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IGNITION PHYSICS STUDY GROUP SUPPORT OF THE ENGINEERING TEST REACTOR PROGRAM

A PRESENTATION AT THE FTP/A REVIEW

OFFICE OF FUSION ENERGY, GERMANTOWN

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MASTER

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TO ESTABLISH A GOOD DESIGN FOR THE ETR WE MUST

* ESTABLISH A RELIABLE EMPIRICAL TRANSPORT SCALING OR VALIDATE THEORETICAL MODELS

* PROVIDE SOME BASIS IN MHD TO FIX A BETA LIMIT AND RELATE IT TO OTHER PLASMA PARAMETERS R/a, b/a, q,...

* ESTABLISH DENSITY LIMIT FOR PROPOSED OPERATING CONDITIONS

* FIND OPTIMUM CURRENT DRIVE SCHEME

* GENERALLY, ESTABLISH SELF-CONSISTENT CONDITIONS

* ESTABLISH A DATA BASE AND ANALYSE FUNDED WORLD PROGRAM TO IDENTIFY WEAK AREAS

* FIND OPTIMUM MACHINE PARAMETERS USING SYSTEMS CODE WITH WELL ESTABLISHED CONSTRAINTS (POSSIBLE CONFINEMENT UNCERTAINTY)

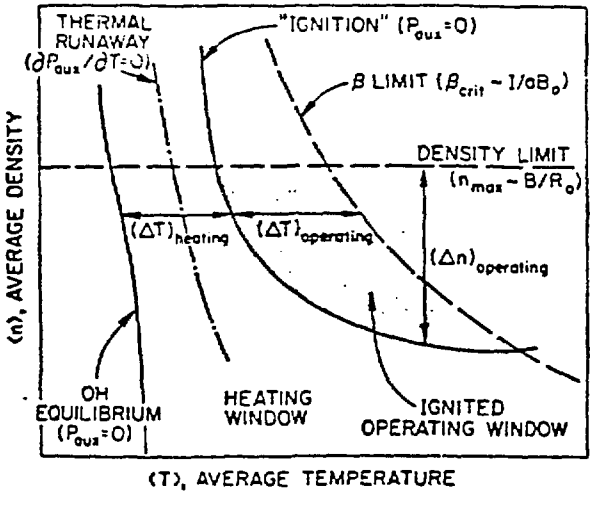
PLASMA PARAMETER OPERATING SPACE IS CONSTRAINED BY:

CIT:
- Confinement (ion & electron transport, impurities)
- MHD effects (β limit, q_ψ, etc.)
- Density limit (Murakami limit)

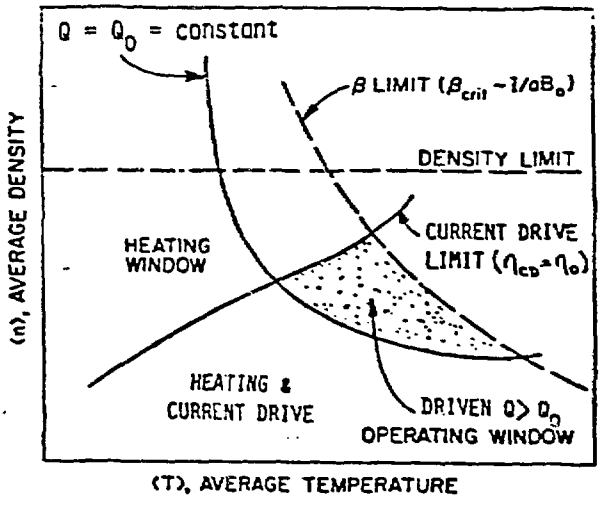
ETR:
- Confinement (ion & electron transport, impurities)
- MHD effects (β limit, q_ψ, etc.)
- Density limit (Murakami limit)
- **current drive requirements**

