

M3D-K Modeling: Sawteeth, Kink, TAE, and Fast Ion Transport

Guoyong Fu, March 2, 2012

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F. Wang

N. Crocker, E. Fredrickson, M. Podesta, B. Tobias,
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Introduction

- Goal: Predict beam-driven Alfvén modes and beam ion transport in NSTX-U.
- Recent M3D-K modeling:

Beam-driven Alfvén Eigenmodes in DIII-D (J. Lang et al)

Sawteeth and fast ion transport (W. Shen et al)

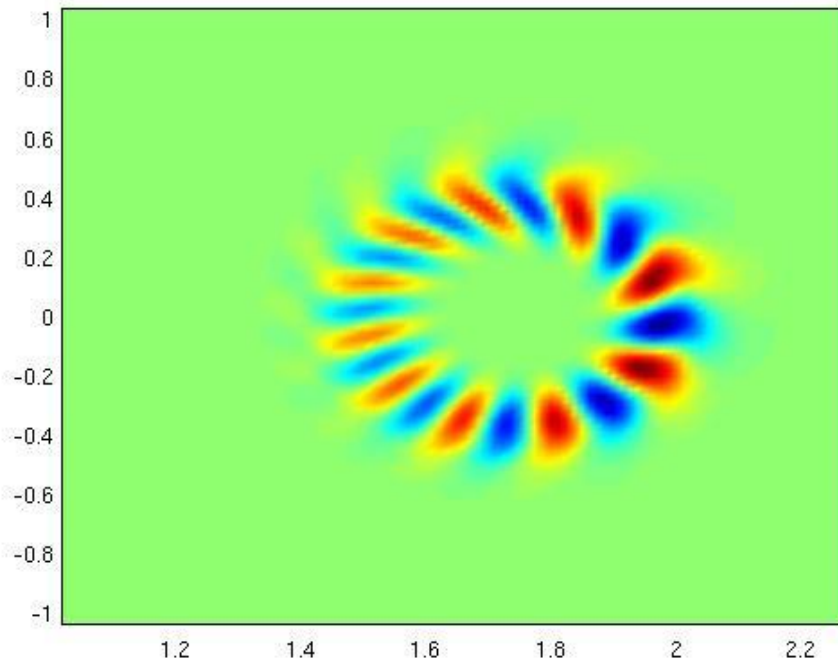
Non-resonant kink and fast ion transport in NSTX (F. Wang et al)

Beam-driven TAEs in NSTX (G.Y. Fu, D.Y. Liu et al)

- Possible Near Term M3D-K Upgrades
- Future Work

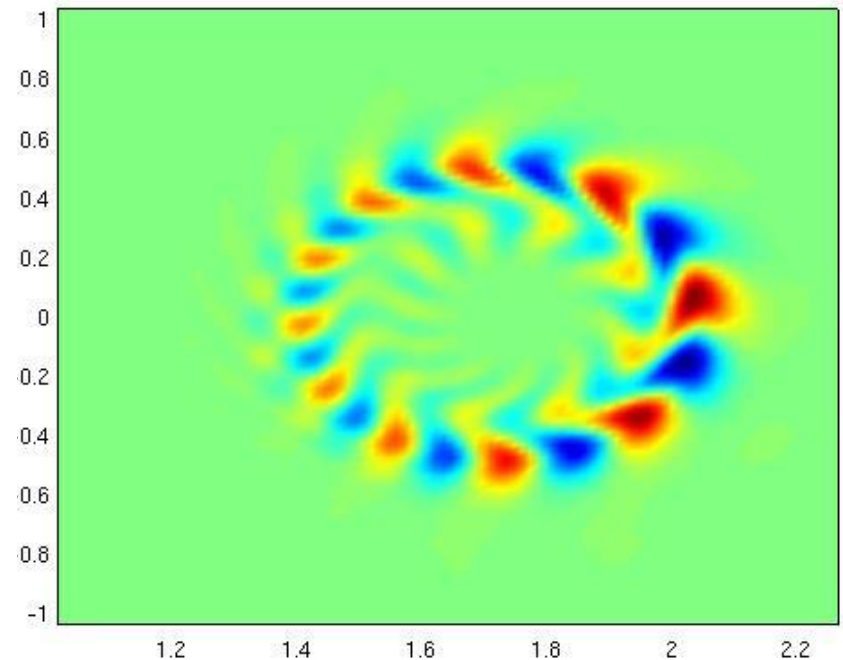
M3D-K Simulations of Beam-driven Alfvén Eigenmodes in DIII-D Plasmas

