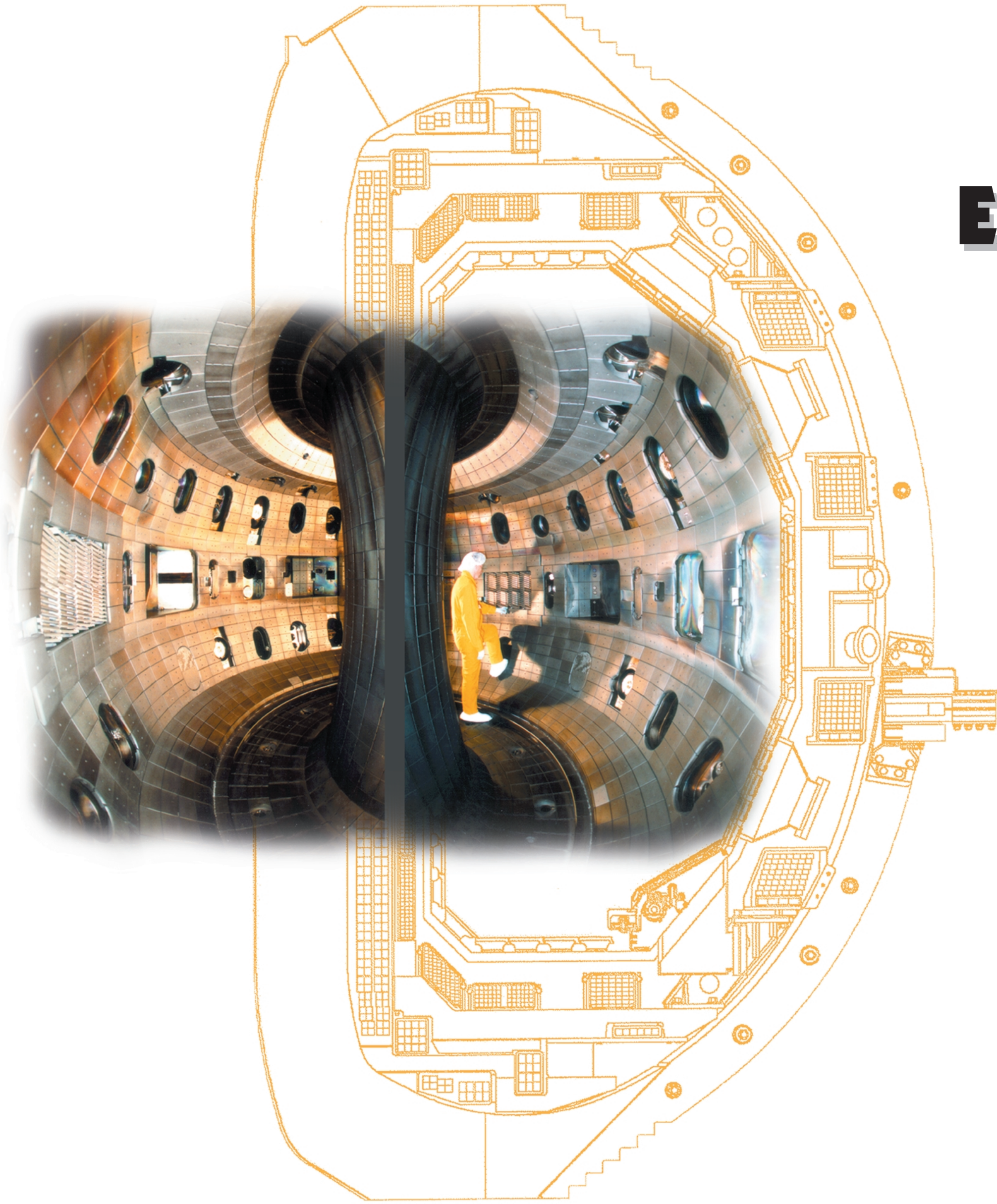
Overview of the 2000 DIII–D Experimental Campaign



by
J.S. deGrassie
and The DIII–D Team

Presented at
the American Physical Society
Division of Plasma Physics Meeting
Quebec City, Canada

