# XP 24:
# Neoclassical Tearing Modes on NSTX

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At the NSTX results forum

Princeton Plasma Physics Laboratory, Princeton NJ

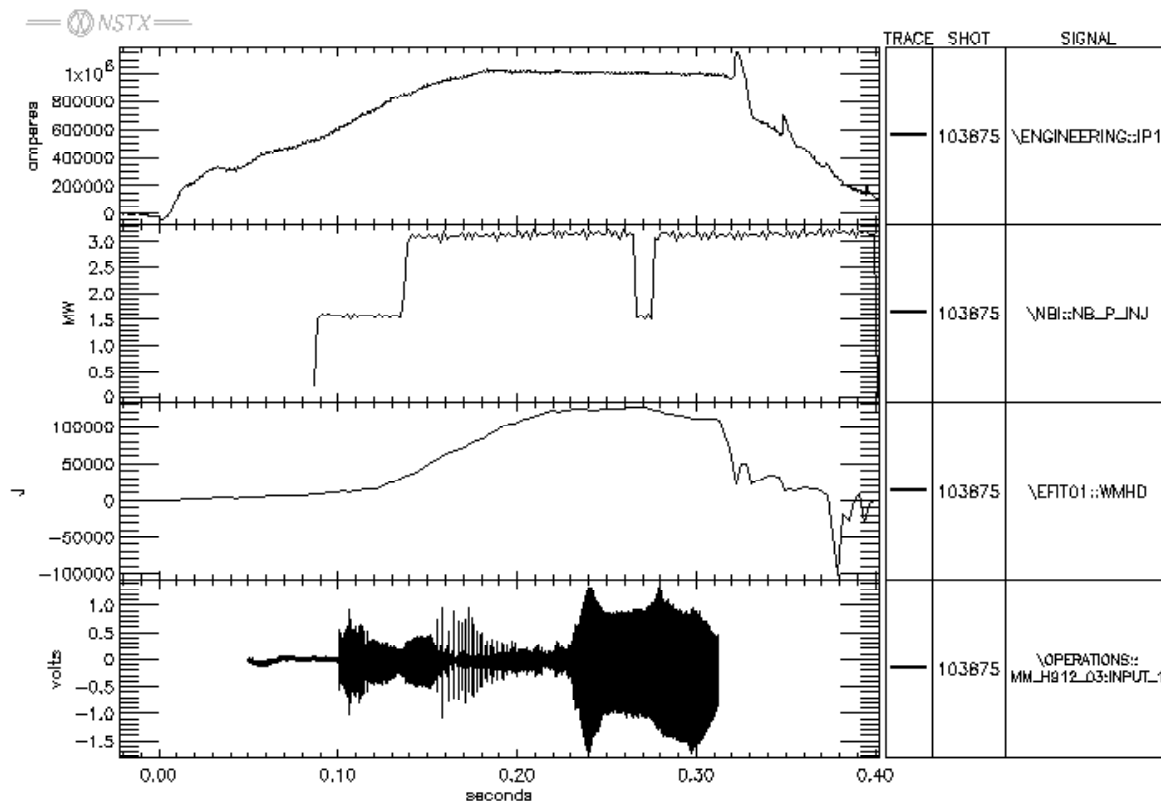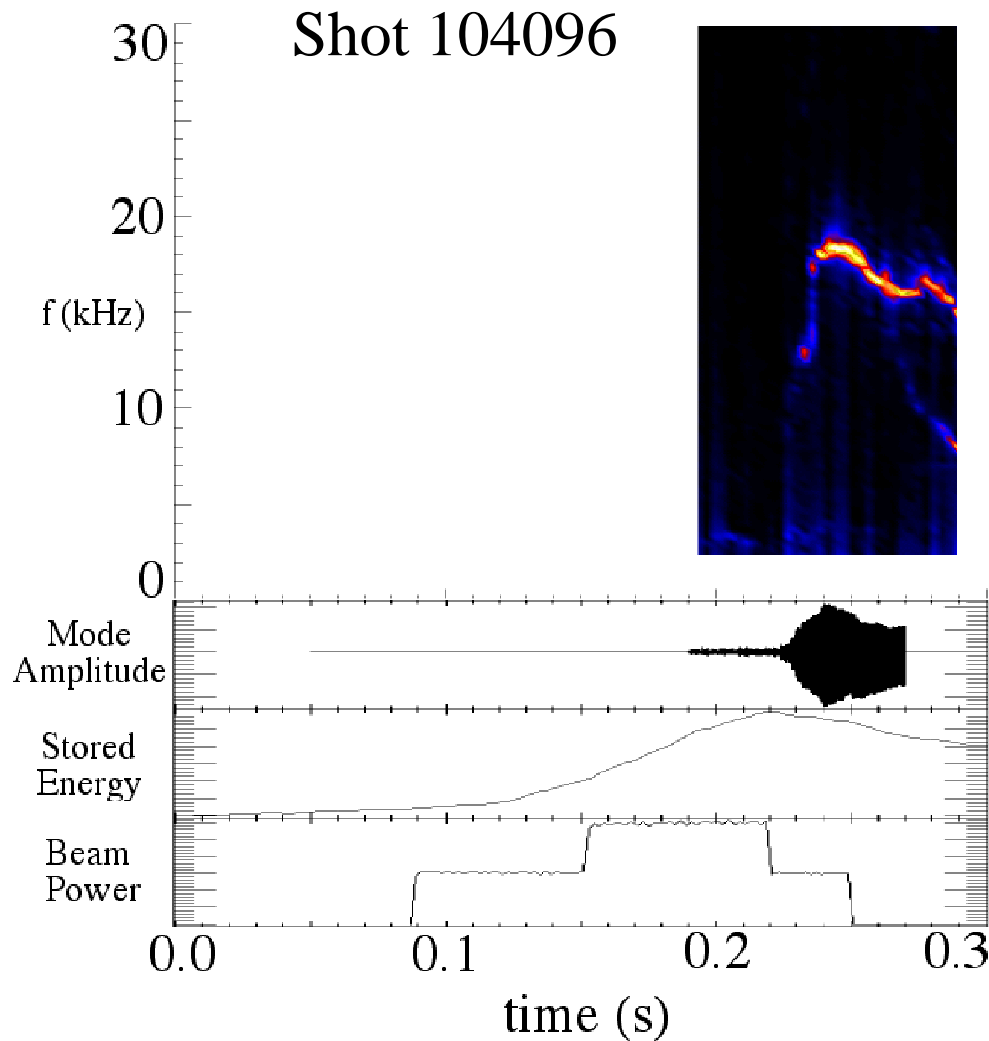9/19/01

