Research
Supported by

NSTX

ELMs in the National Spherical Torus Experiment

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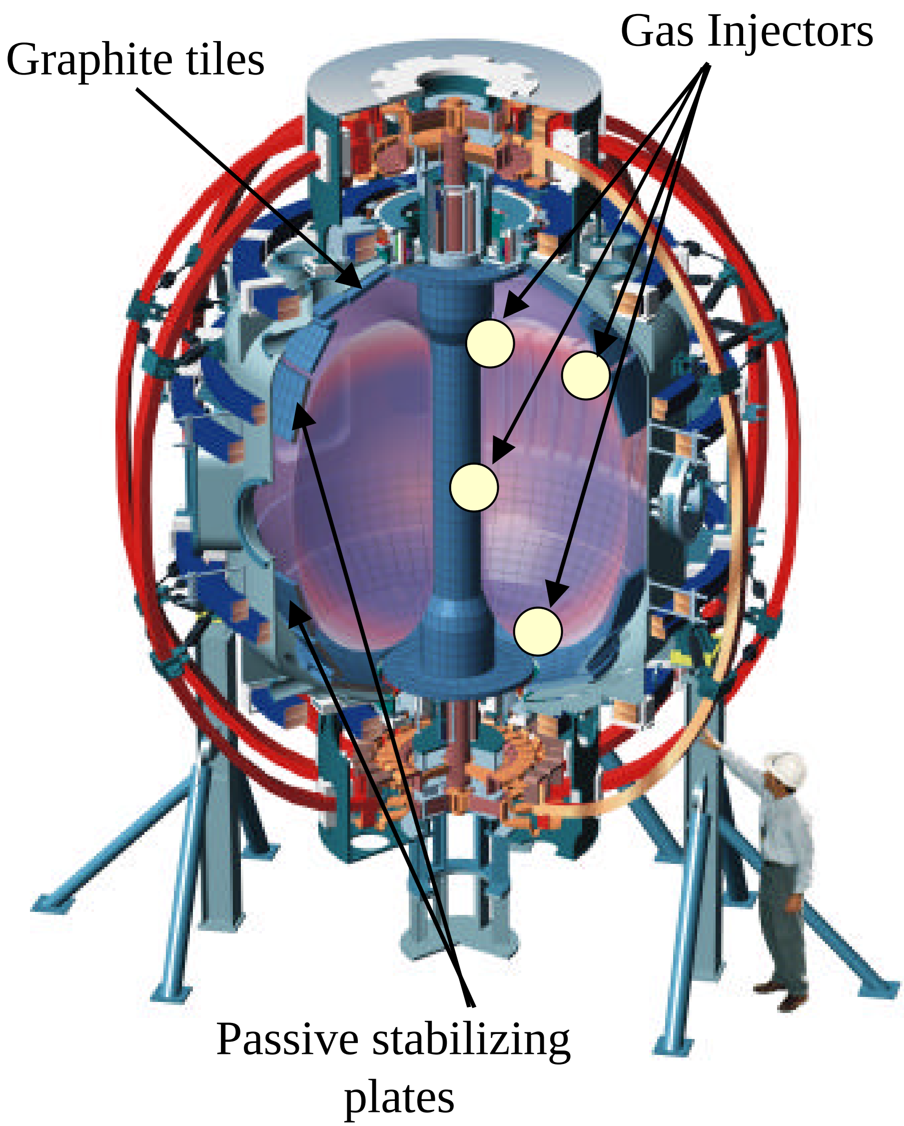
NSTX Explores Low Aspect Ratio (A=R/a) physics regime



Parameters	Design	Achieved
Major Radius	0.85m	A ≥ 1.27
Minor Radius	0.67m	
Plasma Current	1MA	1.5MA
Toroidal Field	0.6T	0.6T
Heating and Current Drive		
NBI (100keV)	5MW	7 MW
RF (30MHz)	6MW	6 MW

Wall Conditioning:

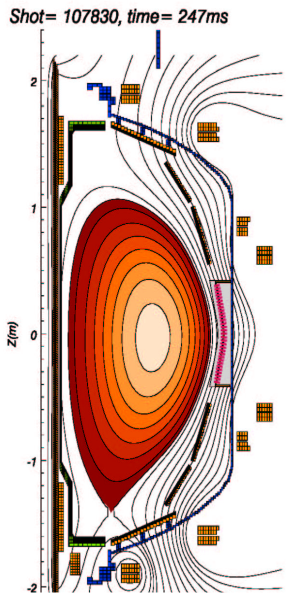
350 deg. bakeout of graphite tiles

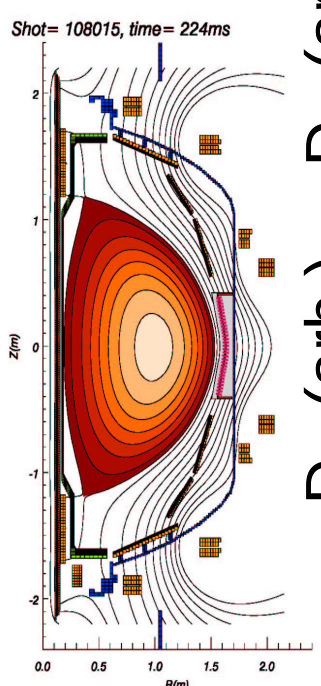
Regular boronization (~3 weeks)

