Stabilization of the Resistive Wall Mode Using Moving Metal Walls

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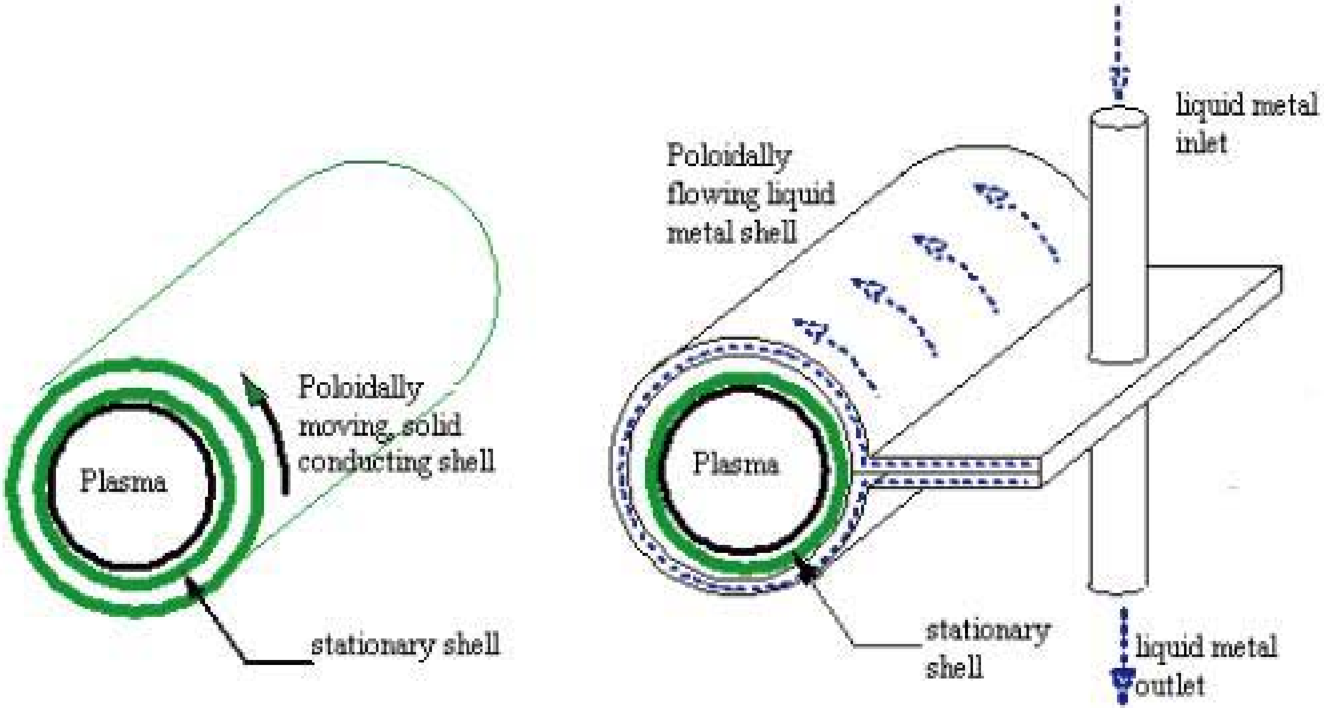
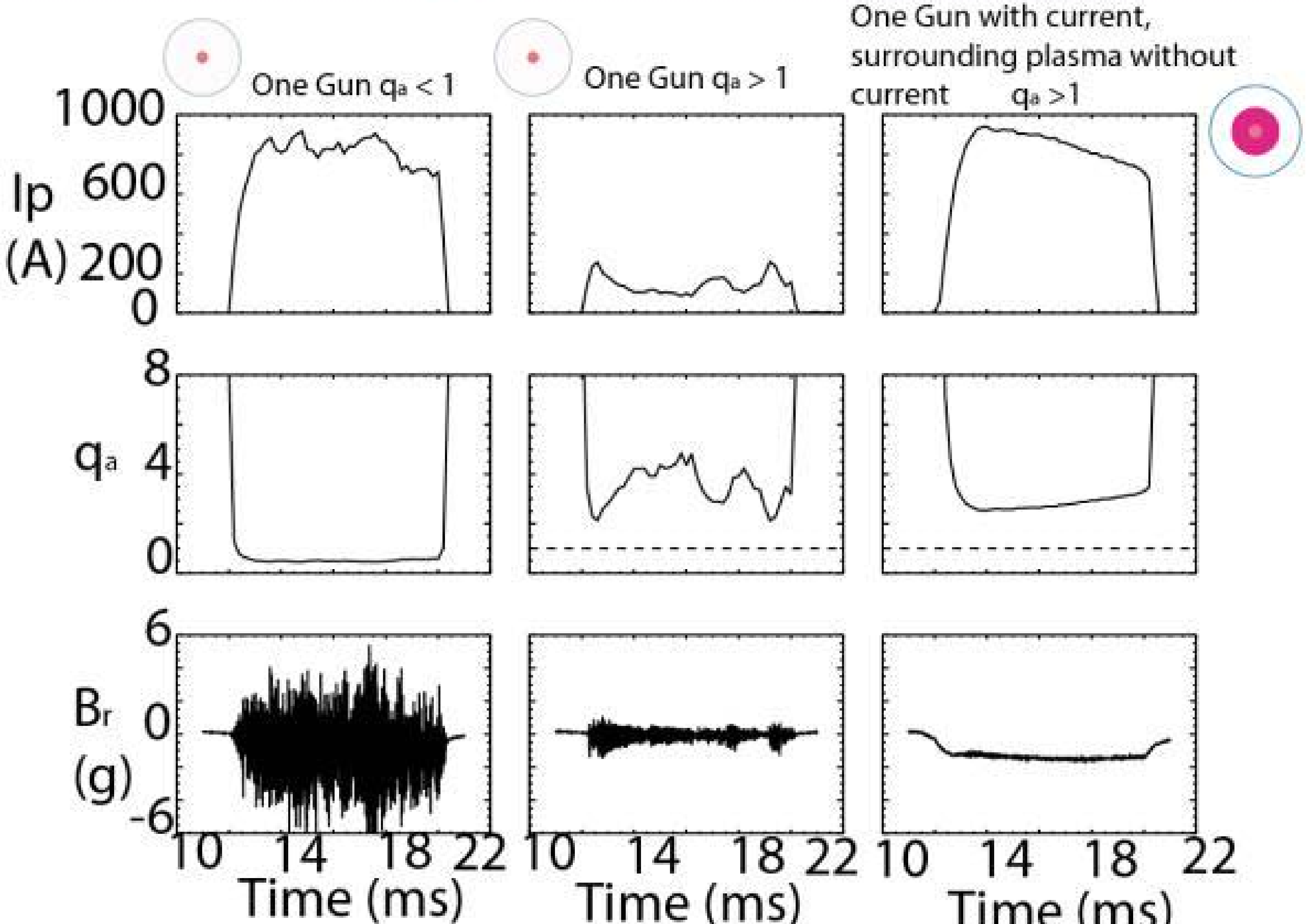
Goal of rotating wall machine