October 25, 2000

DIII–D
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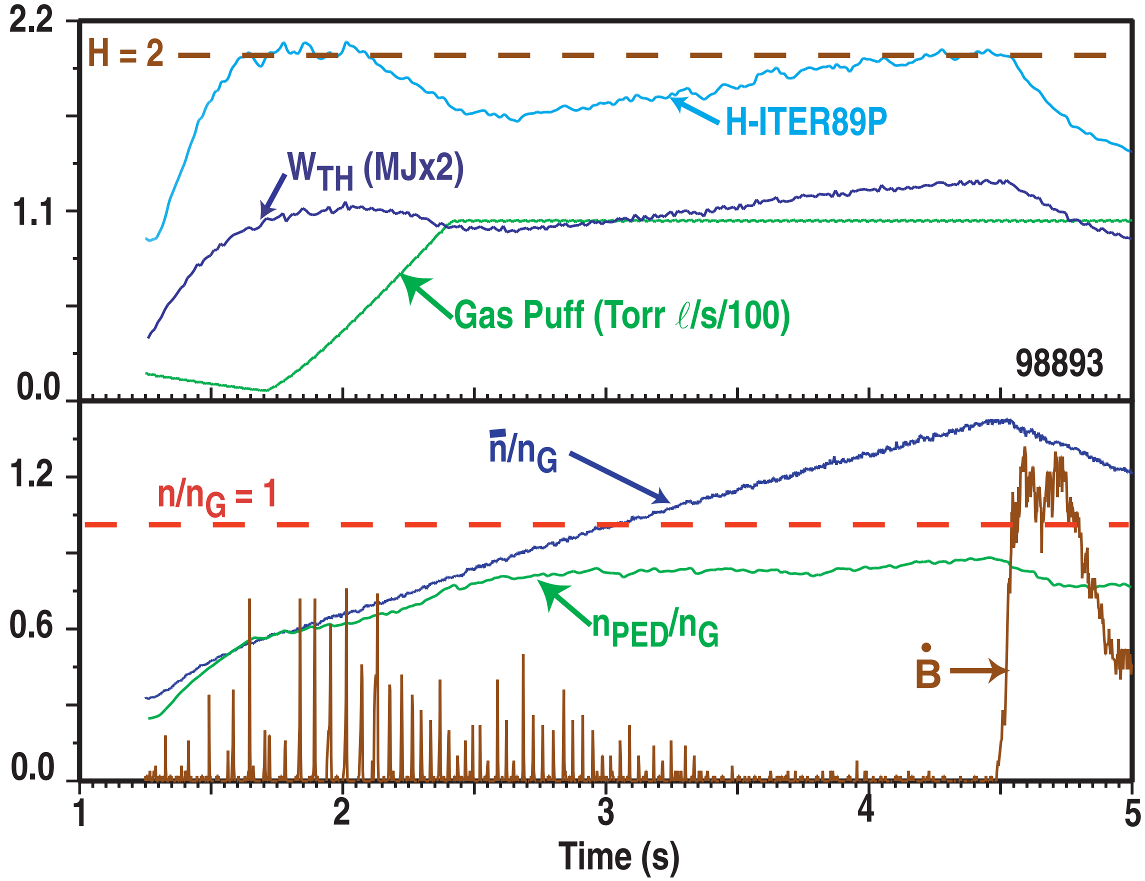
263-00/JSdG/jy

GREENWALD LIMIT IS EXCEEDED IN ELMING H–MODE

- Density rises monotonically to 1.4 × Greenwald
- Density pedestal saturates at 90% of Greenwald
- Stored energy exceeds its peak value at low density
- High confinement phase is terminated after MHD mode
- No evidence of radiative instabilities



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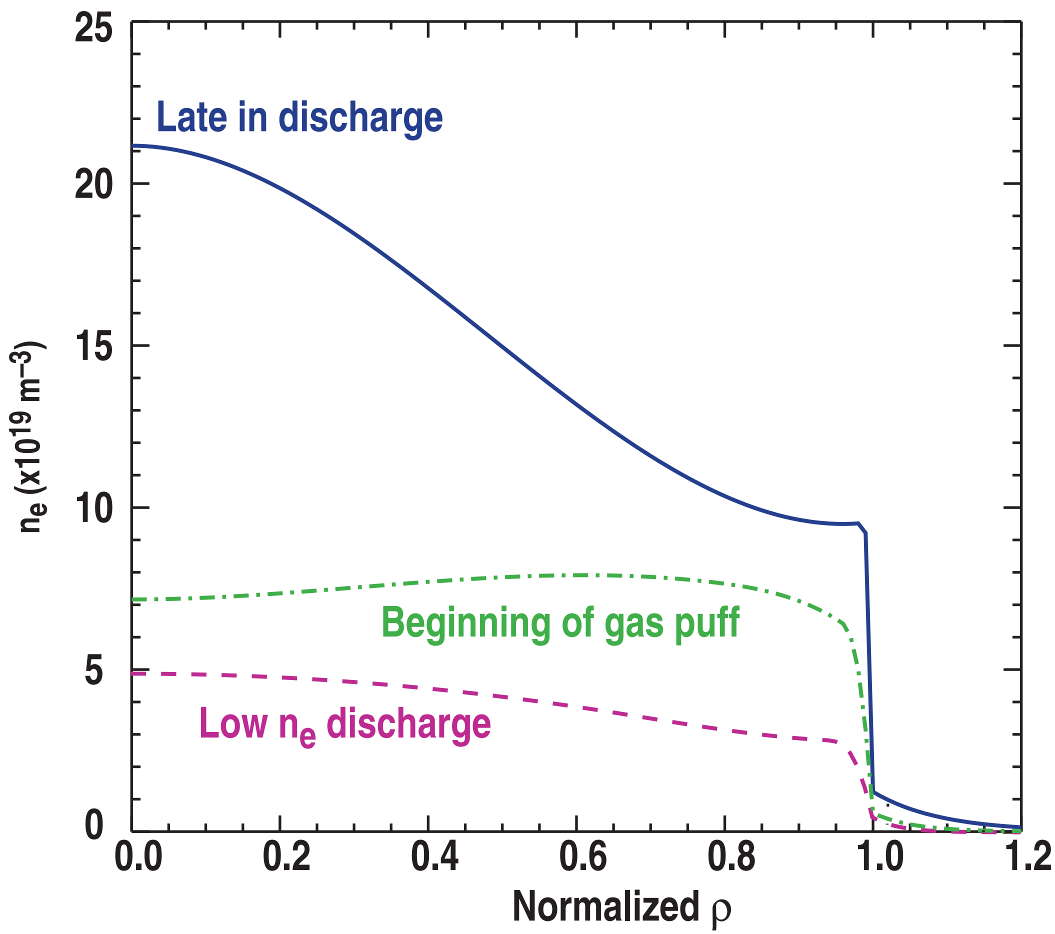
GENERAL ATOMICS