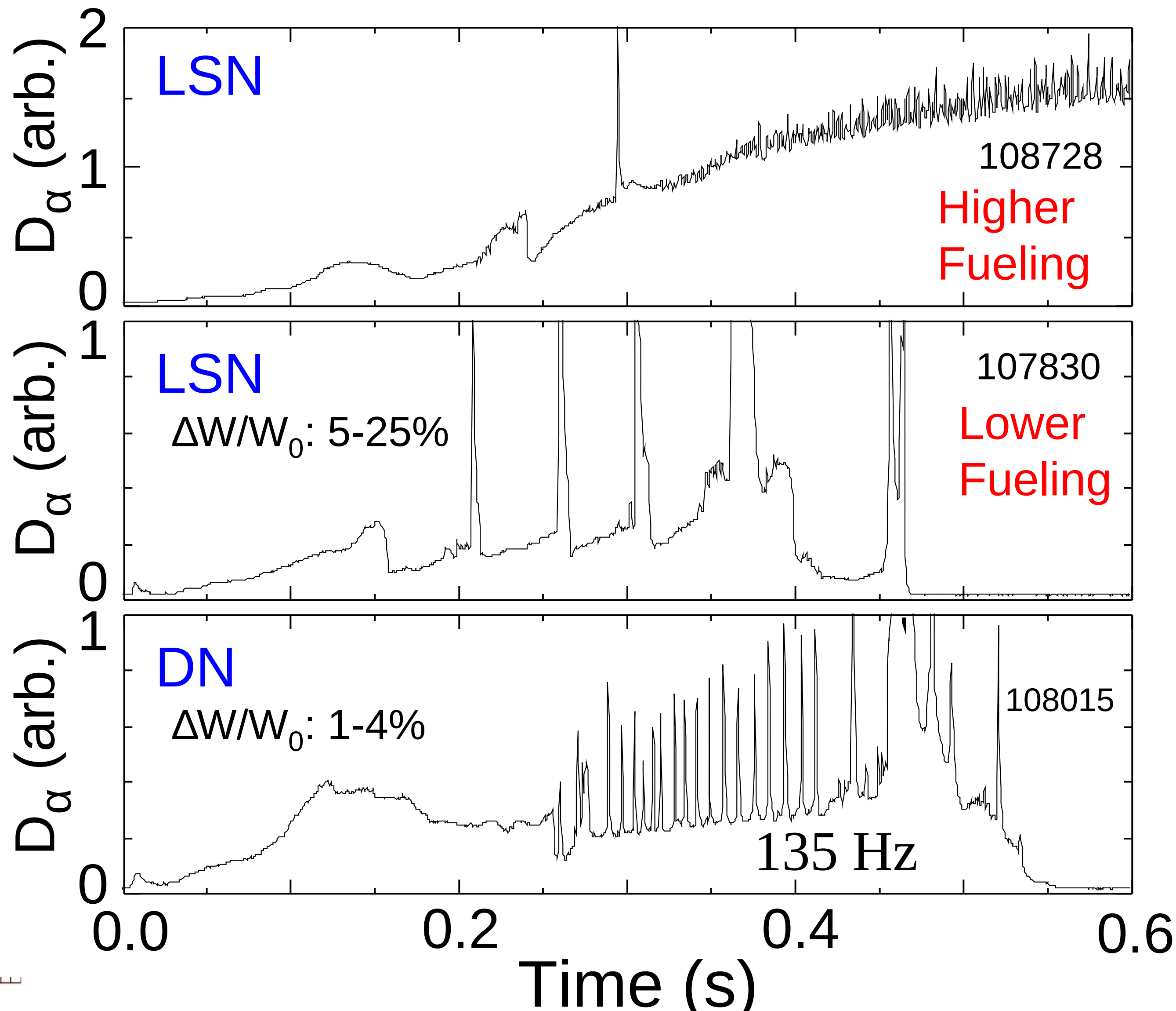
Helium Glow between discharges

Center stack gas injection

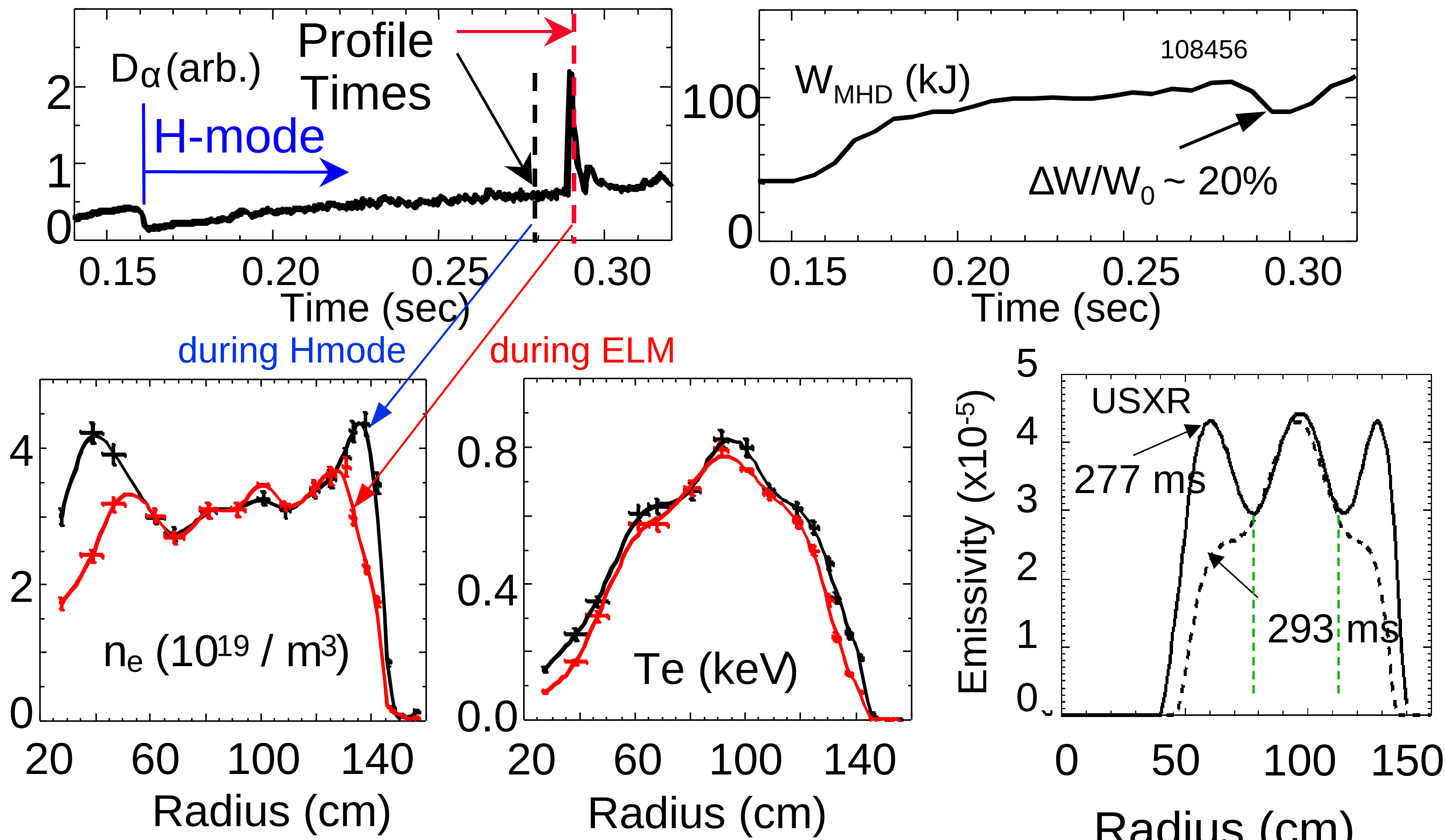
ELM Behavior Depends on Operating Conditions







