A comparison of locked modes in two reversed field pinch devices

J-A Malmberg[1], P Brunsell[1], Y Yagi[2]

[1] Division of Fusion Plasma Physics, Alfvén Laboratory, Royal Institute of Technology, SE-100 44 Stockholm, Sweden, Association EURATOM/NFR

[2] Electrotechnical Laboratory, 1-1-4 Umezono, Tsukuba-shi, Ibaraki, Japan

Introduction - TPE-RX and T2

Locked modes - detection

Locked mode distribution in TPE-RX and T2

TPE-RX and T2 mode spectra

## Locked mode dependence on operational parameters

Summary

# EXTRAP-T2 and TPE-RX reversed field pinches

| Parameters	TPE-RX	EXTRAP-T2
R/a	$1.72/0.45m = 3.8$	$1.24/0.183m = 6.8$
Ip_{max}	$\sim$500 kA	$\sim$250 kA
First wall material	Stainless steel	Graphite tiles
Limiters	Mo limiters	none
Shell system	Conducting shell syst Double layered thin shell $\sim$10 ms and single thick shell $\sim$330 ms	Resistive shell $\sim$1.5 ms
τ_{pulse}	$\sim 100ms$	$\sim 15ms$
b/a	1.08 (thin) 1.16 (thick)	1.09 (shell)

Last closed flux surface reconstruction
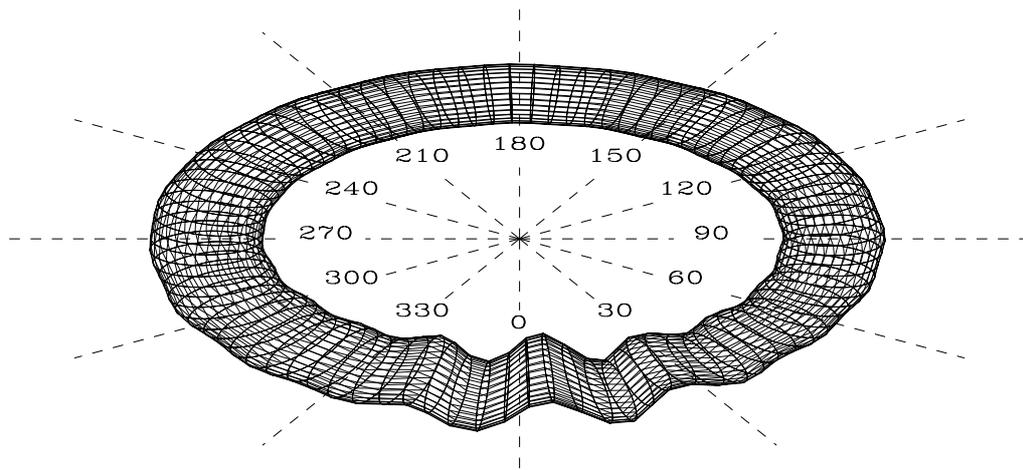
P Zanca and S Martini,
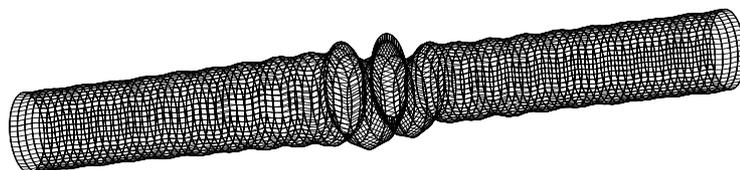Reconstruction of the plasma surface in a RFP in
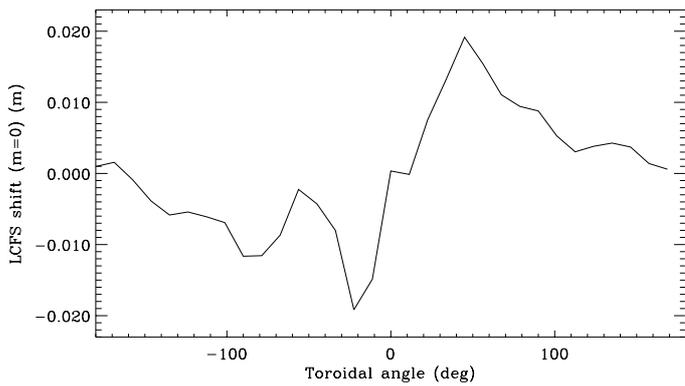the presence of non-axisymmetric perturbations,
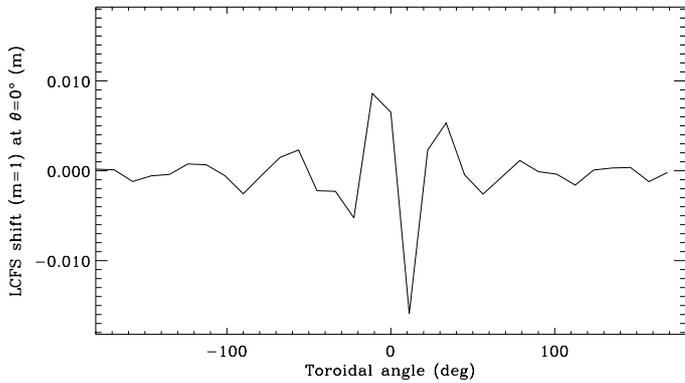
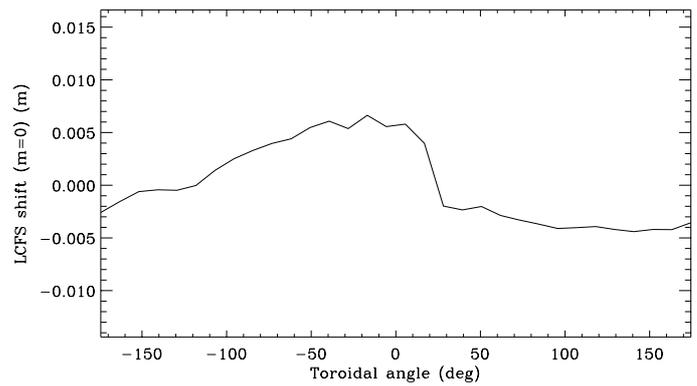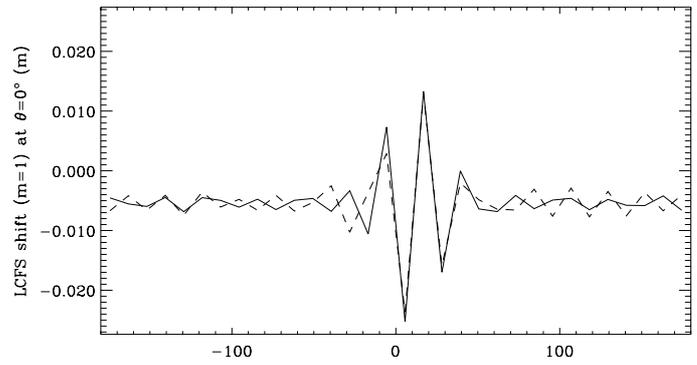# Last closed flux surface reconstruction
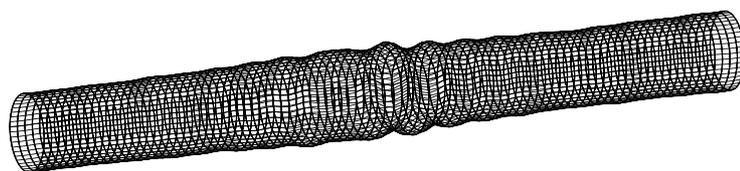
1.5 ms
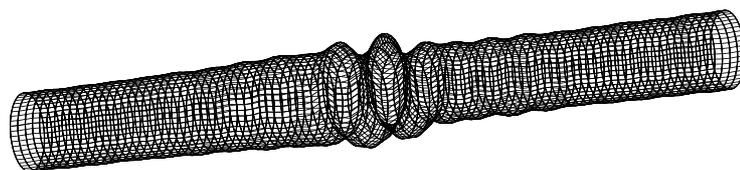
2.5 ms

5.0 ms

Last closed flux surface reconstruction

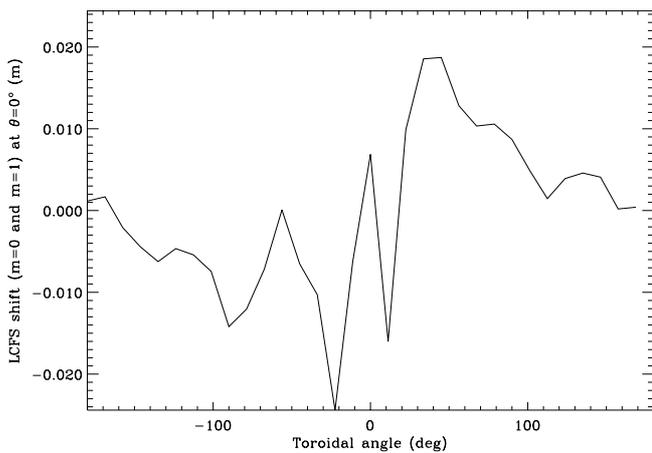**TPE-RX m=1 (top) and m=0 (bottom) average LCFS (θ=0).**

