Neoclassical Tearing Mode Stabilization with Optimal Electron Cyclotron Current Drive Alignment in DIII–D

by
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for the DIII–D Team

Oral at the 47th
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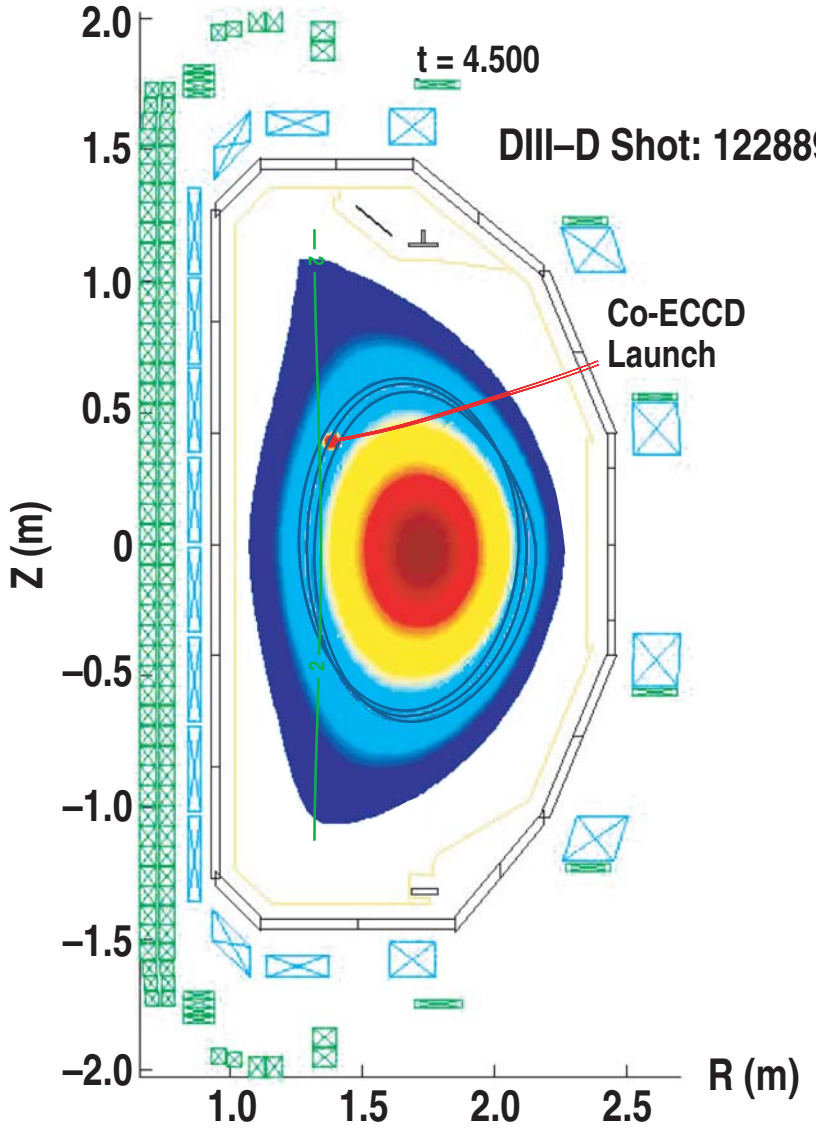
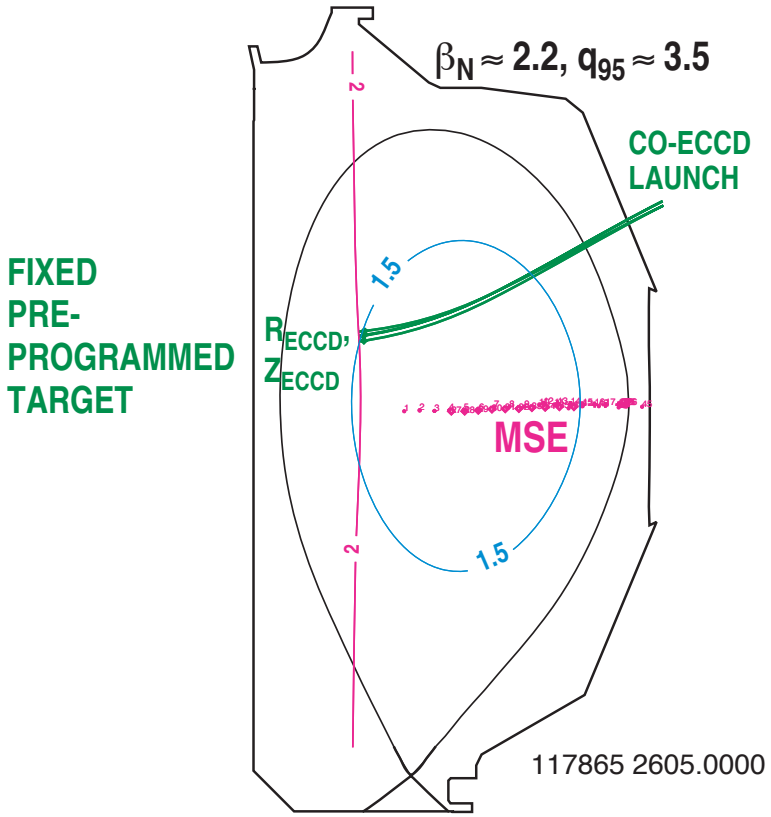
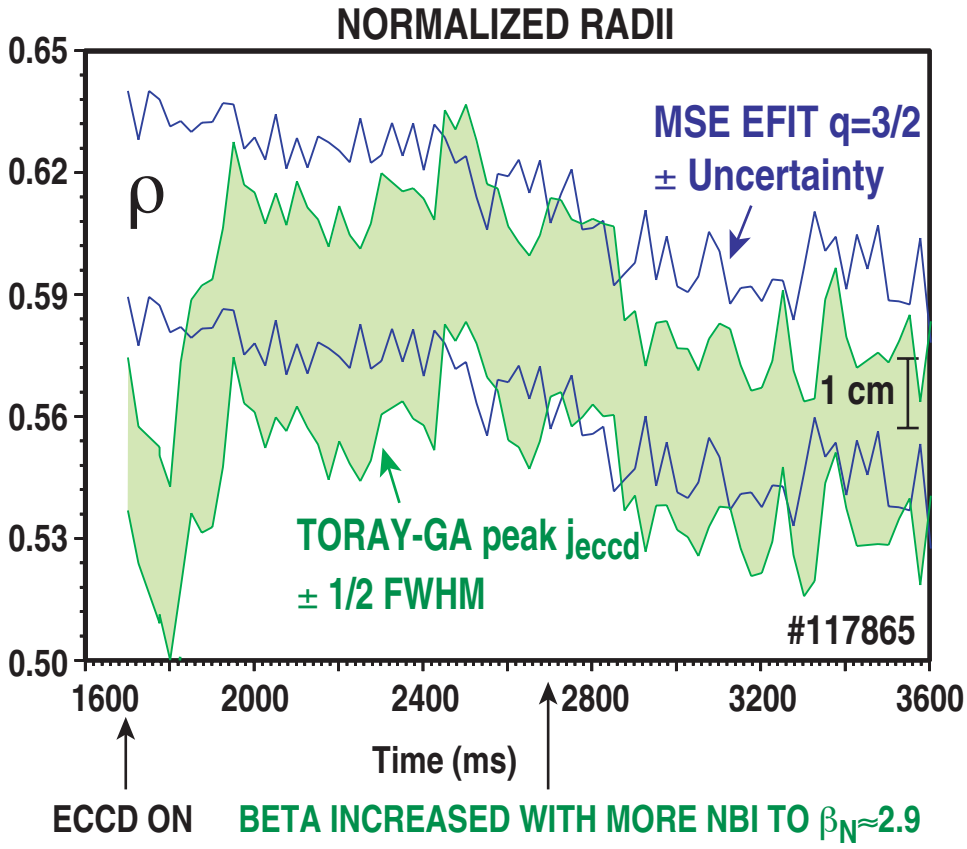


Preemptive ECCD Can Avoid a NTM Occurring I.

