NSTX

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

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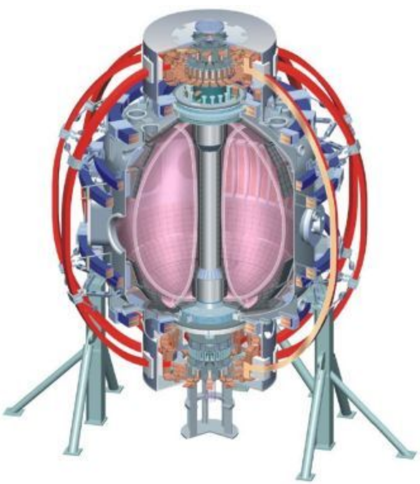
ASC Group Review
March 16, 2010



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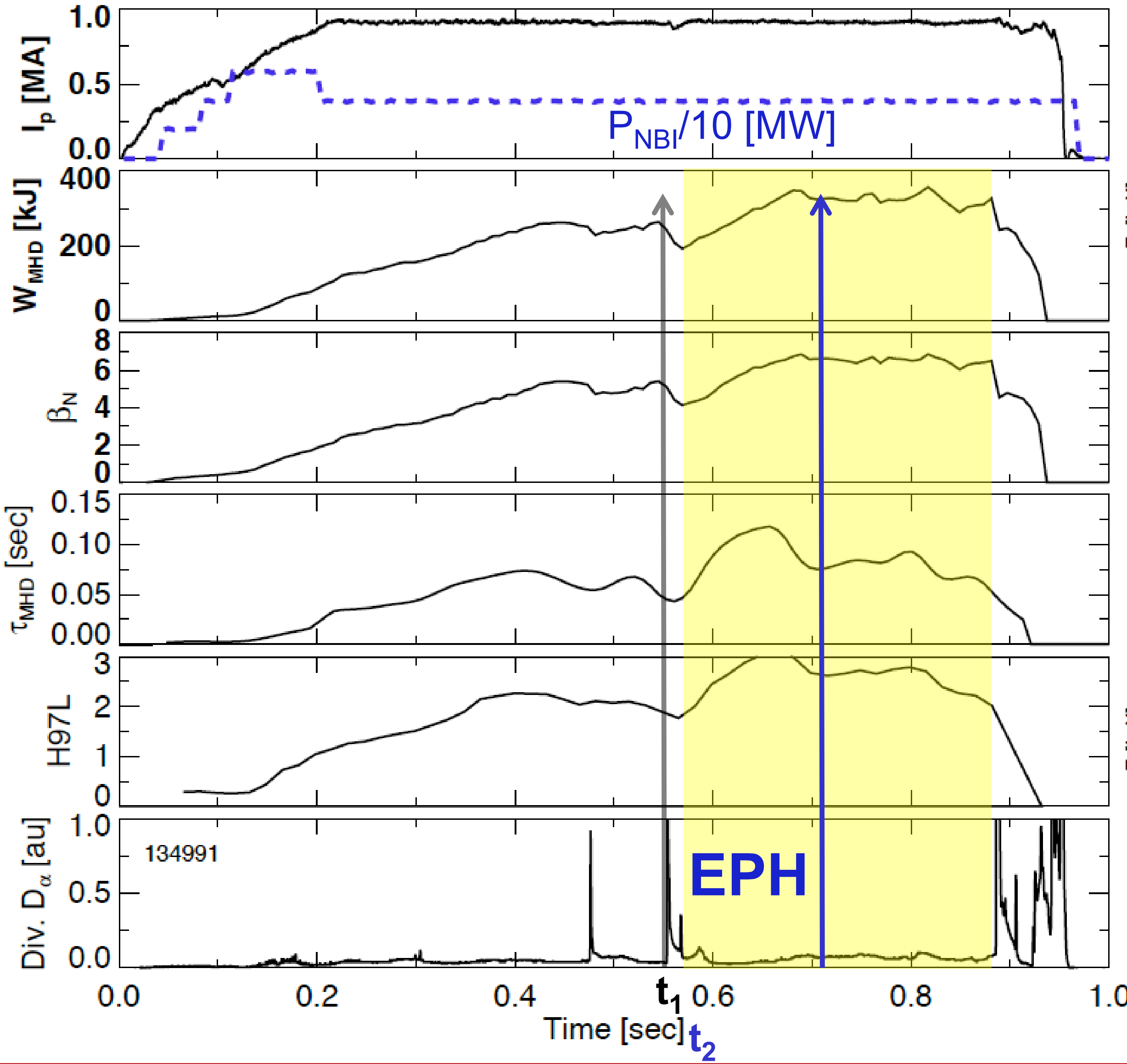
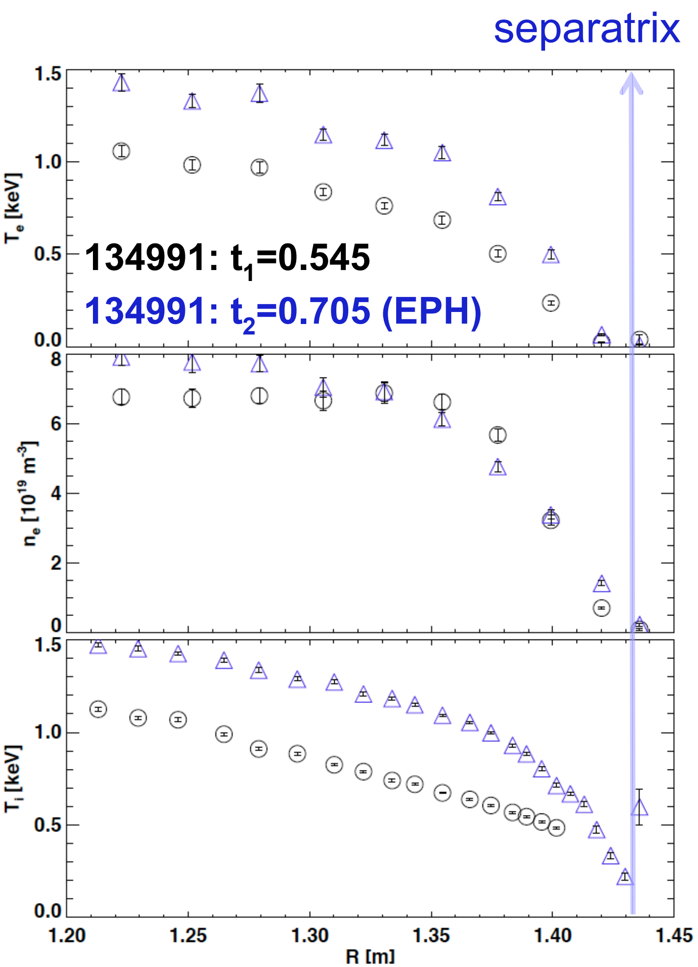
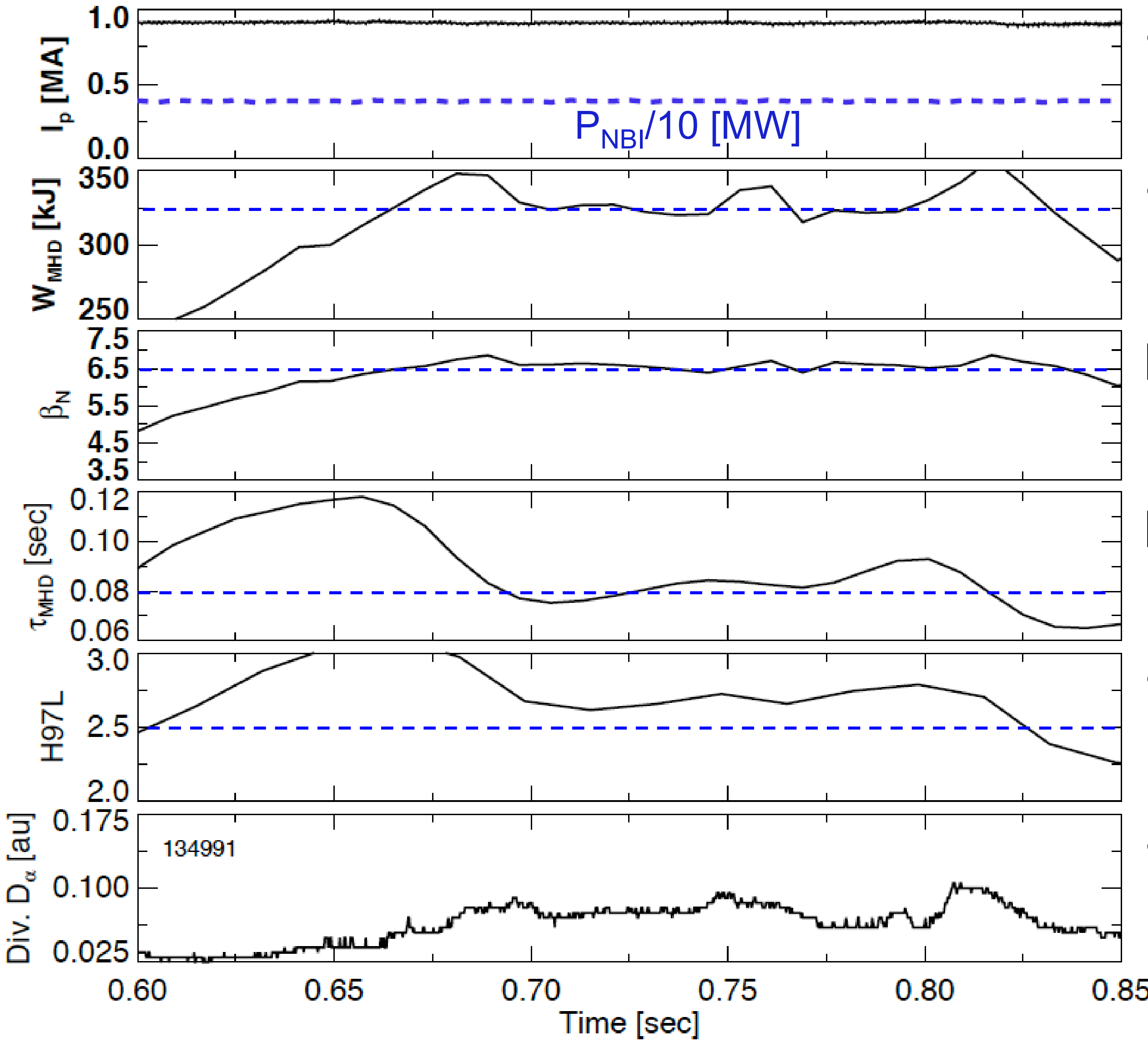
Enhanced Pedestal H-mode (EPH): "Spontaneous" transition to increased P_{ped}, confinement