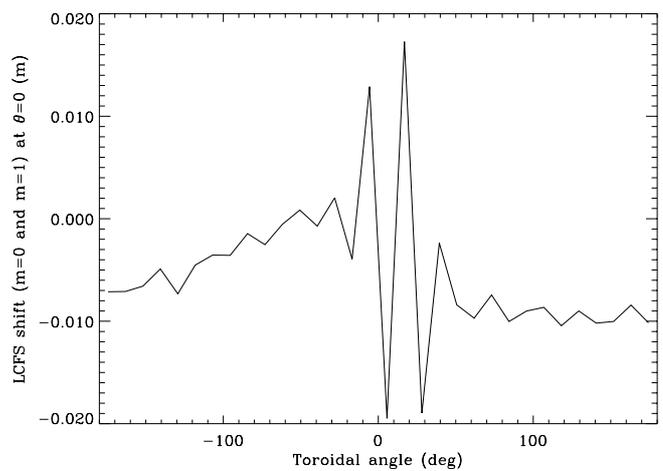**T2 m=1 (top) and m=0 (bottom) average LCFS (θ=0).**
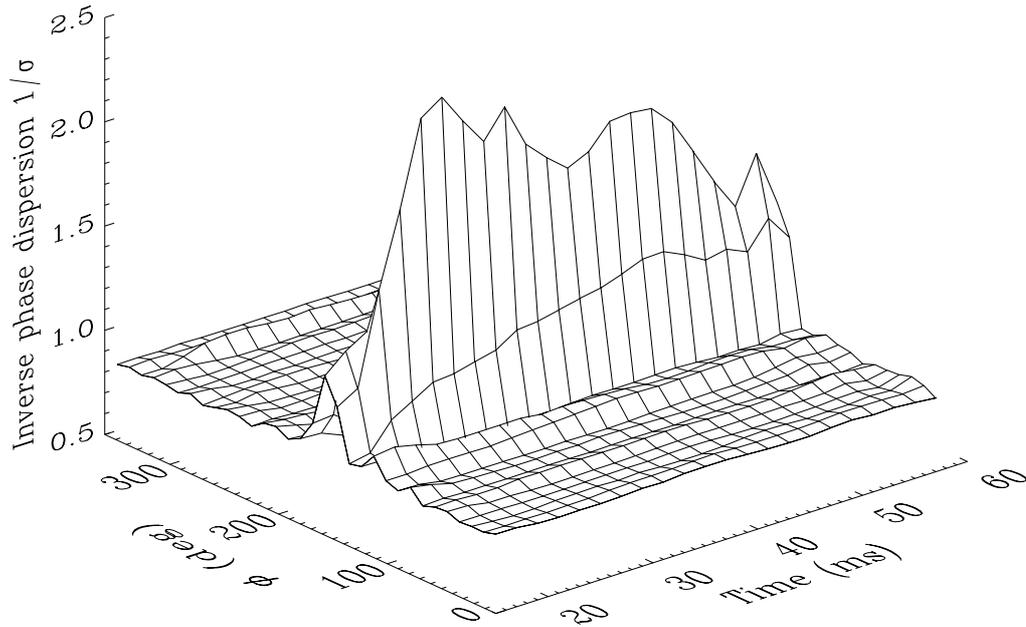

TPE-RX m=0 + m=1 average LCFS.
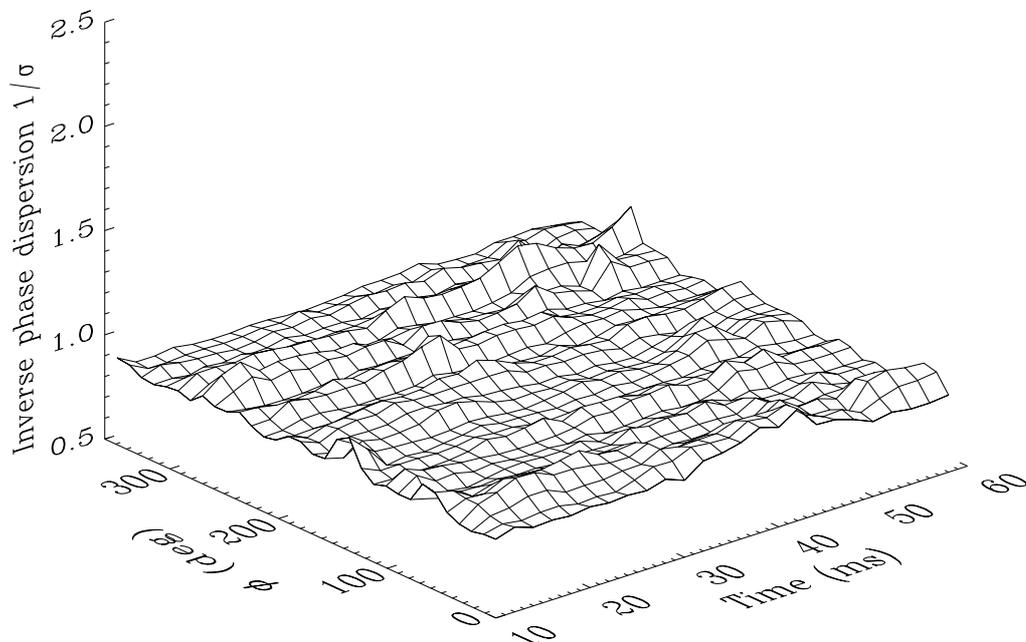

T2 m=0 + m=1 average LCFS.

Inverse dispersion of phases

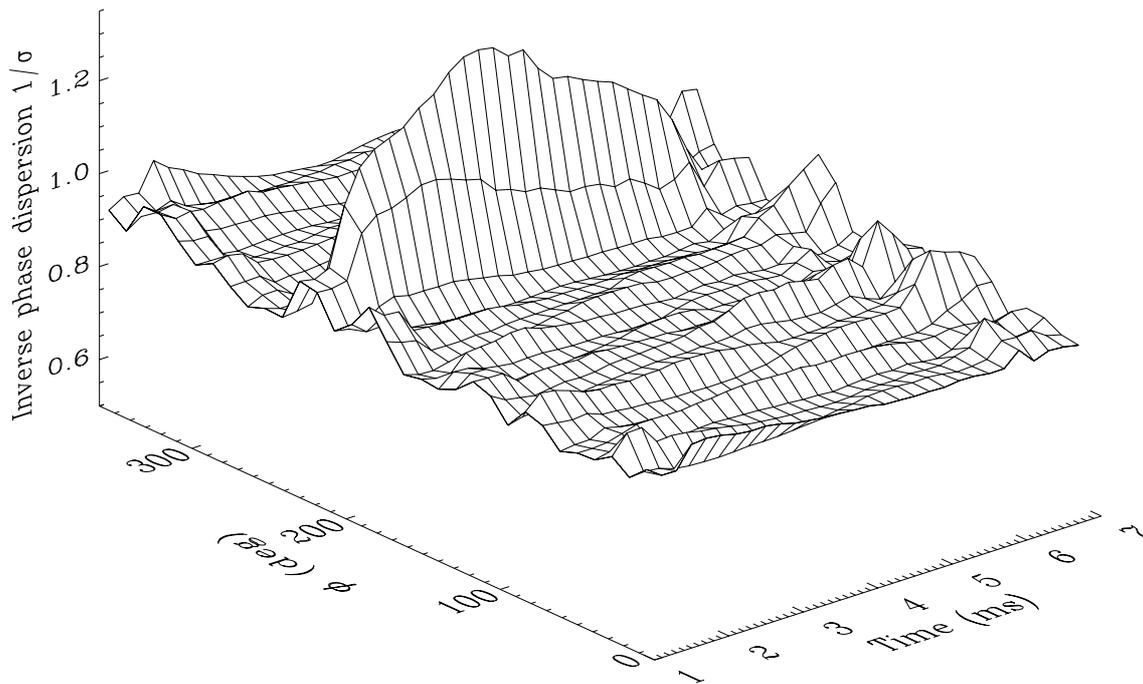## $1/\sigma$ clearly locked discharge, TPE-RX