J. Lang et al.



$$q_{\min} = 3.27$$

The mode frequency/structure agree well with NOVA results (RSAE at $q_{\min}$ location).

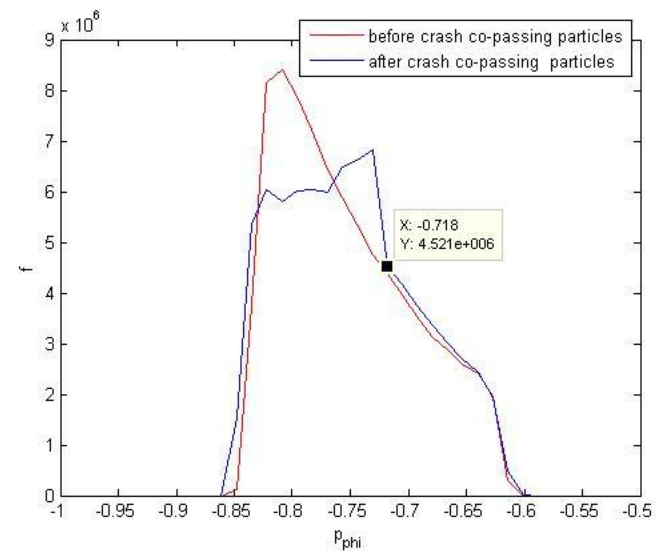
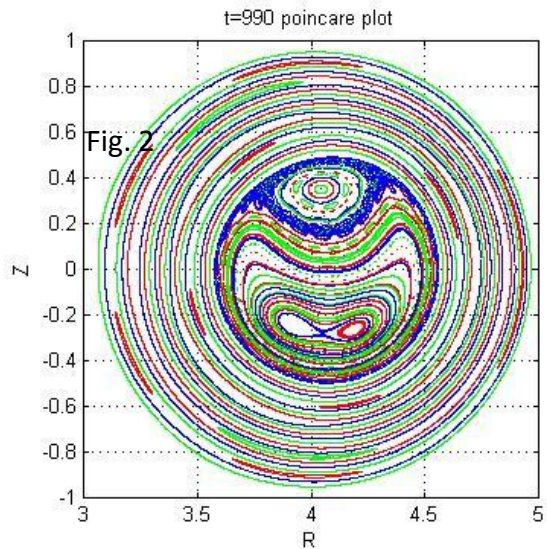
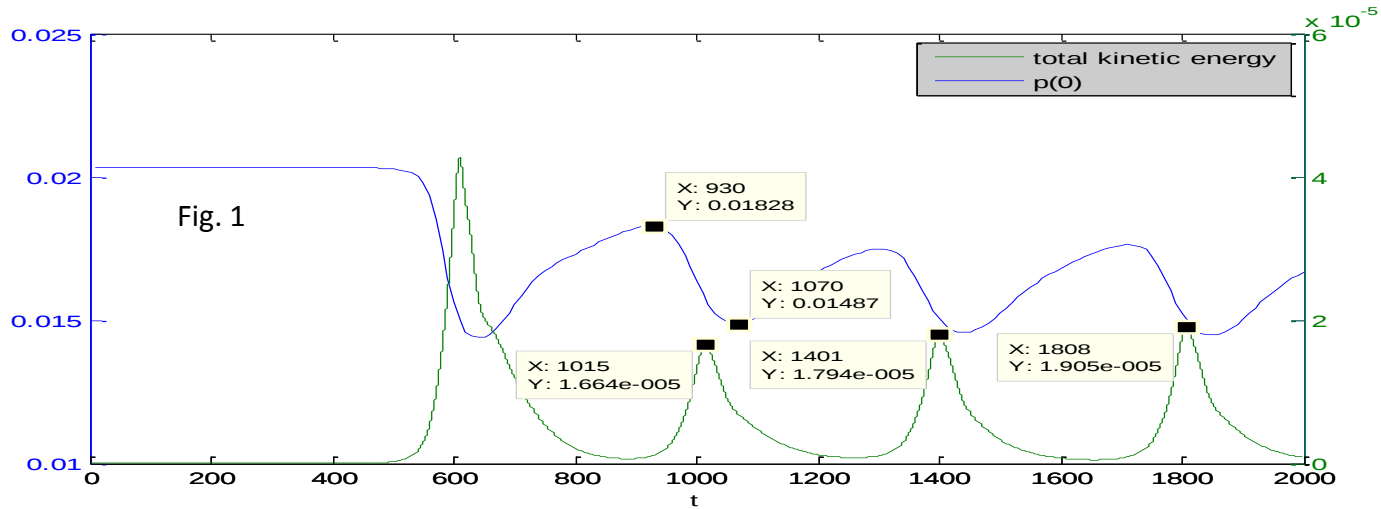