286-00 jy

DENSITY PROFILE EVOLUTION IS A KEY FACTOR IN CONFINEMENT AND TEARING MODE BEHAVIOR

- Initially, the edge density increases relative to the core, resulting in a flat profile
  - During this phase confinement decreases
- As the density wave moves inward, the profile becomes peaked
  - During this stage, stored energy increases monotonically, and eventually exceeds its initial value
  - Pressure profile becomes steeper in the plasma interior
- Confinement behavior is consistent with stiff transport
- Some pedestal pressure loss occurs with gas puffing



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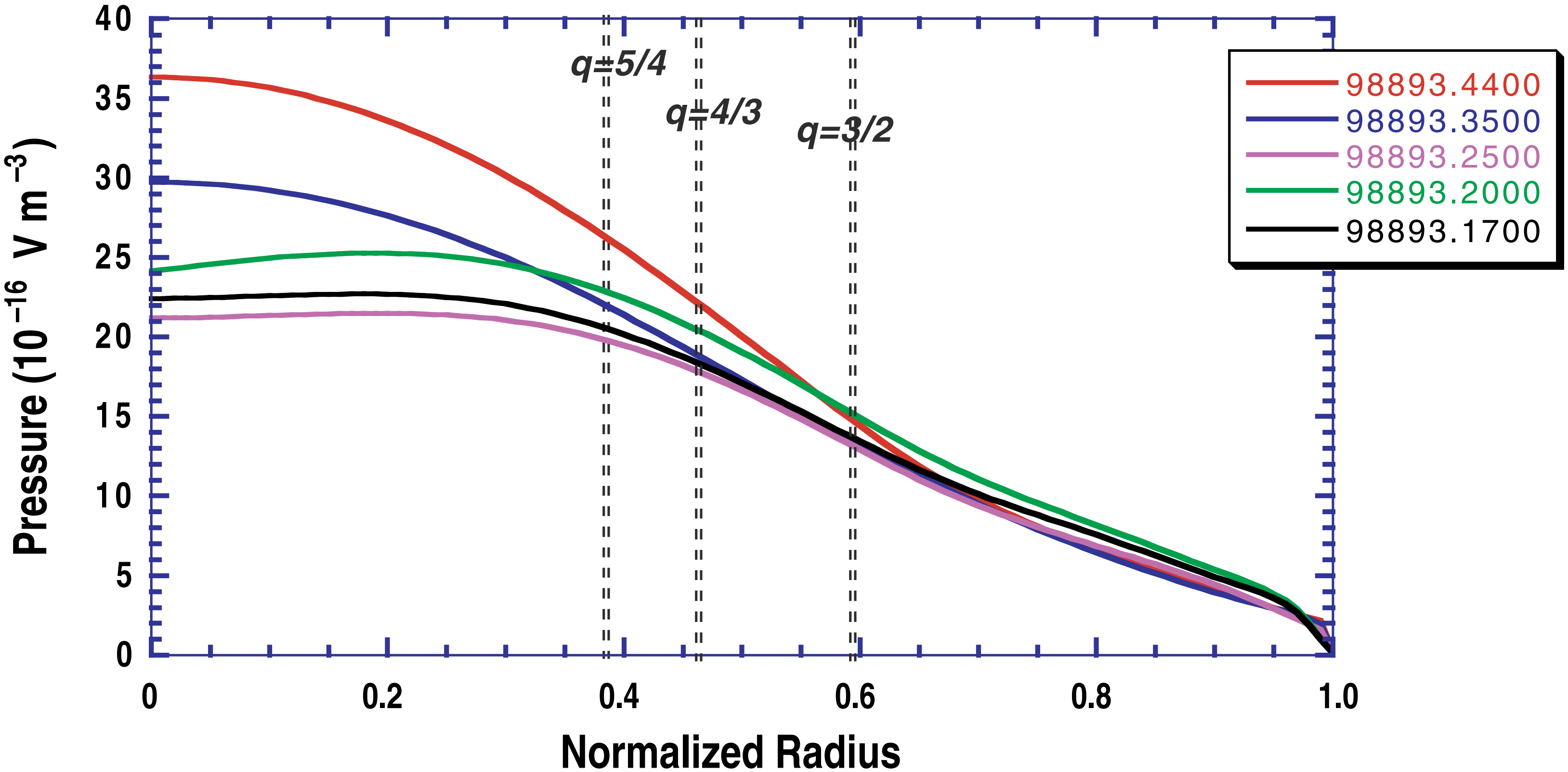
PEDESTAL PRESSURE LOSS IS COMPENSATED BY CORE PRESSURE INCREASE