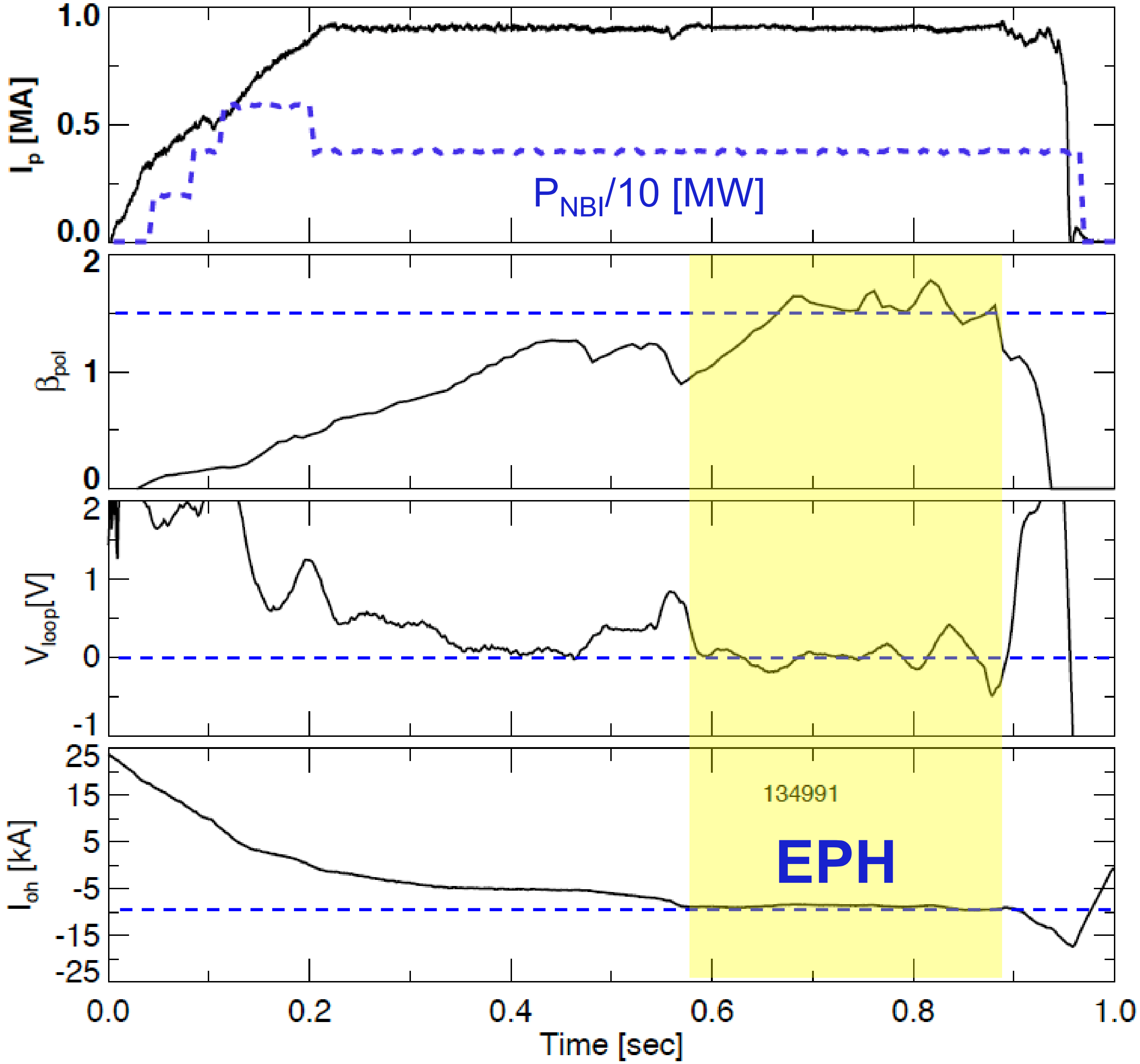


High β_N phase maintained for 2 τ_E



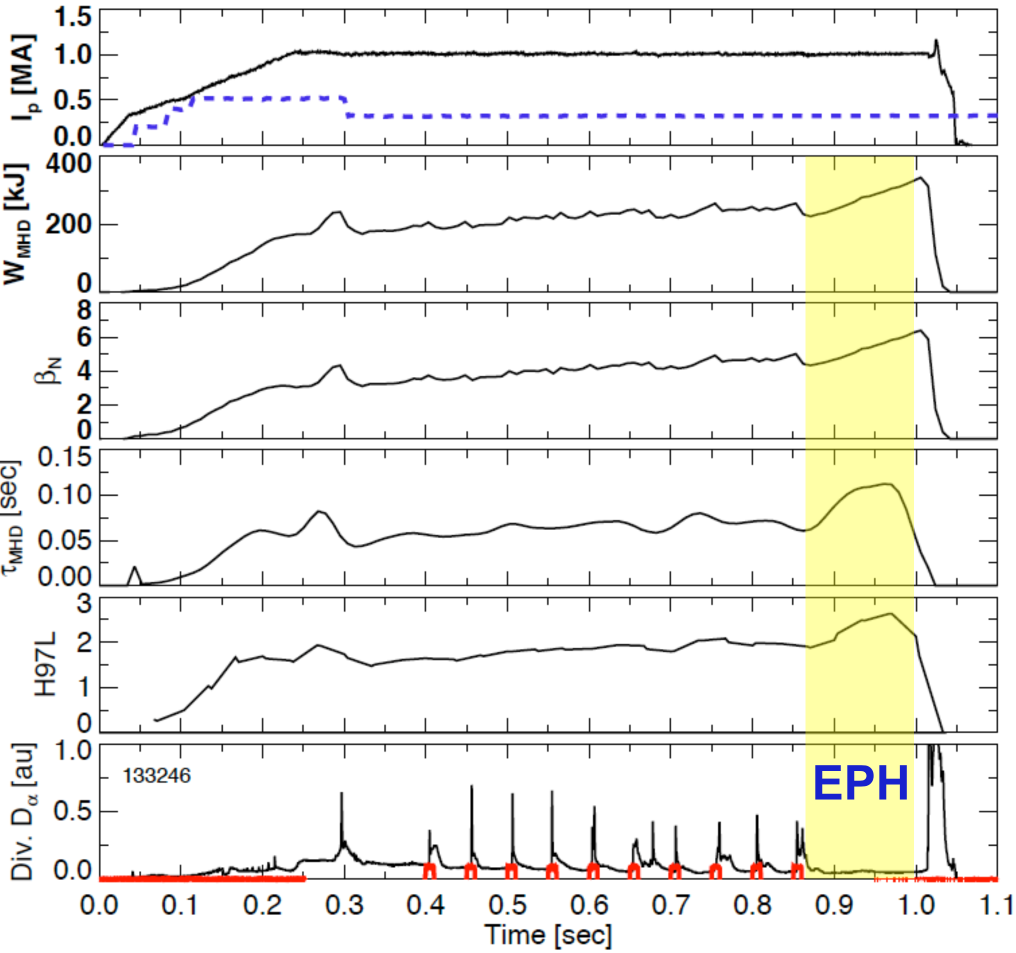
- I_p = 0.9 MA, P_{NBI} = 3.8 MW
- $W_{MHD} \simeq$ 325 kJ
- β_N ~ 6.5
