Research
Supported by

NSTX

ELMs in the National Spherical Torus Experiment

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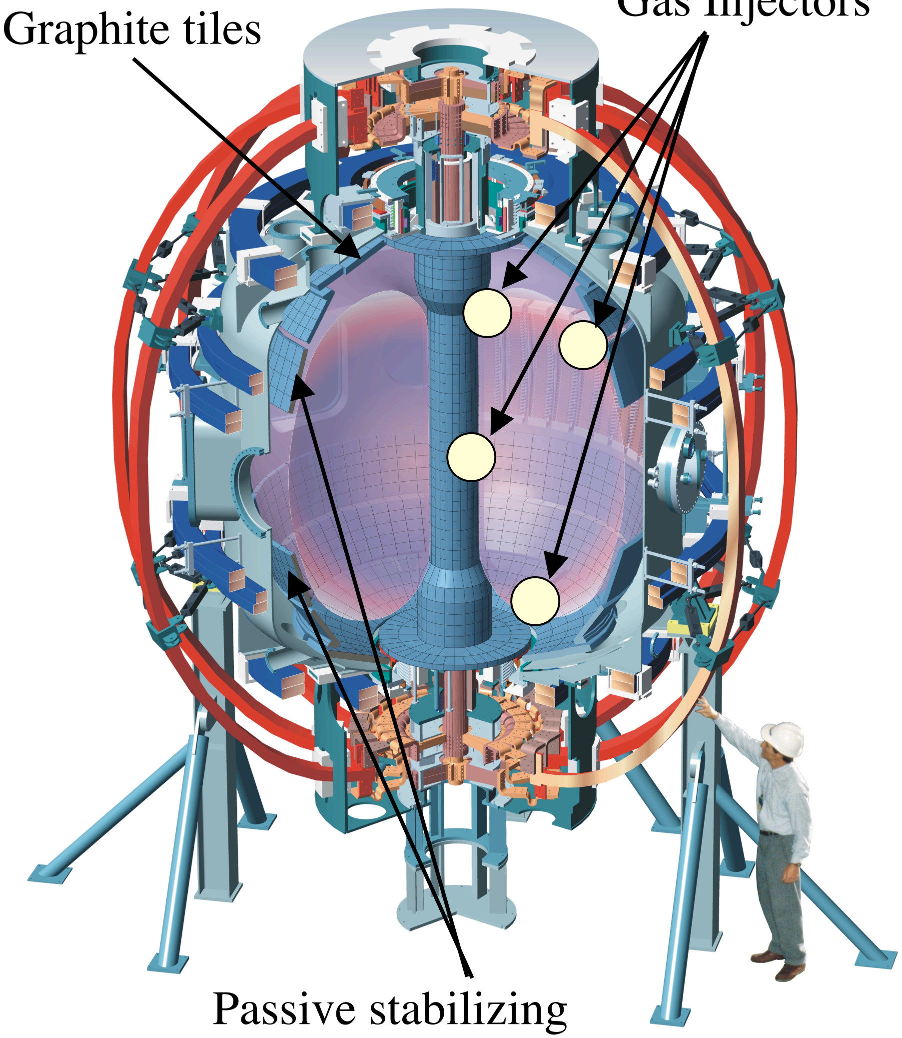
San Diego, CA - USA

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:

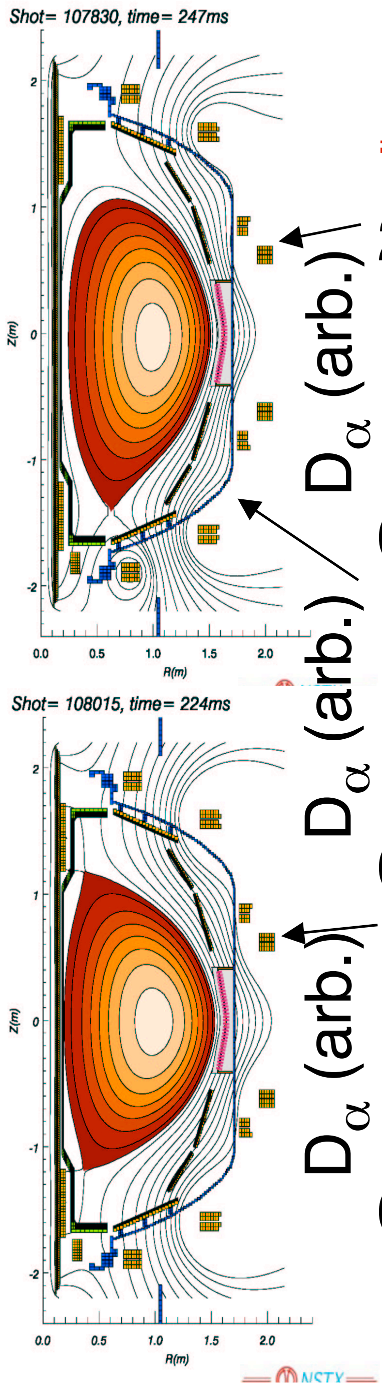
350 deg. bakeout of graphite tiles

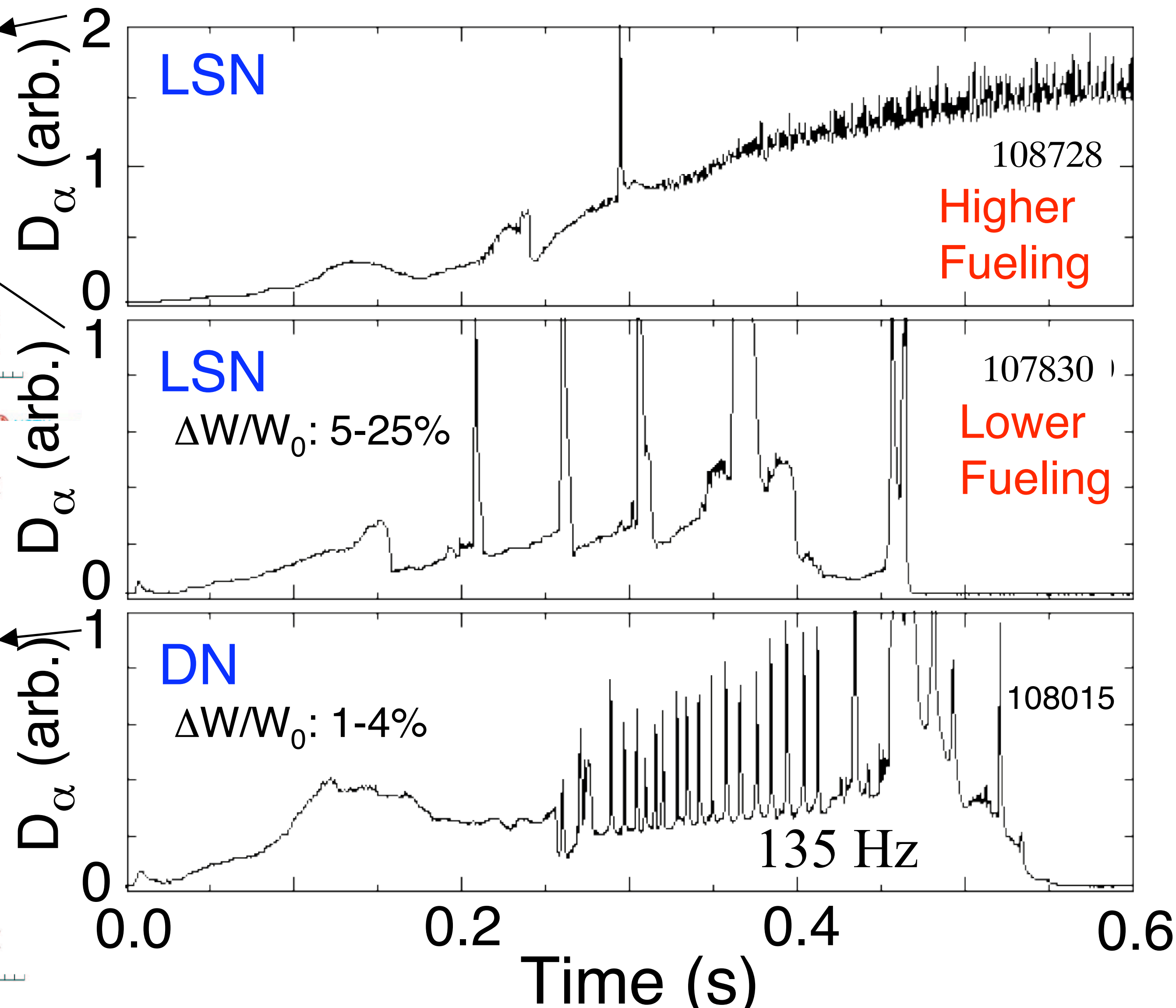
Regular boronization (~3 weeks)

