MAGNETIC FIELD ERROR EFFECTS ON RFP PLASMAS IN MST

(Poster presented at the 31st Annual Meeting of the
APS Division of Plasma Physics, Anaheim, CA, 13-17 November 1989)

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PLP 1069

November 1989

Plasma Studies

University of Wisconsin

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MAGNETIC FIELD ERROR EFFECTS ON RFP PLASMAS IN MST*

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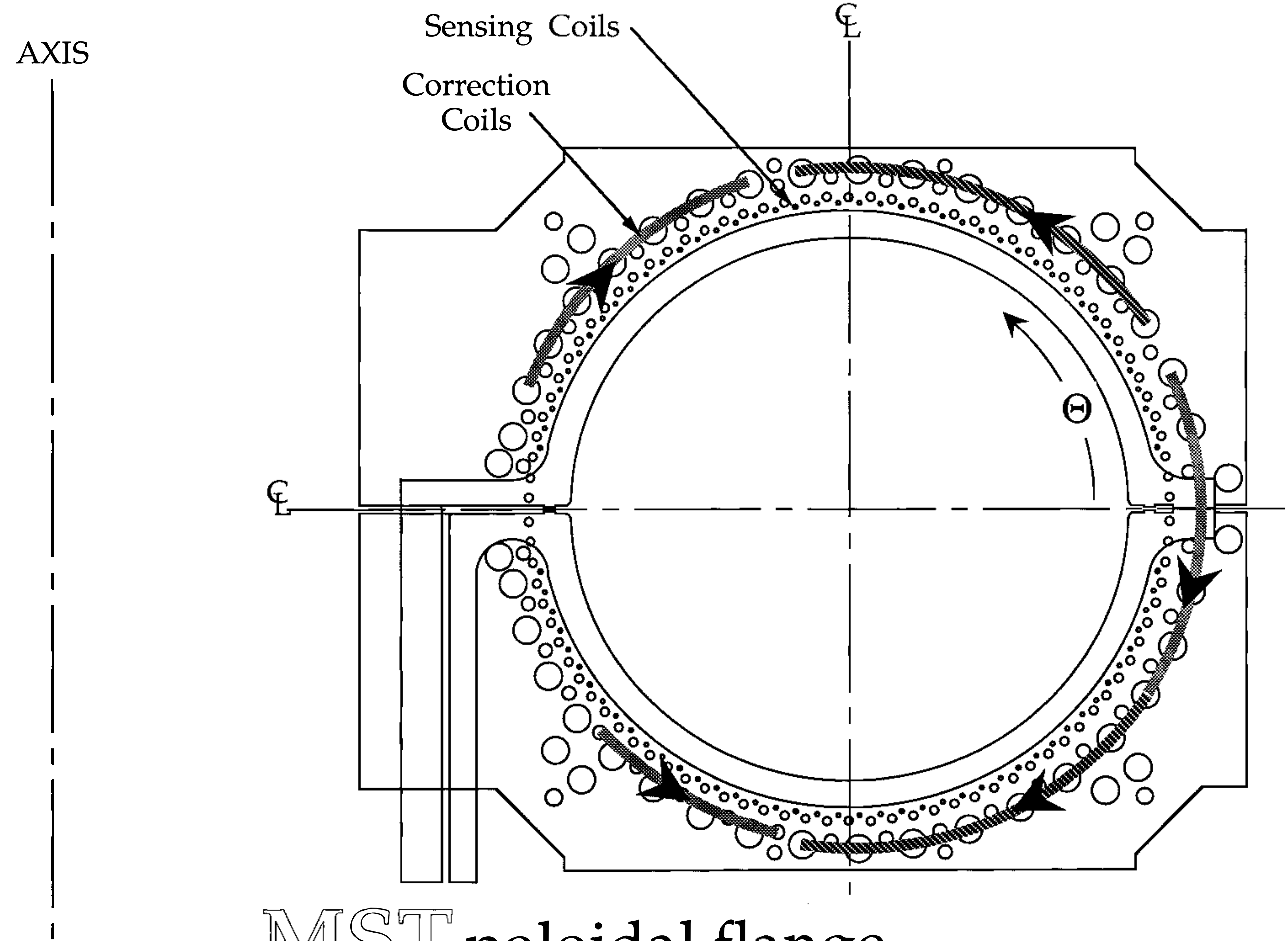
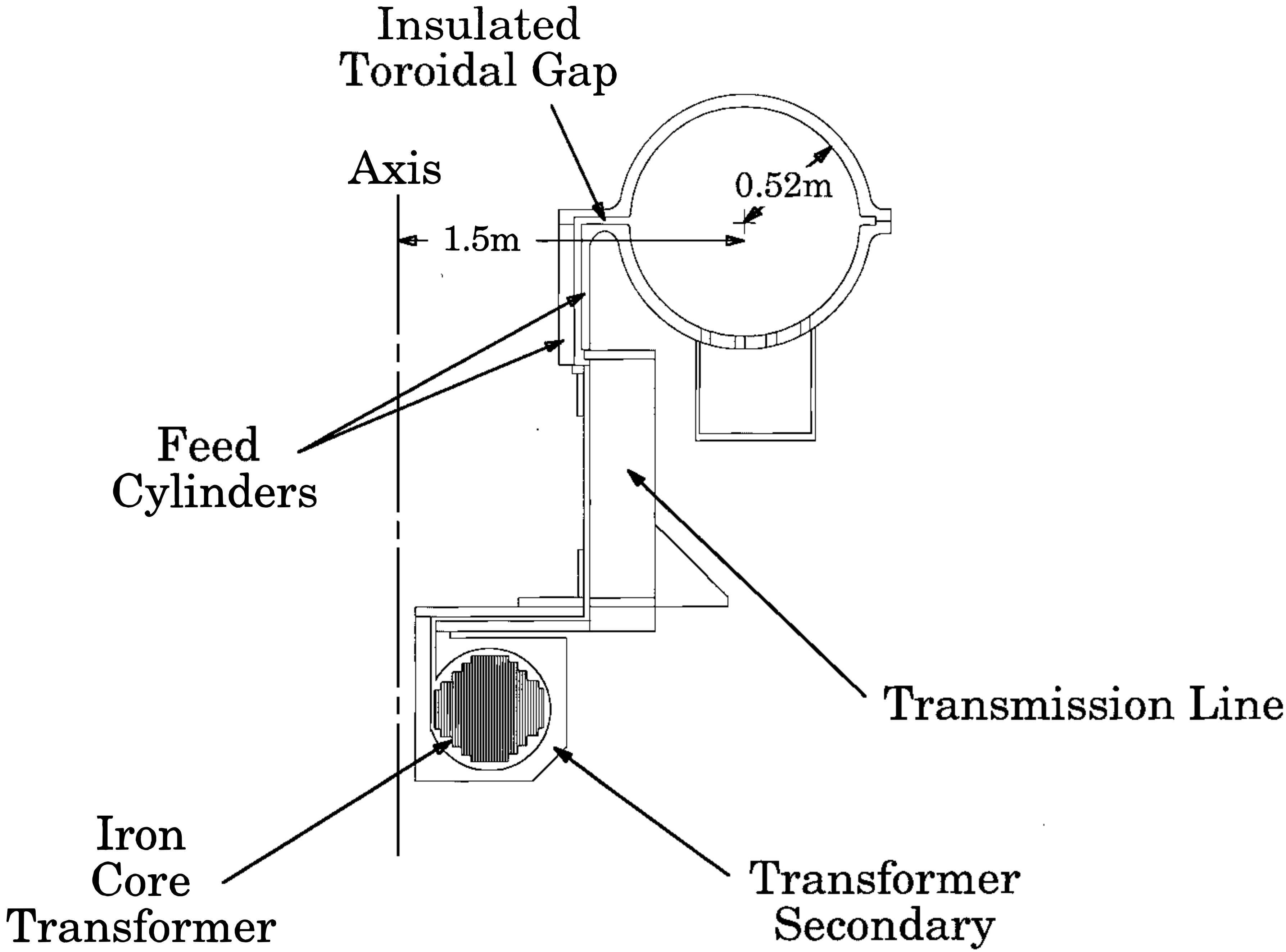
MST was run for a year with a temporary ohmic winding. This winding produced a rather large radial magnetic field at the poloidal gap, about 30% rms of the poloidal field at the wall. A detailed measurement of the spectrum of these radial fields at both toroidal and poloidal gaps was carried out. The dominant modes at the poloidal gap are m=0,1,2,4, and the dominant modes at the toroidal gap are n=0,1. Correction coils were used to reduce the radial field at the poloidal gap. Plasma loop voltage is reduced, and central electron temperature increased as the amplitude of the m=0 component of the radial field is reduced. The amplitude of the n=0 mode at the toroidal gap is also reduced as a result of reducing the m=0 mode. The amplitudes of low m modes (0,1,2) have a minimum at shallow reversal indicating that these modes may be caused by the plasma. Measurement of the asymmetry factor (Λ = -11.5%) shows that the current channel broadens as the amplitude of the m=0 mode of the radial field is reduced. This is also shown by the SXR reconstruction. The permanent ohmic winding was installed in the summer of 1989. Detailed structure of these fields with the new winding will be presented as well

*Work supported by U.S.D.O.E



MST poloidal flange


Insulated
Toroidal Gap
Axis
0.52m
1.5m
Feed
Cylinders
Transmission Line
Iron
Core
Transformer
Transformer
Secondary

MOTIVATION

* Field errors are unaviodable and are an important consideration in RFP physics.

