Expanding Present Between-shots Equilibrium and Stability Capabilities

S. A. Sabbagh

Columbia University

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MHD Stability Group

Princeton Plasma Physics Laboratory

NSTX

MHD Group

Between-Shots Analysis Contributes to 5-Year MHD Goal

- ❑ 5 Year FESAC (IPPA Report) MHD Goal
  - ❑ Develop detailed predictive capability for macroscopic stability, including resistive and kinetic effects
    - Progress measured by the level of agreement between predicted and observed stability regimes and by improvements in the stability of operating confinement devices

- ❑ Requirements
  - ❑ Direct analysis of sufficiently detailed experimental equilibria
  - ❑ Adequate statistics (many shot * times) to determine correlations
    - Requires analysis automation
  - ❑ Broad range of experimentally realized boundary / profile shapes
  - ❑ Progressive increase in physics detail to determine quantitative agreement between theory and experiment at each detail level
    - Requires that between-shots diagnostics exists to support analysis

Between-shots analysis has existed since Day 0 (CY99)

❑ ## CY99 – CY00

   ❑ Routine magnetics-only ST equilibrium reconstruction

❑ ## CY00

   ❑ Testing of stability analysis on magnetics-only reconstructions

      • Qualitative, not quantitative agreement in all experimental regimes due to unknown pressure profile shape