- $\tau_E \geq$ 80 msec for 225 msec
- H97L $\geq$ 2.5
- EPH phase is ELM-free

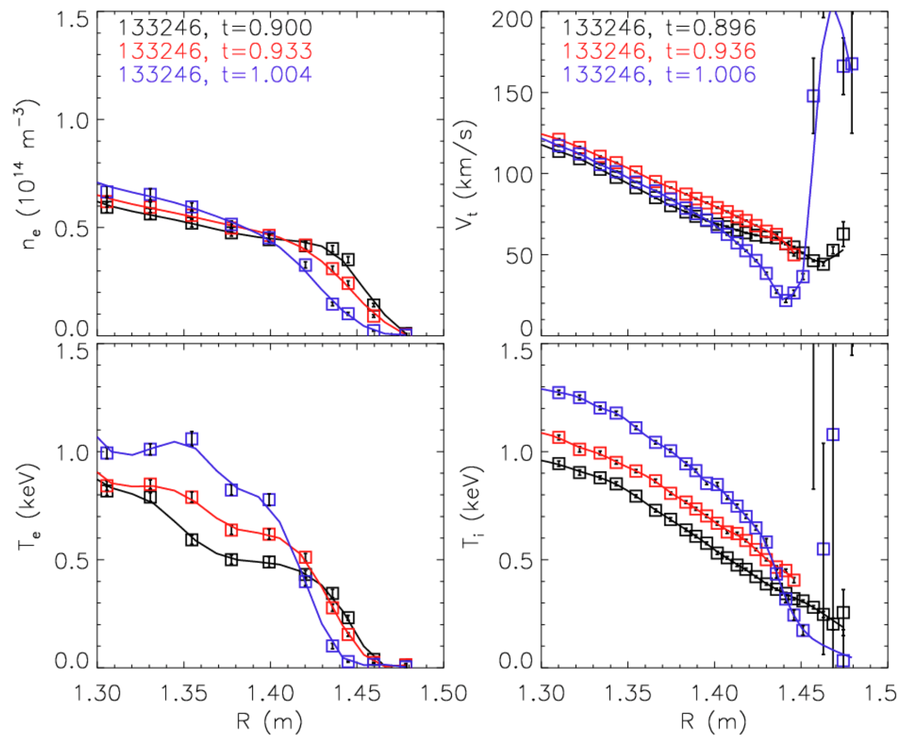
High β_{pol} results in high bootstrap and non-inductive fraction (f_{NI} ~ 0.65 from TRANSP)



