Highlights of Improved Confinement and Future Plans for MST

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LBNL

Key issues for RFP.

1. Improve confinement ⇐ MST and others
   – reduce magnetic stochasticity ($\tilde{B}/B \sim 1\%$)
   – $j(r)$-control, single-helicity dynamo (?)

2. Efficient current sustainment
   – test Oscillating Field Current Drive ⇐ MST
   – Alfvén or other high efficiency RF?

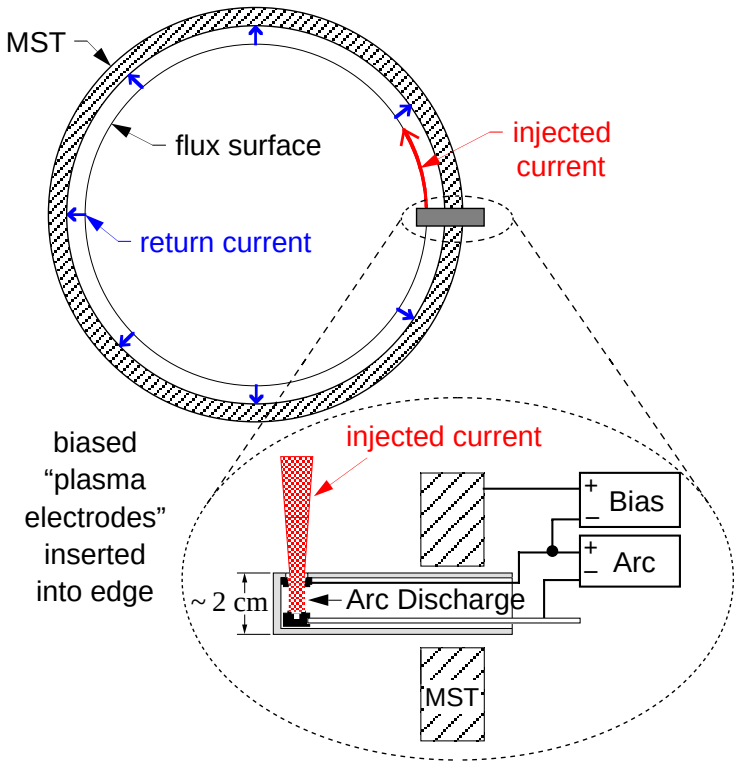
3. Control low-n resistive shell instabilities ⇐ modified RFX (?)
   – feedback, flow, rotating shells?
   – common to all high β configurations

4. Develop large wall loading capability
   – *choice* to realize compact reactor

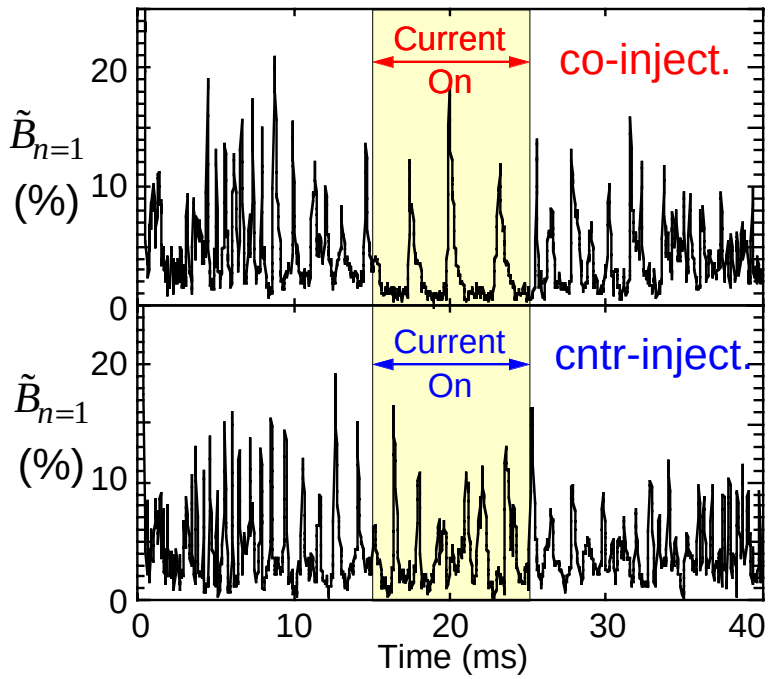
Edge electrostatic current injection controls *m*=0 modes.

Craig et al.