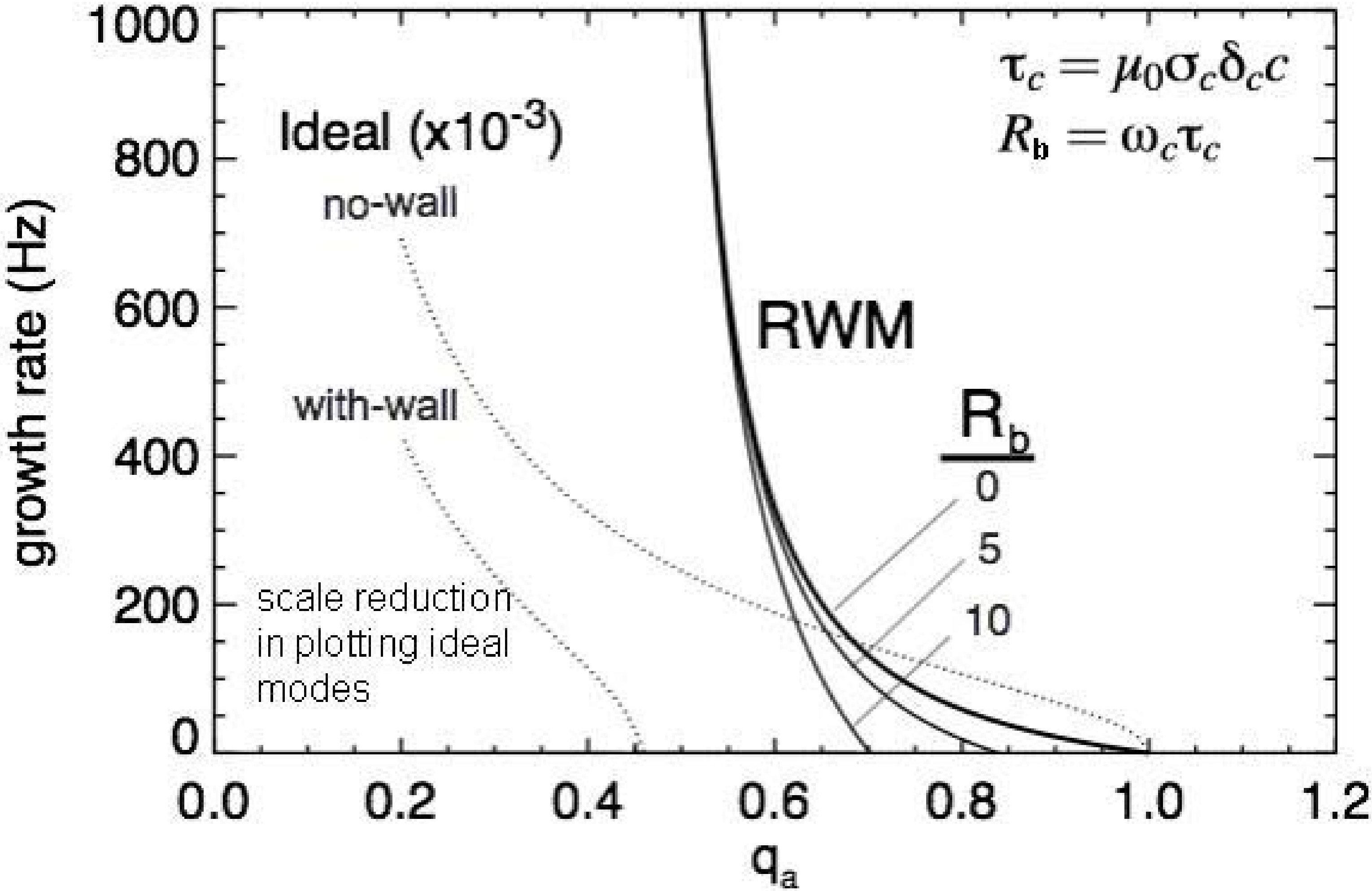


- A second conducting wall, rotating with respect to the first wall, can stabilize the RWM
  - [C.C. Gimblett, Plasma Phys. Cont. Fusion 31, p 2183 (1989).]

Larger Br when q_a <1 & suppression of Br with surrounding plasma

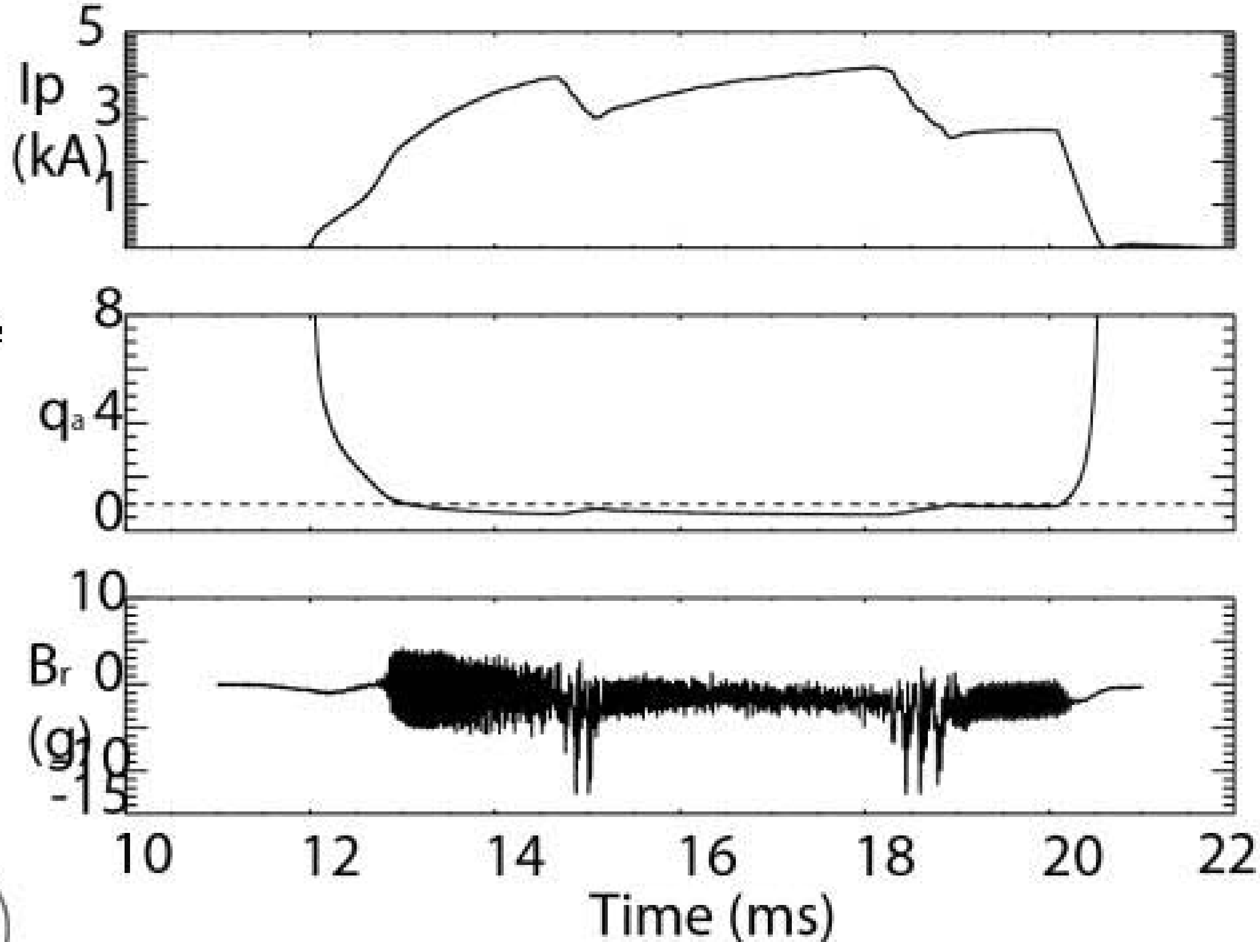


RWM exists between ideal no-wall and with-wall conditions

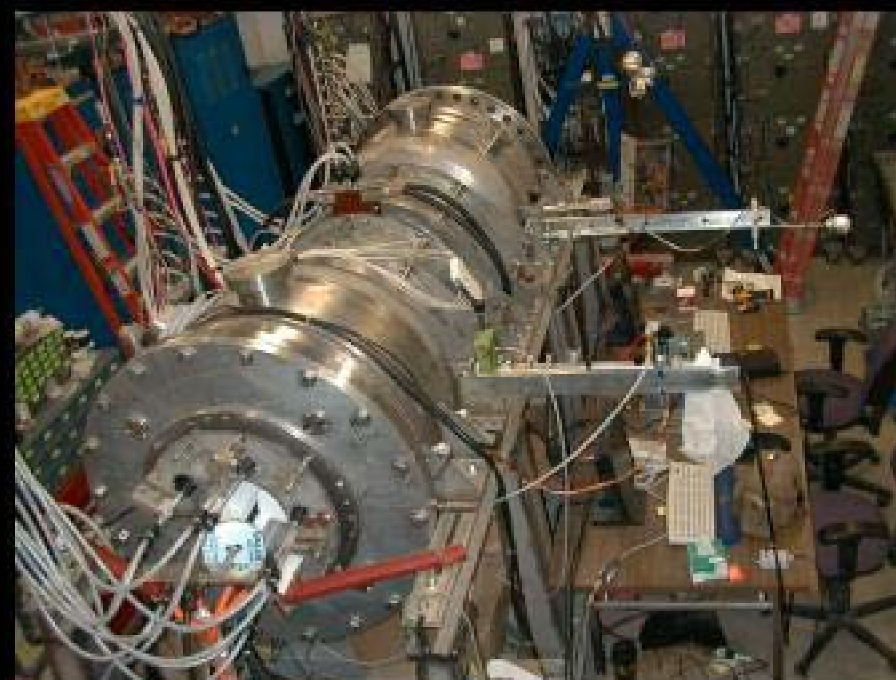


Seven gun plasma current exhibits sawtooth behavior

- sawtooth behavior found in plasma current
- plasma source able to supply plasma through disruption
- analysis underway

