Understanding and Controlling Edge Resonant Modes in MST

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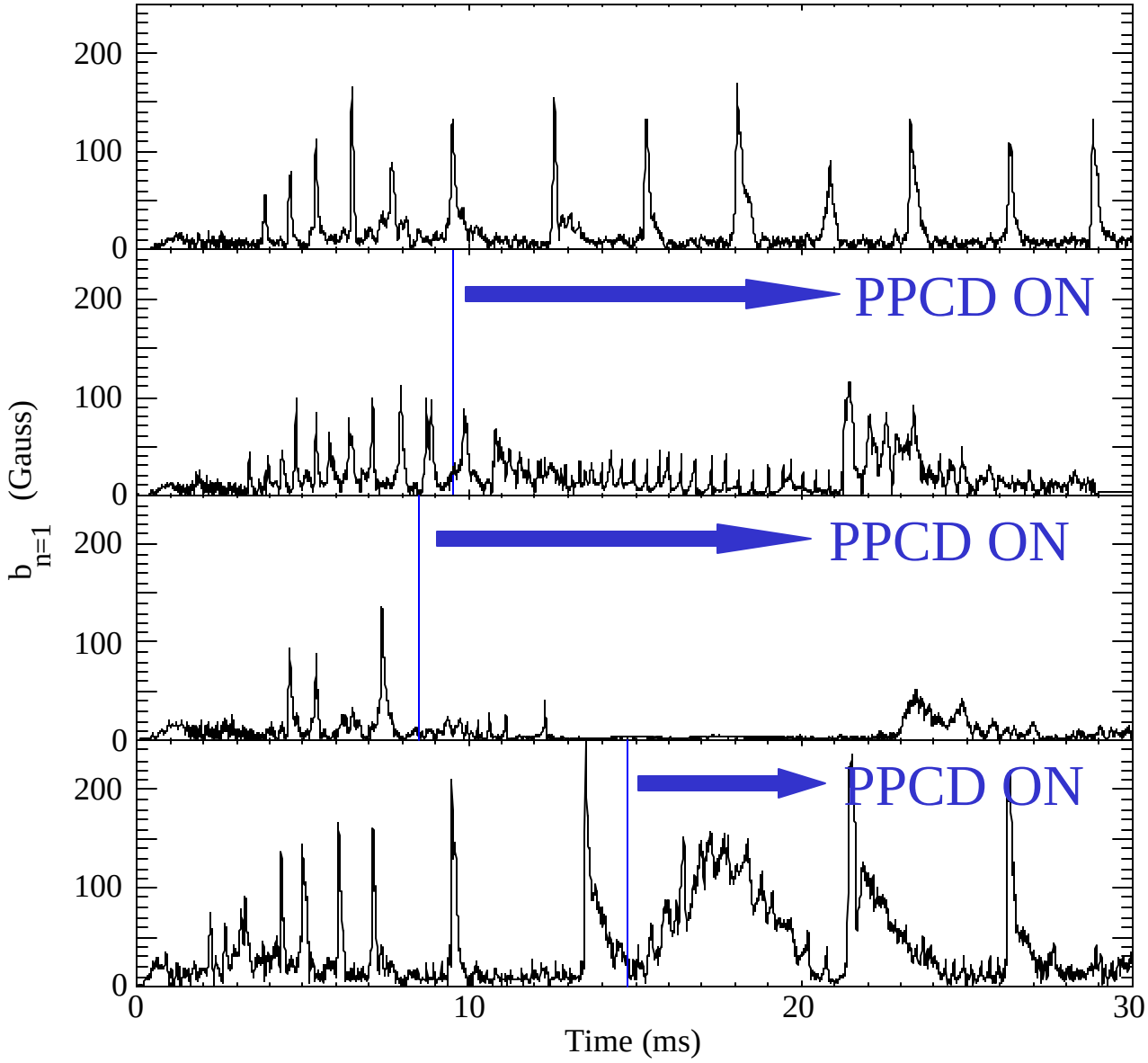
Key Questions

- What do we know about m=0 modes experimentally?
- What drives m=0 modes?
- What is their role in edge and core transport?
- What is their role in relaxation?
- How important is control of m=0 modes?
- By what means can they be controlled?