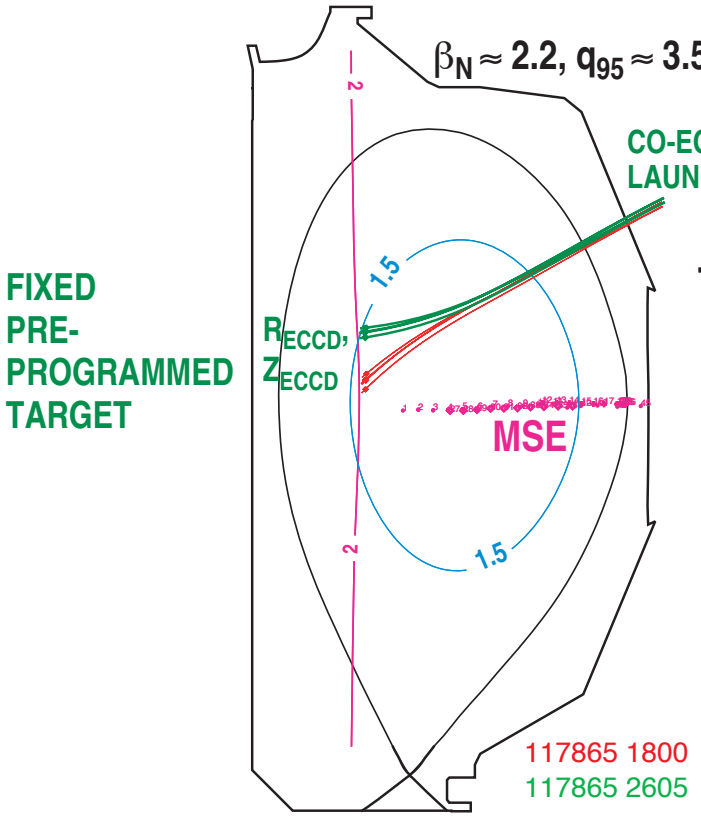
- **ECCD stabilization requires precise alignment ($|\Delta\rho|/\delta_{eccd} \leq 0.5$)**
- **Adjust plasma major radius to put q=3/2 surface on pre-programmed target**
  - ★ accurate location of rational surfaces
    — with motional Stark effect diagnostic
  - ★ Shafranov shift compensated
    — no m/n=3/2 NTM appears