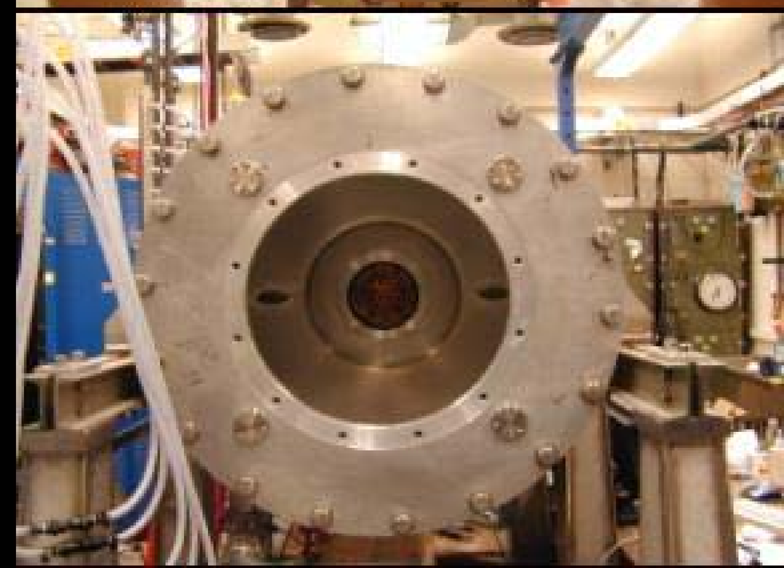




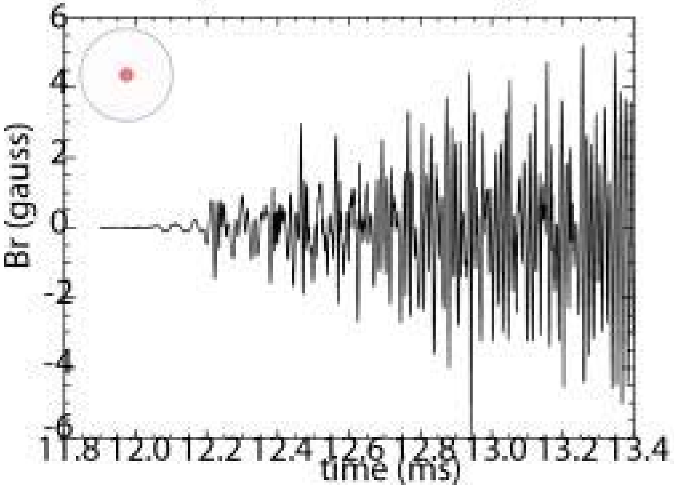




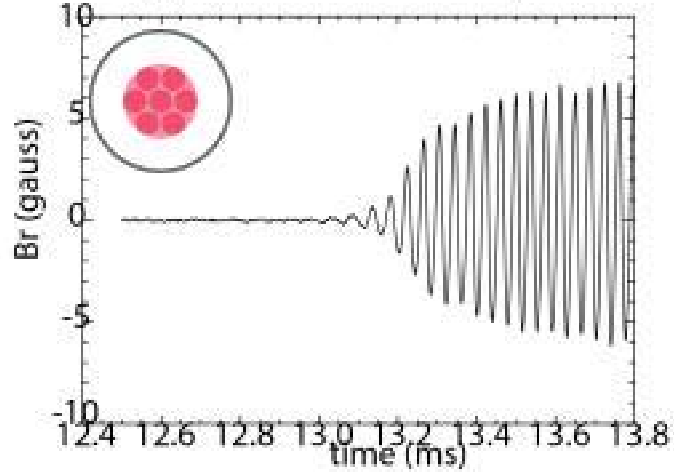


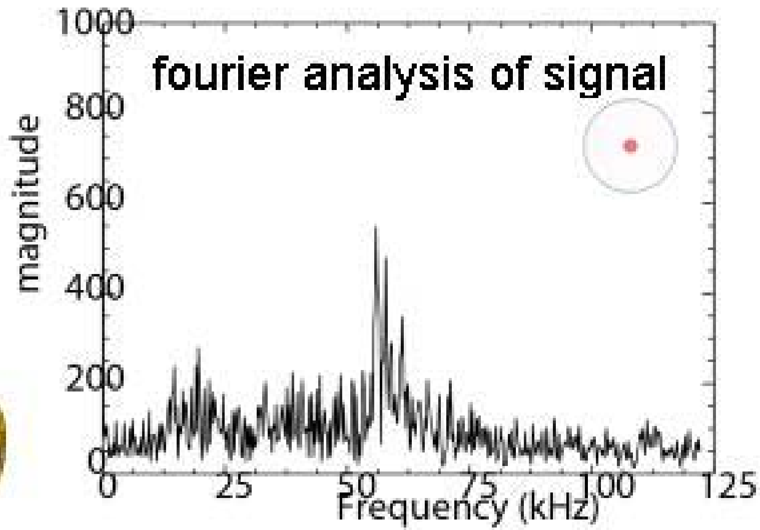
Longer MHD timescale associated with seven gun plasma

