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Development and Use of the β_N Controller in 2010

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and the NSTX Research Team

Late 2010 / Early 2011 Results Review

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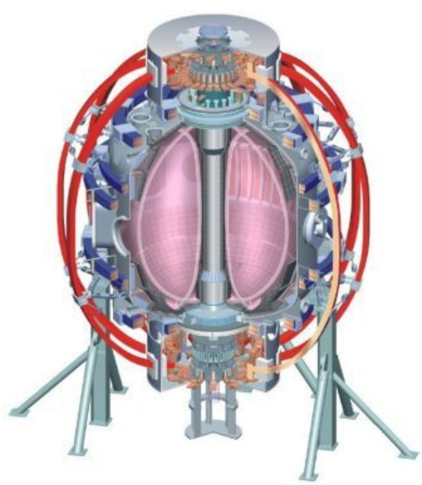

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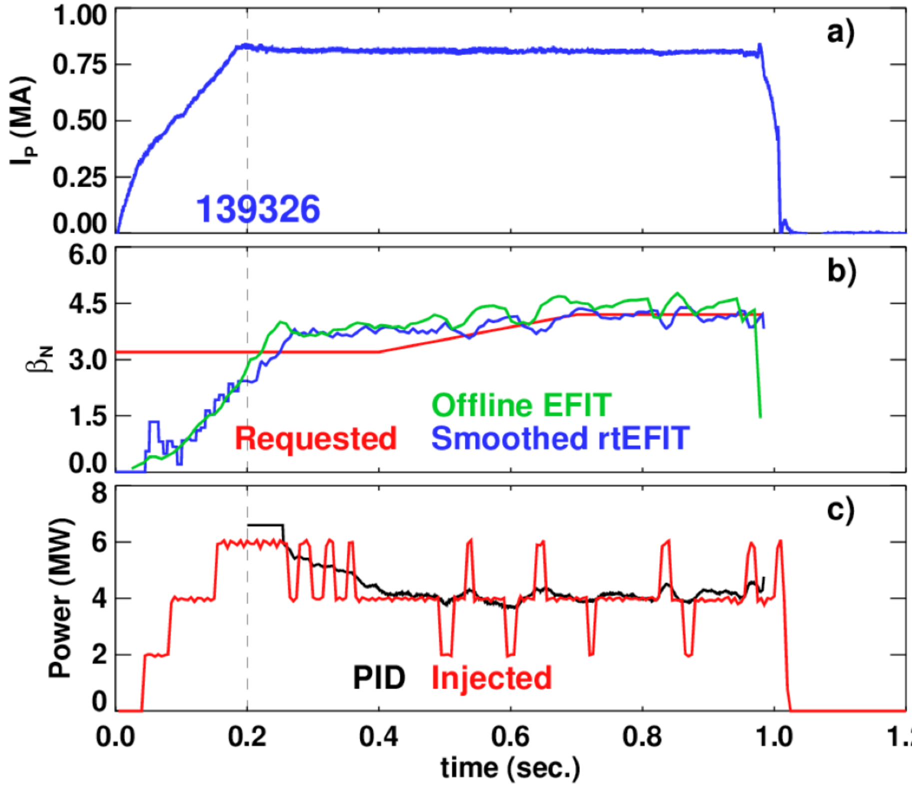
Overview

- Ran an XMP at the beginning of the campaign.
  - Thanks to M. Bell and E. Kolemen for a useful algorithm suggestion.
- Ran an XP looking at performance of controller for high-performance discharges.
- Used the controller for other XPs.
  - R. Buttery XP on high-β error field penetration.
  - K. Tritz XP on electron transport.
    - Use (partial) pre-programming capability.
  - S. Sabbagh XP on MHD control in high-β_N plasmas.
  - Canik/Maingi/Gerhardt XP on EPH development.
- FS&T paper nearly through review describing the system.

