STUDIES OF A POLOIDAL DIVERTOR RFP ON TOKAPOLE II

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Studies of a Poloidal Divertor RFP on Tokapole II.* J.S. SARFF, J.C. SPROTT, University of Wisconsin-Madison-- The presumed need for a nearby conducting boundary in Reversed-Field Pinches has motivated us to consider the possibility of obtaining an RFP plasma in a poloidal divertor configuration. Using the Tokapole II device, we previously have obtained plasmas in which a reversal surface is formed far from a conducting wall for up to 100 μsec. Further studies of this configuration with the inclusion of poloidal scrape-off plates are reported here. The prominent feature differentiating these plasmas from those obtained earlier is the presence of large diamagnetic currents near the scrape-off plates in the seperatrix region. From magnetic probe measurements we obtained the equilibrium field profiles, pressure profiles, and the force-free parameter ($\lambda=J/B$) profiles. We also operated the large Wisconsin Levitated-Octupole in the poloidal divertor mode obtaining similiar results; RFP studies will be continued on this device.

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Plasmas with a reversed-toroidal field profile have been obtained in a poloidal-divertor configuration; the reversed profile diffuses in $\cong$100 μsec, half of which time a reversal surface is within the separatrix. Plasma features include reduced fluctuations coincident with reversal and a large diamagnetic current near the separatrix.

OUTLINE:

* The TOKAPOLE II device and its operation with reversed-field programming

* Description of magnetic field profile data acquisition and polynomial fitting

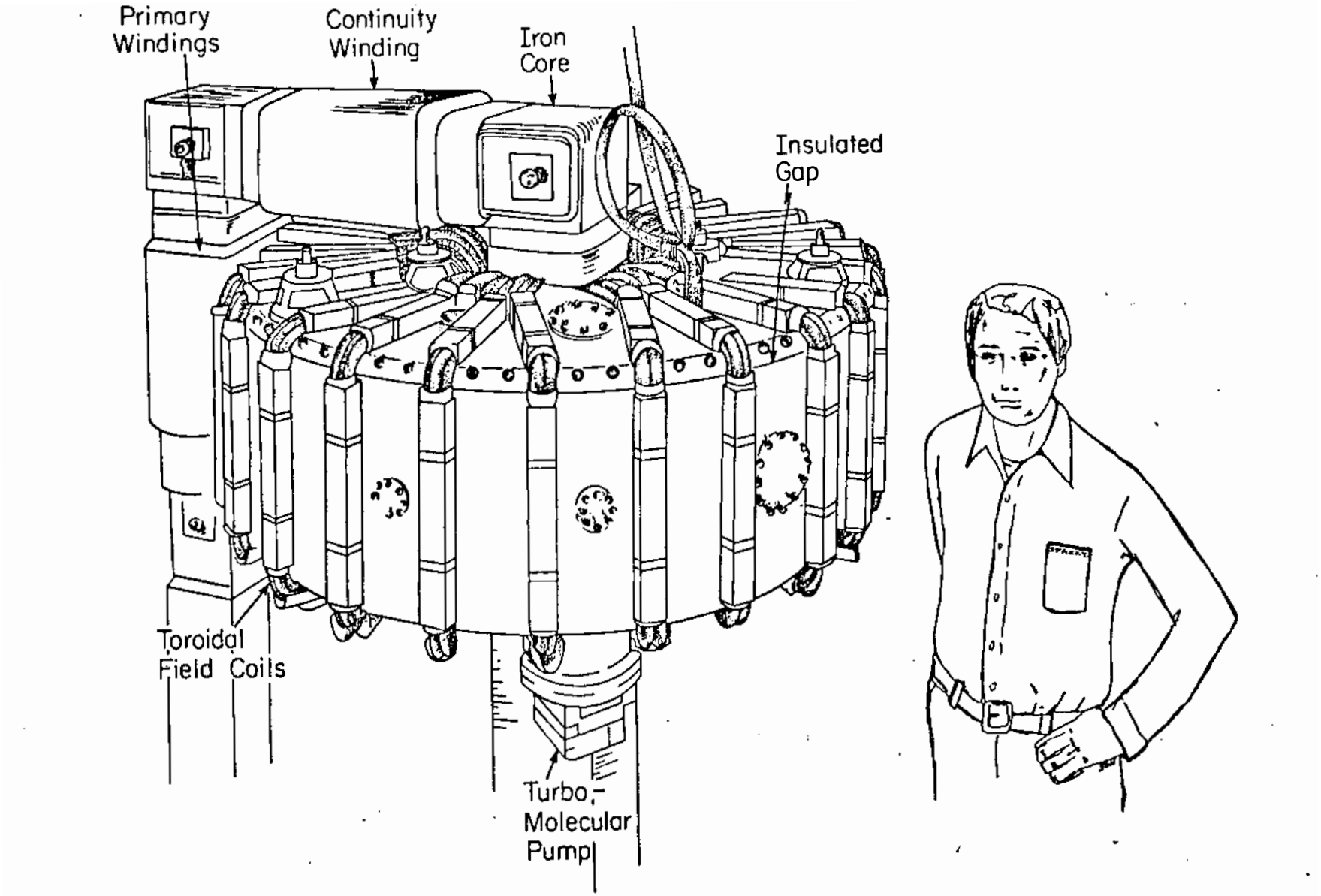
* Equilibrium profiles of the magnetic field, current density, force-free parameter (λ=J/B), and the plasma pressure

