U.S. SMALL TOKAMAK PROGRAM
(Presented at the 1983 Tokamak Seminar at
Princeton Plasma Physics Laboratory on Feburary 1, 1983)

J.C. Sprott

PLP 892

February 1983

Plasma Studies

University of Wisconsin

U.S. SMALL TOKAMAK PROGRAM

J.C. SPROTT

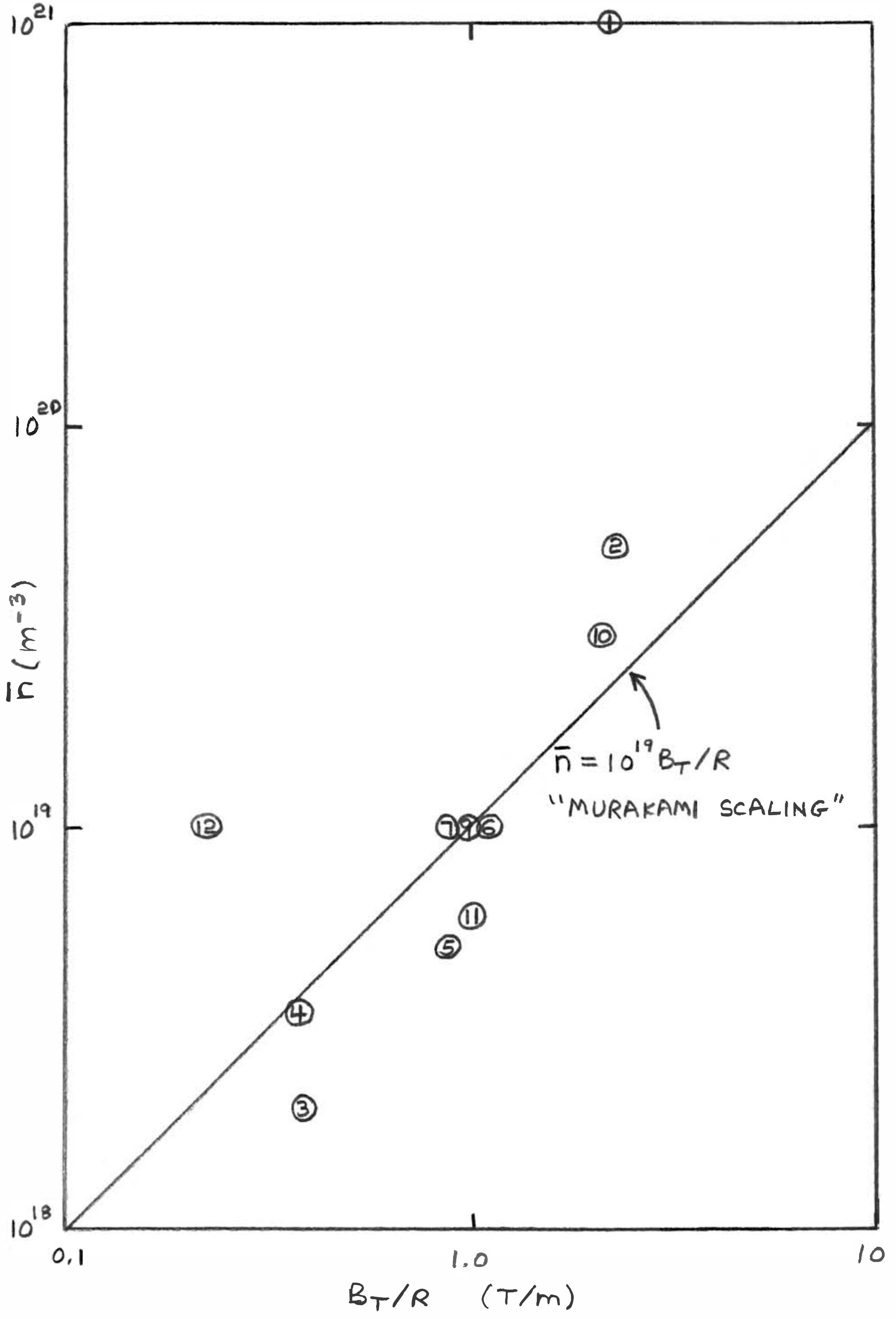
PRESENTED AT THE 1983 TOKAMAK SEMINAR AT PRINCETON PLASMA PHYSICS LABORATORY ON FEBRUARY 1, 1983.

