



U.S. DEPARTMENT OF
ENERGY

Office of
Science



Ideal stability limits in NSTX-U and reduced kinetic stability model development

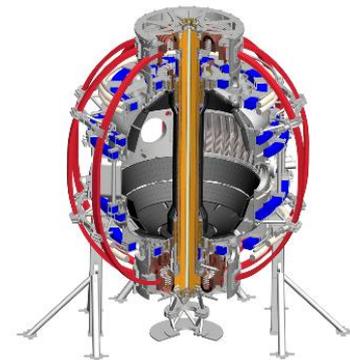
Jack Berkery
Columbia University

S.A. Sabbagh¹, Y.S. Park¹, R.E. Bell², S.P. Gerhardt², C.E. Meyers²

¹Columbia University, ²Princeton Plasma Physics Laboratory

NSTX-U Results Review
September 22, 2016

 COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK



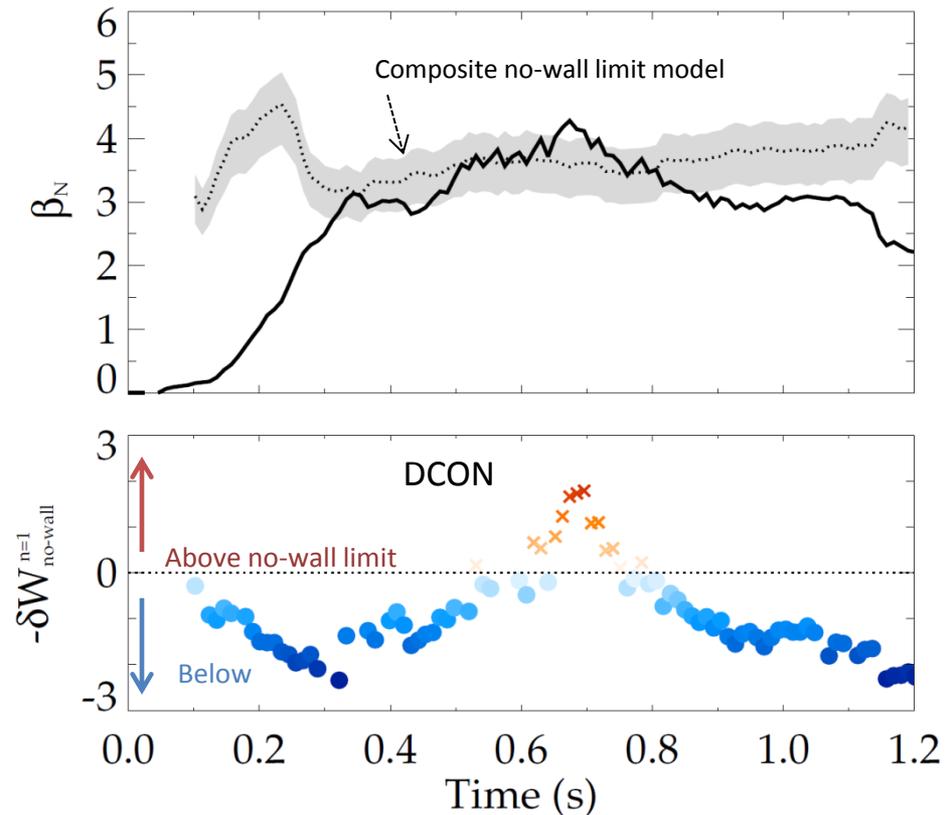
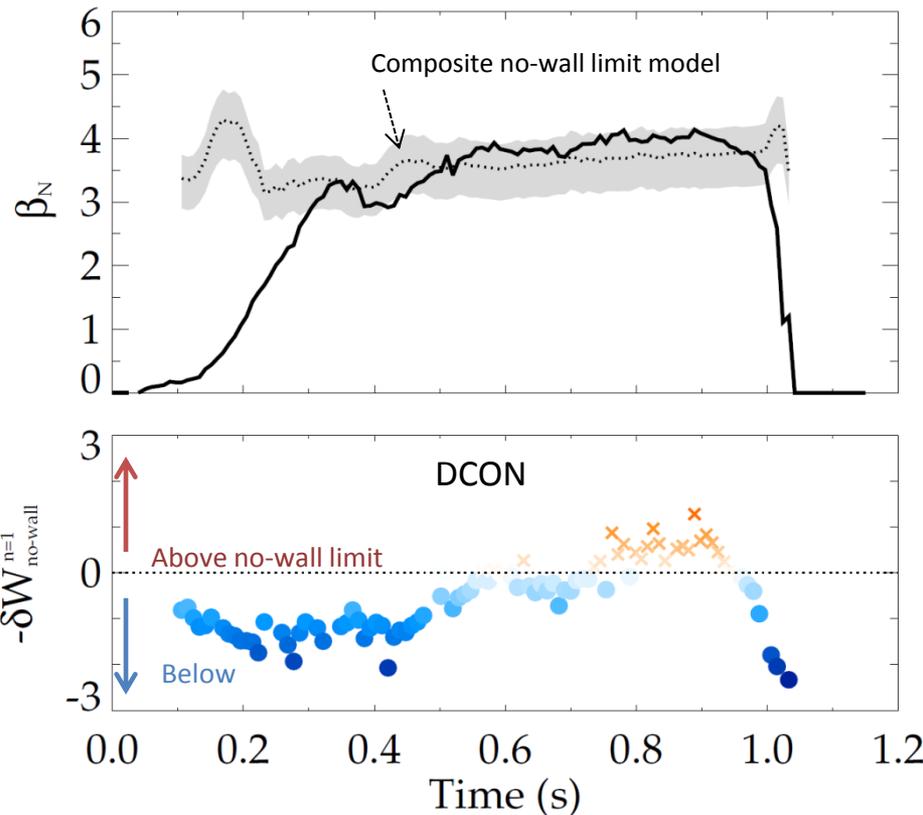
**This work supported by the
US DOE contracts DE-AC02-
09CH11466 and DE-FG02-
99ER54524*