- Increased pressure gradient destabilizes tearing mode

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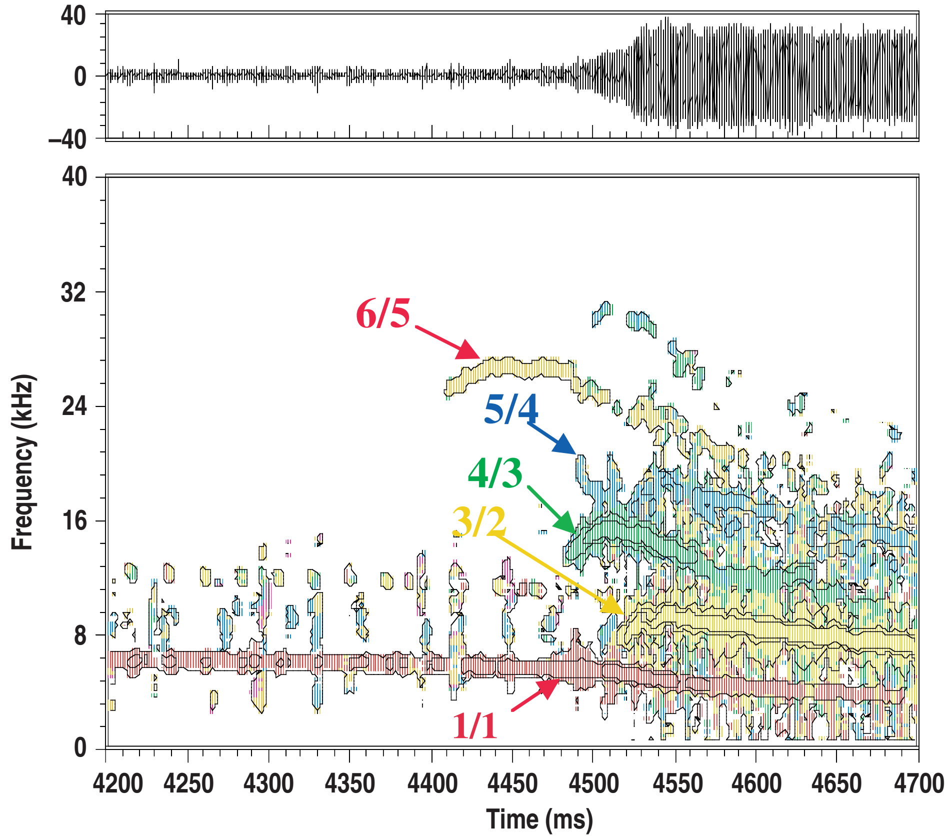
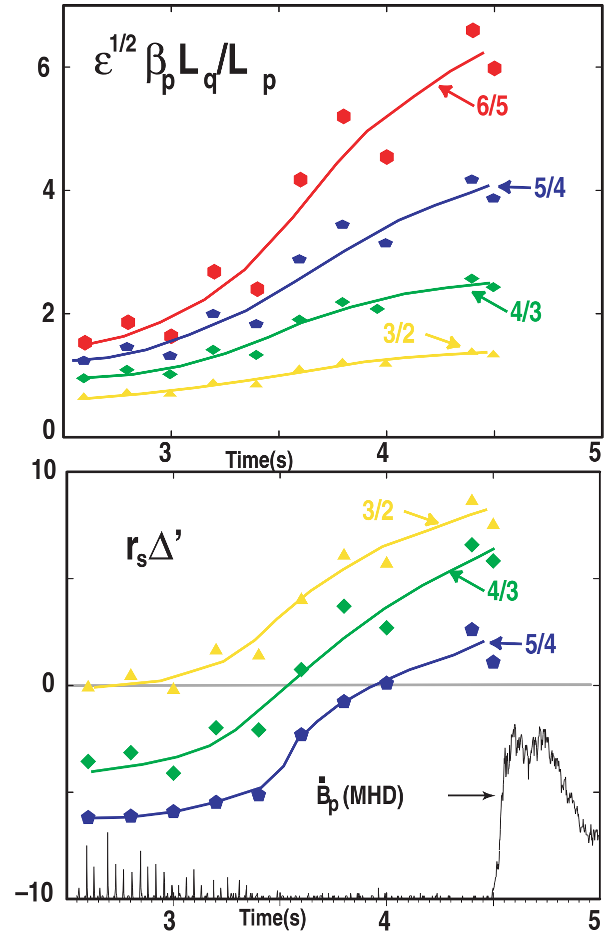
PRESSURE PROFILE PEAKING DESTABILIZES MHD MODES

- Termination of high n_e, high τ_E discharges is correlated with onset of MHD modes
- Both classical and neoclassical tearing mode drives increase with time





