Plasma Operation and Interface Issues at High Power Density

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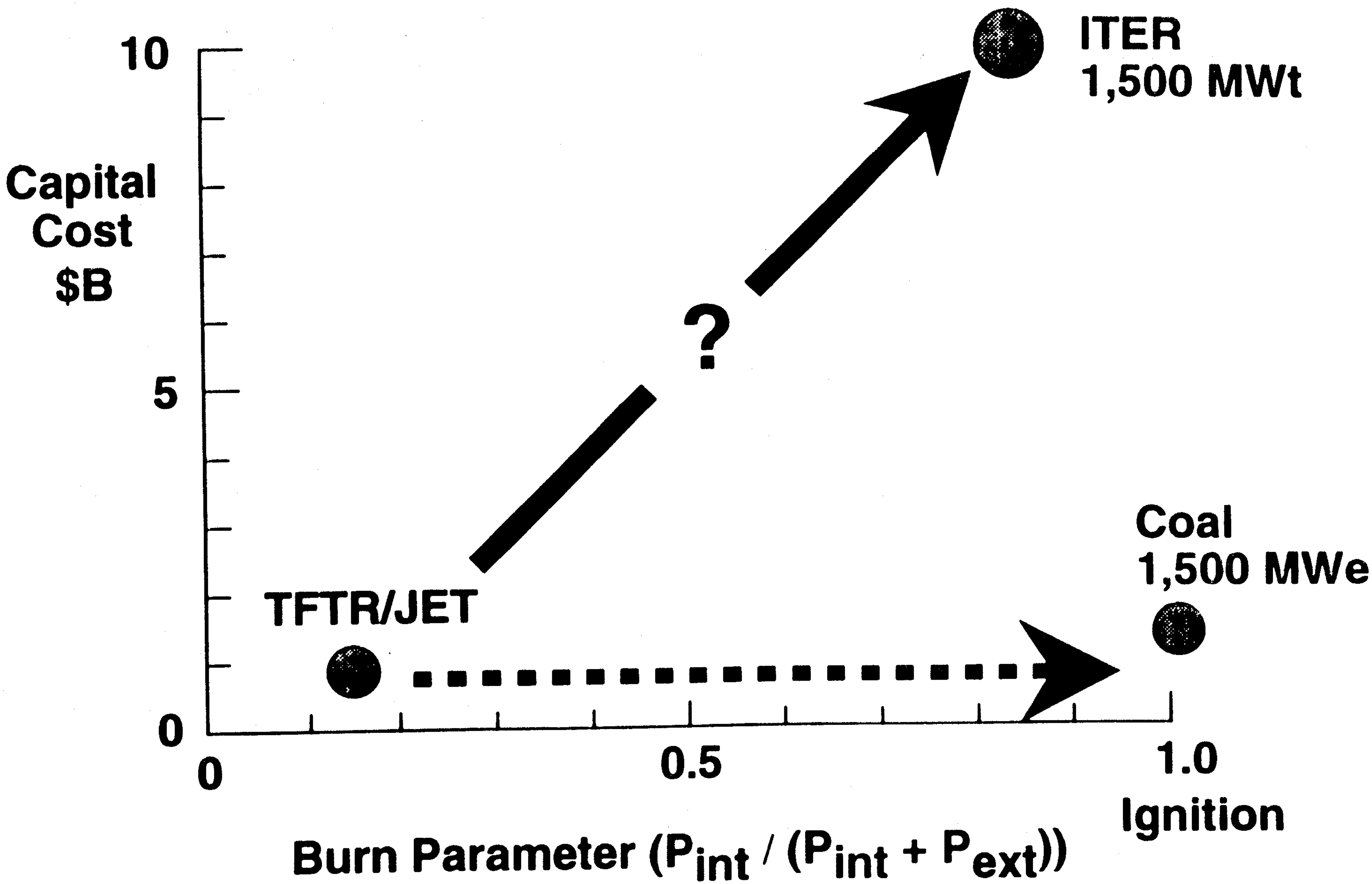
The Path to Ignition (Fusion)?



Engineering/Manufacturing Innovations are Needed.

- Magnetic fusion is faced with the same general problem as inertial fusion and accelerator builders, the unit cost of the next stage device must be reduced significantly.

New Engineering Approaches

- Let engineering/cost considerations drive the design.
- Incorporate new manufacturing approaches (innovations) into the design.
- Setup Engineering/Manufacturing Initiative ASAP(Skunk Works)
- Some examples:
    - R. D. Woolley: ANS Reno, 1996
    - G. V. Sheffield: A new approach
    - Plasma heating and power supplies
- Look for radical solutions