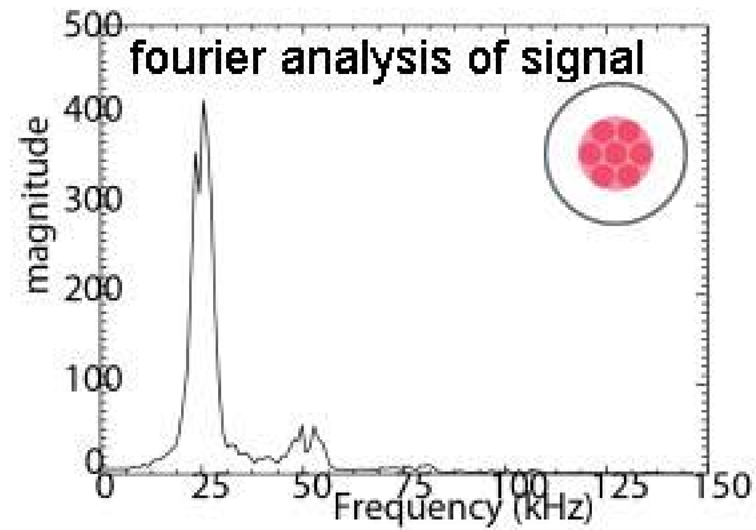
Br signal from one gun



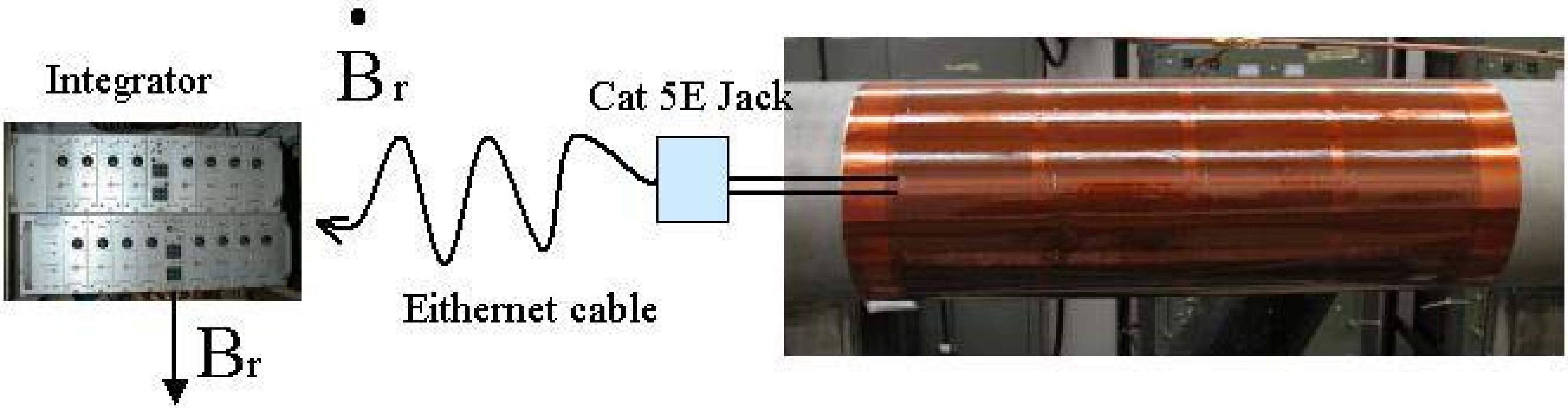
Br signal from seven guns







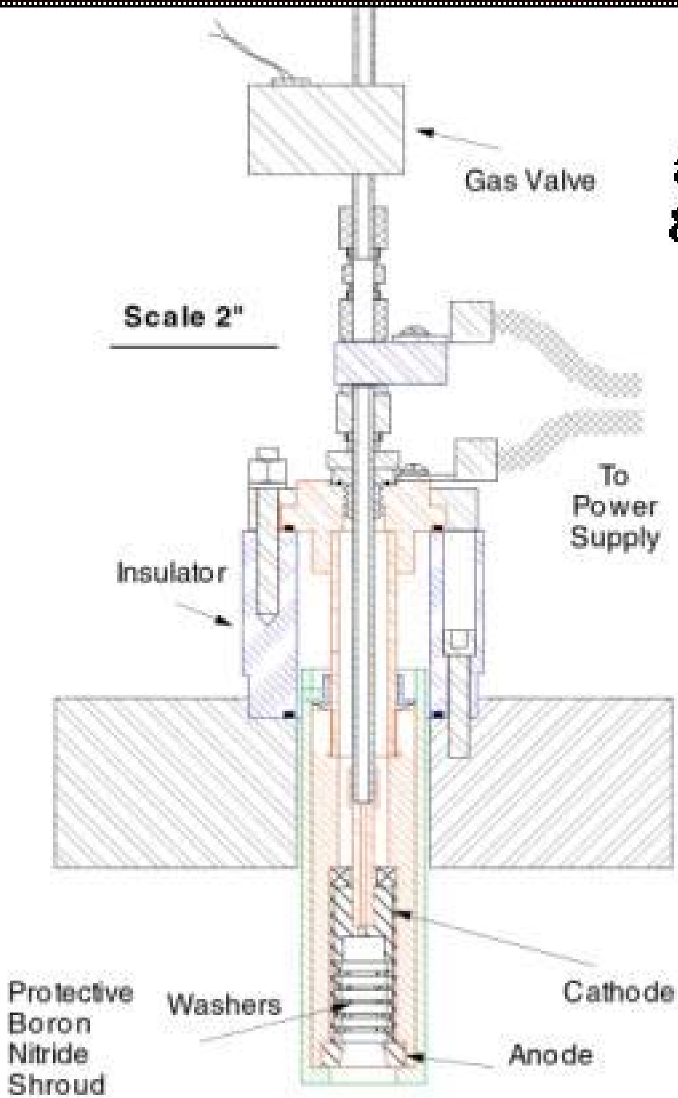
Flux loops on vessel surface monitor Br



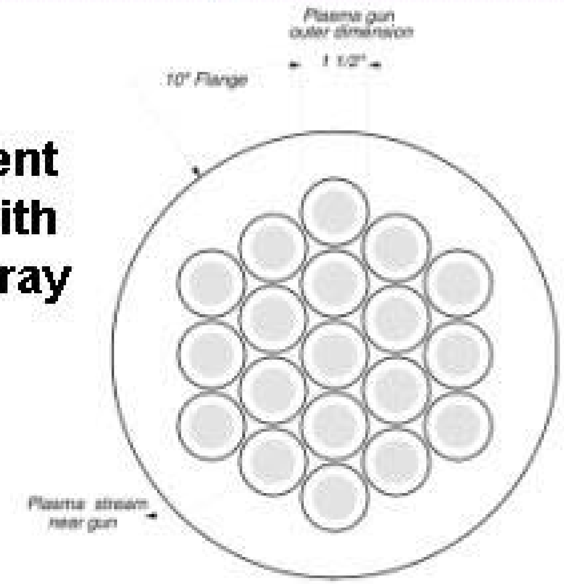
- two sheets each have 4X10 sets of 10 turn loops to act as pickups for flux
- eight loops along machine axis
- ten loops through poloidal plane.

