Field line modeling of RWM/EF perturbations for ELM modification studies (XP525)

Presented by
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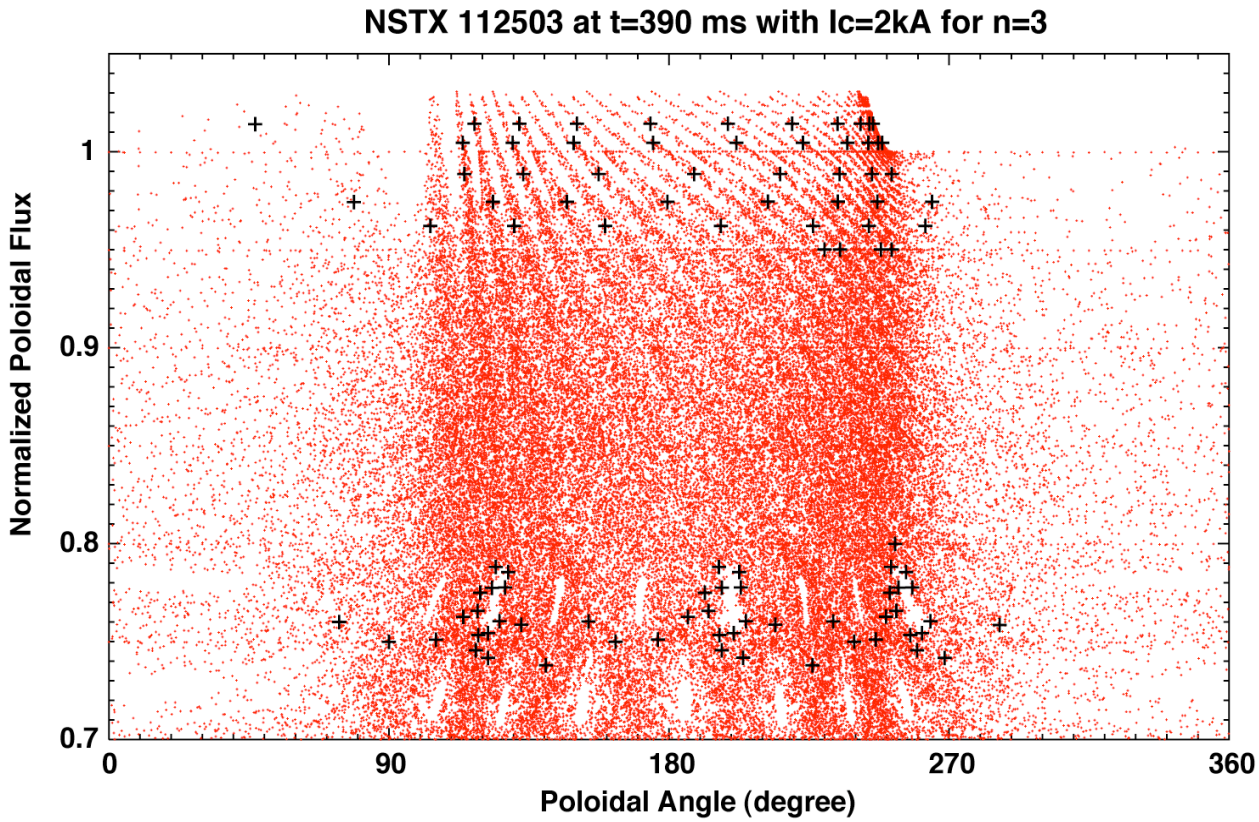
General Atomics

Presented at the
NSTX Results Review

December 12, 2005

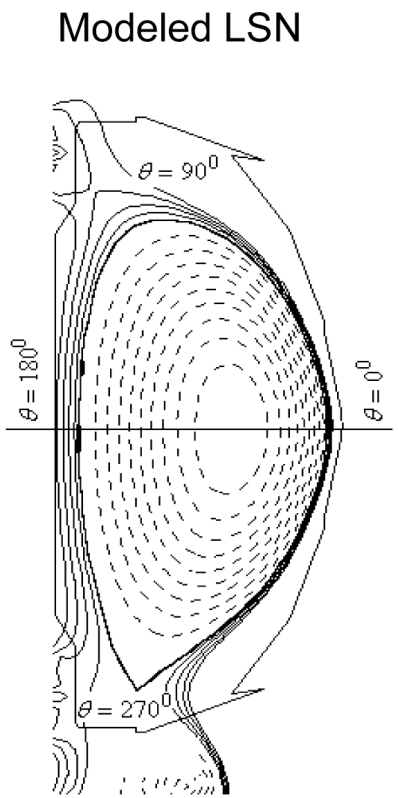


*In collaboration with:
L. Yan (SWIPP), S. Kaye (PPPL) and R. Maingi (ORNL)