PEST 3 code calculation

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GENERAL ATOMICS

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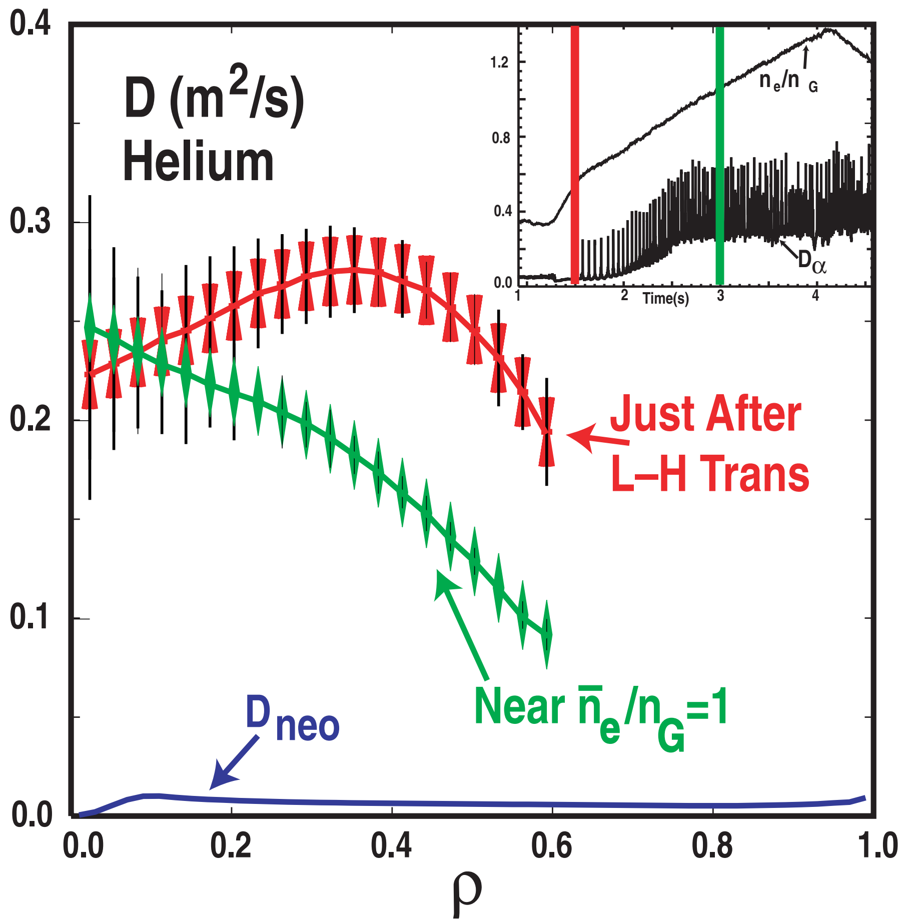
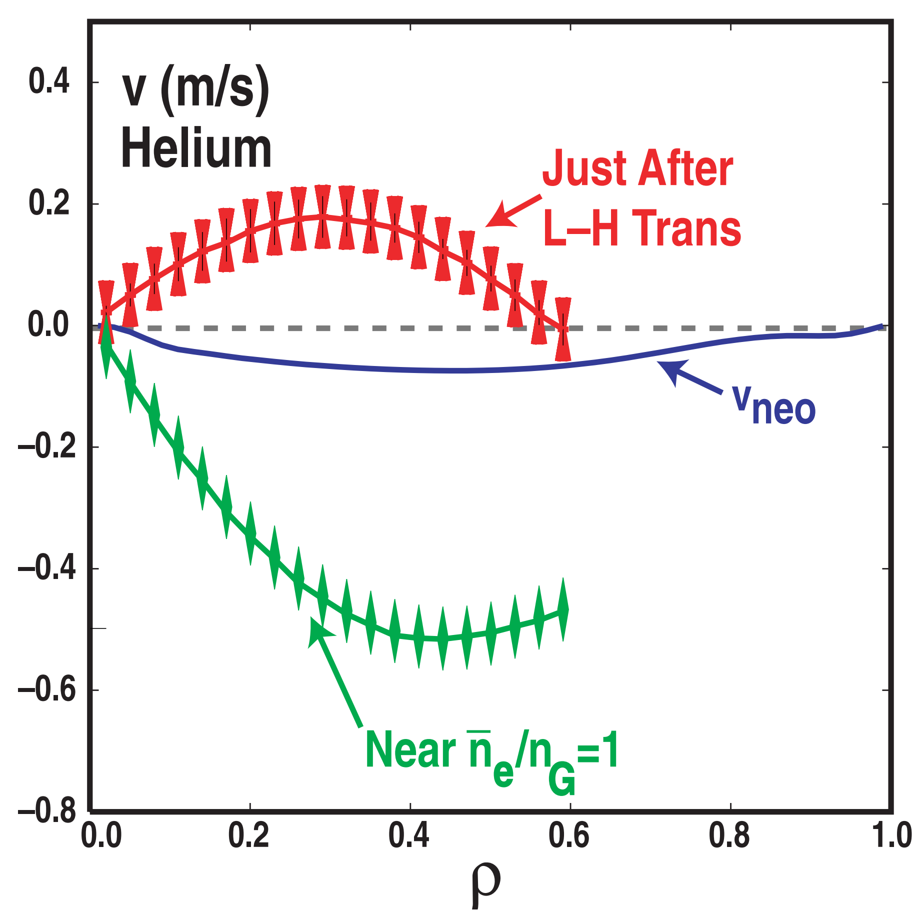
AT HIGH DENSITY PARTICLE DIFFUSIVITY DECREASES AND A LARGE PARTICLE PINCH DEVELOPS

- D and v measurements from He puff
- Helium pinch is much larger than neoclassical (Ware) value





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IN GAS FUELED DISCHARGES PEDESTAL DENSITY IS TIGHTLY COUPLED TO THE SEPARATRIX DENSITY