m=0 Modes are Large and Bursty in MST



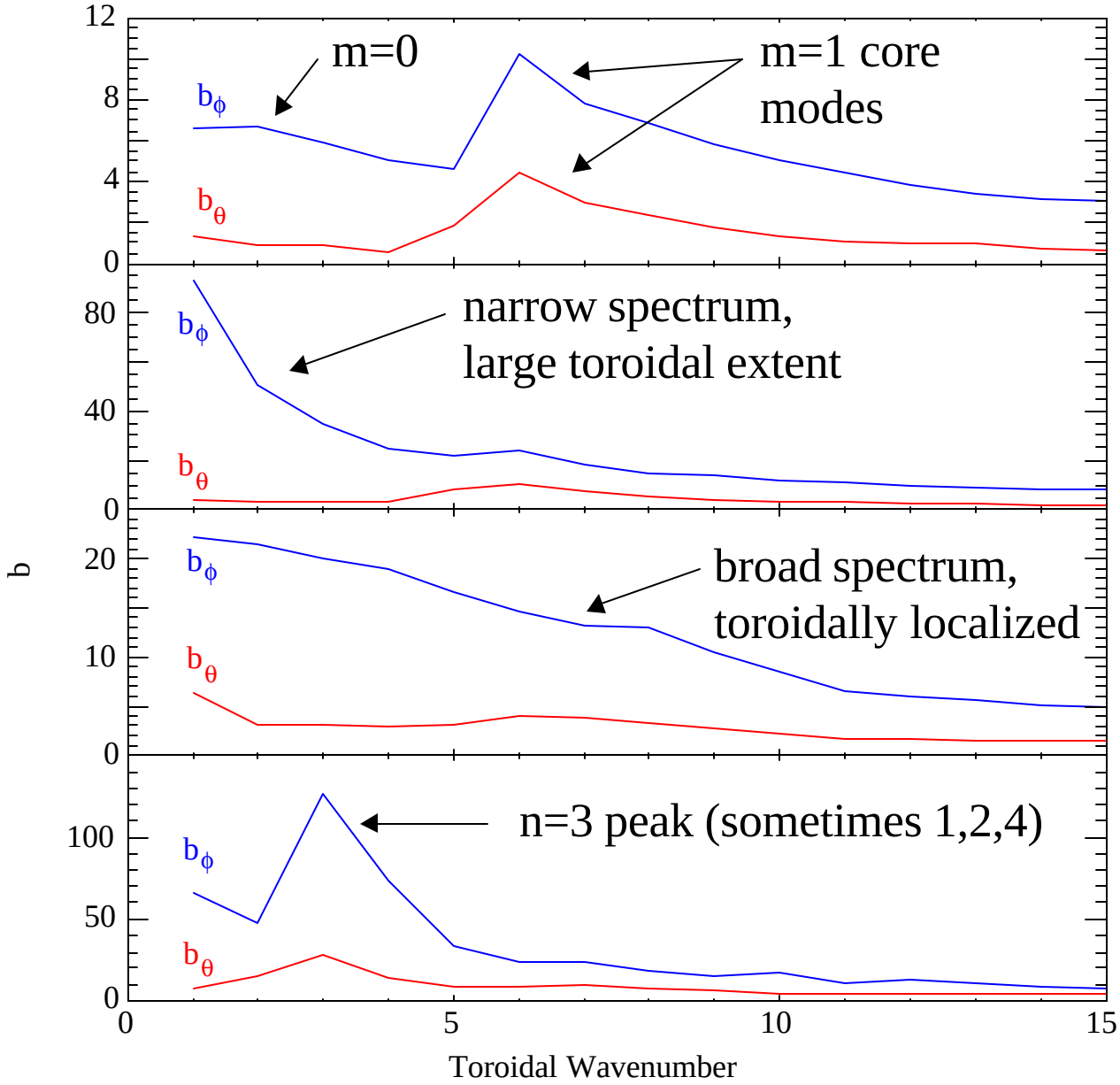
Standard 200 kA discharge

200 kA PPCD with rapid bursts

200 kA PPCD burst free

300 kA PPCD overdriven

m=0 Spectrum Exhibits Great Variety



200 kA Standard Between Crashes

200 kA Standard During Crashes

200 kA PPCD During Bursts

300 kA PPCD Overdriven

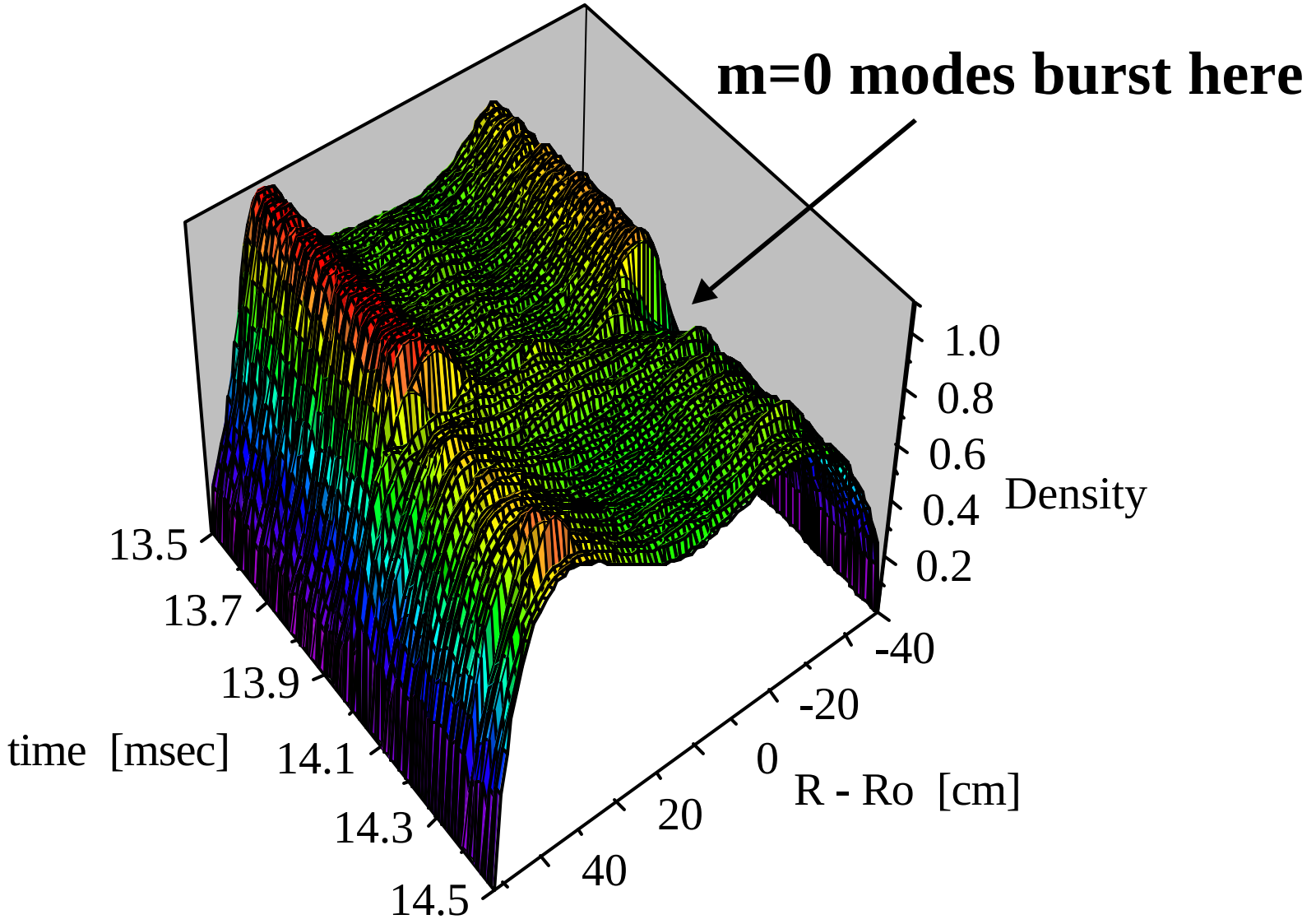
What Drives m=0 Modes in MST?

- Nonlinear coupling to m=1 core modes may provide some power but is clearly not the only source. (Which way does power flow actually go?)

