ELM Physics in NSTX - Onset and Characteristics

C. E. Bush[1], R. Maingi[1], S. Kaye[2], S. Zweben[2], R. Maqueda, S. Kubota, V. A. Soukhanovskii, and D. Stutman

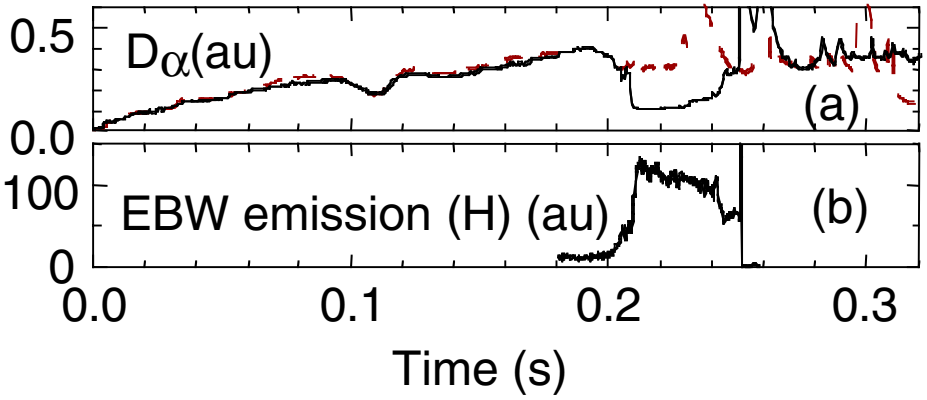
1. Oak Ridge National Laboratory
2. Princeton Plasma Physics Laboratory

NSTX Research Forum
Princeton Plasma Physics Laboratory
Princeton, November 28-30, 2001

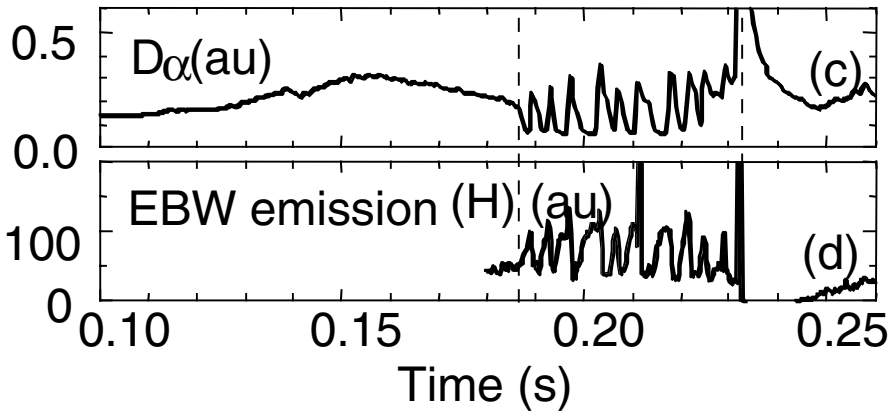
Want to classify ELMs in "conventional" Types: I, II, III

- ELM-free and ELMy H-modes observed in NSTX:

