Resistive wall mode studies in the Extrap T2R reversed-field pinch

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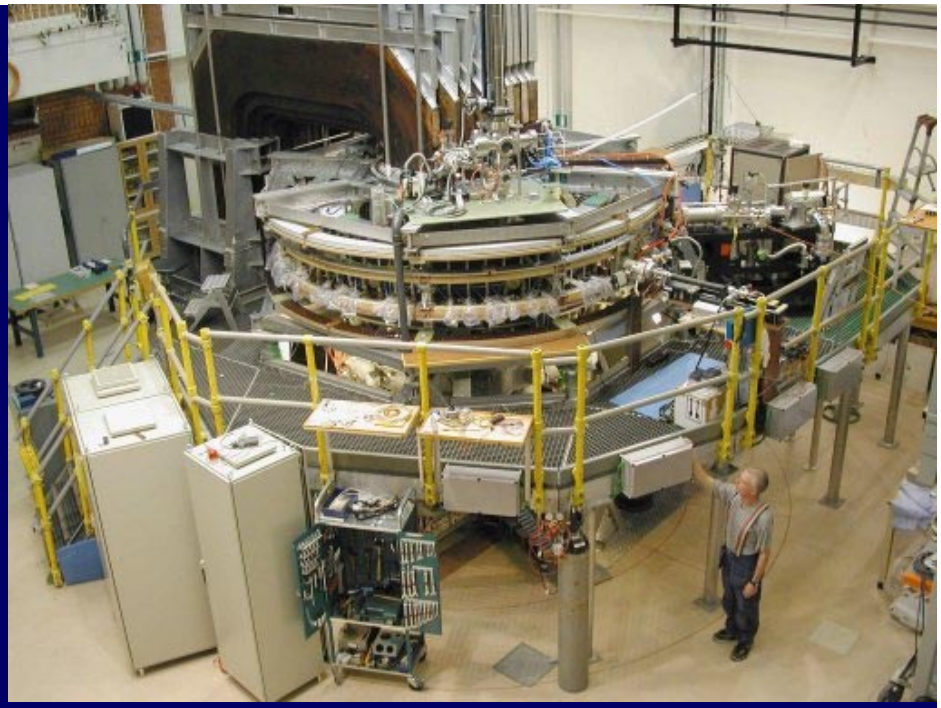
Aim:

To analyze magnetic fluctuation data for resistive wall modes in the Extrap T2R RFP for future feedback experiments

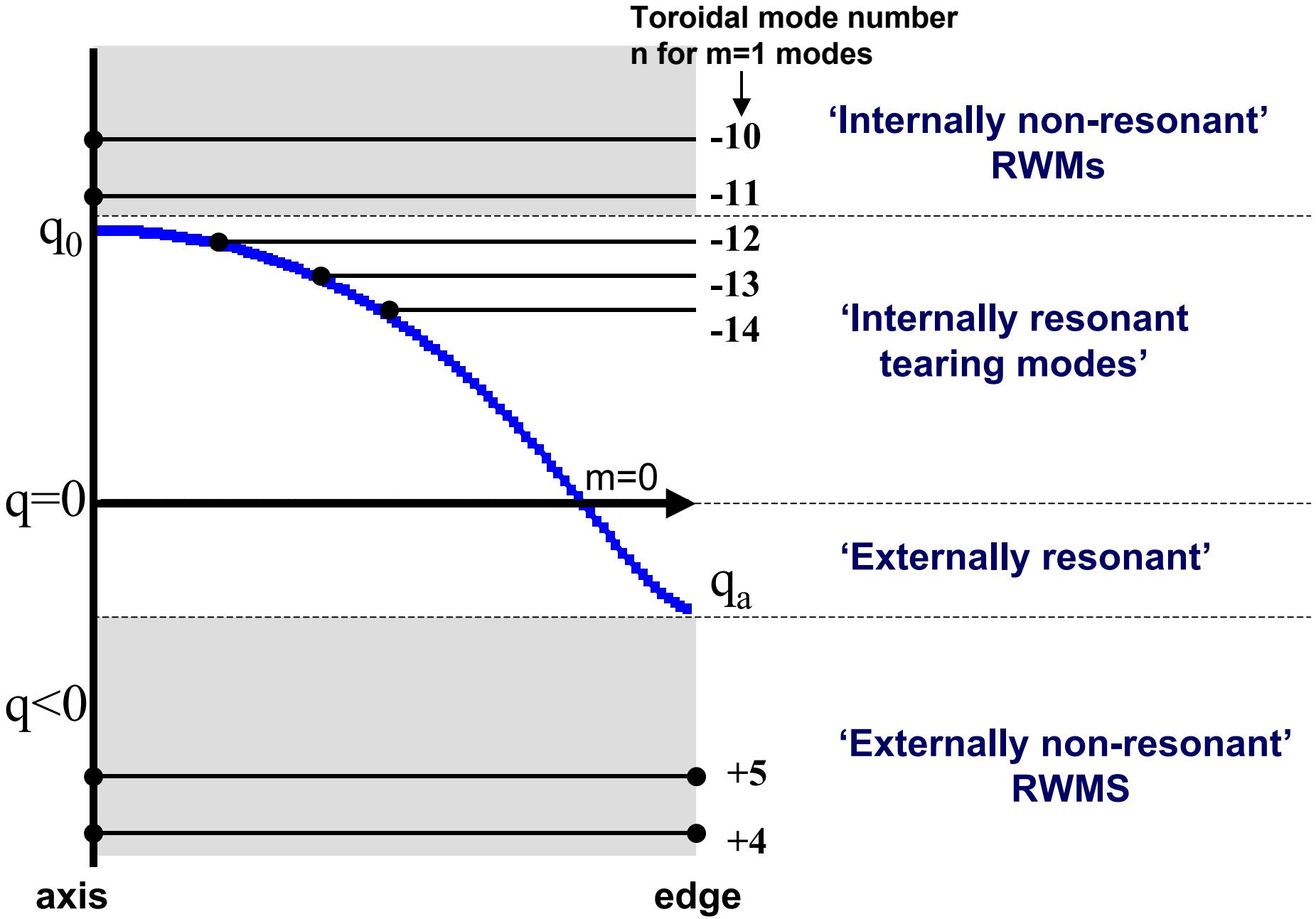
- Determine the level at which modes can be identified in the raw data.
- Detemine the most suitable sensor configurations for mode identification.
- Measure mode spectra and growth rates for various RFP current profile equilibria.
- Compare observed growth rates with linear theory.

