H-mode Experiments

Presented by

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H-mode Power Threshold Scaling: Continuation of XP215

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NSTX H-mode operating window.

- Obtained in lower-single null (LSN) and in double null divertor (DND) Obtained with NBI or RF heating, or both.
- Wide range of NBI heating power: 0.32 - 7 MW
- Wide n_e range at transition: 1.5 - 4.8e19 m-3
- Good I_p range: 0.7-1.3 MA (NBI)
- B_t range: 0.3 - 0.6 T
- The β range: $\beta_t = 32\%$, $\beta_p \leq 0.95$
- Duration > 500ms (NBI)
- Power Threshold Studies underway - interesting results
- ELM characterization underway

Main Goals of XP

- Determine the dependence of the NSTX L-H threshold power (P_{th}) on (in order of priority):

  B_t , n , I_p

- Compare the NSTX P_{th} dependence to those for the international H-mode database (IHMDB) :
  - Add the data from the P_{th} study to the (IHMDB).

<u>Secondary:</u>

- Obtain and analyze detailed edge profile data and compare with L-H mode physics models and theories:
  - N_e, T_e, T_i,V_ϕ, fluctuations etc …; ExB paradigm, critical values of edge T_e and T_i.

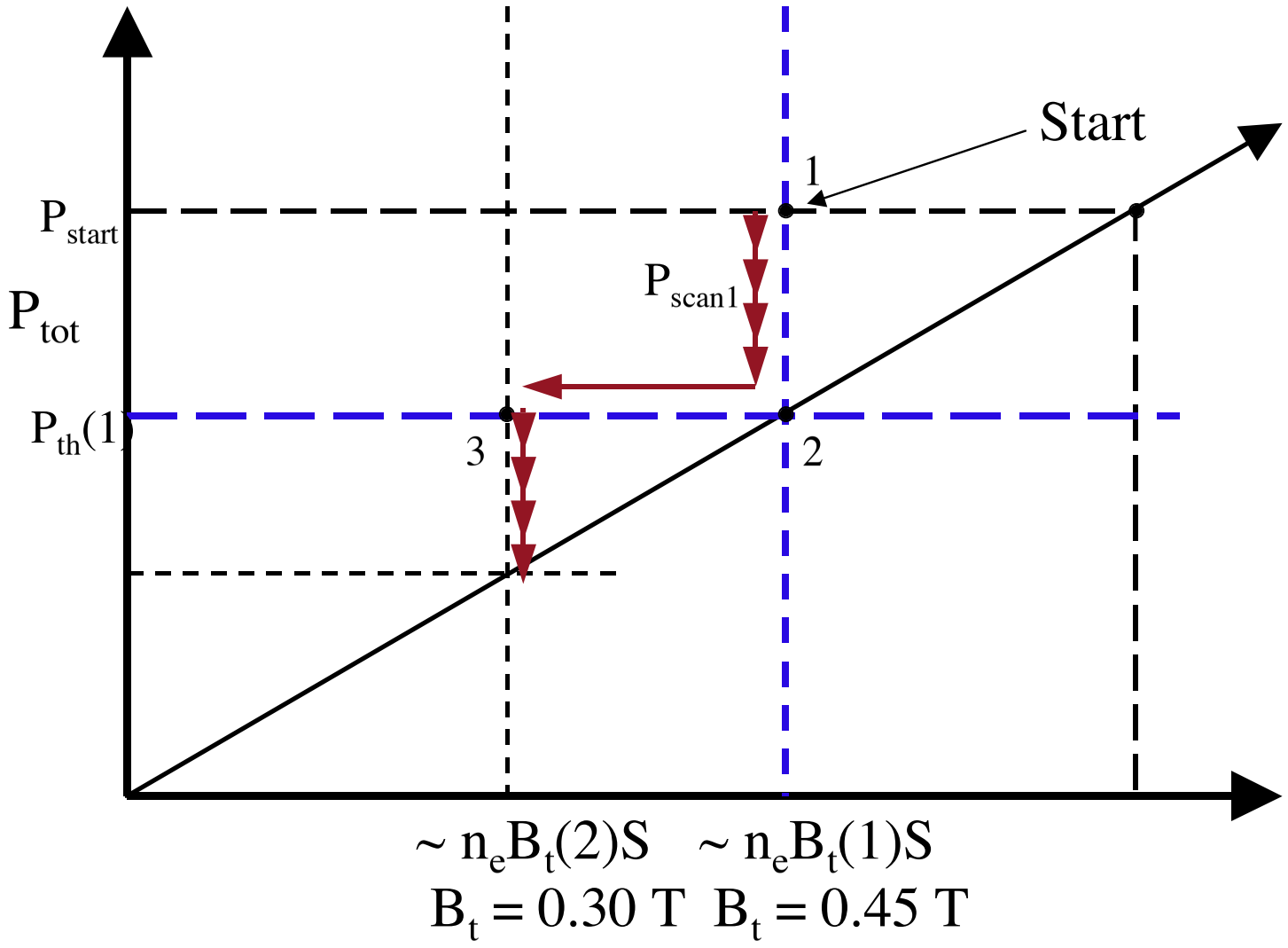
Main Results from XP-215

- XP-215 database of 42 shots, 31 H-modes and 11 L-modes
- Good beginning on I_p and B_t scans
  - Need high Ip point
  - Bt scan partially corruted by presence of Neon (CHERS calib)
- All in LSND configuration
  - But have P_{th} for DND at single I_p,B_t set from XP-227
- Interesting scaling indications
  - Possible P_{th} scaling with I_p
  - Possible non-monotonic dependence on B_t
- Have no density scan data

Expected Results from Continuation of XP-215

- Better documentation for threshold and physics studies: Improved diagnostics
  - MPTS: 60 Hz, 20 channel; CHERS; Edge FireTips
  - Multiple fast fluctuation data: GPI, Probe, Reflectometers (UCLA,ORNL)
- Must make contact with previous run (after “Good” bakeout)
- Obtain Pth at high Bt
  - Last run Bt scan was corrupted by Neon presence
- Obtain P_{th} at high I_p
- Do density scan for the first time (low, med, high)