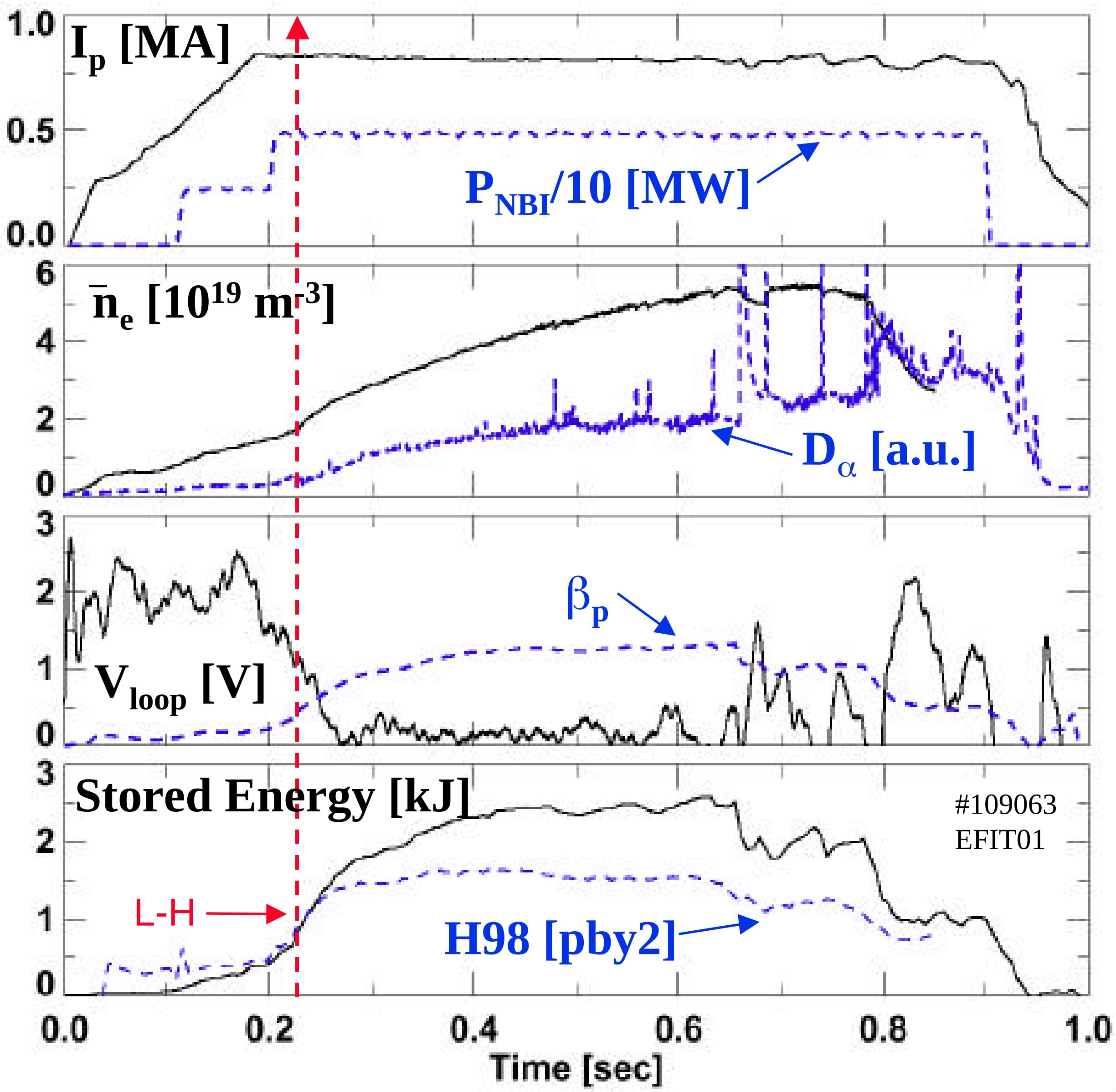
Large ELMs penetrate deep into the plasma



Bush, LeBlanc, Stutman

Single-null

Long pulse H-modes are mostly ELM-free and have D_α like FDR H-mode in PDX and EDA H-mode in C-MOD



