Study of Type I ELM Systematics Using Soft X-ray Analysis on NSTX

K. Tritz, D. Stutman, L. Delgado-Aparicio, and M. Finkenthal

The Johns Hopkins University

R. Bell, R. Kaita, B. LeBlanc, L. Roquemore
PPPL

R. Maingi
ORNL

S. Sabbagh
Columbia University

and the NSTX Team

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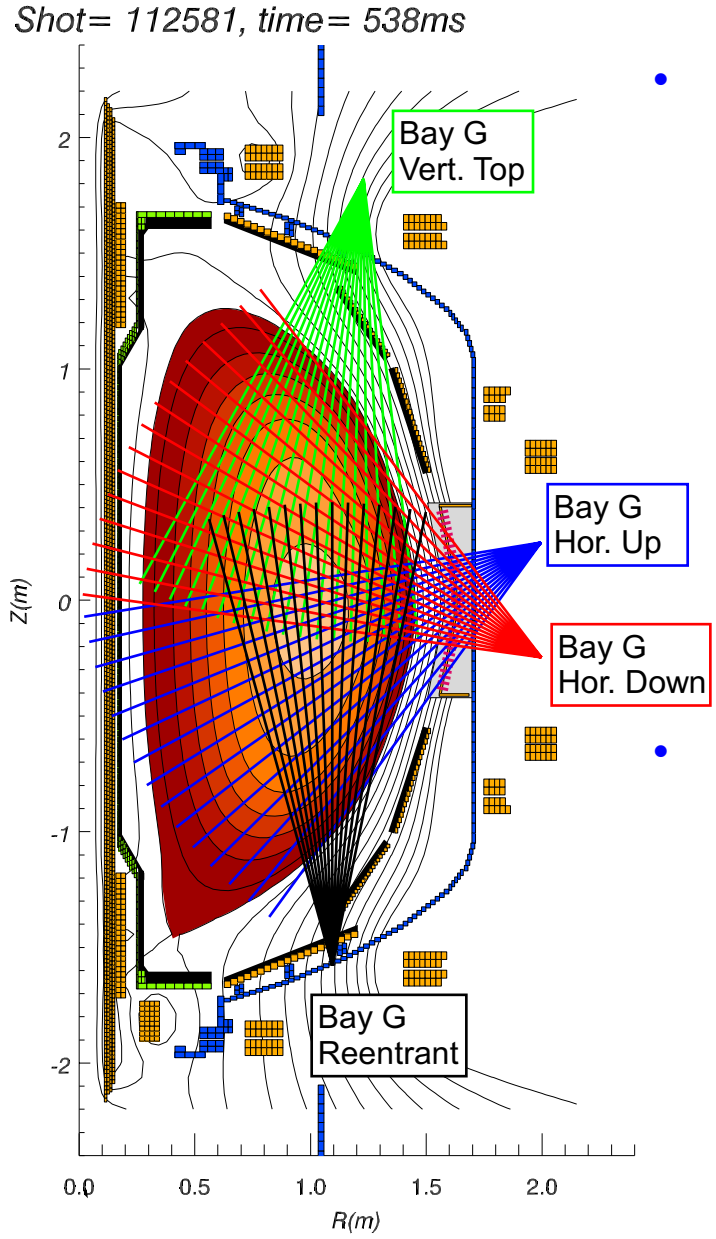
Bay G SXR system provides poloidal spatial coverage