* The need for limiting the common flux region plasma current

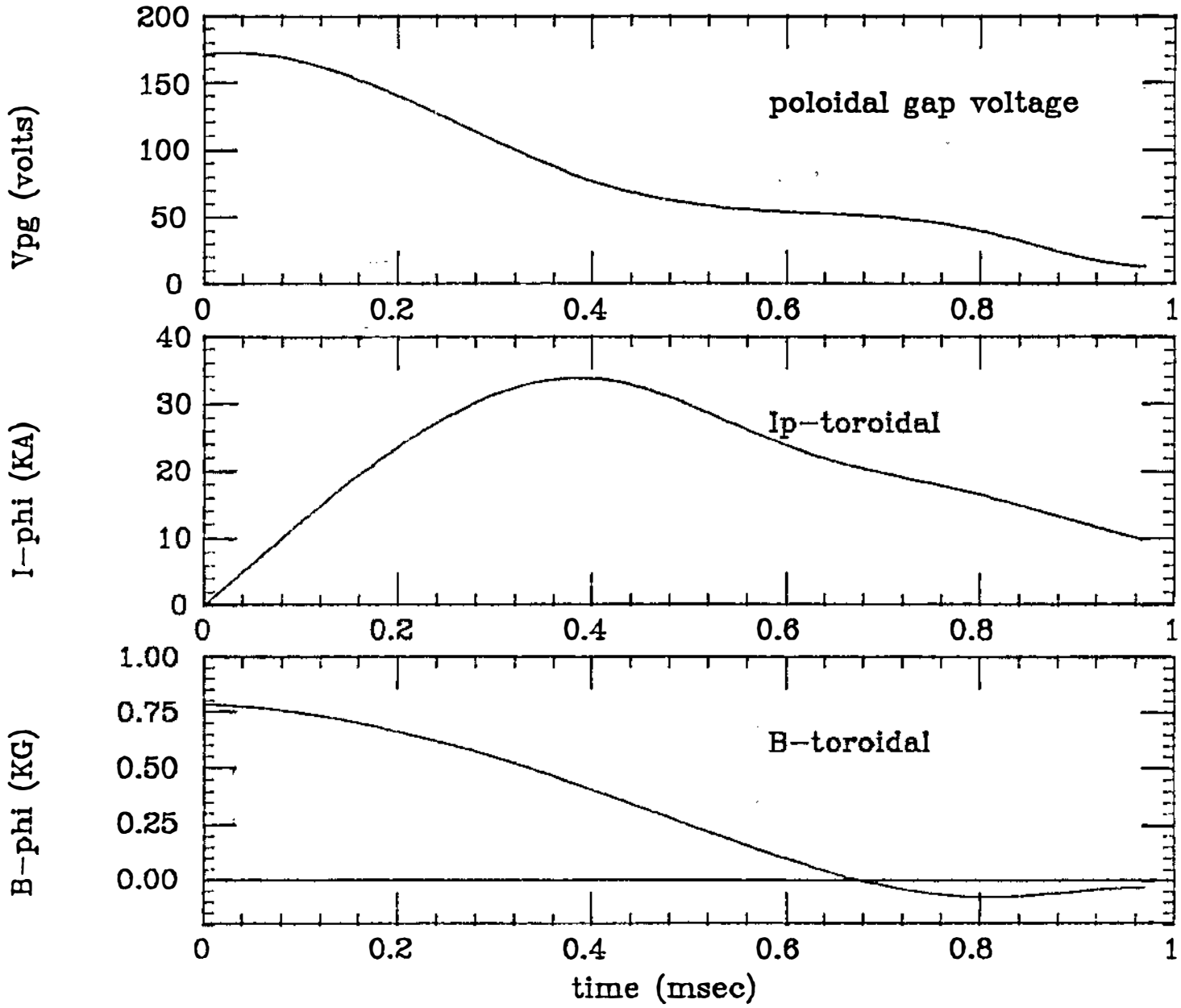
* Equilibrium for the poloidally limited plasmas

* Summary

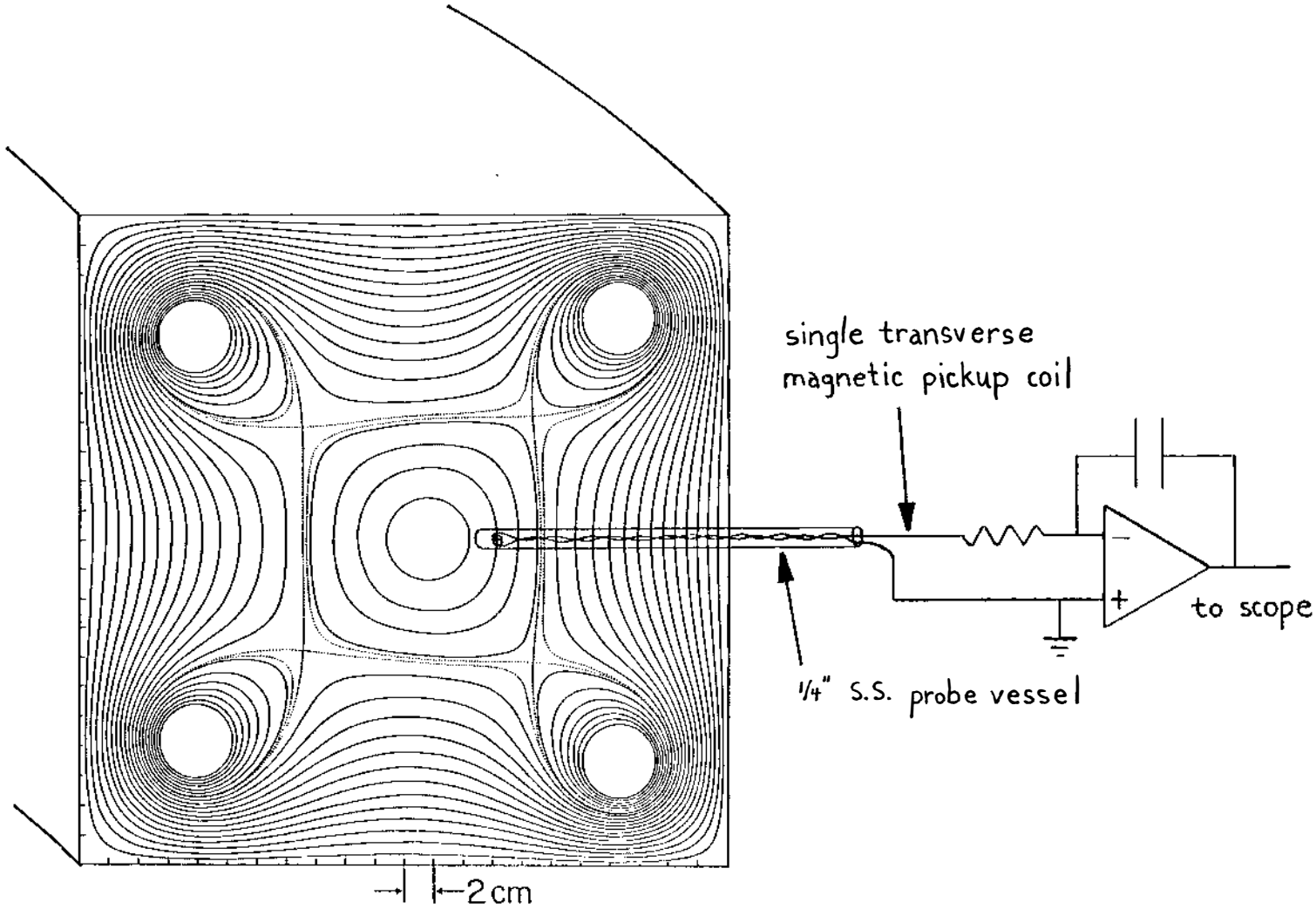
Tokapole II has four internal conducting rings which are inductively driven with the plasma to produce a poloidal-divertor configuration (internal magnetic separatrix).