Dedicated ELM characterization experiments just begin

NSTX

- Dedicated scans
  - ✱ Density (fueling rate) - DN, LSN
  - ✱ NBI power scan - DN
  - ✱ Magnetic balance scan (drsep from EFIT) - DN
  - ✱ Inner gap scan - LSN
- **Marked differences in lower single-null and double-nulls**

ornl

ELM analysis uses data from multiple diagnostics

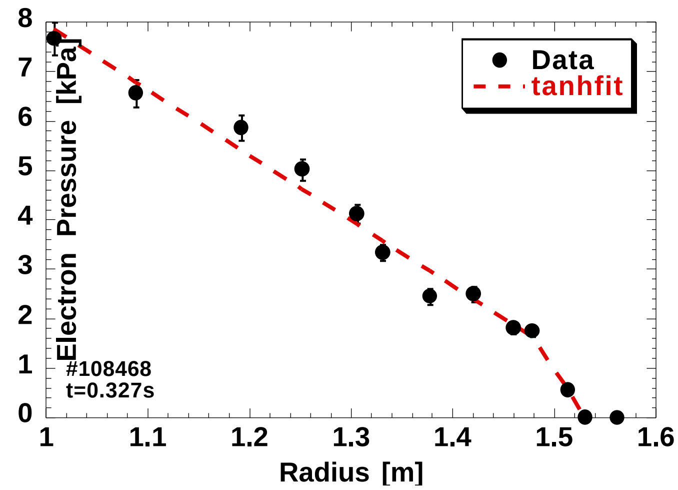
- ELM times from time derivative of D_α
- ELM frequency from period between ELM times (from D_α)
- ELM energy loss from fast EFIT analysis (1ms resolution, using magnetics data only)
- Pedestal energy from modified tanhfit to Thomson pressure profile (20 points spatial, 60 Hz)

$$W_{ped}=0.92*volume_{EFIT}* p_e^{ped}*3.0$$

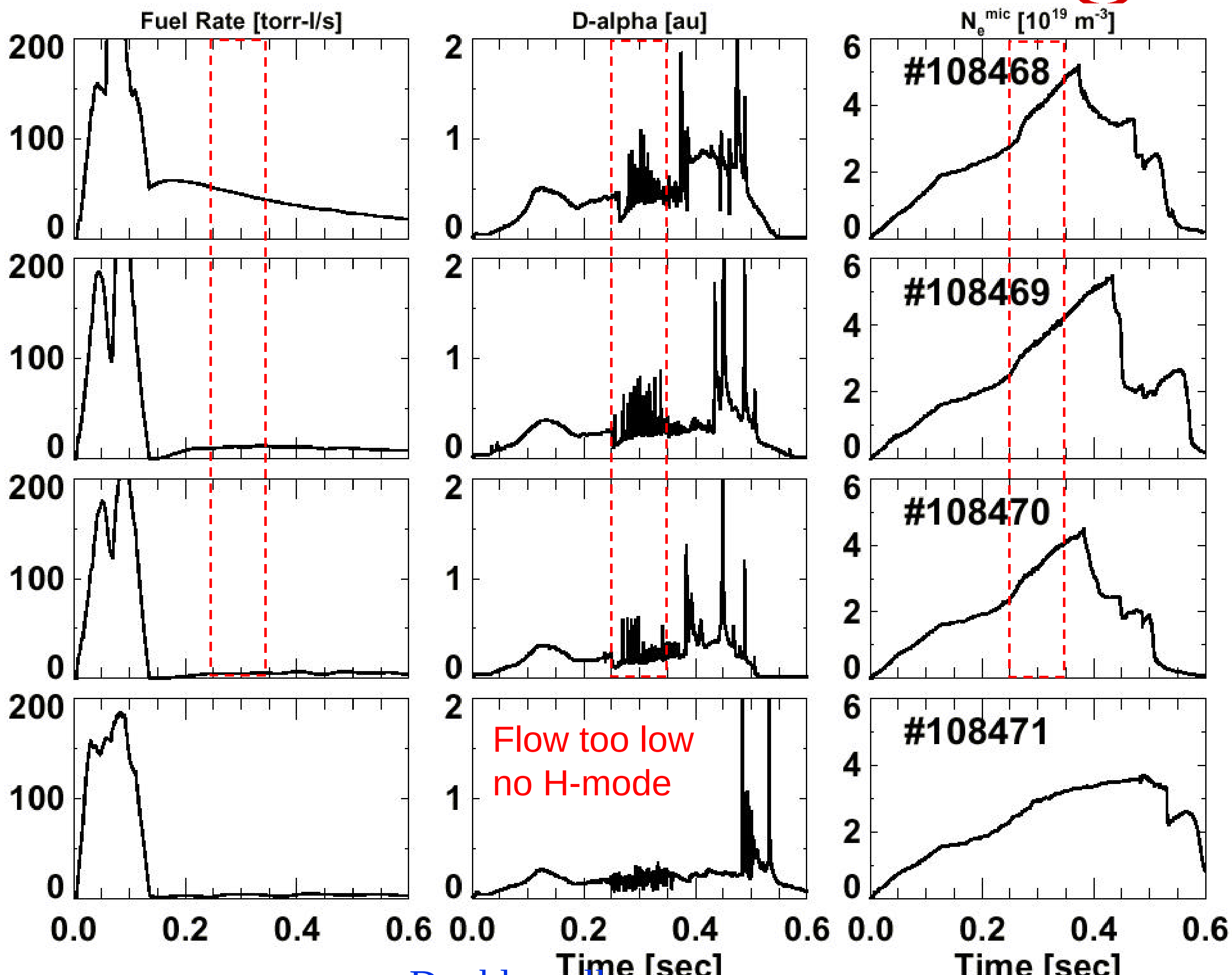
- Pedestal energy fraction from

$(\Delta W/W_0)*(W_0/W_{ped})$, where W_{ped}

from nearest time point with good tanhfit



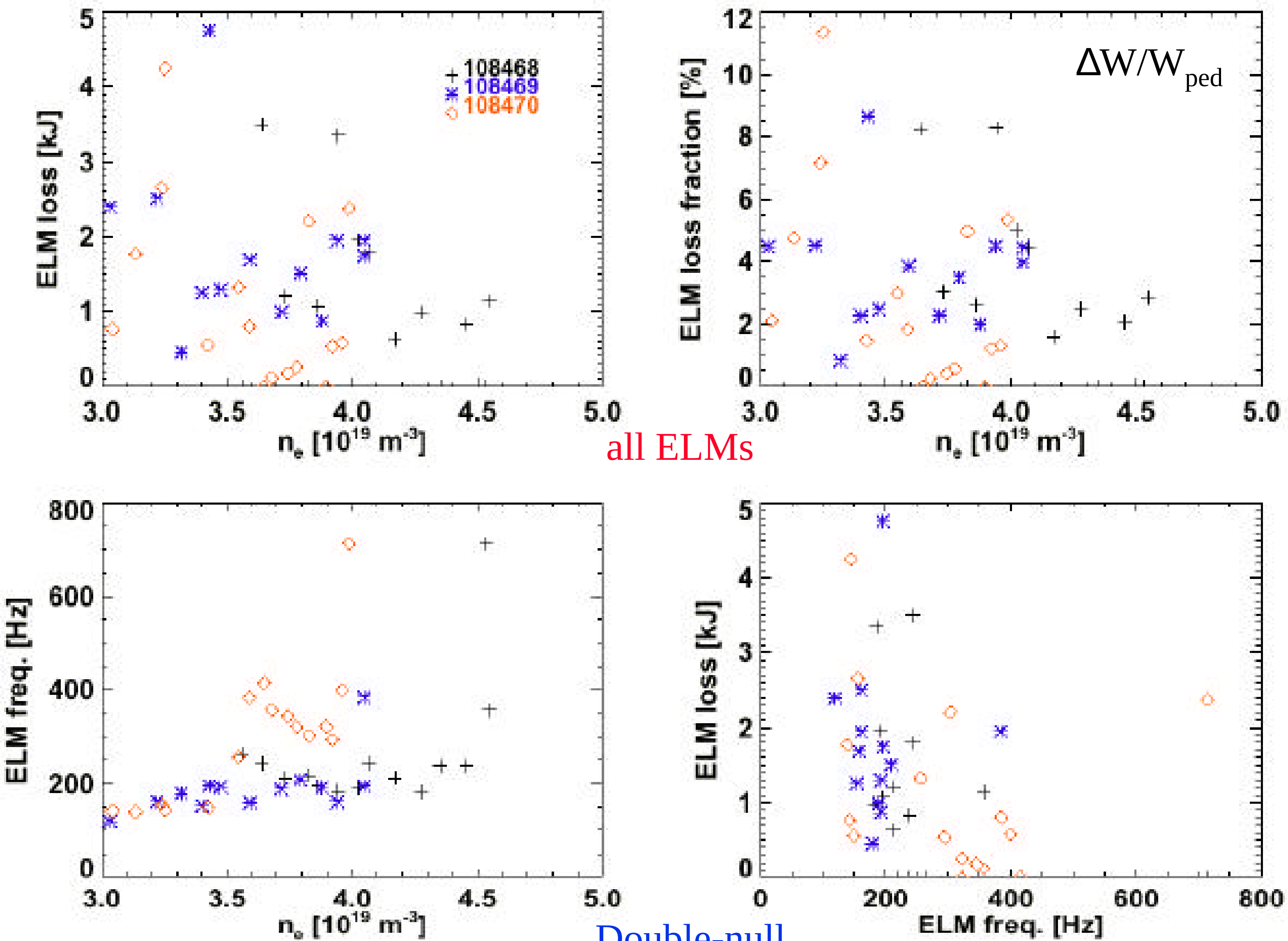
Density ramps throughout discharge and affects ELMs modestly