  relays → vacuum tubes → transistors → VLSI

Better, Faster and Cheaper Fusion

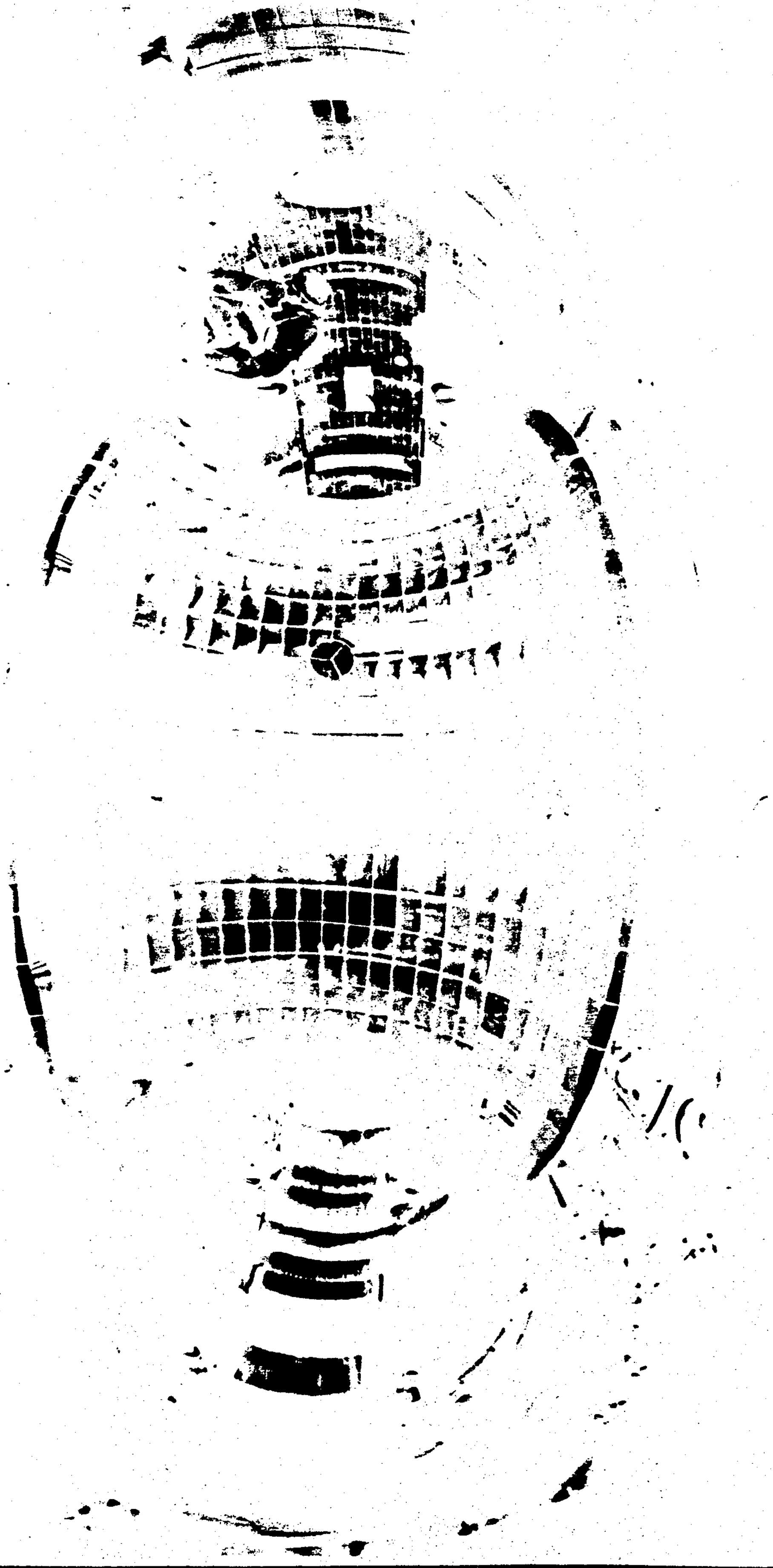
- The goal of developing radically better fusion systems is strongly advocated.

- Achieving the APEX goals is an important/critical part of making fusion economically attractive

He says very timely

Experience with Li Coated Limiter(First Wall) on TFTR at High Power Density

	TFTR	APEX
First Wall Power Density		
$\langle P_n \rangle$ = 8 MW/100m^2	~0.1	~7
$\langle P_{plasma} \rangle$ = 42 MW/100m^2	0.4	1.5
P_{plasma}peak ~ 30MW/(~1m^2)	30	
Pulse Length (s)	~2	steady
Surface Temperature (°C)	~1100	TBD