$$q_{\min} = 3.15$$

The mode structure is at the outside of the $q_{\min}$ location. The mode frequency is lower than the NOVA result (TAE at $q_{\min}$ location).

M3D-K Simulation of Sawteeth and Fast Ion Transport

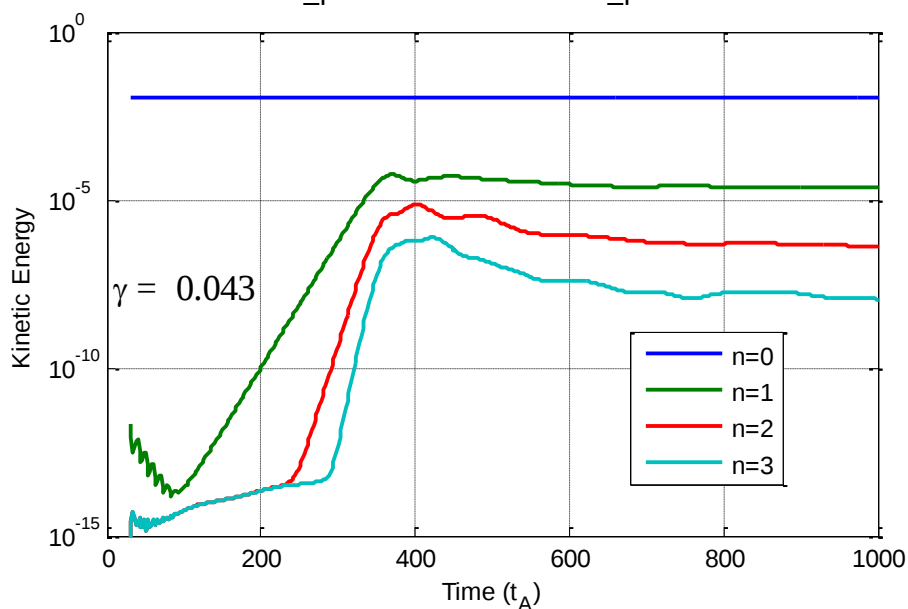
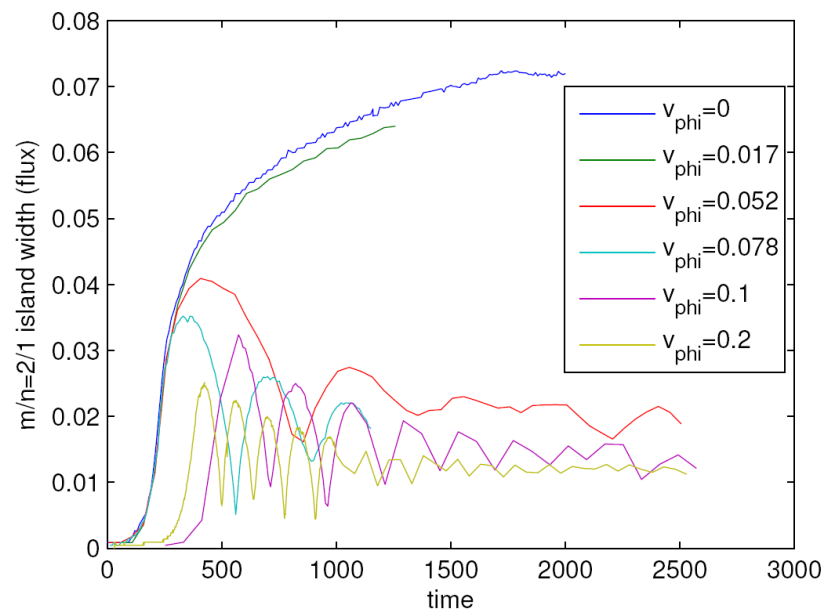
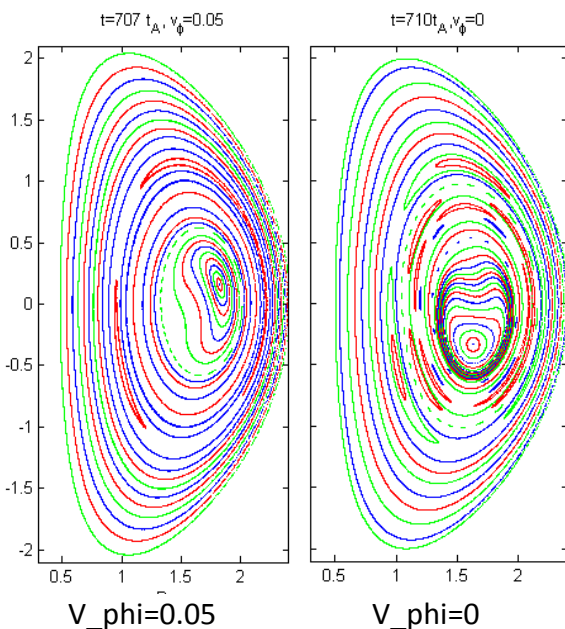
W. Shen, G.Y. Fu



