NSTX

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ELM Destabilization by Magnetic Perturbations at NSTX

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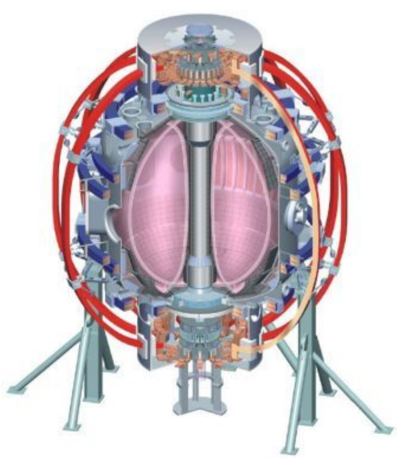

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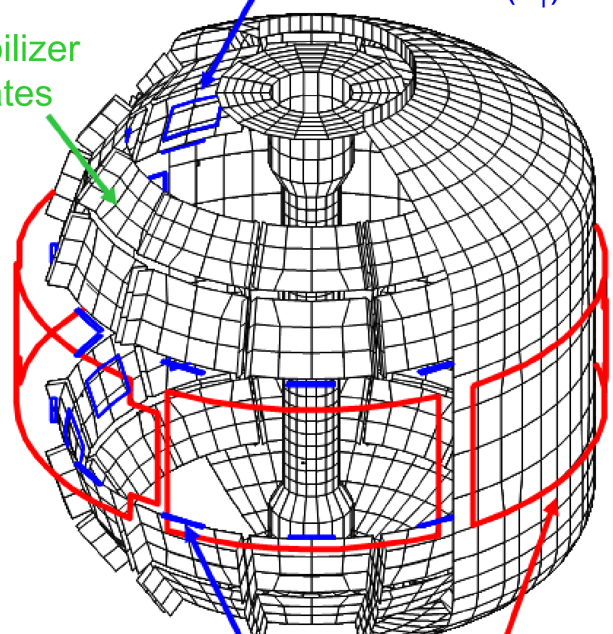
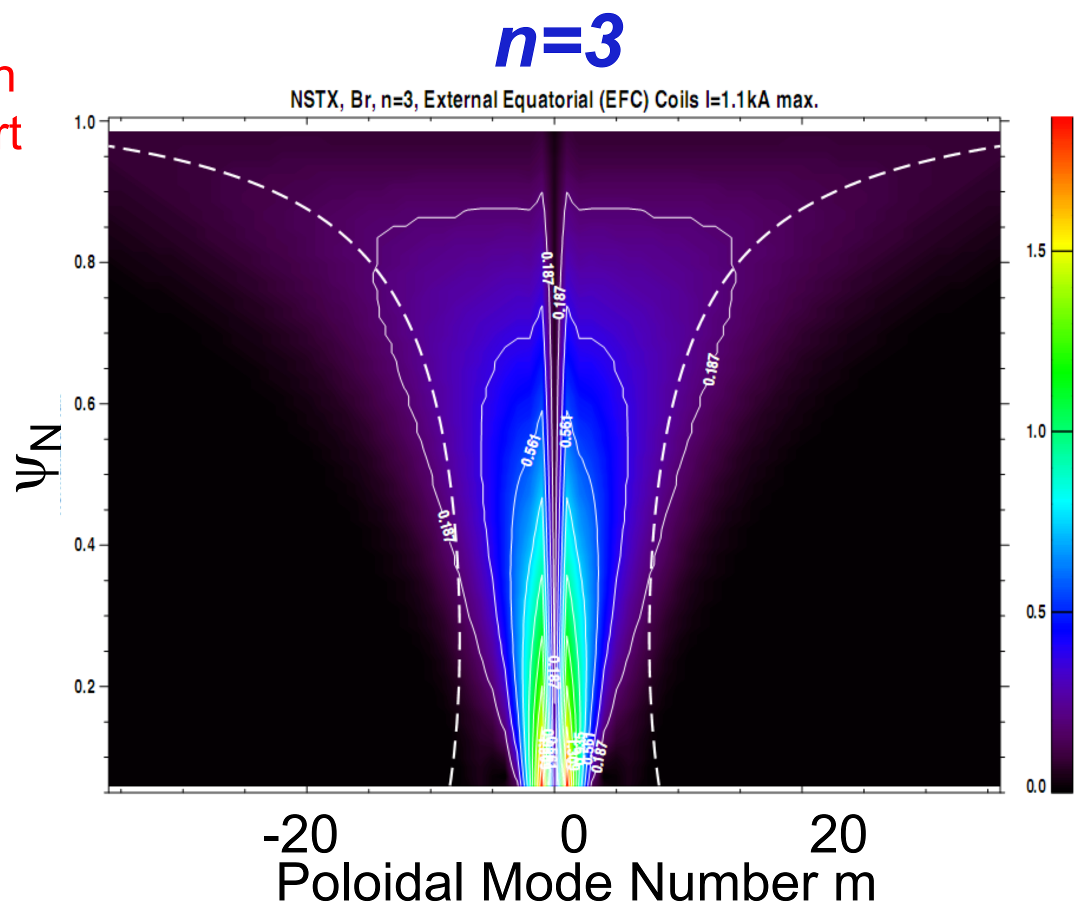
n=3 field from external midplane coils is used to induce ELMs