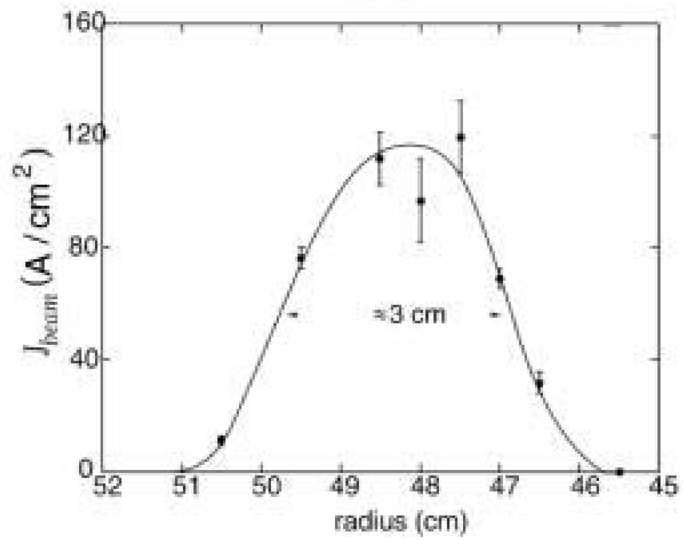
$$\nabla \times E = \dot{B}$$

Electrostatic plasma source provides control for density and current profiles



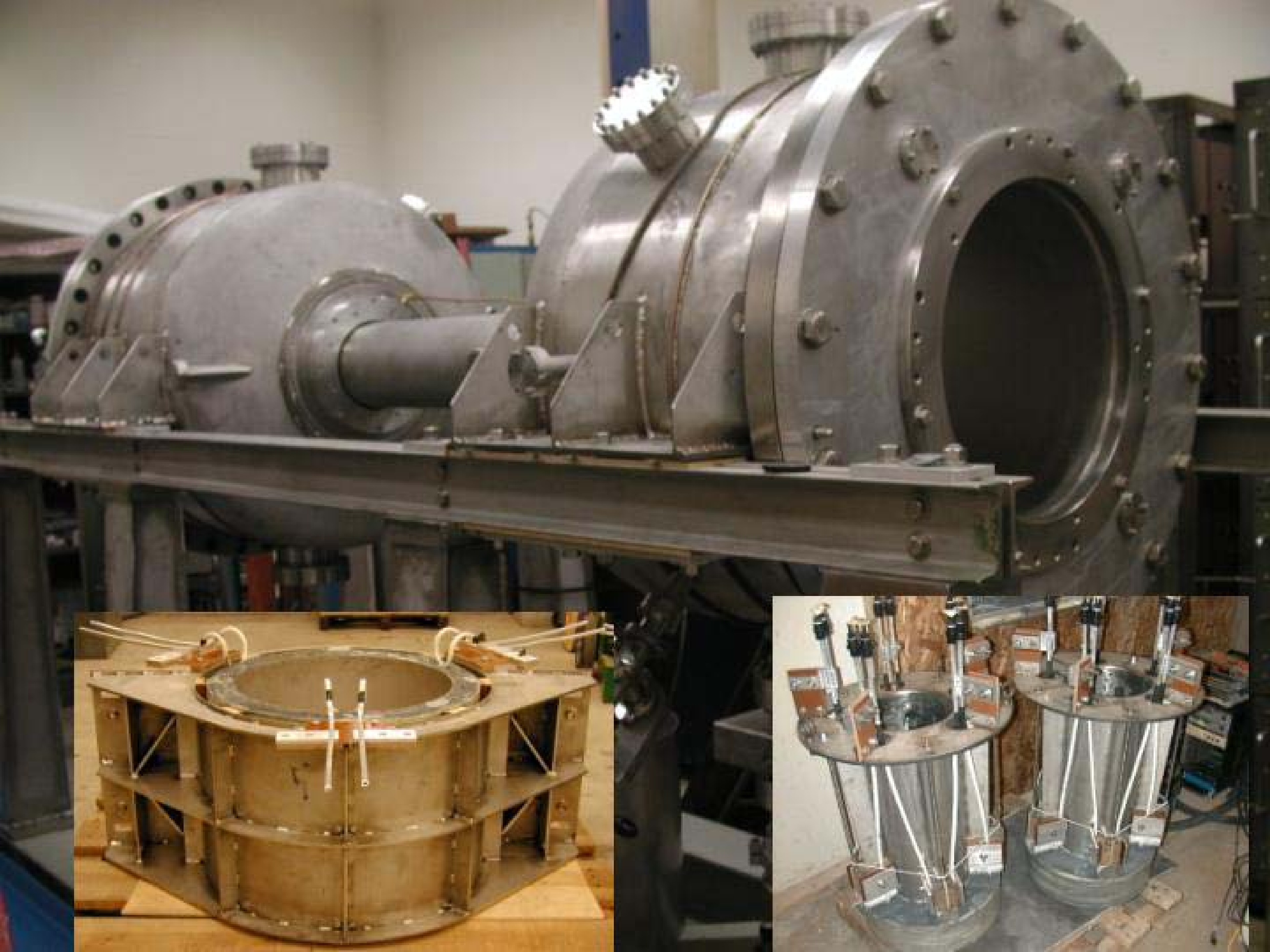
adjust current & density with gun array





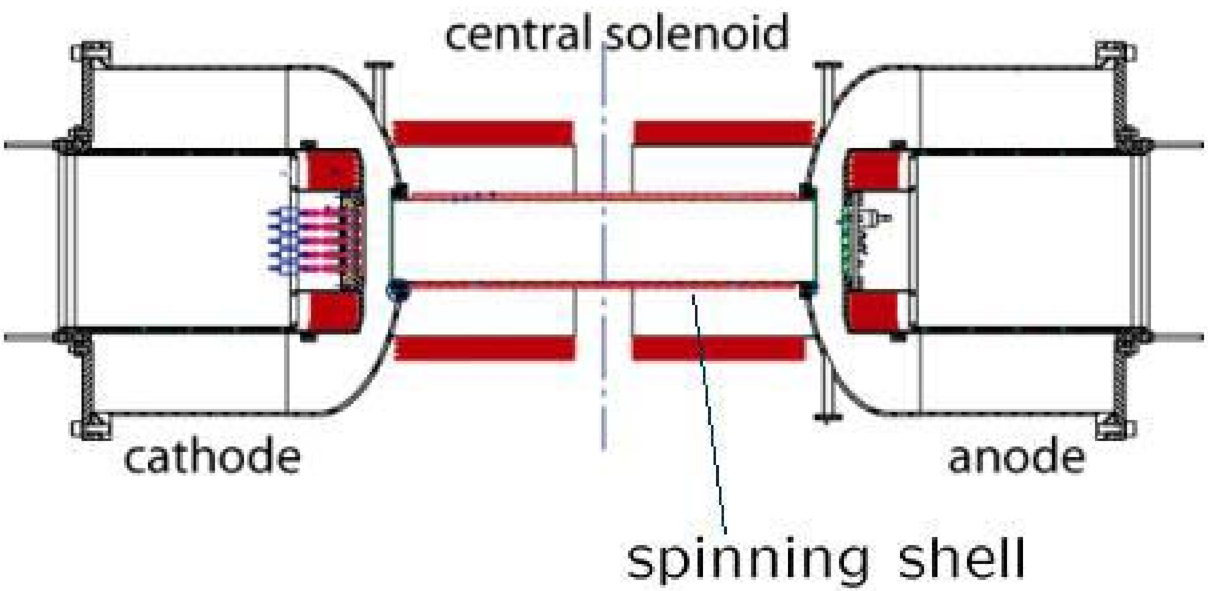
Outline

- Motivation for moving walls
- Theory of the RWM in a line-tied pinch
- Description of apparatus
- Initial results of no wall limit
- Summary



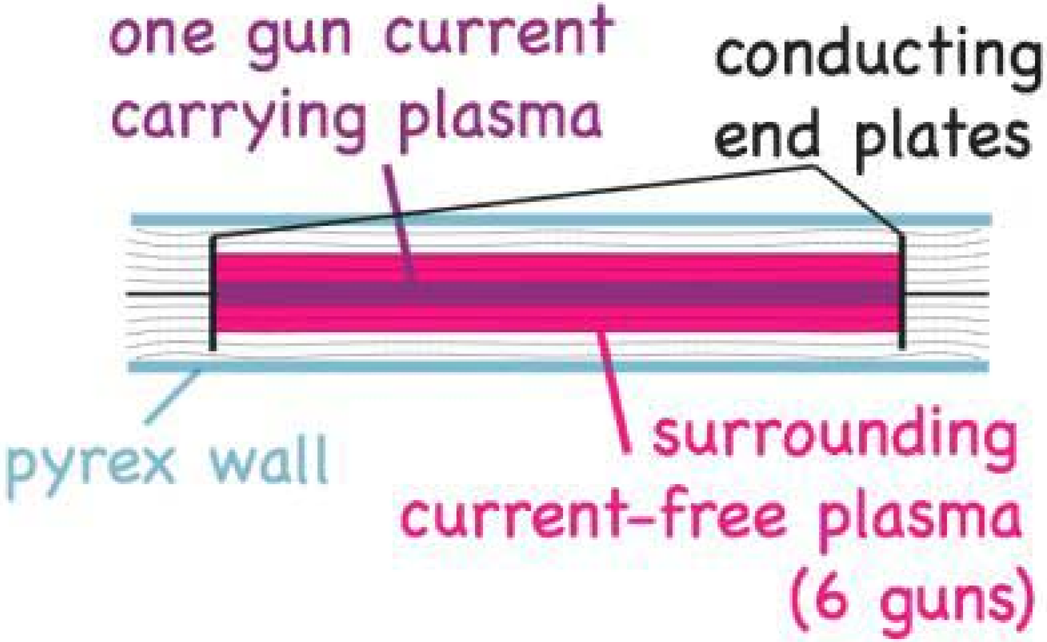
The experiment: use current driven kink mode in a linear device as a RWM