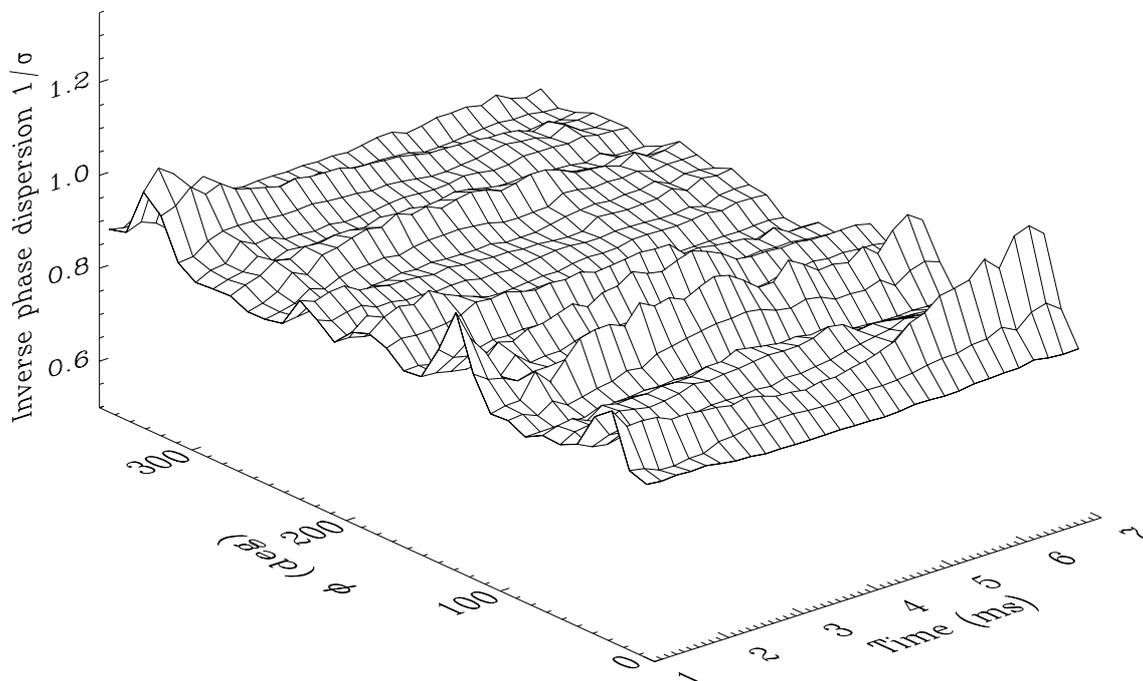
$1/\sigma$ unclearly locked discharge, TPE-RX
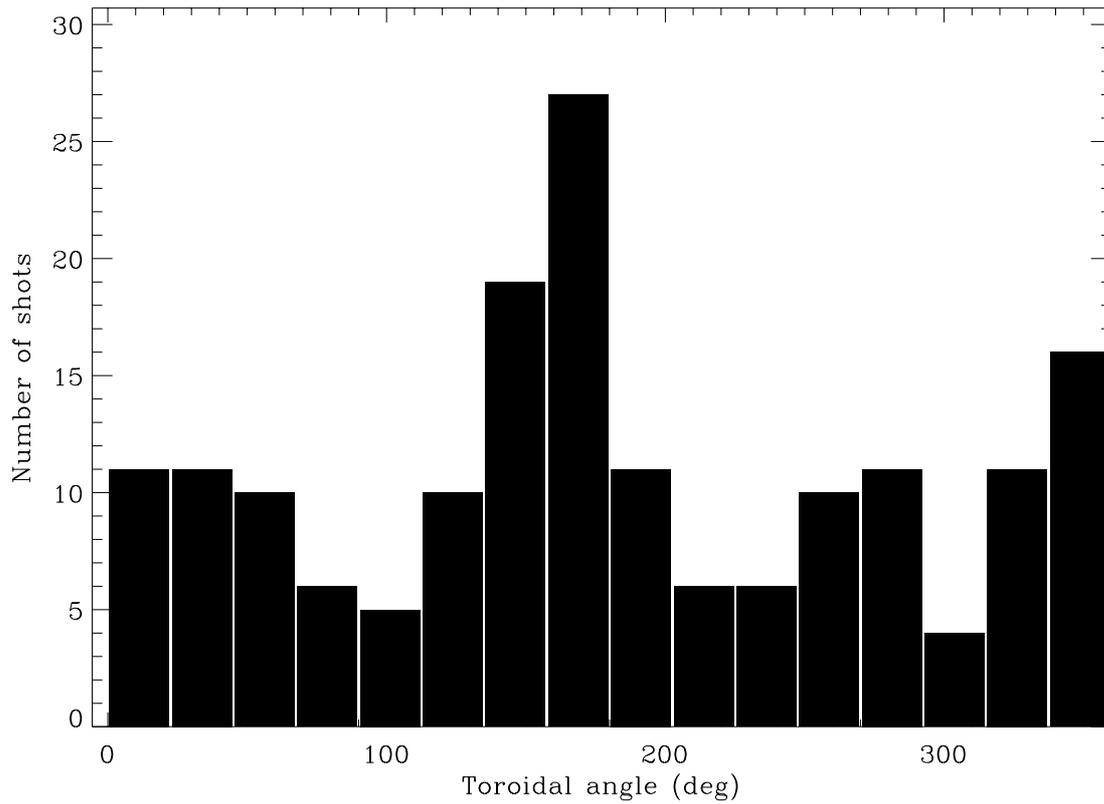
Inverse dispersion of phases

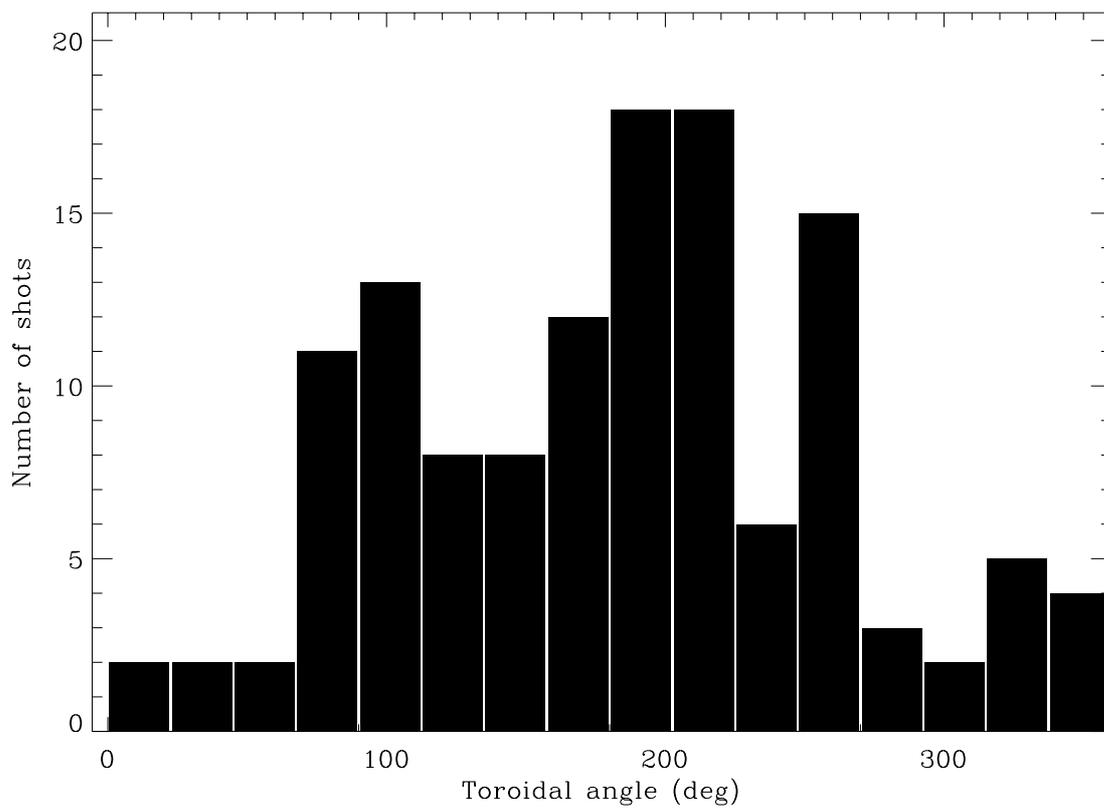## $1/\sigma$ clearly locked discharge, T2

$1/\sigma$ unclearly locked discharge, T2
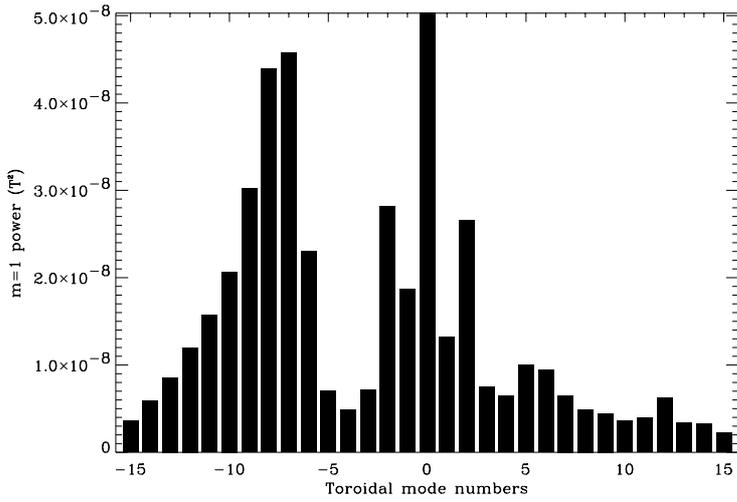
Toroidal distribution of locked mode in TPE-RX

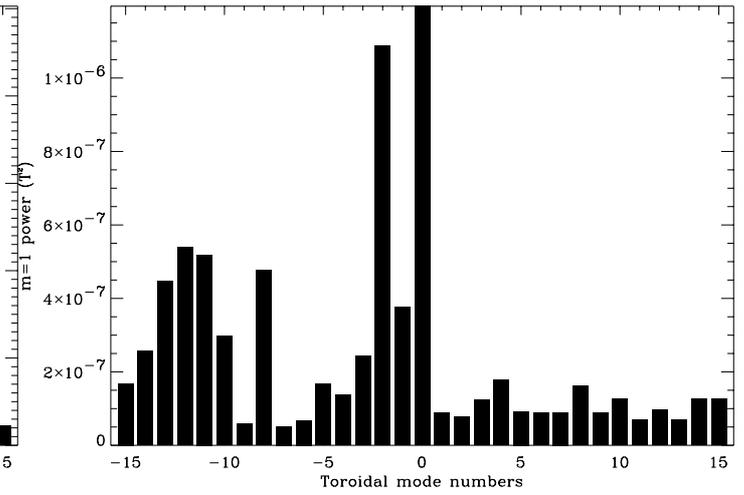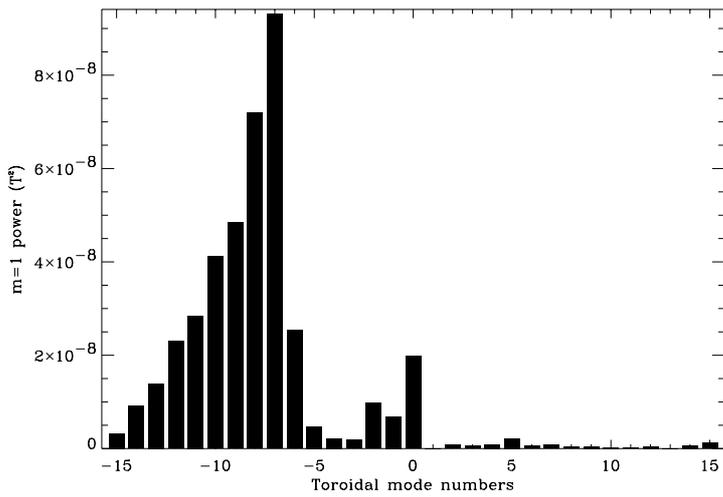# Toroidal distribution of locked mode in T2

