Edge magnetic field line studies for a proposed set of internal RMP coils on NSTX

T. E. Evans*
General Atomics,
San Diego, CA

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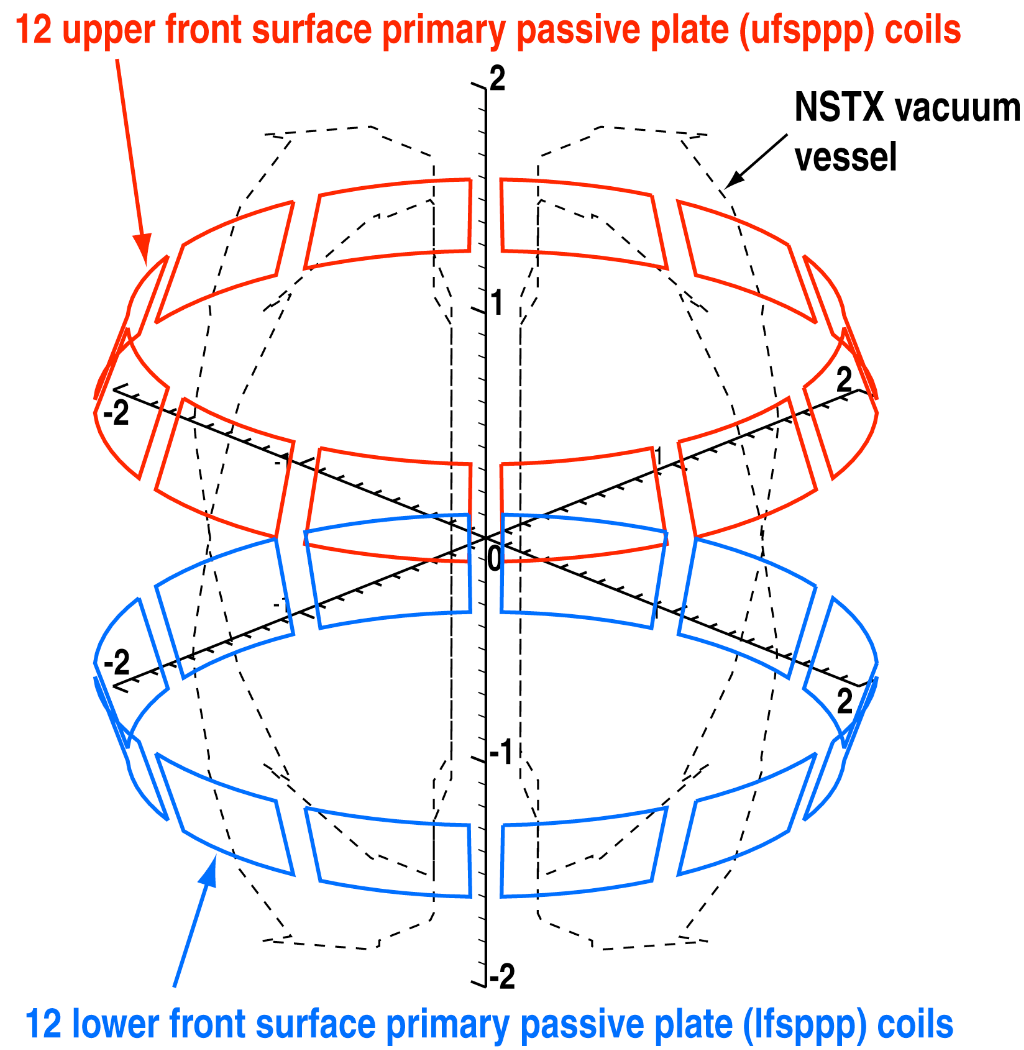
*In collaboration with:
J. Jayakuma, R. C. Kalling
General Atomics,
San Diego, CA

and

D. Orlov

University of California San Diego
San Diego, CA

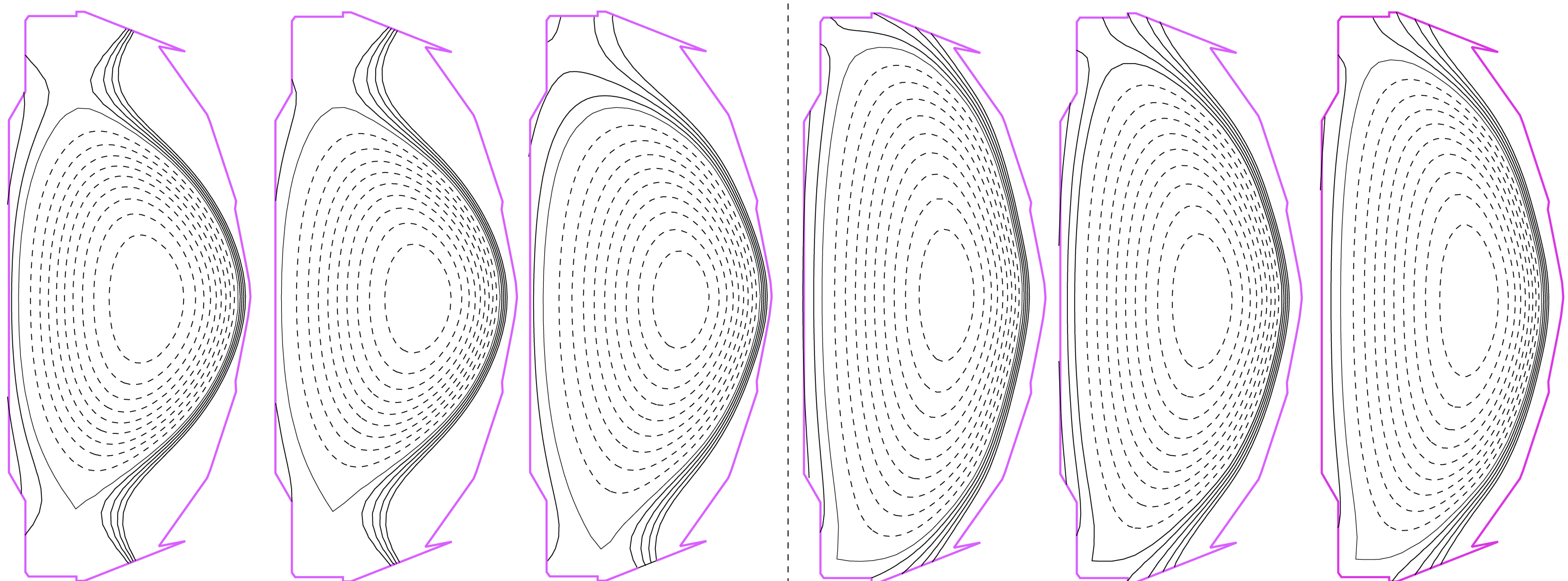


Goals and parameters

- Quantify field line properties for a proposed set of internal RMP coils on NSTX configured for:
  - n = 6 (and some n=3) operations using:
    - Several plasma shapes with different values of q_{95}, dRsep, and κ
- Coil properties:
  - 2 rows of 12 coils
  - Mounted in front of the upper and lower primary passive plates
    - Referred to here as the Front Surface Primary Passive Plate (**FSPPP**) coils
  - Maximum single-turn current, 1 kA (square wave)
- Quantitative measures:
  - Stochastic layer width:
    - maximum width over which the Chirikov parameter exceeds unity
  - Field line loss fraction