* Since RFP confinement is thought to be determined by the outer region of the plasma, RFP s are vulnerable to m=0 radial fields. Perturbations with m=0 are resonant on the reversal surface and have the potential to create islands which could destroy reversal and confinement.

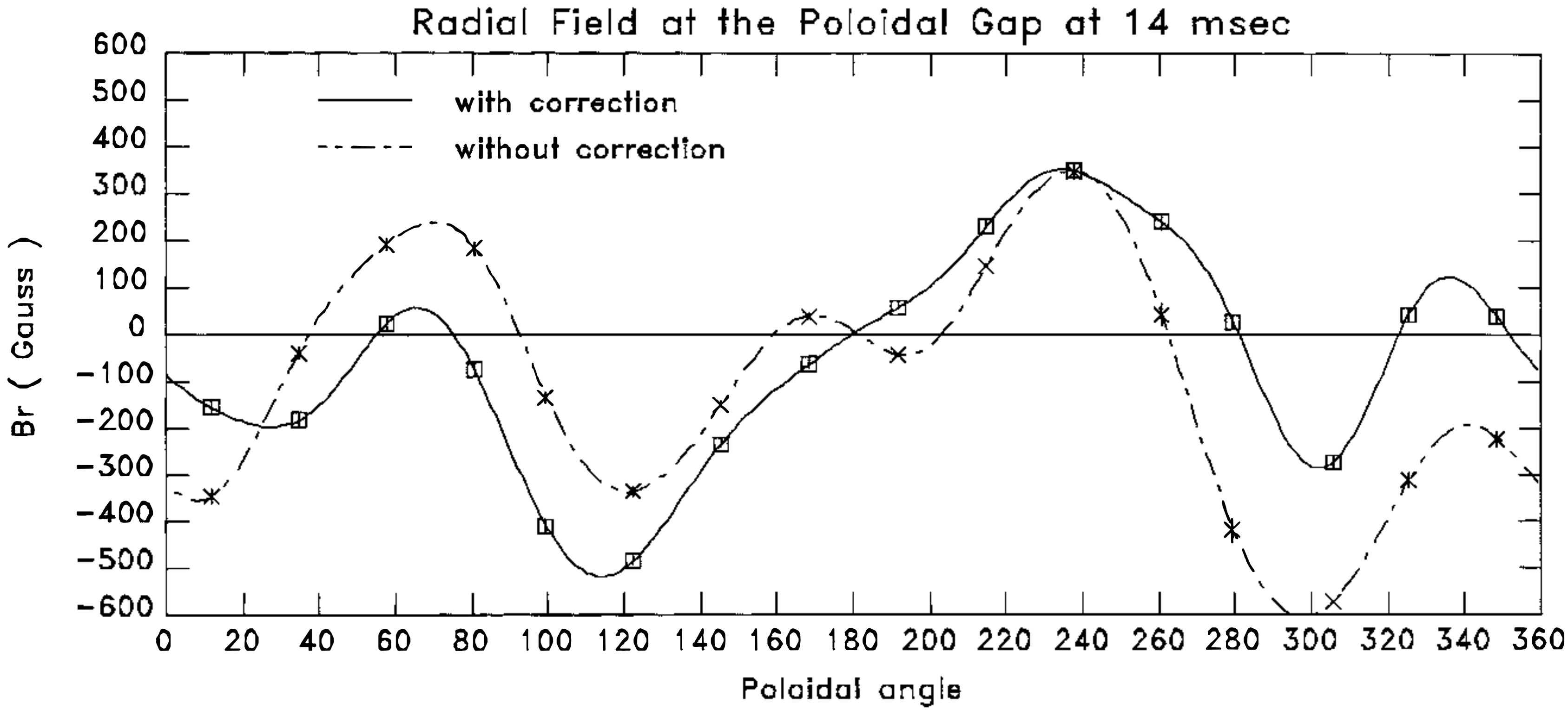
* Perturbations with m=1 have been linked to RFP dynamo effect and production of m=0 islands through nonlinear coupling of (1,n1) and (1,n2) modes.

The radial magnetic field at the poloidal gap is reduced as shown below by using correction coils which are driven by the primary current (waveform).