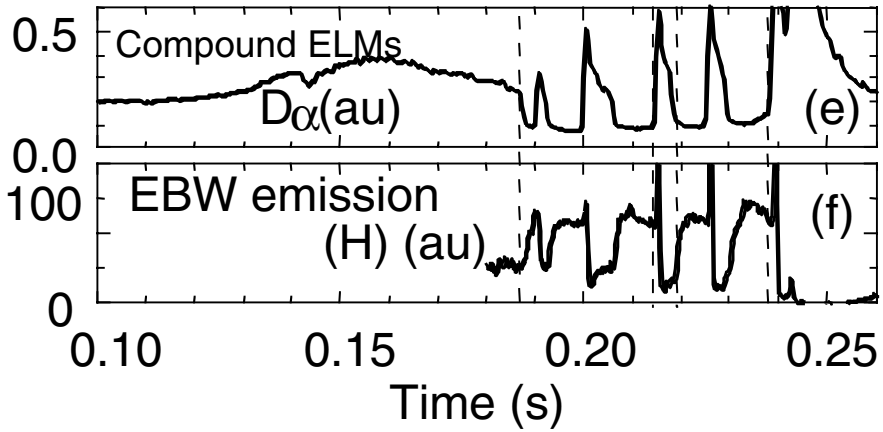
ELM-free



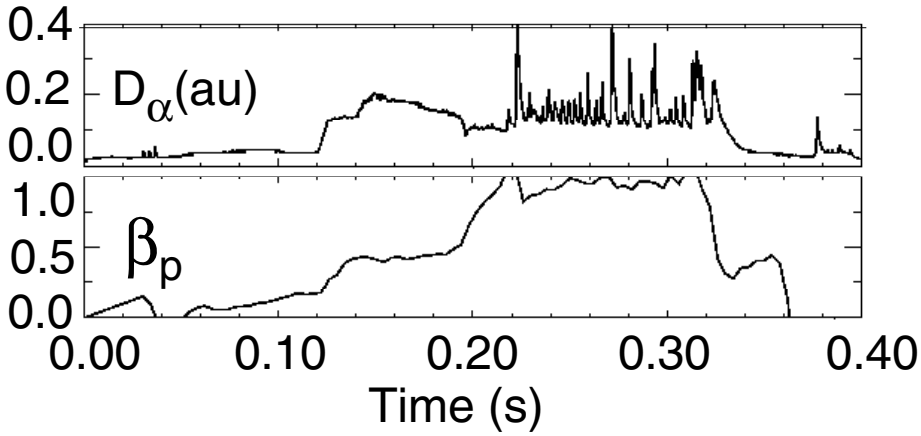
Small ELMs



Large ELMs

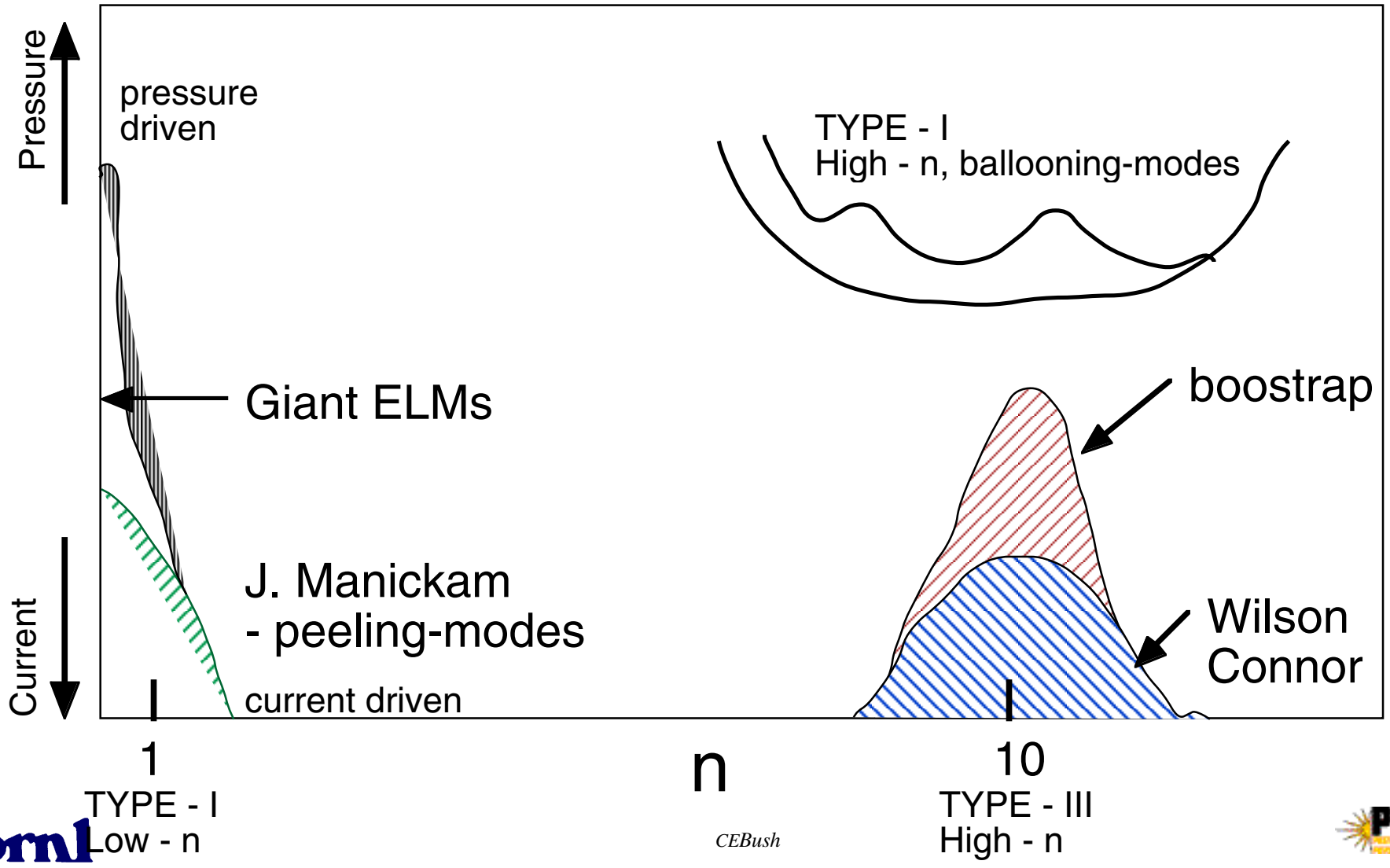


Grassy ELMs (RF)



ELM models are the peeling mode and the high n ballooning-mode

- Type I can be low n kink (peeling); Type III, ballooning



Conventional Tokamaks: Difference Between ELM Types I, II, III

- Type I: $P_{heat}/P_{th} >> 1$, $\nu_{ELM} \uparrow$ with P_{heat}/P_{th}
- Type II: DIII-D, $s/q^2 \leq 0.1$, (high S)
- Type III: $P_{heat}/P_{th} \geq 1$, $\nu_{ELM} \downarrow$ with P_{heat}/P_{th}

Experiment:

Create ELMy H-modes with NBI and or RF

Document ELM behavior based on

- ν_{ELM} dependence on P_{heat}
- Magnetic pre-cursor signals

Goal: Use ELMs as Tool

- Optimize discharge for long ELM free duration
- Controlled ELM trigger based on earlier experiments type-classifying ELMs
  — Flush plasma of impurities
- Change gas puffing, now have several different positions for gas puff.
- Time to divert has effect on getting ELMy or ELM-free.

