Research Supported by

ELMS and the H-mode Pedestal in NSTX

Rajesh Maingi

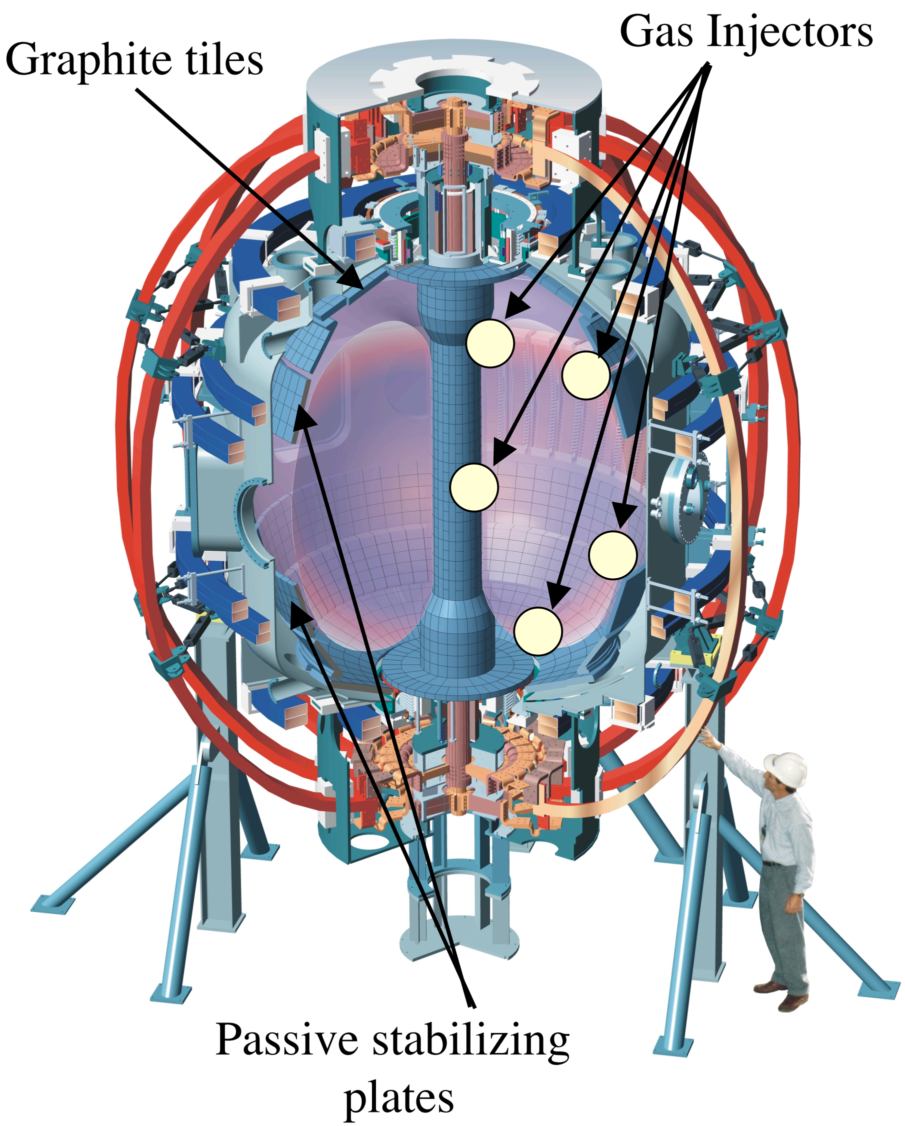
Oak Ridge National Laboratory

E.D. Fredrickson[b], J.E. Menard[b], N. Nishino[c], A.L. Roquemore[b], S.A. Sabbagh[d], K. Tritz[e], C.E. Bush[a], D. Stutman[d], M.G. Bell[b], R.E. Bell[b], T. Biewer[b], D.A. Gates[b], D.W. Johnson[b], R. Kaita[b], S.M. Kaye[b], H.W. Kugel[b], B.P. LeBlanc[b], D. Mueller[b], R. Raman[f], V.A. Soukhanovskii[g], T. Stevenson[b]

a) Oak Ridge National Laboratory
b) Princeton Plasma Physics Laboratory
c) Hiroshima University
d) Columbia University Johns Hopkins University
e) Johns Hopkins University
f) Univ. Washington - Seattle
g) Lawrence Livermore National Laboratory

2004 EPS Meeting on Controlled Fusion and Plasma Physics
London, UK
June 28-July 2, 2004

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	7.2 MW
RF (30MHz)	6MW	6 MW

Wall Conditioning:

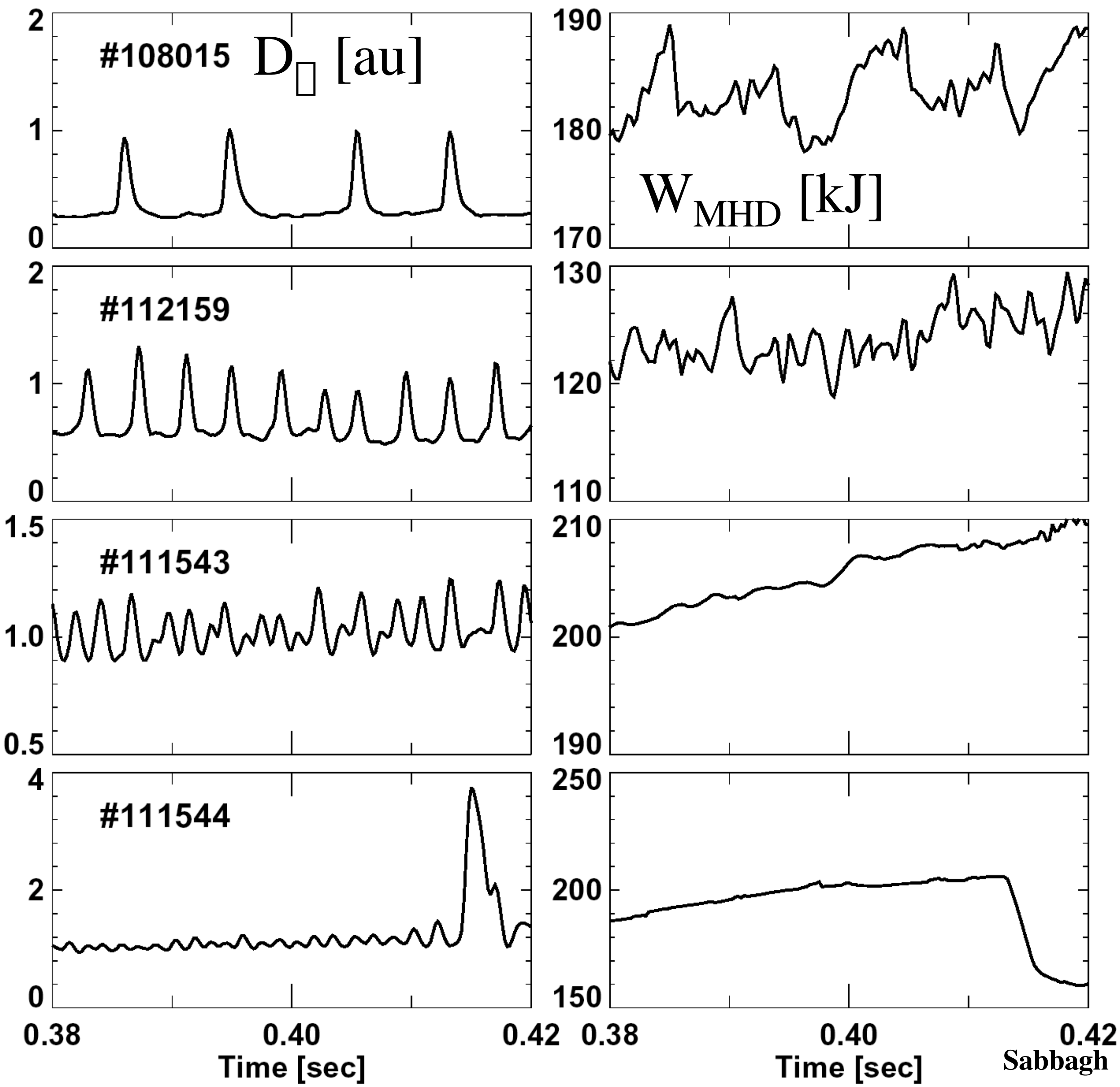
350 deg. bakeout of graphite tiles

Regular boronization (~3 weeks)

