CY 02 - 05 XP Ideas Supporting Proposed MHD Stability and Active Mode Control Research

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Existing three year work plan provides the foundation for our proposed 2002 - 2005 research

- Phase I XPs focus on establishing equilibria
  - Scope out operational space of ohmic plasmas
- Phase II XPs will focus on examining β limits / modes
  - Determine wall and no-wall limits and compare to theory
  - Determine effect of boundary and profile variation
  - Determine if kink/ballooning limit has an aspect ratio scaling
  - Determine limiting instabilities and role of resistive wall mode
  - Test low A effects on high-*n* mode stability limit
- Phase III XPs will focus on exceeding "standard" β limits
  - Surpass β limits with forms of control (i.e. active feedback on RWM)

(Blue: completed) (Green: present work) (Red: future work)

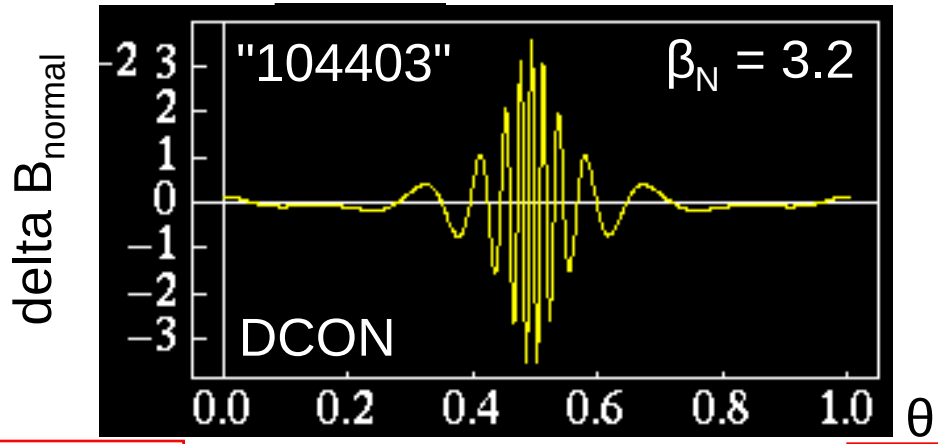
Status of group XPs: CY 1999 - 2001

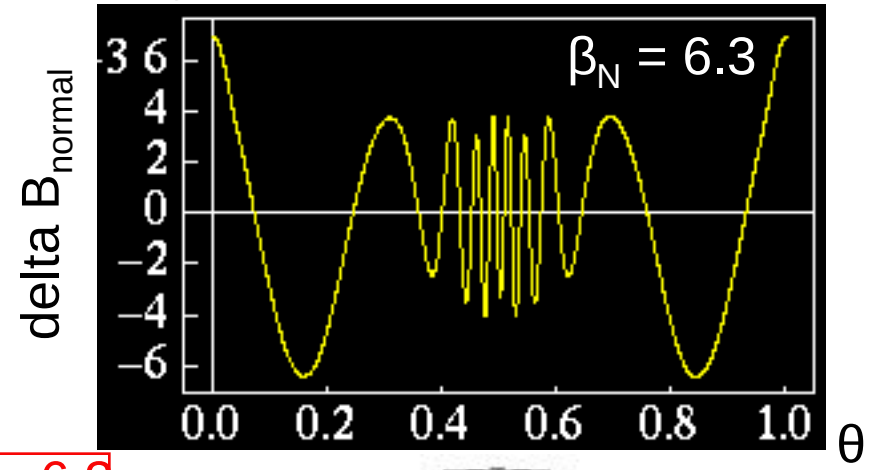
- XP4: Establish NSTX Equilibrium Domain
  - Run complete, data published
- XP17 Influence of J profile on MHD stability at low A
  - Presently running
- XP20 Characterization of resistive wall modes at low A
  - Pending final review
- XP: Effectiveness of configuration on resistive wall mode stabilization
  - Submitted to ET1 MHD Stability Task Force
- XP: Physics of ballooning mode stabilization at low A
  - Awaiting availability of internal magnetic measurements

