ANTENNA OPTIMIZATION FOR SHEAR ALFVÈN WAVE HEATING

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PLP 961

November 1985

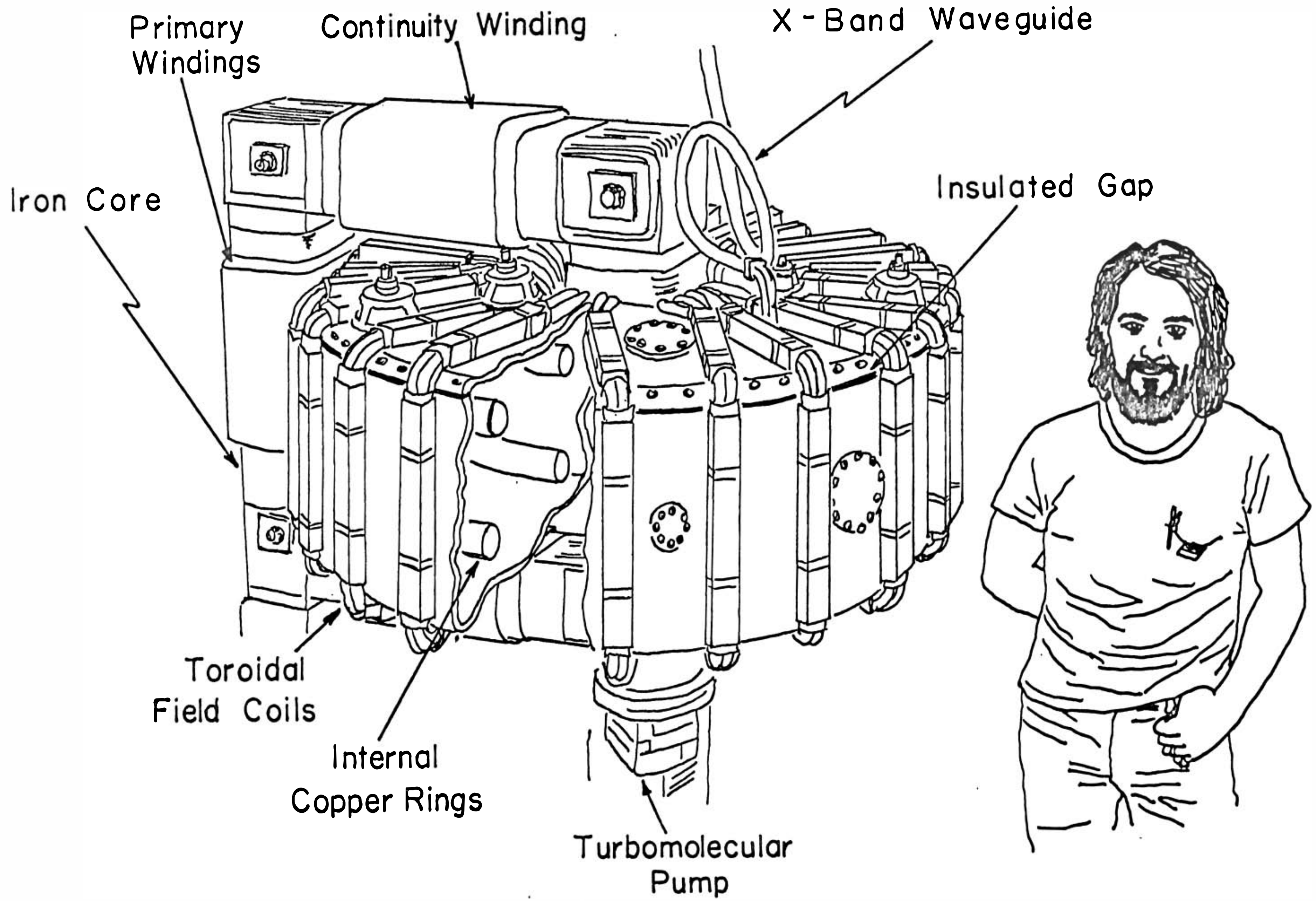
Plasma Studies

University of Wisconsin

ABSTRACT

Antenna Optimization for Shear Alfvèn Wave Heating.* D. KORTBAWI, S.Y. ZHU, T. CASAVANT, J.C. SPROTT, and S.C. PRAGER, University of Wisconsin-Madison--Two new antennas are now installed in the Tokapole II Tokamak. They are Faraday shielded and can be rotated a full 360° to launch waves of any polarization. They are located 180° apart poloidally. They have been operated at low power in a very limited range of plasma parameters. Preliminary results are that these antennas do not couple very strongly to the plasma. Radiation resistance varies from 241 mΩ to nearly the vacuum value of 94 mΩ as the antennas are rotated from $\tilde{B}$ perpendicular to B_o to $\tilde{B}$ parallel to B_o. The reactive component is very small in all cases. The loading observed is the same whether one or both antennas are operated. Further results, covering a broad range of plasma parameters, will be presented.

*This work is supported by the U.S.D.O.E.


Primary
Windings
Continuity Winding
X - Band Waveguide
Iron Core
Insulated Gap
Toroidal
Field Coils
Internal
Copper Rings
Turbomolecular
Pump

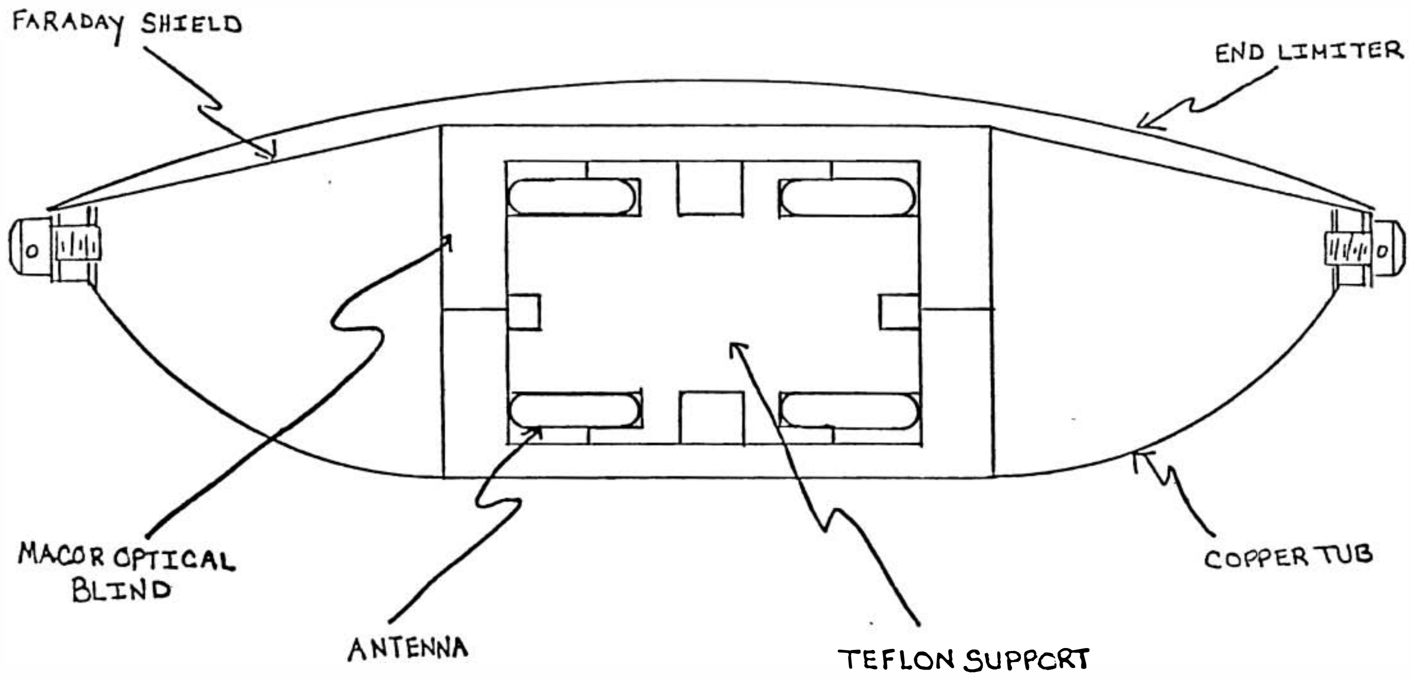
TOKAPOLE II

TOKAPOLE II PARAMETERS

- FOUR NODE POLOIDAL DIVERTOR	
- MICROWAVE PREIONIZATION	
- MAJOR RADIUS	50 cm
- MINOR RADIUS	6-10 cm
- TOROIDAL FIELD	4.5 kG
- PLASMA CURRENT	~30 kA
- LINE AVERAGED DENSITY	$5*10^{12}$ cm^{-3}
- ELECTRON TEMPERATURE	~100 eV
- ION TEMPERATURE	~20 eV
- DISCHARGE LENGTH	~3-10 msec
- BASE VACUUM	$6*10^{-7}$ Torr

TYPE I ANTENNAS

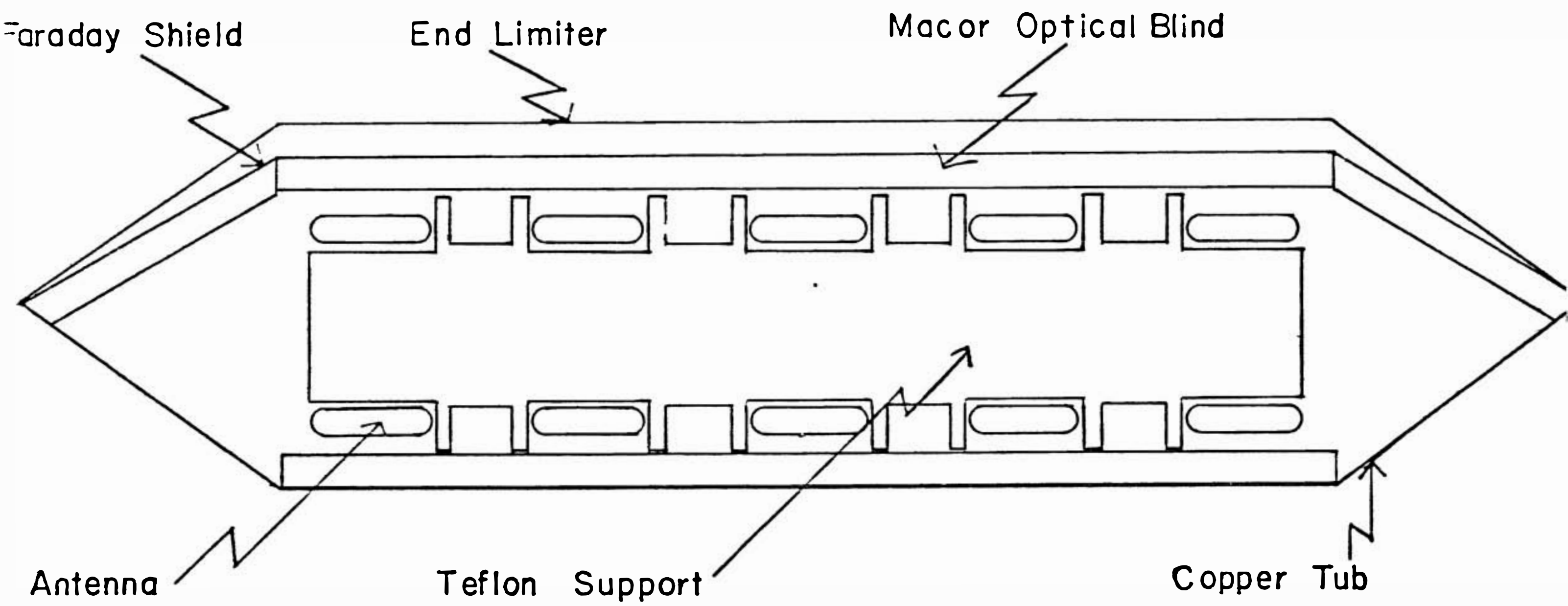
Maximum rotation $\pm 45^{o}$
wrt the toroidal axis
Radial insertion range 6cm



Two antennas of this type have been in use for some time.