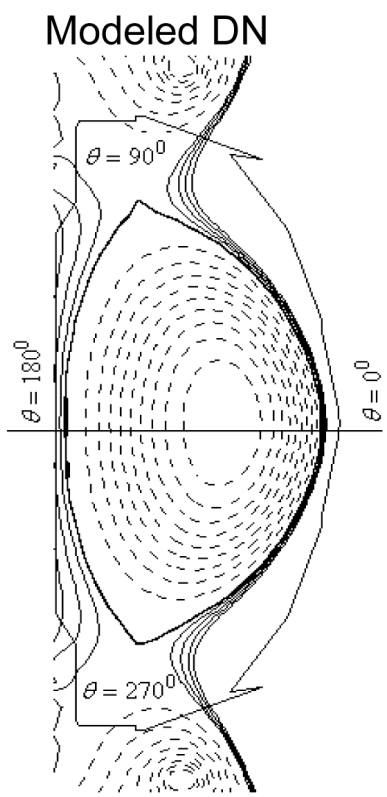
Preliminary field line modeling done prior to XP525 for planning purposes: follow-up in progress

- Two NSTX configurations modeled:
  - Lower single null (112503, 390 ms, B_T=0.44 T, I_P=0.8 MA, q_{95}=6.1)
  - Double null (111378, 343 ms, B_T=0.44 T, I_P=0.5 MA, q_{95}=9.7)
    - Applied n=1 and n=3 RWM/EF perturbations in both cases
    - Coil current range: 0.5 kA-turn ≤ $I_{RWM/EF}$ ≤ 3.0 kA-turn
- General conclusions:
  - Field line escape structure more complex for n = 3
  - With equivalent current, n = 3 is more stochastic than n = 1
    - For 2 kA-turn: flux loss from ψ_N = 0.75 (n = 3) and ψ_N = 0.85 (n = 1)
- Additional modeling of XP525 shot 117142 in progress
  - Coil current range: 0.3 kA-turn ≤ $I_{RWM/EF}$ ≤ 0.8 kA-turn

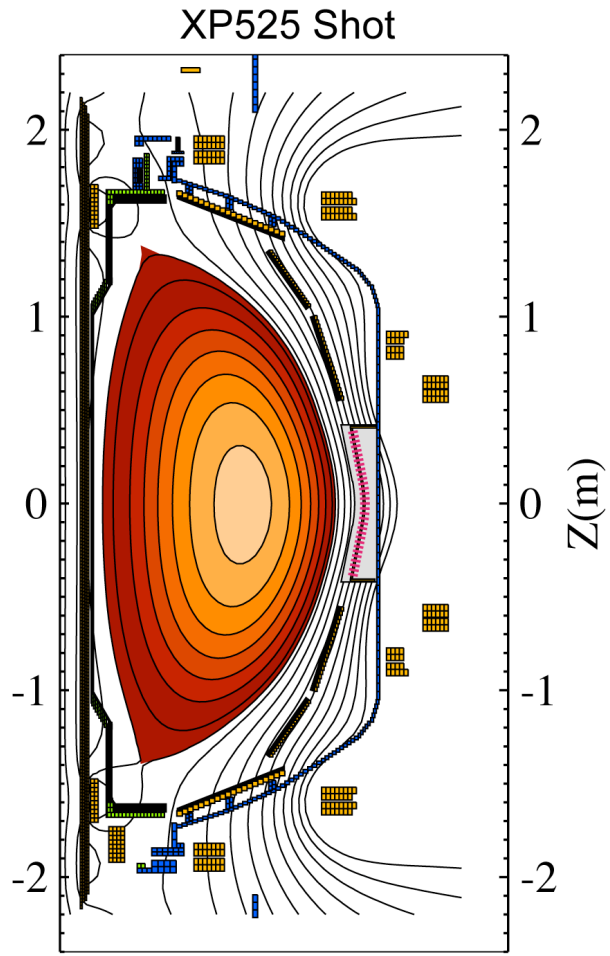
Modeled DN case is similar to XP525 shot but has smaller upper and lower δ's and smaller κ