DCON confirms NSTX-U above the no-wall limit; NSTX-based model gives good estimate

NSTX-U H-mode discharges: 204112

204118

(April 2016)

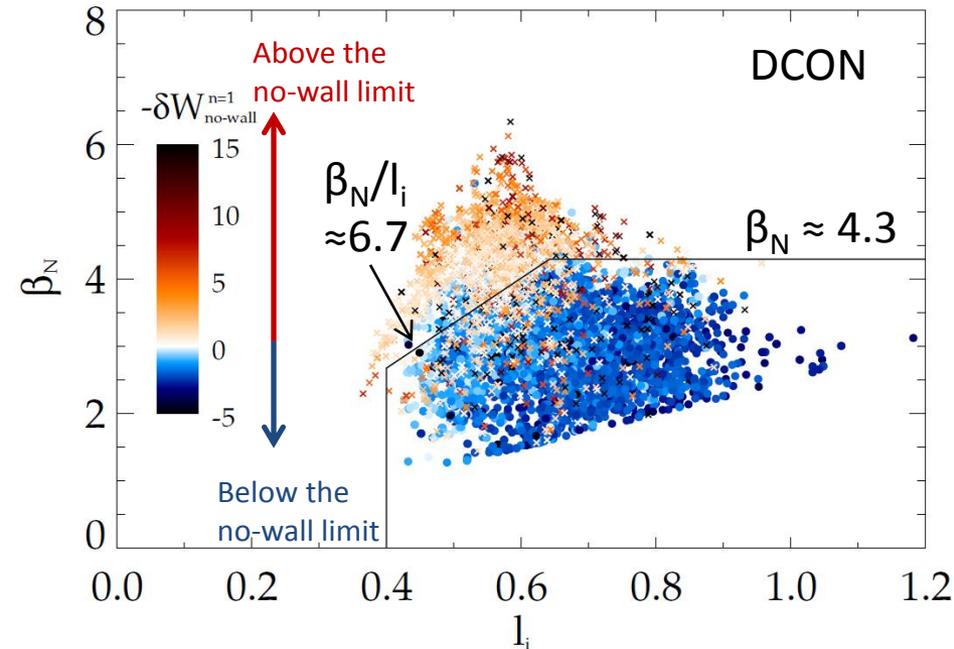


J.W. Berkery, S.A. Sabbagh (Columbia University)

