MHD Stability Regimes for FIRE

S. C. Jardin, C. Kessel, J. Manickam

Workshop on Physics Issues for FIRE
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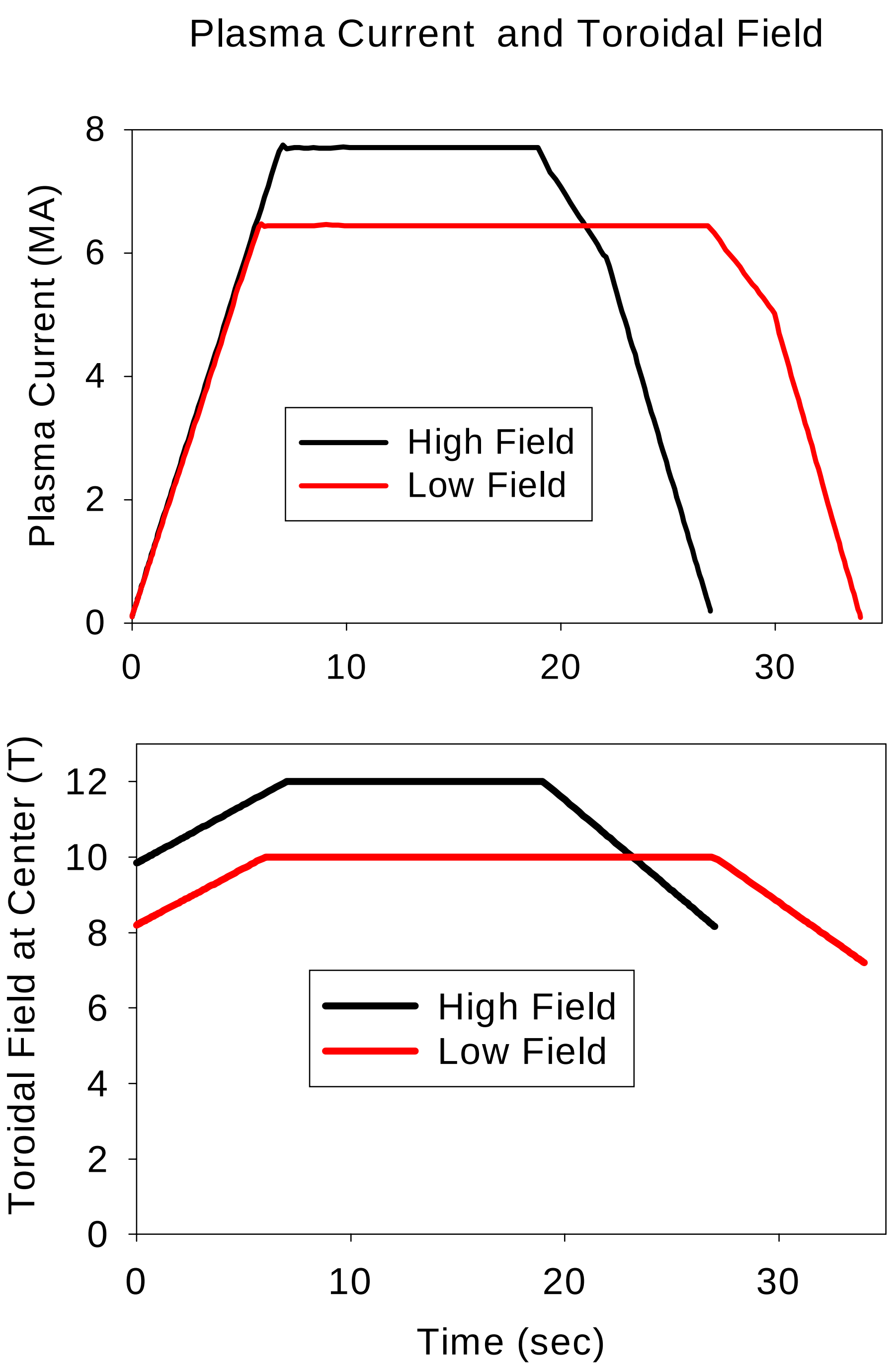
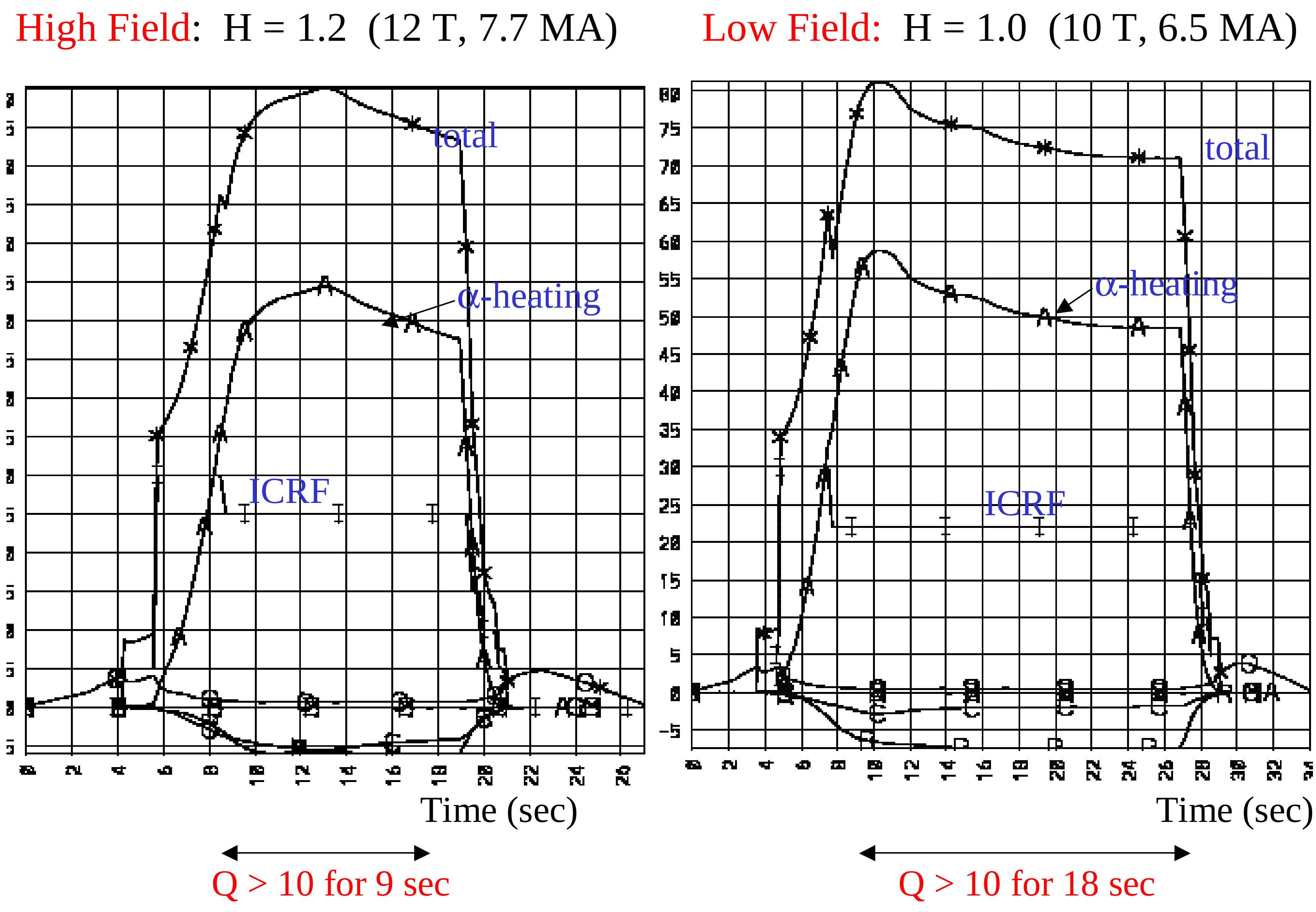
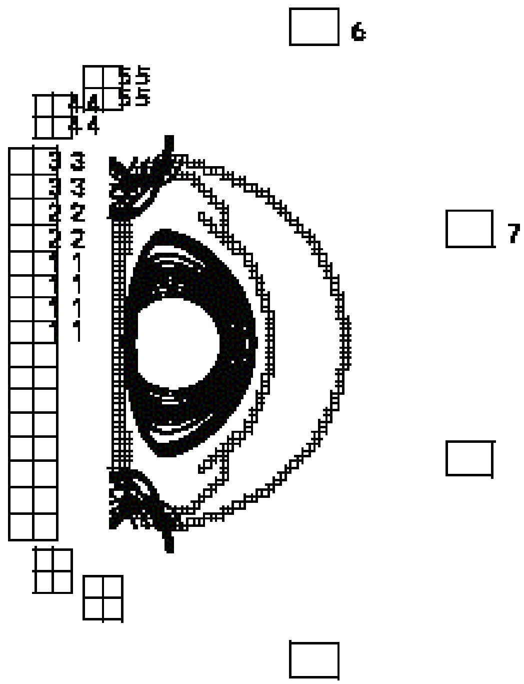