Extrap T2R



Major radius	1.24 m
Minor radius	0.183 m
Plasma current	60-120 kA
Electron density	$0.5\text{-}1.5\times10^{19}$ m^{-3}
Magnetic fluctuation level	0.2-0.5%
Poloidal beta	10-15%
τ_{pulse}	10-25 ms
τ_{shell}	6.5 ms

Unstable modes in Extrap T2R

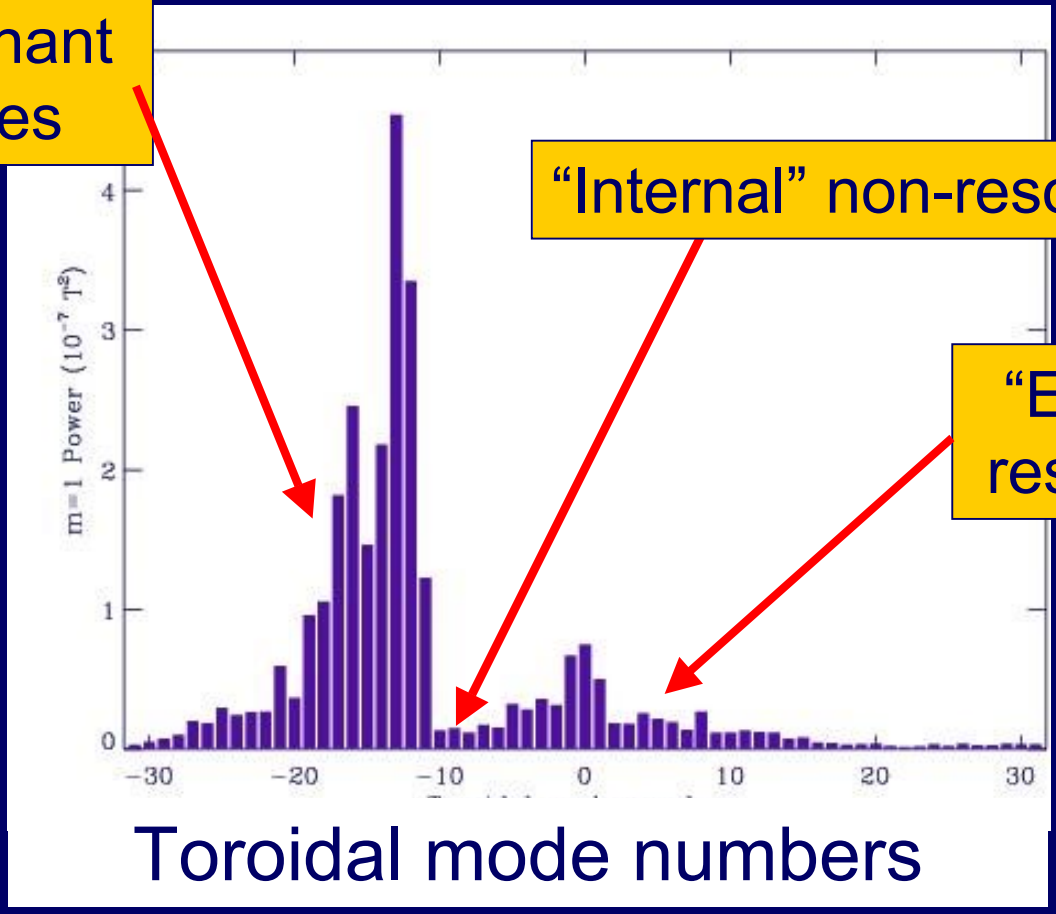


Tearing modes