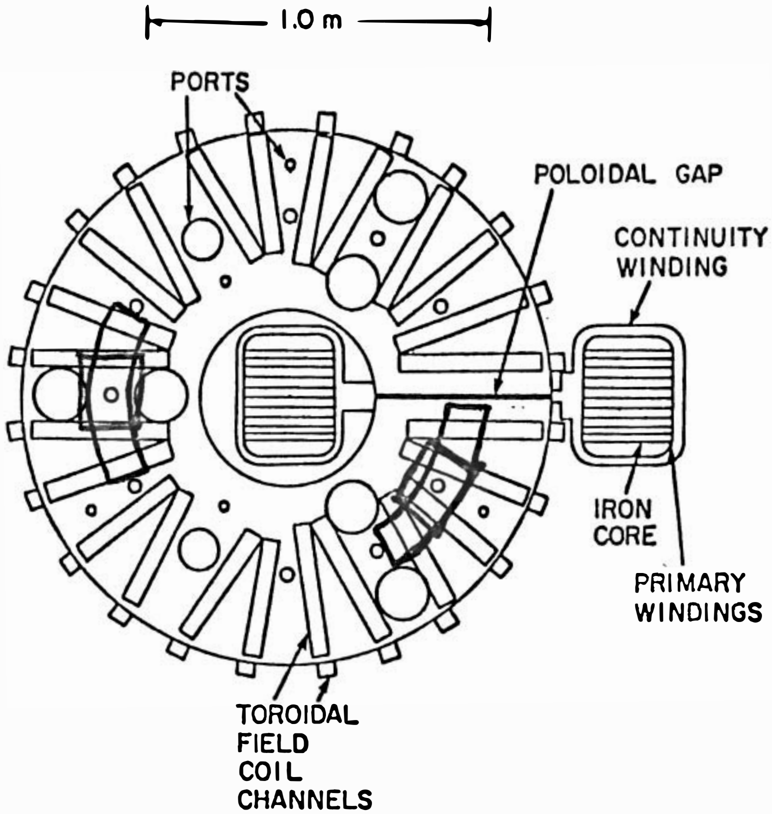
TYPE II ANTENNAS

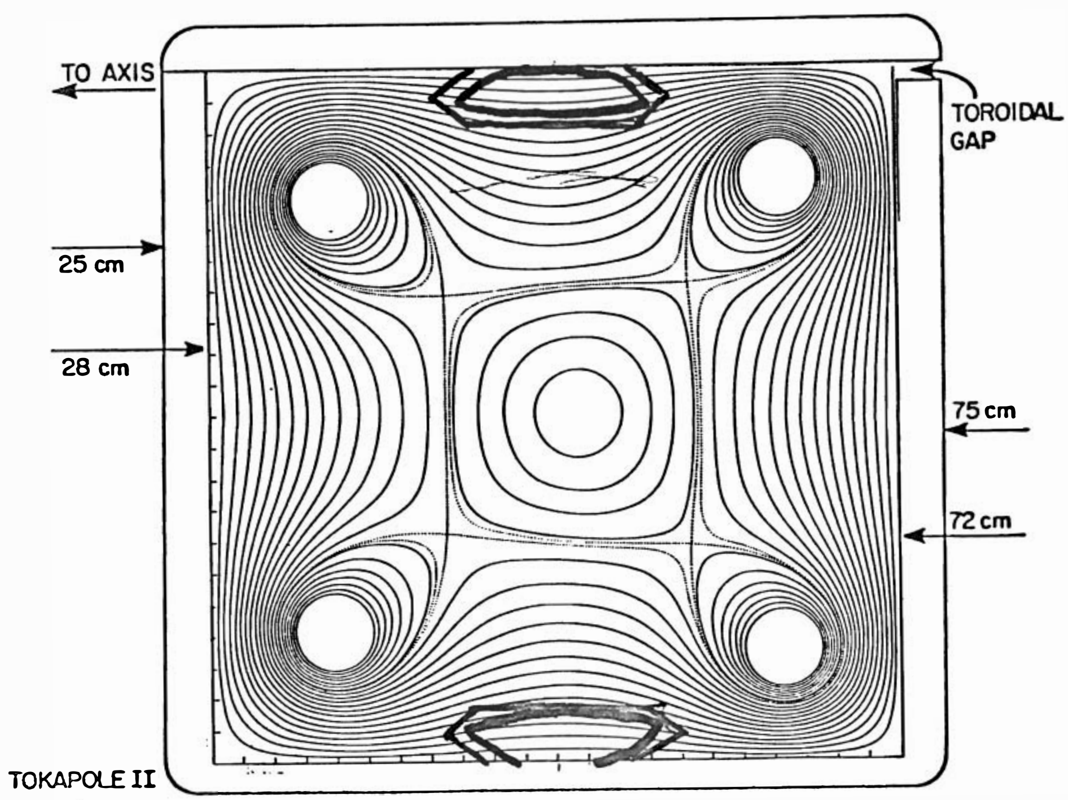
Rotation range 360^o
Radial insertion range 6cm



Two antennas of this type have recently been installed and operated at low power. Two more are to be constructed.

OF ALFVEN WAVE ANTENNAS

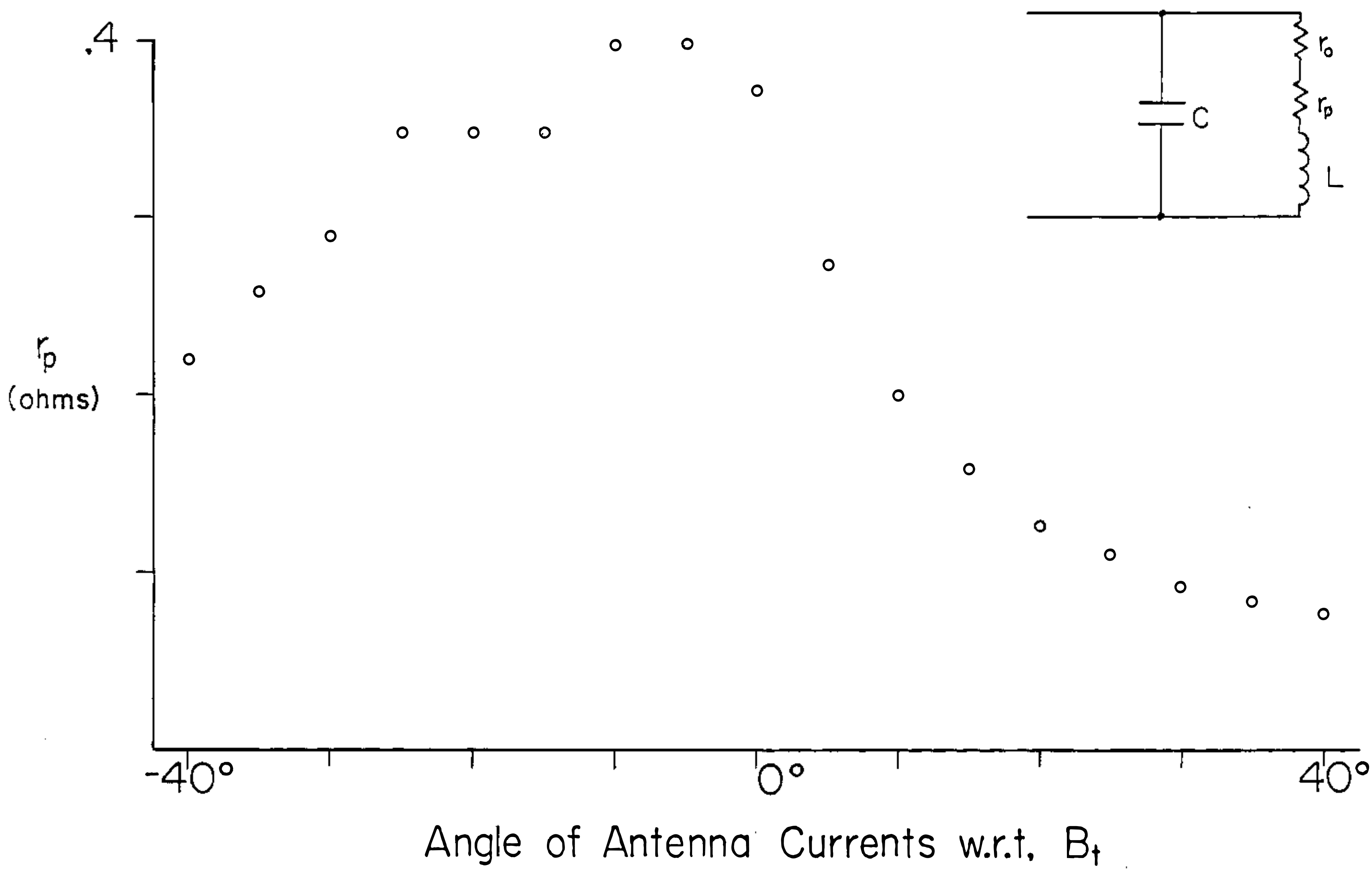




FOUR ANTENNAS WILL BE USED.

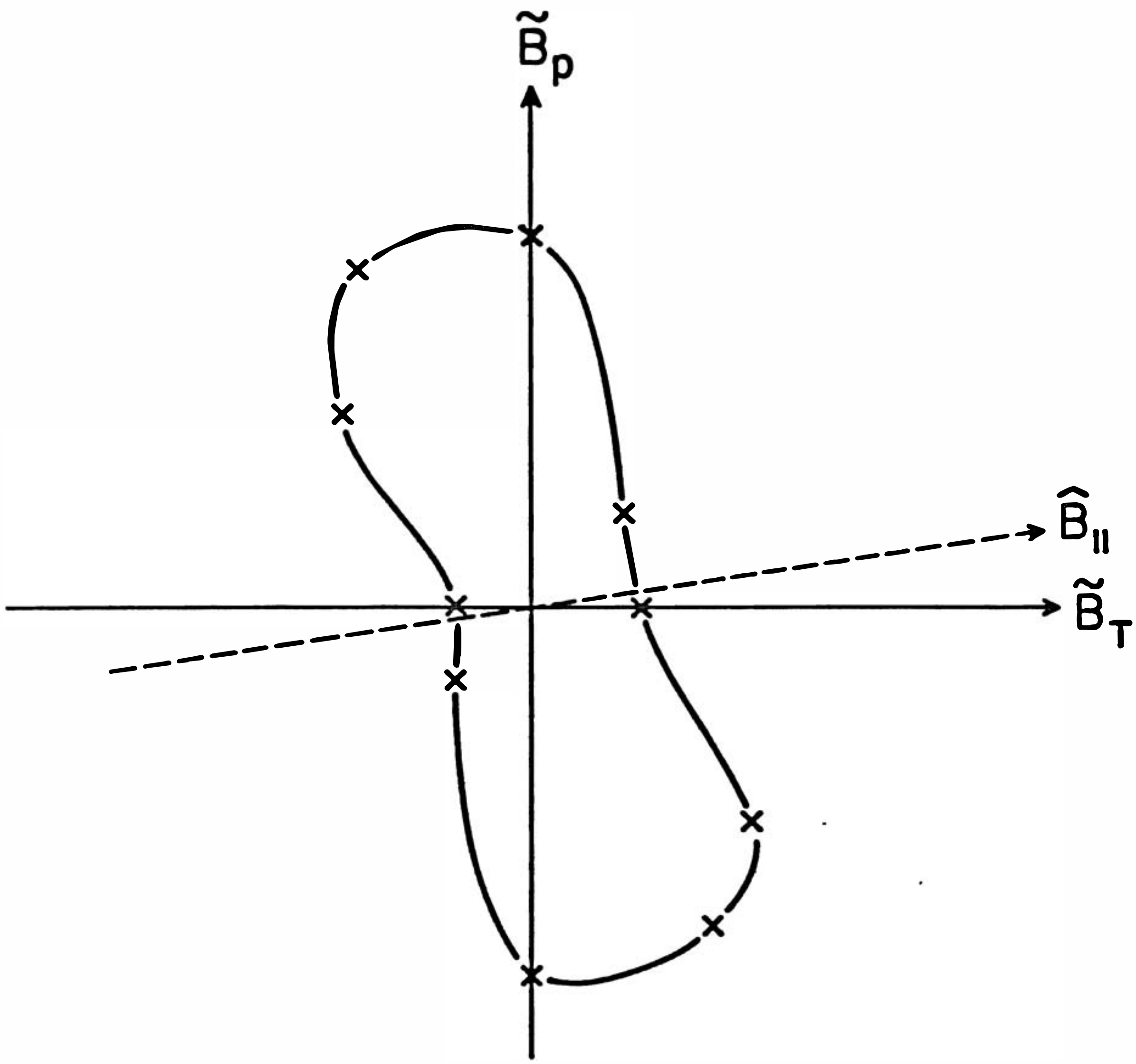
TYPE I ANTENNAS WERE DOMINATED BY PARASITIC LOADING.

The loading seen was quite insensitive to plasma parameters and peaked when the antenna currents were ~ parallel to the equilibrium fields. Most of the energy was dissipated in the surface.



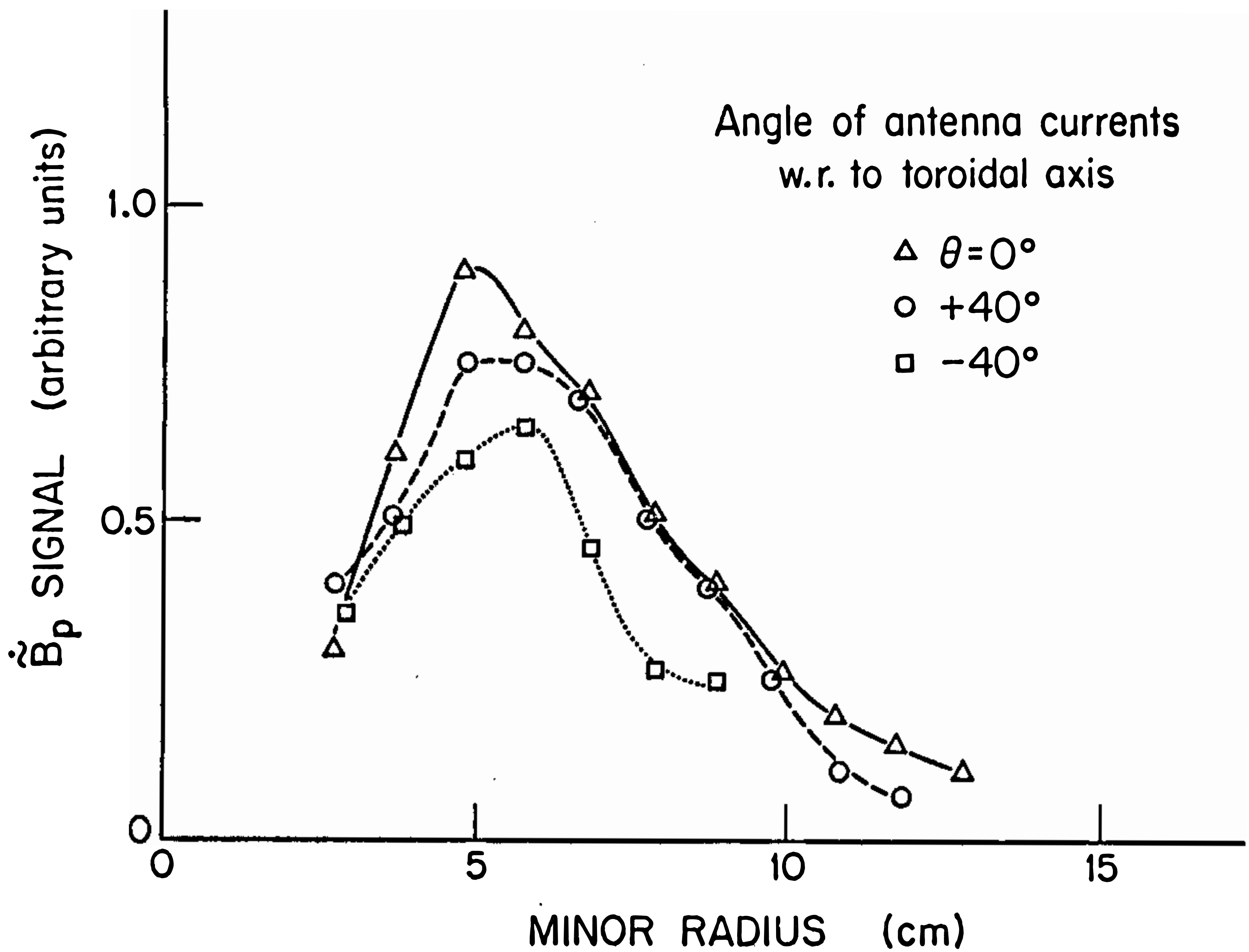
.4
r_p
(ohms)
-40°
0°
40°
Angle of Antenna Currents w.r.t. B_t
C
r_o
r_p
L

PROBE SIGNALS ARE POLARIZED PERPENDICULAR TO THE EQUILIBRIUM FIELD.