# Outline

- Motivation
- Experiment and Analysis method
- Results
- Summary

# Slow growing internal modes observed to limit plasma performance



- Increase in $\beta$ limited by mode, but mode does not cause termination
- Can be avoided with rapid increases in $\beta$.
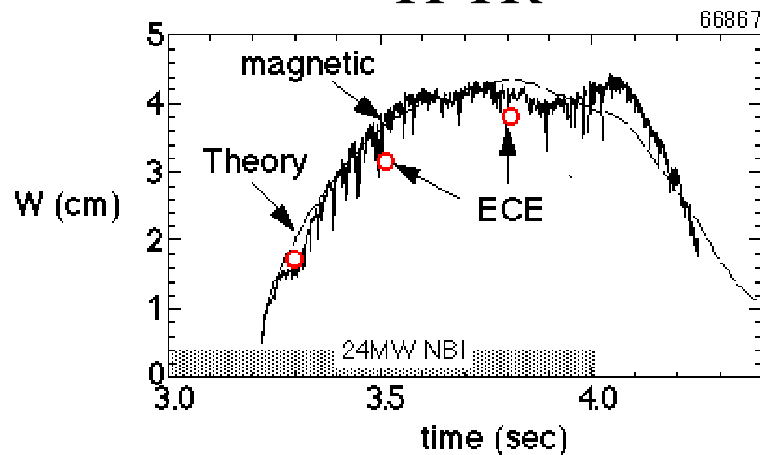
# Beam turn off technique developed for tokamaks

Shot 104096



- Mode appears at constant poloidal $\beta$ ($\beta_p \sim 0.4$)