Analysis tools have been developed to support this effort - and results are easily accessed

- Establish equilibrium analysis
  - Between-shots EFIT capability established and fully-automated
  - NSTX model established (to be published in Nuclear Fusion)
  - Data available to all (several 10^5 shots) via EFIT MDS+ tree
- Establish stability analysis
  - Between-shots DCON capability semi-automated during last run
  - DCON MDS+ tree implemented and ready to accept results
  - Full automation available for next run
- Evaluate passive mode control and design an active mode control system
  - Analysis noted above now providing input to VALEN
  - 3D NSTX model completed and initial analyses underway

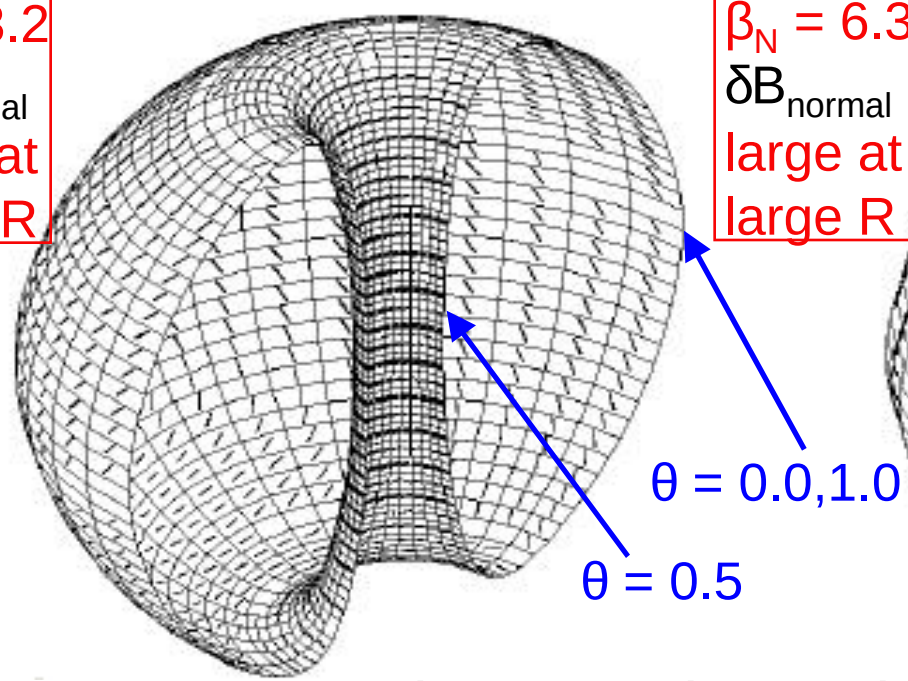
Edge B_{Normal} eigenfunction analysis for mode control