Average mode spectra

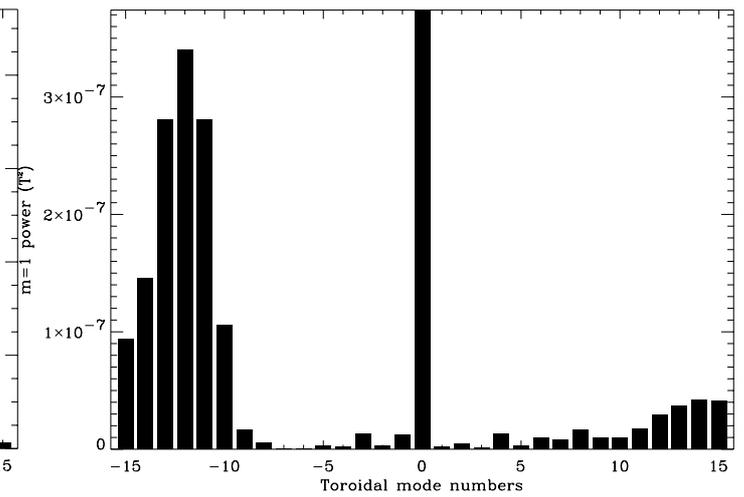## TPE-RX average m=1 mode spectrum
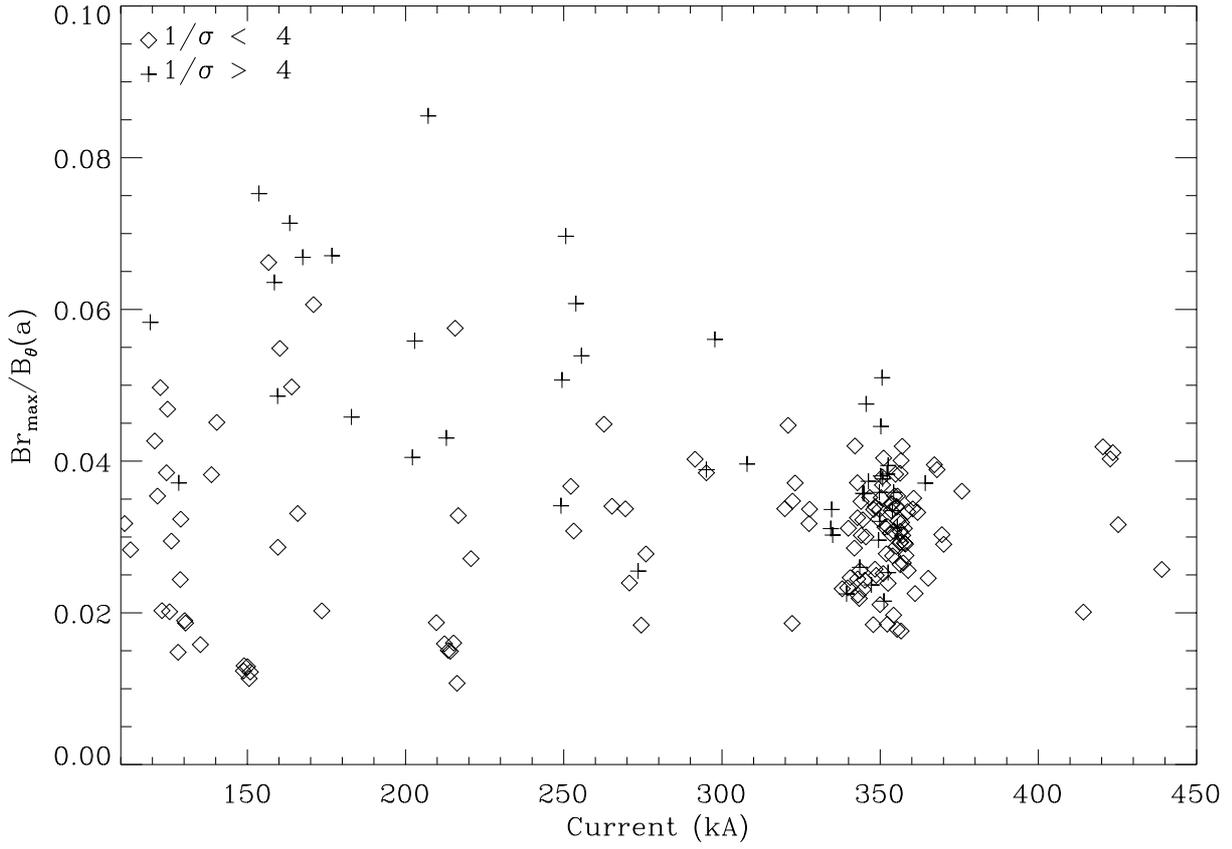

T2 average m=1 mode spectrum

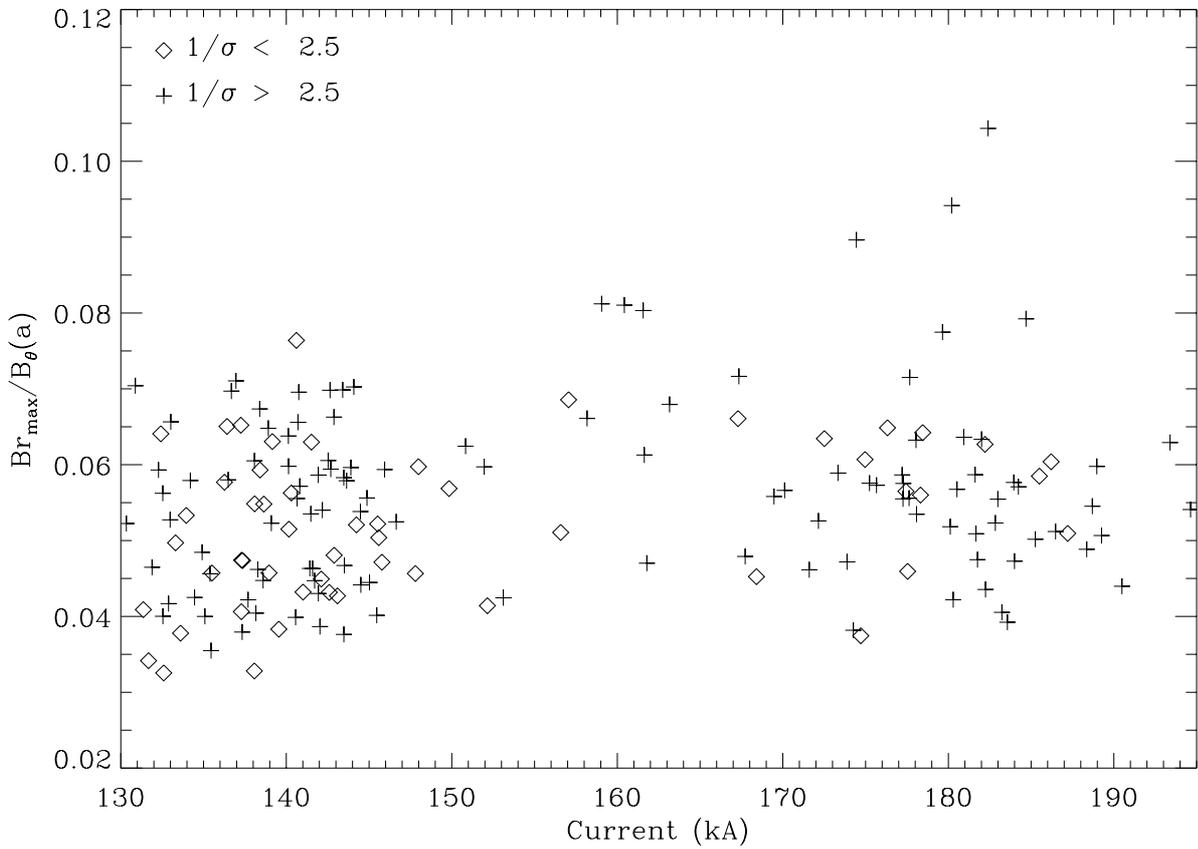## TPE-RX artificially rotated m=1 mode spectrum
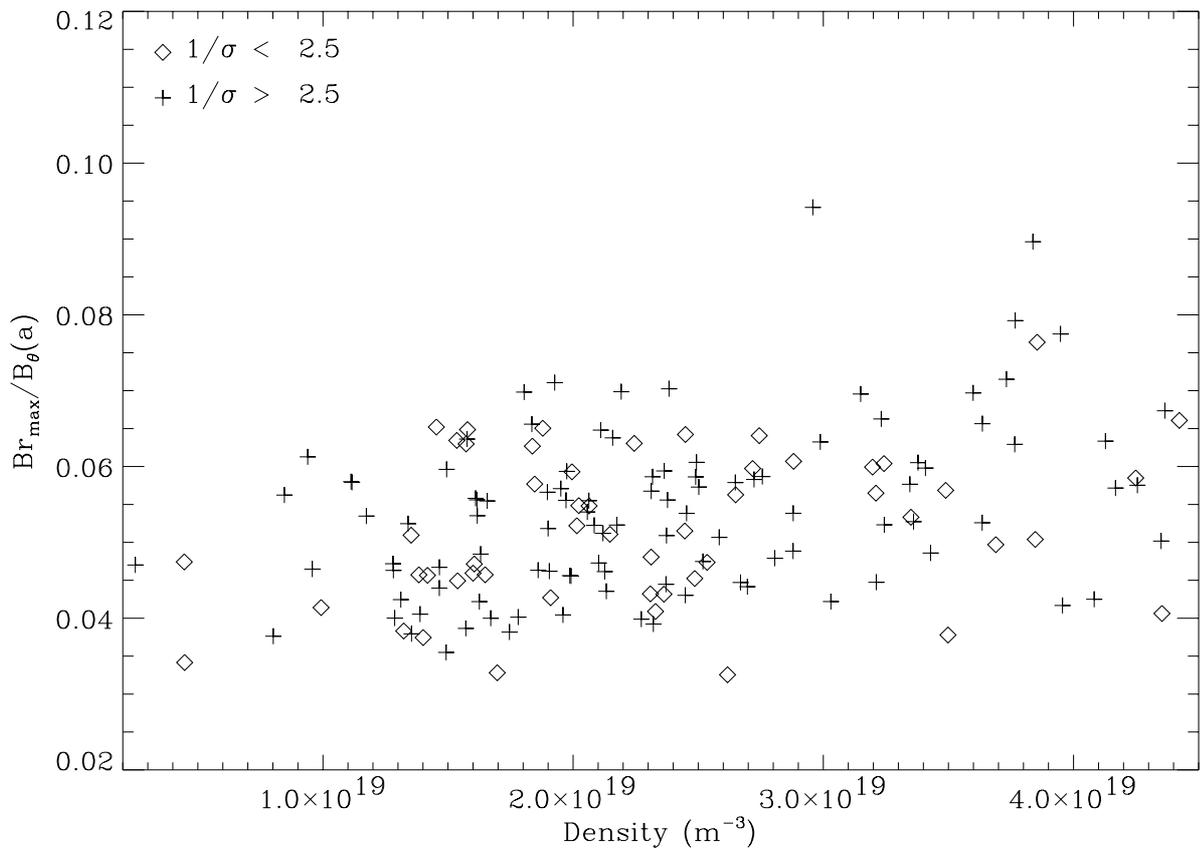