M3D Simulation of Non-Resonant Internal Kink in NSTX (shot #124379) :

rotation effects on magnetic island

F. Wang, G.Y. Fu, J.A. Breslau



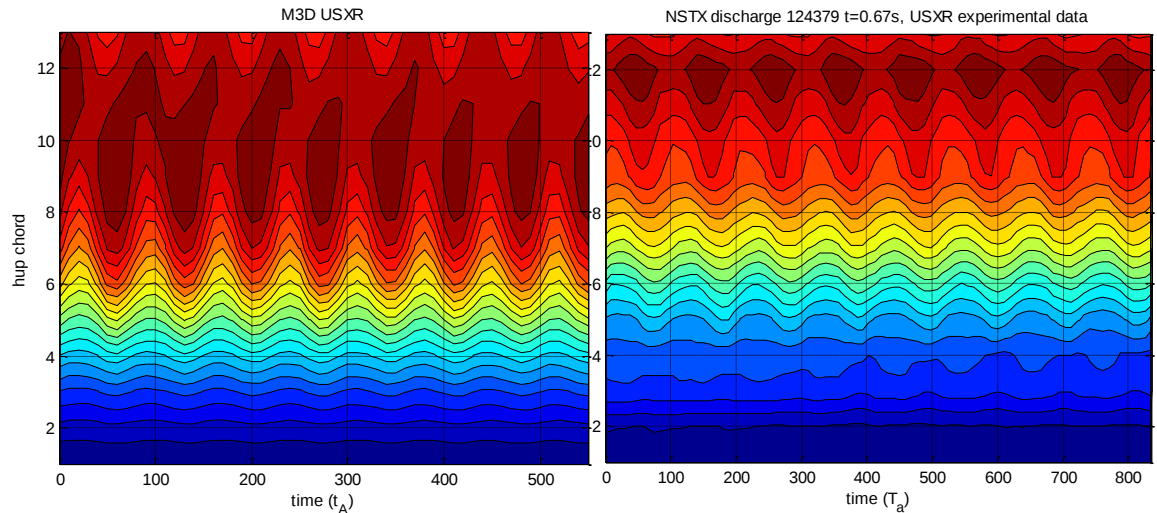
- Rotation have significant effects on both 2/1 and 1/1 islands.
- With finite rotation, the 2/1 island width exhibits oscillation in the initial evolution before final steady state saturation, and the oscillation speed (0.0188) is approximately equal to the difference between mode rotation speed (0.0313) and plasma rotation speed at $q=2$ (0.0139) surface.