Br (rms) = [282 gauss without correction

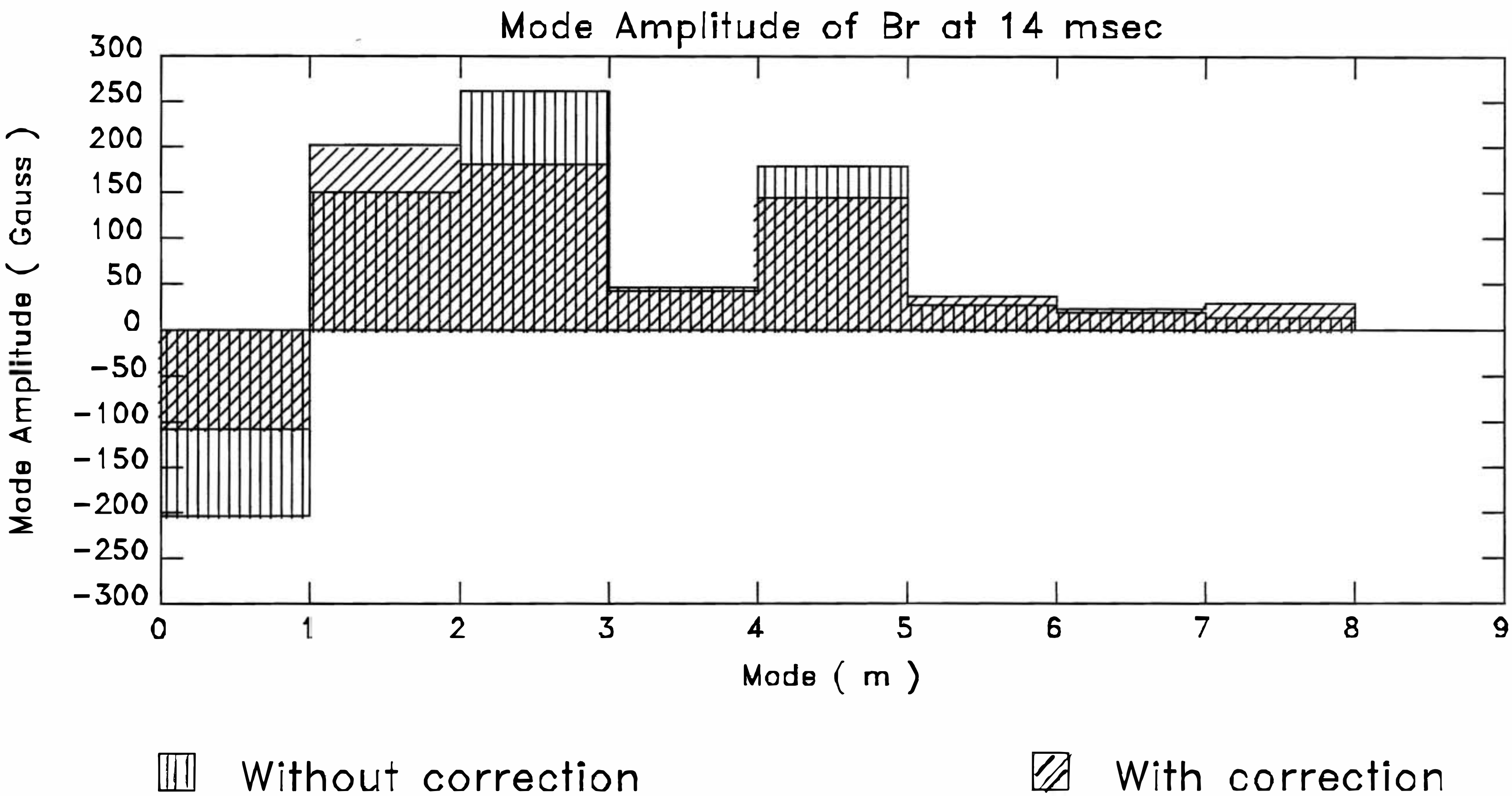
236 gauss with correction

Radial magnetic field at the poloidal gap with and without correction



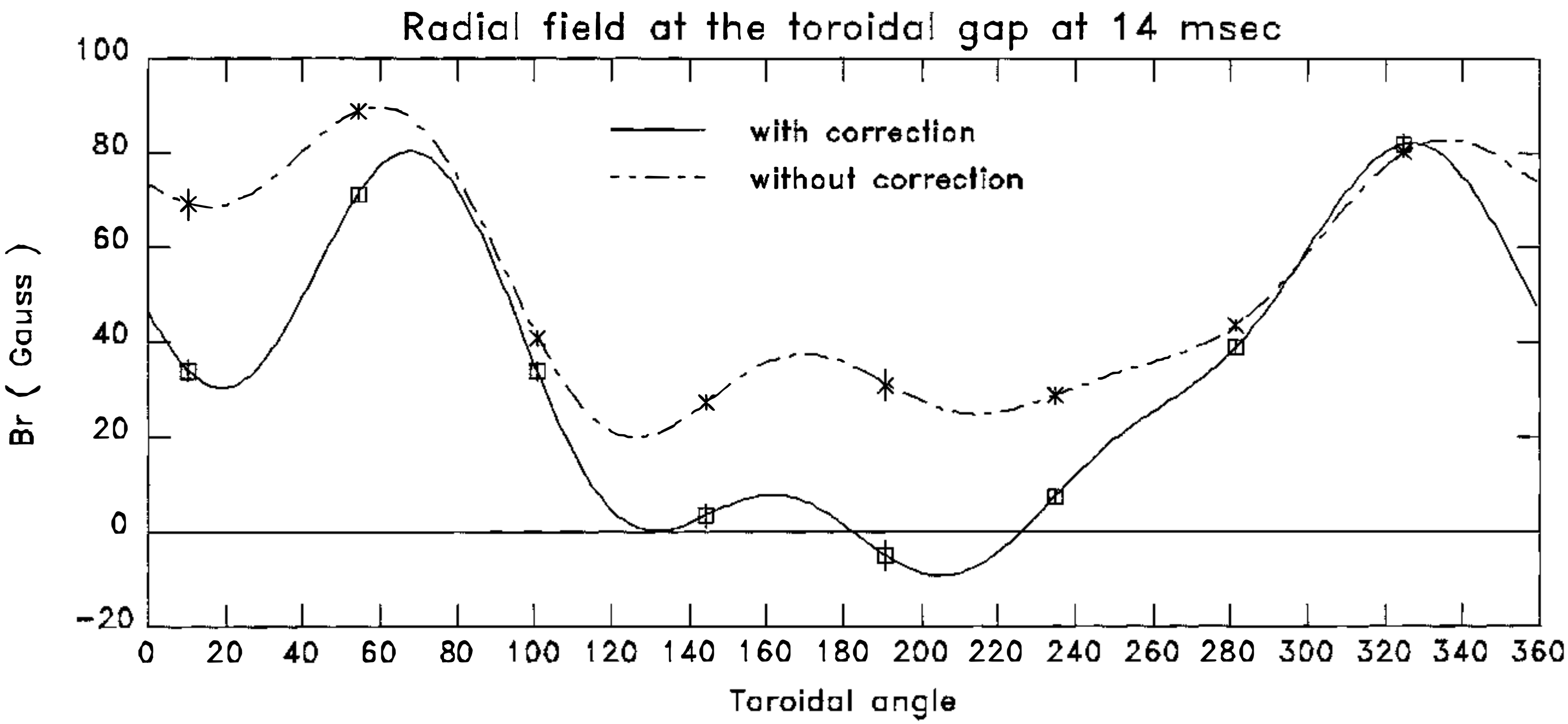
rms (W/O corr. _ . _) = 282 +/- 3 Gauss

rms (With corr. ___) = 235 +/- 3 Gauss

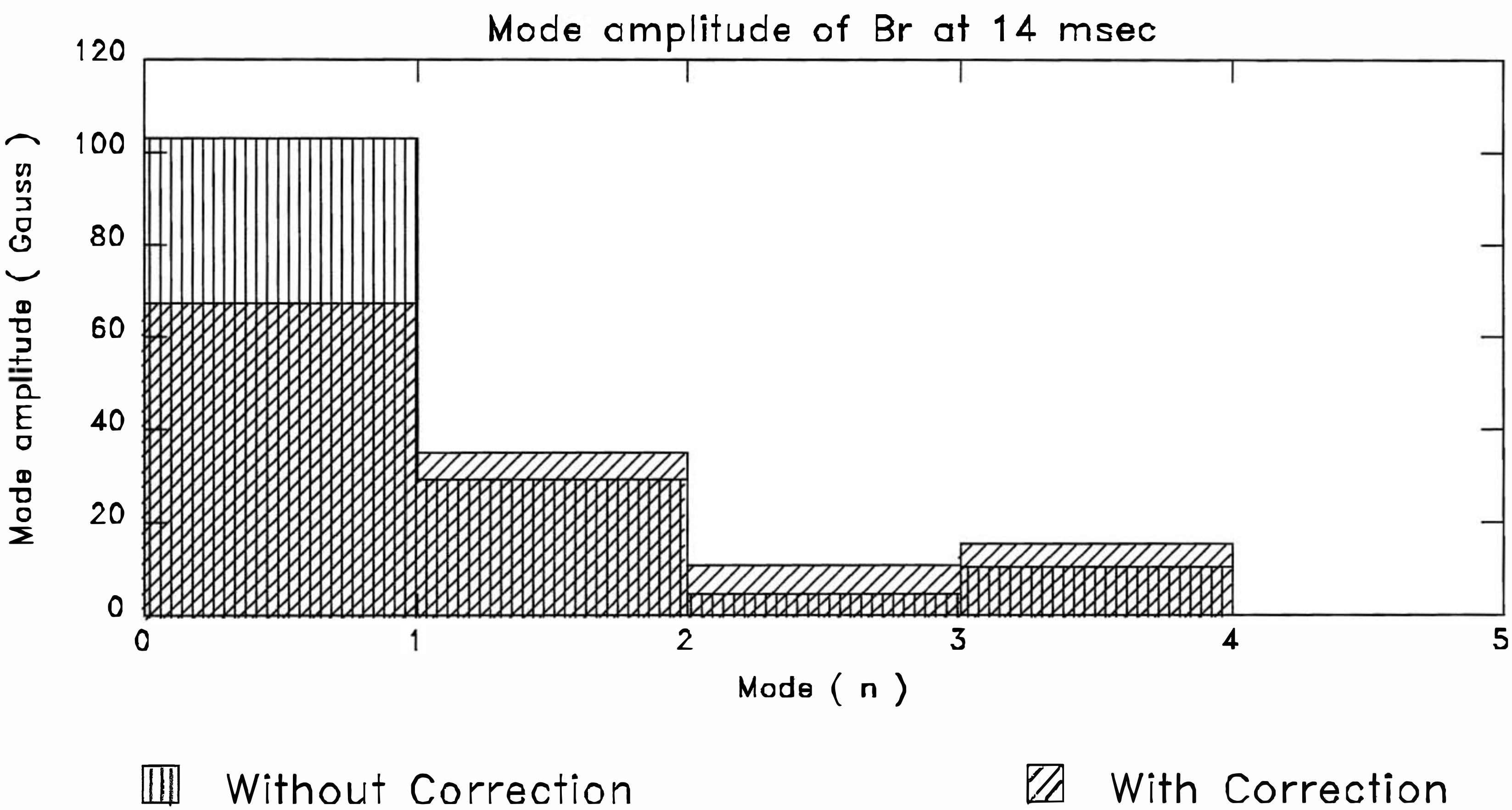


Mode Amplitude of Br at 14 msec
Mode Amplitude (Gauss)
300
250
200
150
100
50
0
−50
−100
−150
−200
−250
−300
0
1
2
3
4
5
6
7
8
9
Mode (m)
Without correction
With correction

Radial magnetic field at the toroidal gap with and without correction



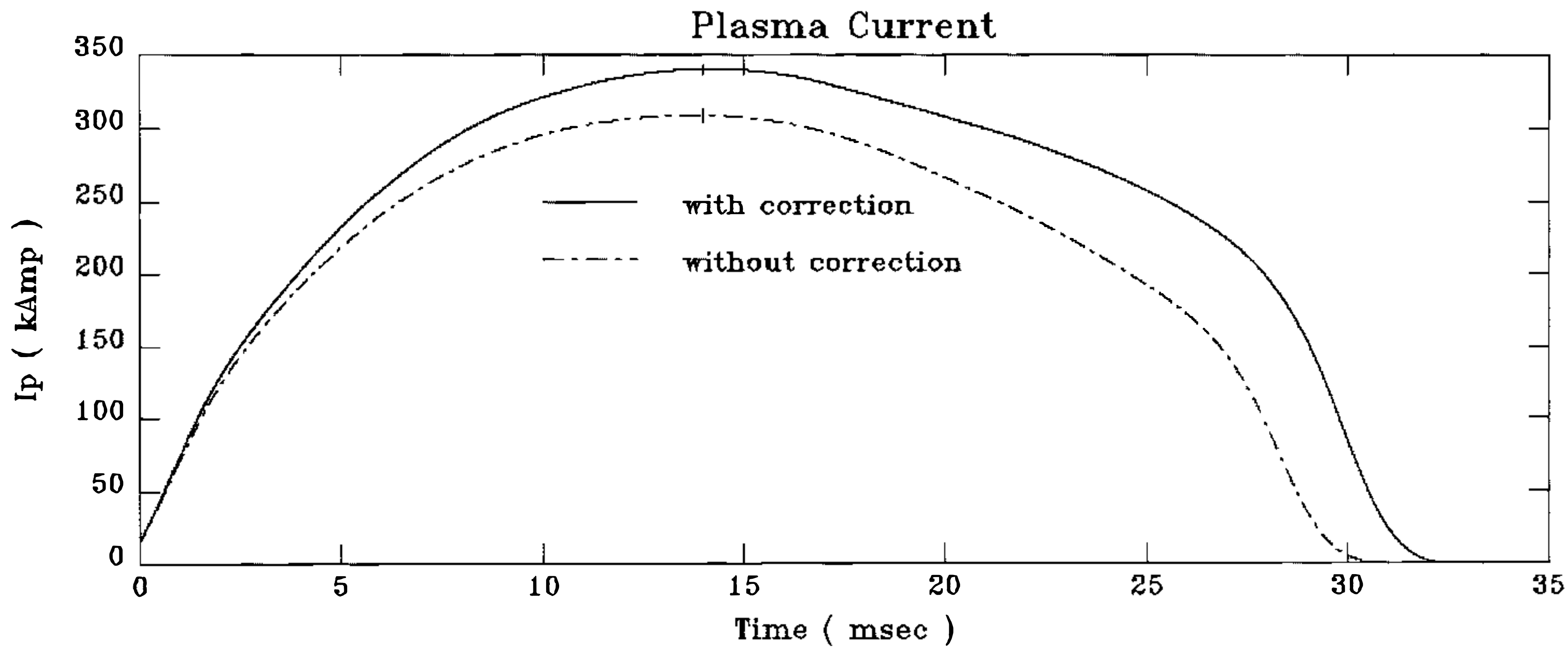
rms (W/O corr. _ . _) = 56 +/- 0.70000 Gauss rms (With corr. ___) = 44 +/- 0.62000 Gauss


