Global Mode Stabilization Present and Future Physics Studies

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MHD Stability Group

Princeton Plasma Physics Laboratory

Proposed research aimed at understanding physics of β-limiting modes and stability limits

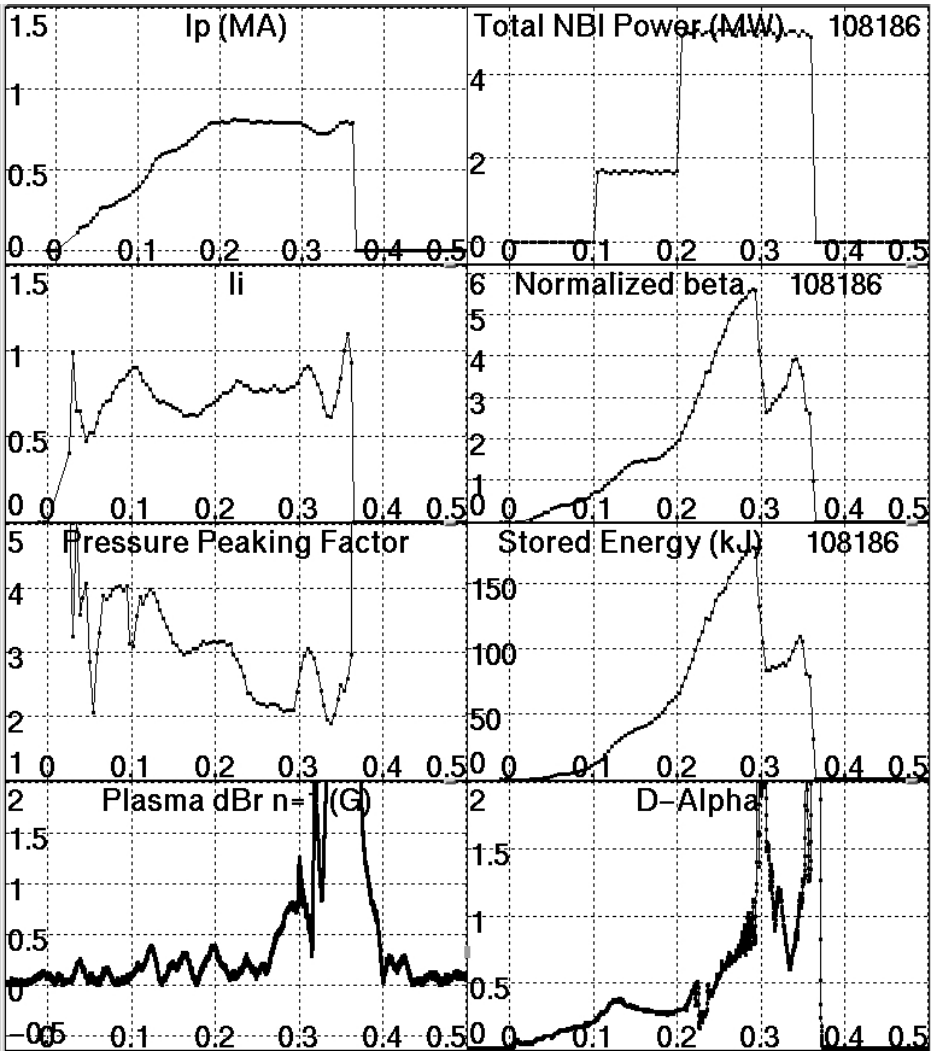
- Phase I research focussed on establishing equilibria
  - Developed both experimental plasmas and supporting equilibrium analysis
- Phase II research focussed on examining β limits / modes
  - Determine wall and no-wall limits and compare to theory
  - Determine effect of boundary and profile variation
  - Determine β-limiting instability physics / role of resistive wall mode (RWM)
- Phase III research focuses on high β operation
  - Surpass no-wall β limit with passive stabilization
  - Sustain operation above no-wall limit for increasing pulse lengths
  - Design / implement active feedback system to stabilize RWM

