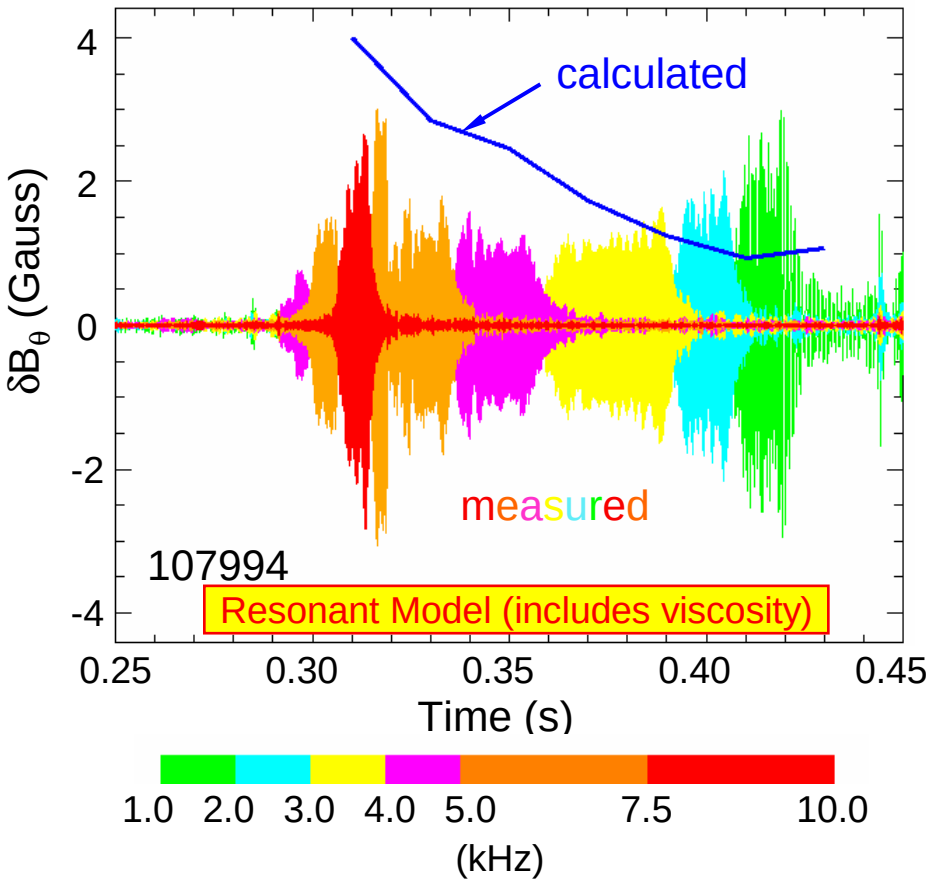
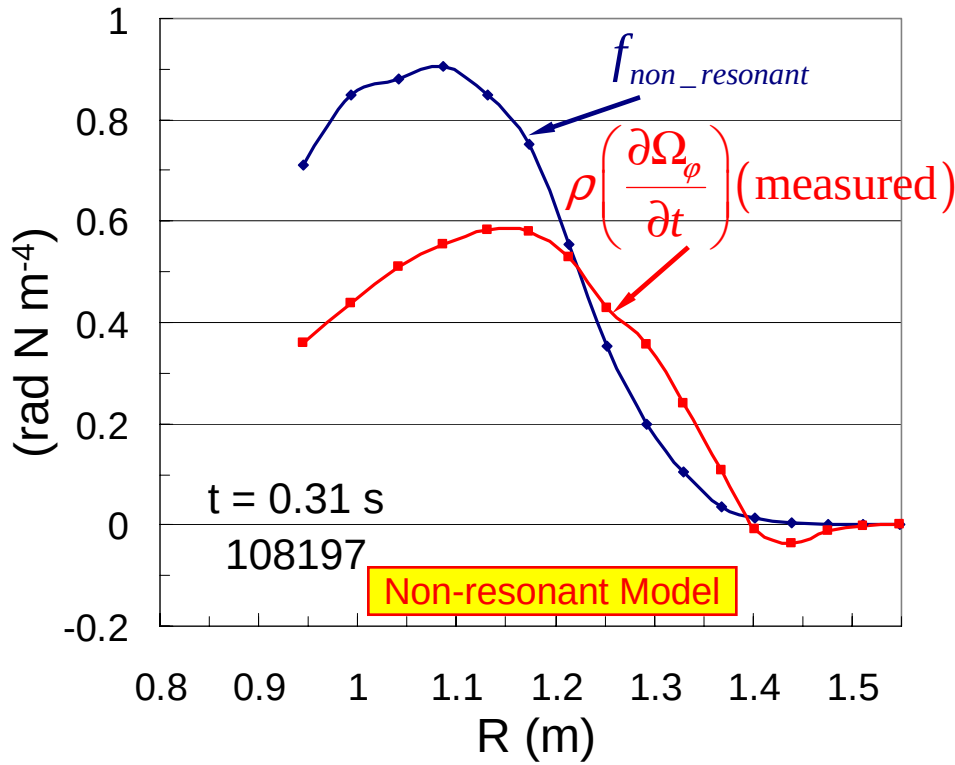
XP-314: Rotation Damping Physics in High β_N ST Plasma (Approved)