Helium Glow between discharges

Center stack gas injection

Wide variety of ELMS observed in NSTX



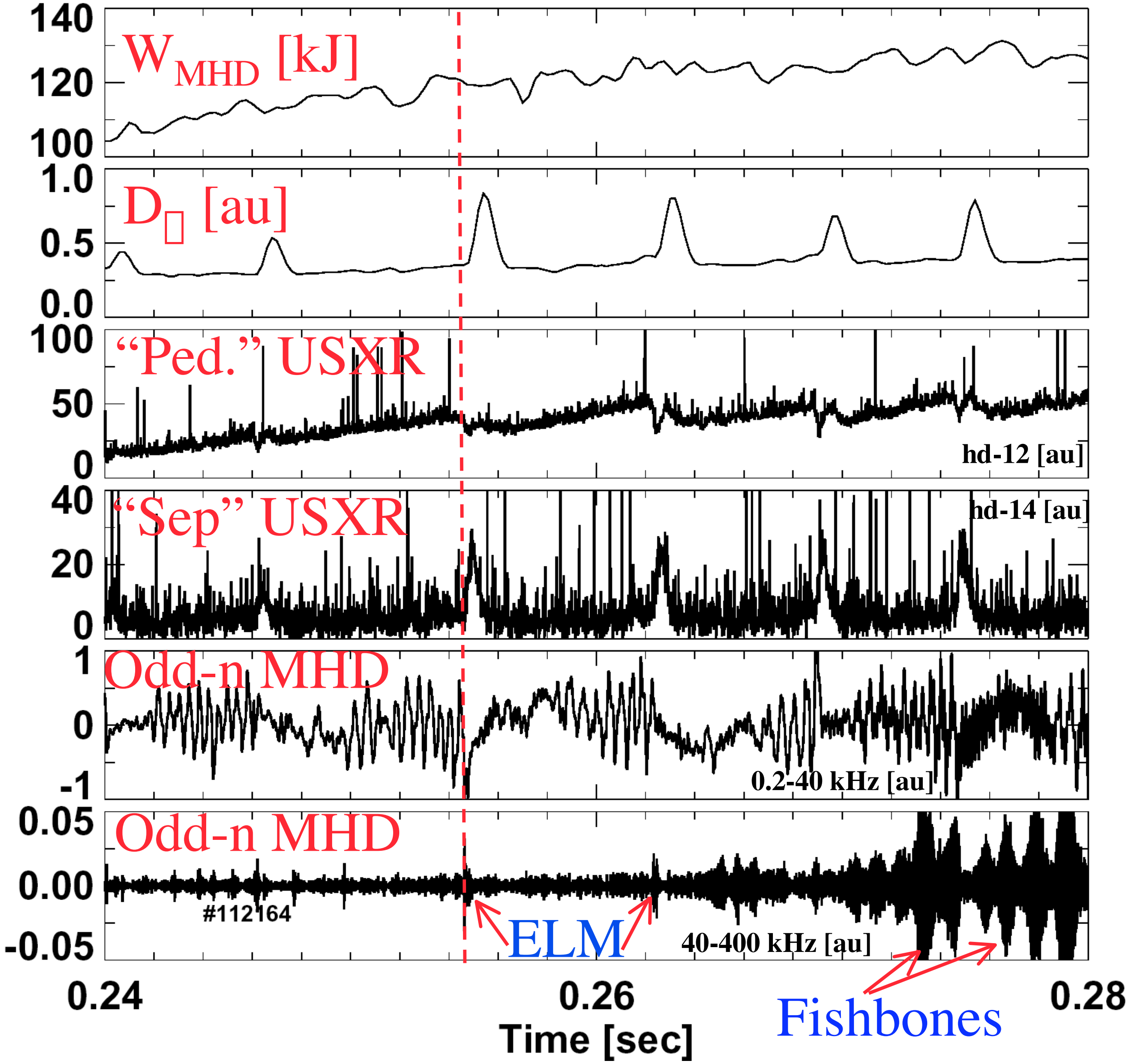
Type I - Mid □W_{MHD}
No magnetic pre-cursor
$P_{heat} >> P_{L-H}$

Type III - Small □W_{MHD}
Magnetic signature
And low frequency pre-cursor

NEW, type V
Tiny(?) □W_{MHD}
Magnetic signature n=1
No clear pre-cursor

Mixed Type V + 'Giant ELM'
(couples to core mode?)
Large □W_{MHD}

Characteristics of Type III ELMs



Little impact per each ELM

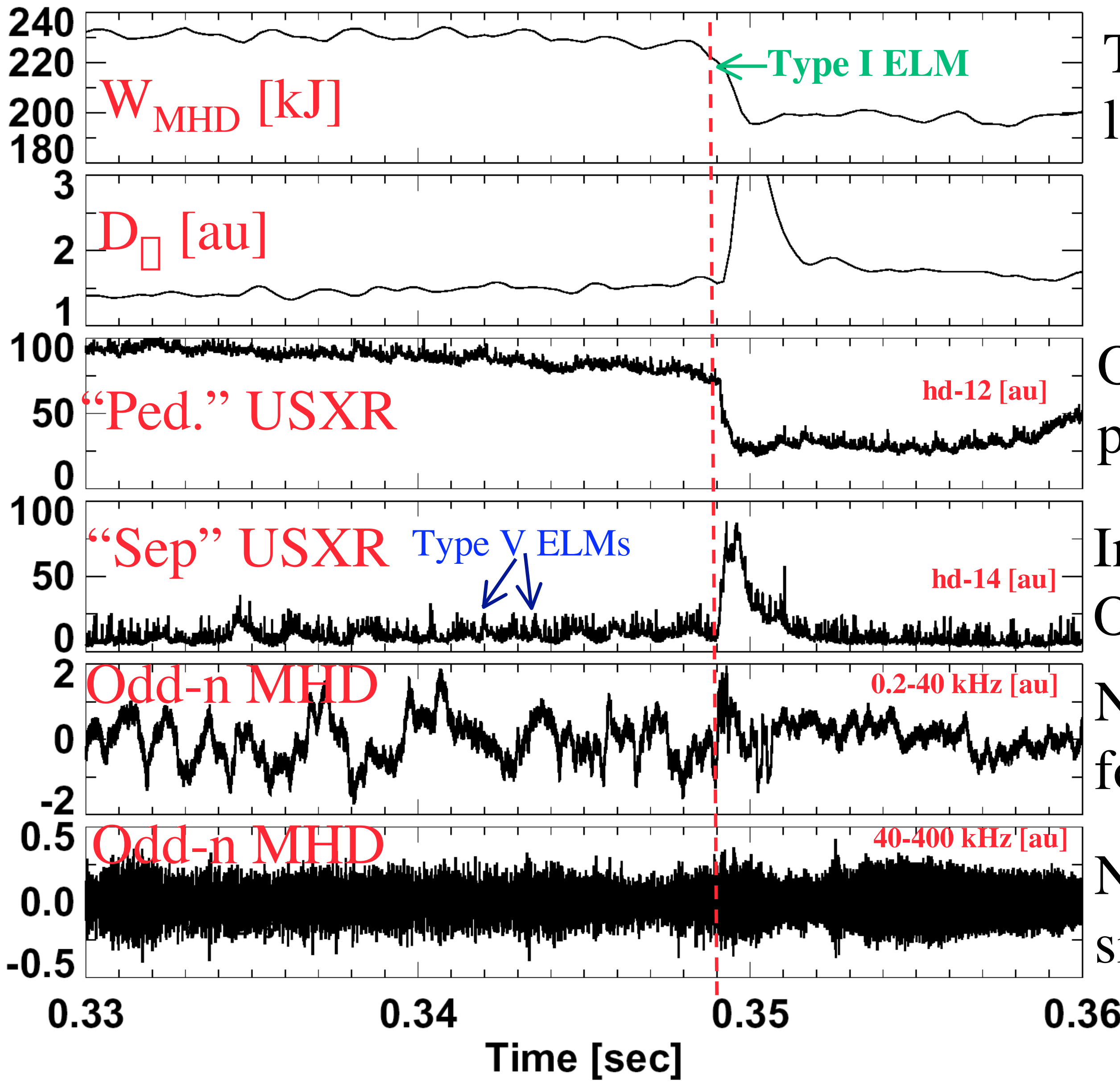
Outflux from pedestal

Influx to SOL Or separatrix

Low frequency 2 kHz pre-cursor

High frequency signature

Characteristics of Type I and V ELMs



Type I ELM large □W_{MHD}

Outflux from pedestal

Influx to SOL Or separatrix

No pre-cursors for Type I

No clear Type I signatures

Type I *(III, V)* ELMs do *(not)* burn through MARFE-like region near inner X-point