- Density pedestal is the main component of $\bar{n}_e$
- With gas fueling alone, extension of "Engelhardt" model to poloidally asymmetric shapes, shows

  $$n_{PED} \propto n_{SEP} / f(\theta_0),$$

  where $f(\theta_0)$ is flux expansion at the location of gas source

  - Pedestal density increases when gas source is away from X–point
  - Model predicts pedestal width decreases with pedestal height
    - ★ Supported by DIII–D data
- Divertor detachment sets an upper bound on separatrix density
  - Limits the pedestal density

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GENERAL ATOMICS

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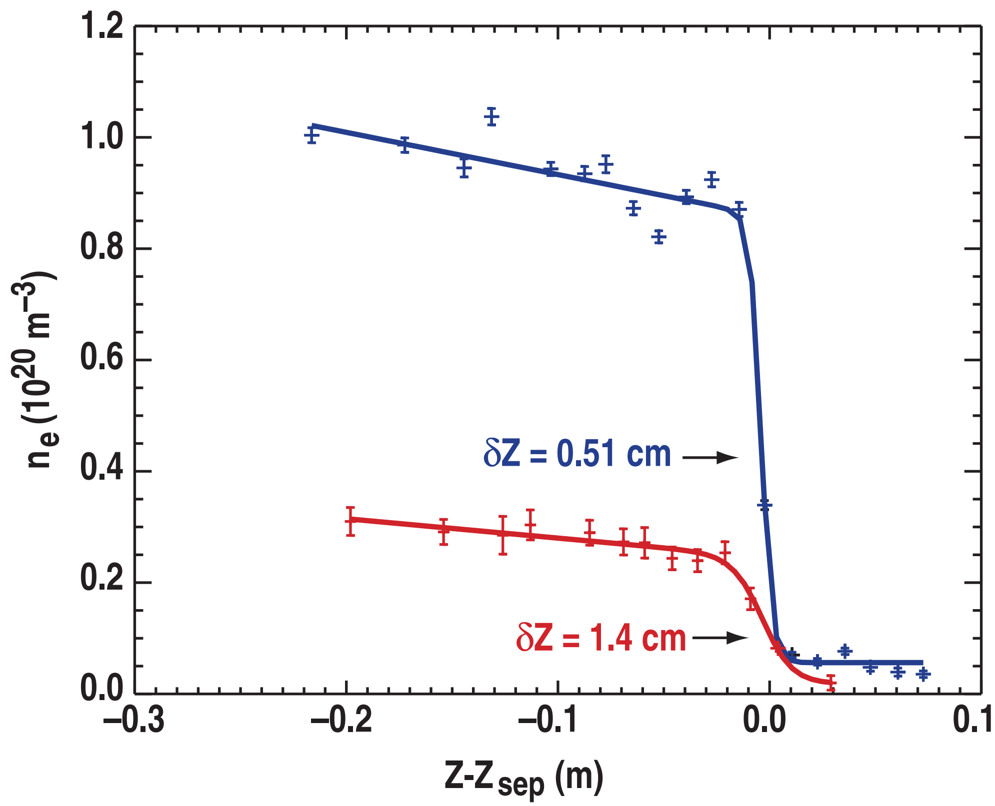
DENSITY PEDESTAL WIDTH SCALES INVERSELY WITH DENSITY PEDESTAL HEIGHT AS PREDICTED BY MODEL

- Density pedestal profile is determined by neutral ionization
  - it is much narrower than the pressure profile



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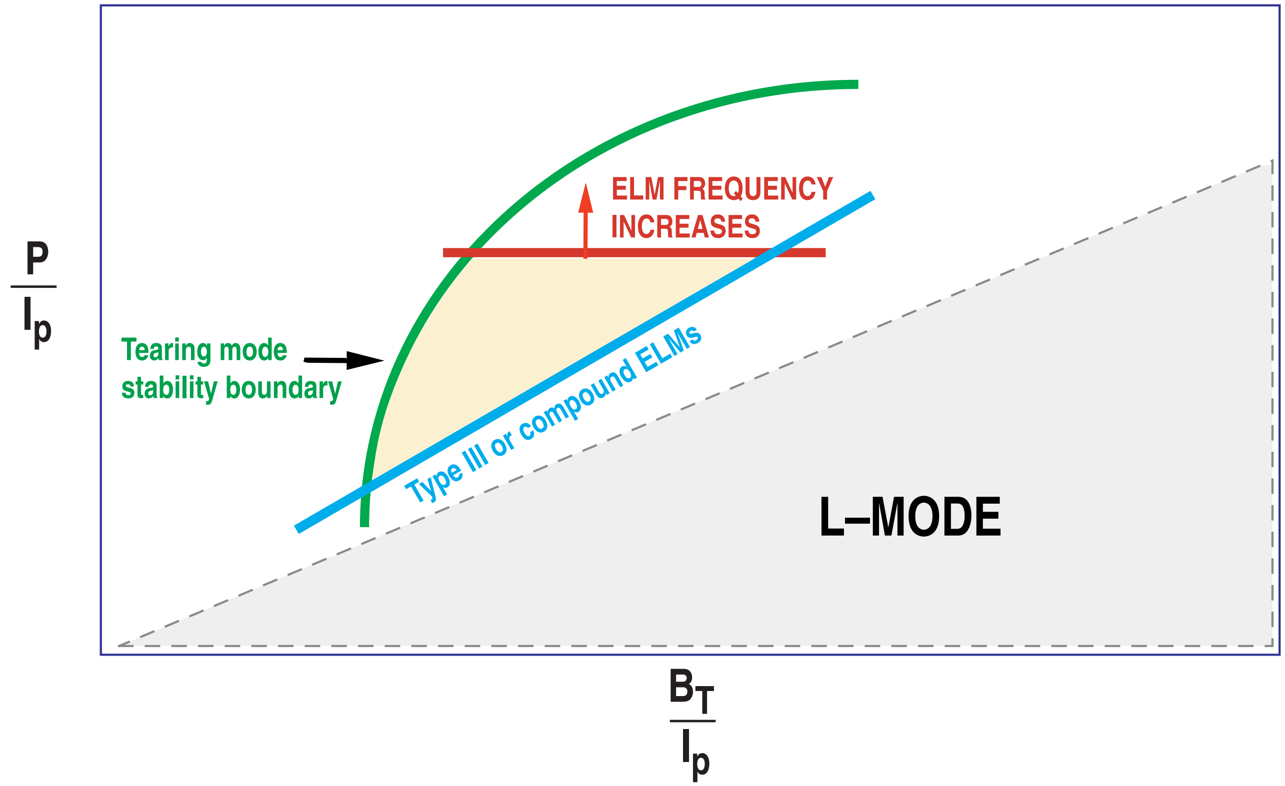
HIGH–DENSITY OPERATING WINDOW IS RESTRICTED BY PARTICLE LOSS DUE TO TEARING MODE, H-L TRANSITIONS, AND ELMS



