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XP818: Exploring ELM Mitigation with Midplane Control Coils

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(joint ELM mitigation team)

NSTX Results Review
Princeton Plasma Physics Laboratory
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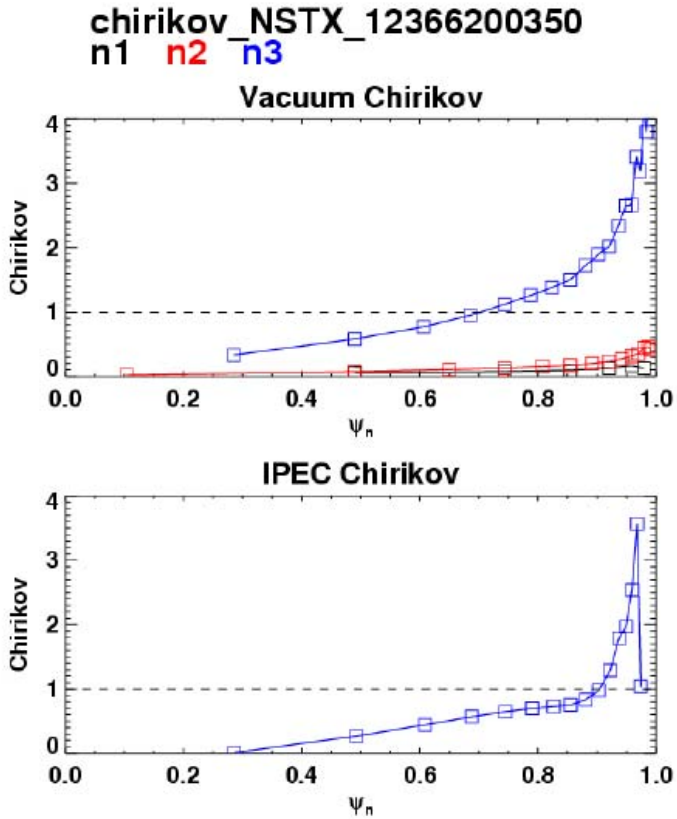
XP818: Exploratory approach to finding ELM mitigation solution with midplane non-axisymmetric coils

- Goal
  - Demonstration of ELM mitigation with NSTX midplane RWM coil set
- Approach
  - Target development
    - (i) low $q_{95} < 6$; (ii) sweep q_{95} to insure mitigation not missed due to resonance ; (iii) high $q_{95} > 8$
  - Application of DC fields (broader *n* spectrum, new 2008 capabilities)
    - Past odd parity fields ($n = 3$) operating on low q_{95} target
    - New even parity field ($n = 2$ (strong $n = 4$), 6) capability for 2008
    - New combined odd/even parity (present favorite $n = 2 + 3$)
  - Application of AC fields
    - Using either/both odd and even parity fields
  - Repeat techniques showing most potential in low recycling (post-LITER)
- Overall Progress
  - ELM affected by fields, not mitigated, LITER led to ELM mitigation w/o applied field, edge plasma rotation an important variable?