Mode amplitude of Br at 14 msec
Mode amplitude (Gauss)
120
100
80
60
40
20
0
0
1
2
3
4
5
Mode (n)
Without Correction
With Correction

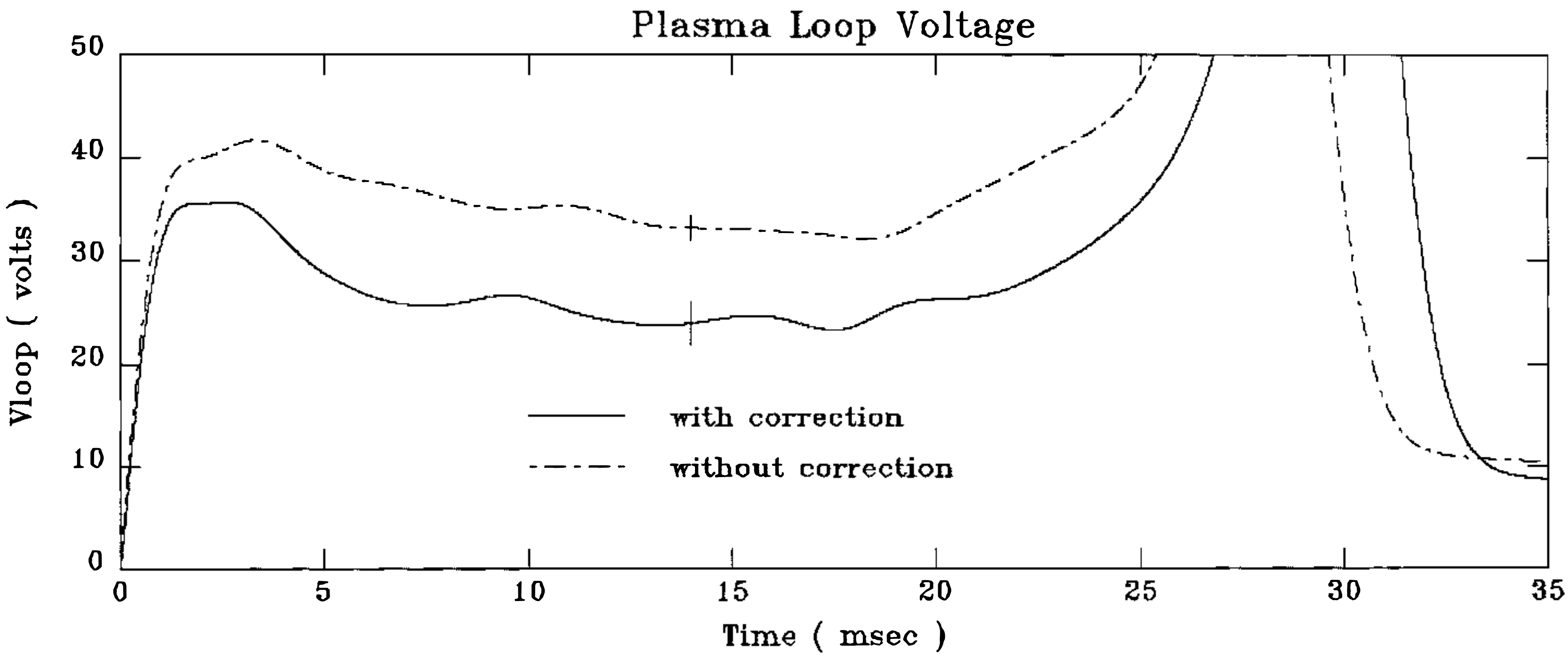
Plasma improvement can be seen on the following signals indicating enhanced plasma confinement and reduced plasma–wall interaction.

. Higher plasma current.
. Lower loop voltage.
. Longer reversal.
. Longer discharge.

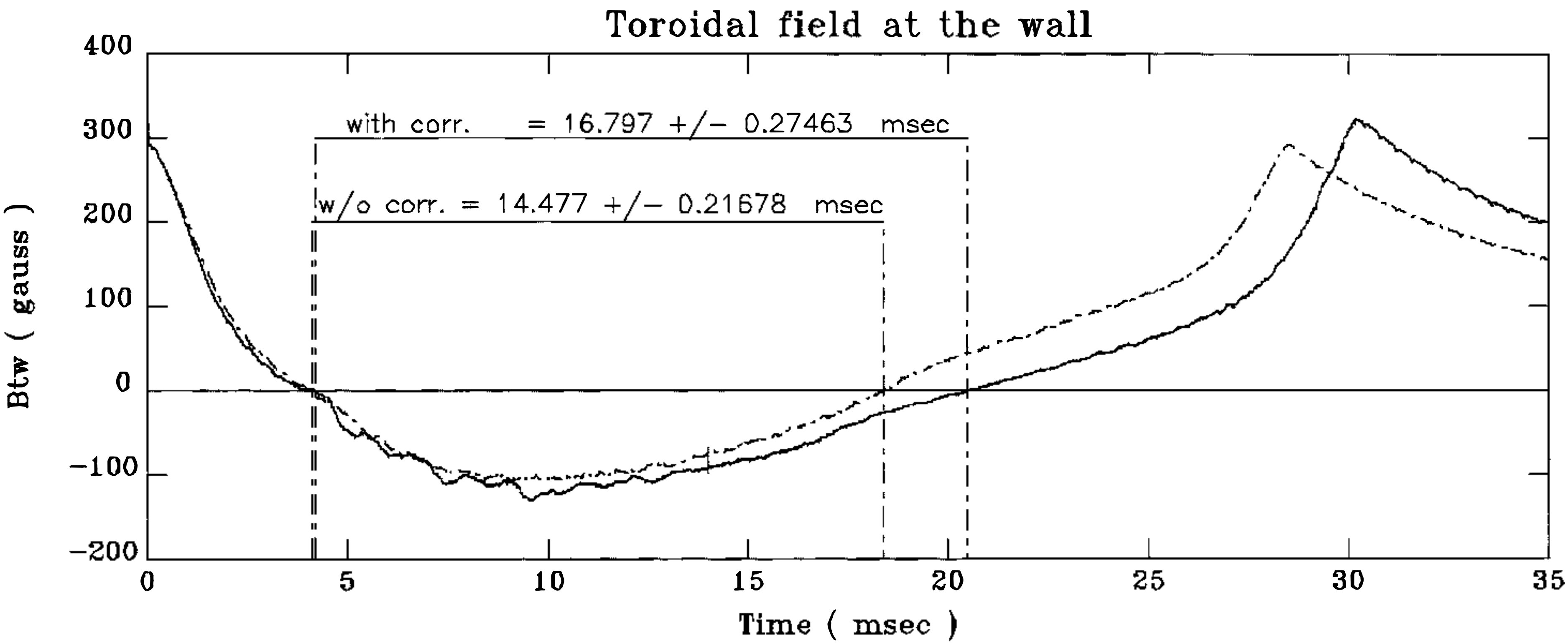
Plasma current and discharge duration increase with reduced radial magnetic field at the poloidal gap.