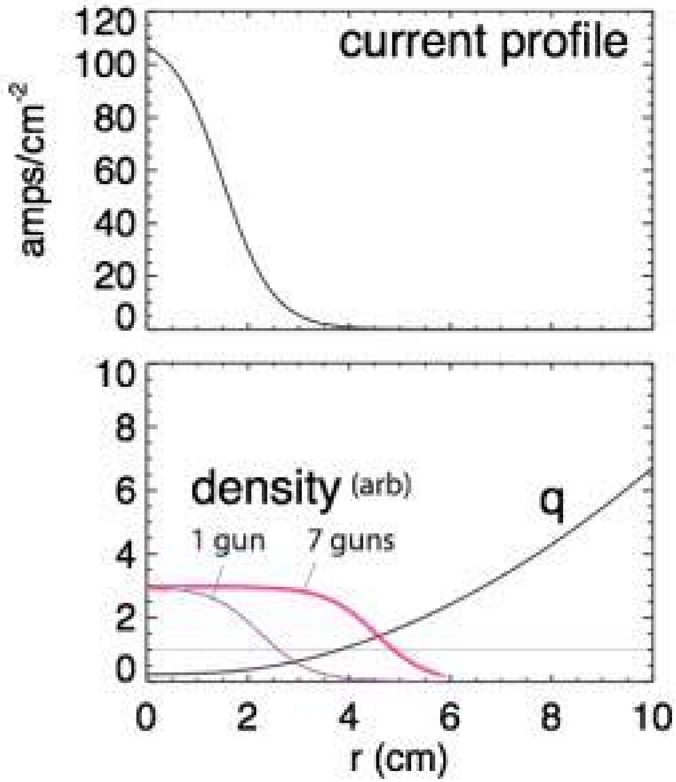
B_z	0.2 T
I_p	20 kA
τ_{pulse}	20 ms
L	1 m
b, c	0.10,0.11 m
$\delta_{b,c}$	1-3 mm
τ_w	8-24 ms
f_{shell}	$<$ 100 Hz
Rm_b	5-15



Conductive endplates in plasma column provide line tying boundary condition

Current free plasma improves stability

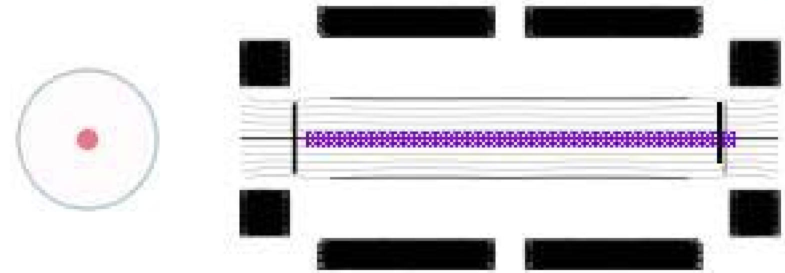




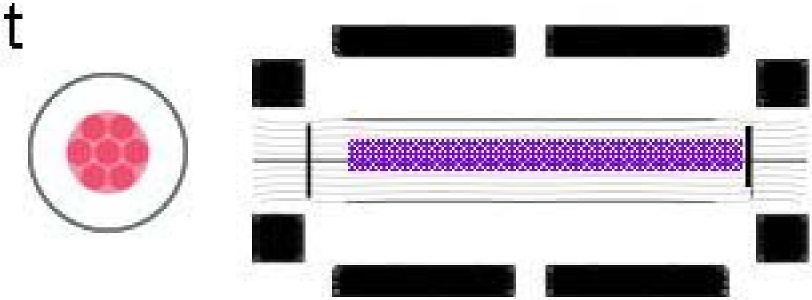
edge q changes when plasma column diameter changes