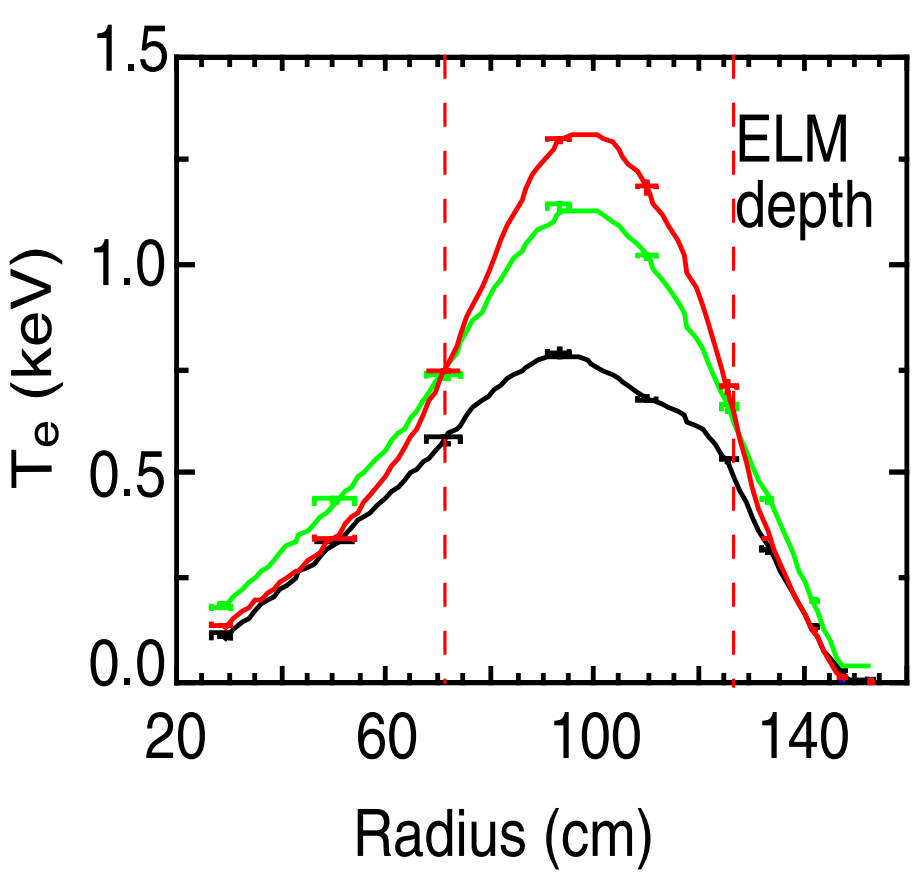
Review and Motivation

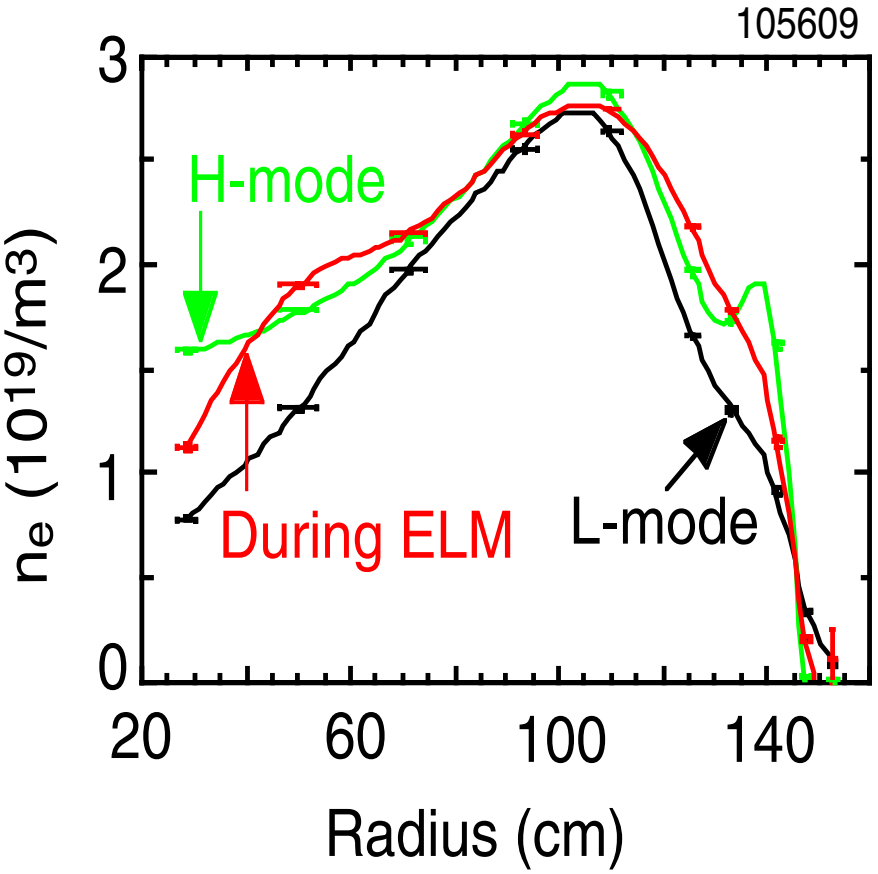
- ELMs obtained first time when LSND formed early.
  — Does this imply pressure profile / q combination?
- NBI heated H-modes often ELM-free; RF: ELMy.
  — Heating type/profile/stability connection?
  — Variety of ELM behavior observed
- Must characterize ELMs and edge pedestal in low aspect ratio device.
  — Expand present ELM database.
- Additional and improved edge diagnostics now available.
- Compare ELMs in NSTX with MAST, DIII-D, and theory.

Experiments on ELMs and Edge Pedestal

- Obtain an ELMy H-mode (NBI alone, RF alone)
  - vary power, study effect on ELMs
  - vary n_e at fixed power
- Perform a controlled turn on of ELMs in ELM-free Shot
- Do NSTX ELMs fit in the DIII-D Types I, II, III ?
- Stability studies
  - peeling or ballooning model? - high n?
  - diagnose edge pedestal in detail: profile/turbulence
  - analysis: apply stability codes.
- ELM effect on impurity accumulation
  - radial extent of ELM effect
- Turbulent fluctuations during and between ELMs

The Edge Peak goes away at ELM, but returns Between ELMs. Large ELMs Reach Deep Inside Plasma.