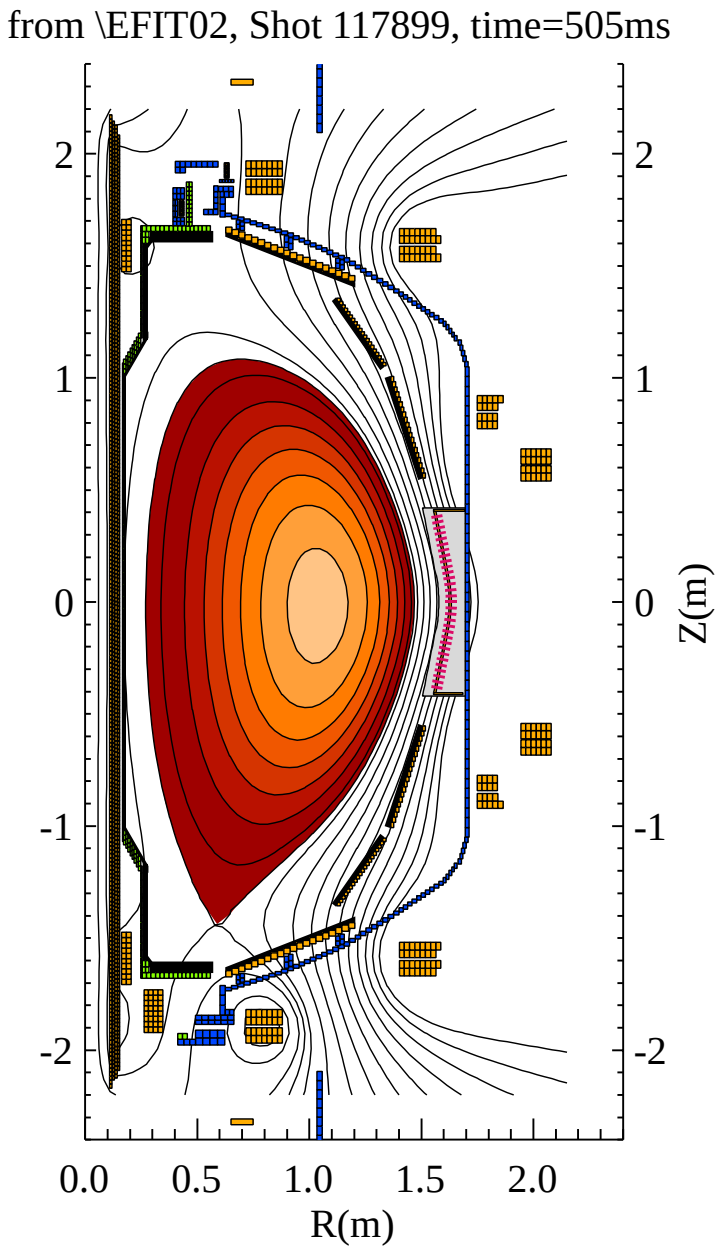


- Imaging and tomographic reconstruction used to analyze plasma activity
  - Oscillatory events (MHD modes, islands)
  - Intermittent events (sawteeth, ELMs, reconnections)
  - Slow phenomena (rotating/locked modes, RWMs)
- Arrays utilize variable filter settings to change plasma region focus
  - 0.4μm Ti filter views primarily edge C emission
  - 10μm Be filter passes X-rays from bulk plasma
  - 100μm Be filter focuses on core plasma emission

What Causes Type I ELM Variability?

- Type I ELMs can cause a range of energy loss from ~3-5% to >20%
  - Large energy loss corresponds with global drop of T_e profile
- Global T_e perturbation possibly due to transport effects
  - Only small precursors observed on Mirnovs regardless of ELM size
  - No large MHD modes seen on SXR arrays
  - Time scales of profile perturbation ~100's of μsec
  - No corresponding global perturbation of n_e profile
- If perturbation is driven by transport effects, try to modify electron transport
  - Experiment run on NSTX to scan I_p and measure ELM perturbations