- Slower growth $\Rightarrow$ resistive mode

- Beam turn off experiment indicates amplitude reduction with stored energy

  - *indicative of bootstrap current driven tearing mode*
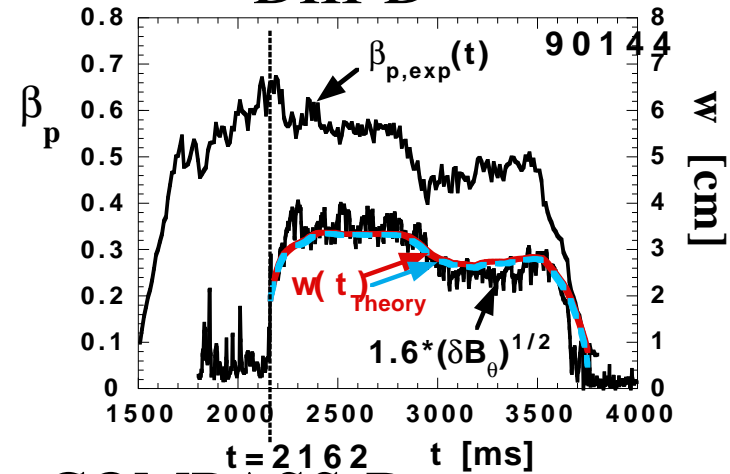
# Saturated island width scales like $\beta_p$

NSTX

## DIII-D



$$w_{sat} = -a_1 \varepsilon^{1/2}\left(\frac{L_q}{L_p}\right)\frac{\beta_p}{\Delta'}$$
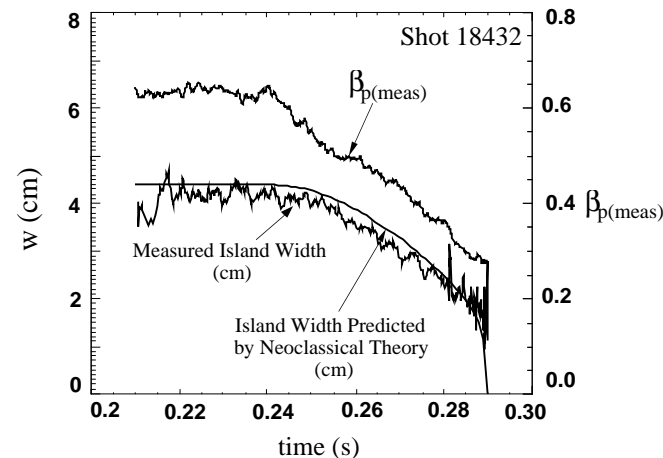
## TFTR



## COMPASS-D

*Non_Ideal MHD and Neoclassical Islands*, D. A. Gates and R. J. LaHaye, and the ITER MHD Expert Group, Chapter 2.3, Nucl. Fusion **39**, (1999) 2272