- Motivation:
  - Understand 3D field effects on pedestal stability and transport
  - Provide mechanism for impurity control in Lithium-enhanced ELM-free H-modes

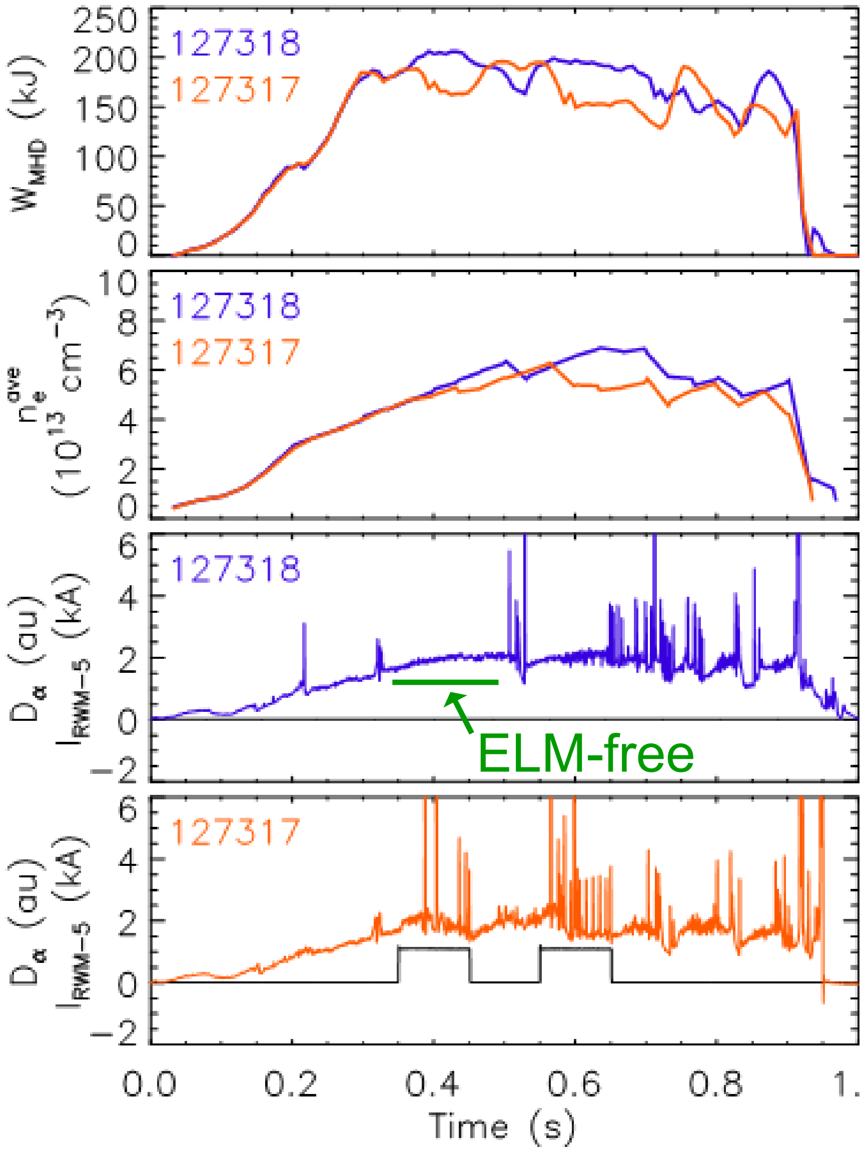




- Island overlap parameter:
  - $\sigma_{CH} > 1$ for $\psi_N > 0.6$ (vacuum)
  - $\sigma_{CH} > 1$ for $\psi_N > 0.9$ (IPEC)