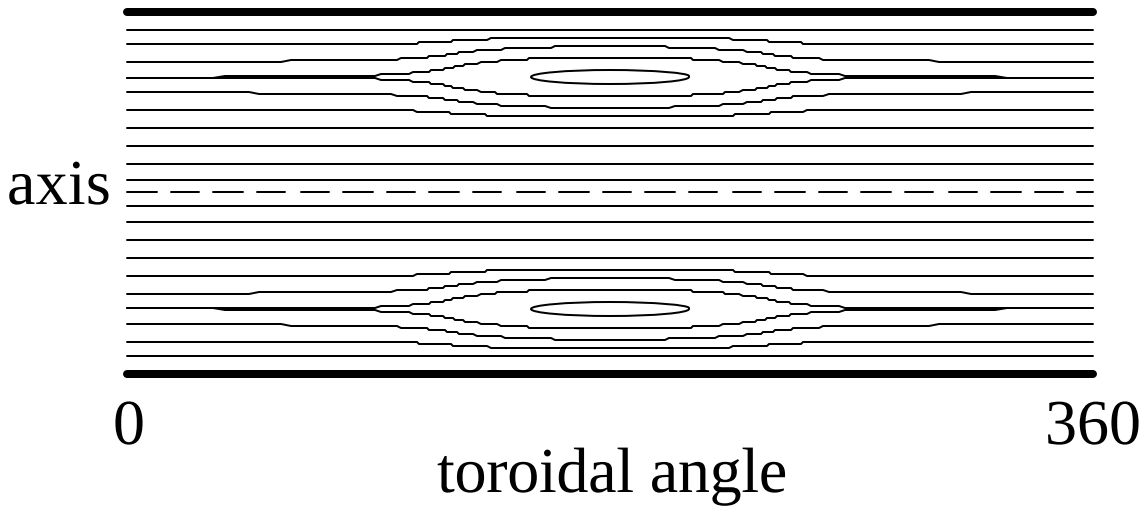
- Bursts in PPCD high confinement could be related to either current or pressure gradients.

- Overdriven PPCD seems to suggest current gradient drive in that case. (Why n spectrum not peaked at n=1?)

m=0 Bursts Degrade Confinement



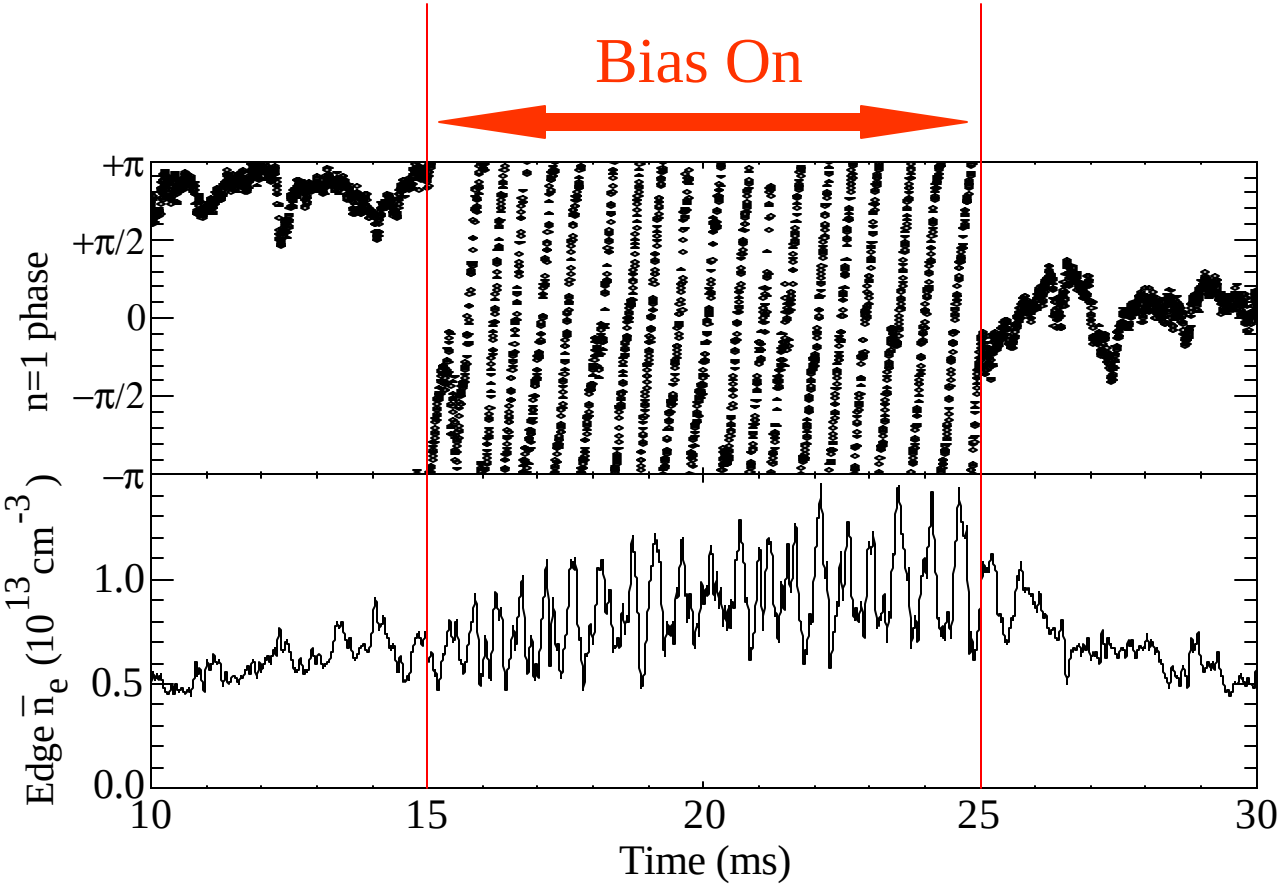
m=0 Modes Create Toroidally Localized Ring



