MAGNETIC FIELD ERROR MEASUREMENTS AND EFFECTS ON PLASMA IN THE MST REVERSED FIELD PINCH

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MST (Madison Symmetric Torus) has been in operation since June 1988. The vacuum vessel is 5-cm-thick aluminum, 1.5 meters in major radius and 0.52 meters in minor radius. The vessel serves as the toroidal field winding and conducting shell, with a single poloidal gap and a single toroidal gap. These gaps are a potential source of error fields if great care is not used in designing the winding system. The toroidal field system produces a vacuum error field with a dominant n=4, m=0 fourier component of magnitude of order 0.2% of the toroidal field on axis as was expected. With the present temporary ohmic winding the rms of the radial magnetic field at the poloidal gap for a typical plasma is about 30% of the poloidal field at the wall. The radial and poloidal fields at the poloidal gap are measured. Correction coils are added to the poloidal gap to cancel the error field which has a large m=1 component. With the correction coils the radial field is reduced to about 20%, and the plasma resistance is reduced. With correction a coherent precursor (m=1,n=-6) on the SXR signals shows the rotation of these modes. Without correction the SXR precursors are not present and the magnetic coils do not show any coherent structure(in most of the shots). Detailed structure of these fields as well as the radial fields at the toroidal gap will be presented

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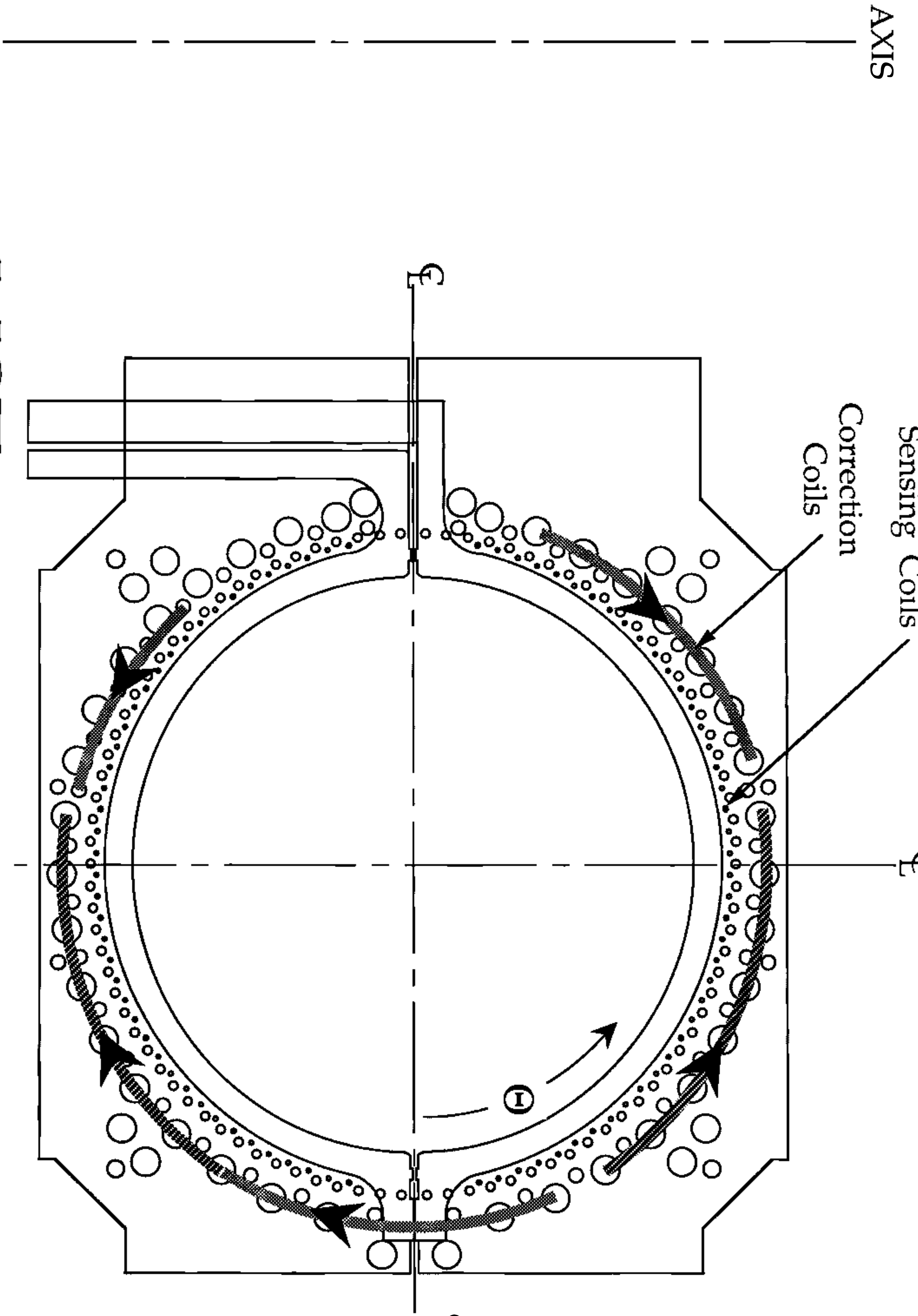


MST poloidal flange

MOTIVATION :

. Field errors are unavoidable and are an important consideration in RFP physics.

. Perturbations with poloidal mode number m=0 are resonant on the reversal surface . They have the potential to create magnetic islands which could destroy reversal.

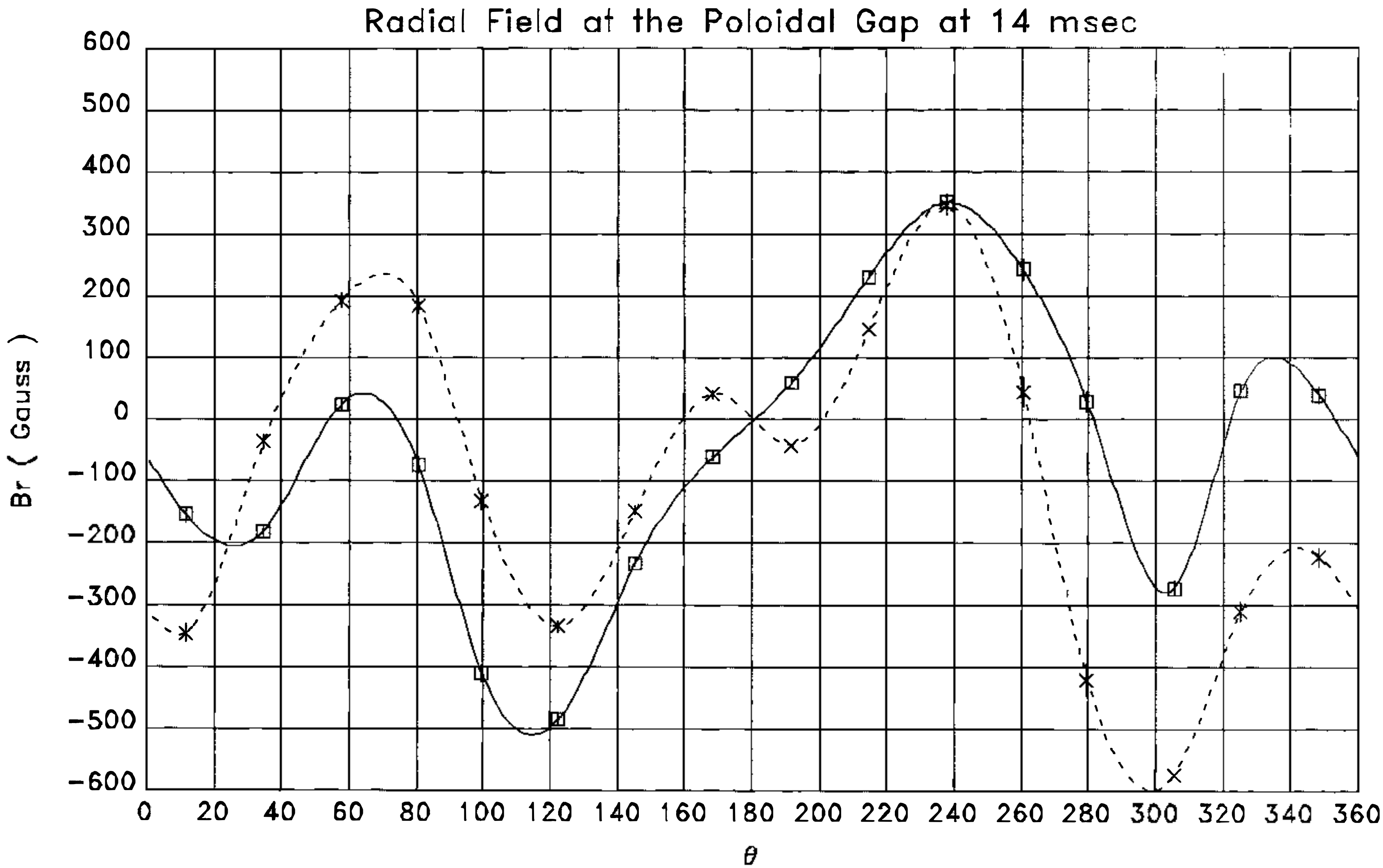
. Perturbations with m=1 have been linked to the RFP dynamo effect.