Application of n=3 field destabilizes ELMs in discharges without Li conditioning

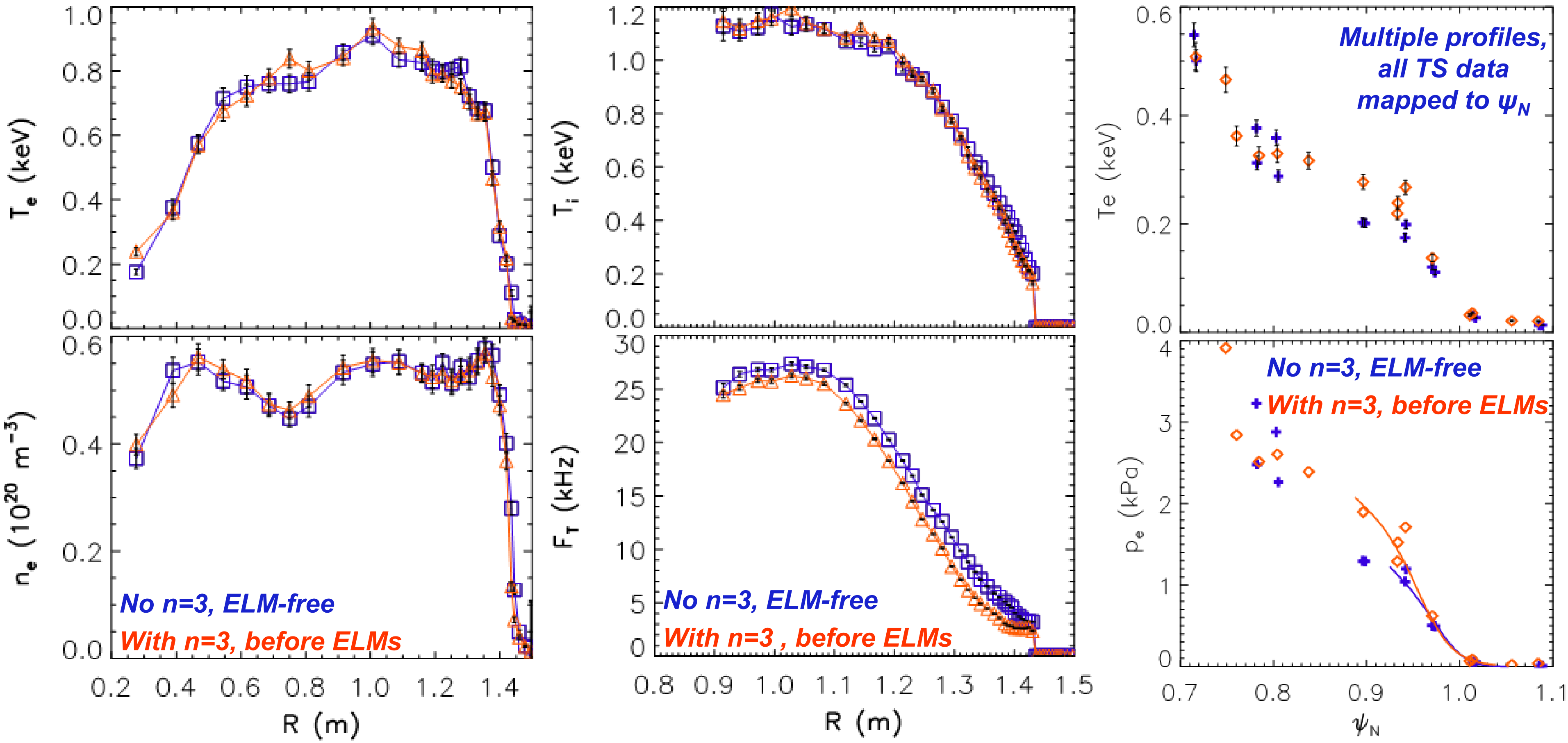
- Discharge parameters:
  - B_t = 0.45 T, I_p = 800 kA, P_{NBI} = 6MW
  - κ=2.0, δ=0.7, dr^{sep} ~ 0, q_{95} ~ 10
  - *No lithium coatings on PFCs*
- No 3D field is applied, ELM-free period lasts until t ~ 0.5 s
- n=3 field is applied during ELM-free phase
  - ELMs begin within ~50 ms
- Presence of ELMs tracks application of n=3 field
  - ELMs cease when perturbation is removed, begin again with reapplication
  - Shot-to-shot timing scan: ELMs start within 50 ms of 3D field application