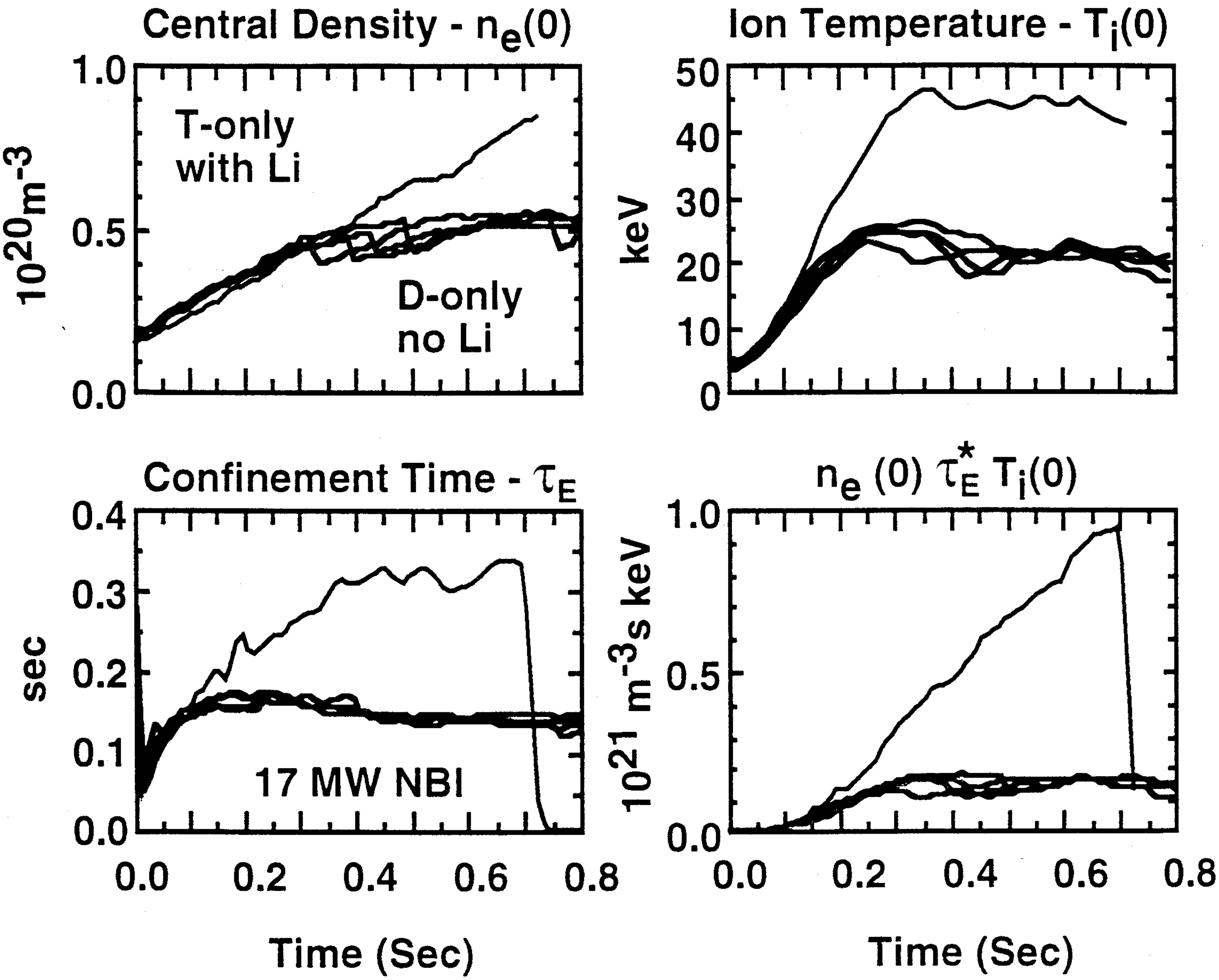


High $n_e(0)$, τ_E, $T_i(0)$ — Record Lawson Product

$$n_H \tau_E^* T_i = 8.5 \times 10^{20}\ m^{-3}\ s\ keV$$

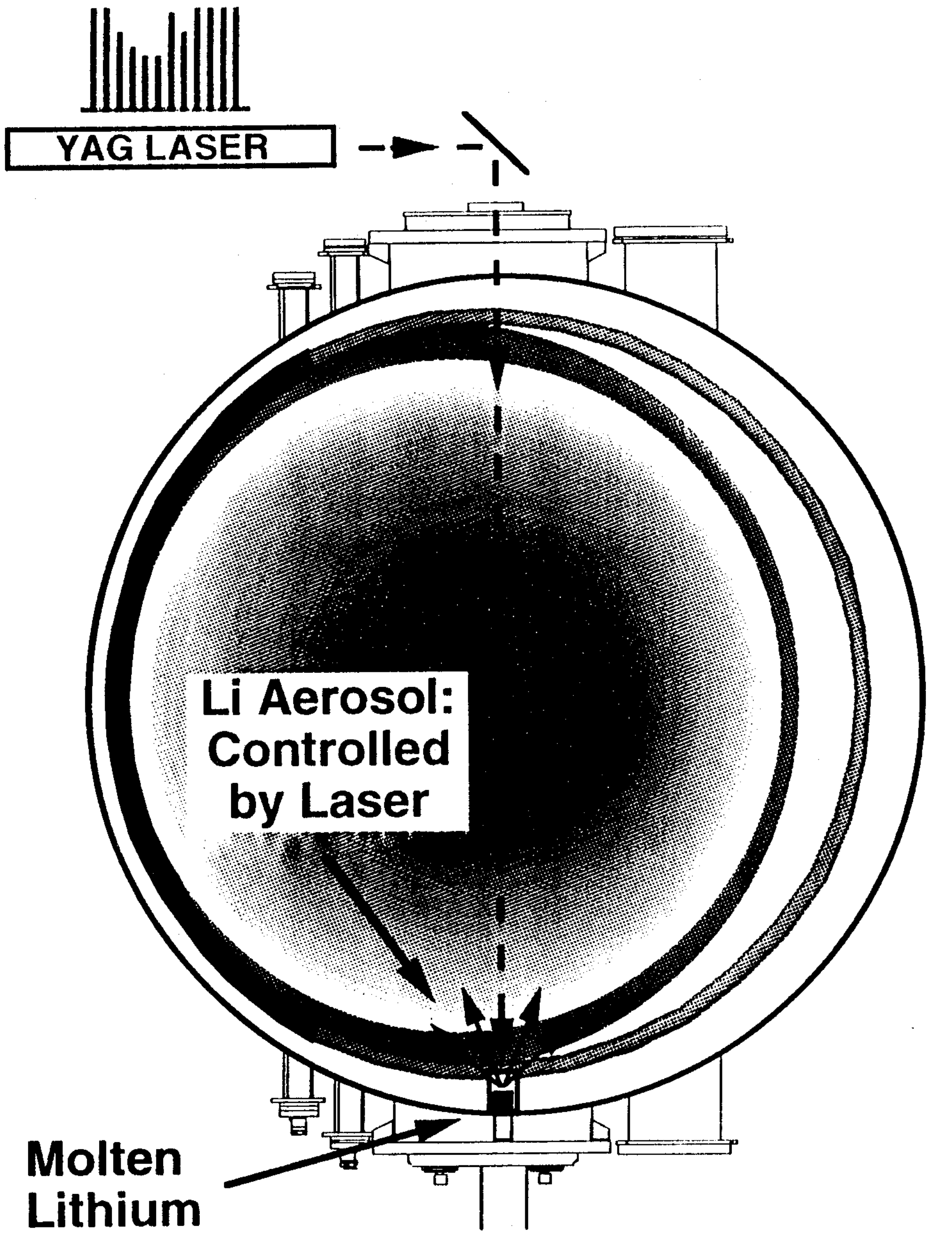
PPPL