Non-resonant Internal Kink in NSTX (shot #124379):

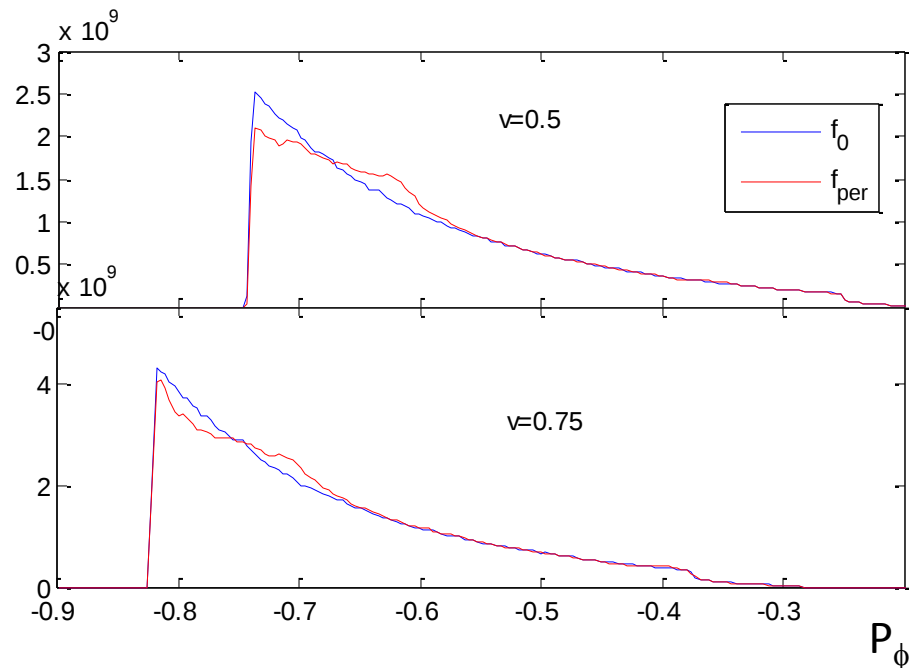
Comparison between M3D and SXR Data, Fast Particles Redistribution

K. Tritz

- M3D's USXR result agrees qualitatively with the experimental data.