Toroidal rotation drops, T_e^{ped} increases when n=3 field is applied

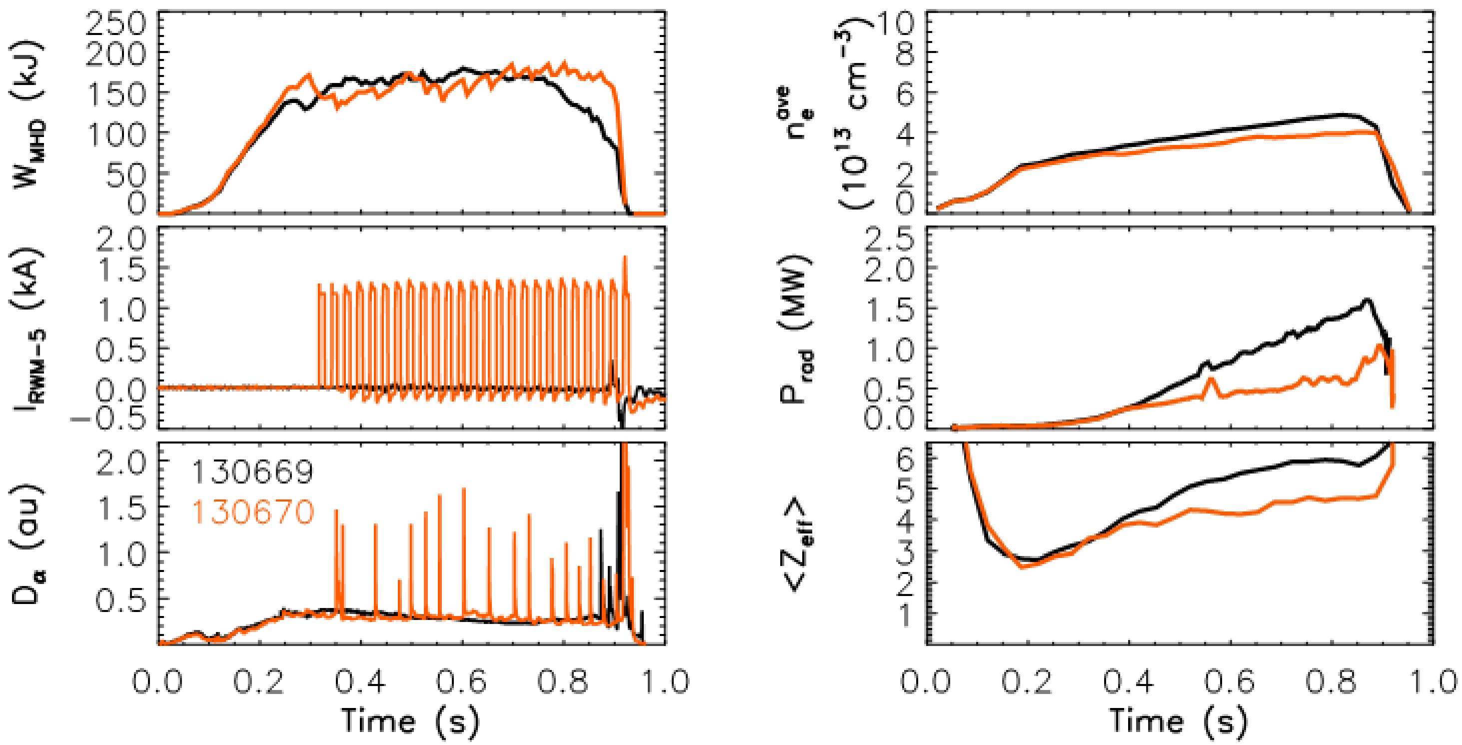
- Blue profiles: no n=3 applied
- Red profiles: 20 ms after n=3 applied (before ELMs)
  - Preliminary PEST calculations: stable before n=3, edge unstable after