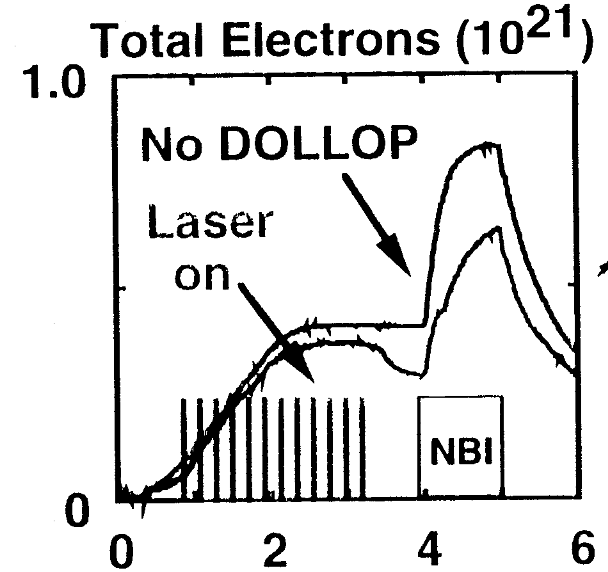
- Tritium-only Supershot 4 Pellets + Painting

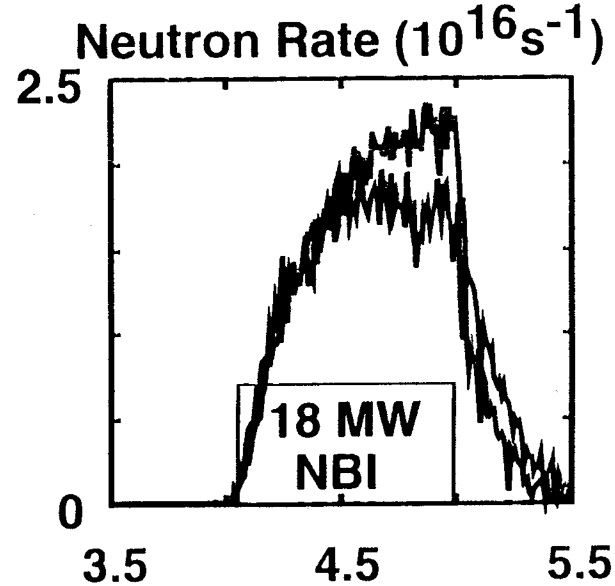


DOLLOP: Li Aerosol Controls Influxes and Increases Performance - Nonperturbing and Controllable