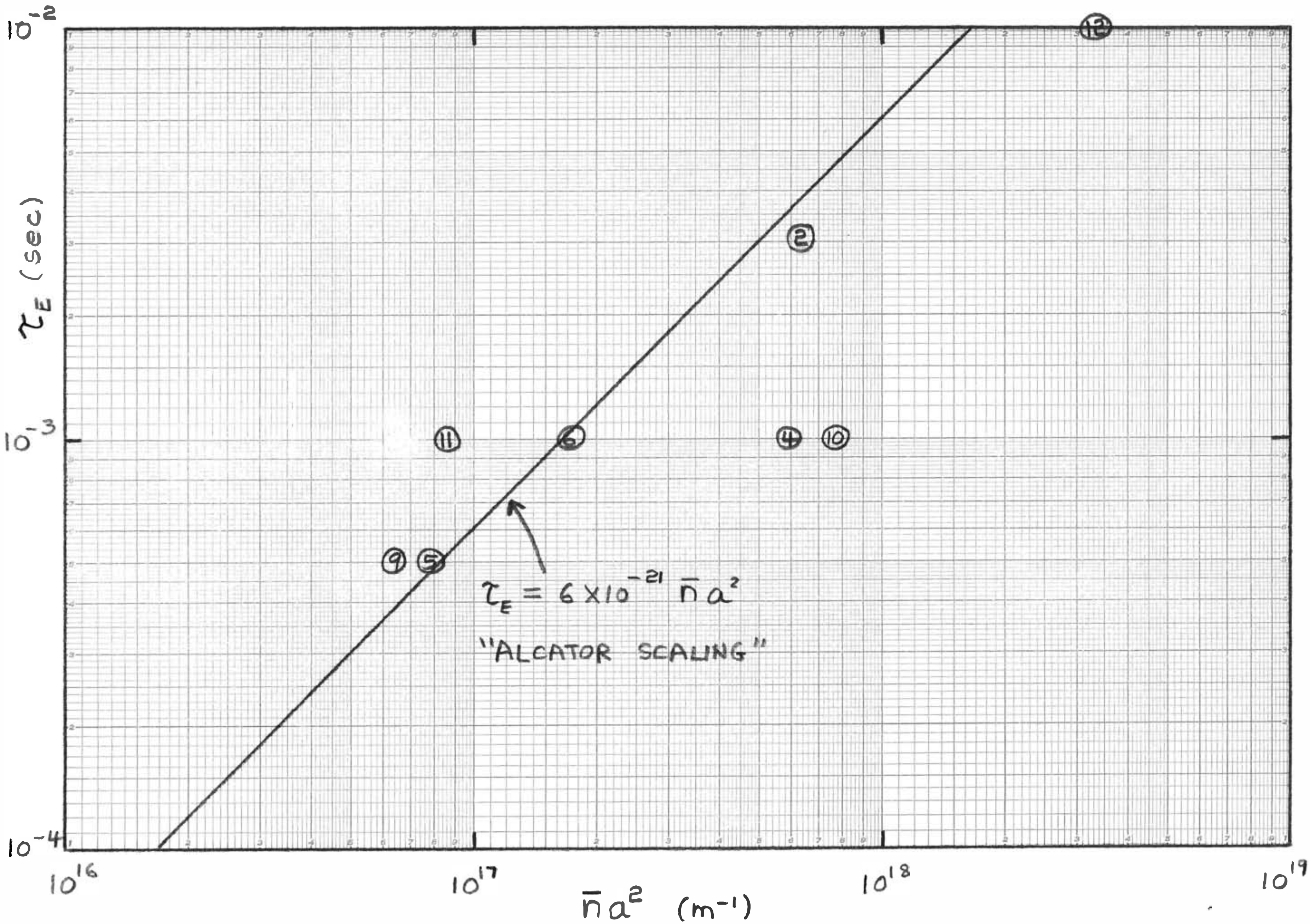
MATERIAL LARGELY TAKEN FROM THE 1982 SMALL TOKAMAK USERS MEETING AT NEW ORLEANS, LA ON NOVEMBER 1, 1982.