Electron Temperature and Density | ***Ion Temperature and Rotation*** | ***Pedestal electron profiles***



Destabilization has been used for magnetic ELM pace-making in Li-enhanced ELM-free H-modes

- n=3 field applied as square wave in κ = 2.4 Li-enhanced discharge
  - ELM-free with Li and no n=3 field
  - ELMs triggered on ~75% of n=3 pulses (11 ms, 40 Hz, 1.2 kA)

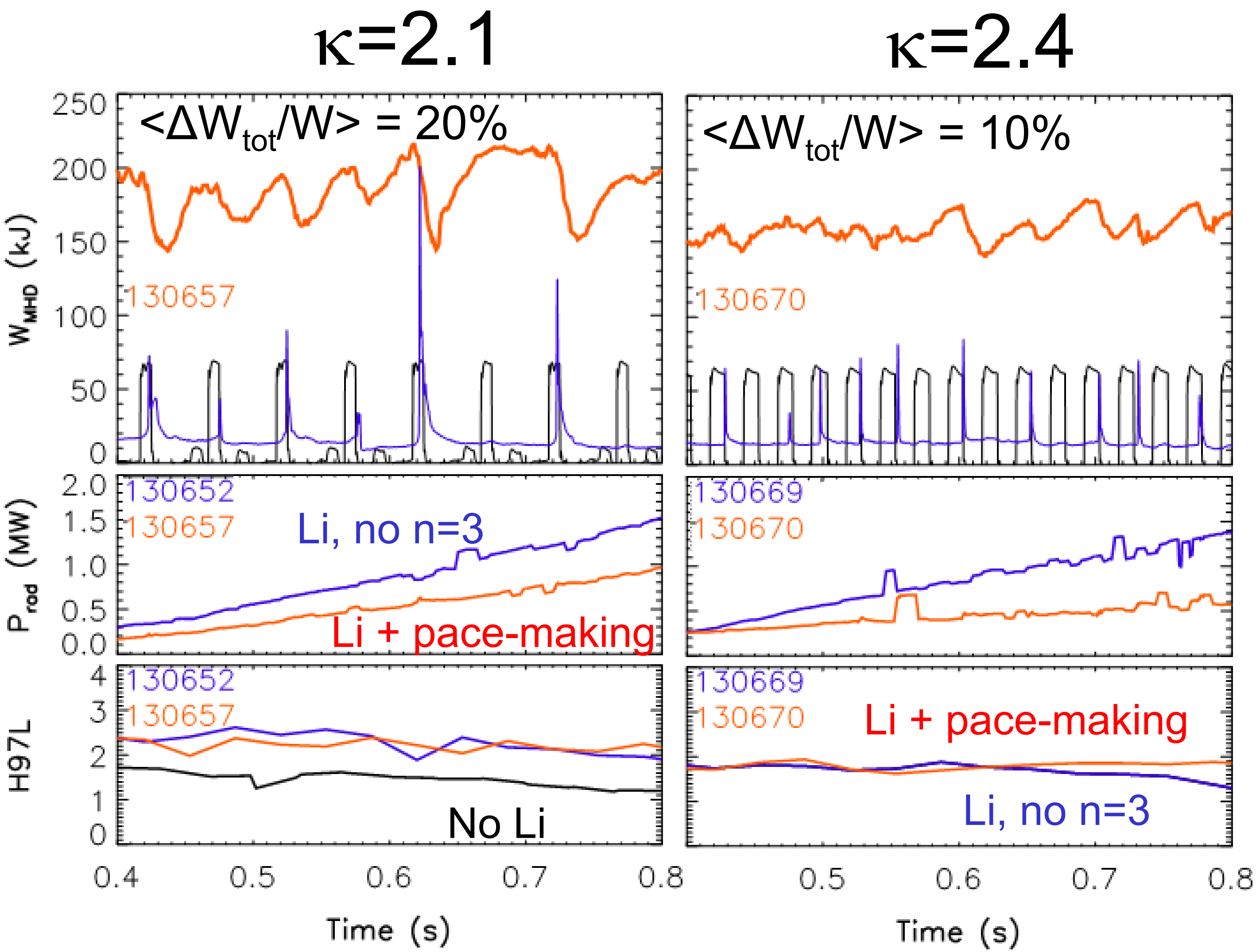


Reduced density

Less radiation

Lower Z_{eff}

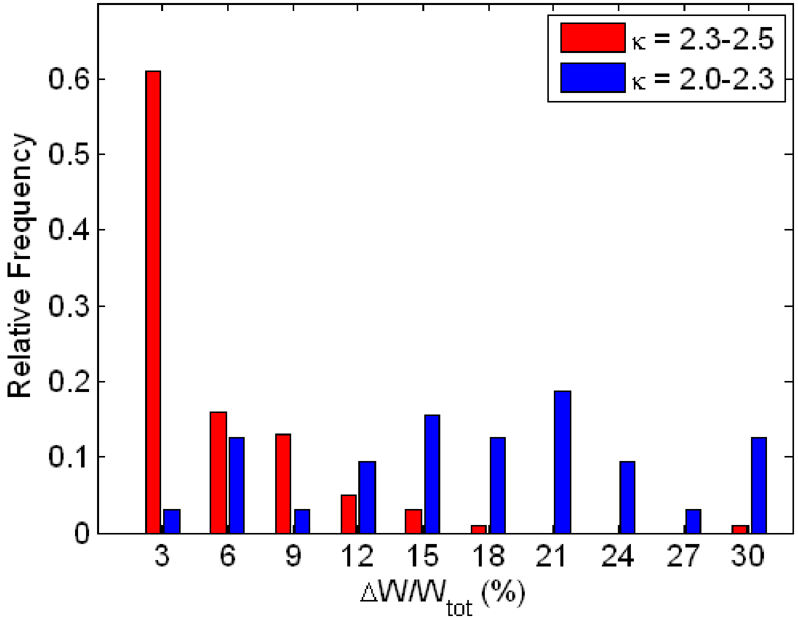
ELM pace-making is more effective at high elongation



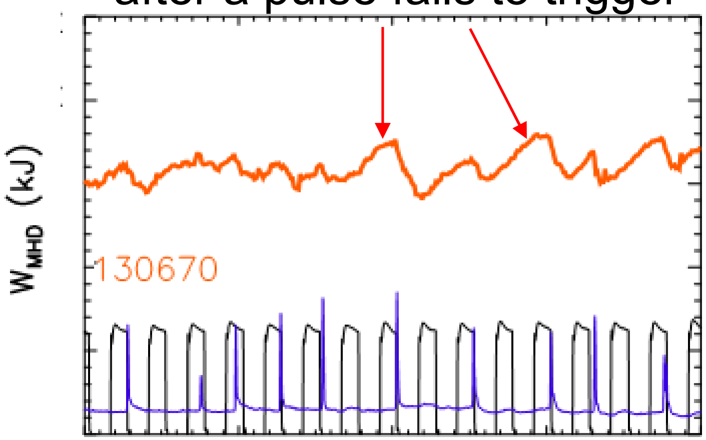
At high κ:

- Smaller, more frequent ELMs are triggered
- Impurity control is more effective
- High H-factor is maintained in both shapes