Time of constant NBI power with no locked mode signature

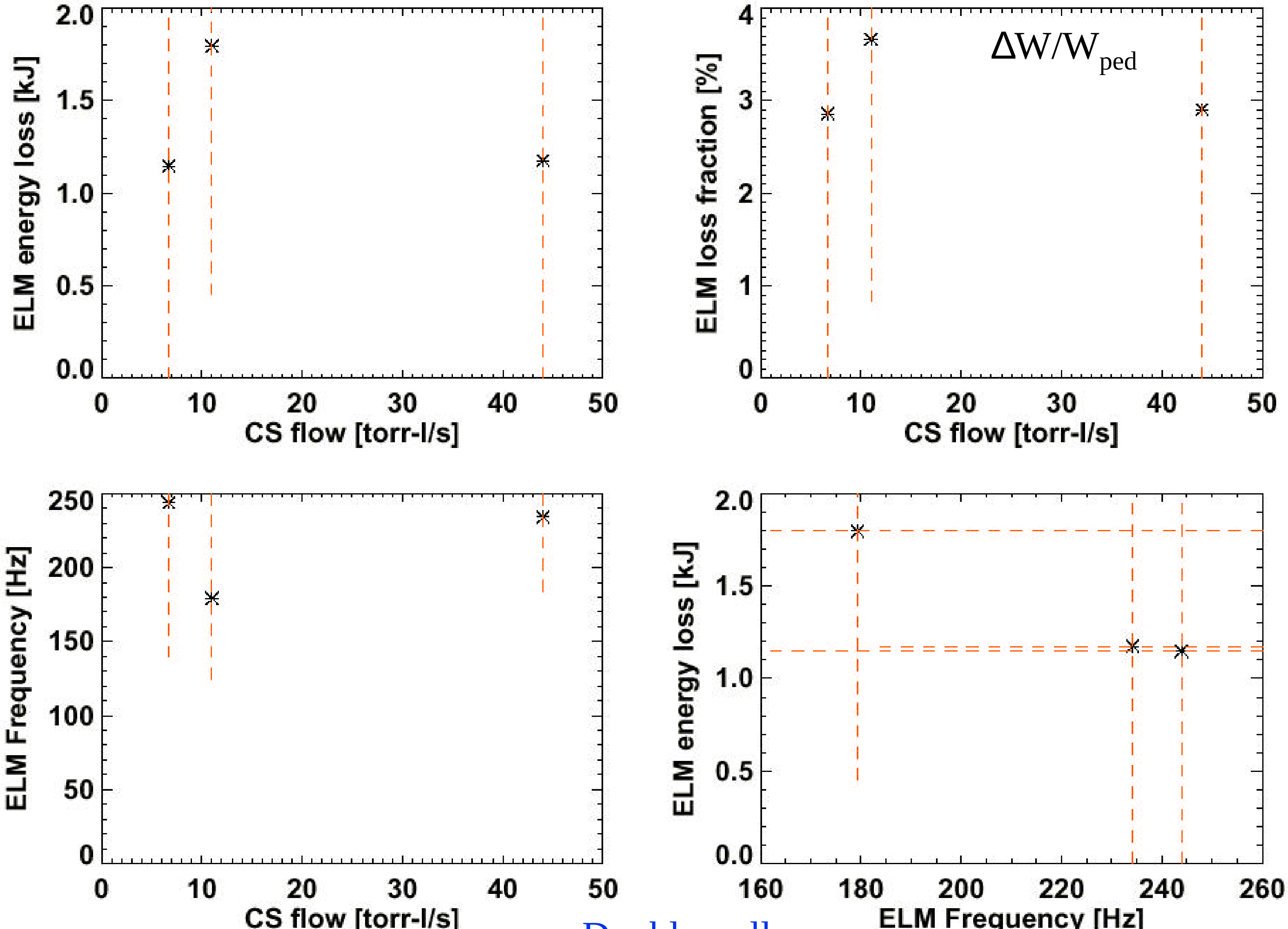
Double-null

Larger ELMs observed at lower density



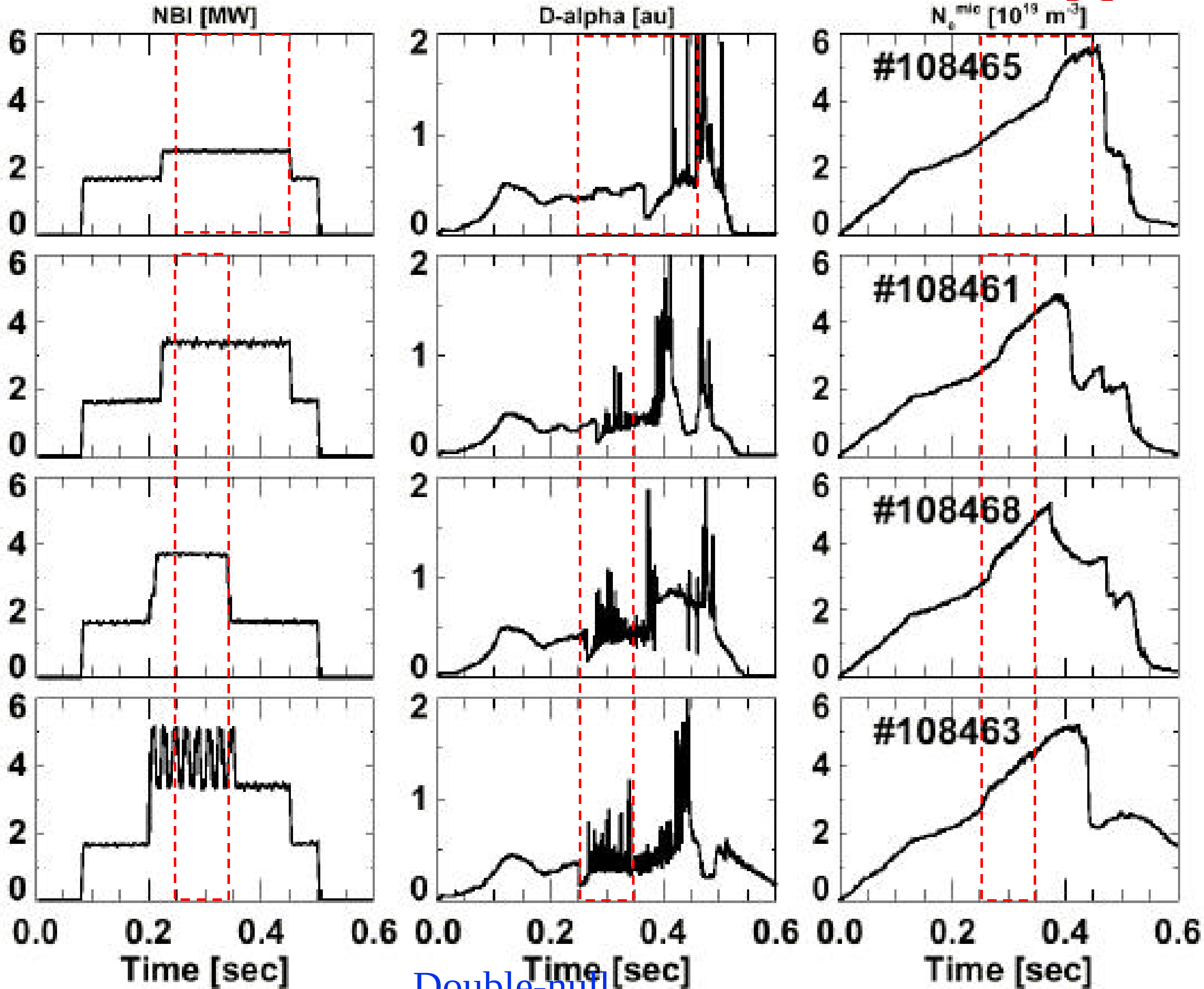
Double-null

Average ELM size and frequency independent of gas flow rate



Double-null

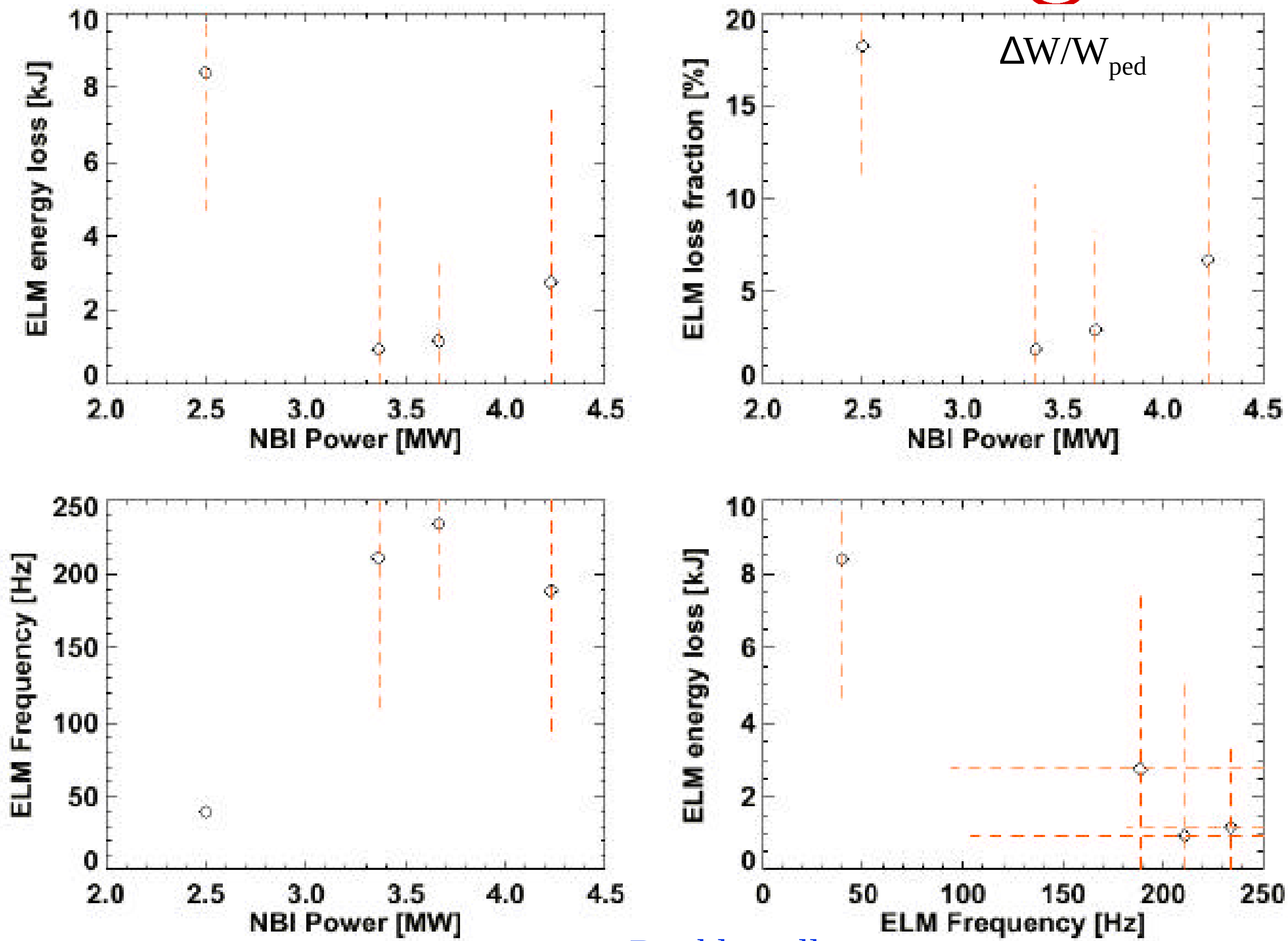
ELM size and frequency affected by NBI heating power