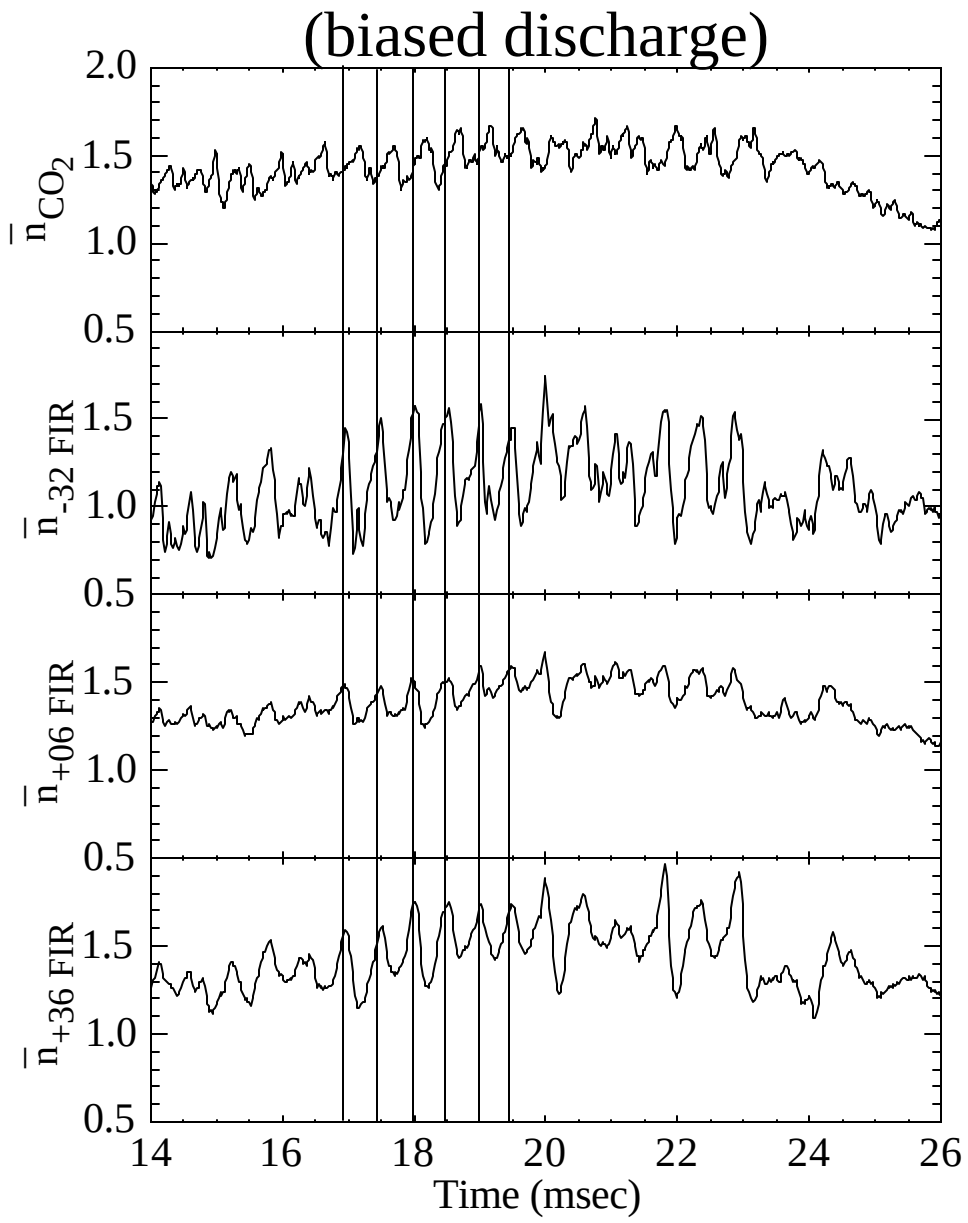
- Broader n spectrum means more toroidally localized.
- Measure large perturbations in n, ϕ, v, J associated with this structure.

Edge Biasing Rotates m=0 Fluctuations

- m=0 modes often locked in standard discharges.
- Edge biasing enables fluctuation measurements.