T2 artificially rotated m=1 mode spectrum

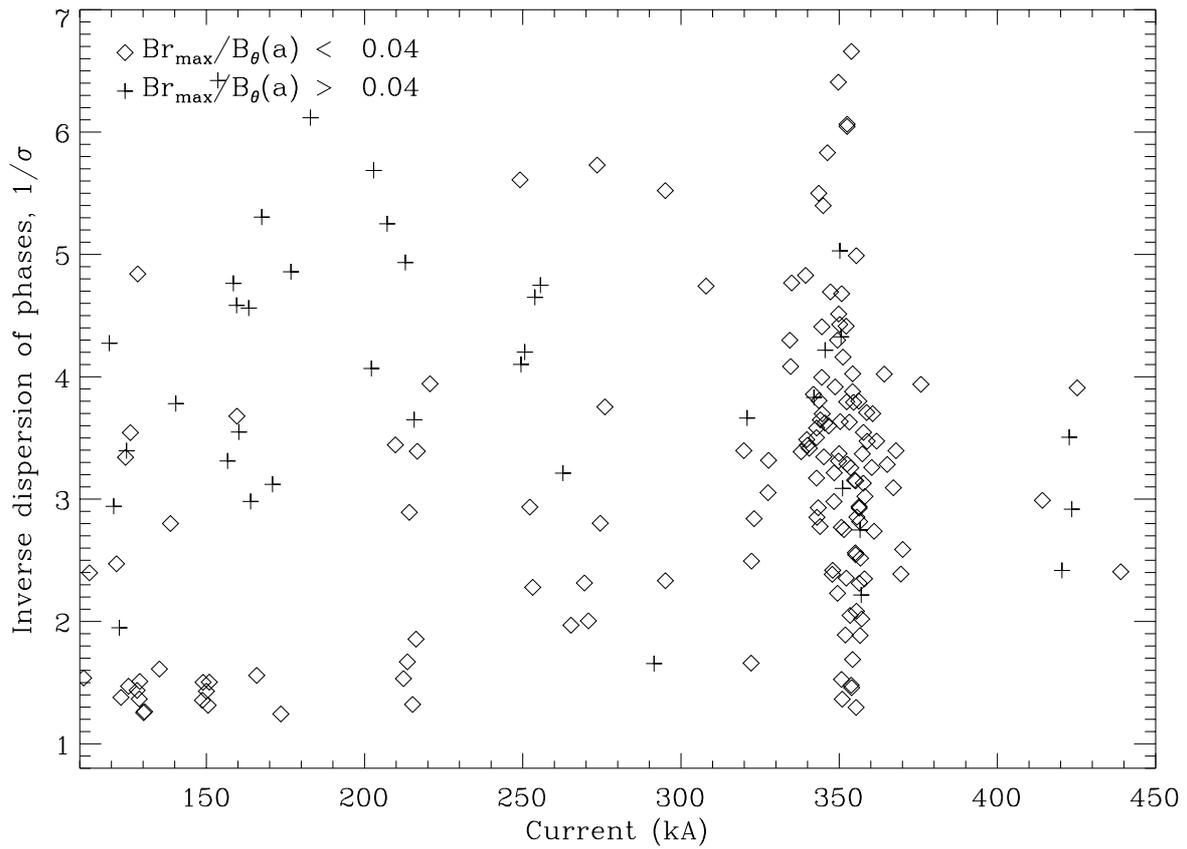# TPE-RX $Br_{max}/B_\theta(a)$ versus plasma current.

T2 $Br_{max}/B_\theta(a)$ versus plasma current.
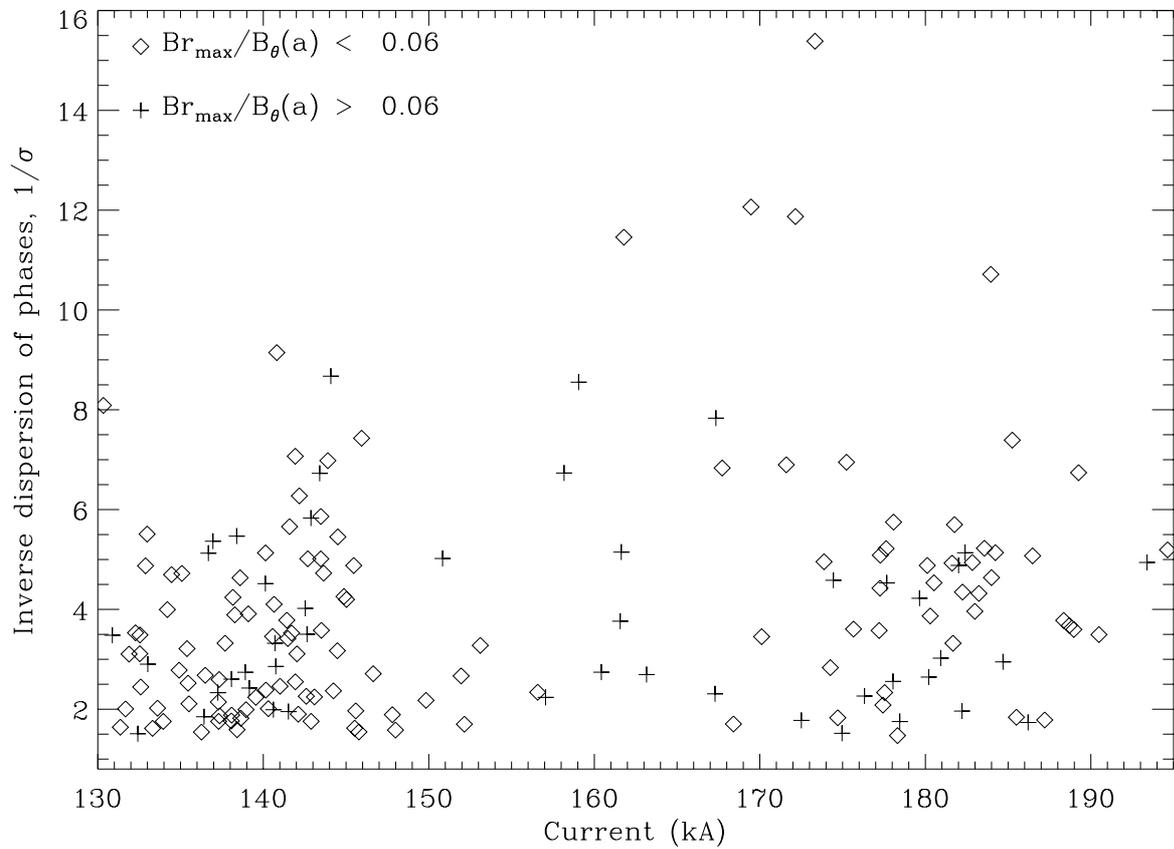
T2 $Br_{max}/B_\theta(a)$ versus electron density.

TPE-RX inverse dispersion of phases versus plasma current.

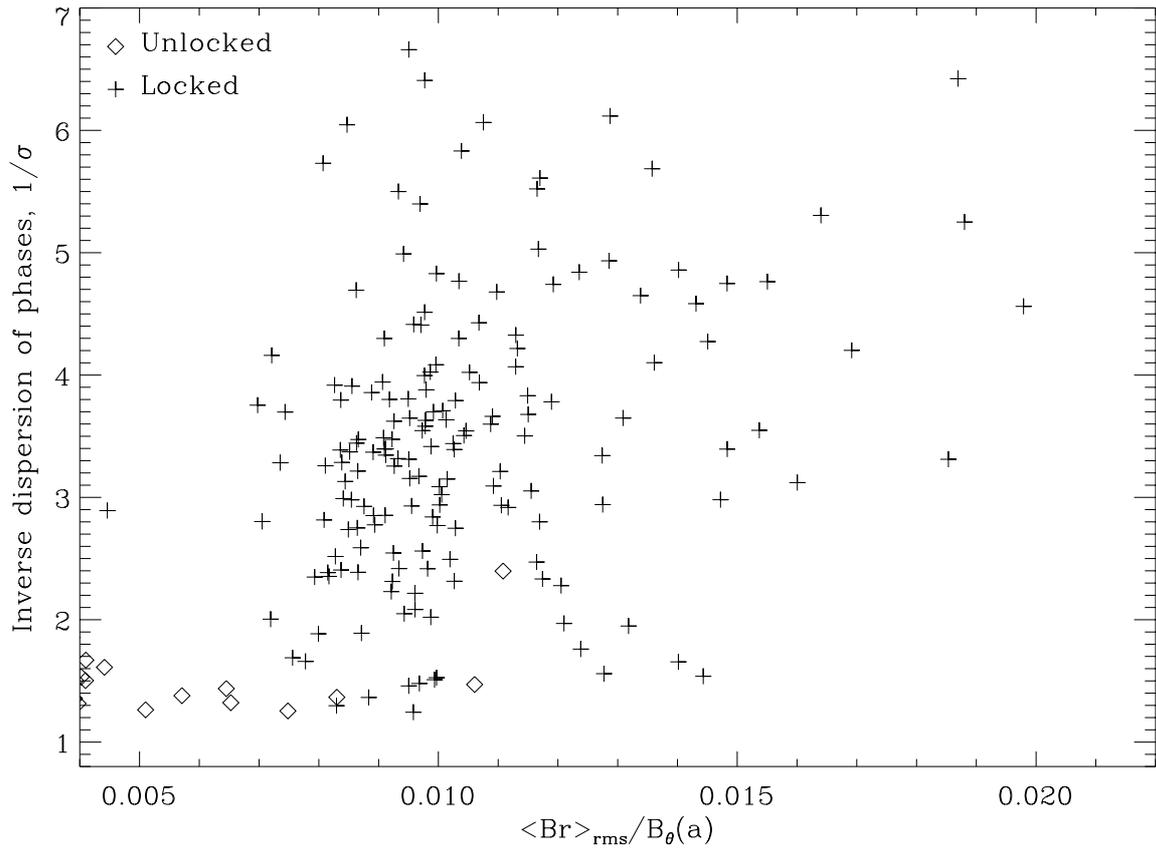## T2 inverse dispersion of phases versus plasma current.