Helium Glow between discharges

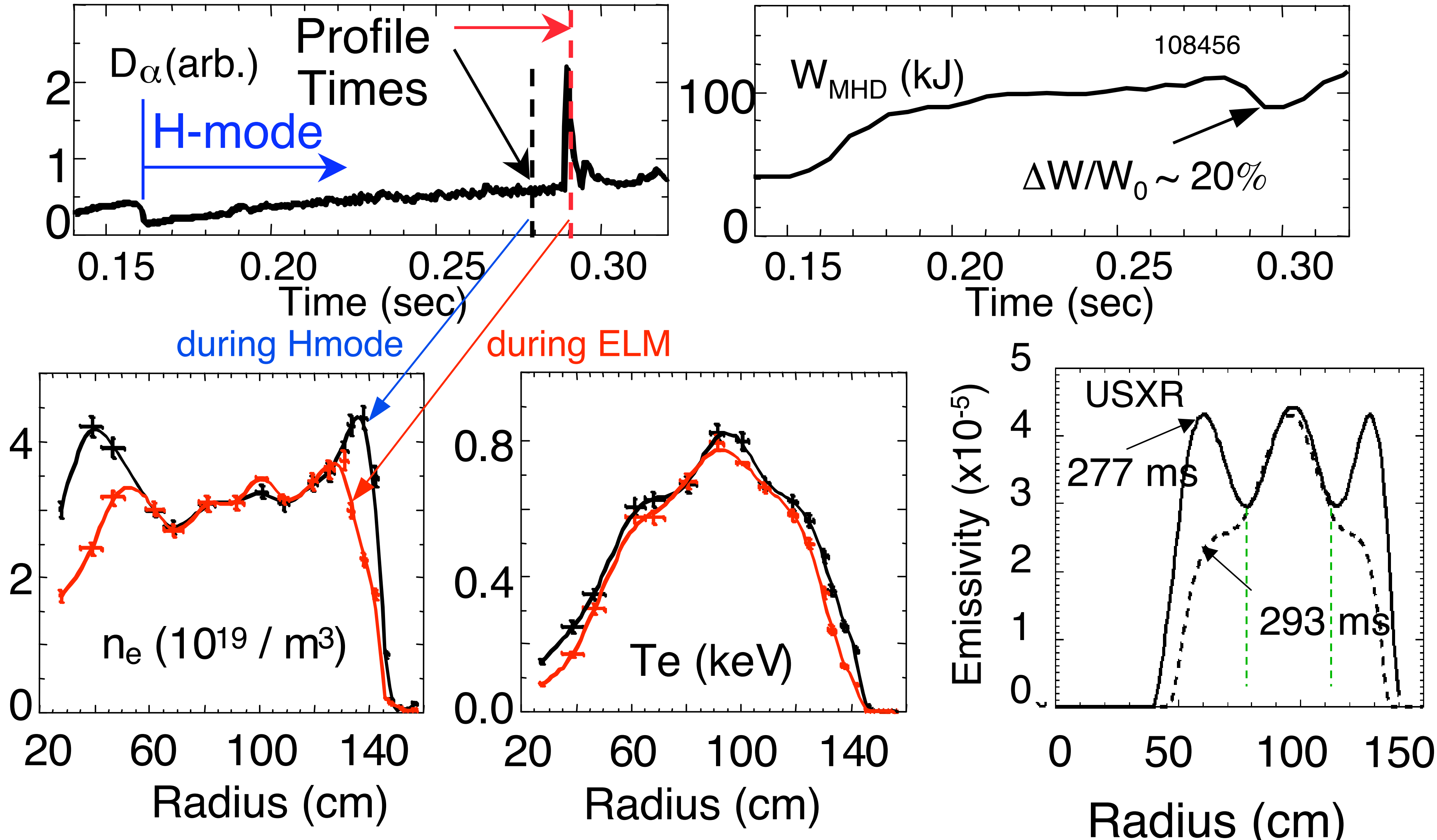
Center stack gas injection

Wide variety of ELMS observed in NSTX



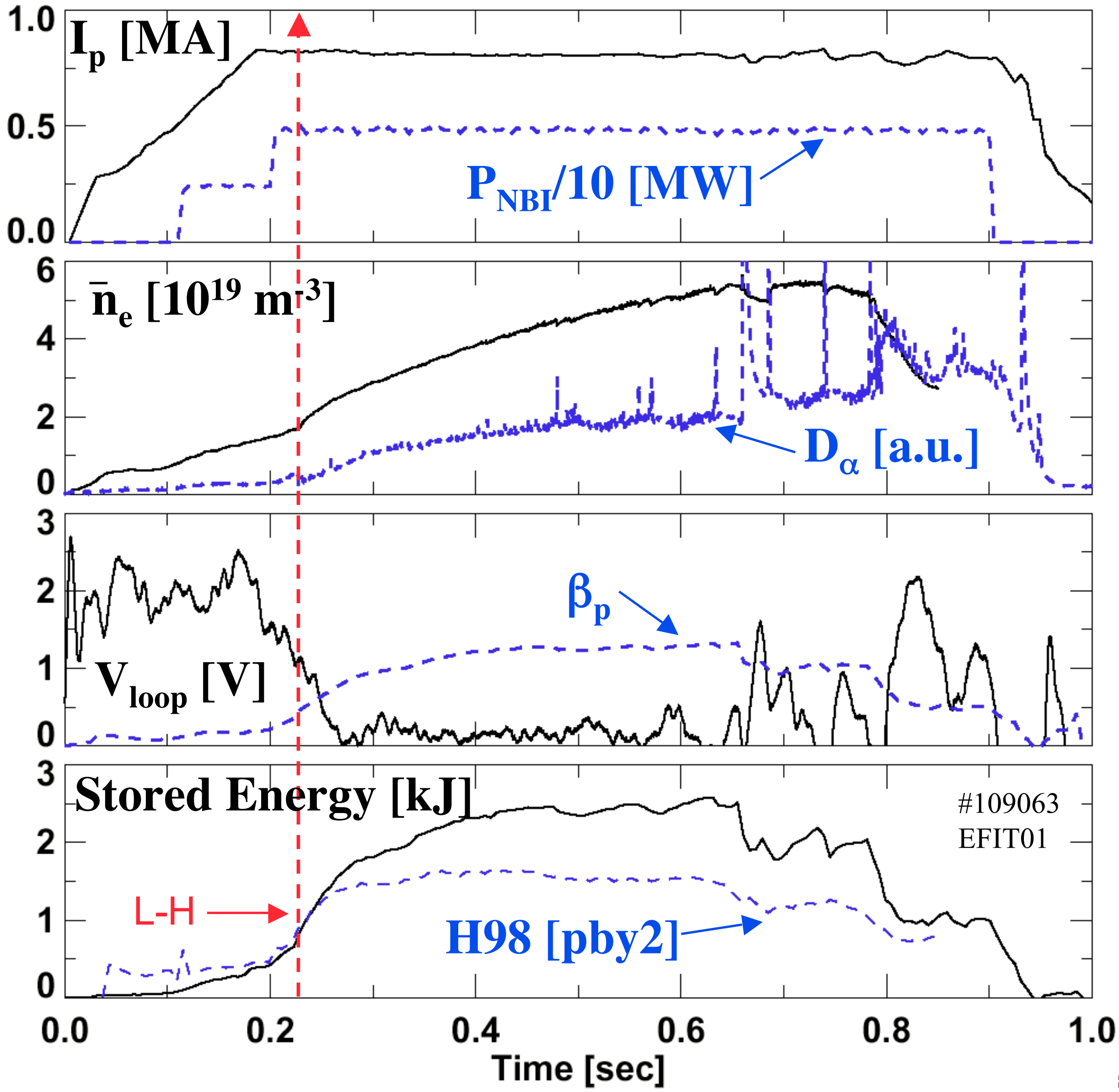


Large ELMs penetrate deep into the plasma



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 begun

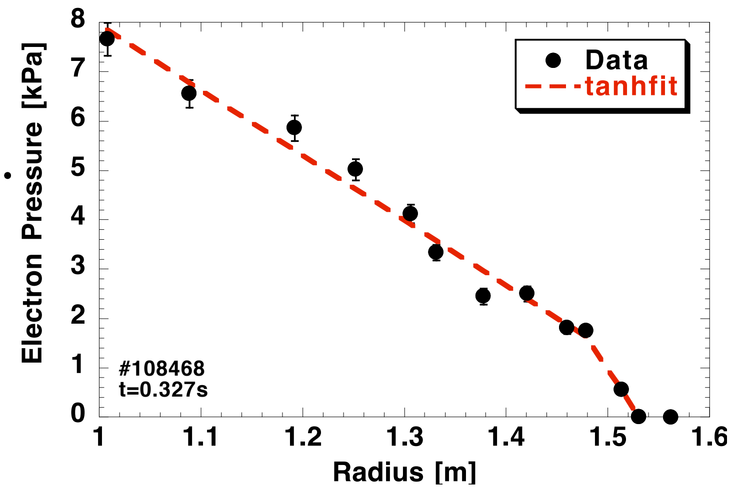
- Dedicated scans
  - ✱ Density (fueling rate) - DN, LSN
  - ✱ NBI power scan - DN
  - ✱ Magnetic balance scan (drsep from EFIT) - DN