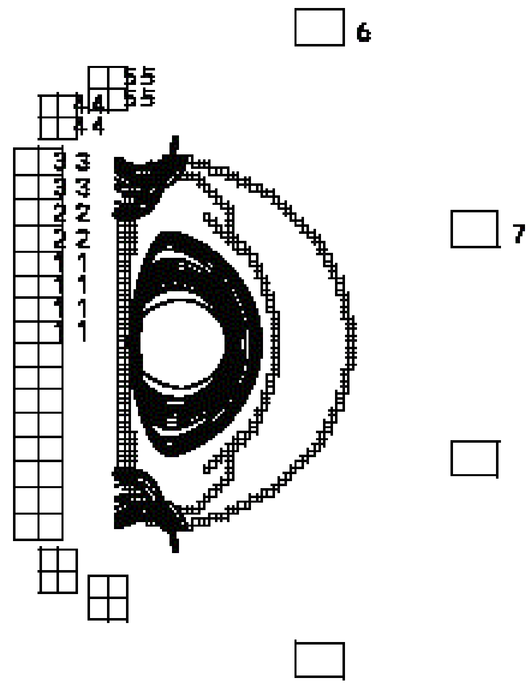
Plasma Current and Toroidal Field
Plasma Current (MA)
8
6
4
2
0
0
10
20
30
High Field
Low Field
Toroidal Field at Center (T)
12
10
8
6
4
2
0
0
10
20
30
Time (sec)
High Field
Low Field



High Field: H = 1.2 (12 T, 7.7 MA)
Low Field: H = 1.0 (10 T, 6.5 MA)
total
α-heating
ICRF
Time (sec)
Q > 10 for 9 sec
Q > 10 for 18 sec