T2 inverse dispersion of phases versus electron density.
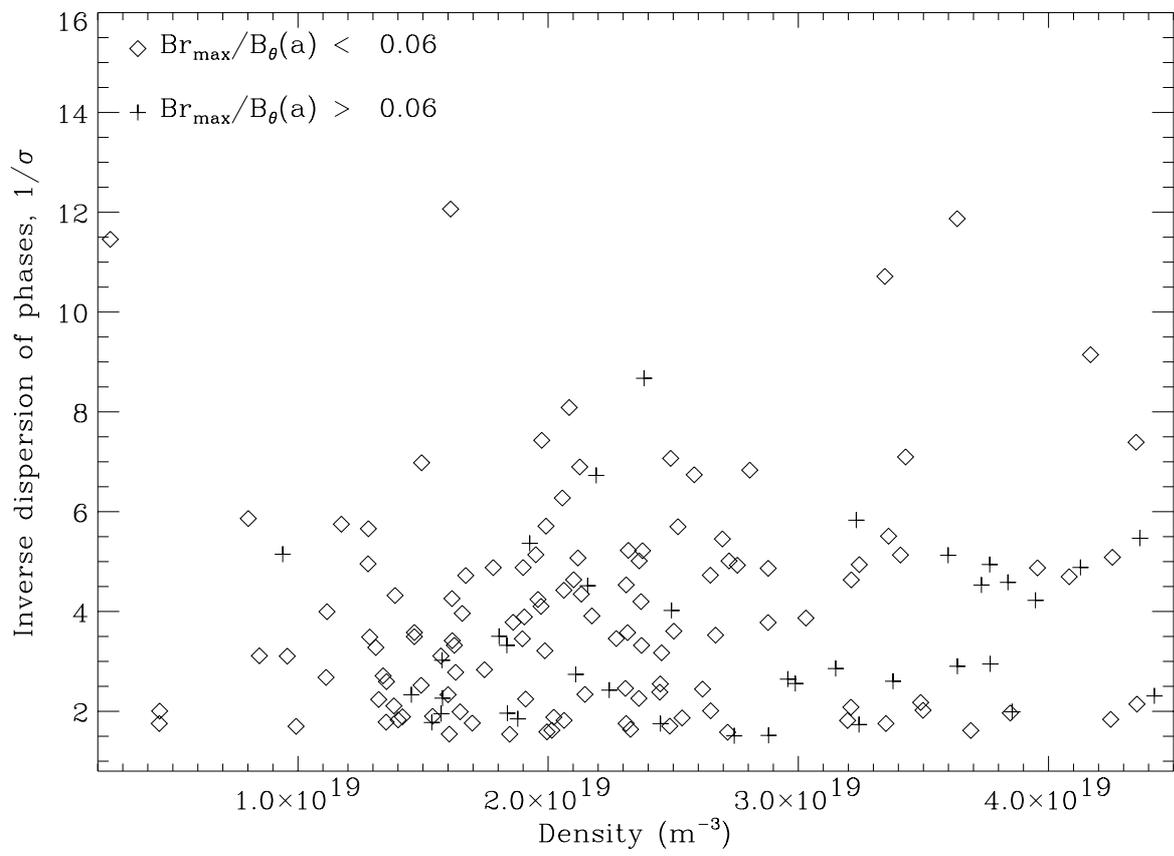
TPE-RX inverse dispersion of phases versus $< Br >_{rms} / B_\theta(a)$.

T2 inverse dispersion of phases versus $< Br >_{rms} / B_\theta(a)$.
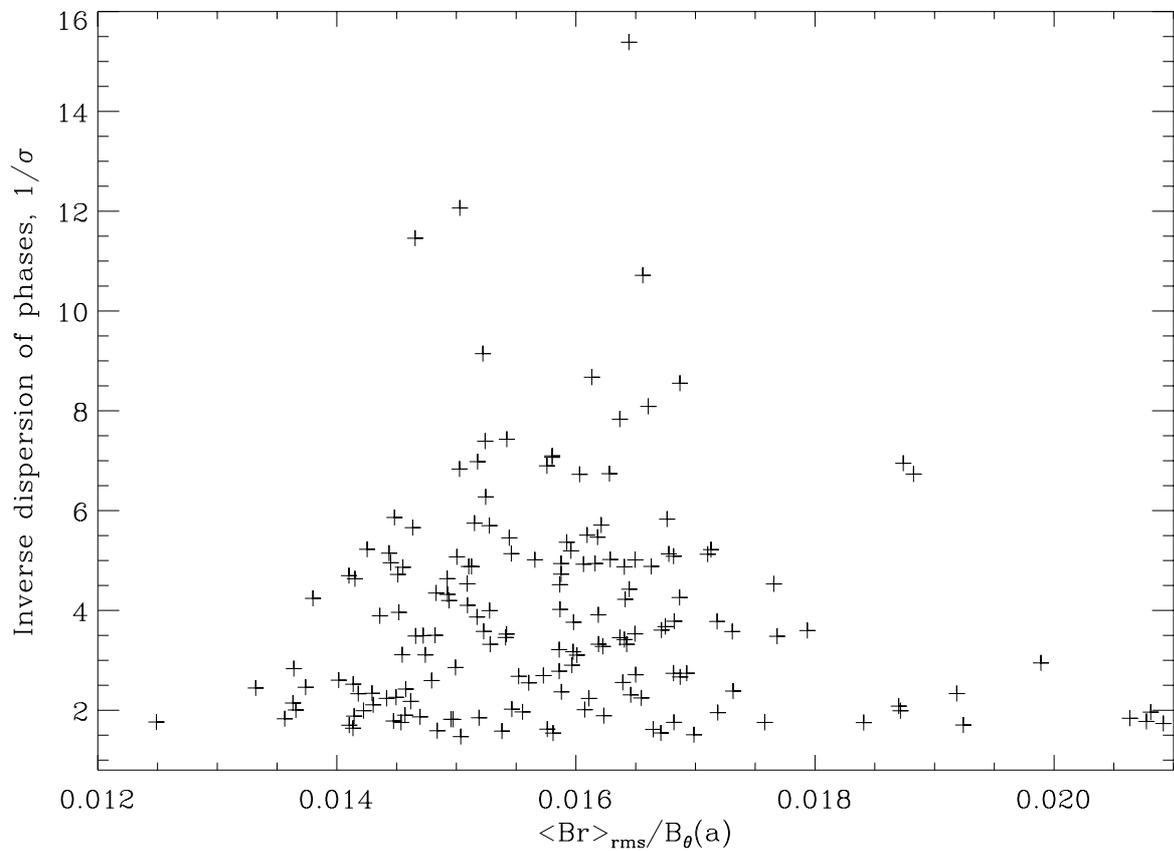
TPE-RX $Br_{max}/< Br >_{rms}$ versus inverse dispersion of phases.
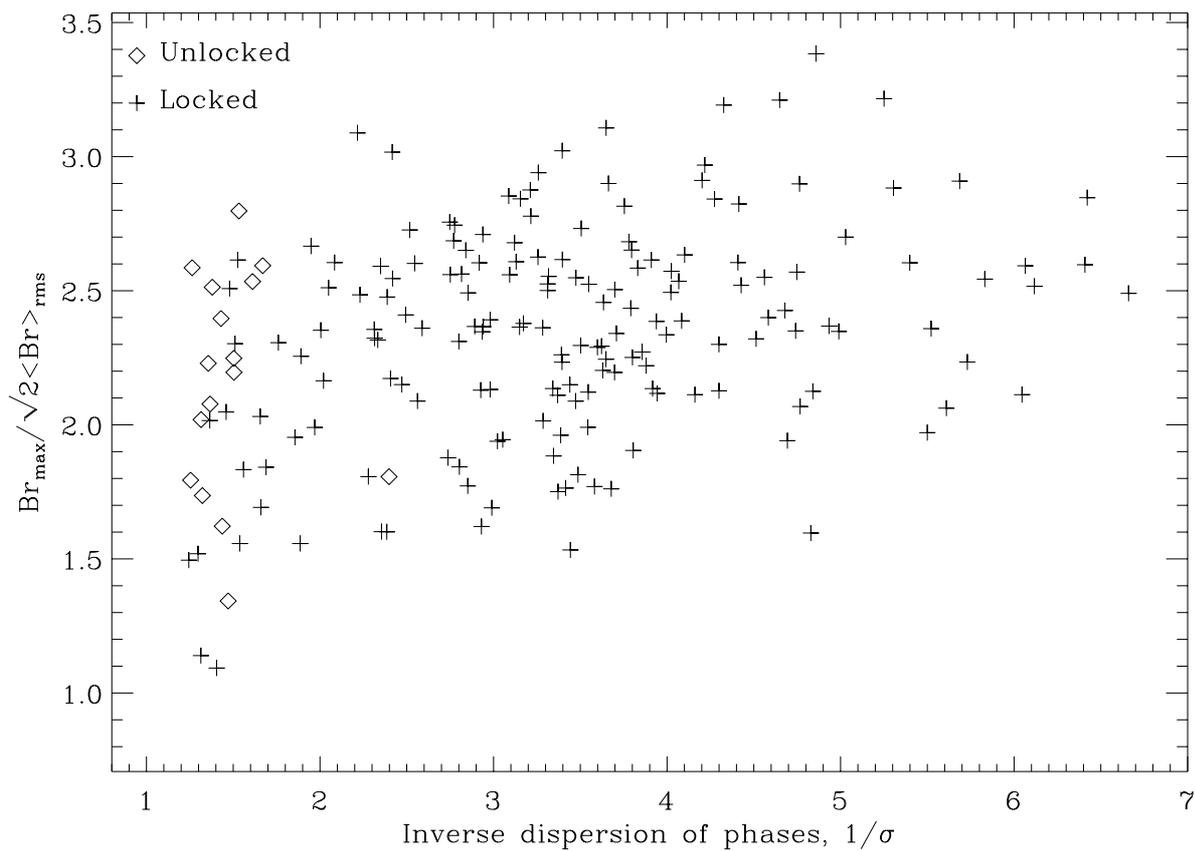
T2 $Br_{max}/< Br >_{rms}$ versus inverse dispersion of phases.
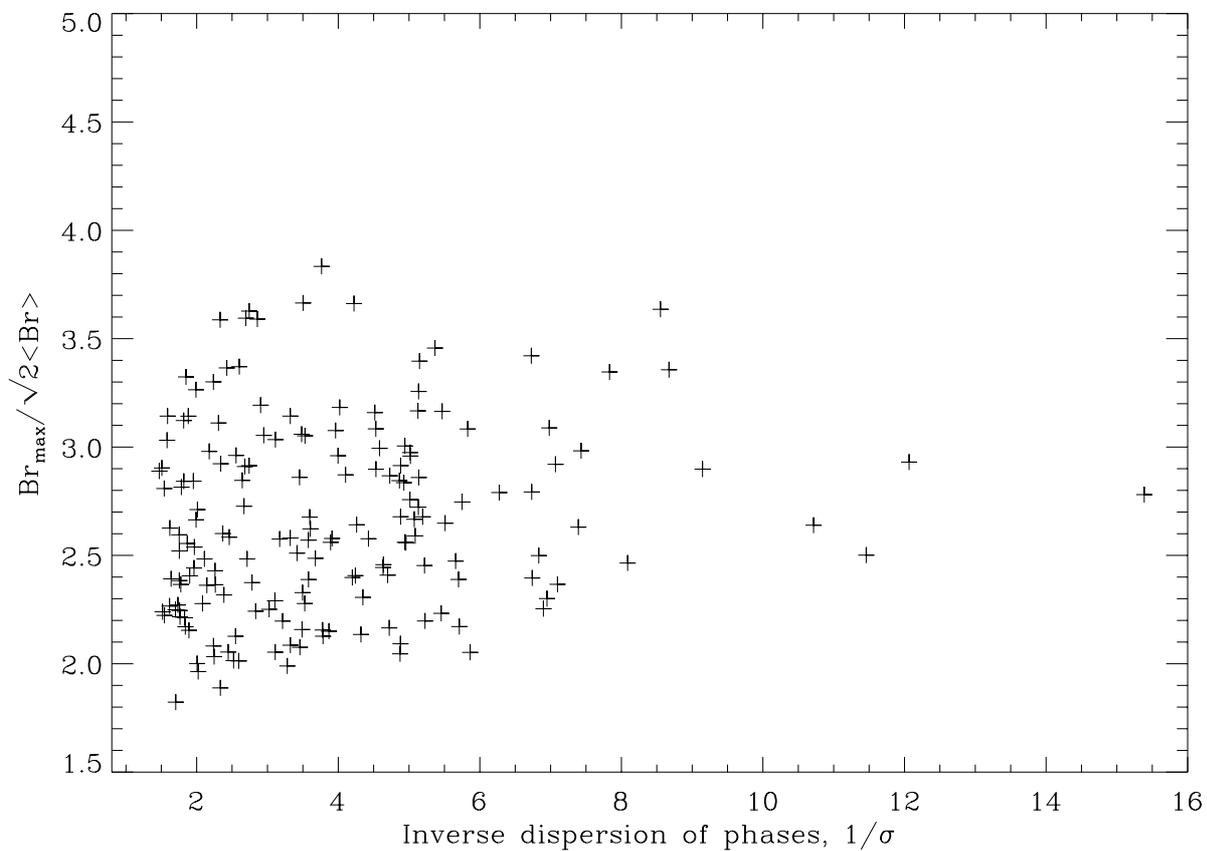
TPE-RX $< Br >_{rms} /B_\theta(a)$ versus plasma current.

