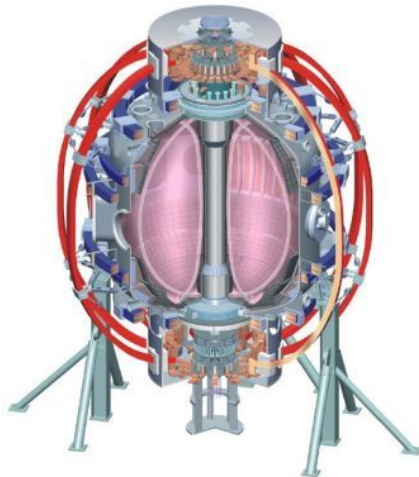


XP 1064: Development of long-pulse enhanced pedestal H-mode

College W&M
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UC Davis
UC Irvine
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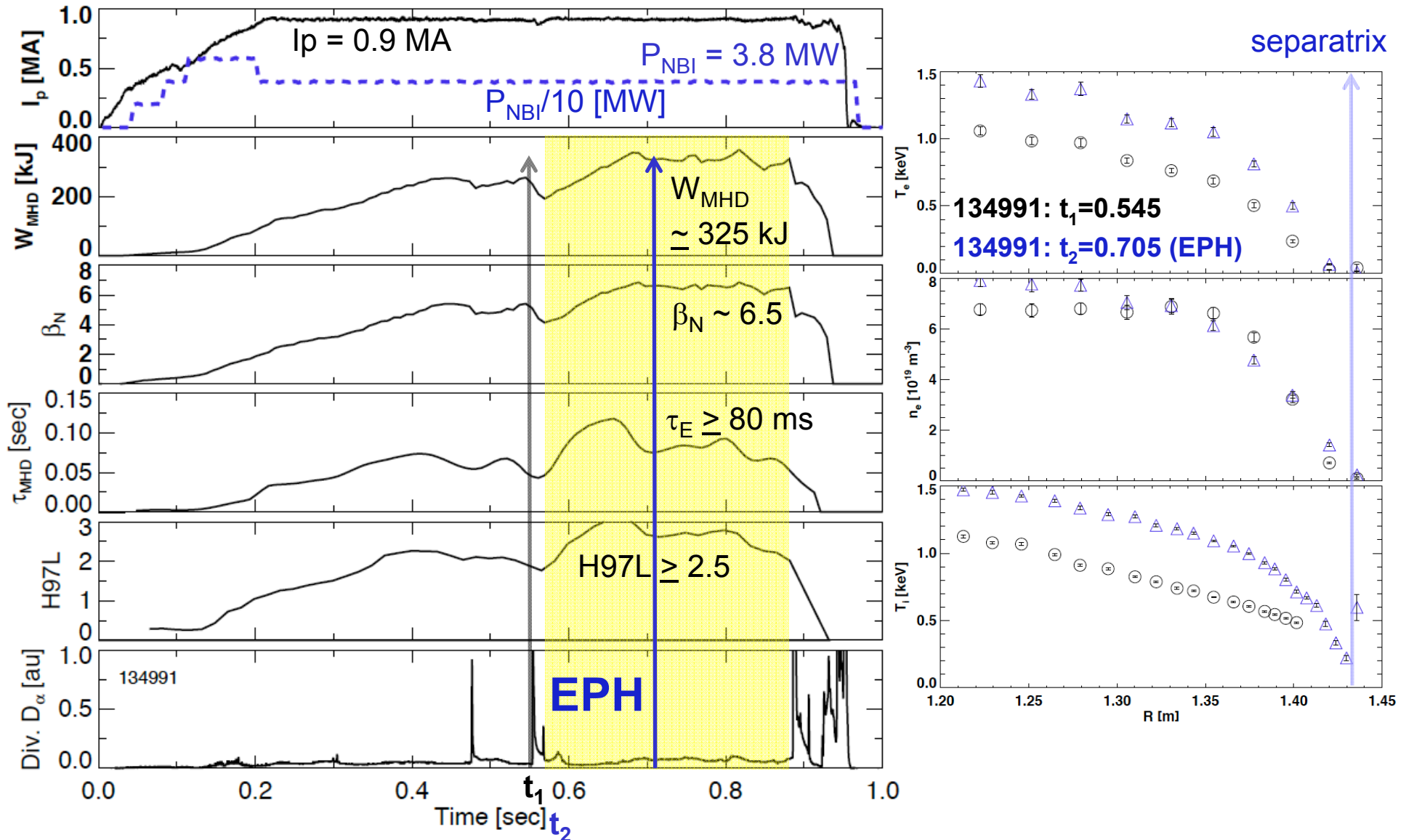
J.M. Canik, R. Maingi, ORNL
S.P. Gerhardt, PPPL