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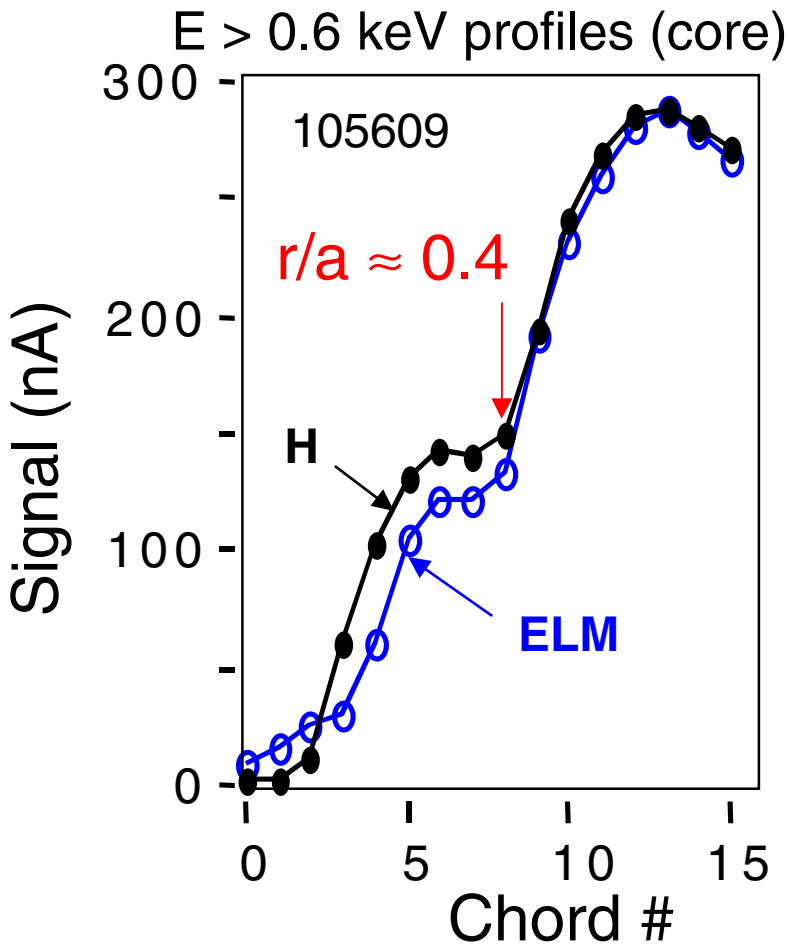
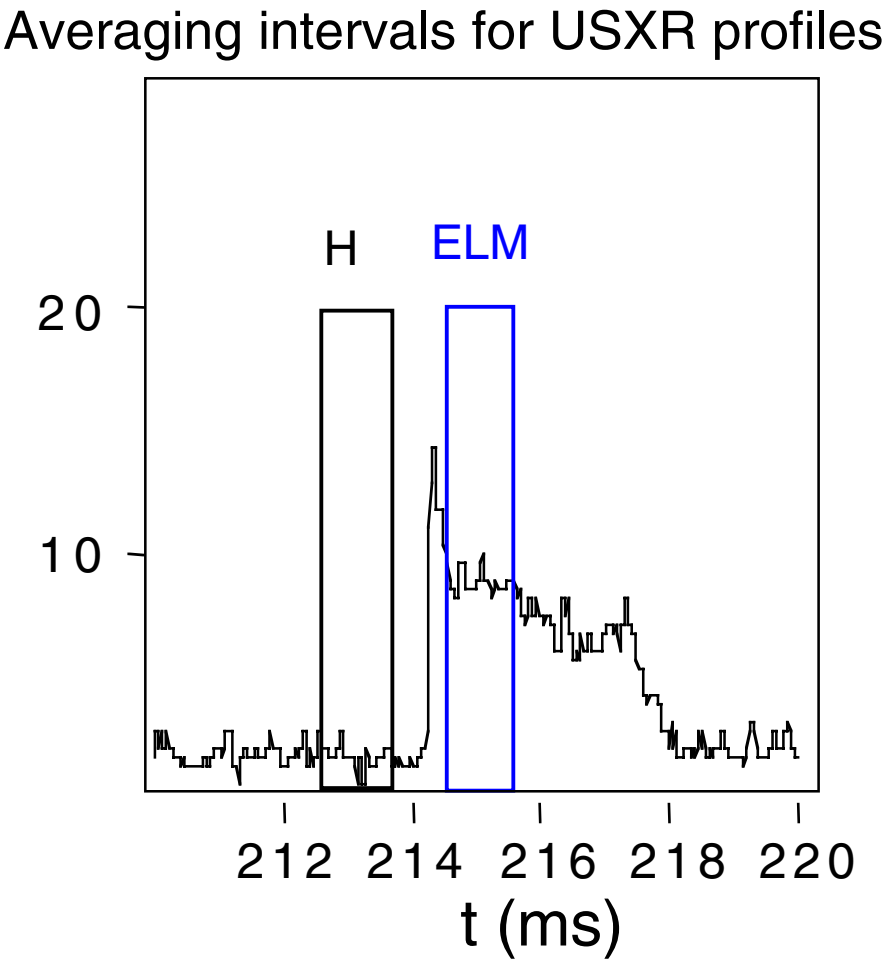
Profiles from the Ultra Soft X-ray Array also Shows Effect of ELMs can Reach Deep into the Plasma to r/a ≈ 0.4