A variety of NSTX plasma shapes were studied

Low δL ~ 0.5, X-point controlled by pf2L, more ITER-like | **High δL ~ 0.7, high κ, X-point controlled by pf1a**

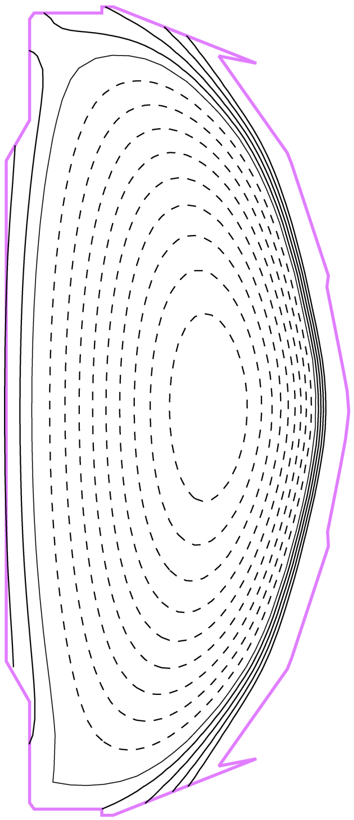


123662:380	125269:465	125272:600 (giant ELM)	125006:343	125200:501	125328:718 (fiducial)
Ip =0.9 MA	Ip =0.8 MA	Ip =0.8 MA	Ip =0.7 MA	Ip =1.2 MA	Ip =0.9 MA
BT = 4.0 kG	BT = 4.5 kG	BT = 4.5 kG	BT = 5.0 kG	BT = 4.5 kG	BT = 4.5 kG
q95 = 5.5	q95 = 8.0	q95 = 7.6	q95 = 13.24	q95 = 7.16	q95 = 9.0
κ = 1.9	κ = 1.85	κ = 2.0	κ = 2.6	κ = 2.4	κ = 2.5
drsep = -0.6	drsep = -0.4	drsep = -2.2	drsep = -0.6	drsep = -0.7	drsep = --1.0

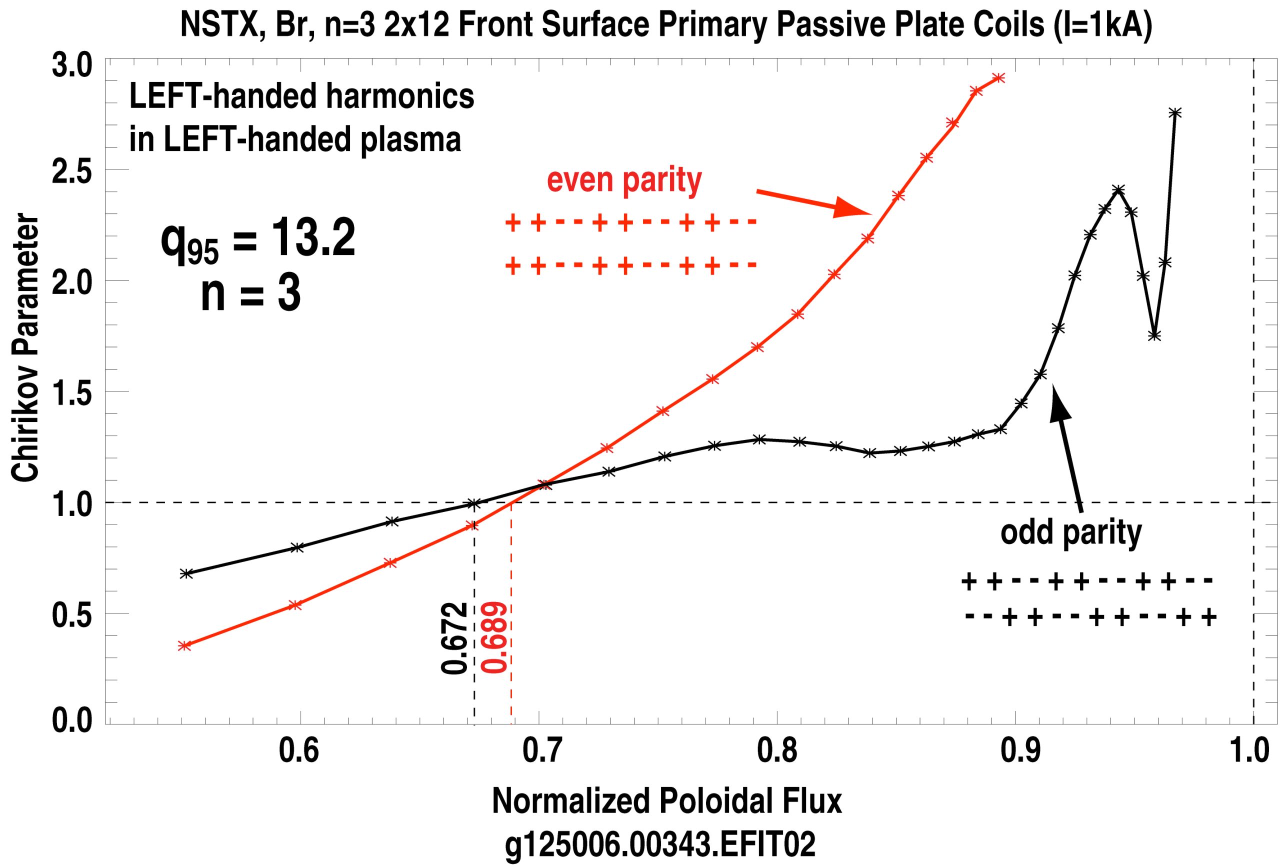
- Comparisons were done using both n=3 and n=6 FSPPP coil perturbations for plasmas with different q_{95}, dRsep, and κ

Edge stochastic layer widths exceed 30% with n=3 even and odd parity FSPPP fields in high δ, κ plasmas