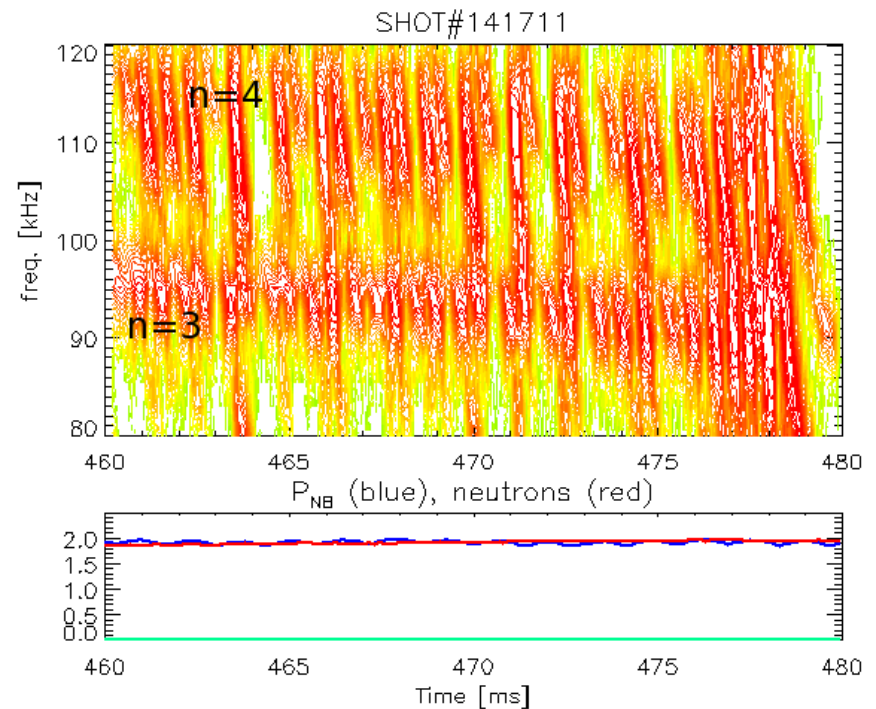
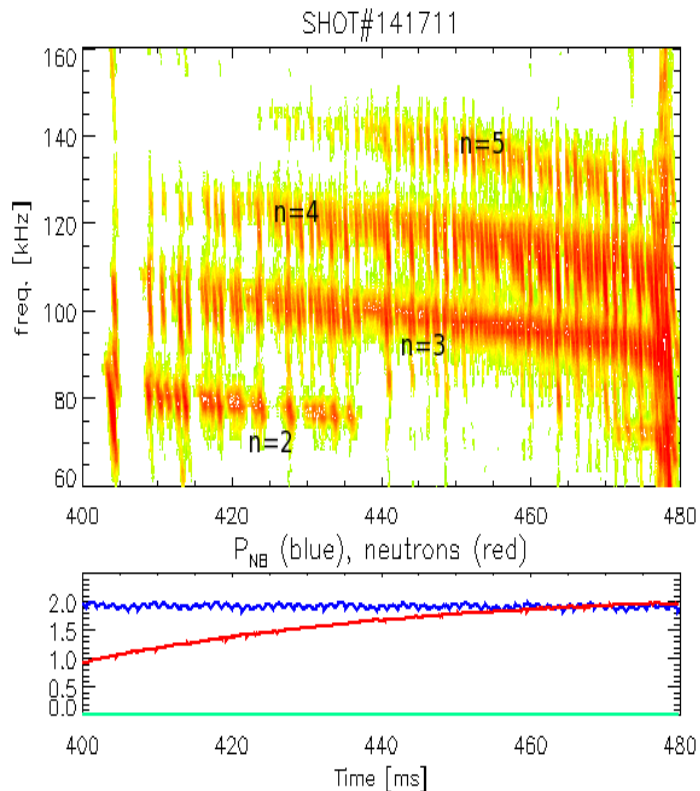


Beam ion distribution function is flattened by the mode.



Multiple beam-driven TAEs were observed in NSTX (shot #14711)