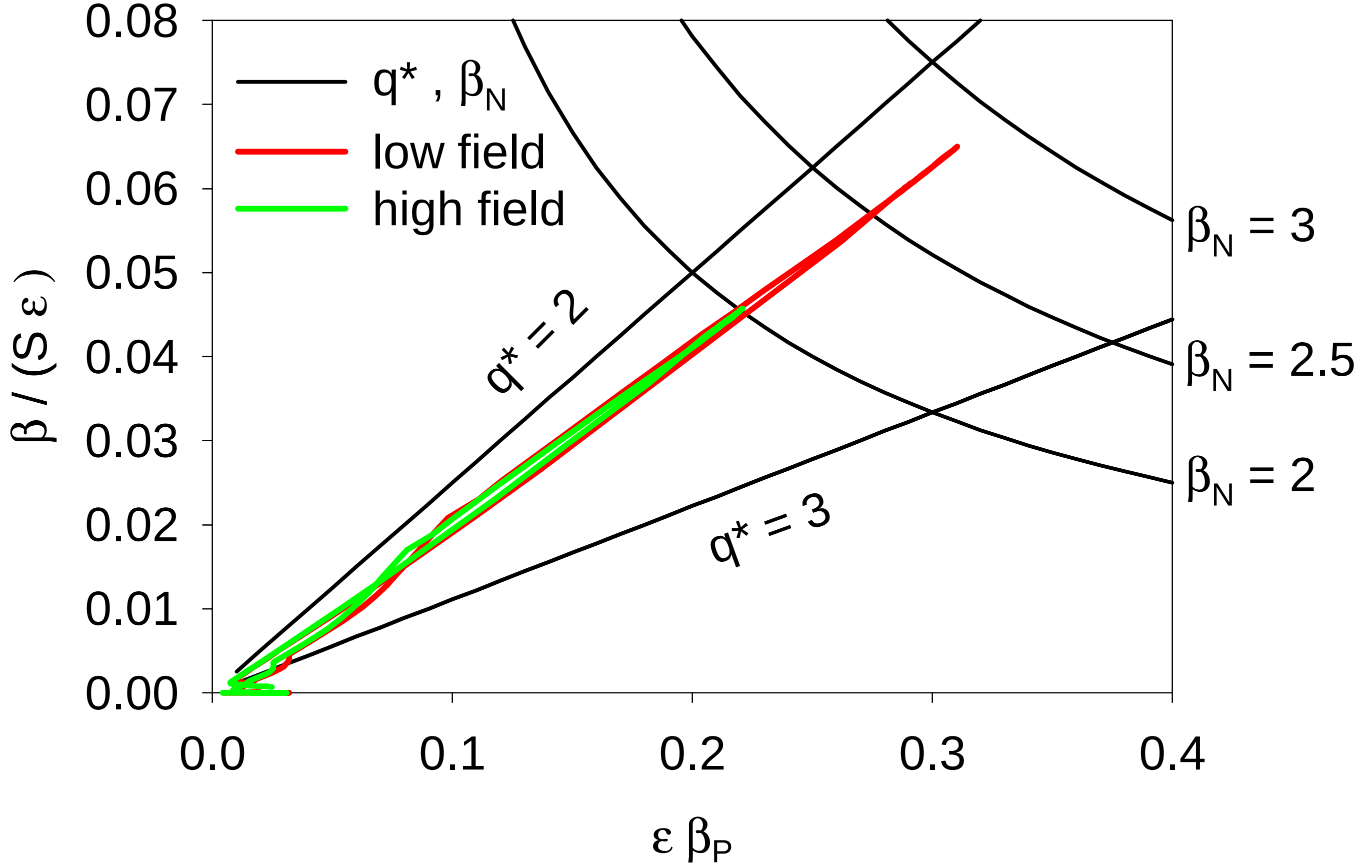


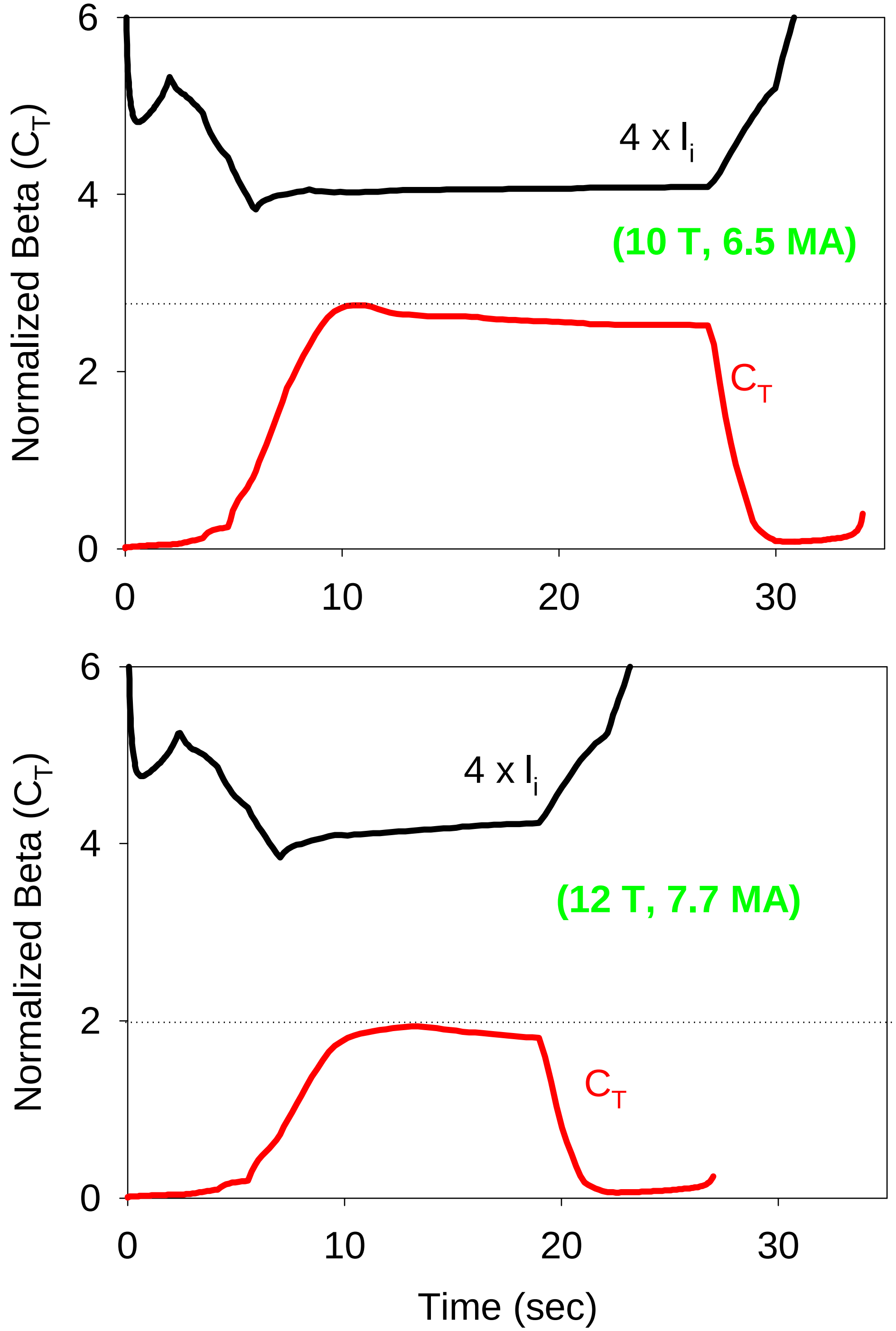
High Field



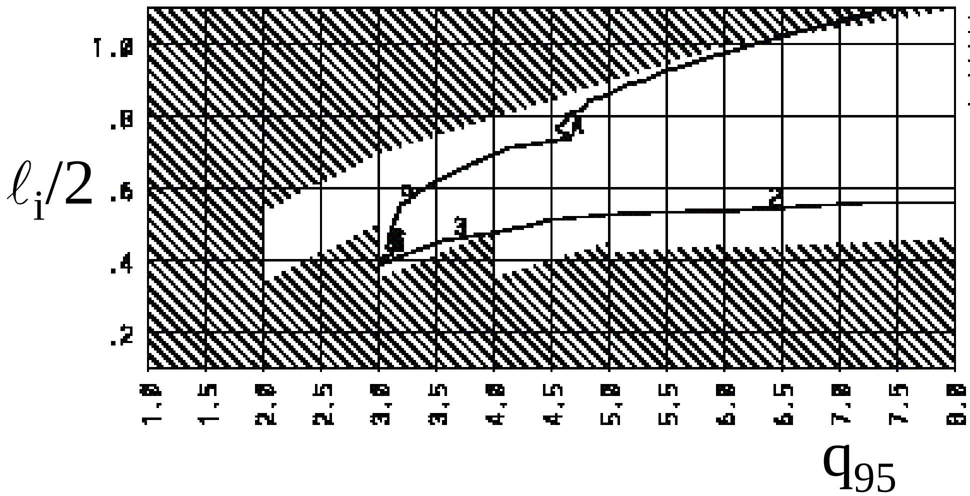
Low Field

FIRE Discharge Trajectories in Stability Space