Large/Small Type I ELM perturbation vs. Ip



I_p 0.7 - 0.95MA

B_T 0.45T

P_{NB} 5.5MW

W_{MHD} 180 - 200kJ

β_T 10 - 15%

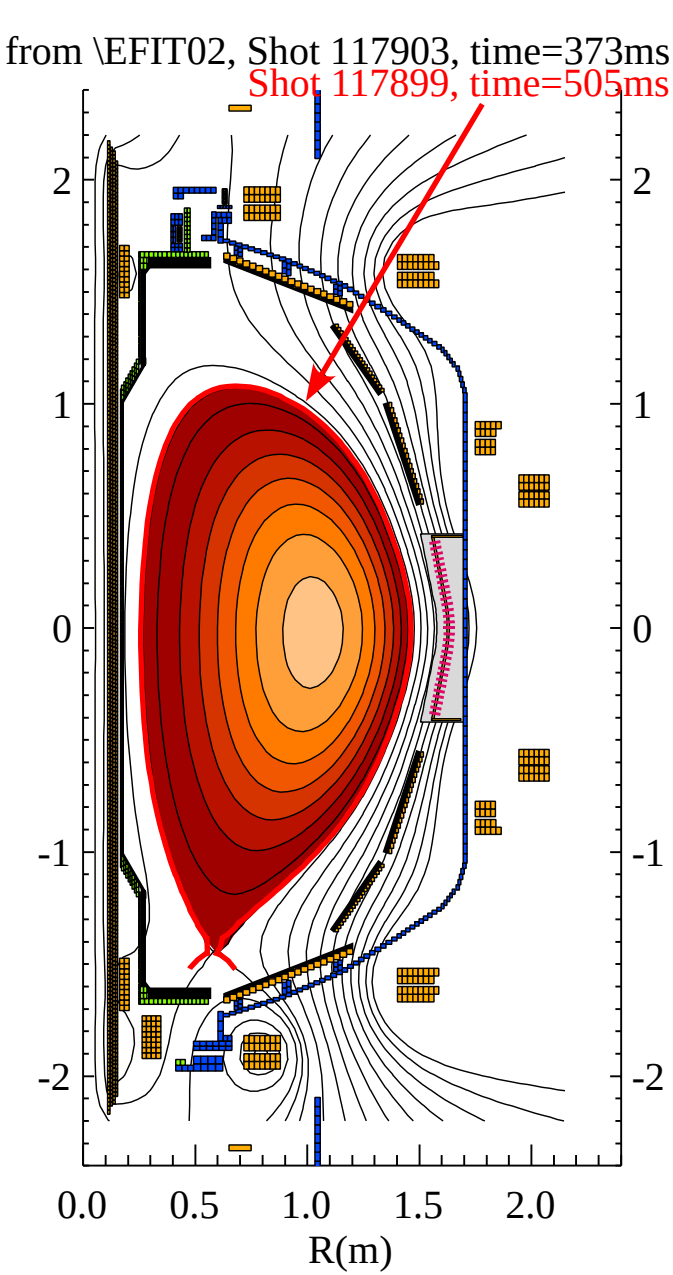
- Qualitative difference seen in ELM perturbation

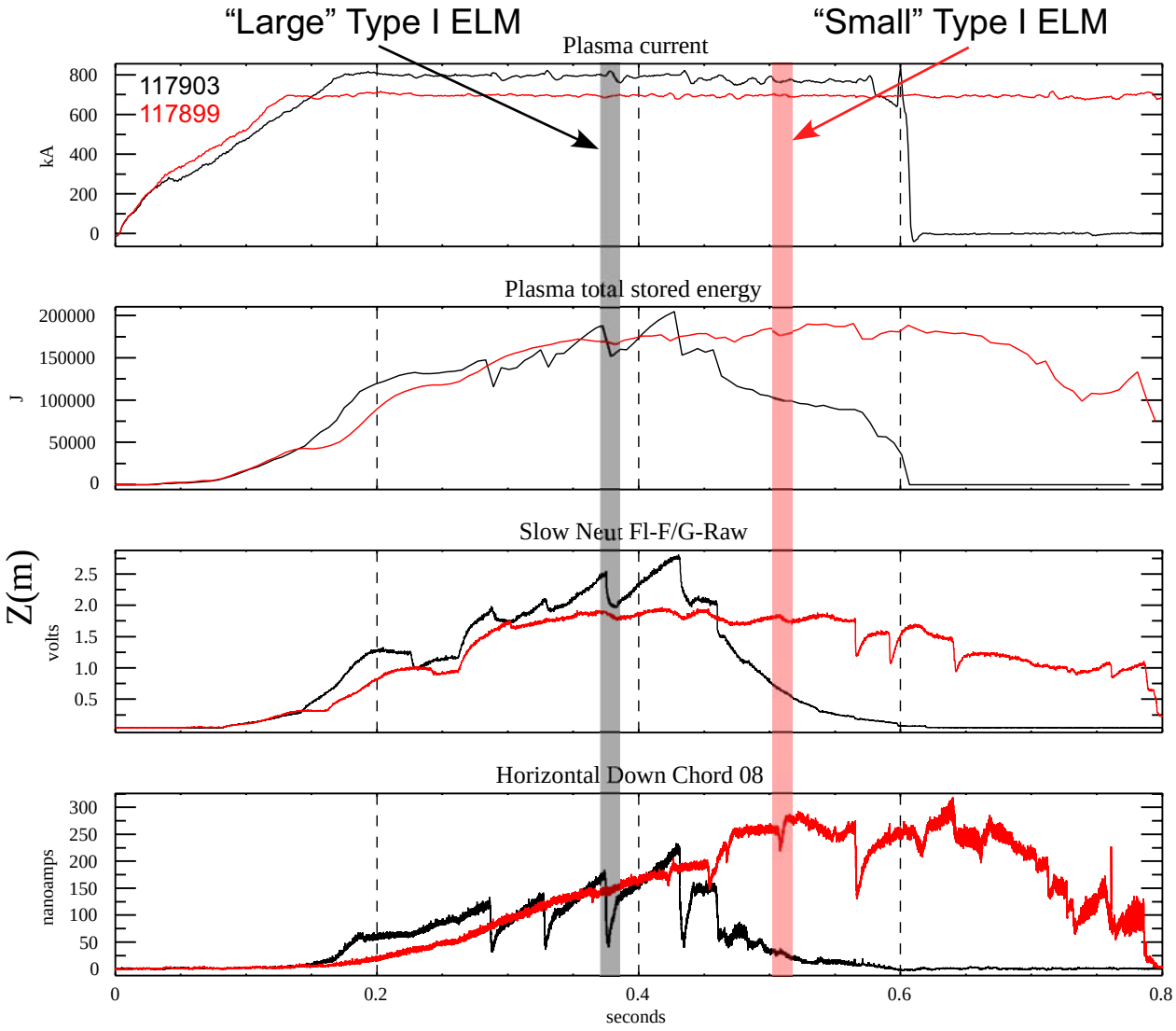
  - Low I_p (0.7MA) → small perturbation ΔW~3-5%