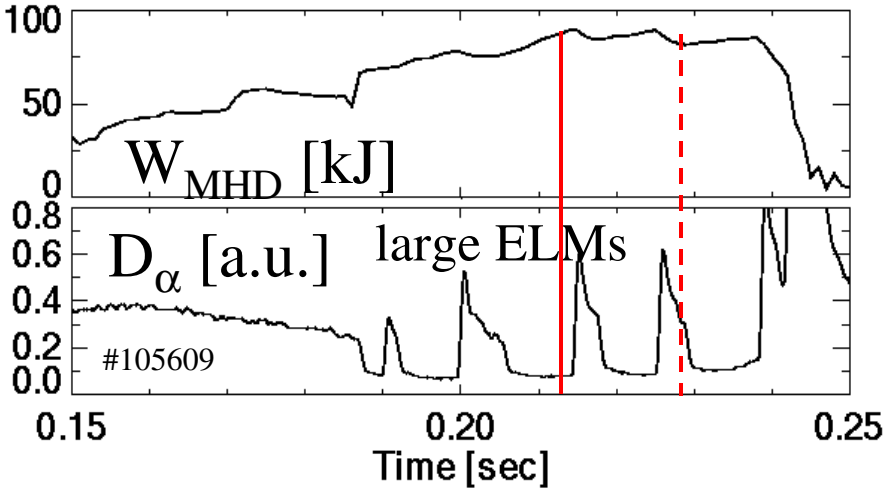


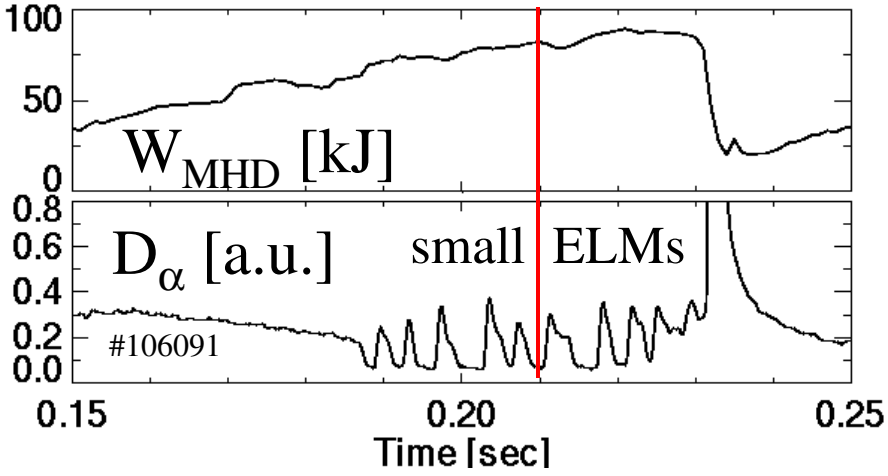


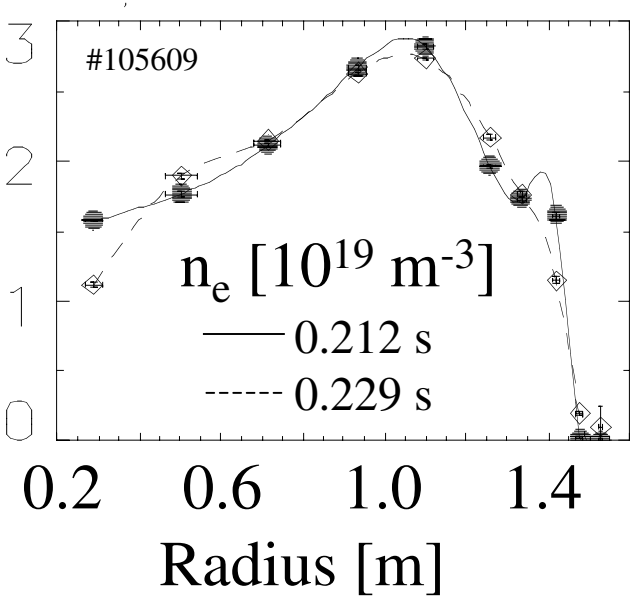
- Inside r/a ≈ 0.4, the profiles are not affected by the ELM (the effect may not be as deep for smaller ELMs).