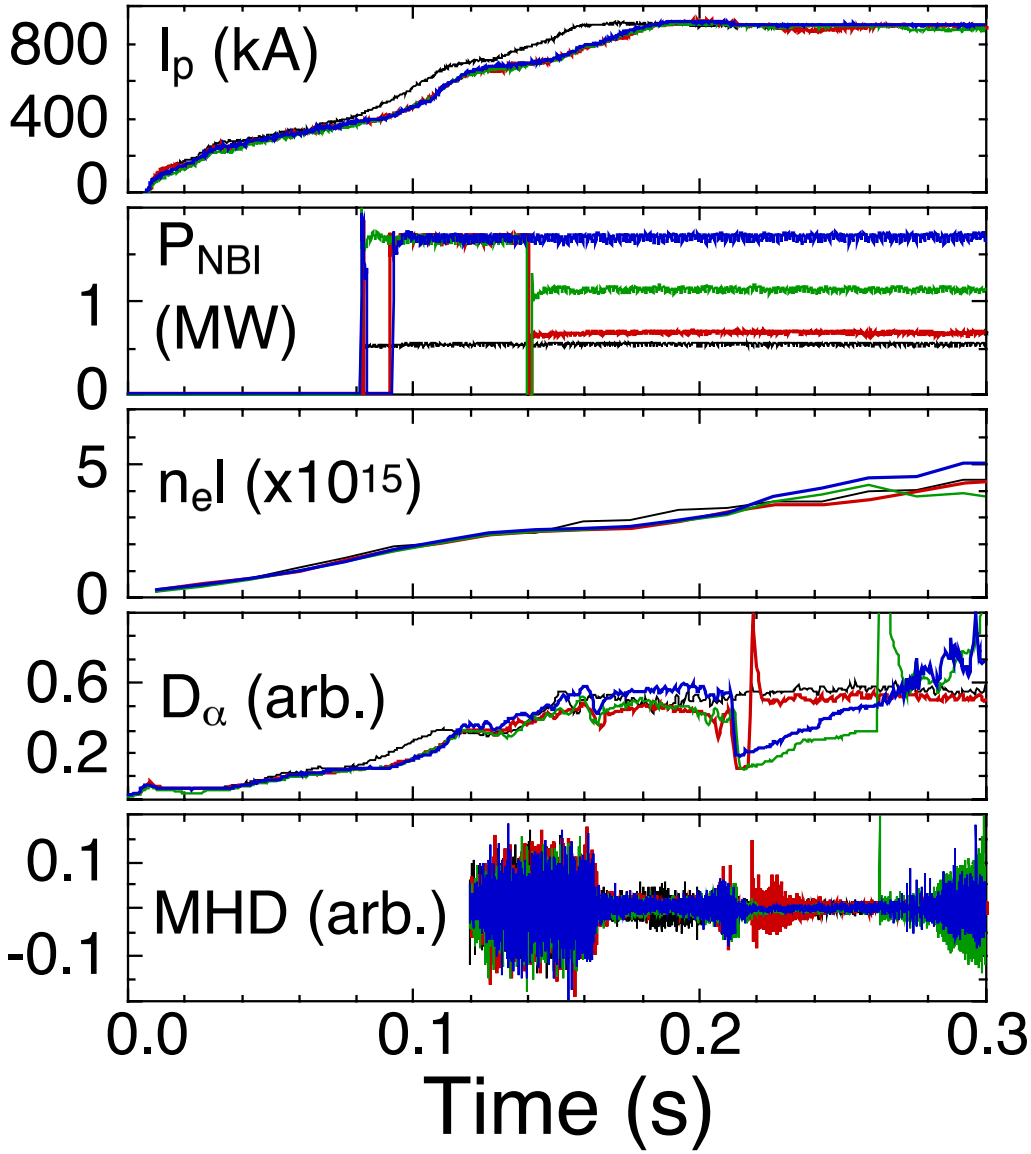
Scheme for parameter scans



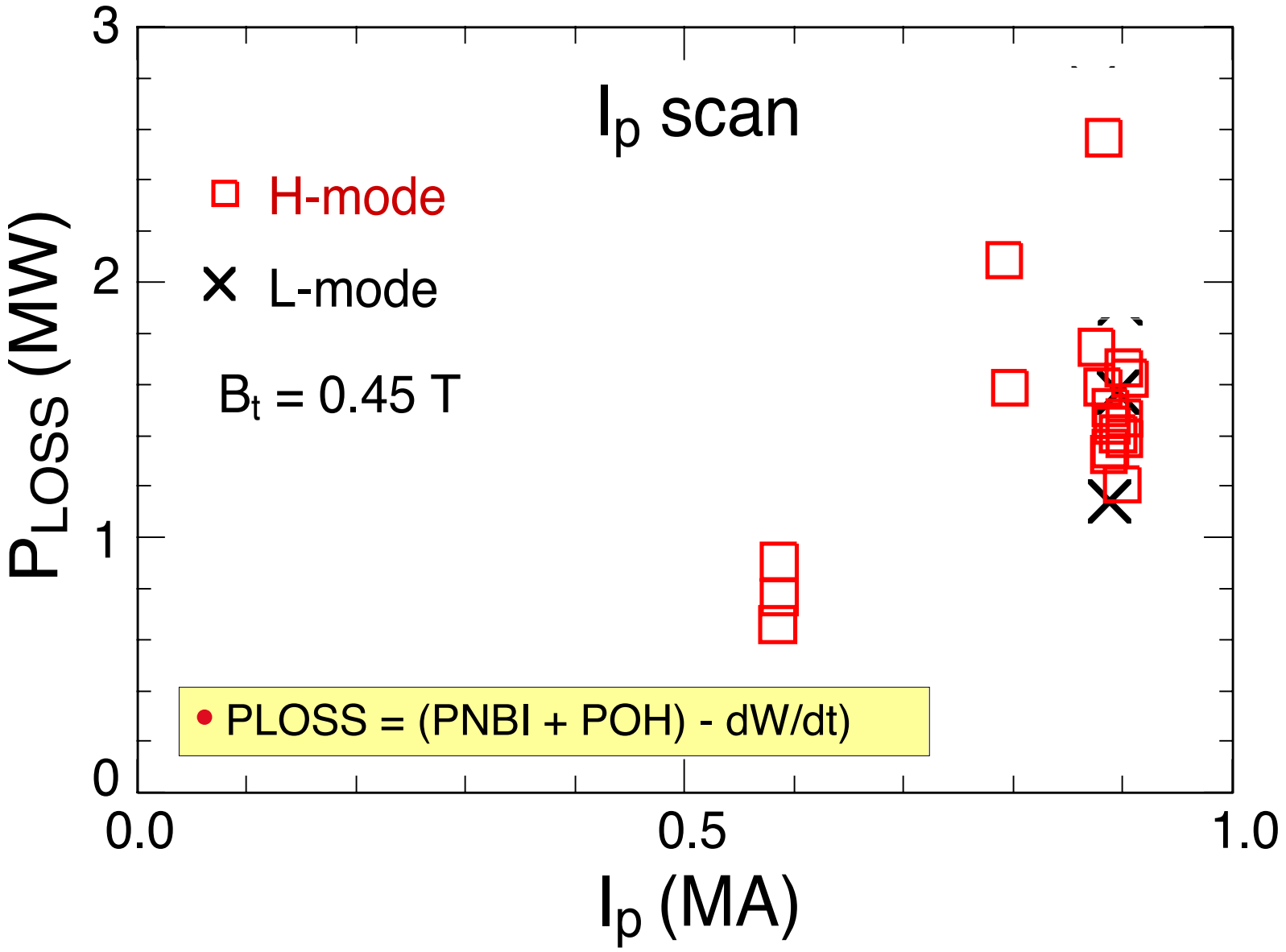
$$P_{thITER}\ (MW) = 0.54 \bullet n_e^{0.49} \bullet B_t^{0.85} \bullet S^{0.84}$$