PPPL





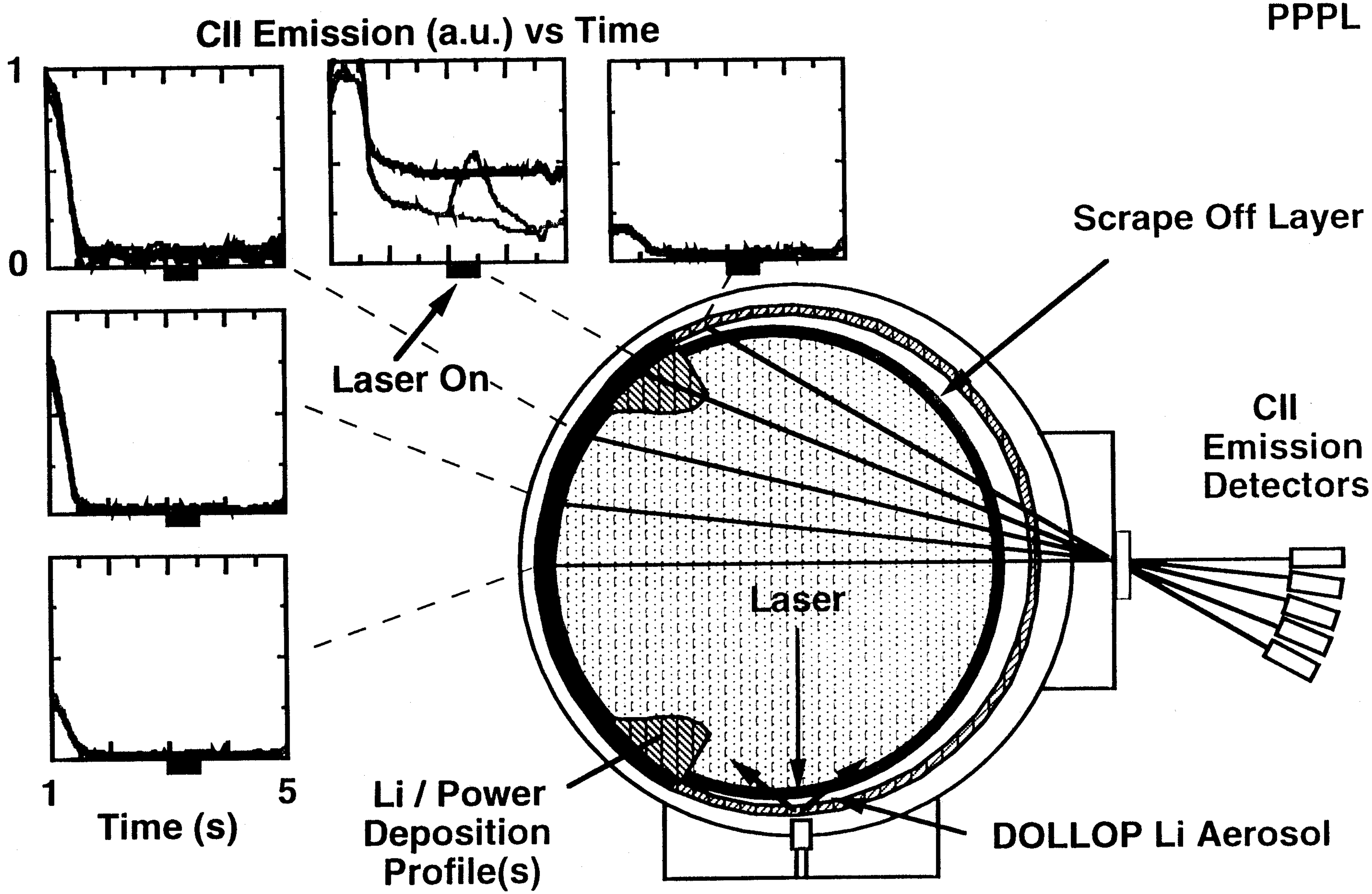


$\Delta N_e(Li) \sim 1.5 \times 10^{20}$

$\Delta N_e(NB) \sim 1 \times 10^{20}$

DOLLOP Deposits Li Preferentially into the Scrape-off Layer - the Li then Migrates to the Contact Point(s)

PPPL



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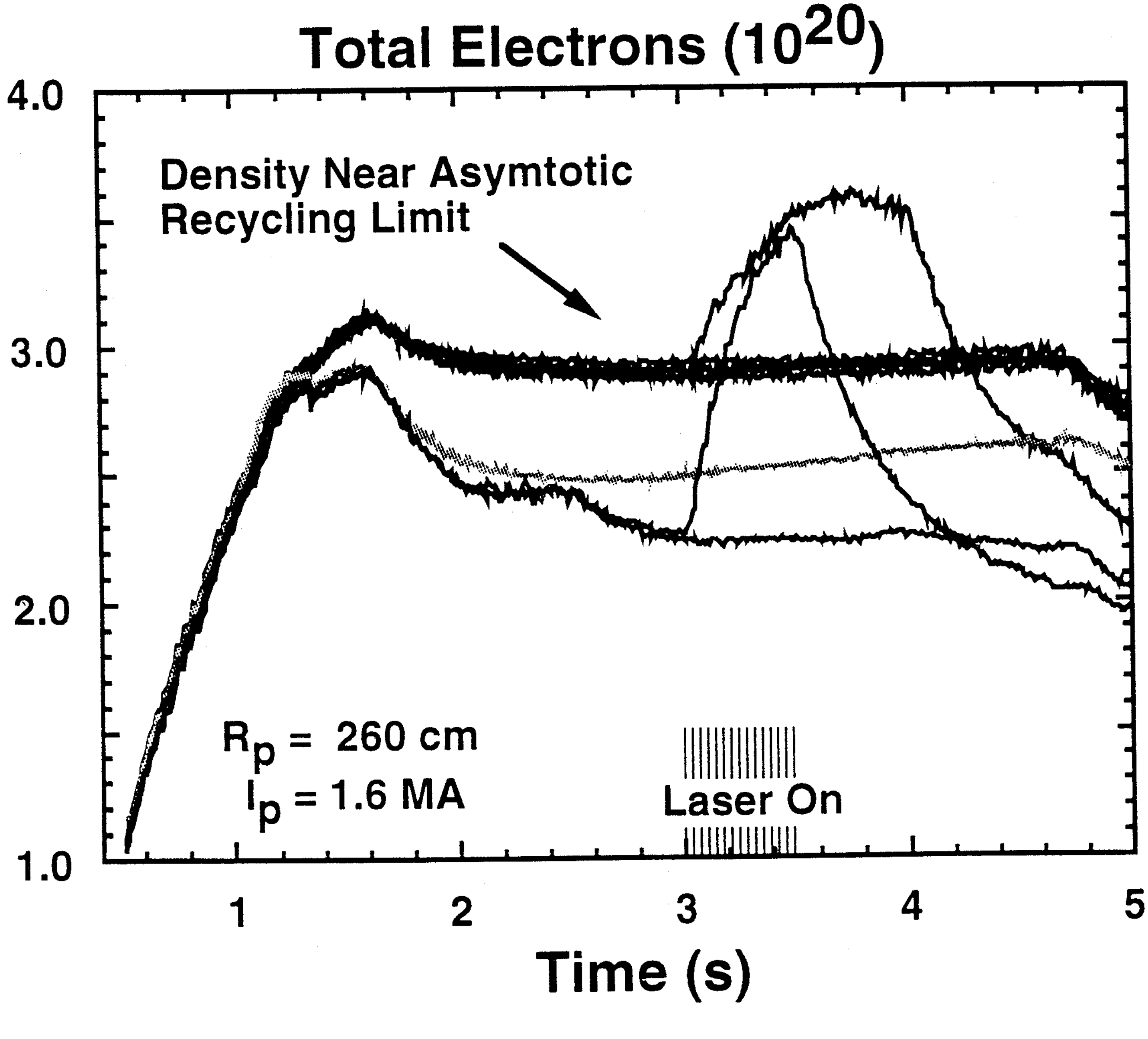
DOLLOP : Initial Effects of Laser-induced Li Aerosol on Ohmic Discharges

PPPL



- Deposition controlled optically

For OH

- 5 % of Li to Plasma - 95 % to SOL
  (<<1% of Li " " during NB)
- Plasma reaction benign