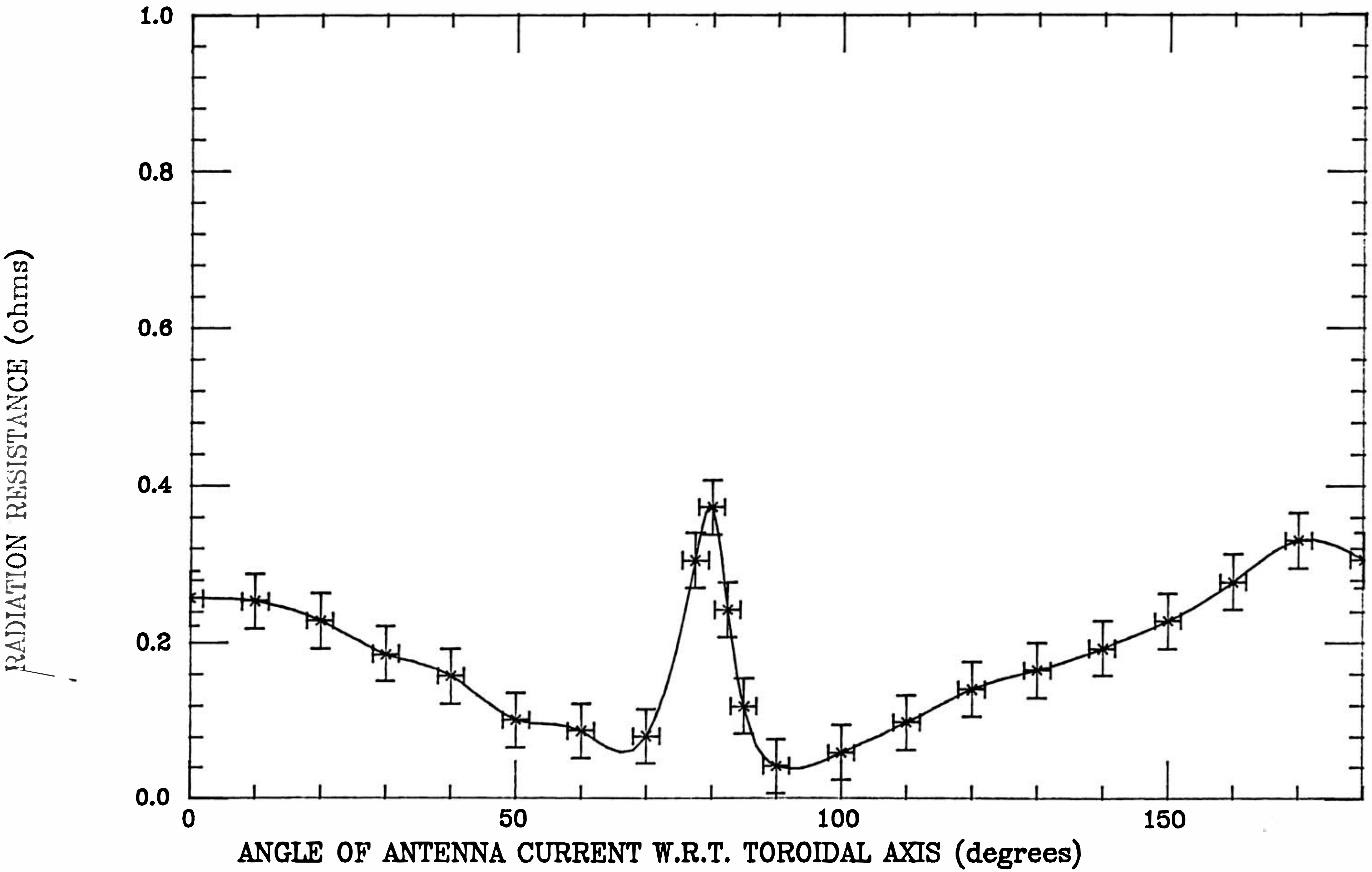
Magnetic probe signals show a resonant spatial structure and polarization consistent with the Shear Alfvén wave. The magnitude of the observed signal was however relatively independent of antenna loading.

PROBE SIGNALS SHOW A SPATIAL RESONANCE.



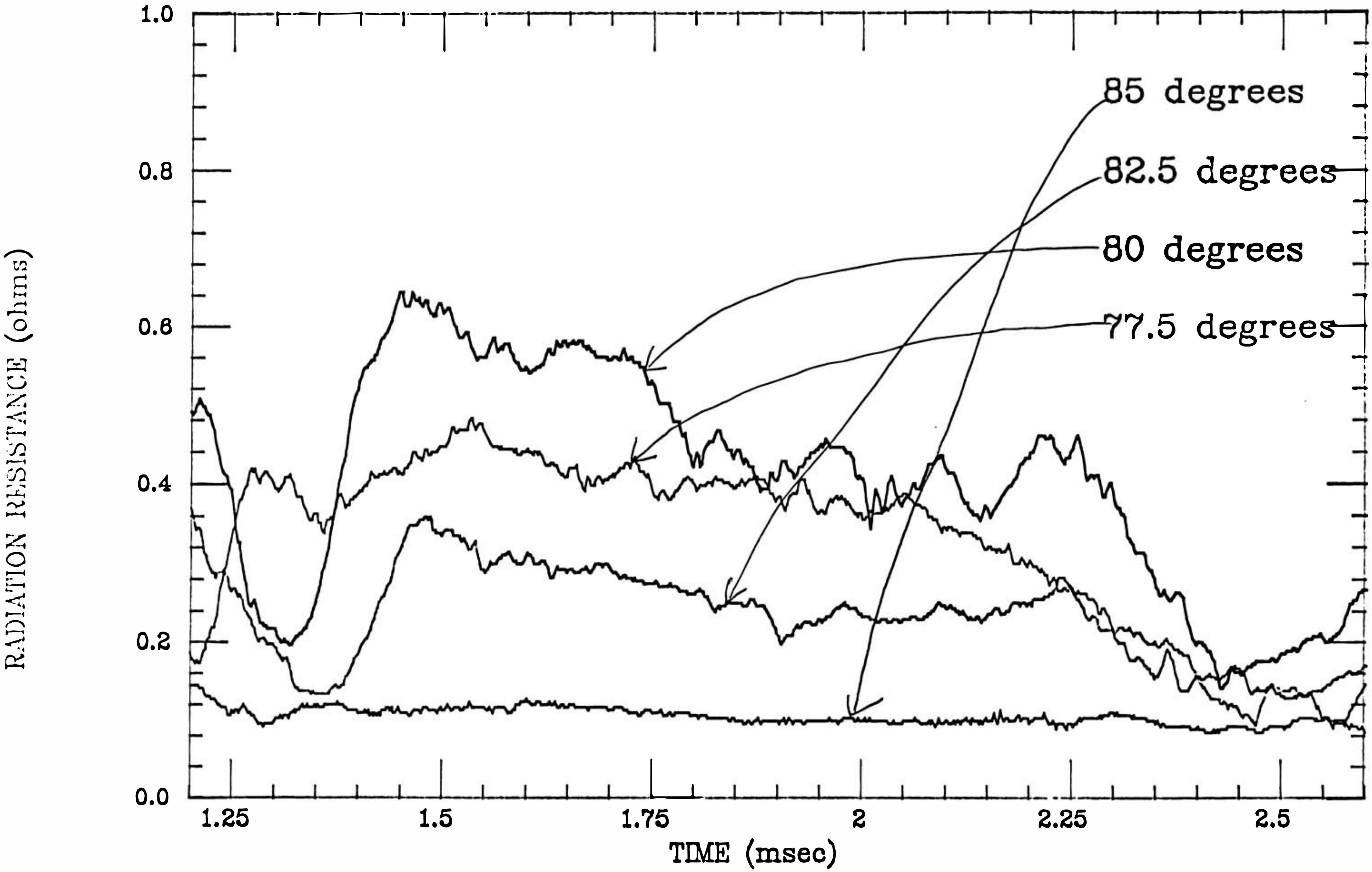
The type II antennas show a similar dependence on angle when nearly toroidal. However when the currents are ~ perpendicular to the equilibrium fields the loading is significantly enhanced.

Loading shows a significant angular dependence



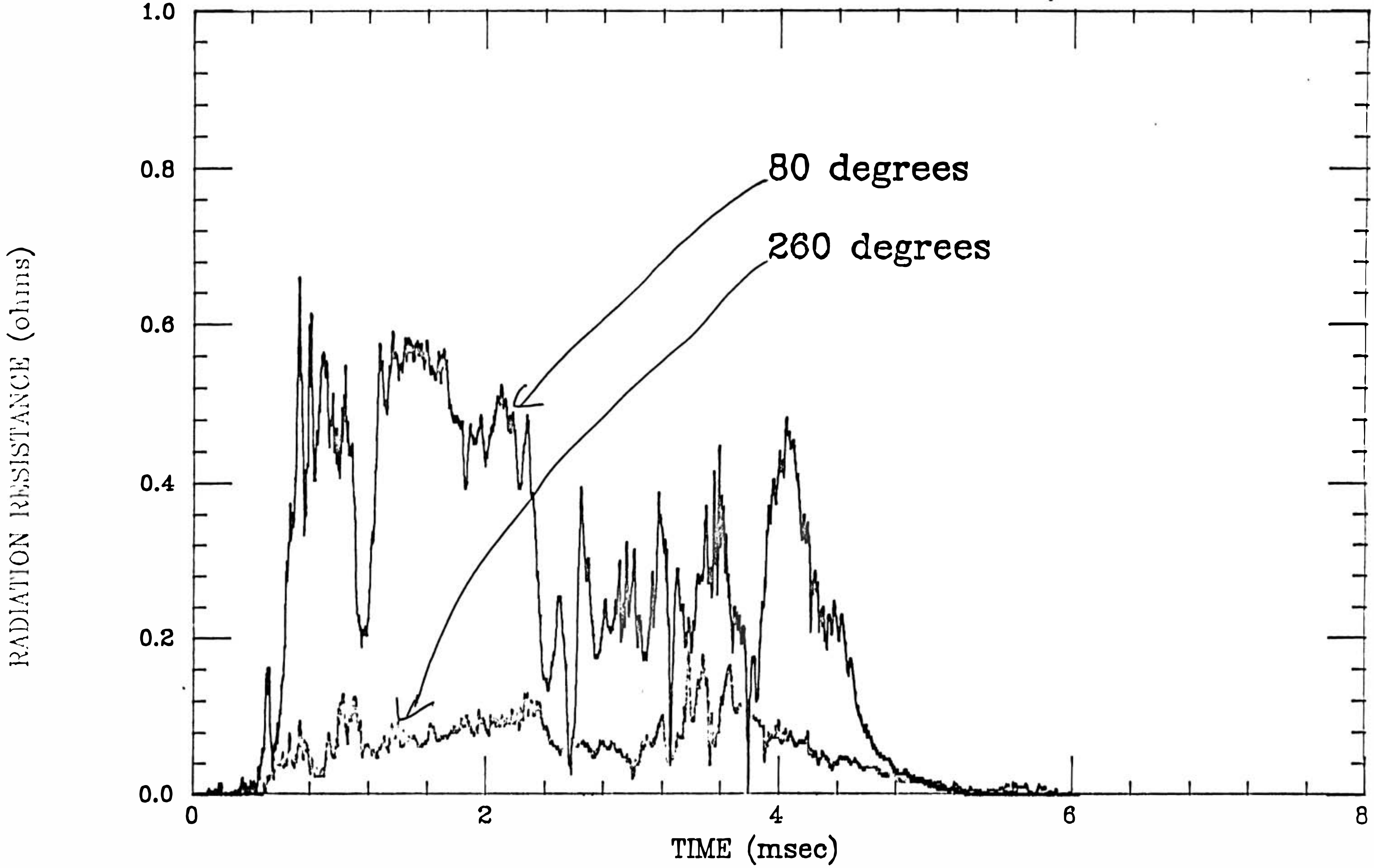
Radiation resistance is a sharp function of antenna angle.

(When antenna current is nearly poloidal)



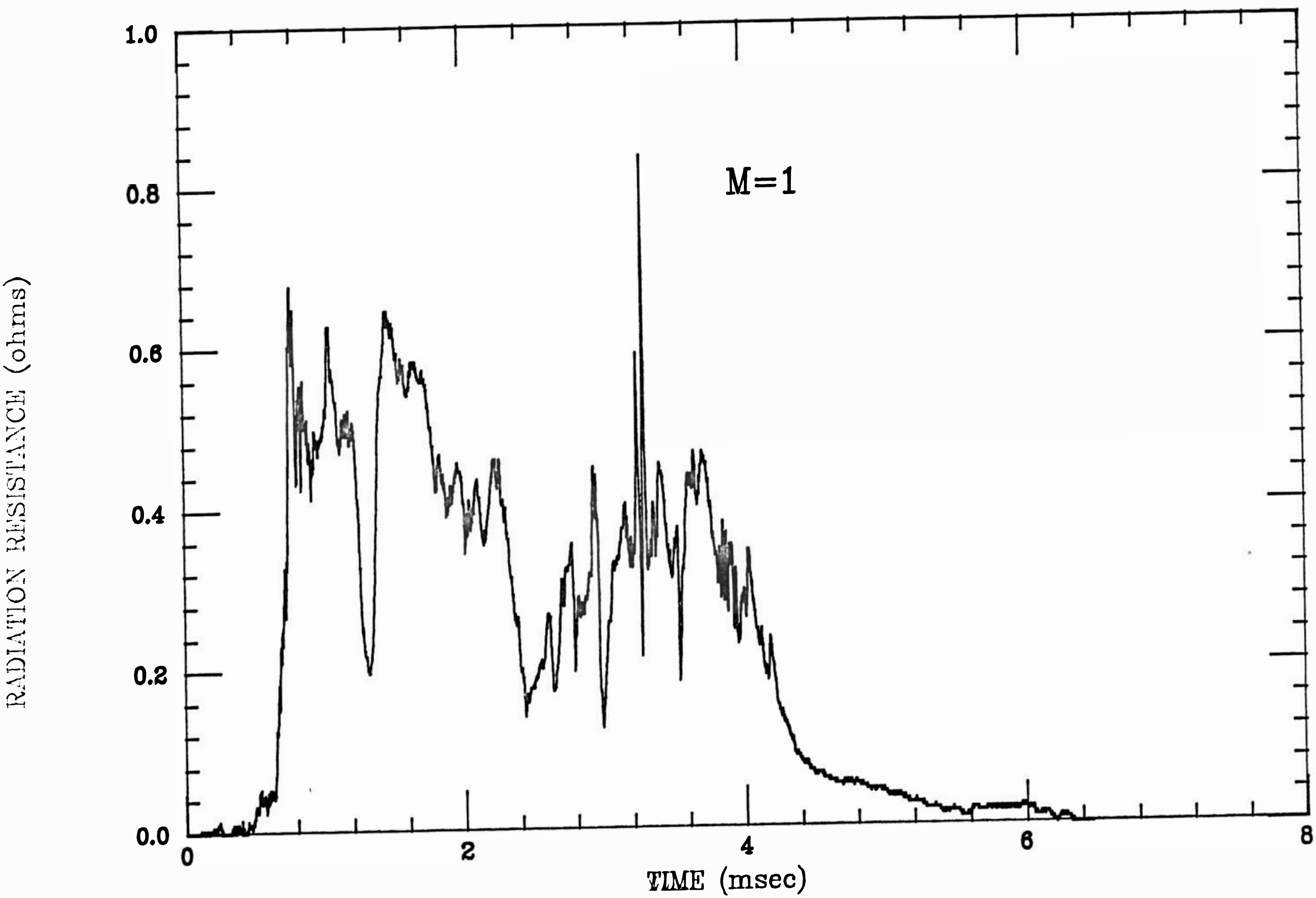
THIS ENHANCED LOADING IS HOWEVER NOT WELL UNDERSTOOD.