. The plasma resistance , confinement and pulse length are sensitively dependent on field errors and equilibrium.

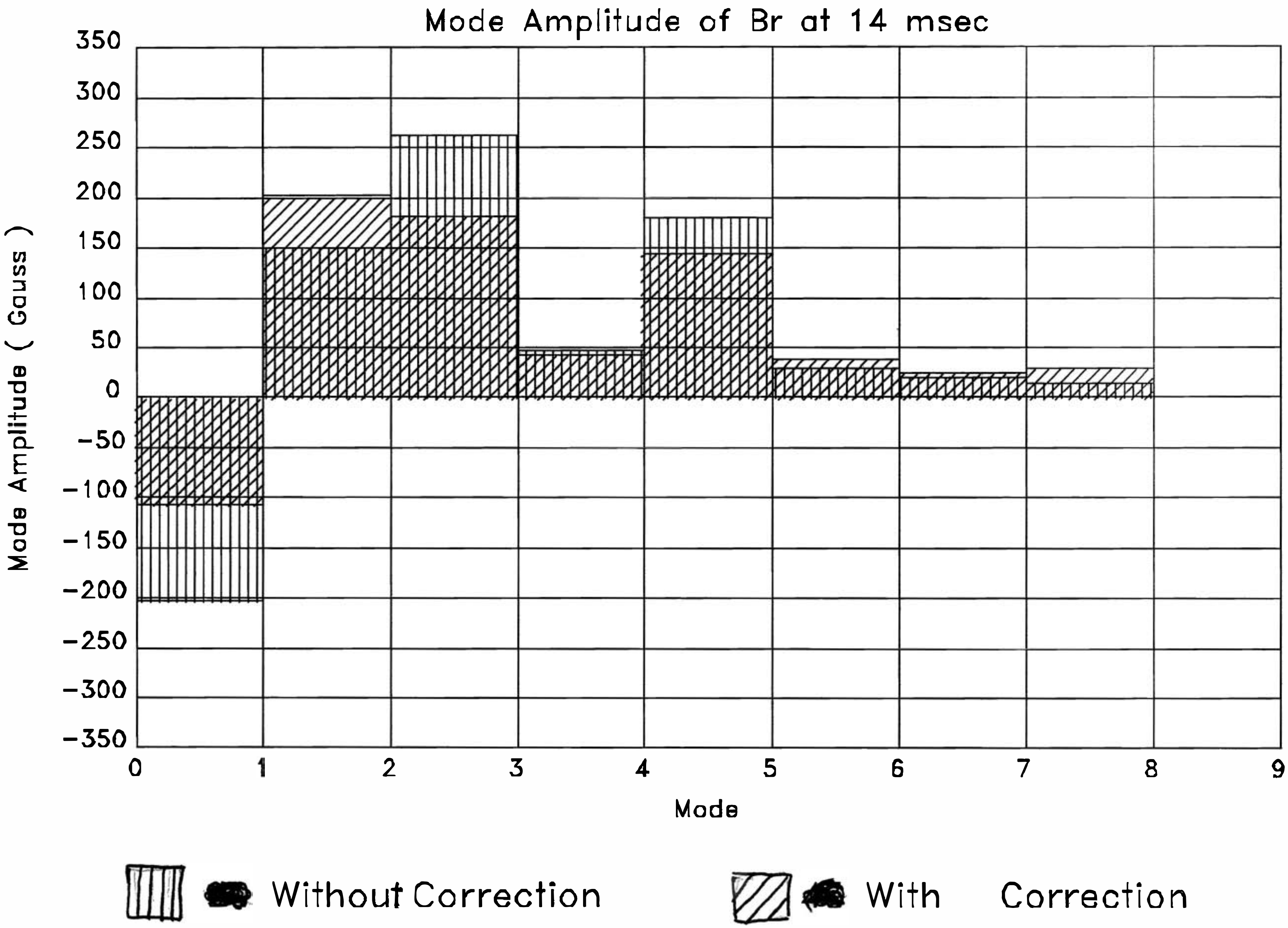
Radial magnetic field at the poloidal gap is reduced as shown below by using correction coils which are driven by the primary current (waveform).

$$Br\,(\text{rms}) = \begin{cases} 282 \text{ gauss} & \text{without correction} \\ 236 \text{ gauss} & \text{with correction} \end{cases}$$