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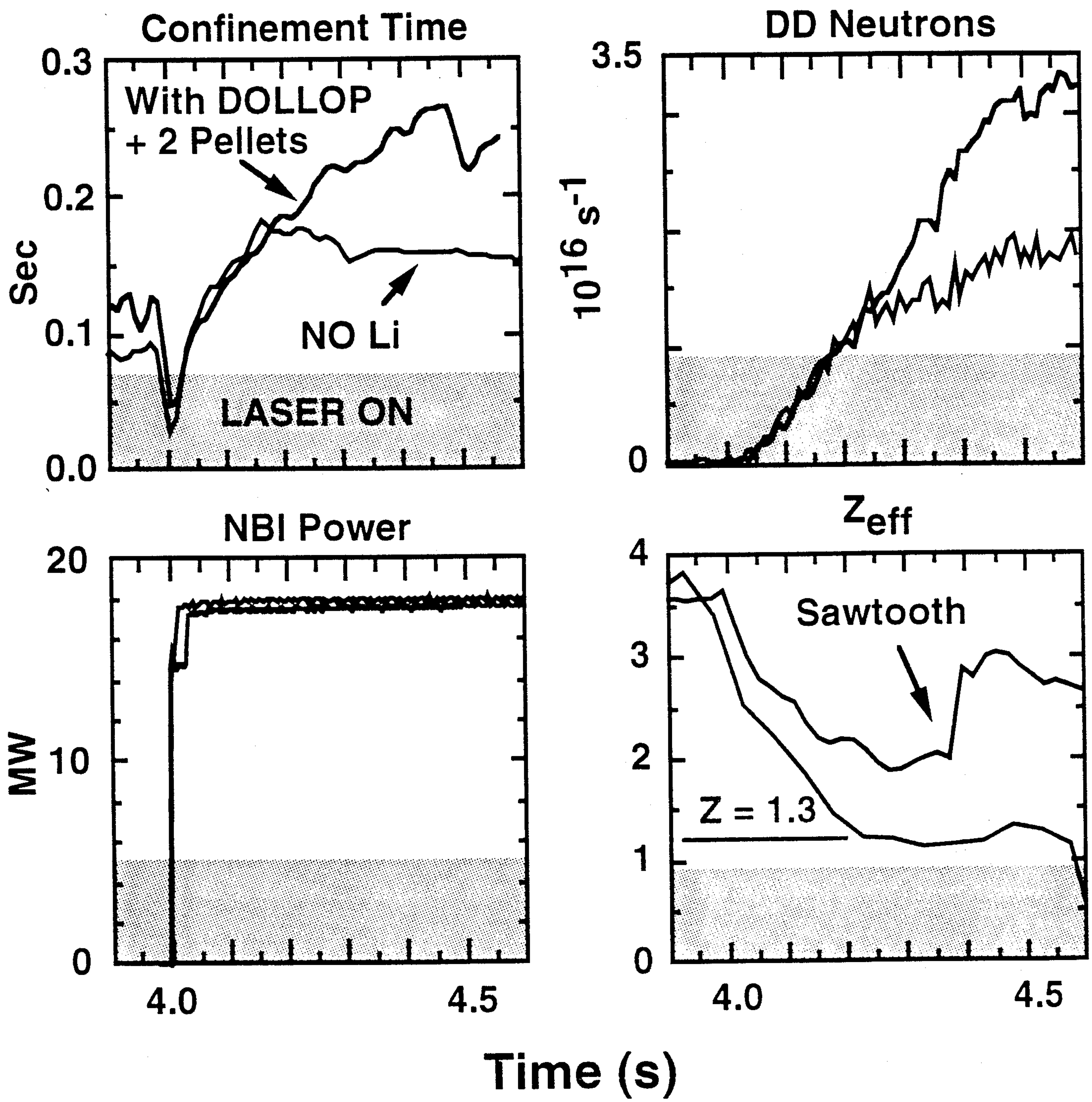
DOLLOP Has Led to Enhanced and Sustained Performance with No Harmful Effects