Shot 112503,
time=390 ms



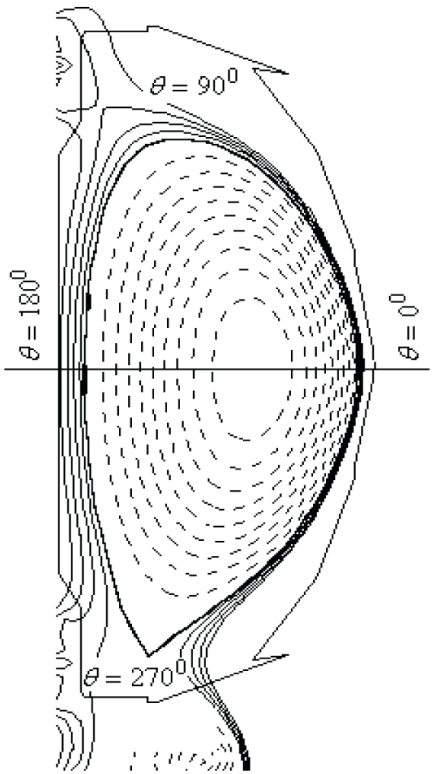
Shot 111378,
time=343 ms

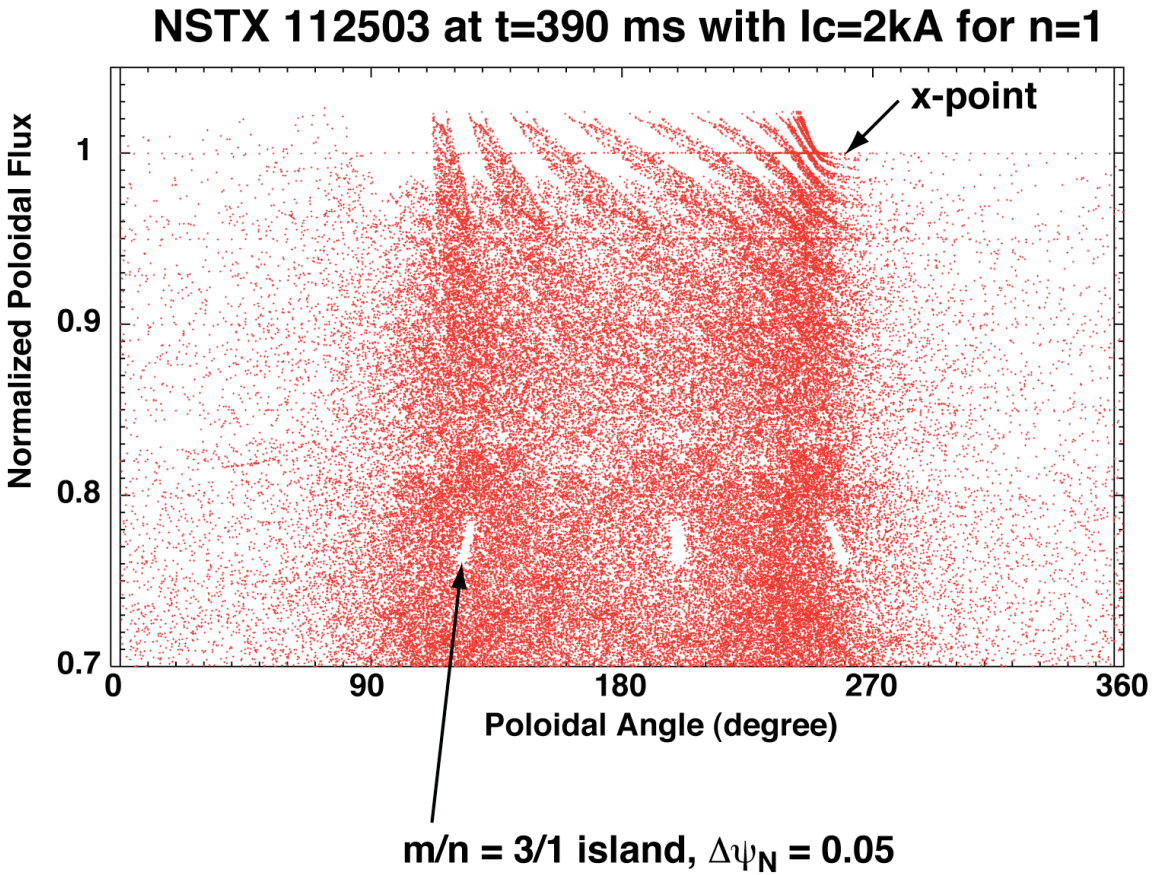


EFIT02, Shot 117142,
time=200ms

Forward going n = 1 field lines escape through inner strike point

Modeled LSN



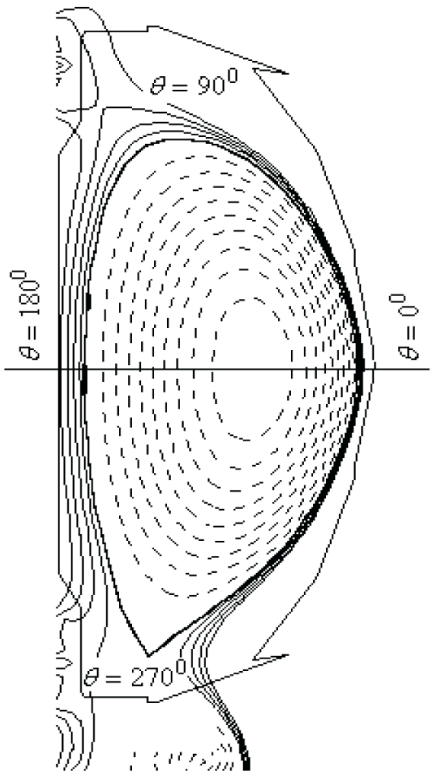


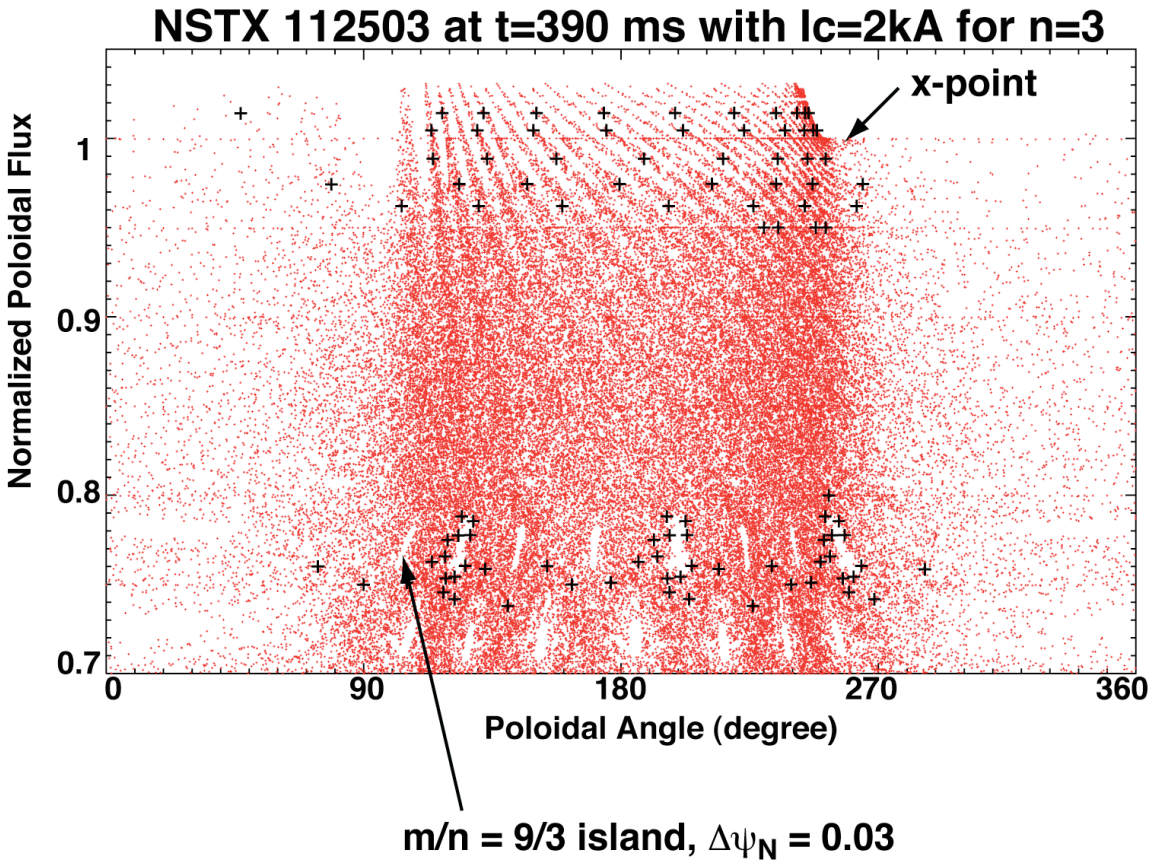
Shot 112503,