"Internal" resonant tearing modes

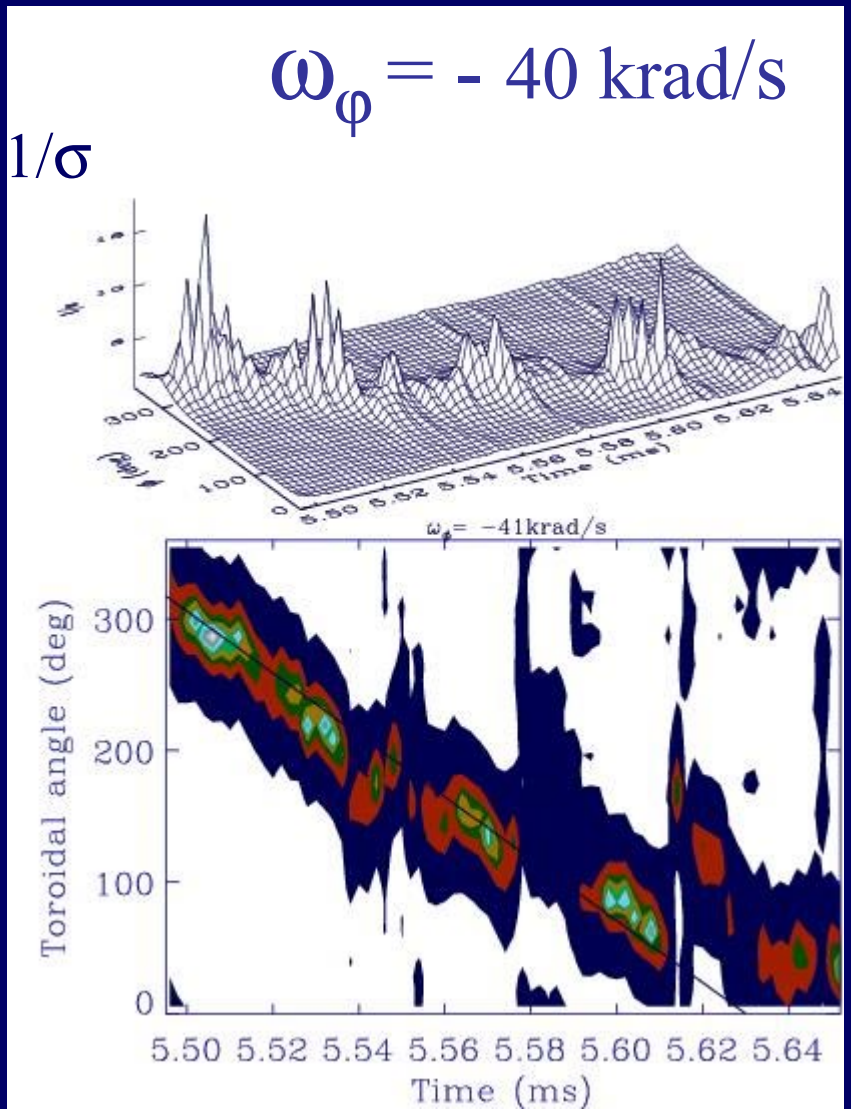
"Internal" non-resonant RWMs

"External" non-resonant RWMs

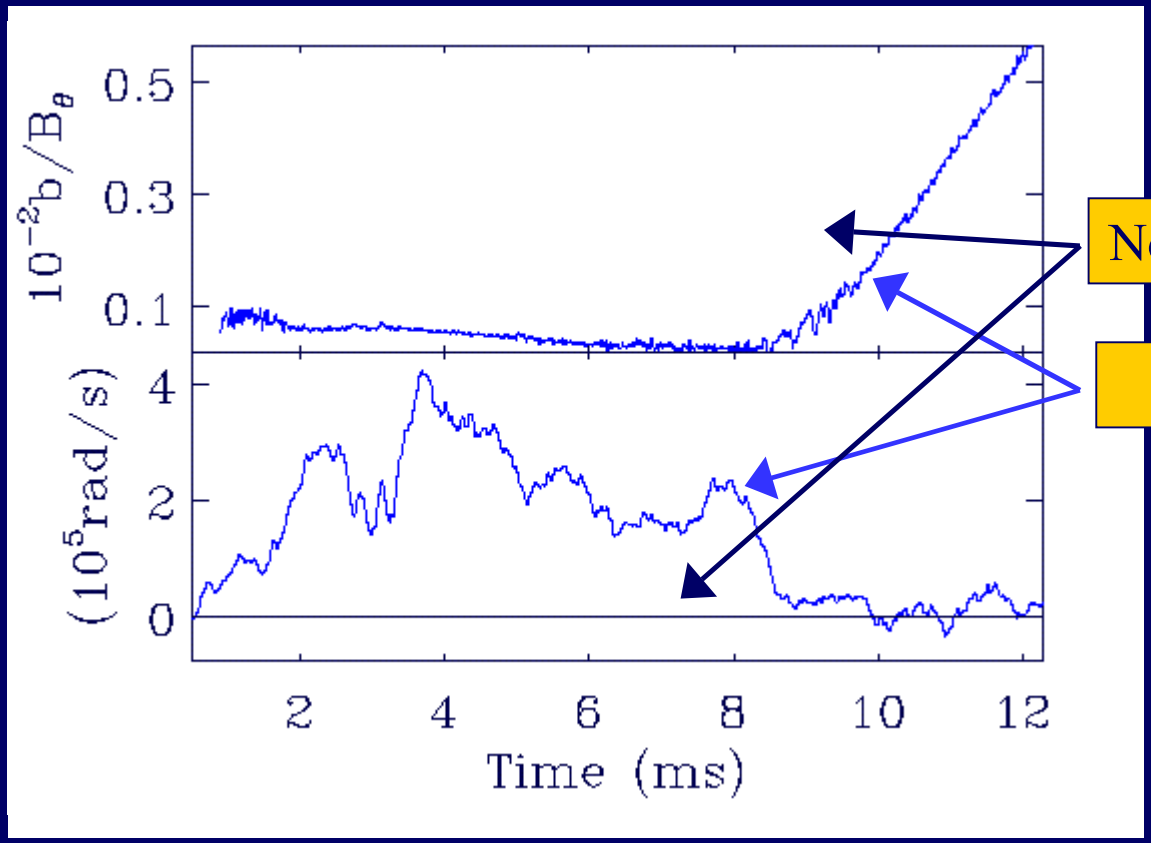


Based on poloidal field coil measurements

Modes resonant inside the reversal surface rotate together forming a ‘slinky’