- I_p = 0.9 MA, P_{NBI} = 3.8 MW
- β_p ~ 1.5, very high for 0.9 MA
- Loop voltage low during EPH, due to high bootstrap
- Very little or no flux consumption

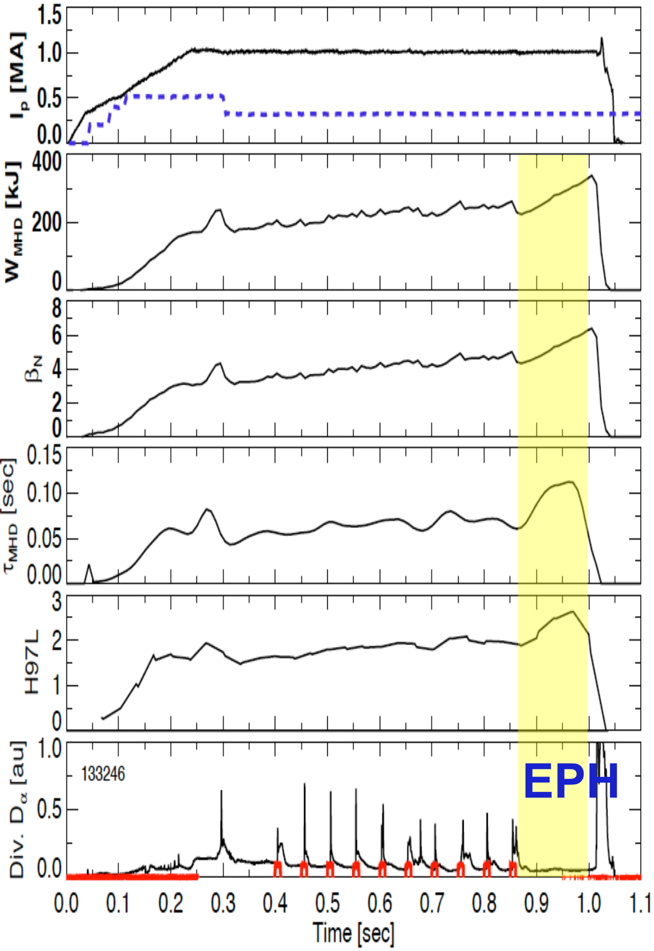
3D fields used for ELM pace making may trigger EPH during periods when 3D fields switched off