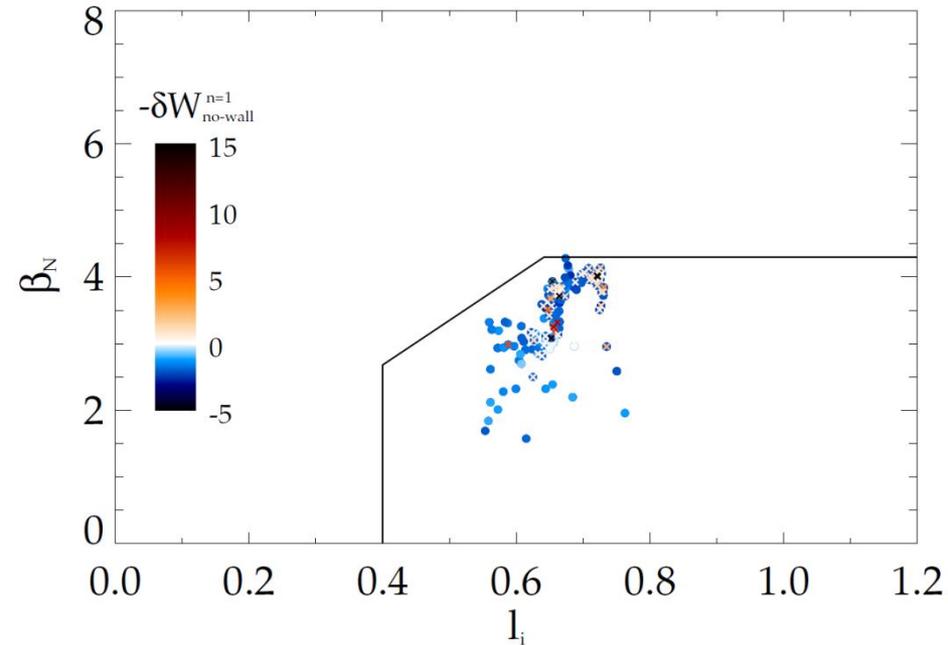
- NSTX no-wall limit model ([J.W. Berkery et al., Nucl. Fusion 55, 123007 (2015)]) includes internal inductance, pressure peaking, and aspect ratio, predicts NSTX-U DCON no-wall limit

$n = 1$ ideal no-wall stability limits for NSTX-U are generally following understanding from NSTX in β_N vs I_i

NSTX discharges from 2010



NSTX-U discharges from April 2016*



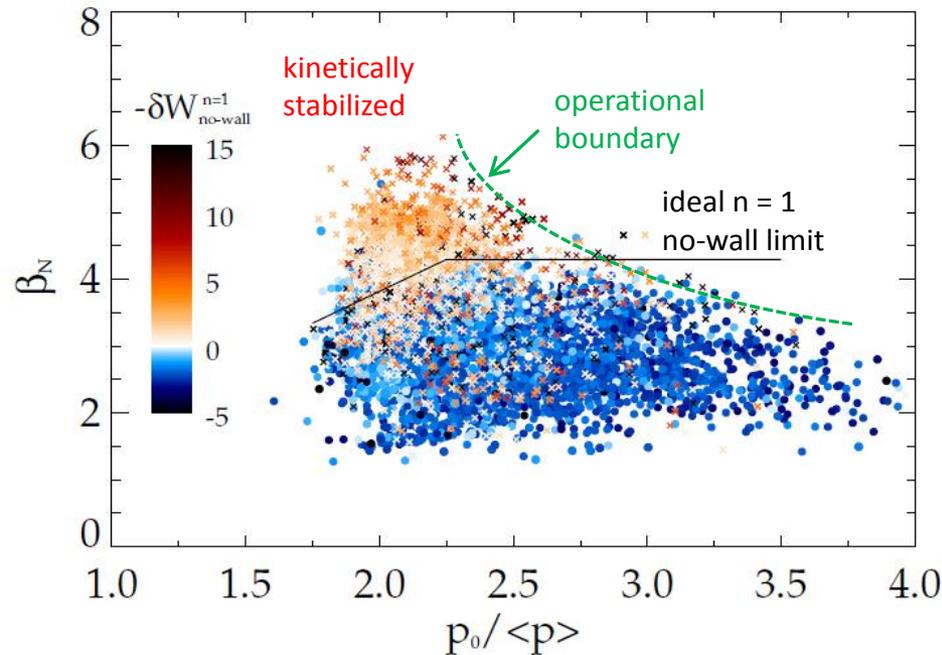
*From shots with $I_p > 500\text{kA}$, $P_{\text{NBI}} > 3.5\text{ MW}$, and with EFIT02.