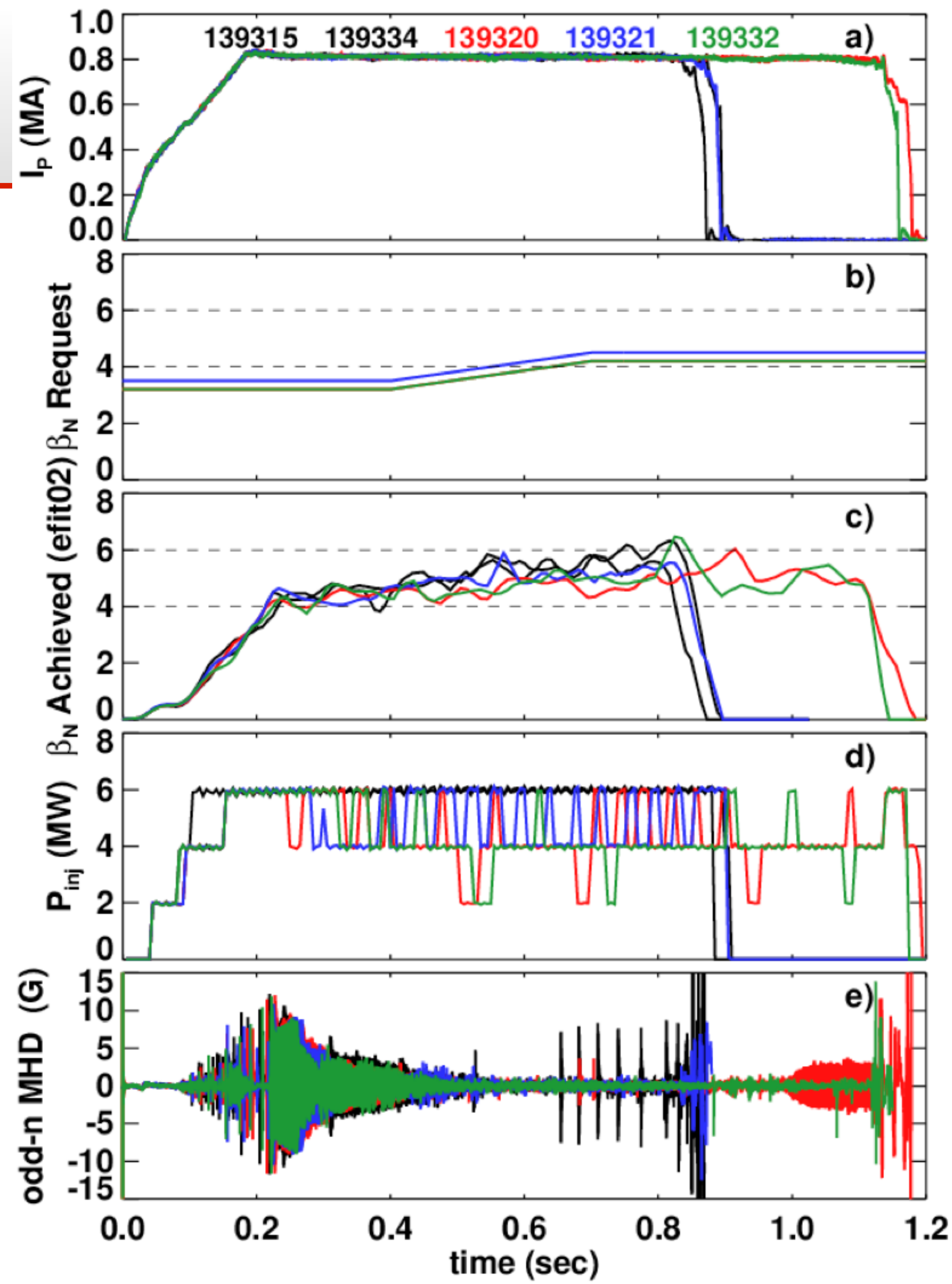
Example Use of the System

- 800 kA, high-κ discharge.
  - 6 MW front-end.
- Two calculations of β_N:
  - EFIT02
  - (causal-RC) Filtered from rtEFIT.
  - Filtering provides some phase lag (undesirable).
- Ramp in β_N request was required to avoid early disruption.
- Controller settles in at about P_{inj}=4MW to achieve requested β_N.