SUMMARY AVAILABLE AS UNIVERSITY OF WISCONSIN PLASMA PHYSICS REPORT #DOE/ET/53051-47.

U.S. SMALL TOKAMAK DEVICES

	DEVICE	R(CM)	2A(CM)	B_T(KG)
1.	COLUMBIA TORUS II	22.5	13x25	5
2.	UCLA MICROTOR	30	20x25	30
3.	CAL TECH ENCORE	38	24	1.5
4.	MIT VERSATOR II	40	30x30	15
5.	RPI RENTOR	45	30	4
6.	TEXAS TECH	46	26	7
7.	CAL TECH	46	32	6
8.	COLORADO	50	16	8
9.	WISCONSIN TOKAPOLE II	50	44x44	10
10.	TEXAS PRETEXT	53	35	11
11.	UC IRVINE	60	34	6
12.	UCLA MACROTOR	90	90x150	6


10^21
10^20
10^19
10^18
n̄ (m^-3)
n̄ = 10^19 B_T/R
"MURAKAMI SCALING"
0.1
1.0
10
B_T/R (T/m)
1
2
3
4
5
6
7
9
10
11
12


10^{-2}
10^{-3}
10^{-4}
τ_E (sec)
10^{16}
10^{17}
10^{18}
10^{19}
$\bar{n}a^2$ (m^{-1})
$\tau_E = 6 \times 10^{-21}\,\bar{n}a^2$
"ALCATOR SCALING"
12
2
11
6
4
10
9
5

MAJOR CURRENT AREAS OF STUDY

RF WAVE PROPAGATION AND HEATING

RF CURRENT DRIVE

TRANSPORT STUDIES

IMPURITY CONTROL

HIGH BETA

LOW Q

DIAGNOSTIC DEVELOPMENT

RF WAVE PROPAGATION AND HEATING

ECRH

VERSATOR II (150 KW - $\Delta T_{EO}/T_E \lesssim 70\%$)

TOKAPOLE II (10KW - $\Delta v_\ell / v_\ell \sim 50\%$)

LOWER HYBRID

VERSATOR II (120 KW - $\Delta T_I = 50$ EV)

ENCORE (RAY TRACING)

ICRF

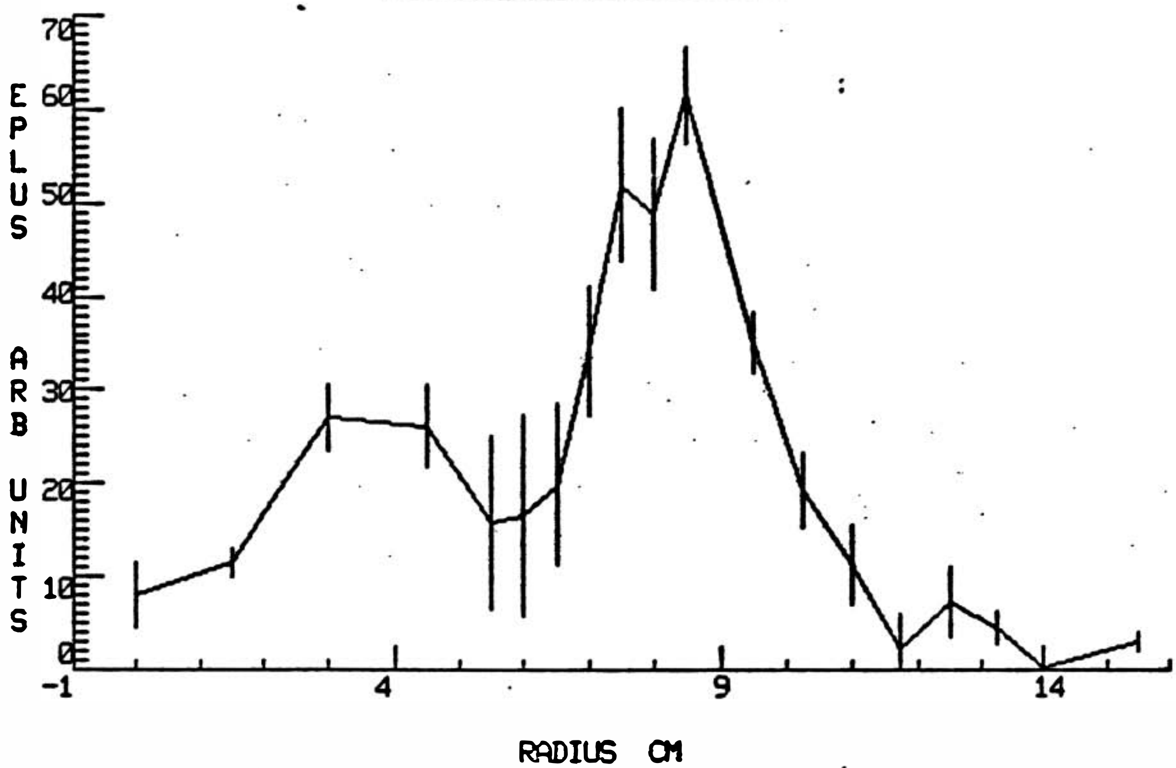
MACROTOR
TOKAPOLE II } (PUMPOUT OBSERVED)