❑ ## CY01

   ❑ Testing of partial kinetic (PK) equilibrium reconstructions

   ❑ Testing of stability analysis on PK reconstructions

      • Qualitative agreement between fast collapses and stability violation

❑ ## CY02

   ❑ Routine partial kinetic equilibrium reconstruction

   ❑ Control room stability analysis for desired high β_N plasmas

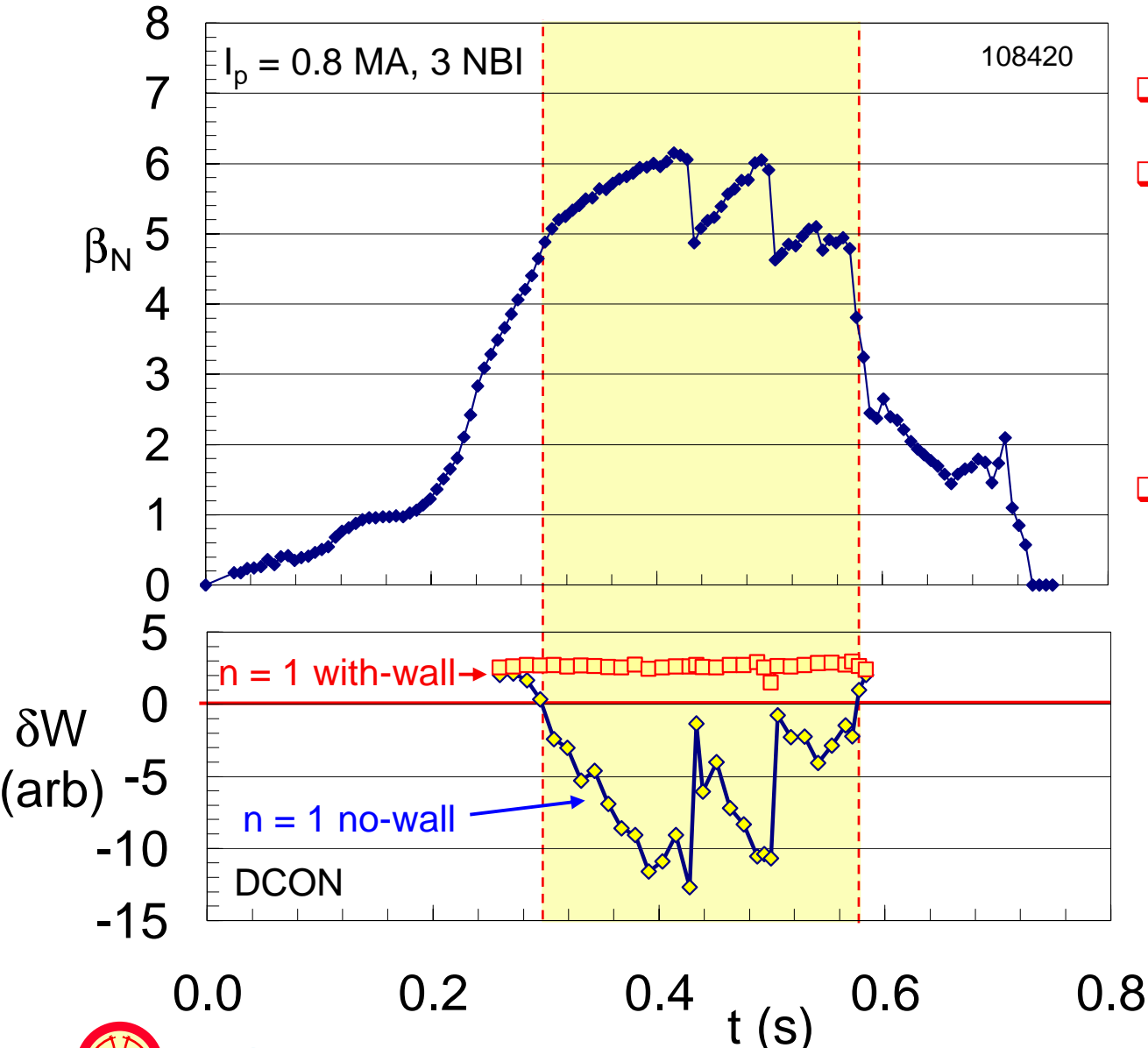   • No-wall and with-wall calculation

Ideal MHD stability compared to plasma evolution
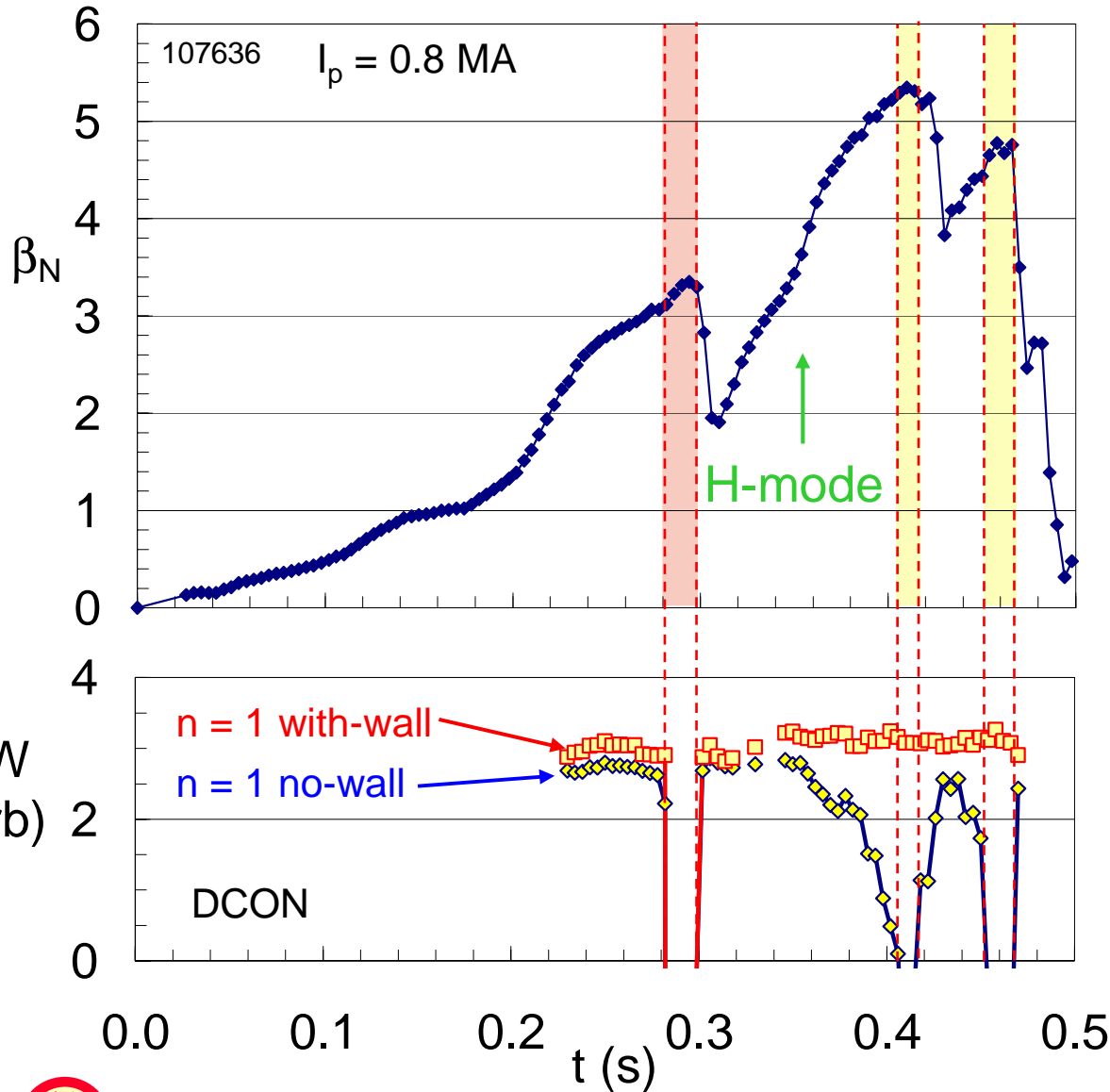
- ❑ "Between-shots" stability analysis using DCON
  - • Computed to support experiments
  - • Several hundred shot*times processed
  - • Error analysis still being evaluated