  - High I_p (>0.8MA) → large perturbation ΔW~10-20%

- SXR arrays show difference in penetration of ELM perturbation

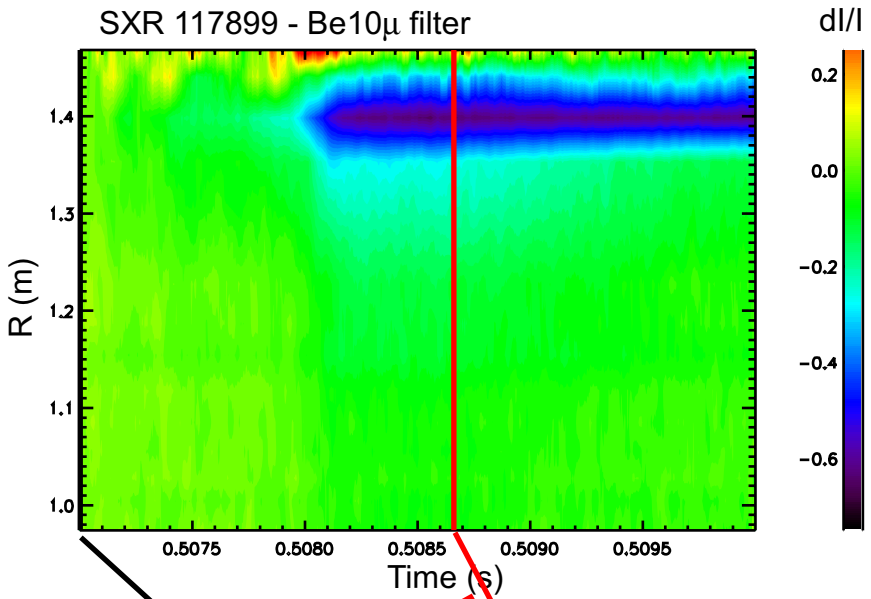
ELMs Show Difference in T_e Related Signals