  - ✱ Inner gap scan - LSN

- **Marked differences in lower single-null and double-nulls**

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)

$$\Rightarrow \quad W_{ped}=0.92*volume_{EFIT}*\ p_e^{ped}*3.$$

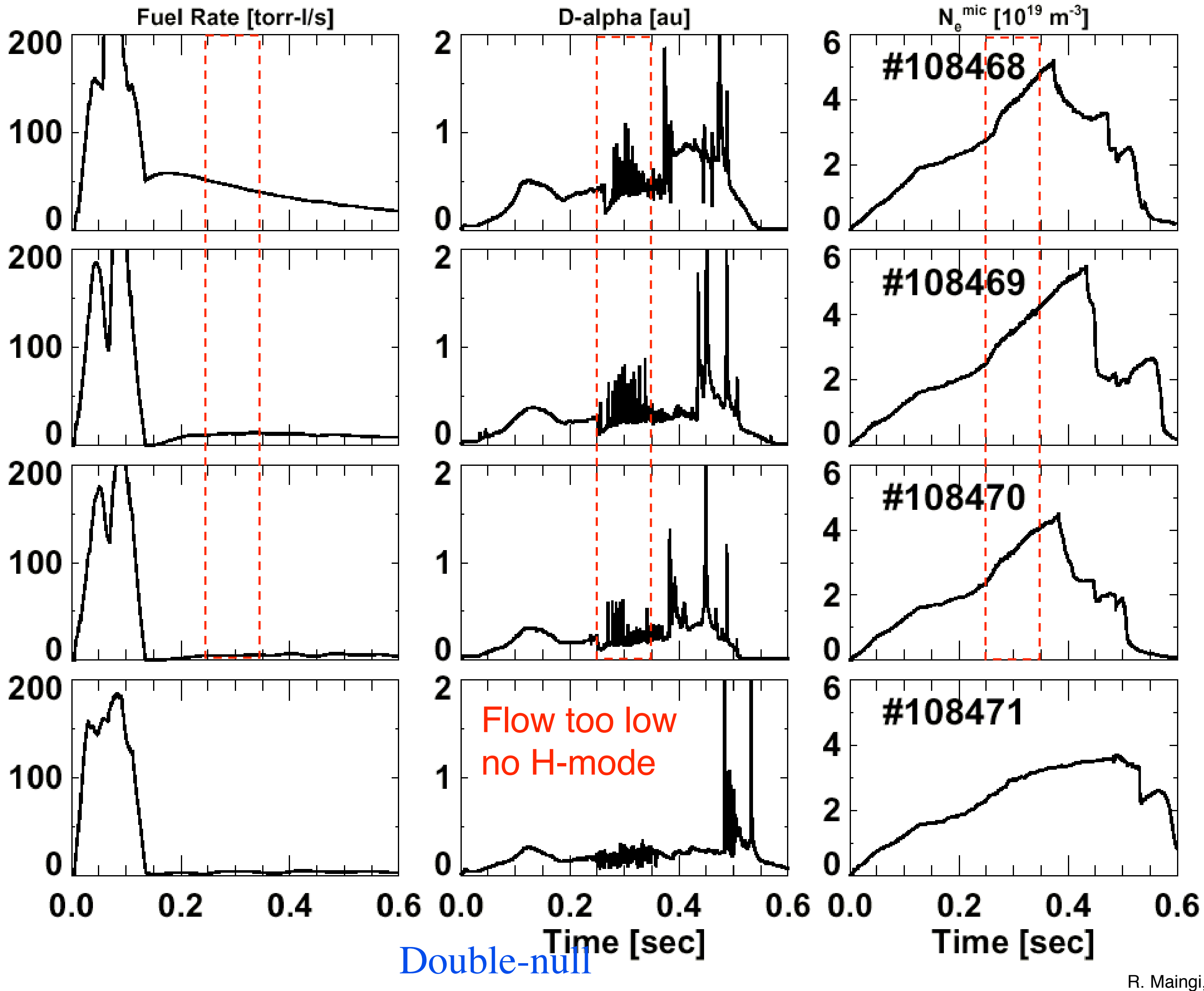


- Pedestal energy fraction from

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

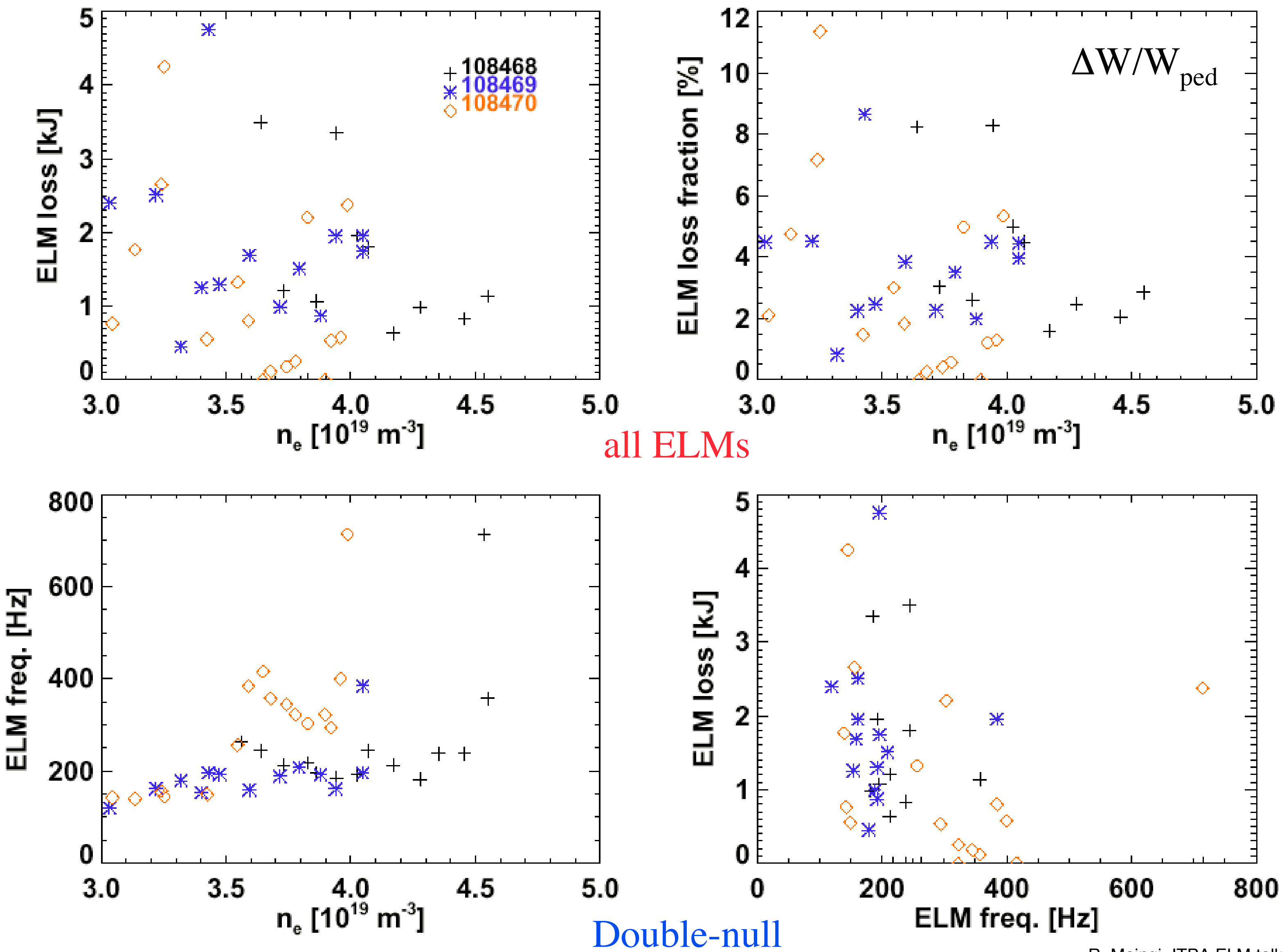
  from nearest time point with good tanhfit