- Within the window pedestal density is determined by diffusive transport and ionization source
  - Beyond the window boundaries additional particle losses reduce density pedestal
- Operating window shrinks in configurations with large H–mode power threshold or low stability limit

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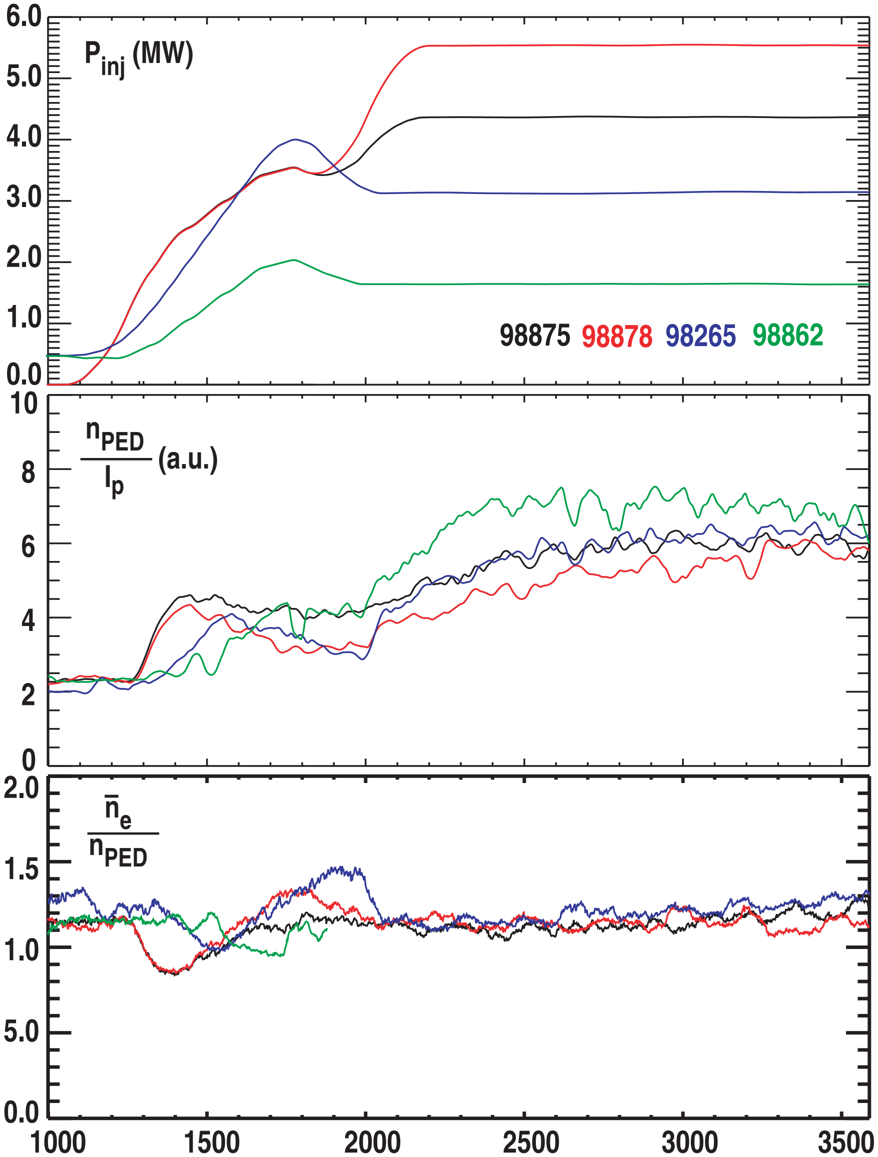
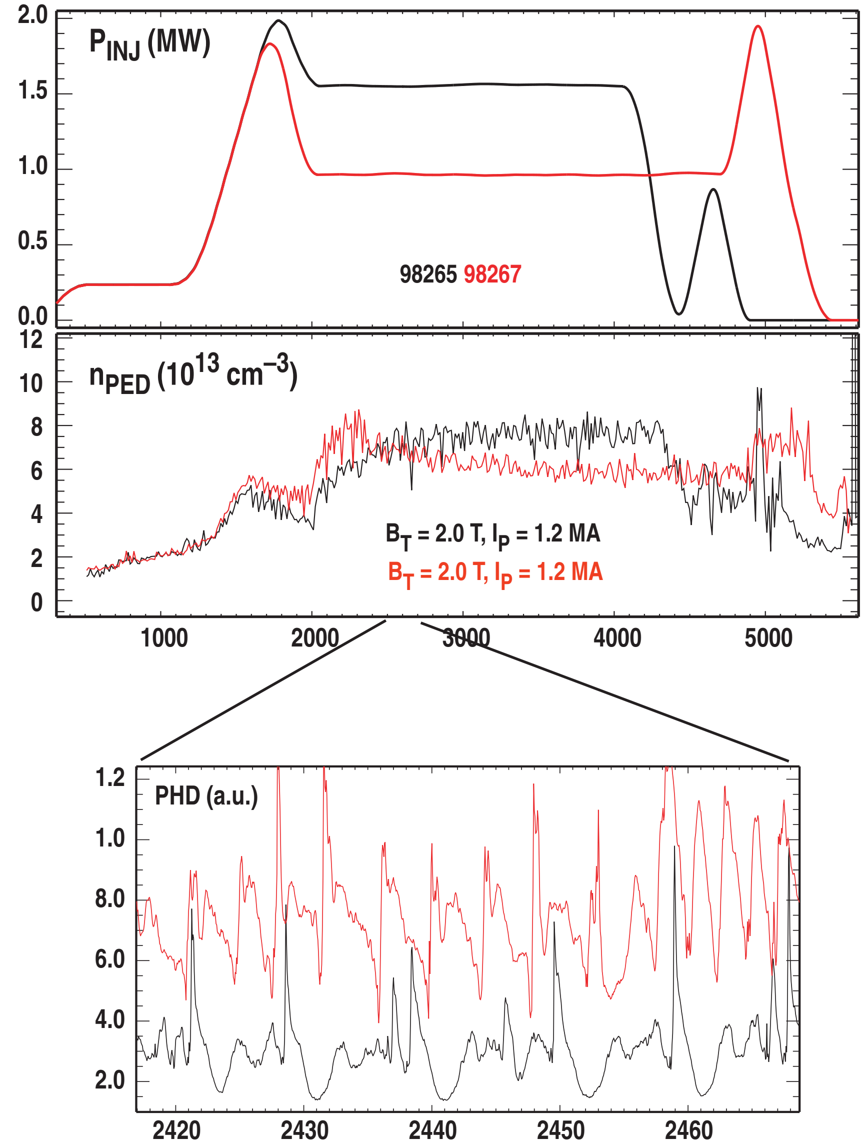
NORMALIZED PEDESTAL DENSITY DECREASES WITH INCREASING POWER



