MHD-Induced Alpha Particle Loss in TFTR

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PPPL
APS '97

Does MHD cause alpha loss in TFTR ?

Will it cause alpha loss in ITER ?

- Data w/ some examples
- Theory and Modeling
- Data vs. Modeling (preliminary)

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TFTR DT Alpha Loss Data

- MHD-induced alpha loss in ≈ 10 % of DT shots

- All types of plasma MHD caused alpha loss:
  - normal coherent low frequency modes
  - higher frequency coherent modes (KBM)
  - stationary magnetic perturbations
  - sawtooth crashes
  - major and minor disruptions

- Alpha loss *not* seen during alpha-driven TAEs

Theory and Modeling

- It is well known that MHD can cause alpha loss
  - stochastic threshold $B_r/B \approx (\varepsilon/n\pi q)^{3/2}\,(1/\rho q') \approx 10^{-2}$

    (Mynick and White, 1989, Goldston, White , Boozer 1981)
  - resonant alpha loss at p/t boundary for KBM

    (Z. Chang, et al, PRL '97)
- Use ORBIT GC code with helical perturbations
  - follow ≈1000 alphas for ≈1000 transits
  - evaluate alpha loss vs. mode size and (m/n)
- Model used so far is highly oversimplified
  - no realistic radial mode structure
  - no real frequency or source modulation

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Data vs. Modelling (prelim.)

- Measured low-n island size of ≈ 4-20 cm is *roughly consistent* with calculated mode size where MHD-induced loss ≈ first-orbit loss

  needs a more realistic mode structure in code to make a quantitative comparison

- Poloidal distribution in experiment seems *more peaked near 60º* than expected from ORBIT

  needs a more careful treatment of the vacuum field structure and limiter shadowing effects

- Modulation of alpha loss in experiment seems *stronger than expected* from ORBIT code

  need to include fluctuations in alpha source profile,as observed on neutron collimator