T2 $< Br >_{rms} /B_\theta(a)$ versus plasma current.
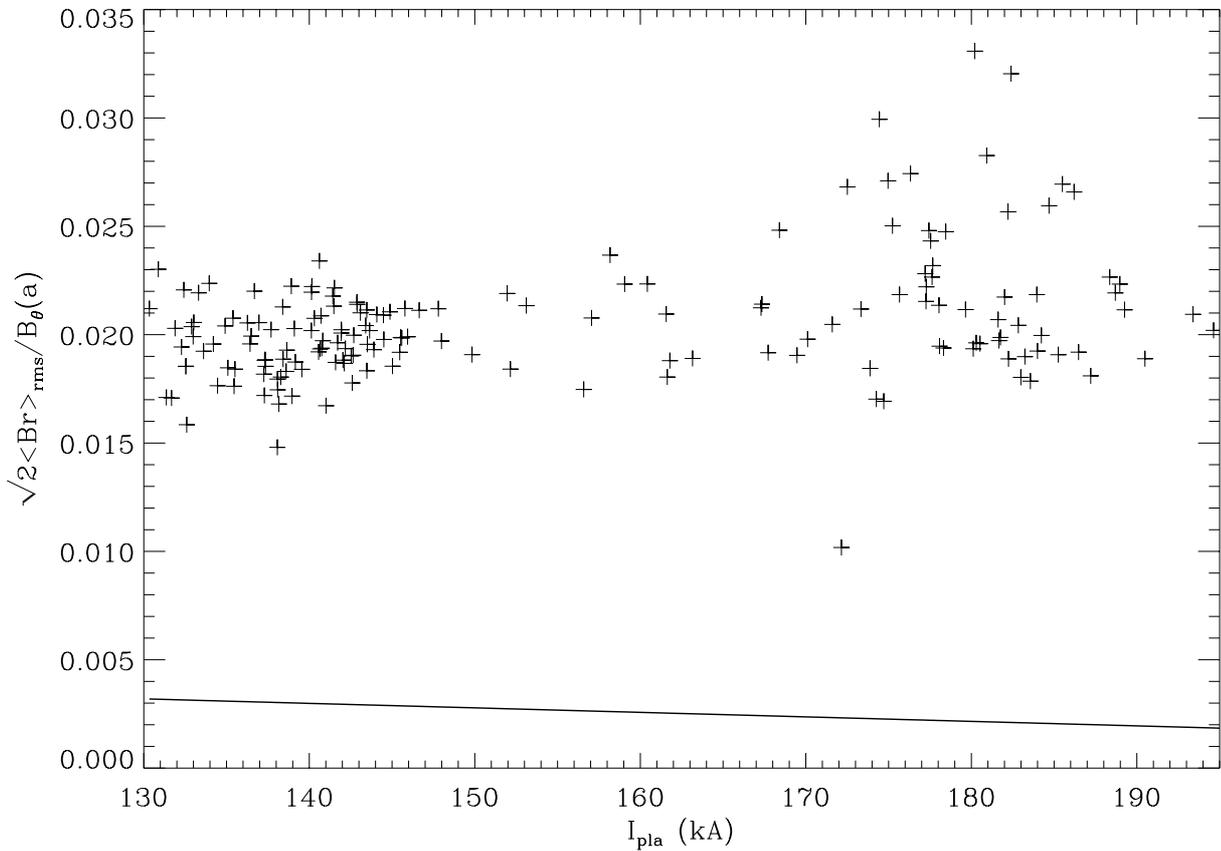
TPE-RX $b^{1,-7}/B_\theta(a)$ versus plasma current.

T2 $b^{1,-13}/B_\theta(a)$ versus plasma current.