High δ_L ~ 0.7, high κ, X-point controlled by pf1a

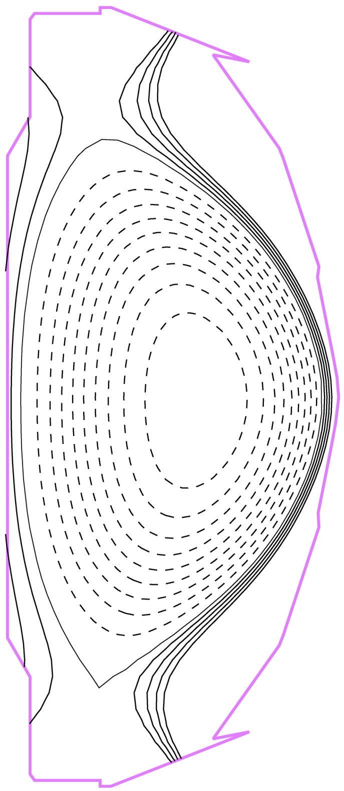


125006:343
Ip =0.7 MA, B_T = 5.0 kG
κ = 2.6, dRsep = -0.6

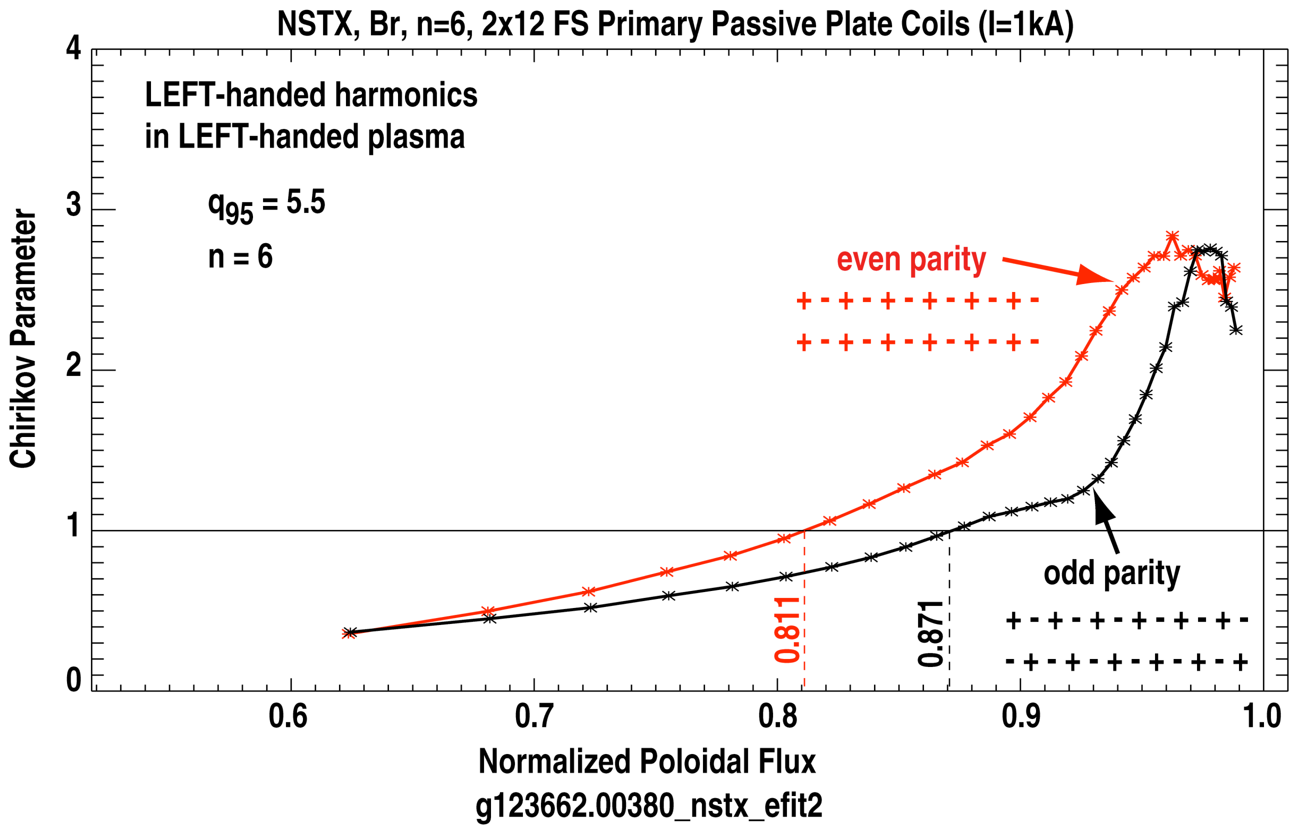


In ITER-like plasmas n=6 FSPPP fields produce a relatively narrow edge stochastic layer width

Low $\delta_L \sim 0.5$, X-point controlled by pf2L, more ITER-like

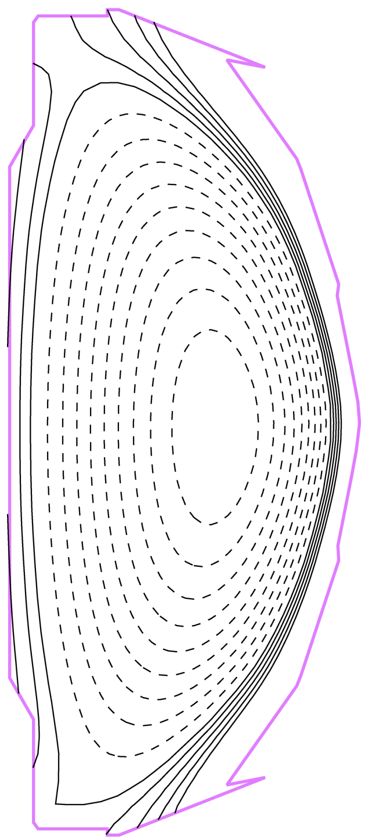


123662:380
I_p =0.9 MA, B_T = 4.0 kG
q_{95} = 5.5, κ = 1.9
drsep = -0.6

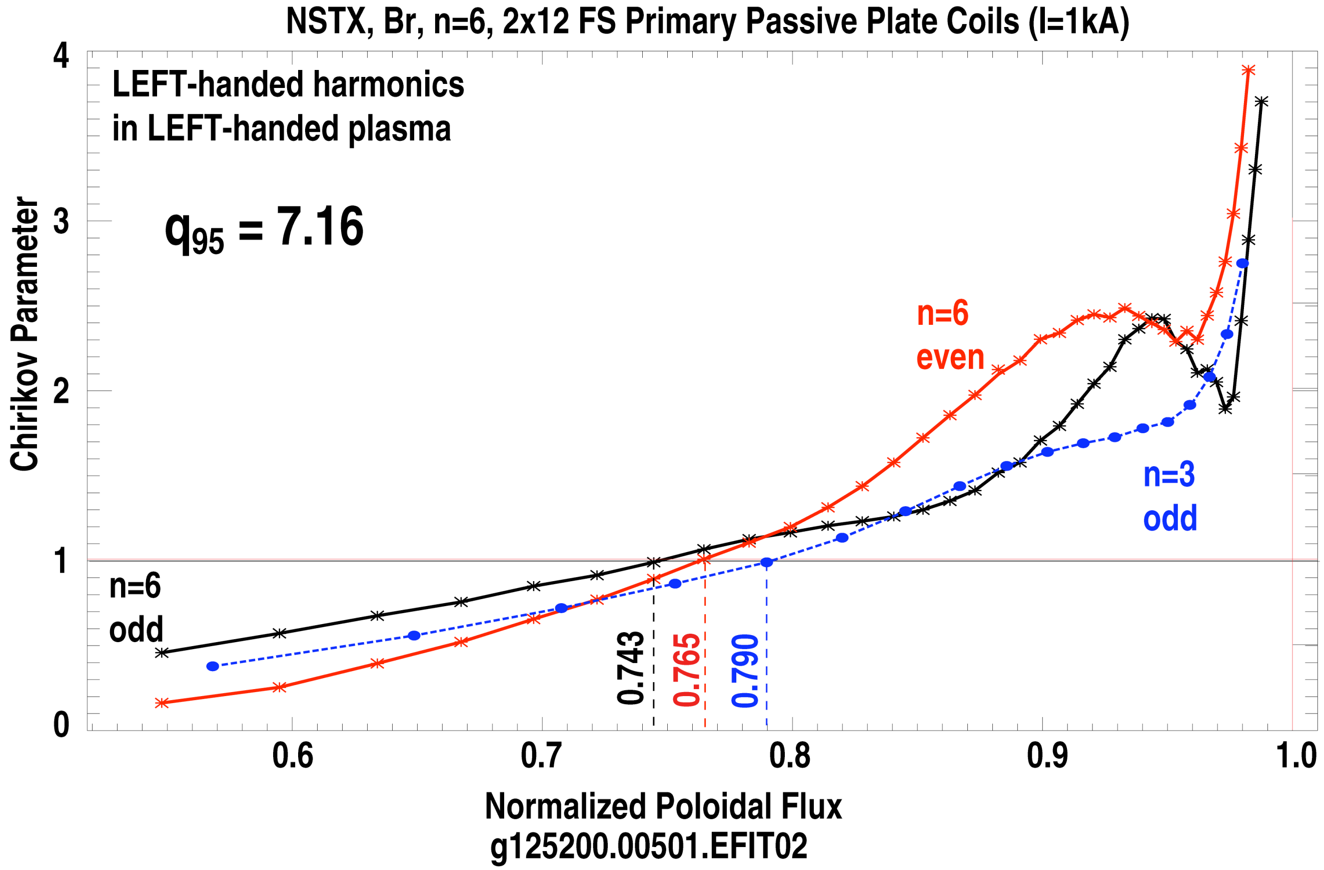


In high δ, κ plasmas n=6 FSPPP fields produce edge stochastic layers similar to those with n=3 fields