NSTX Team Review
April 19, 2010



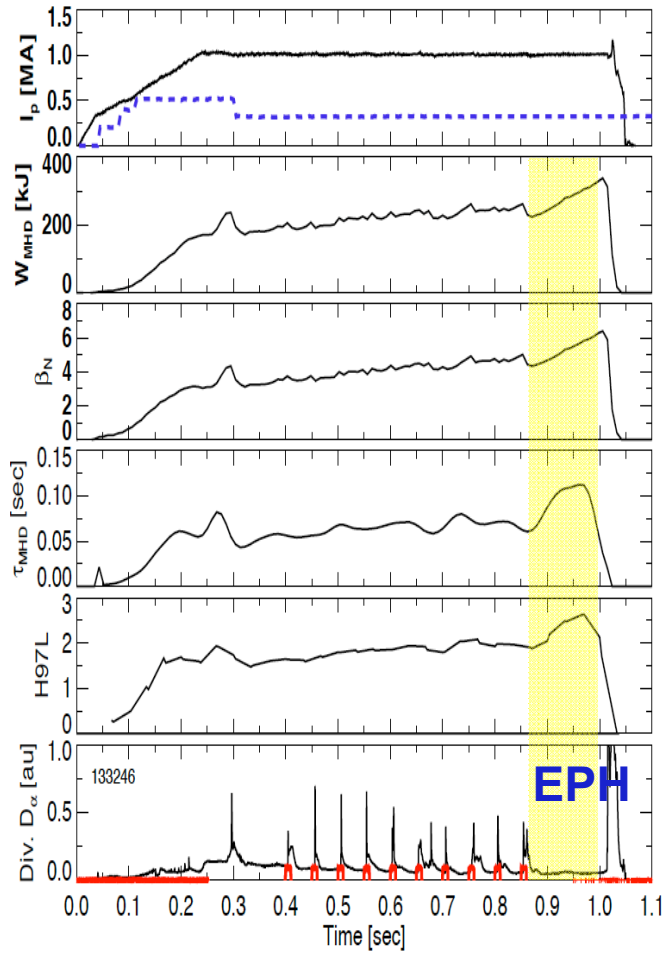
Culham Sci Ctr
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ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

Enhanced Pedestal H-mode (EPH): “Spontaneous” transition to increased P_{ped} , confinement