Time of constant NBI power with no locked mode signature

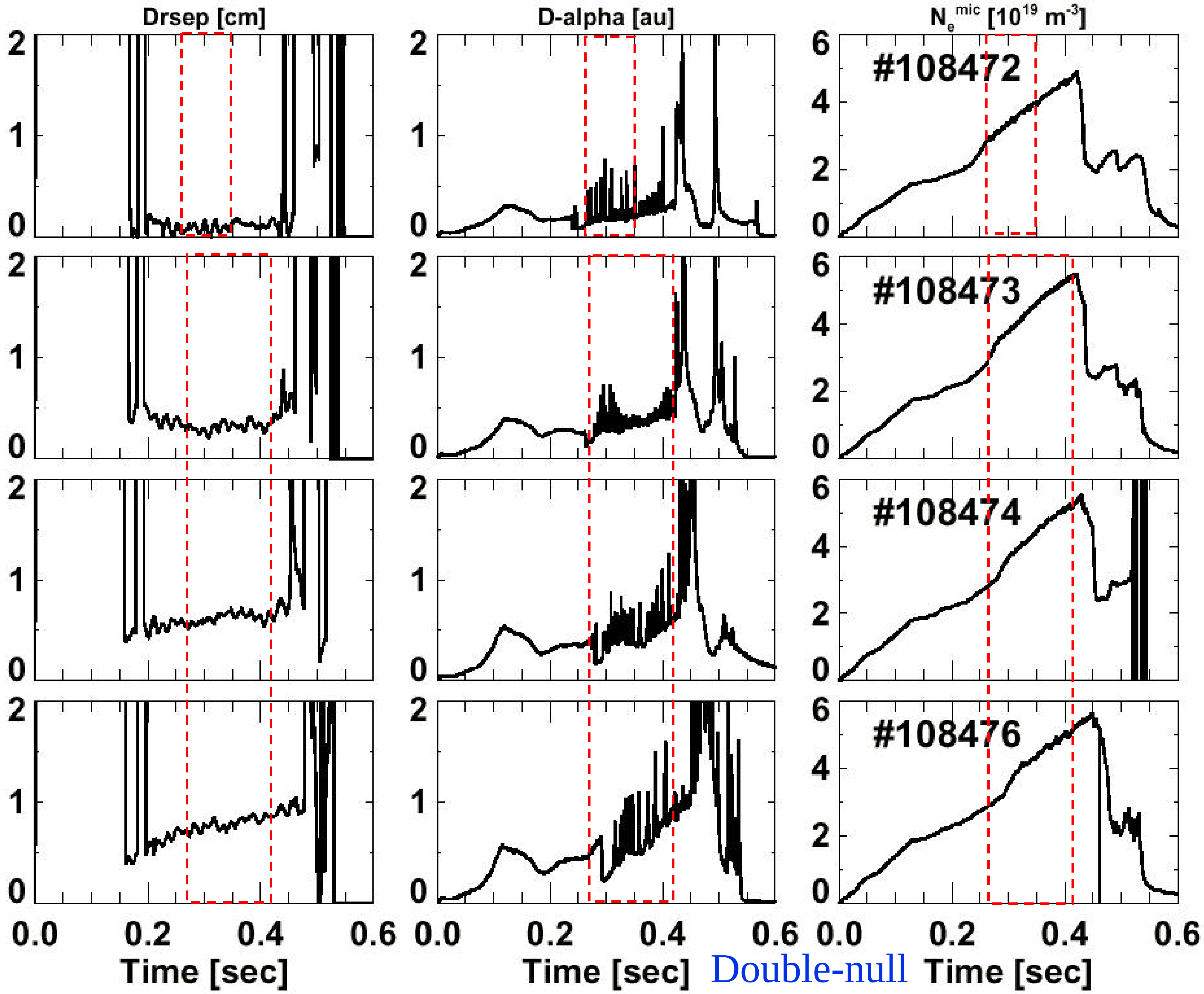
Double-null

Average ELM size largest at low NBI power, and varies inversely with frequency



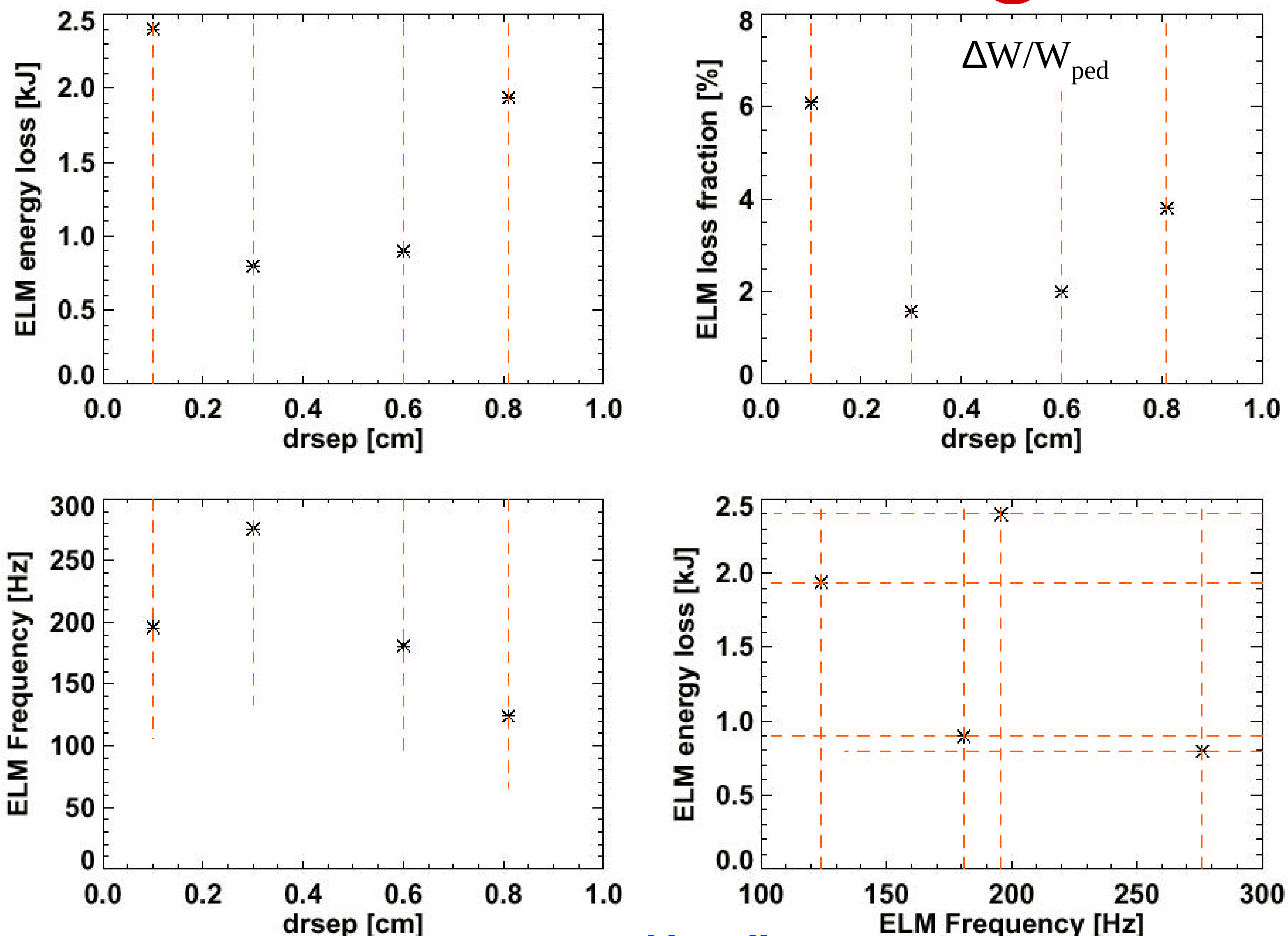
Double-null

ELM characteristics independent of magnetic up/down balance



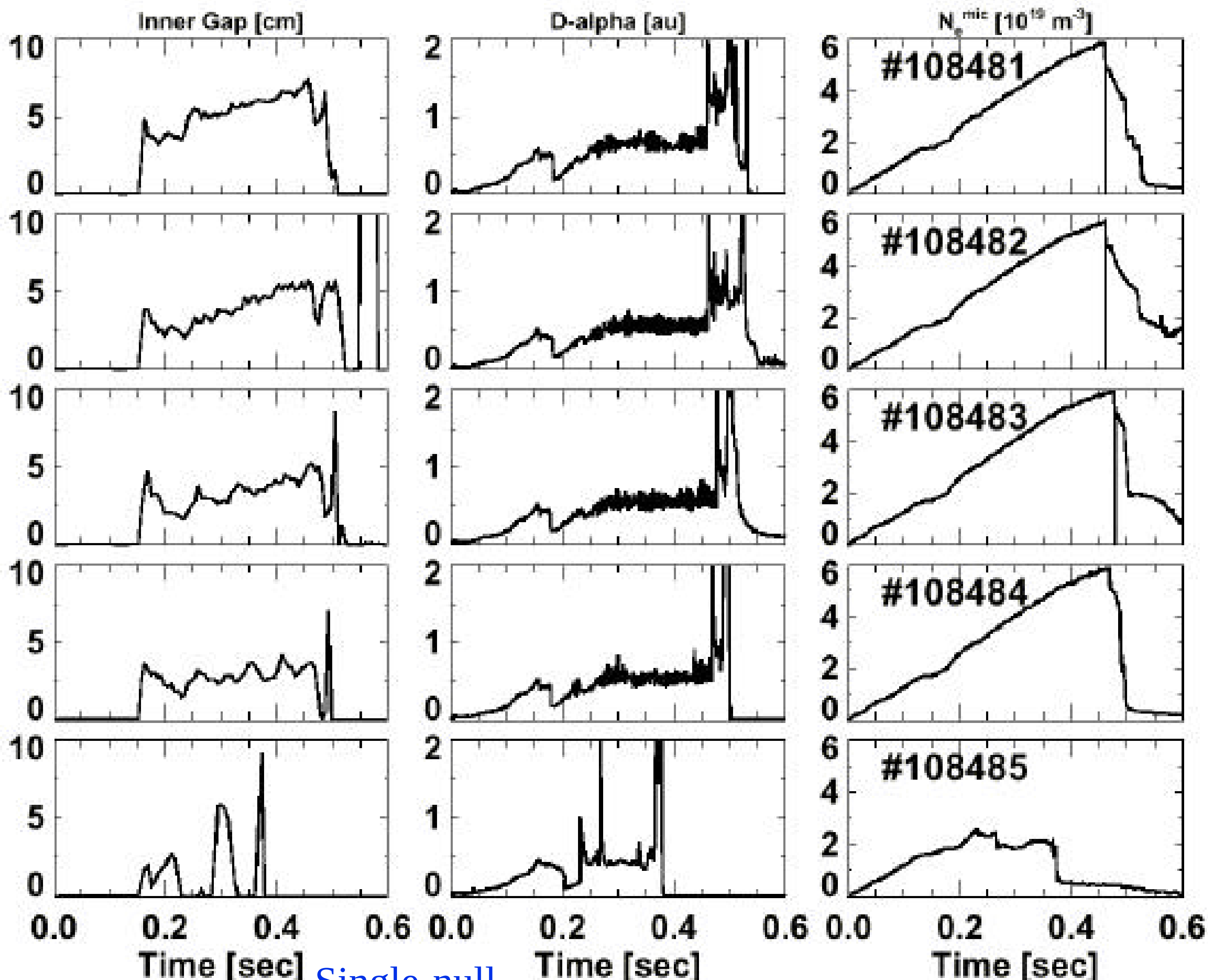
Time of constant NBI power with no locked mode signature