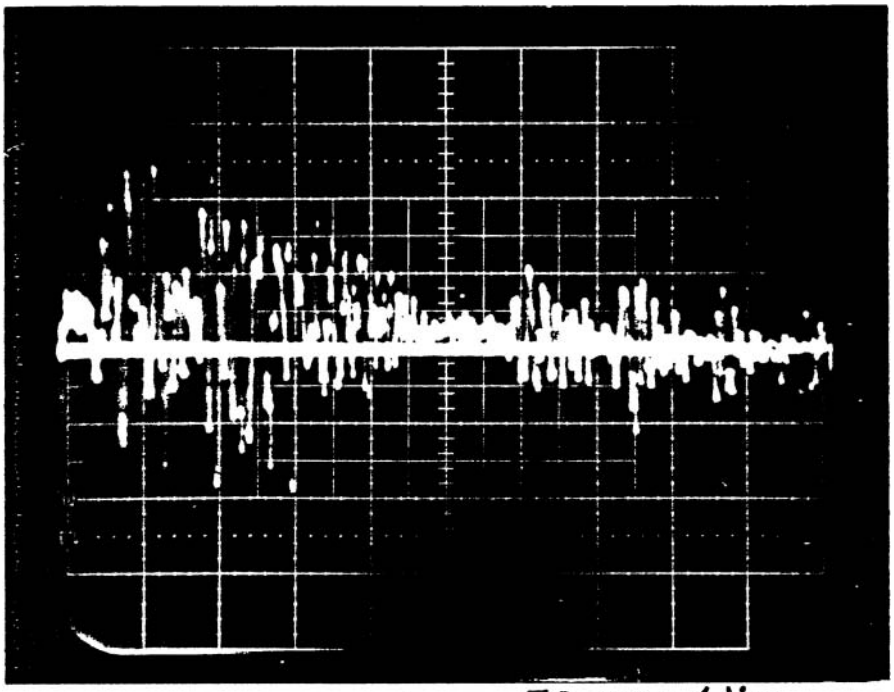
"Aided-reversal" toroidal field programming is used in the "poloidal-divertor RFP" operation of Tokapole II.



A magnetic pickup coil is inserted along the midplane to obtain radial profiles of the equilibrium magnetic fields.



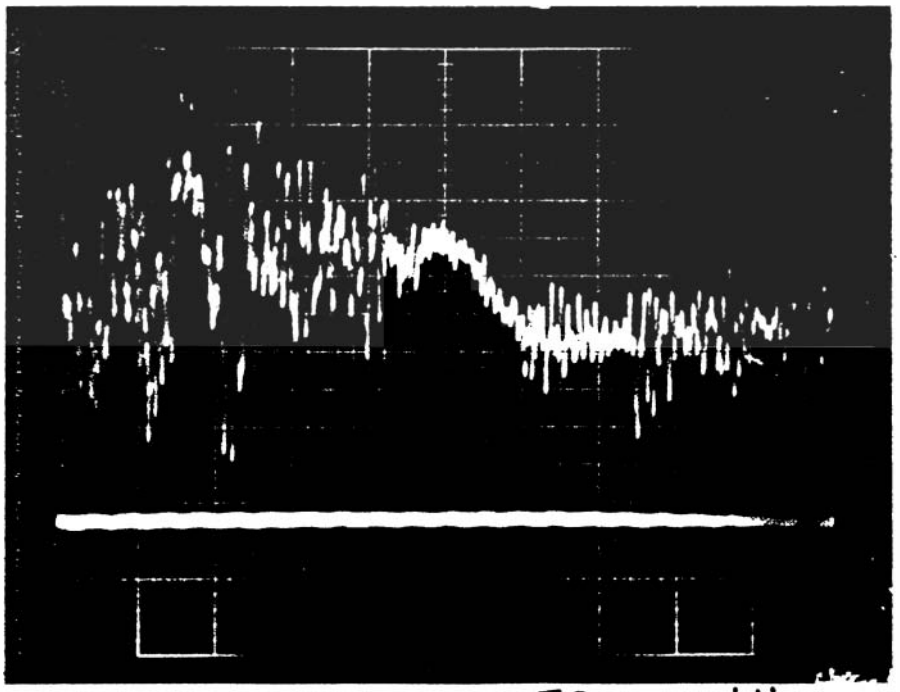
Reduced fluctuations are coincident with the reversal of the toroidal field.