Radial Magnetic Field With and Without Correction



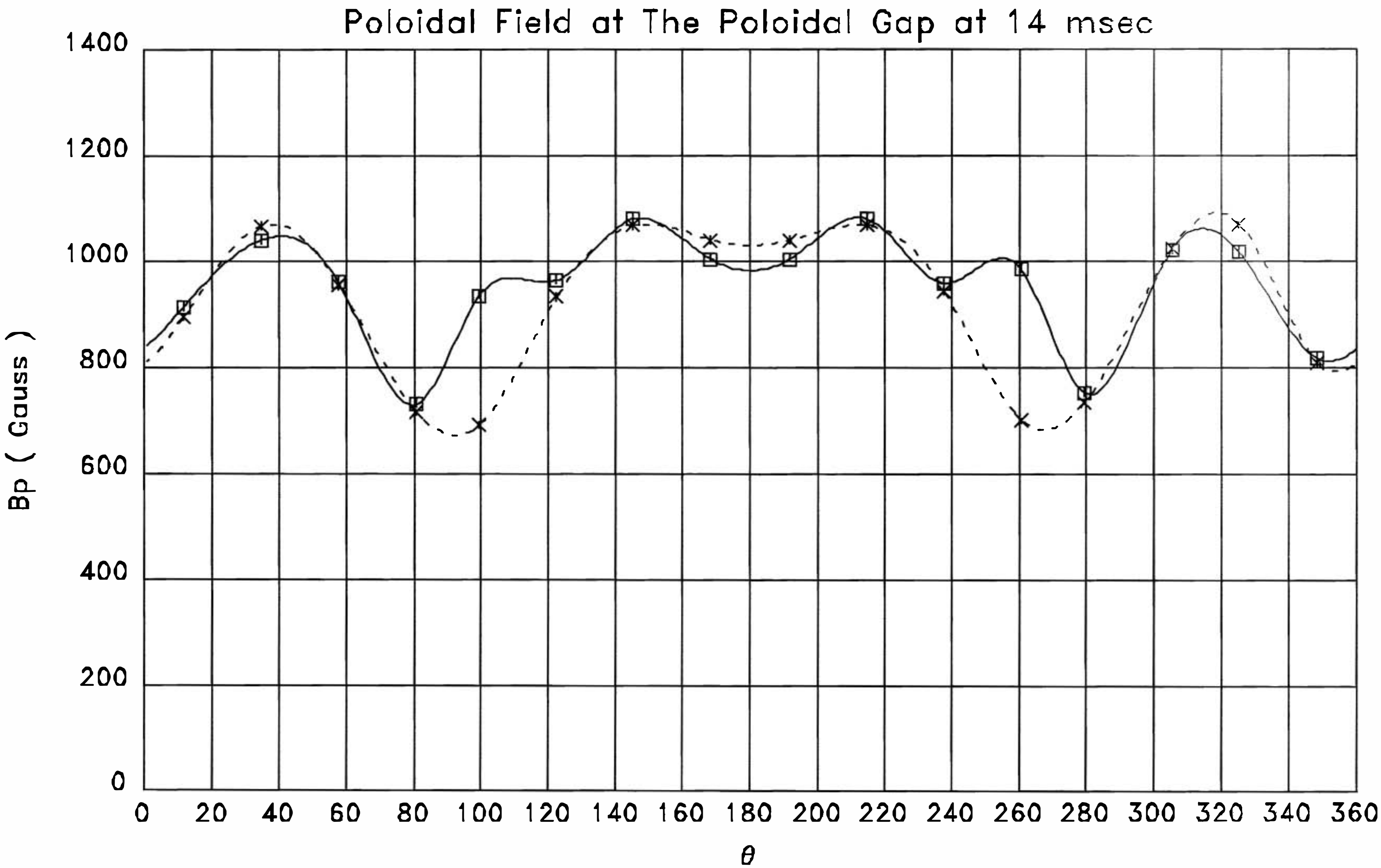
rms (W/O Corr.- -) = 282 +/- 3 Gauss   rms (With Corr.-) = 236 +/- 3 Gauss


Mode Amplitude of Br at 14 msec
350
300
250
200
150
100
50
0
−50
−100
−150
−200
−250
−300
−350
Mode Amplitude (Gauss)
0
1
2
3
4
5
6
7
8
9
Mode
Without Correction
With Correction

Poloidal magnetic field is also affected by the correction , the profiles flatten with the correction.

$$\Lambda \text{ (asymmetry factor)} = \begin{cases} -11.5\ \% & \text{without correction (peaked)} \\ -14.7\ \% & \text{with correction (flatter)} \end{cases}$$

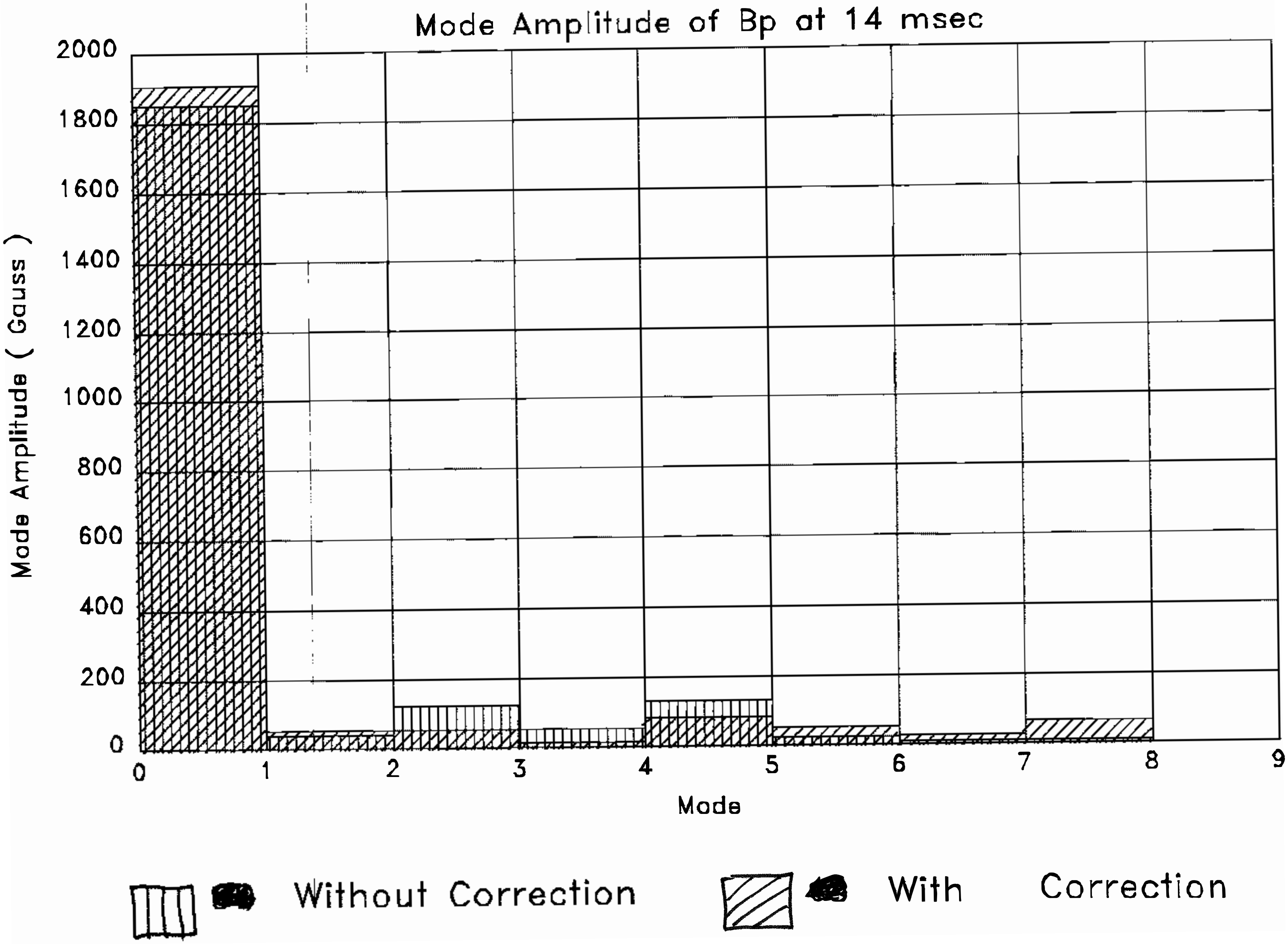
Poloidal Magnetic Field With and Without Correction