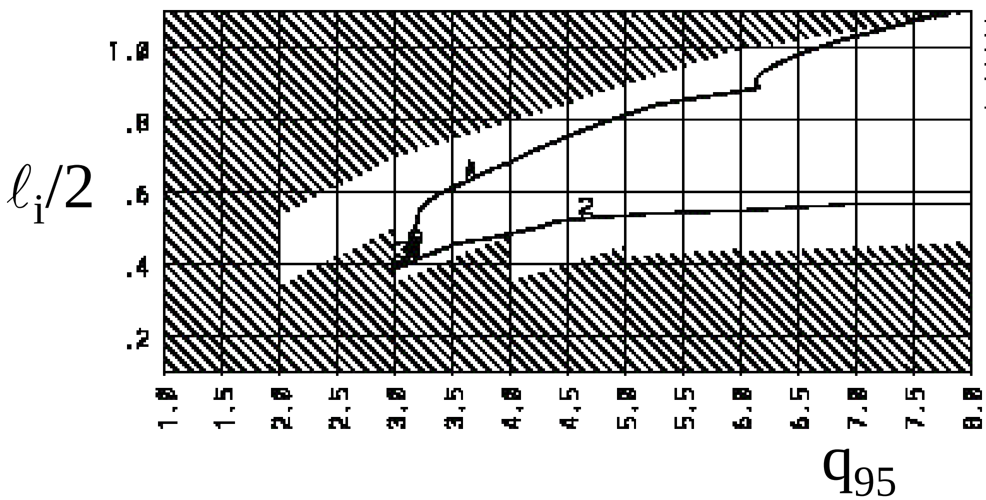




6
4
2
0
Normalized Beta (C_T)
$4 \times I_i$
(10 T, 6.5 MA)
C_T
0
10
20
30
6
4
2
0
Normalized Beta (C_T)
$4 \times I_i$
(12 T, 7.7 MA)
C_T
0
10
20
30
Time (sec)