Average ELM characteristics independent of magnetic up/down balance



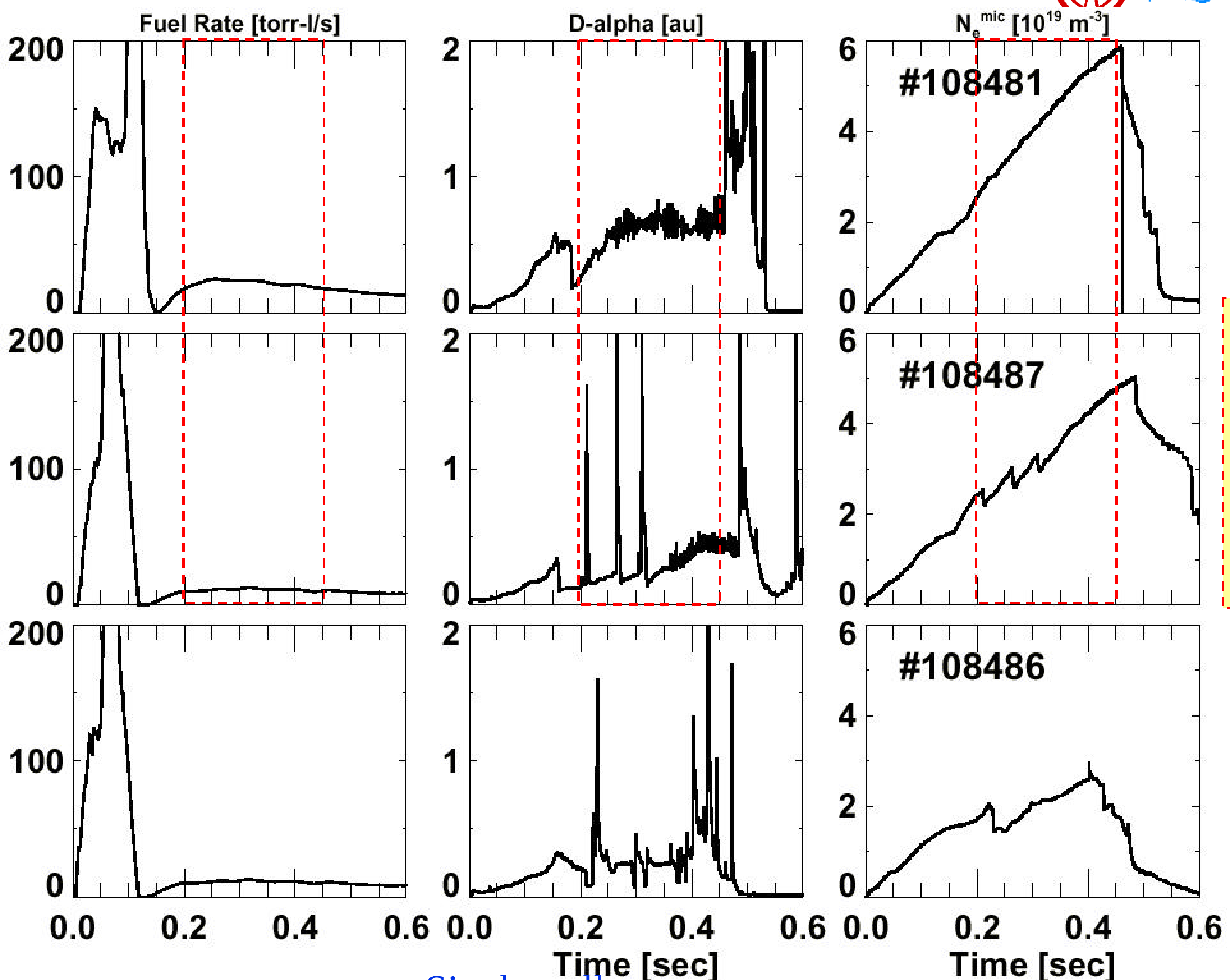
Double-null

ELM characteristics independent of inner-wall gap unless plasma becomes inner-wall limited



Single-null

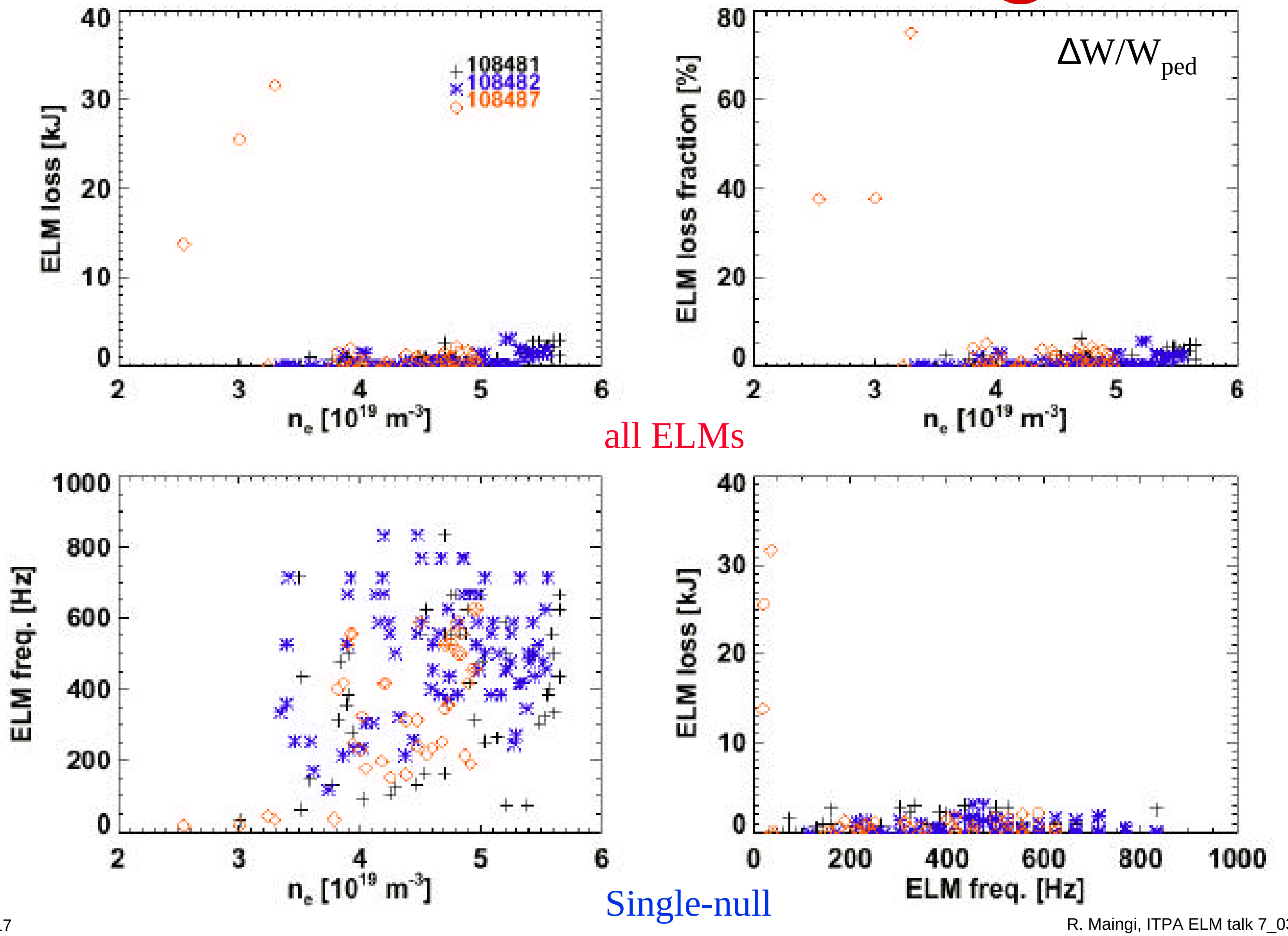
Fueling (density) strongly affects ELMs in single-null



Time of constant NBI power with no locked mode signature

Single-null

Giant ELMs observed at lowest density, but beyond those few ELMs unaffected explicitly by density