Density ramps throughout discharge and affects ELMs modestly

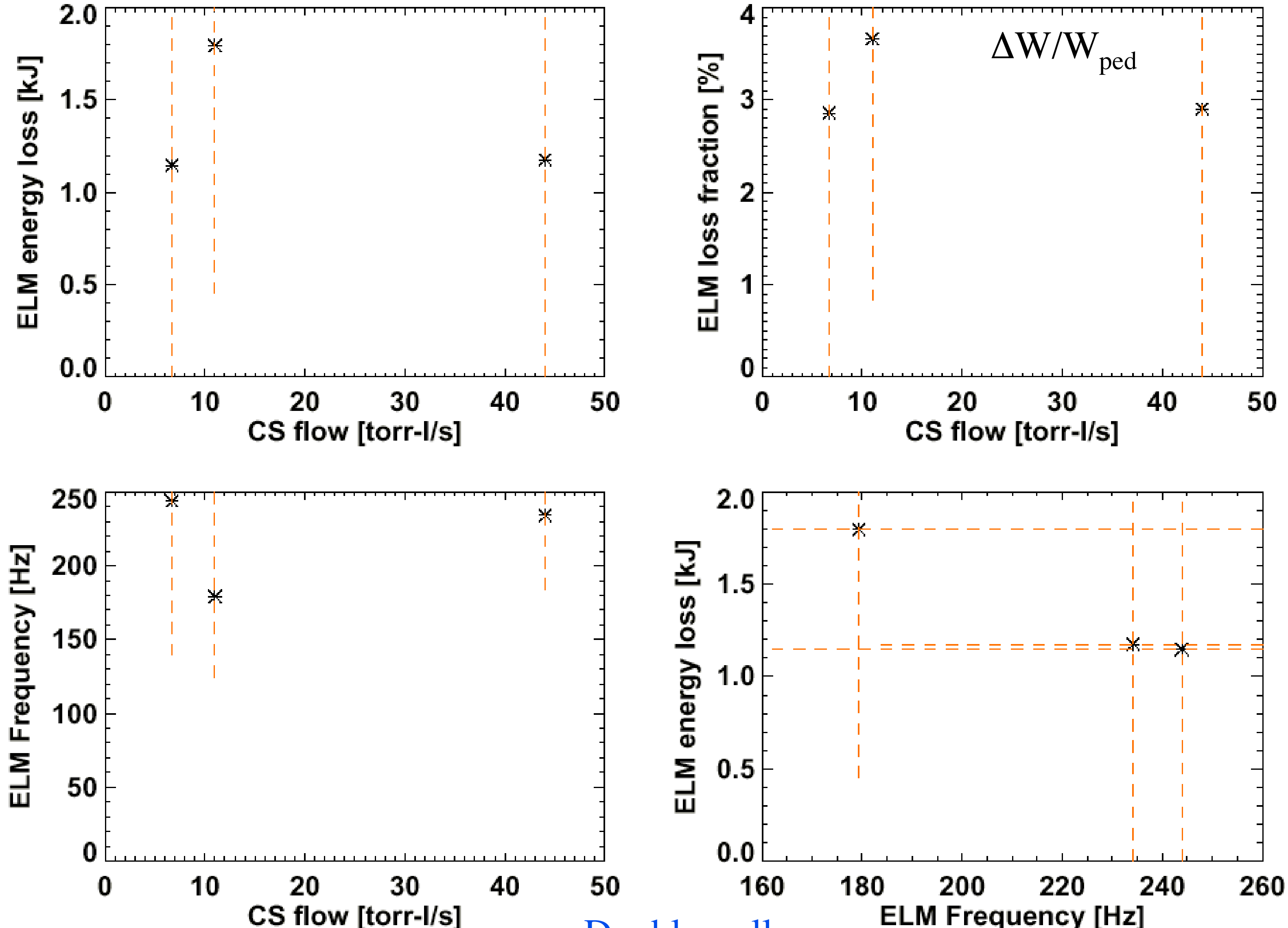


Time of constant NBI power with no locked mode signature

Larger ELMs observed at lower density

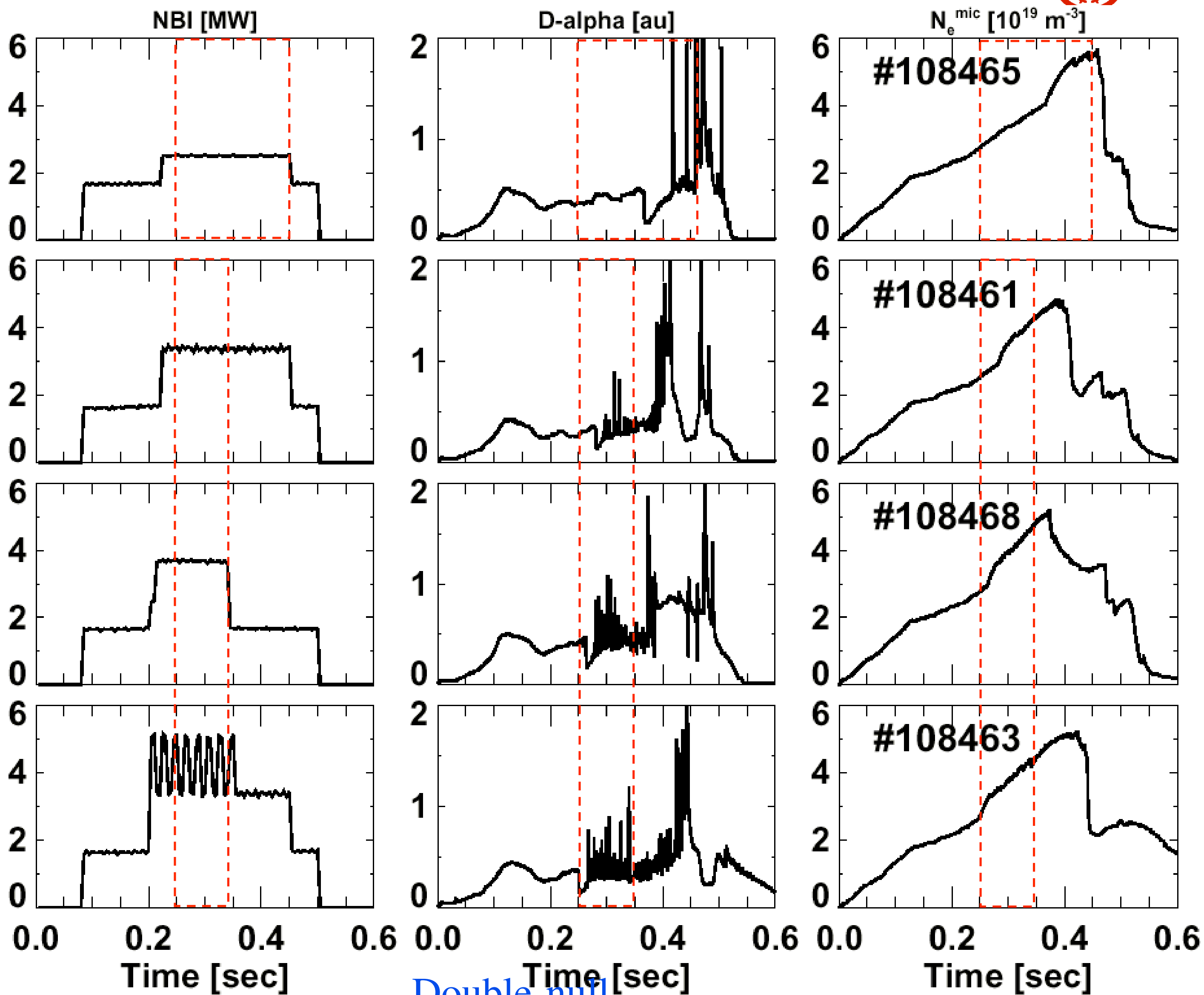