rms (W/O Corr.– –) = 914 +/– 1 Gauss $\Lambda = -11.520$ %

rms (With Corr.–) = 947 +/– 1 Gauss $\Lambda = -14.740$ %

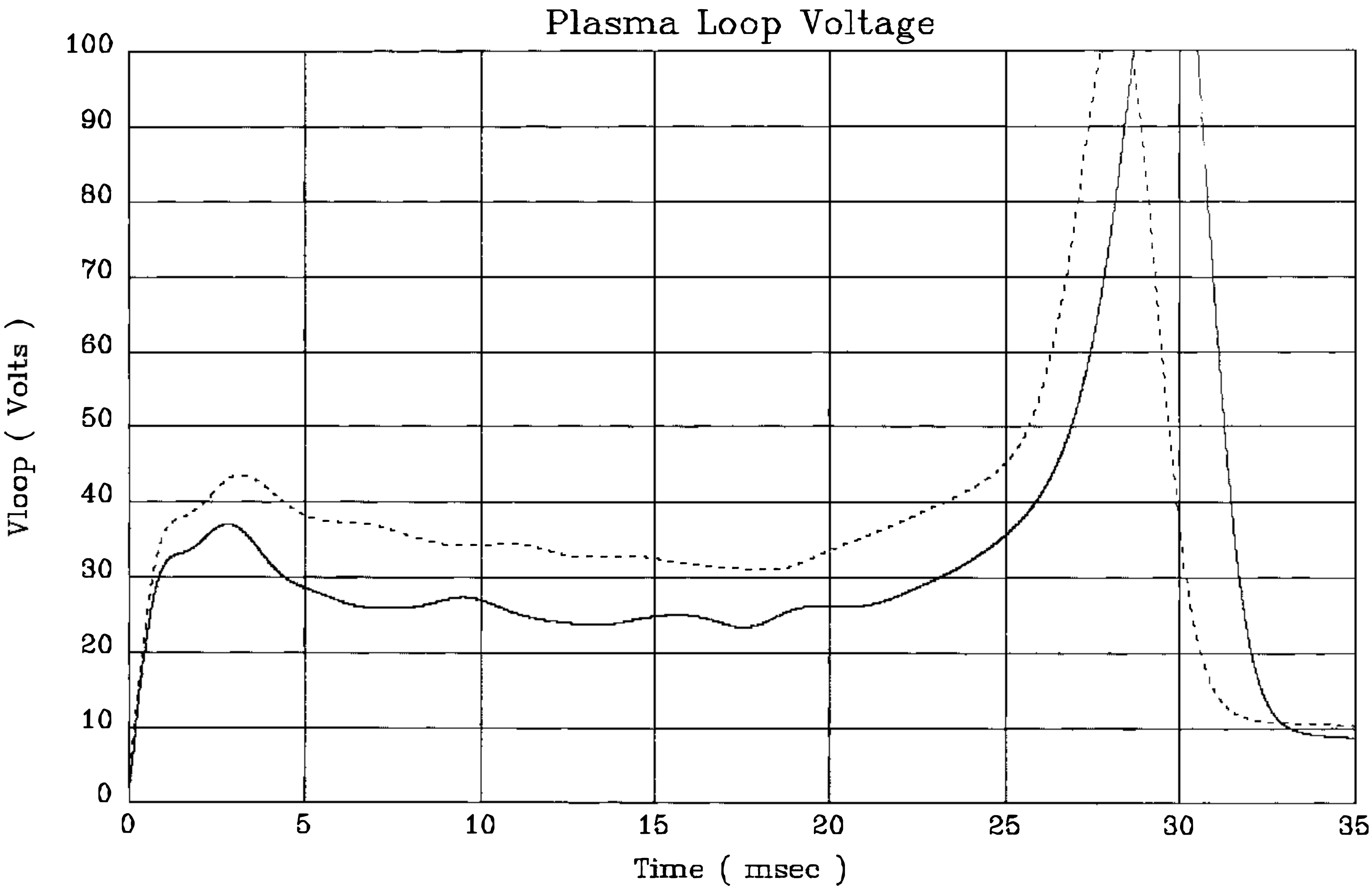
USING DATA FROM APR-6-1984 (N.C. 2 NEW COR.)


Mode Amplitude of Bp at 14 msec
Mode Amplitude (Gauss)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
8
9
Mode
Without Correction
With Correction

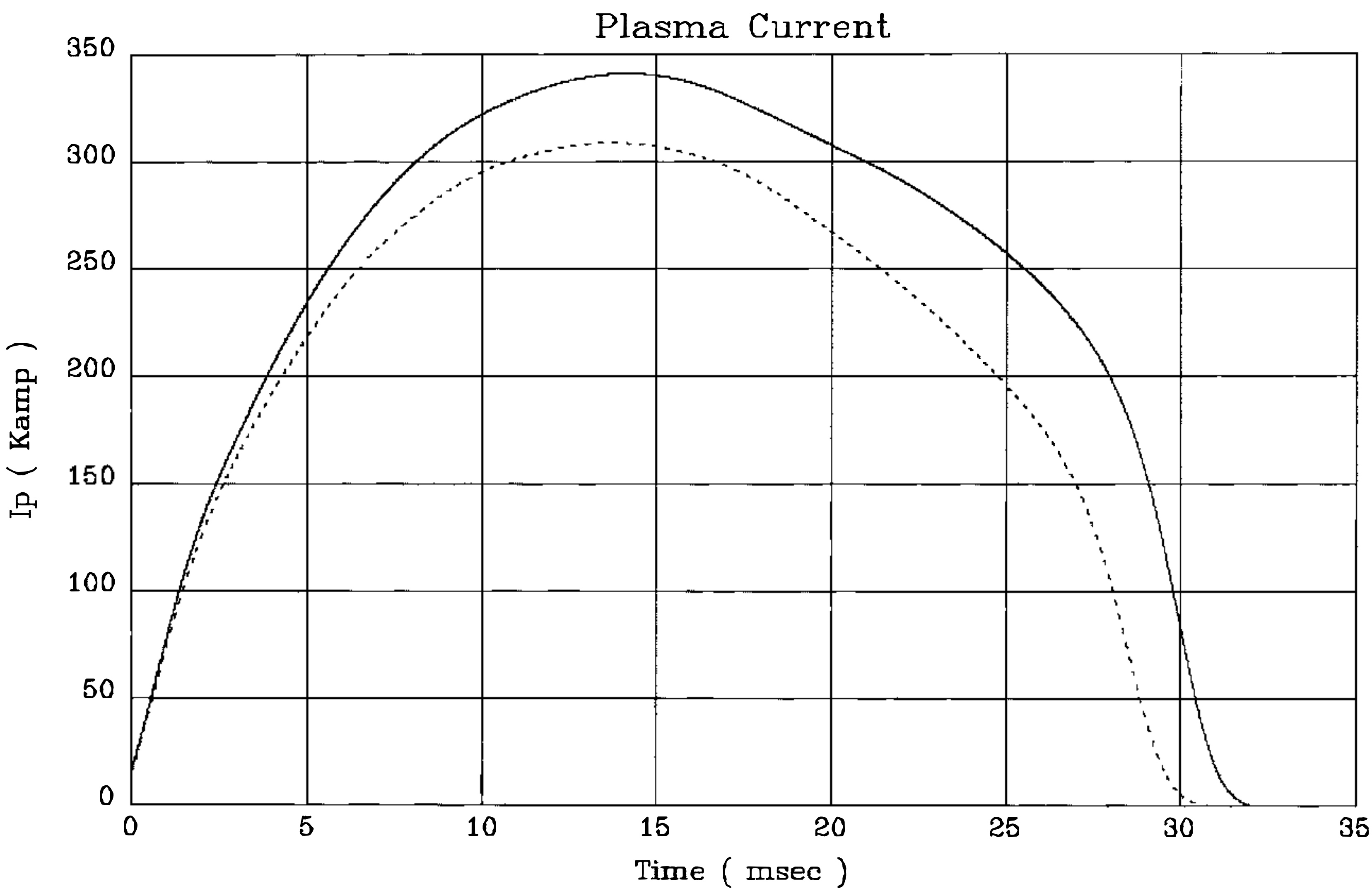
The plasma improvement can be seen more on the following plasma signals indicating enhanced plasma confinement.