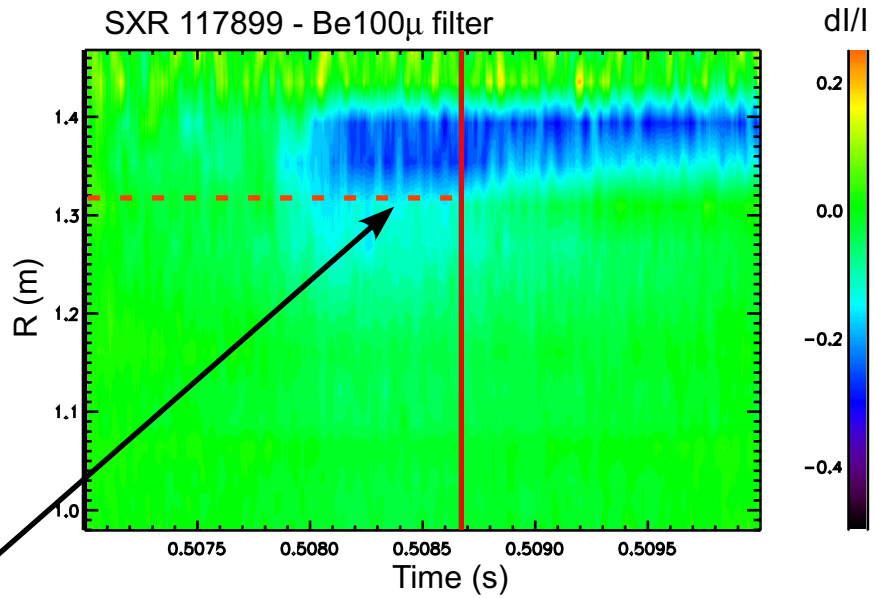




- I_p change appears related to different ELM character

Small Type I ELM Shows Limited Penetration

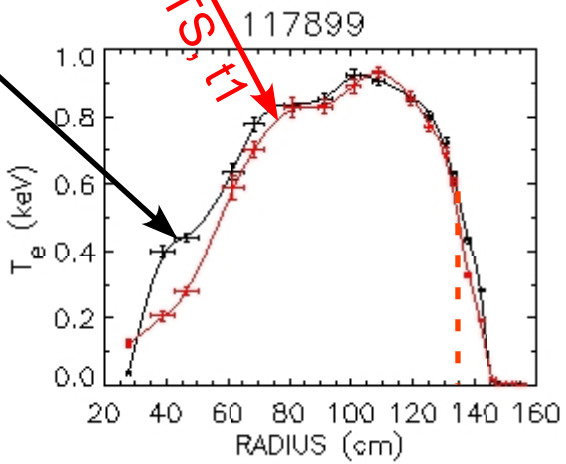


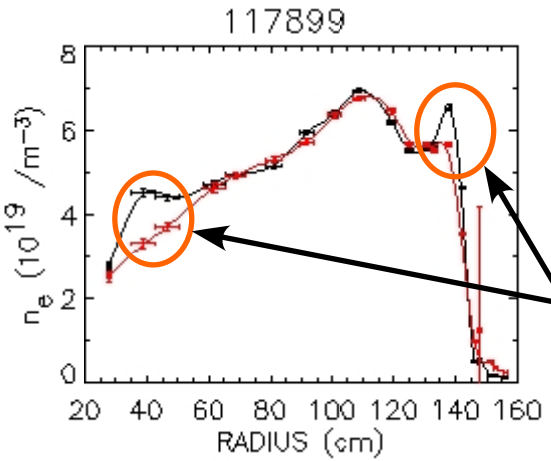


T_e perturbation reaches ~130-135cm

MPTS, t1

MPTS, t1