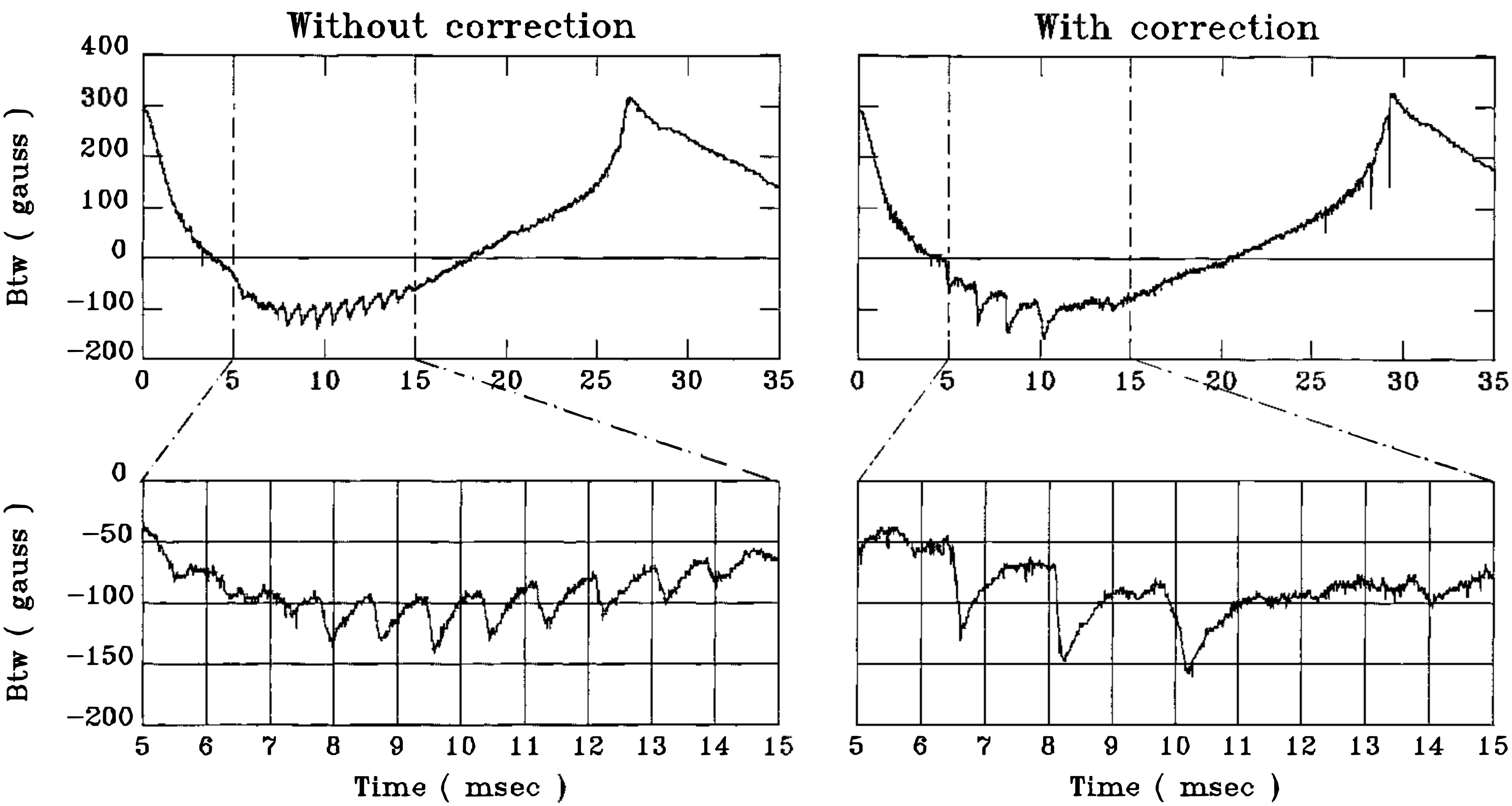
Plasma loop voltage decreases with reduced radial magnetic field at the poloidal gap.



Reversal duration increases with reduced radial magnetic field at the poloidal gap.

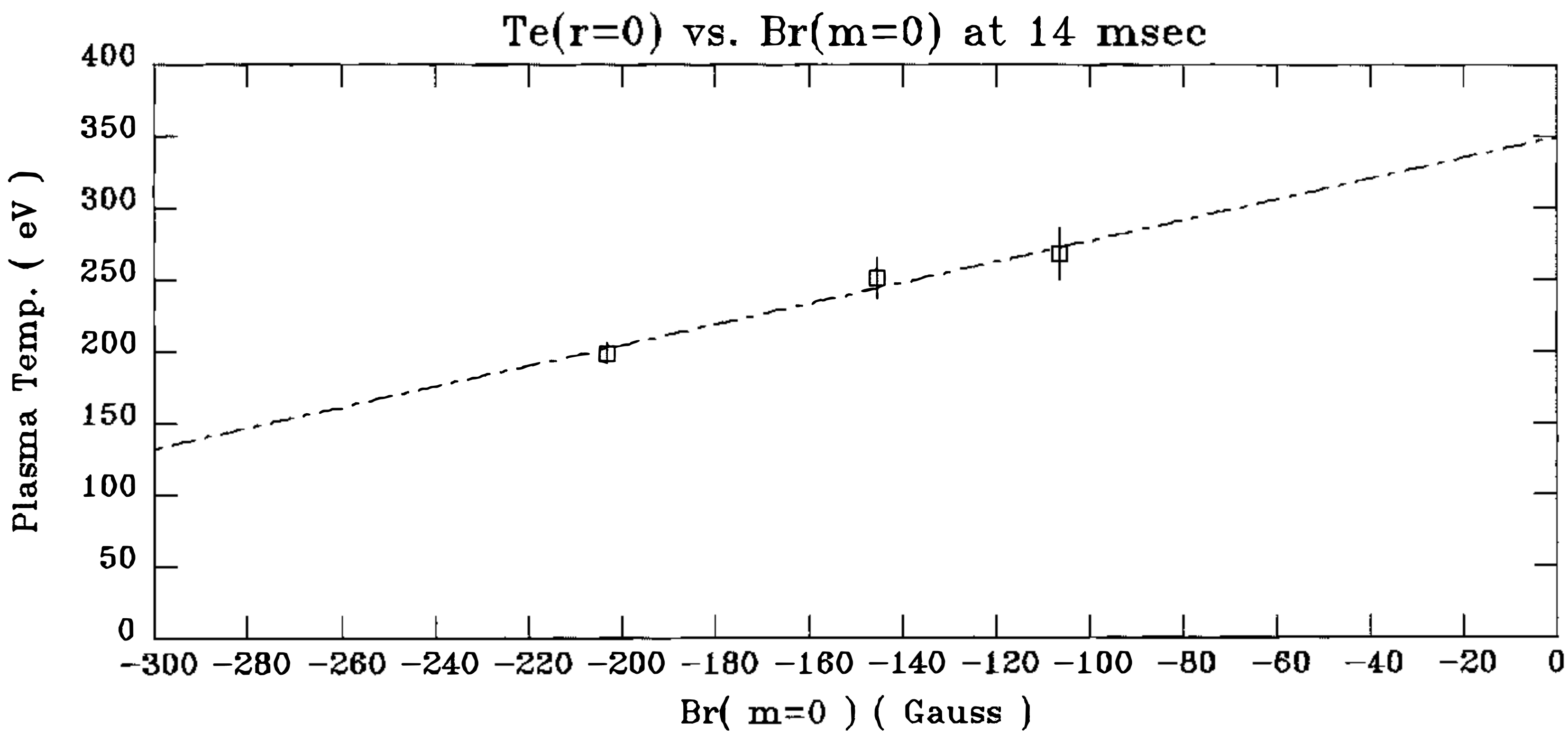


The character of "flux jumps" changes with reduced radial magnetic field at the poloidal gap.

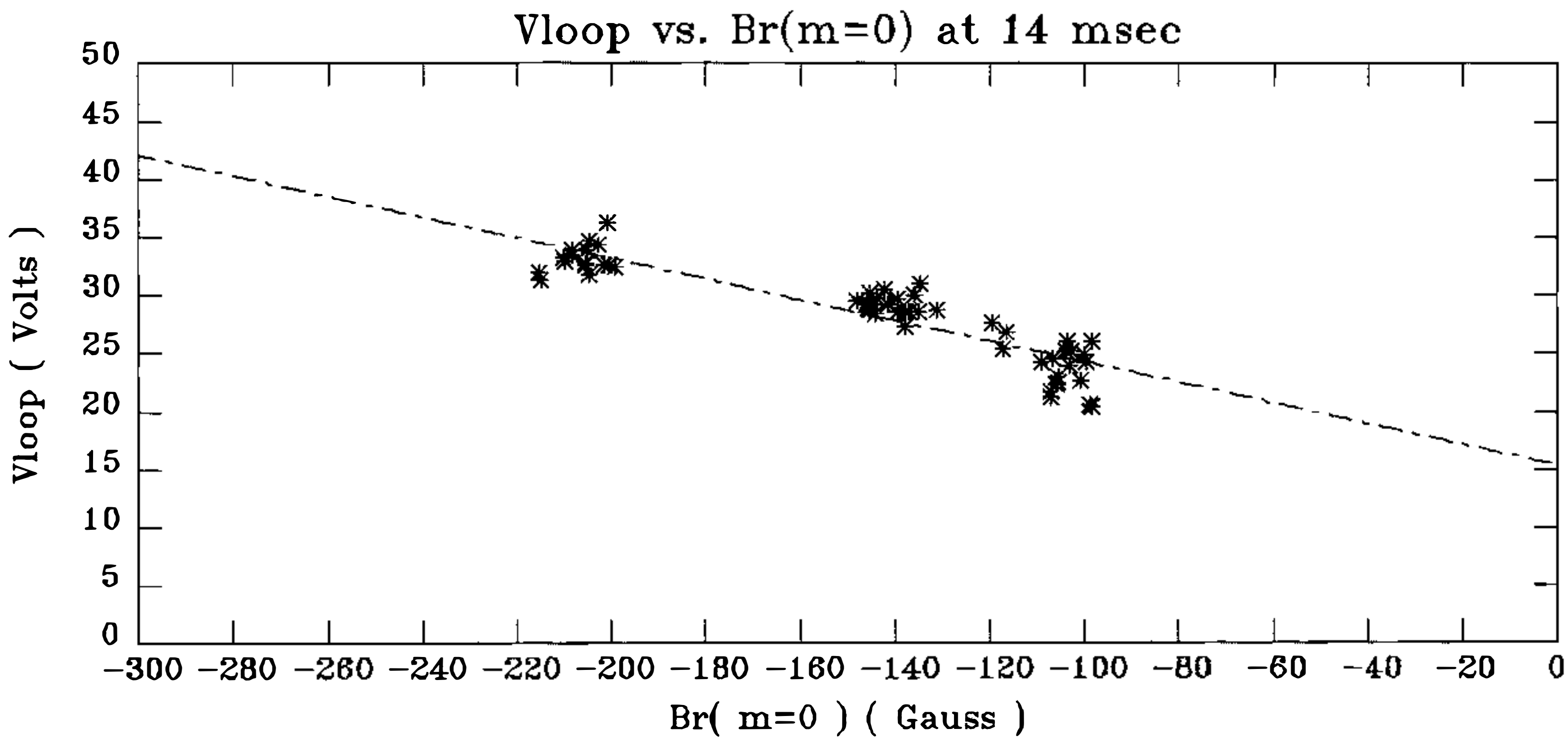


Plasma improvement seems to correlate with the amplitude of the m=0 component of the radial field at the poloidal gap.