Threshold Powers (Pth) Obtained using Parameter and Configuration Scans

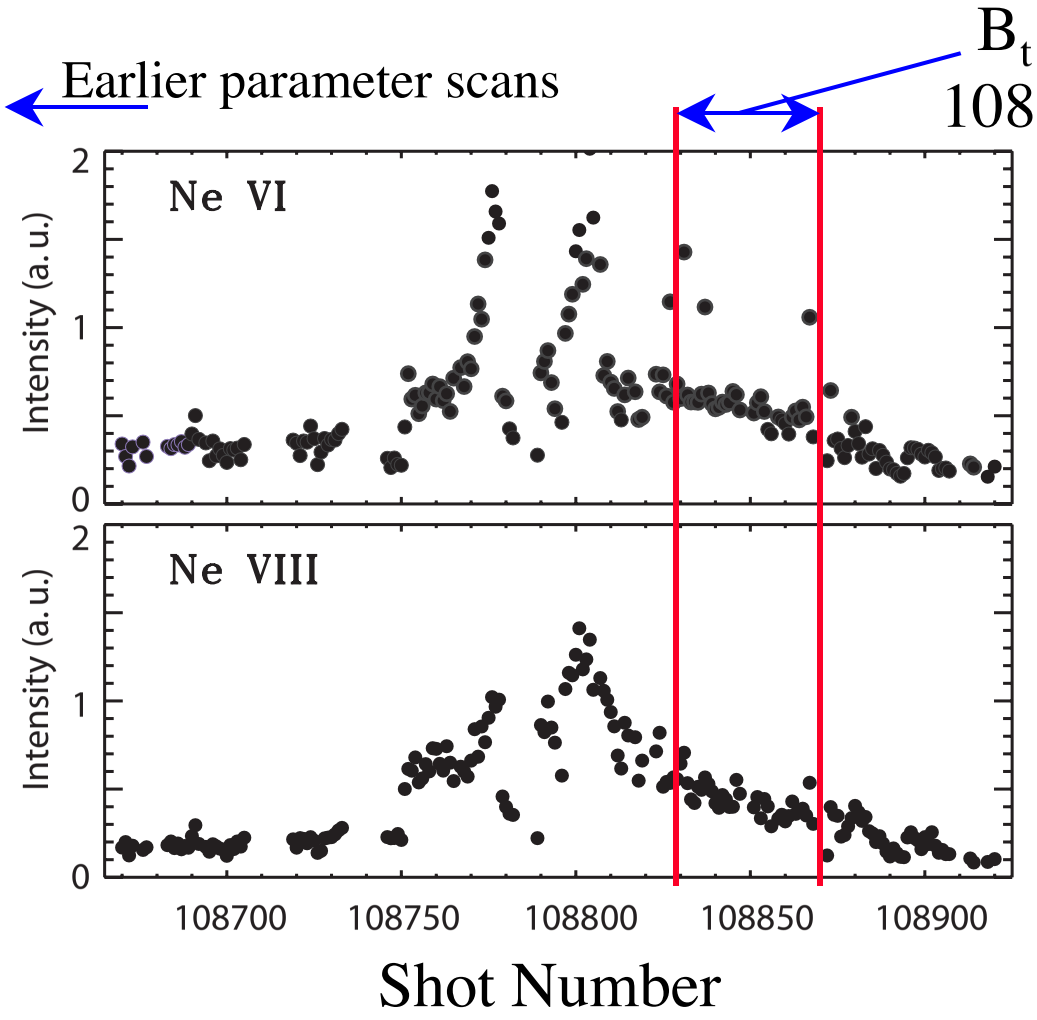
- H-mode studies with
  - Pb, Ip, Bt scans
  - Configuration scans
  - Inner Gap scans
- Here Bt = 45 kG, Ip = 900kA
  - Pb(@Pth) = 530 kW
  - Note: L-H transition at
  - the same time for all Pb
- At Bt = 45 kG, Ip = 600 kA
  - Pb(@Pth) = 315 kW
  - ==> Lowest Pth to date