Chirikov parameter (island overlap) computed for fields applied

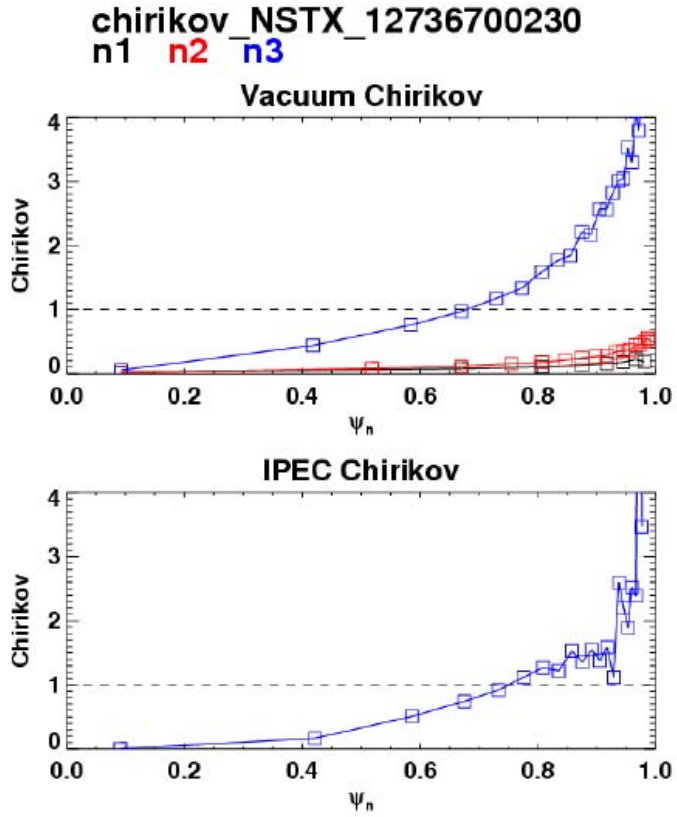
Original Target Shot q95=5.5

For n=3 Each RWM 1kA



XP818 1: Target Shot q95=7

For n=3 Each RWM 1kA



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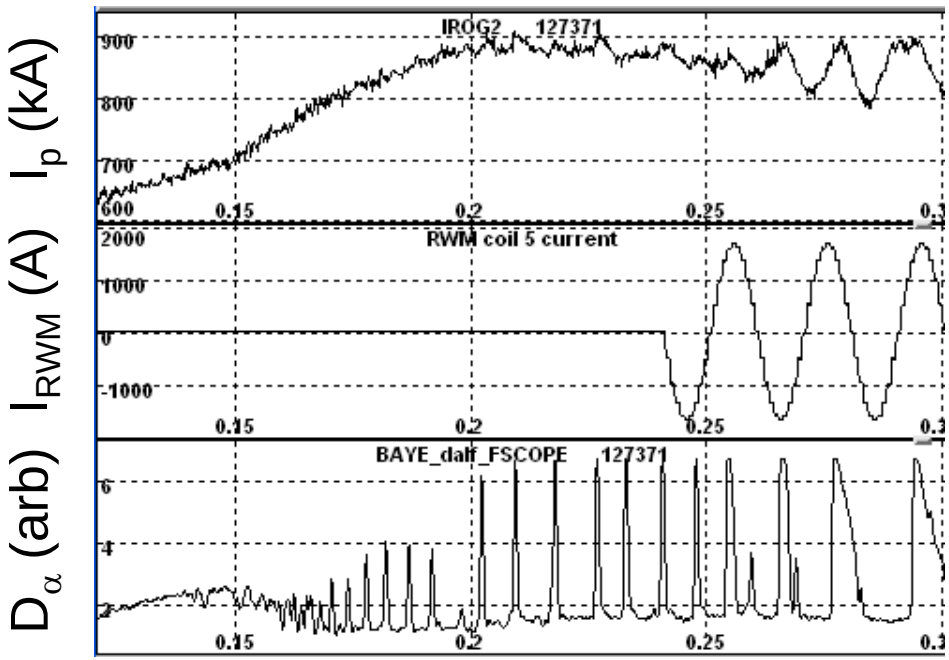
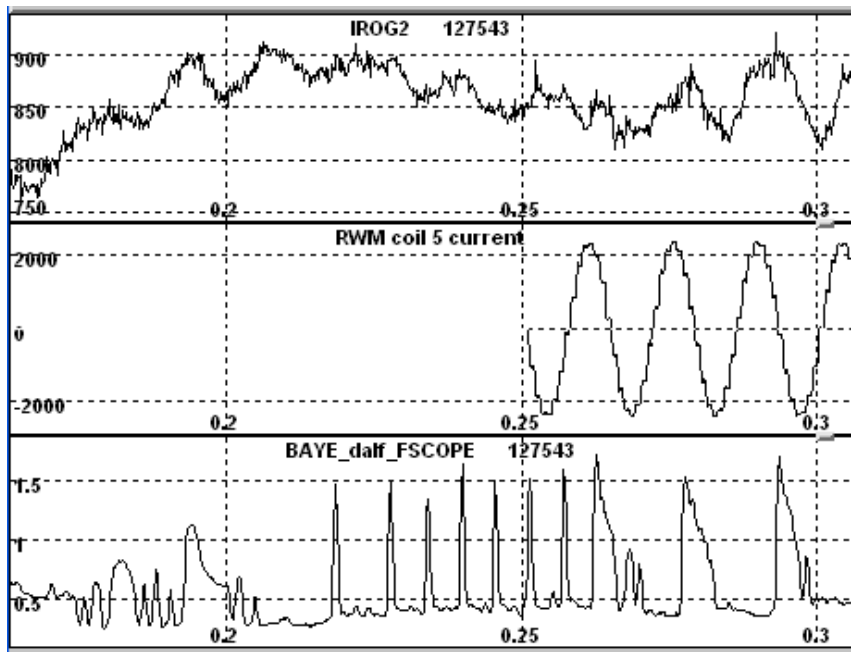
- IPEC showed significant changes to vacuum solution