Summary

Detection of the locked mode -

   LCFS reconstruction

   Inverse dispersion of phases $(1/\sigma)$

Locked mode structure -

   General structure of locked modes in TPE-RX and T2 are similar.
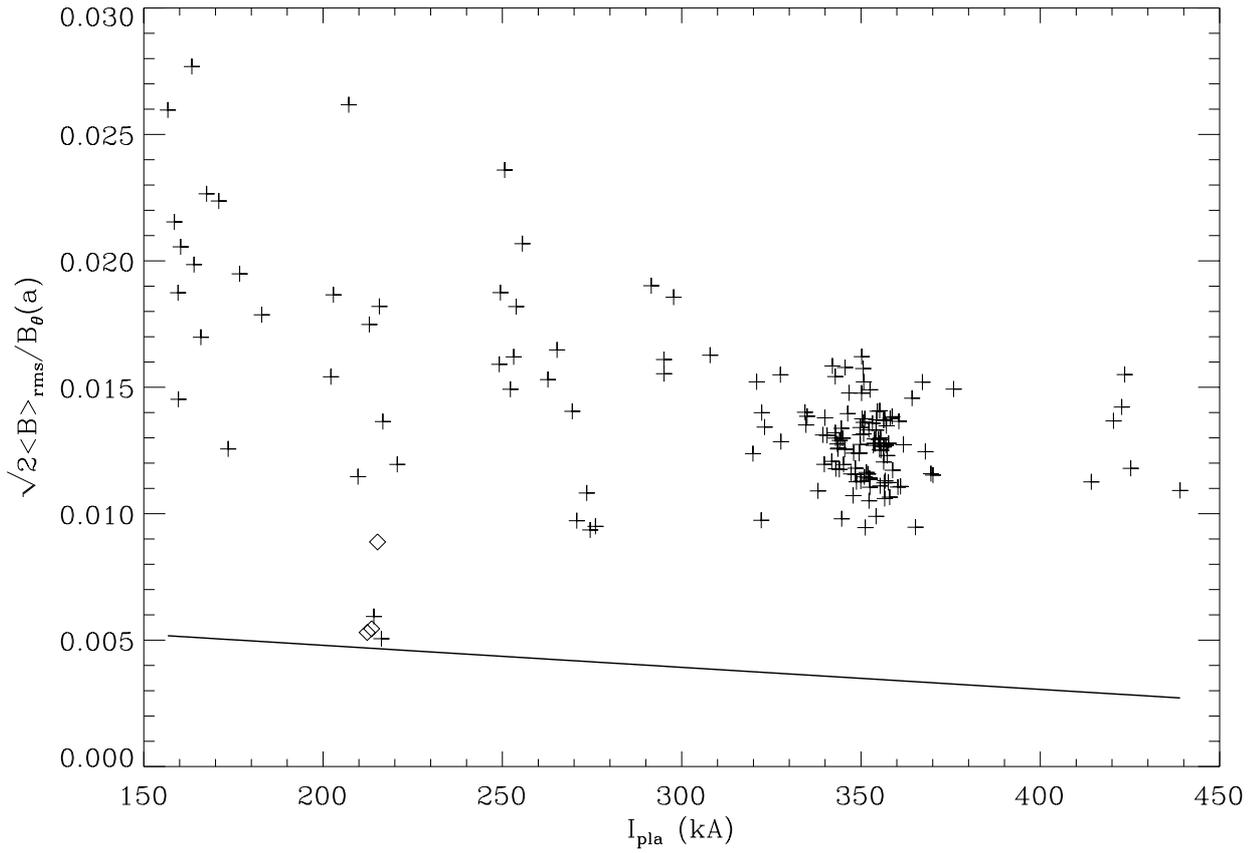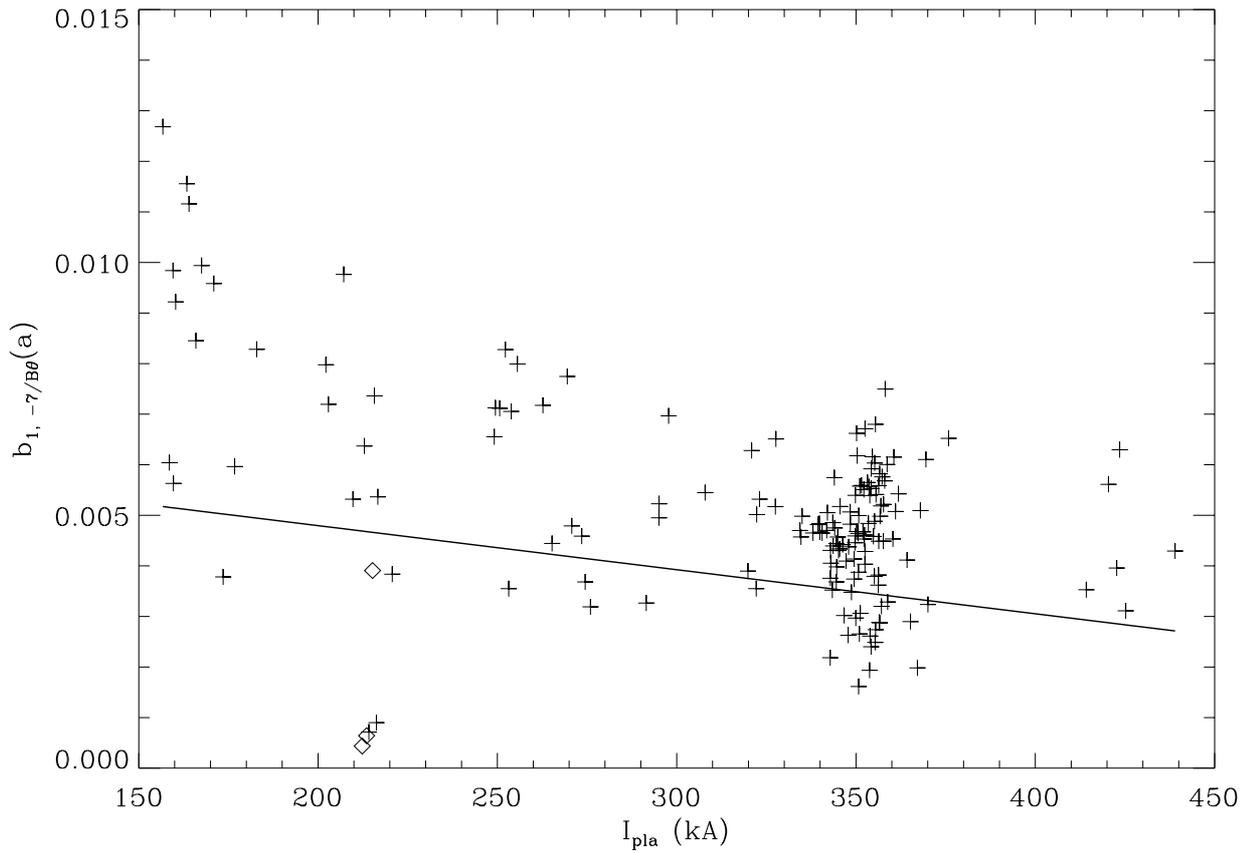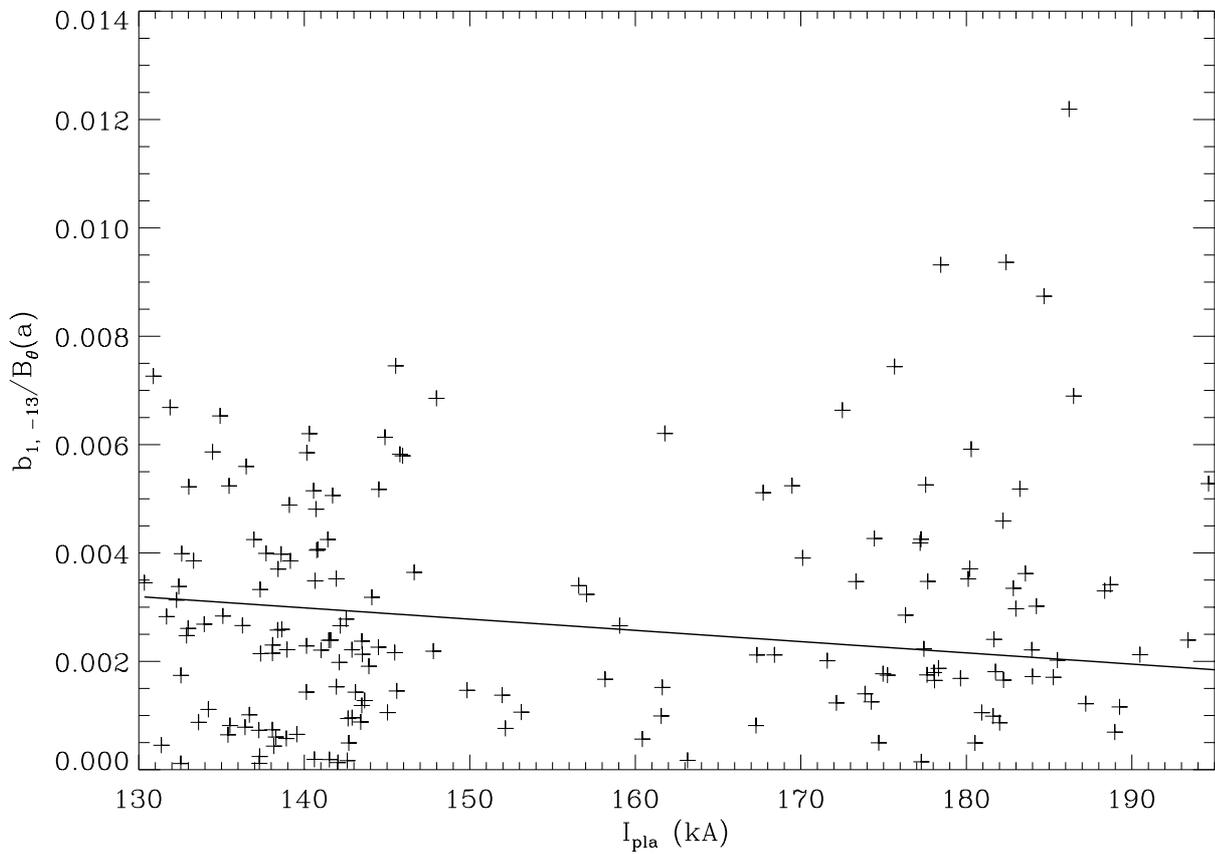
   Toroidal distribution of locked mode:

   TPE-RX - Enhanced probability of locking at shell gap.

   T2 - External field errors play a role in locking.

   Average mode spectra - dominant modes for mode locking:

   TPE-RX - Internally resonant $m = 1, n = $ -6 to about -12

   T2 - Internally resonant $m = 1, n = $ -10 to about -15

Dependence on operational parameters -

   Mode amplitudes $(Br_{max}/B_\theta(a))$:

   TPE-RX - 1% - 9%

   T2 - 3% - 11%

   TPE-RX - $Br_{max}/B_\theta(a)$ decreases with increasing current.

   T2 - $Br_{max}/B_\theta(a)$ increases with increasing current
   and electron density

   Locking probability (determined from $1/\sigma$):

   TPE-RX - Probability increases with increasing
   current (especially if $Br_{max}/B_\theta(a) < 3\%$)

   T2 - Probability increases with increasing
   current (if $Br_{max}/B_\theta(a) < 6\%$)

   TPE-RX and T2 - Probability increases with increasing mode amplitudes.
   $< Br >_{rms} /B_\theta(a)$ threshold for locking in TPE-RX is about 0.7%