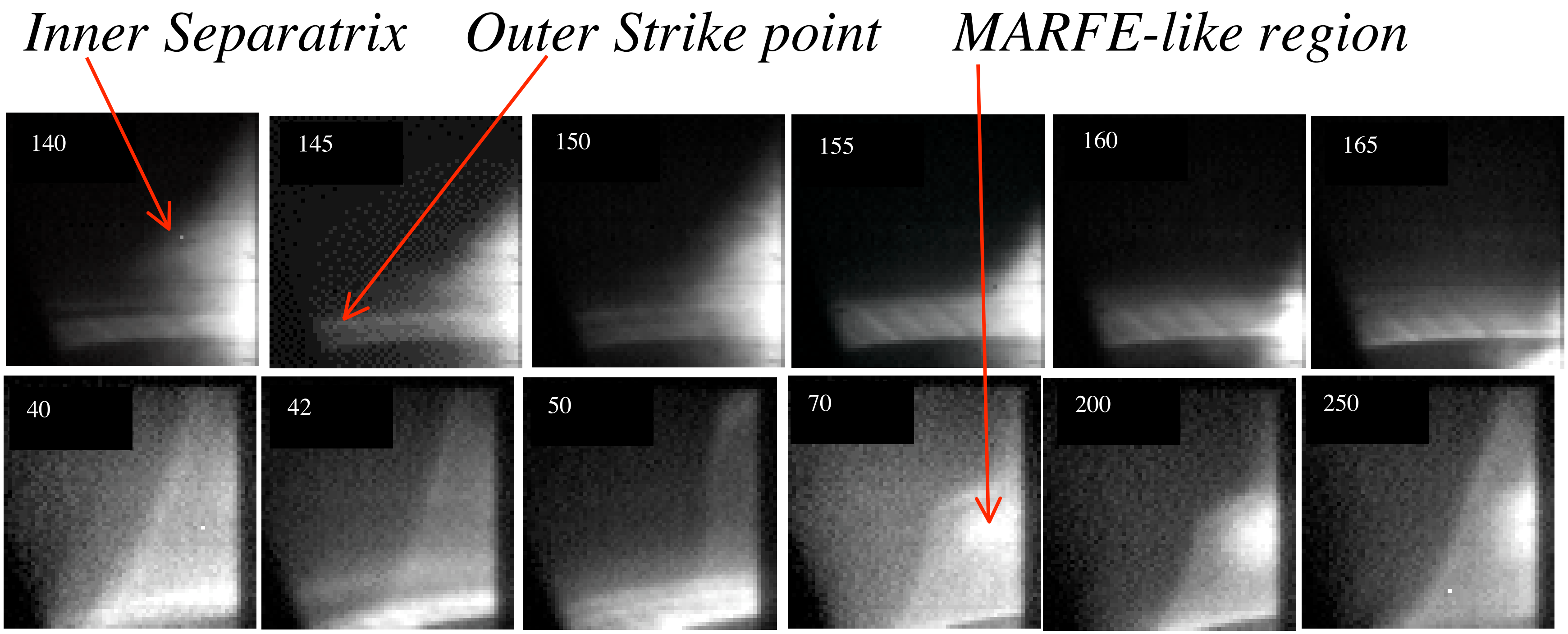
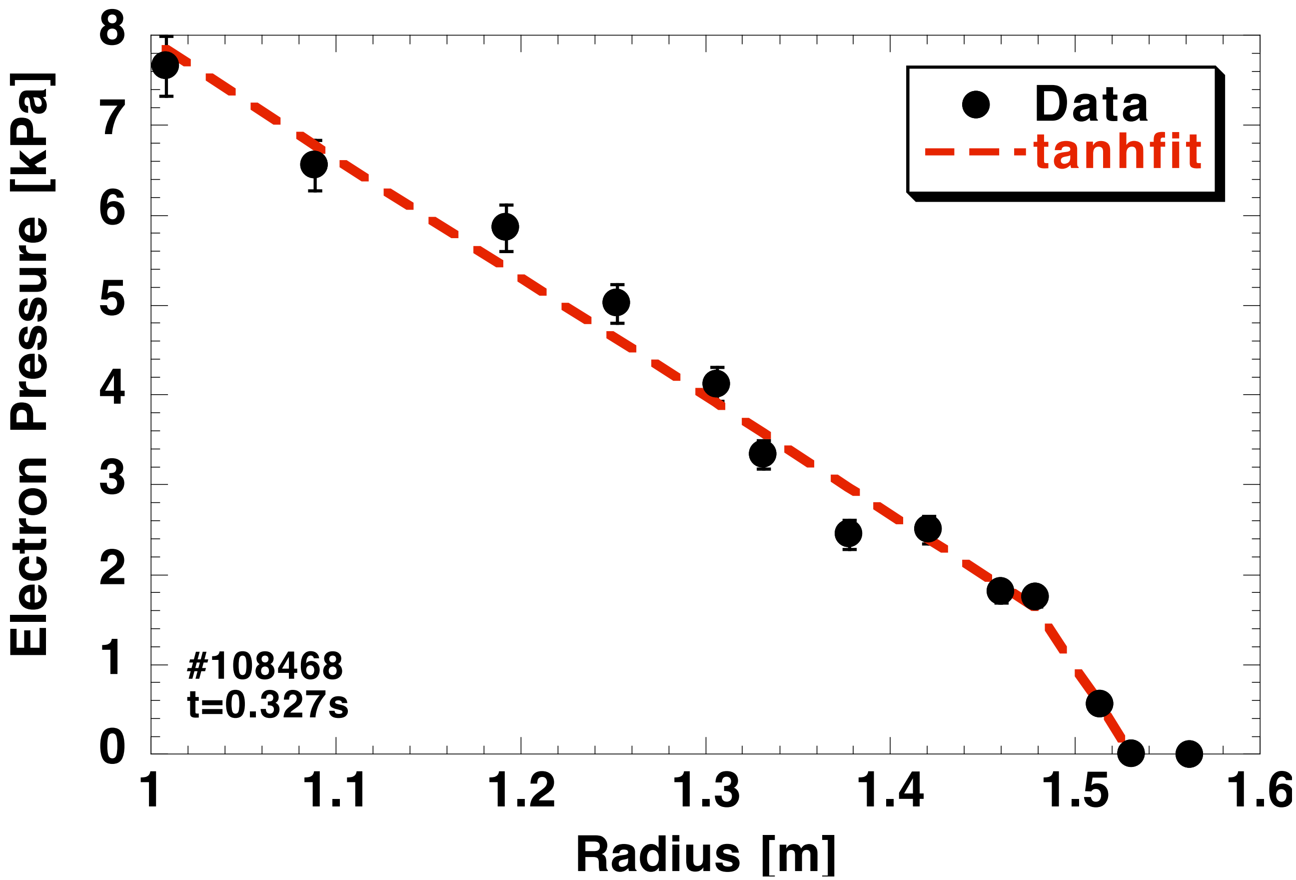


Fig. 4 – unfiltered fast camera images (contrast enhanced) at 40,500 frames per second during one Type I ELM for #112503 (upper set) and one type III ELM for #112164 (lower set). Frame numbers are indicated.

ELM analysis uses data from multiple diagnostics

NSTX

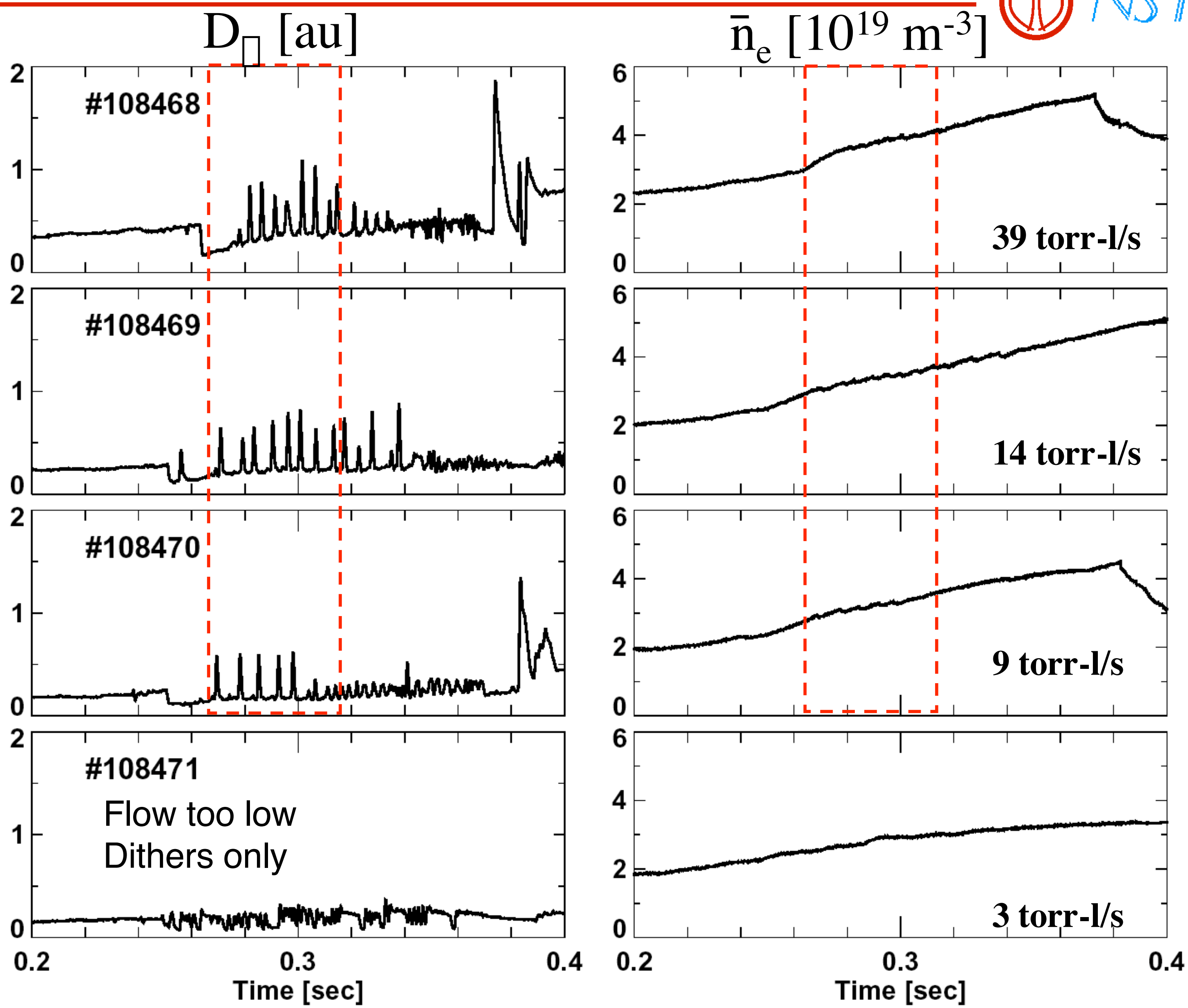


- Total energy drop from fast EFITs (0.25 ms)
- Pedestal energy from modified tanhfit to Thomson pressure profile (20 points spatial, 60 Hz)

$$W_{ped}=0.92 \times volume_{EFIT} \times 3p_e^{ped}$$

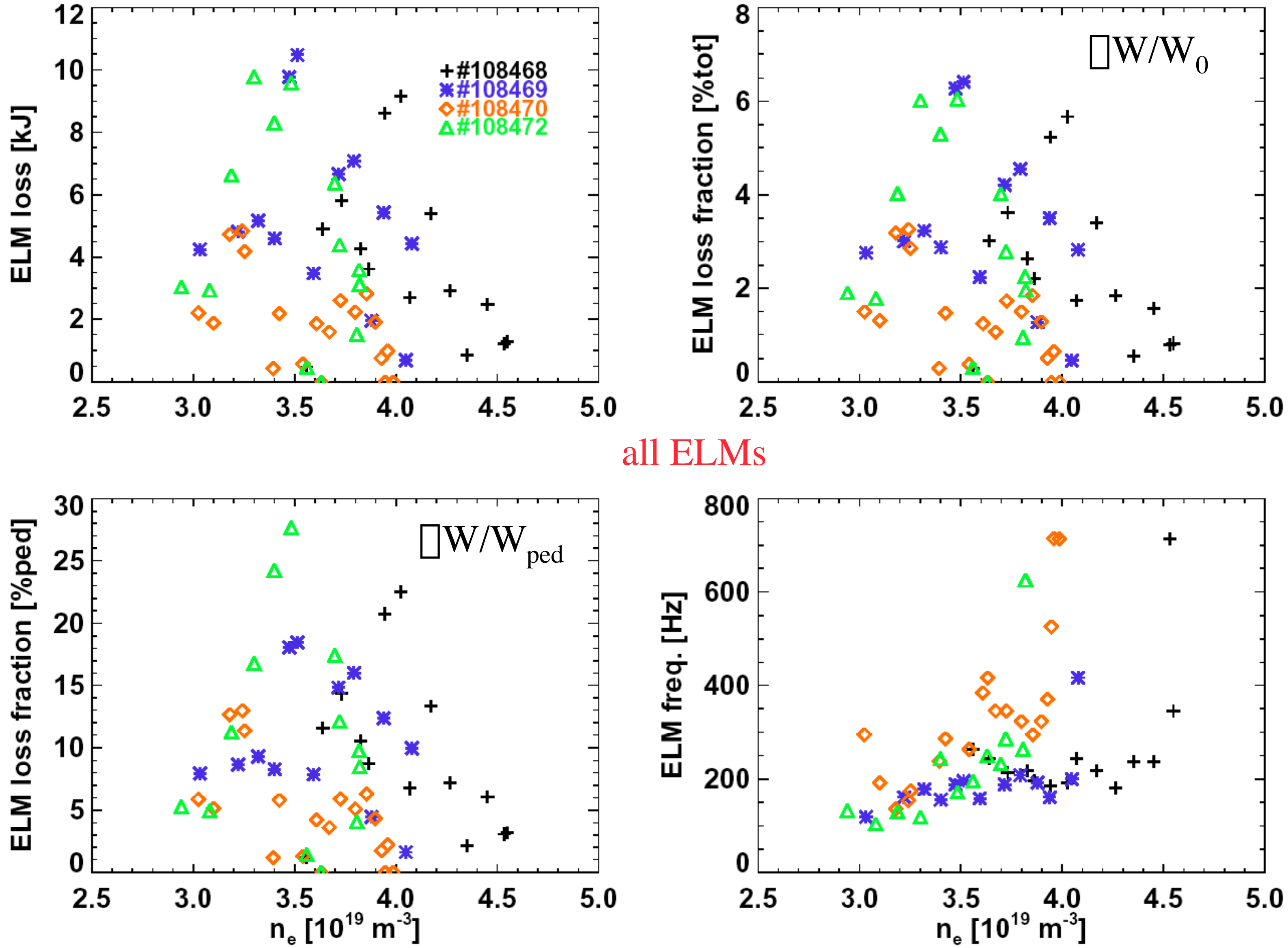
* J. Cordey, et. al., Nucl. Fusion **43** (2003) 670.