L-H Threshold Study Shows Possible I_p Dependence of P_{th}



The B_t Scan was Corrupted by Presence of Neon



Earlier scans Between 107650 -108495

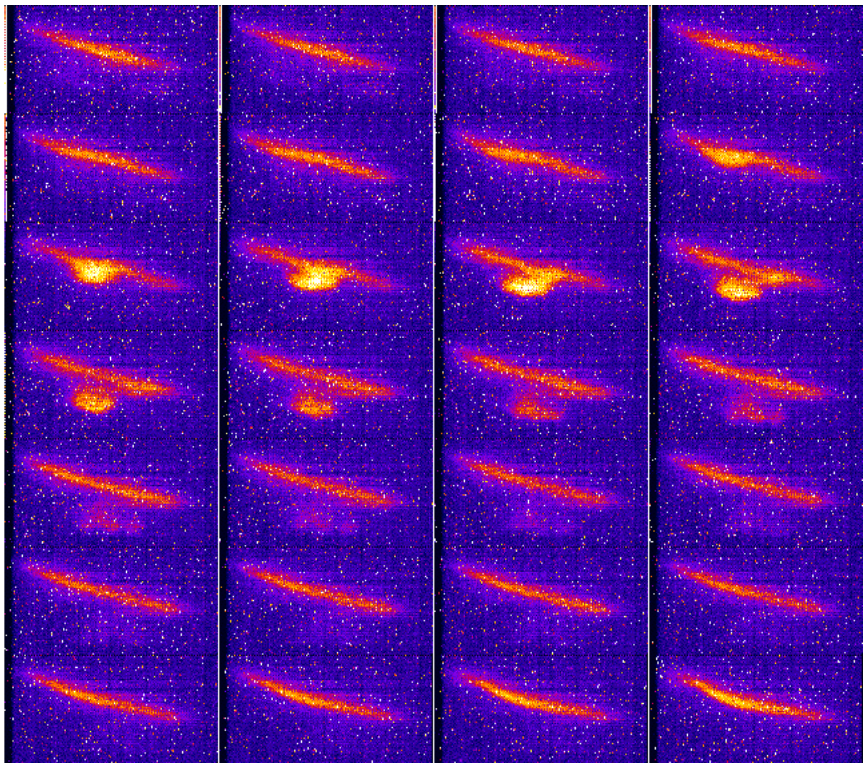
V.Soukhanovskii

- Bt scan shots: 108830 - 108868

Examples of Gas Puff Images of H-mode

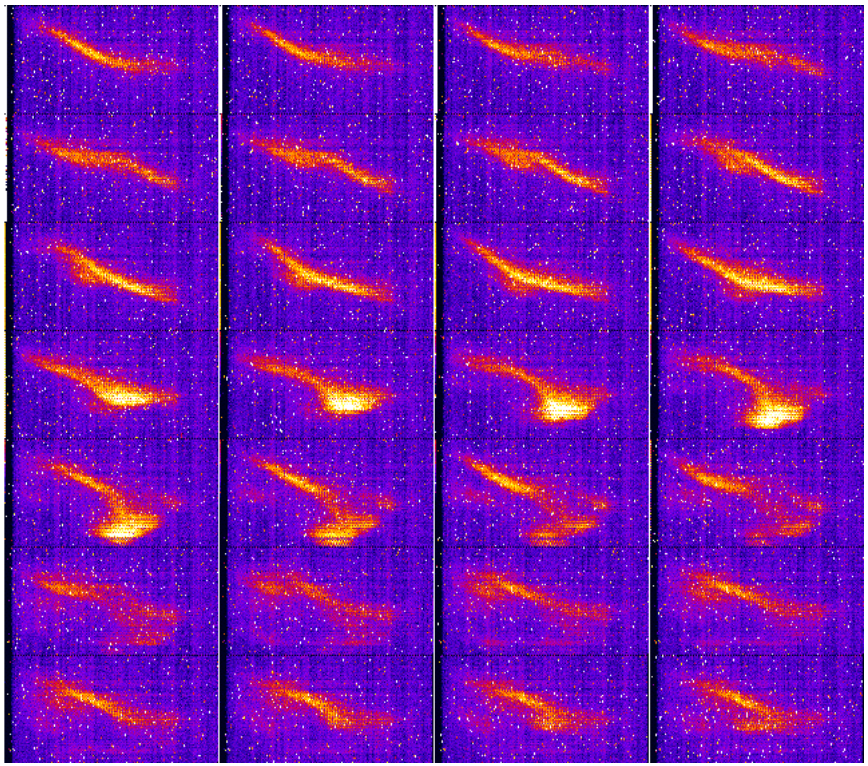
H-mode with blob

NSTX Shot # 108587, 100 kHz, 1000 kA, 4.5 kG, He



Wavy H-mode with blob

NSTX Shot # 108466, 100 kHz, 900 kA, 4.5 kG, He



- for more examples see http://w3.pppl.gov/~szweben/psi/

Expected Results fromContinuation of XP-215

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END
of Power threshold studies