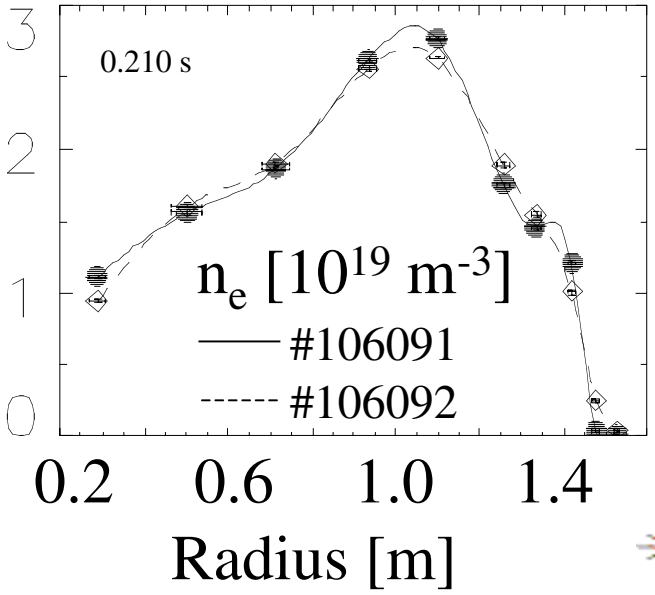
D. Stutman

Large and small ELMs observed in NSTX

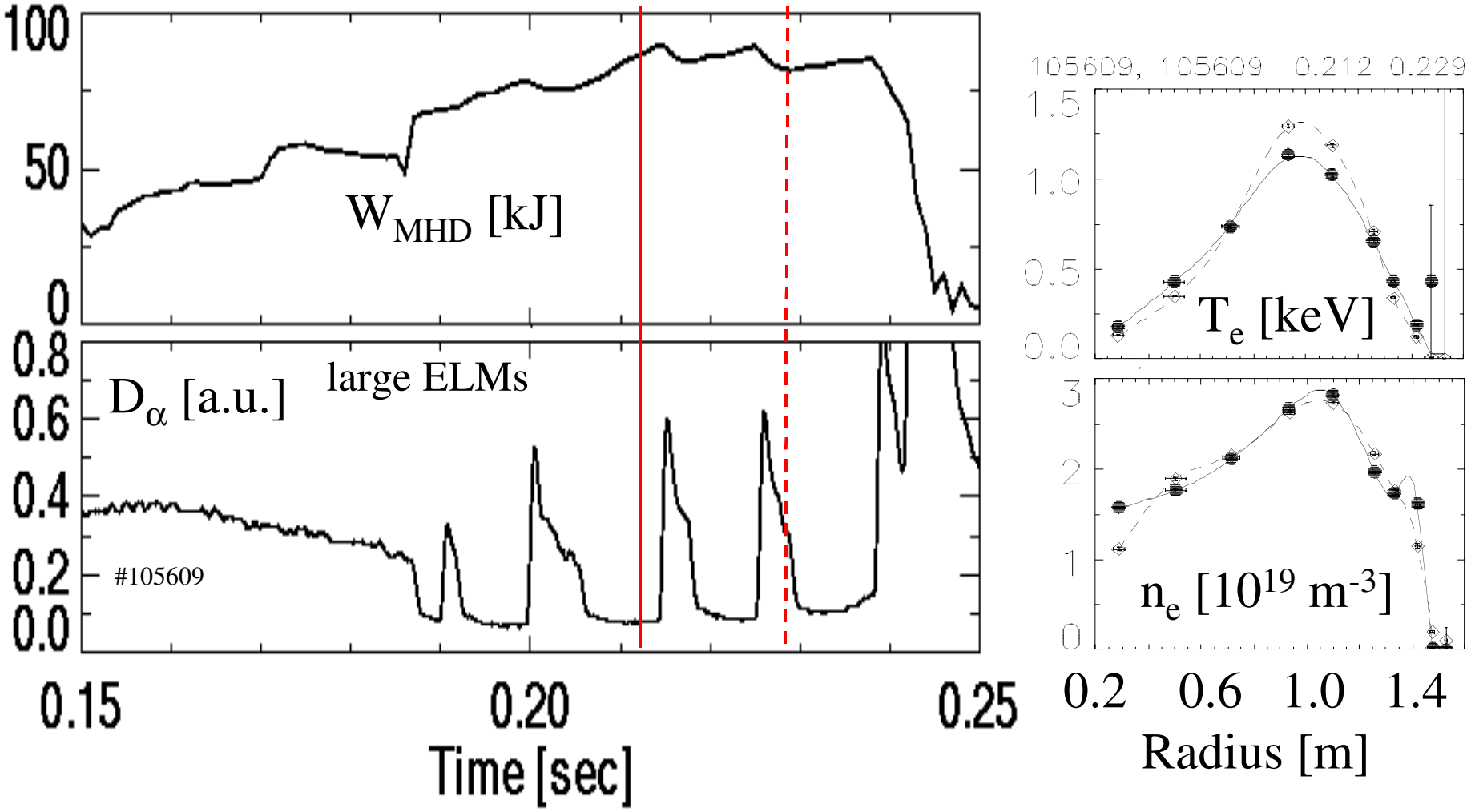