CURRENT DRIVE

INDUCTIVE



NONINDUCTIVE

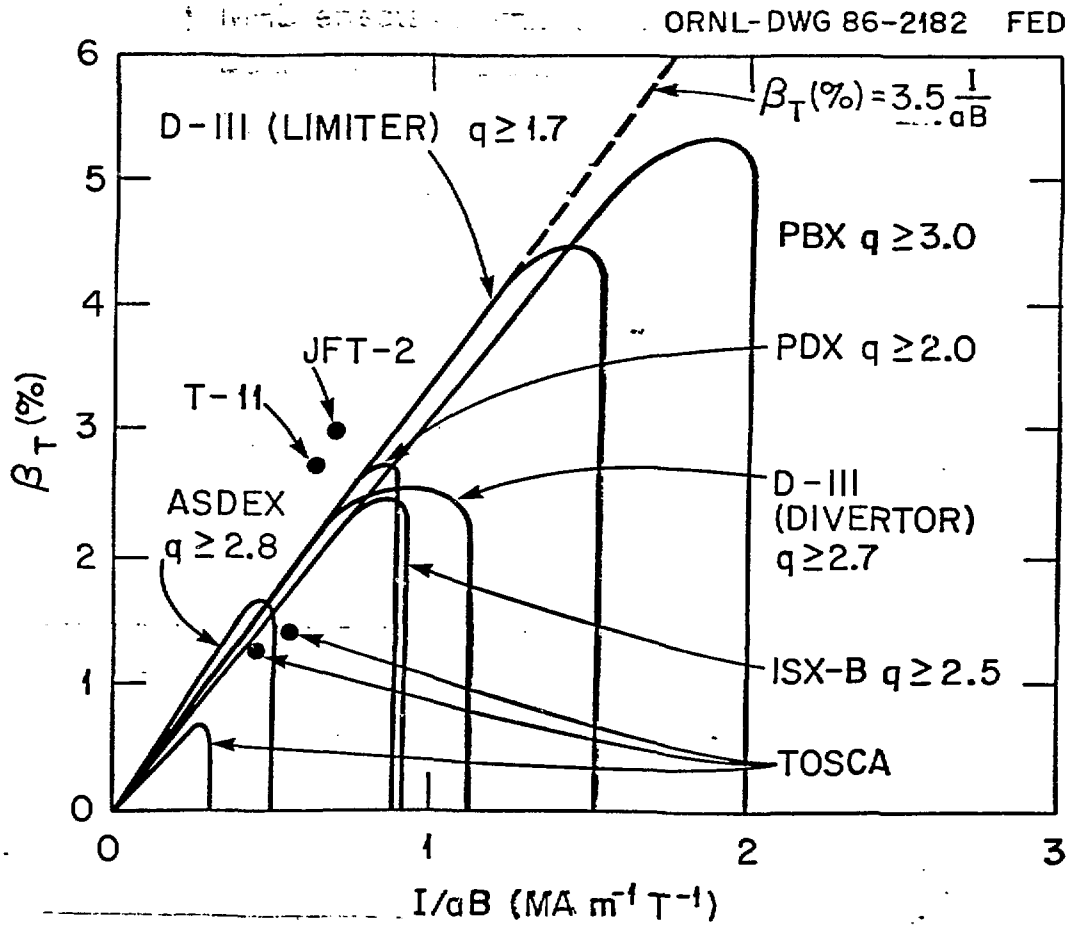


The prime operating conditions, and start up scenario for the CIT differ from those for the non-inductive TIBER scenario.