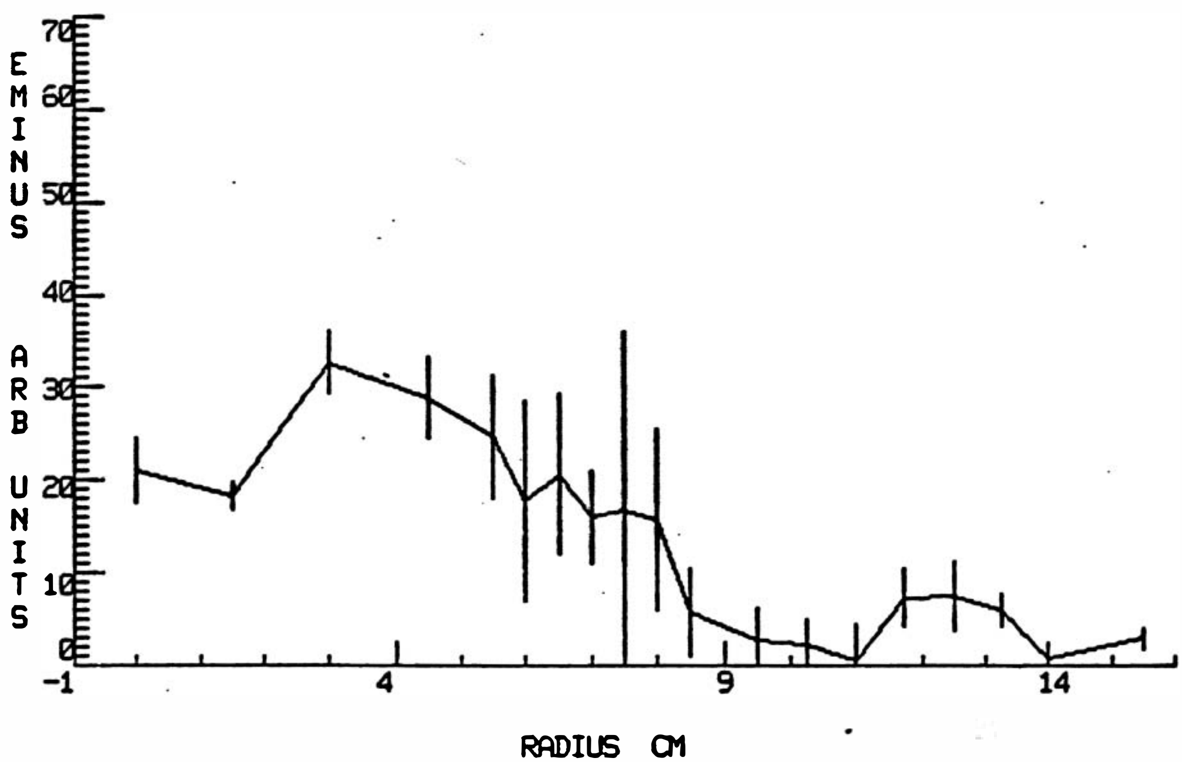
TEXAS TECH (WAVE PROPAGATION)

ALFVÉN WAVES

PRETEXT
TOKAPOLE II } (RESONANCE IDENTIFICATION AND HIGH POWER HEATING)