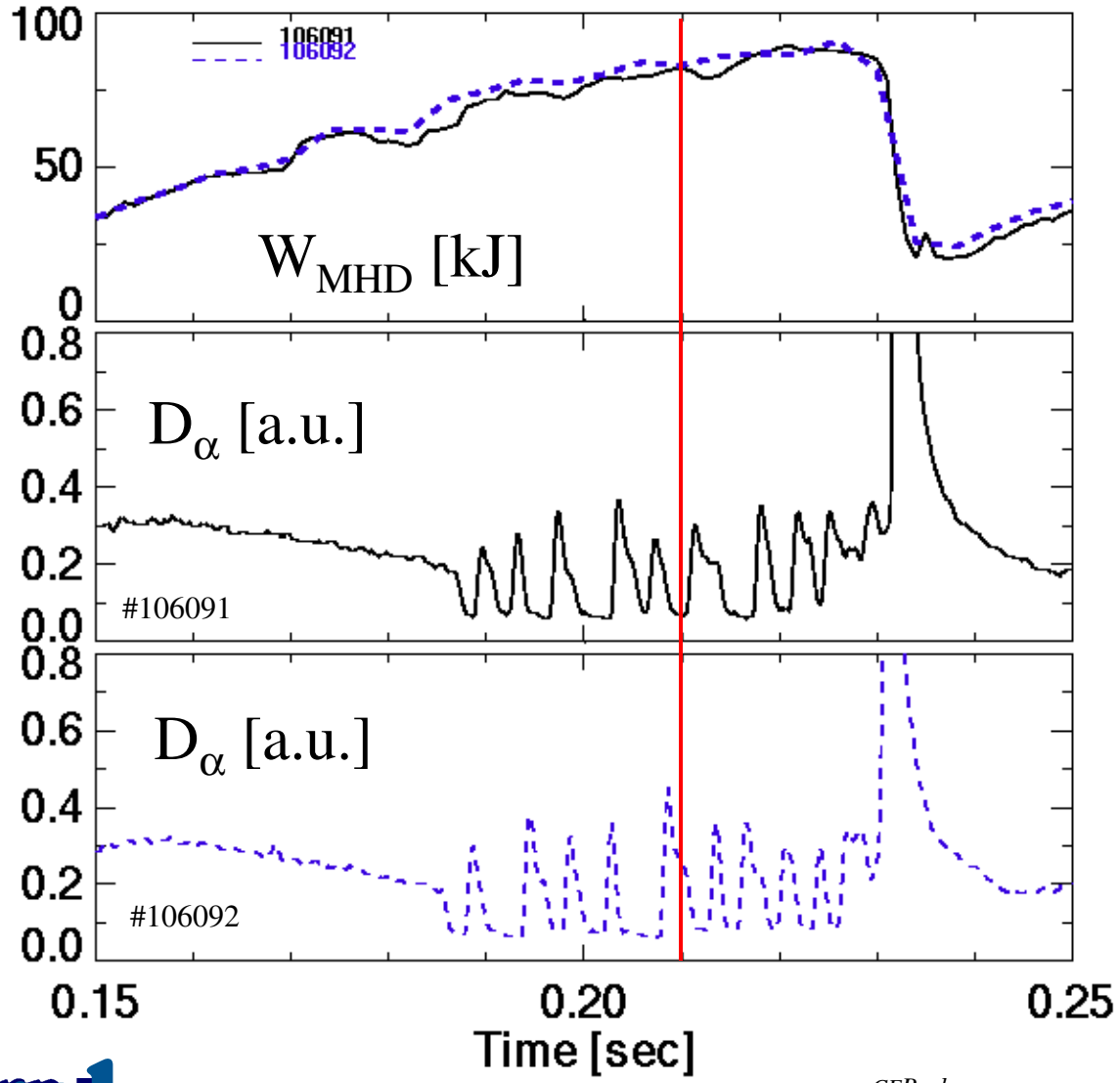


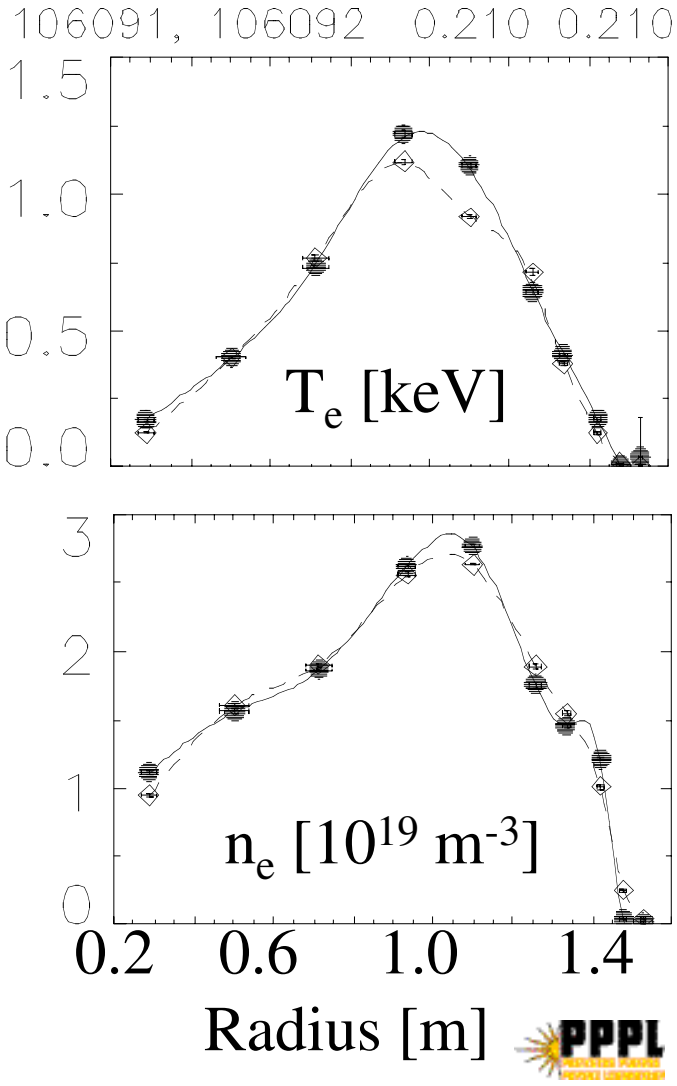


Large ELMs affect profiles deep into plasma - return to L-mode?