Density ramps throughout discharge and affects ELMs modestly (double null)

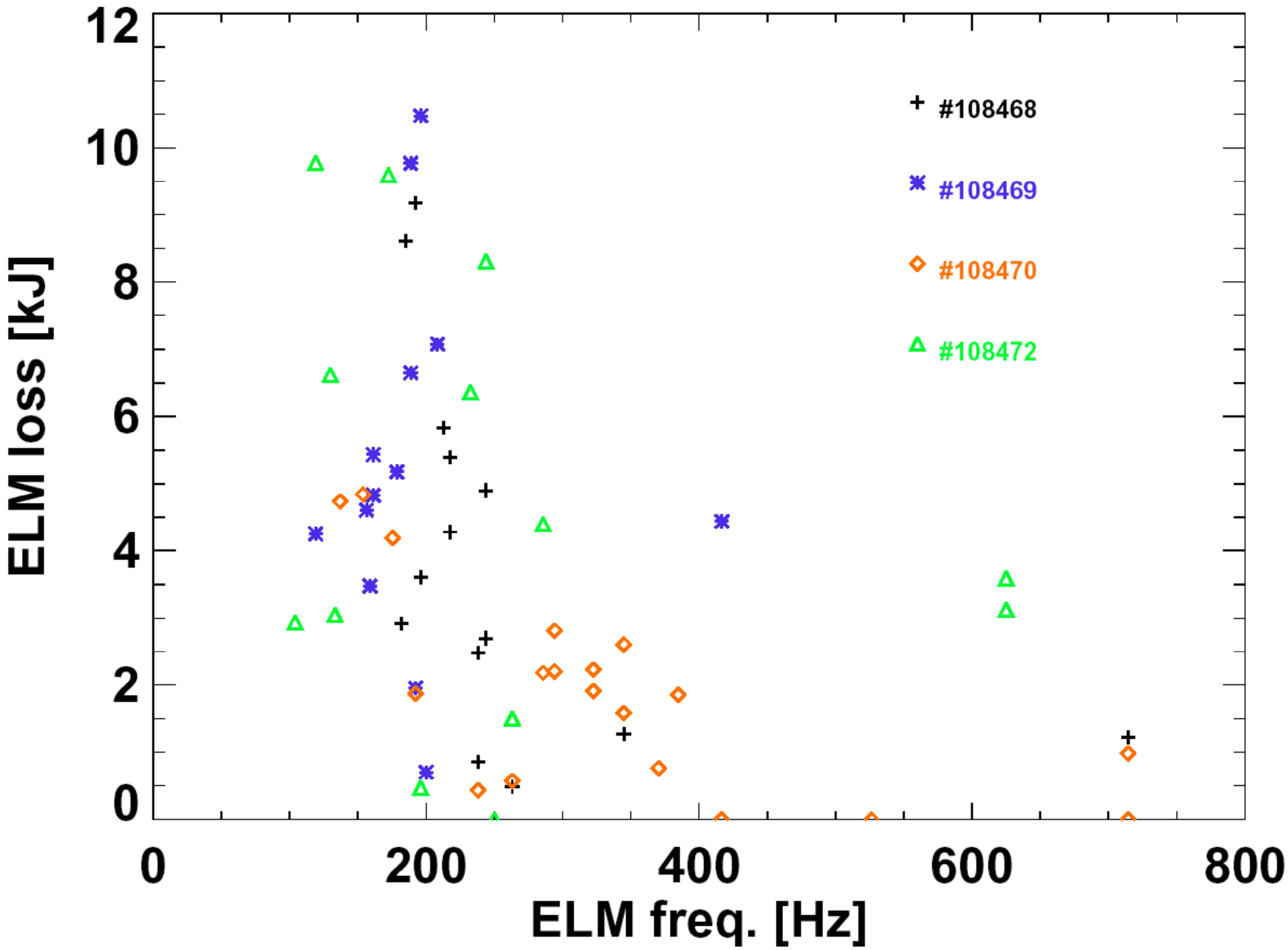


Time of constant NBI power with no locked mode signature

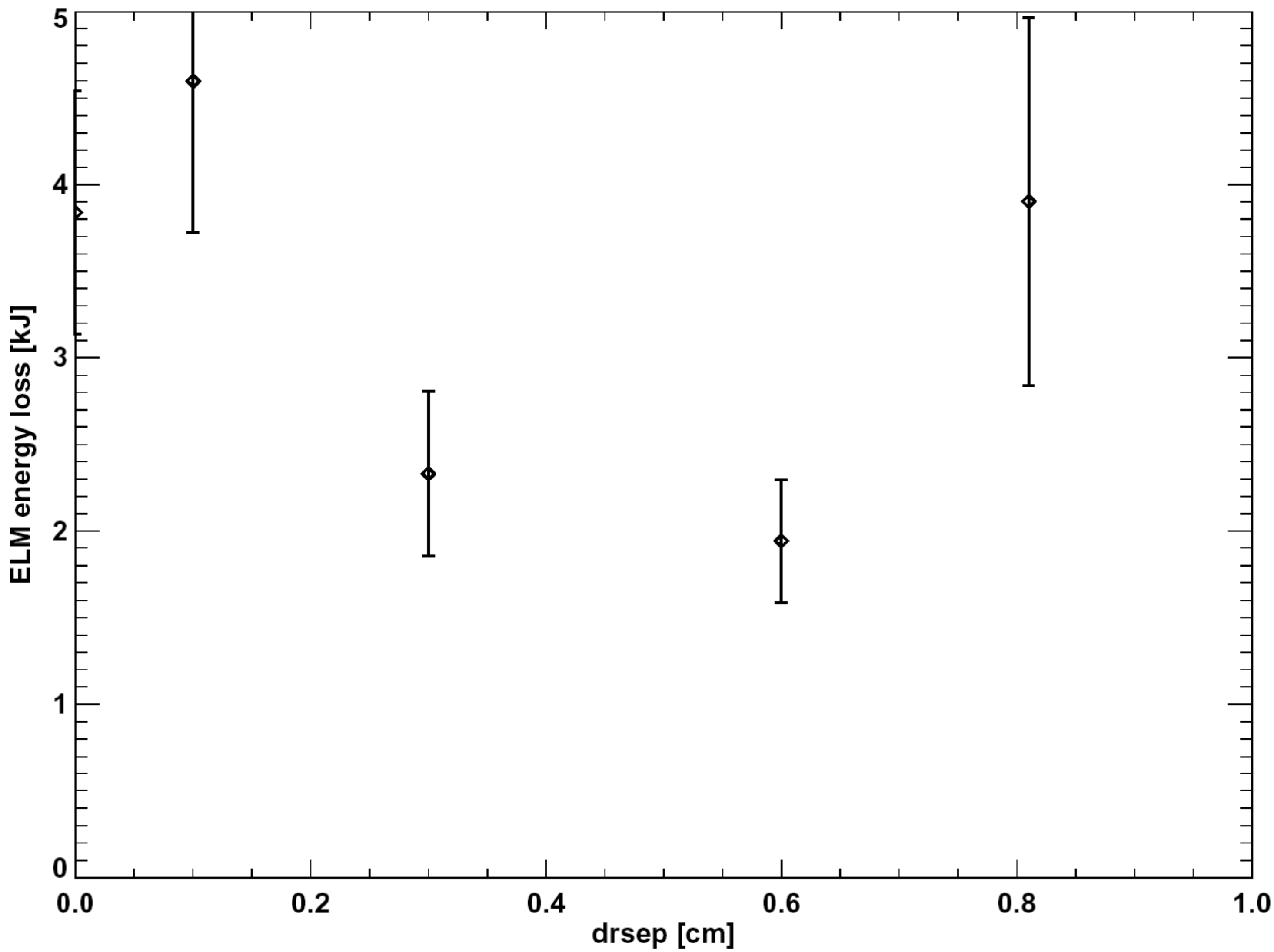
Larger ELMs observed at lower density (double null)