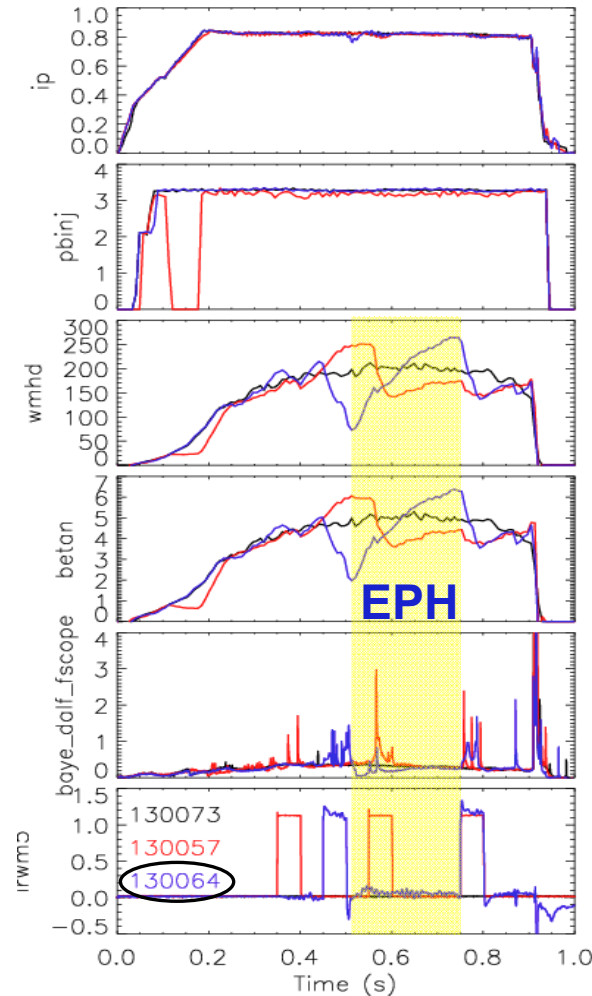


EPH following n=3-triggered ELMs observed, but parameter range is limited

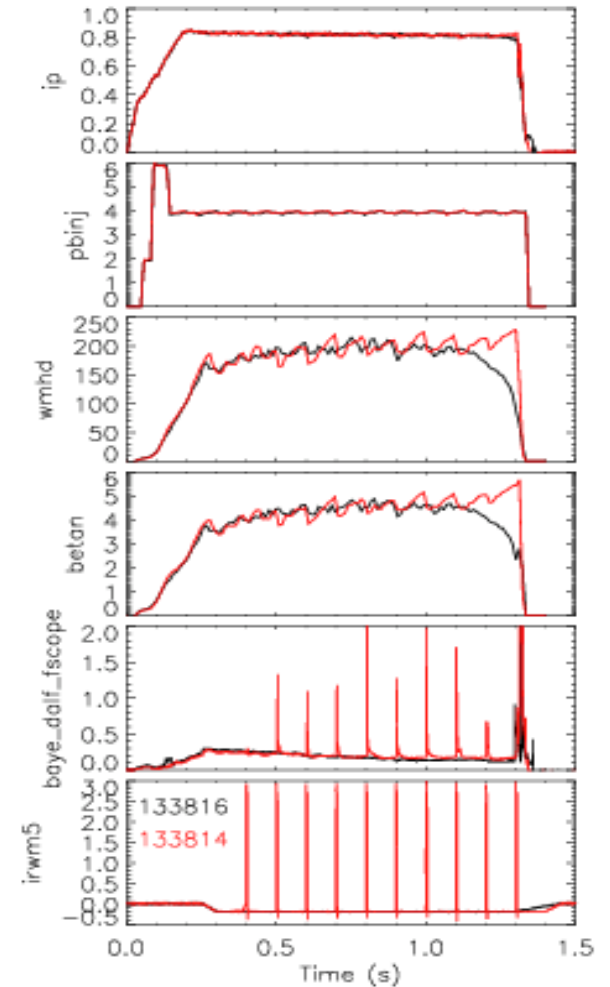
$I_p = 1 \text{ MA}, \kappa = 2.4$



$I_p = 0.8 \text{ MA}, \kappa = 2.0$



$I_p = 0.8 \text{ MA}, \kappa = 2.4$
(maybe)



XP goals: initiate EPH with 3D field ELM trigger, extend with beta feedback

- Test if 3D fields are a reliable EPH trigger
 - Three SPA waveforms to test: trigger one ELM, many ELMs, or no ELMs
 - Starting point: 900kA, $\kappa=2.4$
- Expand parameter space for EPH triggering
 - ELM pacing XPs typically used too high frequency $n=3$ pulses for EPH to develop (limited data set where EPH might be expected)
 - Attempt triggering for a range of I_p , B_t
- Combine with beta feedback and use EPH as a means for sustained high β_t
 - Assuming triggering is successful, goal of the XP is to develop EPH for long-pulse
 - Using beta feedback should remove one limit