Rotating antenna through 180 degrees strongly affects loading.

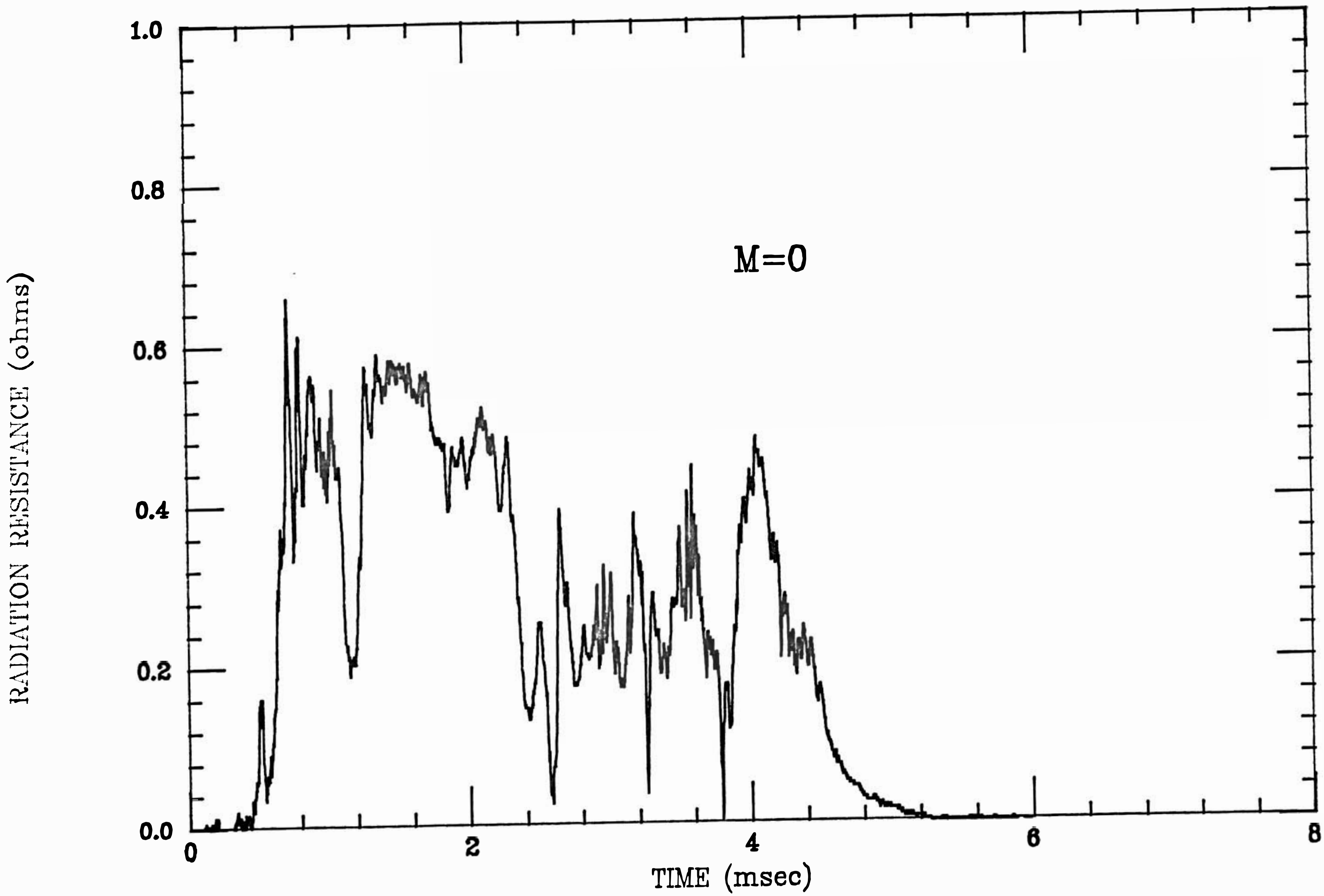


LOADING IS ESSENTIALLY INDEPENDENT
OF ANTENNA PHASING.