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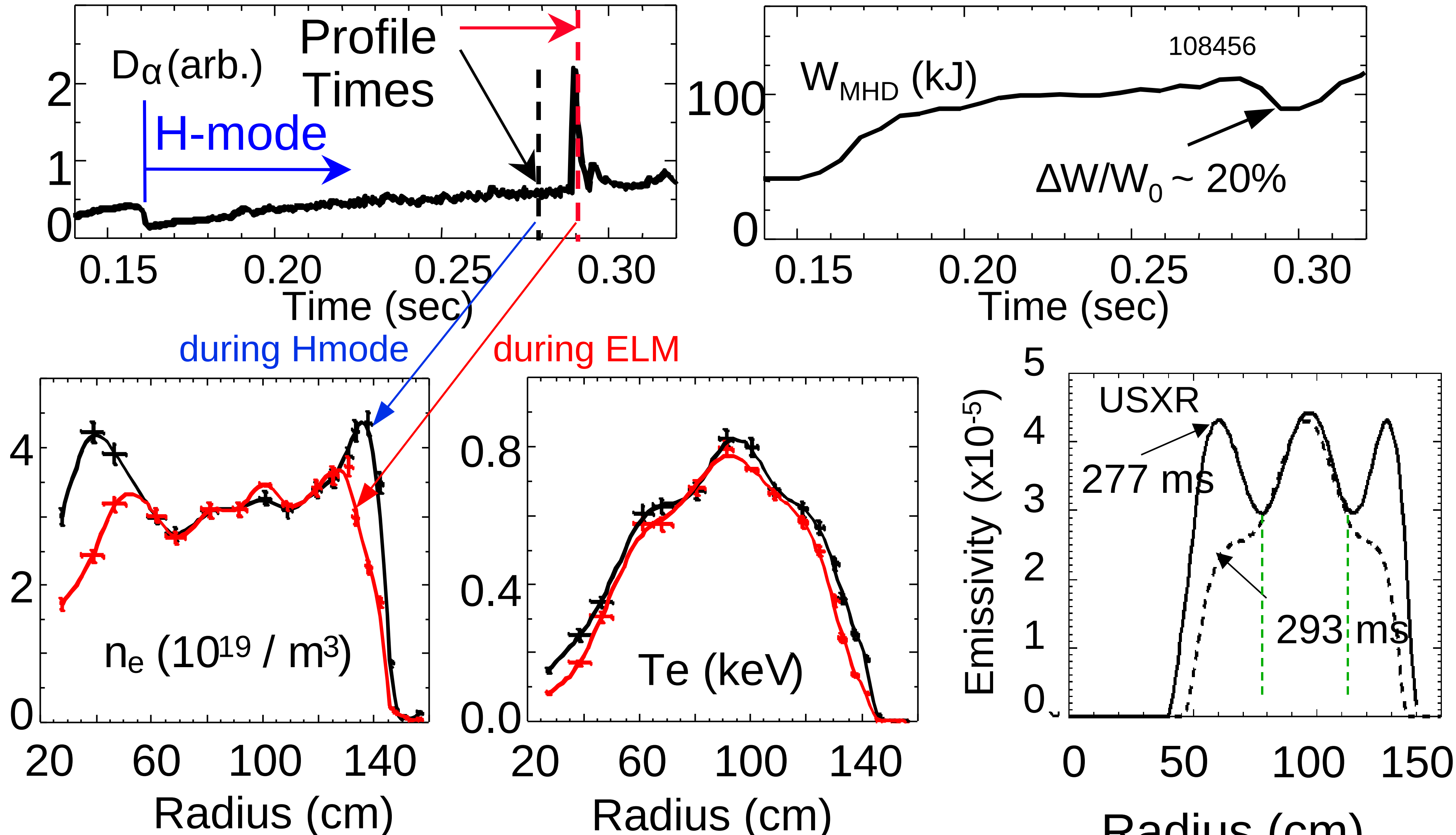
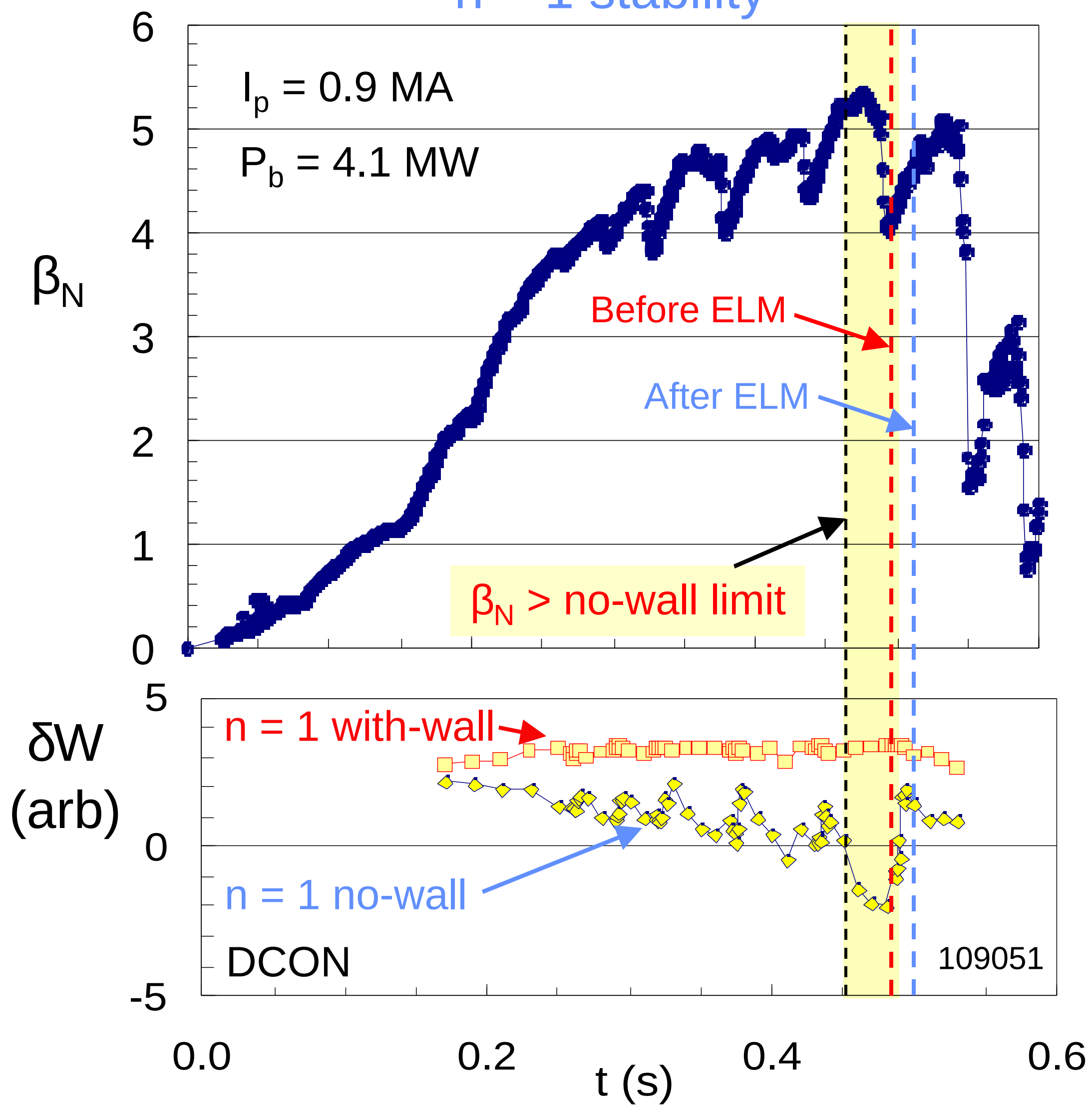
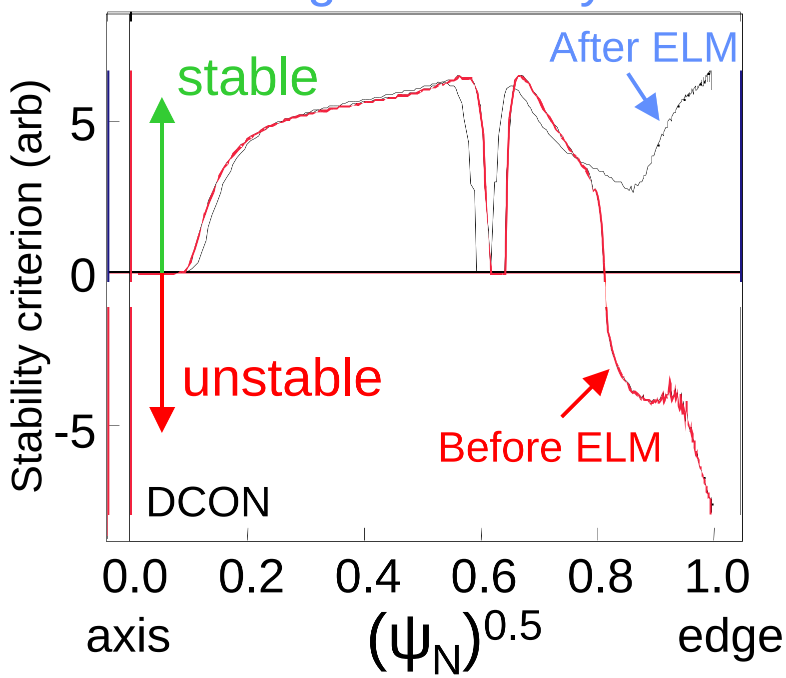


Bush, LeBlanc, Stutman   Single-null

Ideal High-*n* Ballooning Unstable before giant ELM





- Computed as high-n stable after ELM
- n = 1 stabilized by wall
  - No-wall β_N limit exceeded before last ELM

Single-null

Sabbagh, Glasser, Bush

ELM research is just beginning on NSTX

- ELMs in double-nulls have typically ~ $\Delta W/W_{ped} < 10\%$
  - ✱ Similarities to type I ELMs in conventional aspect ratio which increase in size near power threshold and frequency with NBI power
  - ✱ Size not directly correlated with fueling rate, but largest ELMs at low density
  - ✱ independent of magnetic balance
- ELMs in Lower single-null are either very small or giant
  - ✱ Size not directly correlated with fueling rate, but giant ELMs observed reproducibly at low density/fueling
  - ✱ Independent of inner-wall gap if gap > 0

Questions and future plans

- Why do ELMs appear different in LSN vs. DN, but have not apparent dependence on magnetic balance (drsep)?
  - Does drsep need to be >> 1 cm for comparison?
  - Is observed difference related to triangularity?
- Highest performance plasmas in NSTX (i.e. DN) actually have more modest ELMs than LSN giant ELMs - why is this so different from conventional aspect ratio tokamaks?
- Availability of 50 channel T_i from CHERS in FY04 will allow measurement of ion pedestal energy; more accurate than 3*electron pedestal energy