50 μsec/div

$\dot{B}$ from a magnetic probe placed near the wall

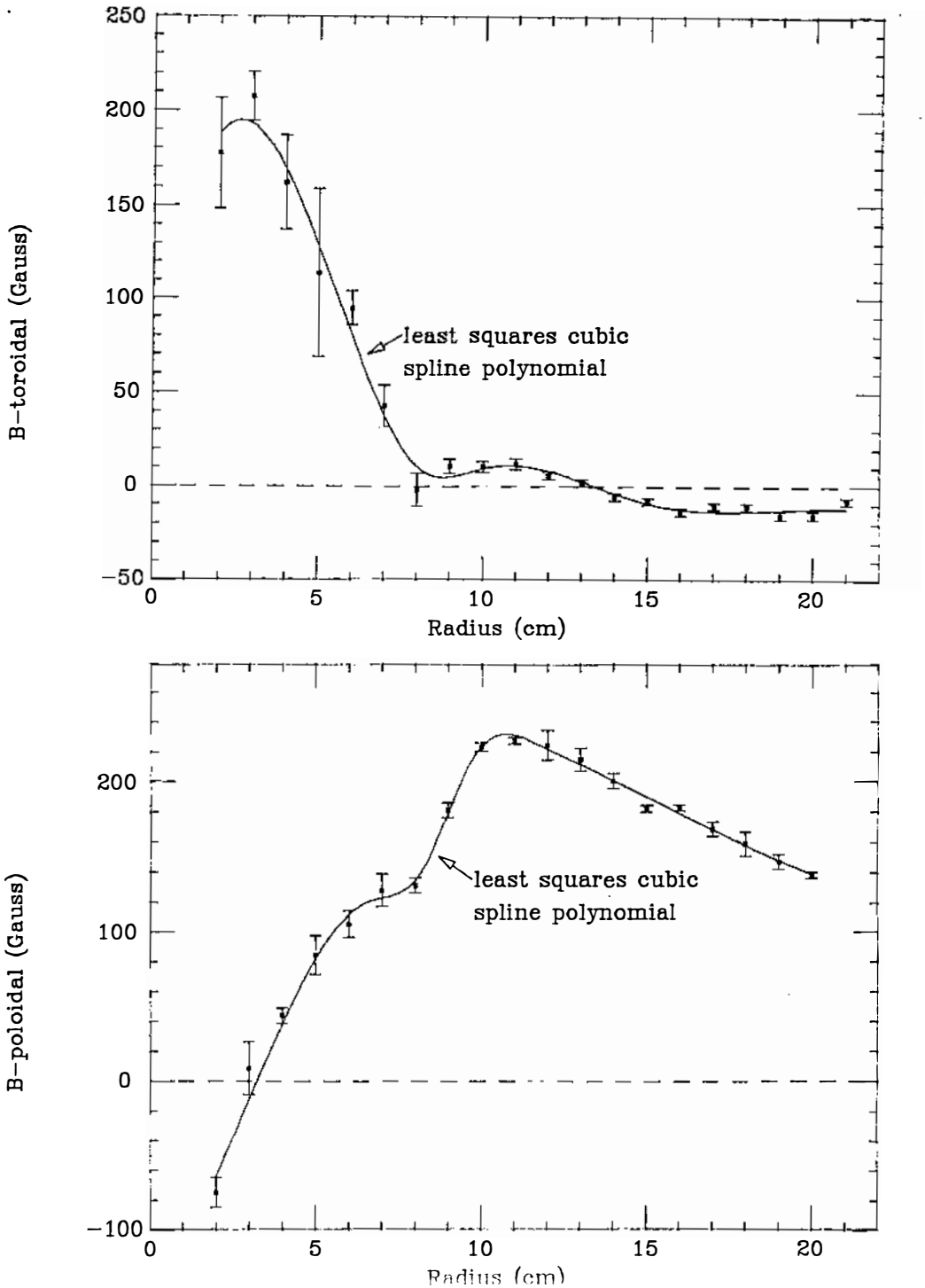
time of reversal of the toroidal field



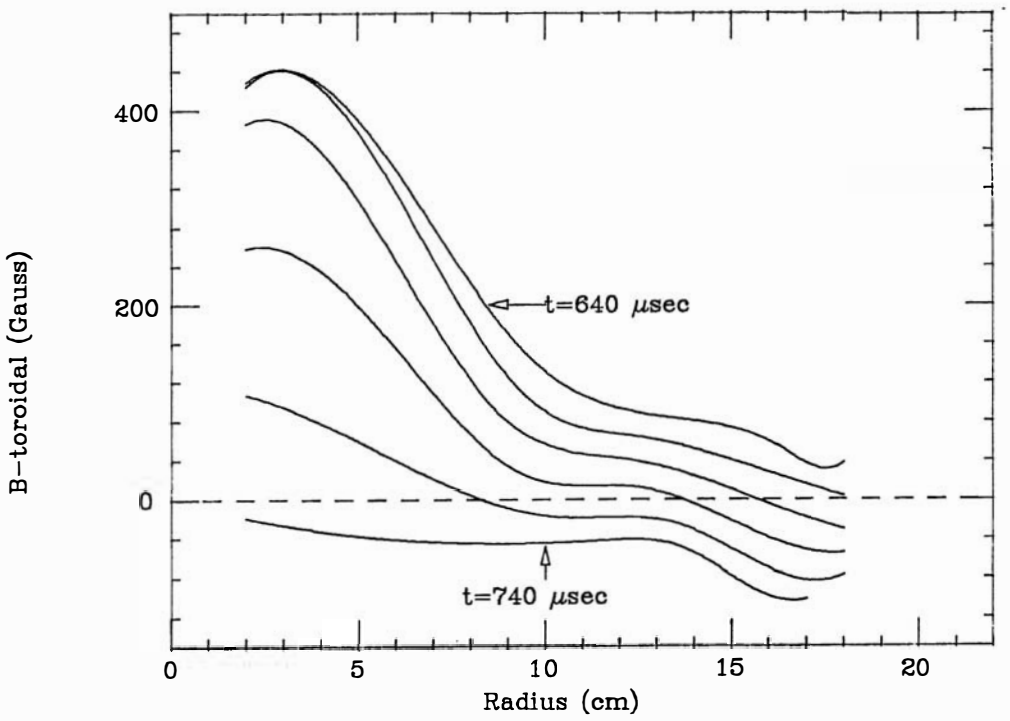
50 μsec/div

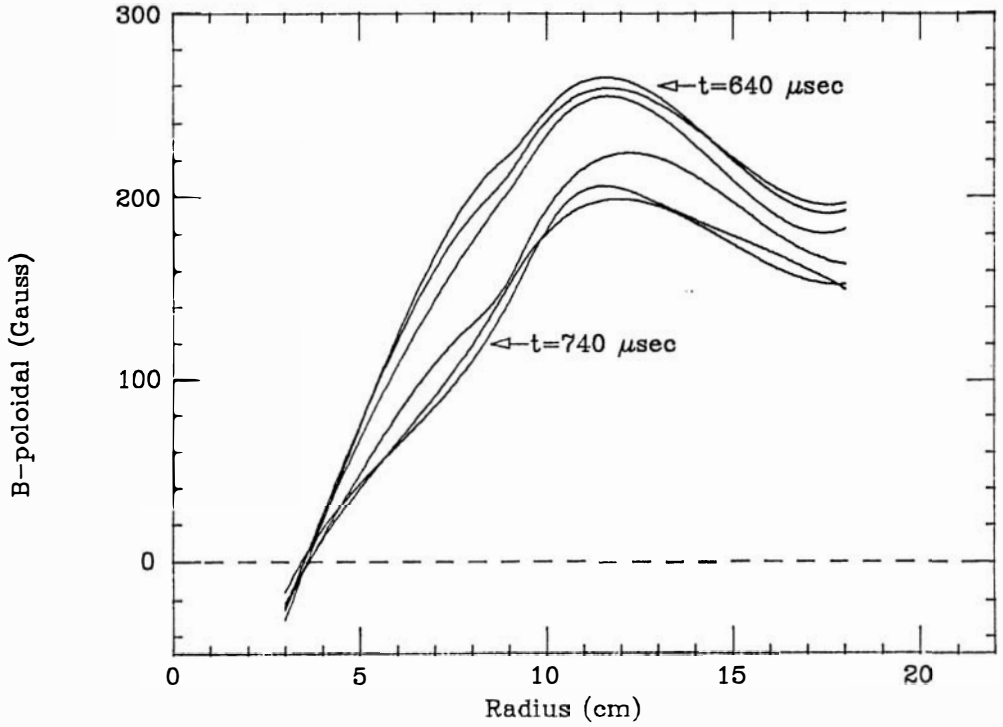
Ion saturation current from a Langmuir probe placed near the wall