2Wcd layer at r=-17.7 cm





CURRENT DRIVE

LOWER HYBRID

- VERSATOR II (120 KW - $\Delta I \sim 10$ KA)
- ENCORE (50 KW - SMALL CURRENT OBSERVED)

ICRF

- MICROTOR (PLANNED)

FAST ALFVÉN WAVE

- TEXAS TECH (PLANNED)

NEUTRAL BEAMS

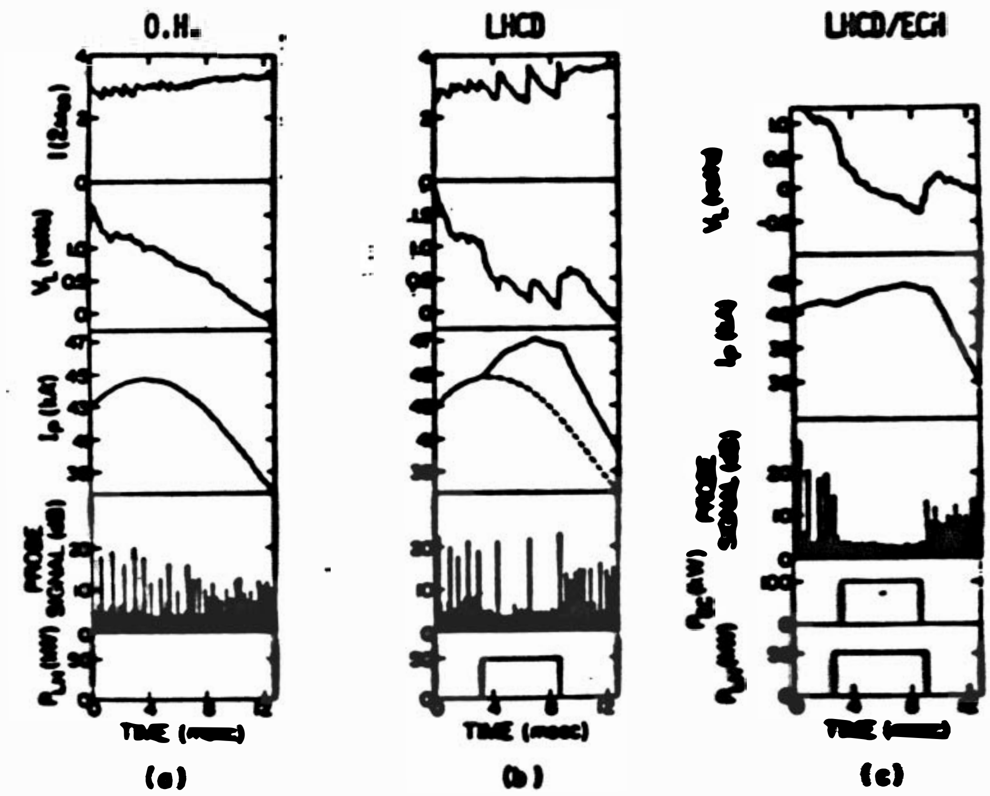
- COLORADO (3 KEV - PLANNED)

BOOTSTRAP CURRENT

- WISCONSIN OCTUPOLE ($I \sim 1$ KA)

VERSATOR II LHCD/ECH EXPERIMENTS

- STABILIZATION OF THE "TAIL-MODE" WITH ECH.



TRANSPORT STUDIES

MACROTOR (DC POTENTIALS)