Different plasmas are represented in the data

- one gun carrying plasma current
  - diameter ~3 cm
  - pyrex wall

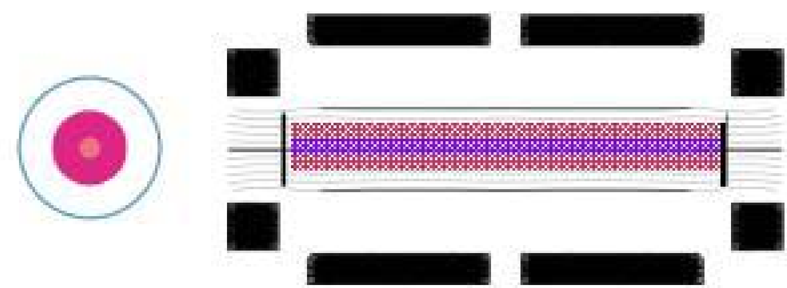


- seven guns carrying plasma current
  - diameter ~10 cm
  - pyrex wall

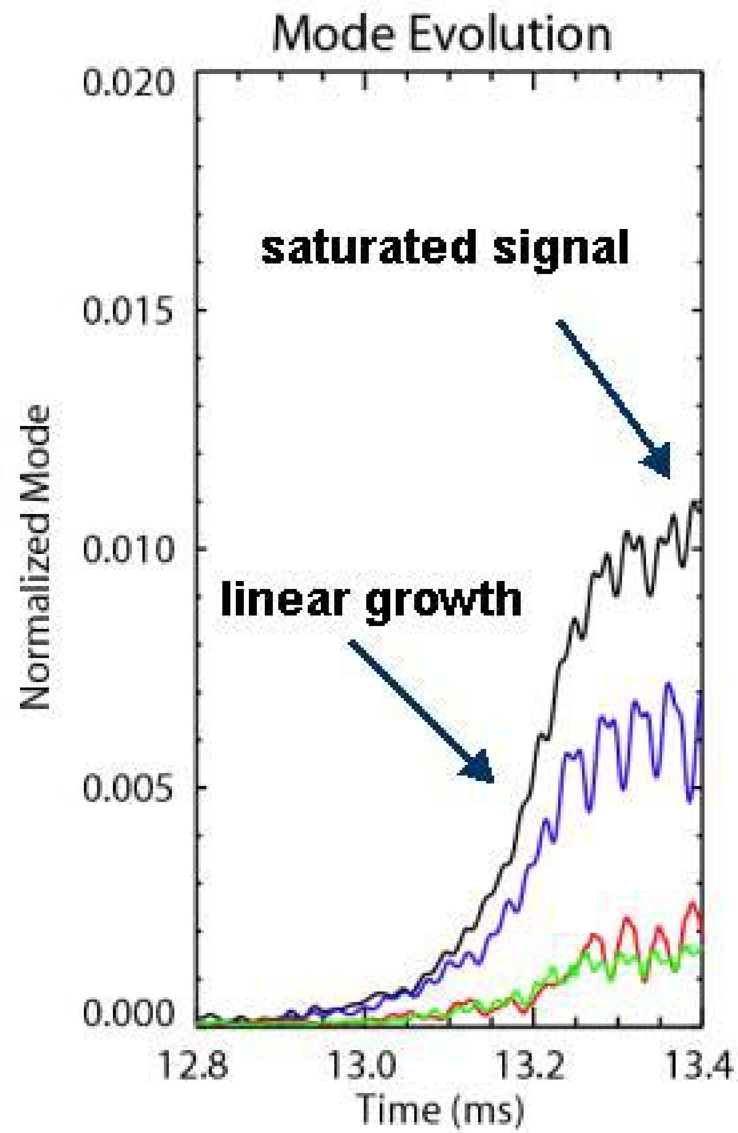


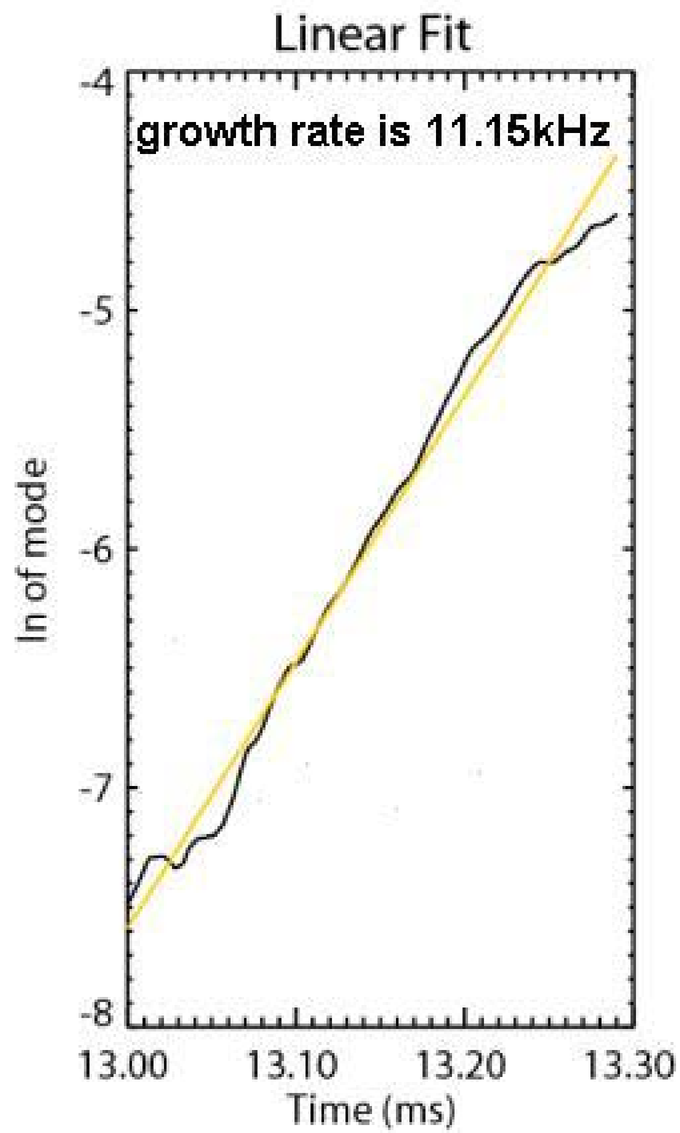
- seven guns, but only center one

  carries plasma current
  - diameter ~10 cm
  - pyrex wall



m = 1 growth rate determined at mode onset

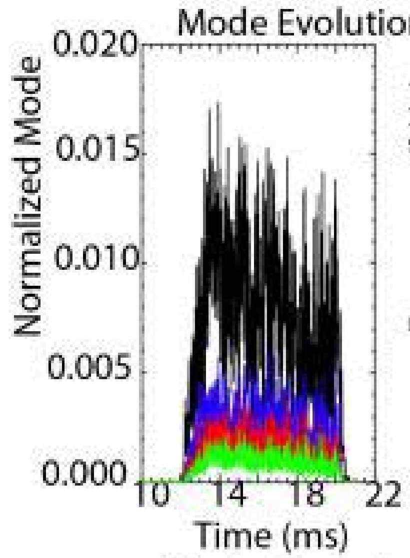


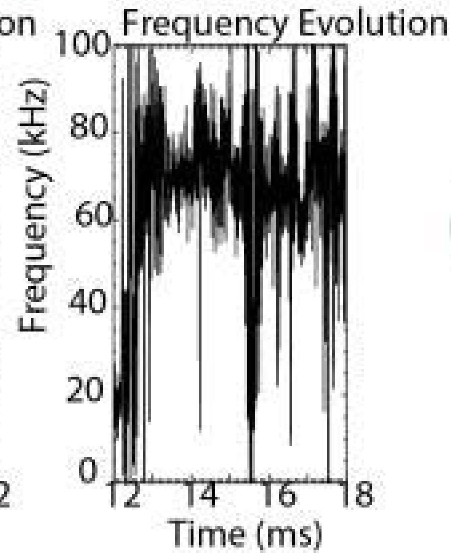


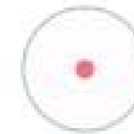
Slower MHD with seven guns reveals plasma rotation and m = 1,2,3,4 structure

One gun

Shot 40622044
Black; m =1
Blue; m = 2
Red; m = 3
Green; m= 4

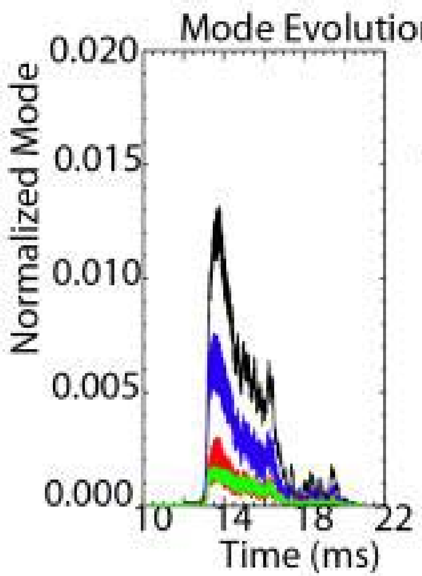


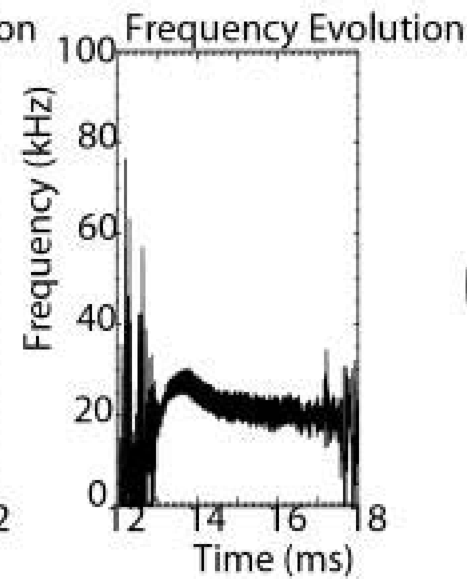


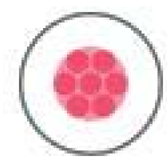


Seven guns

Shot 40929005
Black; m =1
Blue; m = 2
Red; m = 3
Green; m= 4



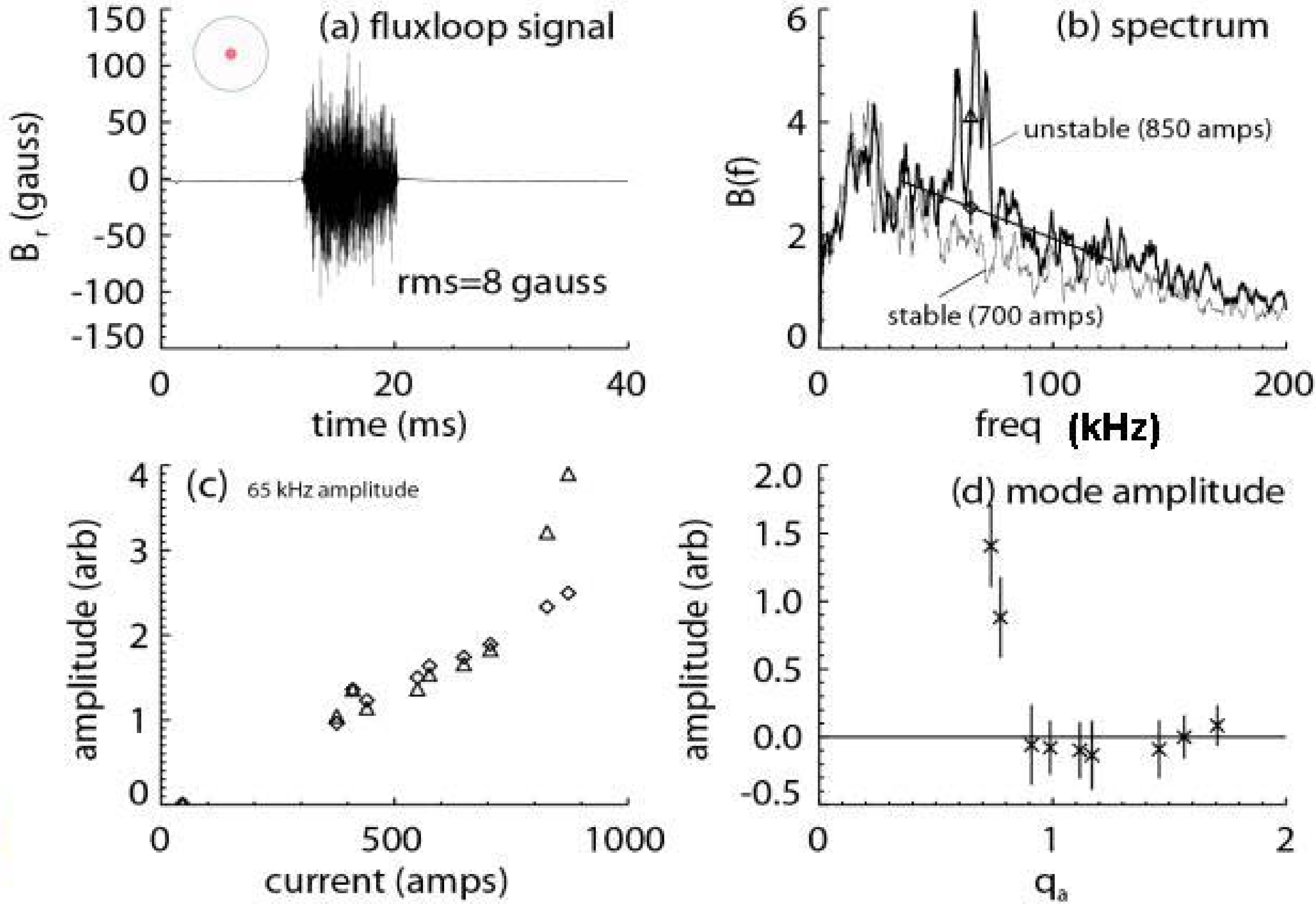




Future directions

- complete parametric stability studies for no wall plasma with seven guns
- establish density and q profiles of plasma
- install thin wall and characterize RWM with one and seven gun plasmas
- install rotating wall on machine and characterize effect on RWM