Reduced ELM frequency observed in several applied field configurations

n = 3 AC field, 70 Hz, 3.8 kA peak-to-peak

n = 2 AC field, 70 Hz, 5.5 kA peak-to-peak



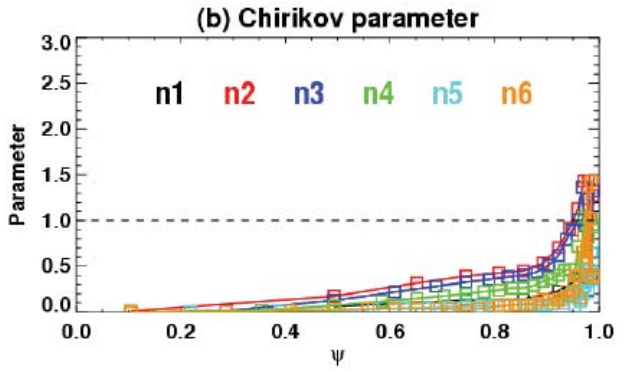


- ELMs broaden, roughly match frequency of applied field
  - Broadening due to multiple ELMs/filaments
- Subsequent DC field application showed similar effect
  - Frequency of broadened ELM events similar in both DC and AC field application

Mixed 2 + 3 field configuration appears favorable for edge ergodization

n=2+3 Mixing Configuration

For #123662.00350



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We can produce this by

	RWM1	RWM2	RWM3	RWM4	RMW5	RMW6	current
n=2	1	0	1	1	0	1	x1kA
n=3	-1	1	-1	1	-1	1	x0.5kA
n=2+3	0.5	0.5	0.5	1.5	-0.5	1.5	