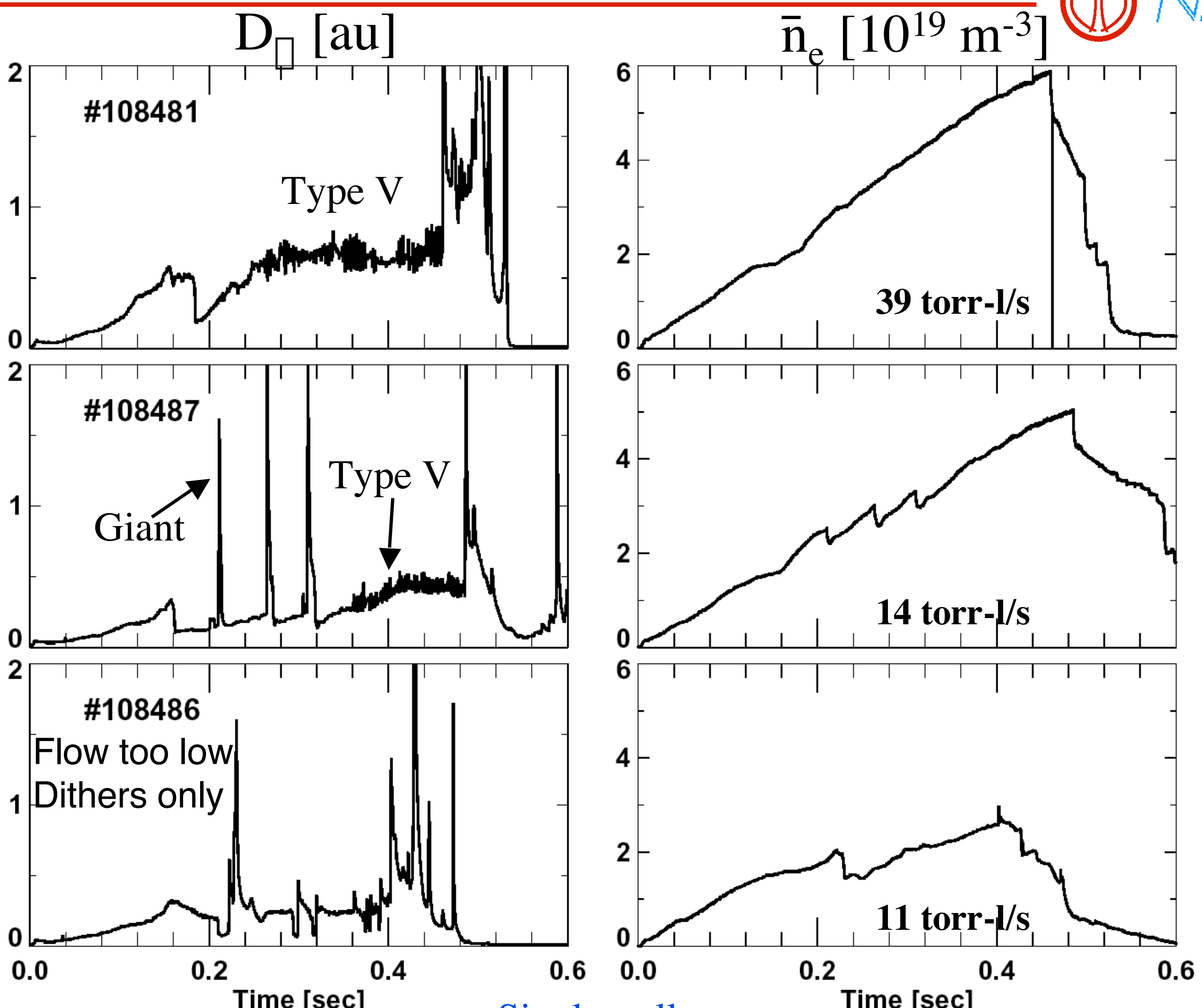
Envelope of ELM size decreases with frequency (double null)