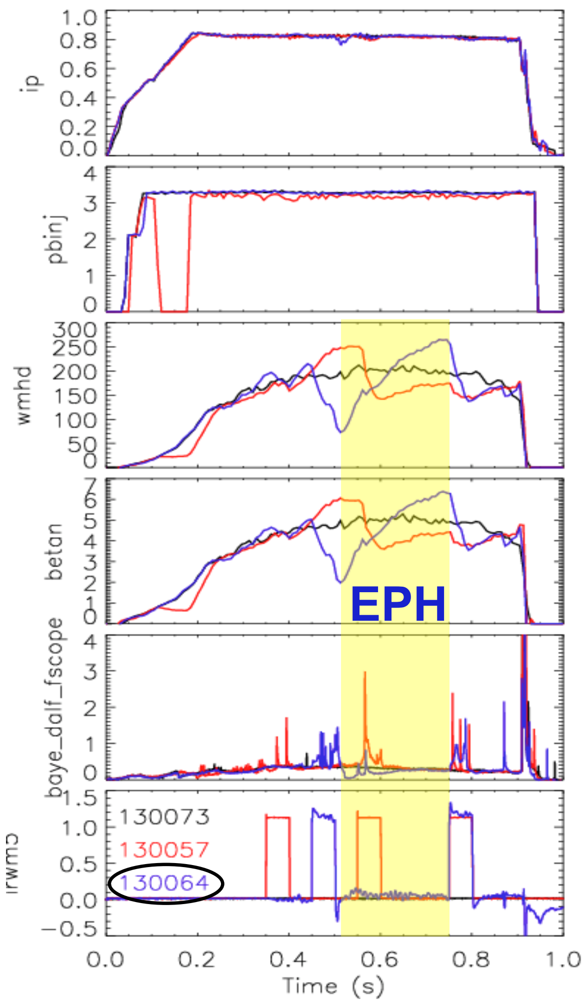


EPH following n=3-triggered ELMs observed over limited range of parameters

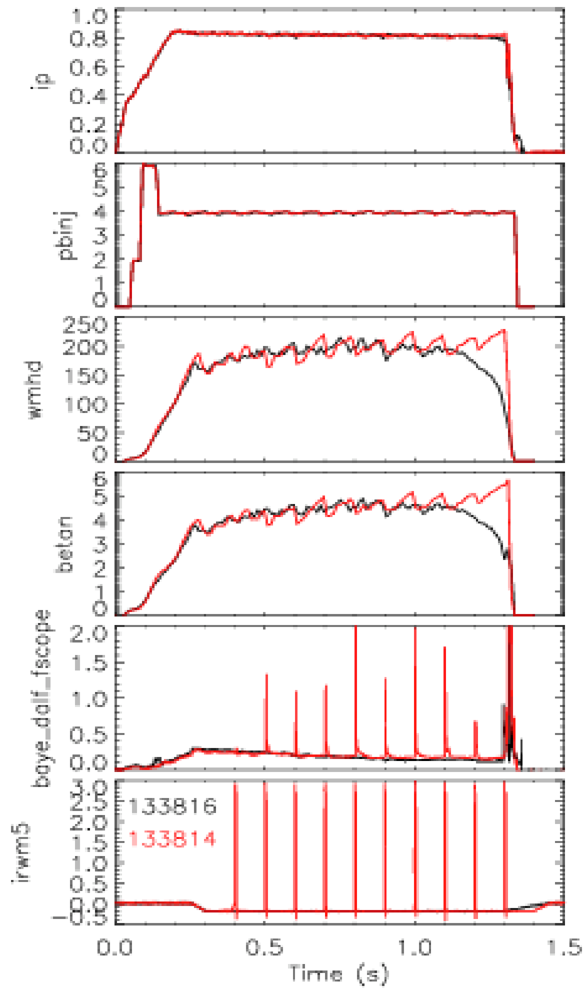
I_p=1 MA, κ=2.4



I_p=0.8 MA, κ=2.0



I_p=0.8 MA, κ=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
  - Two SPA waveforms to test: slow, low amp pulse with several ELMs triggered, or large short pulse with a single big ELM
  - Starting point: 800kA, 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 at least a range of I_p, extend kappa if possible

- Extend duration using beta feedback
  - Assuming triggering is successful, goal of the XP is to develop EPH for long-pulse
  - Using beta feedback should remove one limit

1 day shot plan

- Reload 133816 or 135182 (2 shots):
  - I_p/B_t =0.8/0.45, κ/δ=2.4/0.7, P_{NBI}=4 MW
  - LiTER evaporation, enough to be ELM-free
- Attempt to make EPH using n=3-triggered ELMs (6)
  - SPA waveform 1: 2.5 kA, 8 ms
  - SPA waveform 2: 1. kA, 50 ms
  - Scan timing of n=3 field (400, 700 ms, both)
  - Alternatives/backup
    - Increase outer gap—happens naturally during EPH
    - Change fuelling/pumping with LiTER/SGI—encourage inward n_e shift
- Plasma current scan (12)
  - 1, 1.2, 0.7 MA
  - Use whichever of slow or fast SPA pulses is better (or try both, if not clear)

1 day shot plan

- Kappa scan (8)
  - If EPH triggering not working well, try reducing to 2.0
  - If EPH is working well, raise kappa->move towards high f_{NI} shape
  - For now sticking with high triangularity to avoid LLD contraints, though best EPH so far at intermediate (bullnose SP development).
- Beta feedback done in parallel (mostly)
  - One EPH shot at each parameter set without feedback for diagnosis of EPH, inform feedback settings
  - Optimal gain depends on confinement time ($\sim 1/\tau^2$), which will hopefully be changing dramatically during a shot
    - Might need to take a few shots to adjust gain based on confinement times during EPH (e.g., one with "normal' τ to see what EPH τ is, then one with EPH τ)
    - …but probably not based on Gerhardt modeling of feedback system
- Priority order, assuming everything works
  - I_p/κ = 0.8/2.4,1.0/2.4,1.2/2.4, 0.7/2.4+, 1.0/2.4+

Alternative plan for discussion: break into three ½ days

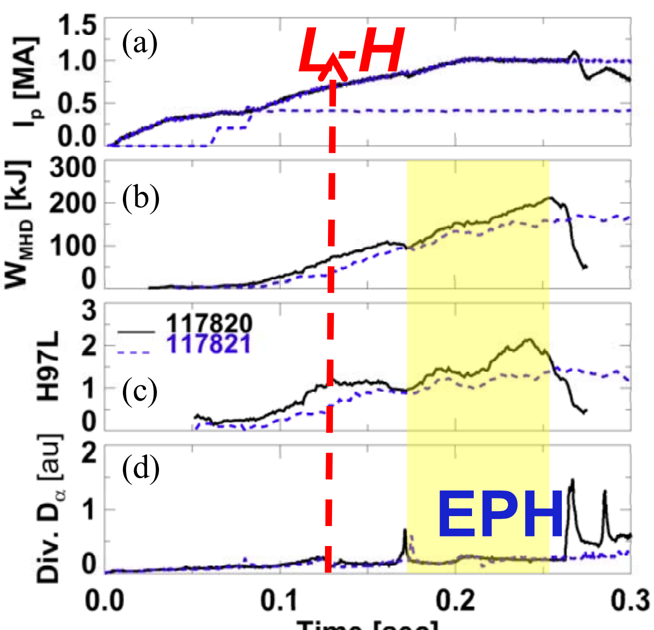
- Learn how to trigger EPH w/o beta feedback (½ day)
  - Test SPA waveforms as in previous list (duration, timing)
  - Parameter scans
    - Use multiple trigger tests per shot? 300,600,900 ms
    - Outer gap: 10, 15 cm
    - LiTER rate: start ELM-free, go up from there, test SGI
    - I_p: 0.8,1.0,1.2
    - Kappa:2.4, 2.0, 2.6?