ELM Characterization on NSTX: Continuation of XP227

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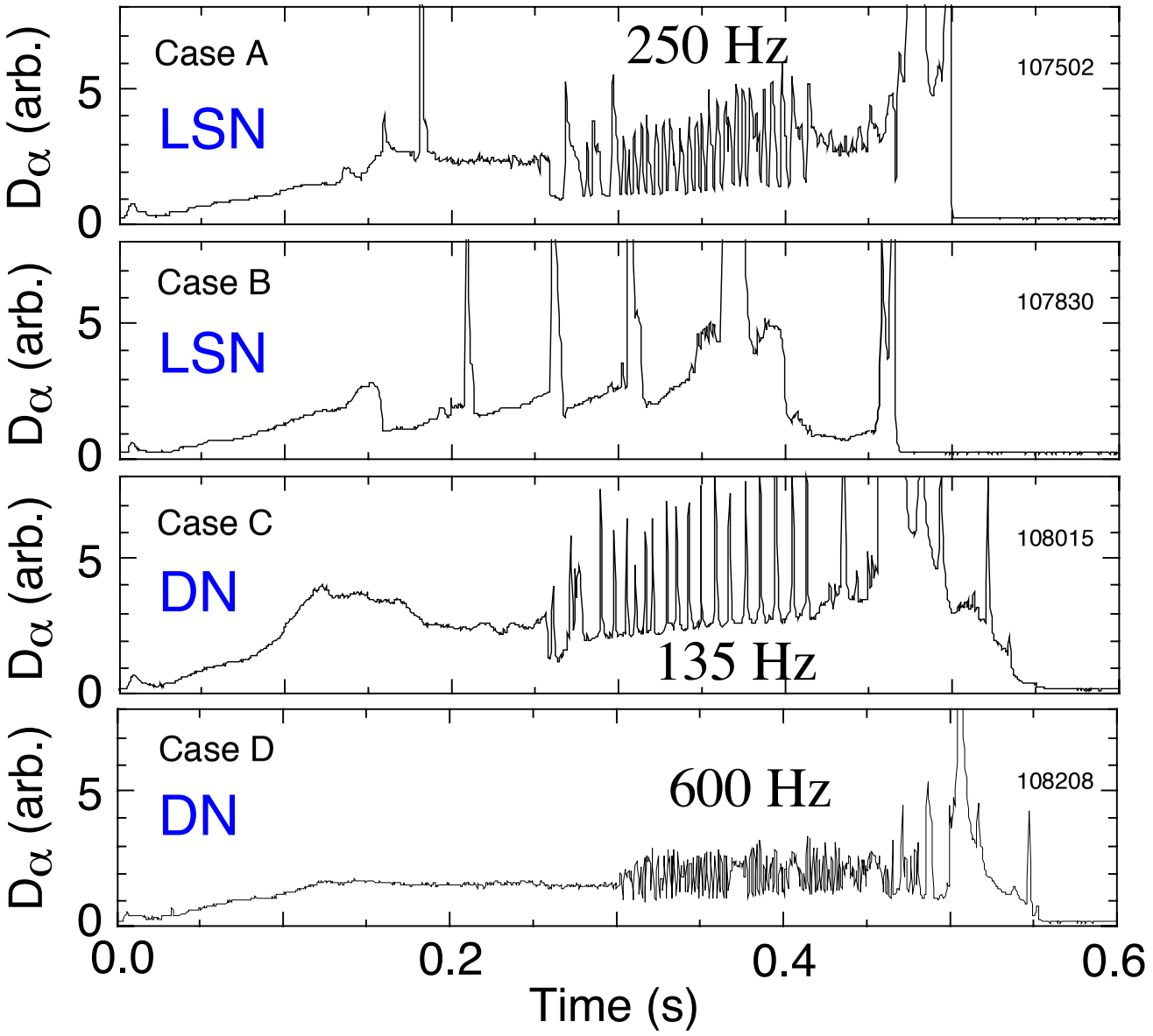
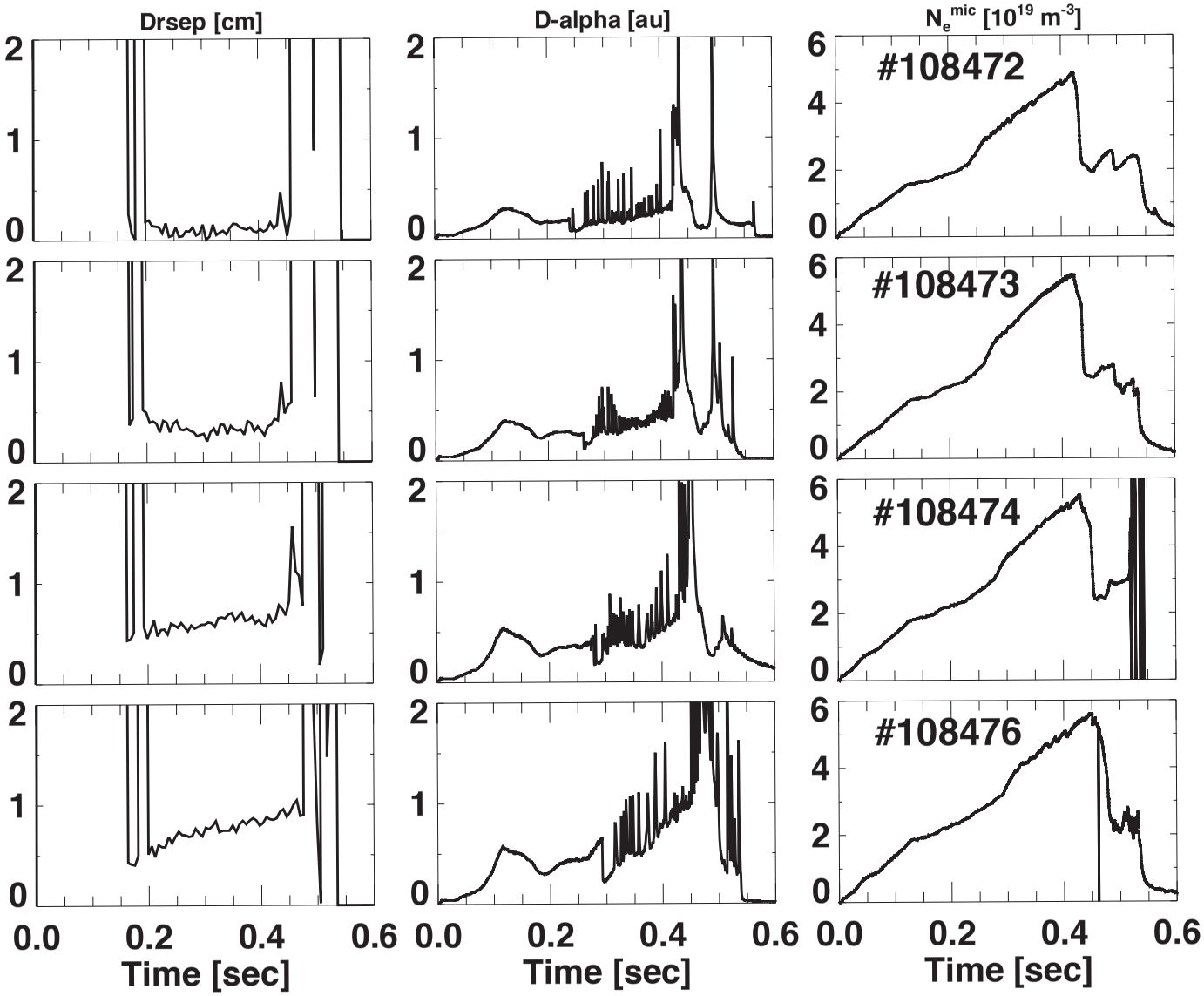
Wide Spectrum of ELM Characteristics Realized on NSTX