PPPL



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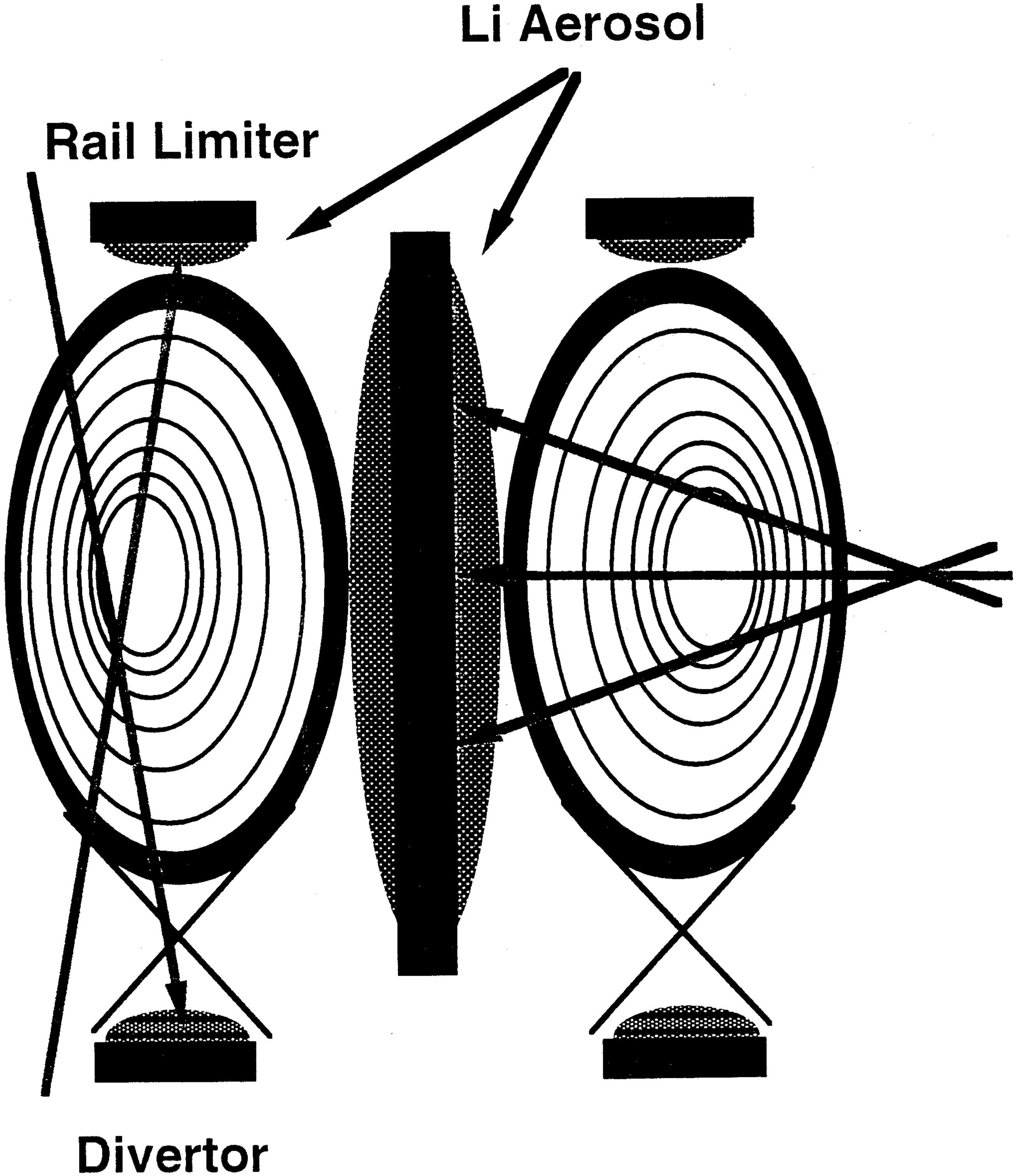
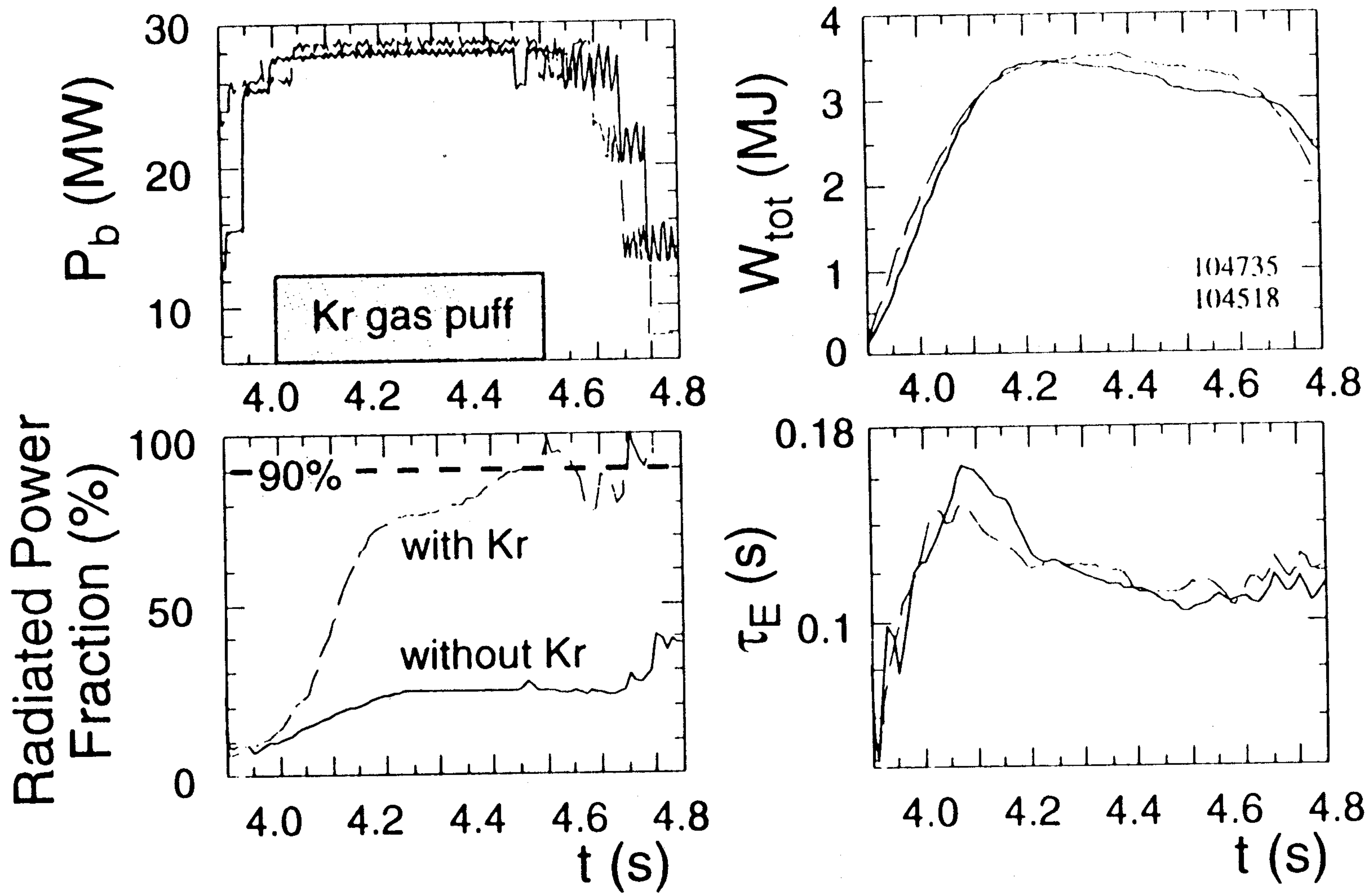
A Few Possibilities ...