Shot plan for first 1/2 day: learning to trigger the EPH

- Start with fiducial-like discharge (2 shots):
 - $I_p/B_t = 0.9/0.45$, $\kappa/\delta = 2.4/0.7$, $P_{\text{NBI}} = 4$ MW
 - LiTER evaporation, enough to be ELM-free
- Attempt to make EPH using n=3-triggered ELMs (4-6)
 - If flat-top long enough, two SPA pulses at 300 and 600 ms, else 300 only
 - SPA waveform 1: 2.5 kA, 10 ms (one ELM)
 - SPA waveform 2: 1.2 kA, 50 ms (several ELMs)
 - SPA waveform 3: reduce duration of #1 (no ELMs)
 - Repeat best waveform (if there is one)
- If EPH is triggered on >1/2 the pulses using the best waveform, scan I_p and B_t (4-6 each)
 - $I_p/B_t = 1.1/0.45$, $1.1/0.55$
 - At each, adjust LiTER to be ELM-free
 - If there is a “best” SPA waveform, test this several times, else try each waveform

Shot plan for first 1/2 day cont.

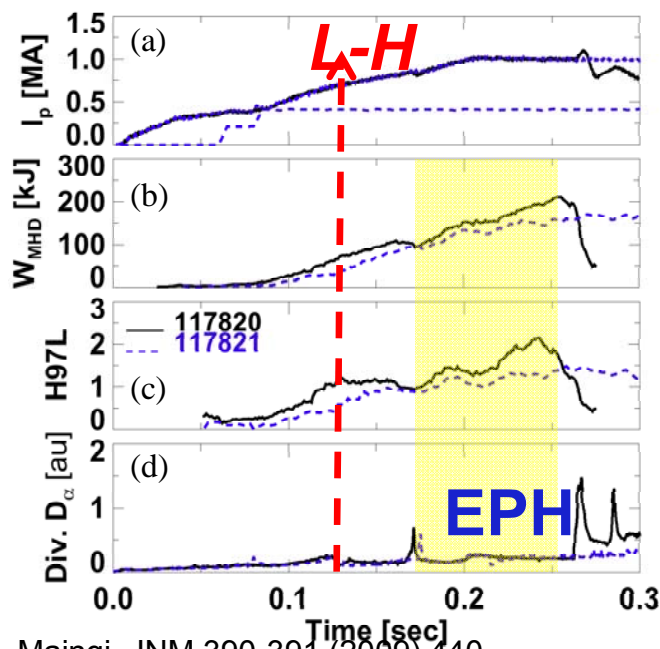
- If EPH triggering is not reliable at $I_p=900$ kA, test other potentially important knobs
 - Increase outer gap to ~13 cm (happens naturally during EPH) (3)
 - Increase LiTER evaporation rate to ~400 mg/shot (3)
 - If still no EPH, replace CS with SGI (3)
 - Can also revert to shot where triggered EPH was previously observed
 - 130057, $I_p=800$ kA, $\kappa\sim 2.0$
- Time permitting, turn on beta feedback for initial test of control during EPH