High δ_L ~ 0.7, high κ, X-point controlled by pf1a

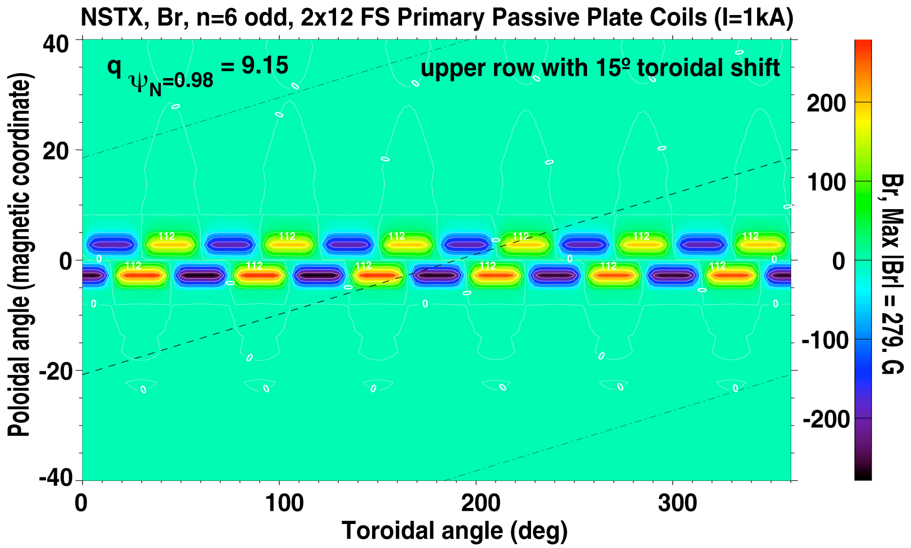


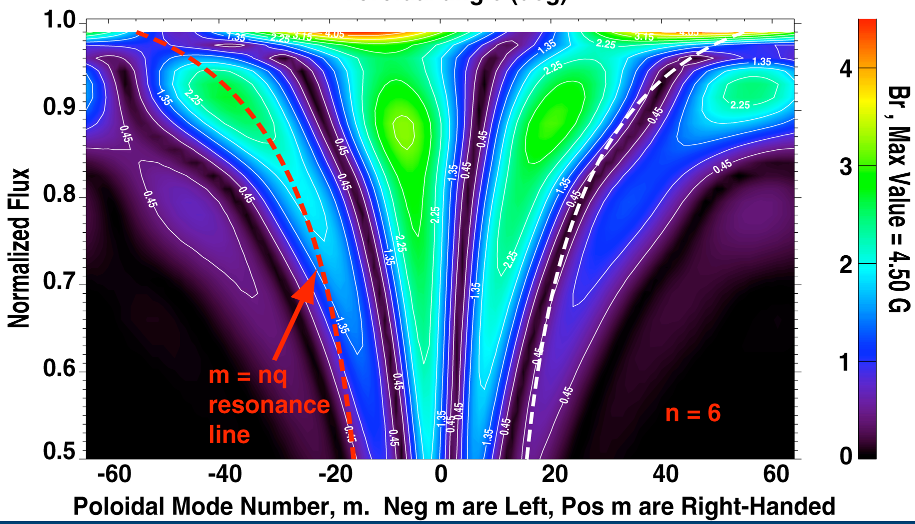
125200:501
I_p =1.2 MA, B_T = 4.5 kG
κ = 2.4, dRsep = -0.7