Average ELM size and frequency independent of gas flow rate



Double-null

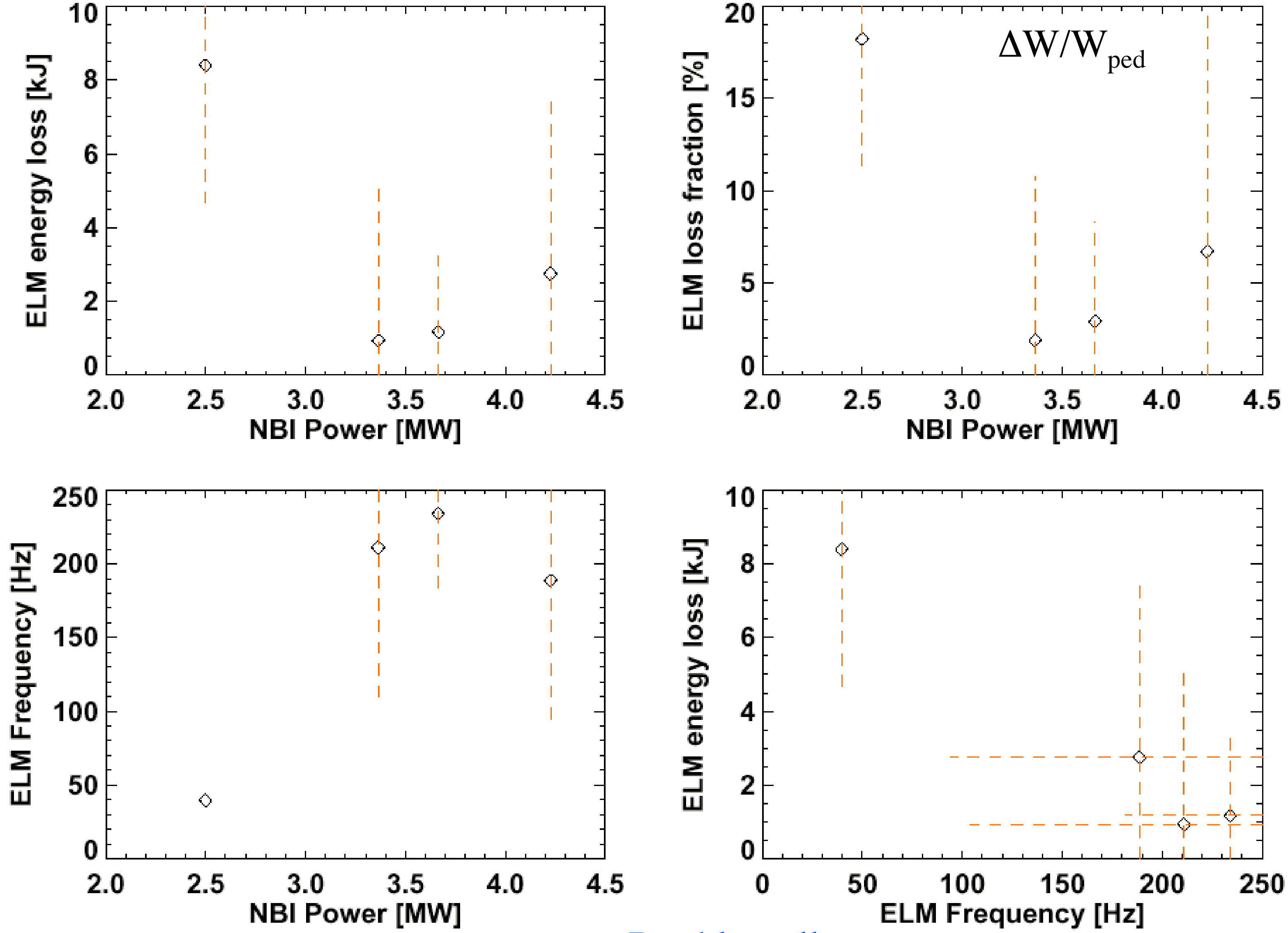
ELM size and frequency affected by NBI heating power



Double-null

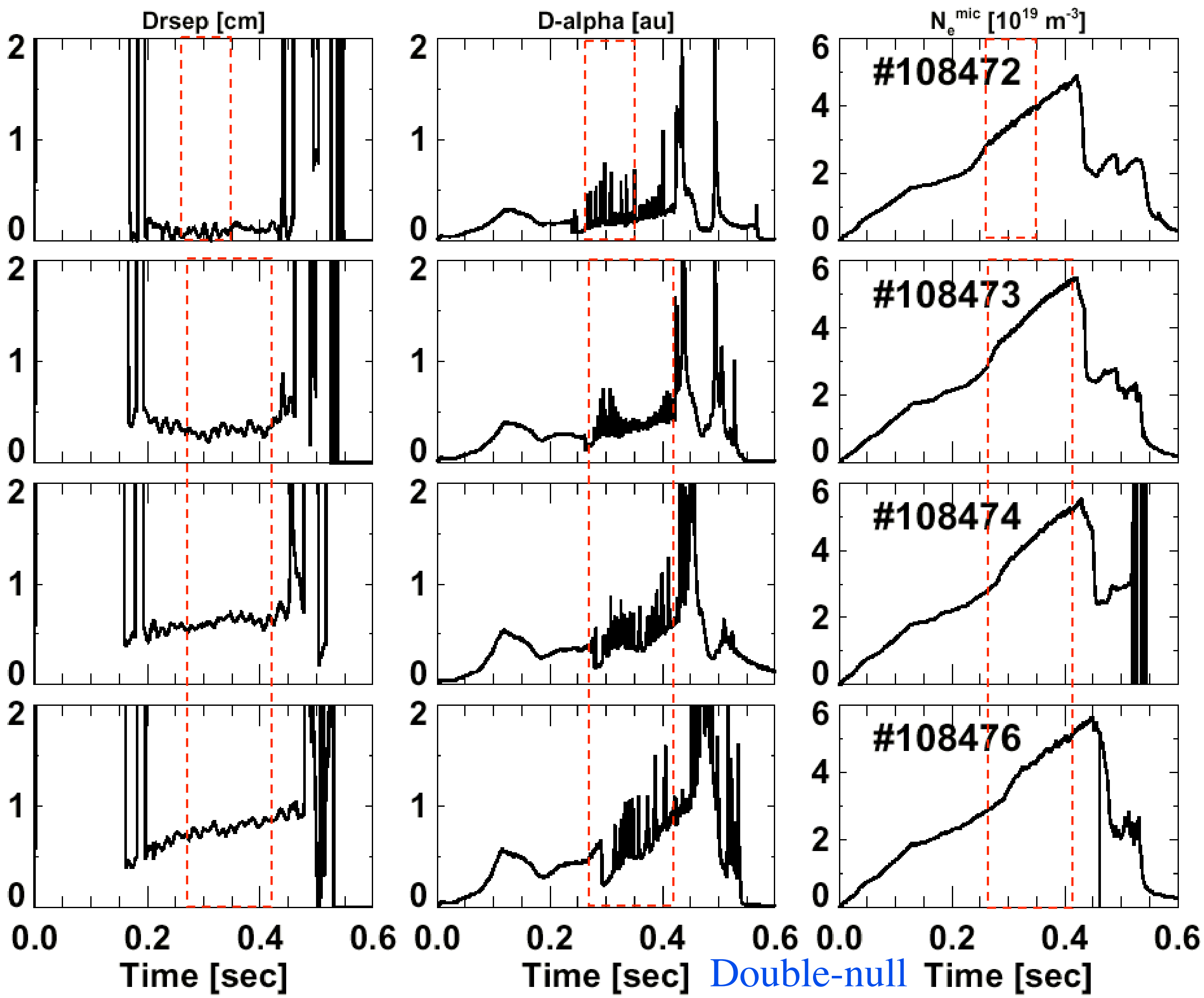
Time of constant NBI power with no locked mode signature