TOKAMAKS HAVE ACHIEVED BETA AT OR NEAR THE TROYON LIMIT

HOWEVER NON-DISRUPTIVE, SUSTAINED OPERATION HAS GENERALLY BEEN AT ONLY 65 -> 80% OF THE REFERENCE LEVEL OF 3.5I/aB %

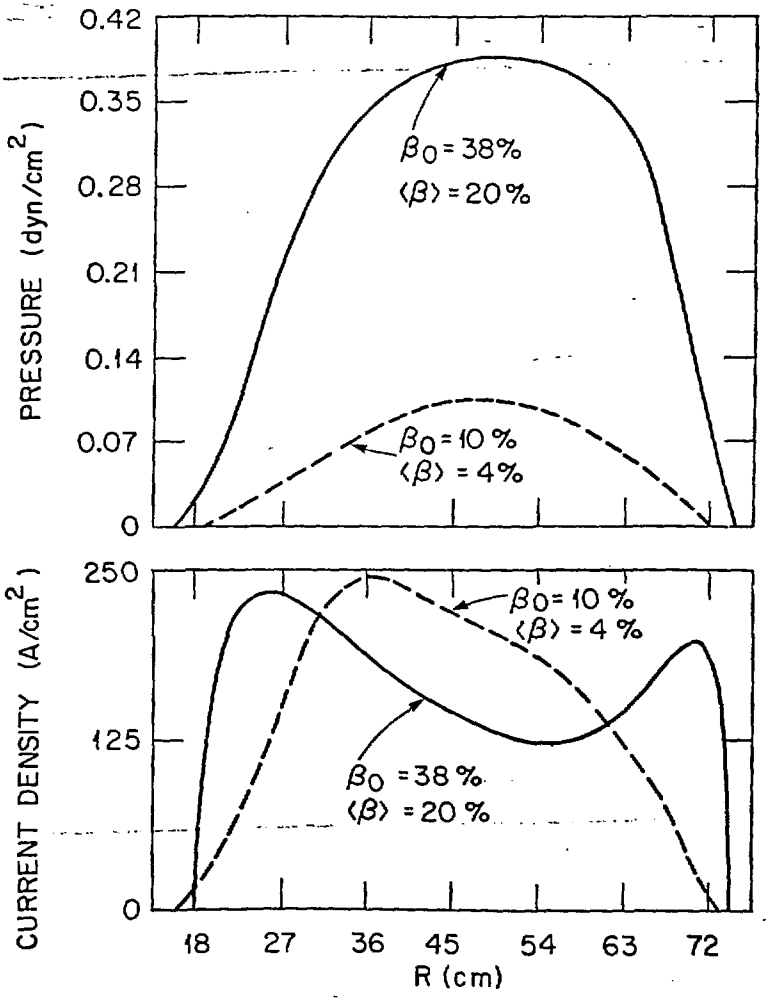
THE RELATIONSHIP BETWEEN b/a, R/a, q AT THE LIMIT IS REQUIRED