- Pulsed ES current in edge from 16 small sources

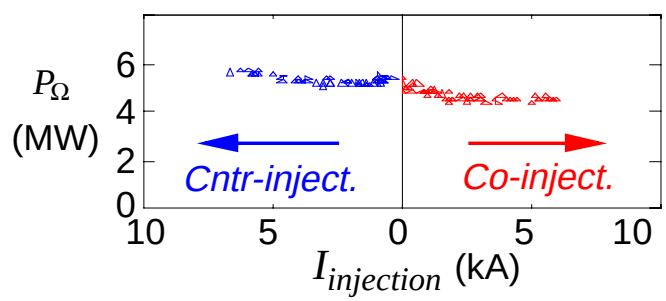


- Sawtooth cycle period increases with co-injection



time averaged m=0 modes reduced with co-injection

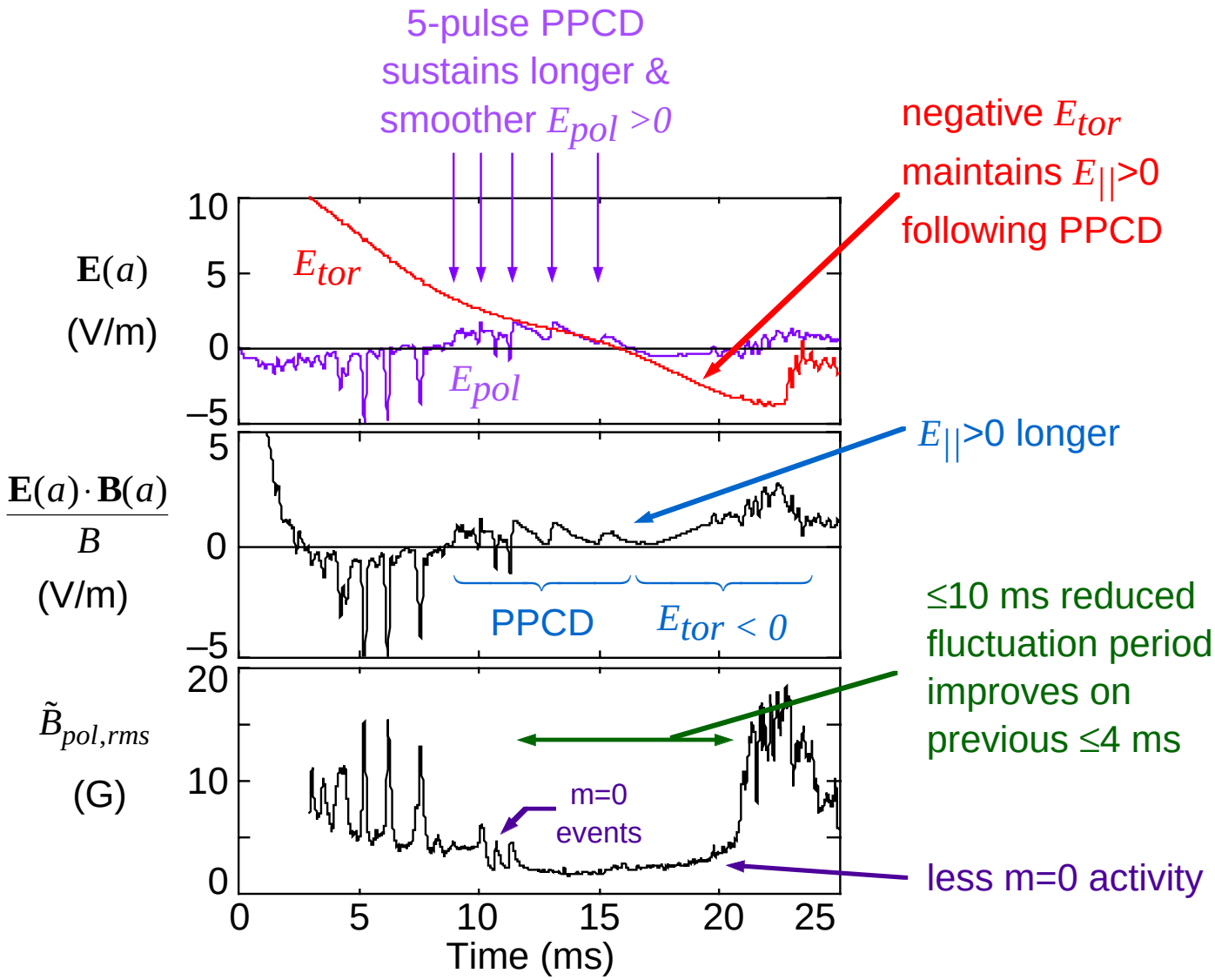
- Ohmic input power smaller for co-injection



Control of both core & edge modes (*m*=1 & *m*=0) important for maximizing RFP performance.

Bigger & longer reduction in fluctuations with refined PPCD.