The Present: XP202 - RWM Characterization in the ST

- Generated many RWM plasmas for study with high β_N <= 6
  - Measured toroidal rotation damping rate due to RWM
  - Measured critical rotation frequency
- Performed outer gap scan
  - Rotation damping rate, β_N limit not sensitive to gap size at high β_N
    - Expected in theory due to long poloidal wavelength on outboard side
    - Expected in theory due to reduction in PF5 error field in CY2002
- Performed toroidal field scan
    - Critical rotation frequency dependence waiting on CHERS profiles
    - Core rotation damping rate increases with time, even at constant β_N
      - need to still sort out B_t dependence
    - RWM observed in locked mode detector at B_t < 4.5kG, not clear at higher B_t
- Measured δT_e during the RWM by altering TS laser timing
  - Mode appears as kink
    - No clear δT_e inversion as would be expected from an island

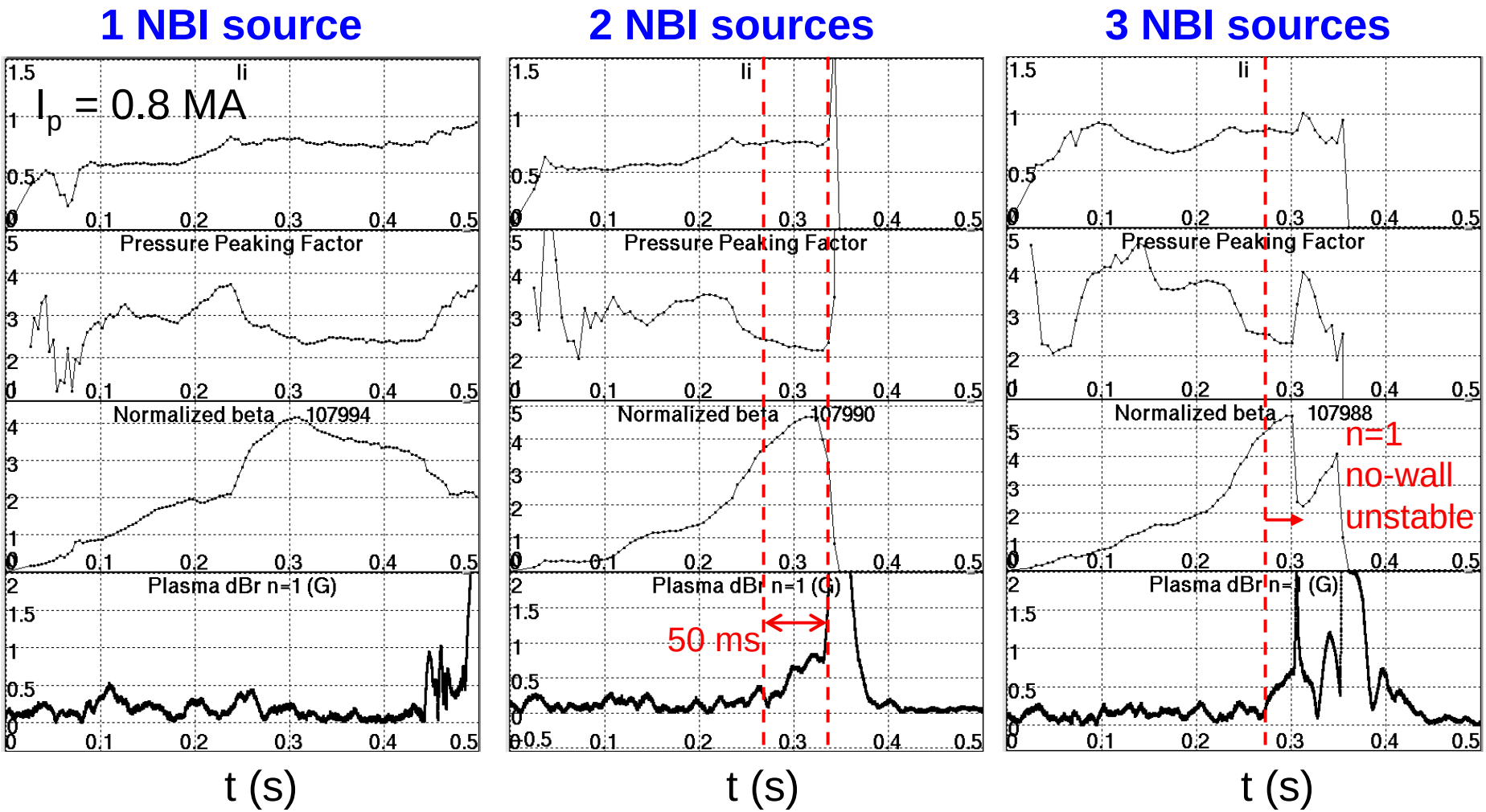
5/8/02

RWM observed on locked mode detector



- LMD signal weaker than observed on CY2001
  - Lower PF5 error field
- RWM is beta dependent
  - Mode not observed at insufficient β_N
- LMD signal growth dependent on β_N
  - Slower growth in shots with β_N constant, rather than strongly increasing
- Core toroidal rotation damping rate increases in time
  - Highest rate (seen in many shots) -500kHz/s
    - Larger than CY2001 run

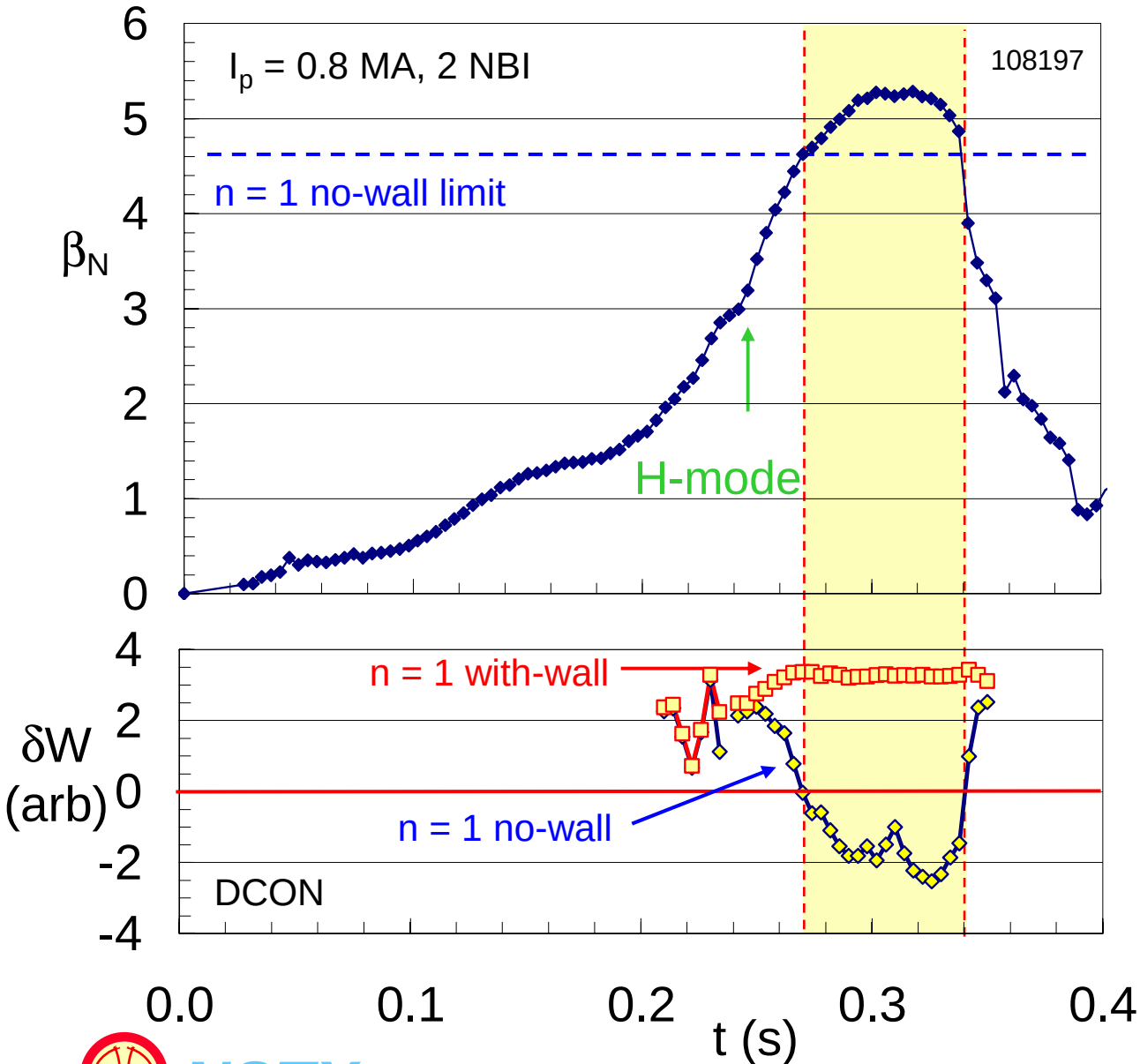
RWM observed at B_t = 4kG and is pressure dependent