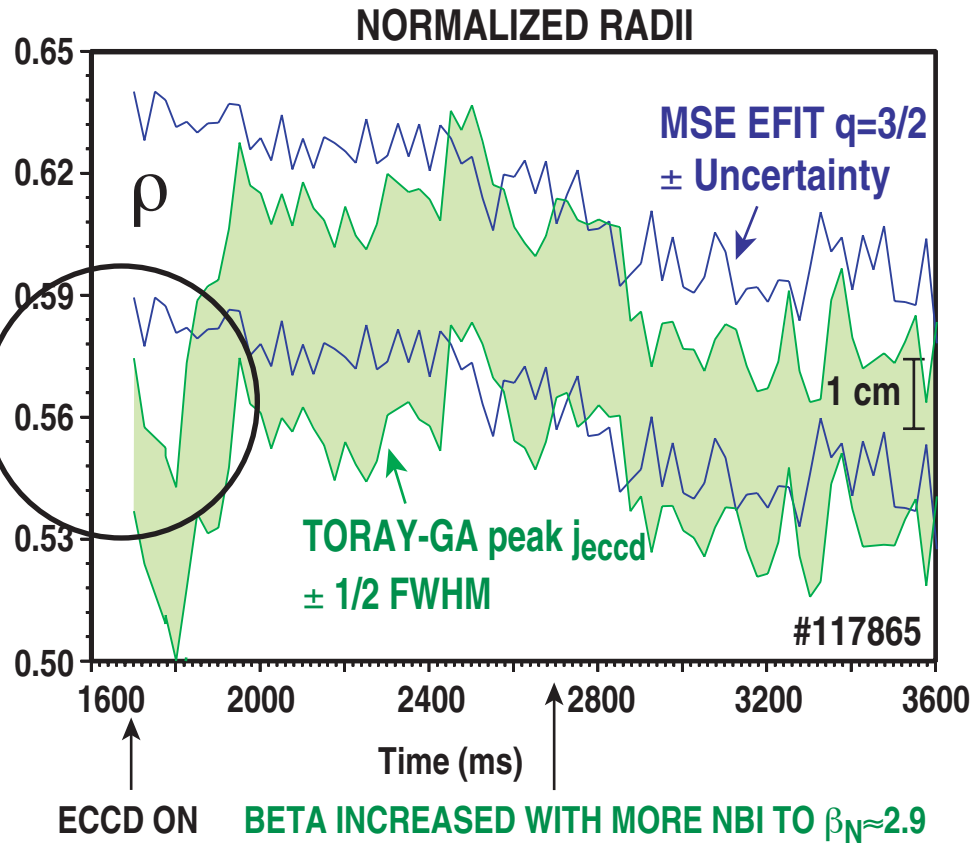




Preemptive ECCD Can Avoid a NTM Occurring II.

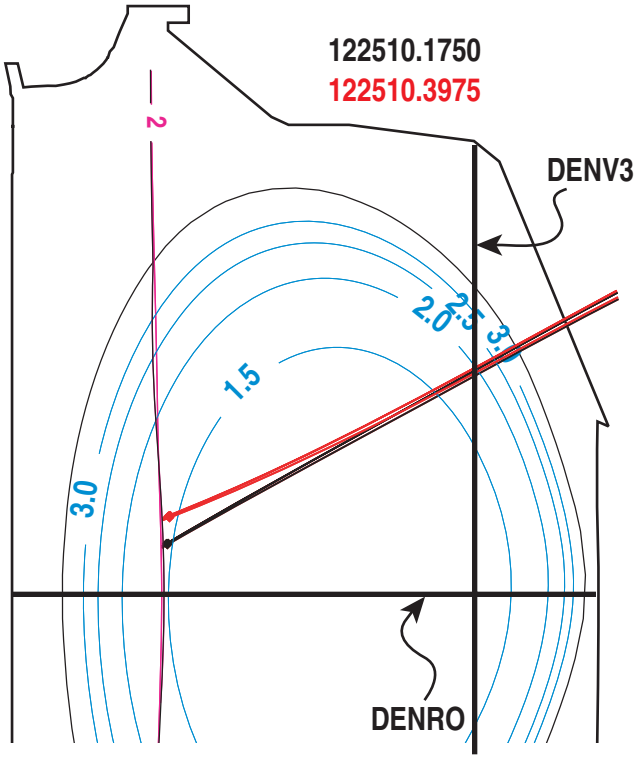
- **Refraction of ECCD can lead to misalignment if not accounted for**
  - ★ density evolving as beta ramping up
    - — the target is moving
      . . . δZ_{ECCD} leads to $\Delta\rho$