Localized Edge m=0 Density Fluctuation



Central, ϕ=60°

Inboard, ϕ=250°

Central, ϕ=250°

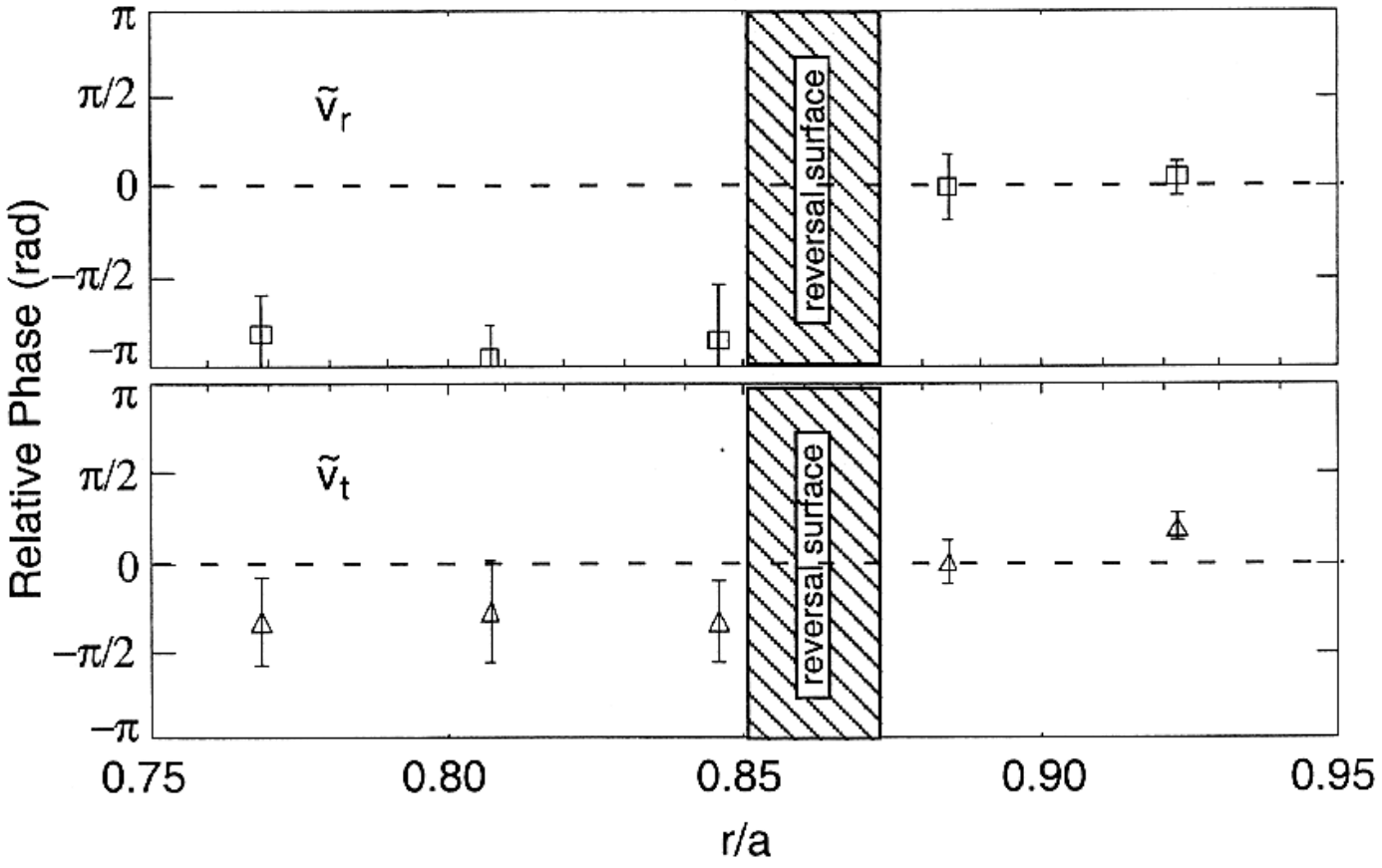
Outboard, ϕ=250°

180 ° out of phase, n=1

In phase, m=0

m=0 Velocity Shows Tearing Parity

- Velocity measured in edge with spectroscopic probe
- Velocity fluctuations in edge incoherent with core modes, dominated by m=0.



What is Effect of m=0 Modes on Confinement?

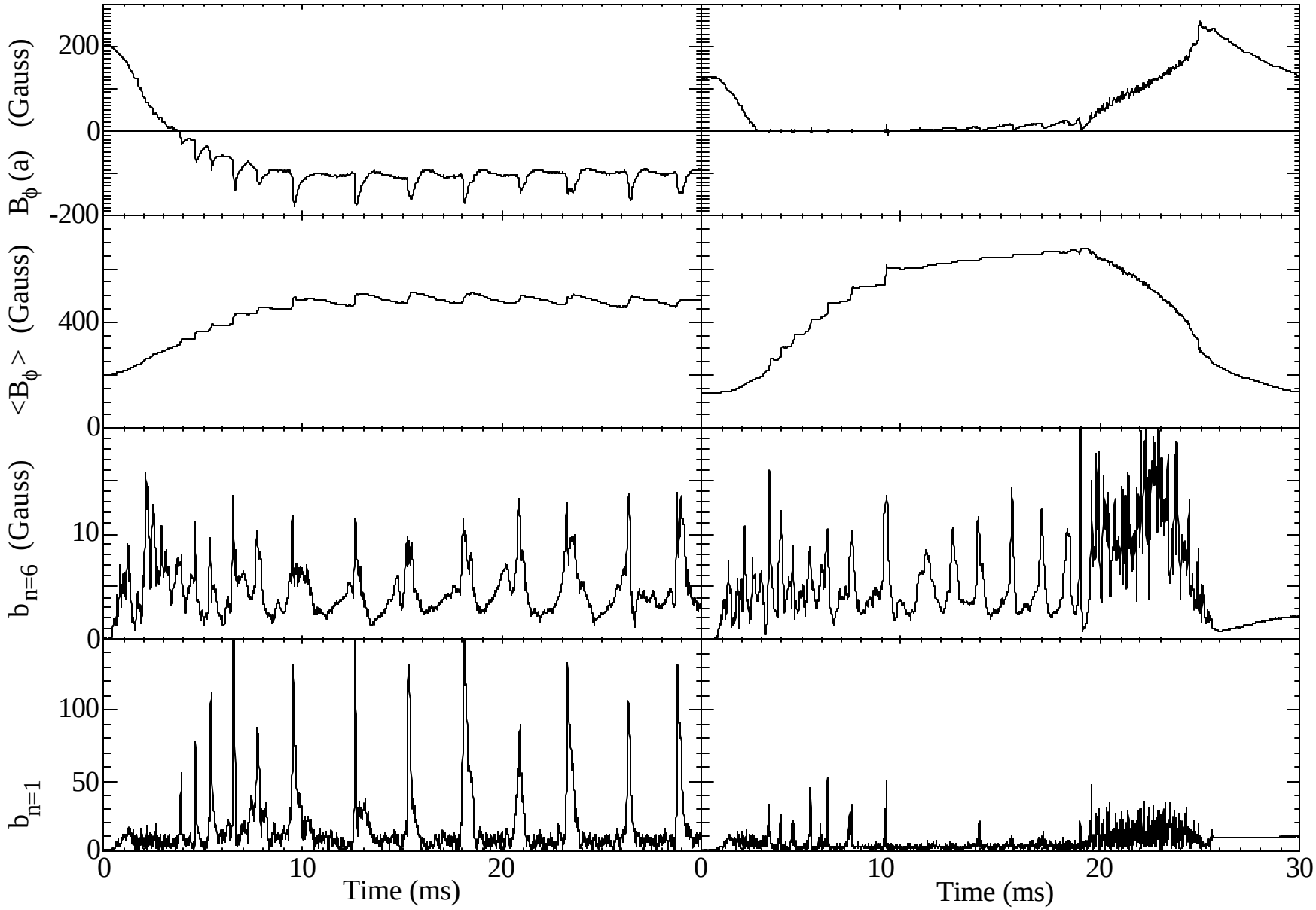
- Empirically, observe degraded confinement when m=0 modes are large.
- PPCD cases show this without large m=1 modes.

  $\Rightarrow$ m=0 modes play a role in confinement
- New question: Is the role of the m=0 modes direct or indirect?
- Do m=0 modes affect transport by broadening the m=1 spectrum, shifting power to edge m=1, …?
- Do m=0 modes directly cause transport?