- Larger plasma current.
- Lower loop voltage.
- Larger SXR signal.

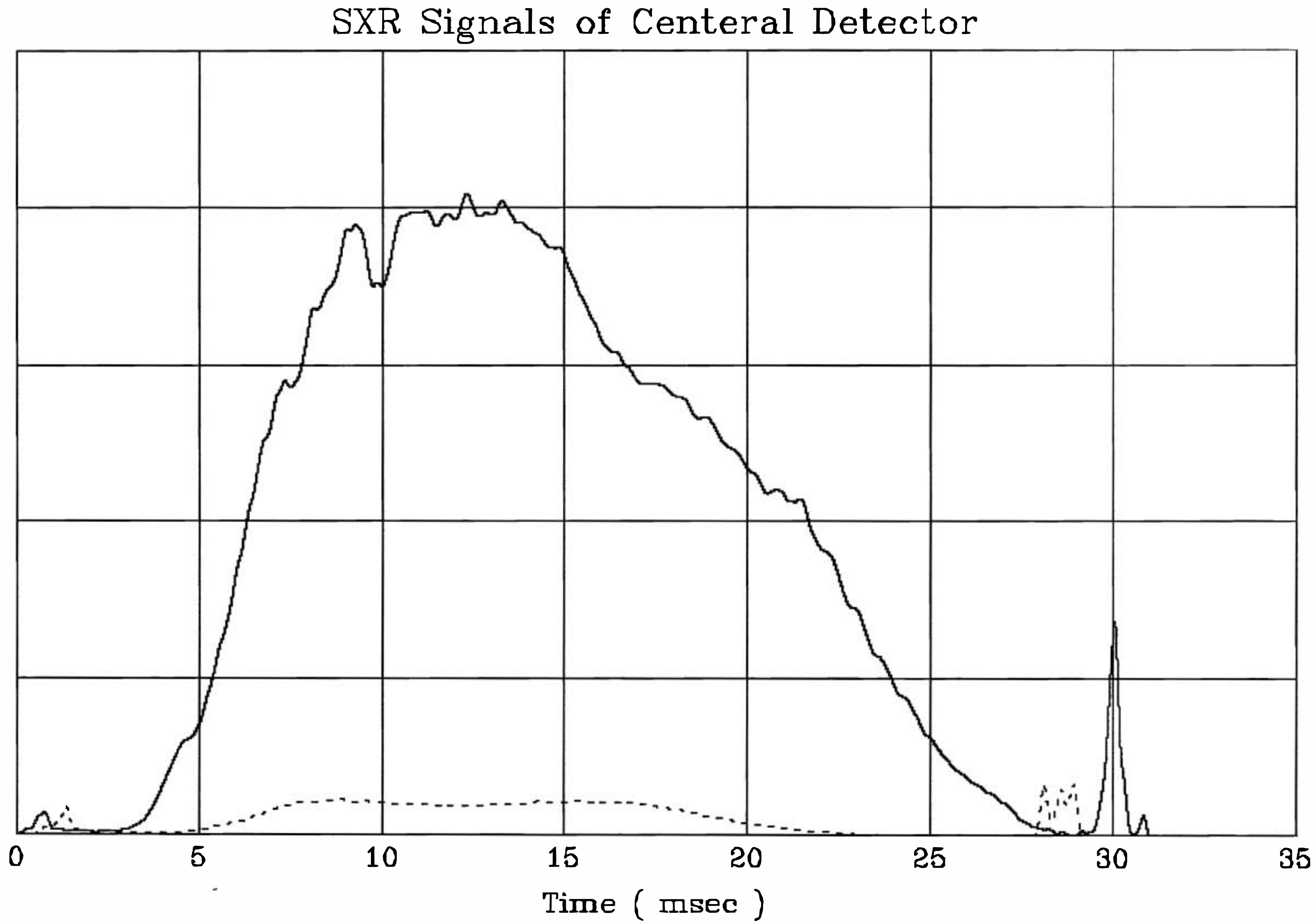
Plasma Loop Voltage Decreases With Correction