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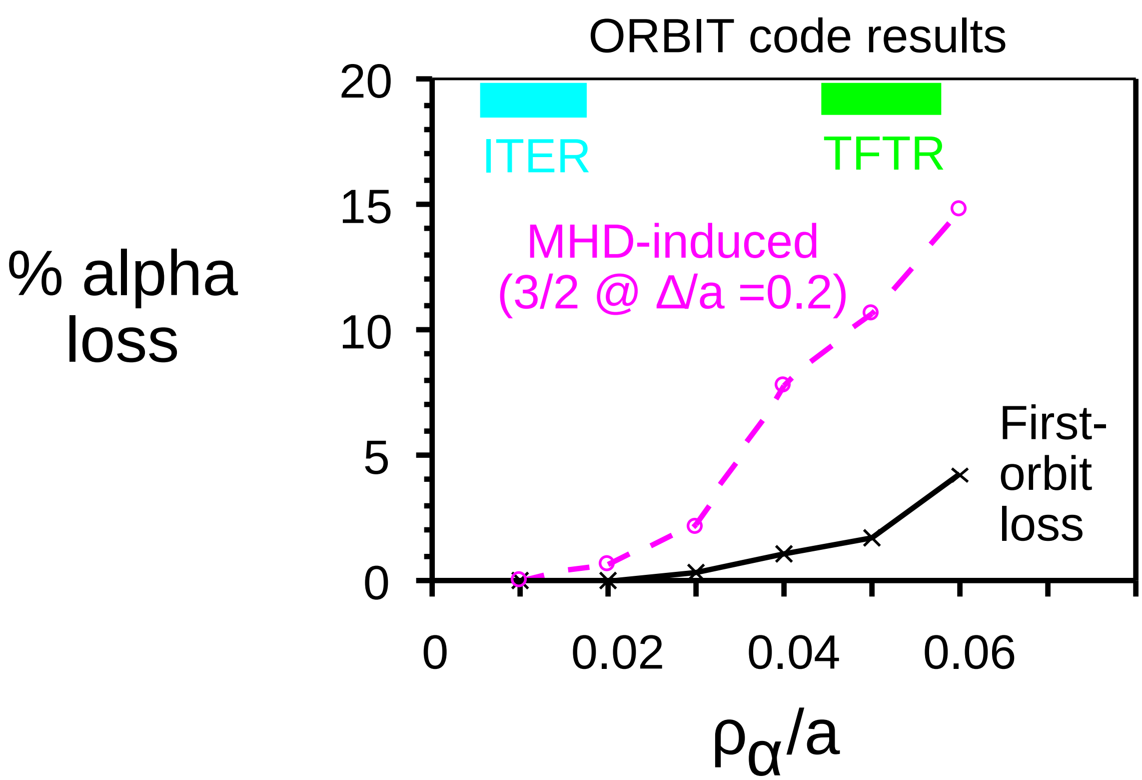
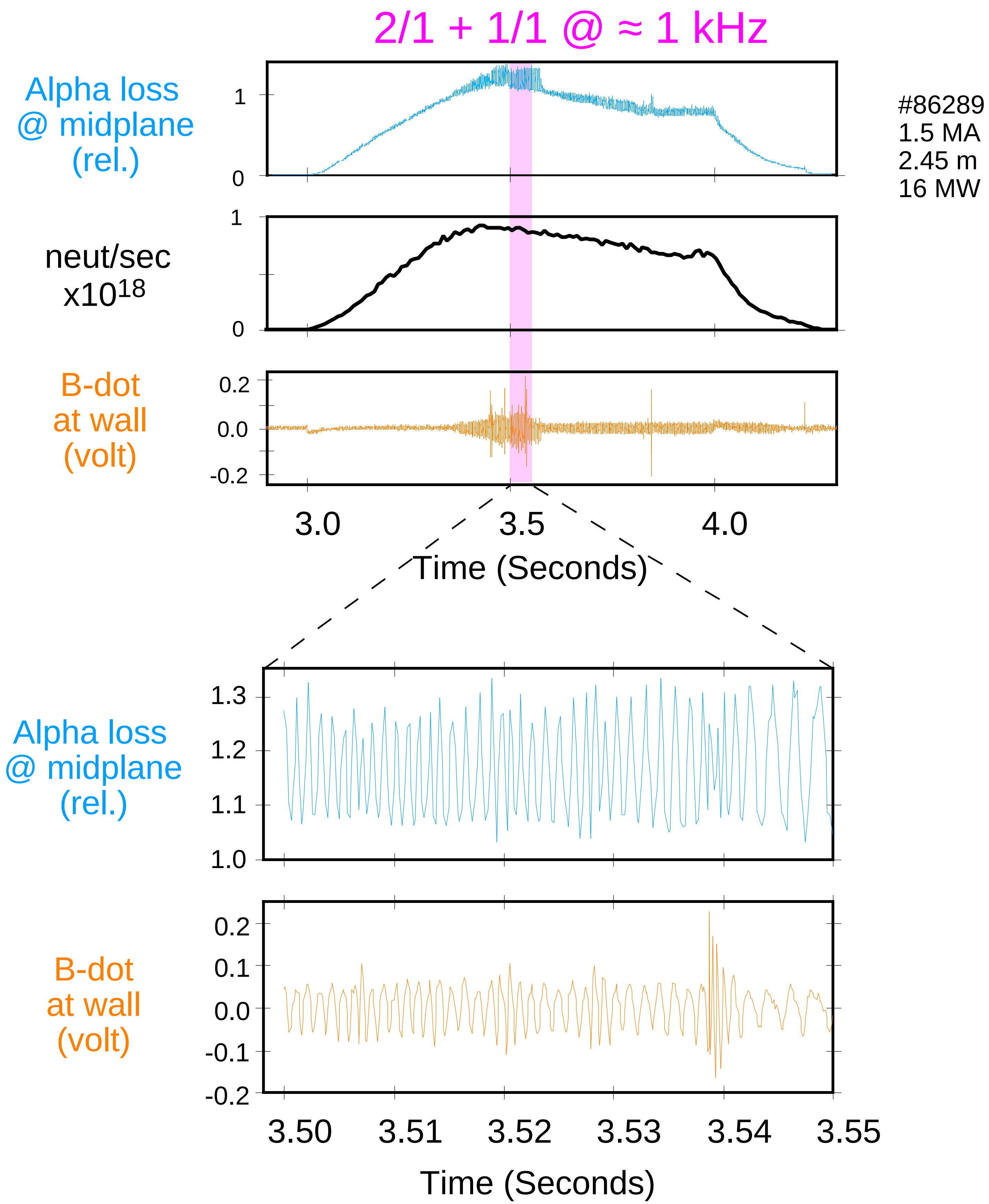
Tentative Conclusions