- Add in tools to improve stability (½ day)
  - E.g., beta feedback

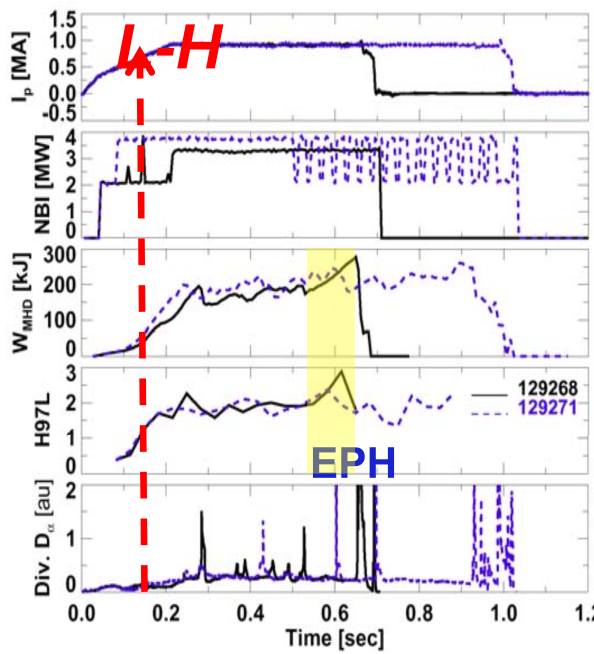
- Optimize long pulse/high f_{NI} EPH discharge (½ day)
  - Target high f_{NI}, either absolute or at higher current