time=390 ms

- Deepest field line escape from $\psi_N \sim 0.85$

Forward n = 3 field line escape starts from $\psi_N = 0.75$

Modeled LSN

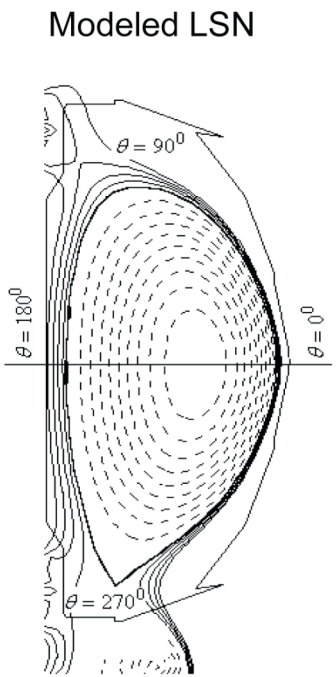




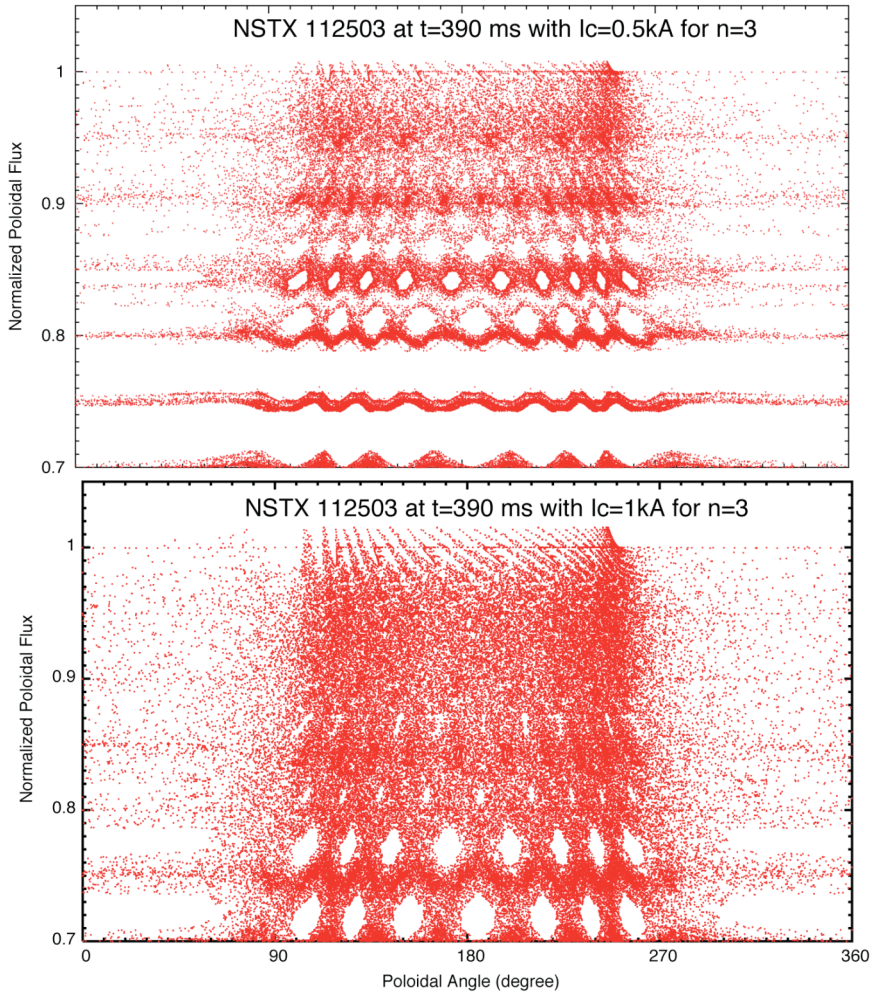
Shot 112503,
time=390 ms

- Some field lines appear to jump from $\psi_N \sim 0.75$ to $\psi_N \sim 0.97$ in a single toroidal transit