Average ELM characteristics weakly dependent on magnetic up/down balance

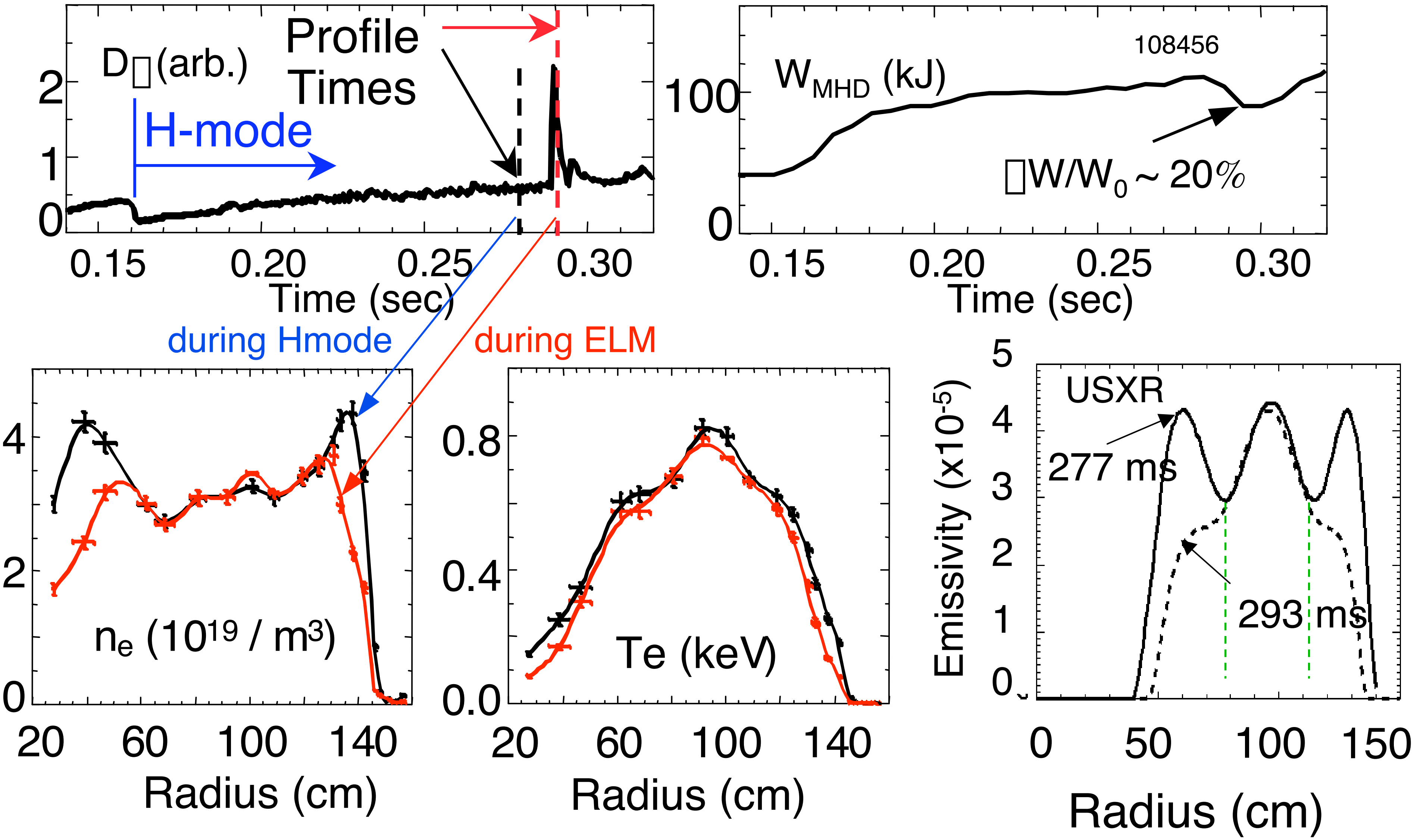


Fueling (density) strongly affects ELMs in single-null



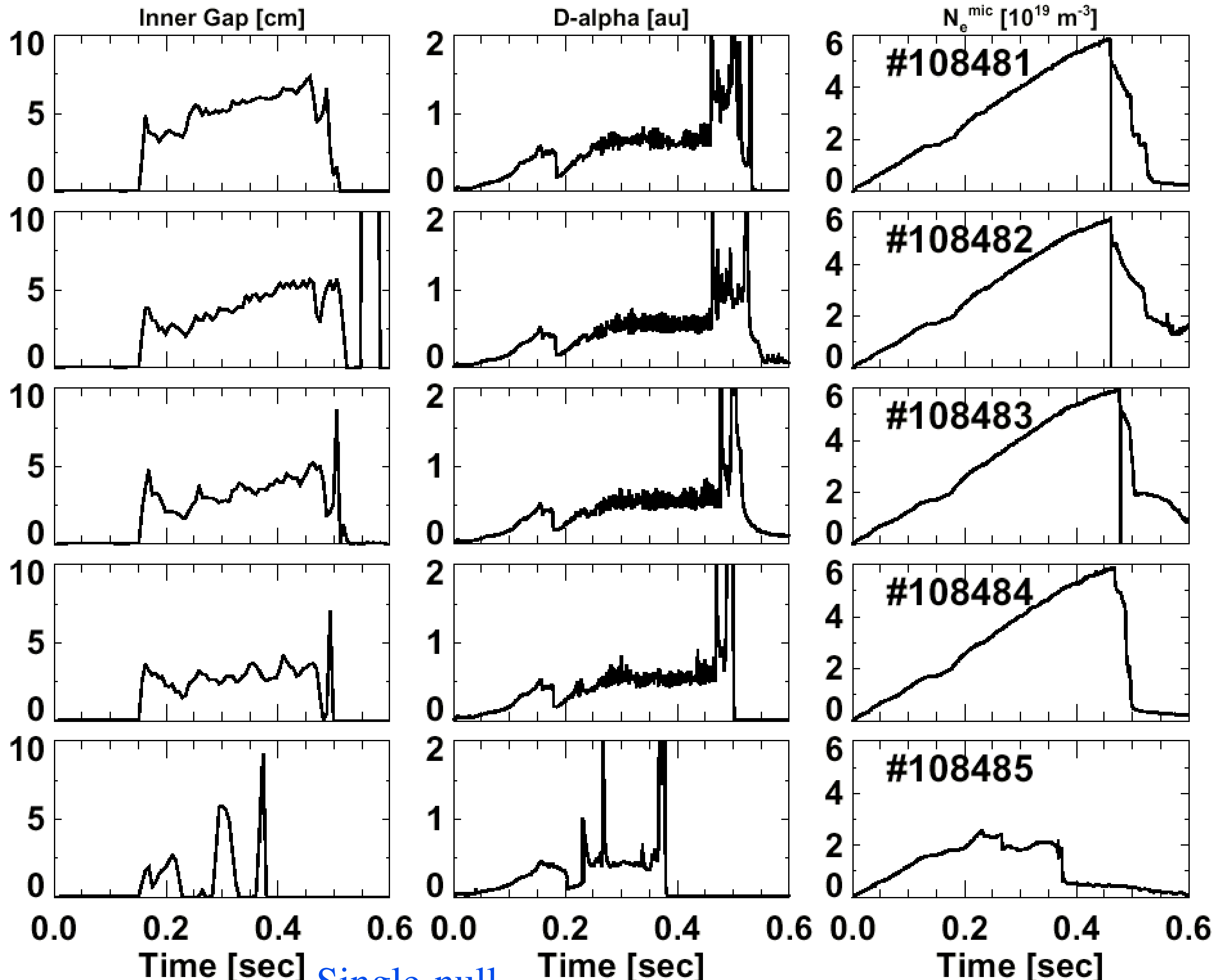
Single-null

Large ELMs penetrate deep into the plasma



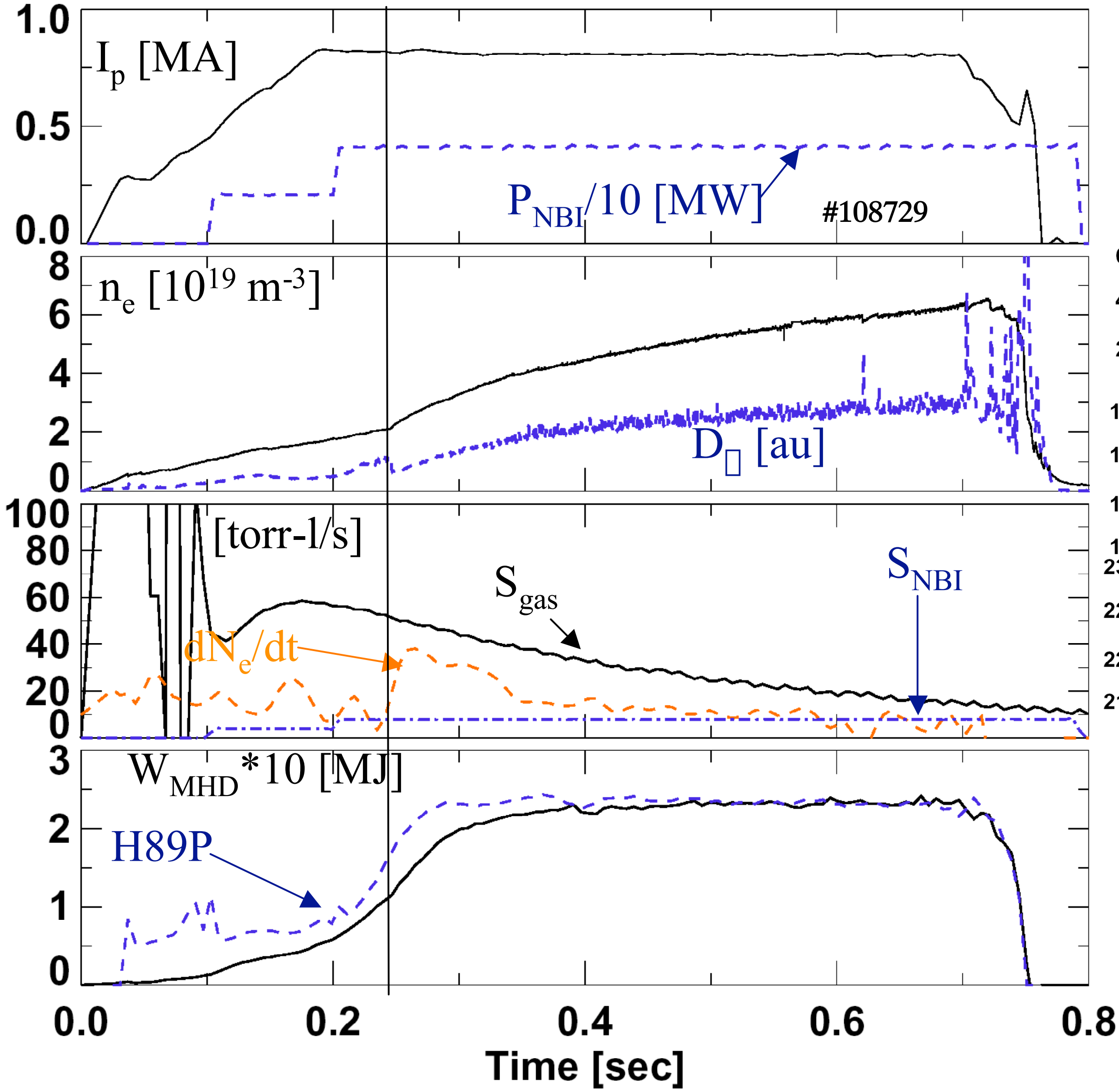
Bush, LeBlanc, Stutman

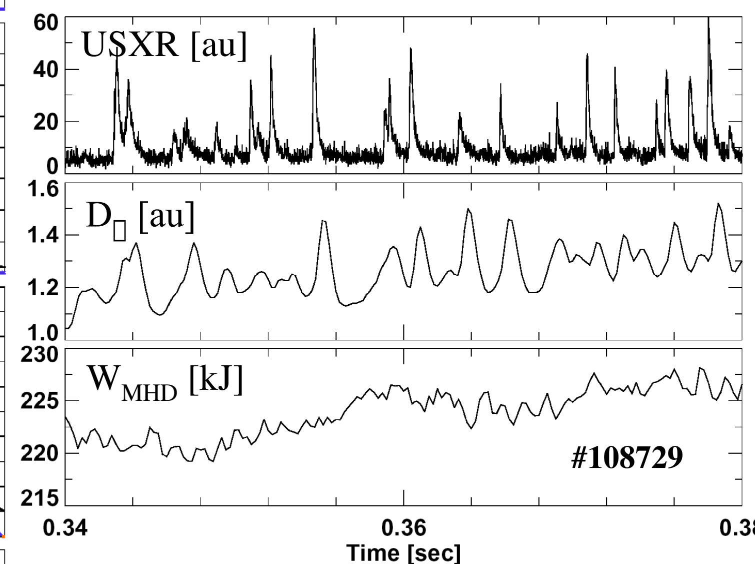
ELM characteristics independent of inner-wall gap unless plasma becomes inner-wall limited



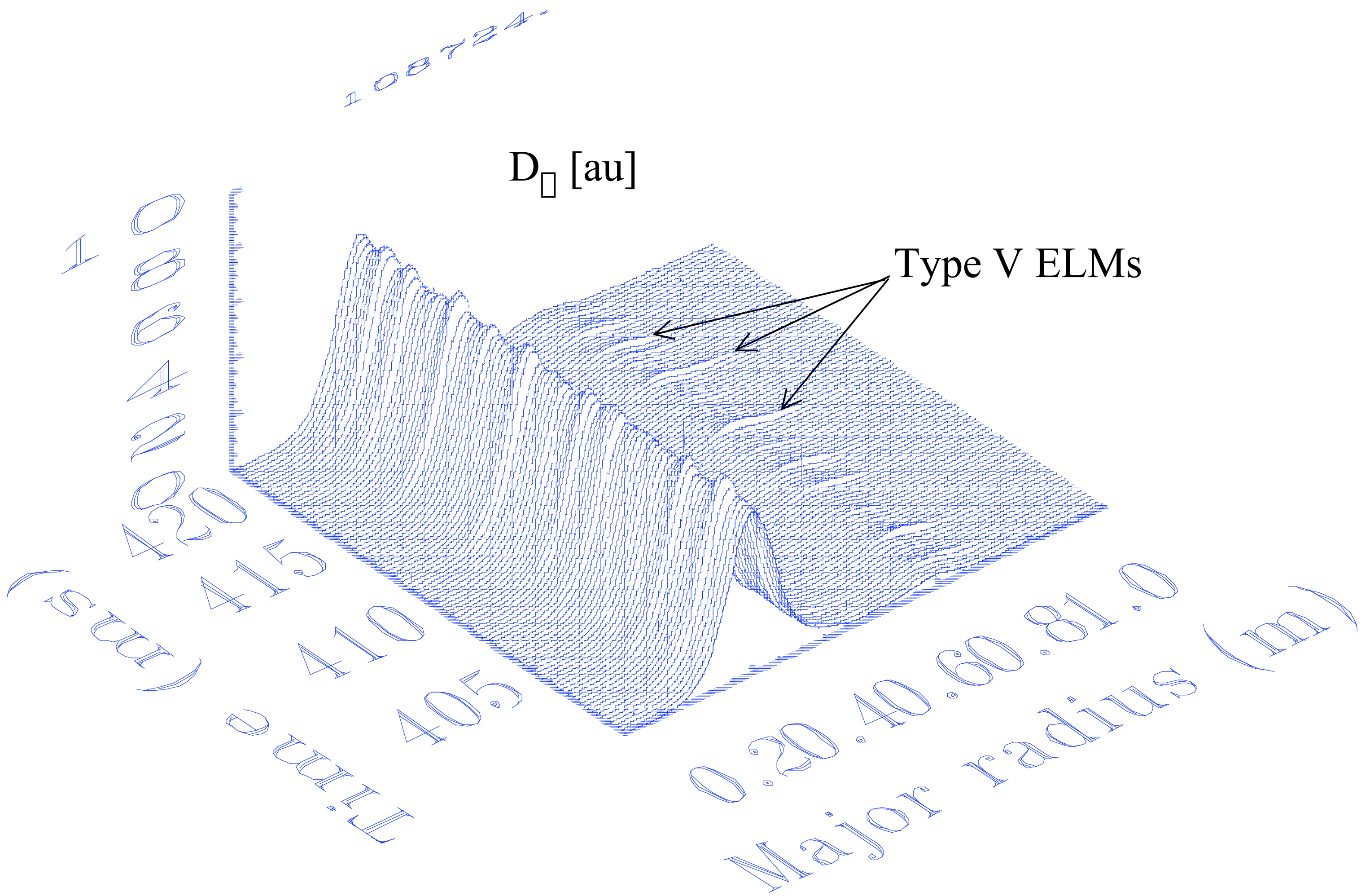
Single-null

Small ELMs in high performance discharge (Type V)