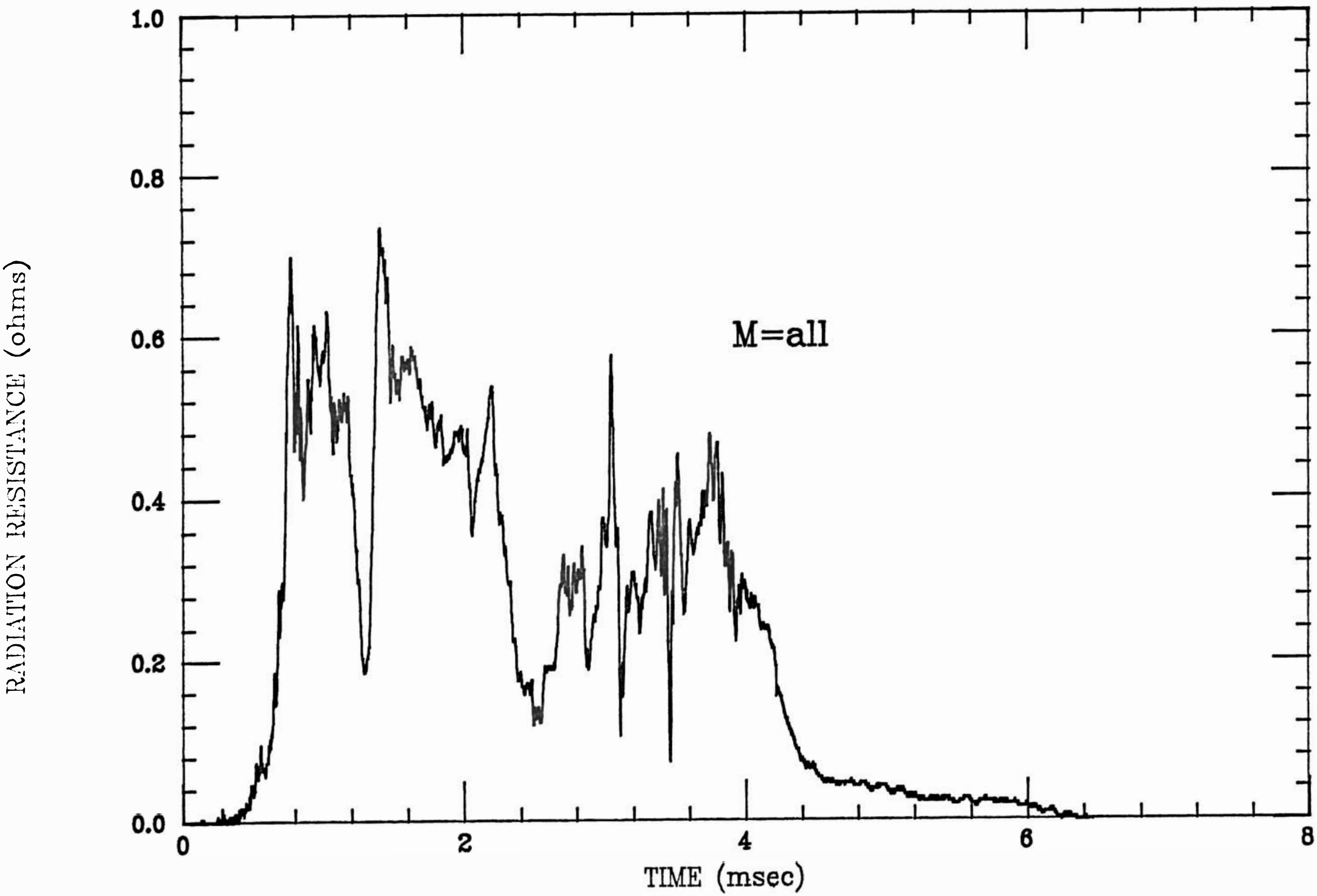
Upper antenna



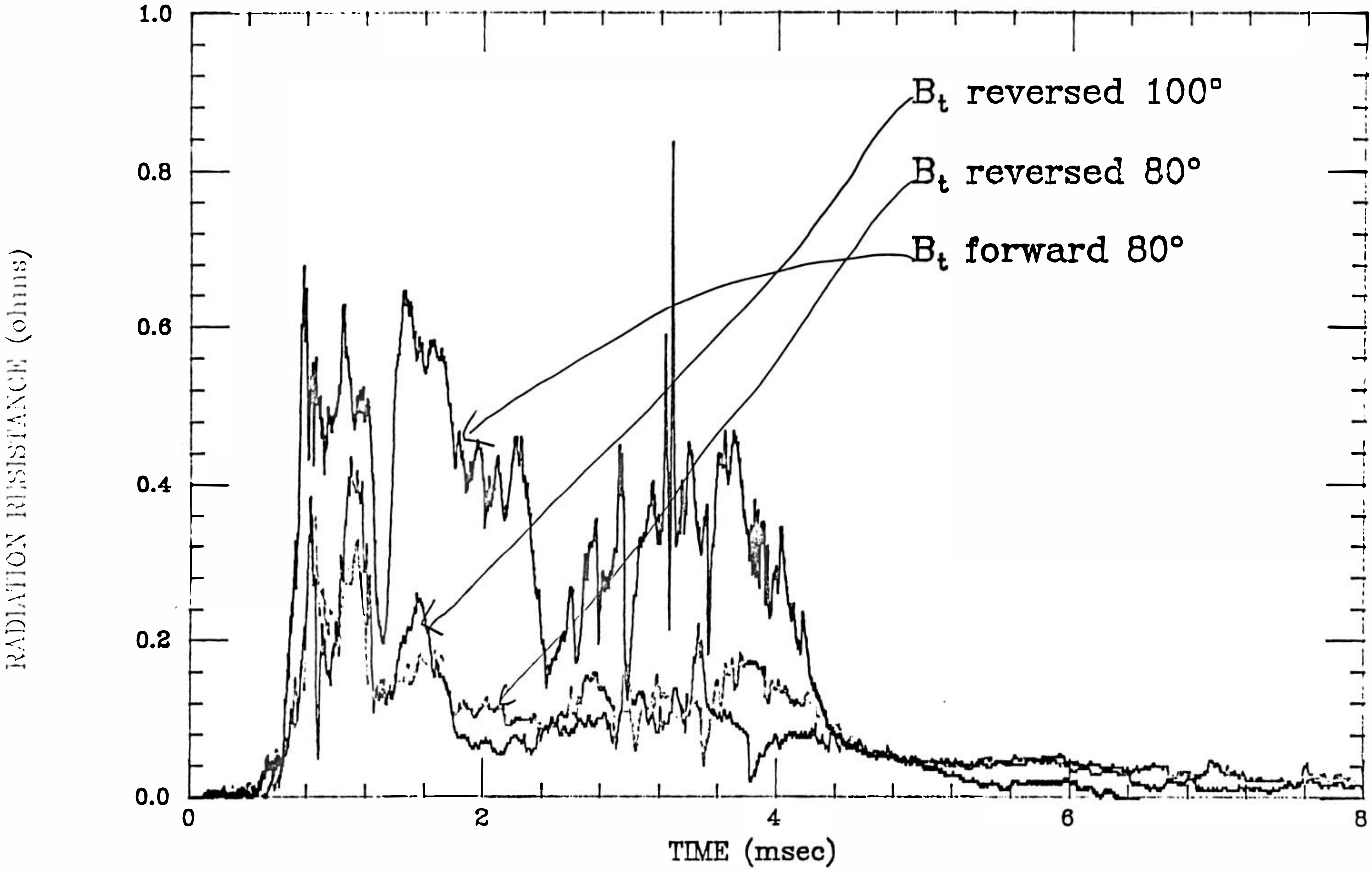
Upper antenna



Upper antenna

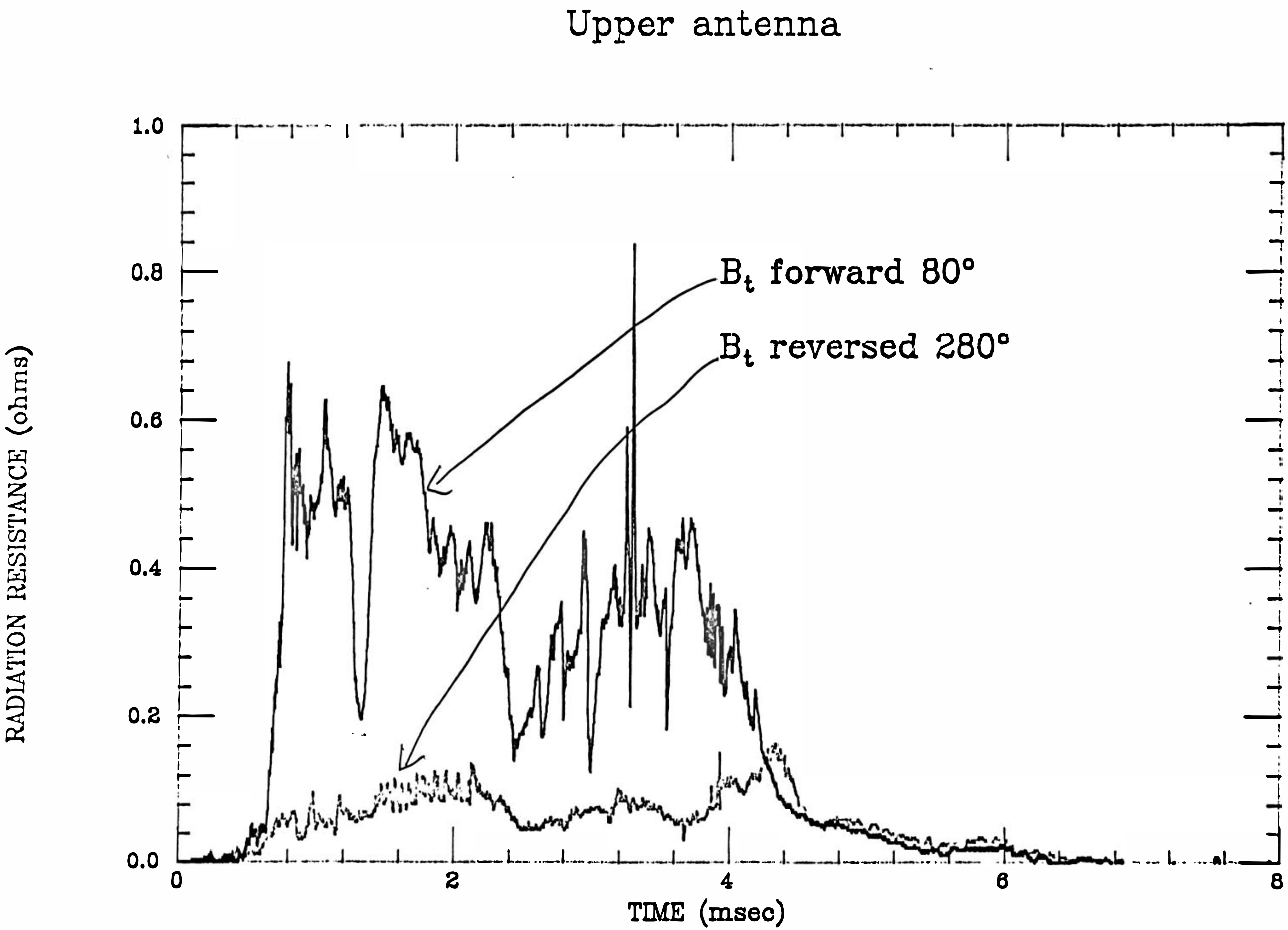


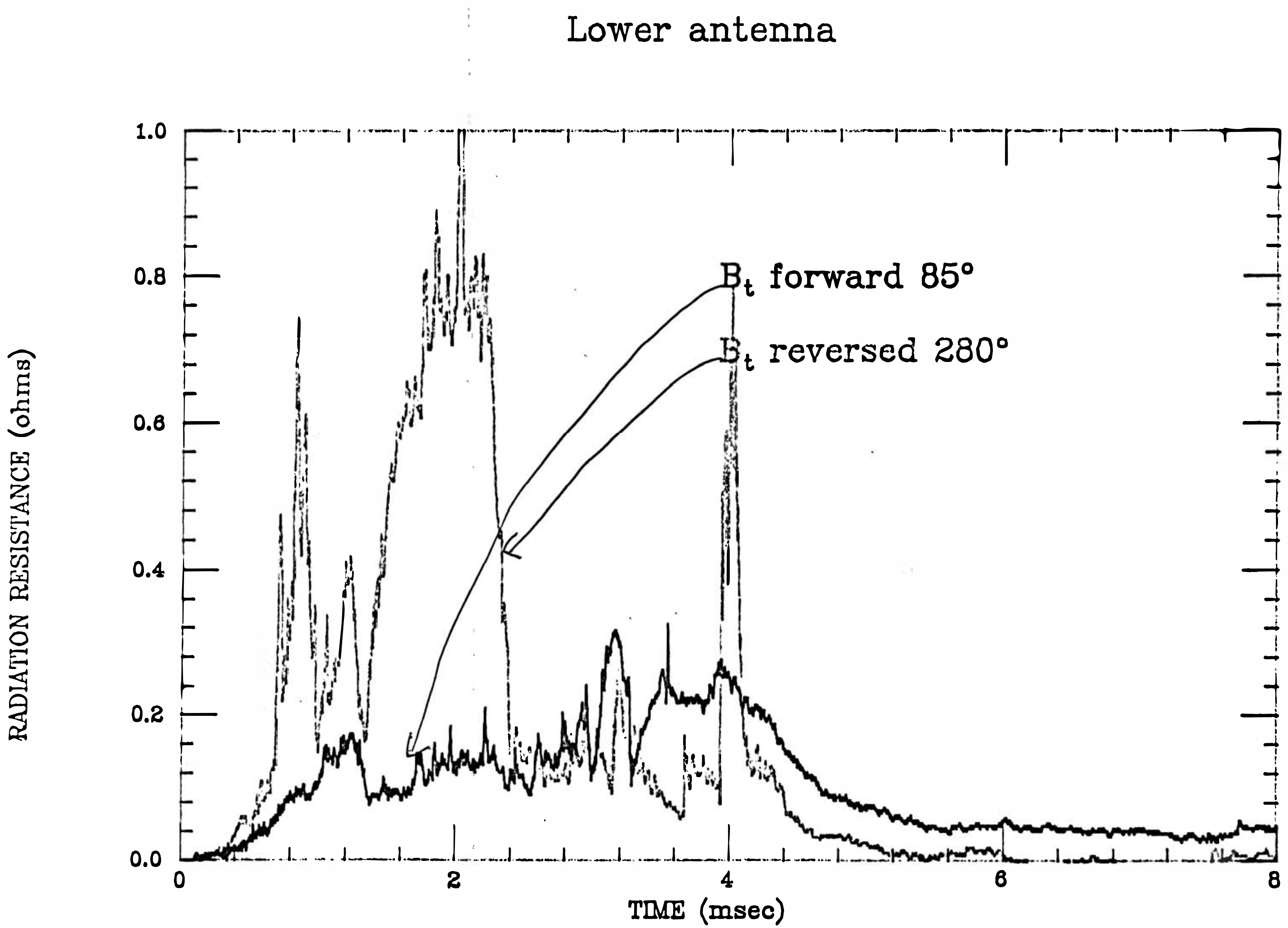
Reversing the direction of the toroidal field wrt the plasma current does not simply shift the peak to the other side of 90°.

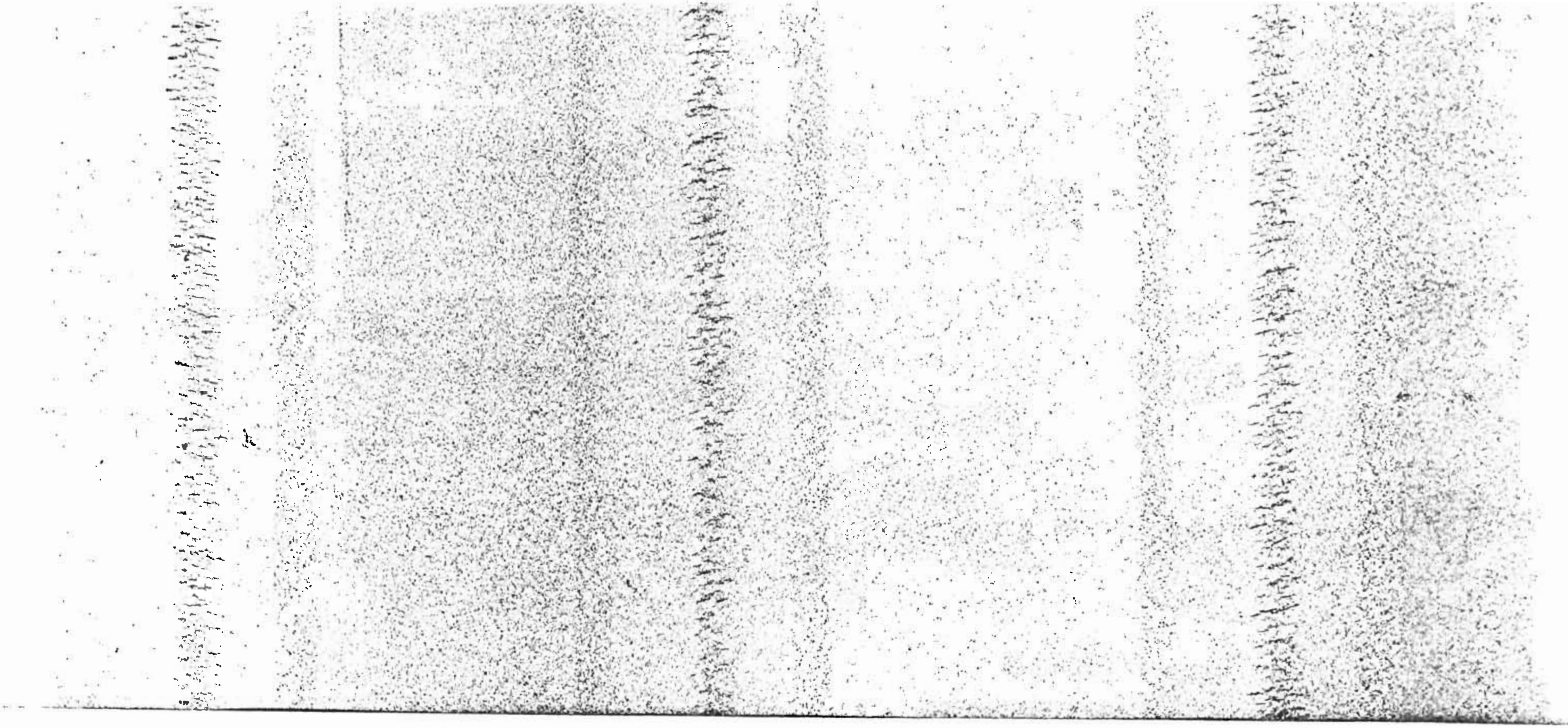


LOADING IS SIGNIFICANTLY DIFFERENT ON THE 2 ANTENNAS.

Which one is more heavily loaded depends on the operating conditions.


Upper antenna
1.0
0.8
0.6
0.4
0.2
0.0
RADIATION RESISTANCE (ohms)
0
2
4
6
8
TIME (msec)
B_t forward 80°
B_t reversed 280°

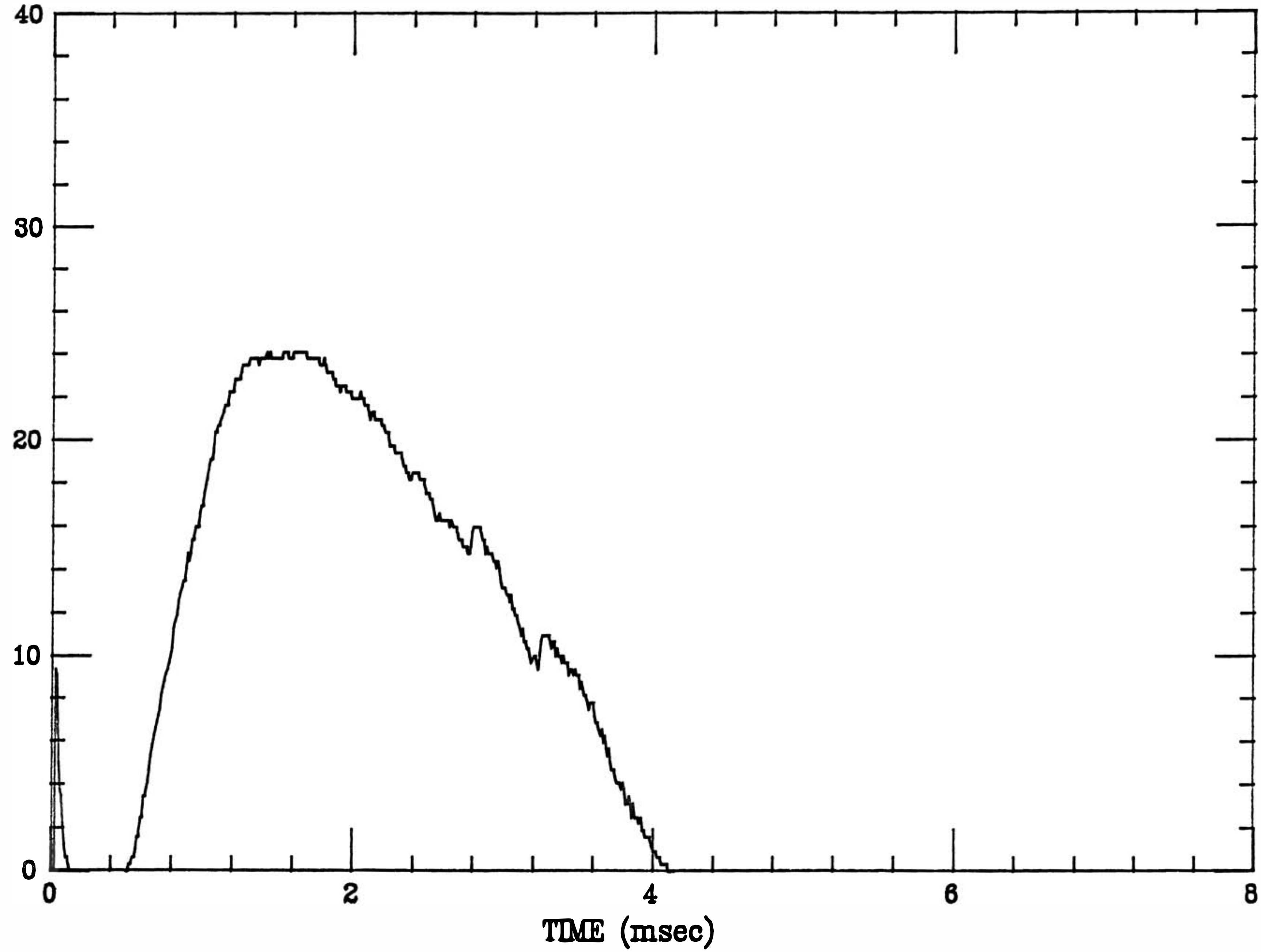

Lower antenna
1.0
0.8
0.6
0.4
0.2
0.0
RADIATION RESISTANCE (ohms)
0
2
4
6
8
TIME (msec)
B_t forward 85°
B_t reversed 280°



THIS LOADING IS ALSO FAIRLY SENSITIVE TO PLASMA PARAMETERS.