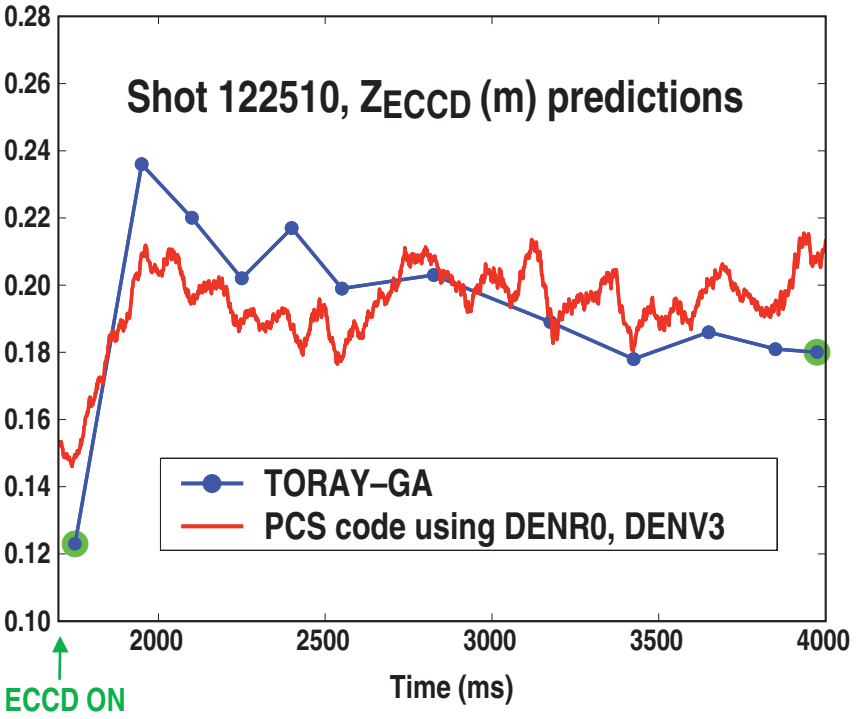




Real-time Compensation for Refraction of ECCD is Now Implemented in the Plasma Control System