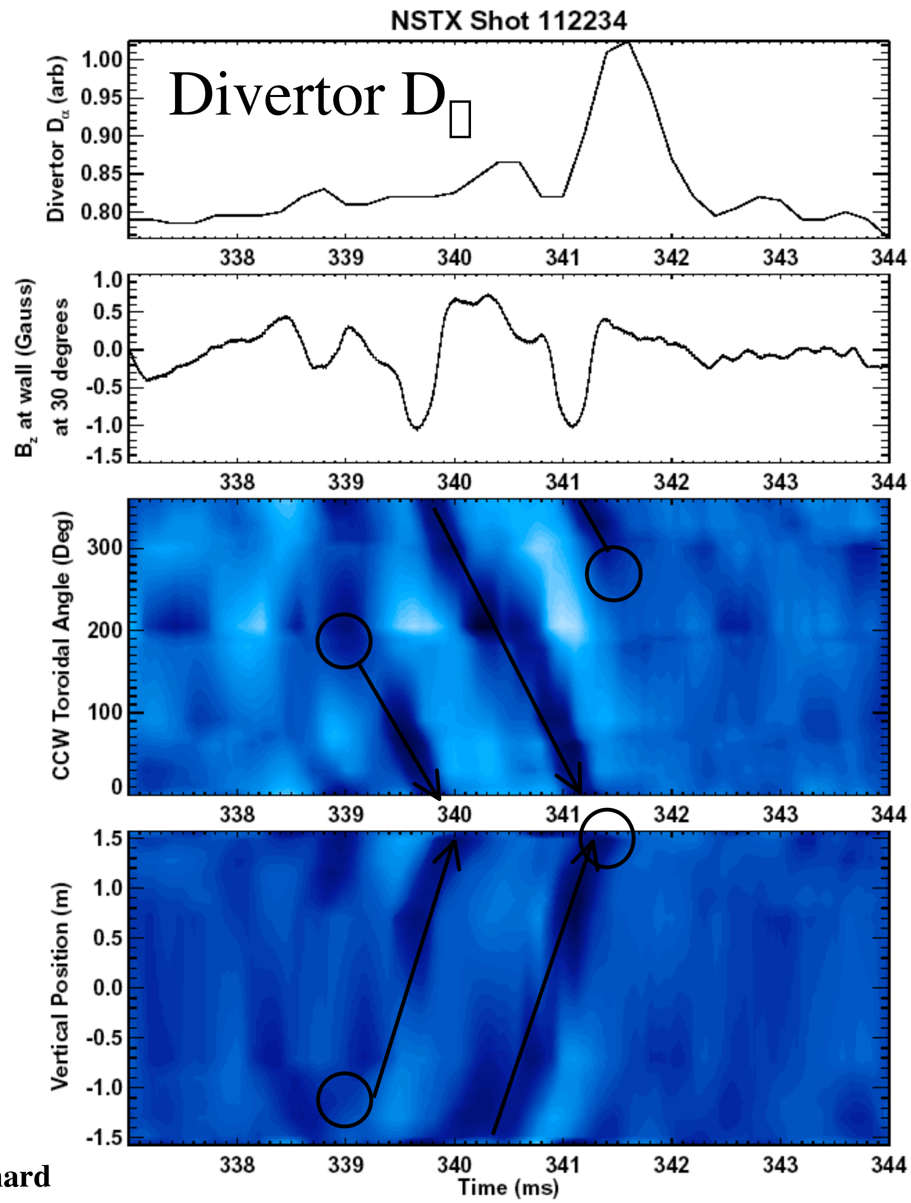


Type V ELMs observed as a 20-30% enhancement of entire lower divertor D profile



Filament-like structure (n=1) observed prior to Ultra-soft X-ray perturbation and Divertor D Increase

NSTX



- Propagates toroidally counter to I_p
- Propagate poloidally from X-point to outer midplane and to top of machine