NEAR H–MODE POWER THRESHOLD DENSITY PEDESTAL DECREASES



- ELM frequency and duration increase at low power

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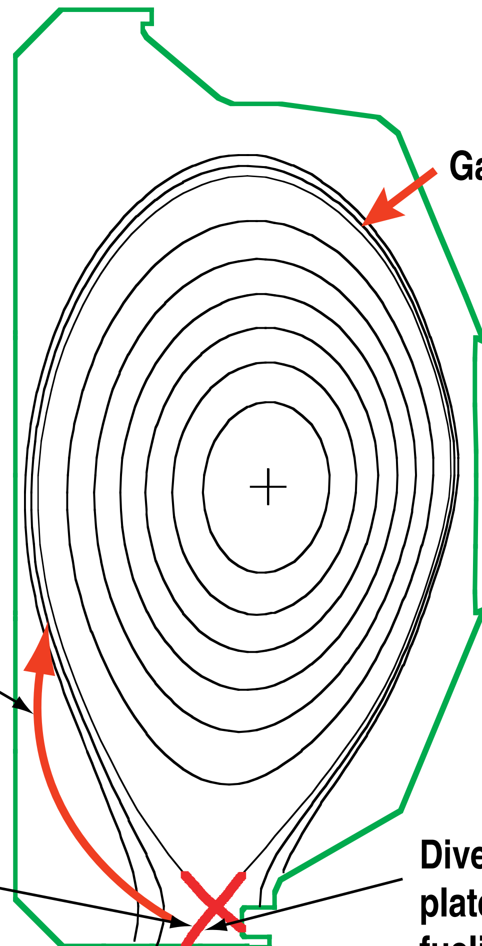
CHOICE OF DIVERTOR GEOMETRY INCREASED FUELING EFFICIENCY AND REDUCED EDGE PARTICLE LOSS

$q_{95} = 3.1$

$\delta \approx 0$

$P_{total} \lesssim 3.1$ MW



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SUMMARY AND CONCLUSIONS

- ELMing H–mode discharges with densities up to 1.4 x Greenwald achieved
- Confinement and stability behavior are prototypical of medium density ELMing H–mode
- Density pedestal of 0.9 x Greenwald within 1 cm of separatrix obtained
  - Tightly coupled to separatrix density
  - Influenced by poloidal location of neutral source