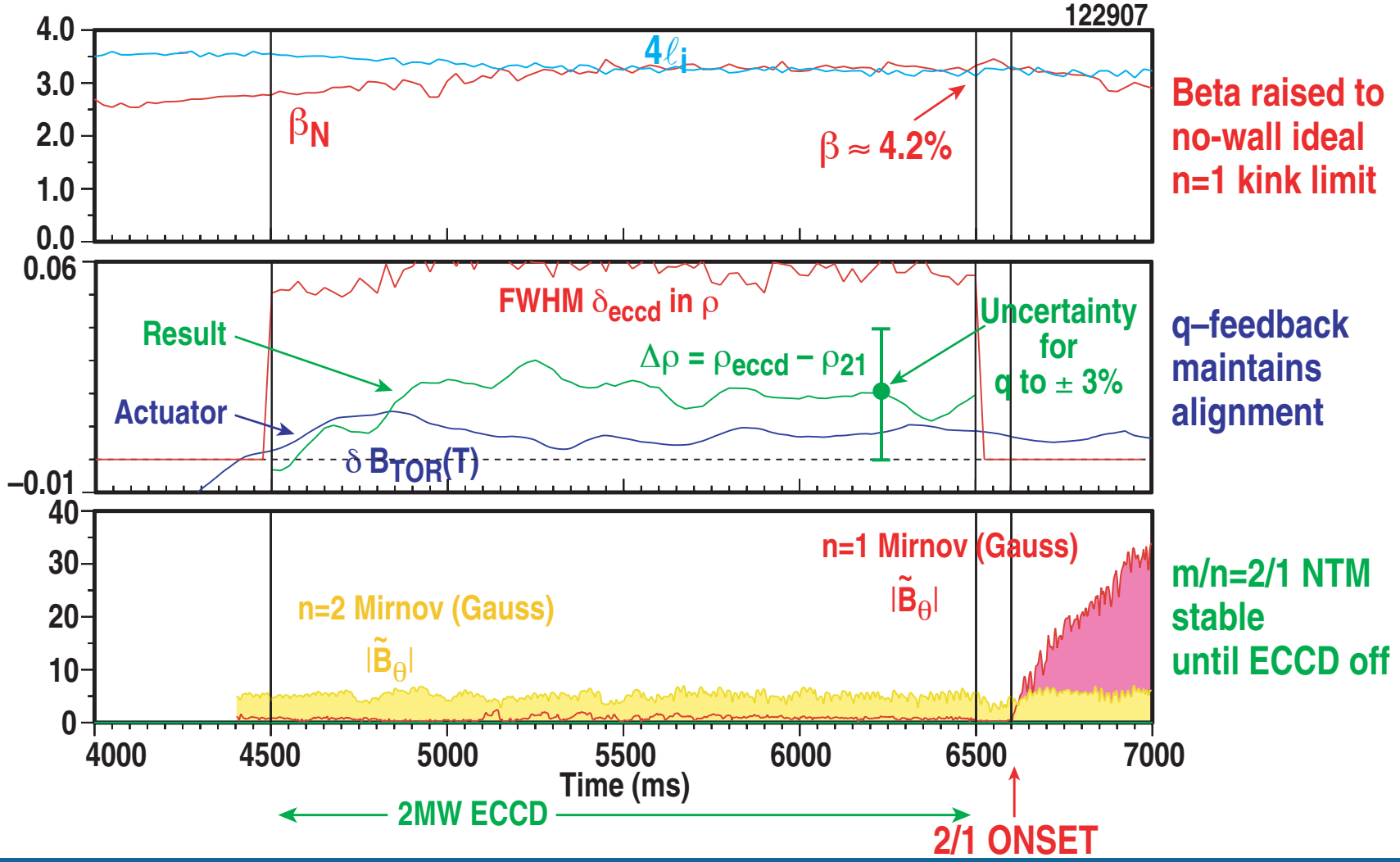
- R_{ECCD} "target" is robust for given toroidal field
  - ★ but refraction can change Z_{ECCD} "target"
- PCS real-time ECCD target implemented to track δZ_{ECCD}
  - ★ for better alignment of ECCD and q=3/2 (or q = 2/1)
    - — uses central and outer interterometer chords





Preemptive ECCD and "q-Feedback" Also Used to Stabilize Otherwise Unstable m/n = 2/1 NTM

- **Hybrid scenario with m/n=3/2 NTM keeping q(0)≈1**
  - ★ Toroidal field adjusted by real-time MSE EFIT to keep peak j_{eccd} on q = 2



Progress in NTM Control by ECCD in DIII–D Includes . . .

- **Real-time tracking of both rational surface and ECCD locations**
- **Higher stable beta to m/n = 3/2 mode**
  - ★ in sawteething H–mode
- **Higher stable beta to m/n = 2/1 mode**
  - ★ in hybrid scenario

2006-2007 Campaign NTM Stabilization Plans Include

- **Preemptive ECCD for no 2/1 mode at $\beta_N > 4\ell_i$ in hybrid scenrio**
  - ★ proximity to pole in Δ'?
- **ECCD control of BOTH 3/2 and 2/1 modes in sawteething H–mode**
  - ★ real-time mirror steering and 6 gyrotrons
- **Verifying modulated ECCD effectiveness**
  - ★ new counter beams
    - — n=2 Mirnov frequency ≈ 20 kHz → ≈ 5 kHz
      . . . well within gyrotron modulation capability

(See also A.S. Welander CP1 Mon. aft. and D. Humphreys LI1b Wed. aft.)

While Narrowest Unmodulated ECCD is Routinely Used, the Issue of Wide ECCD in ITER is Also Being Investigated

- **S'crow (0.69 MW) more effective than S'crow, Katya, Tinman (0.84 MW total)**
  - ★ **but 3/2 island locking to sawteeth ($f_{32} = 2f_{11}$) reduces expectation**