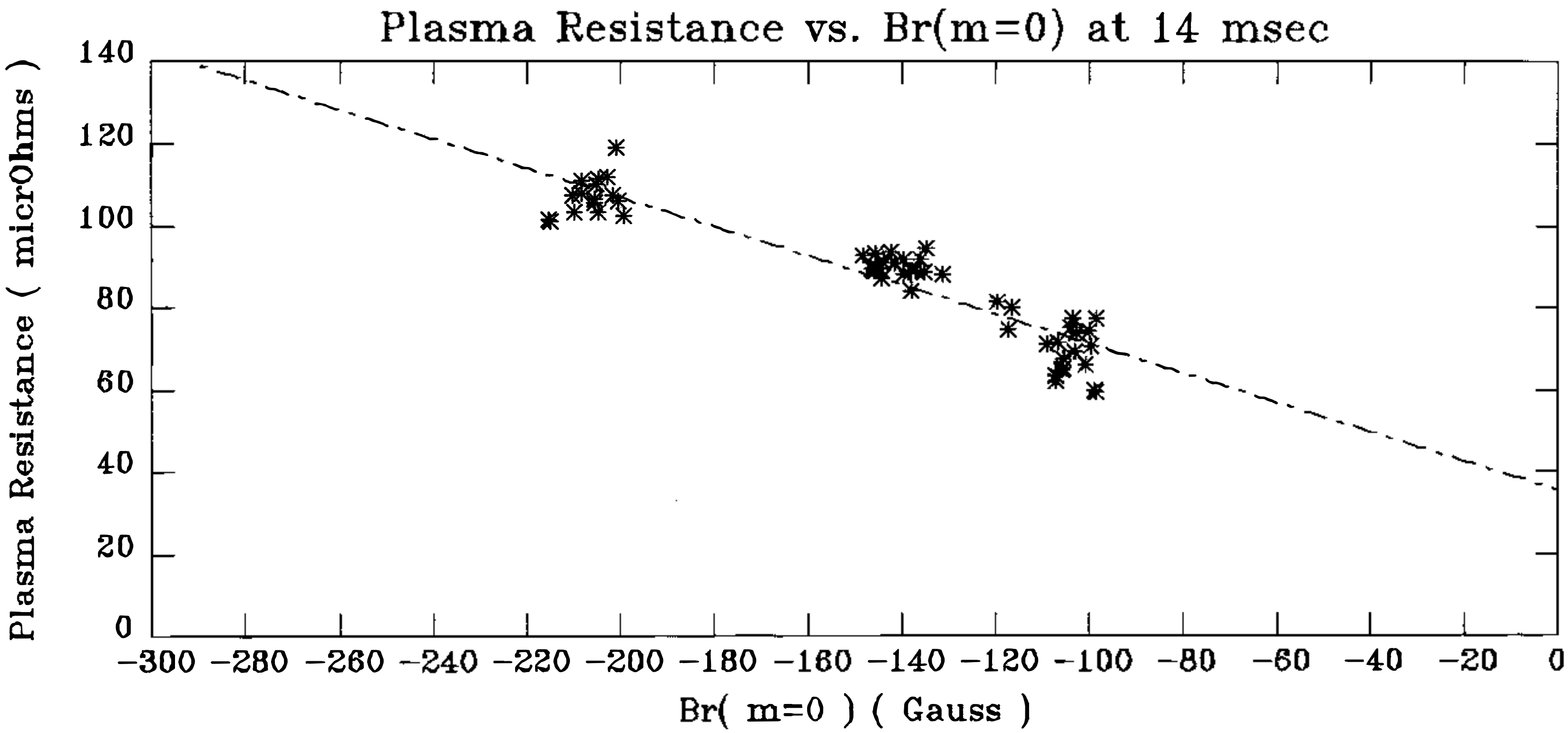
Central plasma temperature increases with decreasing m=0 amplitude.



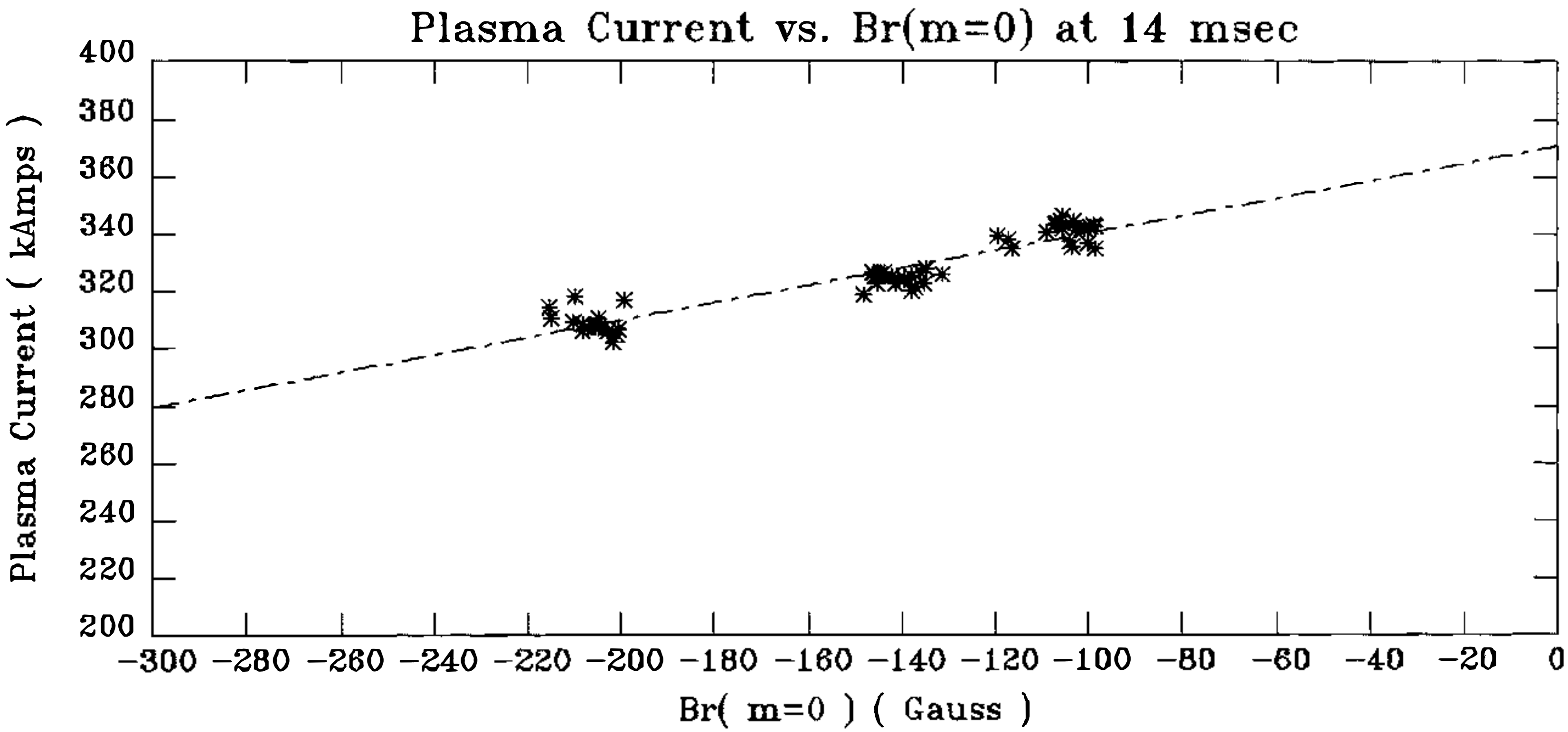
Plasma loop voltage decreases with decreasing m=0 amplitude of radial magnetic field.