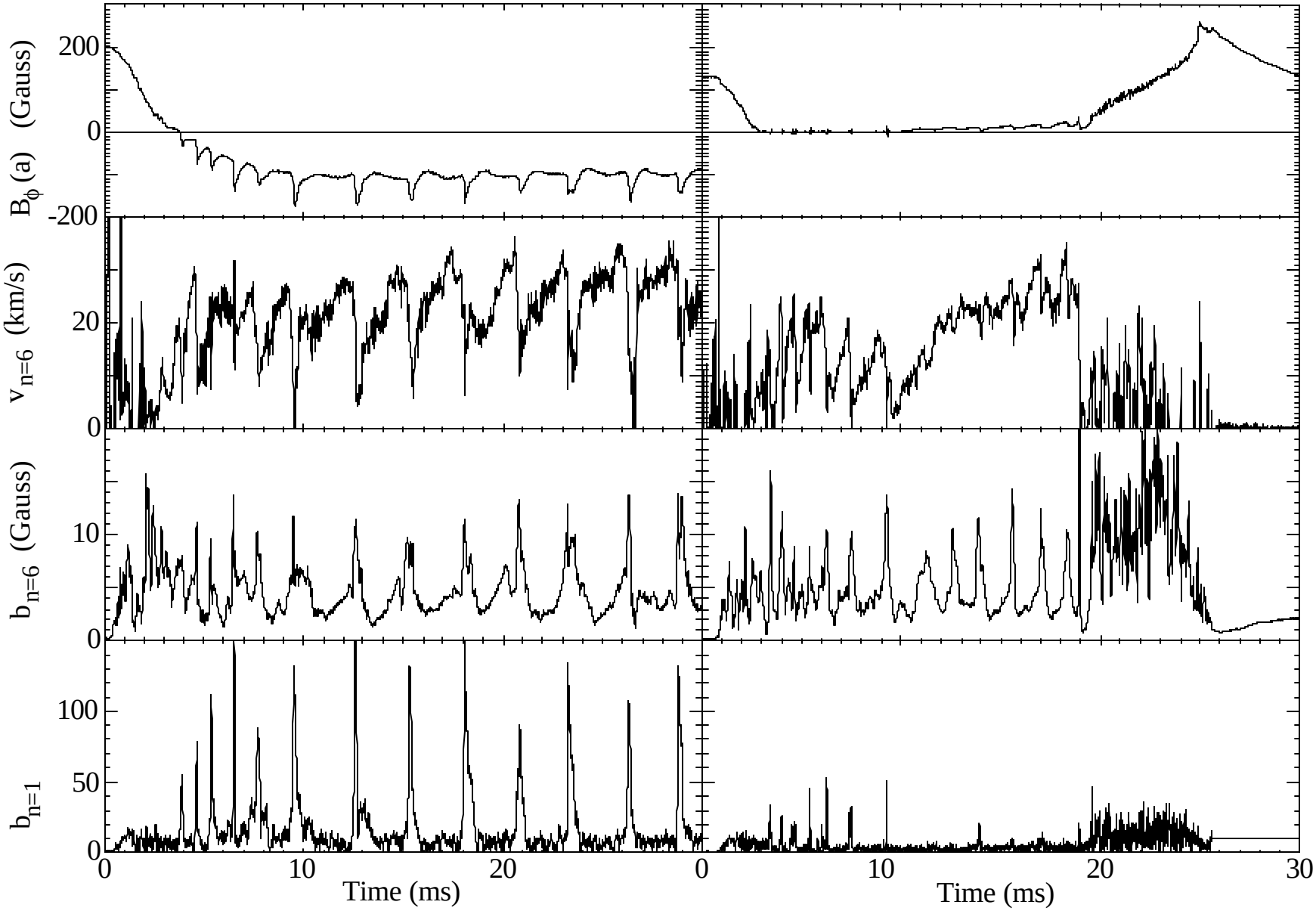
  -Note: Measurement probably requires spatial arrays of probes and biasing for rotation.

  (How do we measure orbit losses to the wall?)

m=0 Important for Magnetic Relaxation



m=0 Important for Momentum Relaxation



What is m=0 Role in Relaxation?

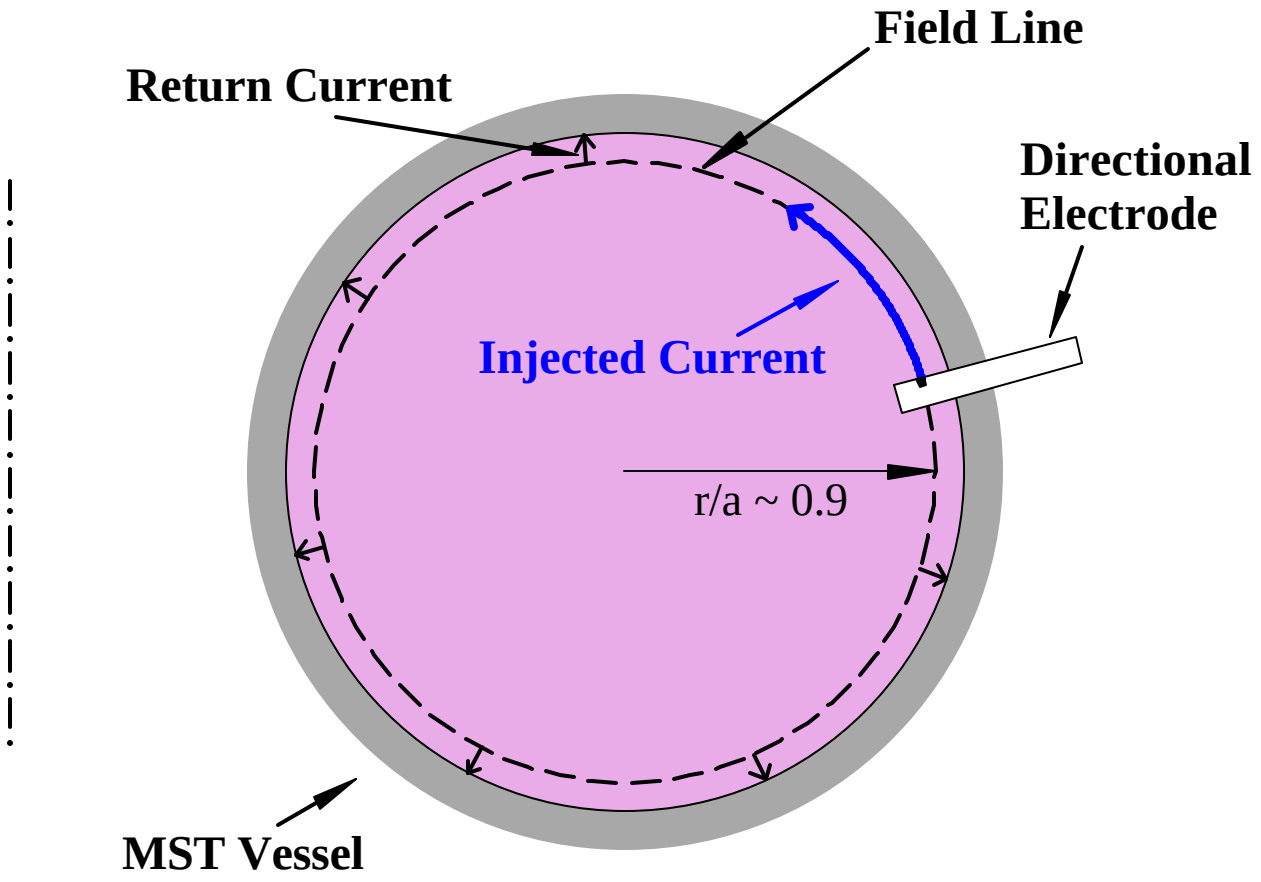
- m=0 produce dynamo in edge of reversed discharges.
- Large toroidal flux generation at sawteeth requires m=0 modes.
- Nonlinear coupling of m=1 and m=0 results in torques and momentum relaxation at sawtooth crashes.