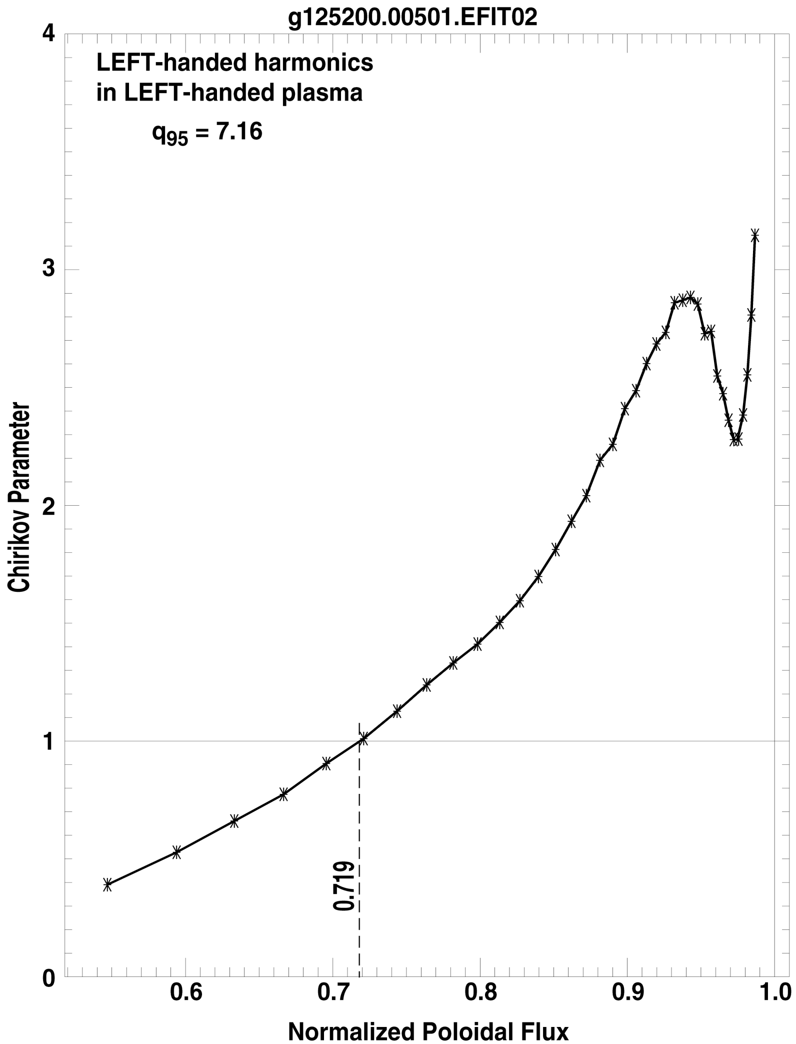


Reference case for n=6 optimization studies

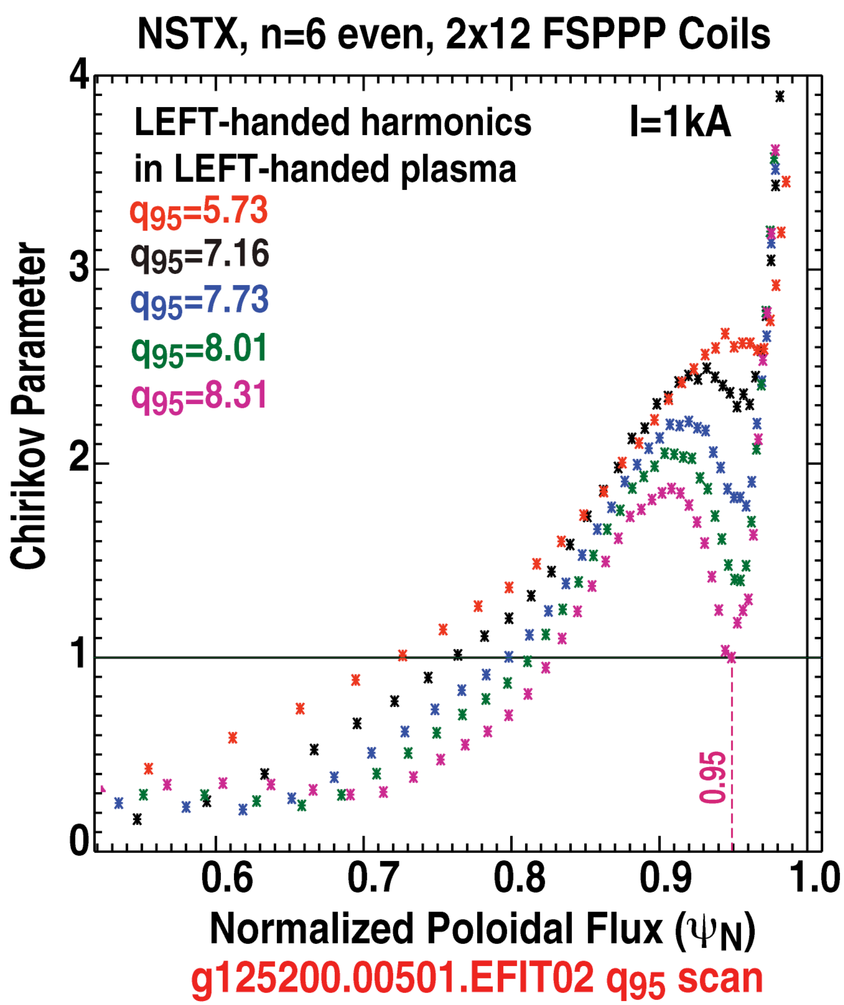
A Δφ = 15° upper coil shift with respect to the lower coil increases the edge stochastic layer width