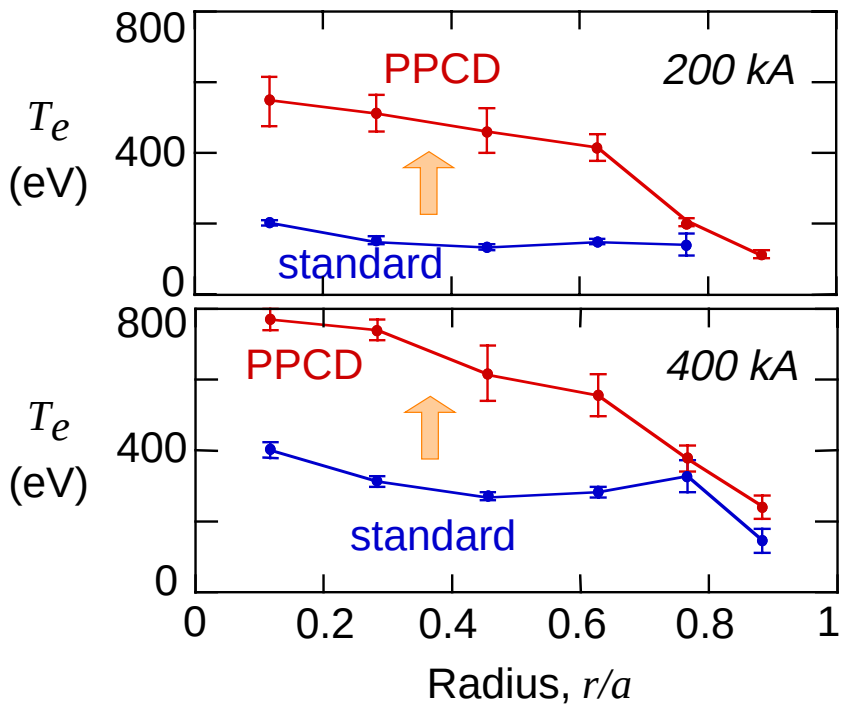
B.Chapman et al.



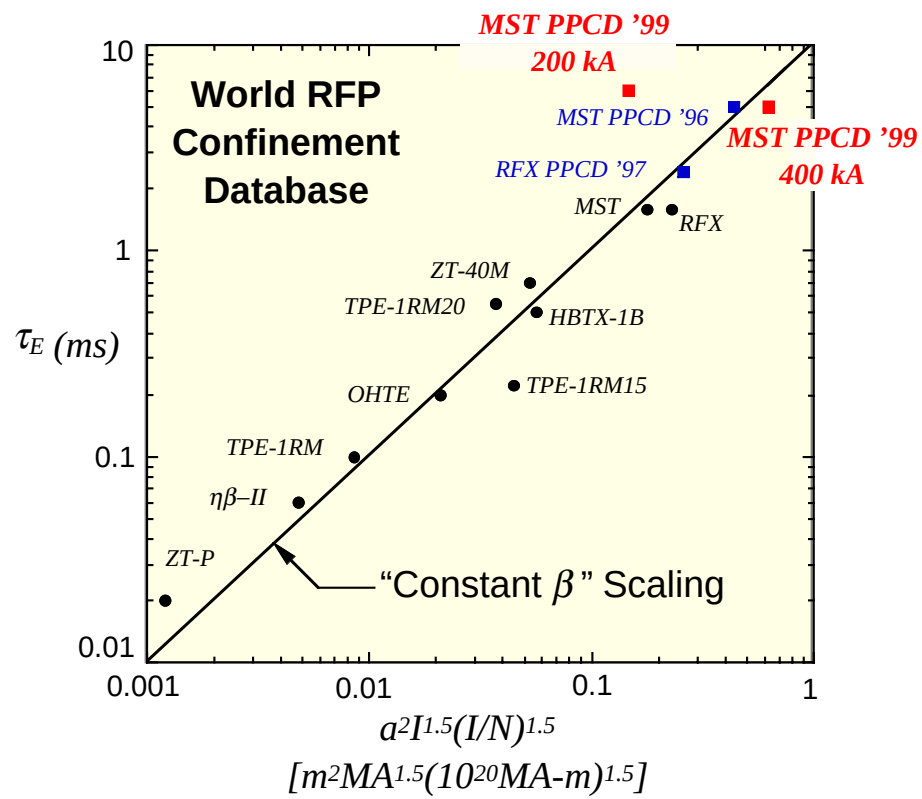
Dramatic peaking of $T_e(r)$ during PPCD.

Biewer et al.

- Single-point Thomson ensembles in standard and PPCD plasmas:



β_{tot} ~ 12%
for
200 kA PPCD

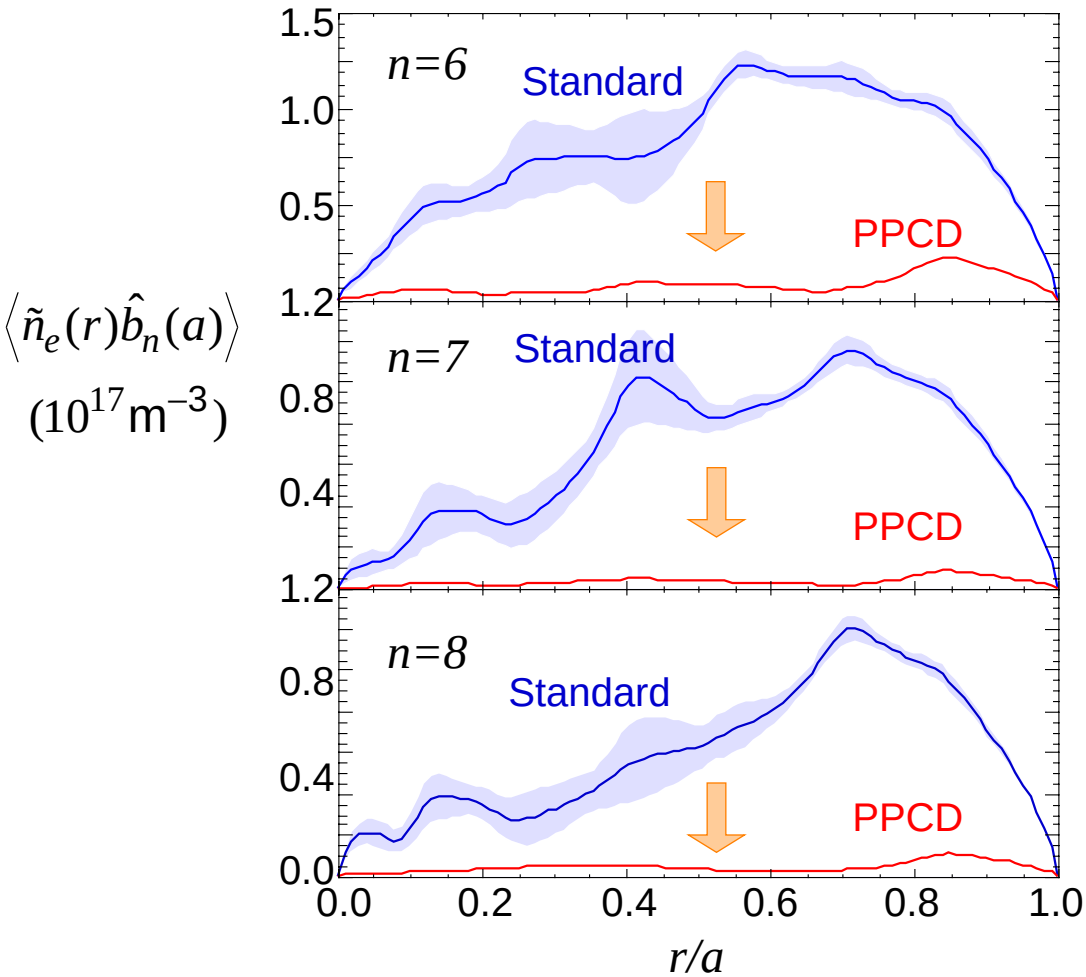


Long wavelength density fluctuations decrease globally.

Lanier et al.

- Density profile $n_e(r)$ measured with 11-chord FIR interferometry
  - correlation with edge magnetic fluctuations