Least square cubic spline polynomials are fit to the raw field profile data near the time period when a reversal surface exists.

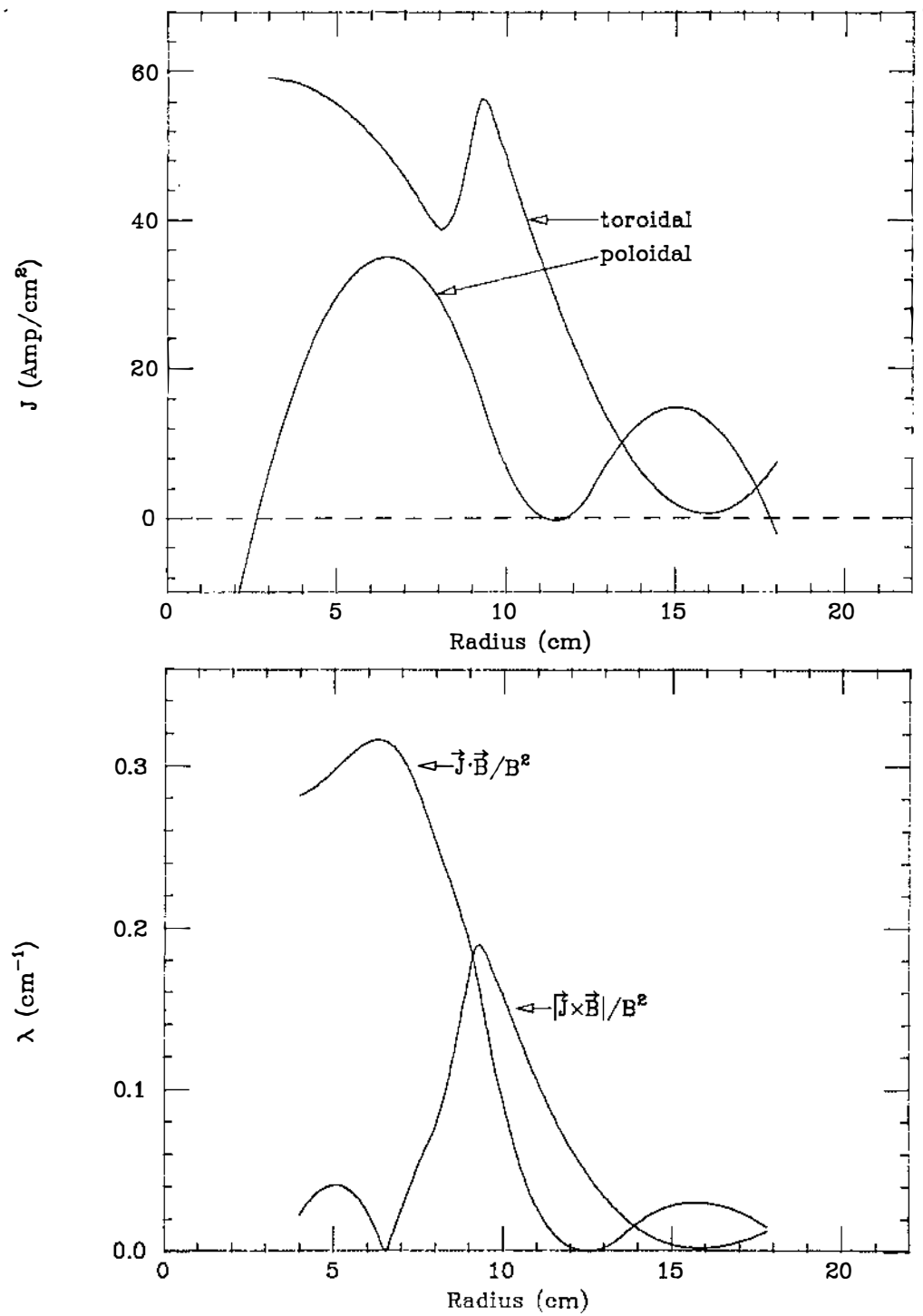


Polynomial representations of the toroidal and poloidal (plasma component) field profiles at 20 μsec intervals.