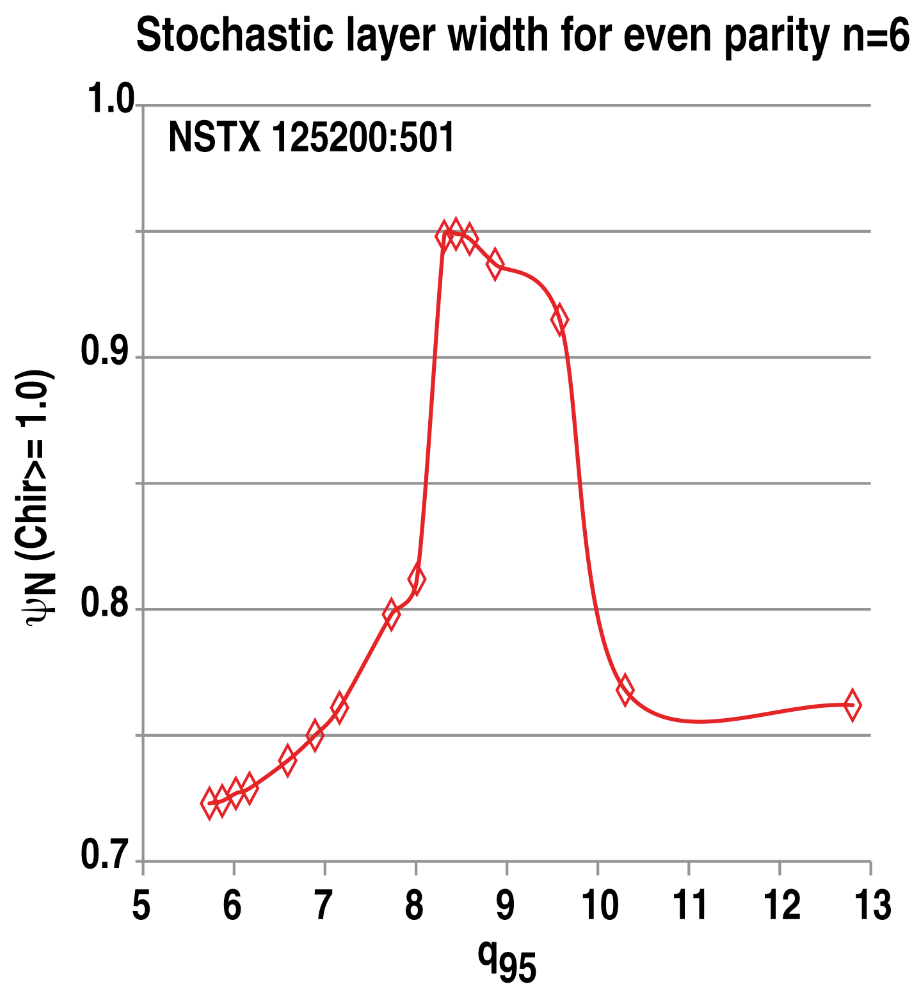






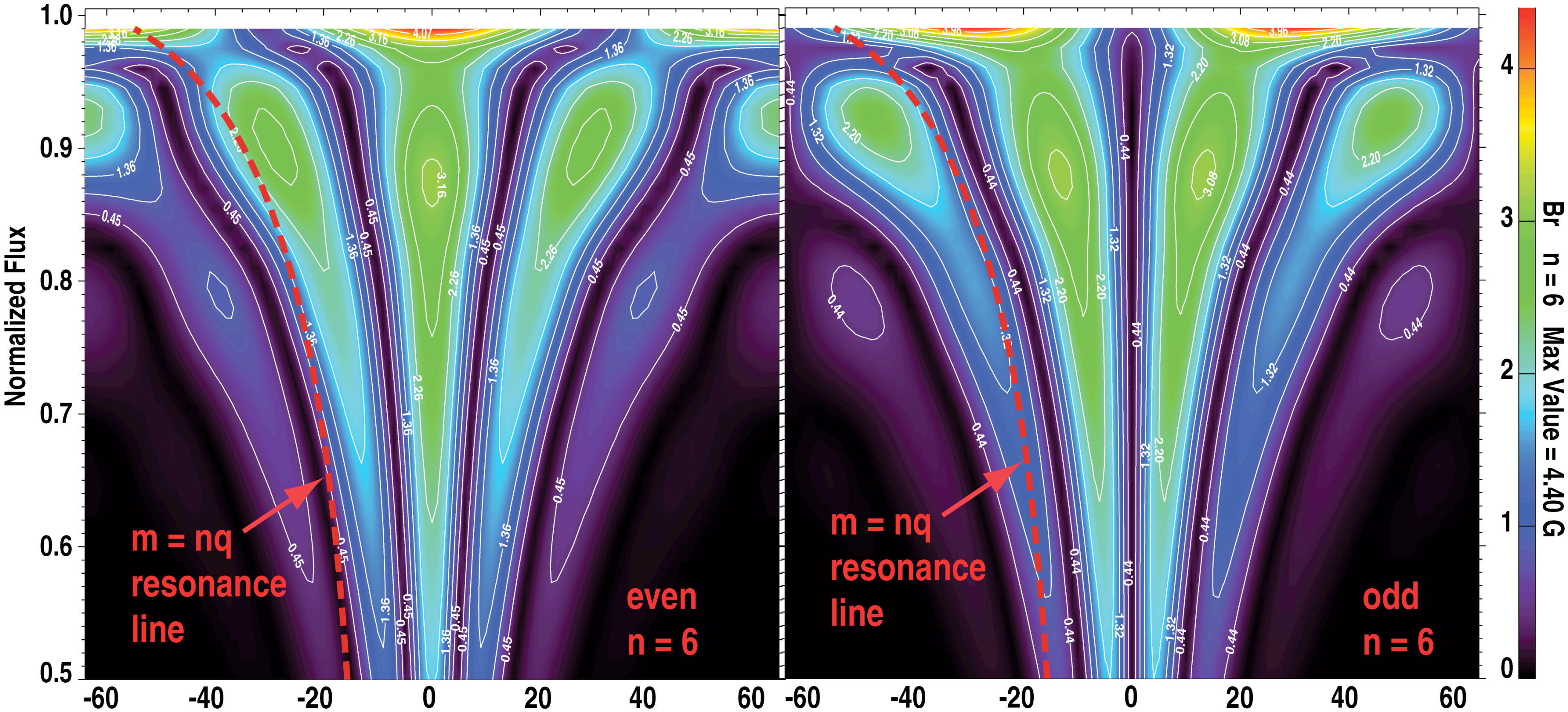
Increasing q_{95} from 5.7 to 8.3 with n=6 even parity FSPPP fields reduces the edge stochastic layer width





The alignment of odd and even parity resonant peaks in the n=6 spectrum facilitates dynamic q_{95} control

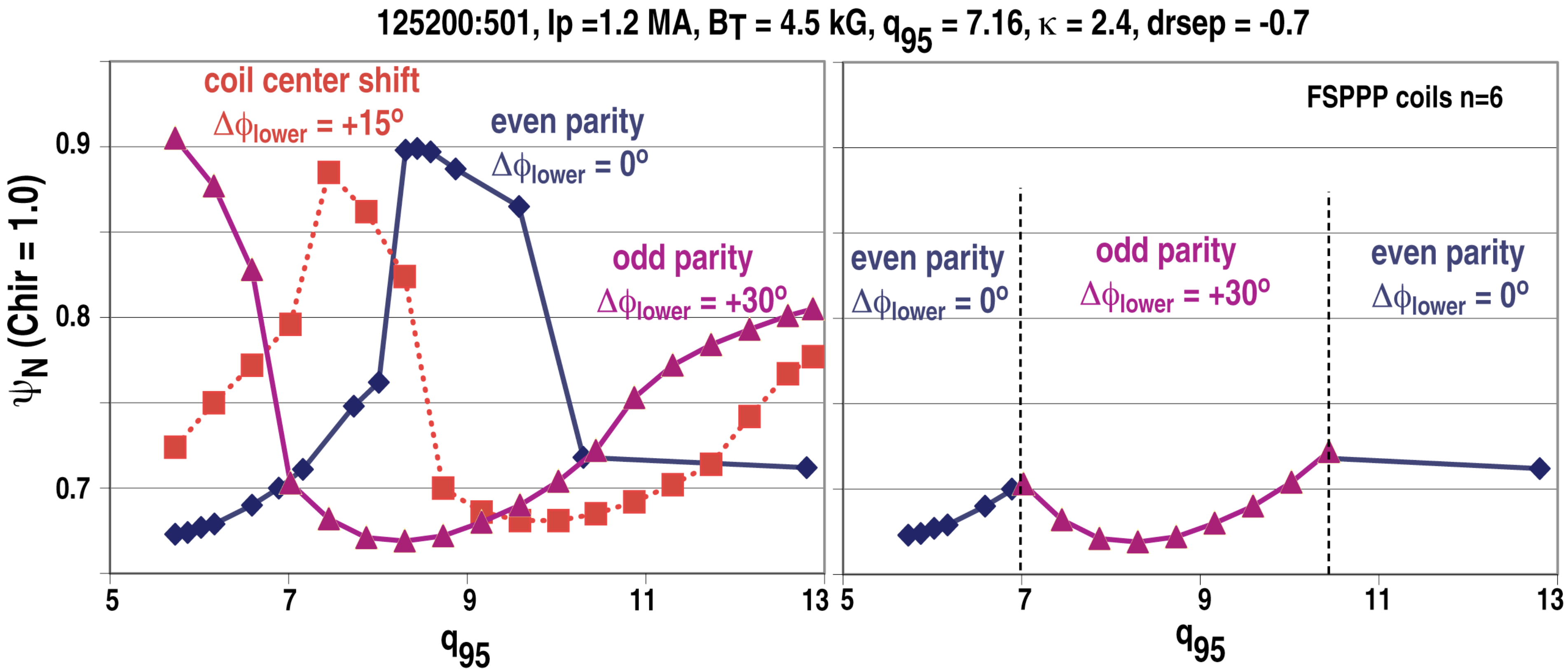
125200:501, Ip =1.2 MA, BT = 4.5 kG, q_{95} = 7.16, κ = 2.4, drsep = -0.7
High δ_L ~ 0.7, high κ, X-point controlled by pf1a, 2x12 FS Primary Passive Plate Coils (I=1kA)



Poloidal Mode Number, m. Neg m are Left, Pos m are Right-Handed
g125200.00501.EFIT02