Plasma Current and Duration Increase With Correction



SXR Signals Increase With Correction



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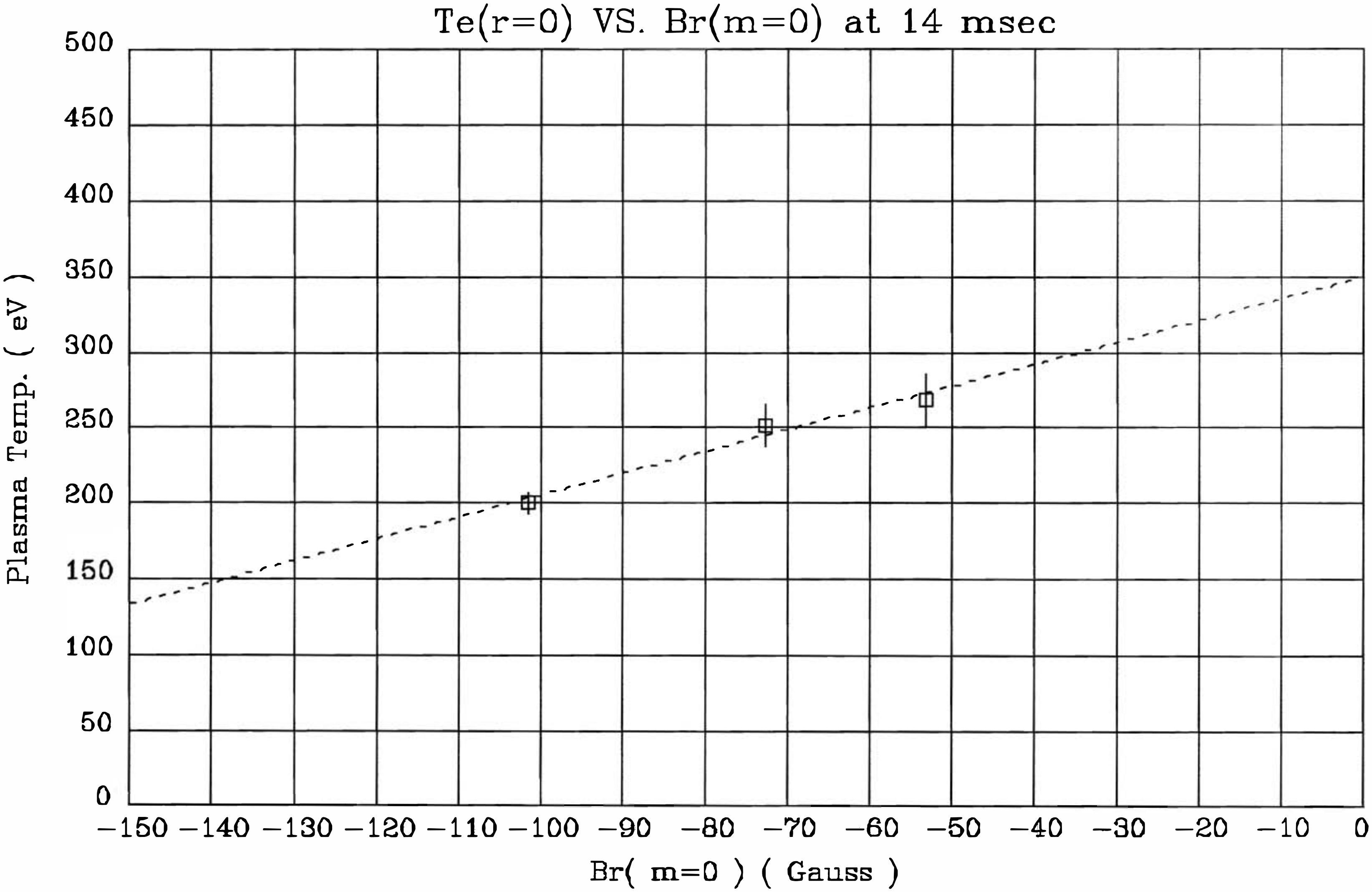
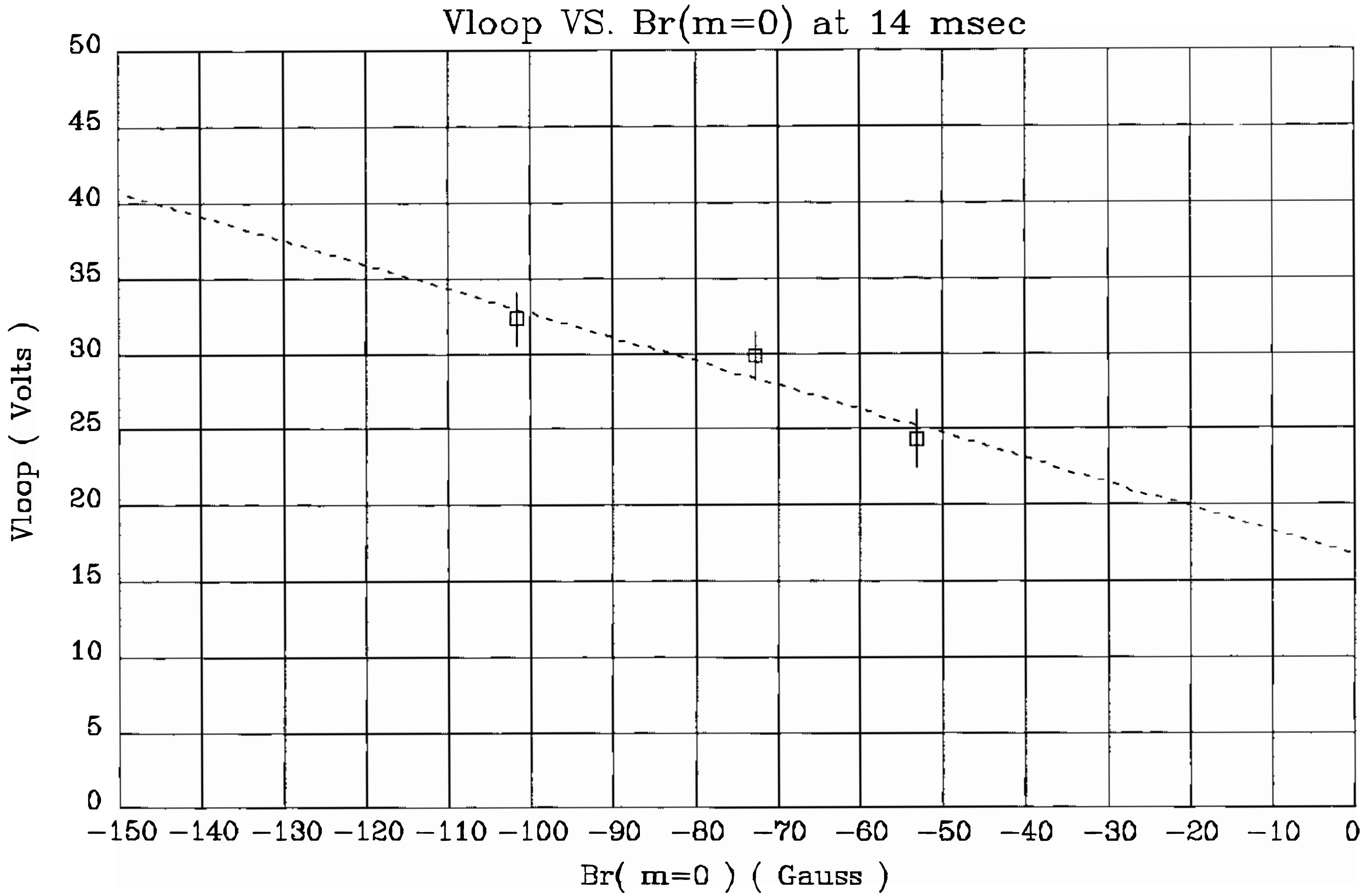
Plasma improvement seems to correlate with the amplitude of the m=0 component of the radial magnetic field.

- . T_e (r = 0) increases with reduced B_r(m=0).
- . n_e (r = 0) decreases with reduced B_r(m=0) (flatting profiles).