Examples of the current density and λ profiles obtained from $\nabla \times \underline{B} = \underline{J}$ and $\lambda_{\parallel,\perp} = J_{\parallel,\perp}/B$. Note the current "bumps" at $r \simeq 9$ and 15 cm. (t=700 μsec)



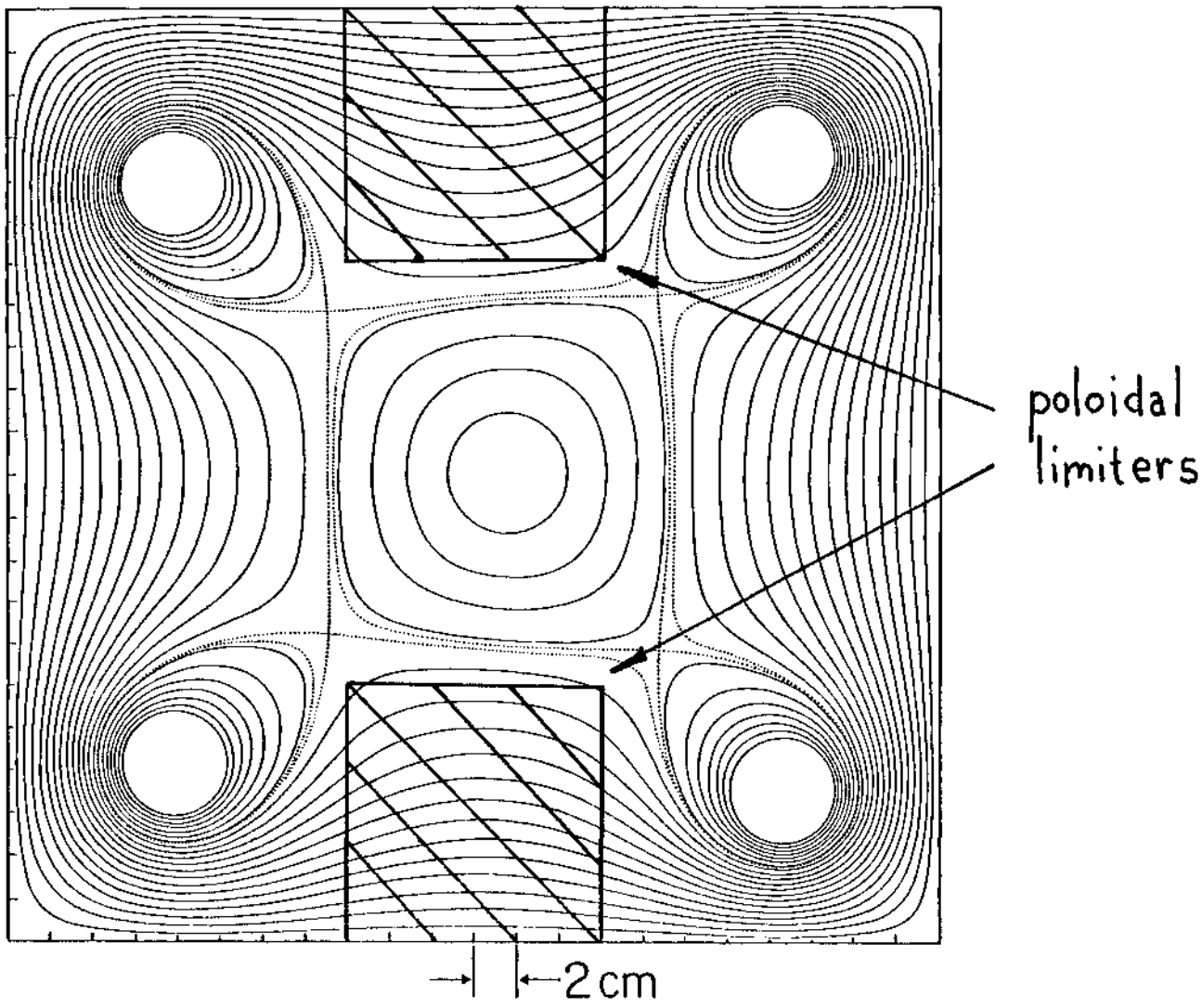
OBSERVATIONS:

* λ vs. r shows, as expected, the separatrix limits the plasma.

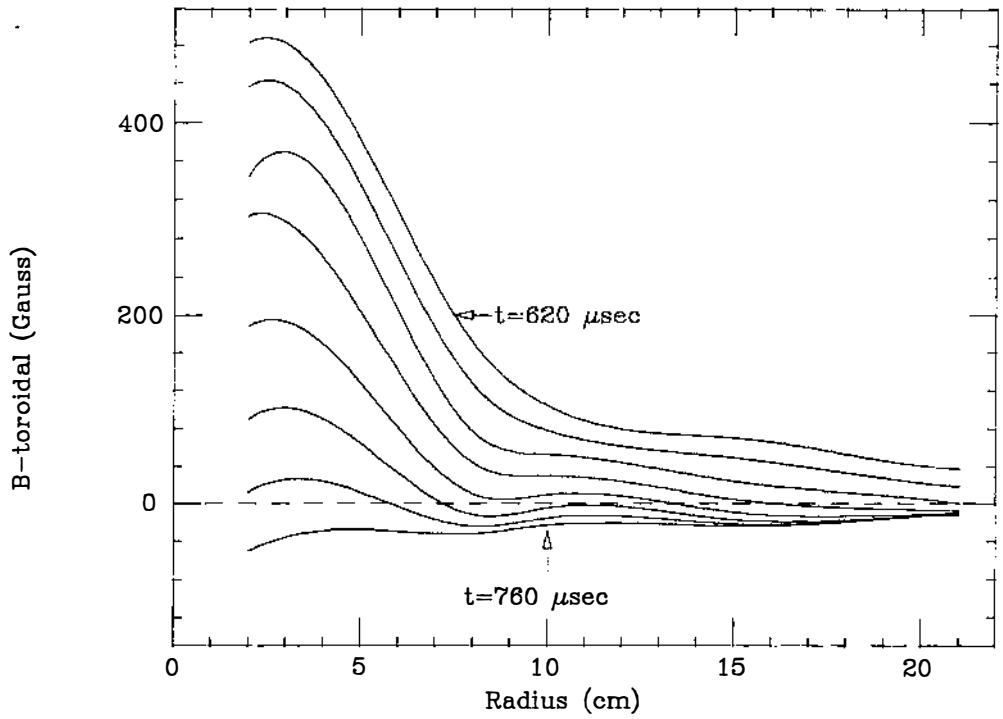
* The plasma is not sustained. Possible explanations are:
  1) The applied electric field is too small.
  2) The common flux region poloidal current "backwinds" the toroidal field coils.
  3) The plasma is unstable.