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

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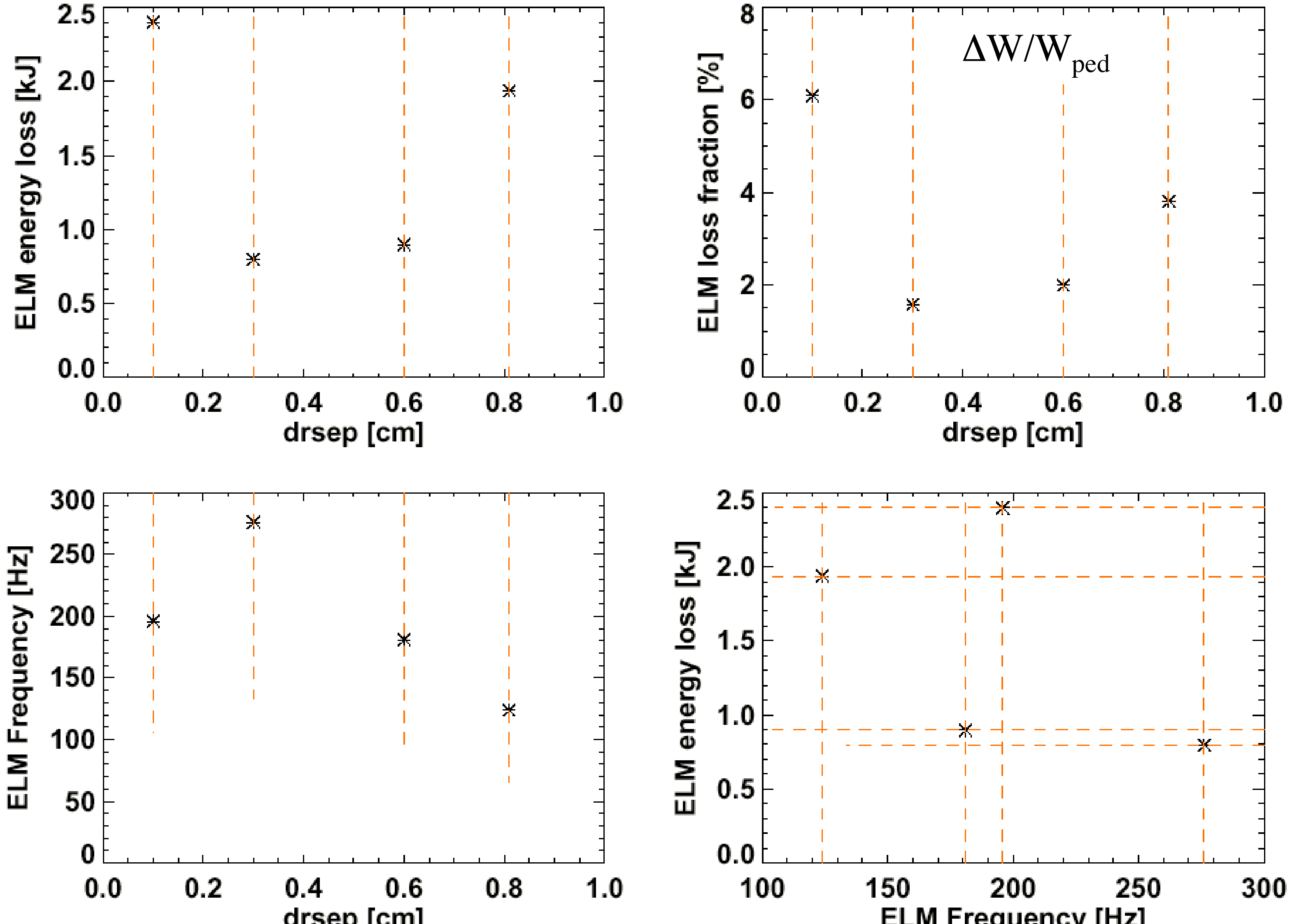
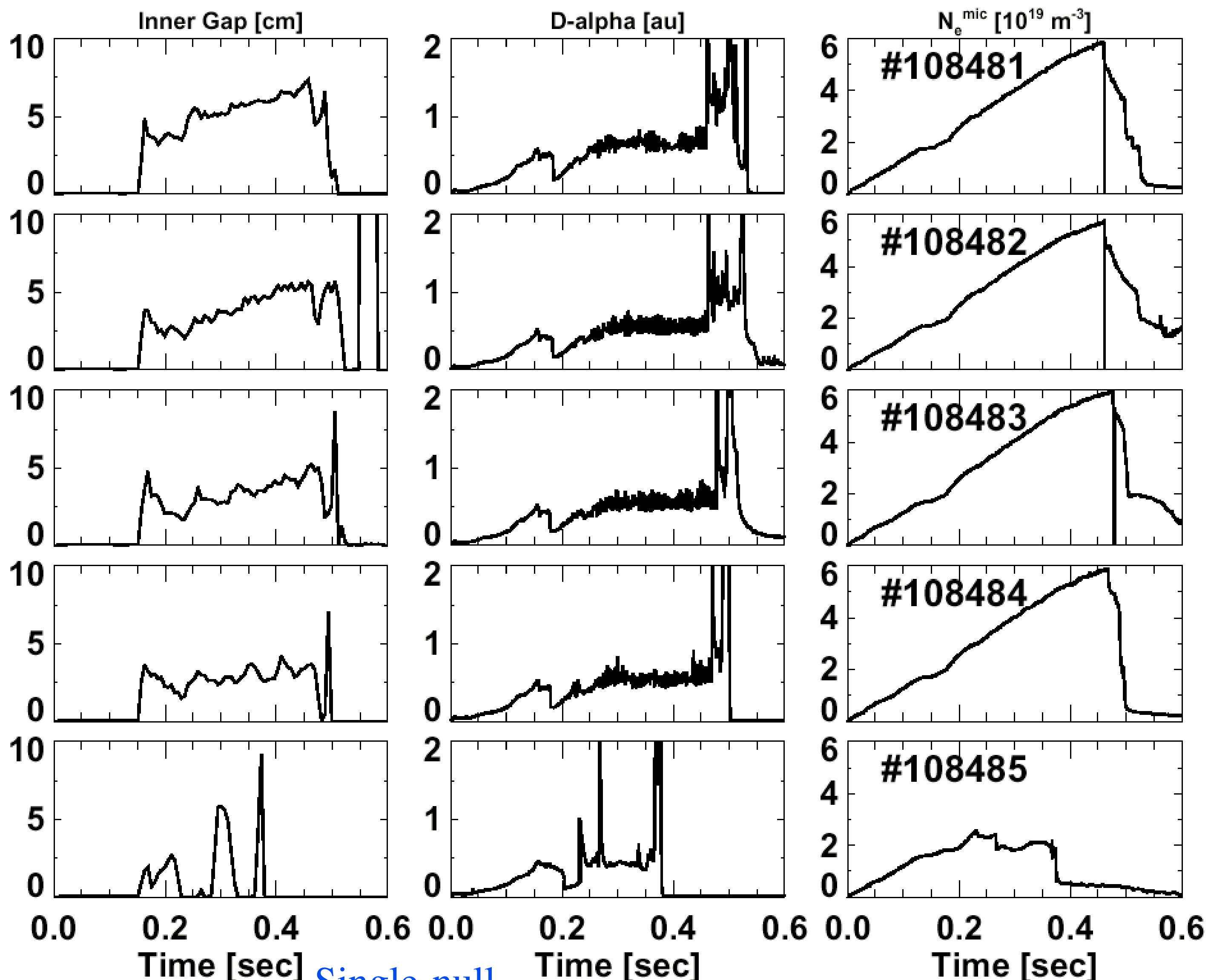