- Decrease in growth rate at high β_N consistent with VALEN computation

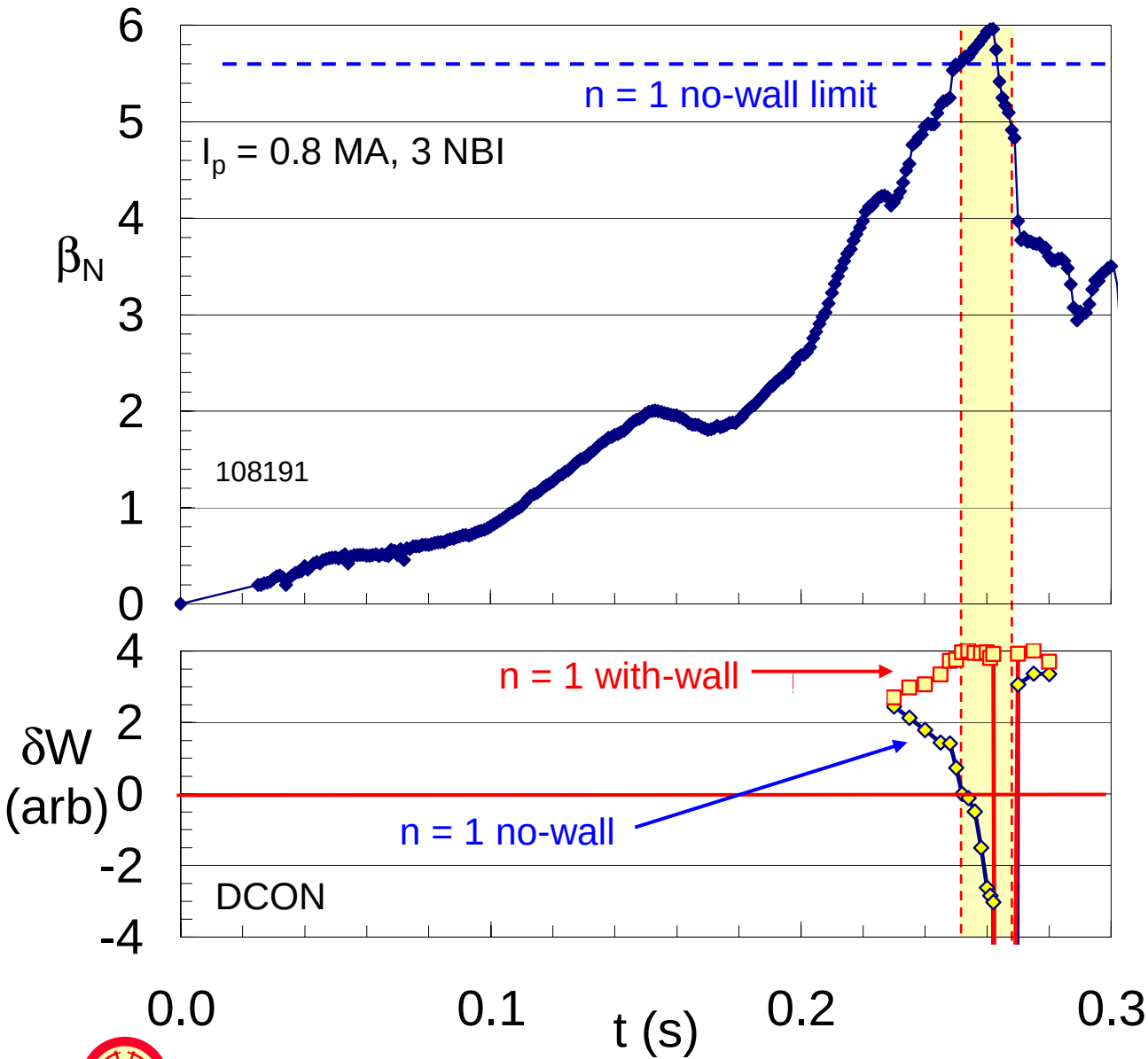
XP222 J. Menard

Ideal no-wall limit exceeded and maintained



- 2 NBI sources allowed plasma to be maintained