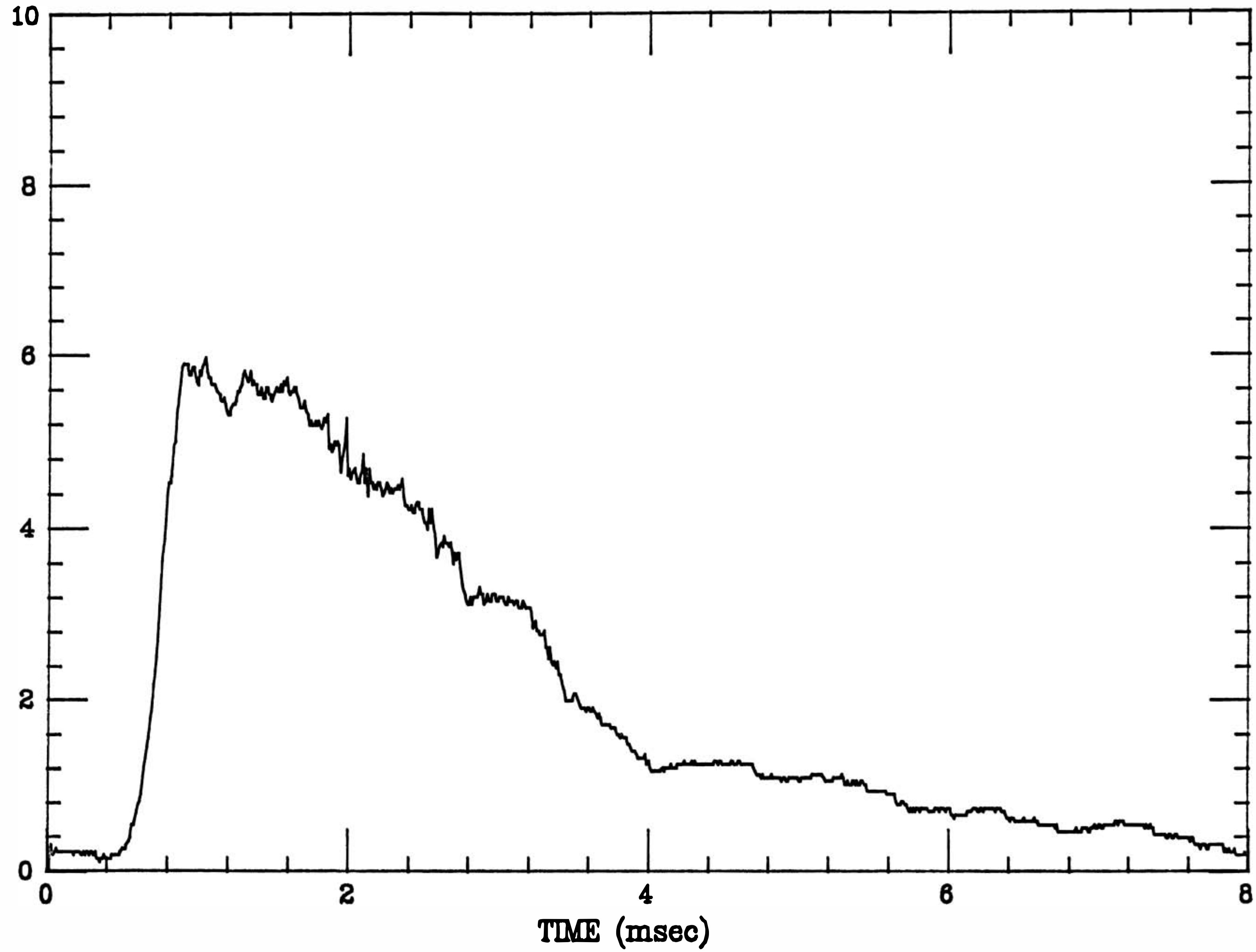
Plasma current (ka)

Shot # A20007



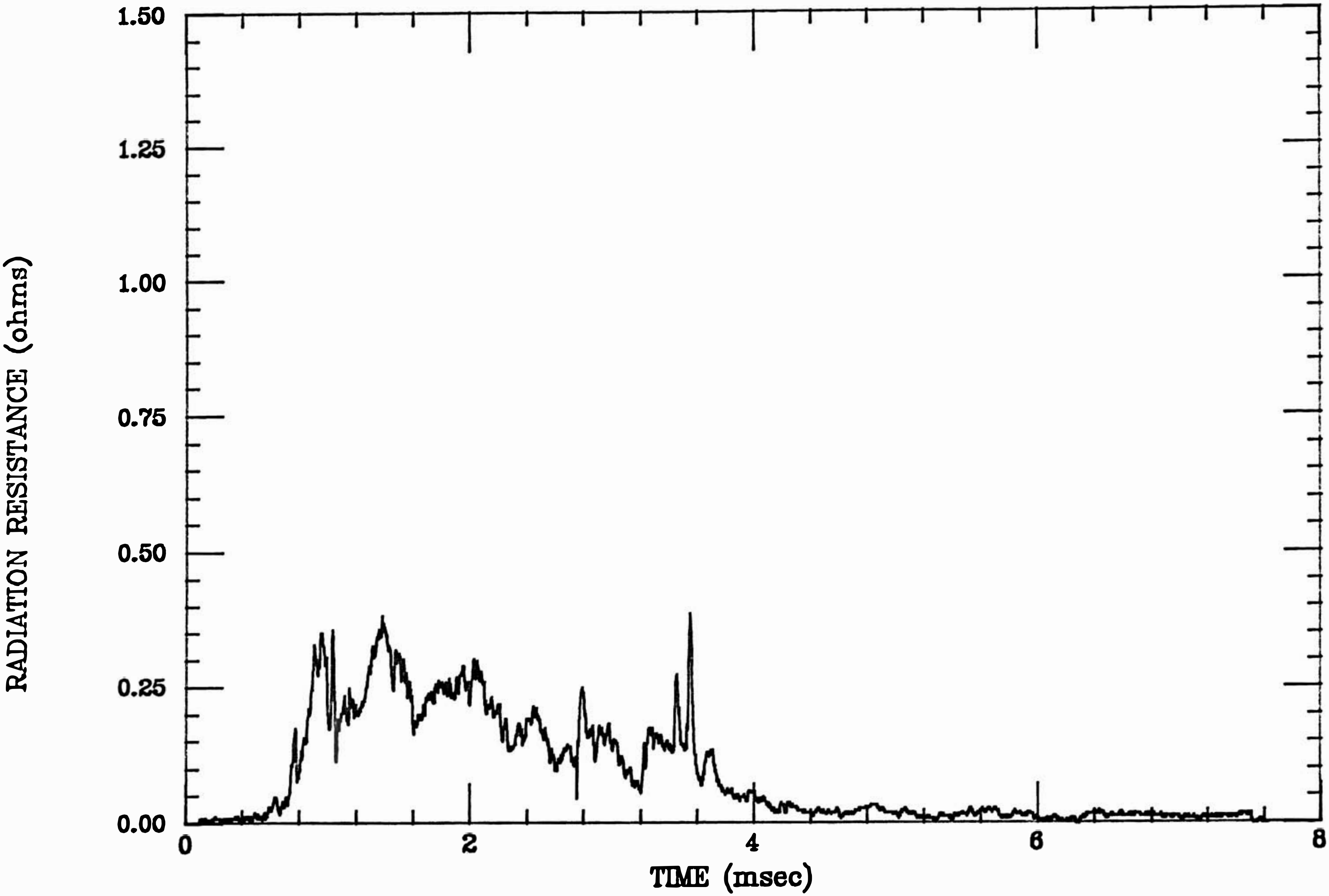
Line averaged density ($cm^{-3} * 10^{12}$)