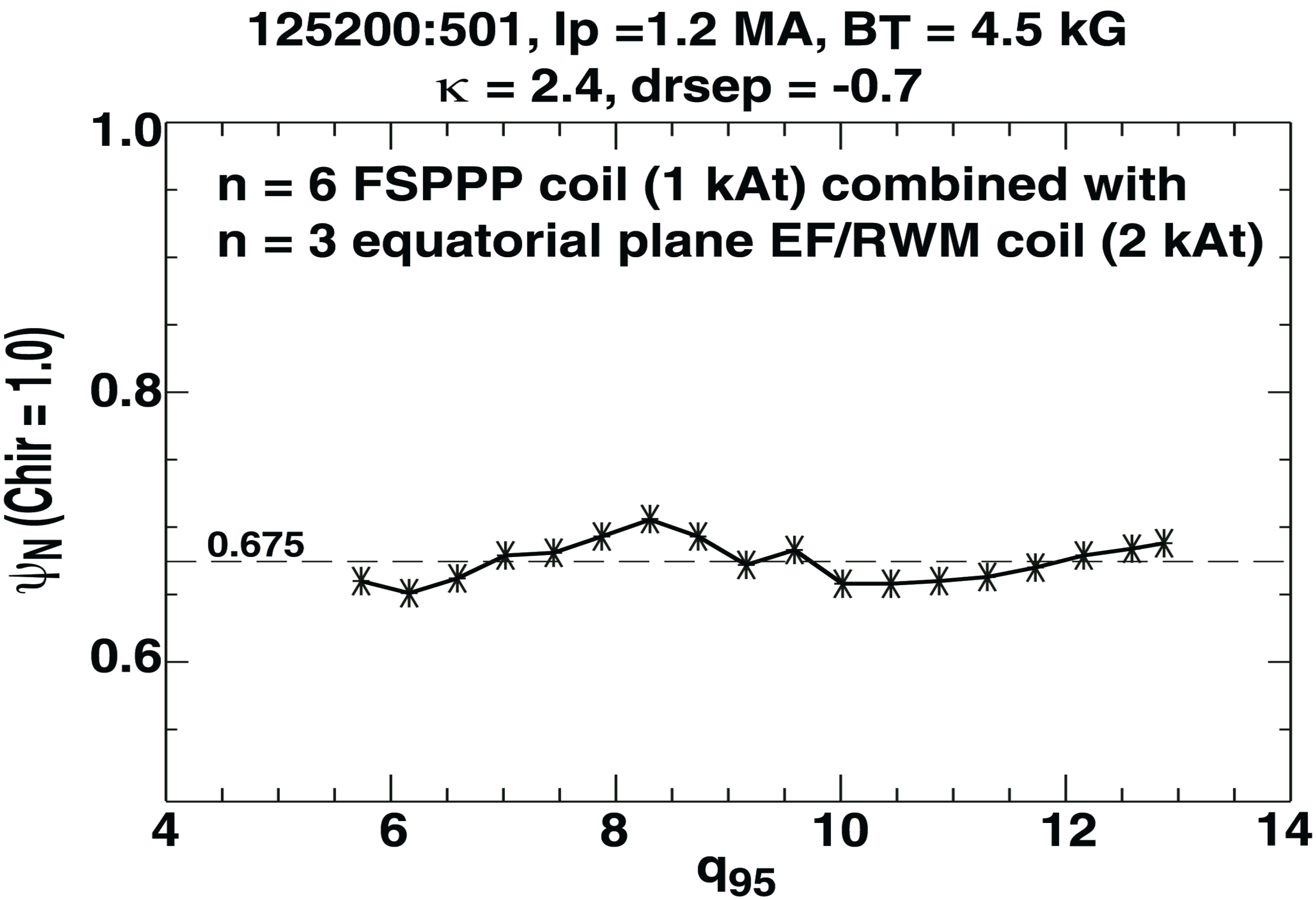
DIII-D NATIONAL FUSION FACILITY

Edge stochastic layer width can be maintained over a wide range of q_{95} by varying the n=6 toroidal phase