Controlling m=0 Modes

- m=0 modes play an important role in transport and relaxation. It is important to be able to control them.
- Observations suggest edge current profile is one important driving mechanism for m=0.
- Use Electrostatic Current Injection to affect m=0.

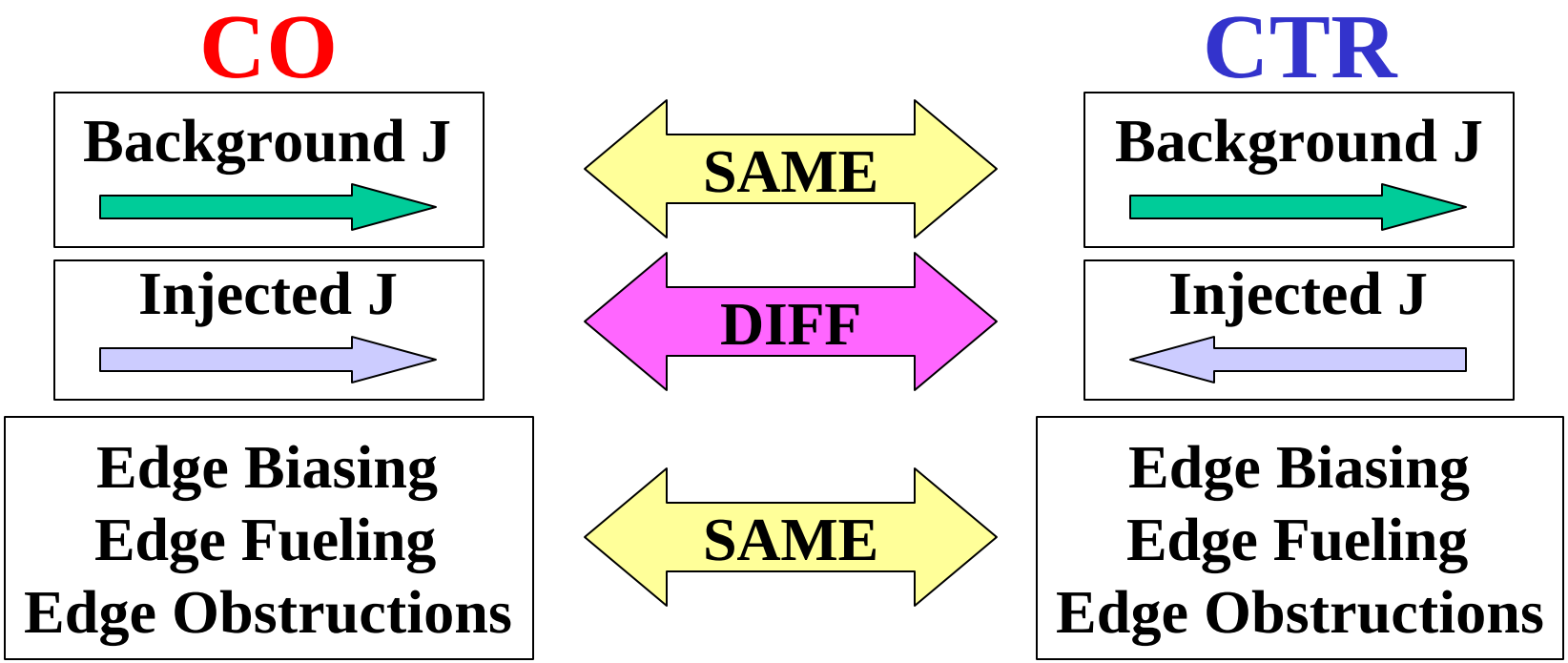
Electrostatic Current Drive

- Unidirectional emission from biased electrodes
- Multiple electrodes to increase and spread out current