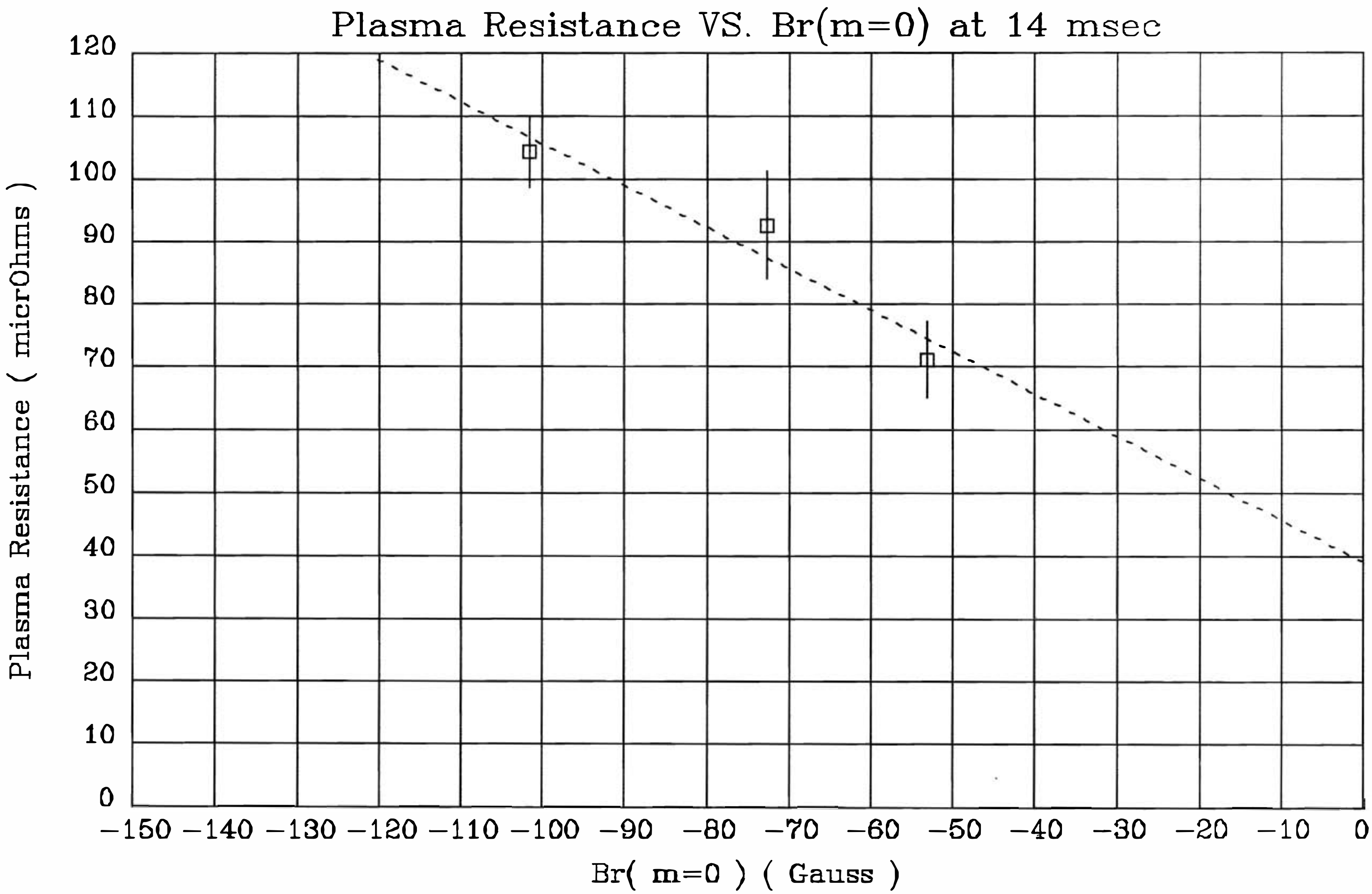
Central Plasma Temperature Increases With Decreasing m=0 Amplitude



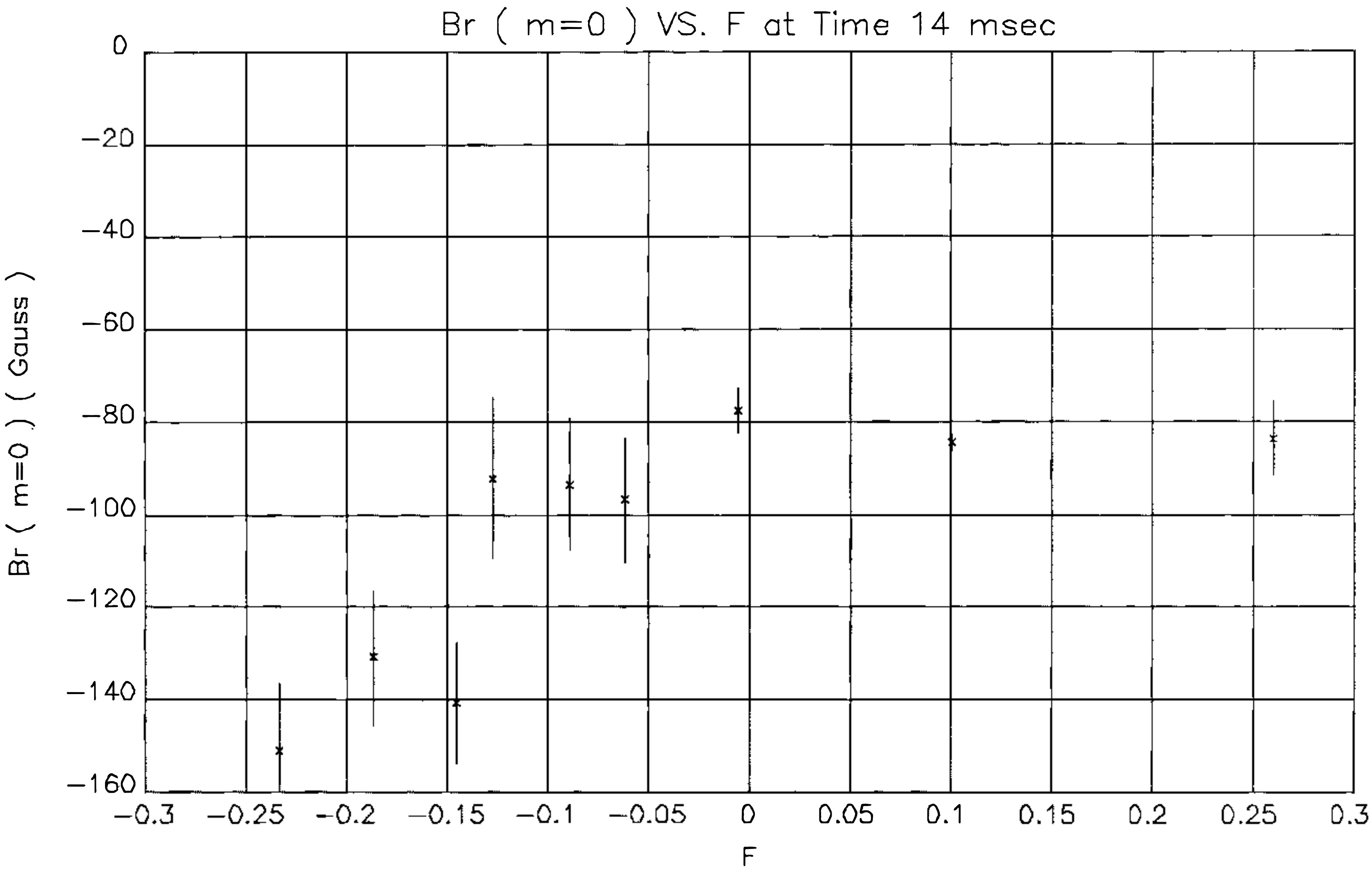
Plasma Loop Voltage Decreases With Decreasing m=0 Amplitude