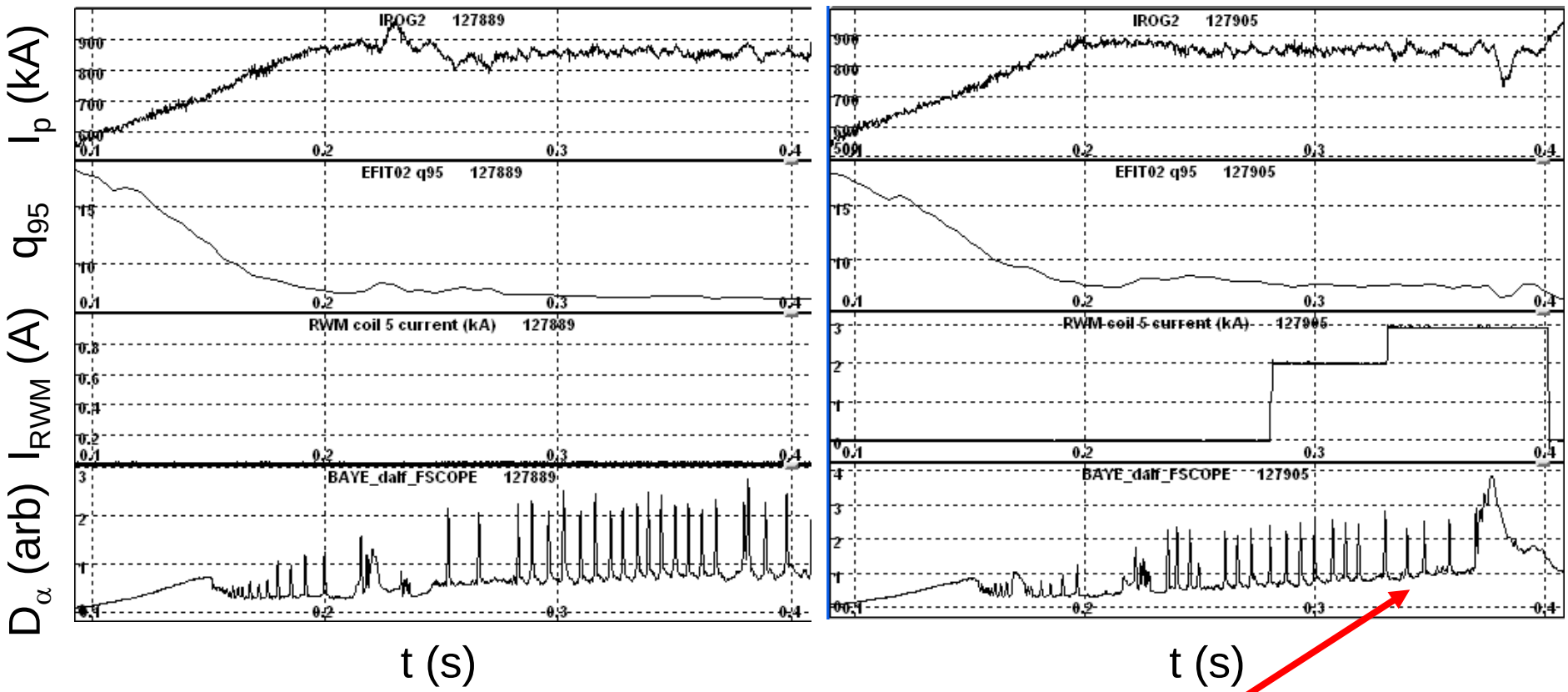
or with any combinations using different currents

- Chirikov > 1 restricted to edge for broad n spectrum

ELMs not mitigated with n = 2 + 3 configuration; frequency lowered at full current

ELM target control shot (no n > 1 field,)

n = 2+3 field, 2.0 – 3.0kA peak RWM current



- Decrease in ELM frequency at maximum applied field
- Continue to investigate physical cause for changes in ELM behavior
  - Results consistent with Chirikov parameter > 1 being necessary, not sufficient condition for ELM mitigation; but could be due to different physics

ELMs not mitigated with expanded applied field configuration, further analysis to focus on discovering key physics

- Operated as low q_{95} as possible that lead to reproducible Type I ELMs
  - Lower q_{95} thought to be favorable for ELM mitigation
  - Range of q_{95} ~ 7 – 8, swept q_{95} to insure mitigation not missed due to resonance
- Used new 2008 capabilities to apply broader *n* spectrum,
  - *n* = 2; 3; 2 + 3; n = 6 configurations
    - n = 6 tried in other XPs – saw no effect on plasma
  - ELMs broadened (multiple events), lowered in frequency mostly by AC fields, but similar effect also seen with DC fields
  - *n* = 2 + 3 configuration showed reduction in ELM frequency at maximum permitted coil current

Is edge pumping a necessary condition?

- Lithium attempted for pumping – edge V_ϕ may be a key variable
  - Small Li evaporation (~10 mg/min) quickly led to ELM mitigation *without* application of non-axisymmetric fields (as in XP728 (Mansfield, et al.))
  - XP728, 809, 818 results show ELM mitigation / destabilization may correlate with increased / reduced edge plasma rotation
    - Increased edge V_ϕ => mitigation, reduced V_ϕ => ELM not mitigated; can trigger