Shot # A2000



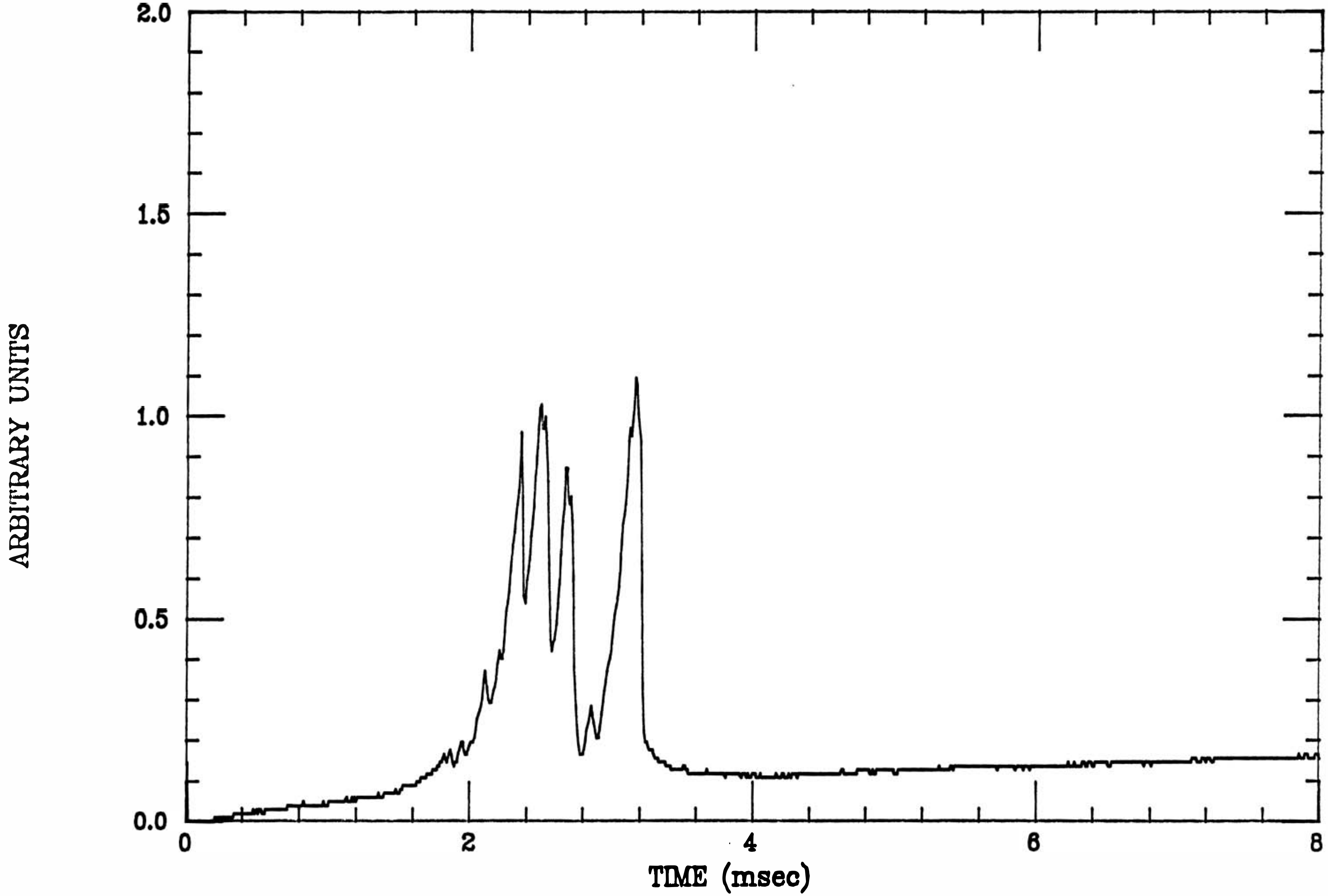
Lower antenna

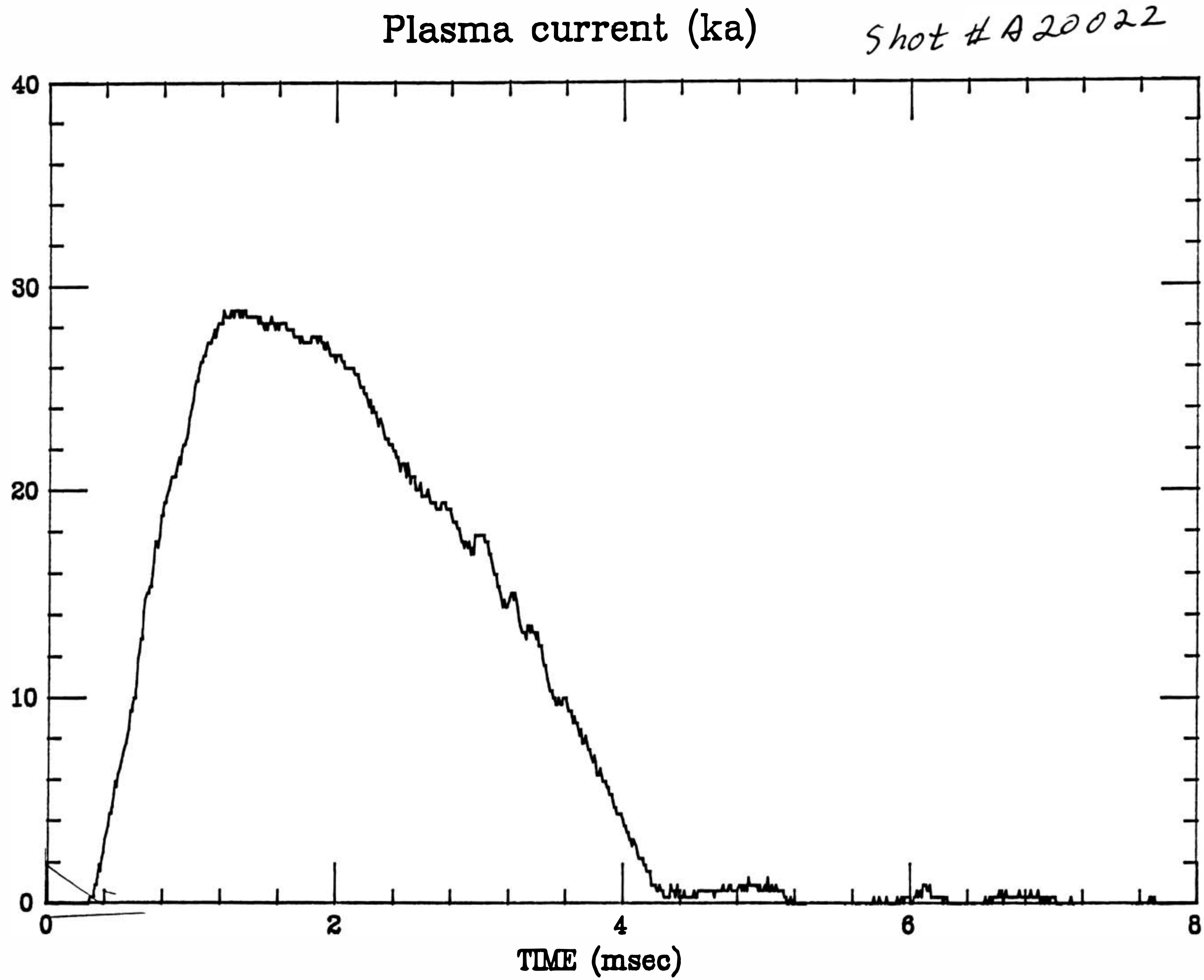
Shot # A 20



Central chord SXR

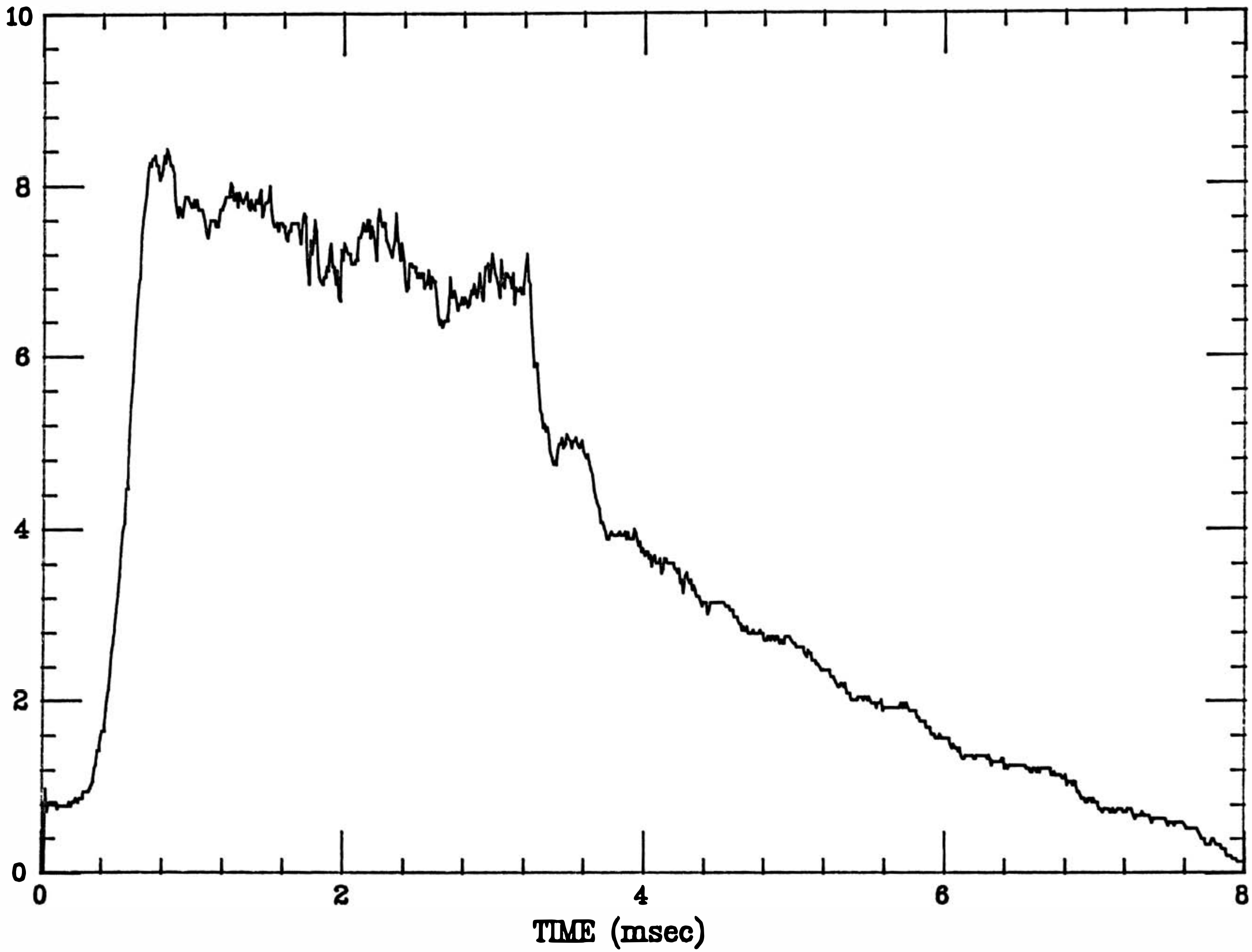
Shot # A2000




Plasma current (ka)
Shot # A 20022
40
30
20
10
0
0
2
4
6
8
TIME (msec)

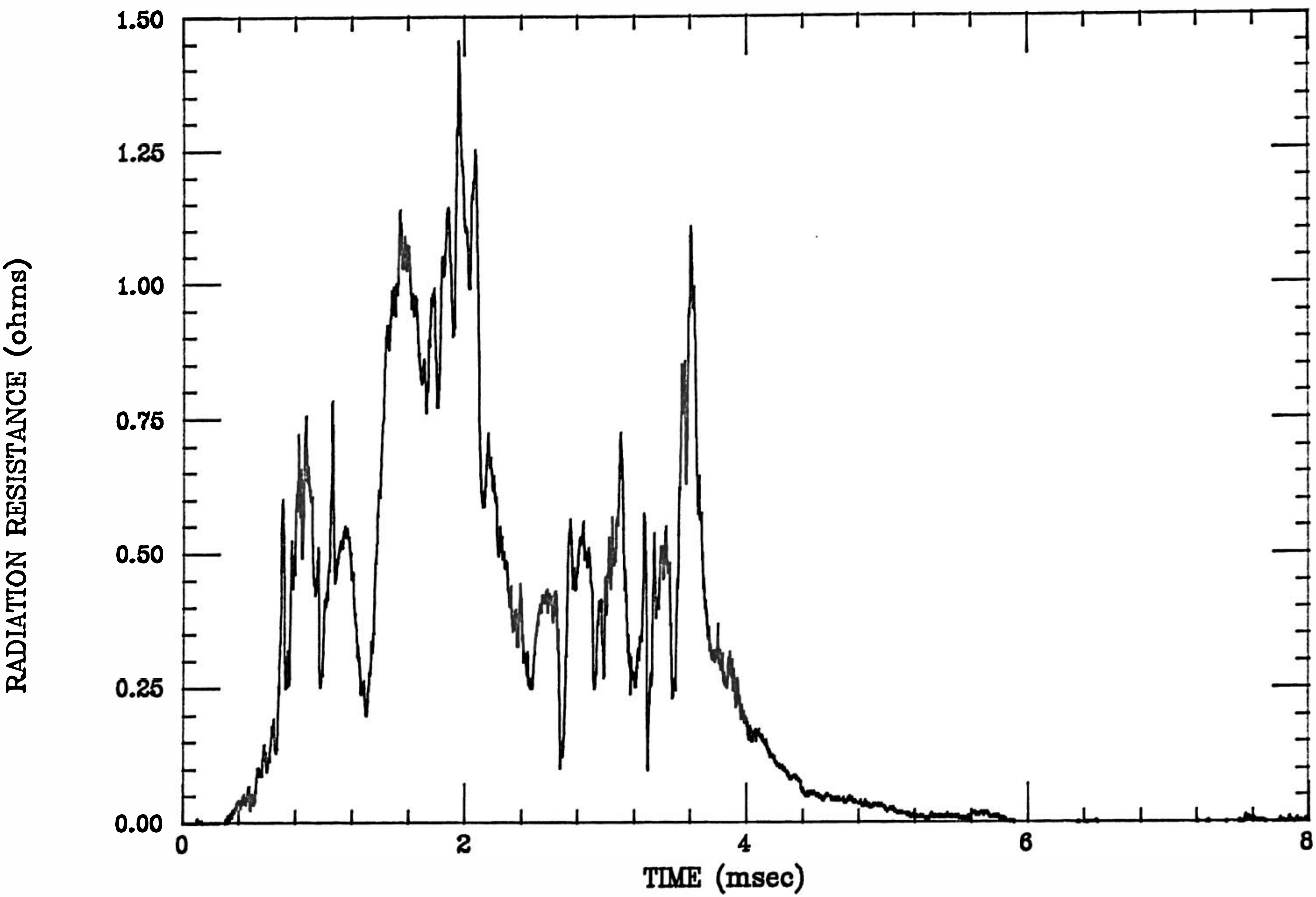
Line averaged density ($cm^{-3} * 10^{12}$)