n = 3 global stochasticity onset seen for coil current between 0.5 to 1 kA-turn



Shot 112503,
time=390 ms

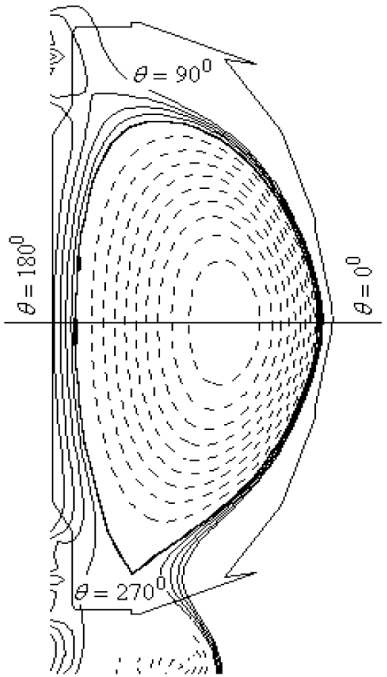


0.5 kA-turn

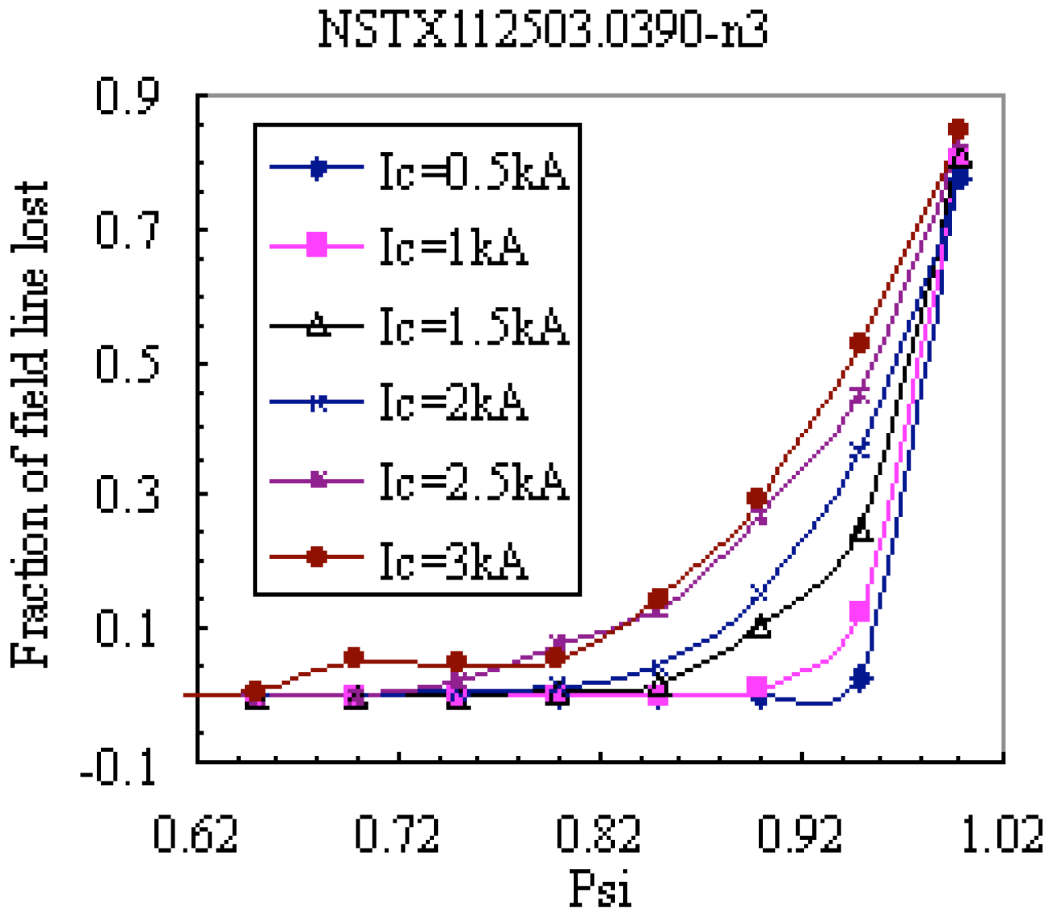
1.0 kA-turn

Field line escape fraction increases with coil current