MHD mode dynamics with a resistive wall boundary

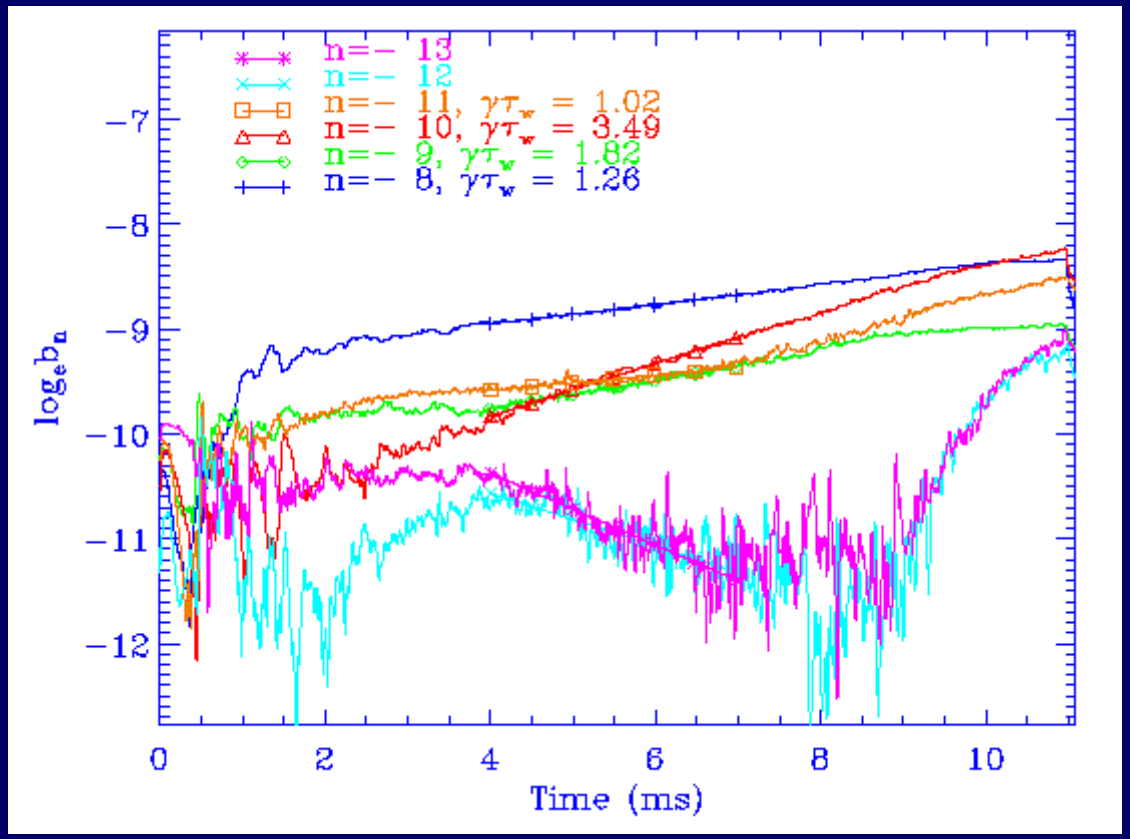


Non-resonant n=-10

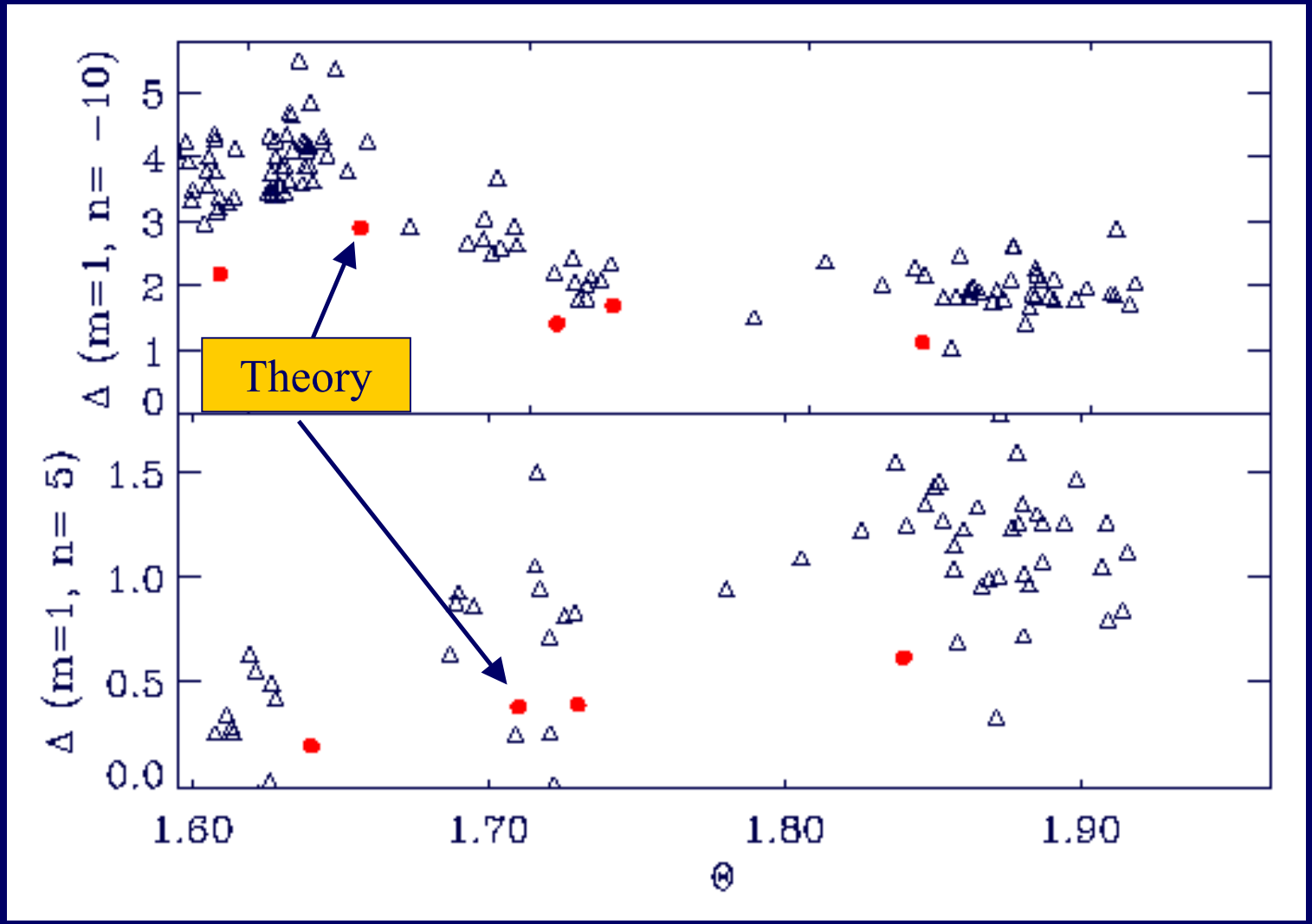
Resonant n=-13

Based on radial field coil measurents