Second ½ day: high β_t with beta feedback

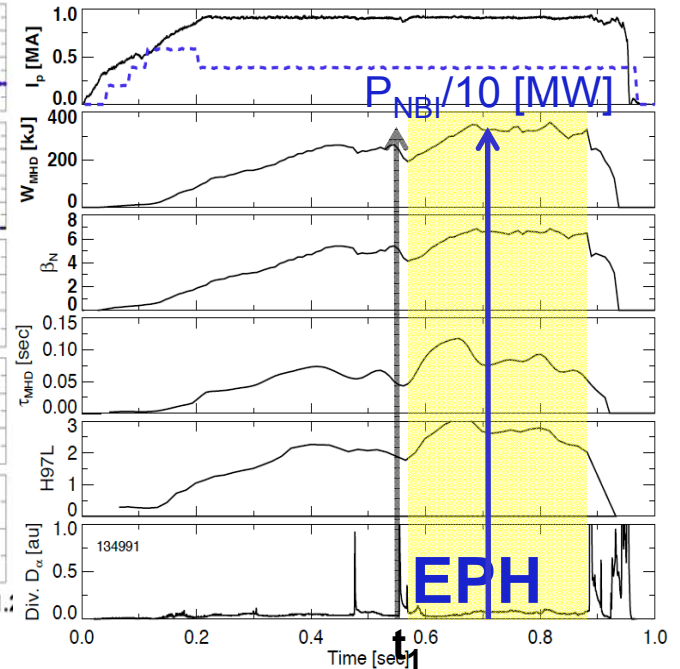
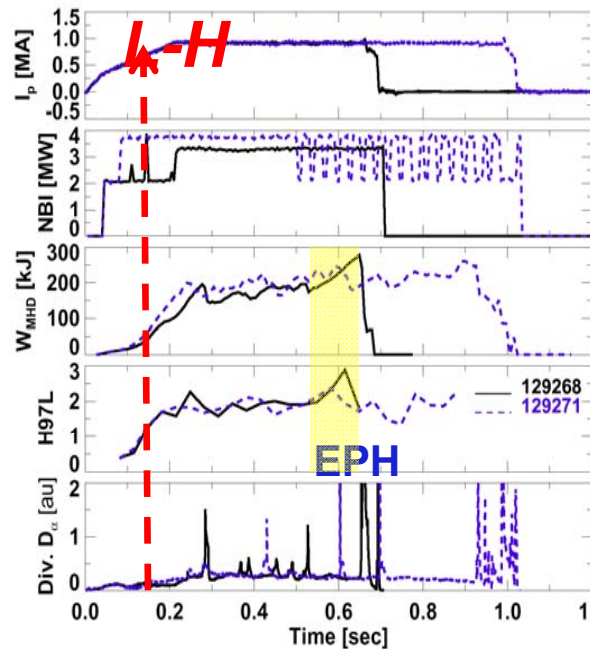
- Starting discharge: same shape as before, $I_p/B_t=1.1/0.45$ (2 shots):
 - Hopefully reload from previous ½ day, else reload 135119
 - LiTER evaporation, enough to be ELM-free
- Demonstrate EPH mode triggering and beta feedback (2)
 - If necessary, reduce gains during EPH
 - Details of beta-feedback likely to be addressed in XP1019
- Reduce toroidal field (4-5 shots each)
 - Set B_t to 0.45, 0.425, 0.4 T
 - At each value, reduce requested β_N to ~80% of previous case, then increase to maximum possible while avoiding disruption
 - Increase kappa as necessary to keep q^* high