AN EXAMPLE OF MHD LIMITED PLASMAS ILLUSTRATES THAT CONTROL OF THE CURRENT PROFILE COULD HELP MAXIMIZE BETA

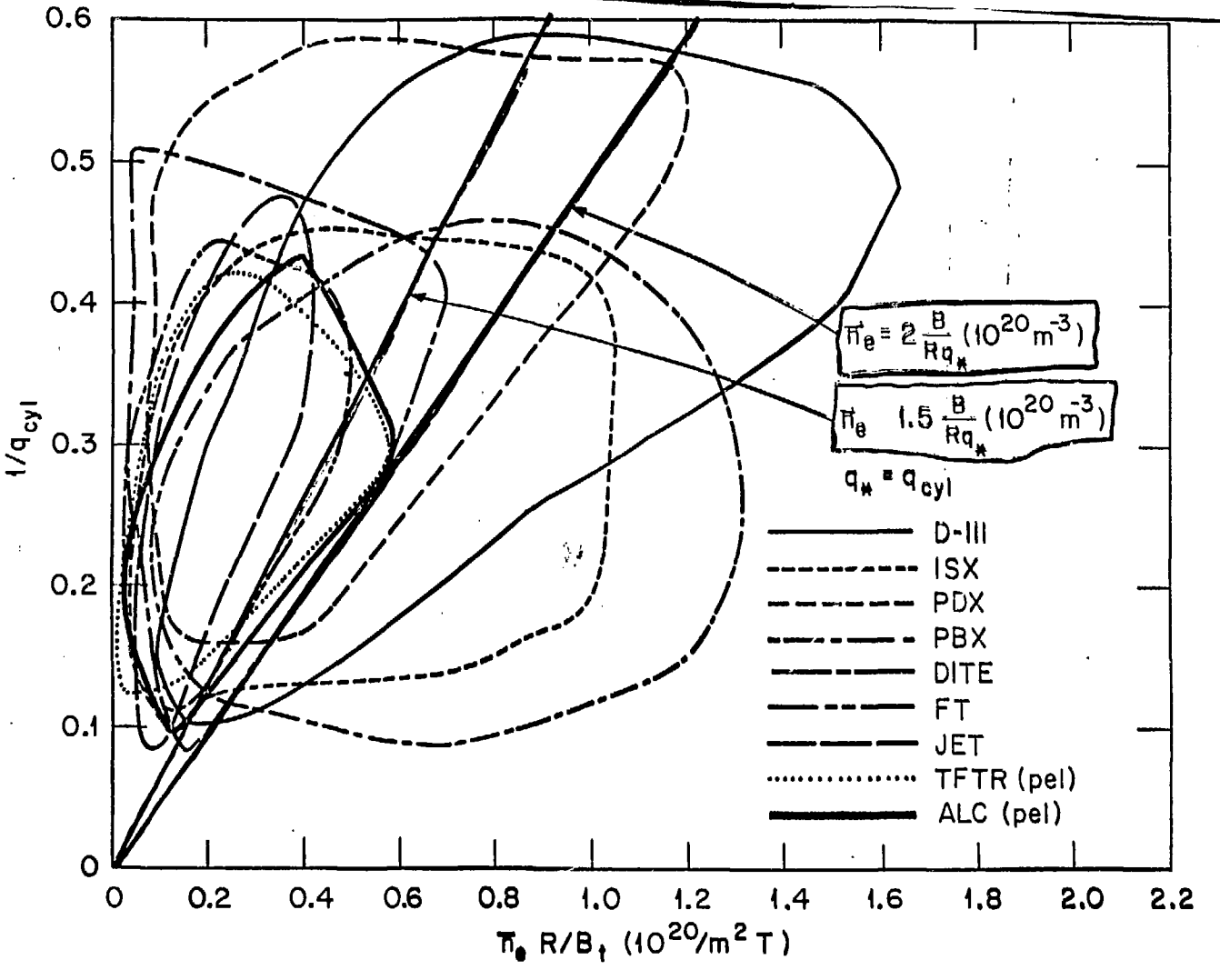
ORNL-DWG 87-2039 FED

STABLE PRESSURE AND CURRENT PROFILES (STX)



A PLOT OF OPERATING DENSITY REGIONS FOR A NUMBER OF TOKAMAKS SHOWS THAT NONCIRCULAR PLASMAS IMPROVE DENSITY LIMITS FOR A GIVEN B/Rq

THE GREENWALD LIMIT $n_{max}(10^{20}\,m^{-3}) \rightarrow I/\pi a^2\,(MA/m^2)$ IS A GOOD FIT TO MODERN DATA