TOROIDAL MIRNOV ARRAY BELOW OUTER MIDPLANE

Top

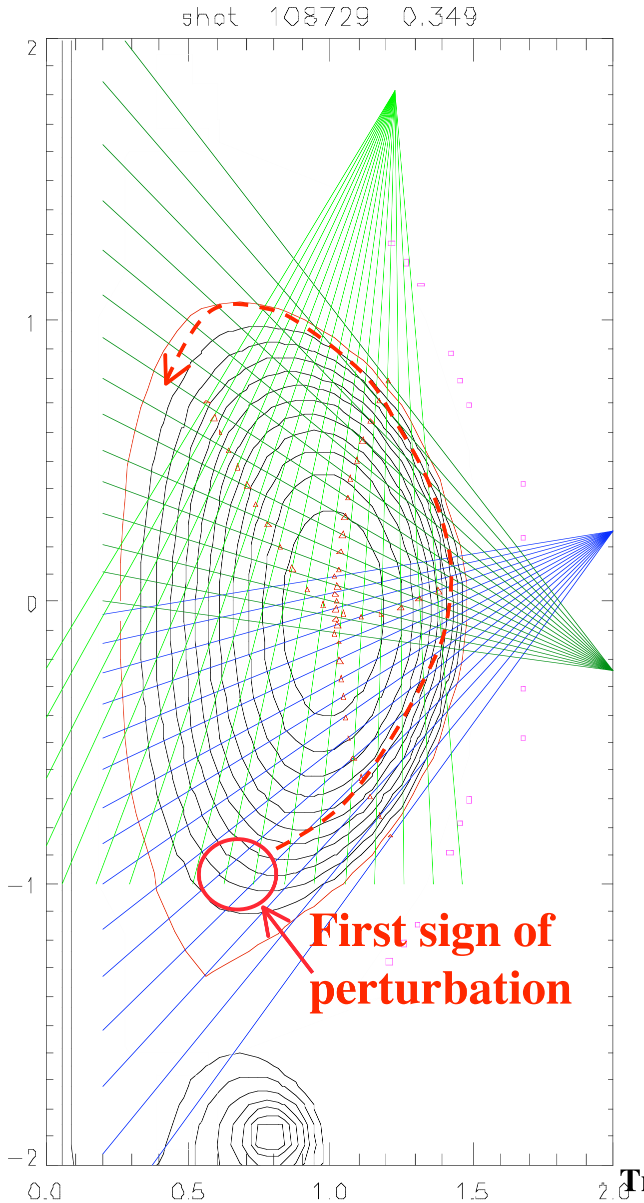
PASSIVE PLATE POLOIDAL MIRNOV ARRAY

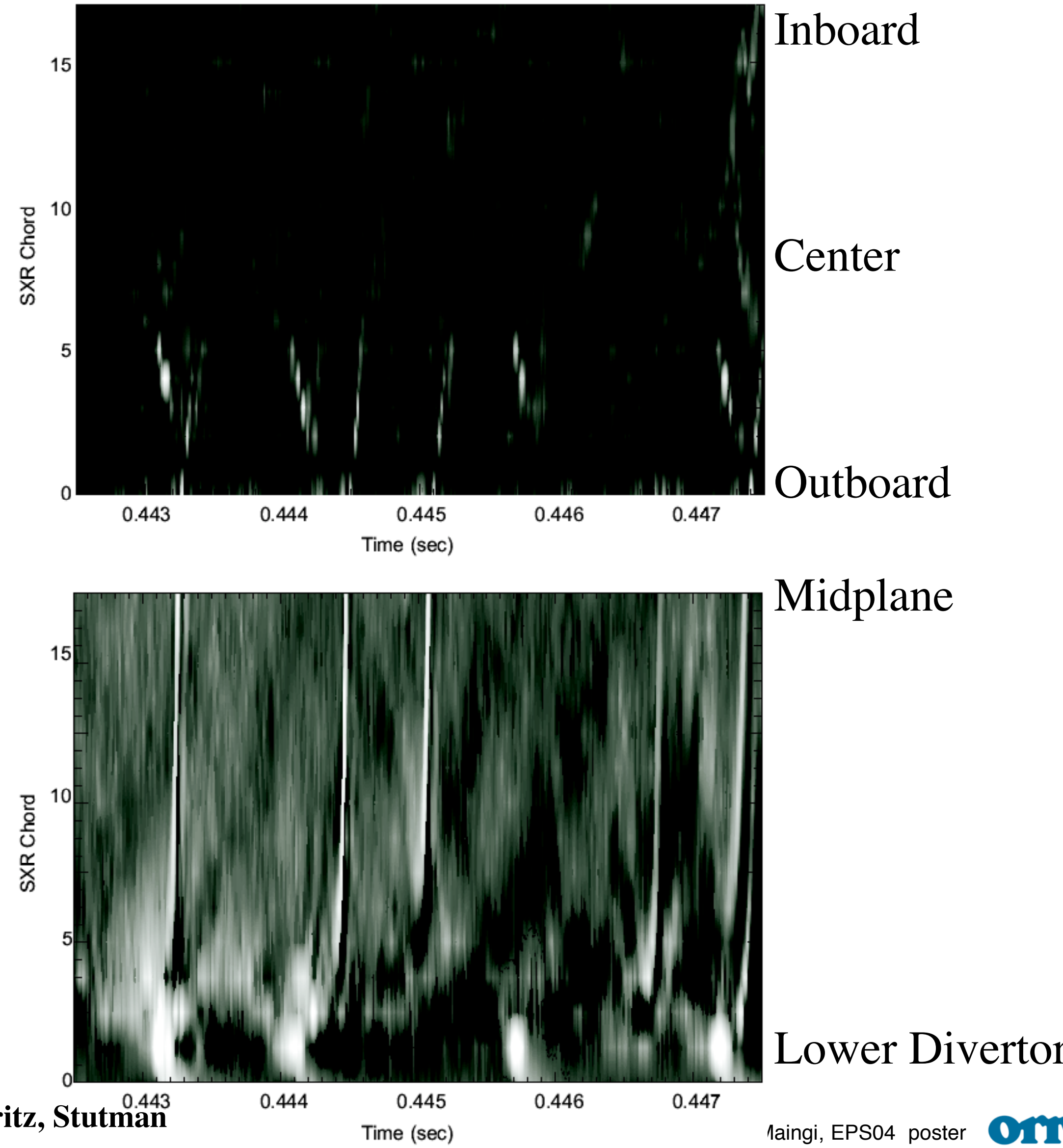
Bottom

Menard

ornl

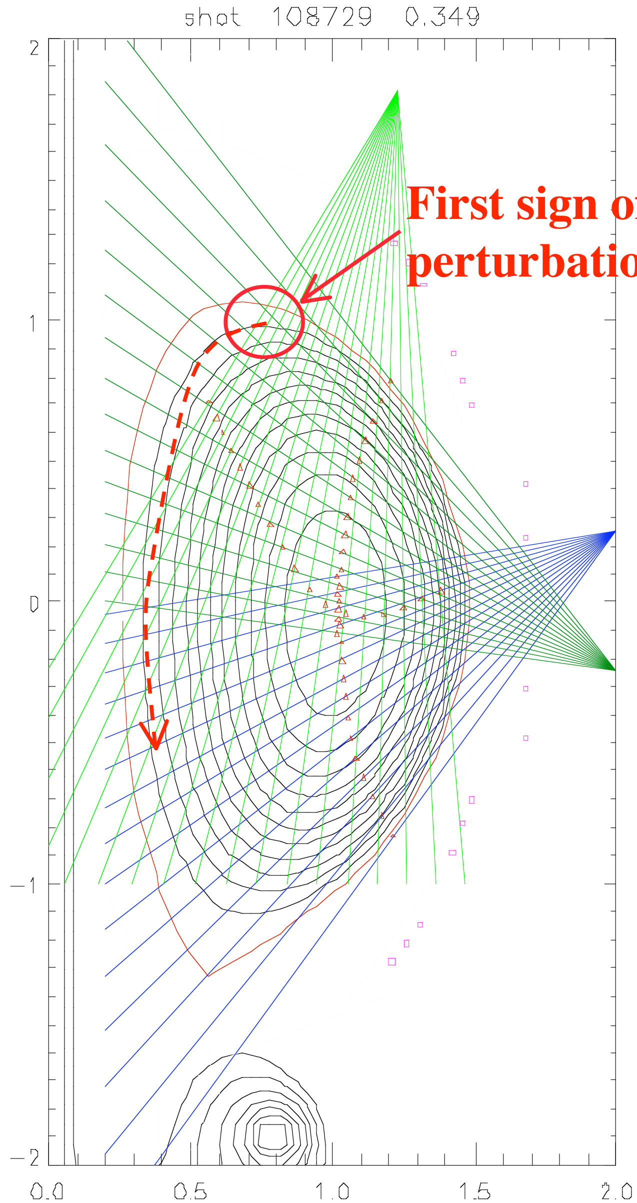
Type V ELMs usually originate in lower divertor region in Ultra-soft X-ray Diagnostic and propagate upward

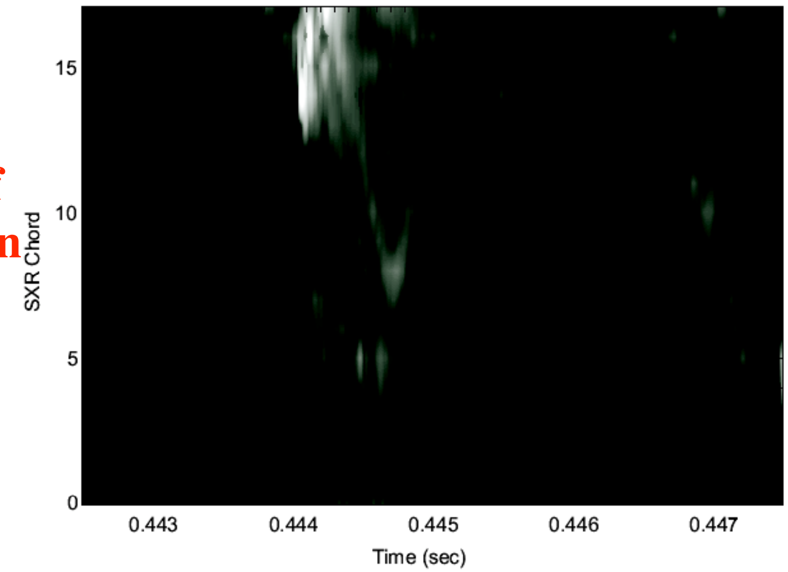




Tritz, Stutman

Type V ELMs occasionally originate near top of machine

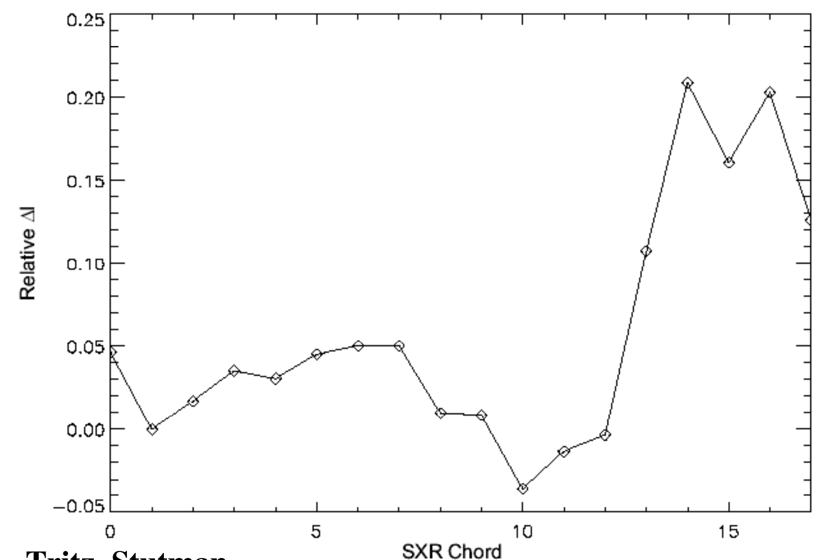




Inboard

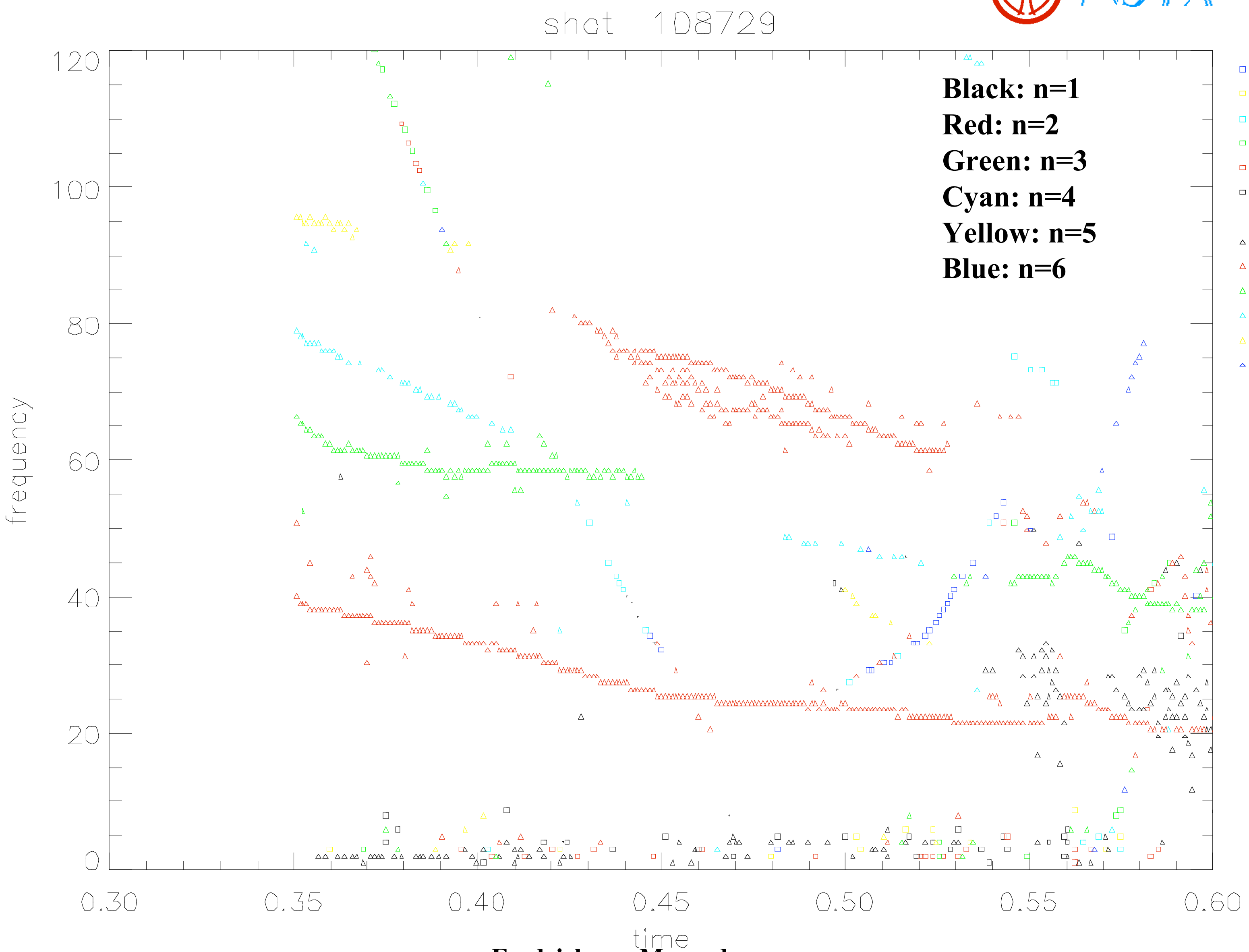
Center

Outboard



Tritz, Stutman

Coherent Modes present in core during type V ELMs, but these persist after ELMs stop



Fredrickson, Menard

Summary and Conclusions

- NSTX has observed ELM from conventional aspect ratio categorizatons
  - Type I or “giant” [ideal ballooning modes]
  - Type III [resistive ballooning modes]
  - Maybe Type II [access to second stability]
- New Type V [physics?]
- Pedestal usually accounts for 1/4 - 1/3 of total stored energy
- Type I ELMs dump ~ 5-10% of total stored energy, and size decreases with increasing density
- High performance regime compatible with type V ELMs

email address for poster copies