Shotlist so far (17):

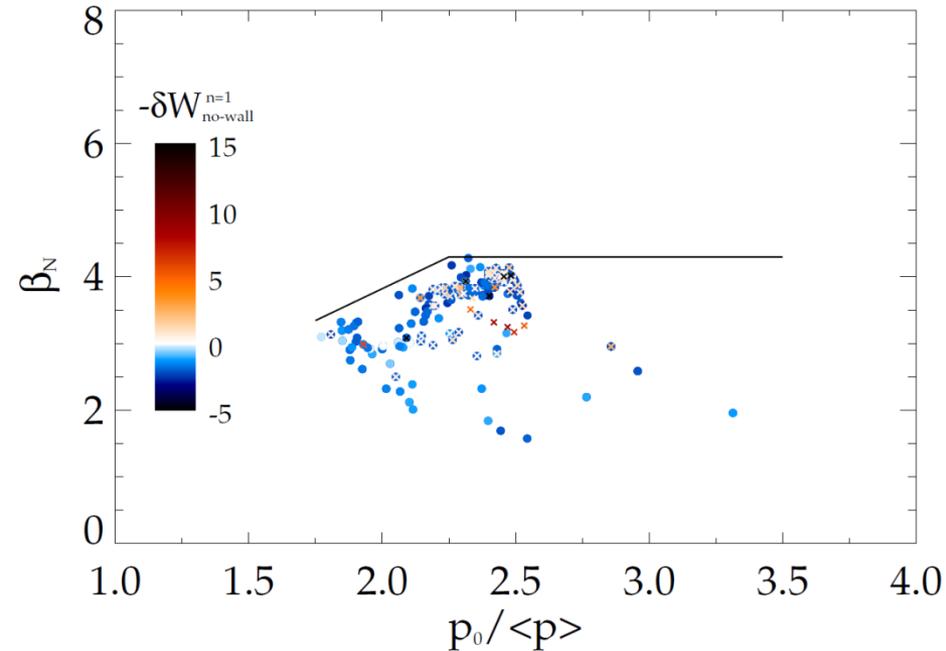
204112,204118,204131,204172,204114,204011,203612,203618,204111,
204135,204170,204171,204174,204180,204181,204188,204194

$n = 1$ ideal no-wall stability limits for NSTX-U are generally following understanding from NSTX in β_N vs p_p

NSTX discharges from 2010



NSTX-U discharges from April 2016*



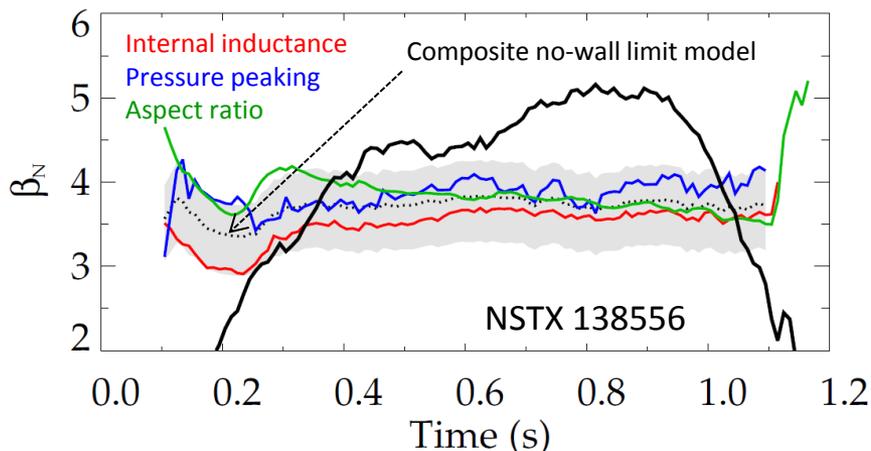
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204112,204118,204131,204172,204114,204011,203612,203618,204111,
204135,204170,204171,204174,204180,204181,204188,204194

Goal is to forecast γ in real-time using parameterized reduced models for δW terms