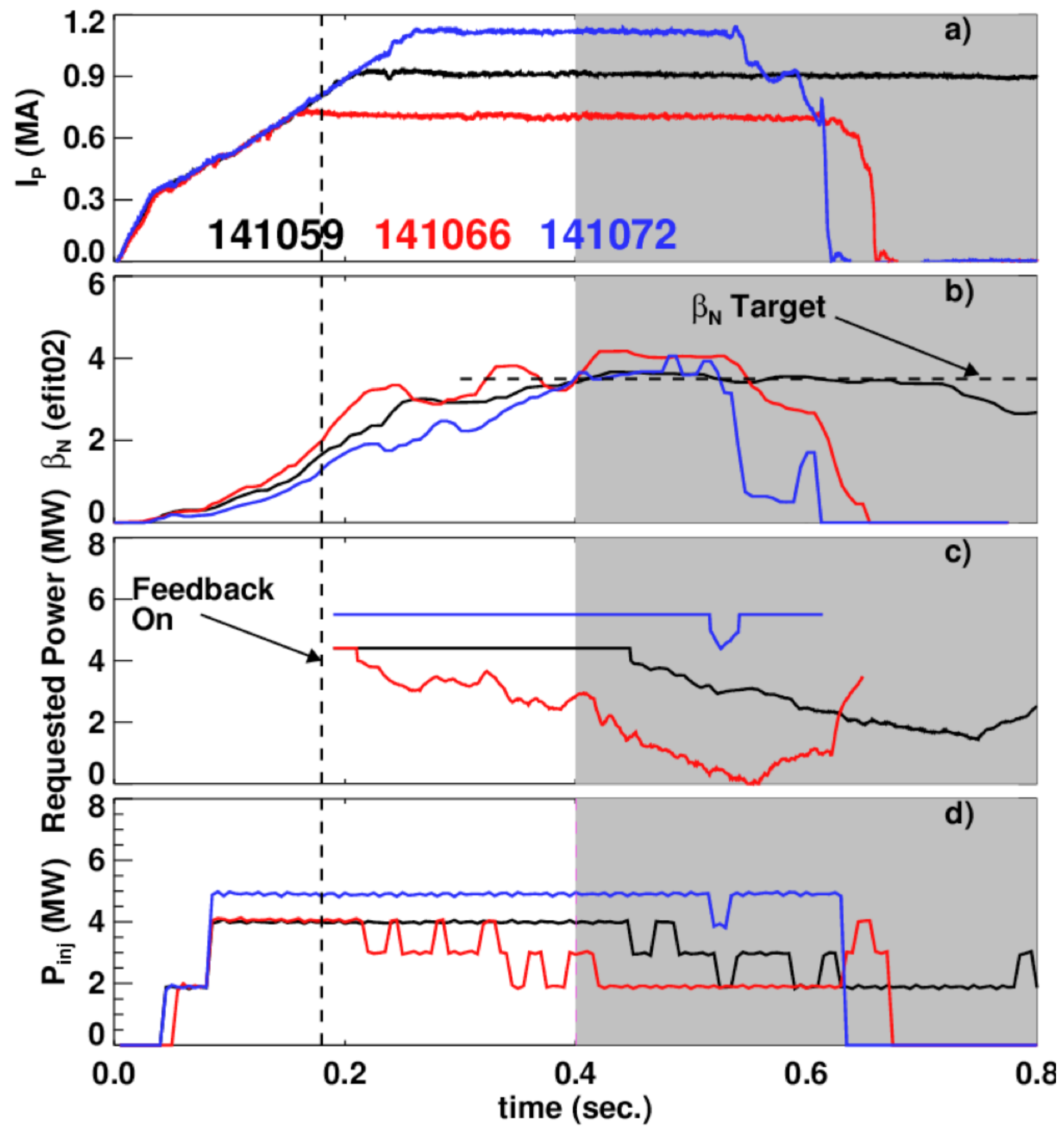
Controller can be used for High-Performance Discharges

- 800 kA, κ=2.6
- Two discharges in black disrupt at ~0.8 sec.
  - RWMs
- Red and green have β_N controller on from ~0.2 sec.
  - Power reduction avoids β_N limit.
  - Ramp in request was useful for avoiding disruptions.
- Blue case with higher request disrupts like the black discharges.