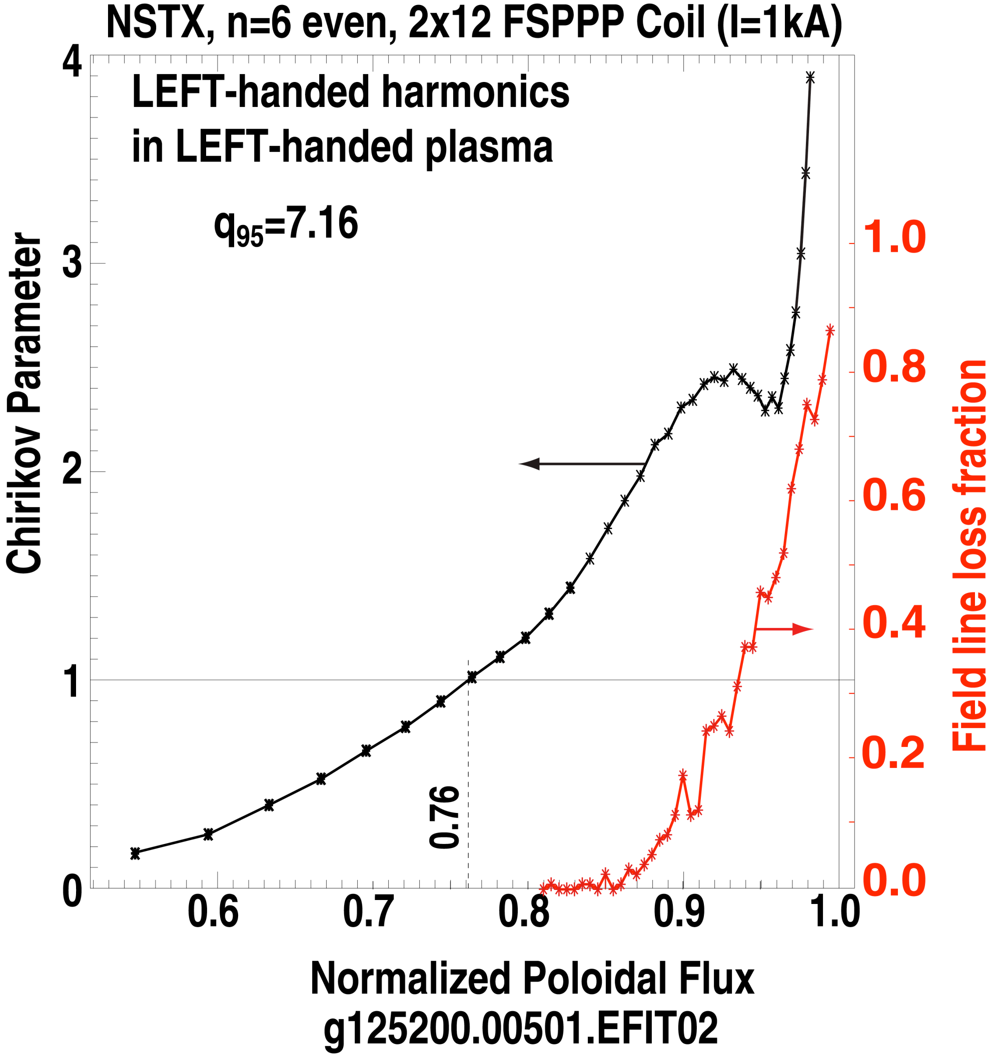


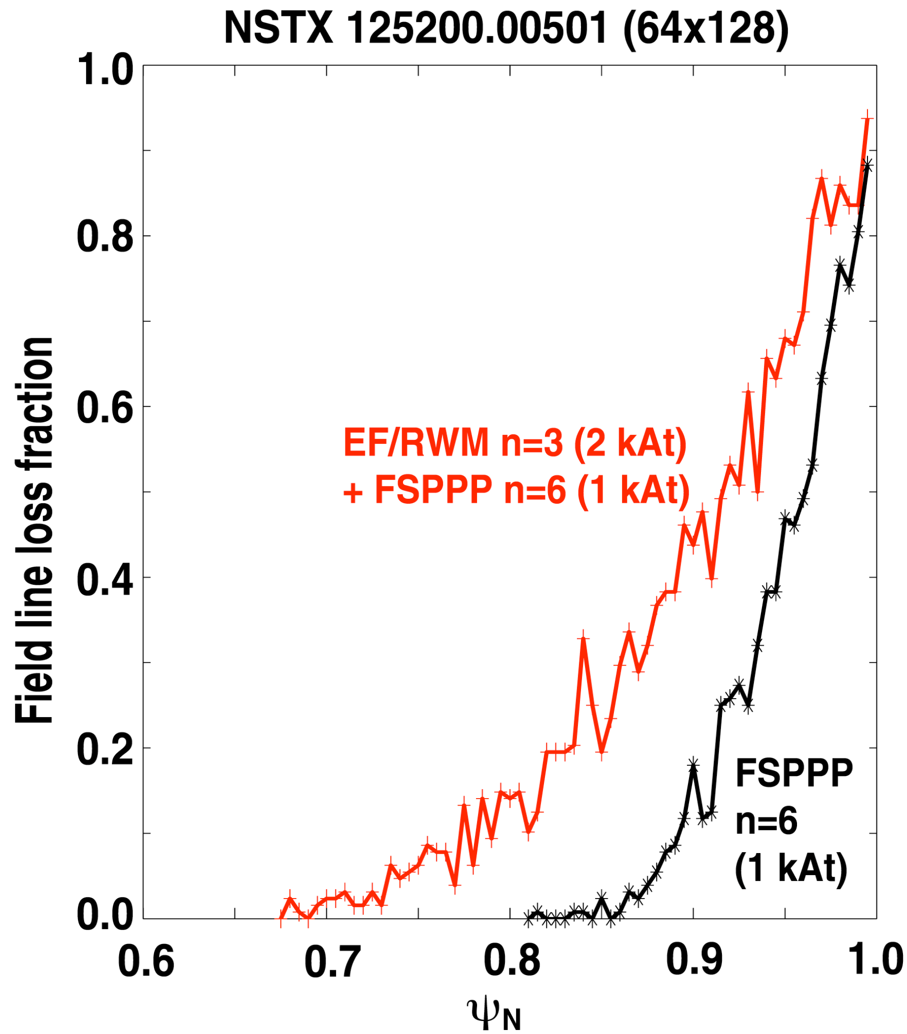
- Edge stochastic layer width ≥ 27% maintained when using:
  - Even parity ($\Delta\phi = 0°$) for $5.3 \le q_{95} \le 7.0$ and $10.3 \le q_{95} \le 12.8$ and
  - Odd parity ($\Delta\phi = 30°$) for $7.0 \le q_{95} \le 10.3$

Edge stochastic layer width versus q_{95} is kept ≥ 30% when n=6 FSPPP coil is combined with n=3 EF/RWM coil

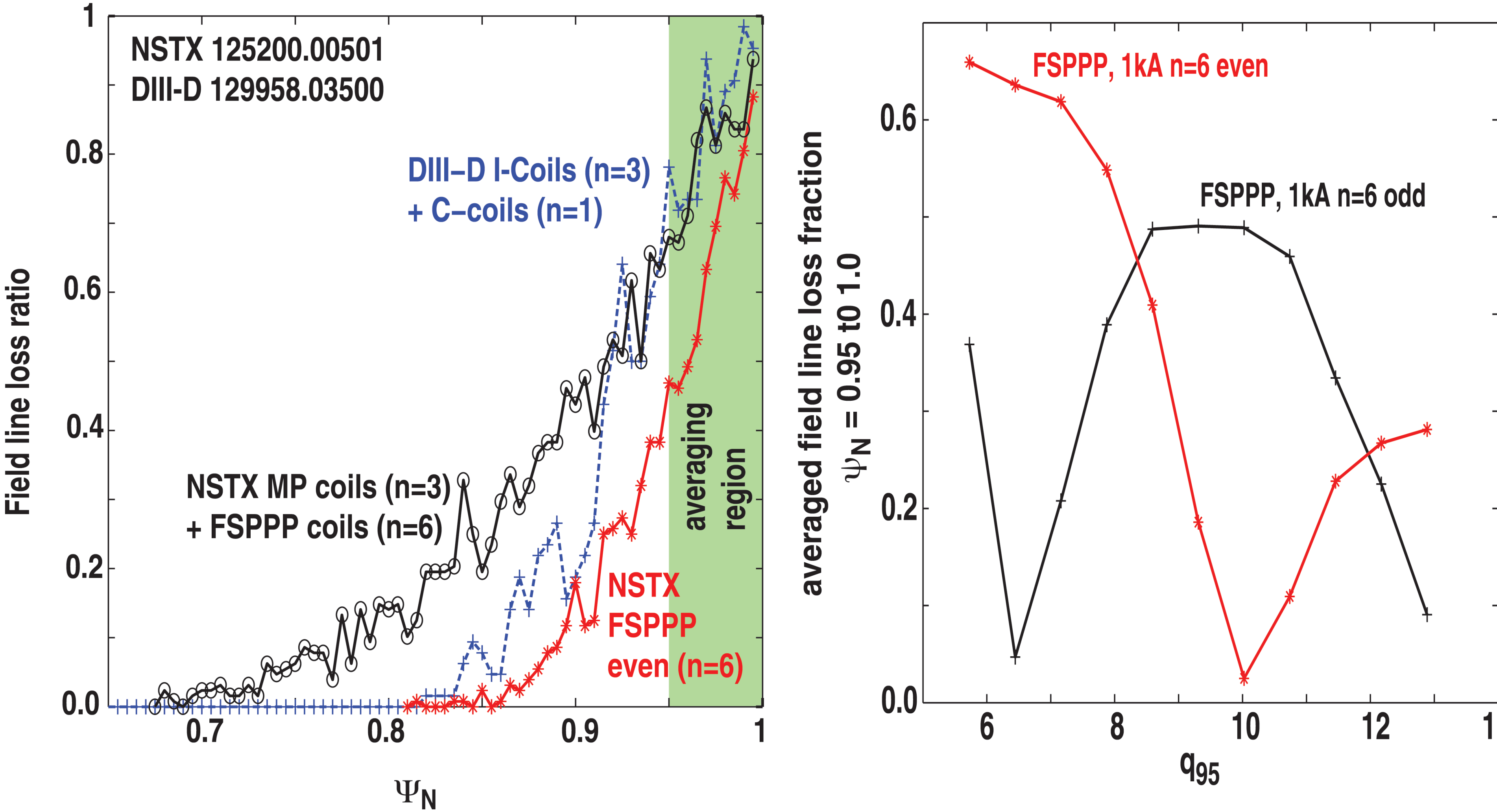


The n=6 FSPPP coil field line loss fraction is relatively small compared to the edge stochastic layer width





The field line loss fraction exceeds that in DIII-D when the n=6 FSPPP coil is combined with n=3 EF/RWM coil



Summary and additional comments

- In high δ, κ DN plasmas, n=6 FSPPP fields produce a wider edge stochastic layer than n=3 I-coil fields in DIII-D
  - Over a wider range in q_{95} (*i.e.*, $5.3 \leq q_{95} \leq 12.8$)
- Combined FSPPP n=6 and EF/RWM n=3 field line loss fractions exceed those due combined n=3 I-coil and n=1 C-coil fields in DIII-D
  - Preliminary results from DIII-D indicate that as the pedestal collisionality increases ELM suppression is correlated with larger field line loss fractions
- Future FSPPP coil geometry optimizations include:
  - Aspect ratio variations
    - Studies of other RMP coil designs (e.g., DIII-D and ITER) indicate that optimizing the coil aperture to match the poloidal wavelength increases the coil efficiency
  - Angular tilt variations
    - Match the flux surface contours better (especially in lower κ plasmas)
  - Comparisons of optimized n=3 FSPPP coils with n=3 EF/RWM coils
  - Plasma response versus β_N and collisionality