Distinguishing between resonant and non-resonant modes

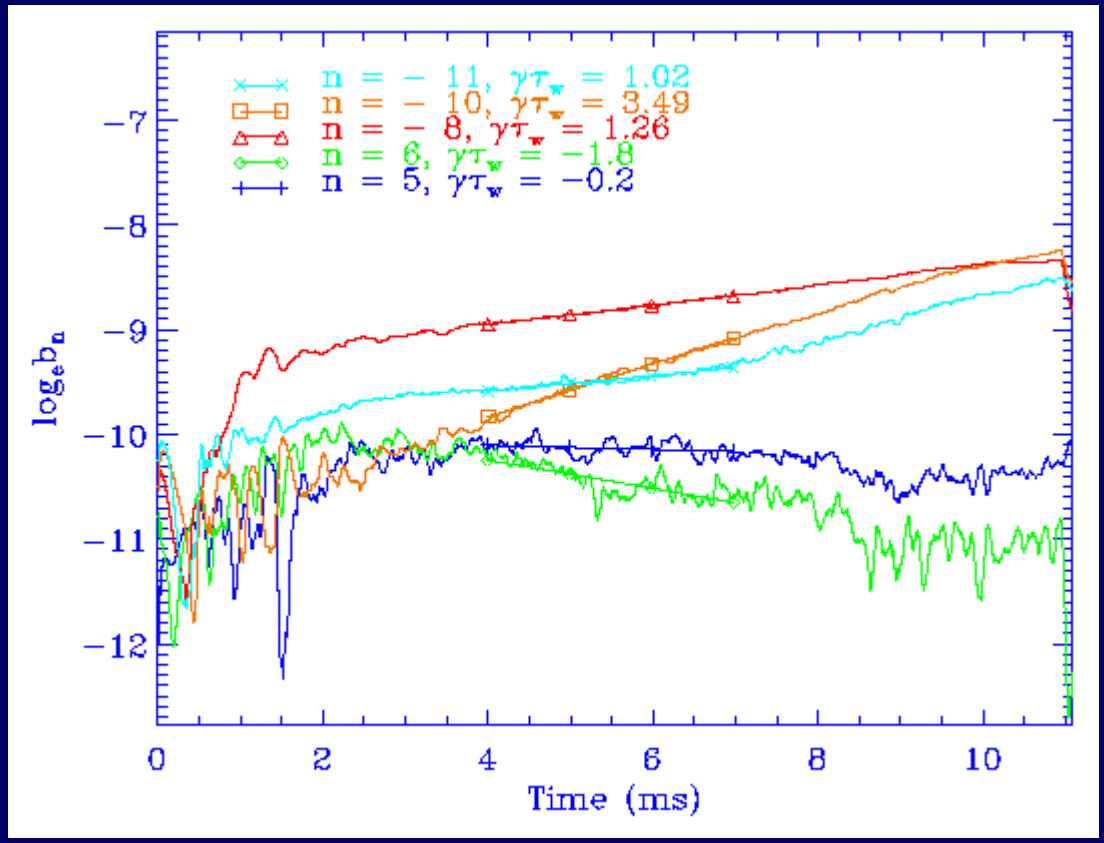


RWM Growth rates for different equilibria

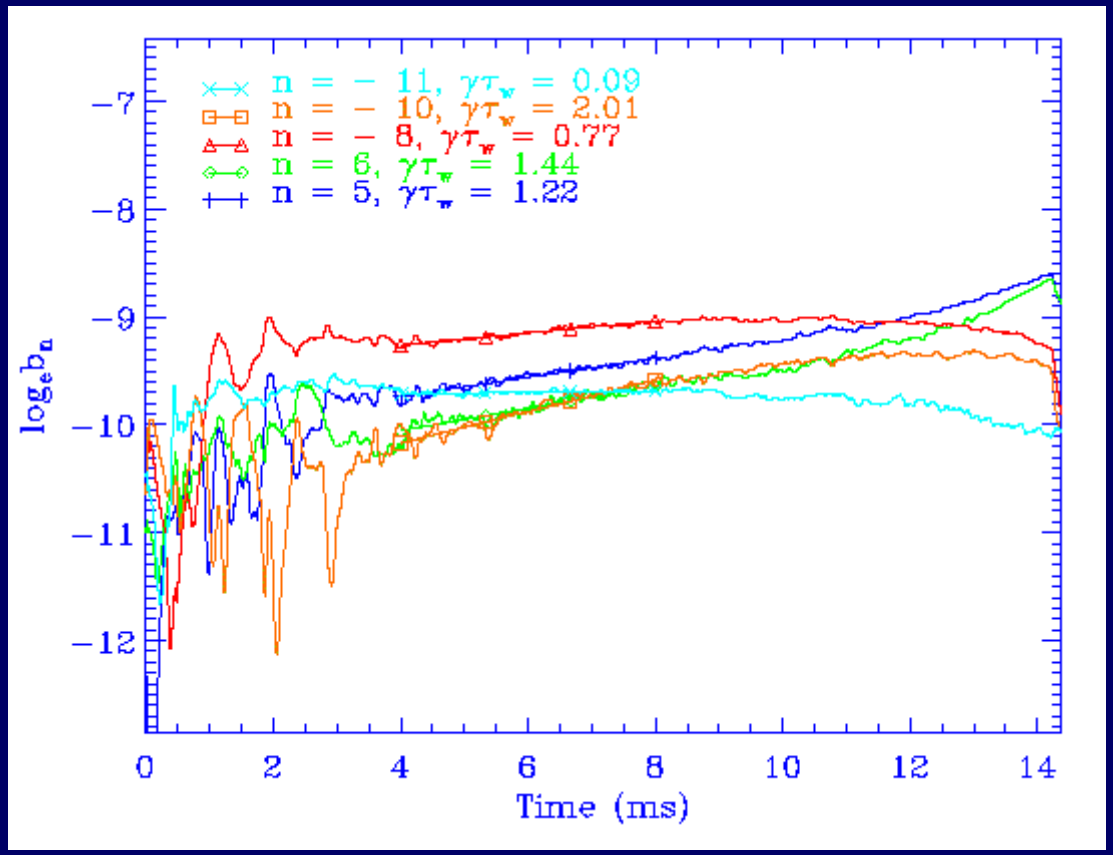


_=B (a)/<B >

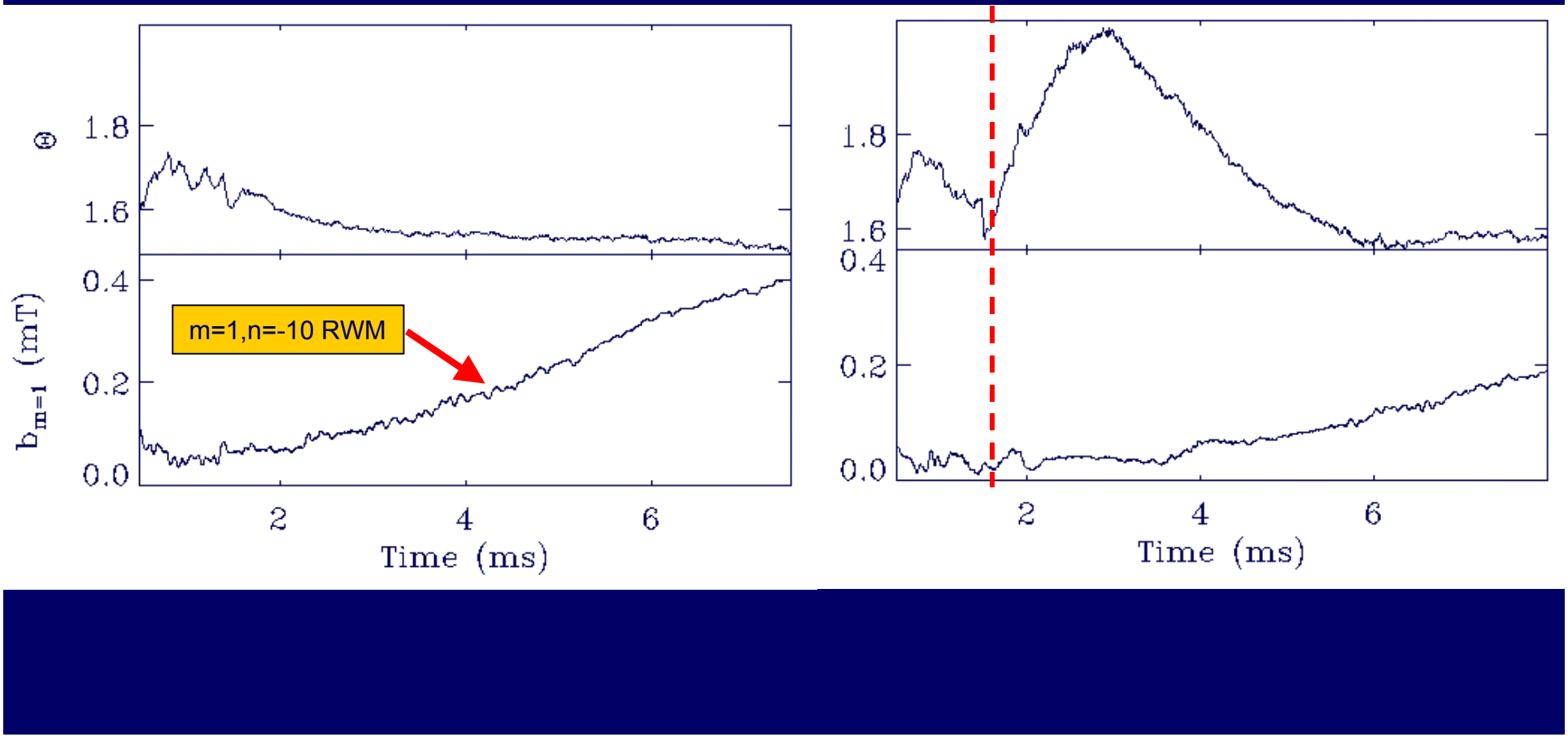
