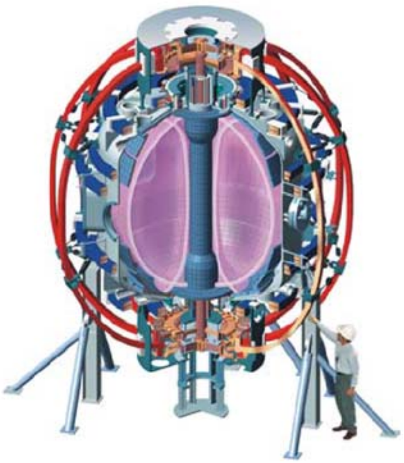
Supported by

XP818: ELM Mitigation with Midplane Control Coils

S. A. Sabbagh, J-K. Park, T. Evans, S. Gerhardt, R. Maingi, J.E. Menard, many others…
(joint ELM mitigation team)

Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
NYU
ORNL
PPPL
PSI
SNL
UC Davis
UC Irvine
UCLA
UCSD
U Maryland
U New Mexico
U Rochester
U Washington
U Wisconsin
Culham Sci Ctr
Hiroshima U
HIST
Kyushu Tokai U
Niigata U
Tsukuba U
U Tokyo
JAERI
Ioffe Inst
TRINITI
KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
U Quebec



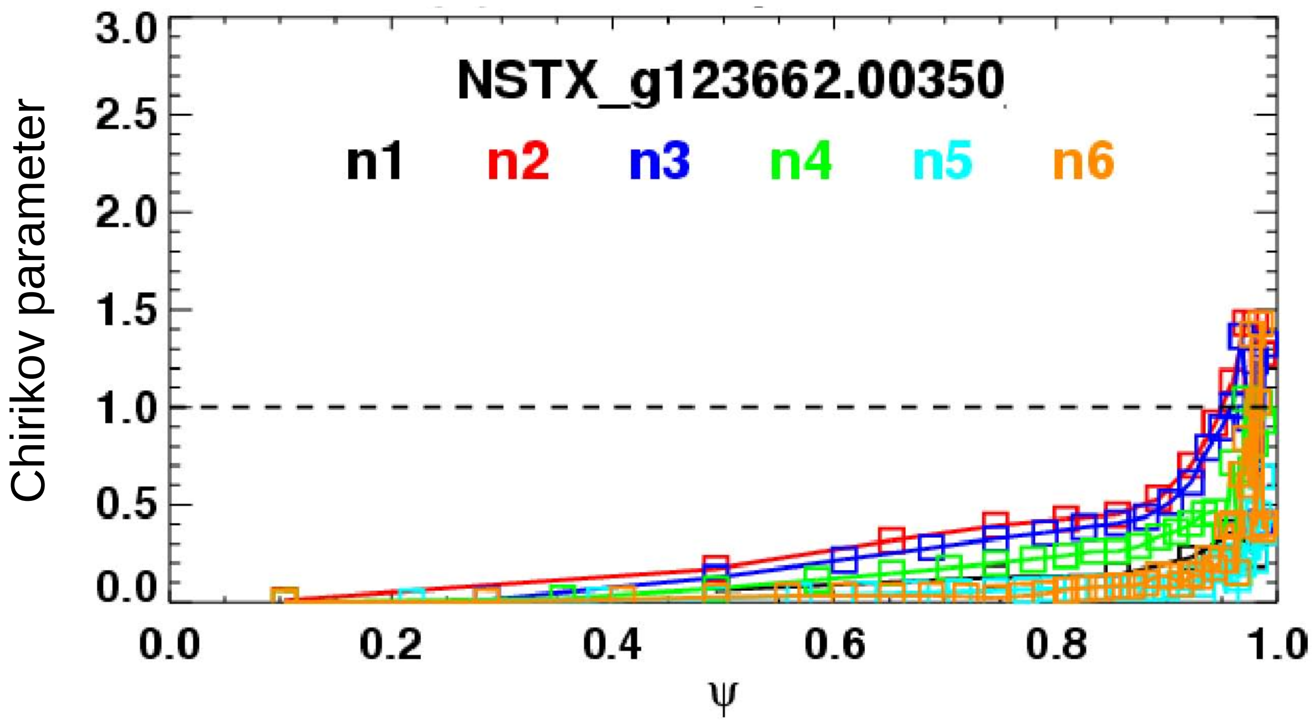
NSTX Team Review

February 19, 2008
Princeton Plasma Physics Laboratory

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) swept 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, 1+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; co/ctr propagation
      - ELM mitigation through effects on edge plasma profiles
    - Feedback on *n* = 1
      - May be useful for giant ELMs, buildup detected by RWM B_r sensors
  - Repeat techniques showing most potential in low recycling (post-LITER)

