NSTX

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Optimization of ELM pace-making with 3D Fields

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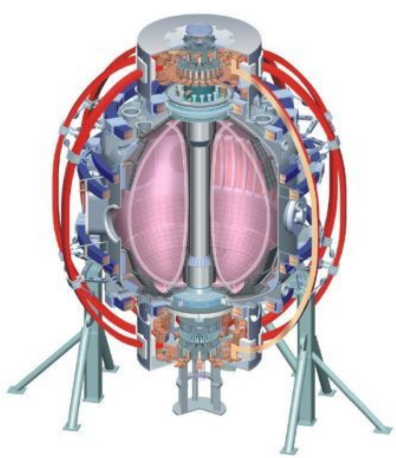
NSTX XP Review
Princeton, NJ
May 6, 2009



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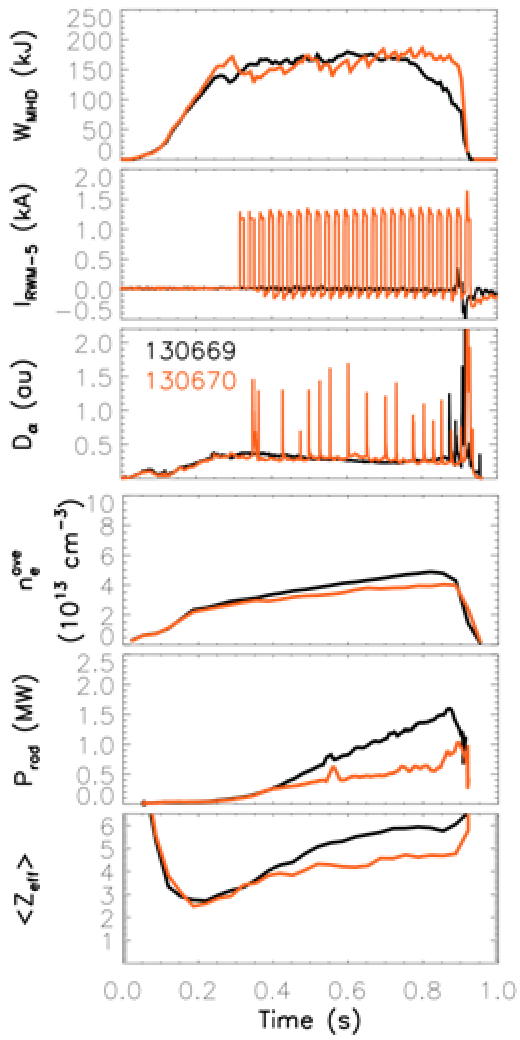
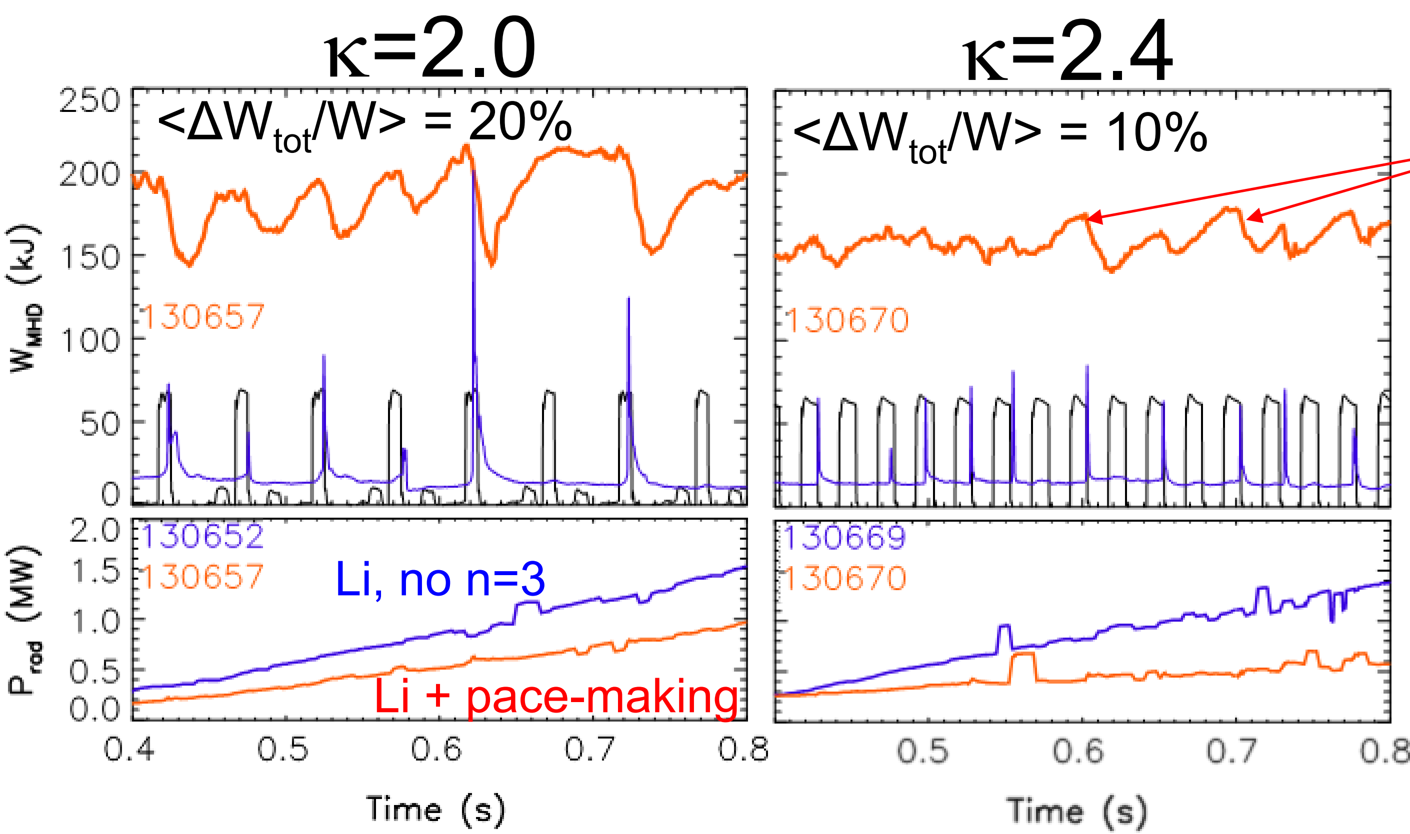
ELM Pacing can reduce impurity buildup during Li-enhanced discharges