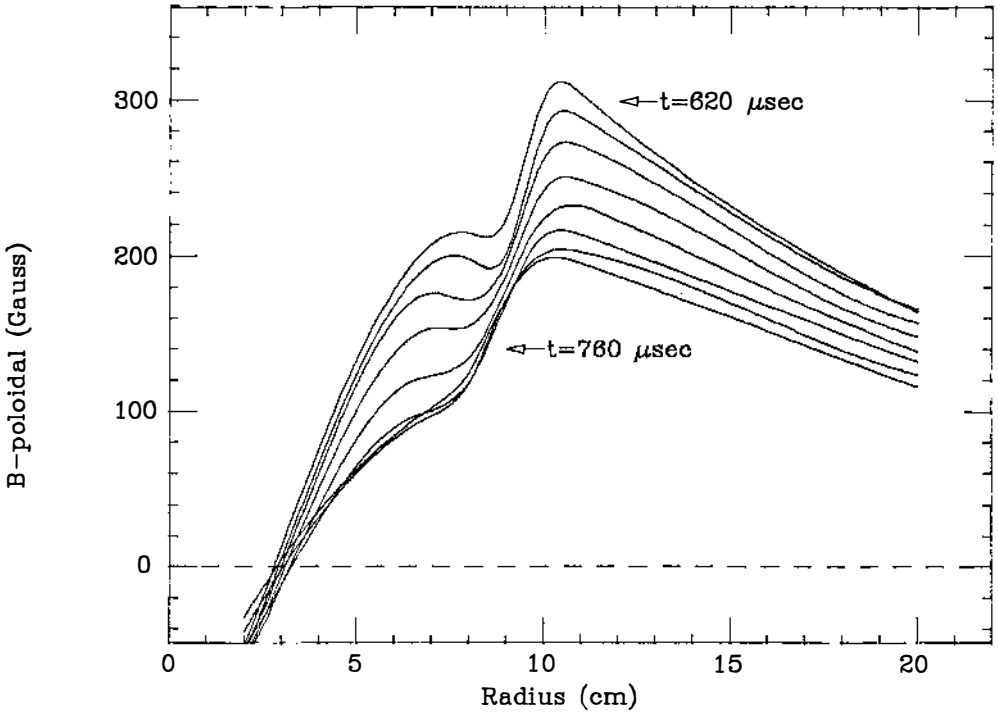
Experimentally we maximized the applied electric field and used available poloidal limiters to reduce the common flux region current.

Schematic view of the poloidal limiters.