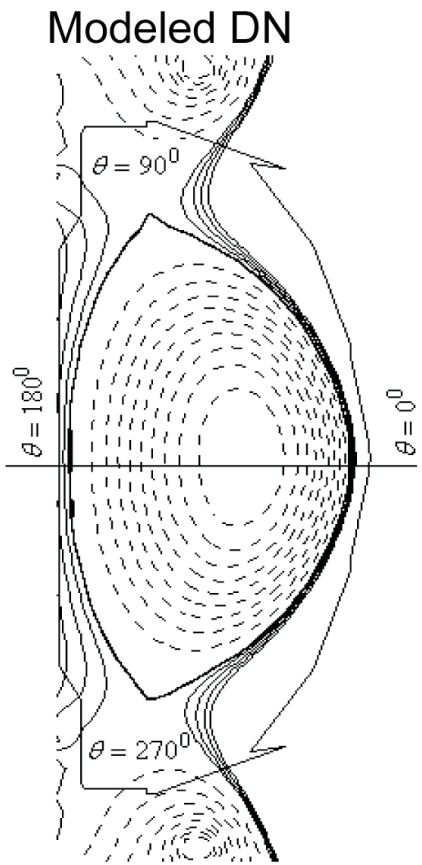
Modeled LSN



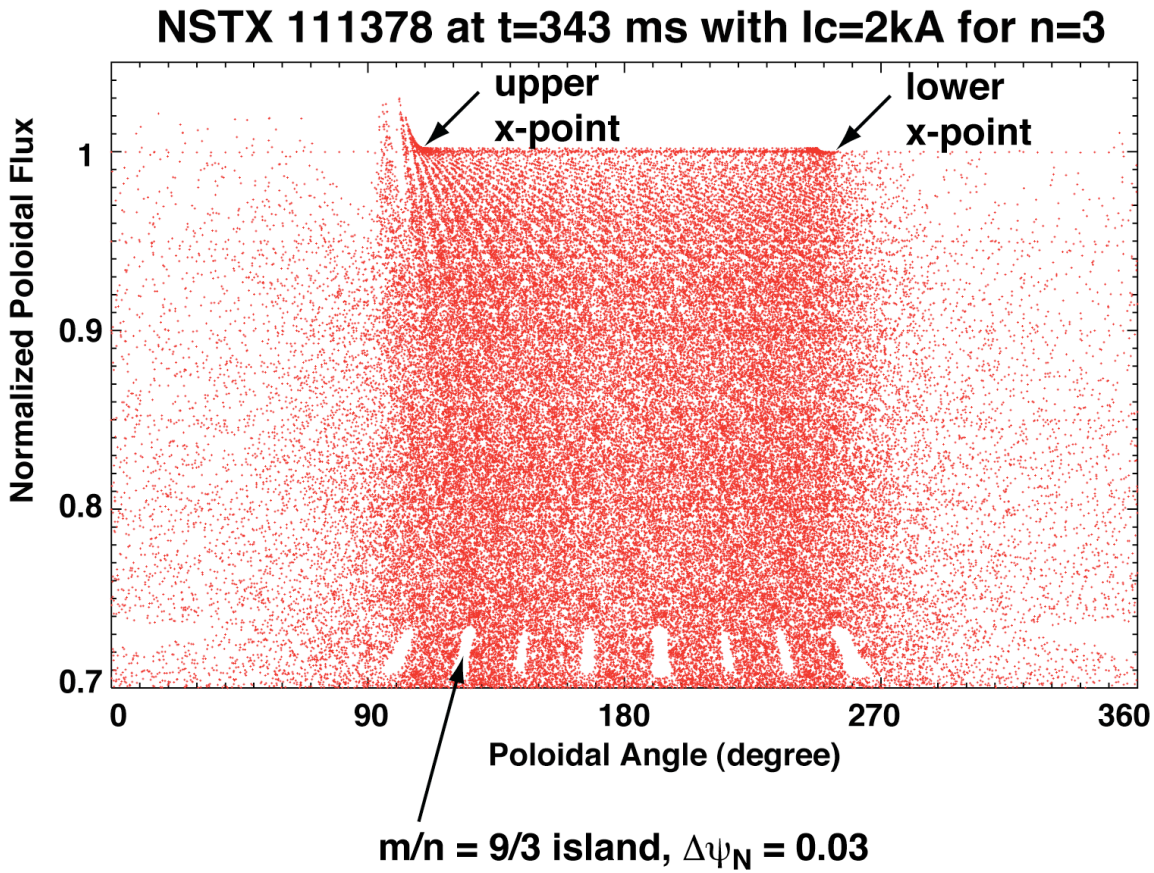
Shot 112503,
time=390 ms



In DN case, forward going field lines lost through upper x-point (backward through lower x-point)

