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Optimization of magnetic ELM pace-making: making a high performance Li+ plasma with steady density and P_{rad}, with small ELMs

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NSTX ASC TSG XP Review
Princeton, NJ
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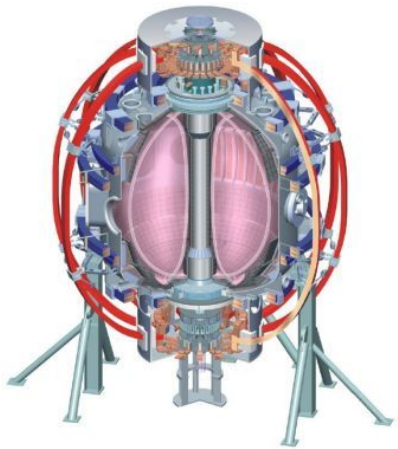
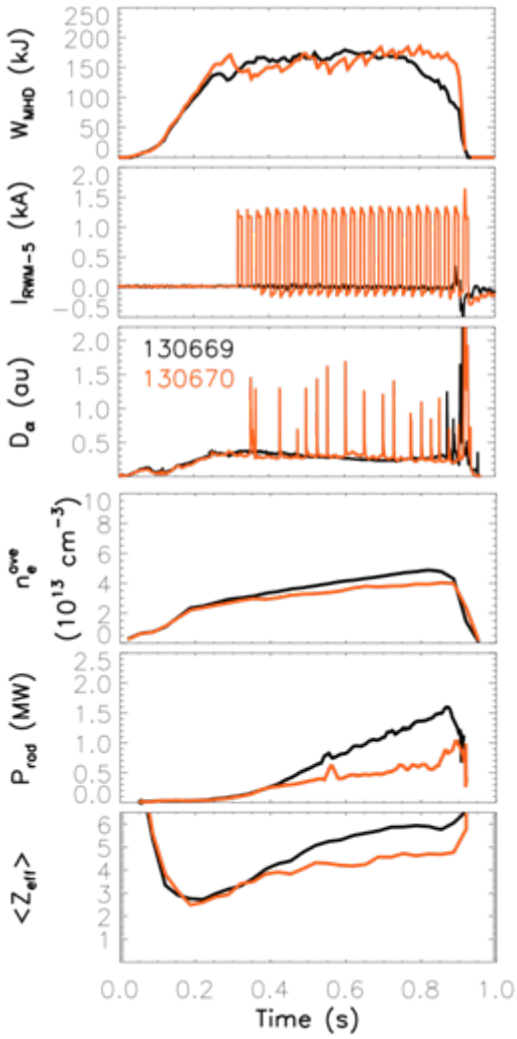
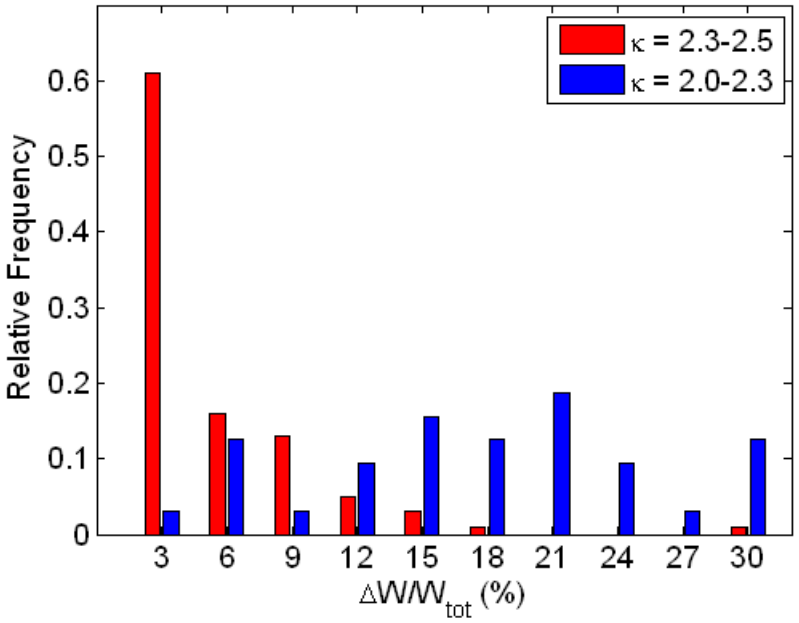