Magnetic ELM pace-making may be improved at higher κ, with internal coils



Largest ELMs occur
after a pulse fails to trigger



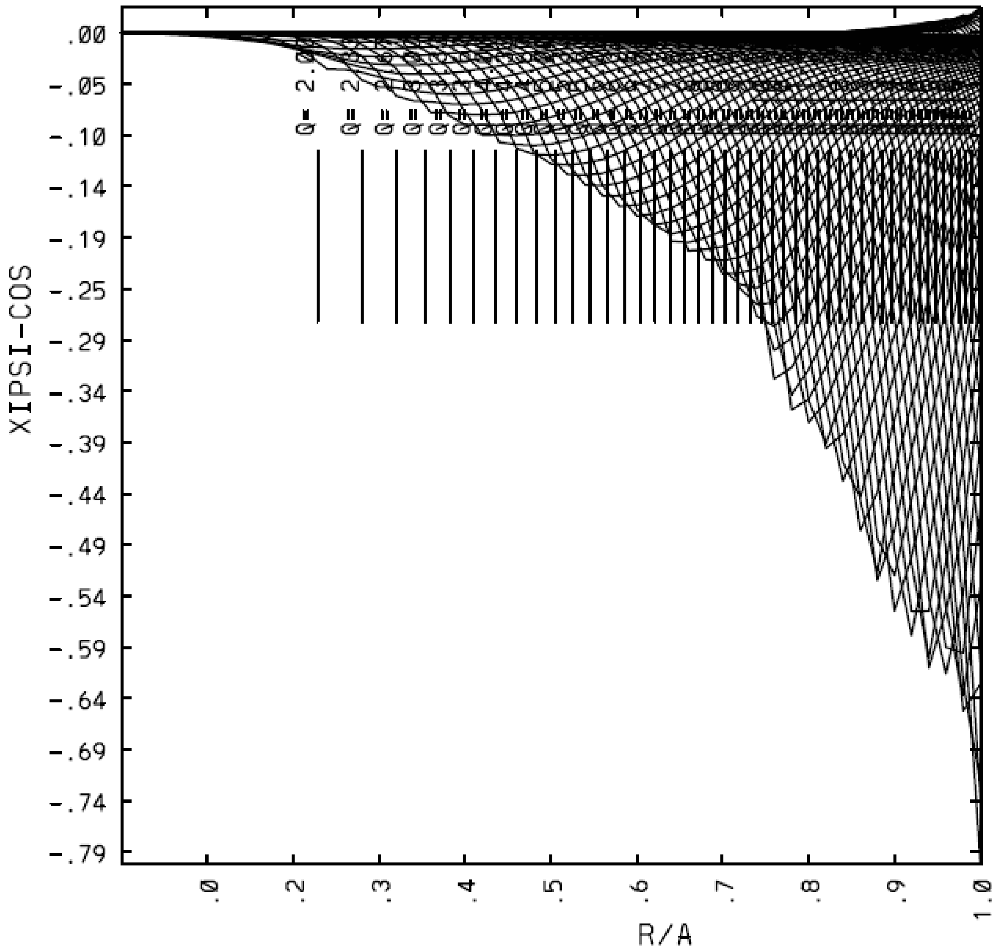
- Triggered ELMs are large, but trends are promising
  - ELMs are much smaller at high κ
  - Optimization for small ELMs will be performed in future experiments
- Internal coils could greatly improve technique
  - Triggering requires 8-10 ms pulses, comparable to ~4 ms field penetration time
  - Internal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

Summary

- Application of n=3 fields can destabilize ELMs during ELM-free H-mode
  – n=3 reduces rotation, increases pedestal electron pressure
  – Plasma returns to ELM-free when 3D field is removed
- ELM triggering has been used for magnetic ELM pace-making in Li-enhanced ELM-free H-modes
  – Li coatings suppress ELMs, improve confinement, but problems with impurity accumulation
  – ELMs are controllable introduced with n=3 fields, reducing density and radiated power
  – ELM triggering shows favorable dependence on elongation
- High confinement is maintained with ELM triggering
  – Viability of lithium coatings + ELM pace-making with 3D fields as a high-performance scenario

Edge is less stable after n=3 is applied

- Preliminary n=3 stability calculations performed with PEST
- Plasma stable before 3D field application
- After 3D field is applied, PEST finds edge instability
  - $(\gamma/\omega_A) = 0.22$
  - Diamagnetic stabilization to be addressed



Midplane coil current scan shows threshold for destabilization

- Threshold coil current for ELM-triggering is ~950 A
  - No triggering at 900 A (natural ELMs start at ~0.5s in control discharge)
  - Intermittent ELMs at 950 and 1000 A
- ELM frequency appears to increase with n=3 field magnitude
  - ELMs become more regular
  - Tendency clouded by tendency of plasma to lock high currents-too much braking