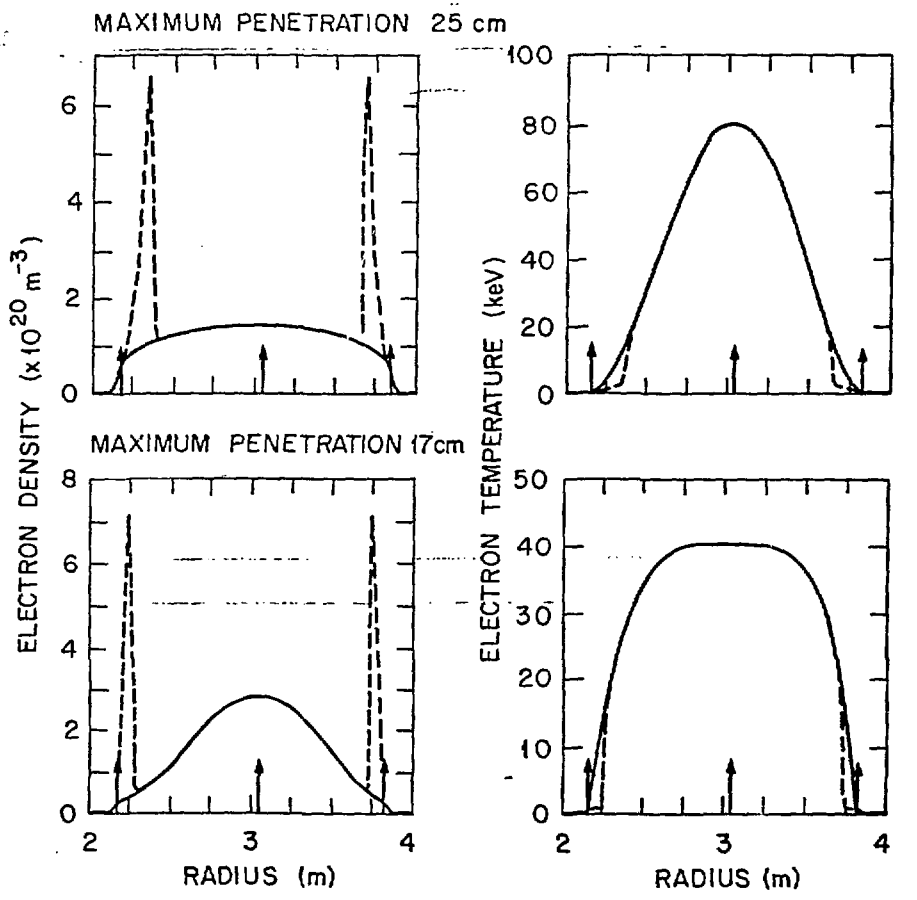


PELLET INJECTION INTO TIBER-WHIST CODE

$\langle T \rangle = 27$ keV $\langle n_e \rangle = 1.1 \times 10^{20}\ m^{-3}$

$V_p = 10\ km \cdot s^{-1}$ $P_\alpha = 54$ MW

——INITIAL - - - FINAL



(EVEN WITH $V_p = 50\ km \cdot s^{-1}$, MAXIMUM PENETRATION IS ONLY 30 cm)

THERE ARE TWO TYPES OF EMPIRICAL CONFINEMENT SCALINGS FOR TOKAMAKS

POWER LAW (e.g., KAYE-GOLDSTON)

OFFSET-LINEAR (e.g., KAYE, POST-KYOTO)

* POWER LAW $\tau_E = \{ 1/(\tau_{NA})^2 + 1/(\tau_{AUX})^2\}^{-0.5}$ (s)

$\tau_{NA} = 0.07\ n_{20}\ aR^2 q_*$ (s)

$\tau_{AUX} = 0.056\ I^{1.24}\ R^{1.65}\ \kappa^{0.28}\ (A_i)^{0.5}/(P^{0.58}\ a^{0.49}\ B^{0.09})$ (s)

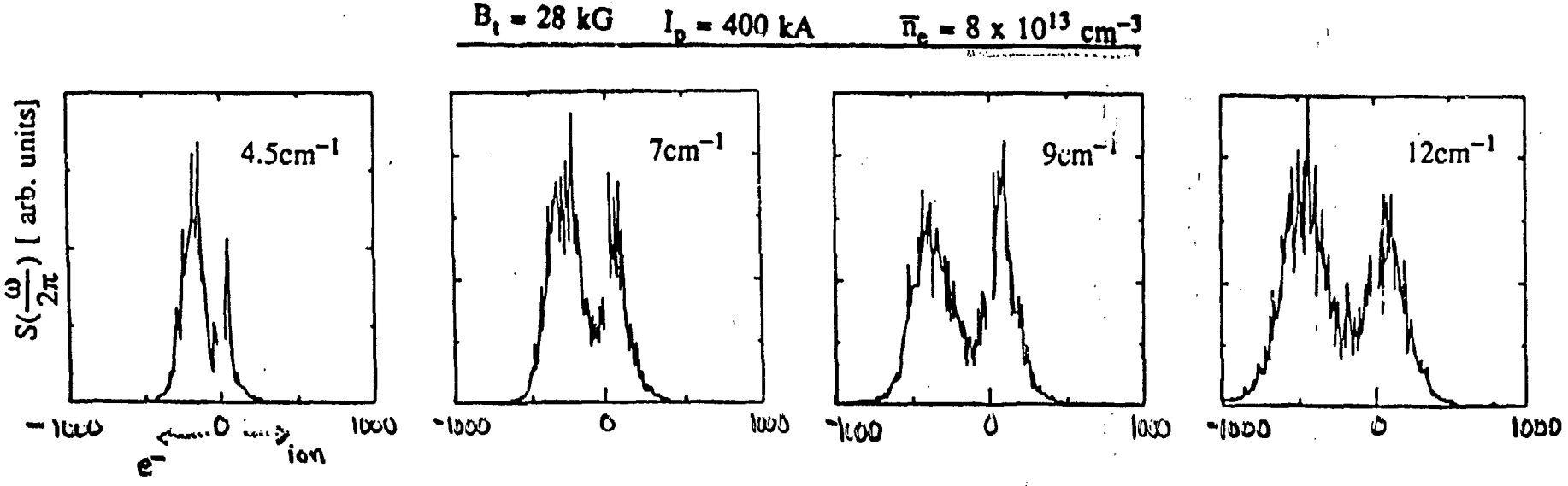
* OFFSET-LINEAR $\tau_E = \tau_{NA}(P_{OH}/P_T) + \tau_{INC}$ (s)