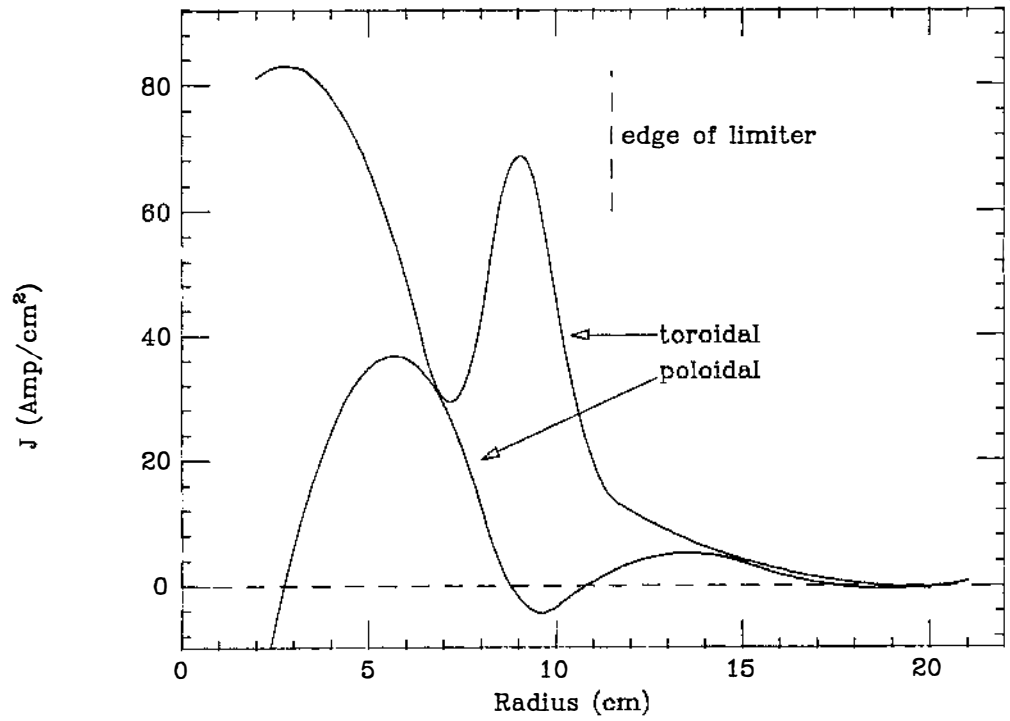


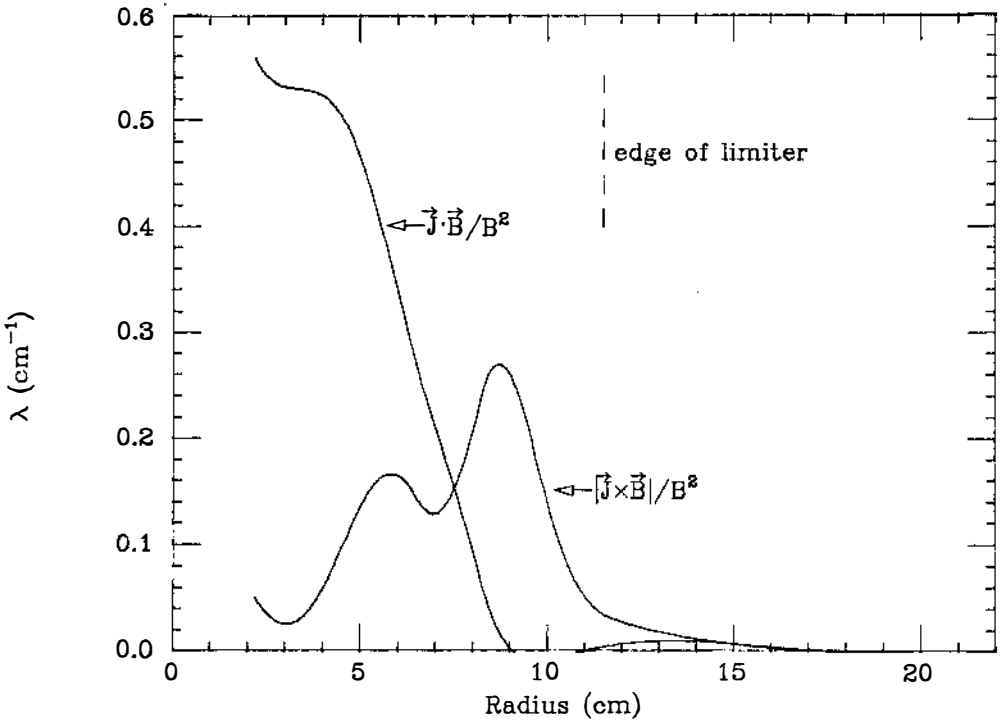
Polynomial representations of the field profiles for the limited plasma shown at 20 μsec intervals.



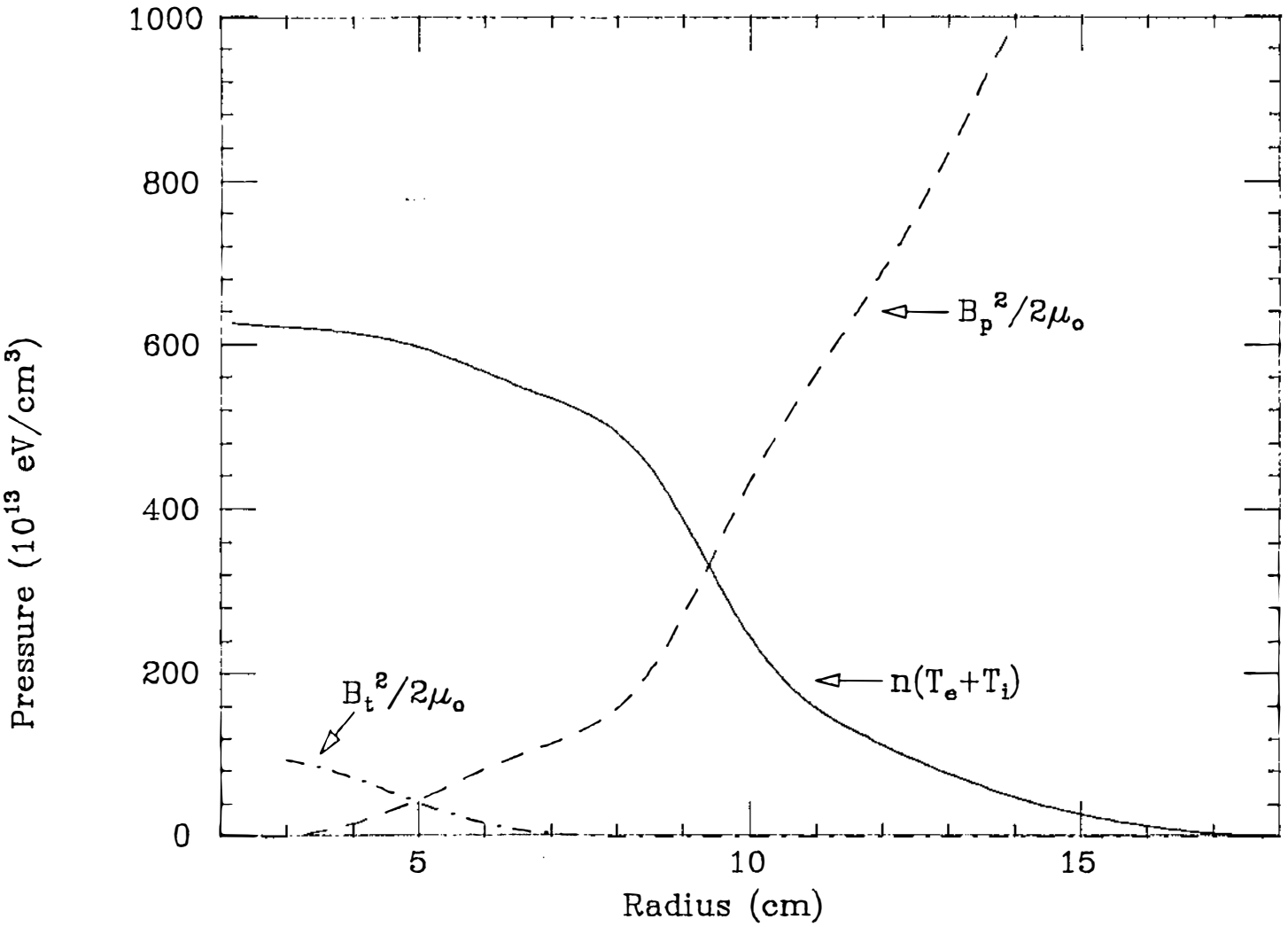


Examples of J and $\lambda_{\parallel,\perp}$ for the limited plasma. Note the current "bumps" at r≈9 and 15 cm. (t=700 μsec)





Representative pressure profiles obtained from force balance, $\underline{J} \times \underline{B} = \nabla p$. (t=700 μsec)



OBSERVATIONS:

* Limiters reduced currents outside the separatrix (improved programming).

* A more prominent diamagnetic current developed near the separatrix.

* Plasma is still not sustained.

The "poloidal-divertor RFP" mode as operated on the Wisconsin Leviated Octupole.