- Core rotation damping rate increases in time at constant β_N
- Exceeded no-wall ideal β_N limit by > 15% in this case
- Ideal no-wall limit violated for 70 ms
  - Several τ_{wall}

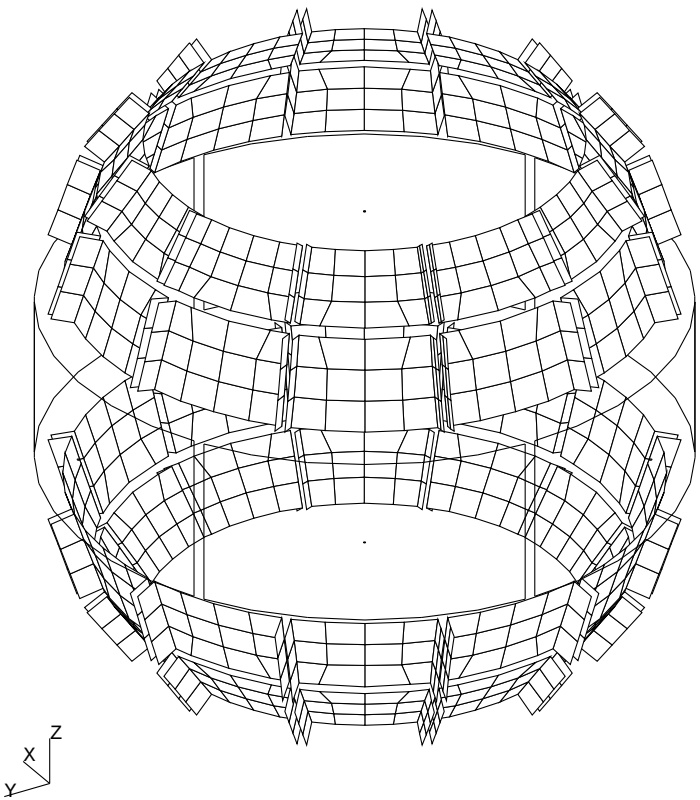
With-wall ideal limit reached with full NBI power