Modeled estimates for NSTX no-wall limit



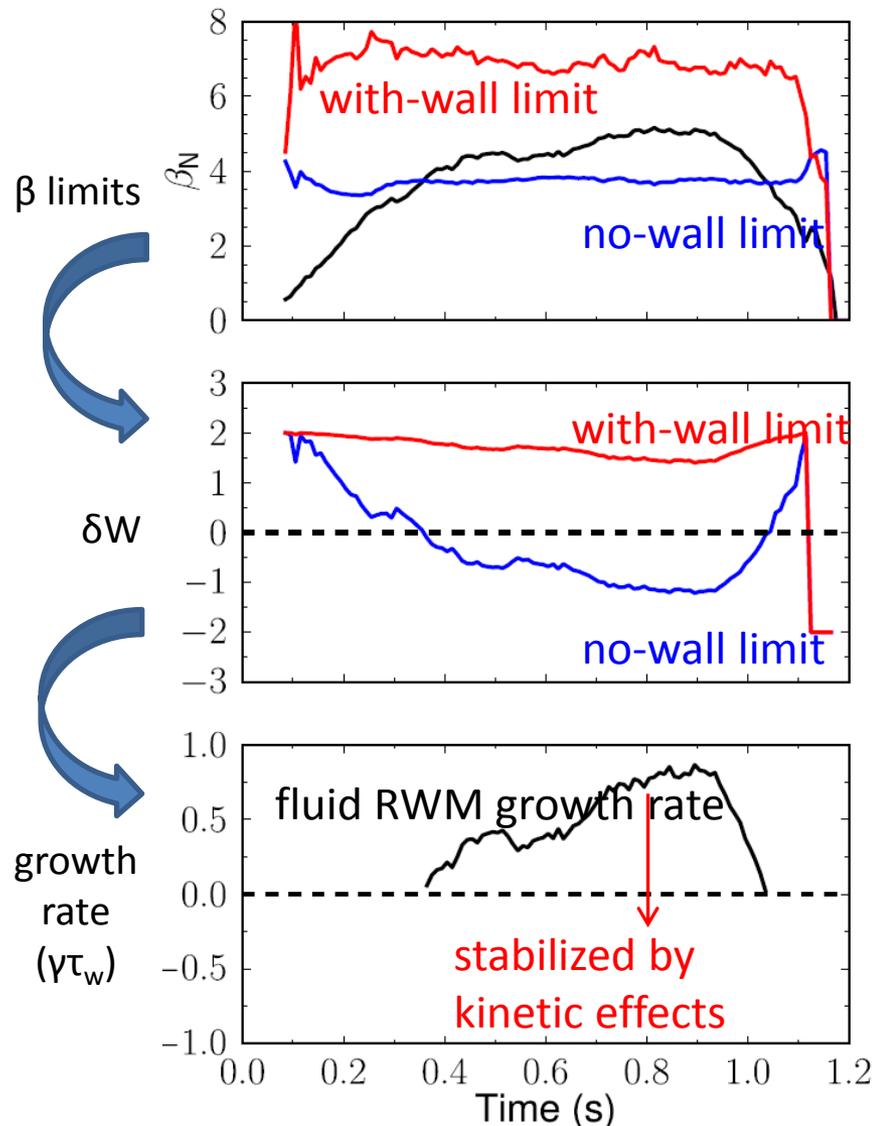
[J.W. Berkery et al., Nucl. Fusion 55, 123007 (2015)]