    $\Rightarrow$ toroidal mode number n-resolved density fluctuation profiles



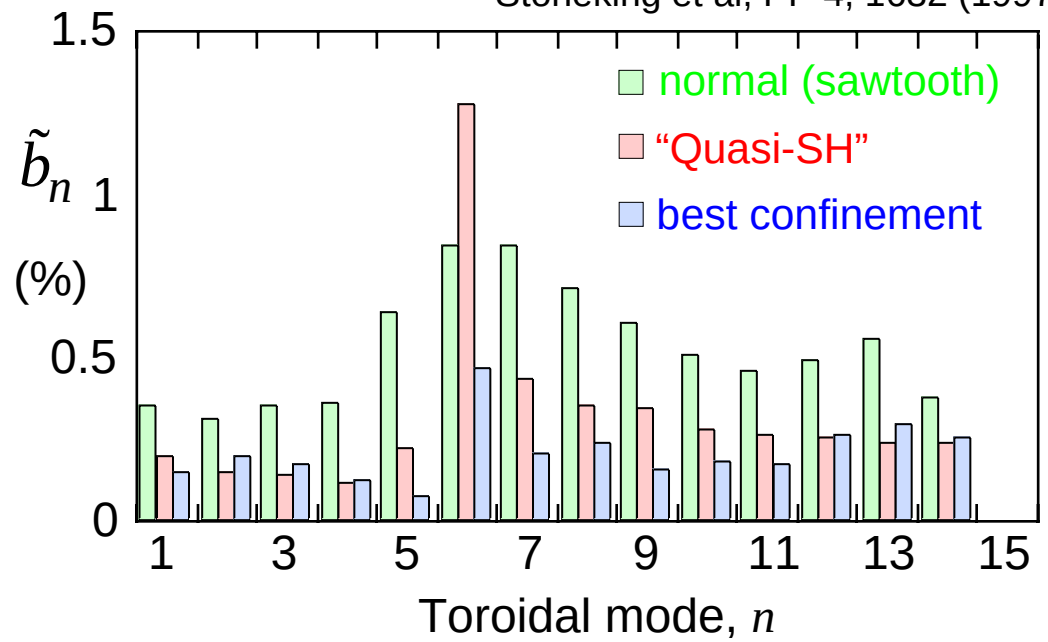
$\tilde{n}/n \sim 1\%$ standard

$\tilde{n}/n \sim 0.1\%$ PPCD

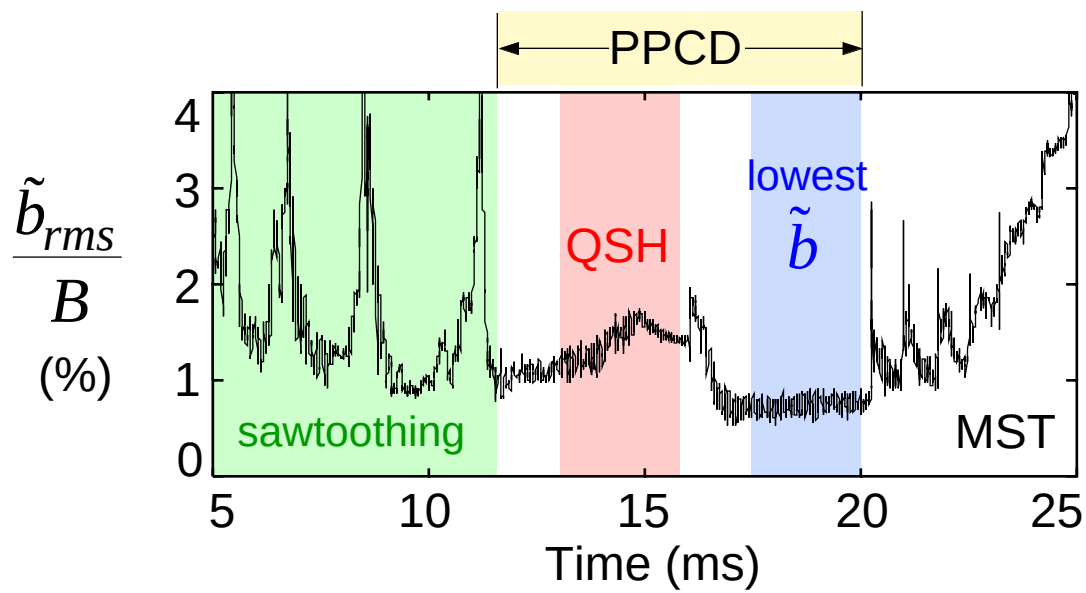
Improved confinement in RFPs correlates with "broadband" mode reduction.

- Consistent with tearing from locally resonant modes.
- "Quasi-single-helicity" observed in all RFPs
  - in MST: typically n=6 (inner most mode)
  - PPCD & spontaneous "sawtooth-free" transitions

Stoneking et al, PP 4, 1632 (1997).



What's role of QSH in broadband mode reduction? (especially in spontaneous transitions)



MST's auxiliary system & diagnostic additions underway.

1. Improve confinement via $j(r)$-control
   - lower hybrid
   - electron Bernstein wave (?)
   - steady-state PPCD & high frequency OFCD

2. Current sustainment via Oscillating Field Current Drive (OFCD)

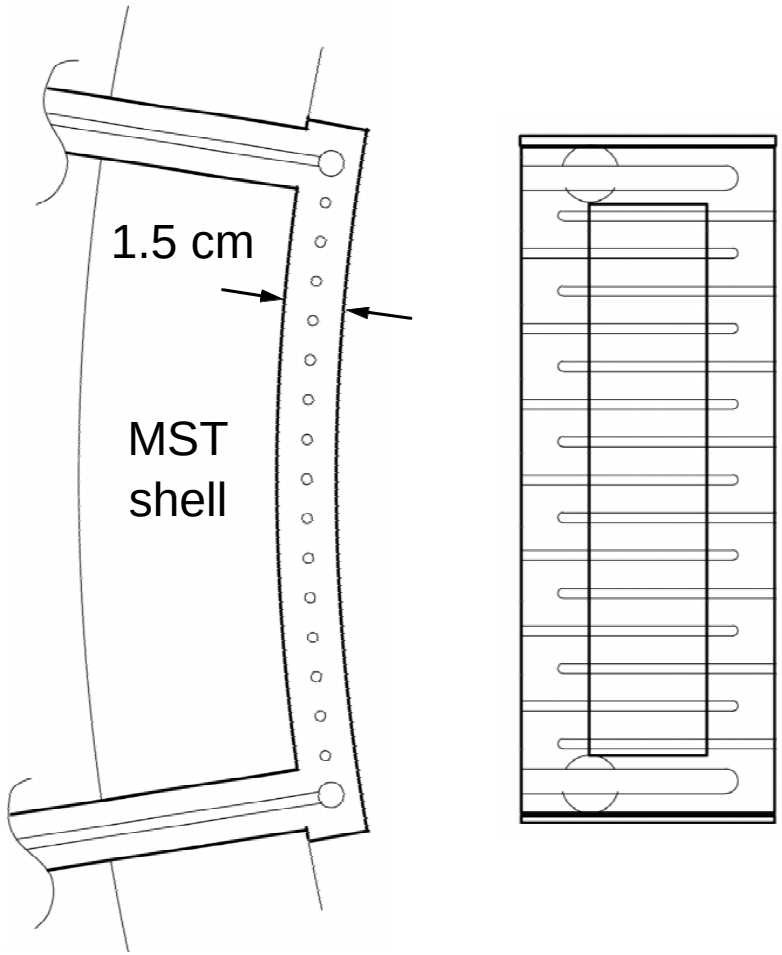
3. Multi-mode rotating magnetic perturbations