- MHD-induced alpha loss due to low-n, low-freq. modes is ≤ first-orbit or ripple loss in TFTR

- This type of MHD-induced alpha loss should be negligible in ITER due to smaller ρ_α/a



Low-n MHD Causes Increased Alpha Loss



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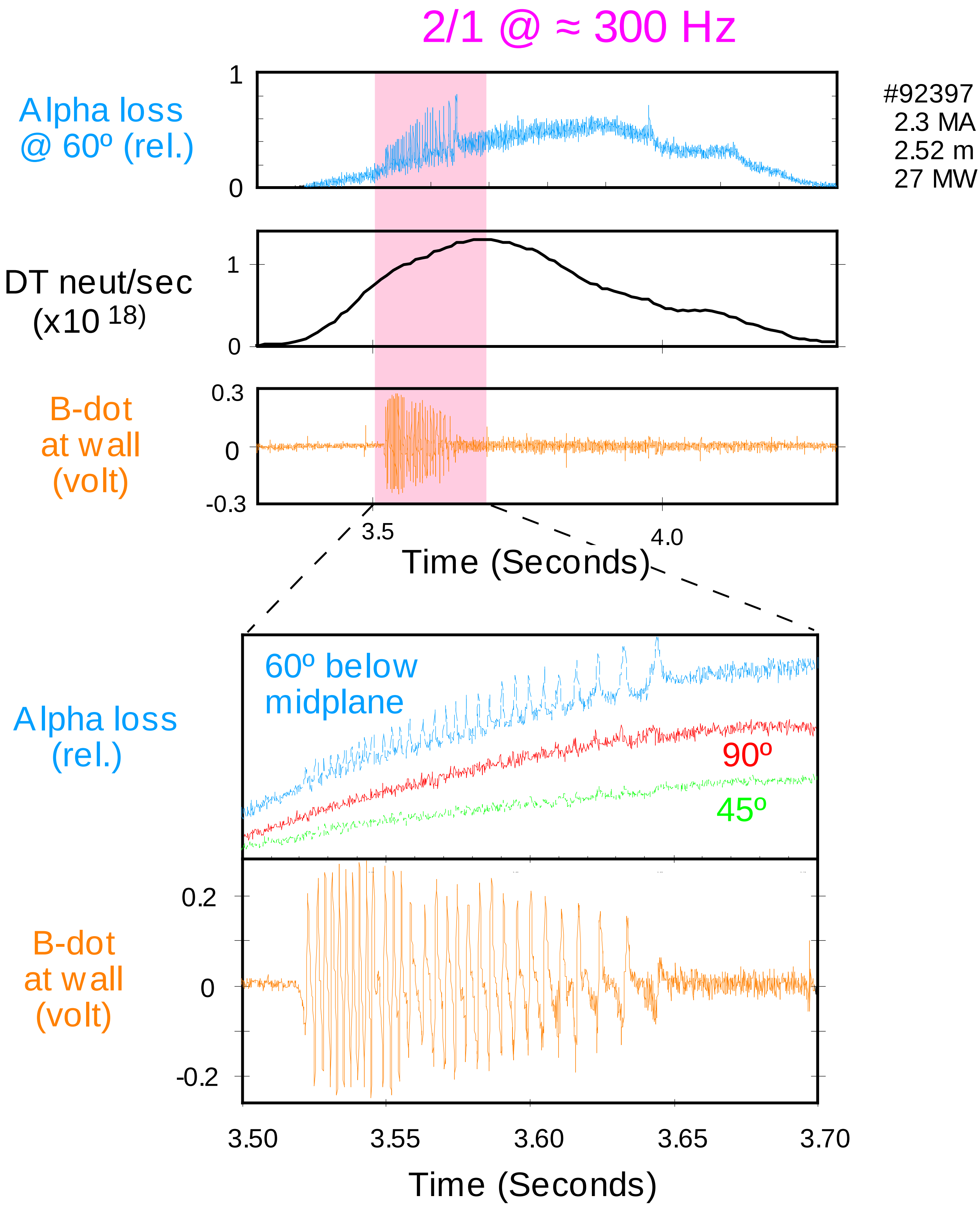
Alpha Loss Can Be Poloidally Non-Uniform