Resistive wall modes (shallow reversal, low Θ)



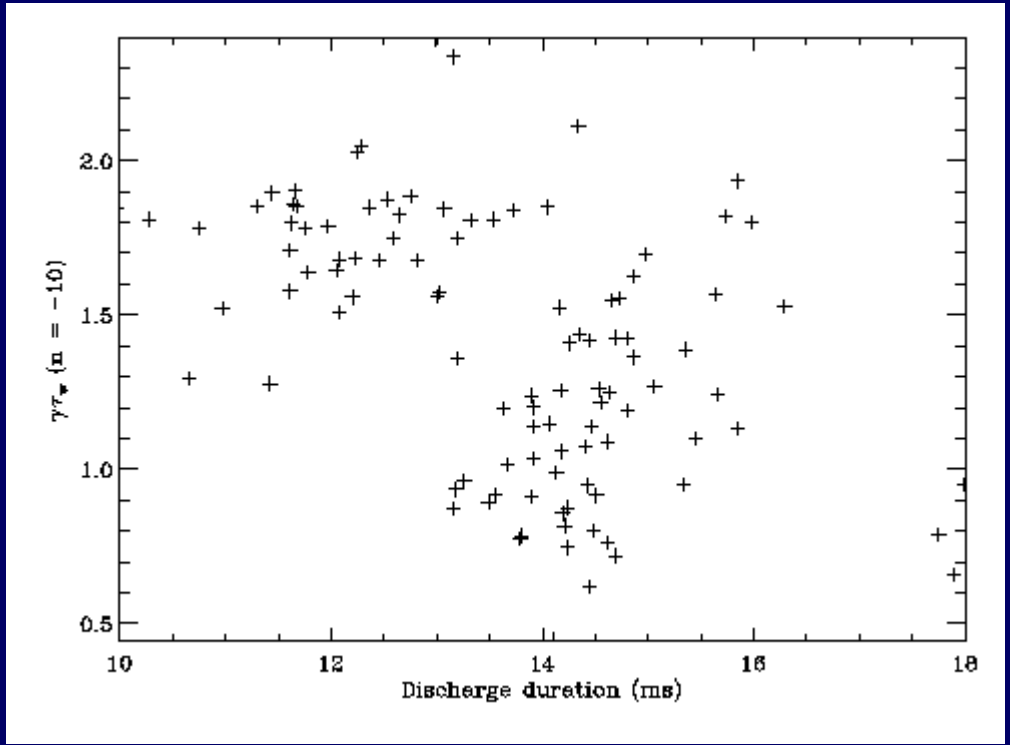
Resistive wall modes (deep reversal, high Θ)



Possible RWM control by equilibrium profile changes



Do the RWMs affect plasma performance?