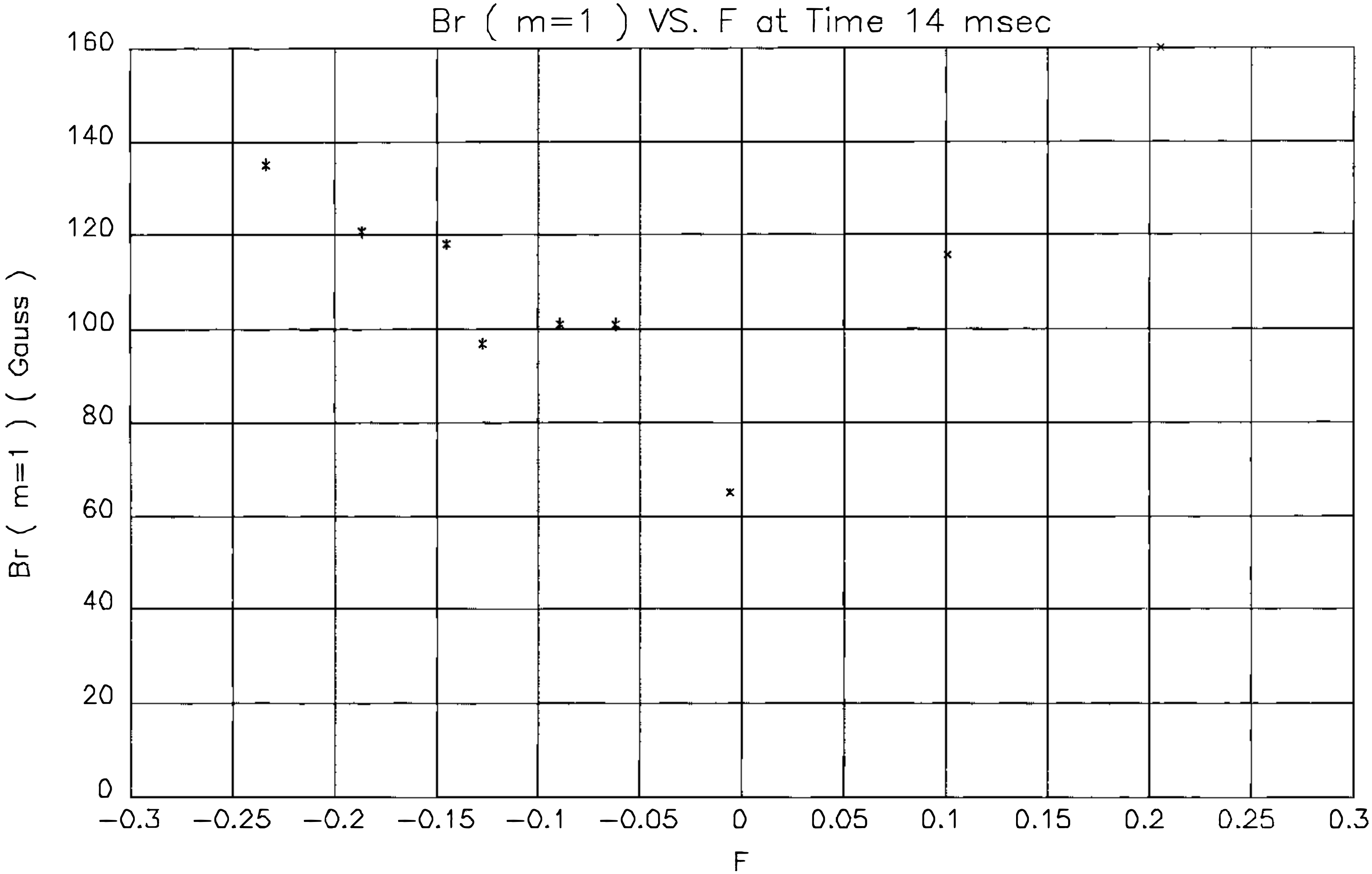
Plasma Resistance Decreases With Decreasing m=0 Amplitude



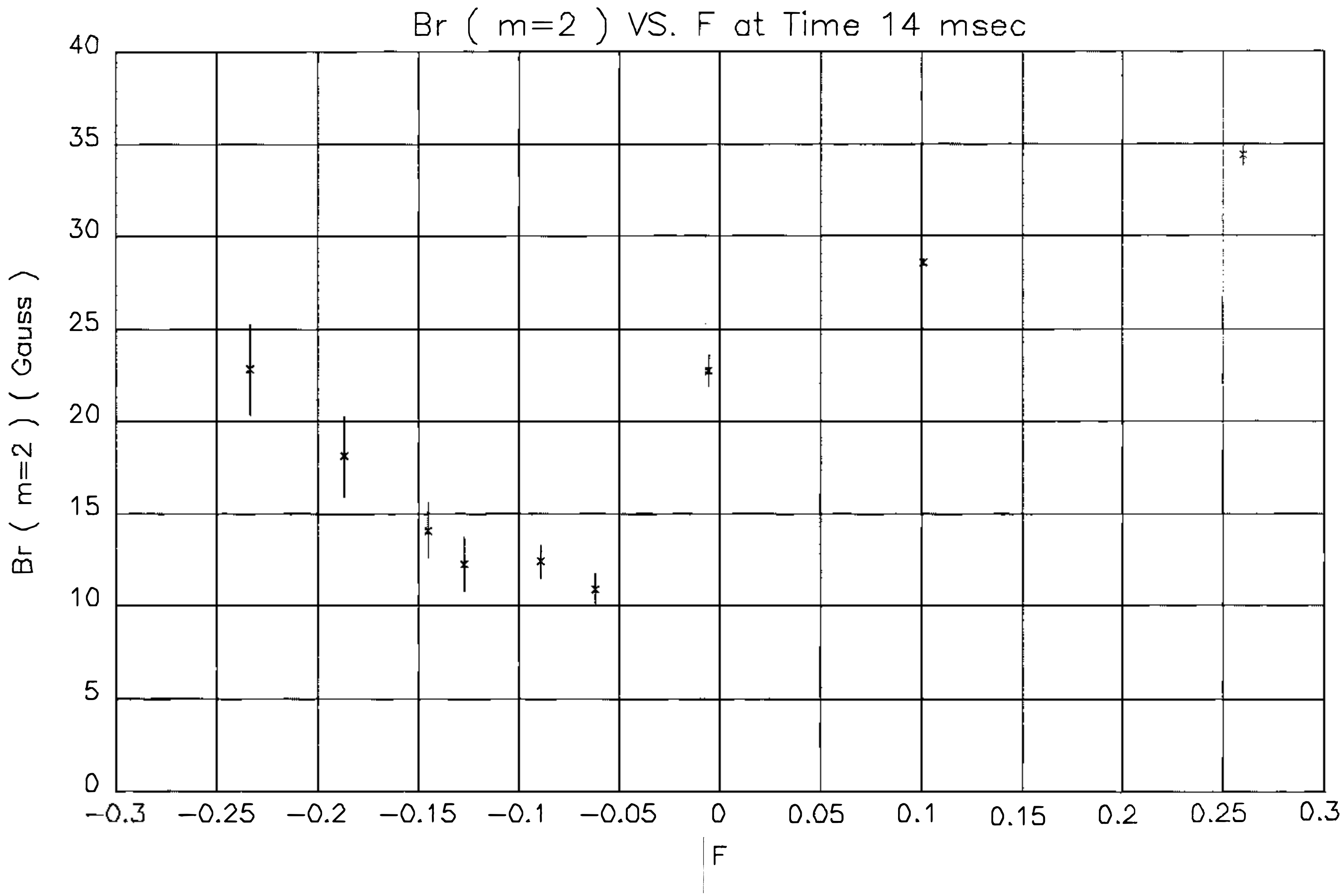
The lower modes ($m = 0, 1, 2$) of B_r depend on the field reversal parameter $F = B_t(\text{wall}) / \langle B_t \rangle$ indicating that these modes are caused by profile changes (plasma displacement).



F Scane Taken on 30−MAR−1989



F Scane Taken on 30−MAR−1989



F Scane Token on 30—MAR—1989

CONCLUSIONS :

- Lower radial magnetic field at the poloidal gap enhances machine performance.
- The performance dependence sensitively on the m=0 component of the radial field.
- Since RFP confinement is thought to be determined by the outer region of the plasma , RFP's are very vulnerable to m=0 radial fields.

. m=0 is resonant at the reversal surface and will cause Islands.

. The m=0 field lines enter the machine at the poloidal gap (very broad n spectrum) and leave the toroid though the toroidal gap . Hence they interact with the plasma over a larger volume , whereas the other modes will effect the magnetic surfaces only at the gap by giving a kick to the field lines forming these surfaces.