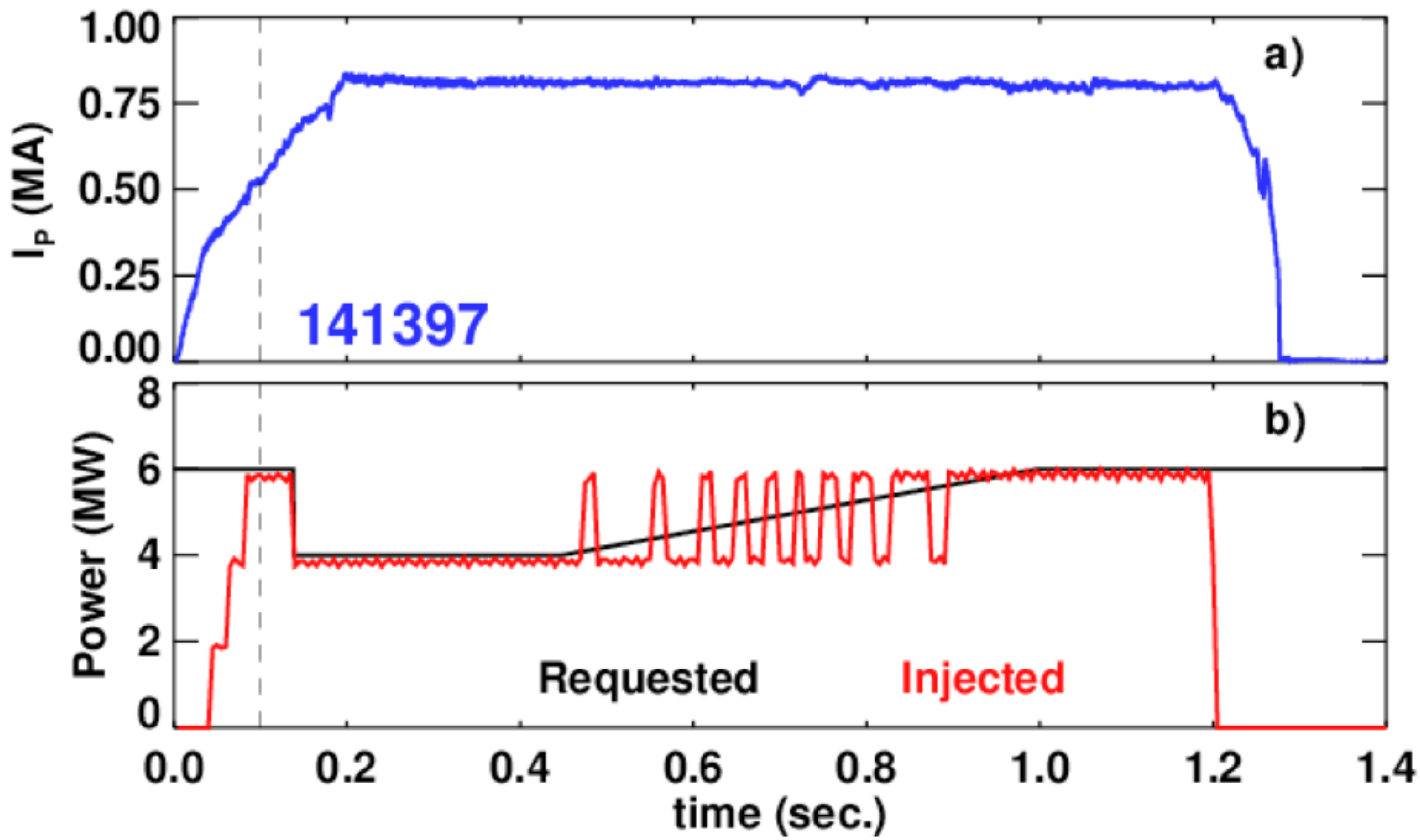
Controller Facilitates Field and Current Scans at Constant β_N

- Scan I_P & B_T.
  - Desire to maintain the same β_N for all shots.
  - Apply large n=1 field starting at t=0.4.
- Turn β_N controller on at t=0.2.
  - Essentially the same β_N by t=0.4.
  - Low current case had slightly higher β_N, as we did not allow source A to modulate.
- Saves a lot of XP time.
  - Not necessary to program the power by hand.



Controller Allows Fine-Scale Power Ramps

- Requested a linear ramp in the power.
  - Modulation calculator gave the required ramp.
- Can be used for XPs next year.
  - Note: Present requirement is that all sources be on before PCS takes over.



Summary

- Controller works for general use.
  - Consider it for more XPs next year.
    - But beware, can make the transport analysis a bit more irritating.
- Must make a judicious choice of β_N request.
  - Ramp in request was sometimes required.
  - Could maybe get around this by:
    - Feeding back on amplification of applied n=1 field (for $\beta_N > \beta_{N,no\text{-}wall}$)
    - Using realtime estimates of $\beta_{N,no\text{-}wall}$.
  - These are long-terms research tasks.
- Potential short term-improvements.
  - Fix integral wind-up (reset integral error if error gets too large).
  - Add a causal median (instead of RC) filter, to filter out bad reconstructions.
  - Any improvements to rtEFIT?
    - In contact with J. Ferron on this issue.