- ❑ First beta collapse occurs when with-wall β limit is violated
  - • Plasma recovery a new feature since PF5 error field reduced

- ❑ High β_N plasma stable with NSTX wall
  - • No-wall limit mildly violated
  - • Late collapse may not be β driven

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Ideal no-wall limit exceeded and maintained

$I_p = 0.8$ MA, 3 NBI

108420

β_N

δW (arb)

n = 1 with-wall →

n = 1 no-wall

DCON

t (s)

- ❑ High $\beta_N / l_i = 8.4$

- ❑ Ideal no-wall limit violated for 270 ms
  - ❑ Duration could be ~ 27 τ_{wall} (VALEN calculation pending)

- ❑ Core toroidal rotation remains high throughout
  - ❑ Greater than RWM critical rotation frequency from XP202
  - ❑ Need to examine v_ϕ profile evolution

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Plan for Between-shots Analysis Expansion

❑ CY02

    ❑ Complete sensitivity analysis of stability and correlation to observed experimental MHD phenomena

❑ CY03+

    ❑ Between-shots equilibria with internal magnetic diagnostics

        ● Requires between-shots MSE

    ❑ Fully-automated between-shots stability analysis

    ❑ Between-shots evolution of extrapolated wall/no-wall β limits

    ❑ Test of rotation effects on reconstructed equilibria

    ❑ Between-shots equilibria with rotation

        ● Requires between-shots v_ϕ profiles

    ❑ Test resistive δW calculation (i.e. resistive DCON: A. Glasser)

        ● May require MSE and greater pressure profile resolution and accuracy

    ❑ Between-shots resistive δW calculation

Discussion

❑ Is there a desired priority for the individual between-shots tasks?

    ❑ Are certain tasks more critical for NSTX, or to support FESAC IPPA goals?

❑ Are there other desirable and tractable between-shots tasks?

❑ Can diagnosticians point out expected difficulties that can be addressed now to help speed up analysis implementation when diagnostics are ready?