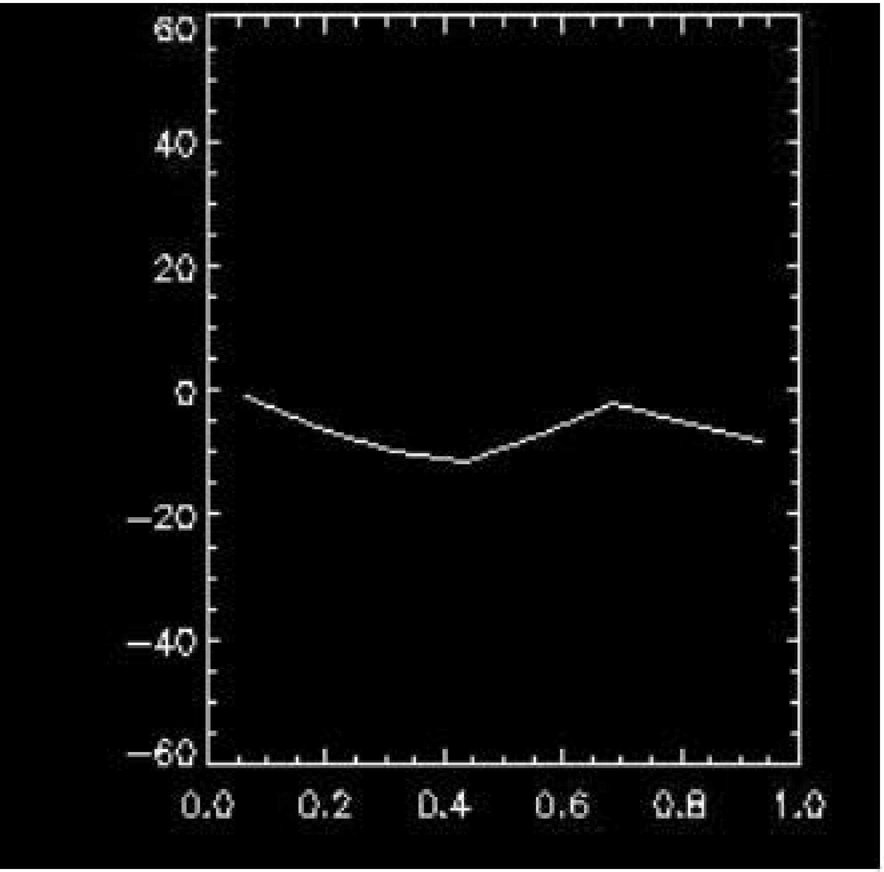
$q_a < 1$ governs onset of MHD

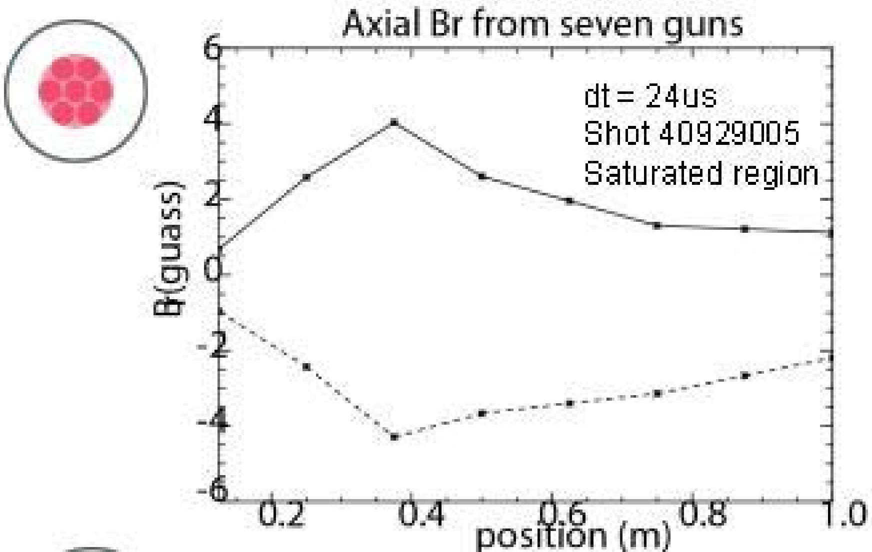


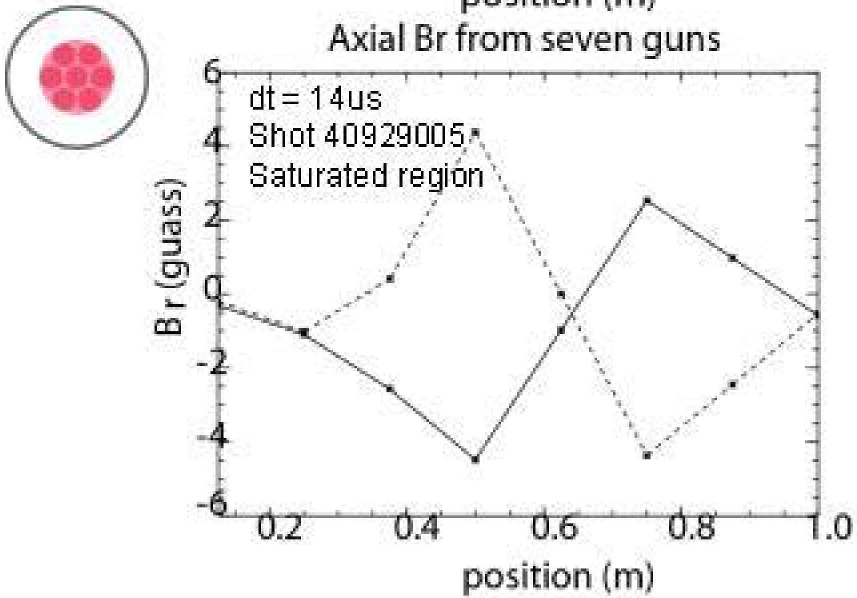
Summary

- no-wall ideal instability grows when $q_a < 1$ (Kruskal Shafranov)
- increasing q_a by enlarging plasma is stabilizing
  - see Mirnov JP1.057 aps
- m=1, n = 1,2 modes dominant
- seven gun plasma has growth rate of 11 kHz

Instability shows coupled n = 1 and n = 2 character and rotation







MHD Stability of the Line-tied Screw Pinch

- the no-wall instability limit set by $q_a=1$ (Kruskal Shafranov)
  - $q_a < 1$, $q_a = \dfrac{4\pi^2 a^2 B_z}{\mu_0 I_p L}$
- with wall instability limit
  - depends upon proximity of shell $q_a - 1 + (\frac{a}{b})^2 < 0$
- Resistive Wall Mode exists between with wall and no-wall ideal limit
- two shells, one spinning
- recent theory
  - C.C. Hegna, Phys. Plasma 11, p 4230 (2004)
  - D.D. Ryutov,et. Al. Phys. Plasma 11, p 4740 (2004)