ELM Pacing can reduce impurity buildup during Li-enhanced discharges

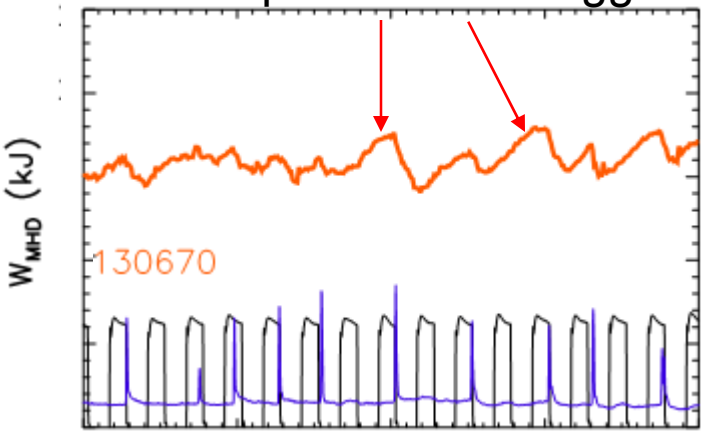
- ELM-free H-mode shots have very large radiated power
- ELM pacing able to control this problem
- Need to develop scenario for long-pulse, steady-state



…but the triggered ELMs are too large



Largest ELMs occur after a pulse fails to trigger



- Triggered ELMs are large, but trends are promising
  - ELMs are much smaller at high κ
  - Optimization for small ELMs will be performed in future experiments
- Internal coils could greatly improve technique
  - Triggering requires 8-10 ms pulses, comparable to ~4 ms field penetration time
  - Internal coils -> faster triggering?
    - Higher frequency, smaller ELMs, better impurity control
    - More reliable triggering, smaller ELMs?

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

1) Produce reference discharge (3 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
   - Increase dr^{sep} to ~ 0

2) Shape optimization step 1: exploit/explore kappa dependence to reduce ELM size (6 shots)
   - Establish a SPA waveform that triggers ELMs, doesn't kill shot: start with SPAs from 130670 (pulse width, amplitude, frequency = 11 ms, 1.2 kA, 40 Hz) (2 shots)
   - Increase elongation while triggering ELMs (4 shots)
     - Goal in this step is κ=2.5 (got close to this in 130670, no problems with ELM triggering)
     - Would like to have one value in between, depending on where κ sits after step 1

3) Waveform optimization: maximize frequency, minimize duty cycle of n=3 (10 shots)
   - Starting values from 2), probably close to those from 130670
   - Increase amplitude as much as possible to try to trigger ELMs faster (6 shots)
     - Start with increments of 500 A in SPAs
     - At each step, will probably have to reduce pulse width to avoid terminating plasma
   - At highest current, decrease pulse length as much as possible with reliable triggering (2 shots)
   - Increase frequency as much as possible, avoiding excessive braking (2 shots)

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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) Shape optimization part 2: push to higher kappa (6 shots)
   - Fix SPA waveform, based on shots taken so far
   - Raise κ to a goal of 2.7
     - Squareness request increase in increments of ~0.02
     - IPF1a adjusted to keep inner gap fixed-note outer gap fixed at ~10 cm for TS

- Special machine requirements
  - LITER at 50 mg/min for 7-8 minute sufficient, 10 min shot cycle (no HeGDC)
  - RWM coils configured for n=3

- Discussion point: what is the best I_p to run?
  - Looking at 1.0 MA so far, but could also do high f_{BS}, or high I_p
  - Should we also include a current scan at the end of the day, using shape etc. as optimized at 1.0 MA?