RWM dispersion relation

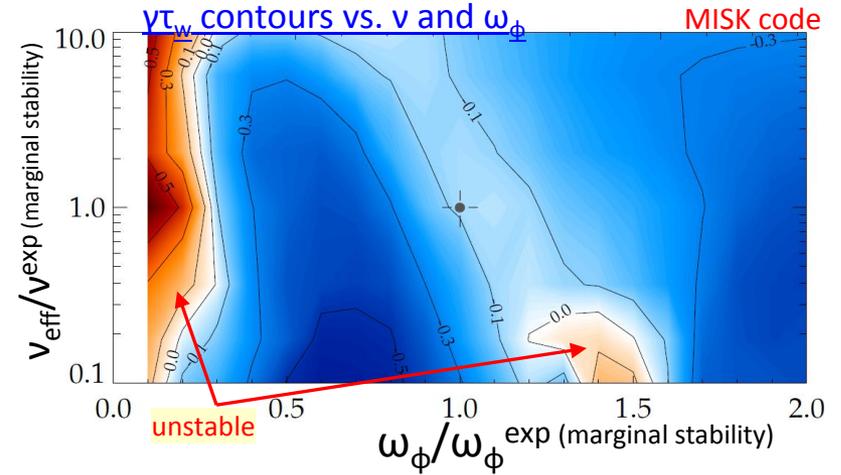
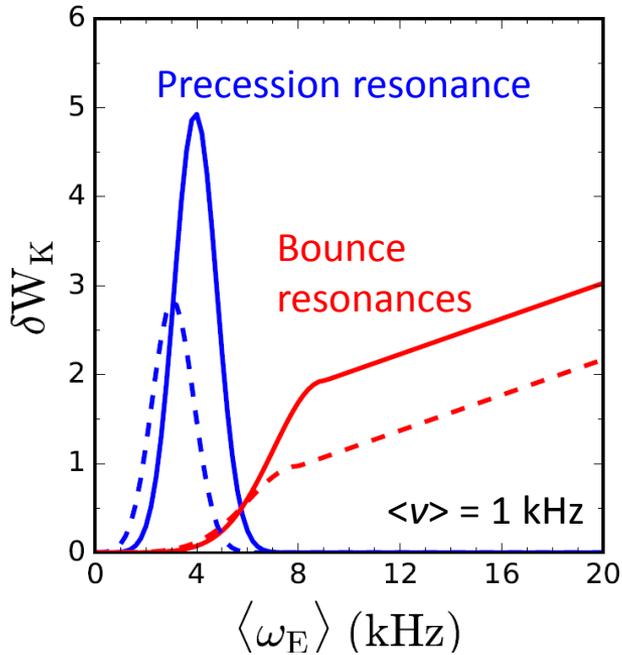
Growth rate Fluid terms Kinetic effects

$$(\gamma - i\omega_r) \tau_w = - \frac{\delta W_\infty + \delta W_K}{\delta W_b + \delta W_K}$$

[B. Hu et al., Phys. Rev. Lett. 93, 105002 (2004)]

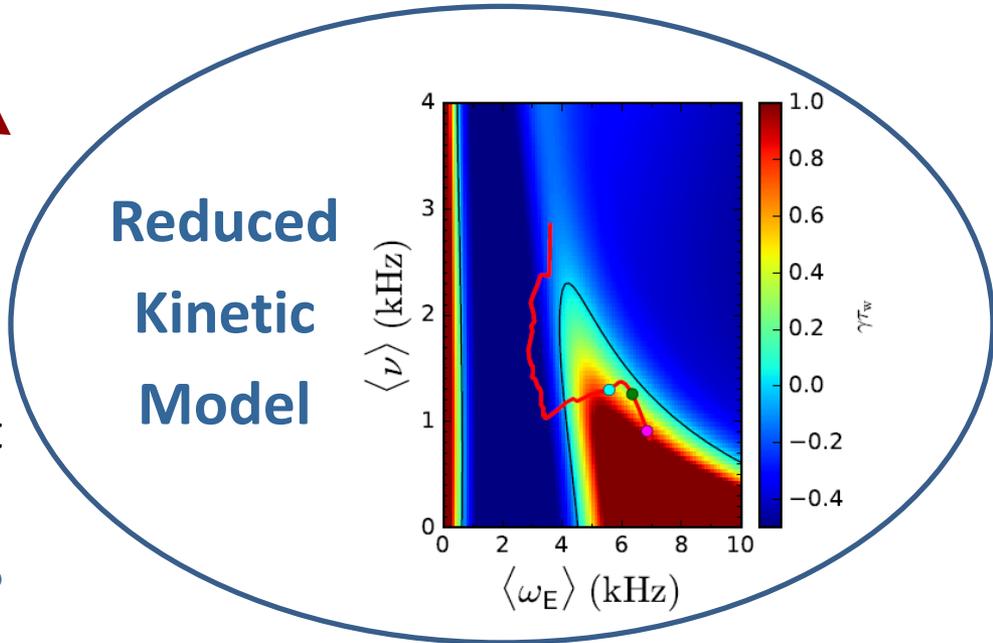


Physics understanding from previous research used to construct a reduced kinetic model