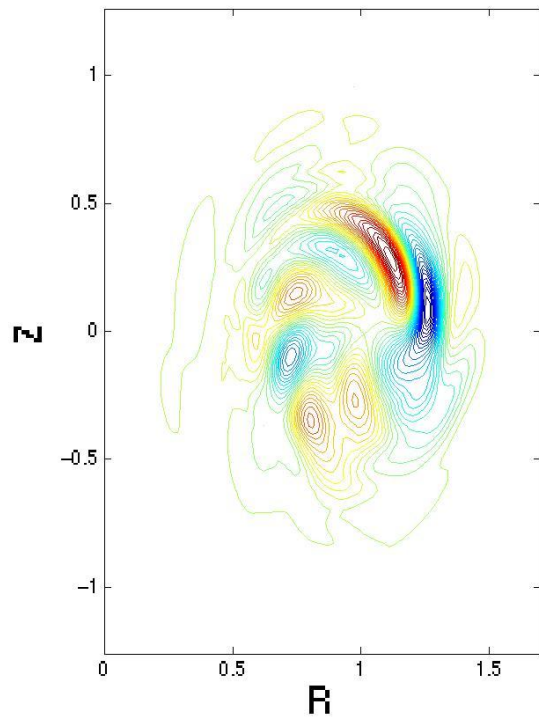
M. Podesta



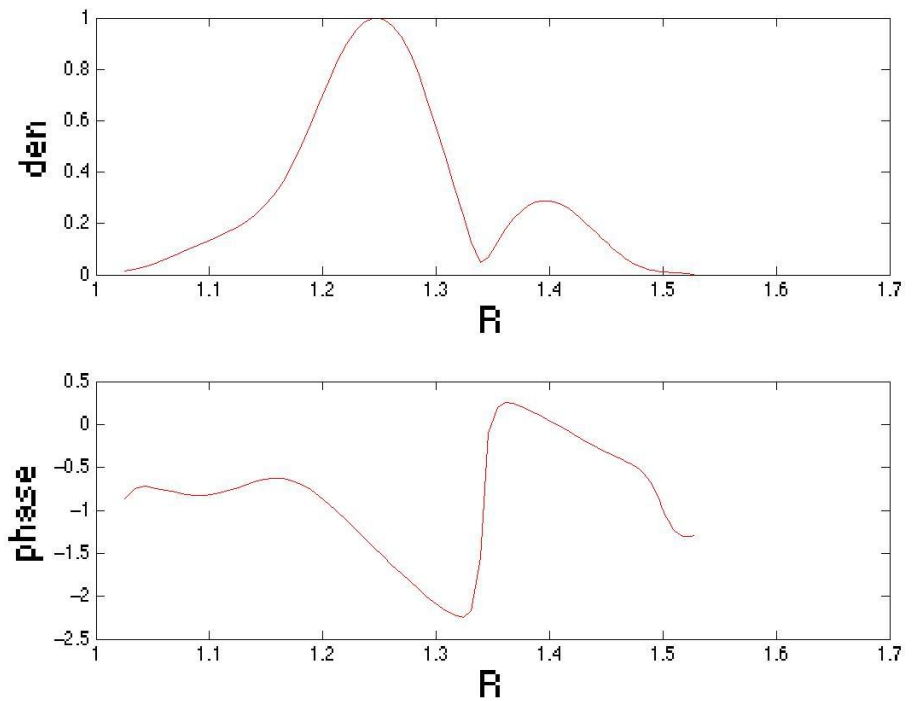
↑
t=470ms

$n=3$ TAE

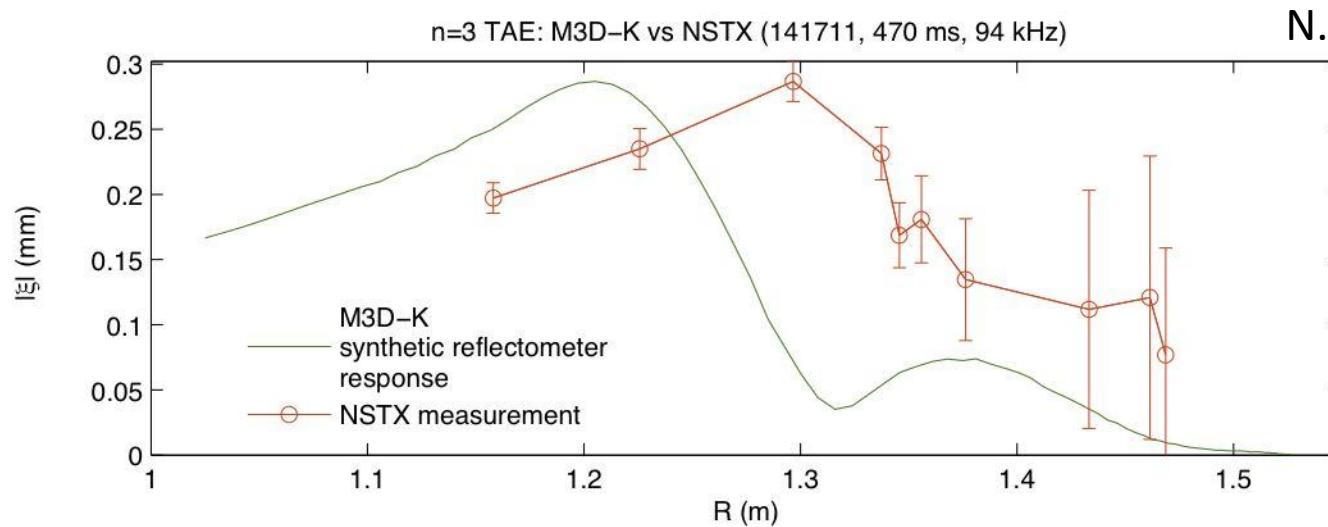
δn_e



$f=97\text{kHz}$

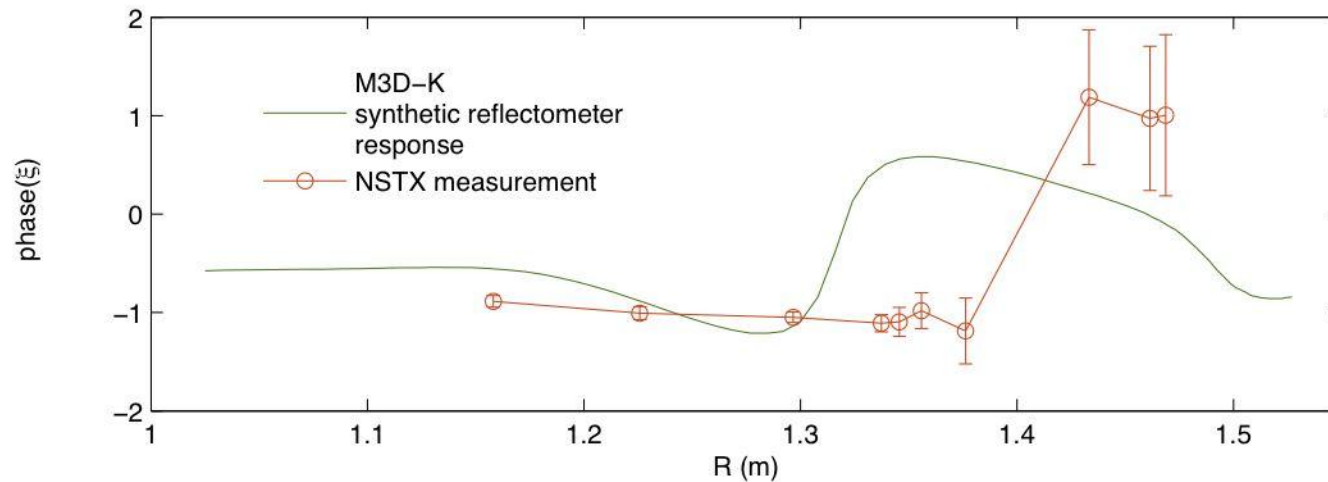


M3D-K's mode structure is similar to the measurement.
The main difference is a shift in mode location.



$$f_{\text{exp}} = 94 \text{ kHz}$$

$$f_{\text{M3D-K}} = 97 \text{ kHz}$$



M3D-K Upgrade

- Interface with beam ion distribution from NUBEAM (< 6 months);
- Implement a CAE/TAE antenna in the code (< one year);
- Extend M3D-K to free-boundary for simulations of resistive wall modes with kinetic effects.

Future Work

- Continue code validation studies for beam-driven TAE in NSTX;
- Study impact of MHD modes on beam ion profile and beam-driven current;
- Nonlinear simulations of multiple TAEs and beam ion transport (self-consistent modeling of chirping and avalanche).