Reasoning behind scanning n=3 timing

- Natural transitions later in discharge seem to be longer-lived than early

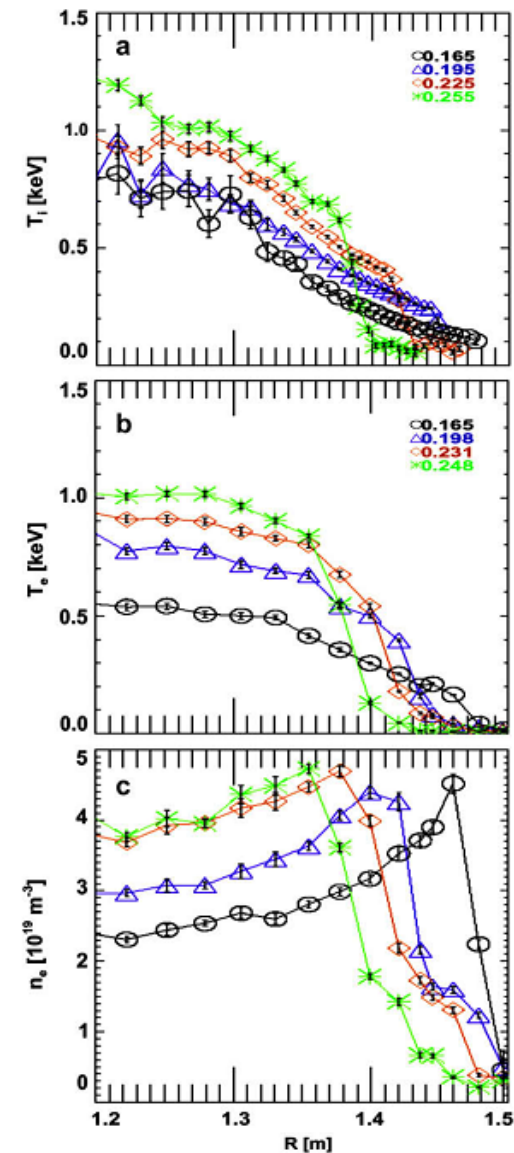
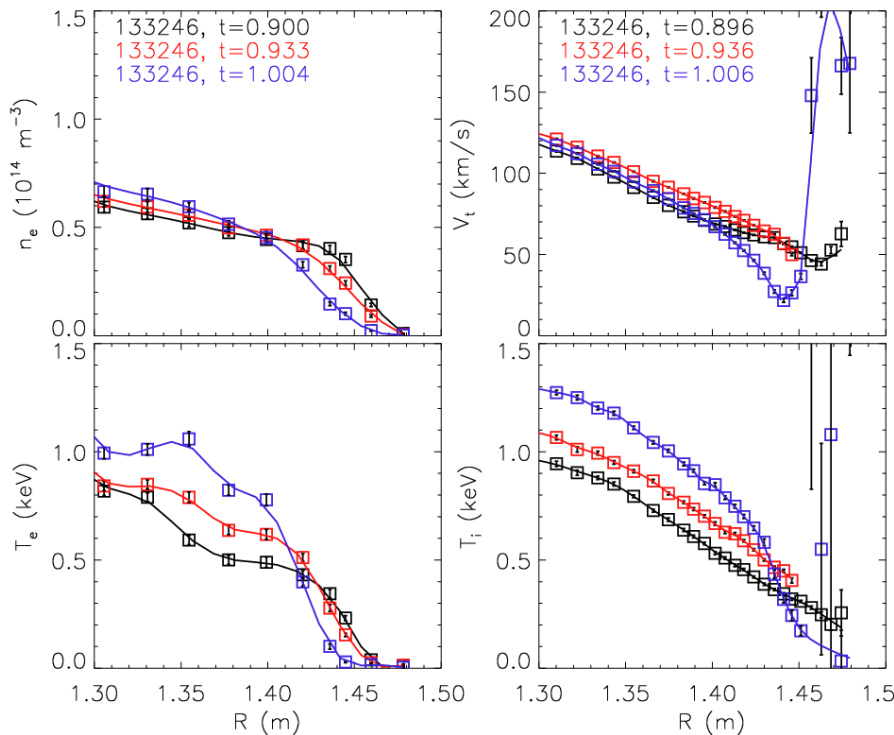