PPPL

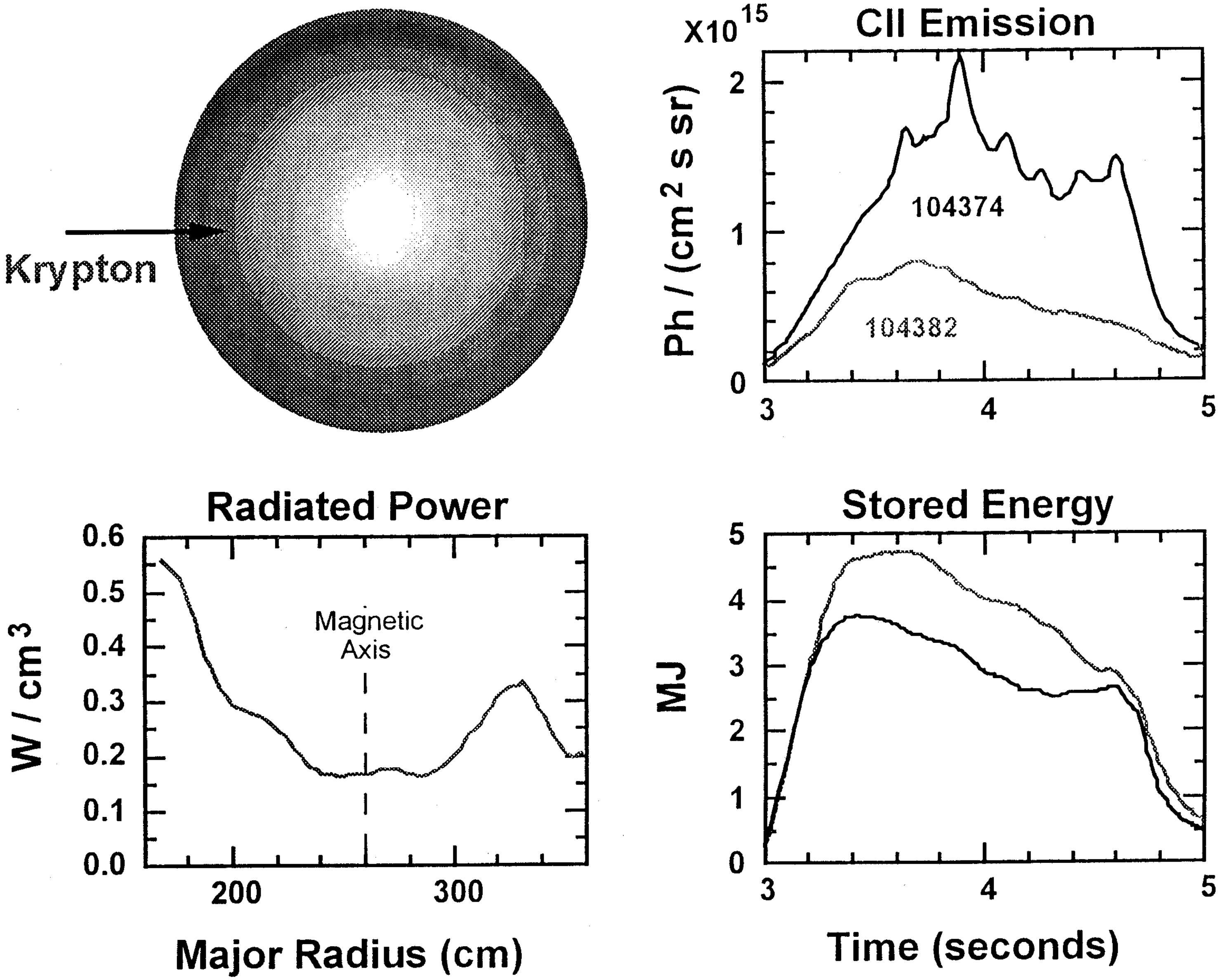


Greater than 90% Radiated Power was Reached with Kr Mantle in High ℓ_i Plasmas with no Decrease in τ_E



- Radiative mantle is a critical element in surpassing limiter power handling constraint
- Radiative mantle suppressed carbon blooms for record D-T fusion yield of 7.6 MJ.

Radiating Mantle Using Krypton Facilitated Record Fusion Energy on TFTR



Plasma Interface Participants

Lee Berry
Dale Meade
Ralph Moir
Mike Ulrickson
Bob Woolley
Clement Wong

Analysts/modelers

Plasma/First-Wall Interface Philosophy

Initial Stage

- Encourage (allow) innovation that will lead to radical engineering solutions
  - What is the "ideal" first wall?
  - Don't rule out solutions with high evaporation, mists, etc.
- Identify potential benefits/problems
- Identify "zealots"

Second Stage

- begin quantifying issues, connect to experience, develop analysis models

Plasma/First-Wall Issues

FW Surface Temperature
- evaporation, mass ejection
  - impurity injection
    - radiation losses (good/bad), spectrum
      - fuel depletion

FW Electrical Conductivity
- eddy currents
  - penetration needed for control fields
  - penetration to be avoided for wall stabilization of kinks

- impact on liquid flow

FW Configuration
- plasma heating/current drive access
- control coils
- diagnostics/control sensors

Develop methodology to assess criticality of issues