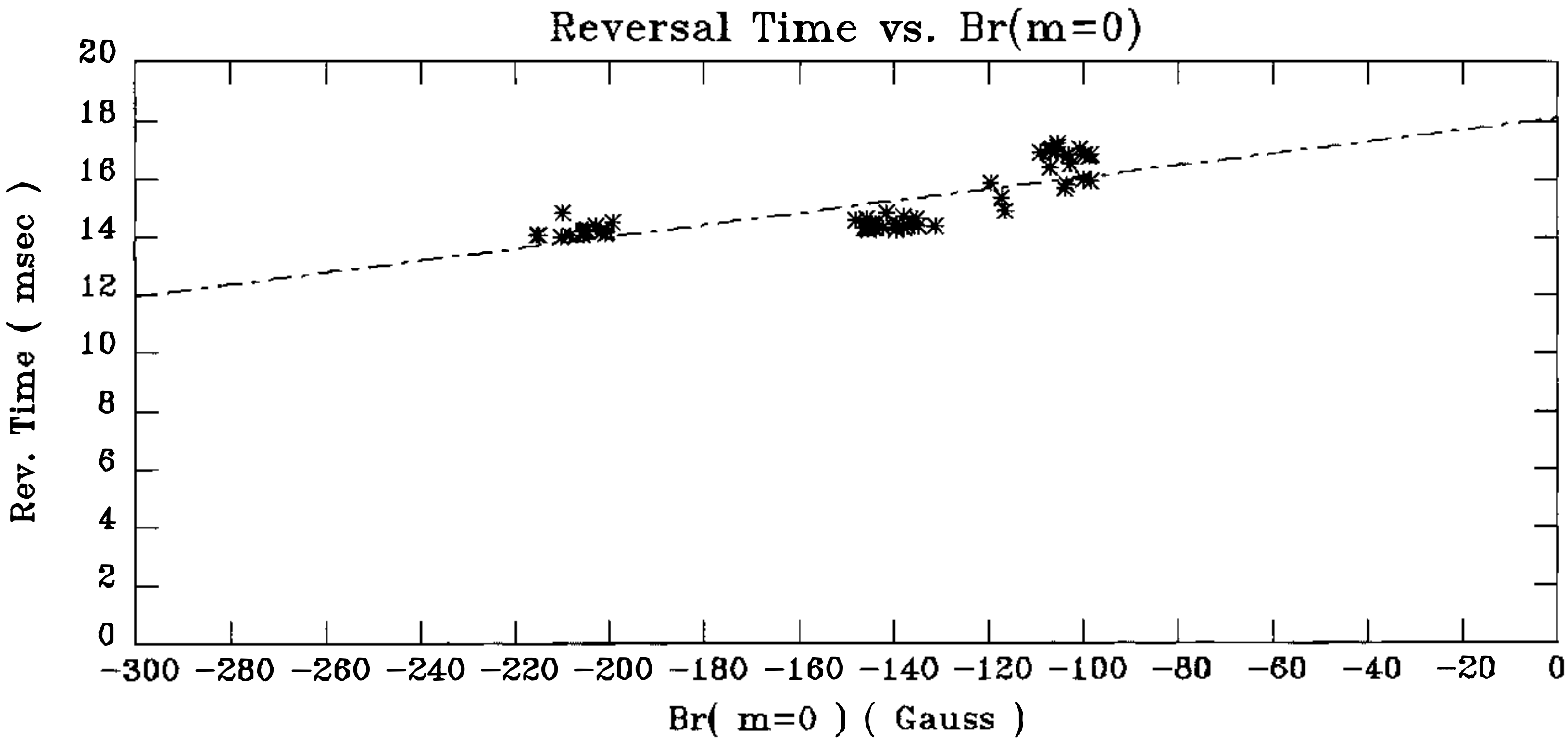
Plasma resistance decreases with decreasing m=0 amplitude of radial magnetic field.



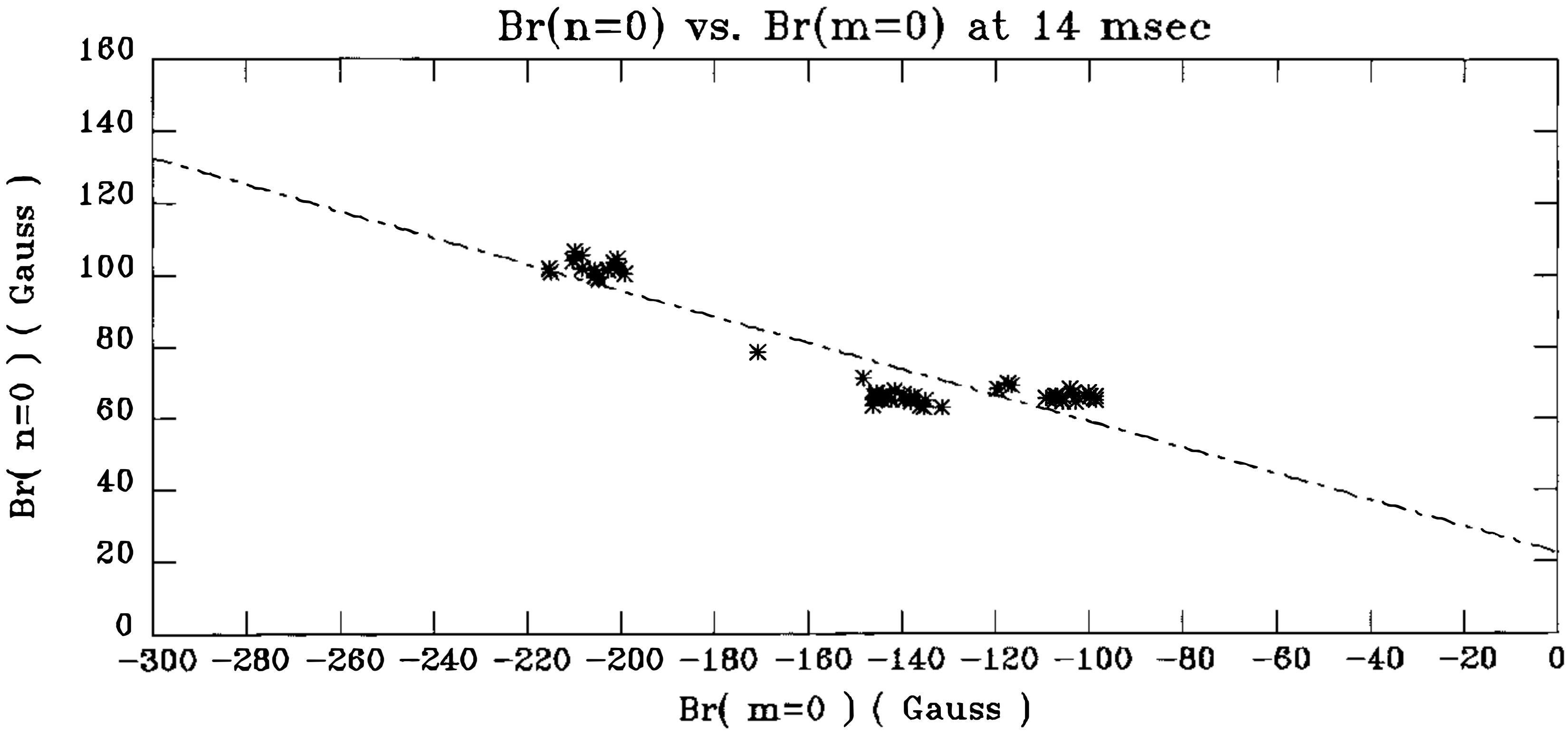
Plasma current increases with decreasing m=0 amplitude of radial magnetic field.



Reversal time increases with decreasing m=0 amplitude of radial magnetic field.



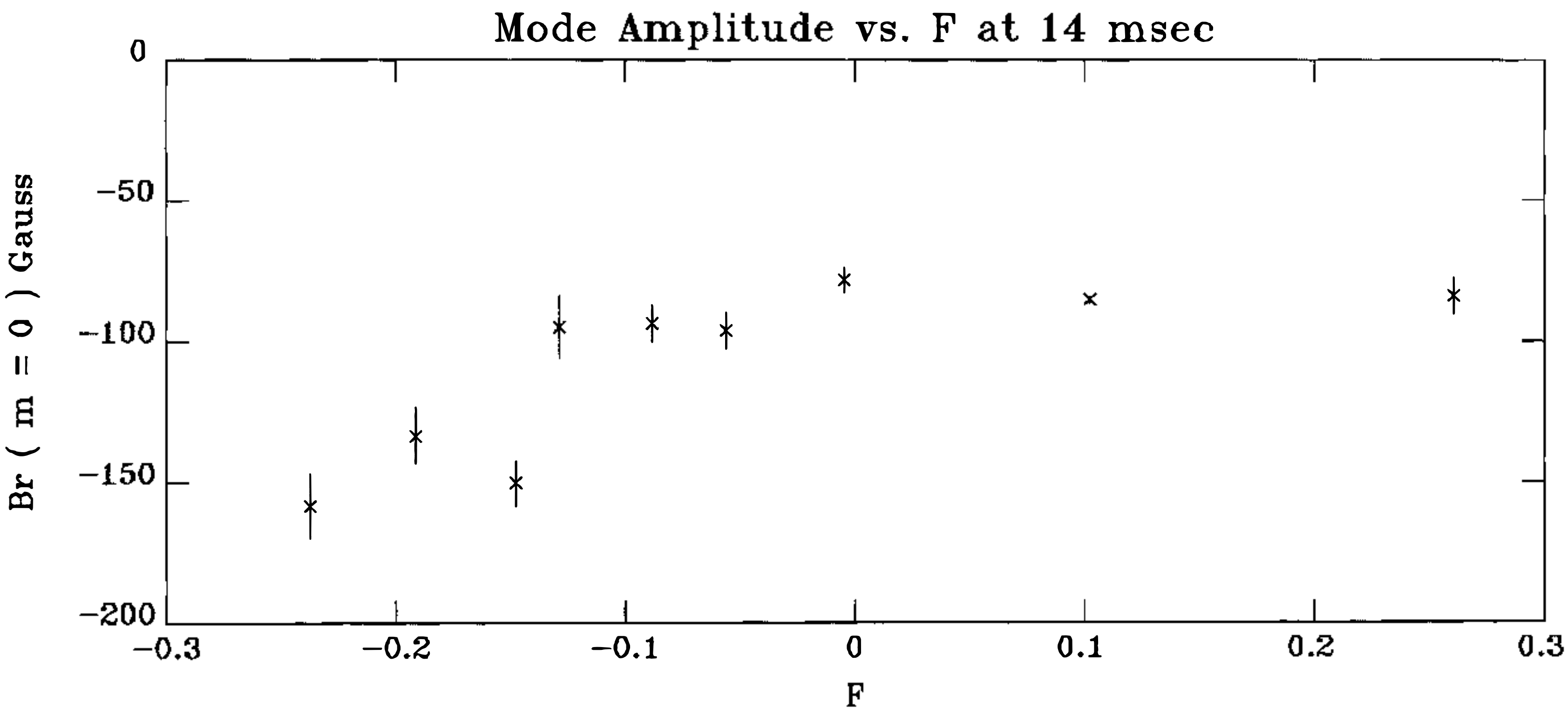
The n=0 amplitude of radial field at the toroidal gap decreases with decreasing m=0 amplitude of radial field at the poloidal gap.