$\phi > 0$ RECYCLES IONS AT EDGE

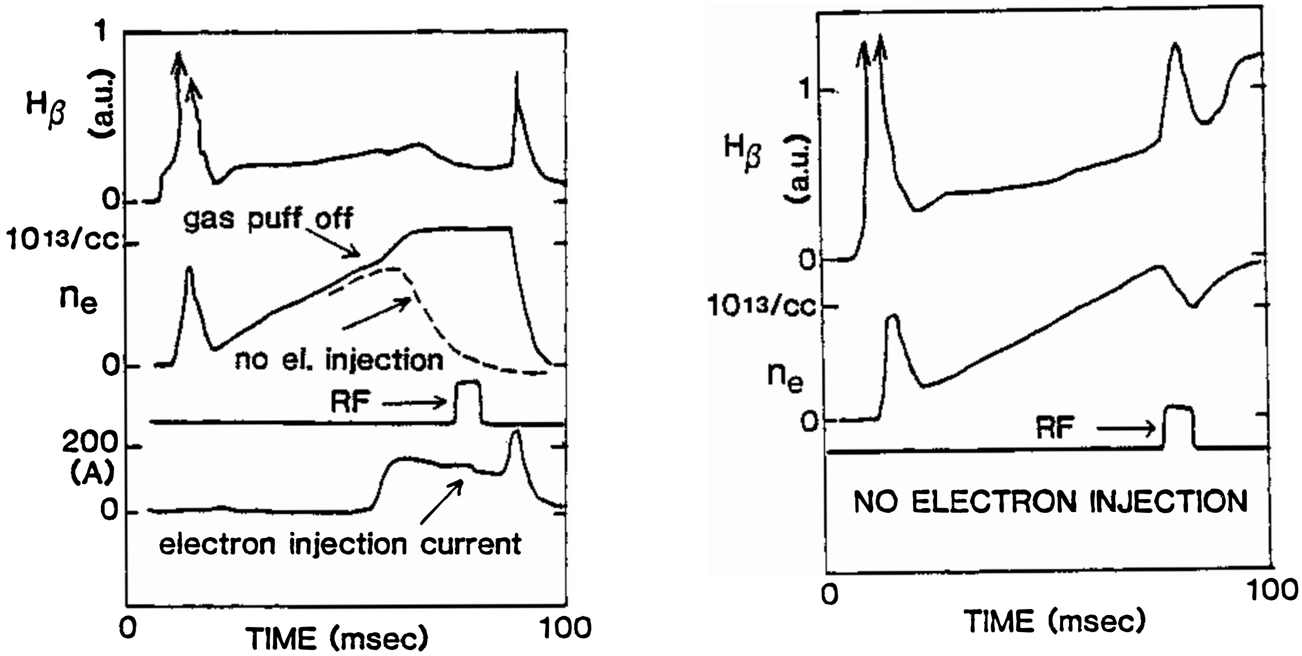
$\phi < 0$ CAUSES IMPURITY ACCUMULATION

CAL TECH (FLUCTUATING POTENTIALS)

$\delta N/N \simeq 0.2 - 0.5$ FOR $.75 < R/A < 1$

$\langle \delta N \delta E \rangle$ GIVES $D \simeq D_{BOHM}$ AT OUTER EDGE

RENTOR (ION BEAM PROBE)



UCLA MACROTOR

IMPURITY CONTROL

MACROTOR-PUMPED LIMITER

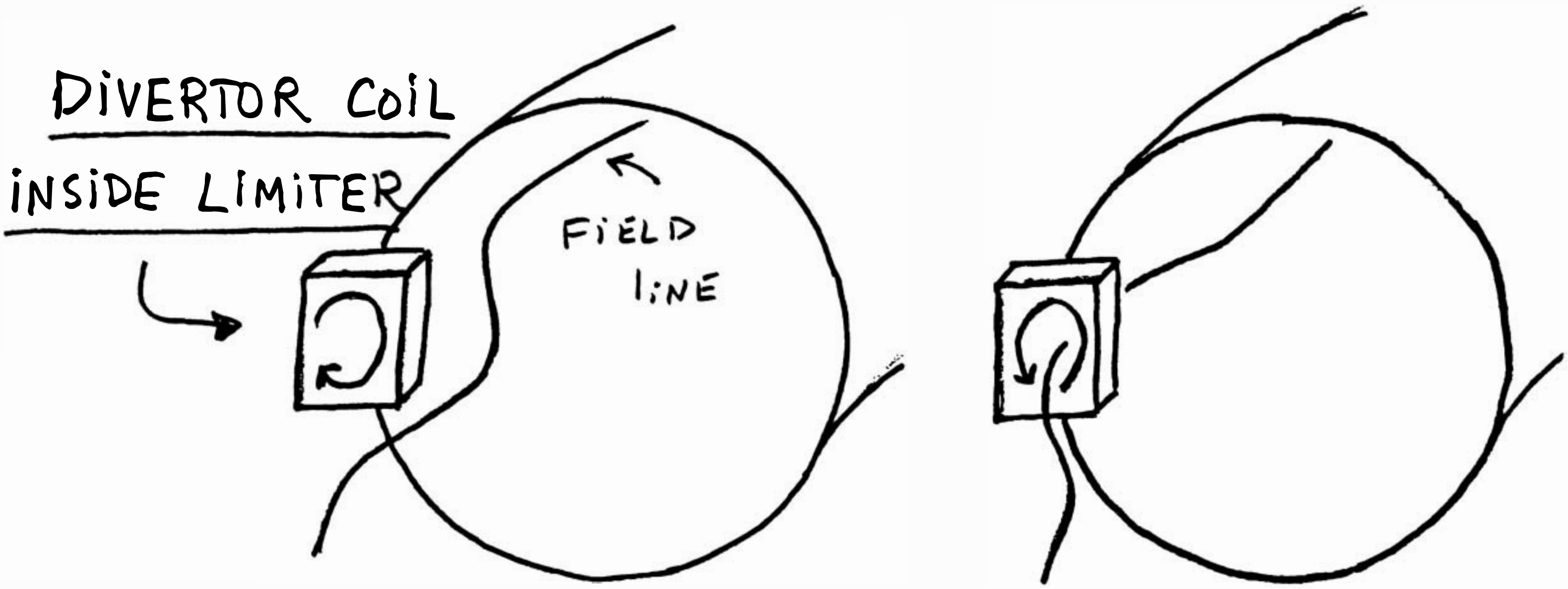
CAL TECH-BIASED LIMITER WITH BUNDLE DIVERTOR