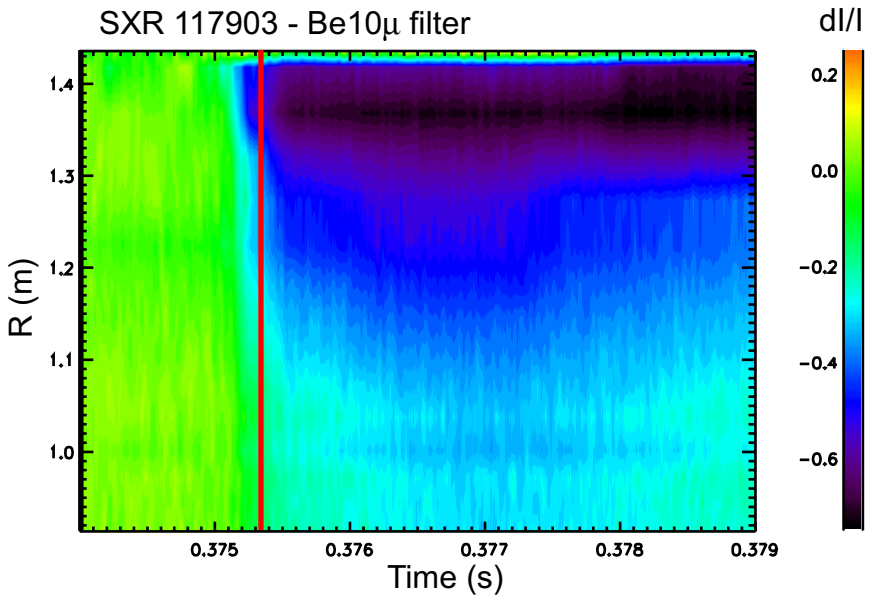


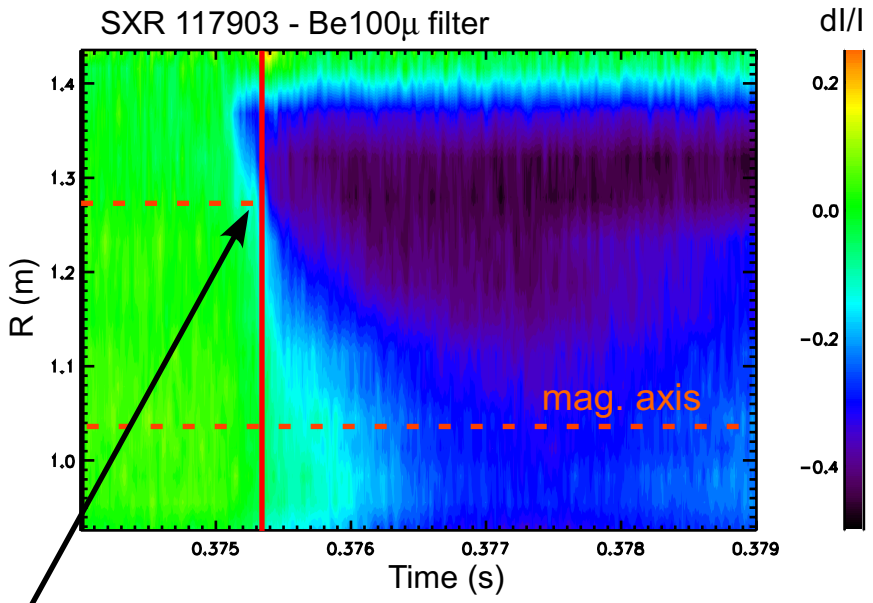


Loss of C impurity "ears"

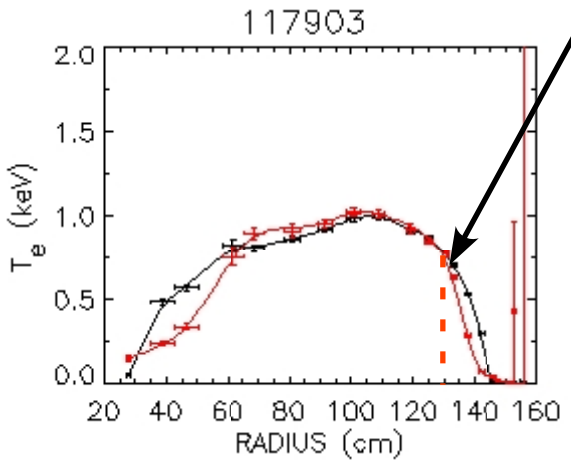
- Core electron density and temperature remains relatively unchanged

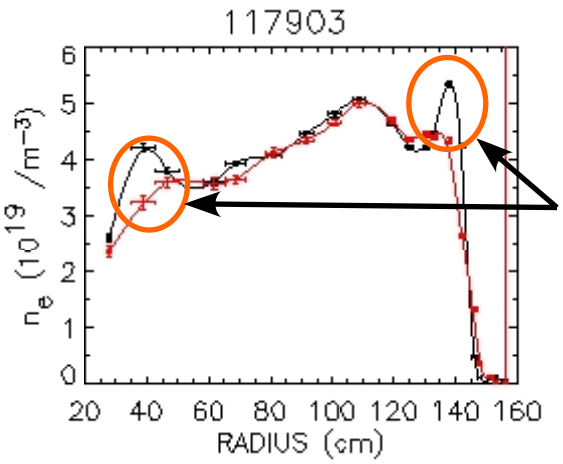
Large Type I ELM Perturbation Extends to Core