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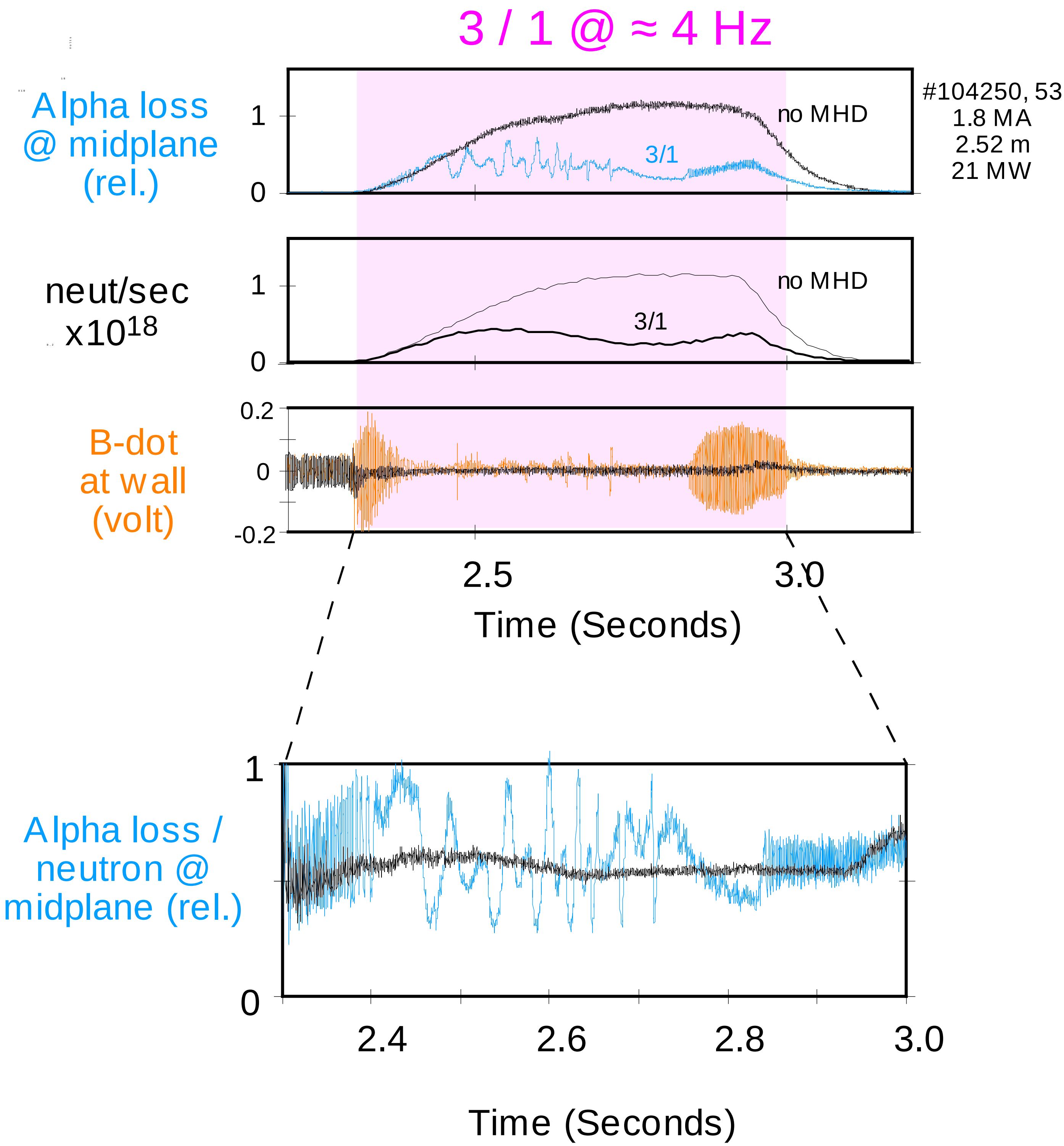
MHD Can Strongly Modulate Alpha Loss