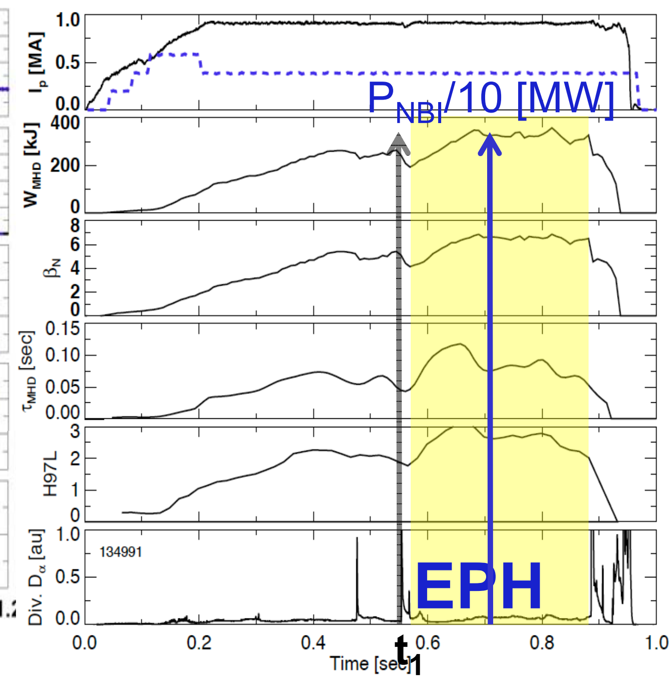
Reasoning behind scanning n=3 timing

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



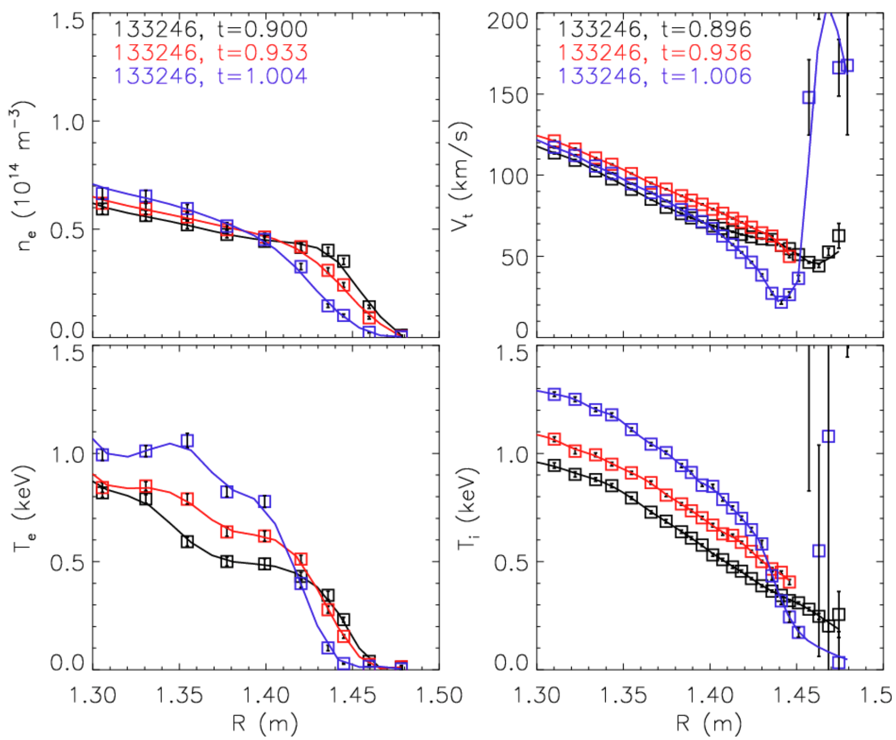
Maingi, JNM 390-391 (2009) 440

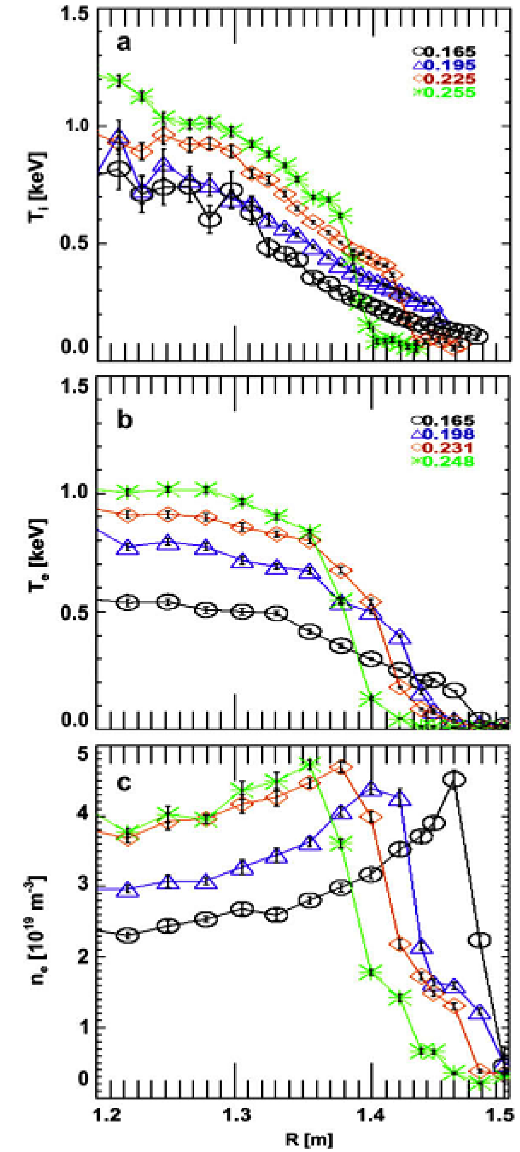




Reasoning behind scanning outer gap

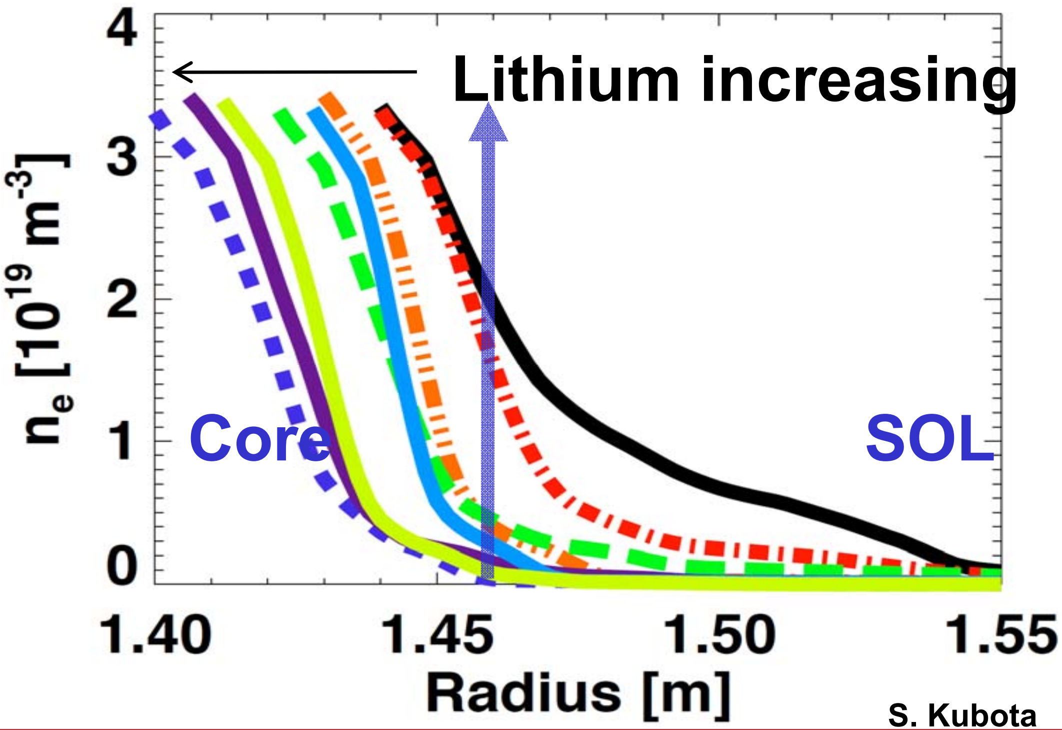
- Following transition to EPH, outer gap increases naturally
- Adjusting gap before EPH may make access easier





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



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