*Neoclassical Islands on COMPASS-D*, D. A. Gates, et al., Nuclear Fusion **37**, (1997) 1593
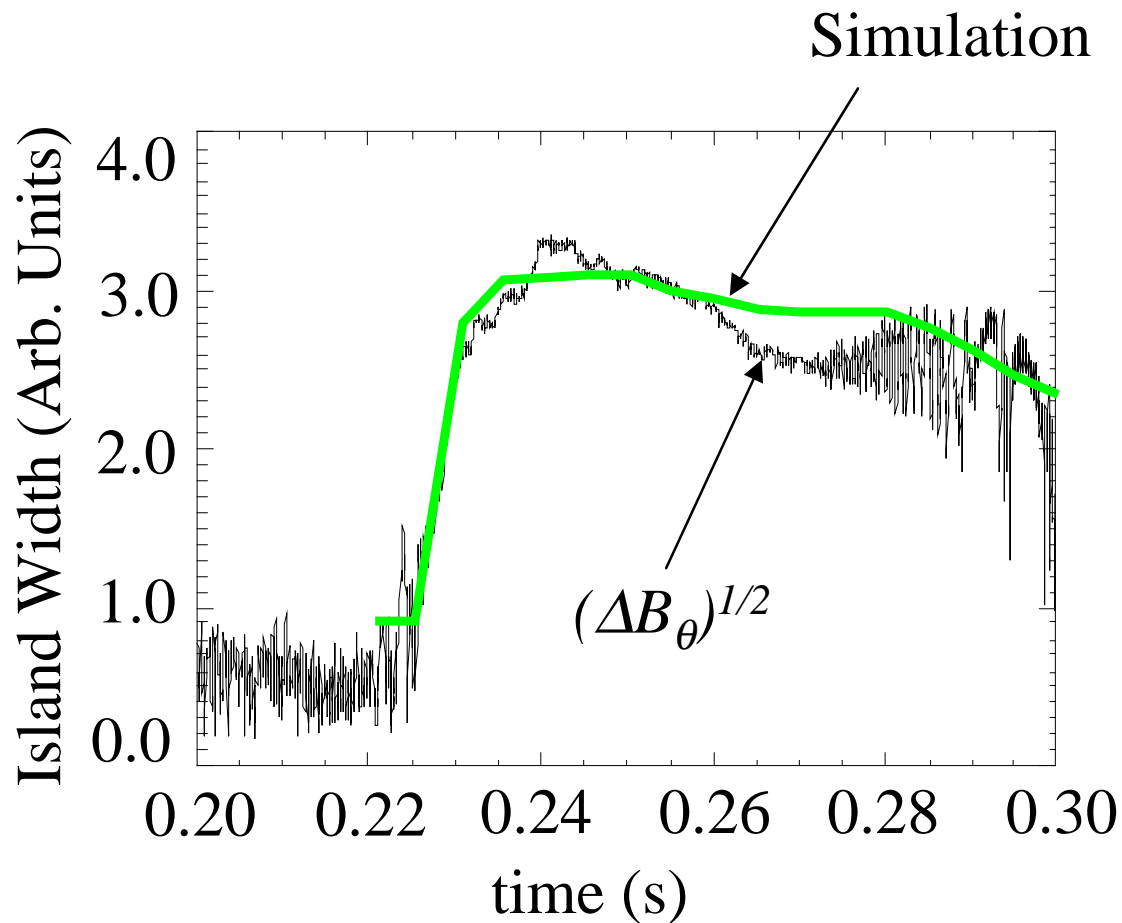
# Analysis

- Solve modified Rutherford equation

$$\frac{\mu_0}{1.22\eta_{nc}}\frac{dw}{dt} = \Delta' + a_1\varepsilon^{1/2}\beta_\theta\frac{L_q}{L_p}\left(\frac{w}{w^2+w_c^2}\right) - a_2\frac{\rho_{\theta i}^2\beta_\theta g(\varepsilon)}{w^3}\left(\frac{L_q}{L_p}\right)^2$$