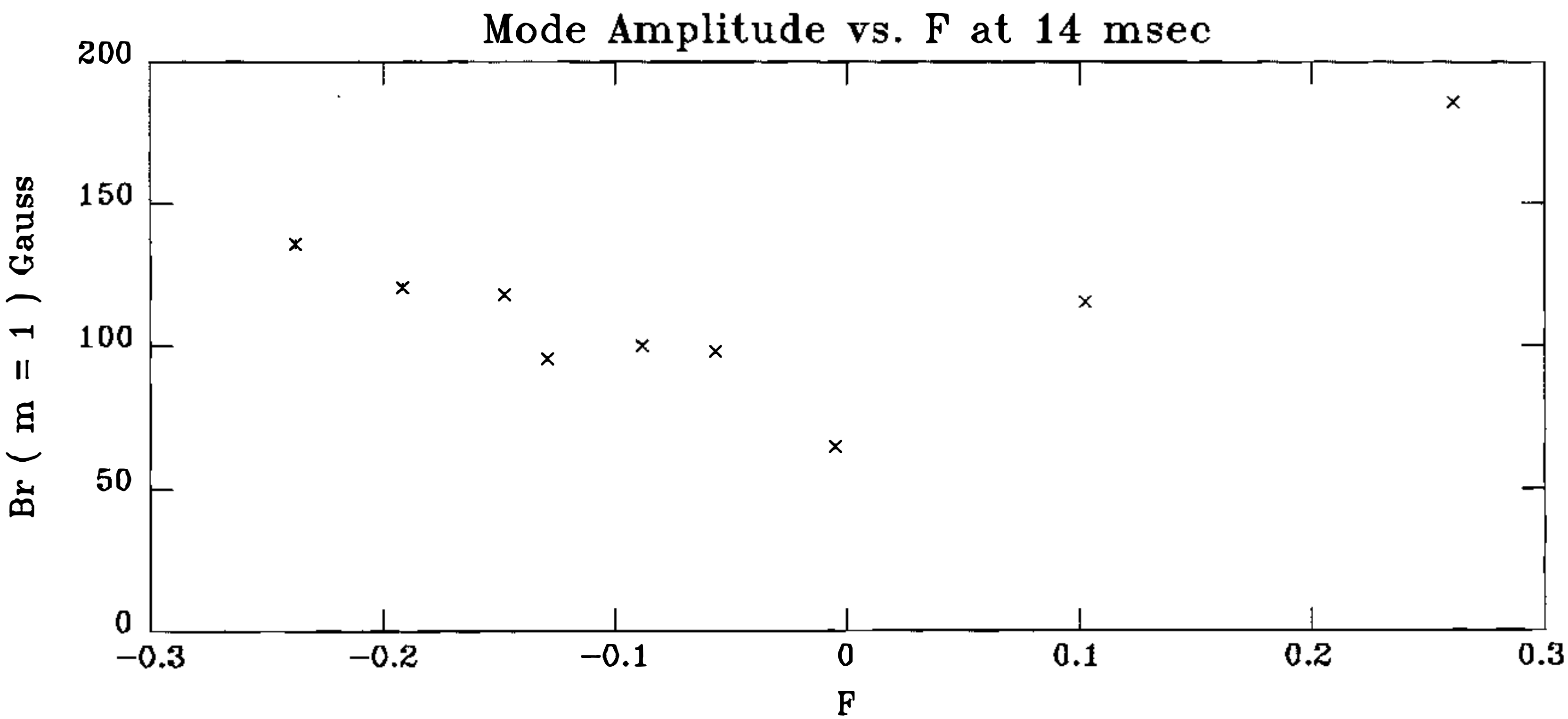
The low order modes (m = 0,1,2) of Br depend on the field reversal parameter F indicating that these modes are caused by profile changes (plasma displacement).

$$F = Bt(wall) \,/\, Bt(aver.)$$

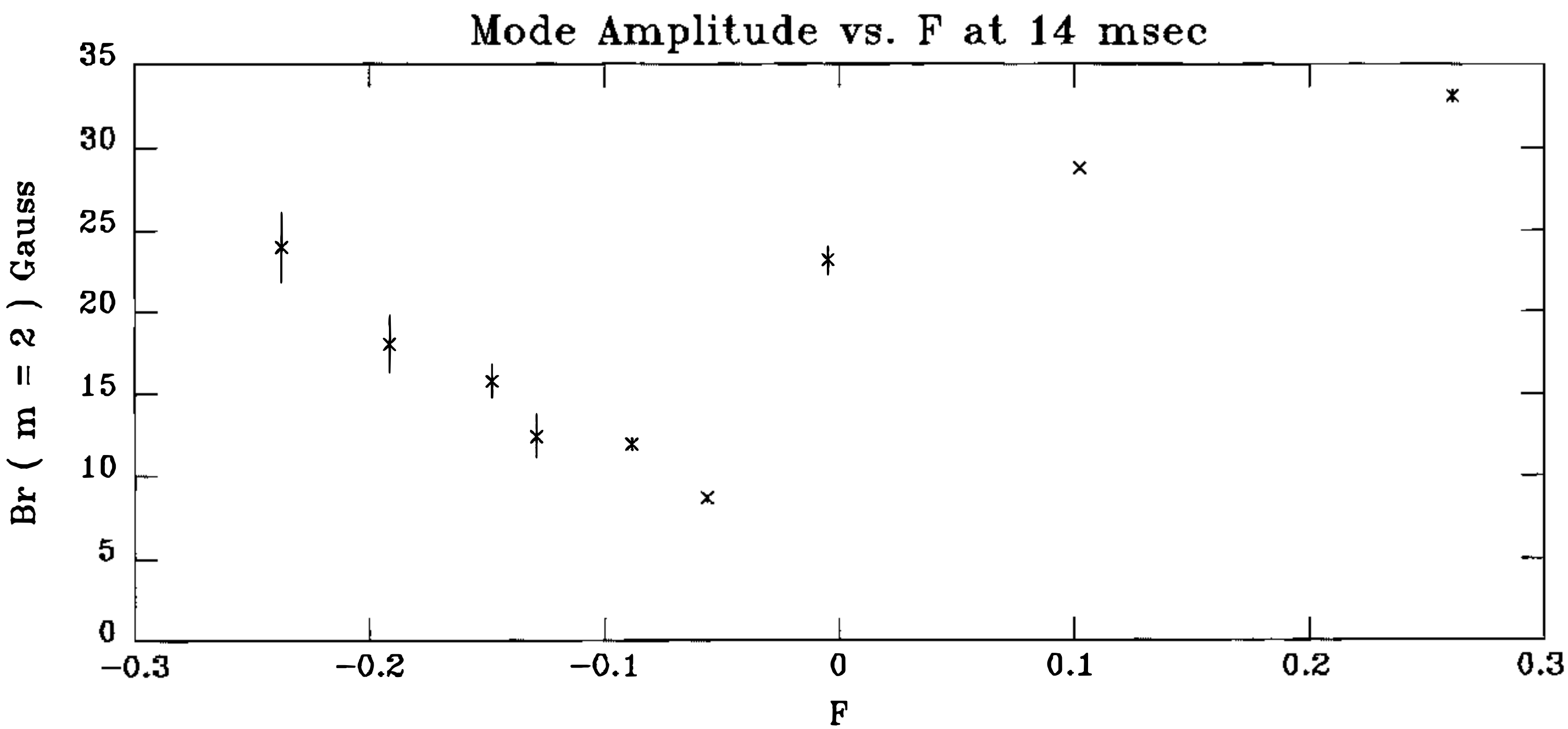
The m = 0 component of the radial magnetic field is small at shallow reversal.



The m = 1 component of the radial magnetic field has a minimum at shallow reversal.



The m = 2 component of the radial magnetic field has a minimum at shallow reversal.



CONCLUSIONS

* Reducing error magnetic field enhances machine performance.

* The performance depends sensitively on the m=0 component of the radial magnetic field at the poloidal gap.

* The presence of this large m=0 component at the gap may be due to the nonlinear coupling of (1,5) and (1,6) modes which may produce a large m=0 mode causing field lines to leave the machine through the poloidal gap in the wall.

FUTURE WORK

* Add m=0 correction coil to examine in more controlled fashion this dependence on the m=0 amplitude.

* Add m=1 correction coil and observe what happens to the m=0 mode at the poloidal gap. Also measure the amplitude of the zero frequency modes n=1,5,6,7 to check the nonlnear coupling of modes (1,5) and (1,6) that may be taking place and producing (0,1) mode.