $\beta_N/\beta_{N\ \text{no-wall}} > 1$

A. n=1 rotating applied field

i. Apply rotating field ($f_{\text{field}}=f_{\text{RWM}}$) when β_N exceeds $\beta_{N\ \text{no-wall}}$ 2
try to unlock RWM, f_{RWM}=100 Hz (or observed f_{RWM} from part 1)
vary applied field current based on step 1)-B)

ii. Vary applied field frequency in steps 3
f_{field}=100Hz → f_{field}=120Hz → f_{field}=140Hz (10 periods each)
f_{field}=100Hz → f_{field}=80Hz → f_{field}=60Hz (10 periods each)
f_{field}=-60Hz → f_{field}=-100Hz → f_{field}=-140Hz (10 periods each)
(frequency ranges need to be revised based on the guidance of XP-501)

iii. Test low applied field frequency 2
f_{field}=20, -20Hz (frequency need to be revised based on XP-501)

B. n=3 Rotating applied field

B. Apply rotating field ($f_{\text{field}}=f_{\text{RWM}}$) when β_N exceeds $\beta_{N\ \text{no-wall}}$ 2
try to unlock RWM, f_{RWM}=100 Hz (or observed f_{RWM} from part 1)
vary applied field current based on step 1)-B)

C. Vary applied field frequency in steps 3
f_{field}=100Hz → f_{field}=120Hz → f_{field}=140Hz (10 periods each)
f_{field}=100Hz → f_{field}=80Hz → f_{field}=60Hz (10 periods each)
f_{field}=-60Hz → f_{field}=-100Hz → f_{field}=-140Hz (10 periods each)
(frequency ranges need to be revised based on the guidance of XP-501)

D. Test low applied field frequency 2
f_{field}=20, -20Hz (frequency need to be revised based on XP-501)

XP524 could be completed in 1.5 days (3)

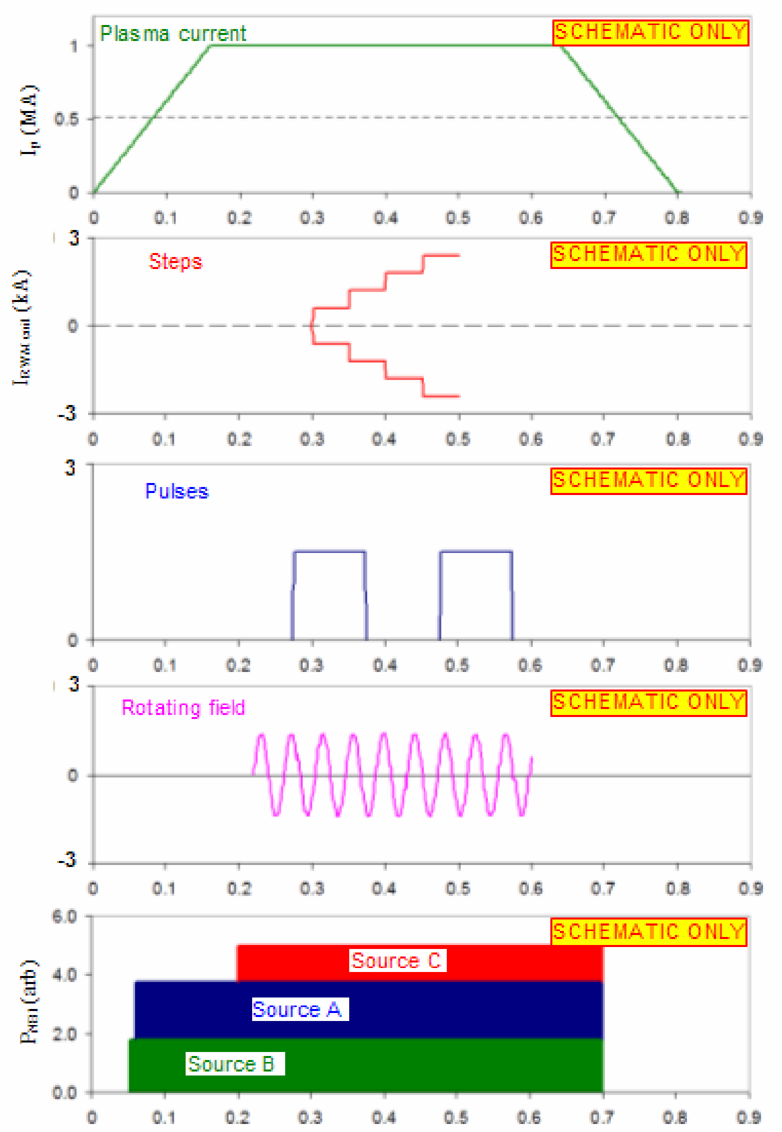
n=2

Repeat the most successful trials above with *n*=2 applied field **15**

Require overnight change to n=2 configuration

n=1, 3	Plasma rotation alteration	16
n=1, 3	RWM rotation alteration	14
n=2		15
Total		45

Schematic waveforms for RWM coil – XP524



Required and Desired Diagnostics – XP524

- Required
  - CHERS toroidal rotation measurement; edge CHERS
  - Locked mode detector measurements (external and internal)
  - Toroidal Mirnov array
  - Thomson scattering
  - Diamagnetic loop
  - Fast camera
- Desired
  - USXR
  - Two toroidal position USXR
  - MSE
  - FIReTIP interfrometer/polarimeter
  - Neutron detectors
  - H-alpha cameras