β_N = 3.2
δB_{normal}
large at
small R

β_N = 6.3
δB_{normal}
large at
large R



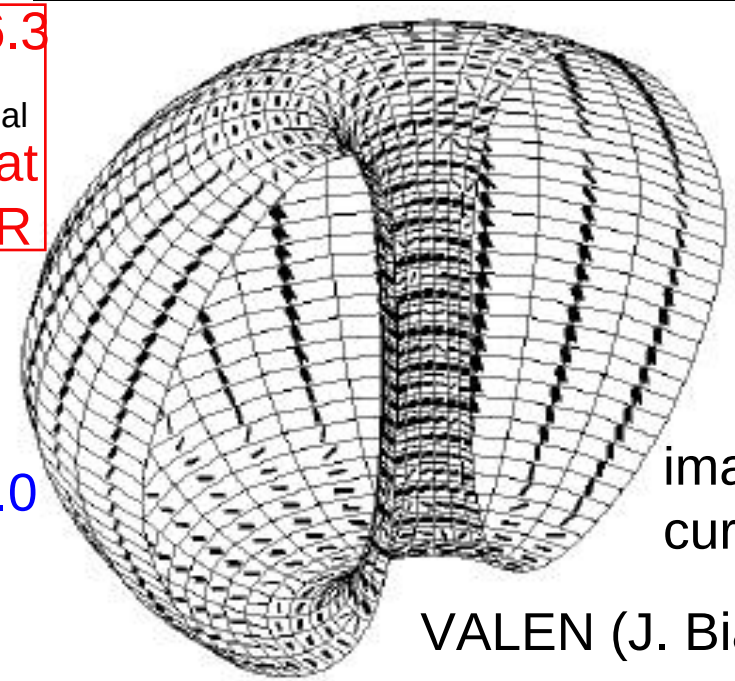
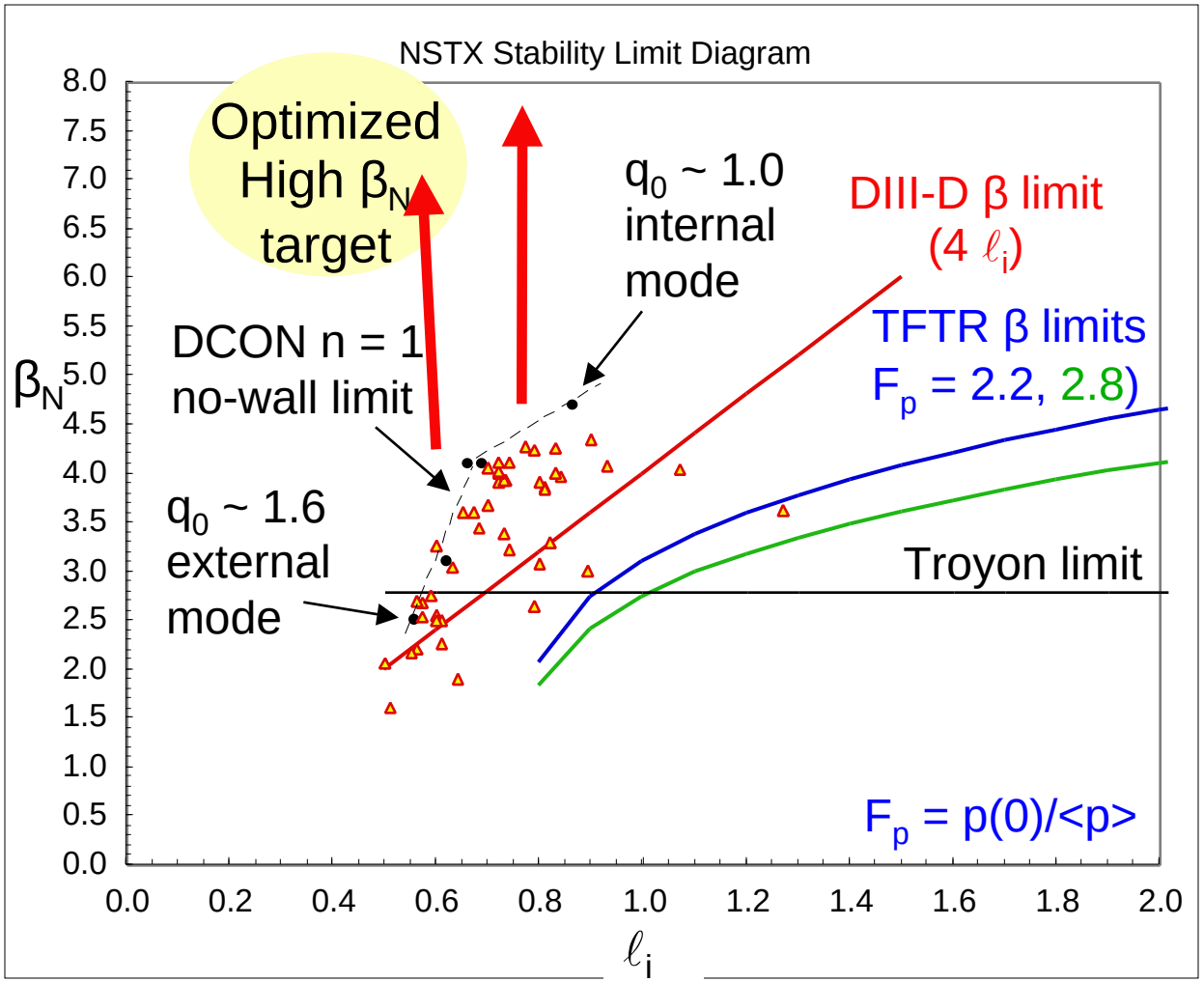