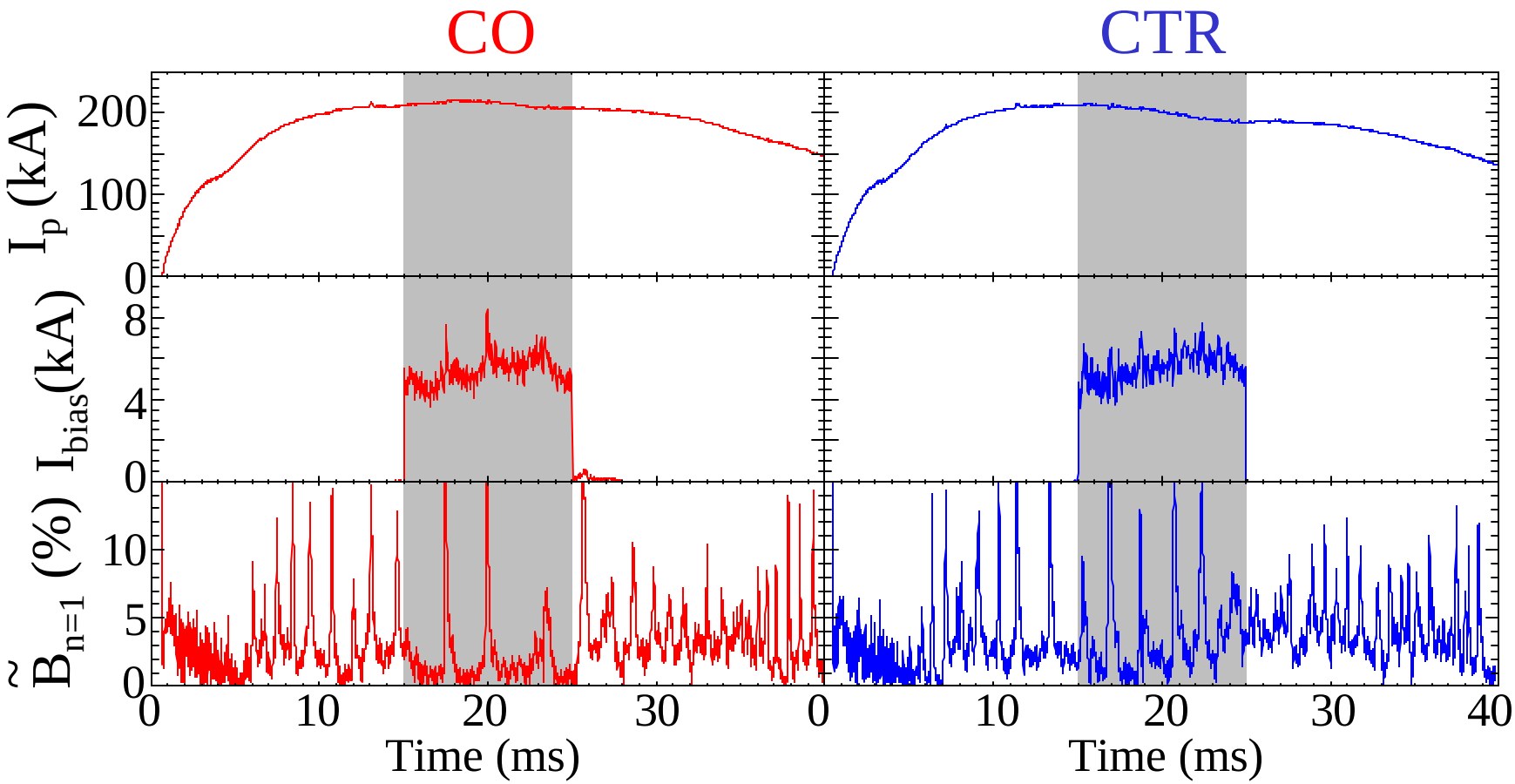
Isolating Current Drive Effects

- Isolate influence of J by contrasting cases with opposite injection direction.



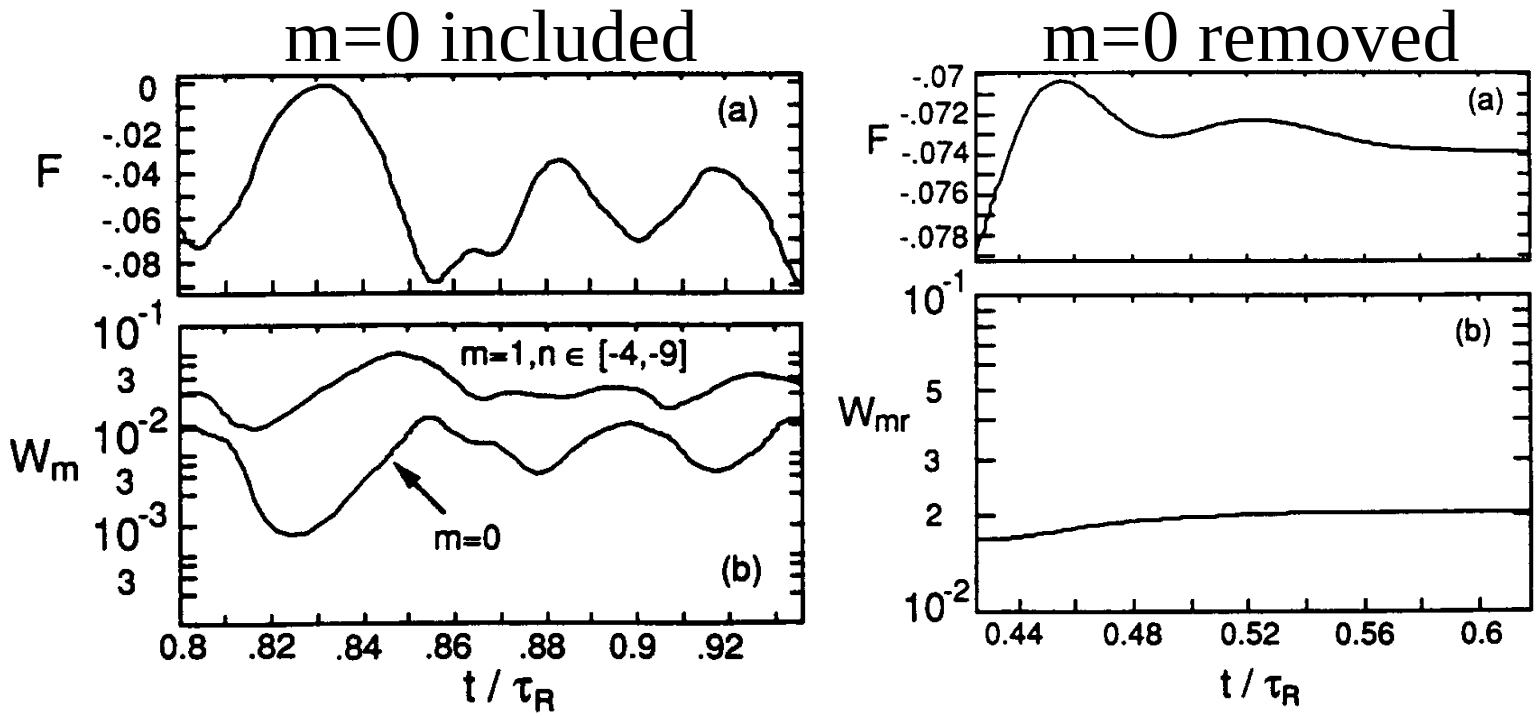
The Plasma Response to Current Drive

- Opposing directions of current drive result in different fluctuation behavior.



Nonlinear MHD Simulations Show Similar Behavior

- MHD simulations suggest m=0 necessary for relaxation oscillations
  - Ho and Craddock, Phys. Fluids B, 1991



Summary

- m=0 modes are an important part of RFP dynamics, especially in MST.
- Although resonant in the edge, these modes have large leverage due to their unique role in coupling.
- m=0 modes often appear in bursty events and play an important role in transport and relaxation.
- m=0 mode control should be developed along with m=1 mode control.
- Adding current outside the reversal surface appears to be a useful technique for controlling m=0 modes.