- ELM-free H-mode shots have very large radiated power
- ELM pacing able to control this problem
- Need to develop scenario for long-pulse, steady-state



…but the triggered ELMs are very large

- ELMs are much smaller at high κ
  - Most probable ELM size is $\Delta W_{tot}/W$ ~3% at κ=2.4, ~20% at κ=2.0
  - Triggering frequency also higher
  - As is effectiveness in reducing P_{rad} buildup



Largest ELMs occur after pulse fails to trigger

Triggering requires 8-10 ms pulses, comparable to ~4 ms field penetration time

Goal of XP: Li + n=3 high performance plasma with small ELMs and steady density/P_{rad}

Oak Ridge National Laboratory

1) Produce reference discharge (2 shots)
   - Reload 132592: I_p=1.0 MA, Bt=0.45 T, κ=2.2, δ=0.8, dr^{sep}~ -1 cm, P_{NBI} = 3 MW, LITER at ~ 50 mg/min, 600 mg/shot
   - Change dr^{sep} to ~ 0, κ to 2.5, adjust LITER to 40 mg/min, ~ 300 mg/shot (1 shot)
   - If necessary, increase LITER evaporation rate to get ELM-free conditions (1)

2) Waveform optimization: maximize frequency, minimize duty cycle of n=3 (13 shots)
   - Starting values from 130670, but lower frequency to reduce braking: 1.2 kA, 11 ms pulses, 20 Hz repetition (1 shot)
   - Increase amplitude as much as possible to try to trigger ELMs faster (3 shots)
     - SPA current scan at fixed pulse width: 1.5, 2.0, 2.5 kA
   - At highest current, decrease pulse length as much as possible with reliable triggering (2 shots)
   - Increase frequency as much as possible, until excessive braking leads to termination of discharge (3 shots)
   - Add short (~2 ms) SPA current reversal to the end of each pulse, test if this allows further increase in pulse frequency (2 shots)

Goal of XP: Li + n=3 high performance plasma with small ELMs and steady density/P_{rad}

3) Shape optimization: minimize ELM size, maximize frequency (12 shots)
   - Reduce κ to 2.1
     - start with best SPA waveform from series 2) (1 shot)
     - reduce pulse frequency until triggering is reliable (2 shots)
   - Raise κ to 2.7 in increments of 0.2. At each shape perform the following:
     - apply low-frequency SPA waveform from κ = 2.1 case (1 shot)
     - increase frequency as much as possible while maintaining reliable triggering (2 shots)
4) Fueling optimization: minimize dn/dt (10 shots)
   - Start with reference discharge, and change CS in increments of 100 torr
   - Replace CS with shoulder
     - Shoulder pressure at ~ half CS
     - Shoulder puff at 100-130 ms (~10-30 ms later than CS)
   - Replace CS with SGI?
5) Vacuum shots with SPA pulses (~5 shots)
   - Restore best SPA waveforms from day, measure vacuum field structure

- Special machine requirements
  - 10 min shot cycle (no HeGDC), LITER sufficient to suppress ELMs
    - Several control shots will be taken through the day to check LITER rate is enough
  - RWM coils configured for n=3