image
currents

VALEN (J. Bialek)

- Input for analysis of passive and active mode control system

Present results provide good start toward high β_N



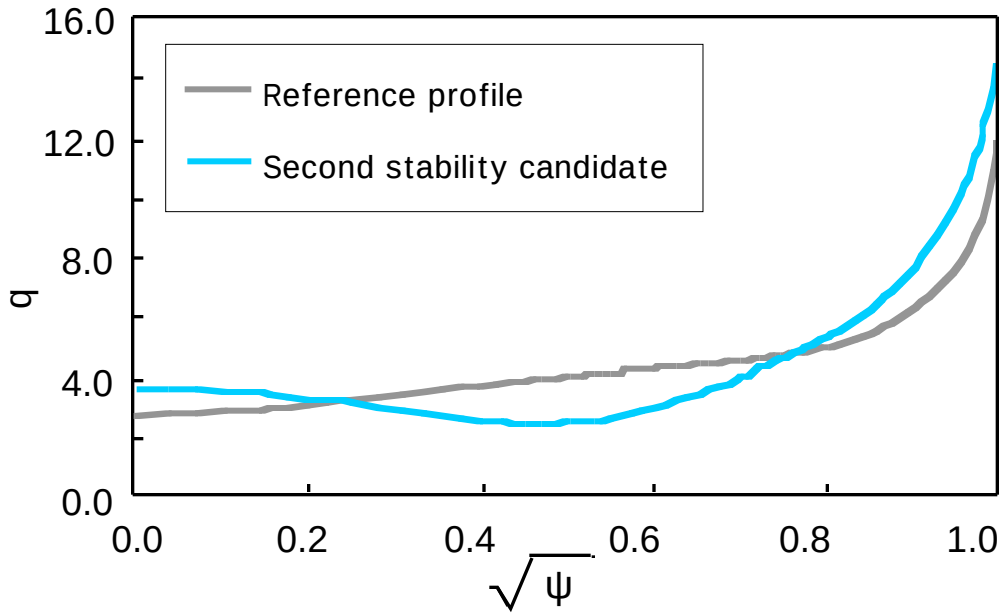
- Troyon limit, TFTR, and DIII-D β limits exceeded (β (EFIT))
- *n* = 1 ideal limit (DCON) in agreement with fast β collapses observed at $\ell_i \leq 0.8$
  - large outer gap => no-wall limit applies
- Ideal β_N limit is yet to be challenged at high ℓ_i
- Wall stabilization required to reach optimized target β_N
  - effective in low l_i plasmas with q(0) > 1