Perturbation at MPTS t2 ~130-135cm



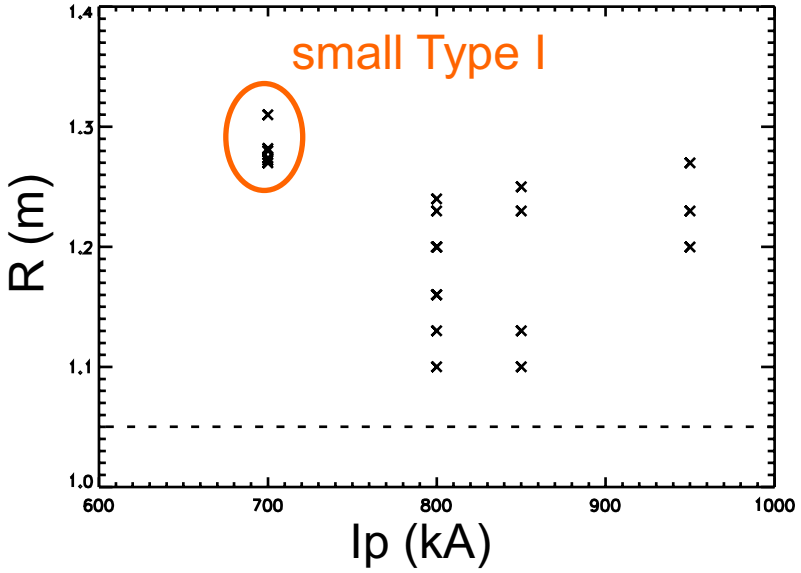


Like "small Type I" loss of ears but no central n_e perturbation

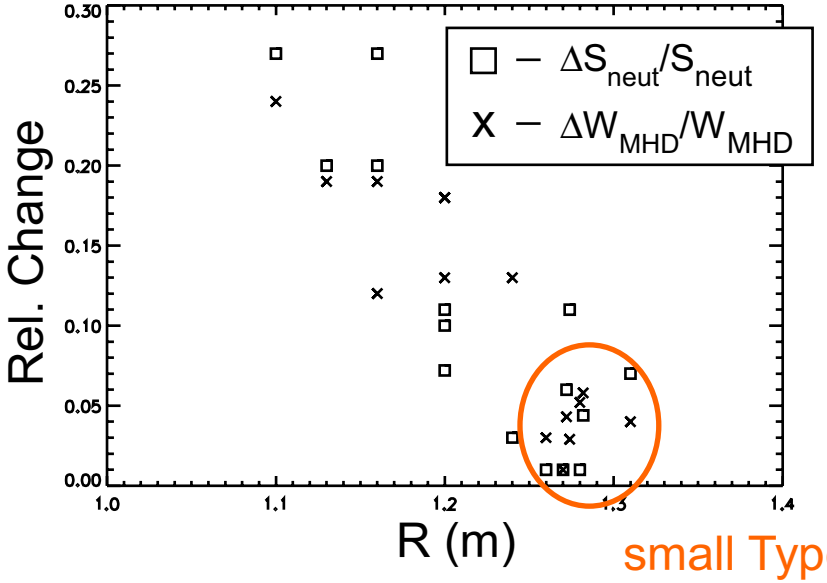
- T_e perturbation reaches core after ~2ms