Ohmic current      Bootstrap current      Polarization current
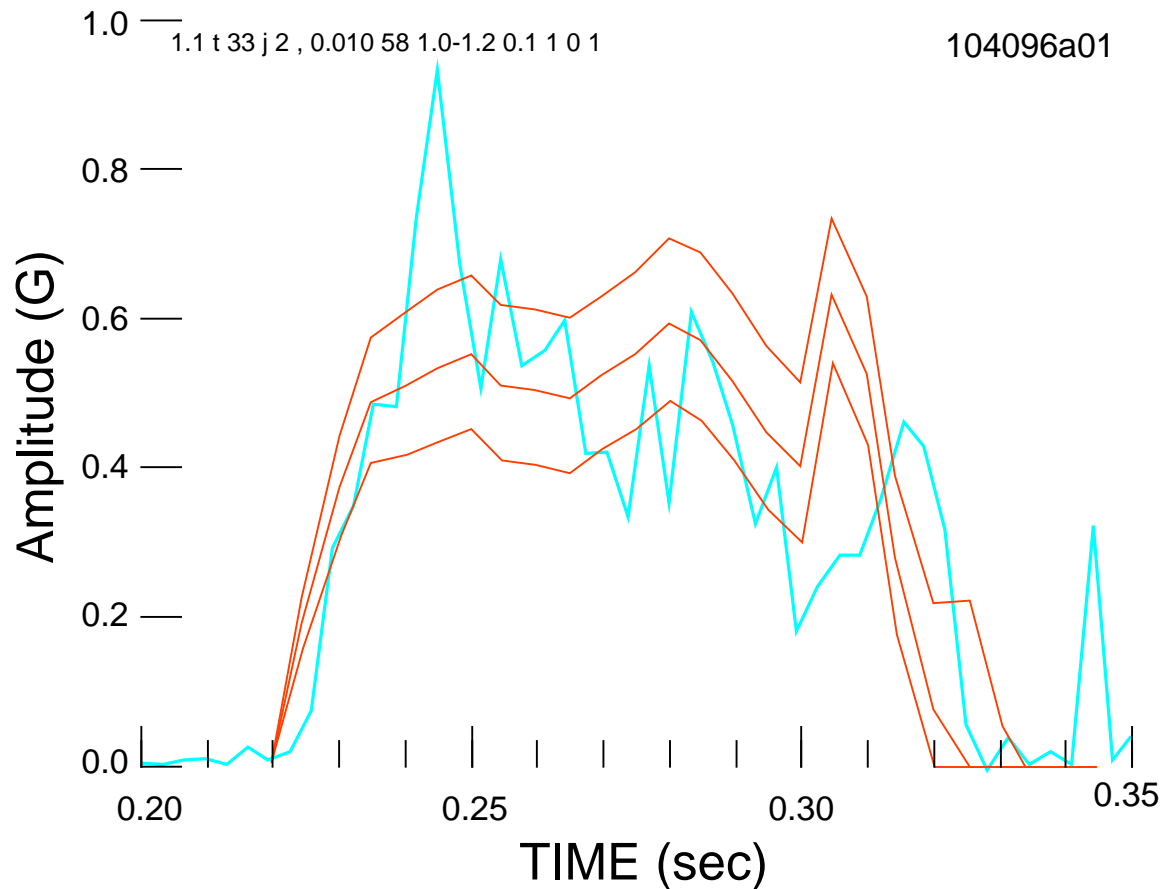
Finite transport correction

- Compare solution to measured field perturbation

# Results



- Analysis shows reasonable agreement with data

- Interesting amplitude modulation behavior at end of shot

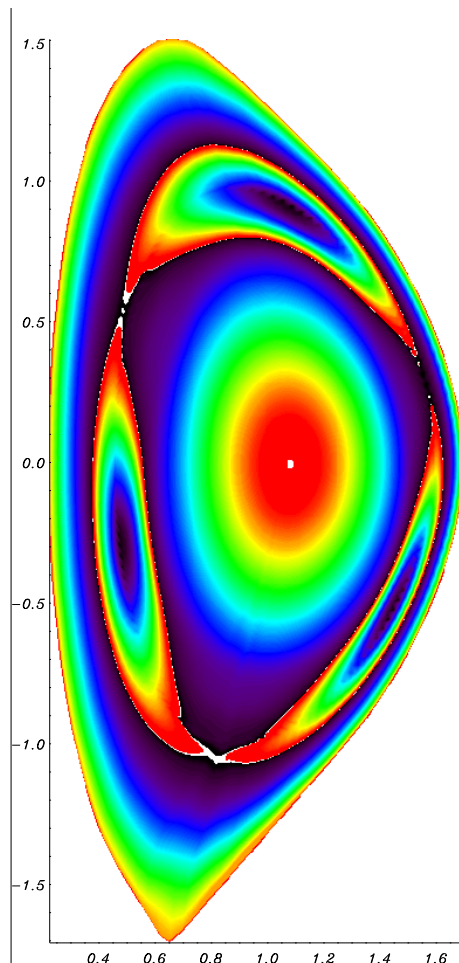- Use similar values of free parameters as for tokamaks

# Measured fields amplitudes also show good agreement



- Surprising given limitations of the cylindrical model
- Requires more accurate geometric model

# Code Development

Low-$\beta$ NSTX equilibrium showing a 3/1 tearing mode

- Use PEST-III to calculate $\Delta'$, and eigen-function

- Use NIMROD subroutines to calculate neoclassical terms

- Combine and plot results in IDL

- Has led to numerous improvements in PEST-III (high-$\beta$, low-A resolution issues)

A. Rosenberg

# Summary

- Initial analysis that the modes that have been observed to limit performance in NSTX long pulse discharges are most likely neoclassical tearing modes
- Limits $\beta_p \sim 0.4$
- Modes appear near $\beta_{crit}$
- Further analysis required

*NSTX*