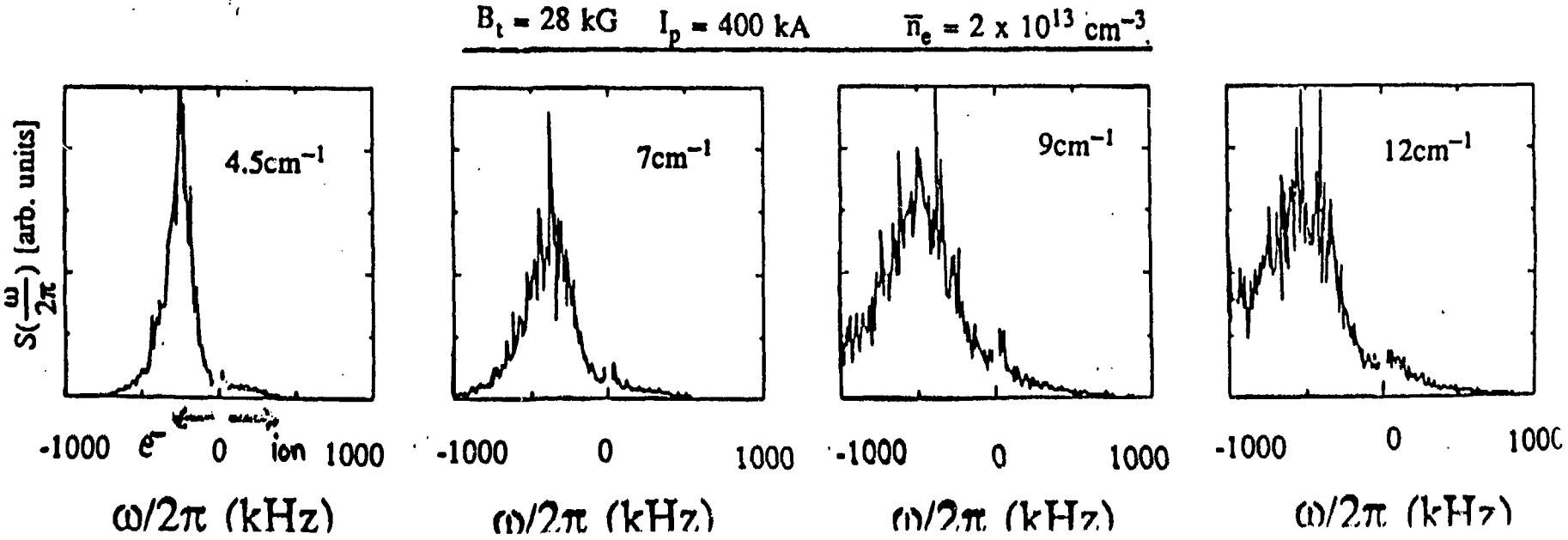
$\tau_{INC} = 0.038\ a^{0.55}\ I\ (A_i)^{0.5}/\ R^{0.09}$ (s)

THE TWO SCALINGS GIVE DIFFERENT PREDICTIONS FOR TIBER IT IS NOT CLEAR WHETHER PRESENT EXPERIMENTS CAN DISTINGUISH BETWEEN THEM

ION PRESSURE GRADIENT (η_i) MODE ?

Brower et al
UCLA





A NUMBER OF PHYSICS AREAS ARE BEING STUDIED BY THE IPSG FOR THE CIT AND THE ETR

* POST-KYOTO REVIEW OF EXPERIMENTS - PPPL FEBRUARY (KAYE/PARKER)

* REVIEW OF TRANSPORT THEORY AND EXPERIMENT - LLNL MARCH (BALDWIN/POST)

* A LIMITED, BUT DETAILED, DATA BASE OF KEY EXPERIMENTAL RESULTS WILL BE ASSEMBLED FOR THE BENCHMARKING OF PREDICTIVE CODES (POST)

* AN EXPERIMENTAL DATA BASE WILL BE COLLECTED WHICH COULD HELP DISTINGUISH BETWEEN THE VARIOUS THEORETICAL MODELS OF ELECTRON TRANSPORT (KAYE)

* A CURENT DRIVE SUB-GROUP WILL BE HEADED BY BERNABEI

* AN ECH SUB-GROUP WIL BE SET UP

* A REASSESSMENT OF DENSITY LIMITS IS BEING MADE (GREENWALD)

* THE MHD GROUP WILL TRY AND CLARIFY THE DEPENDENCE OF BETA LIMITS ON ELLIPTICITY AND SAFETY FACTOR AND ASPECT RATIO (JARDIN/DORY)

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