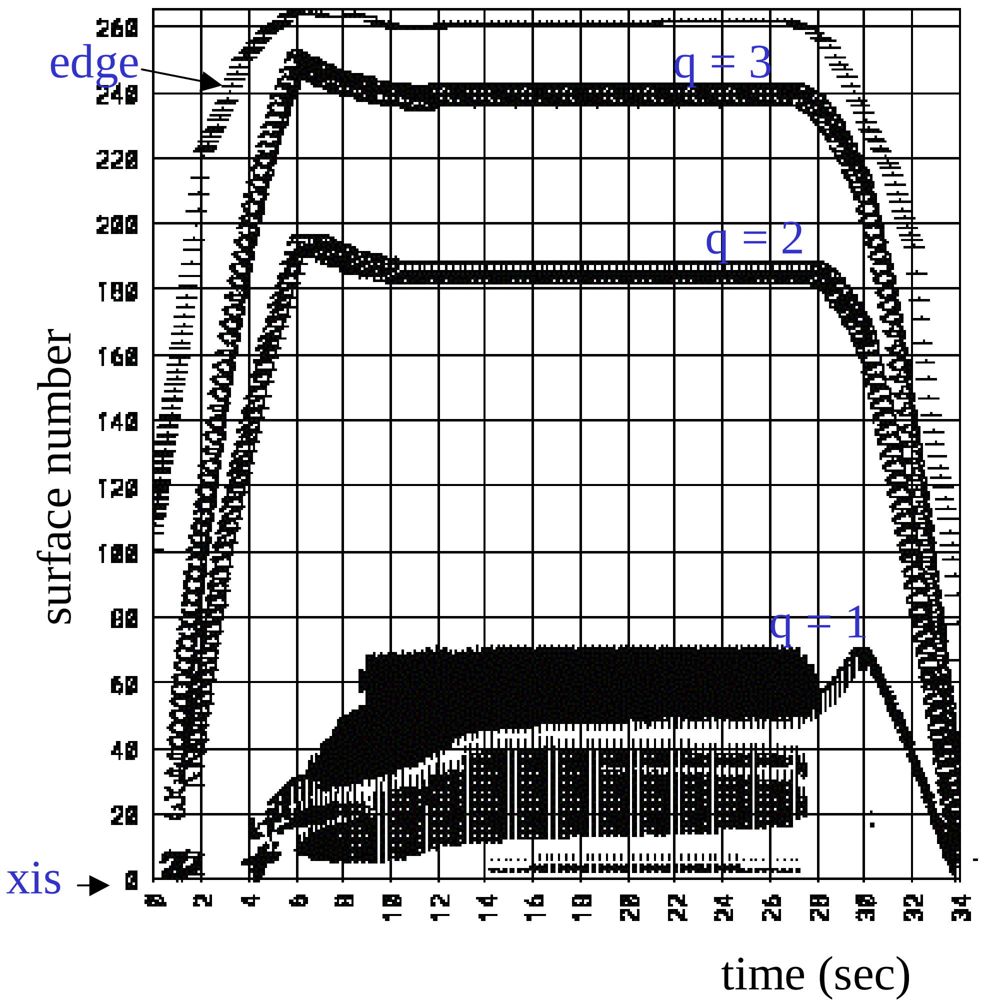
High Field

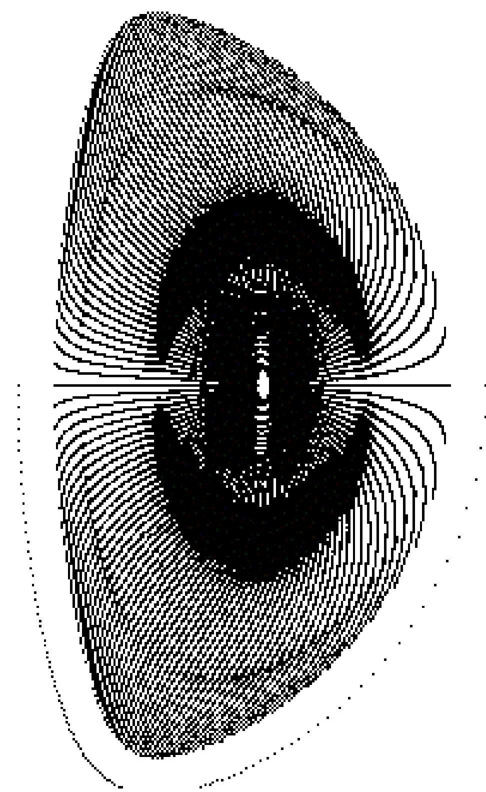


Low Field

Low Field: 10 T, 6.5 MA

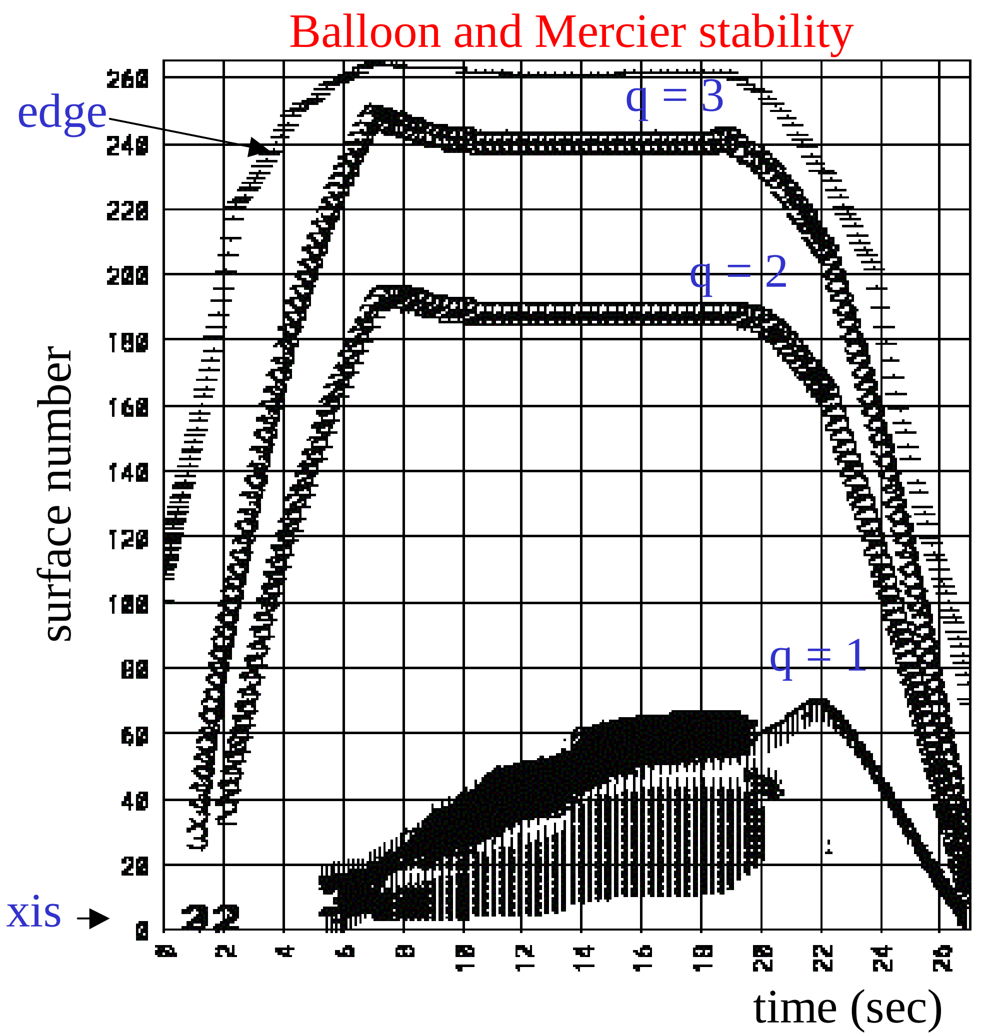
Balloon and Mercier stability

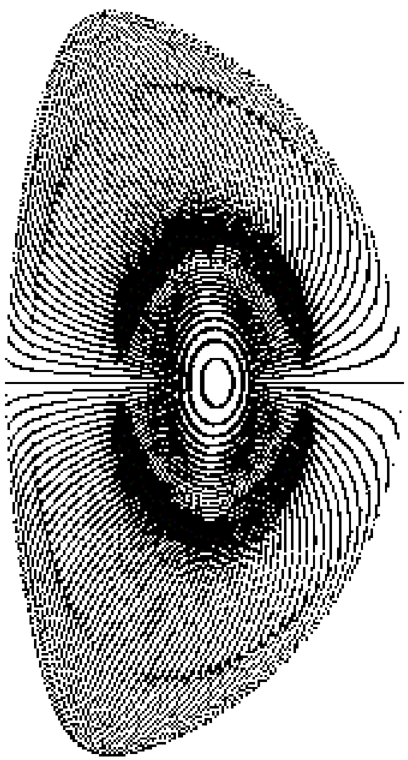




PEST unstable eigenfunction at t=12.5 sec

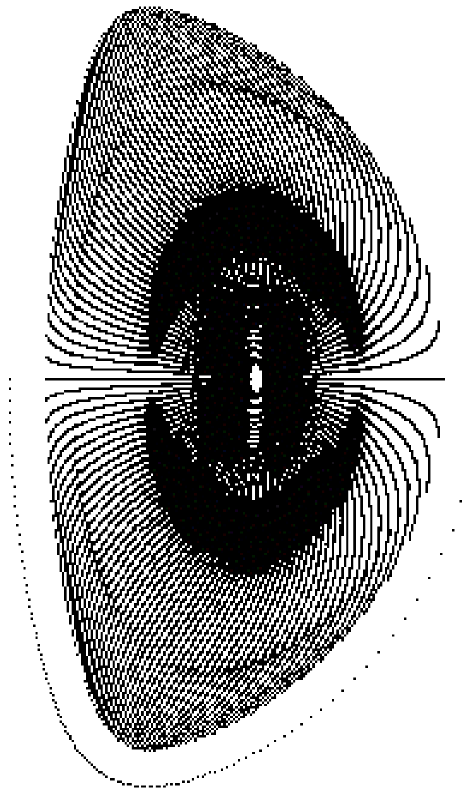
High Field: 12 T, 7.7 MA





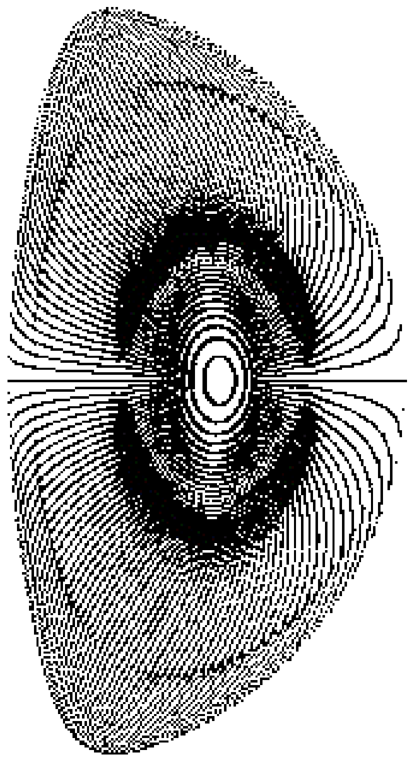
PEST unstable eigenfunction at t=12.5 sec

Comparison of unstable Eigenvalues



Low Field

$\gamma^2 = -.0083$



High Field

$\gamma^2 = -.0039$

conventional operating modes

- consequences of the ideal MHD instability localized near q=1 (?)
  - sawtooth behavior at FIRE parameters
  - delay or eliminate by early heating ?
- neoclassical tearing modes (Rutherford, Perkins)
  - seed island and saturated island size
  - feedback stabilization ?
- the effect of H-mode profiles on MHD stability (Manickam)
  - relation to ELMS, n ~ 5-10 peeling modes, bootstrap currents
- error fields and locked modes

reversed shear operating modes

- stability of no-wall advanced mode for entire discharge (Ramos)
- wall stabilized advanced modes (GA/PPPL/Columbia experiments on DIII)

other advanced modes

- off axis CD to raise q_0 (Kessel)
- edge current drive to improve stability (?)

Summary

- **Self-consistent TSC discharge simulations exist for both the high-field (12 T, 7.7 MA, H=1.0) and low-field (10T, 6.75 MA, H=1.2) operating modes**
- **Overall, MHD stability looks favorable. Primary uncertainty due to:**
    - MHD activity near q=1 surface
    - edge currents due to H-mode pedestals
    - neoclassical tearing modes
    - error fields and locked modes
- **Experimental prototyping of these modes would be very beneficial**
- **"Advanced Modes" need to be further developed**