- Variety of ELM behavior observed in NSTX:

- From Grassy to Giant ELMs to ELM-Free
- Long Pulse ELM-free and ELMy (> 500 ms)
  -- Steady-state ELMY possible
- ELMs w/DN and LSN
- ELMs w/NBI and RF
- Precursors? -Possibly seen by GPI
- Frequency: from < 135 Hz to > 600 Hz

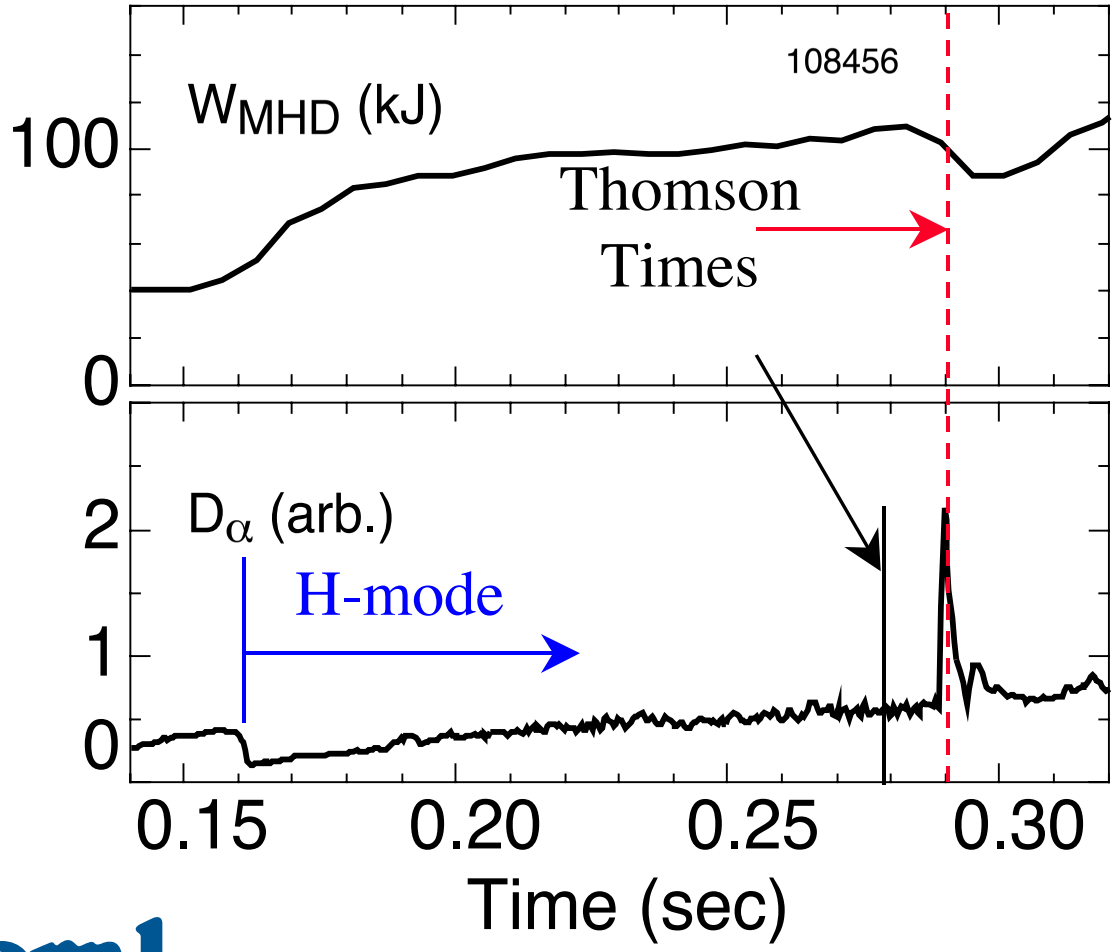


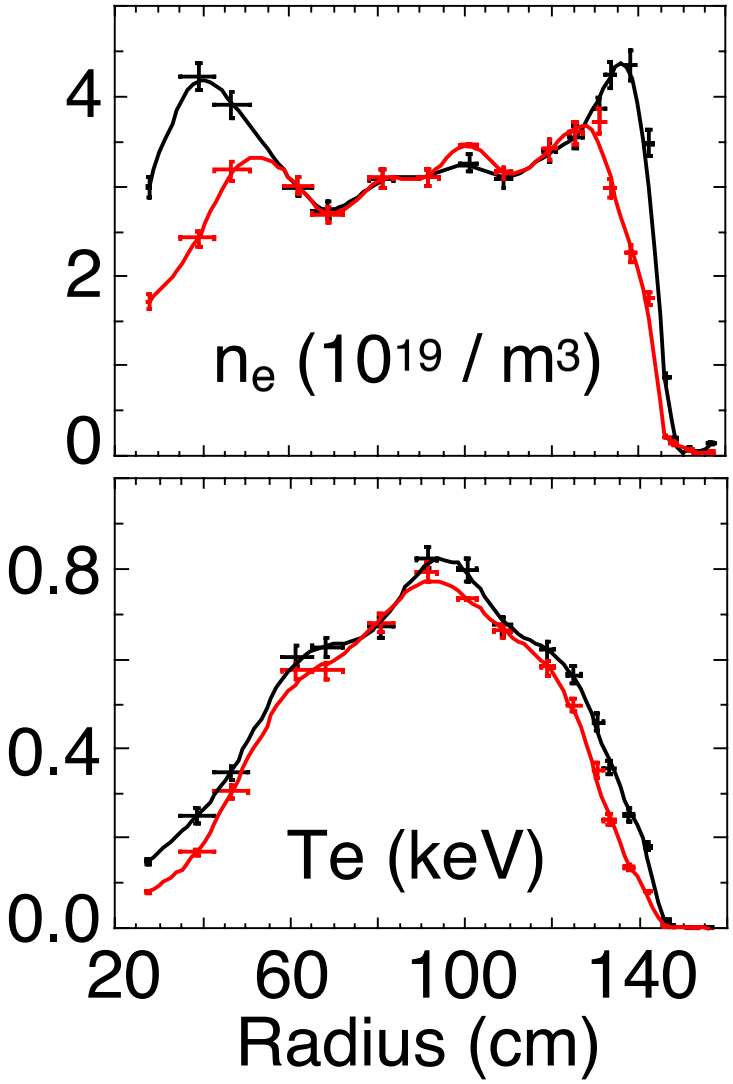
The Divertor Configuration Affects the Transition and the ELM Behavior in NSTX