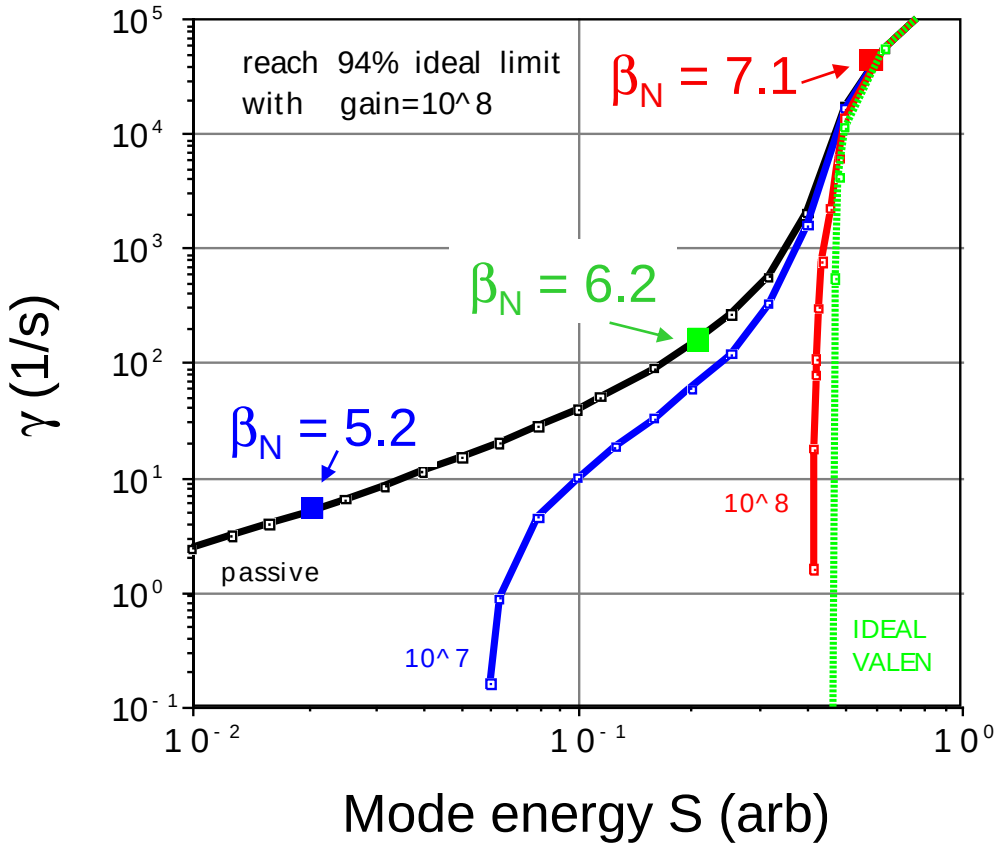


- 3 NBI sources leads to fastest beta collapse
- Core toroidal rotation very slow
- Highest β_N time point shows plasma unstable with conducting wall

Active feedback system options assessed with VALEN

Passive plate and control coil geometry





- Internal midplane control coils can stabilize RWM to 94% of no-wall β limit
- Several configurations analyzed (see GMS meeting notes)

J. Bialek 3/30/02

The Future: some elements of collaborative research

- RWM physics
  - Rotation damping physics
  - Critical rotation frequency dependencies / rotation effects
  - Mode structure measurement / comparison to theory
- Sustained operation approaching ideal with-wall limit
  - GMS work follows GMS meeting results: new sensors, initial active feedback system, RWM modeling, experiments
  - Supporting stability analysis (PK EFIT => DCON => VALEN, etc.)
- Analysis
  - Expanded between-shots stability analysis capabilities
  - VALEN analysis of various active feedback system designs
  - VALEN upgrades: rotation, multi-mode, diagnostics simulation