ELM Perturbation Shows I_p Threshold Effect between 0.7 - 0.8MA

Perturbation penetration

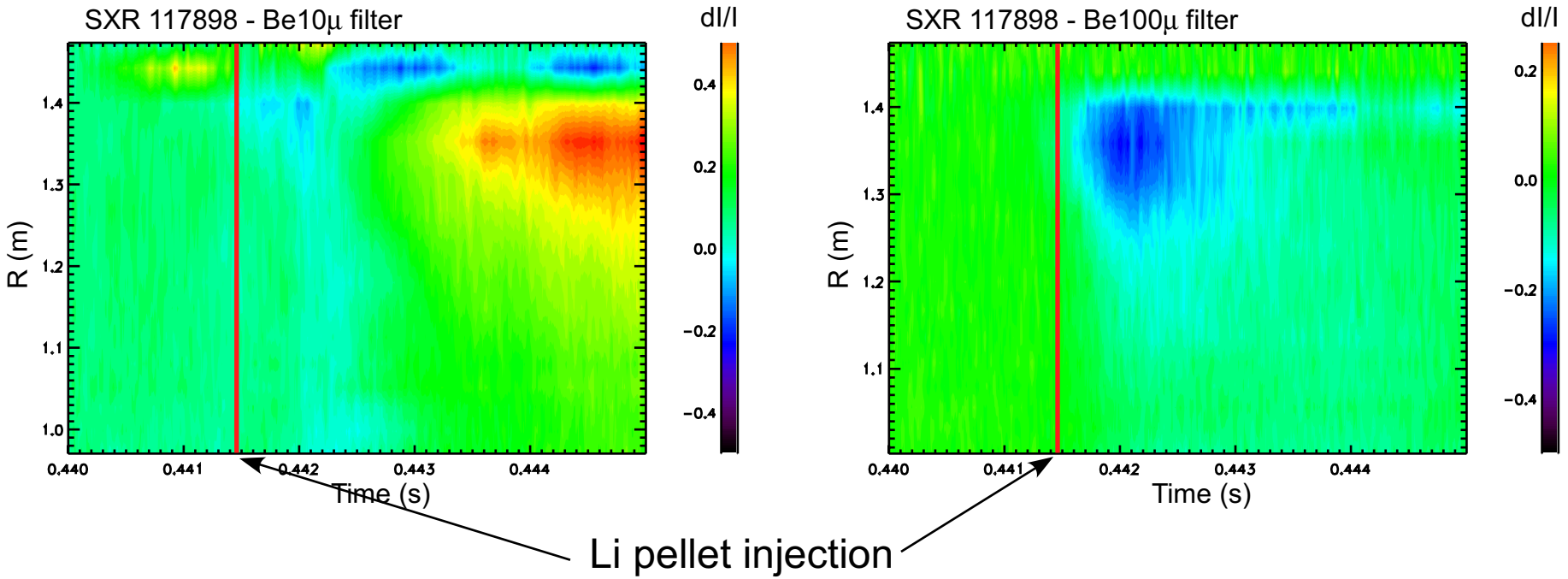


Correlation with W_{MHD}, S_{neut}

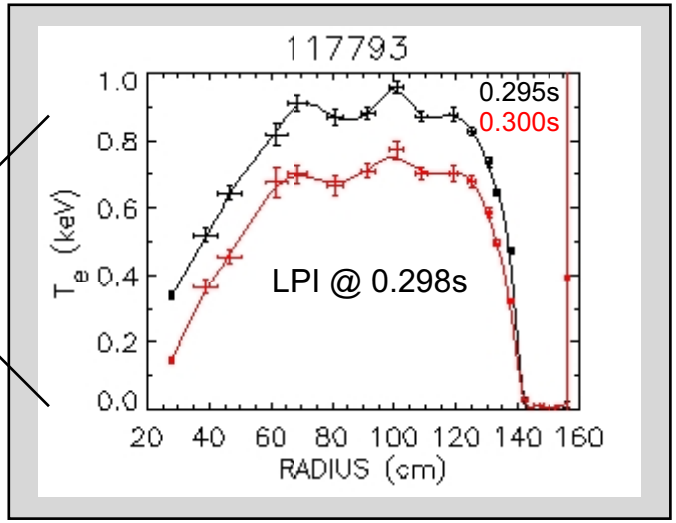


- Below I_p threshold, ELM penetration limited to ~125-135cm
- Above I_p threshold, ELM penetration can extend to plasma core
- W_{MHD} and S_{neut} reductions correlate well to penetration distance (lin. corr. -0.9, -0.85 respectively), consistent with T_e perturbation

Li Pellet Injection used to create edge perturbation



- Injection into 0.7MA “small” Type I discharge causes edge temperature perturbation
- Previous injection into H-mode plasmas have caused global T_e perturbation
- More injections needed to verify behavior



See: Stutman RP1.00027

Future Work

- Experimental study will be continued at high TF to isolate I_p and q dependence
  - Help corroborate existence of threshold
  - Provide information to determine whether perturbation is transport related
- TOSXR system upgraded to higher time resolution for multicolor profiles
  - Multicolor measurements from same plasma volume will aid modeling
  - Direct inversion will improve measurement of radial propagation
- Further comparisons with pellet will help differentiate edge effect from subsequent perturbation
  - Measure radial propagation with controlled edge perturbation
  - Compare pellet cold pulse with ELM perturbation

Summary

- SXR system can be used to follow evolution of ELM perturbations
  - Type I ELMs can cause large T_e crash without corresponding n_e drop
  - Potential I_p threshold for “large”/“small” Type I ELM regime
- Global T_e perturbation possibly due to transport effects
  - Only small precursors observed on Mirnovs regardless of ELM size
  - No large MHD modes seen on SXR arrays
  - Time scales of profile perturbation ~100's of μsec
  - No corresponding global perturbation of n_e profile
- Future investigations to help distinguish between q and I_p effects
  - Higher B_T will allow comparison between q and I_p scan
  - Upgraded MPTS, MSE, and TOSXR diagnostics will improve analysis capability