- Goals
  - Determine the plasma rotation damping physics of ST plasmas at high β_N exceeding the ideal no-wall beta limit
    - Study the global nature of toroidal rotation damping at $\beta_N/\beta_{Nno\text{-}wall} > 1$
    - Study the dependence of rotation damping on toroidal field (q_{min}) and $\beta_N/\beta_{Nno\text{-}wall}$
    - Study the dependence of rotation damping on boundary configuration (LSN vs. DND)
  - Compare experimental results to all applicable theories
    - Non-resonant ideal perturbations: (RWM)
    - Resonant resistive perturbations: (magnetic islands)
    - Edge perturbations: (ELMs)
- Present data show β and B dependence
  - $\beta_N > \beta_{Nno\text{-}wall}$: global and fast; $\beta_N < \beta_{Nno\text{-}wall}$: localized and diffusive
  - When $q_{min} > 2$ rotation is maintained longer

Reasonable Quantitative Agreement with Experiment Using Initial Physics Models





$$\rho\left(\frac{\partial\Omega_\varphi}{\partial t}\right) = f_{non_resonant}$$

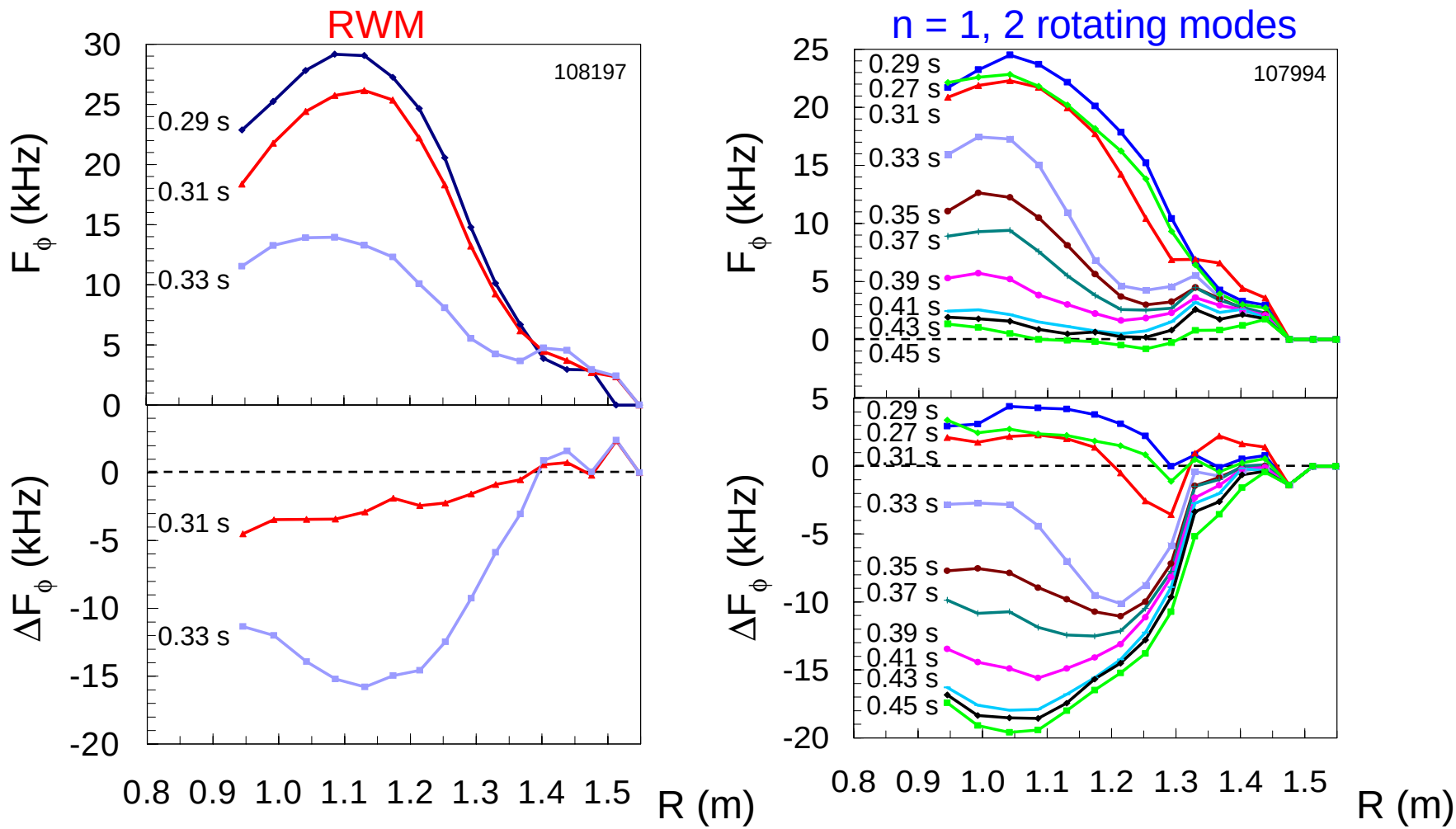
- Good agreement before mode locking phase
- Mode slows and grows in time during locking phase
- Non-resonant viscous physics model matches the measured global damping profile in RWM plasma