MICROTOR-HOT WALL (700^{0}C) OPERATION

TOKAPOLE II

- ECRH STARTUP
- MARSHALL GUN REFUELING

3 LOCAL TOROIDAL DIVERTOR can control plasma-limiter INTERACTION



$B_{coil} \simeq -B_T$

FLUX TO LIMITER DECREASED BY x4

$B_{coil} \simeq +B_T$

FLUX TO LIMITER increased by 60%

- may be USEFUL IN PUMPED-limiters

HIGH BETA

TORUS II

$\langle\beta\rangle \simeq 12\%$, $\beta_0 \simeq 42\%$ OBTAINED

DIAMAGNETISM AND OUTWARD CURRENT SHIFT SEEN

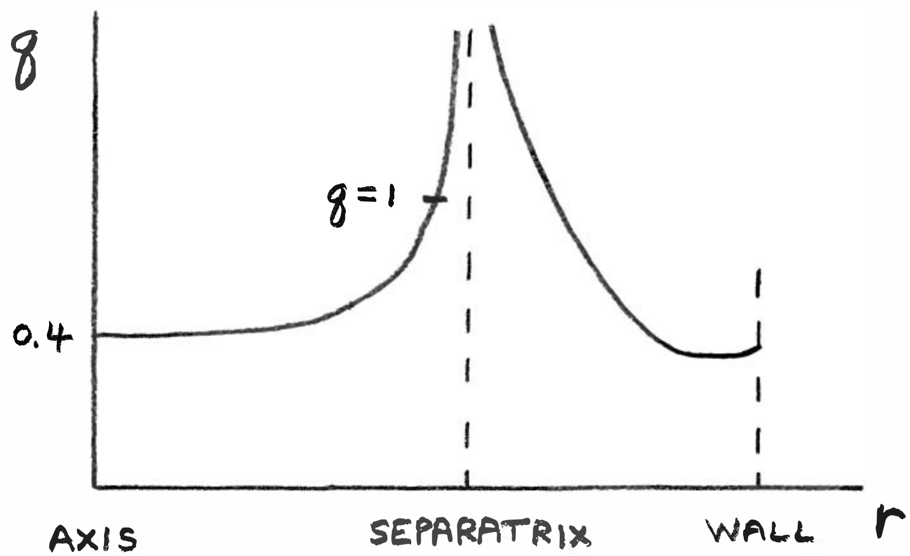
GROWING δN ON OUTSIDE SEEN

VARIABLE PLASMA PRESSURE PROFILE

MACROTOR

$\beta_0 = 8\%$ OBTAINED BY RAMPING DOWN B_T

LOW Q
WISCONSIN TOKAPOLE II



Q REMAINS FIXED AT 0.4 DURING SAWTEETH

SEPARATRIX MAY LIMIT ISLAND GROWTH

POOR ENERGY CONFINEMENT (<100 μSEC),

DIAGNOSTIC DEVELOPMENT

RPI-ION BEAM PROBE ($\delta\phi$, δN)