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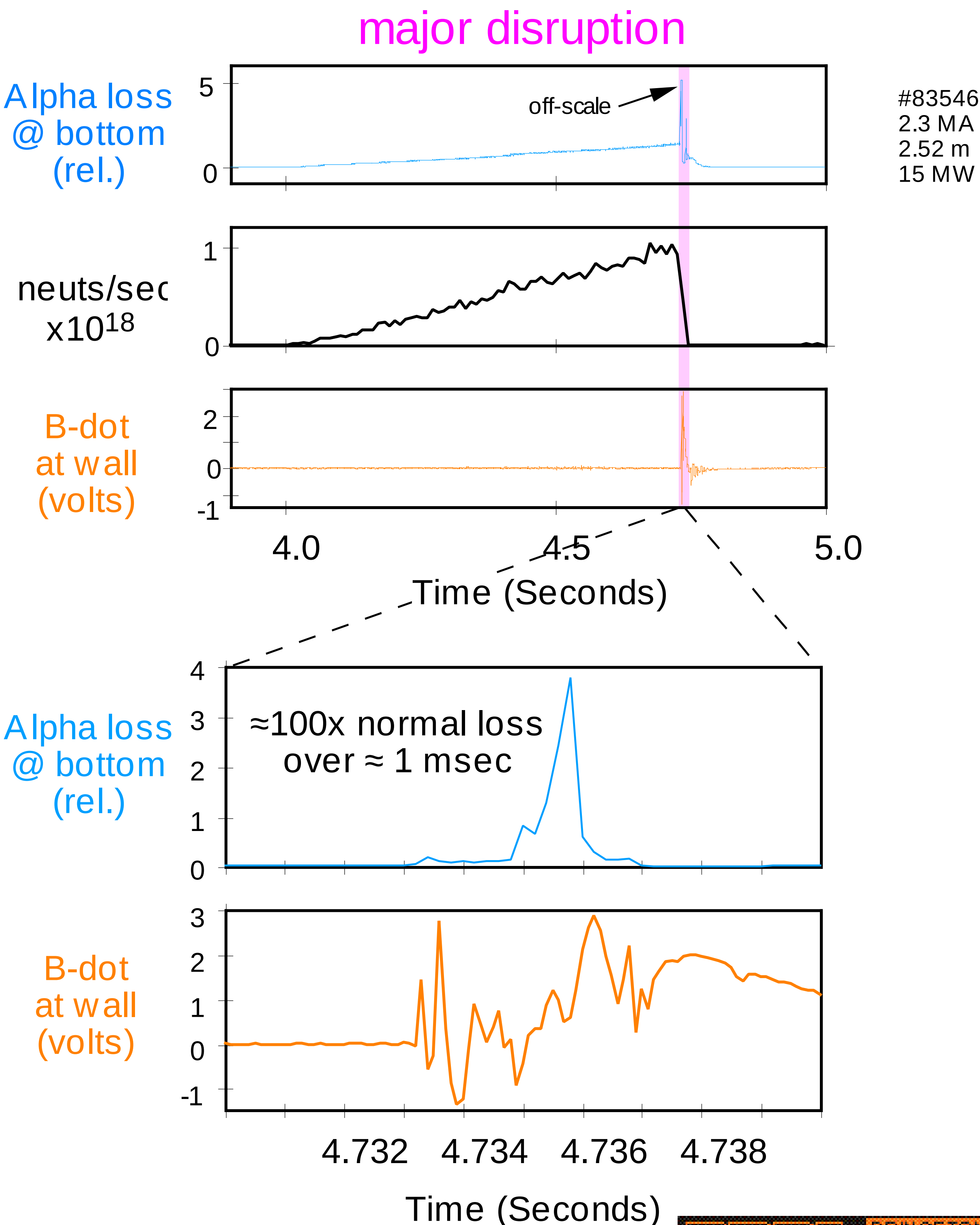
Large Burst of Alpha Loss at Disruption