4. Diagnostics:
   - multi-point Thomson scattering
   - Rutherford scattering (H-DNB)
   - CHERS (He-DNB)
   - MSE (He-DNB)
   - HIBP (collab. w/ RPI)
   - FIR polarimetry (collab. w/ UCLA)

Lower hybrid combline antenna installed, tests begun.

Thomas et al.

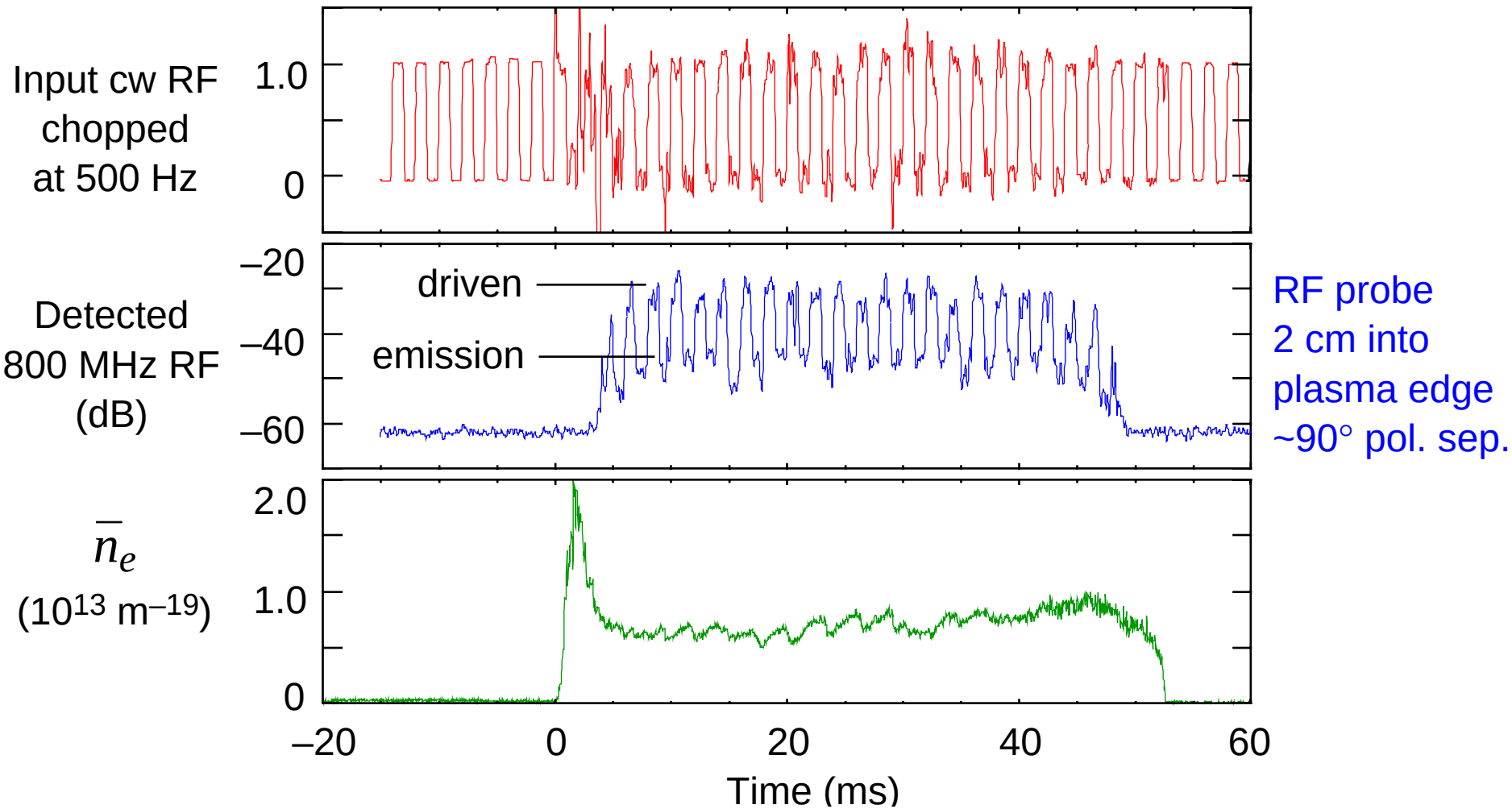
- Traveling wave, $\pi/2$ phasing
  - 800 MHz, $n_{||}$~9
  - feeds interchangable (co- & cntr- drive)
  - short radial build



- Antenna installed inside MST

Driven 800 MHz wave detected in MST plasma.