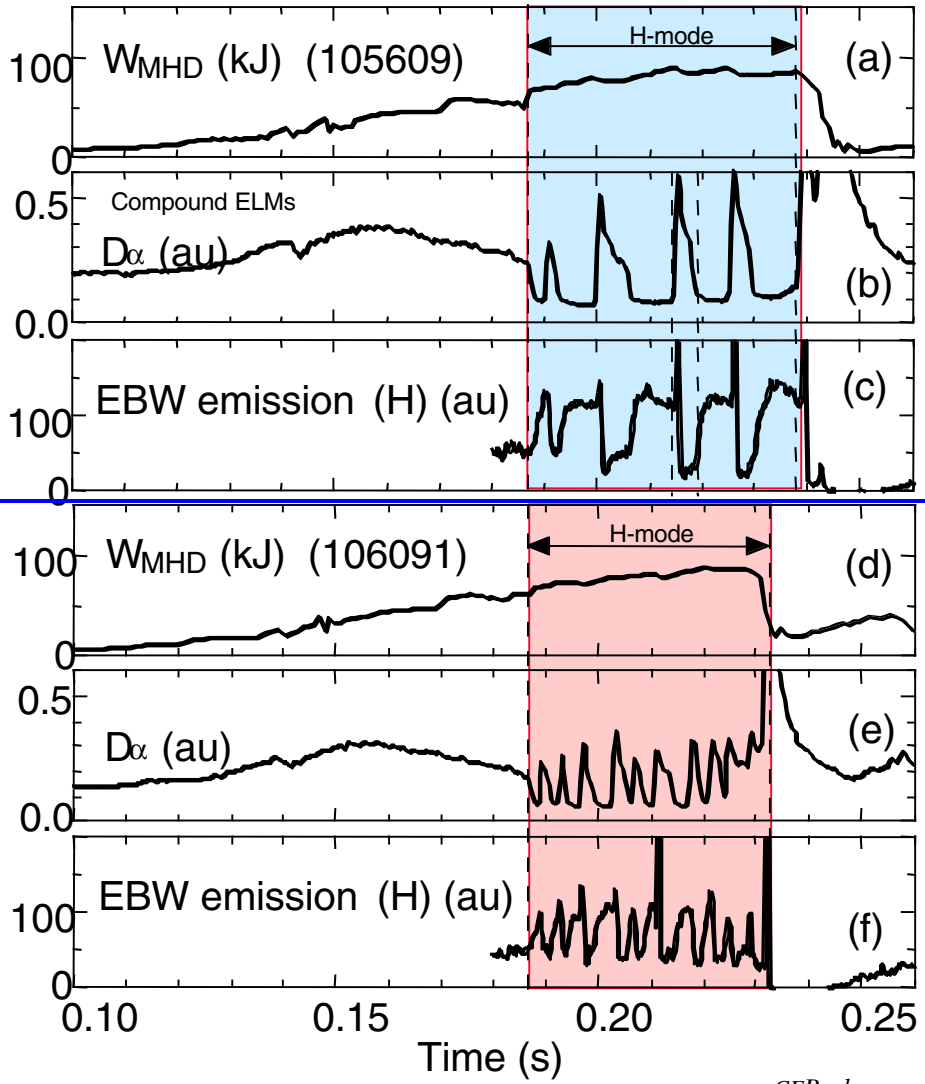


Small ELMs have smaller effect on edge profiles in NSTX





Different ELM behavior found in NBI H-modes



- Large compound ELMs with early divertor
- EBW emission is reduced at each ELM. Recovers between ELMs.
- Smaller high frequency ELMs at $P_{tot} > P_{th}$ ELMs ⇒ dithers near threshold

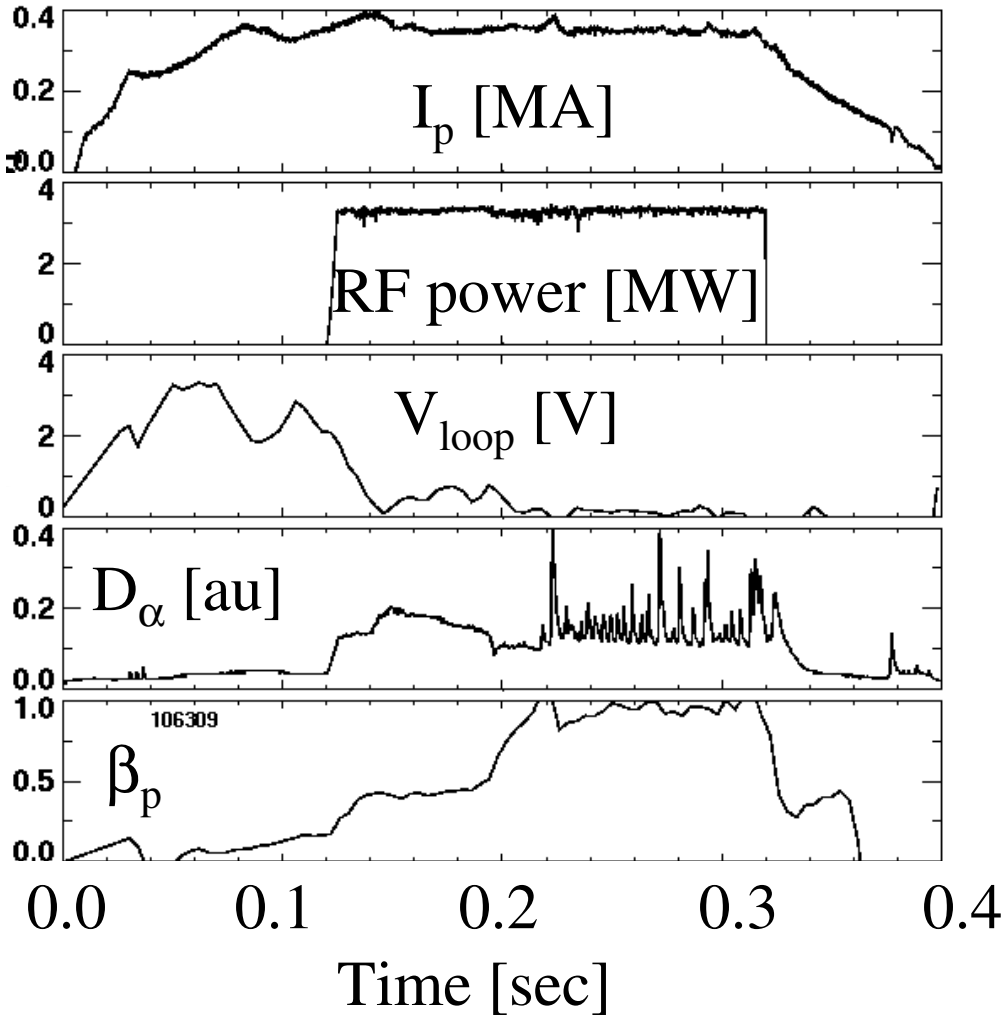
CEBush

ornl

PPPL

Quasi-steady RF ELMy H-modes obtained

- High β_p, low loop voltage ($\varepsilon\beta_p \sim 0.8$)
- ELMy up to 120ms length
- Was limited by TF flattop - TF fix will allow extension
  - Good target for extending pulse length



Improved Diagnostics and Data Analysis -- Advantageous for ELM and Edge Pedestal Studies

- Edge Scanning Reflectometer —
- Edge Profile System (ORNL) —
- Thomson Scattering —
- Reciprocating Probe —
- CHERS —