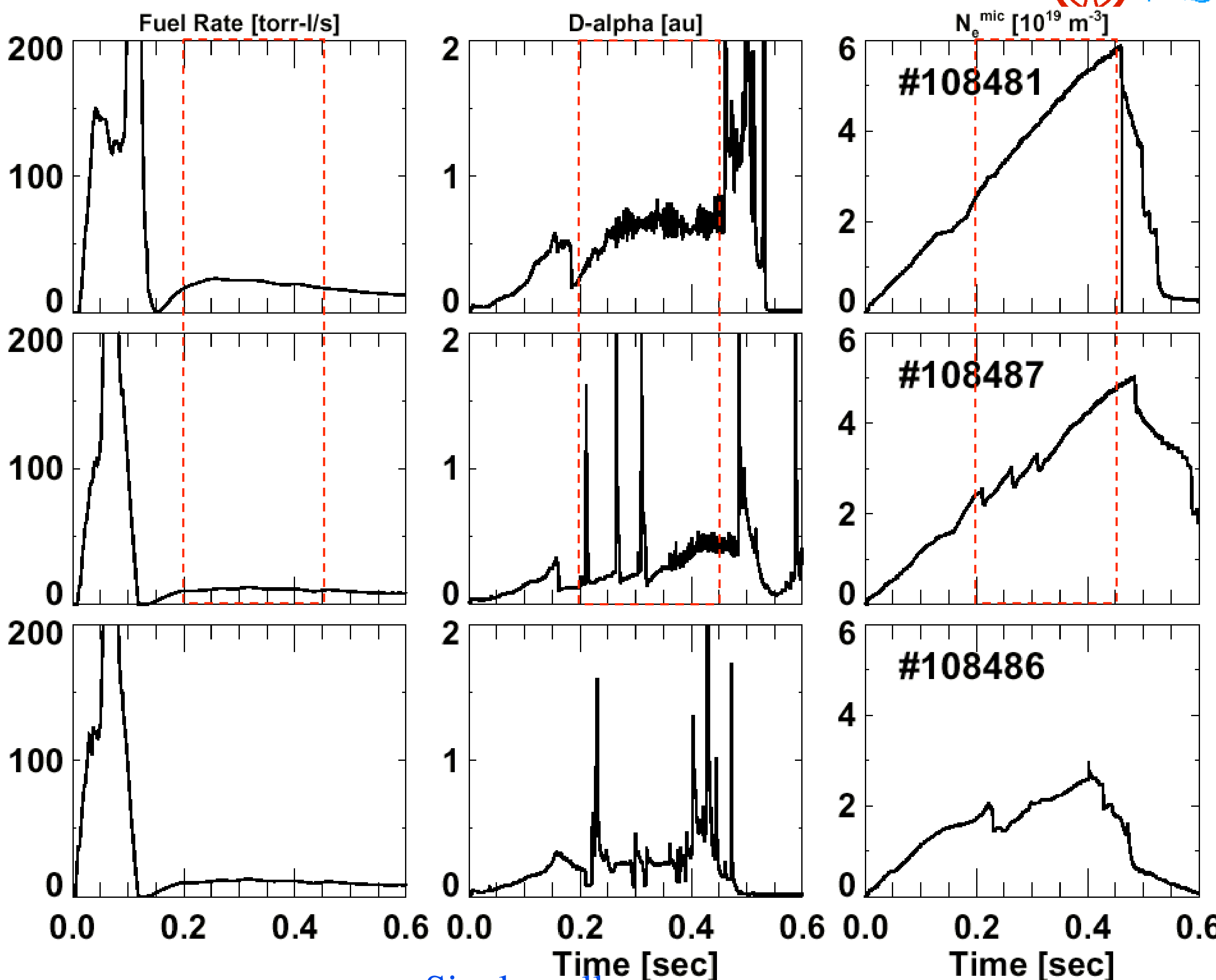
Double-null

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



Single-null

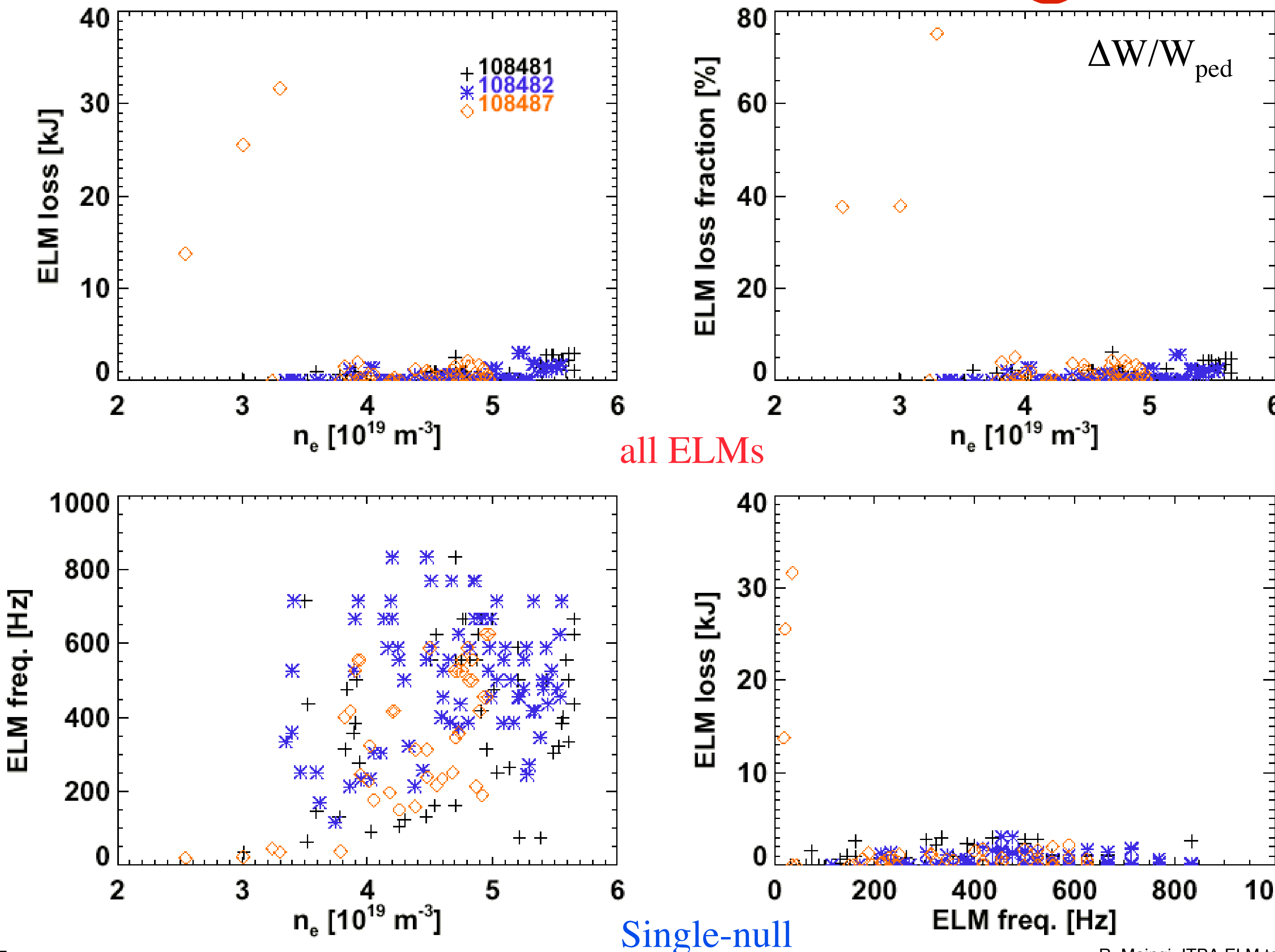
Fueling (density) strongly affects ELMs in single-null