New non-axisymmetric field capability allows new combinations for ELM mitigation

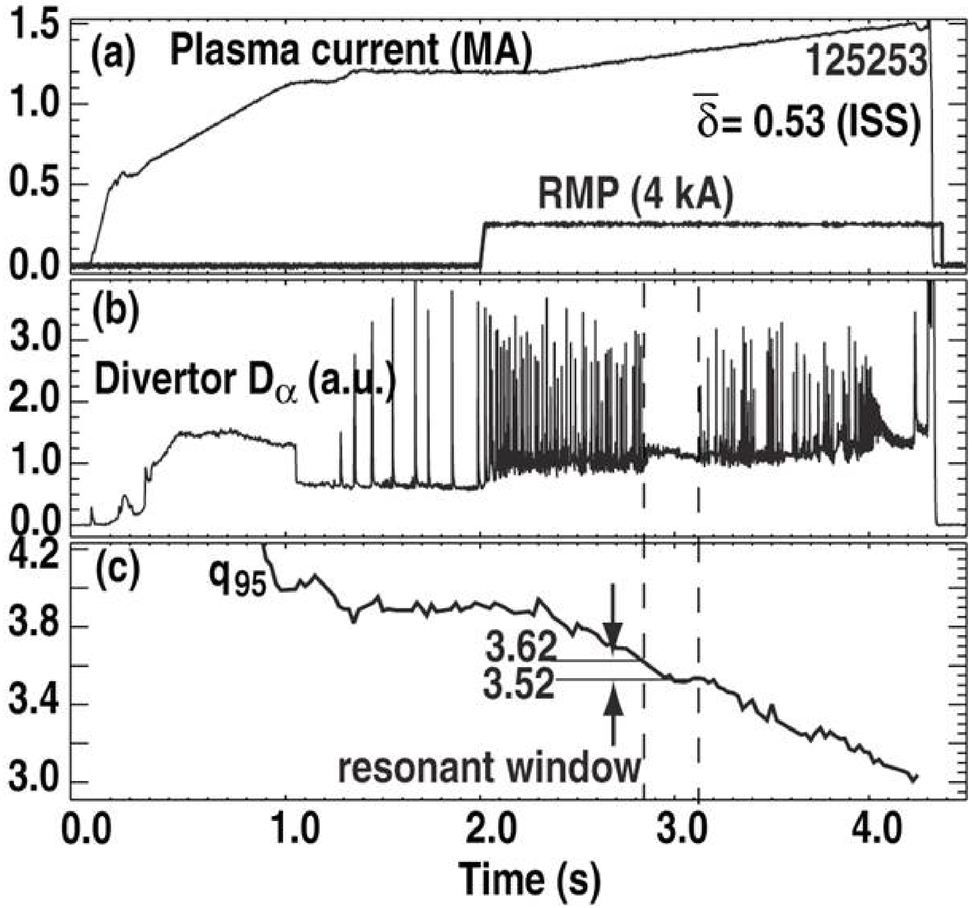


J-K. Park

- n = 2+3 field can produce Chirikov overlap near the plasma edge at reasonable SPA currents
  - Simulation: RWM coils (1-4) 0.5 kA, (2-6) 0.5 kA, (3-5) 1.5 kA

NSTX

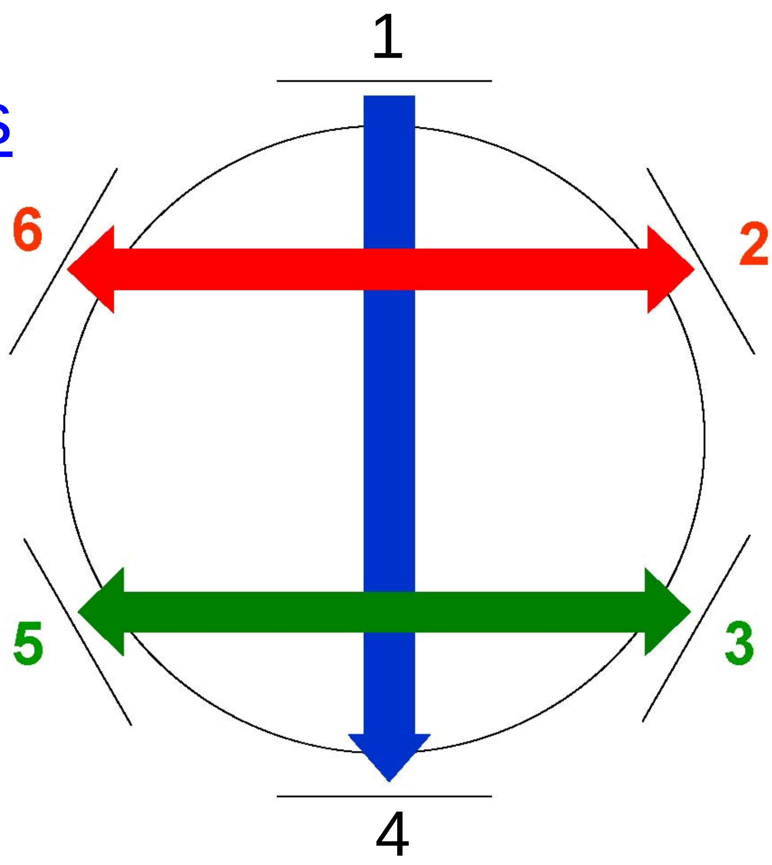
ELM mitigation by DC fields might be resonant effect