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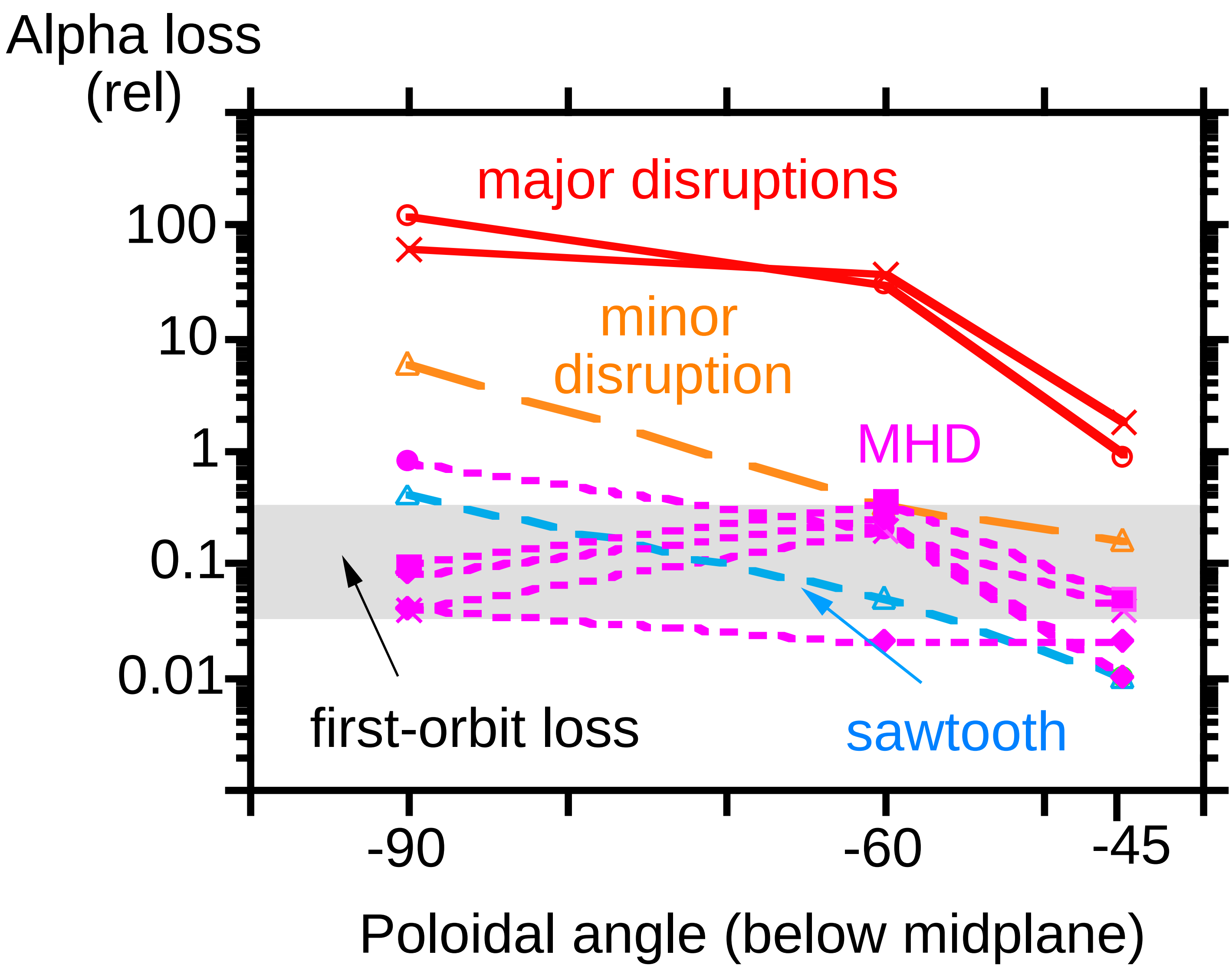
Poloidal Angle Distribution of Alpha Loss



- Coherent MHD usually peaked at -60º
- Disruptions & sawtooth crash peaked at -90º
- Level at -20º depends on detector position

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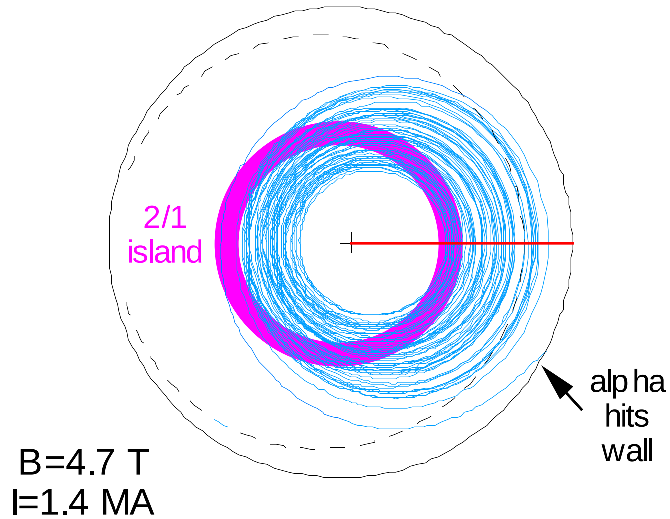
Alpha Loss Increases Linearly with B_r/B_T

2/1 mode in TFTR
$B_r/B_t \approx 5\times10^{-3}$



Outer midplane
crossing point