Upgraded CHERS and Locked Mode Sensors Give Us More Detail about Rotation Dynamics

- XP can be finished in 1.5 run days
  - Day 1:
    - A: DND target: 3, 2, and 1 NBI source above and below $\beta_{Nno\text{-}wall}$, two stage I_p ramp up, B_t ramp down
    - B: LSN target
  - Follow up 0.5 day: complete XP after doing analysis
  - Coordinate with data from XP 313
- Required Diagnostics
  - CHERS toroidal rotation measurement; edge CHERS
  - Internal Locked mode detector measurements
  - USXR
  - Toroidal Mirnov array
  - Thomson scattering
  - Diamagnetic loop
- Desired Diagnostics
  - Fast camera, Flux loops and integrated poloidal Mirnov coil data, FIReTIP interferometer/polarimeter, 2-D x-ray detector (GEM), Neutron detectors, H-alpha cameras

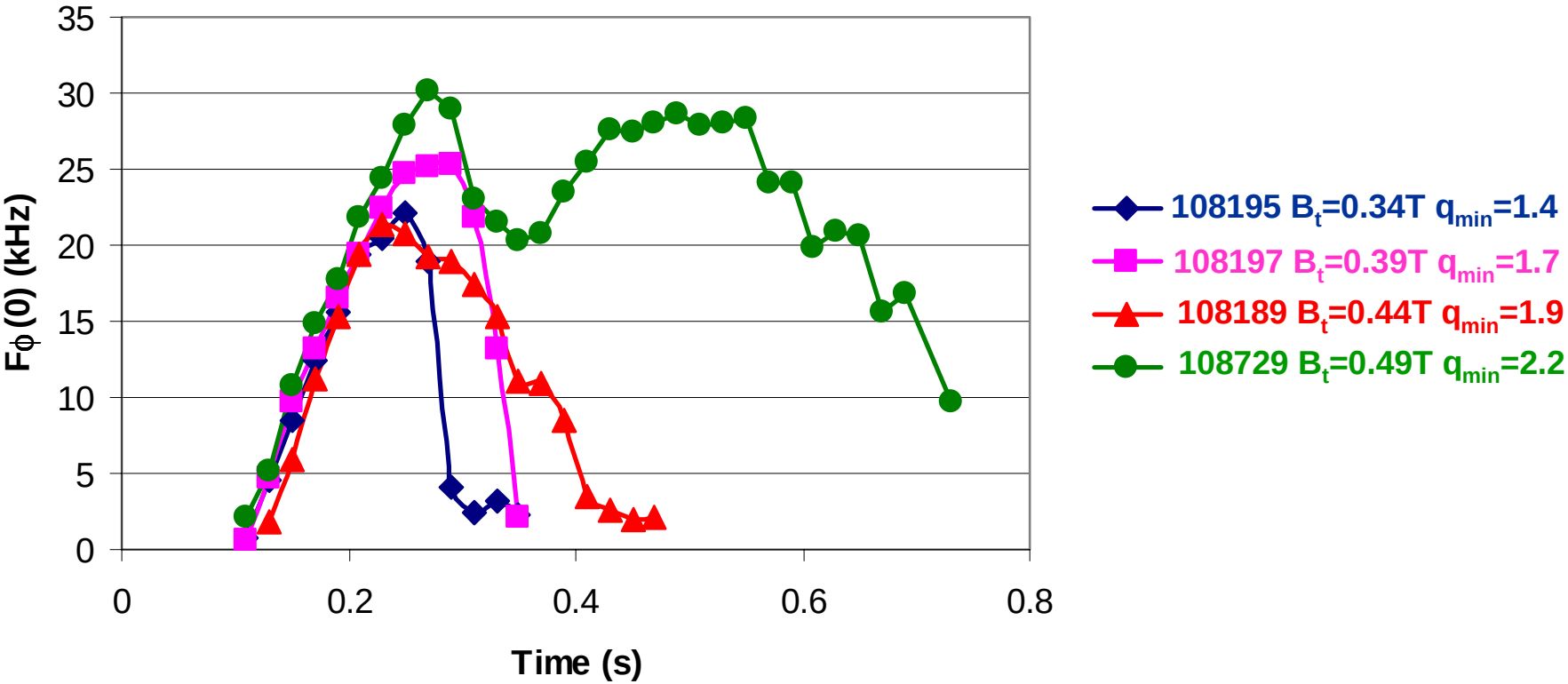
Supporting Slides Follow

RWM Causes Global and Rapid Rotation Damping



- RWM caused rotation damping rate is ~6 times faster than that of rotating modes alone
- Rotating modes cause rotation damping that is localized and diffusive

Core Rotation Damping Rate Decreases with Increasing B_t



- q_{min} increases with toroidal field
- When q_{min} > 2 rotation is maintained longer

*EFIT q_{min} without MSE

NSTX