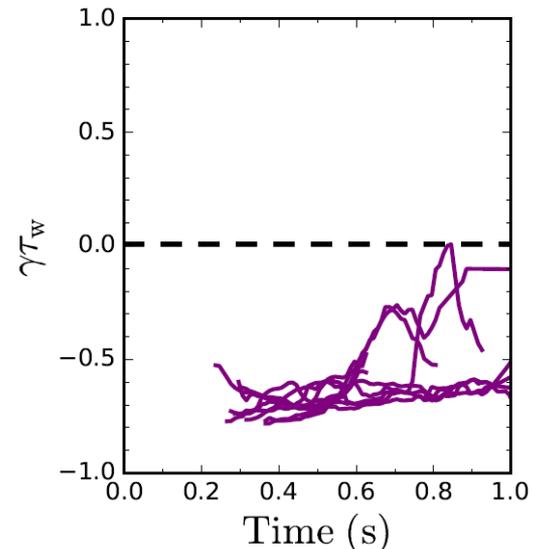
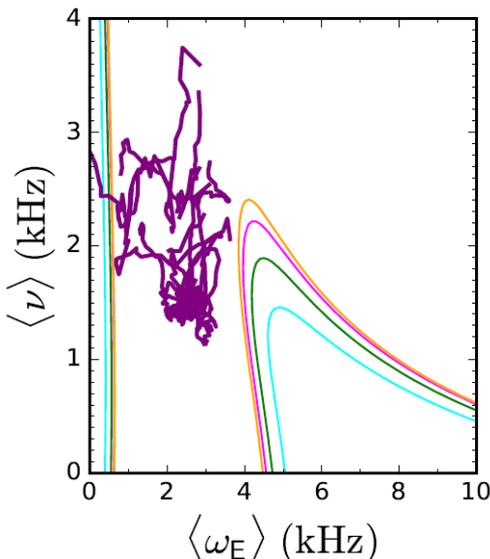
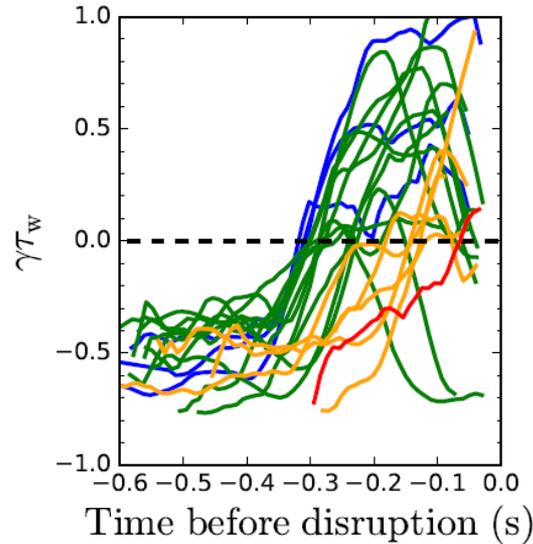
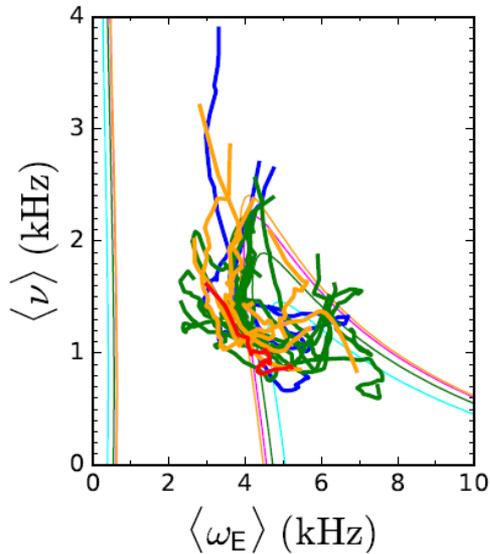


$$\delta W_K \sim \frac{1}{\langle \omega_D \rangle + l\omega_b - i\nu_{\text{eff}} + \omega_E}$$

- Gaussian functions used to represent resonances in the model
 - Positions in $\langle \omega_E \rangle$ determined by ω_D and ω_b
 - Height, width, position all dependent on v



Reduced kinetic model distinguishes between stable and unstable NSTX discharges



- Reduced kinetic model tested on a database of stable and unstable NSTX discharges
- Model fails to capture an experimentally unstable RWM in 7/45 cases, 15.6%
- Sometimes the model warning is associated with minor disruptions that subsequently recover
- If $\langle \omega_E \rangle \sim 0$ warnings are ignored, 10/13, or 77%, of stable cases are stable in the model
- Model development continues to improve forecasting performance