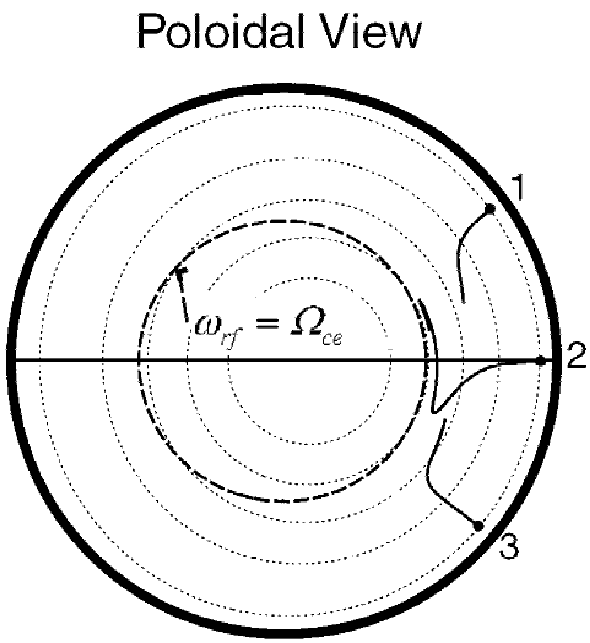
Chattopadhyay et al



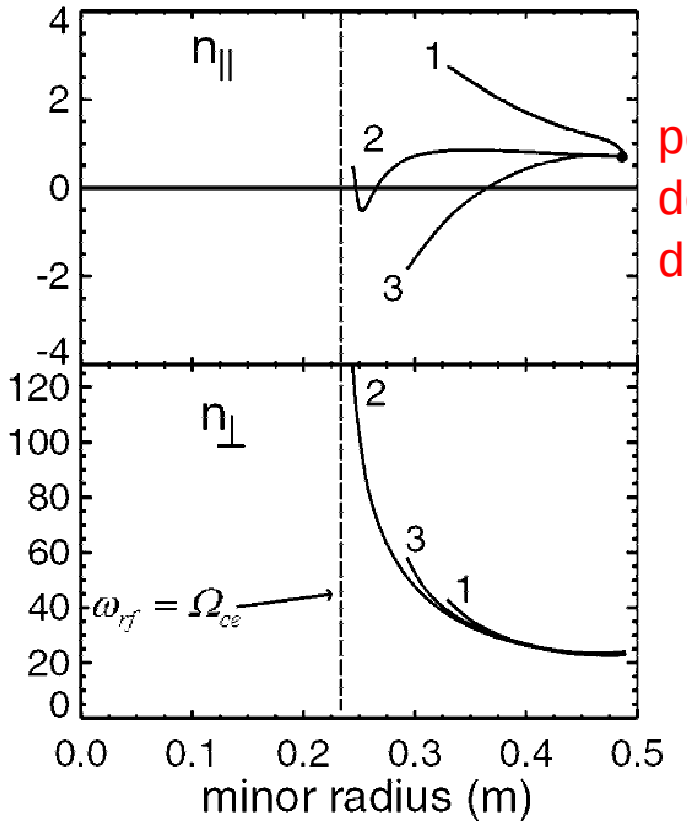
Electron Bernstein wave could better localize current drive.

Forest, Harvey

GENRAY and CQL3D calculated single ray propagation and damping.