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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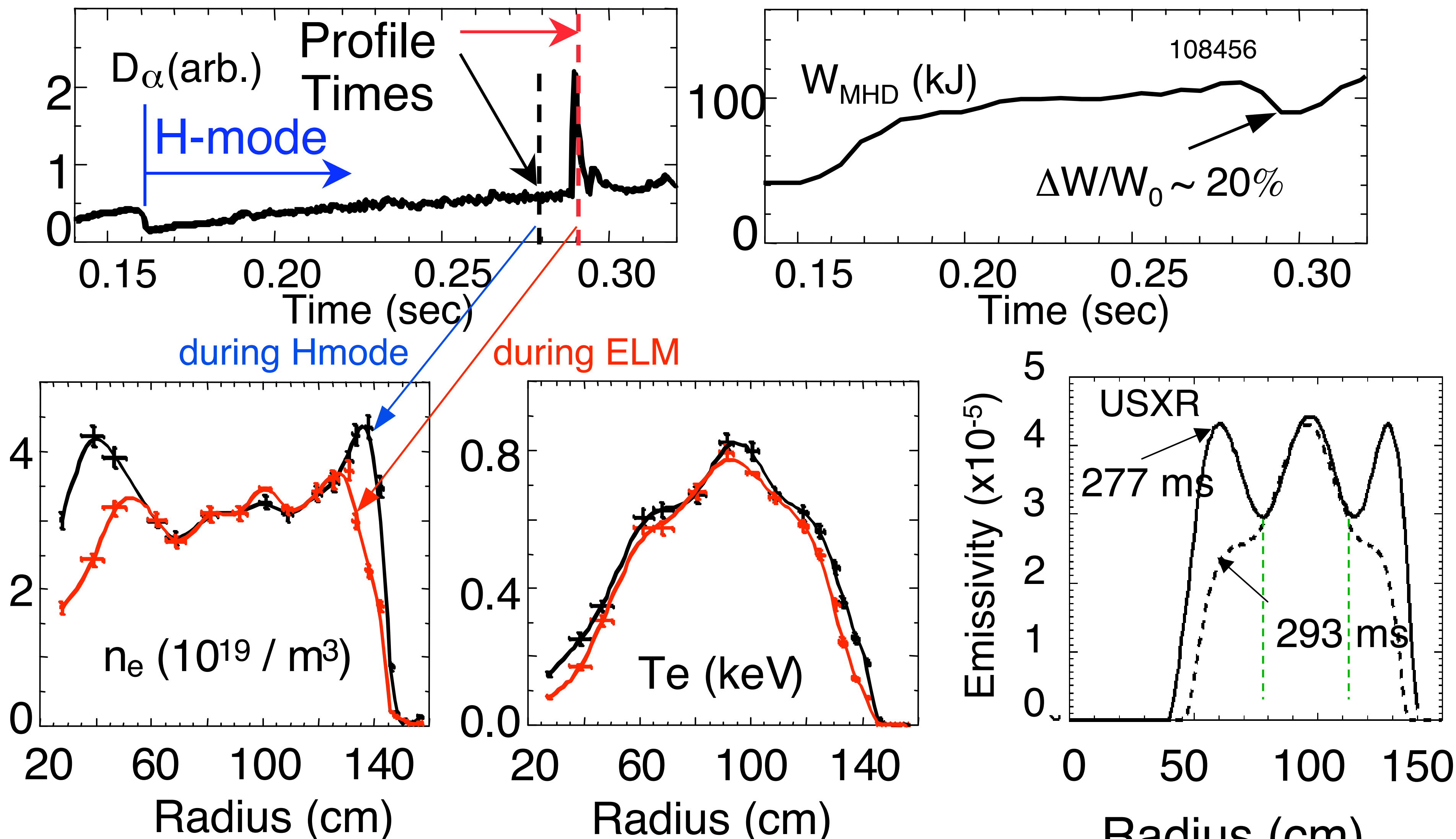
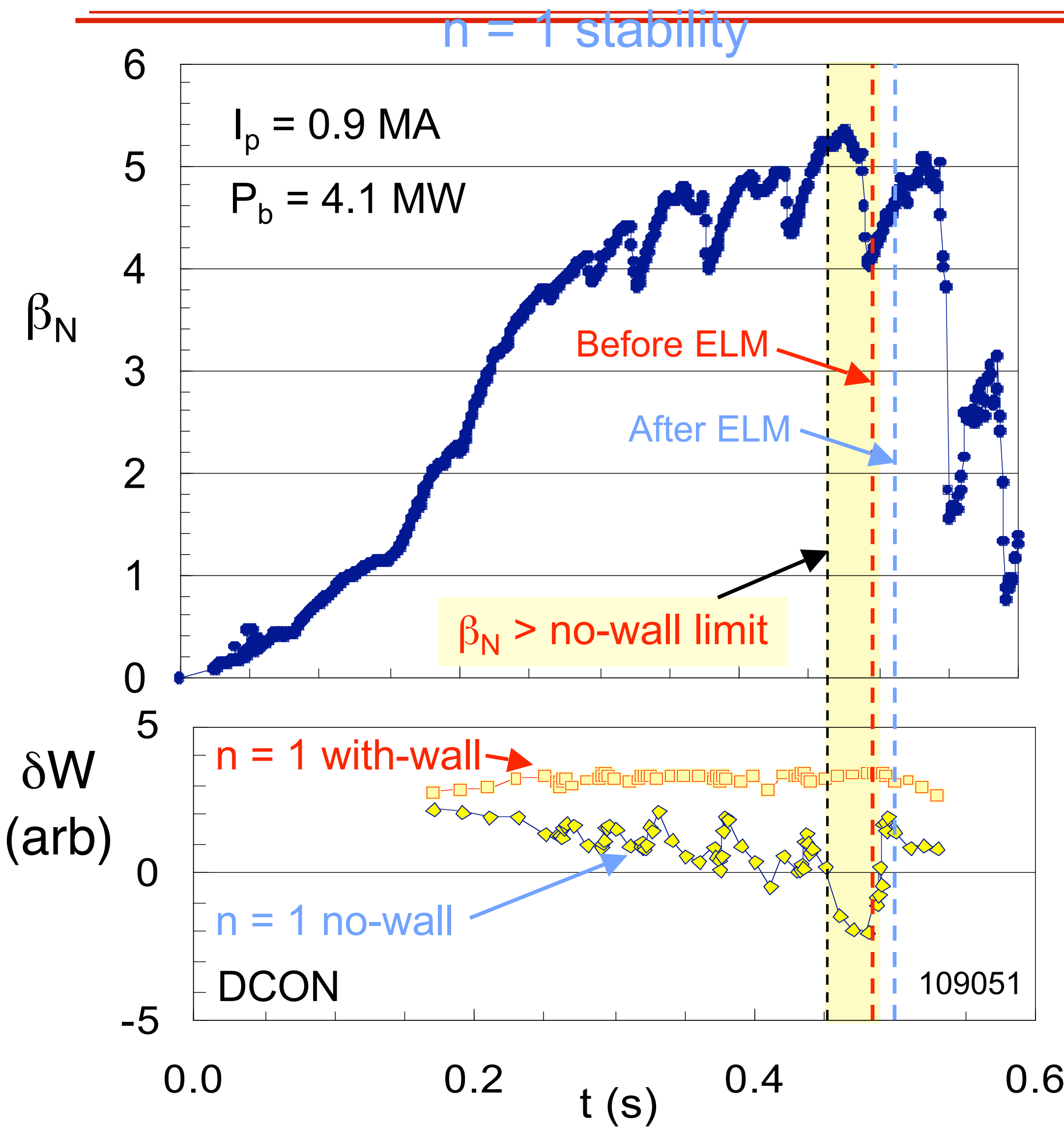
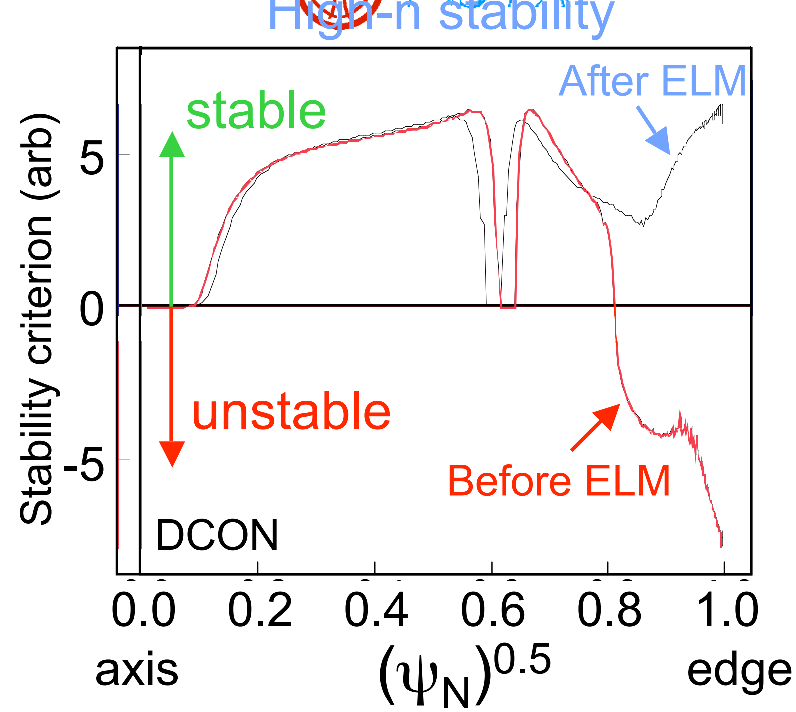


Bush, LeBlanc, Stutman

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