Mainji, JNM 390-391 (2009) 440



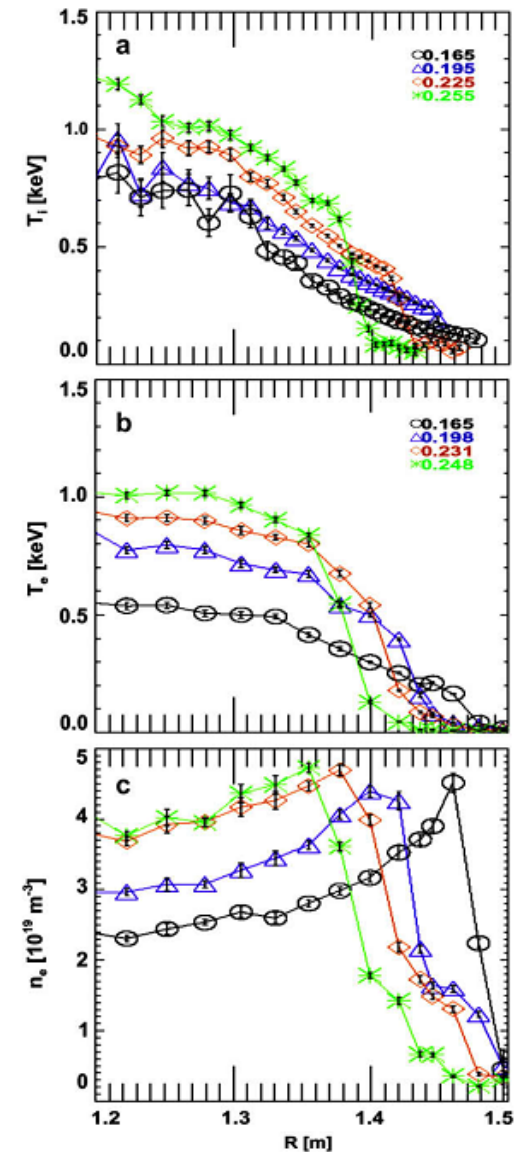
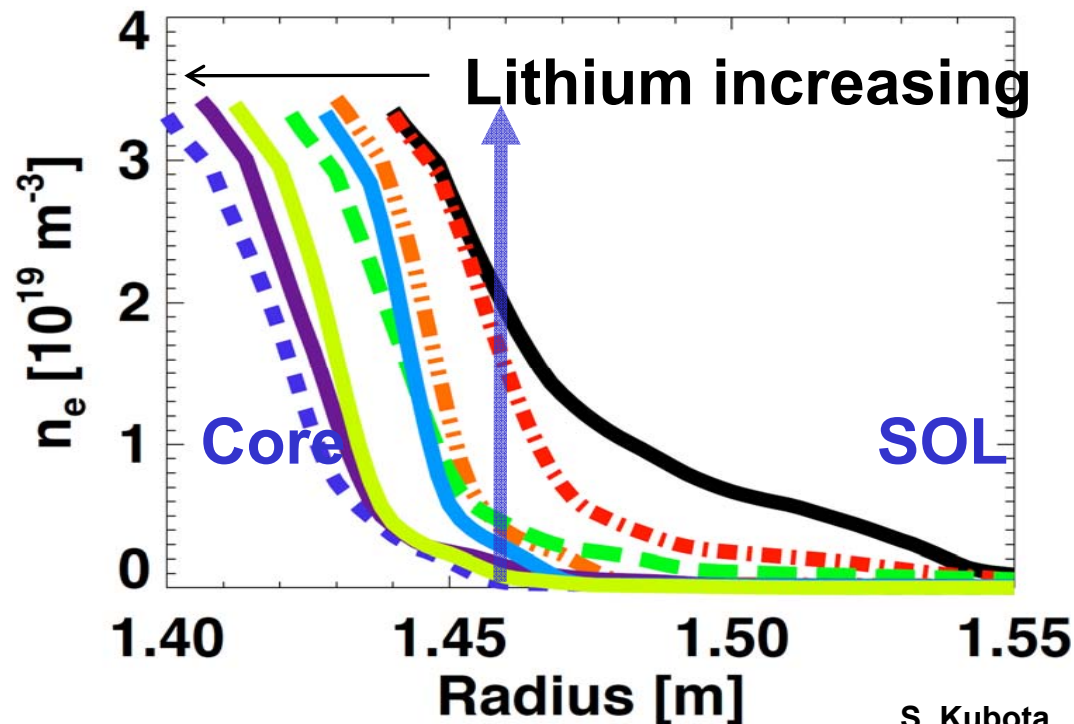
Reasoning behind scanning outer gap

- Following transition to EPH, outer gap increases naturally
- Adjusting gap before EPH may make access easier



Reasoning behind scanning LiTER rate and testing SGI

- Following transition to EPH, outer gap increases naturally
- Reminiscent of effects of lithium scan on density profile
- EPH seems more frequent with lithium, suggesting fuelling matters
- Longest EPH so far used SGI



3D fields used for ELM pace making may trigger EPH during periods when 3D fields switched off