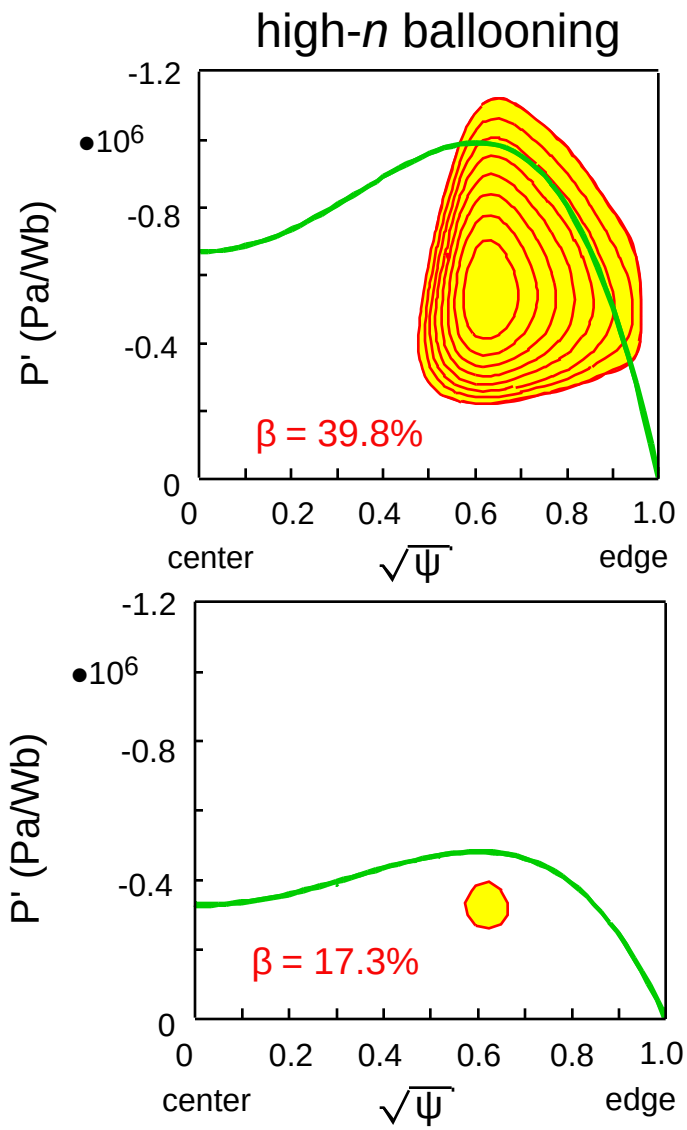
DCON (A. Glasser)

CY 2002 - 2005 proposed research covers mode characterization, and mode control (I)

- Exploration of β-limiting phenomena in ST
  - Determine details of ideal stability limit
    - Find best experimental paths toward high β_N target
    - Determine which plasmas have most margin over no-wall β_N limit
    - Access second stability regime at low A - compare behavior to theory
  - Study passive control of β-limiting instabilities
    - Produce plasmas above the predicted no-wall β_t limit (~ 25%)
    - Measure characterictics of resistive wall mode / compare to theory
    - Determine effectiveness of passive structure
  - Determine effect of rotation at low aspect ratio
    - enhanced toroidal rotation from E_r caused by larger energetic particle loss
  - Investigate the potential for "toroidal ballooning" and mode structure due to reduced toroidal field at low A

Low A yields unexpected second stability behavior





- As P profile is scaled down
  - Closed unstable region shrinks and disappears
  - As β increases, marginally stable to high-n at β = 32.2%
- Due to higher order 1/A effects such as poloidal field curvature (destabilizing)

CY 2002 - 2005 proposed research covers mode characterization, and mode control (II)

- Passive and active control of β-limiting instabilities
  - Analyze magnetic probe and flux loop data as input to the design of a sensor configuration for mode control
    - Additional magnetic diagnostics are highly desired
  - Provide the design basis for an optimized, active control system
    - Model effects of passive stabilizer time constant and 3D geometry effects
    - Design an improved system based on modeling and effectiveness of present plate geometry
  - Design multi-*n* capability active feedback coil geometry to permit control of potential "toroidal ballooning" modes
    - allow application of rotating applied fields
  - Perform experiments with active mode control
    - explore error field amplification near marginal stability
    - create spectrum of statix *m*/*n* edge error fields to enhance stochastic losses to drive larger E_r to study enhanced rotation effects.