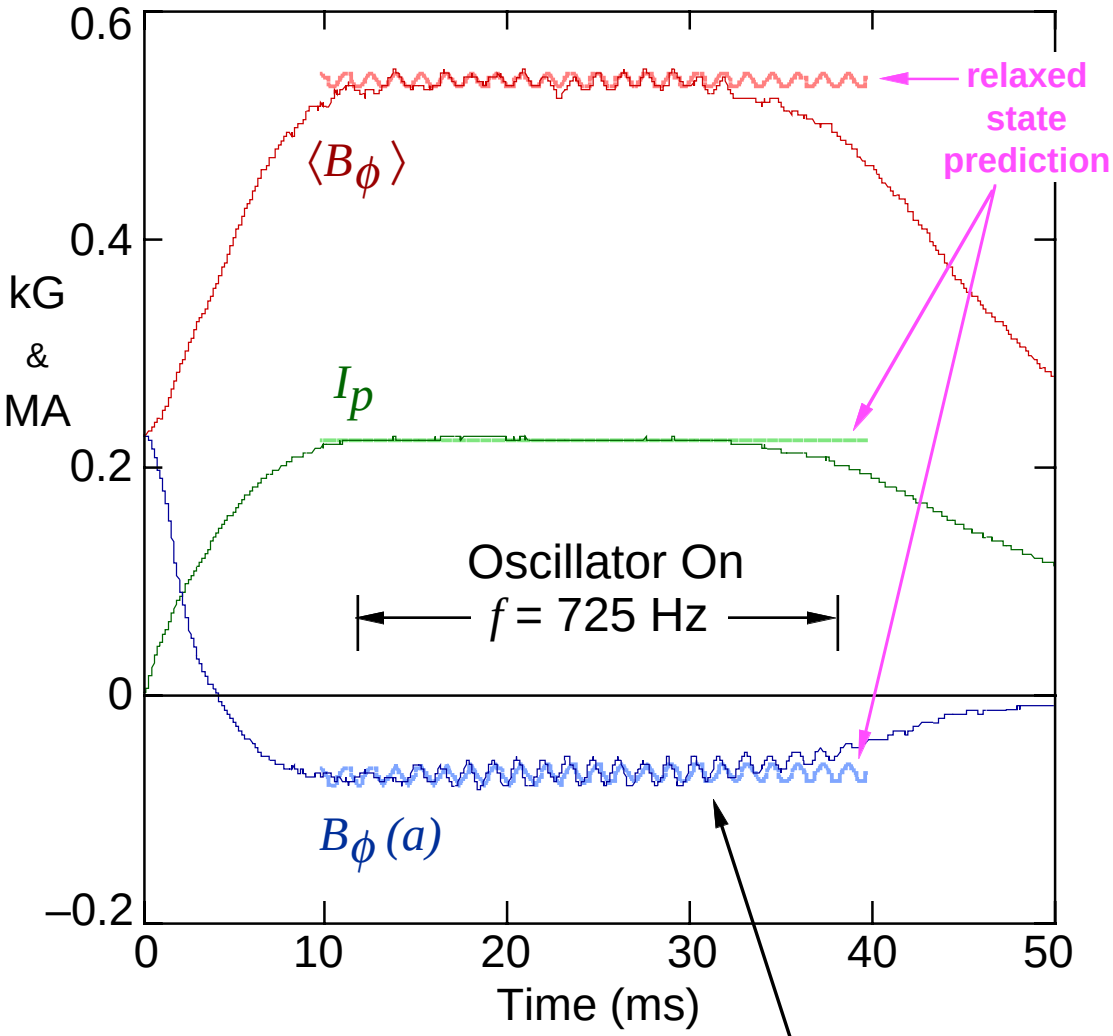
cyclotron nature of wave could provide better localization



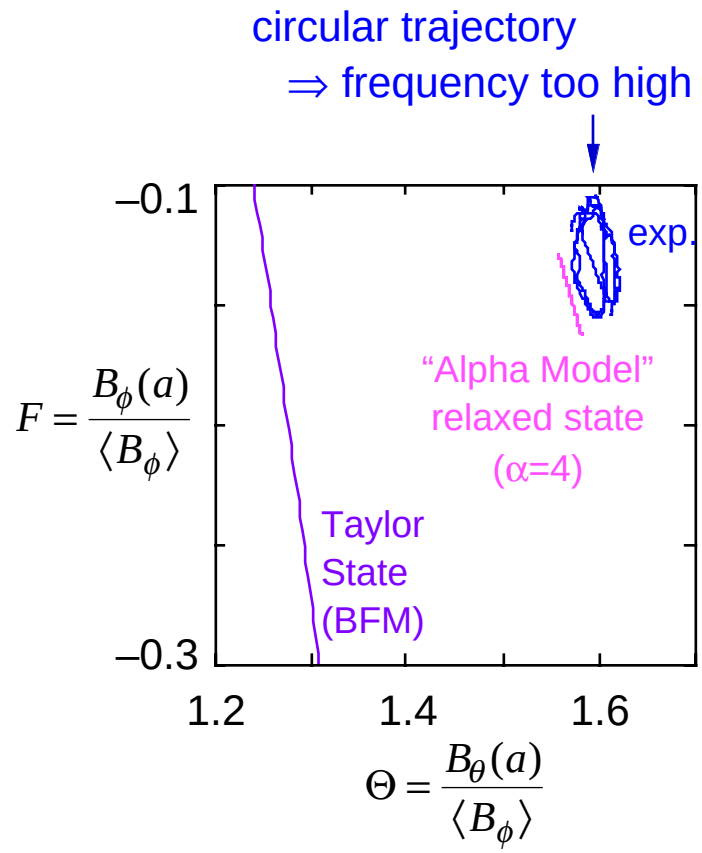
poloidal launch angle determines current drive direction.

Prototype OFCD oscillator probes relaxation physics.

- Low power TF-only modulation experiments suggest f < 700 Hz required



phase difference ⇒ incomplete relaxation



Summary.

- Impact of edge resonant m=0 magnetic fluctuations on plasma behavior and confinement becoming clearer.

- Maximum confinement and beta correlates with biggest and longest lasting magnetic fluctuation reductions (both core and edge resonant):
  - strong peaking of temperature profile
  - "universal" improvement (e.g., electrostatic fluctuations reduced as well)

- MST's auxiliary system and diagnostic additions underway:
  - exciting knobs to manipulate the plasma
  - better diagnosis, especially profiles which are changing in time