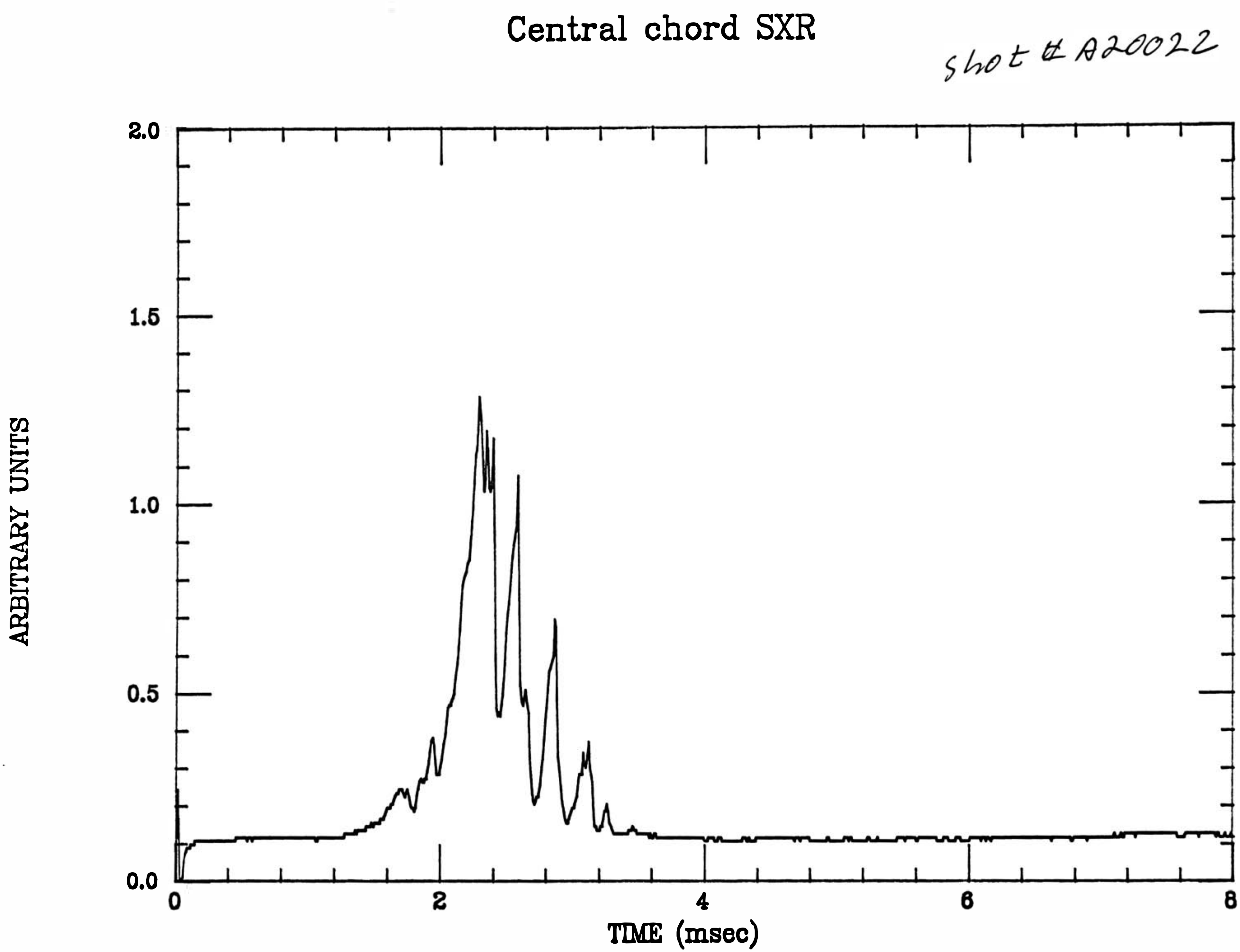
Shot # A 20022

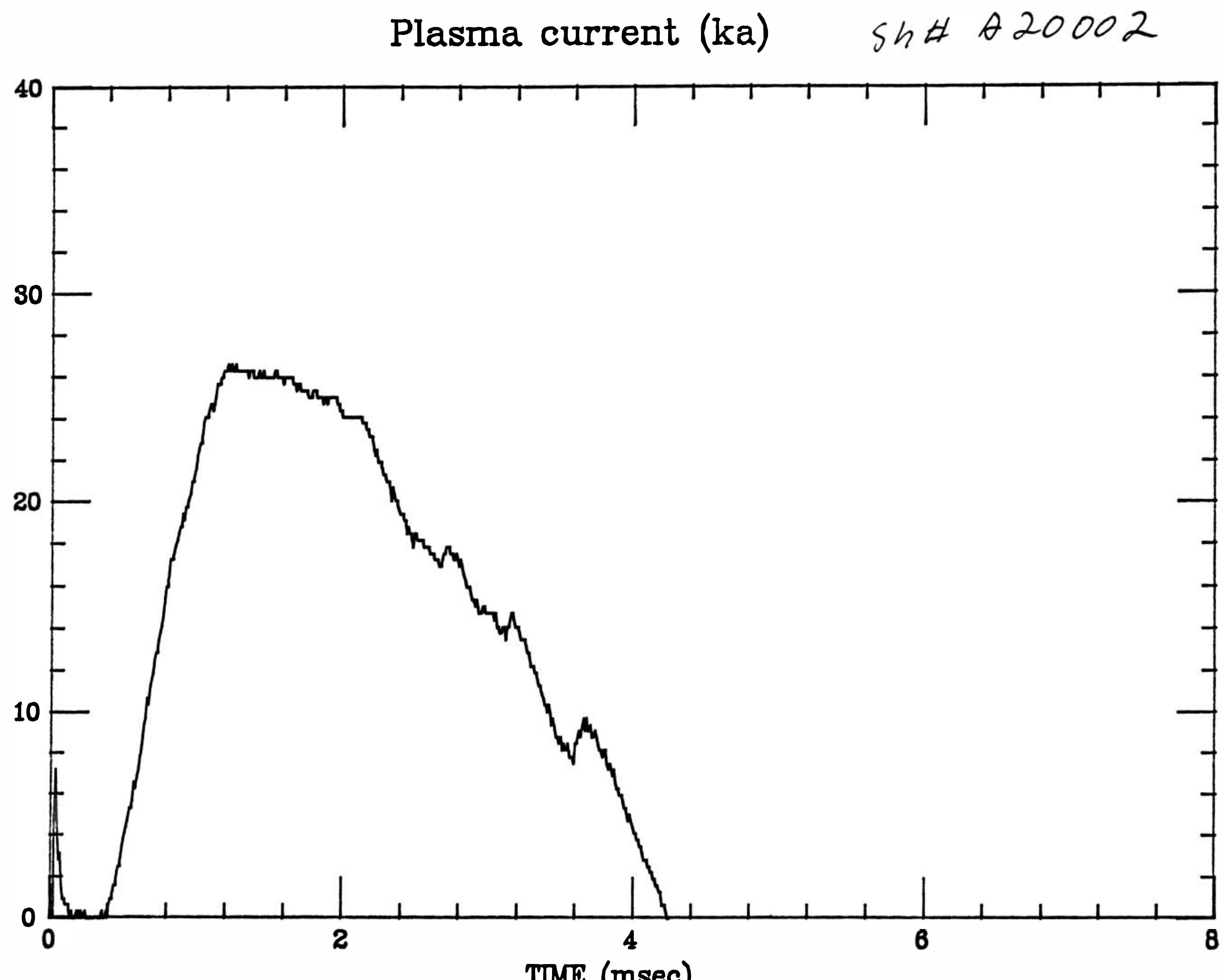


Lower antenna

Shot # A20022



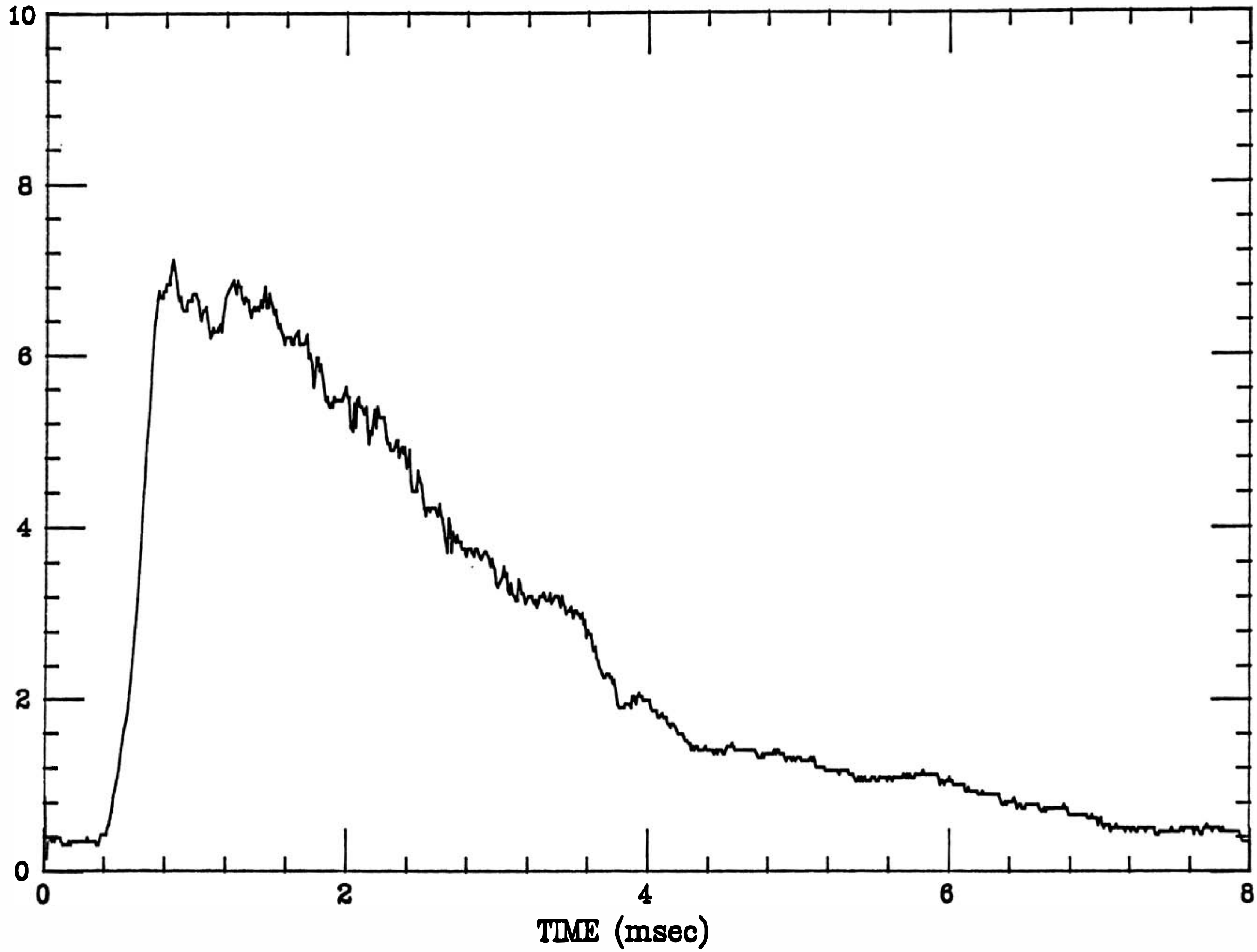

Central chord SXR
Shot # A20022
ARBITRARY UNITS
0.0
0.5
1.0
1.5
2.0
0
2
4
6
8
TIME (msec)



Plasma current (ka)
Sh# A20002
40
30
20
10
0
0
2
4
6
8
TIME (msec)

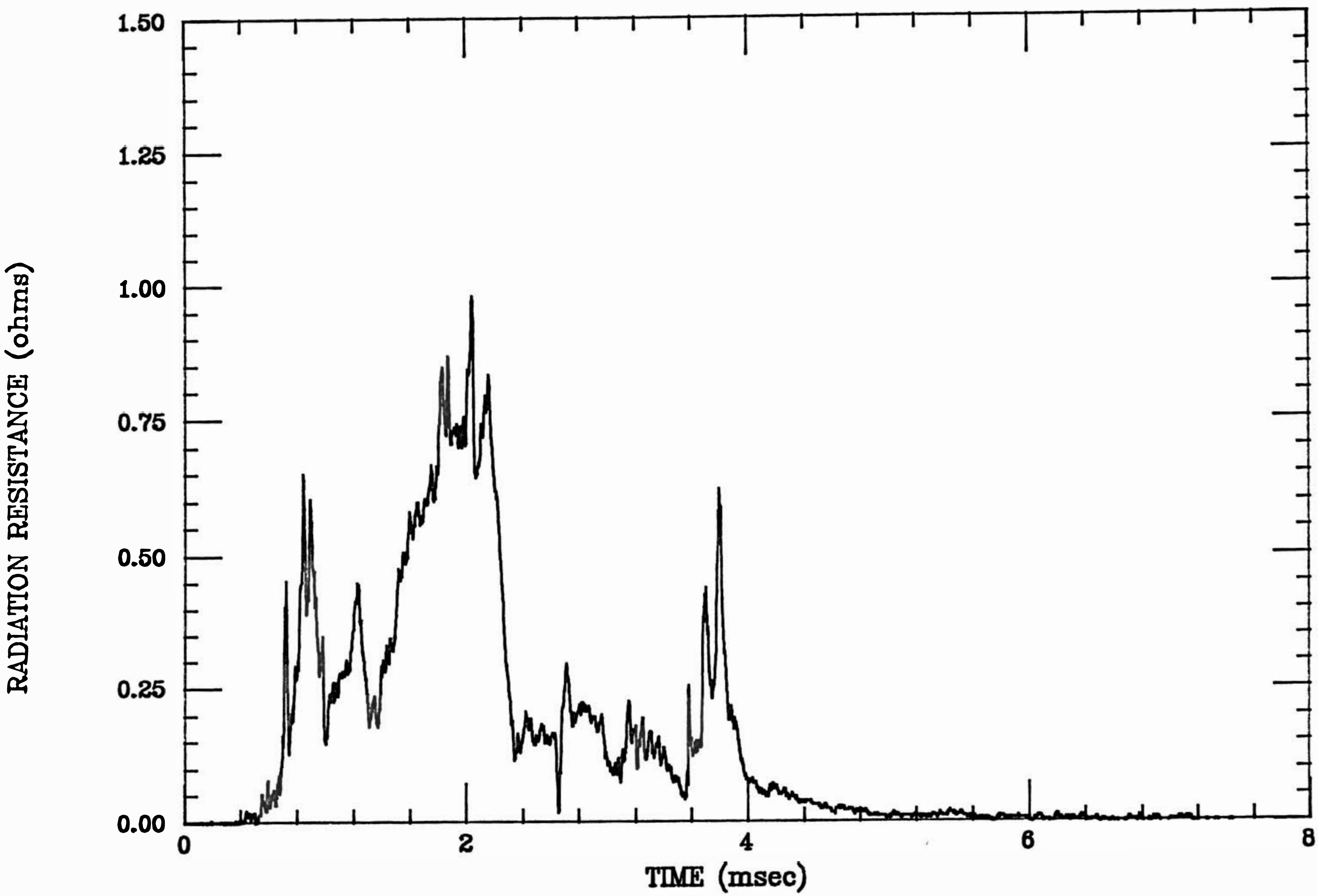
Line averaged density ($cm^{-3} * 10^{12}$)

Shot # A20002



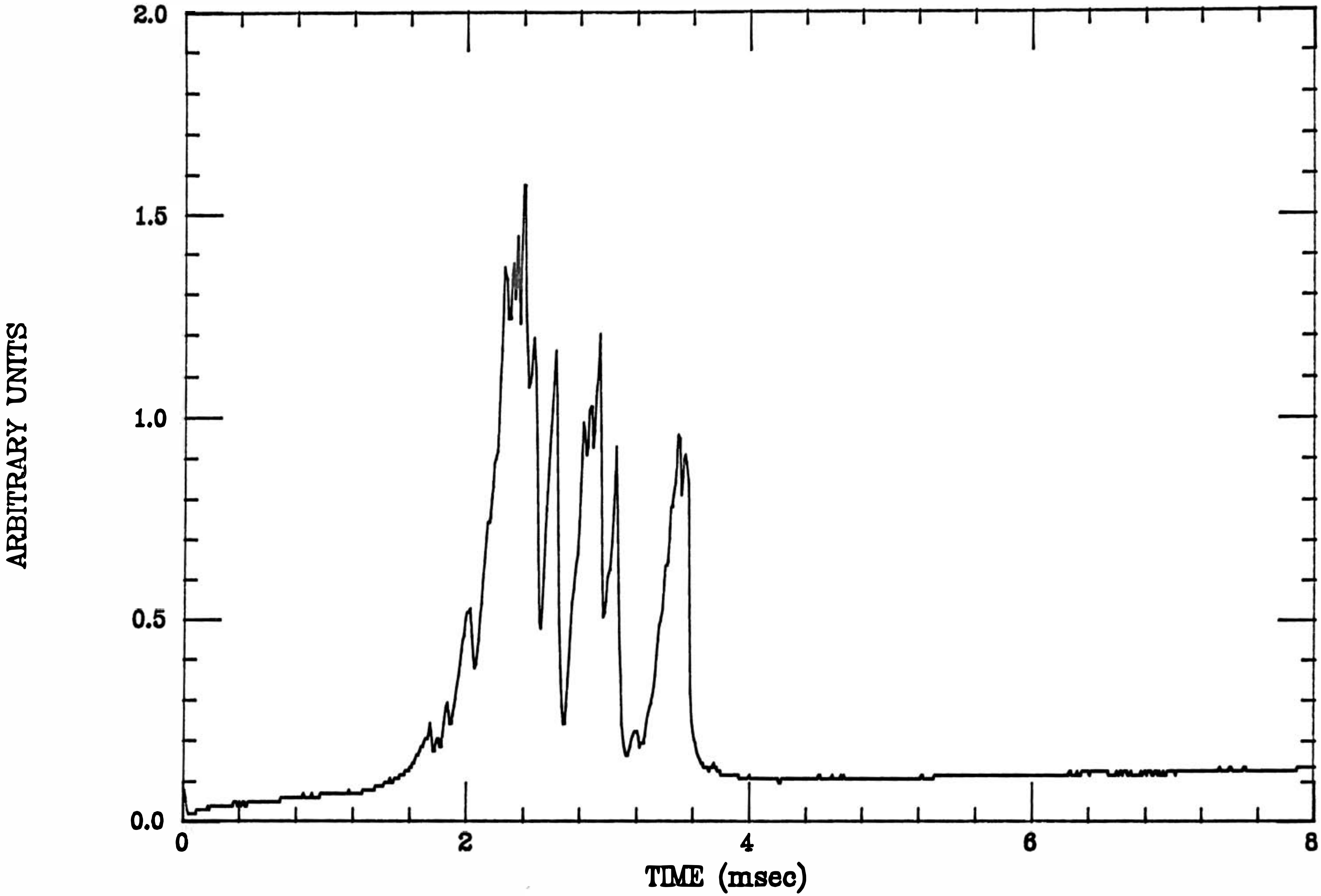
Lower antenna

Shot # A20002



Central chord SXR

Shot # A20002



CONCLUSIONS

Loading increases significantly when antenna currents are nearly perpendicular to the equilibrium field.

This loading has some characteristics which are difficult to explain.

It is fairly sensitive to plasma parameters and is quite reproducible.

IMMEDIATE FUTURE PLANS

Start production of 2 more antennas.

Use magnetic probes to see if enhanced loading gives increased signal.

Move one of the type II antennas to a different toroidal location to see if toroidal mode structure affects loading.