MICROTOR

1-SHOT IR LASER SCATTERING ($\omega(K)$)

FARADAY ROTATION (B_P)

PRETEXT

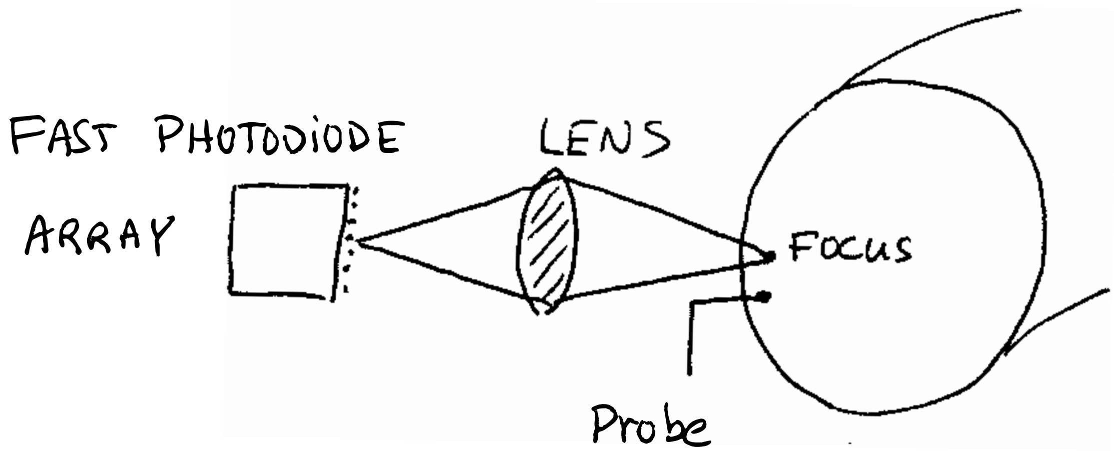
ALFVÉN WAVES + CO_2 LASER INTERFEROMETER ($Q(R)$)

CAL TECH

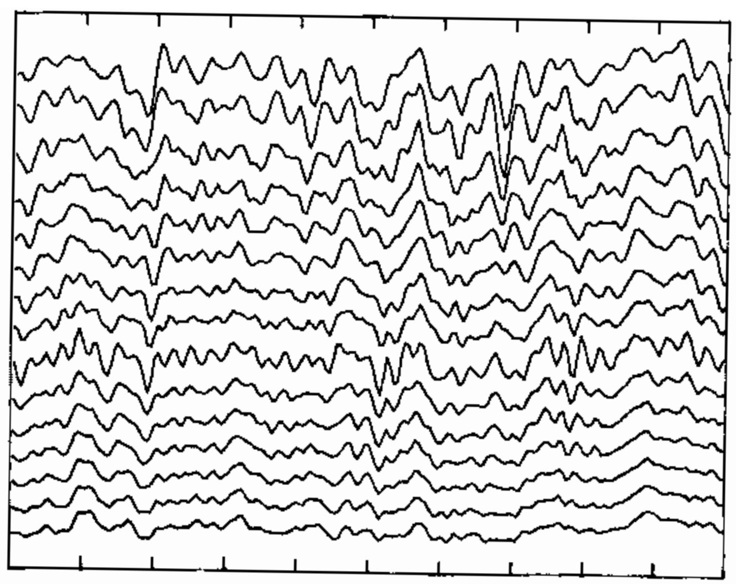
2-D VISIBLE IMAGING OF H_α

CAL TECH TOKAMAK

EDGE TURBULENCE can be seen by visible IMAGING of H_α



photodiode channels ~.5 cm apart poloidally



TIME → (50 μsec / divn)

- Light fluctuations are locally correlated with probe $\tilde{n}$

USES FOR SMALL TOKAMAKS

DETAILED BASIC PLASMA PHYSICS STUDIES

- STABILITY
- CURRENT DRIVE
- IMPURITY CONTROL

TESTING NEW IDEAS QUICKLY AND CHEAPLY

DIAGNOSTIC DEVELOPMENT

STUDENT TRAINING