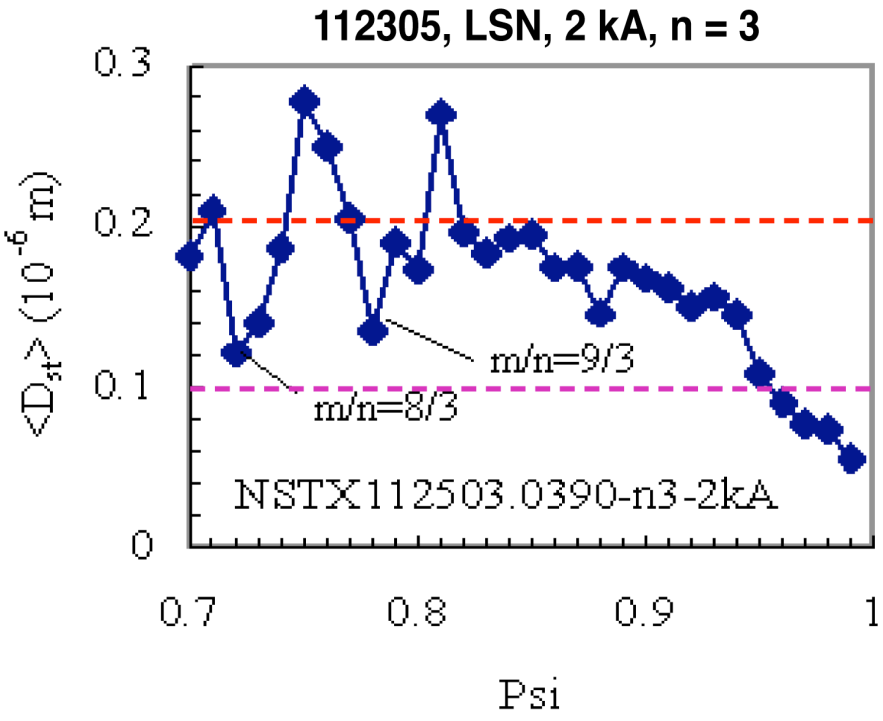


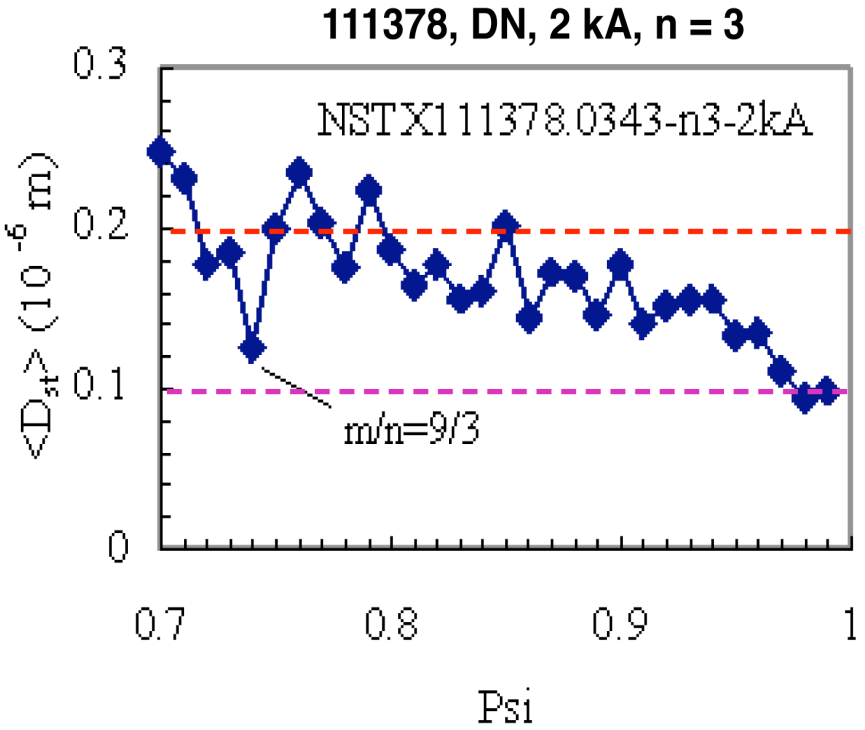
Shot 111378,
time=343 ms



Forward going field lines

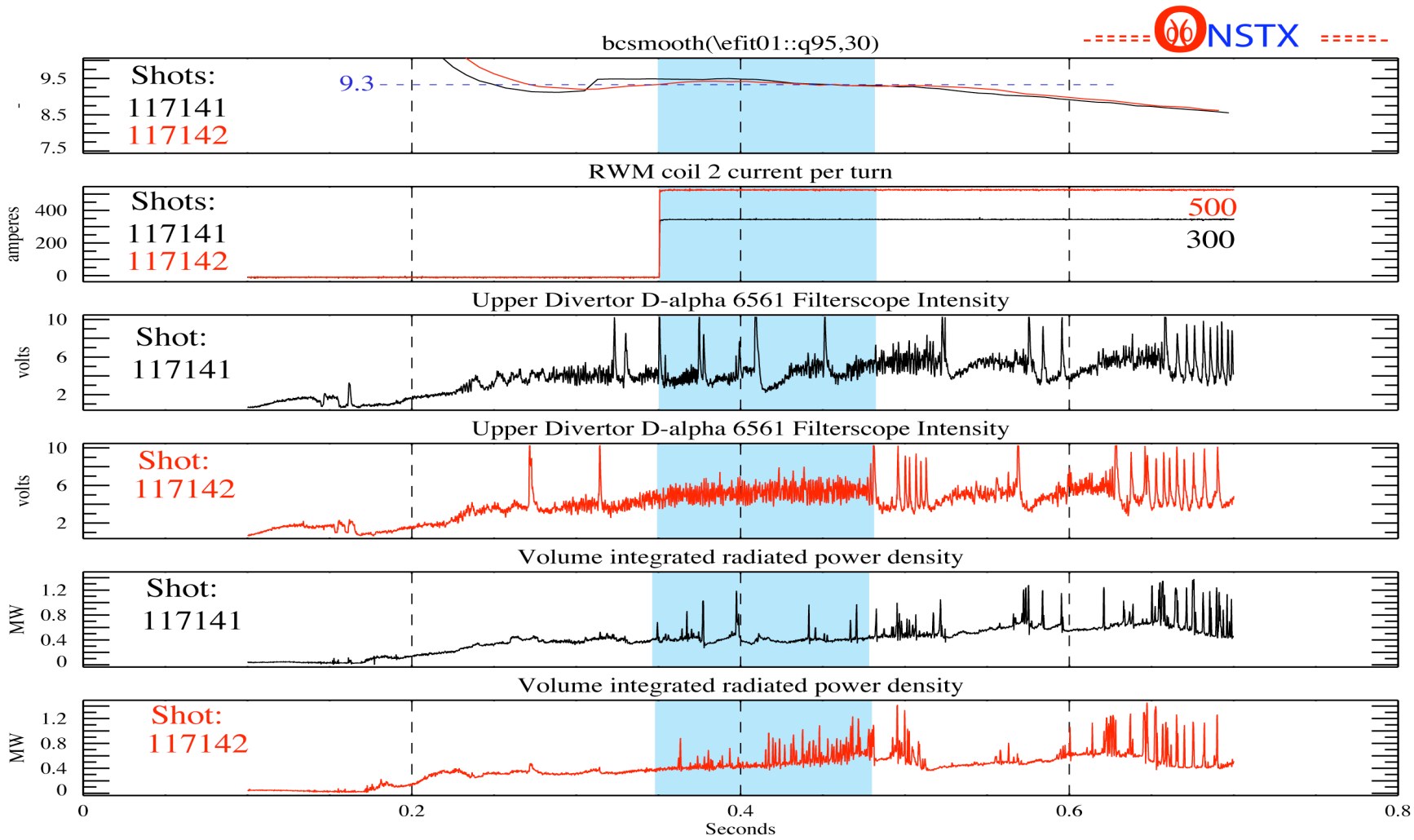
Stochastic field line diffusion larger across pedestal for the DN configuration





- Field line diffusion is reduced across remnant islands (i.e., m/n = 8/3 and 9/3)
- NSTX: at ψ_N = 0.95, $^{TRIP3D}D_{st}$ = 1.0->1.2E-7 m $\Rightarrow \chi_e = v_{Te}D_{st}$ ~0.7 m^2/s
- DIII-D: at ψ_N = 0.95, $^{TRIP3D}D_{st}$ = 3.9E-6 m $\Rightarrow \chi_e = v_{Te}D_{st}$ ~49 m^2/s

ELMs appear to be modified for q_{95} > 9.3 with a coil current of 500 A-turn



Summary

- n = 3 RWM/ER perturbations produce deeper field line loss than n = 1 perturbations in both LSN and DN configurations
- Similar RWM/ER and DIII-D I-coil currents produce significantly smaller magnetic and thermal diffusivity in NSTX
- Results from XP525 shot 117142 show possible ELM modification with:
  - 0.3 kA-turn < $I_{RWM/EF}$ ≤ 0.5 kA-turn
  - q_{95} ~ 9.3
  - 117142 shape similar to modeled DN case
    - Higher upper and lower δ
    - Larger κ
  - Additional modeling will focus on variations of shot 117142