Large ELMs dump edge plasma and effect is radially deep into plasma

- Effect to r/a ~ 0.4, edge Δne/ne > 50 % observed. Can return to sustained L-mode.

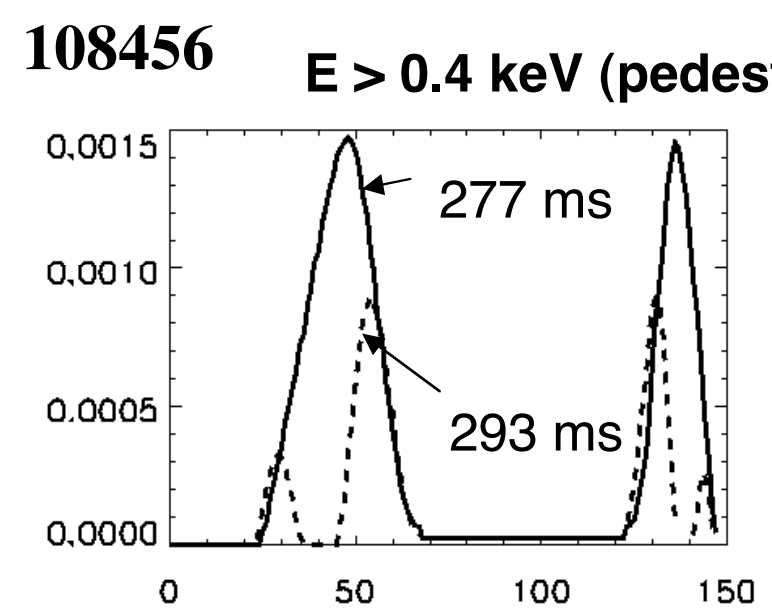


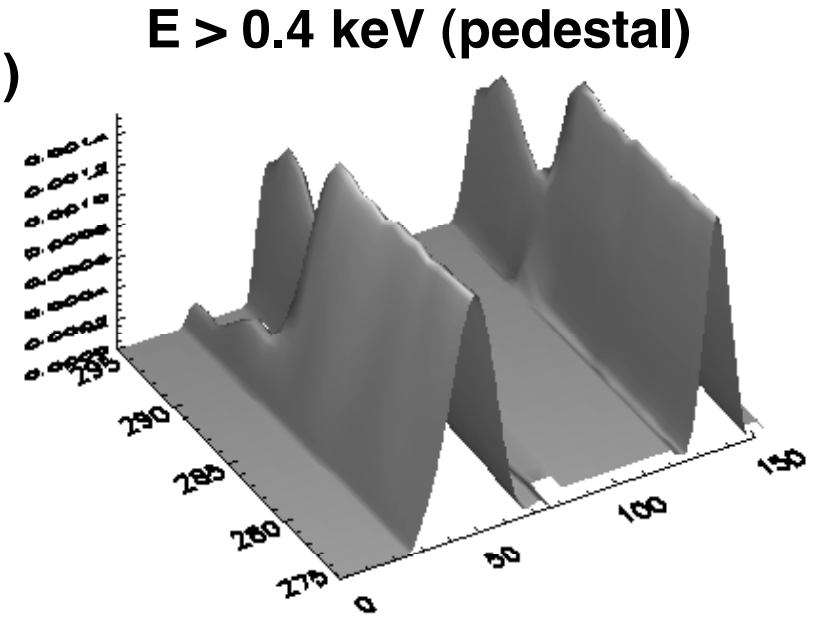


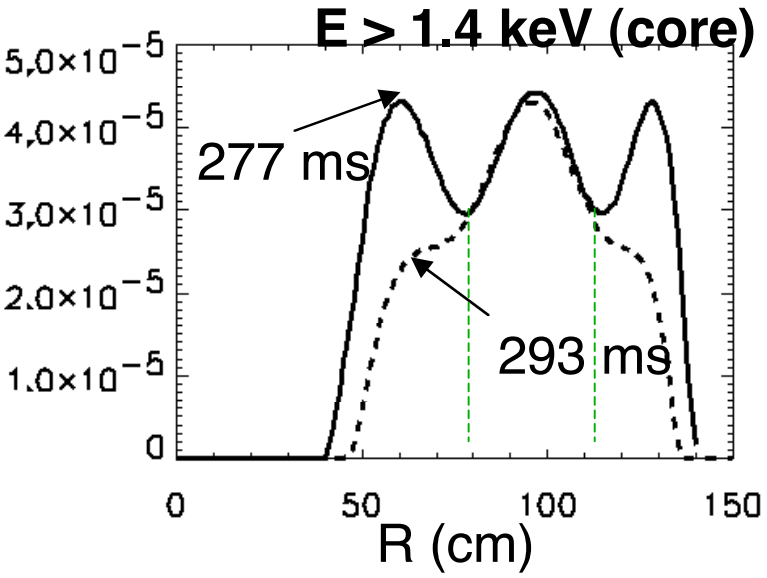
ornl

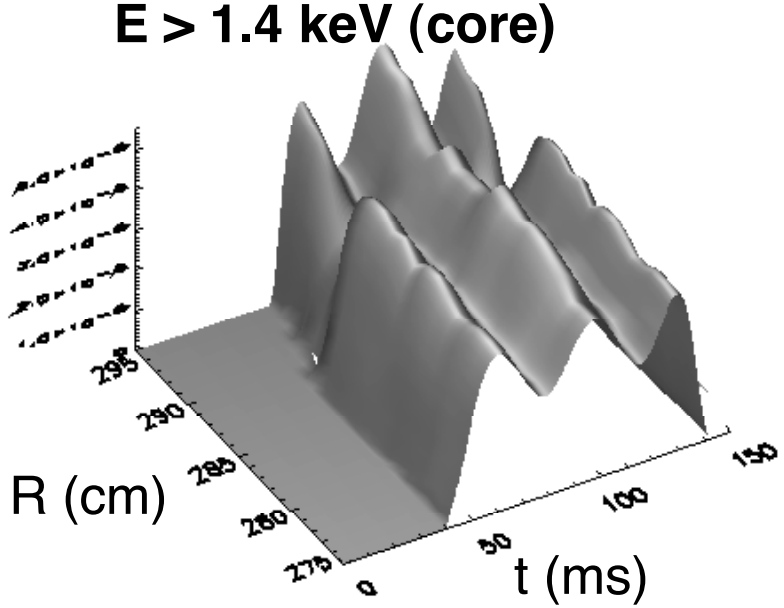
Large ELM effects extend deep into core

108456







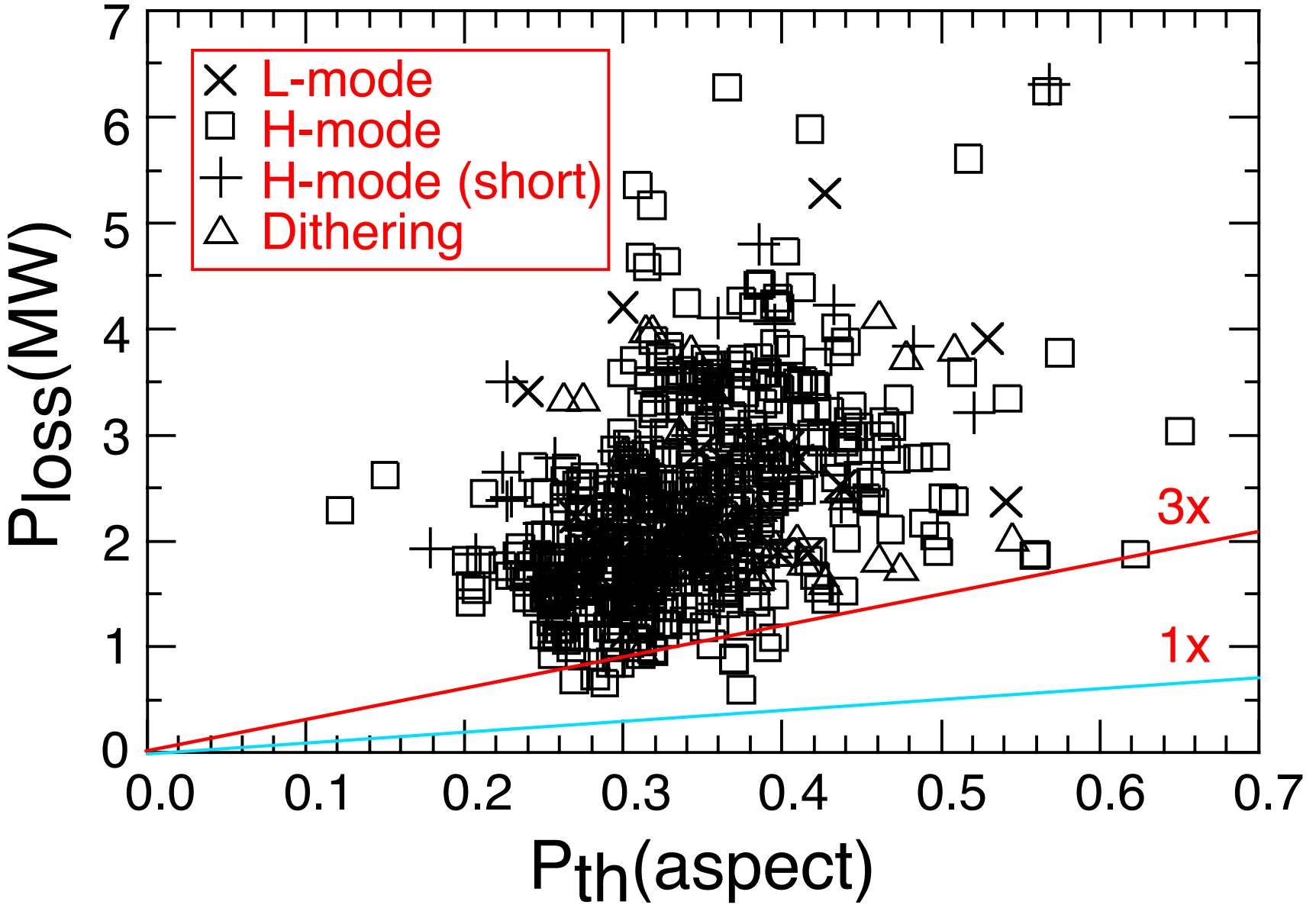


• large crash in high energy emissivity (highly sensitive to temperature) extends to $r/a \approx 0.3$

What ELM Information is Needed?

- **Characterization of parameter changes :**
  - Scaling of energy loss per ELM, Δn, ΔT, etc .. (already started)
  - Radial extent of ELM perturbation - Large, Med, Small ELMs
  -

- **Understand difference in ELM behavior with Divertor Configuration:**
  - Complete the Drsep scan - Go from DND to SND (already started)
  - Why DND ELM readily but SND does not?
  - Why there is a very narrow access window for Giant ELMs?

- **Needs for APS Invited Talk:**

The NSTX H-mode Database Contains more than 500 shots following the "Good" bakeout