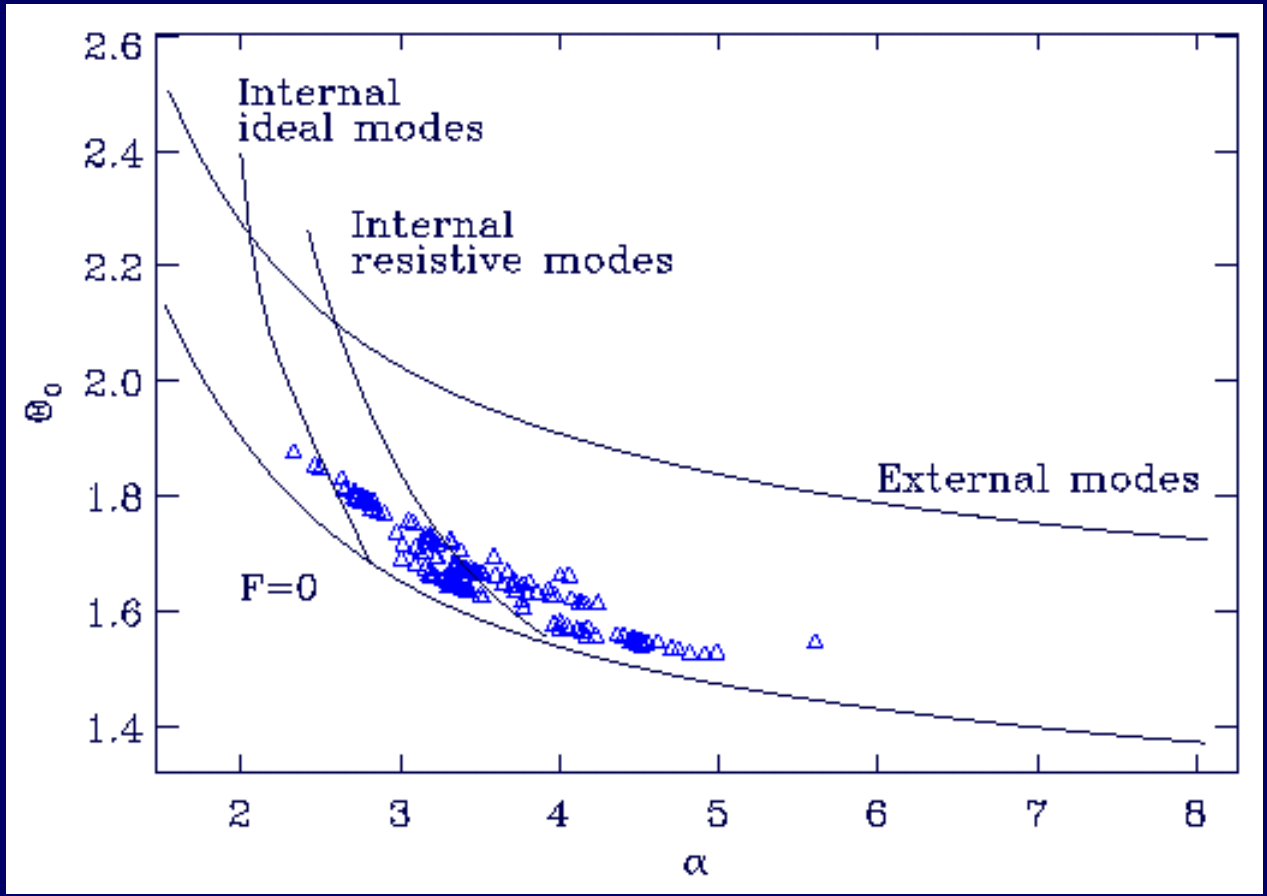
Next step

- Controlling the RWMs with external helical coils in a feedback system.
- Further investigations on RWM control by equilibrium profile changes.
- Study of possible non-linear interaction of RWMs and internally resonant tearing modes.