- DIII-D indicates narrow *q* window for ELM mitigation
- Should scan q_{95} to insure that window is not missed

Planned mixed even/odd parity fields require non-diametrically-opposed coil pairs

RWM coils



- odd parity fields alone are standard anti-series connection
- even parity fields alone are “new” standard series connection

XP818 ELM Mitigation - Run plan

Task	Number of Shots
1) Create target plasmas	
A) Create *q95* < 6 target: (generate at least 10 ELMs with approximately even spacing) (*q95* ~ 5.5 is adequate)	
- Use shot 124349 as setup shot, (*Ip* = 0.8 MA, *Bt* = 0.5 T), change NBI source C to 1 MW unmodulated	2
- Raise *Ip* to 0.9 MA; change *Bt* to 0.45T, then 0.40T	3
- If *q95* > 6 and insufficient ELMs, perform startup optimizations as per J. Menard to raise *qmin*.	(8)
B) Create *q95* ramp target	
- Start from low *q95* target created in step (1A), *Ip* flat-top to 0.7 MA, ramping up to 1.0 MA; adjust eventual *Ip* flat-top if needed to create steady ELMs.	4
- if plasma drops out of H-mode, start *Ip* ramp from 1.0 MA ramping to 0.7 MA	(2)
- vary *Bt* to change range of *q* ramp (optional)	(2)
C) Create *q95* > 8 target	
- Use shot 124349 as setup shot, (*Ip* = 0.8 MA, *Bt* = 0.5 T), change NBI source C to 1 MW unmodulated	
- Drop *Ip* to 0.7 MA; tweak to 0.75 MA if desired	2
2) Attempt ELM mitigation with non-axisymmetric fields under normal recycling conditions	
- DC fields:	
A) Apply *n* = 3 field configuration; vary amplitude from 1.5 kA	4
B) Apply *n* = 3 + 1 field configuration; vary amplitude from 1.0 kA, 0.5 kA	4
C) Apply *n* = 2 + 3 field configuration (start from RWM (1-4) 0.5kA, RWM (2,6) 0.5kA, RWM (3,5) 1.5 kA)	4
D) Apply *n* = 2 field configuration; vary amplitude from 1.5 kA	4
E) Apply *n* = 6 field configuration (primary field is *n* = 0); vary amplitude from 2.5 kA	3
- AC fields (pre-programmed):	
F) Apply *n* = 3; vary *f* above/below ELM frequency; vary amplitude from 2.0 kA	4
G) Apply *n* = 1 (co-propagating); vary *f* above/below ELM frequency; vary amplitude	4
H) Apply *n* = 1 (ctr-propagating); vary *f* above/below ELM frequency; vary amplitude	4
- AC fields (*n* = 1 feedback):	
I) *n* = 1 *Br* feedback: giant ELM target (e.g. 125271), vary (i) gain (ii) phase	6
3) Attempt ELM mitigation with non-axisymmetric fields under reduced recycling conditions	16
Total (optional):	64 (12)

XP818 ELM Mitigation – first "1/2" day run plan

Task	Number of Shots
1) Create target plasmas	
A) Create *q95* < 6 target: (generate at least 10 ELMs with approximately even spacing)	
(*q95* ~ 5.5 is adequate)	
- Use shot 124349 as setup shot, (*Ip* = 0.8 MA, *Bt* = 0.5 T), change NBI source C to 1 MW unmodulated	2
- Raise *Ip* to 0.9 MA; vary Bt to 0.45T, then 0.40T	3
- <u>If</u> *q95* > 6 and insufficient ELMs, perform startup optimization as per J. Menard to raise *qmin*.	(8)
B) Create *q95* ramp target	
- Start from low *q95* target created in step (1A), *Ip* flat-top to 0.7 MA, ramping up to 1.0 MA; adjust eventual *Ip* flat-top if needed to create steady ELMs.	4
- <u>If</u> plasma drops out of H-mode, start *Ip* ramp from 1.0 MA ramping to 0.7 MA	(2)
- Vary *Bt* to change range of *q* ramp (optional)	(2)
2) Attempt ELM mitigation with non-axisymmetric fields under normal recycling conditions	
- <u>DC and AC fields</u>:	
i) Apply DC *n* = 3 field configuration; vary amplitude from 1.5kA	2
ii) Apply AC *n* = 3; vary *f* above/below ELM frequency; vary amplitude	2
iii) Apply DC *n* = 3 + 1 field configuration; vary amplitude from 1.5kA	2
iv) Apply AC *n* = 1 (co-propagating); vary *f* above/below ELM frequency; vary amplitude (optionally include n = 3 based on results from (iii) above)	2
Total (optional):	17 (12)