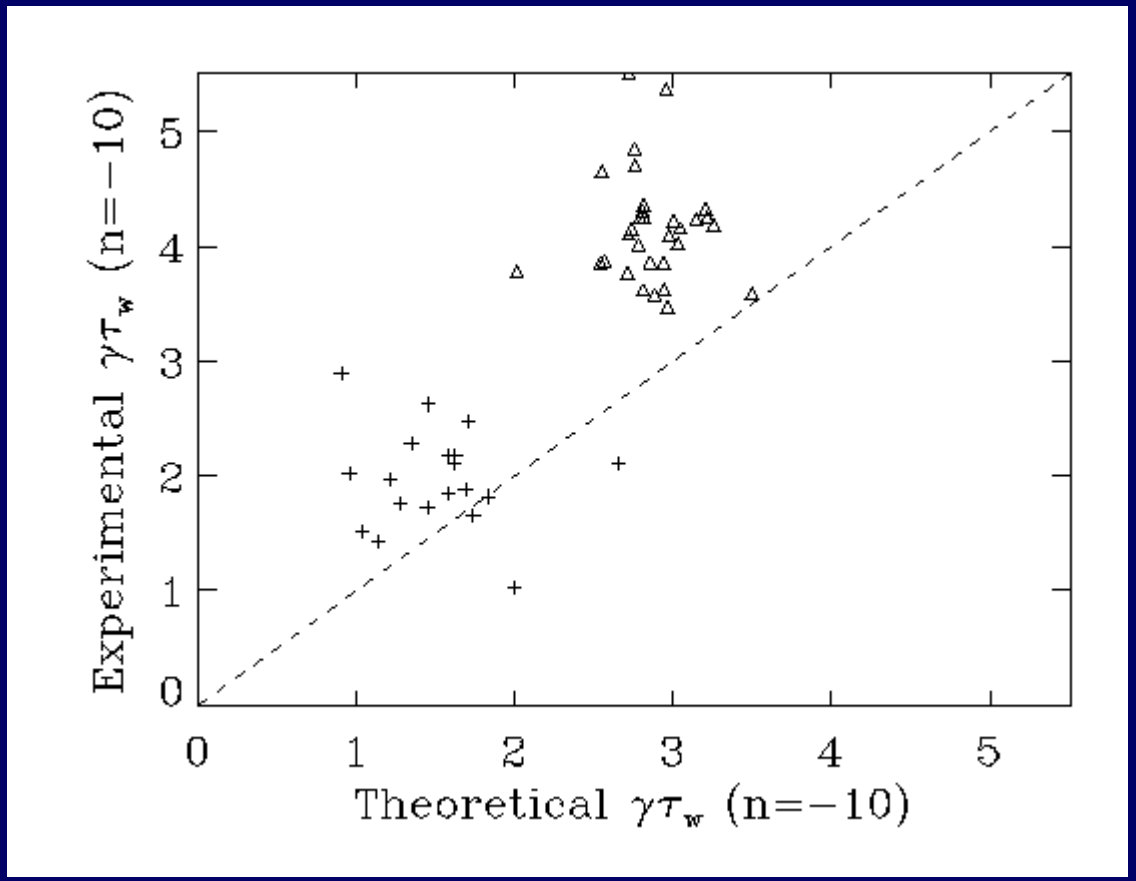
Summary

- Identifying RWMs in T2R -
  - m=1 internally resonant modes rotate resulting in low radial field mode amplitudes. This enables “internally non-resonant” RWM to be identified.
- RWM growth rates in T2R -
  - Growth rates of the internally and externally non-resonant RWMs depend on the RFP current profile equilibrium.
  - The current profile equilibrium in T2R is such that growth rates of “internally non-resonant” RWMs dominate over those of “externally non-resonant” modes.
- Comparing RWM growth rates with linear theory -
  - Reasonable agreement between theory and experiment is observed.

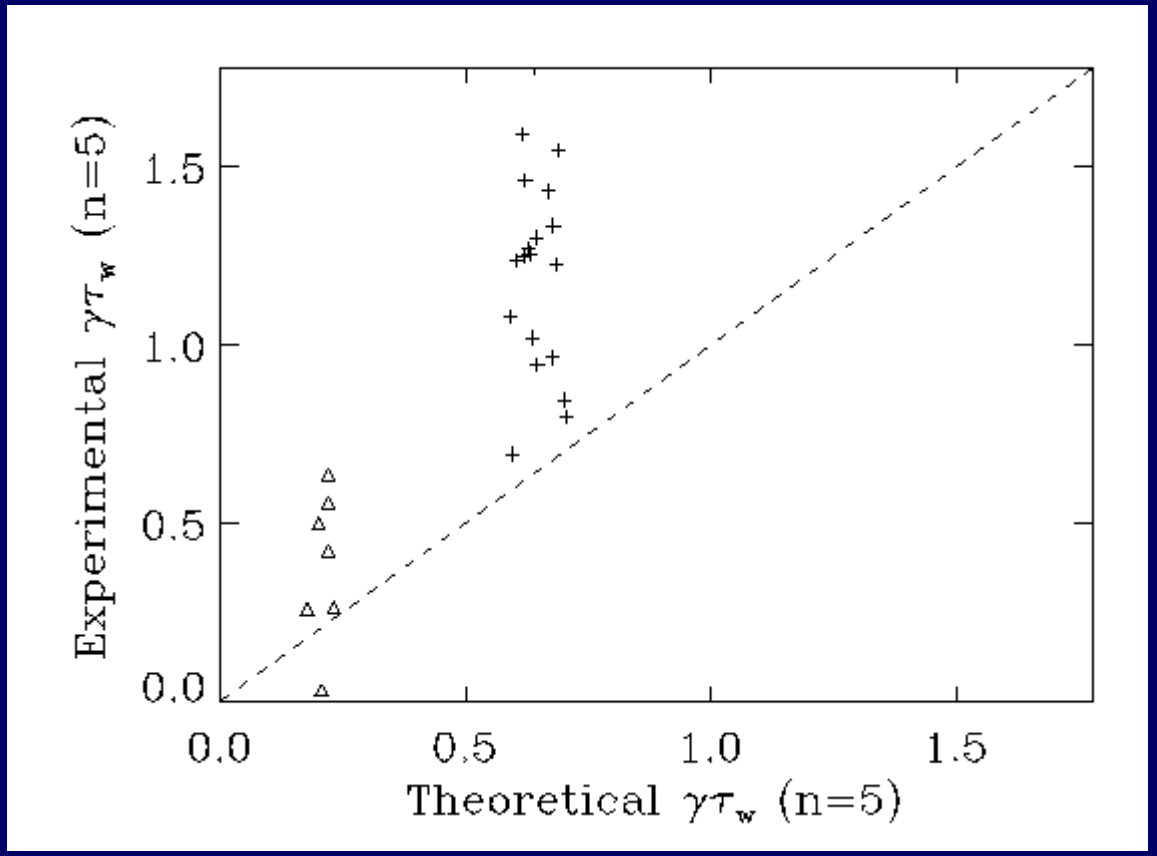
Typical T2R equilibria with stability boundaries



Experimental and theoretical growth rates for m=1, n=-10 mode



Experimental and theoretical growth rates for m=1, n=5 mode



Theoretical and experimental growth rates for two different equilibria